Supplementary Information

Construction of oxygenated 2-azabicyclo[2.2.1]heptanes via palladium-catalyzed 1,2-aminoacyloxylation of cyclopentenes

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1. General Information

Reagents and Solvents: PE refers to petroleum ether b.p. 60 − 90 ℃ and EA refers to ethyl acetate. All starting materials were commercially available and were used without further purification unless otherwise stated.

Chromatography: Flash column chromatography was carried out using commercially available 200–300 mesh under pressure unless otherwise indicated. Gradient flash chromatography was conducted eluting with PE/EA, they are listed as volume ratios.

Data collection: ^{1}H, ^{13}C and ^{19}F NMR spectra were collected on BRUKER AV-300 (300 MHz) or BRUKER AV-400 (400 MHz) spectrometer using $CDCl_3$ as solvent. Chemical shifts of ^{1}H NMR were recorded in parts per million (ppm, δ) relative to tetramethylsilane (δ = 0.00 ppm) in $CDCl_3$ or solvent resonance as internal standards. Data are reported as follows: chemical shift in ppm (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, sept = septet, brs = broad singlet, m = multiplet), coupling constant (Hz), and integration. Chemical shifts of ^{13}C NMR were reported in ppm with the solvent as the internal standard ($CDCl_3$: δ = 77.16 ppm). High Resolution Mass measurement was performed on Agilent Q-TOF 6520 mass spectrometer with electron spray ionization (ESI) as the ion source. Melting point (m.p.) was measured on a microscopic melting point apparatus. X-ray diffraction analyses were carried out on a microcrystalline powder using a Rigaku Oxford Diffraction XtaLAB Synergy-S diffractometer using Mo radiation (λ = 0.71073 Å).

2. Preparation of Starting Materials

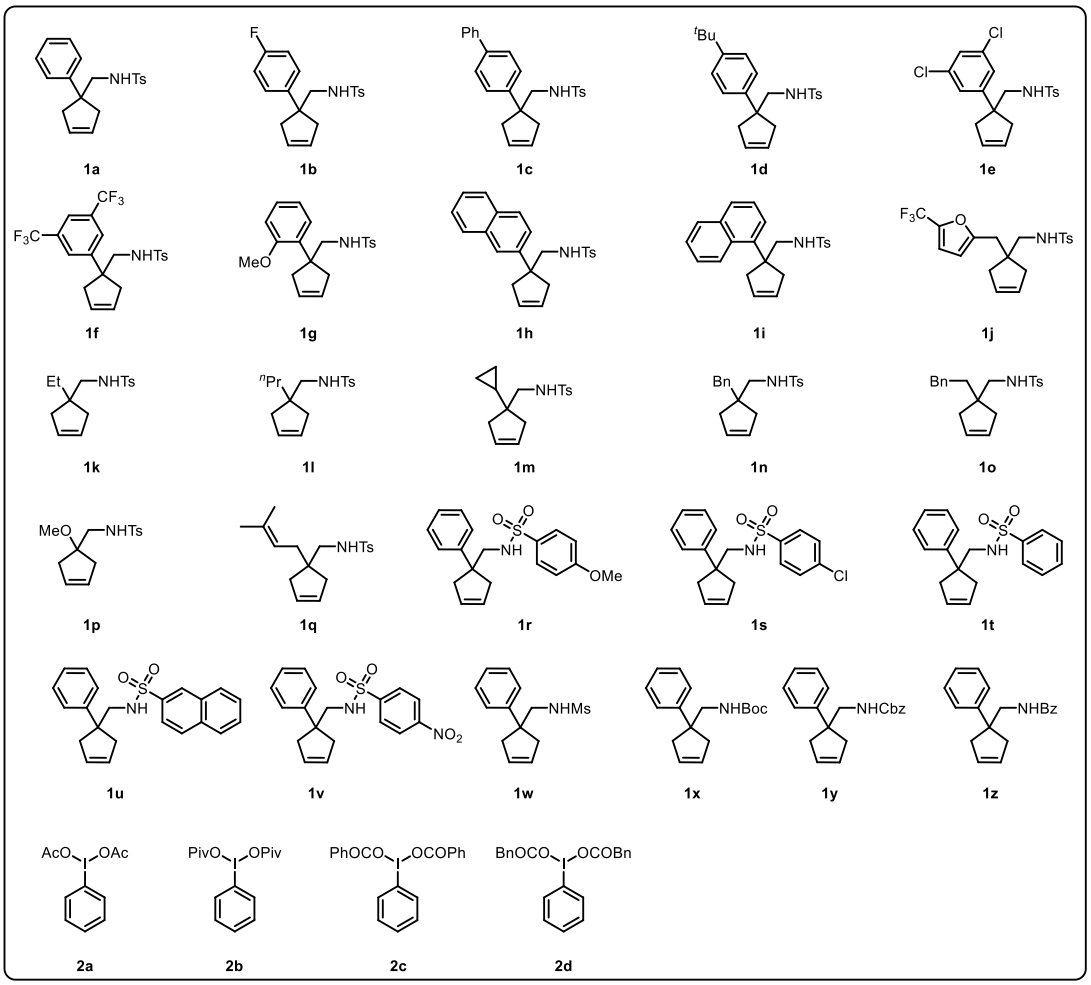
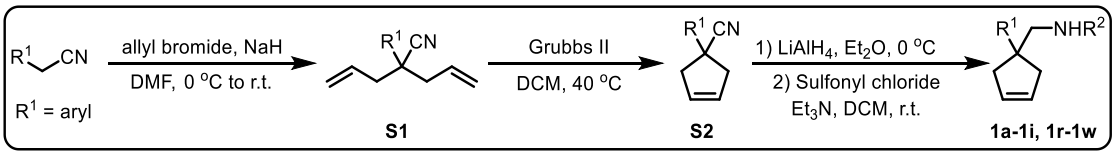


Table S1. Substrates **1** and **2**



General Procedure A: Cyclopentenes **1a-1i** and **1r-1w** were synthesized according to modified literature procedures[1]:

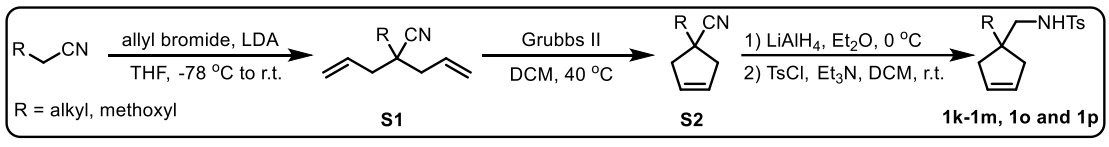
NaH (60% dispersion in mineral oil, 1.2 g, 30 mmol, 3.0 equiv) was added in portions to the solution of nitrile compound (10.0 mmol, 1.0 equiv) in DMF (30.0 mL) at 0 °C, and the mixture was stirred for 30 min at 0 °C. Then allyl bromide (2.6 mL, 30.0 mmol, 3.0 equiv) was added dropwise over 20 min. The reaction mixture was warmed to room temperature and stirred for 24 h. After completion of the reaction, saturated NH_4Cl

solution (100.0 mL) was added slowly to quench the reaction and the aqueous phase was extracted with Et_2O (75.0 mL × 3). The combined organic layer was washed with H_2O, saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. Then the crude product was purified by flash chromatography on silica gel (PE/EA as the eluent) to obtain **S1**.

S1 (1.0 equiv) and Grubbs II catalyst (2.0 mol%) were placed in a dry flask with anhydrous DCM (c = 0.2 M) under Ar atmosphere. The reaction was heated and stirred at 40 °C for 24 h. After completion of the reaction, the mixture was filtered through a short pad of silica gel (DCM) and concentrated under reduced pressure to give the crude product **S2** without further purification.

To a suspended solution of $LiAlH_4$ (2.0 equiv) in Et_2O (c = 0.5 M), a solution of **S2** in Et_2O (c = 1.0 M) was added dropwise at 0 °C under Ar atmosphere. The reaction mixture was stirred for 2 h at 0 °C. The reaction was quenched by wet THF, 15% aqueous NaOH and water (v/v/v=1:1:3). The reaction mixture was stirred at room temperature for 15 min, then the solid was filtered off. The filtrate was concentrated under vacuum to give crude primary amine intermediate.

To a solution of primary amine intermediate and Et_3N (2.0 equiv) in DCM (c = 0.3 M), sulfonyl chloride (1.5 equiv) was added at 0 °C. The reaction mixture was stirred at room temperature for 12 h. Then the mixture was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. Then the crude product was purified by flash chromatography on silica gel (PE/EA as the eluent) to obtain **1a-1i** and **1r-1w**.



General procedure B: Cyclopentenes **1k-1m**, **1o** and **1p** were synthesized according to modified literature procedures[2]:

An oven-dried 2-neck flask containing the solution of nitrile compound (10.0 mmol, 1.0 equiv) in THF (10.0 mL) was cooled to −78 °C under Ar atmosphere, LDA (2.0 M

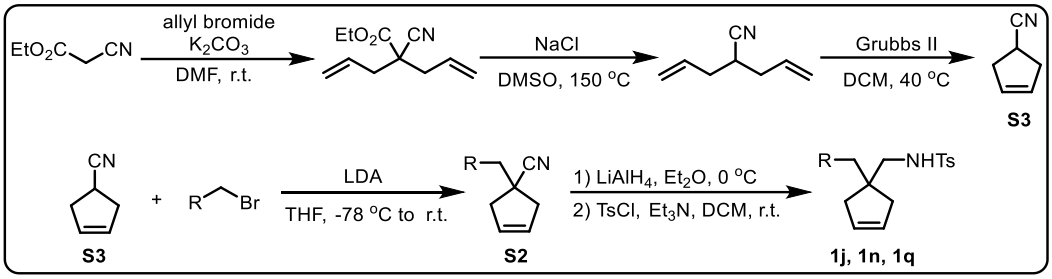
in THF/*n*-heptane/ethylbenzene, 5.5 mL, 1.1 equiv) was added dropwise over 20 min. The mixture was stirred at –78 °C for 90 min, then allyl bromide (0.87 mL, 10.0 mmol, 1.0 equiv) was added dropwise over 20 min. It was stirred at −78 °C for another 15 min, then allowed to warm to room temperature for 90 min. Then solution was re-cooled to −78 °C, and the second part of the LDA (2.0 M in THF/*n*-heptane/ethylbenzene, 5.5 mL, 1.1 equiv) was added dropwise over 20 min. The solution was allowed to warm to 0 °C for 90 min. After re-cooling to –78 °C again, the solution was treated with the second part of allyl bromide (0.87 mL, 10.0 mmol, 1.0 equiv). The reaction mixture was allowed to warm slowly to room temperature and stirred overnight. After completion of the reaction, the reaction was quenched by saturated NH_4Cl solution (25.0 mL) and the aqueous phase was extracted with Et_2O (20.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The crude product was purified by flash chromatography on silica gel (PE/EA as the eluent) to obtain **S1**.

S1 (1.0 equiv) and Grubbs II catalyst (2.0 mol%) were placed in a dry flask with anhydrous DCM (c = 0.2 M) under Ar atmosphere. The reaction was heated and stirred at 40 °C for 24 h. After completion of the reaction, the mixture was filtered through a short pad of silica gel (DCM) and concentrated under reduced pressure to give the crude product **S2** without further purification.

To a suspended solution of $LiAlH_4$ (2.0 equiv) in Et_2O (c = 0.5 M), a solution of **S2** in Et_2O (c = 1.0 M) was added dropwise at 0 °C under Ar atmosphere. The reaction mixture was stirred for 2 h under 0 °C. The reaction was quenched by wet THF, 15% aqueous NaOH and water (v/v/v=1:1:3). Then the reaction mixture was stirred at room temperature for 15 min, and the solid was filtered off. The filtrate was concentrated under vacuum to give crude primary amine intermediate.

To a solution of primary amine intermediate and Et_3N (2.0 equiv) in DCM (c = 0.3 M), TsCl (1.5 equiv) was added at 0 °C. The reaction mixture was stirred at room temperature for 12 h. Then the mixture was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. Then the crude product was purified

by flash chromatography on silica gel (PE/EA as the eluent) to obtain **1k-1m**, **1o** and **1p**.



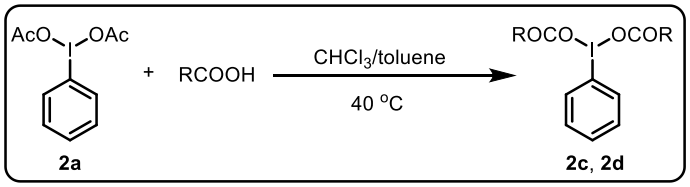
General procedure C: The cyclopent-3-ene-1-carbonitrile **S3** was synthesized according to a reported literature procedure,[3] and substrates **1j**, **1n** and **1q** was prepared as following procedures:

An oven-dried 2-neck flask containing the solution of **S3** (465.7 mg, 5.0 mmol, 1.0 equiv) in THF (20.0 mL) was cooled to −78 ℃ under Ar atmosphere, LDA (2.0 M in THF/*n*-heptane/ethylbenzene, 5.0 mL, 2.0 equiv) was added dropwise over 20 min. The mixture was stirred at –78 °C for 90 min, and then bromides (7.5 mmol, 1.5 equiv) was added dropwise over 20 min. It was stirred at −78 ℃ for another 15 min and then allowed to warm slowly to room temperature. After completion of the reaction, the reaction was quenched by saturated NH_4Cl solution (25.0 mL), and the aqueous phase was extracted with Et_2O (20.0 mL × 3). The combined organic layer was washed saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. Then the crude product was directly used in the next step without further purification.

To a suspended solution of $LiAlH_4$ (380.0 mg, 10.0 mmol, 2.0 equiv) in Et_2O (20.0 mL), a solution of **S2** in Et_2O (5.0 mL) was added dropwise at 0 ℃ under Ar atmosphere. The reaction mixture was stirred for 2 h at 0 ℃. The reaction was quenched by wet THF, 15% aqueous NaOH and water (v/v/v=1:1:3). Then the reaction mixture was stirred at room temperature for 15 min, and the solid was filtered off. The filtrate was concentrated under vacuum to give crude primary amine intermediate.

To a solution of primary amine intermediate and Et_3N (1.4 mL, 10.0 mmol, 2.0 equiv) in DCM (30 mL), TsCl (1.43 g, 7.5 mmol, 1.5 equiv) was added at 0 ℃. The reaction mixture was stirred at room temperature for 12 h. Then the mixture was washed with

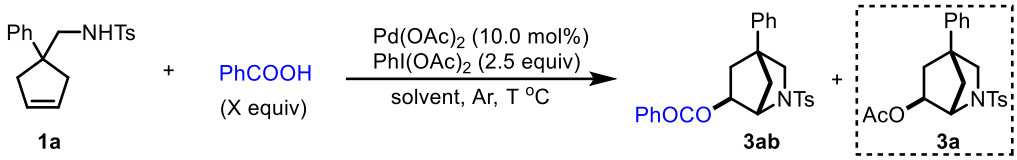
saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. Then the crude product was purified by flash chromatography on silica gel (PE/EA as the eluent) to obtain **1j**, **1n** and **1q**.



General procedure D for the synthesis of hypervalent iodine(III) substrates 2c and 2d:[4] A mixture of $PhI(OAc)_2$ (3.22 g, 10.0 mmol, 1.0 equiv) and carboxylic acid (20.0 mmol, 2.0 equiv) in $CHCl_3$ (100.0 mL) and toluene (100.0 mL) was stirred at 40 ℃ under a residual pressure until complete dryness, and this operation was repeated about 4 times. The residual solid was purified by recrystallization from dichloromethane/hexane to give the substrates **2c** or **2d** as white solid.

3. Condition screening with benzoic acid

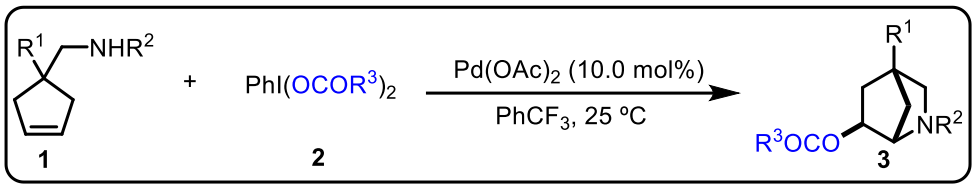
Table S2. Screening of benzoic acid equivalent, solvent and temperature



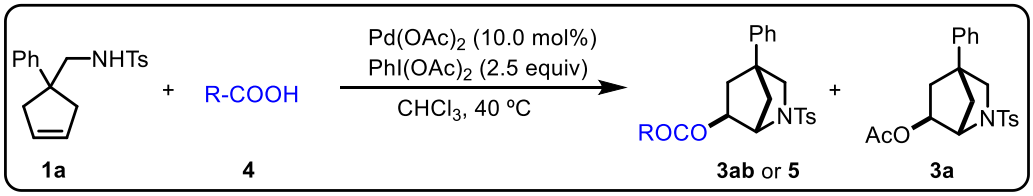
Entry	$PhCO_2H$ (x equiv)	Solvent	T (°C)	Yield of **3x** (%)[b]	Yield of **3a** (%)[b]
1	5.0	$PhCF_3$	25	23	72
2	10.0	$PhCF_3$	25	39	50
3	20.0	$PhCF_3$	25	46	40
4	20.0	$PhCF_3$	40	69	24
5	***10.0***	***$CHCl_3$***	***40***	***70***	***21***
6	10.0	PhMe	40	38	41
7	10.0	DCM	40	31	39

Reaction conditions: **1a** (0.2 mmol), $PhI(OAc)_2$ (0.5 mmol), $PhCO_2H$ (x equiv), $Pd(OAc)_2$ (10.0 mol%), solvent (2.0 mL), at T °C under Ar atmosphere for 36 h, sealed tube.

4. Pd-catalyzed 1,2-Aminoacyloxylation of Cyclopentenes



General procedure E for the synthesis of 3 with hypervalent iodine: To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added $Pd(OAc)_2$ (2.3 mg, 0.01 mmol, 10.0 mol%), **1** (0.1 mmol, 1.0 equiv), **2** (0.25 mmol, 2.5 equiv). Then the schlenk tube was evacuated and filled with argon for three times. After that, $PhCF_3$ (1.0 mL) was added to the tube via a syringe under argon atmosphere. The reaction mixture was stirred at 25 °C (oil bath temperature) for 24 h. After completion of the reaction, the reaction mixture was diluted with DCM (5.0 mL) and filtered through a plug of Celite. Then the solvent was removed in vacuum and the crude product was purified by flash chromatography on silica gel (PE/EA as the eluent) to obtain **3**.

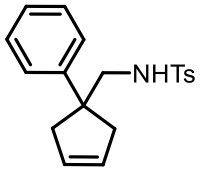


General procedure F for the synthesis of 3ab or 5 with carboxylic acid as carboxylate source: To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added $Pd(OAc)_2$ (4.5 mg, 0.02 mmol, 10.0 mol%), **1a** (65.5 mg, 0.2 mmol, 1.0 equiv), $PhI(OAc)_2$ (161.1 mg, 0.5 mmol, 2.5 equiv) and carboxylic acid (2.0 mmol, 10.0 equiv). Then the schlenk tube was evacuated and filled with argon for three times. After that, $CHCl_3$ (2.0 mL) was added to the tube via a syringe under argon atmosphere. The reaction mixture was stirred at 40 °C (oil bath temperature) for 36 h. After completion of the reaction, the reaction mixture was diluted with DCM (20.0 mL) and filtered through a plug of Celite. The solvent was diluted with saturated aqueous sodium hydrogen carbonate solution (25.0 mL) and extracted with DCM (20.0 mL × 3). The combined organic layer was washed with saturated brine,

dried over Na_2SO_4, and concentrated under reduced pressure. The crude product was purified by flash chromatography on silica gel to obtain product **3ab** or **5** along with byproduct **3a**.

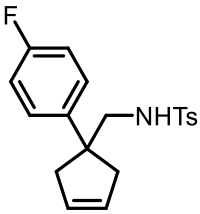
5. Characterization of the title compounds

4-methyl-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1a)



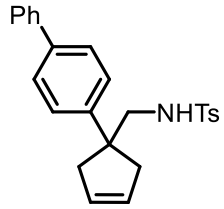
White solid, **m. p.** 125 – 127 ℃, R_f = 0.5 (PE/EA = 6/1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.61 – 7.58 (m, 2H), 7.32 – 7.20 (m, 5H), 7.17 – 7.14 (m, 2H), 5.72 (s, 2H), 4.14 (t, *J* = 6.6 Hz, 1H), 3.01 (d, *J* = 6.6 Hz, 2H), 2.71 – 2.61 (m, 4H), 2.41 (s, 3H) ppm. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 145.6, 143.2, 136.9, 129.6, 129.2, 128.7, 126.91, 126.90, 126.5, 53.2, 50.2, 42.2, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{21}NO_2S + H]^+$ 328.1366, found 328.1363.

N-((1-(4-fluorophenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1b)



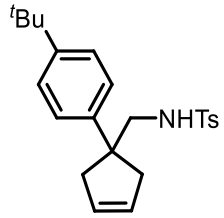
White solid, **m. p.** 121 – 122 ℃, R_f = 0.55 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.26 – 7.23 (m, 2H), 7.13 – 7.06 (m, 2H), 6.98 – 6.90 (m, 2H), 5.71 (s, 2H), 4.36 (t, *J* = 6.8 Hz, 1H), 2.98 (d, *J* = 6.8 Hz, 2H), 2.62 (s, 4H), 2.41 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 161.4 (d, $^1J_{C\text{-}F}$ = 245.4 Hz), 143.4, 141.5 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 136.8, 129.7, 129.3, 128.5 (d, $^3J_{C\text{-}F}$ = 7.8 Hz), 127.0, 115.4 (d, $^2J_{C\text{-}F}$ = 21.1 Hz), 53.2, 49.9, 42.5, 21.5 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -116.39 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{20}FNO_2S + H]^+$ 346.1272, found 346.1274.

N-((1-([1,1'-biphenyl]-4-yl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfon amide (1c)



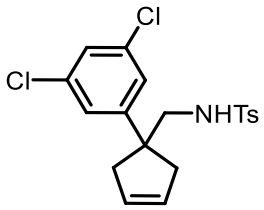
White solid, **m. p.** 144 – 146 ℃, R_f = 0.45 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.63 – 7.50 (m, 6H), 7.47 – 7.41 (m, 2H), 7.38 – 7.32 (m, 1H), 7.26 – 7.20 (m, 4H), 5.74 (s, 2H), 4.18 (t, *J* = 6.7 Hz, 1H), 3.05 (d, *J* = 6.7 Hz, 2H), 2.75 – 2.63 (m, 4H), 2.39 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 144.7, 143.3, 140.5, 139.5, 136.9, 129.7, 129.3, 128.9, 127.41, 127.39, 127.01, 126.99, 53.2, 50.2, 42.4, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{25}H_{25}NO_2S + H]^+$ 404.1679, found 404.1680.

N-((1-(4-(tert-butyl)phenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfon amide (1d)



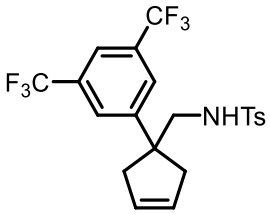
White solid, **m. p.** 160 – 162 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.62 – 7.58 (m, 2H), 7.34 – 7.29 (m, 2H), 7.27 – 7.24 (m, 2H), 7.10 – 7.05 (m, 2H), 5.70 (s, 2H), 4.17 (t, *J* = 6.7 Hz, 1H), 2.99 (d, *J* = 6.7 Hz, 2H), 2.70 – 2.58 (m, 4H), 2.41 (s, 3H), 1.31 (s, 9H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 149.4, 143.3, 142.6, 137.0, 129.7, 129.3, 127.0, 126.6, 125.7, 53.2, 49.9, 42.4, 34.4, 31.4, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{23}H_{29}NO_2S + H]^+$ 384.1992, found 384.1993.

N-((1-(3,5-dichlorophenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfon amide (1e)



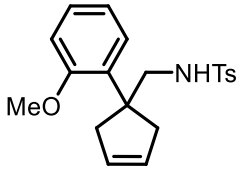
White solid, **m. p.** 115 – 116 ℃, R_f = 0.55 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.60 – 7.57 (m, 2H), 7.27 – 7.23 (m, 2H), 7.14 (t, *J* = 1.9 Hz, 1H), 6.99 (d, *J* = 1.8 Hz, 2H), 5.69 (s, 2H), 4.69 (t, *J* = 6.8 Hz, 1H), 3.01 (d, *J* = 6.8 Hz, 2H), 2.58 (s, 4H), 2.41 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 149.6, 143.5, 136.6, 135.1, 129.7, 129.0, 126.9, 126.7, 125.7, 52.7, 50.5, 42.3, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{19}Cl_2NO_2S+ Na]^+$ 418.0406, found 418.0410.

N-((1-(3,5-bis(trifluoromethyl)phenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzene sulfonamide (1f)



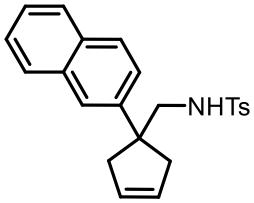
White solid, **m. p.** 121 – 122 ℃, R_f = 0.5 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.69 (s, 1H), 7.59 – 7.53 (m, 4H), 7.21 (d, *J* = 8.1 Hz, 2H), 5.73 (s, 2H), 4.81 (t, *J* = 6.9 Hz, 1H), 3.09 (d, *J* = 6.9 Hz, 2H), 2.73 – 2.61 (m, 4H), 2.40 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 148.8, 143.6, 136.5, 131.6 (q, $^2J_{C\text{-}F}$ = 32.9 Hz), 129.7, 129.0, 127.3 (q, $^4J_{C\text{-}F}$ = 2.6 Hz), 126.9, 123.3 (q, $^1J_{C\text{-}F}$ = 271.1 Hz), 120.5 (sept, $^3J_{C\text{-}F}$ = 3.8 Hz), 52.6, 50.7, 42.5, 21.4 ppm; **^{19}F NMR** (282 MHz, $CDCl_3$) δ -62.71 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{19}F_6NO_2S + H]^+$ 464.1113, found 464.1108.

N-((1-(2-methoxyphenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1g)



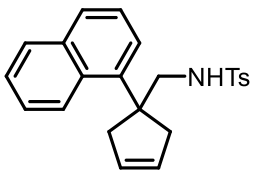
White solid, **m. p.** 117 – 118 ℃, R_f = 0.4 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.56 – 7.53 (m, 2H), 7.25 – 7.18 (m, 3H), 7.13 (dd, *J* = 7.7, 1.7 Hz, 1H), 6.89 (t, *J* = 7.5 Hz, 1H), 6.80 (d, *J* = 8.1 Hz, 1H), 5.66 (s, 2H), 4.24 (t, *J* = 6.2 Hz, 1H), 3.66 (s, 3H), 3.12 (d, *J* = 6.2 Hz, 2H), 2.71 – 2.60 (m, 4H), 2.39 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 157.7, 143.0, 137.0, 132.3, 129.5, 129.3, 129.0, 128.3, 127.0, 120.8, 111.4, 55.0, 49.7 (two overlapping carbon signals), 42.1, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{23}NO_3S + H]^+$ 358.1471, found 358.1477.

4-methyl-N-((1-(naphthalen-2-yl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1h)



White solid, **m. p.** 136 – 138 ℃, R_f = 0.5 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.80 – 7.73 (m, 3H), 7.58 – 7.43 (m, 5H), 7.24 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.15 (d, *J* = 8.0 Hz, 2H), 5.76 (s, 2H), 4.19 (t, *J* = 6.7 Hz, 1H), 3.10 (d, *J* = 6.7 Hz, 2H), 2.82 – 2.69 (m, 4H), 2.36 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 143.0, 136.8, 133.2, 132.1, 129.6, 129.3, 128.6, 128.0, 127.5, 126.9, 126.4, 126.0, 125.4, 125.3, 53.0, 50.5, 42.4, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{23}H_{23}NO_2S + H]^+$ 378.1522, found 378.1530.

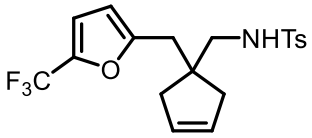
4-methyl-N-((1-(naphthalen-1-yl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1i)



White solid, **m. p.** 123 – 124 ℃, R_f = 0.5 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.90 – 7.83 (m, 2H), 7.73 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.55 – 7.52 (m, 2H), 7.46 – 7.31 (m, 4H), 7.15 (d, *J* = 8.0 Hz, 2H), 5.80 (s, 2H), 4.28 (t, *J* = 6.3 Hz, 1H), 3.33 (d, *J* = 6.3

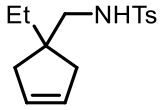
Hz, 2H), 3.02 – 2.80 (m, 4H), 2.36 (s, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 140.8, 136.6, 134.9, 131.5, 129.7, 129.6, 129.3, 128.4, 126.9, 125.9, 125.6, 125.3, 125.1, 125.0, 51.4, 50.7, 44.7, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{23}H_{23}NO_2S + H]^+$ 378.1522, found 378.1527.

4-methyl-N-((1-((5-(trifluoromethyl)furan-2-yl)methyl)cyclopent-3-en-1-yl)methyl) benzenesulfonamide (1j)



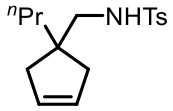
White solid, **m. p.** 103 – 104 ℃, R_f = 0.7 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.68 – 7.64 (m, 2H), 7.22 (d, *J* = 8.1 Hz, 2H), 6.55 (dt, *J* = 2.6, 1.3 Hz, 1H), 6.08 (d, *J* = 3.2 Hz, 1H), 5.45 (s, 2H), 5.32 (t, *J* = 6.9 Hz, 1H), 2.72 – 2.67 (m, 4H), 2.33 (s, 3H), 2.23 – 2.06 (m, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 156.3 (q, $^4J_{C\text{-}F}$ = 1.4 Hz), 143.5, 140.5 (q, $^2J_{C\text{-}F}$ = 42.2 Hz), 136.6, 129.8, 128.7, 127.0, 119.1 (q, $^1J_{C\text{-}F}$ = 264.8 Hz), 112.4 (q, $^3J_{C\text{-}F}$ = 2.8 Hz), 108.8, 50.4, 45.5, 41.9, 35.5, 21.5 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -64.01 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{20}F_3NO_3S + H]^+$ 400.1189, found 400.1193.

N-((1-ethylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1k)



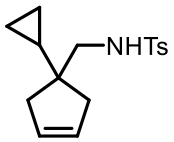
White solid, **m. p.** 79 – 80 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 5.55 (s, 2H), 4.68 (t, *J* = 6.4 Hz, 1H), 2.82 (d, *J* = 6.4 Hz, 2H), 2.43 (s, 3H), 2.17 – 2.04 (m, 4H), 1.42 (q, *J* = 7.4 Hz, 2H), 0.77 (t, *J* = 7.4 Hz, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 136.9, 129.7, 129.2, 127.1, 50.5, 44.6, 41.8, 30.5, 21.5, 8.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{15}H_{21}NO_2S + H]^+$ 280.1366, found 280.1365.

4-methyl-N-((1-propylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1l)



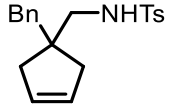
White solid, **m. p.** 67 – 68 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.73 (m, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 5.54 (s, 2H), 4.80 (t, *J* = 6.4 Hz, 1H), 2.81 (d, *J* = 6.4 Hz, 2H), 2.43 (s, 3H), 2.11 (s, 4H), 1.38 – 1.32 (m, 2H), 1.21 – 1.08 (m, 2H), 0.84 (t, *J* = 7.1 Hz, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 136.9, 129.7, 129.2, 127.1, 50.9, 44.4, 42.3, 40.7, 21.5, 17.7, 14.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{16}H_{23}NO_2S + H]^+$ 294.1522, found 294.1522.

N-((1-cyclopropylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1m)



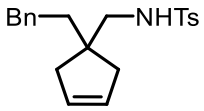
White solid, **m. p.** 80 – 81 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 5.51 (s, 2H), 4.96 (t, *J* = 6.5 Hz, 1H), 2.90 (d, *J* = 6.5 Hz, 2H), 2.43 (s, 3H), 2.04 – 1.90 (m, 4H), 0.75 (tt, *J* = 8.3, 5.4 Hz, 1H), 0.37 – 0.31 (m, 2H), 0.17 – 0.11 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 137.0, 129.7, 129.0, 127.1, 53.4, 44.7, 39.5, 21.5, 17.2, 0.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{16}H_{21}NO_2S + H]^+$ 292.1366, found 292.1370.

N-((1-benzylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1n)



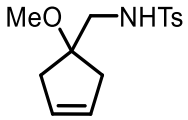
White solid, **m. p.** 103 – 104 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.70 (m, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.24 – 7.18 (m, 3H), 7.09 – 7.06 (m, 2H), 5.56 (s, 2H), 4.71 (t, *J* = 6.4 Hz, 1H), 2.81 (d, *J* = 6.4 Hz, 2H), 2.71 (s, 2H), 2.42 (s, 3H), 2.35 – 2.27 (m, 2H), 2.10 – 2.03 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.4, 138.1, 136.6, 130.2, 129.7, 129.1, 128.2, 127.1, 126.4, 50.3, 45.9, 43.2, 41.8, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{23}NO_2S + H]^+$ 342.1522, found 342.1521.

4-methyl-N-((1-phenethylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1o)



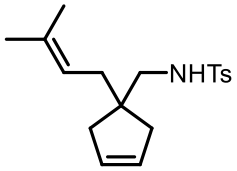
White solid, **m. p.** 112 – 113 ℃, R_f = 0.55 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.74 (m, 2H), 7.28 – 7.10 (m, 7H), 5.55 (s, 2H), 5.15 (t, *J* = 6.5 Hz, 1H), 2.87 (d, *J* = 6.5 Hz, 2H), 2.50 – 2.44 (m, 2H), 2.39 (s, 3H), 2.19 (s, 4H), 1.72 – 1.67 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.4, 142.5, 136.9, 129.8, 129.2, 128.40, 128.39, 127.1, 125.8, 50.7, 44.7, 42.4, 40.3, 31.0, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{25}NO_2S + H]^+$ 356.1679, found 356.1682.

N-((1-methoxycyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1p)



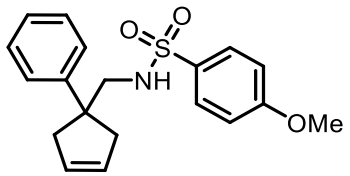
Yellow oil, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.72 (m, 2H), 7.33 – 7.29 (m, 2H), 5.62 (s, 2H), 4.87 (t, *J* = 5.8 Hz, 1H), 3.04 – 3.02 (m, 5H), 2.49 – 2.43 (m, 5H), 2.35 – 2.27 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 136.8, 129.7, 128.4, 127.1, 84.6, 50.2, 49.9, 39.9, 21.5 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{14}H_{19}NO_3S + Na]^+$ 304.0978, found 304.0980.

4-methyl-N-((1-(3-methylbut-2-en-1-yl)cyclopent-3-en-1-yl)methyl)benzene sulfonamide (1q)



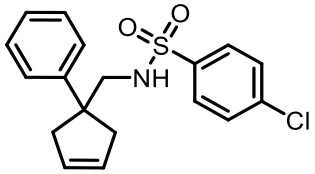
White solid, **m. p.** 95 – 96 ℃, R_f = 0.65 (PE/EA = 6/1).**^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.72 (m, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 5.55 (s, 2H), 5.02 – 4.95 (m, 1H), 4.79 (t, *J* = 6.4 Hz, 1H), 2.83 (d, *J* = 6.4 Hz, 2H), 2.43 (s, 3H), 2.21 – 2.06 (m, 6H), 1.65 (s, 3H), 1.55 (s, 3H) ppm.**^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.3, 136.8, 134.3, 129.7, 129.2, 127.1, 120.0, 51.2, 44.9, 42.0, 36.3, 26.0, 21.6, 18.0 ppm.**HRMS (ESI)** *m*/*z* Calcd for $[C_{18}H_{25}NO_2S + H]^+$ 320.1679, found 320.1678.

4-methoxy-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1r)



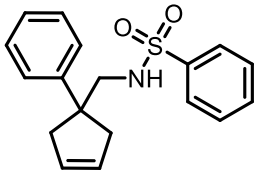
White solid, **m. p.** 116 – 117 ℃, R_f = 0.7 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.67 – 7.62 (m, 2H), 7.33 – 7.26 (m, 2H), 7.24 – 7.13 (m, 3H), 6.93 – 6.89 (m, 2H), 5.72 (s, 2H), 4.13 (t, *J* = 6.7 Hz, 1H), 3.85 (s, 3H), 2.99 (d, *J* = 6.7 Hz, 2H), 2.65 (s, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 162.7, 145.7, 131.5, 129.3, 129.1, 128.8, 127.0, 126.6, 114.2, 55.6, 53.2, 50.3, 42.3 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{19}H_{21}NO_3S + H]^+$ 344.1315, found 344.1311.

4-chloro-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1s)



White solid, **m. p.** 143 – 144 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.44 – 7.39 (m, 2H), 7.33 – 7.19 (m, 3H), 7.18 – 7.12 (m, 2H), 5.73 (s, 2H), 4.23 (t, *J* = 6.6 Hz, 1H), 3.02 (d, *J* = 6.6 Hz, 2H), 2.74 – 2.58 (m, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 145.5, 139.0, 138.4, 129.4, 129.3, 128.8, 128.4, 126.9, 126.7, 53.3, 50.4, 42.2 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{18}H_{18}ClNO_2S + H]^+$ 348.0820, found 348.0813.

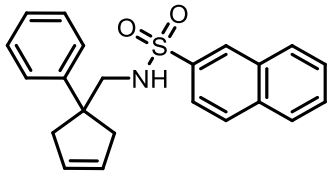
N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1t)



White solid, **m. p.** 85 – 86 ℃, R_f = 0.6 (PE/EA = 6/1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.73 – 7.70 (m, 2H), 7.56 – 7.52 (m, 1H), 7.48 – 7.43 (m, 2H), 7.32 – 7.27 (m, 2H),

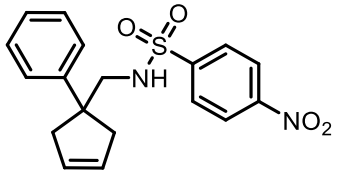
7.23 – 7.19 (m, 1H), 7.16 – 7.13 (m, 2H), 5.72 (s, 2H), 4.21 (t, *J* = 6.7 Hz, 1H), 3.03 (d, *J* = 6.7 Hz, 2H), 2.70 – 2.60 (m, 4H) ppm. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 145.6, 139.9, 132.5, 129.3, 129.1, 128.8, 126.93, 126.92, 126.6, 53.3, 50.3, 42.3 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{18}H_{19}NO_2S + Na]^+$ 336.1029, found 336.1025.

N-((1-phenylcyclopent-3-en-1-yl)methyl)naphthalene-2-sulfonamide (1u)



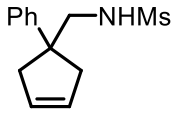
White solid, **m. p.** 111 – 112 ℃, R_f = 0.55 (PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.30 (d, *J* = 1.9 Hz, 1H), 7.92 – 7.86 (m, 3H), 7.66 – 7.55 (m, 3H), 7.28 – 7.10 (m, 5H), 5.69 (s, 2H), 4.37 (t, *J* = 6.6 Hz, 1H), 3.05 (d, *J* = 6.6 Hz, 2H), 2.64 (s, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 145.6, 136.6, 134.7, 132.1, 129.4, 129.24, 129.20, 128.7 (two carbon signals overlap), 128.2, 127.9, 127.5, 126.9, 126.6, 122.1, 53.3, 50.3, 42.2 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{22}H_{21}NO_2S + H]^+$ 364.1366, found 364.1366.

4-nitro-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1v)



White solid, **m. p.** 143 – 145 ℃, R_f = 0.4 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.27 (d, *J* = 8.6 Hz, 2H), 7.86 (d, *J* = 8.3 Hz, 2H), 7.31 – 7.13 (m, 5H), 5.74 (s, 2H), 4.55 (t, *J* = 6.4 Hz, 1H), 3.08 (d, *J* = 6.4 Hz, 2H), 2.74 – 2.59 (m, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 149.9, 145.8, 145.3, 129.3, 128.9, 128.2, 127.0, 126.8, 124.4, 53.4, 50.4, 42.2 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{18}H_{18}N_2O_4S + H]^+$ 359.1060, found 359.1061.

N-((1-phenylcyclopent-3-en-1-yl)methyl)methanesulfonamide (1w)



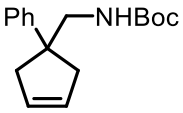
White solid, **m. p.** 62 – 64 °C, R_f = 0.3 (PE/EA = 4/1)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38 – 7.30 (m, 2H), 7.26 – 7.22 (m, 3H), 5.78 (s, 2H), 4.12 (t, *J* = 6.1 Hz, 1H), 3.21 (d, *J* = 6.7 Hz, 2H), 2.78 – 2.66 (m, 7H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 145.9, 129.4, 128.9, 127.2, 126.8, 53.5, 50.7, 42.2, 40.0 ppm.

HRMS (ESI) *m*/*z* Calcd for $[C_{13}H_{17}NO_2S + Na]^+$ 274.0878, found 274.0871.

tert-butyl ((1-phenylcyclopent-3-en-1-yl)methyl)carbamate (1x)



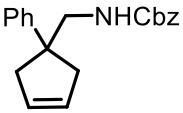
Colorless oil, R_f = 0.65 (PE/EA = 4/1)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35 – 7.29 (m, 2H), 7.24 – 7.17 (m, 3H), 5.76 (s, 2H), 4.38 (t, *J* = 6.2 Hz, 1H), 3.30 (d, *J* = 6.3 Hz, 2H), 2.71 – 2.57 (m, 4H), 1.38 (s, 9H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 156.2, 147.1, 129.3, 128.5, 126.9, 126.1, 79.0, 50.9, 50.7, 42.5, 28.4 ppm.

HRMS (ESI) *m*/*z* Calcd for $[C_{17}H_{23}NO_2 + Na]^+$ 296.1626, found 296.1625.

benzyl ((1-phenylcyclopent-3-en-1-yl)methyl)carbamate (1y)



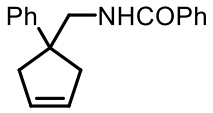
White solid, **m. p.** 72 – 74 °C, R_f = 0.5 (PE/EA = 4/1)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37 – 7.30 (m, 7H), 7.24 – 7.19 (m, 3H), 5.78 (s, 2H), 5.05 (s, 2H), 4.55 – 4.53 (m, 1H), 3.38 (d, *J* = 6.3 Hz, 2H), 2.73 – 2.60 (m, 4H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 156.9, 146.8, 136.6, 129.4, 128.7, 128.6, 128.29, 128.26, 127.0, 126.4, 66.8, 51.5, 50.9, 42.5 ppm.

HRMS (ESI) *m*/*z* Calcd for $[C_{20}H_{21}NO_2 + Na]^+$ 330.1470, found 330.1467.

N-((1-phenylcyclopent-3-en-1-yl)methyl)benzamide (1z)



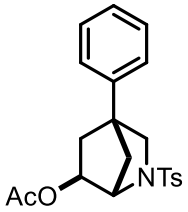
White solid, **m. p.** 92 – 94 °C, R_f = 0.5 (PE/EA = 4/1)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.65 – 7.61 (m, 2H), 7.49 – 7.35 (m, 5H), 7.32 – 7.24 (m, 3H), 5.96 (t, *J* = 6.4 Hz, 1H), 5.83 (s, 2H), 3.63 (d, *J* = 6.0 Hz, 2H), 2.82 – 2.67 (m, 4H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 167.6, 147.0, 134.6, 131.5, 129.5, 128.8, 128.6, 127.0, 126.8, 126.6, 50.9, 50.3, 42.7 ppm.

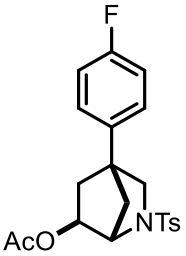
HRMS (ESI) *m*/*z* Calcd for $[C_{19}H_{19}NO + H]^+$ 278.1545, found 278.1541.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3a)



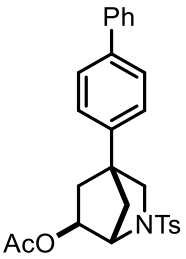
The compound was prepared according to the general procedure **E** from **1a** (32.8 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3a** (36.4 mg, 94% yield), white solid, **m. p.** 128 – 130 °C, R_f = 0.4 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.73 (m, 2H), 7.34 – 7.22 (m, 5H), 7.17 – 7.14 (m, 2H), 5.03 – 5.00 (m, 1H), 4.29 (s, 1H), 3.32 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.16 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.46 – 2.38 (m, 4H), 2.01 (s, 3H), 1.96 (dt, *J* = 10.4, 1.2 Hz, 1H), 1.69 (dt, *J* = 14.0, 2.0 Hz, 1H), 1.46 (ddt, *J* = 10.3, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.8, 139.3, 135.6, 129.9, 128.7, 127.4 (two overlapping carbon signals), 126.2, 75.1, 62.2, 57.9, 51.5, 44.7, 38.3, 21.6, 21.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{23}NO_4S + H]^+$ 386.1421, found 386.1427.

4-(4-fluorophenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3b)



The compound was prepared according to the general procedure **E** from **1b** (34.6 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3b** (34.2 mg, 85% yield), white solid, **m. p.** 165 – 166 °C, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.73 (m, 2H), 7.34 – 7.31 (m, 2H), 7.15 – 7.09 (m, 2H), 7.03 – 6.96 (m, 2H), 5.02 – 4.98 (m, 1H), 4.29 (s, 1H), 3.28 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.13 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.44 – 2.36 (m, 4H), 2.01 (s, 3H), 1.94 (dt, *J* = 10.4, 1.2 Hz, 1H), 1.66 (dt, *J* = 14.0, 2.1 Hz, 1H), 1.46 (ddt, *J* = 10.4, 2.2, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 161.9 (d, $^1J_{C\text{-}F}$ = 244.5 Hz), 143.9, 135.5, 135.1 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 130.0, 127.8 (d, $^3J_{C\text{-}F}$ = 7.9 Hz), 127.4, 115.6 (d, $^2J_{C\text{-}F}$ = 21.0 Hz), 75.0, 62.2, 58.0, 51.0, 44.6, 38.5, 21.6, 21.0 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -114.89 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{22}FNO_4S + H]^+$ 404.1326, found 404.1336.

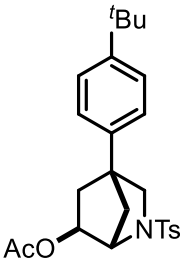
4-([1,1'-biphenyl]-4-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3c)



The compound was prepared according to the general procedure **E** from **1c** (40.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3c** (39.8 mg, 86% yield), white solid, **m. p.** 125 – 127 °C, R_f = 0.3 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.78 – 7.74 (m, 2H), 7.56 – 7.51 (m, 4H), 7.46 – 7.40 (m, 2H), 7.37 – 7.31 (m, 3H),

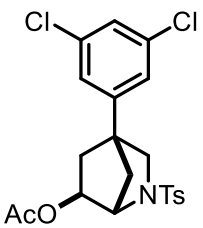
7.25 – 7.20 (m, 2H), 5.05 – 5.01 (m, 1H), 4.32 (s, 1H), 3.35 (dd, *J* = 8.4, 1.3 Hz, 1H), 3.20 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.49 – 2.41 (m, 4H), 2.02 – 1.97 (m, 4H), 1.73 (dt, *J* = 13.9, 2.5 Hz, 1H), 1.49 (ddt, *J* = 10.3, 2.1, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.9, 143.9, 140.5, 140.4, 138.3, 135.5, 130.0, 128.9, 127.5, 127.4 (two overlapping carbon signals), 127.1, 126.7, 75.2, 62.3, 57.9, 51.3, 44.7, 38.4, 21.7, 21.1 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{27}H_{27}NO_4S + H]^+$ 462.1734, found 462.1739.

