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Supplementary information

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# Copper-catalysed synthesis of chiral alkynyl cyclopropanes using enantioconvergent radical cross-coupling of cyclopropyl halides with terminal alkynes

In the format provided by the authors and unedited

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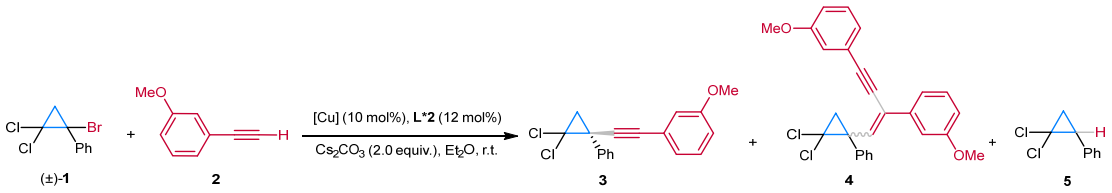
## Supplementary Tables for experiments

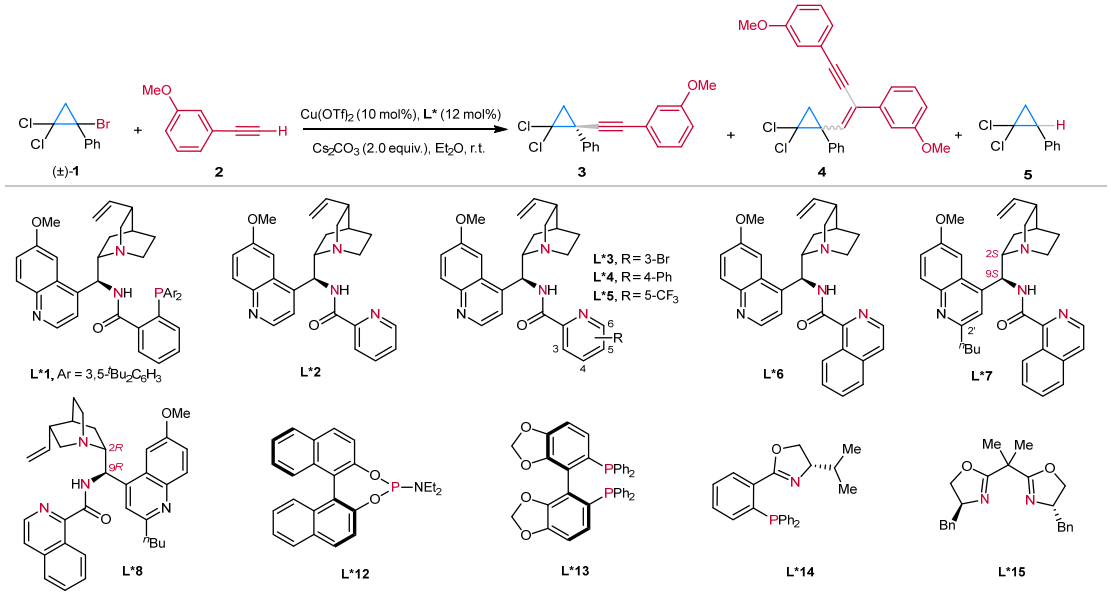
### Supplementary Table 1 | Screening of copper salts[a]




| Entry | [Cu] | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3[d] | 4 | 5 | |
| 1 | CuTc | 5 (22) | 10 | 8 | –68 |
| 2 | CuSCN | 8 (27) | 14 | 8 | –68 |
| 3 | CuI | 5 (29) | 6 | 6 | –68 |
| 4 | $Cu(PPh_3)_3Br$ | 8 (47) | 6 | 3 | –68 |
| 5 | $Cu(MeCN)_4PF_6$ | 5 (29) | 5 | 7 | –68 |
| 6 | $Cu(HCOO)_2$ | 30 (88) | 2 | 2 | –68 |
| 7 | CuOAc | 45 (68) | 17 | 4 | –68 |
| 8 | $Cu(OAc)_2$ | 44 (92) | 4 | ND | –68 |
| 9 | CuOTf·1/2Ph | 24 (69) | 8 | 3 | –68 |
| 10 | $Cu(OTf)_2$ | 44 (96) | 2 | ND | –68 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol), 3-ethynylanisole **2** (1.5 equiv.), [Cu] (10 mol%), **L*2** (12 mol%) and $Cs_2CO_3$ (2.0 equiv.) in $Et_2O$ (1.0 mL) at room temperature (r.t.) for 3 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. [d]The percentage of **3** among the three products is shown in parenthesis. ND, not determined.

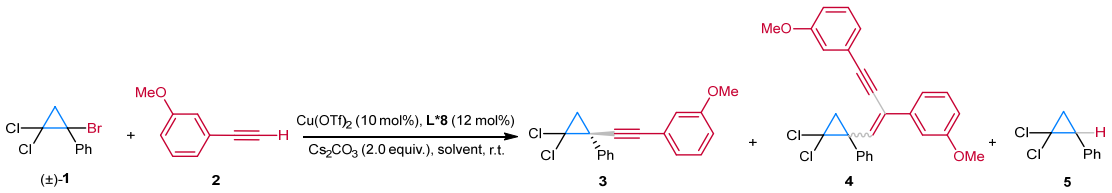
## Supplementary Table 2 | Screening of the ligands[a]




| Entry | L* | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3[d] | 4 | 5 | |
| 1 | **L*1** | 4 (14) | 13 | 11 | 40 |
| 2 | **L*2** | 44 (96) | 2 | ND | –68 |
| 3 | **L*3** | 28 (88) | 2 | 2 | –74 |
| 4 | **L*4** | 38 (88) | 5 | ND | –66 |
| 5 | **L*5** | 49 (96) | 2 | ND | –68 |
| 6 | **L*6** | 95 (98) | 2 | ND | –84 |
| 7 | **L*7** | 95 (98) | 2 | ND | –88 |
| 8 | **L*8** | 95 (99) | 1 | ND | 90 |
| 9 | **L*12** | ND | ND | ND | ND |
| 10 | **L*13** | ND | ND | ND | ND |
| 11 | **L*14** | ND | ND | ND | ND |
| 12 | **L*15** | ND | ND | ND | ND |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*** (12 mol%) and $Cs_2CO_3$ (2.0 equiv.) in $Et_2O$ (1.0 mL) at room temperature (r.t.) for 3 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. [d]The percentage of **3** among the three products is shown in parenthesis. ND, not determined.

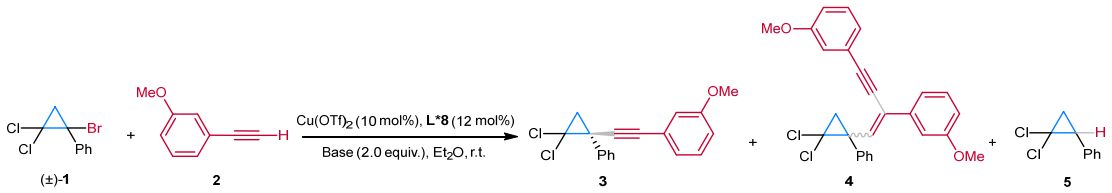
**Supplementary Table 3 | Screening of solvents**[a]




| Entry | Solvent | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | |
| 1 | $CH_2Cl_2$ | 95 | 1 | ND | 80 |
| 2 | EtOAc | 95 | ND | ND | 84 |
| 3 | Cyclohexane | 67 | 1 | ND | 88 |
| 4 | MeCN | 95 | 1 | ND | 80 |
| 5 | Toluene | 95 | 1 | ND | 88 |
| 6 | $PhCF_3$ | 95 | 1 | ND | 88 |
| 7 | THF | 90 | 2 | 5 | 84 |
| 8 | $Et_2O$ | 95 | 1 | ND | 90 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%) and $Cs_2CO_3$ (2.0 equiv.) in solvent (1.0 mL) at room temperature (r.t.) for 3 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. ND, Not determined.

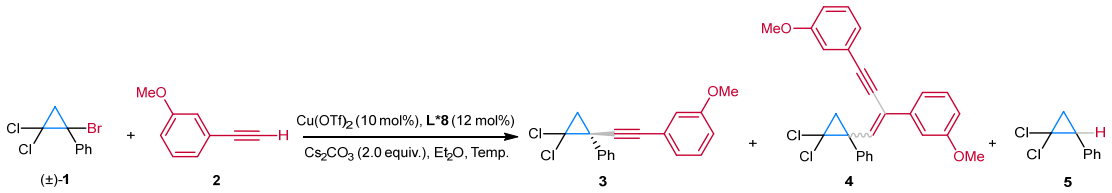
**Supplementary Table 4 | Screening of base additives**[a]




| Entry | Base | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | |
| 1 | LiO$^t$Bu | 27 | 2 | ND | 88 |
| 2 | KO$^t$Bu | 50 | 2 | 3 | 90 |
| 3 | NaOH | 95 | 2 | ND | 88 |
| 4 | $Cs_2CO_3$ | 95 | 1 | ND | 90 |
| 5 | $K_2CO_3$ | 27 | 4 | ND | 90 |
| 6 | NaOAc | ND | ND | ND | ND |
| 7 | DIPEA | Trace | ND | ND | ND |
| 8 | DBU | Trace | ND | 6 | ND |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%) and base (2.0 equiv.) in $Et_2O$ (1.0 mL) at room temperature (r.t.) for 3 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. ND, Not determined.

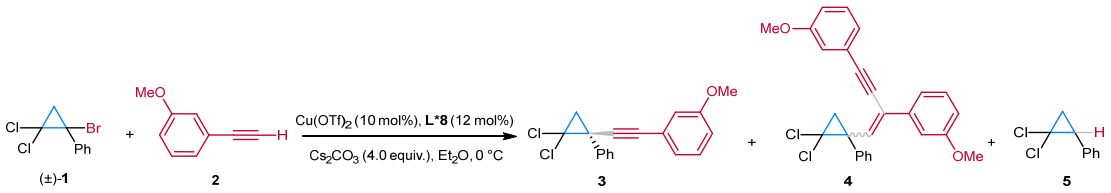
**Supplementary Table 5 | Screening of reaction temperatures**[a]




| Entry | Temp. | Yield (%)[c] | | | E.e. of 3 (%)[d] |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | |
| 1[b] | r.t. | 95 | 1 | ND | 90 |
| 2 | 0 °C | 65 | ND | ND | 92 |
| 3 | −10 °C | Trace | ND | ND | ND |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%) and $Cs_2CO_3$ (2.0 equiv.) in $Et_2O$ (1.0 mL) for 6 d under argon. [b]For 3 d. [c]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [d]E.e. values were based on HPLC analysis. ND, not determined.

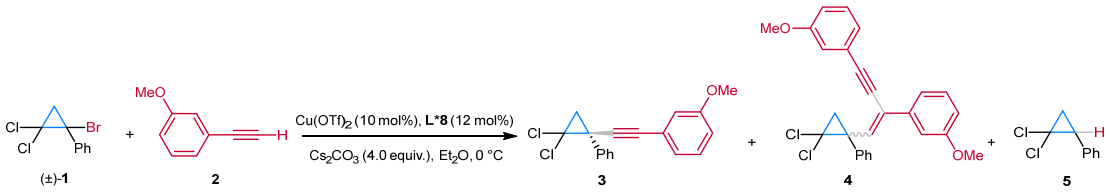
**Supplementary Table 6 | Screening of substrate ratios**[a]




| Entry | E1a/A1 | Yield (%)[e] | | | E.e. of 3 (%)[f] |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | |
| 1[b] | 1.0:1.5 | 65 | ND | ND | 92 |
| 2 | 1.0:1.5 | 78 | ND | ND | 92 |
| 3[c] | 1.0:1.5 | 91 | ND | ND | 92 |
| 4[c] | 1.0:1.0 | 93 | ND | ND | 92 |
| 5 | 1.5:1.0 | 93 | ND | ND | 92 |
| 6[d] | 1.5:1.0 | 84 | ND | ND | 92 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.10 mmol, entries 1–4), 3-ethynylanisole **2** (0.10 mmol, entry 5), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%) and $Cs_2CO_3$ (4.0 equiv.) in $Et_2O$ (1.0 mL) at 0 °C for 6 d under argon. [b]$Cs_2CO_3$ (2.0 equiv.). [c]$Cu(OTf)_2$ (15 mol%) and **L*8** (18 mol%). [d]With NaOH (4.0 equiv.) instead of $Cs_2CO_3$. Although NaOH provided comparable results to $Cs_2CO_3$, we opted for $Cs_2CO_3$ to maximize the functional group tolerance of the cross-coupling reaction due to its milder basicity. [e]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [f]E.e. values were based on HPLC analysis. ND, not determined.

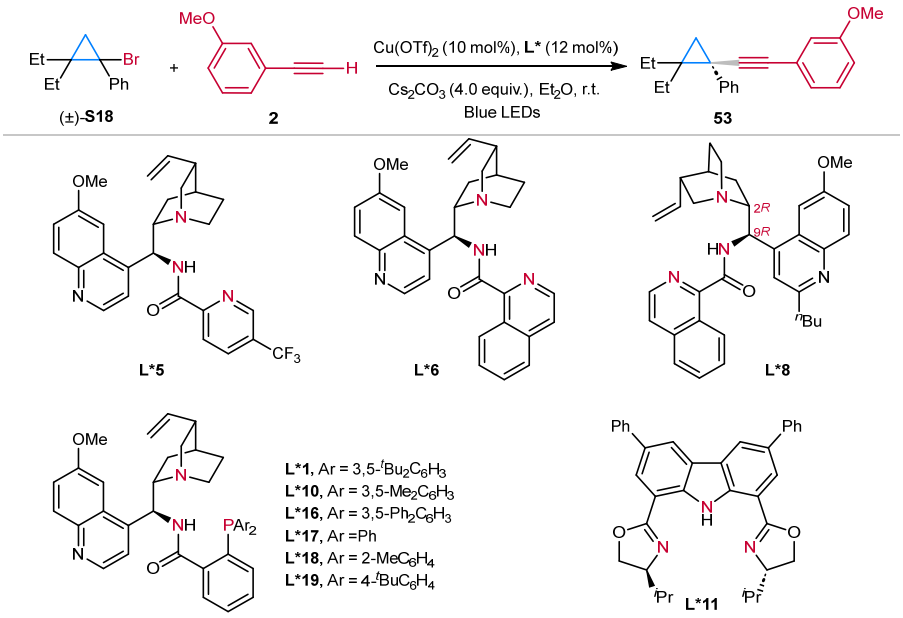
**Supplementary Table 7 | Control experiments concerning catalysts and additives**[a]




| Entry | Variations | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3 | 4 | 5 | |
| 1 | None | 93 | ND | ND | 92 |
| 2 | Without $Cu(OTf)_2$ | 0 | 0 | 0 | ND |
| 3 | Without **L*8** | 4 | 0 | 0 | 0 |
| 4 | Without $Cs_2CO_3$ | 0 | 0 | 0 | ND |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (1.5 equiv.), 3-ethynylanisole **2** (0.050 mmol), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%) and $Cs_2CO_3$ (4.0 equiv.) in $Et_2O$ (0.50 mL) for 6 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. ND, not determined.

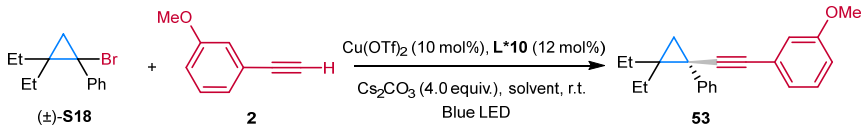
**Supplementary Table 8 | Reaction condition optimizations for racemic S18[a]**




| Entry | L* | Yield (%)[b] | E.e. (%)[c] |
|---|---|---|---|
| 1 | **L*5** | 12 | –4 |
| 2 | **L*6** | 60 | –28 |
| 3 | **L*8** | 46 | 18 |
| 4 | **L*1** | 25 | 32 |
| 5 | **L*10** | 72 | 42 |
| 6 | **L*16** | 56 | 37 |
| 7 | **L*17** | 24 | 25 |
| 8 | **L*18** | ND | ND |
| 9 | **L*19** | 18 | 24 |
| 10 | **L*11** | 90 | -34 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **S18** (0.050 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*** (12 mol%), and $Cs_2CO_3$ (4.0 equiv.) in $Et_2O$ (0.50 mL) at r.t. under the irradiation of blue LEDs (5 W) and argon for 5 d. [b]Yield was based on $^1H$ NMR analysis of the crude product using mesitylene as an internal standard. [c]E.e. values were based on HPLC analysis. ND, not determined.

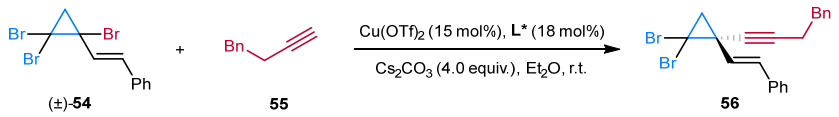
**Supplementary Table 9 | Reaction condition optimizations for racemic S18[a]**




| Entry | Solvent | Yield (%)[b] | E.e. (%)[c] |
|---|---|---|---|
| 1 | $Et_2O$ | 72 | 42 |
| 2 | $CH_2Cl_2$ | 30 | 42 |
| 3 | EtOAc | 58 | 44 |
| 4 | Cyclohexane | 15 | 40 |
| 5 | MeCN | 30 | 44 |
| 6 | Toluene | 65 | 33 |
| 7 | $PhCF_3$ | 40 | 36 |
| 8 | THF | 70 | 42 |
| 9 | 1,4-dioxane | 75 | 47 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **S18** (0.050 mmol), 3-ethynylanisole **2** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*10** (12 mol%), and $Cs_2CO_3$ (4.0 equiv.) in solvent (0.50 mL) at r.t. under the irradiation of blue LEDs (5 W) and argon for 5 d. [b]Yield was based on $^1H$ NMR analysis of the crude product using mesitylene as an internal standard. [c]E.e. values were based on HPLC analysis.

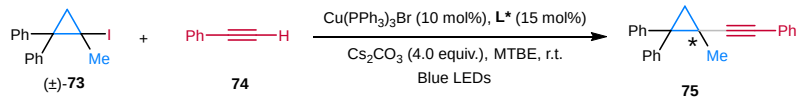
**Supplementary Table 10 | Reaction condition optimizations for racemic 54[a]**

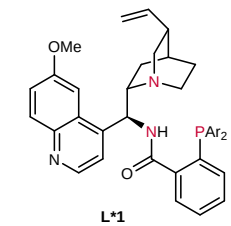


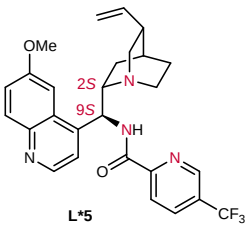

| Entry | L* | [Cu] | Solvent | Yield (%)[b] | E.e. (%)[c] |
|---|---|---|---|---|---|
| 1[d] | **L*8** | $Cu(OTf)_2$ | $Et_2O$ | 11 | –79 |
| 2 | **L*8** | $Cu(OTf)_2$ | $Et_2O$ | 18 | –79 |
| 3 | **L*2** | $Cu(OTf)_2$ | $Et_2O$ | 10 | 84 |
| 4 | **L*3** | $Cu(OTf)_2$ | $Et_2O$ | 12 | 90 |
| 5 | **L*4** | $Cu(OTf)_2$ | $Et_2O$ | 15 | 76 |
| 6 | **L*5** | $Cu(OTf)_2$ | $Et_2O$ | 30 | 92 |
| 7 | **L*5** | CuI | $Et_2O$ | 15 | 90 |
| 8 | **L*5** | $Cu(MeCN)_4PF_6$ | $Et_2O$ | 21 | 89 |
| 9 | **L*5** | CuTc | $Et_2O$ | 48 | 92 |
| 10 | **L*5** | CuTc | THF | 38 | 89 |
| 11 | **L*5** | CuTc | MTBE | 69 | 92 |
| 12[e] | **L*5** | CuTc | MTBE | 93 | 92 |

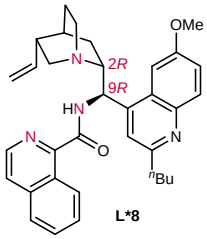
[a]Standard reaction conditions: racemic cyclopropyl bromide **54** (1.5 equiv.), 4-phenyl-1-butyne **55** (0.050 mmol), [Cu] (15 mol%), ligand **L*** (18 mol%) and $Cs_2CO_3$ (4.0 equiv.) in solvent (1.0 mL) at r.t. for 4 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using mesitylene as an internal standard. [c]E.e. values were based on HPLC analysis. [d]$Cu(OTf)_2$ (10 mol%) and ligand **L*8** (12 mol%). [e]The reaction was conducted for 7 d.

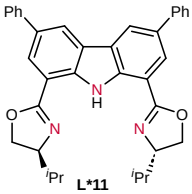
**Supplementary Table 11 | Reaction condition optimizations for racemic 73[a]**

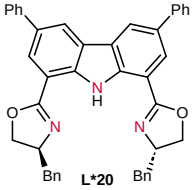


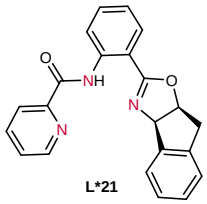



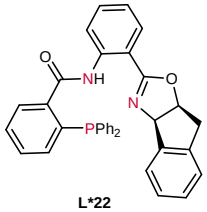



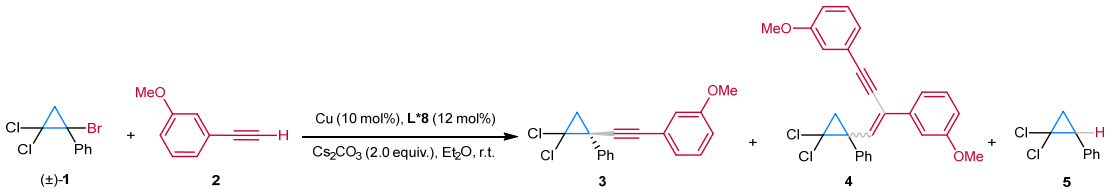




| Entry | L* | Yield of 75 (%)[b] | E.e. of 75 (%)[c] |
|---|---|---|---|
| 1[d] | **L*8** | 0 | ND |
| 2[e] | **L*5** | 0 | ND |
| 3 | **L*1** | Trace | ND |
| 4 | **L*5** | Trace | ND |
| 5 | **L*8** | Trace | ND |
| 6 | **L*11** | 56 | 52 |
| 7 | **L*20** | 32 | 30 |
| 8 | **L*21** | Trace | ND |
| 9 | **L*22** | Trace | ND |

[a]Standard reaction conditions: racemic cyclopropyl halide **73** (1.5 equiv.), phenylacetylene **74** (0.10 mmol), $Cu(PPh_3)_3Br$ (10 mol%), ligand **L*** (15 mol%) and $Cs_2CO_3$ (4.0 equiv.) in MTBE (2.0 mL) at r.t. under the irradiation of blue LEDs (5 W) and argon for 7 d. [b]Isolated yield is shown. [c]E.e. is based on chiral HPLC analysis. [d]Phenylacetylene (0.10 mmol), racemic cyclopropyl halide **73** (1.5 equiv.), $Cu(OTf)_2$ (10 mol%), **L*8** (12 mol%), and $Cs_2CO_3$ (4.0 equiv.) in $Et_2O$ (1.0 mL) under argon at 0 °C for 6 d. [e]Phenylacetylene (0.10 mmol), racemic cyclopropyl halide **73** (1.5 equiv.), CuTc (15 mol%), **L*5** (18 mol%), and $Cs_2CO_3$ (4.0 equiv.) in MTBE (2.0 mL) at r.t. for 7 d under argon. ND, not determined.

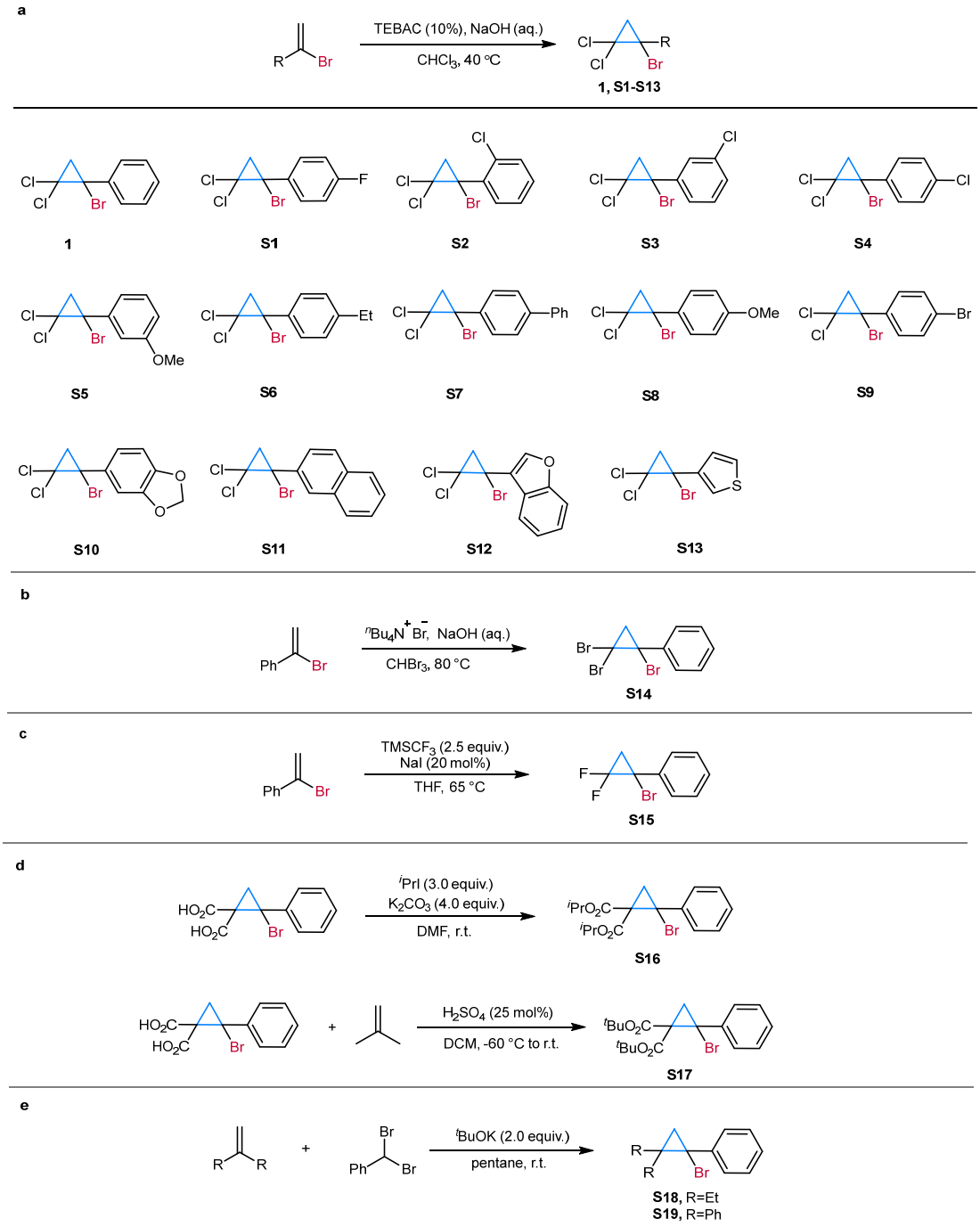
**Supplementary Table 12 | The effect of mixed $Cu(OTf)_2$ and CuOTf·1/2Ph**



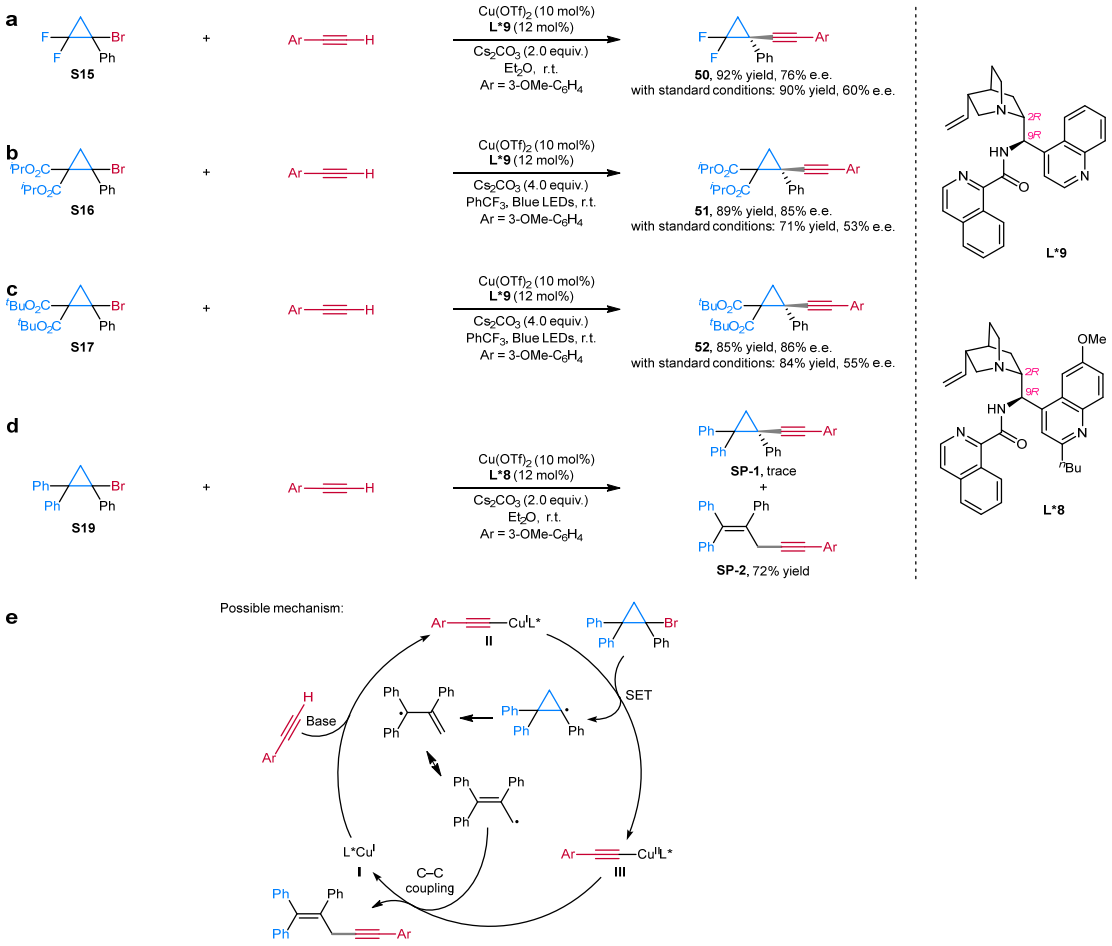

| Entry | $Cu(OTf)_2$:CuOTf·1/2Ph | Yield (%)[b] | | | E.e. of 3 (%)[c] |
|---|---|---|---|---|---|
| | | 3[d] | 4 | 5 | |
| 1 | 10:0 | 95 (97) | 1 | 2 | 90 |
| 2 | 8:2 | 87 (91) | 4 | 5 | 90 |
| 3 | 6:4 | 85 (89) | 6 | 5 | 90 |
| 4 | 4:6 | 81 (85) | 8 | 6 | 90 |
| 5 | 2:8 | 75 (82) | 10 | 7 | 90 |
| 6 | 0:10 | 75 (82) | 10 | 7 | 90 |

[a]Standard reaction conditions: racemic cyclopropyl bromide **1** (0.30 mmol), 3-ethynylanisole **2** (1.5 equiv.), Cu (10 mol%), **L*8** (12 mol%) and $Cs_2CO_3$ (2.0 equiv.) in $Et_2O$ (3.0 mL) at room temperature (r.t.) for 3 d under argon. [b]Yield was based on $^1H$ NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. [c]E.e. values were based on HPLC analysis. [d]The percentage of **3** among the three products is shown in parenthesis.

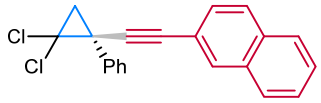
## Supplementary figures for experiments



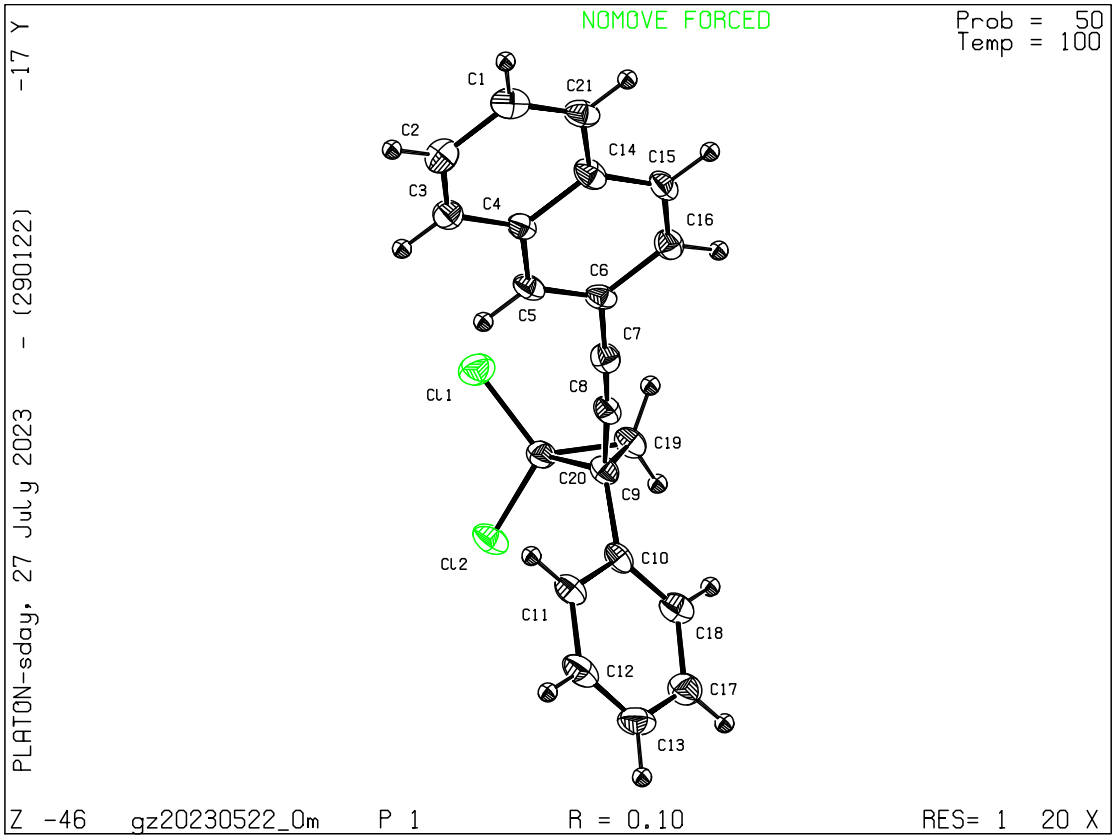

**Supplementary Fig. 1 | The structures and synthesis of racemic cyclopropyl bromides.**



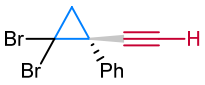

**Supplementary Fig. 2 | Detailed results of additional 1-phenyl-cyclopropyl bromides.**



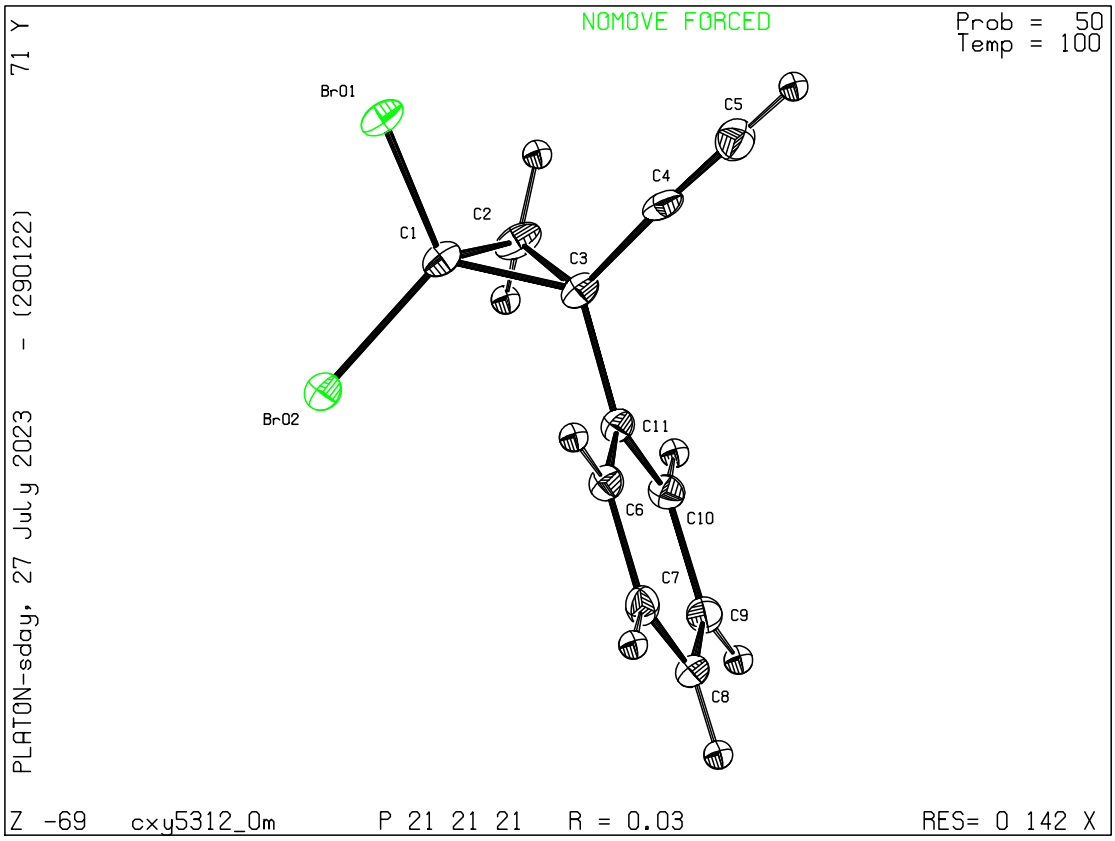

**20**



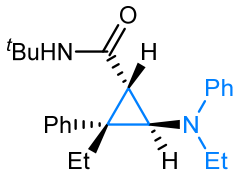

**Supplementary Fig. 3 | The X-ray structure of 20 (CCDC 2264730).**



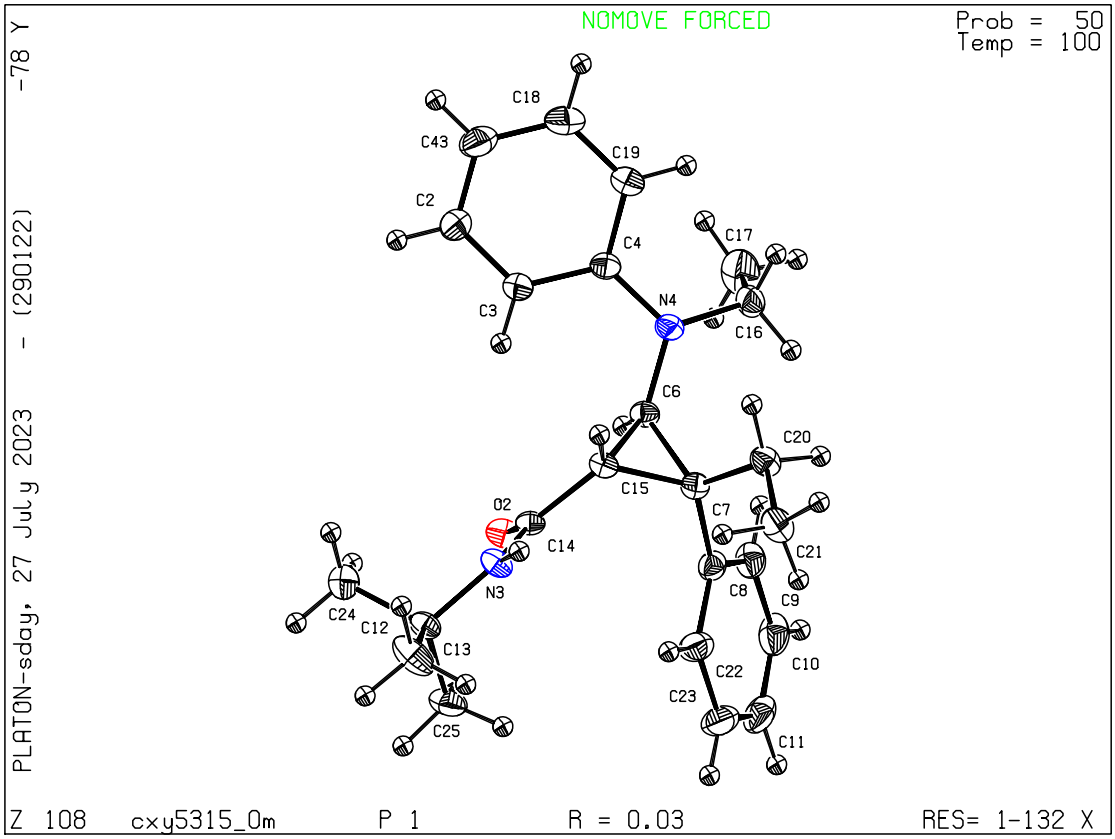

**78**



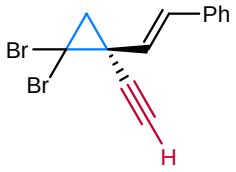

**Supplementary Fig. 4 | The X-ray structure of 78 (CCDC 2267172).**



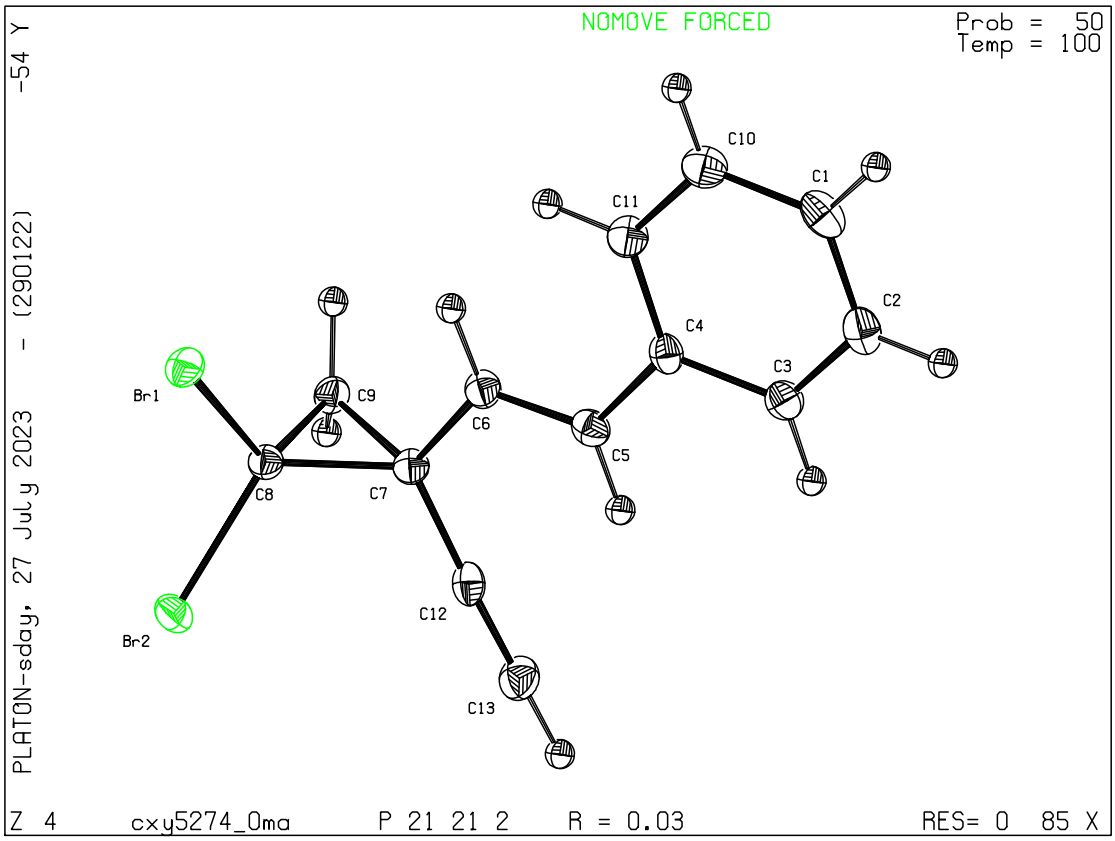

**86**



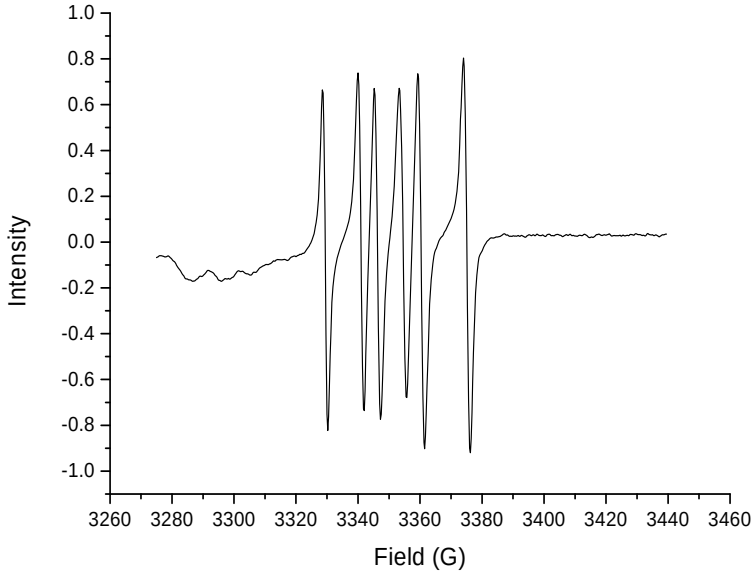

**Supplementary Fig. 5 | The X-ray structure of 86 (CCDC 2267173).**



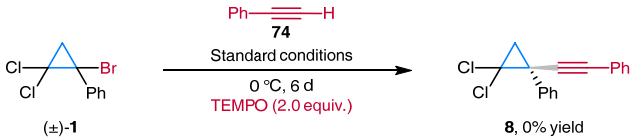

**88**



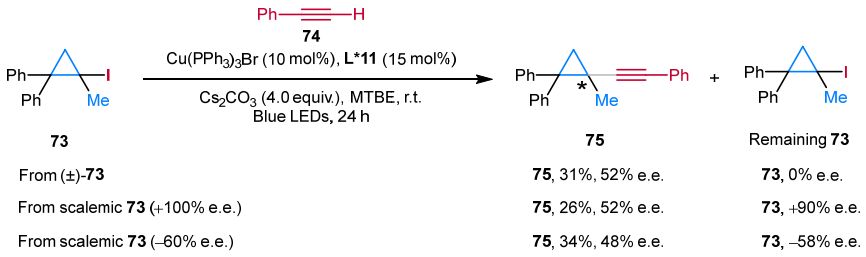

**Supplementary Fig. 6 | The X-ray structure of 88 (CCDC 2264731).**



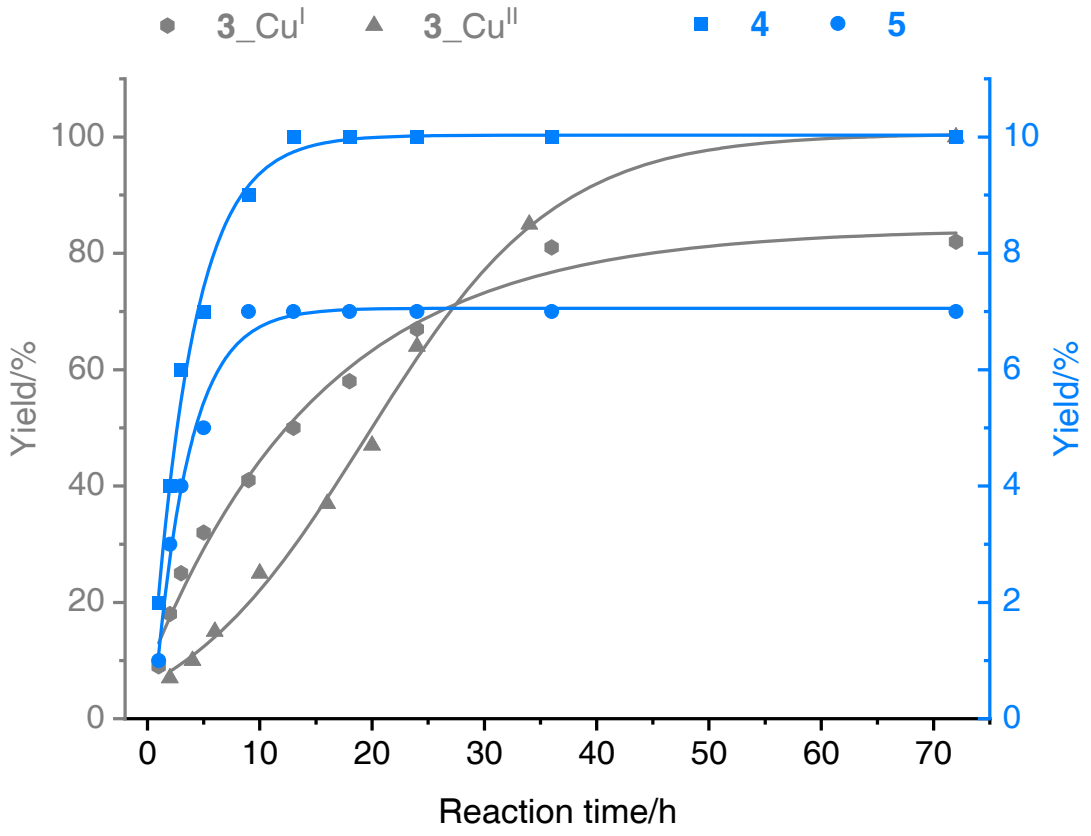

**Supplementary Fig. 7 | Room temperature Q-band CW-EPR spectrum of the spin trap study.** $g$ = 2.0071; $a_H$ = 18.90 G; $a_N$ = 13.37 G. EPR acquisition parameters: temperature = 298 K; MW power = 40 dB; modulation amplitude = 1 G; conversion time = 20 ms.



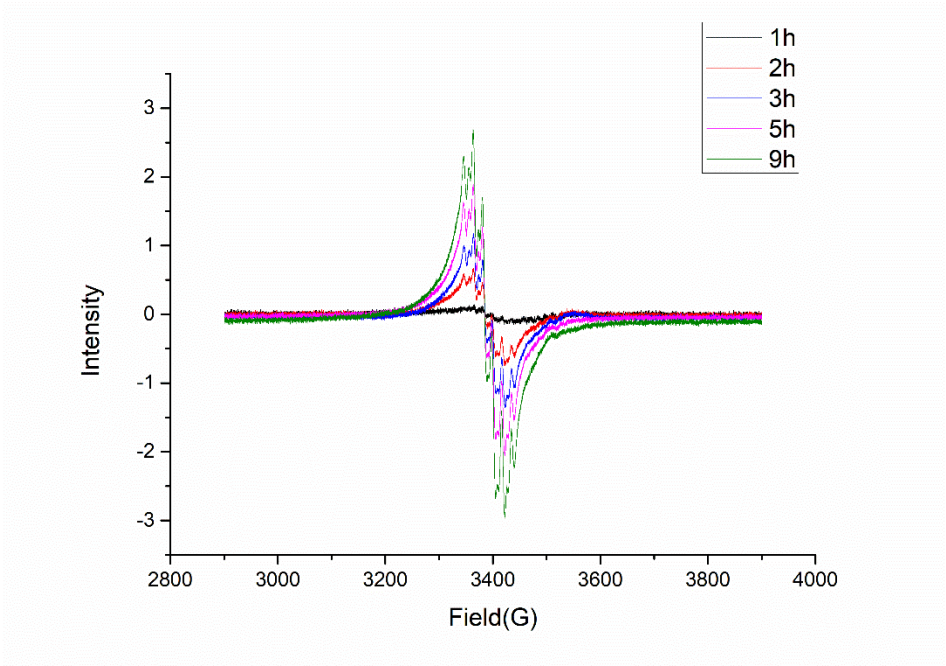

**Supplementary Fig. 8 | Results of the radical inhibition control experiment with TEMPO.**



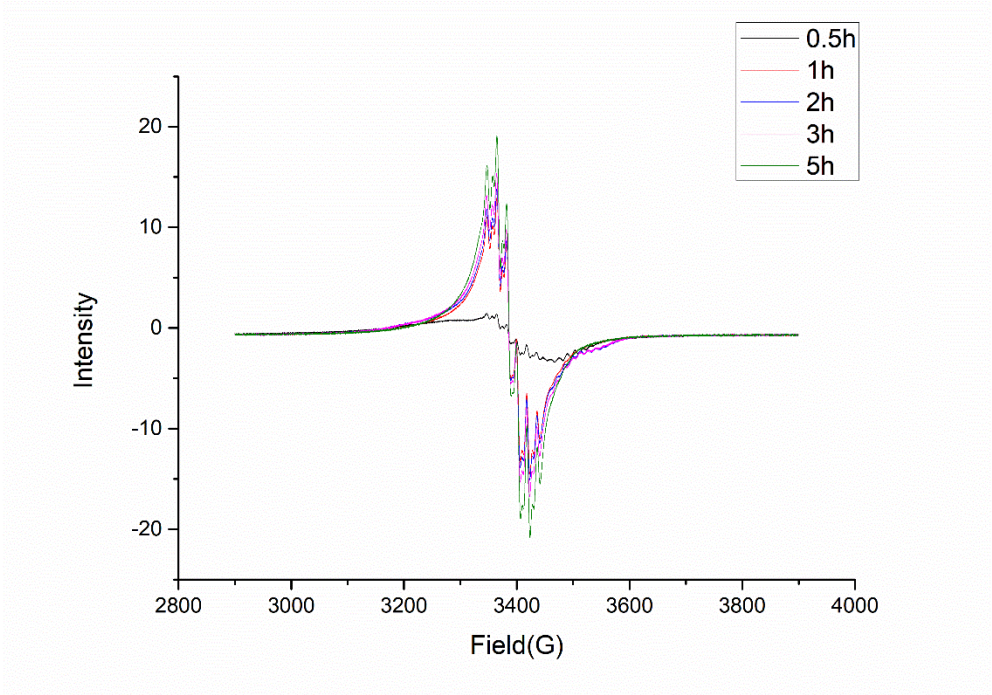

**Supplementary Fig. 9 | Control experiments concerning the enantiopurity of 73.** No changes to the enantiopurities of the recovered **73** were observed in the reactions of either racemic or scalemic **73**, respectively, thus excluding pathways that involve kinetic resolution or fast racemization of **73**. Values aligned horizontally belong to one experiment.




**Supplementary Fig. 10 | Time-course experiment results using $Cu(OTf)_2$ and CuOTf catalyst precursors.** The formation of side products was monitored when CuOTf was employed, as it was completely suppressed when $Cu(OTf)_2$ was used. Solid lines for compounds **4** and **5** represent exponential decay fits to the experimental data. The solid line for compound **3** with CuOTf as the precatalyst is a dose-response fit, while the solid line for compound **3** with $Cu(OTf)_2$ is a Boltzmann fit to the experimental data.




**Supplementary Fig. 11 | Time-course X-band EPR spectra of the reaction mixtures with CuOTf as the catalyst precursor.** EPR acquisition parameters: solvent = toluene; temperature = 298 K; frequency = 9.838739 GHz; MW power = 20 dB; modulation amplitude = 1 G; conversion time = 12 ms.



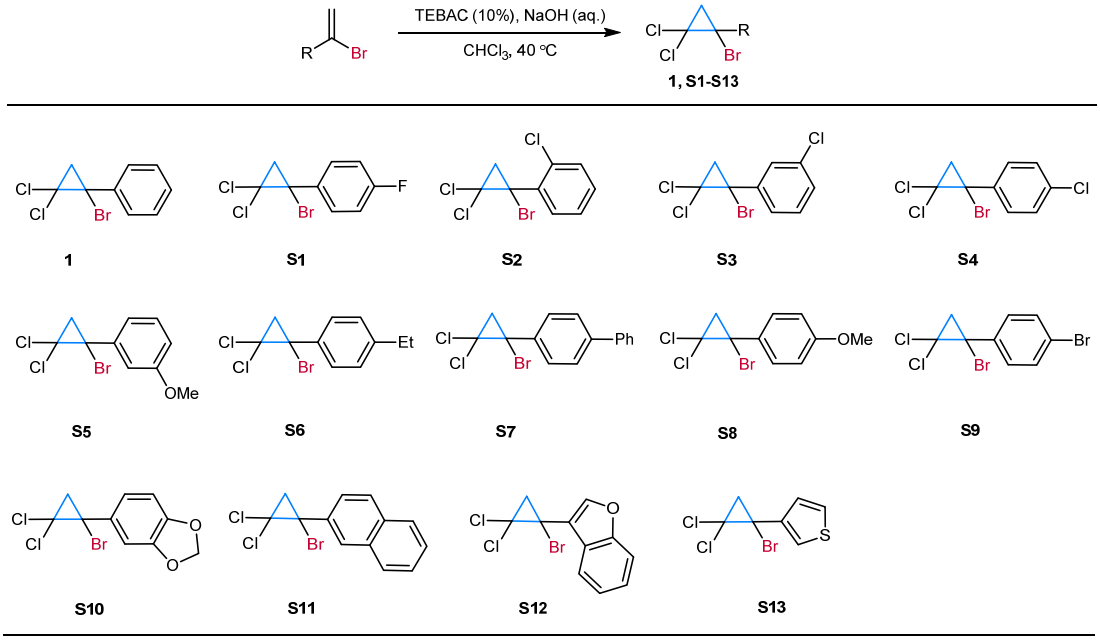

**Supplementary Fig. 12 | Time-course X-band EPR spectra of the reaction mixtures with $Cu(OTf)_2$ as the catalyst precursor.** EPR acquisition parameters: solvent = toluene; temperature = 298 K; frequency = 9.837637 GHz; MW power = 20 dB; modulation amplitude = 1 G; conversion time = 12 ms.

## General information

Reactions were carried out under argon atmosphere using Schlenk techniques. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. $Cu(OTf)_2$ was purchased from TCI. CuTc was purchased from Adamas. $Cu(PPh_3)_3Br$ was purchased from Adamas. Anhydrous diethyl ether ($Et_2O$) was distilled from sodium (Na) and stored under argon. Anhydrous methyl *tert*-butyl ether (MTBE) was purchased from Titan, which was distilled after refluxing with sodium and benzophenone. $Cs_2CO_3$ were purchased from Bide Pharmatech Ltd., which was dried at 200 °C for 3 h in vacuum. Analytical thin layer chromatography (TLC) was performed on precoated silica gel 60 GF254 plates. Flash column chromatography was performed using Tsingdao silica gel (60, particle size 0.040–0.063 mm). As the eluent, the petroleum ether (PE) and EtOAc were purchased from Shanghai Titan Scientific Co. Ltd. without further purification. Visualization on TLC was achieved by use of UV light (254 nm), iodine or basic $KMnO_4$ indicator. NMR spectra were recorded on Bruker DRX-400 spectrometers at 400 MHz for $^1H$ NMR, 100 MHz for $^{13}C$ NMR and 376 MHz for $^{19}F$ NMR, respectively, in $CDCl_3$ with tetramethylsilane (TMS) as internal standard. The chemical shifts were expressed in ppm and coupling constants were given in Hz. Data for $^1H$ NMR are recorded as follows: chemical shift (ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; p, pentet, m, multiplet; br, broad), coupling constant (Hz), integration. Data for $^{13}C$ NMR were reported in terms of chemical shift (δ, ppm). Mass spectrometric data were obtained using Bruker Apex IV RTMS. Enantiomeric excess (e.e.) was determined by Agilent and Shimadzu high-performance liquid chromatography (HPLC) with a Hatachi detector (at an appropriate wavelength). Column conditions were reported in the experimental section below. X-ray diffraction was measured on a 'Bruker APEX-II CCD' diffractometer with Cu–Kα radiation.

## General procedures for the synthesis of substrates

## The structures and synthesis of 1-(hetero)aryl-substituted cyclopropyl bromides:

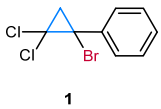



**General procedure 1:**

To a mixture of 1-(hetero)aryl-substituted vinyl bromide (5.0 mmol, 1.0 equiv.) and benzyltriethylammonium chloride (TEBAC) (113.5 mg 0.50 mmol, 10 mol%) in chloroform (20 mL) was added dropwise NaOH (50% aq., 2.0 g, 50 mmol, 10 equiv.) within 2 h under heating at 40 °C with vigorous stirring. Then the mixture was stirred for 1 h at 40 °C. After completion of the reaction (monitored by TLC), the mixture was quenched with water and extracted with $CH_2Cl_2$. The combined organic solution was concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel to provide the corresponding cyclopropyl bromide.

*Note*: Substrate **1** was a known compound and was synthesized according to reported literature[1].

### (1-Bromo-2,2-dichlorocyclopropyl)benzene (1)



**1**

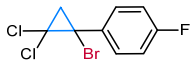
According to **General procedure 1** with (1-bromovinyl)benzene (1.83 g, 10.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **1** as a white solid (2.07 g, 78% yield).

**m.p.** 45–47 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.51 – 7.43 (m, 2H), 7.42 – 7.28 (m, 3H), 2.39 (d, *J* =

9.0 Hz, 1H), 2.15 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 138.9, 129.3, 129.1, 128.8, 63.0, 43.1, 35.5.
**HRMS** (ESI) *m/z* calcd. for $C_9H_8BrCl_2$ $[M + H]^+$ 264.9181, found 264.9186.

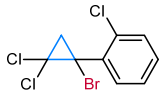
**1-(1-Bromo-2,2-dichlorocyclopropyl)-4-fluorobenzene (S1)**




**S1**

According to **General procedure 1** with 1-(1-bromovinyl)-4-fluorobenzene (1.00 g, 5.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S1** as a colorless liquid (0.60 g, 42% yield).
**$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.39 (m, 2H), 7.12 – 7.00 (m, 2H), 2.34 (d, *J* = 9.0 Hz, 1H), 2.15 (d, *J* = 9.1 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 162.8 (d, *J* = 249.5 Hz), 134.9 (d, *J* = 3.4 Hz), 131.3 (d, *J* = 8.7 Hz), 115.9 (d, *J* = 22.0 Hz), 62.9, 42.3, 35.7.
**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −111.5.
**HRMS** (ESI) *m/z* calcd. for $C_9H_7BrCl_2F$ $[M + H]^+$ 282.9087, found 282.9098.

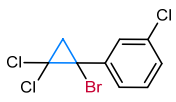
**1-(1-Bromo-2,2-dichlorocyclopropyl)-2-chlorobenzene (S2)**




**S2**

According to **General procedure 1** with 1-(1-bromovinyl)-2-chlorobenzene (0.87 g, 4.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S2** as a white solid (0.60 g, 50% yield). The compound is a mixture of atropisomers (ratio: 1/0.27).
**m.p.** 61–64 °C
**$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.45 (m, 1H), 7.36 – 7.24 (m, 3H), 2.36 (d, *J* = 8.9 Hz, 2H), 2.21 (d, *J* = 8.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.9, 136.3, 130.7, 130.6, 129.9, 127.2, 63.1, 42.0, 36.1.
**HRMS** (ESI) *m/z* calcd. for $C_9H_7BrCl_3$ $[M + H]^+$ 298.8791, found 298.8780.

**1-(1-Bromo-2,2-dichlorocyclopropyl)-3-chlorobenzene (S3)**




**S3**

According to **General procedure 1** with 1-**(**1-bromovinyl)-3-chlorobenzene (1.08 g, 5.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on

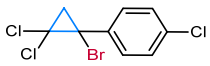
silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S3** as a colorless liquid (0.79 g, 53% yield).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.44 (s, 1H), 7.41 – 7.28 (m, 3H), 2.37 (d, *J* = 9.1 Hz, 1H), 2.15 (d, *J* = 9.1 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.7, 134.6, 130.1, 129.4, 129.3, 127.6, 62.7, 42.0, 35.5.

**HRMS** (ESI) *m/z* calcd. for $C_9H_7BrCl_3$ $[M + H]^+$ 298.8791, found 298.8787.

### 1-(1-Bromo-2,2-dichlorocyclopropyl)-4-chlorobenzene (S4)




**S4**

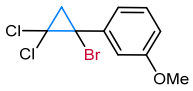
According to **General procedure 1** with 1-(1-bromovinyl)-4-chlorobenzene (1.08 g, 5.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S4** as a colorless liquid (0.65 g, 43% yield).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.28 (m, 4H), 2.33 (d, *J* = 9.1 Hz, 1H), 2.13 (d, *J* = 9.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.4, 135.0, 130.7, 129.1, 62.7, 42.1, 35.5.

**HRMS** (ESI) *m/z* calcd. for $C_9H_7BrCl_3$ $[M + H]^+$ 298.8791, found 298.8797.

### 1-(1-Bromo-2,2-dichlorocyclopropyl)-3-methoxybenzene (S5)




**S5**

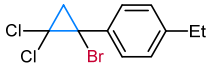
According to **General procedure 1** with 1-(1-bromovinyl)-3-methoxybenzene (0.75 g, 3.5 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S5** as a colorless liquid (0.39 g, 38% yield).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.28 (t, *J* = 8.0 Hz, 1H), 7.06 – 7.00 (m, 1H), 6.99 (t, *J* = 2.1 Hz, 1H), 6.87 (ddd, *J* = 8.3, 2.5, 0.9 Hz, 1H), 3.82 (s, 3H), 2.37 (d, *J* = 9.0 Hz, 1H), 2.12 (d, *J* = 9.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.7, 140.1, 129.8, 121.4, 115.0, 114.7, 63.0, 55.5, 43.0, 35.5.

**HRMS** (ESI) *m/z* calcd. for $C_{10}H_{10}OBrCl_2$ $[M + H]^+$ 294.9287, found 294.9282.

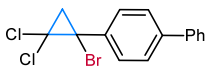
### 1-(1-Bromo-2,2-dichlorocyclopropyl)-4-ethylbenzene (S6)




**S6**

According to **General procedure 1** with 1-(1-bromovinyl)-4-ethylbenzene (1.05 g, 3.5 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S6** as a colorless liquid (0.94 g, 64% yield).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.42 – 7.31 (m, 2H), 7.25 – 7.14 (m, 2H), 2.64 (q, *J* = 7.6 Hz, 2H), 2.34 (d, *J* = 8.9 Hz, 1H), 2.11 (d, *J* = 8.9 Hz, 1H), 1.23 (t, *J* = 7.6 Hz, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 145.3, 136.1, 129.2, 128.3, 63.1, 43.3, 35.5, 28.7, 15.3.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_{12}BrCl_2$ $[M + H]^+$ 292.9494, found 292.9488.

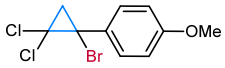
**4-(1-Bromo-2,2-dichlorocyclopropyl)-1,1'-biphenyl (S7)**




**S7**

According to **General procedure 1** with 4-(1-bromovinyl)-1,1'-biphenyl (0.93 g, 3.6 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S7** as a white solid (0.85 g, 69% yield).
**m.p.** 130–132 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.68 – 7.59 (m, 4H), 7.58 – 7.52 (m, 2H), 7.50 – 7.42 (m, 2H), 7.42 – 7.35 (m, 1H), 2.44 (d, *J* = 9.0 Hz, 1H), 2.20 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 142.0, 140.3, 137.8, 129.7, 129.0, 127.9, 127.5, 127.3, 63.0, 43.0, 35.6.
**HRMS** (ESI) *m/z* calcd. for $C_{15}H_{12}BrCl_2$ $[M + H]^+$ 340.9494, found 340.9501.

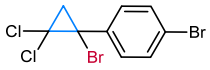
**1-(1-Bromo-2,2-dichlorocyclopropyl)-4-methoxybenzene (S8)**




**S8**

According to **General procedure 1** with 1-(1-bromovinyl)-4-methoxybenzene (0.64 g, 3.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **S8** as a white solid (0.43 g, 48% yield).
**m.p.** 51–55 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.33 (m, 2H), 6.96 – 6.82 (m, 2H), 3.81 (s, 3H), 2.33 (d, *J* = 8.9 Hz, 1H), 2.12 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 160.0, 131.1, 130.7, 114.1, 63.2, 55.5, 43.3, 35.7.
**HRMS** (ESI) *m/z* calcd. for $C_{10}H_{10}OBrCl_2$ $[M + H]^+$ 294.9287, found 294.9283.

**1-Bromo-4-(1-bromo-2,2-dichlorocyclopropyl)benzene (S9)**



**S9**

According to **General procedure 1** with 1-bromo-4-(1-bromovinyl)benzene (1.30 g, 5.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S9** as a white solid (0.69 g, 40% yield).

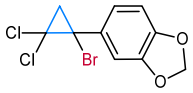
**m.p.** 40–42 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.57 – 7.46 (m, 2H), 7.39 – 7.28 (m, 2H), 2.33 (d, *J* = 9.0 Hz, 1H), 2.14 (d, *J* = 9.1 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.9, 132.0, 130.9, 123.3, 62.6, 42.2, 35.5.

**HRMS** (ESI) *m/z* calcd. for $C_9H_7Br_2Cl_2$ $[M + H]^+$ 342.8286, found 342.8290.

### 5-(1-Bromo-2,2-dichlorocyclopropyl)benzo[*d*][1,3]dioxole (S10)



**S10**

According to **General procedure 1** with 5-(1-bromovinyl)benzo[*d*][1,3]dioxole (0.68 g, 3.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S10** as a white solid (0.35 g, 38% yield).

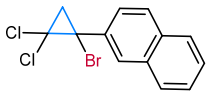
**m.p.** 103–107 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 6.96 (s, 1H), 6.90 (dd, *J* = 8.1, 1.8 Hz, 1H), 6.77 (d, *J* = 8.1 Hz, 1H), 5.98 (brs, 2H), 2.31 (d, *J* = 9.0 Hz, 1H), 2.11 (d, *J* = 9.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 148.3, 147.9, 132.7, 122.9, 110.0, 108.2, 101.7, 63.2, 43.4, 35.9.

**HRMS** (ESI) *m/z* calcd. for $C_{10}H_8O_2BrCl_2$ $[M + H]^+$ 308.9079, found 308.9082.

### 2-(1-Bromo-2,2-dichlorocyclopropyl)naphthalene (S11)



**S11**

According to **General procedure 1** with 2-(1-bromovinyl)naphthalene (0.93 g, 4.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S11** as a white solid (0.69 g, 55% yield).

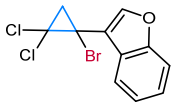
**m.p.** 82–84 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.88 – 7.77 (m, 4H), 7.61 (dd, *J* = 8.6, 1.9 Hz, 1H), 7.52 – 7.45 (m, 2H), 2.50 (d, *J* = 9.0 Hz, 1H), 2.20 (d, *J* = 9.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.3, 133.4, 133.0, 128.8, 128.3, 127.9, 127.8, 127.3,

127.2, 126.8, 63.0, 43.6, 35.5.
**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{10}BrCl_2$ $[M + H]^+$ 314.9337, found 314.9336.

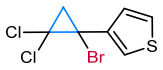
### 3-(1-Bromo-2,2-dichlorocyclopropyl)benzofuran (S12)




**S12**

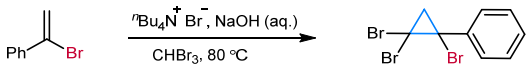
According to **General procedure 1** with 3-(1-bromovinyl)benzofuran (0.23 g, 1.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S12** as a white solid (0.21 g, 68% yield).
**m.p.** 60–63 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.86 – 7.79 (m, 1H), 7.66 (s, 1H), 7.54 – 7.47 (m, 1H), 7.41 – 7.33 (m, 2H), 2.38 (d, $J$ = 8.8 Hz, 1H), 2.23 (d, $J$ = 8.8 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 155.6, 143.8, 126.0, 125.5, 123.5, 121.4, 121.2, 111.9, 62.7, 35.6, 34.8.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_8OBrCl_2$ $[M + H]^+$ 304.9130, found 304.9131.

### 3-(1-Bromo-2,2-dichlorocyclopropyl)thiophene (S13)




**S13**

According to **General procedure 1** with 3-(1-bromovinyl)thiophene (0.57 g, 3.0 mmol, 1.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **S13** as a colorless oil (0.42 g, 51% yield).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.33 (dd, $J$ = 5.0, 3.0 Hz, 1H), 7.29 (dd, $J$ = 3.0, 1.4 Hz, 1H), 7.22 (dd, $J$ = 5.0, 1.4 Hz, 1H), 2.38 (d, $J$ = 9.0 Hz, 1H), 2.14 (d, $J$ = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 139.7, 128.5, 126.6, 125.1, 63.1, 38.6, 36.0.
**HRMS** (ESI) *m/z* calcd. for $C_7H_6BrCl_2S$ $[M + H]^+$ 270.8745, found 270.8741.



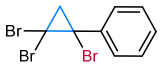

**S14**

To a reaction flask were added (1-bromovinyl)benzene (1.83 g, 10 mmol, 1.0 equiv.), bromoform (3.5 mL, 40 mmol, 4.0 equiv.), NaOH (50% aq., 4.0 g, 100 mmol, 10 equiv.), and *n*-tetrabutylammonium bromide (32.2 mg, 0.10 mmol, 1.0 mol%). The mixture was stirred for 20 h at 80 °C and then $CH_2Cl_2$ (30 mL) and water (30 mL) were added. The water layer was extracted with $CH_2Cl_2$. The combined organic solution was concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to provide **S14**

as a white solid (2.48 g, 70% yield).

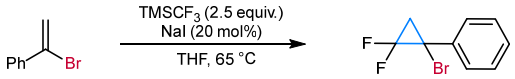
*Note*: Substrate **S14** was a known compound and was synthesized according to reported literature[2].

**(1,2,2-Tribromocyclopropyl)benzene (S14)**



**S14**

**m.p.** 85–88 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.43 (m, 2H), 7.42 – 7.28 (m, 3H), 2.50 (d, *J* = 9.3 Hz, 1H), 2.24 (d, *J* = 9.3 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.1, 129.3, 129.1, 128.7, 43.0, 37.2, 32.0.
**HRMS** (ESI) *m/z* calcd. for $C_9H_8Br_2{}^{81}Br$ $[M + H]^+$ 354.8150, found 354.8135.

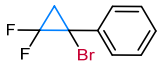



**S15**

(1-bromovinyl)benzene (0.92 g, 5.0 mmol, 1.0 equiv.) was added to a 100 mL three-necked flask that was charged with anhydrous NaI (0.15 g, 0.2 equiv.) and dry THF (20 mL). Then, $TMSCF_3$ (1.78 g, 2.5 equiv.) was added to the solution. Then the reaction mixture was refluxed at 65 °C for 12 h under argon atmosphere. After completion of the reaction, the reaction mixture was filtered, evaporated and purified by column chromatography on silica gel (PE as eluent) to afford the product **S15** as a colorless oil (0.76 g, 65% yield).

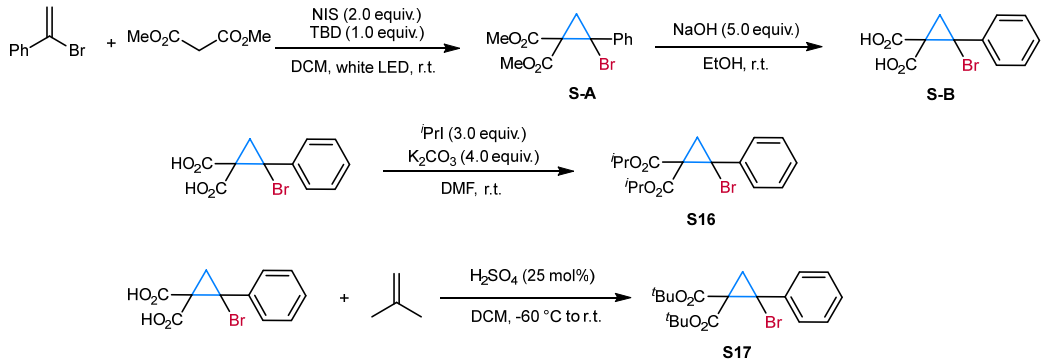
*Note*: Substrate **S15** was a known compound and was synthesized according to reported literature[3].

**(1-Bromo-2,2-difluorocyclopropyl)benzene (S15)**



**S15**

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.43 (m, 2H), 7.41 – 7.29 (m, 3H), 2.23 (ddd, *J* = 13.6, 9.5, 4.6 Hz, 1H), 2.06 (ddd, *J* = 10.8, 9.5, 4.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.3 (t, *J* = 2.0 Hz), 129.38, 129.35, 129.0, 109.7 (dd, *J* = 292.0, 290.5 Hz), 34.3 (t, *J* = 11.9 Hz), 27.1 (t, *J* = 10.7 Hz).
**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −127.1 (d, *J* = 149.1 Hz), −132.1 (d, *J* = 148.8 Hz).
**HRMS** (ESI) *m/z* calcd. for $C_9H_8BrF_2$ $[M + H]^+$ 232.9772, found 232.9769.



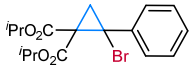

Into an oven-dried reaction vial flushed with argon was added dimethyl malonate (1.2 mL, 10 mmol), (1-bromovinyl)benzene (3.68 g, 2.0 equiv.), NIS (4.50 g, 2.0 equiv.), TBD (1.39 g, 1.0 equiv.), and $CH_2Cl_2$ (30 mL). Then the reaction mixture was stirred for 24 h at r.t. under argon atmosphere in the presence of white LED light. After the reaction was complete, the mixture was poured into $H_2O$ and extracted with $CH_2Cl_2$. The combined organic layer was dried with anhydrous $Na_2SO_4$ and evaporated under vacuum. The crude mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to afford the corresponding product **S-A**.

To a round-bottomed flask were added **S-A** (1.0 equiv.), sodium hydroxide (5.0 equiv.) and EtOH (20 mL). The reaction mixture was stirred for 12 h at r.t.. After completion of the reaction (monitored by TLC), the mixture was partitioned between water and EtOAc and acidified with 4 N HCl to pH < 1. The combined organic solution was concentrated under reduced pressure to afford **S-B** as a white solid (1.20 g, 42% yield over two steps).

Into an oven-dried reaction was added **S-B** (0.29 g, 1.0 mmol), $K_2CO_3$ (0.55 g, 4.0 equiv.) and DMF (10 mL). Then, 2-iodopropane (0.51 g, 3.0 equiv.) was added to the solution. The reaction mixture was stirred for 12 h at r.t.. The mixture was poured into $H_2O$ and extracted with $CH_2Cl_2$. The combined organic layer was dried with anhydrous $Na_2SO_4$ and evaporated under vacuum. The crude mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to afford the product **S16** as a colorless oil (0.20 g, 54% yield).

A solution of **S-B** (0.29 g, 1.0 mmol) in $CH_2Cl_2$ (5.0 mL) was stirred at −60 °C, and isobutene (30 equiv.) in $CH_2Cl_2$ was added. Sulfuric acid (25 mol%) was then added, and the mixture was stirred at r.t. until reaction completed. The mixture was washed with aqueous $NaHCO_3$ and $CH_2Cl_2$. The combined organic layer was dried with anhydrous $Na_2SO_4$ and evaporated under vacuum. The crude mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to afford the product **S17** as a white solid (0.31 g, 76% yield).

**Diisopropyl 2-bromo-2-phenylcyclopropane-1,1-dicarboxylate (S16)**

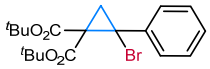


S16

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.42 (m, 2H), 7.33 – 7.24 (m, 3H), 5.23 (hept, *J* = 6.3 Hz, 1H), 4.70 (hept, *J* = 6.3 Hz, 1H), 2.48 (d, *J* = 7.0 Hz, 1H), 2.27 (d, *J* = 7.0 Hz,

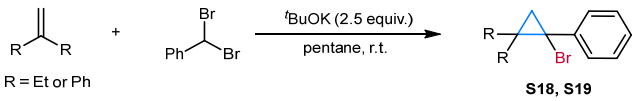
1H), 1.45 – 1.35 (m, 6H), 1.01 (d, *J* = 6.2 Hz, 3H), 0.84 (d, *J* = 6.3 Hz, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 165.7, 165.2, 139.4, 129.0, 128.8, 128.5, 70.2, 69.7, 42.1, 40.6, 26.7, 22.0, 21.9, 21.6, 21.1.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{22}O_4Br$ $[M + H]^+$ 369.0696, found 369.0691.

**Di-*tert*-butyl 2-bromo-2-phenylcyclopropane-1,1-dicarboxylate (S17)**




**S17**

**m.p.** 60–64 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.39 (m, 2H), 7.35 – 7.25 (m, 3H), 2.38 (d, *J* = 6.9 Hz, 1H), 2.16 (d, *J* = 6.9 Hz, 1H), 1.59 (s, 9H), 1.15 (s, 9H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 165.2, 164.7, 139.7, 129.0, 128.6, 128.4, 82.7, 82.4, 43.4, 40.6, 28.2, 27.7, 26.5.
**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{26}O_4Br$ $[M + H]^+$ 397.1009, found 397.0994.

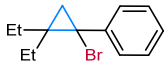



**S18, S19**

**General procedure 2:**

A solution of *α*,*α*-dibromotoluene (1.25 g, 5.0 mmol, 1.0 equiv.) in pentane (5.0 mL) at 0 °C was added dropwise within 1 h to a suspension of $^t$BuOK (1.40 g, 2.5 equiv.) in anhydrous pentane (20 mL) containing alkenes (2.2 equiv.). The resulting mixture was vigorously stirred at r.t. over a period of 2 days. After completion of the reaction (monitored by TLC), the mixture was quenched with $H_2O$ and extracted with $CH_2Cl_2$. The combined organic solution was concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel provide provide the corresponding cyclopropyl bromide **S18** or **S19**.

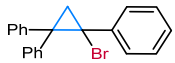
**(1-bromo-2,2-diethylcyclopropyl)benzene (S18)**




**S18**

According to **General procedure 2** with 2-ethyl-1-butene (1.34 mL, 11.0 mmol), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S18** as a colorless oil (0.99 g, 78% yield).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.41 – 7.33 (m, 2H), 7.32 – 7.27 (m, 2H), 7.25 – 7.19 (m, 1H), 2.03 (dq, *J* = 14.6, 7.4 Hz, 1H), 1.71 (dqd, *J* = 14.6, 7.4, 1.1 Hz, 1H), 1.47 (dqd, *J* = 14.5, 7.3, 1.3 Hz, 1H), 1.30 (d, *J* = 6.2 Hz, 1H), 1.18 – 1.06 (m, 4H), 0.80 (t, *J* = 7.4 Hz, 3H), 0.44 (dqd, *J* = 14.3, 7.4, 1.1 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 142.5, 129.5, 128.4, 127.7, 47.5, 32.9, 27.8, 26.7, 25.0, 10.79, 10.76.
**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{18}Br$ $[M + H]^+$ 253.0586, found 253.0585.

**(2-Bromocyclopropane-1,1,2-triyl)tribenzene (S19)**




**S19**

According to **General procedure 2** with 1,1-diphenylethylene (1.98 g, 11.0 mmol), the crude product was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield **S19** as a white solid (1.26 g, 72% yield).

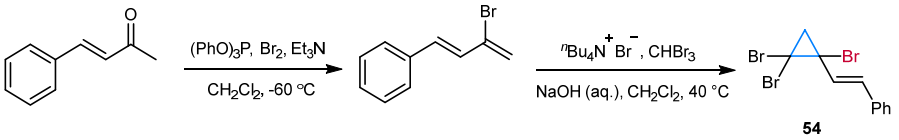
**m.p.** 101–104 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.69 – 7.58 (m, 2H), 7.44 – 7.32 (m, 4H), 7.30 – 7.24 (m, 1H), 7.19 – 7.13 (m, 2H), 7.12 – 7.05 (m, 3H), 7.01 – 6.88 (m, 3H), 2.71 (d, $J$ = 6.9 Hz, 1H), 2.22 (d, $J$ = 7.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 143.6, 140.5, 140.2, 130.6, 129.4, 129.2, 128.3, 128.1, 127.9, 127.7, 127.1, 126.3, 45.2, 43.8, 27.5.

**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{18}Br$ $[M + H]^+$ 349.0586, found 349.0577.

**The structures and synthesis of 1-alkenyl-substituted cyclopropyl bromides:**

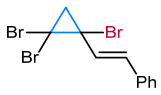



**54**

According to the reported literature[4], to a cold solution of triphenyl phosphite (5.8 mL, 22.0 mmol, 1.1 equiv.) in anhydrous $CH_2Cl_2$ (60 mL) maintained at –60 °C under Ar was added bromine (3.52 g, 22.0 mmol, 1.1 equiv.) dropwise. Then anhydrous triethylamine (3.1 mL, 22.0 mmol, 1.1 equiv.) and (*E*)-4-phenyl-3-buten-2-one (2.92 g, 20.0 mmol, 1.0 equiv.) were added to the faint orange solution. The reaction mixture was stirred for 18 h while warmed to r.t. and then was heated to reflux for a further 2 h. The reaction mixture was cooled to r.t. and concentrated in vacuo. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to give (*E*)-(3-bromobuta-1,3-dien-1-yl)benzene.

To a round-bottomed flask were added (*E*)-(3-bromobuta-1,3-dien-1-yl)benzene (1.0 equiv.), bromoform (4.0 equiv.), sodium hydroxide (50% aq., 10 equiv.), *n*-tetrabutylammonium bromide (10 mol%) and $CH_2Cl_2$ (40 mL). The reaction mixture was stirred for 24 h at 40 °C. After completion of the reaction (monitored by TLC), the mixture was quenched with water and extracted with $CH_2Cl_2$. The combined organic solution was concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel to provide **54** as a white solid (4.27 g, 56% yield over two steps).

**(*E*)-(2-(1,2,2-Tribromocyclopropyl)vinyl)benzene (54)**



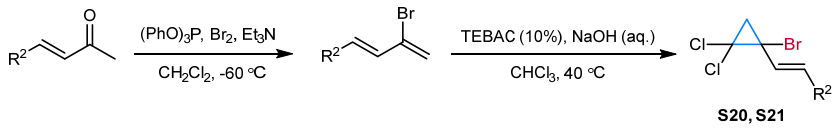

**54**

**m.p.** 89–91 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.46 – 7.39 (m, 2H), 7.38 – 7.27 (m, 3H), 6.71 (d, *J* = 15.4 Hz, 1H), 6.50 (d, *J* = 15.5 Hz, 1H), 2.36 (d, *J* = 9.3 Hz, 1H), 2.17 (d, *J* = 9.3 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 135.4, 135.0, 128.9, 128.81, 128.79, 127.0, 42.6, 37.3, 32.9.

**HRMS** (ESI) *m/z* calcd. for $C_{11}H_{10}Br_3$ $[M + H]^+$ 378.8327, found 378.8318.




**S20, S21**

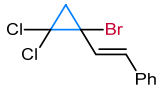
**General procedure 3:**

According to the reported literature[4], to a cold solution of triphenyl phosphite (5.8 mL, 22.0 mmol, 1.1 equiv.) in anhydrous $CH_2Cl_2$ (60 mL) maintained at –60 °C under Ar flow was added bromine (3.52 g, 22.0 mmol, 1.1 equiv.) dropwise. Then anhydrous

triethylamine (3.1 mL, 22.0 mmol, 1.1 equiv.) and *(E)*-4-phenyl-3-buten-2-one (2.92 g, 20.0 mmol, 1.0 equiv.) were added to the faint orange solution. The reaction mixture was stirred for 18 h while warmed to r.t. and then was heated to reflux for a further 2 h. The reaction mixture was cooled to r.t. and concentrated in vacuo. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to give the corresponding 1-alkenyl-substituted vinyl bromide.

To a mixture of 1-alkenyl-substituted vinyl bromide (1.0 equiv.) and benzyltriethylammonium chloride (10 mol%) in chloroform (40 mL) was added dropwise NaOH (50% aq., 10 equiv.) within 2 h under heating at 40 °C with vigorous stirring. Then the mixture was stirred for 12 h at 40 °C. After completion of the reaction (monitored by TLC), the mixture was quenched with water and extracted with $CH_2Cl_2$. The combined organic solution was concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel to provide the corresponding cyclopropyl bromide **S20** or **S21**.

**(*E*)-(2-(1-Bromo-2,2-dichlorocyclopropyl)vinyl)benzene (S20)**




**S20**

According to **General procedure 3** with (*E*)-4-phenyl-3-buten-2-one (1.46 g, 10.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield **S20** as a white solid (1.31 g, 45% yield over two steps).

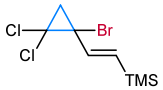
**m.p.** 61–63 °C

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.43 – 7.35 (m, 2H), 7.36 – 7.24 (m, 3H), 6.74 (d, *J* = 15.5 Hz, 1H), 6.44 (d, *J* = 15.5 Hz, 1H), 2.22 (d, *J* = 9.0 Hz, 1H), 2.04 (d, *J* = 9.0 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 135.44, 135.36, 128.9, 128.8, 127.01, 126.99, 63.7, 42.9, 35.5.

**HRMS** (ESI) *m/z* calcd. for $C_{11}H_{10}BrCl_2$ $[M + H]^+$ 290.9337, found 290.9335.

**(*E*)-(2-(1-Bromo-2,2-dichlorocyclopropyl)vinyl)trimethylsilane (S21)**

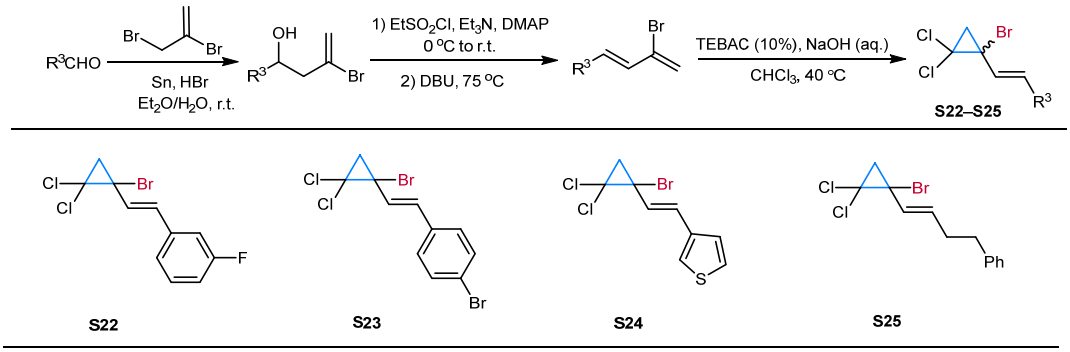



**S21**

According to **General procedure 3** with (*E*)-4-(trimethylsilyl)but-3-en-2-one (0.71 g, 5.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S21** as a colorless oil (0.59 g, 41% yield over two steps).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 6.03 (d, *J* = 18.1 Hz, 1H), 5.96 (d, *J* = 18.1 Hz, 1H), 2.03 (d, *J* = 8.9 Hz, 1H), 1.86 (d, *J* = 8.9 Hz, 1H), 0.00 (s, 9H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 142.6, 137.6, 64.8, 46.4, 36.4, 0.0.
**HRMS** (ESI) *m/z* calcd. for $C_8H_{14}BrCl_2Si$ $[M + H]^+$ 286.9420, found 286.9408.




**General procedure 4:**

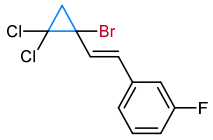
According to the reported literature[5], tin powder (1.75 g, 15.0 mmol, 1.5 equiv.) was suspended in a biphasic mixture of $Et_2O$-$H_2O$ (1:1 v/v, 60 mL). 2,3-Dibromopropene (3.0 mL, 30.0 mmol, 3.0 equiv.) and aldehyde (10.0 mmol, 1.0 equiv.) were then added at r.t. and the resulting mixture was vigorously stirred for 5 min. After that time, HBr (48% aq., 2.2 mL, 20.0 mmol, 2.0 equiv.) [Caution! Corrosive on skin or eye contact and toxic by inhalation. Use with appropriate protective equipment and in a well-ventilated fume hood] was added slowly, not letting the reaction temperature exceed 30 °C (with a temperature probe). The suspension was stirred vigorously for 4 hours until complete as indicated by TLC. Water, $Et_2O$, and brine were then added, the organic layer was separated, and the aqueous layer was further extracted with $Et_2O$. The combined organic layers were dried over anhydrous $Na_2SO_4$, filtered through celite (the drying/filtration sequence was repeated twice), and concentrated in vacuo. The residue was purified by column chromatography on silica gel to give the product alcohols which were submitted directly to the next step.

To a solution of an appropriate alcohol (1.0 equiv.) in $CH_2Cl_2$ (40 mL) at 0 °C were added ethanesulfonyl chloride (2.0 equiv.), $Et_3N$ (3.0 equiv.), and DMAP (10 mol%). The resulting mixture was warmed to r.t., stirred for 3 h, quenched with saturated aqueous $NH_4Cl$, and extracted with $CH_2Cl_2$. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, and concentrated in vacuo. The crude product was dissolved in toluene (20 mL) and DBU (5.0 equiv.) was added. The resulting mixture was stirred at 75 °C for 3 h, cooled to r.t., and quenched with saturated aqueous $NH_4Cl$. The aqueous layer was extracted with $Et_2O$ and the combined organic layers dried over anhydrous $MgSO_4$ and concentrated in vacuo. The residue was purified by column chromatography on silica gel to give the 2-bromodiene products as single alkene regioisomers.

To a mixture of 2-bromodiene (1.0 equiv.) and benzyltriethylammonium chloride (10 mol%) in chloroform (20 mL) was added dropwise of NaOH (50% aq., 10 equiv.) within 2 h under heating at 40 °C with vigorous stirring. Then the mixture was stirred for 12 h at 40 °C. After completion of the reaction (monitored by TLC), the mixture was quenched with water and extracted with $CH_2Cl_2$. The combined organic solution was dried over anhydrous $MgSO_4$ and concentrated under reduced pressure to afford

the residue, which was purified by column chromatography on silica gel to provide the corresponding cyclopropyl bromide.

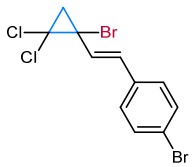
**(*E*)-1-(2-(1-Bromo-2,2-dichlorocyclopropyl)vinyl)-3-fluorobenzene (S22)**




**S22**

According to **General procedure 4** with 3-fluorobenzaldehyde (1.24 g, 10.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S22** as a colorless oil (0.96 g, 31% yield over three steps).
**$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.35 – 7.27 (m, 1H), 7.21 – 7.14 (m, 1H), 7.13 – 7.09 (m, 1H), 6.99 (td, *J* = 8.4, 2.5 Hz, 1H), 6.73 (d, *J* = 15.5 Hz, 1H), 6.43 (d, *J* = 15.5 Hz, 1H), 2.24 (d, *J* = 9.0 Hz, 1H), 2.08 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 163.2 (d, *J* = 246.2 Hz), 137.8 (d, *J* = 7.8 Hz), 134.3 (d, *J* = 2.6 Hz), 130.4 (d, *J* = 8.4 Hz), 128.5, 122.9 (d, *J* = 2.9 Hz), 115.6 (d, *J* = 21.4 Hz), 113.5 (d, *J* = 22.0 Hz), 63.6, 42.5, 35.7.
**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −112.9.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_9BrCl_2F$ $[M + H]^+$ 308.9243, found 308.9239.

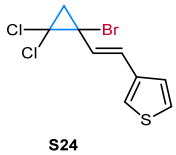
**(*E*)-1-Bromo-4-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)benzene (S23)**




**S23**

According to **General procedure 4** with 4-bromobenzaldehyde (1.85 g, 10.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S23** as a colorless oil (1.37 g, 37% yield over three steps).
**$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.47 (d, *J* = 8.2 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 6.70 (d, *J* = 15.5 Hz, 1H), 6.42 (d, *J* = 15.4 Hz, 1H), 2.23 (d, *J* = 9.0 Hz, 1H), 2.07 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 134.4, 134.2, 132.0, 128.5, 127.8, 122.7, 63.6, 42.6, 35.6.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_9Br_2Cl_2$ $[M + H]^+$ 368.8443, found 368.8432.

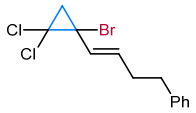
**(*E*)-3-(2-(1-Bromo-2,2-dichlorocyclopropyl)vinyl)thiophene (S24)**




**S24**

According to **General procedure 4** with thiophene-3-carbaldehyde (0.56 g, 5.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S24** as a white solid (0.45 g, 30% yield over three steps).
**m.p.** 70–72 °C
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.30 (dd, *J* = 5.0, 3.1 Hz, 1H), 7.26 (d, *J* = 3.4 Hz, 1H), 7.22 (dd, *J* = 5.0, 1.2 Hz, 1H), 6.75 (d, *J* = 15.5 Hz, 1H), 6.32 (d, *J* = 15.4 Hz, 1H), 2.20 (d, *J* = 8.9 Hz, 1H), 2.04 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 138.1, 129.5, 126.8, 126.7, 125.1, 124.2, 63.6, 42.9, 35.5.
**HRMS** (ESI) *m/z* calcd. for $C_9H_8BrCl_2S$ $[M + H]^+$ 296.8902, found 296.8898.

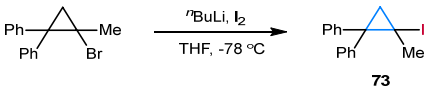
**(*E*)-(4-(1-Bromo-2,2-dichlorocyclopropyl)but-3-en-1-yl)benzene (S25)**



**S25**

According to **General procedure 4** with 3-phenylpropanal (1.34 g, 10.0 mmol, 1.0 equiv.), the crude product was purified by column chromatography on silica gel (petroleum ether) to yield **S25** as a colorless liquid (1.34 g, 42% yield over three steps).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.32 – 7.24 (m, 2H), 7.21 – 7.11 (m, 3H), 5.89 (dt, *J* = 15.1, 6.5 Hz, 1H), 5.79 (d, *J* = 14.9 Hz, 1H), 2.75 – 2.66 (m, 2H), 2.48 – 2.37 (m, 2H), 2.03 (d, *J* = 8.9 Hz, 1H), 1.91 (d, *J* = 9.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 141.2, 136.2, 128.7, 128.6, 128.5, 126.1, 63.4, 42.7, 35.3, 35.1, 33.7.
**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{14}BrCl_2$ $[M + H]^+$ 318.9650, found 318.9639.

**The structures and synthesis of 1-alkyl-substituted cyclopropyl halide**




**73**

An oven-dried two-necked flask was charged under nitrogen atmosphere with a solution of (2-bromo-2-methylcyclopropane-1,1-diyl)dibenzene (2.87 g, 10.0 mmol, 1.0 equiv.) in anhydrous THF (20 mL). The solution was cooled to −78 °C and $^{n}$BuLi (2.5 M in hexanes, 4.0 mL, 10.0 mmol, 1.0 equiv.) was added dropwise. The reaction mixture was stirred for 30 min before the addition of iodine (2.5 g, 10 mmol, 1.0 equiv.). The stirring was continued for 12 h. After completion of the reaction (monitored by TLC), the mixture was quenched with water. Saturated aqueous $Na_2S_2O_3$ and $CH_2Cl_2$ were then added, the organic layer was separated, and the aqueous layer was further extracted with $CH_2Cl_2$. The combined organic solution was dried over anhydrous $MgSO_4$ and concentrated under reduced pressure to afford the residue, which was purified by column chromatography on silica gel to provide **73** as a white solid (2.61 g, 78% yield).

*Note*: (2-bromo-2-methylcyclopropane-1,1-diyl)dibenzene was synthesized according to literature[6].

**(2-Iodo-2-methylcyclopropane-1,1-diyl)dibenzene (73)**


**73**

**m.p.** 87–89 °C

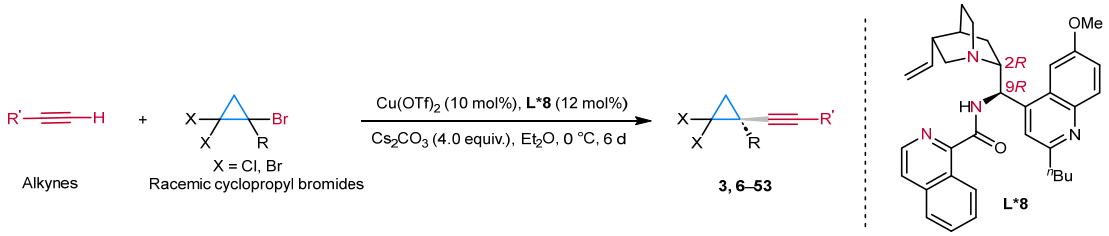
**$^{1}$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.46 (m, 4H), 7.37 – 7.28 (m, 4H), 7.27 – 7.19 (m, 2H), 1.99 (s, 3H), 1.98 (d, $J$ = 6.4 Hz, 1H), 1.75 (d, $J$ = 6.4 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 146.9, 141.0, 129.6, 129.5, 128.7, 128.2, 126.9, 126.8, 42.3, 33.7, 30.8, 15.5.

**HRMS** (ESI) *m/z* calcd. for $C_{16}H_{16}I$ $[M + H]^+$ 335.0291, found 335.0286.

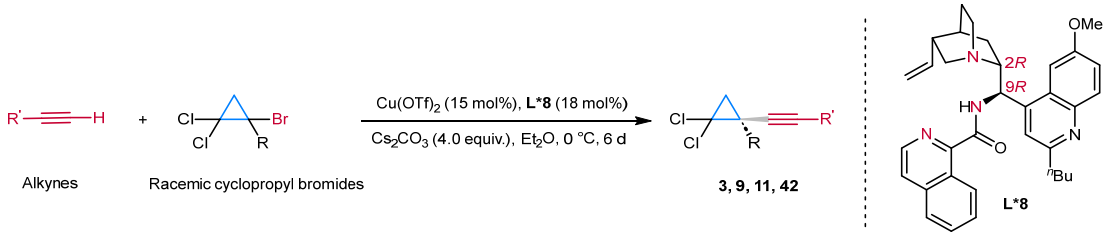
**Enantioconvergent cross-coupling of alkynes with 1-(hetero)aryl-substituted cyclopropyl bromides**

**General procedure A:**



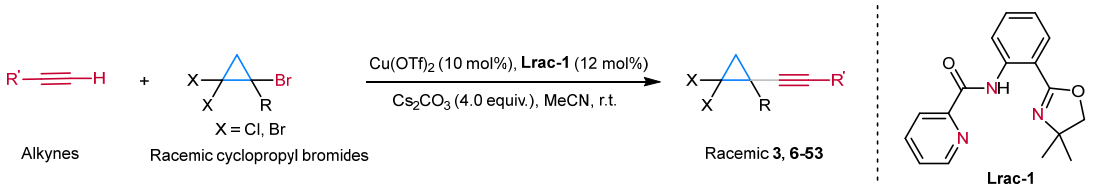

An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (7.20 mg, 0.020 mmol, 10 mol%), chiral ligand **L*8** (12.80 mg, 0.024 mmol, 12 mol%), and $Cs_2CO_3$ (256.0 mg, 0.80 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic 1-(hetero)aryl-substituted cyclopropyl bromide (0.30 mmol, 1.5 equiv.), alkyne (0.20 mmol, 1.0 equiv.), and $Et_2O$ (2.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at 0 °C for 6 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

**General procedure B:**



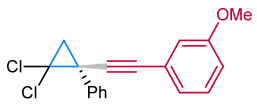

An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (10.85 mg, 0.030 mmol, 15 mol%), chiral ligand **L*8** (19.20 mg, 0.036 mmol, 18 mol%), and $Cs_2CO_3$ (256.0 mg, 0.80 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic 1-(hetero)aryl-substituted cyclopropyl bromide (0.20 mmol, 1.0 equiv.), alkyne (0.20 mmol, 1.0 equiv.), and $Et_2O$ (2.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at 0 °C for 6 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

The preparation of racemic products (±)-**3** and (±)-**6**–**53**:




Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with $Cu(OTf)_2$ (3.60 mg, 0.010 mmol, 10 mol%), **Lrac-1** (3.54 mg, 0.012 mmol, 12 mol%), $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.), and MeCN (1.0 mL). Then, racemic 1-(hetero)aryl-substituted cyclopropyl bromide (0.15 mmol, 1.5 equiv.) and alkyne (0.10 mmol, 1.0 equiv.) were sequentially added into the mixture and the reaction mixture was stirred at r.t. for 3 d. Upon completion, the precipitate was filtered off and washed by EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-3-methoxybenzene (3)**



**3**

According to **General procedure A** with 1-ethynyl-3-methoxybenzene (25.6 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **3** as a colorless oil (58.4 mg, 92% yield, 92% e.e.).

According to **General procedure B** with 1-ethynyl-3-methoxybenzene (25.6 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (53.2 mg, 0.20 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **3** as a colorless oil (58.3 mg, 92% yield, 92% e.e.).

**[α]$_D^{27}$** = −96 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 11.79 min, $t_R$ (major) = 13.65 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.45 (m, 2H), 7.42 – 7.31 (m, 3H), 7.18 (t, *J* = 7.9 Hz, 1H), 7.02 (dt, *J* = 7.6, 1.2 Hz, 1H), 6.94 (dd, *J* = 2.7, 1.4 Hz, 1H), 6.85 (ddd, *J* = 8.3, 2.7, 1.0 Hz, 1H), 3.76 (s, 3H), 2.40 (d, *J* = 7.6 Hz, 1H), 2.20 (d, *J* = 7.6 Hz, 1H).

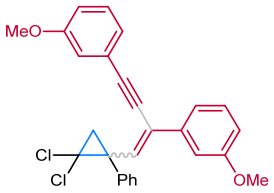
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.4, 136.3, 129.4, 129.1, 128.6, 128.3, 124.5, 123.8, 116.7, 115.1, 89.2, 82.1, 64.9, 55.4, 34.1, 33.2.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}Cl_2O$ $[M + H]^+$ 317.0494, found 317.0490.

Side products **4** and **5** were obtained under indicated conditions according to similar protocols as described above.

**3,3'-(4-(2,2-Dichloro-1-phenylcyclopropyl)but-3-en-1-yne-1,3-**

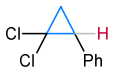
**diyl)bis(methoxybenzene) (4)**




4

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.41 – 7.35 (m, 2H), 7.33 – 7.27 (m, 3H), 7.25 (d, *J* = 8.2 Hz, 1H), 7.23 – 7.17 (m, 1H), 7.04 (dt, *J* = 7.6, 1.2 Hz, 1H), 6.96 (dd, *J* = 2.6, 1.4 Hz, 1H), 6.92 – 6.84 (m, 4H), 6.82 (dd, *J* = 2.6, 1.5 Hz, 1H), 3.79 (s, 3H), 3.76 (s, 3H), 2.04 (dd, *J* = 8.1, 1.2 Hz, 1H), 1.40 (d, *J* = 8.2 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.5, 159.4, 139.1, 138.2, 136.7, 129.5, 129.3, 128.8, 128.7, 127.8, 127.6, 124.4, 124.1, 121.2, 116.4, 115.3, 114.14, 114.09, 90.3, 89.7, 66.3, 55.4, 55.4, 39.5, 31.7.
**HRMS** (ESI) *m/z* calcd. for $C_{27}H_{23}O_2Cl_2$ $[M + H]^+$ 449.1070, found 449.1063.

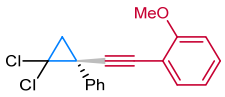
**(2,2-Dichlorocyclopropyl)benzene (5)**




5

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.37 – 7.26 (m, 3H), 7.25 – 7.20 (m, 2H), 2.89 (dd, *J* = 10.6, 8.5 Hz, 1H), 1.94 (dd, *J* = 10.7, 7.4 Hz, 1H), 1.83 (t, *J* = 7.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 134.7, 129.0, 128.4, 127.7, 60.9, 35.6, 25.8.
**HRMS** (ESI) *m/z* calcd. for $C_9H_9Cl_2$ $[M + H]^+$ 187.0076, found 187.0080.

**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-2-methoxybenzene (6)**

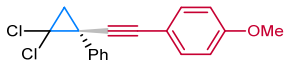



6

According to **General procedure A** with 1-ethynyl-2-methoxybenzene (25.8 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **6** as a pale-yellow solid (50.8 mg, 80% yield, 92% e.e.).
**m.p.** 102–105 °C
**$[\alpha]_D^{27}$** = −88 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 11.60 min, $t_R$ (major) = 13.92 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.46 (m, 2H), 7.44 – 7.28 (m, 4H), 7.27 – 7.20 (m, 1H), 6.86 (t, *J* = 7.5 Hz, 1H), 6.82 (d, *J* = 8.3 Hz, 1H), 3.80 (s, 3H), 2.41 (d, *J* = 7.6 Hz, 1H), 2.21 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 160.5, 136.4, 133.9, 129.9, 129.1, 128.5, 128.1, 120.4, 112.0, 110.9, 93.2, 78.7, 65.1, 55.9, 34.4, 33.2
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}Cl_2O$ $[M + H]^+$ 317.0494, found 317.0491.

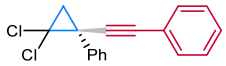
**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-4-methoxybenzene (7)**




**7**

According to **General procedure A** with 1-ethynyl-4-methoxybenzene (26.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **7** as a white solid (57.7 mg, 91% yield, 92% e.e.).
**m.p.** 56–59 °C
**$[\alpha]_D^{27}$** = −114 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 5.68 min, $t_R$ (major) = 7.04 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.43 (m, 2H), 7.42 – 7.28 (m, 5H), 6.88 – 6.72 (m, 2H), 3.77 (s, 3H), 2.37 (d, *J* = 7.5 Hz, 1H), 2.17 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.8, 136.6, 133.4, 129.0, 128.6, 128.2, 114.9, 114.0, 87.9, 82.1, 65.0, 55.4, 34.2, 33.2.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}Cl_2O$ $[M + H]^+$ 317.0494, found 317.0492.

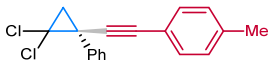
**(*R*)-(2,2-Dichloro-1-(phenylethynyl)cyclopropyl)benzene (8)**




**8**

According to **General procedure A** with ethynylbenzene (21.9 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **8** as a colorless oil (47.1 mg, 82% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −102 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 4.10 min, $t_R$ (major) = 4.62 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.51 – 7.45 (m, 2H), 7.44 – 7.30 (m, 5H), 7.29 – 7.23 (m, 3H), 2.39 (d, *J* = 7.6 Hz, 1H), 2.19 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 132.0, 129.1, 128.6, 128.5, 128.4, 128.2, 122.8, 89.3, 82.2, 64.9, 34.1, 33.2.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{13}Cl_2$ $[M + H]^+$ 287.0389, found 287.0385.

**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-4-methylbenzene (9)**




**9**

According to **General procedure A** with 1-ethynyl-4-methylbenzene (25.3 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **9** as a white solid (52.9 mg, 88% yield, 90% e.e.).

According to **General procedure B** with 1-ethynyl-4-methylbenzene (25.3 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (53.2 mg, 0.20 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **9** as a white solid (51.8 mg, 86% yield, 90% e.e.).

**m.p.** 54–57 °C

**[α]$_D^{27}$** = −105 (c 0.5, $CHCl_3$).

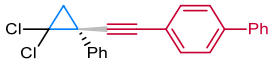
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 9.06 min, $t_R$ (major) = 10.44 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.53 – 7.42 (m, 2H), 7.41 – 7.35 (m, 2H), 7.34 – 7.25 (m, 3H), 7.12 – 7.01 (m, 2H), 2.38 (d, *J* = 7.5 Hz, 1H), 2.31 (s, 3H), 2.17 (d, *J* = 7.5 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 138.6, 136.5, 131.8, 129.11, 129.06, 128.6, 128.2, 119.7, 88.6, 82.4, 65.0, 34.2, 33.2, 21.6.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}Cl_2$ $[M + H]^+$ 301.0545, found 301.0535.

**(*R*)-4-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-1,1'-biphenyl (10)**




**10**

According to **General procedure A** with 4-ethynyl-1,1'-biphenyl (35.6 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **10** as a white solid (62.4 mg, 86% yield, 92% e.e.).

**m.p.** 140–142 °C

**[α]$_D^{27}$** = −124 (c 0.5, $CHCl_3$).

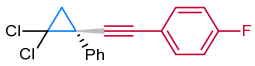
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 14.02 min, $t_R$ (major) = 16.54 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.66 – 7.52 (m, 8H), 7.51 – 7.42 (m, 4H), 7.41 – 7.35 (m, 2H), 2.46 (d, *J* = 7.5 Hz, 1H), 2.26 (d, *J* = 7.7 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 141.2, 140.4, 136.4, 132.4, 129.1, 129.0, 128.6, 128.3, 127.8, 127.1, 127.0, 121.7, 90.0, 82.1, 64.9, 34.2, 33.3.

**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{17}Cl_2$ $[M + H]^+$ 363.0702, found 363.0692.

**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-4-fluorobenzene (11)**




**11**

According to **General procedure A** with 1-ethynyl-4-fluorobenzene (23.0 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) for 8 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **11** as a colorless oil (43.1 mg, 71% yield, 92% e.e.).

According to **General procedure B** with 1-ethynyl-4-fluorobenzene (23.0 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (53.2 mg, 0.20 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **11** as a colorless oil (45.8 mg, 75% yield, 92% e.e.).

**$[\alpha]_D^{27}$** = −103 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 8.56 min, $t_R$ (major) = 9.67 min.

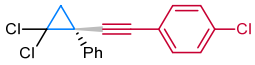
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.53 – 7.44 (m, 2H), 7.44 – 7.29 (m, 5H), 7.03 – 6.89 (m, 2H), 2.39 (d, *J* = 7.5 Hz, 1H), 2.18 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, CDCl3) δ 162.6 (d, *J* = 249.6 Hz), 136.3, 133.9 (d, *J* = 8.4 Hz), 129.1, 128.7, 128.3, 118.9 (d, *J* = 3.5 Hz), 115.7 (d, *J* = 22.1 Hz), 89.0 (d, *J* = 1.5 Hz), 81.2, 64.8, 34.1, 33.2.

**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −110.6.

**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{12}Cl_2F$ $[M + H]^+$ 305.0295, found 305.0287.

**(*R*)-1-Chloro-4-((2,2-dichloro-1-phenylcyclopropyl)ethynyl)benzene (12)**




**12**

According to **General procedure A** with 1-chloro-4-ethynylbenzene (27.2 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) for 8 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **12** as a white solid (45.6 mg, 71% yield, 92% e.e.).

**m.p.** 46–49 °C

**$[\alpha]_D^{27}$** = −109 (c 0.5, $CHCl_3$).

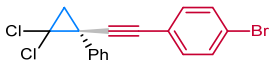
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 214 nm), $t_R$ (minor) = 9.15 min, $t_R$ (major) = 10.85 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.42 (m, 2H), 7.41 – 7.29 (m, 5H), 7.28 – 7.19 (m, 2H), 2.39 (d, *J* = 7.6 Hz, 1H), 2.18 (d, *J* = 7.5 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.2, 134.5, 133.2, 129.1, 128.69, 128.68, 128.3, 121.3, 90.3, 81.1, 64.8, 34.1, 33.2.

**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{12}Cl_3$ $[M + H]^+$ 320.9999, found 320.9991.

**(*R*)-1-Bromo-4-((2,2-dichloro-1-phenylcyclopropyl)ethynyl)benzene (13)**




**13**

According to **General procedure A** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) for 8 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **13** as a white solid (60.1 mg, 82% yield, 92% e.e.).

**m.p.** 75–77 °C

**[α]$_D^{27}$** = −115 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 9.36 min, $t_R$ (major) = 10.10 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.49 – 7.43 (m, 2H), 7.43 – 7.31 (m, 5H), 7.30 – 7.23 (m, 2H), 2.39 (d, *J* = 7.5 Hz, 1H), 2.19 (d, *J* = 7.5 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.1, 133.4, 131.6, 129.1, 128.7, 128.3, 122.7, 121.7, 90.5, 81.2, 64.7, 34.1, 33.2.

**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{12}BrCl_2$ $[M + H]^+$ 364.9494, found 364.9484.

**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-4-(trifluoromethyl)benzene (14)**


**14**

According to **General procedure A** with 1-ethynyl-4-(trifluoromethyl)benzene (32.5 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) for 8 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **14** as a colorless oil (60.5 mg, 85% yield, 90% e.e.).

**[α]$_D^{27}$** = −118 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 9.11 min, $t_R$ (major) = 10.14 min.

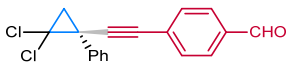
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.48 (m, 4H), 7.48 – 7.43 (m, 2H), 7.43 – 7.32 (m, 3H), 2.41 (d, *J* = 7.6 Hz, 1H), 2.21 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.0, 132.2, 130.2 (q, *J* = 32.7 Hz), 129.1, 128.8, 128.5, 126.7 (q, *J* = 1.3 Hz), 125.3 (q, *J* = 3.9 Hz), 124.0 (q, *J* = 272.7 Hz), 91.9, 80.9, 64.7, 34.1, 33.3.

**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −62.8.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{12}Cl_2F_3$ $[M + H]^+$ 355.0263, found 355.0258.

**(*R*)-4-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)benzaldehyde (15)**




**15**

According to **General procedure A** with 4-ethynylbenzaldehyde (26.0 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **15** as a colorless oil (50.5 mg, 80% yield, 86% e.e.).

**[α]$_D^{27}$** = −148 (c 0.5, $CHCl_3$).

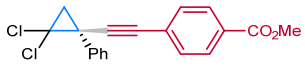
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 214 nm), $t_R$ (minor) = 6.71 min, $t_R$ (major) = 9.00 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 9.98 (s, 1H), 7.85 – 7.74 (m, 2H), 7.62 – 7.52 (m, 2H), 7.51 – 7.44 (m, 2H), 7.43 – 7.33 (m, 3H), 2.44 (d, *J* = 7.6 Hz, 1H), 2.24 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 191.5, 135.9, 135.6, 132.5, 129.6, 129.10, 129.08, 128.7, 128.5, 93.6, 81.4, 64.7, 34.1, 33.4.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{13}Cl_2O$ $[M + H]^+$ 315.0338, found 315.0334.

**Methyl (*R*)-4-((2,2-dichloro-1-phenylcyclopropyl)ethynyl)benzoate (16)**




**16**

According to **General procedure A** with methyl 4-ethynylbenzoate (32.0 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) for 8 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **16** as a colorless oil (48.8 mg, 71% yield, 92% e.e.).

**[α]$_D^{27}$** = −114 (c 0.5, $CHCl_3$).

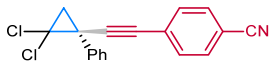
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 7.59 min, $t_R$ (major) = 10.12 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.01 – 7.91 (m, 2H), 7.55 – 7.44 (m, 4H), 7.43 – 7.33 (m, 3H), 3.91 (s, 3H), 2.43 (d, *J* = 7.6 Hz, 1H), 2.23 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 166.6, 136.0, 131.9, 129.7, 129.5, 129.1, 128.7, 128.4, 127.5, 92.4, 81.5, 64.7, 52.4, 34.1, 33.3.

**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{15}Cl_2O_2$ $[M + H]^+$ 345.0444, found 345.0438.

**(*R*)-4-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)benzonitrile (17)**



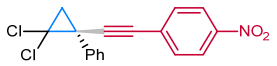

**17**

According to **General procedure A** with 4-ethynylbenzonitrile (26.0 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **17** as a colorless oil (46.2 mg, 74% yield, 84% e.e.).

**[α]$_D^{27}$** = −140 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 214 nm), $t_R$ (minor) = 8.34 min, $t_R$ (major) = 11.97 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.63 – 7.54 (m, 2H), 7.53 – 7.32 (m, 7H), 2.45 (d, *J* = 7.6 Hz, 1H), 2.24 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 135.7, 132.5, 132.1, 129.1, 128.8, 128.5, 127.7, 118.5, 111.8, 94.0, 80.6, 64.6, 34.0, 33.4.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{12}NCl_2$ $[M + H]^+$ 312.0341, found 312.0337.

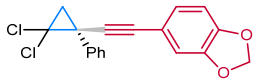
**(*R*)-1-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)-4-nitrobenzene (18)**




**18**

According to **General procedure A** with 1-ethynyl-4-nitrobenzene (29.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 30/1) to yield the product **18** as a colorless oil (62.1 mg, 93% yield, 80% e.e.).
**$[\alpha]_D^{27}$** = −141 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 214 nm), $t_R$ (minor) = 19.89 min, $t_R$ (major) = 26.65 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.26 – 8.07 (m, 2H), 7.61 – 7.52 (m, 2H), 7.52 – 7.32 (m, 5H), 2.47 (d, *J* = 7.7 Hz, 1H), 2.27 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 147.2, 135.6, 132.7, 129.7, 129.1, 128.8, 128.6, 123.6, 94.9, 80.4, 64.6, 34.0, 33.4.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{12}O_2NCl_2$ $[M + H]^+$ 332.0240, found 332.0233.

**(*R*)-5-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)benzo[*d*][1,3]dioxole (19)**

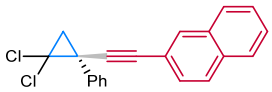



**19**

According to **General procedure A** with 5-ethynylbenzo[*d*][1,3]dioxole (29.2 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **19** as a colorless oil (56.2 mg, 85% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −112 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 11.86 min, $t_R$ (major) = 13.44 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 – 7.45 (m, 2H), 7.43 – 7.33 (m, 3H), 6.97 (dd, *J* = 8.1, 1.6 Hz, 1H), 6.89 (d, *J* = 1.6 Hz, 1H), 6.73 (d, *J* = 8.0 Hz, 1H), 5.95 (s, 2H), 2.40 (d, *J* = 7.6 Hz, 1H), 2.19 (d, *J* = 7.5 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 148.0, 147.4, 136.5, 129.0, 128.6, 128.2, 126.6, 116.0, 111.9, 108.5, 101.4, 87.7, 82.1, 64.9, 34.1, 33.2.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{13}O_2Cl_2$ $[M + H]^+$ 331.0287, found 331.0283.

**(*R*)-2-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)naphthalene (20)**




**20**

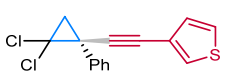
According to **General procedure A** with 2-ethynylnaphthalene (30.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **20** as a white solid (54.4 mg, 81% yield, 90% e.e.).
**m.p.** 109–112 °C
**[α]$_D^{27}$** = −146 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 4.95 min, $t_R$ (major) = 5.90 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.01 (s, 1H), 7.88 – 7.71 (m, 3H), 7.67 – 7.32 (m, 8H), 2.47 (d, *J* = 7.5 Hz, 1H), 2.29 (d, *J* = 7.5 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 133.0, 132.9, 131.9, 129.1, 128.7, 128.6, 128.3, 128.0, 127.85, 127.79, 126.8, 126.6, 120.1, 89.7, 82.6, 64.9, 34.2, 33.3.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{15}Cl_2$ $[M + H]^+$ 337.0545, found 337.0540.

**(*R*)-2-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)thiophene (21)**


**21**

According to **General procedure A** with 2-ethynylthiophene (19.6 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **21** as a colorless oil (43.9 mg, 75% yield, 92% e.e.).
**[α]$_D^{27}$** = −112 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 10.96 min, $t_R$ (major) = 11.98 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.53 – 7.46 (m, 2H), 7.44 – 7.33 (m, 3H), 7.27 – 7.18 (m, 2H), 6.96 (dd, *J* = 5.1, 3.6 Hz, 1H), 2.42 (d, *J* = 7.6 Hz, 1H), 2.23 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.1, 132.5, 129.1, 128.7, 128.3, 127.3, 127.0, 122.8, 93.1, 75.5, 64.8, 34.3, 33.3.
**HRMS** (ESI) *m/z* calcd. for $C_{15}H_{11}Cl_2S$ $[M + H]^+$ 292.9953, found 292.9949.

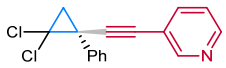
**(*R*)-3-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)thiophene (22)**




**22**

According to **General procedure A** with 3-ethynylthiophene (19.7 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **22** as a colorless oil (51.8 mg, 85% yield, 92% e.e.).
**[α]$_D^{27}$** = −101 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 270 nm), $t_R$ (minor) = 10.32 min, $t_R$ (major) = 11.24 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.44 (m, 2H), 7.43 – 7.30 (m, 4H), 7.22 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.08 (dd, *J* = 5.0, 1.2 Hz, 1H), 2.38 (d, *J* = 7.5 Hz, 1H), 2.18 (d, *J* = 7.5 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 130.1, 129.3, 129.1, 128.6, 128.3, 125.4, 121.8, 88.8, 77.4, 64.8, 34.2, 33.2.
**HRMS** (ESI) *m/z* calcd. for $C_{15}H_{11}Cl_2S$ $[M + H]^+$ 292.9953, found 292.9943.

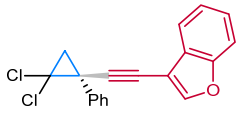
**(*R*)-3-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)pyridine (23)**




**23**

According to **General procedure A** with 3-ethynylpyridine (20.2 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **23** as a white solid (53.5 mg, 93% yield, 86% e.e.).
**m.p.** 54–57 °C
**[α]$_D^{27}$** = −104 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 24.13 min, $t_R$ (major) = 30.85 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.66 (d, *J* = 2.3 Hz, 1H), 8.51 (dd, *J* = 4.9, 1.7 Hz, 1H), 7.70 (dt, *J* = 7.9, 1.9 Hz, 1H), 7.53 – 7.44 (m, 2H), 7.44 – 7.31 (m, 3H), 7.21 (dd, *J* = 7.8, 4.9 Hz, 1H), 2.42 (d, *J* = 7.6 Hz, 1H), 2.23 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 152.5, 148.7, 138.8, 135.9, 129.0, 128.7, 128.4, 123.0, 119.9, 92.7, 78.9, 64.6, 34.0, 33.2.
**HRMS** (ESI) *m/z* calcd. for $C_{16}H_{12}NCl_2$ $[M + H]^+$ 288.0341, found 288.0338.

**(*R*)-3-((2,2-Dichloro-1-phenylcyclopropyl)ethynyl)benzofuran (24)**

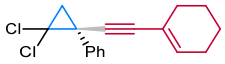



**24**

According to **General procedure A** with 3-ethynylbenzofuran (28.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **24** as a colorless oil (44.5 mg, 68% yield, 92% e.e.).
**[α]$_D^{27}$** = −119 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 10.75 min, $t_R$ (major) = 11.63 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.79 (s, 1H), 7.70 – 7.64 (m, 1H), 7.55 – 7.51 (m, 2H), 7.51 – 7.47 (m, 1H), 7.46 – 7.40 (m, 2H), 7.39 – 7.28 (m, 3H), 2.46 (d, *J* = 7.6 Hz, 1H), 2.26 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 154.6, 148.0, 136.3, 129.1, 128.7, 128.4, 127.9, 125.4, 123.5, 120.7, 111.7, 104.1, 93.9, 71.9, 64.7, 34.4, 33.4.
**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{13}OCl_2$ $[M + H]^+$ 327.0338, found 327.0336.

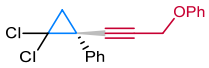
**(*R*)-(2,2-dichloro-1-(cyclohex-1-en-1-ylethynyl)cyclopropyl)benzene (25)**




**25**

According to **General procedure A** with 1-ethynylcyclohex-1-ene (23.5 μL, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **25** as a colorless oil (44.9 mg, 77% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −33 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 9.26 min, $t_R$ (major) = 10.40 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.39 (m, 2H), 7.38 – 7.33 (m, 2H), 7.33 – 7.28 (m, 1H), 6.11 (tt, *J* = 3.8, 1.8 Hz, 1H), 2.32 (d, *J* = 7.5 Hz, 1H), 2.13 – 2.03 (m, 5H), 1.63 – 1.52 (m, 4H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.8, 135.6, 129.0, 128.5, 128.0, 120.3, 86.6, 84.1, 65.0, 34.1, 33.2, 29.2, 25.7, 22.3, 21.6.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{17}Cl_2$ $[M + H]^+$ 291.0702, found 291.0696.

**(*R*)-(2,2-Dichloro-1-(3-phenoxyprop-1-yn-1-yl)cyclopropyl)benzene (26)**

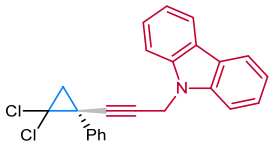



**26**

According to **General procedure A** with (prop-2-yn-1-yloxy)benzene (26.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **26** as a colorless oil (48.2 mg, 76% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −40 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 230 nm), $t_R$ (minor) = 15.55 min, $t_R$ (major) = 18.71 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.44 – 7.17 (m, 7H), 7.08 – 6.84 (m, 3H), 4.71 (s, 2H), 2.28 (d, *J* = 7.6 Hz, 1H), 2.06 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 157.7, 135.9, 129.5, 129.0, 128.6, 128.3, 121.5, 115.2, 87.2, 77.3, 64.4, 56.3, 33.5, 32.9.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}OCl_2$ $[M + H]^+$ 317.0494, found 317.0490.

**(*R*)-9-(3-(2,2-Dichloro-1-phenylcyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (27)**




**27**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **27** as a white solid (73.7 mg, 94% yield, 92% e.e.).

**m.p.** 101–103 °C

**$[\alpha]_D^{27}$** = −12 (c 0.5, $CHCl_3$).

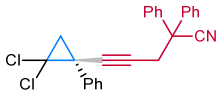
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 10.78 min, $t_R$ (major) = 12.92 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.21 – 8.10 (m, 2H), 7.57 – 7.46 (m, 4H), 7.43 – 7.28 (m, 7H), 5.08 (s, 2H), 2.26 (d, *J* = 7.5 Hz, 1H), 2.01 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.0, 135.9, 128.9, 128.6, 128.3, 125.9, 123.3, 120.5, 119.6, 109.1, 84.0, 76.6, 64.3, 33.4, 32.9, 32.8.

**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{18}NCl_2$ $[M + H]^+$ 390.0811, found 390.0806.

**(*R*)-5-(2,2-Dichloro-1-phenylcyclopropyl)-2,2-diphenylpent-4-ynenitrile (28)**




**28**

According to **General procedure A** with 2,2-diphenylpent-4-ynenitrile (46.2 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **28** as a white solid (64.4 mg, 77% yield, 93% e.e.).

**m.p.** 128–130 °C

**$[\alpha]_D^{27}$** = −18 (c 0.5, $CHCl_3$).

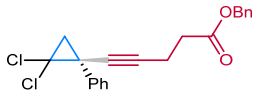
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 13.54 min, $t_R$ (major) = 15.26 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.46 – 7.25 (m, 13H), 7.25 – 7.19 (m, 2H), 3.27 (s, 2H), 2.20 (d, *J* = 7.5 Hz, 1H), 1.90 (d, *J* = 7.5 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 139.0, 138.9, 136.0, 128.9, 128.8, 128.4, 128.3, 128.1, 127.30, 127.26, 121.8, 84.9, 76.9, 64.4, 51.4, 33.5, 32.6, 31.5.

**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{20}NCl_2$ $[M + H]^+$ 416.0967, found 416.0962.

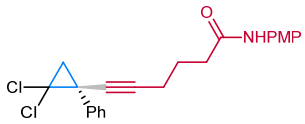
**Benzyl (*R*)-5-(2,2-dichloro-1-phenylcyclopropyl)pent-4-ynoate (29)**




**29**

According to **General procedure A** with benzyl pent-4-ynoate (37.6 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **29** as a pale yellow oil (62.9 mg, 84% yield, 92% e.e.).
**[α]$_D^{27}$** = −39 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 11.00 min, $t_R$ (major) = 12.06 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.41 – 7.30 (m, 10H), 5.13 (s, 2H), 2.67 – 2.51 (m, 4H), 2.27 (d, *J* = 7.5 Hz, 1H), 2.00 (d, *J* = 7.5 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 171.7, 136.6, 135.8, 128.9, 128.7, 128.5, 128.4, 128.3, 128.1, 80.9, 80.8, 66.6, 64.5, 33.7, 33.6, 32.7, 15.0.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{19}O_2Cl_2$ $[M + H]^+$ 373.0757, found 373.0755.

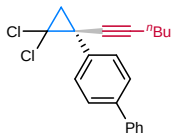
**(*R*)-6-(2,2-Dichloro-1-phenylcyclopropyl)-*N*-(4-methoxyphenyl)hex-5-ynamide (30)**




**30**

According to **General procedure A** with *N*-(4-methoxyphenyl)hex-5-ynamide (43.4 mg, 0.20 mmol) and (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (79.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **30** as a pale-yellow oil (64.2 mg, 80% yield, 92% e.e.).
**[α]$_D^{27}$** = −27 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 75/25, flow rate 1.0 mL/min, λ = 214 nm), $t_R$ (minor) = 15.58 min, $t_R$ (major) = 19.87 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.26 (m, 8H), 6.88 – 6.77 (m, 2H), 3.77 (s, 3H), 2.43 (t, *J* = 7.3 Hz, 2H), 2.32 (t, *J* = 6.8 Hz, 2H), 2.27 (d, *J* = 7.5 Hz, 1H), 2.04 (d, *J* = 7.5 Hz, 1H), 1.90 (p, *J* = 7.0 Hz, 2H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 170.7, 156.4, 136.8, 131.0, 128.8, 128.5, 128.1, 121.9, 114.1, 81.9, 81.2, 64.8, 55.5, 35.9, 33.7, 32.8, 24.3, 18.2.
**HRMS** (ESI) *m/z* calcd. for $C_{22}H_{22}O_2NCl_2$ $[M + H]^+$ 402.1022, found 402.1017.

**(*R*)-4-(2,2-Dichloro-1-(hex-1-yn-1-yl)cyclopropyl)-1,1'-biphenyl (31)**




**31**

According to **General procedure A** with 1-hexyne (22.9 μL, 0.20 mmol) and 4-(1-bromo-2,2-dichlorocyclopropyl)-1,1'-biphenyl **S7** (102.6 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **31** as a white solid (59.2 mg, 88% yield, 94% e.e.).

**m.p.** 90–93 °C

**[α]$_D^{27}$** = −17 (c 0.5, $CHCl_3$).

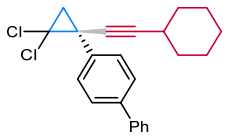
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 8.93 min, $t_R$ (minor) = 11.54 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.67 – 7.59 (m, 4H), 7.54 – 7.43 (m, 4H), 7.41 – 7.35 (m, 1H), 2.34 (d, *J* = 7.5 Hz, 1H), 2.27 (t, *J* = 6.9 Hz, 2H), 2.08 (d, *J* = 7.5 Hz, 1H), 1.60 – 1.39 (m, 4H), 0.95 (t, *J* = 7.2 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.8, 140.6, 136.1, 129.3, 128.9, 127.5, 127.21, 127.18, 83.2, 79.9, 64.9, 33.6, 33.0, 30.8, 22.0, 18.7, 13.7.

**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{21}Cl_2$ $[M + H]^+$ 343.1015, found 343.1011.

**(*R*)-4-(2,2-Dichloro-1-(cyclohexylethynyl)cyclopropyl)-1,1'-biphenyl (32)**




**32**

According to **General procedure A** with ethynylcyclohexane (26.0 μL, 0.20 mmol) and 4-(1-bromo-2,2-dichlorocyclopropyl)-1,1'-biphenyl **S7** (102.6 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **32** as a white solid (63.9 mg, 87% yield, 94% e.e.).

**m.p.** 90–92 °C

**[α]$_D^{27}$** = −19 (c 0.5, $CHCl_3$).

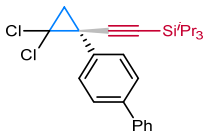
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 7.52 min, $t_R$ (minor) = 14.44 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.68 – 7.57 (m, 4H), 7.53 – 7.42 (m, 4H), 7.41 – 7.32 (m, 1H), 2.47 (tt, *J* = 8.2, 3.8 Hz, 1H), 2.35 (d, *J* = 7.6 Hz, 1H), 2.07 (d, *J* = 7.6 Hz, 1H), 1.85 – 1.67 (m, 4H), 1.56 – 1.46 (m, 3H), 1.39 – 1.28 (m, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.8, 140.6, 136.1, 129.3, 128.9, 127.5, 127.2, 127.1, 87.2, 80.1, 65.0, 33.6, 33.0, 32.6, 29.1, 26.1, 24.7.

**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{23}Cl_2$ $[M + H]^+$ 369.1171, found 369.1165.

**(*R*)-((1-([1,1'-Biphenyl]-4-yl)-2,2-dichlorocyclopropyl)ethynyl)triisopropylsilane (33)**




**33**

According to **General procedure A** with ethynyltriisopropylsilane (22.0 μL, 0.10 mmol) and 4-(1-bromo-2,2-dichlorocyclopropyl)-1,1'-biphenyl **S7** (51.3 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **33** as a colorless oil (23.2 mg, 52% yield, 94% e.e.).

**[α]$_D^{27}$** = −12 (c 0.5, $CHCl_3$).

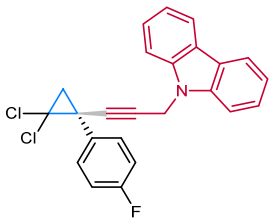
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 100/0, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 17.47 min, $t_R$ (major) = 23.90 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.66 – 7.54 (m, 4H), 7.52 – 7.47 (m, 2H), 7.47 – 7.40 (m, 2H), 7.38 – 7.31 (m, 1H), 2.39 (d, *J* = 7.6 Hz, 1H), 2.11 (d, *J* = 7.6 Hz, 1H), 1.07 (s, 21H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.9, 140.6, 135.2, 129.3, 128.9, 127.6, 127.2, 127.1, 106.7, 83.9, 64.9, 34.3, 33.3, 18.8, 11.4.

**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{33}Cl_2Si$ $[M + H]^+$ 443.1723, found 443.1718.

**(*R*)-9-(3-(2,2-Dichloro-1-(4-fluorophenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (34)**




**34**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-4-fluorobenzene **S1** (85.2 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **34** as a white solid (56.3 mg, 69% yield, 90% e.e.).

**m.p.** 86–88 °C

**[α]$_D^{27}$** = −10 (c 0.5, $CHCl_3$).

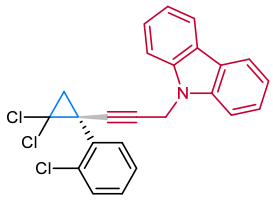
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 32.81 min, $t_R$ (major) = 35.49 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.15 (d, *J* = 7.7 Hz, 2H), 7.56 – 7.45 (m, 4H), 7.36 – 7.25 (m, 4H), 7.11 – 6.98 (m, 2H), 5.10 (s, 2H), 2.20 (d, *J* = 7.6 Hz, 1H), 2.02 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 162.5 (d, *J* = 247.6 Hz), 140.0, 131.8 (d, *J* = 3.2 Hz), 130.7 (d, *J* = 8.4 Hz), 125.9, 123.3, 120.5, 119.6, 115.5 (d, *J* = 21.7 Hz), 109.0, 83.8, 76.8, 64.2, 33.1, 32.9, 32.8.

**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −113.3.
**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{17}NCl_2F$ $[M + H]^+$ 408.0717, found 408.0715.

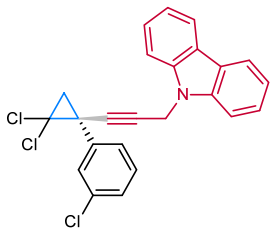
**(*S*)-9-(3-(2,2-Dichloro-1-(2-chlorophenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (35)**



**35**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-2-chlorobenzene **S2** (85.2 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **35** as a white solid (76.3 mg, 90% yield, 93% e.e.).
**m.p.** 106–109 °C
**[α]$_D^{27}$** = −14 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 47.10 min, $t_R$ (major) = 50.99 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.05 (dt, *J* = 7.7, 1.0 Hz, 2H), 7.46 – 7.36 (m, 5H), 7.25 – 7.00 (m, 5H), 5.01 (s, 2H), 2.06 (d, *J* = 7.3 Hz, 1H), 1.98 (d, *J* = 7.3 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.1, 136.4, 134.9, 130.3, 130.1, 129.8, 127.0, 125.9, 123.3, 120.4, 119.5, 109.1, 82.3, 76.4, 64.1, 33.9, 33.0, 29.8.
**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{17}NCl_3$ $[M + H]^+$ 424.0421, found 424.0420.

**(*R*)-9-(3-(2,2-Dichloro-1-(3-chlorophenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (36)**

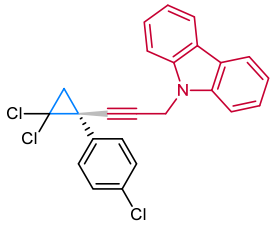


**36**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-3-chlorobenzene **S3** (85.2 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **36** as a colorless oil (80.6 mg, 95% yield, 92% e.e.).
**[α]$_D^{27}$** = −19 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ =

254 nm), $t_R$ (minor) = 37.27 min, $t_R$ (major) = 39.69 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.22 – 8.06 (m, 2H), 7.58 – 7.43 (m, 4H), 7.38 (t, *J* = 1.9 Hz, 1H), 7.35 – 7.27 (m, 4H), 7.24 – 7.19 (m, 1H), 5.11 (s, 2H), 2.23 (d, *J* = 7.7 Hz, 1H), 2.02 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 139.9, 137.8, 134.4, 129.7, 129.1, 128.4, 127.1, 125.9, 123.3, 120.4, 119.5, 108.9, 83.3, 77.1, 63.9, 33.0, 32.9, 32.8.
**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{17}NCl_3$ $[M + H]^+$ 424.0421, found 424.0416.

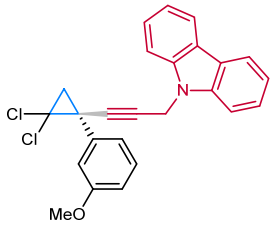
**(*R*)-9-(3-(2,2-Dichloro-1-(4-chlorophenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (37)**




**37**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-4-chlorobenzene **S4** (85.2 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **37** as a white solid (87.8 mg, 97% yield, 91% e.e.).
**m.p.** 103–105 °C
**$[\alpha]_D^{27}$** = −16 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 16.17 min, $t_R$ (major) = 17.99 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.7 Hz, 2H), 7.58 – 7.45 (m, 4H), 7.38 – 7.30 (m, 4H), 7.30 – 7.23 (m, 2H), 5.09 (s, 2H), 2.20 (d, *J* = 7.7 Hz, 1H), 2.02 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.0, 134.4, 134.2, 130.3, 128.7, 125.9, 123.3, 120.5, 119.6, 109.0, 83.5, 77.0, 64.1, 32.9, 32.8.
**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{17}NCl_3$ $[M + H]^+$ 424.0421, found 424.0418.

**(*R*)-9-(3-(2,2-Dichloro-1-(3-methoxyphenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (38)**




**38**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg,

0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-3-methoxybenzene **S5** (88.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **38** as a white solid (75.4 mg, 90% yield, 92% e.e.).

**m.p.** 115–118 °C

**[α]$_D^{27}$** = −11 (c 0.5, $CHCl_3$).

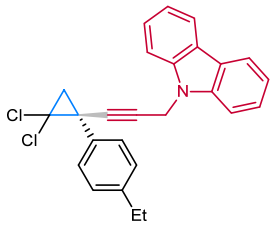
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 15.31 min, $t_R$ (major) = 25.19 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 7.8 Hz, 2H), 7.52 – 7.37 (m, 4H), 7.27 – 7.16 (m, 3H), 6.93 – 6.67 (m, 3H), 5.04 (s, 2H), 3.66 (s, 3H), 2.19 (d, *J* = 7.6 Hz, 1H), 1.94 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.7, 140.0, 137.3, 129.5, 125.9, 123.3, 121.0, 120.5, 119.6, 114.7, 114.0, 109.0, 84.0, 76.6, 64.3, 55.3, 33.4, 33.0, 32.9.

**HRMS** (ESI) *m/z* calcd. for $C_{25}H_{20}ONCl_2$ $[M + H]^+$ 420.0916, found 420.0914.

**(*R*)-9-(3-(2,2-Dichloro-1-(4-ethylphenyl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (39)**




**39**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-4-ethylbenzene **S6** (88.2 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **39** as a colorless oil (80.6 mg, 96% yield, 91% e.e.).

**[α]$_D^{27}$** = −15 (c 0.5, $CHCl_3$).

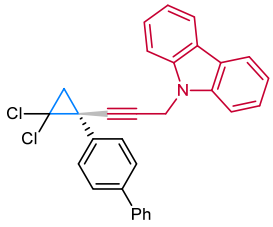
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 10.88 min, $t_R$ (major) = 13.66 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.14 (dt, *J* = 7.8, 0.9 Hz, 2H), 7.55 – 7.47 (m, 4H), 7.35 – 7.26 (m, 4H), 7.24 – 7.17 (m, 2H), 5.08 (s, 2H), 2.70 (q, *J* = 7.6 Hz, 2H), 2.23 (d, *J* = 7.5 Hz, 1H), 1.99 (d, *J* = 7.5 Hz, 1H), 1.29 (t, *J* = 7.6 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 144.3, 140.0, 133.1, 128.8, 128.0, 125.9, 123.3, 120.4, 119.5, 109.1, 84.2, 76.4, 64.4, 33.2, 32.9, 32.8, 28.6, 15.4.

**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{22}NCl_2$ $[M + H]^+$ 418.1124, found 418.1119.

**(*R*)-9-(3-(1-([1,1'-Biphenyl]-4-yl)-2,2-dichlorocyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (40)**




**40**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 4-(1-bromo-2,2-dichlorocyclopropyl)-1,1'-biphenyl **S7** (102.6 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **40** as a white solid (88.3 mg, 95% yield, 92% e.e.).

**m.p.** 157–159 °C

**[α]$_D^{27}$** = +15 (c 0.5, $CHCl_3$).

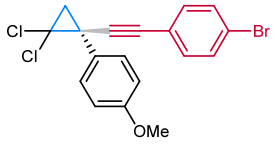
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 23.52 min, $t_R$ (major) = 28.01 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.7 Hz, 2H), 7.67 – 7.57 (m, 4H), 7.56 – 7.46 (m, 6H), 7.45 – 7.38 (m, 3H), 7.37 – 7.29 (m, 2H), 5.10 (s, 2H), 2.29 (d, *J* = 7.6 Hz, 1H), 2.04 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 141.0, 140.4, 140.0, 134.8, 129.3, 128.9, 127.6, 127.2, 127.2, 125.9, 123.3, 120.5, 119.6, 109.0, 84.0, 76.7, 64.4, 33.2, 32.9, 32.9.

**HRMS** (ESI) *m/z* calcd. for $C_{30}H_{22}NCl_2$ $[M + H]^+$ 466.1124, found 466.1123.

**(*R*)-1-Bromo-4-((2,2-dichloro-1-(4-methoxyphenyl)cyclopropyl)ethynyl)benzene (41)**




**41**

According to **General procedure A** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and 1-(1-bromo-2,2-dichlorocyclopropyl)-4-methoxybenzene **S8** (88.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **41** as a colorless oil (56.5 mg, 72% yield, 90% e.e.).

**[α]$_D^{27}$** = −111 (c 0.5, $CHCl_3$).

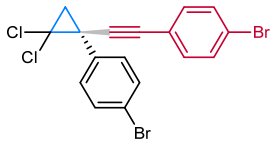
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 11.71 min, $t_R$ (major) = 13.74 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.32 (m, 4H), 7.27 (d, *J* = 8.5 Hz, 2H), 6.91 (d, *J* = 8.3 Hz, 2H), 3.81 (s, 3H), 2.34 (d, *J* = 7.5 Hz, 1H), 2.16 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.6, 133.4, 131.6, 130.2, 128.3, 122.7, 121.9, 114.1, 90.8, 65.0, 55.4, 33.5, 33.4.

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{14}OBrCl_2$ $[M + H]^+$ 394.9600, found 394.9599.

**(*R*)-1-Bromo-4-((1-(4-bromophenyl)-2,2-dichlorocyclopropyl)ethynyl)benzene (42)**



**42**

According to **General procedure A** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and 1-bromo-4-(1-bromo-2,2-dichlorocyclopropyl)benzene **S9** (103.5 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **42** as a colorless oil (66.8 mg, 75% yield, 91% e.e.).

According to **General procedure B** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and 1-bromo-4-(1-bromo-2,2-dichlorocyclopropyl)benzene **S9** (69.0 mg, 0.20 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **42** as a colorless oil (75.6 mg, 85% yield, 91% e.e.).

**[α]$_D^{27}$** = −64 (c 0.5, $CHCl_3$).

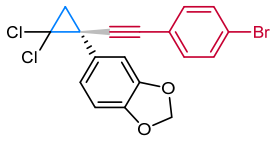
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 214 nm), $t_R$ (minor) = 12.51 min, $t_R$ (major) = 13.11 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.55 – 7.49 (m, 2H), 7.45 – 7.39 (m, 2H), 7.35 – 7.30 (m, 2H), 7.28 – 7.25 (m, 2H), 2.35 (d, *J* = 7.7 Hz, 1H), 2.20 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 135.3, 133.4, 131.9, 131.7, 130.8, 122.9, 122.5, 121.5, 89.9, 81.6, 64.4, 33.7, 33.4.

**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{11}Br_2Cl_2$ $[M + H]^+$ 442.8599, found 442.8587.

**(*R*)-5-(1-((4-Bromophenyl)ethynyl)-2,2-dichlorocyclopropyl)benzo[*d*][1,3]dioxole (43)**



**43**

According to **General procedure A** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and 5-(1-bromo-2,2-dichlorocyclopropyl)benzo[*d*][1,3]dioxole **S10** (93.0 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **43** as a colorless oil (71.6 mg, 87% yield, 84% e.e.).

**[α]$_D^{27}$** = −86 (c 0.5, $CHCl_3$).

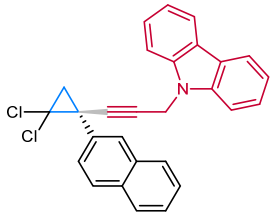
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 14.41 min, $t_R$ (major) = 16.42 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.20 (m, 4H), 7.03 – 6.71 (m, 3H), 5.97 (s, 2H), 2.29 (d, *J* = 7.6 Hz, 1H), 2.15 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 147.9, 147.7, 133.4, 131.6, 130.0, 122.7, 122.4, 121.7,

109.8, 108.3, 101.5, 90.5, 81.1, 64.8, 33.8, 33.6.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{12}O_2BrCl_2$ $[M + H]^+$ 408.9392, found 408.9371.

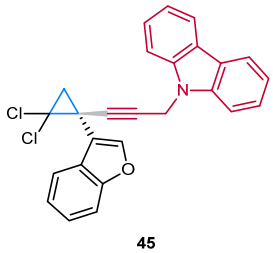
**(*R*)-9-(3-(2,2-Dichloro-1-(naphthalen-2-yl)cyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (44)**




**44**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 2-(1-bromo-2,2-dichlorocyclopropyl)naphthalene **S11** (94.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **44** as a white solid (74.9 mg, 85% yield, 83% e.e.).
**m.p.** 158–160 °C
**$[\alpha]_D^{27}$** = +8.2 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 24.71 min, $t_R$ (minor) = 27.61 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 7.7 Hz, 2H), 7.83 – 7.76 (m, 2H), 7.75 – 7.69 (m, 1H), 7.67 (d, *J* = 1.8 Hz, 1H), 7.50 – 7.39 (m, 7H), 7.26 – 7.22 (m, 2H), 5.05 (s, 2H), 2.34 (d, *J* = 7.6 Hz, 1H), 2.03 (d, *J* = 7.5 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.1, 133.5, 133.15, 133.06, 128.4, 128.1, 127.81, 127.79, 126.9, 126.6, 126.5, 125.9, 123.4, 120.5, 119.6, 109.1, 84.0, 76.9, 64.3, 33.7, 33.0.
**HRMS** (ESI) *m/z* calcd. for $C_{28}H_{20}NCl_2$ $[M + H]^+$ 440.0967, found 440.0963.

**(*S*)-9-(3-(1-(Benzofuran-3-yl)-2,2-dichlorocyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (45)**

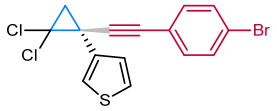



**45**

According to **General procedure A** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (41.0 mg, 0.20 mmol) and 3-(1-bromo-2,2-dichlorocyclopropyl)benzofuran **S12** (91.8 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **45** as a colorless oil (80.1 mg, 93% yield, 81% e.e.).

**[α]$_D^{27}$** = +11 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 53.27 min, $t_R$ (major) = 59.26 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (dt, *J* = 7.8, 1.0 Hz, 2H), 7.62 (dt, *J* = 7.7, 1.0 Hz, 1H), 7.45 (dt, *J* = 8.3, 0.9 Hz, 1H), 7.43 – 7.35 (m, 5H), 7.29 (ddd, *J* = 8.4, 7.2, 1.3 Hz, 1H), 7.26 – 7.21 (m, 2H) 7.15 (td, *J* = 7.6, 1.0 Hz, 1H), 5.03 (s, 2H), 2.10 (d, *J* = 7.3 Hz, 1H), 2.02 (d, *J* = 7.3 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 155.5, 143.6, 140.0, 126.7, 125.9, 125.0, 123.3, 123.1, 120.8, 120.5, 119.6, 118.0, 111.7, 109.0, 82.0, 76.8, 64.1, 33.5, 32.9, 25.2.
**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{18}ONCl_2$ $[M + H]^+$ 430.0760, found 430.0757.

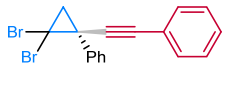
**(*S*)-3-(1-((4-Bromophenyl)ethynyl)-2,2-dichlorocyclopropyl)thiophene (46)**




**46**

According to **General procedure A** with 1-bromo-4-ethynylbenzene (36.2 mg, 0.20 mmol) and 3-(1-bromo-2,2-dichlorocyclopropyl)thiophene **S13** (81.6 mg, 0.30 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **46** as a pale-yellow oil (66.7 mg, 89% yield, 90% e.e.).
**[α]$_D^{27}$** = −109 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 11.77 min, $t_R$ (major) = 12.95 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.48 – 7.37 (m, 2H), 7.36 – 7.22 (m, 4H), 7.18 (d, *J* = 5.1 Hz, 1H), 2.32 (d, *J* = 7.6 Hz, 1H), 2.21 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.0, 133.4, 131.7, 128.2, 126.0, 124.3, 122.8, 121.6, 89.6, 81.3, 64.9, 34.7, 30.3.
**HRMS** (ESI) *m/z* calcd. for $C_{15}H_{10}BrCl_2S$ $[M + H]^+$ 370.9058, found 370.9057.

**(*R*)-(2,2-dibromo-1-(phenylethynyl)cyclopropyl)benzene (47)**

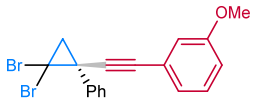



**47**

According to **General procedure A** with ethynylbenzene (21.9 μL, 0.20 mmol) and (1,2,2-tribromocyclopropyl)benzene **S14** (106.5 mg, 0.30 mmol) at −10 °C, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **47** as a colorless oil (60.8 mg, 81% yield, 91% e.e.).
**[α]$_D^{27}$** = −162 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJ-RH (MeCN/$H_2O$ = 70/30, flow rate 0.7 mL/min, λ = 254 nm), $t_R$ (minor) = 15.36 min, $t_R$ (major) = 18.65 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.49 – 7.45 (m, 2H), 7.45 – 7.41 (m, 2H), 7.40 – 7.36 (m, 2H), 7.36 – 7.31 (m, 1H), 7.30 – 7.23 (m, 3H), 2.57 (d, *J* = 7.9 Hz, 1H), 2.34 (d, *J* = 7.9 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.7, 131.9, 129.1, 128.6, 128.5, 128.4, 128.3, 122.9, 90.9, 82.1, 35.3, 34.7, 33.5.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{13}Br_2$ $[M + H]^+$ 374.9379, found 374.9372.

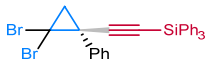
**(*R*)-1-((2,2-Dibromo-1-phenylcyclopropyl)ethynyl)-3-methoxybenzene (48)**




**48**

According to **General procedure A** with 1-ethynyl-3-methoxybenzene (25.6 μL, 0.20 mmol) and (1,2,2-tribromocyclopropyl)benzene **S14** (106.5 mg, 0.30 mmol) at −10 °C, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **48** as a colorless oil (70.7 mg, 87% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −139 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 230 nm), $t_R$ (minor) = 11.72 min, $t_R$ (major) = 12.56 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.46 (m, 2H), 7.45 – 7.34 (m, 3H), 7.21 (t, *J* = 7.9 Hz, 1H), 7.06 (d, *J* = 7.6 Hz, 1H), 6.98 (t, *J* = 1.9 Hz, 1H), 6.88 (dd, *J* = 8.1, 2.5 Hz, 1H), 3.79 (s, 3H), 2.61 (d, *J* = 7.9 Hz, 1H), 2.38 (d, *J* = 7.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.3, 137.7, 129.4, 129.1, 128.6, 128.3, 124.5, 123.8, 116.7, 115.1, 90.6, 81.9, 55.4, 35.2, 34.6, 33.4.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}OBr_2$ $[M + H]^+$ 404.9484, found 404.9479.

**(*R*)-((2,2-Dibromo-1-phenylcyclopropyl)ethynyl)triphenylsilane (49)**

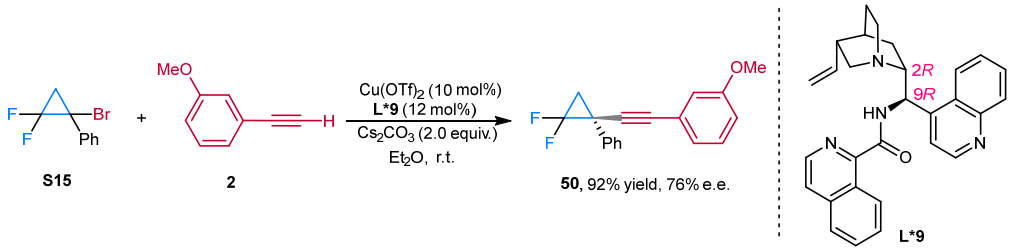



**49**

According to **General procedure A** with ethynyltriphenylsilane (56.9 mg, 0.20 mmol) and (1,2,2-tribromocyclopropyl)benzene **S14** (106.5 mg, 0.30 mmol) at −10 °C, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **49** as a colorless oil (82.6 mg, 74% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = −45 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 230 nm), $t_R$ (minor) = 13.58 min, $t_R$ (major) = 17.83 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.75 – 7.64 (m, 6H), 7.56 – 7.50 (m, 2H), 7.49 – 7.36 (m, 12H), 2.63 (d, *J* = 8.0 Hz, 1H), 2.43 (d, *J* = 7.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.1, 135.7, 133.5, 130.0, 129.1, 128.6, 128.4, 128.0, 110.8, 82.3, 35.1, 33.9, 33.8.
**HRMS** (ESI) *m/z* calcd. for $C_{29}H_{23}Br_2Si$ $[M + H]^+$ 556.9930, found 556.9926.

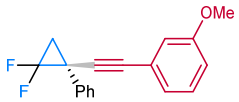
**Gram-scale reaction**

An oven-dried Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (108.0 mg, 0.30 mmol, 10 mol%), chiral ligand **L*8** (192.0 mg, 0.36 mmol, 12 mol%), and $Cs_2CO_3$ (3.91 g, 12.0 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic (1,2,2-tribromocyclopropyl)benzene **S14** (1.60 g, 4.5 mmol, 1.5 equiv.), ethynyltriphenylsilane (0.85 g, 3.0 mmol, 1.0 equiv.), and $Et_2O$ (30 mL) were sequentially added into the mixture under argon. The tube was sealed and the mixture was allowed to stir at −10 °C for 8 d. Upon completion of the reaction (monitored by TLC), the mixture was quenched with water and extracted with $CH_2Cl_2$. The combined organic phase was dried over anhydrous $Na_2SO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to afford the desired product **49** as a colorless oil (1.04 g, 62% yield, 92% e.e.).




An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.61 mg, 0.010 mmol, 10 mol%), chiral ligand **L*9** (5.38 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (64.2 mg, 0.20 mmol, 2.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic (1-bromo-2,2-difluorocyclopropyl)benzene **S15** (23.3 mg, 0.10 mmol, 1.0 equiv.), 1-ethynyl-3-methoxybenzene (19.2 μL, 0.15 mmol, 1.5 equiv.), and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at r.t. for 3 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **50** as a colorless oil (26.1 mg, 92% yield, 76% e.e.).

**(*R*)-1-((2,2-difluoro-1-phenylcyclopropyl)ethynyl)-3-methoxybenzene (50)**




**50**

$[\alpha]_D^{27}$ = −17 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 12.35 min, $t_R$ (minor) = 14.36 min.

