Supporting Information for

Copper-Catalyzed Enantioconvergent Radical C(sp^3)–N Cross-Coupling to Access Chiral α-Amino-β-Lactams

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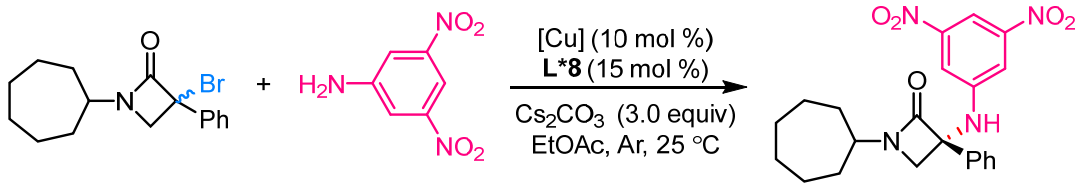
1. Tables for experiments

Table S1. Reaction condition optimization with tertiary α-bromo-β-lactam **E1** and aromatic amine **A1**: screening of different copper catalysts[a]

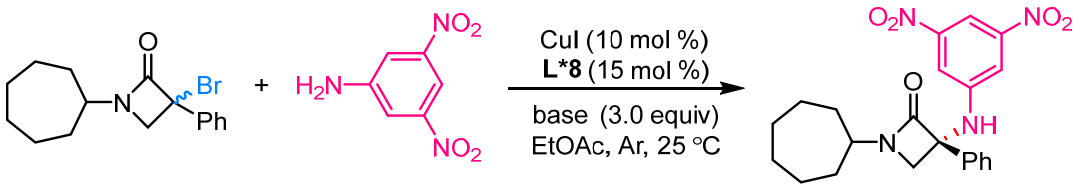


(±)-**E1** **A1** **1**

Entry	[Cu]	Yield (%)	ee (%)
1	CuI	89	88
2	$CuBr{\cdot}SMe_2$	83	87
3	CuOAc	66	66
4	CuTc	84	87
5	$Cu(OAc)_2$	86	84
6	$Cu(acac)_2$	72	82

[a]Reaction conditions: (±)-**E1** (0.05 mmol), **A1** (0.05 mmol), [Cu] (10 mol %), **L*8** (15 mol %), and Cs_2CO_3 (3.0 equiv) in EtOAc (1.0 mL) at rt for 72 h under argon; yield of **1** was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard; ee value was based on HPLC analysis.

Table S2. Reaction condition optimization with tertiary α-bromo-β-lactam **E1** and aromatic amine **A1**: screening of different inorganic bases[a]



(±)-**E1** **A1** **1**

Entry	Base	Yield (%)	ee (%)
1	Cs_2CO_3	89	88
2	K_3PO_4	83	88
3	K_2CO_3	85	88
4	Na_2CO_3	7	86
5	KOMe	38	87
6	KO^{t}Bu	74	85

[a]Reaction conditions: (±)-**E1** (0.05 mmol), **A1** (0.05 mmol), CuI (10 mol %), **L*8** (15 mol %), and base (3.0 equiv) in EtOAc (1.0 mL) at rt for 72 h under argon; yield was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard; ee value was based on HPLC analysis.

2. Figure for experiments

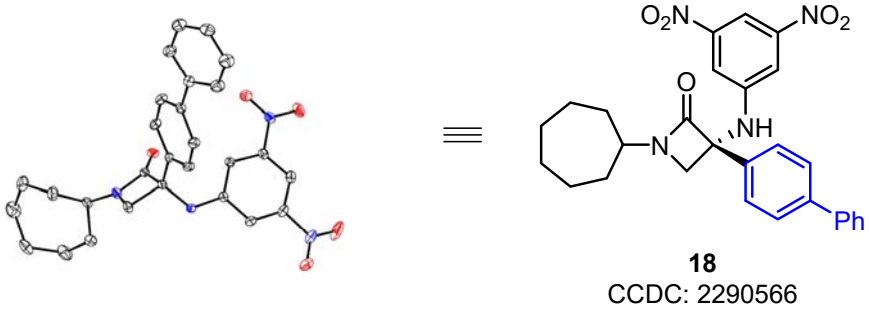


Figure S1. X-ray crystallography for 18

complex	**18**
Empirical formula	$C_{28}H_{28}N_4O_5$
Formula weight (g mol^{-1})	500.54
Temperature/K	100.0(2)
Crystal system	triclinic
space group	P1
a/Å	10.1532(7)
b/Å	11.4776(8)
c/Å	12.4689(9)
α/°	70.110(2)
β/°	66.594(2)
γ/°	84.186(2)
Volume/$Å^3$	1252.98(15)
Z	2
ρ_{calc}g/cm^3	1.327
μ/mm^{-1}	0.482
F(000)	528.0
Crystal size/mm^3	0.21 × 0.19 × 0.18
Radiation	GaKα (λ = 1.34138)
Theta range for data collection/°	7.116 to 5146.894
Index ranges	-14<=h<=14, -16<=k<=16, -17<=k<=17
Reflections collected	76725
Independent reflections	14661 [R_{int} = 0.0473, R_{sigma} = 0.0426]

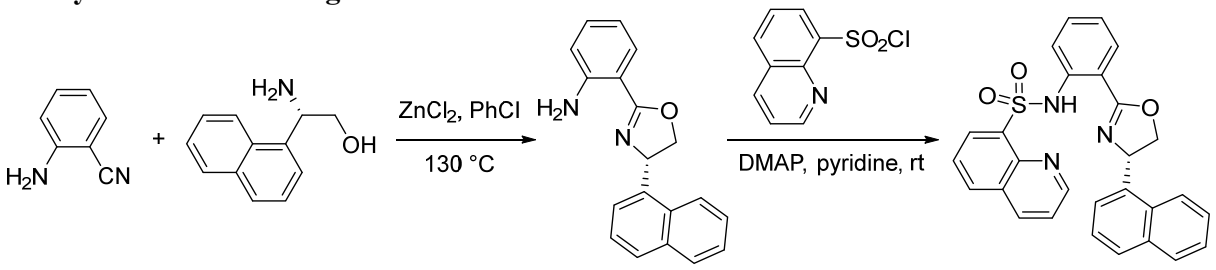
Data / restraints / parameters	14661 / 5 / 667
Goodness-of-fit on F^2	1.096
Final R indexes [I>=2σ (I)]	R_1 = 0.0369, wR_2 = 0.1104
Final R indexes [all data]	R1 = 0.0394, wR2 = 0.1133
Largest diff. peak and hole/e $Å^3$	0.28/-0.26
Flack parameter	0.09(5)

3. General information

Most of 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. CH_2Cl_2, THF, and DMF were purified and dried using a solvent-purification system that contained activated alumina under argon. CuI was purchased from Sigma-Aldrich. Cs_2CO_3 was purchased from Bide Pharmatech Ltd. and treated by hot gun (approximate 300 to 400 °C) for 2 minutes in vacuum. Anhydrous EtOAc, and benzene was purchased from J&K Scientific. 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), EtOAc, CH_2Cl_2 and CH_3OH were purchased from Shanghai Titan Scientific Co. Ltd without further purification. Visualization on TLC was achieved by use of UV light (254 nm), iodine on silica gel or basic $KMnO_4$ indicator. NMR spectra were recorded on Bruker DRX-400 spectrometers at 400 for ^1H NMR, 100 MHz for ^{13}C NMR, and 376 MHz for ^{19}F NMR respectively, in $CDCl_3$ or DMSO-d_6 with tetramethylsilane (TMS) as internal standard. The chemical shifts are expressed in ppm and coupling constants are given in Hz. Data for ^1H NMR are recorded as follows: chemical shift (ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quarter; p, pentet, m, multiplet), coupling constant (Hz), integration. Data for ^{13}C NMR are reported in terms of chemical shift (δ, ppm). Mass spectrometric data were obtained using Bruker Apex IV RTMS. Enantiomeric excess (ee) was determined using Agilent high-performance liquid chromatography (HPLC) with a Hatachi detector (at appropriate wavelength) or SHIMADZU LC-20AD with SPD-20AV detector. Column conditions are reported in the experimental section below. X-ray diffraction was measured on a 'Bruker APEX-II CCD' diffractometer with Cu–Kα radiation.

4. The synthesis of ligands and alkyl halides

The synthesis of chiral ligand L*8



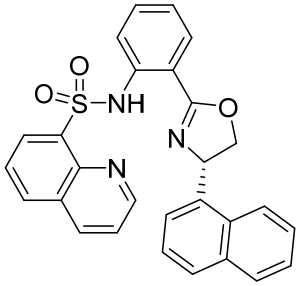
L8-1 L*8

General procedure for preparation of L*8:

According to the literature reported procedure.[1] Under an argon atmosphere, to a solution of 2-aminobenzonitrile (0.92 g, 7.8 mmol, 1.0 equiv) and (*S*)-2-amino-2-(naphthalen-1-yl)ethan-1-ol (1.46 g, 7.8 mmol, 1.0 equiv) in chlorobenzene (30 mL) was added dry $ZnCl_2$ (3.19 g, 23.4 mmol, 3.0 equiv) at once at rt. Then, the reaction mixture was reflux for 24 h. After completion (monitored by TLC), the reaction mixture was dissolved in water, EtOAc, and 2 mL ethylenediamine. Next, the reaction was extracted with EtOAc three times. The combined organic phase was washed with brine, dried over Na_2SO_4, filtered, and concentrated to afford the crude product, which was purified by flash column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to afford the product **L8-1** as a white solid (0.67 g, 29% yield).

Under an argon atmosphere, to a solution of (*S*)-2-(4-(naphthalen-1-yl)-4,5-dihydrooxazol-2-yl)aniline **L8-1** (0.67 g, 2.3 mmol, 1.0 equiv) and quinoline-8-sulfonyl chloride (0.79 g, 3.5 mmol, 1.5 equiv) in pyridine (12 mL, 0.2 M) was added DMAP (56.2 mg, 0.5 mmol, 0.2 equiv) at 0 °C. Then the reaction mixture was warmed up to room temperature and stirred overnight. After completion (monitored by TLC), the reaction was quenched with water and extracted with EtOAc three times. The combined organic phase was washed with brine, dried over Na_2SO_4, filtered, and concentrated to afford the crude product, which was purified by flash column chromatography on silica gel (CH_2Cl_2/CH_3OH = 50/1 to 20/1) to afford the product **L*8** as a white solid (0.56 g, 51% yield).

(*S*)-*N*-(2-(4-(Naphthalen-1-yl)-4,5-dihydrooxazol-2-yl)phenyl)quinoline-8-sulfonamide (L*8)



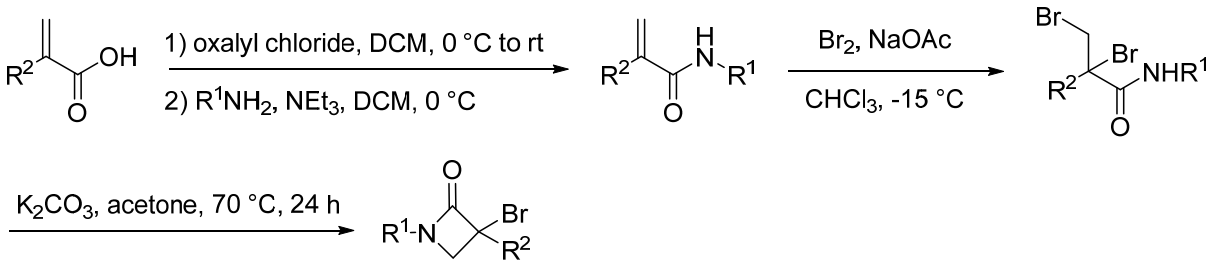
L*8

^{1}H NMR (400 MHz, $CDCl_3$) δ 12.85 (s, 1H), 8.69 – 8.68 (m, 1H), 8.63 – 8.61 (m, 1H), 8.09 – 8.06 (m, 1H), 7.98 – 7.93 (m, 2H), 7.85 – 7.77 (m, 4H), 7.67 – 7.60 (m, 2H), 7.56 – 7.52 (m, 2H), 7.48 – 7.44 (m, 1H), 7.35 – 7.28 (m, 2H), 6.97 – 6.93 (m, 1H), 6.22 (dd, *J* = 10.3, 8.5 Hz, 1H), 4.97 (dd, *J* = 10.3, 8.3 Hz, 1H), 4.13 (t, *J* = 8.3 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 151.4, 143.8, 139.6, 137.7, 136.5, 136.0, 133.8, 133.7,

132.4, 132.2, 130.4, 129.5, 129.1, 128.7, 128.0, 126.4, 125.8, 125.7, 125.1, 123.7, 122.7, 122.0, 121.5, 116.8, 113.0, 73.2, 67.1.
HRMS (ESI) m/z calcd. for $C_{28}H_{22}N_3O_3S$ $[M + H]^+$ 480.1376, found 480.1372.

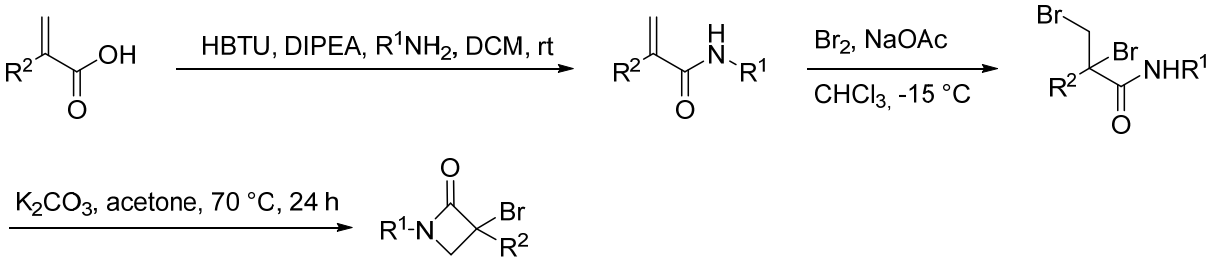
The synthesis of α-bromo-β-lactams



General procedure 1:

According to the literature reported procedure[2] with slight modification. To a solution of the carboxylic acid (30.0 mmol) in anhydrous CH_2Cl_2 (50 mL) was added oxalyl chloride (4.57 g, 36.0 mmol, 1.2 equiv) at 0 °C, and then a few drops of DMF was added as catalyst. After warmed up to room temperature and stirred for 30 min, the resulting acyl chloride was concentrated under reduced pressure to remove the extra oxalyl chloride. The concentrated mixture was dissolved in anhydrous CH_2Cl_2 (50 mL) then cooled to −20 °C. Anhydrous triethylamine (7.59 g, 75.0 mmol, 2.5 equiv) and amine (33.0 mmol, 1.1 equiv) were added, and then the reaction mixture was warmed up to room temperature and stirred at that temperature. After completion (monitored by TLC), the reaction was quenched by the addition of 1.0 M HCl. The organic layer was washed by brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to afford the crude product, which was purified by flash chromatography to yield the acrylamide.

A mixture of acrylamide (30.0 mmol, 1.0 equiv) and sodium acetate (90.0 mmol, 3.0 equiv) in chloroform (0.4 M) was added bromine (Br_2) (60.0 mmol, 2.0 equiv) dropwise at −15 °C under argon atmosphere. After completion (monitored by TLC), the mixture was poured into a solution of 10% sodium thiosulfate, and then extracted with CH_2Cl_2 three times. The combined organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to give the crude product, which was purified by flash chromatography. A mixture of the dibromide and potassium carbonate (90 mmol, 3.0 equiv) in acetone (0.1 M) was heated to reflux for 24 h under an argon atmosphere. After being cooled to room temperature, the mixture was filtered through a short pad of silica gel column. The filtrate was concentrated under reduced pressure, and then the residue was purified by column chromatography on silica gel.



General procedure 2:

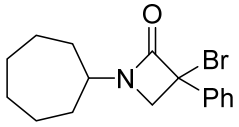
According to the literature reported procedure. [3] The carboxylic acid (20 mmol, 1.0 equiv), 2-(1*H*-benzo[*d*][1,2,3]triazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate(V) (HBTU) (22 mmol, 1.1 equiv), *N*-ethyl-*N*-isopropylpropan-2-amine (DIPEA) (24 mmol, 1.2 equiv), and the corresponding amine (22 mmol, 1.1 equiv) was dissolved in CH_2Cl_2 (100 mL) and stirred at room temperature until TLC showed complete consumption of starting material. The solvent was removed under reduced pressure and the residue was dissolved in CH_2Cl_2 (40 mL) and washed with water (30 mL) and brine (30 mL) sequentially. The collected organic layer was dried over

Na_2SO_4, filtered, and concentrated under reduced pressure to afford the crude product, which was purified by flash chromatography to yield acrylamide.

According to the literature reported procedure[2] with slightly modification. To a mixture of acrylamide (20 mmol, 1.0 equiv) and sodium acetate (60 mmol, 3.0 equiv) in chloroform (0.4 M) was added bromine (20 mmol, 1.0 equiv) dropwise at −10 °C under an argon atmosphere. After being stirred for 10 min, the mixture was poured into a solution of 10% sodium thiosulfate, and then extracted with CH_2Cl_2 three times. The combined organic layer was washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure to give the crude product, which was purified by flash chromatography.

A mixture of the dibromide and potassium carbonate (60 mmol, 3.0 equiv) in acetone (0.1 M) was heated to reflux for 24 h under an argon atmosphere. After being cooled to room temperature, the mixture was filtered through a short pad of silica gel column. The filtrate was concentrated under reduced pressure, and then the residue was purified by column chromatography on silica gel.

3-Bromo-1-cycloheptyl-3-phenylazetidin-2-one (E1)



E1

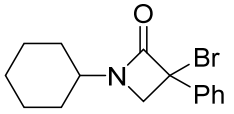
According to **General procedure 1** with 2-phenylacrylic acid (4.45 g, 30.0 mmol, 1.0 equiv) and cycloheptanamine (3.73 g, 33.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E1** as a white solid (2.74 g, 28% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.59 (m, 2H), 7.39 – 7.30 (m, 3H), 3.97 (s, 2H), 3.86 – 3.79 (m, 1H), 2.01 – 1.97 (m, 1H), 1.90 – 1.86 (m, 1H), 1.73 – 1.60 (m, 4H), 1.58 – 1.40 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.8, 137.8, 129.0, 128.8, 127.1, 59.7, 55.9, 53.5, 32.5, 32.3, 27.9, 27.8, 24.1.

HRMS (ESI) m/z calcd. for $C_{16}H_{21}BrNO$ $[M + H]^+$ 322.0801, found 322.0800.

3-Bromo-1-cyclohexyl-3-phenylazetidin-2-one (E2)



E2

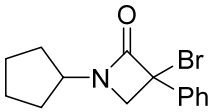
According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20.0 mmol, 1.0 equiv) and cyclohexanamine (2.18 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E2** as a white solid (1.21 g, 20% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.60 (m, 2H), 7.39 – 7.30 (m, 3H), 3.96 (s, 2H), 3.65 – 3.58 (m, 1H), 1.98 – 1.94 (m, 1H), 1.87 – 1.72 (m, 3H), 1.67 – 1.61 (m, 1H), 1.45 – 1.24 (m, 4H), 1.19 – 1.09 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 137.8, 128.9, 128.8 127.1, 59.4, 55.8, 51.6, 30.4, 30.2, 25.2, 24.64, 24.62.

HRMS (ESI) m/z calcd. for $C_{15}H_{19}BrNO$ $[M + H]^+$ 308.0645, found 308.0644.

3-Bromo-1-cyclopentyl-3-phenylazetidin-2-one (E3)



E3

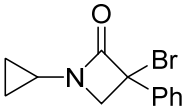
According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20.0 mmol, 1.0 equiv) and cyclopentanamine (1.87 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E3** as a white solid (2.03 g, 35% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.59 (m, 2H), 7.39 – 7.30 (m, 3H), 4.14 – 4.07 (m, 1H), 3.97 – 3.93 (m, 2H), 1.94 – 1.79 (m, 2H), 1.77 – 1.56 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.4, 137.7, 128.9, 128.7, 127.0, 59.3, 56.1, 53.6, 29.9, 29.8, 23.91, 23.87.

HRMS (ESI) m/z calcd. for $C_{14}H_{17}BrNO$ $[M + H]^+$ 294.0488, found 294.0486.

3-Bromo-1-cyclopropyl-3-phenylazetidin-2-one (E4)



E4

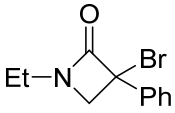
According to **General procedure 1** with 2-phenylacrylic acid (1.48 g, 10.0 mmol, 1.0 equiv) and cyclopropanamine (0.76 mL, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 2/1) to yield the product **E4** as a yellowish solid (0.74 g, 28% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.58 (m, 2H), 7.39 – 7.31 (m, 3H), 3.93 (q, J = 5.9 Hz, 2H), 2.64 – 2.59 (m, 1H), 0.88 – 0.75 (m, 4H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 137.6, 129.0, 128.8, 127.1, 59.6, 58.6, 24.6, 5.3.

HRMS (ESI) m/z calcd. for $C_{12}H_{13}BrNO$ $[M + H]^+$ 266.0175, found 266.0173.

3-Bromo-1-ethyl-3-phenylazetidin-2-one (E5)



E5

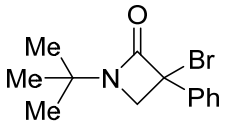
According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20.0 mmol, 1.0 equiv) and ethylamine hydrochloride (1.79 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 2/1) to yield the product **E5** as a yellowish oil (1.40 g, 28% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.59 (m, 2H), 7.39 – 7.30 (m, 3H), 4.00 – 3.97 (m, 2H), 3.41 – 3.26 (m, 2H), 1.18 (t, J = 7.3 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.6, 137.7, 129.0, 128.8, 127.1, 60.1, 57.4, 36.8, 12.2.

HRMS (ESI) m/z calcd. for $C_{11}H_{13}BrNO$ $[M + H]^+$ 254.0175, found 254.0174.

3-Bromo-1-(*tert*-butyl)-3-phenylazetidin-2-one (E6)



E6

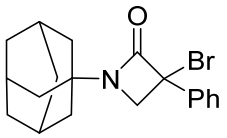
According to **General procedure 2** with 2-phenylacrylic acid (2.00 g, 13.5 mmol, 1.0 equiv) and 2-methylpropan-2-amine (1.09 g, 14.9 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E6** as a white solid (1.14 g, 30% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.60 (m, 2H), 7.40 – 7.31 (m, 3H), 3.95 – 3.91 (m, 2H), 1.36 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.8, 137.9, 128.9, 128.8, 127.1, 58.9, 55.4, 53.9, 27.4.

HRMS (ESI) m/z calcd. for $C_{13}H_{17}BrNO$ $[M + H]^+$ 282.0488, found 282.0486.

1-(Adamantan-1-yl)-3-bromo-3-phenylazetidin-2-one (E7)



E7

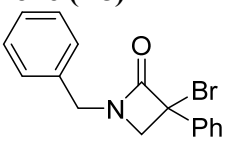
According to **General procedure 2** with 2-phenylacrylic acid (2.00 g, 13.5 mmol, 1.0 equiv) and adamantan-1-amine (2.25 g, 14.9 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E7** as a white solid (0.72 g, 15% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.59 (m, 2H), 7.39 – 7.30 (m, 3H), 3.92 (s, 2H), 2.12 – 2.10 (m, 3H), 2.00 – 1.99 (m, 6H), 1.69 – 1.67 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.7, 138.0, 128.9, 128.8, 127.1, 58.8, 54.5, 54.4, 40.4, 36.0, 28.9.

HRMS (ESI) m/z calcd. for $C_{19}H_{23}BrNO$ $[M + H]^+$ 360.0958, found 360.0956.

1-Benzyl-3-bromo-3-phenylazetidin-2-one (E8)



E8

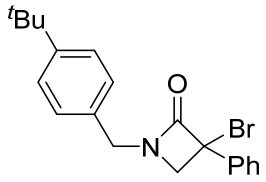
According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20 mmol, 1.0 equiv) and phenylmethanamine (2.36 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E8** as a white solid (2.95 g, 47% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.58 (m, 2H), 7.40 – 7.31 (m, 6H), 7.25 – 7.22 (m, 2H), 4.55 (d, J = 15.1 Hz, 1H), 4.38 (d, J = 15.1 Hz, 1H), 3.90 – 3.86 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 137.5, 134.2, 129.1, 129.0, 128.9, 128.1, 127.1, 60.5, 57.6, 46.2.

HRMS (ESI) m/z calcd. for $C_{16}H_{15}BrNO$ $[M + H]^+$ 316.0332, found 316.0331.

3-Bromo-1-(4-(*tert*-butyl)benzyl)-3-phenylazetidin-2-one (E9)



E9

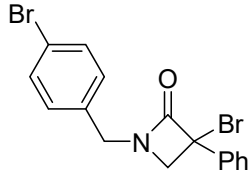
According to **General procedure 1** with 2-phenylacrylic acid (4.45 g, 30.0 mmol, 1.0 equiv) and (4-(*tert*-butyl)phenyl)methanamine (5.39 g, 33.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E9** as a white solid (3.59 g, 32% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.58 (m, 2H), 7.40 – 7.31 (m, 5H), 7.17 – 7.14 (m, 2H), 4.52 (d, *J* = 15.1 Hz, 1H), 4.36 (d, *J* = 15.1 Hz, 1H), 3.90 – 3.87 (m, 2H), 1.31 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 151.1, 137.6, 131.1, 129.1, 128.9, 127.8, 127.1, 125.9, 60.5, 57.6, 45.8, 34.6, 31.3.

HRMS (ESI) m/z calcd. for $C_{20}H_{23}BrNO$ $[M + H]^+$ 372.0958, found 372.0959.

3-Bromo-1-(4-bromobenzyl)-3-phenylazetidin-2-one (E10)



E10

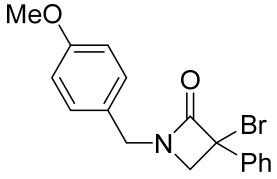
According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20.0 mmol, 1.0 equiv) and (4-bromophenyl)methanamine (4.09 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **E10** as a yellowish solid (2.87 g, 37% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.58 (m, 2H), 7.49 – 7.47 (m, 2H), 7.40 – 7.32 (m, 3H), 7.13 – 7.11 (m, 2H), 4.51 (d, *J* = 15.3 Hz, 1H), 4.33 (d, *J* = 15.3 Hz, 1H), 3.90 – 3.85 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 137.3, 133.3, 132.2, 129.7, 129.2, 128.9, 127.1, 122.1, 60.5, 57.6, 45.6.

HRMS (ESI) m/z calcd. for $C_{16}H_{14}Br_2NO$ $[M + H]^+$ 393.9437, found 393.9434.

3-Bromo-1-(4-methoxybenzyl)-3-phenylazetidin-2-one (E11)

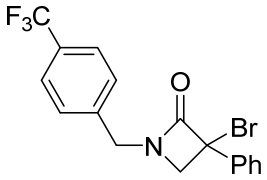


E11

According to **General procedure 1** with 2-phenylacrylic acid (1.48 g, 10.0 mmol, 1.0 equiv) and (4-methoxyphenyl)methanamine (1.44 mL, 11.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the

product **E11** as a white solid (0.40 g, 12% overall yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.39 – 7.30 (m, 3H), 7.17 – 7.14 (m, 2H), 6.89 – 6.85 (m, 2H), 4.49 (d, *J* = 14.9 Hz, 1H), 4.32 (d, *J* = 14.9 Hz, 1H), 3.86 – 3.82 (m, 2H), 3.79 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.0, 159.4, 137.6, 129.5, 129.1, 128.9, 127.1, 126.2, 114.4, 60.4, 57.4, 55.3, 45.7.
HRMS (ESI) m/z calcd. for $C_{17}H_{17}BrNO_2$ $[M + H]^+$ 346.0437, found 346.0435.

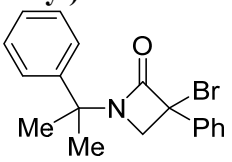
3-Bromo-3-phenyl-1-(4-(trifluoromethyl)benzyl)azetidin-2-one (E12)



E12

According to **General procedure 1** with 2-phenylacrylic acid (2.96 g, 20.0 mmol, 1.0 equiv) and (4-(trifluoromethyl)phenyl)methanamine (3.85 g, 22.0 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E12** as a white solid (2.78 g, 36% overall yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.59 (m, 4H), 7.41 – 7.33 (m, 5H), 4.63 (d, *J* = 15.5 Hz, 1H), 4.43 (d, *J* = 15.5 Hz, 1H), 3.94 – 3.89 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 138.5, 137.3, 130.4 (q, *J* = 32.6 Hz), 129.2, 129.0, 128.3, 127.1, 126.0 (q, *J* = 3.8 Hz), 122.5 (q, *J* = 273.4 Hz), 60.6, 57.8, 45.7.
^{19}F NMR (376 MHz, $CDCl_3$) δ -62.63.
HRMS (ESI) m/z calcd. for $C_{17}H_{14}BrF_3NO$ $[M + H]^+$ 384.0205, found 384.0201.

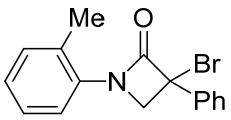
3-Bromo-3-phenyl-1-(2-phenylpropan-2-yl)azetidin-2-one (E13)



E13

According to **General procedure 1** with 2-phenylacrylic acid (2.00 g, 13.5 mmol, 1.0 equiv) and 2-phenylpropan-2-amine (2.01 g, 14.9 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E13** as a white solid (2.74 g, 59% overall yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.60 (m, 2H), 7.40 – 7.32 (m, 7H), 7.29 – 7.26 (m, 1H), 3.81 (d, *J* = 6.1 Hz, 1H), 3.76 (d, *J* = 6.2 Hz, 1H), 1.82 (s, 3H), 1.74 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 143.9, 137.8, 129.0, 128.9, 128.8, 127.4, 127.2, 125.1, 59.4, 59.1, 55.7, 27.8, 27.5.
HRMS (ESI) m/z calcd. for $C_{18}H_{19}BrNO$ $[M + H]^+$ 344.0645, found 344.0643.

3-Bromo-3-phenyl-1-(*o*-tolyl)azetidin-2-one (E14)



E14

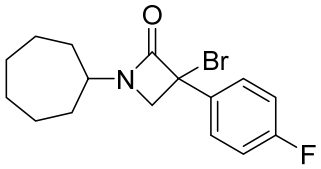
According to **General procedure 1** with 2-phenylacrylic acid (2.00 g, 13.5 mmol, 1.0 equiv) and *o*-toluidine (1.60 g, 14.9 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E14** as a white solid (2.46 g, 57% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.68 (m, 2H), 7.45 – 7.33 (m, 4H), 7.23 – 7.17 (m, 3H), 4.49 – 4.47 (m, 2H), 2.38 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 162.9, 137.4, 135.0, 132.3, 131.6, 129.2, 129.0, 127.21, 127.15, 126.6, 123.0, 60.5, 59.7, 18.9.

HRMS (ESI) m/z calcd. for $C_{16}H_{15}BrNO$ $[M + H]^+$ 316.0332, found 316.0331.

3-Bromo-1-cycloheptyl-3-(4-fluorophenyl)azetidin-2-one (E15)



E15

According to **General procedure 1** with 2-(4-fluorophenyl)acrylic acid (0.83 g, 5.0 mmol, 1.0 equiv) and cycloheptanamine (0.62 g, 5.5 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E15** as a white solid (0.51 g, 30% overall yield).

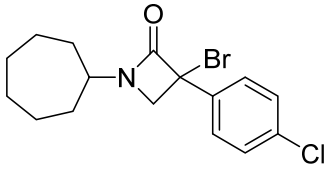
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.57 (m, 2H), 7.09 – 7.03 (m, 2H), 3.97 – 3.92 (m, 2H), 3.85 – 3.78 (m, 1H), 2.03 – 1.96 (m, 1H), 1.92 – 1.85 (m, 1H), 1.75 – 1.65 (m, 2H), 1.63 – 1.41 (m, 8H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.6, 162.8 (d, J = 249.5 Hz), 133.8 (d, J = 3.4 Hz), 129.1 (d, J = 8.4 Hz), 115.9 (d, J = 21.8 Hz), 58.8, 56.0, 53.6, 32.5, 32.2, 27.9, 27.8, 24.1.

^{19}F NMR (376 MHz, $CDCl_3$) δ -111.61.

HRMS (ESI) m/z calcd. for $C_{16}H_{20}BrFNO$ $[M + H]^+$ 340.0707, found 340.0704.

3-Bromo-3-(4-chlorophenyl)-1-cycloheptylazetidin-2-one (E16)

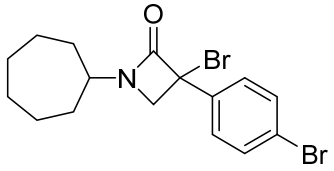


E16

According to **General procedure 1** with 2-(4-chlorophenyl)acrylic acid (1.03 g, 5.0 mmol, 1.0 equiv) and cycloheptanamine (0.62 g, 5.5 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E16** as a white solid (0.56 g, 32% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.53 (m, 2H), 7.36 – 7.33 (m, 2H), 3.96 – 3.91 (m, 2H), 3.85 – 3.78 (m, 1H), 2.02 – 1.95 (m, 1H), 1.91 – 1.84 (m, 1H), 1.73 – 1.62 (m, 4H), 1.58 – 1.41 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 163.4, 136.4, 135.0, 129.1, 128.5, 58.6, 55.8, 53.6, 32.5, 32.2, 27.9, 27.8, 24.1.
HRMS (ESI) m/z calcd. for $C_{16}H_{20}BrClNO$ $[M + H]^+$ 356.0411, found 356.0410.

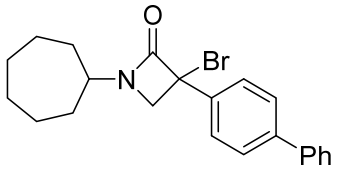
3-Bromo-3-(4-bromophenyl)-1-cycloheptylazetidin-2-one (E17)



E17

According to **General procedure 1** with 2-(4-bromophenyl)acrylic acid (1.48 g, 6.5 mmol, 1.0 equiv) and cycloheptanamine (0.81 g, 7.2 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E17** as a white solid (0.63 g, 24% overall yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.46 (m, 4H), 3.96 – 3.91 (m, 2H), 3.84 – 3.77 (m, 1H), 2.01 – 1.94 (m, 1H), 1.90 – 1.84 (m, 1H), 1.73 – 1.40 (m, 10H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 163.3, 136.8, 132.0, 128.7, 123.2, 58.6, 55.7, 53.6, 32.4, 32.2, 27.80, 27.76, 24.0.
HRMS (ESI) m/z calcd. for $C_{16}H_{20}Br_2NO$ $[M + H]^+$ 399.9906, found 399.9906.

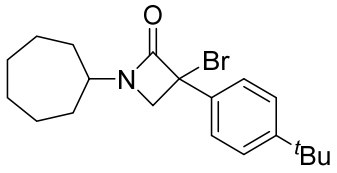
3-([1,1'-Biphenyl]-4-yl)-3-bromo-1-cycloheptylazetidin-2-one (E18)



E18

According to **General procedure 1** with 2-([1,1'-biphenyl]-4-yl)acrylic acid (1.12 g, 5.0 mmol, 1.0 equiv) and cycloheptanamine (0.62 g, 5.5 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E18** as a white solid (0.24 g, 12% overall yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.66 (m, 2H), 7.61 – 7.56 (m, 4H), 7.46 – 7.42 (m, 2H), 7.39 – 7.34 (m, 1H), 4.02 – 3.98 (m, 2H), 3.87 – 3.80 (m, 1H), 2.04 – 1.97 (m, 1H), 1.93 – 1.87 (m, 1H), 1.74 – 1.62 (m, 4H), 1.58 – 1.42 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 163.8, 141.9, 140.2, 136.7, 128.8, 127.7, 127.60, 127.55, 127.1, 59.6, 55.9, 53.6, 32.5, 32.3, 27.90, 27.86, 24.2.
HRMS (ESI) m/z calcd. for $C_{22}H_{25}BrNO$ $[M + H]^+$ 398.1114, found 398.1112.

3-Bromo-3-(4-(*tert*-butyl)phenyl)-1-cycloheptylazetidin-2-one (E19)



E19

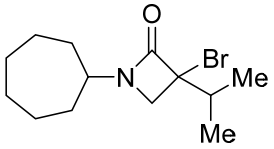
According to **General procedure 1** with 2-(4-(*tert*-butyl)phenyl)acrylic acid (1.02 g, 5.0 mmol, 1.0 equiv) and cycloheptanamine (0.62 g, 5.5 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E19** as a white solid (0.16 g, 8% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.51 (m, 2H), 7.40 – 7.36 (m, 2H), 3.98 – 3.94 (m, 2H), 3.85 – 3.78 (m, 1H), 2.03 – 1.95 (m, 1H), 1.91 – 1.84 (m, 1H), 1.73 – 1.67 (m, 1H), 1.64 – 1.40 (m, 9H), 1.31(s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.9, 152.1, 134.7, 126.8, 125.8, 59.9, 55.9, 53.4, 34.7, 32.5, 32.2, 31.2, 27.9, 27.8, 24.1.

HRMS (ESI) m/z calcd. for $C_{20}H_{29}BrNO$ $[M + H]^+$ 378.1427, found 378.1425.

3-Bromo-1-cycloheptyl-3-isopropylazetidin-2-one (E20)



E20

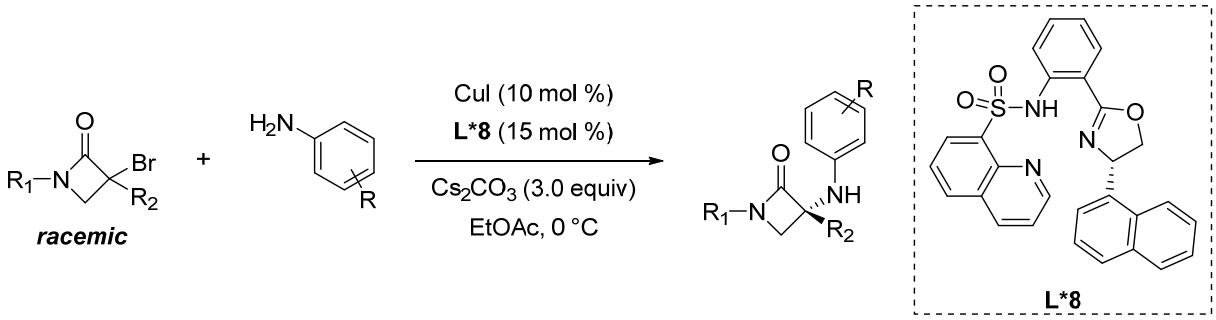
According to **General procedure 1** with 3-methyl-2-methylenebutanoic acid (1.46 g, 12.8 mmol, 1.0 equiv) and cycloheptanamine (1.59 g, 14.1 mmol, 1.1 equiv), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 5/1) to yield the product **E20** as a colorless oil (0.71 g, 19% overall yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 – 3.74 (m, 1H), 3.52 – 3.48 (m, 2H), 2.04 (p, J = 6.6 Hz, 1H), 1.96 – 1.86 (m, 2H), 1.70 – 1.43 (m, 10H), 1.12 (d, J = 6.6 Hz, 3H), 1.02 (d, J = 6.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.0, 69.6, 53.0, 52.1, 34.2, 32.6, 32.2, 27.9, 27.8, 24.2, 24.1, 18.6, 18.5.

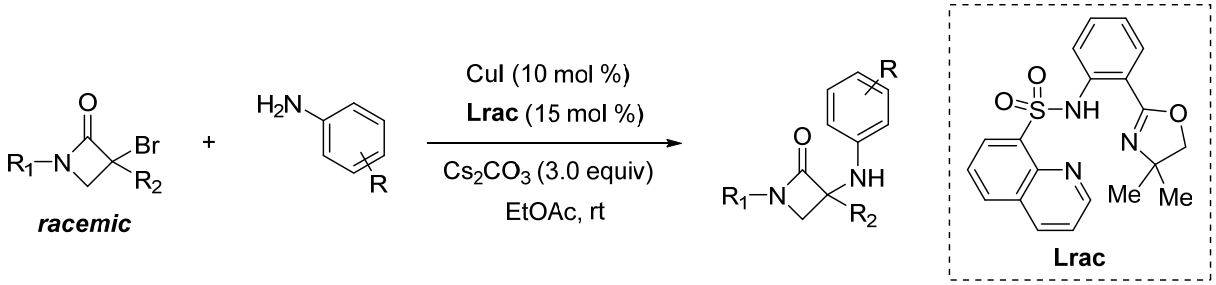
HRMS (ESI) m/z calcd. for $C_{13}H_{23}BrNO$ $[M + H]^+$ 288.0958, found 288.0959.

5. Cross-coupling of racemic tertiary α-bromo-β-lactams and aromatic amines



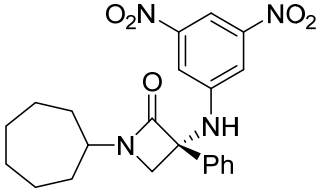
General procedure A:

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (3.8 mg, 0.02 mmol, 10 mol %), **L*8** (14.4 mg, 0.03 mmol, 15 mol %), Cs_2CO_3 (195.5 mg, 0.60 mmol, 3.0 equiv), racemic tertiary α-bromo-β-lactam (0.20 mmol, 1.0 equiv), and aromatic amine (0.20 mmol, 1.0 equiv). Anhydrous EtOAc (4.0 mL) was added into the mixture and the reaction mixture was stirred at 0 °C for 72 h. Upon completion (monitored by TLC), 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.



The racemates of products were prepared following the procedure: Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (3.8 mg, 0.02 mmol, 10 mol %), **Lrac** (11.4 mg, 0.03 mmol, 15 mol %), Cs_2CO_3 (195.5 mg, 0.60 mmol, 3.0 equiv), racemic tertiary α-bromo-β-lactam (0.20 mmol, 1.0 equiv), and aromatic amine (0.20 mmol, 1.0 equiv). Anhydrous EtOAc (4.0 mL) was added into the mixture and the reaction mixture was stirred at room temperature for 72 h. Upon completion (monitored by TLC), 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-Cycloheptyl-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (1)

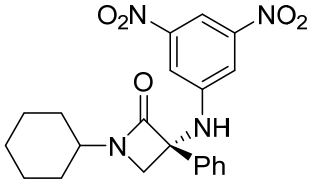


1

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2

mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **1** as a yellow solid (72.1 mg, 85% yield, 92% ee).
[α]$_D^{27}$ = -247 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 13.68 min, t_R (minor) = 17.15 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (t, *J* = 2.0 Hz, 1H), 7.55 (d, *J* = 2.0 Hz, 2H), 7.46 – 7.42 (m, 2H), 7.38 – 7.28 (m, 3H), 7.24 – 7.22 (m, 1H), 4.14 (d, *J* = 5.7 Hz, 1H), 3.95 – 3.88 (m, 1H), 3.70 (d, *J* = 5.7 Hz, 1H), 2.16 – 2.04 (m, 2H), 1.87 – 1.572 (m, 4H), 1.69 – 1.51 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 149.0, 147.5, 134.4, 129.3, 128.6, 125.7, 113.0, 106.9, 70.1, 54.2, 51.3, 32.8, 32.5, 27.8, 24.1.
HRMS (ESI) m/z calcd. for $C_{22}H_{25}N_4O_5$ $[M+H]^+$ 425.1819, found 425.1811.

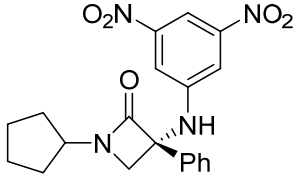
(*R*)-1-Cyclohexyl-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (2)



2

According to **General Procedure A** with 3-bromo-1-cyclohexyl-3-phenylazetidin-2-one **E2** (61.6 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **2** as a yellow solid (80.0 mg, 98% yield, 88% ee).
[α]$_D^{27}$ = -256 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 14.82 min, t_R (minor) = 17.97 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (t, *J* = 2.0 Hz, 1H), 7.56 (d, *J* = 2.0 Hz, 2H), 7.47 – 7.43 (m, 2H), 7.36 – 7.30 (m, 3H), 7.25 (s, 1H), 4.13 (d, *J* = 5.8 Hz, 1H), 3.76 – 3.68 (m, 2H), 2.12 – 2.02 (m, 2H), 1.89 – 1.82 (m, 2H), 1.72 – 1.65 (m, 1H), 1.62 – 1.52 (m, 2H), 1.46 – 1.33 (m, 2H), 1.28 – 1.20 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.3, 149.0, 147.5, 134.4, 129.3, 128.6, 125.7, 113.0, 106.9, 70.0, 52.2, 51.1, 30.7, 30.4, 25.1, 24.63, 24.61.
HRMS (ESI) m/z calcd. for $C_{21}H_{23}N_4O_5$ $[M+H]^+$ 411.1663, found 411.1653.

(*R*)-1-Cyclopentyl-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (3)

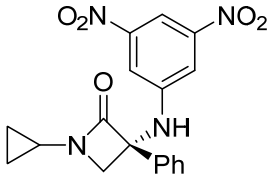


3

According to **General Procedure A** with 3-bromo-1-cyclopentyl-3-phenylazetidin-2-one **E3** (58.8 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc =

3/1) to yield the product **3** as a yellow solid (76.8 mg, 97% yield, 89% ee).
[α]$_D^{27}$ = -259 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 17.54 min, t_R (minor) = 21.24 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (t, *J* = 2.5 Hz, 1H), 7.57 (d, *J* = 2.1 Hz, 2H), 7.45 – 7.43 (m, 2H), 7.36 – 7.30 (m, 3H), 7.26 (s, 1H), 4.25 – 4.18 (m, 1H), 4.12 (d, *J* = 5.8 Hz, 1H), 3.69 (d, *J* = 5.8 Hz, 1H), 2.06 – 1.66 (m, 8H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.5, 149.0, 147.5, 134.5, 129.3, 128.6, 125.7, 113.1, 106.9, 70.0, 54.2, 51.6, 30.4, 30.0, 24.0.
HRMS (ESI) m/z calcd. for $C_{20}H_{21}N_4O_5$ $[M+H]^+$ 397.1506, found 397.1498.

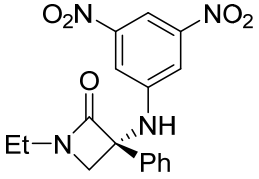
(*R*)-1-Cyclopropyl-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (4)



4

According to **General Procedure A** with 3-bromo-1-cyclopropyl-3-phenylazetidin-2-one **E4** (53.2 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **4** as a yellow solid (55.0 mg, 75% yield, 87% ee).
[α]$_D^{27}$ = -407 (*c* 0.25, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 13.92 min, t_R (minor) = 20.02 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 – 8.23 (m, 1H), 7.57 (d, *J* = 2.0 Hz, 2H), 7.45 – 7.42 (m, 2H), 7.37 – 7.31 (m, 3H), 6.98 – 6.93 (m, 1H), 4.09 (d, *J* = 5.9 Hz, 1H), 3.68 (d, *J* = 5.9 Hz, 1H), 2.80 – 2.75 (m, 1H), 1.04 – 0.85 (m, 4H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 167.4, 149.1, 147.3, 134.4, 129.4, 128.8, 125.8, 113.1, 107.1, 70.6, 53.8, 24.7, 5.54, 5.46.
HRMS (ESI) m/z calcd. for $C_{18}H_{17}N_4O_5$ $[M+H]^+$ 369.1193, found 369.1187.