4-(4-(tert-butyl)phenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3d)



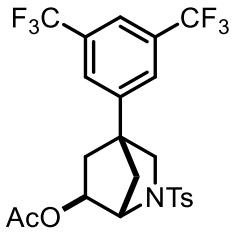
The compound was prepared according to the general procedure **E** from **1d** (38.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3d** (39.9 mg, 90% yield), white solid, **m. p.** 115 – 117 °C, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.77 – 7.72 (m, 2H), 7.35 – 7.30 (m, 4H), 7.11 – 7.07 (m, 2H), 5.03 – 4.99 (m, 1H), 4.29 (s, 1H), 3.31 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.15 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.45 – 2.37 (m, 4H), 2.00 (s, 3H), 1.93 (dt, *J* = 10.4, 1.2 Hz, 1H), 1.70 (dt, *J* = 14.0, 2.1 Hz, 1H), 1.42 (ddt, *J* = 10.4, 2.2, 1.9 Hz, 1H), 1.29 (s, 9H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 150.3, 143.7, 136.2, 135.6, 129.9, 127.4, 125.9, 125.6, 75.2, 62.3, 58.0, 51.2, 44.7, 38.4, 34.5, 31.3, 21.6, 21.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{25}H_{31}NO_4S + H]^+$ 442.2047, found 442.2054.

4-(3,5-dichlorophenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3e)



The compound was prepared according to the general procedure **E** from **1e** (39.7 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3e** (41.5 mg, 91% yield), white solid, **m. p.** 145 – 147 °C, R_f = 0.6 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.73 (m, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.24 (t, *J* = 1.9 Hz, 1H), 7.04 (d, *J* = 1.8 Hz, 2H), 5.01 – 4.97 (m, 1H), 4.31 (s, 1H), 3.30 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.13 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.45 – 2.30 (m, 4H), 2.03 (s, 3H), 1.96 (d, *J* = 10.3 Hz, 1H), 1.67 (dt, *J* = 13.9, 2.6 Hz, 1H), 1.44 (ddt, *J* = 10.3, 2.1, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.7, 144.0, 142.8, 135.4, 135.3, 130.0, 127.6, 127.4, 125.0, 74.8, 62.0, 57.4, 51.2, 44.5, 38.3, 21.6, 21.0 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{21}H_{21}Cl_2NO_4S + H]^+$ 454.0641, found 454.0647.

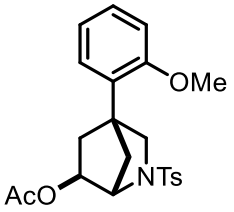
4-(3,5-bis(trifluoromethyl)phenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3f)



The compound was prepared according to the general procedure **E** from **1f** (46.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3f** (44.3 mg, 85% yield), white solid, **m. p.** 160 – 162 °C, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.79 – 7.76 (m, 3H), 7.61 (s, 2H), 7.37 (d, *J* = 8.0 Hz, 2H), 5.06 – 5.02 (m, 1H), 4.37 (s, 1H), 3.39 (dd, *J* = 8.6, 1.3 Hz, 1H), 3.22 (dd, *J* = 8.6, 2.7 Hz, 1H), 2.54 – 2.46 (m, 4H), 2.08 – 2.05 (m, 4H), 1.74 (dt, *J* = 13.9, 2.6 Hz, 1H), 1.58 (ddt, *J* = 10.3, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.7, 144.1, 142.1, 135.4, 132.1 (q, $^2J_{C\text{-}F}$ = 33.3 Hz), 130.0, 127.4, 126.5 (q, $^4J_{C\text{-}F}$ = 2.6 Hz), 123.1 (q, $^1J_{C\text{-}F}$ = 271.1 Hz), 121.5 (sept, $^3J_{C\text{-}F}$ = 3.8 Hz), 74.7, 62.1, 57.4, 51.4, 44.4, 38.5, 21.6, 20.9 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -62.86 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{23}H_{21}F_6NO_4S + H]^+$

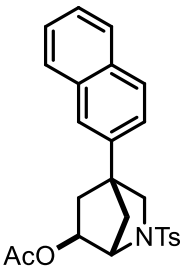
522.1168, found 522.1178.

4-(2-methoxyphenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3g)



The compound was prepared according to the general procedure **E** from **1g** (35.8 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 5/1 to 2/1) generated **3g** (38.6 mg, 93% yield), white solid, **m. p.** 120 – 122 ℃, R_f = 0.7 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.1 Hz, 2H), 7.32 – 7.20 (m, 3H), 7.05 (dd, *J* = 7.5, 1.7 Hz, 1H), 6.88 – 6.83 (m, 2H), 5.01 (dd, *J* = 6.8, 1.9 Hz, 1H), 4.23 (s, 1H), 3.74 (s, 3H), 3.65 (dd, *J* = 8.6, 1.3 Hz, 1H), 3.05 (dd, *J* = 8.4, 2.6 Hz, 1H), 2.73 (ddd, *J* = 14.1, 7.0, 2.4 Hz, 1H), 2.42 (s, 3H), 2.02 – 1.98 (m, 4H), 1.60 – 1.48 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 158.2, 143.5, 135.6, 129.8, 128.7, 127.4, 127.3, 120.4, 110.8, 75.5, 61.2, 55.7, 55.0, 50.5, 42.6, 37.7, 21.6, 21.0 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{22}H_{25}NO_5S + H]^+$ 416.1526, found 416.1531.

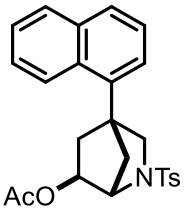
4-(naphthalen-2-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3h)



The compound was prepared according to the general procedure **E** from **1h** (37.8 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 6/1 to 3/1) generated **3h** (39.7 mg, 91% yield), white solid, **m. p.** 130 – 132 ℃, R_f = 0.8 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.81 – 7.75 (m, 5H), 7.58 (d, *J* = 1.8 Hz, 1H), 7.51 – 7.43 (m, 2H), 7.34 – 7.25 (m, 3H), 5.08

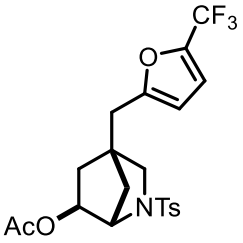
– 5.04 (m, 1H), 4.35 (s, 1H), 3.42 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.27 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.54 – 2.43 (m, 4H), 2.08 – 2.03 (m, 4H), 1.79 (dt, *J* = 13.5, 2.1 Hz, 1H), 1.55 (ddt, *J* = 10.3, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.8, 136.7, 135.6, 133.3, 132.5, 130.0, 128.5, 127.72, 127.67, 127.4, 126.5, 126.1, 124.8, 124.3, 75.2, 62.3, 57.9, 51.7, 44.7, 38.6, 21.6, 21.1 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{25}H_{25}NO_4S + H]^+$ 436.1577, found 436.1584.

4-(naphthalen-1-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3i)



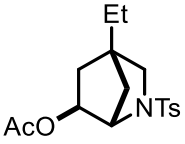
The compound was prepared according to the general procedure **E** from **1i** (37.8 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 6/1 to 3/1) generated **3i** (41.9 mg, 96% yield), white solid, **m. p.** 133 – 134 ℃, R_f = 0.8 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.05 – 8.01 (m, 1H), 7.89 – 7.83 (m, 1H), 7.80 – 7.72 (m, 3H), 7.50 – 7.44 (m, 2H), 7.38 – 7.25 (m, 4H), 5.19 – 5.15 (m, 1H), 4.32 (s, 1H), 3.96 (dd, *J* = 8.8, 1.4 Hz, 1H), 3.17 (dd, *J* = 8.8, 2.6 Hz, 1H), 3.05 (ddd, *J* = 14.3, 7.0, 2.6 Hz, 1H), 2.43 (s, 3H), 2.28 (dt, *J* = 10.4, 1.3 Hz, 1H), 2.01 (s, 3H), 1.80 (dt, *J* = 14.3, 2.7 Hz, 1H), 1.72 (ddt, *J* = 10.4, 2.3, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.8, 136.7, 135.6, 133.2, 132.5, 129.9, 128.5, 127.70, 127.66, 127.4, 126.5, 126.1, 124.8, 124.3, 75.2, 62.3, 57.8, 51.7, 44.8, 38.6, 21.6, 21.1 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{25}H_{25}NO_4S + H]^+$ 436.1577, found 436.1582.

2-tosyl-4-((5-(trifluoromethyl)furan-2-yl)methyl)-2-azabicyclo[2.2.1]heptan-6-yl acetate (3j)



The compound was prepared according to the general procedure **E** from **1j** (40.0 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 6/1 to 3/1) generated **3j** (34.2 mg, 75% yield), pale yellow solid, **m. p.** 107 – 108 °C, R_f = 0.7 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.68 – 7.64 (m, 2H), 7.30 – 7.27 (m, 2H), 6.67 (dd, *J* = 3.3, 1.4 Hz, 1H), 6.08 (d, *J* = 3.2 Hz, 1H), 4.90 – 4.86 (m, 1H), 4.12 (s, 1H), 2.92 (s, 2H), 2.87 (s, 2H), 2.42 (s, 3H), 2.05 – 1.94 (m, 4H), 1.54 (d, *J* = 10.5 Hz, 1H), 1.40 (d, *J* = 14.3 Hz, 1H), 0.96 (ddt, *J* = 10.4, 2.1, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.7, 155.1 (q, $^4J_{C\text{-}F}$ = 1.5 Hz), 143.8, 140.8 (q, $^2J_{C\text{-}F}$ = 42.5 Hz), 135.2, 129.8, 127.3, 119.0 (q, $^1J_{C\text{-}F}$ = 264.9 Hz), 112.3 (q, $^3J_{C\text{-}F}$ = 2.8 Hz), 108.4, 74.9, 62.0, 56.0, 47.6, 42.5, 38.4, 30.5, 21.5, 21.0 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -64.17 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{22}F_3NO_5S + H]^+$ 458.1244, found 458.1251.

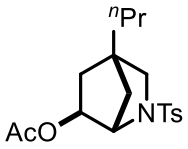
4-ethyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3k)



The compound was prepared according to the general procedure **E** from **1k** (28.0 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3k** (32.5 mg, 96% yield), white solid, **m. p.** 78 – 79 °C, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.72 (m, 2H), 7.32 (d, *J* = 8.0 Hz, 2H), 4.88 – 4.84 (m, 1H), 4.12 (s, 1H), 2.91 (s, 2H), 2.44 (s, 3H), 2.02 – 1.89 (m, 4H), 1.55 (q, *J* = 7.5 Hz, 2H), 1.44 (d, *J* = 10.4 Hz, 1H) 1.33 (d, *J* = 14.7 Hz, 1H), 0.96 (ddt, *J* = 10.3, 2.2, 1.9 Hz, 1H), 0.86 (t, *J* = 7.5

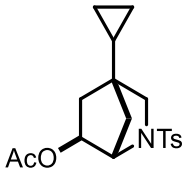
Hz, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.9, 143.6, 135.9, 129.8, 127.4, 75.2, 62.1, 56.4, 49.0, 41.7, 38.2, 24.9, 21.6, 21.1, 10.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{17}H_{23}NO_4S + H]^+$ 338.1421, found 338.1425.

4-propyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3l)



The compound was prepared according to the general procedure **E** from **1l** (29.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3l** (33.1 mg, 94% yield), white solid, **m. p.** 75 – 76 °C, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.71 (m, 2H), 7.32 (d, *J* = 8.3 Hz, 2H), 4.87 – 4.83 (m, 1H), 4.11 (s, 1H), 2.93 – 2.87 (m, 2H), 2.44 (s, 3H), 2.01 – 1.90 (m, 4H), 1.50 – 1.43 (m, 3H), 1.37 – 1.16 (m, 3H), 0.96 (ddt, *J* = 10.5, 2.1, 2.0 Hz, 1H), 0.88 (t, *J* = 7.2 Hz, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.5, 135.8, 129.8, 127.3, 75.2, 62.0, 56.6, 48.3, 42.1, 38.6, 34.6, 21.6, 21.1, 19.1, 14.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{18}H_{25}NO_4S + H]^+$ 352.1577, found 352.1580.

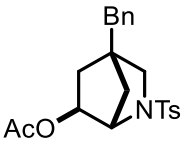
4-cyclopropyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3m)



The compound was prepared according to the general procedure **E** from **1m** (29.2 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 4/1) generated **3m** (31.5 mg, 90% yield), white solid, **m. p.** 81 – 83 °C, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.71 (m, 2H), 7.32 (d, *J* = 7.8 Hz, 2H), 4.86 – 4.82 (m, 1H), 4.09 (s, 1H), 2.97 – 2.89 (m, 2H), 2.44 (s, 3H), 2.00 (s, 3H), 1.89 (ddd, *J* = 13.8, 7.0, 2.6 Hz,

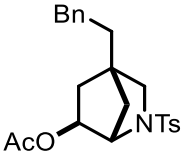
1H), 1.34 – 1.28 (m, 2H), 0.88 – 0.79 (m, 2H), 0.47 – 0.36 (m, 2H), 0.19 – 0.06 (m, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.6, 135.8, 129.8, 127.3, 74.9, 61.7, 56.7, 48.8, 41.8, 36.2, 21.6, 21.1, 11.7, 1.8 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{18}H_{23}NO_4S + H]^+$ 350.1421, found 350.1422.

4-benzyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3n)



The compound was prepared according to the general procedure **E** from **1n** (34.2 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 6/1 to 3/1) generated **3n** (37.2 mg, 93% yield), white solid, **m. p.** 122 – 123 °C, R_f = 0.8 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.63 – 7.59 (m, 2H), 7.27 – 7.21 (m, 5H), 7.01 – 6.98 (m, 2H), 4.85 – 4.81 (m, 1H), 4.07 (s, 1H), 2.91 (dd, *J* = 8.6, 2.8 Hz, 1H), 2.83 – 2.78 (m, 3H), 2.40 (s, 3H), 1.98 (s, 3H), 1.91 (ddd, *J* = 13.9, 7.1, 2.8 Hz, 1H), 1.45 – 1.36 (m, 2H), 0.85 (ddt, *J* = 10.4, 2.3, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.5, 137.5, 135.3, 129.8, 129.4, 128.3, 127.2, 126.6, 75.1, 61.9, 55.9, 49.0, 42.5, 38.8, 38.1, 21.6, 21.1 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{22}H_{25}NO_4S + H]^+$ 400.1577, found 400.1582.

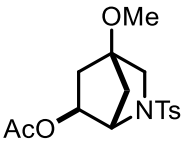
4-phenethyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3o)



The compound was prepared according to the general procedure **E** from **1o** (35.6 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3f** (36.5 mg, 88% yield), white solid, **m. p.** 106 – 108 °C, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.71 (m, 2H), 7.33 – 7.23 (m, 4H), 7.20 – 7.10 (m, 3H), 4.89 – 4.85 (m, 1H), 4.13 (s, 1H), 2.95 (s, 2H), 2.65 – 2.46 (m, 2H), 2.44 (s, 3H), 2.04 – 1.96 (m, 4H), 1.84

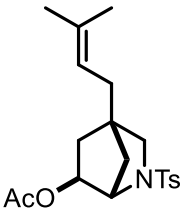
(t, *J* = 8.5 Hz, 2H), 1.49 (d, *J* = 10.4 Hz, 1H), 1.40 (d, *J* = 14.2 Hz, 1H), 1.01 (ddt, *J* = 10.2, 2.1, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.6, 141.6, 135.8, 129.9, 128.5, 128.1, 127.4, 126.1, 75.1, 61.9, 56.4, 48.3, 42.1, 38.7, 34.3, 32.2, 21.6, 21.1 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{23}H_{27}NO_4S + H]^+$ 414.1734, found 414.1737.

4-methoxy-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3p)



The compound was prepared according to the general procedure **E** from **1p** (28.2 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h at 40 ℃. Purification by flash column chromatography (PE/EA = 4/1 to 2/1) generated **3p** (25.7 mg, 76% yield), white solid, **m. p.** 117 – 119 ℃, R_f = 0.4 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.71 (m, 2H), 7.33 (d, *J* = 8.1 Hz, 2H), 4.89 – 4.85 (m, 1H), 4.06 (s, 1H), 3.28 (s, 3H), 3.12 (s, 2H), 2.44 (s, 3H), 2.13 (ddd, *J* = 13.5, 7.1, 2.5 Hz, 1H), 2.03 (s, 3H), 1.78 (d, *J* = 9.9 Hz, 1H), 1.69 (d, *J* = 13.3 Hz, 1H), 1.24 (ddt, *J* = 10.2, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.7, 143.8, 135.4, 129.9, 127.4, 84.3, 73.8, 59.5, 53.7, 52.9, 39.1, 36.0, 21.6, 21.0 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{16}H_{21}NO_5S + H]^+$ 340.1213, found 340.1215.

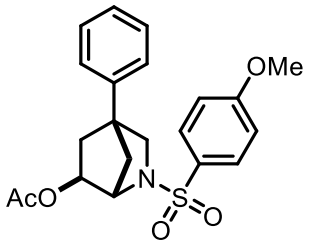
4-(3-methylbut-2-en-1-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3q)



The compound was prepared according to the general procedure **E** from **1q** (32.0 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3q** (29.2 mg, 77% yield), yellow solid, **m. p.** 72 – 73 ℃, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.3 Hz, 2H), 7.32 (d, *J* = 7.9 Hz, 2H), 5.00 (t, *J* = 7.6 Hz, 1H), 4.84 (d, *J* =

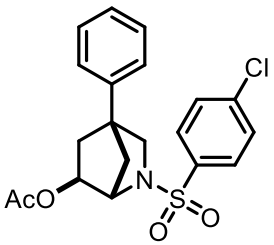
6.7 Hz, 1H), 4.10 (s, 1H), 2.94 – 2.84 (m, 2H), 2.44 (s, 3H), 2.17 (d, *J* = 7.7 Hz, 2H), 2.00 (s, 3H), 1.92 (ddd, *J* = 13.9, 7.1, 2.6 Hz, 1H), 1.67 (s, 3H), 1.55 (s, 3H), 1.42 (d, *J* = 10.4 Hz, 1H), 1.31 (dt, *J* = 13.9, 2.7 Hz, 1H), 0.97 (ddt, *J* = 10.4, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 143.5, 135.8, 134.5, 129.7, 127.4, 119.2, 75.1, 62.0, 56.2, 48.8, 42.2, 38.0, 30.3, 25.8, 21.6, 21.1, 17.8 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{27}NO_4S + H]^+$ 378.1734, found 378.1739.

2-((4-methoxyphenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3r)



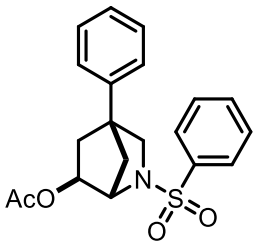
The compound was prepared according to the general procedure **E** from **1r** (34.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 5/1 to 3/1) generated **3r** (34.2 mg, 85% yield), white solid, **m. p.** 104 – 106 °C, R_f = 0.6 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.83 – 7.78 (m, 2H), 7.34 – 7.22 (m, 3H), 7.17 – 7.13 (m, 2H), 7.02 – 6.97 (m, 2H), 5.04 – 5.00 (m, 1H), 4.28 (s, 1H), 3.87 (s, 3H), 3.31 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.15 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.42 (ddd, *J* = 14.0, 6.9, 2.6 Hz, 1H), 2.01 (s, 3H), 1.96 (d, *J* = 10.4 Hz, 1H), 1.70 (dt, *J* = 14.0, 2.1 Hz, 1H), 1.47 (ddt, *J* = 10.3, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 163.1, 139.3, 130.2, 129.5, 128.7, 127.4, 126.2, 114.4, 75.1, 62.2, 57.9, 55.7, 51.5, 44.6, 38.3, 21.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{23}NO_5S + H]^+$ 402.1370, found 402.1375.

2-((4-chlorophenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3s)



The compound was prepared according to the general procedure **E** from **1s** (34.8 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h. Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3s** (31.7 mg, 78% yield), white solid, **m. p.** 107 – 108 ℃, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.84 – 7.79 (m, 2H), 7.53 – 7.49 (m, 2H), 7.35 – 7.23 (m, 3H), 7.18 – 7.15 (m, 2H), 5.01 – 4.96 (m, 1H), 4.30 (s, 1H), 3.32 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.17 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.41 (ddd, *J* = 14.0, 7.0, 2.6 Hz, 1H), 2.02 – 1.98 (s, 4H), 1.73 (dt, *J* = 13.9, 2.7 Hz, 1H), 1.55 (ddt, *J* = 10.4, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 139.4, 139.0, 137.4, 129.6, 128.8, 128.7, 127.5, 126.2, 74.9, 62.2, 57.9, 51.6, 44.5, 38.5, 21.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{20}ClNO_4S + H]^+$ 406.0874, found 406.0880.

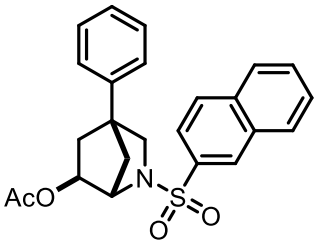
4-phenyl-2-(phenylsulfonyl)-2-azabicyclo[2.2.1]heptan-6-yl acetate (3t)



The compound was prepared according to the general procedure **E** from **1t** (31.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) 48 h at 40 ℃. Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3t** (27.9 mg, 75% yield), white solid, **m. p.** 105 – 107 ℃, R_f = 0.4 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.90 – 7.86 (m, 2H), 7.64 – 7.51 (m, 3H), 7.34 – 7.21 (m, 3H), 7.16 – 7.12 (m, 2H), 5.03 – 4.99 (m, 1H), 4.31 (s, 1H), 3.33 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.17 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.42 (ddd, *J* = 14.0, 7.0, 2.6 Hz, 1H), 2.01 – 1.94 (m, 4H), 1.70 (dt, *J* = 14.0, 2.1 Hz, 1H), 1.44 (ddt, *J* = 10.3, 2.2, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz,

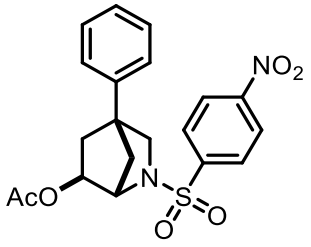
$CDCl_3$) δ 169.8, 139.2, 138.5, 133.0, 129.3, 128.8, 127.4, 127.3, 126.2, 75.1, 62.3, 58.0, 51.5, 44.6, 38.3, 21.0 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{20}H_{21}NO_4S + H]^+$ 372.1264, found 372.1270.

2-(naphthalen-2-ylsulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3u)



The compound was prepared according to the general procedure **E** from **1u** (36.4 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) for 48 h at 40 ℃. Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3u** (37.9 mg, 90% yield), white solid, **m. p.** 123 – 124 ℃, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.44 (s, 1H), 8.00 – 7.84 (m, 4H), 7.68 – 7.59 (m, 2H), 7.31 – 7.22 (m, 3H), 7.14 – 7.11 (m, 2H), 5.05 (d, *J* = 5.9 Hz, 1H), 4.40 (s, 1H), 3.37 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.24 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.42 (ddd, *J* = 14.0, 7.0, 2.6 Hz, 1H), 2.01 – 1.95 (s, 4H), 1.70 (dt, *J* = 14.0, 2.6 Hz, 1H), 1.52 (ddt, *J* = 10.4, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 139.2, 135.6, 134.9, 132.2, 129.7, 129.4, 129.0, 128.7, 128.0, 127.7, 127.4, 126.2, 122.6, 75.2, 62.3, 58.0, 51.6, 44.6, 38.5, 21.1 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{24}H_{23}NO_4S + H]^+$ 422.1421, found 422.1425.

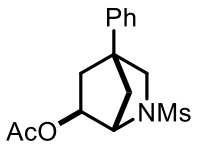
2-((4-nitrophenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3v)



The compound was prepared according to the general procedure **E** from **1v** (35.9 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) 48 h at 50 ℃. Purification by flash column chromatography (PE/EA = 4/1 to 2/1) generated **3v** (32.2 mg, 77% yield), pale yellow solid, **m. p.** 133 – 134 ℃, R_f = 0.6 (PE/EA = 2/1). **^{1}H NMR** (300

MHz, $CDCl_3$) δ 8.41 – 8.36 (m, 2H), 8.10 – 8.06 (m, 2H), 7.36 – 7.24 (m, 3H), 7.20 – 7.16 (m, 2H), 4.97 – 4.92 (m, 1H), 4.36 (s, 1H), 3.37 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.23 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.41 (ddd, *J* = 14.0, 7.0, 2.5 Hz, 1H), 2.09 – 2.02 (s, 4H), 1.76 (dt, *J* = 13.9, 2.3 Hz, 1H), 1.61 (ddt, *J* = 10.5, 2.2, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.8, 150.2, 144.9, 138.7, 128.8, 128.5, 127.6, 126.1, 124.6, 74.7, 62.3, 58.0, 51.7, 44.2, 38.7, 21.0 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{20}N_2O_6S + NH_4]^+$ 434.1380, found 434.1386.

2-(methylsulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3w)



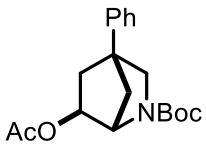
The compound was prepared according to the general procedure **E** from **1w** (25.1 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 6/1 to 4/1) generated **3w** (23.2 mg, 75% yield), colorless oil, R_f = 0.2 (PE/EA = 4/1).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40 – 7.26 (m, 5H), 5.09 – 5.04 (m, 1H), 4.28 – 4.27 (m, 1H), 3.39 – 3.31 (m, 2H), 2.94 (s, 3H), 2.52 (ddd, *J* = 14.0, 7.0, 2.6 Hz, 1H), 2.18 (dt, *J* = 10.5, 1.2 Hz, 1H), 2.06 – 2.00 (m, 4H), 1.80 (dt, *J* = 13.9, 2.7 Hz, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 170.0, 139.2, 128.9, 127.6, 126.3, 75.2, 61.8, 57.9, 51.7, 44.5, 39.2, 38.9, 21.1 ppm.

HRMS (ESI) *m*/*z* Calcd for $[C_{15}H_{19}NO_4S + Na]^+$ 332.0932, found 332.0933.

tert-butyl 6-acetoxy-4-phenyl-2-azabicyclo[2.2.1]heptane-2-carboxylate (3x)



The compound was prepared according to the general procedure **E** from **1x** (27.3 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) at 25 °C for 36 h. Purification by flash column chromatography (PE/EA = 6/1 to 4/1) generated **3x** (22.2 mg, 67% yield), colorless oil, R_f = 0.55 (PE/EA = 4/1).

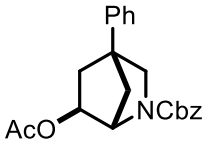
^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38 – 7.27 (m, 5H), 4.93 – 4.88 (m, 1H), 4.38 – 4.25

(m, 1H), 3.39 – 3.22 (m, 2H), 2.55 – 2.36 (m, 1H), 2.12 – 1.97 (m, 5H), 1.78 – 1.68 (m, 1H), 1.51 – 1.45 (m, 9H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 170.1, 154.3, 153.9, 140.4, 128.7, 127.2, 126.4, 80.1, 79.9, 74.8, 59.8, 58.8, 57.4, 56.4, 51.4, 50.6, 45.4, 44.6, 39.0, 38.7, 28.6, 21.3, 21.2 ppm (Multiple signals are observed due to the existence of two amide rotamers. We simply listed each observed signal).

HRMS (ESI) *m/z* Calcd for $[C_{19}H_{25}NO_4 + Na]^+$ 354.1681, found 354.1682.

benzyl 6-acetoxy-4-phenyl-2-azabicyclo[2.2.1]heptane-2-carboxylate (3y)



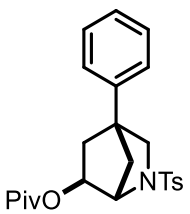
The compound was prepared according to the general procedure **E** from **1y** (30.7 mg, 0.1 mmol, 1.0 equiv) and **2a** (80.6 mg, 0.25 mmol, 2.5 equiv) at 25 °C for 36 h. Purification by flash column chromatography (PE/EA = 6/1 to 4/1) generated **3y** (21.1 mg, 58% yield), colorless oil, R_f = 0.3 (PE/EA = 4/1).

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44 – 7.26 (m, 10H), 5.24 – 5.13 (m, 2H), 4.98 – 4.92 (m, 1H), 4.45 – 4.39 (m, 1H), 3.40 – 3.36 (m, 2H), 2.53 – 2.38 (m, 1H), 2.16 – 2.12 (m, 1H), 2.04 – 1.98 (m, 4H), 1.78 – 1.71 (m, 1H) ppm.

^{13}C NMR (75 MHz, $CDCl_3$) δ 170.1, 154.6, 154.4, 140.1, 140.0, 136.8, 136.7, 128.79, 128.76, 128.6, 128.2, 128.12, 128.08, 128.06, 127.3, 126.4, 74.7, 74.5, 67.12, 67.06, 59.7, 59.4, 57.0, 56.9, 51.4, 50.6, 45.3, 44.9, 39.2, 38.8, 21.3, 21.2 ppm (Multiple signals are observed due to the existence of two amide rotamers. We simply listed each observed signal).

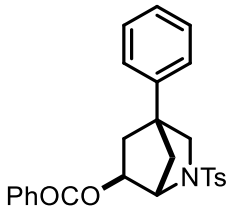
HRMS (ESI) *m/z* Calcd for $[C_{22}H_{23}NO_4 + Na]^+$ 388.1525, found 388.1519.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl pivalate (3aa)



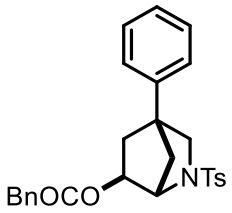
The compound was prepared according to the general procedure **E** from **1a** (32.8 mg, 0.1 mmol, 1.0 equiv) and **2b** (101.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 15/1 to 10/1) generated **3aa** (34.4 mg, 80% yield), white solid, **m. p.** 134 – 136 ℃, R_f = 0.7 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.78 – 7.74 (m, 2H), 7.35 – 7.23 (m, 5H), 7.17 – 7.13 (m, 2H), 5.02 – 4.98 (m, 1H), 4.30 (s, 1H), 3.30 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.15 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.47 – 2.40 (m, 4H), 1.91 (d, *J* = 10.5 Hz, 1H), 1.62 (dt, *J* = 14.0, 2.1 Hz, 1H), 1.49 (ddt, *J* = 10.3, 2.3, 2.0 Hz, 1H), 1.16 (s, 9H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 177.2, 143.8, 139.4, 135.6, 129.9, 128.8, 127.4, 126.2, 74.9, 62.3, 58.0, 51.5, 44.7, 38.5, 38.3, 27.1, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{24}H_{29}NO_4S + H]^+$ 428.1890, found 428.1900.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzoate (3ab)



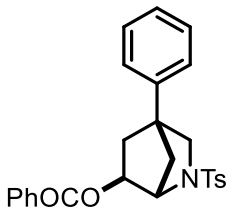
The compound was prepared according to the general procedure **E** from **1a** (32.8 mg, 0.1 mmol, 1.0 equiv) and **2c** (110.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3ab** (36.3 mg, 81% yield), white solid, **m. p.** 125 – 126 ℃, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.01 – 7.97 (m, 2H), 7.81 – 7.77 (m, 2H), 7.59 – 7.53 (m, 1H), 7.45 – 7.39 (m, 2H), 7.35 – 7.22 (m, 5H), 7.20 – 7.15 (m, 2H), 5.29 – 5.25 (m, 1H), 4.46 (s, 1H), 3.38 (dd, *J* = 8.4, 1.3 Hz, 1H), 3.21 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.54 (ddd, *J* = 14.0, 6.9, 2.6 Hz, 1H), 2.44 (s, 3H), 2.07 (dd, *J* = 10.4, 1.2 Hz, 1H), 1.87 (dt, *J* = 14.1, 2.1 Hz, 1H), 1.54 (ddt, *J* = 10.4, 2.1, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 165.3, 143.8, 139.3, 135.6, 133.3, 130.0, 129.8, 129.6, 128.8, 128.5, 127.4, 126.2, 75.6, 62.3, 58.0, 51.6, 44.6, 38.5, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{25}NO_4S + H]^+$ 448.1577, found 448.1579.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-phenylacetate (3ac)



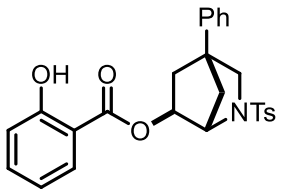
The compound was prepared according to the general procedure **E** from **1a** (32.8 mg, 0.1 mmol, 1.0 equiv) and **2d** (118.6 mg, 0.25 mmol, 2.5 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated **3ac** (35.7 mg, 77% yield), pale yellow solid, **m. p.** 127 – 129 °C, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.72 (m, 2H), 7.34 – 7.22 (m, 10H), 7.12 – 7.08 (m, 2H), 5.04 – 5.00 (m, 1H), 4.28 (s, 1H), 3.57 (s, 2H), 3.29 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.15 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.42 – 2.34 (m, 4H), 1.87 (d, *J* = 10.4 Hz, 1H), 1.63 (dt, *J* = 14.0, 2.6 Hz, 1H), 1.43 (ddt, *J* = 10.4, 2.1, 1.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 170.3, 143.8, 139.3, 135.6, 133.7, 129.9, 129.3, 128.74, 128.68, 127.4 (two overlapping carbon signals), 127.25, 126.18, 75.5, 62.2, 57.8, 51.5, 44.7, 41.3, 38.4, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{27}H_{27}NO_4S + NH_4]^+$ 479.1999, found 479.2001.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzoate (3ab)



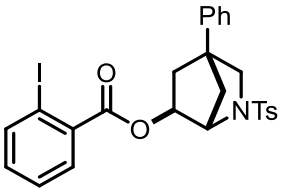
The compound was prepared according to the general procedure **F** with benzoic acid (244.3 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 20/1 to 5/1) generated product **3ab** (62.3 mg, 70% yield) along with byproduct **3a** (16.2 mg, 21% yield).

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-hydroxybenzoate (5a)



The compound was prepared according to the general procedure **F** with salicylic acid (276.3 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 15/1 to 5/1) generated product **5a** (59.4 mg, 64% yield) along with byproduct **3a** (8.5 mg, 11% yield). Pale yellow solid, **m. p.** 65 – 66 °C, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 10.68 (s, 1H), 7.79 – 7.76 (m, 2H), 7.72 (dd, *J* = 8.0, 1.8 Hz, 1H), 7.45 (ddd, *J* = 8.8, 7.2, 1.8 Hz, 1H), 7.35 – 7.26 (m, 5H), 7.24 – 7.16 (m, 2H), 6.97 (dd, *J* = 8.4, 1.1 Hz, 1H), 6.84 (ddd, *J* = 8.1, 7.2, 1.2 Hz, 1H), 5.31 – 5.27 (m, 1H), 4.47 (s, 1H), 3.39 (dd, *J* = 8.6, 1.3 Hz, 1H), 3.19 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.58 – 2.44 (m, 4H), 2.05 (d, *J* = 10.5 Hz, 1H), 1.90 (dt, *J* = 14.1, 2.6 Hz, 1H), 1.54 (ddt, *J* = 10.5, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 169.1, 161.9, 143.9, 139.0, 136.1, 135.5, 130.0, 129.7, 128.8, 127.6, 127.4, 126.2, 119.2, 117.8, 112.0, 76.0, 62.2, 57.9, 51.6, 44.3, 38.4, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{25}NO_5S + H]^+$ 464.1526, found 464.1528.

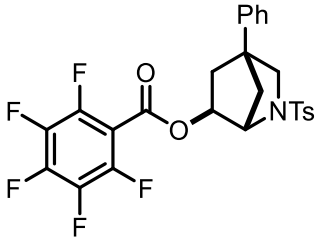
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-iodobenzoate (5b)



The compound was prepared according to the general procedure **F** with 2-iodobenzoic acid (496.1 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 20/1 to 5/1) generated product **5b** (77.8 mg, 68% yield) along with byproduct **3a** (10.7 mg, 14% yield). White solid, **m. p.** 77 – 79 °C, R_f = 0.45 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.96 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.79 – 7.76 (m, 2H), 7.72 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.42 – 7.25 (m, 6H), 7.19 – 7.12 (m, 3H), 5.30 – 5.26 (m, 1H), 4.48 (s, 1H), 3.38 (dd, *J* = 8.4, 1.3 Hz, 1H), 3.20 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.55 (ddd, *J*

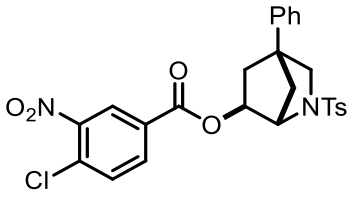
= 14.1, 6.9, 2.6 Hz, 1H), 2.44 (s, 3H), 2.16 (d, *J* = 10.8 Hz, 1H), 1.94 (dt, *J* = 14.0, 2.5 Hz, 1H), 1.53 (ddt, *J* = 10.5, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 165.4, 143.8, 141.3, 139.2, 135.6, 135.0, 132.8, 131.1, 130.0, 128.8, 128.0, 127.4 (two overlapping carbon signals), 126.2, 93.8, 76.6, 62.2, 58.0, 51.7, 44.7, 38.7, 21.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{24}INO_4S + H]^+$ 574.0543, found 574.0543.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2,3,4,5,6-pentafluorobenzoate (5c)



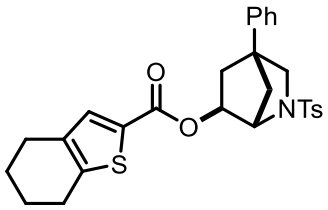
The compound was prepared according to the general procedure **F** with pentafluorobenzoic acid (424.2 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 7/1) generated product **5c** (93.7 mg, 87% yield) and the byproduct **3a** was not detected. Pale yellow oil, R_f = 0.6 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.78 – 7.75 (m, 2H), 7.36 – 7.24 (m, 5H), 7.18 – 7.14 (m, 2H), 5.32 (dd, *J* = 6.7, 1.9 Hz, 1H), 4.42 (s, 1H), 3.39 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.19 (dd, *J* = 8.5, 2.6 Hz, 1H), 2.55 (ddd, *J* = 14.2, 6.9, 2.5 Hz, 1H), 2.44 (s, 3H), 2.03 (d, *J* = 10.6 Hz, 1H), 1.85 (dt, *J* = 14.2, 2.6 Hz, 1H), 1.52 (ddt, *J* = 10.6, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 157.7, 145.5 (dm, $^1J_{C\text{-}F}$ = 261.8 Hz), 144.0, 143.4 (dm, $^1J_{C\text{-}F}$ = 255.0 Hz), 138.9, 137.7 (dm, $^1J_{C\text{-}F}$ = 251.3 Hz), 135.5, 130.0, 128.8, 127.5, 127.4, 126.1, 107.8 (m), 77.3, 62.0, 57.8, 51.7, 44.5, 38.4, 21.6 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -137.84 (m), -147.75 (tt, *J* = 21.0, 4.9 Hz), -160.07 (m) ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{20}F_5NO_4S + NH_4]^+$ 555.1371, found 555.1377.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 4-chloro-3-nitrobenzoate (5d)



The compound was prepared according to the general procedure **F** with 4-chloro-3-nitrobenzoic acid (403.2 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 20/1 to 7/1) generated product **5d** (82.4 mg, 78% yield) along with byproduct **3a** (4.6 mg, 6% yield). Pale yellow solid, **m. p.** 81 – 82 ℃, R_f = 0.7 (PE/EA = 5/1, twice). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 2.0 Hz, 1H), 8.12 (dd, *J* = 8.4, 2.0 Hz, 1H), 7.79 – 7.77 (m, 2H), 7.64 (d, *J* = 8.4 Hz, 1H), 7.36 – 7.25 (m, 5H), 7.19 – 7.17 (m, 2H), 5.32 – 5.29 (m, 1H), 4.45 (s, 1H), 3.39 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.19 (dd, *J* = 8.6, 2.6 Hz, 1H), 2.58 (ddd, *J* = 14.1, 7.0, 2.5 Hz, 1H), 2.45 (s, 3H), 2.03 (dt, *J* = 10.6, 1.3 Hz, 1H), 1.86 (dt, *J* = 14.1, 2.0 Hz, 1H), 1.58 – 1.54 (m, 1H) ppm. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.5, 147.9, 143.9, 138.9, 135.5, 133.6, 132.3, 132.0, 130.0, 129.7, 128.8, 127.6, 127.4, 126.4, 126.2, 76.8, 62.1, 57.9, 51.7, 44.5, 38.5, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{23}ClN_2O_6S + NH_4]^+$ 544.1304, found 544.1301.

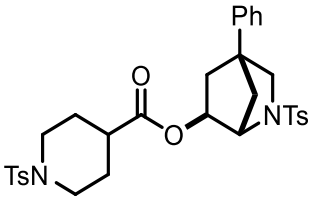
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 4,5,6,7-tetrahydrobenzo[b] thiophene-2-carboxylate (5e)



The compound was prepared according to the general procedure **F** with 4,5,6,7-tetrahydrobenzo[b]thiophene-2-carboxylic acid (364.5 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 20/1 to 6/1) generated product **5e** (64.4 mg, 63% yield) along with byproduct **3a** (13.9 mg, 18% yield), white solid, **m. p.** 48 – 49 ℃, R_f = 0.65 (PE/EA = 5/1 twice). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.79 – 7.76 (m, 2H), 7.42 (s, 1H), 7.34 – 7.22 (m, 5H), 7.18 – 7.14 (m, 2H), 5.18 (d, *J* = 5.5 Hz, 1H), 4.41 (s, 1H), 3.34 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.19 (dd, *J* = 8.4, 2.7 Hz, 1H), 2.76 (t, *J* = 5.9 Hz, 2H), 2.59 (t, *J* = 5.8 Hz, 2H), 2.51 – 2.44 (m, 4H), 2.03 (d, *J* = 10.4 Hz, 1H), 1.87 – 1.74 (m, 5H), 1.51 (ddt, *J* = 10.4, 2.3, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 161.3, 144.8, 143.8, 139.3, 136.6, 135.7, 134.5, 129.9, 128.8, 128.7,

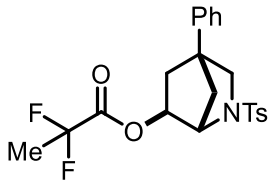
127.4 (two overlapping carbon signals), 126.2, 75.4, 62.3, 58.0, 51.6, 44.6, 38.5, 25.5, 25.3, 23.2, 22.6, 21.6 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{28}H_{29}NO_4S_2 + NH_4]^+$ 525.1876, found 525.1883.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 1-tosylpiperidine-4-carboxylate (5f)



The compound was prepared according to the general procedure **F** with 1-(4-methylphenyl)sulfonylpiperidine-4-carboxylic acid (566.7 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 3/1) generated product **5f** (82.6 mg, 68% yield) along with byproduct **3a** (20.8 mg, 27% yield), white solid, **m. p.** 47 – 48 °C, R_f = 0.4 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.71 (m, 2H), 7.63 – 7.61 (m, 2H), 7.34 – 7.23 (m, 7H), 7.14 – 7.11 (m, 2H), 5.00 (d, *J* = 5.5 Hz, 1H), 4.25 (s, 1H), 3.64 – 3.59 (m, 2H), 3.30 (dd, *J* = 8.5, 1.2 Hz, 1H), 3.12 (dd, *J* = 8.5, 2.6 Hz, 1H), 2.48 – 2.37 (m, 9H), 2.24 – 2.16 (m, 1H), 1.96 – 1.70 (m, 5H), 1.59 (dt, *J* = 13.9, 2.5 Hz, 1H), 1.44 (ddt, *J* = 10.4, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 172.5, 143.9, 143.7, 139.1, 135.5, 133.0, 130.0, 129.8, 128.8, 127.7, 127.5, 127.4, 126.1, 75.3, 62.1, 57.9, 51.5, 45.3, 44.7, 40.0, 38.3, 27.4, 21.62, 21.58 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{32}H_{36}N_2O_6S_2 + NH_4]^+$ 626.2353, found 626.2358.

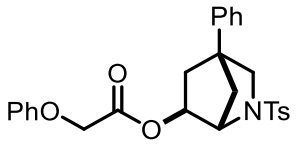
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2,2-difluoropropanoate (5g)



The compound was prepared according to the general procedure **F** with 2,2-difluoropropionic acid (220.2 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 10/1 to 5/1) generated product **5g** (64.5 mg, 74% yield) along with byproduct **3a** (6.3 mg, 8% yield). White solid, **m. p.** 110 – 112 °C, R_f = 0.4

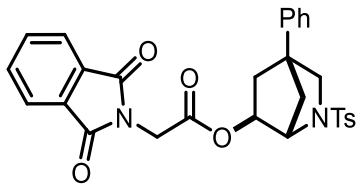
(PE/EA = 6/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.74 (m, 2H), 7.35 – 7.23 (m, 5H), 7.17 – 7.14 (m, 2H), 5.16 (dd, *J* = 6.8, 2.0 Hz, 1H), 4.37 (s, 1H), 3.36 (dd, *J* = 8.6, 1.4 Hz, 1H), 3.15 (dd, *J* = 8.6, 2.6 Hz, 1H), 2.55 – 2.44 (m, 4H), 1.97 (d, *J* = 10.6 Hz, 1H), 1.85 – 1.72 (m, 4H), 1.50 (ddt, *J* = 10.5, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 163.1 (t, $^{2}J_{C\text{-}F}$ = 33.2 Hz), 144.0, 138.7, 135.3, 130.0, 128.8, 127.6, 127.4, 126.2, 115.0 (t, $^{1}J_{C\text{-}F}$ = 246.7 Hz), 77.1, 61.9, 57.9, 51.6, 44.2, 38.2, 21.6, 21.3 (t, $^{2}J_{C\text{-}F}$ = 25.0 Hz) ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -99.01 (*app.* d, *J* = 3.0 Hz) ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{22}H_{23}F_2NO_4S + NH_4]^+$ 453.1654, found 453.1658.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-phenoxyacetate (5h)



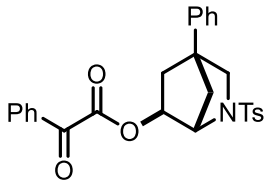
The compound was prepared according to the general procedure **F** with phenoxyacetic acid (304.3 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 4/1) generated product **5h** (80.5 mg, 84% yield) and byproduct **3a** was not detected. White solid, **m. p.** 119 – 120 ℃, R_f = 0.2 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.72 (m, 2H), 7.32 – 7.23 (m, 7H), 7.09 – 7.06 (m, 2H), 7.01 – 6.95 (m, 1H), 6.90 – 6.85 (m, 2H), 5.14 – 5.10 (m, 1H), 4.59 (s, 2H), 4.29 (s, 1H), 3.31 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.14 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.44 – 2.37 (m, 4H), 1.79 (d, *J* = 10.5 Hz, 1H), 1.65 (dt, *J* = 14.0, 2.7 Hz, 1H), 1.39 (ddt, *J* = 10.5, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 167.9, 157.7, 143.8, 139.0, 135.5, 130.0, 129.7, 128.7, 127.5, 127.4, 126.2, 121.9, 114.6, 75.9, 65.3, 62.0, 57.7, 51.5, 44.6, 38.3, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{27}H_{27}NO_5S + NH_4]^+$ 495.1948, found 495.1955.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-(1,3-dioxoisoindolin-2-yl)acetate (5i)



The compound was prepared according to the general procedure **F** with N-phthaloylglycine (410.4 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 6/1 to 2/1) generated product **5i** (81.7 mg, 77% yield) along with byproduct **3a** (15.6 mg, 20% yield). Pale yellow solid, **m. p.** 63 – 64 °C, R_f = 0.2 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.90 – 7.85 (m, 2H), 7.78 – 7.72 (m, 4H), 7.34 – 7.23 (m, 5H), 7.15 – 7.12 (m, 2H), 5.08 (d, *J* = 6.0 Hz, 1H), 4.40 (d, *J* = 3.7 Hz, 2H), 4.33 (s, 1H), 3.31 (d, *J* = 8.5 Hz, 1H), 3.16 (dd, *J* = 8.5, 2.6 Hz, 1H), 2.44 – 2.36 (s, 4H), 1.92 (d, *J* = 10.5 Hz, 1H), 1.75 (dt, *J* = 14.0, 2.5 Hz, 1H), 1.47 (d, *J* = 10.3 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 167.4, 166.1, 143.8, 139.0, 135.5, 134.4, 131.9, 130.0, 128.8, 127.5, 127.4, 126.2, 123.7, 76.4, 61.9, 57.8, 51.5, 44.3, 38.9, 38.3, 21.6 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{29}H_{26}N_2O_6S + H]^+$ 531.1584, found 531.1588.