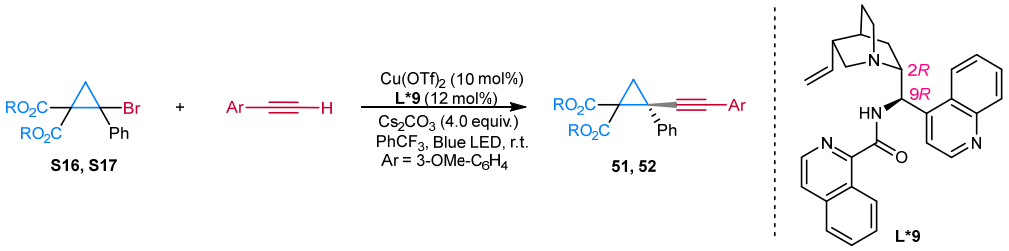
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.53 – 7.44 (m, 2H), 7.43 – 7.29 (m, 3H), 7.19 (t, *J* = 8.0 Hz, 1H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.99 – 6.92 (m, 1H), 6.85 (dd, *J* = 8.4, 2.7 Hz, 1H), 3.77 (s, 3H), 2.25 – 2.05 (m, 2H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.4, 134.2 (d, *J* = 2.2 Hz), 129.4, 128.8, 128.4, 128.3,

128.0, 124.5, 123.7, 116.7, 115.2, 111.9 (t, $J$ = 292.7 Hz), 86.1, 82.1, 55.4, 28.4 (dd, $J$ = 14.5, 10.4 Hz), 24.9 (t, $J$ = 9.1 Hz).

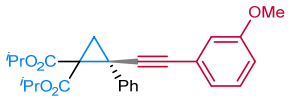
**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ –129.7 (d, $J$ = 142.9 Hz), –134.8 (d, $J$ = 143.0 Hz).

**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{15}OF_2$ $[M + H]^+$ 285.1085, found 285.1081.




**General procedure C**: An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.61 mg, 0.010 mmol, 10 mol%), chiral ligand **L*9** (5.38 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (128.4 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic cyclopropyl bromide (0.10 mmol, 1.0 equiv.), 1-ethynyl-3-methoxybenzene (19.2 μL, 0.15 mmol, 1.5 equiv.), and $PhCF_3$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir under the irradiation of blue LEDs (5 W) at r.t. for 3 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

**Diisopropyl (*R*)-2-((3-methoxyphenyl)ethynyl)-2-phenylcyclopropane-1,1-dicarboxylate (51)**




**51**

According to **General procedure C** with diisopropyl 2-bromo-2-phenylcyclopropane-1,1-dicarboxylate **S16** (36.9 mg, 0.10 mmol, 1.0 equiv.) and 1-ethynyl-3-methoxybenzene (19.2 μL, 1.5 equiv.) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **51** as a colorless oil (37.3 mg, 89% yield, 85% e.e.).

**$[\alpha]_D^{27}$** = −121 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 19.78 min, $t_R$ (major) = 21.91 min.

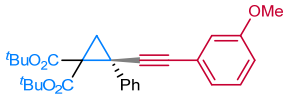
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.51 – 7.44 (m, 2H), 7.34 – 7.24 (m, 3H), 7.15 (t, $J$ = 7.9 Hz, 1H), 6.96 (dt, $J$ = 7.6, 1.2 Hz, 1H), 6.88 (dd, $J$ = 2.7, 1.4 Hz, 1H), 6.82 (ddd, $J$ = 8.3, 2.6, 1.0 Hz, 1H), 5.14 (hept, $J$ = 6.3 Hz, 1H), 4.66 (hept, $J$ = 6.3 Hz, 1H), 3.75 (s, 3H), 2.51 (d, $J$ = 5.6 Hz, 1H), 2.26 (d, $J$ = 5.5 Hz, 1H), 1.33 – 1.27 (m, 6H), 0.93 (d, $J$ = 6.3 Hz, 3H), 0.86 (d, $J$ = 6.2 Hz, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 166.3, 165.5, 159.3, 136.4, 129.3, 129.0, 128.3, 127.9,

124.4, 124.0, 116.5, 114.9, 89.4, 81.6, 69.6, 69.3, 55.3, 43.8, 32.4, 24.2, 22.0, 21.9, 21.3, 21.3.

**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{29}O_5$ $[M + H]^+$ 421.2009, found 421.2001.

### Di-*tert*-butyl (*R*)-2-((3-methoxyphenyl)ethynyl)-2-phenylcyclopropane-1,1-dicarboxylate (52)




**52**

According to **General procedure C** with di-*tert*-butyl 2-bromo-2-phenylcyclopropane-1,1-dicarboxylate **S17** (39.7 mg, 0.10 mmol, 1.0 equiv.) and 1-ethynyl-3-methoxybenzene (19.2 μL, 1.5 equiv.) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **52** as a colorless oil (38.2 mg, 85% yield, 86% e.e.).

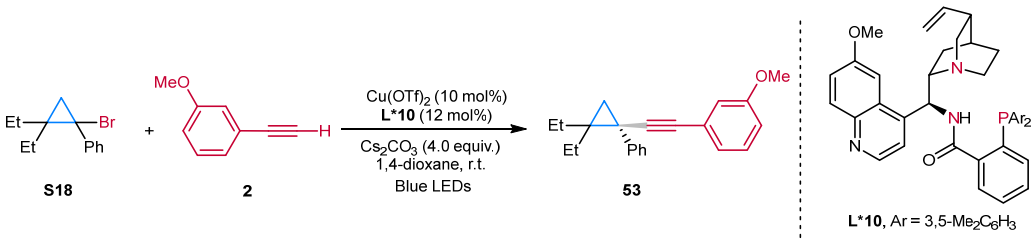
**[α]$_D^{27}$** = −46 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 22.48 min, $t_R$ (major) = 24.74 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.44 (m, 2H), 7.34 – 7.24 (m, 3H), 7.15 (t, *J* = 8.0 Hz, 1H), 6.97 (dt, *J* = 7.6, 1.2 Hz, 1H), 6.89 (dd, *J* = 2.8, 1.4 Hz, 1H), 6.82 (ddd, *J* = 8.4, 2.7, 1.0 Hz, 1H), 3.75 (s, 3H), 2.41 (d, *J* = 5.5 Hz, 1H), 2.15 (d, *J* = 5.5 Hz, 1H), 1.52 (s, 9H), 1.10 (s, 9H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 165.8, 165.0, 159.2, 136.7, 129.3, 129.2, 128.3, 127.7, 124.4, 124.2, 116.4, 114.9, 89.9, 82.0, 81.8, 81.2, 55.3, 45.1, 31.9, 28.2, 27.5, 23.9.

**HRMS** (ESI) *m/z* calcd. for $C_{28}H_{33}O_5$ $[M + H]^+$ 449.2322, found 449.2311.




**S18** **2** **53** **L*10**, Ar = 3,5-$Me_2C_6H_3$

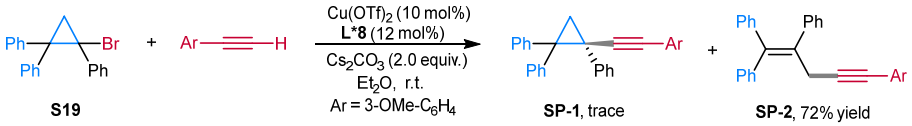
An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (7.22 mg, 0.020 mmol, 10 mol%), chiral ligand **L*10** (15.93 mg, 0.024 mmol, 12 mol%), and $Cs_2CO_3$ (256.8 mg, 0.80 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic cyclopropyl bromide **S18** (50.6 mg, 0.20 mmol, 1.0 equiv.), 1-ethynyl-3-methoxybenzene (38.4 μL, 0.30 mmol, 1.5 equiv.), and 1,4-dioxane (2.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir under the irradiation of blue LEDs (5 W) at r.t. for 5 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to afford the desired

product **53** as a colorless oil (45.7 mg, 75% yield, 47% e.e.).

**(*R*)-1-((2,2-diethyl-1-phenylcyclopropyl)ethynyl)-3-methoxybenzene (53)**

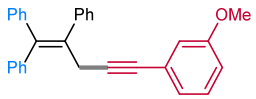

**53**

**[α]$_D^{27}$** = −26 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJ-RH (MeCN/ $H_2O$ = 70/30, flow rate 0.7 mL/min, λ = 254 nm), $t_R$ (minor) = 15.72 min, $t_R$ (major) = 18.00 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.40 – 7.35 (m, 2H), 7.33 – 7.26 (m, 2H), 7.24 – 7.18 (m, 1H), 7.13 (t, *J* = 7.9 Hz, 1H), 6.95 (dt, *J* = 7.6, 1.2 Hz, 1H), 6.88 (dd, *J* = 2.6, 1.4 Hz, 1H), 6.78 (dd, *J* = 8.2, 2.6 Hz, 1H), 3.73 (s, 3H), 1.94 (dq, *J* = 14.6, 7.3 Hz, 1H), 1.71 (dq, *J* = 14.5, 7.4 Hz, 1H), 1.39 (d, *J* = 4.8 Hz, 1H), 1.30 (dt, *J* = 14.2, 7.2 Hz, 1H), 1.14 (t, *J* = 7.4 Hz, 3H), 1.10 (d, *J* = 4.7 Hz, 1H), 0.79 (t, *J* = 7.3 Hz, 3H), 0.58 (dq, *J* = 14.8, 7.4 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.3, 140.0, 129.5, 129.2, 128.2, 126.5, 125.4, 124.3, 116.6, 114.0, 94.6, 78.1, 55.3, 36.1, 28.5, 26.4, 26.0, 24.0, 10.8, 10.6.
**HRMS** (ESI) *m/z* calcd. for $C_{22}H_{25}O$ $[M + H]^+$ 305.1900, found 305.1892.




An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.61 mg, 0.010 mmol, 10 mol%), chiral ligand **L*8** (6.40 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (64.2 mg, 0.20 mmol, 2.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic (2-bromocyclopropane-1,1,2-triyl)tribenzene **S19** (34.9 mg, 0.10 mmol, 1.0 equiv.), 1-ethynyl-3-methoxybenzene (19.2 μL, 0.15 mmol, 1.5 equiv.), and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at r.t. for 5 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the ring-opening side product **SP-2** as a colorless oil (28.9 mg, 72% yield), the desired product **SP-1** is rarely provided.

**(5-(3-methoxyphenyl)pent-1-en-4-yne-1,1,2-triyl)tribenzene (SP-2)**



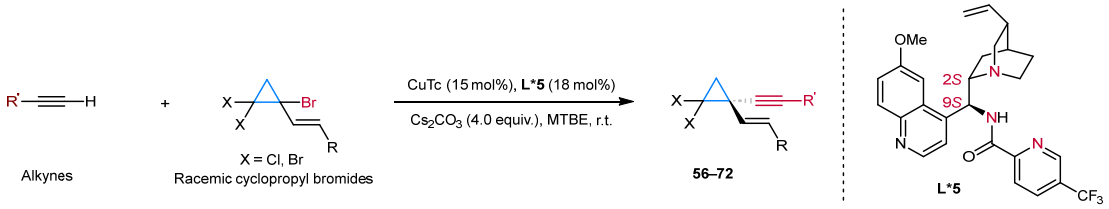

**SP-2**

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.42 – 7.34 (m, 4H), 7.32 – 7.27 (m, 1H), 7.25 – 7.11 (m, 6H), 7.07 – 6.98 (m, 3H), 6.96 – 6.90 (m, 2H), 6.87 (dt, *J* = 7.6, 1.2 Hz, 1H), 6.82

– 6.75 (m, 2H), 3.74 (s, 3H), 3.56 (s, 2H).
**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 159.3, 142.7, 142.5, 141.6, 141.2, 135.0, 130.8, 129.9, 129.8, 129.3, 128.5, 128.0, 127.6, 127.3, 126.7, 126.4, 125.1, 124.2, 116.7, 114.2, 88.3, 81.8, 55.3, 27.5.
**HRMS** (ESI) *m/z* calcd. for $C_{30}H_{25}O$ $[M + H]^+$ 401.1900, found 401.1892.

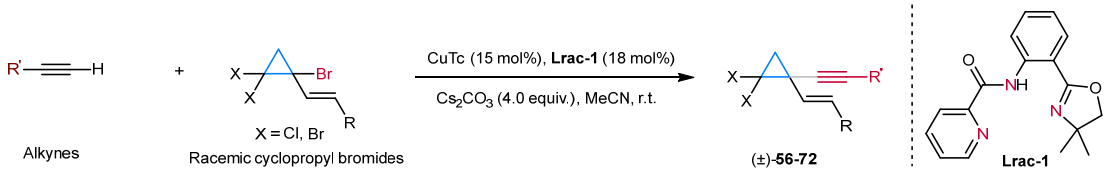
**Enantioconvergent cross-coupling of alkynes with 1-alkenyl-substituted cyclopropyl bromides**

**General procedure D:**




An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with CuTc (2.85 mg, 0.015 mmol, 15 mol%), **L*5** (8.90 mg, 0.018 mmol, 18 mol%), and $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic 1-alkenyl-substituted cyclopropyl bromide (0.15 mmol, 1.5 equiv.), alkyne (0.10 mmol, 1.0 equiv.), and MTBE (2.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at r.t. for 7 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

The preparation of racemic products (±)-**56**–**72**:




Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuTc (2.85 mg, 0.015 mmol, 15 mol%), **Lrac-1** (5.31 mg, 0.018 mmol, 18 mol%), $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.), and MeCN (1.0 mL). Then 1-alkenyl-substituted cyclopropyl bromide (0.15 mmol, 1.5 equiv.) and alkyne (0.10 mmol, 1.0 equiv.) were sequentially added into the mixture and the reaction mixture was stirred at r.t. for 3 d. Upon completion, the precipitate was filtered off and washed by EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

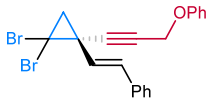
**(*S*,*E*)-(2-(2,2-Dibromo-1-(4-phenylbut-1-yn-1-yl)cyclopropyl)vinyl)benzene (56)**

**56**

According to **General procedure D** with 4-phenyl-1-butyne (14.0 μL, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum

ether/EtOAc = 100/1) to yield the product **56** as a colorless oil (40.2 mg, 93% yield, 92% e.e.).
**[α]$_D^{27}$** = −27 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 16.26 min, $t_R$ (minor) = 18.65 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.37 – 7.20 (m, 10H), 6.89 (d, *J* = 15.5 Hz, 1H), 6.01 (d, *J* = 15.5 Hz, 1H), 2.90 (t, *J* = 7.4 Hz, 2H), 2.63 (t, *J* = 7.4 Hz, 2H), 2.13 (d, *J* = 7.5 Hz, 1H), 2.06 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.6, 136.6, 133.7, 128.9, 128.73, 128.67, 128.5, 127.9, 126.7, 126.5, 84.8, 78.9, 38.2, 35.4, 35.1, 30.4, 21.1.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{19}Br_2$ $[M + H]^+$ 428.9848, found 428.9837.

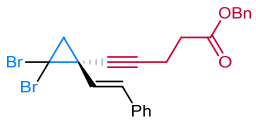
**(*S*,*E*)-(2-(2,2-Dibromo-1-(3-phenoxyprop-1-yn-1-yl)cyclopropyl)vinyl)benzene (57)**



**57**

According to **General procedure D** with phenyl propargyl ether (12.8 μL, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **57** as a colorless oil (32.1 mg, 74% yield, 87% e.e.).
**[α]$_D^{27}$** = −36 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 13.77 min, $t_R$ (major) = 18.74 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.35 – 7.22 (m, 7H), 7.09 – 6.95 (m, 3H), 6.90 (d, *J* = 15.6 Hz, 1H), 5.98 (d, *J* = 15.6 Hz, 1H), 4.83 (s, 2H), 2.21 (d, *J* = 7.7 Hz, 1H), 2.09 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 157.7, 136.3, 134.2, 129.6, 128.8, 128.1, 127.7, 126.6, 121.6, 115.2, 85.5, 79.7, 56.2, 38.2, 34.2, 30.2.
**HRMS** (ESI) *m/z* calcd. for $C_{20}H_{17}OBr_2$ $[M + H]^+$ 430.9641, found 430.9636.

**Benzyl (*S*,*E*)-5-(2,2-dibromo-1-styrylcyclopropyl)pent-4-ynoate (58)**

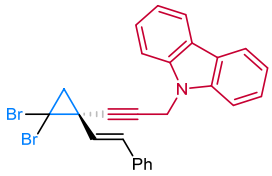


**58**

According to **General procedure D** with benzyl pent-4-ynoate (18.8 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **58** as a colorless oil (35.2 mg, 72% yield, 90% e.e.).
**[α]$_D^{27}$** = −29 (c 1.0, $CHCl_3$).

**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 23.94 min, $t_R$ (major) = 27.17 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.41 – 7.29 (m, 9H), 7.27 – 7.22 (m, 1H), 6.98 (d, *J* = 15.5 Hz, 1H), 6.01 (d, *J* = 15.6 Hz, 1H), 5.15 (s, 2H), 2.70 – 2.62 (m, 4H), 2.12 (d, *J* = 7.6 Hz, 1H), 2.05 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 171.8, 136.6, 135.8, 133.8, 128.8, 128.7, 128.6, 128.44, 128.38, 128.0, 126.6, 83.4, 79.1, 66.7, 38.1, 35.1, 33.8, 30.3, 15.1.
**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{21}O_2Br_2$ $[M + H]^+$ 486.9903, found 486.9898.

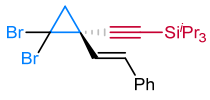
**(*S*,*E*)-9-(3-(2,2-Dibromo-1-styrylcyclopropyl)prop-2-yn-1-yl)-9*H*-carbazole (59)**




**59**

According to **General procedure D** with 9-(prop-2-yn-1-yl)-9*H*-carbazole (20.5 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **59** as a colorless oil (45.9 mg, 91% yield, 84% e.e.).
**$[\alpha]_D^{27}$** = −53 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 20.41 min, $t_R$ (major) = 23.79 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.10 (dt, *J* = 7.8, 1.0 Hz, 2H), 7.57 – 7.42 (m, 4H), 7.29 – 7.19 (m, 5H), 7.17 – 7.12 (m, 2H), 6.73 (d, *J* = 15.6 Hz, 1H), 5.89 (d, *J* = 15.7 Hz, 1H), 5.14 (s, 2H), 2.09 (d, *J* = 7.7 Hz, 1H), 1.99 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.1, 136.2, 134.1, 128.7, 128.0, 127.6, 126.6, 126.0, 123.5, 120.6, 119.7, 109.0, 82.2, 79.1, 38.1, 34.2, 32.9, 30.2.
**HRMS** (ESI) *m/z* calcd. for $C_{26}H_{20}NBr_2$ $[M + H]^+$ 503.9957, found 503.9952.

**(*S*,*E*)-((2,2-Dibromo-1-styrylcyclopropyl)ethynyl)triisopropylsilane (60)**




**60**

According to **General procedure D** with ethynyltriisopropylsilane (22.0 μL, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **60** as a colorless oil (39.9 mg, 83% yield, 91% e.e.). The e.e. value of **60** was determined by converting it to the corresponding terminal alkyne **88**.
**$[\alpha]_D^{27}$** = −17 (c 0.5, $CHCl_3$).

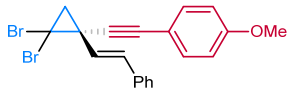
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.40 – 7.36 (m, 2H), 7.35 – 7.30 (m, 2H), 7.29 – 7.23 (m, 1H), 7.14 (d, *J* = 15.6 Hz, 1H), 6.03 (d, *J* = 15.5 Hz, 1H), 2.23 (d, *J* = 7.6 Hz, 1H), 2.12 (d, *J* = 7.6 Hz, 1H), 1.13 (s, 21H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.6, 134.2, 128.8, 128.4, 128.0, 126.6, 104.7, 86.6, 39.0, 34.8, 31.2, 18.8, 11.4.
**HRMS** (ESI) *m/z* calcd. for $C_{22}H_{31}Br_2Si$ $[M + H]^+$ 481.0556, found 481.0551.

**(*S*,*E*)-(2-(2,2-Dibromo-1-(phenylethynyl)cyclopropyl)vinyl)benzene (61)**


**61**

According to **General procedure D** with ethynylbenzene (11.0 μL, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **61** as a colorless oil (29.6 mg, 74% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = +13 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 8.82 min, $t_R$ (minor) = 11.52 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.49 (m, 2H), 7.45 – 7.40 (m, 2H), 7.37 – 7.30 (m, 5H), 7.27 (d, *J* = 7.2 Hz, 1H), 7.09 (d, *J* = 15.6 Hz, 1H), 6.12 (d, *J* = 15.6 Hz, 1H), 2.34 (d, *J* = 7.7 Hz, 1H), 2.21 (d, *J* = 7.6 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.5, 134.2, 132.0, 128.8, 128.7, 128.5, 128.3, 128.1, 126.7, 122.8, 87.7, 84.7, 38.6, 35.2, 30.8.
**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{15}Br_2$ $[M + H]^+$ 400.9535, found 400.9523.

**(*S*,*E*)-1-((2,2-Dibromo-1-styrylcyclopropyl)ethynyl)-4-methoxybenzene (62)**

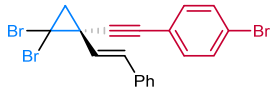



**62**

According to **General procedure D** with 1-ethynyl-4-methoxybenzene (13.2 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 30/1) to yield the product **62** as a colorless oil (30.1 mg, 70% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = +19 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) =16.04 min, $t_R$ (major) = 17.16 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.48 – 7.39 (m, 4H), 7.35 – 7.30 (m, 2H), 7.27 – 7.23 (m, 1H), 7.08 (d, *J* = 15.6 Hz, 1H), 6.86 (d, *J* = 8.8 Hz, 2H), 6.12 (d, *J* = 15.5 Hz, 1H), 3.81 (s, 3H), 2.32 (d, *J* = 7.6 Hz, 1H), 2.20 (d, *J* = 7.6 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.9, 136.6, 134.1, 133.5, 128.8, 128.5, 128.0, 126.7, 114.8, 114.1, 86.3, 84.6, 55.5, 38.6, 35.5, 30.9.
**HRMS** (ESI) *m/z* calcd. for $C_{20}H_{17}OBr_2$ $[M + H]^+$ 430.9641, found 430.9636.

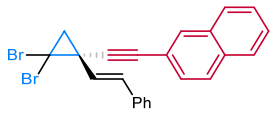
**(*S*,*E*)-1-Bromo-4-((2,2-dibromo-1-styrylcyclopropyl)ethynyl)benzene (63)**




**63**

According to **General procedure D** with 1-bromo-4-ethynylbenzene (17.8 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **63** as a colorless oil (25.0 mg, 52% yield, 88% e.e.).
**$[\alpha]_D^{27}$** = +23 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 14.92 min, $t_R$ (minor) = 17.02 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.50 – 7.45 (m, 2H), 7.44 – 7.40 (m, 2H), 7.39 – 7.30 (m, 4H), 7.28 (d, *J* = 7.2 Hz, 1H), 7.04 (d, *J* = 15.6 Hz, 1H), 6.11 (d, *J* = 15.6 Hz, 1H), 2.34 (d, *J* = 7.7 Hz, 1H), 2.22 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 134.2, 133.4, 131.8, 128.8, 128.2, 128.0, 126.7, 122.9, 121.7, 89.0, 83.6, 38.5, 34.9, 30.7.
**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{14}Br_3$ $[M + H]^+$ 478.8640, found 478.8630.

**(*S*,*E*)-2-((2,2-Dibromo-1-styrylcyclopropyl)ethynyl)naphthalene (64)**

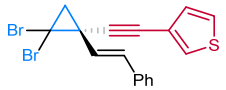



**64**

According to **General procedure D** with 2-ethynylnaphthalene (15.2 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **64** as a colorless oil (29.3 mg, 65% yield, 92% e.e.).
**$[\alpha]_D^{27}$** = +29 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 16.14 min, $t_R$ (major) = 18.77 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.84 – 7.76 (m, 3H), 7.55 (dd, *J* = 8.5, 1.6 Hz, 1H), 7.51 – 7.41 (m, 4H), 7.36 – 7.30 (m, 2H), 7.30 – 7.24 (m, 1H), 7.13 (d, *J* = 15.6 Hz, 1H), 6.15 (d, *J* = 15.6 Hz, 1H), 2.38 (d, *J* = 7.7 Hz, 1H), 2.23 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.5, 134.2, 133.1, 131.9, 128.8, 128.6, 128.33, 128.28, 128.2, 128.1, 127.92, 127.86, 126.9, 126.8, 126.7, 120.0, 88.1, 85.0, 38.6, 35.3, 30.9.

**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{17}Br_2$ $[M + H]^+$ 450.9691, found 450.9689.

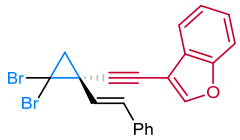
**(*S*,*E*)-3-((2,2-Dibromo-1-styrylcyclopropyl)ethynyl)thiophene (65)**




**65**

According to **General procedure D** with 3-ethynylthiophene (10.0 μL, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **65** as a colorless oil (31.6 mg, 78% yield, 92% e.e.).
**[α]$_D^{27}$** = +12 (c 1.0, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 13.33 min, $t_R$ (minor) = 17.83 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.52 (dd, *J* = 3.0, 1.2 Hz, 1H), 7.45 – 7.39 (m, 2H), 7.35 – 7.30 (m, 2H), 7.29 – 7.24 (m, 2H), 7.18 (dd, *J* = 5.0, 1.2 Hz, 1H), 7.06 (d, *J* = 15.6 Hz, 1H), 6.11 (d, *J* = 15.6 Hz, 1H), 2.32 (d, *J* = 7.7 Hz, 1H), 2.20 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.5, 134.1, 130.2, 129.4, 128.8, 128.2, 128.1, 126.7, 125.5, 121.7, 87.2, 79.8, 38.5, 35.1, 30.8.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{13}Br_2S$ $[M + H]^+$ 406.9099, found 406.9097.

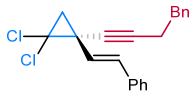
**(*S*,*E*)-3-((2,2-Dibromo-1-styrylcyclopropyl)ethynyl)benzofuran (66)**




**66**

According to **General procedure D** with 3-ethynylbenzofuran (14.2 mg, 0.10 mmol) and (*E*)-(2-(1,2,2-tribromocyclopropyl)vinyl)benzene **54** (57.1 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **66** as a colorless oil (33.8 mg, 76% yield, 90% e.e.).
**[α]$_D^{27}$** = +7.1 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 16.85 min, $t_R$ (minor) = 21.21 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.87 (s, 1H), 7.74 (d, *J* = 7.3 Hz, 1H), 7.51 (d, *J* = 7.8 Hz, 1H), 7.45 – 7.40 (m, 2H), 7.37 – 7.24 (m, 5H), 7.12 (d, *J* = 15.6 Hz, 1H), 6.15 (d, *J* = 15.6 Hz, 1H), 2.38 (d, *J* = 7.7 Hz, 1H), 2.26 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 154.7, 148.1, 136.4, 134.2, 128.8, 128.2, 128.1, 127.9, 126.7, 125.4, 123.6, 120.7, 111.8, 104.1, 92.2, 74.3, 38.7, 34.8, 31.0.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{15}OBr_2$ $[M + H]^+$ 440.9484, found 440.9479.

**(*S*,*E*)-(2-(2,2-Dichloro-1-(4-phenylbut-1-yn-1-yl)cyclopropyl)vinyl)benzene (67)**




**67**

According to **General procedure D** with 4-phenyl-1-butyne (14.0 μL, 0.10 mmol) and (*E*)-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)benzene **S20** (43.8 mg, 0.15 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **67** as a colorless oil (32.0 mg, 94% yield, 90% e.e.).

**[α]$_D^{27}$** = −17 (c 0.5, $CHCl_3$).

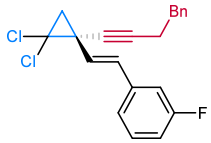
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 10.94 min, $t_R$ (minor) = 13.72 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.39 – 7.16 (m, 10H), 6.88 (d, *J* = 15.6 Hz, 1H), 5.97 (d, *J* = 15.7 Hz, 1H), 2.89 (t, *J* = 7.4 Hz, 2H), 2.62 (t, *J* = 7.4 Hz, 2H), 1.95 (d, *J* = 7.3 Hz, 1H), 1.85 (d, *J* = 7.2 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.6, 136.6, 133.8, 128.70, 128.66, 128.5, 127.9, 127.0, 126.6, 126.5, 84.8, 77.6, 65.7, 36.0, 35.1, 31.6, 21.1.

**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{19}Cl_2$ $[M + H]^+$ 341.0858, found 341.0856.

**(*S*,*E*)-1-(2-(2,2-Dichloro-1-(4-phenylbut-1-yn-1-yl)cyclopropyl)vinyl)-3-fluorobenzene (68)**




**68**

According to **General procedure D** with 4-phenyl-1-butyne (14.0 μL, 0.10 mmol) and (*E*)-1-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)-3-fluorobenzene **S22** (46.5 mg, 0.15 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **68** as a colorless oil (32.6 mg, 91% yield, 90% e.e.).

**[α]$_D^{27}$** = −15 (c 0.5, $CHCl_3$).

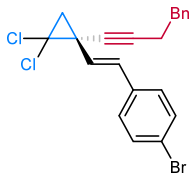
**HPLC** analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 16.73 min, $t_R$ (major) = 21.79 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.33 – 7.20 (m, 6H), 7.10 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.02 (dt, *J* = 10.2, 2.1 Hz, 1H), 6.93 (tdd, *J* = 8.4, 2.6, 1.0 Hz, 1H), 6.82 (d, *J* = 15.6 Hz, 1H), 5.97 (d, *J* = 15.5 Hz, 1H), 2.89 (t, *J* = 7.3 Hz, 2H), 2.63 (t, *J* = 7.3 Hz, 2H), 1.97 (d, *J* = 7.3 Hz, 1H), 1.86 (d, *J* = 7.3 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 163.2 (d, *J* = 245.4 Hz), 140.5, 138.9 (d, *J* = 7.7 Hz), 132.7 (d, *J* = 2.6 Hz), 130.1 (d, *J* = 8.4 Hz), 128.7, 128.5, 128.4, 126.5, 122.5 (d, *J* = 2.8 Hz), 114.7 (d, *J* = 21.4 Hz), 113.2 (d, *J* = 21.8 Hz), 85.1, 77.3, 65.6, 36.1, 35.0, 31.5, 21.0.

**$^{19}$F NMR** (376 MHz, $CDCl_3$) δ −113.4.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{18}Cl_2F$ $[M + H]^+$ 359.0764, found 359.0758.

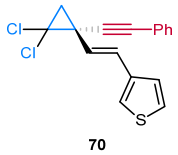
**(*S*,*E*)-1-Bromo-4-(2-(2,2-dichloro-1-(4-phenylbut-1-yn-1-yl)cyclopropyl)vinyl)benzene (69)**



**69**

According to **General procedure D** with 4-phenyl-1-butyne (14.0 μL, 0.10 mmol) and (*E*)-1-bromo-4-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)benzene **S23** (55.6 mg, 0.15 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **69** as a colorless oil (38.6 mg, 92% yield, 90% e.e.).
**$[\alpha]_D^{27}$** = −34 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 14.21 min, $t_R$ (minor) = 19.79 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.40 (m, 2H), 7.31 – 7.17 (m, 7H), 6.79 (d, *J* = 15.6 Hz, 1H), 5.94 (d, *J* = 15.6 Hz, 1H), 2.88 (t, *J* = 7.3 Hz, 2H), 2.62 (t, *J* = 7.3 Hz, 2H), 1.96 (d, *J* = 7.2 Hz, 1H), 1.85 (d, *J* = 7.3 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.5, 135.5, 132.6, 131.8, 128.7, 128.5, 128.1, 127.8, 126.5, 121.7, 85.0, 77.4, 65.6, 36.1, 35.0, 31.5, 21.0.
**HRMS** (ESI) *m/z* calcd. for $C_{21}H_{18}BrCl_2$ $[M + H]^+$ 418.9963, found 418.9954.

**(*S*,*E*)-3-(2-(2,2-Dichloro-1-(phenylethynyl)cyclopropyl)vinyl)thiophene (70)**



**70**

According to **General procedure D** with ethynylbenzene (11.0 μL, 0.10 mmol) and (*E*)-3-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)thiophene **S24** (44.7 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **70** as a colorless oil (29.1 mg, 91% yield, 88% e.e.).
**$[\alpha]_D^{27}$** = +90 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 5.85 min, $t_R$ (minor) = 6.47 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.56 – 7.47 (m, 2H), 7.37 – 7.31 (m, 3H), 7.30 – 7.26 (m, 1H), 7.24 – 7.19 (m, 2H), 7.06 (d, *J* = 15.6 Hz, 1H), 5.94 (d, *J* = 15.6 Hz, 1H), 2.15 (d, *J* = 7.3 Hz, 1H), 1.98 (d, *J* = 7.3 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 139.0, 132.1, 128.7, 128.5, 128.3, 126.4, 126.1, 125.1,

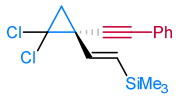
122.9, 122.7, 86.3, 84.7, 65.7, 36.3, 31.8.
**HRMS** (ESI) *m/z* calcd. for $C_{17}H_{13}Cl_2S$ $[M + H]^+$ 319.0109, found 319.0103.

**(*S*,*E*)-(4-(2,2-Dichloro-1-(4-phenylbut-1-en-1-yl)cyclopropyl)but-3-yn-1-yl)benzene (71)**


**71**

According to **General procedure D** with 4-phenyl-1-butyne (14.0 μL, 0.10 mmol) and (*E*)-(4-(1-bromo-2,2-dichlorocyclopropyl)but-3-en-1-yl)benzene **S25** (48 mg, 0.15 mmol) at r.t., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **71** as a colorless oil (30.0 mg, 81% yield, 84% e.e.).
**[α]$_D^{27}$** = +44 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 214 nm), $t_R$ (minor) = 13.30 min, $t_R$ (major) = 19.27 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.33 – 7.25 (m, 4H), 7.24 – 7.14 (m, 6H), 5.99 (dt, *J* = 15.1, 6.8 Hz, 1H), 5.28 (d, *J* = 15.1 Hz, 1H), 2.83 (t, *J* = 7.5 Hz, 2H), 2.69 (t, *J* = 7.9 Hz, 2H), 2.56 (t, *J* = 7.5 Hz, 2H), 2.41 – 2.35 (m, 2H), 1.81 (d, *J* = 7.2 Hz, 1H), 1.66 (d, *J* = 7.1 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 141.8, 140.6, 134.4, 128.65, 128.56, 128.5, 128.4, 127.4, 126.4, 126.0, 84.1, 78.0, 65.3, 35.7, 35.3, 35.1, 34.2, 30.9, 21.0.
**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{23}Cl_2$ $[M + H]^+$ 369.1171, found 369.1168.

**(*S*,*E*)-(2-(2,2-Dichloro-1-(phenylethynyl)cyclopropyl)vinyl)trimethylsilane (72)**



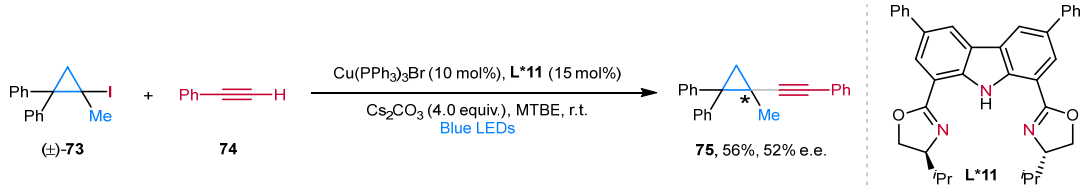

**72**

According to **General procedure D** with ethynylbenzene (11.0 μL, 0.10 mmol) and (*E*)-(2-(1-bromo-2,2-dichlorocyclopropyl)vinyl)trimethylsilane **S21** (43.2 mg, 0.15 mmol) at 10 °C for 10 d, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **72** as a colorless oil (15.5 mg, 50% yield, 86% e.e.).
**[α]$_D^{27}$** = −26 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 4.65 min, $t_R$ (minor) = 6.38 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.46 – 7.31 (m, 2H), 7.28 – 7.14 (m, 3H), 6.34 (d, *J* = 18.3 Hz, 1H), 5.69 (d, *J* = 18.3 Hz, 1H), 1.98 (d, *J* = 7.3 Hz, 1H), 1.83 (d, *J* = 7.3 Hz, 1H), 0.00 (s, 9H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 142.0, 136.3, 133.2, 129.7, 129.6, 124.0, 87.5, 86.2, 66.6, 37.1, 34.8, 0.0.

**HRMS** (ESI) *m/z* calcd. for $C_{16}H_{19}Cl_2Si$ $[M + H]^+$ 309.0628, found 309.0625.

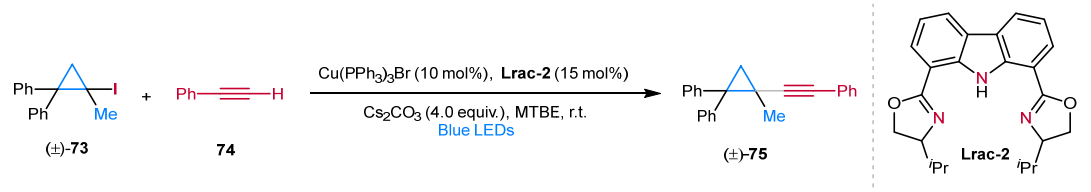
**Enantioconvergent cross-coupling of alkynes with 1-alkyl-2,2-diphenylcyclopropyl iodide**

**General procedure E:**



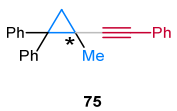

An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(PPh_3)_3Br$ (9.30 mg, 0.010 mmol, 10 mol%), **L*11** (8.12 mg, 0.015 mmol, 15 mol%), and $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic 1-alkyl-substituted cyclopropyl iodine **73** (50.1 mg, 0.15 mmol, 1.5 equiv.), phenylacetylene (11.0 μL, 0.10 mmol, 1.0 equiv.), and MTBE (2.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir under the irradiation of blue LEDs (5 W) at r.t. for 7 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product **75** as a colorless oil (17.3 mg, 56% yield, 52% e.e.).

The preparation of racemic products (±)-**75**:




Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with $Cu(PPh_3)_3Br$ (9.30 mg, 0.010 mmol, 10 mol%), **Lrac-2** (5.80 mg, 0.015 mmol, 15 mol%), $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.), and MTBE (1.0 mL). Then 1-alkyl-substituted cyclopropyl iodine **73** (50.1 mg, 0.15 mmol, 1.5 equiv.) and phenylacetylene (11.0 μL, 0.10 mmol, 1.0 equiv.) were sequentially added into the mixture and the reaction mixture was stirred at r.t. for 7 d. Upon completion, the precipitate was filtered off and washed by EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

**(2-Methyl-2-(phenylethynyl)cyclopropane-1,1-diyl)dibenzene (75)**



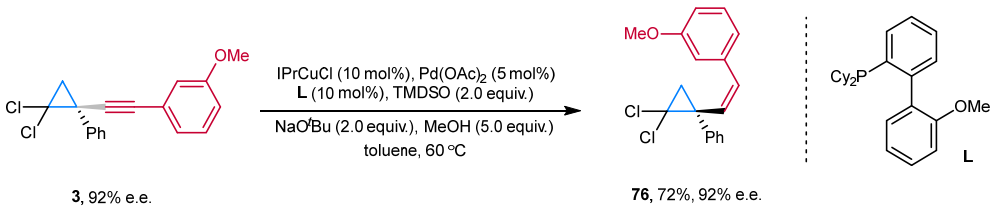

$[\alpha]_D^{27} = -59$ (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ =

254 nm), $t_R$ (major) = 9.41 min, $t_R$ (minor) = 10.79 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.60 – 7.56 (m, 2H), 7.47 – 7.43 (m, 2H), 7.30 – 7.24 (m, 4H), 7.20 – 7.15 (m, 5H), 7.09 – 7.04 (m, 2H), 1.85 (d, *J* = 4.7 Hz, 1H), 1.60 (d, *J* = 4.7 Hz, 1H), 1.28 (s, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 143.9, 142.1, 131.4, 130.1, 129.9, 128.6, 128.1, 128.0, 127.4, 126.7, 126.5, 124.0, 94.7, 81.6, 43.3, 28.7, 22.9, 19.7.
**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{21}$ $[M + H]^+$ 309.1638, found 309.1633.

## Synthetic applications

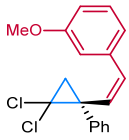
### Synthesis of 76




**3**, 92% e.e. **76**, 72%, 92% e.e.

To a flamed Schlenk tube charged with a stir bar were added NaO$^t$Bu (19.2 mg, 0.20 mmol, 2.0 equiv.), **3** (31.7 mg, 0.10 mmol, 1.0 equiv., 92% e.e.), $Pd(OAc)_2$ (1.1 mg, 0.0050 mmol, 5.0 mol%), **L** (3.8 mg, 0.010 mmol, 10 mol%), IPrCuCl (4.9 mg, 0.010 mmol, 10 mol%), TMDSO (1,1,3,3-tetramethyldisiloxane) (26.8 mg, 0.20 mmol, 2.0 equiv.), MeOH (16.0 mg, 0.50 mmol, 5.0 equiv.) and toluene (1.0 mL). The reaction mixture was stirred at 60 °C for 12 h. Upon completion (monitored by TLC), the reaction mixture was filtered through a short plug of silica gel eluted with EtOAc and purified by column chromatography (petroleum ether/EtOAc = 100/1) to afford **76** as a colorless oil (22.8 mg, 72% yield, 92% e.e.).

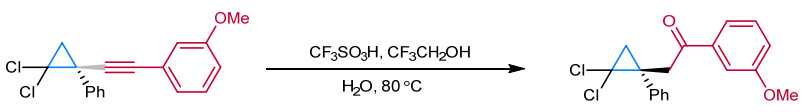
#### (*S*,*Z*)-1-(2-(2,2-Dichloro-1-phenylcyclopropyl)vinyl)-3-methoxybenzene (76)




**76**

**[α]$_D^{27}$** = +196 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 10.17 min, $t_R$ (major) = 20.38 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.43 – 7.36 (m, 4H), 7.32 – 7.26 (m, 1H), 7.21 (t, *J* = 7.9 Hz, 1H), 6.85 – 6.73 (m, 3H), 6.63 (d, *J* = 11.6 Hz, 1H), 6.40 (dd, *J* = 11.5, 1.1 Hz, 1H), 3.75 (s, 3H), 2.22 (dd, *J* = 8.0, 1.2 Hz, 1H), 1.51 (d, *J* = 8.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 159.4, 139.2, 137.2, 132.7, 130.4, 129.1, 128.6, 128.5, 127.5, 121.6, 114.2, 113.4, 66.9, 55.4, 38.6, 31.5.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{17}OCl_2$ $[M + H]^+$ 319.0651, found 319.0643.

### Synthesis of 77

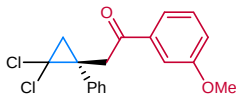



**3**, 92% e.e. **77**, 61%, 92% e.e.

To a solution of **3** (31.7 mg, 0.10 mmol, 1.0 equiv., 92% e.e.) in $CF_3CH_2OH$ (0.50

mL) were added $CF_3SO_3H$ (3.0 mg, 0.020 mmol, 20 mol%) and water (3.6 mg, 0.20 mmol, 2.0 equiv.). The reaction mixture was stirred at 80 °C for 24 h. After evaporation under reduced pressure, the residue was purified with column chromatography on silica gel (petroleum ether/EtOAc = 30/1) to yield the product **77** as a colorless oil (20.5 mg, 61% yield, 92% e.e.).

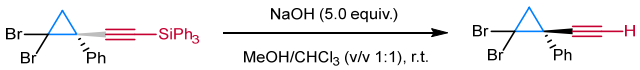
**(*R*)-2-(2,2-Dichloro-1-phenylcyclopropyl)-1-(3-methoxyphenyl)ethan-1-one (77)**




**77**

**[α]$_D^{27}$** = −35 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 8.59 min, $t_R$ (minor) = 13.61 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.41 (m, 2H), 7.38 (dt, *J* = 7.6, 1.2 Hz, 1H), 7.34 – 7.25 (m, 4H), 7.25 – 7.20 (m, 1H), 7.05 (dd, *J* = 8.1, 2.3 Hz, 1H), 4.00 (dd, *J* = 17.5, 1.4 Hz, 1H), 3.79 (s, 3H), 3.45 (d, *J* = 17.5 Hz, 1H), 2.22 (dd, *J* = 7.9, 1.3 Hz, 1H), 1.88 (d, *J* = 8.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 196.4, 159.9, 139.3, 138.2, 129.9, 129.7, 128.4, 127.6, 120.7, 120.0, 112.1, 65.1, 55.5, 46.7, 37.2, 31.7.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{17}O_2Cl_2$ $[M + H]^+$ 335.0600, found 335.0592.

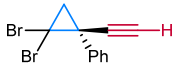
**Synthesis of 78**




**49**, 92% e.e. **78**, 87%, 92% e.e.

To a solution of **49** (1.12 g, 2.0 mmol, 1.0 equiv., 92% e.e.) in MeOH/$CHCl_3$ (v/v 1:1, 20 mL) was added NaOH (0.40 g, 10.0 mmol, 5.0 equiv.) and the resulting mixture was stirred at r.t. for 1 h. After completion of the reaction (monitored by TLC), the mixture was concentrated under reduced pressure and purified by column chromatography (petroleum ether/EtOAc = 100/1) to yield **78** as a white solid (0.52 g, 87% yield, 92% e.e.).

**(*S*)-(2,2-Dibromo-1-ethynylcyclopropyl)benzene (78)**

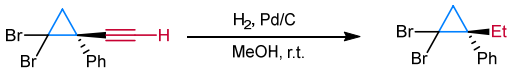



**78**

**m.p.** 69–71 °C
**[α]$_D^{27}$** = −15 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (minor) = 12.63 min, $t_R$ (major) = 14.09 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.46 – 7.31 (m, 5H), 2.50 (d, *J* = 7.9 Hz, 1H), 2.36 (s, 1H), 2.27 (d, *J* = 7.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 137.3, 129.0, 128.6, 128.4, 84.8, 70.5, 34.7, 33.0, 32.6.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_9Br_2$ $[M + H]^+$ 298.9065, found 298.9062.

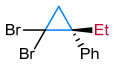
**Synthesis of 79**




**78**, 92% e.e. **79**, 83%, 92% e.e.

To a mixture of Pd/C (10% w/w Pd on carbon, 79.5 mg, 0.075 mmol, 5 mol%,) in MeOH (20 mL) was added **78** (0.45 g, 1.5 mmol, 1.0 equiv., 92% e.e.) under argon atmosphere. Then the reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under the hydrogen atmosphere at r.t. for 2 h. After completion, the reaction mixture was filtered and rinsed with EtOAc. The filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to afford **79** as a pale-yellow liquid (0.38 g, 83% yield, 92% e.e.).

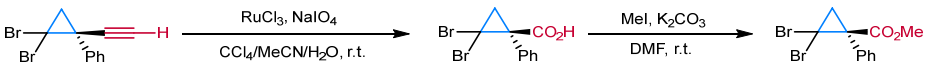
**(*R*)-(2,2-Dibromo-1-ethylcyclopropyl)benzene (79)**




**79**

**$[\alpha]_D^{27}$** = −87 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 230 nm), $t_R$ (major) = 11.81 min, $t_R$ (minor) = 15.14 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.12 (m, 5H), 2.15 (dt, *J* = 14.7, 7.3 Hz, 1H), 2.04 (d, *J* = 7.5 Hz, 1H), 1.79 (dt, *J* = 14.7, 7.3 Hz, 1H), 1.72 (d, *J* = 7.6 Hz, 1H), 0.85 (t, *J* = 7.4 Hz, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.3, 129.6, 128.3, 127.4, 41.1, 36.9, 33.8, 32.9, 11.5.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_{13}Br_2$ $[M + H]^+$ 302.9378, found 302.9368.

**Synthesis of 80**



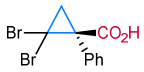

**78**, 92% e.e. **80**, 75% **80-1**, 95%, 92% e.e.

To a mixture of $RuCl_3$ (1.5 mg, 0.010 mmol, 5 mol%) and sodium periodate (171.0 mg, 0.80 mmol, 4.0 equiv.) in a mixed solvent of $CCl_4$ (0.40 mL) and water (0.60 mL) was added a solution of **78** (60.0 mg, 0.20 mmol, 1.0 equiv., 92% e.e.) in MeCN (0.40 mL) in one portion. The reaction mixture was stirred at r.t. for 8 h, and then, was concentrated. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 2/1) to afford the product **80** as a white solid (48.3 mg, 75%

yield). The e.e. value of **80** was determined by converting it to the corresponding ester **80-1**.

To a solution of **80** (32.0 mg, 0.10 mmol, 1.0 equiv.) in anhydrous DMF (1.0 mL) were added MeI (28.4 mg, 0.20 mmol, 2.0 equiv.) and $K_2CO_3$ (27.6 mg, 0.20 mmol, 2.0 equiv.) at r.t. Then it was stirred for 2 h. Upon completion (monitored by TLC), the reaction was quenched with water and extracted with EtOAc. The organic phase was concentered and purified with by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to afford the product **80-1** as a white solid (31.9 mg, 95% yield, 92% e.e.).

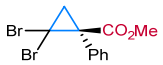
**(*R*)-2,2-Dibromo-1-phenylcyclopropane-1-carboxylic acid (80)**




**80**

**m.p.** 75–78 °C
**[α]$_D^{27}$** = +32 (c 0.5, $CHCl_3$).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.63 (s, 1H), 7.51 – 7.45 (m, 2H), 7.40 – 7.35 (m, 3H), 2.76 (d, *J* = 8.0 Hz, 1H), 2.24 (d, *J* = 8.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 173.3, 135.2, 131.0, 128.8, 128.4, 44.2, 32.4, 28.0.
**HRMS** (ESI) *m/z* calcd. for $C_{10}H_9O_2Br_2$ $[M + H]^+$ 318.8964, found 318.8964.

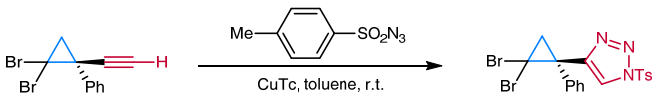
**Methyl (*R*)-2,2-dibromo-1-phenylcyclopropane-1-carboxylate (80-1)**




**80-1**

**m.p.** 88–90 °C
**[α]$_D^{27}$** = +20 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 13.22 min, $t_R$ (minor) = 16.27 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.55 – 7.46 (m, 2H), 7.42 – 7.32 (m, 3H), 3.75 (s, 3H), 2.78 (d, *J* = 8.0 Hz, 1H), 2.22 (d, *J* = 7.9 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 168.3, 135.6, 130.9, 128.7, 128.3, 53.4, 44.6, 32.3, 28.3.
**HRMS** (ESI) *m/z* calcd. for $C_{11}H_{11}O_2Br_2$ $[M + H]^+$ 332.9120, found 332.9114.

**Synthesis of 81**

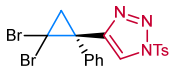



**78**, 92% e.e. **81**, 82%, 91% e.e.

To a solution of **78** (30.0 mg, 0.10 mmol, 1.0 equiv., 92% e.e.) in toluene (1.0 mL) were added 4-methylbenzenesulfonyl azide (23.6 mg, 0.12 mmol, 1.2 equiv.) and

copper thiophene-2-carboxylate (0.95 mg, 0.0050 mmol, 5 mol%) under argon atmosphere. The reaction mixture was stirred at r.t. for 8 h, and then, was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **81** as a colorless oil (40.7 mg, 82% yield, 91% e.e.).

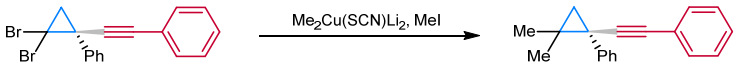
### (*R*)-4-(2,2-Dibromo-1-phenylcyclopropyl)-1-tosyl-1H-1,2,3-triazole (81)




**81**

$[\alpha]_D^{27}$ = +52 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 70/30, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 7.65 min, $t_R$ (major) = 10.24 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.99 – 7.88 (m, 2H), 7.54 – 7.46 (m, 2H), 7.44 – 7.32 (m, 5H), 3.01 (d, *J* = 8.0 Hz, 1H), 2.48 (d, *J* = 7.9 Hz, 1H), 2.43 (s, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 147.7, 147.6, 139.1, 132.8, 130.6, 129.8, 128.92, 128.87, 128.4, 123.1, 36.7, 33.2, 33.0, 22.0.
**HRMS** (ESI) *m/z* calcd. for $C_{18}H_{16}O_2N_3Br_2S$ $[M + H]^+$ 495.9324, found 495.9314.

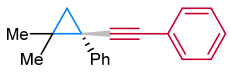
### Synthesis of 82




**47**, 91% e.e. **82**, 65%, 91% e.e.

To a flamed Schlenk tube charged with a stir bar were added cuprous thiocyanate (134.9 mg, 1.1 mmol) and dry ether (1.0 mL). Methyllithium (2.0 mmol) was added to the suspension at −78 °C under argon atmosphere and the mixture was gradually warmed up to 0 °C in 30 min. Then the mixture was cooled to −20 °C and a solution of **47** (37.6 mg, 0.10 mmol, 1.0 equiv., 91% e.e.) in dry ether (1.0 mL) and HMPA (43.5 μL, 0.25 mmol) was added dropwise to the mixture at −20 °C. The reaction mixture was stirred for 1h and much excess of methyl iodide (0.50 mL) was added at −40 °C. After 1 h, the reaction mixture was quenched with aqueous $NH_4Cl$ at −78 °C and precipitates were filtrated off on a celite bed. The filtrated was extracted with ether and the organic layer was washed with brine. The organic layer was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (petroleum ether) to afford **82** as a colorless oil (16.1 mg, 65% yield, 91% e.e.).

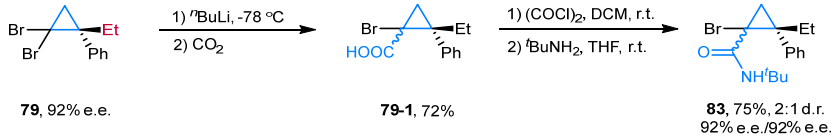
### (*R*)-(2,2-dimethyl-1-(phenylethynyl)cyclopropyl)benzene (82)




**82**

**[α]$_D^{27}$** = −96 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJ-RH (MeCN/$H_2O$ = 70/30, flow rate 0.7 mL/min, λ = 254 nm), $t_R$ (minor) = 15.36 min, $t_R$ (major) = 18.65 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.44 – 7.38 (m, 4H), 7.36 – 7.31 (m, 2H), 7.29 – 7.24 (m, 4H), 1.54 (s, 3H), 1.47 (d, *J* = 4.8 Hz, 1H), 1.18 (d, *J* = 4.8 Hz, 1H), 0.83 (s, 3H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 140.3, 131.7, 129.4, 128.3, 128.2, 127.5, 126.6, 124.3, 94.6, 78.6, 27.8, 27.6, 26.4, 24.1, 22.3.
**HRMS** (ESI) *m/z* calcd. for $C_{19}H_{19}$ $[M + H]^+$ 247.1481, found 247.1477.

**Synthesis of 83**

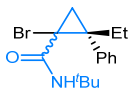



**79**, 92% e.e. **79-1**, 72% **83**, 75%, 2:1 d.r. 92% e.e./92% e.e.

An oven-dried two-necked flask was charged under nitrogen atmosphere with a solution of **79** (300.0 mg, 1.0 mmol, 1.0 equiv.) in anhydrous THF (10 mL). The solution was cooled to –78 °C and $^n$BuLi (2.5 M in hexanes, 0.38 mL, 0.95 mmol, 0.95 equiv.) was added dropwise over the course of 15 min. After the addition was complete, the reaction mixture was warmed to −61 °C and stirred for 20 min. The cold solution was then cannulated into a 1-L flask containing freshly condensed $CO_2$. The reaction mixture was stirred for 2 h under constant flow of dry $CO_2$ gas while allowed to warm to r.t.. The mixture was partitioned between water and $CHCl_3$ and acidified with 4 N HCl. The aqueous layer was extracted with $CHCl_3$. The combined organic phases were then back-extracted with saturated $NaHCO_3$. The combined aqueous extracts were washed with $CHCl_3$, acidified to pH < 1, and extracted with $CHCl_3$. The combined organic phases were dried with anhydrous $MgSO_4$ and concentrated in vacuum. The residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 2/1) to afford **79-1** as a colorless oil (193.8 mg, 72% yield).

A flame-dried round-bottom flask equipped with a dried magnetic stir bar was charged with **79-1** obtained above, DMF (2 drops), and $CH_2Cl_2$ (10 mL). The mixture was then treated with oxalyl chloride (0.10 mL, 1.1 mmol, 1.5 equiv.) at 0 °C, stirred for 15 min, warmed to r.t. and additionally stirred for 2 h. The solvent was then removed in vacuum and the crude acyl chloride was dissolved in dry THF (5.0 mL), followed by the addition of a solution of *tert*-butyl amine (0.20 mL, 2.2 mmol, 3.0 equiv.) in THF (5.0 mL). The reaction mixture was stirred overnight. After the reaction was complete, the solvent was removed in vacuum and the resulting residue was partitioned between EtOAc and water. The combined organic phases were dried over anhydrous $Na_2SO_4$ and concentrated. The residue was purified by chromatography on silica gel (petroleum ether/EtOAc = 20/1) to afford **83** as a white solid (175.3 mg, 75% yield, 2:1 d.r., 92% e.e./92% e.e.).

**(2*R*)-1-Bromo-*N*-(*tert*-butyl)-2-ethyl-2-phenylcyclopropane-1-carboxamide (83)**




**83**

**m.p.** 44–46 °C

**[α]$_D^{27}$** = +12 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel IG and IC (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 230 nm), $t_R$ (minor1) = 19.14 min, $t_R$ (major1) = 20.62 min, $t_R$ (minor2) = 22.84 min, $t_R$ (major2) = 23.94 min.

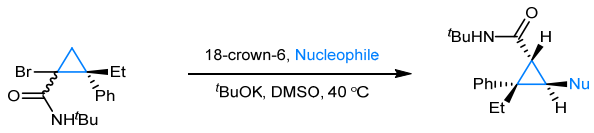
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.39 – 7.32 (m, 1H), 7.31 – 7.21 (m, 2H+3H×0.50), 7.20 – 7.14 (m, 2H+2H×0.50), 6.31 (s, 1H×0.50), 6.25 (s, 1H), 2.49 (dd, *J* = 6.2, 1.7 Hz, 1H), 2.16 – 2.05 (m, 1H+1H×0.50), 1.95 – 1.77 (m, 1H+1H×0.50), 1.65 – 1.52 (m, 2H×0.50), 1.41 (s, 9H×0.50), 1.19 (d, *J* = 6.2 Hz, 1H), 1.10 (s, 9H), 0.84 (t, *J* = 7.4 Hz, 3H), 0.77 (t, *J* = 7.3 Hz, 3H×0.50).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) (major) δ 165.3, 138.4, 129.0, 128.0, 126.9, 51.5, 45.7, 40.1, 33.8, 28.3, 25.2, 11.4.

**$^{13}$C NMR** (100 MHz, $CDCl_3$) (minor) δ 166.8, 141.3, 129.8, 128.1, 127.1, 52.0, 42.9, 41.1, 28.7, 27.3, 24.8, 11.6.

**HRMS** (ESI) *m/z* calcd. for $C_{16}H_{23}ONBr$ $[M + H]^+$ 324.0957, found 324.0953.

**Synthesis of 84–87**

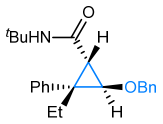



**83** **84-87**

**General procedure F**:

An oven-dried 10-mL Weaton vial was charged with 18-crown-6 (2.7 mg, 0.010 mmol, 10 mol%), $^t$BuOK (67.0 mg, 0.60 mmol, 6.0 equiv.), nucleophile (0.30 mmol, 3.0 equiv.), and anhydrous DMSO (2.0 mL). The mixture was stirred at r.t. for 1 min and **83** (32.4 mg, 0.10 mmol, 1.0 equiv.) was added in a single portion. The reaction mixture was stirred at 40 °C for 24 h. Then the reaction mixture was poured into a separatory funnel and was partitioned between water and EtOAc. The organic layers were washed with brine, dried over $MgSO_4$, filtered and evaporated. The residue was purified by chromatography on silica gel to afford the desired product.

**(1*S*,2*S*,3*R*)-3-(Benzyloxy)-*N*-(*tert*-butyl)-2-ethyl-2-phenylcyclopropane-1-carboxamide (84)**




**84**

According to **General procedure F** with benzyl alcohol (31.0 μL, 0.30 mmol, 3.0

equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **84** as a white solid (28.6 mg, 81% yield, 92% e.e., > 20:1 d.r.).

**m.p.** 62–64 °C

**[α]$_D^{27}$** = –8.5 (c 0.5, $CHCl_3$).

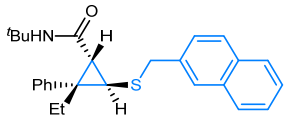
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (major) = 4.48 min, $t_R$ (minor) = 7.62 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.24 (m, 7H), 7.23 – 7.15 (m, 3H), 4.96 (s, 1H), 4.75 – 4.62 (m, 2H), 4.09 (d, *J* = 3.3 Hz, 1H), 1.97 (dq, *J* = 14.6, 7.4 Hz, 1H), 1.76 (dq, *J* = 14.3, 7.3 Hz, 1H), 1.64 (d, *J* = 3.4 Hz, 1H), 1.15 (s, 9H), 0.88 (t, *J* = 7.4 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 168.2, 139.2, 137.8, 129.8, 128.6, 128.2, 128.1, 127.9, 127.0, 73.4, 67.2, 51.1, 43.0, 36.3, 28.8, 28.4, 11.6.

**HRMS** (ESI) *m/z* calcd. for $C_{23}H_{30}O_2N$ $[M + H]^+$ 352.2271, found 352.2266.

**(1*R*,2*S*,3*R*)-*N*-(*tert*-Butyl)-2-ethyl-3-((naphthalen-2-ylmethyl)thio)-2-phenylcyclopropane-1-carboxamide (85)**




**85**

According to **General procedure F** with naphthalen-2-ylmethanethiol (52.2 mg, 0.30 mmol, 3.0 equiv.)., the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **85** as a colorless oil (28.6 mg, 72% yield, 90% e.e., > 20:1 d.r.).

**[α]$_D^{27}$** = –9.8 (c 0.5, $CHCl_3$).

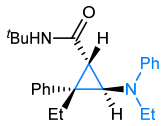
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 8.68 min, $t_R$ (minor) = 10.88 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.96 – 7.66 (m, 4H), 7.59 – 7.35 (m, 3H), 7.24 – 6.95 (m, 5H), 4.74 (s, 1H), 4.15 – 3.87 (m, 2H), 2.89 (d, *J* = 5.0 Hz, 1H), 2.02 (dq, *J* = 15.1, 7.6 Hz, 1H), 1.74 (dq, *J* = 15.1, 7.6 Hz, 1H), 1.51 (d, *J* = 5.0 Hz, 1H), 1.04 (s, 9H), 0.79 (t, *J* = 7.4 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 167.6, 139.8, 136.0, 133.4, 132.6, 129.6, 128.5, 128.1, 127.9, 127.7, 127.6, 127.3, 126.9, 126.3, 125.9, 51.1, 42.8, 39.1, 38.4, 31.5, 30.8, 28.7, 11.6.

**HRMS** (ESI) *m/z* calcd. for $C_{27}H_{32}ONS$ $[M + H]^+$ 418.2199, found 418.2192.

**(1*S*,2*S*,3*R*)-*N*-(*tert*-Butyl)-2-ethyl-3-(ethyl(phenyl)amino)-2-phenylcyclopropane-1-carboxamide (86)**




**86**

According to **General procedure F** with *N*-ethylaniline (36.3 mg, 0.30 mmol, 3.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **86** as a white solid (29.2 mg, 80% yield, 92% e.e., > 20:1 d.r.).

**m.p.** 65–68 °C

**[α]$_D^{27}$** = –12 (c 0.5, $CHCl_3$).

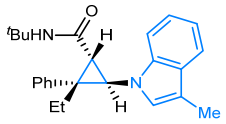
**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 9.02 min, $t_R$ (minor) = 12.14 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.31 – 7.19 (m, 7H), 7.06 – 6.90 (m, 2H), 6.85 – 6.76 (m, 1H), 5.24 (s, 1H), 3.74 (dq, *J* = 14.1, 7.0 Hz, 1H), 3.56 – 3.36 (m, 2H), 1.88 – 1.73 (m, 2H), 1.53 (d, *J* = 4.4 Hz, 1H), 1.24 (s, 9H), 1.17 (t, *J* = 7.1 Hz, 3H), 0.88 (t, *J* = 7.4 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 168.3, 149.3, 140.1, 129.6, 129.0, 128.2, 126.9, 118.6, 116.9, 51.3, 48.5, 46.9, 45.4, 37.4, 28.9, 27.7, 11.9, 10.9.

**HRMS** (ESI) *m/z* calcd. for $C_{24}H_{33}ON_2$ $[M + H]^+$ 365.2587, found 365.2582.

### (1*S*,2*S*,3*R*)-*N*-(*tert*-Butyl)-2-ethyl-3-(3-methyl-1*H*-indol-1-yl)-2-phenylcyclopropane-1-carboxamide (87)




**87**

According to **General procedure F** with 3-methyl-1*H*-indole (39.3 mg, 0.30 mmol, 3.0 equiv.), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **87** as a white solid (26.4 mg, 70% yield, 92% e.e., > 20:1 d.r.).

**m.p.** 70–73 °C

**[α]$_D^{27}$** = –62 (c 0.5, $CHCl_3$).

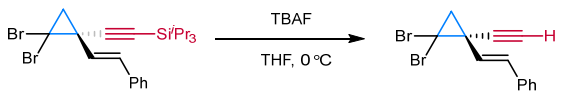
**HPLC** analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 230 nm), $t_R$ (minor) = 3.75 min, $t_R$ (major) = 6.22 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.64 – 7.53 (m, 2H), 7.49 – 7.42 (m, 2H), 7.41 – 7.33 (m, 2H), 7.32 – 7.26 (m, 2H), 7.15 (t, *J* = 7.5 Hz, 1H), 6.94 (s, 1H), 5.35 (s, 1H), 4.30 (d, *J* = 4.3 Hz, 1H), 2.33 (s, 3H), 2.27 (d, *J* = 4.3 Hz, 1H), 1.56 – 1.44 (m, 2H), 1.26 (s, 9H), 0.77 (t, *J* = 7.3 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 167.1, 138.8, 137.9, 129.7, 129.5, 128.5, 127.4, 125.7, 122.0, 119.3, 119.2, 111.0, 110.4, 51.5, 44.0, 43.1, 35.3, 28.8, 28.5, 11.5, 9.7.

**HRMS** (ESI) *m/z* calcd. for $C_{25}H_{31}ON_2$ $[M + H]^+$ 375.2431, found 375.2426.

### Synthesis of 88




**60** **88**, 94%, 91% e.e.

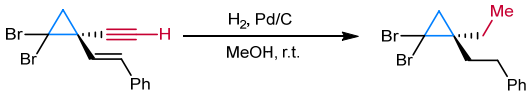
Compound **60** (289.2 mg, 0.60 mmol, 1.0 equiv.) was dissolved in anhydrous THF (10.0 mL) under argon atmosphere in a 25-mL Schlenk flask. Then TBAF (1 M in THF, 1.2 mL, 1.2 mmol, 2.0 equiv.) was added into the solution, and the mixture was stirred at 0 °C for 3 h. Upon completion of the reaction, the reaction mixture was poured into water and extracted with $CH_2Cl_2$. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The thus-obtained crude product was purified by column chromatography on silica gel (petroleum ether/ EtOAc = 100/1) to yield the product **88** as a white solid (183.9 mg, 94% yield, 91% e.e.).

**(*S*,*E*)-(2-(2,2-Dibromo-1-ethynylcyclopropyl)vinyl)benzene (88)**


**88**

**m.p.** 83–85 °C
**[α]$_D^{27}$** = –98 (c 0.5, $CHCl_3$).
**HPLC** analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (major) = 9.56 min, $t_R$ (minor) = 14.80 min.
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.44 – 7.37 (m, 2H), 7.36 – 7.30 (m, 2H), 7.29 – 7.24 (m, 1H), 7.04 (d, *J* = 15.6 Hz, 1H), 6.03 (d, *J* = 15.6 Hz, 1H), 2.52 (s, 1H), 2.25 (d, *J* = 7.7 Hz, 1H), 2.12 (d, *J* = 7.7 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 134.2, 128.8, 128.2, 127.7, 126.7, 81.8, 73.0, 38.1, 33.6, 30.0.
**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{11}Br_2$ $[M + H]^+$ 324.9222, found 324.9224.

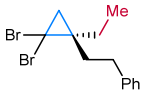
**Synthesis of 89**




**88**, 91% e.e. **89**, 84%, 90% e.e.

To a mixture of Pd/C (10% w/w Pd on carbon, 5.0 mg, 0.0050 mmol, 5 mol%) in MeOH (2.0 mL) was added **88** (32.6 mg, 0.10 mmol, 1.0 equiv., 91% e.e.) under argon atmosphere. Then, the reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under the hydrogen atmosphere at r.t. for 4 h. After completion, the reaction mixture was filtered and rinsed with EtOAc. The filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (petroleum ether) to afford **89** as a colorless oil (27.9 mg, 84% yield, 90% e.e.).

**(*R*)-(2-(2,2-Dibromo-1-ethylcyclopropyl)ethyl)benzene (89)**




**89**

$[\alpha]_D^{27}$ = –39 (c 0.5, $CHCl_3$).

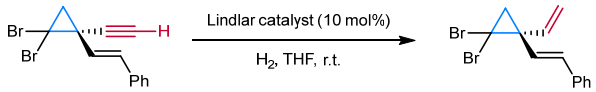
**HPLC** analysis: Chiralcel OJ3 (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 13.50 min, $t_R$ (minor) = 14.32 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.32 – 7.26 (m, 2H), 7.25 – 7.16 (m, 3H), 2.83 (ddd, *J* = 13.4, 10.3, 6.4 Hz, 1H), 2.67 (ddd, *J* = 13.5, 10.5, 6.9 Hz, 1H), 2.04 – 1.89 (m, 2H), 1.84 (dq, *J* = 14.7, 7.5 Hz, 1H), 1.71 (dq, *J* = 14.7, 7.5 Hz, 1H), 1.44 – 1.35 (m, 2H), 1.08 (t, *J* = 7.4 Hz, 3H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 141.9, 128.6, 128.4, 126.2, 39.5, 36.7, 34.1, 33.9, 32.5, 28.0, 10.7.

**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{17}Br_2$ $[M + H]^+$ 330.9691, found 330.9683.

**Synthesis of 90**




**88**, 91% e.e. **90**, 82%, 90% e.e.

A flask containing a magnetic stirrer was charged with **88** (32.6 mg, 0.10 mmol, 1.0 equiv., 91% e.e.), Lindlar catalyst (21.1 mg, 0.010 mmol, 10 mol%), and THF (2.0 mL). Then the reaction flask was evacuated and refilled with hydrogen through a balloon. The mixture was stirred at r.t. under the hydrogen atmosphere for 4 h. Upon completion as monitored by TLC, EtOAc was added, and the mixture was passed through a membrane filter. After filtration and evaporation in vacuo, the thus-obtained residue was purified by column chromatography on silica gel (petroleum ether) to afford **90** as a colorless oil (26.9 mg, 82% yield, 90% e.e.).

**(*R*,*E*)-(2-(2,2-Dibromo-1-vinylcyclopropyl)vinyl)benzene (90)**


**90**

$[\alpha]_D^{27}$ = –34 (c 0.5, $CHCl_3$).

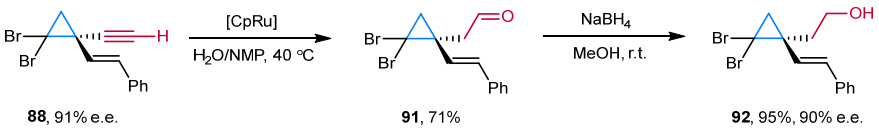
**HPLC** analysis: Chiralcel OJ3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), $t_R$ (major) = 19.56 min, $t_R$ (minor) = 22.40 min.

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.43 – 7.37 (m, 2H), 7.35 – 7.30 (m, 2H), 7.27 – 7.24 (m, 1H), 6.51 (d, *J* = 15.9 Hz, 1H), 6.39 (d, *J* = 15.9 Hz, 1H), 6.10 (dd, *J* = 17.1, 10.3 Hz, 1H), 5.40 (dd, *J* = 10.3, 1.0 Hz, 1H), 5.26 (dd, *J* = 17.1, 1.0 Hz, 1H), 2.09 (q, *J* = 7.7 Hz, 2H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 138.0, 136.7, 133.8, 129.5, 128.8, 128.0, 126.5, 118.9, 38.3, 36.5, 33.7.

**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{13}Br_2$ $[M + H]^+$ 326.9378, found 326.9380.

**Synthesis of 91 and 92**

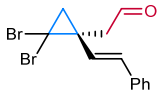



**88**, 91% e.e. **91**, 71% **92**, 95%, 90% e.e.

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with 5,5'- bis(trifluoromethyl)-2,2'-bipyridine (11.7 mg, 0.040 mmol, 0.20 equiv.), tris(acetonitrile) ($\eta^5$-cyclopentadienyl)ruthenium hexafluorophosphate (18.4 mg, 0.040 mmol, 0.20 equiv.), a mixture of water and *N*-methyl-2-pyrrolidinone (20% v/v, 1.0 mL), and **88** (65.2 mg, 0.20 mmol, 1.0 equiv., 91% e.e.). The mixture was stirred at 40 °C for 48 h. Upon completion of the reaction, the reaction mixture was poured into water and extracted with $CH_2Cl_2$. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The thus-obtained crude product was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **91** as a colorless oil (48.8 mg, 71% yield). The e.e. value of **91** was determined by converting it to the corresponding alcohol **92**.

To a vial equipped with a magnetic stirring bar was added aldehyde **91** (34.4 mg, 0.10 mmol, 1.0 equiv.) in MeOH (1.0 mL) at r.t. Then $NaBH_4$ (7.6 mg, 0.20 mmol, 2.0 equiv.) was added and the reaction was stirred under the same conditions. Upon completion as monitored by TLC, the reaction was quenched by the addition of water and extracted with $CH_2Cl_2$. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The thus-obtained crude product was purified by column chromatography on silica gel (petroleum ether/ EtOAc = 5/1) to yield the product **92** as a colorless oil (32.9 mg, 95% yield, 90% e.e.).

**(*S*,*E*)-2-(2,2-Dibromo-1-styrylcyclopropyl)acetaldehyde (91)**




**91**

**[α]$_D^{27}$** = +28 (c 0.5, $CHCl_3$).
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 9.84 (s, 1H), 7.38 – 7.24 (m, 5H), 6.48 (d, *J* = 16.0 Hz, 1H), 6.32 (d, *J* = 16.0 Hz, 1H), 3.09 (d, *J* = 17.9 Hz, 1H), 2.96 (d, *J* = 17.8 Hz, 1H), 2.11 (d, *J* = 8.0 Hz, 1H), 1.89 (d, *J* = 8.0 Hz, 1H).
**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 199.5, 136.2, 133.7, 129.6, 128.8, 128.3, 126.5, 50.2, 35.0, 34.0, 31.7.
**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{13}OBr_2$ $[M + H]^+$ 342.9328, found 342.9323.

**(*S*,*E*)-2-(2,2-Dibromo-1-styrylcyclopropyl)ethan-1-ol (92)**


**92**

$[\alpha]_D^{27}$ = +12 (c 0.5, $CHCl_3$).

**HPLC** analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), $t_R$ (minor) = 15.50 min, $t_R$ (major) = 23.01 min.

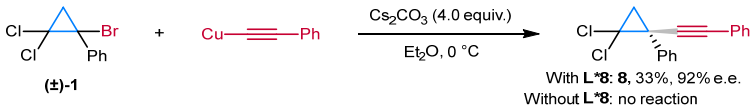
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.44 – 7.36 (m, 2H), 7.36 – 7.29 (m, 2H), 7.28 – 7.24 (m, 1H), 6.48 (d, *J* = 15.9 Hz, 1H), 6.32 (d, *J* = 15.9 Hz, 1H), 3.96 – 3.72 (m, 2H), 2.27 (dt, *J* = 13.4, 6.5 Hz, 1H), 2.04 (dt, *J* = 13.4, 6.5 Hz, 1H) 2.00 (d, *J* = 7.5 Hz, 1H), 1.77 (d, *J* = 7.7 Hz, 1H).

**$^{13}$C NMR** (100 MHz, $CDCl_3$) δ 136.4, 133.6, 129.7, 128.8, 128.1, 126.5, 60.9, 39.9, 37.0, 34.2, 33.1.

**HRMS** (ESI) *m/z* calcd. for $C_{13}H_{15}OBr_2$ $[M + H]^+$ 344.9484, found 344.9473.

## Mechanistic studies

### The effect of ligand and copper phenylacetylide on the reaction initiation.

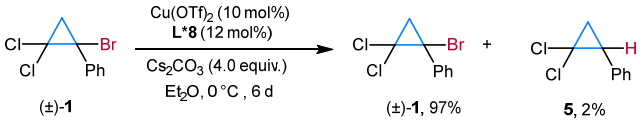



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with copper phenylacetylide (16.5 mg, 0.10 mmol, 1.0 equiv.), (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (26.6 mg, 0.10 mmol, 1.5 equiv.), **L*8** (53.4 mg, 0.10 mmol, 1.0 equiv.), $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.), and anhydrous $Et_2O$ (1.0 mL). The resulting reaction mixture was stirred at 0 °C for 6 d. Upon completion as monitored by TLC, the reaction mixture was filtered and washed by EtOAc. After evaporation under reduced pressure, the residue was analyzed by $^1H$ NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard. The product was then separated by preparative TLC. The e.e. value of **8** was determined by chiral HPLC analysis.

The procedure for the reaction in the absence of **L*8** was the same with that described above except that **L*8** was not added. No desired product **8** was observed.

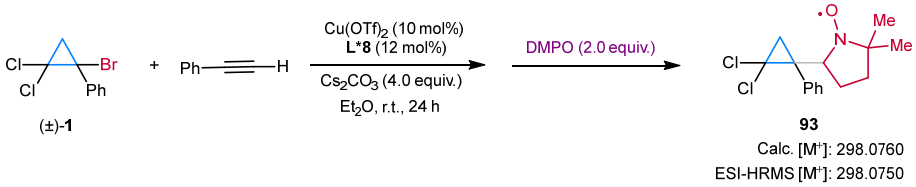
*Note*: copper phenylacetylide was synthesized according to literature[7].

### Control experiment without alkyne

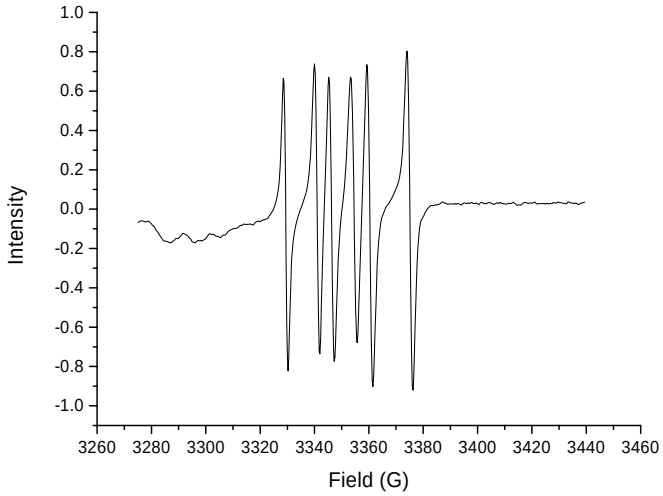



An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.61 mg, 0.010 mmol, 10 mol%), chiral ligand **L*8** (6.40 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (26.6 mg, 0.10 mmol) and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at 0 °C for 6 d. The reaction mixture was filtered and washed by EtOAc. After evaporation under reduced pressure, the residue was analyzed by $^1H$ NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard.

### EPR and HRMS experiments for the detection of radical intermediates during the reaction.

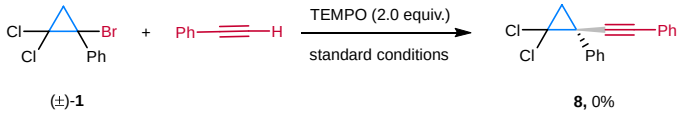



An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.6 mg, 0.010 mmol, 10 mol%), chiral ligand **L*8** (6.4 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic **1** (39.9 mg, 0.15 mmol, 1.5 equiv.), phenylacetylene (11.0 μL, 0.10 mmol, 1.0 equiv.), and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at r.t. for 24 h. Next, 5,5-dimethyl-1-pyrroline *N*-oxide (DMPO) (22.6 mg, 0.20 mmol, 2.0 equiv.) was added and the reaction mixture was stirred at r.t. for another 1 h. The resulting reaction mixture was analyzed by EPR. The EPR results revealed the likely formation of persistent radical **93**, a DMPO-trapped cyclopropyl radical, in the reaction, which was further supported by the ESI-HRMS results. Therefore, we concluded the formation of cyclopropyl radicals in this reaction.




**Supplementary Fig. 7′ | Room Temperature Q-band CW-EPR spectrum of the spin trap study.** $g$ = 2.0071; $A_H$ = 18.90 G; $A_N$ = 13.37 G. EPR acquisition parameters: temperature = 298 K; MW power = 40 dB; modulation amplitude = 1 G; conversion time = 20 ms.

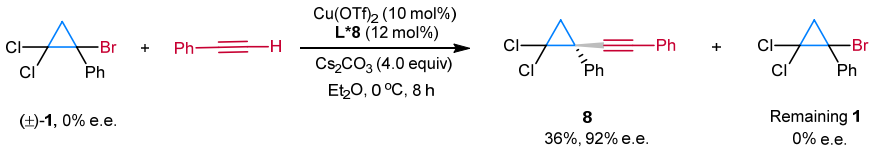
## Radical inhibition experiment with TEMPO



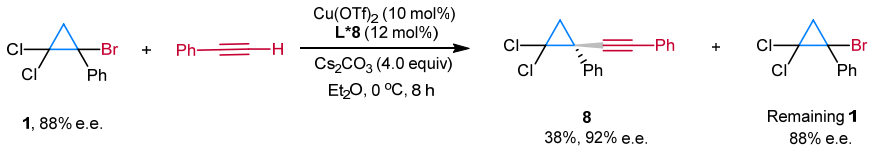

An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with $Cu(OTf)_2$ (3.6 mg, 0.010 mmol, 10 mol%), chiral ligand **L*8** (6.4 mg,

0.012 mmol, 12 mol%), and $Cs_2CO_3$ (128.0 mg, 0.40 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then racemic **1** (39.9 mg, 0.15 mmol, 1.5 equiv.), phenylacetylene (11.0 μL, 0.1 mmol, 1.0 equiv.), TEMPO (31.3 mg, 0.20 mmol, 2.0 equiv.) and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was allowed to stir at 0 °C for 6 d. The reaction mixture was filtered and washed by EtOAc. After evaporation under reduced pressure, the residue was analyzed by $^1H$ NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard.

**Control experiments with racemic and scalemic cyclopropyl bromide 1**

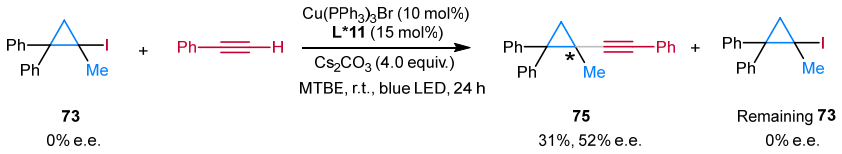



According to **General procedure A** with racemic (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (13.3 mg, 0.050 mmol, 1.0 equiv.) and ethynylbenzene (5.5 μL, 0.05 mmol, 1.0 equiv.) at 0 °C for 8 h, the reaction mixture was filtered and washed by EtOAc. After evaporation, the thus-obtained residue was analyzed by $^1H$ NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard. The product was then separated by preparative TLC. The e.e. values of **8** and the remaining **1** were determined by chiral HPLC analysis.

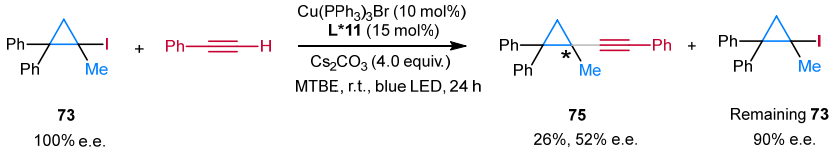



The procedure for the reaction with scalemic (1-bromo-2,2-dichlorocyclopropyl)benzene **1** was the same with that described above except that enantioenriched **1** (13.3 mg, 0.050 mmol, 1.0 equiv., 88% e.e.) was used instead of racemic **1**.

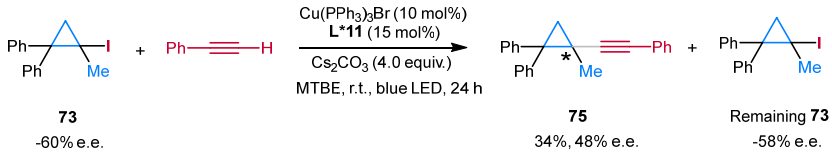
**Control experiments with racemic and scalemic 1-alkyl-substituted cyclopropyl iodine 73**



According to **General procedure E** with racemic (2-iodo-2-methylcyclopropane-1,1-diyl)dibenzene **73** (25.1 mg, 0.075 mmol, 1.5 equiv.) and ethynylbenzene (5.5 μL, 0.05 mmol, 1.0 equiv.) at r.t. for 24 h, the reaction mixture was filtered and washed by EtOAc. After evaporation, the thus-obtained residue was analyzed by $^1$H NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard. The product was then separated by preparative TLC. The e.e. values of **75** and remaining **73** were determined by chiral HPLC analysis.

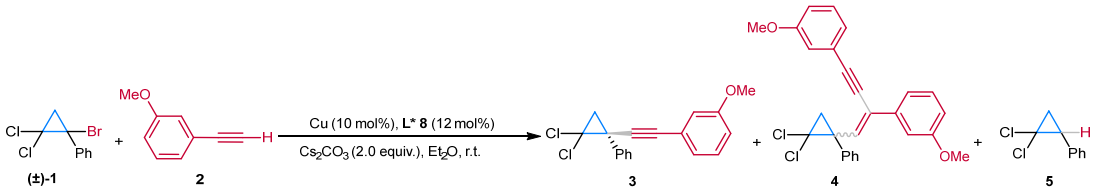



The procedure for the reaction with scalemic (2-iodo-2-methylcyclopropane-1,1-diyl)dibenzene **73** was the same with that described above except that enantioenriched **73** (25.1 mg, 0.075 mmol, 1.5 equiv., 100% e.e.) was used instead of racemic **73**.



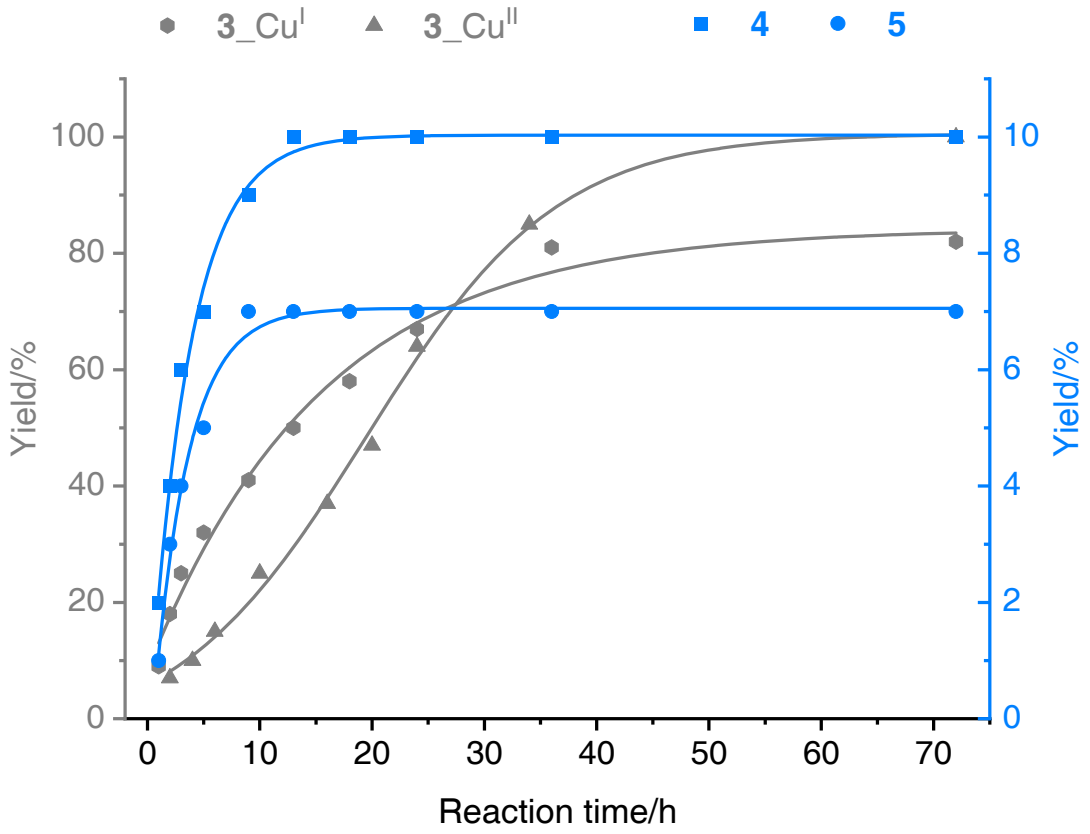

The procedure for the reaction with scalemic (2-iodo-2-methylcyclopropane-1,1-diyl)dibenzene **73** was the same with that described above except that enantioenriched **73** (25.1 mg, 0.075 mmol, 1.5 equiv., –60% e.e.) was used instead of racemic **73**.

## Time-course experiment




The time-course experiment sample were prepared following the general procedure: an oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with CuOTf·1/2Ph (2.51 mg, 0.010 mmol, 10 mol%) or $Cu(OTf)_2$ (3.61 mg, 0.010 mmol, 10 mol%), chiral ligand **L*8** (6.40 mg, 0.012 mmol, 12 mol%), and $Cs_2CO_3$ (65.2 mg, 0.20 mmol, 2.0 equiv.). The tube was evacuated and backfilled with argon three times. Then (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (26.6 mg, 0.10 mmol, 1.0 equiv.), 1-ethynyl-3-methoxybenzene (19.2 μL, 0.15 mmol, 1.5 equiv.), and $Et_2O$ (1.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was stirred at r.t. for appropriate time. Upon completion, the precipitate was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated and the residue was analyzed by $^1$H NMR spectroscopy using

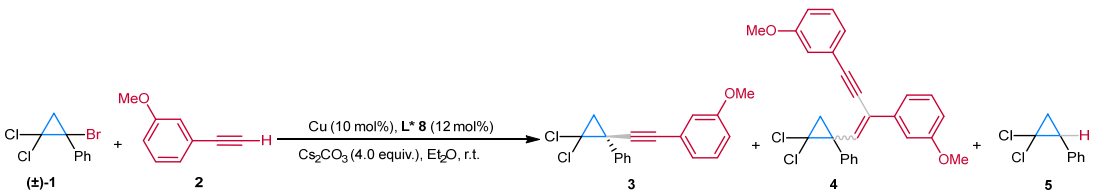
1,3,5-trimethoxybenzene as an internal standard.




**Supplementary Fig. 10′ | Time-course experiment results using $Cu(OTf)_2$ and CuOTf catalyst precursors.** The formation of side products was monitored when CuOTf was employed, as it was substantially suppressed when $Cu(OTf)_2$ was used. Solid lines for compounds **4** and **5** represent exponential decay fits to the experimental data. The solid line for compound **3** with CuOTf as the precatalyst is a dose-response fit, while the solid line for compound **3** with $Cu(OTf)_2$ is a Boltzmann fit to the experimental data.

## EPR experiments for the Cu(II) concentration during reaction

### Sample Prepare

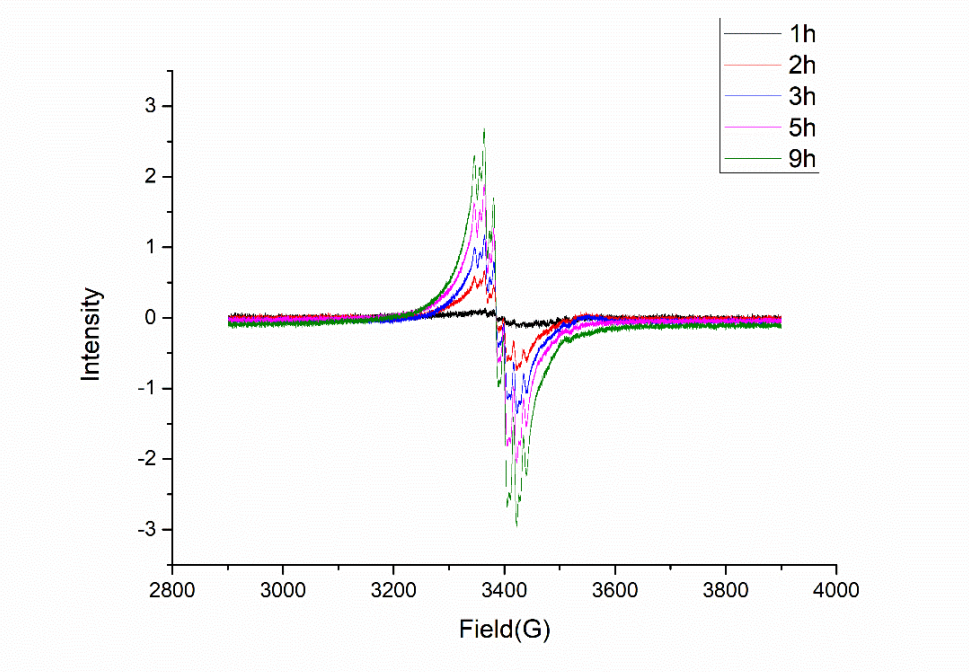



The EPR sample were prepared following the general procedure: an oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with CuOTf·1/2Ph (7.53 mg, 0.030 mmol, 10 mol%) or $Cu(OTf)_2$ (10.83 mg, 0.030 mmol, 10 mol%), chiral ligand **L*8** (19.20 mg, 0.036 mmol, 12 mol%), and $Cs_2CO_3$ (391.2

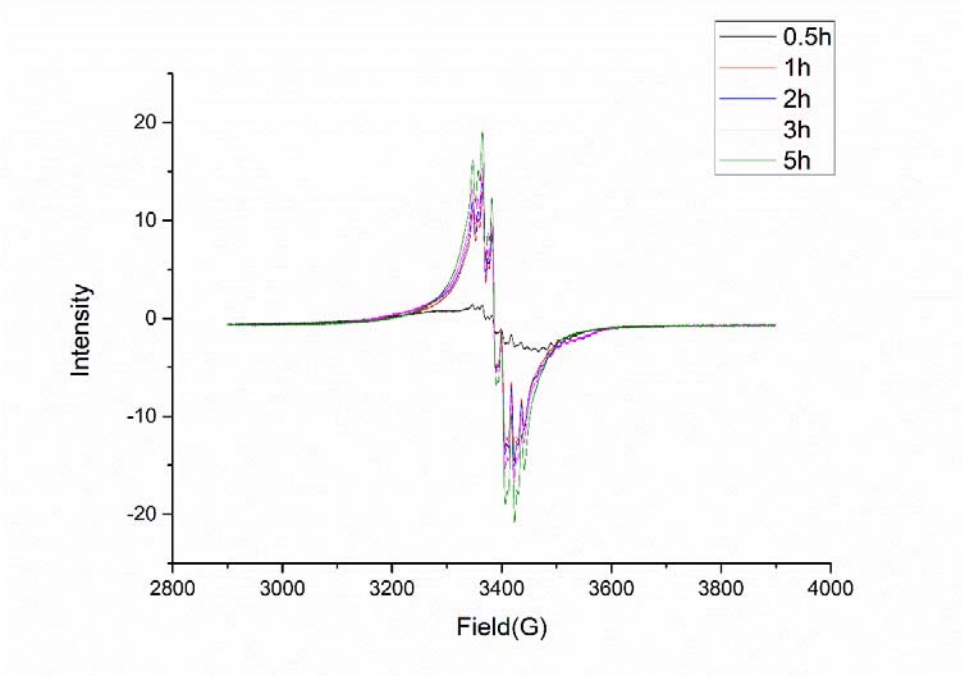
mg, 1.20 mmol, 4.0 equiv.). The tube was evacuated and backfilled with argon three times. Then (1-bromo-2,2-dichlorocyclopropyl)benzene **1** (119.7 mg, 0.45 mmol, 1.5 equiv.), 1-ethynyl-3-methoxybenzene (38.4 μL, 0.30 mmol, 1.0 equiv.), and $Et_2O$ (3.0 mL) were sequentially added into the mixture under argon. The tube was sealed and the reaction mixture was stirred at r.t.. Samples were transferred into quartz tubes in glovebox and sealed for EPR test.

**X-Band EPR Details**

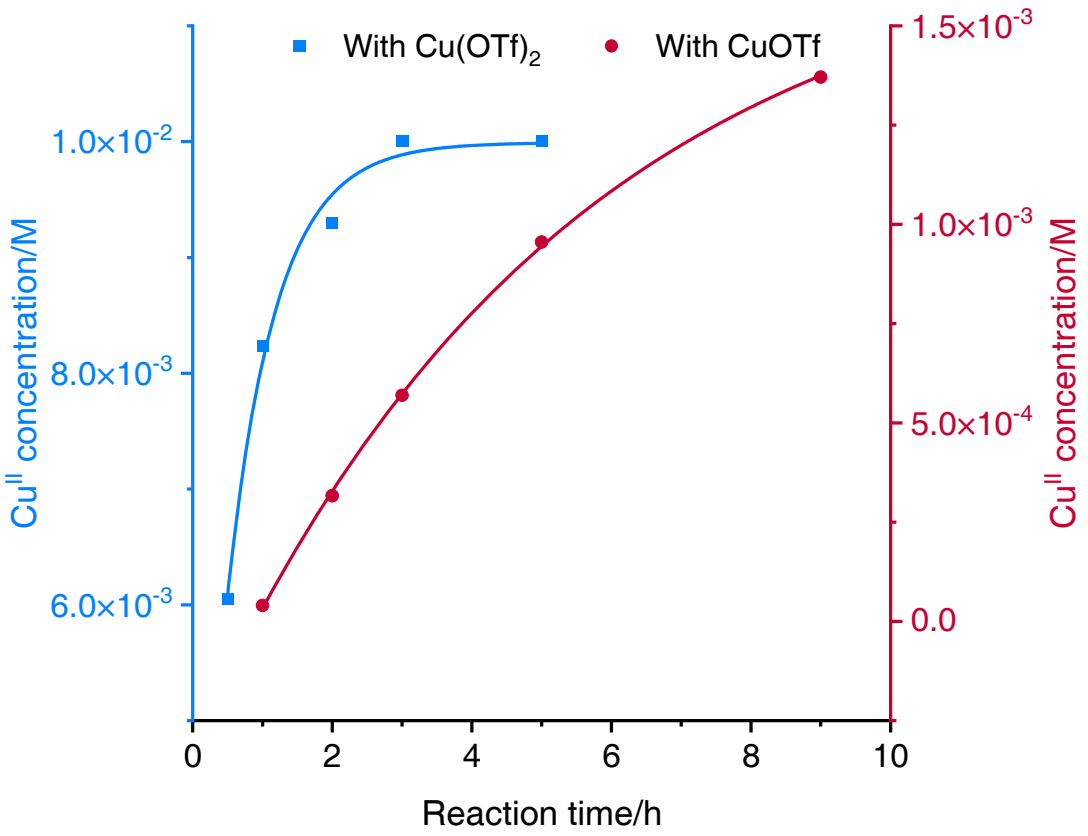
EPR measurements were performed in 4mm quartz tubes. All spectra were baseline-corrected. EPR spectra were recorded on a Bruker EMXPlus-10/12 EPR X-band spectrometer at room temperature.




**Supplementary Fig. 11′ | Time-course X-band EPR spectra of the reaction mixtures with CuOTf·1/2Ph as the catalyst precursor.** EPR acquisition parameters: solvent = toluene; temperature = 298 K; frequency = 9.838739 GHz; MW power = 20 dB; modulation amplitude = 1 G; conversion time = 12 ms.




**Supplementary Fig. 12′ | Time-course X-band EPR spectra of the reaction mixtures with $Cu(OTf)_2$ as the catalyst precursor.** EPR acquisition parameters: solvent = toluene; temperature = 298 K; frequency = 9.837637 GHz; MW power = 20 dB; modulation amplitude = 1 G; conversion time = 12 ms.




**Supplementary Fig. 13 | Calculated $Cu^{II}$ concentrations based on EPR spectroscopy.** Spin quantification was conducted using an internal standard of $Cu(edta)_2$ with a known concentration, employing the Bruker Xenon software. Following region definition and double integration, the $Cu^{II}$ concentrations of the respective samples were plotted against time. The solid lines represent exponential decay fits to the experimental data.

# Computational studies

## 1. Computational Details

All density functional theory (DFT) calculation results are obtained with Gaussian 16 program [8]. Default G16 SCF convergence criteria, optimization convergence criteria and integral grid parameters for Gaussian 16 are applied unless otherwise stated. (5d,7f) keyword in Gaussian 16 was used.

Geometry optimizations are conducted with B3LYP functional [9-10], employing the D3 version of Grimme's dispersion corrections[11] with Becke-Johnson damping [12]. LANL2DZ basis set [13-18] is used for copper and 6-31G(d) basis set is used for all other light elements (C, H, N, O, Cl).

Single-point energies and solvent effects at diethyl ether are also evaluated with B3LYP functional with Grimme's dispersion corrections and Becke-Johnson damping. SDD basis set [13,17-20] is used for copper and 6-311+G(d,p) basis set is used for all other light elements (C, H, N, O, Cl). The solvation energies are calculated with a self-consistent reaction field (SCRF) using the SMD implicit solvent model [21].

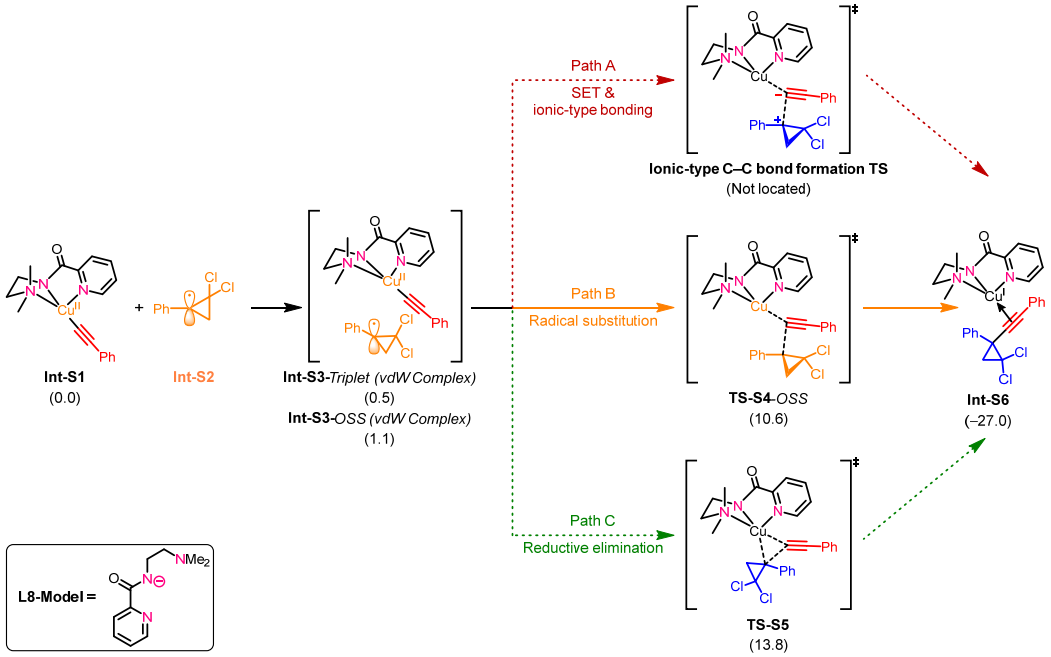
Frequency analysis is also performed at the same level of theory as geometry optimization using harmonic oscillator model to confirm whether optimized stationary points are either local minimum or transition state, as well as to evaluate zero-point vibrational energies and thermal corrections for enthalpies and free energies at 298.15 K. Mulliken spin population analysis is obtained at the same level of theory as geometry optimization.

In addition, geometry optimization, frequency analysis and single point energy of open-shell transition states and local minimums are calculated with unrestricted open-shell DFT methods, while same computations for closed-shell structures were performed with restricted closed-shell DFT methods. Wavefunction stability test at the same level of theory as geometry optimizations is employed to ensure that the SCF converged wavefunction was stable.

To correct the Gibbs free energies under 1 atm to the standard state in solution (1 mol/L), a correction of $RT\ln(c_s/c_g)$ is added to energies of all species. $c_s$ stands for the standard molar concentration in solution (1 mol/L), $c_g$ stands for the standard molar concentration in gas phase (about 0.040876 mol/L), and $R$ is the gas constant. For calculated intermediates at the standard state of 1 mol/L at 298.15 K, the correction value equaling to 1.89 kcal/mol is used.

The 3D diagrams of optimized structures shown in this supplementary information for computations are generated with CYLview software [22].

## 2. Discussion on the Cu-Mediated C–C Bonding Mechanism of Cyclopropyl Radicals and Alkynyl Nucleophiles



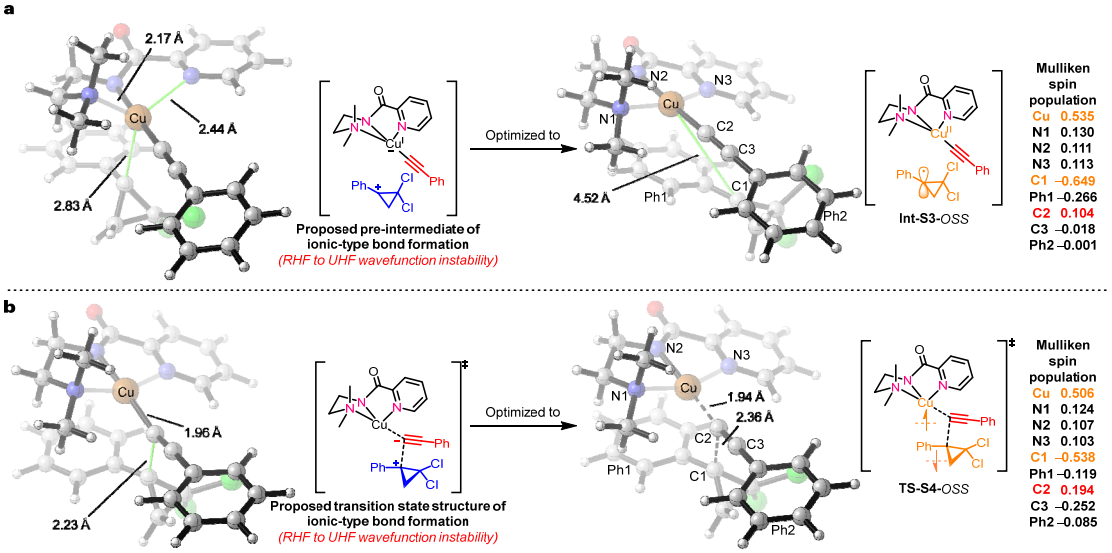

**Supplementary Fig. 14 | DFT exploration on the C–C bond formation mechanism of (L8-Model)Cu(II)(alkynyl) species Int-S1 and cyclopropyl radical Int-S2.** Free energies in kcal/mol shown in parentheses are compared to the sum of **Int-S1** and **Int-S2**.

DFT calculations in model systems are performed to study the Cu-mediated C–C bond formation pathway for cyclopropyl radicals and alkynyl nucleophiles. Simplified N,N,N-ligand based on **L*8** is used for calculations in this section.

The proposed C–C bond formation pathways between **(L8-Model)**Cu(II)(alkynyl) species **Int-S1** and tertiary cyclopropyl radical **Int-S2** include three major possibilities: sequential SET (single-electron transfer) and ionic-type C–C bond formation (Path A in **Supplementary Fig. 14**), outer-sphere radical-substitution-type C–C bond formation via **TS-S4**-*OSS* (Path B in **Supplementary Fig. 14**), and reductive elimination via **TS-S5** (Path C in **Supplementary Fig. 14**).

For Path A (SET and ionic-type C–C bonding), despite our considerable efforts, the ionic-type C–C bond formation transition state could not be identified. Furthermore, we conducted a detailed examination of the pre-intermediates of this transition state and found them to exhibit an RHF (restricted Hartree–Fock) to UHF (unrestricted Hartree–Fock) wavefunction instability. Upon employing stable wavefunctions and subsequent geometry structure optimization, we obtained a radical substitution-type

transition state pre-intermediate, **Int-S3**-*OSS*. Mulliken spin population analysis indicated that **Int-S3**-*OSS* is an open-shell singlet (**Supplementary Fig. 15a**). Similarly, the proposed transition state structure also demonstrated an RHF to UHF wavefunction instability, and further optimization yielded an open-shell singlet radical substitution-type transition state **TS-S4**-*OSS*. (**Supplementary Fig. 15b**) Therefore, the ionic-type C–C bond formation reaction pathway is likely not operative.

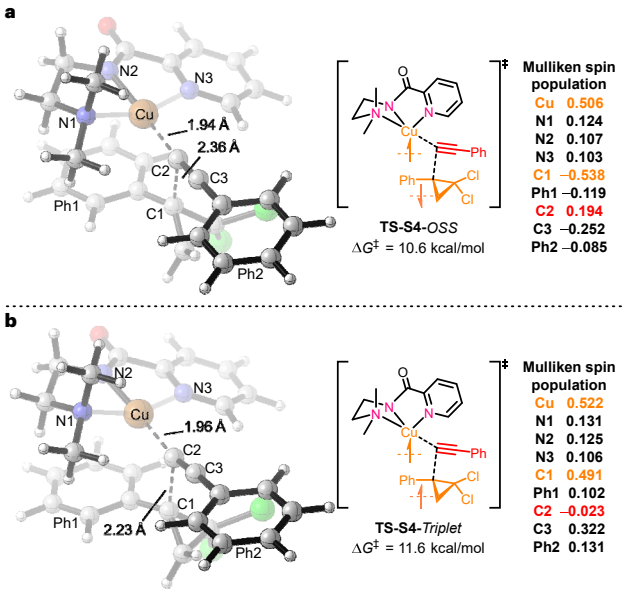



**Supplementary Fig. 15 | Detailed investigations on the sequential SET and ionic-type C–C bond formation pathway. a**, The proposed pre-intermediate structure. **b**, The proposed transition state structure. These structures have an RHF to UHF wavefunction instability, and further optimizations using UHF wavefunctions lead to a radical substitution pathway.

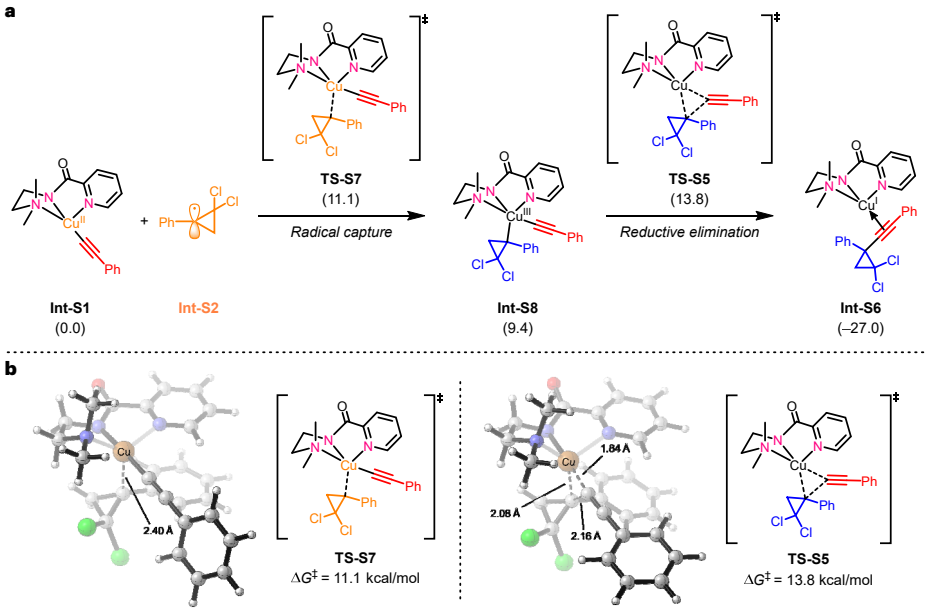
For Path B (radical substitution), both the open-shell singlet transition state **TS-S4**-*OSS* (**Supplementary Fig. 16a**) and the triplet transition state **TS-S4**-*Triplet* (**Supplementary Fig. 16b**) were located. Mulliken spin population analysis confirmed their respective open-shell singlet and triplet nature. The free energy barrier of radical substitution via **TS-S4**-*OSS* is favored by 1.0 kcal/mol compared to **TS-S4**-*Triplet*. The overall free energy barrier of C–C via the radical substitution pathway is 10.6 kcal/mol.

For Path (C–C reductive elimination), the pathway involves the radical capture via **TS-S7** to form a Cu(III) intermediate **Int-S8** and the following reductive elimination of **Int-S8** via **TS-S5**, presenting an overall free energy barrier of 13.8 kcal/mol (**Supplementary Fig. 17**). Compared to the radical substitution process, this pathway exhibits a higher energy barrier (10.6 kcal/mol via **TS-S4** vs 13.8 kcal/mol via **TS-S5**). Thus, the C–C reductive elimination pathway is not favored.

To sum up, the calculation results mentioned above support a radical substitution pathway with an open-shell singlet transition state **TS-S4**-*OSS*, resulting in a free energy barrier of 10.6 kcal/mol for the Cu-mediated C–C bond formation between tertiary cyclopropyl radical **Int-S2** and the phenylacetylene nucleophile.




**Supplementary Fig. 16 | Details of the located transition states in the radical substitution pathway. a**, Located open-shell singlet radical substitution transition state. **b**, Located triplet radical substitution transition state. Free energy barriers in kcal/mol are compared to the sum of **Int-S1** and **Int-S2**.



**Supplementary Fig. 17 | Detailed investigations on the sequential radical capture and reductive elimination pathway. a**, Located C–C reductive elimination pathway. **b**, Key radical capture and reductive elimination transition states. Free energies in kcal/mol shown in parentheses are compared to the sum of **Int-S1** and **Int-S2**.

## 3. Table of Energies

**Supplementary Table 13 |** Energies in **Supplementary Figs. 14**, **15**, **16**, and **17**. Zero-point correction (***ZPE***), thermal correction to enthalpy (***TCH***), thermal correction to Gibbs free energy (***TCG***), energies (***E***), enthalpies (***H***), and Gibbs free energies (***G***) (in Hartree) of the structures calculated at B3LYP-D3(BJ)/6-311+G(d,p)-SDD-SMD(Ether)//B3LYP-D3(BJ)/6-31G(d)-LANL2DZ level of theory.

| Structure | *ZPE* | *TCH* | *TCG* | *E* | *H* | *G* | Imaginary Frequency |
|---|---|---|---|---|---|---|---|
| **Int-S1** | 0.339674 | 0.362490 | 0.284300 | −1134.555782 | −1134.193292 | −1134.271482 | |
| **Int-S2** | 0.130367 | 0.141298 | 0.092211 | −1267.675745 | −1267.534447 | −1267.583534 | |
| **Int-S3**-*OSS* | 0.471441 | 0.506022 | 0.401859 | −2402.252078 | −2401.746056 | −2401.850219 | |
| **Int-S3**-*Triplet* | 0.471447 | 0.506026 | 0.400844 | −2402.252096 | −2401.746070 | −2401.851252 | |
| **TS-S4**-*OSS* | 0.471630 | 0.505136 | 0.405097 | −2402.240211 | −2401.735075 | −2401.835114 | 247.9*i* |
| **TS-S4**-*Triplet* | 0.471367 | 0.504911 | 0.403442 | −2402.236924 | −2401.732013 | −2401.833482 | 275.1*i* |
| **TS-S5** | 0.472434 | 0.505608 | 0.406174 | −2402.236131 | −2401.730523 | −2401.829957 | 178.5*i* |
| **Int-S6** | 0.472862 | 0.507061 | 0.403664 | −2402.298748 | −2401.791687 | −2401.895084 | |
| **TS-S7** | 0.471717 | 0.505267 | 0.404748 | −2402.239124 | −2401.733857 | −2401.834376 | 102.6*i* |
| **Int-S8** | 0.473359 | 0.507056 | 0.406563 | −2402.243643 | −2401.736587 | −2401.837080 | |

## 4. Cartesian Coordinates of Computed Species

### Int-S1

Charge = 0, Multiplicity = 2

| | | | |
|---|---|---|---|
| Cu | -0.79033000 | -0.47292100 | -0.06526300 |
| N | -2.69143000 | -0.74044500 | 0.01052300 |
| C | -2.75445100 | 1.61823500 | 0.00025800 |
| C | -3.52096100 | 0.31266000 | 0.07406900 |
| O | -4.75241300 | 0.31169700 | 0.18030800 |
| C | -3.39475800 | 2.85272800 | 0.01647200 |
| C | -0.65585000 | 2.62210700 | -0.12272300 |
| C | -2.61557000 | 4.00757900 | -0.04407100 |
| H | -4.47693700 | 2.86853600 | 0.07773600 |
| C | -1.22534100 | 3.89441700 | -0.11440600 |
| H | 0.41538400 | 2.45071300 | -0.16969500 |
| H | -3.08510700 | 4.98706300 | -0.03467700 |
| C | -3.21162800 | -2.08575000 | 0.09999600 |
| C | -2.15198400 | -3.00839900 | -0.50265800 |
| H | -3.42778000 | -2.36237700 | 1.14381800 |
| H | -2.15450400 | -2.88641200 | -1.59007300 |
| N | -0.79257100 | -2.62618700 | -0.03913700 |
| C | 0.25518300 | -3.21096200 | -0.89002200 |
| H | 0.08850400 | -2.90832900 | -1.92657700 |
| H | 1.22485200 | -2.82605300 | -0.57096700 |
| H | 0.24431100 | -4.30997300 | -0.82813100 |
| C | -0.56239800 | -2.98321600 | 1.37156200 |
| H | -0.59849300 | -4.07445600 | 1.51181400 |
| H | 0.41936300 | -2.60917500 | 1.67026900 |
| H | -1.32342000 | -2.51798300 | 2.00160800 |
| N | -1.41428400 | 1.52254600 | -0.06825500 |
| C | 1.12140400 | -0.20585700 | -0.05175500 |
| C | 2.33330700 | -0.01787300 | -0.02388800 |
| C | 3.74407000 | 0.19535200 | 0.00988900 |
| C | 4.41290000 | 0.40420800 | 1.23252700 |
| C | 4.50165700 | 0.20176000 | -1.17830800 |
| C | 5.78945400 | 0.61118100 | 1.26236800 |

| | | | |
|---|---|---|---|
| H | 3.83564700 | 0.40123200 | 2.15199400 |
| C | 5.87785500 | 0.41000200 | -1.14162100 |
| H | 3.99312100 | 0.04220300 | -2.12411700 |
| C | 6.52877600 | 0.61538500 | 0.07716800 |
| H | 6.28810700 | 0.77039000 | 2.21474700 |
| H | 6.44562000 | 0.41203600 | -2.06826400 |
| H | 7.60264900 | 0.77737500 | 0.10310400 |
| H | -0.58961100 | 4.77220700 | -0.16042500 |
| H | -2.34855800 | -4.06754200 | -0.27525000 |
| H | -4.15626900 | -2.19104400 | -0.44780000 |

## Int-S2

Charge = 0, Multiplicity = 2

| | | | |
|---|---|---|---|
| C | 1.27751400 | 1.74849300 | 0.00097300 |
| C | 0.26537700 | 0.68298900 | -0.00032600 |
| C | 1.63351800 | 0.26680700 | 0.00011900 |
| H | 1.47540100 | 2.31054900 | -0.91454600 |
| H | 1.47441800 | 2.30911600 | 0.91758500 |
| C | -1.07552400 | 0.28906700 | -0.00030300 |
| C | -1.41700200 | -1.09181000 | -0.00105100 |
| C | -2.12147300 | 1.25136100 | 0.00041700 |
| C | -2.74666000 | -1.48171300 | -0.00106000 |
| H | -0.61945200 | -1.82797600 | -0.00159100 |
| C | -3.44627700 | 0.84426100 | 0.00039700 |
| H | -1.86332000 | 2.30600200 | 0.00098900 |
| C | -3.76764000 | -0.52051400 | -0.00034400 |
| H | -2.99829700 | -2.53826300 | -0.00161900 |
| H | -4.23907900 | 1.58674000 | 0.00095900 |
| H | -4.80751300 | -0.83307400 | -0.00036600 |
| Cl | 2.35294300 | -0.44753500 | -1.48425800 |
| Cl | 2.35098900 | -0.44933200 | 1.48459000 |

## Int-S3-*OSS*

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | -1.67968300 | 1.02081800 | -0.40519200 |

| | | | |
|---|---|---|---|
| N | -3.49129200 | 0.36670800 | -0.37009300 |
| C | -2.50708000 | -1.56390900 | -1.29984400 |
| C | -3.74900600 | -0.89284400 | -0.75108900 |
| O | -4.82134200 | -1.50747600 | -0.69063800 |
| C | -2.52389100 | -2.86981300 | -1.77794900 |
| C | -0.22968200 | -1.35429100 | -1.73310600 |
| C | -1.33314000 | -3.42263500 | -2.24801100 |
| H | -3.46366800 | -3.40989400 | -1.76039200 |
| C | -0.16555500 | -2.65777000 | -2.22293100 |
| H | 0.63852600 | -0.70798500 | -1.66974000 |
| H | -1.31231900 | -4.44136800 | -2.62470900 |
| C | -4.53758500 | 1.19264800 | 0.18617000 |
| C | -3.86795900 | 2.20748900 | 1.11554000 |
| H | -5.10270900 | 1.70544300 | -0.60760900 |
| H | -3.58214200 | 1.70431000 | 2.04297900 |
| N | -2.61340400 | 2.73085800 | 0.51704500 |
| C | -1.76353400 | 3.38325700 | 1.52254500 |
| H | -1.55603700 | 2.67876100 | 2.33142100 |
| H | -0.81618800 | 3.65992200 | 1.05734300 |
| H | -2.25565000 | 4.27522000 | 1.93994100 |
| C | -2.87414900 | 3.64919900 | -0.60548700 |
| H | -3.40960000 | 4.54785000 | -0.26248600 |
| H | -1.91926400 | 3.94067700 | -1.04868700 |
| H | -3.47439400 | 3.14413000 | -1.36499200 |
| N | -1.37820600 | -0.83380700 | -1.29195000 |
| C | 0.12056500 | 1.71587200 | -0.52445100 |
| C | 1.29360500 | 2.07067300 | -0.57947600 |
| C | 2.66842800 | 2.44603600 | -0.62298700 |
| C | 3.18955100 | 3.39545500 | 0.27924100 |
| C | 3.55069000 | 1.84102300 | -1.54210500 |
| C | 4.54281000 | 3.72266800 | 0.26377800 |
| H | 2.51785400 | 3.86382900 | 0.99226000 |
| C | 4.90336200 | 2.17091300 | -1.55056500 |
| H | 3.16064400 | 1.10101600 | -2.23283000 |
| C | 5.40636800 | 3.11200100 | -0.64903900 |
| H | 4.92666700 | 4.45523500 | 0.96866400 |
| H | 5.56837200 | 1.68752200 | -2.26072100 |

| | | | |
|---|---|---|---|
| H | 6.46242800 | 3.36584100 | -0.65620300 |
| H | 0.78437200 | -3.05672900 | -2.56002200 |
| H | -4.54375200 | 3.03786800 | 1.37314600 |
| H | -5.26680600 | 0.59489900 | 0.74714500 |
| C | 3.15308700 | -0.49299500 | 1.34469300 |
| C | 1.88786700 | -1.22665700 | 1.20621500 |
| C | 3.06108300 | -1.86406700 | 0.69292300 |
| H | 3.36274000 | 0.35764500 | 0.69592800 |
| H | 3.63359700 | -0.43827800 | 2.32450900 |
| C | 0.54190300 | -1.38198800 | 1.55014600 |
| C | -0.14230300 | -2.59332600 | 1.25966200 |
| C | -0.17432100 | -0.32836400 | 2.17951100 |
| C | -1.48620500 | -2.73191300 | 1.57145700 |
| H | 0.40342000 | -3.40069700 | 0.78342300 |
| C | -1.51491600 | -0.48948500 | 2.49378300 |
| H | 0.34171900 | 0.60355200 | 2.38201500 |
| C | -2.18306700 | -1.68316700 | 2.18551600 |
| H | -2.00395700 | -3.65484000 | 1.33062800 |
| H | -2.05387000 | 0.31677700 | 2.98209000 |
| H | -3.24042100 | -1.78952100 | 2.40513300 |
| Cl | 3.31931600 | -1.98228700 | -1.09181500 |
| Cl | 3.75484500 | -3.29156400 | 1.53402700 |

**Int-S3**-*Triplet*

Charge = 0, Multiplicity = 3

| | | | |
|---|---|---|---|
| Cu | -1.68148900 | 1.01906400 | -0.40550600 |
| N | -3.49186900 | 0.36168000 | -0.36944200 |
| C | -2.50451800 | -1.56758600 | -1.29868600 |
| C | -3.74745300 | -0.89849300 | -0.74985300 |
| O | -4.81868200 | -1.51497400 | -0.68873300 |
| C | -2.51917700 | -2.87375200 | -1.77614400 |
| C | -0.22761100 | -1.35421200 | -1.73260400 |
| C | -1.32758900 | -3.42471800 | -2.24627100 |
| H | -3.45799200 | -3.41548600 | -1.75801800 |
| C | -0.16133800 | -2.65780300 | -2.22186000 |
| H | 0.63953200 | -0.70642900 | -1.66958100 |

| | | | |
|---|---|---|---|
| H | -1.30509000 | -4.44359300 | -2.62248500 |
| C | -4.53957600 | 1.18581400 | 0.18688800 |
| C | -3.87150300 | 2.20322500 | 1.11455500 |
| H | -5.10660300 | 1.69638900 | -0.60695900 |
| H | -3.58402100 | 1.70182400 | 2.04246900 |
| N | -2.61857200 | 2.72863100 | 0.51454700 |
| C | -1.76961400 | 3.38456500 | 1.51849700 |
| H | -1.56011000 | 2.68188000 | 2.32842800 |
| H | -0.82312400 | 3.66256300 | 1.05233800 |
| H | -2.26345600 | 4.27613400 | 1.93470500 |
| C | -2.88210300 | 3.64455900 | -0.60927500 |
| H | -3.41952300 | 4.54247900 | -0.26743100 |
| H | -1.92815400 | 3.93765600 | -1.05343400 |
| H | -3.48150300 | 3.13687200 | -1.36769800 |
| N | -1.37692300 | -0.83552100 | -1.29144700 |
| C | 0.11754800 | 1.71699000 | -0.52595200 |
| C | 1.29059400 | 2.07177700 | -0.58094300 |
| C | 2.66547600 | 2.44688600 | -0.62382300 |
| C | 3.18701800 | 3.39395000 | 0.28064200 |
| C | 3.54749800 | 1.84357300 | -1.54428500 |
| C | 4.54045400 | 3.72048400 | 0.26605800 |
| H | 2.51550800 | 3.86096500 | 0.99472500 |
| C | 4.90034300 | 2.17277600 | -1.55187100 |
| H | 3.15713600 | 1.10536500 | -2.23675400 |
| C | 5.40377300 | 3.11148100 | -0.64809900 |
| H | 4.92463700 | 4.45119600 | 0.97268900 |
| H | 5.56516400 | 1.69066700 | -2.26307300 |
| H | 6.45997300 | 3.36475400 | -0.65455600 |
| H | 0.78920300 | -3.05527200 | -2.55896800 |
| H | -4.54898000 | 3.03240300 | 1.37164100 |
| H | -5.26691600 | 0.58699000 | 0.74916500 |
| C | 3.15555500 | -0.48862700 | 1.34386400 |
| C | 1.89011200 | -1.22191900 | 1.20507700 |
| C | 3.06343200 | -1.85998100 | 0.69277900 |
| H | 3.36603600 | 0.36158700 | 0.69482400 |
| H | 3.63543800 | -0.43361300 | 2.32397300 |
| C | 0.54442200 | -1.37759300 | 1.54990600 |

| | | | |
|---|---|---|---|
| C | -0.13931400 | -2.58961500 | 1.26104800 |
| C | -0.17207400 | -0.32375000 | 2.17858500 |
| C | -1.48289000 | -2.72871100 | 1.57395100 |
| H | 0.40655800 | -3.39714600 | 0.78525700 |
| C | -1.51238300 | -0.48534900 | 2.49391400 |
| H | 0.34350900 | 0.60871300 | 2.37971900 |
| C | -2.18000600 | -1.67974000 | 2.18738400 |
| H | -2.00025600 | -3.65219800 | 1.33443700 |
| H | -2.05147200 | 0.32116300 | 2.98166700 |
| H | -3.23713000 | -1.78657000 | 2.40786500 |
| Cl | 3.32267700 | -1.97929600 | -1.09171600 |
| Cl | 3.75622600 | -3.28725000 | 1.53513300 |

**TS-S4**-*OSS*

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | 0.86618400 | -0.99897400 | -0.57078900 |
| N | 2.76755000 | -1.29689200 | -0.73201100 |
| C | 2.72549400 | 0.84369500 | -1.71798700 |
| C | 3.54941400 | -0.32798800 | -1.22415900 |
| O | 4.78436500 | -0.30055000 | -1.30119800 |
| C | 3.31595000 | 1.99586500 | -2.22557500 |
| C | 0.58815400 | 1.71862500 | -2.01752400 |
| C | 2.49184100 | 3.04559700 | -2.63129800 |
| H | 4.39802200 | 2.03588000 | -2.27710900 |
| C | 1.10607000 | 2.90706000 | -2.52960600 |
| H | -0.47482900 | 1.55251700 | -1.88993300 |
| H | 2.92359400 | 3.96308700 | -3.02084900 |
| C | 3.35114800 | -2.51069700 | -0.21299400 |
| C | 2.31427900 | -3.15256500 | 0.71127800 |
| H | 3.63303800 | -3.19694800 | -1.02664100 |
| H | 2.30282100 | -2.61166300 | 1.66027000 |
| N | 0.94397200 | -3.03043000 | 0.14905700 |
| C | -0.07159300 | -3.38864500 | 1.14804200 |
| H | 0.06688700 | -2.77007300 | 2.03537000 |
| H | -1.06159300 | -3.18680100 | 0.73664600 |
| H | 0.00987400 | -4.45059900 | 1.42720600 |

| | | | |
|---|---|---|---|
| C | 0.76354000 | -3.84090500 | -1.06830200 |
| H | 0.88340100 | -4.91303300 | -0.84846600 |
| H | -0.24097100 | -3.66497700 | -1.46173000 |
| H | 1.49478600 | -3.54562300 | -1.82280300 |
| N | 1.38886200 | 0.72515300 | -1.62021400 |
| C | -1.04147400 | -0.68628200 | -0.35679100 |
| C | -2.26069600 | -0.84295400 | -0.49852300 |
| C | -3.66596000 | -0.98244900 | -0.59996800 |
| C | -4.37176600 | -1.82406200 | 0.28976200 |
| C | -4.39741500 | -0.27763300 | -1.58176100 |
| C | -5.75383000 | -1.95106200 | 0.19932200 |
| H | -3.81613700 | -2.36738900 | 1.04835400 |
| C | -5.77864800 | -0.41190700 | -1.66505800 |
| H | -3.86153900 | 0.37381900 | -2.26351500 |
| C | -6.46396800 | -1.24706300 | -0.77734900 |
| H | -6.28109900 | -2.60063500 | 0.89258200 |
| H | -6.32682000 | 0.13909300 | -2.42418000 |
| H | -7.54324900 | -1.34755000 | -0.84573200 |
| H | 0.43286600 | 3.70322900 | -2.82821300 |
| H | 2.54747000 | -4.20998300 | 0.91321300 |
| H | 4.27054400 | -2.30614200 | 0.35056800 |
| C | -2.07797200 | 1.05697200 | 2.05203400 |
| C | -0.78060300 | 0.92906200 | 1.33745500 |
| C | -1.55596300 | 2.15369200 | 1.15526500 |
| H | -2.93409500 | 0.49649000 | 1.67895400 |
| H | -2.08216000 | 1.24534600 | 3.12599700 |
| C | 0.55287000 | 0.73675100 | 1.85071100 |
| C | 1.64733100 | 1.48238800 | 1.36399900 |
| C | 0.79496900 | -0.24740200 | 2.83167400 |
| C | 2.93825100 | 1.21489300 | 1.80558600 |
| H | 1.46966900 | 2.26366100 | 0.63459600 |
| C | 2.08746600 | -0.50096200 | 3.28077100 |
| H | -0.04892200 | -0.79924900 | 3.23546000 |
| C | 3.16797100 | 0.21652200 | 2.75662800 |
| H | 3.77261400 | 1.77825500 | 1.39902500 |
| H | 2.25556400 | -1.25802200 | 4.04242400 |
| H | 4.17874300 | 0.00742400 | 3.09345800 |

| | | | |
|---|---|---|---|
| Cl | -2.44853500 | 2.54452700 | -0.35409300 |
| Cl | -0.96996900 | 3.66773400 | 1.92855800 |

**TS-S4**-*Triplet*

Charge = 0, Multiplicity = 3

| | | | |
|---|---|---|---|
| Cu | 0.90399500 | -0.92526900 | -0.62144000 |
| N | 2.80226000 | -1.21334900 | -0.78518800 |
| C | 2.76894000 | 0.95720000 | -1.70710400 |
| C | 3.58742500 | -0.22786200 | -1.24096000 |
| O | 4.82286100 | -0.20143600 | -1.30040800 |
| C | 3.36203900 | 2.12437400 | -2.17510500 |
| C | 0.63248000 | 1.83853900 | -1.99272400 |
| C | 2.53901800 | 3.18452000 | -2.55583900 |
| H | 4.44438400 | 2.16776000 | -2.21770000 |
| C | 1.15308100 | 3.04205600 | -2.46592100 |
| H | -0.43100300 | 1.66874500 | -1.87487100 |
| H | 2.97214700 | 4.11342300 | -2.91553200 |
| C | 3.38651200 | -2.43461500 | -0.28122400 |
| C | 2.33368100 | -3.10790200 | 0.60014400 |
| H | 3.69605200 | -3.09657600 | -1.10445900 |
| H | 2.28898100 | -2.59054800 | 1.56152700 |
| N | 0.97864300 | -2.98680700 | 0.00052700 |
| C | -0.05762000 | -3.38984400 | 0.96100500 |
| H | 0.03567100 | -2.78074400 | 1.86059400 |
| H | -1.04000000 | -3.21071700 | 0.52252000 |
| H | 0.04737000 | -4.45354800 | 1.22496200 |
| C | 0.84628000 | -3.76020900 | -1.24662100 |
| H | 0.98471700 | -4.83615200 | -1.05881600 |
| H | -0.15214900 | -3.59455600 | -1.65933400 |
| H | 1.58846000 | -3.42441800 | -1.97281800 |
| N | 1.43187200 | 0.83331900 | -1.62256700 |
| C | -1.00373100 | -0.58589300 | -0.34767600 |
| C | -2.21832100 | -0.78284700 | -0.54542900 |
| C | -3.61285700 | -0.94783900 | -0.67510800 |
| C | -4.30549700 | -1.88988900 | 0.12419500 |
| C | -4.35455600 | -0.18179000 | -1.60599200 |

| | | | |
|---|---|---|---|
| C | -5.67942100 | -2.05360500 | -0.00464900 |
| H | -3.74396900 | -2.47792900 | 0.84398200 |
| C | -5.72780600 | -0.35457000 | -1.72643000 |
| H | -3.83089100 | 0.54600600 | -2.21583900 |
| C | -6.39802400 | -1.28870100 | -0.92935800 |
| H | -6.19570900 | -2.77887600 | 0.61824100 |
| H | -6.28309400 | 0.24356900 | -2.44352100 |
| H | -7.47184200 | -1.41854200 | -1.02706000 |
| H | 0.48115600 | 3.84678900 | -2.74357500 |
| H | 2.57240500 | -4.16752700 | 0.78298300 |
| H | 4.28915600 | -2.23341700 | 0.30937900 |
| C | -2.20108000 | 1.00472900 | 2.04700900 |
| C | -0.88400400 | 0.82867200 | 1.37278600 |
| C | -1.58461400 | 2.10220800 | 1.22008300 |
| H | -3.07019700 | 0.50497300 | 1.61951300 |
| H | -2.24022700 | 1.15143500 | 3.12661200 |
| C | 0.41100300 | 0.56854000 | 1.96218700 |
| C | 1.56776600 | 1.24212600 | 1.51878100 |
| C | 0.55283700 | -0.41879500 | 2.95798100 |
| C | 2.82062200 | 0.91434800 | 2.02788300 |
| H | 1.46791600 | 2.02347800 | 0.77495300 |
| C | 1.80691200 | -0.73366700 | 3.47534900 |
| H | -0.33710000 | -0.92322500 | 3.32391400 |
| C | 2.94916300 | -0.07788400 | 3.00365800 |
| H | 3.70219600 | 1.42807500 | 1.65604600 |
| H | 1.89567200 | -1.49094800 | 4.25007900 |
| H | 3.92845600 | -0.33164700 | 3.39836700 |
| Cl | -2.40204900 | 2.60427500 | -0.30669600 |
| Cl | -0.95254400 | 3.55448200 | 2.07198600 |

## TS-S5

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | 0.85633700 | -0.85851900 | -0.27693900 |
| N | 2.72720700 | -1.10107100 | 0.24030400 |
| C | 3.05395100 | 1.00828500 | -0.84305700 |
| C | 3.64981700 | -0.24867000 | -0.24194600 |

| | | | |
|---|---|---|---|
| O | 4.87937800 | -0.41089400 | -0.28639000 |
| C | 3.82659000 | 2.15517700 | -1.02383900 |
| C | 1.19259600 | 2.02868100 | -1.76991300 |
| C | 3.22779800 | 3.28143100 | -1.58193700 |
| H | 4.86670300 | 2.13031900 | -0.71983700 |
| C | 1.88375900 | 3.22290800 | -1.95785200 |
| H | 0.14463000 | 1.92154500 | -2.03489400 |
| H | 3.79711400 | 4.19647300 | -1.71966600 |
| C | 3.14287100 | -2.48516400 | 0.40018100 |
| C | 1.99543900 | -3.40345600 | -0.07020500 |
| H | 4.06027000 | -2.66454000 | -0.17336700 |
| H | 1.27066300 | -3.55371700 | 0.73733900 |
| N | 1.23858000 | -2.79718900 | -1.19295100 |
| C | 0.01881700 | -3.55940500 | -1.48624100 |
| H | -0.59185000 | -3.62751500 | -0.58403300 |
| H | -0.55915300 | -3.03104000 | -2.24788400 |
| H | 0.25681600 | -4.57324800 | -1.84604900 |
| C | 2.06214300 | -2.65319200 | -2.40222700 |
| H | 2.38272300 | -3.63667400 | -2.78220100 |
| H | 1.47372800 | -2.14927600 | -3.17340100 |
| H | 2.94232900 | -2.04796000 | -2.18535100 |
| N | 1.76882700 | 0.94900700 | -1.23264300 |
| C | -0.94265400 | -0.55622100 | -0.54383500 |
| C | -2.08612100 | -0.30527400 | -0.90204600 |
| C | -3.41422900 | -0.00564900 | -1.30580600 |
| C | -4.45666100 | -0.92918200 | -1.08778000 |
| C | -3.71749200 | 1.23416500 | -1.90485500 |
| C | -5.76017900 | -0.61827400 | -1.46176200 |
| H | -4.22500100 | -1.87851000 | -0.61595400 |
| C | -5.02453800 | 1.53679700 | -2.27454100 |
| H | -2.91593000 | 1.94793700 | -2.06868200 |
| C | -6.04972300 | 0.61285200 | -2.05662400 |
| H | -6.55548600 | -1.33721000 | -1.28635700 |
| H | -5.24548300 | 2.49587300 | -2.73463800 |
| H | -7.06883600 | 0.85145500 | -2.34676800 |
| H | 1.37937200 | 4.08279100 | -2.38605200 |
| H | 2.38089400 | -4.39635800 | -0.35542800 |

| | | | |
|---|---|---|---|
| H | 3.38132800 | -2.73842100 | 1.44362200 |
| C | 0.48764700 | -0.84904100 | 2.56085100 |
| C | -0.11701400 | -0.07638600 | 1.39030100 |
| C | -0.99095400 | -0.83917100 | 2.34302300 |
| H | 1.00719400 | -1.78400200 | 2.39167800 |
| H | 0.89197200 | -0.24758500 | 3.37173600 |
| C | -0.02282100 | 1.39897100 | 1.37007400 |
| C | -1.11356300 | 2.20706600 | 1.01494000 |
| C | 1.20656700 | 2.00355400 | 1.66938200 |
| C | -0.97201500 | 3.59084700 | 0.96513000 |
| H | -2.06351500 | 1.74479900 | 0.77643500 |
| C | 1.34907000 | 3.38760900 | 1.60698500 |
| H | 2.05555100 | 1.37491200 | 1.91805800 |
| C | 0.25968100 | 4.18571200 | 1.25419800 |
| H | -1.82525000 | 4.20800400 | 0.69773700 |
| H | 2.31235200 | 3.83961100 | 1.82337900 |
| H | 0.36828500 | 5.26554100 | 1.20456100 |
| Cl | -1.73370100 | -2.38797500 | 1.86454100 |
| Cl | -2.03484100 | 0.06362000 | 3.46203500 |

## Int-S6

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | -0.68719000 | 0.61981500 | 0.24101500 |
| N | 0.19843200 | 2.21245200 | 0.93506500 |
| C | 1.27781600 | 0.81170500 | 2.54804300 |
| C | 1.13443700 | 2.17449800 | 1.88088100 |
| O | 1.89864600 | 3.09317000 | 2.23753700 |
| C | 2.34681200 | 0.60044500 | 3.42285000 |
| C | 0.56306700 | -1.37085200 | 2.80862700 |
| C | 2.51517900 | -0.65759800 | 3.99580000 |
| H | 3.01342400 | 1.43241900 | 3.61651000 |
| C | 1.60791200 | -1.67047700 | 3.68204600 |
| H | -0.16462700 | -2.12855900 | 2.52725800 |
| H | 3.34348800 | -0.84919600 | 4.67255500 |
| C | -0.03167800 | 3.46522900 | 0.25683900 |
| C | -0.89349800 | 3.21128300 | -0.98721000 |

| | | | |
|---|---|---|---|
| H | -0.51908800 | 4.19098200 | 0.92681500 |
| H | -0.26559400 | 2.75128300 | -1.75837000 |
| N | -2.00647900 | 2.27216500 | -0.73471600 |
| C | -2.65372800 | 1.88204100 | -1.98349200 |
| H | -1.91304400 | 1.42176400 | -2.64487400 |
| H | -3.43598200 | 1.14600000 | -1.77497900 |
| H | -3.10997300 | 2.74046600 | -2.50859900 |
| C | -2.97801000 | 2.79987600 | 0.22309700 |
| H | -3.45524700 | 3.72943600 | -0.13572900 |
| H | -3.75610400 | 2.04901600 | 0.39321000 |
| H | -2.47979500 | 3.00059500 | 1.17390100 |
| N | 0.39338900 | -0.16401500 | 2.25742300 |
| C | -0.34802500 | -1.09613200 | -1.00971800 |
| C | -1.50160300 | -1.12416400 | -0.57367100 |
| C | -2.87515300 | -1.29152500 | -0.20069100 |
| C | -3.83351500 | -1.66801300 | -1.15929300 |
| C | -3.28285700 | -1.03611200 | 1.12308500 |
| C | -5.17314900 | -1.78413200 | -0.79753400 |
| H | -3.51620100 | -1.85836000 | -2.17955300 |
| C | -4.62470500 | -1.15552500 | 1.47395400 |
| H | -2.53906600 | -0.73949700 | 1.85685800 |
| C | -5.57228600 | -1.52684600 | 0.51651800 |
| H | -5.90806700 | -2.07343000 | -1.54297700 |
| H | -4.93178400 | -0.95605500 | 2.49628800 |
| H | -6.61863800 | -1.61559400 | 0.79325700 |
| H | 1.70458000 | -2.66840600 | 4.09770400 |
| H | -1.27529600 | 4.16712500 | -1.38929500 |
| H | 0.90850700 | 3.93819900 | -0.06119800 |
| C | 1.11936200 | -2.46582700 | -2.57440700 |
| C | 0.96017800 | -1.28692400 | -1.60263000 |
| C | 1.72579600 | -2.55834000 | -1.21668500 |
| H | 0.24531800 | -3.07667900 | -2.77395400 |
| H | 1.79735600 | -2.31938800 | -3.40916400 |
| C | 1.70486800 | -0.00225100 | -1.85930300 |
| C | 2.35812000 | 0.64271700 | -0.80528700 |
| C | 1.63108500 | 0.61504200 | -3.11059000 |
| C | 2.92395000 | 1.90175900 | -0.99299800 |

| | | | |
|---|---|---|---|
| H | 2.40258900 | 0.16686900 | 0.16703100 |
| C | 2.20188000 | 1.87439000 | -3.30283300 |
| H | 1.11533400 | 0.11690000 | -3.92745900 |
| C | 2.84216100 | 2.52035900 | -2.24194800 |
| H | 3.37848600 | 2.41208200 | -0.14981200 |
| H | 2.14049600 | 2.35213500 | -4.27655400 |
| H | 3.27250400 | 3.50701100 | -2.38754500 |
| Cl | 1.00253800 | -3.67342100 | -0.04277600 |
| Cl | 3.48816100 | -2.48122900 | -1.07346900 |

## TS-S7

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | 0.83802000 | -0.79623900 | -0.53598300 |
| N | 2.64523300 | -1.06732100 | 0.06457400 |
| C | 3.01265800 | 1.11910400 | -0.80981400 |
| C | 3.58633100 | -0.14446400 | -0.21022900 |
| O | 4.80970300 | -0.26365300 | -0.06007600 |
| C | 3.78783000 | 2.26134100 | -0.98937700 |
| C | 1.14297800 | 2.14369400 | -1.72725200 |
| C | 3.19005300 | 3.38573700 | -1.55560000 |
| H | 4.82662100 | 2.23475600 | -0.68066800 |
| C | 1.84499900 | 3.33147200 | -1.92599300 |
| H | 0.09384800 | 2.03145600 | -1.98251300 |
| H | 3.76284600 | 4.29697400 | -1.70293500 |
| C | 3.08315800 | -2.43360800 | 0.29116600 |
| C | 1.94133500 | -3.38020300 | -0.11296500 |
| H | 3.99495600 | -2.63030900 | -0.28701800 |
| H | 1.22112600 | -3.48001900 | 0.70453000 |
| N | 1.18425000 | -2.83680400 | -1.26422800 |
| C | -0.03531500 | -3.61152600 | -1.52584800 |
| H | -0.64471700 | -3.64391900 | -0.62323100 |
| H | -0.61360800 | -3.11311000 | -2.30579100 |
| H | 0.20988100 | -4.63763900 | -1.84294000 |
| C | 2.00417500 | -2.74855500 | -2.48238100 |
| H | 2.33292200 | -3.74774700 | -2.81012200 |
| H | 1.40694900 | -2.29366000 | -3.27676500 |

| | | | |
|---|---|---|---|
| H | 2.87851400 | -2.12288800 | -2.30097200 |
| N | 1.72550100 | 1.06925900 | -1.19017600 |
| C | -0.97326900 | -0.51630400 | -1.03532900 |
| C | -2.15269800 | -0.25874000 | -1.24101100 |
| C | -3.53663800 | 0.05501800 | -1.37382400 |
| C | -4.38841500 | -0.06014300 | -0.25532600 |
| C | -4.08179600 | 0.50138100 | -2.59307200 |
| C | -5.73811900 | 0.26566100 | -0.35824500 |
| H | -3.97329900 | -0.40986000 | 0.68514500 |
| C | -5.43342700 | 0.82255900 | -2.68838500 |
| H | -3.43114200 | 0.59097100 | -3.45764700 |
| C | -6.26719700 | 0.70785000 | -1.57330200 |
| H | -6.38038000 | 0.17230900 | 0.51332100 |
| H | -5.83879300 | 1.16482800 | -3.63684000 |
| H | -7.32093900 | 0.96025600 | -1.65107100 |
| H | 1.34444600 | 4.19078000 | -2.35951400 |
| H | 2.32846300 | -4.38664900 | -0.34166000 |
| H | 3.34739000 | -2.62183500 | 1.34189600 |
| C | 0.68475100 | -0.93418000 | 2.76132200 |
| C | 0.13131900 | -0.10430500 | 1.65342200 |
| C | -0.78748500 | -0.97269000 | 2.40050400 |
| H | 1.25962800 | -1.82684000 | 2.53330400 |
| H | 0.97461900 | -0.43345100 | 3.68484400 |
| C | 0.14964900 | 1.32757000 | 1.51649800 |
| C | -0.98553500 | 2.03881200 | 1.07072800 |
| C | 1.33466400 | 2.03659100 | 1.80510200 |
| C | -0.93192400 | 3.41920000 | 0.93467400 |
| H | -1.88631800 | 1.49183900 | 0.82303400 |
| C | 1.38316200 | 3.41709200 | 1.65543700 |
| H | 2.21060800 | 1.48388600 | 2.12990200 |
| C | 0.25045400 | 4.11310200 | 1.22118900 |
| H | -1.81154200 | 3.96010900 | 0.59785800 |
| H | 2.30347300 | 3.95185000 | 1.86991600 |
| H | 0.28881700 | 5.19237900 | 1.10363400 |
| Cl | -1.43661300 | -2.48544100 | 1.71573200 |
| Cl | -1.96595500 | -0.22156100 | 3.51442600 |

## Int-S8

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | 0.77135300 | -0.85755700 | -0.27791000 |
| N | 2.66194100 | -0.97739000 | 0.01565800 |
| C | 2.79859600 | 1.20330600 | -0.99348000 |
| C | 3.49513700 | -0.02553600 | -0.45837000 |
| O | 4.72852400 | -0.11167000 | -0.53570700 |
| C | 3.49058000 | 2.40035000 | -1.17508700 |
| C | 0.83729400 | 2.11629500 | -1.80836500 |
| C | 2.79536500 | 3.49640100 | -1.67987700 |
| H | 4.54206300 | 2.43916200 | -0.91459900 |
| C | 1.44203000 | 3.35808400 | -1.99559500 |
| H | -0.21266800 | 1.94577900 | -2.02868600 |
| H | 3.29755500 | 4.44943900 | -1.82024600 |
| C | 3.17104700 | -2.34103500 | 0.06460900 |
| C | 2.08878900 | -3.28892700 | -0.49115200 |
| H | 4.09988800 | -2.39350900 | -0.51401800 |
| H | 1.43165600 | -3.62331300 | 0.31623900 |
| N | 1.21694100 | -2.59191500 | -1.47040400 |
| C | 0.03281200 | -3.40337500 | -1.79091000 |
| H | -0.51842300 | -3.61642400 | -0.87388600 |
| H | -0.62054700 | -2.83499200 | -2.45443000 |
| H | 0.32638500 | -4.34678700 | -2.27658200 |
| C | 1.93432300 | -2.22404700 | -2.70149200 |
| H | 2.24601100 | -3.12465000 | -3.25295400 |
| H | 1.26983700 | -1.62867400 | -3.33187400 |
| H | 2.81370800 | -1.62799000 | -2.46144700 |
| N | 1.50675500 | 1.06498700 | -1.32913000 |
| C | -1.05917300 | -0.71102400 | -0.62402500 |
| C | -2.23666600 | -0.49811500 | -0.87123000 |
| C | -3.59748500 | -0.17960600 | -1.14865500 |
| C | -4.59219500 | -1.17577500 | -1.17321800 |
| C | -3.97435300 | 1.15805400 | -1.38475700 |
| C | -5.91975900 | -0.84180700 | -1.42679400 |
| H | -4.30738500 | -2.20627700 | -0.98589400 |
| C | -5.30393800 | 1.48471800 | -1.63613900 |

| | | | |
|---|---|---|---|
| H | -3.20955800 | 1.92870800 | -1.36224100 |
| C | -6.28181300 | 0.48730200 | -1.65960100 |
| H | -6.67653600 | -1.62130200 | -1.44089900 |
| H | -5.57924300 | 2.52060400 | -1.81493300 |
| H | -7.31874000 | 0.74400000 | -1.85652800 |
| H | 0.86425600 | 4.19307000 | -2.37789000 |
| H | 2.53963600 | -4.18340300 | -0.94966900 |
| H | 3.42388100 | -2.65953200 | 1.08568800 |
| C | 1.11468400 | -0.69471800 | 2.68425200 |
| C | 0.33201500 | -0.07900400 | 1.54819500 |
| C | -0.34924400 | -0.99237900 | 2.50872400 |
| H | 1.81065300 | -1.50223800 | 2.48905500 |
| H | 1.39986200 | -0.03572200 | 3.50202300 |
| C | 0.11919700 | 1.37235700 | 1.46976900 |
| C | -1.14105100 | 1.92795900 | 1.19022400 |
| C | 1.21759700 | 2.22911000 | 1.64429000 |
| C | -1.29094200 | 3.30704500 | 1.08813300 |
| H | -1.98829700 | 1.27056900 | 1.04793000 |
| C | 1.06752100 | 3.60855800 | 1.52698400 |
| H | 2.19242800 | 1.79990300 | 1.85322500 |
| C | -0.18777000 | 4.15201900 | 1.24750600 |
| H | -2.27247200 | 3.72520200 | 0.88236700 |
| H | 1.92993900 | 4.25715700 | 1.64895800 |
| H | -0.30785800 | 5.22809300 | 1.15758000 |
| Cl | -0.77992700 | -2.65518600 | 2.02048100 |
| Cl | -1.51939600 | -0.33783800 | 3.67612100 |

## Proposed Pre-intermediate of Ion-type Bond Formation

Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | 0.90399500 | -0.92526900 | -0.62144000 |
| N | 2.80226000 | -1.21334900 | -0.78518800 |
| C | 2.76894000 | 0.95720000 | -1.70710400 |
| C | 3.58742500 | -0.22786200 | -1.24096000 |
| O | 4.82286100 | -0.20143600 | -1.30040800 |
| C | 3.36203900 | 2.12437400 | -2.17510500 |
| C | 0.63248000 | 1.83853900 | -1.99272400 |

| | | | |
|---|---|---|---|
| C | 2.53901800 | 3.18452000 | -2.55583900 |
| H | 4.44438400 | 2.16776000 | -2.21770000 |
| C | 1.15308100 | 3.04205600 | -2.46592100 |
| H | -0.43100300 | 1.66874500 | -1.87487100 |
| H | 2.97214700 | 4.11342300 | -2.91553200 |
| C | 3.38651200 | -2.43461500 | -0.28122400 |
| C | 2.33368100 | -3.10790200 | 0.60014400 |
| H | 3.69605200 | -3.09657600 | -1.10445900 |
| H | 2.28898100 | -2.59054800 | 1.56152700 |
| N | 0.97864300 | -2.98680700 | 0.00052700 |
| C | -0.05762000 | -3.38984400 | 0.96100500 |
| H | 0.03567100 | -2.78074400 | 1.86059400 |
| H | -1.04000000 | -3.21071700 | 0.52252000 |
| H | 0.04737000 | -4.45354800 | 1.22496200 |
| C | 0.84628000 | -3.76020900 | -1.24662100 |
| H | 0.98471700 | -4.83615200 | -1.05881600 |
| H | -0.15214900 | -3.59455600 | -1.65933400 |
| H | 1.58846000 | -3.42441800 | -1.97281800 |
| N | 1.43187200 | 0.83331900 | -1.62256700 |
| C | -1.00373100 | -0.58589300 | -0.34767600 |
| C | -2.21832100 | -0.78284700 | -0.54542900 |
| C | -3.61285700 | -0.94783900 | -0.67510800 |
| C | -4.30549700 | -1.88988900 | 0.12419500 |
| C | -4.35455600 | -0.18179000 | -1.60599200 |
| C | -5.67942100 | -2.05360500 | -0.00464900 |
| H | -3.74396900 | -2.47792900 | 0.84398200 |
| C | -5.72780600 | -0.35457000 | -1.72643000 |
| H | -3.83089100 | 0.54600600 | -2.21583900 |
| C | -6.39802400 | -1.28870100 | -0.92935800 |
| H | -6.19570900 | -2.77887600 | 0.61824100 |
| H | -6.28309400 | 0.24356900 | -2.44352100 |
| H | -7.47184200 | -1.41854200 | -1.02706000 |
| H | 0.48115600 | 3.84678900 | -2.74357500 |
| H | 2.57240500 | -4.16752700 | 0.78298300 |
| H | 4.28915600 | -2.23341700 | 0.30937900 |
| C | -2.20108000 | 1.00472900 | 2.04700900 |
| C | -0.88400400 | 0.82867200 | 1.37278600 |

| | | | |
|---|---|---|---|
| C | -1.58461400 | 2.10220800 | 1.22008300 |
| H | -3.07019700 | 0.50497300 | 1.61951300 |
| H | -2.24022700 | 1.15143500 | 3.12661200 |
| C | 0.41100300 | 0.56854000 | 1.96218700 |
| C | 1.56776600 | 1.24212600 | 1.51878100 |
| C | 0.55283700 | -0.41879500 | 2.95798100 |
| C | 2.82062200 | 0.91434800 | 2.02788300 |
| H | 1.46791600 | 2.02347800 | 0.77495300 |
| C | 1.80691200 | -0.73366700 | 3.47534900 |
| H | -0.33710000 | -0.92322500 | 3.32391400 |
| C | 2.94916300 | -0.07788400 | 3.00365800 |
| H | 3.70219600 | 1.42807500 | 1.65604600 |
| H | 1.89567200 | -1.49094800 | 4.25007900 |
| H | 3.92845600 | -0.33164700 | 3.39836700 |
| Cl | -2.40204900 | 2.60427500 | -0.30669600 |
| Cl | -0.95254400 | 3.55448200 | 2.07198600 |