(*R*)-3-((3,5-Dinitrophenyl)amino)-1-ethyl-3-phenylazetidin-2-one (5)

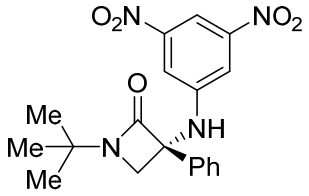


5

According to **General Procedure A** with 3-bromo-1-ethyl-3-phenylazetidin-2-one **E5** (50.8 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **5** as a yellow solid (70.0 mg, 98% yield, 90% ee).
[α]$_D^{27}$ = -248 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R

(major) = 13.59 min, t_R (minor) = 16.46 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (t, *J* = 2.0 Hz, 1H), 7.58 (d, *J* = 1.9 Hz, 2H), 7.48 – 7.44 (m, 2H), 7.39 – 7.32 (m, 3H), 6.87 (s, 1H), 4.12 (d, *J* = 5.7 Hz, 1H), 3.71 (d, *J* = 5.8 Hz, 1H), 3.56 – 3.41 (m, 2H), 1.33 (t, *J* = 7.3 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 149.1, 147.4, 134.5, 129.4, 128.7, 125.8, 113.1, 107.1, 71.3, 52.8, 37.1, 12.5.
HRMS (ESI) m/z calcd. for $C_{17}H_{17}N_4O_5$ $[M+H]^+$ 357.1193, found 357.1188.

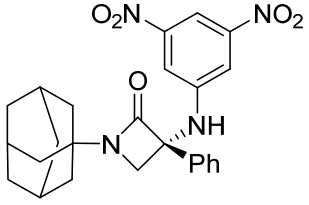
(*R*)-1-(*Tert*-butyl)-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (6)



6

According to **General Procedure A** with 3-bromo-1-(*tert*-butyl)-3-phenylazetidin-2-one **E6** (56.4 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **6** as a yellow solid (73.8 mg, 96% yield, 91% ee).
$[\alpha]_D^{27}$ = -270 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 25.83 min, t_R (minor) = 34.23 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (t, *J* = 1.7 Hz, 1H), 7.59 (d, *J* = 2.0 Hz, 2H), 7.44 – 7.41 (m, 2H), 7.34 – 7.27 (m, 4H), 4.11 (d, *J* = 5.6 Hz, 1H), 3.66 (d, *J* = 5.7 Hz, 1H), 1.52 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 149.1, 147.6, 134.5, 129.4, 128.5, 125.7, 113.1, 106.8, 69.2, 54.2, 50.6, 27.6.
HRMS (ESI) m/z calcd. for $C_{19}H_{21}N_4O_5$ $[M+H]^+$ 385.1506, found 385.1501.

(*R*)-1-(Adamantan-1-yl)-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (7)

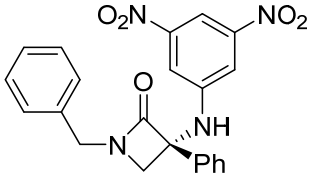


7

According to **General Procedure A** with 1-(adamantan-1-yl)-3-bromo-3-phenylazetidin-2-one **E7** (72.1 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **7** as a yellow solid (89.3 mg, 97% yield, 91% ee).
$[\alpha]_D^{27}$ = -256 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 10.76 min, t_R (minor) = 14.86 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (t, *J* = 2.0 Hz, 1H), 7.60 (d, *J* = 2.0 Hz, 2H), 7.43 – 7.39 (m 3H), 7.29 – 7.28 (m, 3H), 4.12 (d, *J* = 5.7 Hz, 1H), 3.66 (d, *J* = 5.8 Hz, 1H), 2.22 – 2.17 (m, 9H),

1.77 – 1.72 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 149.1, 147.8, 134.6, 129.3, 128.4, 125.7, 113.1, 106.7, 68.8, 55.0, 49.3, 40.8, 36.0, 29.0.
HRMS (ESI) m/z calcd. for $C_{25}H_{27}N_4O_5$ $[M+H]^+$ 463.1976, found 463.1972.

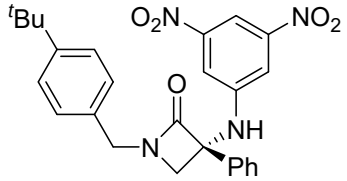
(*R*)-1-Benzyl-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (8)



8

According to **General Procedure A** with 1-benzyl-3-bromo-3-phenylazetidin-2-one **E8** (63.2 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **8** as a yellow solid (68.0 mg, 81% yield, 89% ee).
$[\alpha]_D^{27}$ = -231 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 9.30 min, t_R (minor) = 12.4 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (t, *J* = 2.0 Hz, 1H), 7.56 (d, *J* = 2.0 Hz, 2H), 7.43 – 7.39 (m, 4H), 7.37 – 7.31 (m, 6H), 6.77 (s, 1H), 4.65 (d, *J* = 14.9 Hz, 1H), 4.52 (d, *J* = 14.9 Hz, 1H), 3.99 (d, *J* = 5.9 Hz, 1H), 3.59 (d, *J* = 5.9 Hz, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.8, 149.1, 147.1, 134.3, 134.2, 129.4, 129.2, 128.9, 128.4, 125.8, 113.2, 107.4, 71.8, 53.2, 46.6.
HRMS (ESI) m/z calcd. for $C_{22}H_{19}N_4O_5$ $[M + H]^+$ 419.1350, found 419.1346.

(*R*)-1-(4-(*Tert*-butyl)benzyl)-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (9)

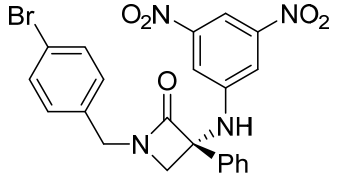


9

According to **General Procedure A** with 3-bromo-1-(4-(*tert*-butyl)benzyl)-3-phenylazetidin-2-one **E9** (74.5 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **9** as a yellow solid (85.9 mg, 91% yield, 90% ee).
$[\alpha]_D^{27}$ = -202 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 8.43 min, t_R (minor) = 10.05 min.
^{1}H NMR (400 MHz, $CDCl_3$)δ 8.23 (t, *J* = 1.9 Hz, 1H), 7.56 (d, *J* = 2.0 Hz, 2H), 7.43 – 7.40 (m, 4H), 7.36 – 7.30 (m, 3H), 7.27 – 7.25 (m, 2H), 6.94 (s, 1H), 4.63 (d, *J* = 14.9 Hz, 1H), 4.50 (d, *J* = 14.9 Hz, 1H), 4.02 (d, *J* = 5.9 Hz, 1H), 3.60 (d, *J* = 5.9 Hz, 1H), 1.32 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 151.4, 149.1, 147.2, 134.3, 131.0, 129.4, 128.8, 128.0, 126.1, 125.8, 113.2, 107.2, 71.7, 53.1, 46.2, 34.6, 31.2.

HRMS (ESI) m/z calcd. for $C_{26}H_{27}N_4O_5$ $[M+H]^+$ 475.1976, found 475.1970.

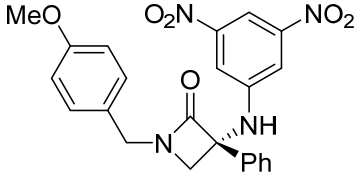
(*R*)-1-(4-Bromobenzyl)-3-((3,5-dinitrophenyl)amino)-3-phenylazetidin-2-one (10)



10

According to **General Procedure A** with 3-bromo-1-(4-bromobenzyl)-3-phenylazetidin-2-one **E10** (79.0 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **10** as a yellow solid (89.5 mg, 90% yield, 90% ee).
$[\alpha]_D^{27}$ = -364 (*c* 0.25, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 13.87 min, t_R (minor) = 17.41 min.
^{1}H NMR (400 MHz, DMSO-d_6) δ 8.56 (s, 1H), 7.97 (t, *J* = 2.0 Hz, 1H), 7.80 (d, *J* = 2.1 Hz, 2H), 7.60 – 7.57 (m, 2H), 7.47 – 7.39 (m, 4H), 7.35 – 7.28 (m, 3H), 4.55 (d, *J* = 15.2 Hz, 1H), 4.47 (d, *J* = 15.2 Hz, 1H), 3.76 (d, *J* = 6.0 Hz, 1H), 3.61 (d, *J* = 6.0 Hz, 1H).
^{13}C NMR (100 MHz, DMSO-d_6) δ 166.4, 148.9, 148.6, 136.5, 135.5, 132.2, 130.8, 129.6, 128.8, 126.3, 121.4, 113.8, 106.1, 72.4, 54.4, 45.2.
HRMS (ESI) m/z calcd. for $C_{22}H_{18}BrN_4O_5$ $[M+H]^+$ 497.0455, found 497.0459.

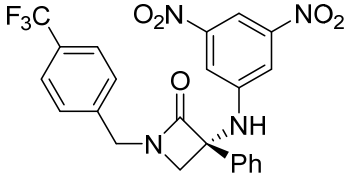
(*R*)-3-((3,5-Dinitrophenyl)amino)-1-(4-methoxybenzyl)-3-phenylazetidin-2-one (11)



11

According to **General Procedure A** with 3-bromo-1-(4-methoxybenzyl)-3-phenylazetidin-2-one **E11** (69.2 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **11** as a yellow solid (85.3 mg, 95% yield, 88% ee).
$[\alpha]_D^{27}$ = -208 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 12.44 min, t_R (minor) = 15.89 min.
^{1}H NMR (400 MHz, DMSO-d_6) δ 8.52 (s, 1H), 7.96 (t, *J* = 2.0 Hz, 1H), 7.79 (d, *J* = 2.0 Hz, 2H), 7.46 – 7.38 (m, 4H), 7.34 – 7.30 (m, 1H), 7.27 – 7.25 (m, 2H), 6.95 – 6.93 (m, 2H), 4.49 (d, *J* = 14.9 Hz, 1H), 4.41 (d, *J* = 14.8 Hz, 1H), 3.74 (s, 3H), 3.71 (d, *J* = 6.2 Hz, 1H)., 3.55 (d, *J* = 6.0 Hz, 1H).
^{13}C NMR (100 MHz, DMSO-d_6) δ 166.1, 159.3, 149.0, 148.6, 136.6, 130.0, 129.6, 128.7, 127.7, 126.3, 114.7, 113.7, 106.1, 72.1, 55.6, 54.1, 45.2
HRMS (ESI) m/z calcd. for $C_{23}H_{21}N_4O_6$ $[M+H]^+$ 449.1456, found 449.1450.

(*R*)-3-((3,5-Dinitrophenyl)amino)-3-phenyl-1-(4-(trifluoromethyl)benzyl)azetidin-2-one (12)



12

According to **General Procedure A** with 3-bromo-3-phenyl-1-(4-(trifluoromethyl)benzyl)azetidin-2-one **E12** (76.9 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **12** as a yellow solid (96.2 mg, 99% yield, 88% ee).

[α]$_D^{27}$ = -177 (*c* 0.5, $CHCl_3$).

HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 11.52 min, t_R (minor) = 14.98 min.

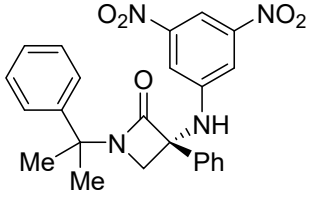
^{1}H NMR (400 MHz, DMSO-d_6) δ 8.57 (s, 1H), 7.97 (t, *J* = 2.0 Hz, 1H), 7.81 (d, *J* = 2.0 Hz, 2H), 7.77 – 7.75 (m, 2H), 7.58 – 7.56 (m, 2H), 7.49 – 7.47 (m, 2H), 7.43 – 7.39 (m, 2H), 7.35 – 7.31 (m, 1H), 4.69 (d, *J* = 15.5 Hz, 1H), 4.61 (d, *J* = 15.5 Hz, 1H), 3.82 (d, *J* = 6.0 Hz, 1H), 3.66 (d, *J* = 6.1 Hz, 1H).

^{13}C NMR (100 MHz, DMSO-d_6) δ 166.6, 149.0, 148.6, 140.9, 136.5, 129.6, 129.3, 128.833 (q, *J* = 31.8 Hz), 128.826, 126.4, 126.2 (q, *J* = 3.8 Hz), 124.6 (q, *J* = 270.4 Hz), 113.8, 106.2, 72.6, 54.7, 45.4.

^{19}F NMR (376 MHz, DMSO-d_6) δ -61.06.

HRMS (ESI) m/z calcd. for $C_{23}H_{18}F_3N_4O_5$ $[M+H]^+$ 487.1224, found 487.1222.

(*R*)-3-((3,5-Dinitrophenyl)amino)-3-phenyl-1-(2-phenylpropan-2-yl)azetidin-2-one (13)



13

According to **General Procedure A** with 3-bromo-3-phenyl-1-(2-phenylpropan-2-yl)azetidin-2-one **E13** (68.9 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **13** as a yellow solid (73.7 mg, 83% yield, 90% ee).

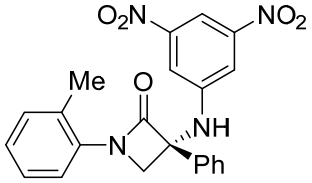
[α]$_D^{27}$ = -243 (*c* 0.5, $CHCl_3$).

HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 8.21 min, t_R (minor) = 11.07 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (s, 1H), 7.52 (s, 2H), 7.48 – 7.44 (m, 4H), 7.39 – 7.27 (m, 6H), 7.20 (s, 1H), 3.99 (d, *J* = 5.9 Hz, 1H), 3.52 (d, *J* = 6.0 Hz, 1H), 1.92 (d, *J* = 2.7 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 166.5, 149.0, 147.4, 143.6, 134.4, 129.4, 128.8, 128.7, 127.7, 125.9, 125.2, 113.1, 107.0, 69.5, 59.6, 51.0, 27.9, 27.4.
HRMS (ESI) m/z calcd. for $C_{24}H_{23}N_4O_5$ $[M+H]^+$ 447.1663, found 447.1654.

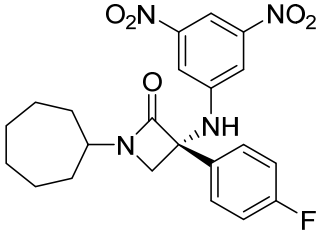
(*R*)-3-((3,5-Dinitrophenyl)amino)-3-phenyl-1-(*o*-tolyl)azetidin-2-one (14)



14

According to **General Procedure A** with 3-bromo-3-phenyl-1-(*o*-tolyl)azetidin-2-one **E14** (63.2 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **14** as a yellow solid (82.5 mg, 99% yield, 80% ee).
$[\alpha]_D^{27}$ = -231 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) =12.58 min, t_R (minor) = 22.52 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (s, 1H), 7.59 – 7.56 (m, 4H), 7.42 – 7.34 (m, 4H), 7.28 – 7.21 (m, 3H), 7.14 (s, 1H), 4.53 (d, *J* = 6.0 Hz, 1H), 4.25 (d, *J* = 6.0 Hz, 1H), 2.45 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.0, 149.1, 147.1, 134.8, 134.2, 132.1, 131.7, 129.6, 129.0, 127.5, 126.7, 125.8, 122.5, 113.2, 107.3, 70.8, 56.0, 19.1.
HRMS (ESI) m/z calcd. for $C_{22}H_{19}N_4O_5$ $[M+H]^+$ 419.1350, found 419.1353.

(*R*)-1-Cycloheptyl-3-((3,5-dinitrophenyl)amino)-3-(4-fluorophenyl)azetidin-2-one (15)

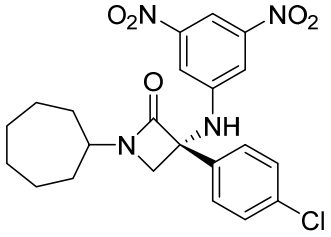


15

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-(4-fluorophenyl)azetidin-2-one **E15** (68.1 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **15** as a yellow solid (77.5 mg, 88% yield, 88% ee).
$[\alpha]_D^{27}$ = -250 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.20 min, t_R (minor) = 9.19 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.26 (t, *J* = 2.0 Hz, 1H), 7.59 (d, *J* = 2.0 Hz, 2H), 7.44 – 7.39 (m, 2H), 7.09 (s, 1H), 7.06 – 7.00 (m, 2H), 4.10 (d, *J* = 5.9 Hz, 1H), 3.94 – 3.87 (m, 1H), 3.71 (d, *J* = 5.9 Hz, 1H), 2.15 – 2.04 (m, 2H), 1.86 – 1.72 (m, 4H), 1.68 – 1.52 (m, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 162.7 (d, *J* = 247.2 Hz), 149.2, 147.3, 130.3 (d, *J* = 3.3Hz), 127.7(d, *J* = 8.3 Hz), 116.4(d, *J* = 21.6 Hz), 113.1, 107.2, 69.7, 54.3, 51.4, 32.8, 32.5, 27.8, 24.1.
^{19}F NMR (376 MHz, $CDCl_3$) δ -112.67.
HRMS (ESI) m/z calcd. for $C_{22}H_{24}FN_4O_5$ $[M+H]^+$ 443.1725, found 443.1723.

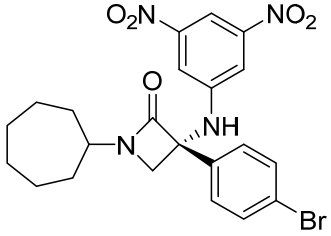
(*R*)-3-(4-Chlorophenyl)-1-cycloheptyl-3-((3,5-dinitrophenyl)amino)azetidin-2-one (16)



16

According to **General Procedure A** with 3-bromo-3-(4-chlorophenyl)-1-cycloheptylazetidin-2-one **E16** (71.3 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **16** as a yellow solid (88.9 mg, 97% yield, 81% ee).
$[\alpha]_D^{27}$ = -243 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 10.30 min, t_R (minor) = 16.16 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (t, *J* = 2.0 Hz, 1H), 7.57 (d, *J* = 2.0 Hz, 2H), 7.37 – 7.33 (m, 2H), 7.32 – 7.26 (m, 2H), 7.20 (s, 1H), 4.10 (d, *J* = 5.9 Hz, 1H), 3.94 – 3.87 (m, 1H), 3.71 (d, *J* = 5.9 Hz, 1H), 2.15 – 2.04 (m, 2H), 1.84 – 1.73 (m, 4H), 1.68 – 1.52 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 149.1, 147.2, 134.7, 133.1, 129.6, 127.2, 113.1, 107.2, 69.7, 54.4, 51.3, 32.8, 32.4, 27.8, 24.1.
HRMS (ESI) m/z calcd. for $C_{22}H_{24}ClN_4O_5$ $[M+H]^+$ 459.1430, found 459.1421.

(*R*)-3-(4-Bromophenyl)-1-cycloheptyl-3-((3,5-dinitrophenyl)amino)azetidin-2-one (17)

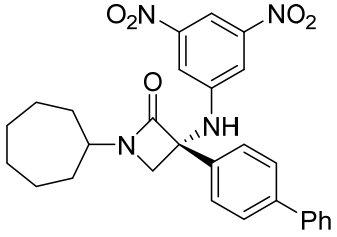


17

According to **General Procedure A** with 3-bromo-3-(4-bromophenyl)-1-cycloheptylazetidin-2-one **E17** (80.2 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **17** as a yellow solid (84.2 mg, 84% yield, 89% ee).
$[\alpha]_D^{27}$ = -239 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 10.58 min, t_R (minor) = 16.62 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.27 (t, *J* = 2.0 Hz, 1H), 7.57 (d, *J* = 2.0 Hz, 2H), 7.47 – 7.44 (m, 2H), 7.30 – 7.28 (m, 2H), 6.98 (s, 1H), 4.08 (d, *J* = 5.9 Hz, 1H), 3.93 – 3.86 (m, 1H), 3.69 (d, *J* = 5.9 Hz, 1H), 2.14 – 2.03 (m, 2H), 1.82 – 1.71 (m, 4H), 1.68 – 1.54 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 149.1, 147.2, 133.6, 132.5, 127.5, 122.8, 113.1, 107.2, 69.8, 54.4, 51.3, 32.8, 32.4, 27.8, 24.1.
HRMS (ESI) m/z calcd. for $C_{22}H_{24}BrN_4O_5$ $[M+H]^+$ 503.0925, found 503.0917.

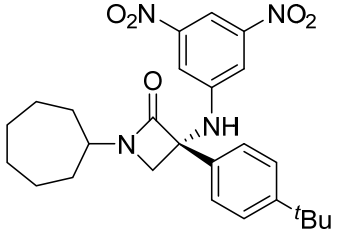
(*R*)-3-([1,1'-Biphenyl]-4-yl)-1-cycloheptyl-3-((3,5-dinitrophenyl)amino)azetidin-2-one (18)



18

According to **General Procedure A** with 3-([1,1'-biphenyl]-4-yl)-3-bromo-1-cycloheptylazetidin-2-one **E18** (79.7 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **18** as a yellow solid (62.2 mg, 62% yield, 89% ee).
$[\alpha]_D^{27}$ = -240 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 13.57 min, t_R (minor) = 19.74 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (t, *J* = 1.9 Hz, 1H), 7.63 (d, *J* = 1.9 Hz, 2H), 7.55 – 7.46 (m, 6H), 7.39 – 7.30 (m, 3H), 7.08 (s, 1H), 4.17 (d, *J* = 5.8 Hz, 1H), 3.97 – 3.90 (m, 1H), 3.73 (d, *J* = 5.8 Hz, 1H), 2.18 – 2.06 (m, 2H), 1.86 – 1.74 (m, 4H), 1.68 – 1.55 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 149.2, 147.5, 141.5, 139.9, 133.4, 128.8, 128.0, 127.6, 126.9, 126.3, 113.1, 107.1, 70.1, 54.3, 51.2, 32.9, 32.5, 27.9, 24.2.
HRMS (ESI) m/z calcd. for $C_{28}H_{29}N_4O_5$ $[M+H]^+$ 501.2132, found 501.2140.

(*R*)-3-(4-(*Tert*-butyl)phenyl)-1-cycloheptyl-3-((3,5-dinitrophenyl)amino)azetidin-2-one (19)

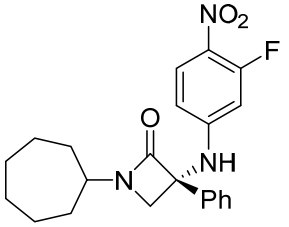


19

According to **General Procedure A** with 3-bromo-3-(4-(*tert*-butyl)phenyl)-1-cycloheptylazetidin-2-one **E19** (75.7 mg, 0.20 mmol, 1.0 equiv) and 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **19** as a yellow solid (82.8 mg, 86% yield, 90% ee).
$[\alpha]_D^{27}$ = -236 (*c* 0.5, $CHCl_3$).

HPLC analysis: Chiralcel IB (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 11.60 min, t_R (minor) = 14.68 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (t, *J* = 2.0 Hz, 1H), 7.58 (d, *J* = 2.0 Hz, 2H), 7.41 – 7.35 (m, 4H), 7.09 (s, 1H), 4.13 (d, *J* = 5.7 Hz, 1H), 3.94 – 3.87 (m, 1H), 3.68 (d, *J* = 5.7 Hz, 1H), 2.14 – 2.03 (m, 2H), 1.83 – 1.72 (m, 4H), 1.67 – 1.53 (m, 6H), 1.27 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 151.7, 149.1, 147.6, 131.4, 126.3, 125.6, 113.0, 106.8, 70.0, 54.1, 51.0, 34.5, 32.8, 32.5, 31.1, 27.9, 24.2.
HRMS (ESI) m/z calcd. for $C_{26}H_{33}N_4O_5$ $[M+H]^+$ 481.2445, found 481.2442.

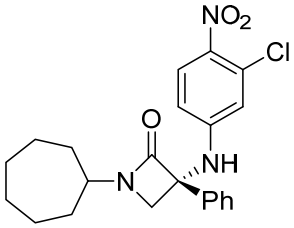
(*R*)-1-Cycloheptyl-3-((3-fluoro-4-nitrophenyl)amino)-3-phenylazetidin-2-one (21)



21

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 3-fluoro-4-nitroaniline **A2** (31.2 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **21** as a yellow solid (52.3 mg, 66% yield, 83% ee).
$[\alpha]_D^{27}$ = -306 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 14.92 min, t_R (minor) = 18.73 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (t, *J* = 8.8 Hz, 1H), 7.40 – 7.32 (m, 5H), 6.77 (s, 1H), 6.20 (dd, *J* = 9.1, 2.4 Hz, 1H), 6.10 (dd, *J* = 13.5, 2.5 Hz, 1H), 3.99 (d, *J* = 5.8 Hz, 1H), 3.91 – 3.84 (m, 1H), 3.64 (d, *J* = 5.8 Hz, 1H), 2.11 – 1.99 (m, 2H), 1.81 – 1.49 (m, 10H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 157.8 (d, *J* = 261.4 Hz), 152.3 (d, *J* = 11.7 Hz), 134.7, 129.3, 128.6, 128.1, 127.7 (d, *J* = 6.4 Hz), 125.4, 109.2 (d, *J* = 2.2 Hz), 101.2 (d, *J* = 25.0 Hz), 70.2, 53.9, 52.1, 32.8, 32.5, 27.9, 27.8, 24.2, 24.1.
^{19}F NMR (376 MHz, $CDCl_3$) δ -113.46.
HRMS (ESI) m/z calcd. for $C_{22}H_{25}FN_3O_3$ $[M+H]^+$ 398.1874, found 398.1871.

(*R*)-3-((3-Chloro-4-nitrophenyl)amino)-1-cycloheptyl-3-phenylazetidin-2-one (22)

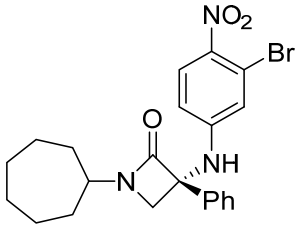


22

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 3-chloro-4-nitroaniline **A3** (34.5mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum

ether/EtOAc = 3/1) to yield the product **22** as a yellow solid (52.1 mg, 63% yield, 86% ee).
[α]$_D^{27}$ = -291 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 12.57 min, t_R (minor) = 15.65 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 9.1 Hz, 1H), 7.38 – 7.32 (m, 5H), 6.60 (s, 1H), 6.45 (d, *J* = 2.4 Hz, 1H), 6.29 – 6.26 (m, 1H), 3.99 (d, *J* = 5.8 Hz, 1H), 3.91 – 3.83 (m, 1H), 3.64 (d, *J* = 5.7 Hz, 1H), 2.10 – 1.99 (m, 2H), 1.81 – 1.51 (m, 10H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 150.0, 137.4, 134.9, 130.1, 129.3, 128.6, 128.5, 125.5, 115.6, 111.6, 70.2, 53.9, 52.0, 32.8, 32.5, 27.88, 27.86, 24.17, 24.15.
HRMS (ESI) m/z calcd. for $C_{22}H_{25}ClN_3O_3$ $[M+H]^+$ 414.1579, found 414.1575.

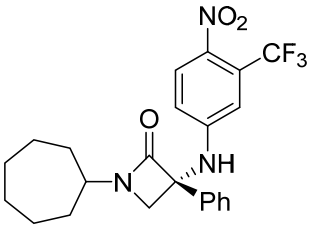
(*R*)-3-((3-Bromo-4-nitrophenyl)amino)-1-cycloheptyl-3-phenylazetidin-2-one (23)



23

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 3-bromo-4-nitroaniline **A4** (43.4mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **23** as a yellow solid (50.0 mg, 55% yield, 85% ee).
[α]$_D^{27}$ = -278 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) =13.52 min, t_R (minor) =16.69 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 9.1 Hz, 1H), 7.39 – 7.31 (m, 5H), 6.73 (s, 1H), 6.69 (d, *J* = 2.5 Hz, 1H), 6.30 – 6.27 (m, 1H), 3.99 (d, *J* = 5.7 Hz, 1H), 3.90 – 3.83 (m, 1H), 3.64 (d, *J* = 5.8 Hz, 1H), 2.11 – 1.99 (m, 2H), 1.79 – 1.70 (m, 4H), 1.66 – 1.51 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 150.0, 139.0, 134.9, 129.3, 128.5, 128.4, 125.5, 119.1, 117.4, 112.0, 70.2, 53.9, 52.0, 32.8, 32.5, 27.9, 27.8, 24.2, 24.1.
HRMS (ESI) m/z calcd. for $C_{22}H_{25}BrN_3O_3$ $[M+H]^+$ 458.1074, found 458.1067.

(*R*)-1-Cycloheptyl-3-((4-nitro-3-(trifluoromethyl)phenyl)amino)-3-phenylazetidin-2-one (24)

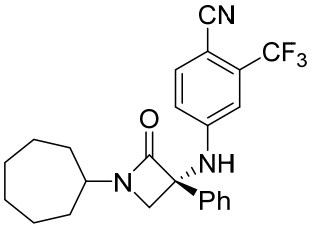


24

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 4-nitro-3-(trifluoromethyl)aniline **A5** (41.2mg, 0.20 mmol,

1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **24** as a yellow solid (70.0 mg, 78% yield, 80% ee).
[α]$_D^{27}$ = -235 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) =12.36 min, t_R (minor) = 16.19 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 9.1 Hz, 1H), 7.40 – 7.32 (m, 5H), 6.96 (d, *J* = 4.6 Hz, 1H), 6.88 (d, *J* = 2.5 Hz, 1H), 6.43 – 6.40 (m, 1H), 4.01 (d, *J* = 5.7 Hz, 1H), 3.90 – 3.83 (m, 1H), 3.63 (d, *J* = 5.8 Hz, 1H), 2.11 – 1.99 (m, 2H), 1.80 – 1.70 (m, 4H), 1.65 – 1.51 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 149.7, 137.5, 134.6, 129.3, 128.6, 128.5, 126.2 (q, *J* = 33.2 Hz), 125.5, 122.0 (q, *J* = 271.6 Hz), 114.3, 113.2 (q, *J* = 6.1 Hz), 70.2, 54.0, 52.0, 32.8, 32.5, 27.9, 27.8, 24.2, 24.1.
^{19}F NMR (376 MHz, $CDCl_3$) δ -60.31.
HRMS (ESI) m/z calcd. for $C_{23}H_{25}F_3N_3O_3$ $[M+H]^+$ 448.1843, found 448.1838.

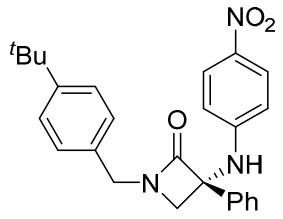
(*R*)-4-((1-Cycloheptyl-2-oxo-3-phenylazetidin-3-yl)amino)-2-(trifluoromethyl)benzonitrile (25)



25

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 4-amino-2-(trifluoromethyl)benzonitrile **A6** (37.2 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **25** as a yellow solid (58.9 mg, 69% yield, 84% ee).
[α]$_D^{27}$ = -259 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.98 min, t_R (minor) = 10.30 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.31 (m, 6H), 7.02 (s, 1H), 6.82 (d, *J* = 2.3 Hz, 1H), 6.45 – 6.42 (m, 1H), 3.98 (d, *J* = 5.7 Hz, 1H), 3.89 – 3.82 (m, 1H), 3.61 (d, *J* = 5.7 Hz, 1H), 2.10 – 1.98 (m, 2H), 1.79 – 1.70 (m, 4H), 1.66 – 1.50 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.8, 149.0, 135.8, 134.8, 133.8 (q, *J* = 32.1 Hz), 129.2, 128.5, 125.4, 122.3 (q, *J* = 272.3 Hz), 116.8, 115.1, 112.2 (q, *J* = 4.6 Hz), 96.4 (q, *J* = 2.3 Hz), 70.1, 53.9, 52.0, 32.8, 32.4, 27.81, 27.79, 24.10, 24.09.
^{19}F NMR (376 MHz, $CDCl_3$) δ -62.53.
HRMS (ESI) m/z calcd. for $C_{24}H_{25}F_3N_3O$ $[M+H]^+$ 428.1944, found 428.1939.

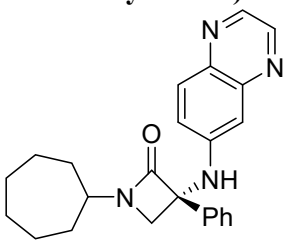
(*R*)-1-(4-(*Tert*-butyl)benzyl)-3-((4-nitrophenyl)amino)-3-phenylazetidin-2-one (26)



26

According to **General Procedure A** with 3-bromo-1-(4-(*tert*-butyl)benzyl)-3-phenylazetidin-2-one **E9** (74.5 mg, 0.20 mmol, 1.0 equiv) and 4-nitroaniline **A7** (27.6mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **26** as a yellow solid (53.9 mg, 63% yield, 83% ee).
[α]$_D^{27}$ = -230 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel AS3 (*n*-hexane/*i*-PrOH = 80/20, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 16.80 min, t_R (major) = 22.68 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.93 (m, 2H), 7.43 – 7.41 (m, 2H), 7.38 – 7.32 (m, 5H), 7.26 – 7.24 (m, 2H), 6.42 – 6.39 (m, 2H), 5.96 (s, 1H), 4.55 – 4.46 (m, 2H), 3.86 (d, *J* = 5.8 Hz, 1H), 3.59 (d, *J* = 5.9 Hz, 1H), 1.33 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 151.4, 150.7, 139.0, 135.3, 131.2, 129.2, 128.5, 128.1, 126.0, 125.9, 125.7, 113.0, 71.9, 53.7, 46.1, 34.6, 31.3.
HRMS (ESI) m/z calcd. for $C_{26}H_{28}N_3O_3$ $[M+H]^+$ 430.2125, found 430.2121.

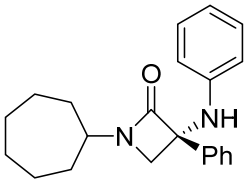
(*R*)-1-Cycloheptyl-3-phenyl-3-(quinoxalin-6-ylamino)azetidin-2-one (27)



27

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and quinoxalin-6-amine **A8** (29.0 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 4/1) to yield the product **27** as a brown solid (45.8 mg, 59% yield, 76% ee).
[α]$_D^{27}$ = -138 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 39.20 min, t_R (major) = 53.39 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.57 (s, 1H), 8.50 (s, 1H), 7.83 (d, *J* = 9.1 Hz, 1H), 7.50 – 7.48 (m, 2H), 7.36 – 7.32 (m, 2H), 7.29 – 7.27 (m, 1H), 7.19 – 7.16 (m, 1H), 6.61 (d, *J* = 2.4 Hz, 1H), 6.13 (s, 1H), 4.07 (d, *J* = 5.7 Hz, 1H), 3.93 – 3.86 (m, 1H), 3.76 (d, *J* = 5.7 Hz, 1H), 2.10 – 1.98 (m, 2H), 1.75 – 1.50 (m, 10H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.1, 146.4, 144.8, 144.7, 140.8, 138.1, 135.3, 130.3, 129.0, 128.1, 125.7, 122.6, 106.2, 70.5, 53.5, 51.6, 32.9, 32.5, 27.91, 27.88, 24.2, 24.1.
HRMS (ESI) m/z calcd. for $C_{24}H_{27}N_4O$ $[M+H]^+$ 387.2179, found 387.2182.

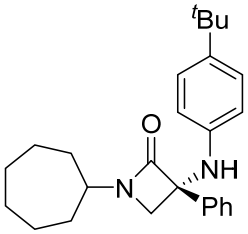
(*R*)-1-Cycloheptyl-3-phenyl-3-(phenylamino)azetidin-2-one (28)



28

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and aniline **A9** (18.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 3/1) to yield the product **28** as a yellow solid (18.8 mg, 28% yield, <5% ee).
[α]$_D^{27}$ = 2.0 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 17.34 min, t_R (major) = 21.27 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.46 (m, 2H), 7.36 – 7.32 (m, 2H), 7.29– 7.26 (m, 1H), 7.12 – 7.08 (m, 2H), 6.73 – 6.69 (m, 1H), 6.48 – 6.46 (m, 2H), 4.90 (s, 1H), 3.91 – 3.84 (m, 2H), 3.68 (d, *J* = 5.5 Hz, 1H), 2.06 – 1.95 (m, 2H), 1.73 – 1.59 (m, 6H), 1.56 – 1.47 (m, 4H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 144.8, 136.8, 129.2, 128.8, 127.8, 125.9, 118.2, 114.2, 70.7, 53.2, 51.8, 33.0, 32.5, 28.0, 27.9, 24.22, 24.19.
HRMS (ESI) m/z calcd. for $C_{22}H_{27}N_2O$ $[M+H]^+$ 335.2118, found 335.2115.

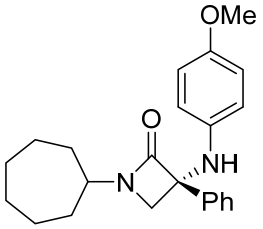
(*R*)-3-((4-(*Tert*-butyl)phenyl)amino)-1-cycloheptyl-3-phenylazetidin-2-one (29)



29

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 4-(*tert*-butyl)aniline **A10** (29.9 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 4/1) to yield the product **29** as a red solid (53.0 mg, 68% yield, <5% ee).
[α]$_D^{27}$ = 8.0 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IG (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 12.62 min, t_R (major) = 14.45 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.47 (m, 2H), 7.36 – 7.32 (m, 2H), 7.29 – 7.26 (m, 1H), 7.13 – 7.11 (m, 2H), 6.43 – 6.40 (m, 2H), 4.76 (s, 1H), 3.90 – 3.83 (m, 2H), 3.68 (d, *J* = 5.5 Hz, 1H), 2.04 – 1.92 (m, 2H), 1.72 – 1.59 (m, 6H), 1.56 – 1.47 (m, 4H), 1.24 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 142.3, 140.9, 137.1, 128.8, 127.7, 126.0, 125.9, 113.9, 70.9, 53.0, 51.6, 33.8, 32.9, 32.5, 31.4, 28.0, 27.9, 24.20, 24.18.
HRMS (ESI) m/z calcd. for $C_{26}H_{35}N_2O$ $[M+H]^+$ 391.2744, found 391.2742.

(*R*)-1-Cycloheptyl-3-((4-methoxyphenyl)amino)-3-phenylazetidin-2-one (30)

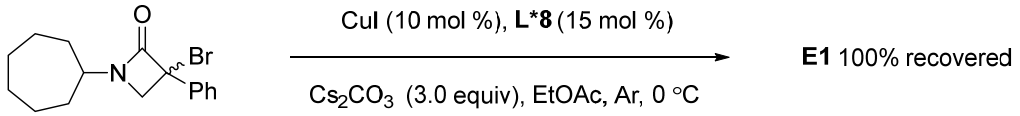


30

According to **General Procedure A** with 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv) and 4-methoxyaniline **A11** (24.6 mg, 0.20 mmol, 1.0 equiv) for 72 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 4/1) to yield the product **30** as a yellow solid (41.1 mg, 56% yield, <5% ee).
$[\alpha]_D^{27}$ = 6.0 (*c* 0.5, $CHCl_3$).
HPLC analysis: Chiralcel IB (*n*-hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.26 min, t_R (minor) = 10.52 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.47 (m, 2H), 7.36 – 7.32 (m, 2H), 7.29 – 7.27 (m, 1H), 6.72 – 6.68 (m, 2H), 6.51 – 6.48 (m, 2H), 4.53 (s, 1H), 3.89 – 3.84 (m, 1H), 3.82 (d, *J* = 5.5 Hz, 1H), 3.70 (s, 3H), 3.63 (d, *J* = 5.5 Hz, 1H), 2.01 – 1.90 (m, 2H), 1.70 – 1.58 (m, 6H), 1.53 – 1.46 (m, 4H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 152.8, 138.6, 137.3, 128.8, 127.8, 126.0, 116.3, 114.7, 71.6, 55.6, 53.0, 51.4, 32.9, 32.4, 27.9, 24.20, 24.17.
HRMS (ESI) m/z calcd. for $C_{23}H_{29}N_2O_2$ $[M+H]^+$ 365.2224, found 365.2226.

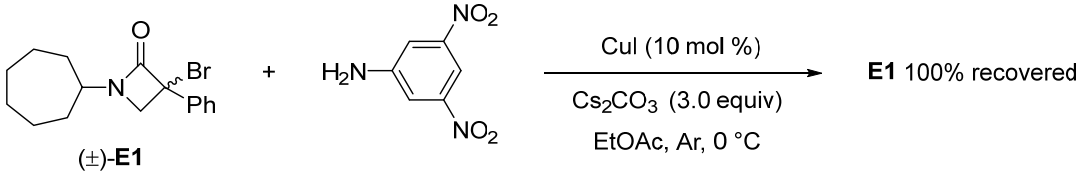
6. Mechanistic studies

Effect of nucleophile and ligand on reaction initiation



(±)-**E1**

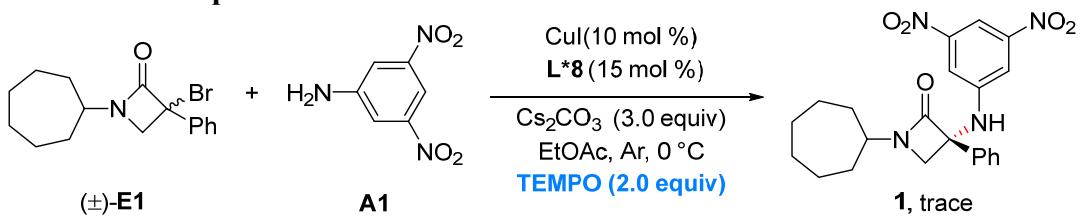
Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (0.9 mg, 0.005 mmol, 10 mol %), **L*8** (3.6 mg, 0.075 mmol, 15 mol %), Cs_2CO_3 (48.9 mg, 0.15 mmol, 3.0 equiv), and 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (16.0 mg, 0.05 mmol, 1.0 equiv). Anhydrous EtOAc (1.0 mL) was added into the mixture and the reaction mixture was stirred at 0 °C for 72 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by EtOAc. The filtrate was concentrated to afford the crude product and determined by ^{1}H NMR spectra (recovery of **E1** was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard, remaining **E1** 100%). Although we failed to synthesize the chiral ligand-chelated Cu(I)-amido complex, a control experiment without **A1** showed that no conversion of **E1** was observed. Thus, it is the ligand exchange of Cu(I) with the aromatic amine that possibly occurs first rather than the single electron-transfer between Cu(I) and **E1**.



(±)-**E1**

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (0.9 mg, 0.005 mmol, 10 mol %) Cs_2CO_3 (48.9 mg, 0.15 mmol, 3.0 equiv), 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (16.0 mg, 0.05 mmol, 1.0 equiv), and 3,5-dinitroaniline **A1** (9.2 mg, 0.05 mmol, 1.0 equiv). Anhydrous EtOAc (1.0 mL) was added into the mixture and the reaction mixture was stirred at 0 °C for 72 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by EtOAc. The filtrate was concentrated to afford the crude product and determined by ^{1}H NMR spectra (recovery of **E1** was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard, remaining **E1** 100%). Control experiments confirmed that no reaction takes place in the absence of the chiral ligand.

Radical inhibition experiment

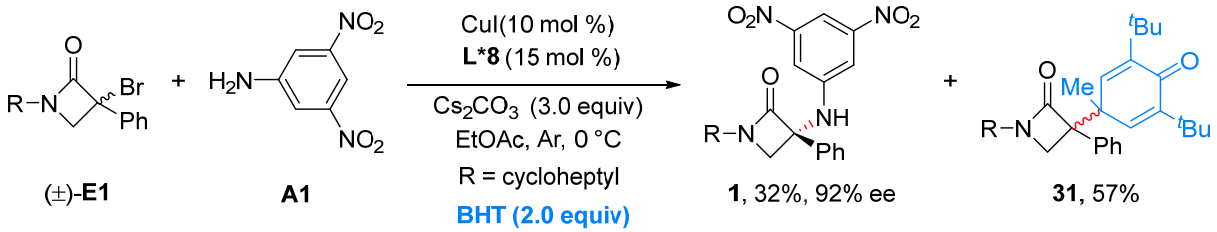


(±)-**E1** **A1** **1**, trace

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (3.8 mg, 0.02 mmol, 10 mol %), **L*8** (14.4 mg, 0.03 mmol, 15 mol %), Cs_2CO_3 (195.5 mg, 0.60 mmol, 3.0 equiv), 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1**

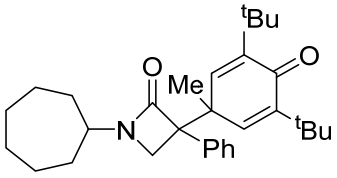
(64.2 mg, 0.20 mmol, 1.0 equiv), 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv), and 2,2,6,6-tetramethylpiperidinyloxy (TEMPO) (62.5 mg, 0.40 mmol, 2.0 equiv). Anhydrous EtOAc (4.0 mL) was added into the mixture and the reaction mixture was stirred at 0 °C for 72 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by EtOAc. The filtrate was concentrated to afford the crude product and determined by ^{1}H NMR spectra (yield of **1** was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard).

Radical trap experiment



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (3.8 mg, 0.02 mmol, 10 mol %), **L*8** (14.4 mg, 0.03 mmol, 15 mol %), Cs_2CO_3 (195.5 mg, 0.60 mmol, 3.0 equiv), 3-bromo-1-cycloheptyl-3-phenylazetidin-2-one **E1** (64.2 mg, 0.20 mmol, 1.0 equiv), 3,5-dinitroaniline **A1** (36.6 mg, 0.20 mmol, 1.0 equiv), and butylated hydroxytoluene (BHT) (88.1 mg, 0.40 mmol, 2.0 equiv). Anhydrous EtOAc (4.0 mL) was added into the mixture and the reaction mixture was stirred at 0 °C for 72 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by EtOAc. The filtrate was evaporated and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1 to 4/1) to yield the product **1** as a yellow solid (26.9 mg, 32% yield, 92% ee) and **31** as a colorless oil (52.6 mg, 57% yield).