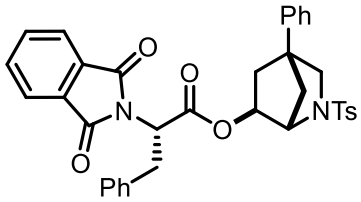
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-oxo-2-phenylacetate (5j)



The compound was prepared according to the general procedure **F** with phenylglyoxylic acid (300.3 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 15/1 to 4/1) generated product **5j** (51.6 mg, 54% yield, d.r. value was not determined) along with byproduct **3a** (10.8 mg, 14% yield). White solid, **m. p.** 47 – 48 °C, R_f = 0.4 (PE/EA = 5/1 twice). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.02 – 7.99 (m, 2H), 7.78 – 7.75 (m, 2H), 7.71 – 7.65 (m, 1H), 7.55 – 7.50 (m, 2H), 7.35 – 7.23 (m, 5H), 7.17 – 7.13 (m, 2H), 5.36 – 5.32 (m, 1H), 4.44 (s, 1H), 3.40 (dd, *J* = 8.6, 1.3 Hz, 1H), 3.17 (dd, *J* = 8.6, 2.6 Hz, 1H), 2.57 (ddd, *J* = 14.2, 6.9, 2.6 Hz, 1H), 2.44

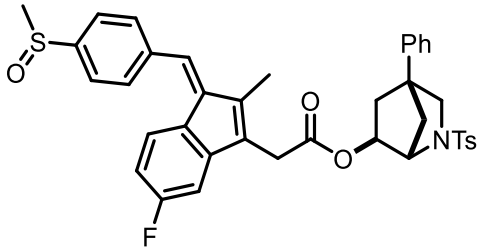
(s, 3H), 2.03 (d, *J* = 10.7 Hz, 1H), 1.87 (dt, *J* = 14.1, 2.7 Hz, 1H), 1.48 (ddt, *J* = 10.6, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 185.7, 162.4, 144.0, 138.8, 135.4, 135.2, 132.2, 130.1, 130.0, 129.1, 128.8, 127.6, 127.4, 126.2, 76.8, 62.1, 57.9, 51.7, 44.5, 38.3, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{27}H_{25}NO_5S + NH_4]^+$ 493.1792, found 493.1795.

4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl (S)-2-(1,3-dioxoisoindolin-2-yl)-3-phenyl propanoate (5k)



The compound was prepared according to the general procedure **F** with N-phthaloyl-*L*-phenylalanine (590.6 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 6/1 to 2/1) generated product **5k** (90.6 mg, 73% yield, d.r. = 1:1, after purification from ^{1}H NMR) along with byproduct **3a** (17.5 mg, 23% yield). White solid, **m. p.** 107 – 109 °C, R_f = 0.2 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.78 – 7.66 (m, 6H), 7.33 – 7.23 (m, 5H), 7.20 – 7.07 (m, 7H), 5.16 – 5.08 (m, 2H), 4.34 (s, 0.5H), 4.27 (s, 0.5H), 3.60 – 3.41 (m, 2H), 3.33 – 3.28 (m, 1H), 3.17 – 3.13 (m, 1H), 2.43 – 2.36 (m, 4H), 1.79 – 1.67 (m, 2H), 1.45 (ddt, *J* = 10.5, 2.2, 2.1 Hz, 0.5H), 1.33 (ddt, *J* = 10.5, 2.2, 2.1 Hz, 0.5H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 167.7, 167.42, 167.37, 143.8, 139.1, 139.0, 136.5, 135.7, 135.5, 134.32, 134.27, 131.50, 131.45, 130.0, 128.9, 128.8, 128.7, 128.6, 127.5, 127.4, 127.0, 126.2, 126.1, 123.5, 76.6, 76.5, 62.0, 61.9, 57.9, 57.6, 53.3, 53.2, 51.5, 51.4, 44.5, 44.0, 38.5, 38.3, 34.8, 34.7, 21.6 ppm (Two group of signals are observed due to the existence of two diastereoisomers. We simply listed each observed signal). **HRMS (ESI)** *m*/*z* Calcd for $[C_{36}H_{32}N_2O_6S + NH_4]^+$ 638.2319, found 638.2330.

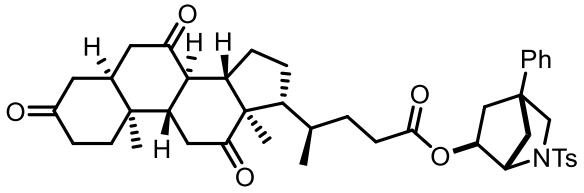
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-(5-fluoro-2-methyl-1-((Z)-4-(methylsulfinyl) benzylidene)-1H-inden-3-yl)acetate (5l)



The compound was prepared according to the general procedure **F** with sulindac (712.9 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 5/1 to DCM/MeOH = 40/1) generated product **5l** (78.6 mg, 58% yield, d.r. value was not determined) along with byproduct **3a** (7.9 mg, 10% yield). After hydrolysis of **5l**, the corresponding alcohol **10** was isolated with >30:1 dr. Since sulindac is a racemic molecule, the dr value of product **5l** was calculated to be 1:1. Yellow solid, **m. p.** 85 – 86 °C, R_f = 0.6 (DCM/MeOH = 30/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.64 (m, 6H), 7.32 – 7.21 (m, 5H), 7.17 – 7.13 (m, 2H), 7.08 – 7.05 (m, 2H), 6.85 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.56 (td, *J* = 8.8, 2.4 Hz, 1H), 5.06 – 5.02 (m, 1H), 4.29 (s, 1H), 3.53 (s, 2H), 3.30 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.14 (dd, *J* = 8.5, 2.6 Hz, 1H), 2.81 (s, 3H), 2.42 – 2.34 (m, 4H), 2.20 (s, 3H), 1.86 (d, *J* = 10.4 Hz, 1H), 1.62 (dt, *J* = 14.0, 2.5 Hz, 1H), 1.41 (ddt, *J* = 10.3, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 168.8, 163.3 (d, $^1J_{C\text{-}F}$ = 245.0 Hz), 146.6 (d, $^3J_{C\text{-}F}$ = 8.7 Hz), 145.5, 143.8, 141.5, 139.6, 139.2, 138.5, 135.5, 131.4 (d, $^4J_{C\text{-}F}$ = 2.5 Hz), 130.3, 129.9, 129.6 (d, $^4J_{C\text{-}F}$ = 3.0 Hz), 128.7, 128.6 (d, $^5J_{C\text{-}F}$ = 1.5 Hz), 127.40, 127.35, 126.1, 123.9, 123.8 (d, $^3J_{C\text{-}F}$ = 9.4 Hz), 110.8 (d, $^2J_{C\text{-}F}$ = 22.4 Hz), 106.1 (d, $^2J_{C\text{-}F}$ = 23.9 Hz), 75.8, 62.1, 57.6, 51.5, 44.9, 43.9, 38.4, 31.9, 21.6, 10.7 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -112.92 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{39}H_{36}FNO_5S_2 + H]^+$ 682.2092, found 682.2095.

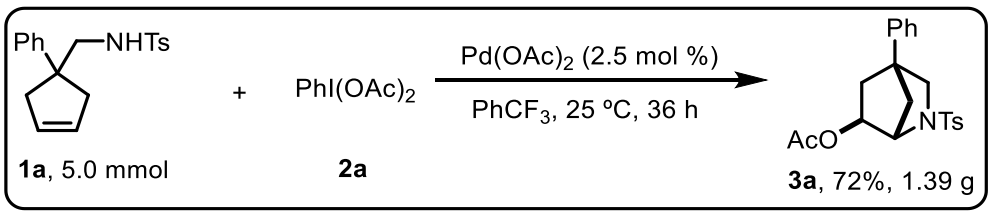
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl (R)-4-((5S,8R,9S,10S,13R,14S,17R) -10,13-dimethyl-3,7,12-trioxohexadecahydro-1H-cyclopenta[a]phenanthren-17-yl)

pentanoate (5m)



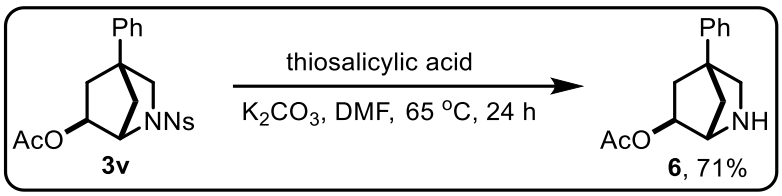
The compound was prepared according to the general procedure **F** with dehydrocholic acid (805.1 mg, 2.0 mmol, 10.0 equiv). Purification by flash column chromatography (PE/EA = 5/1 to DCM/MeOH = 50/1) generated product **5m** (68.2 mg, 47% yield) along with byproduct **3a** (19.8 mg, 26% yield). The dr value was determined by ^{13}C NMR-spectroscopy to be 1:1. Colorless oil, R_f = 0.8 (DCM/MeOH = 30/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.73 (m, 2H), 7.34 – 7.23 (m, 5H), 7.17 – 7.13 (m, 2H), 5.04 – 5.00 (m, 1H), 4.29 (s, 1H), 3.33 – 3.30 (m, 1H), 3.16 – 3.12 (m, 1H), 2.96 – 2.80 (m, 3H), 2.44 (s, 3H), 2.40 – 2.28 (m, 5H), 2.25 – 2.10 (m, 6H), 2.07 – 1.93 (m, 6H), 1.88 – 1.75 (m, 2H), 1.71 – 1.61 (m, 2H), 1.47 – 1.40 (m, 4H), 1.38 – 1.27 (m, 3H), 1.06 – 1.05 (m, 3H), 0.84 – 0.82 (m, 3H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 212.0, 209.2, 208.80, 208.78, 172.76, 172.70, 143.7, 139.34, 139.29, 135.5, 129.9, 128.7, 127.4, 126.2, 75.0, 62.3, 62.2, 57.9, 56.9, 51.8, 51.5, 49.0, 46.8, 45.58, 45.55, 45.50, 45.0, 44.83, 44.78, 42.8, 38.7, 38.3, 36.5, 36.0, 35.4, 35.3, 31.3, 30.33, 30.27, 27.7, 25.1, 21.9, 21.6, 18.6, 11.9, 11.8 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{43}H_{53}NO_7S + NH_4]^+$ 745.3881, found 745.3894.

6. Scale-up experiments and synthetic utility



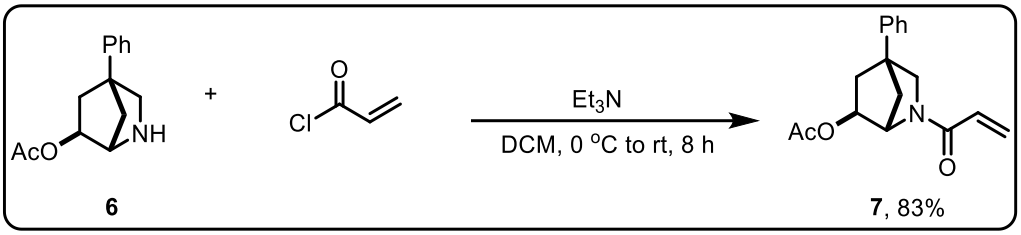
To an oven-dried 100-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added $Pd(OAc)_2$ (28.1 mg, 0.125 mmol, 2.5 mol %), **1a** (1.637 g, 5.0 mmol, 1.0 equiv), **2a** (4.026 g, 12.5 mmol, 2.5 equiv). Then the schlenk tube was evacuated

and filled with argon for three times. After that, $PhCF_3$ (50.0 mL) was added to the tube via a syringe under argon atmosphere. The reaction mixture was stirred at 25 ℃ (oil bath temperature) for 36 h. After completion of the reaction, the mixture was diluted with DCM (50.0 mL) and filtered through a plug of Celite. Then the solvent was removed in vacuum and the crude product was purified by flash chromatography on silica gel (PE/EA = 10/1 to 5/1) to obtain **3a** (1.39 g) in 72% yield.

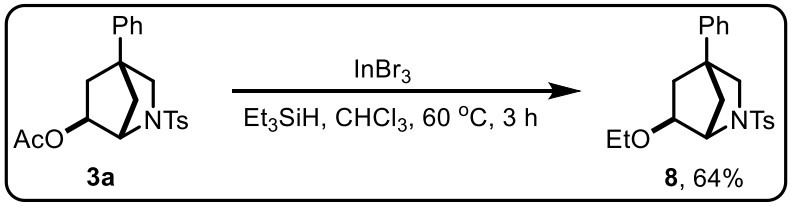


4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (6) To an oven-dried 10 mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **3v** (82.3 mg, 0.2 mmol, 1.0 equiv), thiosalicylic acid (61.7 mg, 0.4 mmol, 2.0 equiv) and K_2CO_3 (110.6 mg, 0.8 mmol, 4.0 equiv). Then the schlenk tube was evacuated and filled with argon for three times. After that, DMF (2.0 mL) was added to the tube via a syringe under argon atmosphere. The reaction mixture was stirred at 65 ℃ in oil bath for 24 h. After completion of the reaction, the reaction mixture was diluted with EA (20.0 mL) and filtered through a plug of Celite. The solvent was washed with saturated aqueous sodium hydrogen carbonate solution (25.0 mL) and aqueous phase was extracted with EA (15.0 mL × 3). The organic layer was concentrated under reduced pressure. Then the residue was dissolved in DCM (20.0 mL) and washed by HCl (1 M, 5.0 mL × 3) and aqueous phase was adjusted the PH to 8.0 with aqueous NaOH solution (1 M). And the aqueous phase was extracted with DCM (10.0 mL × 3). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (DCM/MeOH = 50:1 to 30:1) to obtain the compound **6** (32.7 mg) in 71% yield, colorless oil, R_f = 0.6 (DCM/MeOH = 30/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.37 – 7.22 (m, 5H), 4.82 (ddt, *J* = 7.2, 2.7, 1.4 Hz, 1H), 3.57 (s, 1H), 3.00 – 2.91 (m, 2H), 2.38 (ddd, *J* = 13.6, 7.2, 2.4 Hz, 1H), 2.08 – 1.95 (m, 6H), 1.75 (dt, *J* = 13.6, 2.8 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 170.5, 141.4, 128.5, 126.7, 126.5, 59.2, 56.1, 50.7, 44.6, 38.9, 21.2 ppm. **HRMS (ESI)**

m/*z* Calcd for $[C_{14}H_{17}NO_2 + H]^+$ 232.1332, found 232.1336.

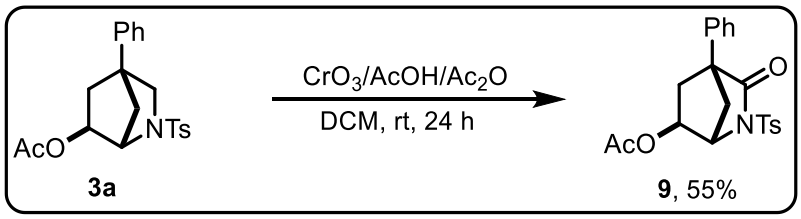


2-acryloyl-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (7) To an oven-dried 10-mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **6** (34.7 mg, 0.15 mmol, 1.0 equiv), acryloyl chloride (18 μL, 0.225 mmol, 1.5 equiv) and DCM (1.0 mL). The mixture was stirred at 0 °C, while Et_3N (31 μL, 0.225 mmol, 1.5 equiv) was added via a microsyringe. The reaction mixture was allowed to room temperature slowly for another 8 h. After completion of the reaction, the solvent was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (DCM/MeOH = 30:1) to obtain the compound **7** (35.5 mg) in 83% yield, colorless oil, R_f = 0.7 (DCM/MeOH = 30/1). Two amide rotamers were observed from the ^{1}H NMR and ^{13}C NMR spectra. **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.40 – 7.26 (m, 5H), 6.73 – 6.26 (m, 2H), 5.78 – 5.69 (m, 1H), 4.96 – 4.46 (m, 2H), 3.61 – 3.44 (m, 2H), 2.57 – 2.33 (m, 1H), 2.22 – 2.17 (m, 1H), 2.08 – 2.00 (m, 4H), 1.92 – 1.74 (m, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 170.6, 169.9, 164.6, 163.8, 139.8, 139.6, 128.8, 128.7, 128.6, 128.5, 127.8, 127.7, 127.4, 127.3, 126.3, 75.3, 74.0, 60.2, 58.3, 57.7, 56.5, 51.5, 50.0, 45.2, 43.5, 39.3, 38.0, 21.11, 21.05 ppm (Multiple signals are observed due to the existence of two amide rotamers. We simply listed each observed signal). **HRMS (ESI)** *m*/*z* Calcd for $[C_{17}H_{19}NO_3 + H]^+$ 286.1438, found 286.1435.



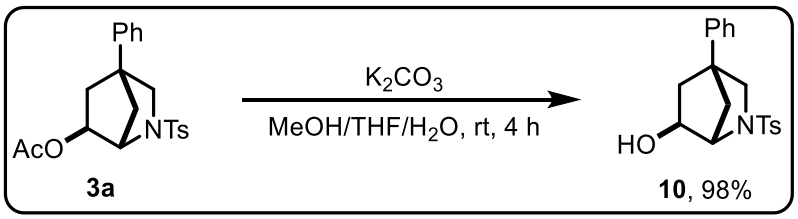
6-ethoxy-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (8) The reductive deoxygenation of **3a** was conducted following a modified literature procedure.[5] To an

oven-dried 10 mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **3a** (57.8 mg, 0.15 mmol, 1.0 equiv) and $InBr_3$ (15.6 mg, 0.045 mmol, 30 mol%). Then the schlenk tube was evacuated and filled with argon for three times. After that, $CHCl_3$ (0.4 mL) and Et_3SiH (192 μL, 1.2 mmol, 8.0 equiv) were added to the tube in sequence via a syringe under argon atmosphere. The reaction mixture was stirred at 60 ℃ in oil bath for 3 h. After completion of the reaction, H_2O (8.0 mL) was added to quench the reaction and the aqueous phase was extracted with DCM (8.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/EA = 10/1) to obtain the compound **8** (35.6 mg) in 64% yield, white solid, **m. p.** 73 – 74 ℃, R_f = 0.7 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.70 (m, 2H), 7.33 – 7.20 (m, 5H), 7.16 – 7.13 (m, 2H), 4.26 (s, 1H), 3.92 (ddt, *J* = 6.8, 2.4, 1.4 Hz, 1H), 3.60 – 3.43 (m, 2H), 3.32 (dd, *J* = 8.4, 1.4 Hz, 1H), 3.05 (dd, *J* = 8.4, 2.8 Hz, 1H), 2.42 (s, 3H), 2.26 (ddd, *J* = 13.4, 6.8, 2.5 Hz, 1H), 1.96 (dt, *J* = 10.2, 1.2 Hz, 1H), 1.68 – 1.62 (m, 1H), 1.25 – 1.15 (m, 4H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.6, 140.1, 135.5, 129.8, 128.6, 127.4, 127.1, 126.2, 80.9, 64.4, 62.1, 57.8, 51.1, 44.9, 37.6, 21.6, 15.5 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{21}H_{25}NO_3S + H]^+$ 372.1628, found 372.1632.



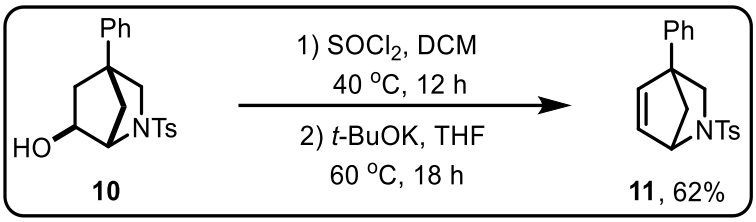
3-oxo-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (9) The C-H oxidation of **3a** was conducted following a modified literature procedure.[6] To an oven-dried 10 mL schlenk tube equipped with a tefloncoated magnetic stir bar was added CrO_3 (60.0 mg, 0.6 mmol, 3.0 equiv), AcOH (115.0 μL, 2.0 mmol, 10.0 equiv) and Ac_2O (98.0 μL, 1.0 mmol, 5.0 equiv). After stirring at room temperature for 15 min, the mixture was added in one portion to the solution of **3a** (77.1 mg, 0.2 mmol, 1.0 equiv) in DCM (4.0 mL). The reaction mixture was stirred at room temperature for 24

h. After completion of the reaction, the mixture was diluted with DCM (5.0 mL) and quenched with saturated aqueous sodium hydrogen carbonate solution (20.0 mL). Then the aqueous phase was extracted with DCM (15.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/EA = 3/1) to obtain the compound **9** (43.9 mg) in 55% yield, pale yellow oil, R_f = 0.6 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.99 – 7.96 (m, 2H), 7.39 – 7.30 (m, 5H), 7.28 – 7.24 (m, 2H), 5.05 (d, *J* = 6.0 Hz, 1H), 4.78 (s, 1H), 2.48 – 2.39 (m, 5H), 2.30 (dd, *J* = 10.5, 1.6 Hz, 1H), 2.07 (s, 3H), 1.89 (dd, *J* = 14.2, 2.7 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 173.4, 169.9, 145.5, 135.7, 134.6, 129.9, 128.6, 128.1 (two overlapping carbon signals), 127.4, 73.4, 61.3, 57.8, 40.2, 39.1, 21.8, 20.9 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{21}H_{21}NO_5S + H]^+$ 400.1213, found 400.1216.



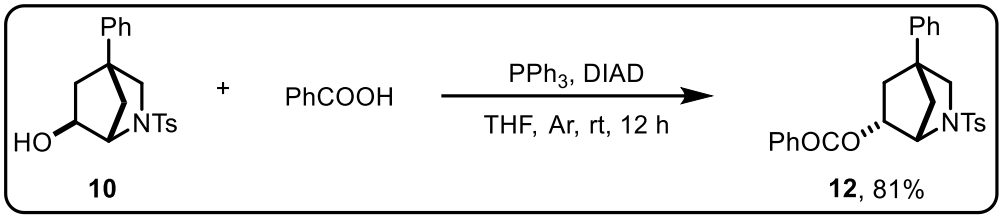
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-ol (10) In a 100-mL round bottom flask equipped with a tefloncoated magnetic stir bar, **3a** (771.0 mg, 2.0 mmol, 1.0 equiv) was dissolved in THF/H_2O/MeOH (v/v/v = 1:1:1, 45.0 mL). Then K_2CO_3 (691.1 mg, 5.0 mmol, 2.5 equiv) was added and the mixture was stirred at room temperature for about 4 h and monitored by TLC. After completion of the reaction, H_2O (50.0 mL) was added to quench the reaction and the aqueous phase was extracted with EA (30.0 mL × 3). The organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/EA = 2/1) to obtain the compound **10** (675.4 mg) in 98% yield, white solid, **m. p.** 74 – 76 °C, R_f = 0.3 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.73 – 7.71 (m, 2H), 7.31 – 7.19 (m, 5H), 7.16 – 7.12 (m, 2H), 4.34 (d, *J* = 6.7 Hz, 1H), 4.16 (s, 1H), 3.30 (dd, *J* = 8.4, 1.3 Hz, 1H), 3.06 – 3.02 (m, 2H), 2.40 (s, 3H), 2.32 (ddd, *J* = 13.5, 6.8, 2.4 Hz, 1H), 2.05 (d, *J* = 10.3 Hz, 1H), 1.62 (dt, *J* = 13.4, 2.5 Hz, 1H), 1.23 (ddt, *J*

= 10.4, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.8, 140.0, 135.2, 130.0, 128.7, 127.4, 127.2, 126.3, 73.7, 64.9, 57.7, 51.4, 46.7, 37.2, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{21}NO_3S + H]^+$ 344.1315, found 344.1319.

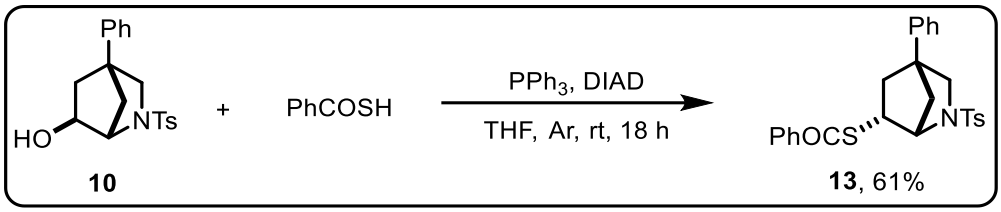


4-phenyl-2-tosyl-2-azabicyclo[2.2.1]hept-5-ene (11) To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **10** (68.9 mg, 0.2 mmol, 1.0 equiv) and DCM (1.0 mL). And the $SOCl_2$ (22.0 μL, 0.3 mmol, 1.5 equiv) was added at 0 ℃. Then the reaction was stirred at 40 ℃ in oil bath for 12 h. After completion of the reaction, it was quenched with saturated aqueous sodium hydrogen carbonate solution (15.0 mL) and extracted with DCM (10.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The crude intermediate was directly used in the next step without further purification.

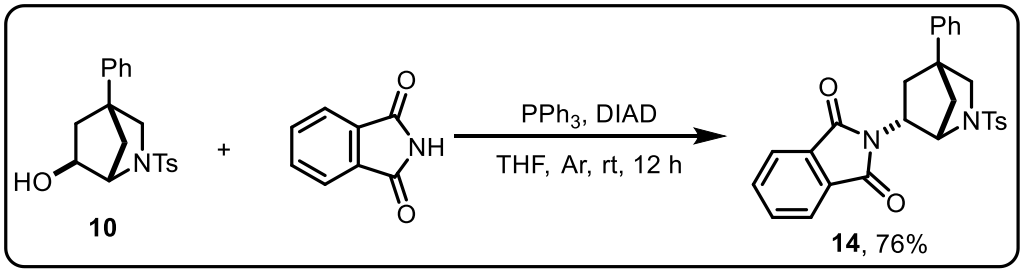
The chloro-intermediate was added to a sealed tube with *t*-BuOK (67.4 mg, 0.4 mmol, 2.0 equiv) and THF (2.0 mL). Then the mixture was stirred at 60 ℃ in oil bath for 18 h. After completion of the reaction, the crude product was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 10/1) to obtain the desired product **11** (40.4 mg) in 62% yield, pale yellow solid, **m. p.** 108 – 109 °C, R_f = 0.6 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.2 Hz, 2H), 7.38 – 7.23 (m, 7H), 6.21 (dd, *J* = 5.5, 1.6 Hz, 1H), 6.13 (dd, *J* = 5.5, 2.4 Hz, 1H), 4.79 (s, 1H), 3.51 (d, *J* = 8.4 Hz, 1H), 2.91 (d, *J* = 8.4 Hz, 1H), 2.42 (s, 3H), 1.79 (s, 2H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.5, 140.6, 139.1, 136.2, 133.6, 129.7, 128.9, 127.8, 127.5, 126.5, 65.1, 59.4, 52.8, 51.9, 21.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{19}NO_2S + H]^+$ 326.1209, found 326.1213.



***endo*-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzoate (12)** The Mitsunobu reaction of secondary alcohol **10** was conducted following a modified literature procedure.[7] To an oven-dried 10 mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **10** (85.9 mg, 0.25 mmol, 1.0 equiv), PhCOOH (51.9 mg, 0.425 mmol, 1.7 equiv) and PPh_3 (111.5 mg, 0.425 mmol, 1.7 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, freshly distilled THF (2.0 mL) was added to the tube via a syringe under argon atmosphere. The solution was stirred at 0 ℃, then DIAD (85.0 μL, 0.425 mmol, 1.7 equiv) was added via a microsyringe over a period of 10 min. The reaction was kept at 0 ℃ for 30 min and allowed to warm to room temperature for another 12 h. After completion of the reaction, the mixture was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 20/1 to 5/1) to obtain the desired product **12** (91.1 mg) in 81% yield, white solid, **m. p.** 119 – 121 ℃, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.01 – 7.97 (m, 2H), 7.81 – 7.76 (m, 2H), 7.58 – 7.52 (m, 1H), 7.44 – 7.39 (m, 2H), 7.35 – 7.22 (m, 5H), 7.19 – 7.15 (m, 2H), 5.29 – 5.25 (m, 1H), 4.46 (s, 1H), 3.38 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.20 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.54 (ddd, *J* = 14.0, 6.9, 2.5 Hz, 1H), 2.43 (s, 3H), 2.07 (dt, *J* = 10.4, 1.2 Hz, 1H), 1.87 (dt, *J* = 14.1, 2.5 Hz, 1H), 1.53 (ddt, *J* = 10.4, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 165.3, 143.8, 139.3, 135.6, 133.3, 130.0, 129.8, 129.6, 128.8, 128.5, 127.4 (two overlapping carbon signals), 126.2, 75.6, 62.4, 58.1, 51.6, 44.6, 38.5, 21.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{25}NO_4S + H]^+$ 448.1577, found 448.1582.

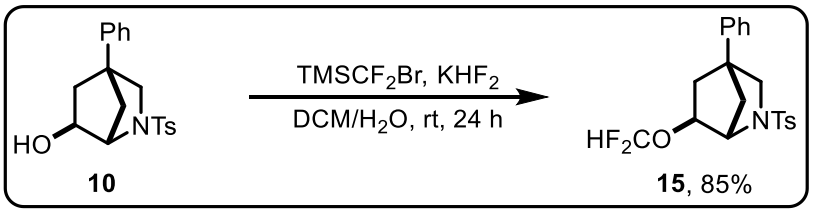


***endo*-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzothioate (14)** To an oven-dried 10 mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **10** (85.9 mg, 0.25 mmol, 1.0 equiv), PhCOSH (58.8 mg, 0.425 mmol, 1.7 equiv) and PPh_3 (111.5 mg, 0.425 mmol, 1.7 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, freshly distilled THF (2.0 mL) was added to the tube via a syringe under argon atmosphere. The solution was stirred at 0 ℃, then DIAD (85.0 μL, 0.425 mmol, 1.7 equiv) was added via a microsyringe over a period of 10 min. The reaction was kept at 0 ℃ for 30 min and allowed to warm to room temperature for another 18 h. After completion of the reaction, the mixture was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 20/1 to 4/1) to obtain the desired product **13** (70.9 mg) in 61% yield, white solid, **m. p.** 143 – 145 °C, R_f = 0.5 (PE/EA = 4/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.95 – 7.91 (m, 2H), 7.87 – 7.84 (m, 2H), 7.60 – 7.54 (m, 1H), 7.47 – 7.41 (m, 2H), 7.34 – 7.22 (m, 5H), 7.18 – 7.14 (m, 2H), 4.37 (s, 1H), 4.12 – 4.06 (m, 1H), 3.43 (dd, *J* = 8.7, 1.2 Hz, 1H), 3.31 (dd, *J* = 8.6, 2.9 Hz, 1H), 2.51 (ddd, *J* = 13.8, 8.6, 2.4 Hz, 1H), 2.43 (s, 3H), 2.00 (d, *J* = 10.5 Hz, 1H), 1.81 (ddd, *J* = 13.7, 4.2, 2.8 Hz, 1H), 1.61 (ddt, *J* = 10.4, 2.2, 2.1 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 190.1, 143.6, 139.6, 136.6, 136.0, 133.6, 129.9, 128.8, 128.7, 127.6, 127.41, 127.37, 126.1, 64.5, 58.3, 52.4, 44.9, 42.8, 39.5, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{26}H_{25}NO_3S_2 + H]^+$ 464.1349, found 464.1351.



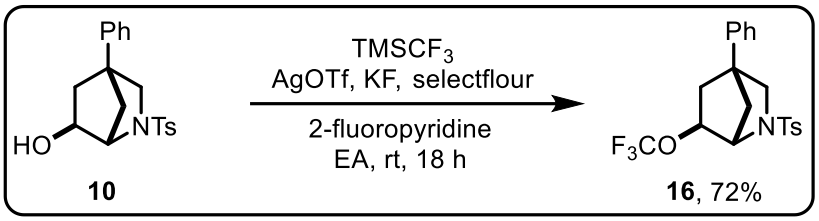
***endo*-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl)isoindoline-1,3-dione (14)**

To an oven-dried 10-mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **10** (85.9 mg, 0.25 mmol, 1.0 equiv), phthalimide (62.6 mg, 0.425 mmol, 1.7 equiv) and PPh_3 (111.5 mg, 0.425 mmol, 1.7 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, freshly distilled THF (2.0 mL) was added to the tube via a syringe under argon atmosphere. The solution was stirred at 0 ℃, then DIAD (85.0 μL, 0.425 mmol, 1.7 equiv) was added via a microsyringe over a period of 10 min. The reaction was kept at 0 ℃ for 30 min and allowed to warm to room temperature for another 12 h. After completion of the reaction, the mixture was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA from 10/1 to 2/1) to obtain the desired product **14** (89.6 mg) in 76% yield, white solid, **m. p.** 76 – 78 ℃, R_f = 0.4 (PE/EA = 2/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.84 – 7.78 (m, 4H), 7.75 – 7.69 (m, 2H), 7.35 – 7.22 (m, 7H), 4.70 (dd, *J* = 8.2, 4.7 Hz, 1H), 4.61 (s, 1H), 3.49 (dd, *J* = 8.5, 1.3 Hz, 1H), 3.31 (dd, *J* = 8.6, 2.7 Hz, 1H), 2.65 (d, *J* = 10.5 Hz, 1H), 2.53 (ddd, *J* = 13.4, 4.8, 2.7 Hz, 1H), 2.43 – 2.33 (m, 4H), 1.50 (ddt, *J* = 10.5, 2.0, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 168.3, 143.6, 139.7, 135.7, 134.3, 131.6, 129.9, 128.7, 127.5, 127.2, 126.3, 123.3, 63.4, 57.6, 56.0, 52.2, 41.6, 40.7, 21.6 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{27}H_{24}N_2O_4S + H]^+$ 473.1530, found 473.1534.



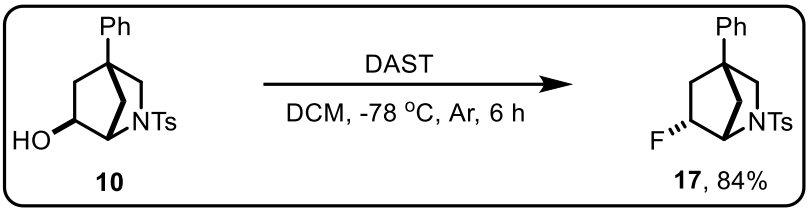
6-(difluoromethoxy)-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (15) The difluoromethylation of secondary alcohol **10** was conducted following a modified literature procedure.[8] To a 10-mL plastic tube equipped with a cap and a tefloncoated magnetic stir bar was added **10** (68.7 mg, 0.2 mmol, 1.0 equiv) and KHF_2 (218.7 mg, 2.8 mmol, 14.0 equiv). Then DCM (0.3 mL), H_2O (0.3 mL) and $TMSCF_2Br$ (220 μL, 1.4 mmol, 7.0 equiv) were added in sequence. The reaction mixture was stirred at room temperature for 24 h. After completion of the reaction, the mixture was concentrated in

vacuum and purified by flash chromatography on silica gel (PE/EA = 7/1) to obtain the desired product **15** (66.7 mg) in 85% yield, white solid, **m. p.** 107 – 109 °C, R_f = 0.7 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.72 (m, 2H), 7.34 – 7.22 (m, 5H), 7.17 – 7.13 (m, 2H), 6.21 (t, *J* = 74.3 Hz, 1H), 4.59 (d, *J* = 7.8 Hz, 1H), 4.31 (s, 1H), 3.34 (dd, *J* = 8.5, 1.4 Hz, 1H), 3.10 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.43 (s, 3H), 2.37 (ddd, *J* = 14.0, 7.1, 2.6 Hz, 1H), 2.00 (d, *J* = 10.5 Hz, 1H), 1.84 (dt, *J* = 13.9, 2.5 Hz, 1H), 1.39 (ddt, *J* = 10.5, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.9, 139.1, 135.4, 130.0, 128.8, 127.4, 127.3, 126.2, 115.9 (t, $^1J_{C\text{-}F}$ = 258.8 Hz), 75.5 (t, $^3J_{C\text{-}F}$ = 3.5 Hz), 63.0, 57.7, 51.3, 44.6, 37.7, 21.6 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -81.15 (d, *J* = 7.2 Hz) ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{20}H_{21}F_2NO_3S + Na]^+$ 416.1102, found 416.1108.



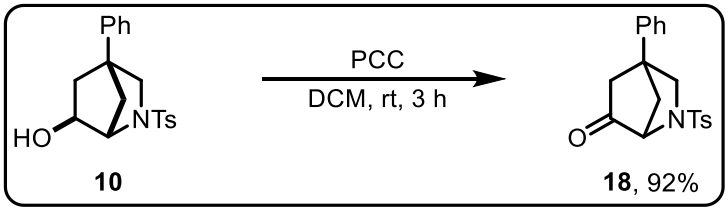
4-phenyl-2-tosyl-6-(trifluoromethoxy)-2-azabicyclo[2.2.1]heptane (16) The silver-mediated oxidative trifluoromethylation of alcohol **10** was conducted following a reported procedure.[9] To an oven-dried 10 mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **10** (85.9 mg, 0.25 mmol, 1.0 equiv), AgOTf (128.5 mg, 0.5 mmol, 2.0 equiv), KF (43.6 mg, 0.75 mmol, 3.0 equiv) and selectflour (132.9 mg, 0.375 mmol, 1.5 equiv). Then the schlenk tube was evacuated and filled with argon for three times. After that, EA (1.5 mL), 2-fluorpyridine (43.0 μL, 0.5 mmol, 2.0 equiv) and $TMSCF_3$ (74.0 μL, 0.5 mmol, 2.0 equiv) were added to the tube in sequence via a syringe under argon atmosphere. The reaction mixture was stirred at room temperature for 18 h. After completion of the reaction, the mixture was diluted with EA (8.0 mL) and filtered through a plug of silica. The solvent was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 10/1) to obtain the desired product **16** (73.8 mg) in 72% yield, white solid, **m. p.** 102 – 103 °C, R_f = 0.75 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.72 (m, 2H), 7.35 – 7.23

(m, 5H), 7.17 – 7.13 (m, 2H), 4.68 – 4.64 (m, 1H), 4.36 (s, 1H), 3.35 (dd, *J* = 8.4, 1.4 Hz, 1H), 3.11 (dd, *J* = 8.5, 2.7 Hz, 1H), 2.45 – 2.37 (m, 4H), 2.00 (dt, *J* = 10.7, 1.2 Hz, 1H), 1.91 (dd, *J* = 14.1, 2.5 Hz, 1H), 1.43 (ddt, *J* = 10.7, 2.2, 2.0 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 144.0, 138.7, 135.3, 130.0, 128.8, 127.6, 127.3, 126.1, 121.2 (q, $^1J_{C\text{-}F}$ = 254.7 Hz), 78.1 (q, $^3J_{C\text{-}F}$ = 2.2 Hz), 62.4, 57.6, 51.3, 44.2, 37.7, 21.6 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -58.48 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{20}H_{20}F_3NO_3S + H]^+$ 412.1189, found 412.1193.

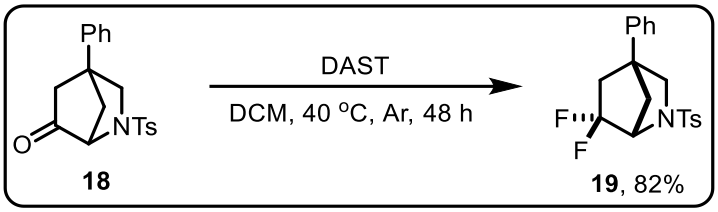


***endo*-6-fluoro-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (17)** The stereoselective dehydroxyfluorination of secondary alcohol **10** using DAST was conducted following a modified literature procedure.[10] To an oven-dried 10-mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **10** (68.7 mg, 0.20 mmol, 1.0 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, DCM (2.0 mL) was added to the tube via a syringe under argon atmosphere. The solution was stirred at -78 ℃, then the solution of DAST (67.0 μL, 0.5 mmol, 2.5 equiv) in DCM (1.0 mL) was added via a syringe over a period of 10 min. Then the reaction was stirred at -78 ℃ for 6 h. After completion of the reaction, it was quenched with saturated aqueous potassium carbonate solution (15.0 mL) and extracted with DCM (10.0 mL × 3). The organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/EA = 8/1) to obtain the desired product **17** (57.8 mg) in 84% yield, white solid, **m. p.** 95 – 96 ℃, R_f = 0.6 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.71 (m, 2H), 7.34 – 7.22 (m, 5H), 7.17 – 7.12 (m, 2H), 5.12 – 4.91 (m, 1H), 4.35 (s, 1H), 3.30 (dd, *J* = 8.4, 1.5 Hz, 1H), 3.07 (dt, *J* = 8.4, 2.7 Hz, 1H), 2.43 – 2.29 (m, 4H), 2.02 – 1.79 (m, 2H), 1.39 – 1.33 (m, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.8, 138.9, 135.1, 129.9, 128.7, 127.3, 127.2, 126.1, 92.3 (d, $^1J_{C\text{-}F}$ = 189.4

Hz), 62.1 (d, $^{2}J_{C\text{-}F}$ = 28.4 Hz), 57.4 (d, $^{4}J_{C\text{-}F}$ = 1.3 Hz), 51.0, 44.6 (d, $^{2}J_{C\text{-}F}$ = 20.8 Hz), 37.4, 21.5 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -164.58 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{20}FNO_2S + H]^+$ 346.1272, found 346.1274.

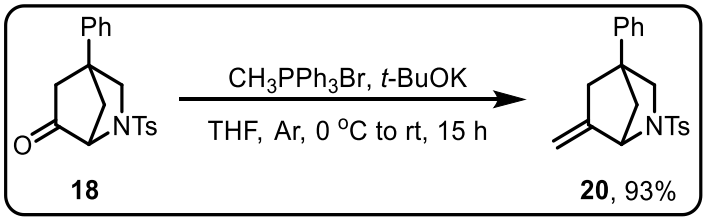


4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-one (18) In a 100-mL round bottom flask equipped with a tefloncoated magnetic stir bar, **10** (343.5 mg, 1.0 mmol, 1.0 equiv) was dissolved in DCM (25.0 mL). Then PCC (538.9 mg, 2.5 mmol, 2.5 equiv) was added in one potion and the reaction mixture was stirred at room temperature for 3 h. After completion of the reaction, the mixture was diluted with DCM (25.0 mL) and filtered through a plug of silica. The solvent was concentrated in vacuum and the crude product purified by flash chromatography on silica gel (PE/EA = 4/1) to obtain the desired product **18** (313.5 mg) in 92% yield, white solid, **m. p.** 135 – 137 °C, R_f = 0.2 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.74 – 7.70 (m, 2H), 7.39 – 7.27 (m, 5H), 7.19 – 7.15 (m, 2H), 4.32 (s, 1H), 3.54 (dd, *J* = 8.8, 2.2 Hz, 1H), 3.40 (dd, *J* = 8.8, 1.4 Hz, 1H), 2.44 (s, 3H), 2.29 (dd, *J* = 17.6, 2.1 Hz, 1H), 2.21 – 2.11 (m, 2H), 1.97 (dt, *J* = 10.9, 1.4 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 203.3, 144.2, 138.3, 134.6, 129.8, 129.0, 127.9, 127.8, 125.9, 65.5, 57.1, 49.8, 47.7, 40.1, 21.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{19}NO_3S + H]^+$ 342.1158, found 342.1159.



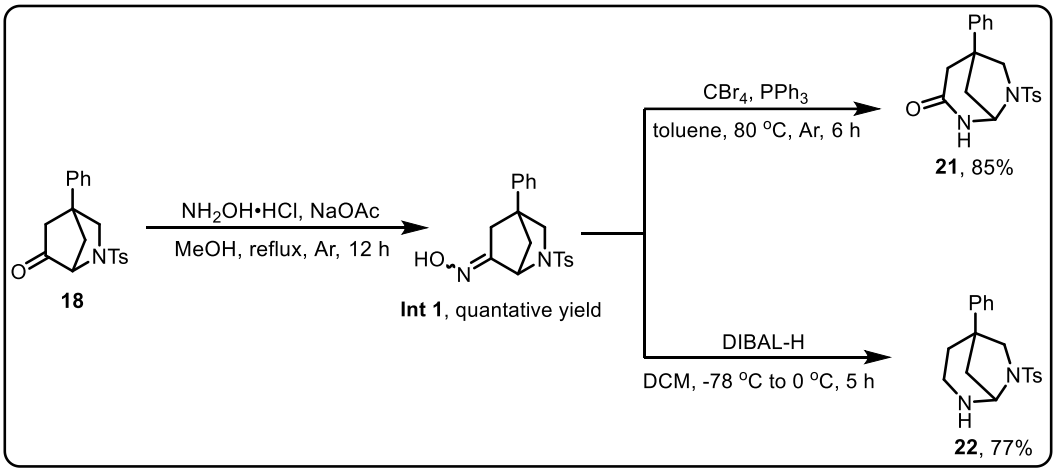
6,6-difluoro-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (19) The reductive difluorination of the carbonyl unit of compound **18** was performed following a modified literature procedure.[11] To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **18** (34.2 mg, 0.1 mmol, 1.0 equiv). Then the

schlenk tube was evacuated and filled with argon for three times. After that, DCM (1.0 mL) and DAST (67.0 μL, 0.5 mmol, 5.0 equiv) were added via a syringe in sequence under argon atmosphere. Then the reaction mixture was stirred at 40 ℃ in oil bath for 48 h. After completion of the reaction, it was quenched with saturated aqueous potassium carbonate solution (15.0 mL) and extracted with DCM (10.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (PE/EA = 7/1) to obtain the desired product **19** (29.7 mg) in 82% yield, pale yellow solid, **m. p.** 99 – 101 ℃, R_f = 0.45 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.76 – 7.73 (m, 2H), 7.37 – 7.26 (m, 5H), 7.14 – 7.11 (m, 2H), 4.38 (s, 1H), 3.43 (d, *J* = 8.6 Hz, 1H), 3.31 (dt, *J* = 8.5, 2.1 Hz, 1H), 2.43 – 2.17 (m, 5H), 2.04 (d, *J* = 9.6 Hz, 1H), 1.69 – 1.63 (m, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.9, 138.3, 135.6, 129.9, 128.9, 127.8, 127.4, 126.3 (dd, $^1J_{C\text{-}F}$ = 262.8, $^1J'_{C\text{-}F}$ = 254.0 Hz) 125.9, 63.3 (dd, $^2J_{C\text{-}F}$ = 34.8, $^2J'_{C\text{-}F}$ = 20.9 Hz), 57.4 (d, $^4J_{C\text{-}F}$ = 1.9 Hz), 51.1 (t, $^3J_{C\text{-}F}$ = 3.7 Hz), 46.9 (t, $^2J_{C\text{-}F}$ = 23.0 Hz), 39.2 (d, $^3J_{C\text{-}F}$ = 2.0 Hz), 21.6 ppm. **^{19}F NMR** (282 MHz, $CDCl_3$) δ -93.37 (d, *J* = 219.7 Hz), -110.52 (d, *J* = 219.7 Hz) ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{19}H_{19}F_2NO_2S + H]^+$ 364.1177, found 364.1180.