## Proposed Transition State Structure of Ion-type Bond Formation

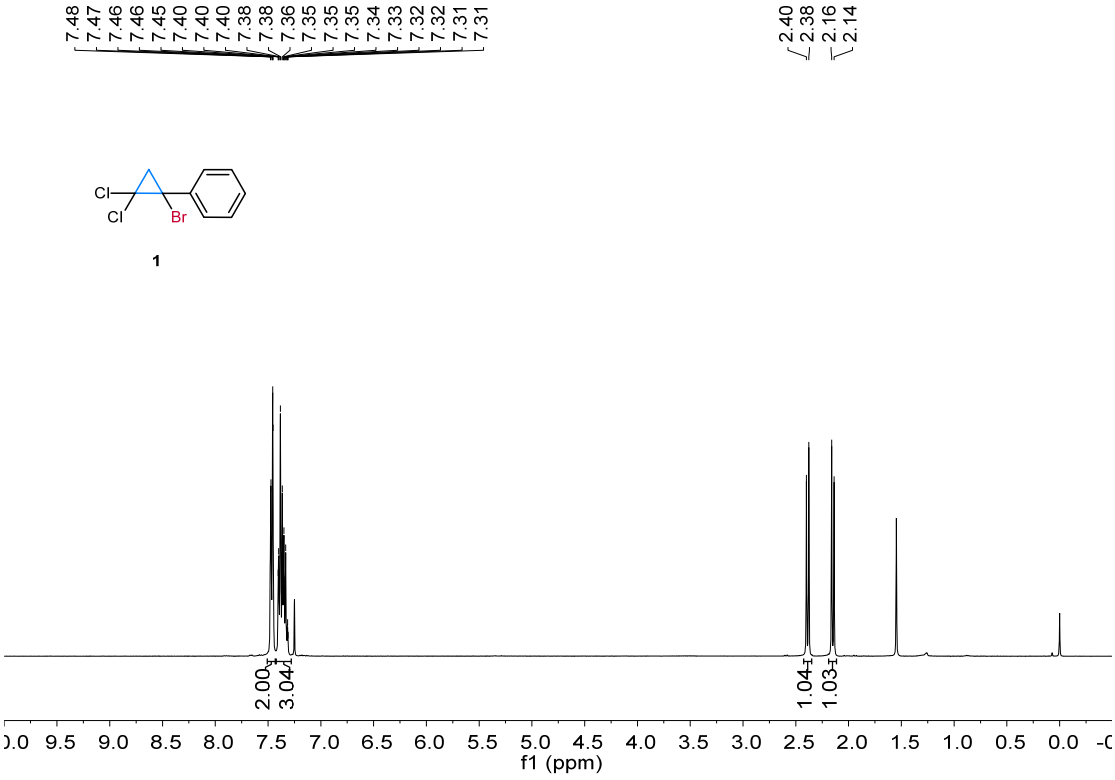
Charge = 0, Multiplicity = 1

| | | | |
|---|---|---|---|
| Cu | -0.12402800 | -0.83132200 | -0.55555700 |
| N | -2.02189600 | -1.18121800 | -0.78312800 |
| C | -2.02237900 | -2.16276300 | 1.42559200 |
| C | -2.73657800 | -1.87538100 | 0.12287600 |
| O | -3.87779200 | -2.33768900 | -0.04371000 |
| C | -2.75220600 | -2.47394700 | 2.57575400 |
| C | -0.01652900 | -2.48586000 | 2.52114400 |
| C | -2.05847700 | -2.78152900 | 3.74279100 |
| H | -3.83462100 | -2.47412500 | 2.51985400 |
| C | -0.66134300 | -2.78952600 | 3.71952700 |
| H | 1.06840300 | -2.47961700 | 2.44351900 |
| H | -2.59520200 | -3.01667000 | 4.65763800 |
| C | -2.47012400 | -1.30739100 | -2.16567700 |
| C | -1.26884400 | -1.05414800 | -3.08423500 |
| H | -2.82458100 | -2.33910300 | -2.31681200 |
| H | -1.02980800 | 0.01687000 | -3.03080100 |
| N | -0.05215300 | -1.72852200 | -2.53198200 |

| | | | |
|---|---|---|---|
| C | 1.16366100 | -1.36046700 | -3.27228100 |
| H | 1.21184100 | -0.27277600 | -3.36482700 |
| H | 2.03696400 | -1.68955900 | -2.70782200 |
| H | 1.18083000 | -1.81281000 | -4.27410200 |
| C | -0.15727500 | -3.19088000 | -2.41272000 |
| H | -0.24700000 | -3.67797800 | -3.39447800 |
| H | 0.74689800 | -3.55797900 | -1.92031000 |
| H | -1.01600300 | -3.45461200 | -1.79535900 |
| N | -0.67978100 | -2.18032700 | 1.40053700 |
| C | 1.71877400 | -0.54905400 | -0.31725300 |
| C | 2.92899300 | -0.40256200 | -0.20357900 |
| C | 4.33833900 | -0.21631100 | -0.09374800 |
| C | 5.06314300 | -0.76939300 | 0.98029900 |
| C | 5.03788600 | 0.53591500 | -1.05884700 |
| C | 6.43793400 | -0.57482300 | 1.08301400 |
| H | 4.53101700 | -1.35087900 | 1.72684400 |
| C | 6.41232000 | 0.72805500 | -0.94963100 |
| H | 4.48533100 | 0.96331500 | -1.89019800 |
| C | 7.11915800 | 0.17404900 | 0.12044900 |
| H | 6.98102700 | -1.00912400 | 1.91803900 |
| H | 6.93509600 | 1.31159700 | -1.70269600 |
| H | 8.19175600 | 0.32443700 | 0.20334700 |
| H | -0.08368500 | -3.02978100 | 4.60653600 |
| H | -1.52219900 | -1.28329200 | -4.09824000 |
| H | -3.28416000 | -0.67541500 | -2.45351600 |
| C | 0.32417400 | 3.15195900 | -0.81909300 |
| C | -0.48496000 | 1.97035300 | -0.36914100 |
| C | 0.25503100 | 2.80096600 | 0.63873200 |
| H | 1.26619200 | 2.97935000 | -1.36855000 |
| H | -0.19927300 | 4.05501600 | -1.17907200 |
| C | -2.02188400 | 2.05174900 | -0.42242300 |
| C | -2.77369000 | 1.80535200 | 0.72672800 |
| C | -2.66233200 | 2.37190100 | -1.61945200 |
| C | -4.16565400 | 1.87845100 | 0.67860800 |
| H | -2.26850600 | 1.55222100 | 1.67010300 |
| C | -4.05467000 | 2.44602900 | -1.66752000 |
| H | -2.06993800 | 2.56630500 | -2.52521400 |

| | | | |
|---|---|---|---|
| C | -4.80638100 | 2.19923900 | -0.51879800 |
| H | -4.75832900 | 1.68363500 | 1.58419000 |
| H | -4.55934300 | 2.69887900 | -2.61136600 |
| H | -5.90390300 | 2.25687300 | -0.55648200 |
| Cl | 1.67811200 | 2.12600900 | 1.42414500 |
| Cl | -0.65807500 | 3.84079500 | 1.72620300 |

# NMR spectra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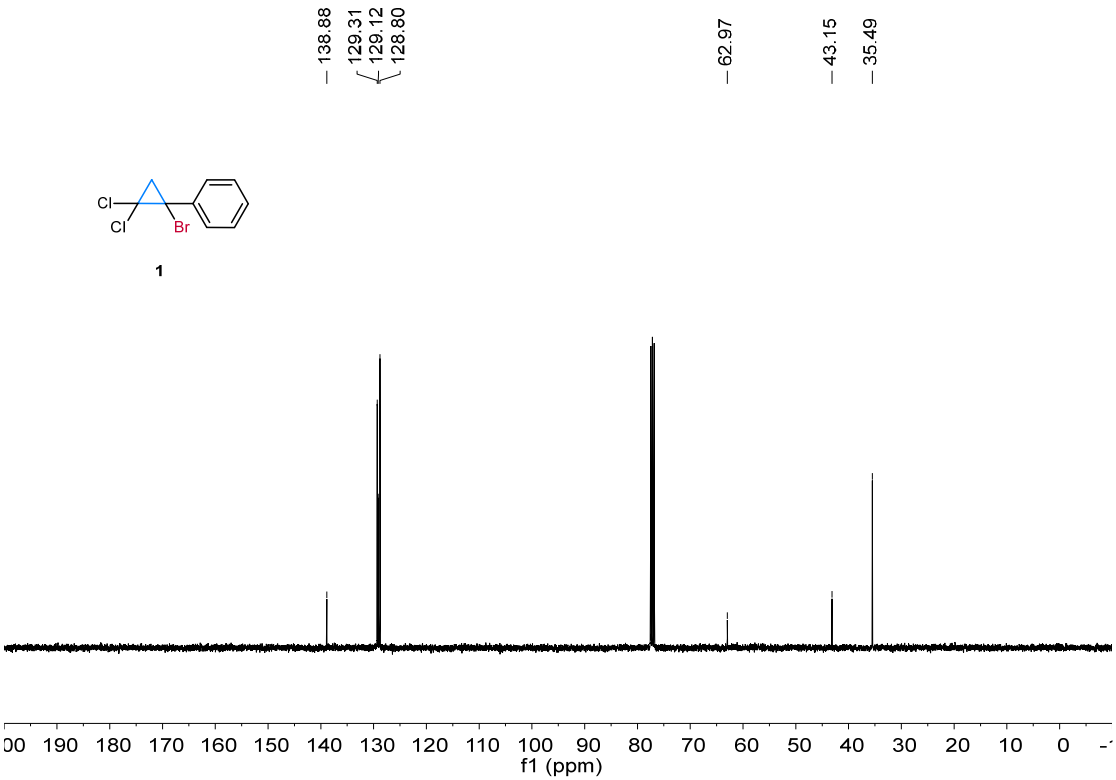
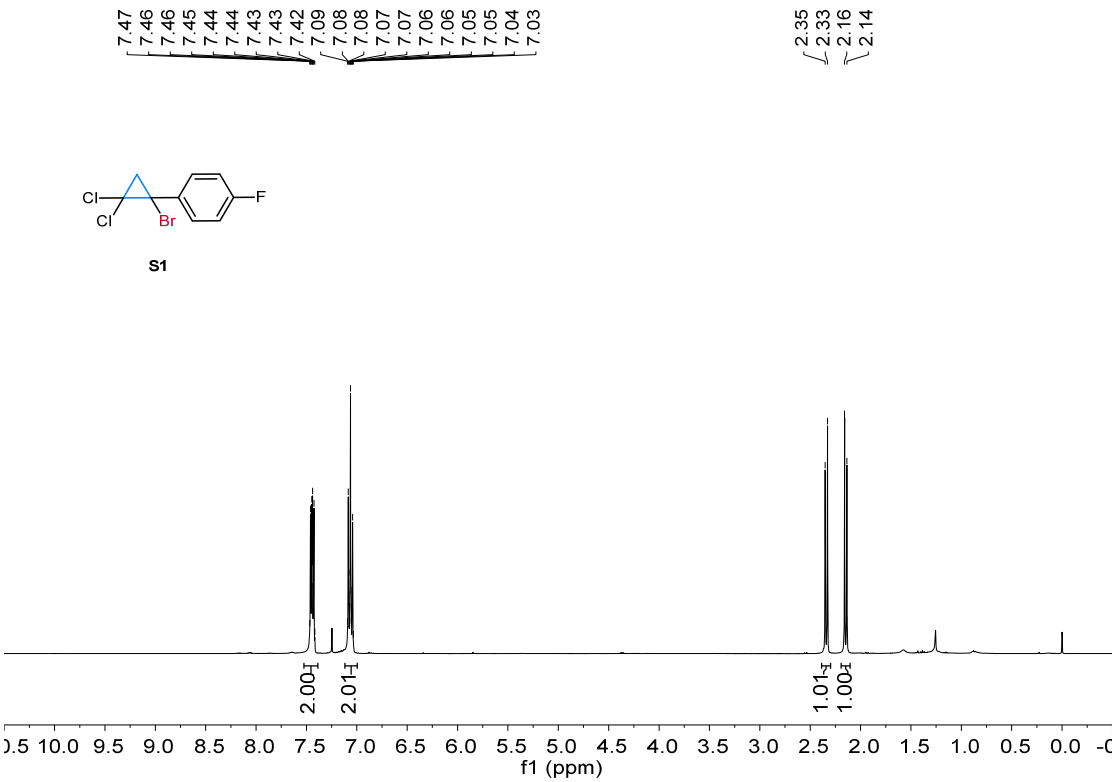
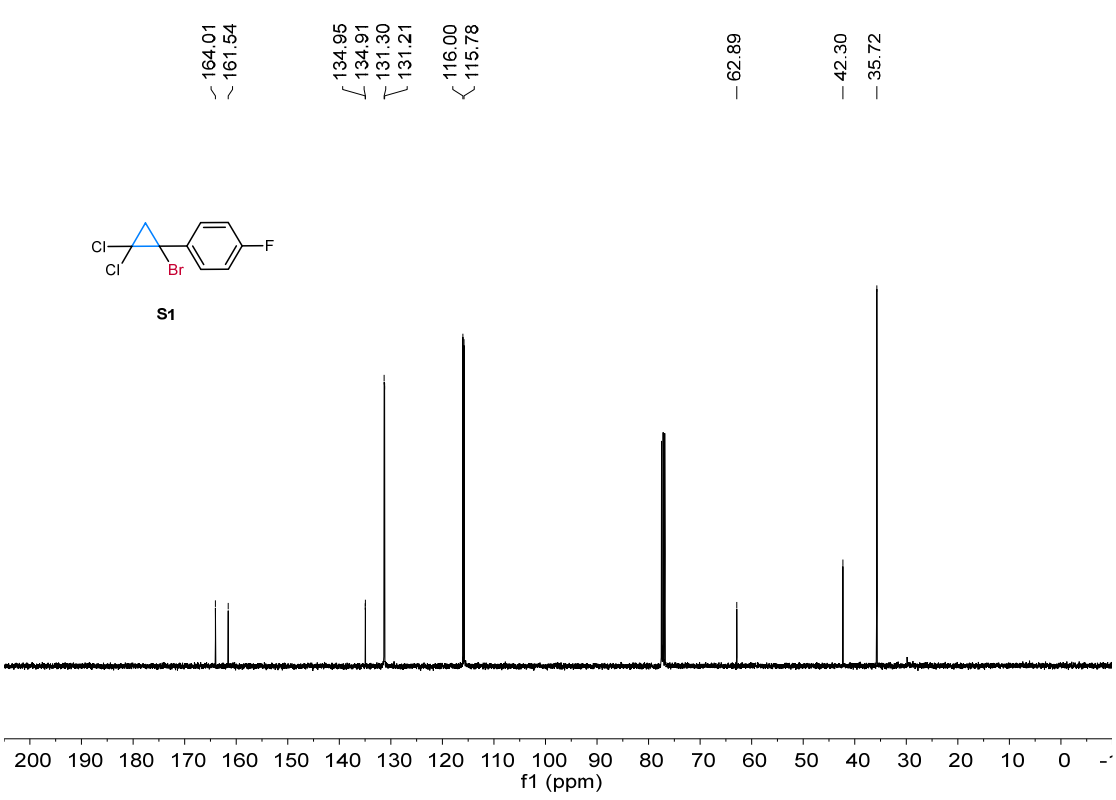
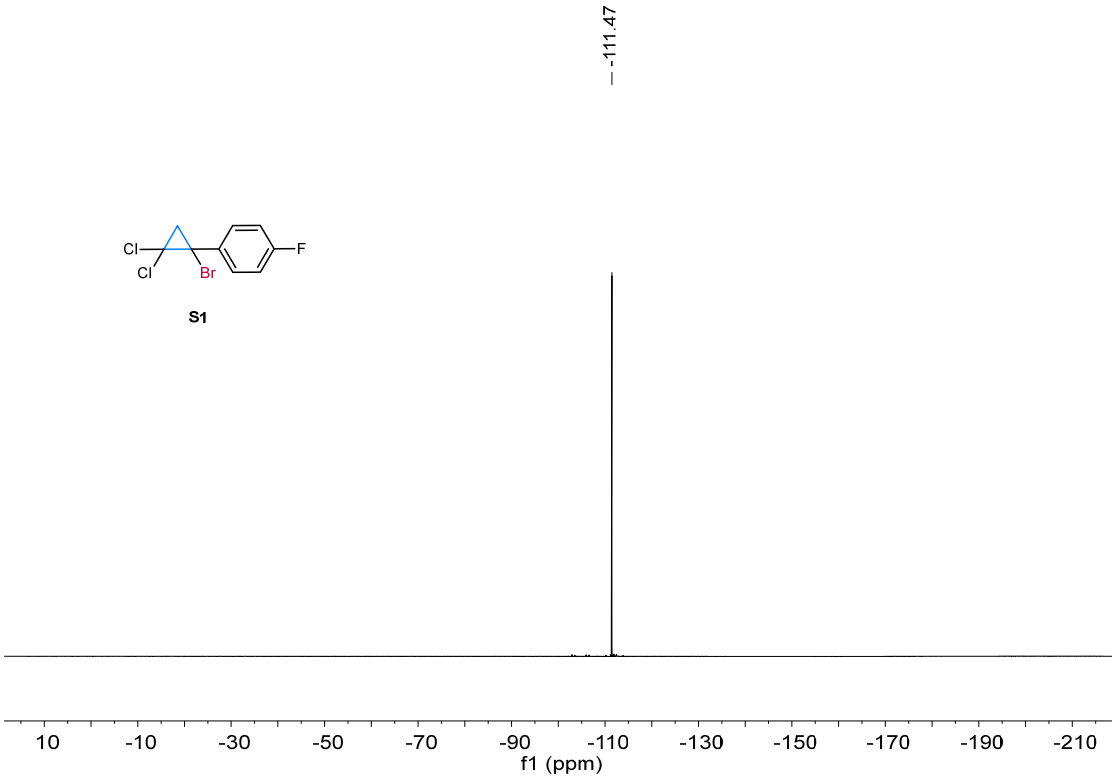
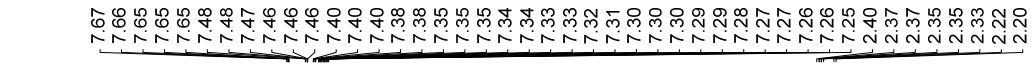
7.46
7.46
7.45
7.40
7.40
7.40
7.38
7.38
7.36
7.35
7.35
7.35
7.34
7.33
7.32
7.32
7.31
7.31
2.40
2.38
2.16
2.14
Cl
Cl
Br
1
2.00
3.04
1.04
1.03
f1 (ppm)


138.88
129.31
129.12
128.80
62.97
43.15
35.49
Cl
Cl
Br
1
f1 (ppm)


7.47
7.46
7.46
7.45
7.44
7.44
7.43
7.43
7.42
7.09
7.08
7.08
7.07
7.07
7.06
7.06
7.05
7.05
7.04
7.03
2.35
2.33
2.16
2.14
Cl
Cl
Br
F
S1
2.00
2.01
1.01
1.00
f1 (ppm)


164.01
161.54
134.95
134.91
131.30
131.21
116.00
115.78
62.89
42.30
35.72
Cl
Cl
Br
F
S1
f1 (ppm)


-111.47
Cl
Cl
Br
F
S1
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
f1 (ppm)


7.67
7.66
7.65
7.65
7.65
7.48
7.48
7.47
7.46
7.46
7.46
7.40
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7.40
7.38
7.38
7.35
7.35
7.34
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7.28
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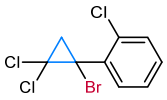
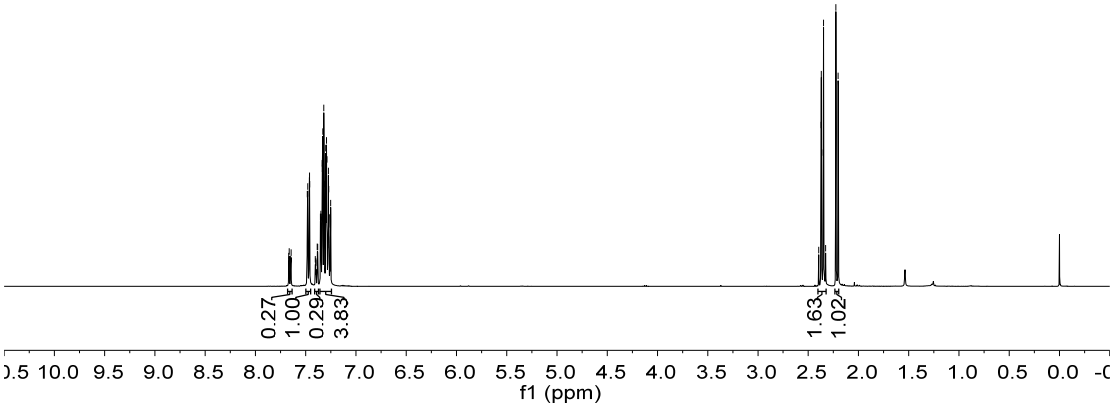
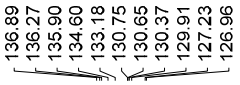
2.37
2.35
2.35
2.33
2.22
2.20


Cl
Cl
Cl
Br

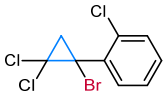
**S2**


0.27
1.00
0.29
3.83
1.63
1.02
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

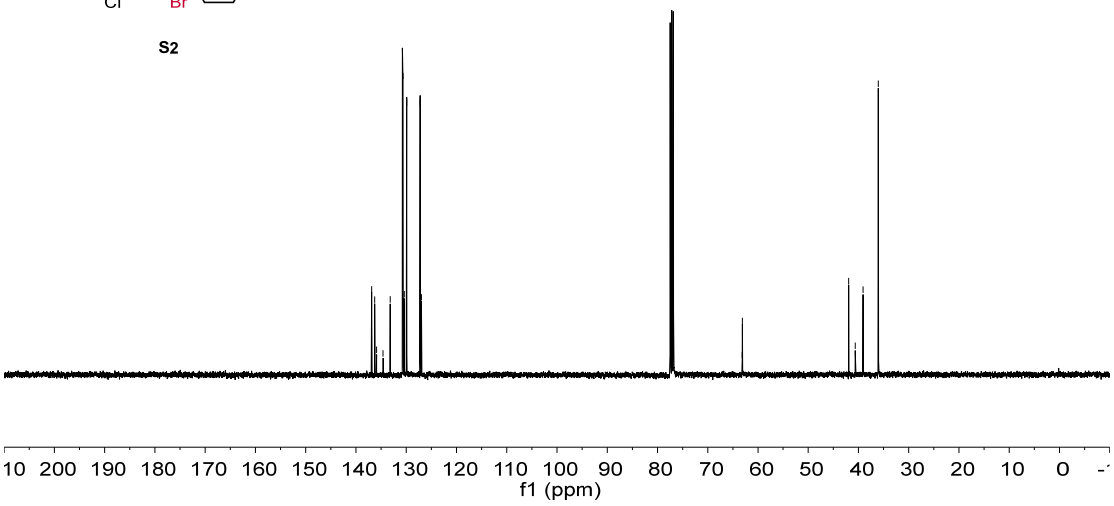

136.89
136.27
135.90
134.60
133.18
130.75
130.65
130.37
129.91
127.23
126.96

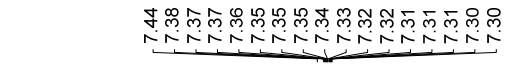

63.15
63.10


41.96
40.66
39.10
36.06

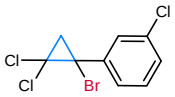

Cl
Cl
Cl
Br

**S2**

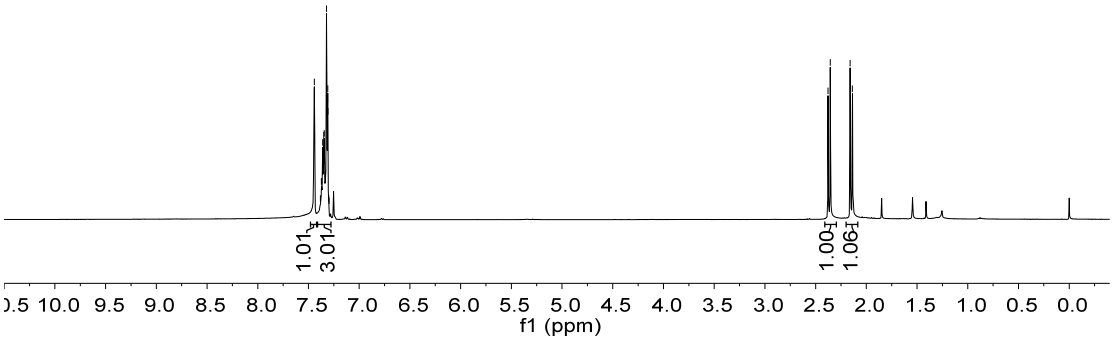

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

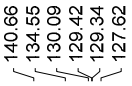

7.44
7.38
7.37
7.37
7.36
7.35
7.35
7.35
7.34
7.33
7.32
7.32
7.31
7.31
7.31
7.30
7.30

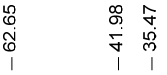

2.38
2.36
2.16
2.14

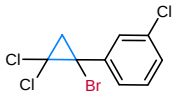

Cl
Cl
Cl
Br

**S3**

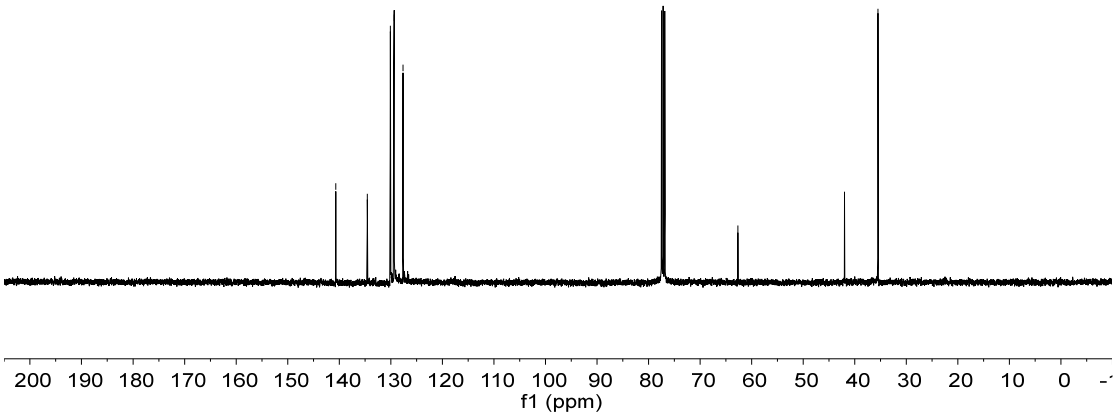

1.01
3.01
1.00
1.06
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

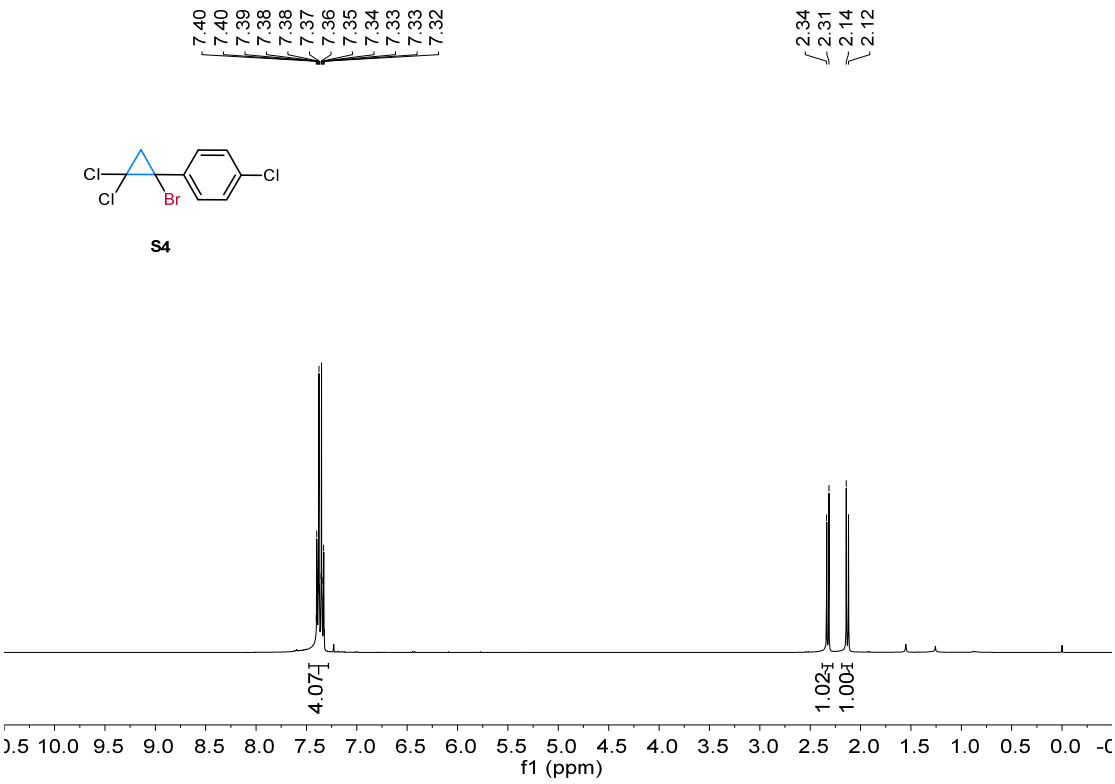

140.66
134.55
130.09
129.42
129.34
127.62

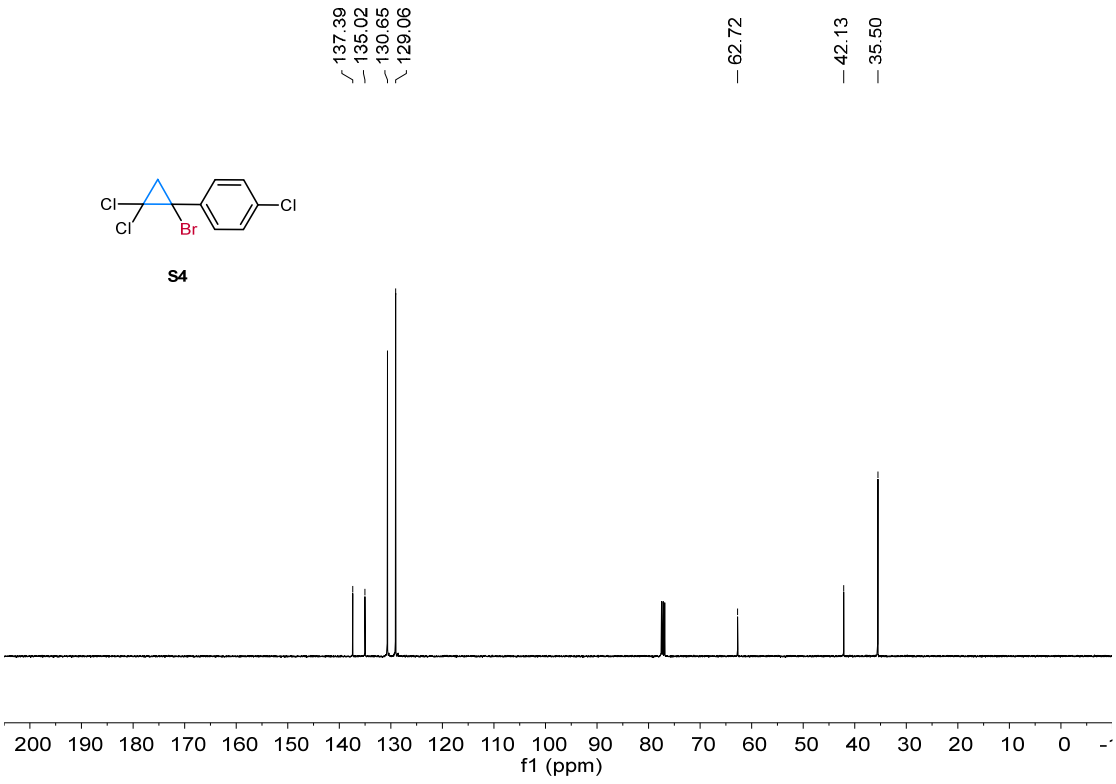

62.65
41.98
35.47

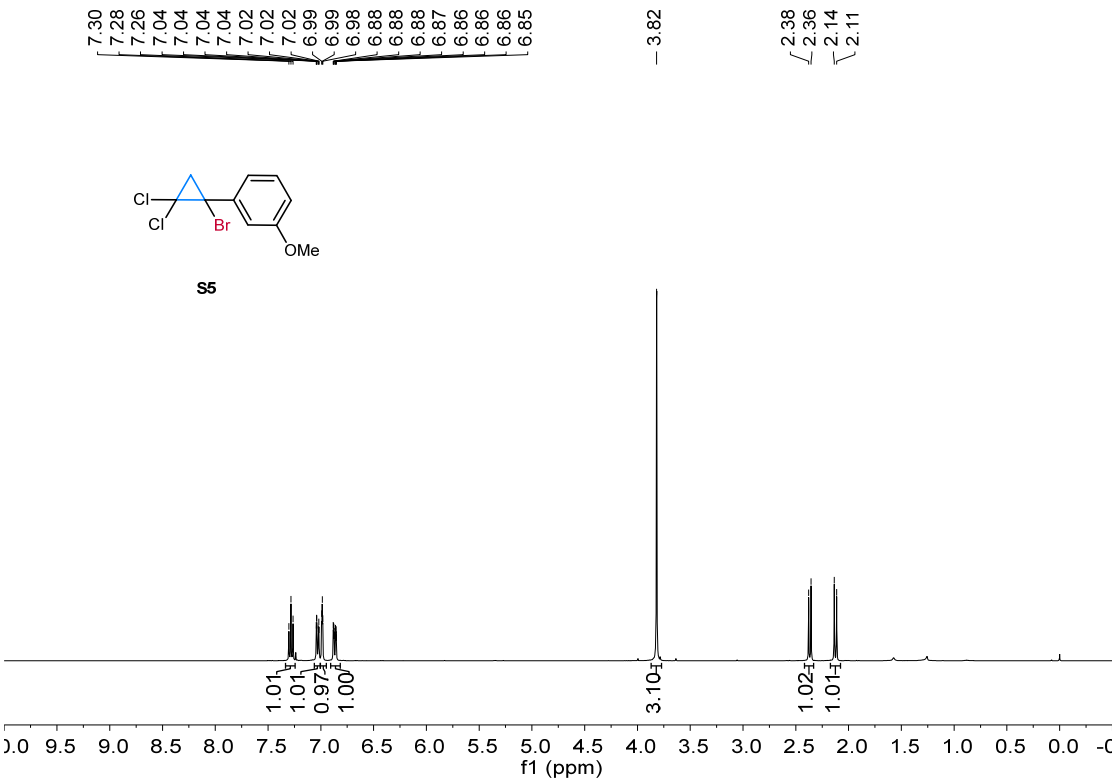

Cl
Cl
Cl
Br

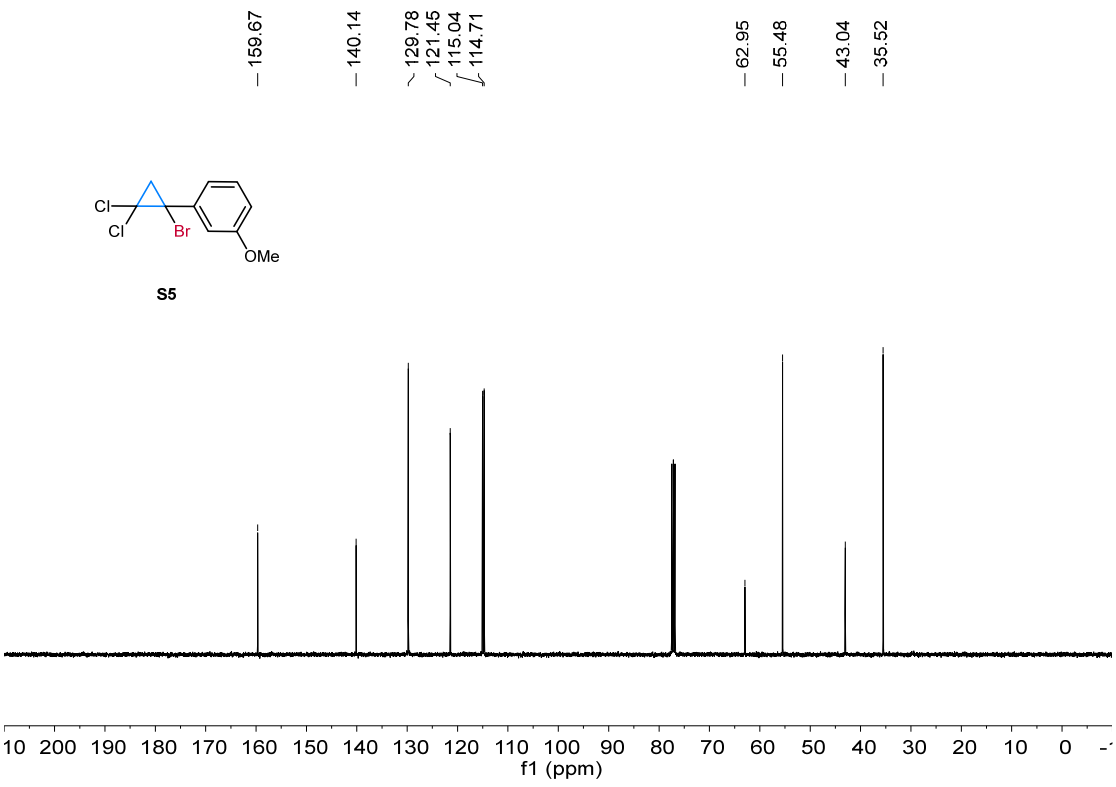
**S3**


200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.40
7.40
7.39
7.38
7.38
7.37
7.36
7.35
7.34
7.33
7.33
7.32
2.34
2.31
2.14
2.12
Cl
Cl
Cl
Br
S4
4.07
1.02
1.00
f1 (ppm)


137.39
135.02
130.65
129.06
62.72
42.13
35.50
Cl
Cl
Cl
Br
S4
f1 (ppm)


7.30
7.28
7.26
7.04
7.04
7.04
7.04
7.02
7.02
7.02
6.99
6.99
6.98
6.88
6.88
6.88
6.87
6.86
6.86
6.86
6.85
3.82
2.38
2.36
2.14
2.11
Cl
Cl
Br
OMe
S5
1.01
1.01
0.97
1.00
3.10
1.02
1.01
f1 (ppm)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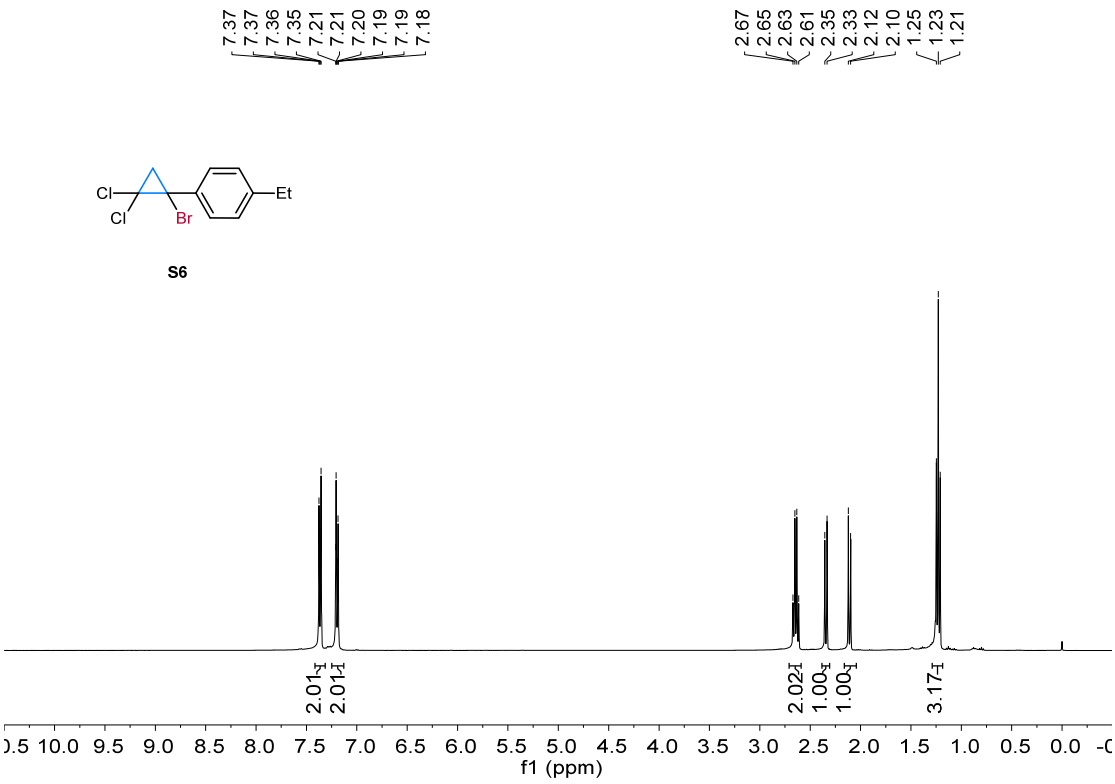
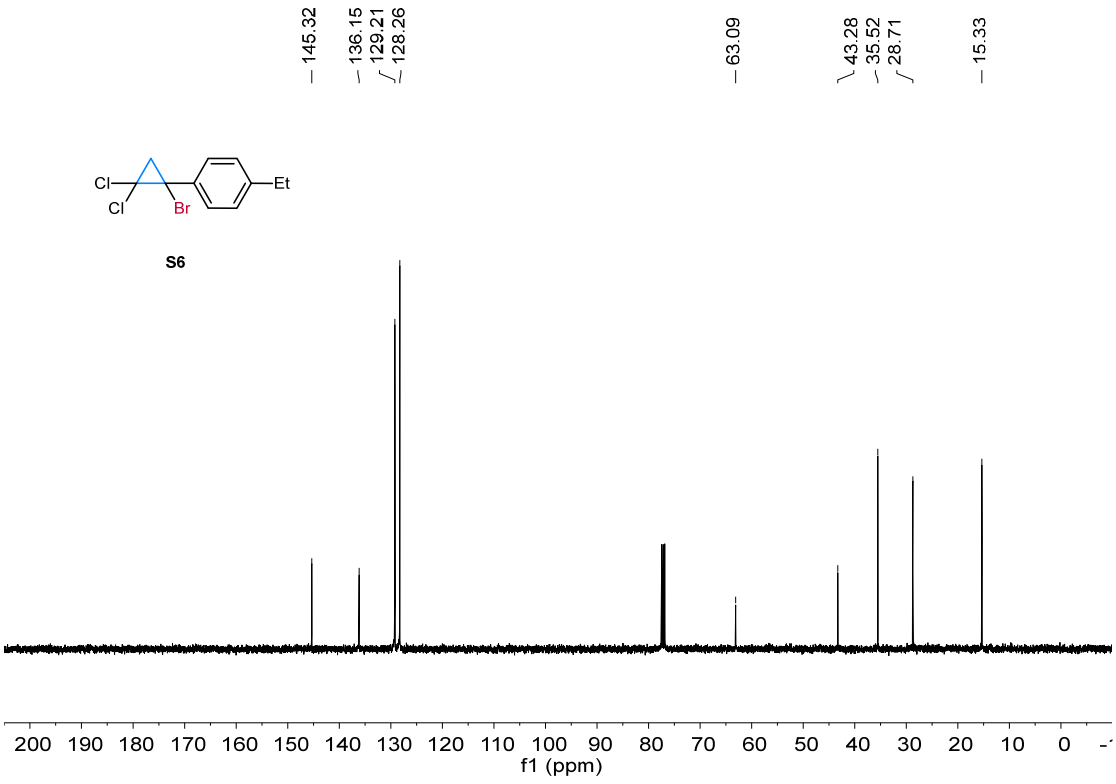
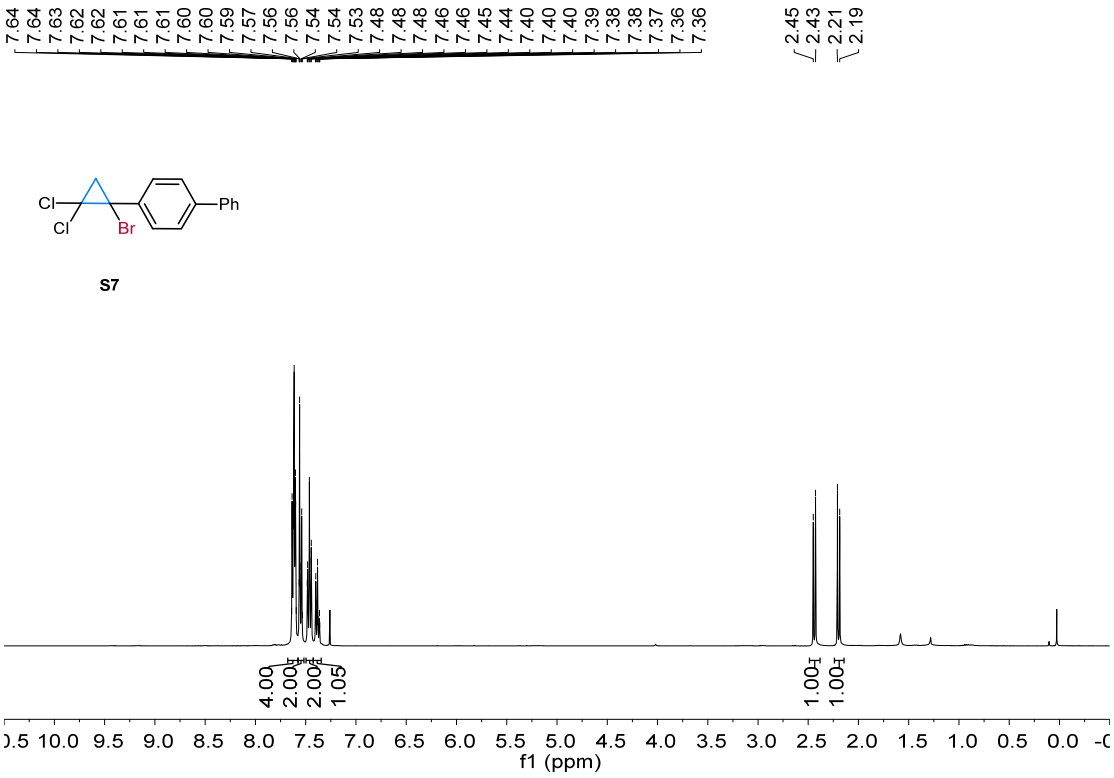
140.14
129.78
121.45
115.04
114.71
62.95
55.48
43.04
35.52
Cl
Cl
Br
OMe
S5
f1 (ppm)


7.37
7.37
7.36
7.35
7.21
7.21
7.20
7.19
7.19
7.18
2.67
2.65
2.63
2.61
2.35
2.33
2.12
2.10
1.25
1.23
1.21
Cl
Cl
Br
Et
S6
2.01
2.01
2.02
1.00
1.00
3.17
f1 (ppm)


145.32
136.15
129.21
128.26
63.09
43.28
35.52
28.71
15.33
Cl
Cl
Br
Et
S6
f1 (ppm)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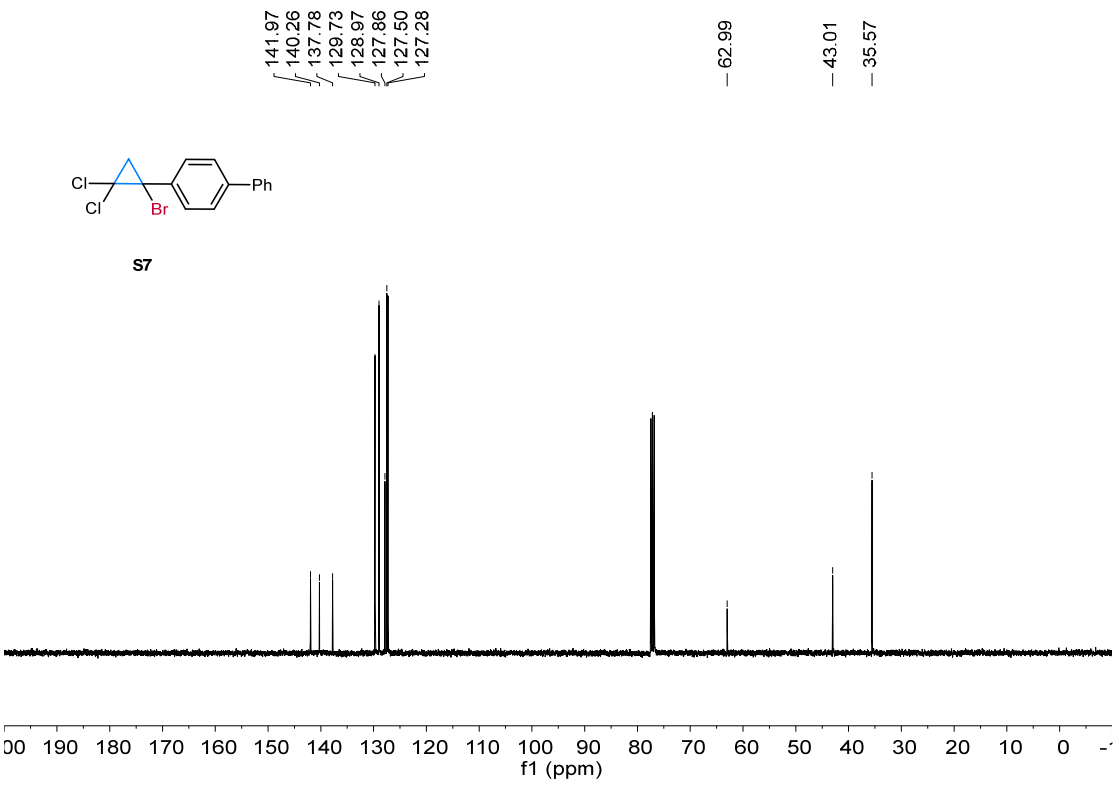
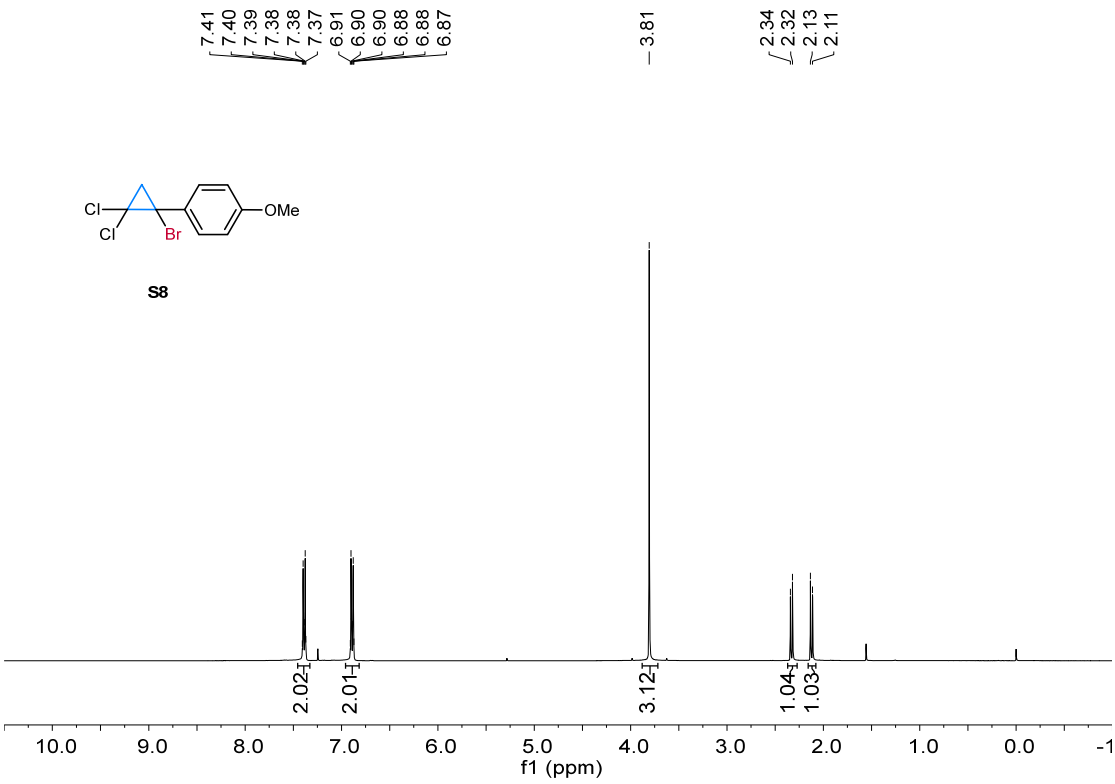
7.64
7.63
7.62
7.62
7.61
7.61
7.61
7.60
7.60
7.59
7.57
7.56
7.56
7.54
7.54
7.53
7.48
7.48
7.48
7.46
7.46
7.45
7.44
7.40
7.40
7.39
7.38
7.38
7.37
7.36
7.36
2.45
2.43
2.21
2.19
Cl
Cl
Br
Ph
S7
4.00
2.00
2.00
1.05
1.00
1.00
f1 (ppm)


141.97
140.26
137.78
129.73
128.97
127.86
127.50
127.28
62.99
43.01
35.57
Cl
Cl
Br
Ph
S7
f1 (ppm)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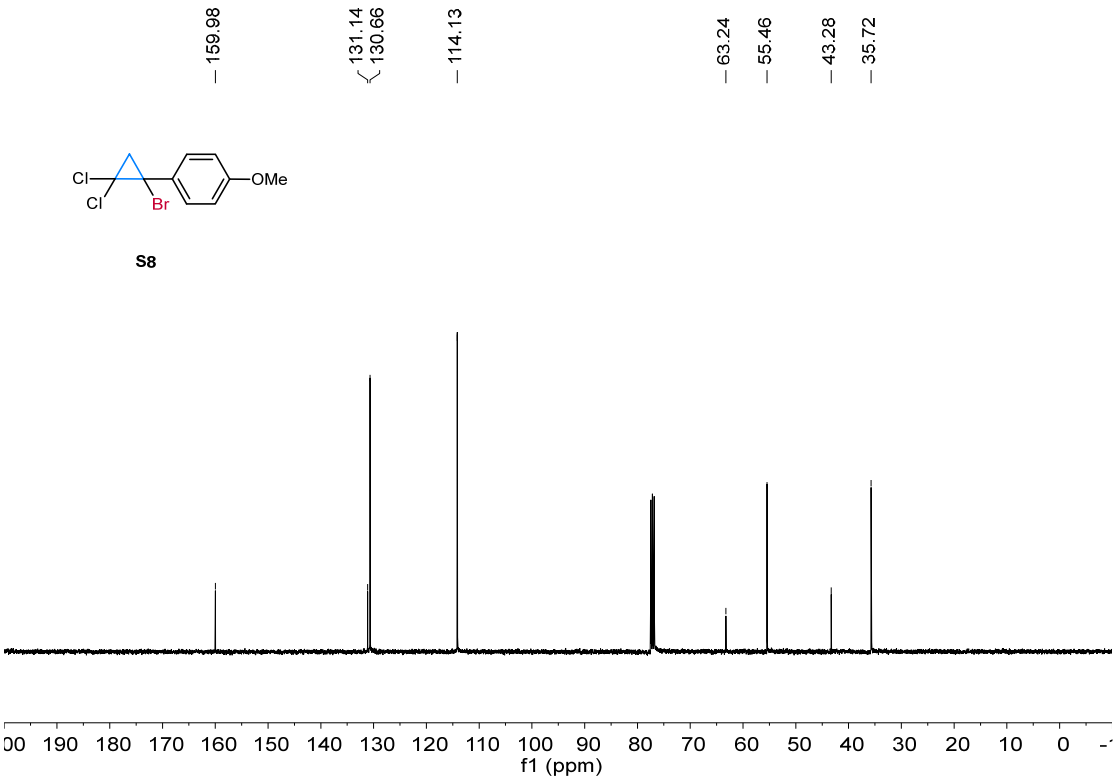
7.39
7.38
7.38
7.37
6.91
6.90
6.90
6.88
6.88
6.87
3.81
2.34
2.32
2.13
2.11
Cl
Cl
Br
OMe
S8
2.02
2.01
3.12
1.04
1.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)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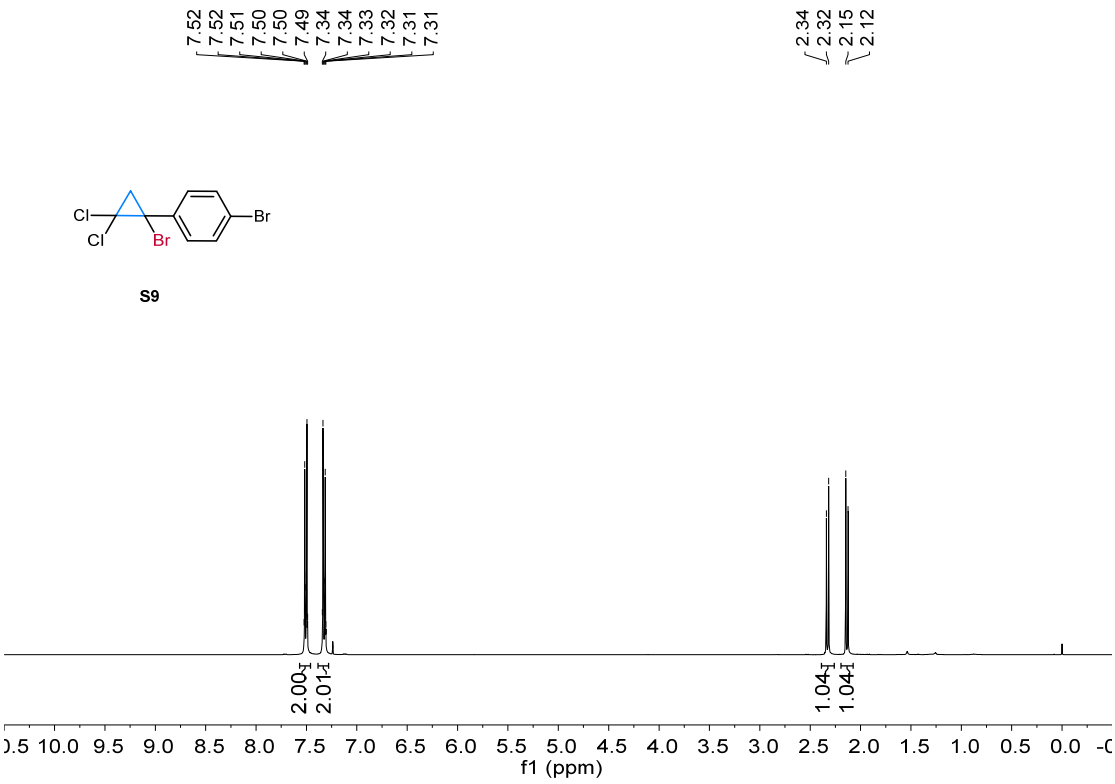
131.14
130.66
114.13
63.24
55.46
43.28
35.72
Cl
Cl
Br
OMe
S8
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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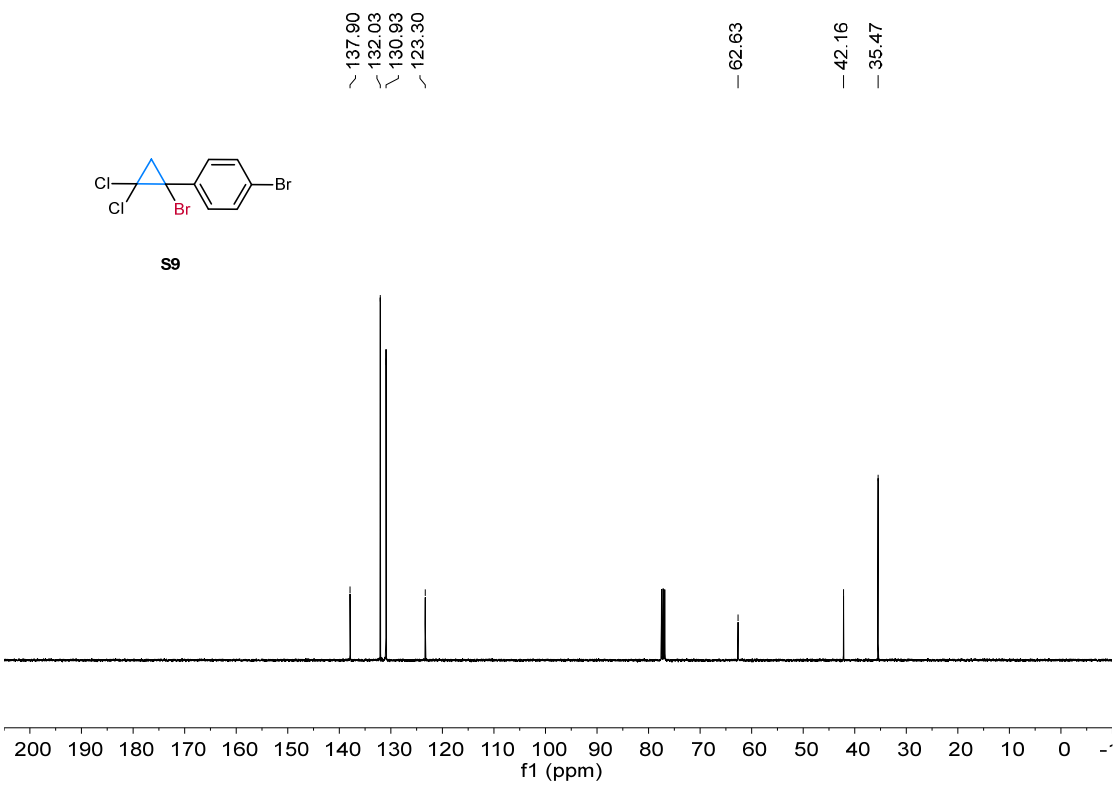
7.52
7.51
7.50
7.50
7.49
7.34
7.34
7.33
7.32
7.31
7.31
2.34
2.32
2.15
2.12
Cl
Cl
Br
Br
S9
2.00
2.01
1.04
1.04
f1 (ppm)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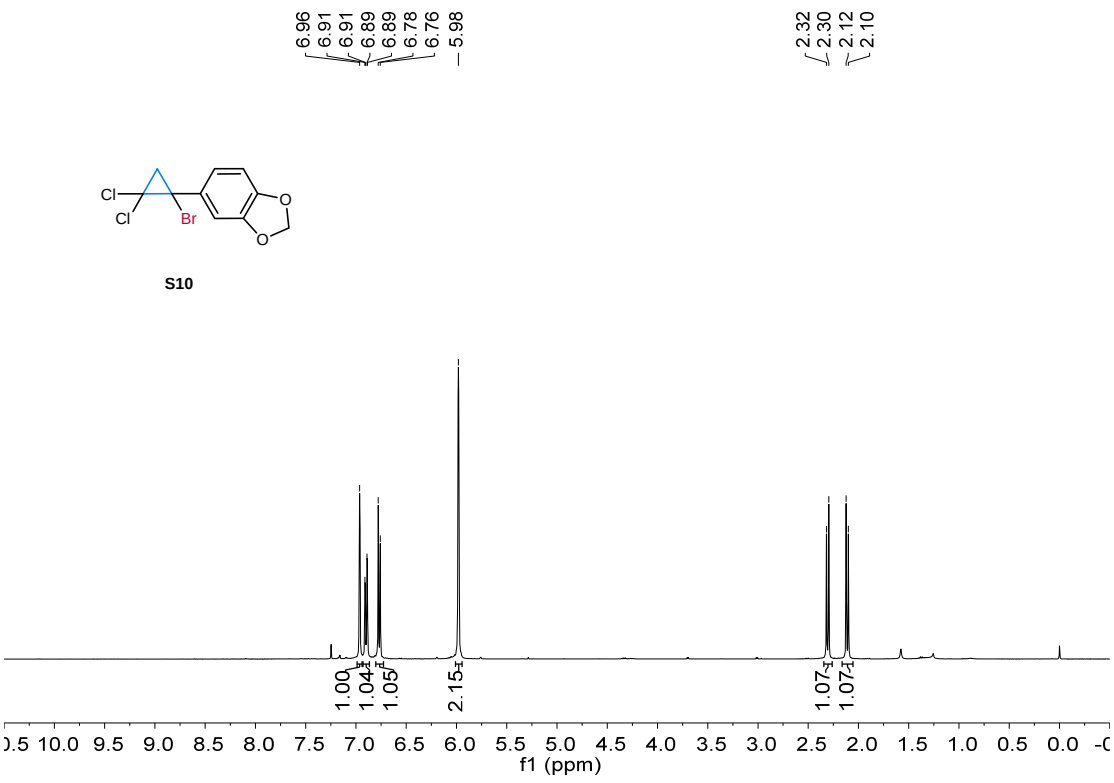
130.93
123.30
62.63
42.16
35.47
Cl
Cl
Br
Br
S9
f1 (ppm)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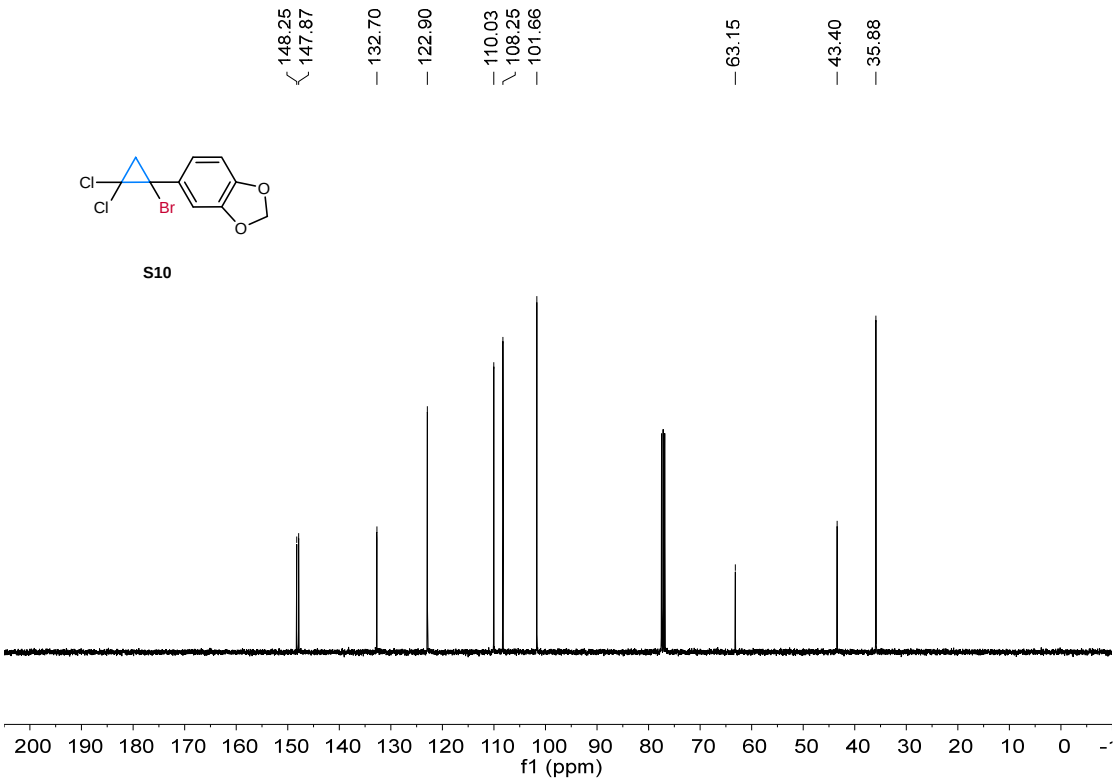
6.91
6.91
6.89
6.89
6.78
6.76
5.98
2.32
2.30
2.12
2.10
Cl
Cl
Br
O
O
S10
1.00
1.04
1.05
2.15
1.07
1.07
f1 (ppm)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132.70
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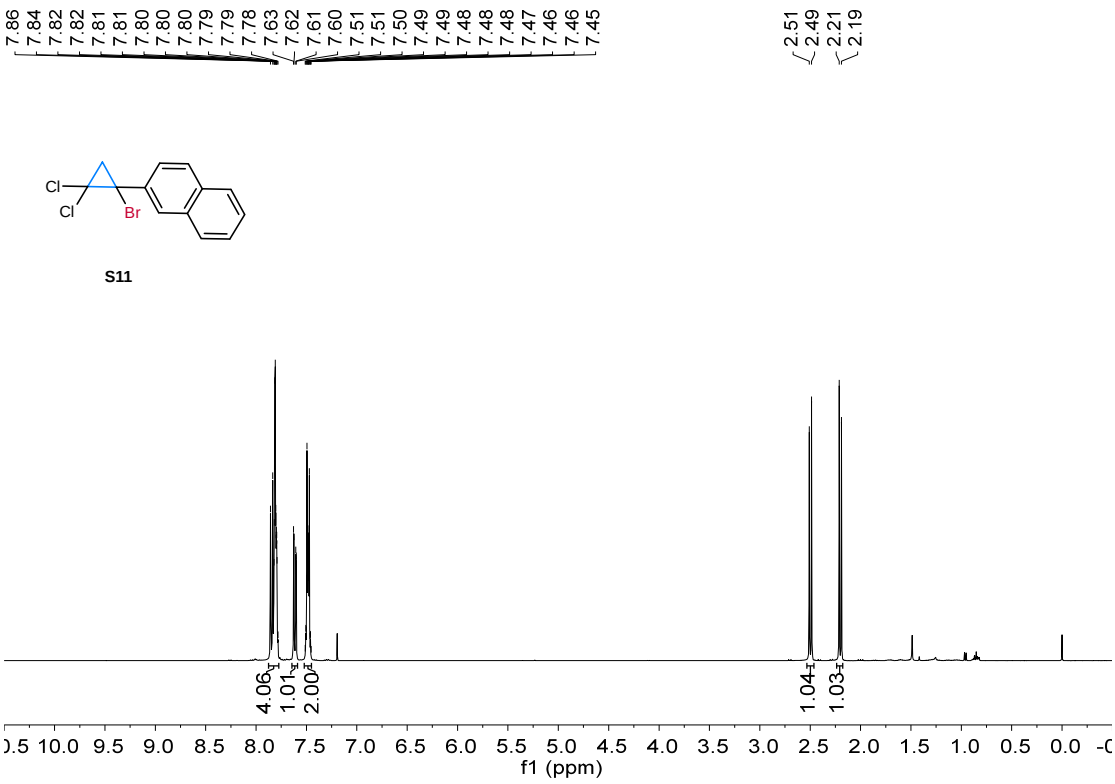
110.03
108.25
101.66
63.15
43.40
35.88
Cl
Cl
Br
O
O
S10
f1 (ppm)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7.82
7.82
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7.81
7.80
7.80
7.80
7.79
7.79
7.78
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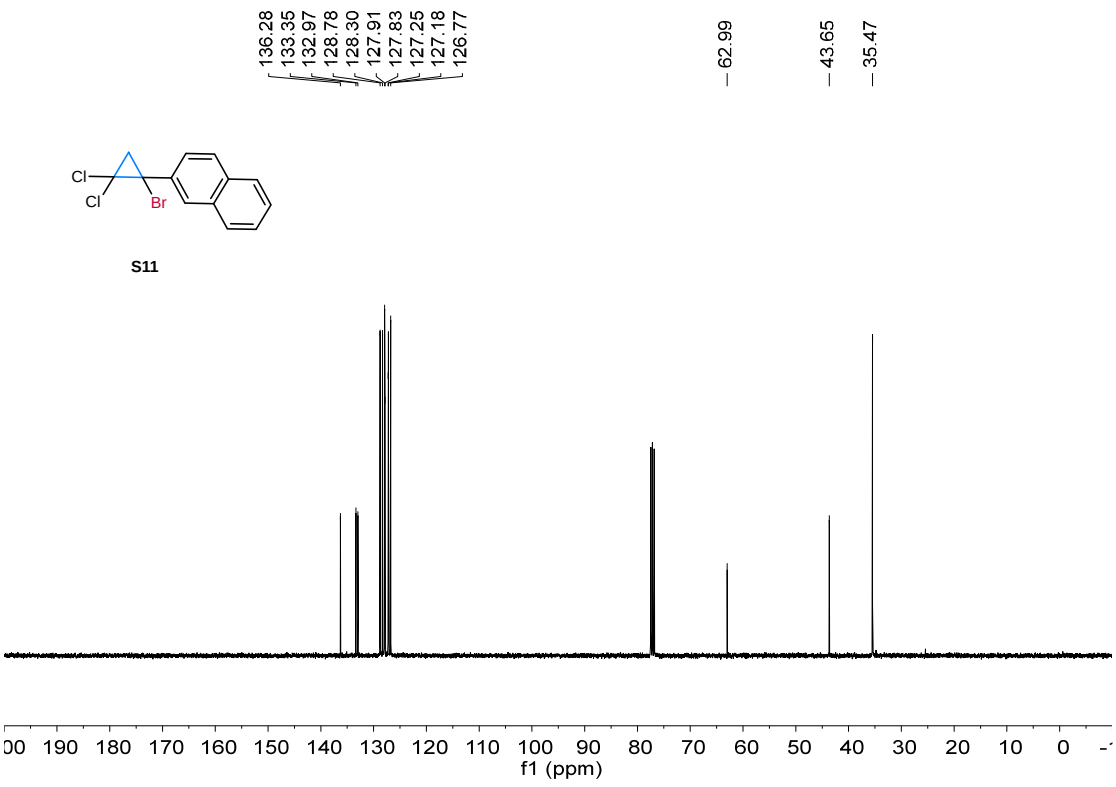
7.62
7.61
7.60
7.51
7.51
7.50
7.49
7.49
7.48
7.48
7.48
7.47
7.46
7.46
7.45
2.51
2.49
2.21
2.19
Cl
Cl
Br
S11
4.06
1.01
2.00
1.04
1.03
f1 (ppm)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133.35
132.97
128.78
128.30
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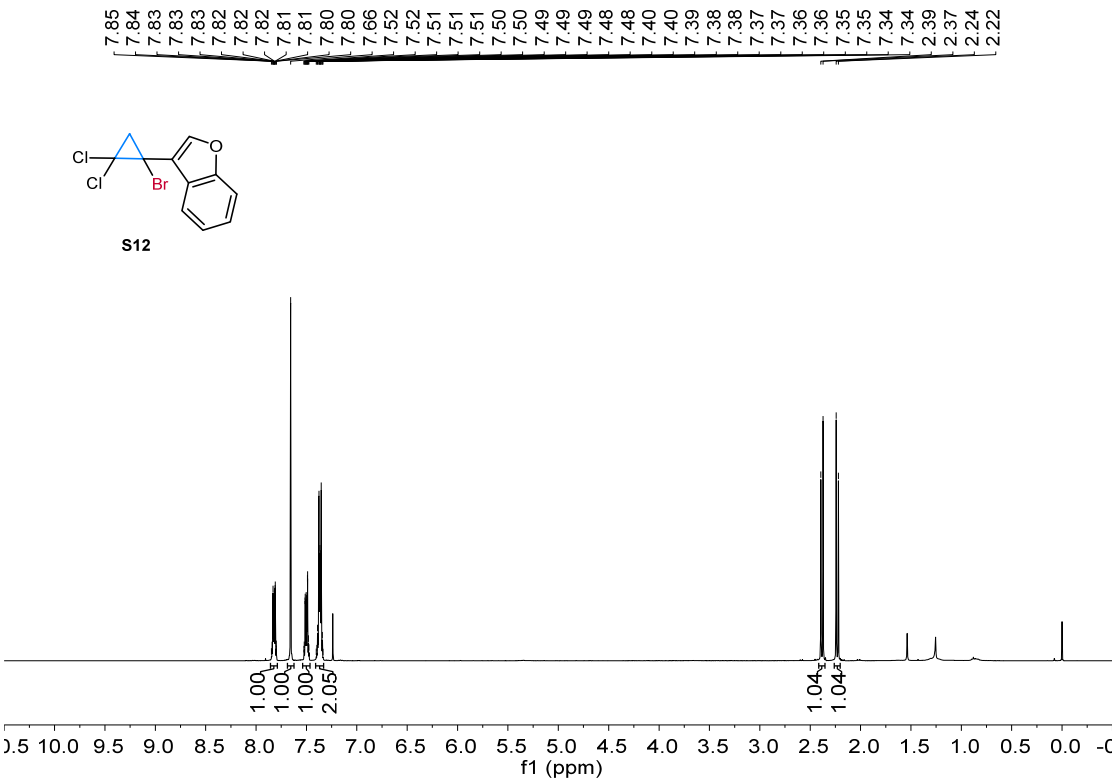
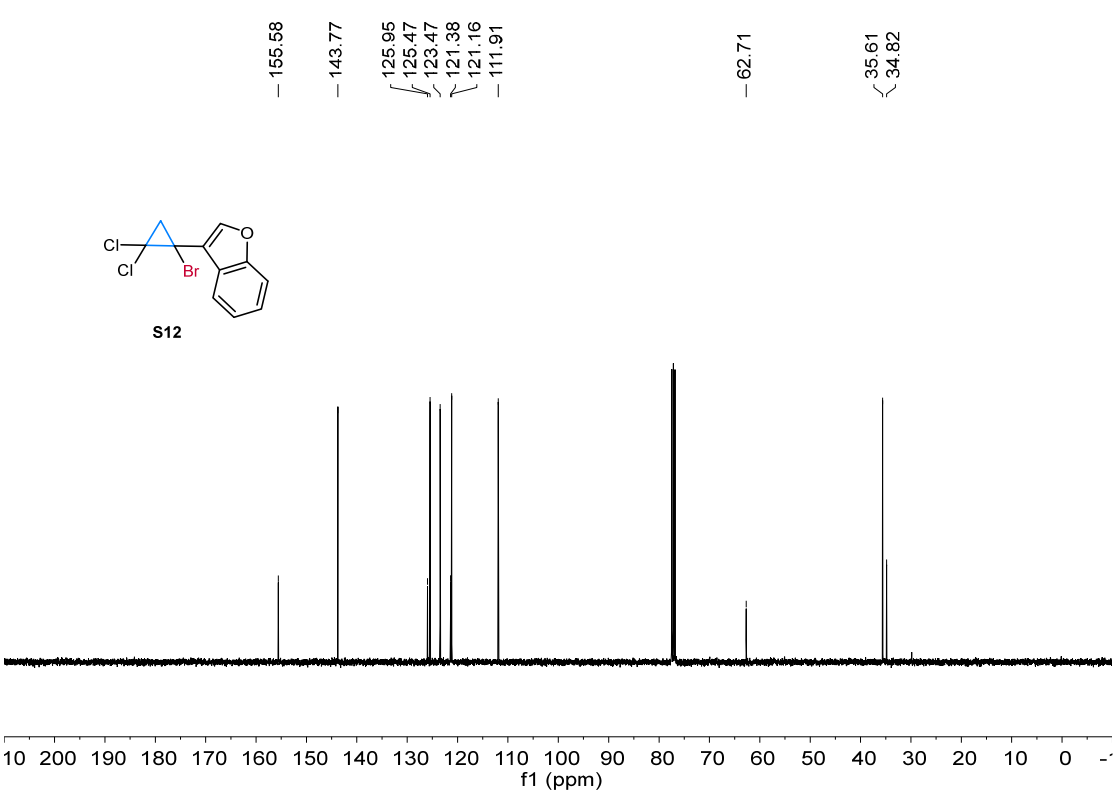
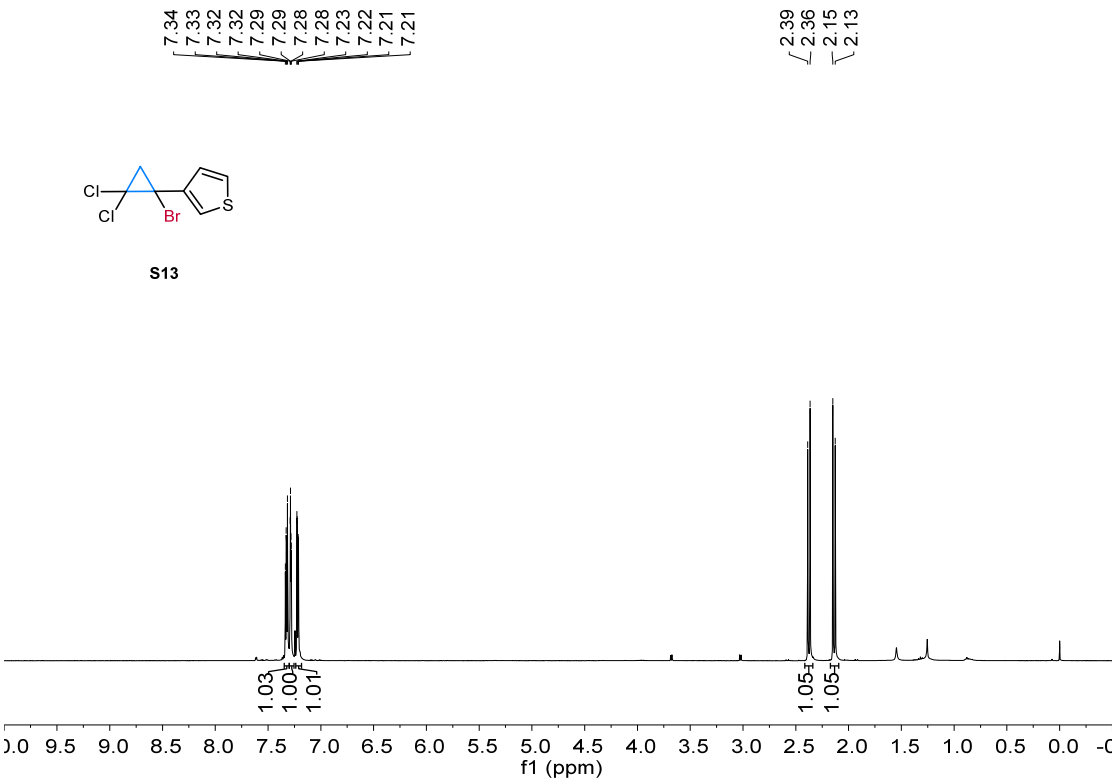
127.25
127.18
126.77
62.99
43.65
35.47
Cl
Cl
Br
S11
f1 (ppm)


7.85 7.84 7.83 7.83 7.83 7.82 7.82 7.82 7.81 7.81 7.80 7.80 7.66 7.52 7.52 7.51 7.51 7.51 7.50 7.50 7.49 7.49 7.49 7.48 7.48 7.40 7.40 7.39 7.38 7.38 7.37 7.37 7.36 7.36 7.35 7.35 7.34 7.34 2.39 2.37 2.24 2.22
Cl
Cl
Br
O
S12
1.00 1.00 1.00 2.05 1.04 1.04
f1 (ppm)


155.58 143.77 125.95 125.47 123.47 121.38 121.16 111.91 62.71 35.61 34.82
Cl
Cl
Br
O
S12
f1 (ppm)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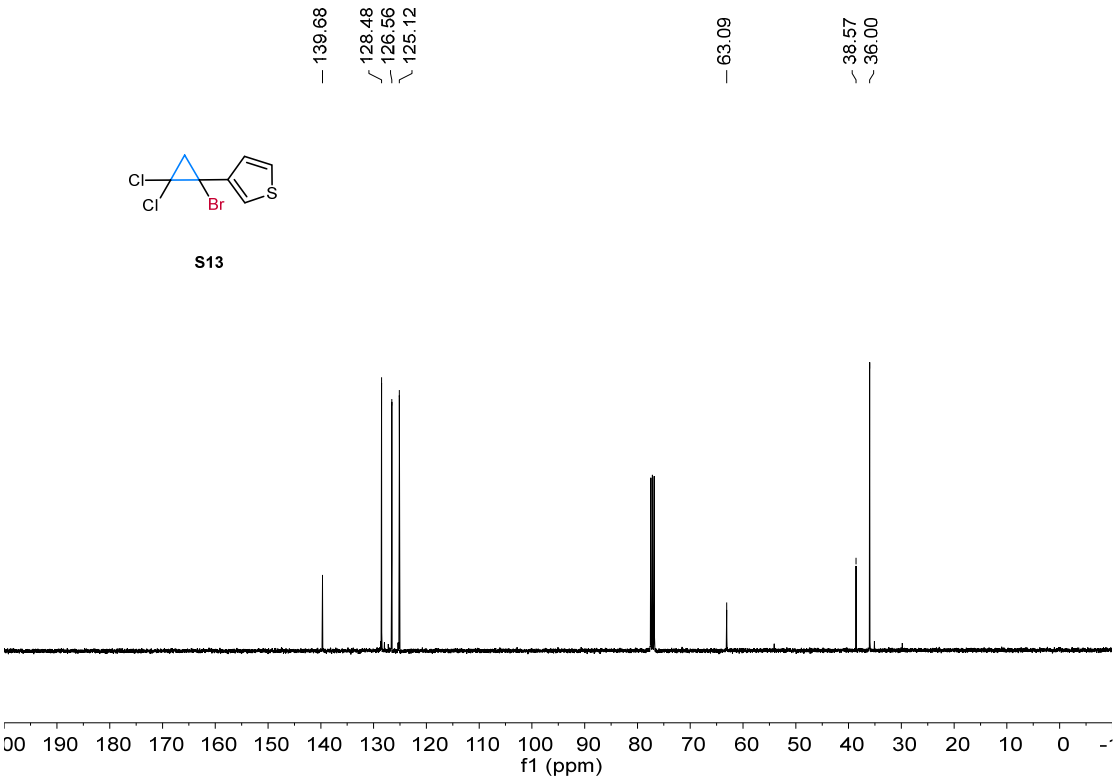
7.33
7.32
7.32
7.29
7.29
7.28
7.28
7.23
7.22
7.21
7.21
2.39
2.36
2.15
2.13
Cl
Cl
Br
S
S13
1.03
1.00
1.01
1.05
1.05
f1 (ppm)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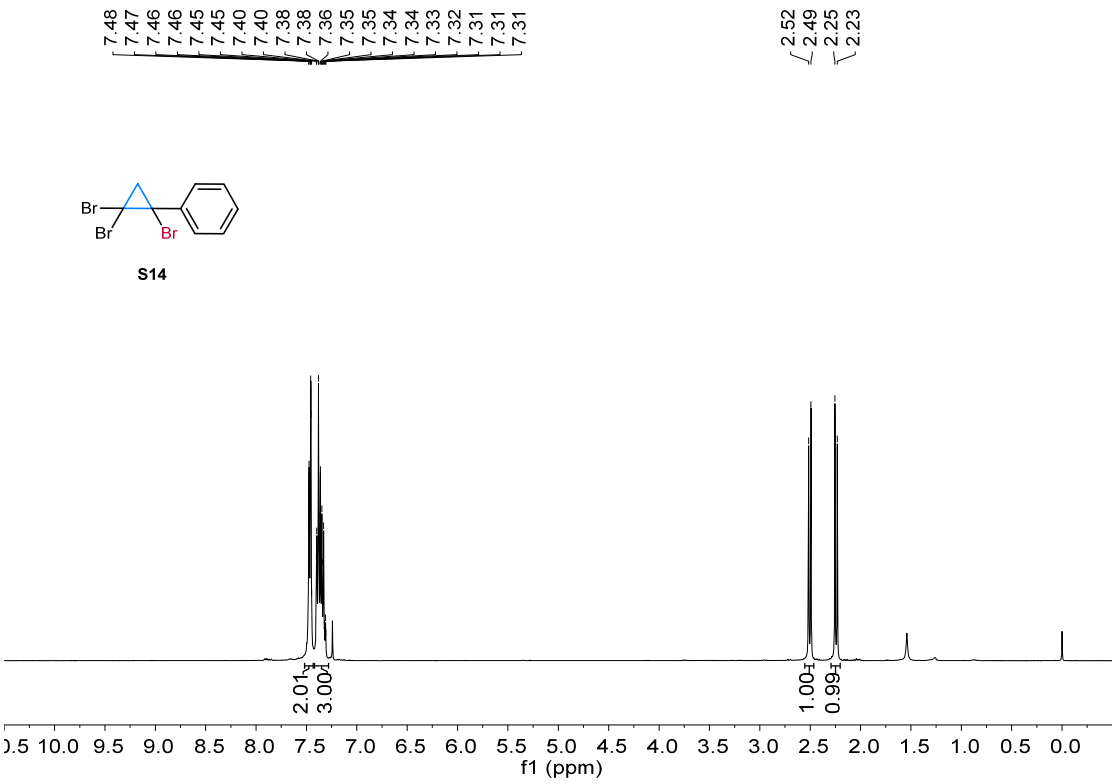
126.56
125.12
63.09
38.57
36.00
Cl
Cl
Br
S
S13
f1 (ppm)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7.46
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7.45
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7.40
7.38
7.38
7.36
7.35
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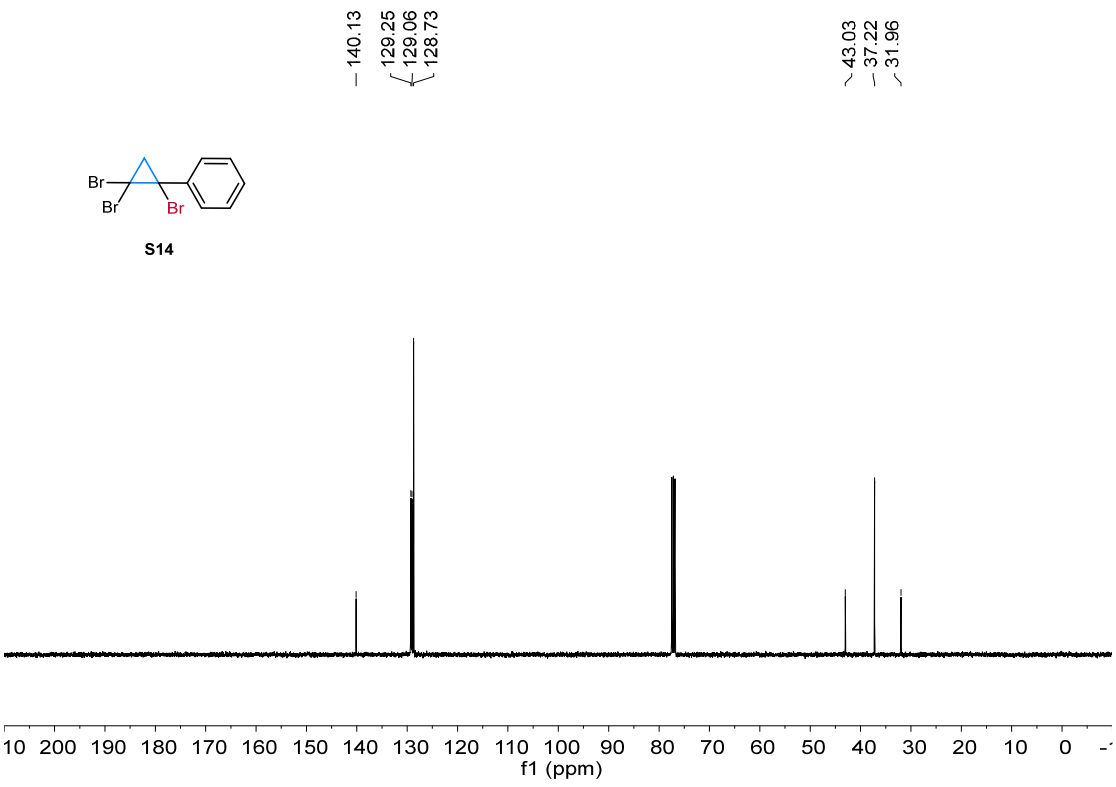
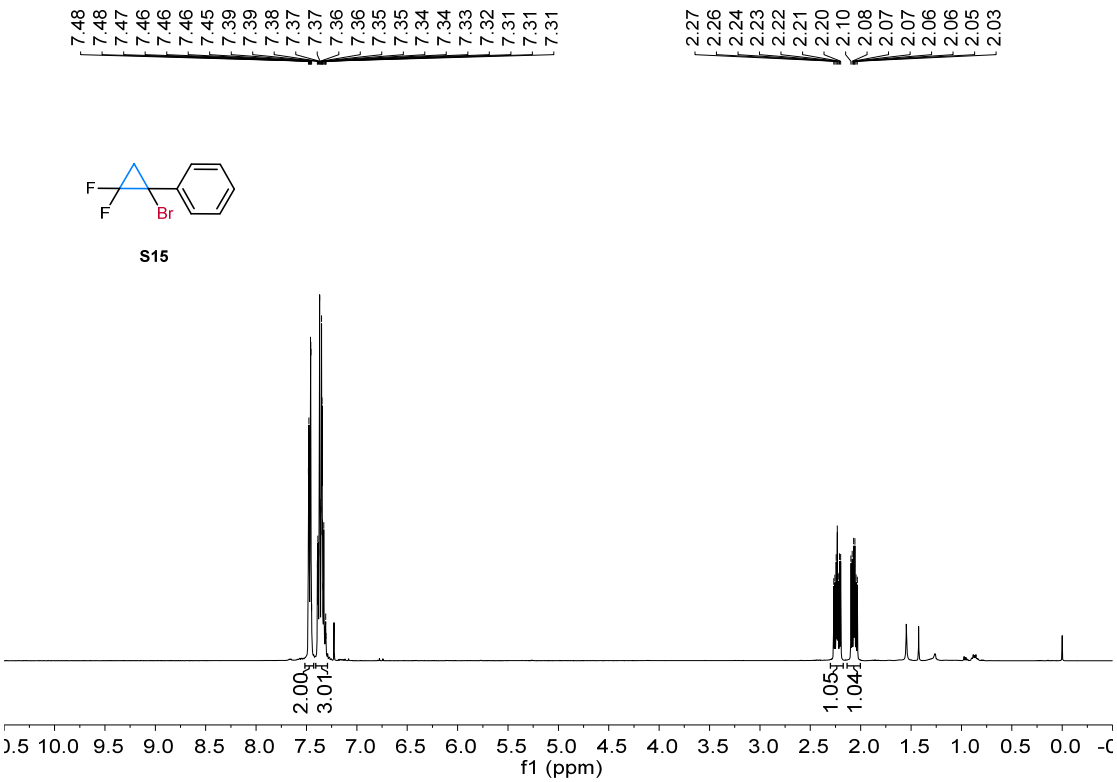
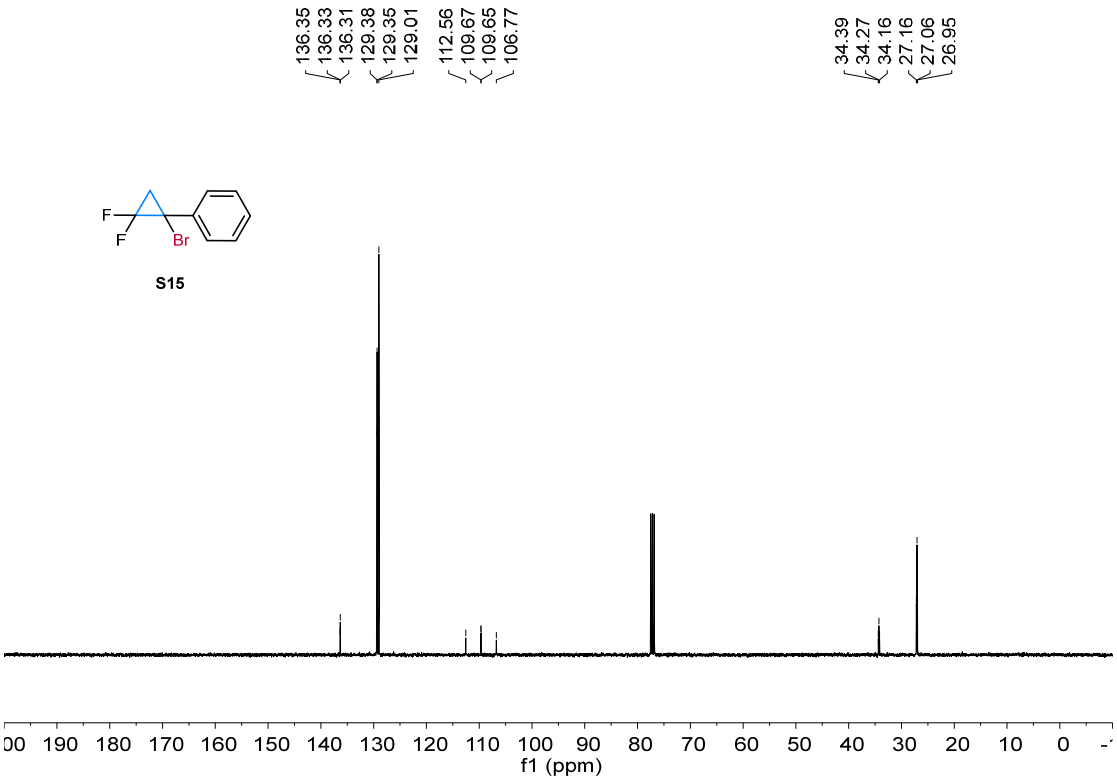
7.34
7.34
7.33
7.32
7.31
7.31
7.31
2.52
2.49
2.25
2.23
Br
Br
Br
S14
2.01
3.00
1.00
0.99
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


140.13
129.25
129.06
128.73
43.03
37.22
31.96
Br
Br
Br
S14
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.48
7.48
7.47
7.46
7.46
7.46
7.45
7.39
7.39
7.38
7.37
7.37
7.36
7.36
7.35
7.35
7.34
7.34
7.33
7.32
7.31
7.31
7.31
2.27
2.26
2.24
2.23
2.22
2.21
2.20
2.10
2.08
2.07
2.07
2.06
2.06
2.05
2.03
F
F
Br
S15
2.00
3.01
1.05
1.04
f1 (ppm)


136.35
136.33
136.31
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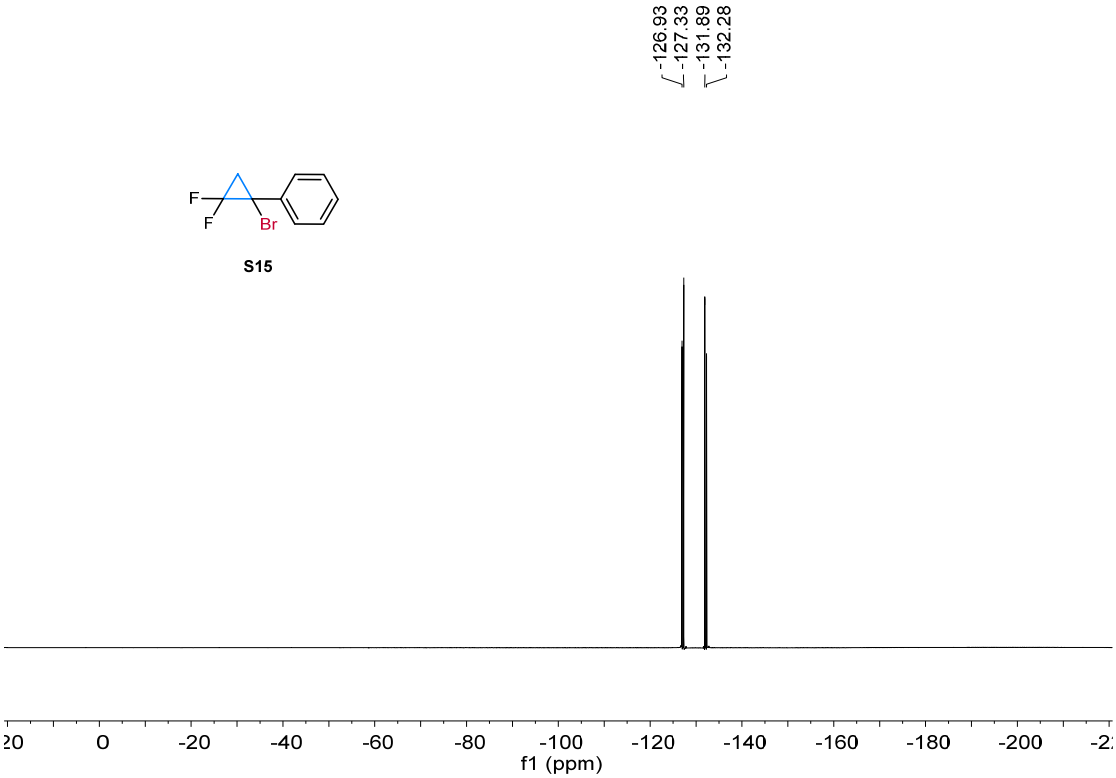
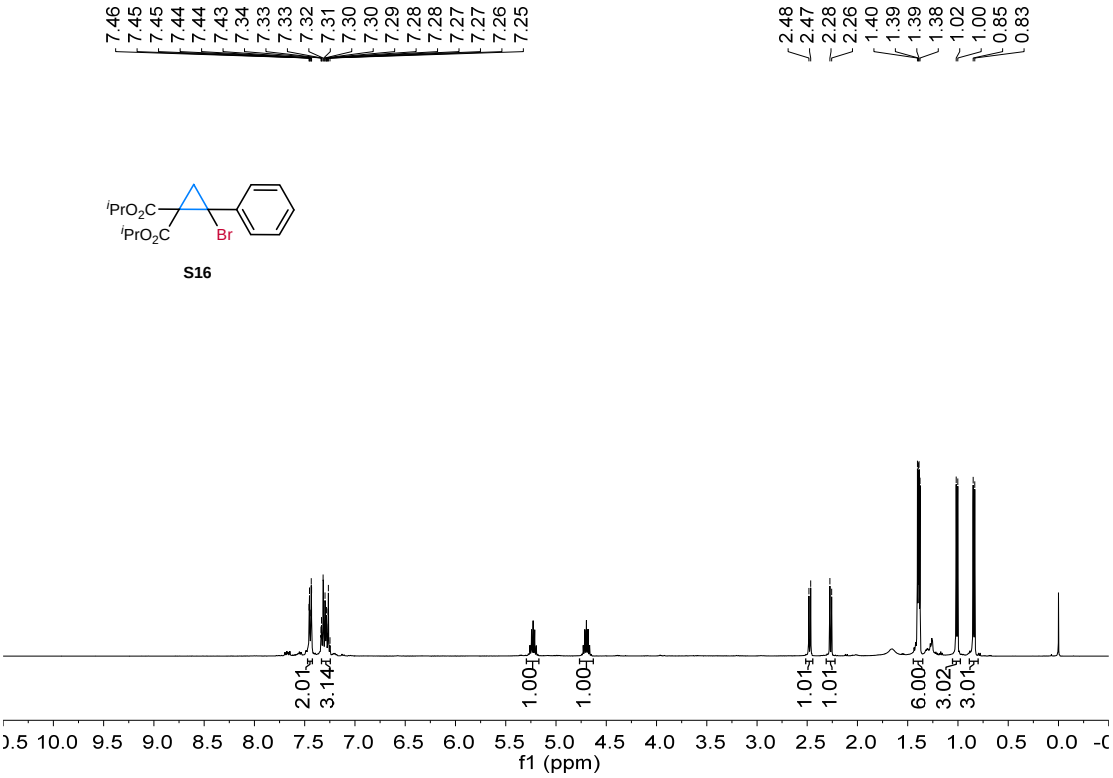
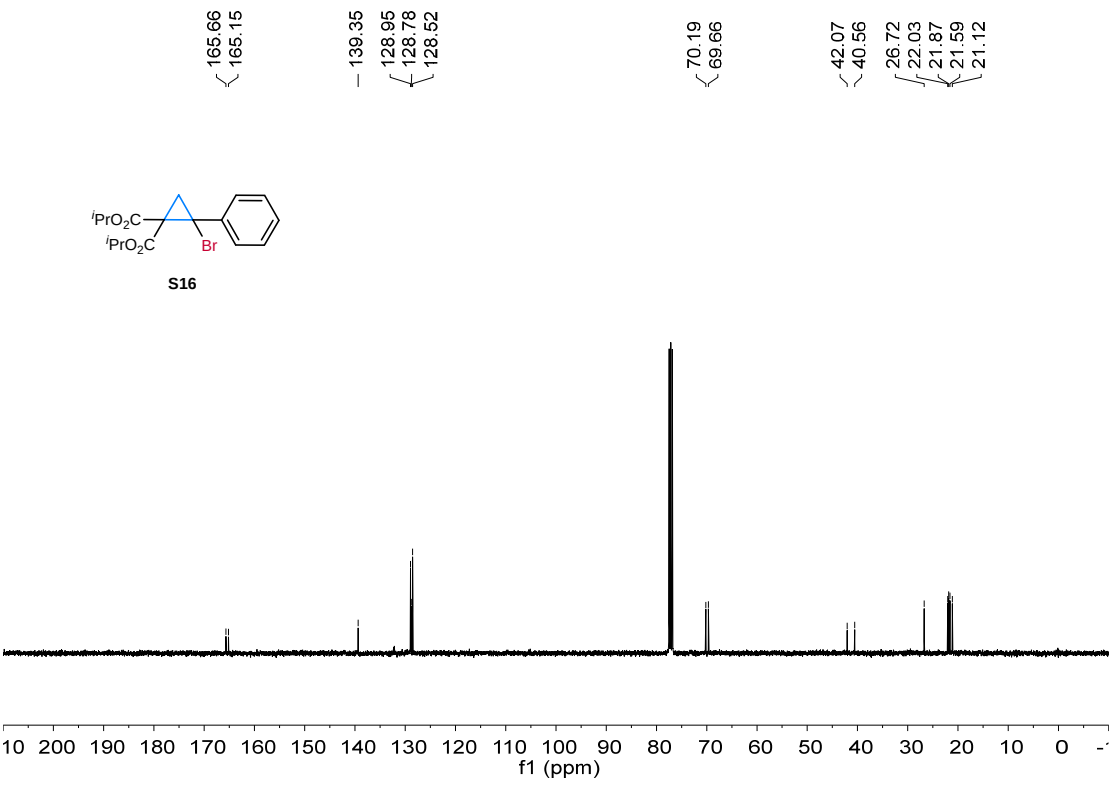
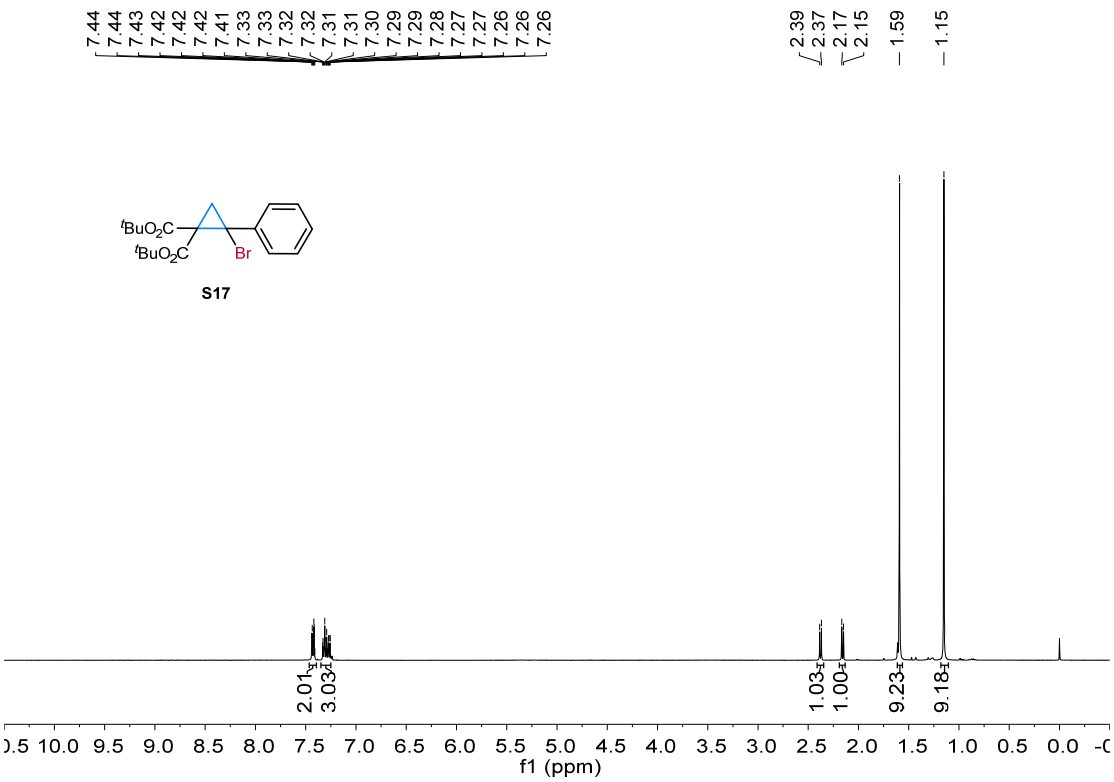
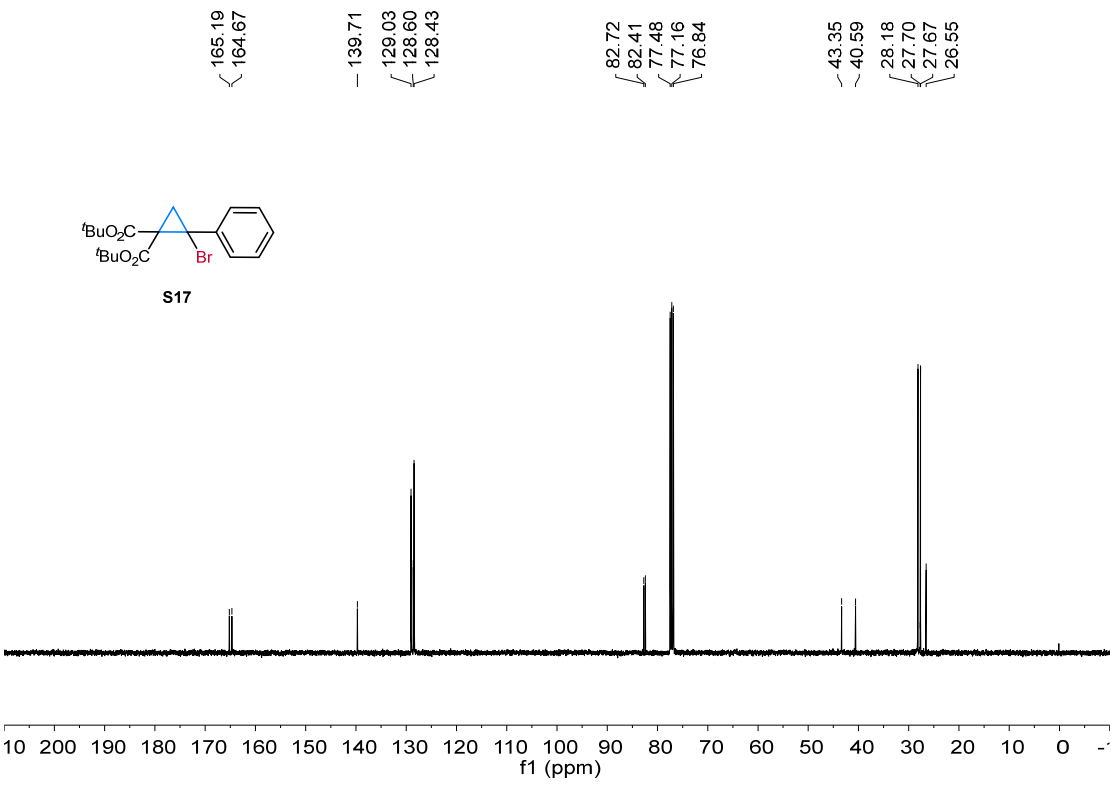
129.35
129.01
112.56
109.67
109.65
106.77
34.39
34.27
34.16
27.16
27.06
26.95
F
F
Br
S15
f1 (ppm)

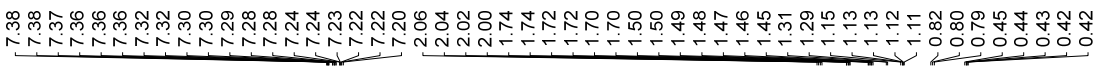

-126.93
-127.33
-131.89
-132.28
F
F
Br
S15
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
f1 (ppm)

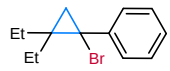

7.46
7.45
7.45
7.44
7.44
7.43
7.34
7.33
7.33
7.32
7.31
7.30
7.30
7.29
7.28
7.28
7.27
7.27
7.26
7.25
2.48
2.47
2.28
2.26
1.40
1.39
1.39
1.38
1.02
1.00
0.85
0.83
iPrO2C
iPrO2C
Br
S16
2.01
3.14
1.00
1.00
1.01
1.01
6.00
3.02
3.01
f1 (ppm)


165.66
165.15
139.35
128.95
128.78
128.52
70.19
69.66
42.07
40.56
26.72
22.03
21.87
21.59
21.12
iPrO2C
iPrO2C
Br
S16
f1 (ppm)

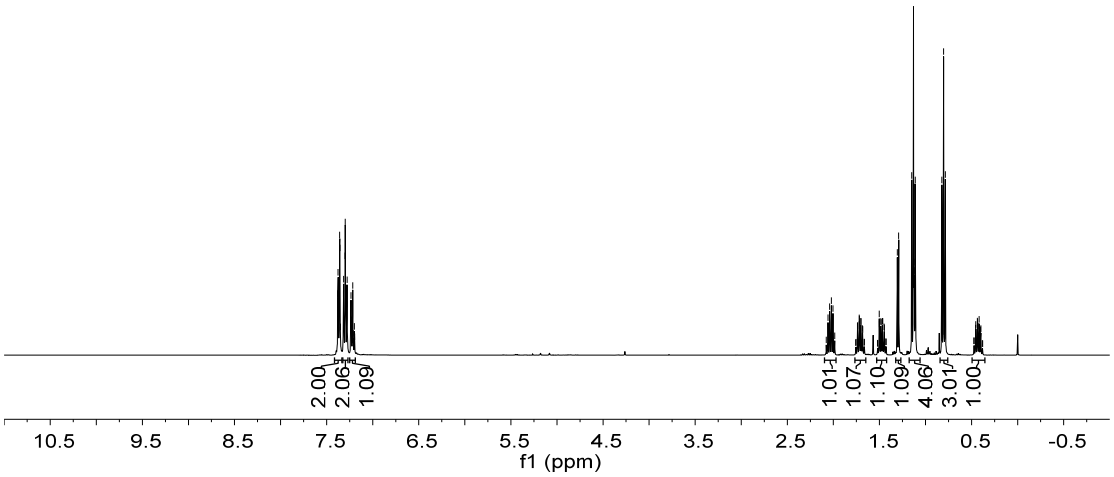

7.44
7.44
7.43
7.42
7.42
7.42
7.41
7.33
7.33
7.32
7.32
7.31
7.31
7.30
7.29
7.29
7.28
7.27
7.27
7.26
7.26
7.26
2.39
2.37
2.17
2.15
1.59
1.15
tBuO2C
tBuO2C
Br
S17
2.01
3.03
1.03
1.00
9.23
9.18
f1 (ppm)

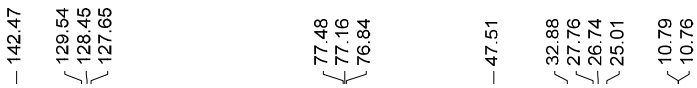

165.19
164.67
139.71
129.03
128.60
128.43
82.72
82.41
77.48
77.16
76.84
43.35
40.59
28.18
27.70
27.67
26.55
tBuO2C
tBuO2C
Br
S17
f1 (ppm)

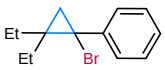

7.38
7.38
7.37
7.36
7.36
7.36
7.32
7.32
7.30
7.30
7.29
7.28
7.28
7.24
7.24
7.23
7.22
7.22
7.20
2.06
2.04
2.02
2.00
1.74
1.74
1.72
1.72
1.70
1.70
1.50
1.50
1.49
1.48
1.47
1.46
1.45
1.31
1.29
1.15
1.13
1.13
1.12
1.11
0.82
0.80
0.79
0.45
0.44
0.43
0.42
0.42


Et
Et
Br

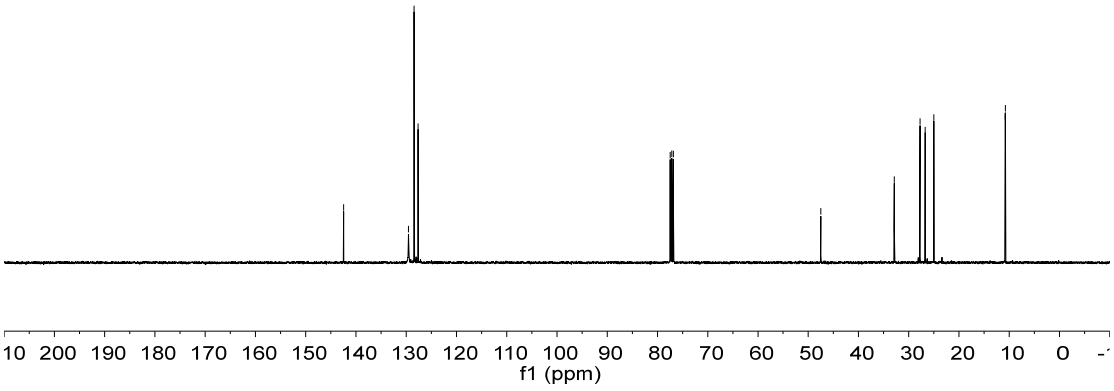
**S18**

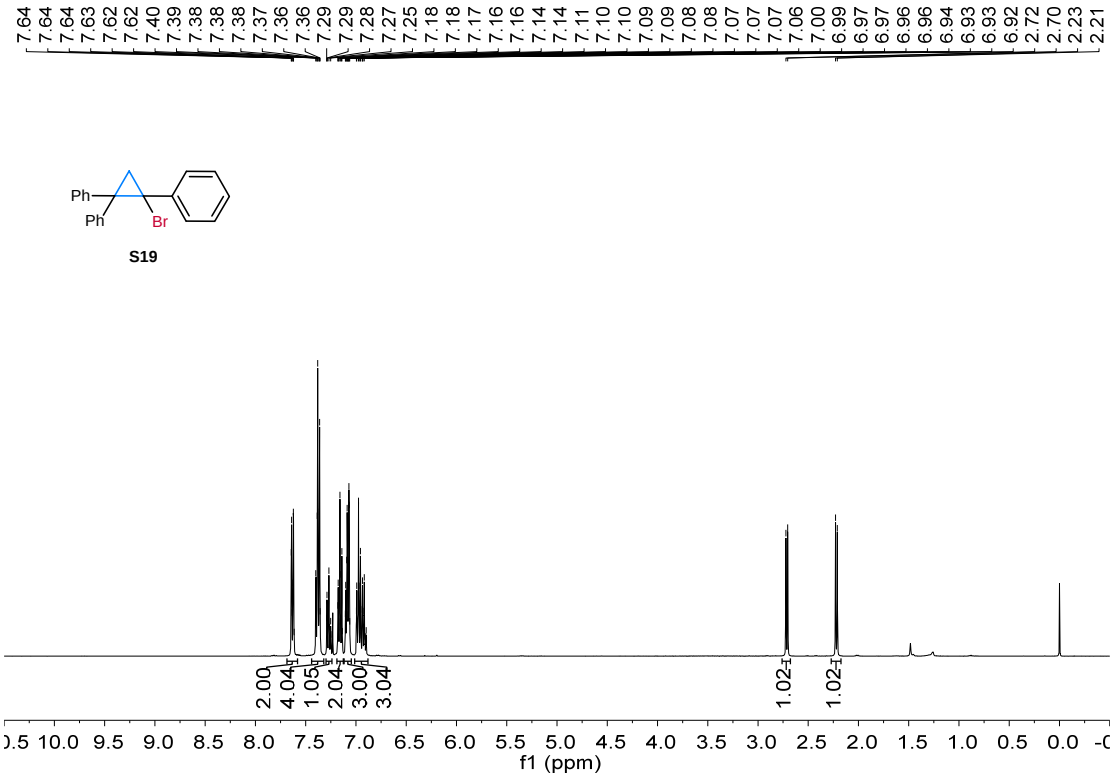

2.00
2.06
1.09
1.01
1.07
1.10
1.09
4.06
3.01
1.00
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
f1 (ppm)

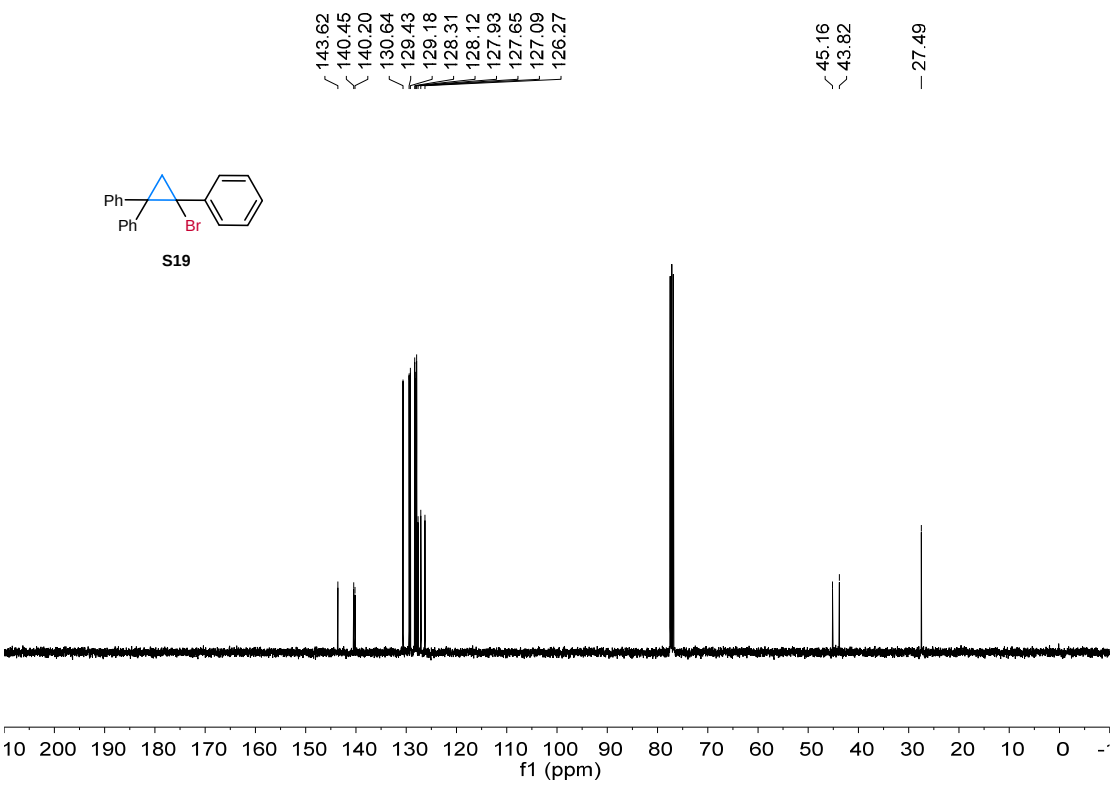

142.47
129.54
128.45
127.65
77.48
77.16
76.84
47.51
32.88
27.76
26.74
25.01
10.79
10.76

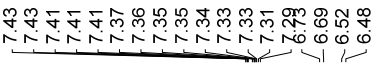

Et
Et
Br

**S18**


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.64 7.64 7.64 7.63 7.62 7.62 7.40 7.39 7.38 7.38 7.38 7.37 7.36 7.36 7.29 7.29 7.28 7.27 7.25 7.18 7.18 7.17 7.16 7.16 7.14 7.14 7.11 7.10 7.10 7.09 7.09 7.08 7.08 7.07 7.07 7.07 7.06 7.00 6.99 6.97 6.97 6.96 6.96 6.94 6.93 6.93 6.92 2.72 2.70 2.23 2.21
Ph
Ph
Br
S19
2.00 4.04 1.05 2.04 3.00 3.04 1.02 1.02
f1 (ppm)

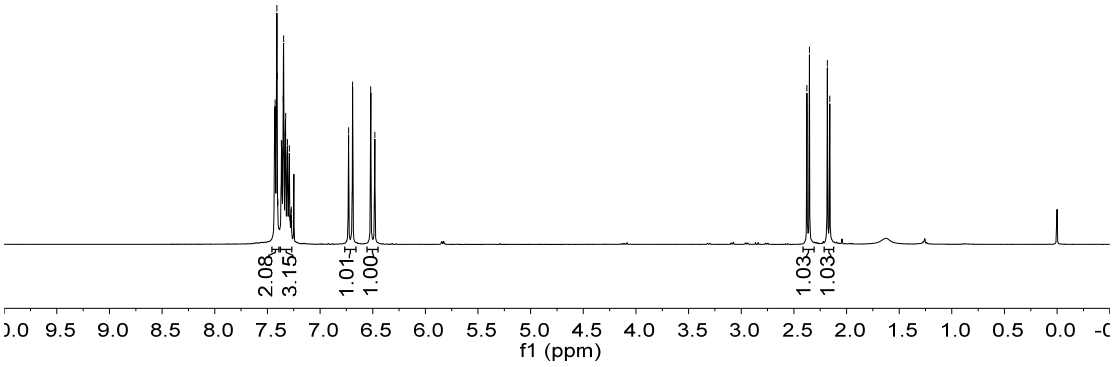

143.62 140.45 140.20 130.64 129.43 129.18 128.31 128.12 127.93 127.65 127.09 126.27
45.16 43.82
27.49
Ph
Ph
Br
S19
f1 (ppm)

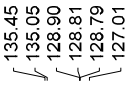

7.43
7.43
7.41
7.41
7.41
7.37
7.36
7.35
7.35
7.34
7.33
7.33
7.31
7.29
6.73
6.69
6.52
6.48


2.38
2.35
2.18
2.16

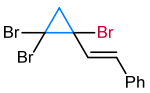

Br
Br
Br
Ph

**54**

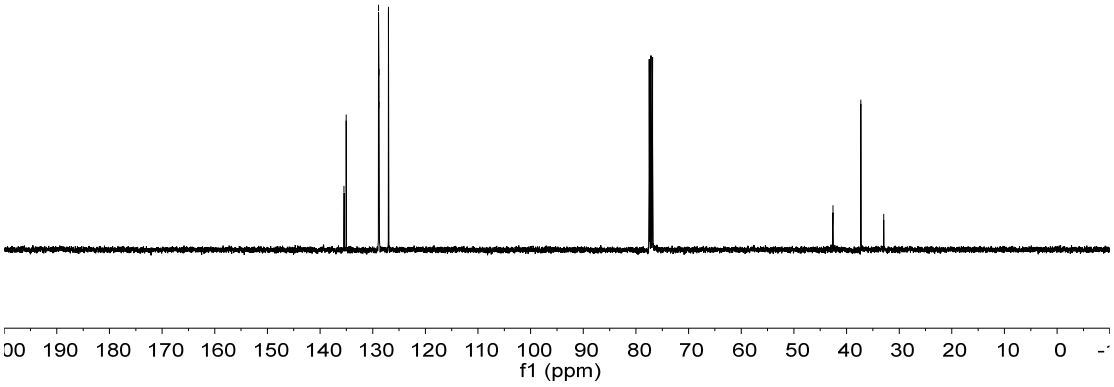

2.08
3.15
1.01
1.00
1.03
1.03
f1 (ppm)

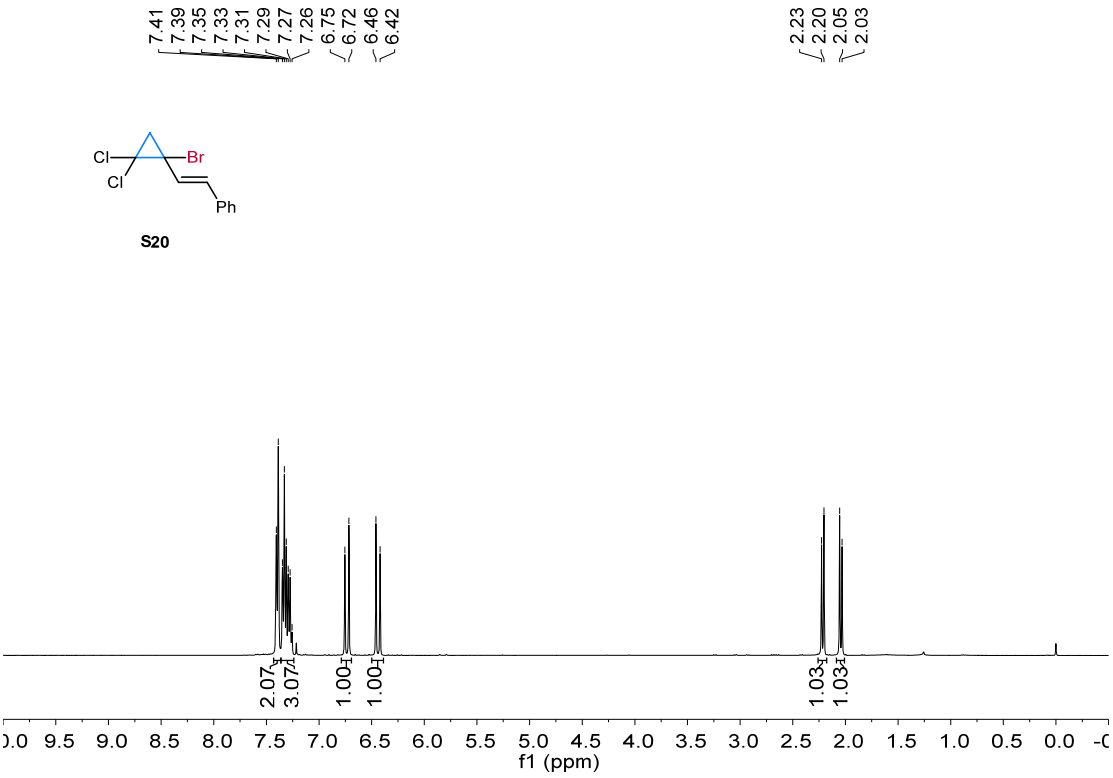

135.45
135.05
128.90
128.81
128.79
127.01

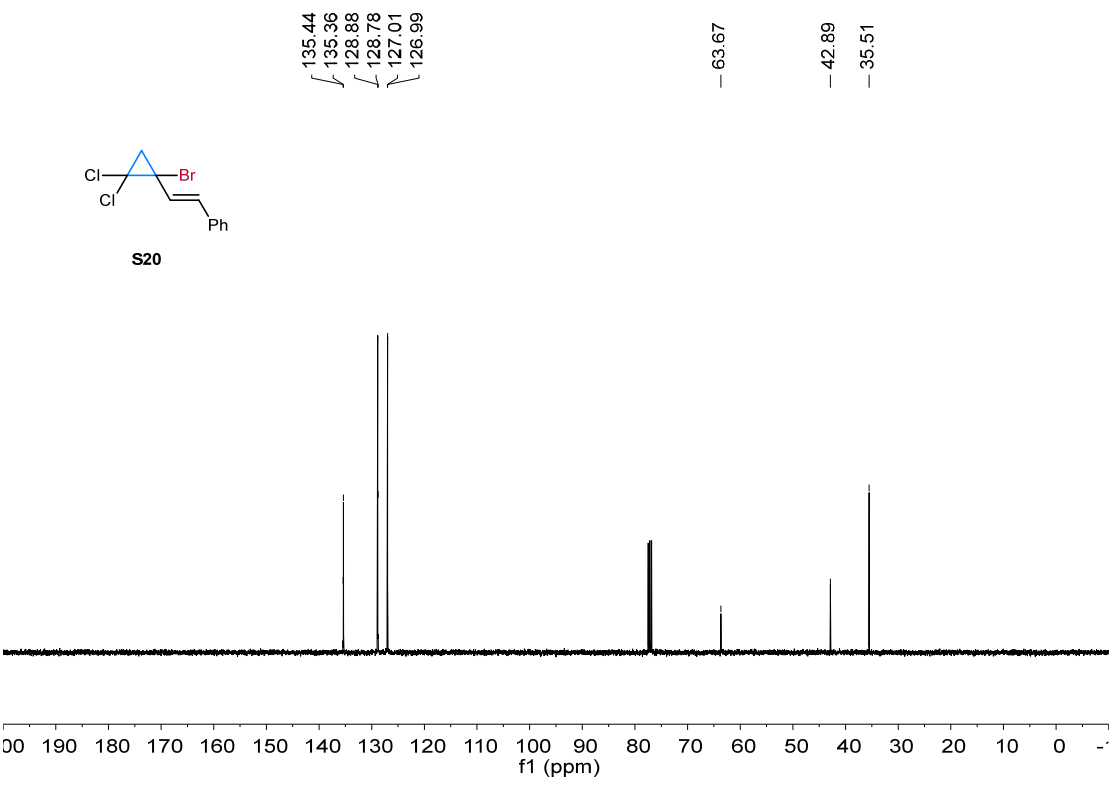

42.58
37.28
32.93


Br
Br
Br
Ph

**54**


f1 (ppm)


7.41
7.39
7.35
7.33
7.31
7.29
7.27
7.26
6.75
6.72
6.46
6.42
2.23
2.20
2.05
2.03
Cl
Cl
Br
Ph
S20
2.07
3.07
1.00
1.00
1.03
1.03
f1 (ppm)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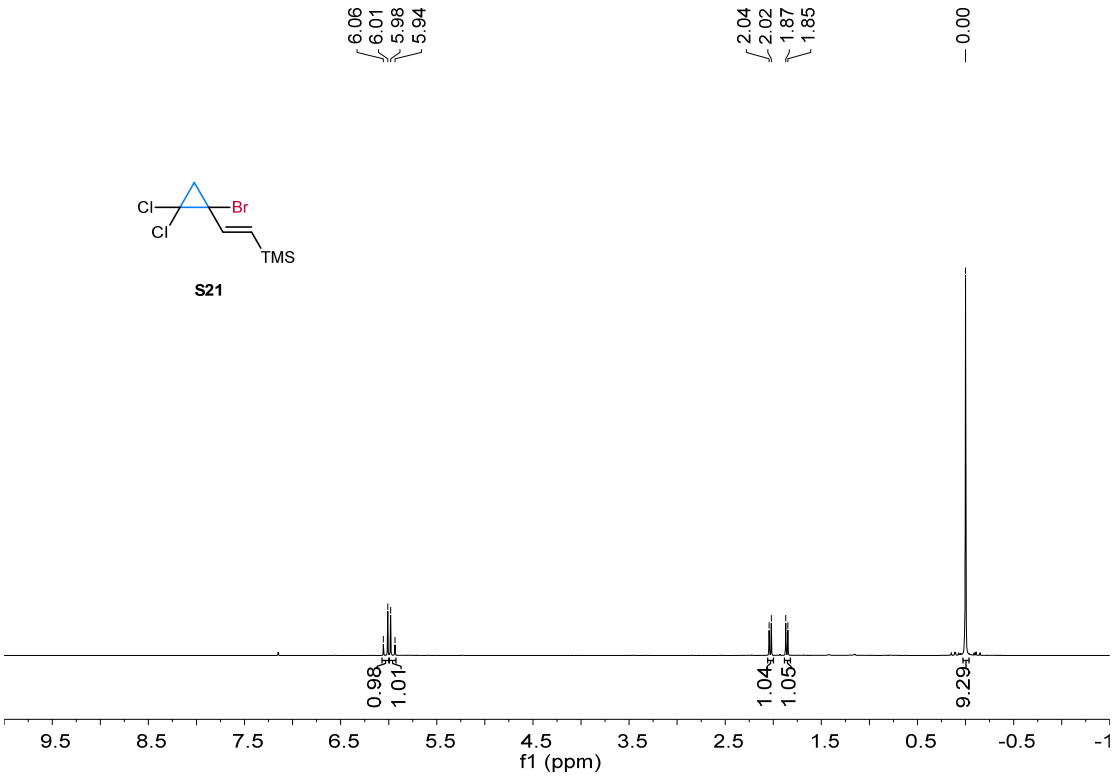
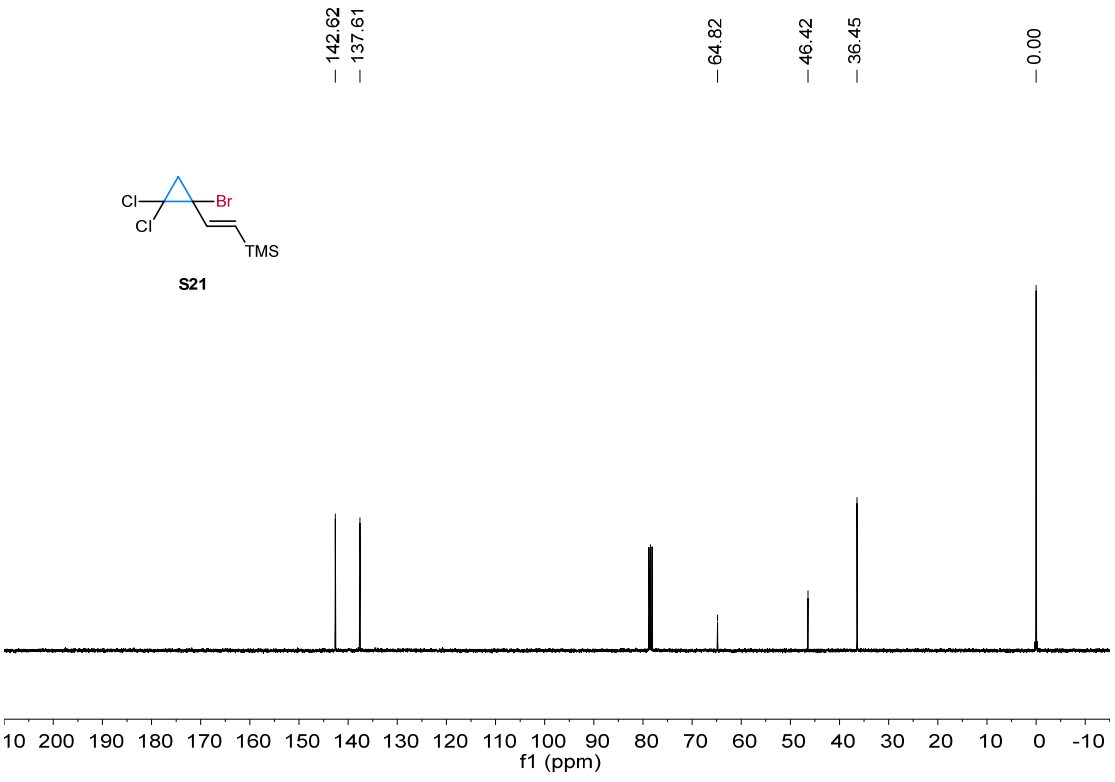
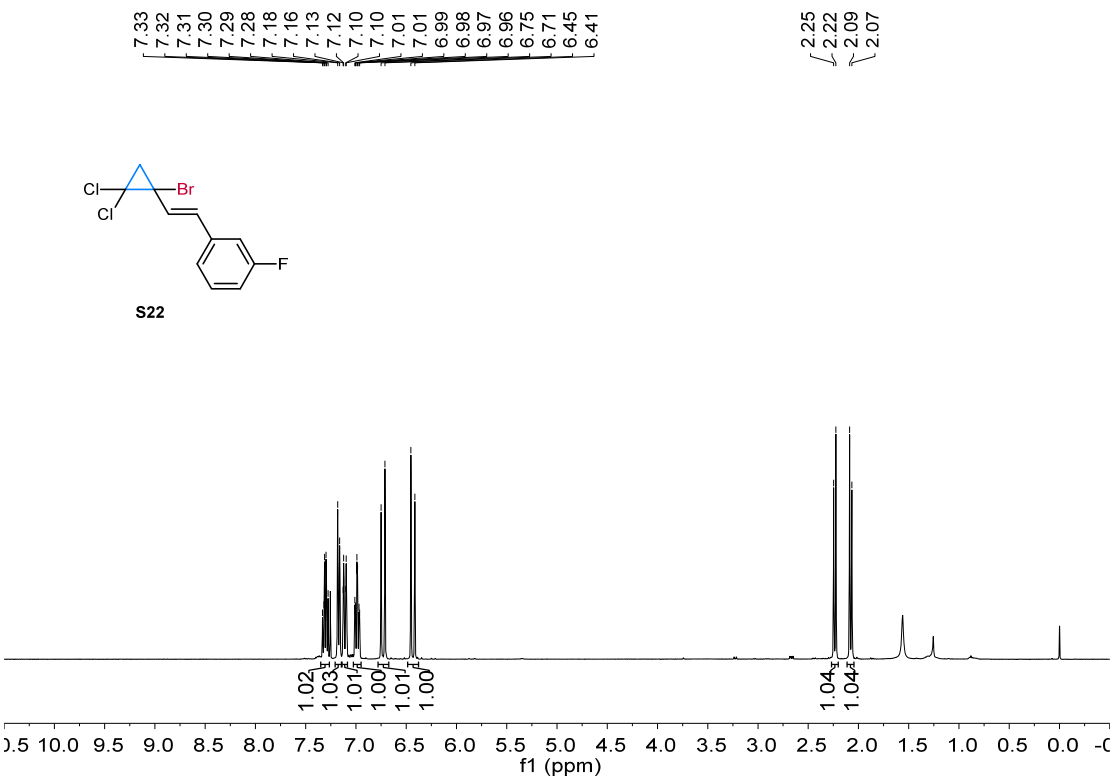
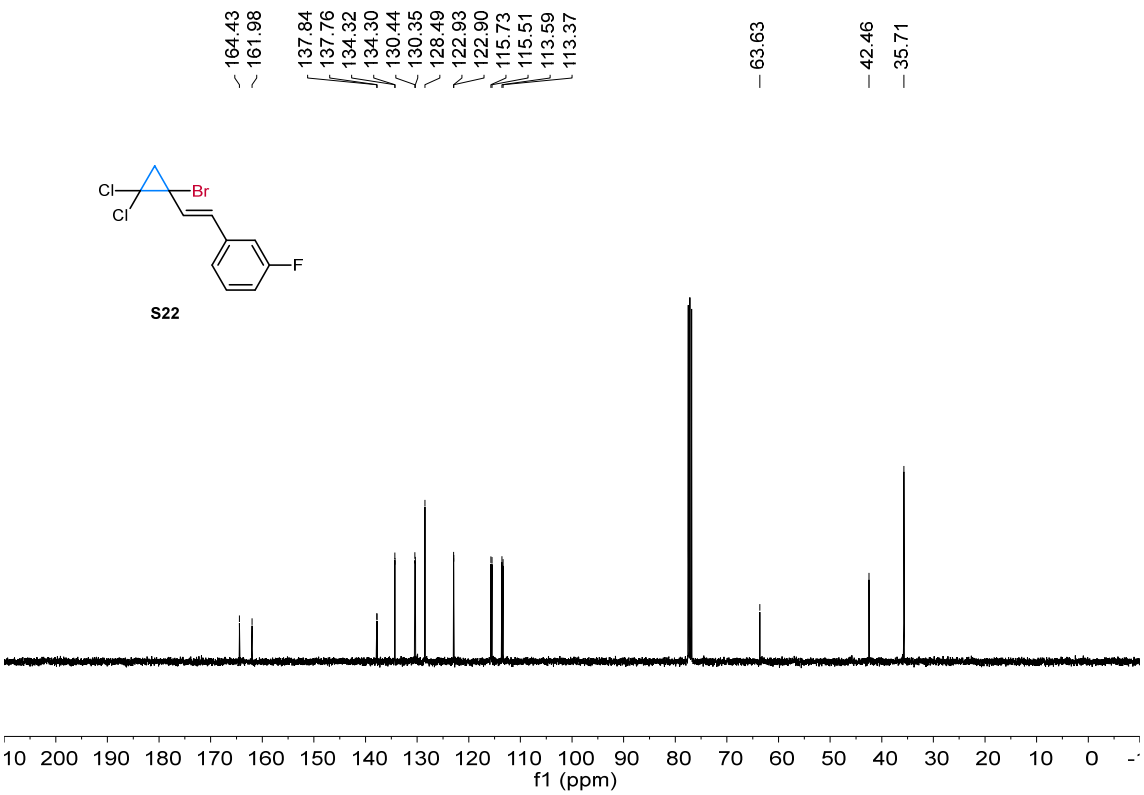
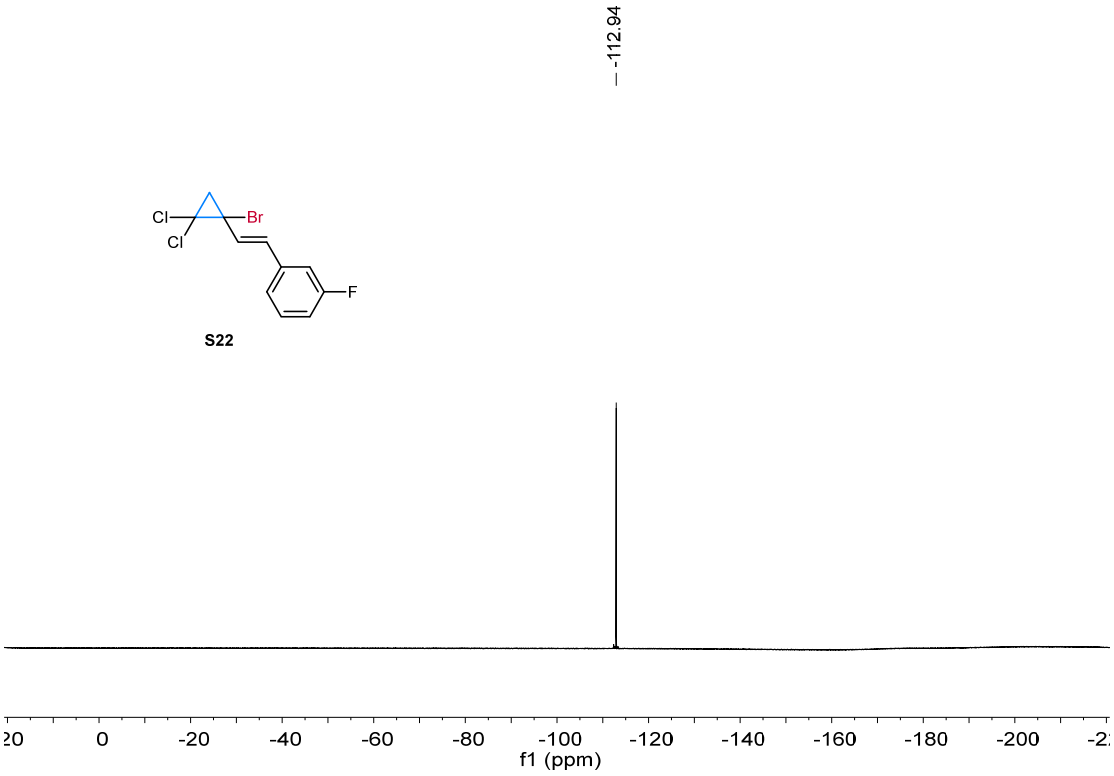
135.36
128.88
128.78
127.01
126.99
63.67
42.89
35.51
Cl
Cl
Br
Ph
S20
f1 (ppm)

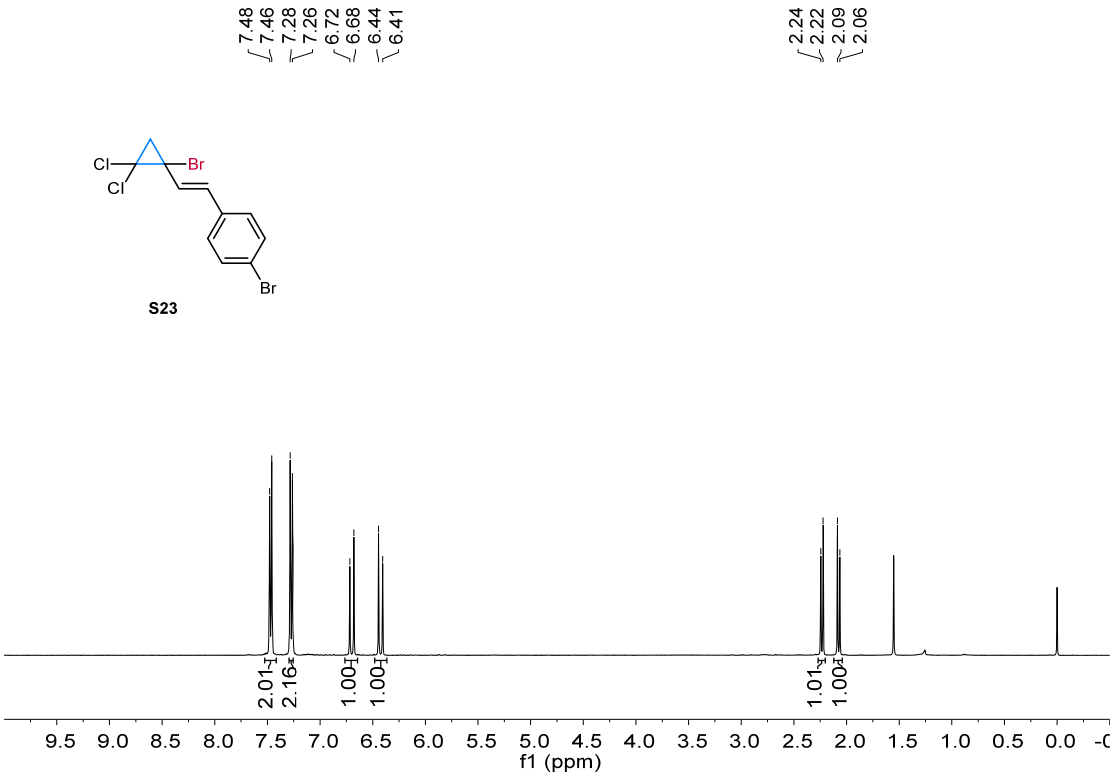

6.06
6.01
5.98
5.94
2.04
2.02
1.87
1.85
0.00
Cl
Cl
Br
TMS
S21
0.98
1.01
1.04
1.05
9.29
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
-1
f1 (ppm)

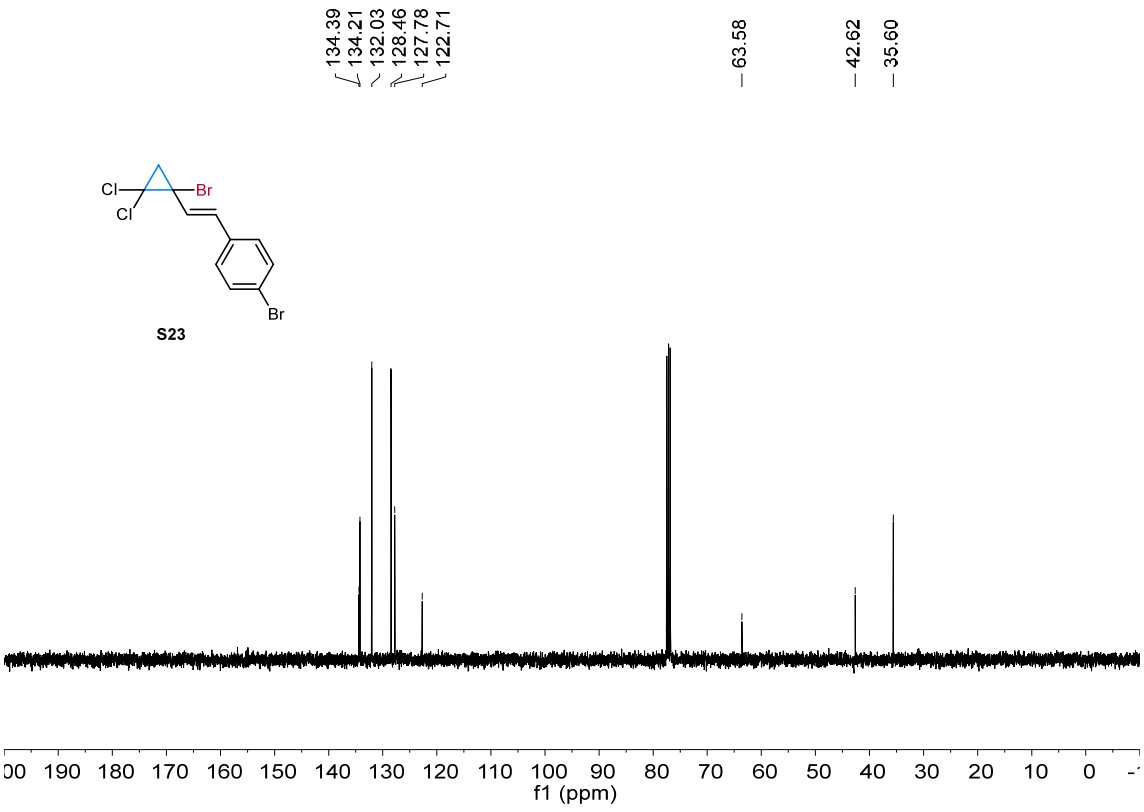

142.62
137.61
64.82
46.42
36.45
0.00
Cl
Cl
Br
TMS
S21
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

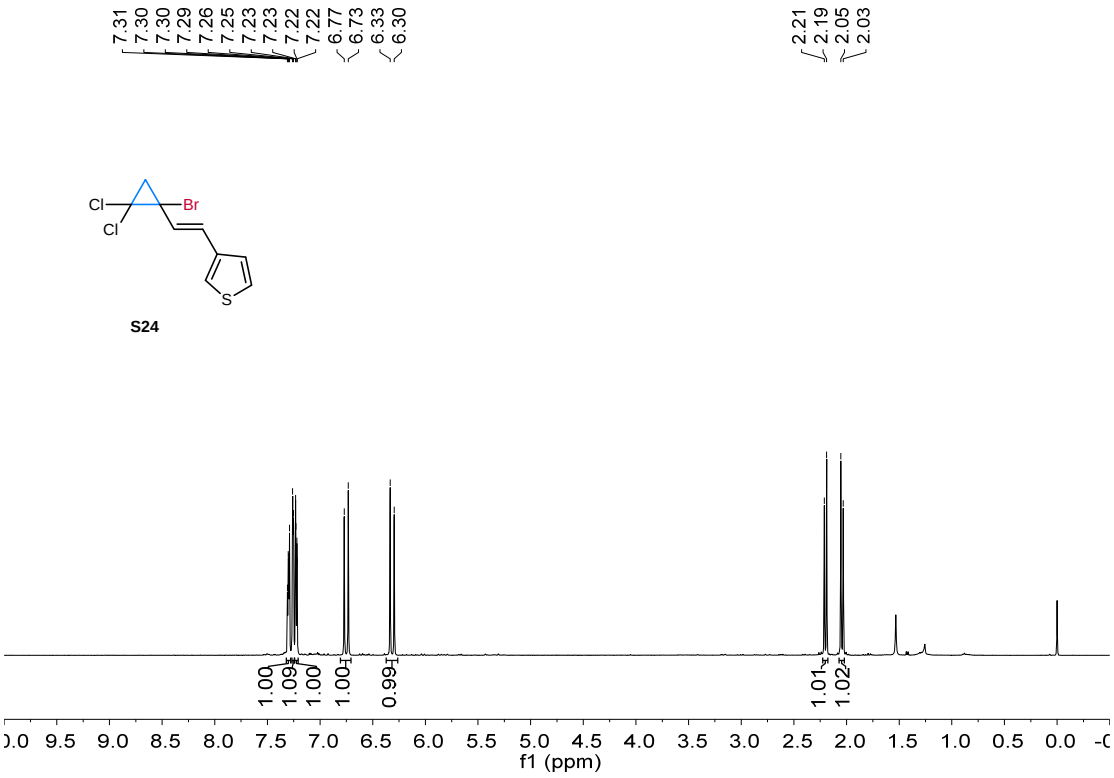

7.33
7.32
7.31
7.30
7.29
7.28
7.18
7.16
7.13
7.12
7.10
7.10
7.01
7.01
6.99
6.98
6.97
6.96
6.75
6.71
6.45
6.41
2.25
2.22
2.09
2.07
Cl
Cl
Br
F
S22
1.02
1.03
1.01
1.00
1.01
1.00
1.04
1.04
f1 (ppm)

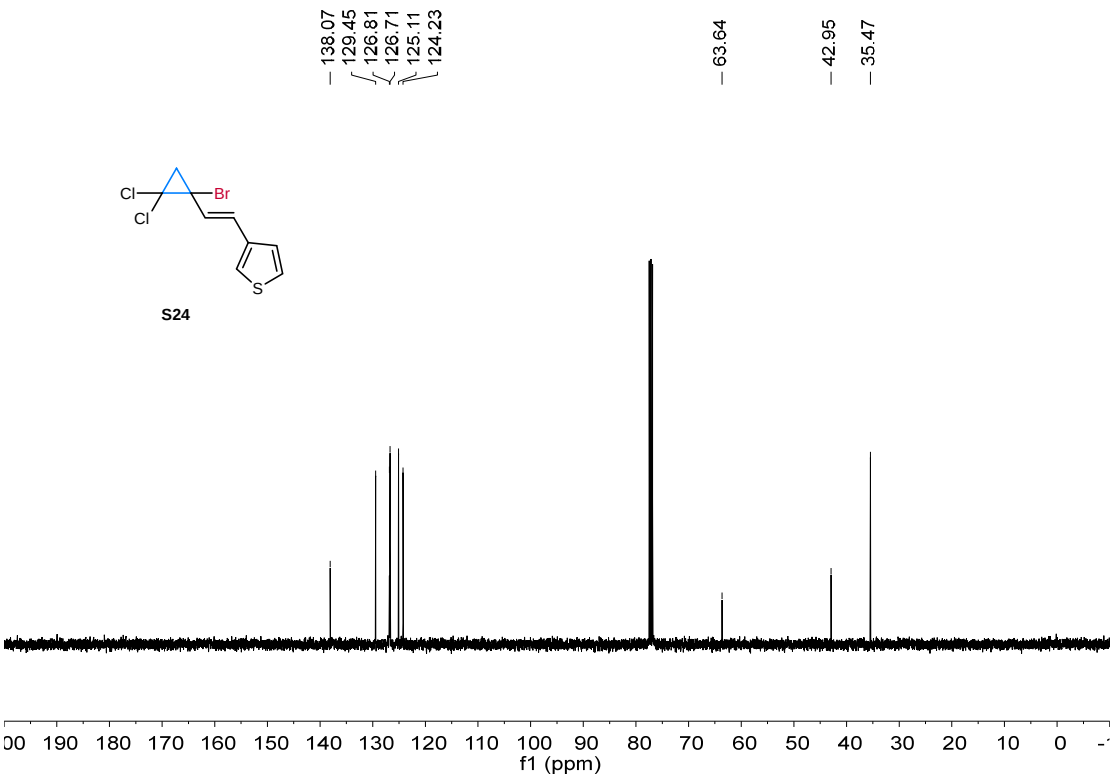

164.43
161.98
137.84
137.76
134.32
134.30
130.44
130.35
128.49
122.93
122.90
115.73
115.51
113.59
113.37
63.63
42.46
35.71
Cl
Cl
Br
F
S22
f1 (ppm)


-112.94
Cl
Cl
Br
F
S22
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
f1 (ppm)

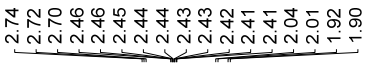

7.48
7.46
7.28
7.26
6.72
6.68
6.44
6.41
2.24
2.22
2.09
2.06
Cl
Cl
Br
Br
S23
2.01
2.16
1.00
1.00
1.01
1.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

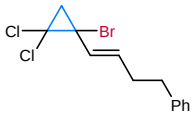

134.39
134.21
132.03
128.46
127.78
122.71
63.58
42.62
35.60
Cl
Cl
Br
Br
S23
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.31
7.30
7.30
7.29
7.26
7.25
7.23
7.23
7.22
7.22
6.77
6.73
6.33
6.30
2.21
2.19
2.05
2.03
Cl
Cl
Br
S
S24
1.00
1.09
1.00
1.00
0.99
1.01
1.02
f1 (ppm)

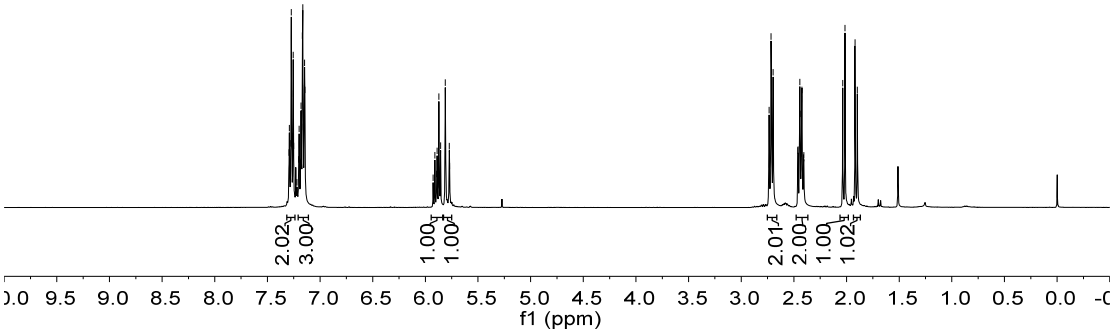

138.07
129.45
126.81
126.71
125.11
124.23
63.64
42.95
35.47
Cl
Cl
Br
S
S24
f1 (ppm)


7.29
7.29
7.28
7.27
7.27
7.26
7.26
7.25
7.20
7.20
7.18
7.17
7.16
7.16
7.15
7.15
7.14
5.93
5.91
5.89
5.89
5.87
5.86
5.81
5.77
5.77

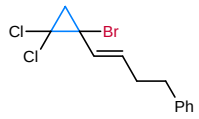

2.74
2.72
2.70
2.46
2.46
2.45
2.44
2.44
2.43
2.43
2.42
2.41
2.41
2.04
2.01
1.92
1.90