1-Cycloheptyl-3-(3,5-di-*tert*-butyl-1-methyl-4-oxocyclohexa-2,5-dien-1-yl)-3-phenylazetidin-2-one (31)



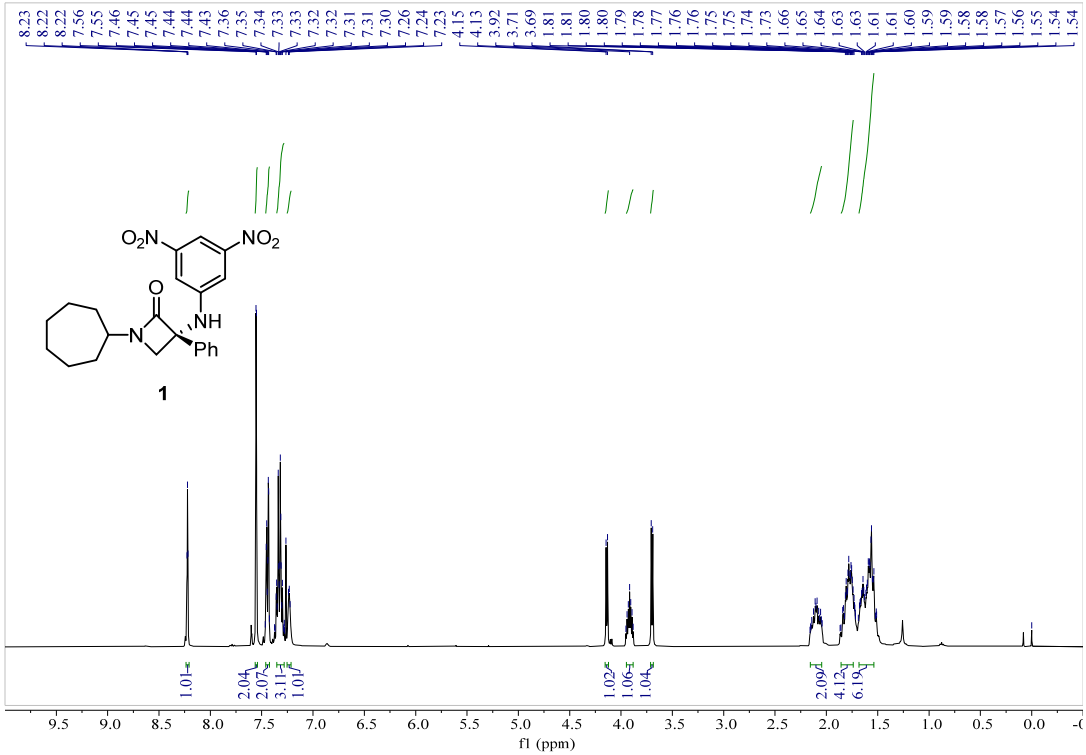
31

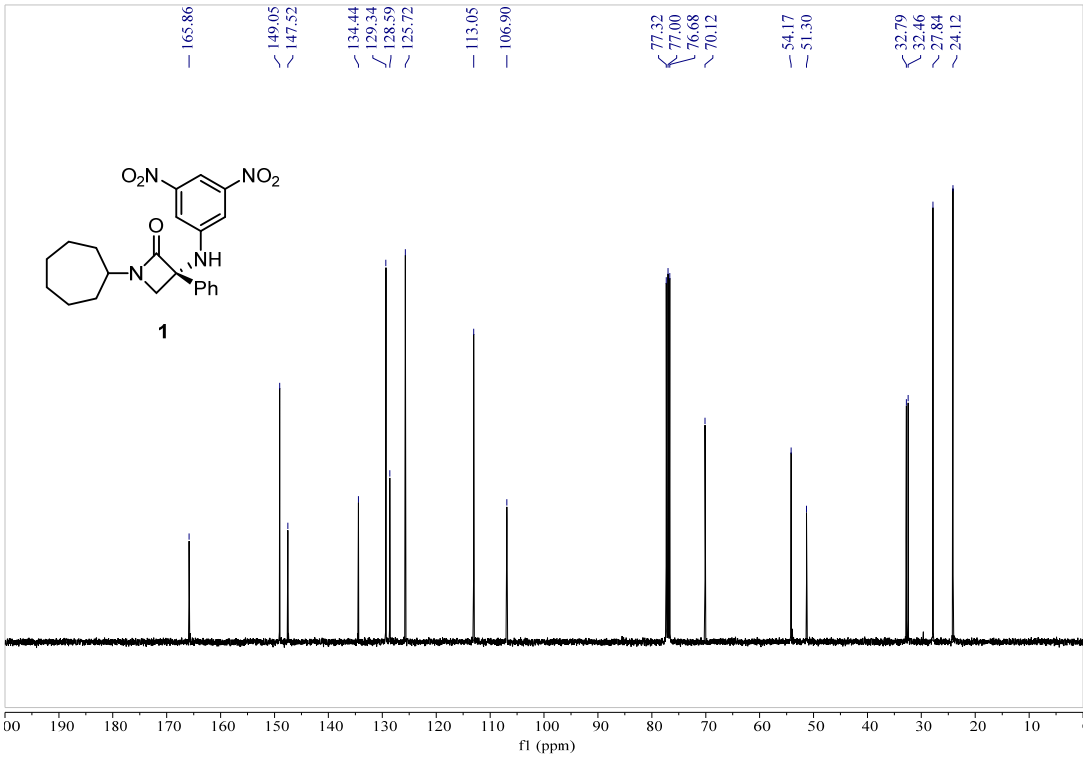
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.35 (m, 2H), 7.30 – 7.25 (m, 3H), 6.63 (d, *J* = 3.0 Hz, 1H), 6.56 (d, *J* = 3.0 Hz, 1H), 3.76 – 3.69 (m, 1H), 3.33 – 3.29 (m, 2H), 1.96 – 1.90 (m, 1H), 1.81 – 1.74 (m, 1H), 1.67 – 1.54 (m, 5H), 1.51 – 1.38 (m, 5H), 1.30 (s, 3H), 1.23 (s, 9H), 1.15 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 185.8, 167.4, 148.3, 146.6, 143.3, 142.3, 136.4, 129.2, 127.5, 127.4, 65.3, 53.0, 46.8, 42.6, 34.9, 34.8, 33.0, 32.5, 29.32, 29.26, 27.94, 27.86, 24.19, 24.16, 21.5.
HRMS (ESI) m/z calcd. for $C_{31}H_{44}NO_2$ $[M + H]^+$ 462.3367, found 462.3362.

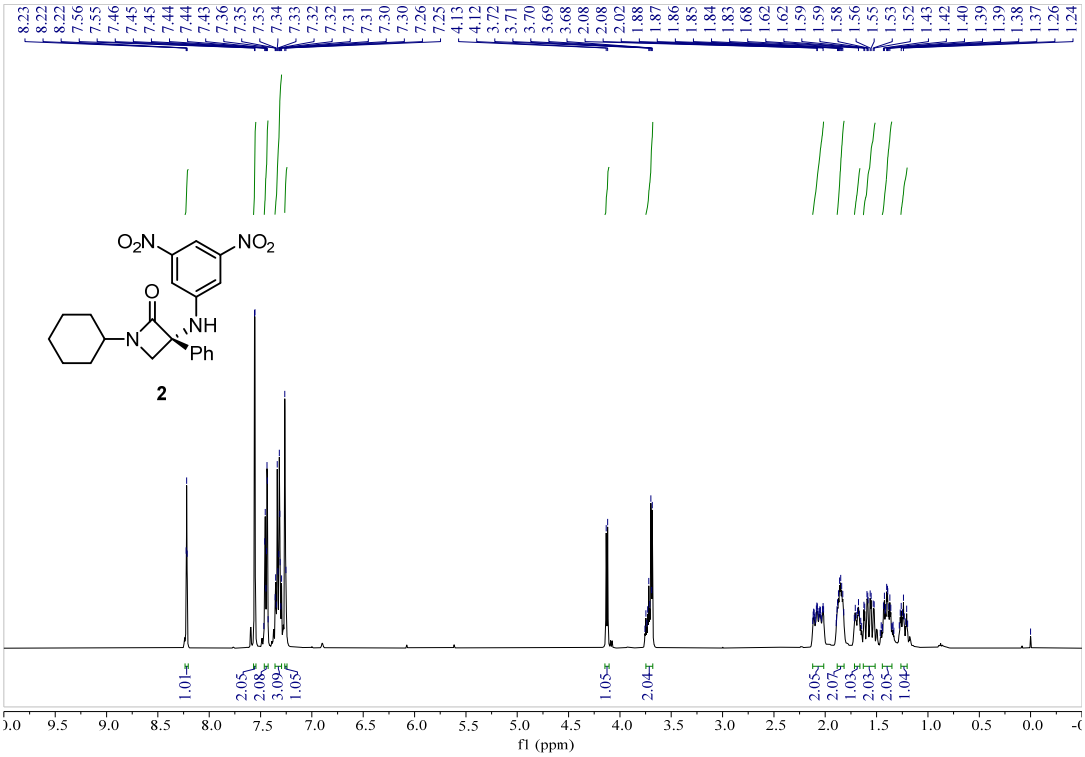
7. References

1. Chen, J-J.; Zhang, J.-Y.; Fang, J.-H.; Du, X.-Y.; Xia, H.-D.; Cheng, B.; Li, N.; Yu, Z.-L.; Bian, J.-Q.; Wang, F.-L.; Zheng, J.-J.; Liu, W.-L.; Gu, Q.-S.; Li, Z.-L.; Liu, X.-Y. Copper-Catalyzed Enantioconvergent Radical C(sp^3)–N Cross-Coupling of Activated Racemic Alkyl Halides with (Hetero)aromatic Amines under Ambient Conditions. *J. Am. Chem. Soc*. **2023**, *145*, 14686−14696.
2. Wang, F.-L.; Yang, C.-J.; Liu, J.-R.; Yang, N.-Y.; Dong, X.-Y.; Jiang, R.-Q.; Chang, X.-Y.; Li, Z.-L.; Xu. G.-X.; Yuan, D.-L.; Zhang, Y.-S.; Gu, Q.-S.; Hong, X.; Liu, X.-Y. Mechanism-Based Ligand Design for Copper-Catalysed Enantioconvergent C(sp^3)–C(sp) Cross-Coupling of Tertiary Electrophiles with Alkynes. *Nat. Chem*. **2022**. *14*, 949–957.
3. Yusof, Y.; Tan, D. T. C.; Arjomandi, O. K.; Schenk, G.; McGeary, R. P. Captopril Analogues as Metallo-β-Lactamase Inhibitors. *Bioorg. Med. Chem. Lett.* **2016**, *26*, 1589–1593.