6-methylene-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (20) To an oven-dried 10-mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added methyltriphenylphosphonium bromide (142.9 mg, 0.4 mmol, 2.0 equiv) and *t*-BuOK (40.5 mg, 0.36 mmol, 1.8 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, THF (2.0 mL) was added via a syringe under argon atmosphere. The mixture was stirred at 0 ℃, while the solution of **18** (68.3 mg, 0.2 mmol, 1.0 equiv) in THF (1.0 mL) was added via a syringe over a period of 15 min. Then the reaction mixture was kept stirring at 0 ℃ for 3 h and slowly warmed to room

temperature for another 12 h. After completion of the reaction, the solvent was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 7/1) to obtain the desired product **20** (63.0 mg) in 93% yield, pale yellow oil, R_f = 0.5 (PE/EA = 5/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.71 (m, 2H), 7.34 – 7.21 (m, 5H), 7.18 – 7.14 (m, 2H), 5.08 (t, *J* = 2.6 Hz, 1H), 4.70 (t, *J* = 2.1 Hz, 1H), 4.57 (t, *J* = 1.4 Hz, 1H), 3.35 – 3.34 (m, 2H), 2.45 – 2.37 (m, 4H), 2.30 (ddt, *J* = 16.2, 2.4, 2.3 Hz, 1H), 1.86 (dt, *J* = 10.0, 2.3 Hz, 1H), 1.79 (d, *J* = 9.9 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 146.6, 143.3, 140.3, 135.6, 129.4, 128.7, 127.8, 127.3, 126.1, 107.3, 65.6, 58.1, 52.3, 42.5, 41.9, 21.6 ppm. **HRMS (ESI)** *m/z* Calcd for $[C_{20}H_{21}NO_2S + H]^+$ 340.1366, found 340.1369.

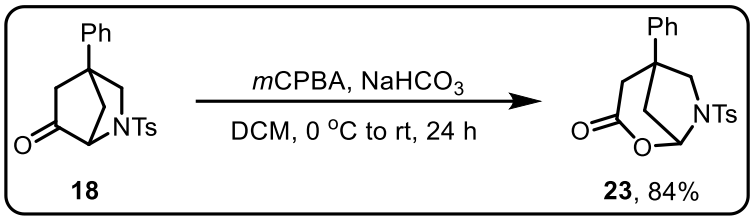


5-phenyl-7-tosyl-2,7-diazabicyclo[3.2.1]octan-3-one (21) The synthesis of oxime **Int-1** was performed following a modified literature procedure.[12] To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **18** (170.8 mg, 0.5 mmol, 1.0 equiv), hydroxylamine hydrochloride (38.3mg, 0.55 mmol, 1.1 equiv) and NaOAc (45.2 mg, 0.55 mmol, 1.1 equiv). Then the schlenk tube was evacuated and filled with argon for three times. After that, pre-dried MeOH (2.0 mL) was added via a syringe under argon atmosphere. Then the reaction mixture was stirred at 65 °C in oil bath for 12 h. After completion of the reaction, it was quenched with H_2O (30.0 mL) and extracted with DCM (20.0 mL × 3). The organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The oxime **Int-1** could be obtained in quantitive yield (178.1 mg) without the need of further purification.

The Beckmann rearrangement of **Int-1** was conducted following a reported literature procedure.[13] To an oven-dried 10-mL schlenk tube equipped with a tefloncoated magnetic stir bar was added **Int-1** (35.7 mg, 0.1 mmol, 1.0 equiv), CBr_4 (3.8 mg, 0.011 mmol, 11 mol%) and PPh_3 (2.9 mg, 0.011 mmol, 11 mol%). Then the schlenk tube was evacuated and filled with argon for three times. After that, toluene (1.0 mL) was added via a syringe under argon atmosphere. Then the reaction mixture was stirred at 80 ºC in oil bath for 6 h. After completion of the reaction, the crude product was concentrated in vacuum and purified by flash chromatography on silica gel (PE/EA = 4/1 to 2/1) to obtain the desired product **21** (30.2 mg) in 85% yield, pale yellow oil, R_f = 0.3 (PE/EA = 2/1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.01 (s, 1H), 7.77 – 7.74 (m, 2H), 7.36 – 7.27 (m, 5H), 7.20 – 7.17 (m, 2H), 4.74 (t, *J* = 1.4 Hz, 1H), 3.46 (dd, *J* = 9.0, 2.7 Hz, 1H), 3.30 (dd, *J* = 8.9, 1.4 Hz, 1H), 2.58 (dd, *J* = 17.8, 2.7 Hz, 1H), 2.43 (s, 3H), 2.33 (dd, *J* = 17.8, 3.5 Hz, 1H), 2.10 (ddd, *J* = 10.3, 3.6, 2.0 Hz, 1H), 1.88 (dt, *J* = 10.3, 1.3 Hz, 1H) ppm. **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.9, 143.8, 139.0, 134.8, 129.6, 128.9, 128.0, 127.7, 126.0, 62.1, 57.6, 51.1, 42.5, 38.1, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{20}N_2O_3S + H]^+$ 357.1267, found 357.1270.

5-phenyl-7-tosyl-2,7-diazabicyclo[3.2.1]octane (22) The DIBALH-mediated reductive ring-expansion reaction of **Int-1** was performed following the modified literature procedures.[14] To an oven-dried 10 mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added **Int-1** (107.0 mg, 0.3 mmol, 1.0 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, DCM (1.0 mL) was added via a syringe under argon atmosphere. The mixture was stirred at -78 ºC, while DIBAL-H (1 M in hexane, 1.8 mL, 1.8 mmol, 6.0 equiv) was added via a syringe over a period of 10 min. Then the reaction mixture was warmed to -20 ºC and stirred for 2 h. Then the reaction mixture was warmed to 0 ºC and stirred for another 4 h. After completion of the reaction, it was quenched with saturated aqueous Rochelle salt (30.0 mL) at 0 ºC, and extracted with DCM (20.0 mL × 3). The combined organic layer was washed with saturated brine, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column

chromatography on silica gel (DCM/MeOH = 20/1) to obtain the desired product **22** (79.5 mg) in 77% yield, white solid, **m. p.** 143 – 145 °C, R_f = 0.3 (DCM/MeOH = 20/1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.75 – 7.70 (m, 2H), 7.33 – 7.20 (m, 5H), 7.06 – 7.02 (m, 2H), 4.17 (dd, *J* = 6.1, 3.5 Hz, 1H), 3.90 (dd, *J* = 9.4, 1.1 Hz, 1H), 3.28 (dd, *J* = 9.5, 1.6 Hz, 1H), 3.06 (dt, *J* = 13.8, 2.7 Hz, 1H), 2.95 (dd, *J* = 13.7, 2.8 Hz, 1H), 2.79 (dd, *J* = 13.6, 1.7 Hz, 1H), 2.72 (d, *J* = 13.4 Hz, 1H), 2.48 (brs, 1H), 2.39 (s, 3H), 1.97 (d, *J* = 11.0 Hz, 1H), 1.70 (ddt, *J* = 11.1, 6.2, 2.4 Hz, 1H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 143.6, 142.5, 135.4, 129.9, 128.7, 127.2, 127.1, 125.7, 58.9, 58.8, 56.1, 50.8, 48.3, 39.5, 21.6 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{22}N_2O_2S + H]^+$ 343.1475, found 343.1481.



5-phenyl-7-tosyl-2-oxa-7-azabicyclo[3.2.1]octan-3-one (24) The Baeyer-Villiger rearrangement of **18** was conducted following a modified literature procedure.[15] To an oven-dried 10-mL reaction tube equipped with a tefloncoated magnetic stir bar and a rubber plug was added *m*-CPBA (85 wt%, 91.4 mg, 0.45 mmol, 3.0 equiv) and $NaHCO_3$ (75.7 mg, 0.9 mmol, 6.0 equiv). Then the reaction tube was evacuated and filled with argon for three times. After that, DCM (2.0 mL) was added via a syringe under argon atmosphere. The mixture was stirred at 0 ℃, while the solution of **18** (51.3 mg, 0.15 mmol, 1.0 equiv) in DCM (1.0 mL) was added via a syringe over a period of 10 min. Then the reaction mixture was warmed to room temperature and stirred for 24 h. After completion of the reaction, it was quenched with saturated aqueous sodium thiosulfate (15.0 mL) and extracted with DCM (10.0 mL × 3). The organic layer was washed with saturated aqueous sodium hydrogen carbonate solution and brine in sequence, dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product **23** (45.3 mg) in 84% yield, white solid, **m. p.** 137 – 138 ℃, R_f = 0.4 (DCM/MeOH = 2/1). **^{1}H NMR** (300

MHz, $CDCl_3$) δ 7.83 – 7.81 (m, 2H), 7.40 – 7.28 (m, 5H), 7.16 – 7.12 (m, 2H), 6.16 (d, *J* = 3.3 Hz, 1H), 3.62 (s, 2H), 2.78 (s, 2H), 2.50 – 2.36 (m, 5H) ppm. **^{13}C NMR** (75 MHz, $CDCl_3$) δ 167.7, 144.5, 140.2, 135.2, 130.0, 129.3, 128.1, 127.6, 125.1, 87.2, 58.1, 46.2, 45.7, 39.5, 21.7 ppm. **HRMS (ESI)** *m*/*z* Calcd for $[C_{19}H_{19}NO_4S + H]^+$ 358.1108, found 358.1107.

7. X-ray Crystallography Data of 3a

Procedure for recrystallization of compounds **3a**: the hexane was slowly added into the solution of target product in dichloromethane (with different concentration), then the dichloromethane was evaporated from the mixed solvent system at room temperature under dark and the crystals were obtained after a few days.

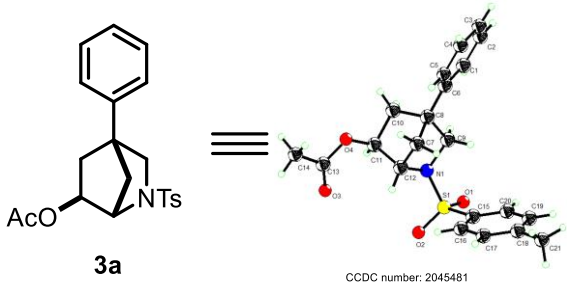


Figure S1. ORTEP plot of the crystal structure of 3a, and thermal ellipsoid is set at 50% probability.

X-ray Crystallographic Data of 3a

CCDC number	2045481
Bond precision	C-C = 0.0045 A Wavelength=0.71073
Cell	a=16.6782(6) b=8.0492(3) c=14.5029(5) alpha=90 beta=90 gamma=90
Temperature	170 K
Volume	1946.96(12)
Space group	P c a 21
Sum formula	$C_{21}H_{23}NO_4S$
Mr	385.46
Dx, g cm-3	1.315
Z	4
Mu (mm-1)	0.193
F000	816.0
h, k, lmax	20,10,18
Nref	3794
Tmin, Tmax	0.703, 0.745
Correction method	#Reported T Limits: Tmin=0.703 Tmax=0.745
AbsCorr	MULTI-SCAN
Data completeness	1.82/0.95
Theta(max)	26.405
R(reflections)	0.0355(3282)
wR2(reflections)	0.0818(3794)
S	1.088

8. References

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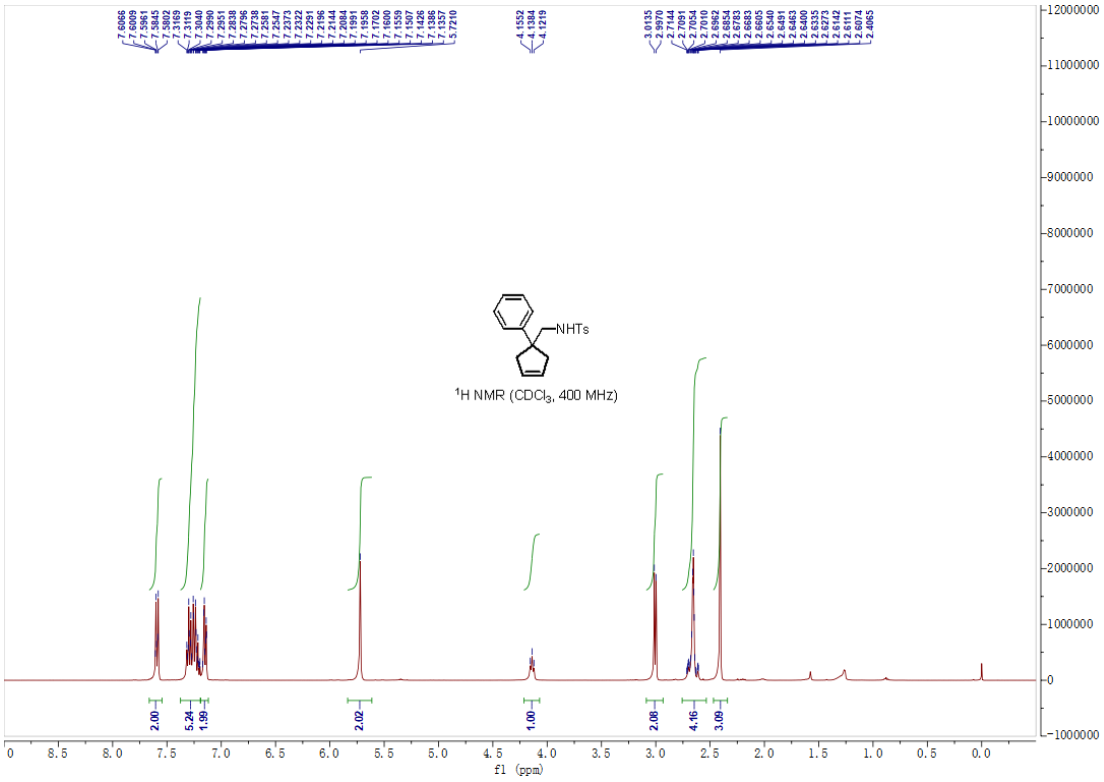
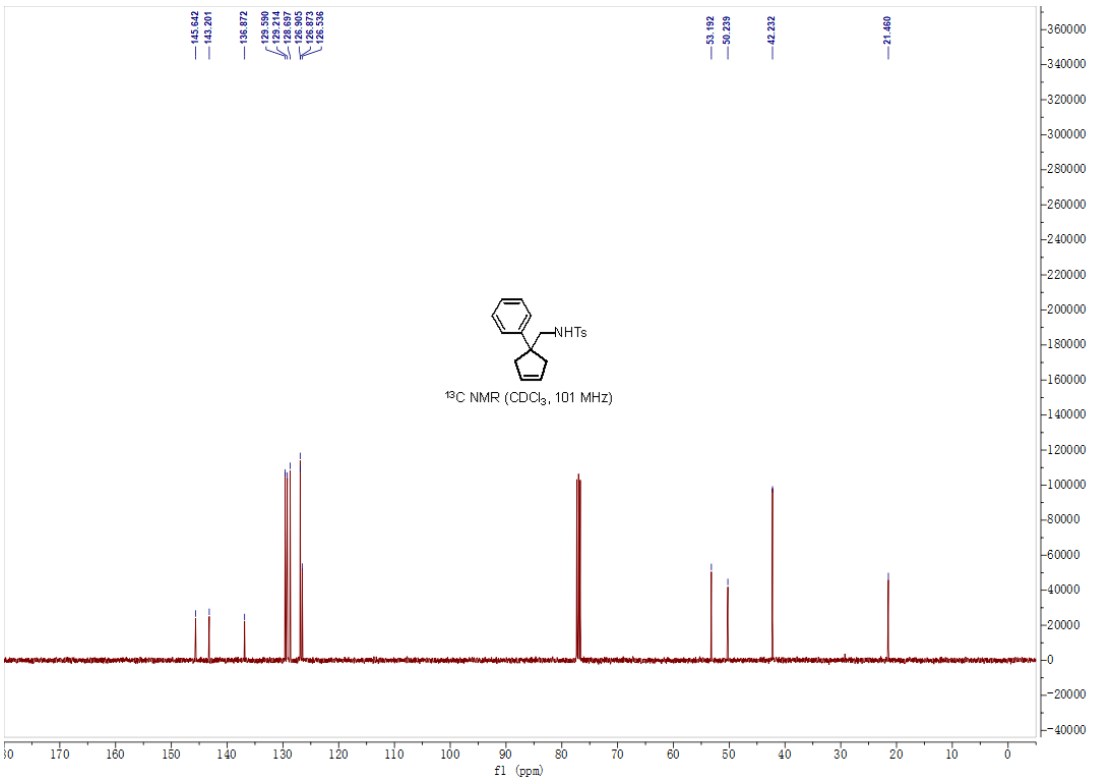
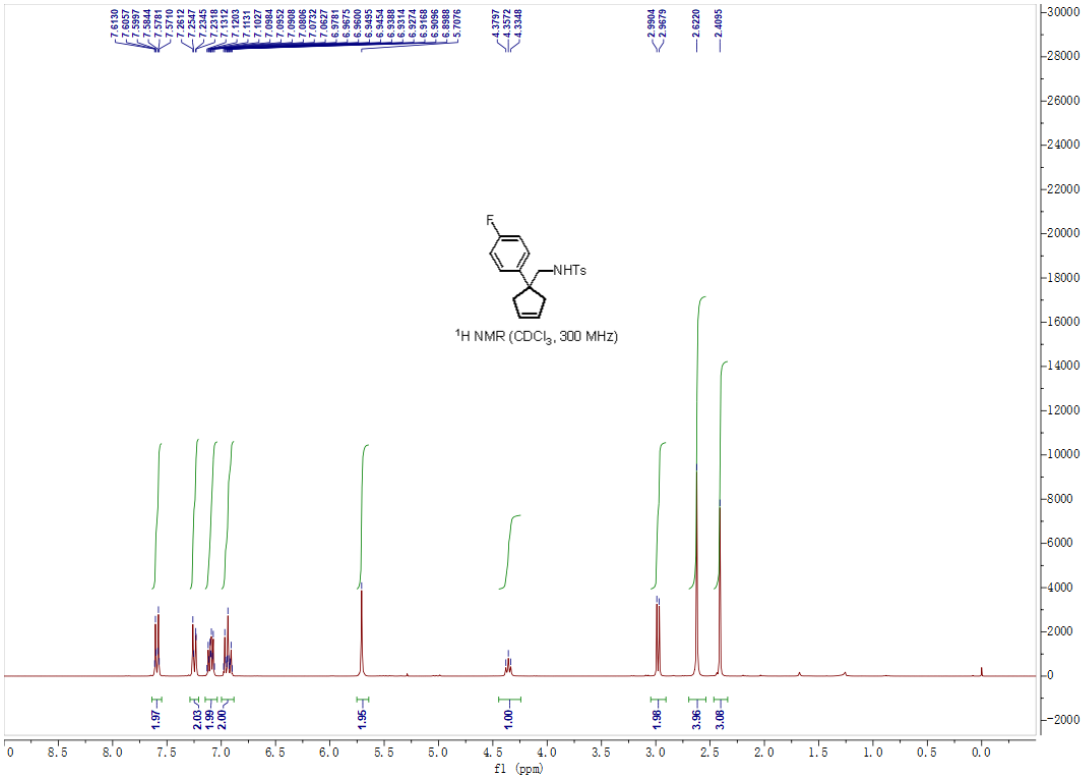
9. ^{1}H and ^{13}C NMR Spectra of Title Compounds

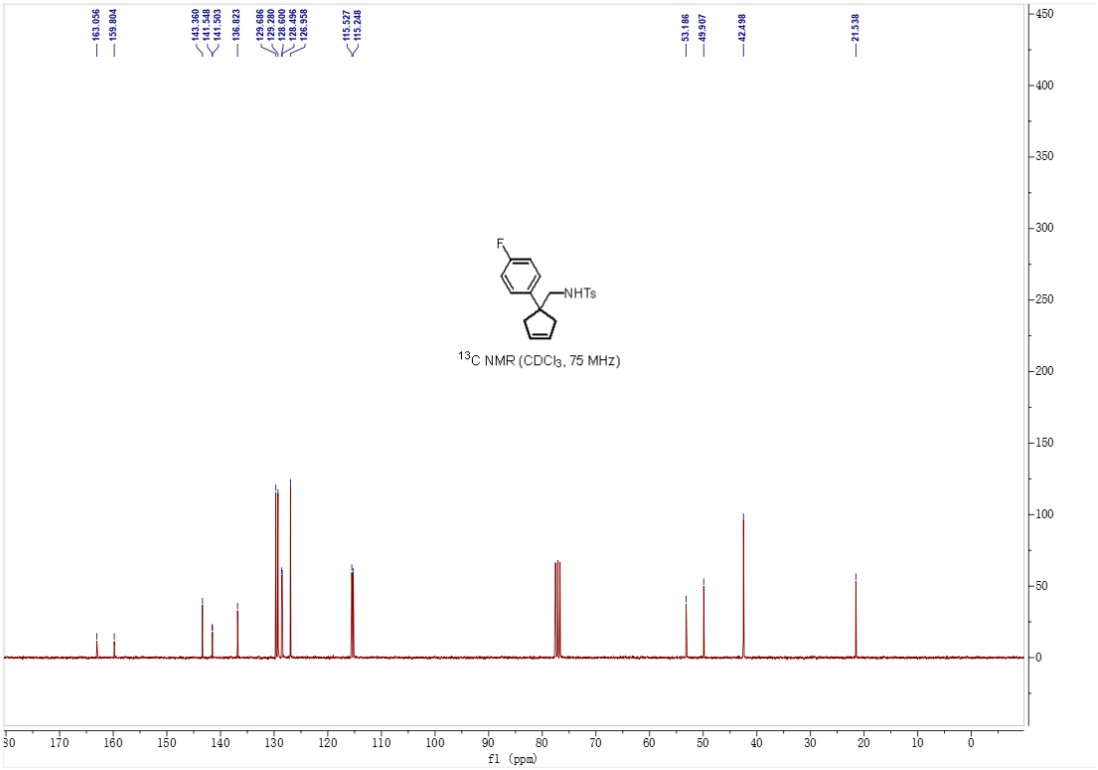
4-methyl-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1a)

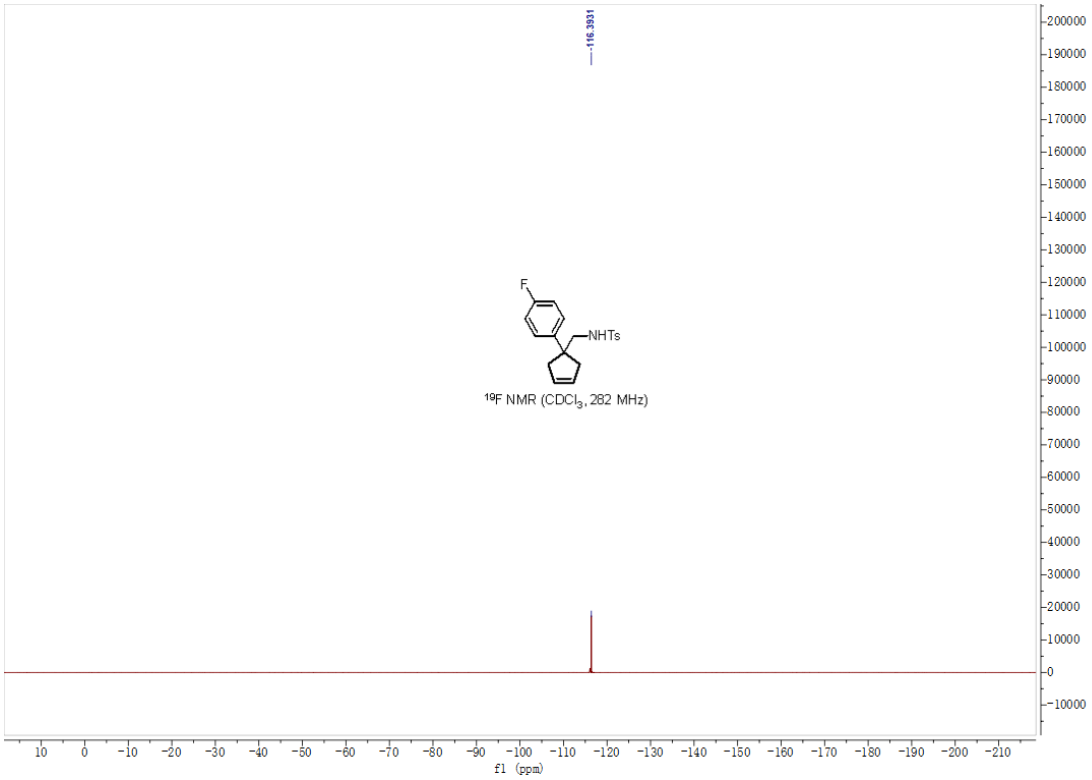




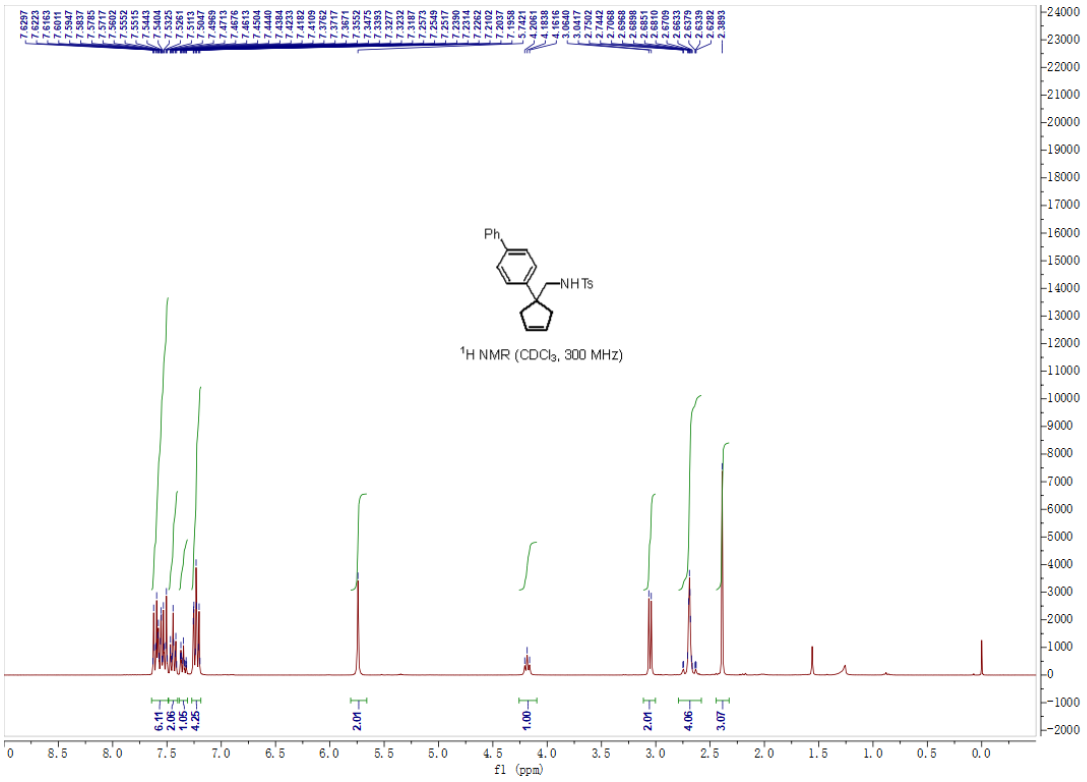
N-((1-(4-fluorophenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1b)

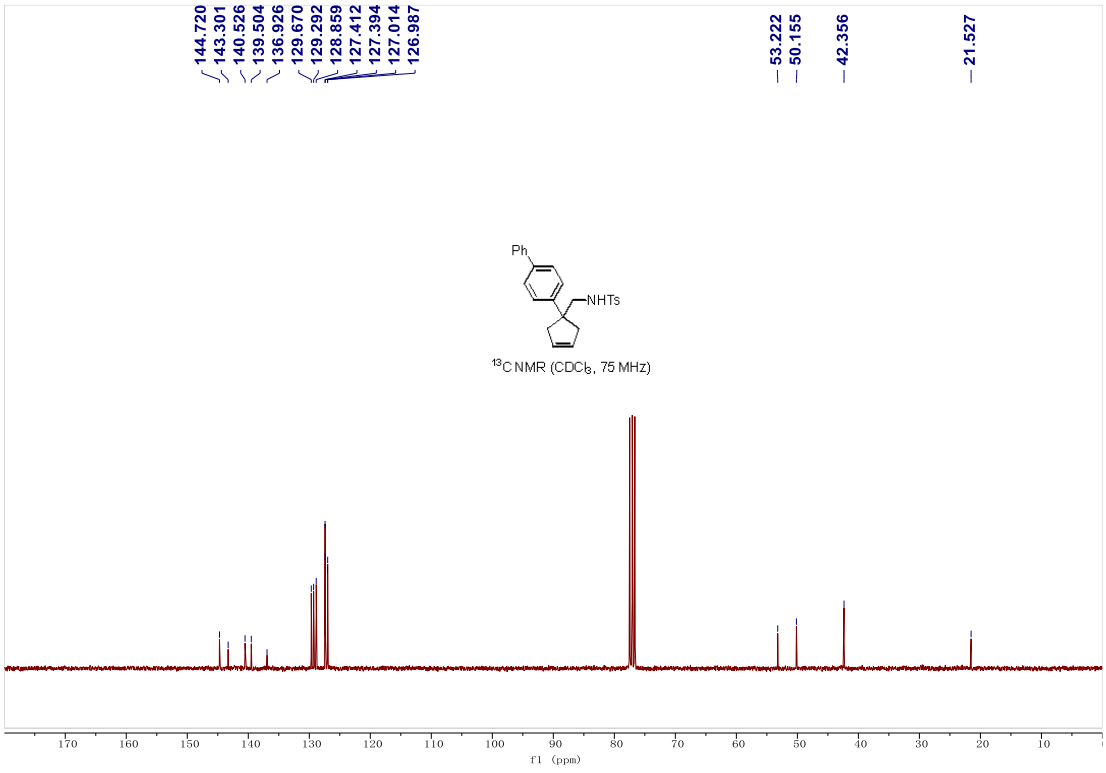




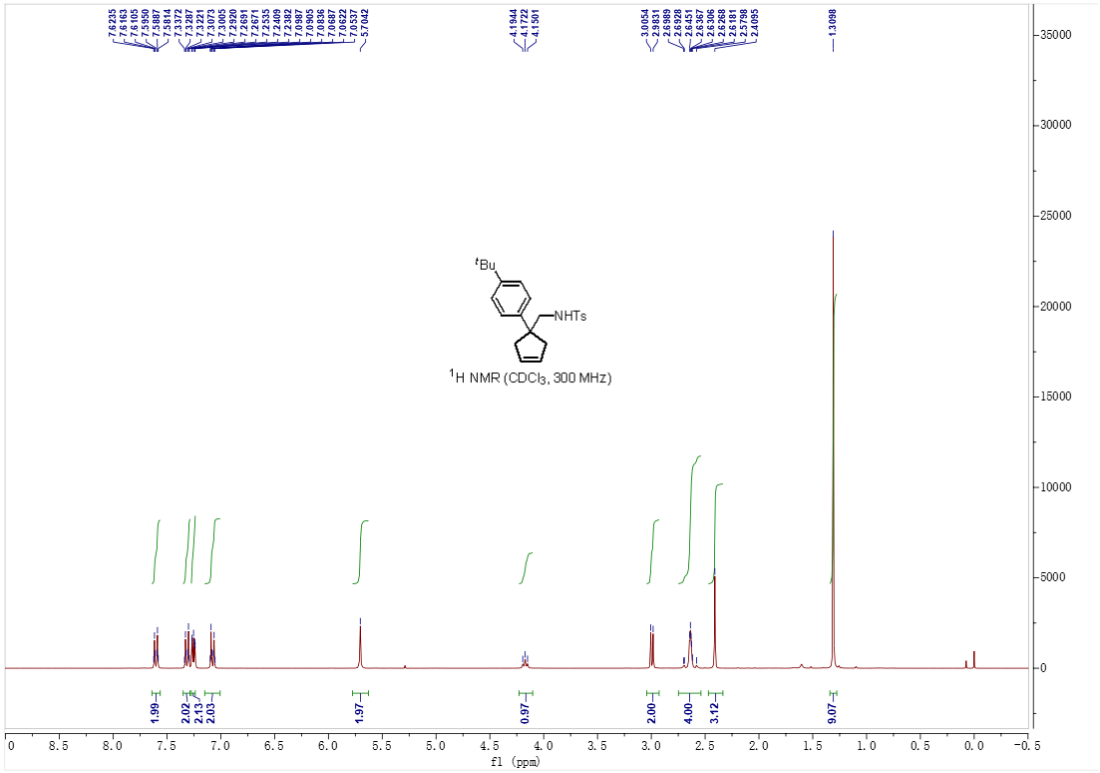

-116.3931
F
NHTs
^{19}F NMR ($CDCl_3$, 282 MHz)
f1 (ppm)

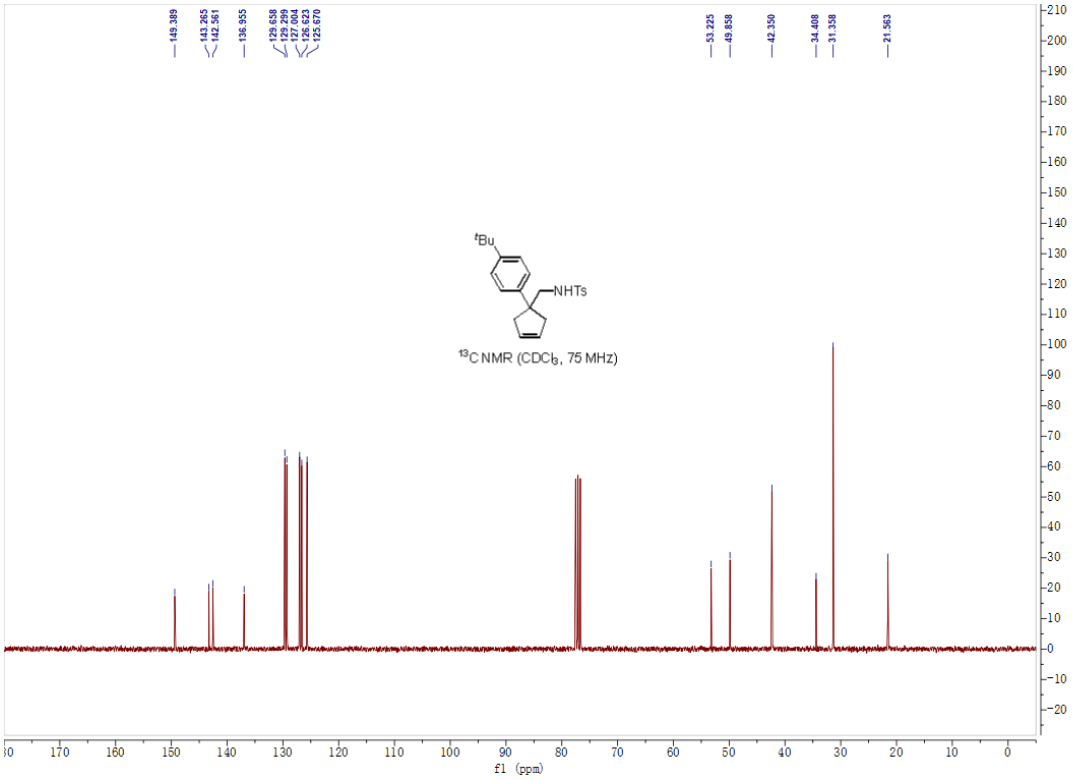
N-((1-([1,1'-biphenyl]-4-yl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1c)



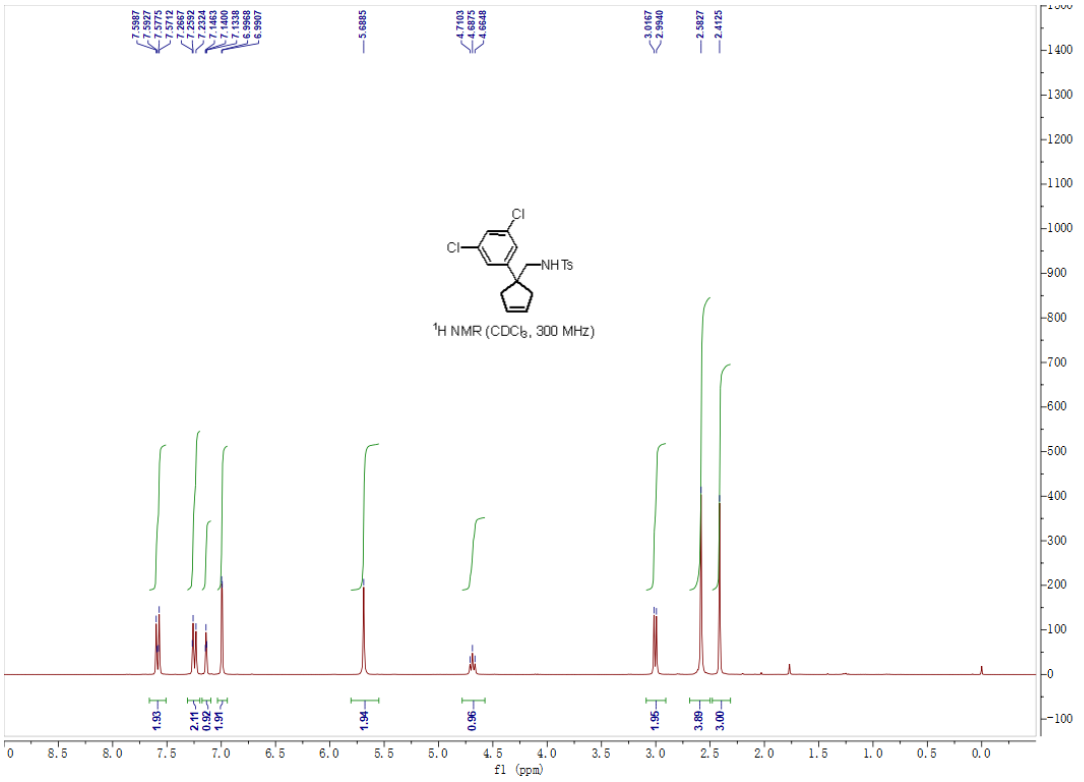


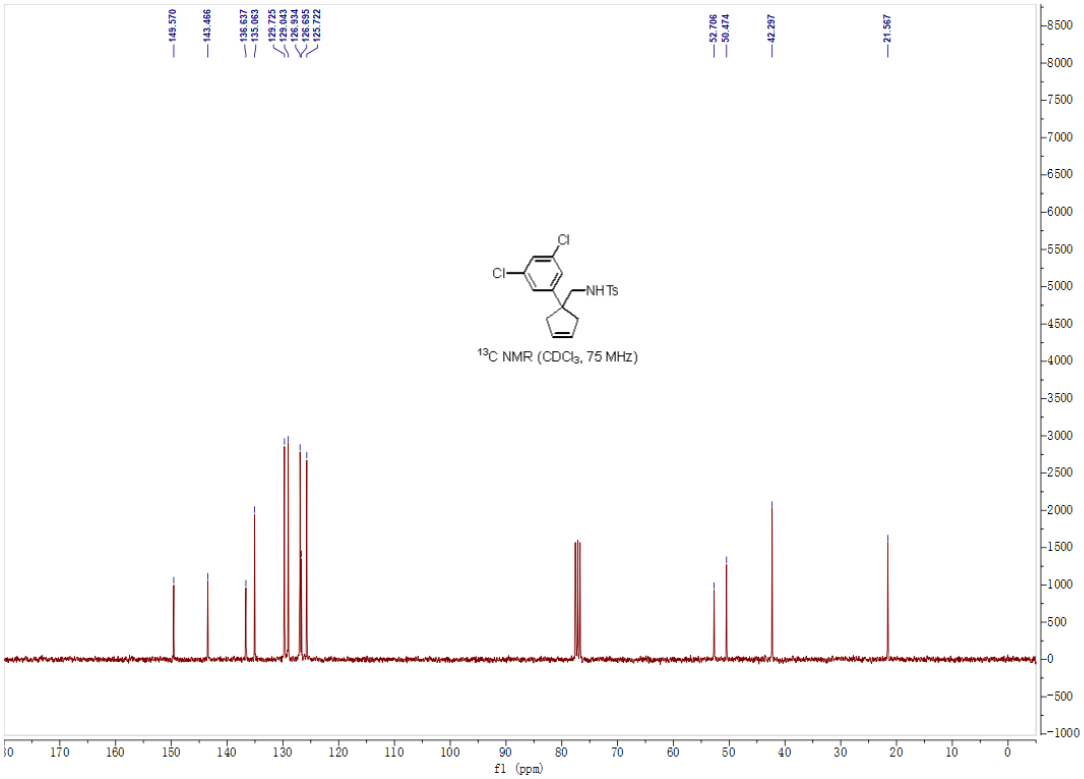
N-((1-(4-(tert-butyl)phenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1d)



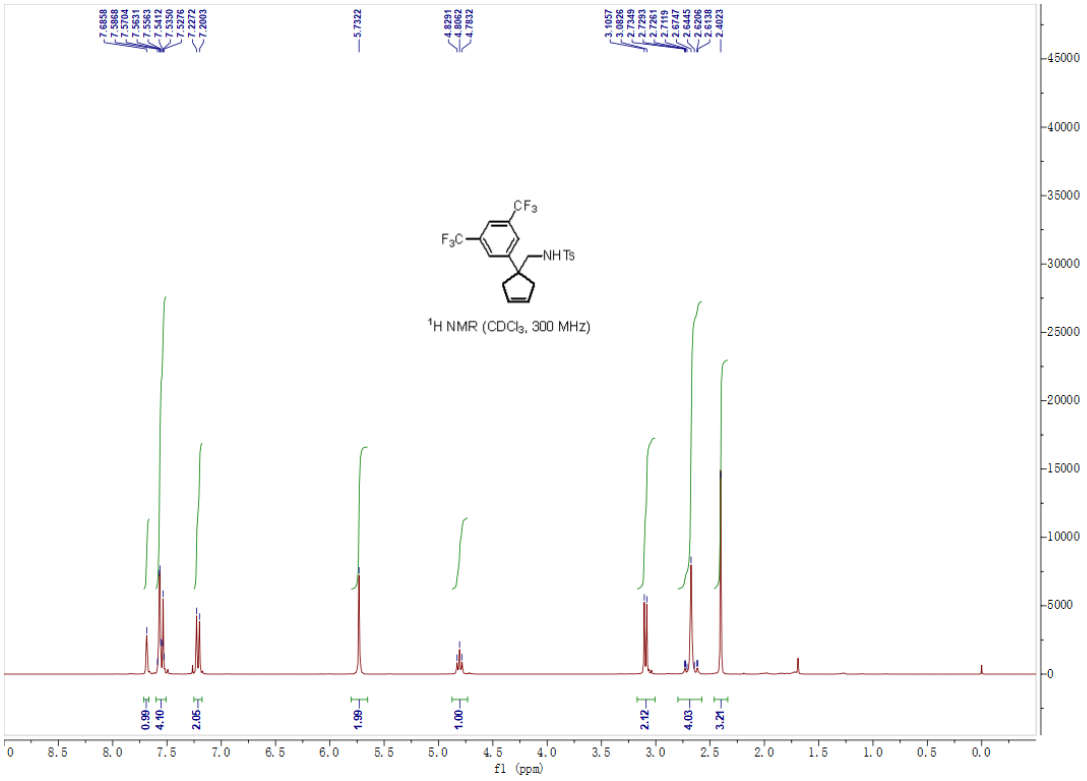


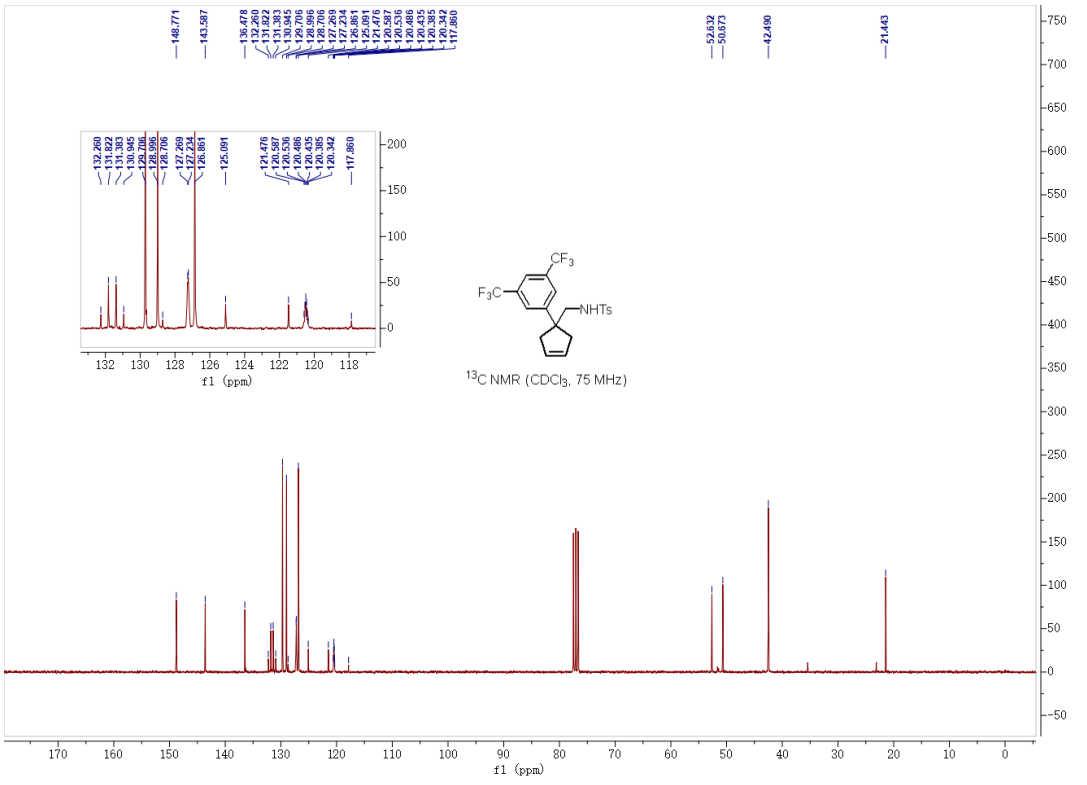
N-((1-(3,5-dichlorophenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1e)