Cl
Cl
Br
Ph

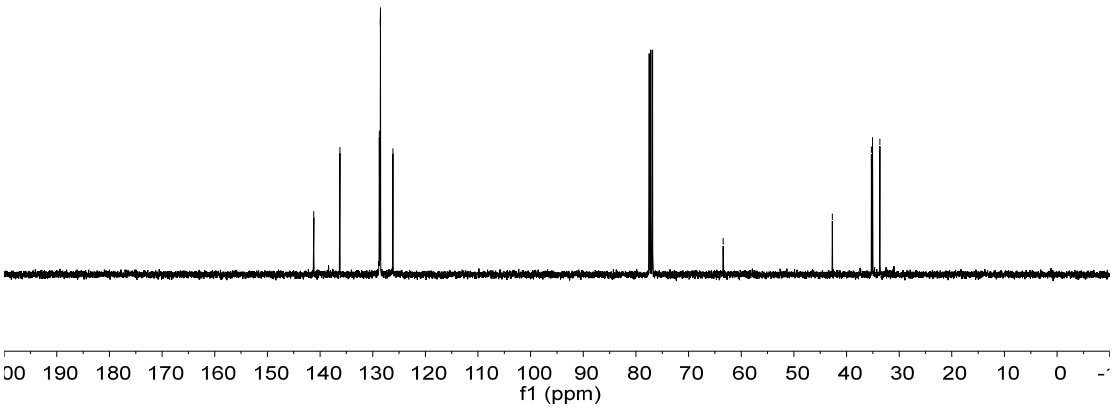
**S25**

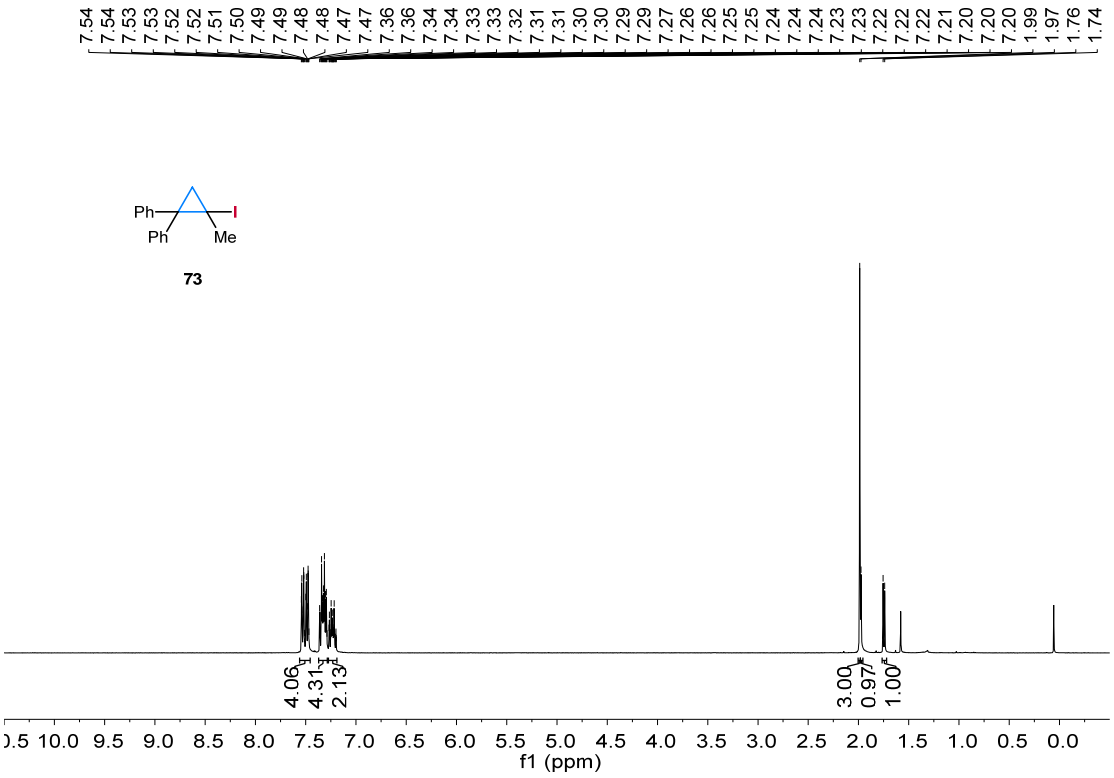

2.02
3.00
1.00
1.00
2.01
2.00
1.00
1.02
f1 (ppm)


141.20
136.24
128.74
128.56
128.53
126.15
63.42
42.71
35.27
35.07
33.65


Cl
Cl
Br
Ph

**S25**


f1 (ppm)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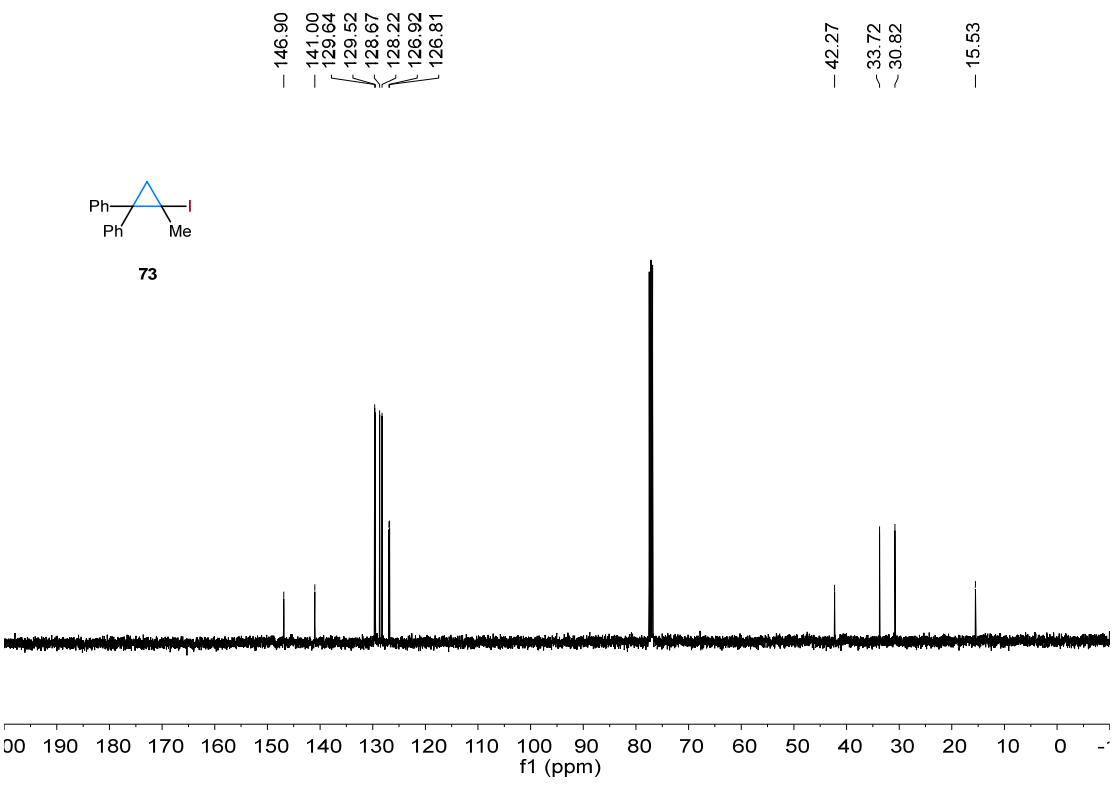
Ph
Ph
I
Me
73
4.06
4.31
2.13
3.00
0.97
1.00
f1 (ppm)


146.90
141.00
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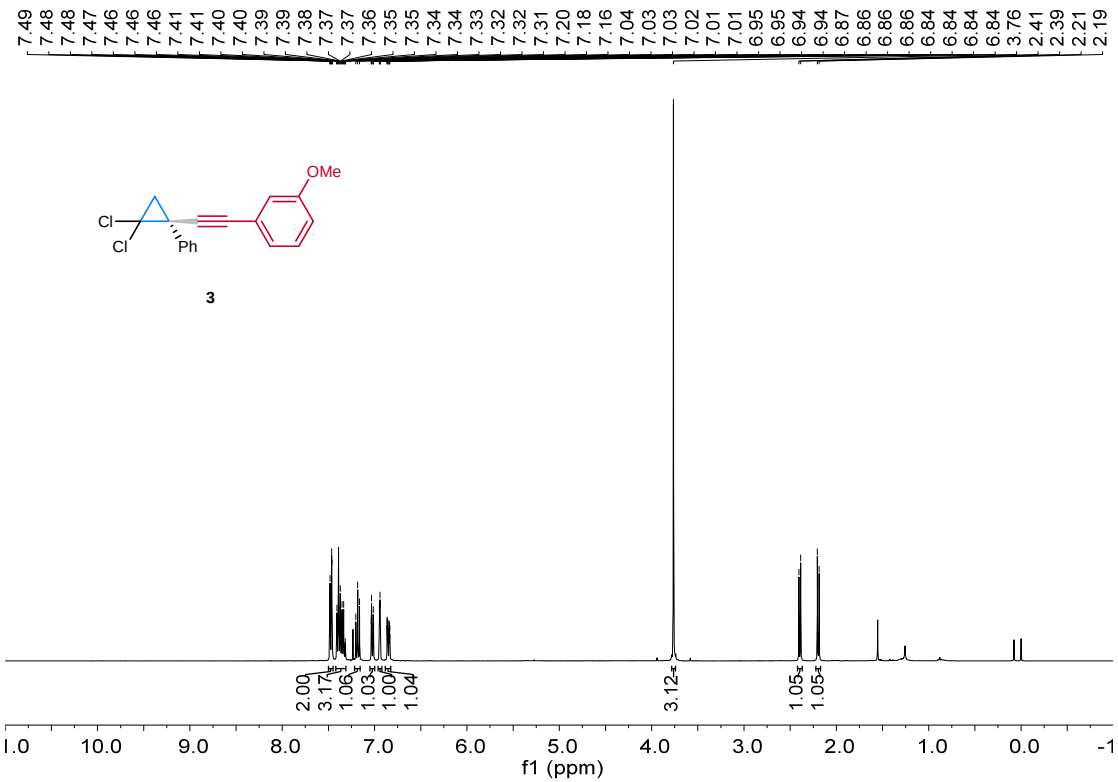
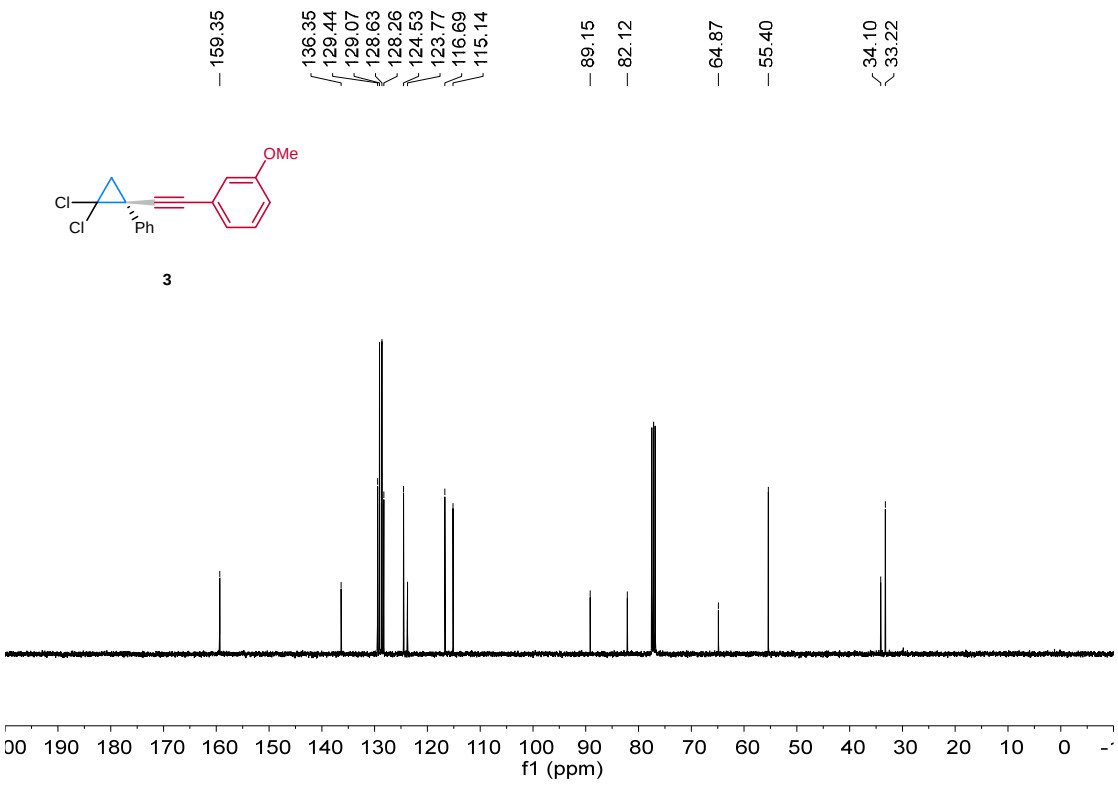
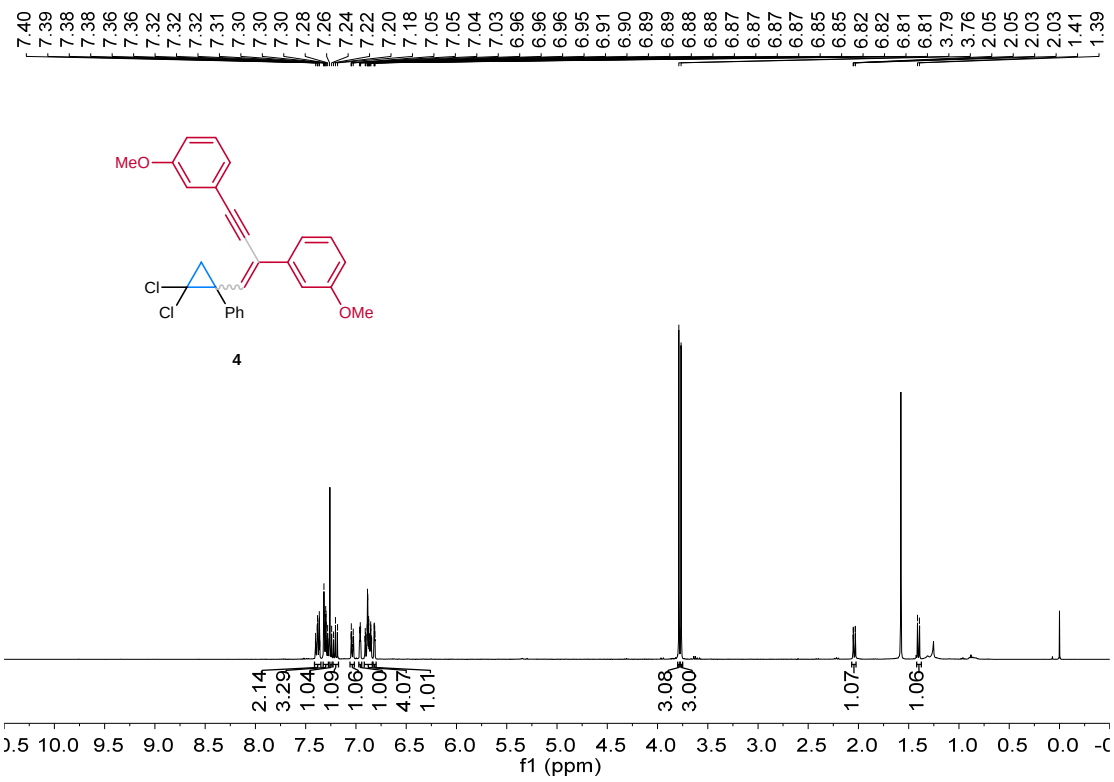
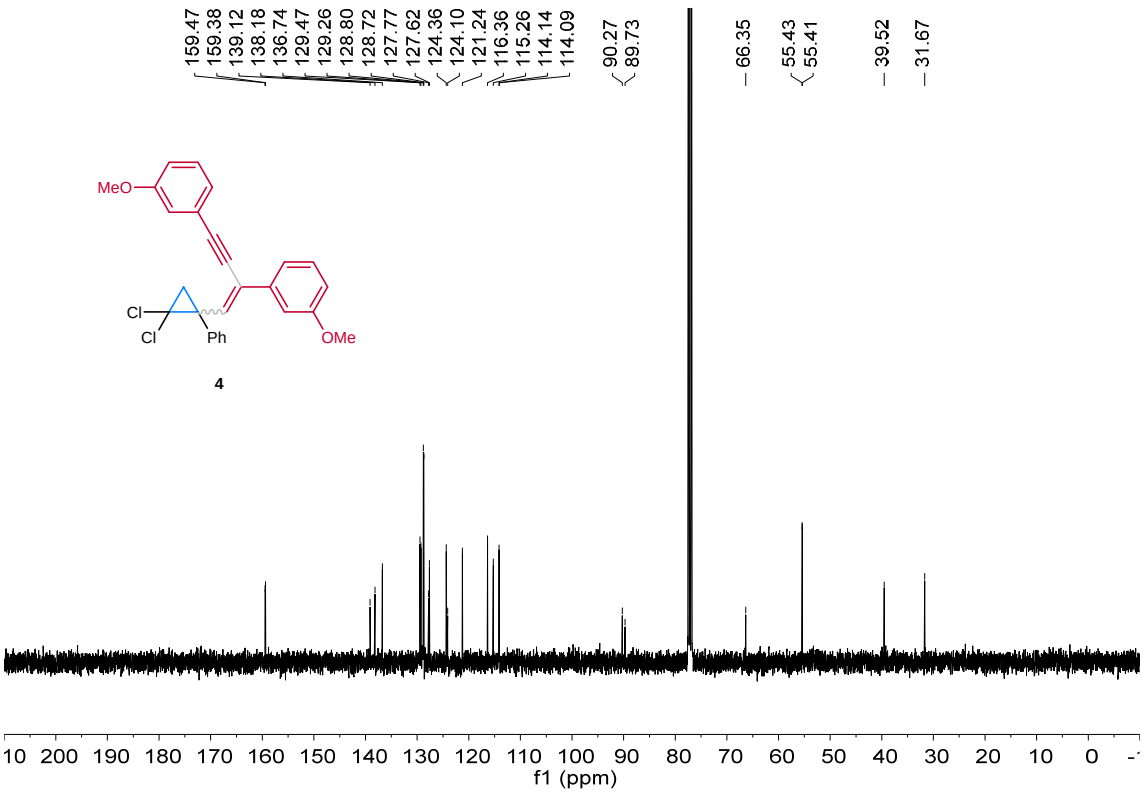
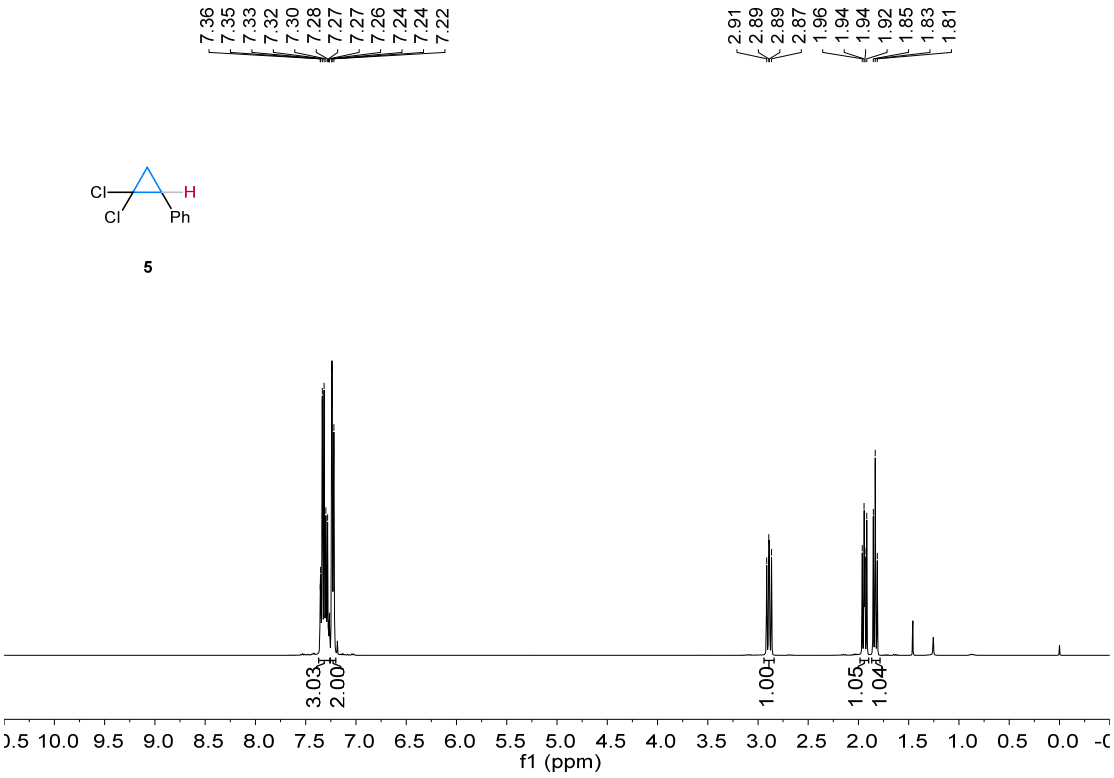
129.52
128.67
128.22
126.92
126.81
42.27
33.72
30.82
15.53
Ph
Ph
I
Me
73
f1 (ppm)


7.49 7.48 7.48 7.47 7.46 7.46 7.46 7.41 7.41 7.40 7.40 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.35 7.34 7.34 7.33 7.32 7.32 7.31 7.20 7.18 7.16 7.04 7.03 7.03 7.02 7.01 7.01 6.95 6.95 6.94 6.94 6.87 6.86 6.86 6.86 6.84 6.84 6.84 6.84 3.76 2.41 2.39 2.21 2.19
OMe
Cl
Cl
Ph
3
2.00 3.17 1.06 1.03 1.00 1.04 3.12 1.05 1.05
f1 (ppm)


159.35
136.35 129.44 129.07 128.63 128.26 124.53 123.77 116.69 115.14
89.15 82.12 64.87 55.40 34.10 33.22
OMe
Cl
Cl
Ph
3
f1 (ppm)


7.40 7.39 7.38 7.38 7.36 7.36 7.32 7.32 7.32 7.31 7.30 7.30 7.30 7.28 7.26 7.24 7.22 7.20 7.18 7.05 7.05 7.04 7.03 6.96 6.96 6.96 6.95 6.91 6.90 6.89 6.89 6.88 6.88 6.87 6.87 6.87 6.87 6.85 6.85 6.82 6.82 6.81 6.81 3.79 3.76 2.05 2.05 2.03 2.03 1.41 1.39
MeO
Cl
Cl
Ph
OMe
4
2.14 3.29 1.04 1.09 1.06 1.00 4.07 1.01 3.08 3.00 1.07 1.06
f1 (ppm)


159.47 159.38 139.12 138.18 136.74 129.47 129.26 128.80 128.72 127.77 127.62 124.36 124.10 121.24 116.36 115.26 114.14 114.09 90.27 89.73 66.35 55.43 55.41 39.52 31.67
MeO
Cl
Cl
Ph
OMe
4
f1 (ppm)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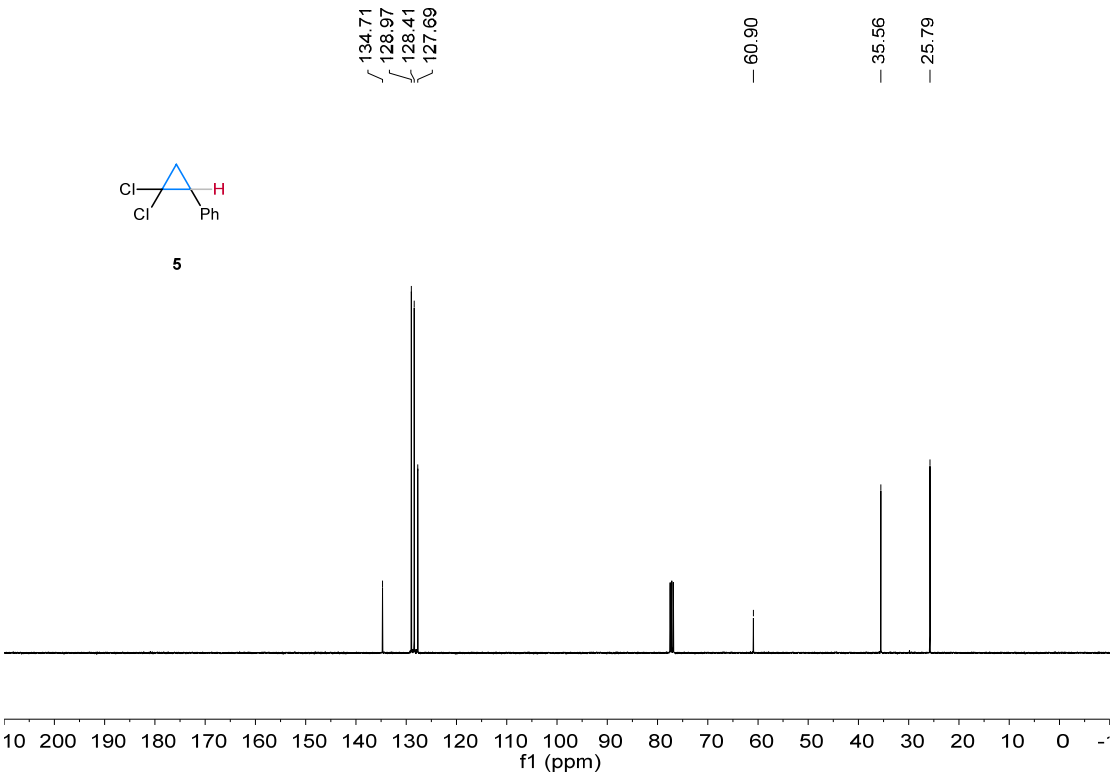
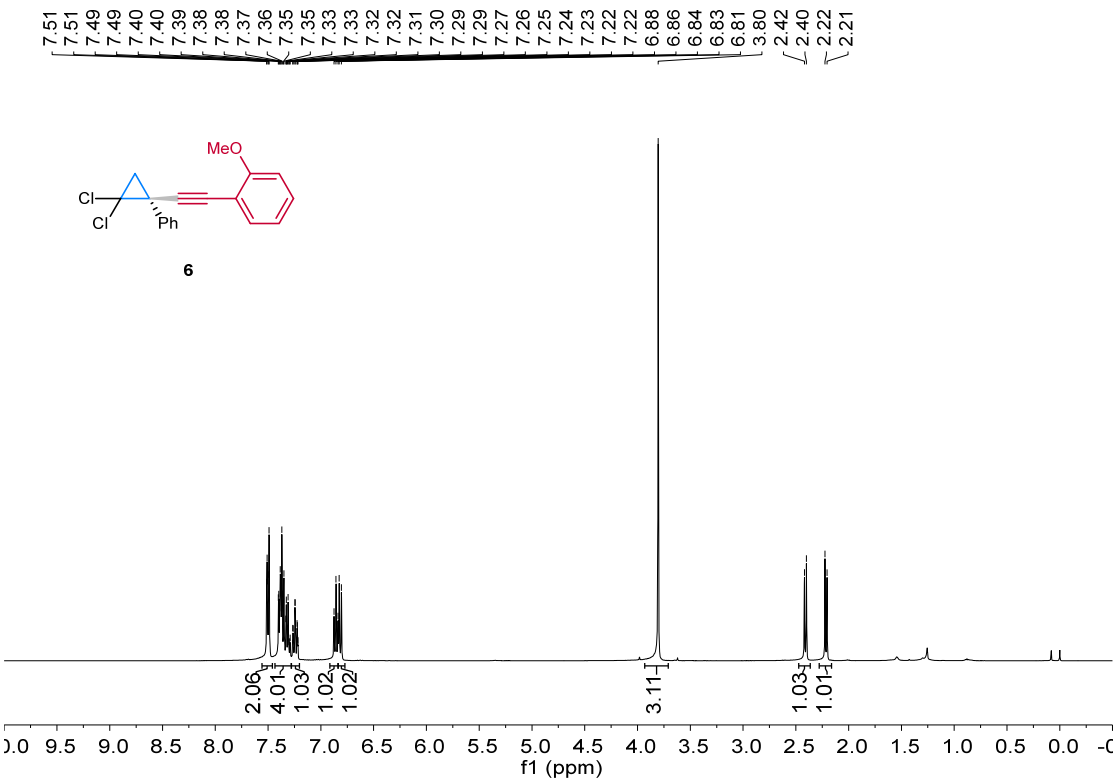
7.35
7.33
7.32
7.30
7.28
7.27
7.27
7.26
7.24
7.24
7.22
2.91
2.89
2.89
2.87
1.96
1.94
1.94
1.92
1.85
1.83
1.81
Cl
Cl
H
Ph
5
3.03
2.00
1.00
1.05
1.04
f1 (ppm)


134.71
128.97
128.41
127.69
60.90
35.56
25.79
Cl
Cl
H
Ph
5
f1 (ppm)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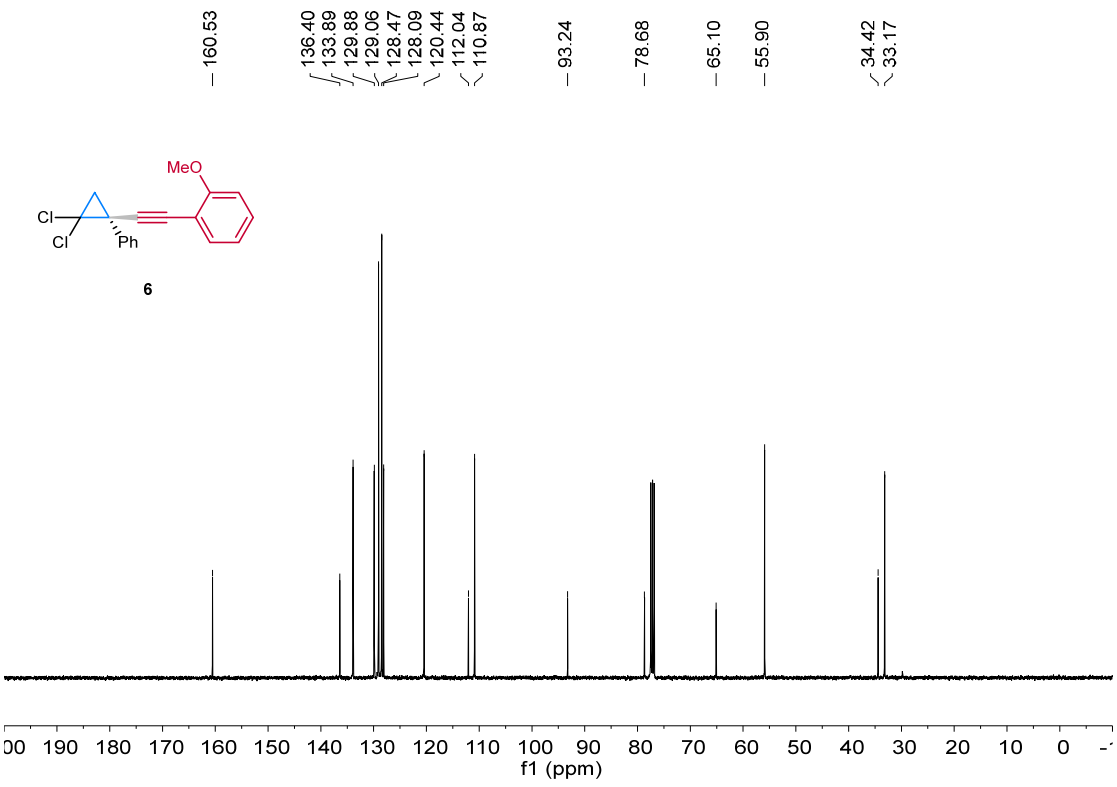
7.51
7.49
7.49
7.40
7.40
7.39
7.38
7.38
7.37
7.36
7.35
7.35
7.33
7.33
7.32
7.32
7.31
7.30
7.29
7.29
7.27
7.26
7.25
7.24
7.23
7.22
7.22
6.88
6.86
6.84
6.83
6.81
3.80
2.42
2.40
2.22
2.21
MeO
Cl
Cl
Ph
6
2.06
4.01
1.03
1.02
1.02
3.11
1.03
1.01
f1 (ppm)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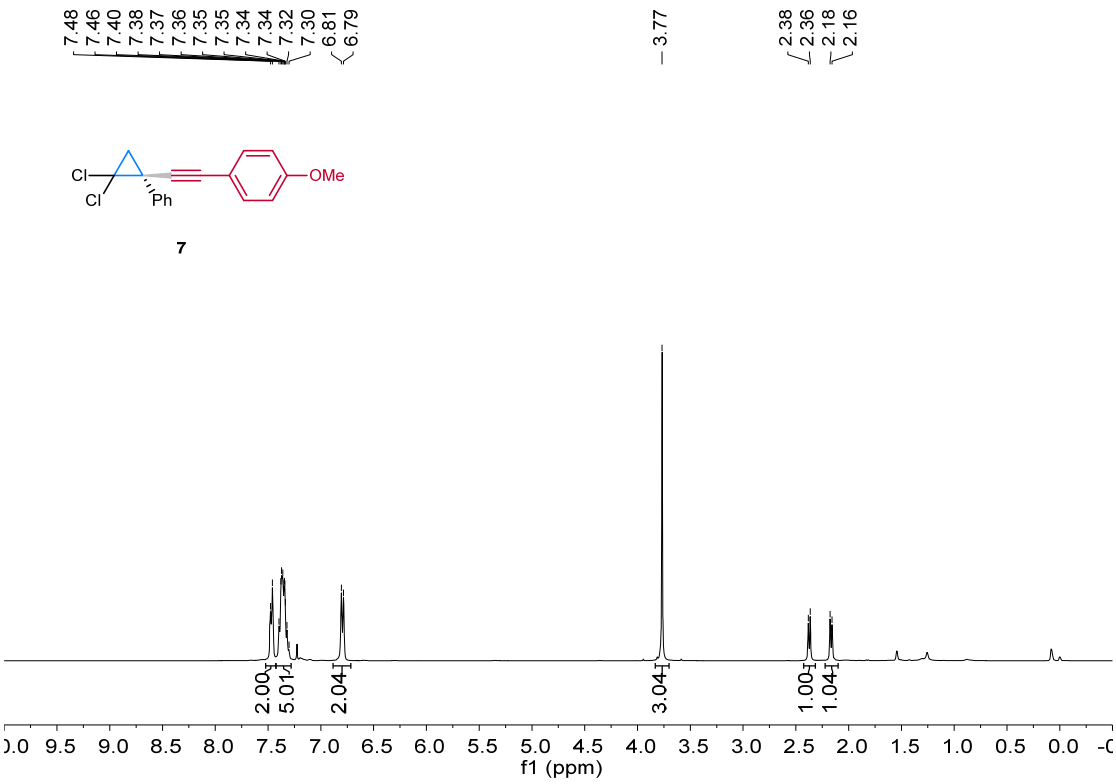
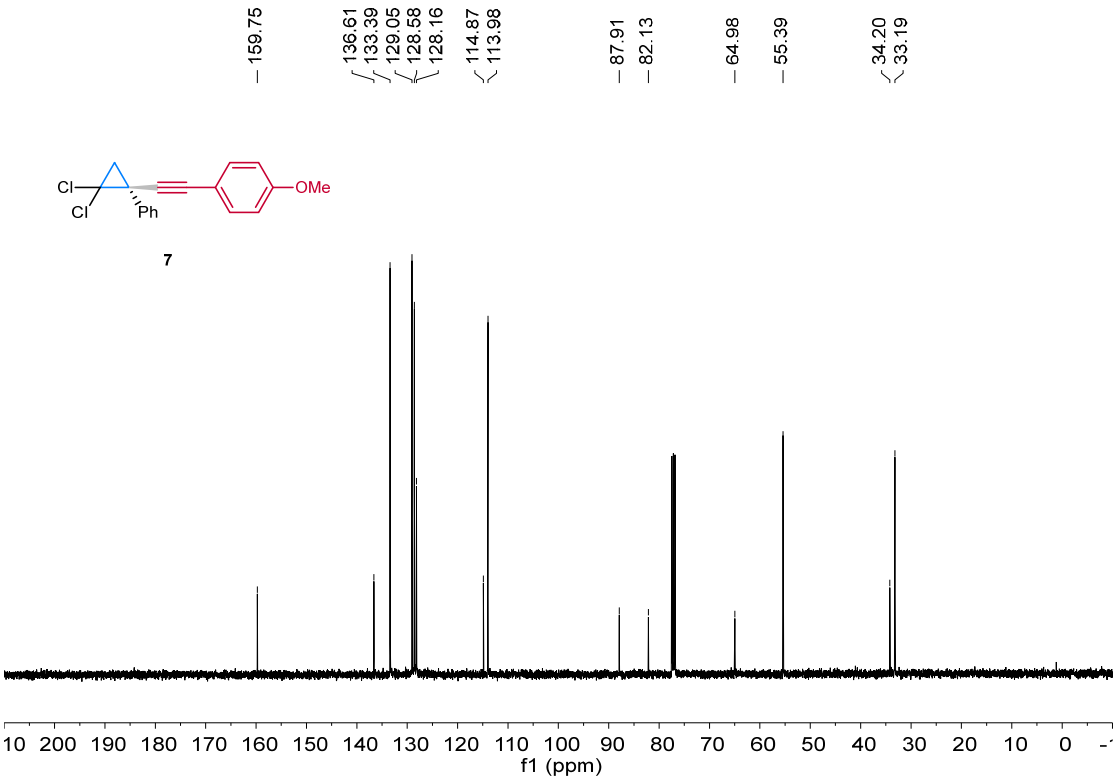
136.40
133.89
129.88
129.06
128.47
128.09
120.44
112.04
110.87
93.24
78.68
65.10
55.90
34.42
33.17
MeO
Cl
Cl
Ph
6
f1 (ppm)


7.48
7.46
7.40
7.38
7.37
7.36
7.35
7.35
7.34
7.34
7.32
7.30
6.81
6.79
3.77
2.38
2.36
2.18
2.16
Cl
Cl
Ph
OMe
7
2.00
5.01
2.04
3.04
1.00
1.04
f1 (ppm)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128.16
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113.98
87.91
82.13
64.98
55.39
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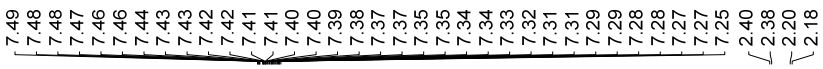
33.19
Cl
Cl
Ph
OMe
7
f1 (ppm)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7.48
7.48
7.47
7.46
7.46
7.44
7.43
7.43
7.42
7.42
7.41
7.41
7.40
7.40
7.39
7.38
7.37
7.37
7.35
7.35
7.34
7.34
7.33
7.32
7.31
7.31
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7.29
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7.27
7.27
7.25
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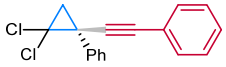
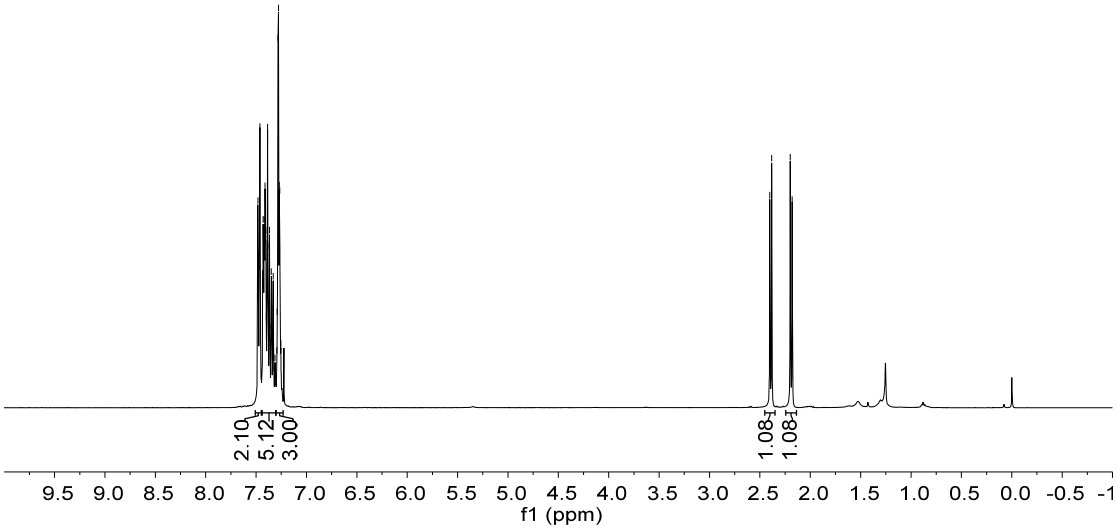
2.38
2.20
2.18


Cl
Cl
Ph

**8**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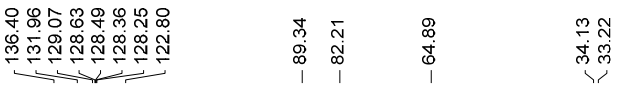
5.12
3.00
1.08
1.08
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


136.40
131.96
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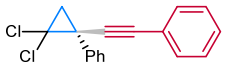
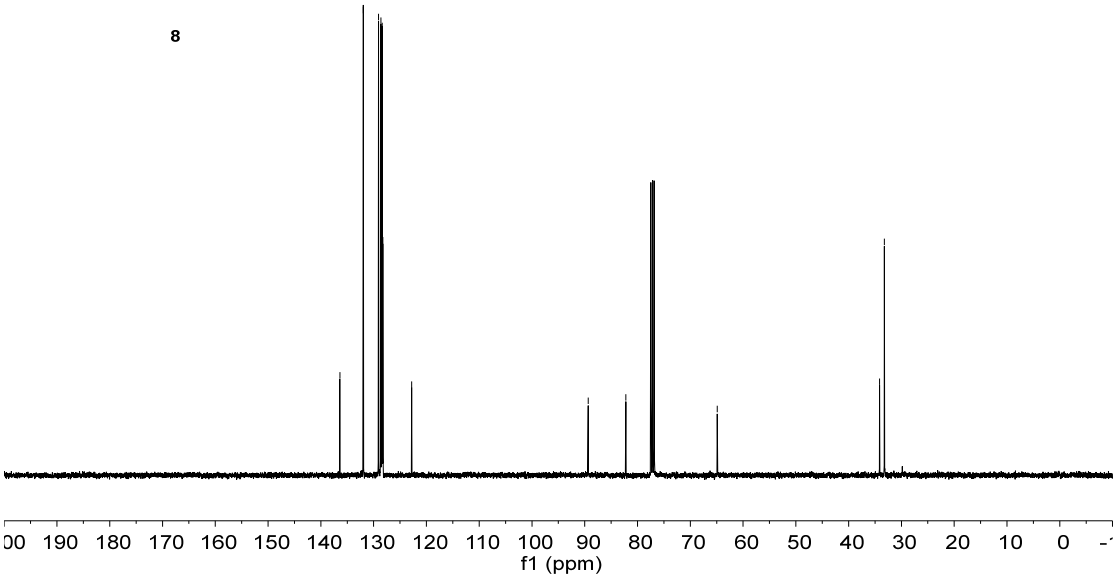
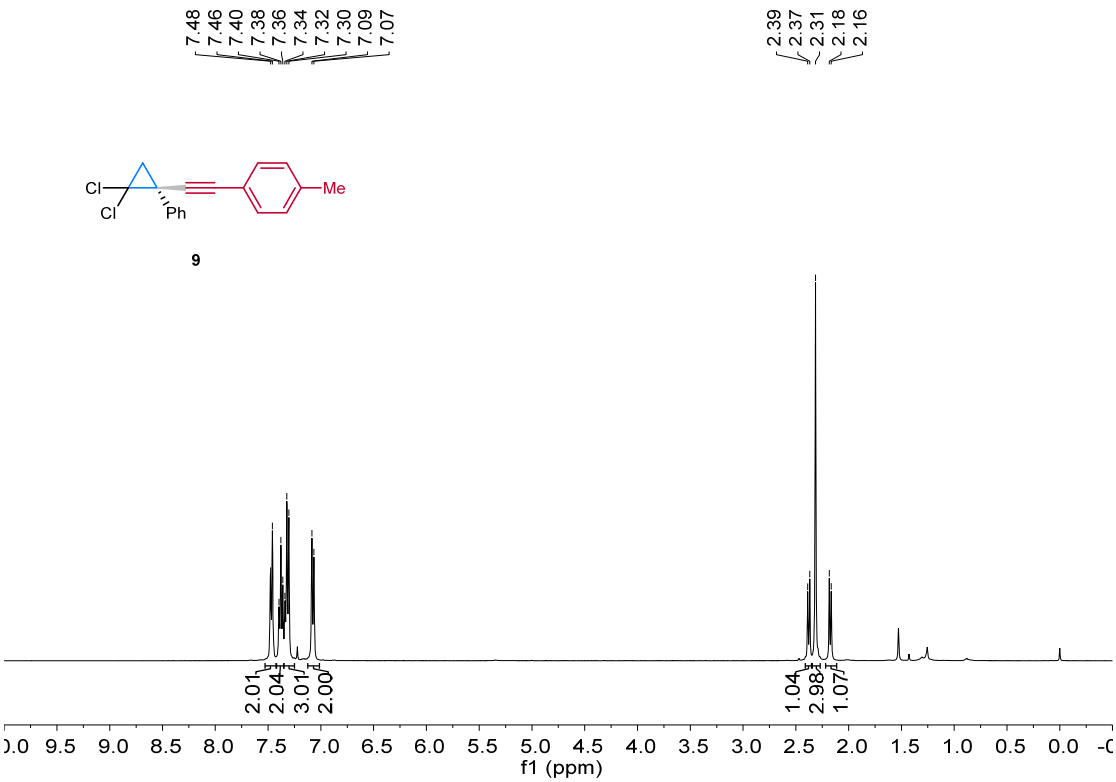
128.63
128.49
128.36
128.25
122.80
89.34
82.21
64.89
34.13
33.22


Cl
Cl
Ph

**8**


00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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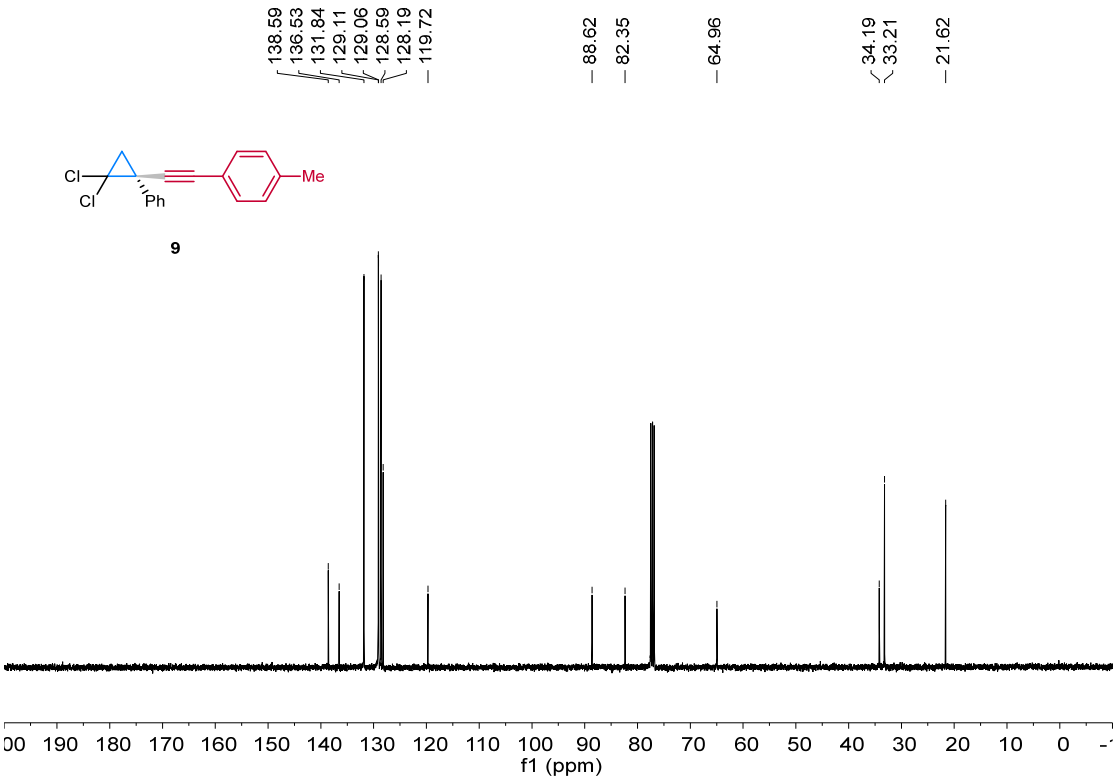
7.46
7.40
7.38
7.36
7.34
7.32
7.30
7.09
7.07
2.39
2.37
2.31
2.18
2.16
Cl
Cl
Ph
Me
9
2.01
2.04
3.01
2.00
1.04
2.98
1.07
f1 (ppm)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128.59
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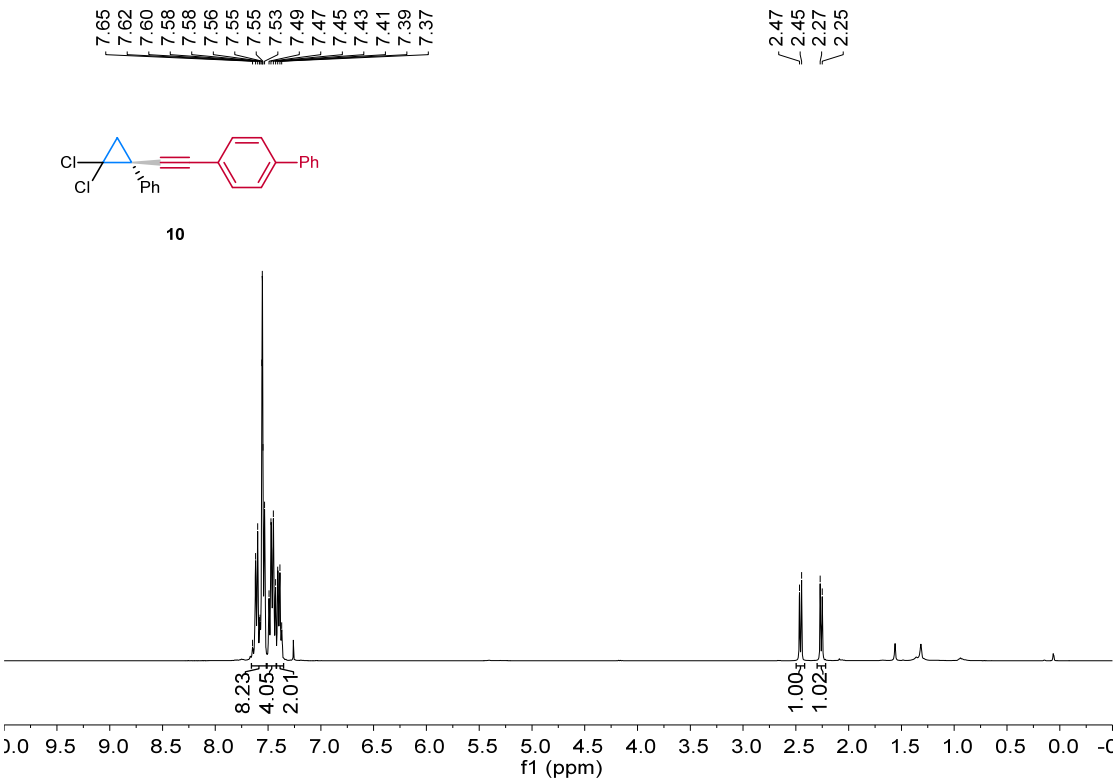
82.35
64.96
34.19
33.21
21.62
Cl
Cl
Ph
Me
9
f1 (ppm)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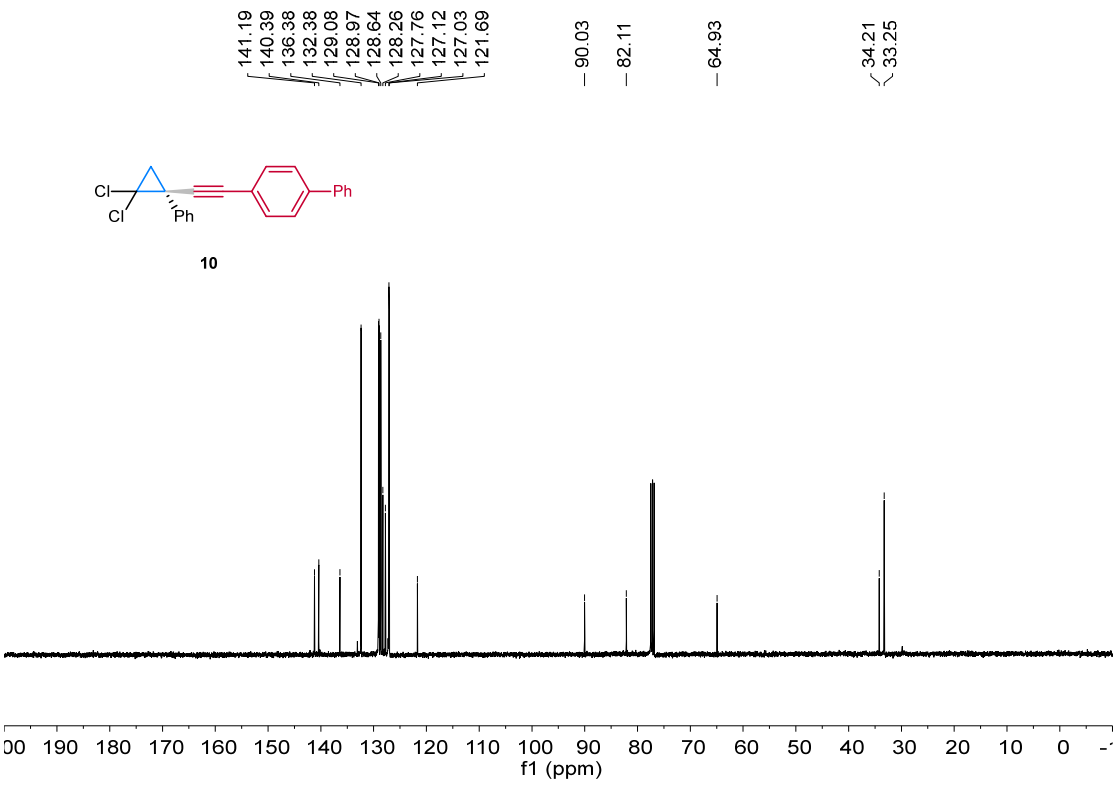
7.55
7.53
7.49
7.47
7.45
7.43
7.41
7.39
7.37
2.47
2.45
2.27
2.25
Cl
Cl
Ph
Ph
10
8.23
4.05
2.01
1.00
1.02
f1 (ppm)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140.39
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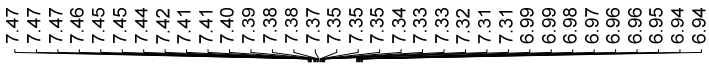
132.38
129.08
128.97
128.64
128.26
127.76
127.12
127.03
121.69
90.03
82.11
64.93
34.21
33.25
Cl
Cl
Ph
Ph
10
f1 (ppm)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7.46
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7.45
7.44
7.42
7.41
7.41
7.40
7.39
7.38
7.38
7.37
7.35
7.35
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6.94
6.94
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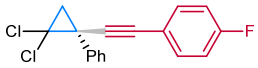
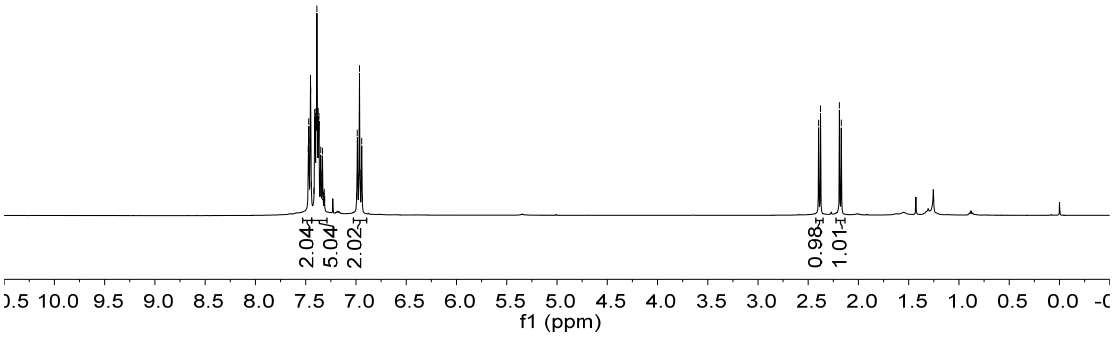
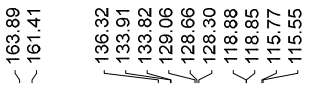
2.38
2.19
2.17


Cl
Cl
Ph
F

**11**


2.04
5.04
2.02
0.98
1.01
f1 (ppm)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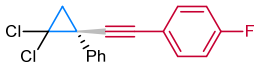
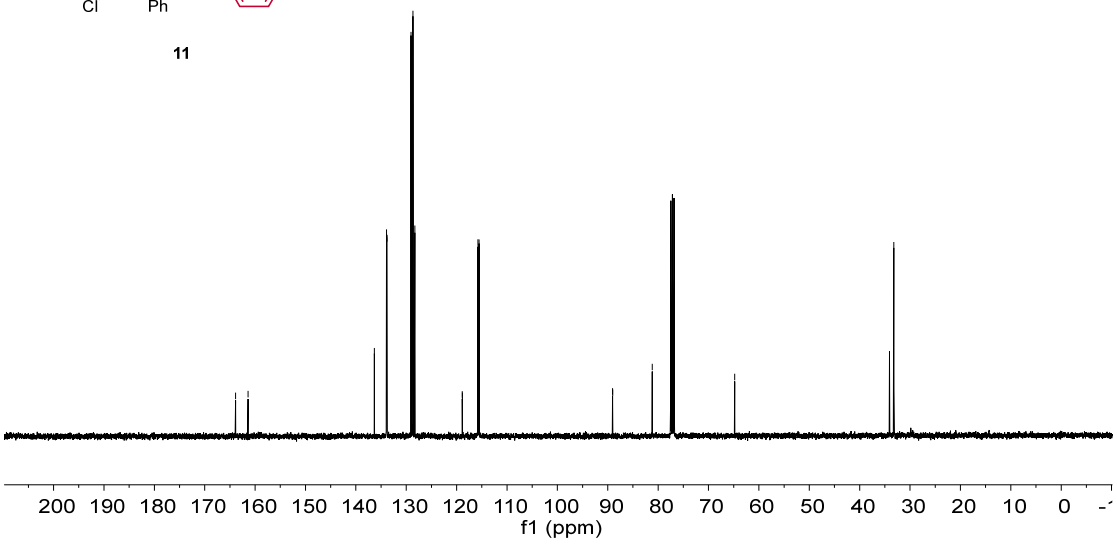
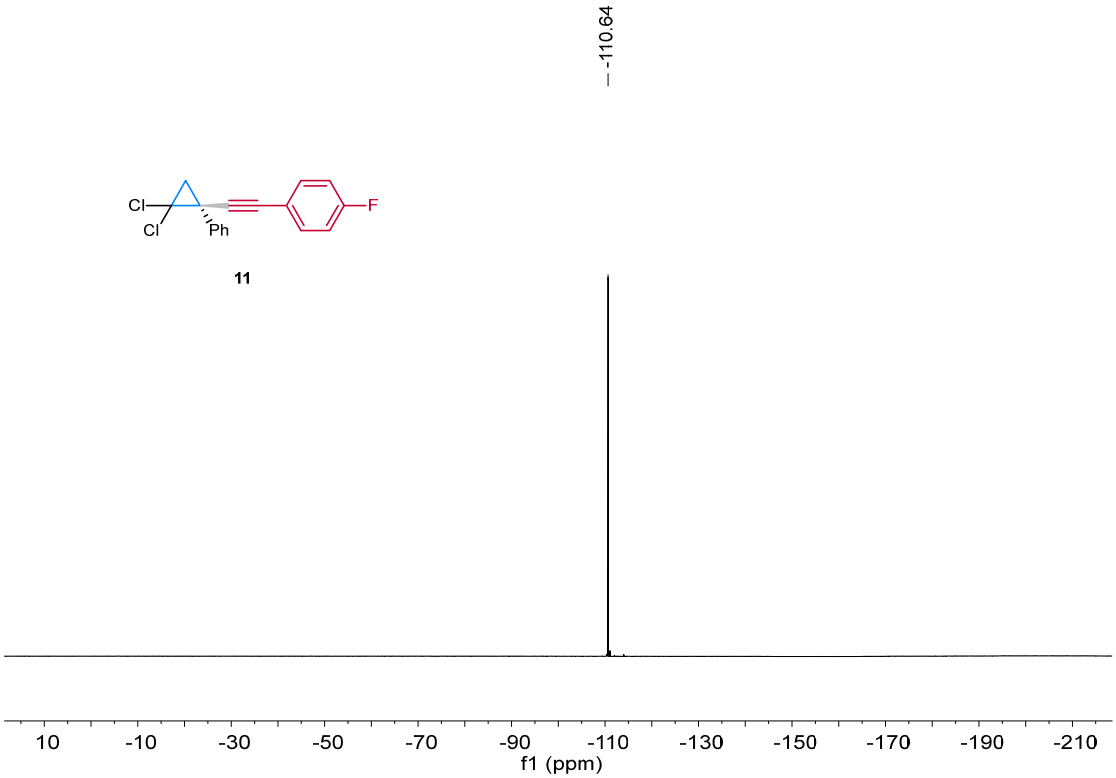
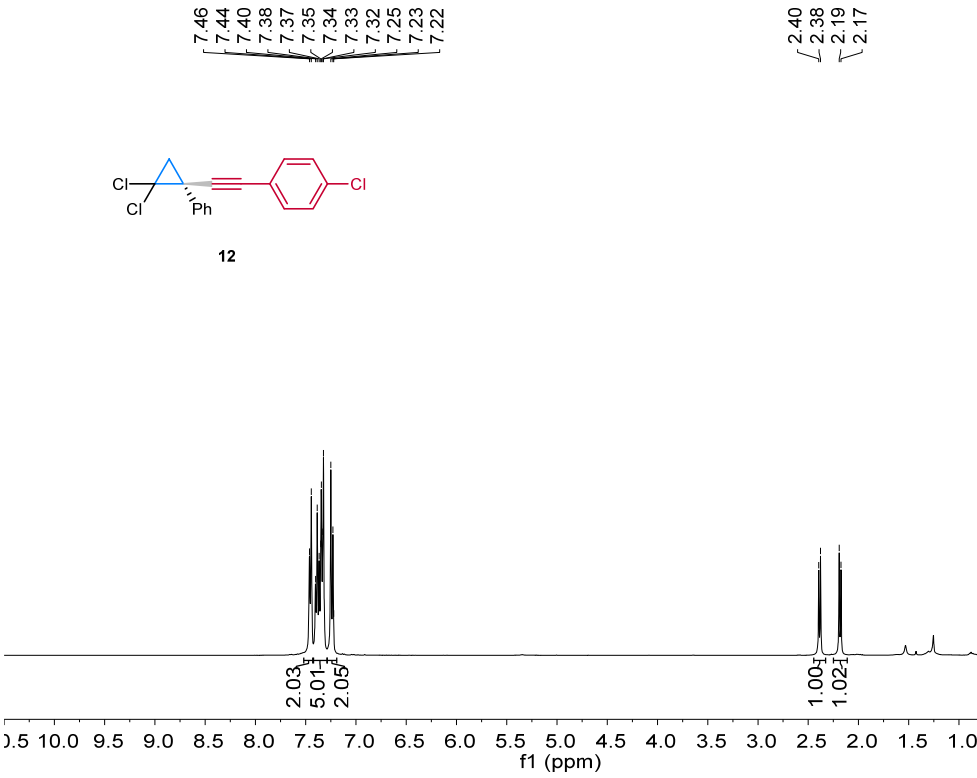
133.82
129.06
128.66
128.30
118.88
118.85
115.77
115.55
89.04
89.03
81.16
64.81
34.07
33.21

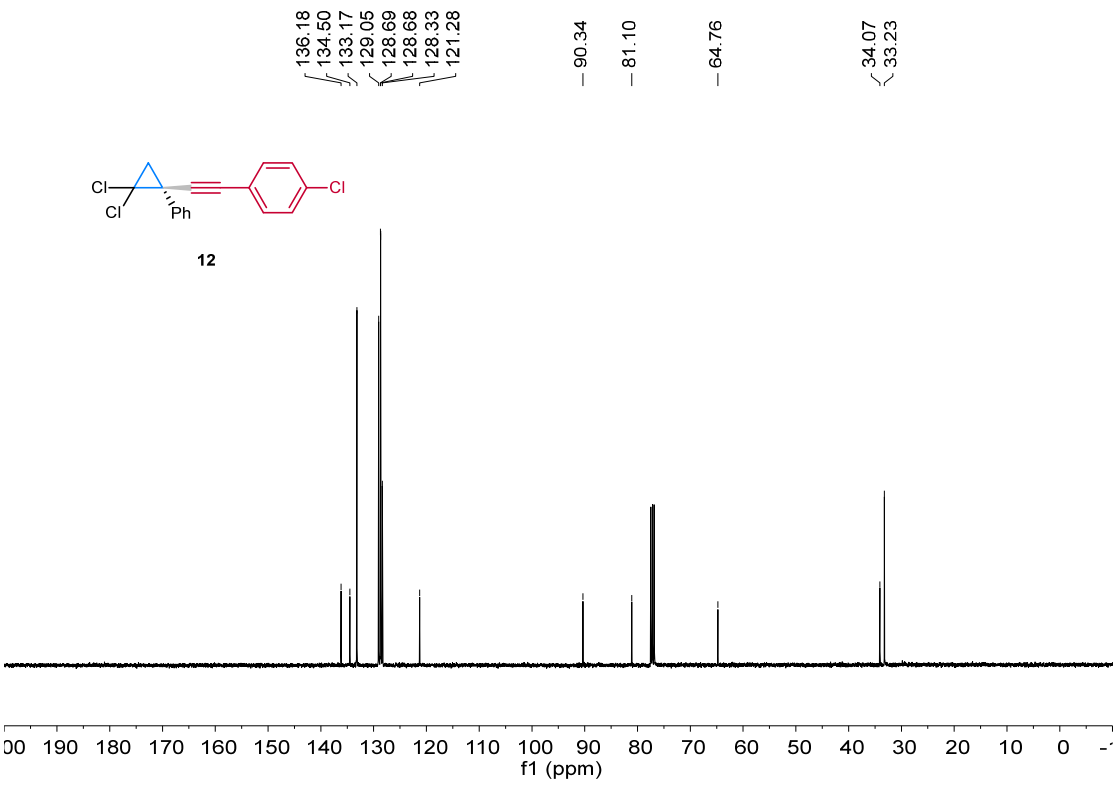

Cl
Cl
Ph
F

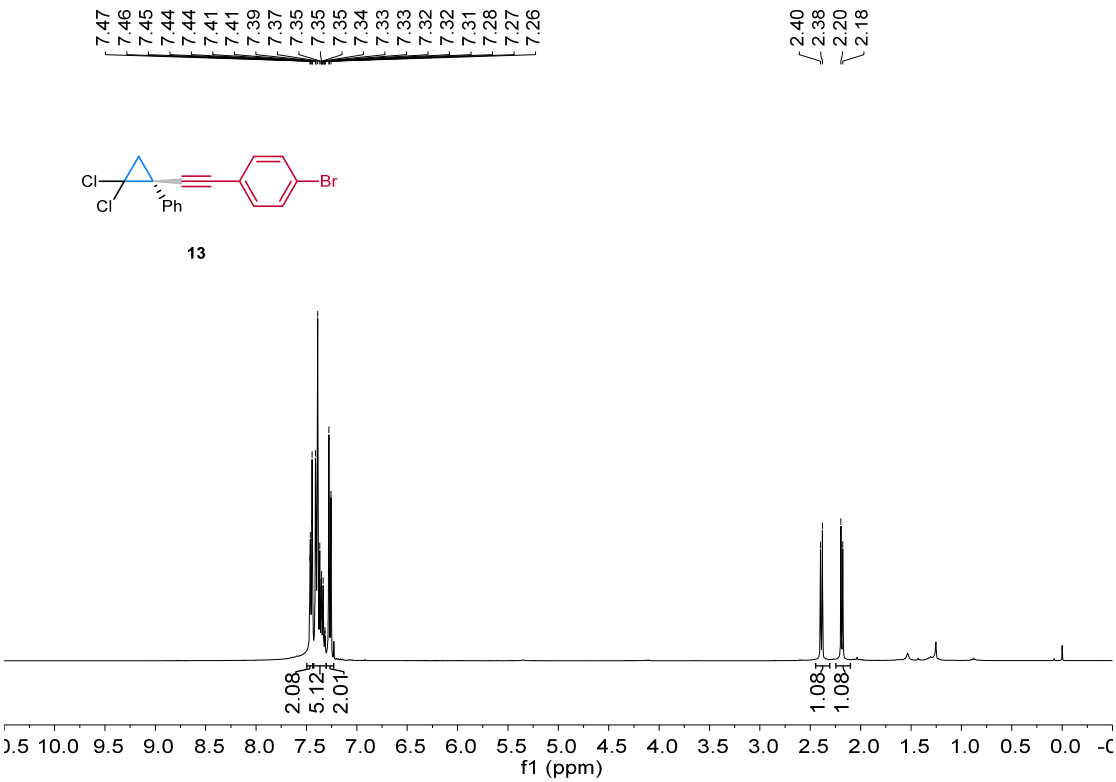
**11**

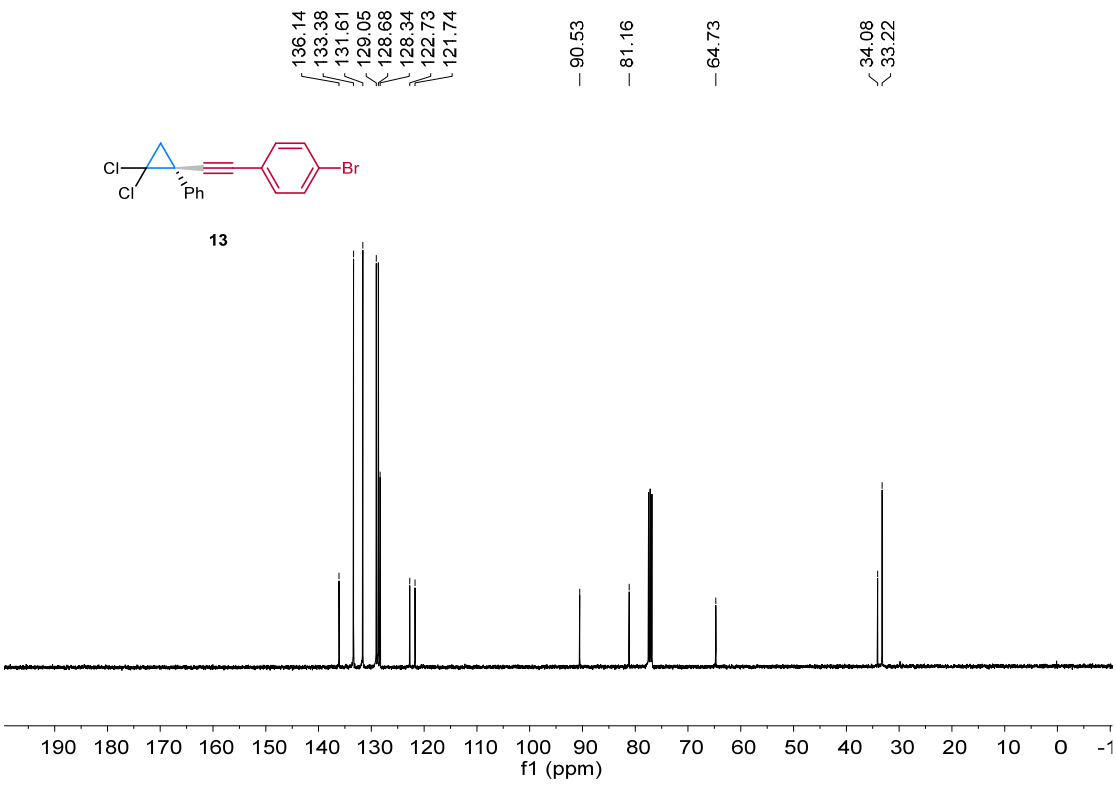

f1 (ppm)

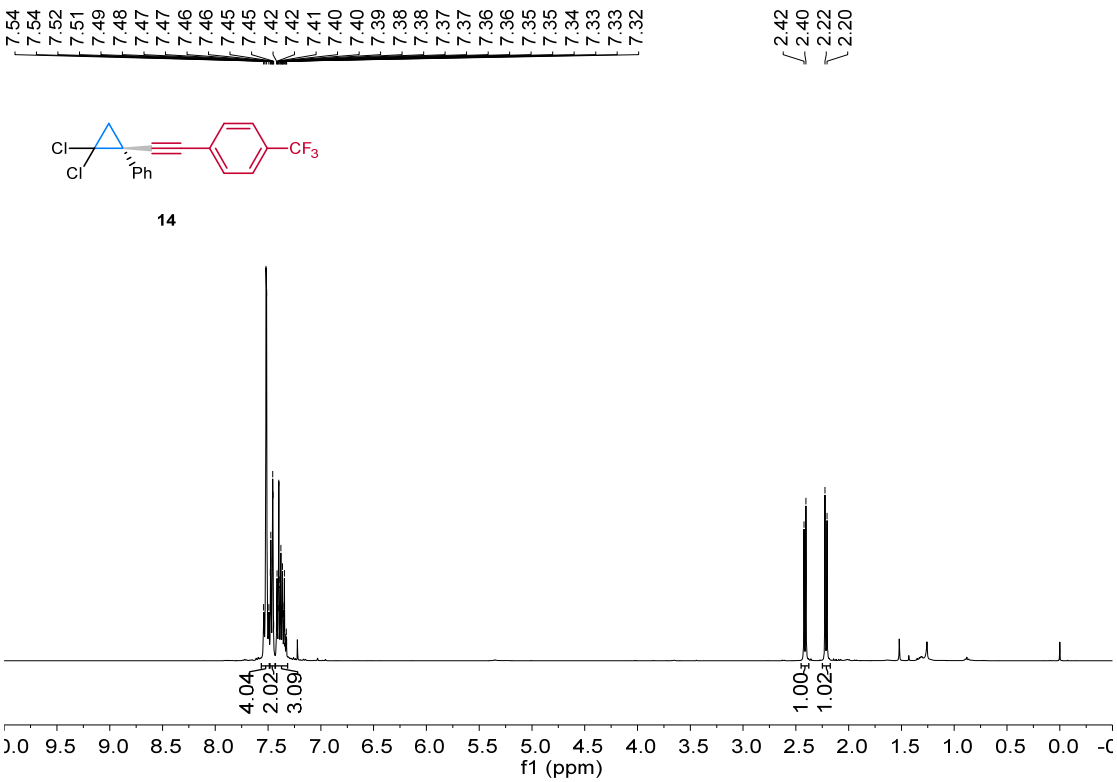

-110.64
Cl
Cl
Ph
F
11
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
f1 (ppm)

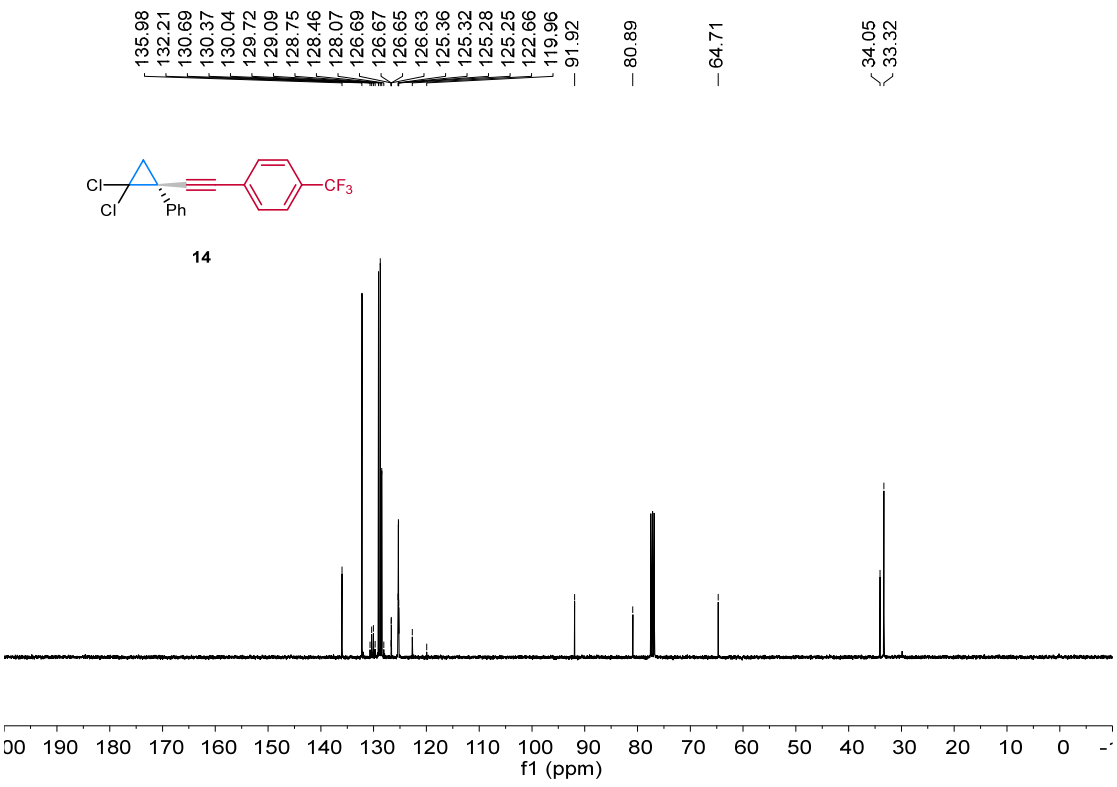

7.46
7.44
7.40
7.38
7.37
7.35
7.34
7.33
7.32
7.25
7.23
7.22
2.40
2.38
2.19
2.17
Cl
Cl
Ph
Cl
12
2.03
5.01
2.05
1.00
1.02
f1 (ppm)

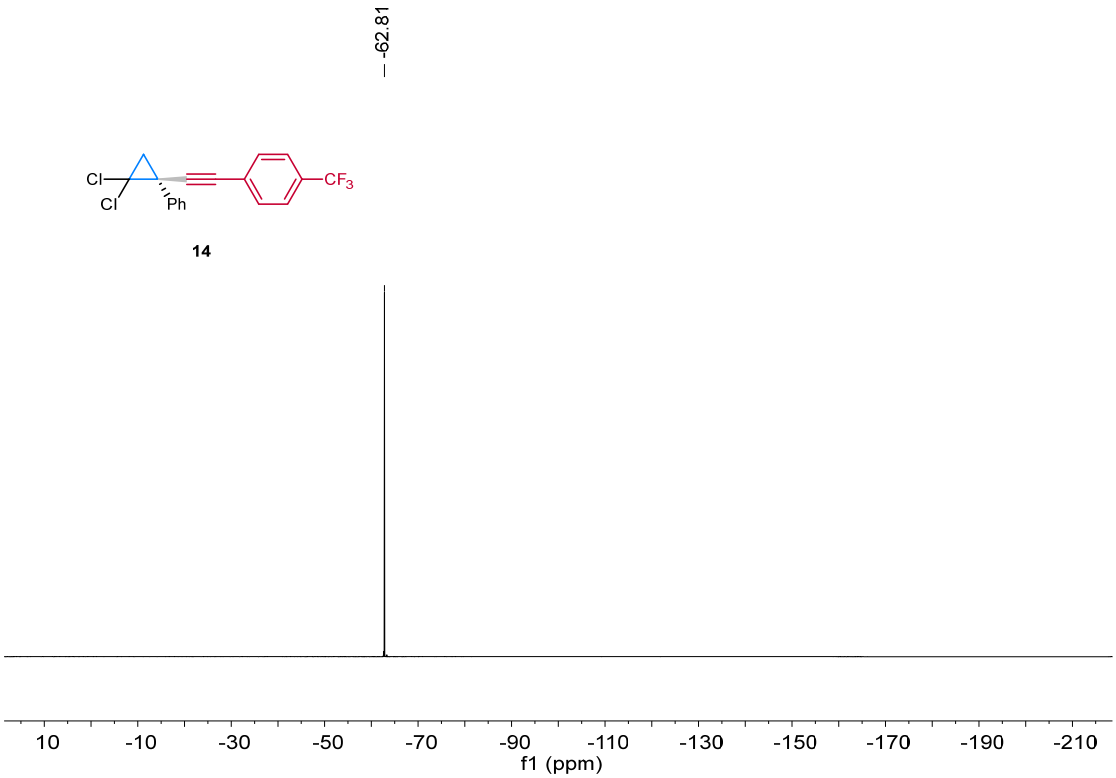

136.18
134.50
133.17
129.05
128.69
128.68
128.33
121.28
90.34
81.10
64.76
34.07
33.23
Cl
Cl
Ph
Cl
12
f1 (ppm)

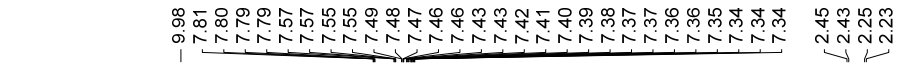

7.47
7.46
7.45
7.44
7.44
7.41
7.41
7.39
7.37
7.35
7.35
7.35
7.34
7.33
7.33
7.32
7.32
7.31
7.28
7.27
7.26
2.40
2.38
2.20
2.18
Cl
Cl
Ph
Br
13
2.08
5.12
2.01
1.08
1.08
f1 (ppm)


136.14
133.38
131.61
129.05
128.68
128.34
122.73
121.74
90.53
81.16
64.73
34.08
33.22
Cl
Cl
Ph
Br
13
f1 (ppm)


7.54 7.54 7.52 7.51 7.49 7.48 7.47 7.47 7.46 7.46 7.45 7.45 7.42 7.42 7.41 7.40 7.40 7.39 7.38 7.38 7.37 7.37 7.36 7.36 7.35 7.35 7.34 7.33 7.33 7.32
2.42 2.40 2.22 2.20
Cl
Cl
Ph
CF3
14
4.04
2.02
3.09
1.00
1.02
f1 (ppm)

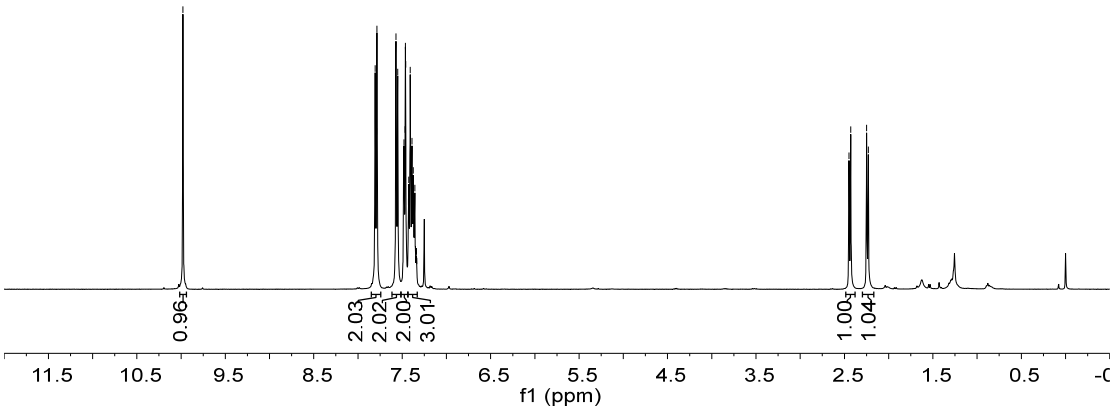

135.98 132.21 130.69 130.37 130.04 129.72 129.09 128.75 128.46 128.07 126.69 126.67 126.65 126.63 125.36 125.32 125.28 125.25 122.66 119.96 91.92 80.89 64.71 34.05 33.32
Cl
Cl
Ph
CF3
14
f1 (ppm)

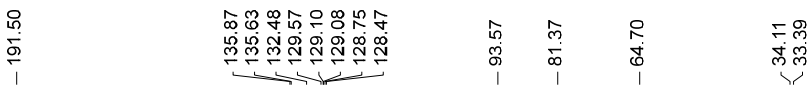

-62.81
Cl
Cl
Ph
CF3
14
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
f1 (ppm)

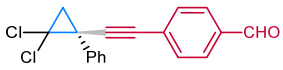

9.98
7.81
7.80
7.79
7.79
7.57
7.57
7.55
7.55
7.49
7.48
7.47
7.46
7.46
7.43
7.43
7.42
7.41
7.40
7.39
7.38
7.37
7.37
7.36
7.36
7.35
7.34
7.34
7.34
2.45
2.43
2.25
2.23


Cl
Cl
Ph
CHO

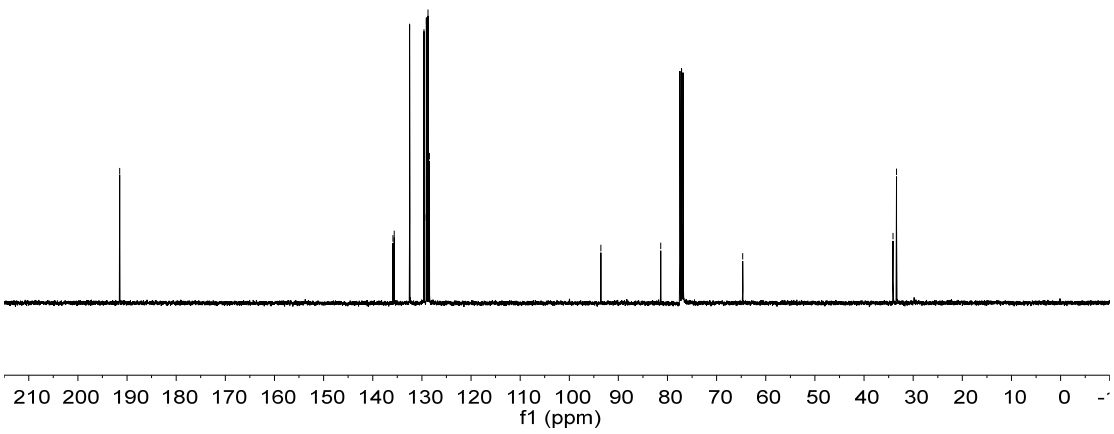
**15**

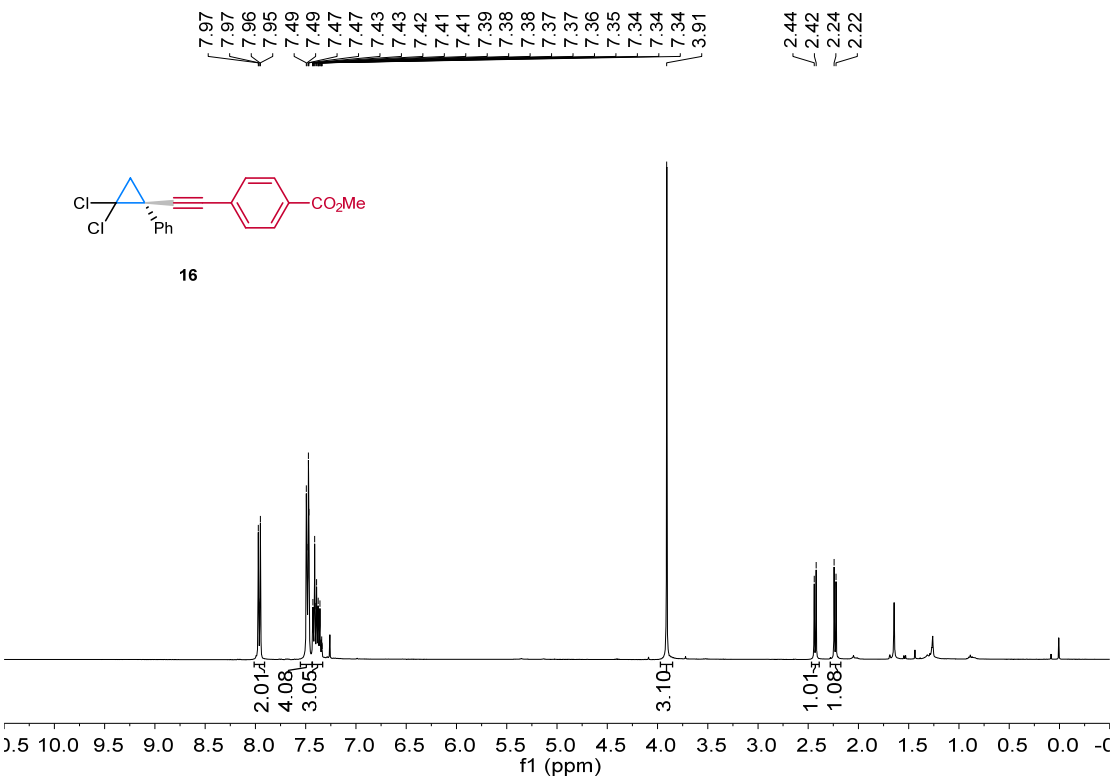

0.96
2.03
2.02
2.00
3.01
1.00
1.04
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)

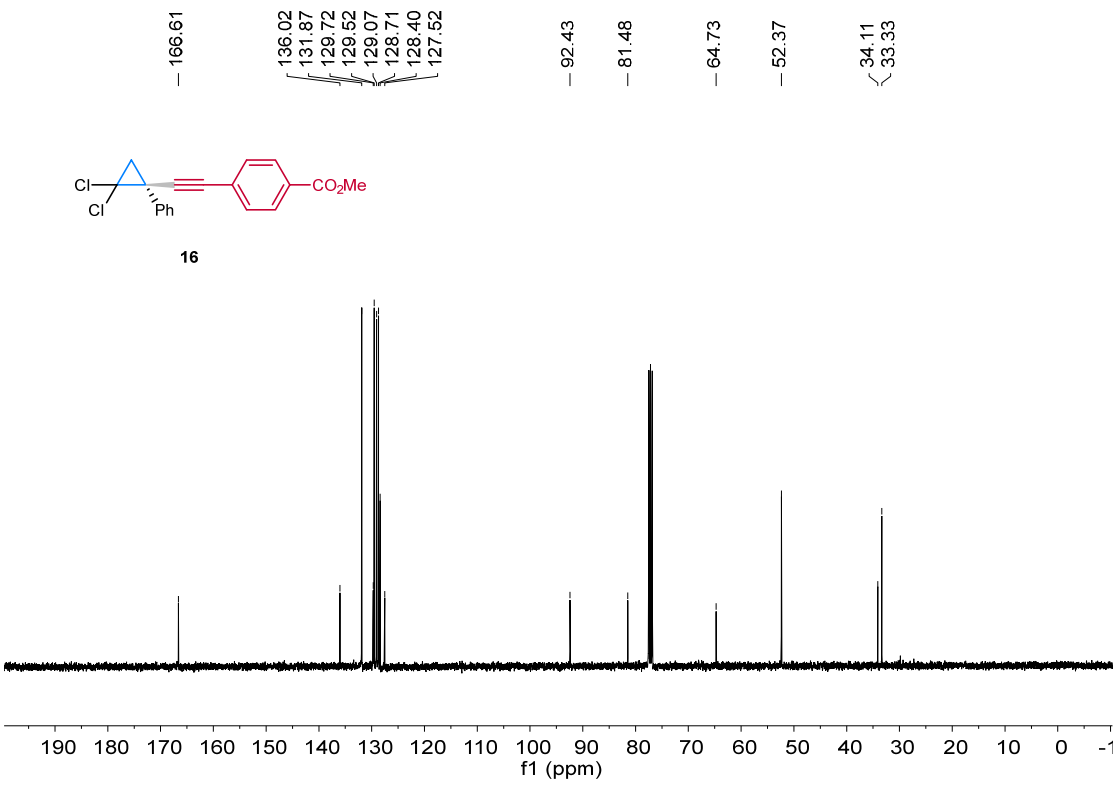

191.50
135.87
135.63
132.48
129.57
129.10
129.08
128.75
128.47
93.57
81.37
64.70
34.11
33.39

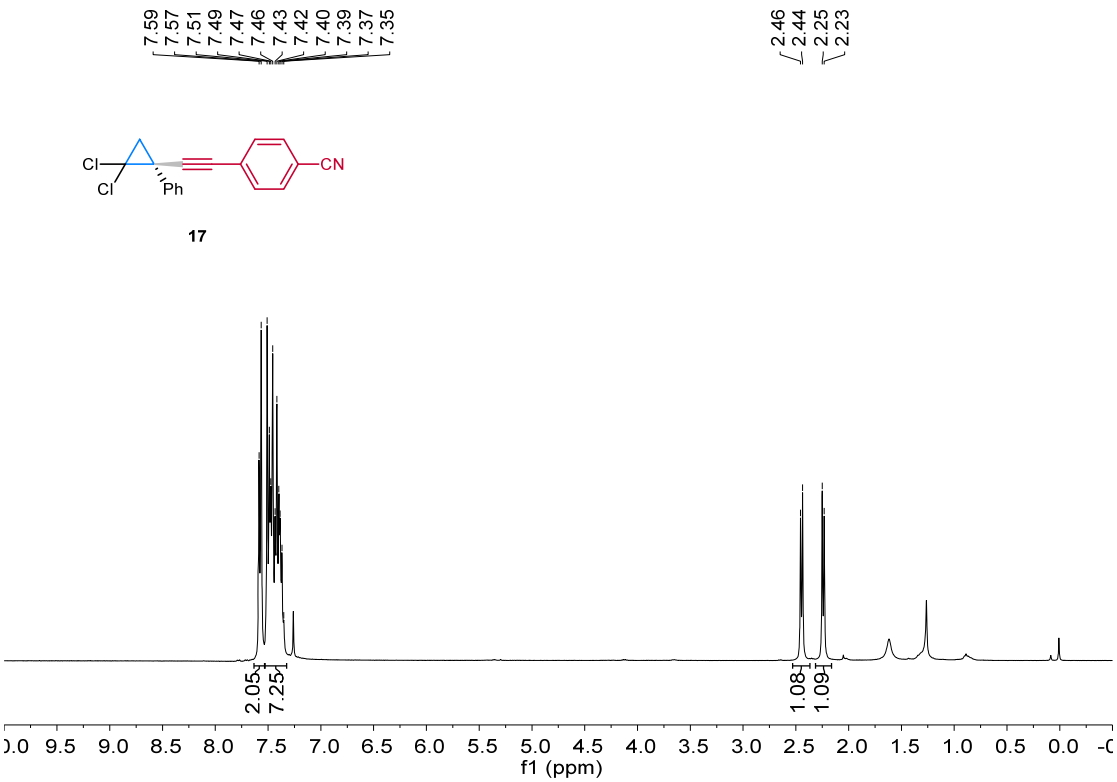

Cl
Cl
Ph
CHO

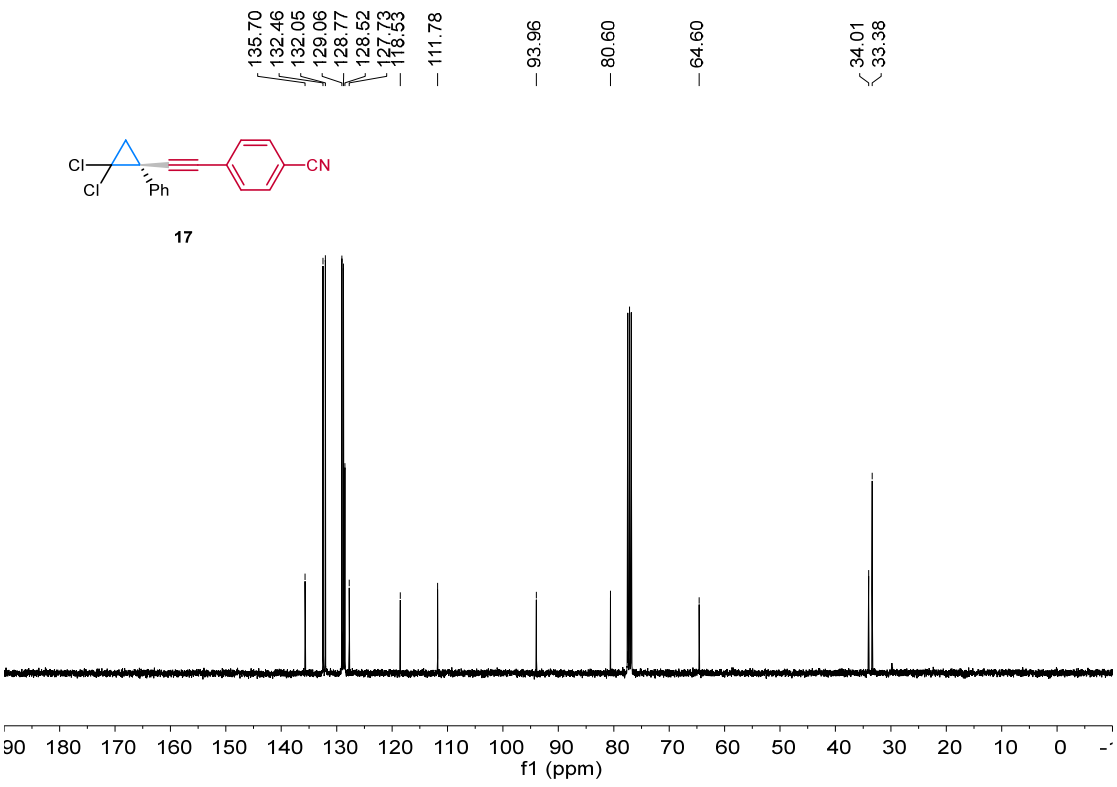
**15**

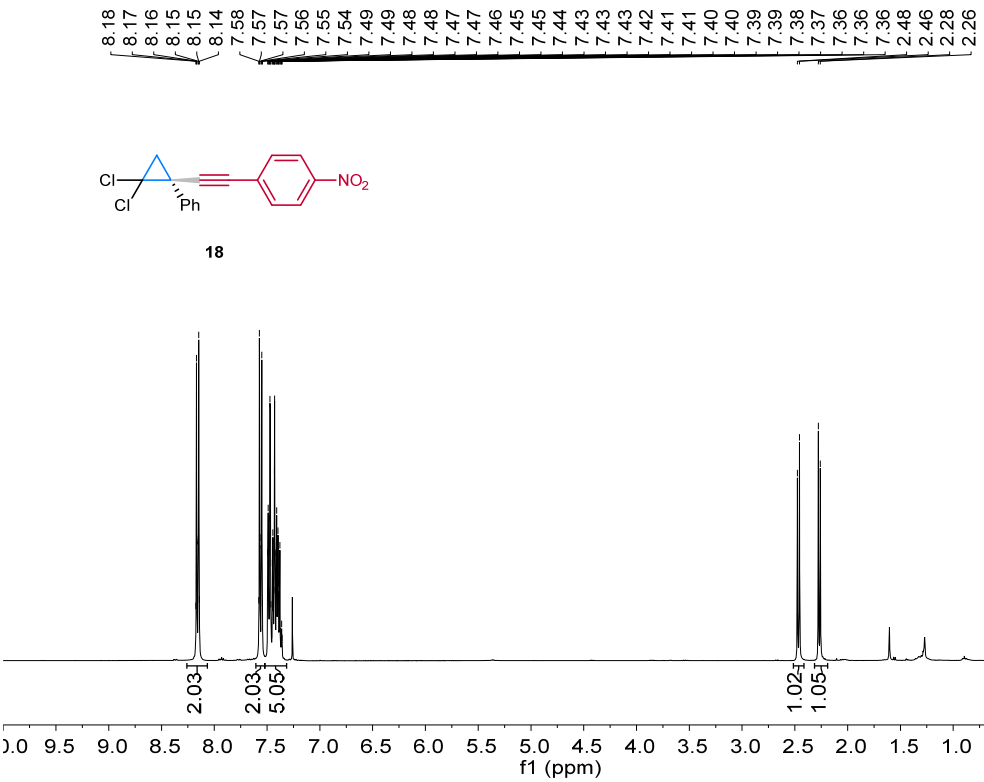

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

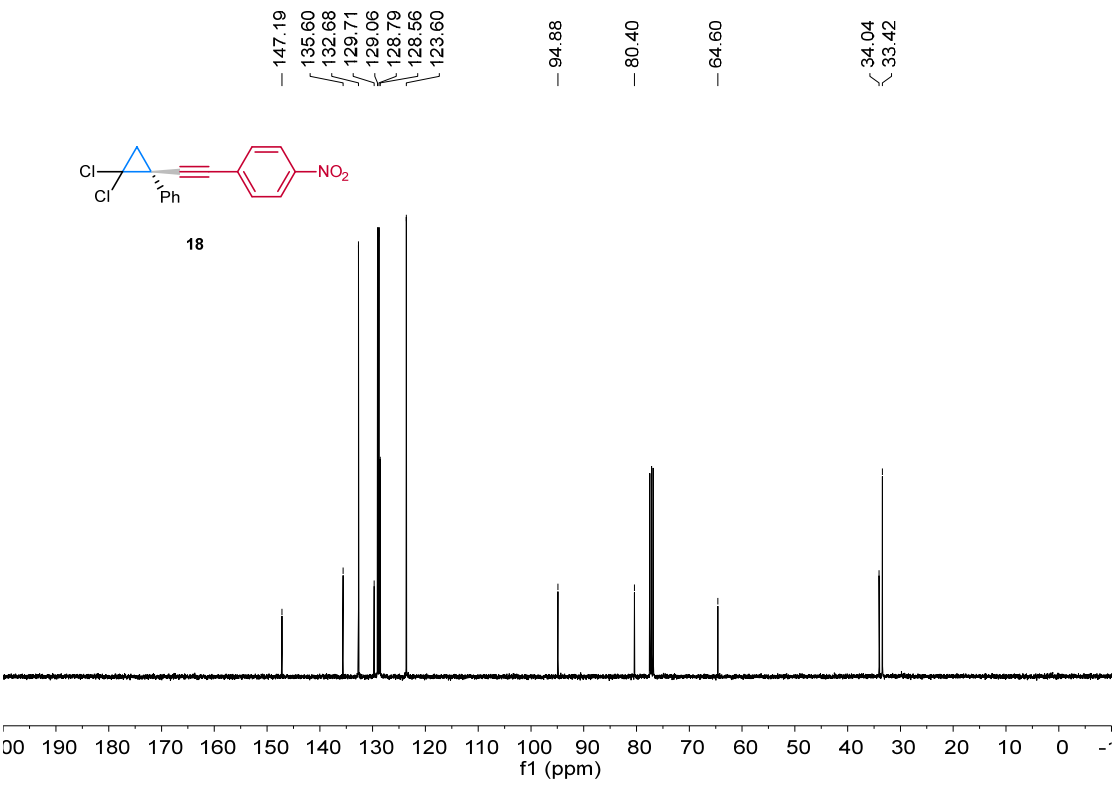

7.97
7.97
7.96
7.95
7.49
7.49
7.47
7.47
7.43
7.43
7.42
7.41
7.41
7.39
7.38
7.38
7.37
7.37
7.36
7.35
7.34
7.34
7.34
3.91
2.44
2.42
2.24
2.22
Cl
Cl
Ph
CO2Me
16
2.01
4.08
3.05
3.10
1.01
1.08
f1 (ppm)

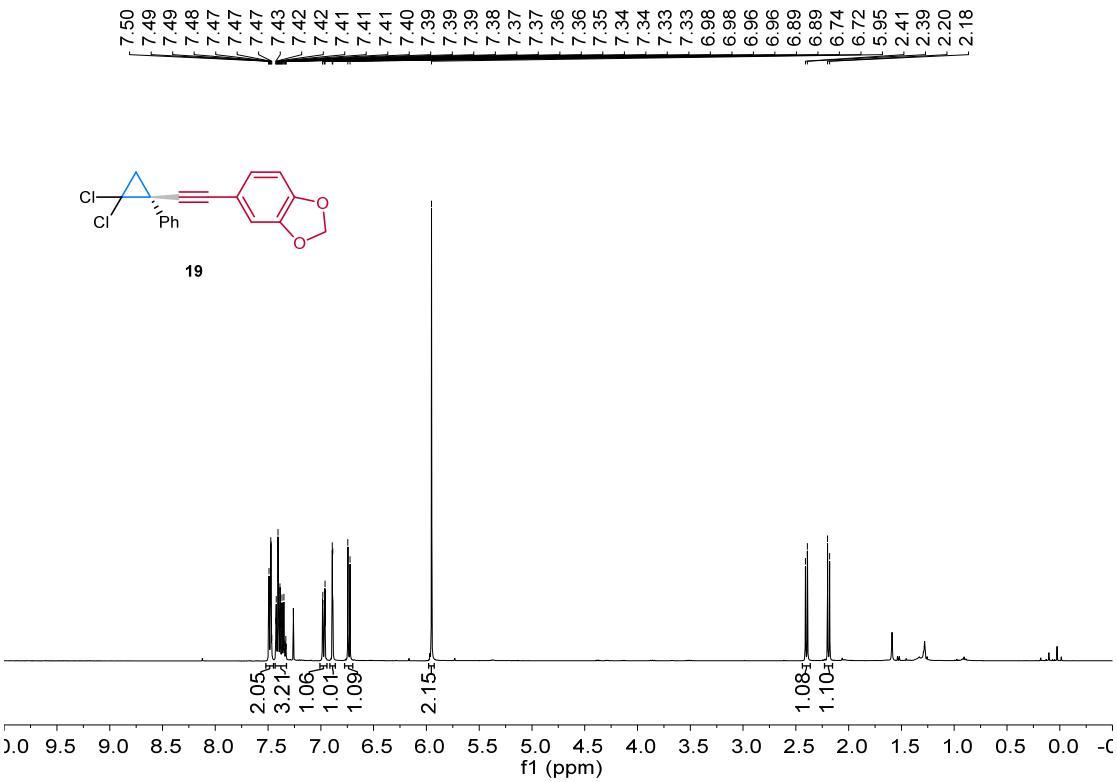

166.61
136.02
131.87
129.72
129.52
129.07
128.71
128.40
127.52
92.43
81.48
64.73
52.37
34.11
33.33
Cl
Cl
Ph
CO2Me
16
f1 (ppm)

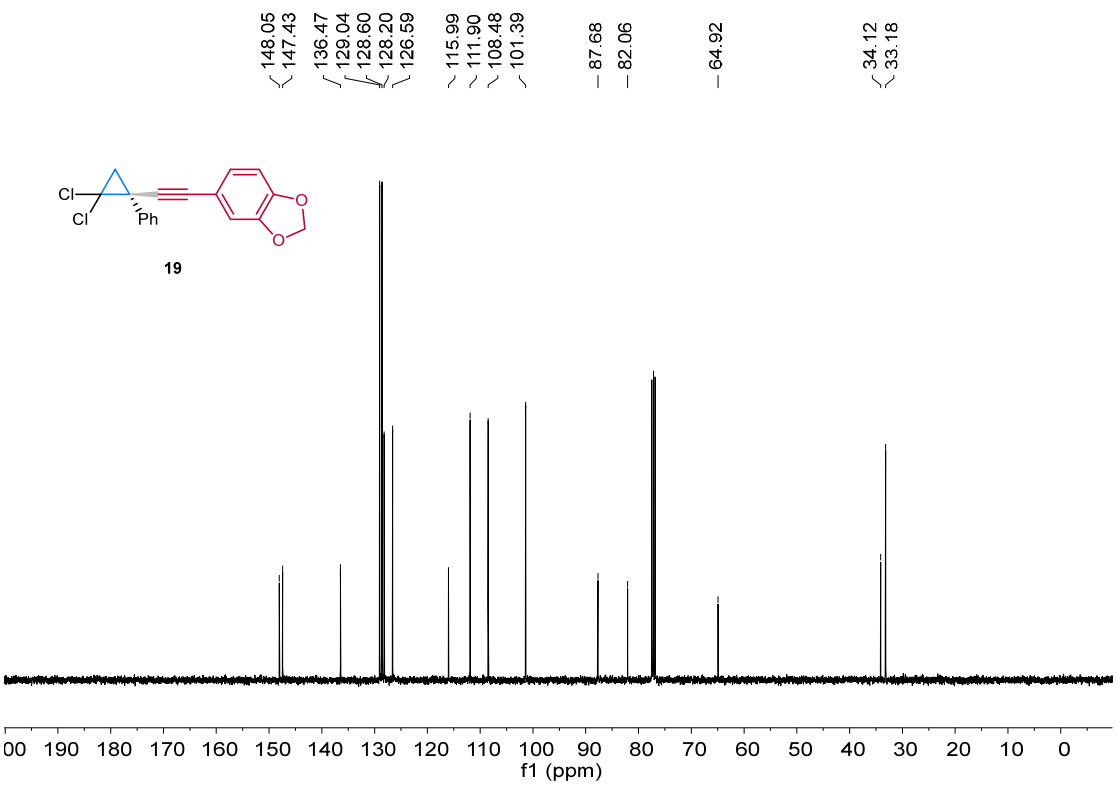

7.59
7.57
7.51
7.49
7.47
7.46
7.43
7.42
7.40
7.39
7.37
7.35
2.46
2.44
2.25
2.23
Cl
Cl
Ph
CN
17
2.05
7.25
1.08
1.09
f1 (ppm)

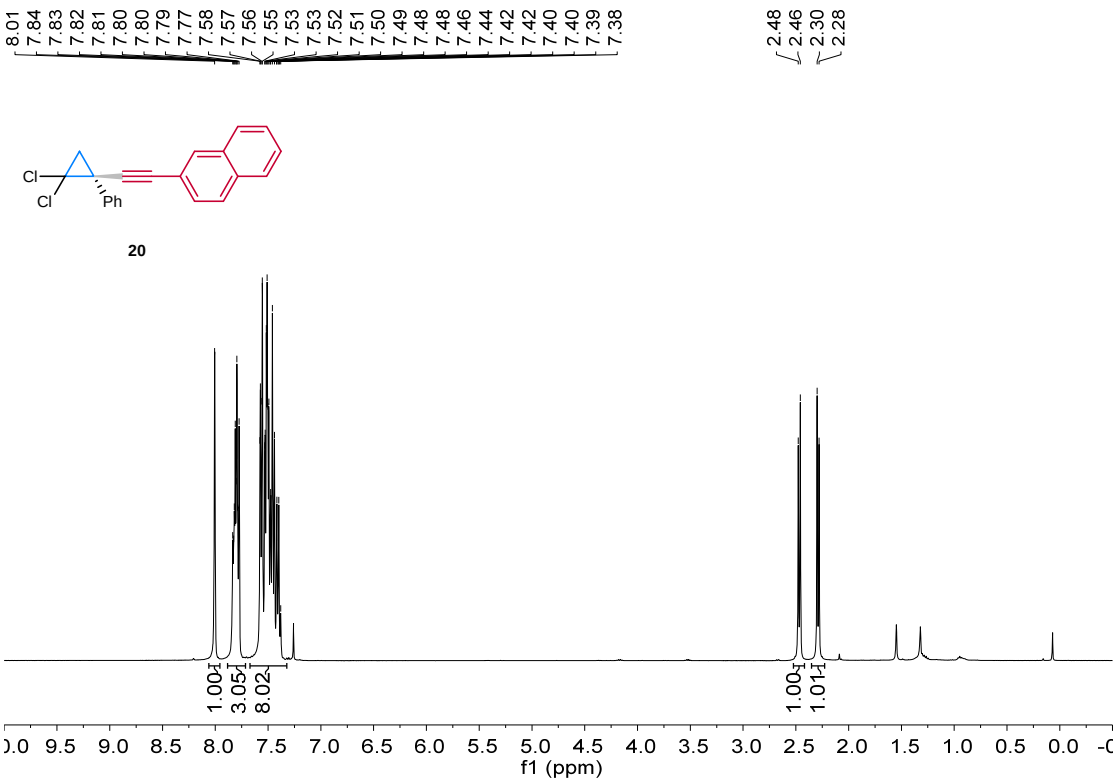

135.70
132.46
132.05
129.06
128.77
128.52
127.73
118.53
111.78
93.96
80.60
64.60
34.01
33.38
Cl
Cl
Ph
CN
17
f1 (ppm)


8.18
8.17
8.16
8.15
8.15
8.14
7.58
7.57
7.57
7.56
7.55
7.54
7.49
7.49
7.48
7.48
7.47
7.47
7.46
7.45
7.45
7.44
7.43
7.43
7.42
7.41
7.41
7.40
7.40
7.39
7.39
7.38
7.37
7.36
7.36
7.36
2.48
2.46
2.28
2.26
Cl
Cl
Ph
NO2
18
2.03
2.03
5.05
1.02
1.05
f1 (ppm)


147.19
135.60
132.68
129.71
129.06
128.79
128.56
123.60
94.88
80.40
64.60
34.04
33.42
Cl
Cl
Ph
NO2
18
f1 (ppm)


7.50 7.49 7.49 7.48 7.47 7.47 7.47 7.43 7.42 7.42 7.41 7.41 7.41 7.40 7.39 7.39 7.39 7.38 7.37 7.37 7.36 7.36 7.35 7.34 7.34 7.33 7.33 6.98 6.98 6.96 6.96 6.89 6.89 6.74 6.72 5.95 2.41 2.39 2.20 2.18
Cl
Cl
Ph
O
O
19
2.05 3.21 1.06 1.01 1.09 2.15 1.08 1.10
f1 (ppm)


148.05 147.43 136.47 129.04 128.60 128.20 126.59 115.99 111.90 108.48 101.39 87.68 82.06 64.92 34.12 33.18
Cl
Cl
Ph
O
O
19
f1 (ppm)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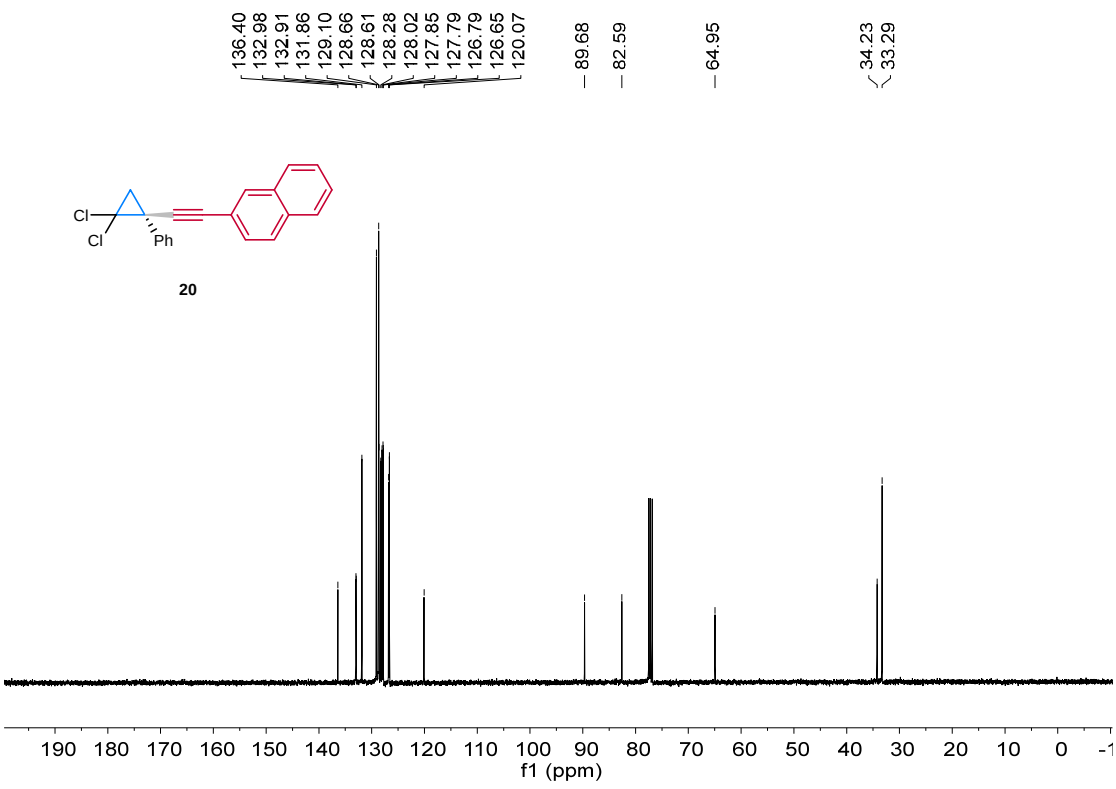
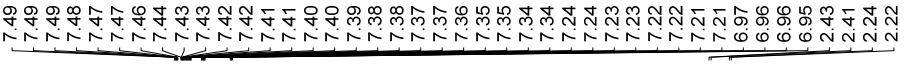
7.83
7.82
7.81
7.80
7.80
7.79
7.77
7.58
7.57
7.56
7.55
7.53
7.53
7.52
7.51
7.50
7.49
7.48
7.48
7.46
7.44
7.42
7.42
7.40
7.40
7.39
7.38
2.48
2.46
2.30
2.28
Cl
Cl
Ph
20
1.00
3.05
8.02
1.00
1.01
f1 (ppm)


136.40
132.98
132.91
131.86
129.10
128.66
128.61
128.28
128.02
127.85
127.79
126.79
126.65
120.07
89.68
82.59
64.95
34.23
33.29
Cl
Cl
Ph
20
f1 (ppm)


7.49
7.49
7.49
7.48
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7.47
7.46
7.44
7.43
7.43
7.42
7.42
7.41
7.41
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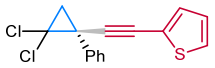
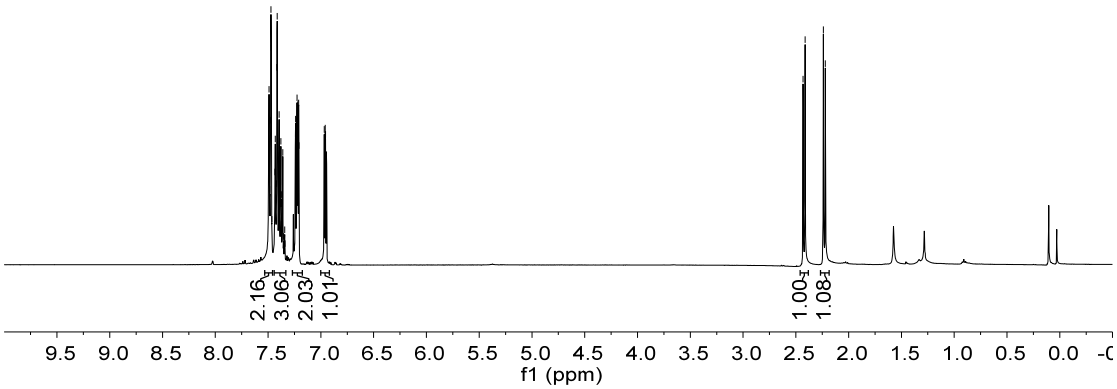
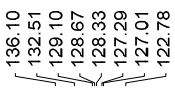
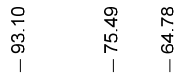
7.38
7.38
7.37
7.37
7.36
7.35
7.35
7.34
7.34
7.24
7.24
7.23
7.23
7.22
7.22
7.21
7.21
6.97
6.96
6.96
6.95
2.43
2.41
2.24
2.22

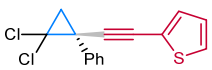

Cl
Cl
Ph
S

**21**

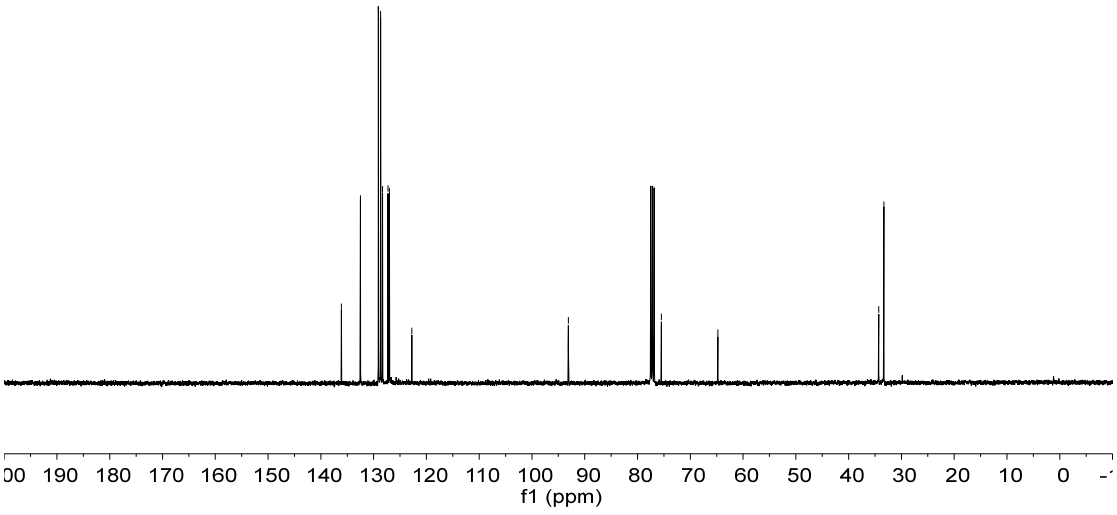

2.16
3.06
2.03
1.01
1.00
1.08
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

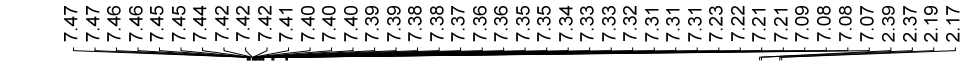

136.10
132.51
129.10
128.67
128.33
127.29
127.01
122.78


93.10
75.49
64.78
34.30
33.32


Cl
Cl
Ph
S

**21**


00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.47
7.46
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7.45
7.44
7.42
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7.42
7.41
7.40
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7.39
7.39
7.38
7.38
7.37
7.36
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7.35
7.35
7.34
7.33
7.33
7.32
7.31
7.31
7.31
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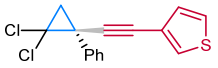
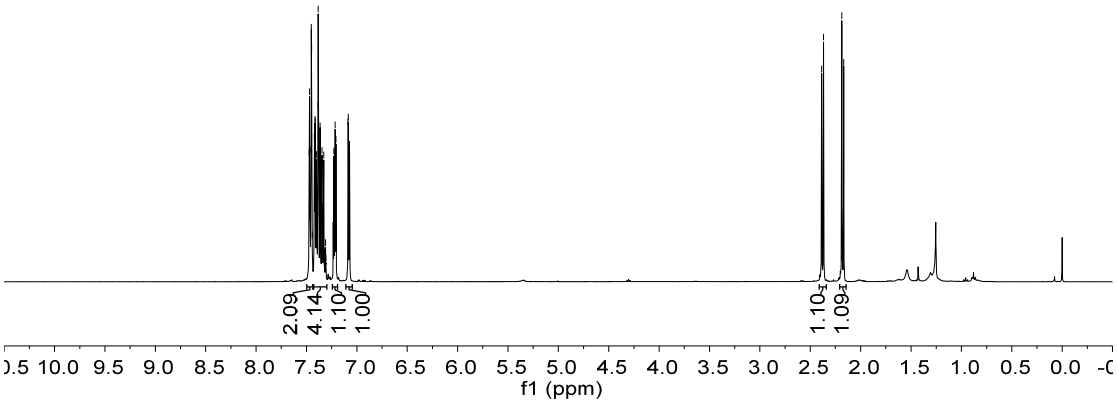
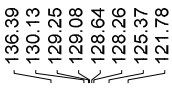
7.08
7.08
7.07
2.39
2.37
2.19
2.17

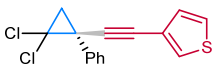

Cl
Cl
Ph
S

22

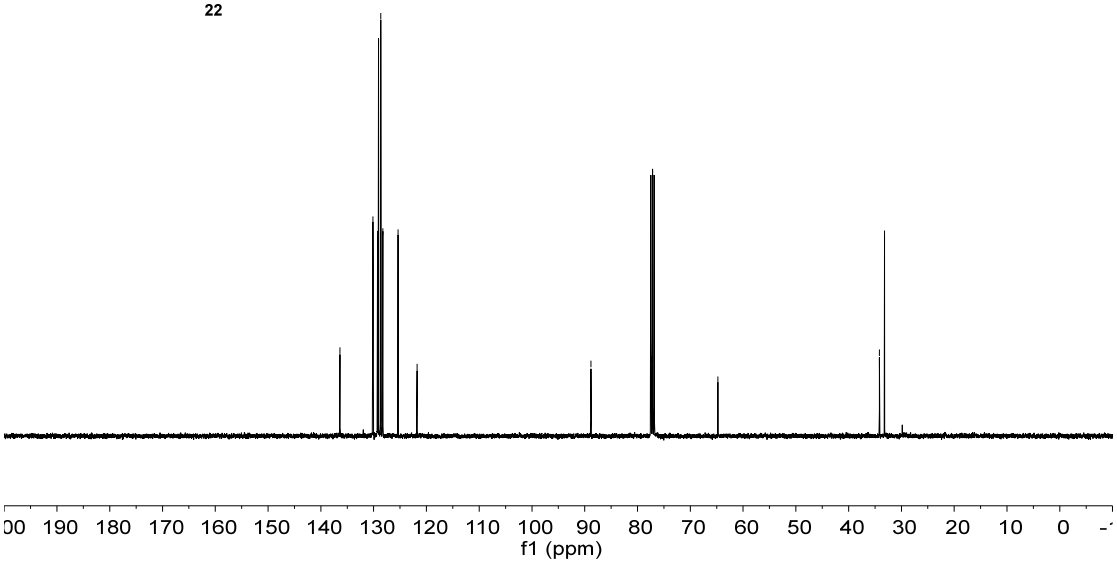

2.09
4.14
1.10
1.00
1.10
1.09
f1 (ppm)

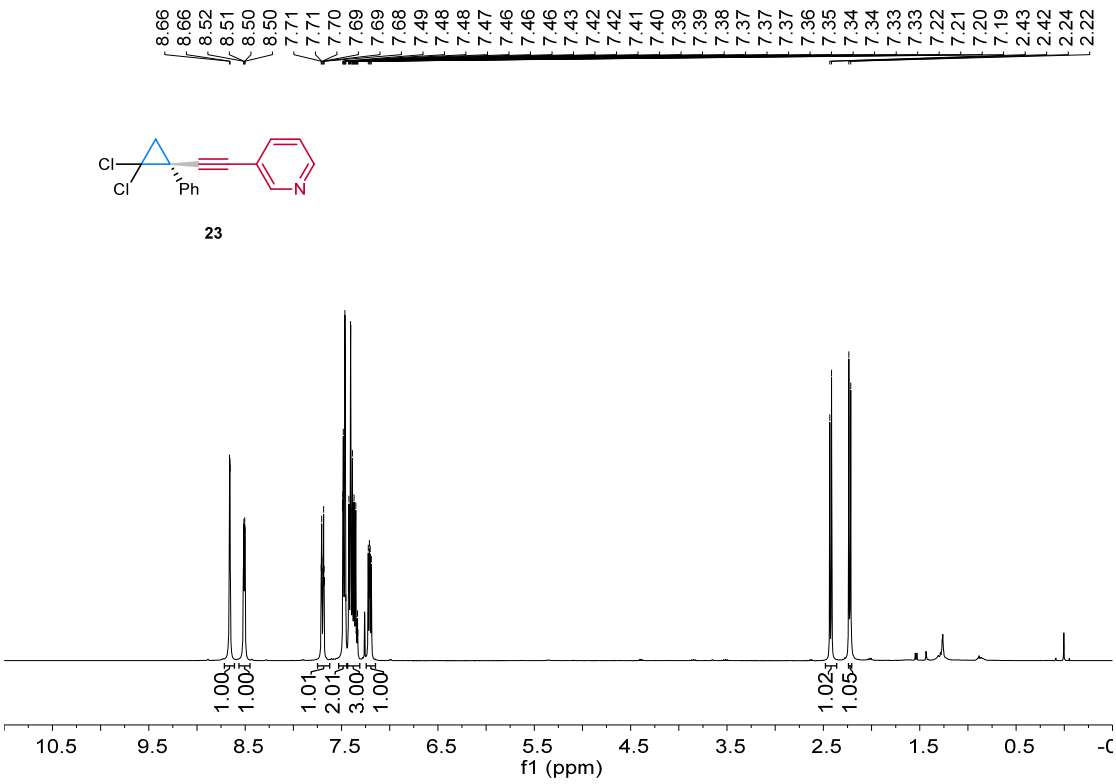

136.39
130.13
129.25
129.08
128.64
128.26
125.37
121.78

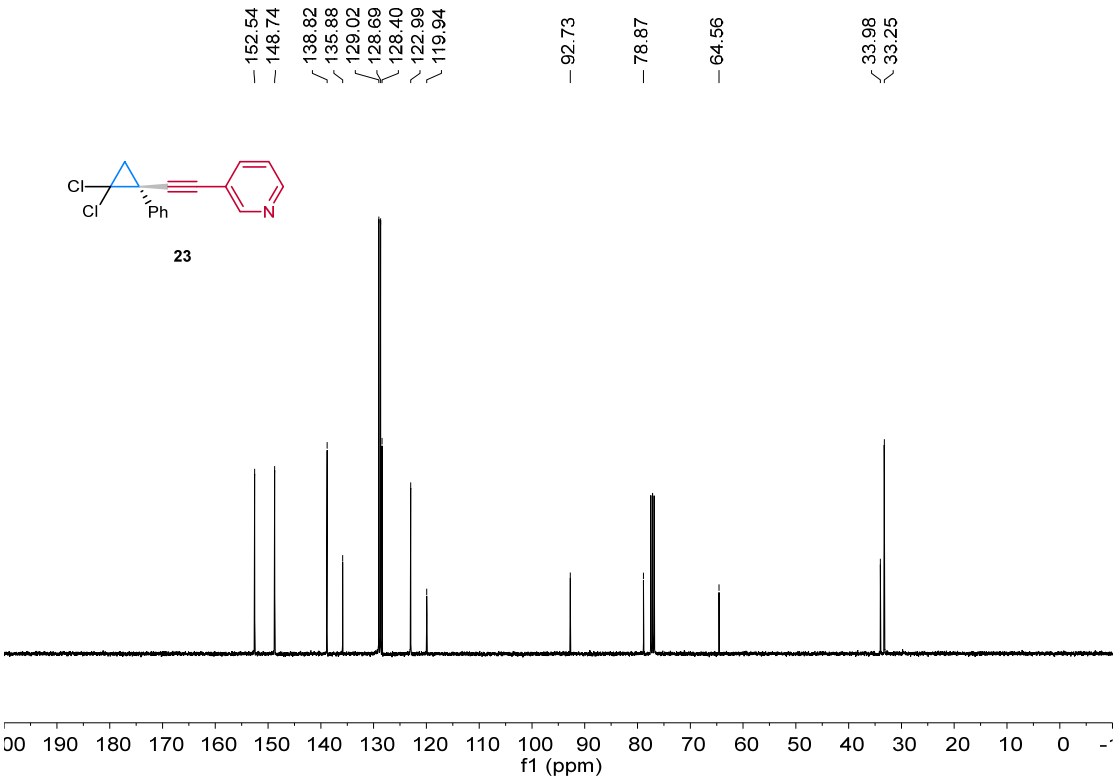

88.83
77.39
64.79
34.16
33.21

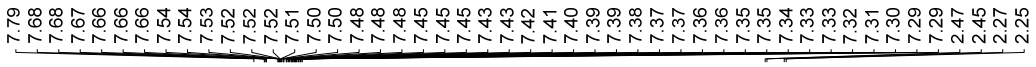

Cl
Cl
Ph
S

22


f1 (ppm)


8.66 8.66 8.52 8.51 8.50 8.50 7.71 7.71 7.70 7.69 7.69 7.68 7.49 7.48 7.48 7.47 7.46 7.46 7.46 7.43 7.42 7.42 7.41 7.40 7.39 7.39 7.38 7.37 7.37 7.37 7.36 7.35 7.34 7.34 7.33 7.33 7.22 7.21 7.20 7.19 2.43 2.42 2.24 2.22
Cl
Cl
Ph
N
23
1.00 1.00 1.01 2.01 3.00 1.00 1.02 1.05
10.5 9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)


152.54 148.74 138.82 135.88 129.02 128.69 128.40 122.99 119.94 92.73 78.87 64.56 33.98 33.25
Cl
Cl
Ph
N
23
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.68
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7.66
7.66
7.54
7.54
7.53
7.52
7.52
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7.50
7.50
7.48
7.48
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7.45
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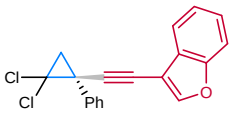
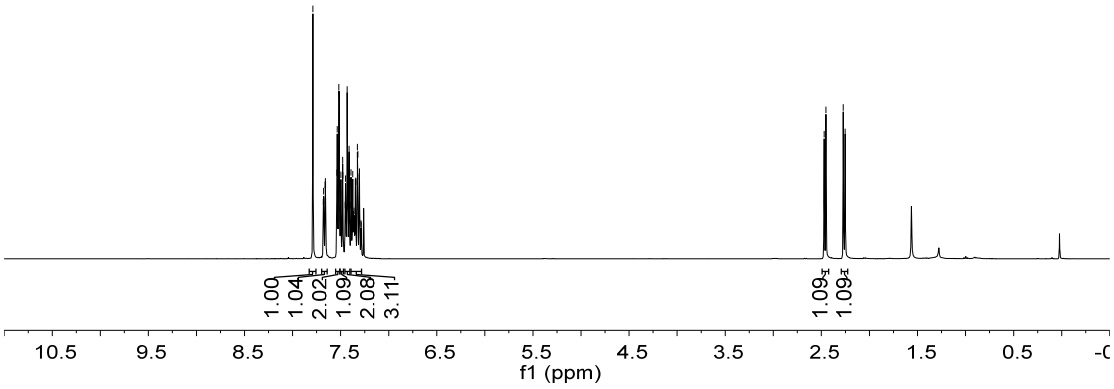
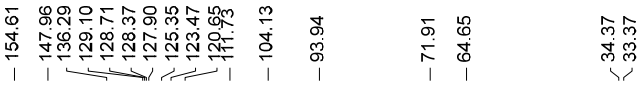
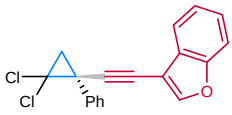
7.29
7.29
2.47
2.45
2.27
2.25


Cl
Cl
Ph
O

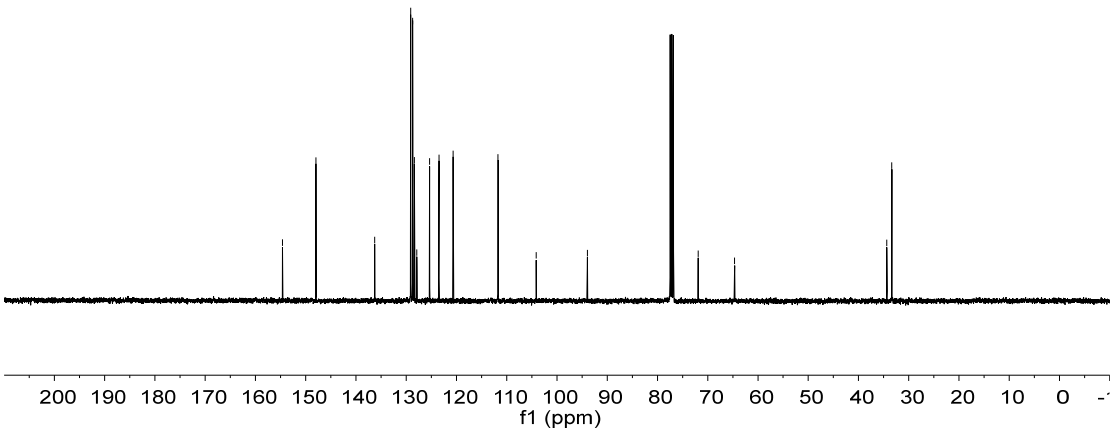
**24**

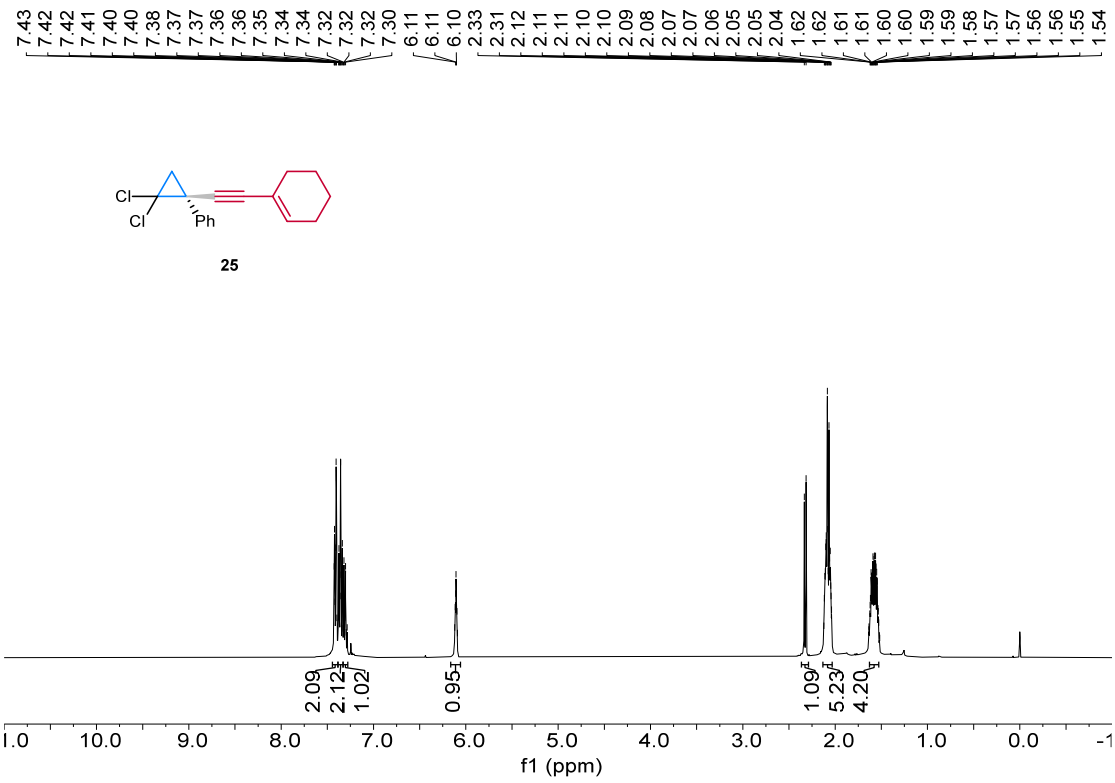

1.00
1.04
2.02
1.09
2.08
3.11
1.09
1.09
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)

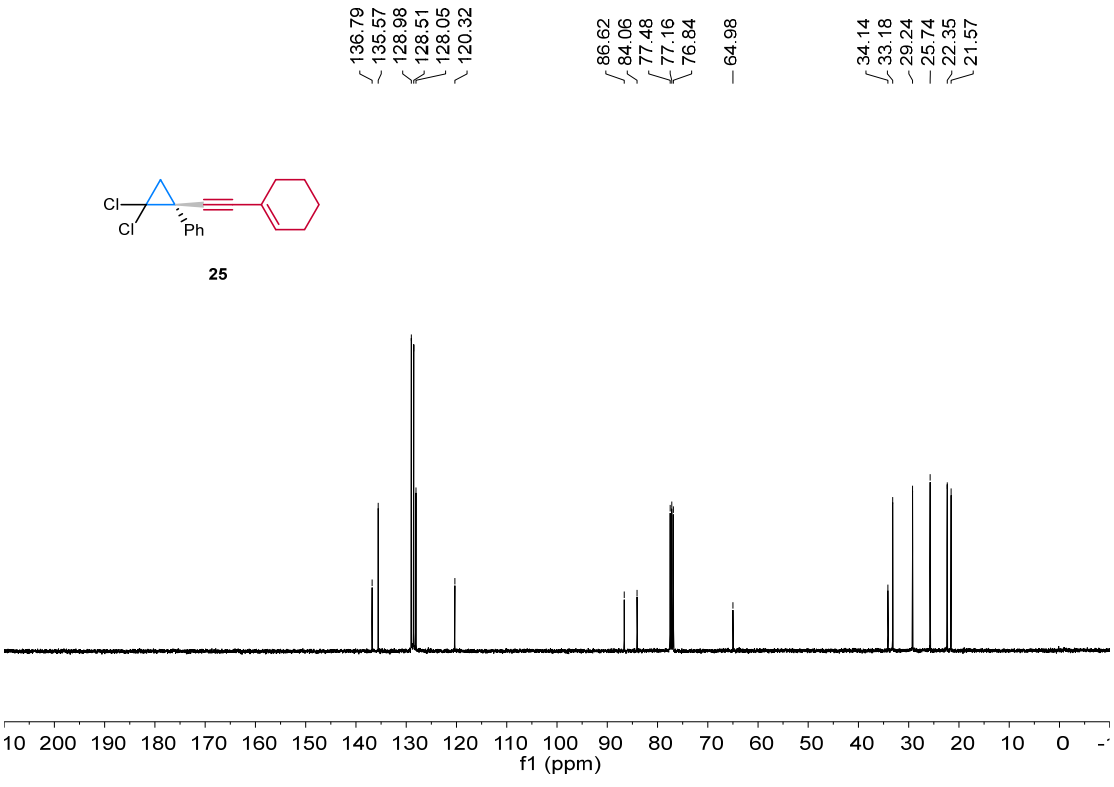

154.61
147.96
136.29
129.10
128.71
128.37
127.90
125.35
123.47
120.65
111.73
104.13
93.94
71.91
64.65
34.37
33.37

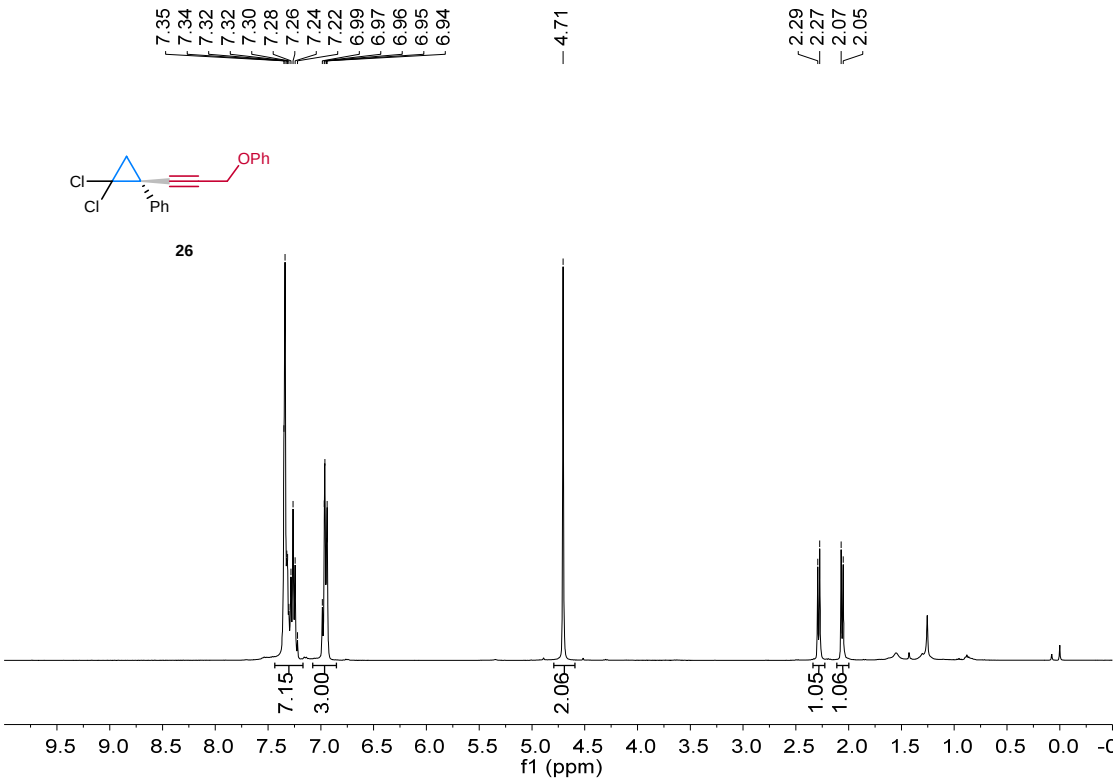

Cl
Cl
Ph
O

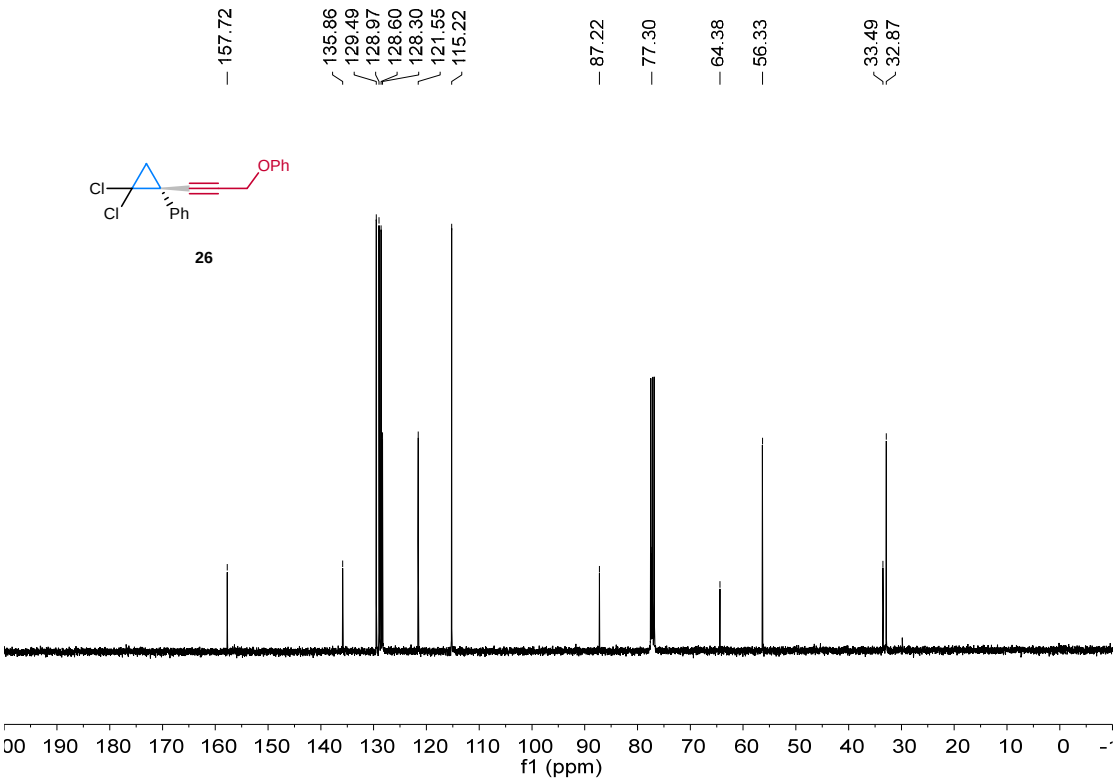
**24**


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.43 7.42 7.42 7.41 7.40 7.40 7.38 7.37 7.37 7.36 7.36 7.35 7.34 7.34 7.32 7.32 7.32 7.30 6.11 6.11 6.10 2.33 2.31 2.12 2.11 2.11 2.10 2.10 2.09 2.08 2.07 2.07 2.06 2.05 2.05 2.04 1.62 1.62 1.61 1.61 1.60 1.60 1.59 1.59 1.58 1.57 1.57 1.56 1.56 1.55 1.54
Cl
Cl
Ph
25
2.09
2.12
1.02
0.95
1.09
5.23
4.20
f1 (ppm)


136.79 135.57 128.98 128.51 128.05 120.32
86.62 84.06 77.48 77.16 76.84 64.98
34.14 33.18 29.24 25.74 22.35 21.57
Cl
Cl
Ph
25
f1 (ppm)


7.35
7.34
7.32
7.32
7.30
7.28
7.26
7.24
7.22
6.99
6.97
6.96
6.95
6.94
4.71
2.29
2.27
2.07
2.05
Cl
Cl
Ph
OPh
26
7.15
3.00
2.06
1.05
1.06
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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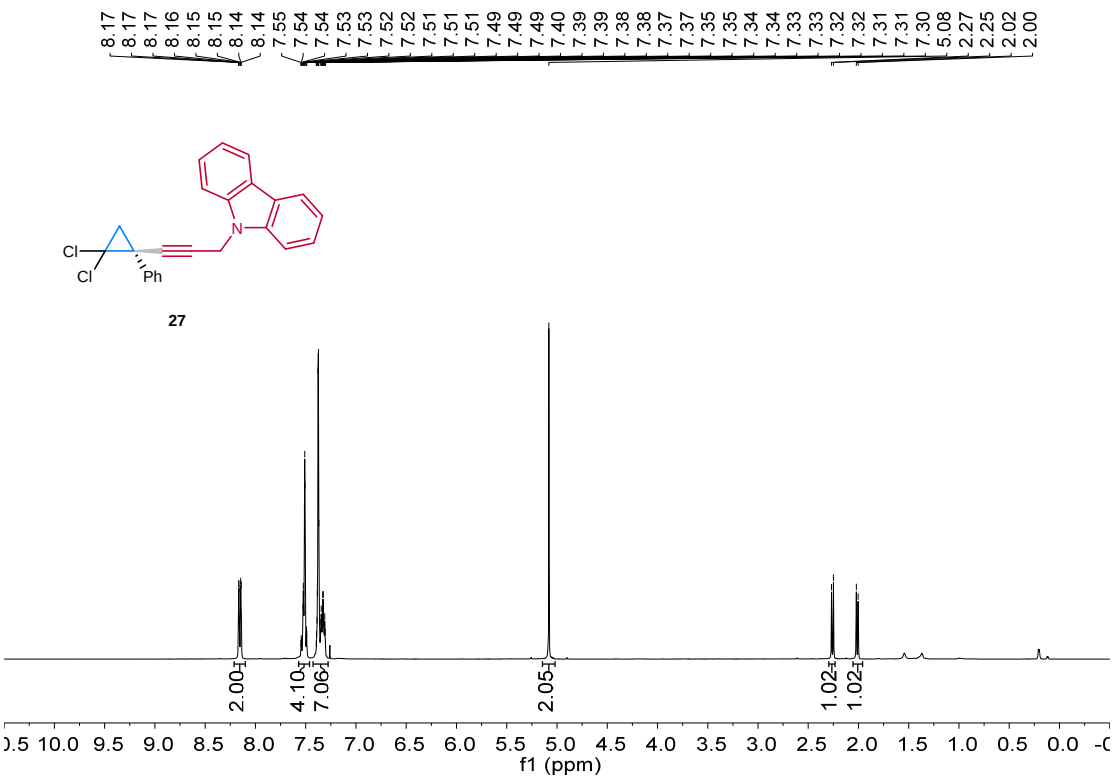
135.86
129.49
128.97
128.60
128.30
121.55
115.22
87.22
77.30
64.38
56.33
33.49
32.87
Cl
Cl
Ph
OPh
26
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.17 8.17 8.17 8.16 8.15 8.15 8.14 8.14 7.55 7.54 7.54 7.53 7.53 7.52 7.52 7.51 7.51 7.51 7.49 7.49 7.49 7.40 7.39 7.39 7.38 7.38 7.37 7.37 7.35 7.35 7.34 7.34 7.33 7.33 7.32 7.32 7.31 7.31 7.30 5.08 2.27 2.25 2.02 2.00
Cl
Cl
Ph
N
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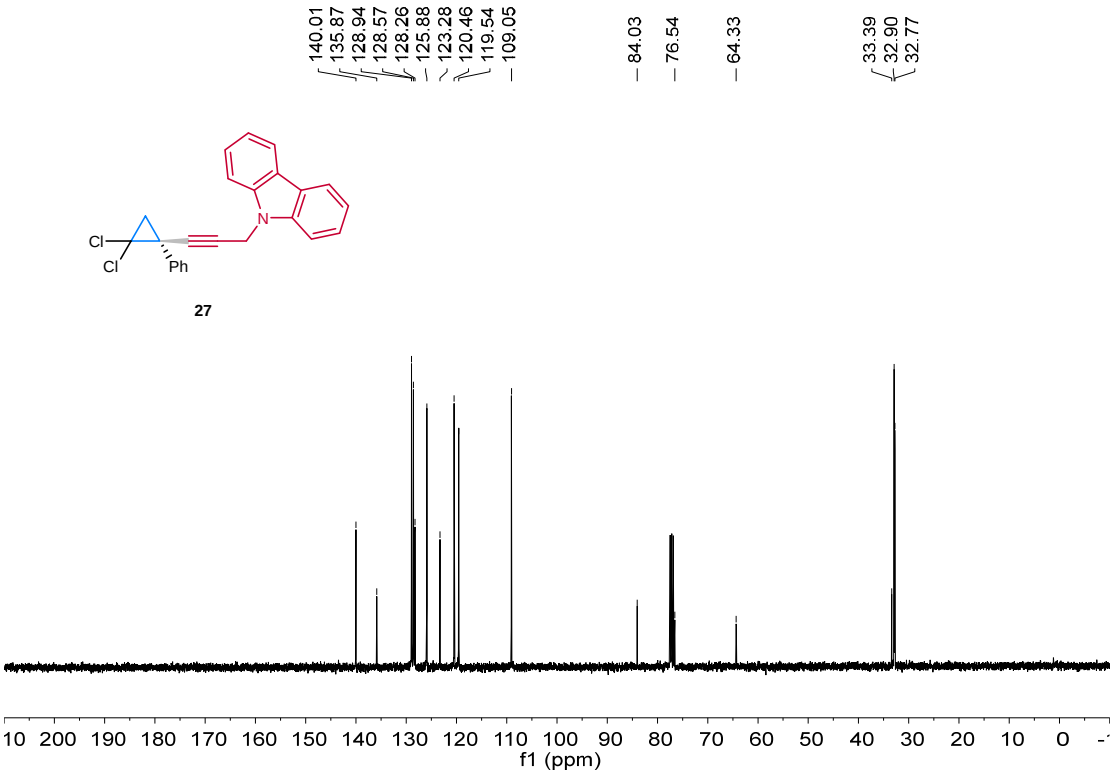
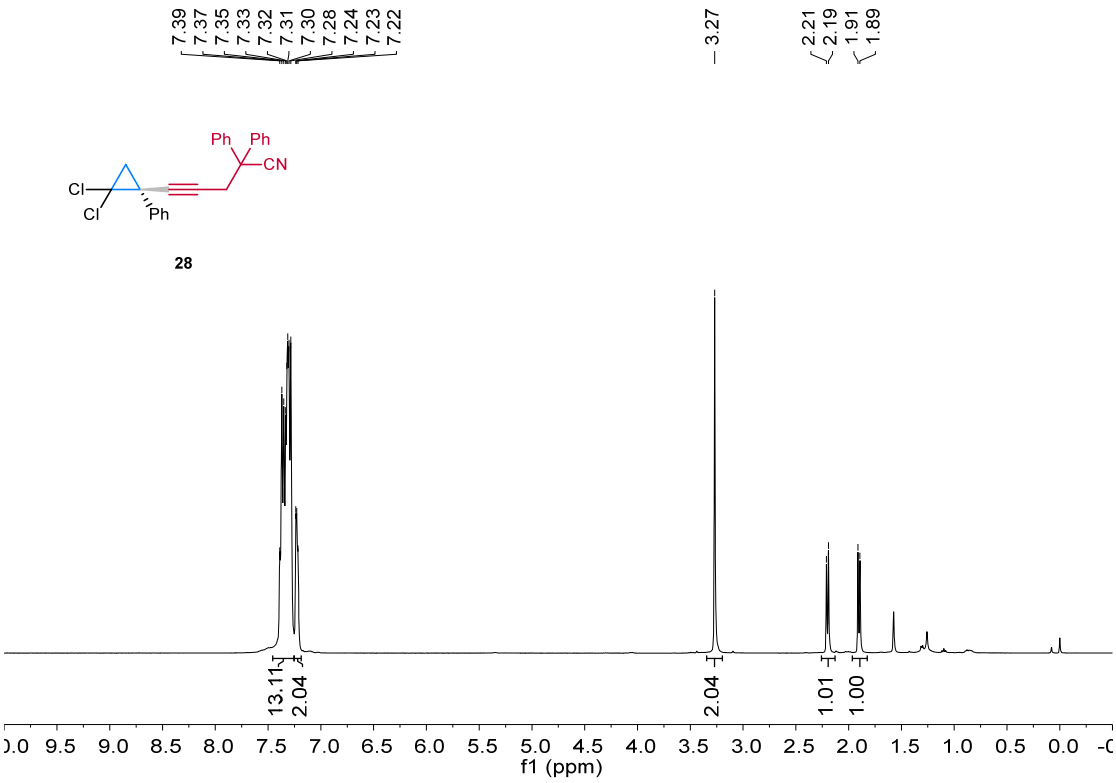
2.00
4.10
7.06
2.05
1.02
1.02
f1 (ppm)