8. NMR spectra



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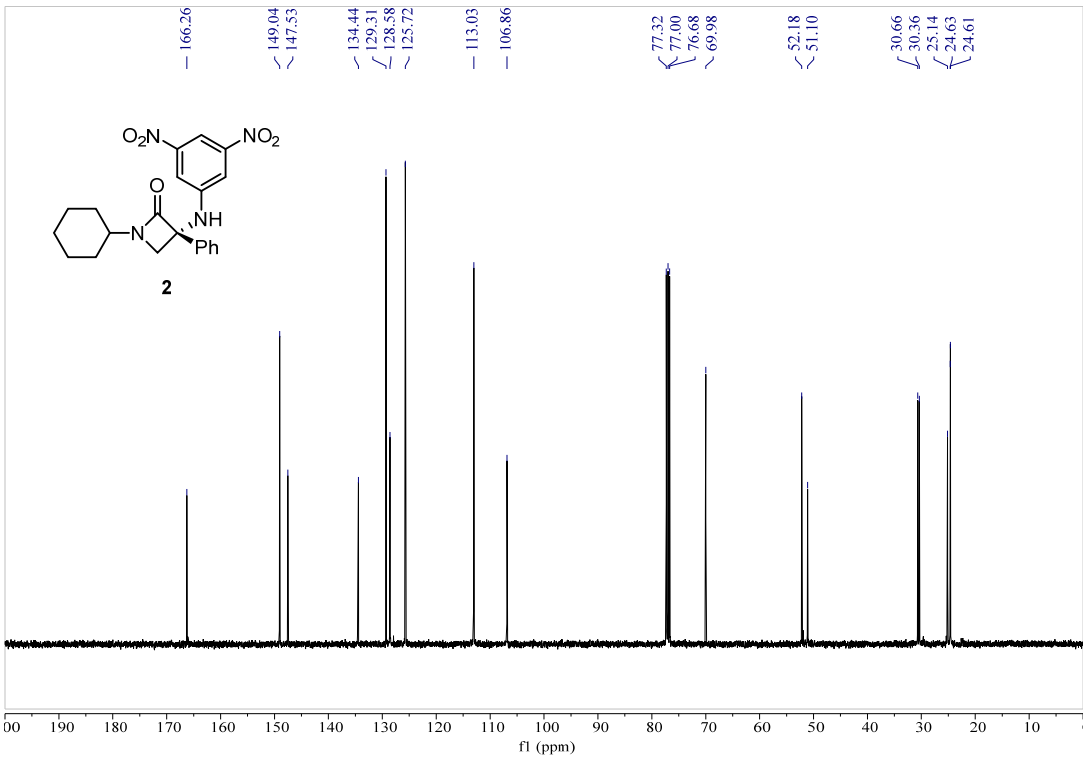
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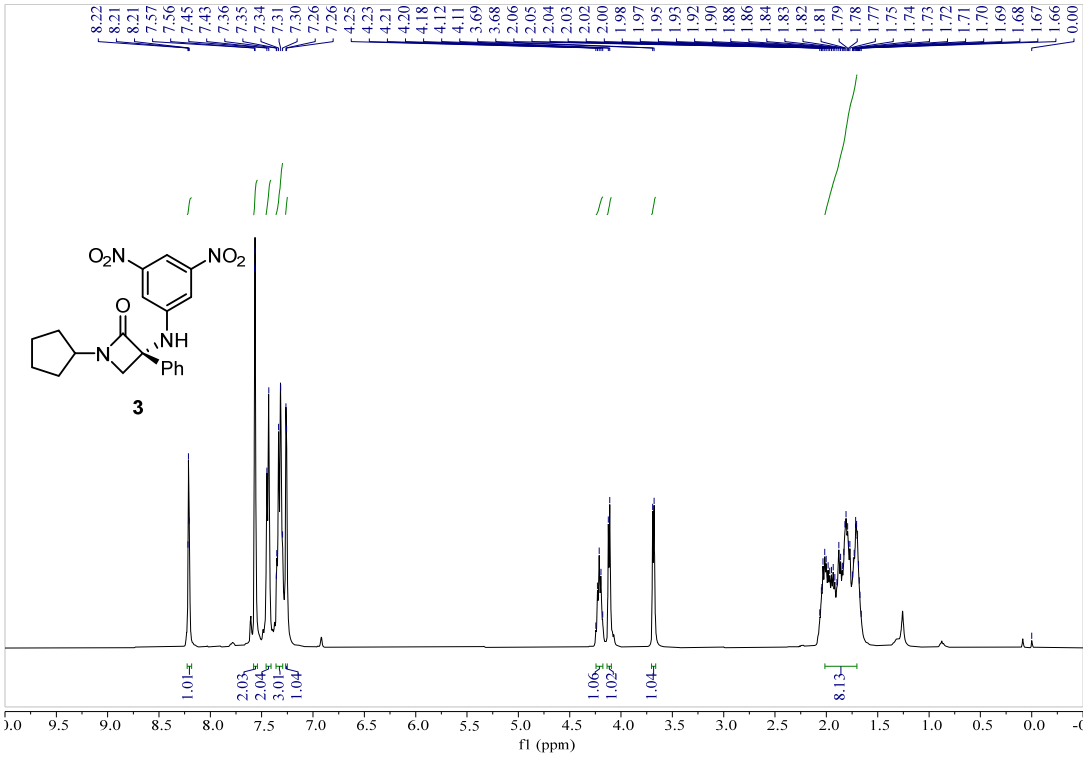
f1 (ppm)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7.34
7.31
7.30
7.26
7.26
4.25
4.23
4.21
4.20
4.18
4.12
4.11
3.69
3.68
2.06
2.05
2.04
2.03
2.02
2.00
1.98
1.97
1.95
1.93
1.92
1.90
1.88
1.86
1.84
1.83
1.82
1.81
1.79
1.78
1.77
1.75
1.74
1.73
1.72
1.71
1.70
1.69
1.68
1.67
1.66
0.00
O2N
NO2
O
N
NH
Ph
3
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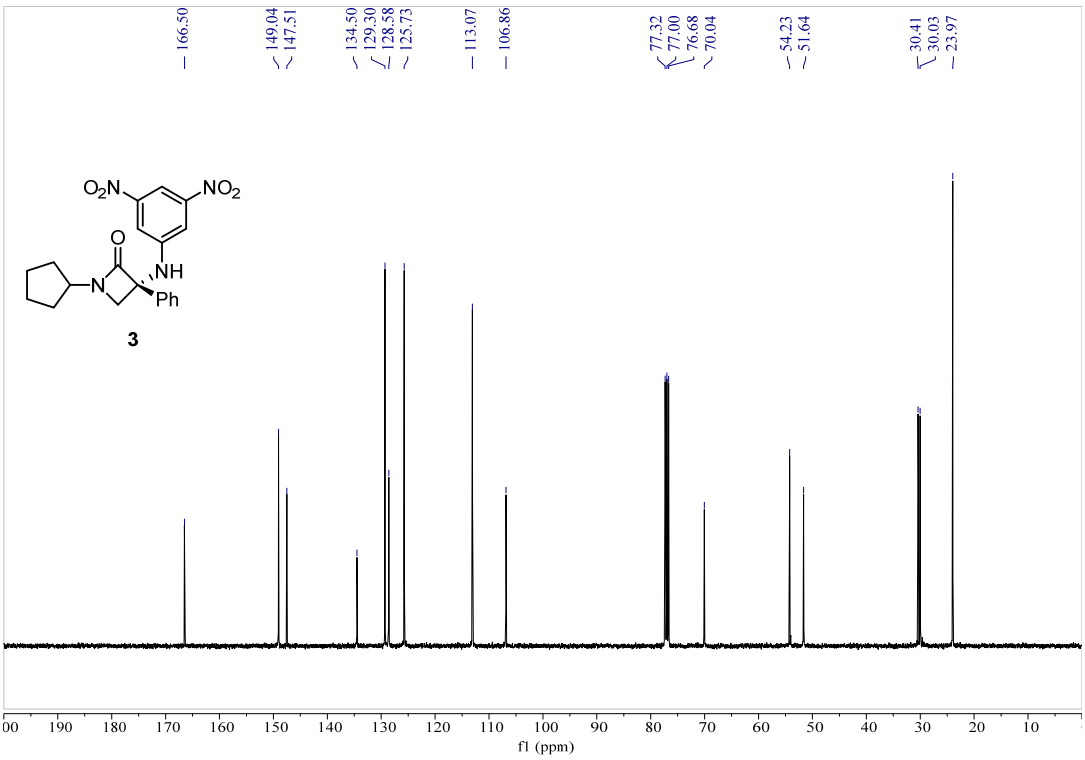
2.03
2.04
3.01
1.04
1.06
1.02
1.04
8.13
f1 (ppm)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128.58
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113.07
106.86
77.32
77.00
76.68
70.04
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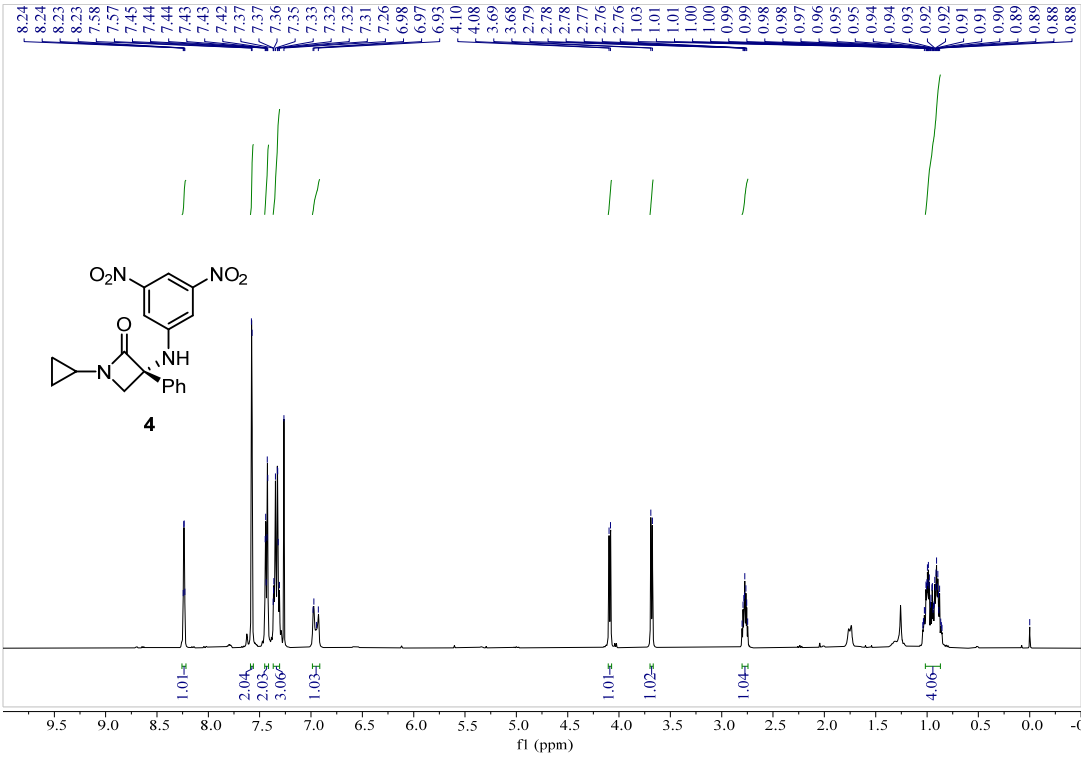
30.41
30.03
23.97
O2N
NO2
O
N
NH
Ph
3
f1 (ppm)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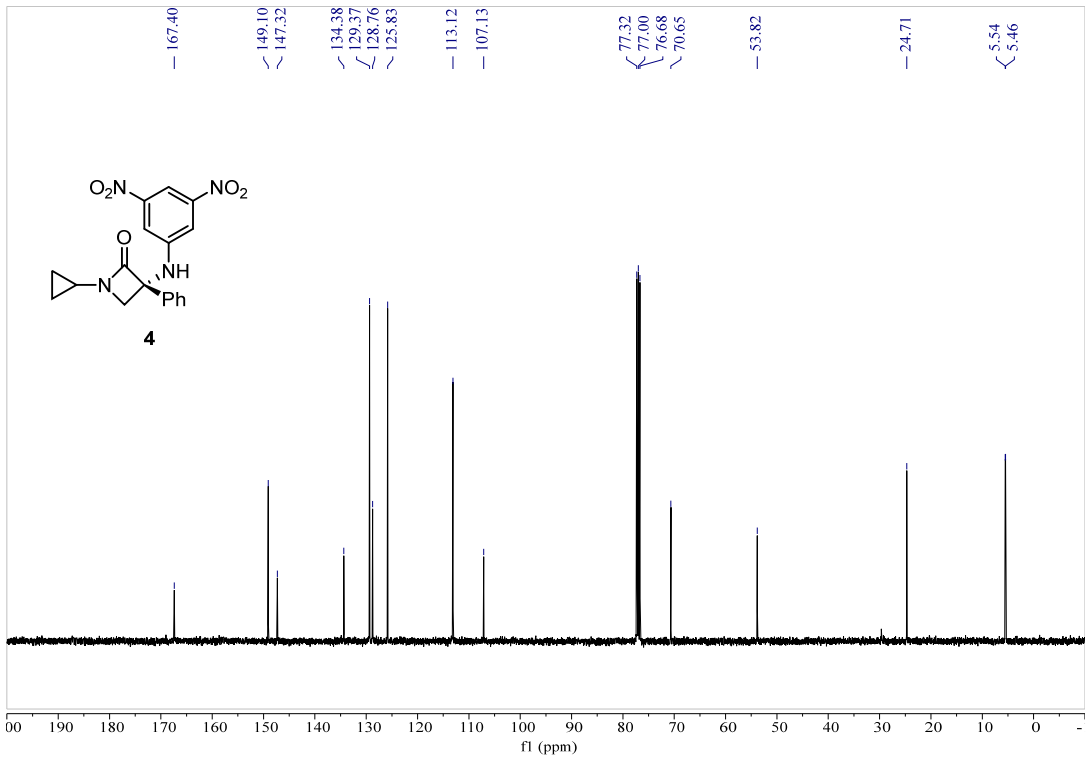
O2N
NO2
O
NH
N
Ph
4
1.01 2.04 2.03 3.06 1.03 1.01 1.02 1.04 4.06
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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128.76
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113.12
107.13
77.32
77.00
76.68
70.65
53.82
24.71
5.54
5.46
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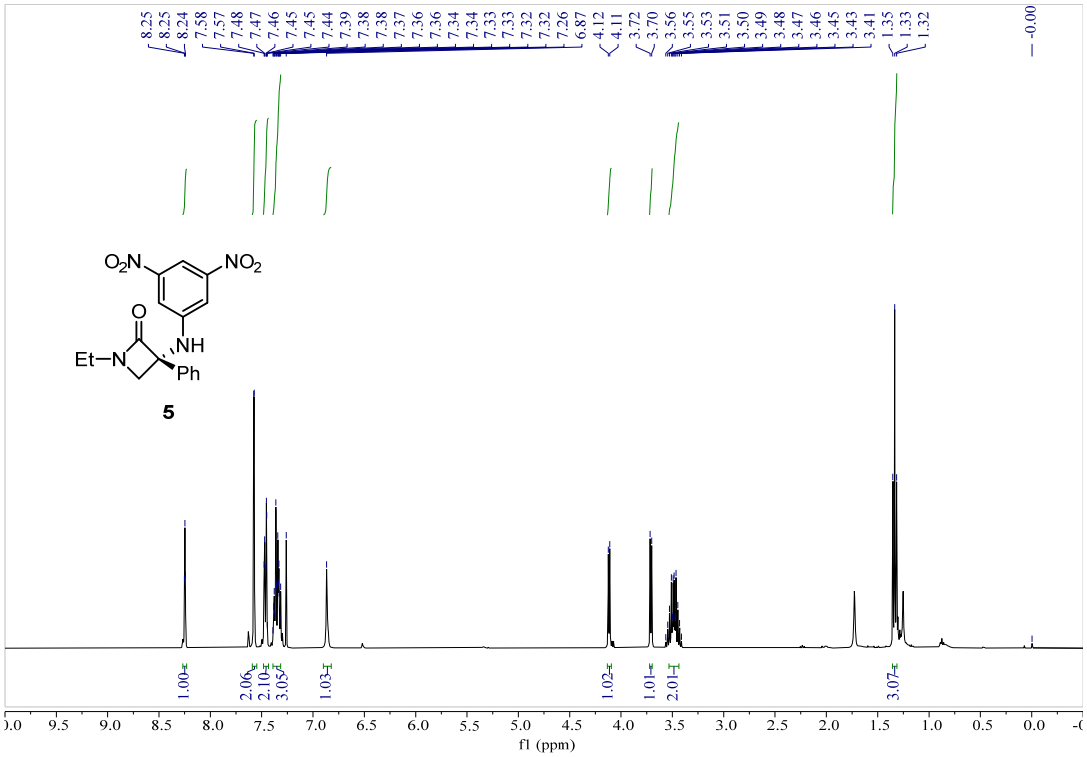
NO2
O
NH
N
Ph
4
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.46
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7.45
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7.38
7.38
7.37
7.36
7.36
7.34
7.34
7.33
7.33
7.32
7.32
7.26
6.87
4.12
4.11
3.72
3.70
3.56
3.55
3.53
3.51
3.50
3.49
3.48
3.47
3.46
3.45
3.43
3.41
1.35
1.33
1.32
-0.00
O2N
NO2
O
NH
Et—N
Ph
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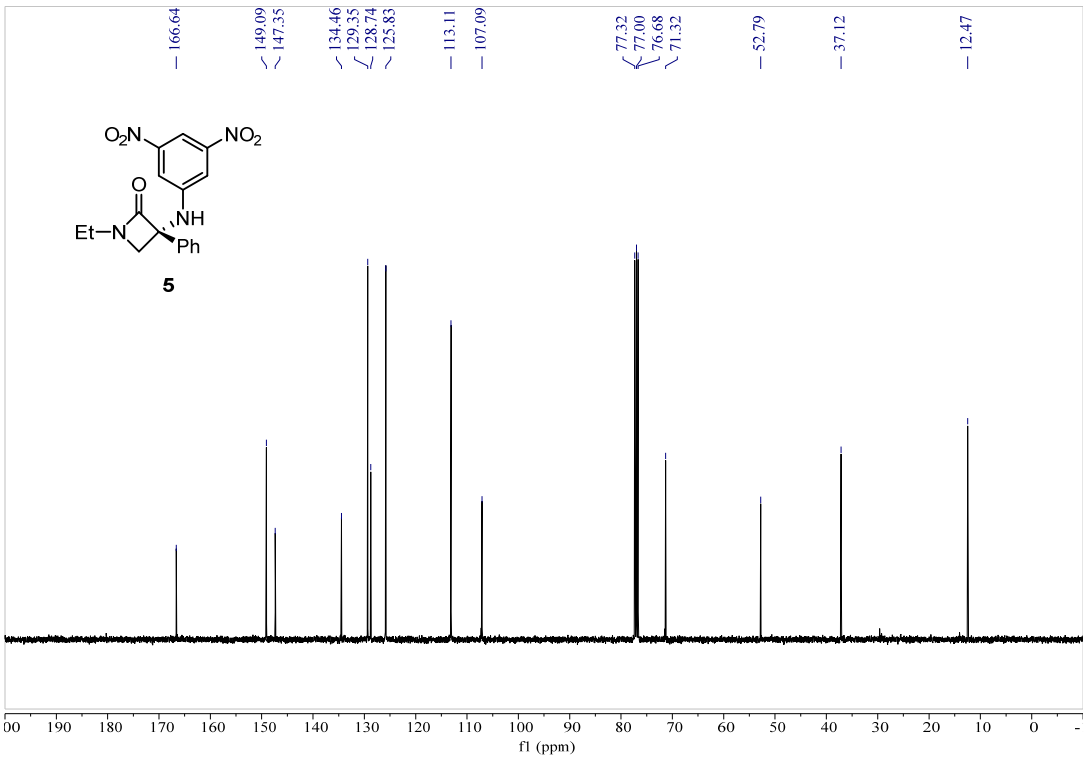
2.06
2.10
3.05
1.03
1.02
1.01
2.01
3.07
fl (ppm)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113.11
107.09
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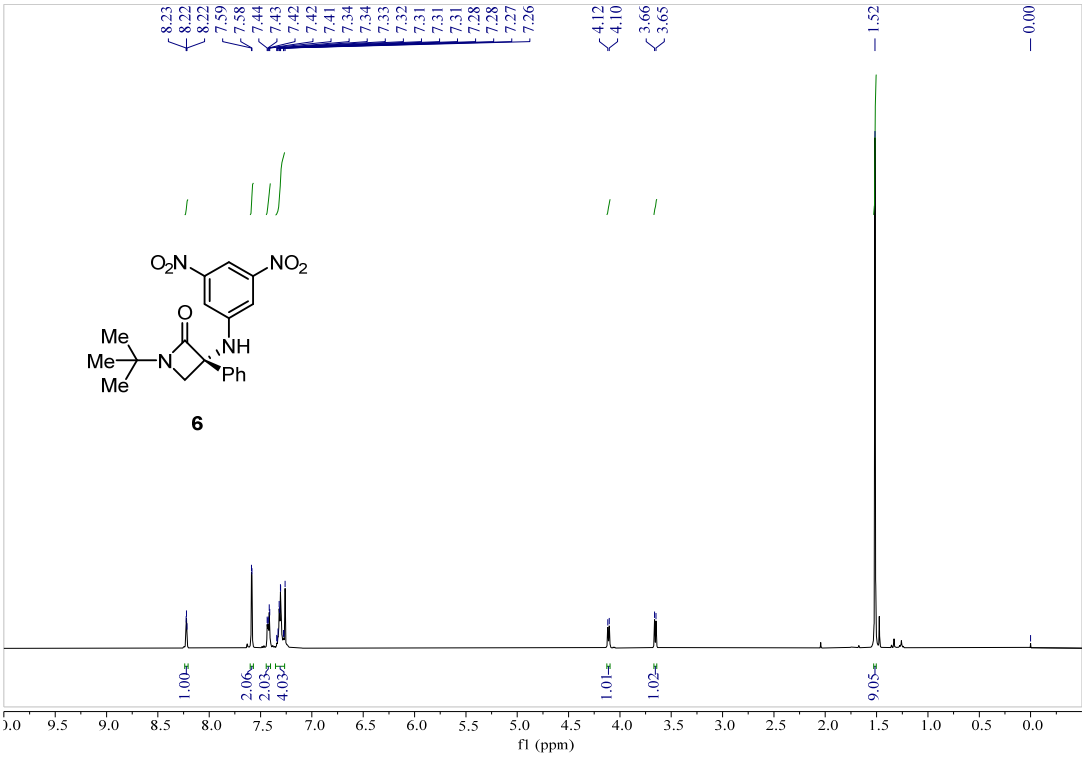
52.79
37.12
12.47
O2N
NO2
O
NH
Et—N
Ph
5
fl (ppm)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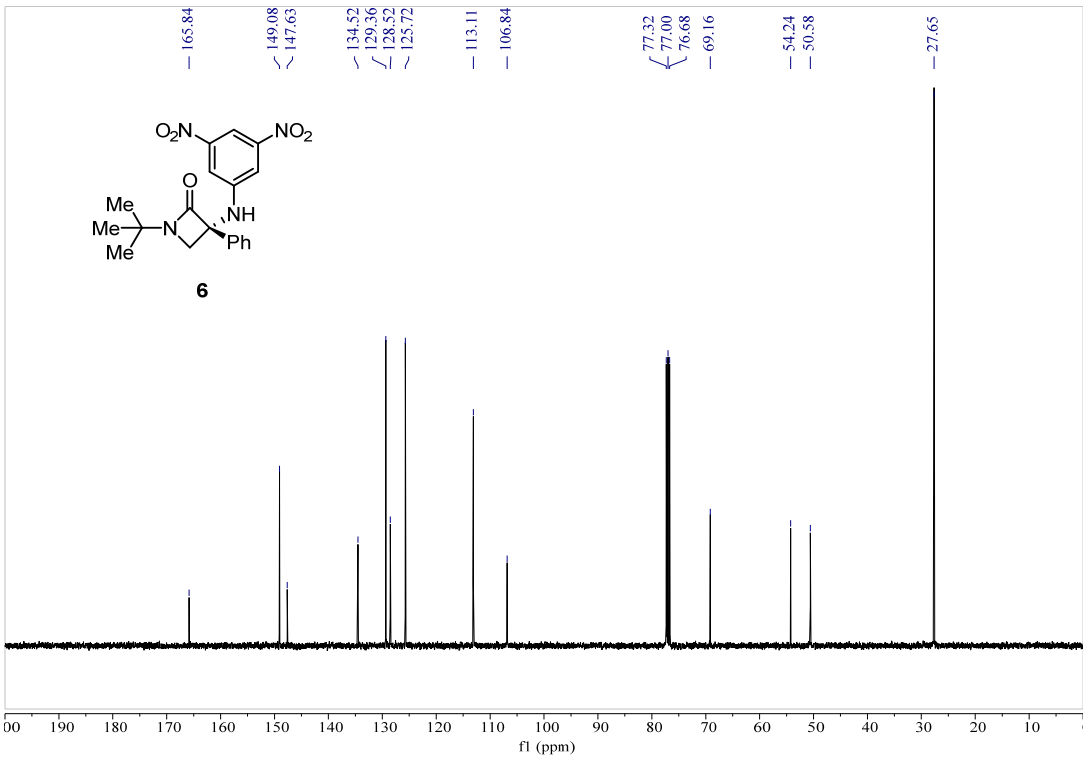
7.43
7.42
7.42
7.41
7.34
7.34
7.33
7.32
7.31
7.31
7.31
7.28
7.28
7.27
7.26
4.12
4.10
3.66
3.65
1.52
0.00
O2N
NO2
O
Me
Me
Me
N
NH
Ph
6
1.00
2.06
2.03
4.03
1.01
1.02
9.05
f1 (ppm)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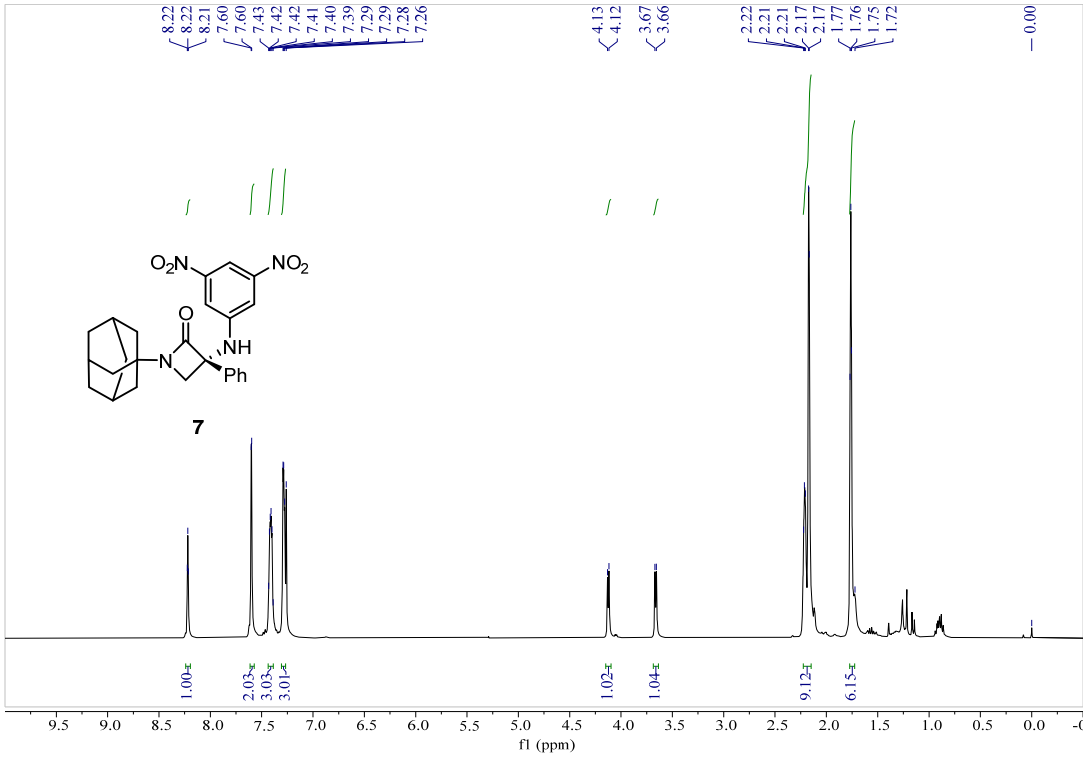
128.52
125.72
113.11
106.84
77.32
77.00
76.68
69.16
54.24
50.58
27.65
O2N
NO2
O
Me
Me
Me
N
NH
Ph
6
f1 (ppm)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7.40
7.39
7.29
7.29
7.28
7.26
4.13
4.12
3.67
3.66
2.22
2.21
2.21
2.17
2.17
1.77
1.76
1.75
1.72
0.00
O2N
NO2
O
N
NH
Ph
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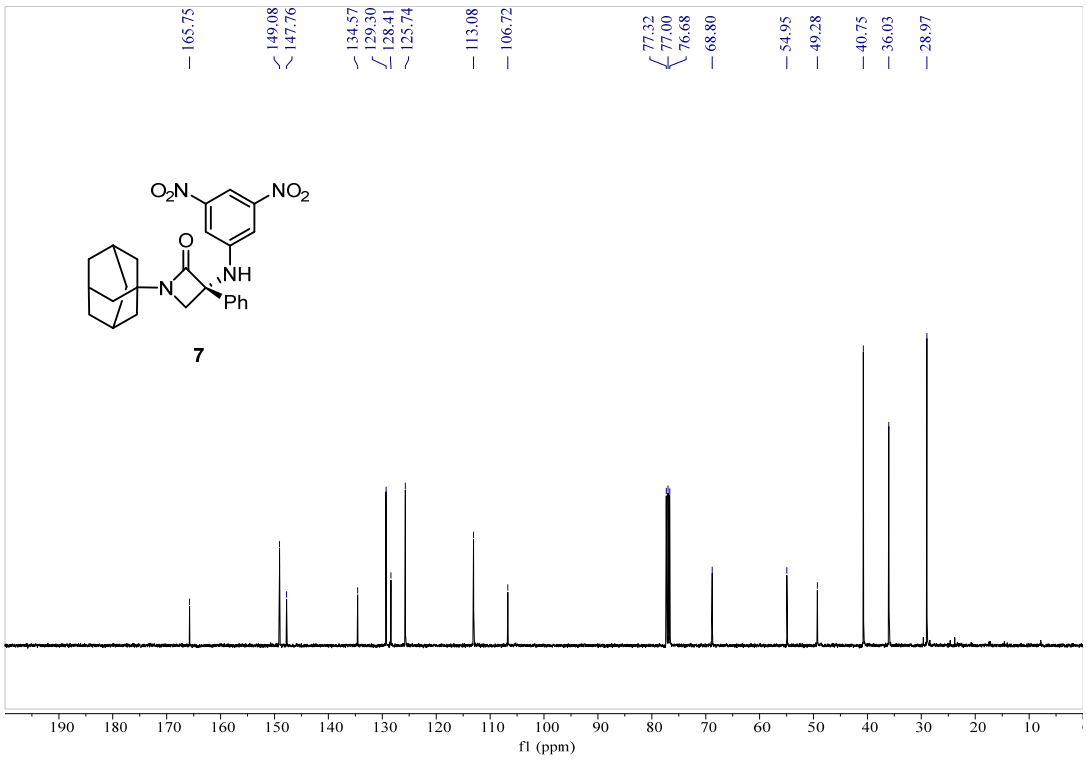
1.00
2.03
3.03
3.01
1.02
1.04
9.12
6.15
fl (ppm)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125.74
113.08
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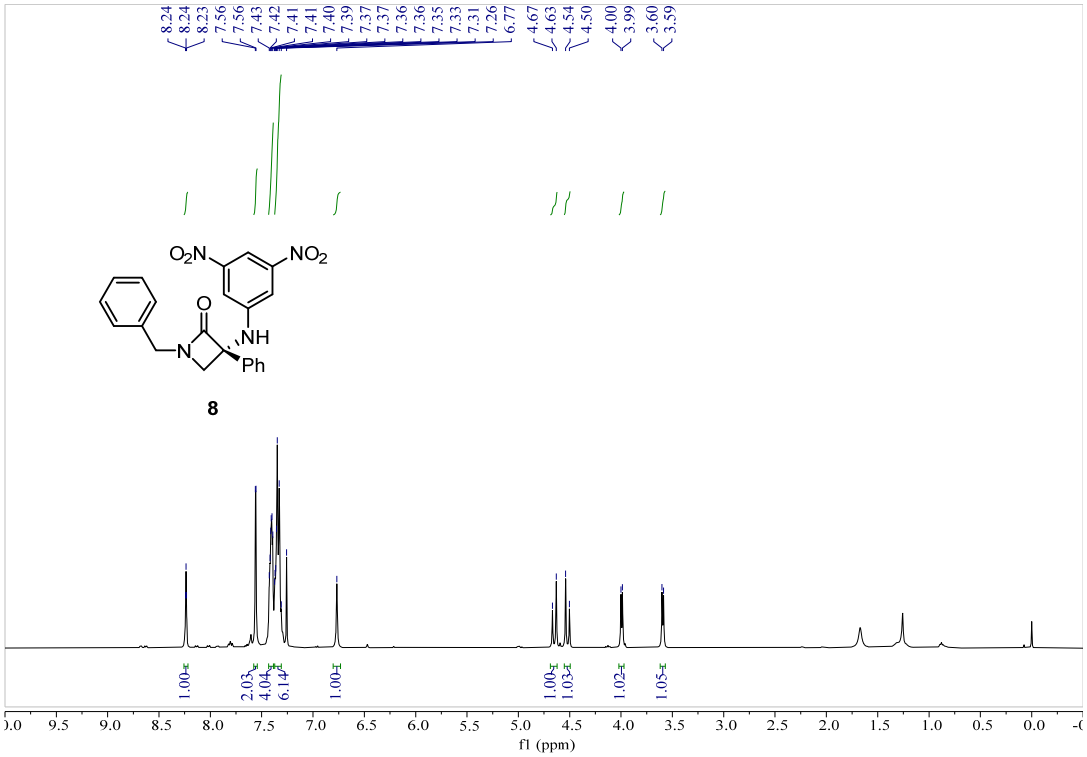
77.32
77.00
76.68
68.80
54.95
49.28
40.75
36.03
28.97
O2N
NO2
O
N
NH
Ph
7
fl (ppm)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7.41
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7.39
7.37
7.37
7.36
7.36
7.35
7.33
7.31
7.26
6.77
4.67
4.63
4.54
4.50
4.00
3.99
3.60
3.59
O2N
NO2
O
NH
N
Ph
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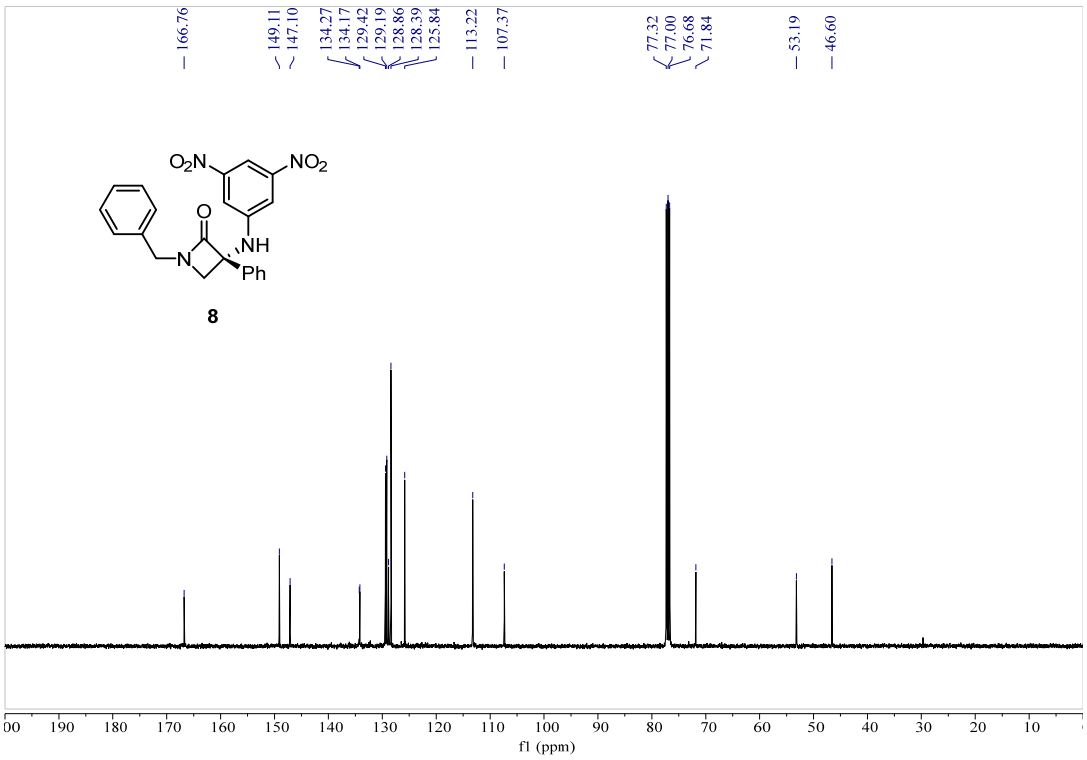
1.00
2.03
4.04
6.14
1.00
1.00
1.03
1.02
1.05
f1 (ppm)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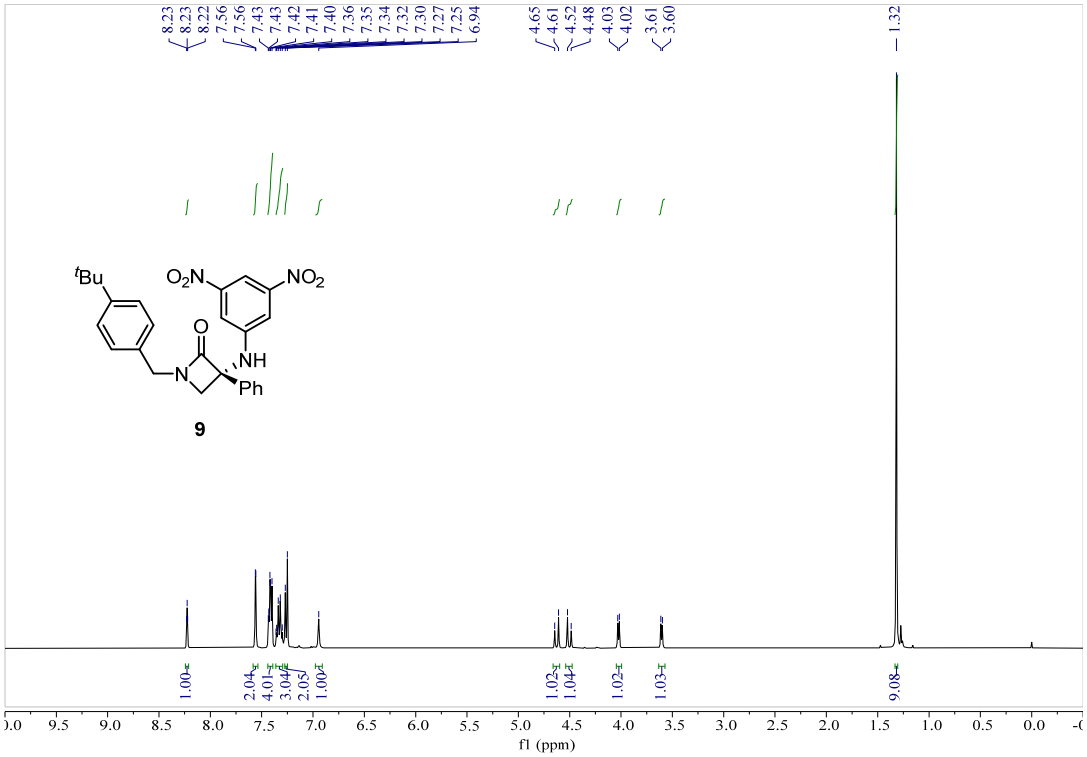
128.86
128.39
125.84
113.22
107.37
77.32
77.00
76.68
71.84
53.19
46.60
O2N
NO2
O
NH
N
Ph
8
f1 (ppm)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7.40
7.36
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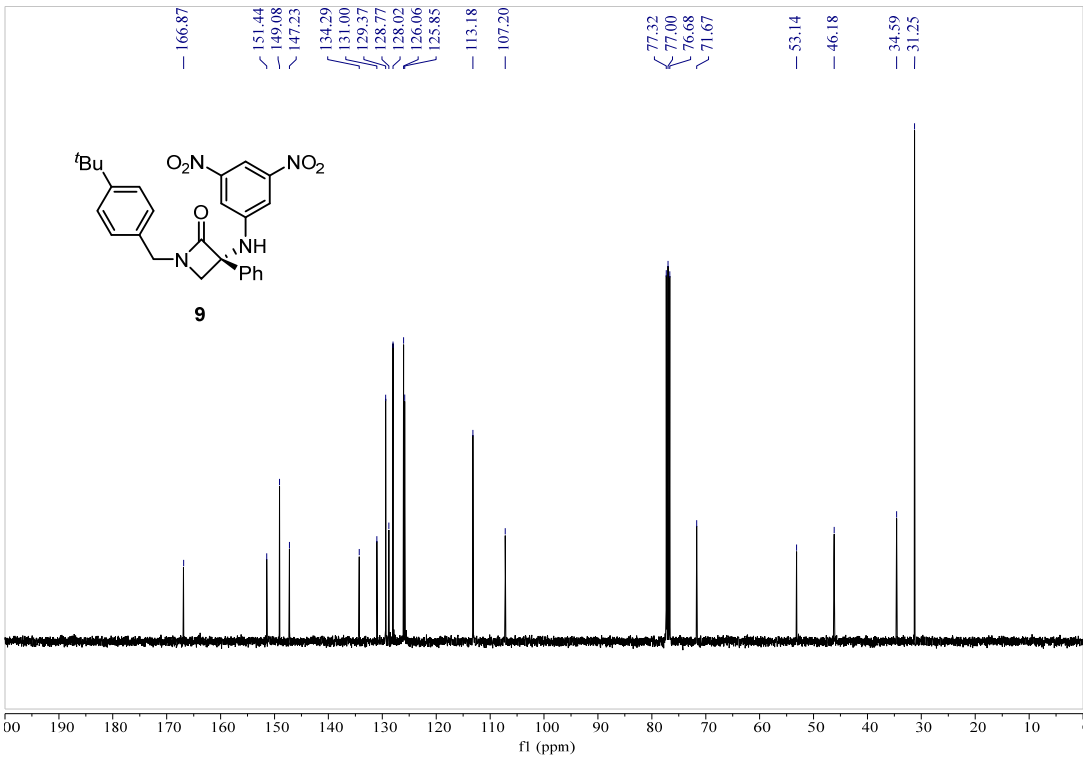
7.34
7.32
7.30
7.27
7.25
6.94
4.65
4.61
4.52
4.48
4.03
4.02
3.61
3.60
1.32
tBu
O2N
NO2
O
N
NH
Ph
9
1.00
2.04
4.01
3.04
2.05
1.00
1.02
1.04
1.02
1.03
9.08
f1 (ppm)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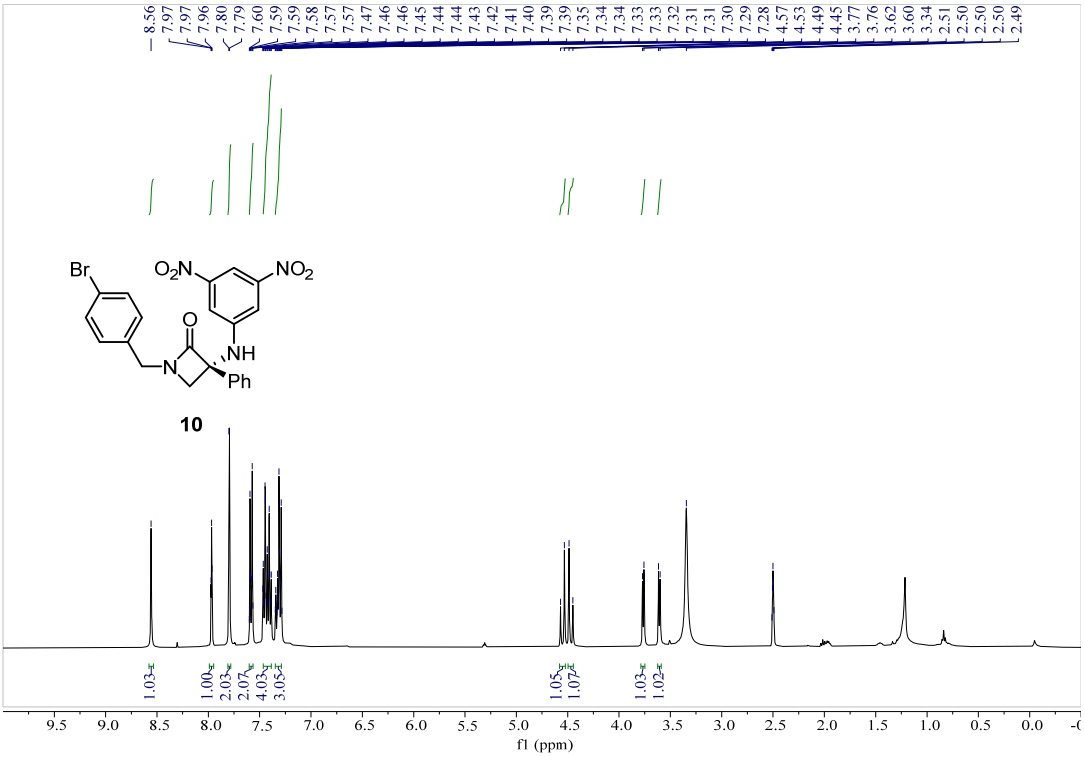
113.18
107.20
77.32
77.00
76.68
71.67
53.14
46.18
34.59
31.25
tBu
O2N
NO2
O
N
NH
Ph
9
f1 (ppm)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7.47
7.46
7.46
7.45
7.44
7.44
7.43
7.42
7.41
7.40
7.39
7.39
7.35
7.34
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7.32
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7.31
7.30
7.29
7.28
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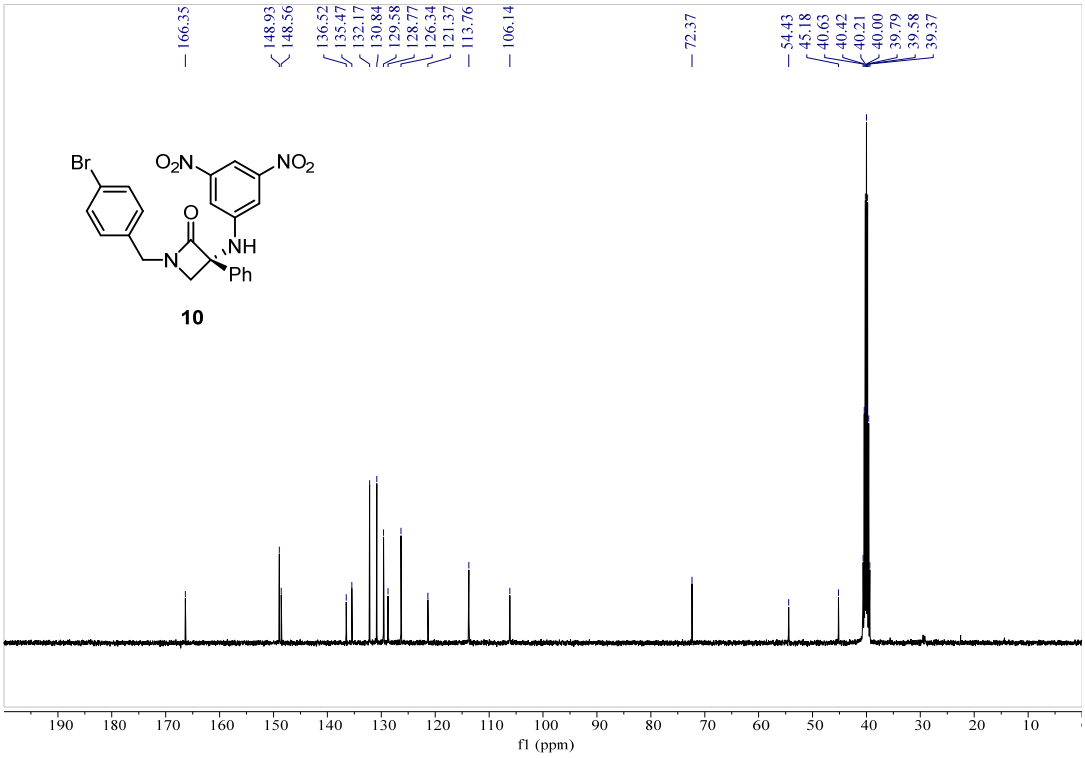
4.49
4.45
3.77
3.76
3.62
3.60
3.34
2.51
2.50
2.50
2.50
2.49
Br
O2N
NO2
O
NH
N
Ph
10
1.03
1.00
2.03
2.07
4.03
3.05
1.05
1.07
1.03
1.02
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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121.37
113.76
106.14
72.37
54.43
45.18
40.63
40.42
40.21
40.00
39.79
39.58
39.37
Br
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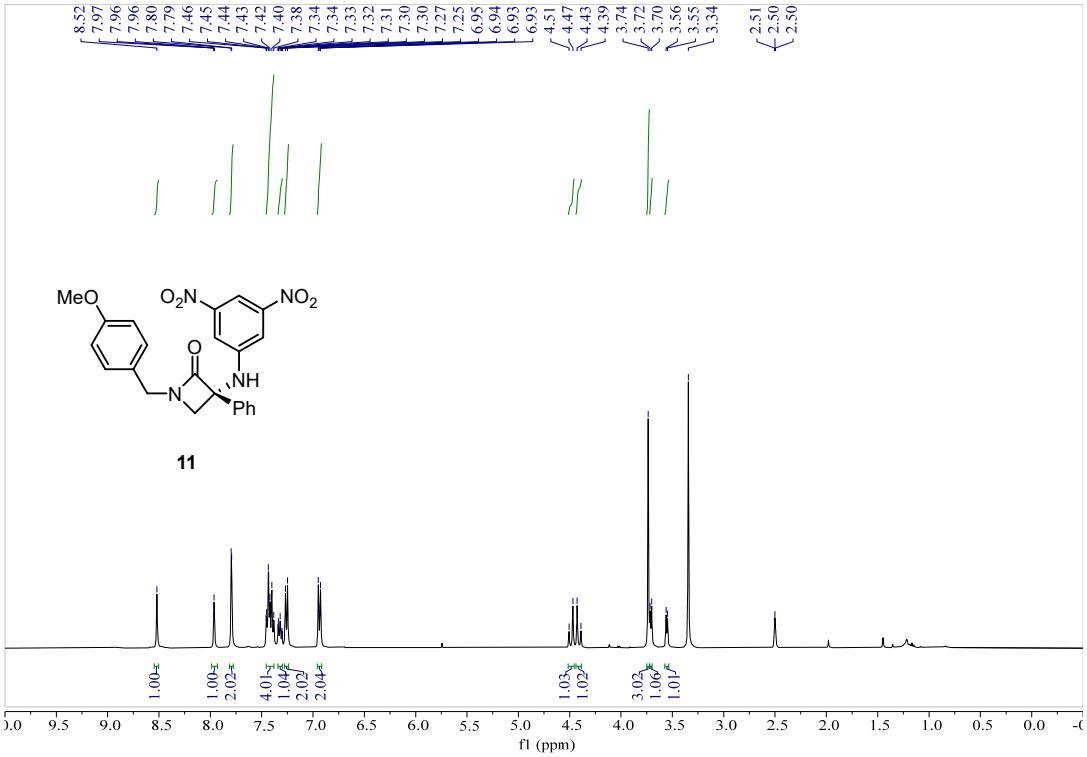
NO2
O
NH
N
Ph
10
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)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7.38
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7.34
7.33
7.32
7.31
7.30
7.30
7.27
7.25
6.95
6.94
6.93
6.93
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4.47
4.43
4.39
3.74
3.72
3.70
3.56
3.55
3.34
2.51
2.50
2.50
MeO
O2N
NO2
O
NH
N
Ph
11
1.00
1.00
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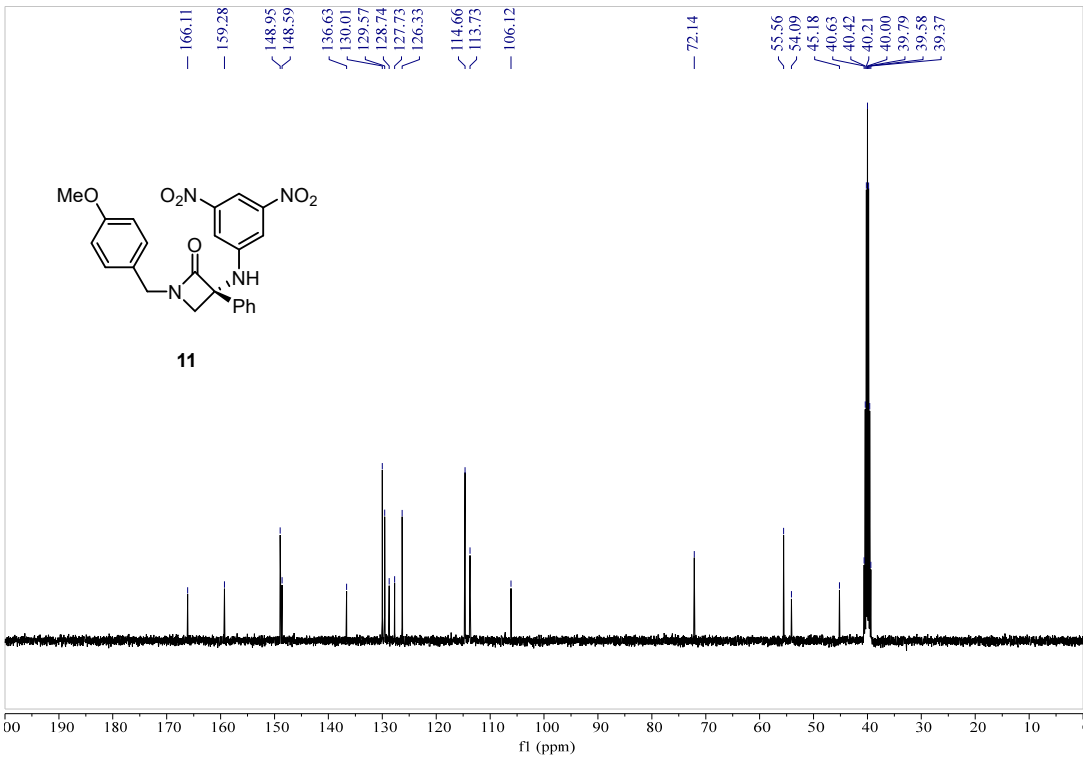
1.04
2.02
2.04
1.03
1.02
3.02
1.06
1.01
f1 (ppm)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130.01
129.57
128.74
127.73
126.33
114.66
113.73
106.12
72.14
55.56
54.09
45.18
40.63
40.42
40.21
40.00
39.79
39.58
39.37
MeO
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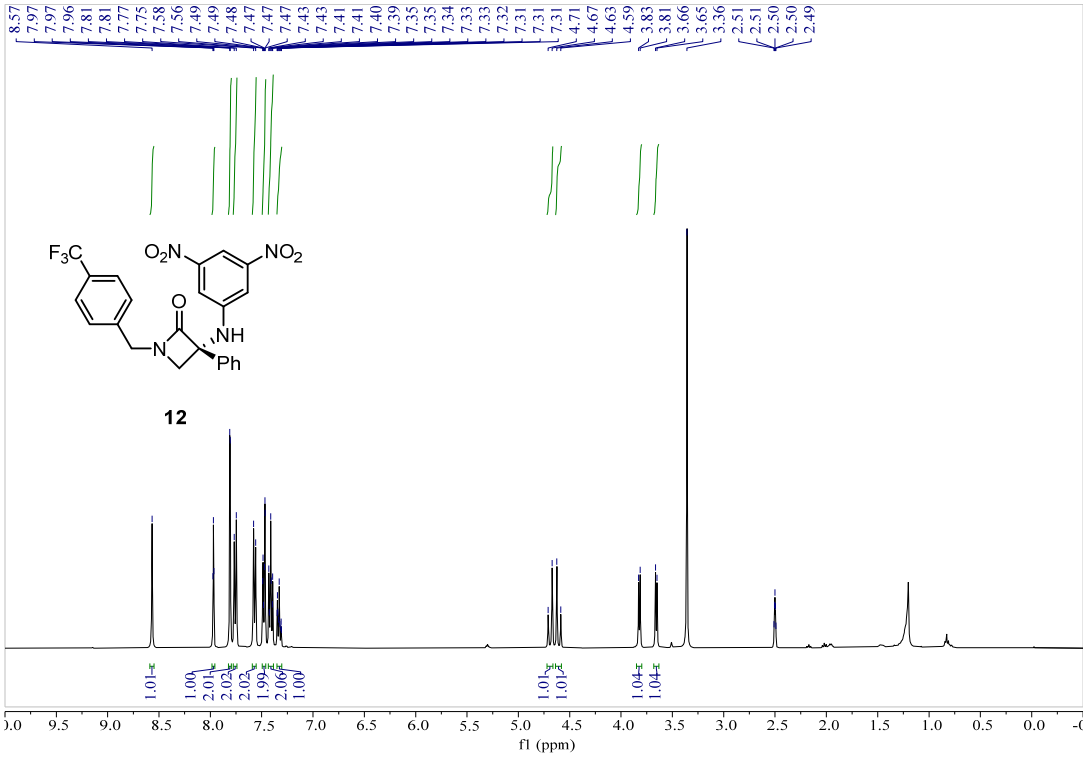
NO2
O
NH
N
Ph
11
f1 (ppm)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4.59
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3.81
3.66
3.65
3.36
2.51
2.51
2.50
2.50
2.49
F3C
O2N
NO2
O
NH
N
Ph
12
1.01
1.00
2.01
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2.02
1.99
2.06
1.00
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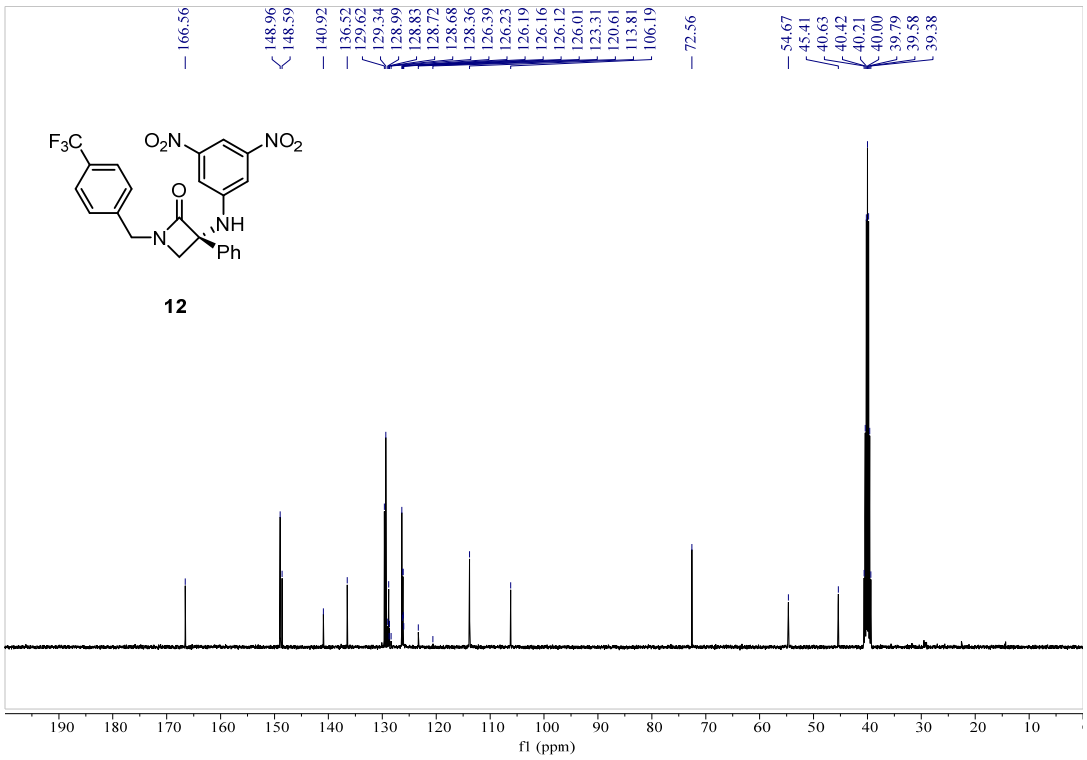
1.01
1.04
1.04
f1 (ppm)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126.39
126.23
126.19
126.16
126.12
126.01
123.31
120.61
113.81
106.19
72.56
54.67
45.41
40.63
40.42
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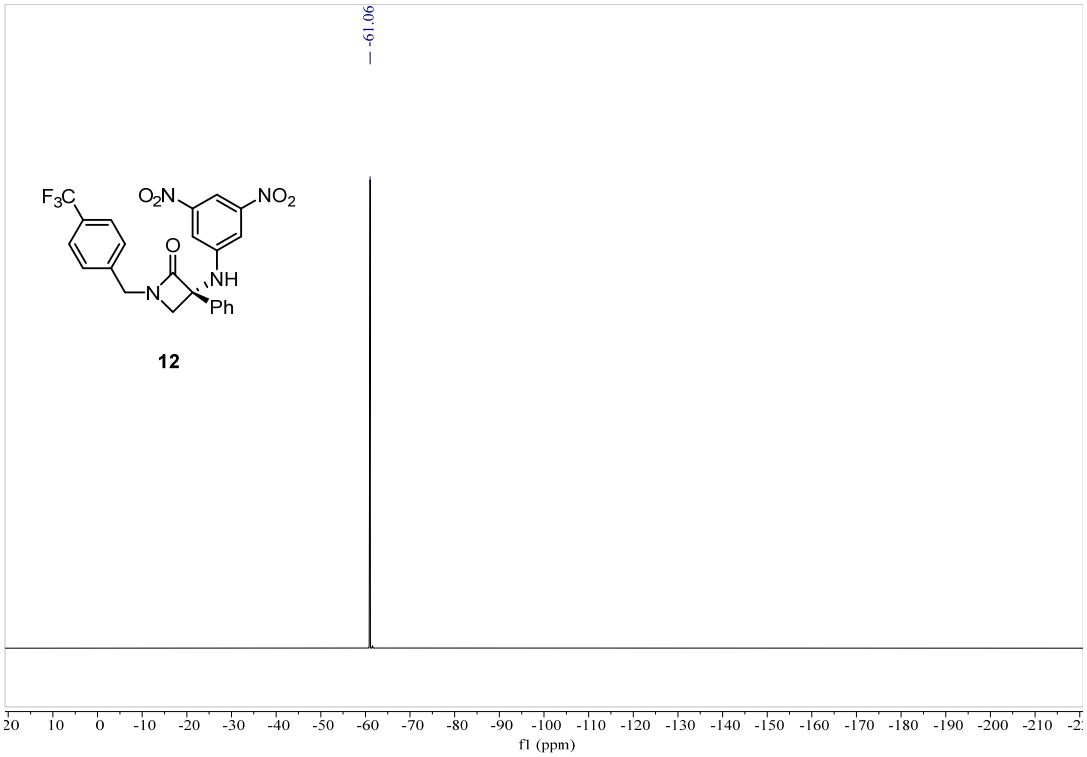
NO2
O
NH
N
Ph
12
f1 (ppm)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F3C
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NH
N
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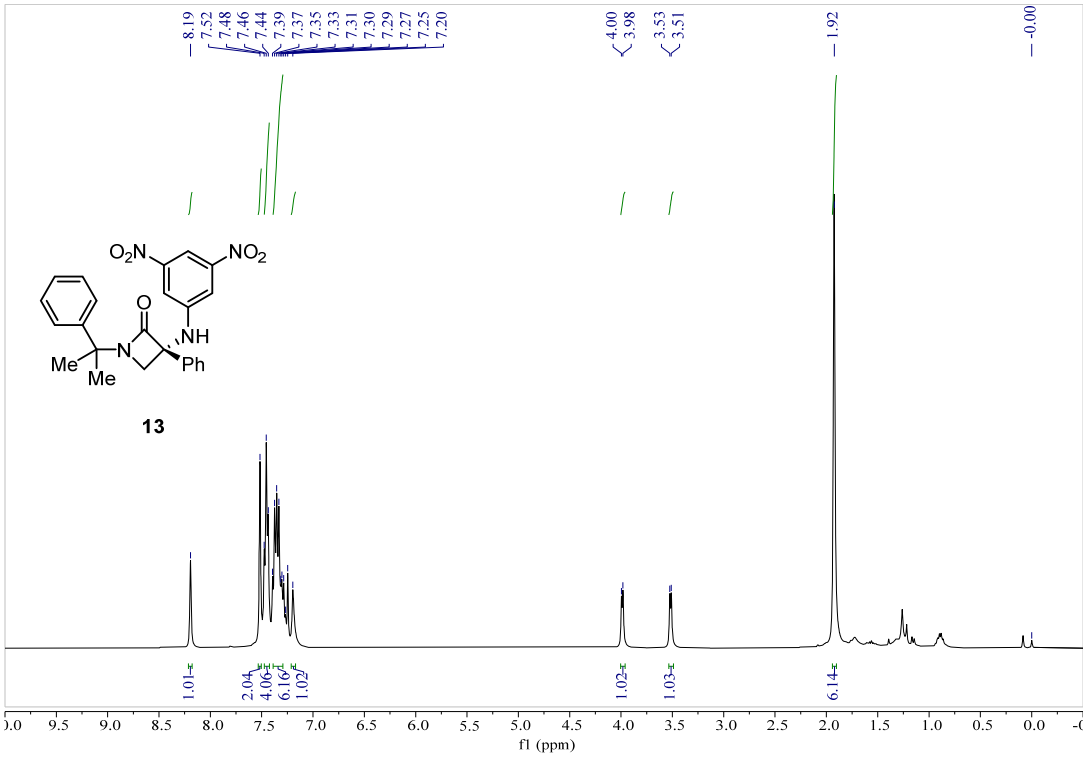
f1 (ppm)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7.37
7.35
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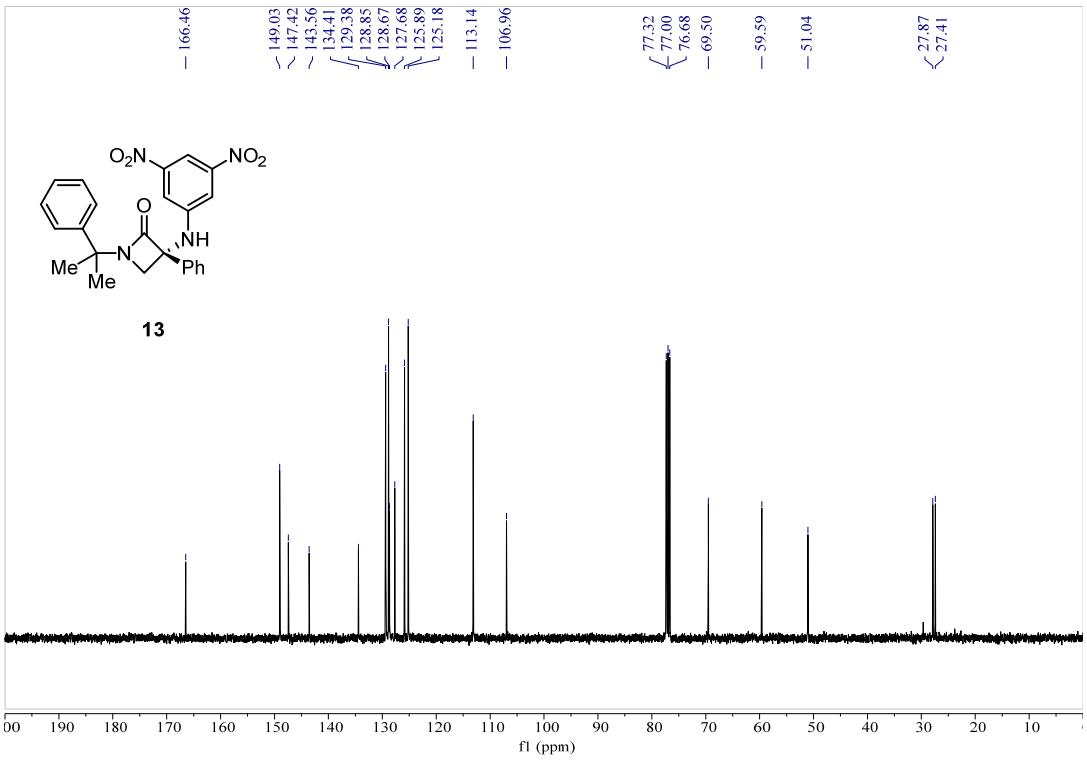
7.31
7.30
7.29
7.27
7.25
7.20
4.00
3.98
3.53
3.51
1.92
-0.00
O2N
NO2
O
NH
N
Me
Me
Ph
13
1.01
2.04
4.06
6.16
1.02
1.02
1.03
6.14
fl (ppm)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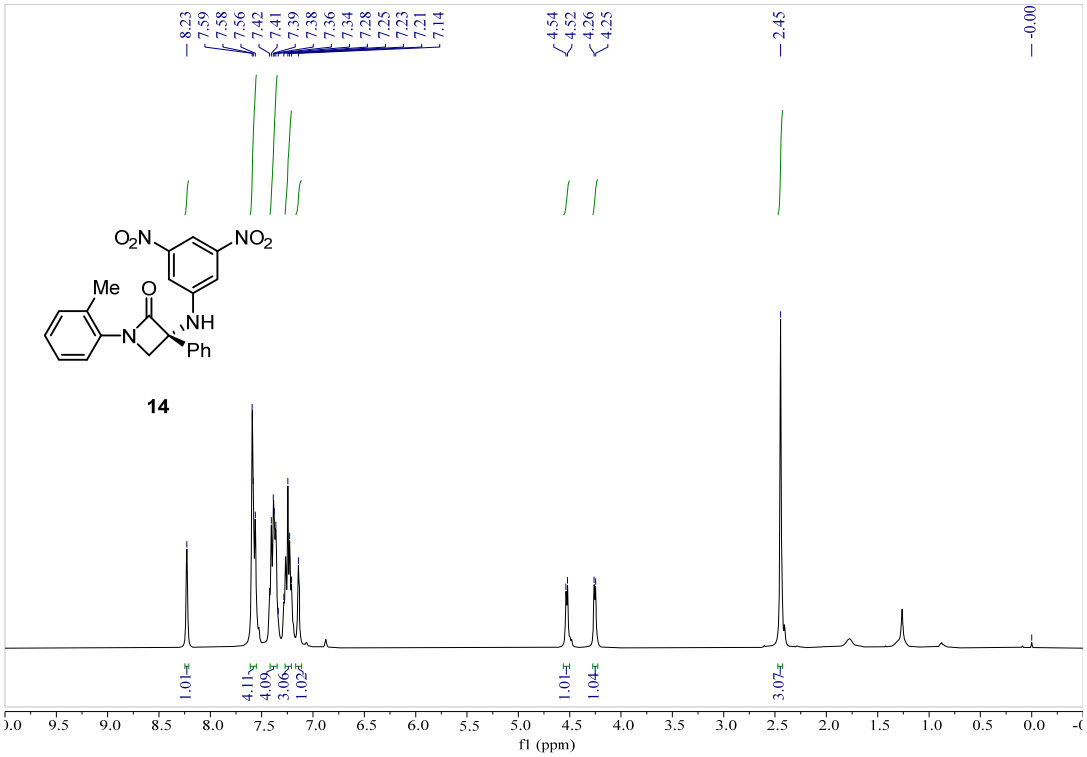
125.89
125.18
113.14
106.96
77.32
77.00
76.68
69.50
59.59
51.04
27.87
27.41
O2N
NO2
O
NH
N
Me
Me
Ph
13
fl (ppm)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7.34
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7.23
7.21
7.14
4.54
4.52
4.26
4.25
2.45
-0.00
O2N
NO2
Me
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NH
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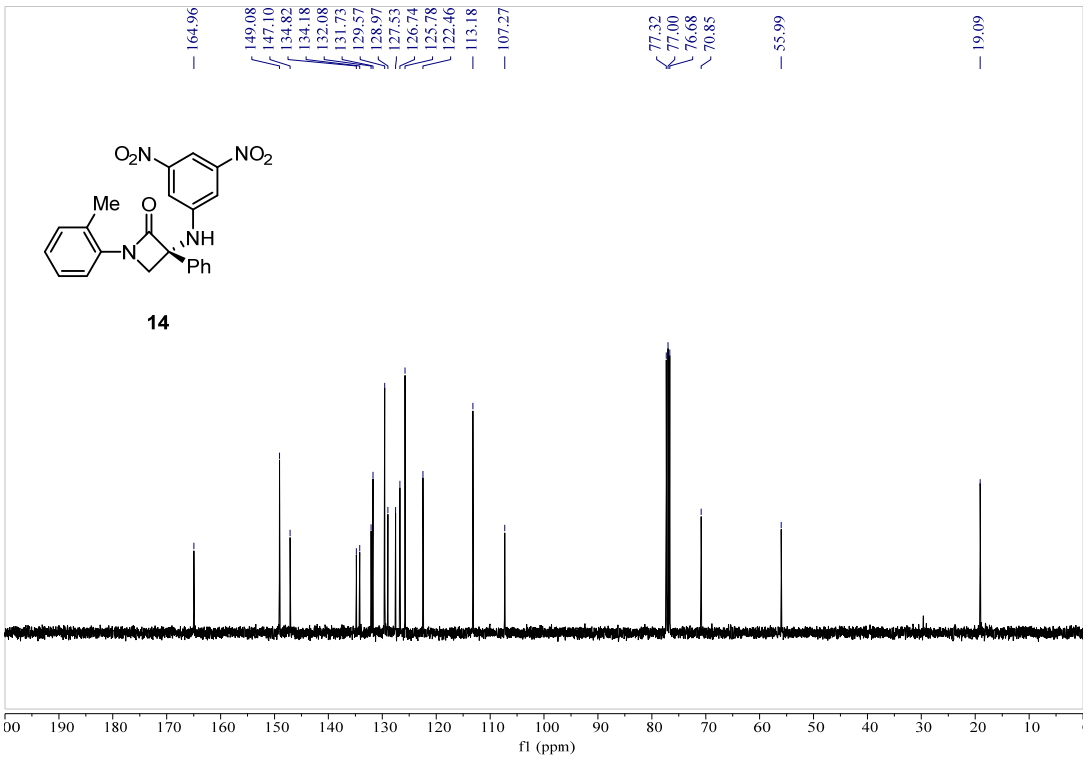
4.11
4.09
3.06
1.02
1.01
1.04
3.07
f1 (ppm)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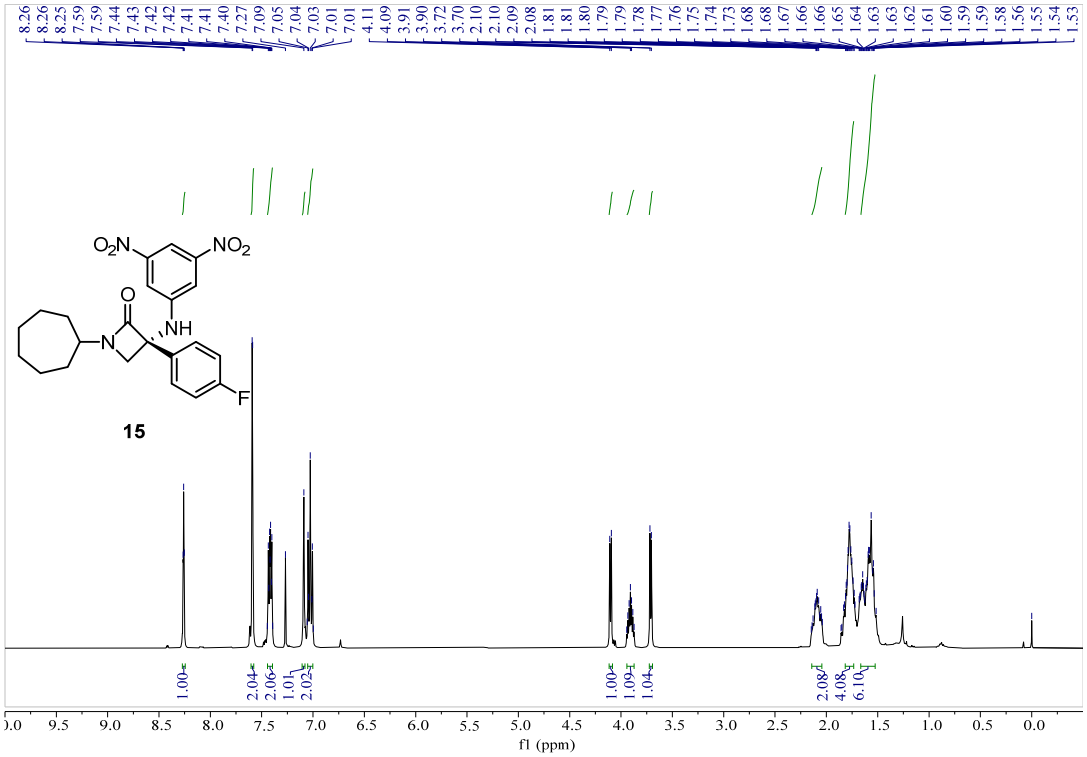
122.46
113.18
107.27
77.32
77.00
76.68
70.85
55.99
19.09
O2N
NO2
Me
O
N
NH
Ph
14
f1 (ppm)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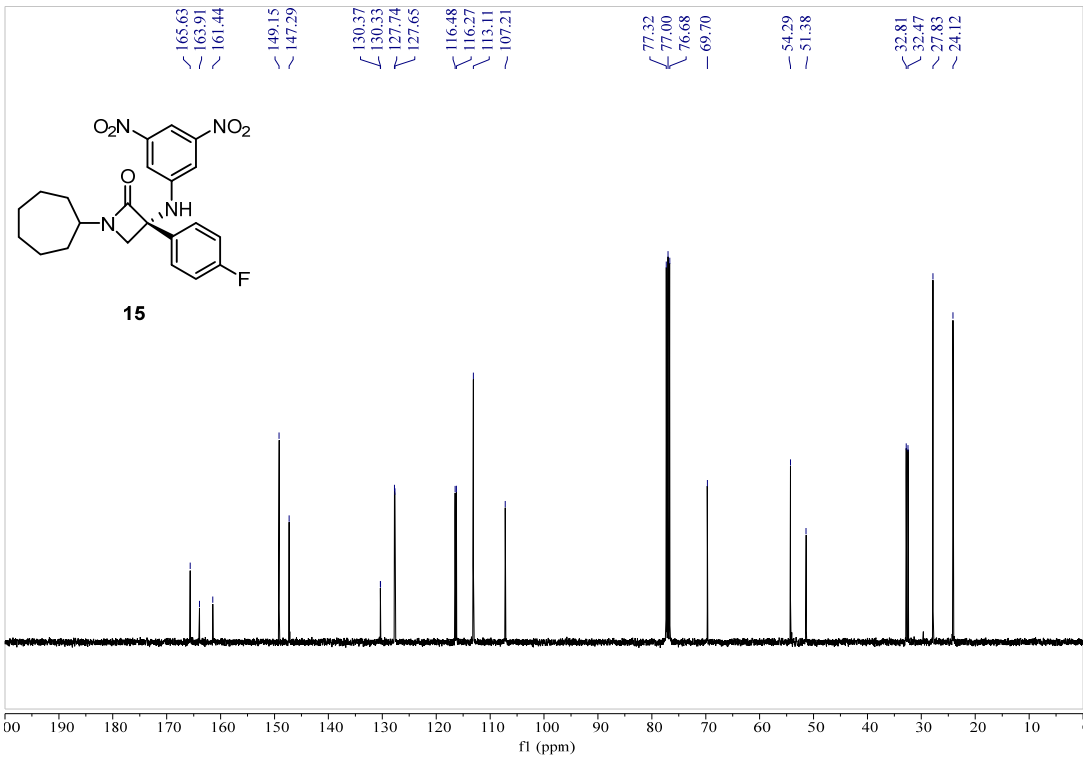
7.41
7.40
7.27
7.09
7.05
7.04
7.03
7.01
7.01
4.11
4.09
3.91
3.90
3.72
3.70
2.10
2.10
2.09
2.08
1.81
1.80
1.79
1.79
1.78
1.77
1.76
1.75
1.74
1.73
1.68
1.68
1.67
1.66
1.66
1.65
1.64
1.63
1.63
1.62
1.61
1.60
1.59
1.59
1.58
1.56
1.55
1.54
1.53
O2N
NO2
O
NH
N
F
15
1.00
2.04
2.06
1.01
2.02
1.00
1.09
1.04
2.08
4.08
6.10
fl (ppm)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163.91
161.44
149.15
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130.37
130.33
127.74
127.65
116.48
116.27
113.11
107.21
77.32
77.00
76.68
69.70
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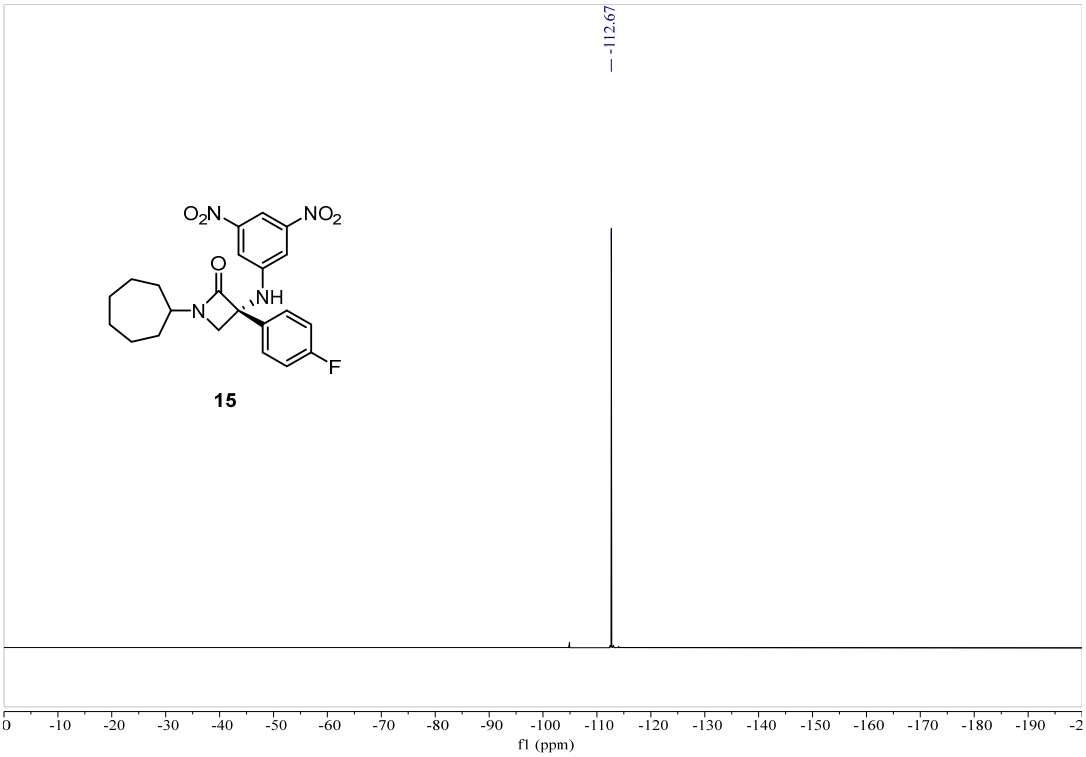
32.47
27.83
24.12
O2N
NO2
O
NH
N
F
15
fl (ppm)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NO2
O
NH
N
F
15
0
-10
-20
-30
-40
-50
-60
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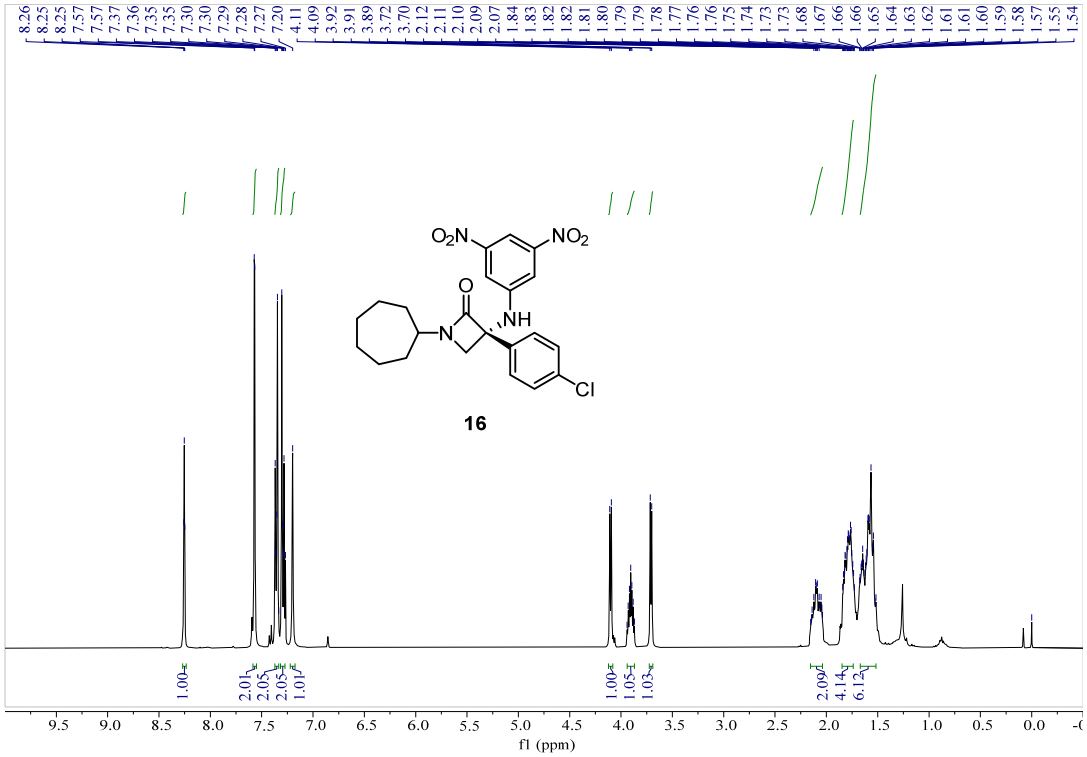
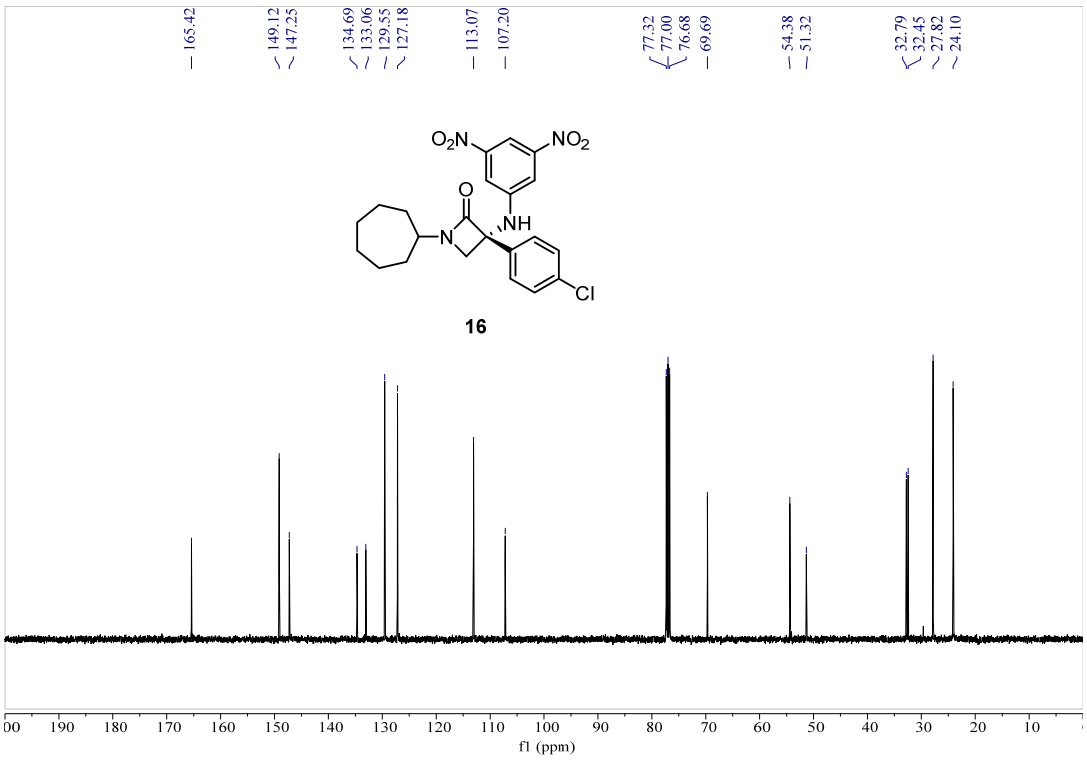
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-2
f1 (ppm)