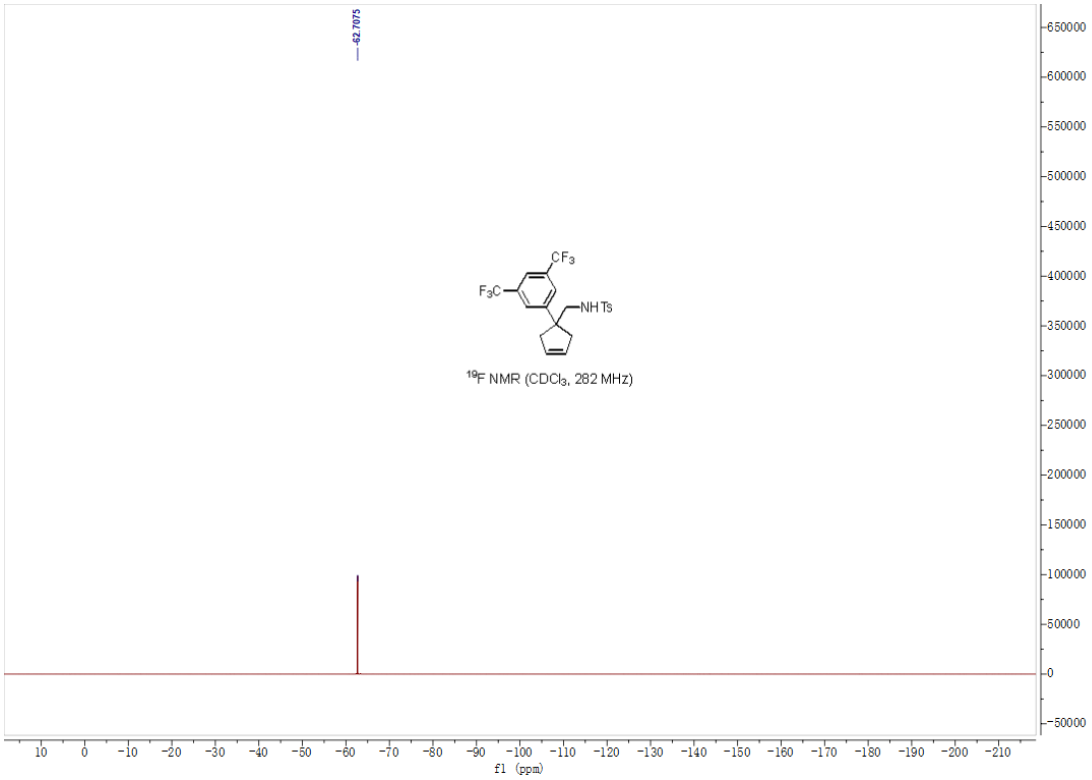




N-((1-(3,5-bis(trifluoromethyl)phenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1f)



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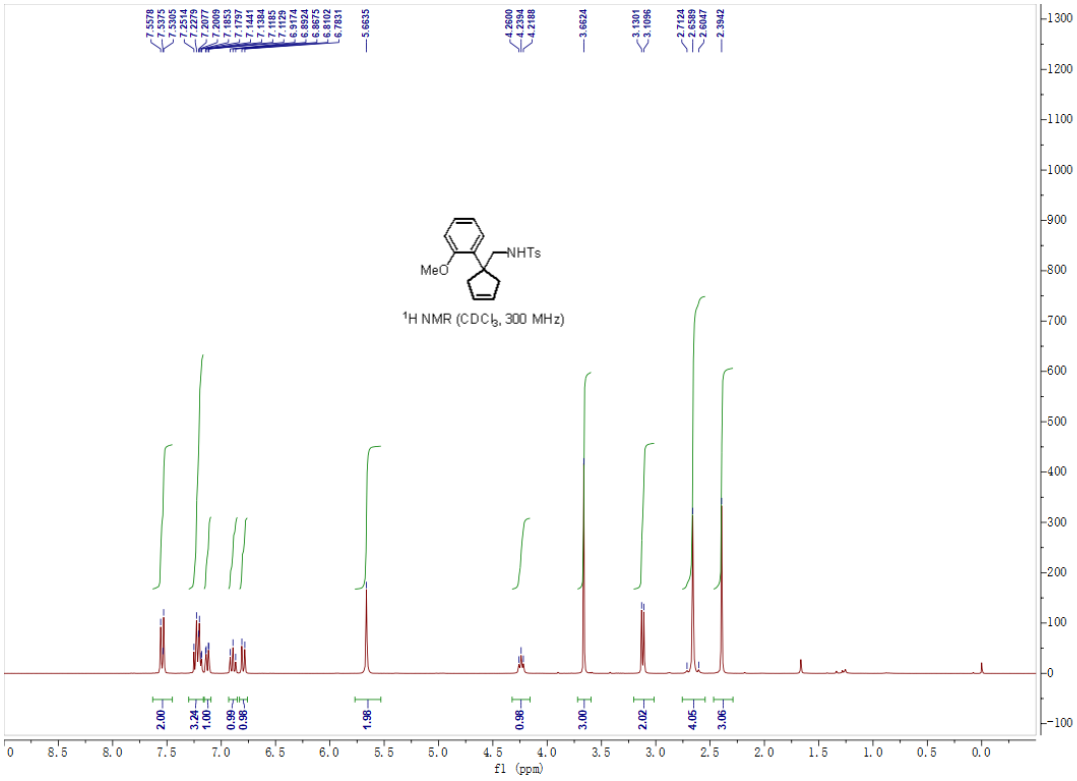
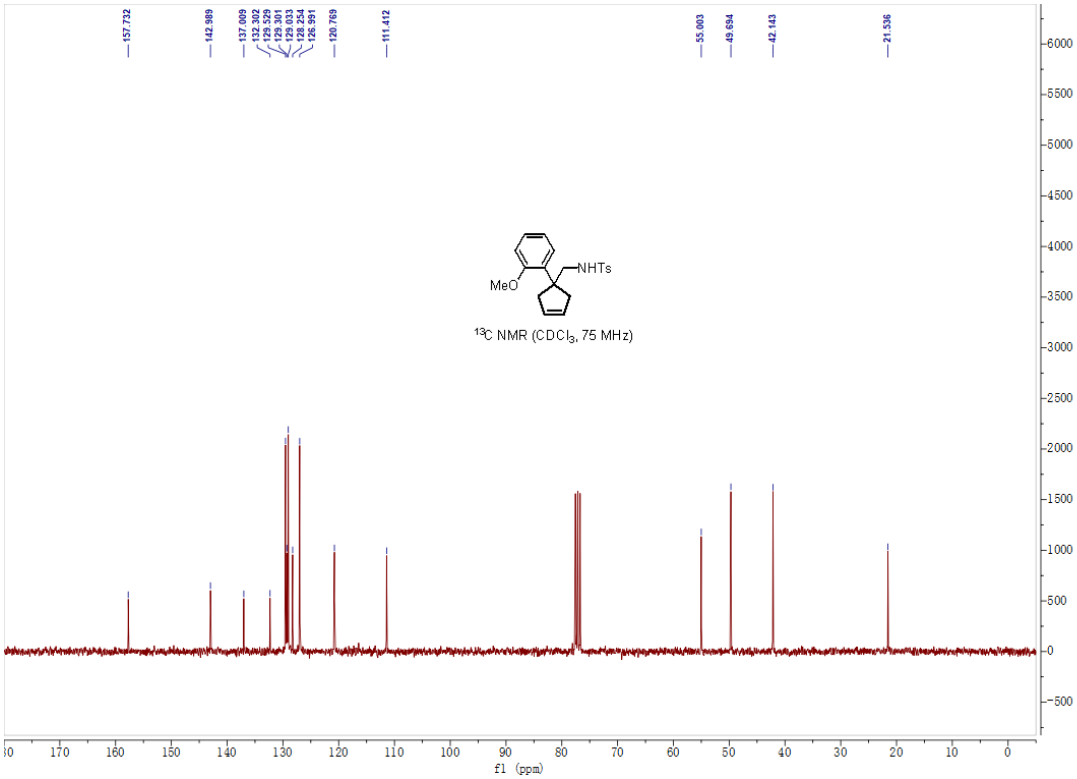
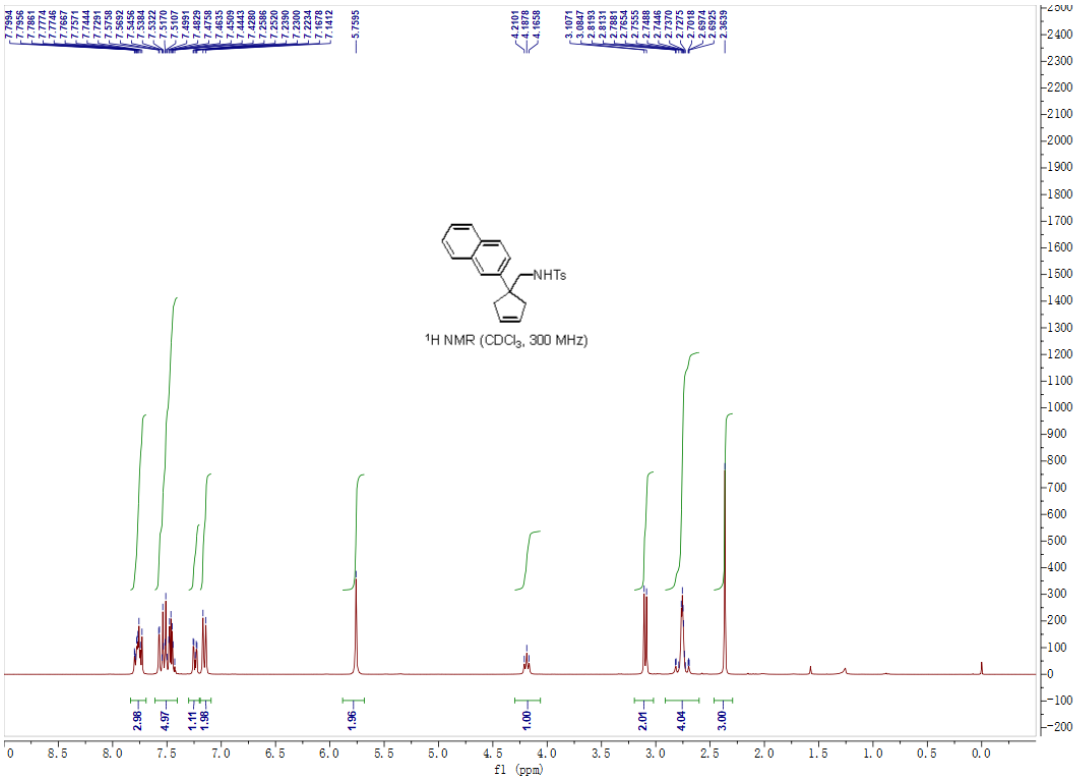
CF3
F3C
NHTs
19F NMR (CDCl3, 282 MHz)
650000
600000
550000
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
-50000
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

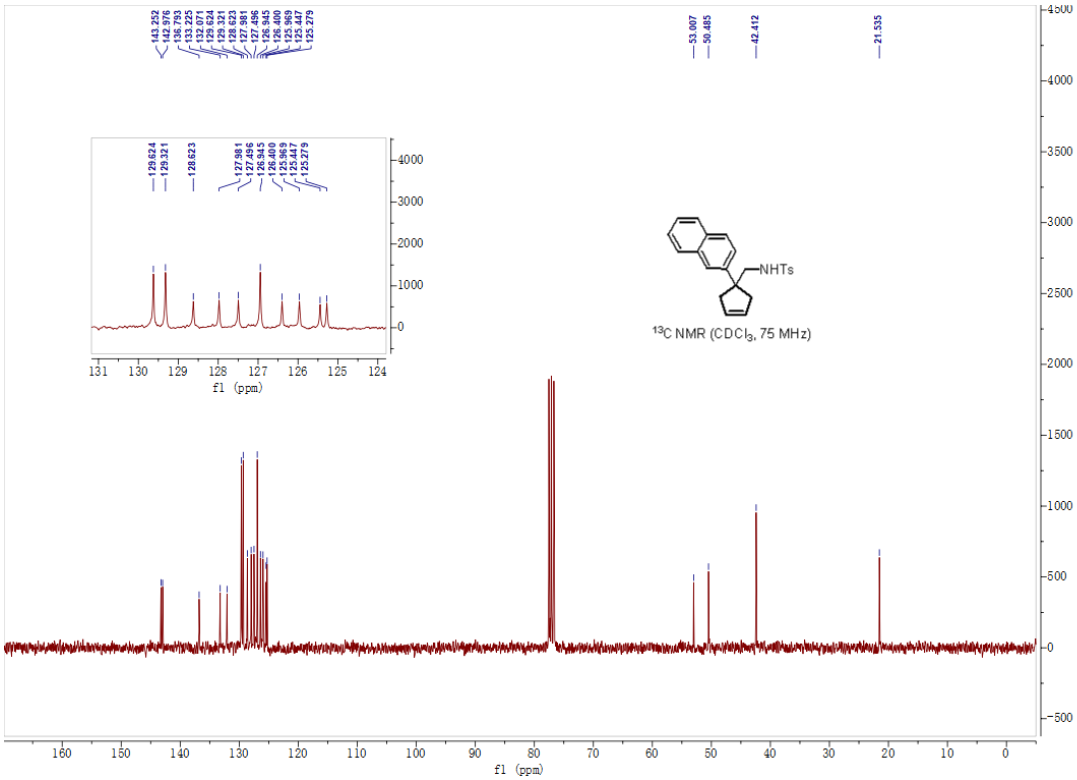
N-((1-(2-methoxyphenyl)cyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1g)



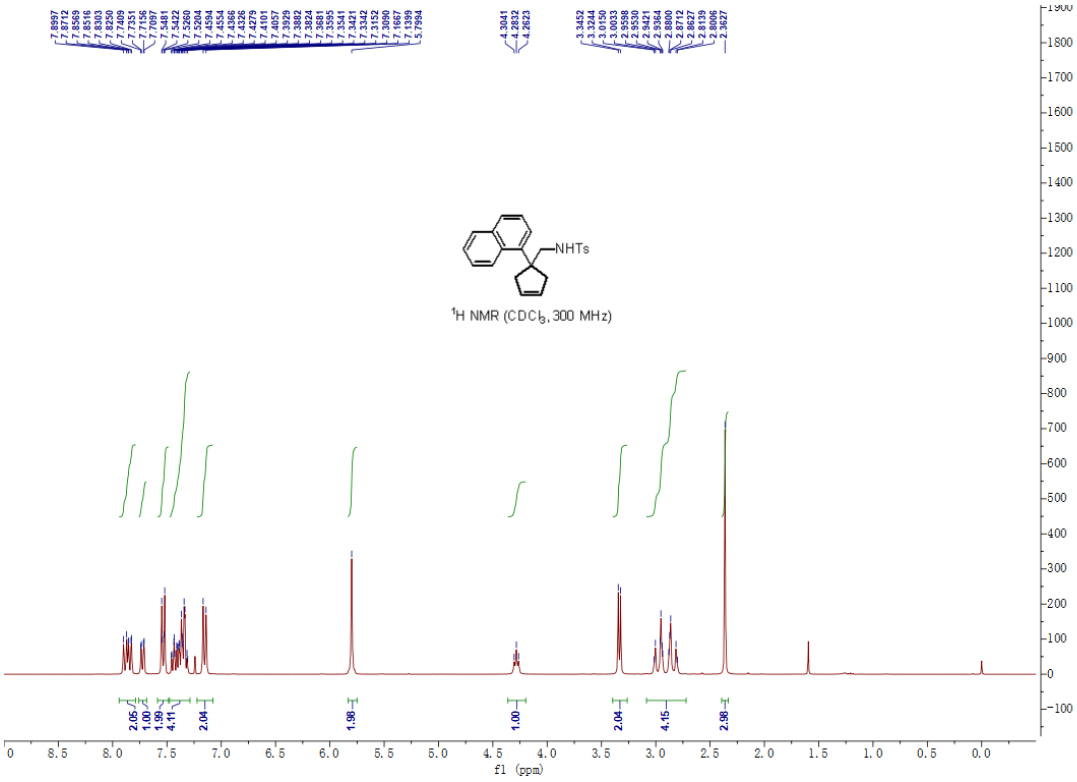


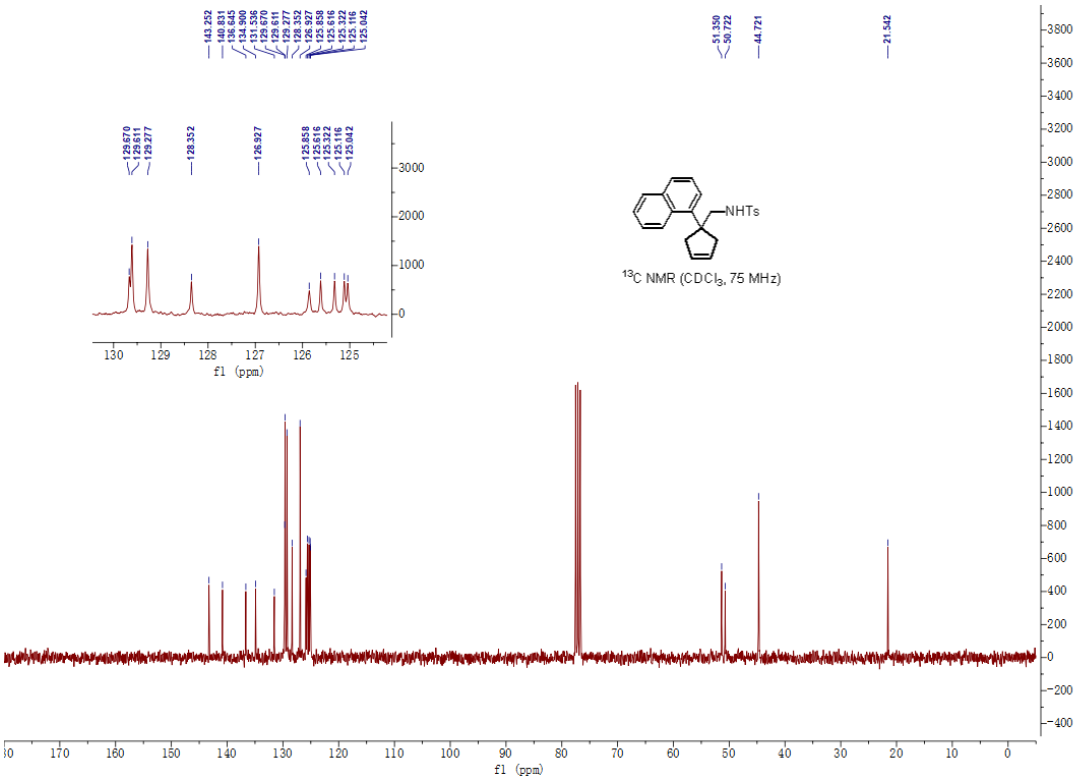
4-methyl-N-((1-(naphthalen-2-yl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1h)



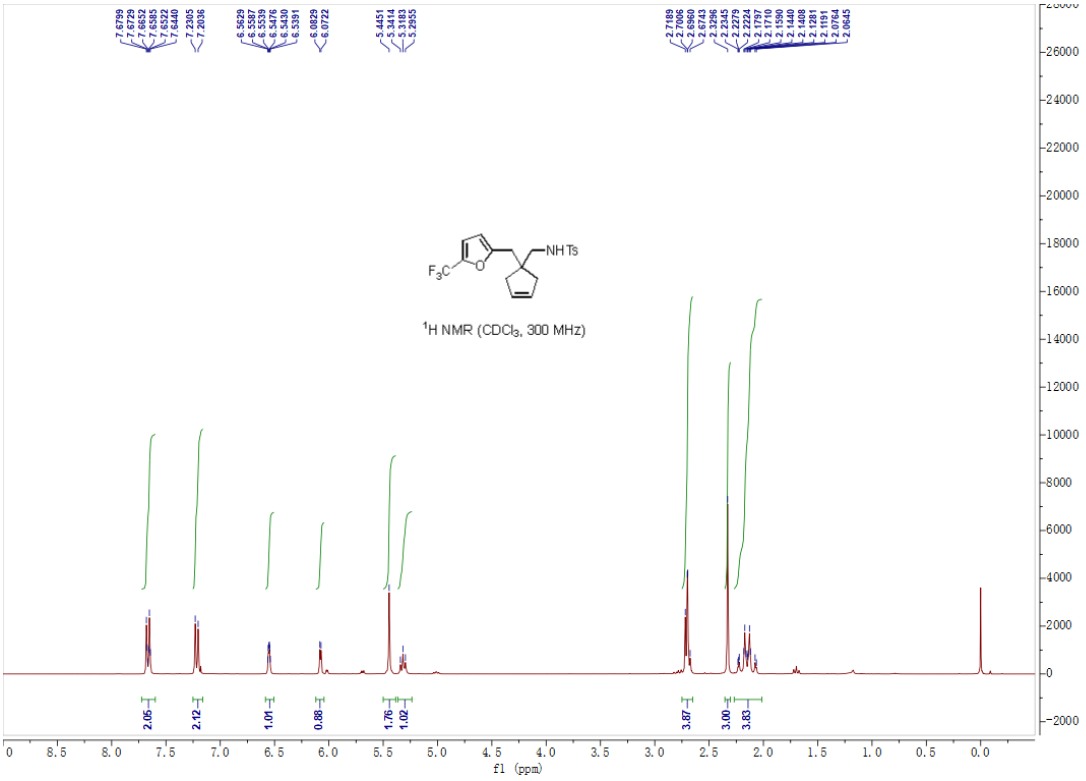


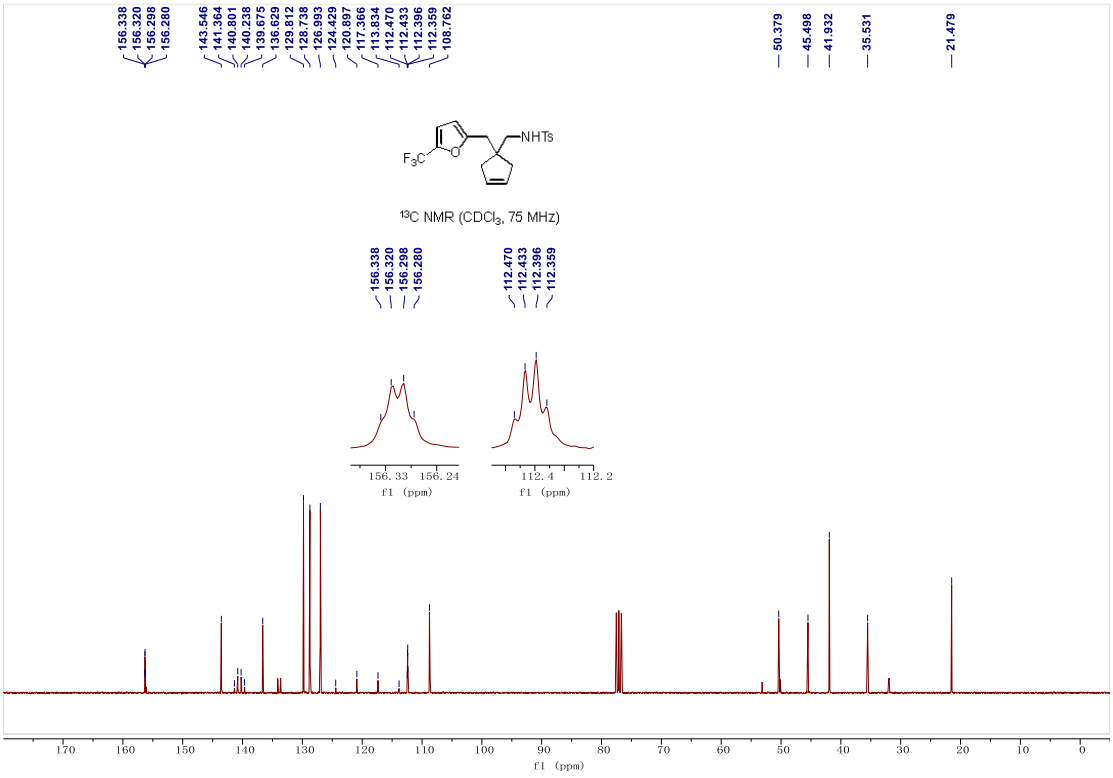
4-methyl-N-((1-(naphthalen-1-yl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1i)

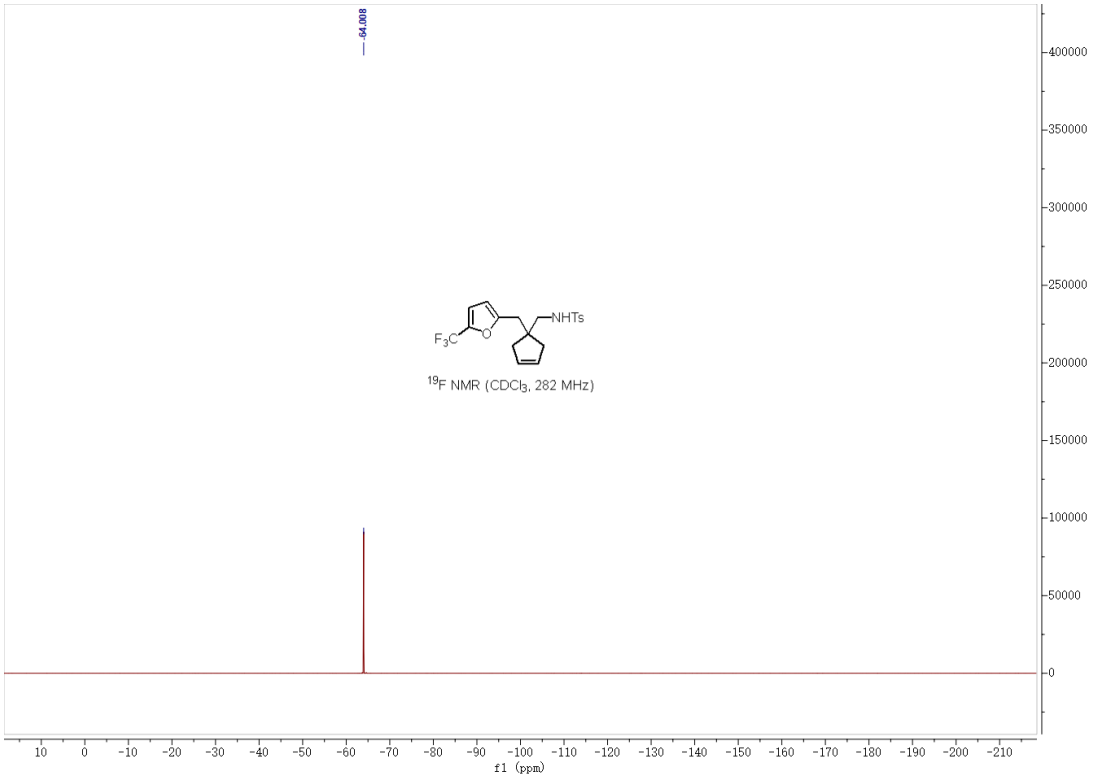




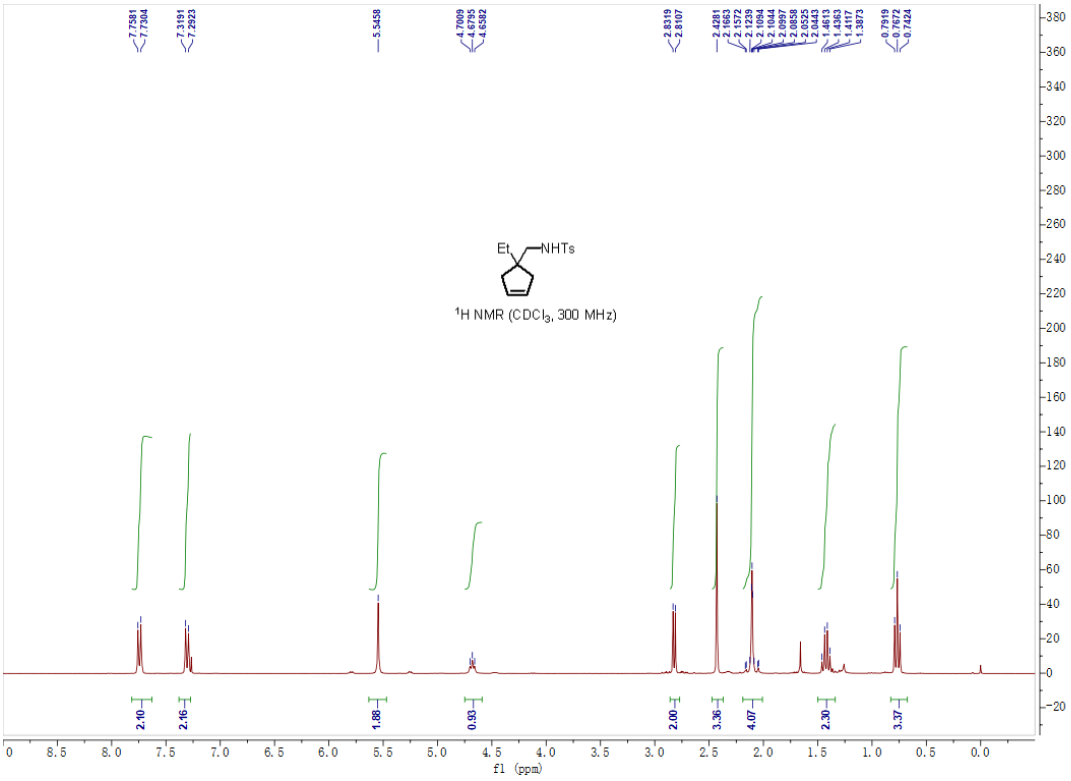
4-methyl-N-((1-((5-(trifluoromethyl)furan-2-yl)methyl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1j)

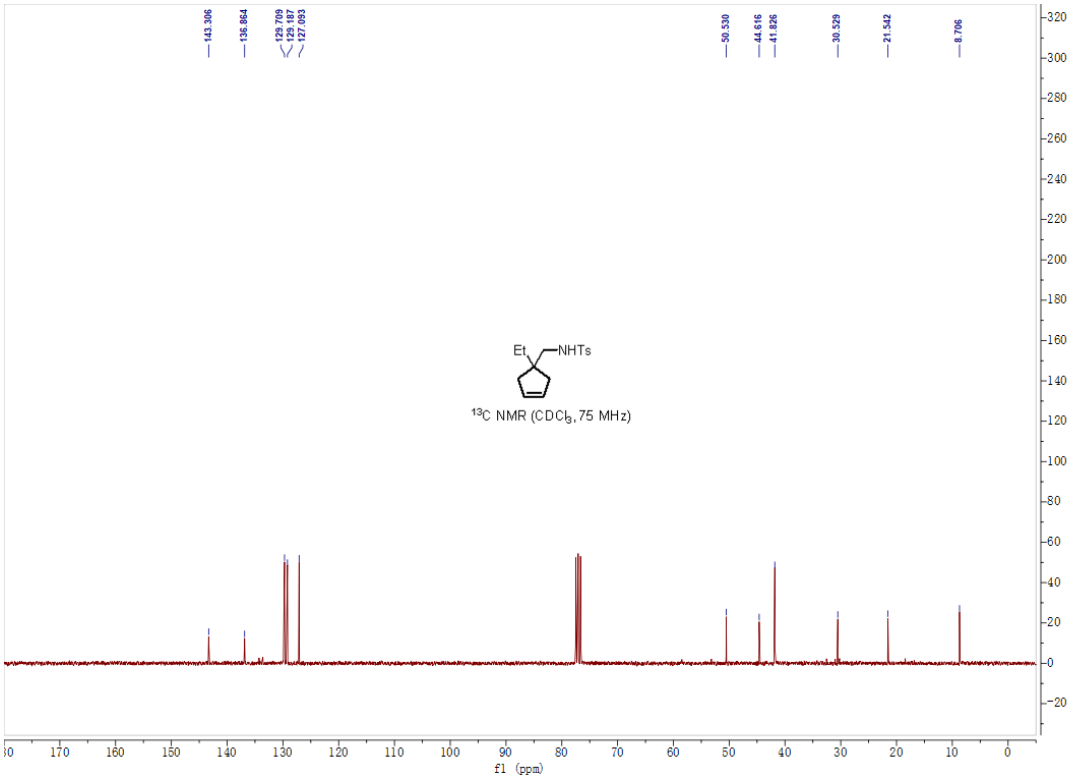




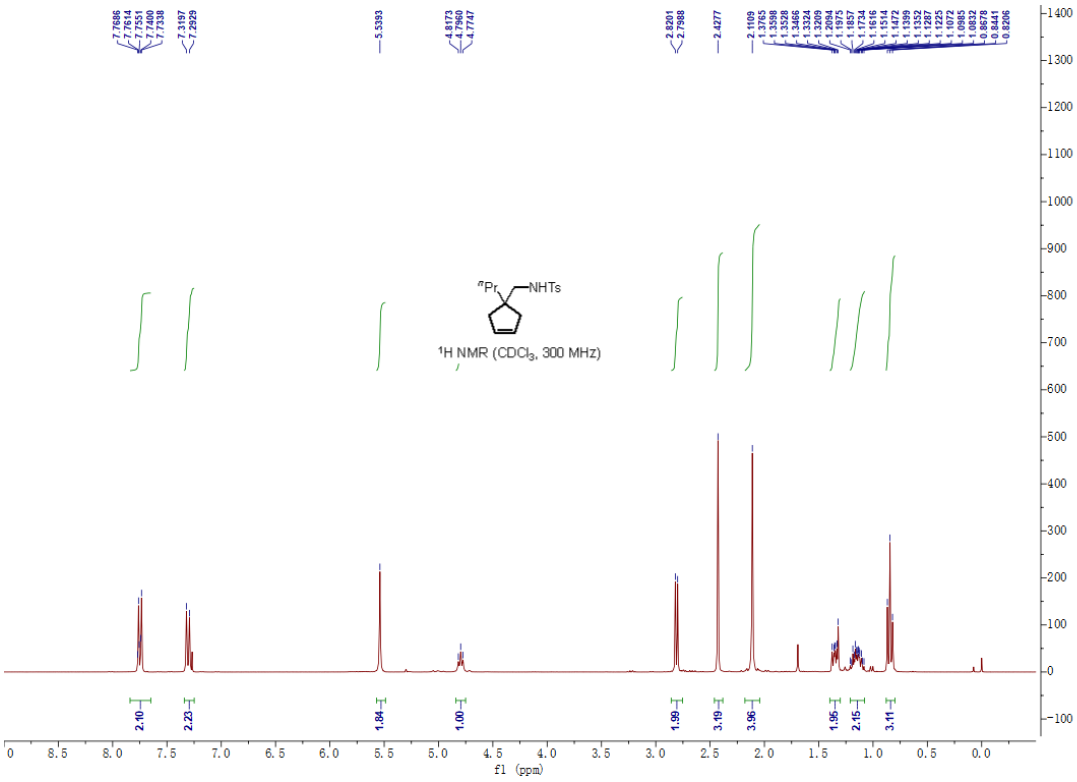

-64.008
NHTs
F3C
19F NMR (CDCl3, 282 MHz)
400000
350000
300000
250000
200000
150000
100000
50000
0
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

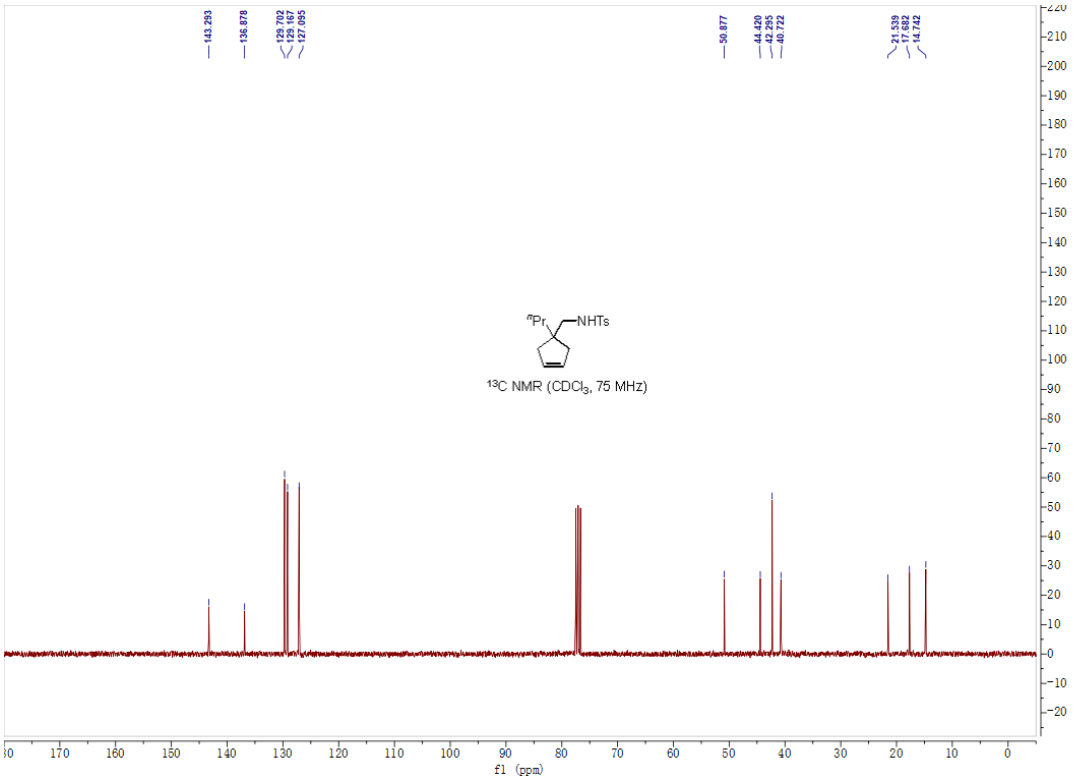
N-((1-ethylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1k)



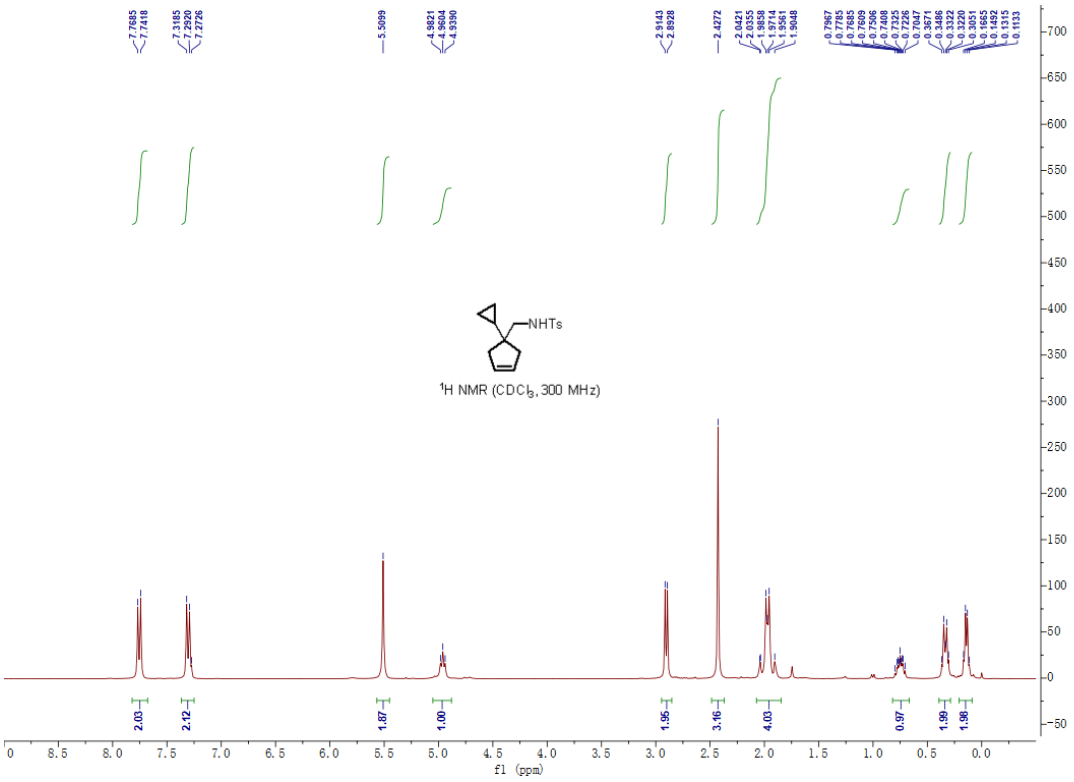


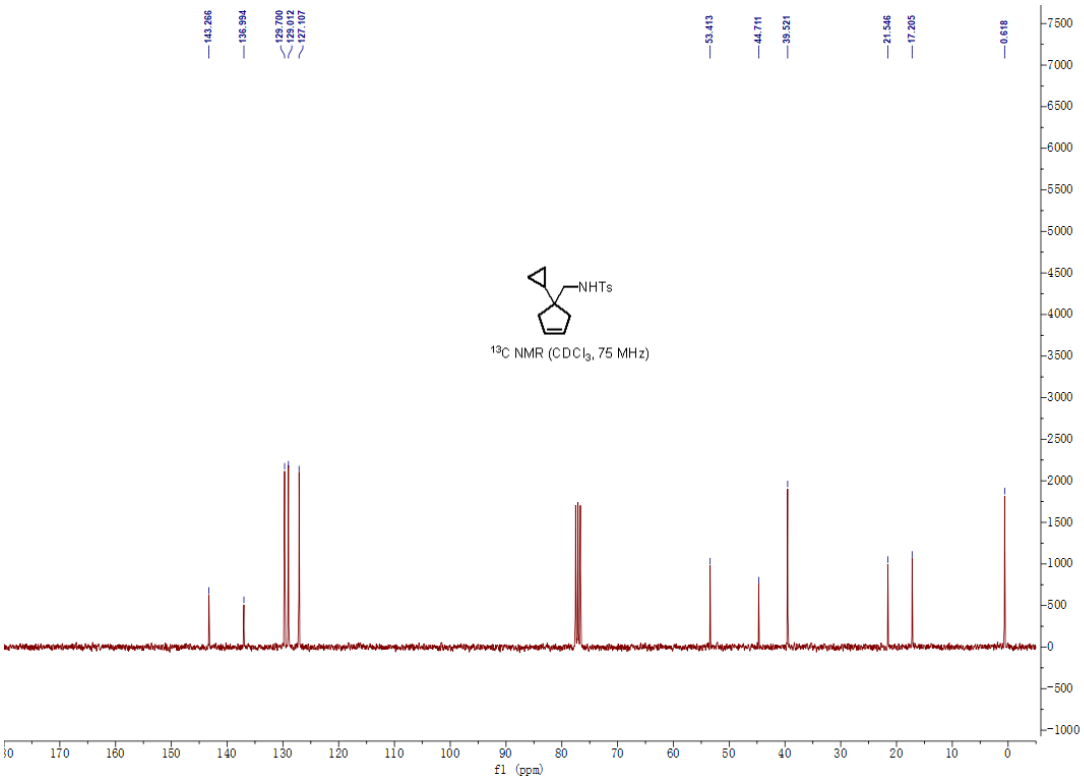
4-methyl-N-((1-propylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1l)



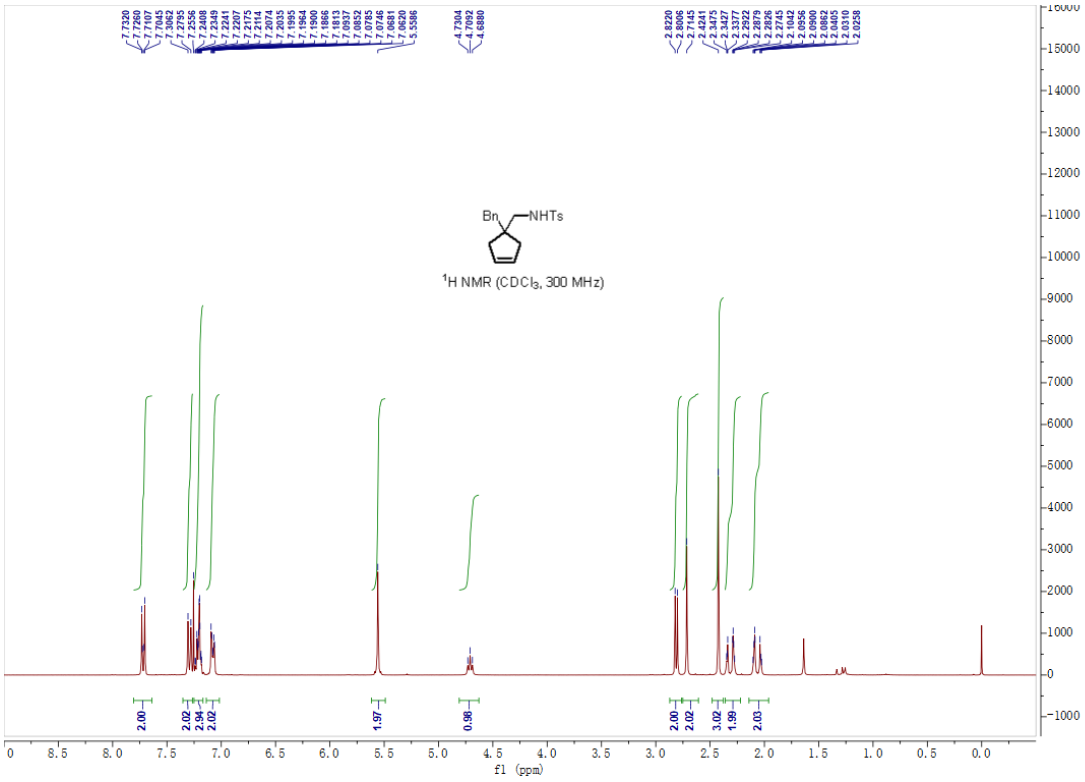


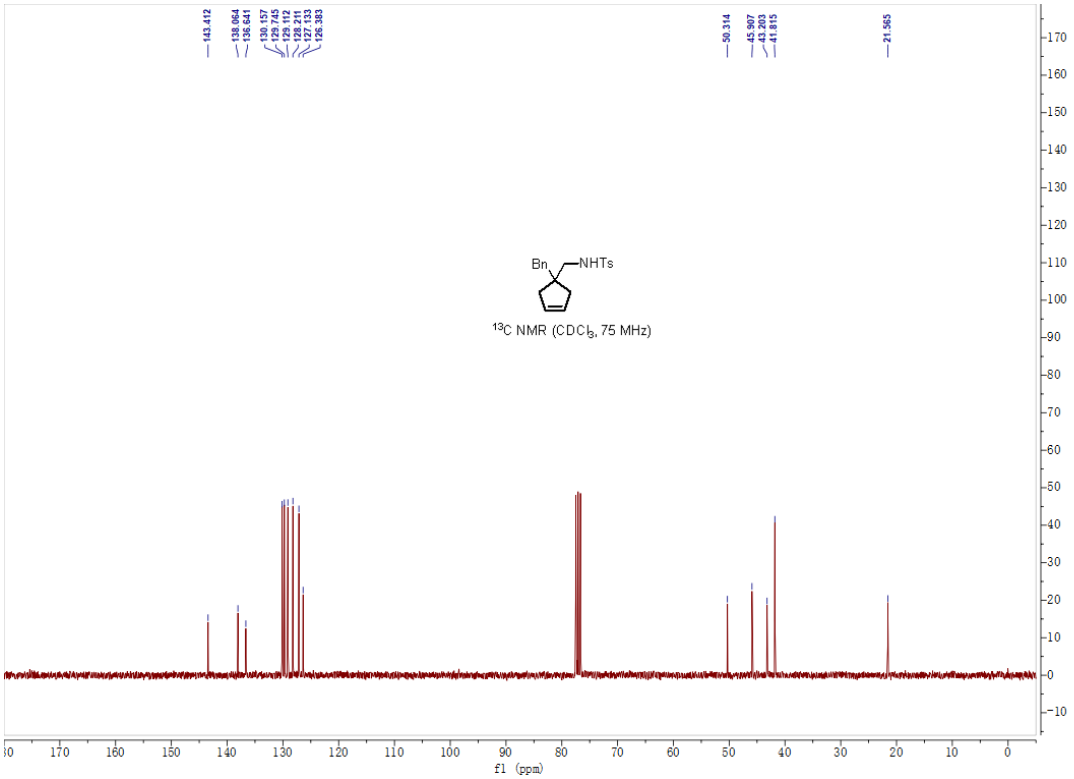
N-((1-cyclopropylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1m)