140.01 135.87 128.94 128.57 128.26 125.88 123.28 120.46 119.54 109.05 84.03 76.54 64.33 33.39 32.90 32.77
Cl
Cl
Ph
N
27
f1 (ppm)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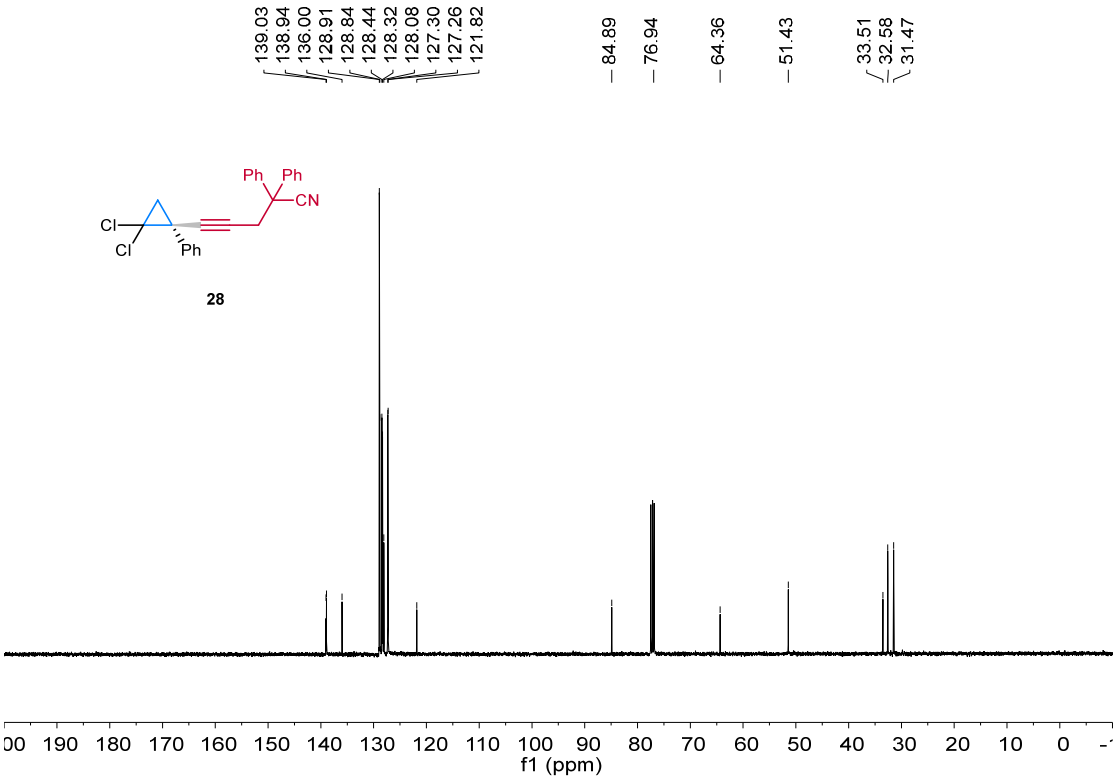
7.37
7.35
7.33
7.32
7.31
7.30
7.28
7.24
7.23
7.22
3.27
2.21
2.19
1.91
1.89
Ph
Ph
CN
Cl
Cl
Ph
28
13.11
2.04
2.04
1.01
1.00
f1 (ppm)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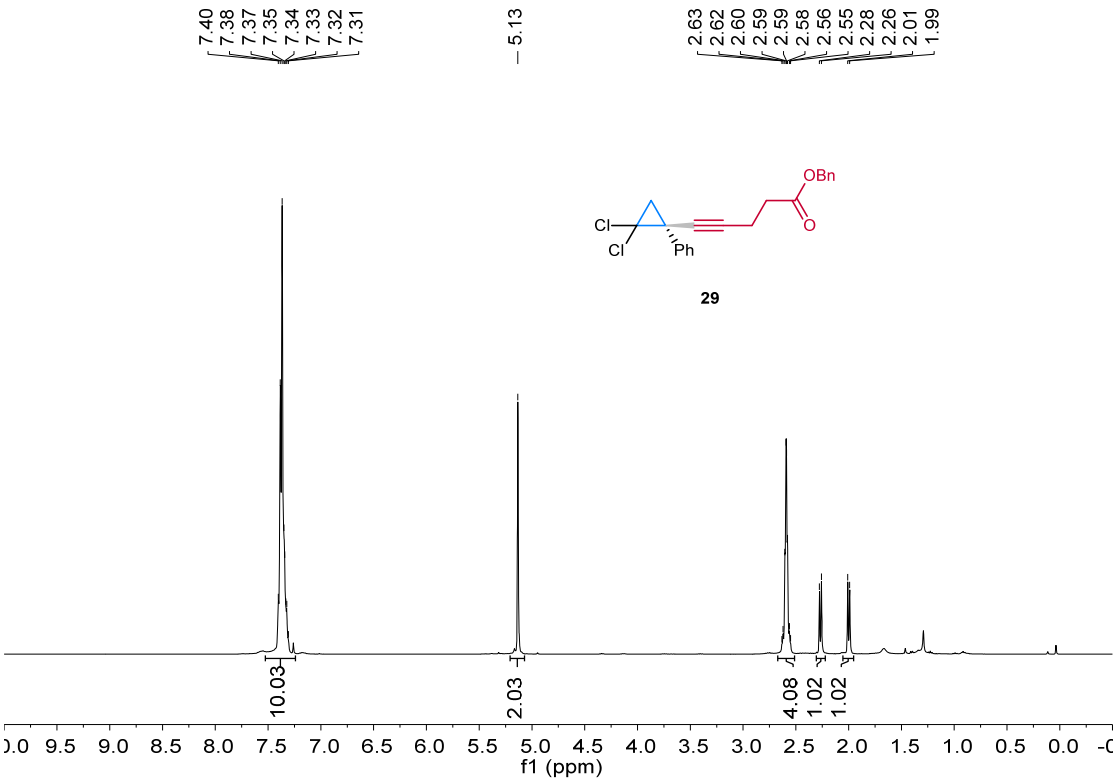
128.44
128.32
128.08
127.30
127.26
121.82
84.89
76.94
64.36
51.43
33.51
32.58
31.47
Ph
Ph
CN
Cl
Cl
Ph
28
f1 (ppm)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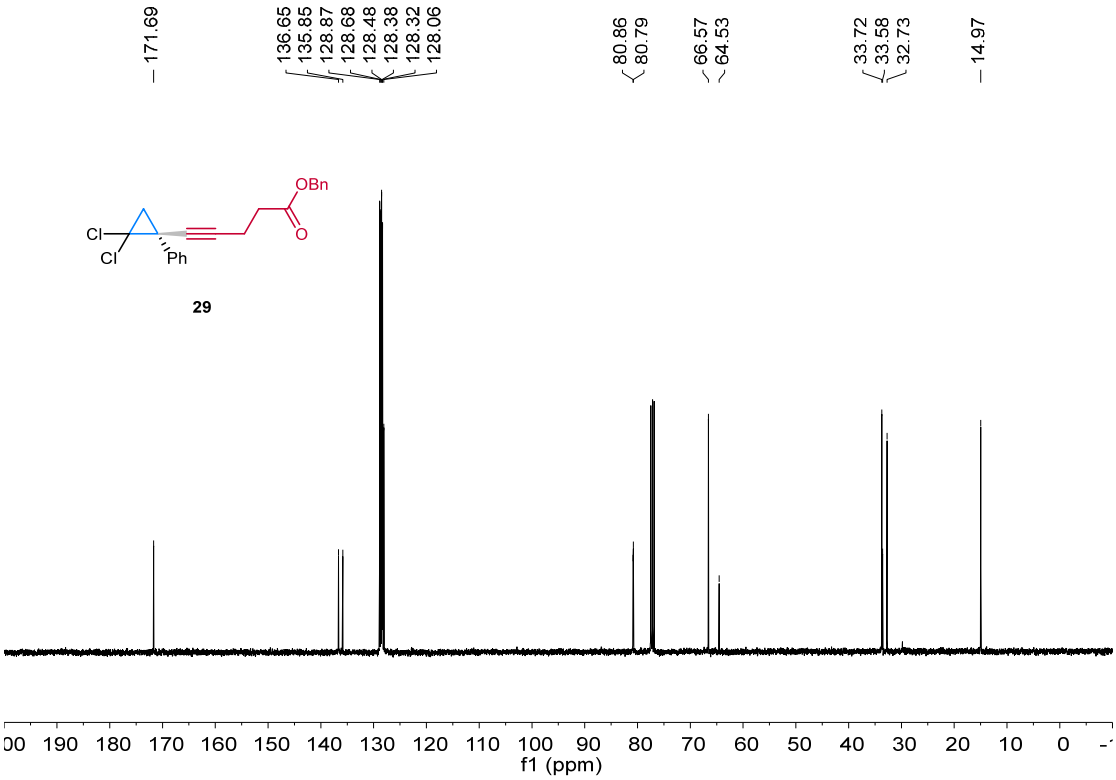
7.34
7.33
7.32
7.31
5.13
2.63
2.62
2.60
2.59
2.59
2.58
2.56
2.55
2.28
2.26
2.01
1.99
OBn
O
Cl
Cl
Ph
29
10.03
2.03
4.08
1.02
1.02
f1 (ppm)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128.32
128.06
80.86
80.79
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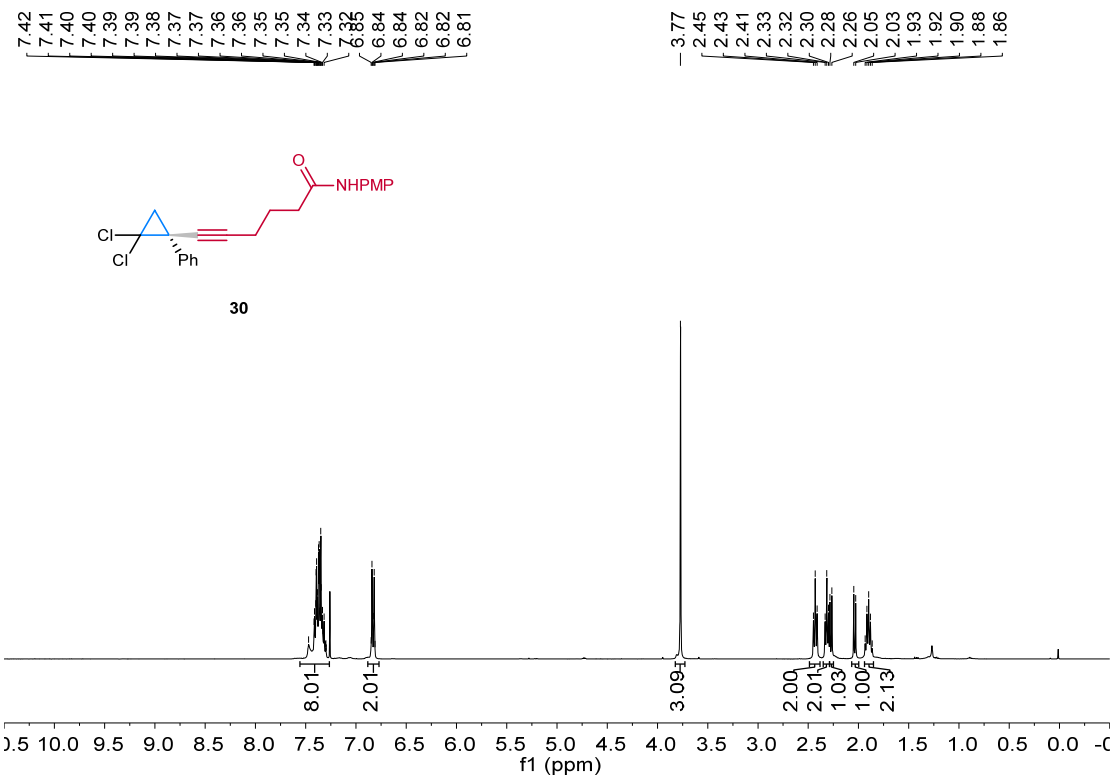
64.53
33.72
33.58
32.73
14.97
OBn
O
Cl
Cl
Ph
29
f1 (ppm)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7.36
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7.35
7.34
7.33
7.32
6.85
6.84
6.84
6.82
6.82
6.81
3.77
2.45
2.43
2.41
2.33
2.32
2.30
2.28
2.26
2.05
2.03
1.93
1.92
1.90
1.88
1.86
O
NHPMP
Cl
Cl
Ph
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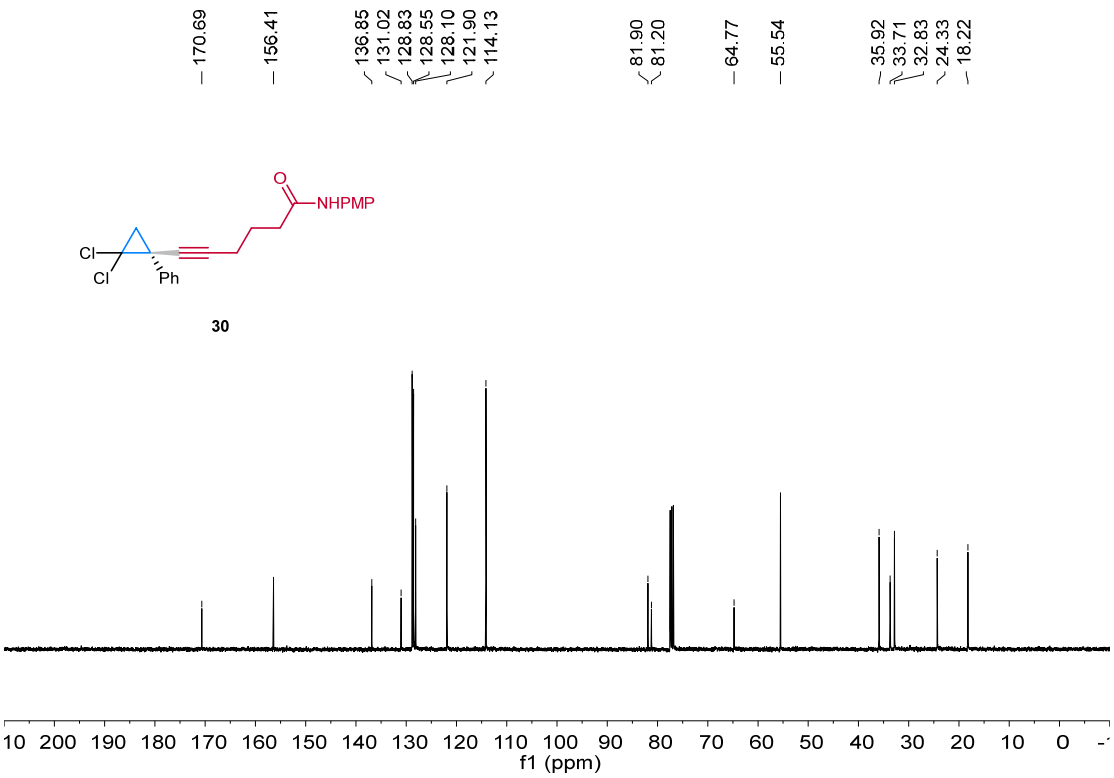
8.01
2.01
3.09
2.00
2.01
1.03
1.00
2.13
f1 (ppm)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156.41
136.85
131.02
128.83
128.55
128.10
121.90
114.13
81.90
81.20
64.77
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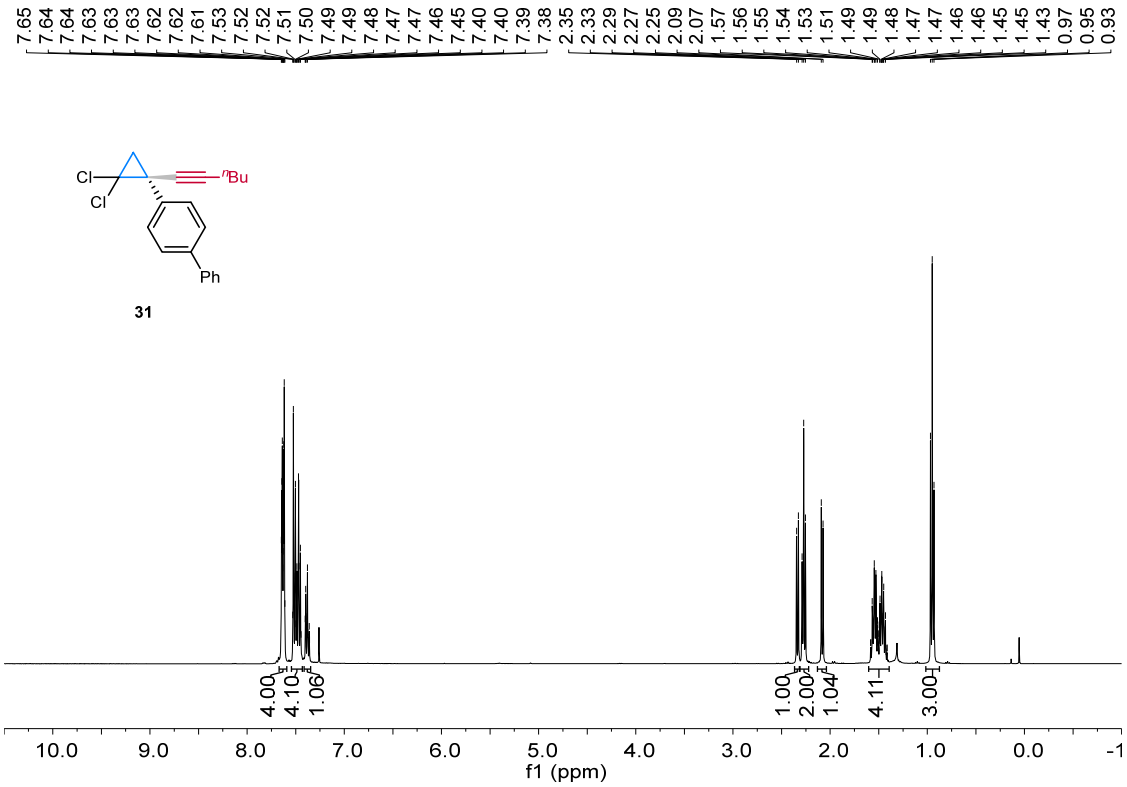
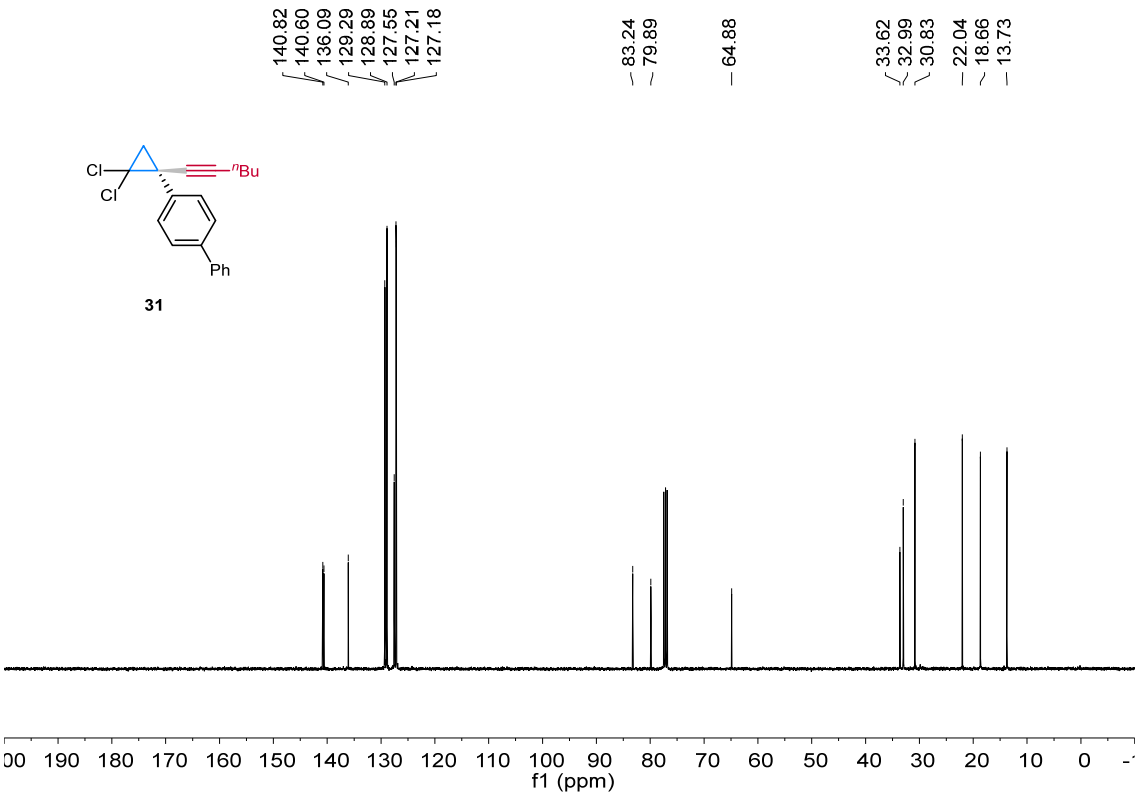
O
NHPMP
Cl
Cl
Ph
30
f1 (ppm)


7.65 7.64 7.64 7.63 7.63 7.63 7.62 7.62 7.61 7.53 7.52 7.52 7.51 7.50 7.49 7.49 7.48 7.47 7.47 7.46 7.45 7.40 7.40 7.39 7.38
2.35 2.33 2.29 2.27 2.25 2.09 2.07 1.57 1.56 1.55 1.54 1.53 1.51 1.49 1.49 1.48 1.47 1.47 1.46 1.46 1.45 1.45 1.43 0.97 0.95 0.93
Cl
Cl
nBu
Ph
31
4.00
4.10
1.06
1.00
2.00
1.04
4.11
3.00
10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 -1
f1 (ppm)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140.60
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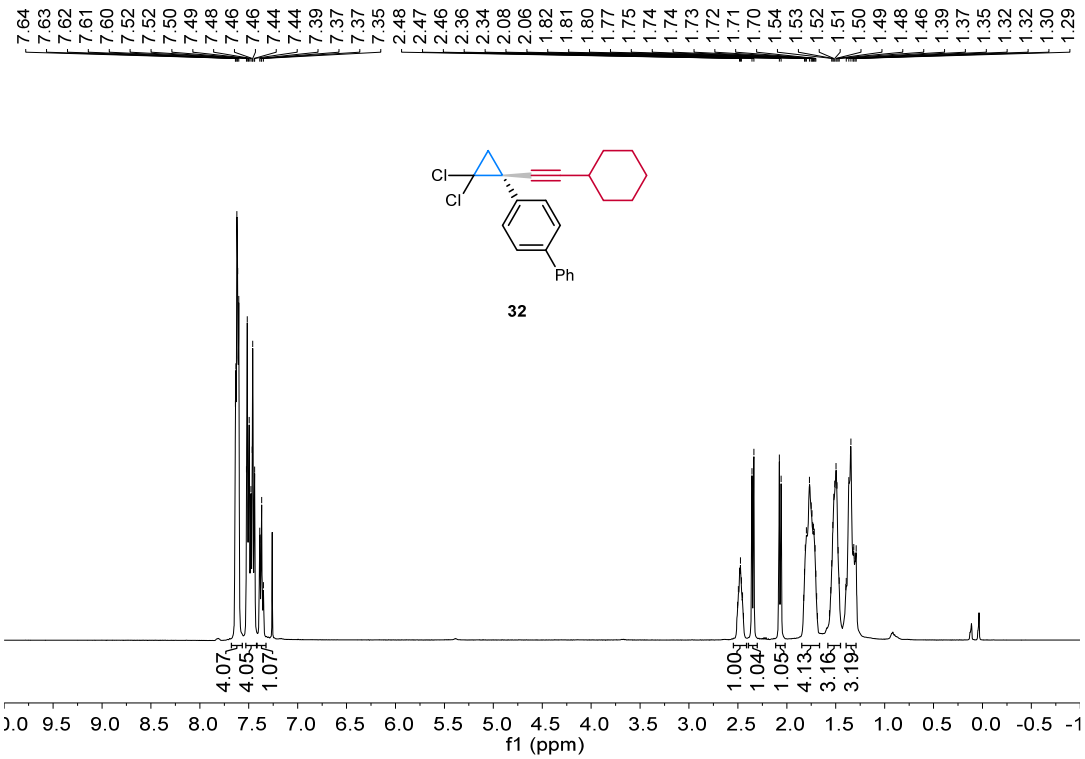
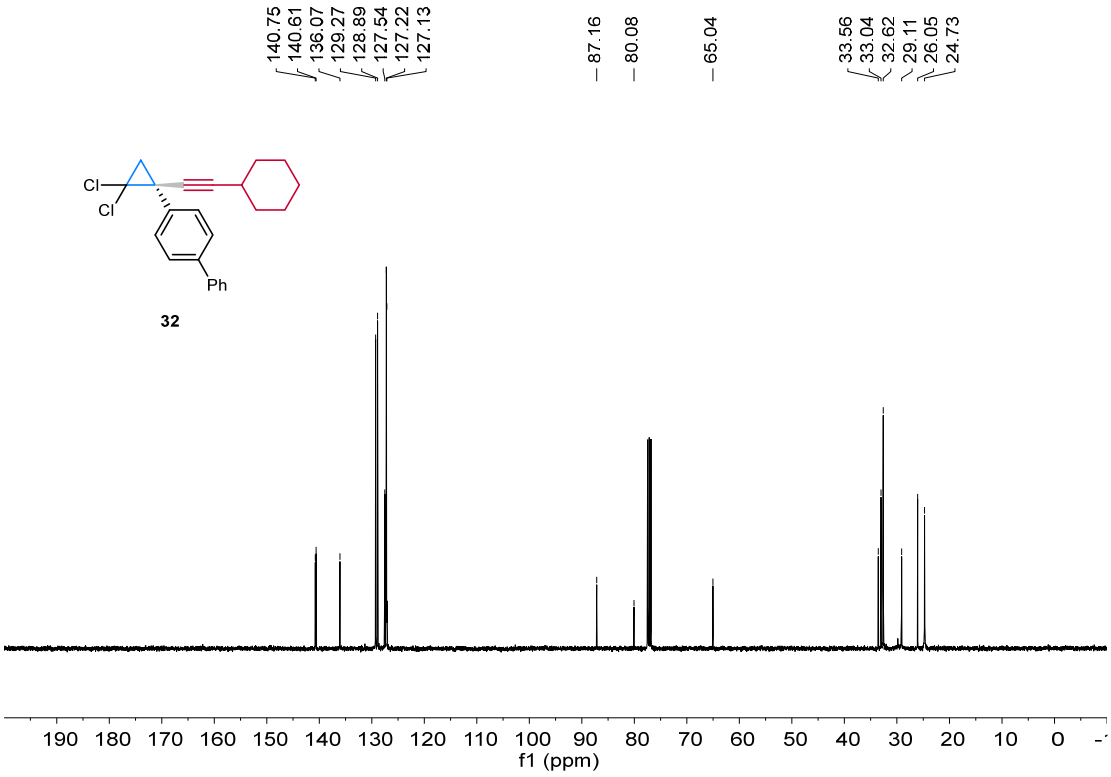
129.29
128.89
127.55
127.21
127.18
83.24
79.89
64.88
33.62
32.99
30.83
22.04
18.66
13.73
Cl
Cl
nBu
Ph
31
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.64 7.63 7.62 7.61 7.60 7.52 7.52 7.50 7.49 7.48 7.46 7.46 7.44 7.44 7.39 7.37 7.37 7.35
2.48 2.47 2.46 2.36 2.34 2.08 2.06 1.82 1.81 1.80 1.77 1.75 1.74 1.74 1.73 1.72 1.71 1.70 1.54 1.53 1.52 1.51 1.50 1.49 1.48 1.46 1.39 1.37 1.35 1.32 1.32 1.30 1.29
Cl
Cl
Ph
32
4.07
4.05
1.07
1.00
1.04
1.05
4.13
3.16
3.19
f1 (ppm)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140.61
136.07
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127.54
127.22
127.13
87.16
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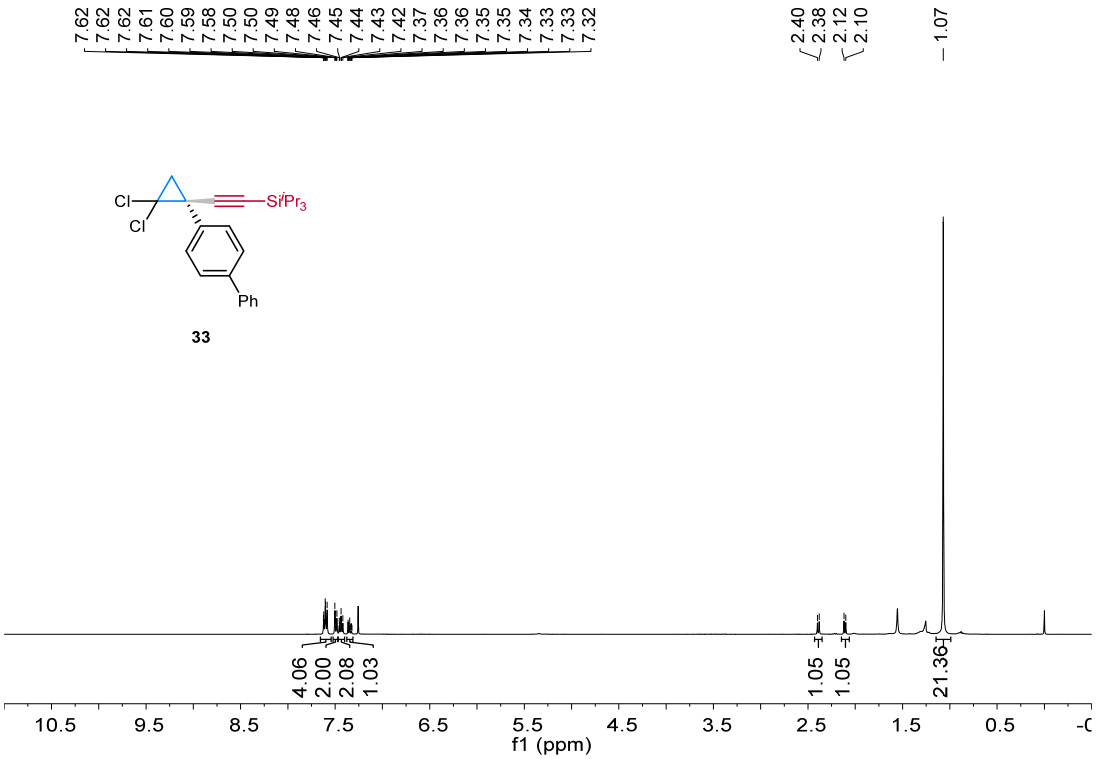
33.56
33.04
32.62
29.11
26.05
24.73
Cl
Cl
Ph
32
f1 (ppm)


7.62
7.62
7.62
7.61
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7.58
7.50
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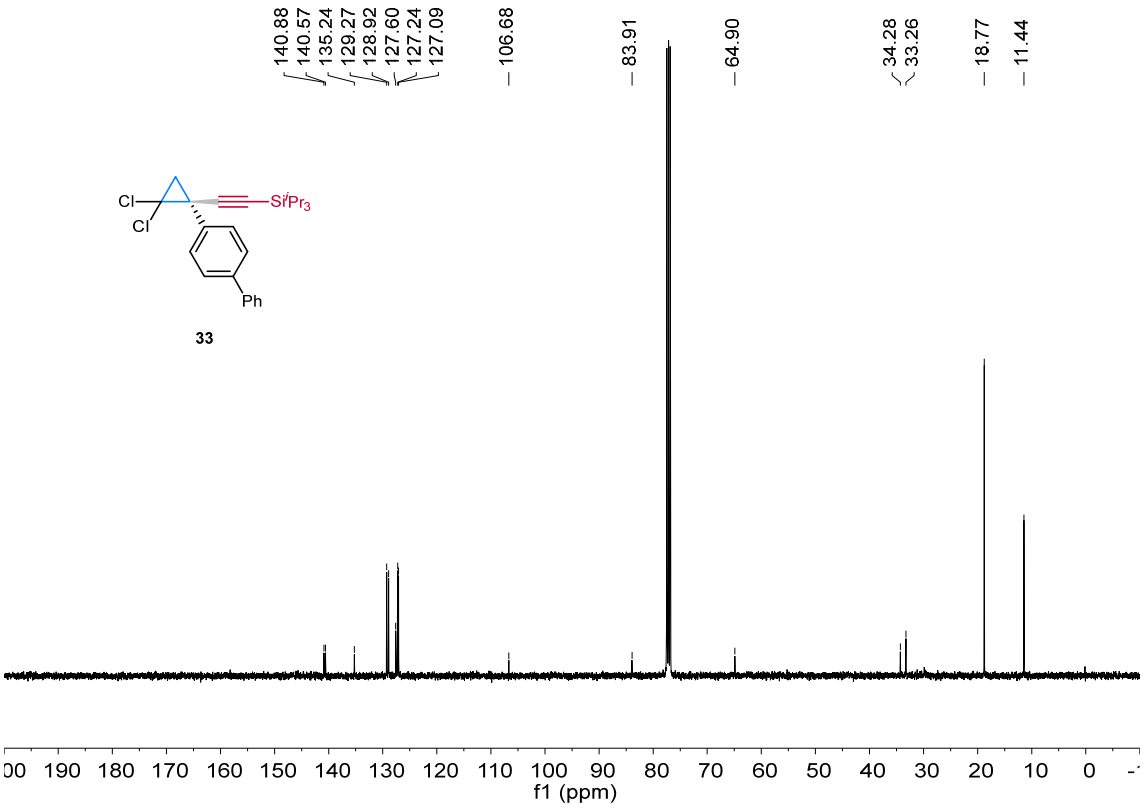
7.48
7.46
7.45
7.44
7.43
7.42
7.37
7.36
7.36
7.35
7.35
7.34
7.33
7.33
7.32
2.40
2.38
2.12
2.10
1.07
Cl
Cl
SiiPr3
Ph
33
4.06
2.00
2.08
1.03
1.05
1.05
21.36
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)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83.91
64.90
34.28
33.26
18.77
11.44
Cl
Cl
SiiPr3
Ph
33
190
180
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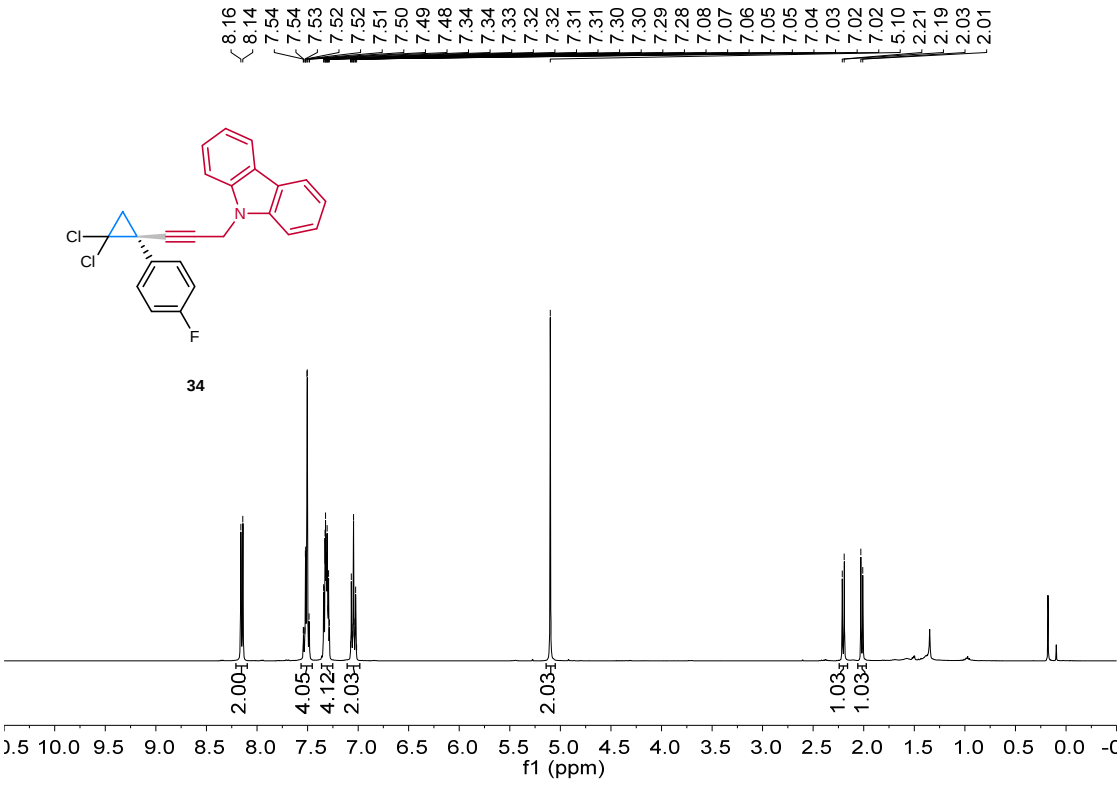
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.48
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7.34
7.33
7.32
7.31
7.31
7.30
7.30
7.29
7.28
7.08
7.07
7.06
7.05
7.05
7.04
7.03
7.02
7.02
5.10
2.21
2.19
2.03
2.01
Cl
Cl
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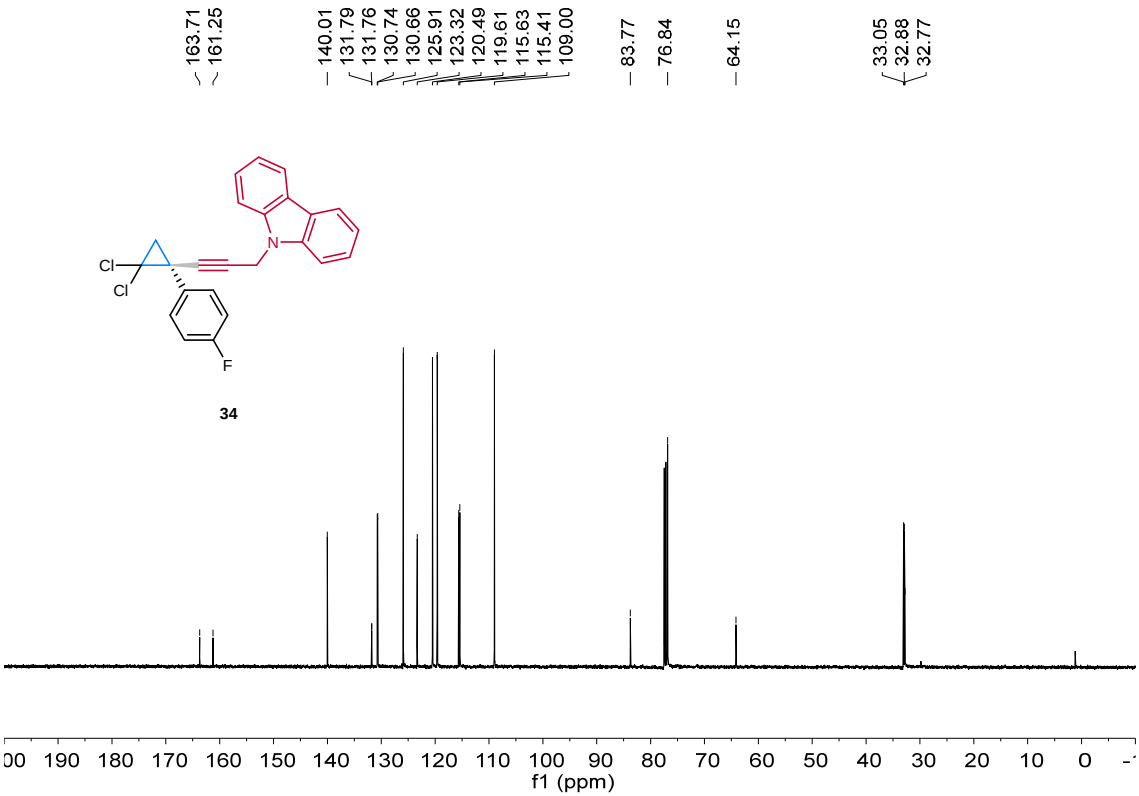
F
34
2.00
4.05
4.12
2.03
2.03
1.03
1.03
f1 (ppm)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120.49
119.61
115.63
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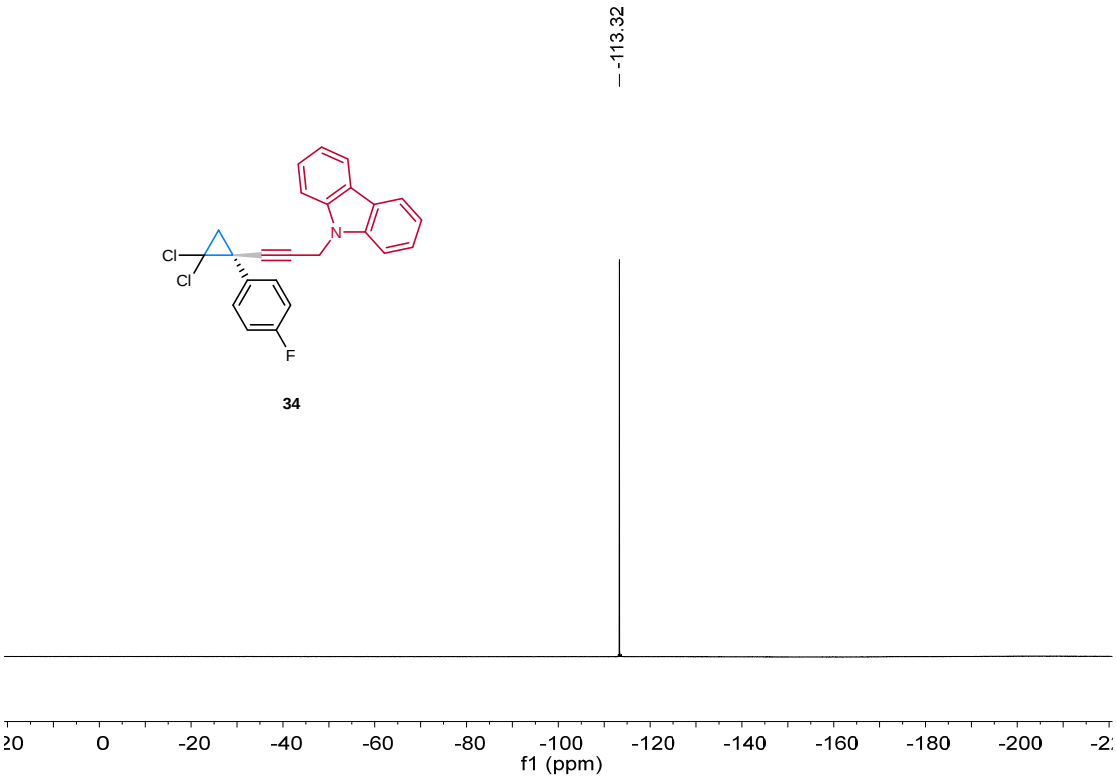
76.84
64.15
33.05
32.88
32.77
Cl
Cl
N
F
34
f1 (ppm)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Cl
Cl
N
F
34
20
0
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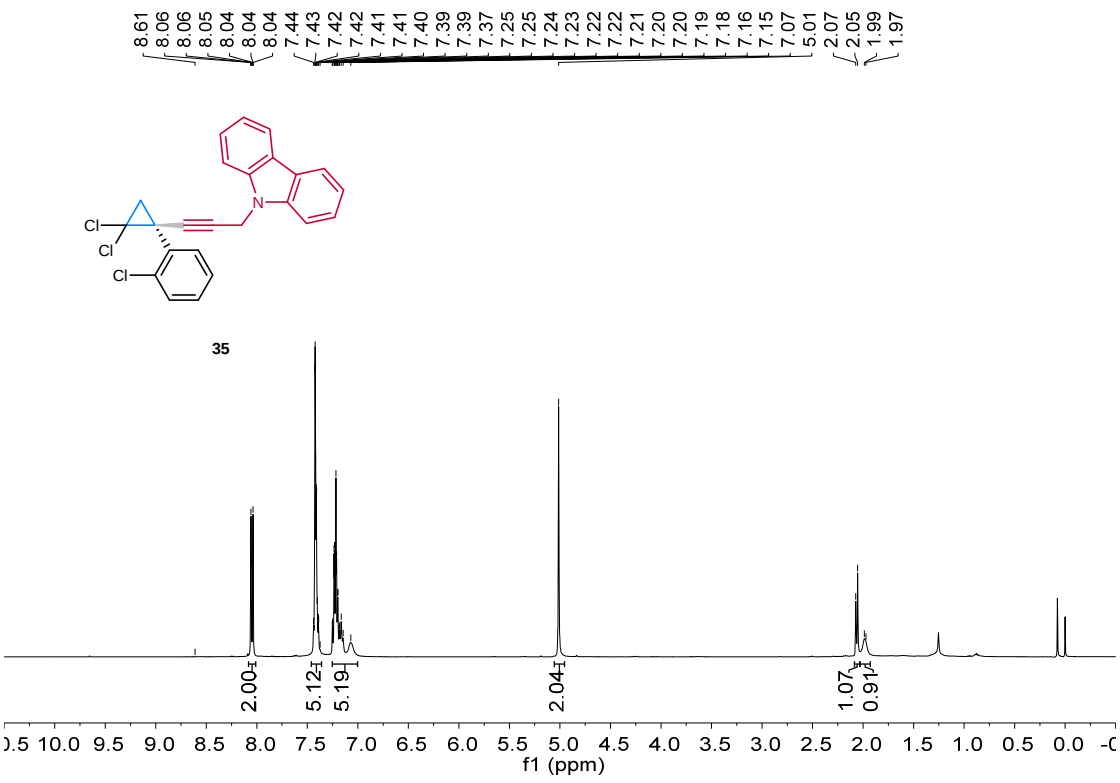
-40
-60
-80
-100
-120
-140
-160
-180
-200
f1 (ppm)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8.06
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8.04
8.04
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7.43
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7.41
7.41
7.40
7.39
7.39
7.37
7.25
7.25
7.24
7.23
7.22
7.22
7.21
7.20
7.20
7.19
7.18
7.16
7.15
7.07
5.01
2.07
2.05
1.99
1.97
Cl
Cl
Cl
N
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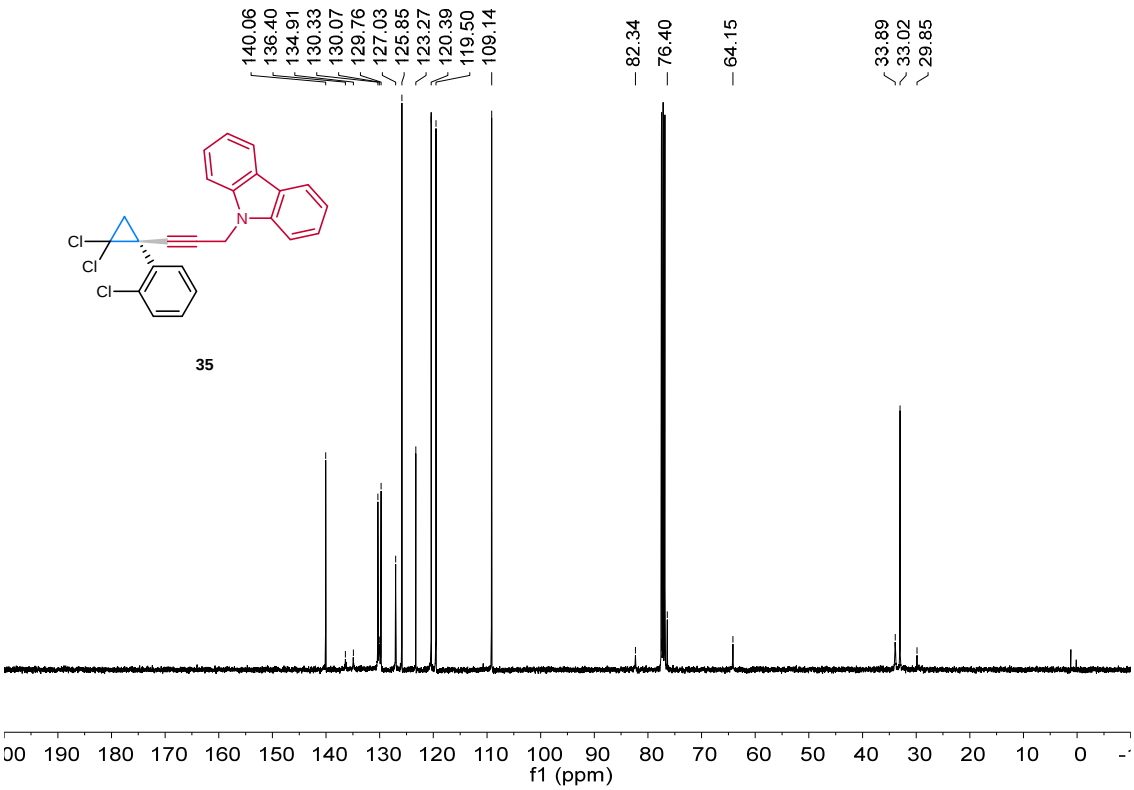
2.00
5.12
5.19
2.04
1.07
0.91
f1 (ppm)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130.07
129.76
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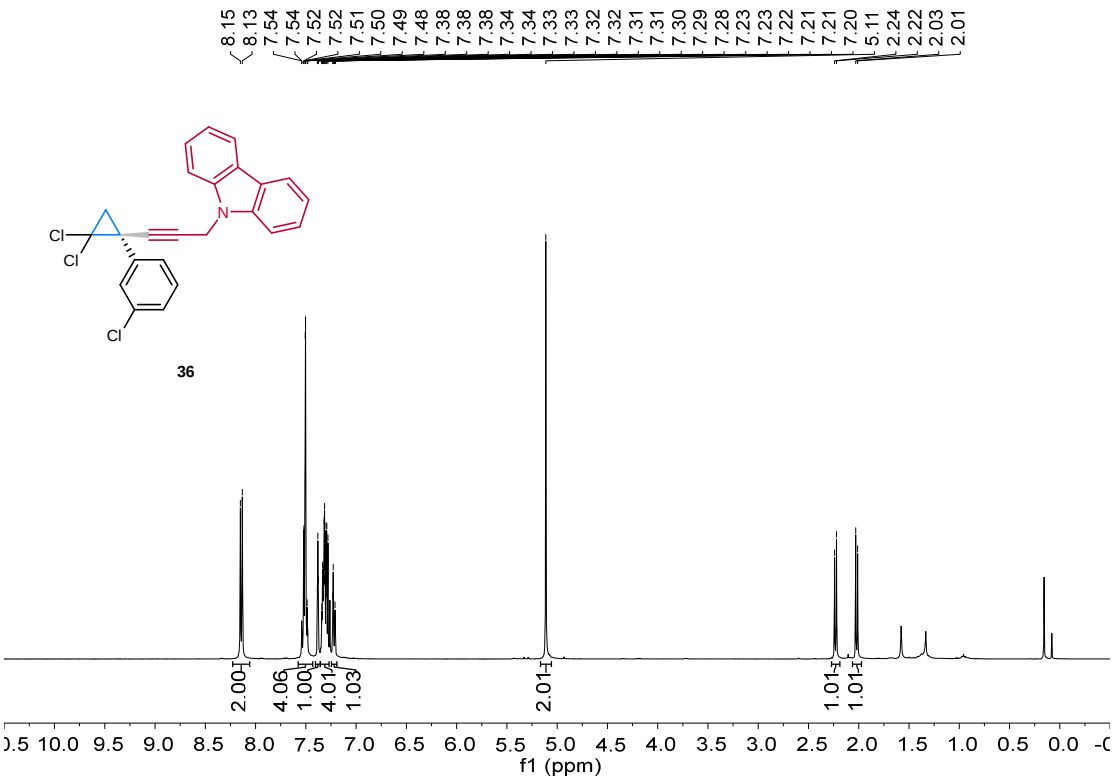
125.85
123.27
120.39
119.50
109.14
82.34
76.40
64.15
33.89
33.02
29.85
Cl
Cl
Cl
N
35
f1 (ppm)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8.13
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7.51
7.50
7.49
7.48
7.38
7.38
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7.32
7.32
7.31
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7.29
7.28
7.23
7.23
7.22
7.21
7.21
7.20
5.11
2.24
2.22
2.03
2.01
Cl
Cl
Cl
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2.00
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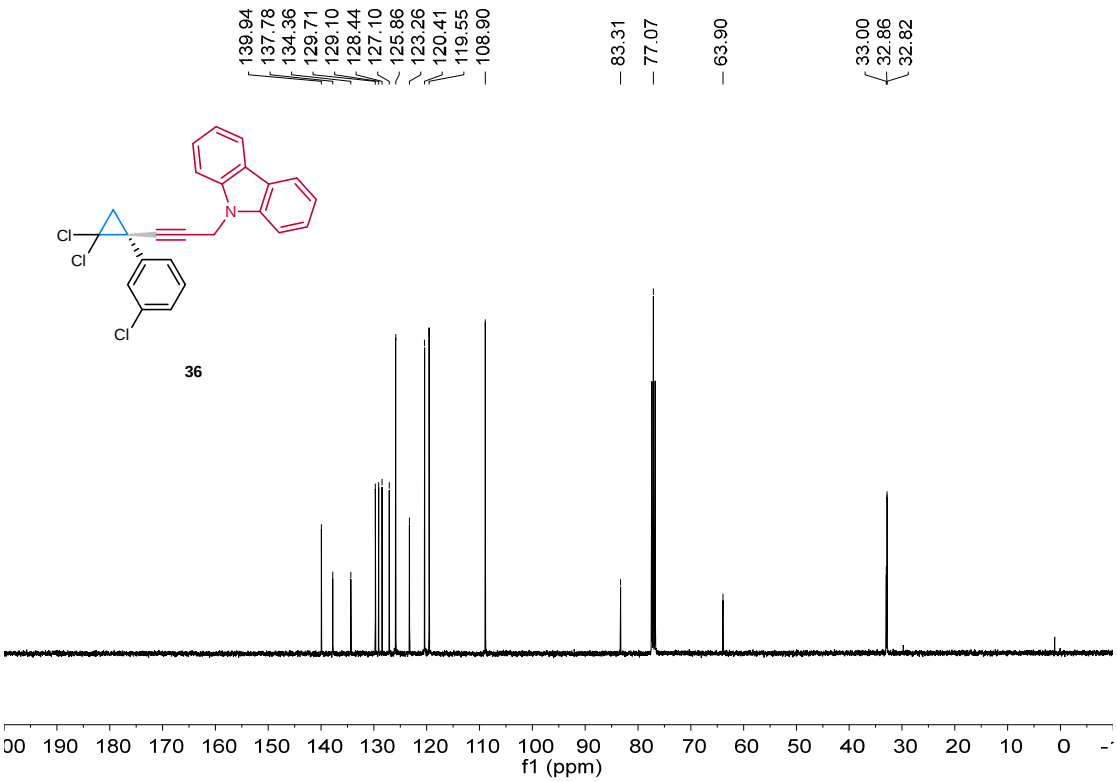
1.00
4.01
1.03
2.01
1.01
1.01
f1 (ppm)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129.10
128.44
127.10
125.86
123.26
120.41
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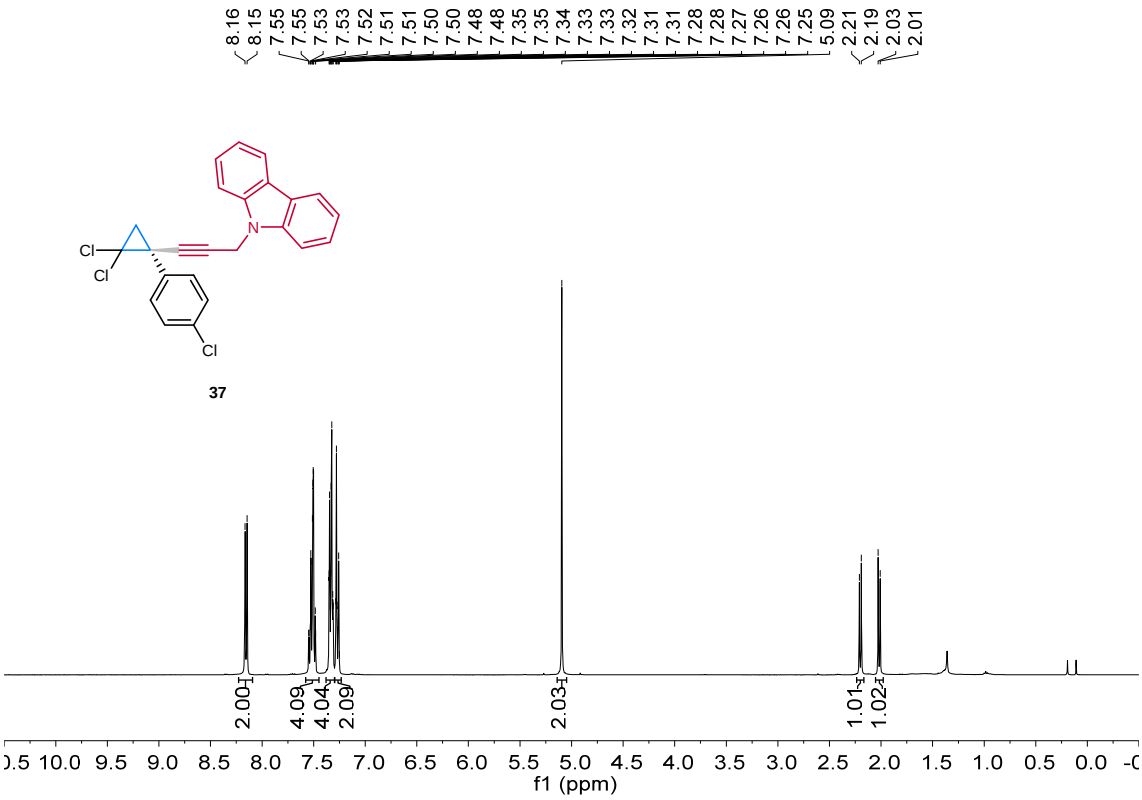
77.07
63.90
33.00
32.86
32.82
Cl
Cl
Cl
N
36
f1 (ppm)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7.52
7.51
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7.50
7.50
7.48
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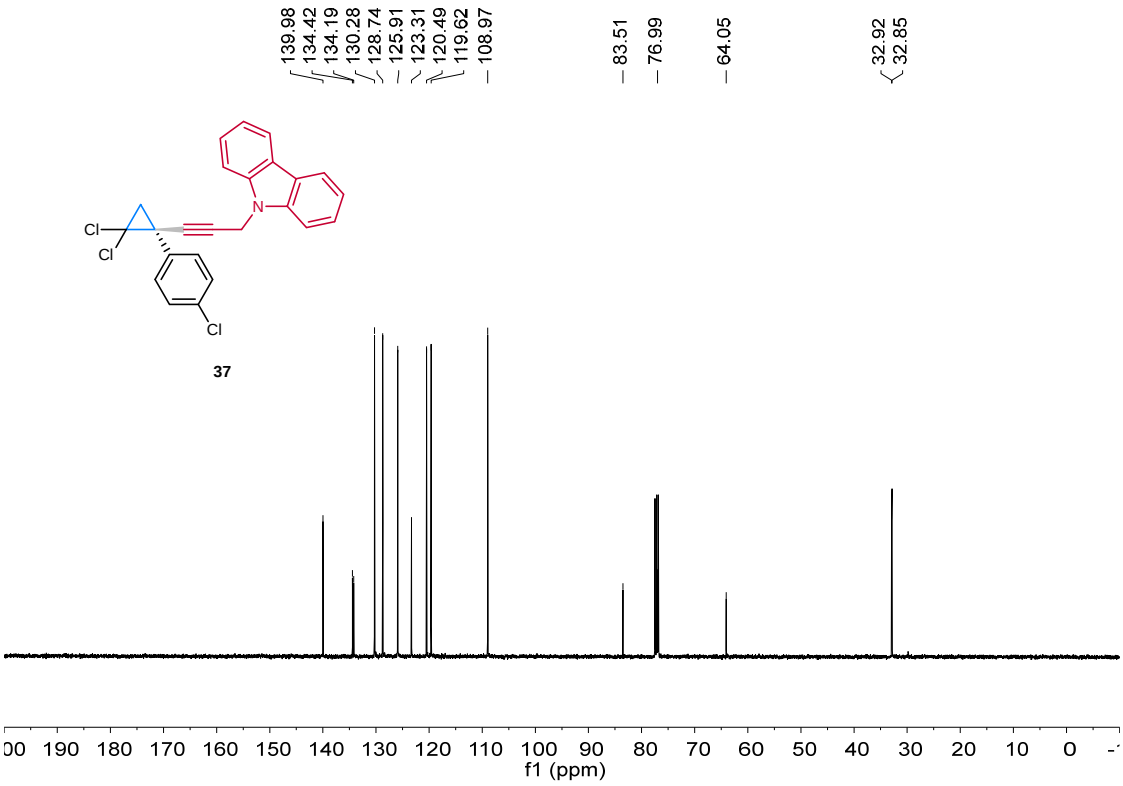
7.35
7.35
7.34
7.33
7.33
7.32
7.31
7.31
7.28
7.28
7.27
7.26
7.26
7.25
5.09
2.21
2.19
2.03
2.01
Cl
Cl
Cl
N
37
2.00
4.09
4.04
2.09
2.03
1.01
1.02
f1 (ppm)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83.51
76.99
64.05
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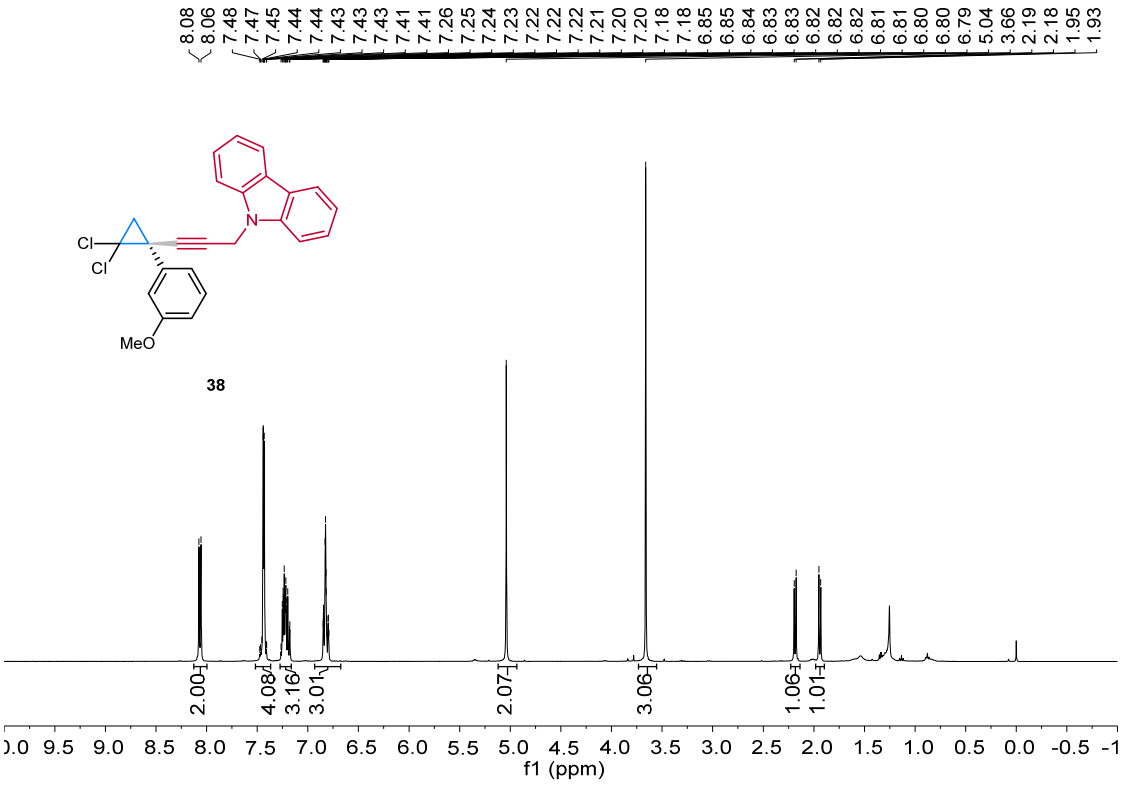
32.85
Cl
Cl
Cl
N
37
f1 (ppm)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7.43
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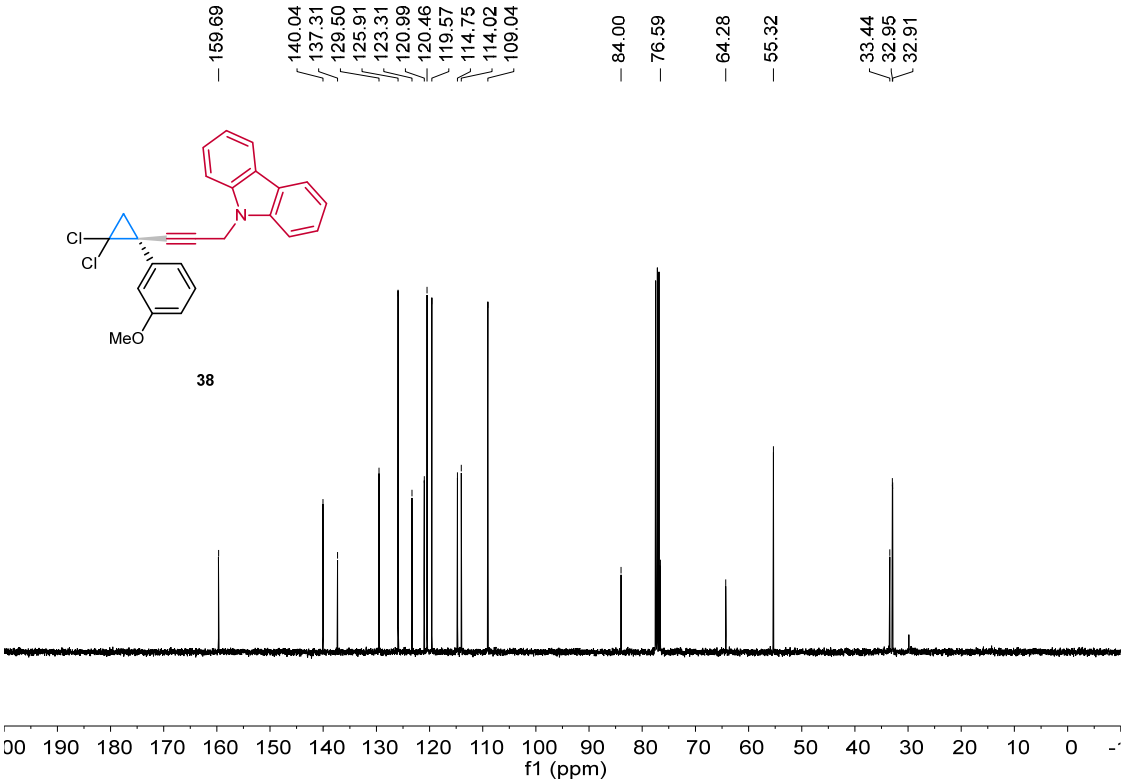
7.41
7.41
7.26
7.25
7.24
7.23
7.22
7.22
7.21
7.20
7.20
7.18
7.18
6.85
6.85
6.84
6.83
6.83
6.82
6.82
6.82
6.81
6.81
6.80
6.80
6.79
5.04
3.66
2.19
2.18
1.95
1.93
Cl
Cl
MeO
N
38
2.00
4.08
3.16
3.01
2.07
3.06
1.06
1.01
f1 (ppm)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114.75
114.02
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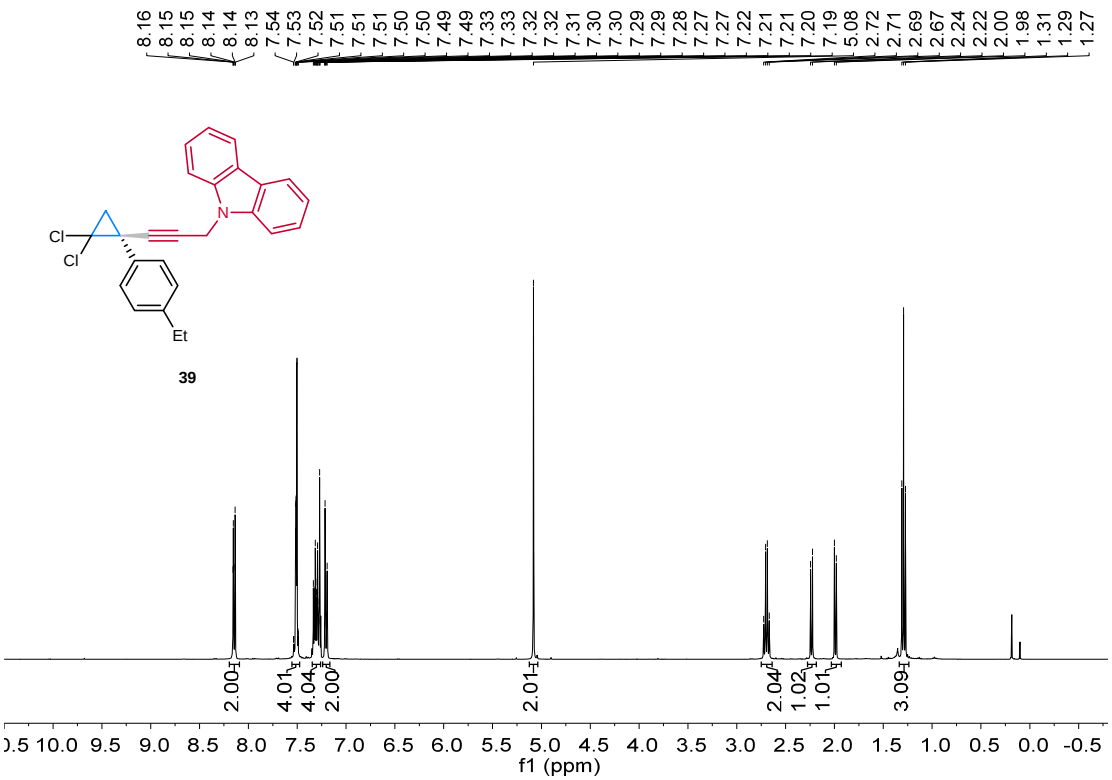
64.28
55.32
33.44
32.95
32.91
Cl
Cl
MeO
N
38
f1 (ppm)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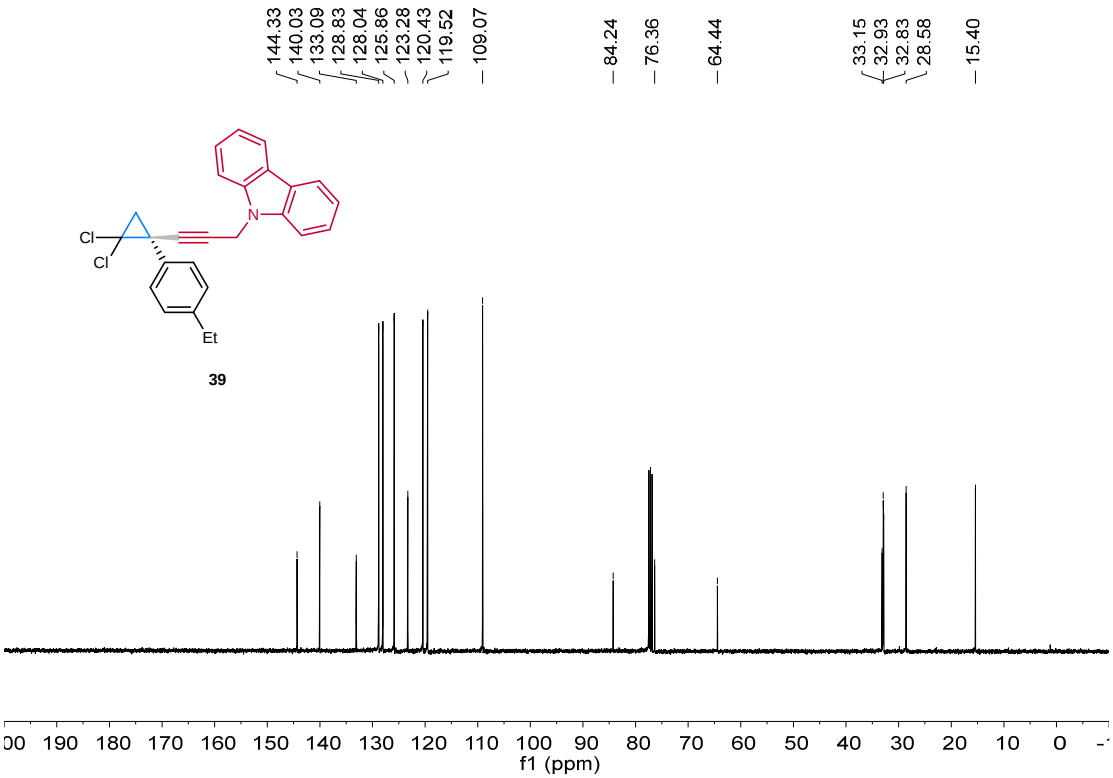
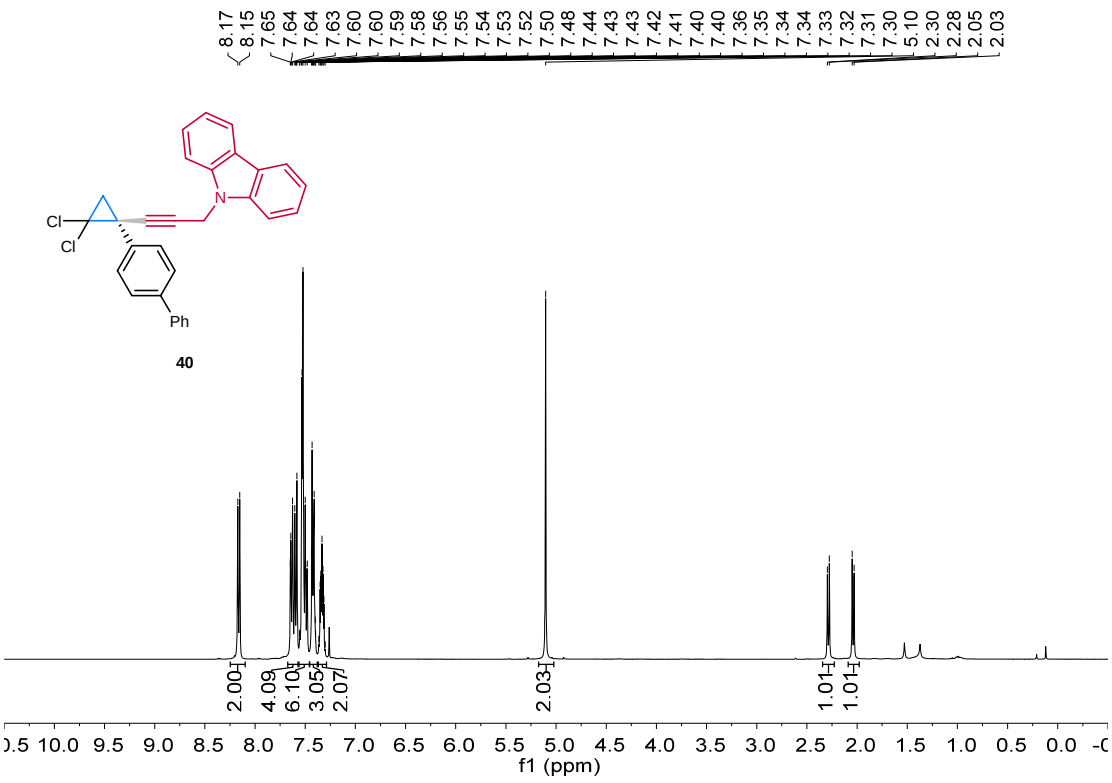
Cl
N
Et
39
2.00 4.01 4.04 2.00 2.01 2.04 1.02 1.01 3.09
f1 (ppm)


144.33 140.03 133.09 128.83 128.04 125.86 123.28 120.43 119.52 109.07 84.24 76.36 64.44 33.15 32.93 32.83 28.58 15.40
Cl
Cl
N
Et
39
f1 (ppm)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7.58
7.56
7.55
7.54
7.53
7.52
7.50
7.48
7.44
7.43
7.43
7.42
7.41
7.40
7.40
7.36
7.35
7.34
7.34
7.33
7.32
7.31
7.30
5.10
2.30
2.28
2.05
2.03
Cl
Cl
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Ph
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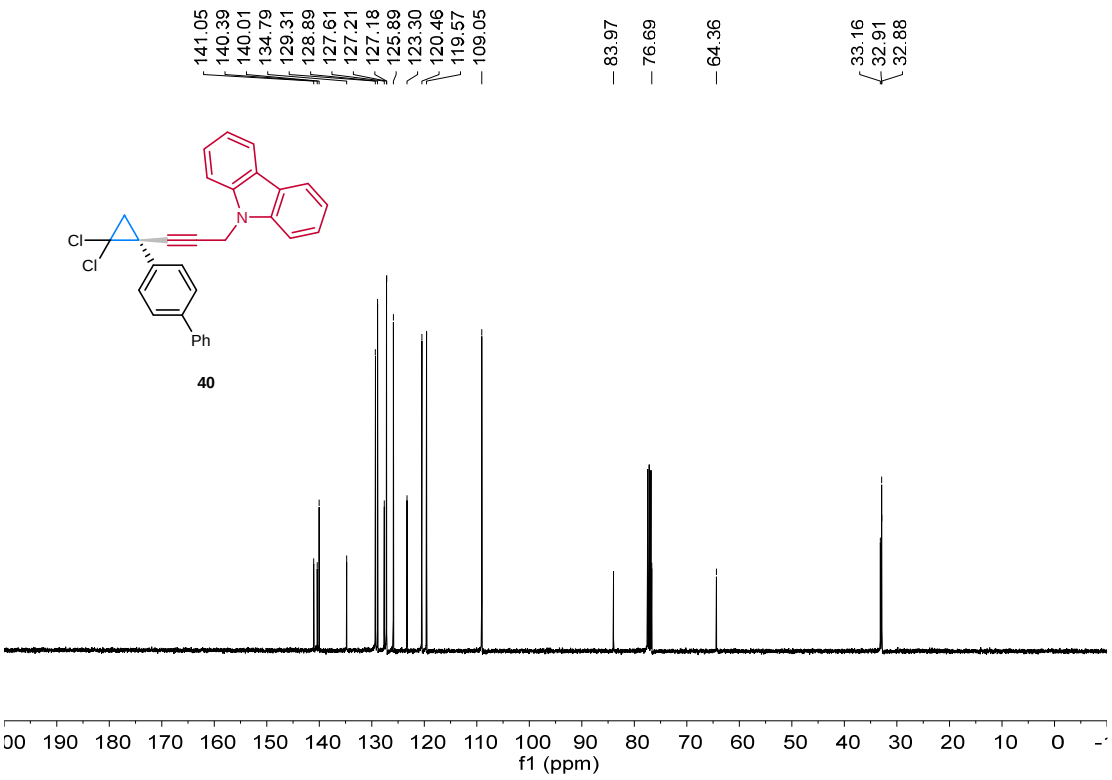
4.09
6.10
3.05
2.07
2.03
1.01
1.01
f1 (ppm)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120.46
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76.69
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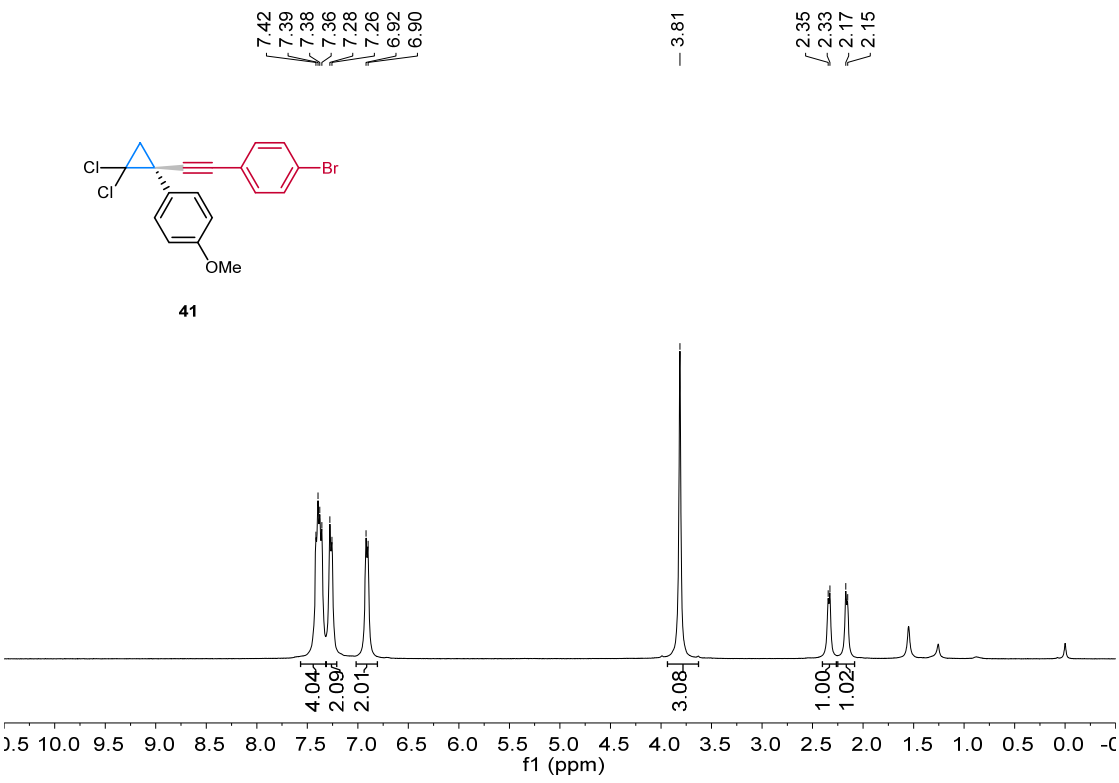
32.88
Cl
Cl
N
Ph
40
f1 (ppm)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7.26
6.92
6.90
3.81
2.35
2.33
2.17
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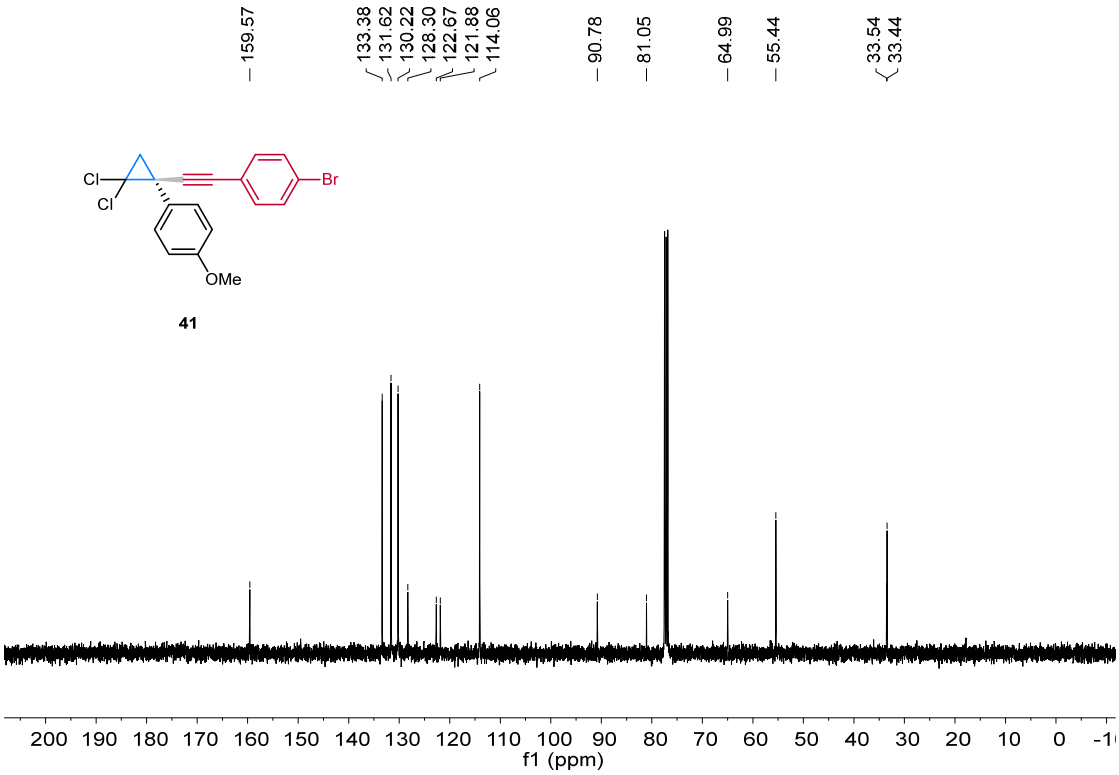
Cl
Br
OMe
41
4.04
2.09
2.01
3.08
1.00
1.02
f1 (ppm)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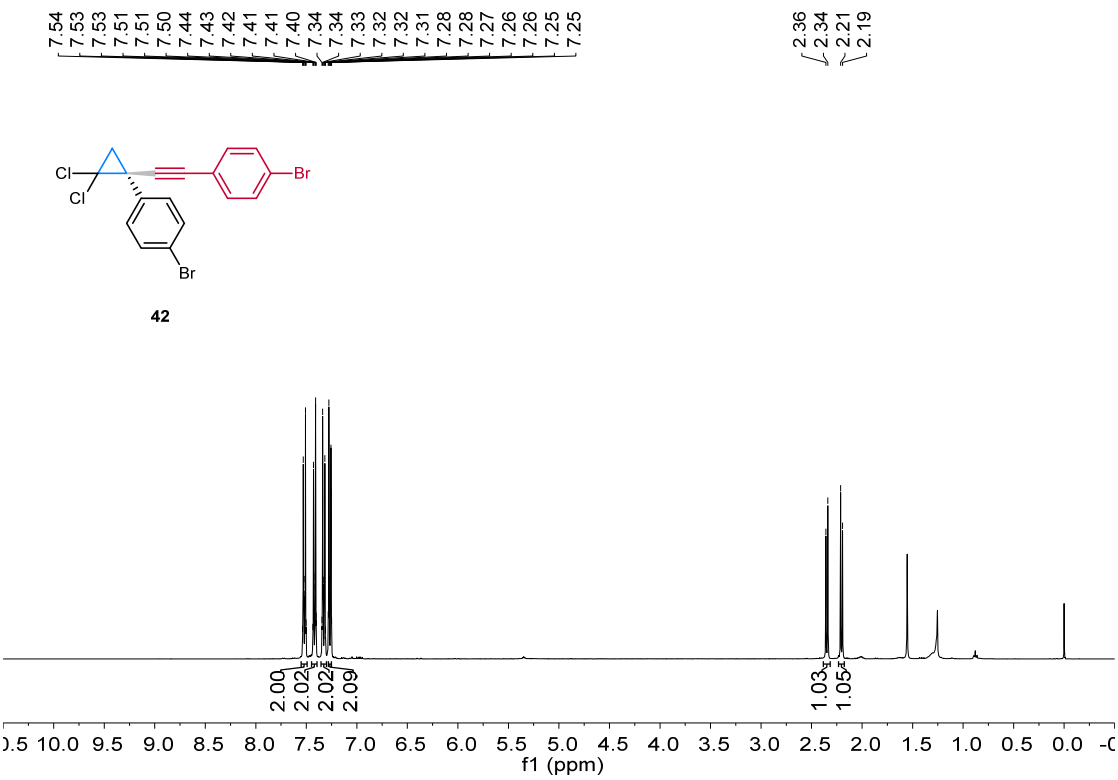
33.54
33.44
Cl
Cl
Br
OMe
41
f1 (ppm)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7.33
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7.32
7.31
7.28
7.28
7.27
7.26
7.26
7.25
7.25
2.36
2.34
2.21
2.19
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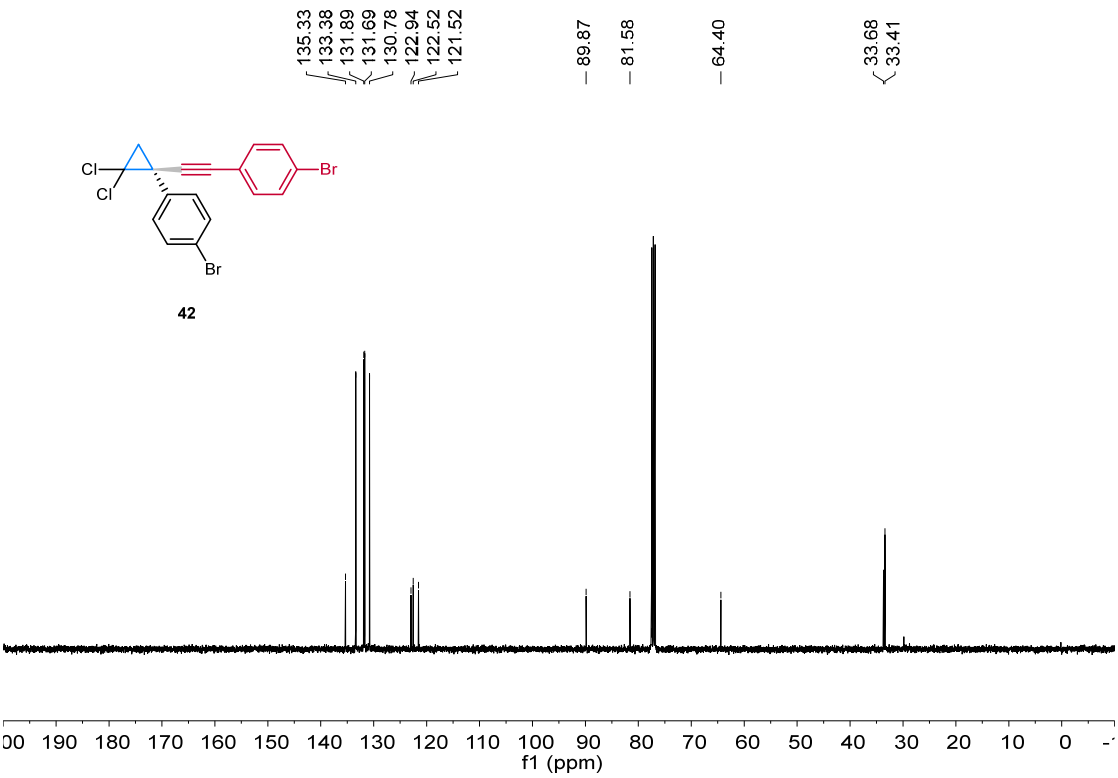
Cl
Br
Br
42
2.00
2.02
2.02
2.09
1.03
1.05
f1 (ppm)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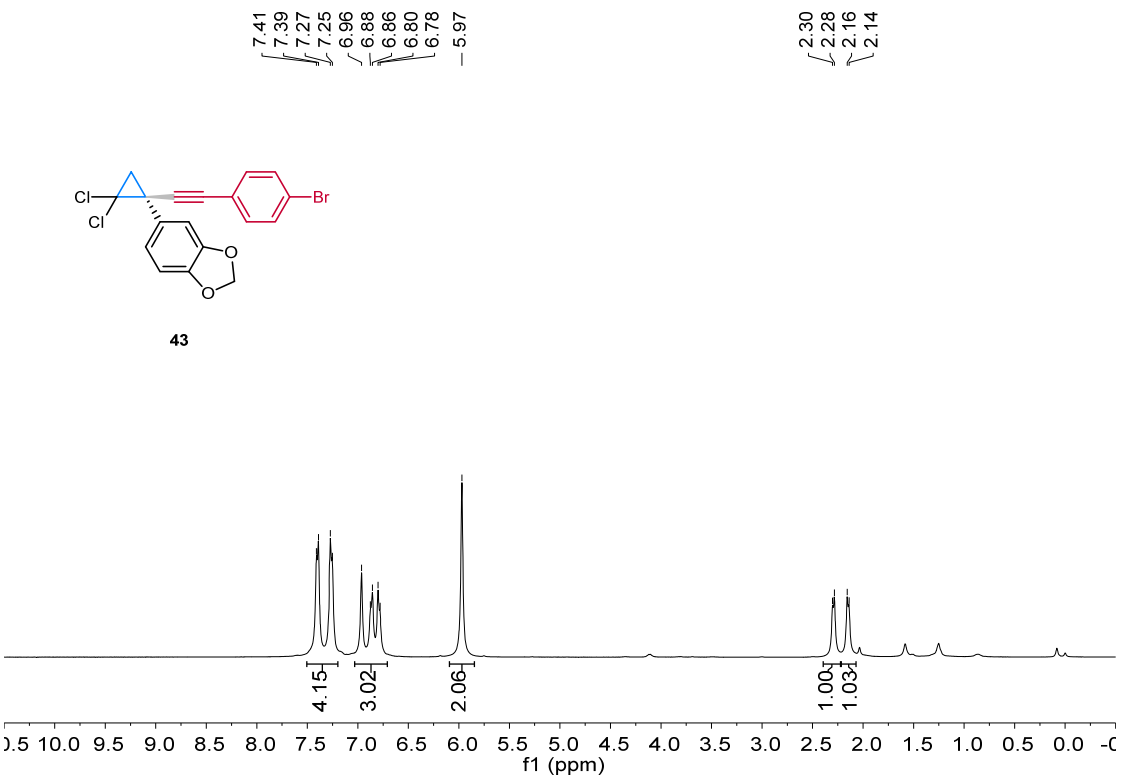
81.58
64.40
33.68
33.41
Cl
Cl
Br
Br
42
f1 (ppm)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6.86
6.80
6.78
5.97
2.30
2.28
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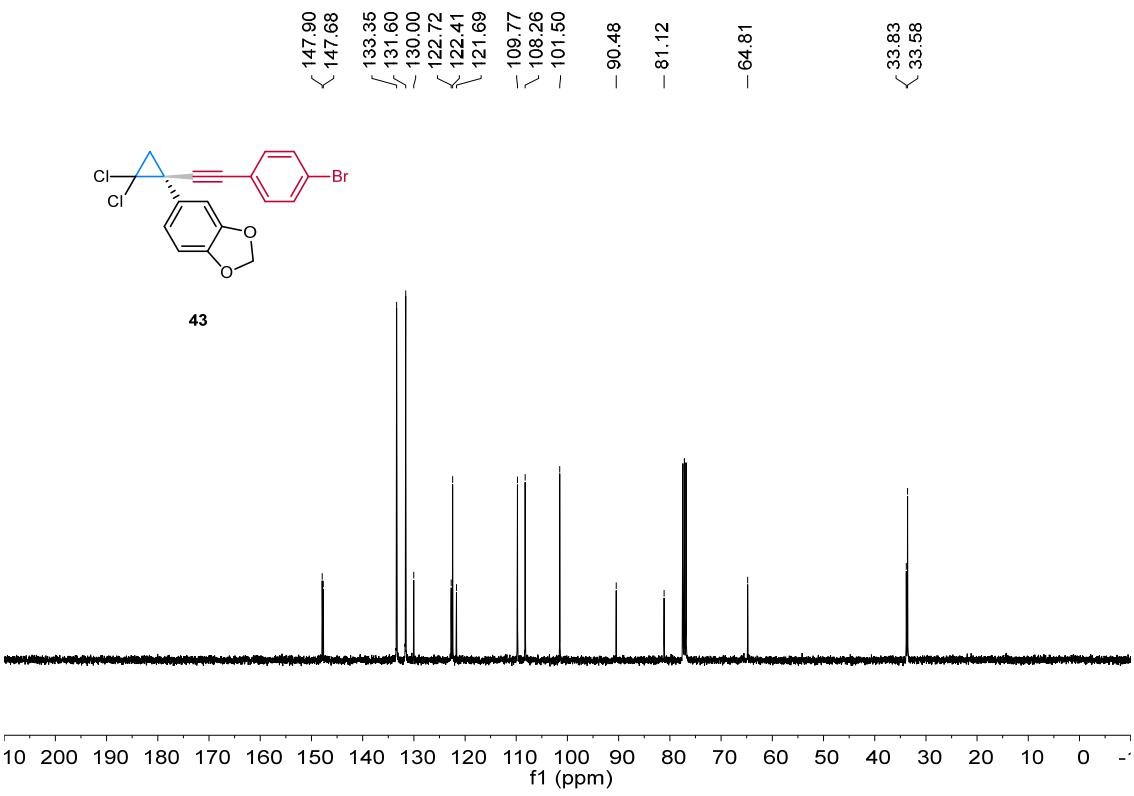
2.14
Cl
Cl
Br
O
O
43
4.15
3.02
2.06
1.00
1.03
f1 (ppm)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147.68
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121.69
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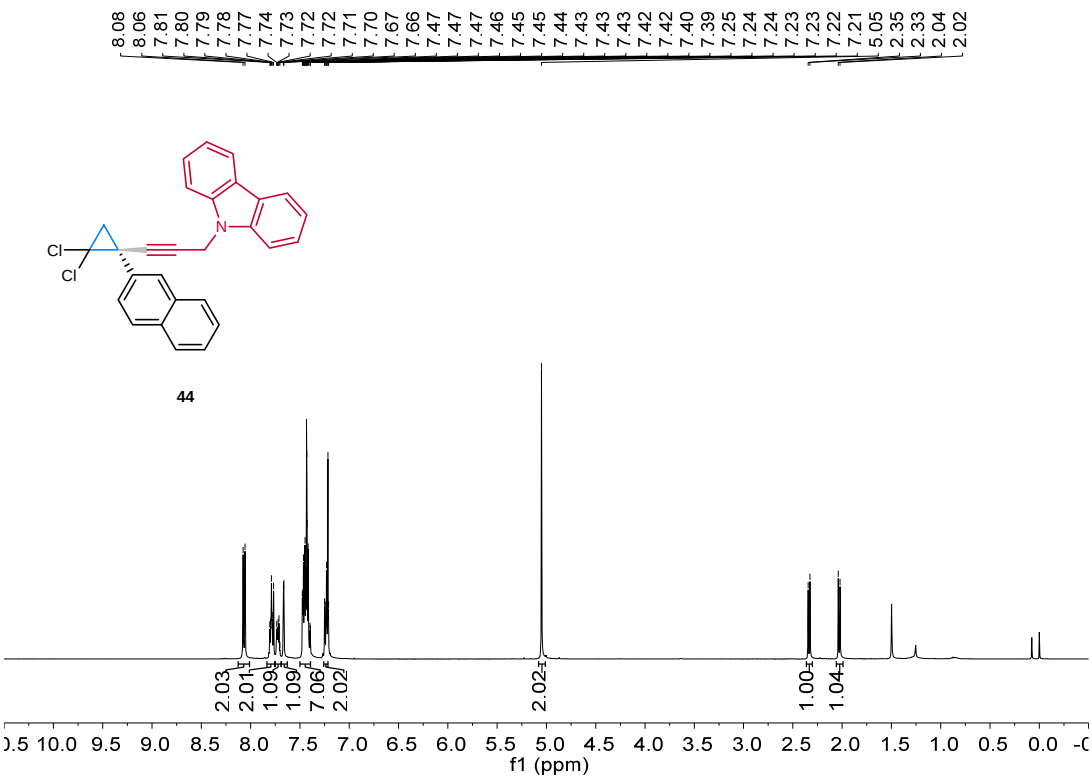
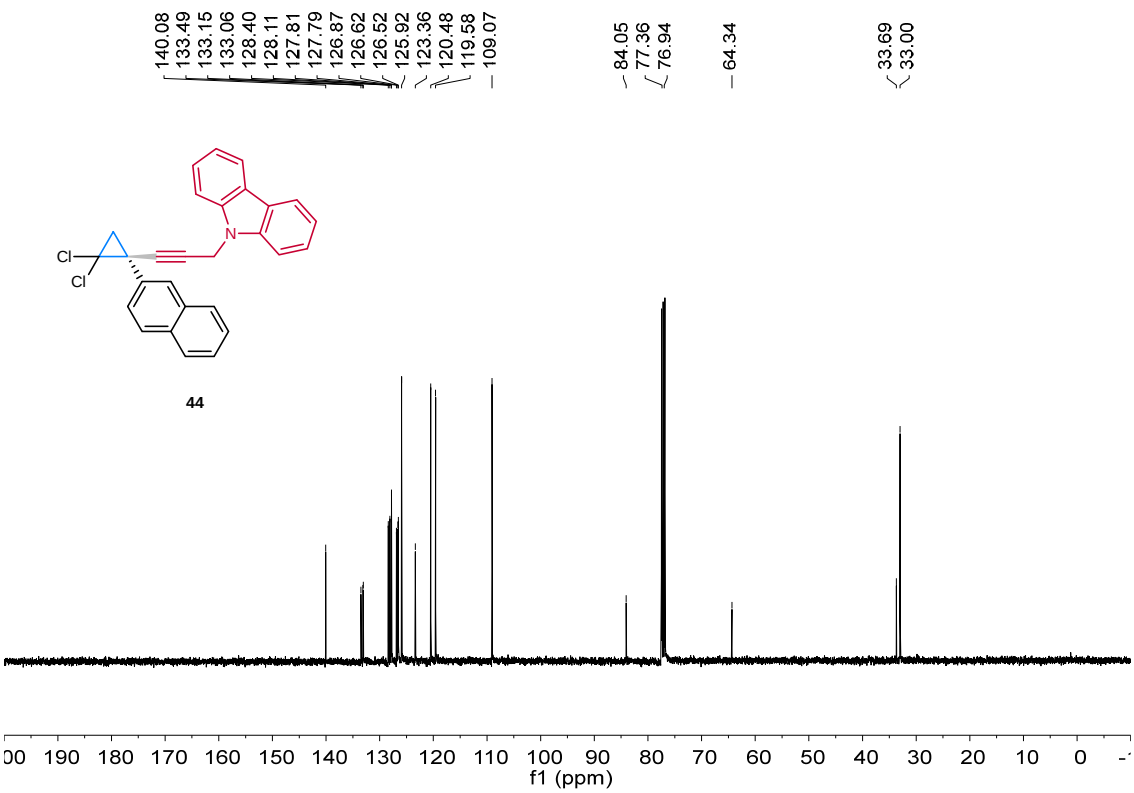
33.58
Cl
Cl
Br
O
O
43
f1 (ppm)


8.08 8.06 7.81 7.80 7.79 7.78 7.77 7.74 7.73 7.72 7.72 7.71 7.70 7.67 7.66 7.47 7.47 7.47 7.46 7.45 7.45 7.44 7.43 7.43 7.42 7.42 7.40 7.39 7.25 7.24 7.24 7.23 7.23 7.22 7.21 5.05 2.35 2.33 2.04 2.02
Cl
Cl
N
44
2.03 2.01 1.09 1.09 7.06 2.02 2.02 1.00 1.04
f1 (ppm)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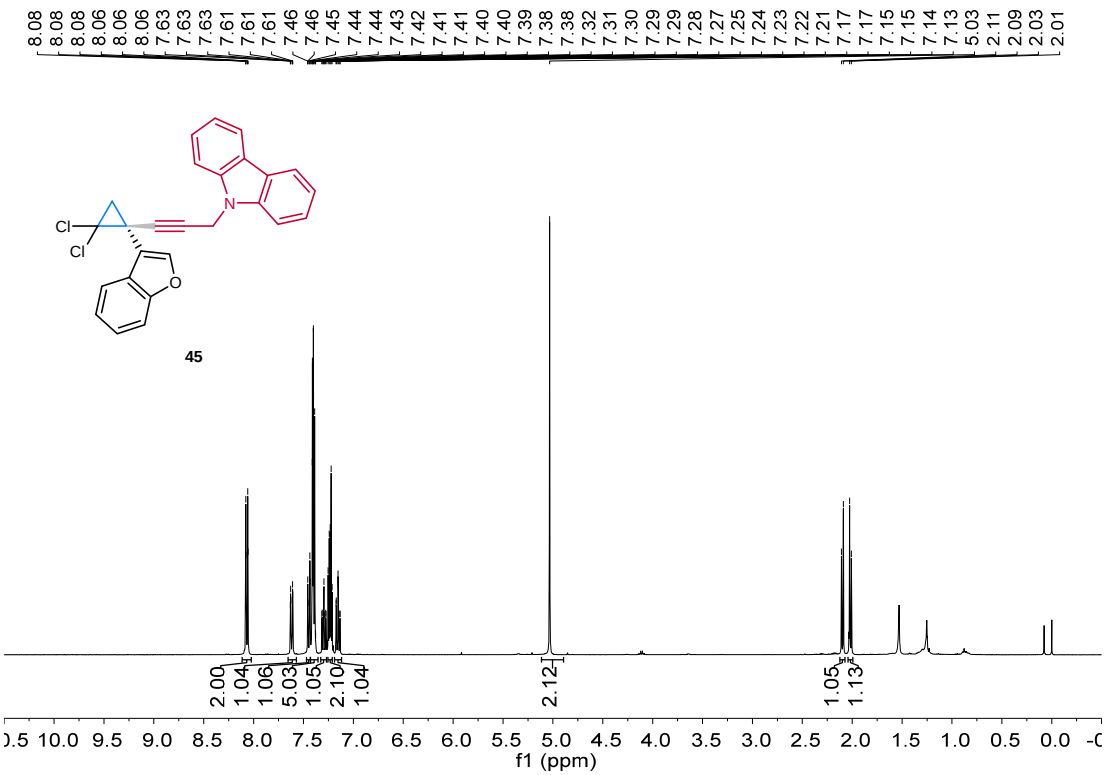
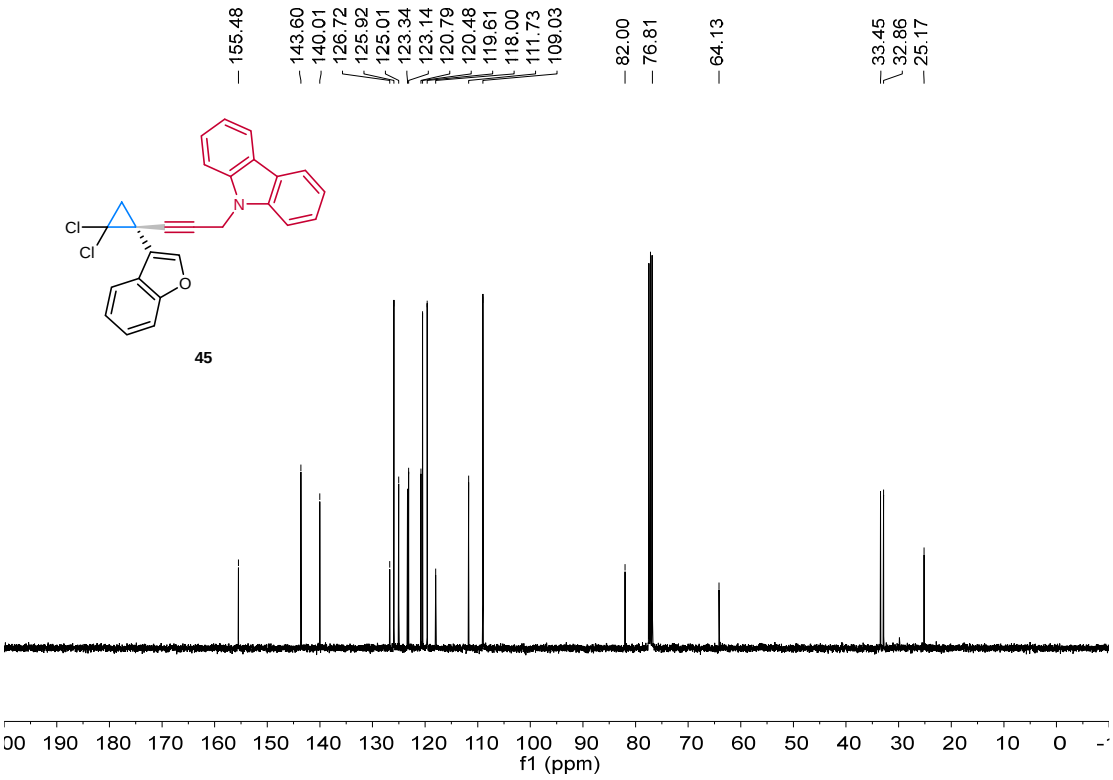
84.05 77.36 76.94
64.34
33.69 33.00
Cl
Cl
N
44
f1 (ppm)


8.08 8.08 8.08 8.06 8.06 8.06 7.63 7.63 7.63 7.61 7.61 7.61 7.46 7.46 7.45 7.44 7.44 7.43 7.42 7.41 7.41 7.40 7.40 7.39 7.38 7.38 7.32 7.31 7.30 7.29 7.29 7.28 7.27 7.25 7.24 7.23 7.22 7.21 7.17 7.17 7.15 7.15 7.14 7.13 5.03 2.11 2.09 2.03 2.01
Cl
Cl
N
O
45
2.00 1.04 1.06 5.03 1.05 2.10 1.04 2.12 1.05 1.13
f1 (ppm)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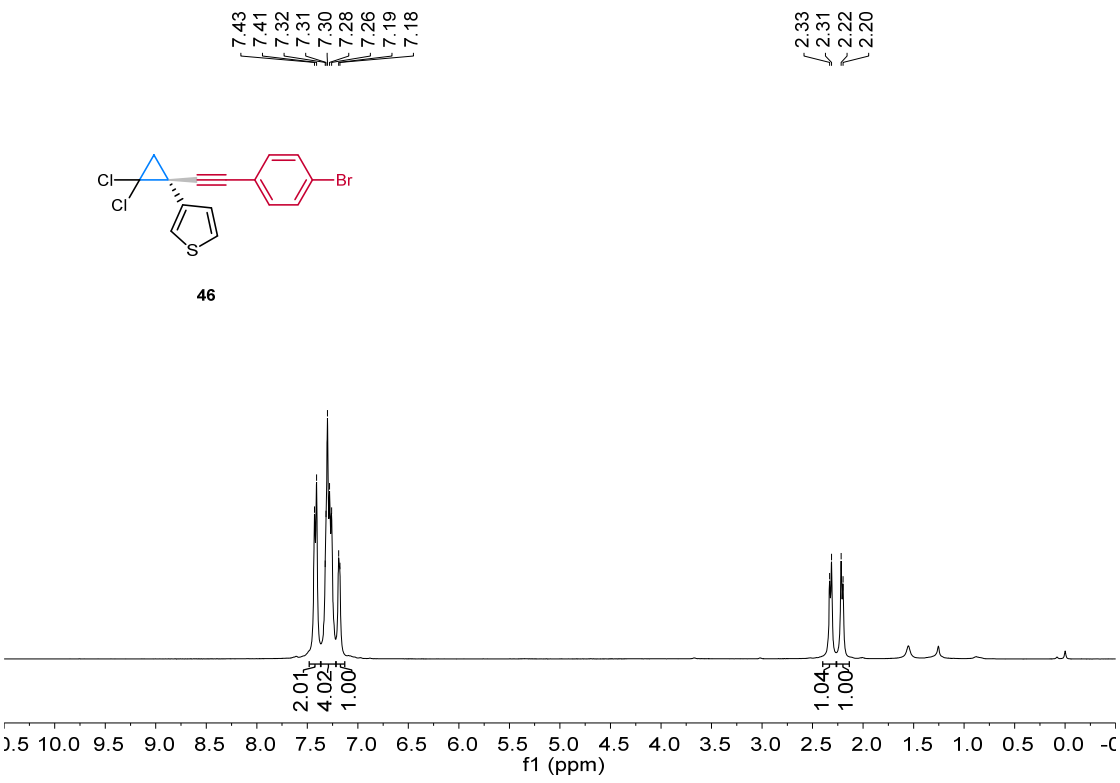
Cl
Cl
N
O
45
f1 (ppm)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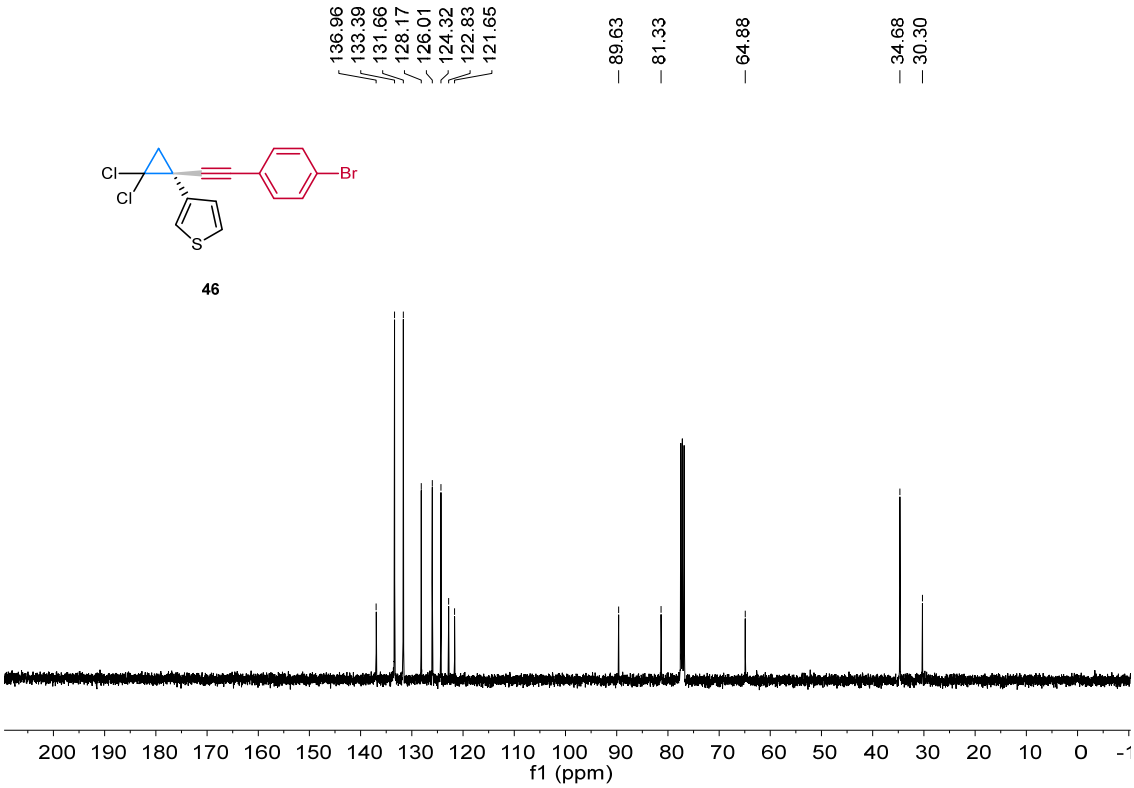
7.32
7.31
7.30
7.28
7.26
7.19
7.18
2.33
2.31
2.22
2.20
Cl
Cl
Br
S
46
2.01
4.02
1.00
1.04
1.00
f1 (ppm)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133.39
131.66
128.17
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121.65
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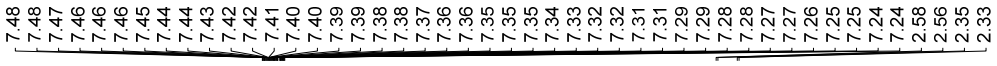
81.33
64.88
34.68
30.30
Cl
Cl
Br
S
46
f1 (ppm)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7.42
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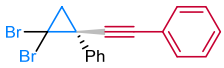
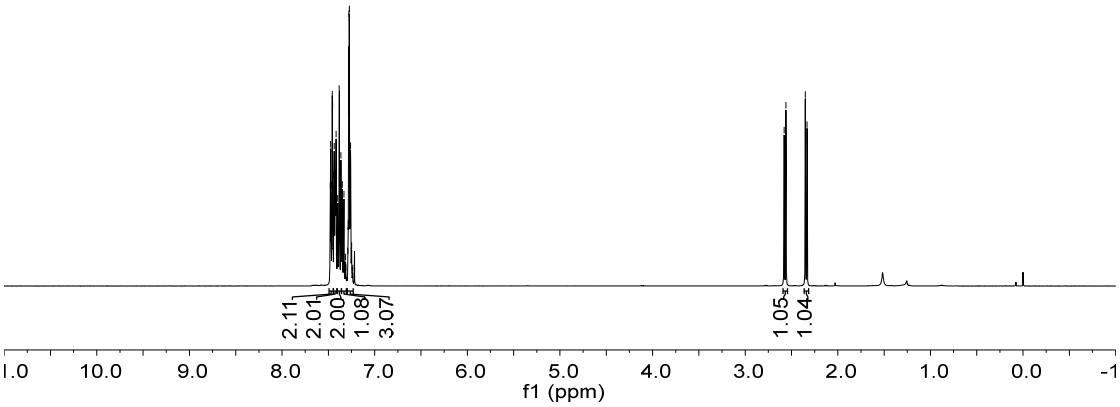
2.56
2.35
2.33


Br
Br
Ph

**47**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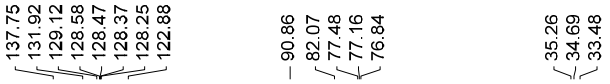
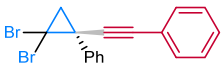
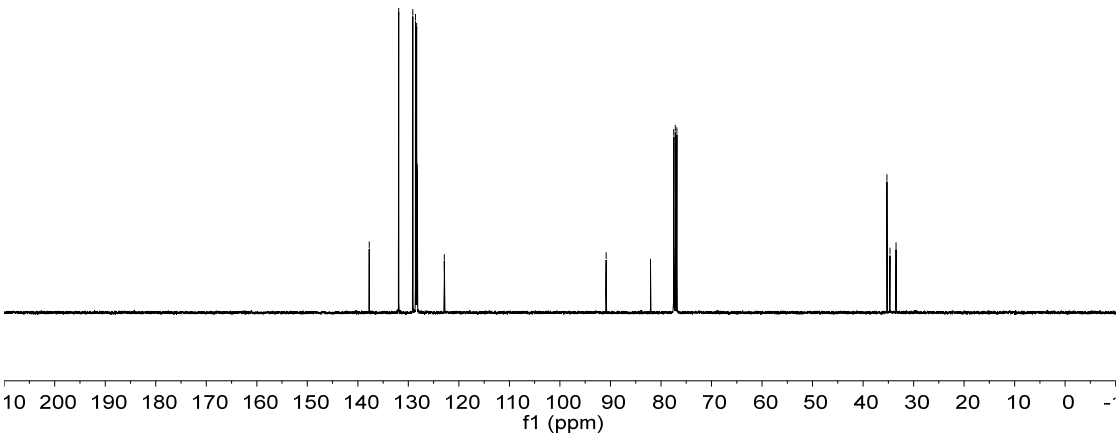
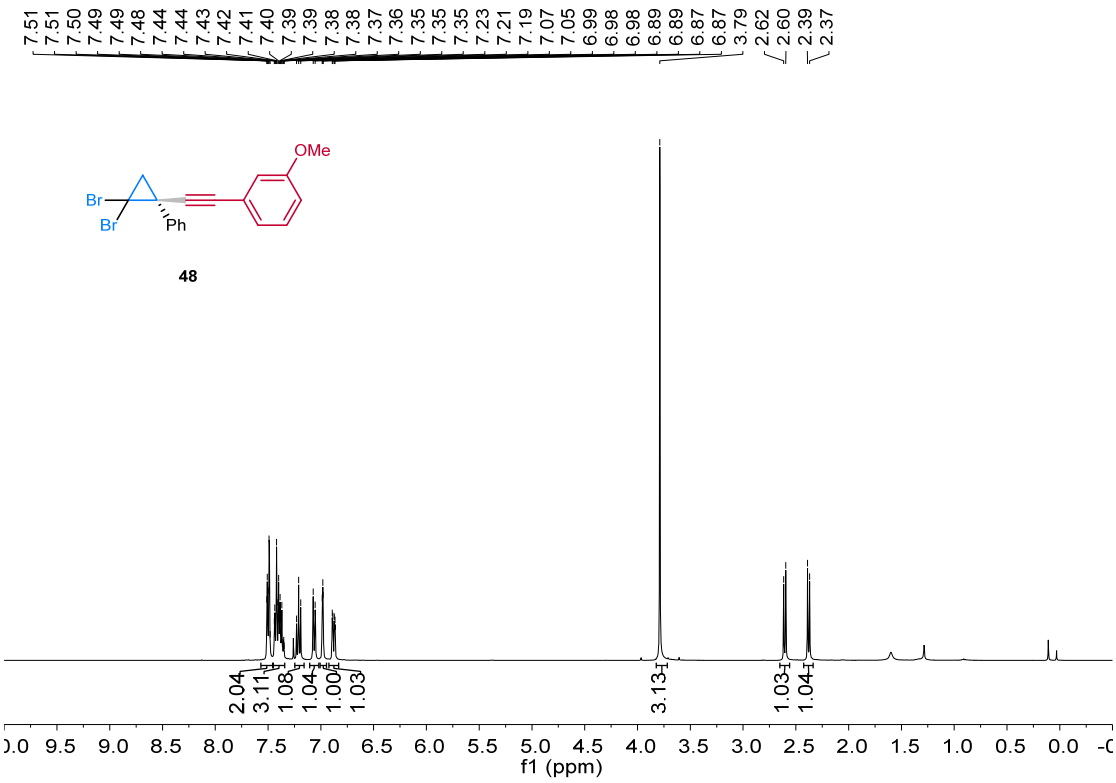
2.01
2.00
1.08
3.07
1.05
1.04
1.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)


137.75
131.92
129.12
128.58
128.47
128.37
128.25
122.88
90.86
82.07
77.48
77.16
76.84
35.26
34.69
33.48


Br
Br
Ph

**47**


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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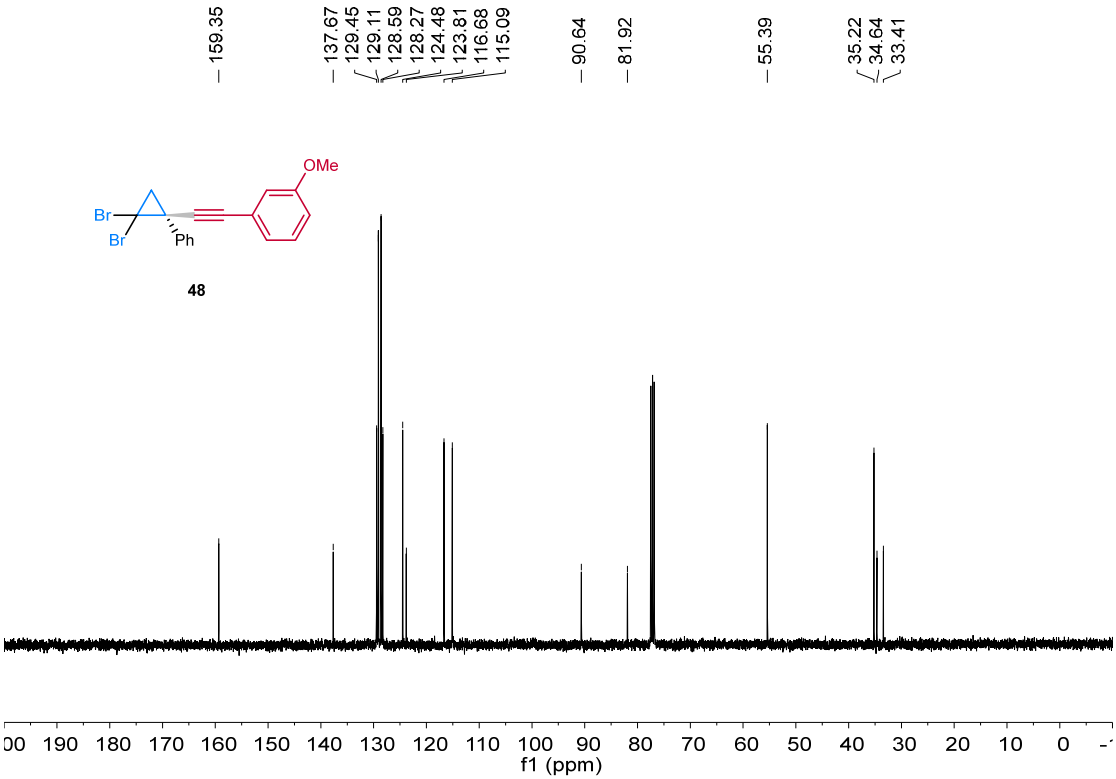
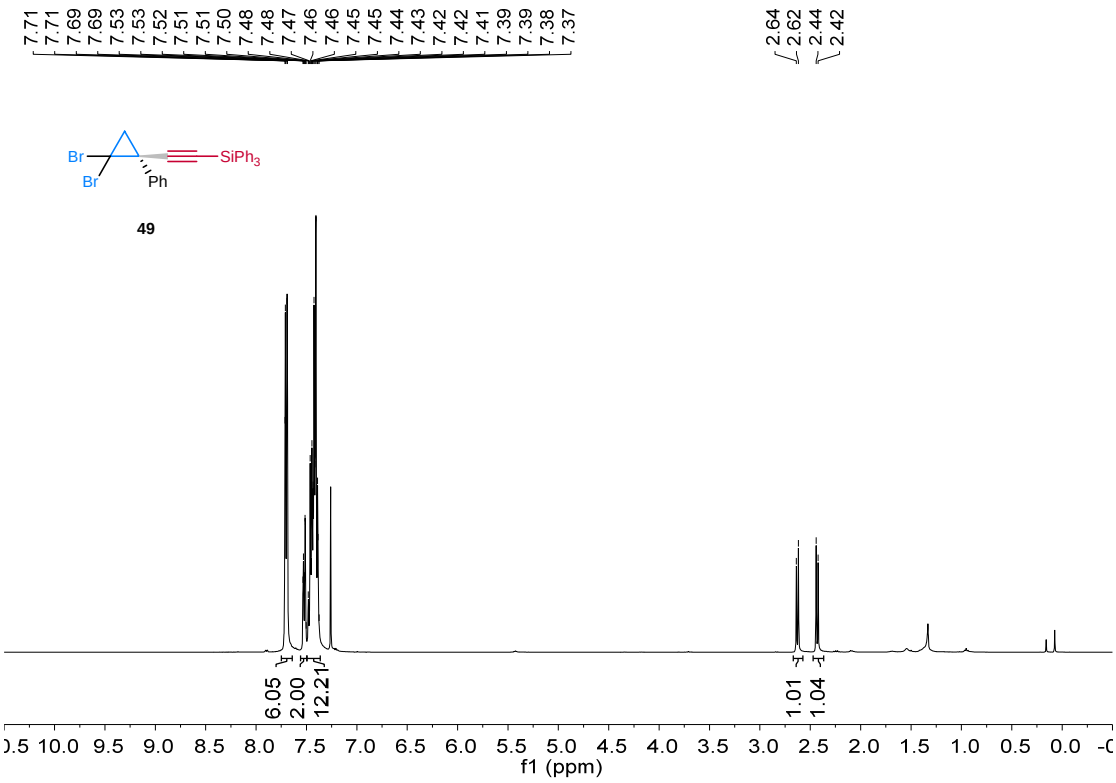
7.48
7.44
7.44
7.43
7.42
7.41
7.40
7.39
7.39
7.38
7.38
7.37
7.36
7.35
7.35
7.23
7.21
7.19
7.07
7.05
6.99
6.98
6.98
6.89
6.89
6.87
6.87
3.79
2.62
2.60
2.39
2.37
OMe
Br
Br
Ph
48
2.04
3.11
1.08
1.04
1.00
1.03
3.13
1.03
1.04
f1 (ppm)


159.35
137.67
129.45
129.11
128.59
128.27
124.48
123.81
116.68
115.09
90.64
81.92
55.39
35.22
34.64
33.41
OMe
Br
Br
Ph
48
f1 (ppm)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7.71
7.69
7.69
7.53
7.53
7.52
7.51
7.51
7.50
7.48
7.48
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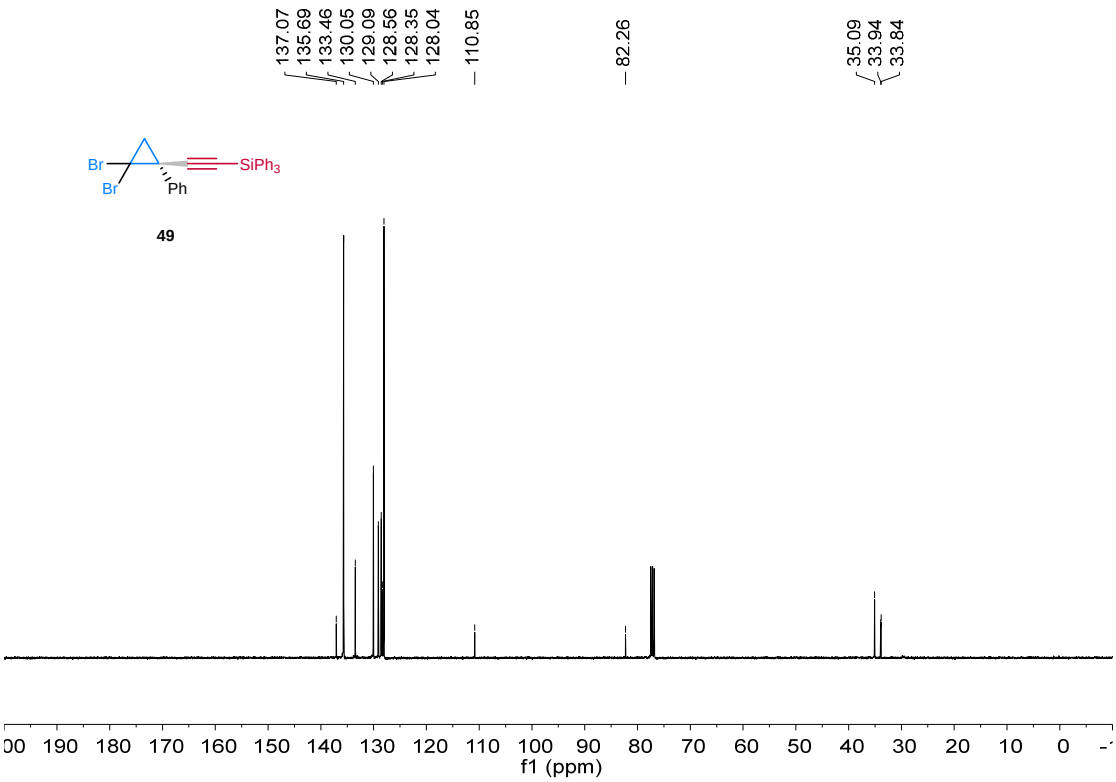
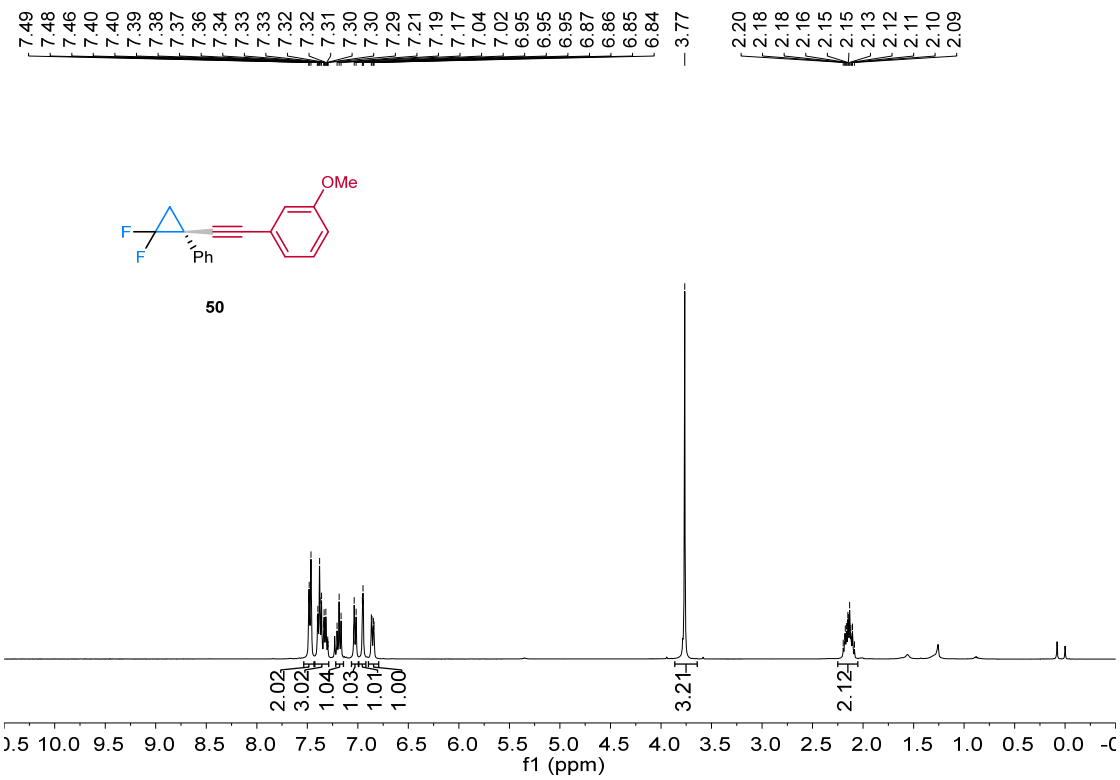
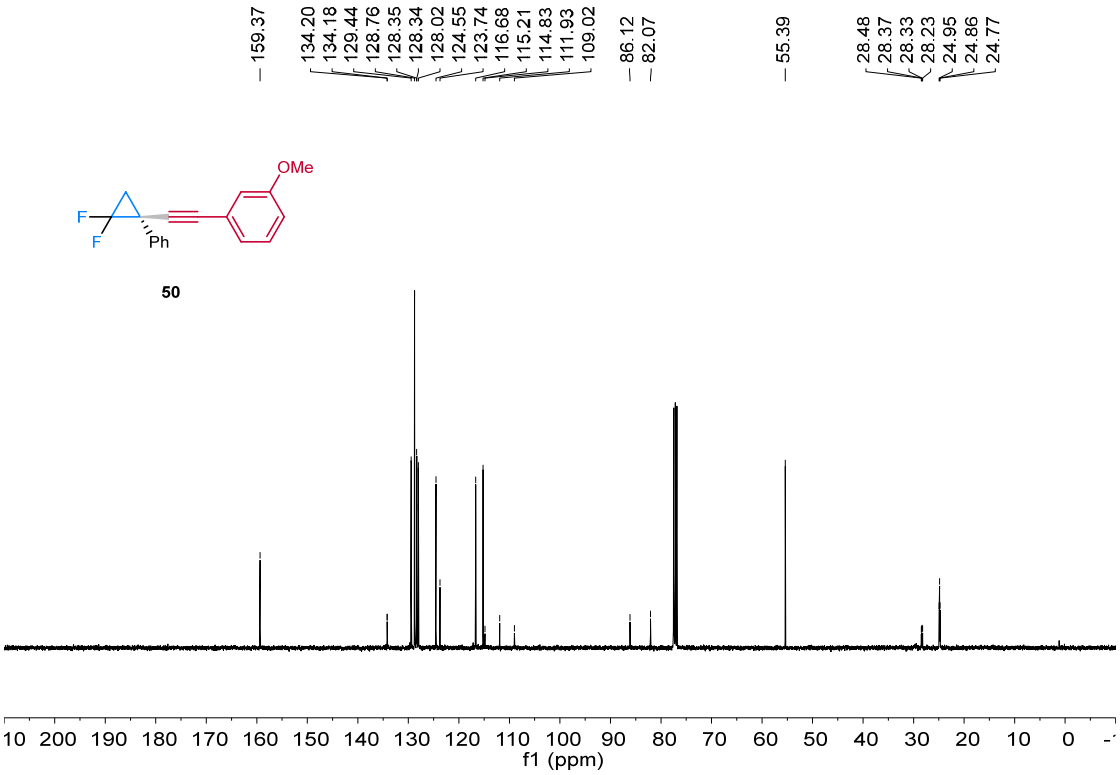
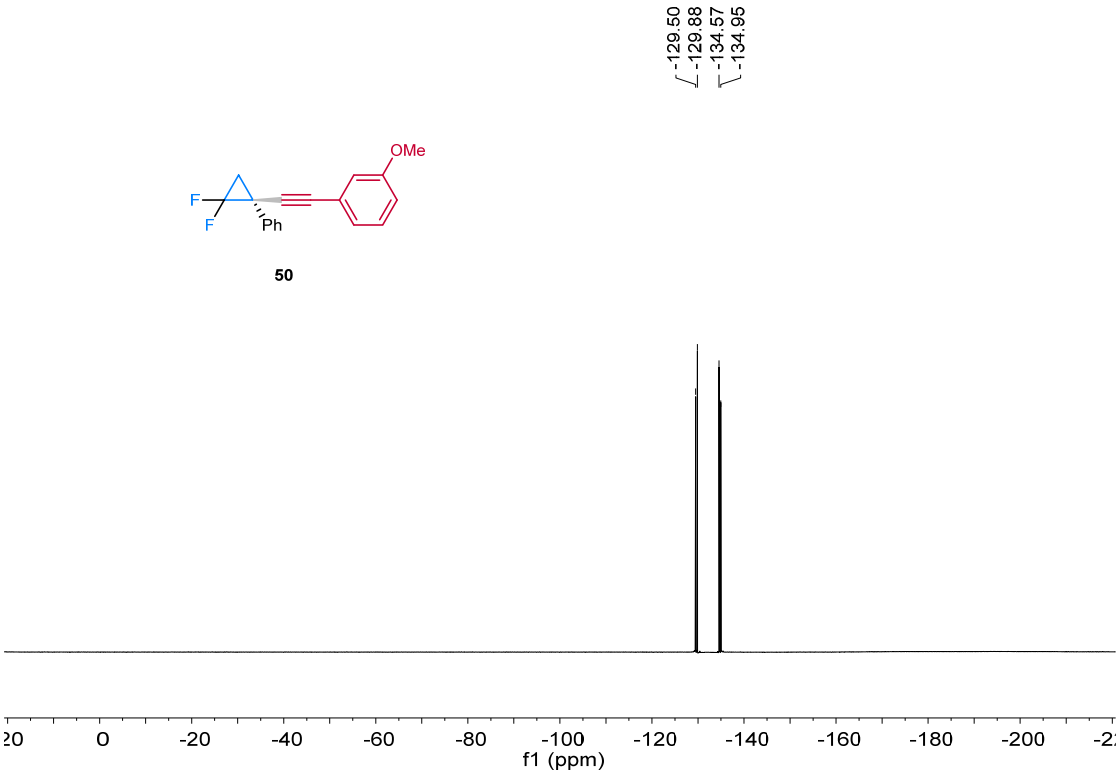
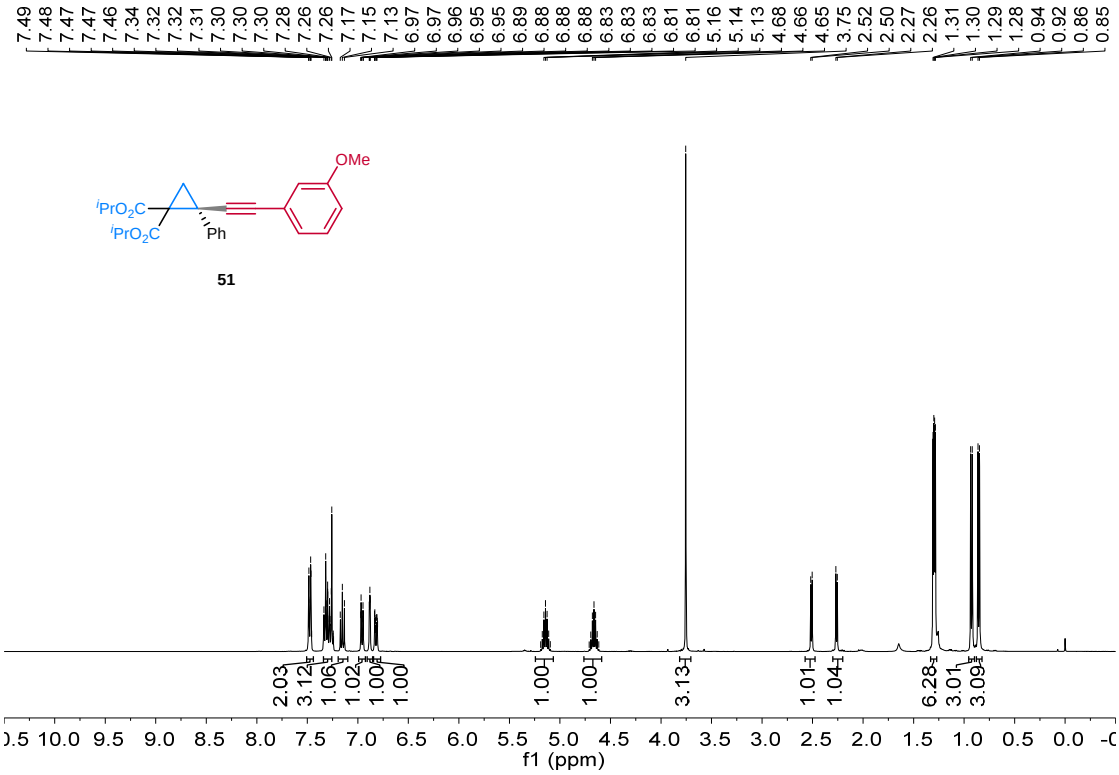
7.46
7.46
7.45
7.45
7.44
7.43
7.42
7.42
7.41
7.39
7.38
7.37
2.64
2.62
2.44
2.42
Br
Br
Ph
SiPh3
49
6.05
2.00
12.21
1.01
1.04
f1 (ppm)

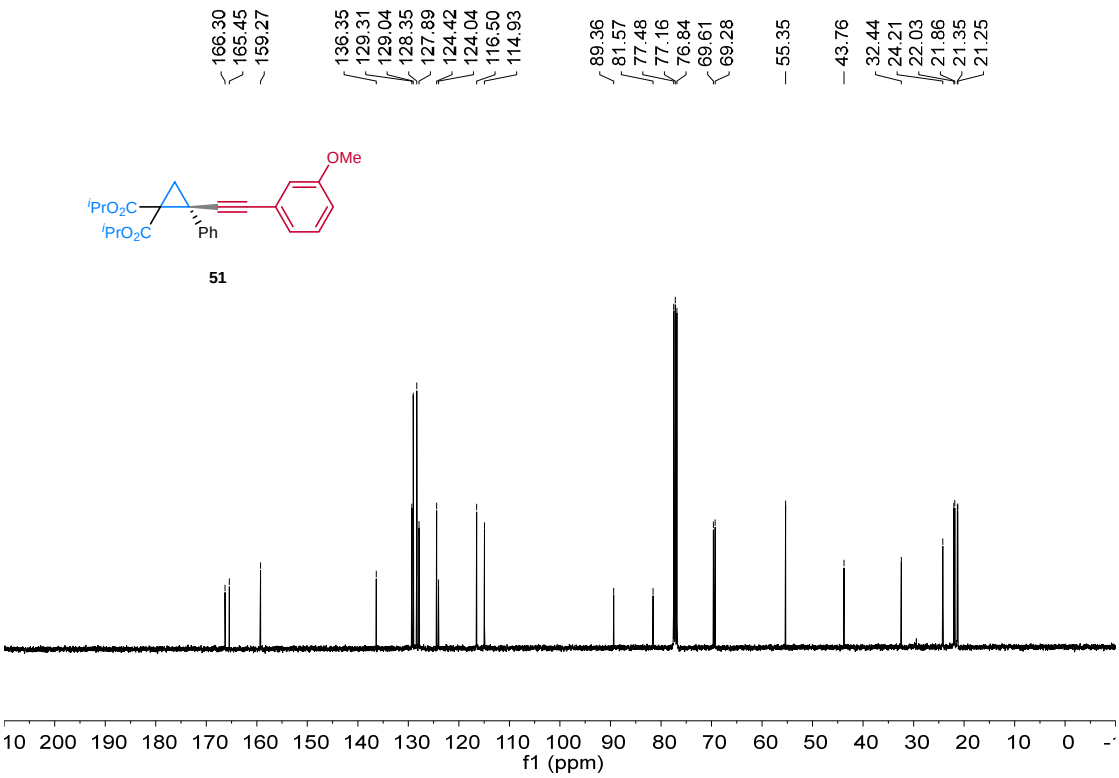

137.07
135.69
133.46
130.05
129.09
128.56
128.35
128.04
110.85
82.26
35.09
33.94
33.84
Br
Br
Ph
SiPh3
49
f1 (ppm)

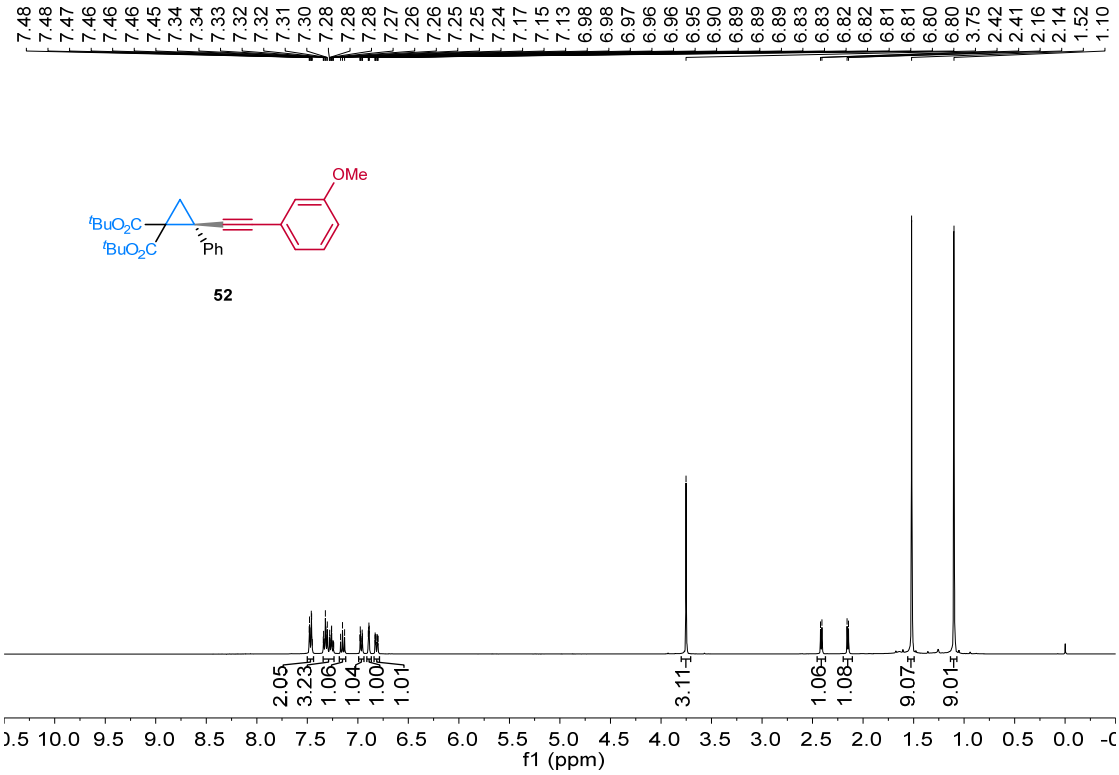

7.49 7.48 7.46 7.40 7.40 7.39 7.38 7.37 7.36 7.34 7.33 7.33 7.32 7.32 7.31 7.30 7.30 7.29 7.21 7.19 7.17 7.04 7.02 6.95 6.95 6.87 6.86 6.85 6.84 3.77
2.20 2.18 2.18 2.16 2.15 2.15 2.13 2.12 2.11 2.10 2.09
OMe
F
F
Ph
50
2.02 3.02 1.04 1.03 1.01 1.00 3.21 2.12
f1 (ppm)

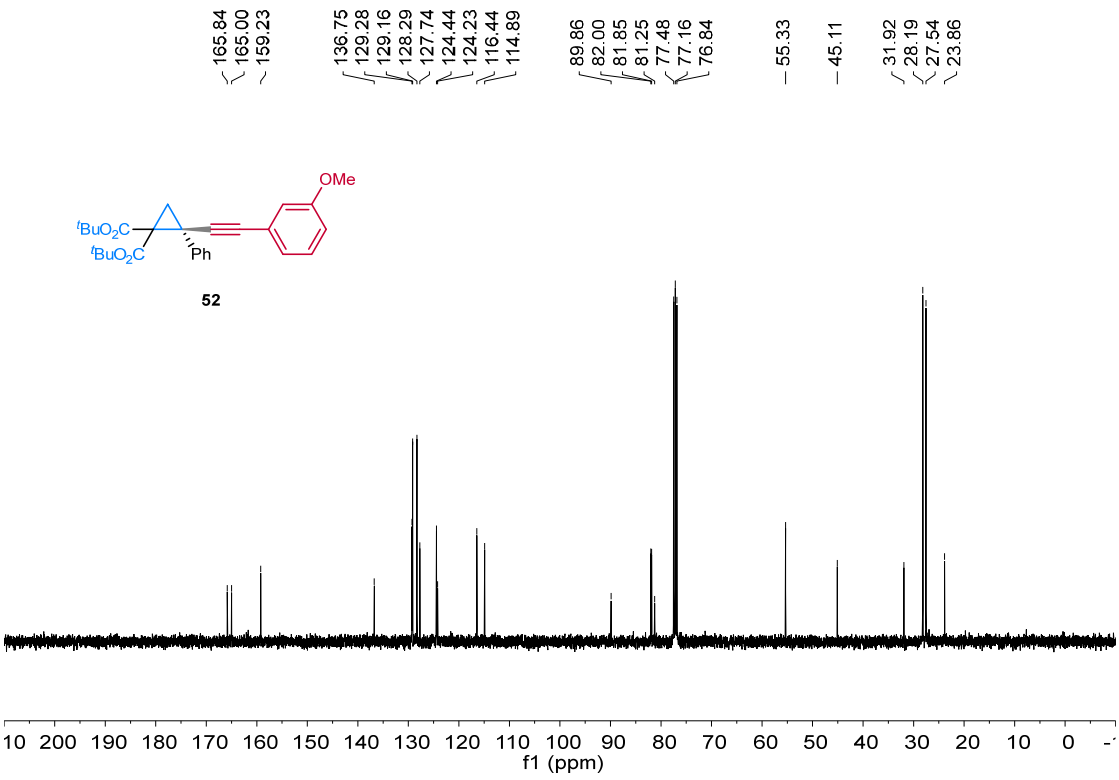

159.37
134.20 134.18 129.44 128.76 128.35 128.34 128.02 124.55 123.74 116.68 115.21 114.83 111.93 109.02
86.12 82.07
55.39
28.48 28.37 28.33 28.23 24.95 24.86 24.77
OMe
F
F
Ph
50
f1 (ppm)

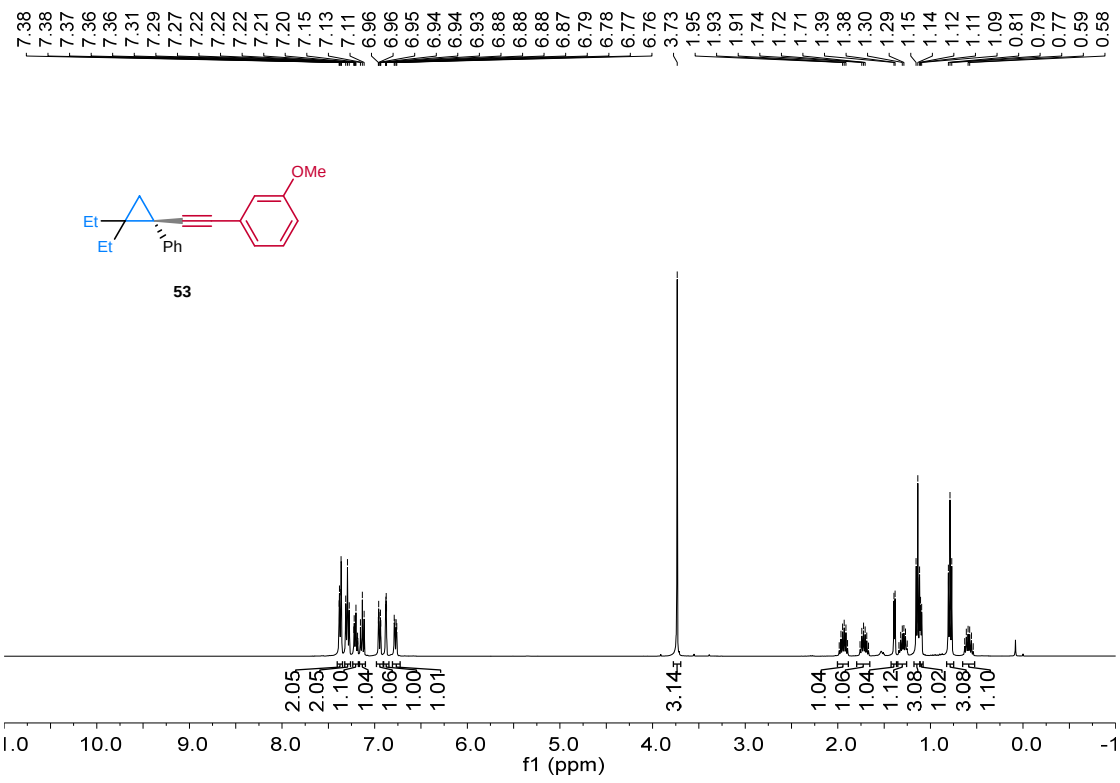

-129.50
-129.88
-134.57
-134.95
OMe
F
F
Ph
50
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
f1 (ppm)


7.49 7.48 7.47 7.47 7.46 7.34 7.32 7.32 7.31 7.30 7.30 7.30 7.28 7.26 7.26 7.17 7.15 7.13 6.97 6.97 6.96 6.95 6.89 6.88 6.88 6.88 6.83 6.83 6.81 6.81 5.16 5.14 5.13 4.68 4.66 4.65 3.75 2.52 2.50 2.27 2.26 1.31 1.30 1.29 1.28 0.94 0.92 0.86 0.85
OMe
iPrO2C
iPrO2C
Ph
51
2.03 3.12 1.06 1.02 1.00 1.00 1.00 1.00 3.13 1.01 1.04 6.28 3.01 3.09
f1 (ppm)


166.30 165.45 159.27 136.35 129.31 129.04 128.35 127.89 124.42 124.04 116.50 114.93 89.36 81.57 77.48 77.16 76.84 69.61 69.28 55.35 43.76 32.44 24.21 22.03 21.86 21.35 21.25
OMe
iPrO2C
iPrO2C
Ph
51
f1 (ppm)


7.48 7.48 7.47 7.46 7.46 7.46 7.45 7.34 7.34 7.33 7.32 7.32 7.31 7.30 7.28 7.28 7.28 7.27 7.26 7.26 7.25 7.25 7.24 7.17 7.15 7.13 6.98 6.98 6.97 6.96 6.96 6.95 6.90 6.89 6.89 6.89 6.83 6.83 6.82 6.82 6.81 6.81 6.80 6.80 3.75 2.42 2.41 2.16 2.14 1.52 1.10
OMe
tBuO2C
tBuO2C
Ph
52
2.05 3.23 1.06 1.04 1.00 1.01 3.11 1.06 1.08 9.07 9.01
f1 (ppm)


165.84 165.00 159.23 136.75 129.28 129.16 128.29 127.74 124.44 124.23 116.44 114.89 89.86 82.00 81.85 81.25 77.48 77.16 76.84 55.33 45.11 31.92 28.19 27.54 23.86
OMe
tBuO2C
tBuO2C
Ph
52
f1 (ppm)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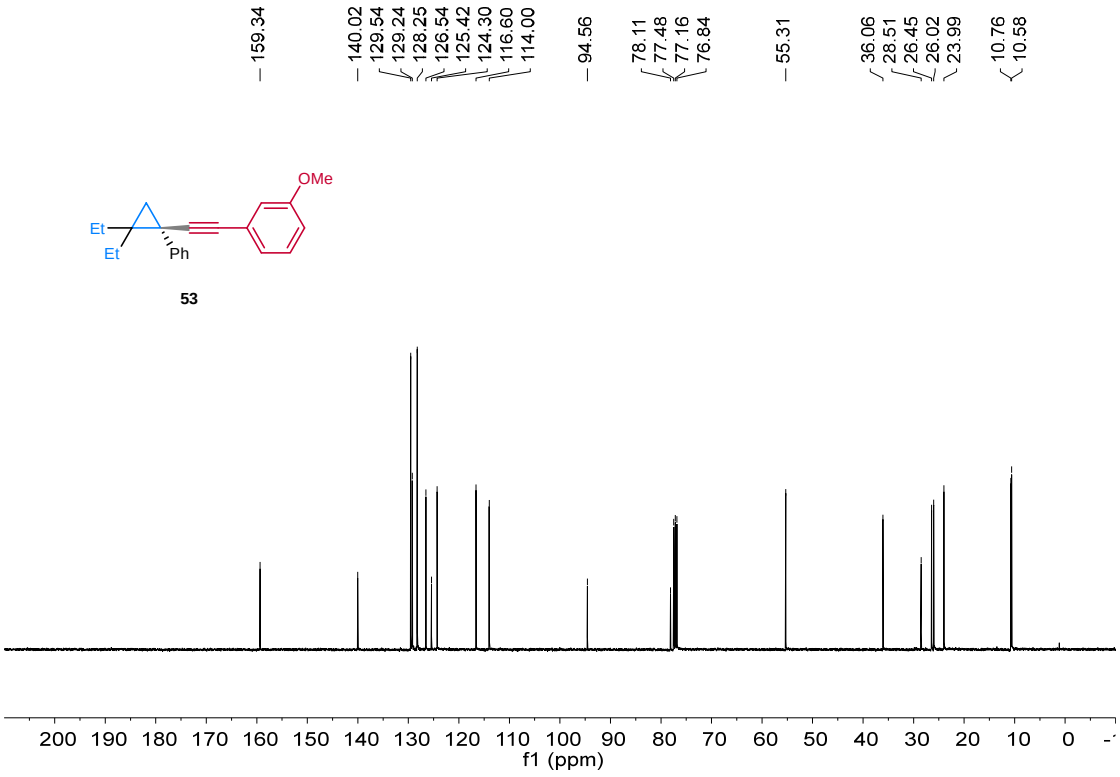
7.36
7.31
7.29
7.27
7.22
7.22
7.21
7.20
7.15
7.13
7.11
6.96
6.96
6.95
6.94
6.94
6.93
6.88
6.88
6.87
6.79
6.78
6.77
6.76
3.73
1.95
1.93
1.91
1.74
1.72
1.71
1.39
1.38
1.30
1.29
1.15
1.14
1.12
1.11
1.09
0.81
0.79
0.77
0.59
0.58
OMe
Et
Et
Ph
53
2.05
2.05
1.10
1.04
1.06
1.00
1.01
3.14
1.04
1.06
1.04
1.12
3.08
1.02
3.08
1.10
f1 (ppm)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128.25
126.54
125.42
124.30
116.60
114.00
94.56
78.11
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77.16
76.84
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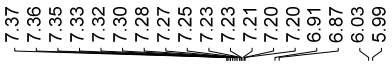
10.58
OMe
Et
Et
Ph
53
f1 (ppm)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7.36
7.35
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7.32
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7.23
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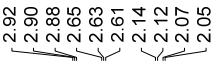
7.21
7.20
7.20
6.91
6.87
6.03
5.99


2.92
2.90
2.88
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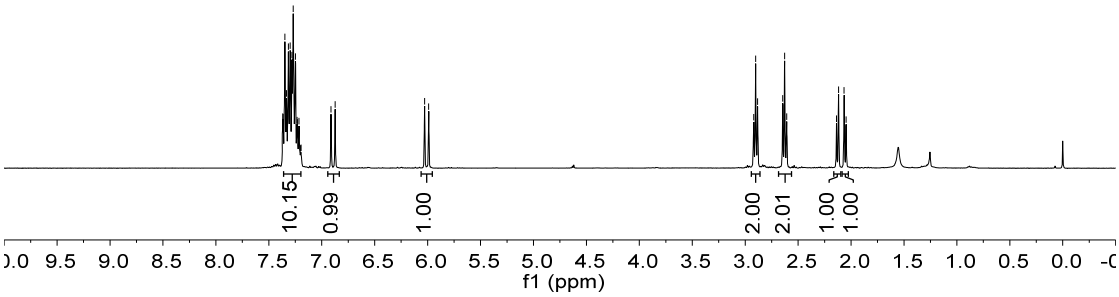
2.63
2.61
2.14
2.12
2.07
2.05


Br
Br
Ph
Ph

**56**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1.00
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1.00
1.00
f1 (ppm)


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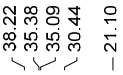
127.93
126.65
126.47


84.75
78.91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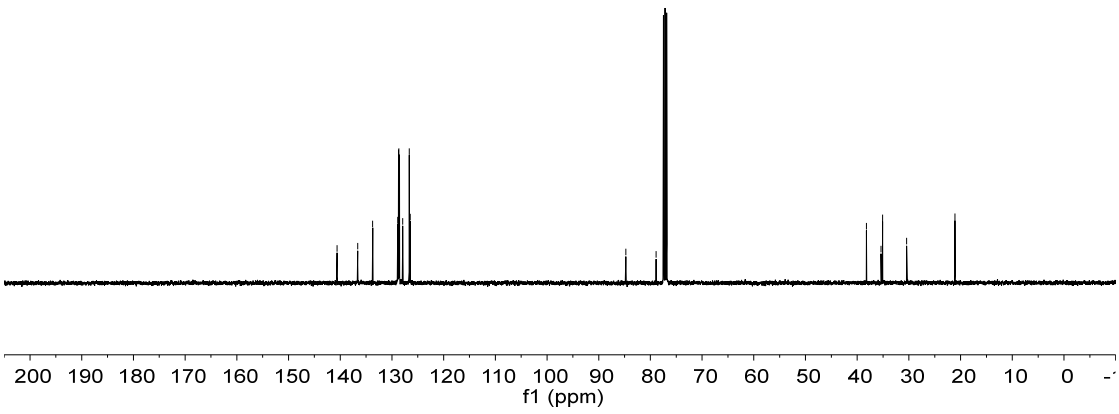
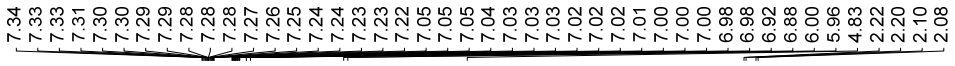
35.38
35.09
30.44
21.10


Br
Br
Ph
Ph

**56**


f1 (ppm)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7.28
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7.25
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7.23
7.23
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7.05
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7.04
7.03
7.03
7.03
7.02
7.02
7.02
7.01
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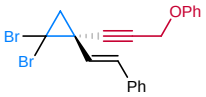
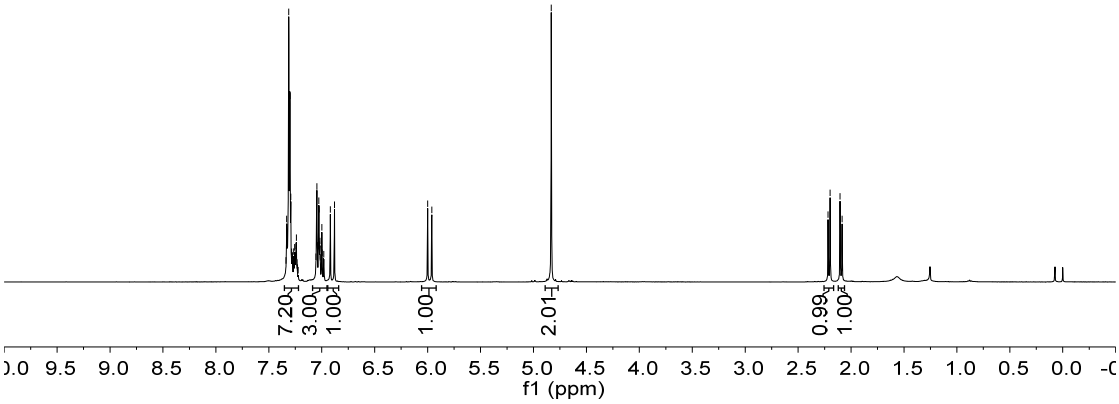
7.00
7.00
6.98
6.98
6.92
6.88
6.00
5.96
4.83
2.22
2.20
2.10
2.08


OPh
Br
Br
Ph

**57**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1.00
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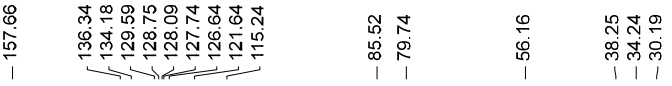
0.99
1.00
f1 (ppm)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129.59
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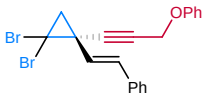
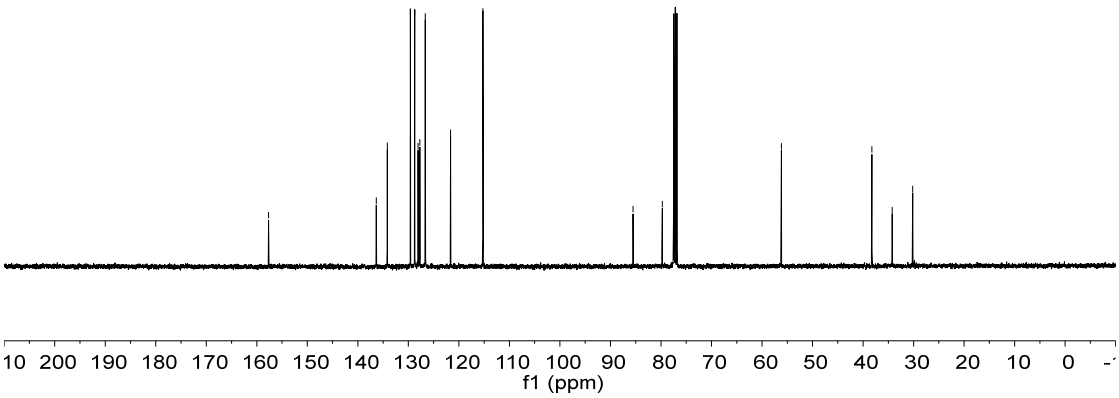
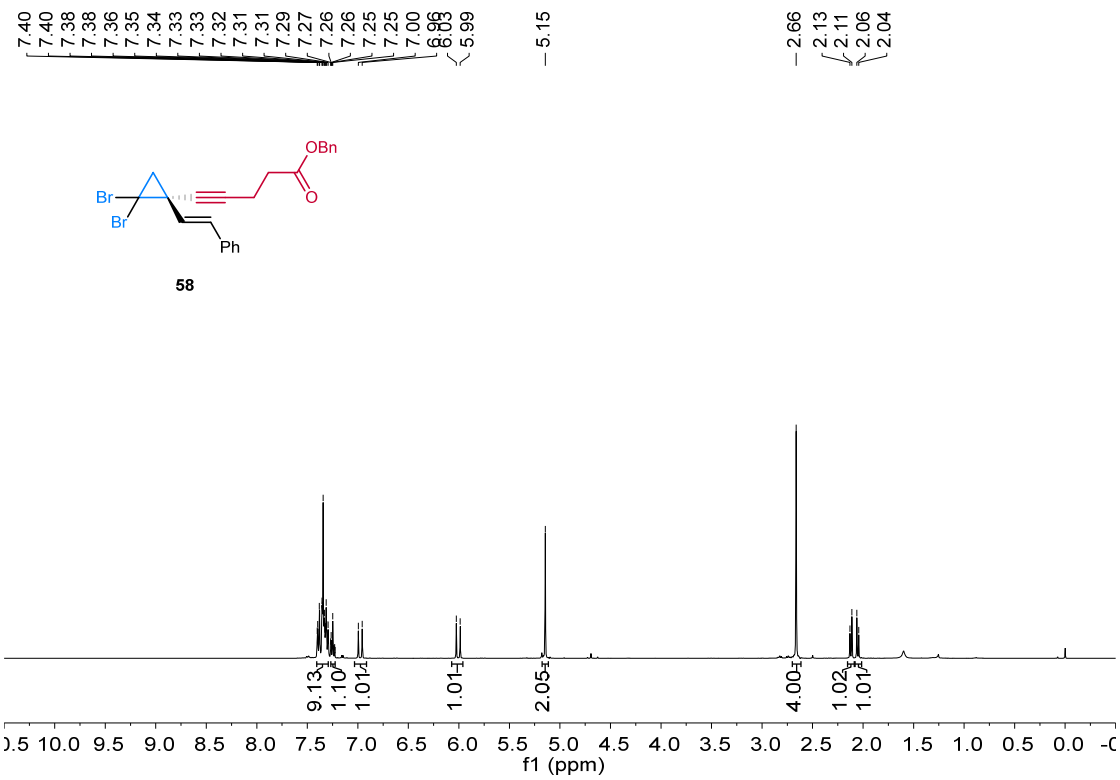
128.09
127.74
126.64
121.64
115.24
85.52
79.74
56.16
38.25
34.24
30.19