8.26 8.25 8.25 7.57 7.57 7.37 7.36 7.35 7.35 7.30 7.30 7.29 7.28 7.27 7.20 4.11 4.09 3.92 3.91 3.89 3.72 3.70 2.12 2.11 2.10 2.09 2.07 1.84 1.83 1.82 1.82 1.81 1.80 1.79 1.79 1.78 1.77 1.76 1.76 1.75 1.74 1.73 1.73 1.68 1.67 1.66 1.66 1.65 1.64 1.63 1.62 1.61 1.61 1.60 1.59 1.58 1.57 1.55 1.54
O2N
NO2
O
NH
N
Cl
16
1.00 2.01 2.05 2.05 1.01 1.00 1.05 1.03 2.09 4.14 6.12
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)


165.42 149.12 147.25 134.69 133.06 129.55 127.18 113.07 107.20 77.32 77.00 76.68 69.69 54.38 51.32 32.79 32.45 27.82 24.10
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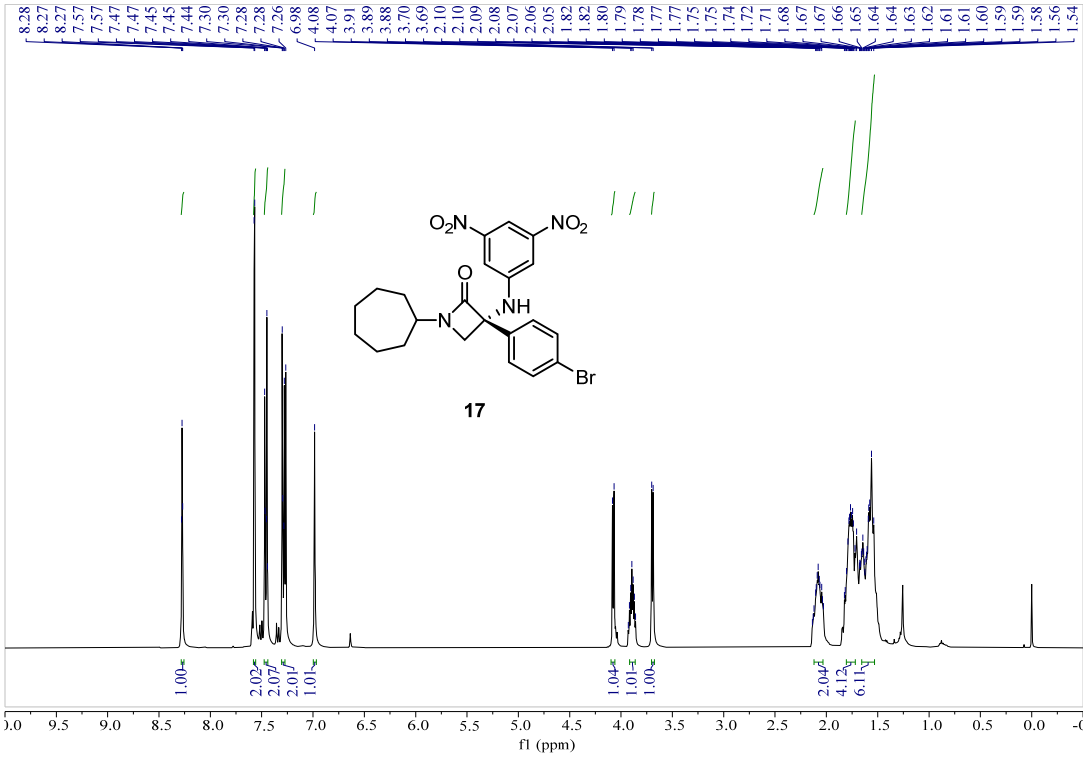
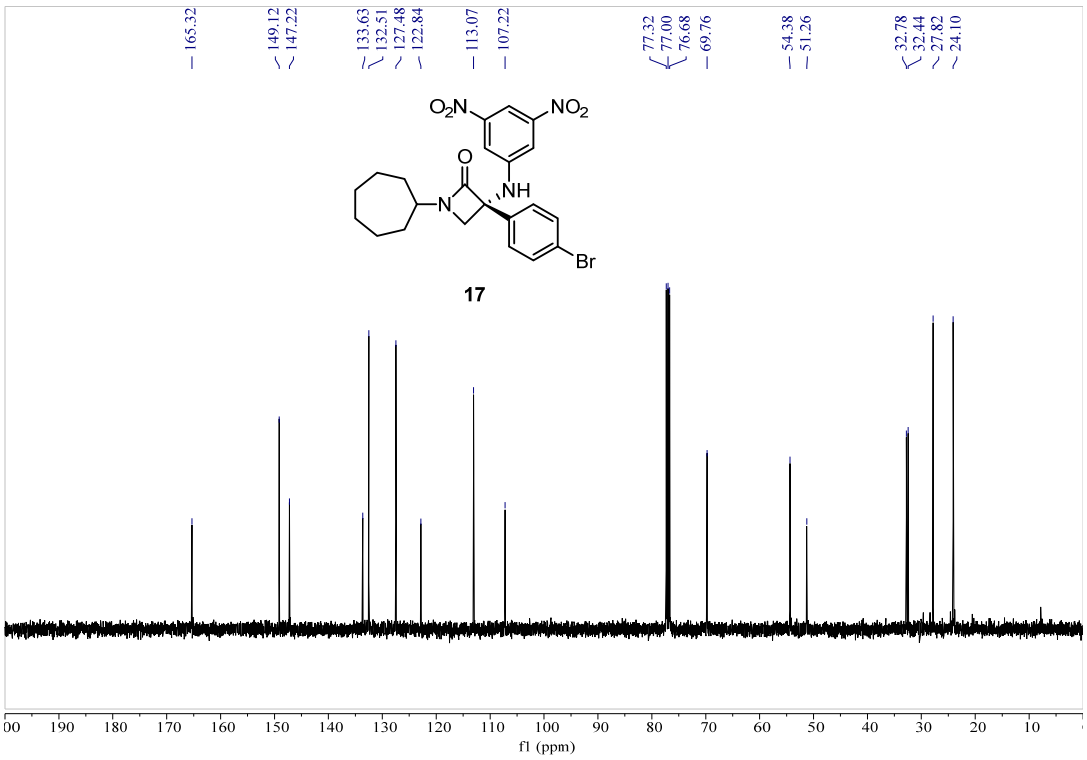
NO2
O
NH
N
Cl
16
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


8.28 8.27 8.27 7.57 7.57 7.47 7.47 7.45 7.45 7.44 7.30 7.30 7.28 7.28 7.26 6.98 4.08 4.07 3.91 3.89 3.88 3.70 3.69 2.10 2.10 2.09 2.08 2.07 2.06 2.05 1.82 1.82 1.80 1.79 1.78 1.77 1.77 1.75 1.75 1.74 1.72 1.71 1.68 1.67 1.67 1.66 1.65 1.64 1.64 1.63 1.62 1.61 1.61 1.60 1.59 1.59 1.58 1.56 1.54
O2N
NO2
O
NH
N
Br
17
1.00 2.02 2.07 2.01 1.01 1.04 1.01 1.00 2.04 4.12 6.11
f1 (ppm)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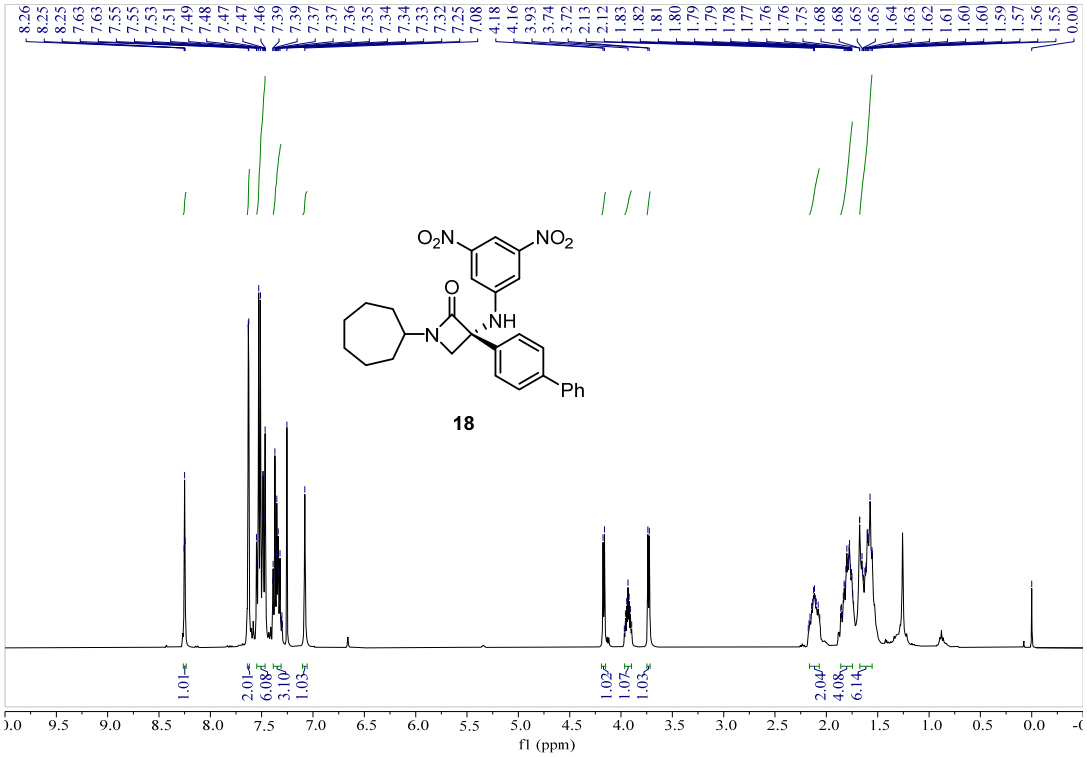
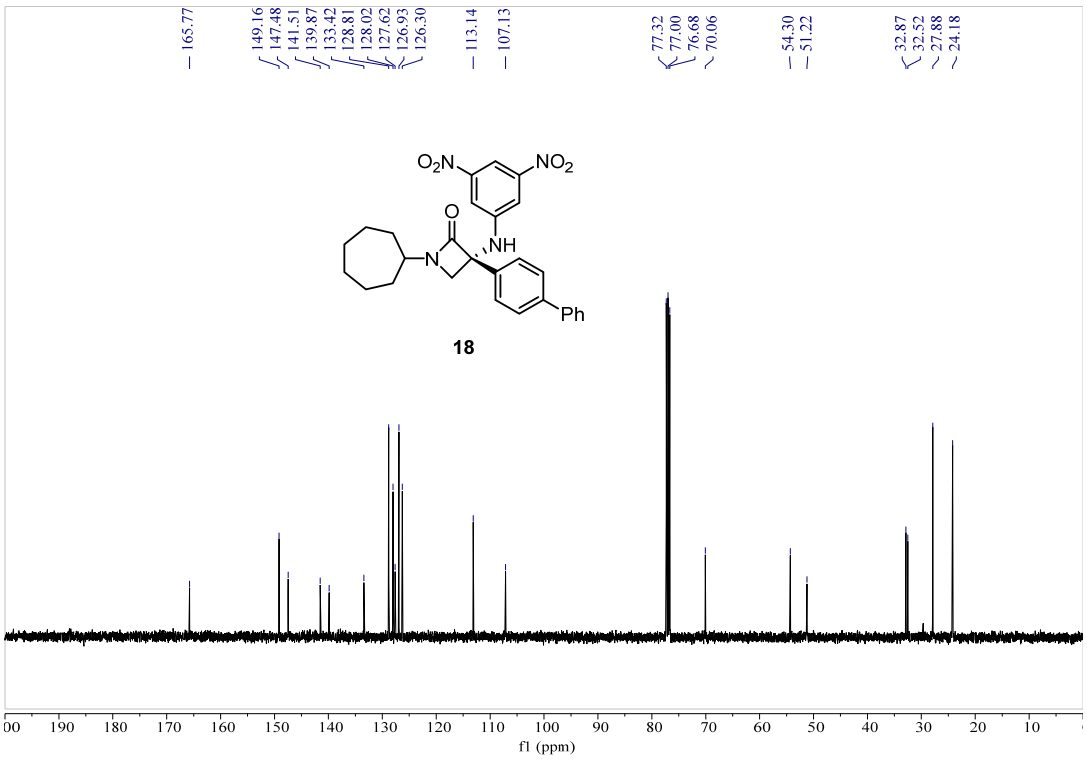
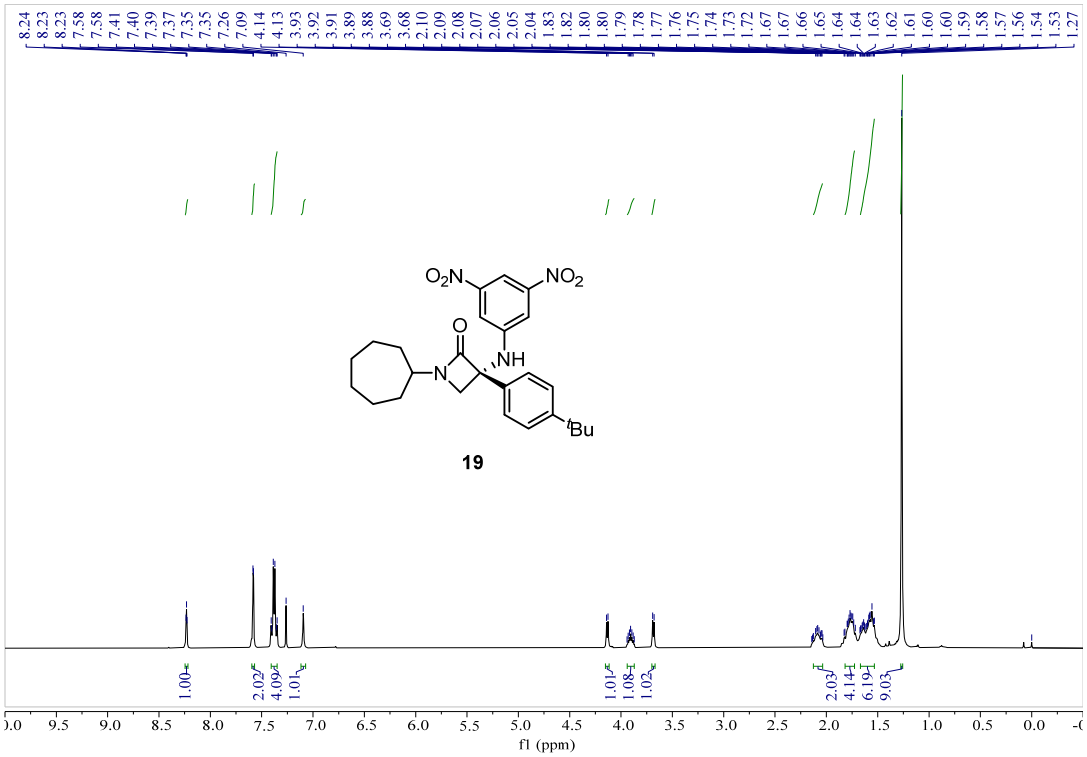
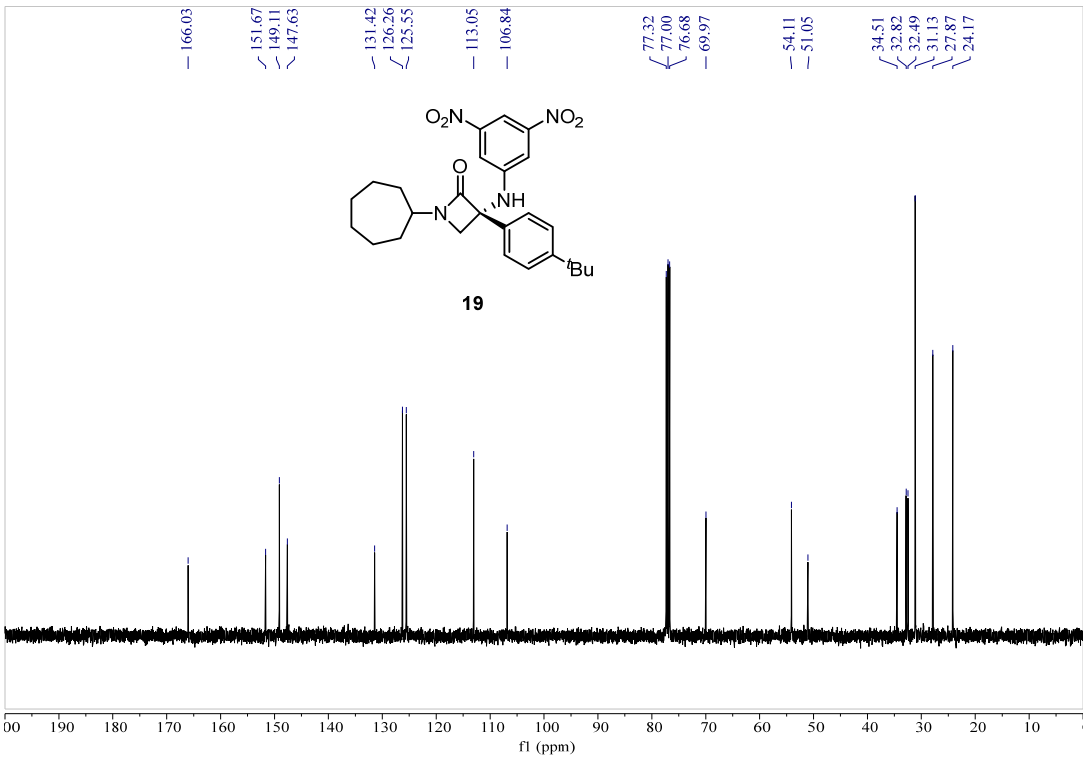
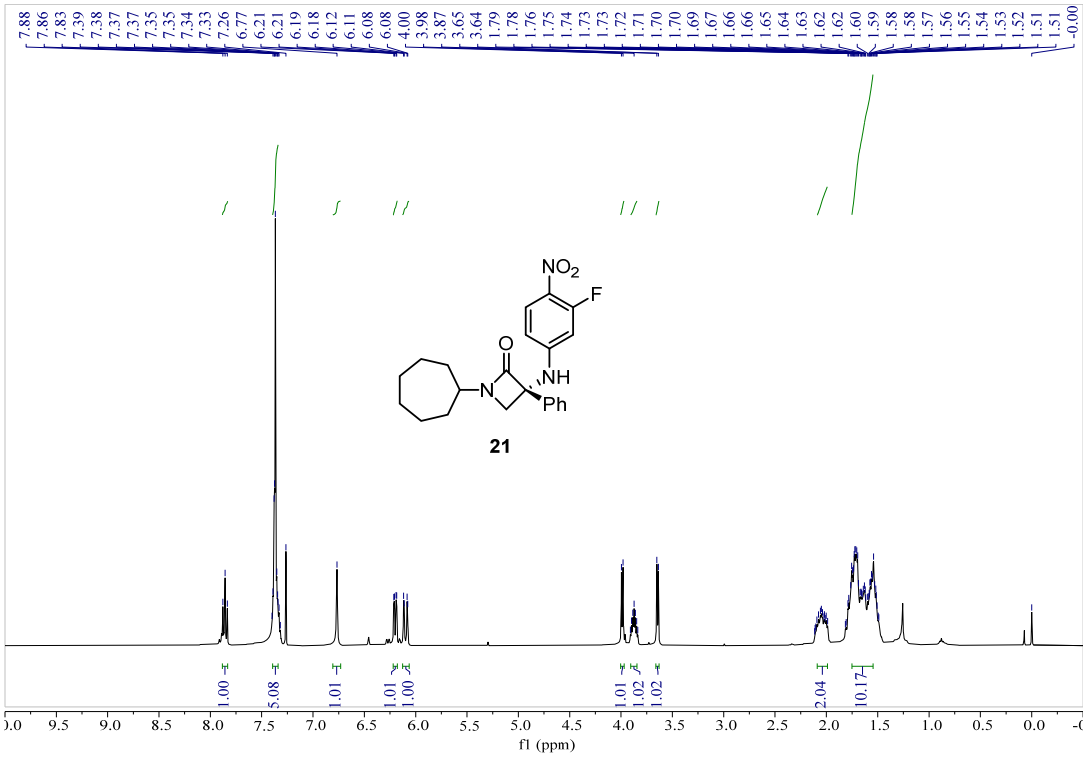
149.12
147.22
133.63
132.51
127.48
122.84
113.07
107.22
77.32
77.00
76.68
69.76
54.38
51.26
32.78
32.44
27.82
24.10
O2N
NO2
O
NH
N
Br
17
f1 (ppm)

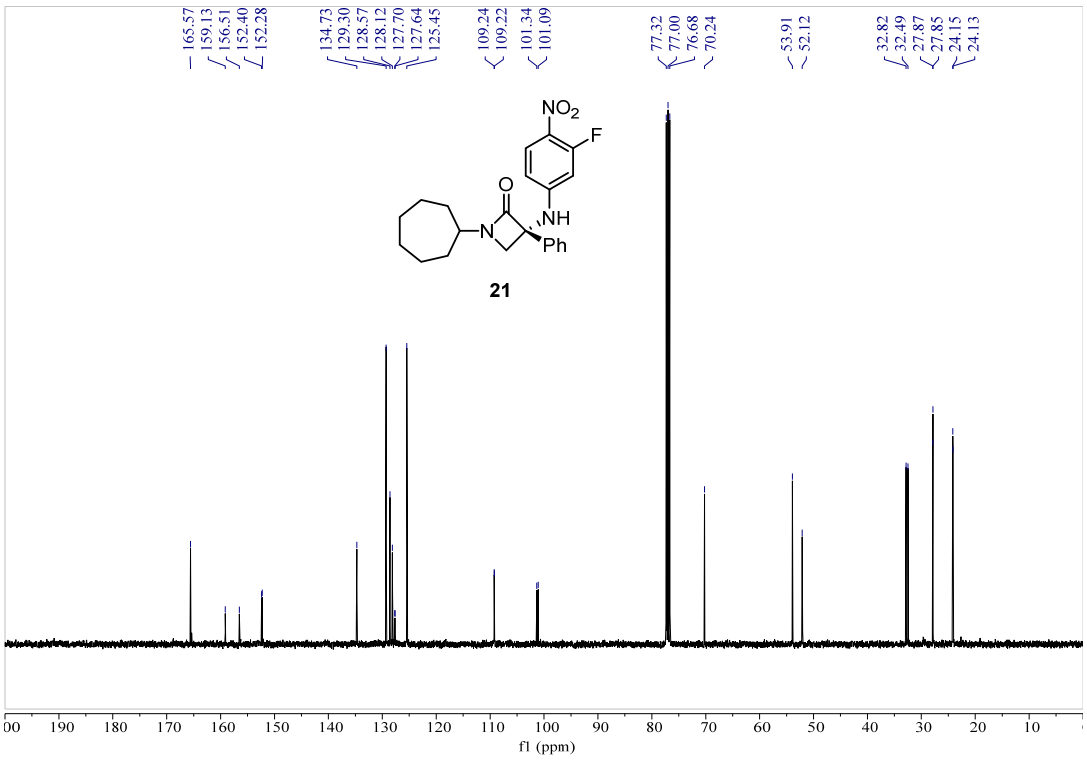

8.26 8.25 8.25 7.63 7.63 7.55 7.55 7.53 7.51 7.49 7.48 7.47 7.47 7.46 7.39 7.39 7.37 7.37 7.36 7.35 7.34 7.34 7.33 7.32 7.25 7.08 4.18 4.16 3.93 3.74 3.72 2.13 2.12 1.83 1.82 1.81 1.80 1.79 1.79 1.78 1.77 1.76 1.76 1.75 1.68 1.68 1.65 1.65 1.64 1.63 1.62 1.61 1.60 1.60 1.59 1.57 1.56 1.55 0.00
O2N
NO2
O
NH
N
Ph
18
1.01 2.01 6.08 3.10 1.03 1.02 1.07 1.03 2.04 4.08 6.14
f1 (ppm)

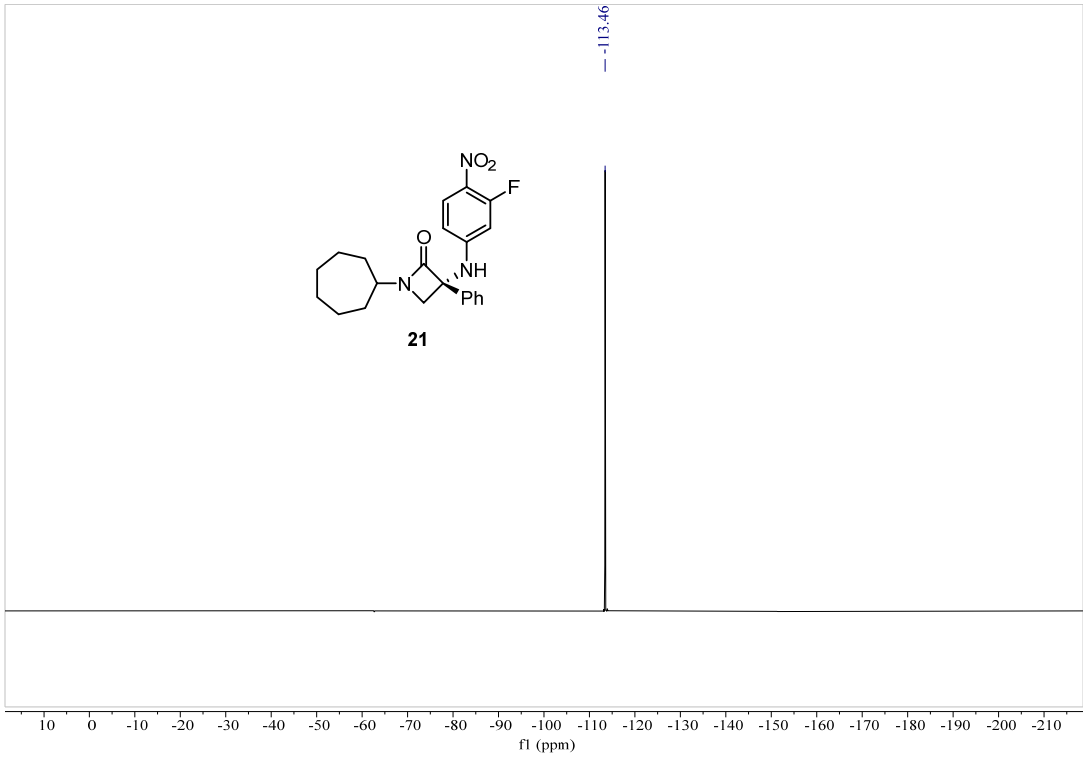

165.77 149.16 147.48 141.51 139.87 133.42 128.81 128.02 127.62 126.93 126.30 113.14 107.13 77.32 77.00 76.68 70.06 54.30 51.22 32.87 32.52 27.88 24.18
O2N
NO2
O
NH
N
Ph
18
f1 (ppm)


8.24 8.23 8.23 7.58 7.58 7.41 7.40 7.39 7.37 7.35 7.35 7.26 7.09 4.14 4.13 3.93 3.92 3.91 3.89 3.88 3.69 3.68 2.10 2.09 2.08 2.07 2.06 2.05 2.04 1.83 1.82 1.80 1.80 1.79 1.78 1.77 1.76 1.75 1.74 1.73 1.72 1.67 1.67 1.66 1.65 1.64 1.64 1.63 1.62 1.61 1.60 1.60 1.59 1.58 1.57 1.56 1.54 1.53 1.27
O2N
NO2
O
NH
N
tBu
19
1.00 2.02 4.09 1.01 1.01 1.08 1.02 2.03 4.14 6.19 9.03
f1 (ppm)


166.03 151.67 149.11 147.63 131.42 126.26 125.55 113.05 106.84 77.32 77.00 76.68 69.97 54.11 51.05 34.51 32.82 32.49 31.13 27.87 24.17
O2N
NO2
O
NH
N
tBu
19
f1 (ppm)


7.88 7.86 7.83 7.39 7.38 7.37 7.37 7.35 7.35 7.34 7.33 7.26 6.77 6.21 6.21 6.19 6.18 6.12 6.11 6.08 6.08 4.00 3.98 3.87 3.65 3.64 1.79 1.78 1.76 1.75 1.74 1.73 1.73 1.72 1.71 1.70 1.70 1.69 1.67 1.66 1.66 1.65 1.64 1.63 1.62 1.62 1.60 1.59 1.58 1.58 1.57 1.56 1.55 1.54 1.53 1.52 1.51 1.51 -0.00
NO2
F
O
NH
Ph
N
21
1.00 5.08 1.01 1.01 1.00 1.01 1.02 1.02 2.04 10.17
f1 (ppm)


165.57 159.13 156.51 152.40 152.28 134.73 129.30 128.57 128.12 127.70 127.64 125.45 109.24 109.22 101.34 101.09 77.32 77.00 76.68 70.24 53.91 52.12 32.82 32.49 27.87 27.85 24.15 24.13
NO2
F
O
NH
Ph
N
21
f1 (ppm)


-113.46
NO2
F
O
NH
N
Ph
21
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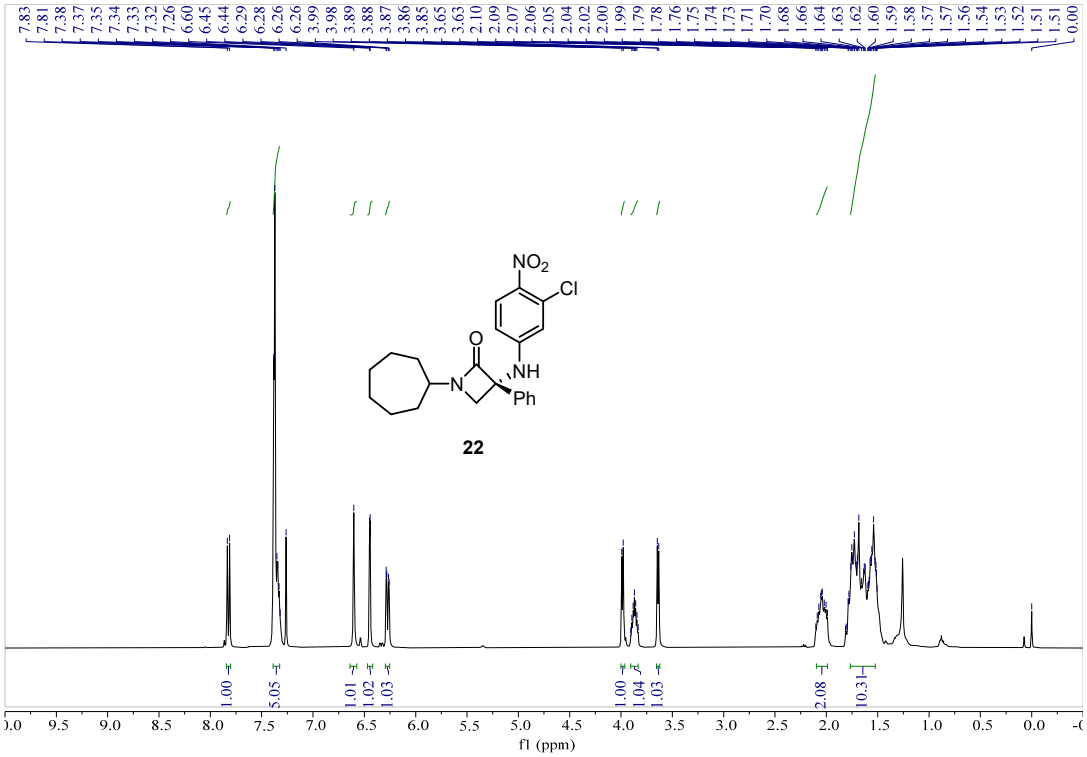
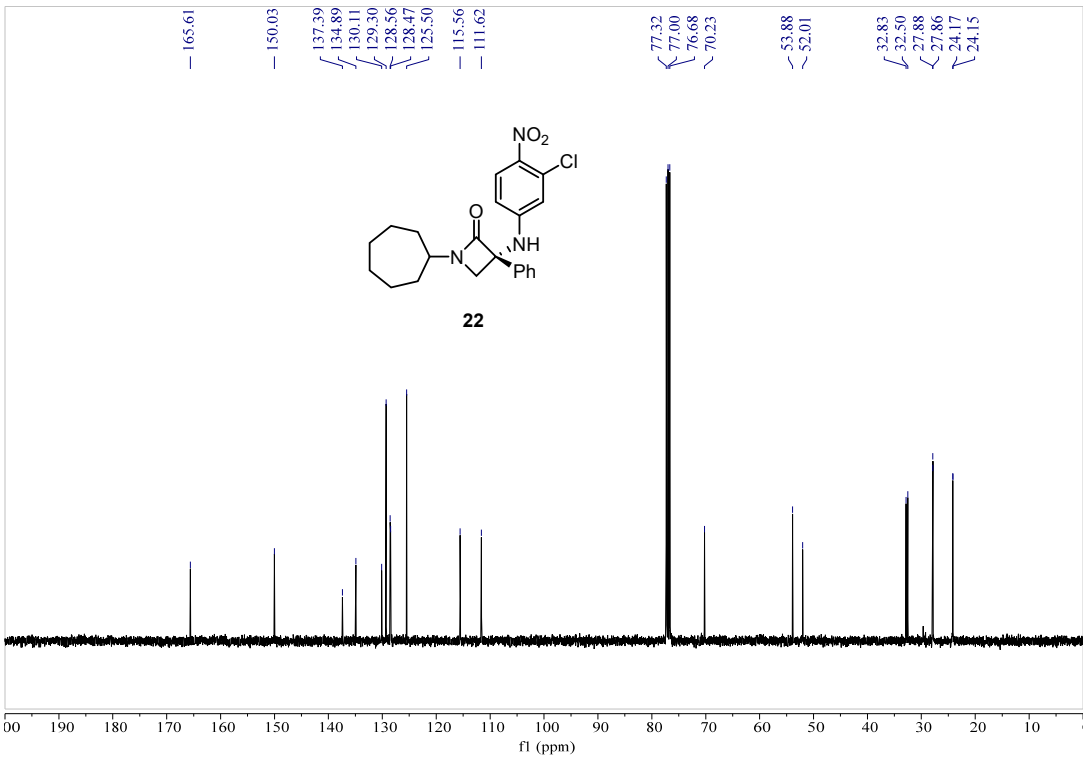
f1 (ppm)


NO2
Cl
O
N
NH
Ph
22
f1 (ppm)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Cl
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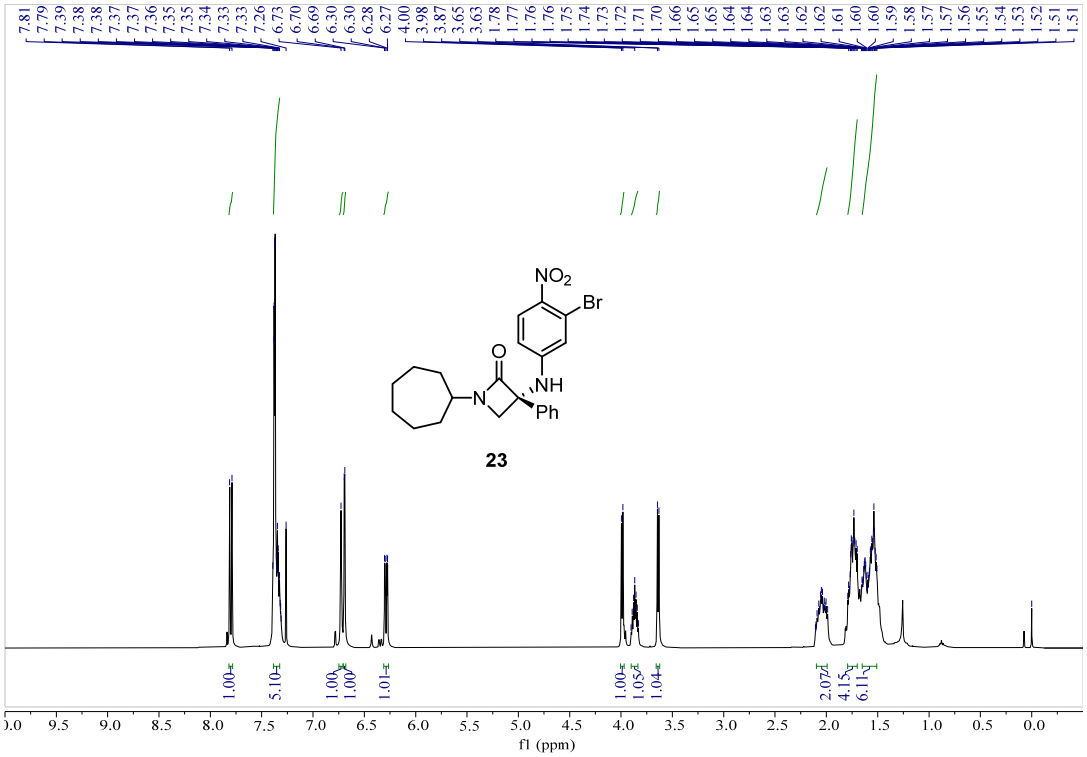
NH
Ph
22
f1 (ppm)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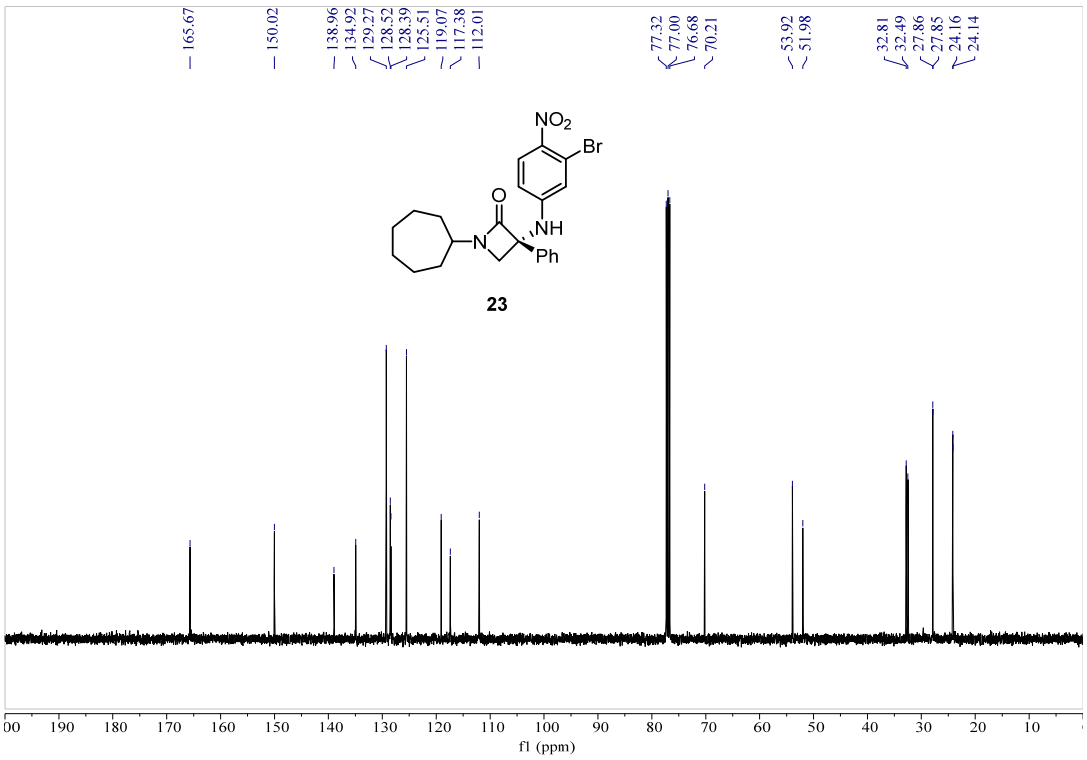
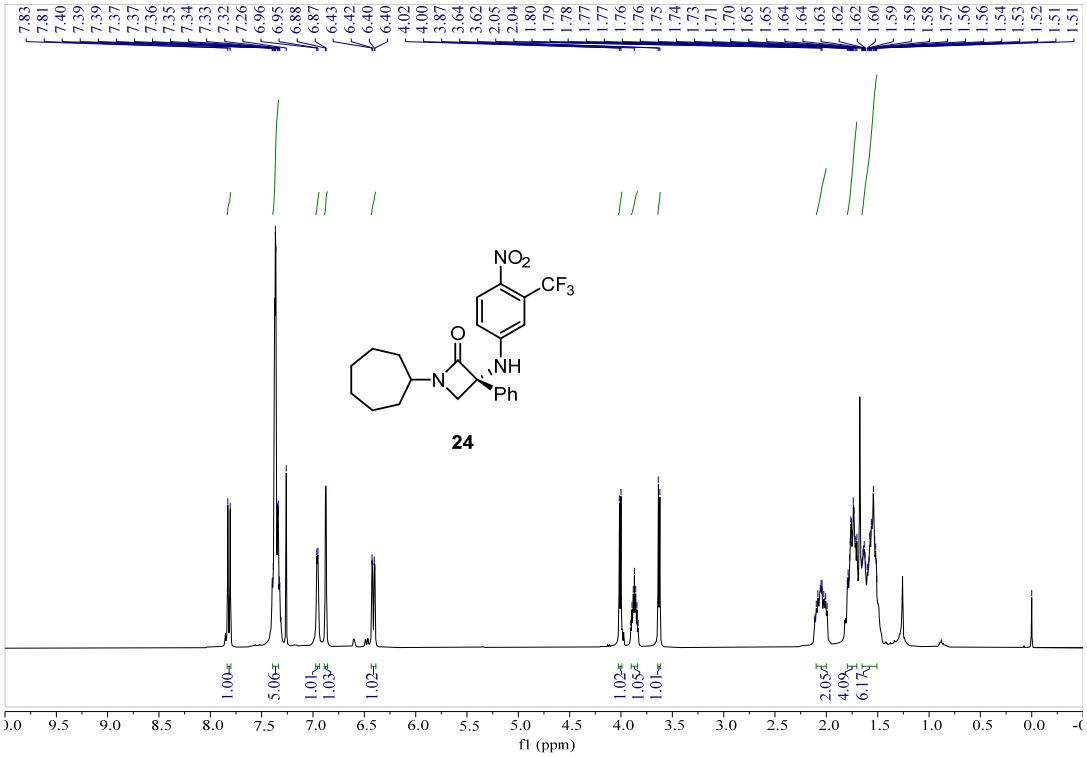
Br
O
NH
Ph
N
23
f1 (ppm)