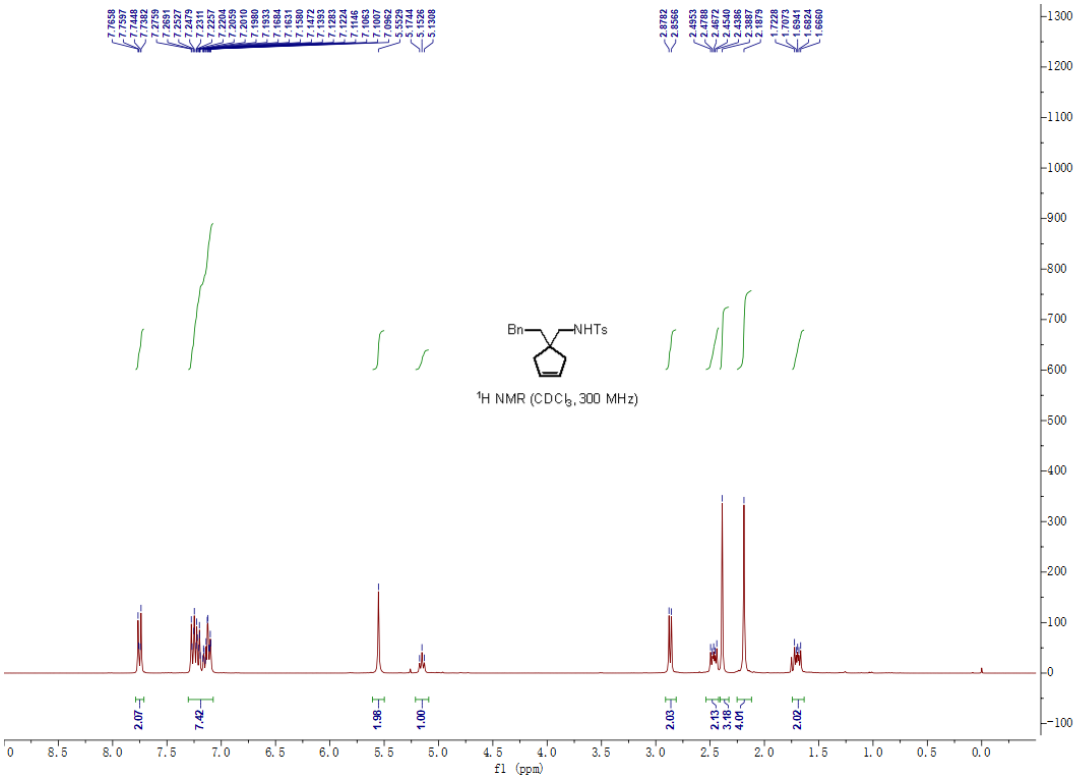


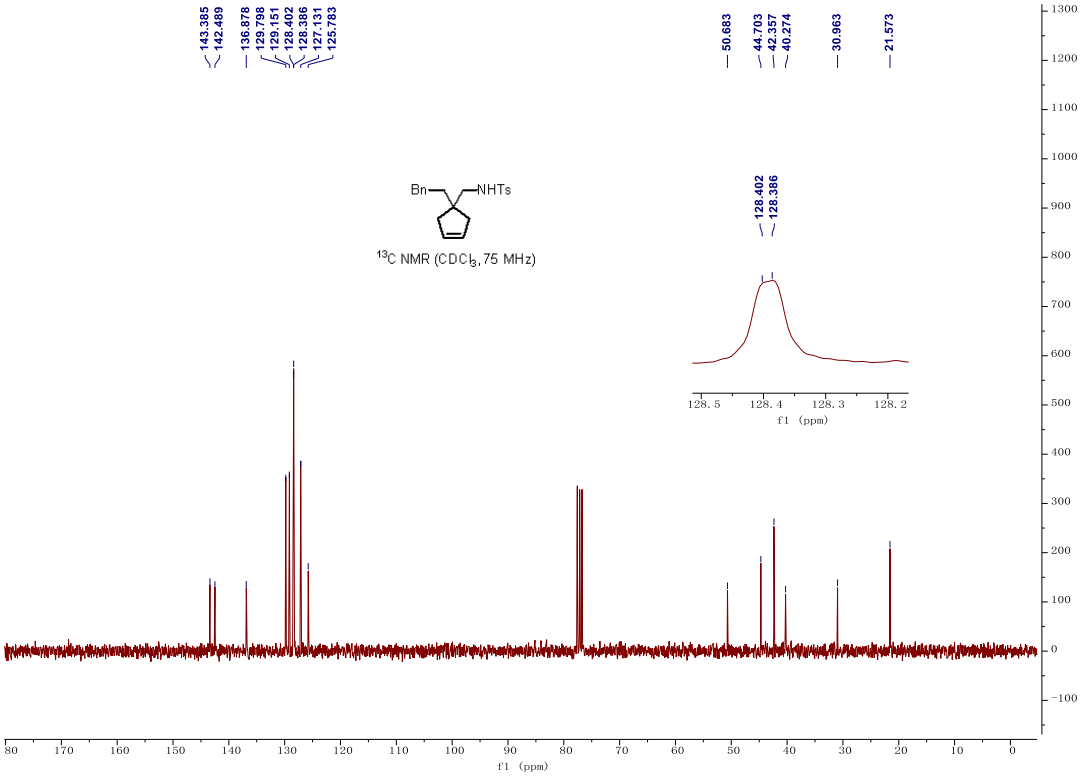
N-((1-benzylcyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1n)



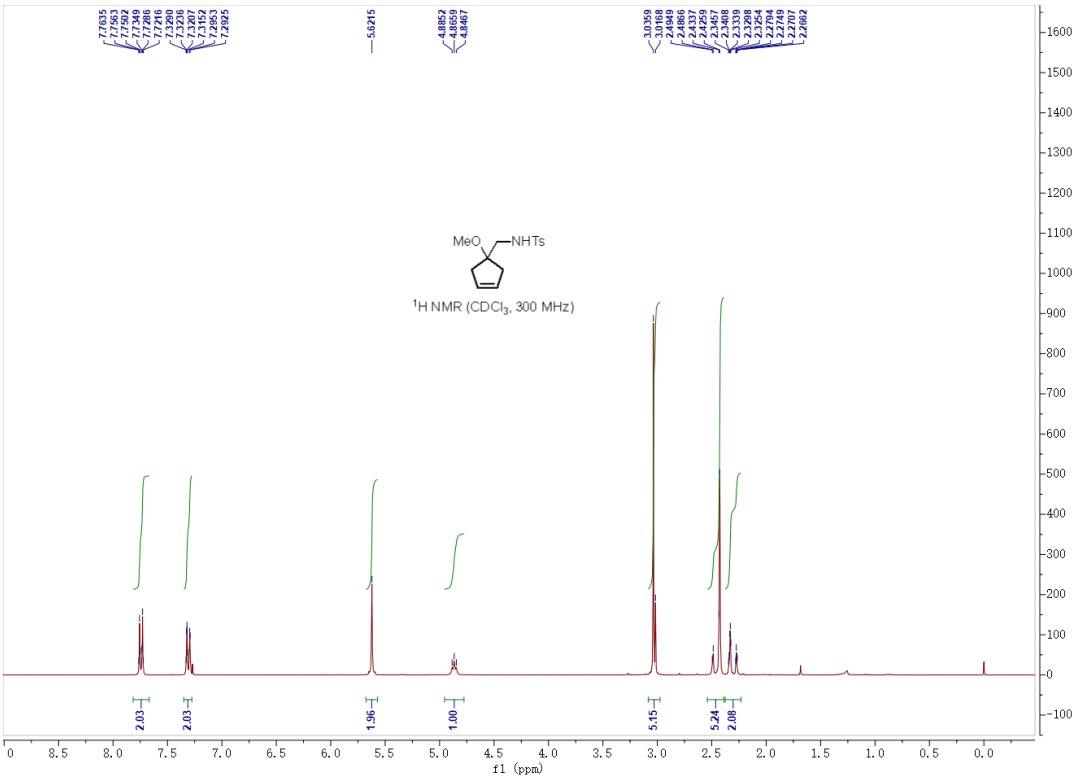


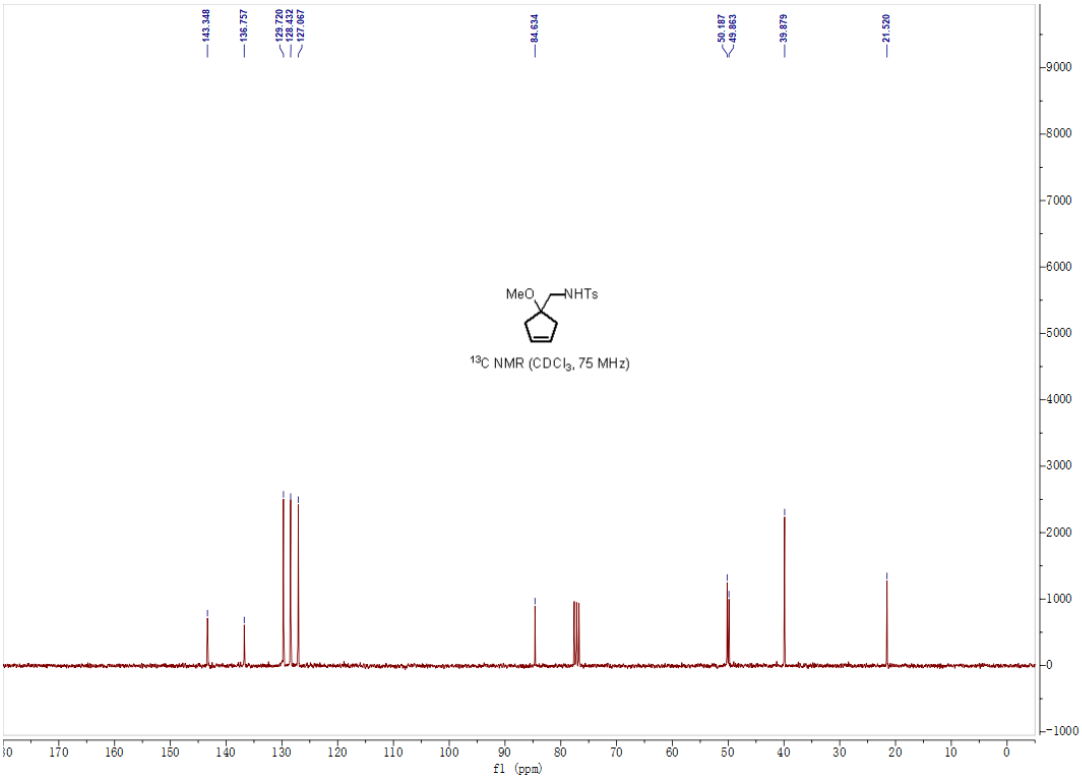
4-methyl-N-((1-phenethylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1o)



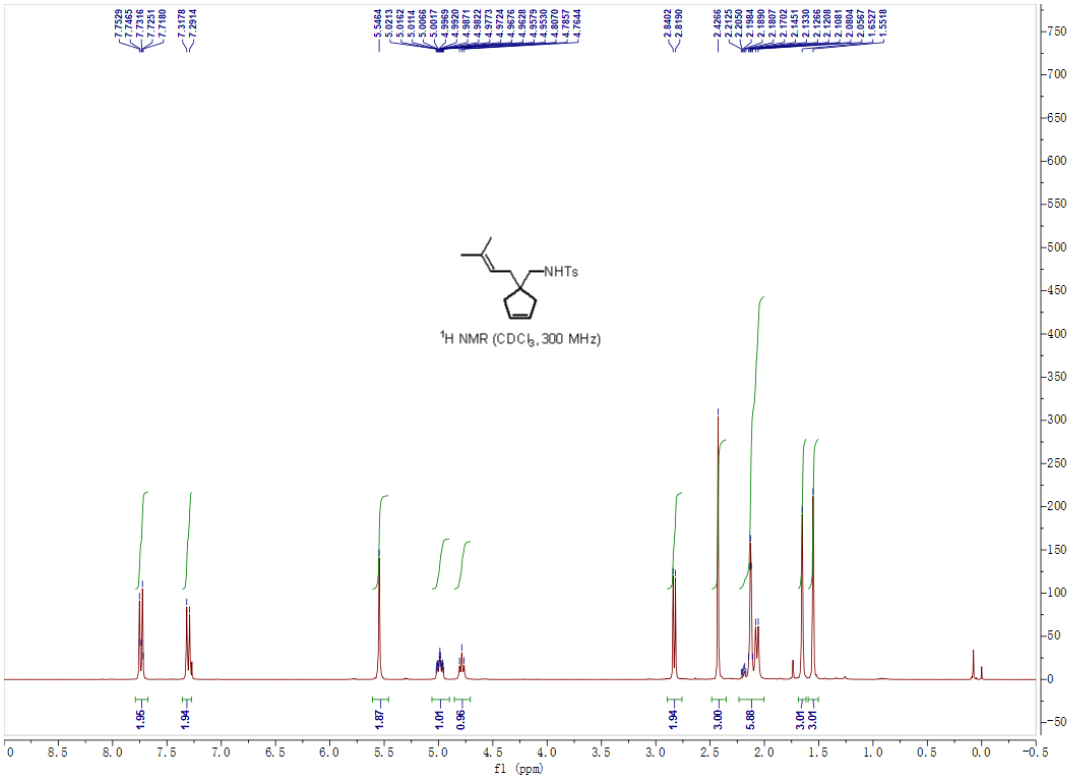


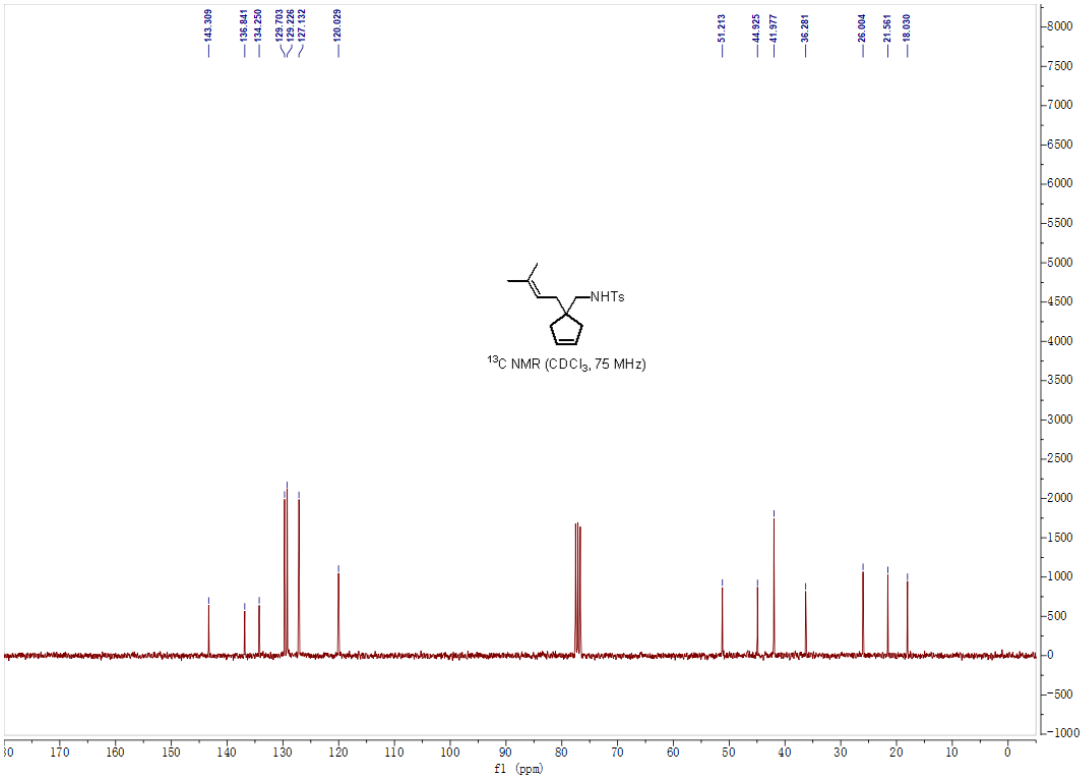
N-((1-methoxycyclopent-3-en-1-yl)methyl)-4-methylbenzenesulfonamide (1p)



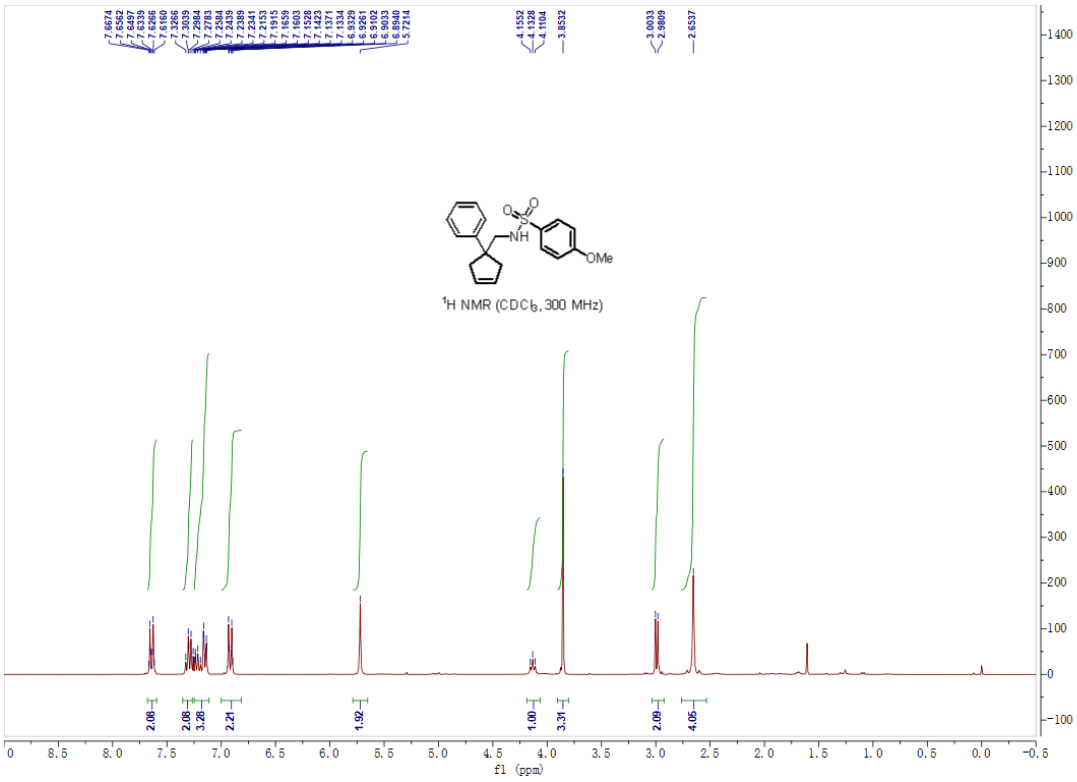


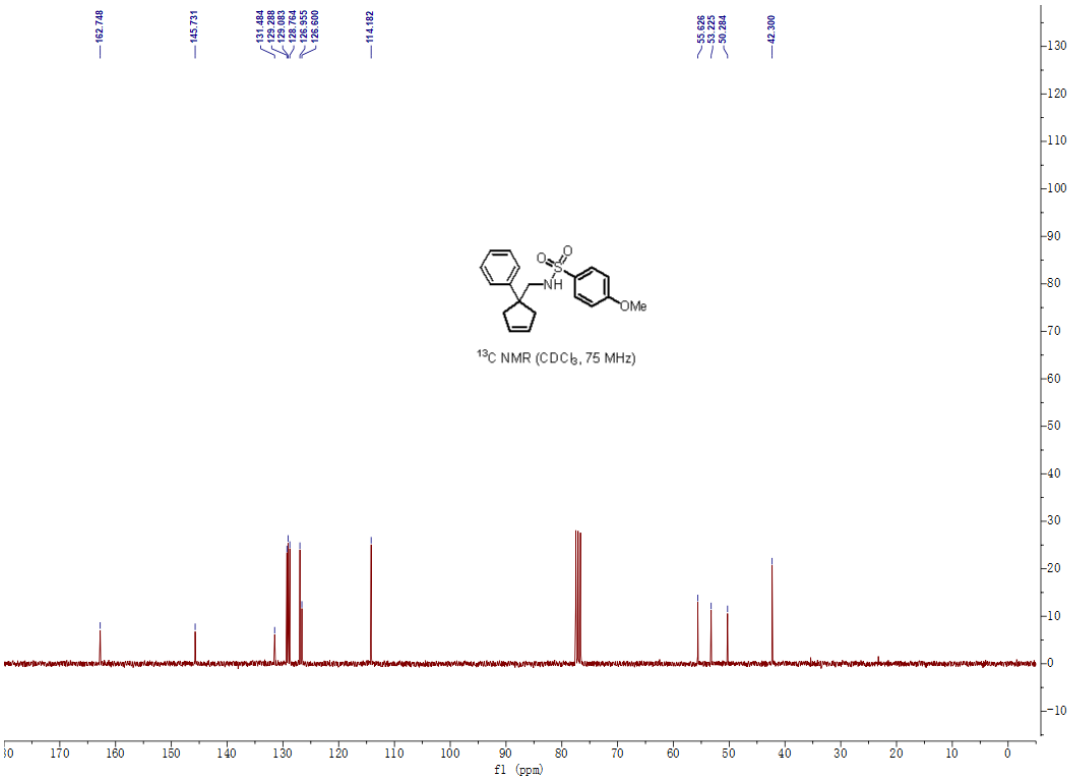
4-methyl-N-((1-(3-methylbut-2-en-1-yl)cyclopent-3-en-1-yl)methyl)benzenesulfonamide (1q)



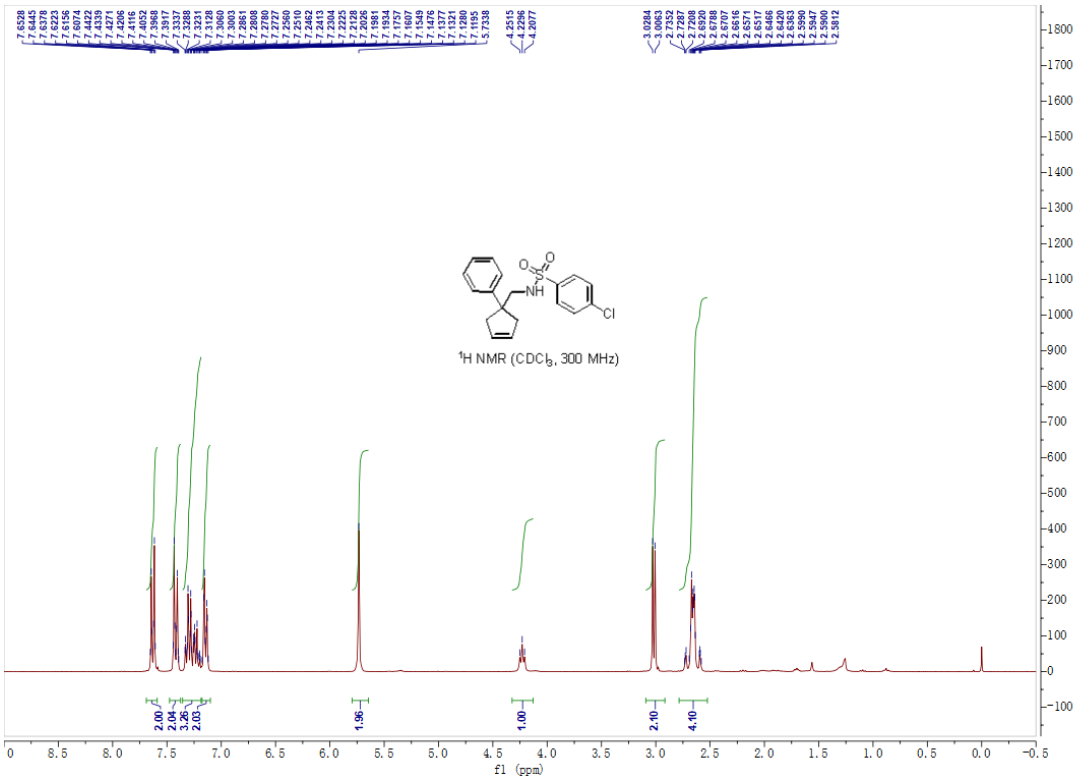


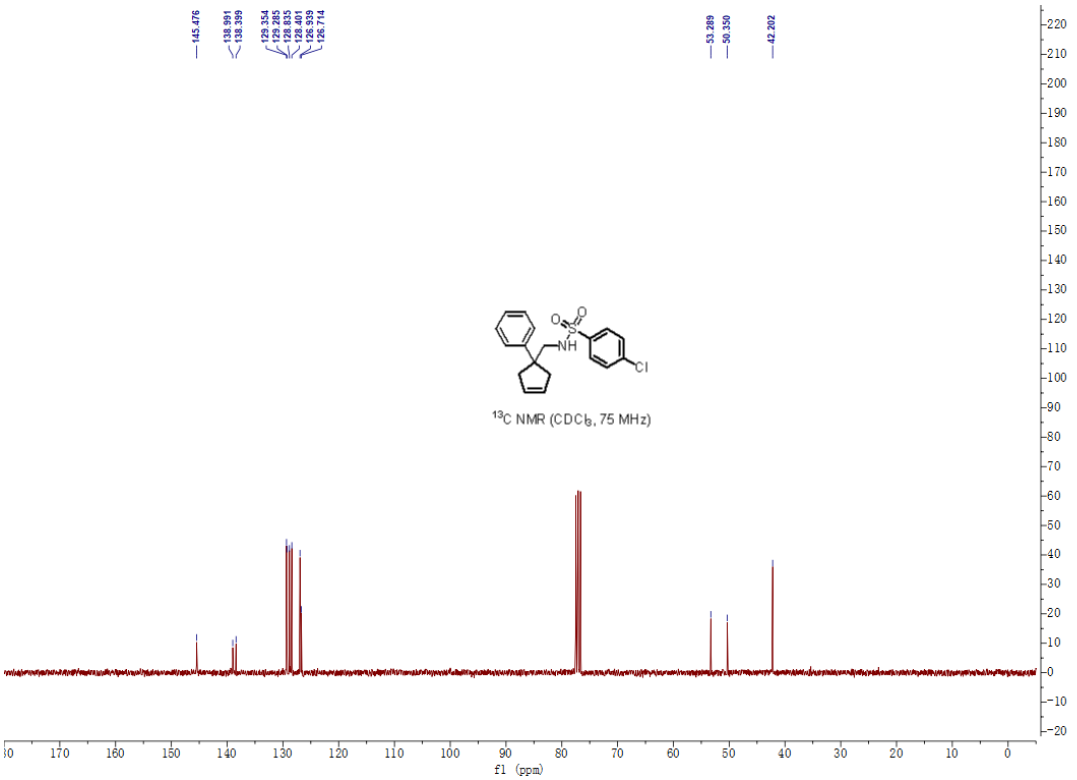
4-methoxy-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1r)



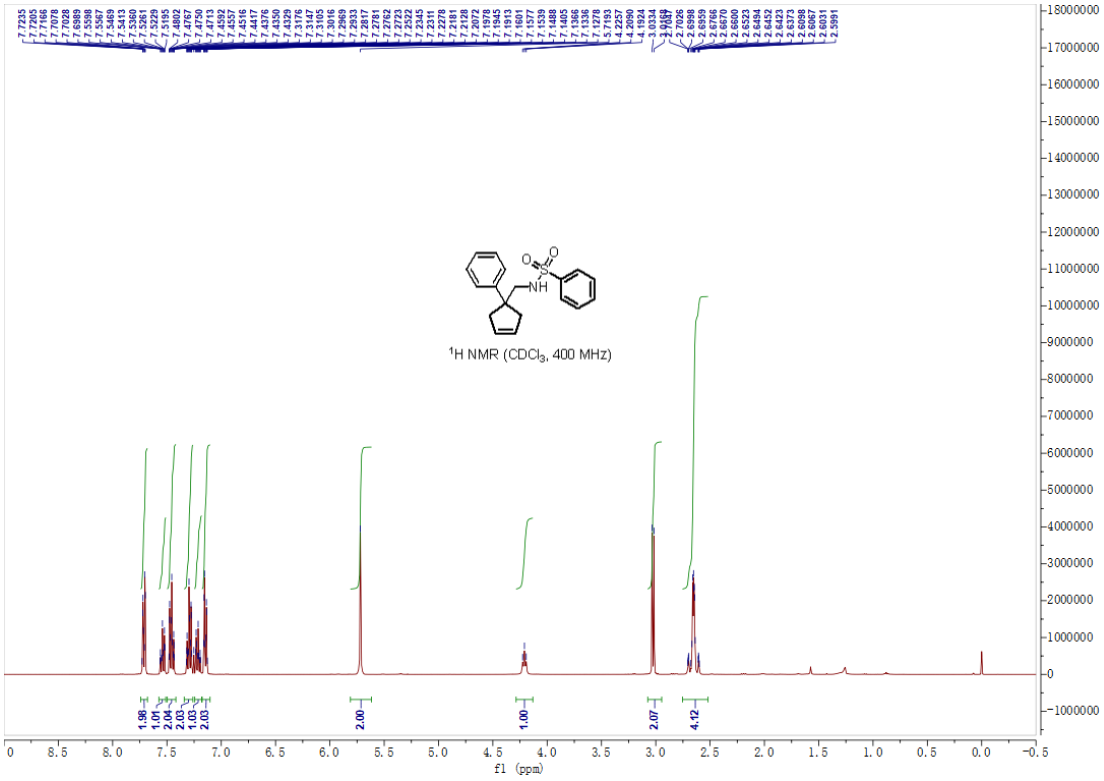


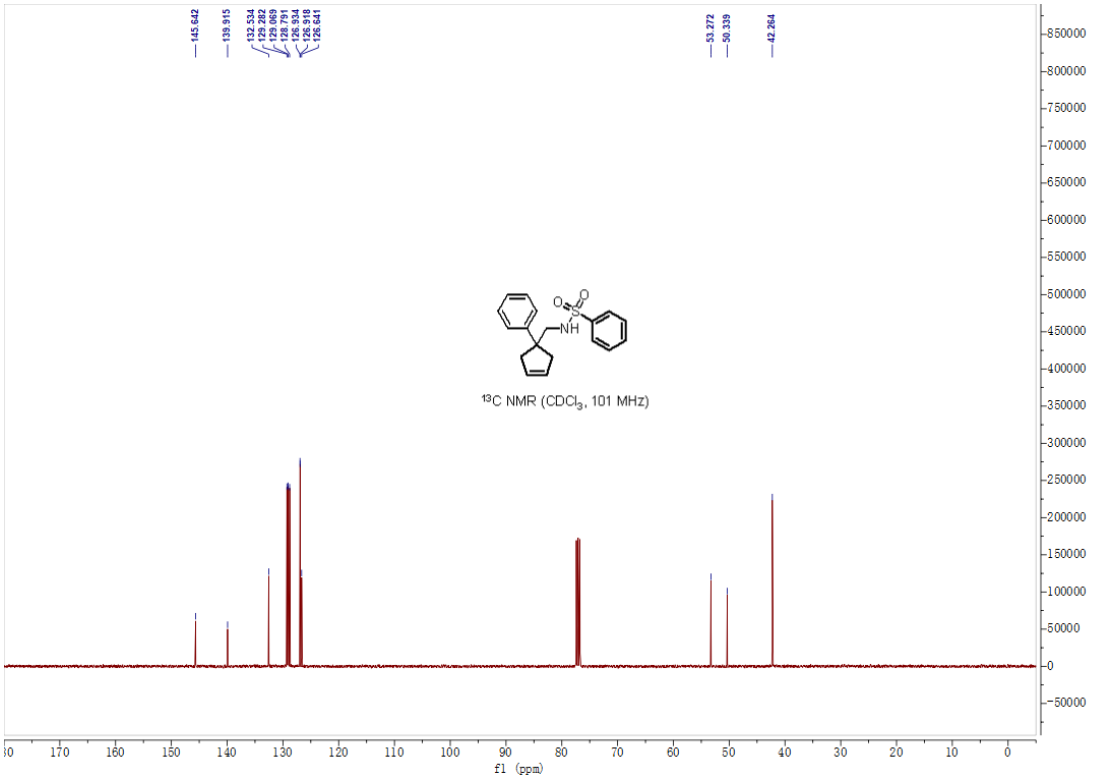
4-chloro-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1s)



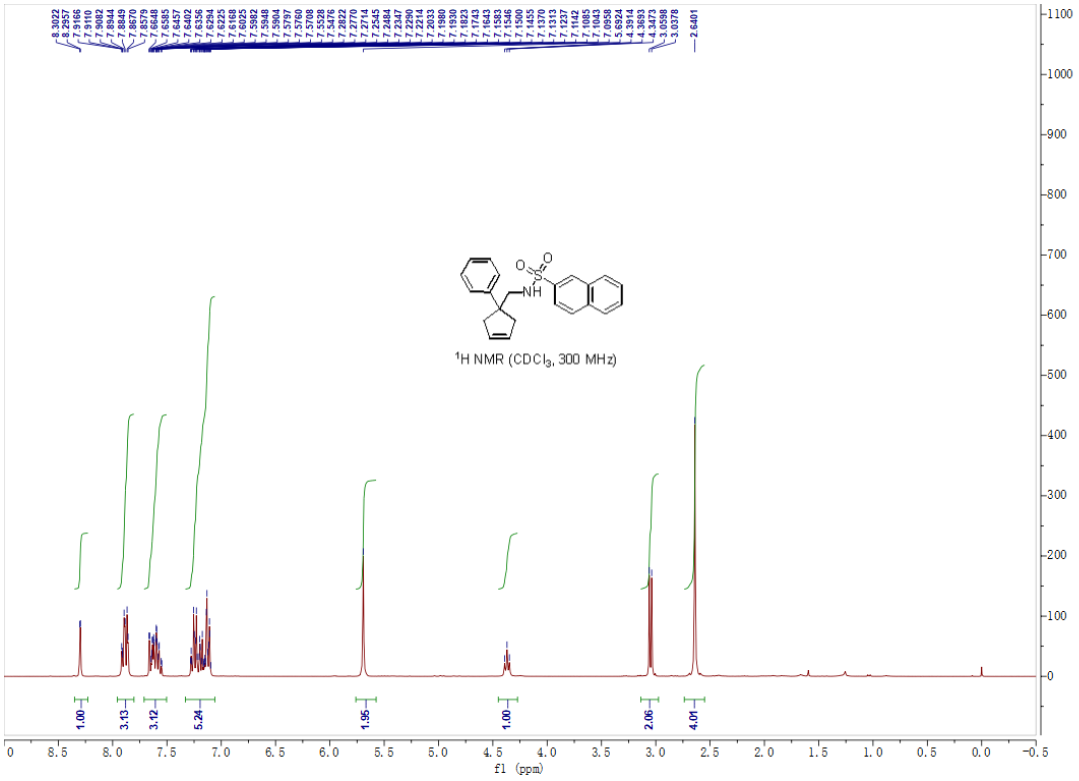


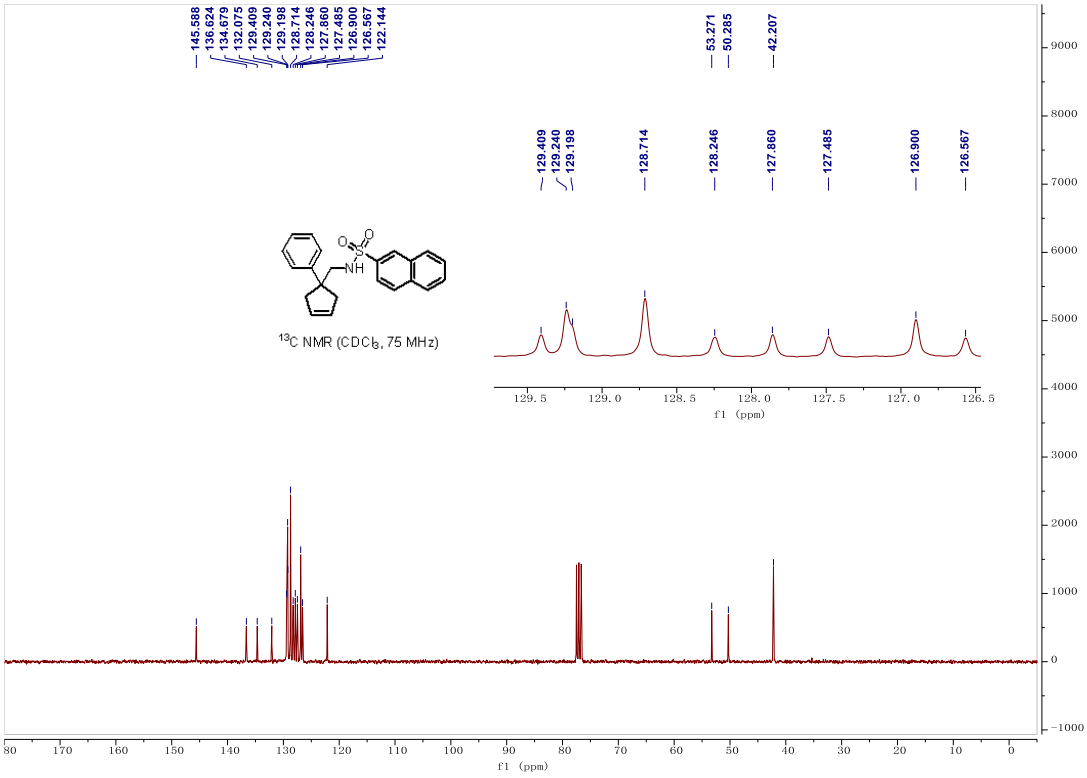
N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1t)



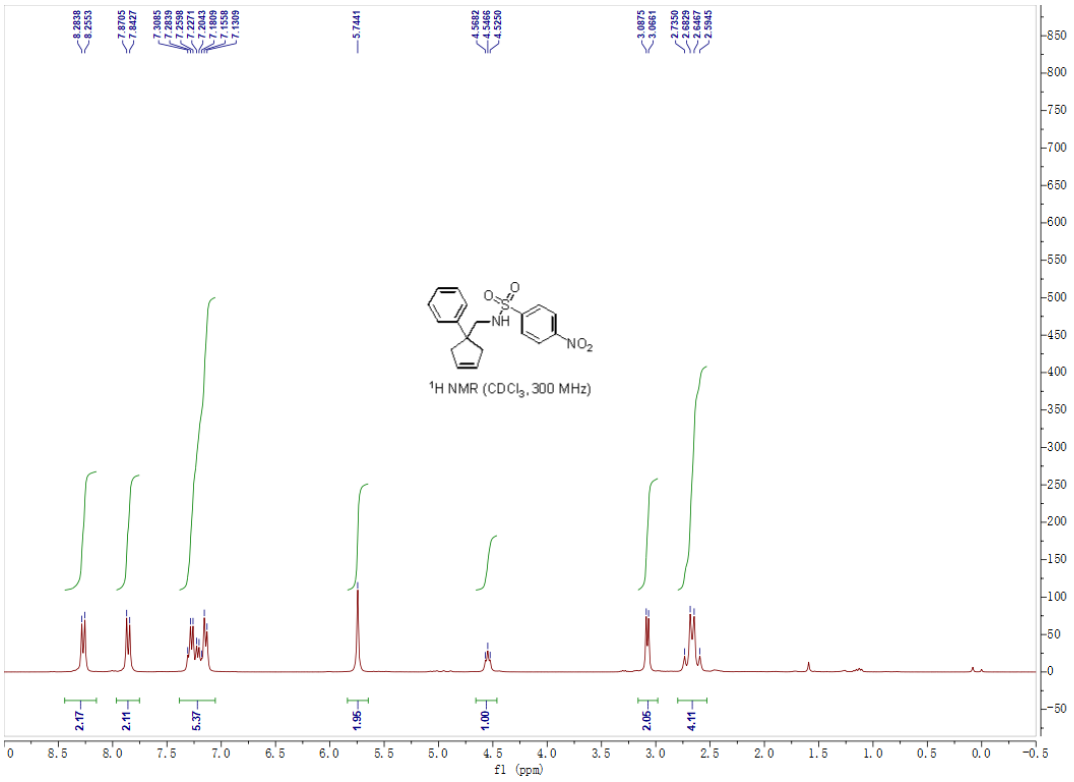


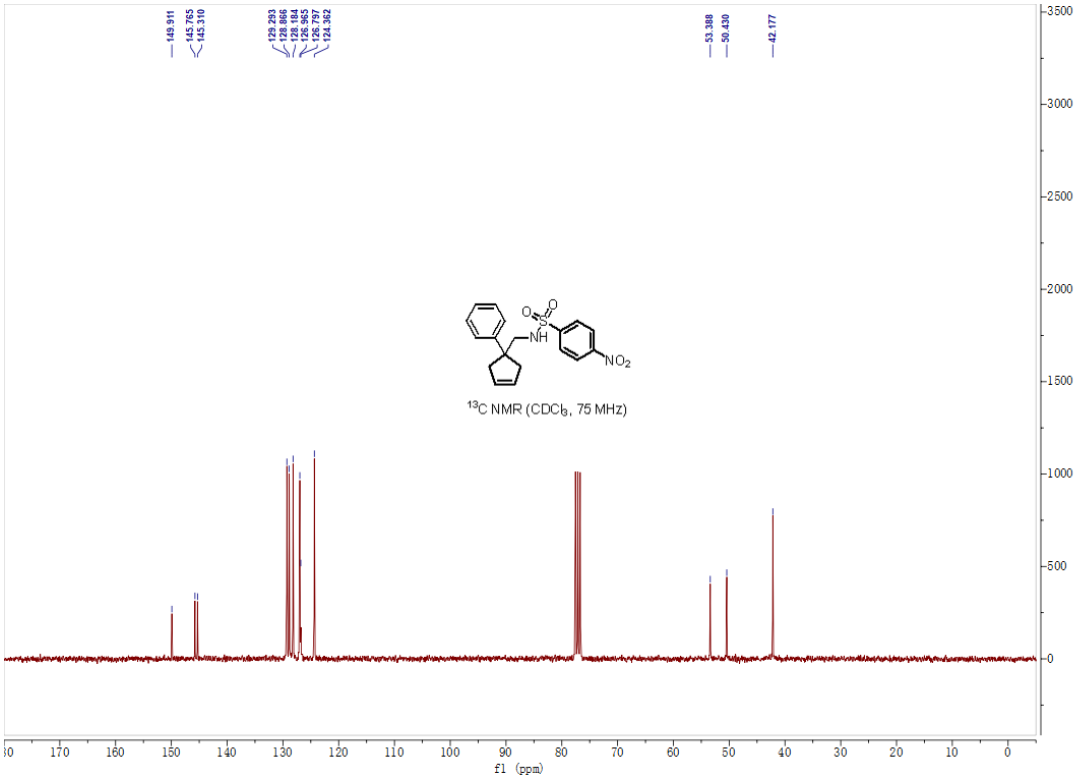
N-((1-phenylcyclopent-3-en-1-yl)methyl)naphthalene-2-sulfonamide (1u)



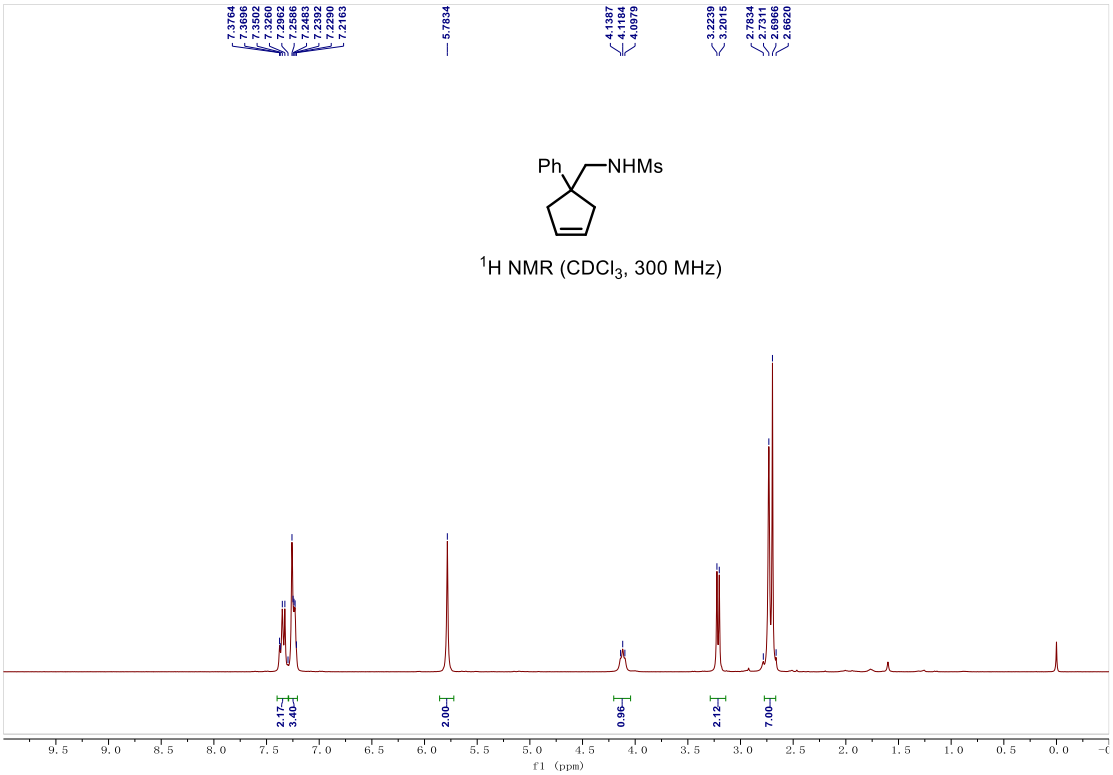


4-nitro-N-((1-phenylcyclopent-3-en-1-yl)methyl)benzenesulfonamide (1v)