OPh
Br
Br
Ph

**57**


f1 (ppm)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7.32
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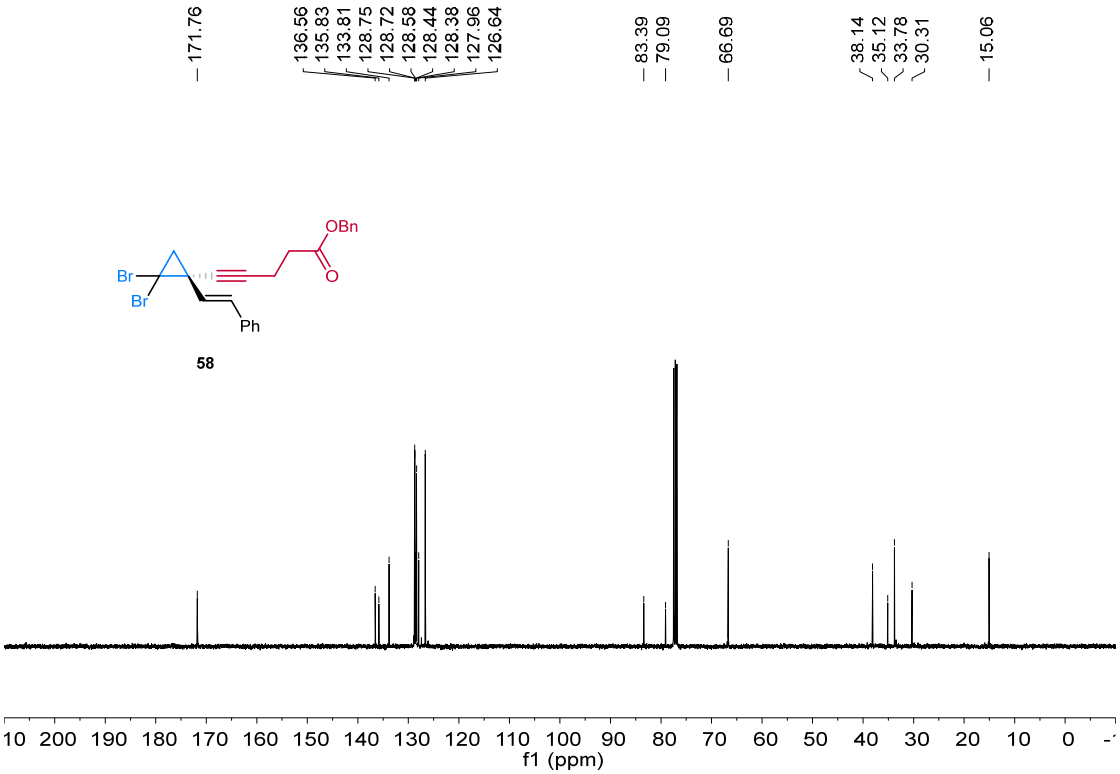
7.31
7.29
7.27
7.26
7.26
7.25
7.25
7.00
6.96
6.03
5.99
5.15
2.66
2.13
2.11
2.06
2.04
OBn
O
Br
Br
Ph
58
9.13
1.10
1.01
1.01
2.05
4.00
1.02
1.01
f1 (ppm)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133.81
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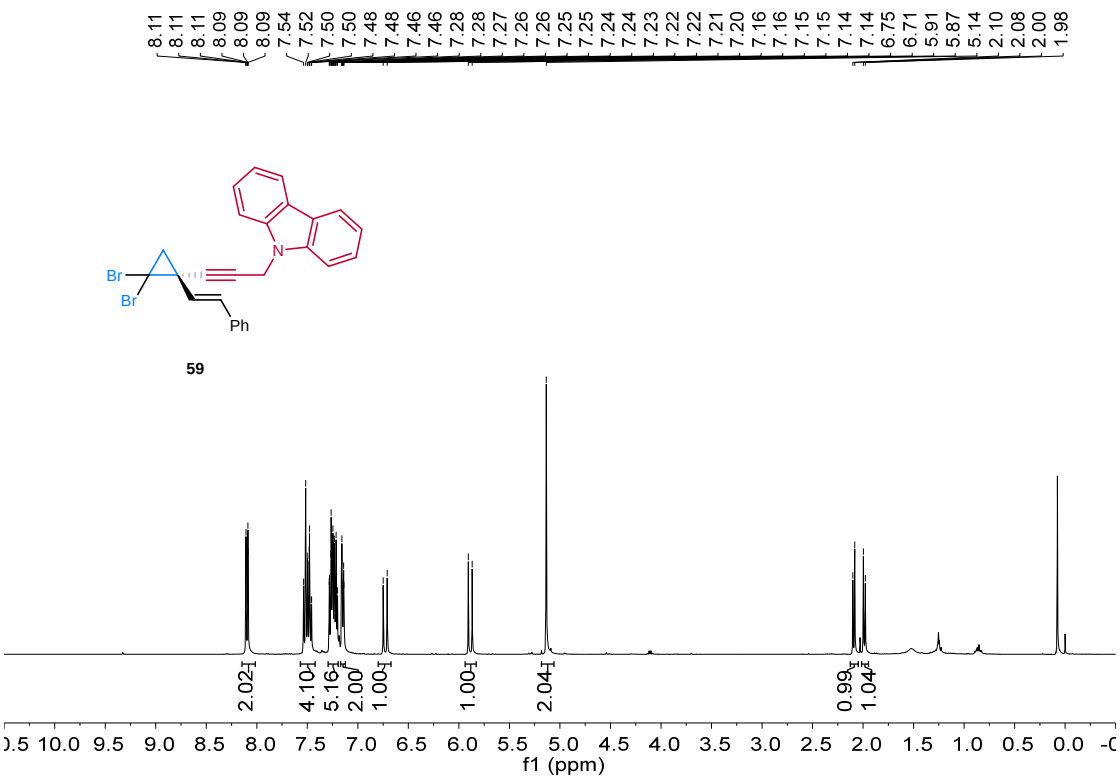
128.72
128.58
128.44
128.38
127.96
126.64
83.39
79.09
66.69
38.14
35.12
33.78
30.31
15.06
OBn
O
Br
Br
Ph
58
f1 (ppm)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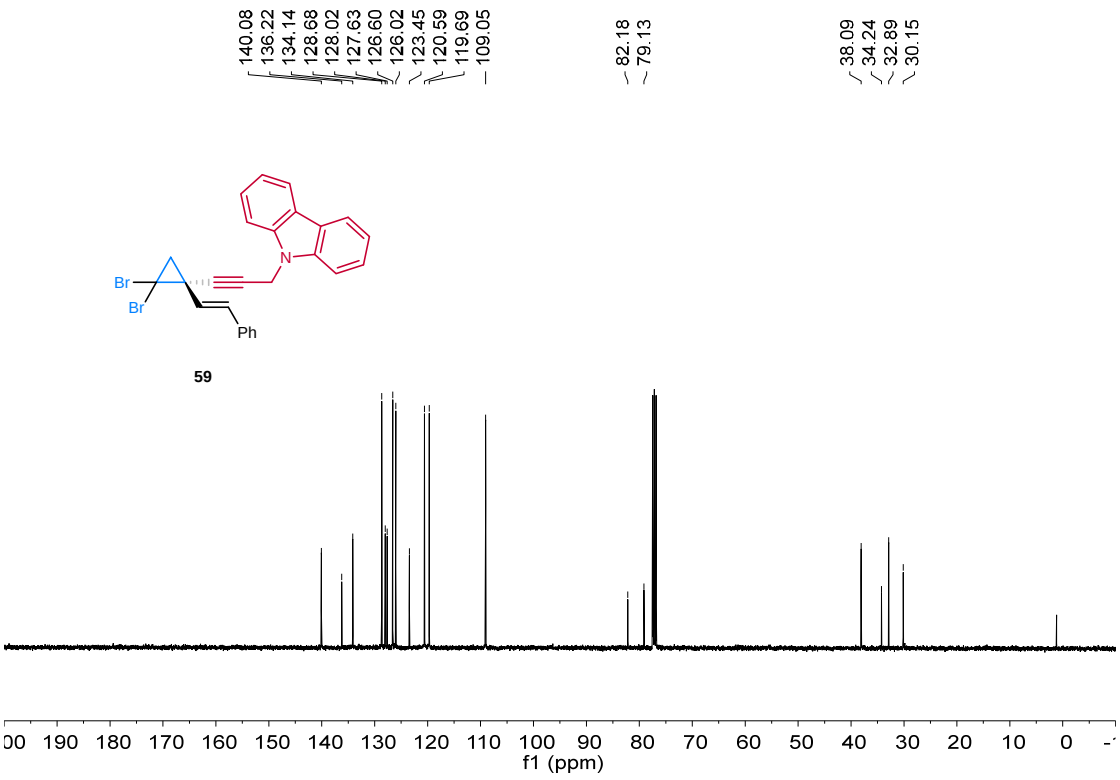
8.11
8.09
8.09
8.09
7.54
7.52
7.50
7.50
7.48
7.48
7.46
7.46
7.28
7.28
7.27
7.26
7.26
7.25
7.25
7.24
7.24
7.23
7.22
7.22
7.21
7.20
7.16
7.16
7.15
7.15
7.14
7.14
6.75
6.71
5.91
5.87
5.14
2.10
2.08
2.00
1.98
Br
Br
N
Ph
59
2.02
4.10
5.16
2.00
1.00
1.00
2.04
0.99
1.04
f1 (ppm)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136.22
134.14
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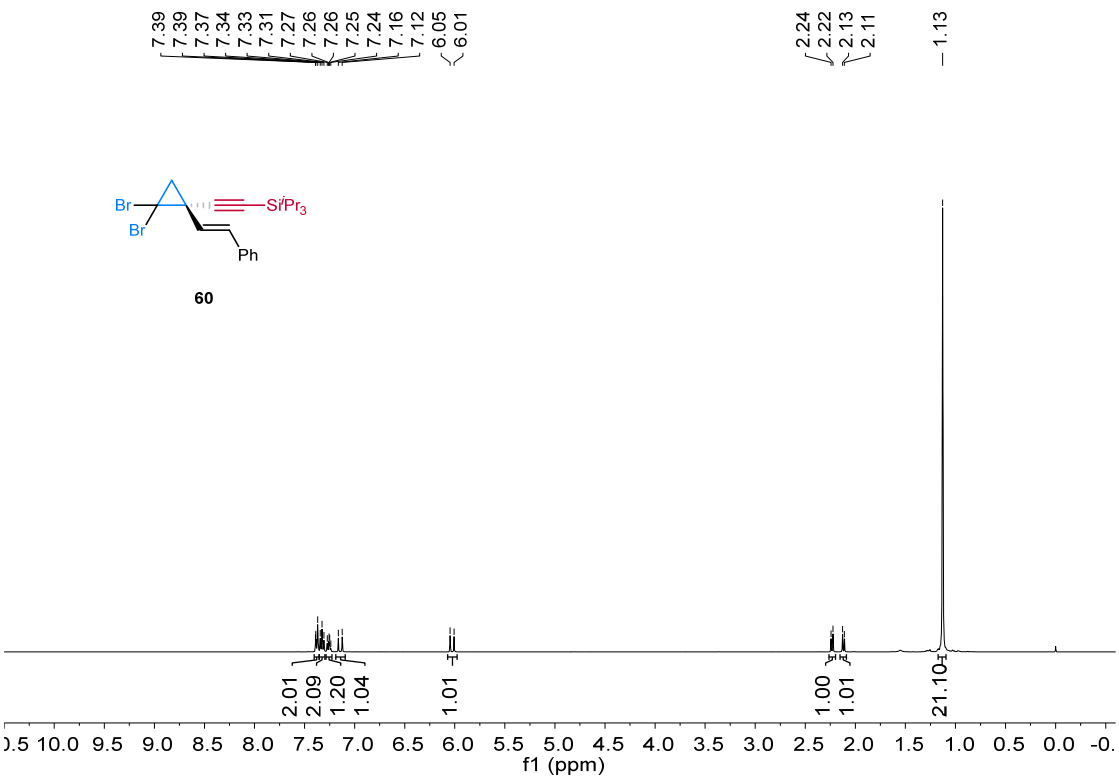
128.02
127.63
126.60
126.02
123.45
120.59
119.69
109.05
82.18
79.13
38.09
34.24
32.89
30.15
Br
Br
N
Ph
59
f1 (ppm)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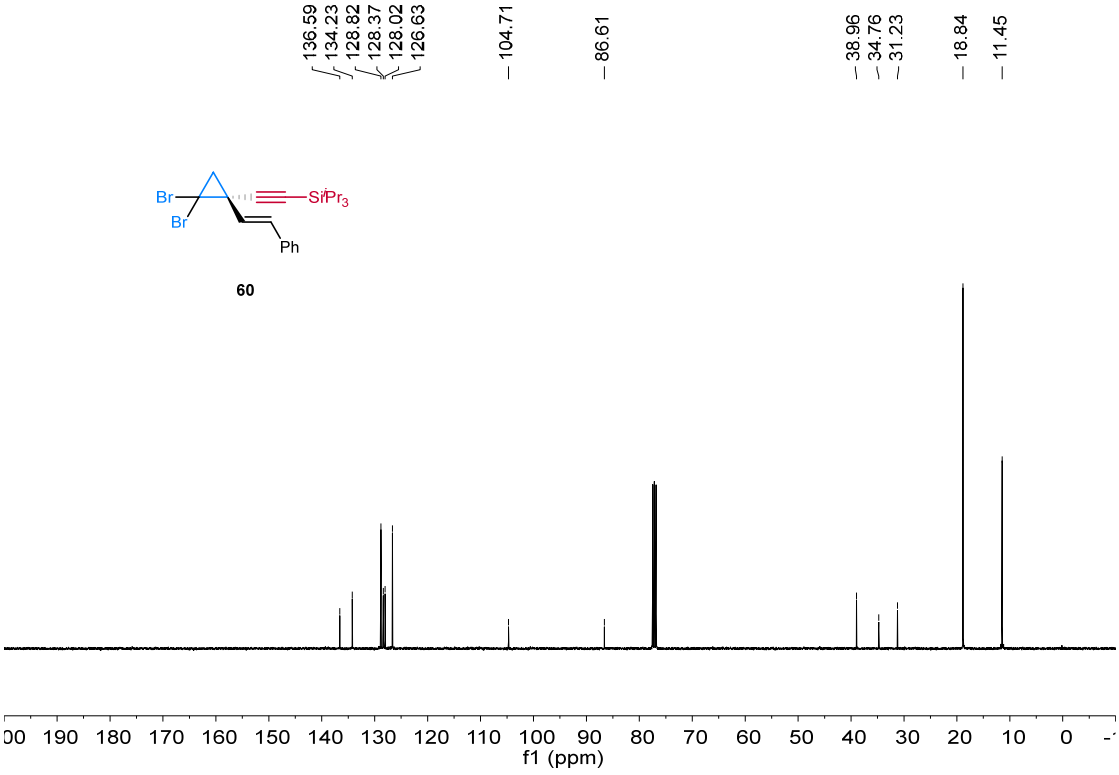
7.37
7.34
7.33
7.31
7.27
7.26
7.26
7.25
7.24
7.16
7.12
6.05
6.01
2.24
2.22
2.13
2.11
1.13
Br
Br
SiiPr3
Ph
60
2.01
2.09
1.20
1.04
1.01
1.00
1.01
21.10
f1 (ppm)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134.23
128.82
128.37
128.02
126.63
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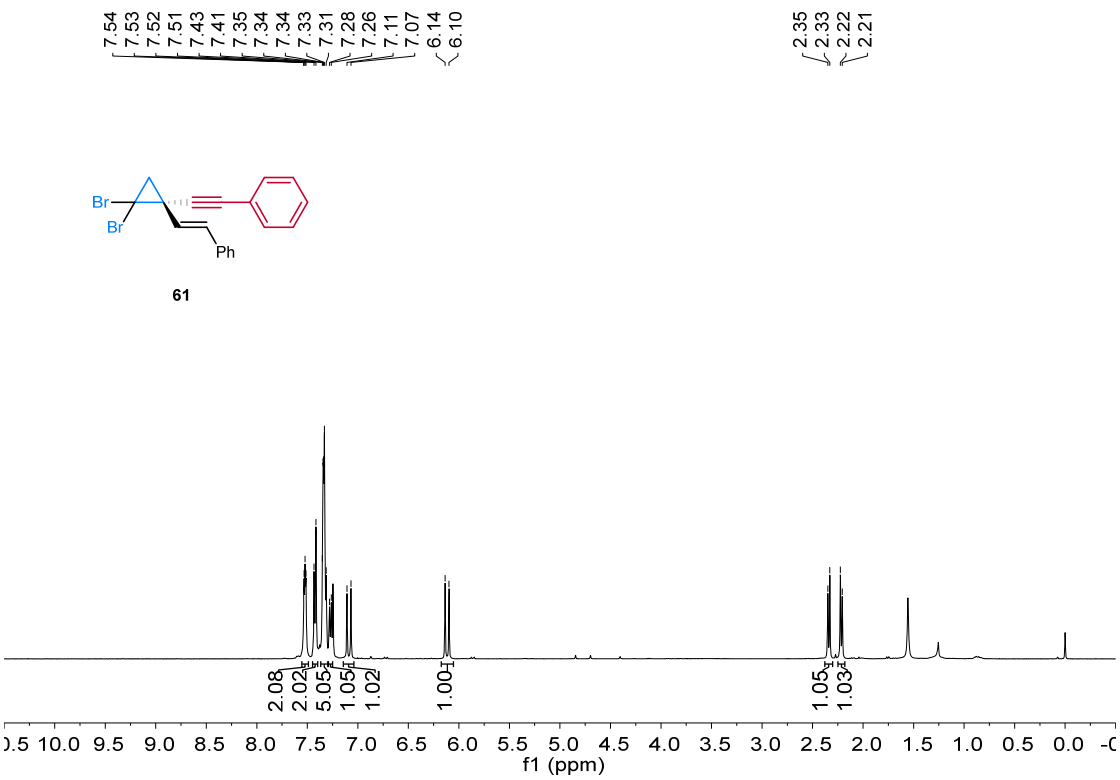
34.76
31.23
18.84
11.45
Br
Br
SiiPr3
Ph
60
f1 (ppm)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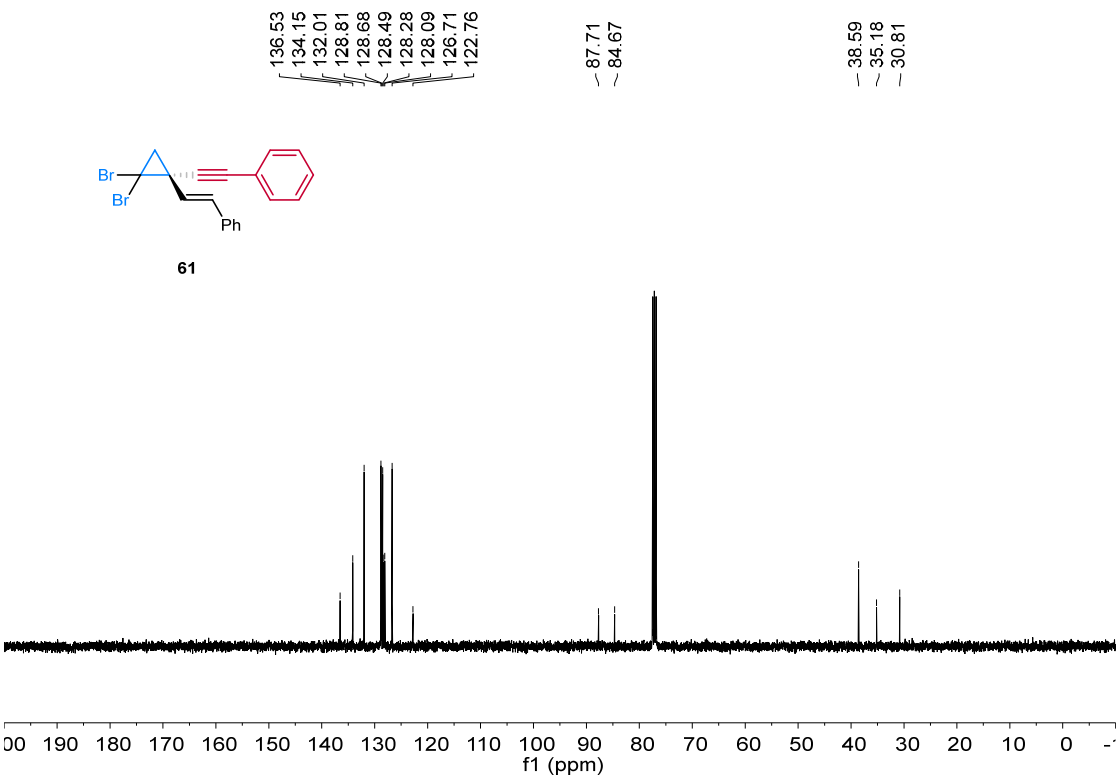
7.53
7.52
7.51
7.43
7.41
7.35
7.34
7.34
7.33
7.31
7.28
7.26
7.11
7.07
6.14
6.10
2.35
2.33
2.22
2.21
Br
Br
Ph
61
2.08
2.02
5.05
1.05
1.02
1.00
1.05
1.03
f1 (ppm)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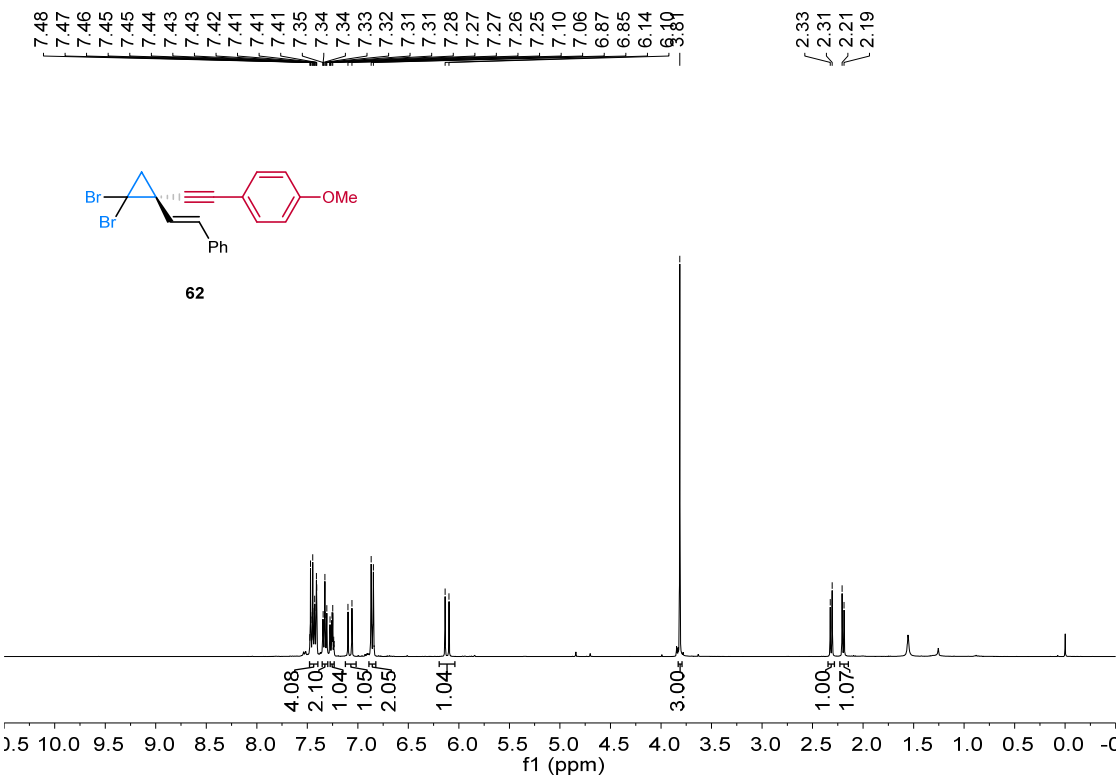
134.15
132.01
128.81
128.68
128.49
128.28
128.09
126.71
122.76
87.71
84.67
38.59
35.18
30.81
Br
Br
Ph
61
f1 (ppm)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7.45
7.44
7.43
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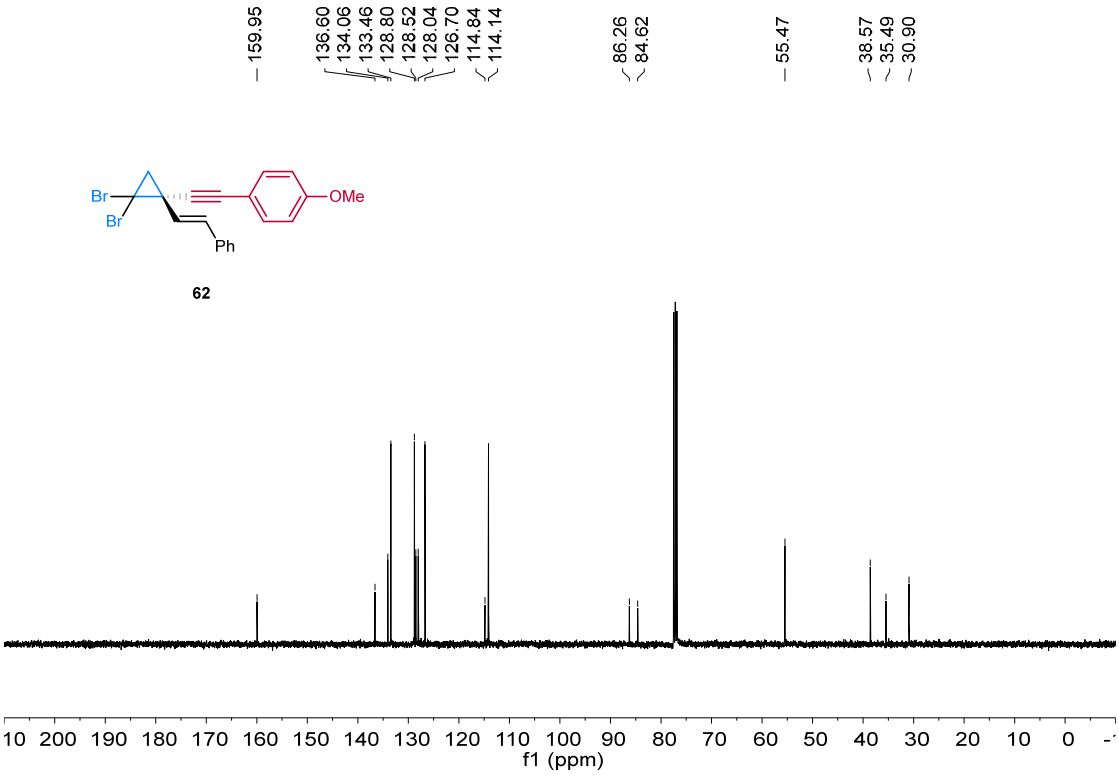
7.41
7.41
7.41
7.35
7.34
7.34
7.33
7.32
7.31
7.31
7.28
7.27
7.27
7.26
7.25
7.10
7.06
6.87
6.85
6.14
6.10
3.81
2.33
2.31
2.21
2.19
Br
Br
OMe
Ph
62
4.08
2.10
1.04
1.05
2.05
1.04
3.00
1.00
1.07
f1 (ppm)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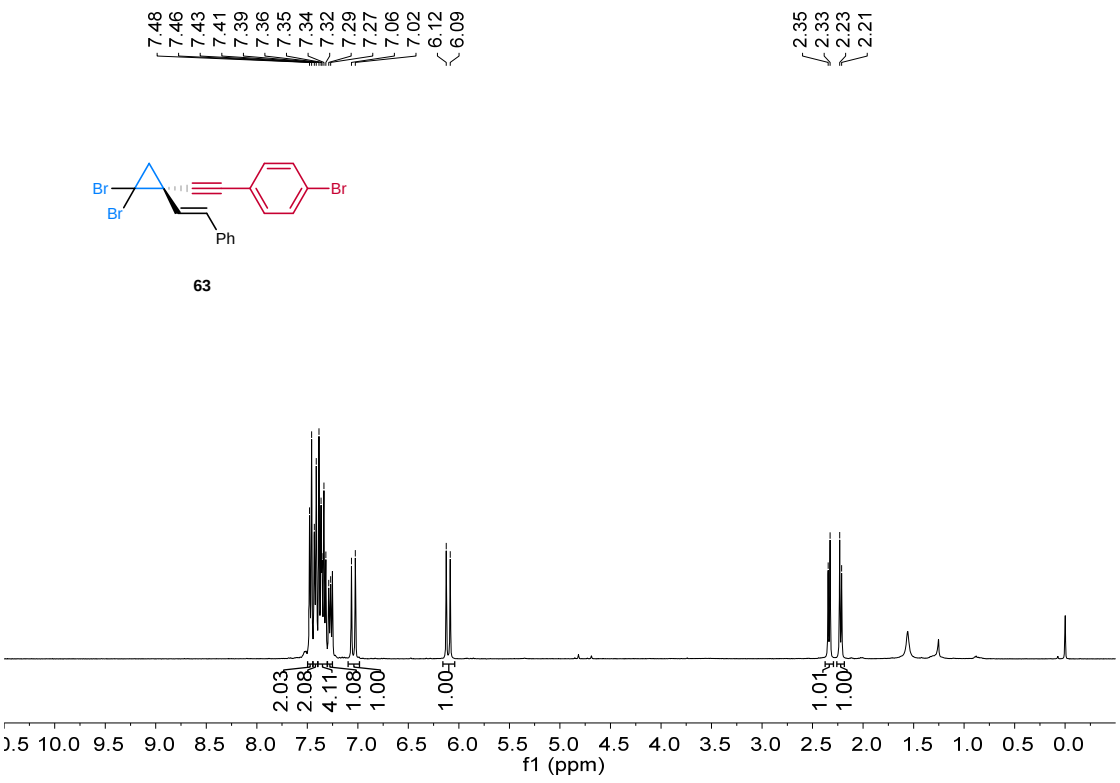
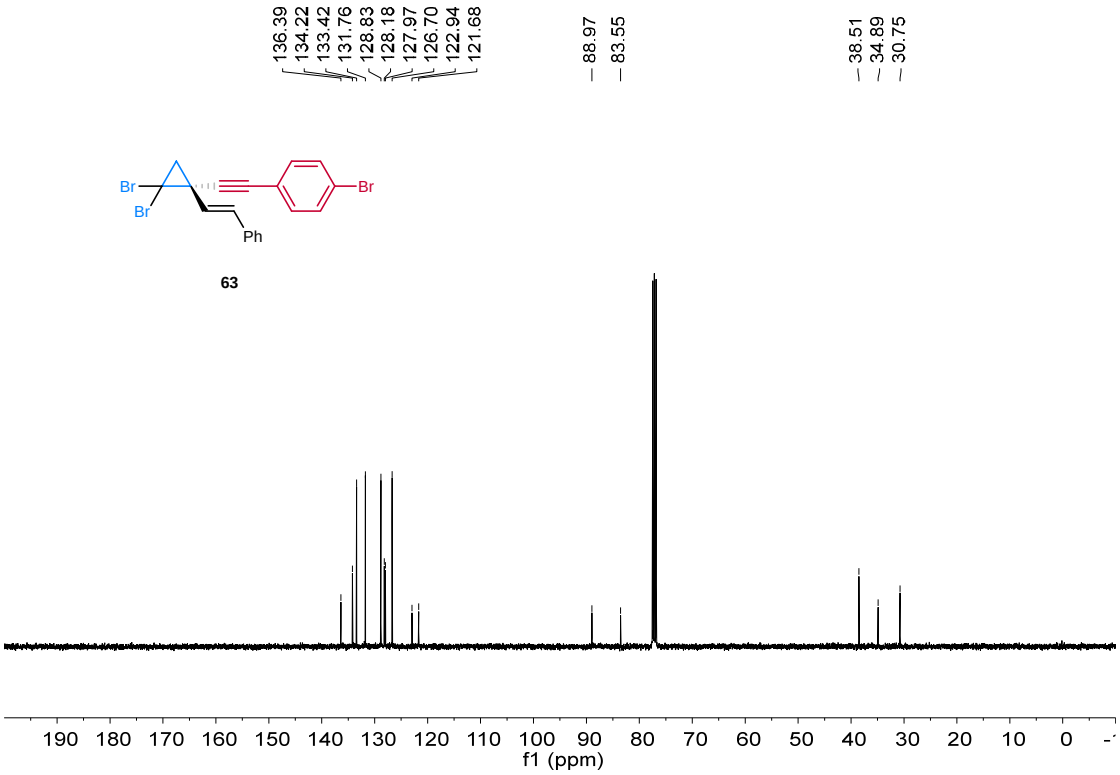
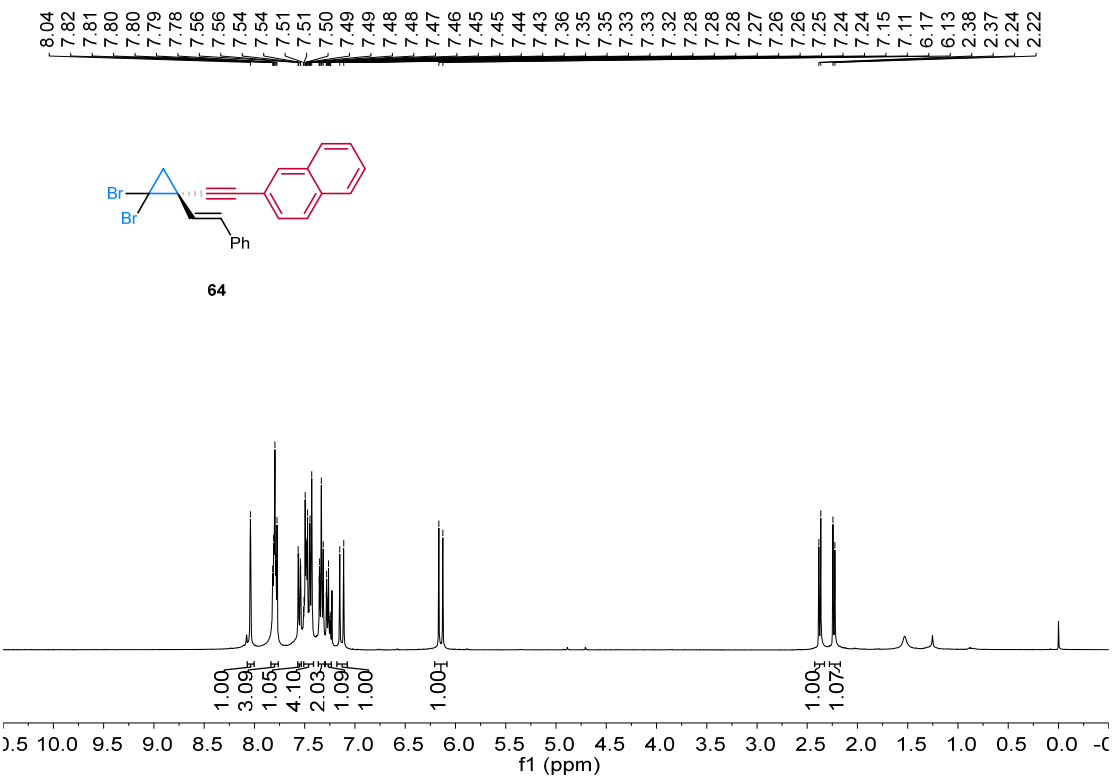
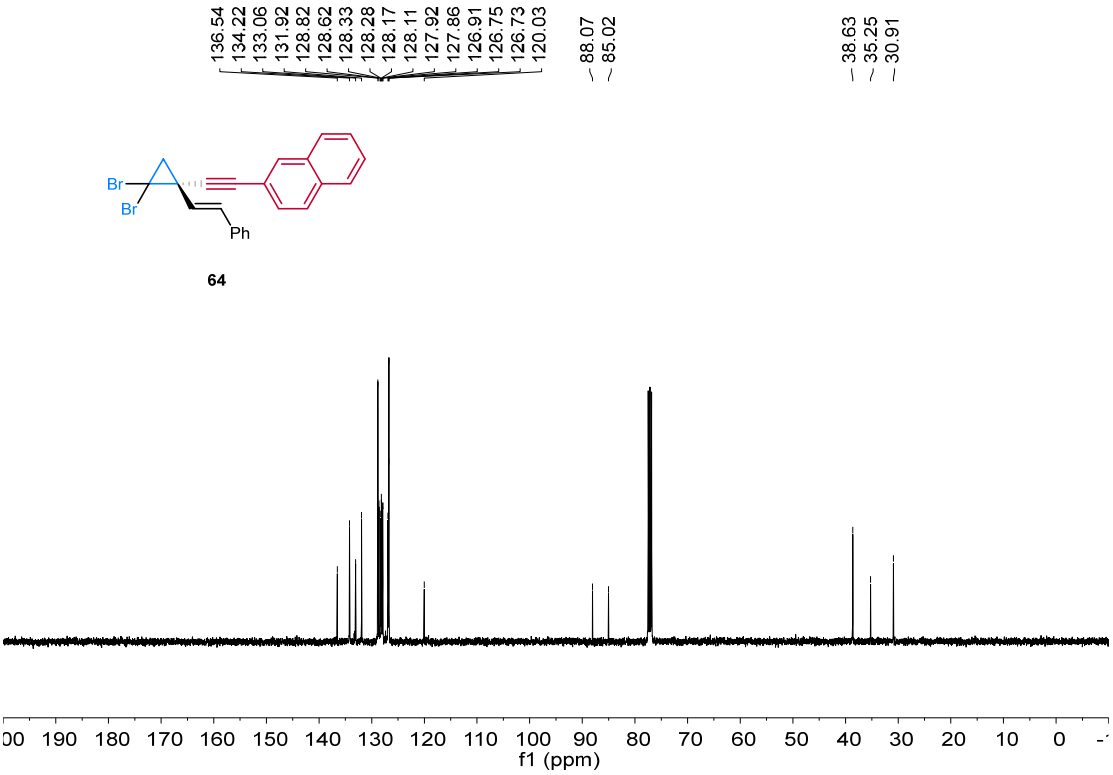
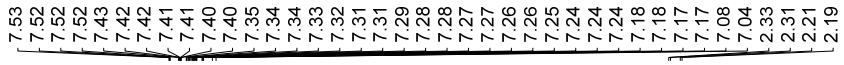
128.80
128.52
128.04
126.70
114.84
114.14
86.26
84.62
55.47
38.57
35.49
30.90
Br
Br
OMe
Ph
62
f1 (ppm)


7.48
7.46
7.43
7.41
7.39
7.36
7.35
7.34
7.32
7.29
7.27
7.06
7.02
6.12
6.09
2.35
2.33
2.23
2.21
Br
Br
Br
Ph
63
2.03
2.08
4.11
1.08
1.00
1.00
1.01
1.00
f1 (ppm)


136.39
134.22
133.42
131.76
128.83
128.18
127.97
126.70
122.94
121.68
88.97
83.55
38.51
34.89
30.75
Br
Br
Br
Ph
63
f1 (ppm)


8.04 7.82 7.81 7.80 7.80 7.79 7.78 7.56 7.56 7.54 7.54 7.51 7.51 7.50 7.49 7.49 7.48 7.48 7.47 7.46 7.45 7.45 7.44 7.43 7.36 7.35 7.35 7.33 7.33 7.32 7.28 7.28 7.28 7.27 7.26 7.26 7.25 7.24 7.24 7.15 7.11 6.17 6.13 2.38 2.37 2.24 2.22
Br
Br
Ph
64
1.00 3.09 1.05 4.10 2.03 1.09 1.00 1.00 1.00 1.07
f1 (ppm)


136.54 134.22 133.06 131.92 128.82 128.62 128.33 128.28 128.17 128.11 127.92 127.86 126.91 126.75 126.73 120.03 88.07 85.02 38.63 35.25 30.91
Br
Br
Ph
64
f1 (ppm)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7.40
7.35
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7.34
7.33
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7.27
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7.26
7.25
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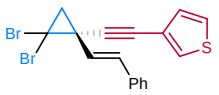
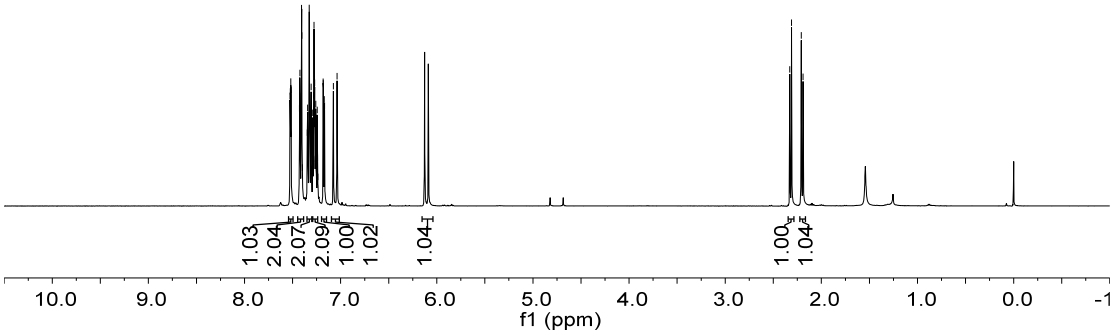
7.08
7.04
2.33
2.31
2.21
2.19


Br
Br
S
Ph

**65**


1.03
2.04
2.07
2.09
1.00
1.02
1.04
1.00
1.04
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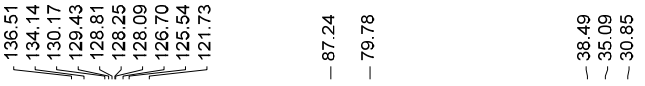
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)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130.17
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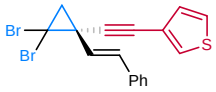
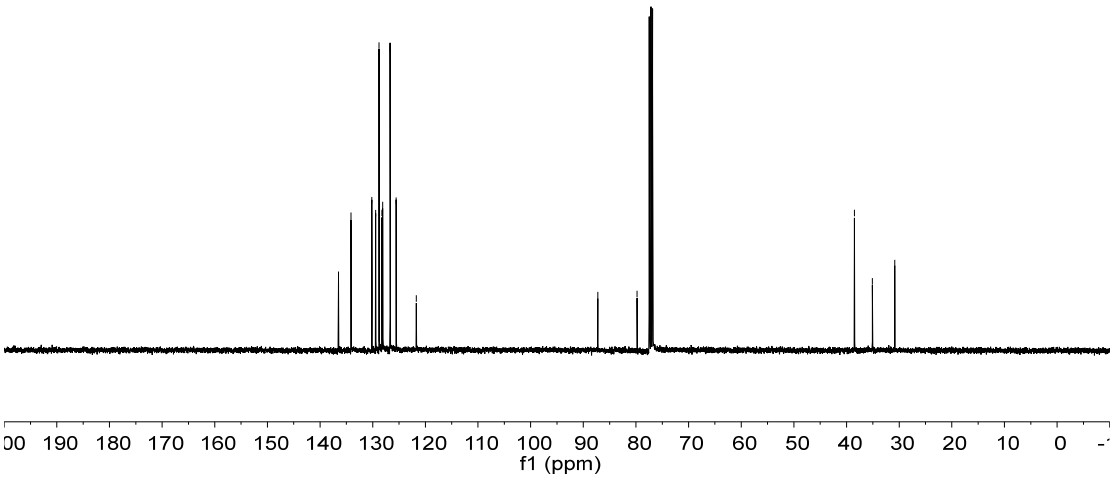
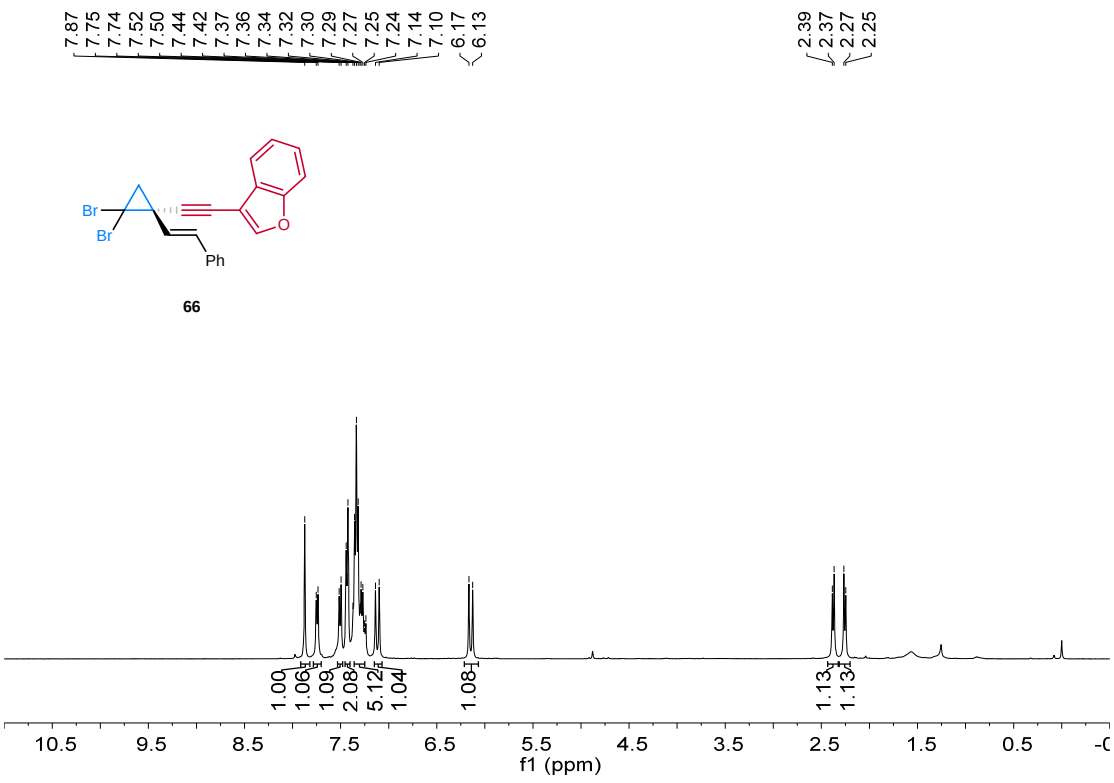
126.70
125.54
121.73
87.24
79.78
38.49
35.09
30.85


Br
Br
S
Ph

**65**


00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.42
7.37
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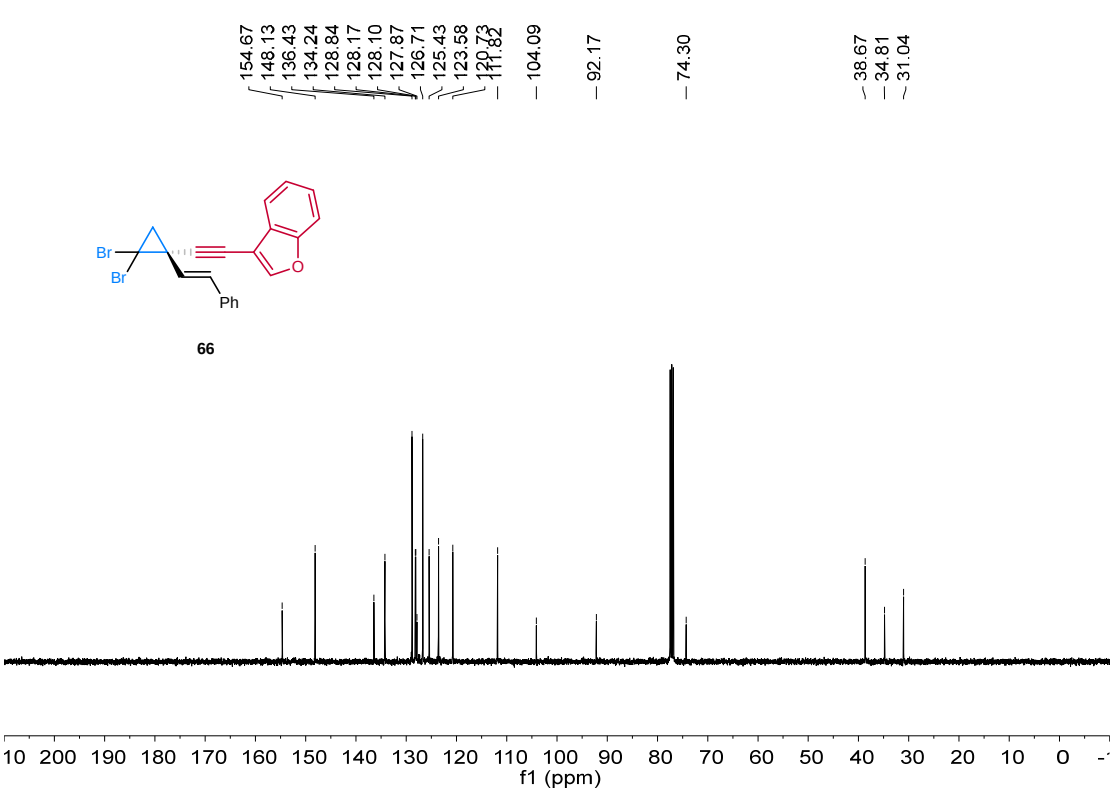
7.34
7.32
7.30
7.29
7.27
7.25
7.24
7.14
7.10
6.17
6.13
2.39
2.37
2.27
2.25
Br
Br
O
Ph
1.00
1.06
1.09
2.08
5.12
1.04
1.08
1.13
1.13
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)

66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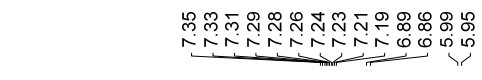
136.43
134.24
128.84
128.17
128.10
127.87
126.71
125.43
123.58
120.73
111.82
104.09
92.17
74.30
38.67
34.81
31.04
Br
Br
O
Ph
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

66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7.33
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7.29
7.28
7.26
7.24
7.23
7.21
7.19
6.89
6.86
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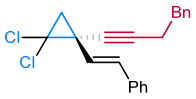
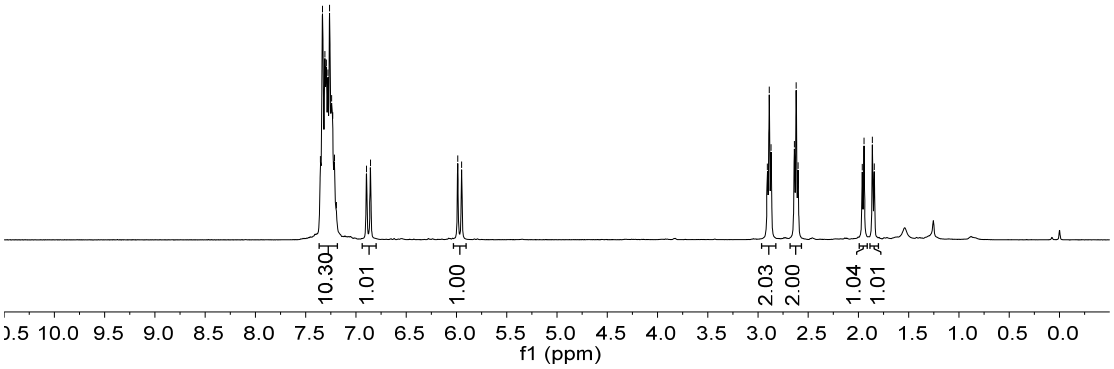
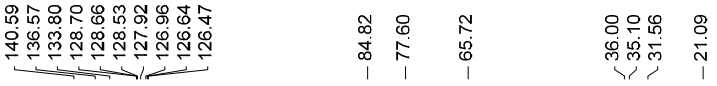
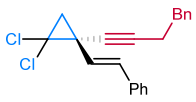
2.62
2.60
1.96
1.94
1.86
1.84


Bn
Cl
Cl
Ph

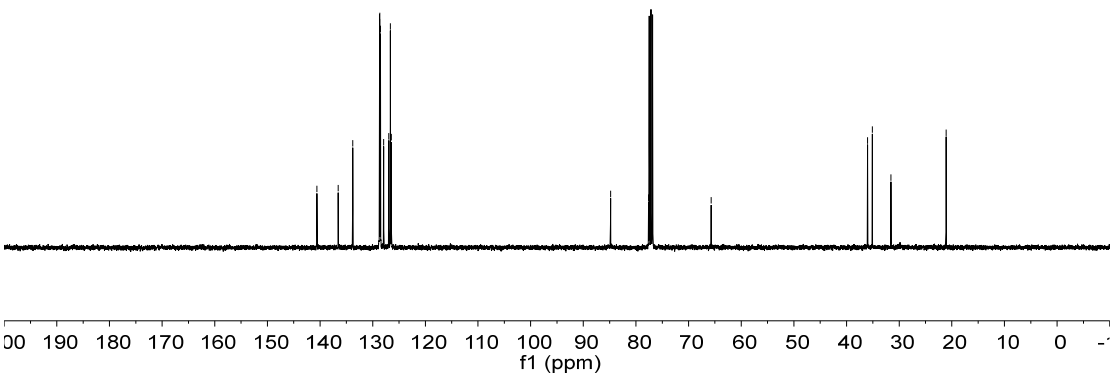
**67**

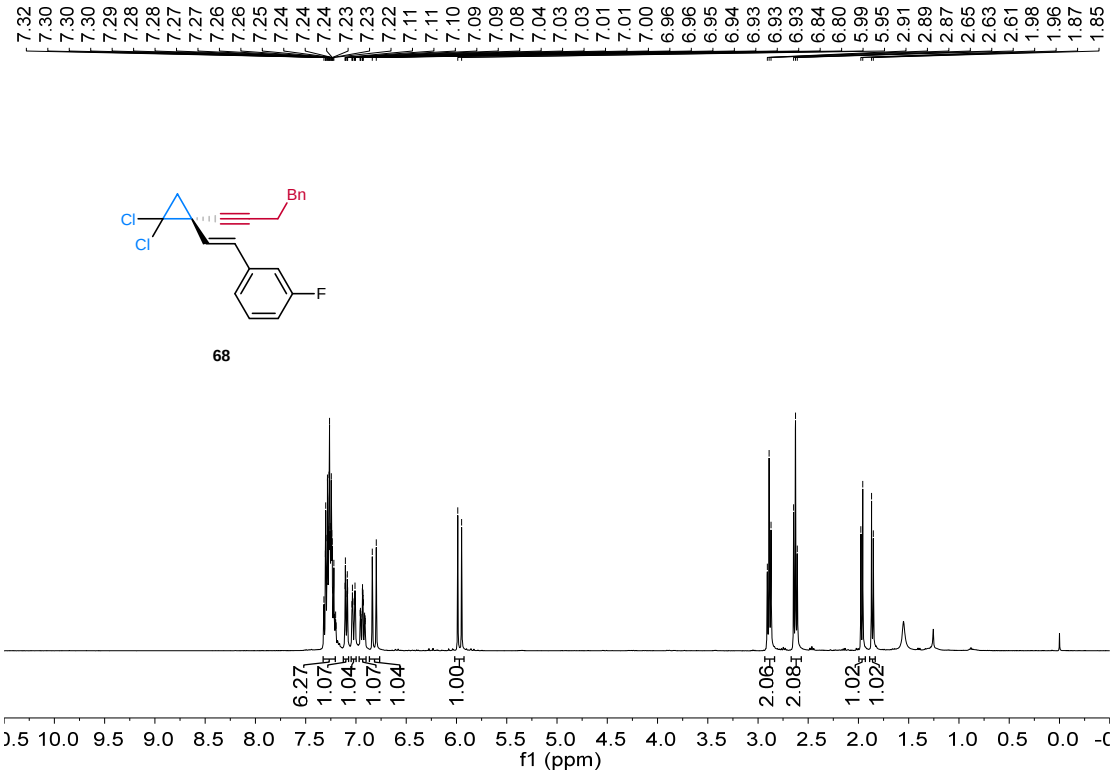

10.30
1.01
1.00
2.03
2.00
1.04
1.01
f1 (ppm)

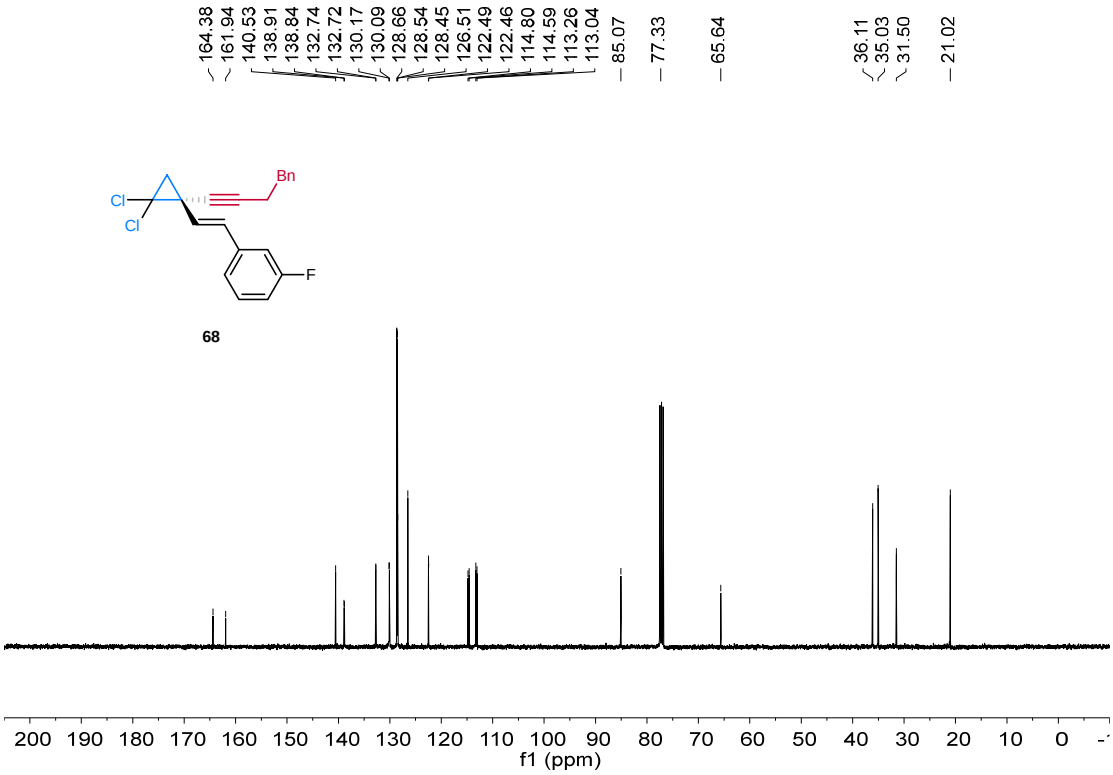

140.59
136.57
133.80
128.70
128.66
128.53
127.92
126.96
126.64
126.47
84.82
77.60
65.72
36.00
35.10
31.56
21.09

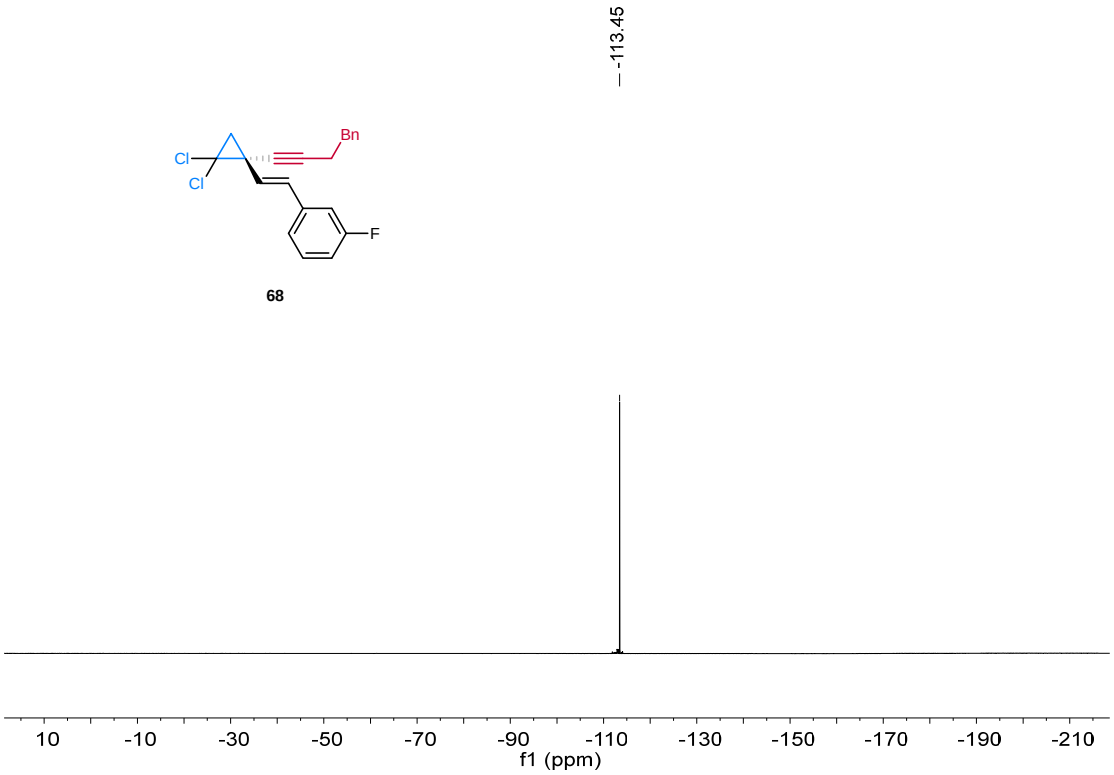

Bn
Cl
Cl
Ph

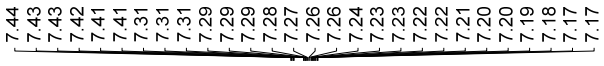
**67**

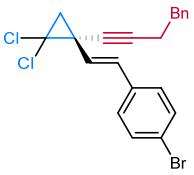

f1 (ppm)


7.32 7.30 7.30 7.30 7.29 7.28 7.28 7.27 7.27 7.26 7.26 7.25 7.24 7.24 7.24 7.23 7.23 7.22 7.11 7.11 7.10 7.09 7.09 7.08 7.04 7.03 7.03 7.01 7.01 7.00 6.96 6.96 6.95 6.94 6.93 6.93 6.93 6.84 6.80 5.99 5.95 2.91 2.89 2.87 2.65 2.63 2.61 1.98 1.96 1.87 1.85
Cl
Cl
Bn
F
68
6.27 1.07 1.04 1.07 1.04 1.00 2.06 2.08 1.02 1.02
f1 (ppm)

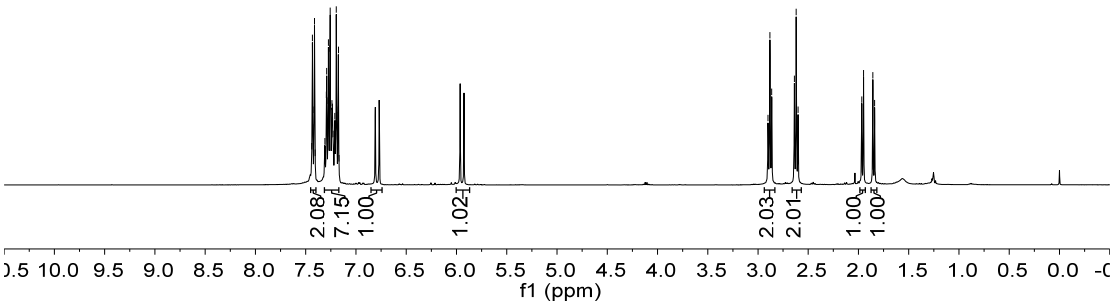

164.38 161.94 140.53 138.91 138.84 132.74 132.72 130.17 130.09 128.66 128.54 128.45 126.51 122.49 122.46 114.80 114.59 113.26 113.04 85.07 77.33 65.64 36.11 35.03 31.50 21.02
Cl
Cl
Bn
F
68
f1 (ppm)

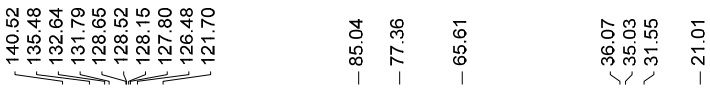

-113.45
Bn
Cl
Cl
F
68
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
f1 (ppm)

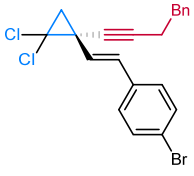

7.44
7.43
7.43
7.42
7.41
7.41
7.31
7.31
7.29
7.29
7.29
7.28
7.27
7.26
7.26
7.24
7.23
7.23
7.22
7.22
7.21
7.20
7.20
7.19
7.18
7.17
7.17
2.90
2.88
2.86
2.64
2.62
2.60
1.97
1.95
1.86
1.84


Bn
Cl
Cl
Br

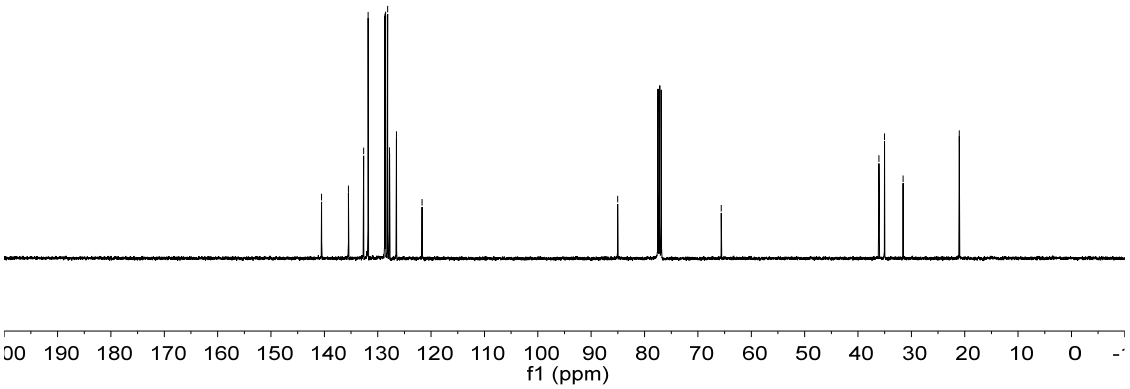
**69**

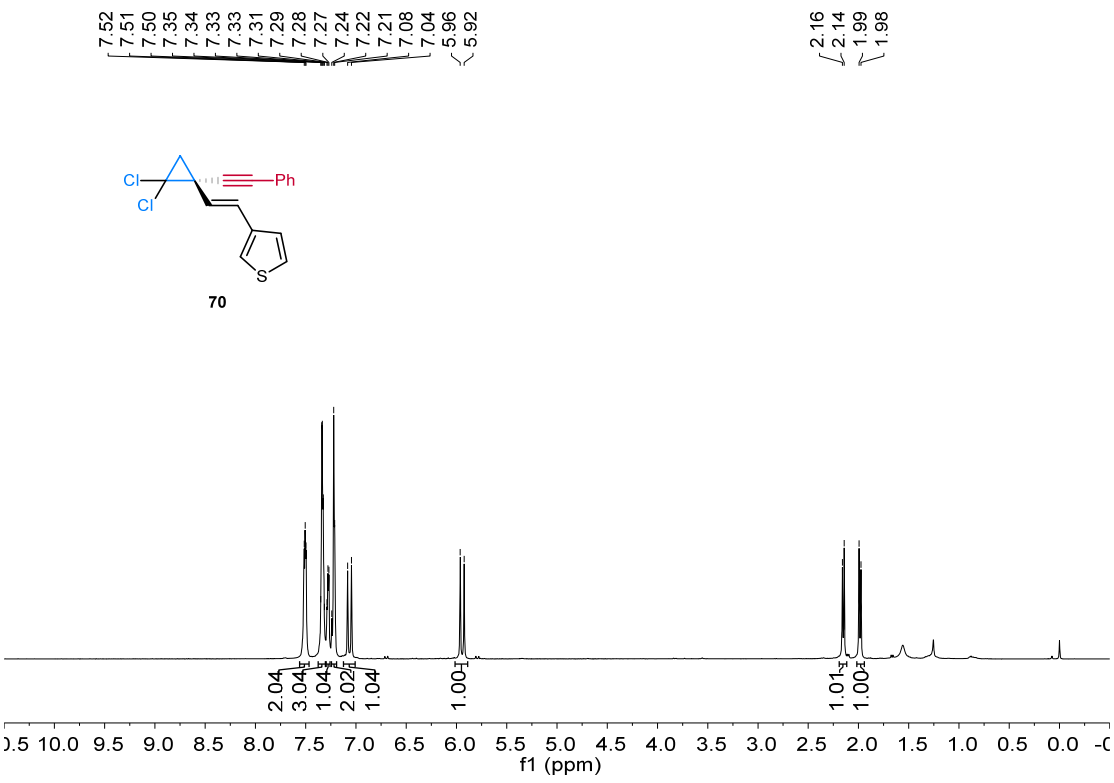

2.08
7.15
1.00
1.02
2.03
2.01
1.00
1.00
f1 (ppm)

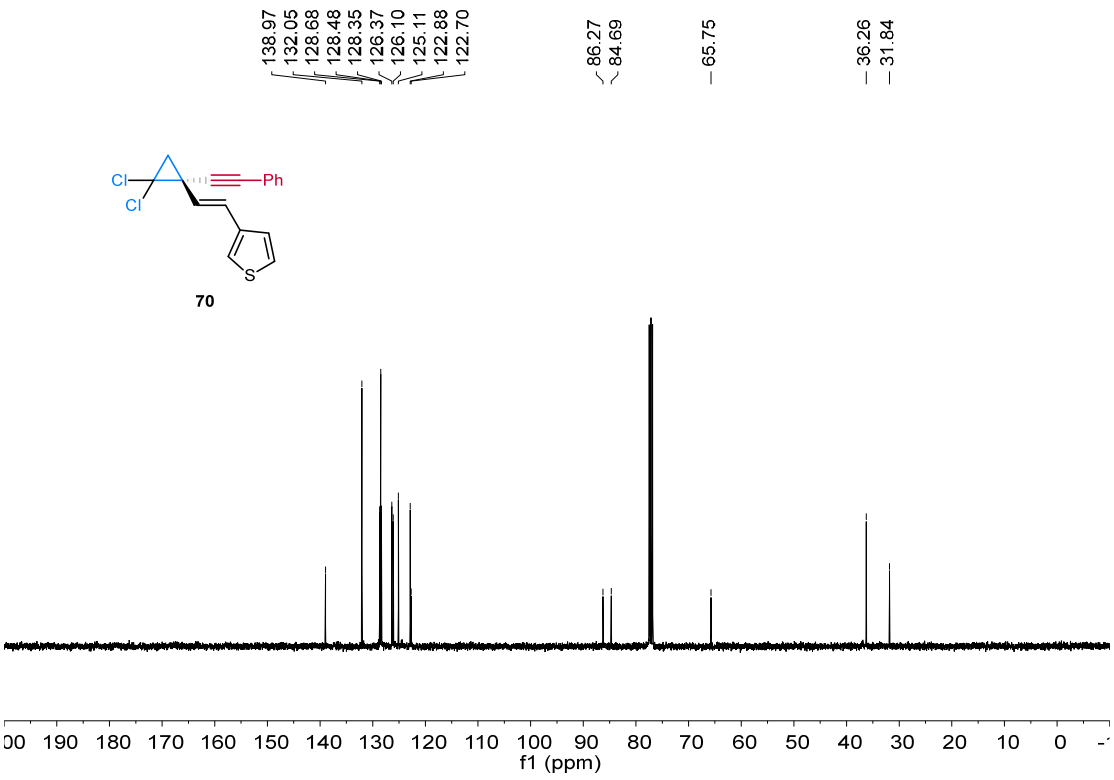

140.52
135.48
132.64
131.79
128.65
128.52
128.15
127.80
126.48
121.70
85.04
77.36
65.61
36.07
35.03
31.55
21.01

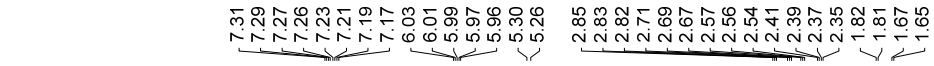

Bn
Cl
Cl
Br

**69**


f1 (ppm)

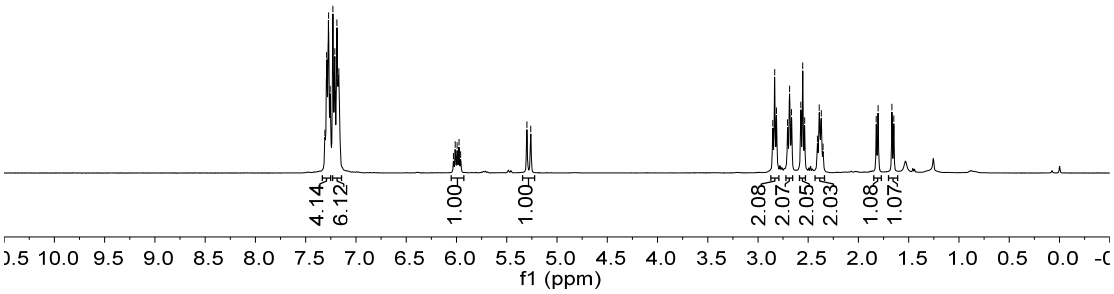

7.52
7.51
7.50
7.35
7.34
7.33
7.33
7.31
7.29
7.28
7.27
7.24
7.22
7.21
7.08
7.04
5.96
5.92
2.16
2.14
1.99
1.98
Cl
Cl
Ph
S
70
2.04
3.04
1.04
2.02
1.04
1.00
1.01
1.00
f1 (ppm)

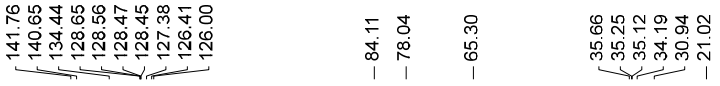

138.97
132.05
128.68
128.48
128.35
126.37
126.10
125.11
122.88
122.70
86.27
84.69
65.75
36.26
31.84
Cl
Cl
Ph
S
70
f1 (ppm)


7.31
7.29
7.27
7.26
7.23
7.21
7.19
7.17
6.03
6.01
5.99
5.97
5.96
5.30
5.26
2.85
2.83
2.82
2.71
2.69
2.67
2.57
2.56
2.54
2.41
2.39
2.37
2.35
1.82
1.81
1.67
1.65


Cl
Cl
Bn
Bn

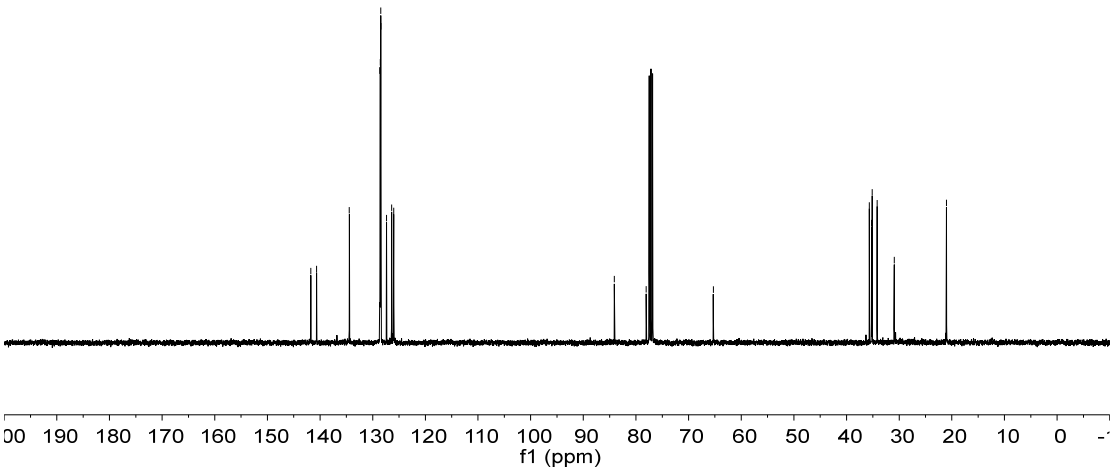
**71**

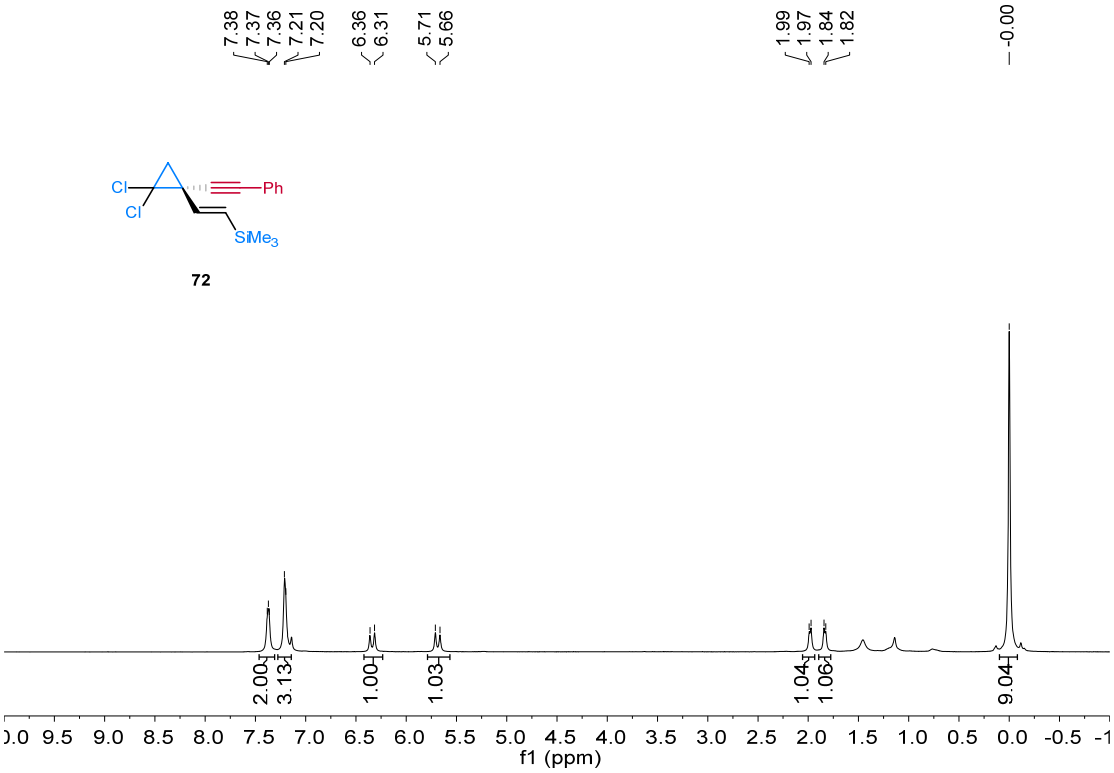

4.14
6.12
1.00
1.00
2.08
2.07
2.05
2.03
1.08
1.07
f1 (ppm)

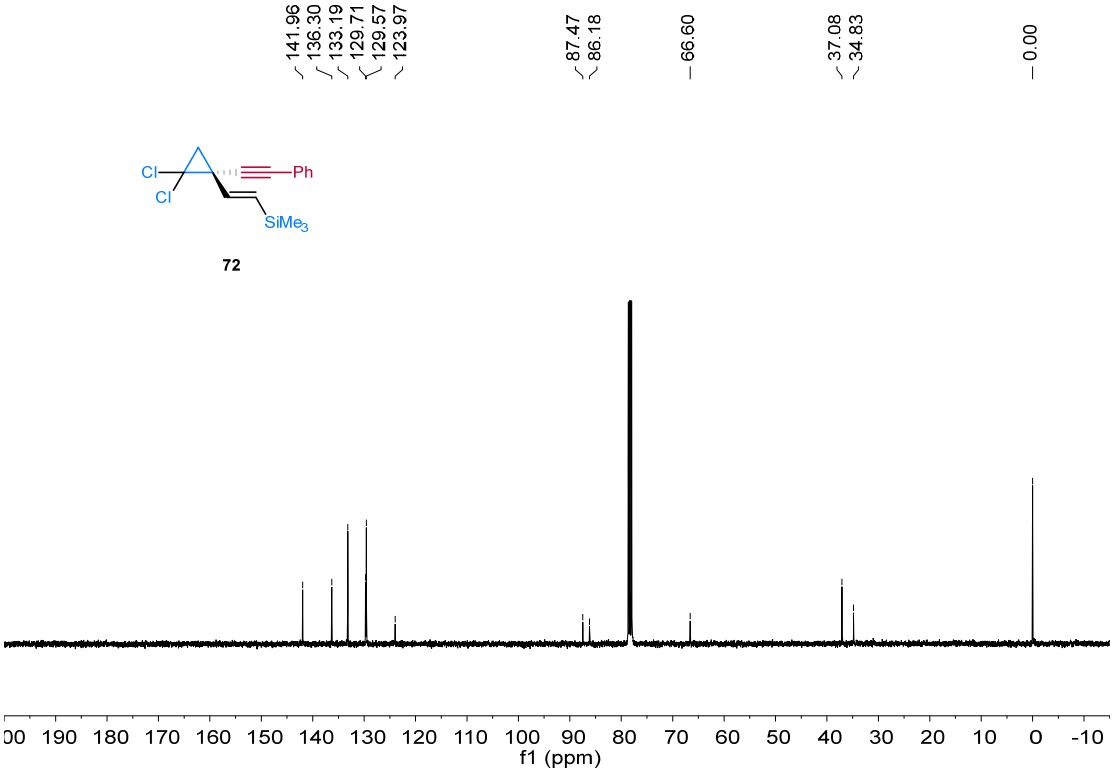

141.76
140.65
134.44
128.65
128.56
128.47
128.45
127.38
126.41
126.00
84.11
78.04
65.30
35.66
35.25
35.12
34.19
30.94
21.02

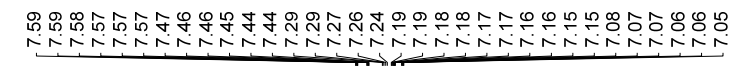

Cl
Cl
Bn
Bn

**71**


f1 (ppm)


7.38
7.37
7.36
7.21
7.20
6.36
6.31
5.71
5.66
1.99
1.97
1.84
1.82
-0.00
Cl
Cl
Ph
SiMe3
72
2.00
3.13
1.00
1.03
1.04
1.06
9.04
f1 (ppm)


141.96
136.30
133.19
129.71
129.57
123.97
87.47
86.18
66.60
37.08
34.83
0.00
Cl
Cl
Ph
SiMe3
72
f1 (ppm)


7.59
7.59
7.58
7.57
7.57
7.57
7.47
7.46
7.46
7.45
7.44
7.44
7.29
7.29
7.27
7.26
7.24
7.19
7.19
7.18
7.18
7.17
7.17
7.16
7.16
7.15
7.15
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7.07
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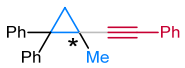
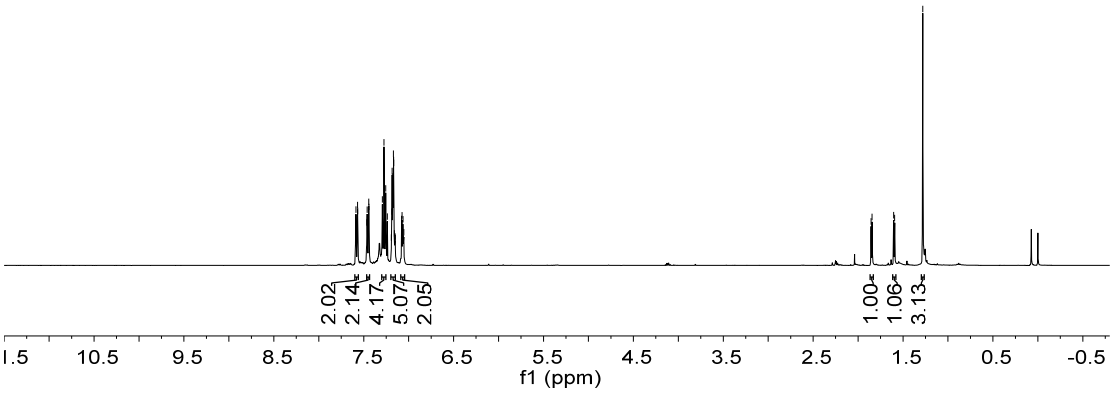
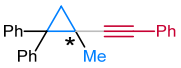
7.05
1.86
1.84
1.60
1.59
1.28


Ph
Ph
*
Me
Ph

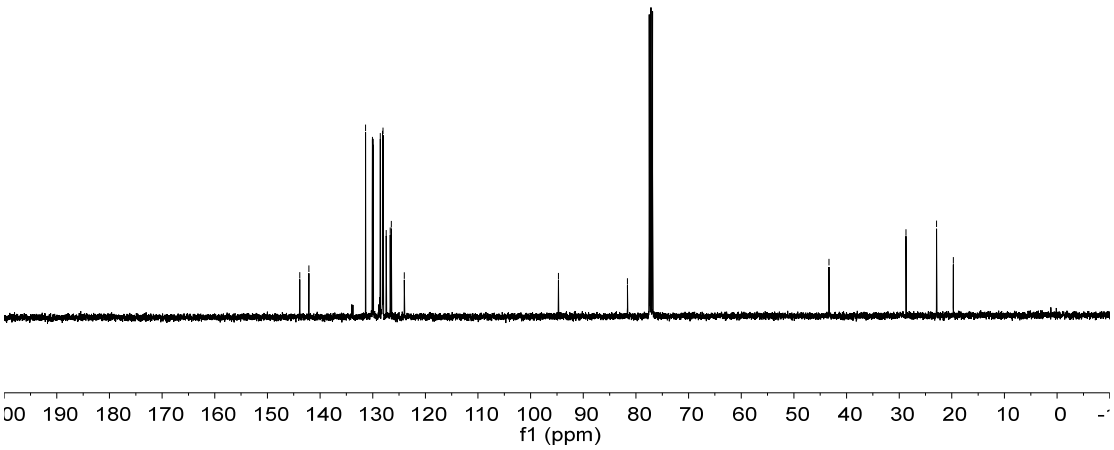
**75**

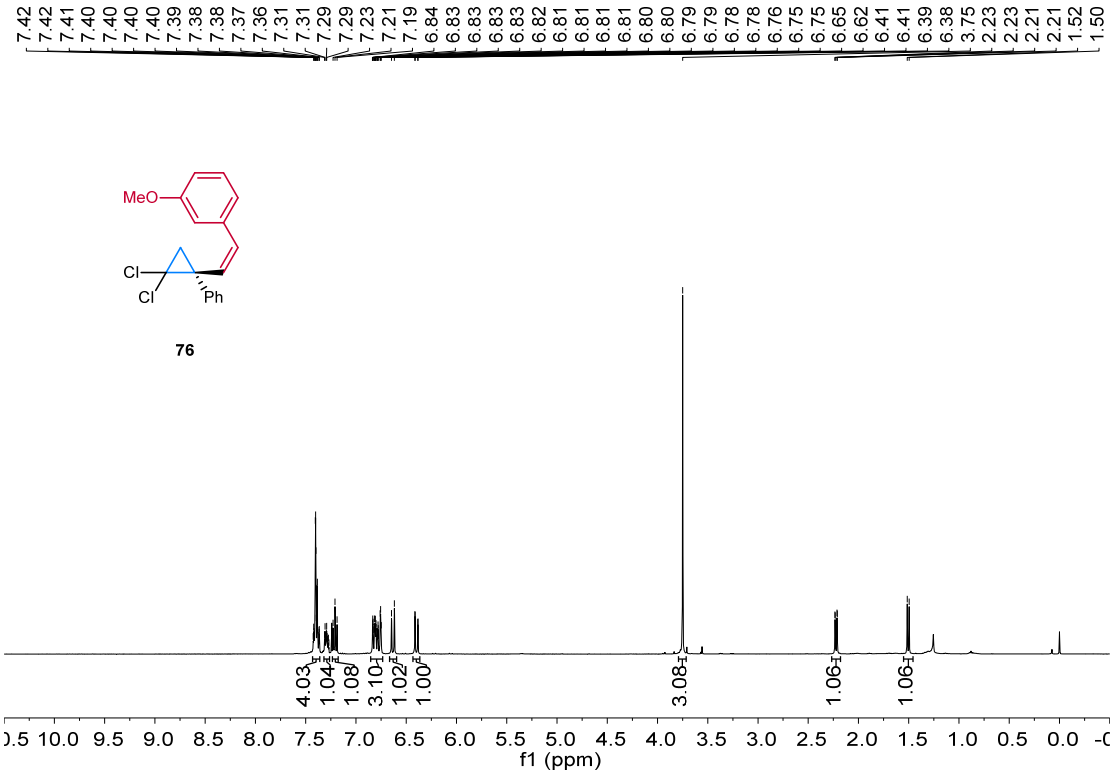

2.02
2.14
4.17
5.07
2.05
1.00
1.06
3.13
1.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
f1 (ppm)

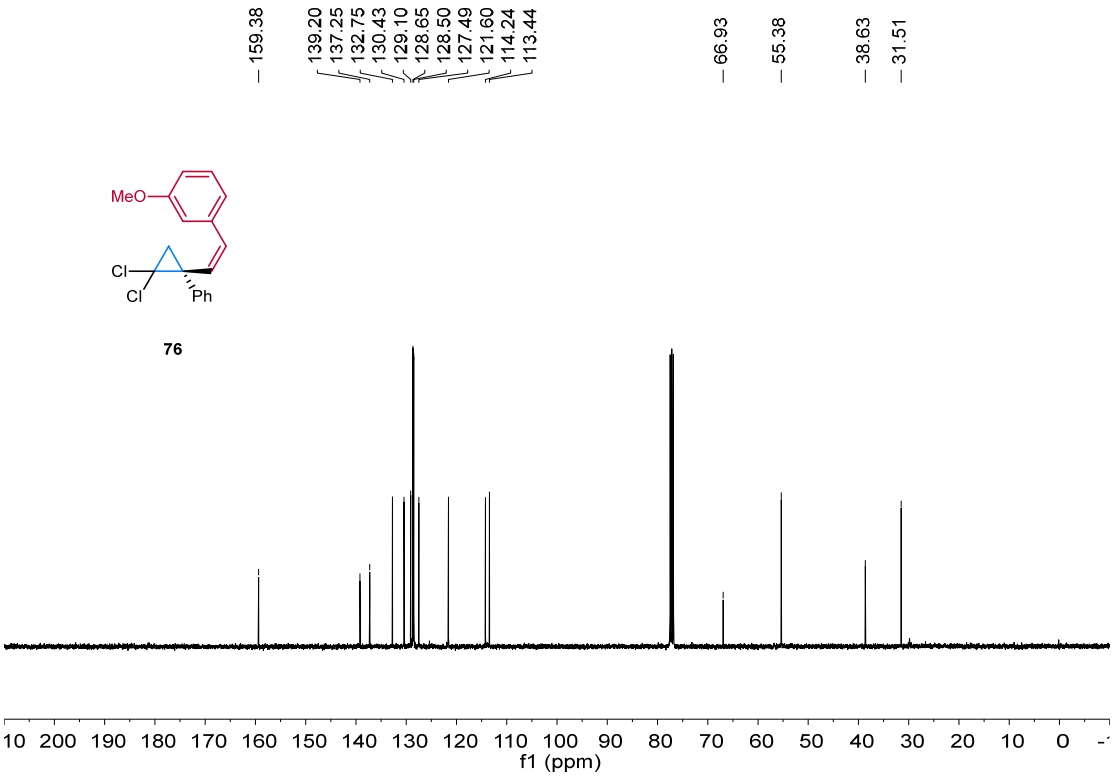

143.87
142.12
131.35
130.06
129.89
128.58
128.13
128.04
127.44
126.69
126.47
123.99
94.73
81.62
43.34
28.70
22.91
19.72

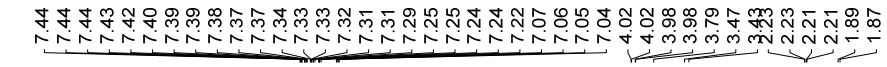

Ph
Ph
*
Me
Ph

**75**


00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.42 7.42 7.41 7.40 7.40 7.40 7.40 7.39 7.38 7.38 7.37 7.36 7.31 7.31 7.29 7.29 7.23 7.21 7.19 6.84 6.83 6.83 6.83 6.83 6.82 6.81 6.81 6.81 6.81 6.80 6.80 6.79 6.79 6.78 6.78 6.76 6.75 6.75 6.65 6.62 6.41 6.41 6.39 6.38 3.75 2.23 2.23 2.21 2.21 1.52 1.50
MeO
Cl
Cl
Ph
76
4.03 1.04 1.08 3.10 1.02 1.00 3.08 1.06 1.06
f1 (ppm)


159.38 139.20 137.25 132.75 130.43 129.10 128.65 128.50 127.49 121.60 114.24 113.44 66.93 55.38 38.63 31.51
MeO
Cl
Cl
Ph
76
f1 (ppm)


7.44
7.44
7.44
7.43
7.42
7.40
7.39
7.39
7.38
7.37
7.37
7.34
7.33
7.33
7.32
7.31
7.31
7.29
7.25
7.25
7.24
7.24
7.22
7.07
7.06
7.05
7.04
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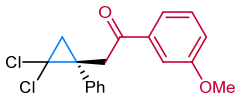
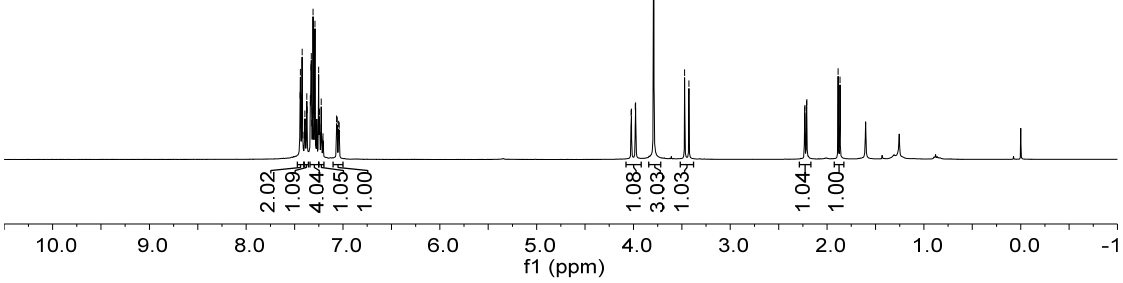
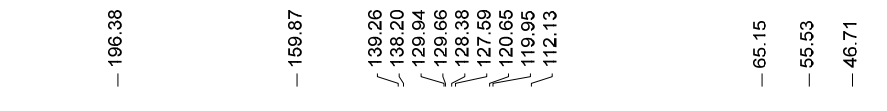
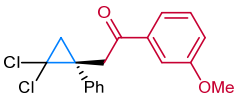
2.23
2.23
2.21
2.21
1.89
1.87


O
Cl
Cl
Ph
OMe

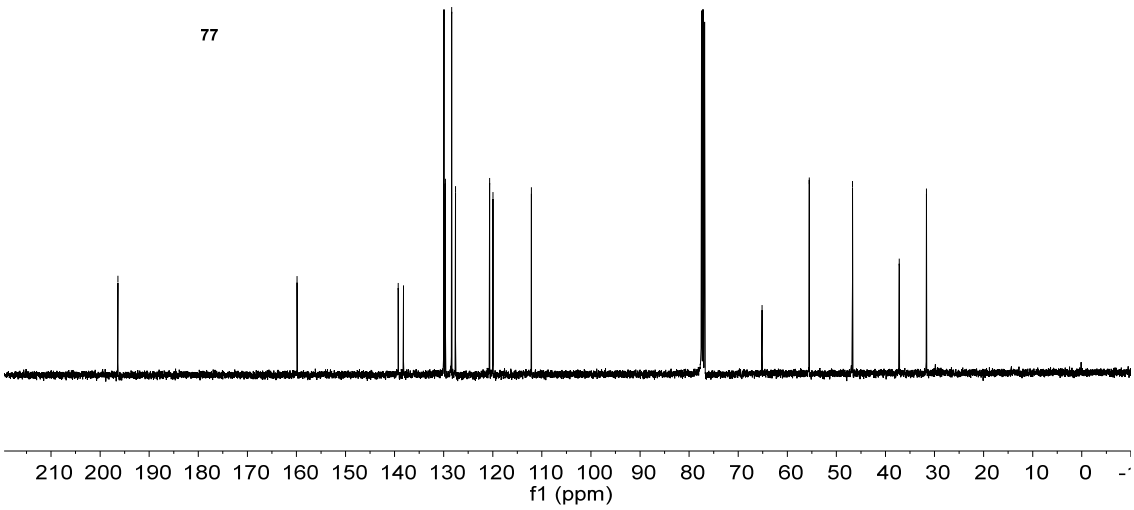
77

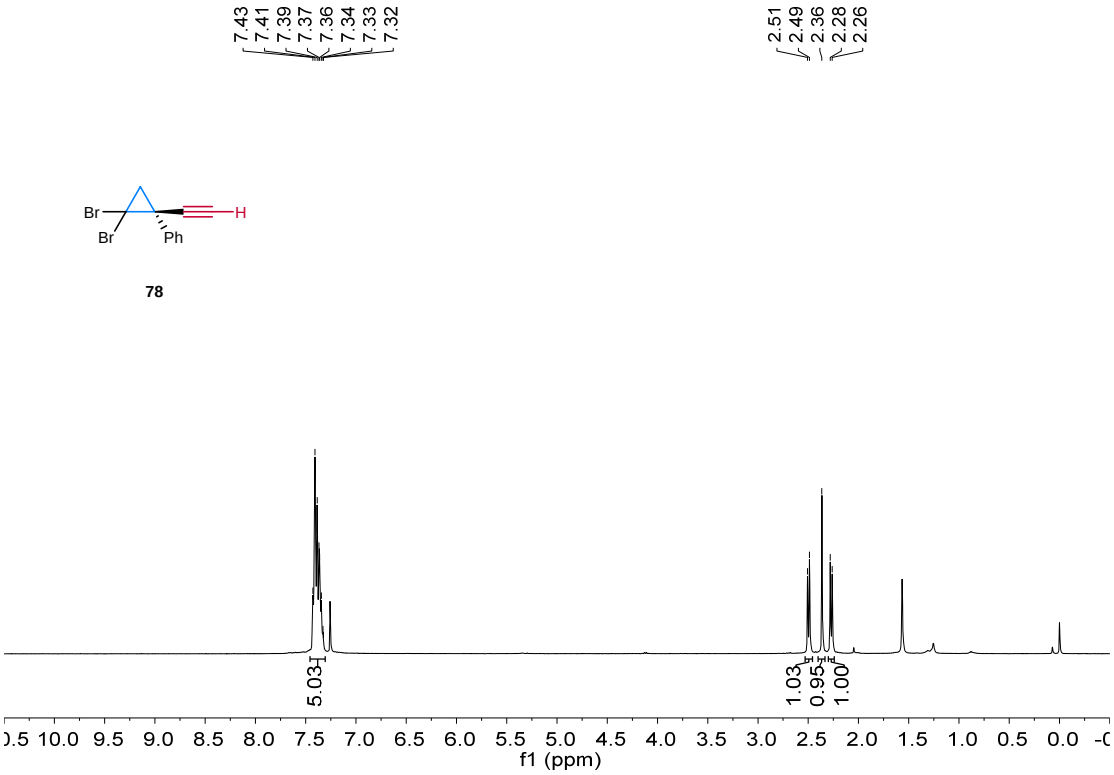

2.02
1.09
4.04
1.05
1.00
1.08
3.03
1.03
1.04
1.00
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1
f1 (ppm)

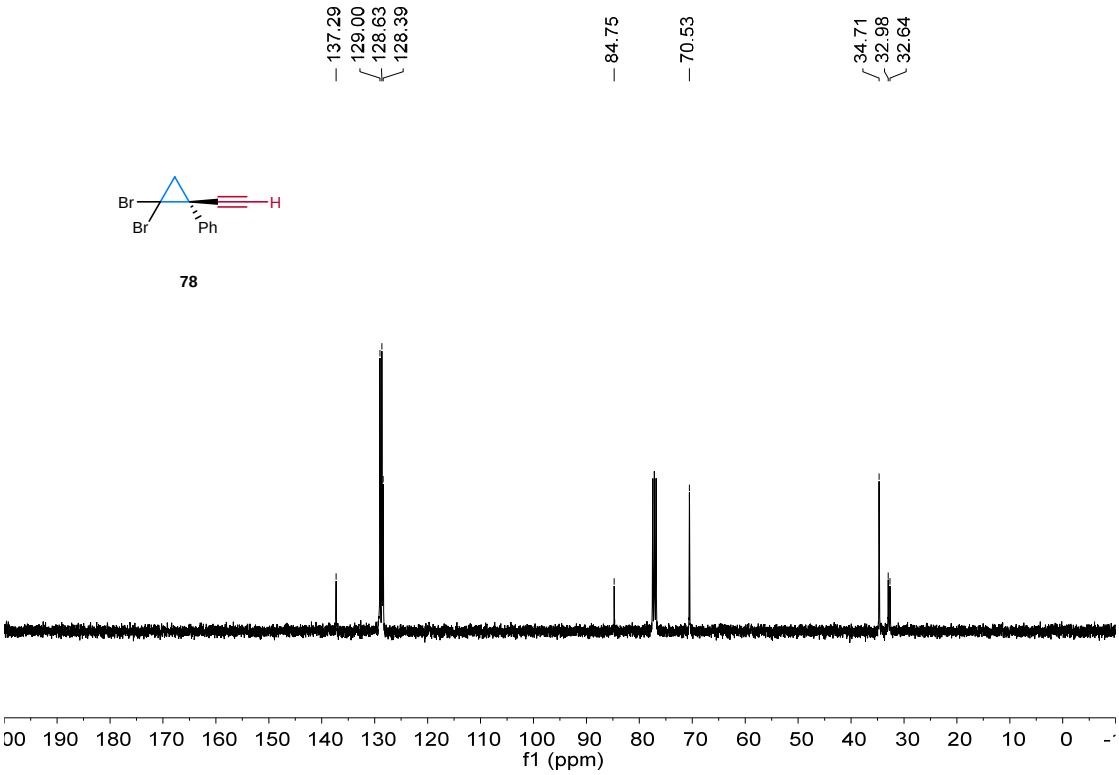

196.38
159.87
139.26
138.20
129.94
129.66
128.38
127.59
120.65
119.95
112.13
65.15
55.53
46.71
37.20
31.66

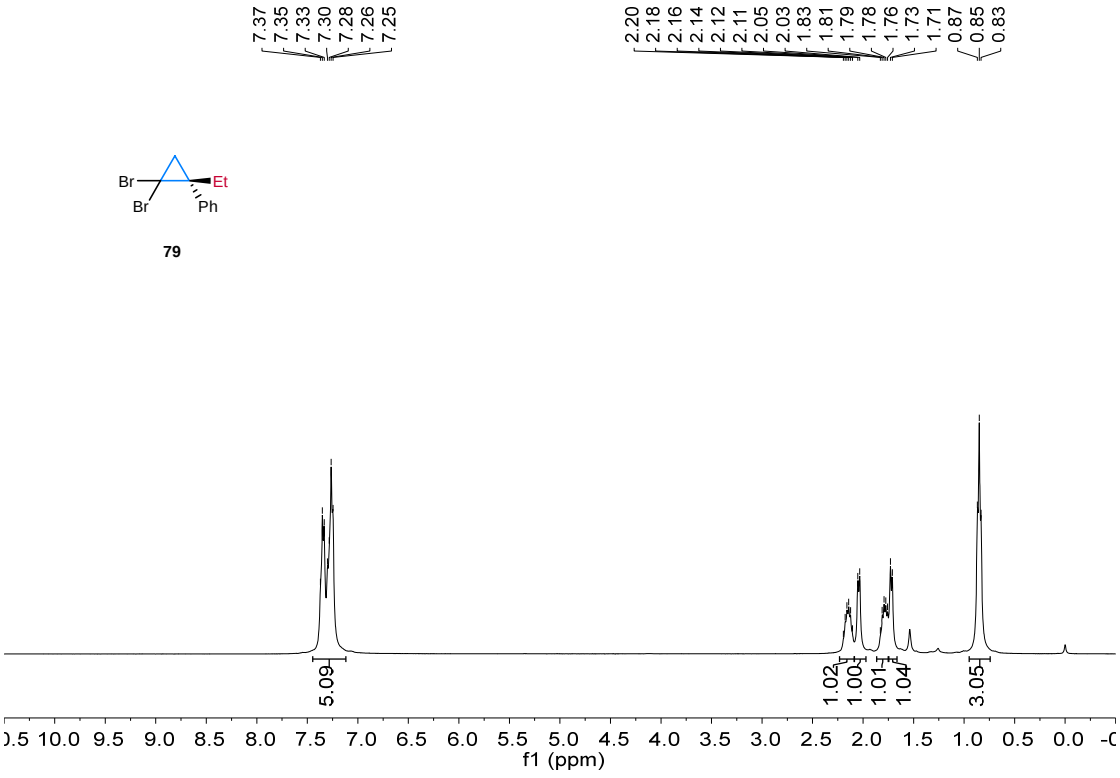

O
Cl
Cl
Ph
OMe

77


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.43
7.41
7.39
7.37
7.36
7.34
7.33
7.32
2.51
2.49
2.36
2.28
2.26
Br
Br
Ph
H
78
5.03
1.03
0.95
1.00
f1 (ppm)


137.29
129.00
128.63
128.39
84.75
70.53
34.71
32.98
32.64
Br
Br
Ph
H
78
f1 (ppm)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7.35
7.33
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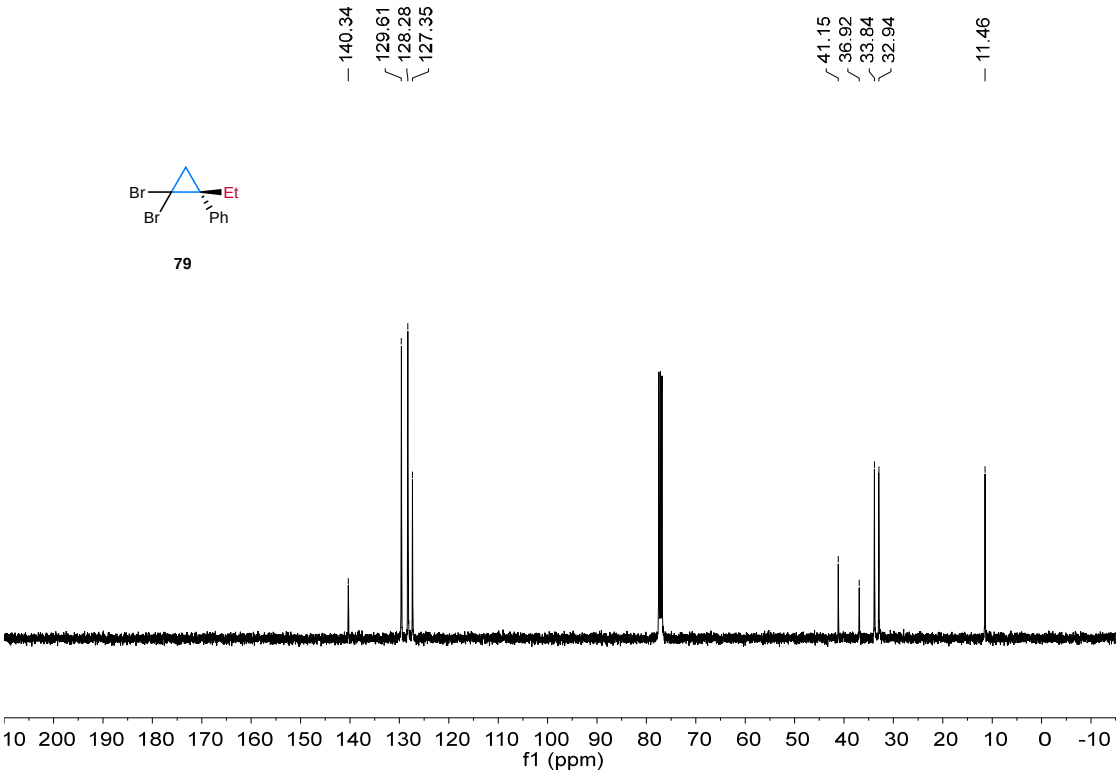
7.28
7.26
7.25
2.20
2.18
2.16
2.14
2.12
2.11
2.05
2.03
1.83
1.81
1.79
1.78
1.76
1.73
1.71
0.87
0.85
0.83
Br
Br
Et
Ph
79
5.09
1.02
1.00
1.01
1.04
3.05
f1 (ppm)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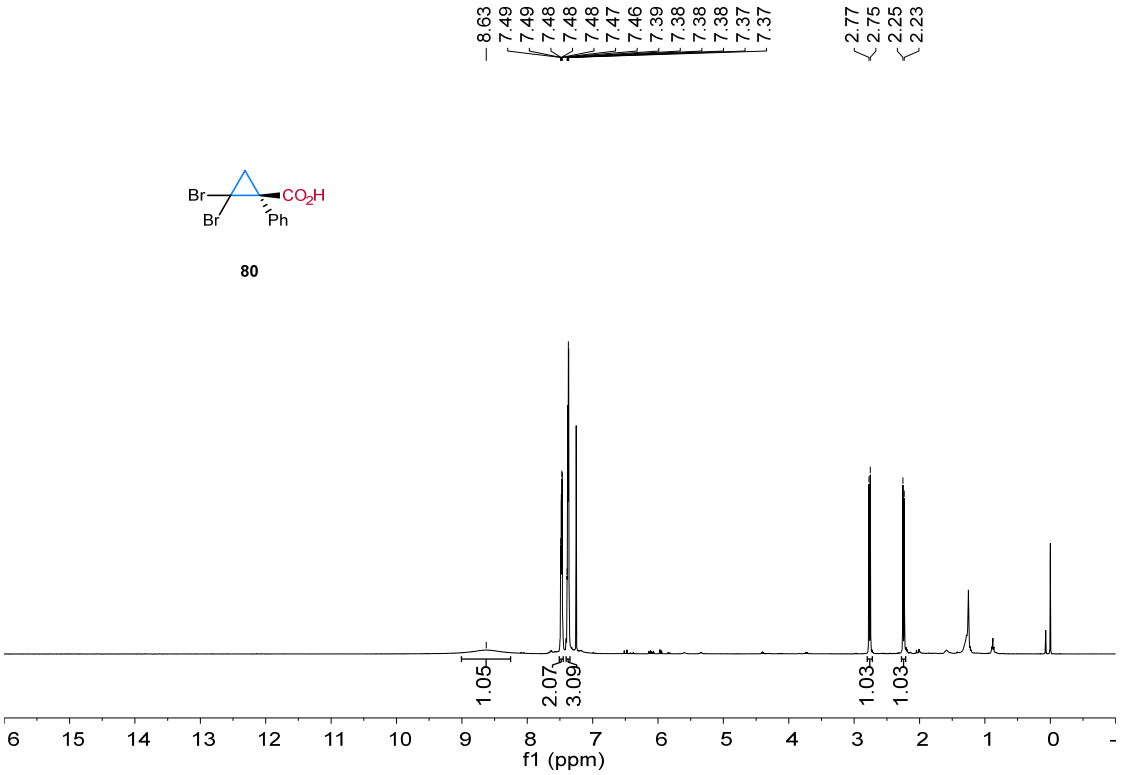
36.92
33.84
32.94
11.46
Br
Br
Et
Ph
79
f1 (ppm)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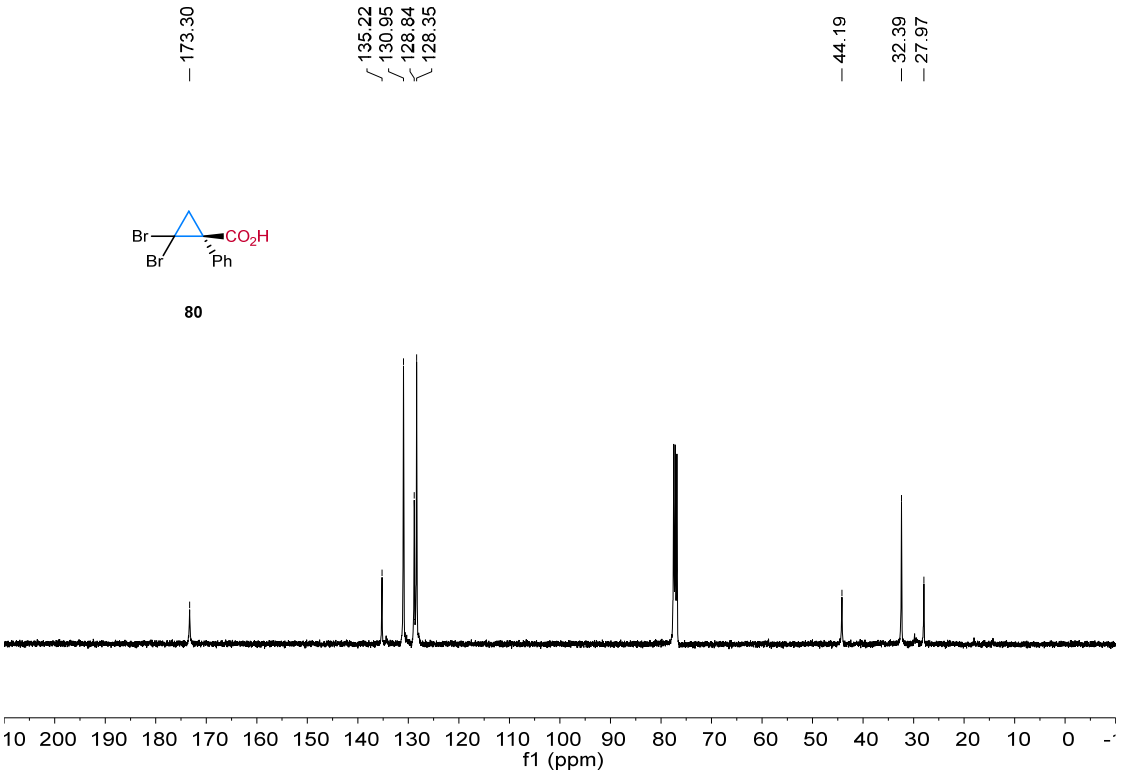
7.49
7.48
7.48
7.48
7.47
7.46
7.39
7.38
7.38
7.38
7.37
7.37
2.77
2.75
2.25
2.23
Br
Br
CO2H
Ph
80
1.05
2.07
3.09
1.03
1.03
f1 (ppm)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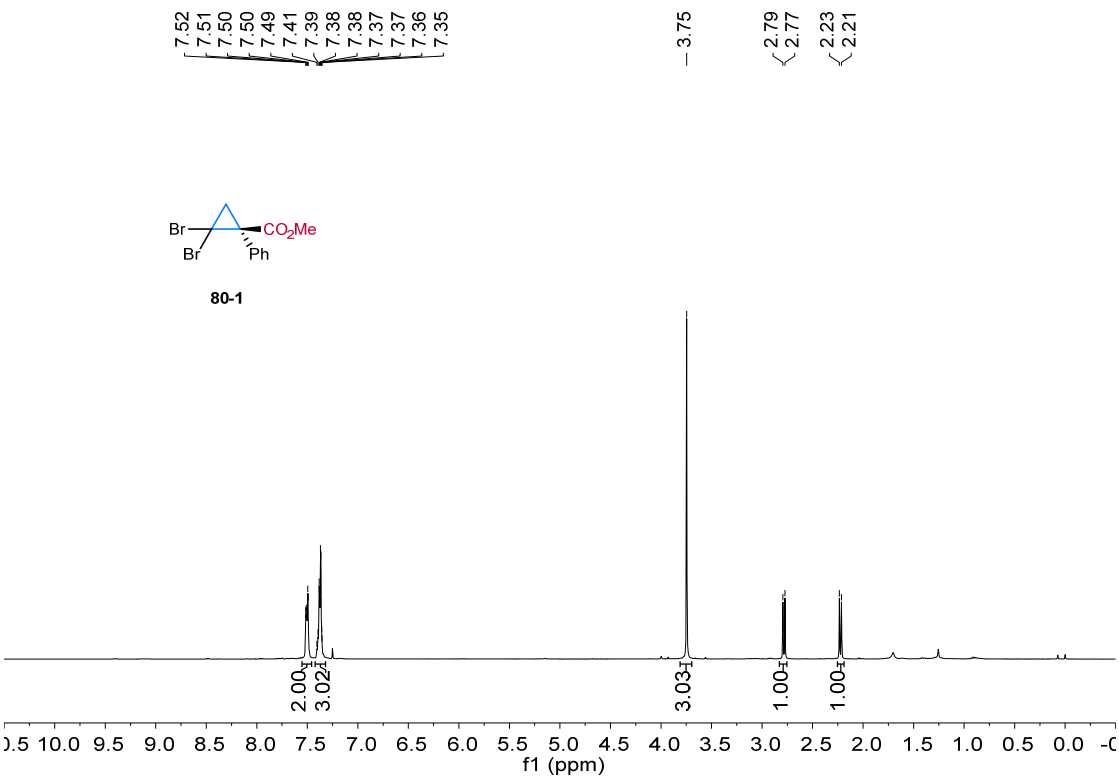
128.84
128.35
44.19
32.39
27.97
Br
Br
CO2H
Ph
80
f1 (ppm)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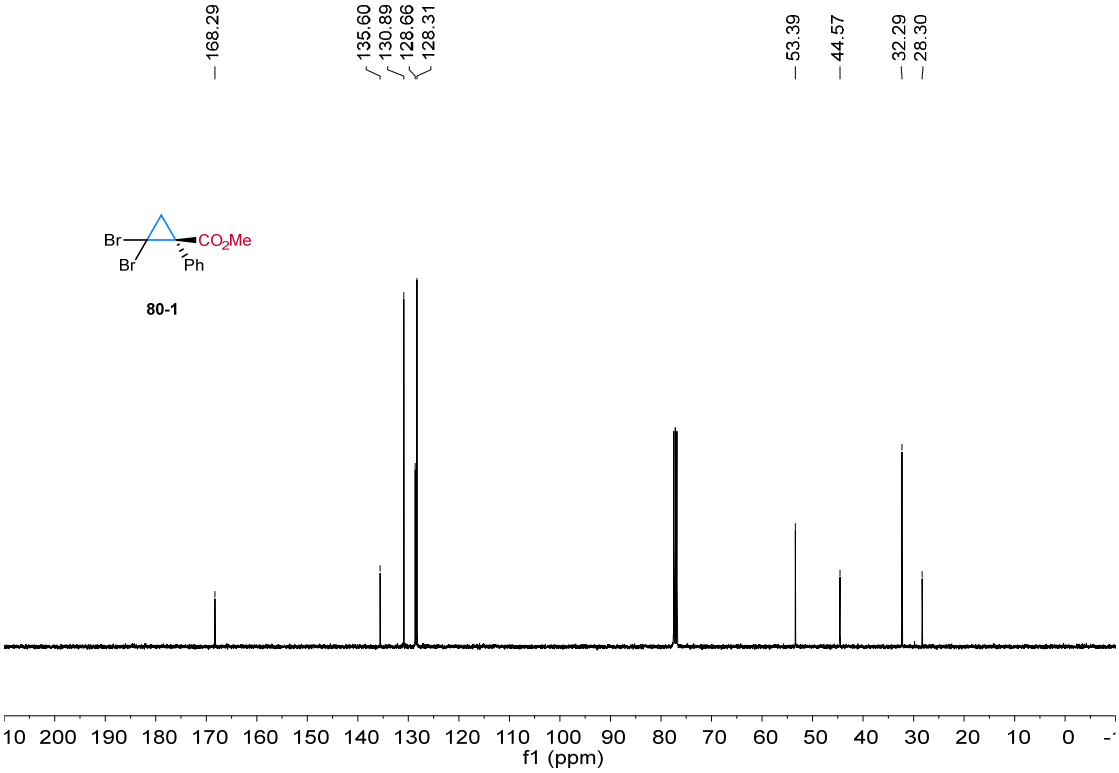
7.49
7.41
7.39
7.38
7.38
7.37
7.37
7.36
7.35
3.75
2.79
2.77
2.23
2.21
Br
Br
CO2Me
Ph
80-1
2.00
3.02
3.03
1.00
1.00
f1 (ppm)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135.60
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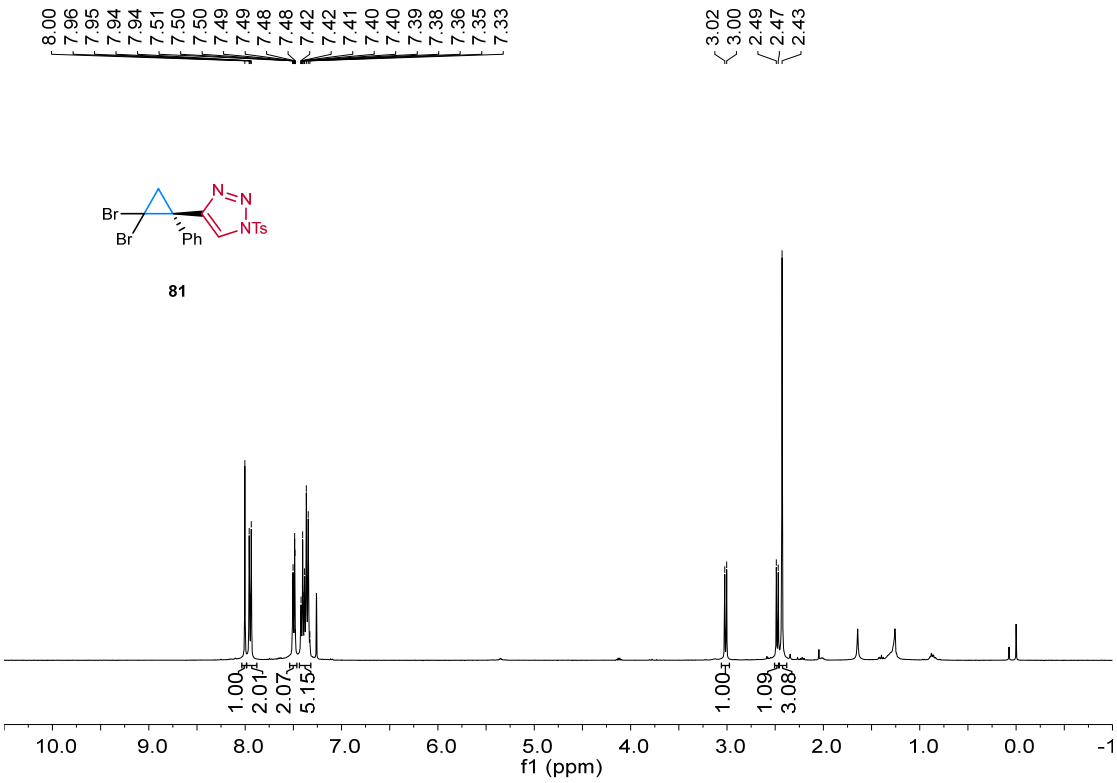
128.31
53.39
44.57
32.29
28.30
Br
Br
CO2Me
Ph
80-1
f1 (ppm)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7.96
7.95
7.94
7.94
7.51
7.50
7.50
7.49
7.49
7.48
7.48
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7.42
7.41
7.40
7.40
7.39
7.38
7.36
7.35
7.33
3.02
3.00
2.49
2.47
2.43
Br
Br
Ph
N
N
NTs
81
1.00
2.01
2.07
5.15
1.00
1.09
3.08
10.0
9.0
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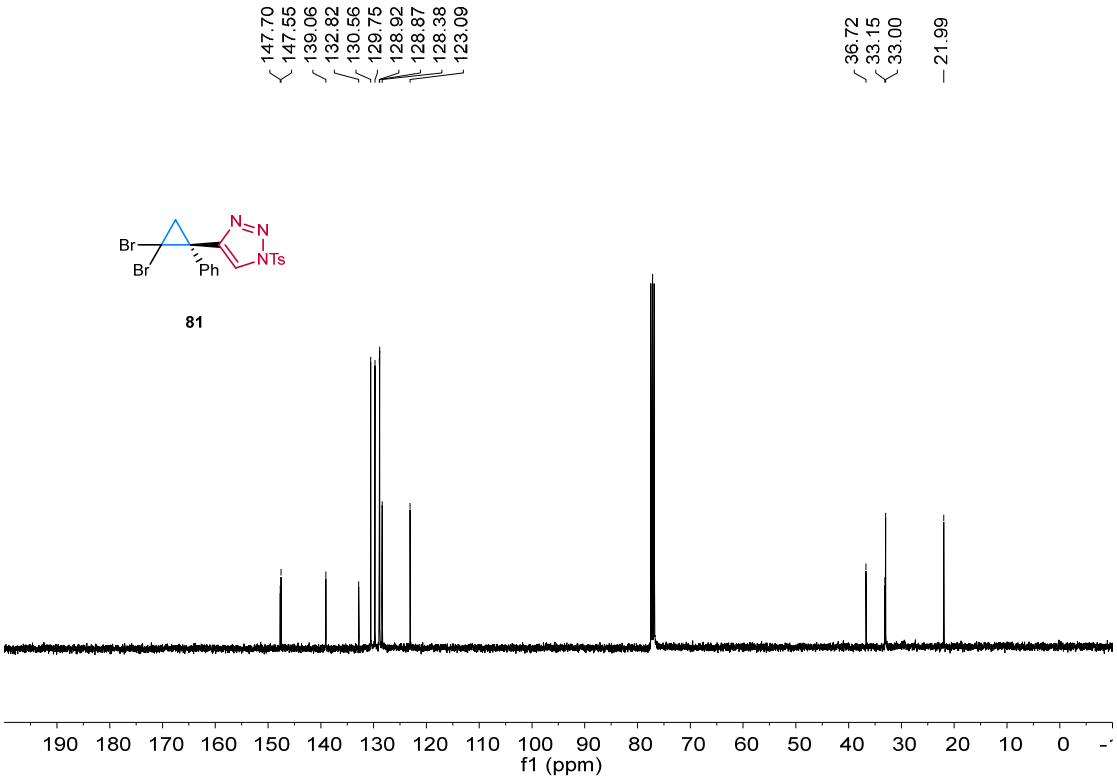
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)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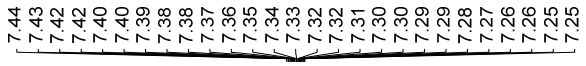
147.55
139.06
132.82
130.56
129.75
128.92
128.87
128.38
123.09
36.72
33.15
33.00
21.99
Br
Br
Ph
N
N
NTs
81
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.43
7.42
7.42
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7.40
7.39
7.38
7.38
7.37
7.36
7.35
7.34
7.33
7.32
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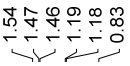
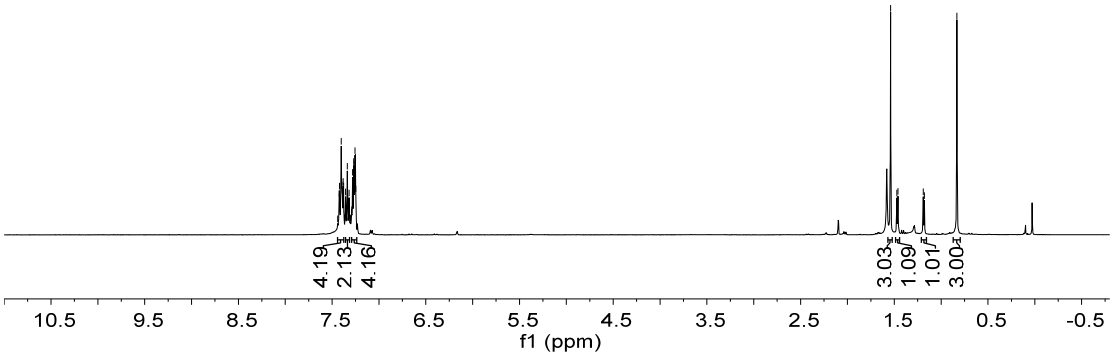
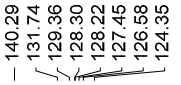
7.28
7.27
7.26
7.26
7.25
7.25


1.54
1.47
1.46
1.19
1.18
0.83


Me
Me
Ph

**82**


4.19
2.13
4.16
3.03
1.09
1.01
3.00
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
f1 (ppm)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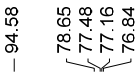
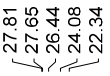
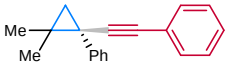
131.74
129.36
128.30
128.22
127.45
126.58
124.35


94.58

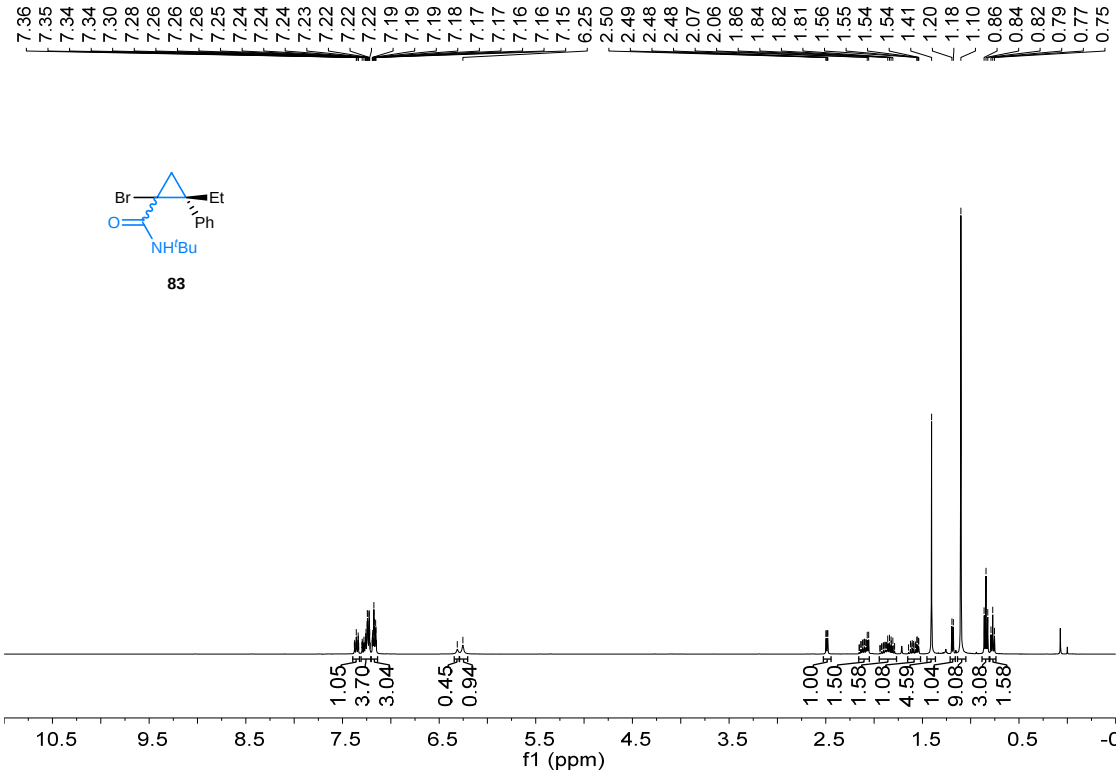

78.65
77.48
77.16
76.84

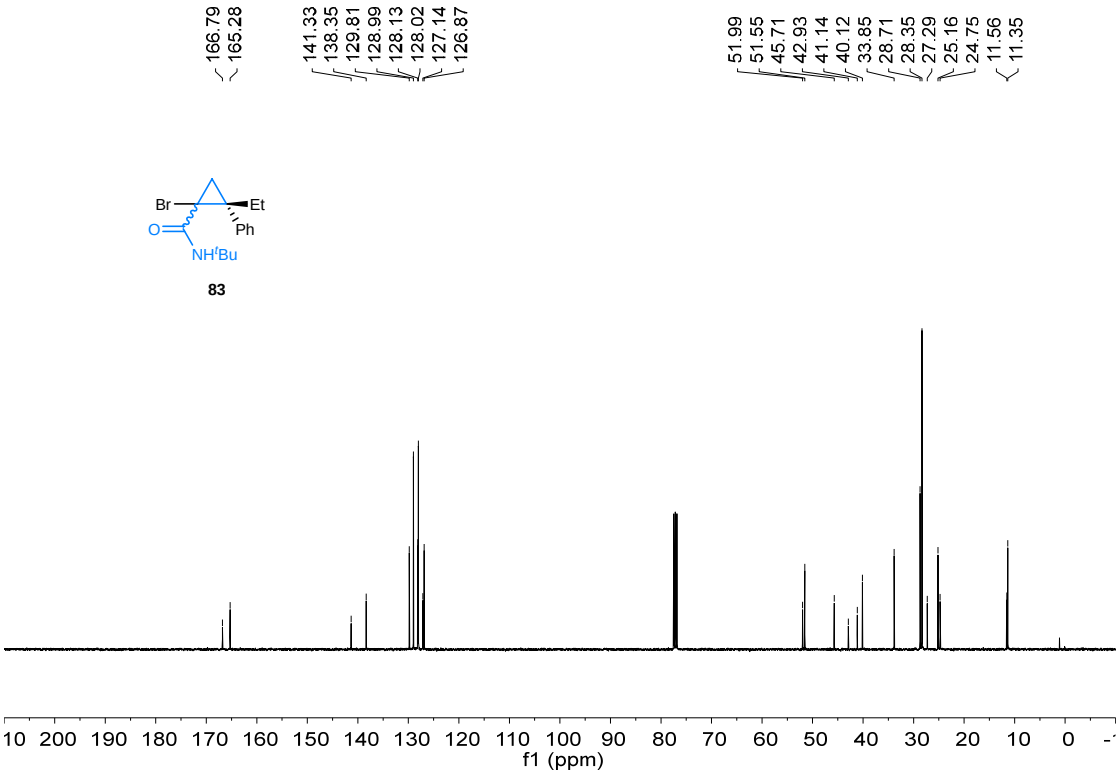

27.81
27.65
26.44
24.08
22.34

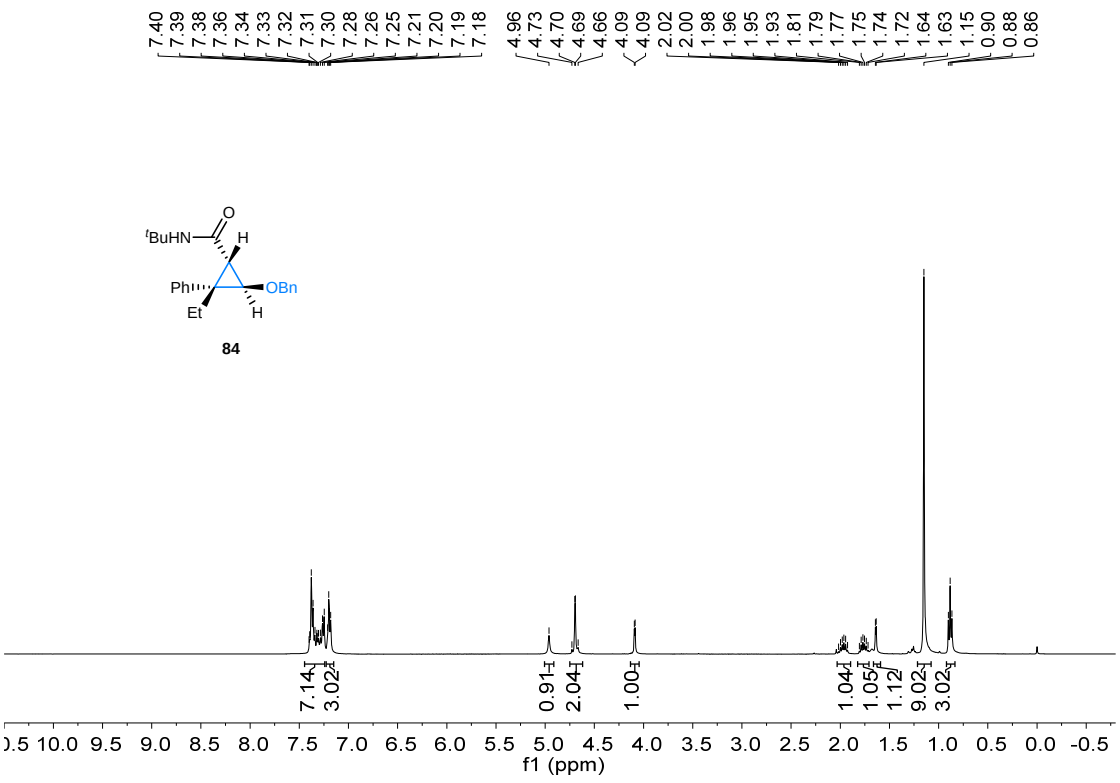

Me
Me
Ph

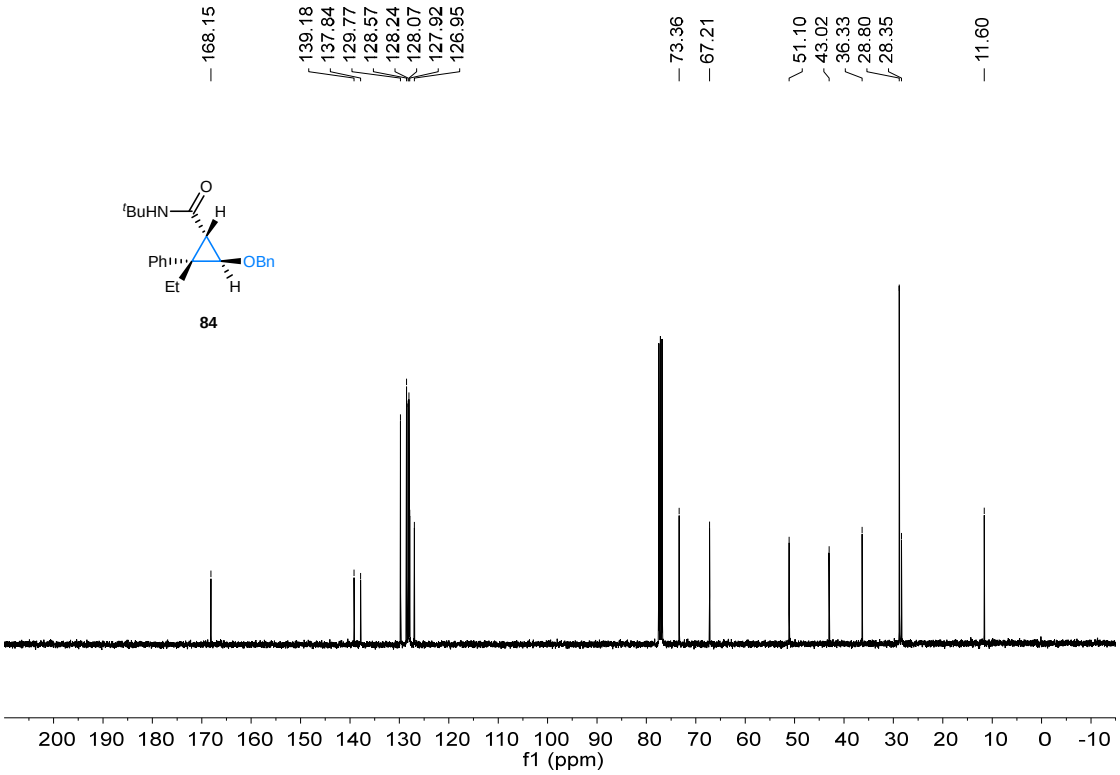
**82**

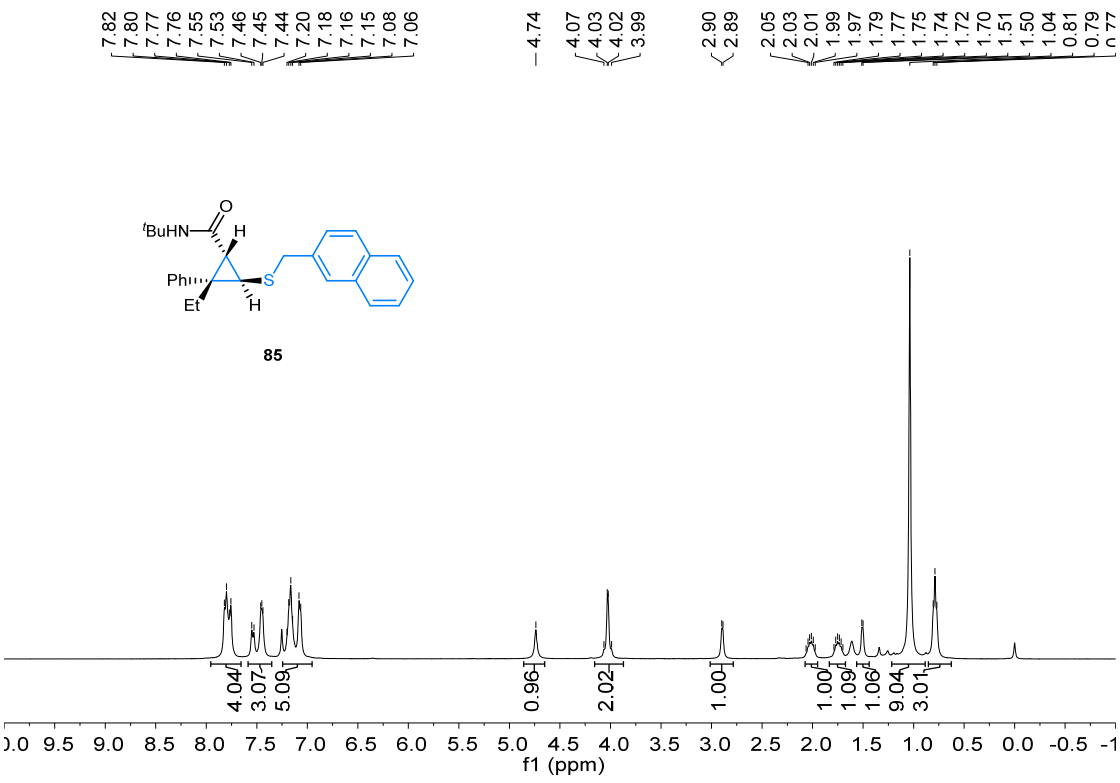

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.36 7.35 7.34 7.34 7.30 7.28 7.26 7.26 7.26 7.25 7.24 7.24 7.24 7.23 7.22 7.22 7.22 7.19 7.19 7.19 7.18 7.17 7.17 7.16 7.16 7.15 6.25 2.50 2.49 2.48 2.48 2.07 2.06 1.86 1.84 1.82 1.81 1.56 1.55 1.54 1.54 1.41 1.20 1.18 1.10 0.86 0.84 0.82 0.79 0.77 0.75
Br
Et
Ph
O
NHᵗBu
83
1.05 3.70 3.04 0.45 0.94 1.00 1.50 1.58 1.08 4.59 1.04 9.08 3.08 1.58
10.5 9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)


166.79 165.28 141.33 138.35 129.81 128.99 128.13 128.02 127.14 126.87 51.99 51.55 45.71 42.93 41.14 40.12 33.85 28.71 28.35 27.29 25.16 24.75 11.56 11.35
Br
Et
Ph
O
NHᵗBu
83
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.40 7.39 7.38 7.36 7.34 7.33 7.32 7.31 7.30 7.28 7.26 7.25 7.21 7.20 7.19 7.18
4.96 4.73 4.70 4.69 4.66 4.09 4.09
2.02 2.00 1.98 1.96 1.95 1.93 1.81 1.79 1.77 1.75 1.74 1.72 1.64 1.63 1.15 0.90 0.88 0.86
tBuHN
O
H
Ph
OBn
Et
H
84
7.14 3.02 0.91 2.04 1.00 1.04 1.05 1.12 9.02 3.02
f1 (ppm)


168.15
139.18 137.84 129.77 128.57 128.24 128.07 127.92 126.95
73.36 67.21
51.10 43.02 36.33 28.80 28.35
11.60
tBuHN
O
H
Ph
OBn
Et
H
84
f1 (ppm)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7.76
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7.53
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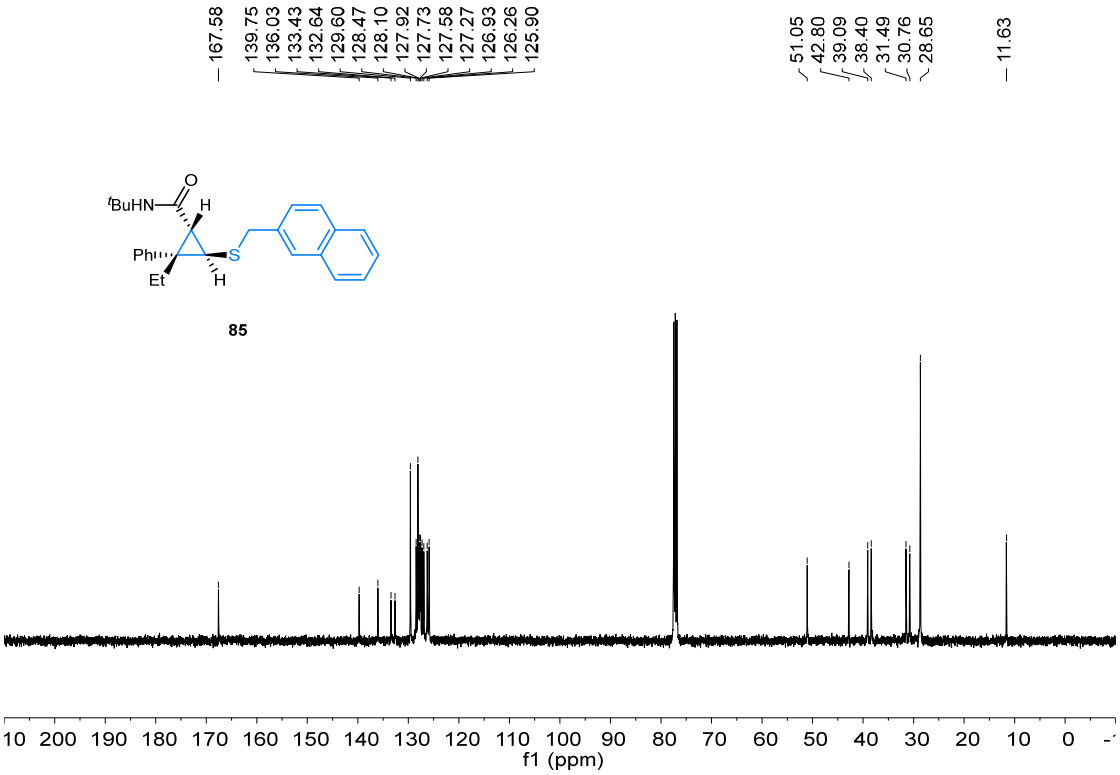
7.45
7.44
7.20
7.18
7.16
7.15
7.08
7.06
4.74
4.07
4.03
4.02
3.99
2.90
2.89
2.05
2.03
2.01
1.99
1.97
1.79
1.77
1.75
1.74
1.72
1.70
1.51
1.50
1.04
0.81
0.79
tBuHN
O
H
Ph
Et
S
H
4.04
3.07
5.09
0.96
2.02
1.00
1.00
1.09
1.06
9.04
3.01
f1 (ppm)

85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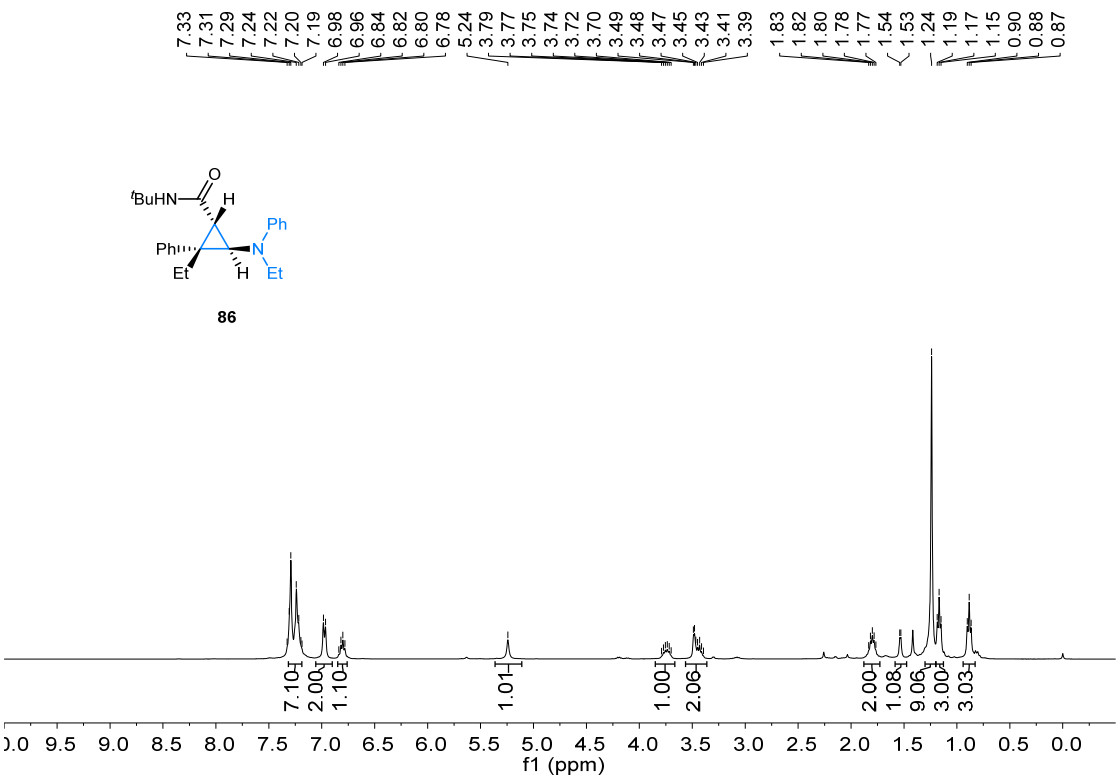
133.43
132.64
129.60
128.47
128.10
127.92
127.73
127.58
127.27
126.93
126.26
125.90
51.05
42.80
39.09
38.40
31.49
30.76
28.65
11.63
tBuHN
O
H
Ph
Et
S
H
f1 (ppm)

85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7.20
7.19
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6.96
6.84
6.82
6.80
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5.24
3.79
3.77
3.75
3.74
3.72
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3.48
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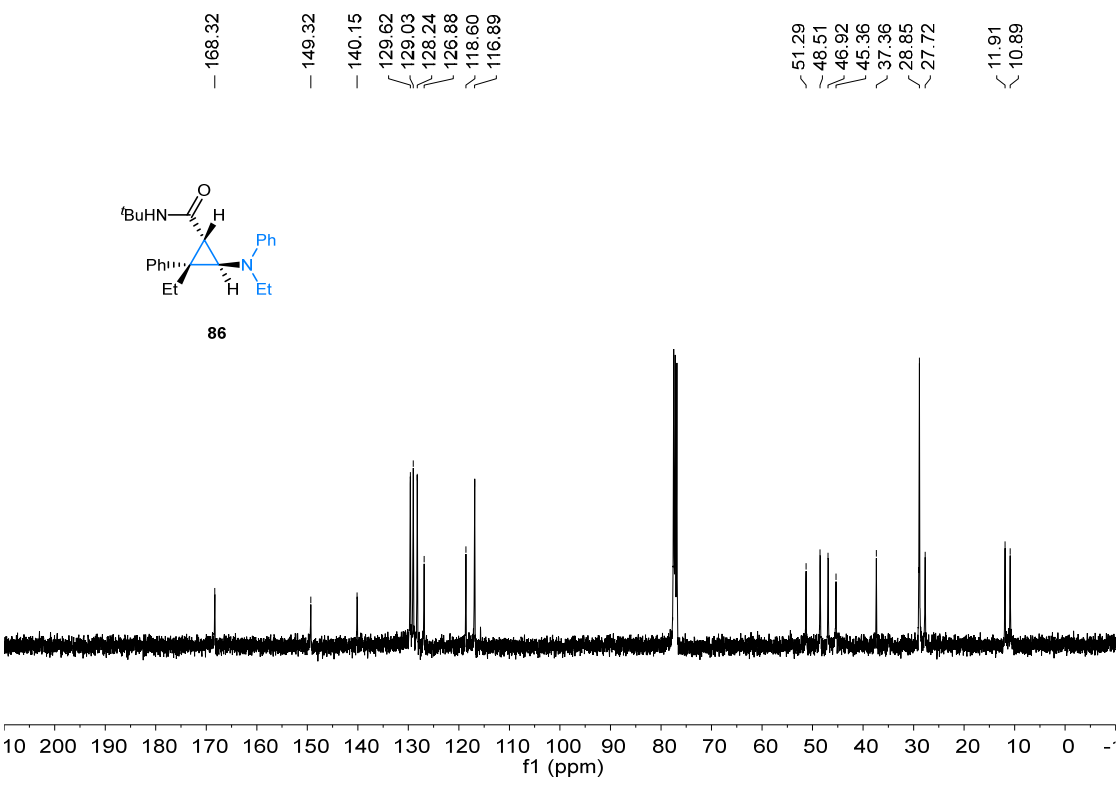
3.45
3.43
3.41
3.39
1.83
1.82
1.80
1.78
1.77
1.54
1.53
1.24
1.19
1.17
1.15
0.90
0.88
0.87
tBuHN
O
H
Ph
Ph
N
Et
Et
H
7.10
2.00
1.10
1.01
1.00
2.06
2.00
1.08
9.06
3.00
3.03
f1 (ppm)

**86**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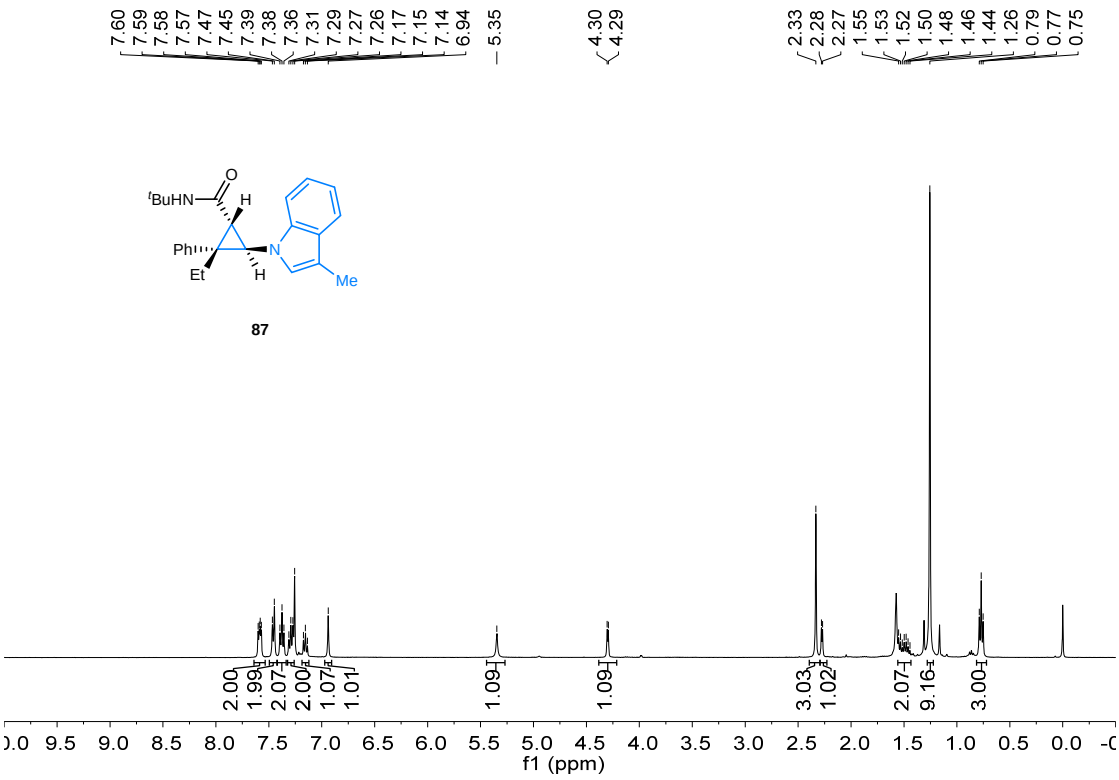
140.15
129.62
129.03
128.24
126.88
118.60
116.89
51.29
48.51
46.92
45.36
37.36
28.85
27.72
11.91
10.89
tBuHN
O
H
Ph
Ph
N
Et
Et
H
f1 (ppm)