NO2
Br
O
NH
Ph
N
23
f1 (ppm)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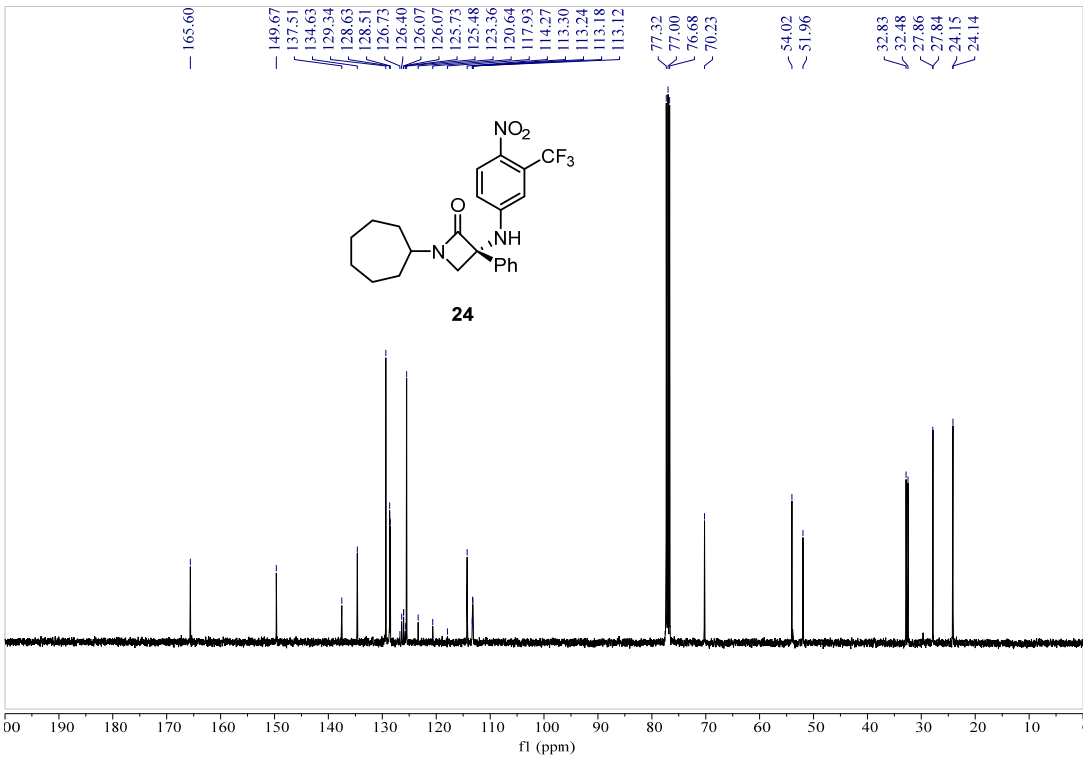
CF3
O
N
NH
Ph
24
f1 (ppm)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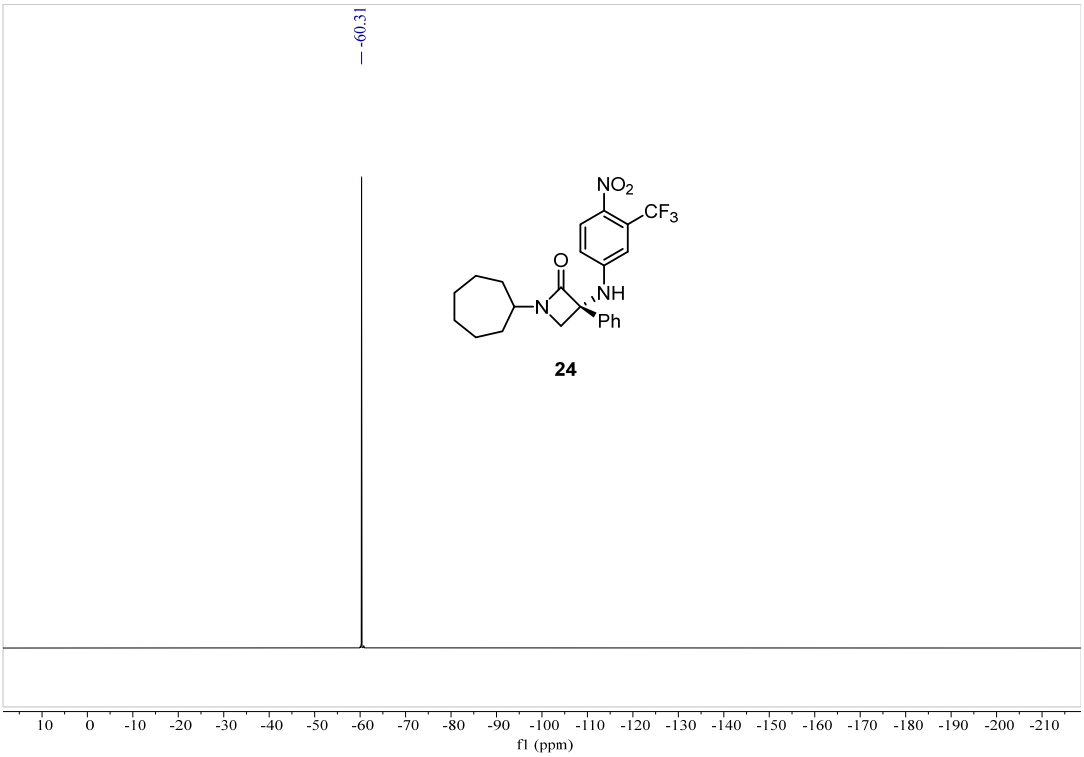
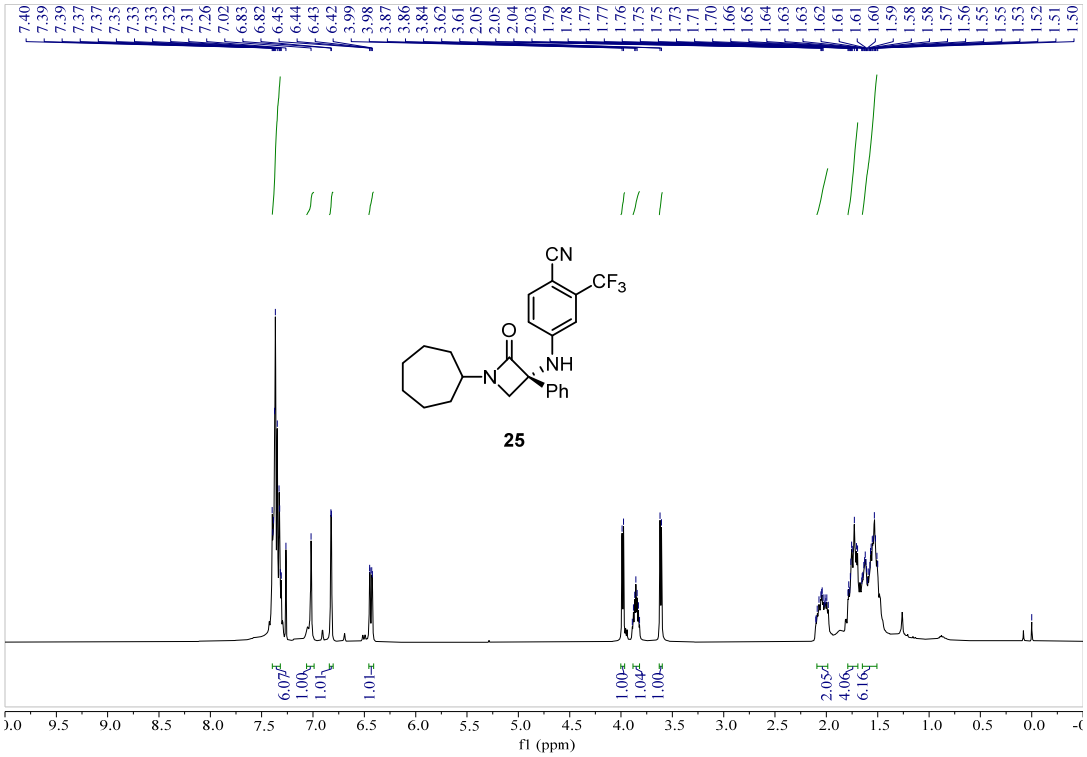
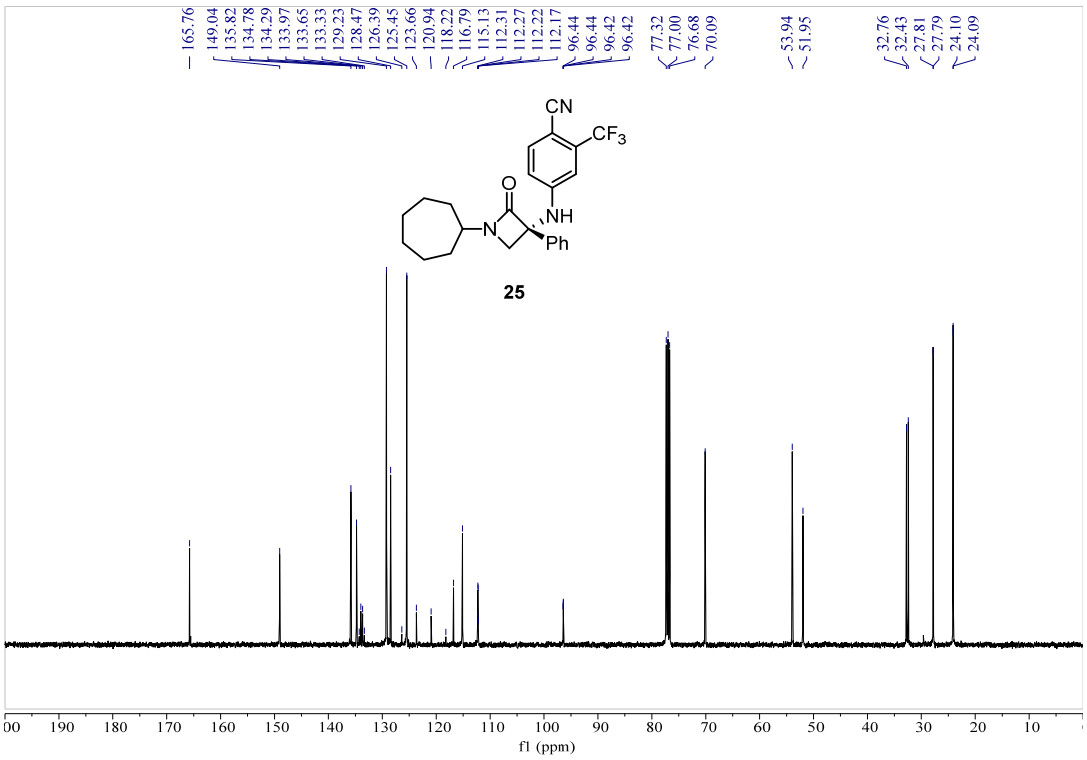
CF3
O
N
NH
Ph
24
f1 (ppm)


-60.31
NO2
CF3
O
NH
N
Ph
24
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)


CN
CF3
O
NH
Ph
N
25
f1 (ppm)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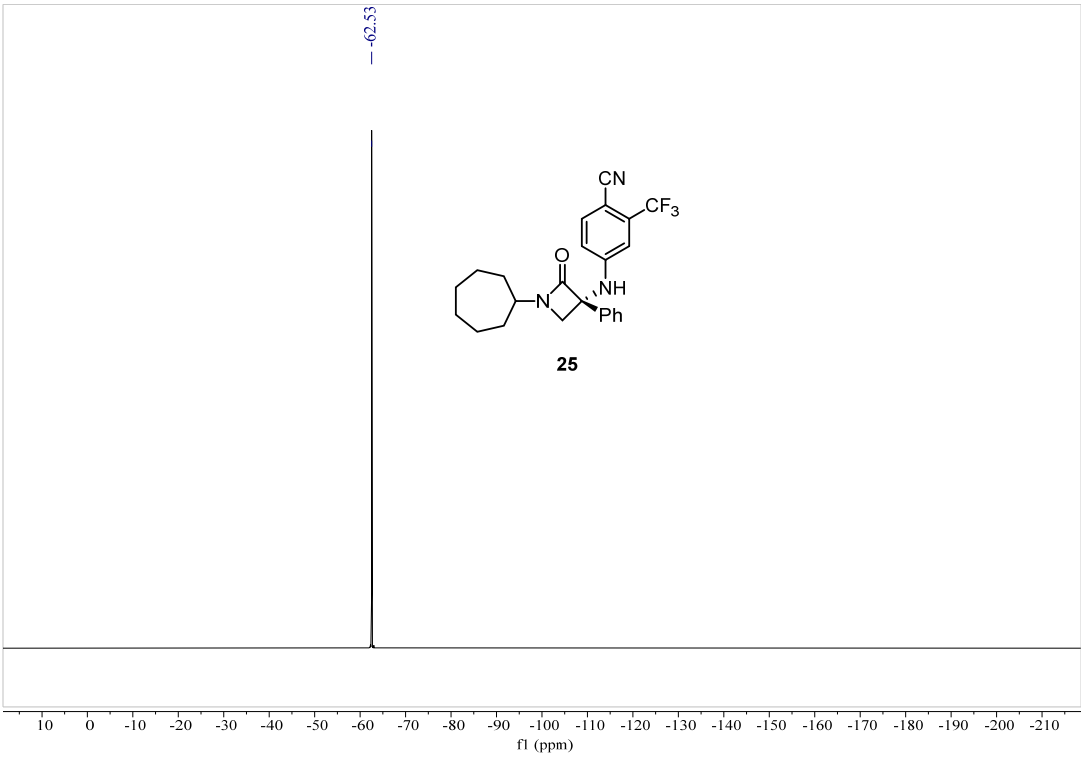
CF3
O
NH
Ph
N
25
f1 (ppm)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Ph
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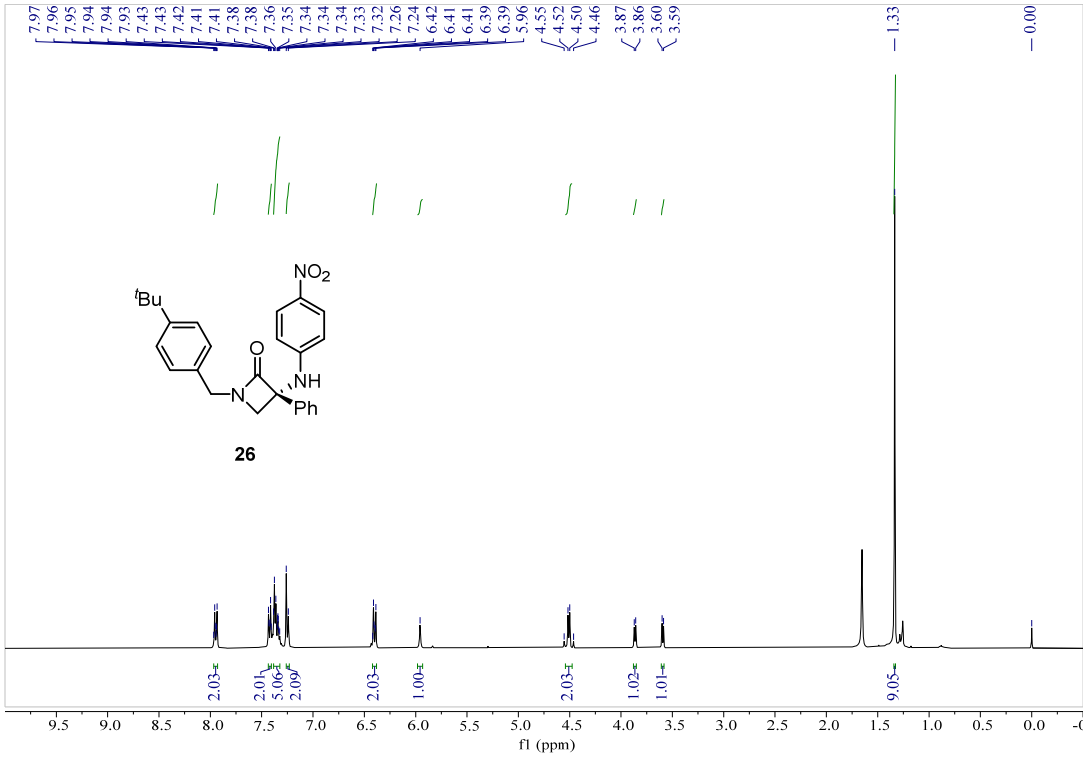
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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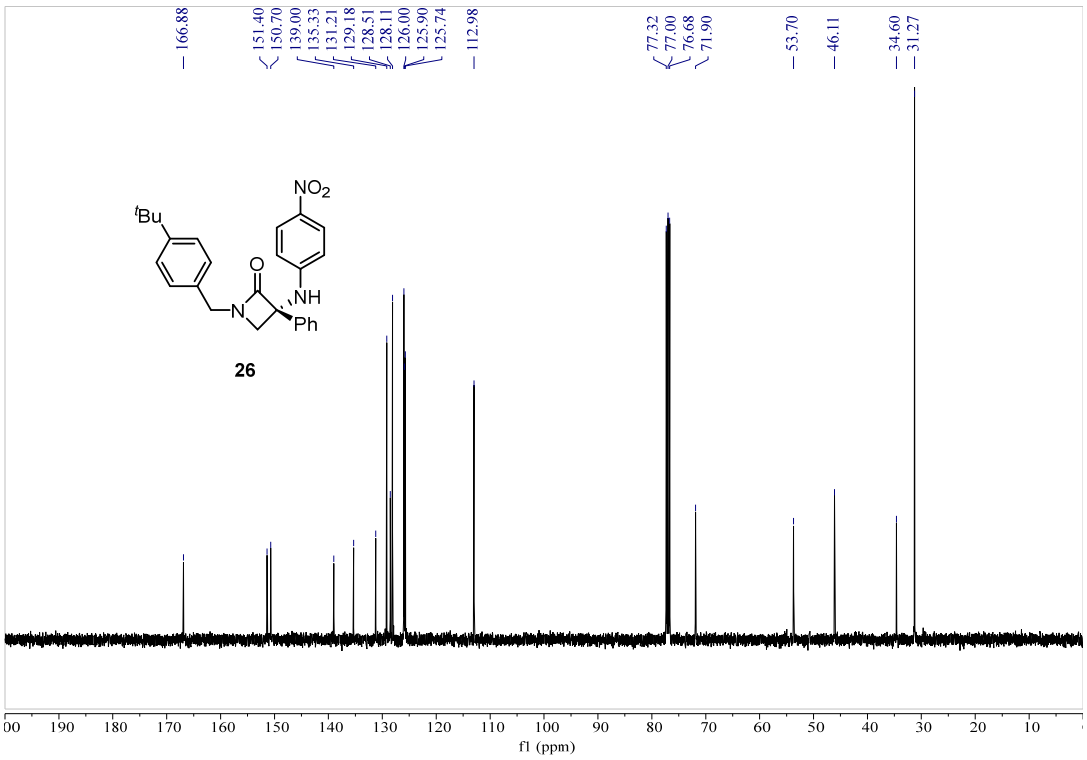
7.35
7.34
7.34
7.34
7.33
7.32
7.26
7.24
6.42
6.41
6.41
6.39
6.39
5.96
4.55
4.52
4.50
4.46
3.87
3.86
3.60
3.59
1.33
0.00
NO2
tBu
O
NH
Ph
26
2.03
2.01
5.06
2.09
2.03
1.00
2.03
1.02
1.01
9.05
f1 (ppm)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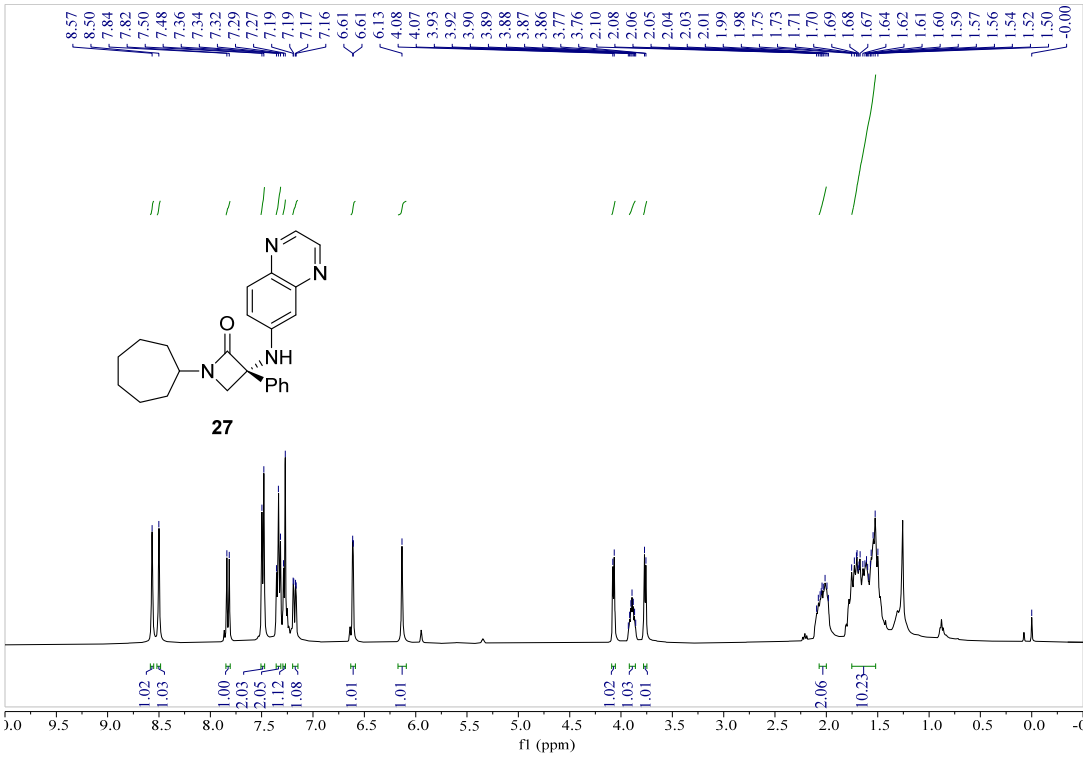
131.21
129.18
128.51
128.11
126.00
125.90
125.74
112.98
77.32
77.00
76.68
71.90
53.70
46.11
34.60
31.27
NO2
tBu
O
NH
Ph
26
f1 (ppm)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7.29
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7.19
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7.16
6.61
6.61
6.13
4.08
4.07
3.93
3.92
3.90
3.89
3.88
3.87
3.86
3.77
3.76
2.10
2.08
2.06
2.05
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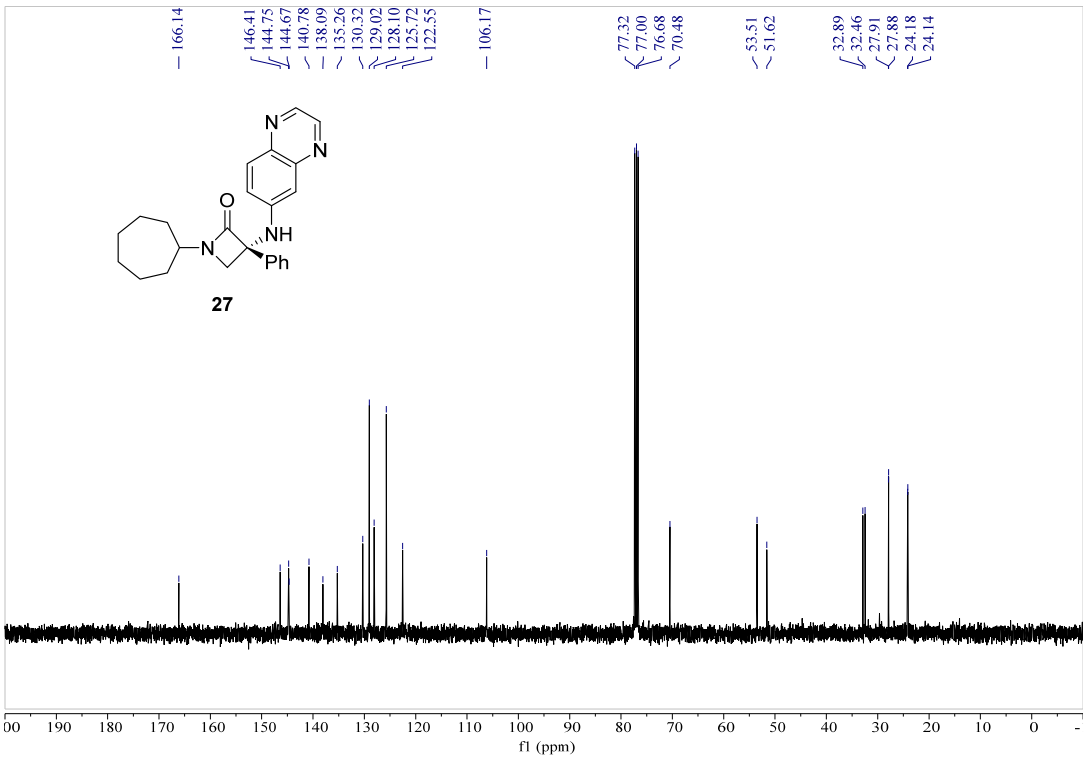
1.64
1.62
1.61
1.60
1.59
1.57
1.56
1.54
1.52
1.50
-0.00
N
N
O
NH
N
Ph
27
1.02
1.03
1.00
2.03
2.05
1.12
1.08
1.01
1.01
1.02
1.03
1.01
2.06
10.23
f1 (ppm)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138.09
135.26
130.32
129.02
128.10
125.72
122.55
106.17
77.32
77.00
76.68
70.48
53.51
51.62
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27.91
27.88
24.18
24.14
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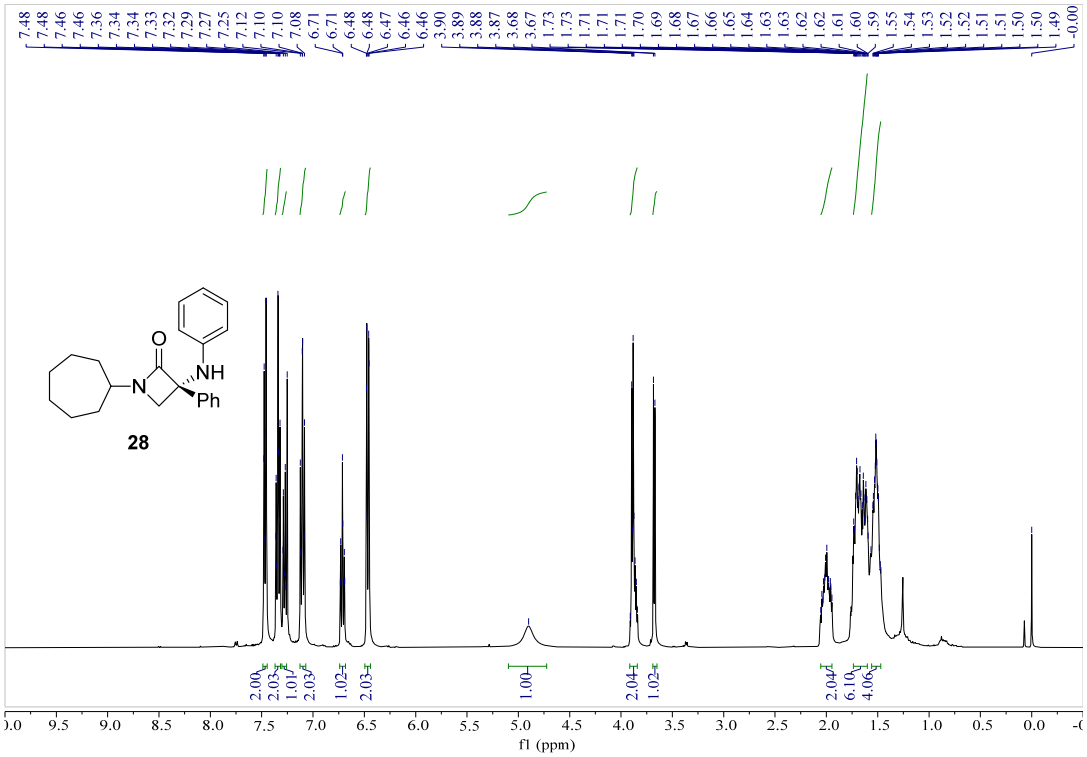
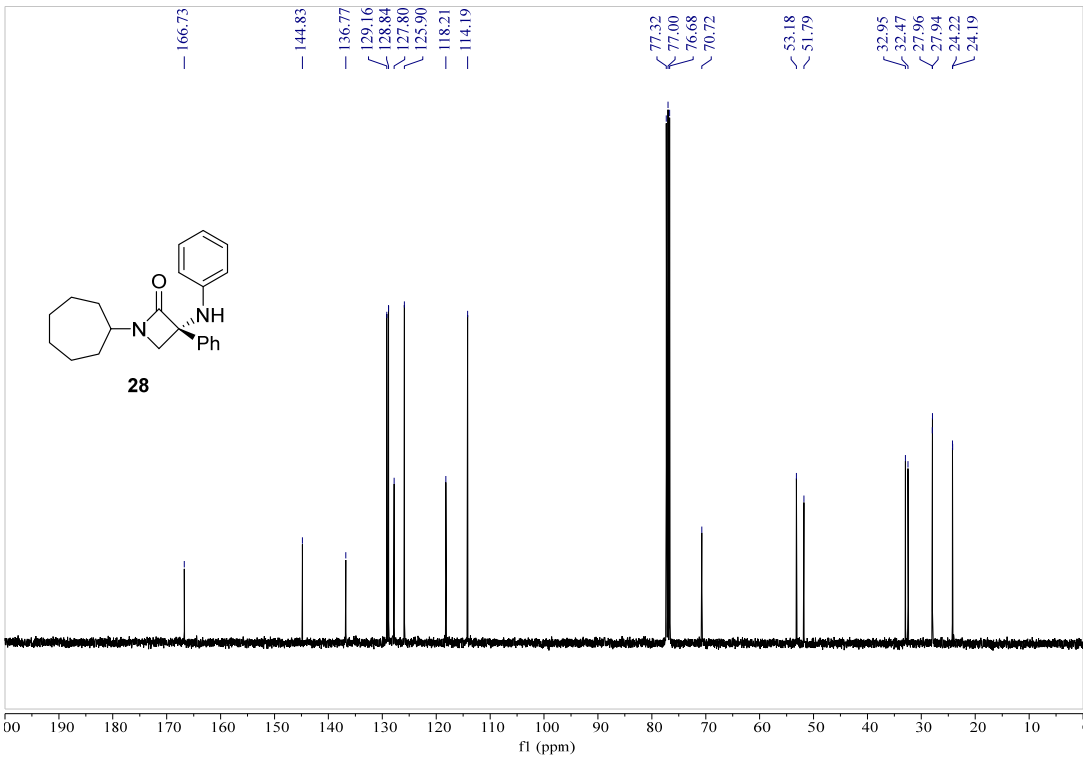
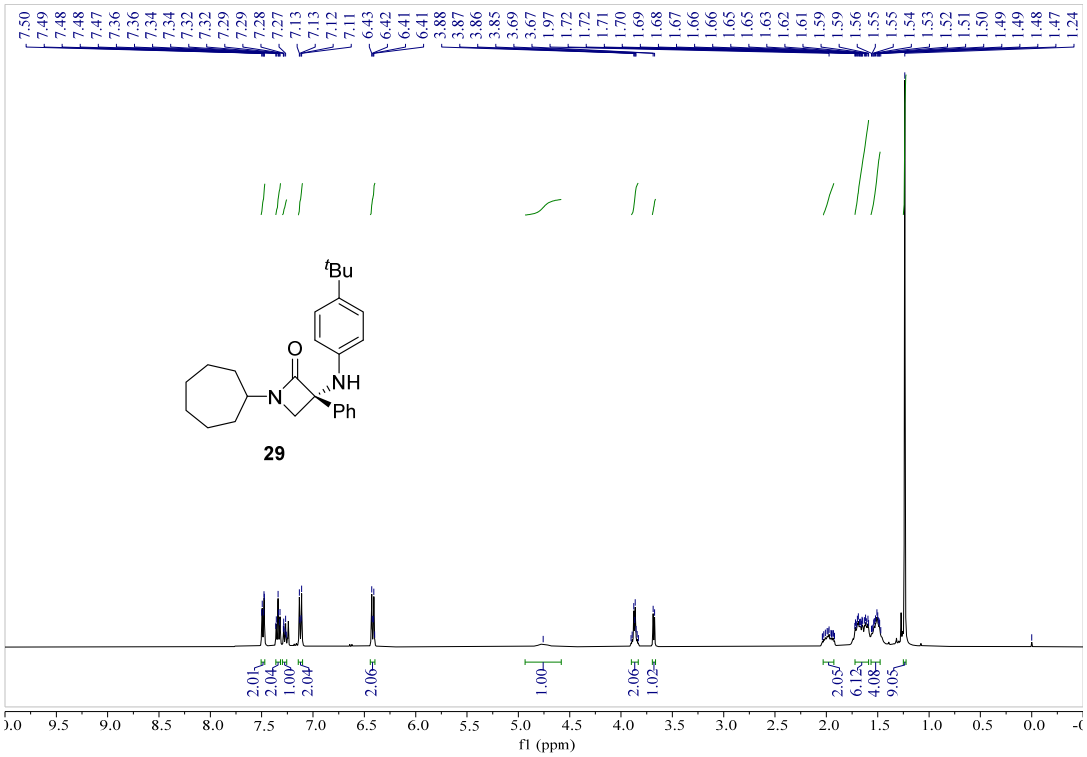
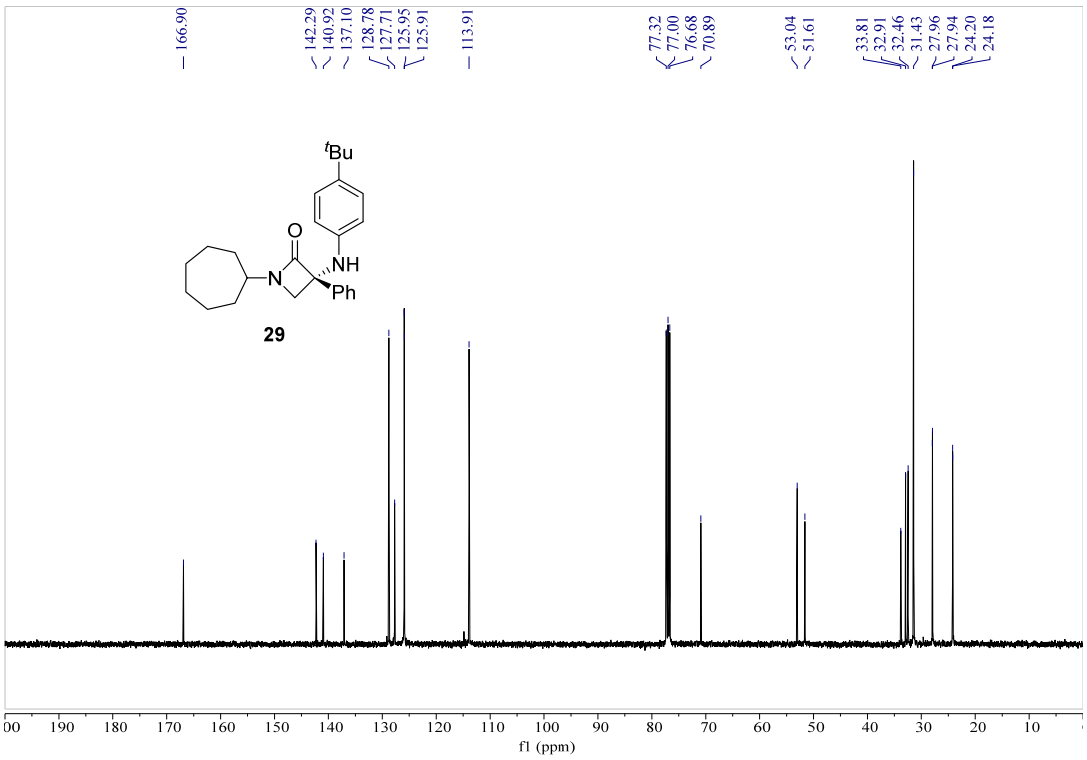
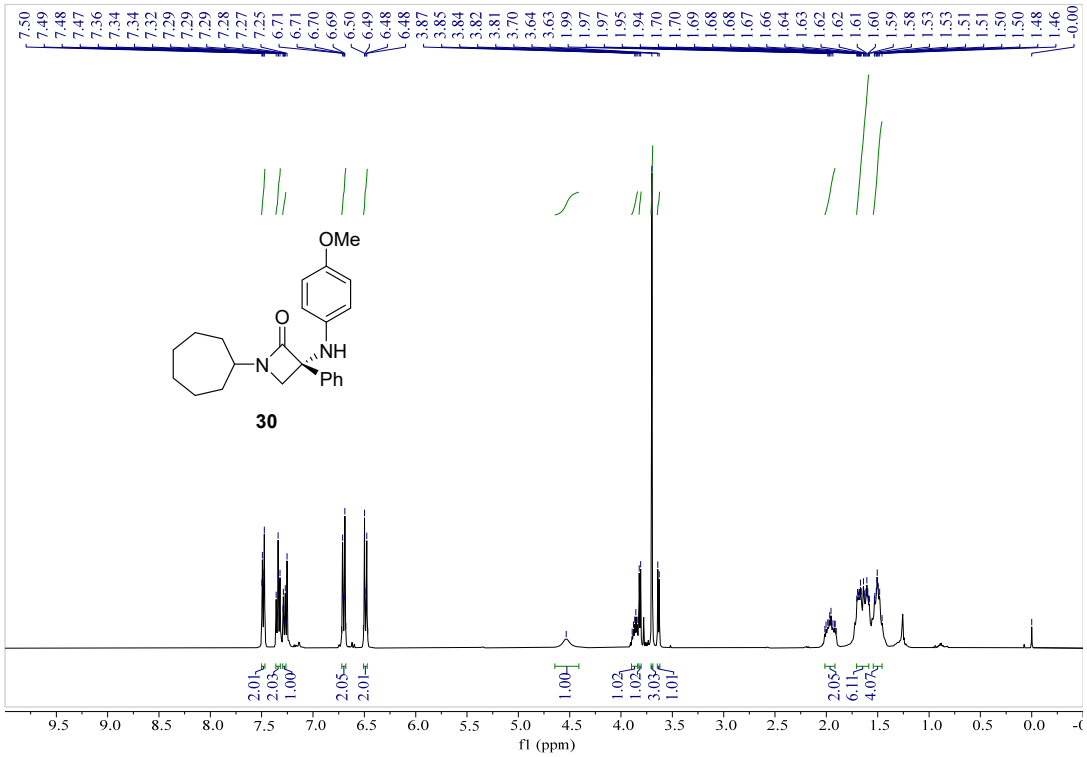
N
O
NH
N
Ph
27
f1 (ppm)

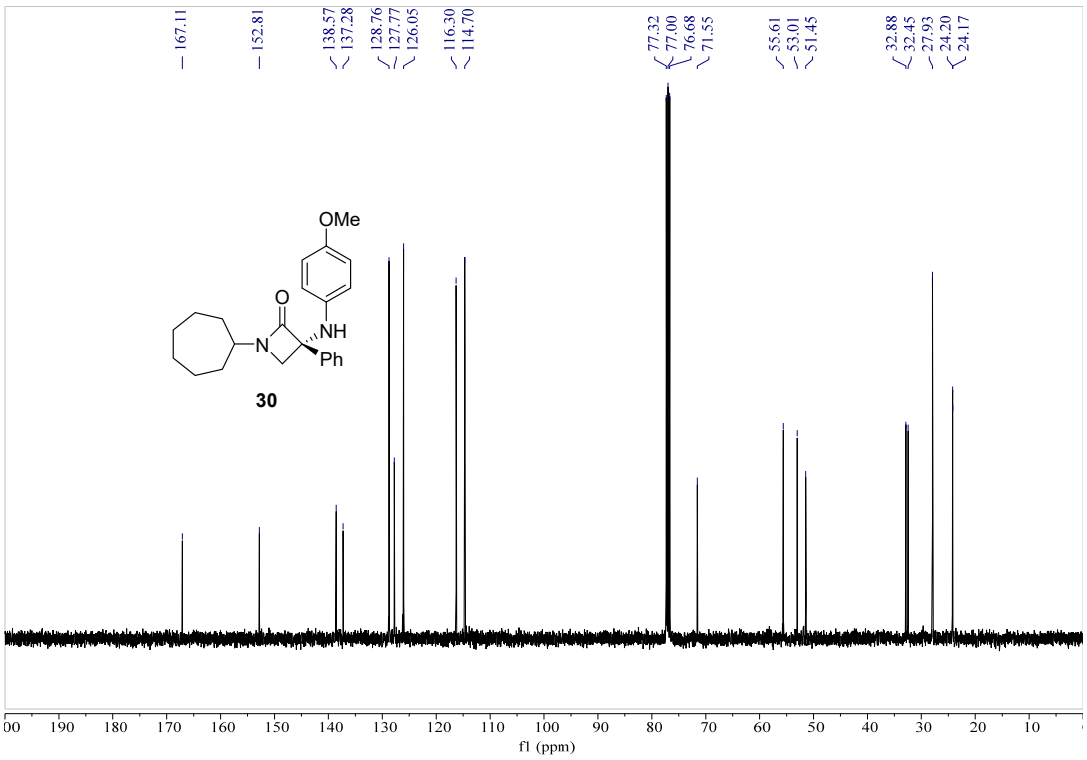

7.48 7.48 7.46 7.46 7.36 7.34 7.34 7.33 7.32 7.29 7.27 7.25 7.12 7.10 7.10 7.08 6.71 6.71 6.48 6.48 6.47 6.46 6.46 3.90 3.89 3.88 3.87 3.68 3.67 1.73 1.73 1.71 1.71 1.71 1.70 1.69 1.68 1.67 1.66 1.65 1.64 1.63 1.63 1.62 1.62 1.61 1.60 1.59 1.55 1.54 1.53 1.52 1.52 1.51 1.51 1.50 1.50 1.49 -0.00
O
NH
Ph
N
28
2.00 2.03 1.01 2.03 1.02 2.03 1.00 2.04 1.02 2.04 6.10 4.06
f1 (ppm)

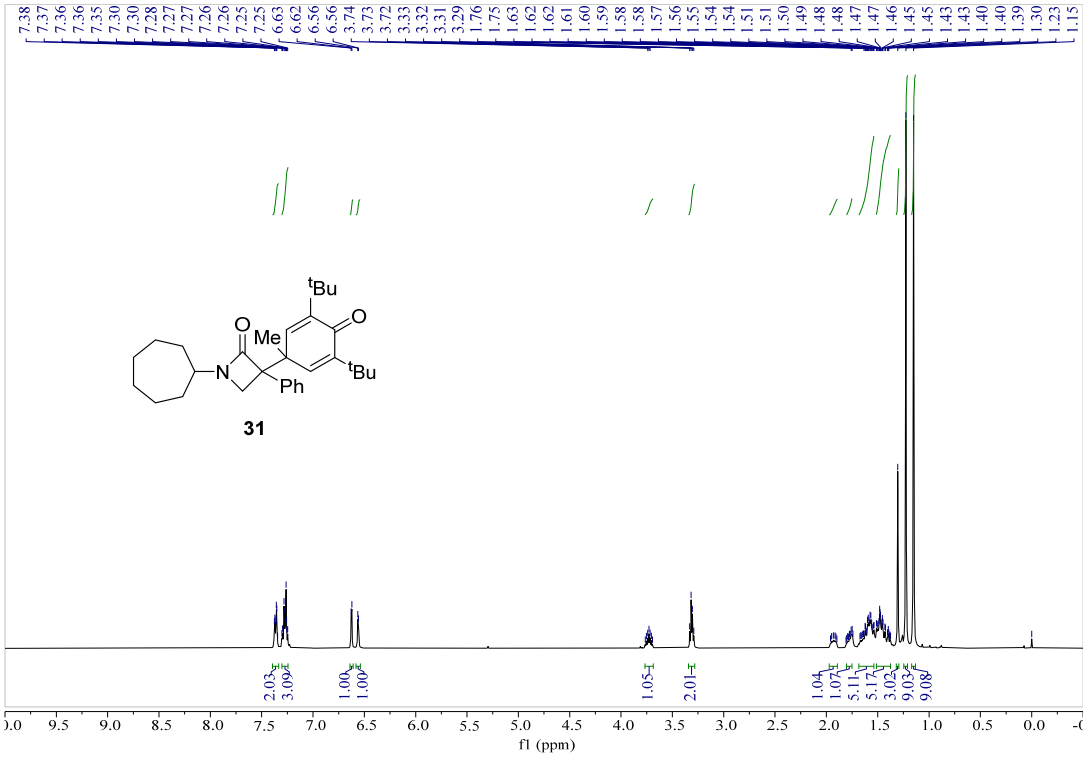

166.73 144.83 136.77 129.16 128.84 127.80 125.90 118.21 114.19 77.32 77.00 76.68 70.72 53.18 51.79 32.95 32.47 27.96 27.94 24.22 24.19
O
NH
Ph
N
28
f1 (ppm)

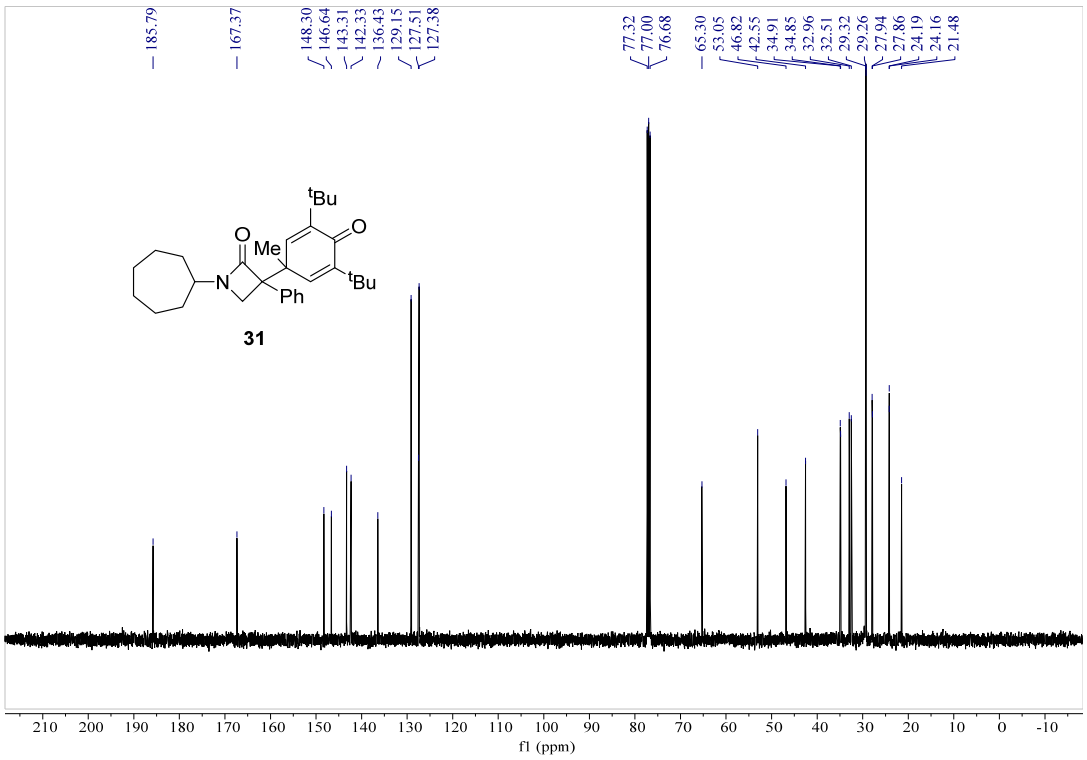

7.50 7.49 7.48 7.48 7.47 7.36 7.36 7.34 7.34 7.32 7.32 7.29 7.29 7.28 7.27 7.13 7.13 7.12 7.11 6.43 6.42 6.41 6.41 3.88 3.87 3.86 3.85 3.69 3.67 1.97 1.72 1.72 1.71 1.70 1.69 1.68 1.67 1.66 1.66 1.65 1.65 1.63 1.62 1.61 1.59 1.59 1.56 1.55 1.55 1.54 1.53 1.52 1.51 1.50 1.49 1.49 1.48 1.47 1.24
tBu
O
NH
N
Ph
29
2.01 2.04 1.00 2.04 2.06 1.00 2.06 1.02 2.05 6.13 4.08 9.05
fl (ppm)