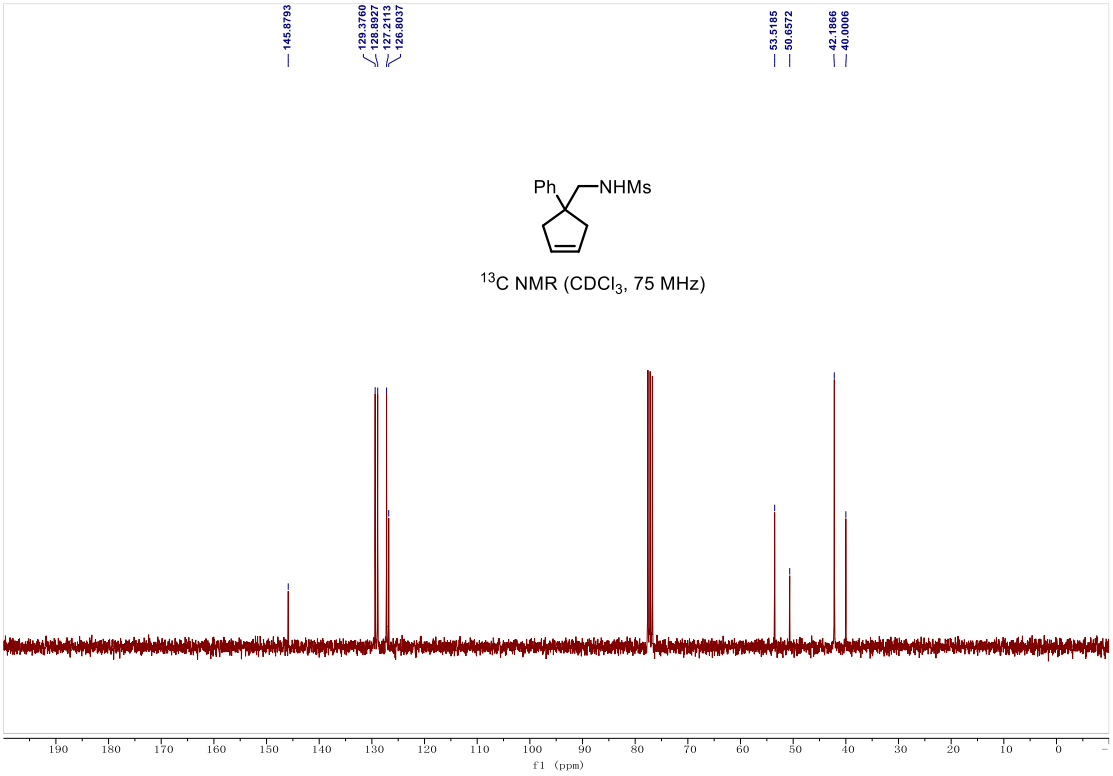




N-((1-phenylcyclopent-3-en-1-yl)methyl)methanesulfonamide (1w)

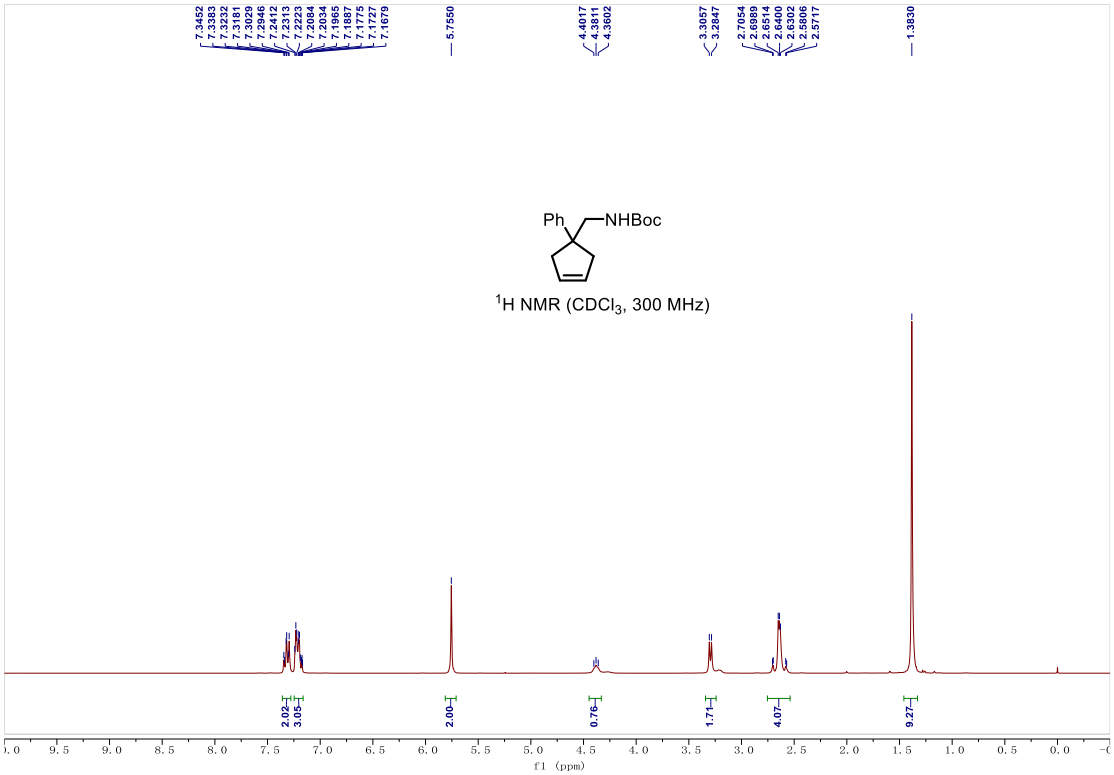


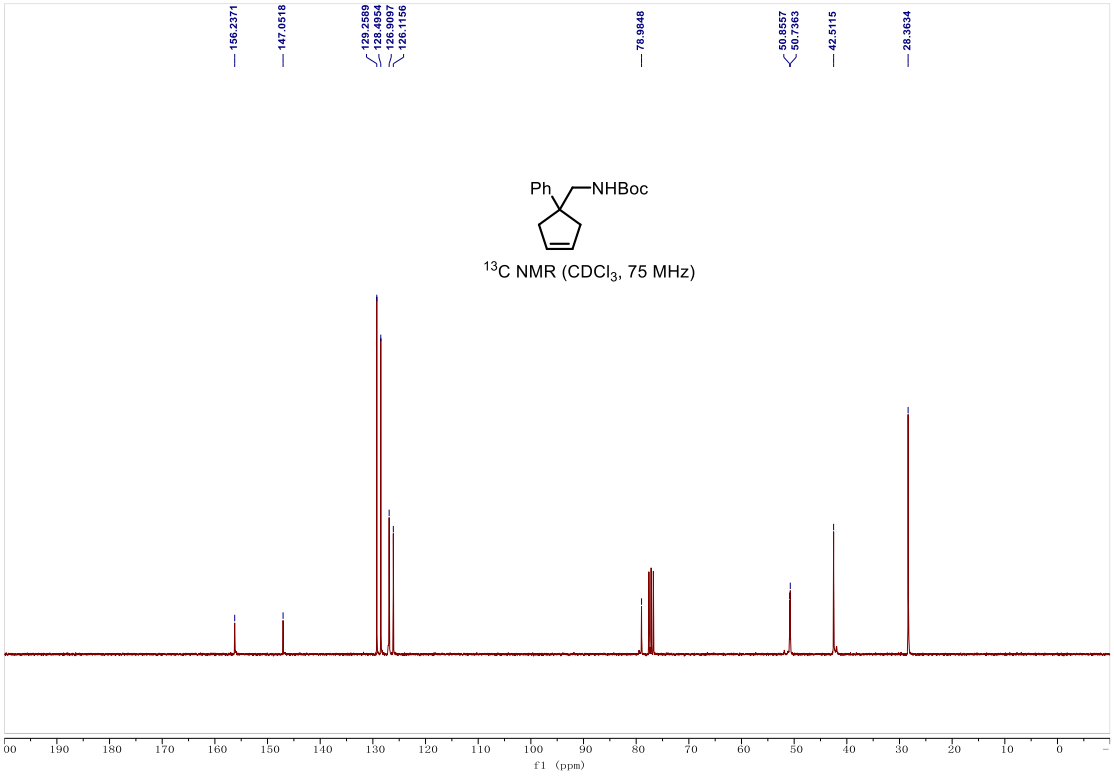
^{1}H NMR ($CDCl_3$, 300 MHz)



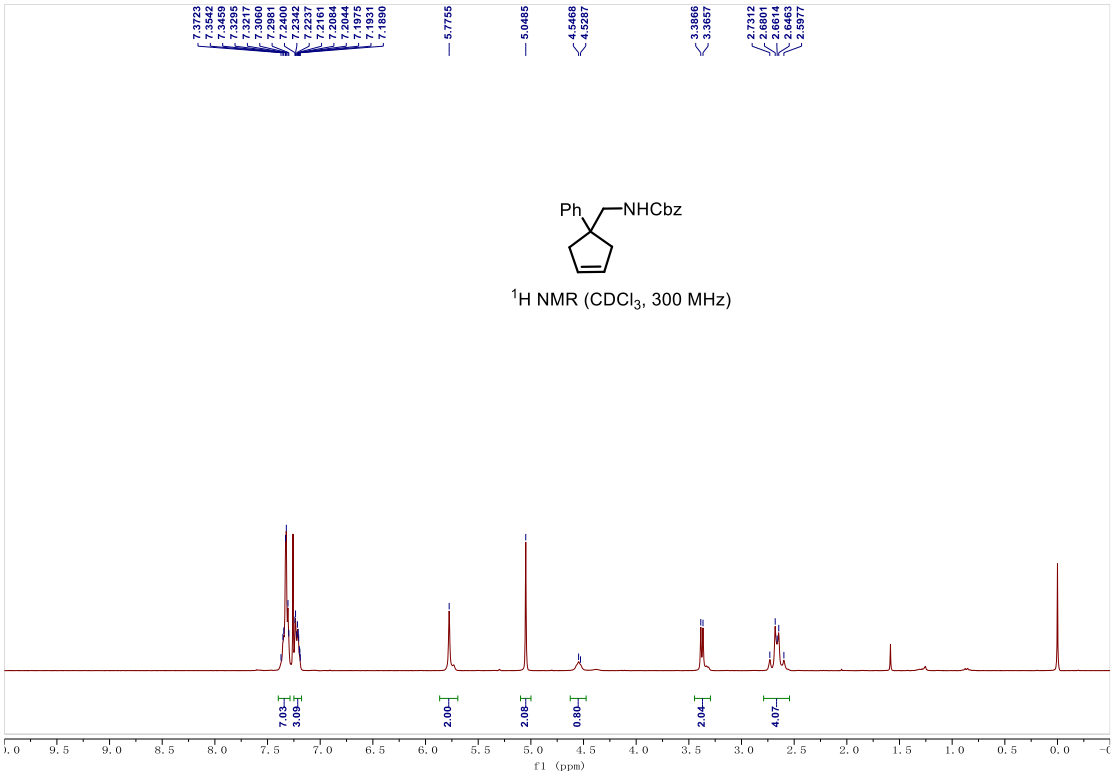
^{13}C NMR ($CDCl_3$, 75 MHz)

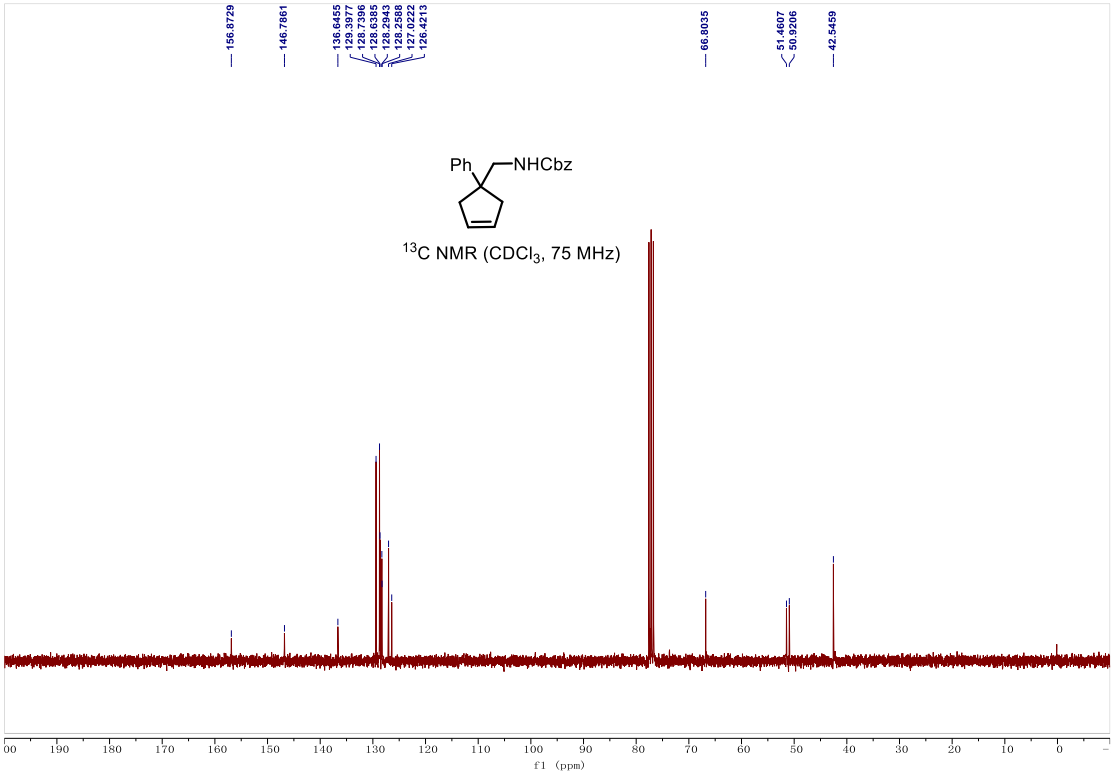
tert-butyl ((1-phenylcyclopent-3-en-1-yl)methyl)carbamate (1x)



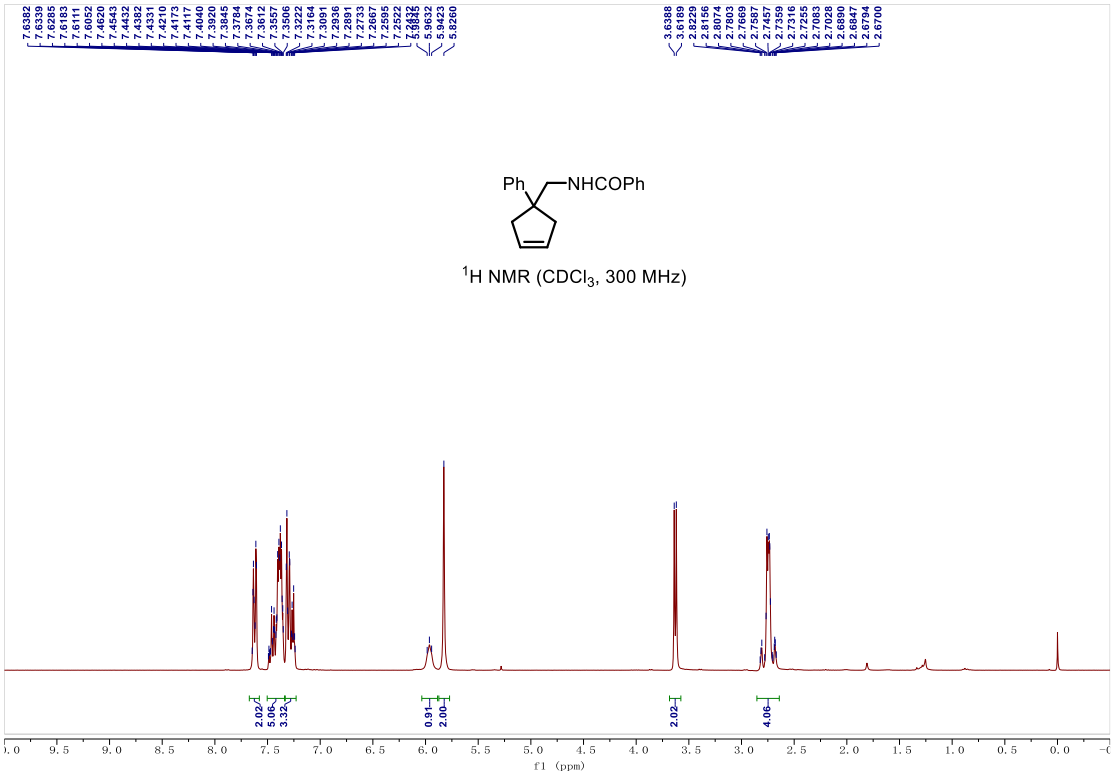


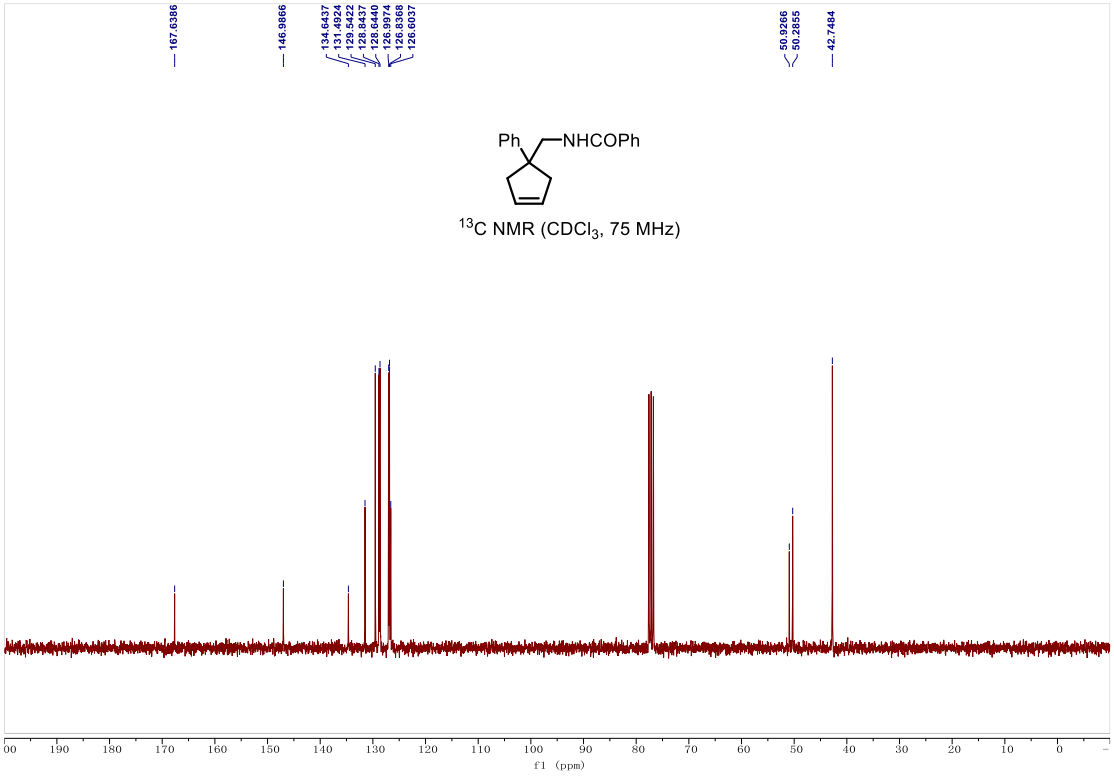
benzyl ((1-phenylcyclopent-3-en-1-yl)methyl)carbamate (1y)



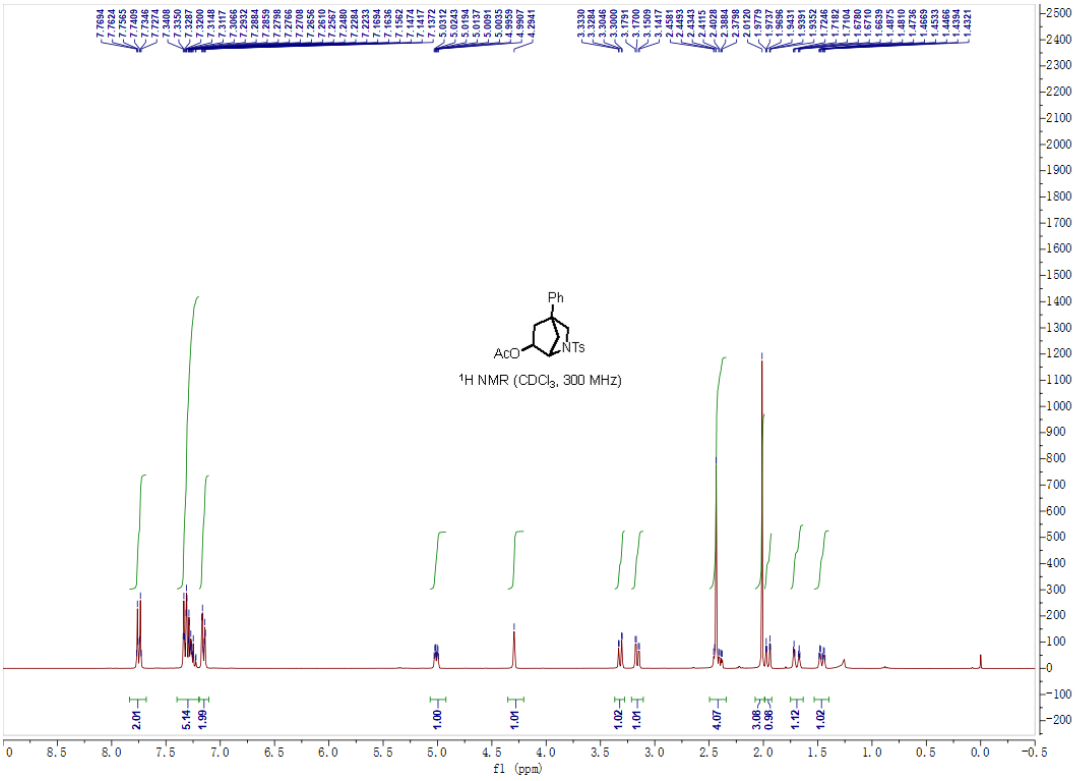


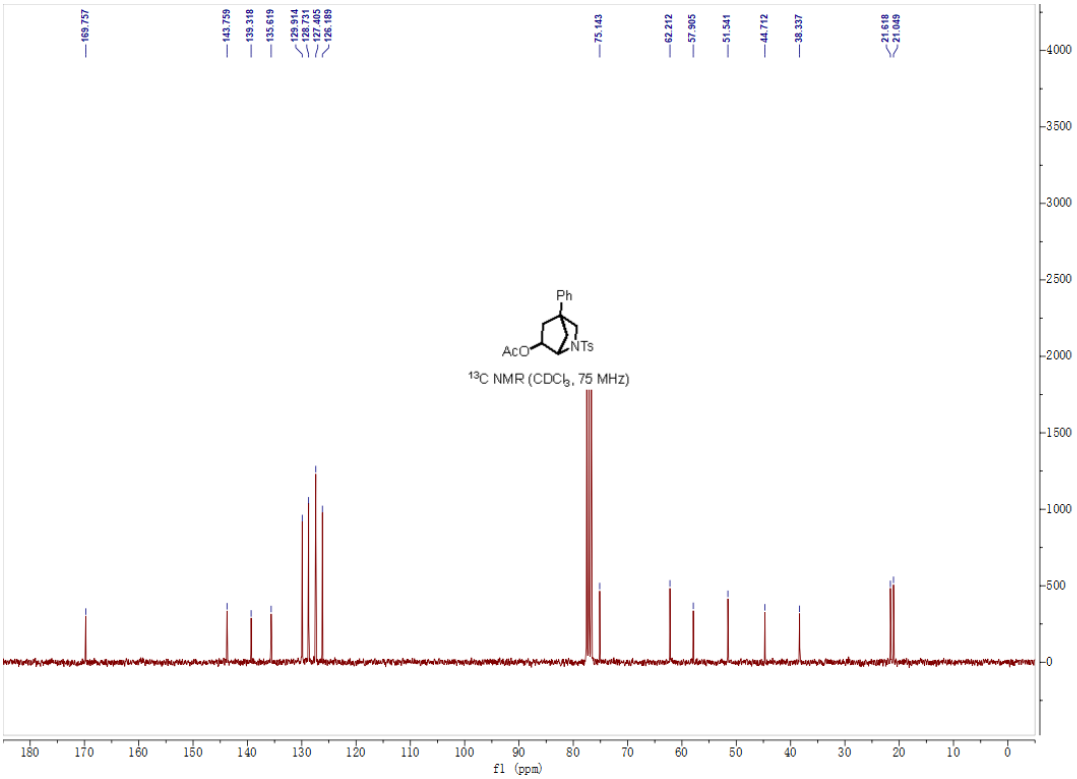
N-((1-phenylcyclopent-3-en-1-yl)methyl)benzamide (1z)



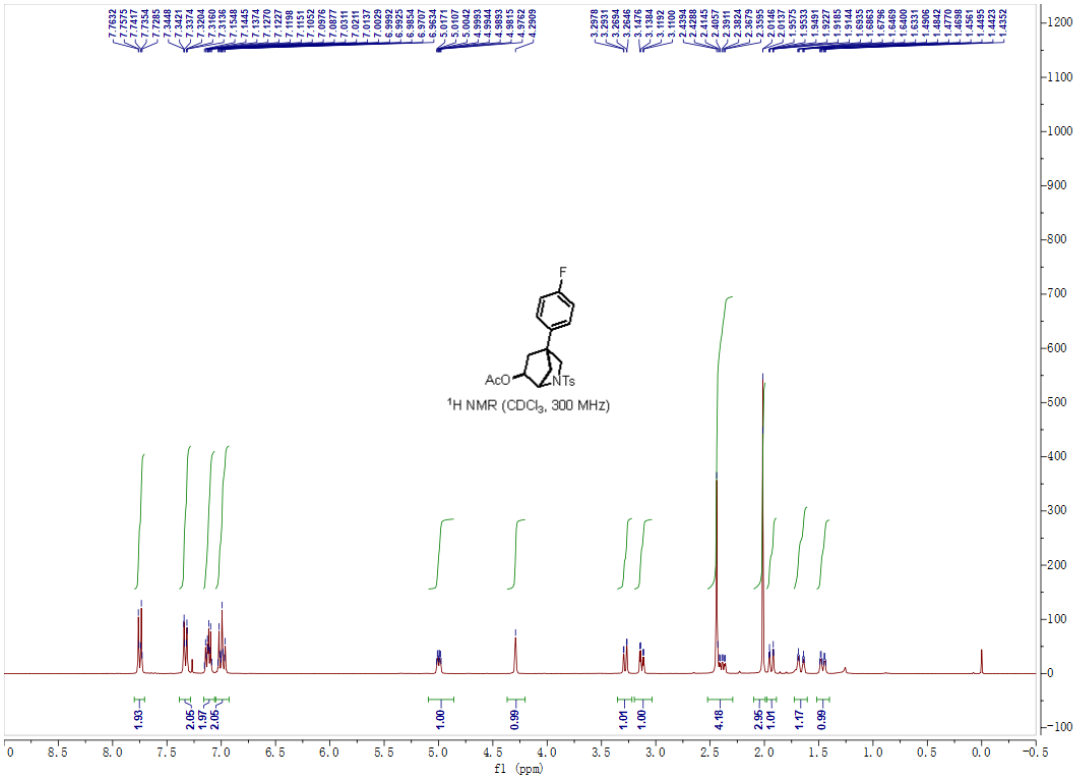


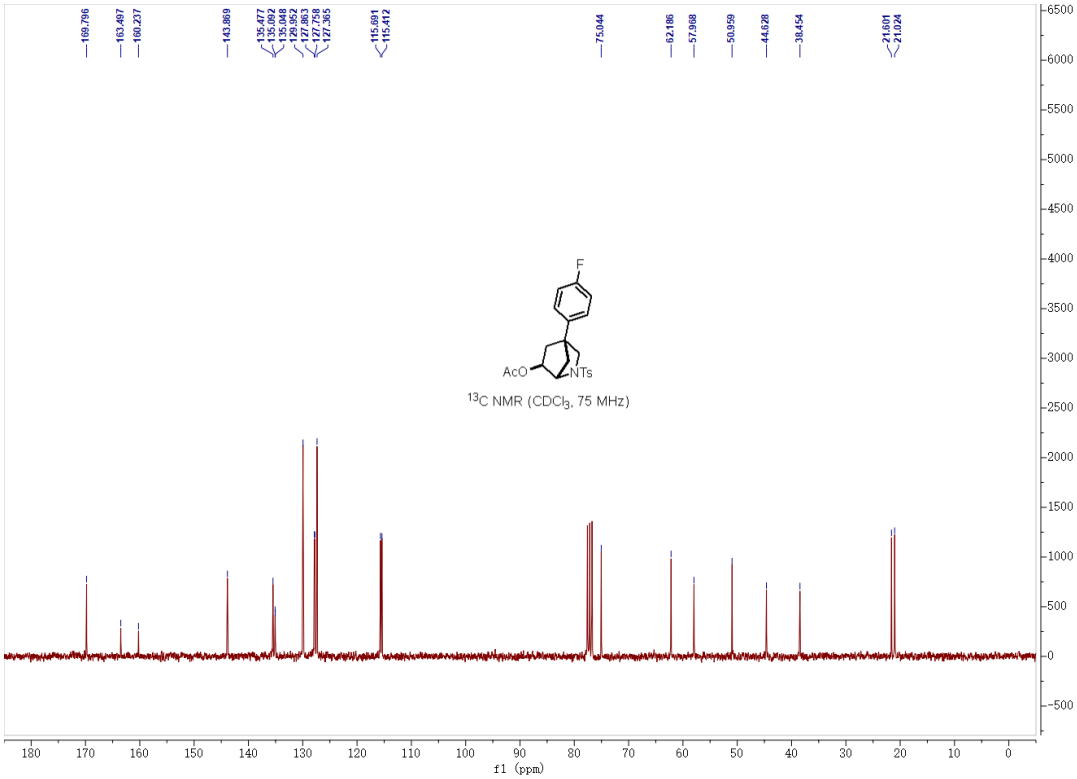
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3a)

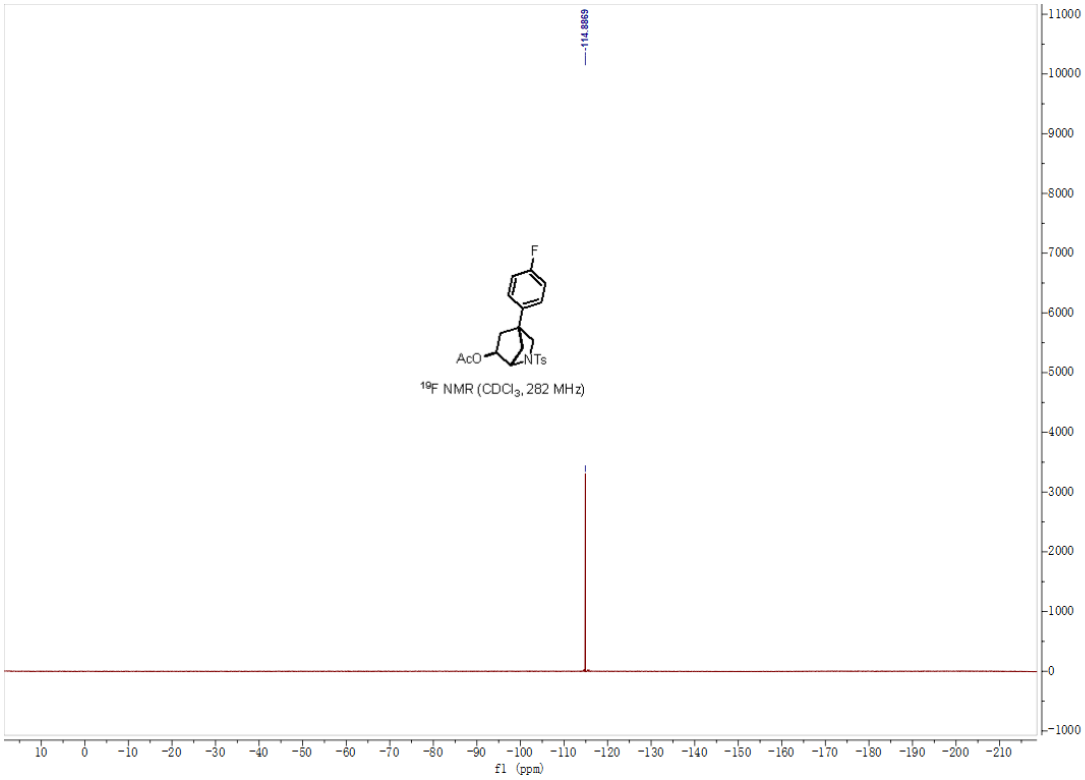




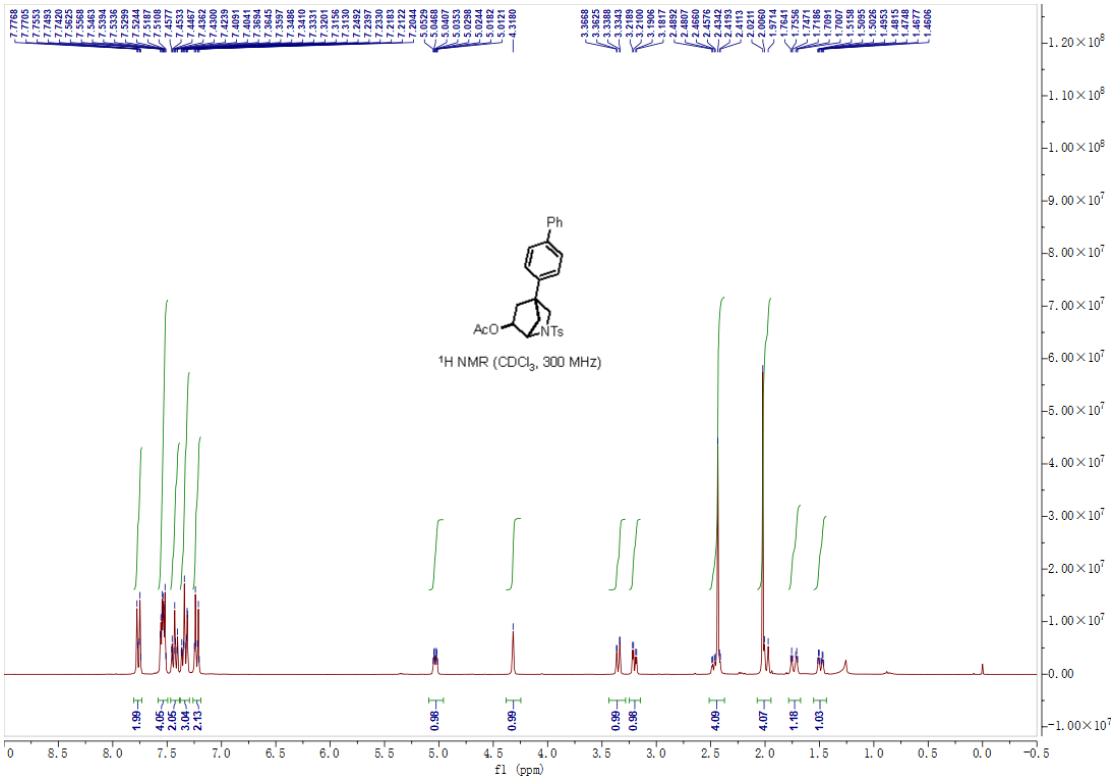
4-(4-fluorophenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3b)

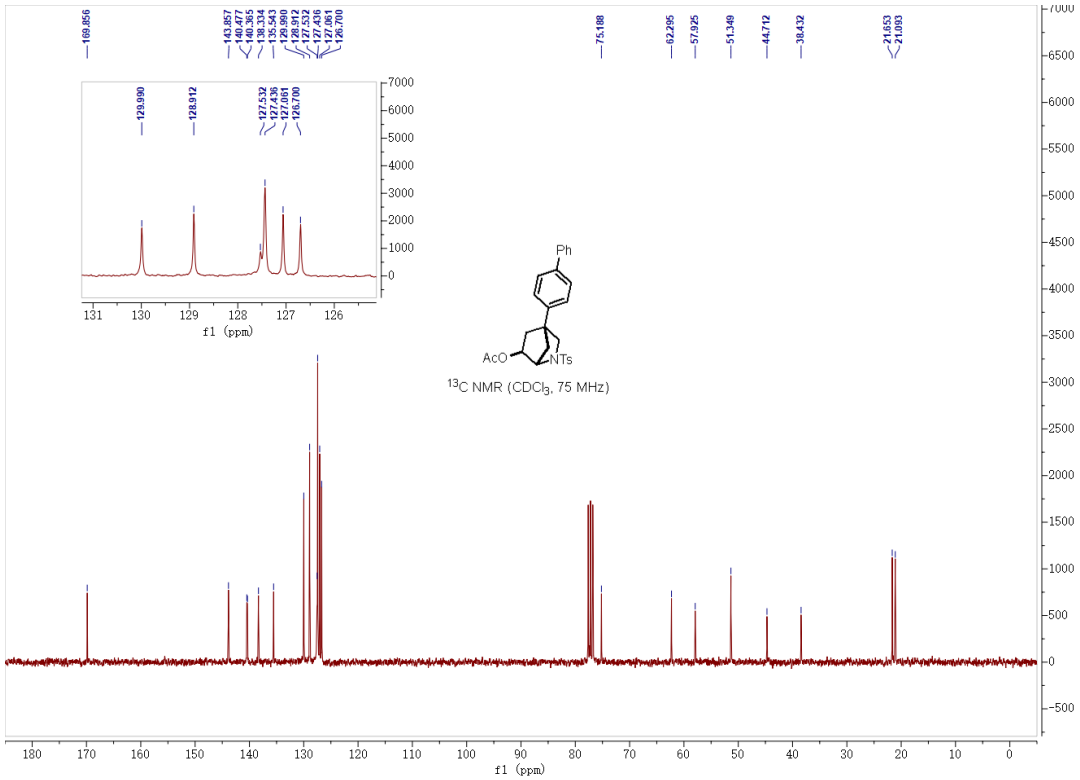




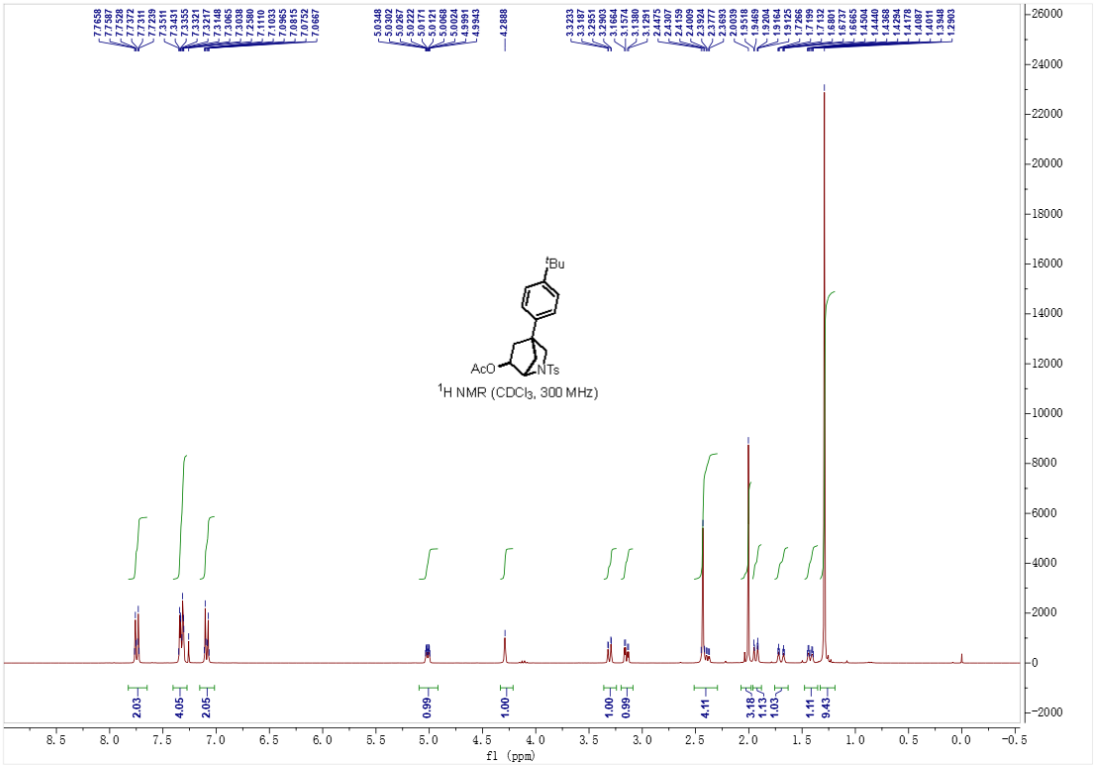

-114.8869
F
AcO
NTs
^{19}F NMR ($CDCl_3$, 282 MHz)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

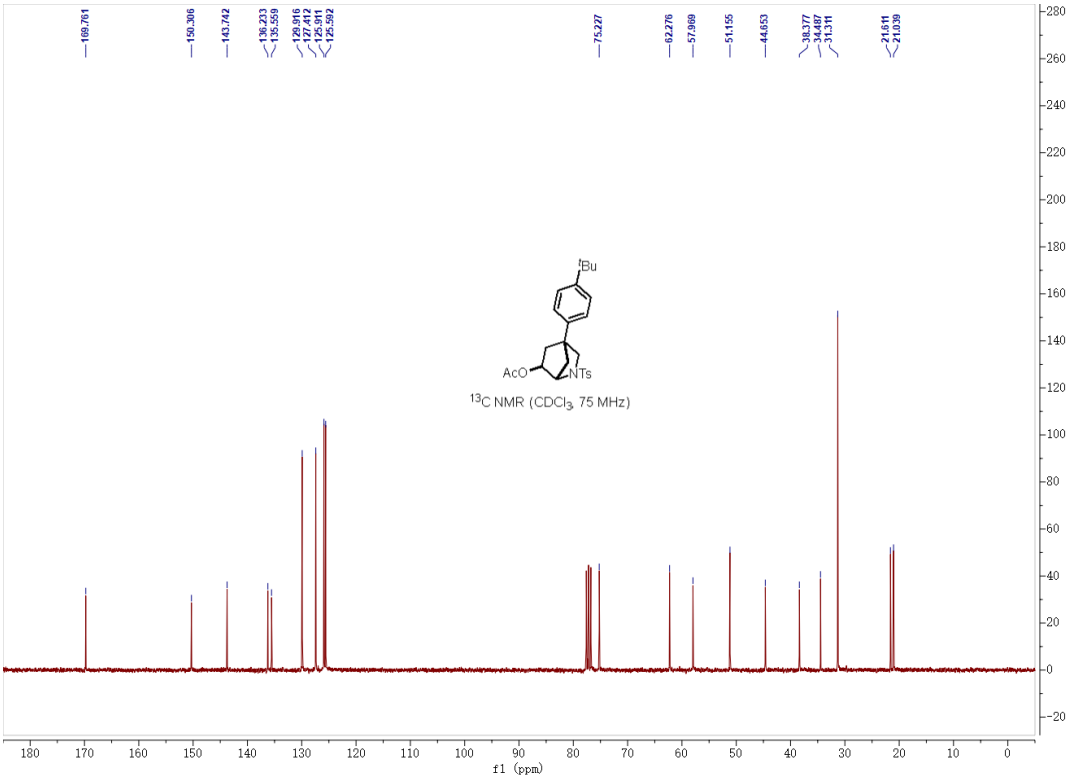
4-([1,1'-biphenyl]-4-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3c)



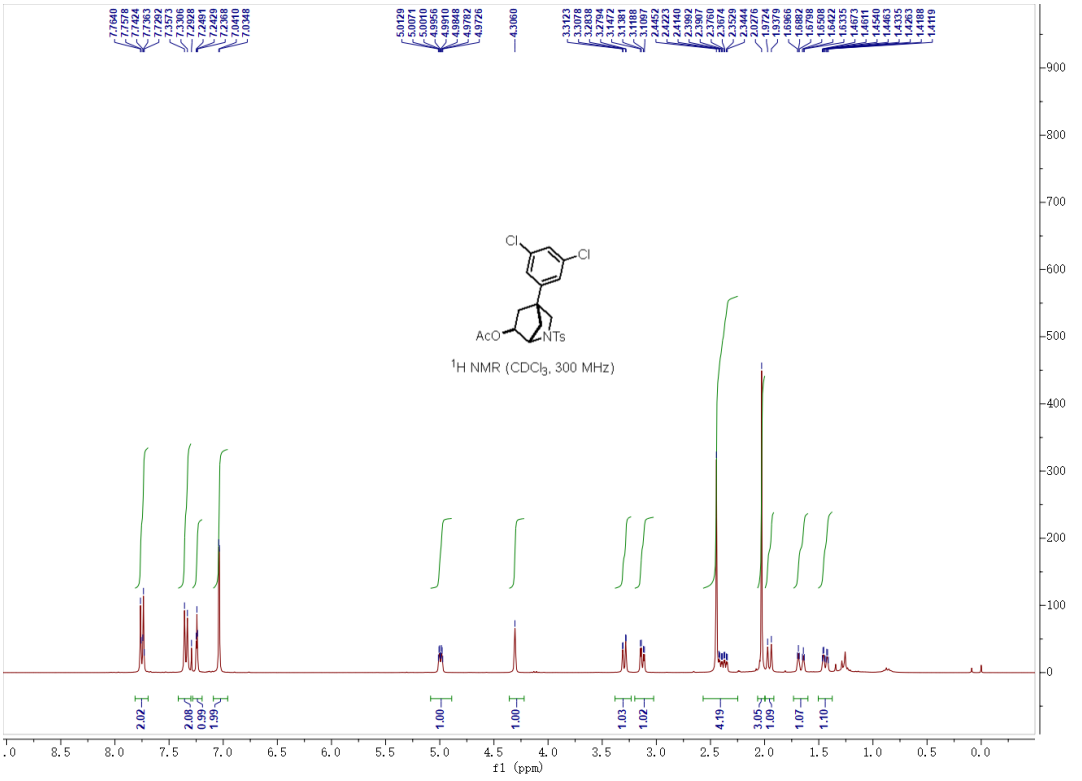


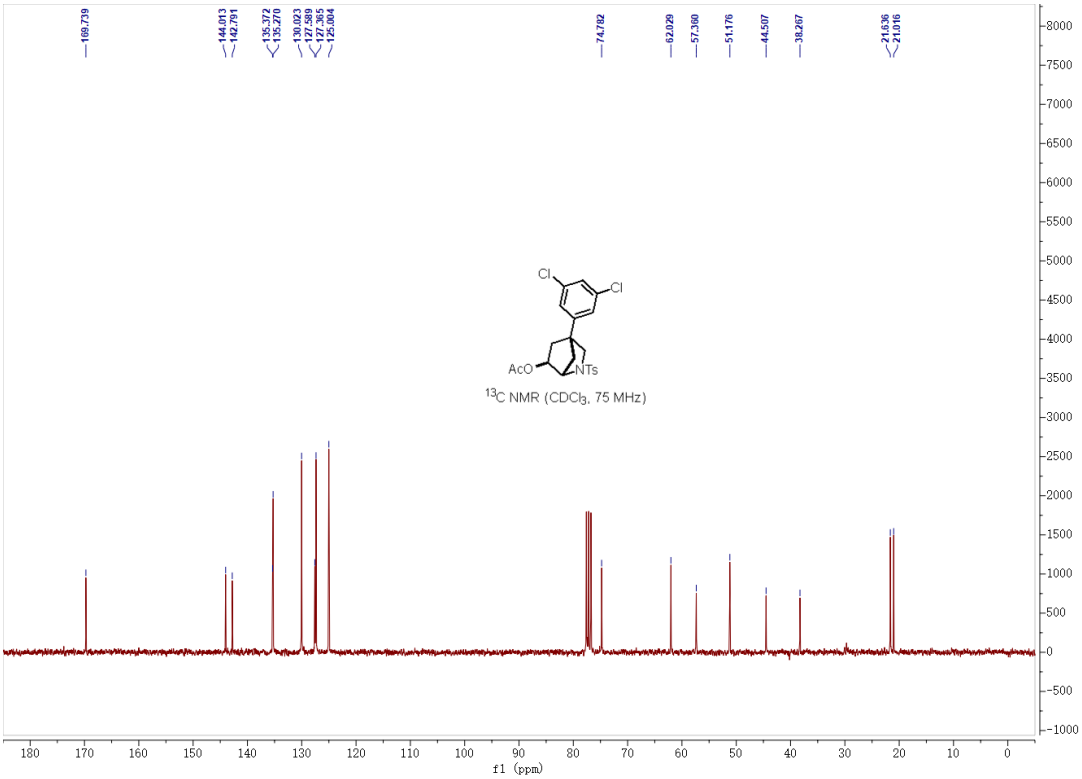
4-(4-(tert-butyl)phenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3d)