**86**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7.59
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7.57
7.47
7.45
7.39
7.38
7.36
7.31
7.29
7.27
7.26
7.17
7.15
7.14
6.94
5.35
4.30
4.29
2.33
2.28
2.27
1.55
1.53
1.52
1.50
1.48
1.46
1.44
1.26
0.79
0.77
0.75
tBuHN
O
H
Ph
Et
H
N
Me
87
2.00
1.99
2.07
2.00
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1.01
1.09
1.09
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1.02
2.07
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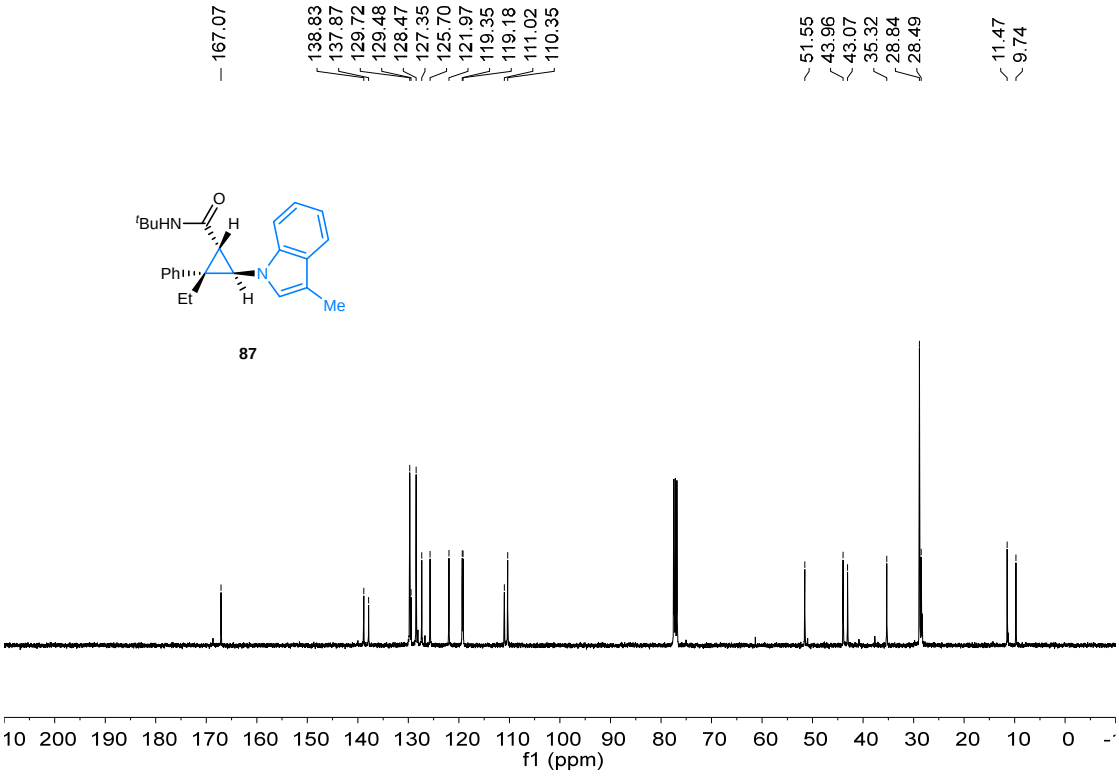
3.00
f1 (ppm)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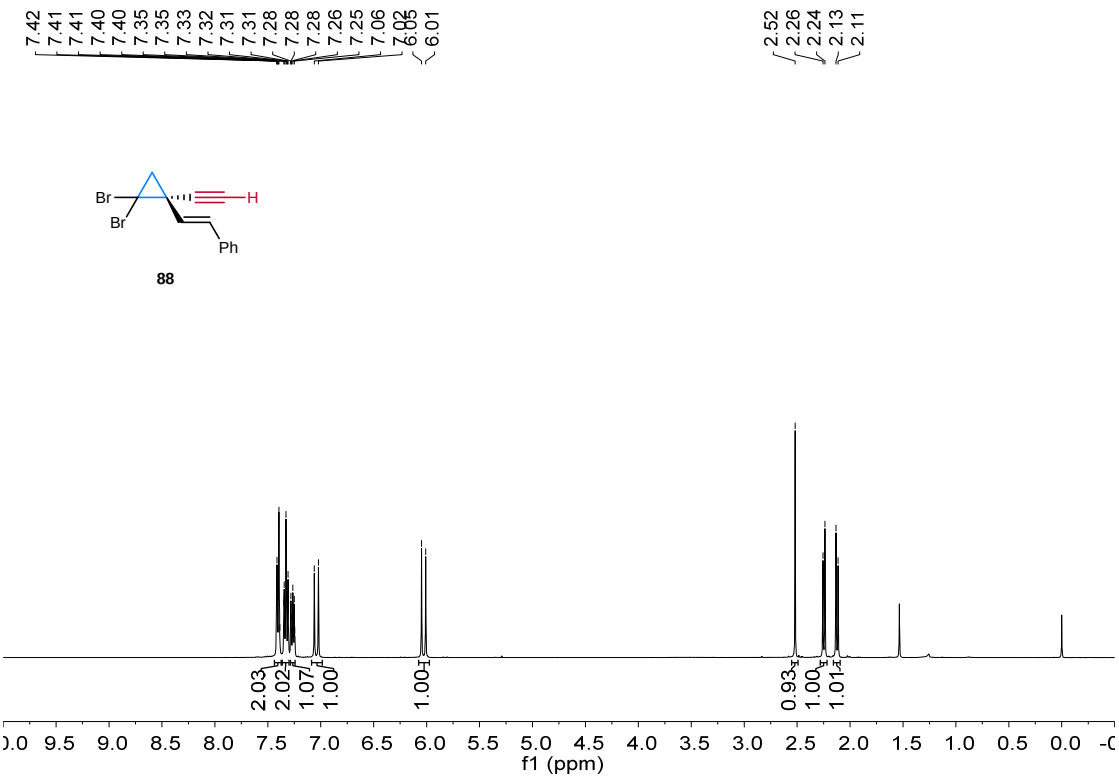
129.72
129.48
128.47
127.35
125.70
121.97
119.35
119.18
111.02
110.35
51.55
43.96
43.07
35.32
28.84
28.49
11.47
9.74
tBuHN
O
H
Ph
Et
H
N
Me
87
f1 (ppm)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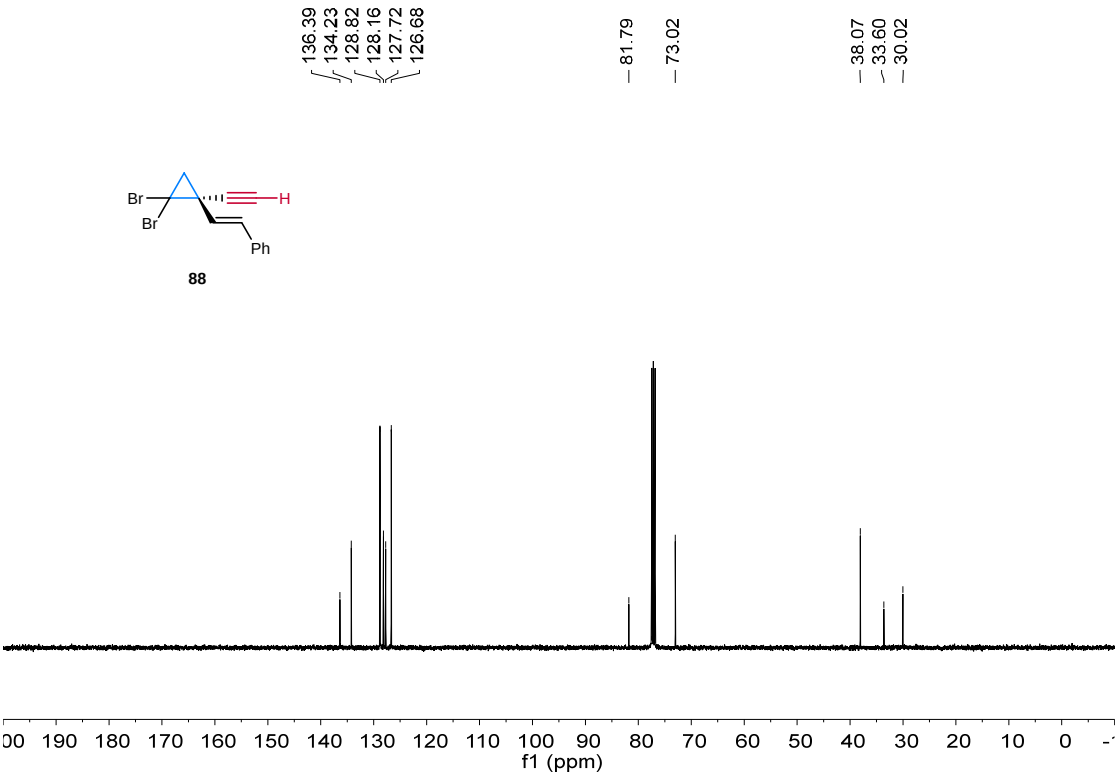
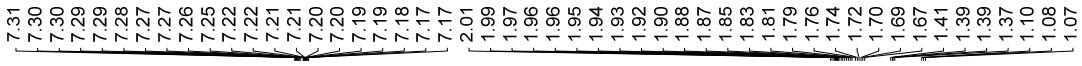
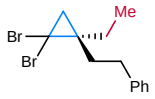
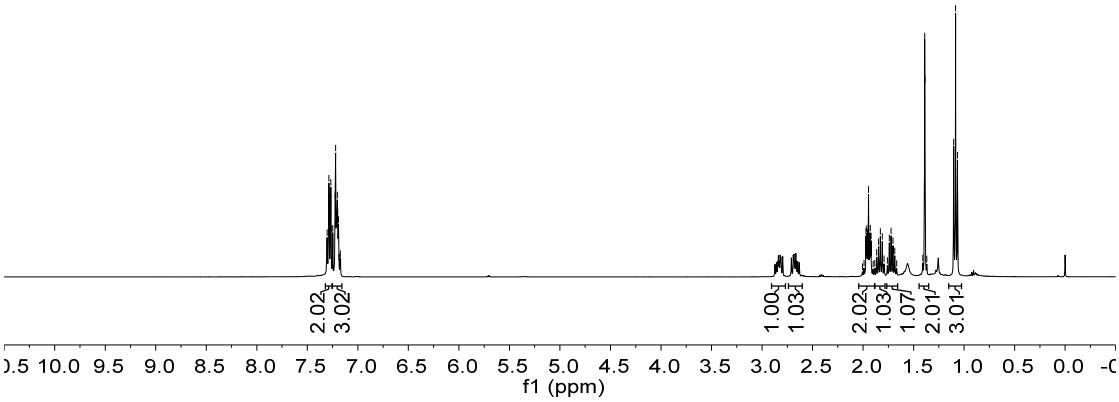
7.28
7.28
7.26
7.25
7.06
7.02
6.05
6.01
2.52
2.26
2.24
2.13
2.11
Br
Br
H
Ph
88
2.03
2.02
1.07
1.00
1.00
0.93
1.00
1.01
f1 (ppm)


136.39
134.23
128.82
128.16
127.72
126.68
81.79
73.02
38.07
33.60
30.02
Br
Br
H
Ph
88
f1 (ppm)


7.31 7.30 7.30 7.29 7.29 7.28 7.27 7.27 7.26 7.25 7.22 7.22 7.21 7.21 7.20 7.20 7.19 7.19 7.18 7.17 7.17
2.01 1.99 1.97 1.96 1.96 1.95 1.94 1.93 1.92 1.90 1.88 1.87 1.85 1.83 1.81 1.79 1.76 1.74 1.72 1.70 1.69 1.67 1.41 1.39 1.39 1.37 1.10 1.08 1.07


Me
Br
Br
Ph

**89**


2.02
3.02
1.00
1.03
2.02
1.03
1.07
2.01
3.01
f1 (ppm)


141.86
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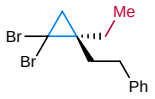
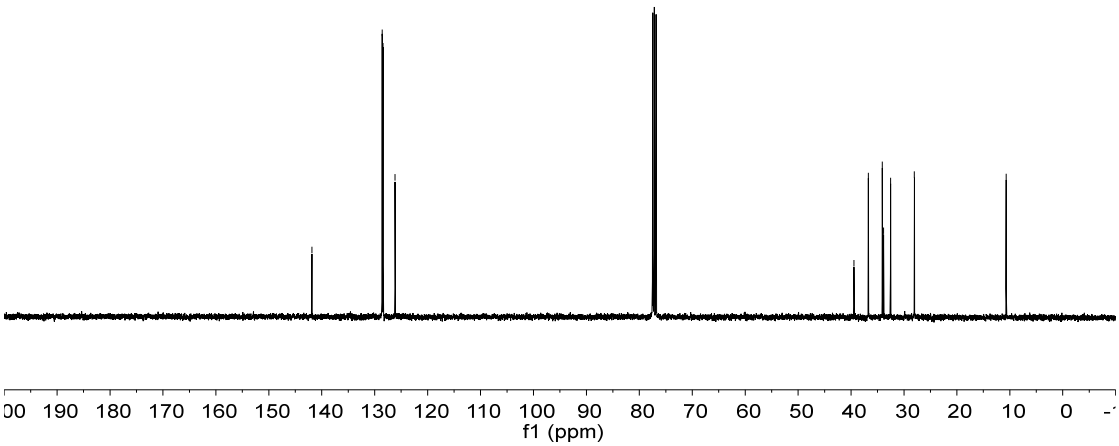
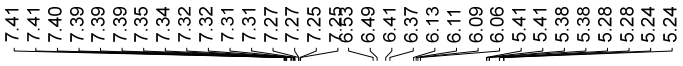
128.41
126.16
39.46
36.74
34.09
33.85
32.54
28.04
10.69


Me
Br
Br
Ph

**89**


f1 (ppm)


7.41
7.41
7.40
7.39
7.39
7.39
7.35
7.34
7.32
7.32
7.31
7.31
7.27
7.27
7.25
6.53
6.49
6.41
6.37
6.13
6.11
6.09
6.06
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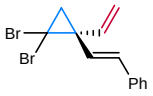
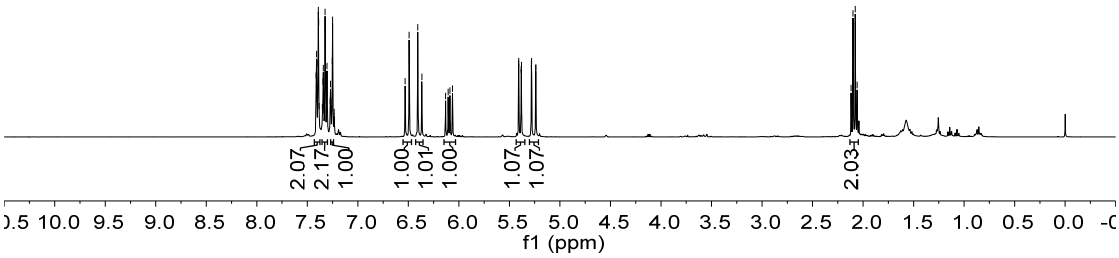
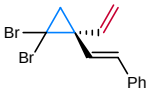
5.28
5.24
5.24
2.12
2.10
2.08
2.06


Br
Br
Ph

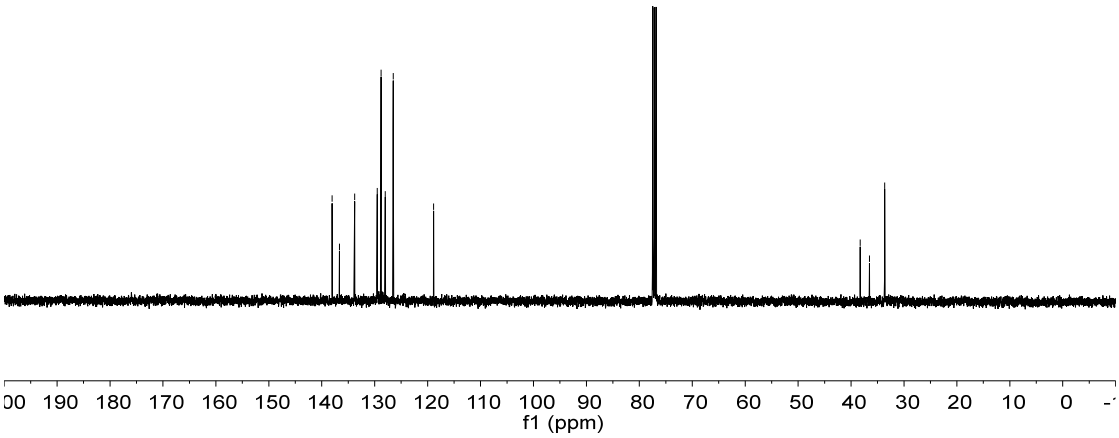
**90**

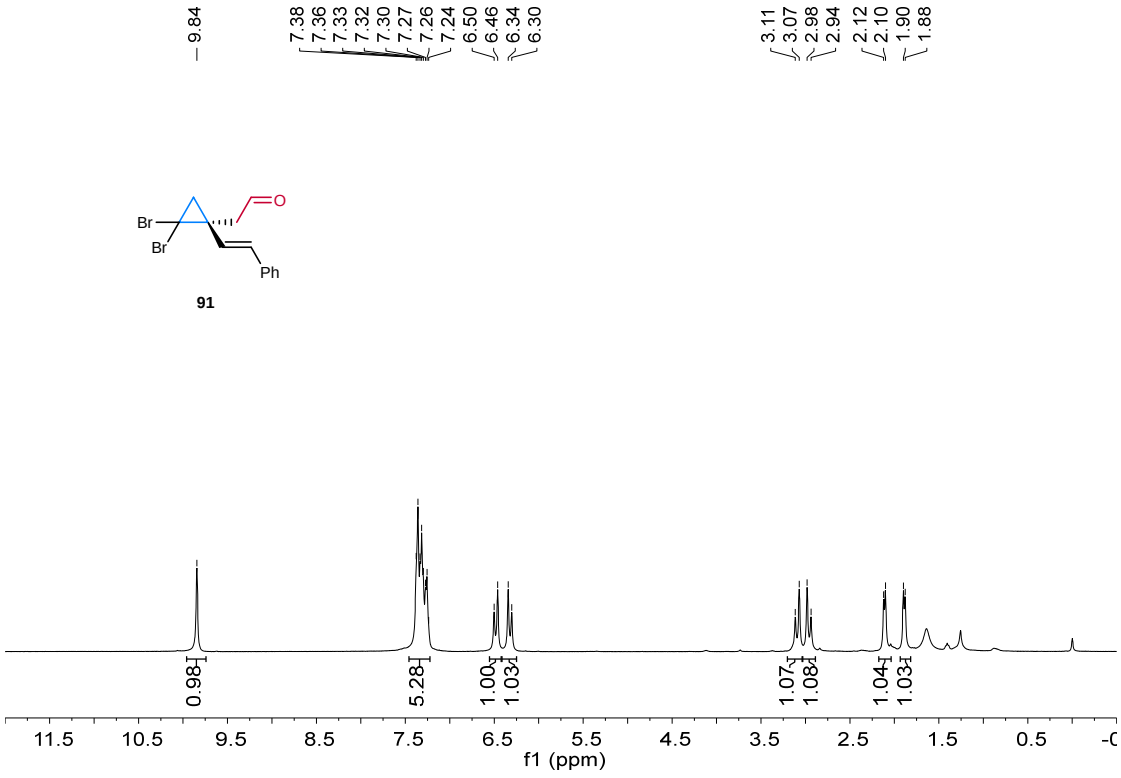

2.07
2.17
1.00
1.00
1.01
1.00
1.07
1.07
2.03
f1 (ppm)

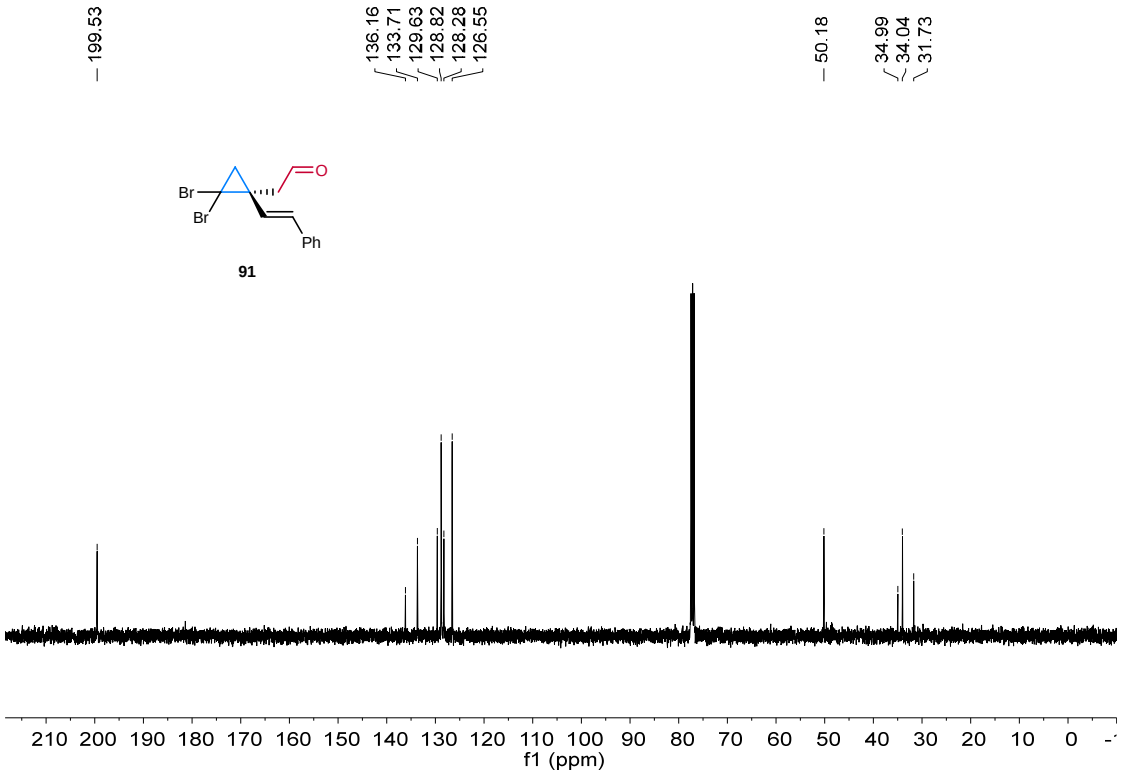

138.03
136.67
133.79
129.53
128.80
128.02
126.50
118.87
38.28
36.53
33.65

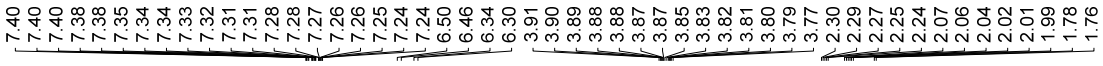

Br
Br
Ph

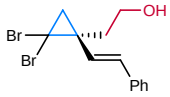
**90**


f1 (ppm)

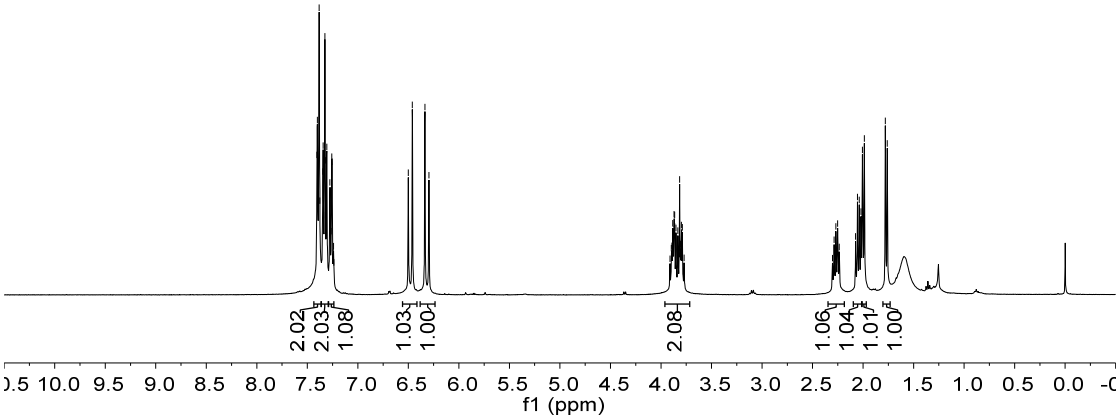

9.84
7.38
7.36
7.33
7.32
7.30
7.27
7.26
7.24
6.50
6.46
6.34
6.30
3.11
3.07
2.98
2.94
2.12
2.10
1.90
1.88
Br
Br
O
Ph
91
0.98
5.28
1.00
1.03
1.07
1.08
1.04
1.03
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)


199.53
136.16
133.71
129.63
128.82
128.28
126.55
50.18
34.99
34.04
31.73
Br
Br
O
Ph
91
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

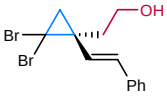

7.40
7.40
7.40
7.38
7.38
7.35
7.34
7.34
7.33
7.32
7.31
7.31
7.28
7.28
7.27
7.26
7.26
7.25
7.24
7.24
6.50
6.46
6.34
6.30
3.91
3.90
3.89
3.88
3.88
3.87
3.87
3.85
3.83
3.82
3.81
3.80
3.79
3.77
2.30
2.29
2.27
2.25
2.24
2.07
2.06
2.04
2.02
2.01
1.99
1.78
1.76


OH
Br
Br
Ph

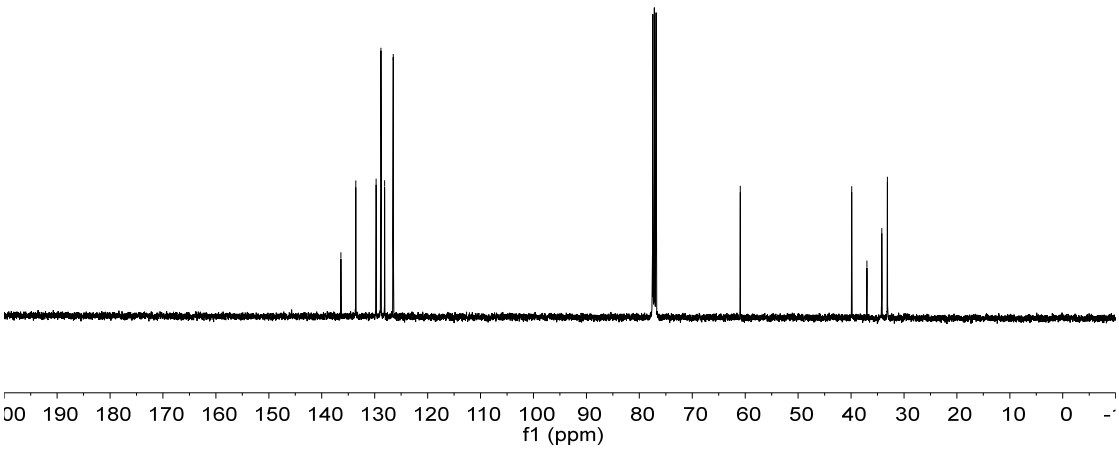
92

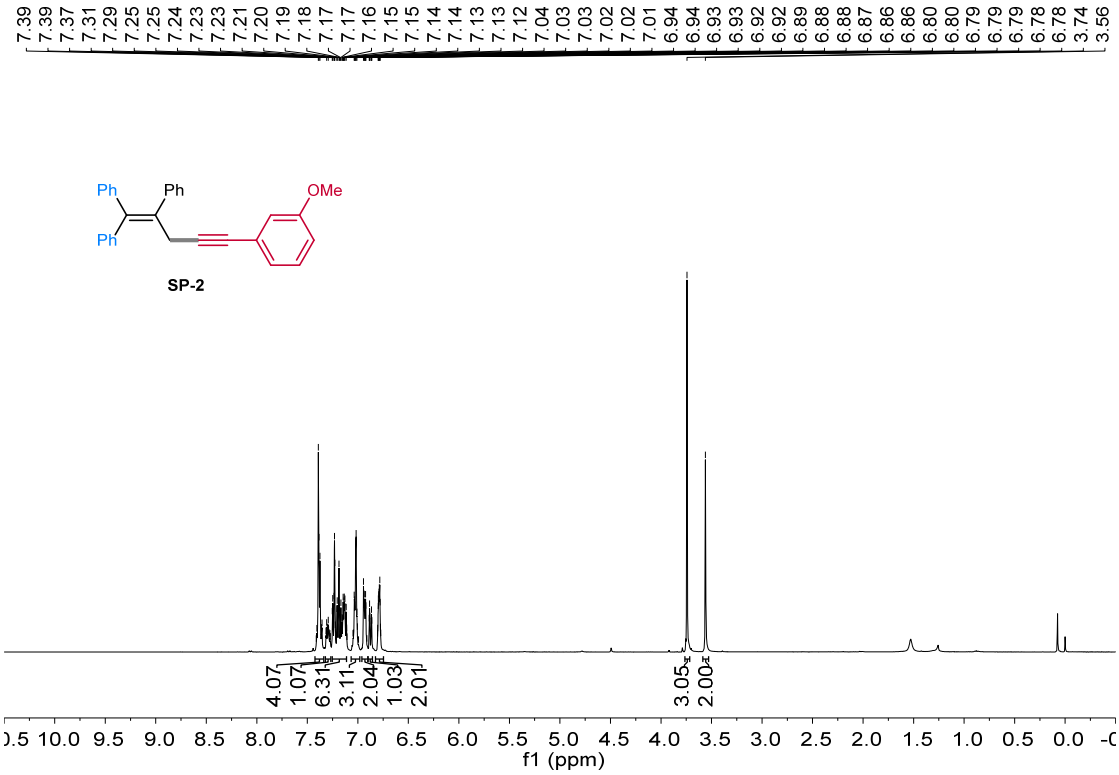

2.02
2.03
1.08
1.03
1.00
2.08
1.06
1.04
1.01
1.00
f1 (ppm)

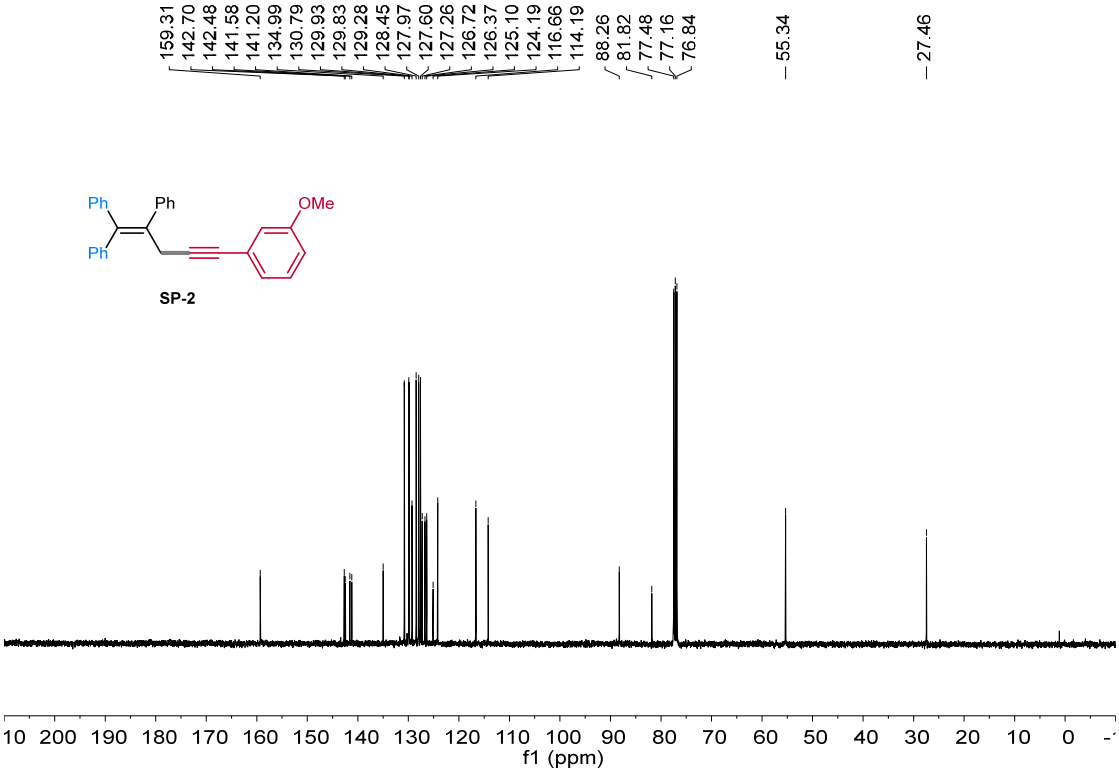

136.38
133.56
129.72
128.83
128.13
126.50
60.93
39.86
37.00
34.20
33.12


OH
Br
Br
Ph

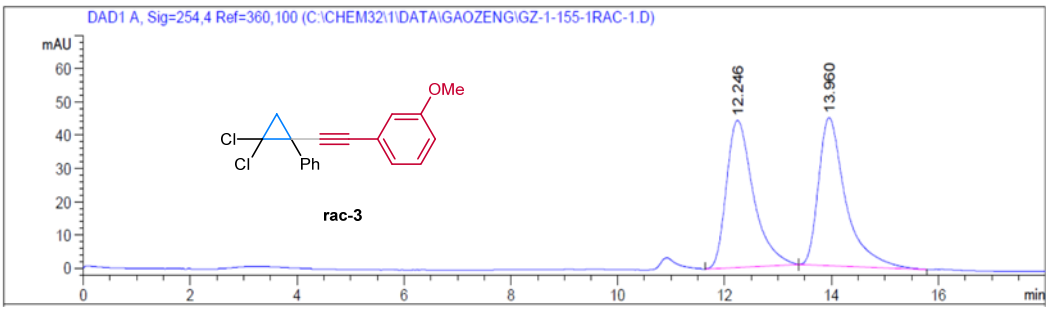
92


f1 (ppm)


7.39
7.39
7.37
7.31
7.29
7.25
7.25
7.24
7.23
7.23
7.21
7.20
7.19
7.18
7.17
7.17
7.16
7.15
7.15
7.14
7.14
7.13
7.13
7.12
7.04
7.03
7.03
7.02
7.02
7.01
6.94
6.94
6.93
6.93
6.92
6.92
6.89
6.88
6.88
6.87
6.86
6.86
6.80
6.80
6.79
6.79
6.79
6.78
6.78
3.74
3.56
Ph
Ph
Ph
OMe
SP-2
4.07
1.07
6.31
3.11
2.04
1.03
2.01
3.05
2.00
f1 (ppm)

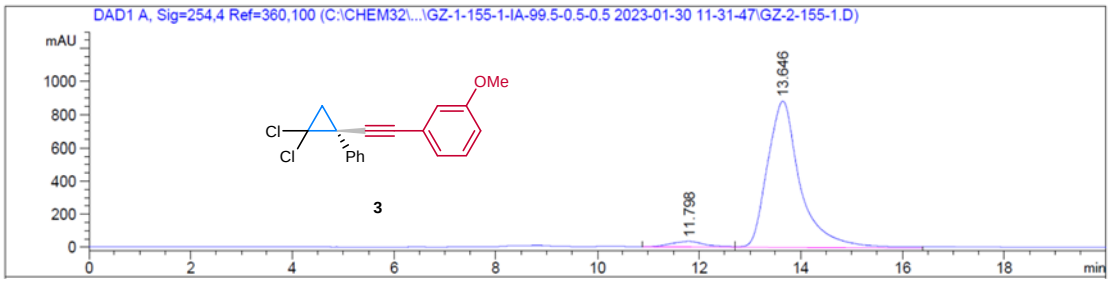

159.31
142.70
142.48
141.58
141.20
134.99
130.79
129.93
129.83
129.28
128.45
127.97
127.60
127.26
126.72
126.37
125.10
124.19
116.66
114.19
88.26
81.82
77.48
77.16
76.84
55.34
27.46
Ph
Ph
Ph
OMe
SP-2
f1 (ppm)

# HPLC spectra



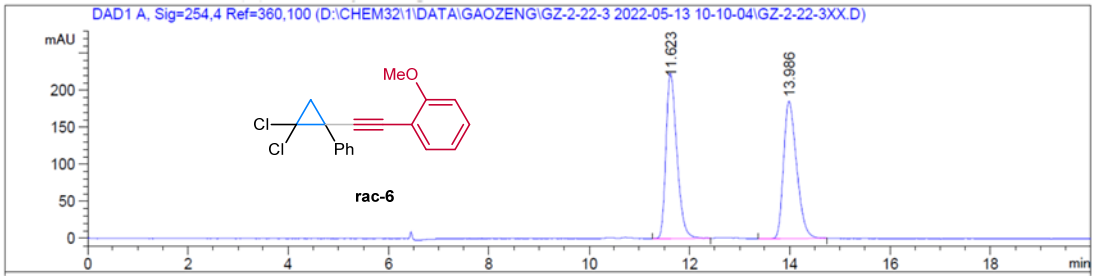

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.246 | BB | 0.5260 | 1544.36060 | 44.16593 | 49.6701 |
| 2 | 13.960 | BB | 0.5227 | 1564.87415 | 44.45662 | 50.3299 |
| Totals : | | | | 3109.23474 | 88.62255 | |



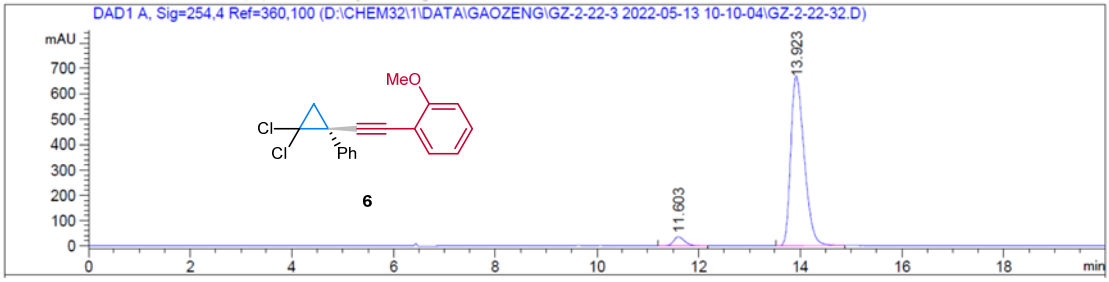

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.798 | MF R | 0.7599 | 1536.05957 | 33.68901 | 3.7116 |
| 2 | 13.646 | MF R | 0.7511 | 3.98491e4 | 884.19171 | 96.2884 |
| Totals : | | | | 4.13851e4 | 917.88072 | |



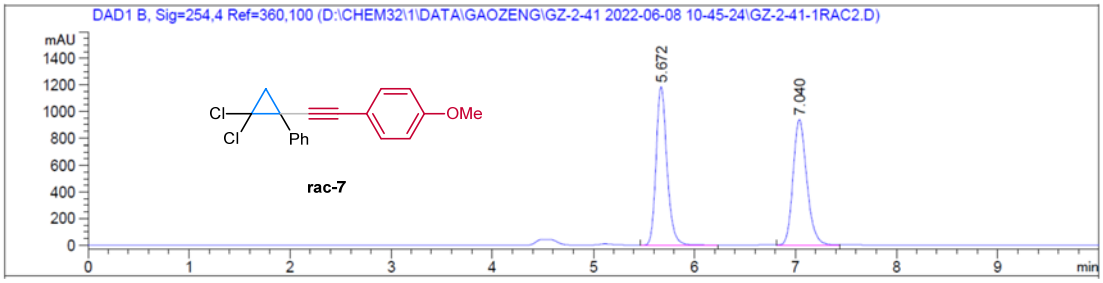

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.623 | BV R | 0.2307 | 3378.04517 | 223.04590 | 50.0734 |
| 2 | 13.986 | VV R | 0.2780 | 3368.13892 | 185.33647 | 49.9266 |
| Totals : | | | | 6746.18408 | 408.38237 | |



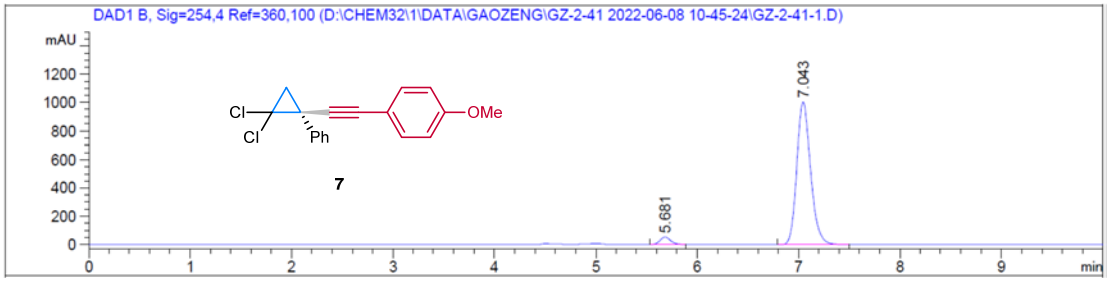

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.603 | VV R | 0.2291 | 530.98621 | 35.37651 | 4.1355 |
| 2 | 13.923 | BV R | 0.2844 | 1.23087e4 | 669.72052 | 95.8645 |
| Totals : | | | | 1.28397e4 | 705.09703 | |



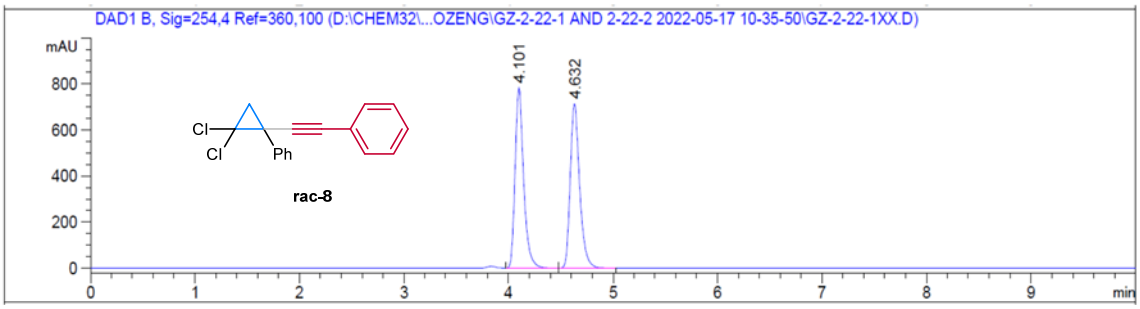

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 5.672 | BB | 0.1155 | 8890.93164 | 1185.70374 | 49.9534 |
| 2 | 7.040 | VV | 0.1466 | 8907.52246 | 939.64233 | 50.0466 |
| Totals : | | | | 1.77985e4 | 2125.34607 | |



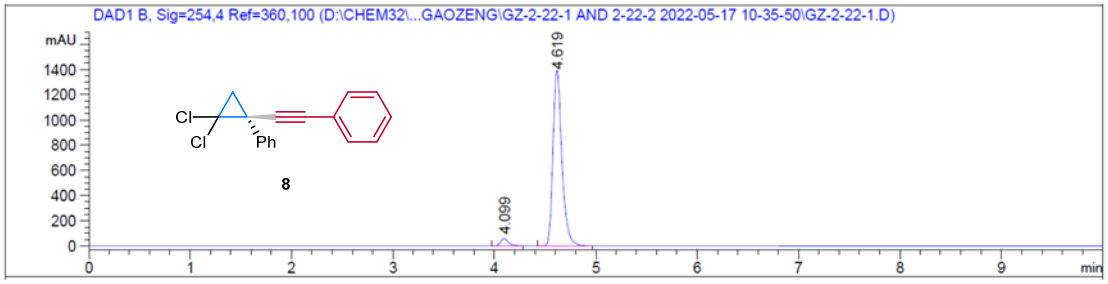

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 5.681 | FM R | 0.1227 | 395.08945 | 53.67612 | 3.9998 |
| 2 | 7.043 | MF R | 0.1574 | 9482.63281 | 1004.31403 | 96.0002 |
| Totals : | | | | 9877.72226 | 1057.99015 | |



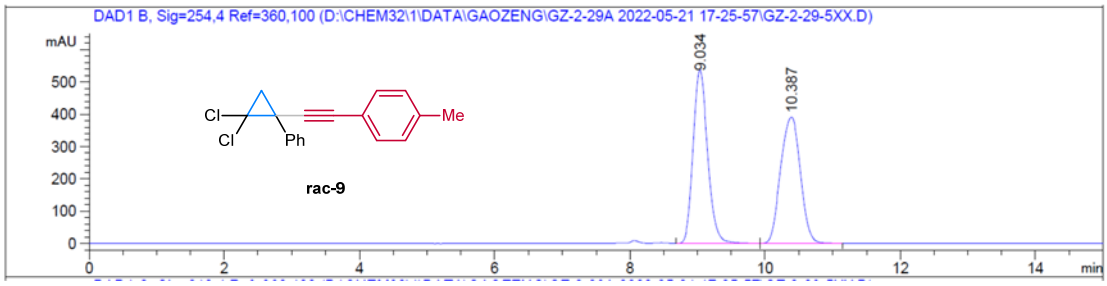

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.101 | VB | 0.0865 | 4453.23535 | 781.27679 | 49.9748 |
| 2 | 4.632 | BV | 0.0949 | 4457.73389 | 713.66992 | 50.0252 |
| Totals : | | | | 8910.96924 | 1494.94672 | |



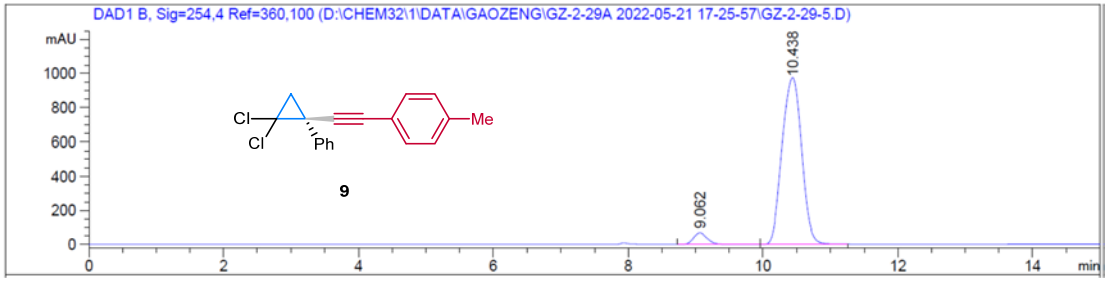

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.099 | MF R | 0.0920 | 331.92282 | 60.11448 | 3.7390 |
| 2 | 4.619 | MF R | 0.1017 | 8545.46777 | 1400.56592 | 96.2610 |
| Totals : | | | | 8877.39059 | 1460.68039 | |



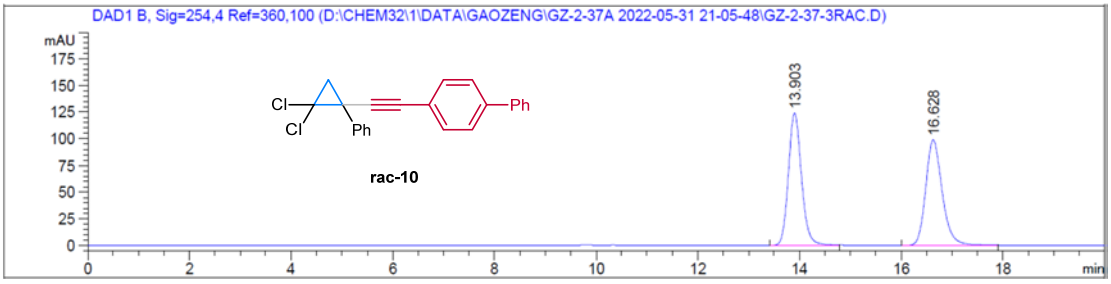

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.034 | BB | 0.2302 | 8008.40332 | 536.19440 | 50.2294 |
| 2 | 10.387 | MF R | 0.3388 | 7935.24414 | 390.34964 | 49.7706 |
| Totals : | | | | 1.59436e4 | 926.54404 | |



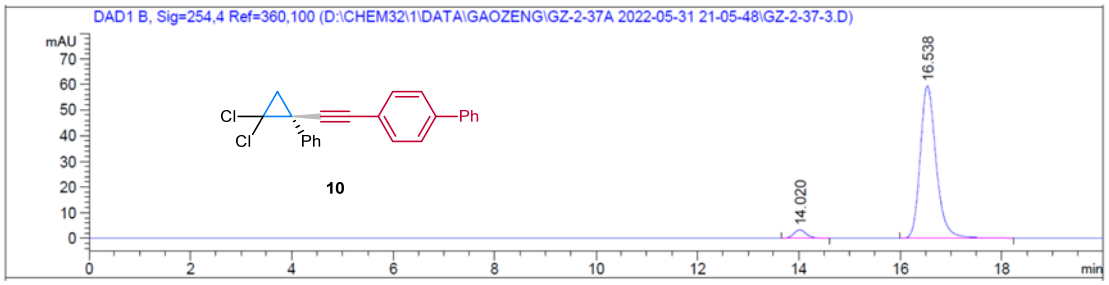

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.062 | BV | 0.2254 | 1015.55902 | 69.12321 | 4.8637 |
| 2 | 10.438 | MF R | 0.3386 | 1.98649e4 | 977.88190 | 95.1363 |
| Totals : | | | | 2.08805e4 | 1047.00511 | |



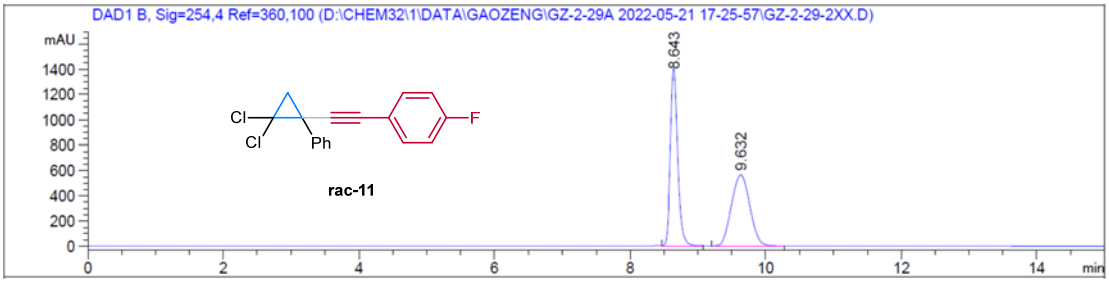

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.903 | MF R | 0.2996 | 2225.51001 | 123.81416 | 49.8069 |
| 2 | 16.628 | MF R | 0.3782 | 2242.76685 | 98.84414 | 50.1931 |
| Totals : | | | | 4468.27686 | 222.65830 | |



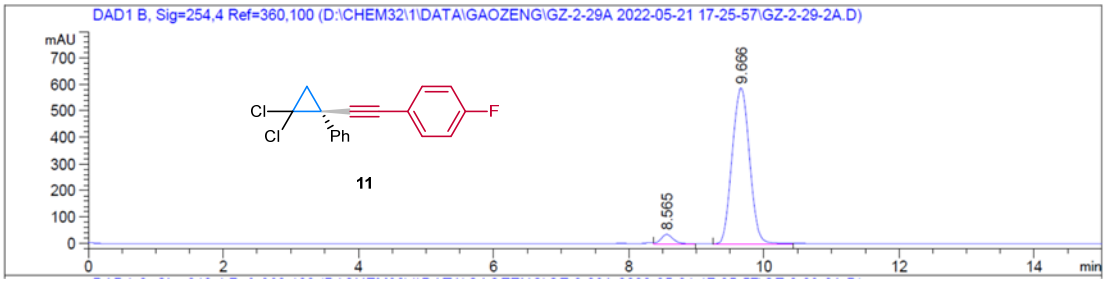

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 14.020 | BB | 0.2674 | 55.24406 | 3.23214 | 4.0889 |
| 2 | 16.538 | BB | 0.3321 | 1295.81409 | 59.48830 | 95.9111 |
| Totals : | | | | 1351.05815 | 62.72044 | |



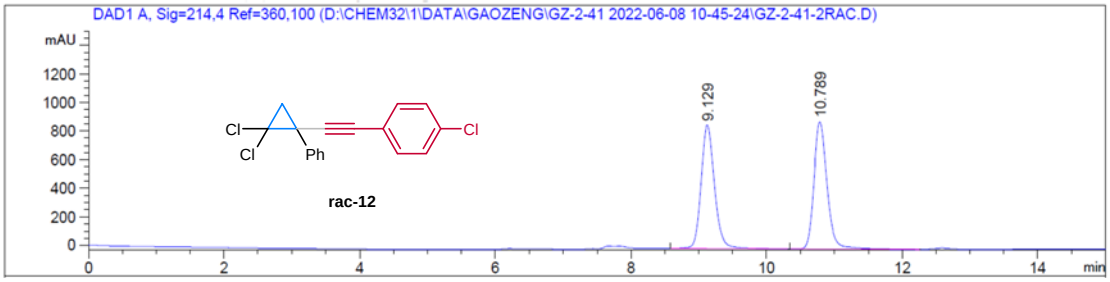

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.643 | VV | 0.1161 | 1.06235e4 | 1407.34534 | 49.8001 |
| 2 | 9.632 | VB | 0.3023 | 1.07087e4 | 567.00201 | 50.1999 |
| Totals : | | | | 2.13322e4 | 1974.34735 | |



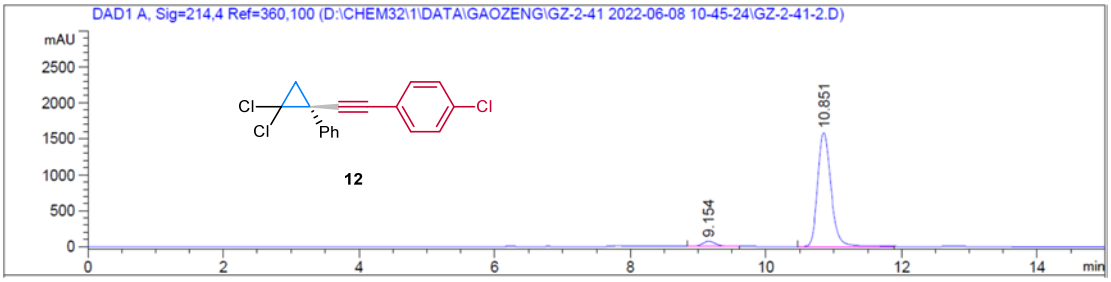

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.565 | VB | 0.1882 | 443.37091 | 35.86748 | 4.0536 |
| 2 | 9.666 | MF R | 0.2977 | 1.04944e4 | 587.56189 | 95.9464 |
| Totals : | | | | 1.09378e4 | 623.42937 | |



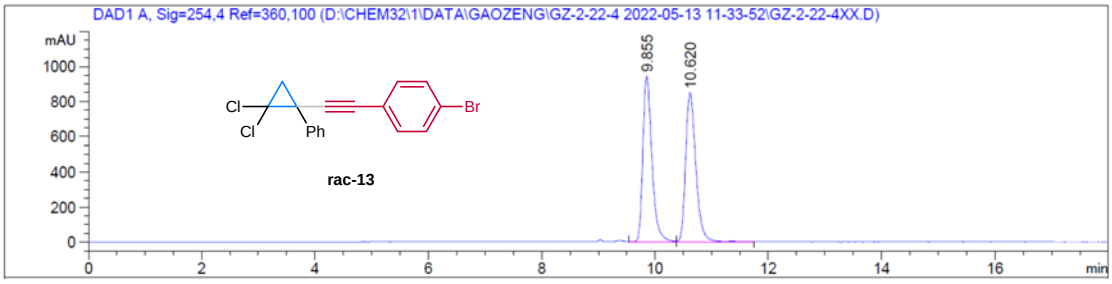

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.129 | BB | 0.2121 | 1.20356e4 | 866.39014 | 50.1464 |
| 2 | 10.789 | BB | 0.2067 | 1.19653e4 | 890.60474 | 49.8536 |
| Totals : | | | | 2.40010e4 | 1756.99487 | |



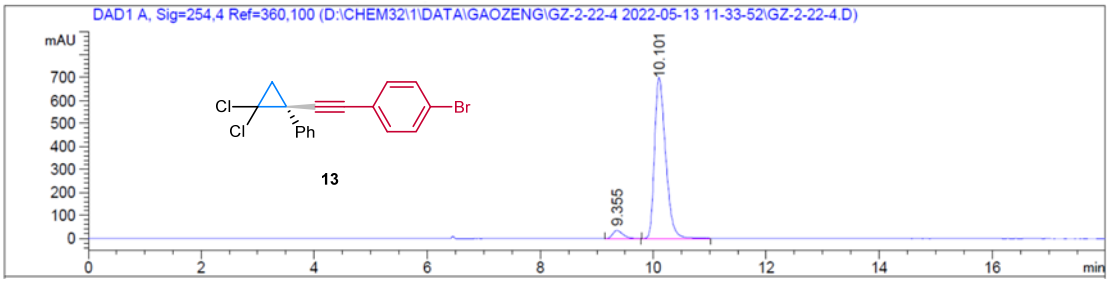

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.154 | BB | 0.2073 | 940.32690 | 70.63223 | 4.1462 |
| 2 | 10.851 | MF R | 0.2292 | 2.17391e4 | 1581.00220 | 95.8538 |
| Totals : | | | | 2.26794e4 | 1651.63442 | |



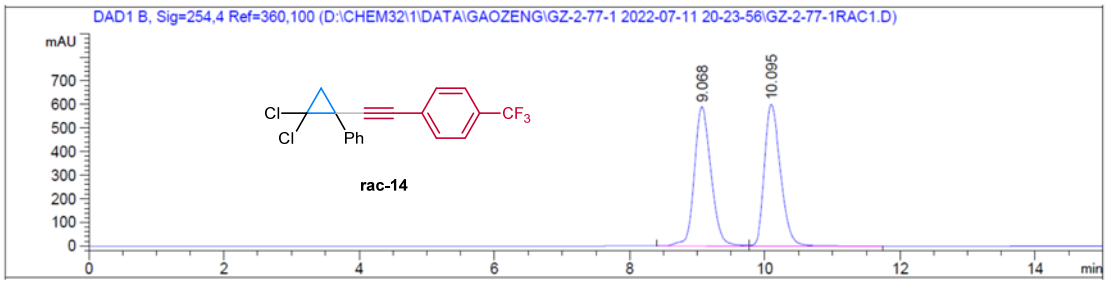

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.855 | BV | 0.1699 | 1.04786e4 | 941.27509 | 49.7612 |
| 2 | 10.620 | VV R | 0.1911 | 1.05792e4 | 848.33759 | 50.2388 |
| Totals : | | | | 2.10578e4 | 1789.61267 | |



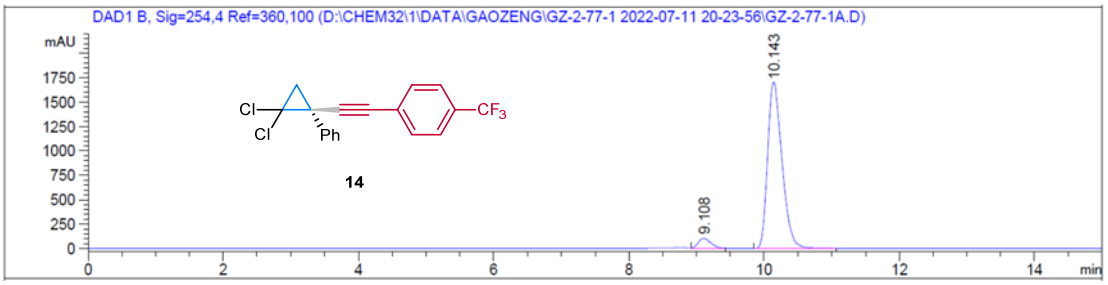

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.355 | BV R | 0.1824 | 427.42328 | 35.00928 | 4.2972 |
| 2 | 10.101 | BV R | 0.2062 | 9519.17578 | 701.82184 | 95.7028 |
| Totals : | | | | 9946.59906 | 736.83112 | |



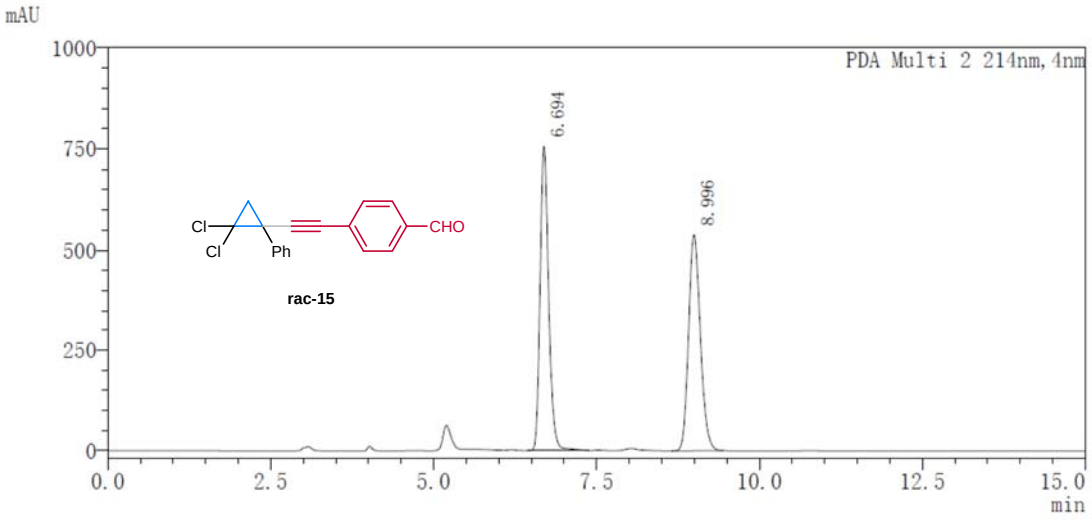

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.068 | BV | 0.2661 | 1.01106e4 | 589.37531 | 50.5256 |
| 2 | 10.095 | VB | 0.2544 | 9900.25781 | 600.27911 | 49.4744 |
| Totals : | | | | 2.00109e4 | 1189.65442 | |



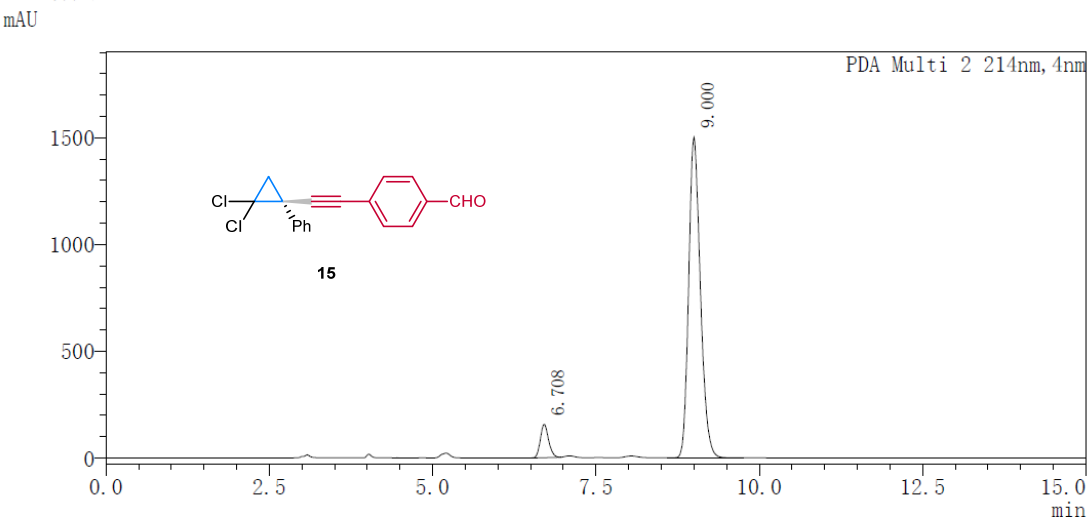

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.108 | FM R | 0.2221 | 1416.50110 | 106.29203 | 5.3095 |
| 2 | 10.143 | MF R | 0.2471 | 2.52622e4 | 1704.01721 | 94.6905 |
| Totals : | | | | 2.66787e4 | 1810.30924 | |



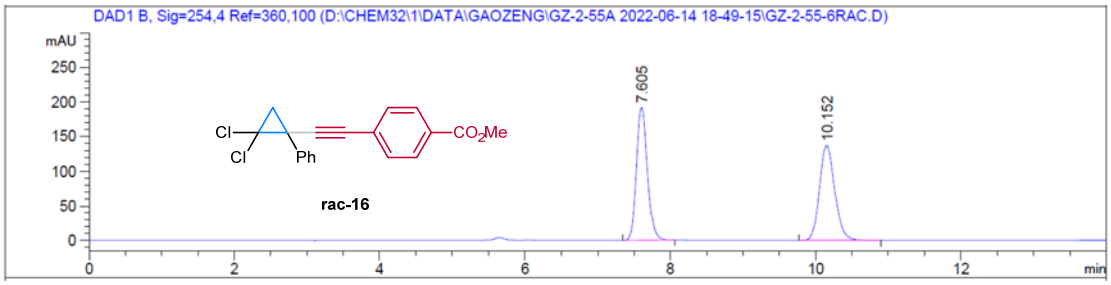

PDA Ch2 214nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 6.694 | 755012 | 6927562 | 50.567 |
| 8.996 | 538555 | 6772306 | 49.433 |



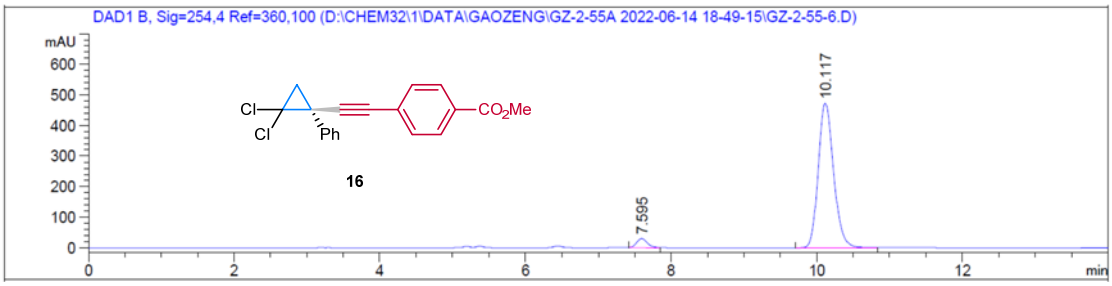

PDA Ch2 214nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 6.708 | 156293 | 1367955 | 6.808 |
| 9.000 | 1500689 | 18725663 | 93.192 |



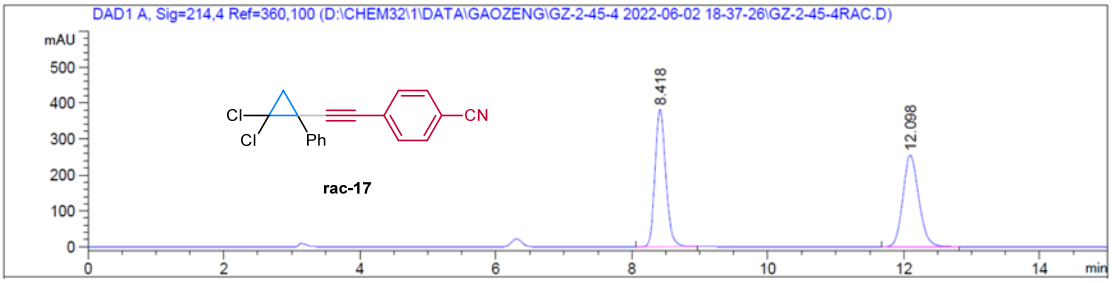

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 7.605 | BB | 0.1618 | 1998.87427 | 191.40591 | 49.9494 |
| 2 | 10.152 | BB | 0.2266 | 2002.92603 | 136.94254 | 50.0506 |
| Totals : | | | | 4001.80029 | 328.34845 | |



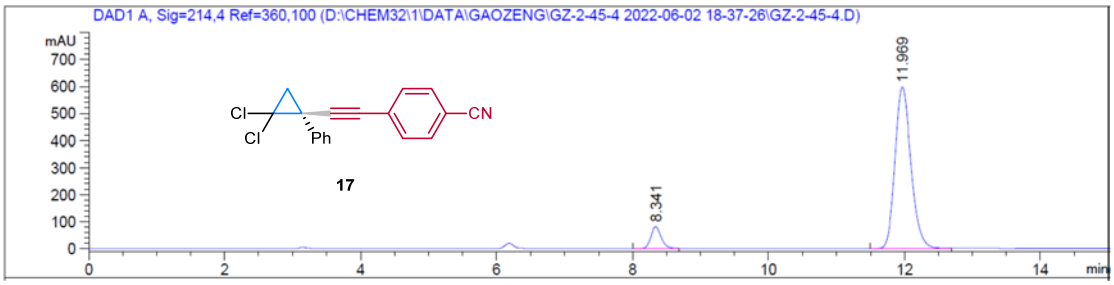

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 7.595 | FM R | 0.1722 | 305.55423 | 29.57558 | 4.2214 |
| 2 | 10.117 | MF R | 0.2445 | 6932.65039 | 472.51431 | 95.7786 |
| Totals : | | | | 7238.20462 | 502.08990 | |



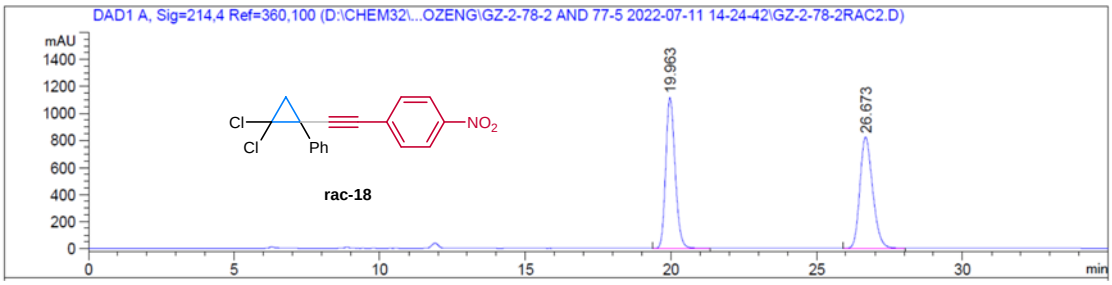

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.418 | BB | 0.1673 | 4161.02100 | 381.34067 | 50.0351 |
| 2 | 12.098 | BB | 0.2496 | 4155.18896 | 255.62955 | 49.9649 |
| Totals : | | | | 8316.20996 | 636.97021 | |



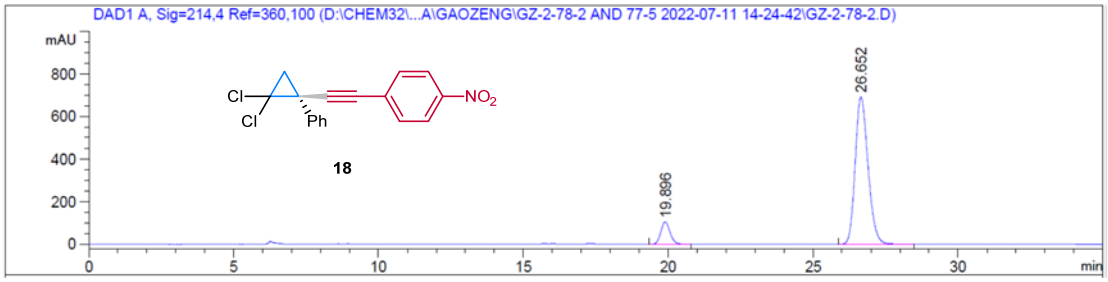

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.341 | MF R | 0.1772 | 867.84839 | 81.61297 | 8.1570 |
| 2 | 11.969 | MF R | 0.2723 | 9771.45020 | 598.05707 | 91.8430 |
| Totals : | | | | 1.06393e4 | 679.67004 | |



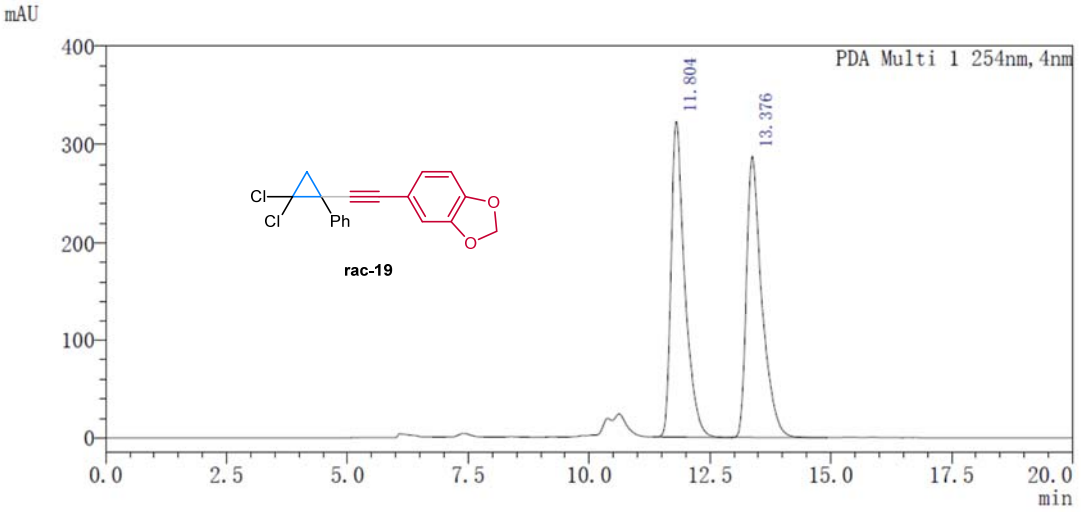

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 19.963 | BB | 0.3471 | 2.49516e4 | 1115.09436 | 49.8167 |
| 2 | 26.673 | MF R | 0.5102 | 2.51352e4 | 821.10950 | 50.1833 |
| Totals : | | | | 5.00868e4 | 1936.20386 | |



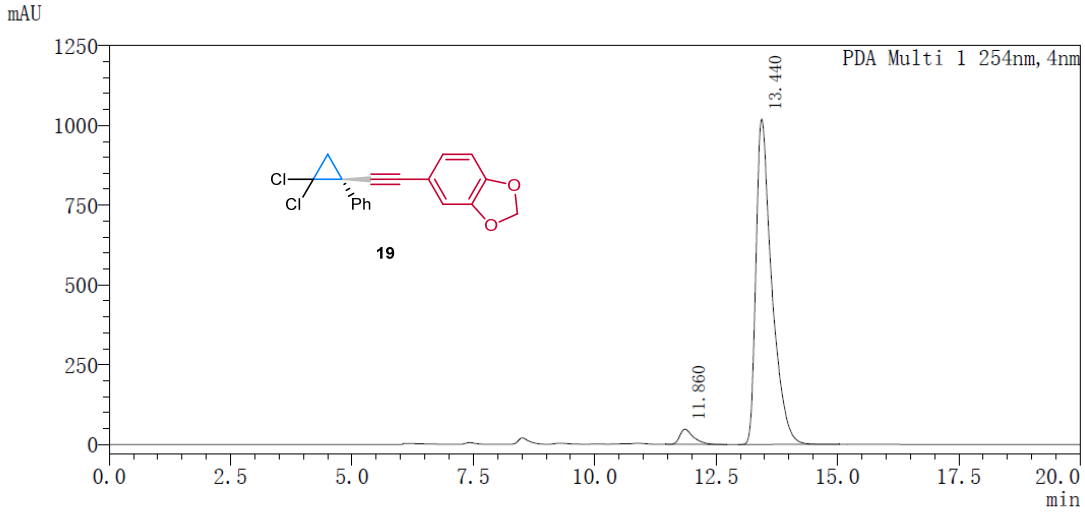

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 19.896 | BB | 0.3398 | 2333.91699 | 105.63633 | 9.8744 |
| 2 | 26.652 | BB | 0.4698 | 2.13021e4 | 690.78723 | 90.1256 |
| Totals : | | | | 2.36360e4 | 796.42356 | |




PDA Ch1 254nm

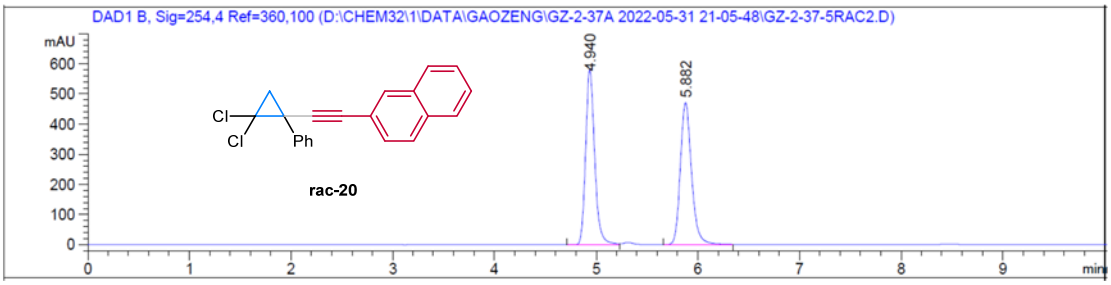
| T | Hight | Area | Area% |
|---|---|---|---|
| 11.804 | 322858 | 6400967 | 49.983 |
| 13.376 | 287602 | 6405426 | 50.017 |




Peak Table

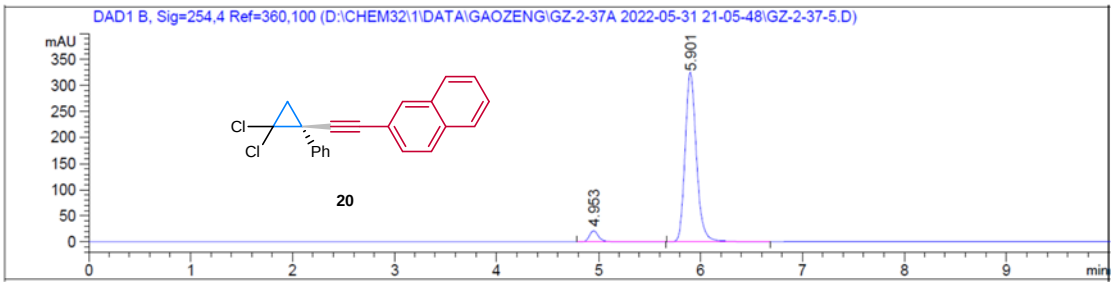
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 11.860 | 935572 | 3.892 |
| 2 | 13.440 | 23104116 | 96.108 |



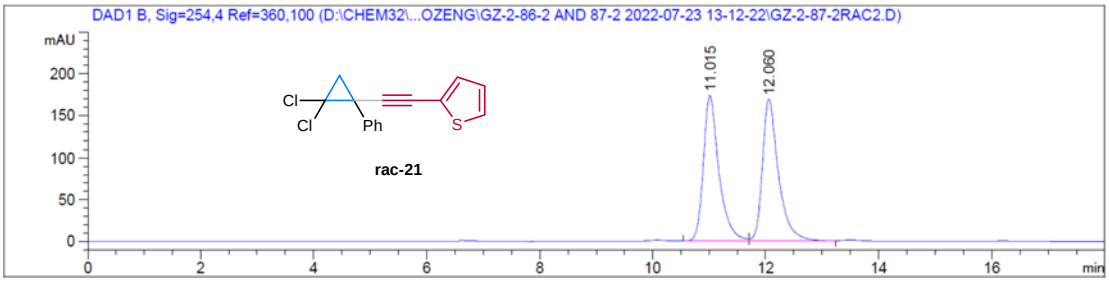

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.940 | BV | 0.0962 | 3594.59644 | 581.17987 | 49.6953 |
| 2 | 5.882 | MF R | 0.1285 | 3638.67065 | 471.80038 | 50.3047 |
| Totals : | | | | 7233.26709 | 1052.98026 | |




Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.953 | BB | 0.0954 | 133.12120 | 21.16086 | 5.0352 |
| 2 | 5.901 | BB | 0.1180 | 2510.66895 | 325.41650 | 94.9648 |
| Totals : | | | | 2643.79015 | 346.57736 | |

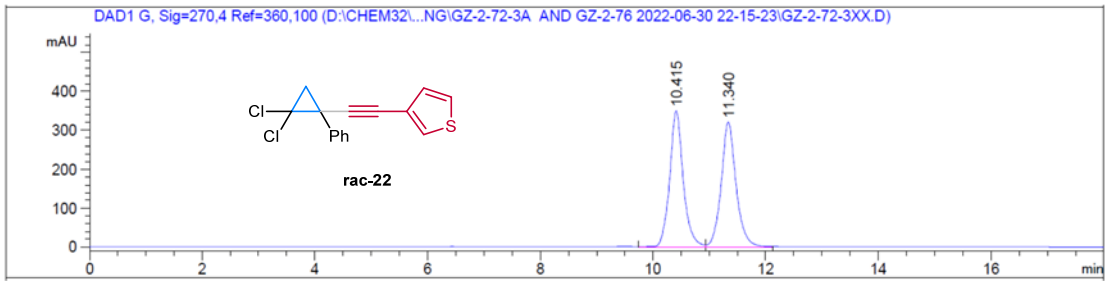



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.015 | BV | 0.2810 | 3312.56641 | 173.28084 | 49.8823 |
| 2 | 12.060 | VB | 0.2921 | 3328.20093 | 168.77985 | 50.1177 |
| Totals : | | | | 6640.76733 | 342.06068 | |

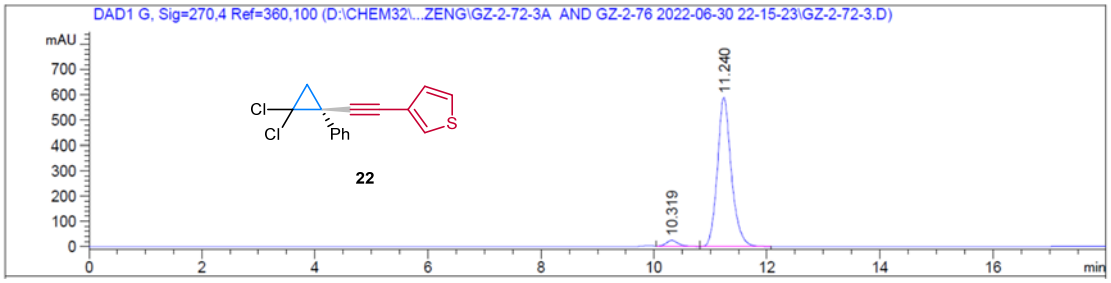

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.962 | BB | 0.2477 | 474.59125 | 28.29502 | 4.1625 |
| 2 | 11.978 | MF R | 0.3180 | 1.09270e4 | 572.77887 | 95.8375 |
| Totals : | | | | 1.14016e4 | 601.07389 | |



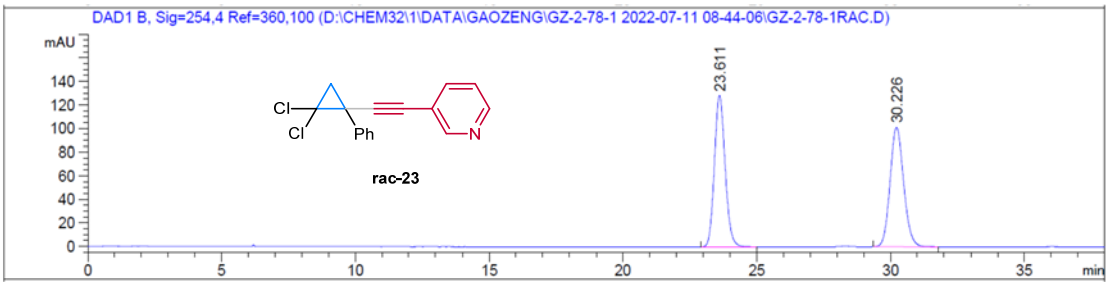

Signal 7: DAD1 G, Sig=270,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.415 | BV | 0.2453 | 5848.51855 | 349.40112 | 49.8032 |
| 2 | 11.340 | MF R | 0.3068 | 5894.73926 | 320.22665 | 50.1968 |
| Totals : | | | | 1.17433e4 | 669.62778 | |



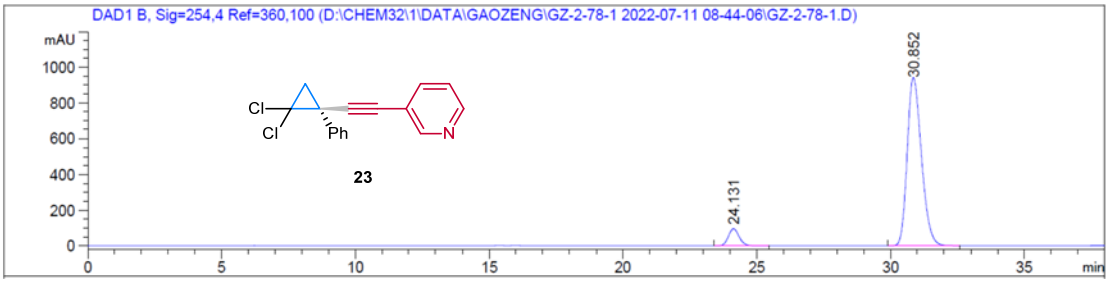

Signal 7: DAD1 G, Sig=270,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.319 | VV | 0.2321 | 391.79510 | 24.83173 | 3.7141 |
| 2 | 11.240 | MF R | 0.2874 | 1.01570e4 | 588.96472 | 96.2859 |
| Totals : | | | | 1.05488e4 | 613.79645 | |



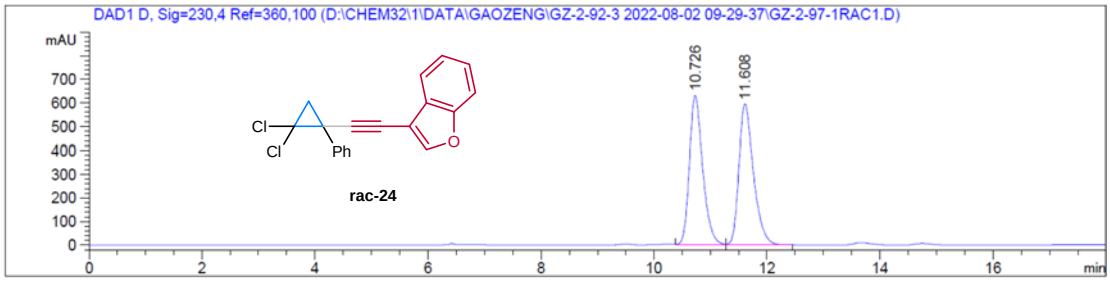

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 23.611 | BB | 0.4337 | 3580.63330 | 128.24510 | 49.9928 |
| 2 | 30.226 | BB | 0.5400 | 3581.66211 | 100.93671 | 50.0072 |
| Totals : | | | | 7162.29541 | 229.18182 | |



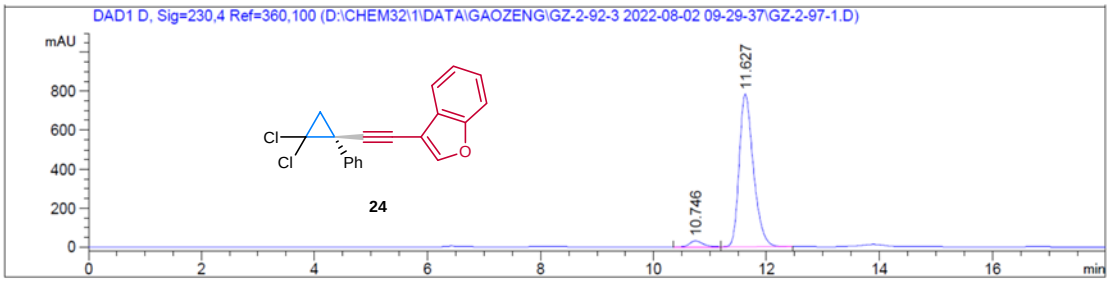

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 24.131 | BB | 0.4366 | 2704.75928 | 96.02908 | 7.1992 |
| 2 | 30.852 | MF R | 0.6158 | 3.48656e4 | 943.59320 | 92.8008 |
| Totals : | | | | 3.75704e4 | 1039.62228 | |



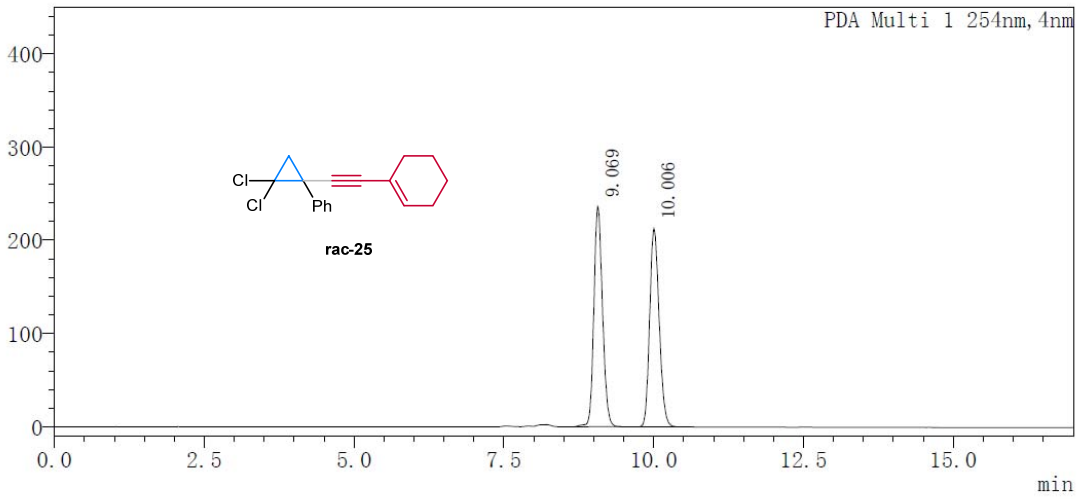

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.726 | VV | 0.2476 | 1.03642e4 | 631.07007 | 49.2113 |
| 2 | 11.608 | MF R | 0.2998 | 1.06964e4 | 594.60132 | 50.7887 |
| Totals : | | | | 2.10607e4 | 1225.67139 | |



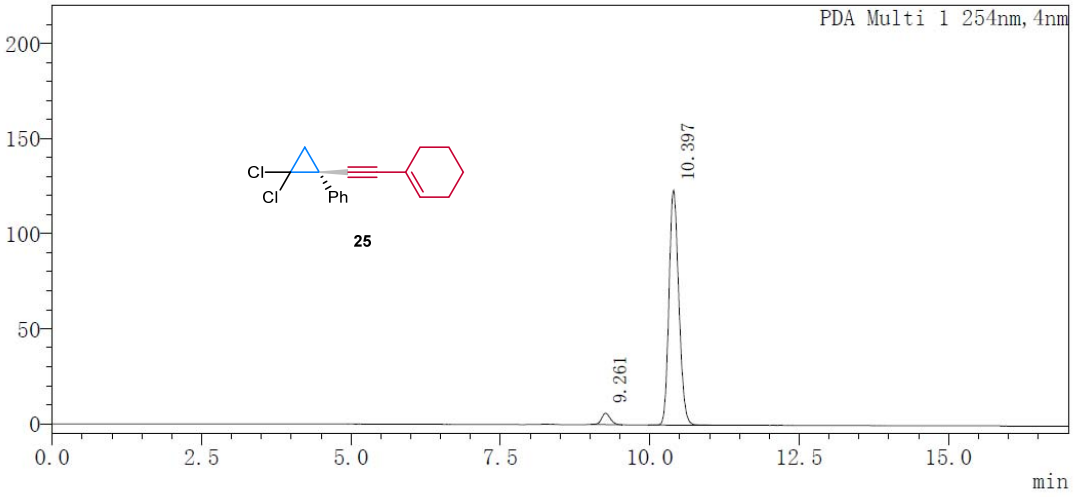

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.746 | BV | 0.2426 | 507.47772 | 31.72584 | 3.5705 |
| 2 | 11.627 | VB | 0.2639 | 1.37057e4 | 784.37036 | 96.4295 |
| Totals : | | | | 1.42132e4 | 816.09620 | |



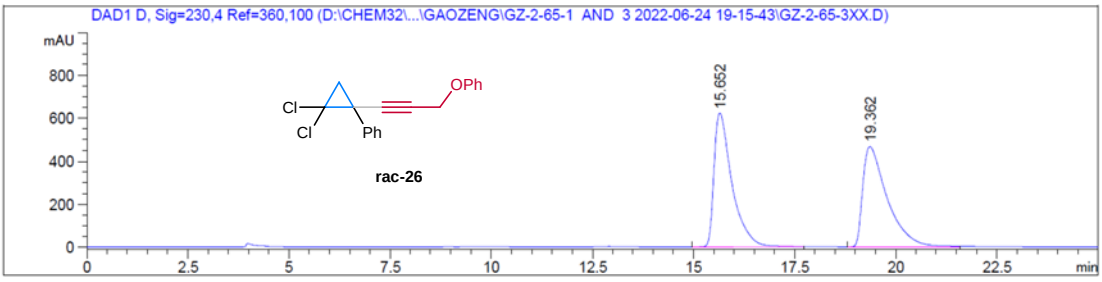

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.069 | 236183 | 2374659 | 50.324 |
| 10.006 | 212694 | 2344054 | 49.676 |



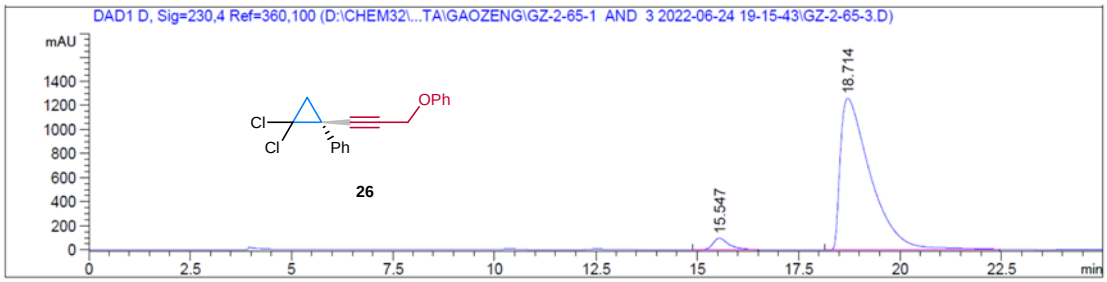

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.261 | 5942 | 59729 | 4.052 |
| 10.397 | 123548 | 1414240 | 95.948 |



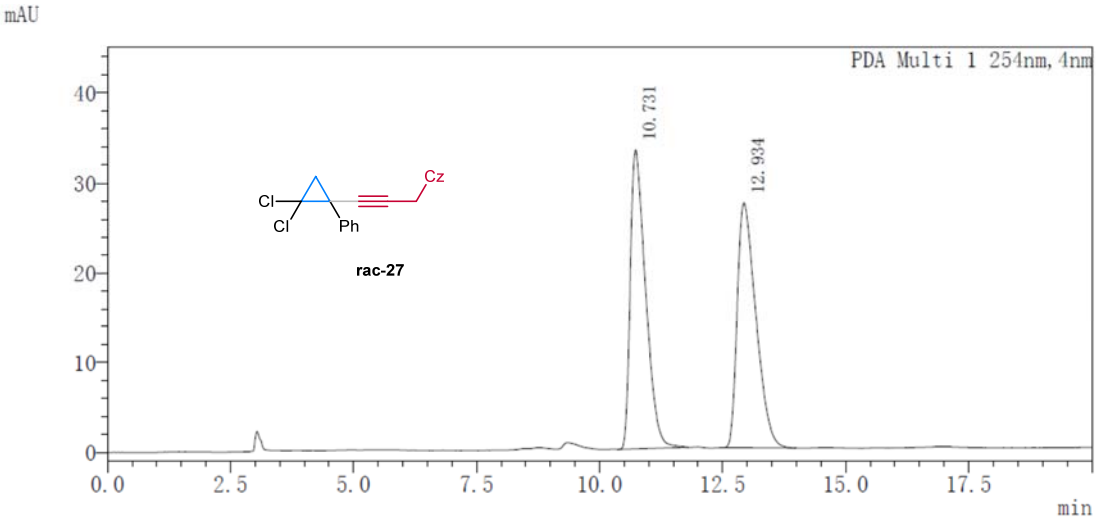

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.652 | BB | 0.4630 | 1.92373e4 | 621.77954 | 49.2746 |
| 2 | 19.362 | MF R | 0.7041 | 1.98037e4 | 468.79950 | 50.7254 |
| Totals : | | | | 3.90409e4 | 1090.57904 | |



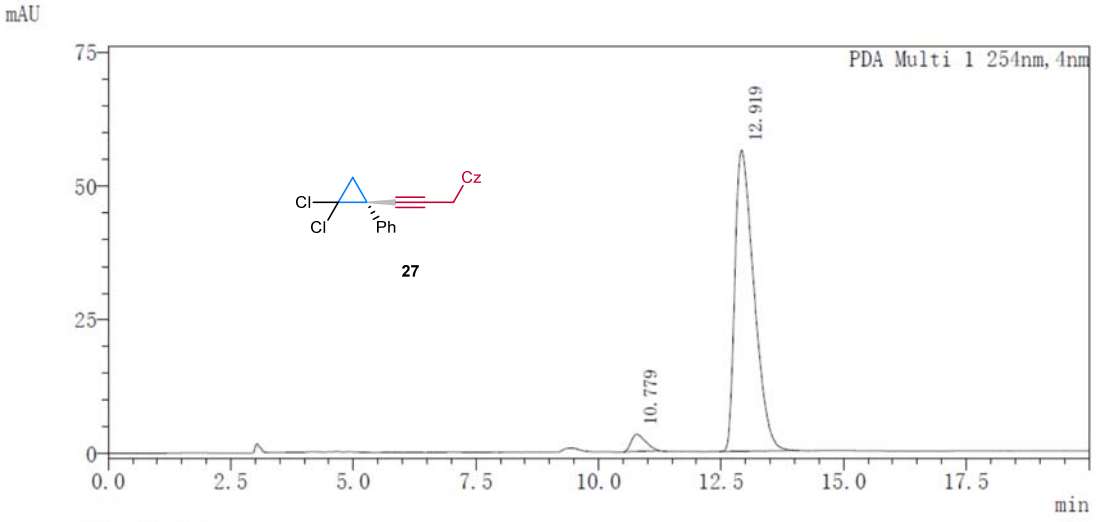

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.547 | MF R | 0.4576 | 2659.13770 | 96.85825 | 3.9168 |
| 2 | 18.714 | MF R | 0.8629 | 6.52316e4 | 1259.90015 | 96.0832 |
| Totals : | | | | 6.78907e4 | 1356.75839 | |



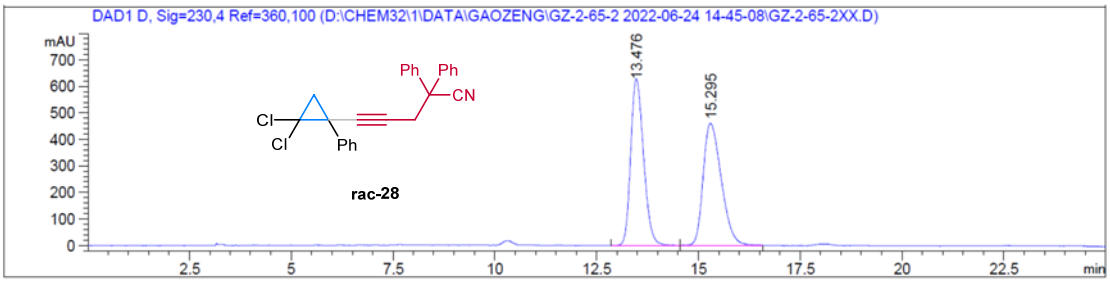

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 10.731 | 33253 | 721882 | 50.044 |
| 12.934 | 27320 | 720625 | 49.956 |



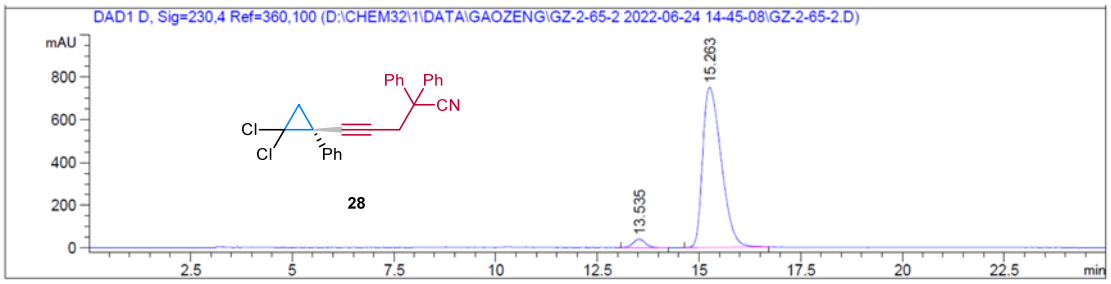

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 10.779 | 3165 | 64161 | 4.033 |
| 12.919 | 56312 | 1526703 | 95.967 |



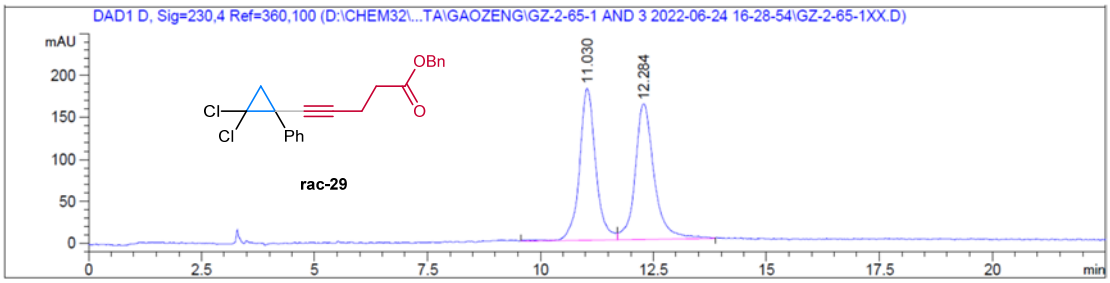

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.476 | VV R | 0.3429 | 1.38426e4 | 628.26355 | 49.2037 |
| 2 | 15.295 | VV R | 0.4419 | 1.42906e4 | 460.22842 | 50.7963 |
| Totals : | | | | 2.81332e4 | 1088.49197 | |



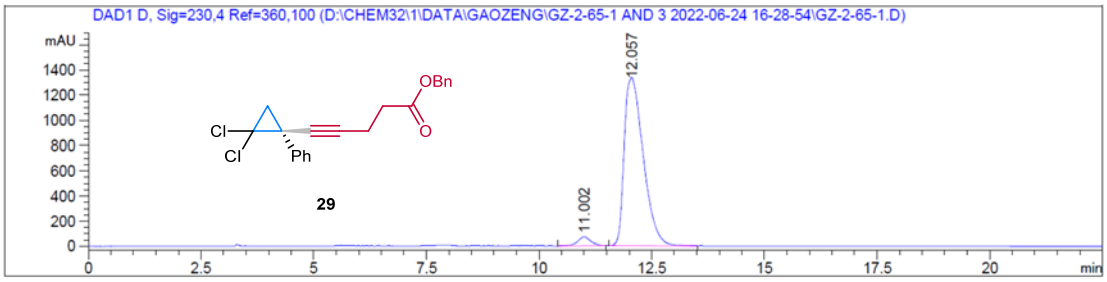

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.535 | VV R | 0.2862 | 855.11780 | 40.20064 | 3.4617 |
| 2 | 15.263 | BV R | 0.4494 | 2.38469e4 | 748.90234 | 96.5383 |
| Totals : | | | | 2.47021e4 | 789.10299 | |



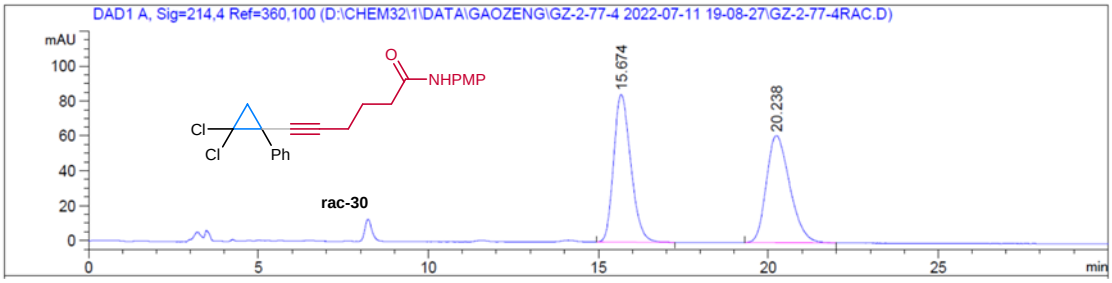

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.030 | MF R | 0.4202 | 4555.41504 | 180.66690 | 48.8934 |
| 2 | 12.284 | FM R | 0.4918 | 4761.61377 | 161.35999 | 51.1066 |
| Totals : | | | | 9317.02881 | 342.02689 | |



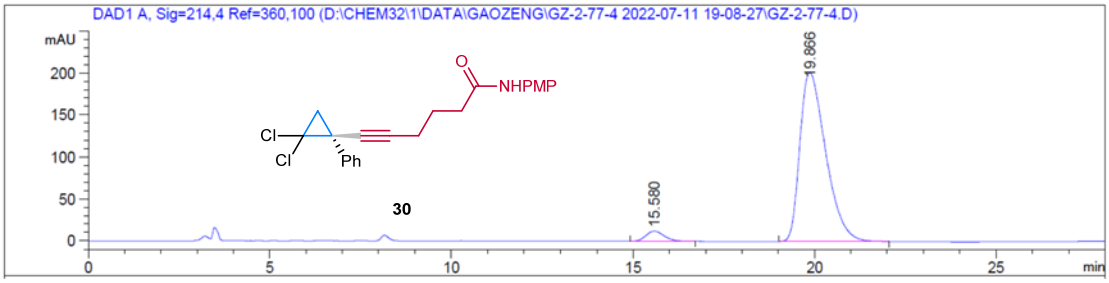

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.002 | VB R | 0.2955 | 1485.90344 | 71.77244 | 3.6485 |
| 2 | 12.057 | BV R | 0.4119 | 3.92408e4 | 1338.95984 | 96.3515 |
| Totals : | | | | 4.07267e4 | 1410.73228 | |




Signal 1: DAD1 A, Sig=214,4 Ref=360,100

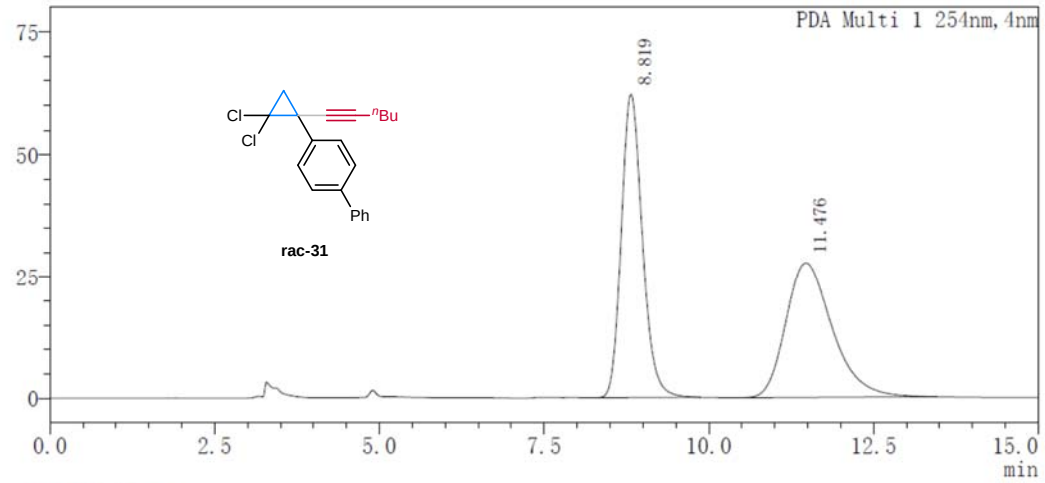
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.674 | BB | 0.5416 | 2968.71240 | 84.56567 | 50.2925 |
| 2 | 20.238 | BB | 0.7115 | 2934.18091 | 61.40513 | 49.7075 |
| Totals : | | | | 5902.89331 | 145.97080 | |




Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.580 | BB | 0.4281 | 421.89581 | 12.11939 | 4.0628 |
| 2 | 19.866 | BB | 0.7491 | 9962.40820 | 201.40533 | 95.9372 |
| Totals : | | | | 1.03843e4 | 213.52473 | |

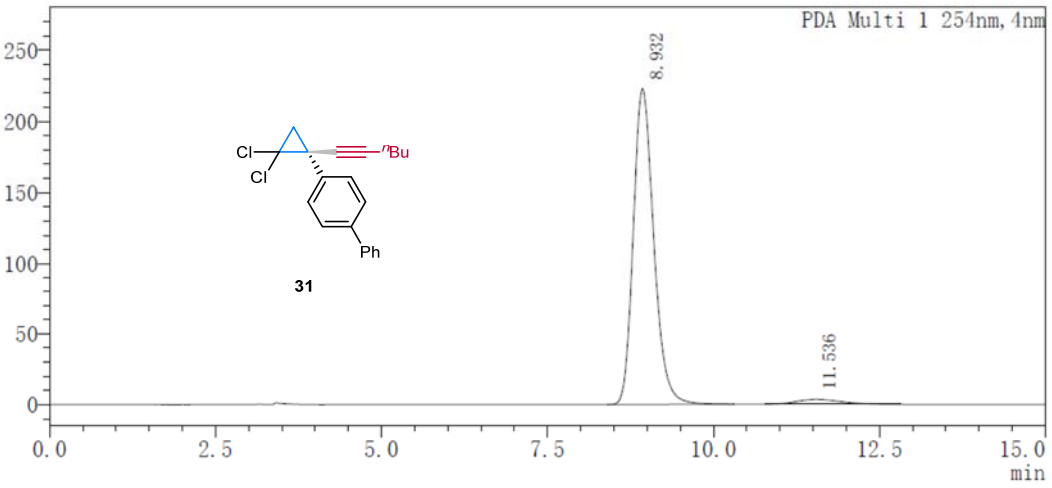
mAU




PDA Ch1 254nm

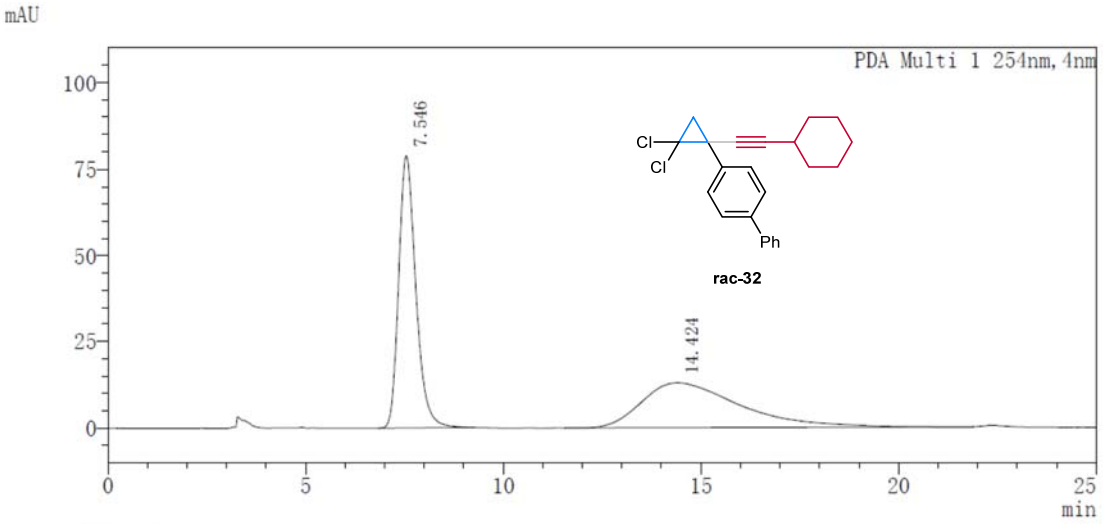
| T | Hight | Area | Area% |
|---|---|---|---|
| 8.819 | 62112 | 1386377 | 50.533 |
| 11.476 | 27680 | 1357110 | 49.467 |

mAU



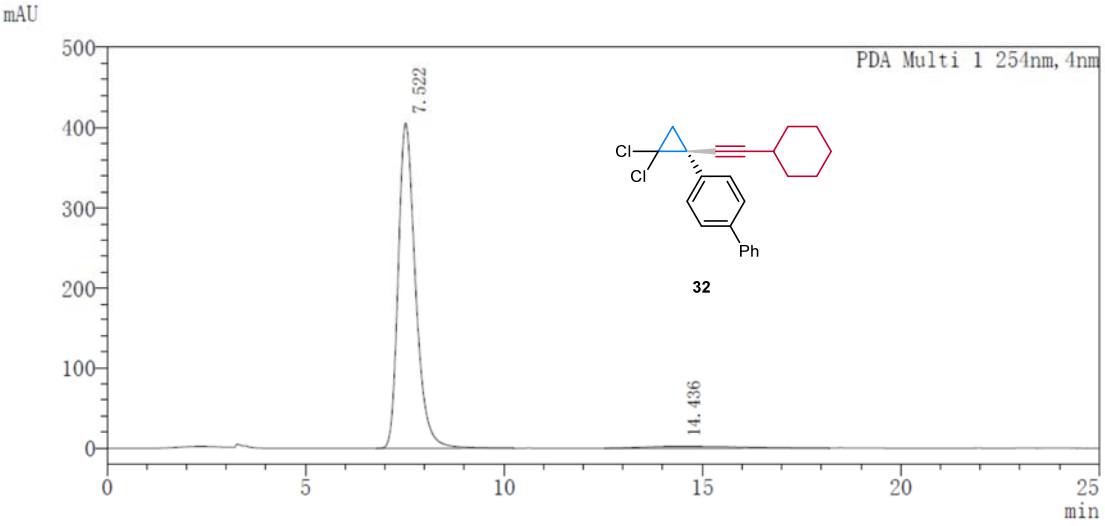

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 8.932 | 222927 | 4784706 | 96.776 |
| 11.536 | 3449 | 159408 | 3.224 |



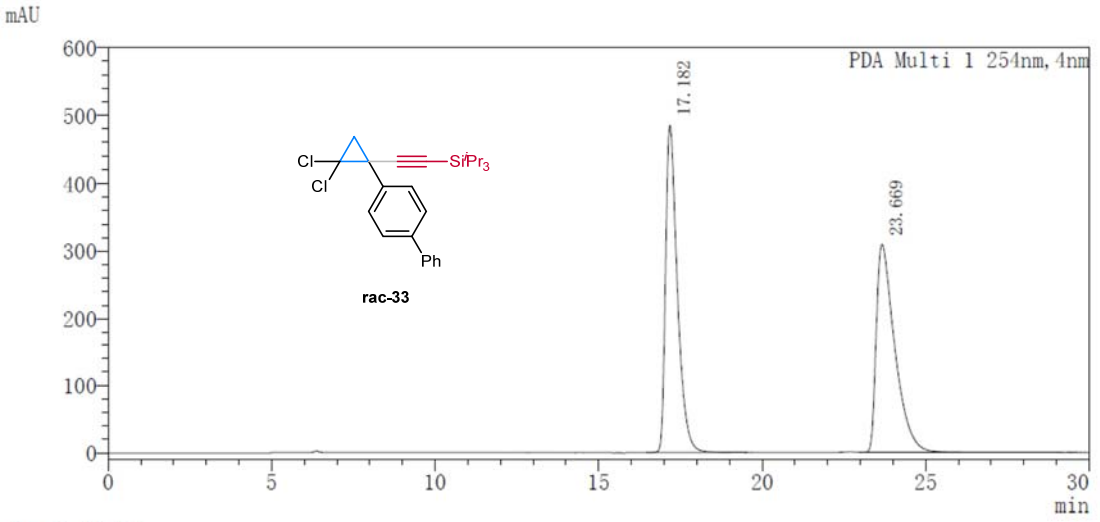

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 7.546 | 78659 | 2375238 | 51.578 |
| 14.424 | 12909 | 2229910 | 48.422 |




PDA Ch1 254nm

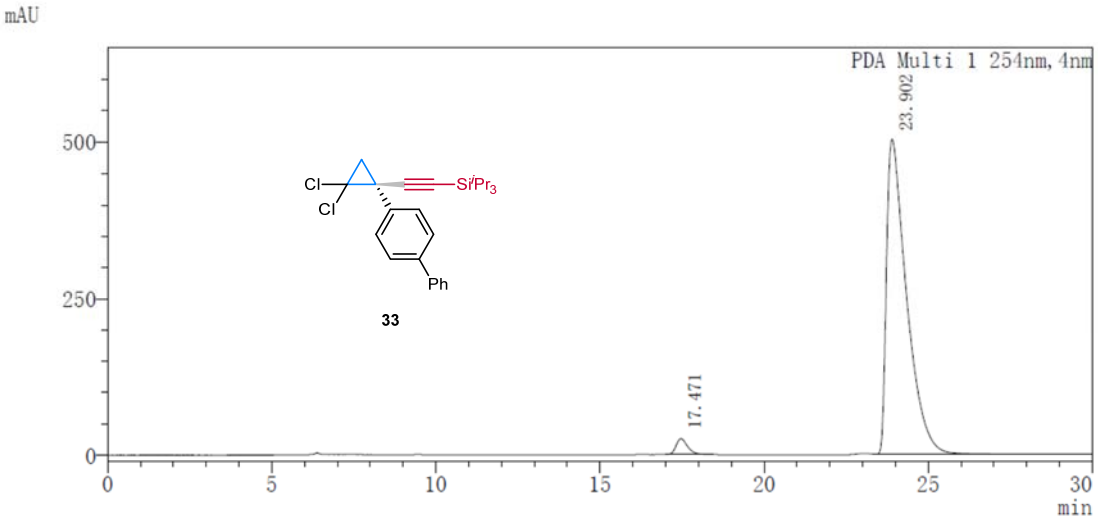
| T | Hight | Area | Area% |
|---|---|---|---|
| 7.522 | 405322 | 12274748 | 97.228 |
| 14.436 | 2303 | 349907 | 2.772 |




Peak Table

PDA Ch1 254nm

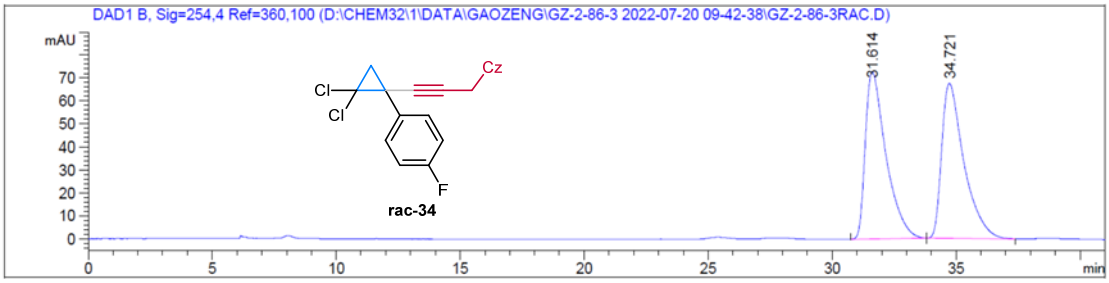
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 17.182 | 12185673 | 50.014 |
| 2 | 23.669 | 12178614 | 49.986 |




Peak Table

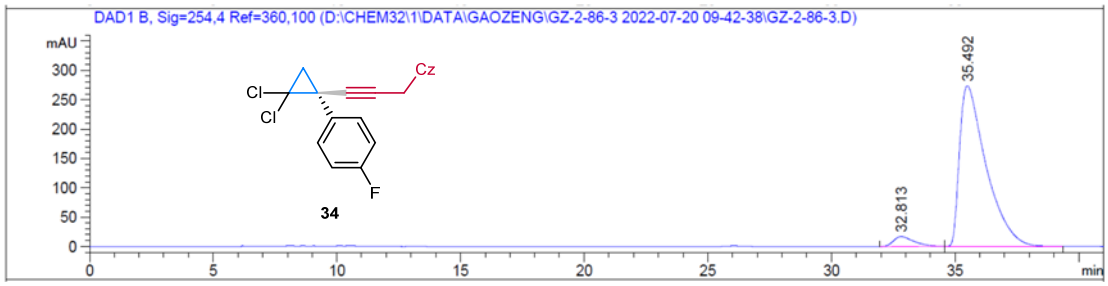
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 17.471 | 617729 | 2.813 |
| 2 | 23.902 | 21344312 | 97.187 |



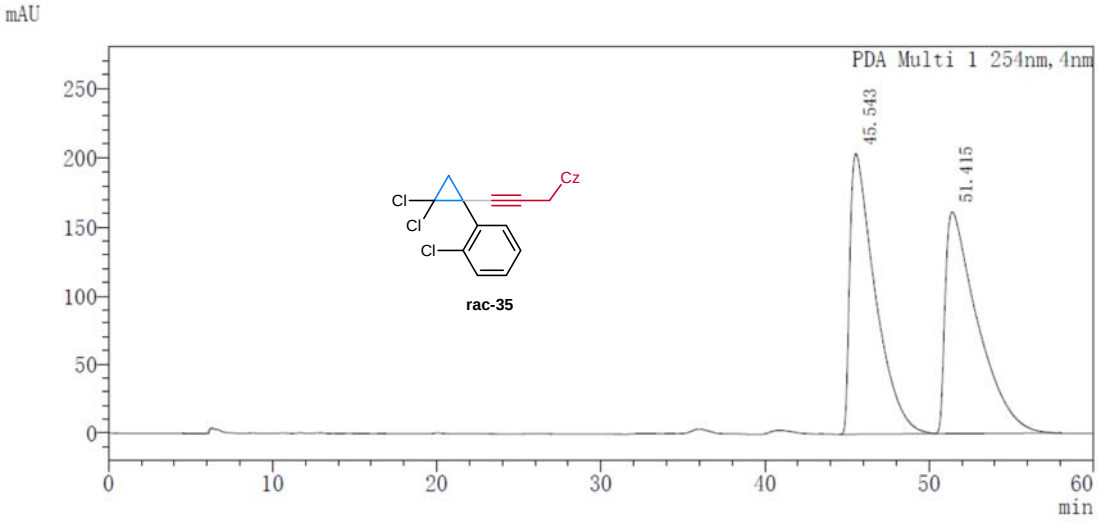

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 31.614 | BB | 0.8395 | 4211.40234 | 72.73378 | 50.0280 |
| 2 | 34.721 | BB | 0.9164 | 4206.68799 | 67.37827 | 49.9720 |
| Totals : | | | | 8418.09033 | 140.11205 | |



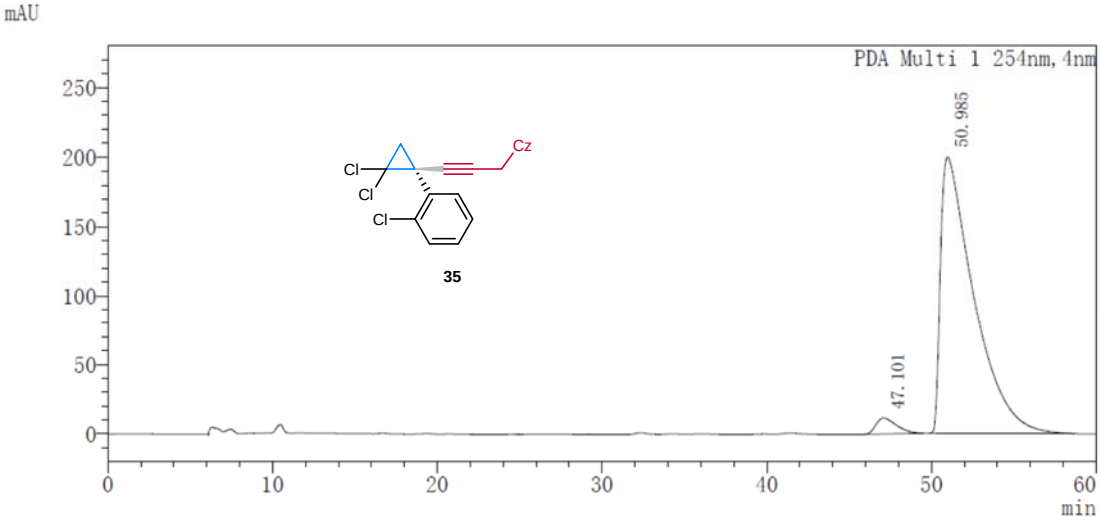

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 32.813 | BB | 0.8030 | 981.45569 | 16.91350 | 4.5862 |
| 2 | 35.492 | BB | 1.0785 | 2.04189e4 | 273.03793 | 95.4138 |
| Totals : | | | | 2.14003e4 | 289.95144 | |



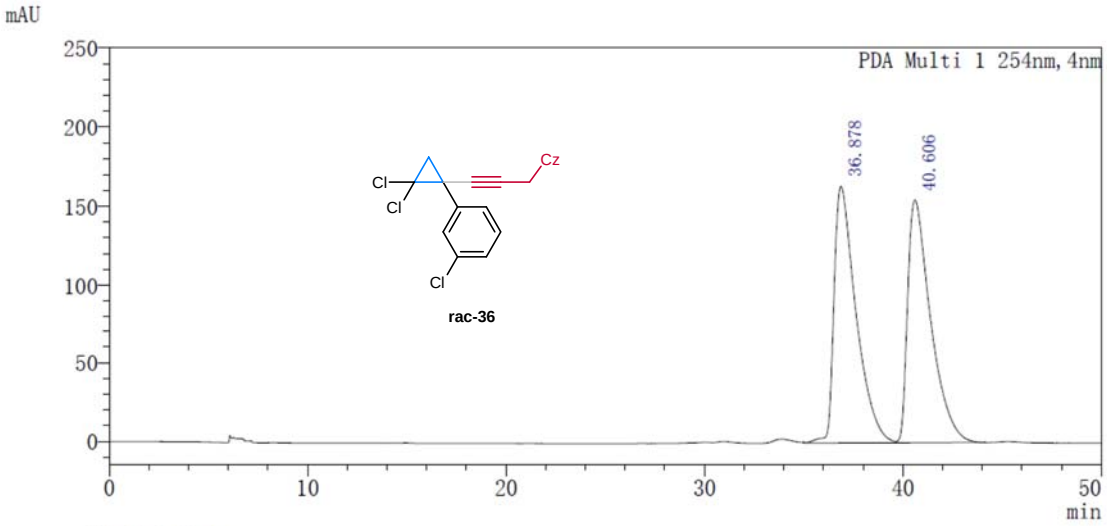

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 45.543 | 203625 | 21912104 | 49.746 |
| 51.415 | 161614 | 22135794 | 50.254 |



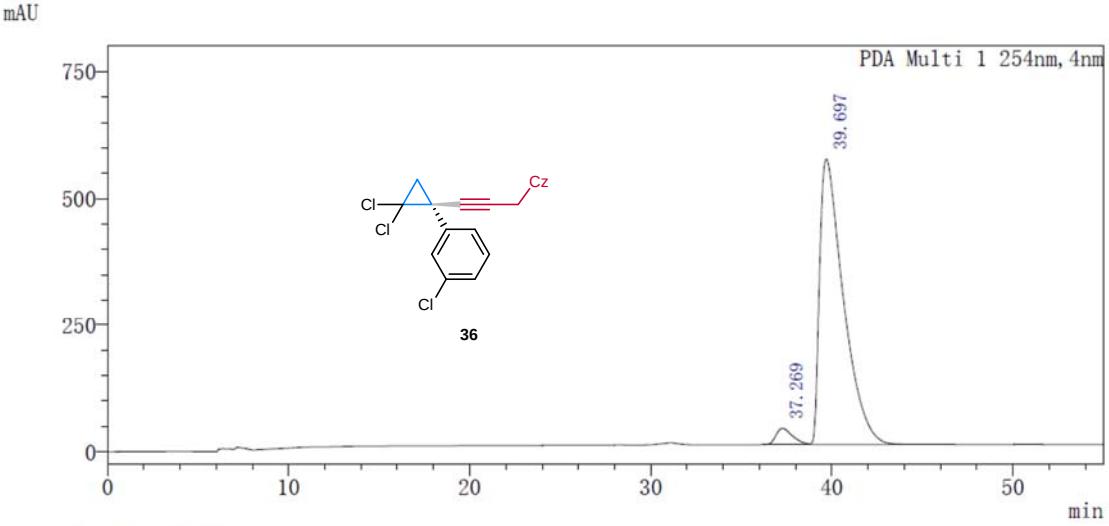

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 47.101 | 11369 | 983887 | 3.394 |
| 50.985 | 199500 | 28001496 | 96.606 |



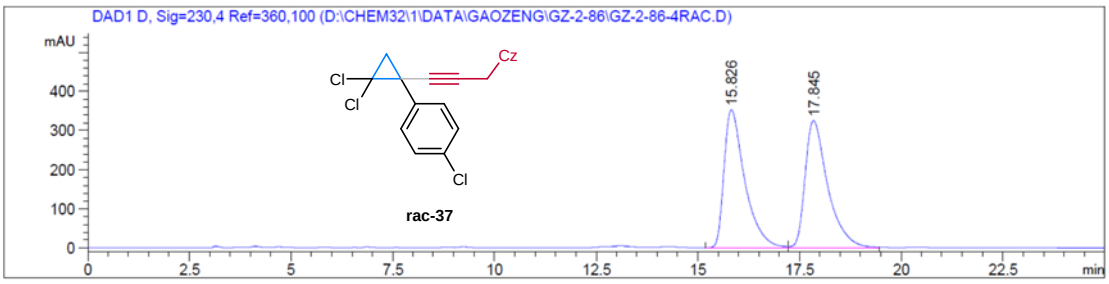

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 36.878 | 163629 | 12638279 | 50.319 |
| 40.606 | 154858 | 12477867 | 49.681 |



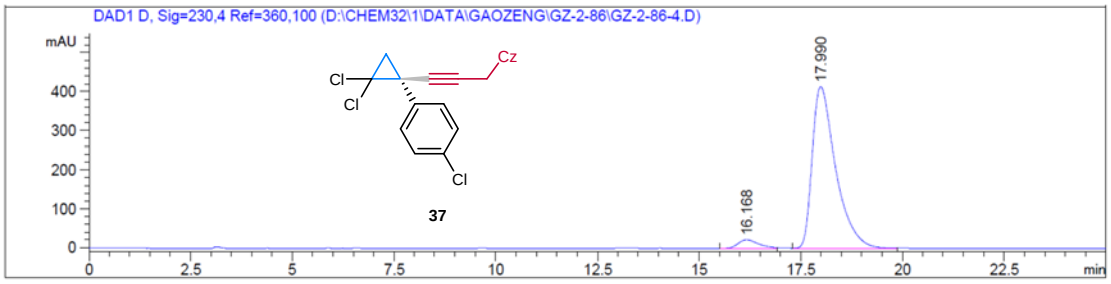

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 37.269 | 32395 | 2067511 | 3.859 |
| 39.697 | 564436 | 51512568 | 96.141 |



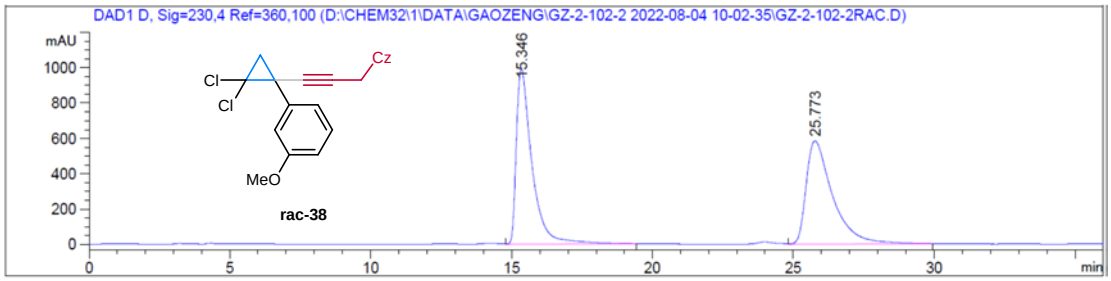

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.826 | BV | 0.5281 | 1.25280e4 | 352.94241 | 49.8711 |
| 2 | 17.845 | MF R | 0.6463 | 1.25928e4 | 324.73535 | 50.1289 |
| Totals : | | | | 2.51208e4 | 677.67776 | |



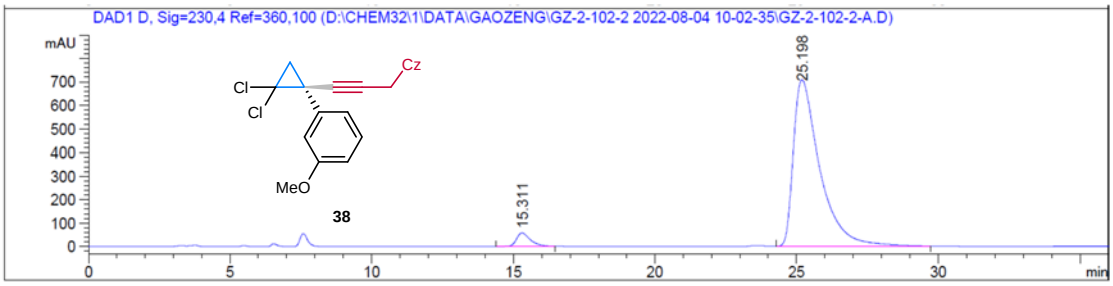

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.168 | MF R | 0.5791 | 768.17157 | 22.10682 | 4.4119 |
| 2 | 17.990 | MF R | 0.6694 | 1.66432e4 | 414.38925 | 95.5881 |
| Totals : | | | | 1.74114e4 | 436.49607 | |



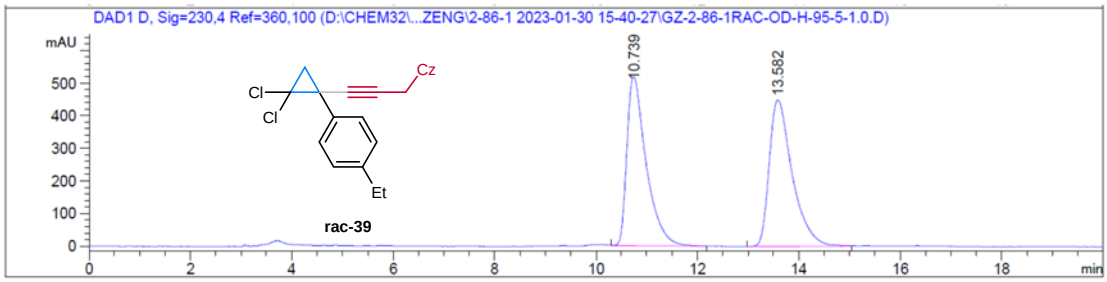

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.346 | MF R | 0.6486 | 3.86042e4 | 991.91559 | 50.2093 |
| 2 | 25.773 | MF R | 1.0924 | 3.82824e4 | 584.07513 | 49.7907 |
| Totals : | | | | 7.68866e4 | 1575.99072 | |



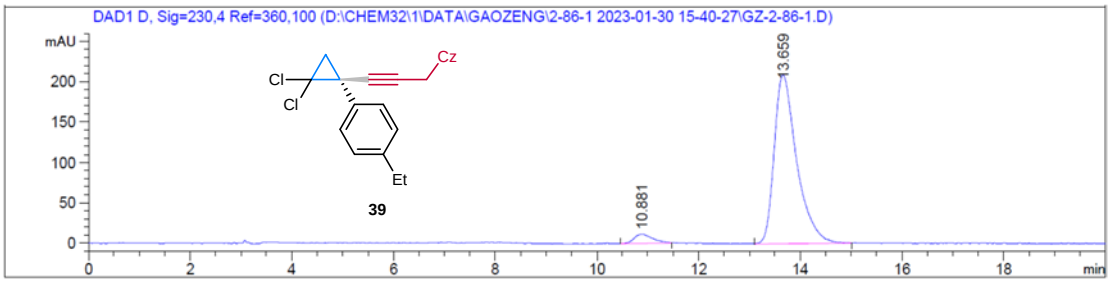

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 15.311 | MF R | 0.5897 | 2072.41333 | 58.57244 | 4.3058 |
| 2 | 25.198 | MF R | 1.0860 | 4.60582e4 | 706.84021 | 95.6942 |
| Totals : | | | | 4.81306e4 | 765.41265 | |



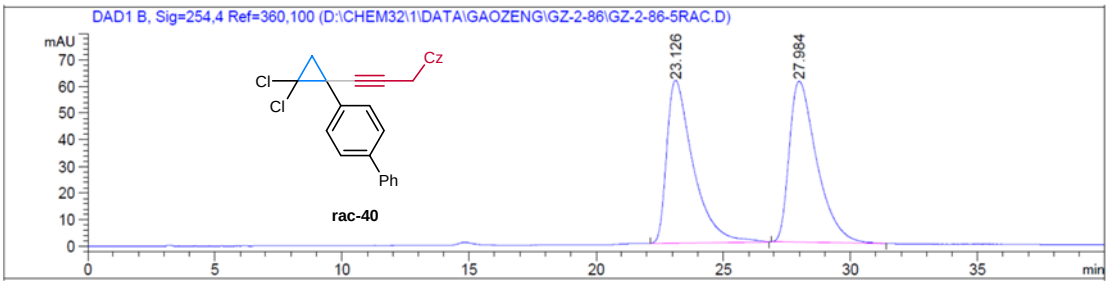

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.739 | FM R | 0.4392 | 1.36710e4 | 518.77765 | 49.1694 |
| 2 | 13.582 | BV R | 0.4754 | 1.41329e4 | 448.82864 | 50.8306 |
| Totals : | | | | 2.78039e4 | 967.60629 | |



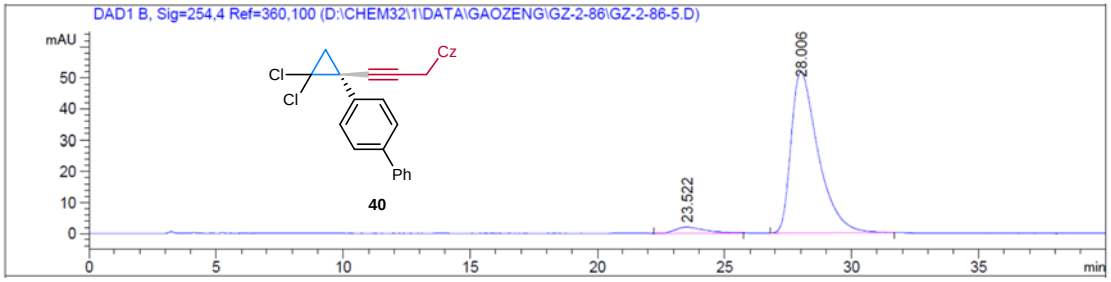

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.881 | MF R | 0.4284 | 303.02078 | 11.78842 | 4.5049 |
| 2 | 13.659 | BV R | 0.4504 | 6423.44873 | 209.11108 | 95.4951 |
| Totals : | | | | 6726.46951 | 220.89951 | |



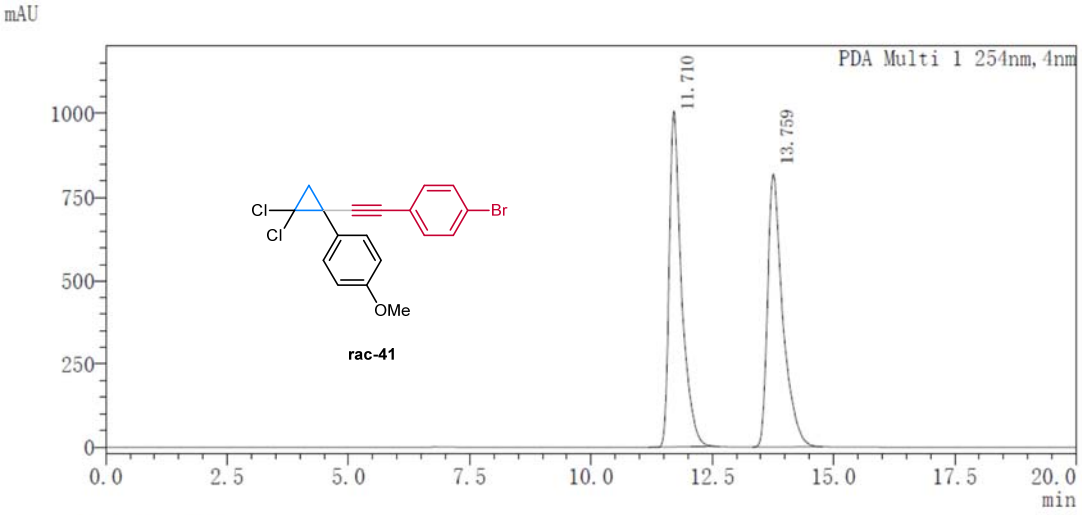

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 23.126 | BB | 1.0305 | 4416.49414 | 61.15915 | 49.1628 |
| 2 | 27.984 | BB | 1.0566 | 4566.91309 | 60.50277 | 50.8372 |
| Totals : | | | | 8983.40723 | 121.66192 | |



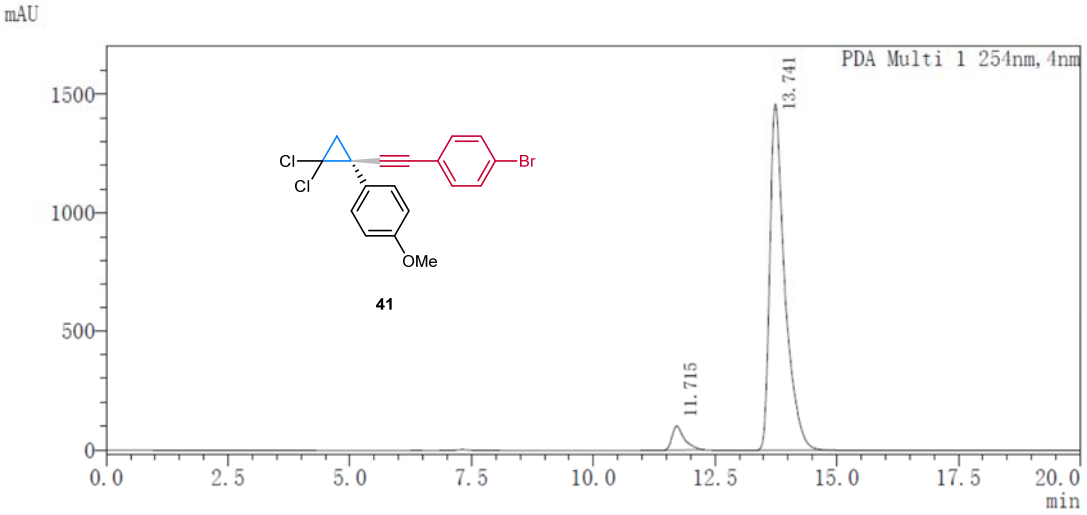

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 23.522 | MM R | 1.3645 | 164.24826 | 2.00627 | 4.0999 |
| 2 | 28.006 | BB | 1.0869 | 3841.87012 | 51.70651 | 95.9001 |
| Totals : | | | | 4006.11838 | 53.71278 | |



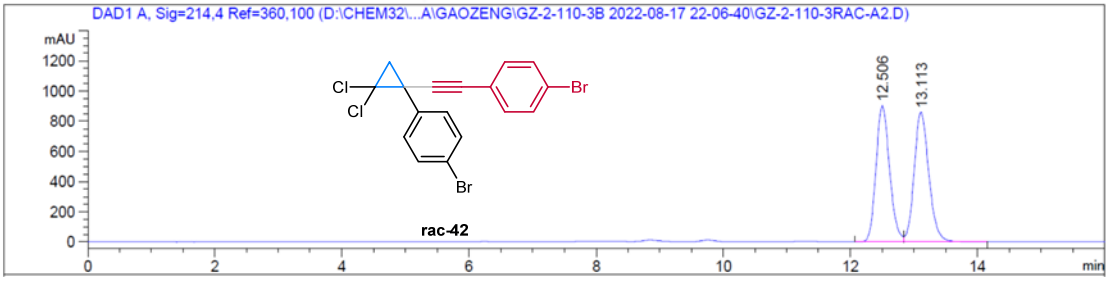

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 11.710 | 1004689 | 17818102 | 49.974 |
| 13.759 | 818970 | 17836339 | 50.026 |



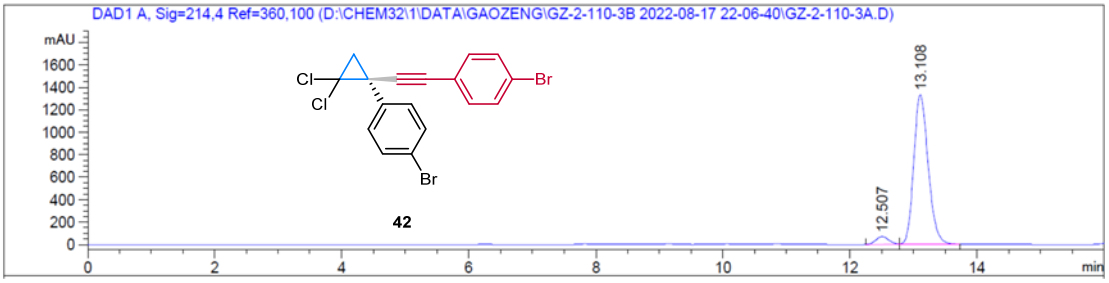

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 11.715 | 101325 | 1777797 | 5.365 |
| 13.741 | 1459106 | 31360879 | 94.635 |



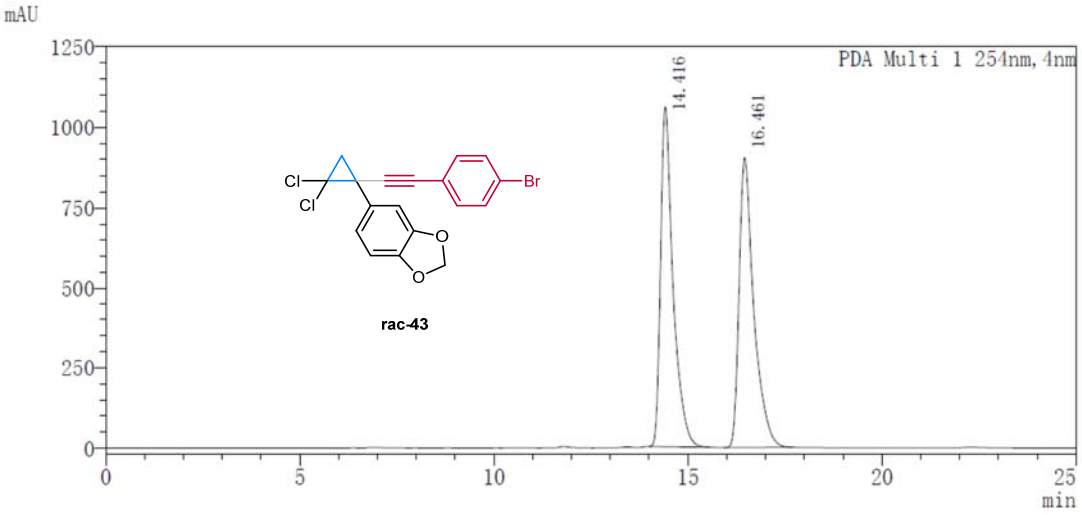

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.506 | BV | 0.2292 | 1.33692e4 | 900.31714 | 49.2261 |
| 2 | 13.113 | VB | 0.2472 | 1.37896e4 | 859.48138 | 50.7739 |
| Totals : | | | | 2.71589e4 | 1759.79852 | |



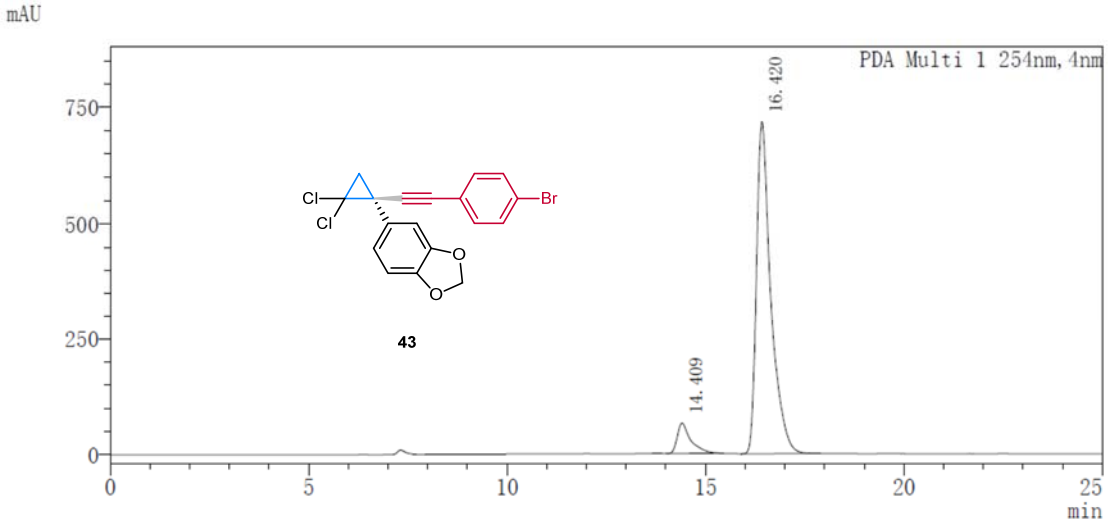

Signal 1: DAD1 A, Sig=214,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.507 | FM R | 0.2396 | 1015.90656 | 70.65785 | 4.5983 |
| 2 | 13.108 | MF R | 0.2637 | 2.10770e4 | 1332.22119 | 95.4017 |
| Totals : | | | | 2.20929e4 | 1402.87904 | |



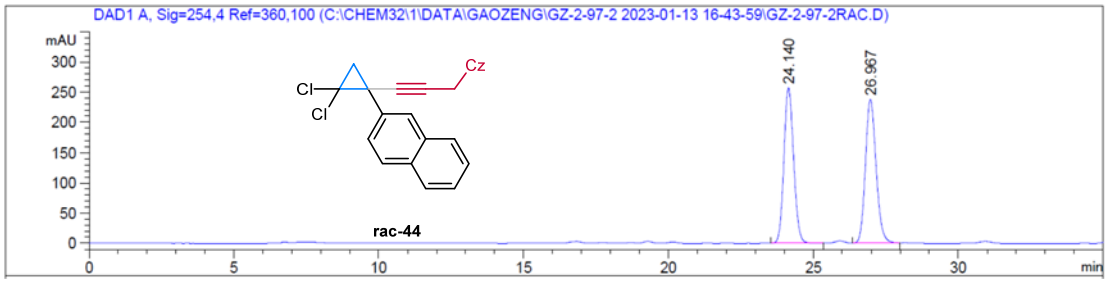

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 14.416 | 1059226 | 23648655 | 49.840 |
| 16.461 | 903476 | 23800441 | 50.160 |



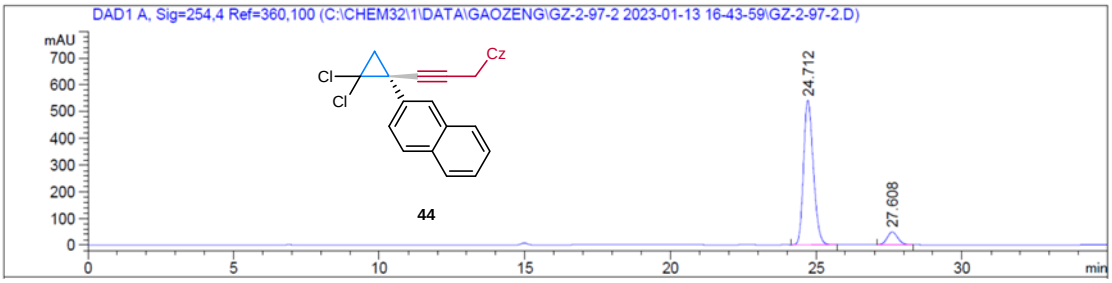

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 14.409 | 65664 | 1551481 | 7.915 |
| 16.420 | 717425 | 18051391 | 92.085 |



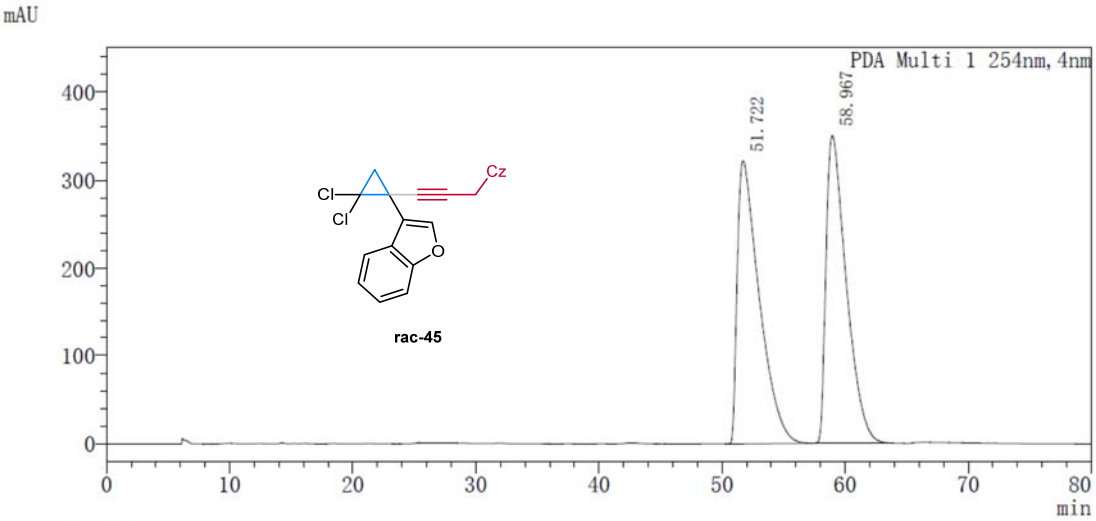

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 24.140 | BB | 0.3622 | 5993.90088 | 256.88849 | 49.6025 |
| 2 | 26.967 | BB | 0.3954 | 6089.97119 | 237.29114 | 50.3975 |
| Totals : | | | | 1.20839e4 | 494.17963 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

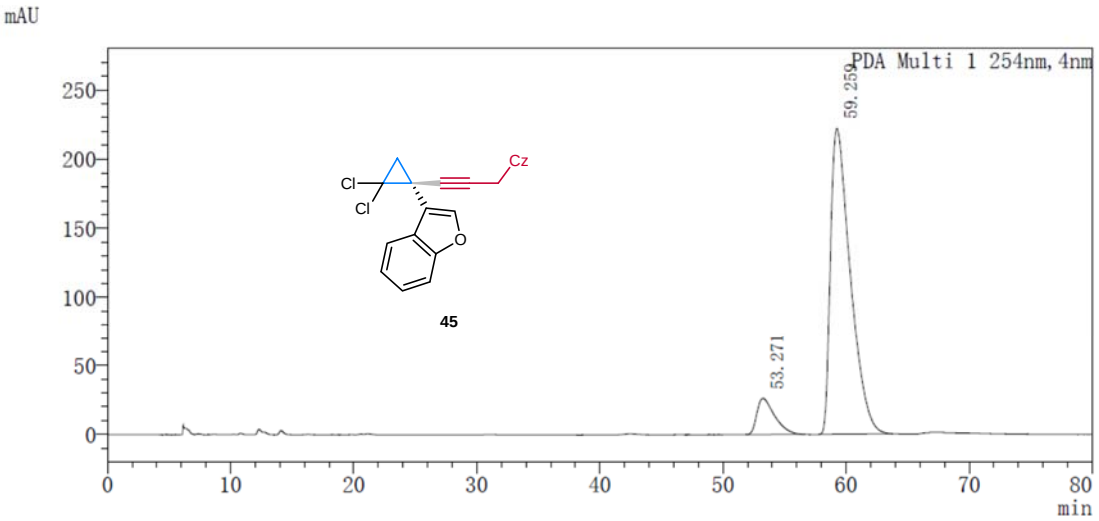
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 24.712 | MF R | 0.3884 | 1.25875e4 | 540.09961 | 91.4907 |
| 2 | 27.608 | BB | 0.3844 | 1170.72900 | 47.36433 | 8.5093 |
| Totals : | | | | 1.37582e4 | 587.46394 | |




Peak Table

PDA Ch1 254nm

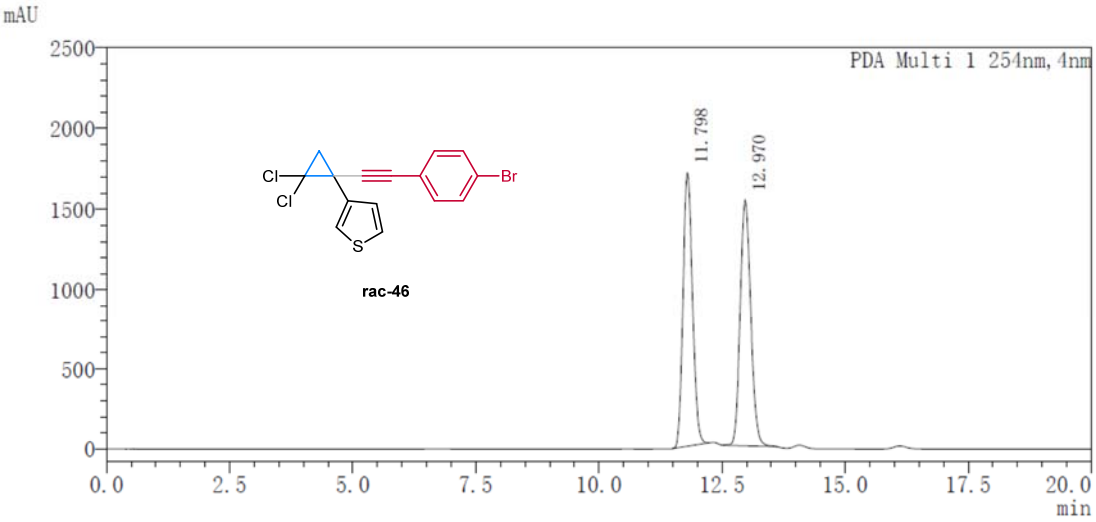
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 51.722 | 39978442 | 50.015 |
| 2 | 58.967 | 39954579 | 49.985 |




Peak Table

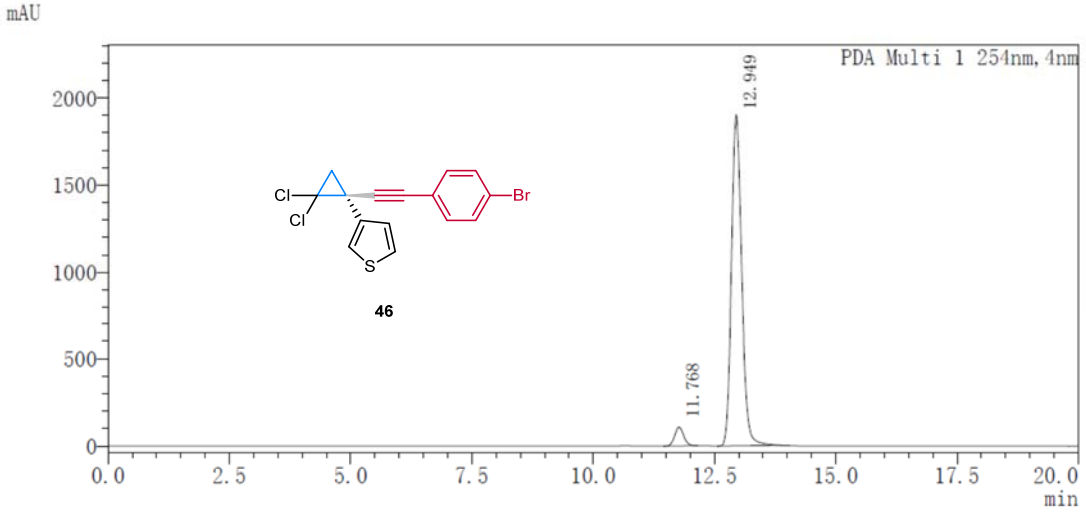
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 53.271 | 2633111 | 9.565 |
| 2 | 59.259 | 24895374 | 90.435 |




PDA Ch1 254nm

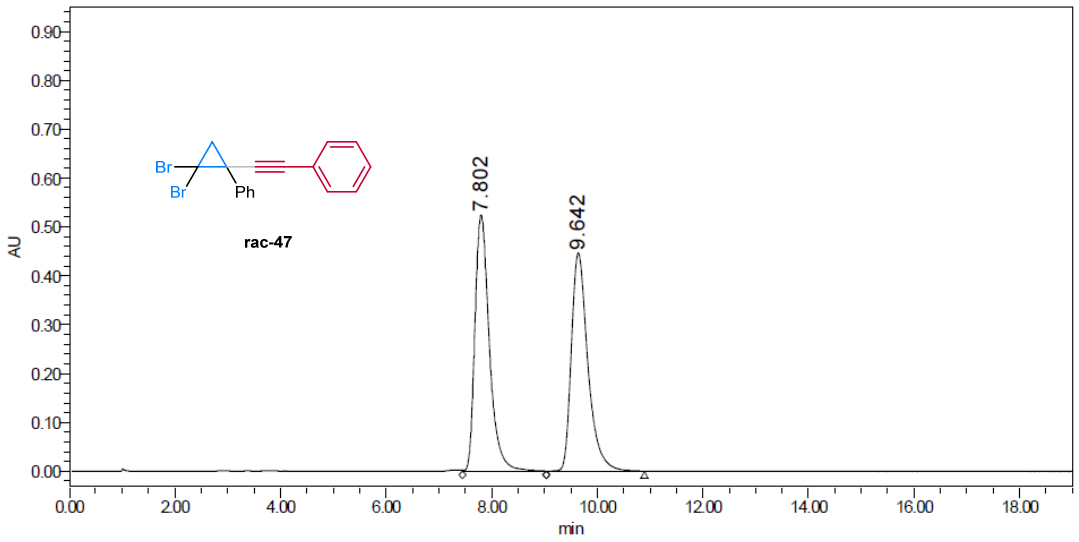
| T | Hight | Area | Area% |
|---|---|---|---|
| 11.798 | 1708944 | 22869419 | 49.790 |
| 12.970 | 1537100 | 23062216 | 50.210 |




PDA Ch1 254nm

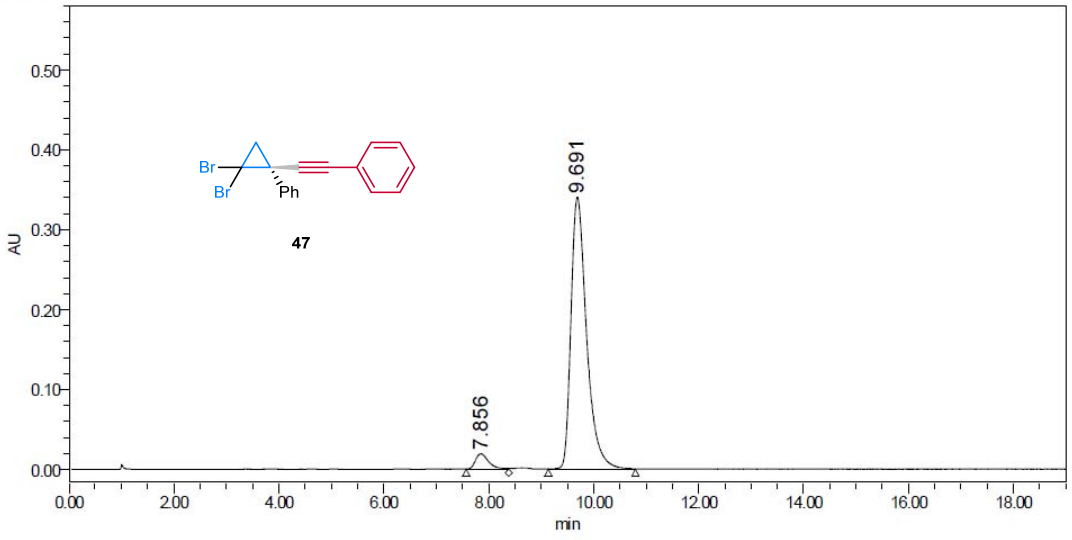
| T | Hight | Area | Area% |
|---|---|---|---|
| 11.768 | 106964 | 1380695 | 4.705 |
| 12.949 | 1899972 | 27962181 | 95.295 |