166.90
142.29 140.92 137.10 128.78 127.71 125.95 125.91 113.91
77.32 77.00 76.68 70.89
53.04 51.61
33.81 32.91 32.46 31.43 27.96 27.94 24.20 24.18
tBu
O
NH
N
Ph
29
fl (ppm)

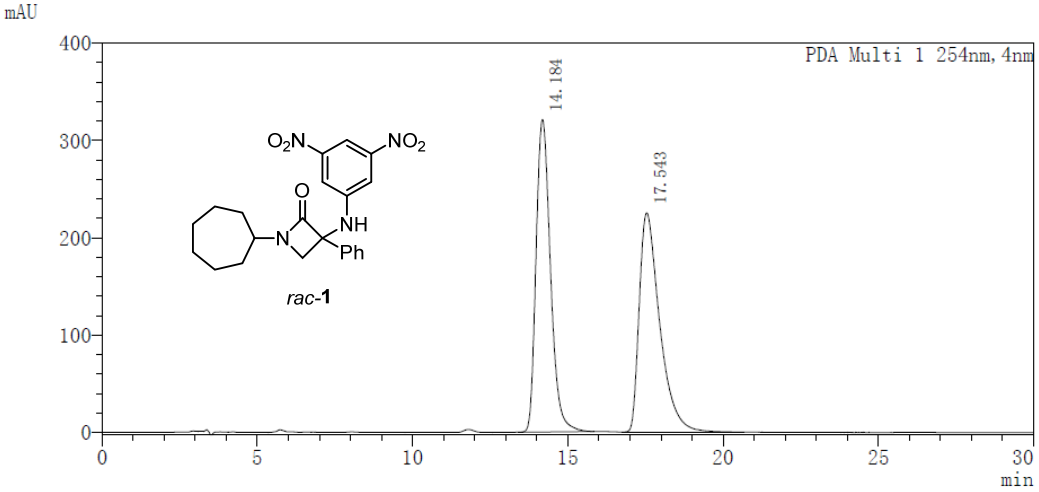

OMe
O
NH
N
Ph
30
fl (ppm)


OMe
O
NH
N
Ph
30
fl (ppm)


tBu
O
Me
O
N
tBu
Ph
31
fl (ppm)


tBu
O
Me
O
N
tBu
Ph
31
fl (ppm)

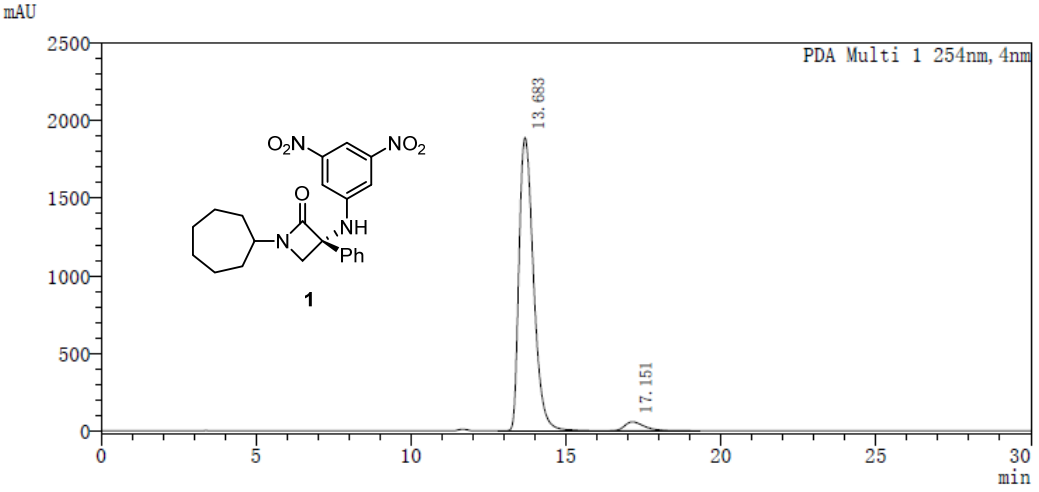
9. HPLC spectra



Peak Table

PDA Ch1 254nm

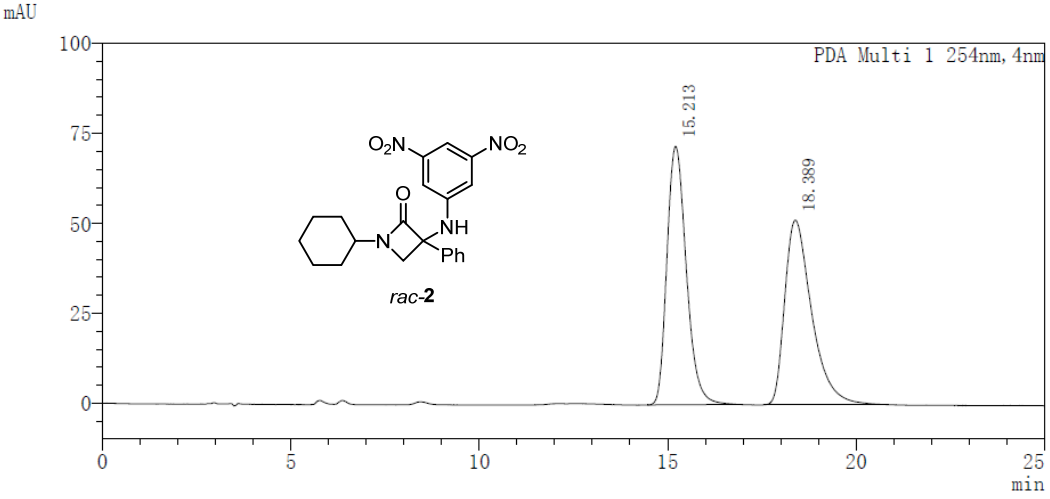
Peak#	Ret. Time	Area	Area%
1	14.184	10380734	50.147
2	17.543	10319798	49.853



Peak Table

PDA Ch1 254nm

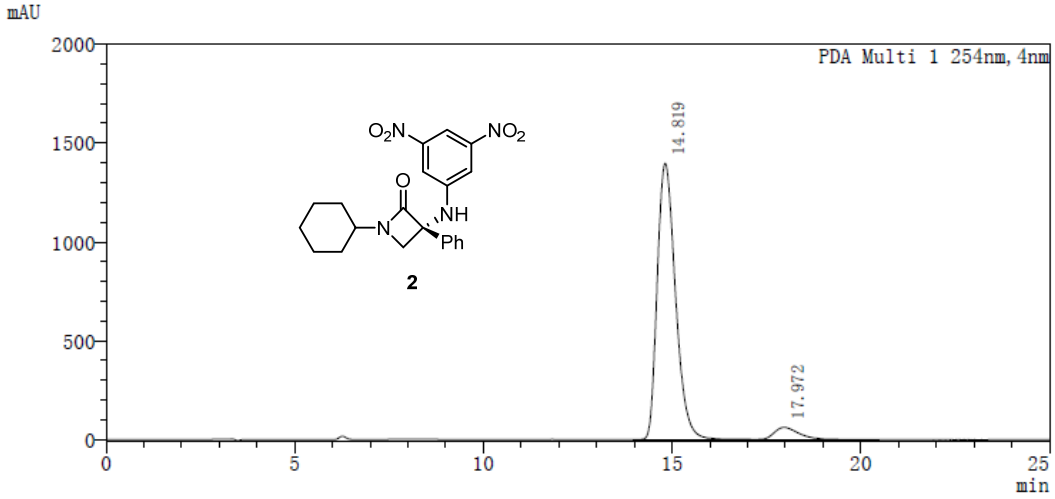
Peak#	Ret. Time	Area	Area%
1	13.683	61784131	96.084
2	17.151	2518274	3.916



Peak Table

PDA Ch1 254nm

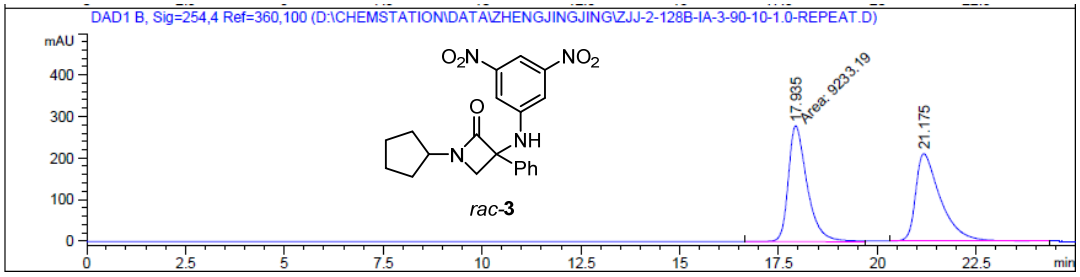
Peak#	Ret. Time	Area	Area%
1	15.213	2573664	50.207
2	18.389	2552479	49.793



Peak Table

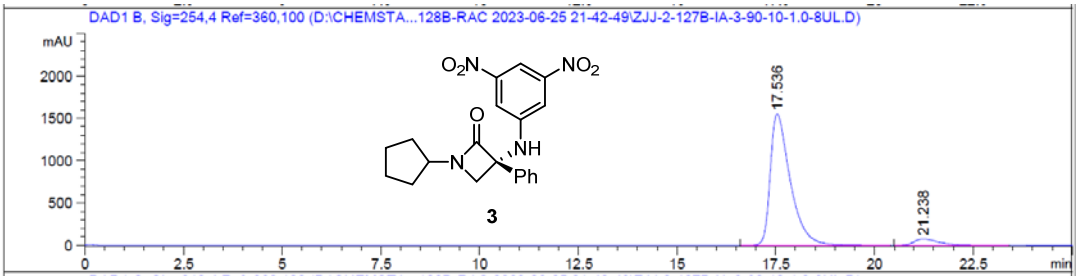
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	14.819	47140337	94.220
2	17.972	2891639	5.780



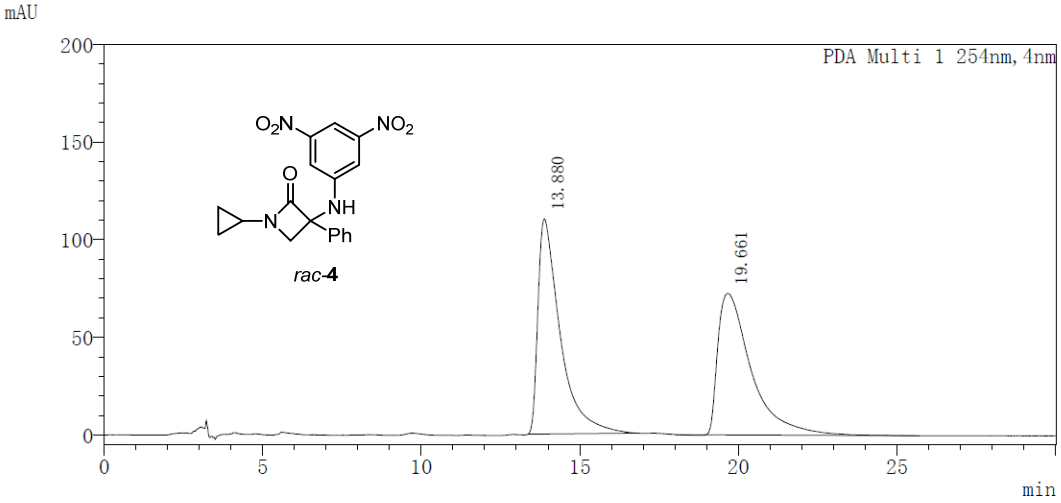
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.935	MM	0.5532	9233.18750	278.16382	50.0435
2	21.175	BB	0.6430	9217.12988	210.43494	49.9565
Totals :				1.84503e4	488.59875	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

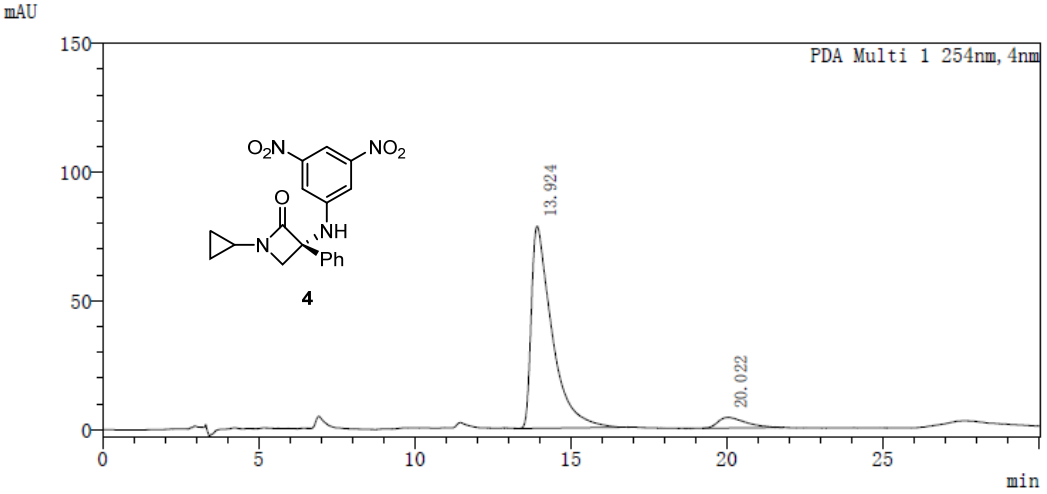
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.536	BB	0.5223	5.48429e4	1551.93860	94.3056
2	21.238	BB	0.6420	3311.54785	76.04895	5.6944
Totals :				5.81545e4	1627.98755	



Peak Table

PDA Ch1 254nm

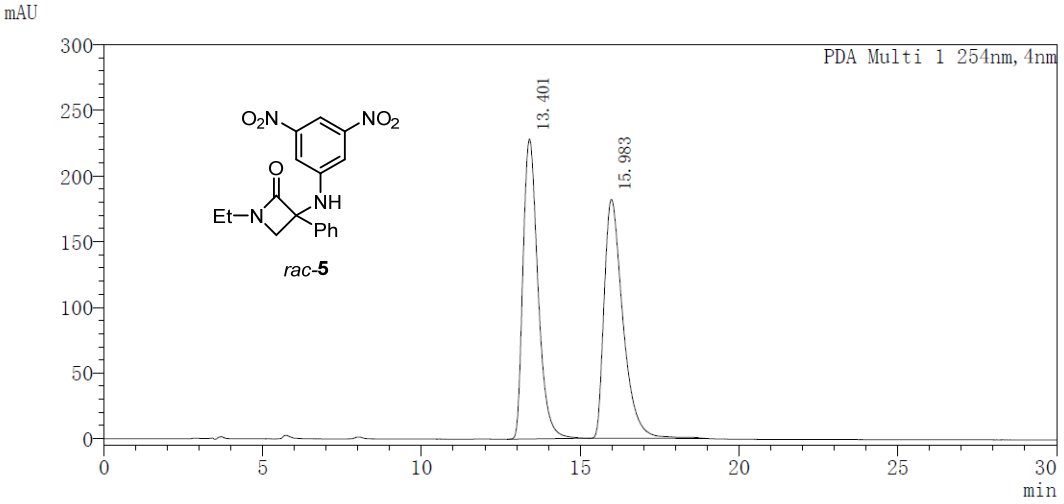
Peak#	Ret. Time	Area	Area%
1	13.880	5372678	50.292
2	19.661	5310277	49.708



Peak Table

PDA Ch1 254nm

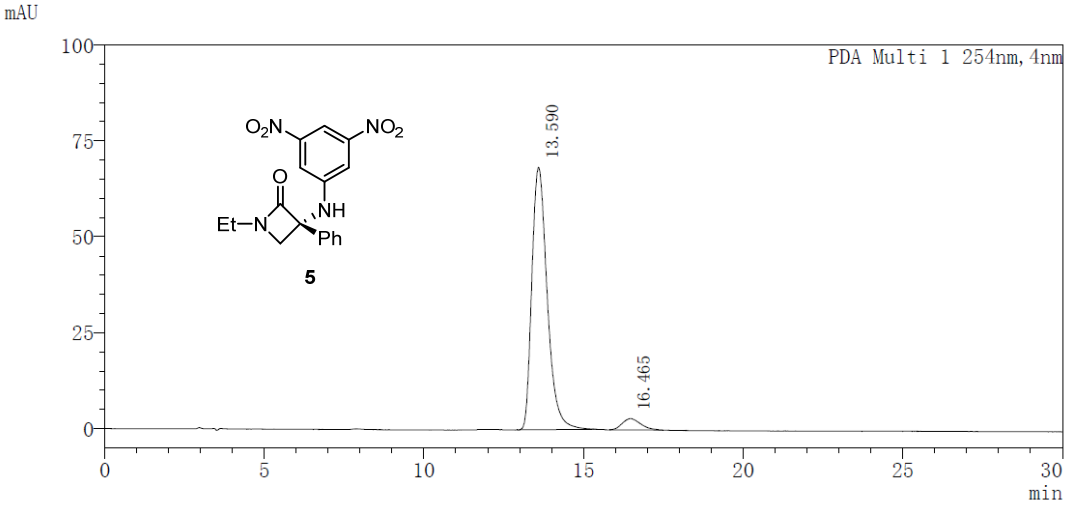
Peak#	Ret. Time	Area	Area%
1	13.924	3621920	93.449
2	20.022	253903	6.551



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	13.401	7481747	49.963
2	15.983	7492783	50.037

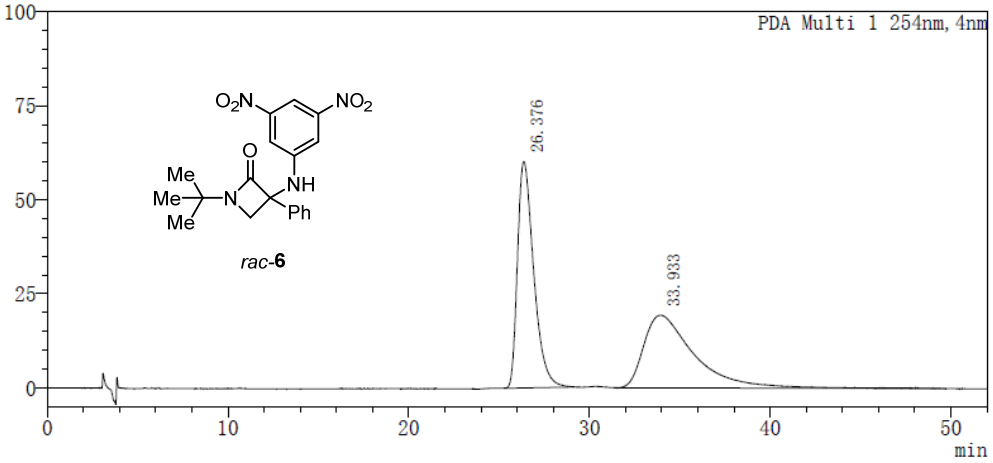


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	13.590	2292285	95.148
2	16.465	116902	4.852

mAU

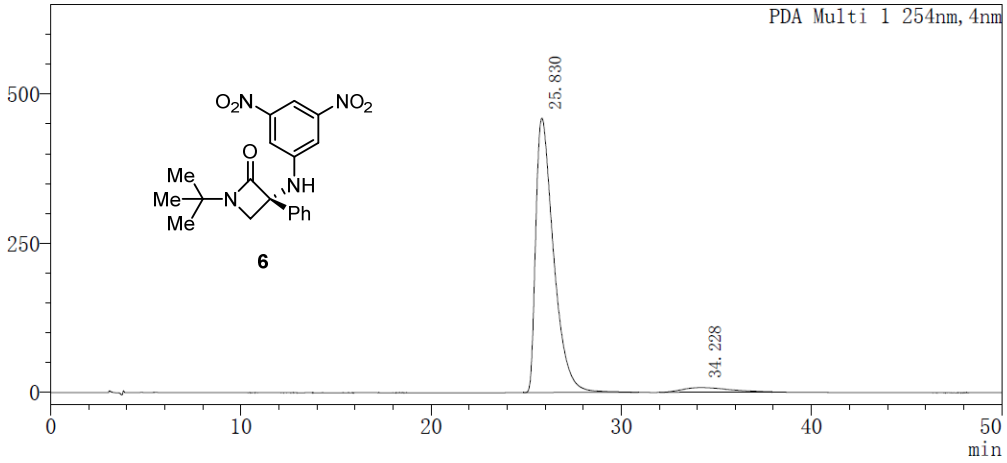


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	26.376	3758092	50.038
2	33.933	3752333	49.962

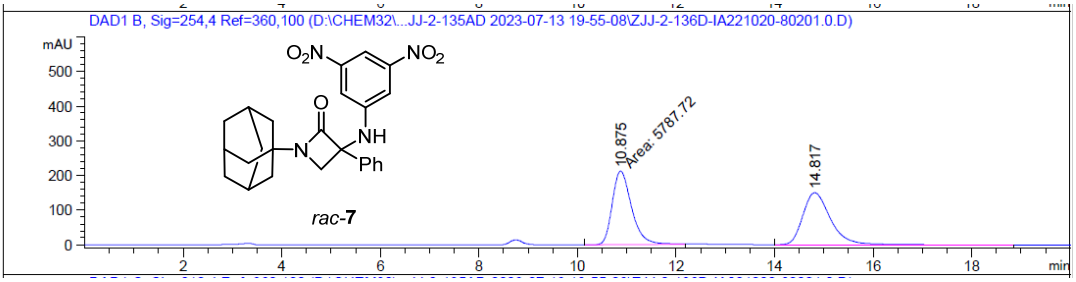
mAU



Peak Table

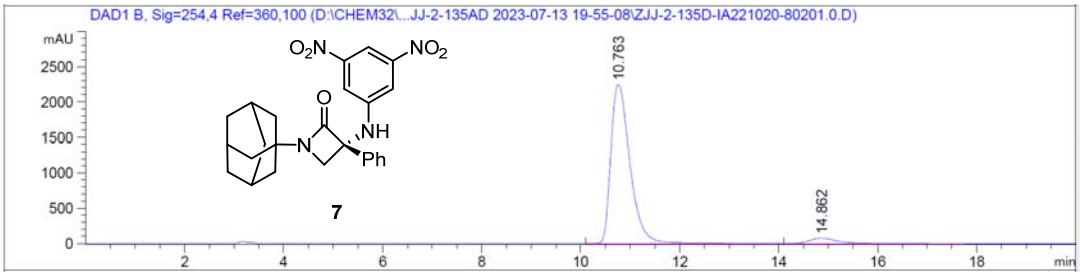
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	25.830	29949106	95.694
2	34.228	1347580	4.306



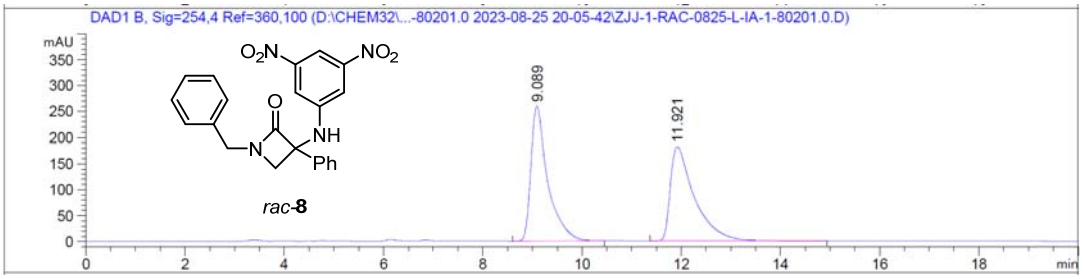
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.875	MM	0.4550	5787.72070	211.99913	49.7033
2	14.817	BB	0.6001	5856.81348	149.81439	50.2967
Totals :				1.16445e4	361.81352	



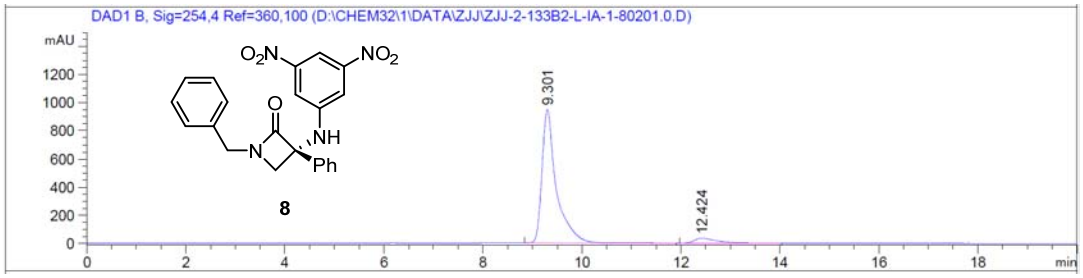
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.763	BB	0.4120	6.00029e4	2243.72974	95.5395
2	14.862	BB	0.5818	2801.38062	73.65028	4.4605
Totals :				6.28043e4	2317.38001	



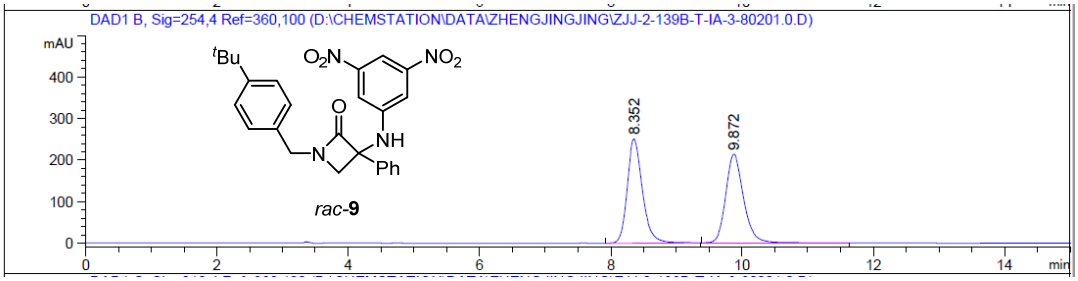
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.089	BB	0.3428	6119.02490	259.74069	49.8248
2	11.921	BB	0.4893	6162.05615	181.84819	50.1752
Totals :				1.22811e4	441.58888	



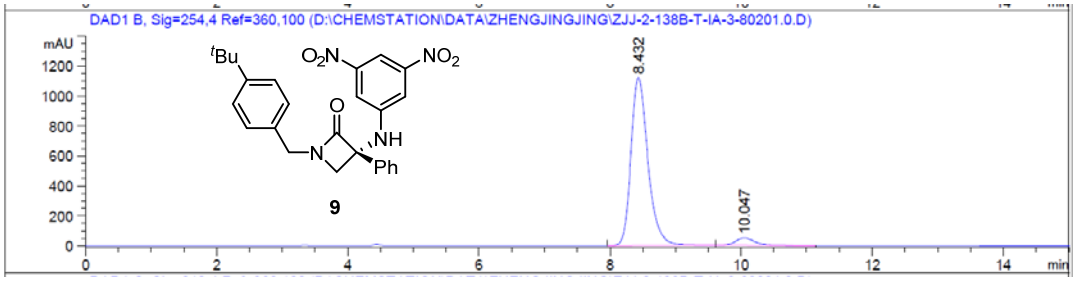
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.301	BB	0.2914	1.90792e4	945.61725	94.3666
2	12.424	BB	0.4691	1138.96326	35.23597	5.6334
Totals :				2.02181e4	980.85321	



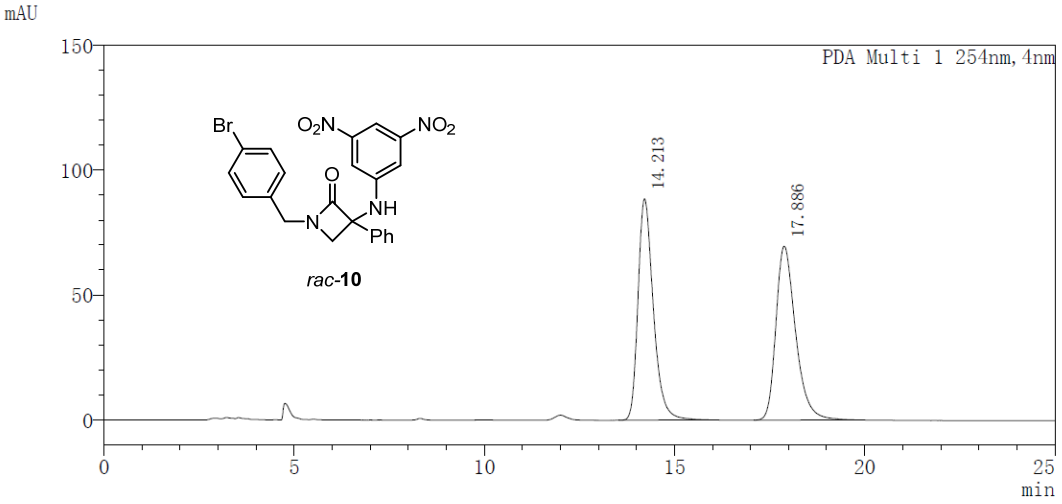
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.352	BB	0.2451	4027.23608	251.09586	50.0512
2	9.872	BB	0.2876	4018.99243	213.52142	49.9488
Totals :				8046.22852	464.61728	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

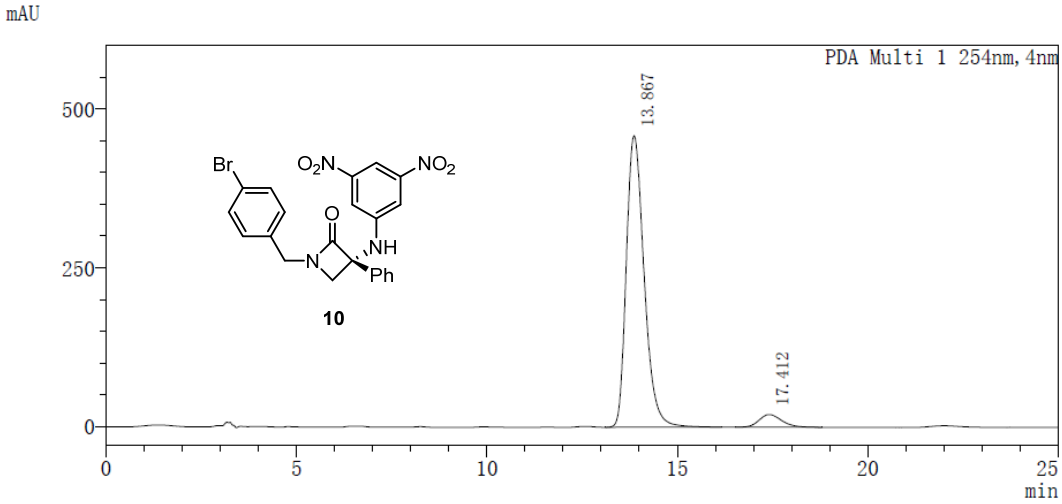
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.432	BB	0.2759	2.01609e4	1120.74963	95.1854
2	10.047	BB	0.3117	1019.76605	50.05503	4.8146
Totals :				2.11807e4	1170.80466	



Peak Table

PDA Ch1 254nm

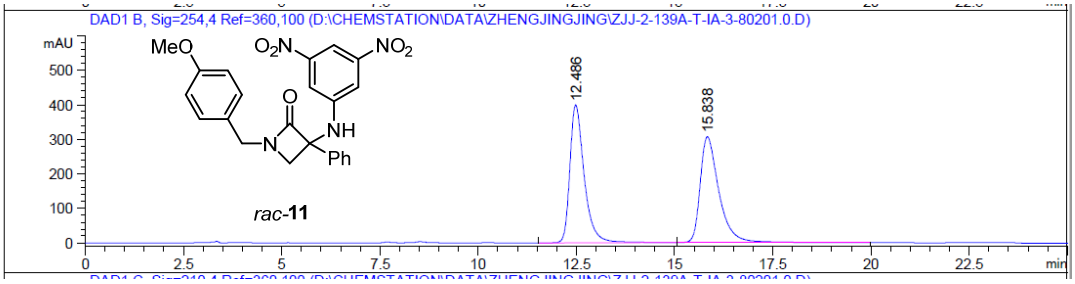
Peak#	Ret. Time	Area	Area%
1	14.213	2488256	49.819
2	17.886	2506293	50.181



Peak Table

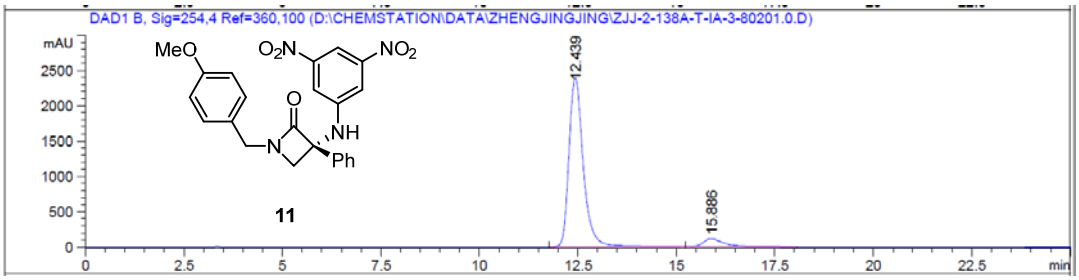
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	13.867	14921366	94.876
2	17.412	805783	5.124



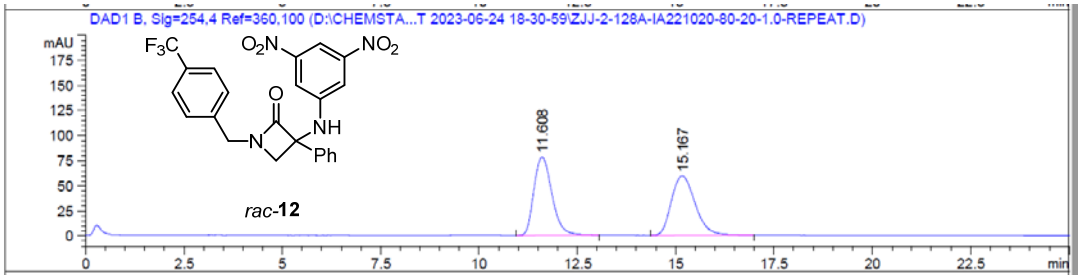
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.486	BB	0.3821	1.01156e4	398.57224	49.8981
2	15.838	BB	0.4972	1.01569e4	305.99948	50.1019
Totals :				2.02725e4	704.57172	



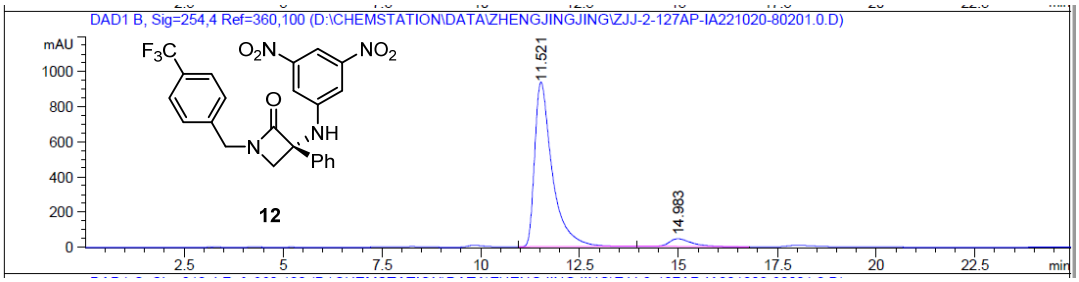
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.439	BB	0.3847	6.01379e4	2397.42700	93.8301
2	15.886	BB	0.5171	3954.43213	113.33216	6.1699
Totals :				6.40923e4	2510.75916	



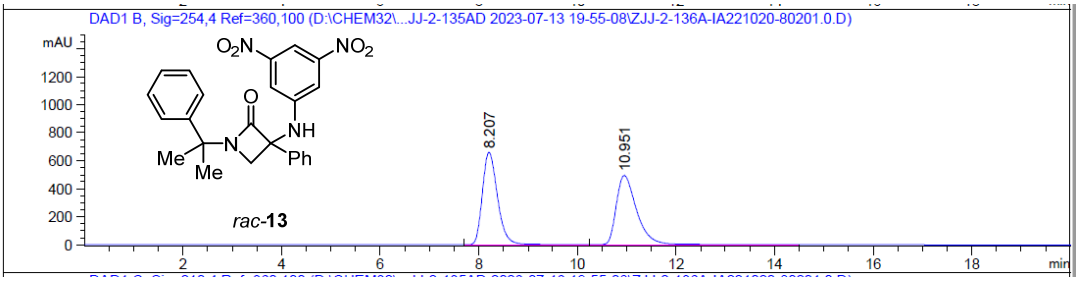
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.608	BB	0.5046	2483.98022	77.78592	50.0054
2	15.167	BB	0.6460	2483.44238	59.13467	49.9946
Totals :				4967.42261	136.92059	



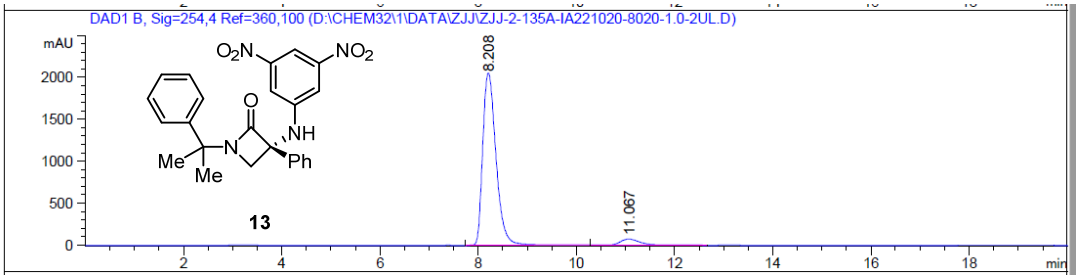
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.521	BB	0.4569	2.90536e4	939.13513	94.0325
2	14.983	BB	0.6002	1843.79761	45.17266	5.9675
Totals :				3.08974e4	984.30780	



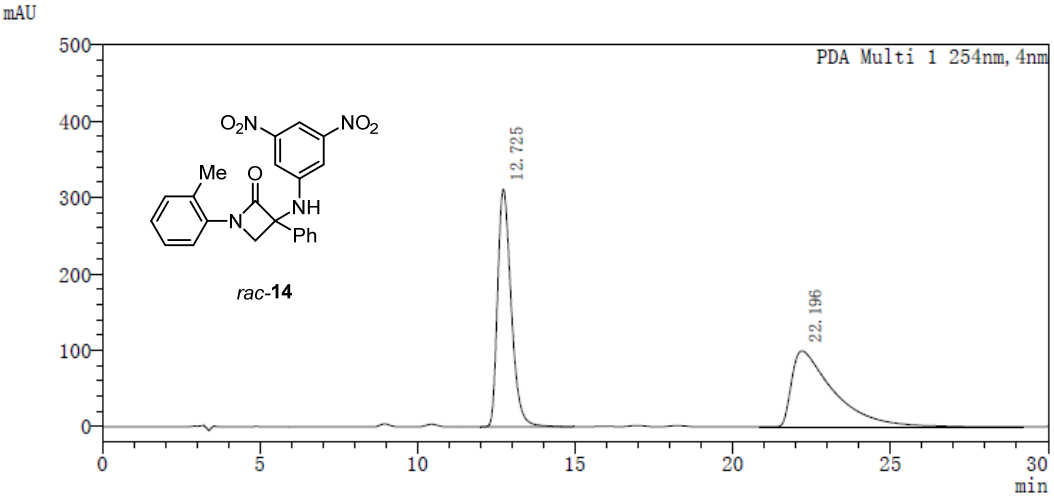
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.207	BB	0.3314	1.40891e4	658.96533	49.8459
2	10.951	BB	0.4371	1.41762e4	493.61322	50.1541
Totals :				2.82654e4	1152.57855	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

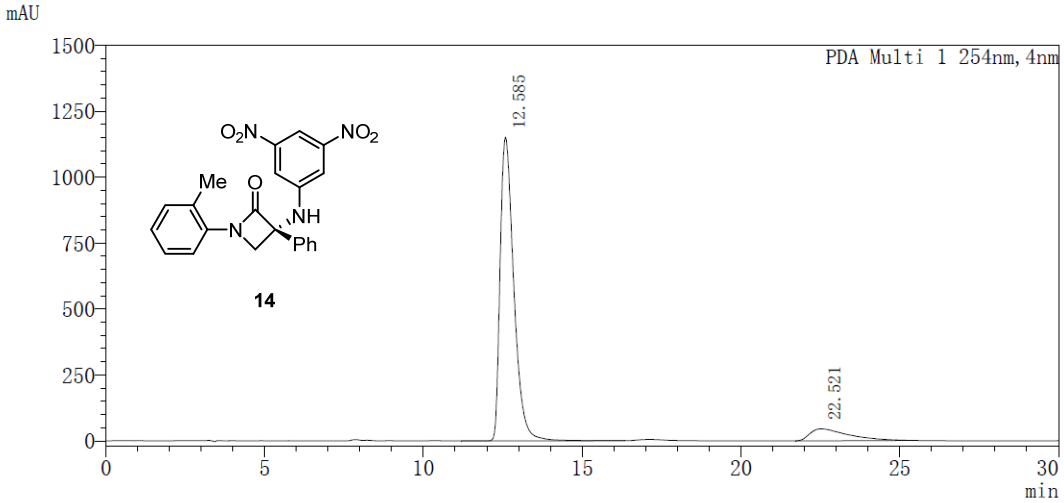
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.208	BB	0.2895	3.82207e4	2050.43994	95.2371
2	11.067	BB	0.4129	1911.46826	71.27647	4.7629
Totals :				4.01322e4	2121.71641	



Peak Table

PDA Ch1 254nm

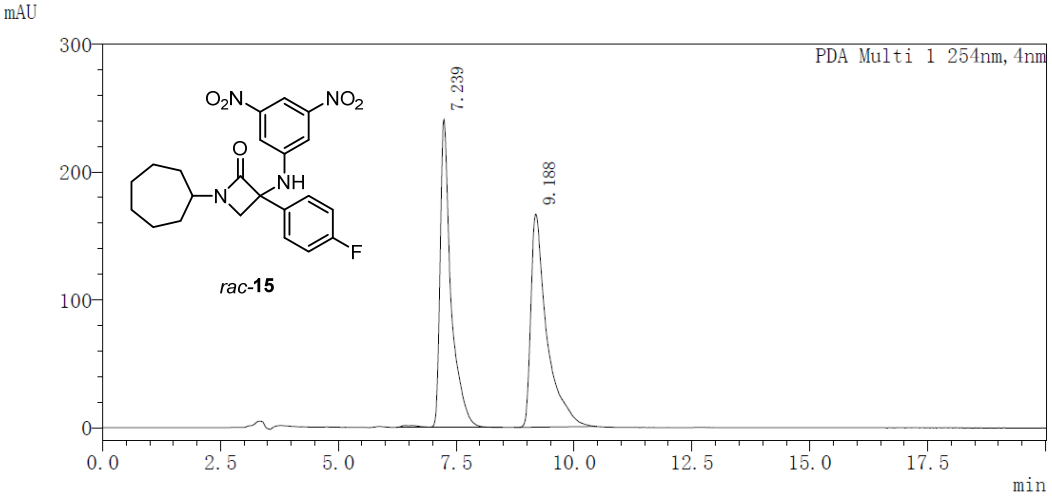
Peak#	Ret. Time	Area	Area%
1	12.725	9327082	50.159
2	22.196	9267834	49.841



Peak Table

PDA Ch1 254nm

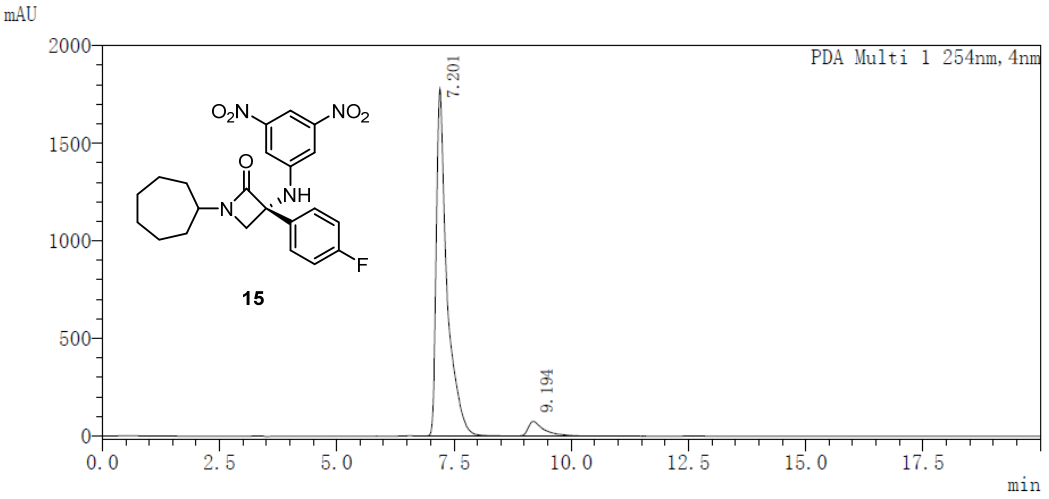
Peak#	Ret. Time	Area	Area%
1	12.585	34543007	90.096
2	22.521	3797071	9.904



Peak Table

PDA Ch1 254nm

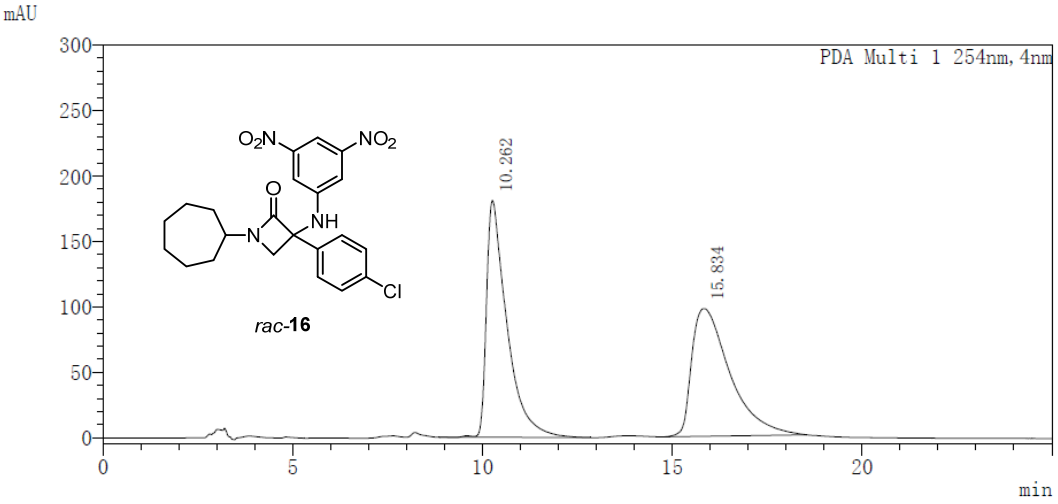
Peak#	Ret. Time	Area	Area%
1	7.239	3912353	49.679
2	9.188	3962835	50.321



Peak Table

PDA Ch1 254nm

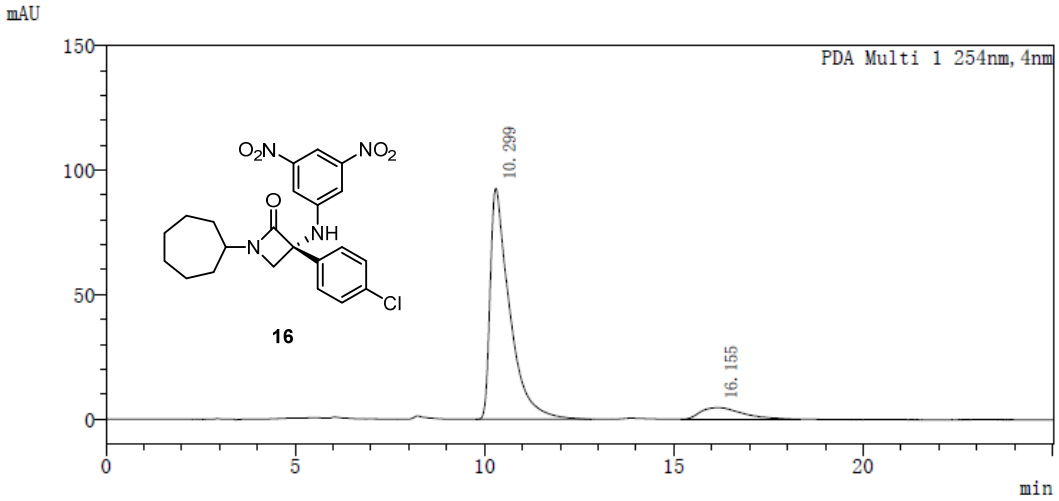
Peak#	Ret. Time	Area	Area%
1	7.201	28539780	94.183
2	9.194	1762580	5.817



Peak Table

PDA Ch1 254nm

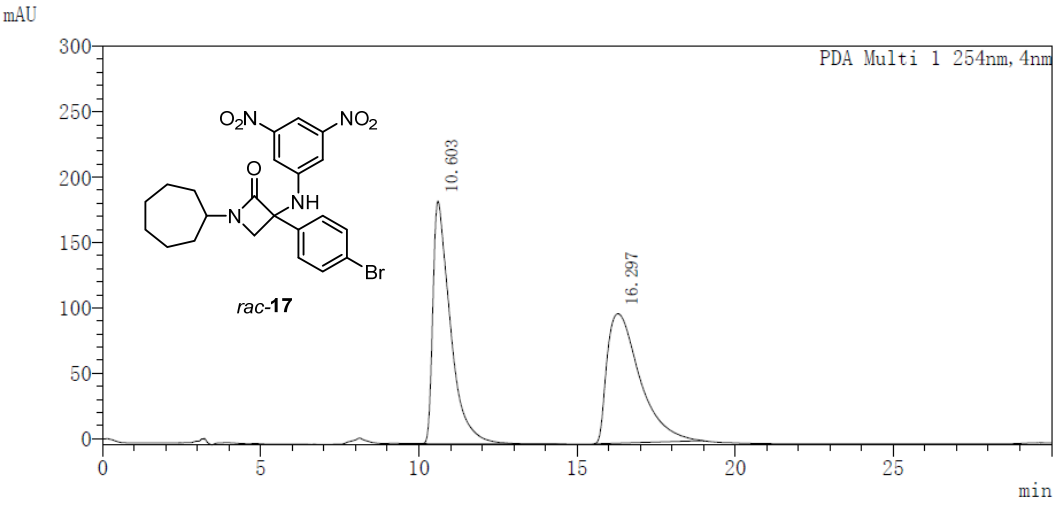
Peak#	Ret. Time	Area	Area%
1	10.262	6786345	49.843
2	15.834	6829011	50.157



Peak Table

PDA Ch1 254nm

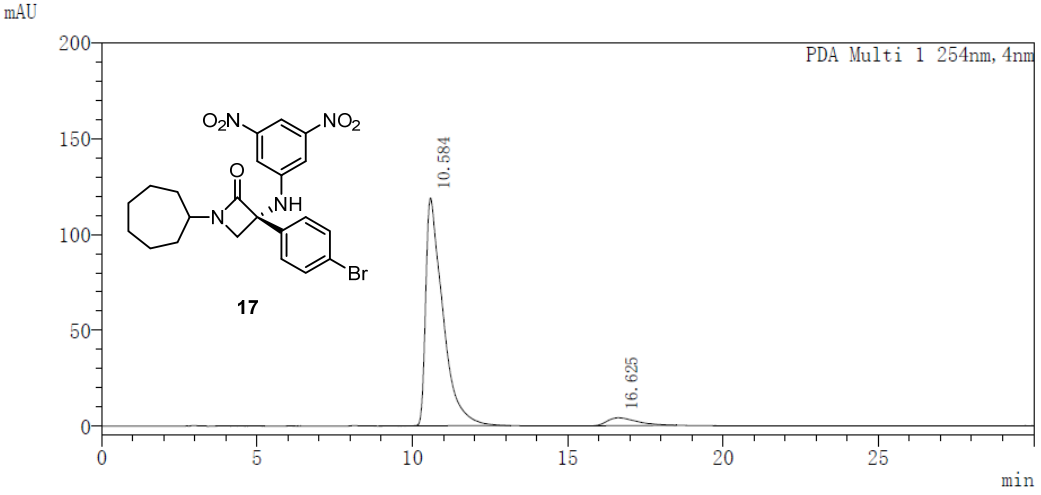
Peak#	Ret. Time	Area	Area%
1	10.299	3304063	90.276
2	16.155	355904	9.724



Peak Table

PDA Ch1 254nm

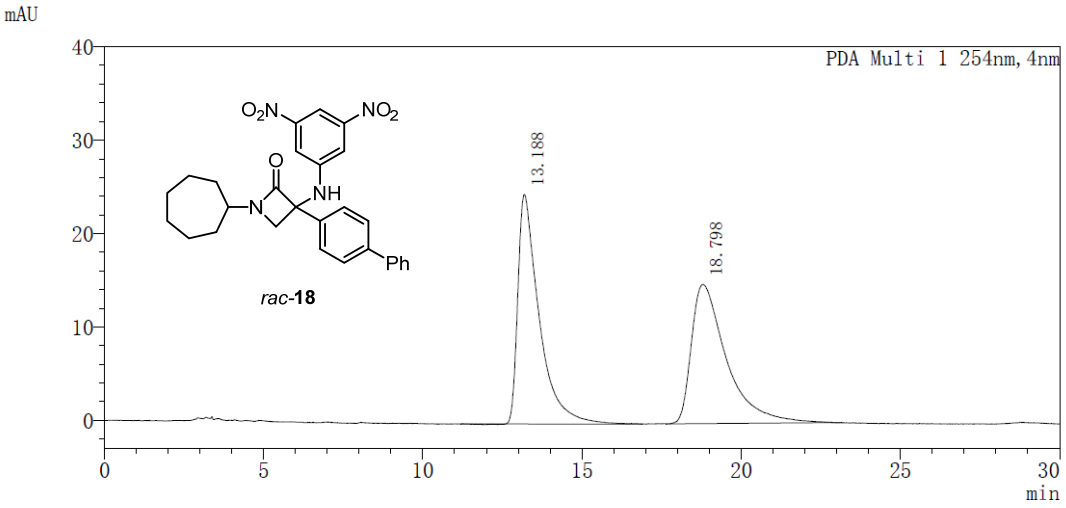
Peak#	Ret. Time	Area	Area%
1	10.603	7153202	49.972
2	16.297	7161225	50.028



Peak Table

PDA Ch1 254nm

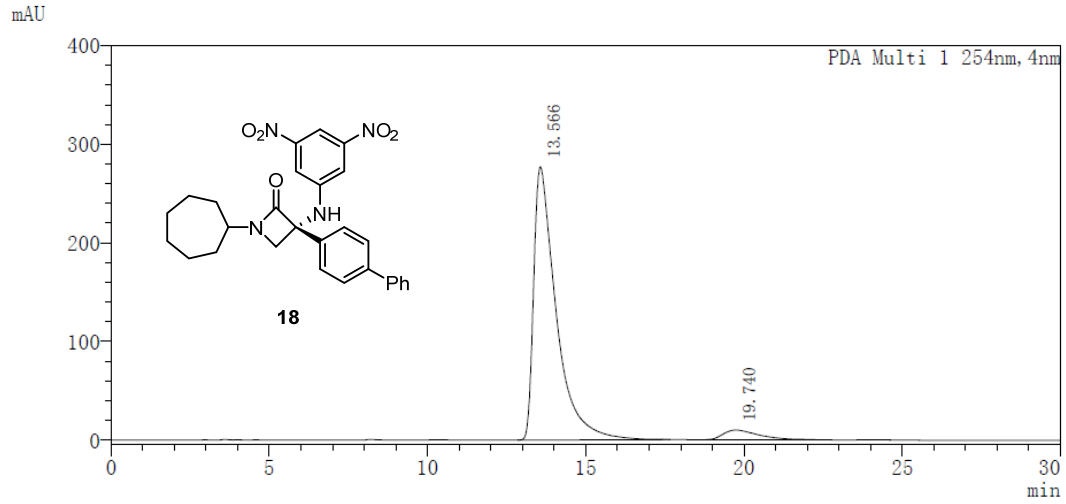
Peak#	Ret. Time	Area	Area%
1	10.584	4565216	94.384
2	16.625	271631	5.616



Peak Table

PDA Ch1 254nm

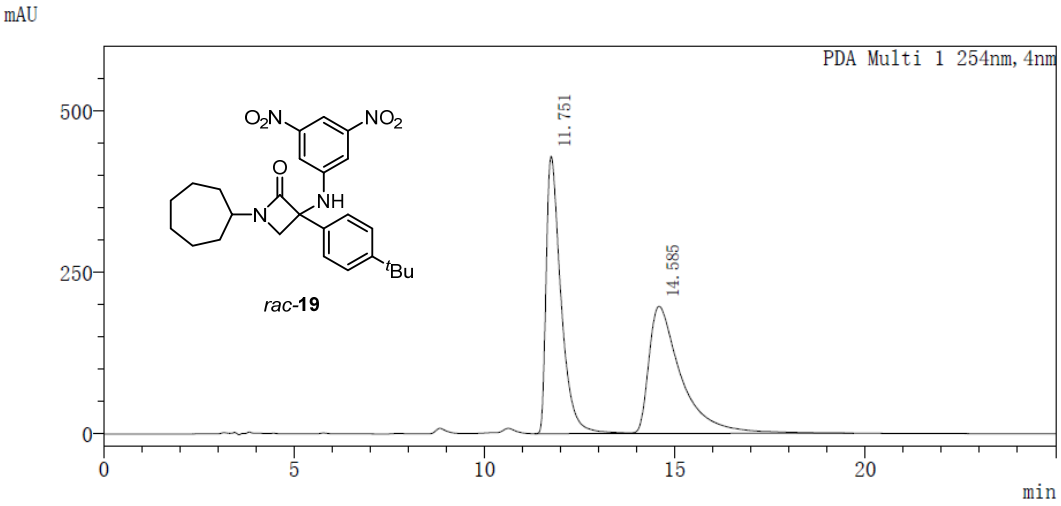
Peak#	Ret. Time	Area	Area%
1	13.188	1143579	50.030
2	18.798	1142219	49.970



Peak Table

PDA Ch1 254nm

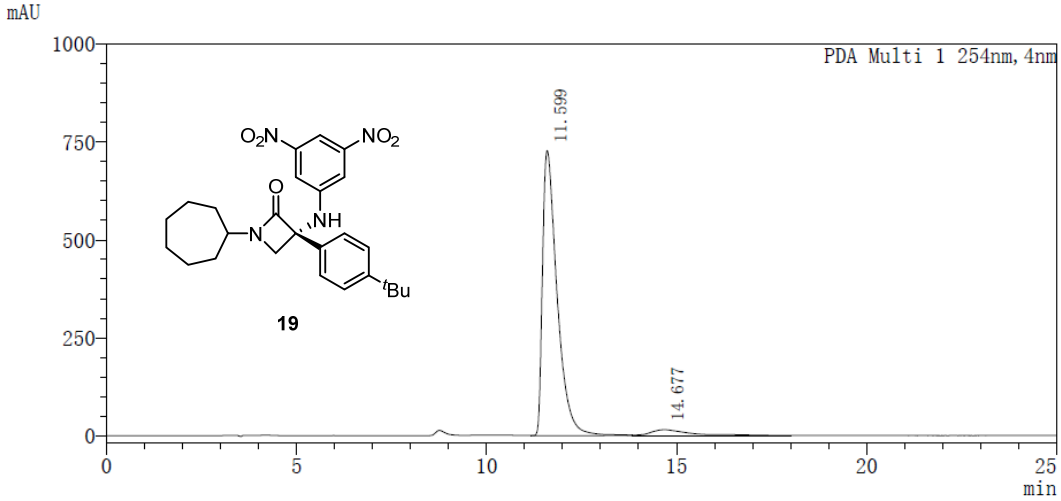
Peak#	Ret. Time	Area	Area%
1	13.566	13714083	94.544
2	19.740	791449	5.456



Peak Table

PDA Ch1 254nm

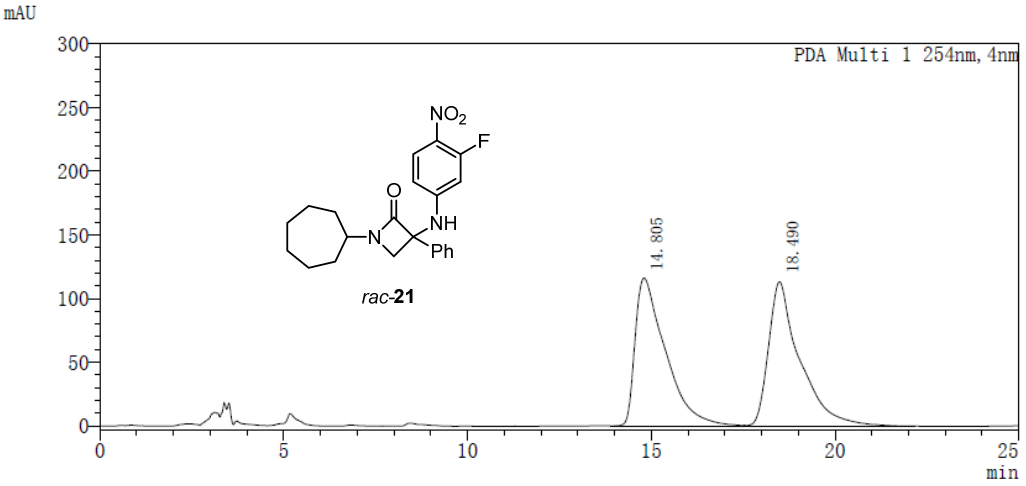
Peak#	Ret. Time	Area	Area%
1	11.751	11650097	50.017
2	14.585	11642065	49.983



Peak Table

PDA Ch1 254nm

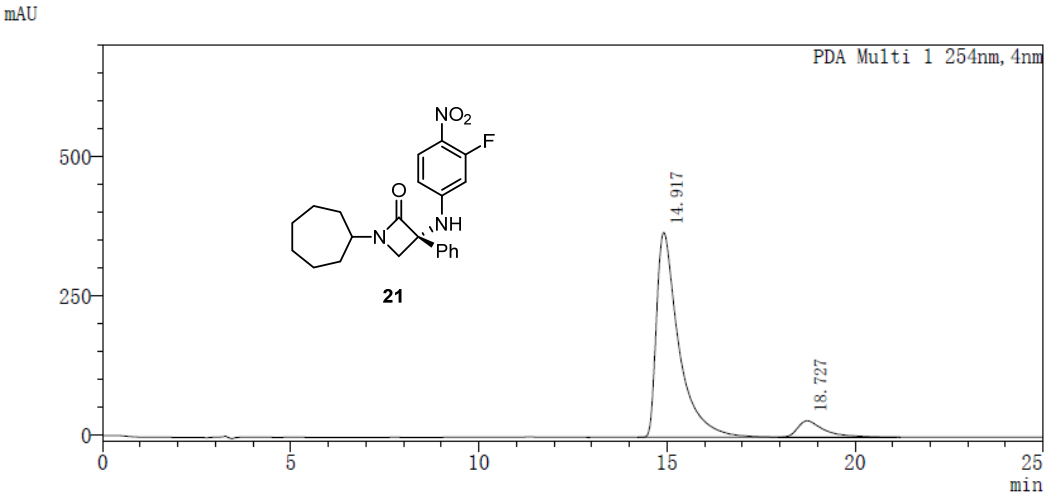
Peak#	Ret. Time	Area	Area%
1	11.599	19492657	94.779
2	14.677	1073864	5.221



Peak Table

PDA Ch1 254nm

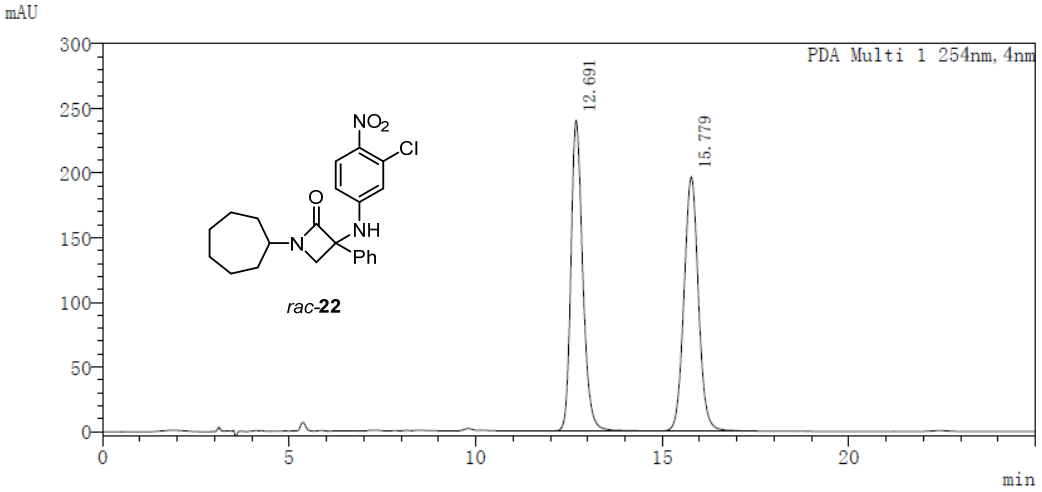
Peak#	Ret. Time	Area	Area%
1	14.805	6721927	49.929
2	18.490	6740930	50.071



Peak Table

PDA Ch1 254nm

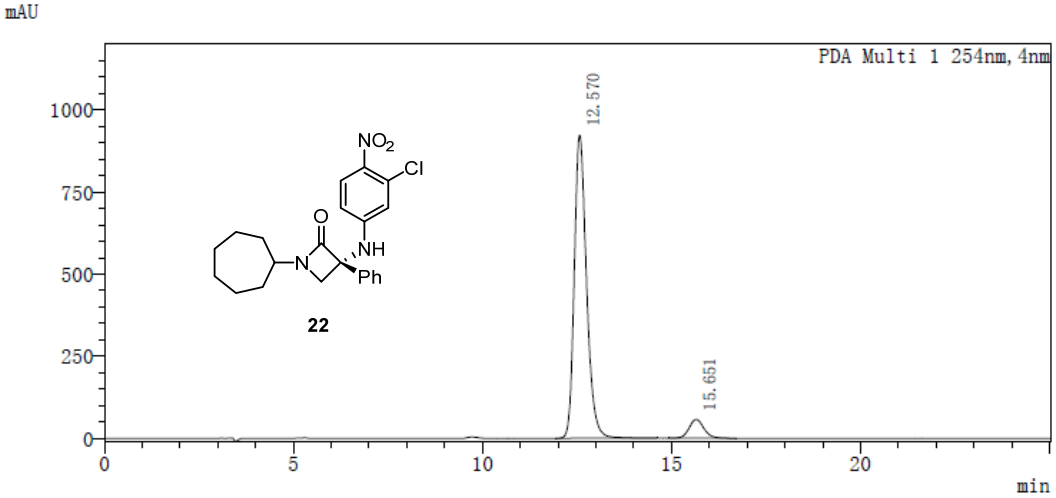
Peak#	Ret. Time	Area	Area%
1	14.917	15282162	91.545
2	18.727	1411408	8.455



Peak Table

PDA Ch1 254nm

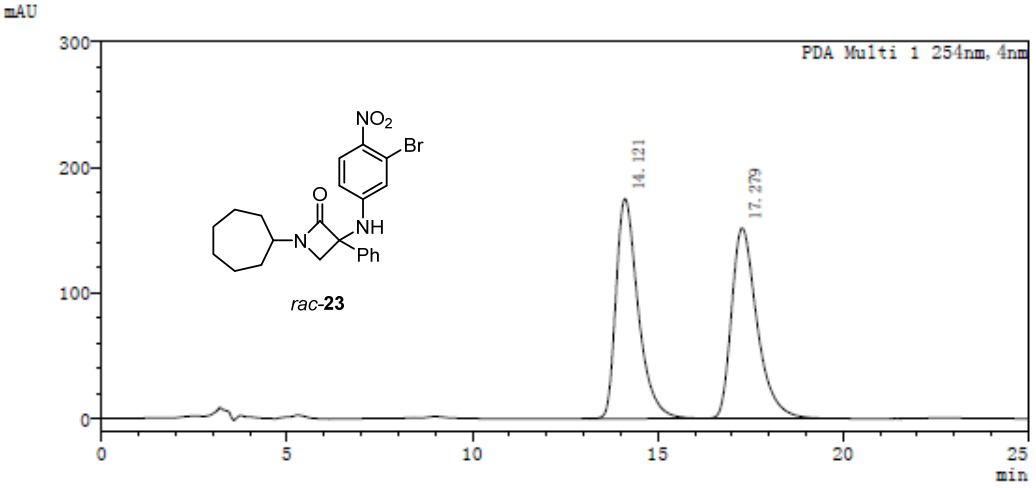
Peak#	Ret. Time	Area	Area%
1	12.691	5286833	50.078
2	15.779	5270281	49.922



Peak Table

PDA Ch1 254nm

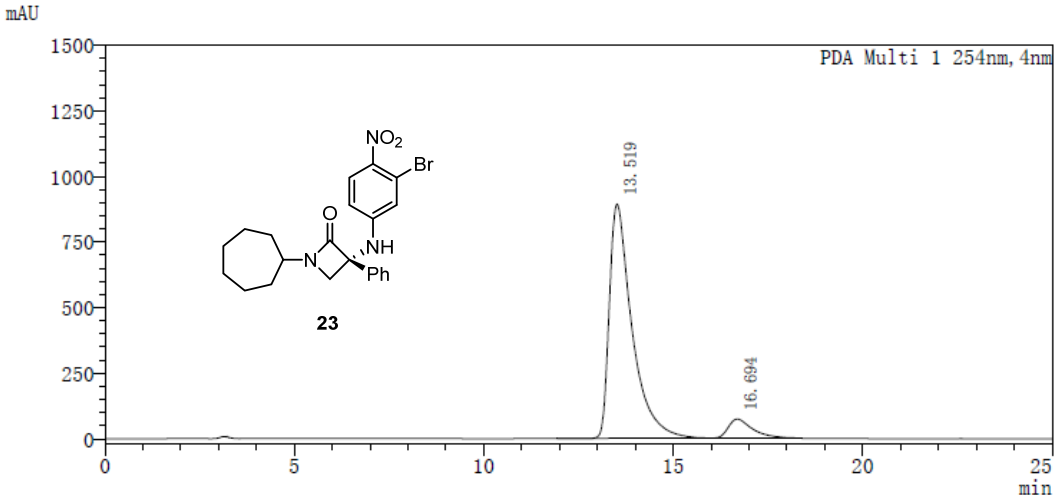
Peak#	Ret. Time	Area	Area%
1	12.570	20752921	93.047
2	15.651	1550674	6.953



Peak Table

PDA Ch1 254nm

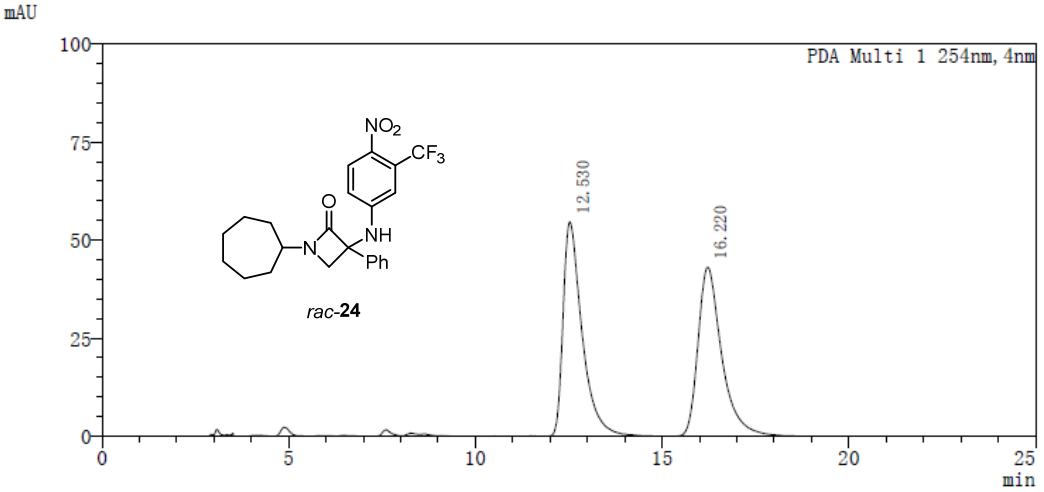
Peak#	Ret. Time	Area	Area%
1	14.121	7296567	49.972
2	17.279	7304748	50.028



Peak Table

PDA Ch1 254nm

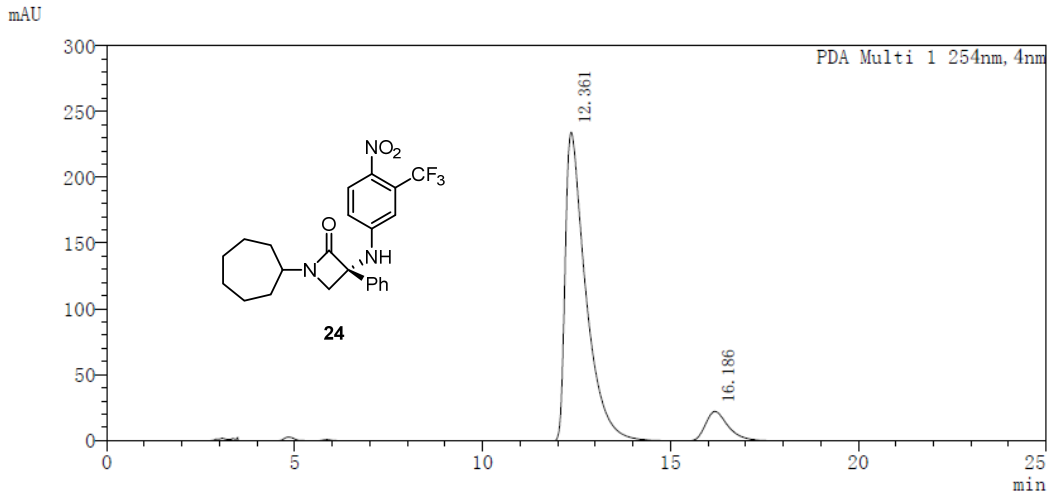
Peak#	Ret. Time	Area	Area%
1	13.519	37129472	92.261
2	16.694	3114510	7.739



Peak Table

PDA Ch1 254nm

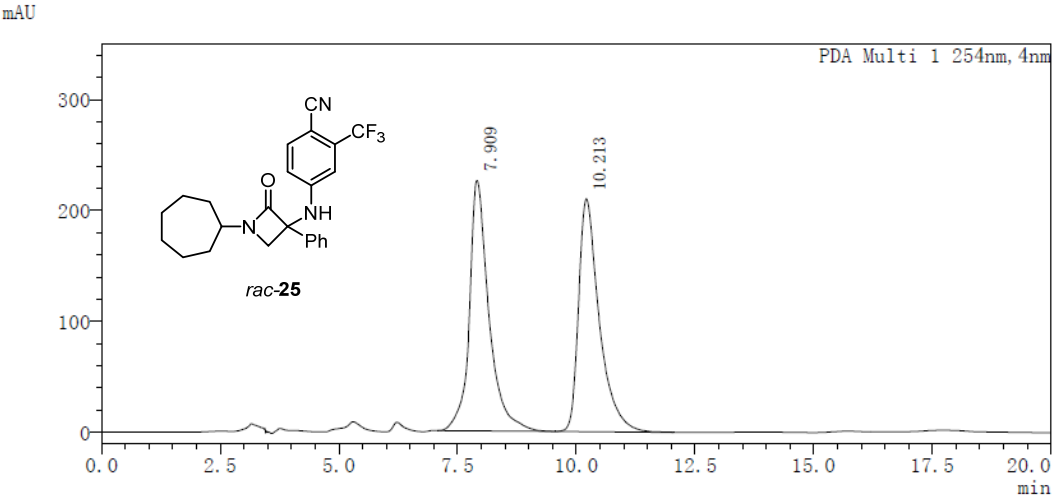
Peak#	Ret. Time	Area	Area%
1	12.530	1942745	50.281
2	16.220	1921042	49.719



Peak Table

PDA Ch1 254nm

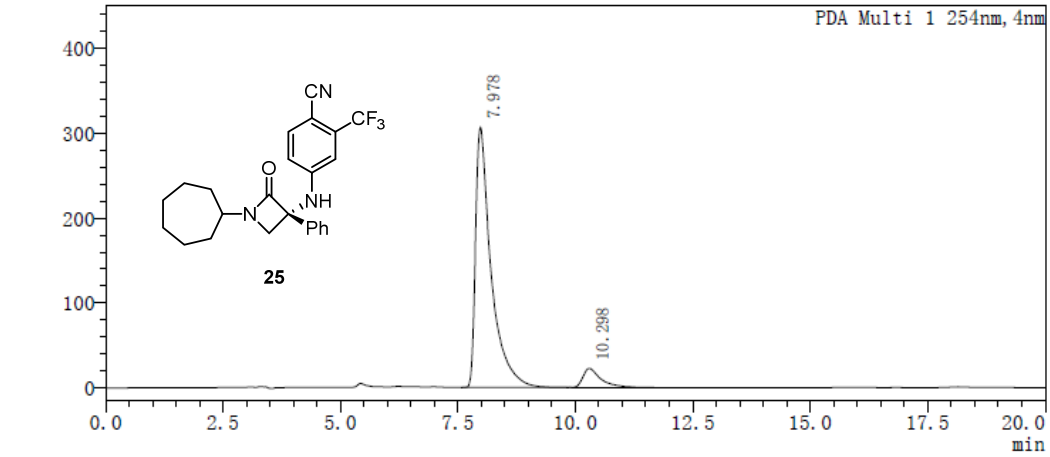
Peak#	Ret. Time	Area	Area%
1	12.361	9023087	90.129
2	16.186	988198	9.871



Peak Table

PDA Ch1 254nm

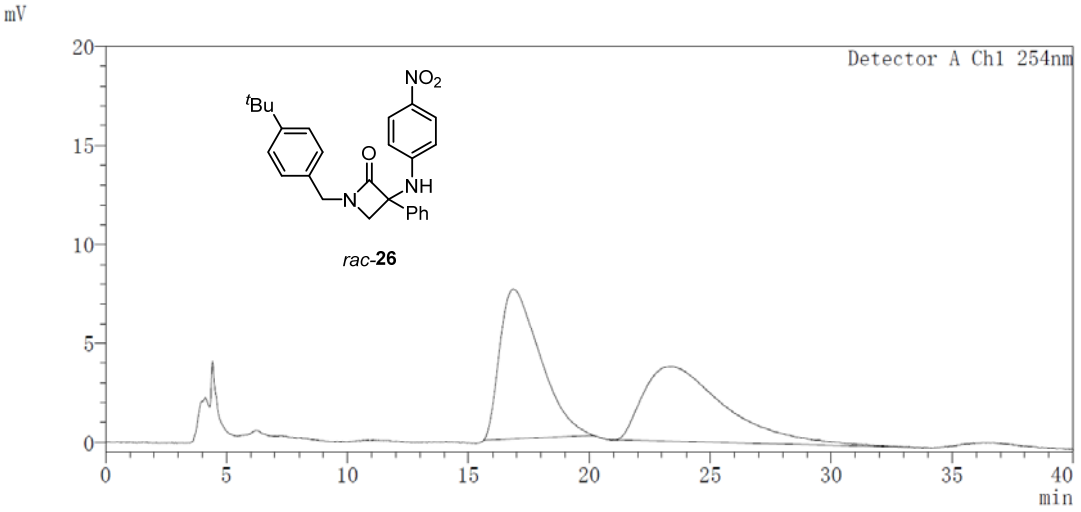
Peak#	Ret. Time	Area	Area%
1	7.909	6504611	50.463
2	10.213	6385346	49.537



Peak Table

PDA Ch1 254nm

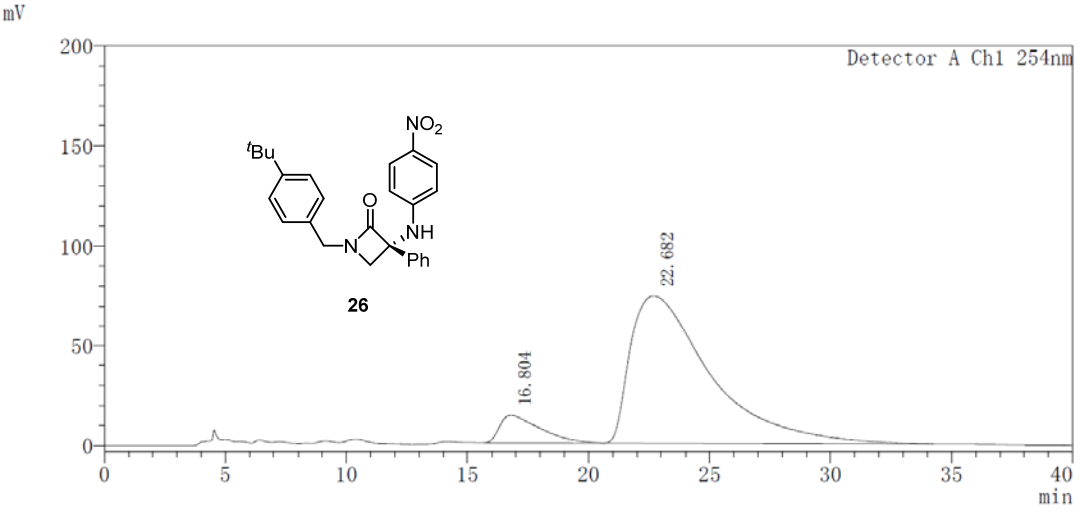
Peak#	Ret. Time	Area	Area%
1	7.978	7060752	91.938
2	10.298	619122	8.062



Peak Table

Detector A Ch1 254nm

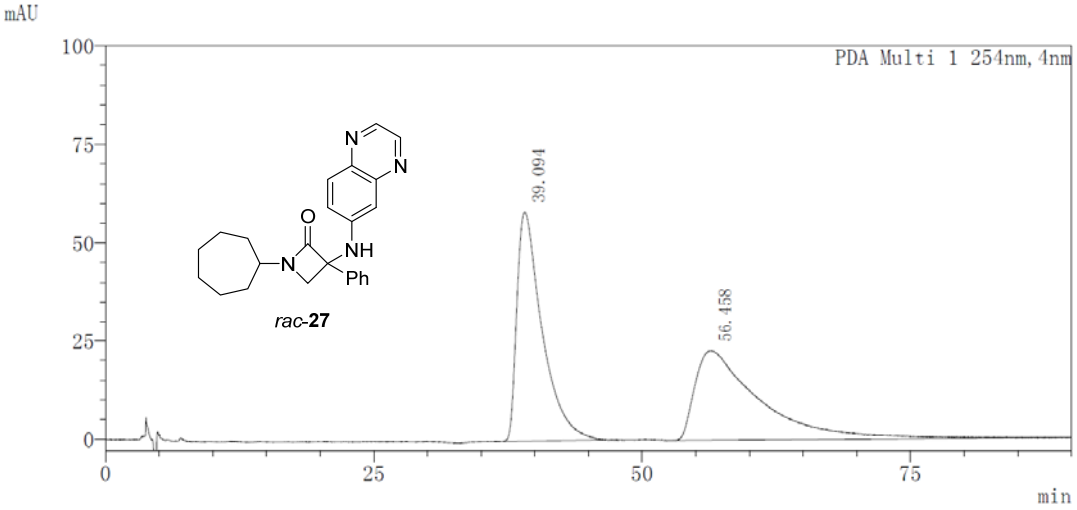
Peak#	Ret. Time	Area	Area%
1	16.841	881513	49.885
2	23.424	885573	50.115



Peak Table

Detector A Ch1 254nm

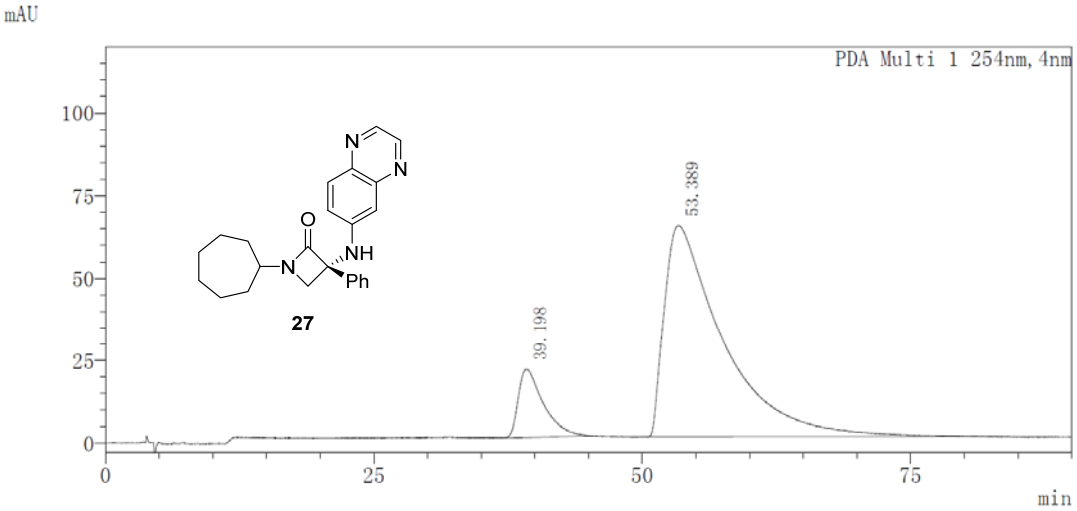
Peak#	Ret. Time	Area	Area%
1	16.804	1589805	8.575
2	22.682	16951038	91.425



Peak Table

PDA Ch1 254nm

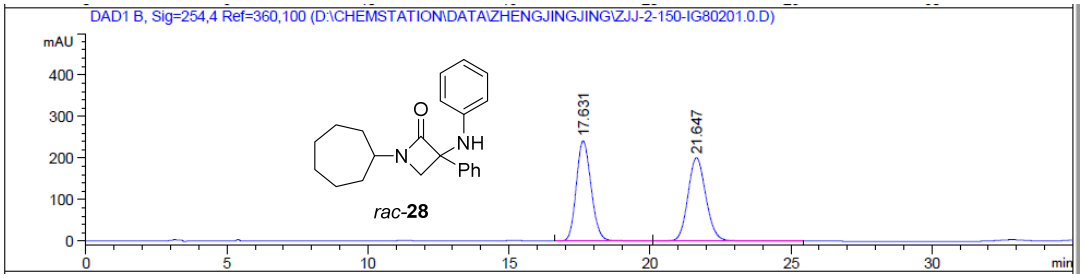
Peak#	Ret. Time	Area	Area%
1	39.094	9516986	50.083
2	56.458	9485598	49.917



Peak Table

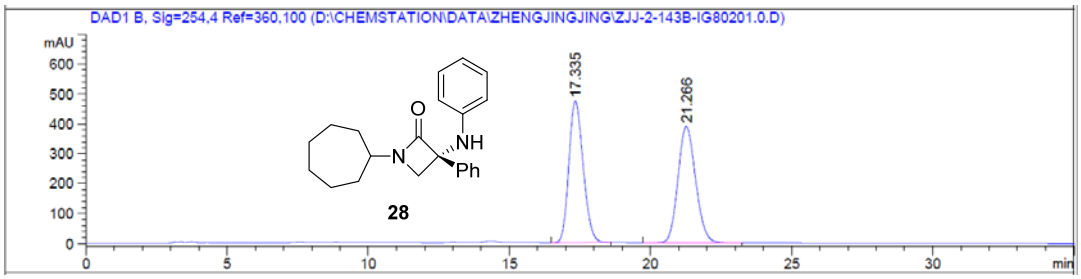
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	39.198	3362407	12.031
2	53.389	24585437	87.969



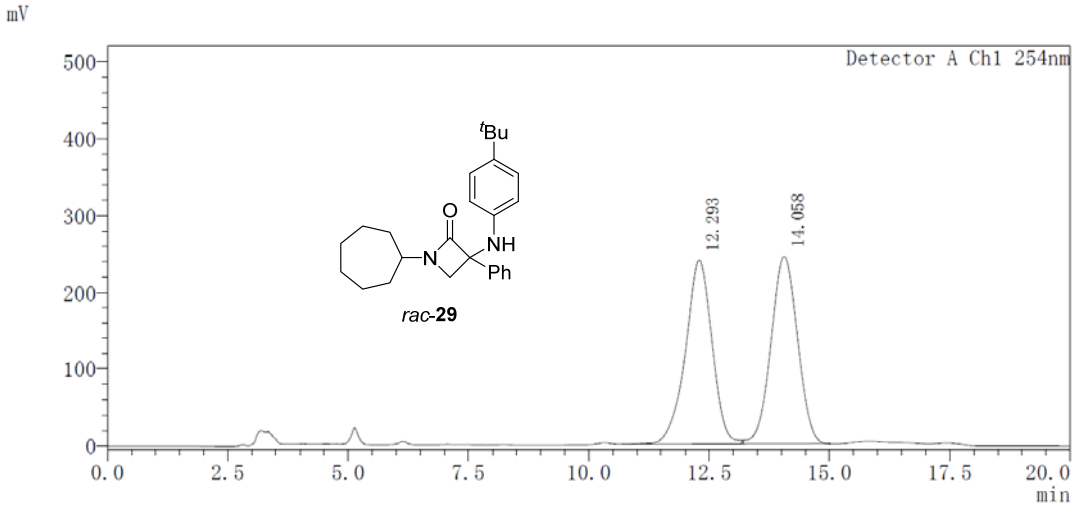
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.631	BB	0.5680	8796.81738	240.89122	49.9367
2	21.647	BB	0.6822	8819.12305	200.11014	50.0633
Totals :				1.76159e4	441.00136	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

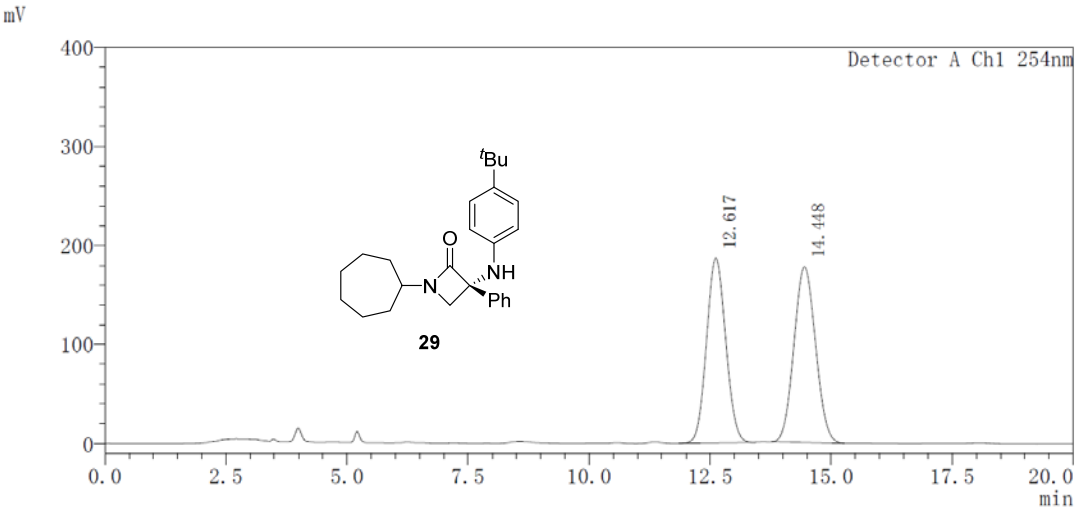
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.335	BB	0.5468	1.66800e4	473.76199	49.5179
2	21.266	BB	0.6794	1.70047e4	389.42560	50.4821
Totals :				3.36847e4	863.18759	



Peak Table

Detector A Ch1 254nm

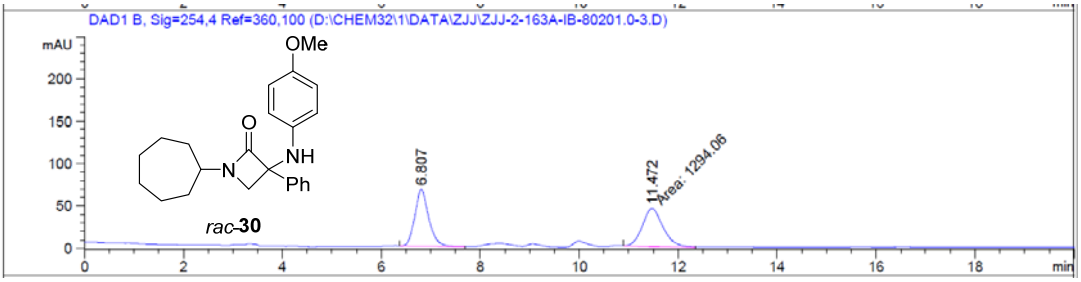
Peak#	Ret. Time	Area	Area%
1	12.293	9242949	49.809
2	14.058	9313788	50.191



Peak Table

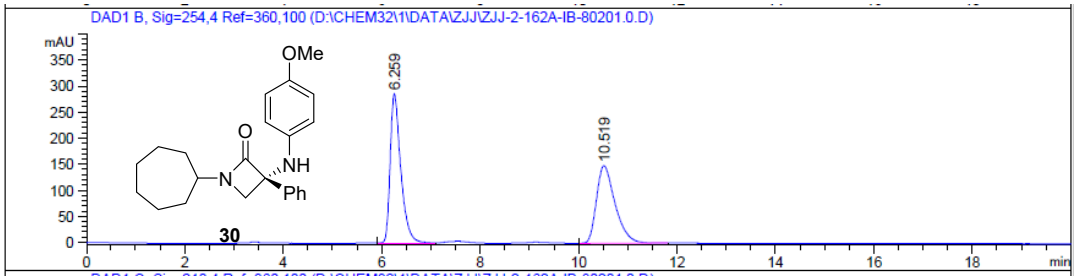
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	12.617	5147735	48.328
2	14.448	5503957	51.672



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.807	BB	0.2808	1302.26221	67.58798	50.1579
2	11.472	MM	0.4807	1294.06396	44.87082	49.8421
Totals :				2596.32617	112.45881	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.259	BB	0.2218	4264.47607	286.22333	52.2370
2	10.519	BB	0.3939	3899.23901	148.72061	47.7630
Totals :				8163.71509	434.94394	