PDA 254nm

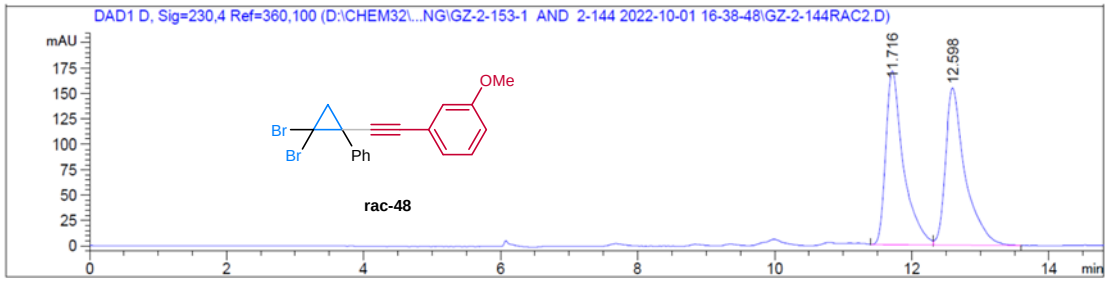



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 7.802 | 9843194 | 50.13 | 524688 |
| 2 | 9.642 | 9792247 | 49.87 | 446638 |

PDA 254nm

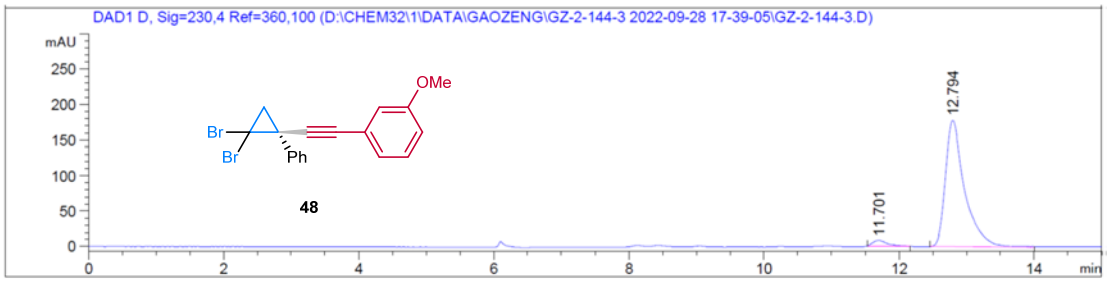



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 7.856 | 333823 | 4.52 | 19066 |
| 2 | 9.691 | 7049473 | 95.48 | 340040 |



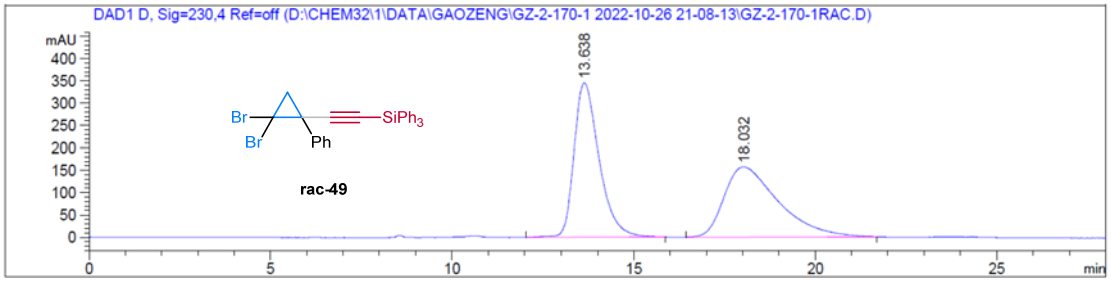

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.716 | BV | 0.2575 | 3046.78857 | 171.31827 | 49.6249 |
| 2 | 12.598 | VB | 0.2894 | 3092.85229 | 154.57343 | 50.3751 |
| Totals : | | | | 6139.64087 | 325.89169 | |



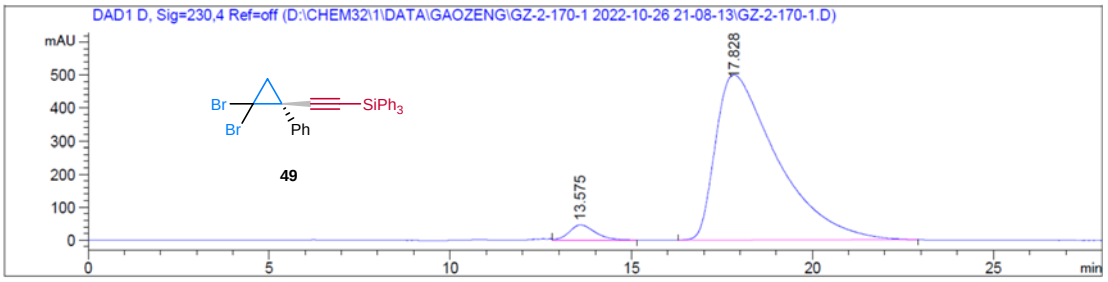

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.701 | MM R | 0.2619 | 135.46072 | 8.61915 | 3.7101 |
| 2 | 12.794 | MM R | 0.3296 | 3515.65723 | 177.79204 | 96.2899 |
| Totals : | | | | 3651.11795 | 186.41119 | |



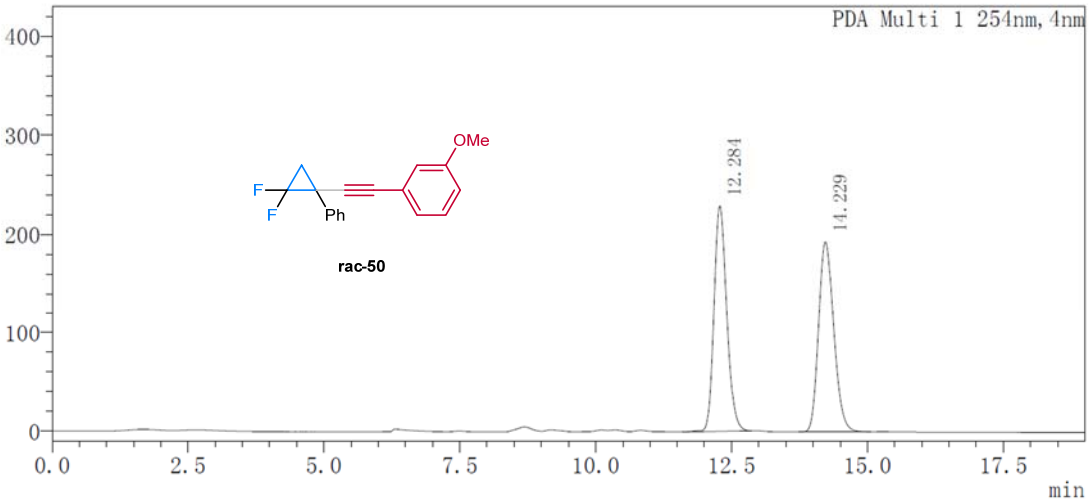

Signal 4: DAD1 D, Sig=230,4 Ref=off

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.638 | VV R | 0.7095 | 1.66404e4 | 345.77271 | 50.3982 |
| 2 | 18.032 | BB | 1.2408 | 1.63775e4 | 157.55028 | 49.6018 |
| Totals : | | | | 3.30179e4 | 503.32298 | |



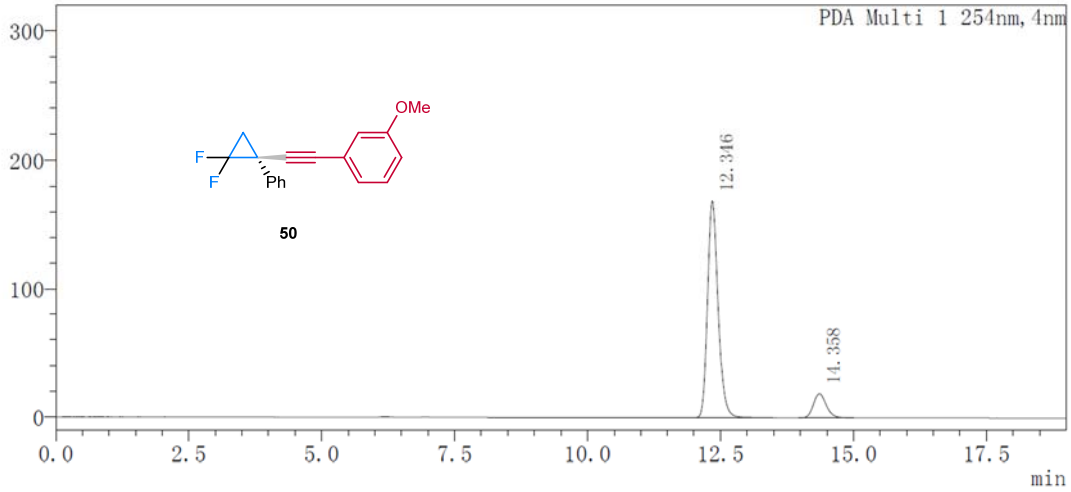

Signal 4: DAD1 D, Sig=230,4 Ref=off

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.575 | FM R | 0.8214 | 2249.65308 | 45.64775 | 3.6577 |
| 2 | 17.828 | VV R | 1.3989 | 5.92545e4 | 500.60257 | 96.3423 |
| Totals : | | | | 6.15042e4 | 546.25032 | |



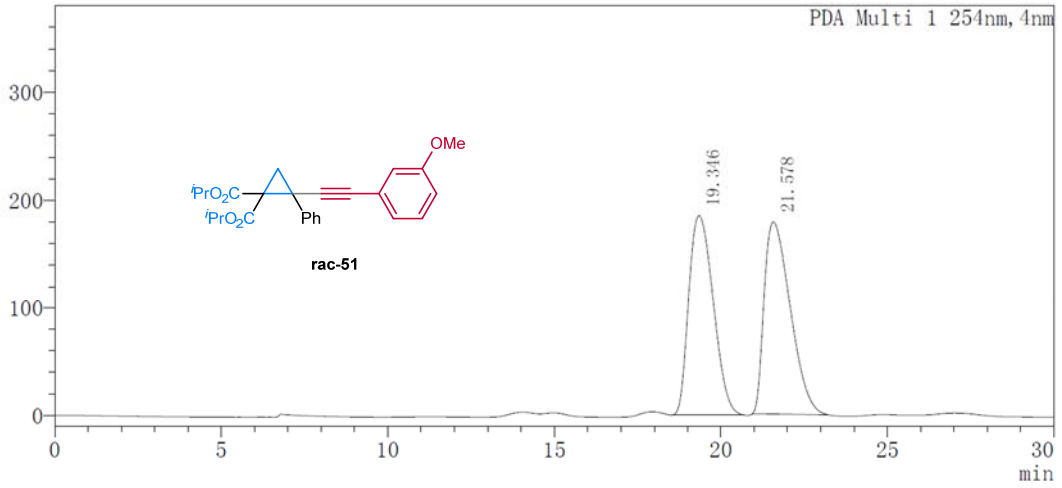

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 12.284 | 228899 | 3765998 | 49.982 |
| 14.229 | 193344 | 3768778 | 50.018 |




PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 12.346 | 168853 | 2344934 | 88.253 |
| 14.358 | 18712 | 312139 | 11.747 |

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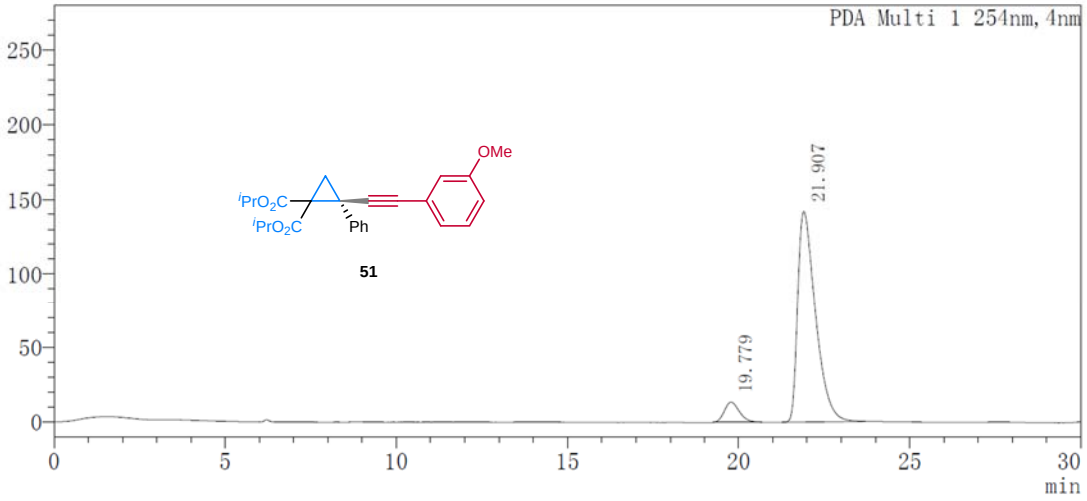
PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 19.346 | 185686 | 9499032 | 49.321 |
| 21.578 | 178785 | 9760726 | 50.679 |

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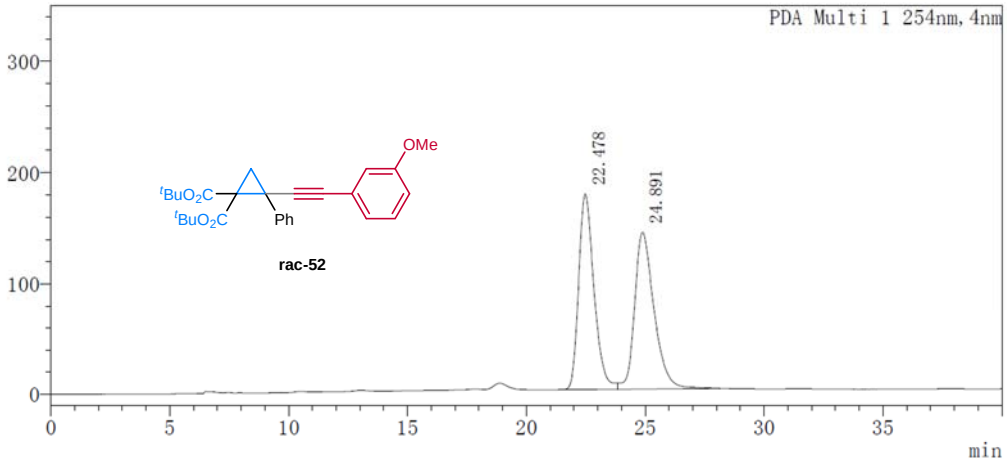
PDA Ch1 254nm

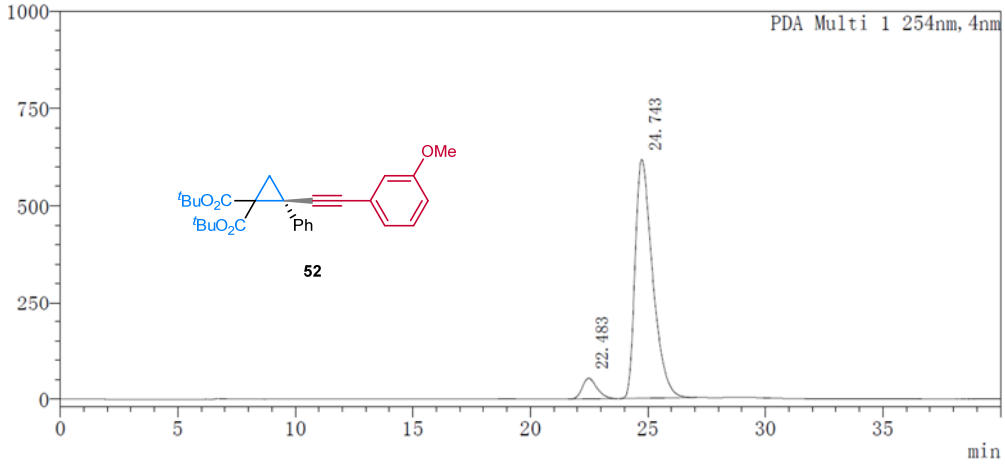
| T | Hight | Area | Area% |
|---|---|---|---|
| 19.779 | 13623 | 415907 | 7.485 |
| 21.907 | 142068 | 5140657 | 92.515 |




Peak Table

PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 22.478 | 7915233 | 49.538 |
| 2 | 24.891 | 8062942 | 50.462 |

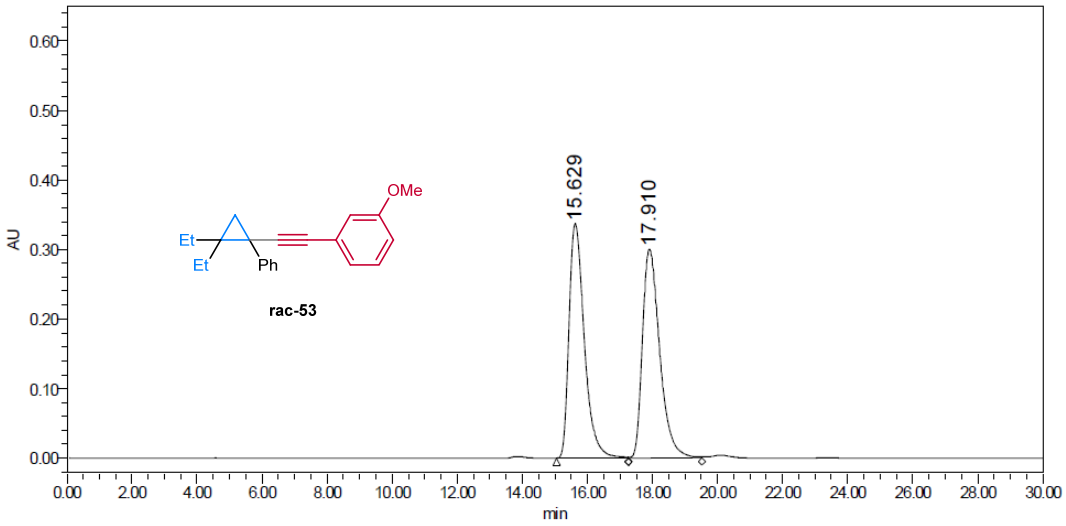



Peak Table

PDA Ch1 254nm

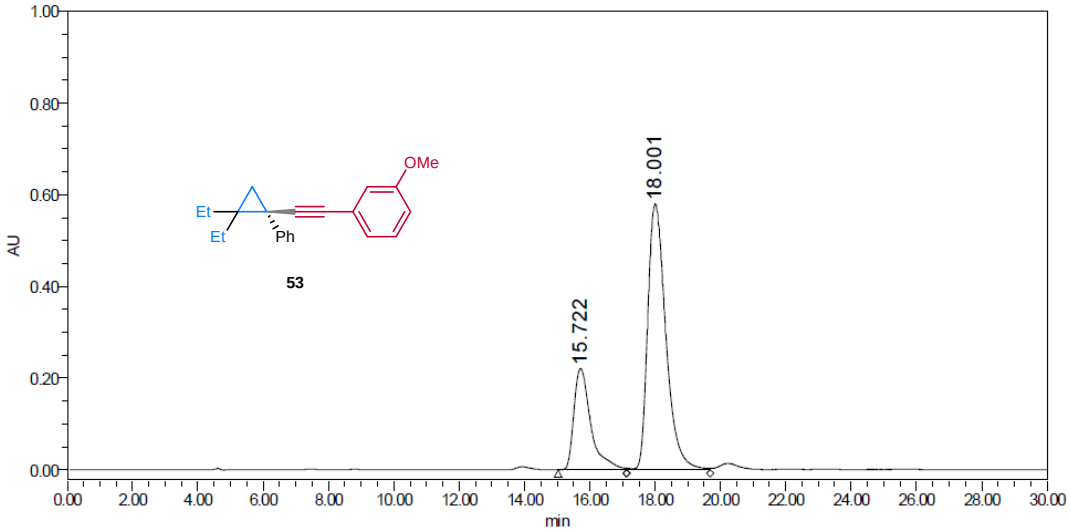
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 22.483 | 2304047 | 6.709 |
| 2 | 24.743 | 32038821 | 93.291 |

PDA 254nm

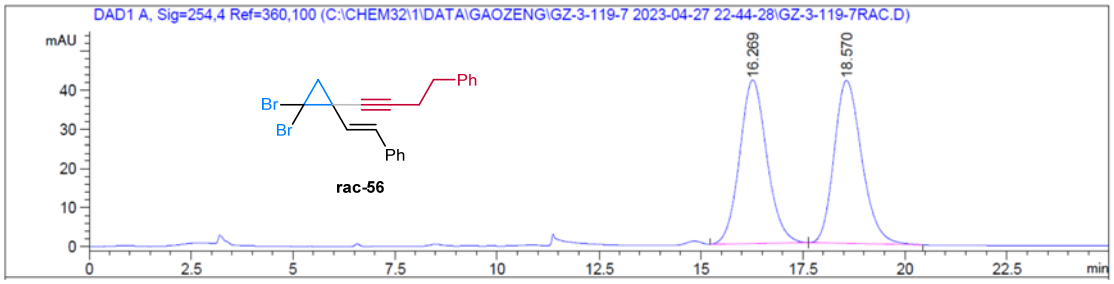



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 15.629 | 11057312 | 50.16 | 337071 |
| 2 | 17.910 | 10984757 | 49.84 | 300573 |

PDA 254nm

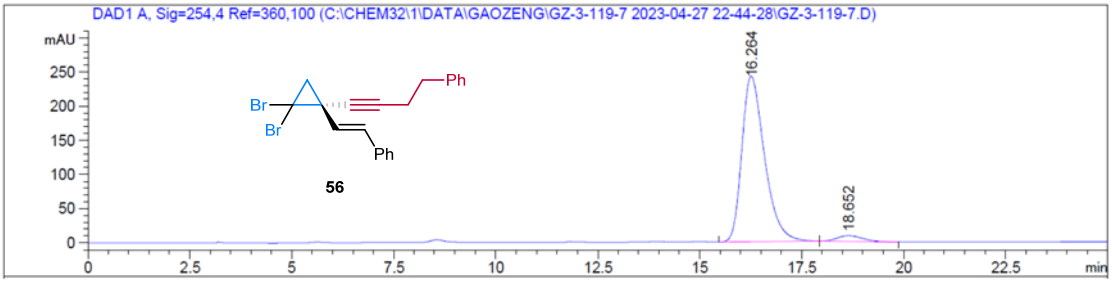



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 15.722 | 7938040 | 26.52 | 220752 |
| 2 | 18.001 | 21994050 | 73.48 | 578724 |



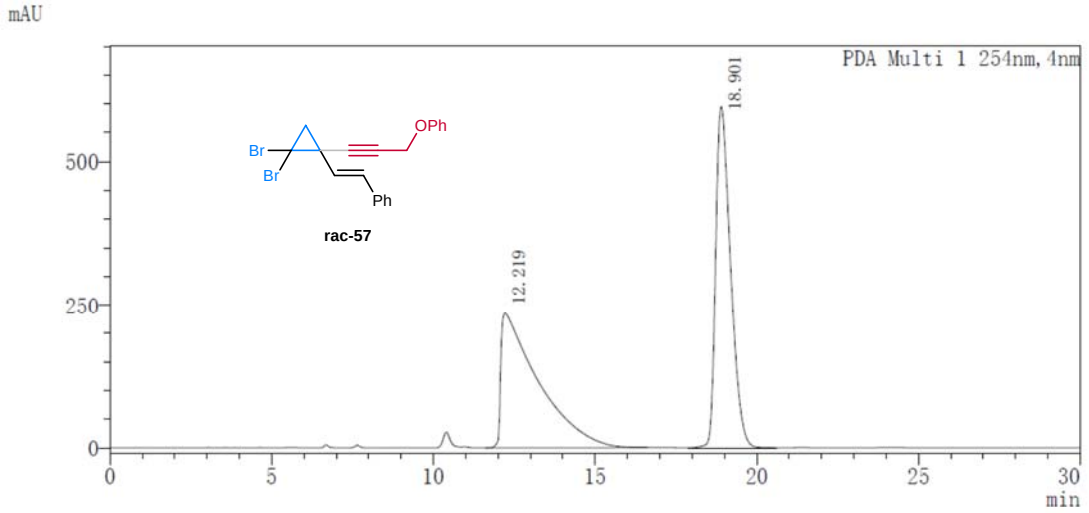

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.269 | BB | 0.7137 | 1944.04089 | 41.86842 | 49.6874 |
| 2 | 18.570 | MF R | 0.7870 | 1968.49829 | 41.68915 | 50.3126 |
| Totals : | | | | 3912.53918 | 83.55756 | |



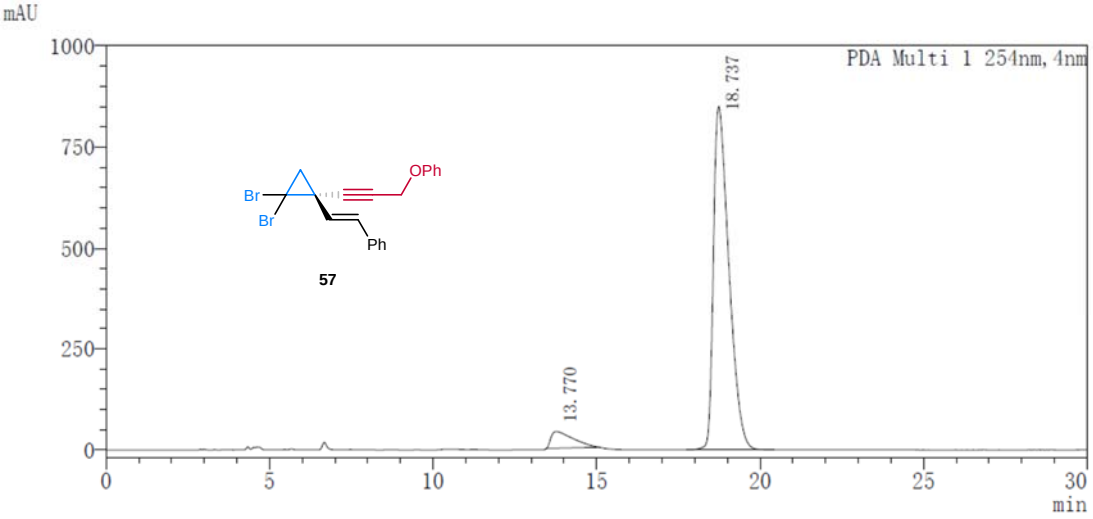

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.264 | BB | 0.5913 | 9374.26074 | 242.35936 | 96.2334 |
| 2 | 18.652 | BB | 0.6747 | 366.91513 | 8.51500 | 3.7666 |
| Totals : | | | | 9741.17587 | 250.87436 | |



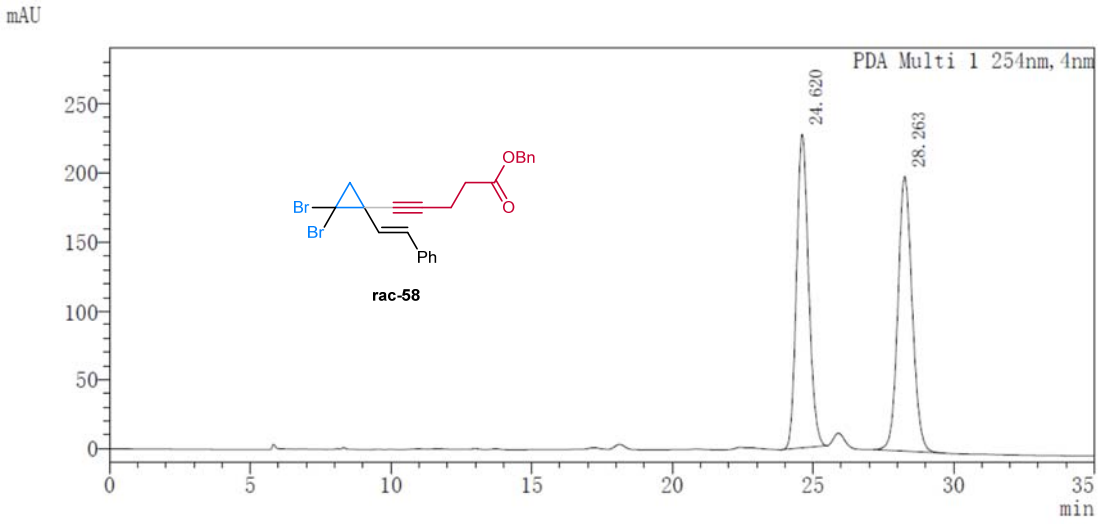

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 12.219 | 234716 | 18945511 | 49.774 |
| 18.901 | 595081 | 19117369 | 50.226 |



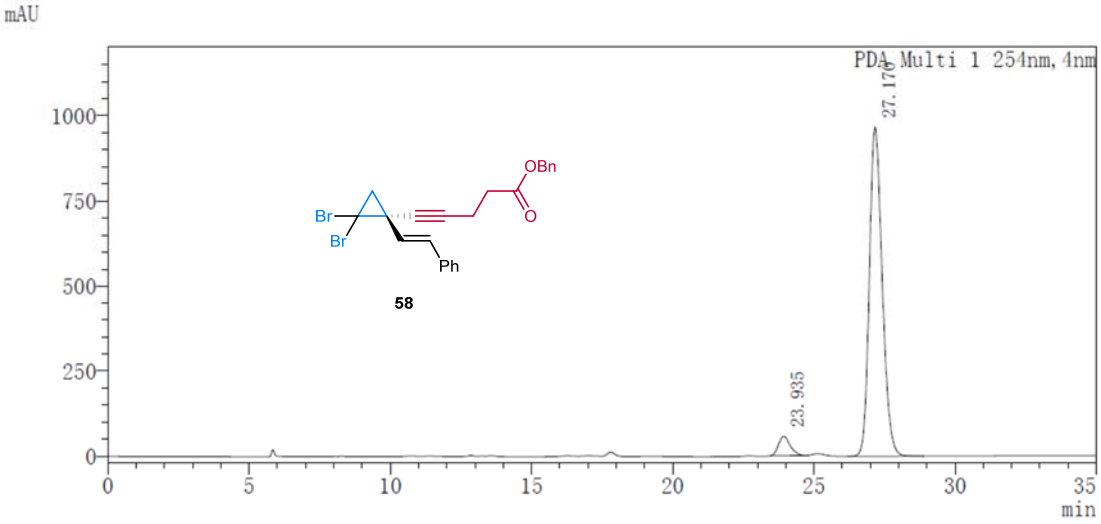

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 13.770 | 41311 | 1956001 | 6.519 |
| 18.737 | 850446 | 28047385 | 93.481 |



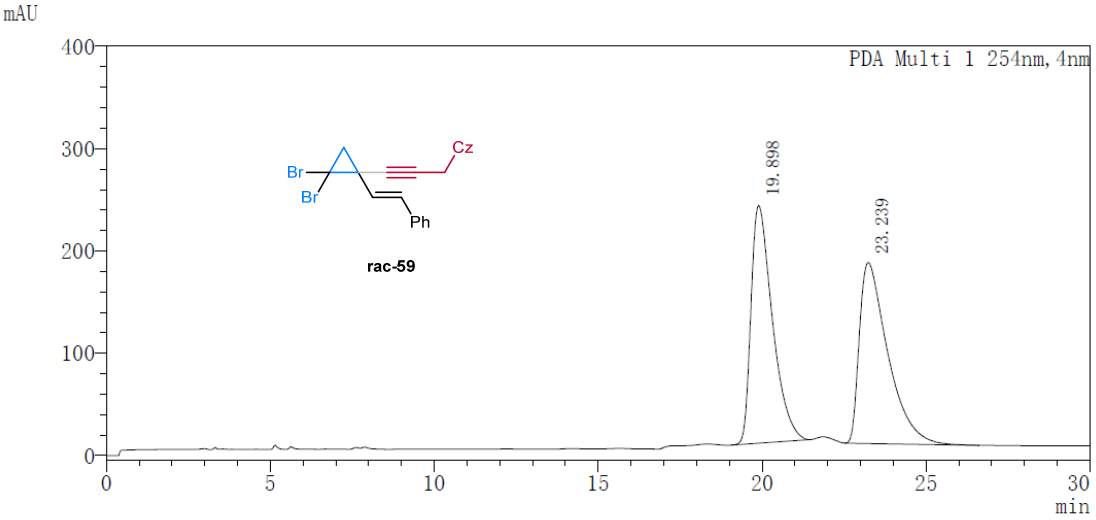

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 24.620 | 227597 | 6810328 | 49.139 |
| 28.263 | 199360 | 7048916 | 50.861 |



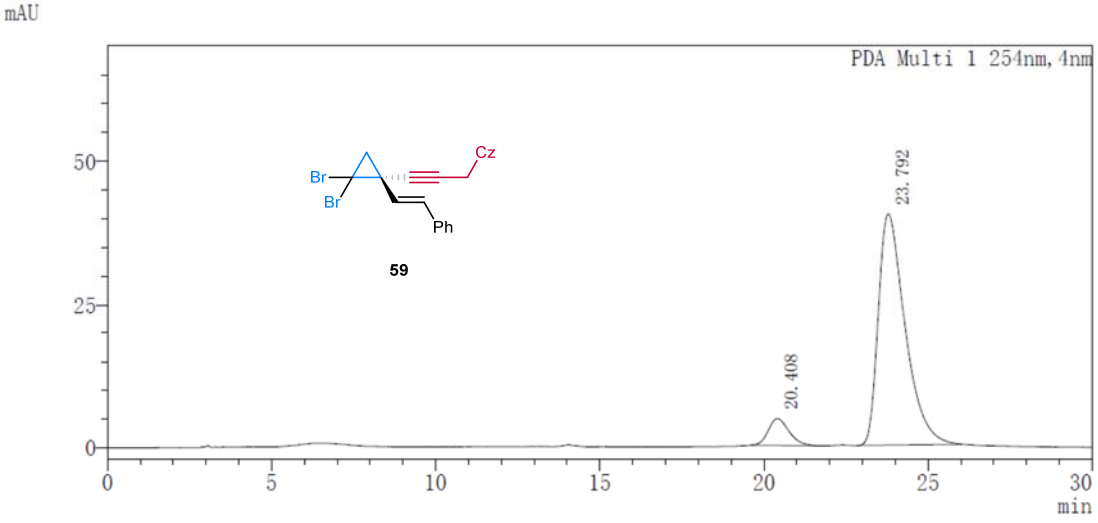

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 23.935 | 57261 | 1655643 | 5.129 |
| 27.170 | 966127 | 30621966 | 94.871 |



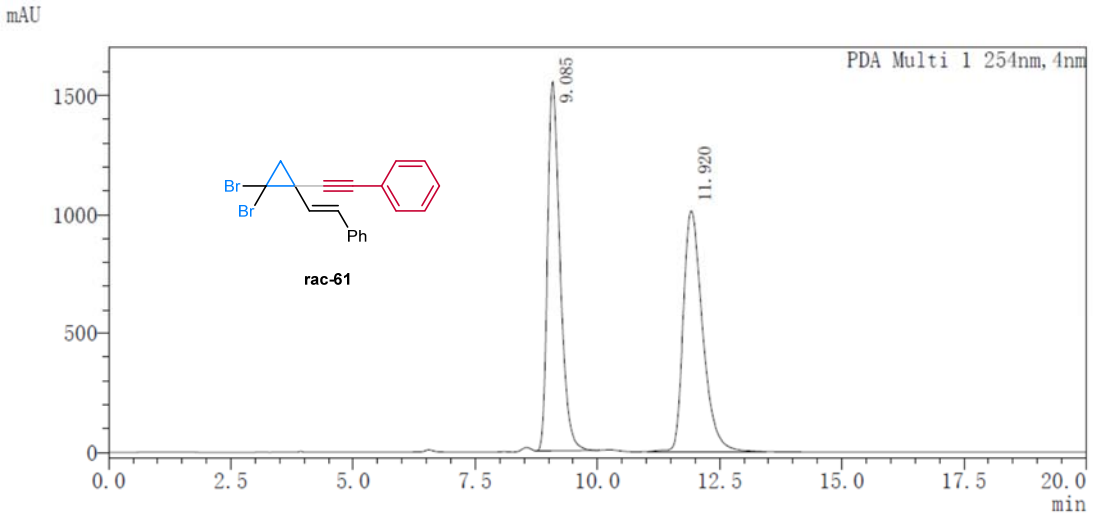

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 19.898 | 232374 | 10555523 | 49.692 |
| 23.239 | 176952 | 10686185 | 50.308 |



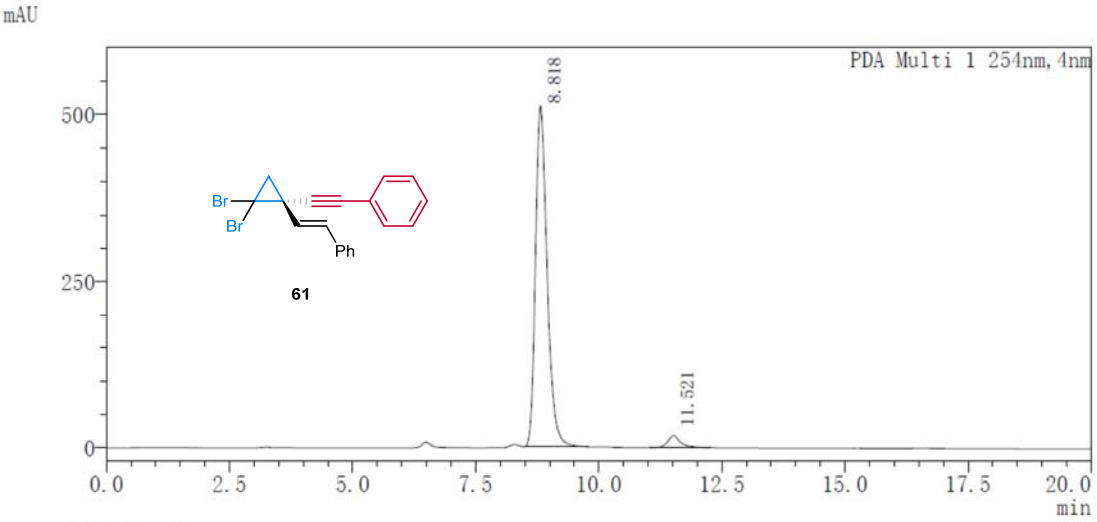

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 20.408 | 4648 | 202568 | 8.126 |
| 23.792 | 40352 | 2290210 | 91.874 |



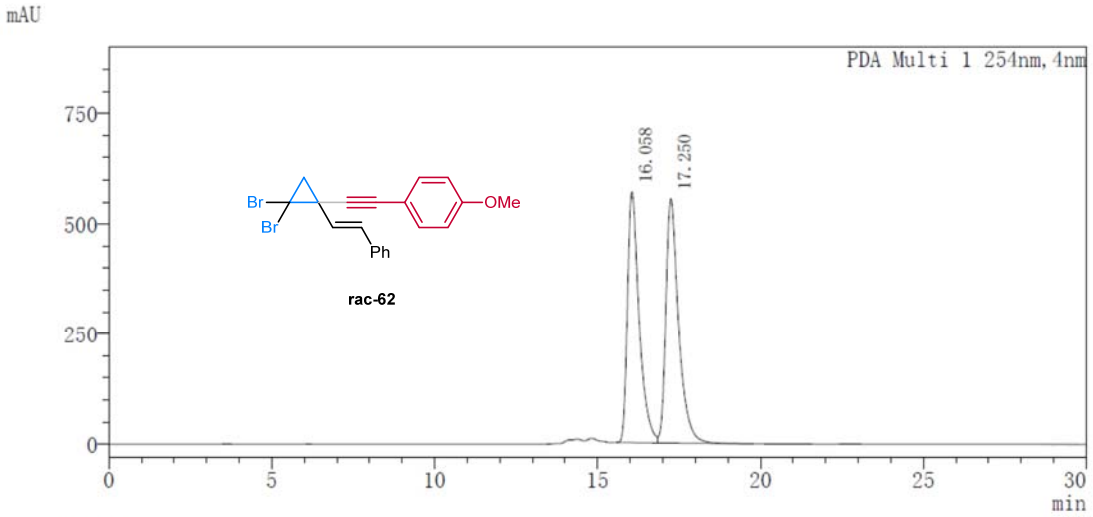

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.085 | 1551242 | 27546234 | 49.684 |
| 11.920 | 1012713 | 27896798 | 50.316 |




PDA Ch1 254nm

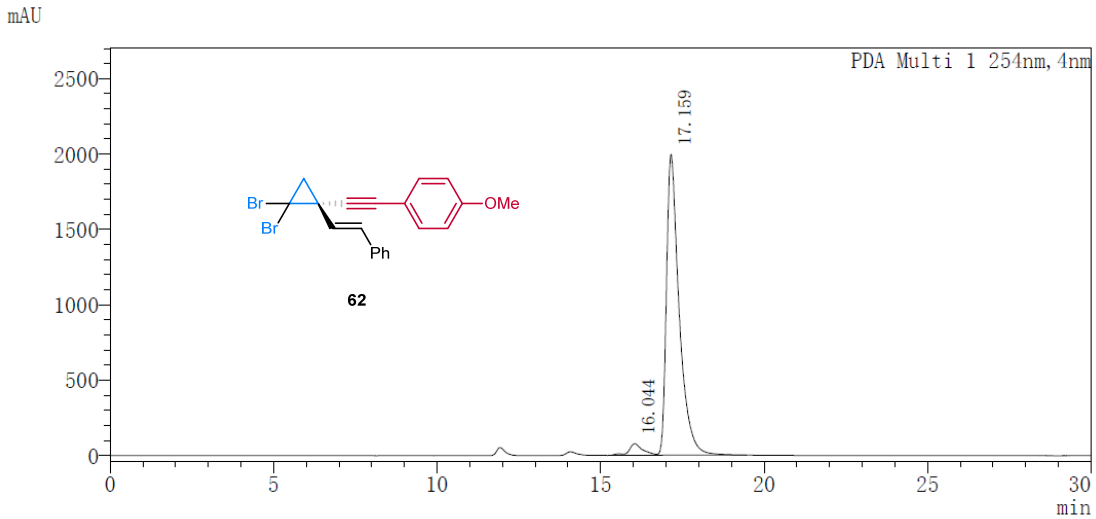
| T | Hight | Area | Area% |
|---|---|---|---|
| 8.818 | 511149 | 8408799 | 96.264 |
| 11.521 | 18196 | 326317 | 3.736 |




Peak Table

PDA Ch1 254nm

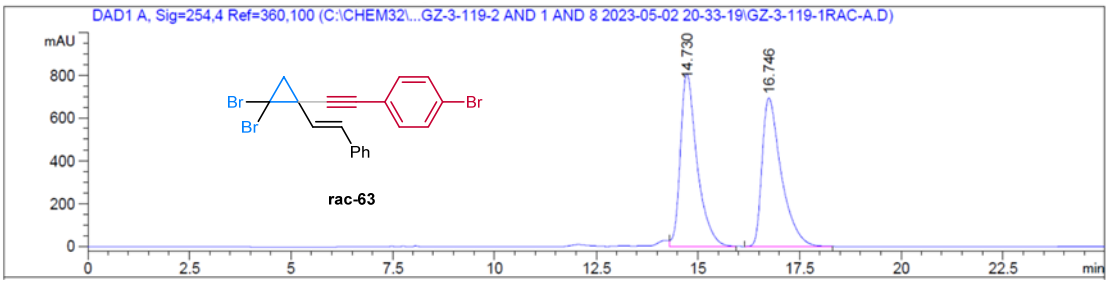
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 16.058 | 14189895 | 48.504 |
| 2 | 17.250 | 15065385 | 51.496 |




Peak Table

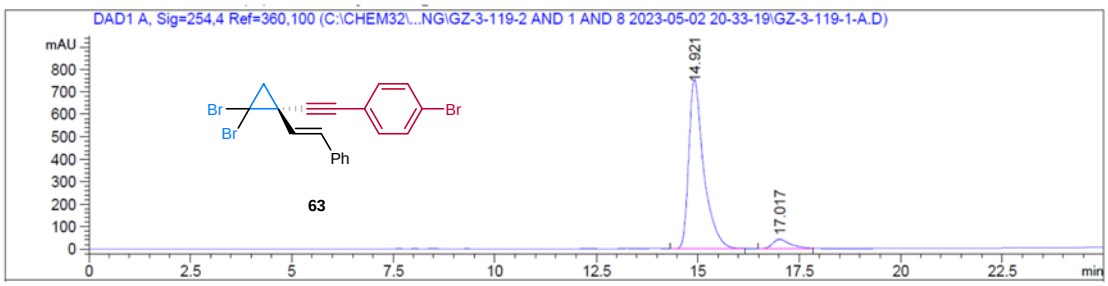
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 16.044 | 2246226 | 3.998 |
| 2 | 17.159 | 53939471 | 96.002 |



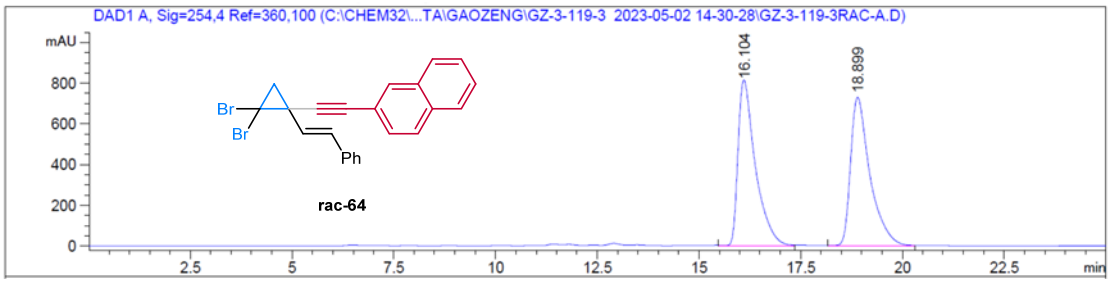

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 14.730 | MF R | 0.4773 | 2.31847e4 | 809.56775 | 50.2729 |
| 2 | 16.746 | MF R | 0.5508 | 2.29330e4 | 693.98761 | 49.7271 |
| Totals : | | | | 4.61178e4 | 1503.55536 | |



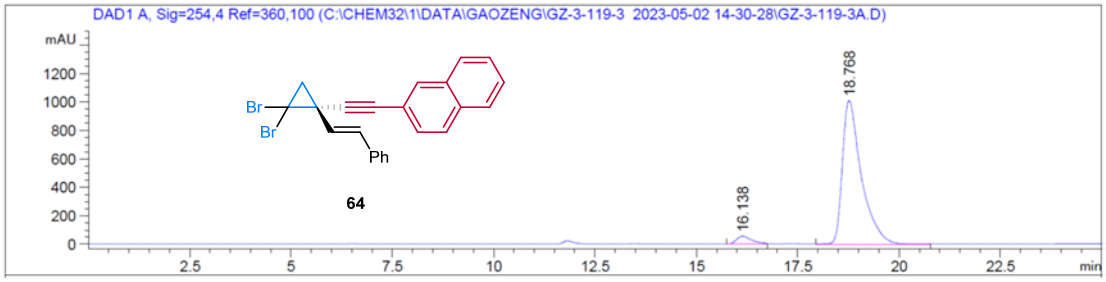

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 14.921 | MF R | 0.4257 | 1.92792e4 | 754.73895 | 93.9676 |
| 2 | 17.017 | MF R | 0.4973 | 1237.65125 | 41.48273 | 6.0324 |
| Totals : | | | | 2.05169e4 | 796.22168 | |



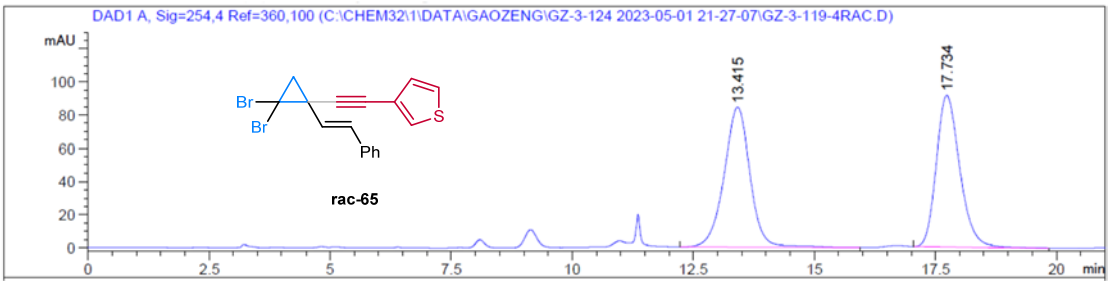

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.104 | FM R | 0.4938 | 2.41761e4 | 815.91705 | 49.9974 |
| 2 | 18.899 | FM R | 0.5514 | 2.41786e4 | 730.85938 | 50.0026 |
| Totals : | | | | 4.83547e4 | 1546.77643 | |



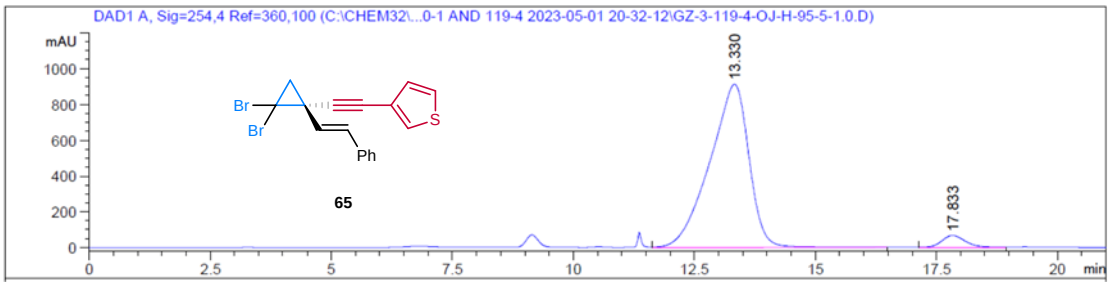

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.138 | MM R | 0.4422 | 1474.19019 | 55.56740 | 4.2096 |
| 2 | 18.768 | MM R | 0.5521 | 3.35453e4 | 1012.71283 | 95.7904 |
| Totals : | | | | 3.50195e4 | 1068.28023 | |



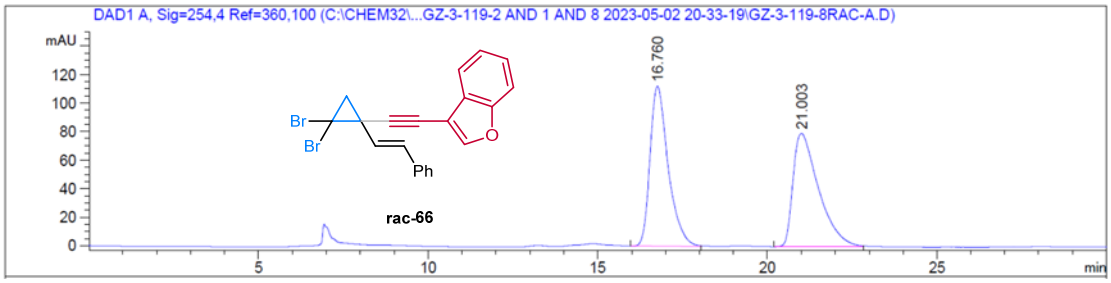

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.415 | BB | 0.5682 | 3155.50928 | 84.40516 | 50.5428 |
| 2 | 17.734 | BB | 0.5198 | 3087.73828 | 91.47199 | 49.4572 |
| Totals : | | | | 6243.24756 | 175.87715 | |



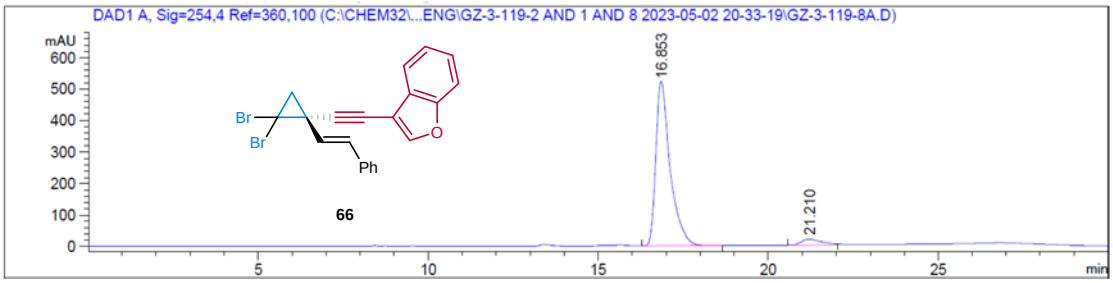

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.330 | VB | 0.8117 | 5.12696e4 | 912.16748 | 95.9131 |
| 2 | 17.833 | BB | 0.5082 | 2184.61230 | 65.99548 | 4.0869 |
| Totals : | | | | 5.34543e4 | 978.16296 | |



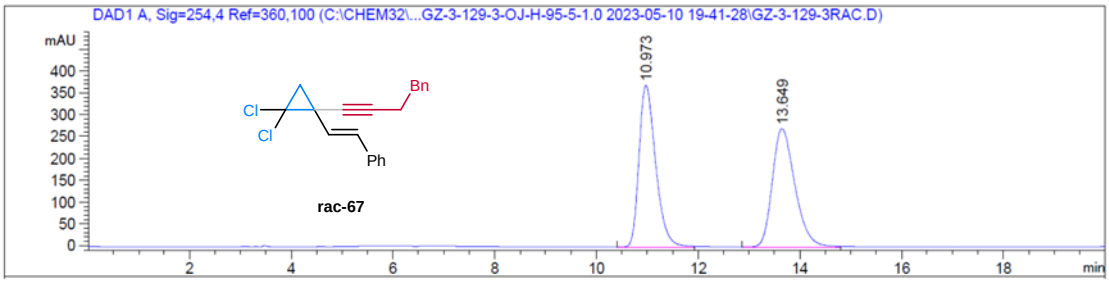

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.760 | MF R | 0.6206 | 4180.24316 | 112.25492 | 49.9308 |
| 2 | 21.003 | MF R | 0.8810 | 4191.82861 | 79.29884 | 50.0692 |
| Totals : | | | | 8372.07178 | 191.55376 | |



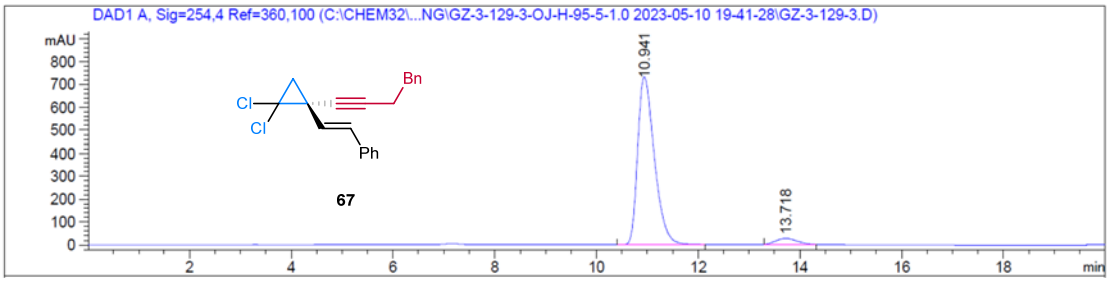

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 16.853 | BB | 0.4313 | 1.52880e4 | 522.61011 | 95.3272 |
| 2 | 21.210 | FM R | 0.6873 | 749.40558 | 18.17309 | 4.6728 |
| Totals : | | | | 1.60375e4 | 540.78320 | |



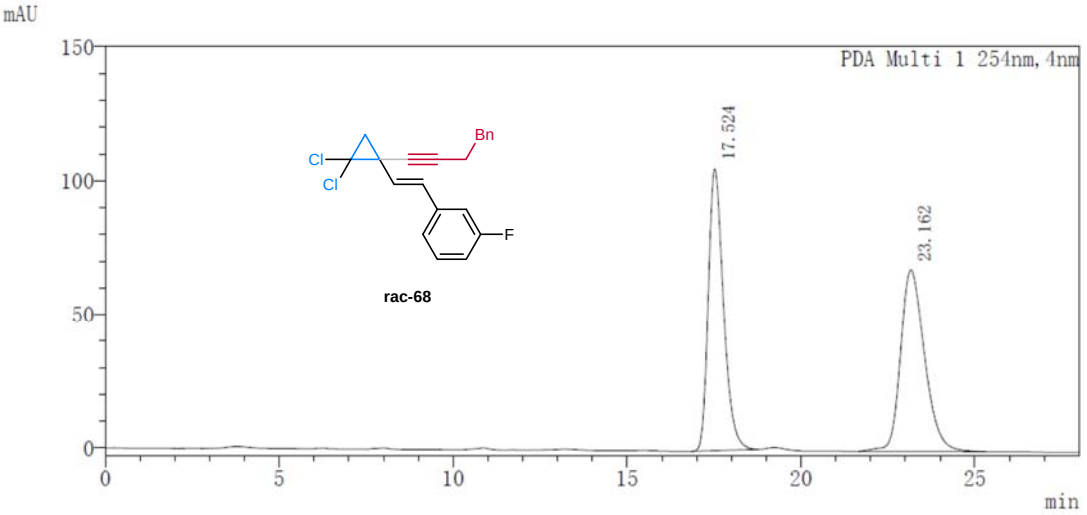

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.973 | MF R | 0.3788 | 8414.79785 | 370.27197 | 50.1266 |
| 2 | 13.649 | MF R | 0.5157 | 8372.29883 | 270.60547 | 49.8734 |
| Totals : | | | | 1.67871e4 | 640.87744 | |



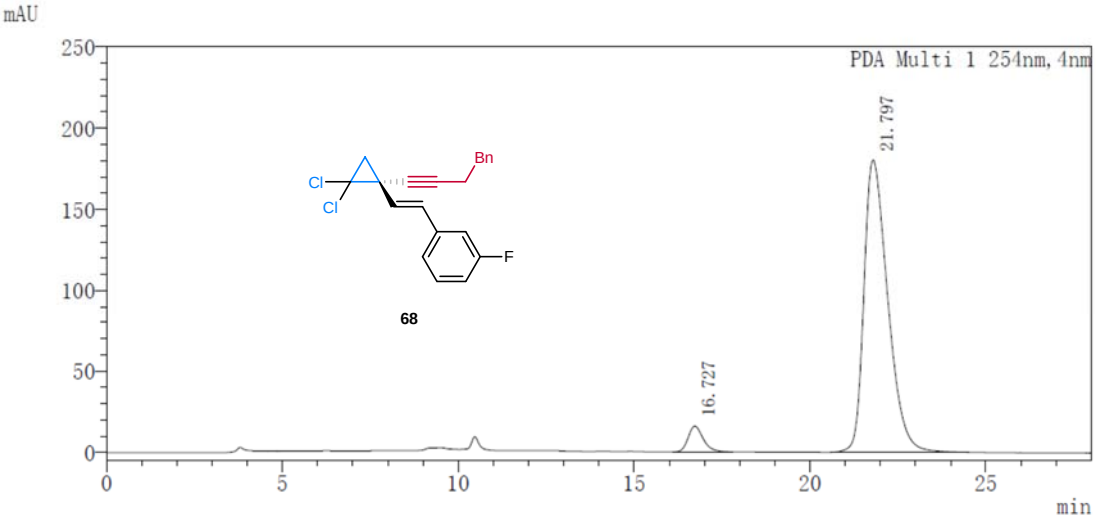

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.941 | MF R | 0.3809 | 1.67404e4 | 732.52246 | 95.2343 |
| 2 | 13.718 | MF R | 0.5094 | 837.72638 | 27.40740 | 4.7657 |
| Totals : | | | | 1.75781e4 | 759.92986 | |



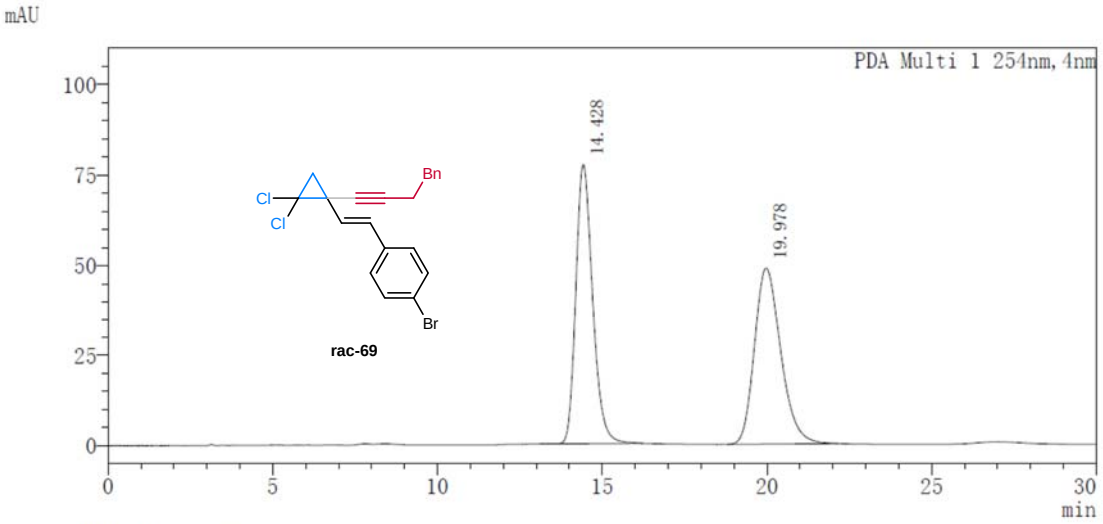

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 17.524 | 105474 | 3206114 | 49.513 |
| 23.162 | 68032 | 3269184 | 50.487 |



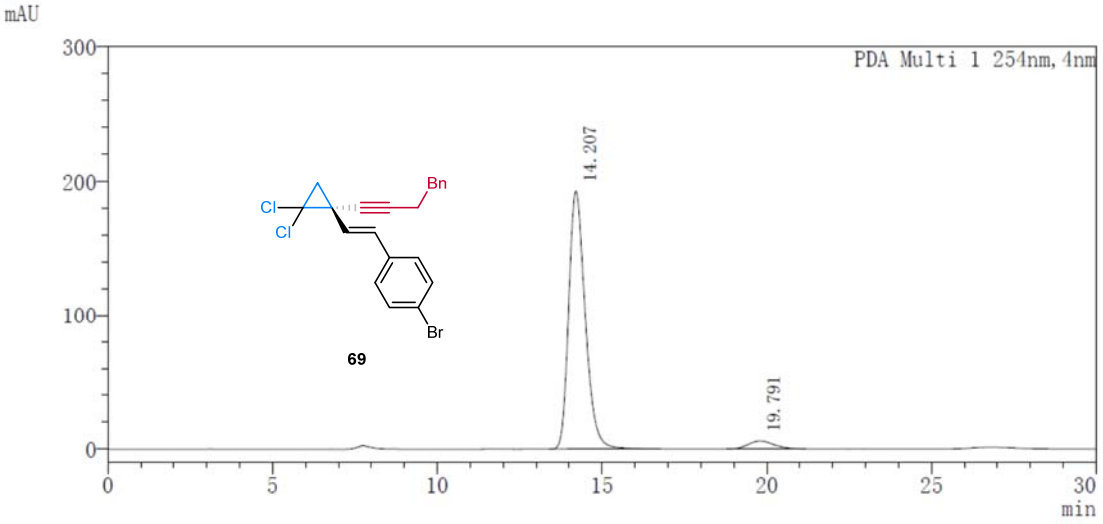

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 16.727 | 15742 | 464992 | 5.196 |
| 21.797 | 180224 | 8483691 | 94.804 |



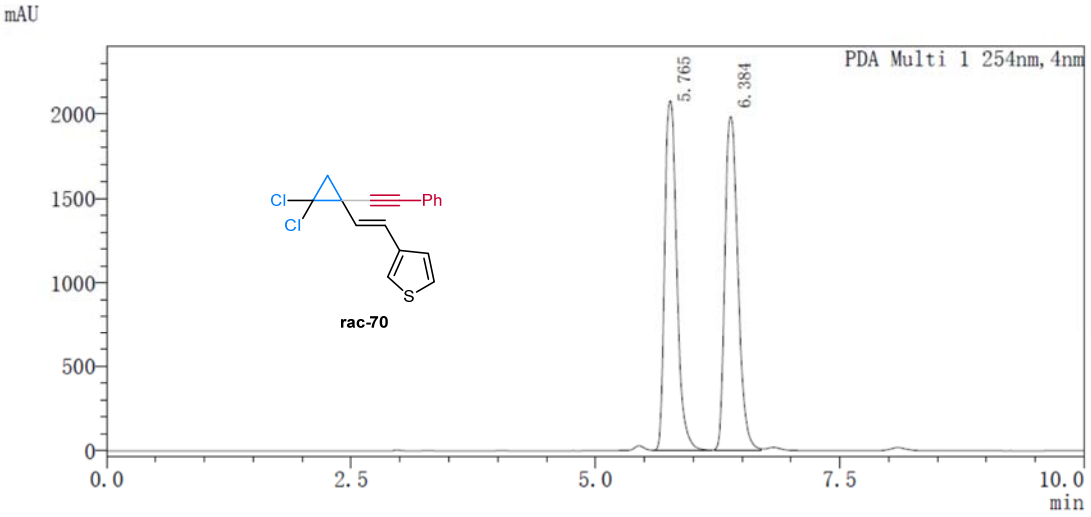

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 14.428 | 77376 | 2748660 | 50.262 |
| 19.978 | 48959 | 2719977 | 49.738 |




PDA Ch1 254nm

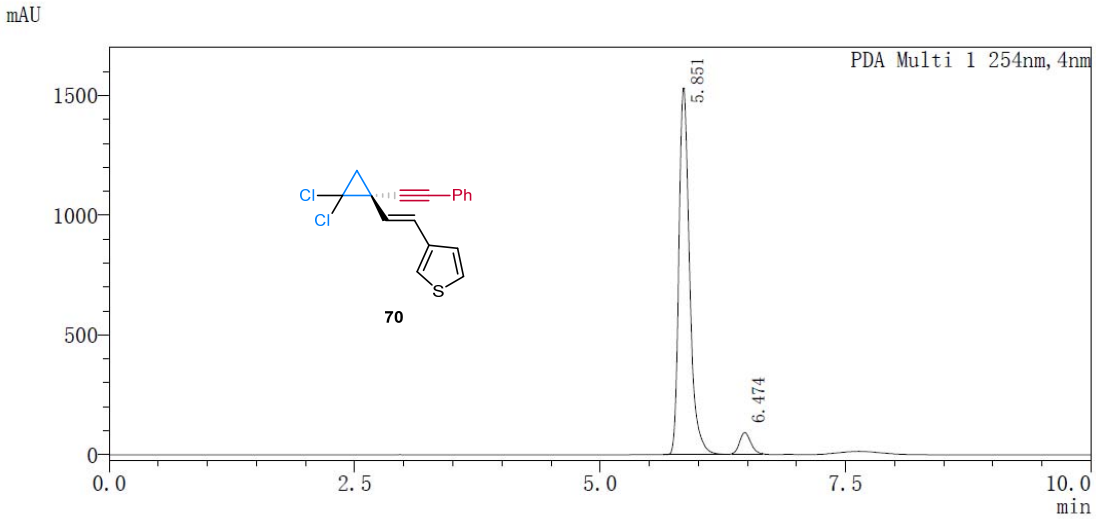
| T | Hight | Area | Area% |
|---|---|---|---|
| 14.207 | 192787 | 6696638 | 95.393 |
| 19.791 | 5953 | 323416 | 4.607 |




Peak Table

PDA Ch1 254nm

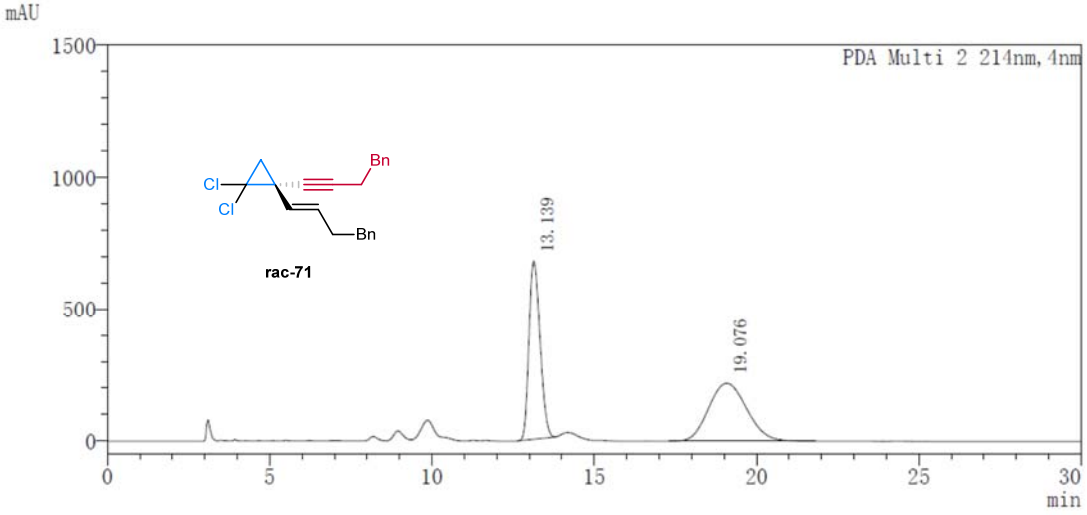
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 5.765 | 17993793 | 49.297 |
| 2 | 6.384 | 18507089 | 50.703 |




Peak Table

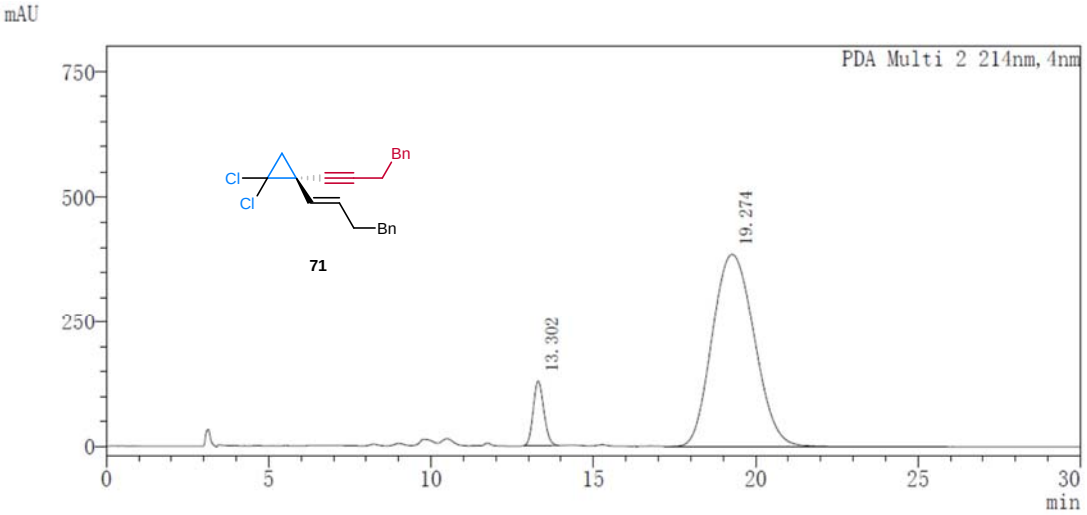
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 5.851 | 11604836 | 93.978 |
| 2 | 6.474 | 743580 | 6.022 |



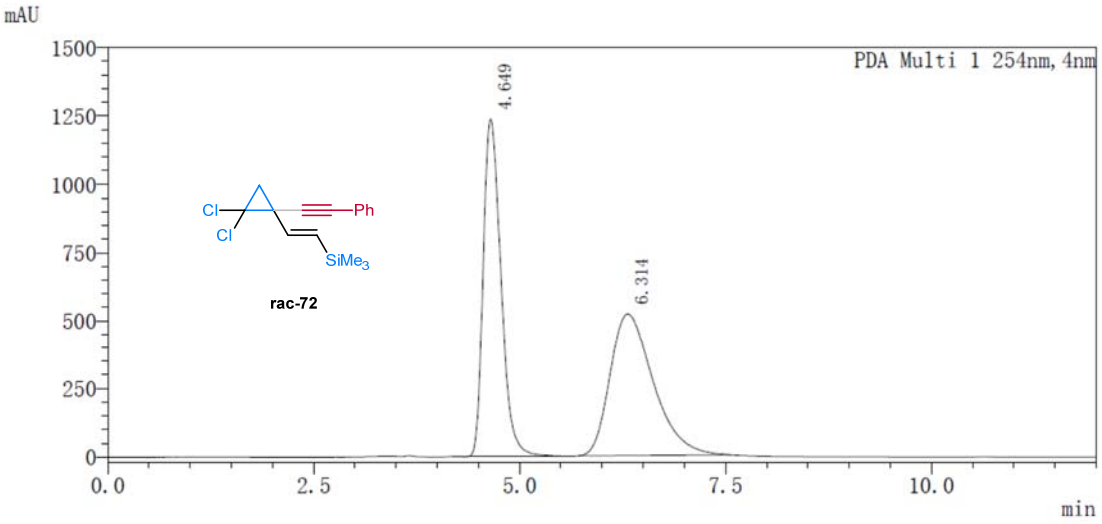

PDA Ch2 214nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 13.139 | 675572 | 16087953 | 47.413 |
| 19.076 | 218525 | 17843866 | 52.587 |




PDA Ch2 214nm

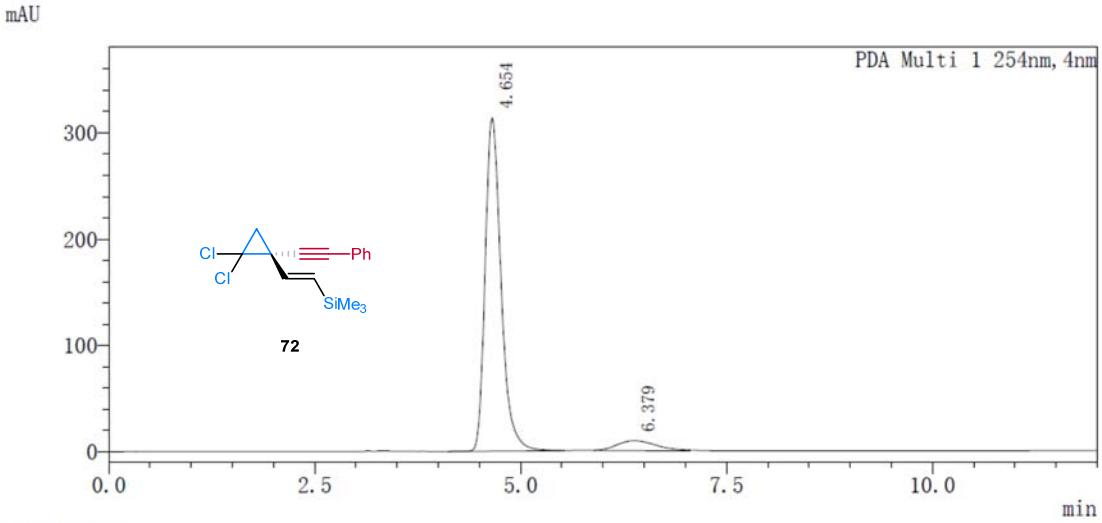
| T | Hight | Area | Area% |
|---|---|---|---|
| 13.302 | 129934 | 2962018 | 7.832 |
| 19.274 | 386926 | 34856516 | 92.168 |




Peak Table

PDA Ch1 254nm

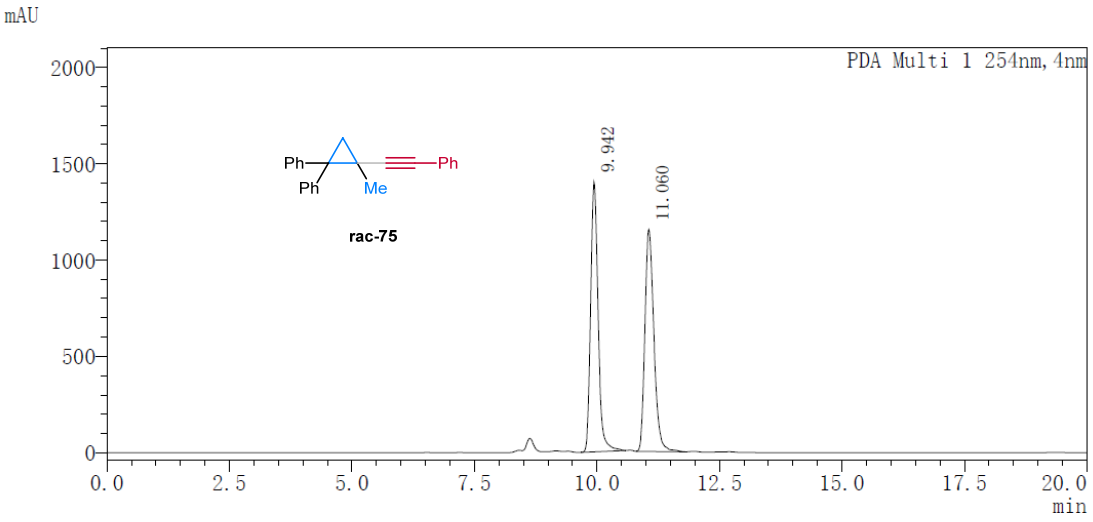
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.649 | 18482556 | 49.415 |
| 2 | 6.314 | 18919850 | 50.585 |




Peak Table

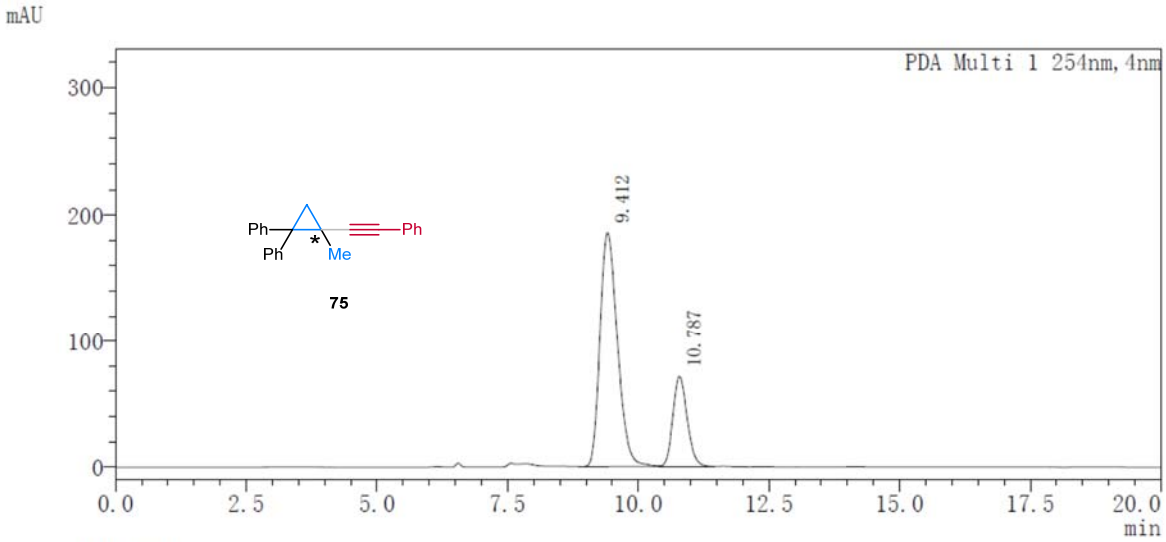
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.654 | 4217850 | 93.197 |
| 2 | 6.379 | 307889 | 6.803 |



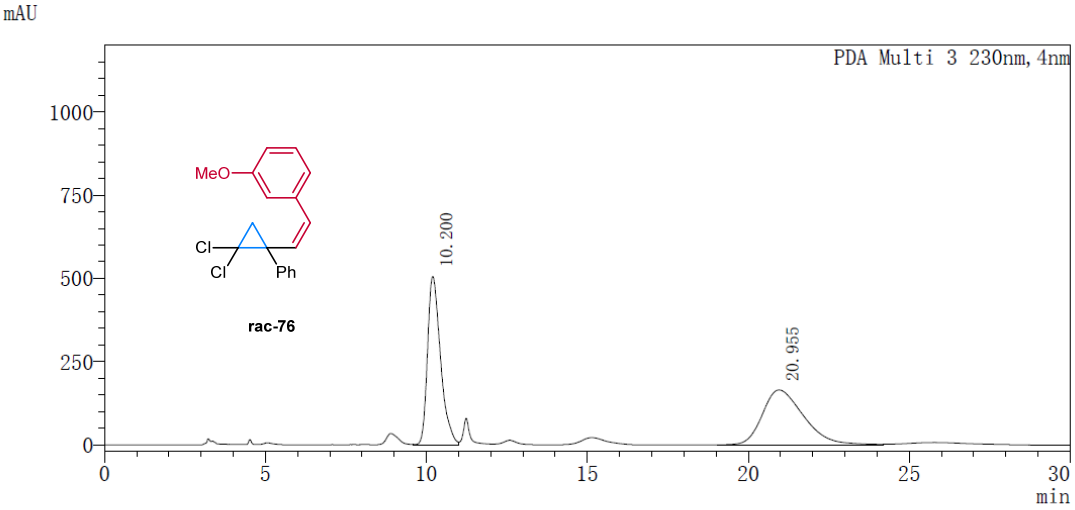

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.942 | 1402210 | 14934785 | 50.314 |
| 11.060 | 1151799 | 14748238 | 49.686 |




PDA Ch1 254nm

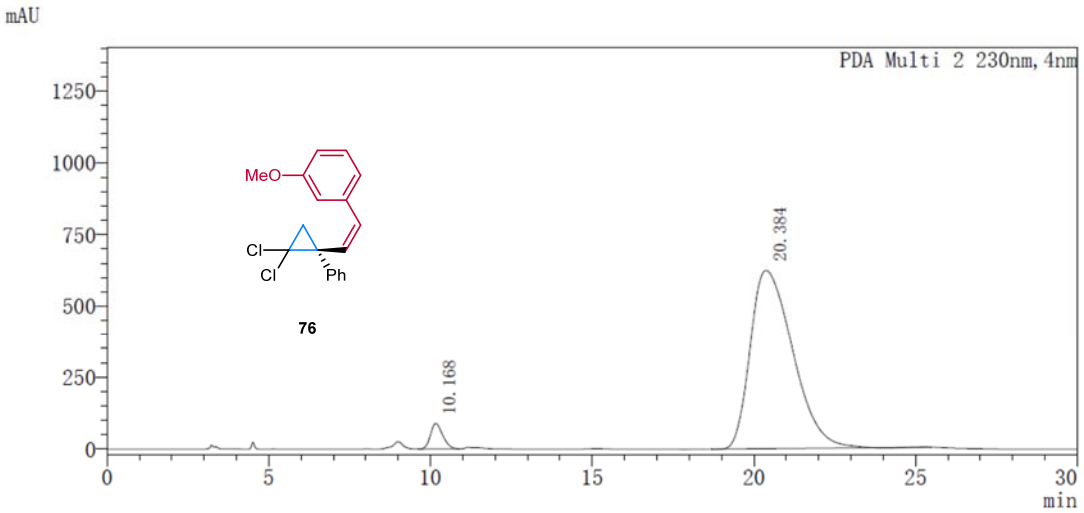
| T | Hight | Area | Area% |
|---|---|---|---|
| 9.412 | 185701 | 4313143 | 76.051 |
| 10.787 | 71332 | 1358264 | 23.949 |




Peak Table

PDA Ch3 230nm

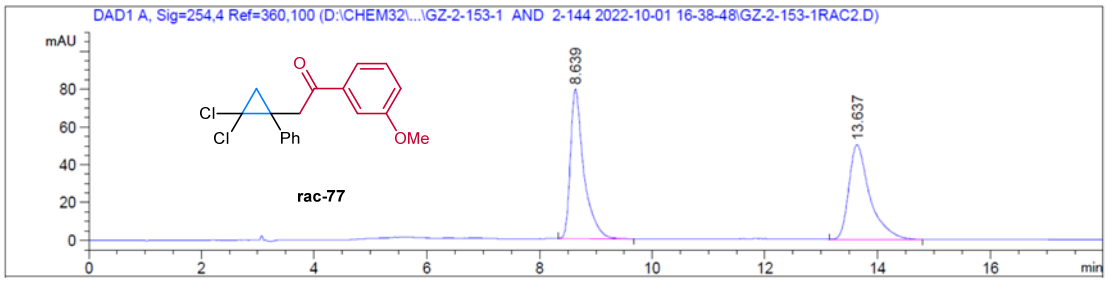
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 10.200 | 14213112 | 49.125 |
| 2 | 20.955 | 14719539 | 50.875 |




Peak Table

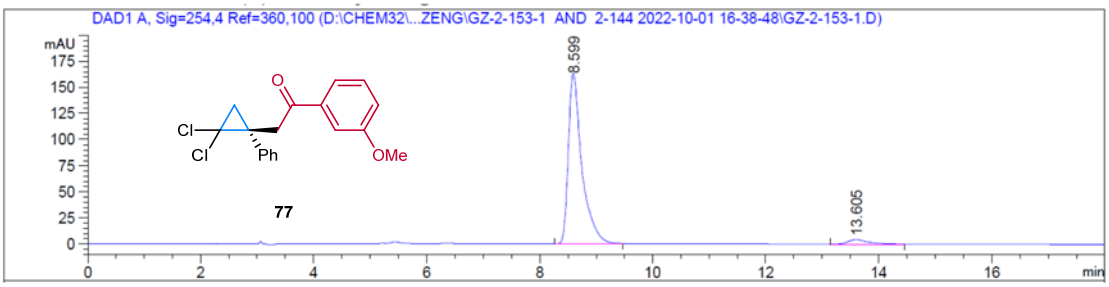
PDA Ch2 230nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 10.168 | 2355249 | 3.976 |
| 2 | 20.384 | 56882947 | 96.024 |



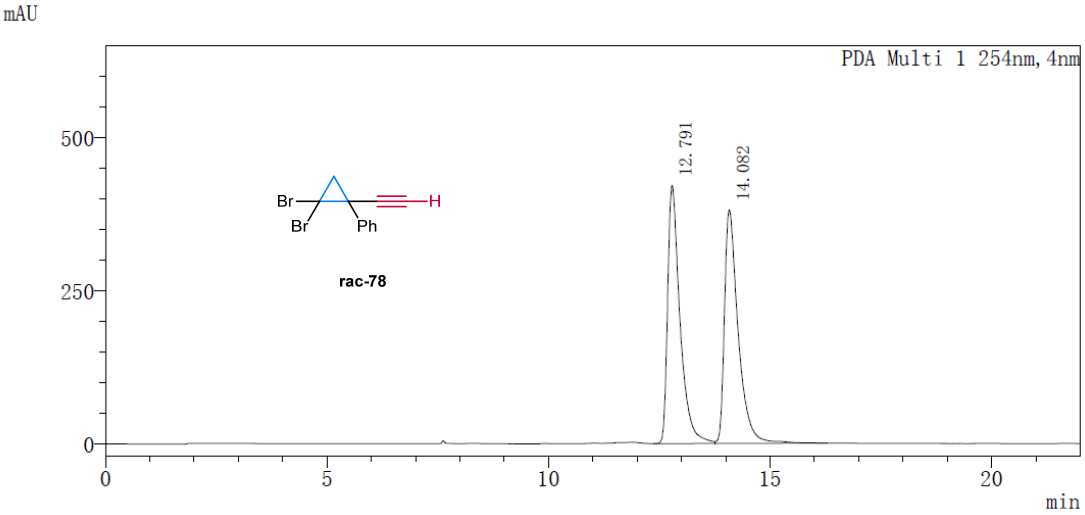

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.639 | BB | 0.2426 | 1303.38879 | 78.94127 | 50.1596 |
| 2 | 13.637 | BB | 0.3801 | 1295.09631 | 50.02019 | 49.8404 |
| Totals : | | | | 2598.48511 | 128.96146 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

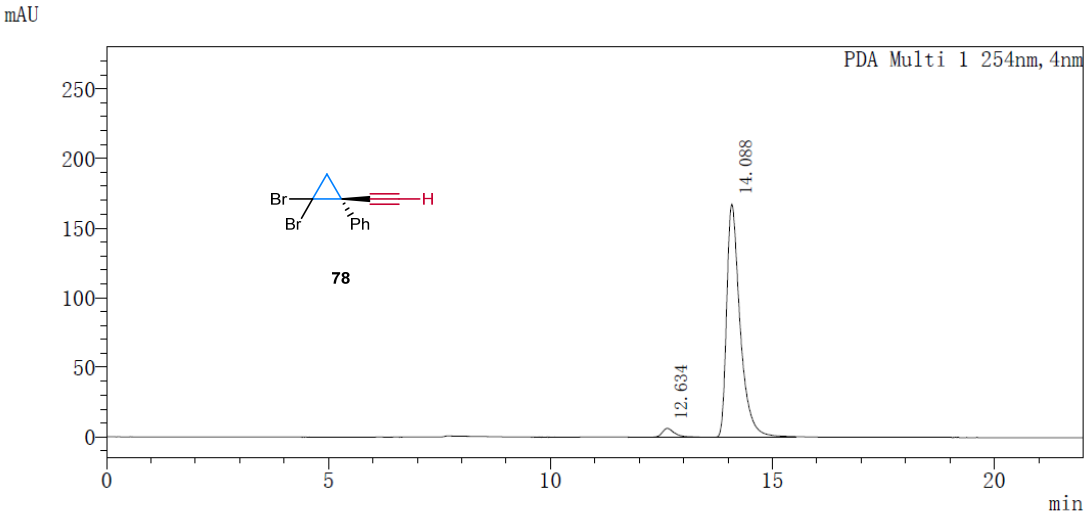
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.599 | BB | 0.2430 | 2708.05469 | 163.74033 | 95.9767 |
| 2 | 13.605 | BB | 0.3703 | 113.52175 | 4.35294 | 4.0233 |
| Totals : | | | | 2821.57644 | 168.09326 | |




Peak Table

PDA Ch1 254nm

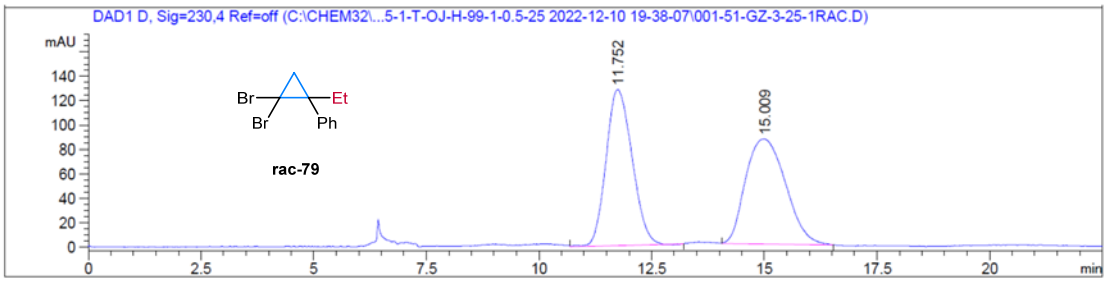
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 12.791 | 8183539 | 49.914 |
| 2 | 14.082 | 8211605 | 50.086 |




Peak Table

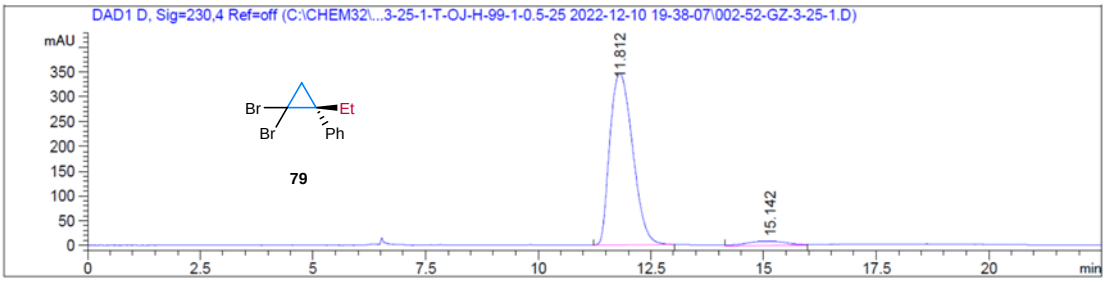
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 12.634 | 129166 | 3.521 |
| 2 | 14.088 | 3539765 | 96.479 |



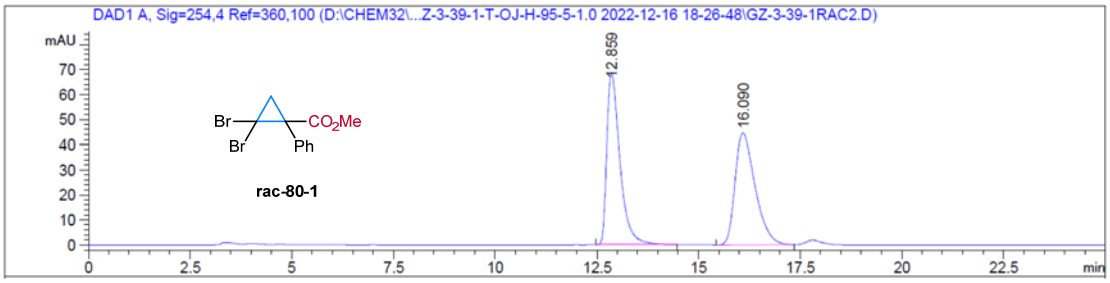

Signal 4: DAD1 D, Sig=230,4 Ref=off

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.752 | MM R | 0.6704 | 5140.88184 | 127.80561 | 49.1224 |
| 2 | 15.009 | MM R | 1.0321 | 5324.57373 | 85.98619 | 50.8776 |
| Totals : | | | | 1.04655e4 | 213.79180 | |



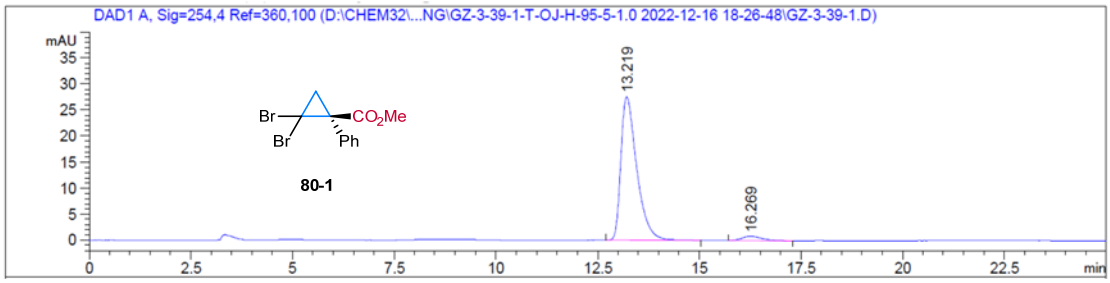

Signal 4: DAD1 D, Sig=230,4 Ref=off

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.812 | BV R | 0.5667 | 1.21818e4 | 346.03873 | 95.9357 |
| 2 | 15.142 | MF R | 1.0091 | 516.08777 | 8.52367 | 4.0643 |
| Totals : | | | | 1.26979e4 | 354.56239 | |



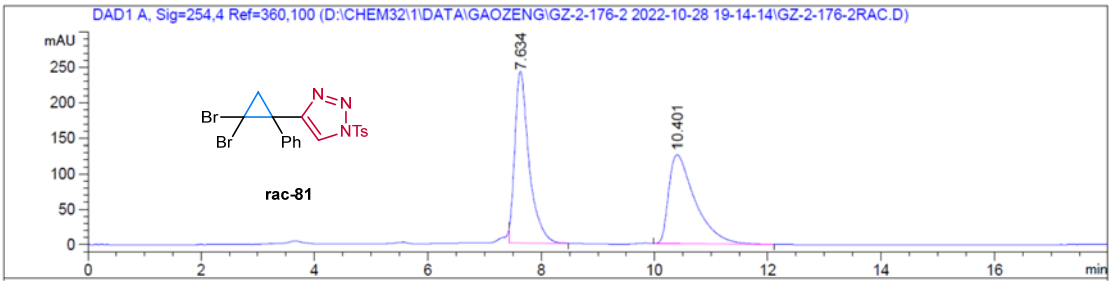

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.859 | BB | 0.3414 | 1534.81714 | 68.50484 | 50.1324 |
| 2 | 16.090 | BB | 0.5239 | 1526.71118 | 44.53648 | 49.8676 |
| Totals : | | | | 3061.52832 | 113.04132 | |



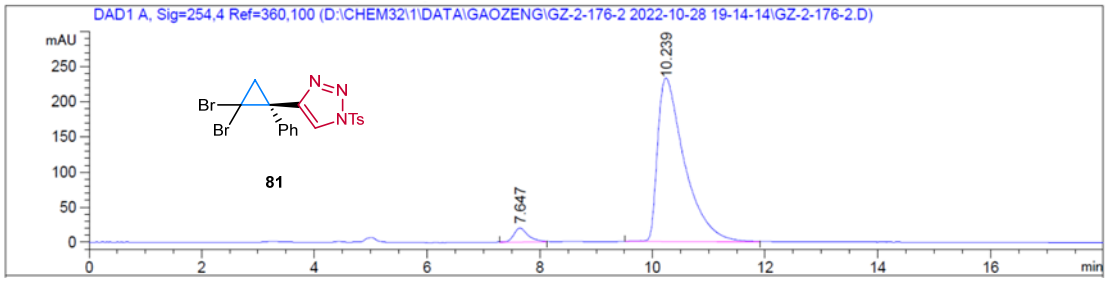

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.219 | BB | 0.4093 | 748.70435 | 27.53009 | 96.4218 |
| 2 | 16.269 | MM R | 0.5523 | 27.78392 | 8.38436e-1 | 3.5782 |
| Totals : | | | | 776.48826 | 28.36853 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

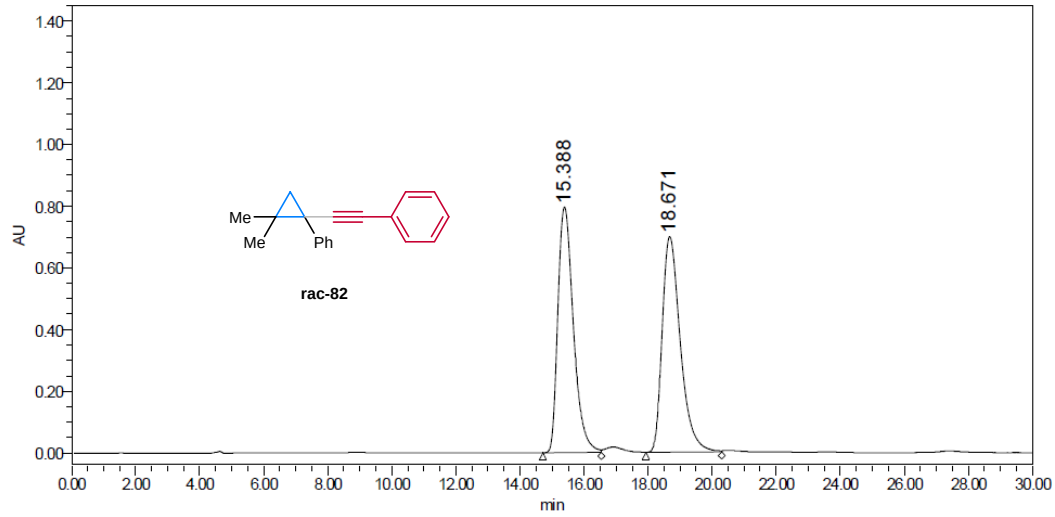
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 7.634 | FM R | 0.2911 | 4235.69629 | 242.48491 | 51.0057 |
| 2 | 10.401 | BB | 0.4714 | 4068.65649 | 125.79124 | 48.9943 |
| Totals : | | | | 8304.35278 | 368.27615 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

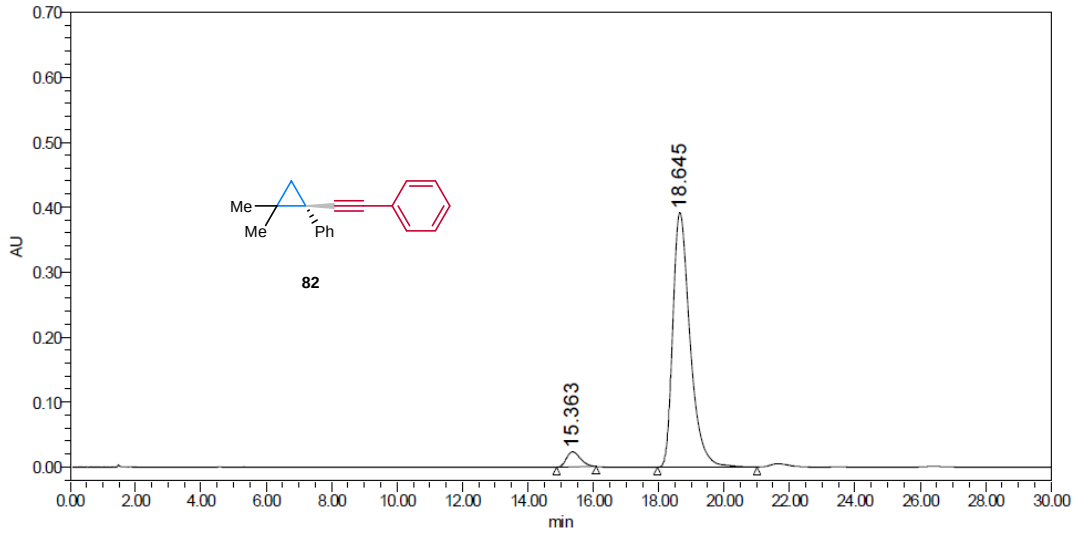
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 7.647 | FM R | 0.2963 | 357.52658 | 20.11223 | 4.4023 |
| 2 | 10.239 | MF R | 0.5555 | 7763.85498 | 232.94995 | 95.5977 |
| Totals : | | | | 8121.38156 | 253.06219 | |

PDA 254nm

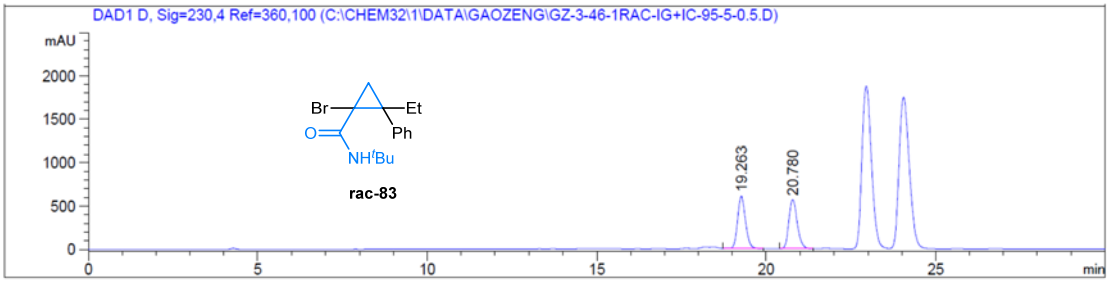



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 15.388 | 26958722 | 49.43 | 796031 |
| 2 | 18.671 | 27581950 | 50.57 | 698387 |

PDA 254nm

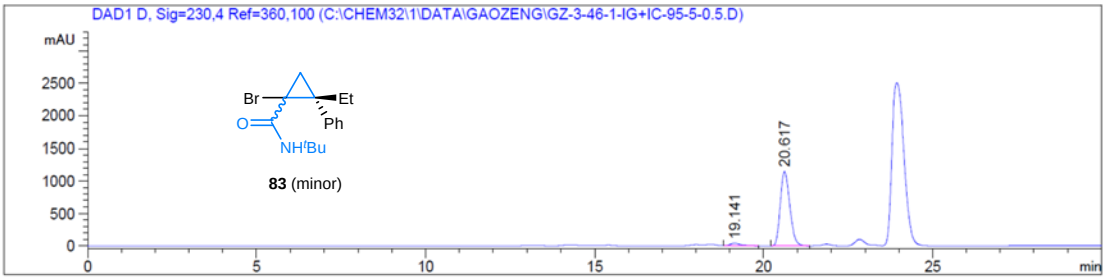



| | RT | Area | % Area | Height |
|---|---|---|---|---|
| 1 | 15.363 | 682736 | 4.53 | 23220 |
| 2 | 18.645 | 14397750 | 95.47 | 391988 |



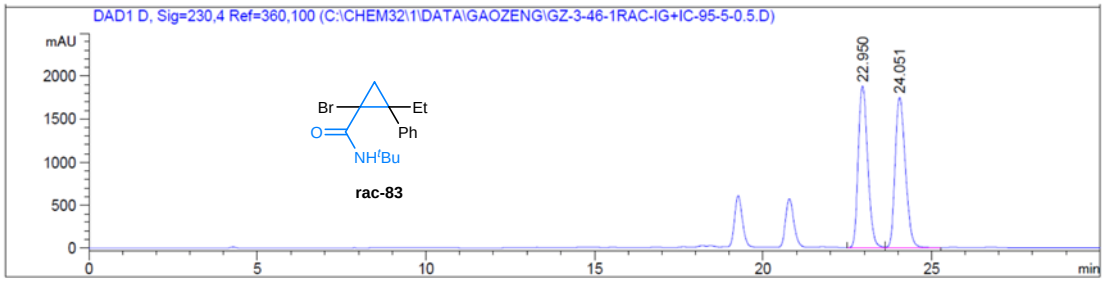

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 19.263 | VB R | 0.2501 | 9776.22852 | 604.66412 | 49.9673 |
| 2 | 20.780 | MF R | 0.2879 | 9789.02051 | 566.61035 | 50.0327 |
| Totals : | | | | 1.95652e4 | 1171.27448 | |



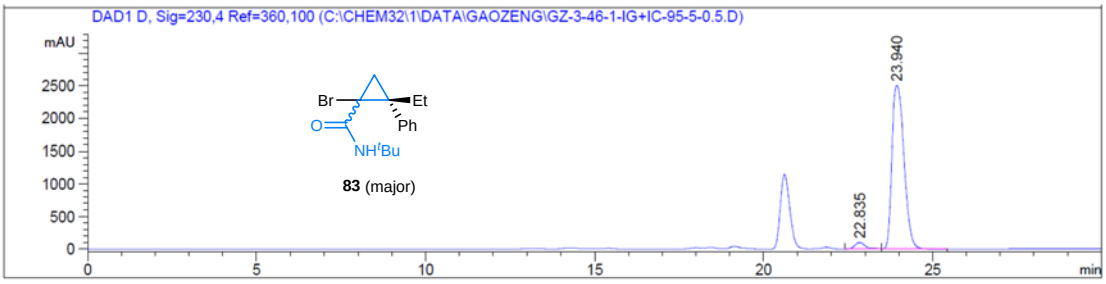

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 19.141 | VB | 0.3118 | 804.18414 | 38.47950 | 3.4646 |
| 2 | 20.617 | MF R | 0.3249 | 2.24074e4 | 1149.60327 | 96.5354 |
| Totals : | | | | 2.32115e4 | 1188.08277 | |




Signal 4: DAD1 D, Sig=230,4 Ref=360,100

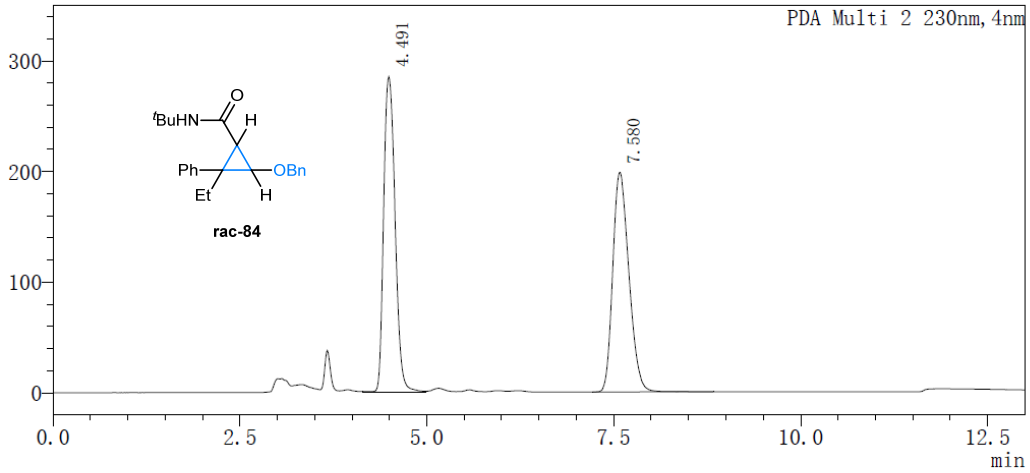
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 22.950 | BV | 0.3079 | 3.66847e4 | 1877.72131 | 49.8516 |
| 2 | 24.051 | VB | 0.3328 | 3.69031e4 | 1744.74841 | 50.1484 |
| Totals : | | | | 7.35878e4 | 3622.46973 | |




Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 22.835 | BV | 0.3290 | 2216.36816 | 102.20673 | 3.4426 |
| 2 | 23.940 | VB | 0.3932 | 6.21638e4 | 2507.36914 | 96.5574 |
| Totals : | | | | 6.43802e4 | 2609.57587 | |

mAU

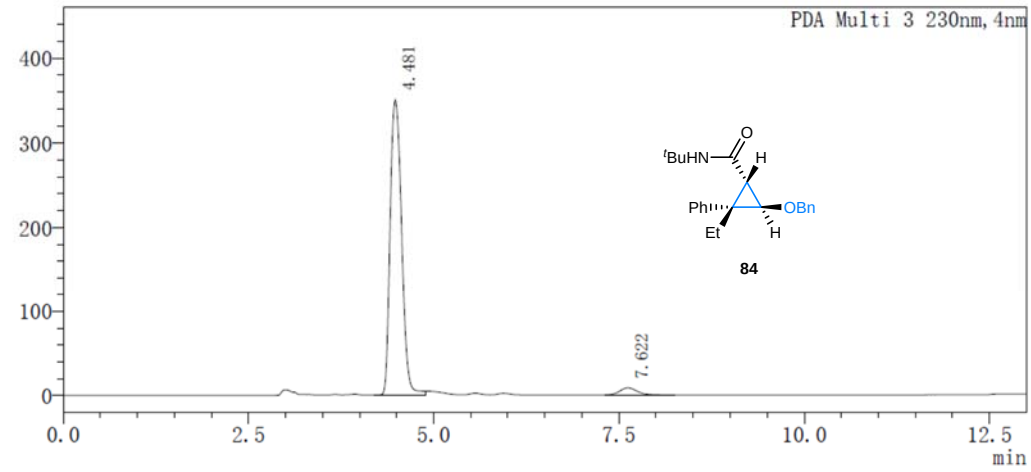



Peak Table

PDA Ch2 230nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.491 | 3037100 | 50.431 |
| 2 | 7.580 | 2985129 | 49.569 |

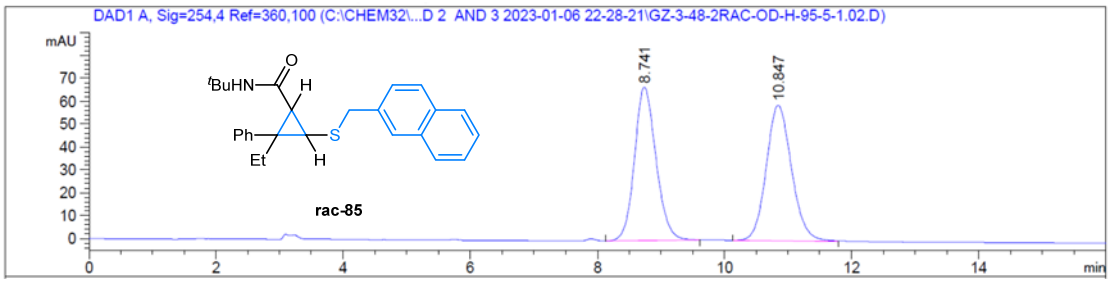
mAU




Peak Table

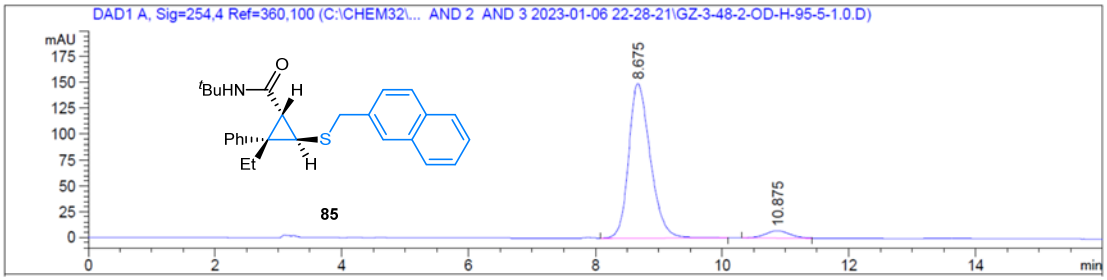
PDA Ch3 230nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.481 | 3772044 | 96.402 |
| 2 | 7.622 | 140791 | 3.598 |



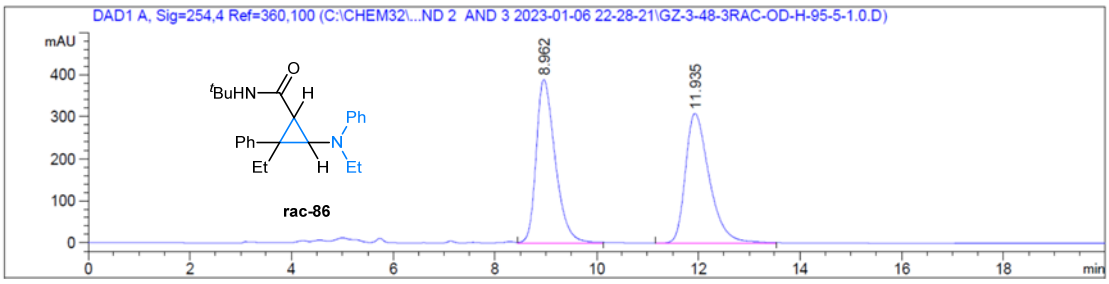

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.741 | BB | 0.3603 | 1575.42773 | 67.00132 | 48.9959 |
| 2 | 10.847 | MF R | 0.4613 | 1639.99915 | 59.25490 | 51.0041 |
| Totals : | | | | 3215.42688 | 126.25622 | |



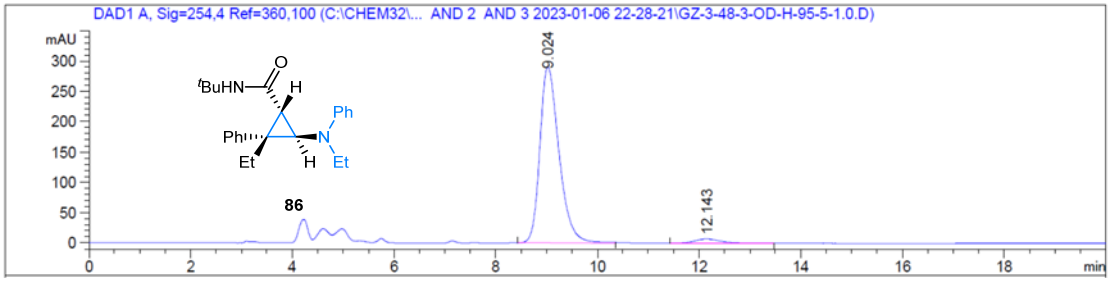

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.675 | BB | 0.3623 | 3540.07471 | 149.45584 | 95.0604 |
| 2 | 10.875 | MF R | 0.4366 | 183.95291 | 7.02285 | 4.9396 |
| Totals : | | | | 3724.02762 | 156.47869 | |



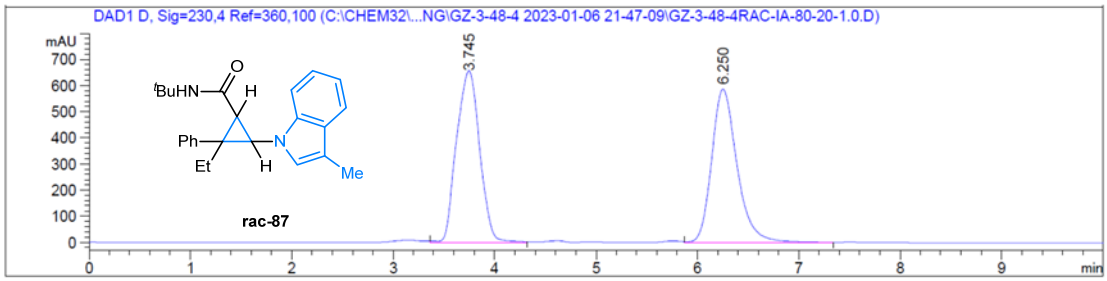

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.962 | MF R | 0.4338 | 1.01135e4 | 388.57239 | 50.0728 |
| 2 | 11.935 | MF R | 0.5454 | 1.00841e4 | 308.14670 | 49.9272 |
| Totals : | | | | 2.01976e4 | 696.71909 | |



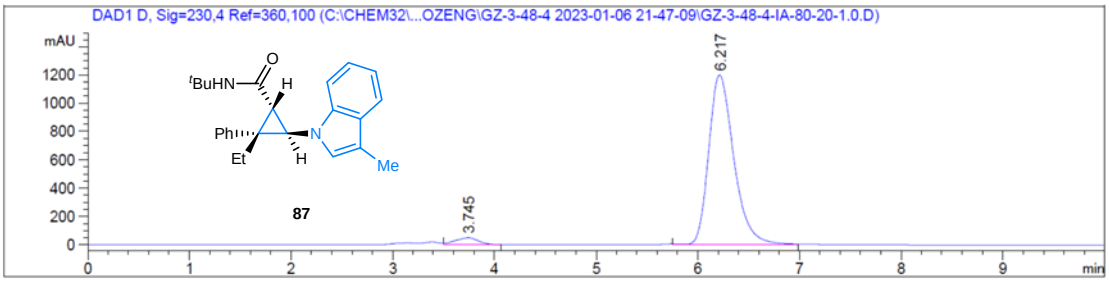

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.024 | MF R | 0.4367 | 7620.42285 | 290.82623 | 96.9401 |
| 2 | 12.143 | BB | 0.5227 | 240.53670 | 6.90020 | 3.0599 |
| Totals : | | | | 7860.95955 | 297.72643 | |



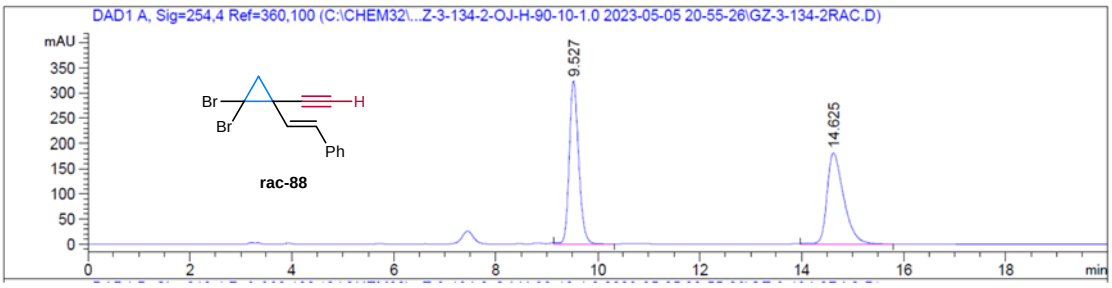

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 3.745 | MF R | 0.2642 | 1.04384e4 | 658.44598 | 50.5230 |
| 2 | 6.250 | FM R | 0.2898 | 1.02223e4 | 587.94098 | 49.4770 |
| Totals : | | | | 2.06607e4 | 1246.38696 | |



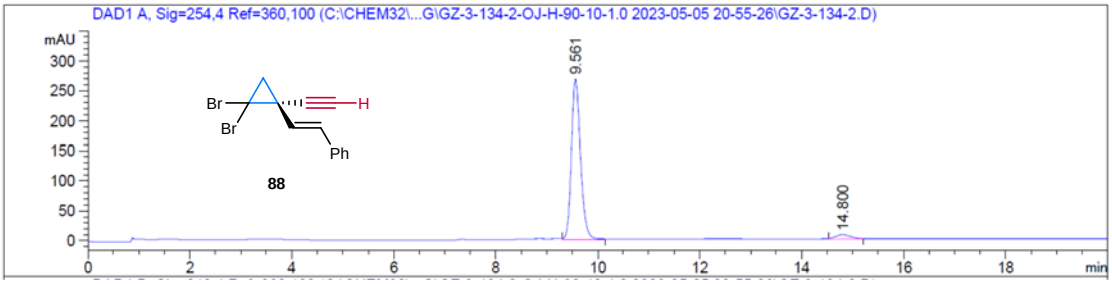

Signal 4: DAD1 D, Sig=230,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 3.745 | VB | 0.2353 | 776.95667 | 48.92669 | 3.6129 |
| 2 | 6.217 | FM R | 0.2880 | 2.07284e4 | 1199.61401 | 96.3871 |
| Totals : | | | | 2.15053e4 | 1248.54070 | |



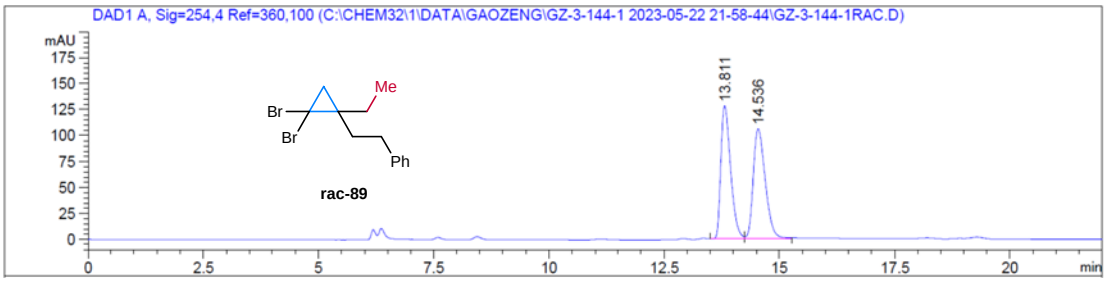

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.527 | FM R | 0.2142 | 4160.56885 | 323.70178 | 50.2183 |
| 2 | 14.625 | MF R | 0.3790 | 4124.39063 | 181.37109 | 49.7817 |
| Totals : | | | | 8284.95947 | 505.07288 | |



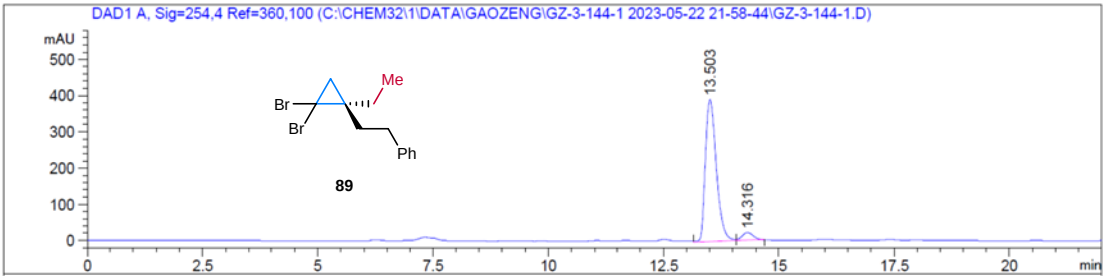

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.561 | MF R | 0.2066 | 3318.20947 | 267.62881 | 95.5100 |
| 2 | 14.800 | FM R | 0.3571 | 155.99007 | 7.28092 | 4.4900 |
| Totals : | | | | 3474.19954 | 274.90973 | |



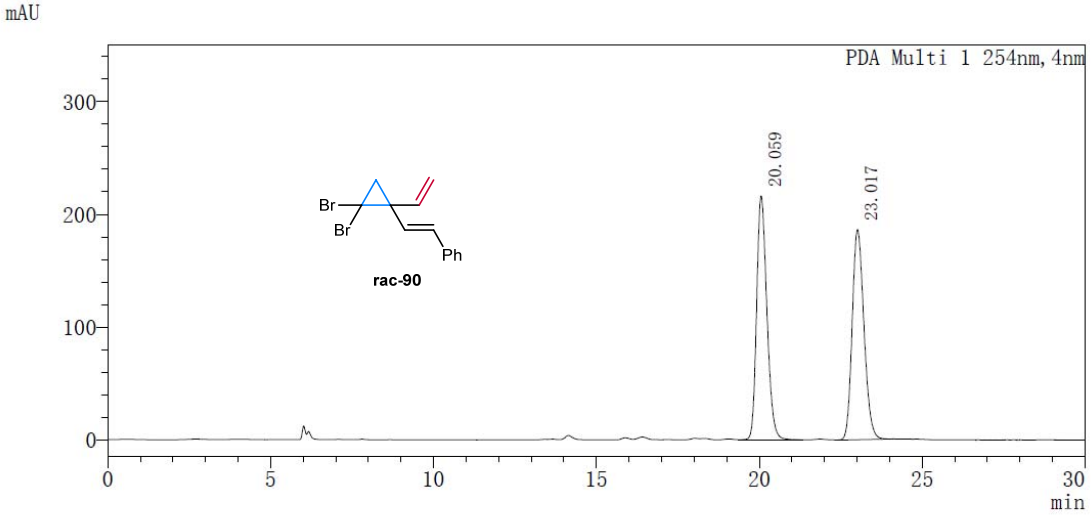

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.811 | BV | 0.2275 | 1886.90088 | 128.35933 | 49.4674 |
| 2 | 14.536 | MF R | 0.3027 | 1927.53076 | 106.13022 | 50.5326 |
| Totals : | | | | 3814.43164 | 234.48955 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

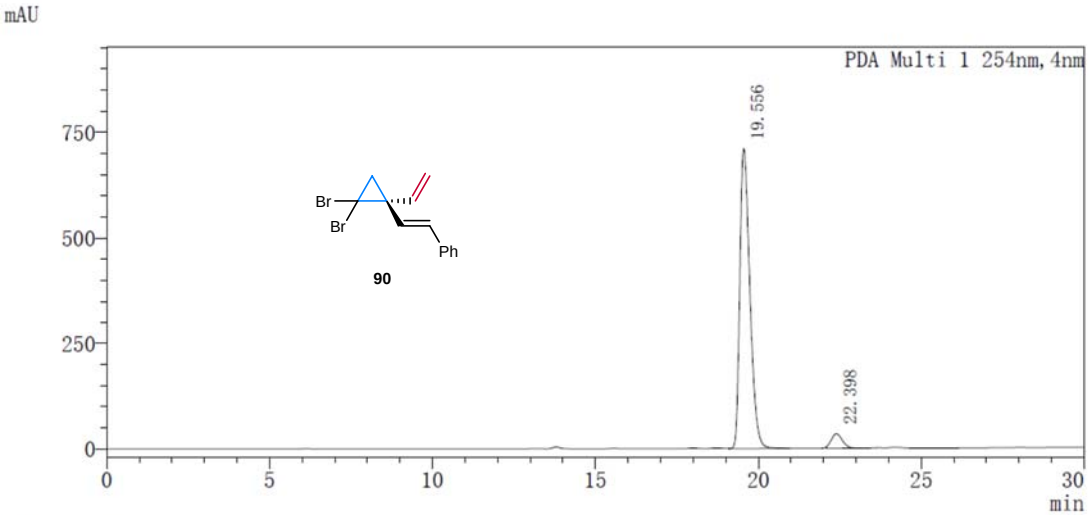
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 13.503 | MF R | 0.2770 | 6516.35303 | 392.06116 | 95.0988 |
| 2 | 14.316 | FM R | 0.2706 | 335.84055 | 20.68396 | 4.9012 |
| Totals : | | | | 6852.19357 | 412.74512 | |




Peak Table

PDA Ch1 254nm

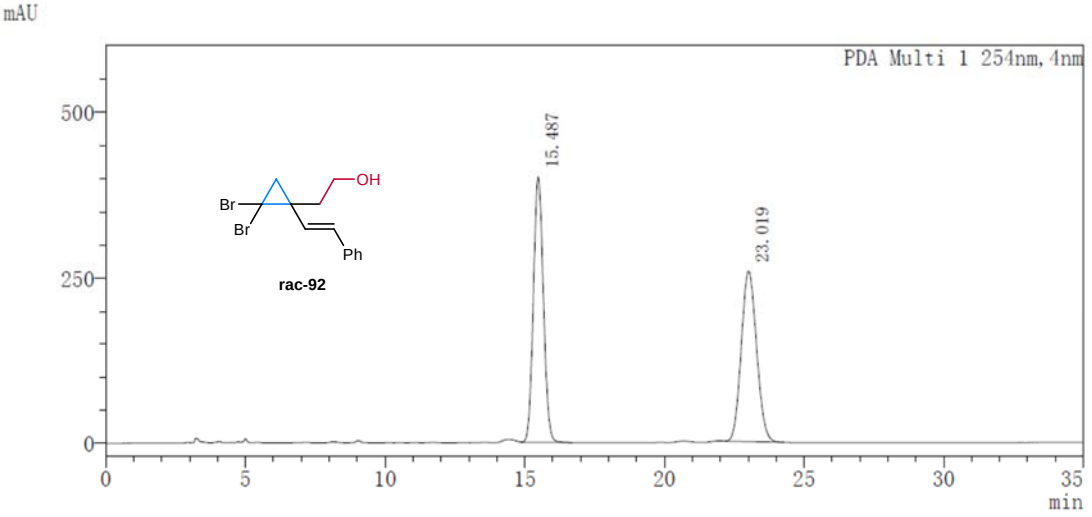
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 20.059 | 4741868 | 50.320 |
| 2 | 23.017 | 4681615 | 49.680 |




Peak Table

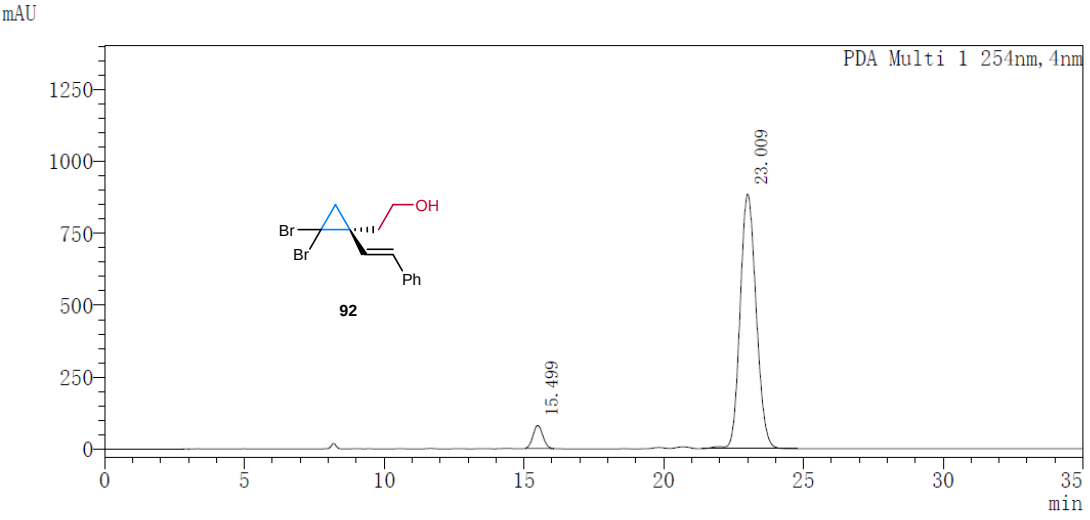
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 19.556 | 15187257 | 94.839 |
| 2 | 22.398 | 826524 | 5.161 |



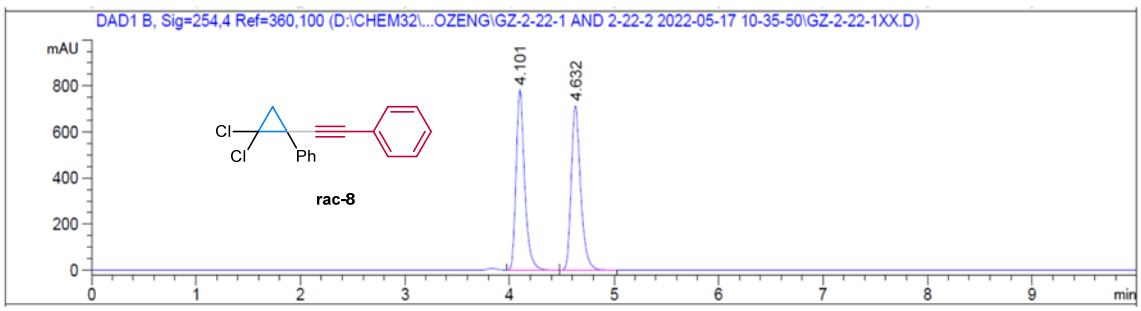

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 15.487 | 401198 | 9972998 | 50.298 |
| 23.019 | 258776 | 9854837 | 49.702 |



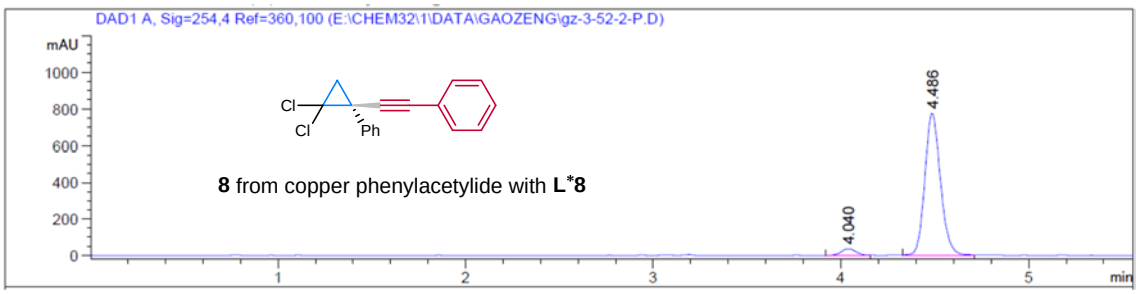

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 15.499 | 79727 | 1935217 | 5.189 |
| 23.009 | 884526 | 35360022 | 94.811 |



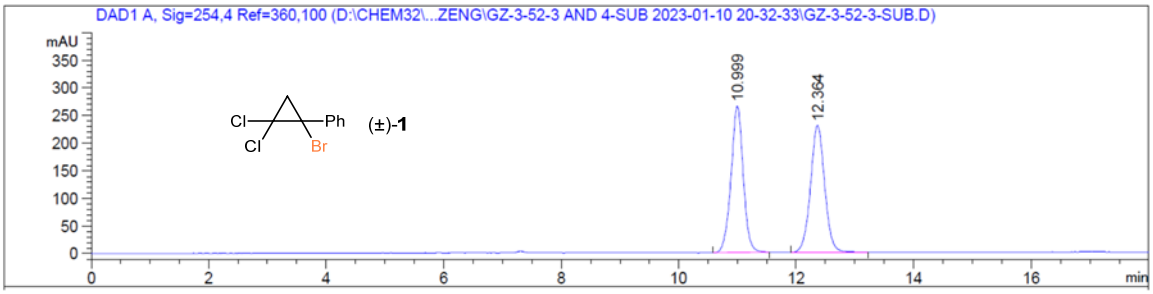

Signal 2: DAD1 B, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.101 | VB | 0.0865 | 4453.23535 | 781.27679 | 49.9748 |
| 2 | 4.632 | BV | 0.0949 | 4457.73389 | 713.66992 | 50.0252 |
| Totals : | | | | 8910.96924 | 1494.94672 | |



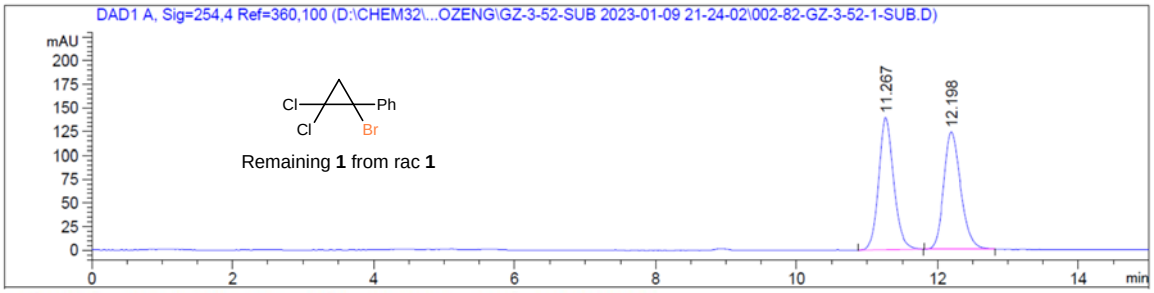

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.040 | FM R | 0.0918 | 202.39581 | 36.75843 | 4.3008 |
| 2 | 4.486 | MF R | 0.0964 | 4503.58398 | 778.42743 | 95.6992 |
| Totals : | | | | 4705.97980 | 815.18586 | |



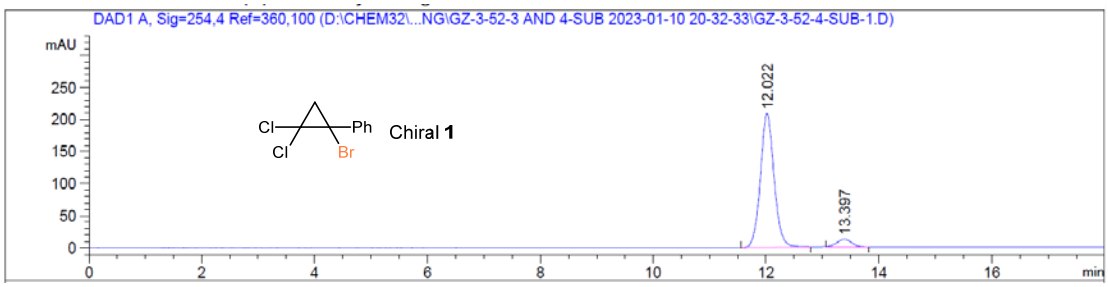

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 10.999 | BB | 0.2193 | 3838.51709 | 264.57318 | 49.9694 |
| 2 | 12.364 | BB | 0.2555 | 3843.21069 | 229.33238 | 50.0306 |
| Totals : | | | | 7681.72778 | 493.90556 | |



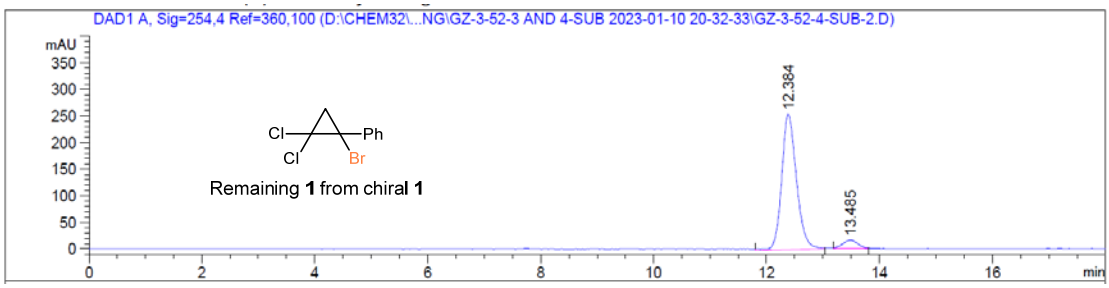

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 11.267 | BB | 0.2261 | 2083.58594 | 139.66383 | 50.1119 |
| 2 | 12.198 | BB | 0.2558 | 2074.27686 | 123.58104 | 49.8881 |
| Totals : | | | | 4157.86279 | 263.24487 | |



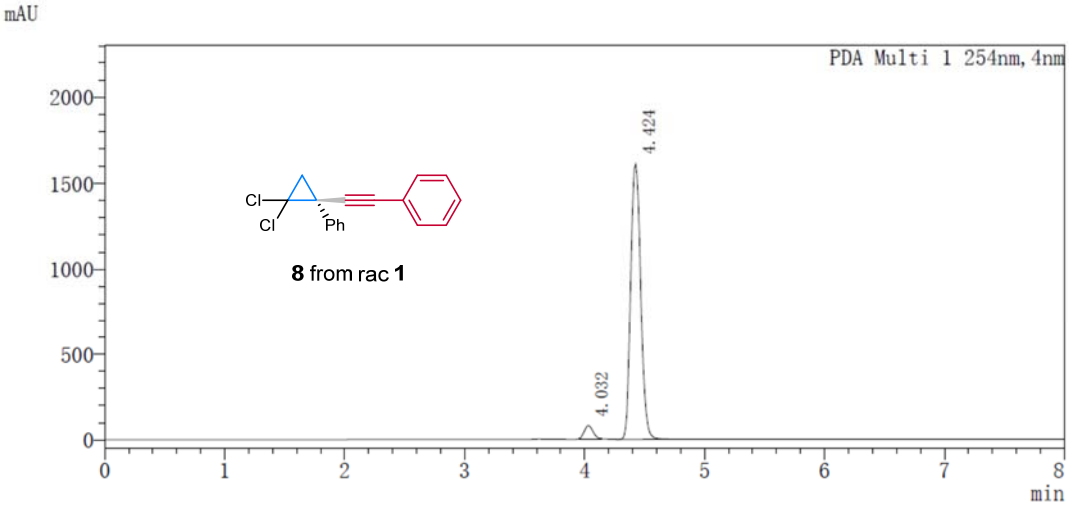

Signal 1: DAD1 A, Sig=254,4 Ref=360,100

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.022 | BV R | 0.2555 | 3499.64331 | 208.83693 | 93.8747 |
| 2 | 13.397 | FM R | 0.3020 | 228.34953 | 12.60070 | 6.1253 |
| Totals : | | | | 3727.99284 | 221.43763 | |




Signal 1: DAD1 A, Sig=254,4 Ref=360,100

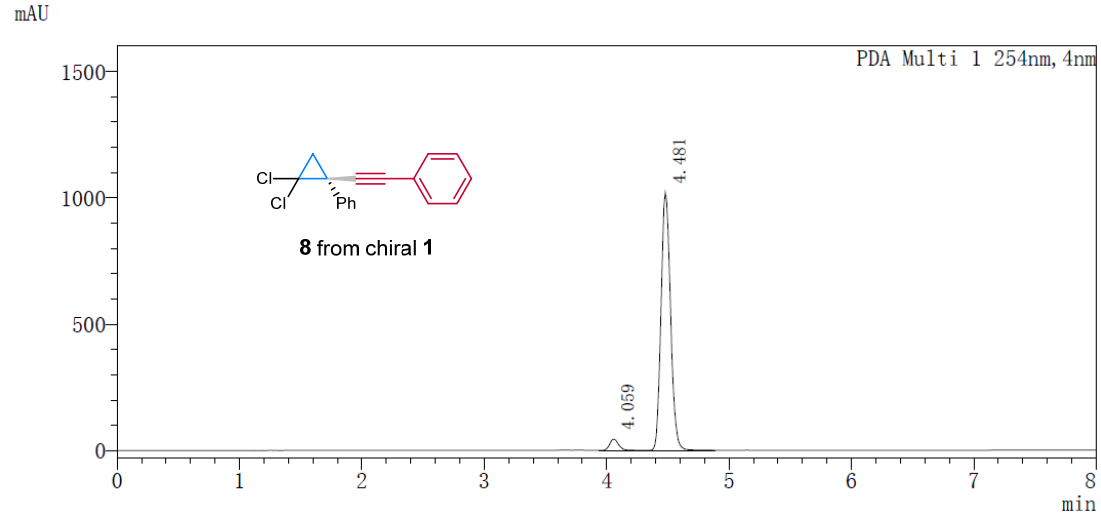
| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 12.384 | MM R | 0.3020 | 4605.14111 | 254.15686 | 93.6414 |
| 2 | 13.485 | MM R | 0.3197 | 312.70697 | 16.30370 | 6.3586 |
| Totals : | | | | 4917.84808 | 270.46056 | |




Peak Table

PDA Ch1 254nm

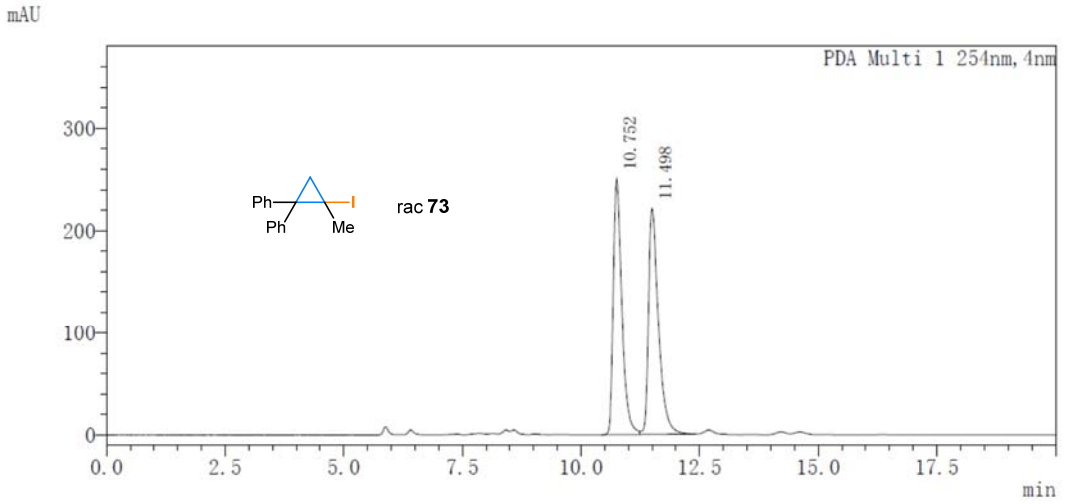
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.032 | 423389 | 4.310 |
| 2 | 4.424 | 9401149 | 95.690 |




Peak Table

PDA Ch1 254nm

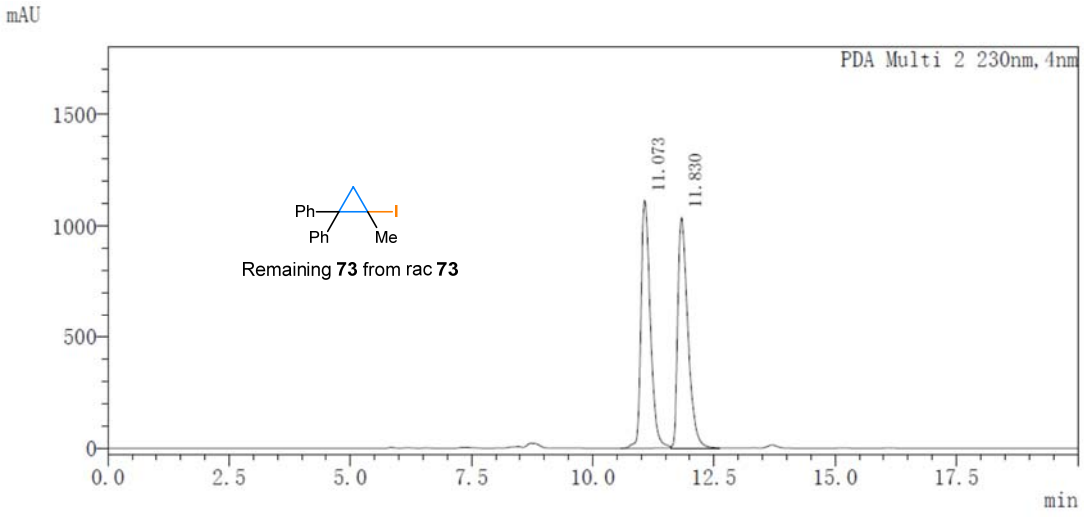
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 4.059 | 229834 | 4.016 |
| 2 | 4.481 | 5493351 | 95.984 |




Peak Table

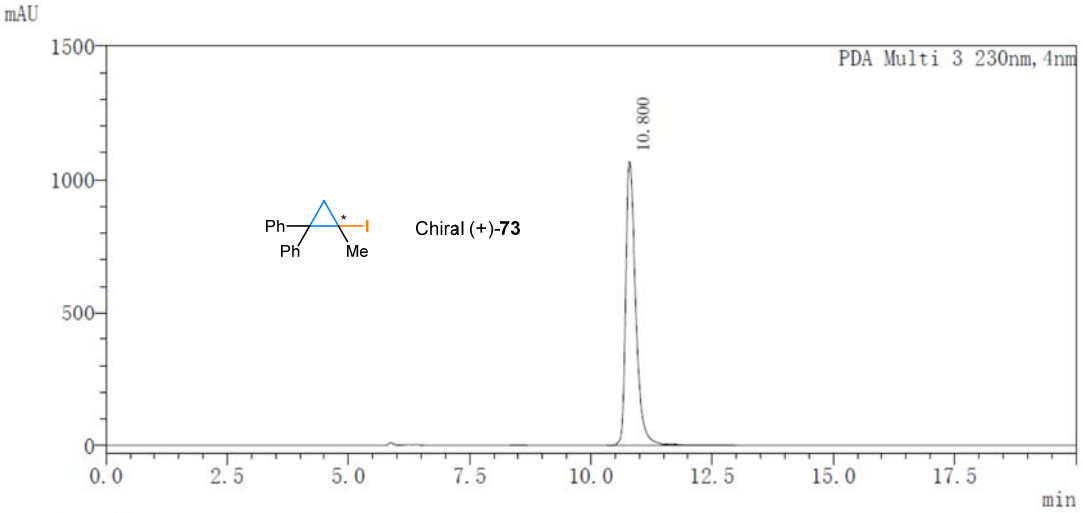
PDA Ch1 254nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 10.752 | 3167127 | 49.436 |
| 2 | 11.498 | 3239398 | 50.564 |




PDA Ch2 230nm

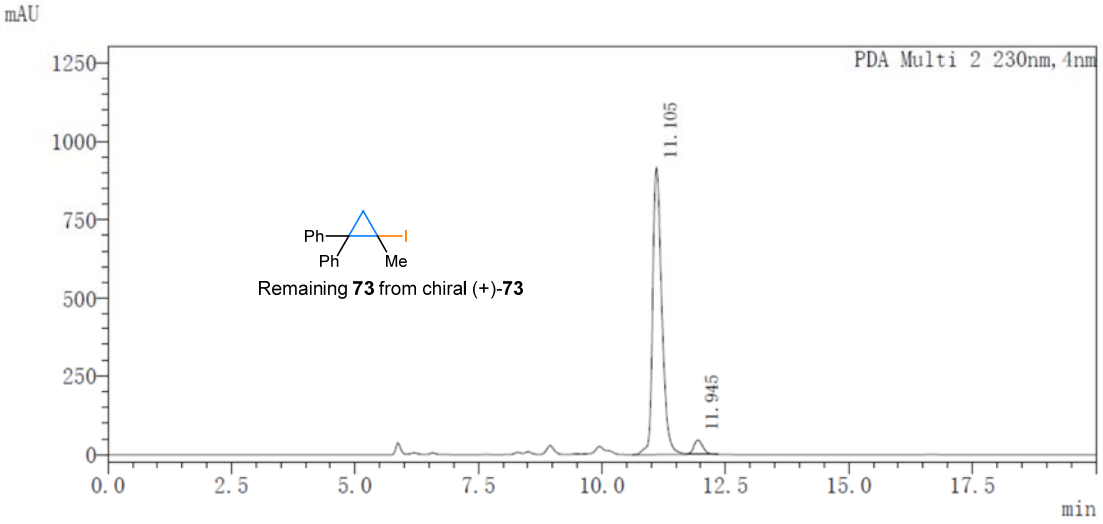
| T | Hight | Area | Area% |
|---|---|---|---|
| 11.073 | 1113892 | 14982229 | 49.911 |
| 11.830 | 1037101 | 15035610 | 50.089 |




Peak Table

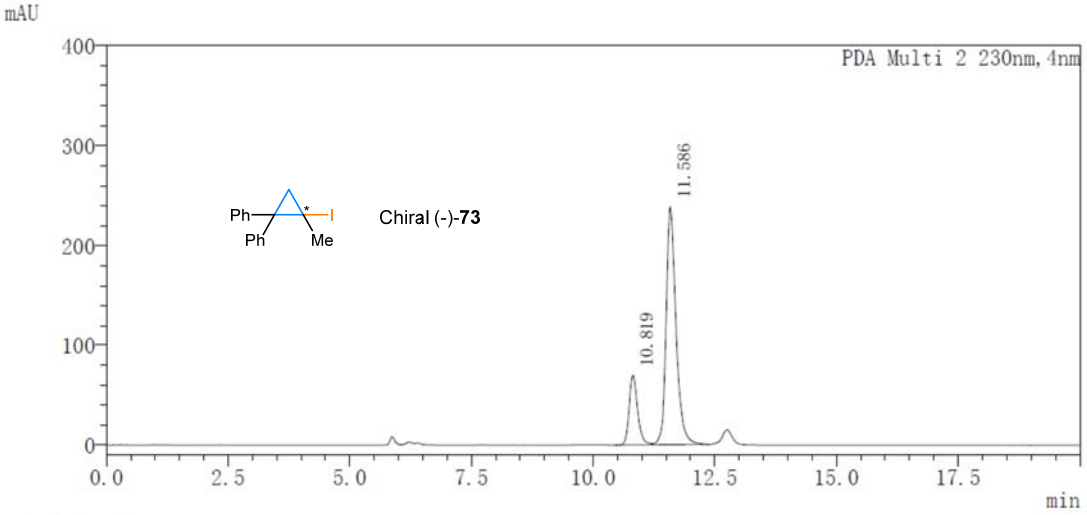
PDA Ch3 230nm

| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 10.800 | 15370428 | 100.000 |




PDA Ch2 230nm

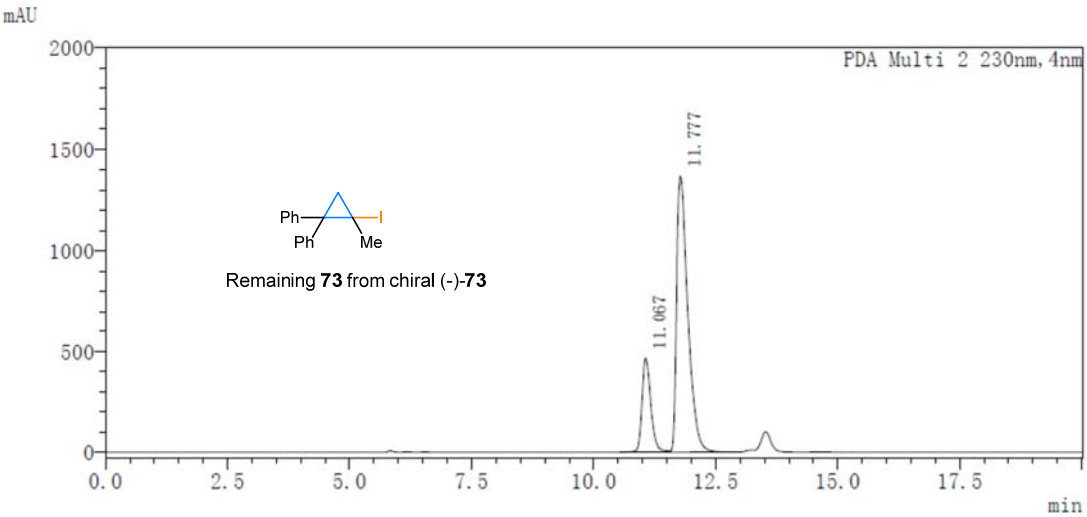
| T | Hight | Area | Area% |
|---|---|---|---|
| 11.105 | 915138 | 11833499 | 95.230 |
| 11.945 | 46126 | 592685 | 4.770 |




Peak Table

PDA Ch2 230nm

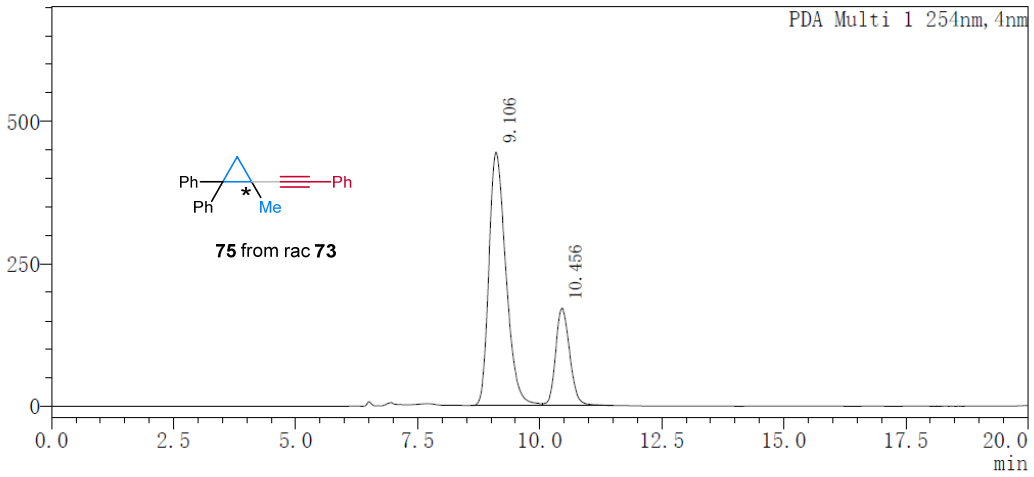
| Peak# | Ret. Time | Area | Area% |
|---|---|---|---|
| 1 | 10.819 | 842523 | 20.042 |
| 2 | 11.586 | 3361294 | 79.958 |




PDA Ch2 230nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 11.067 | 464727 | 5863524 | 21.114 |
| 11.777 | 1367370 | 21906689 | 78.886 |

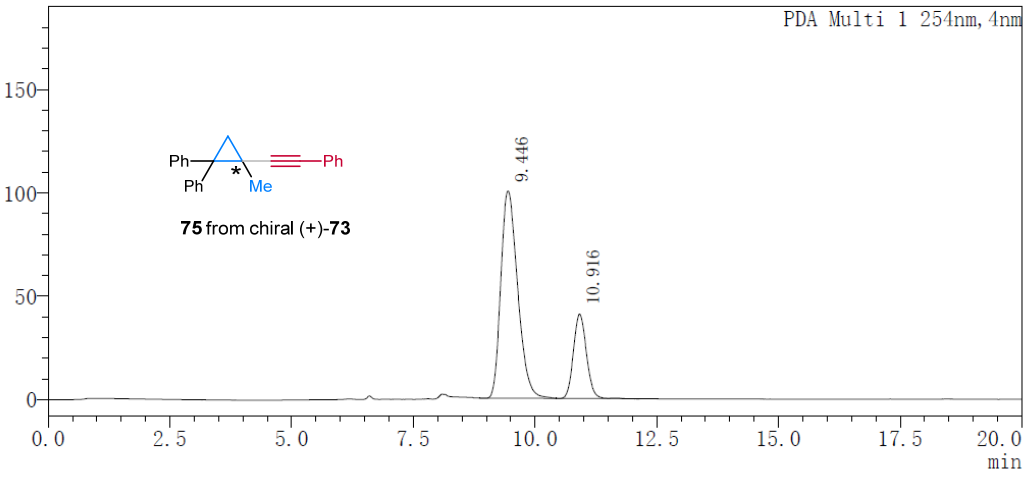
mAU




PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.106 | 444356 | 10808823 | 75.856 |
| 10.456 | 170693 | 3440377 | 24.144 |

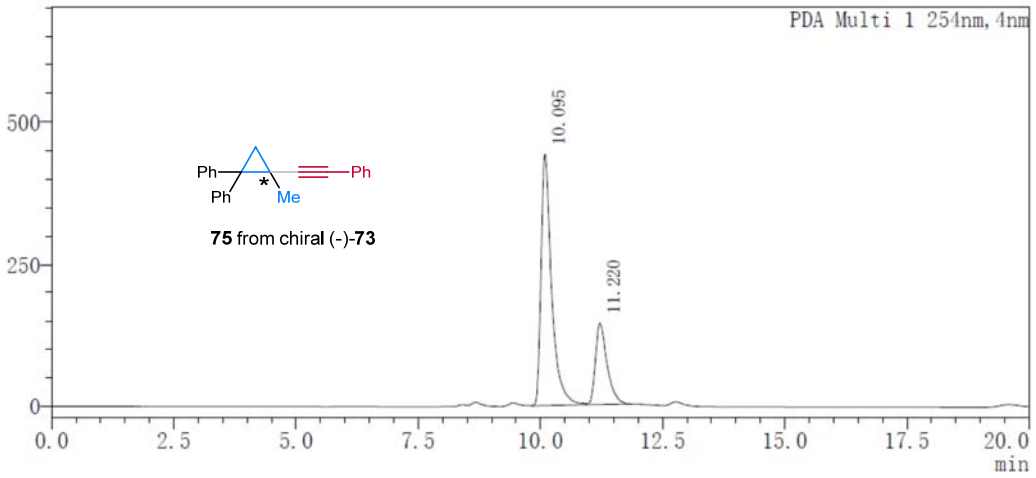
mAU




PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 9.446 | 100226 | 2408480 | 76.035 |
| 10.916 | 40808 | 759099 | 23.965 |

mAU




**75** from chiral (-)-**73**

PDA Ch1 254nm

| T | Hight | Area | Area% |
|---|---|---|---|
| 10.095 | 442319 | 6639745 | 73.725 |
| 11.220 | 142476 | 2366402 | 26.275 |

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