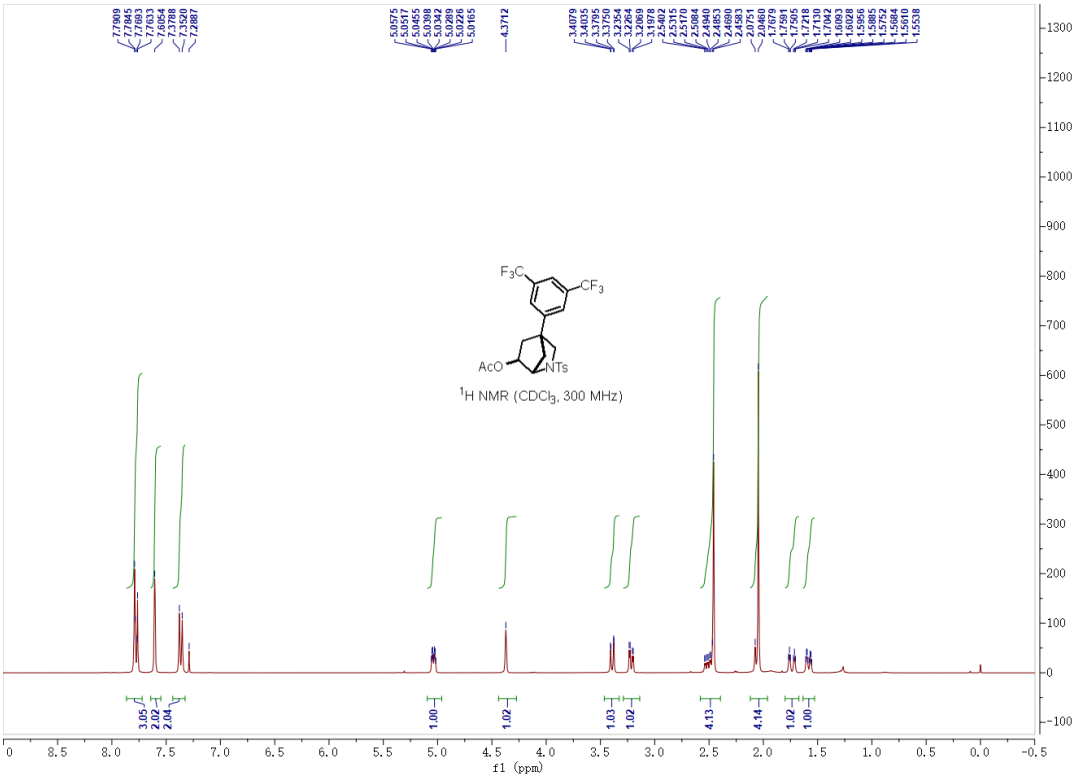


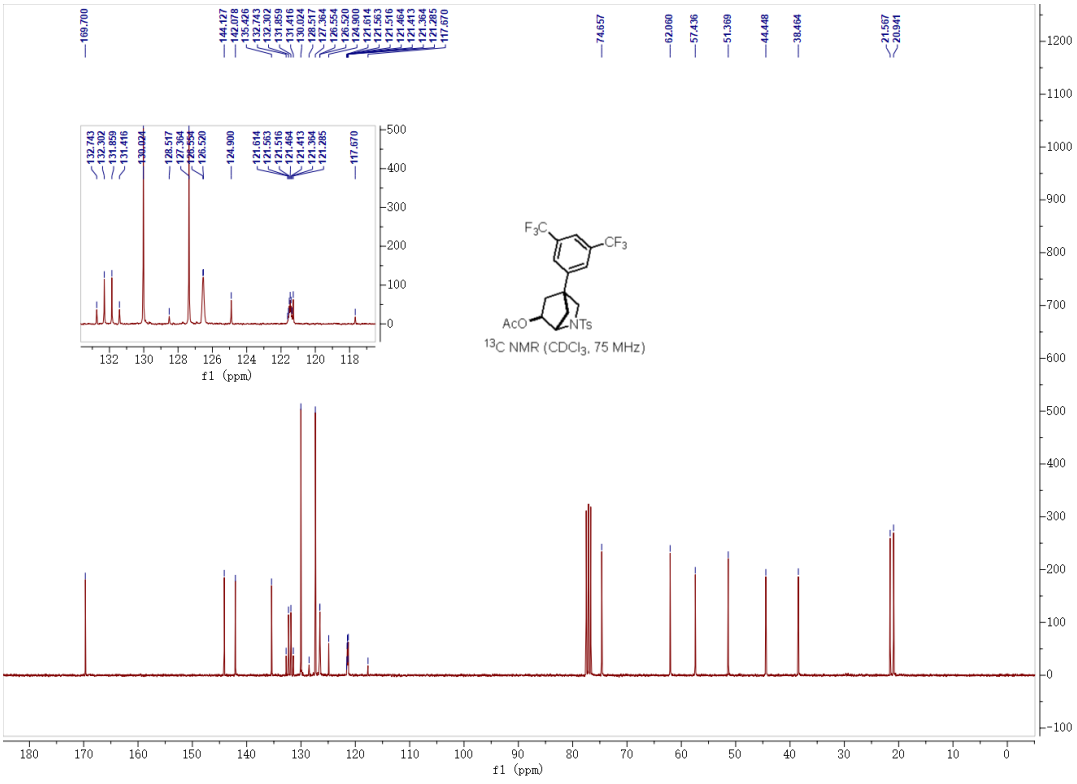
4-(3,5-dichlorophenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3e)

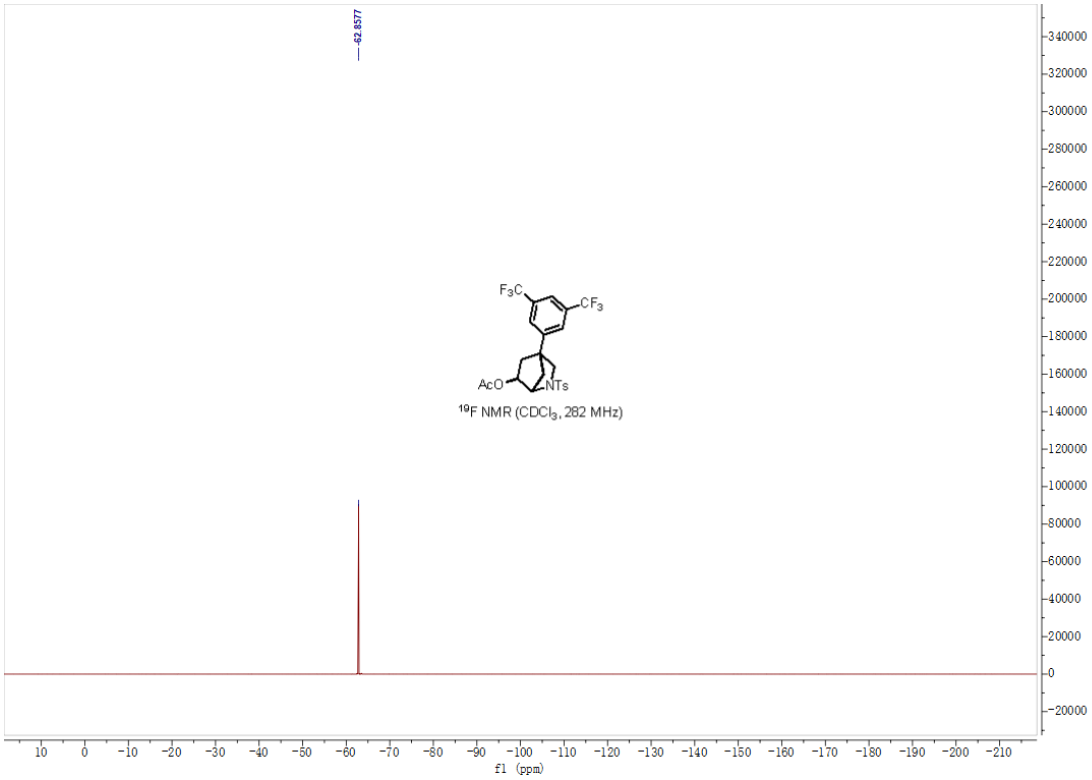




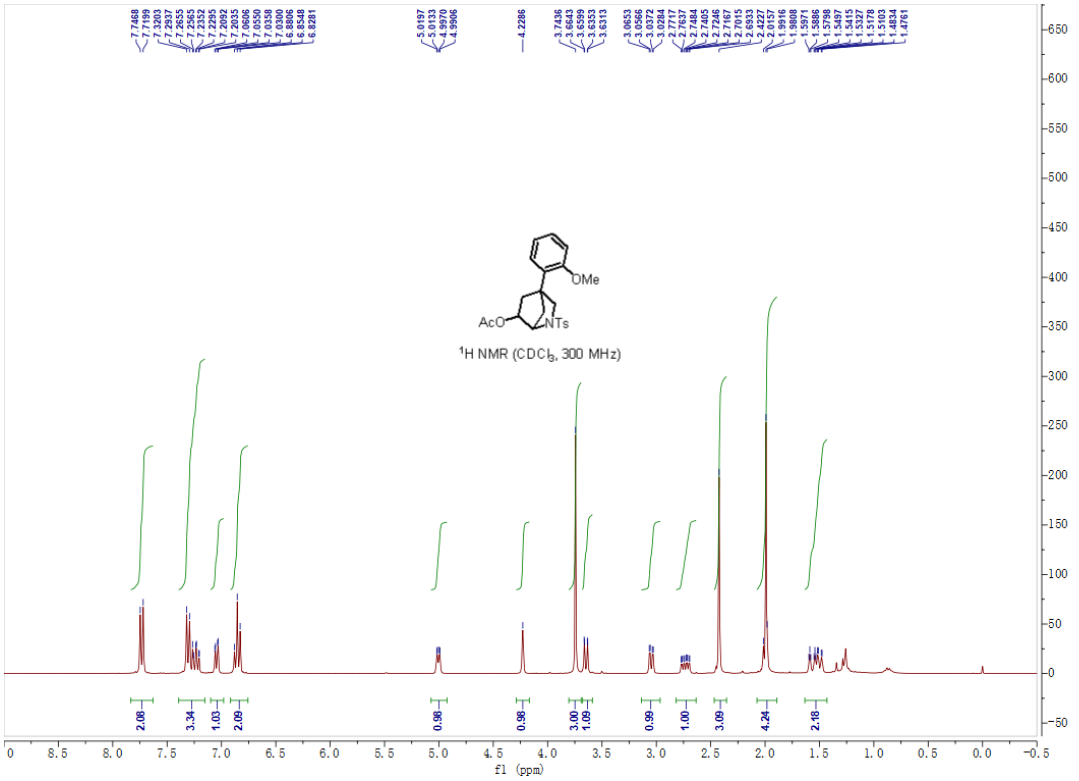
4-(3,5-bis(trifluoromethyl)phenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3f)

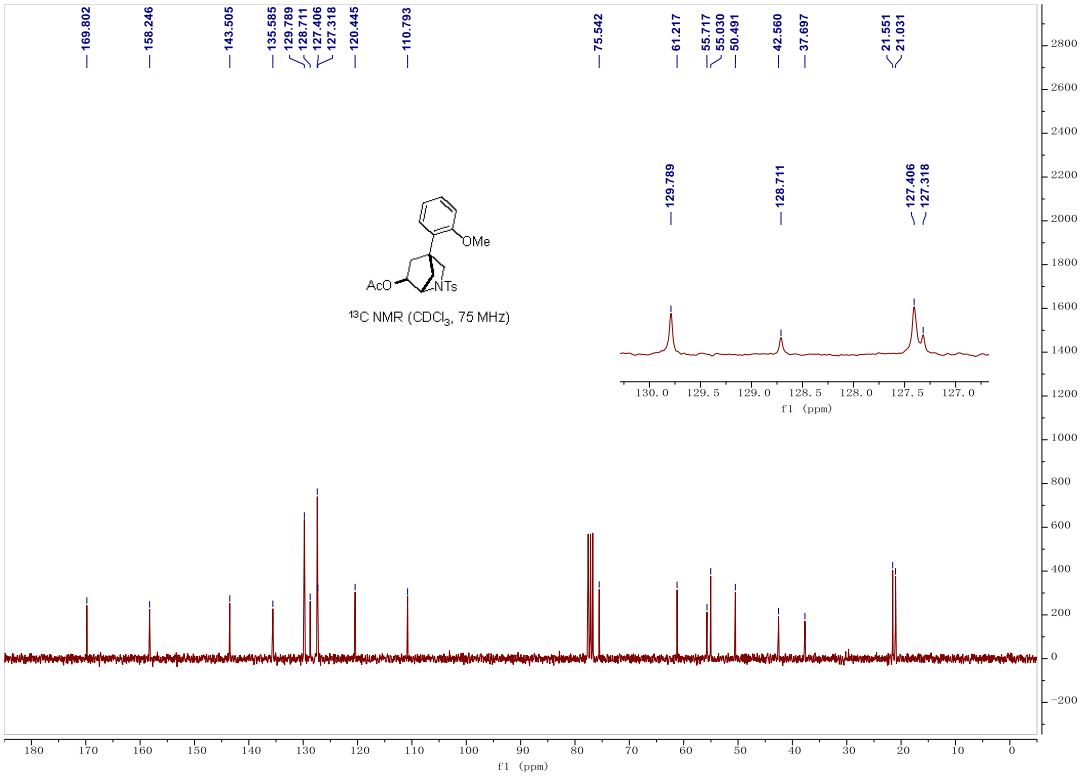




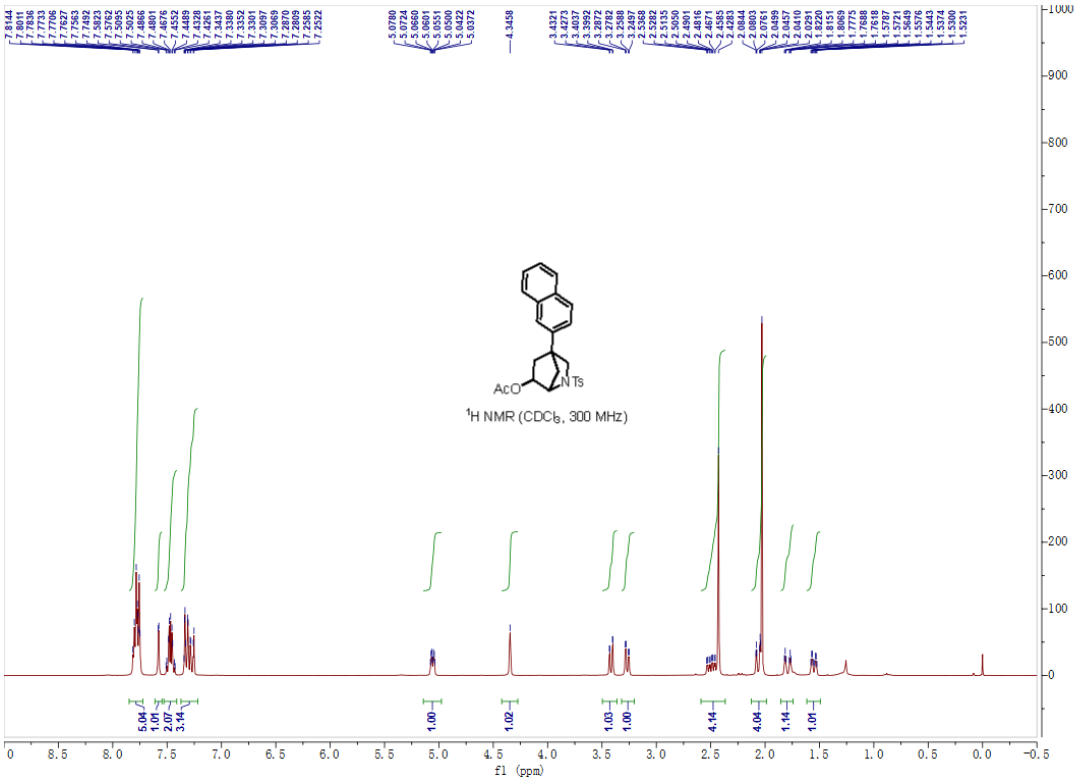

-62.8577
F3C
CF3
AcO
NTs
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

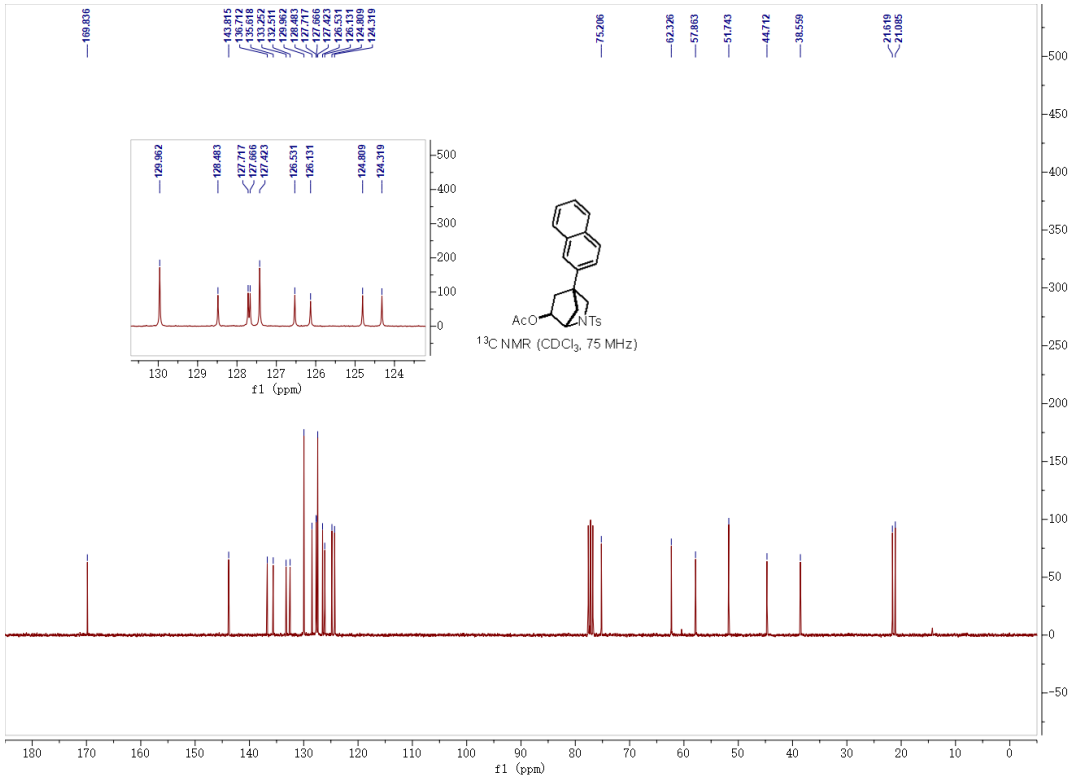
4-(2-methoxyphenyl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3g)



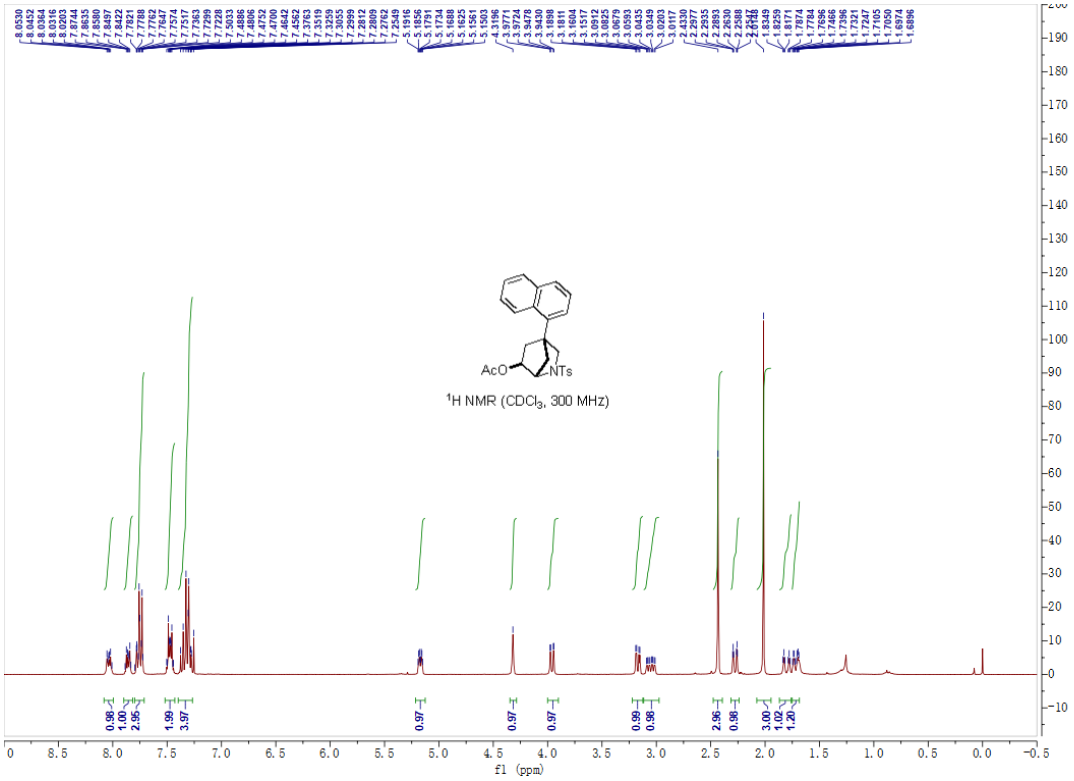


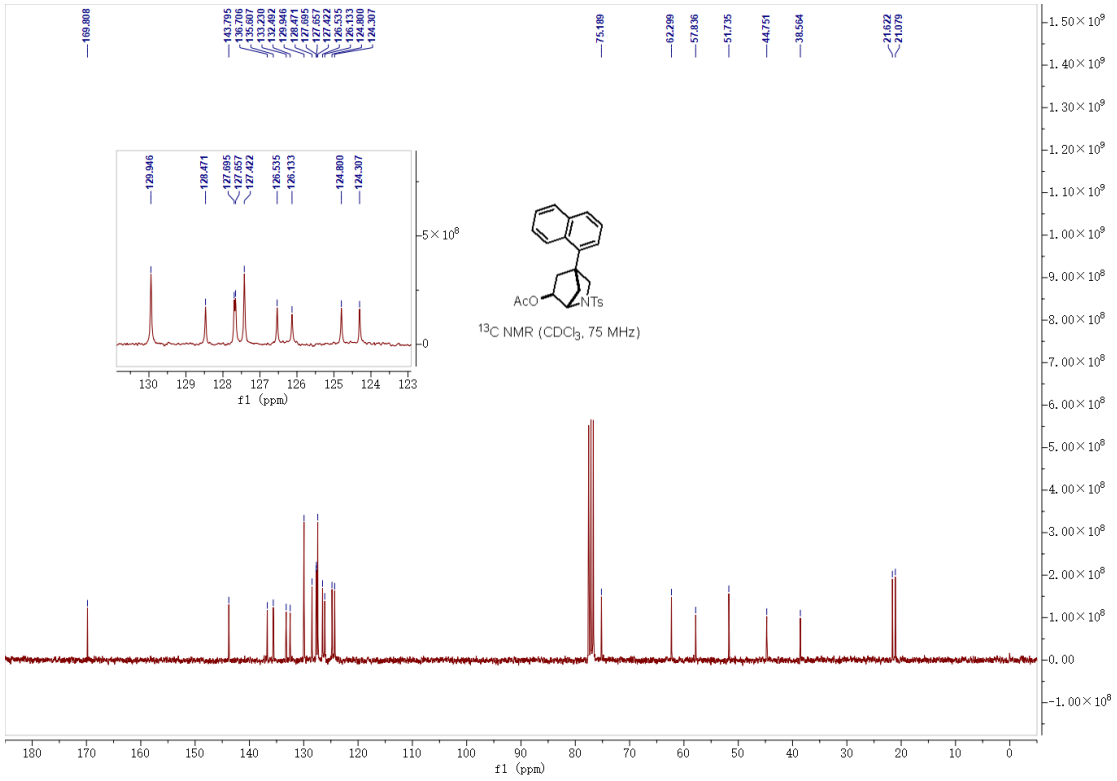
4-(naphthalen-2-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3h)



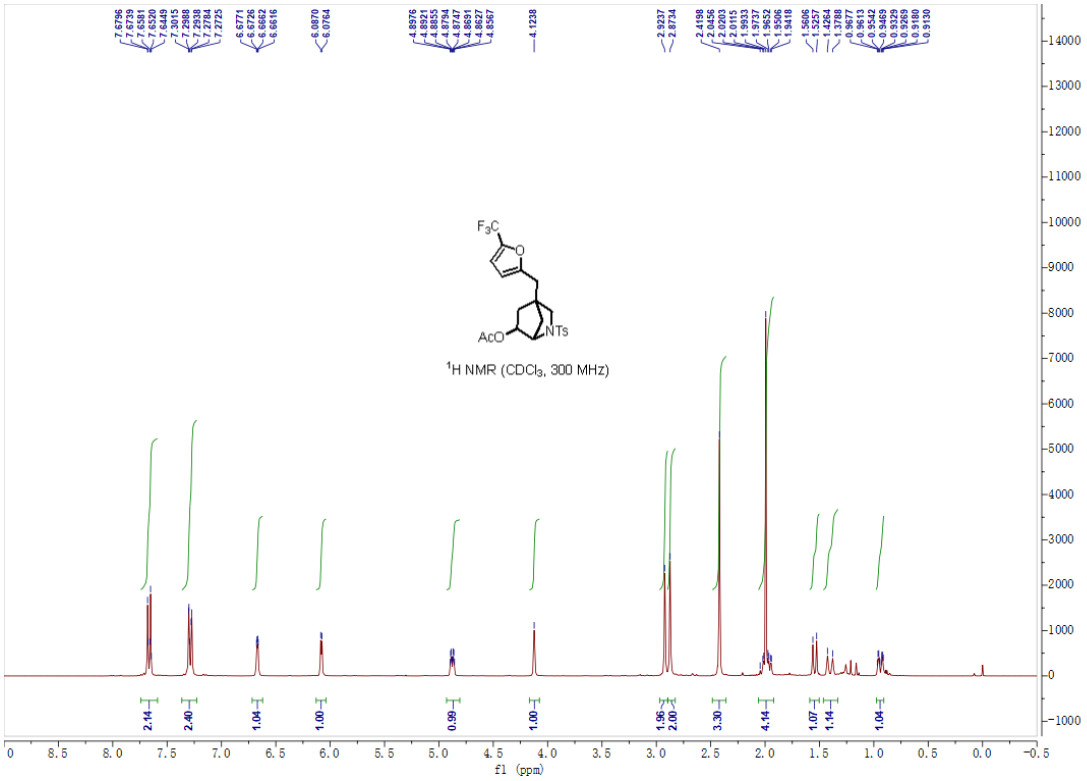


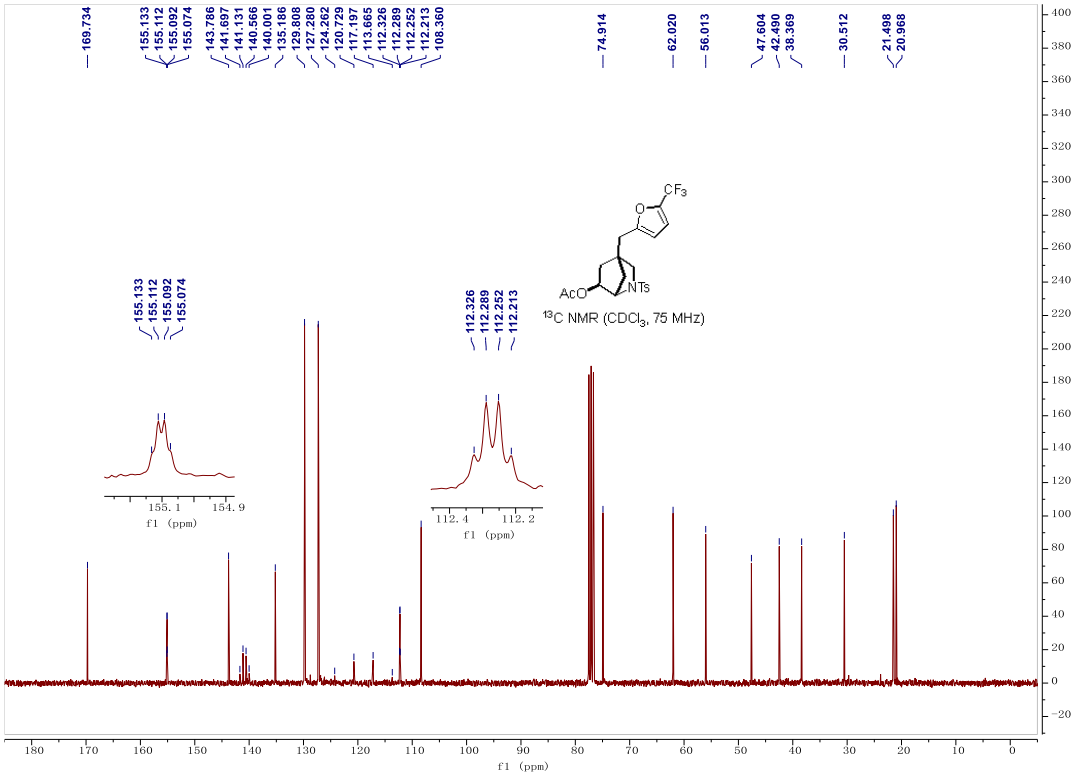
4-(naphthalen-1-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3i)

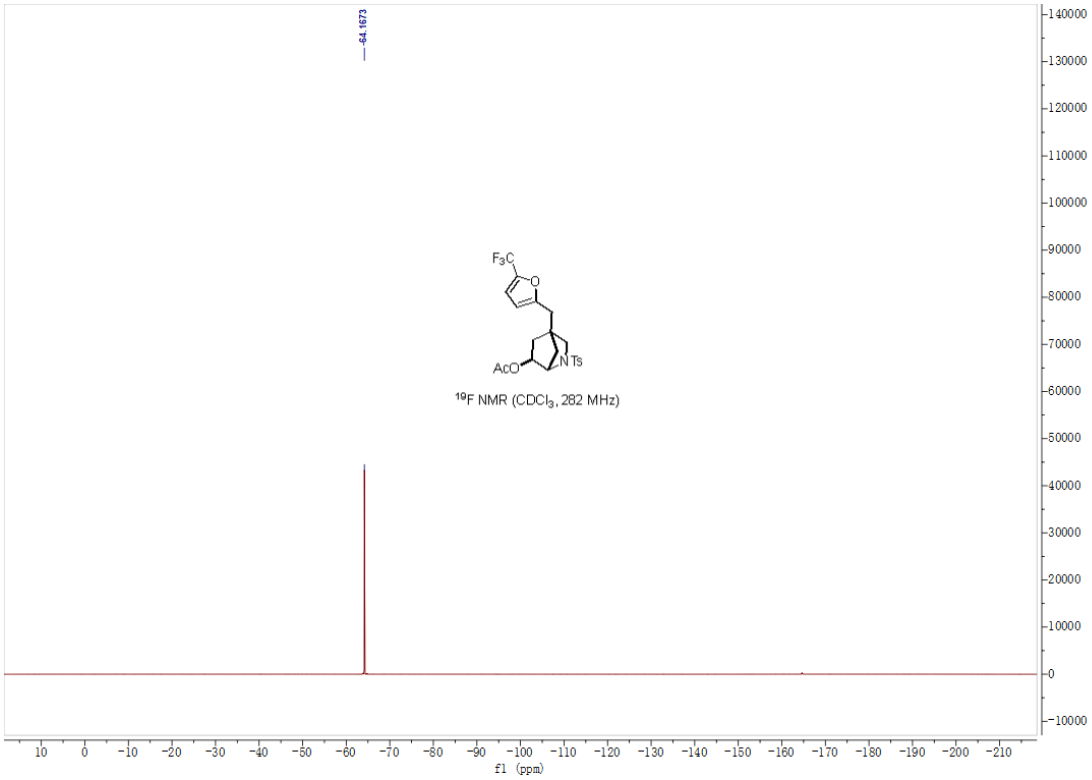




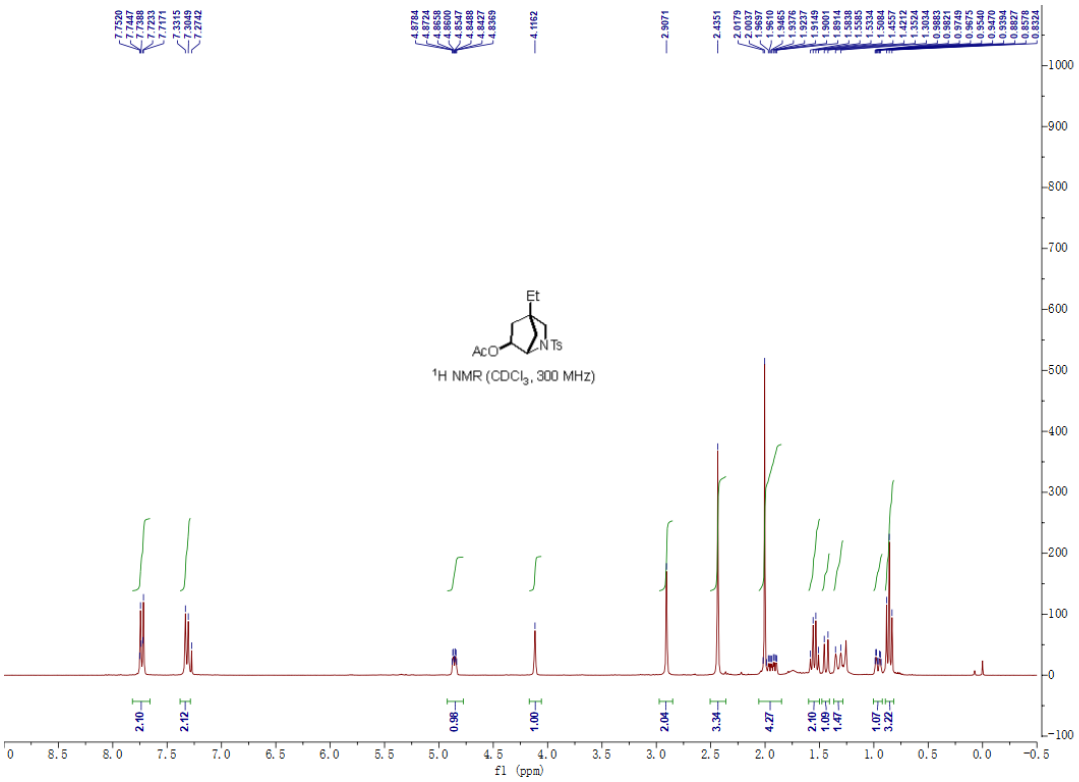
2-tosyl-4-((5-(trifluoromethyl)furan-2-yl)methyl)-2-azabicyclo[2.2.1]heptan-6-yl acetate (3j)

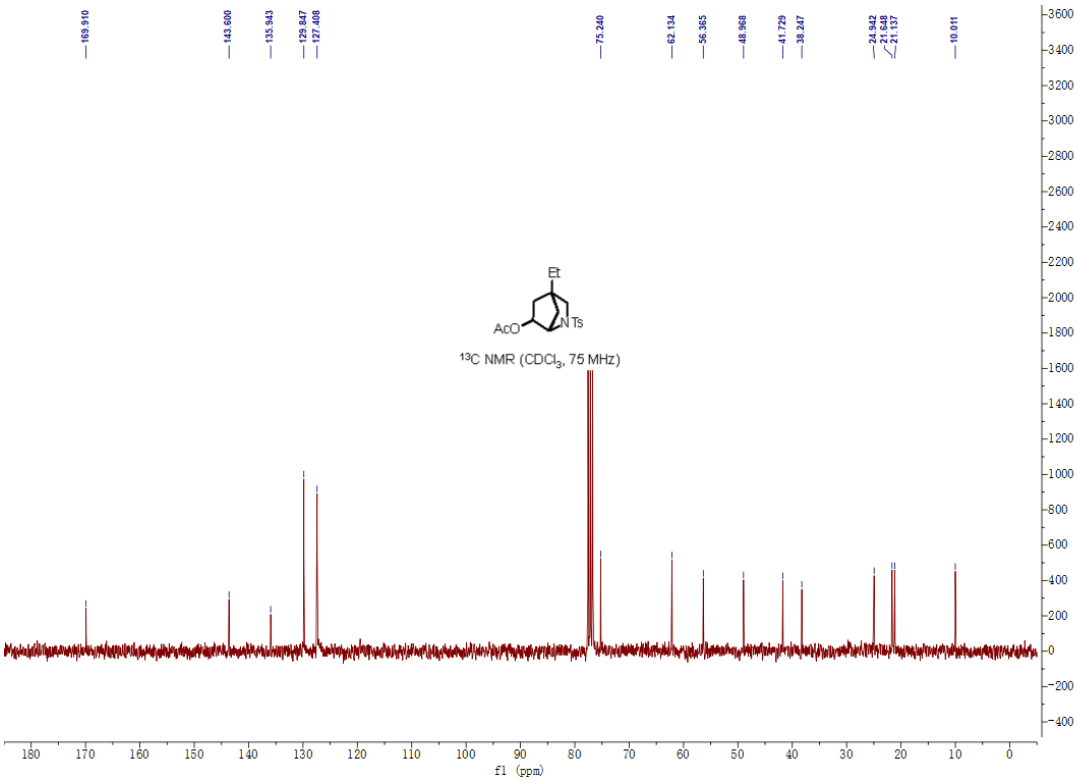




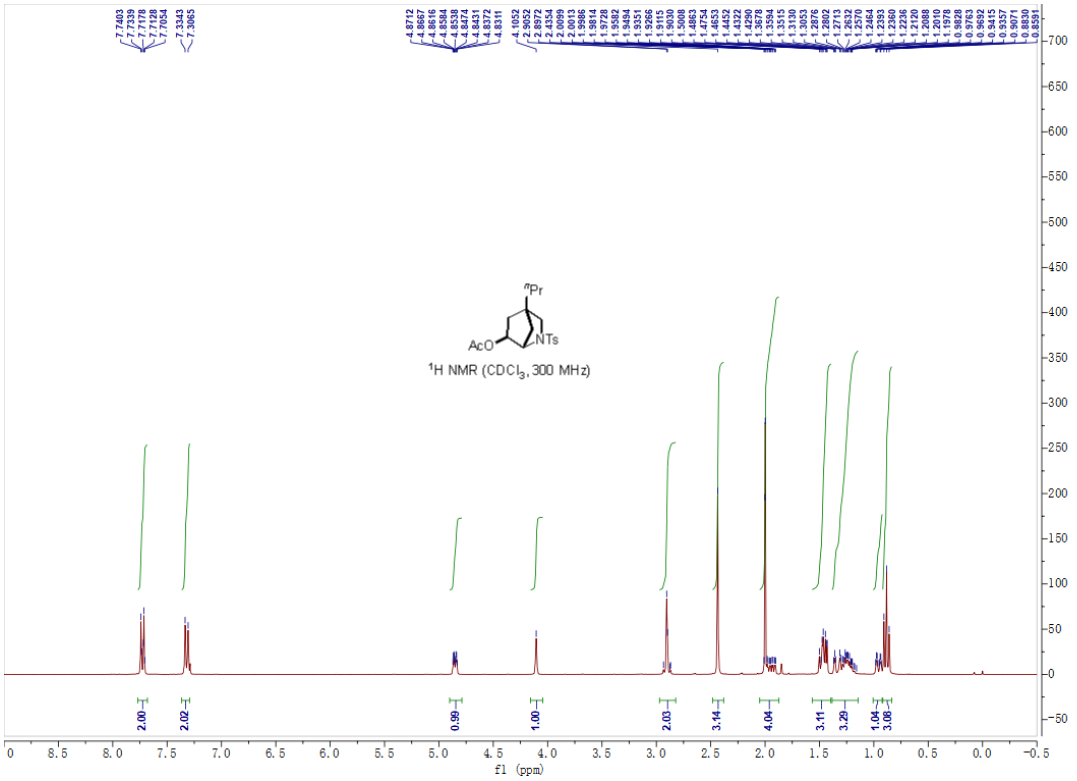

-64.1673
F3C
O
AcO
NTs
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

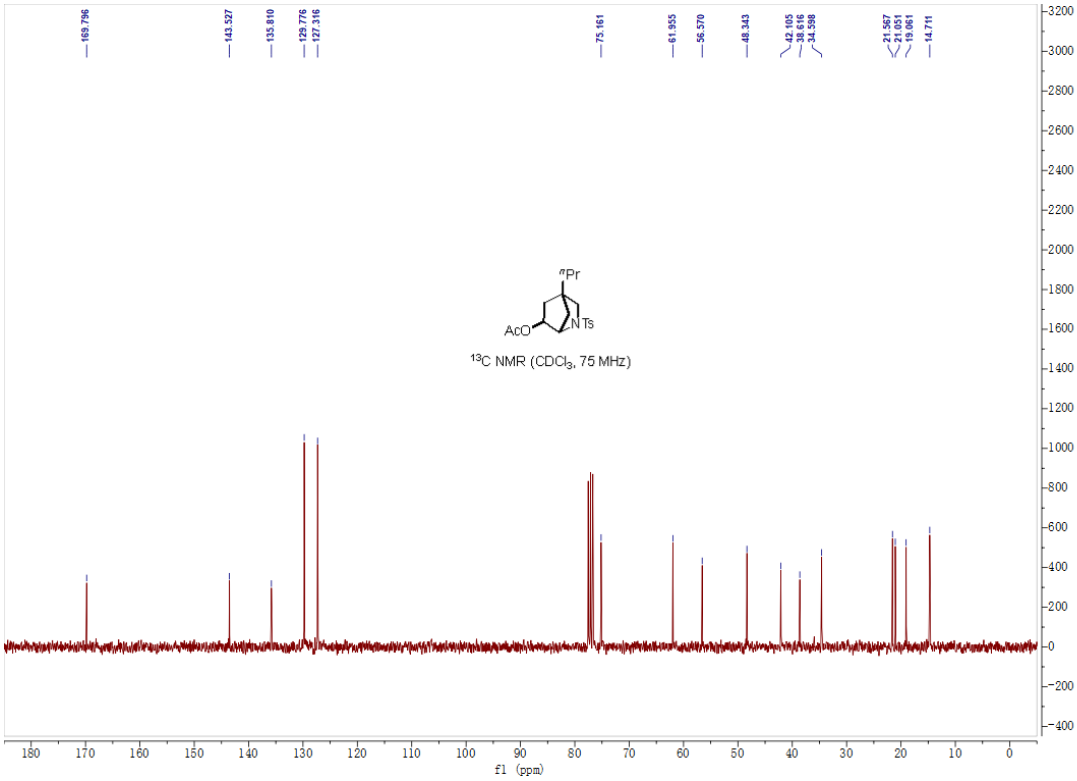
4-ethyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3k)



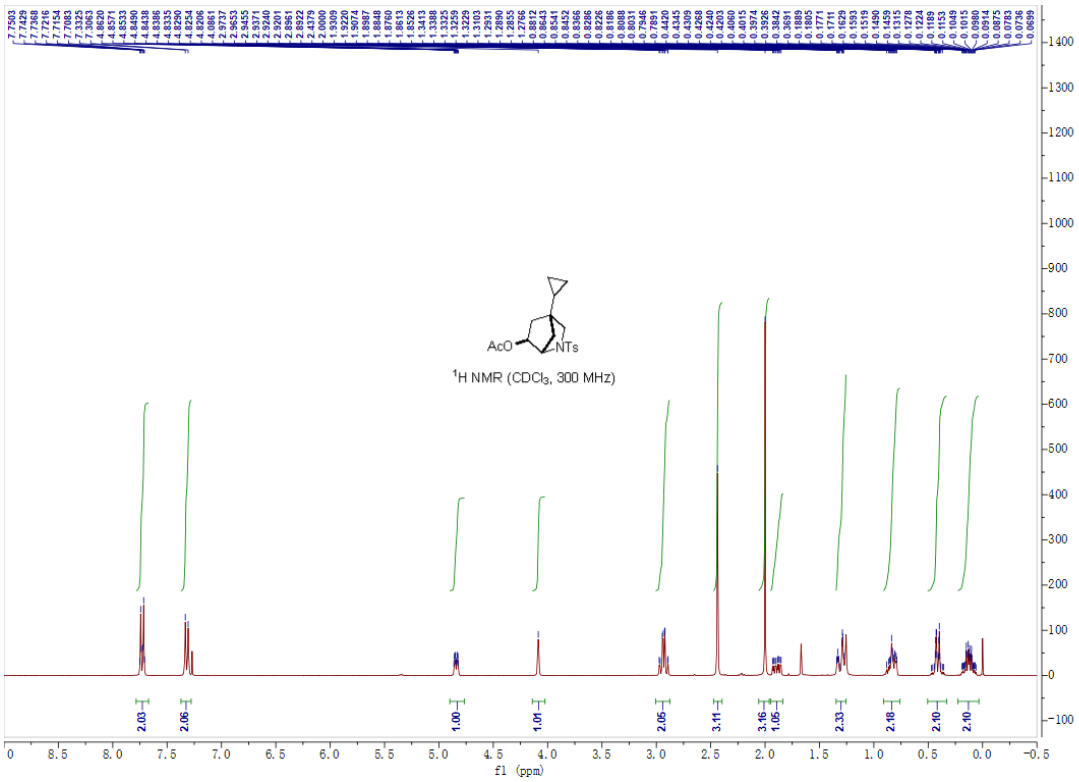


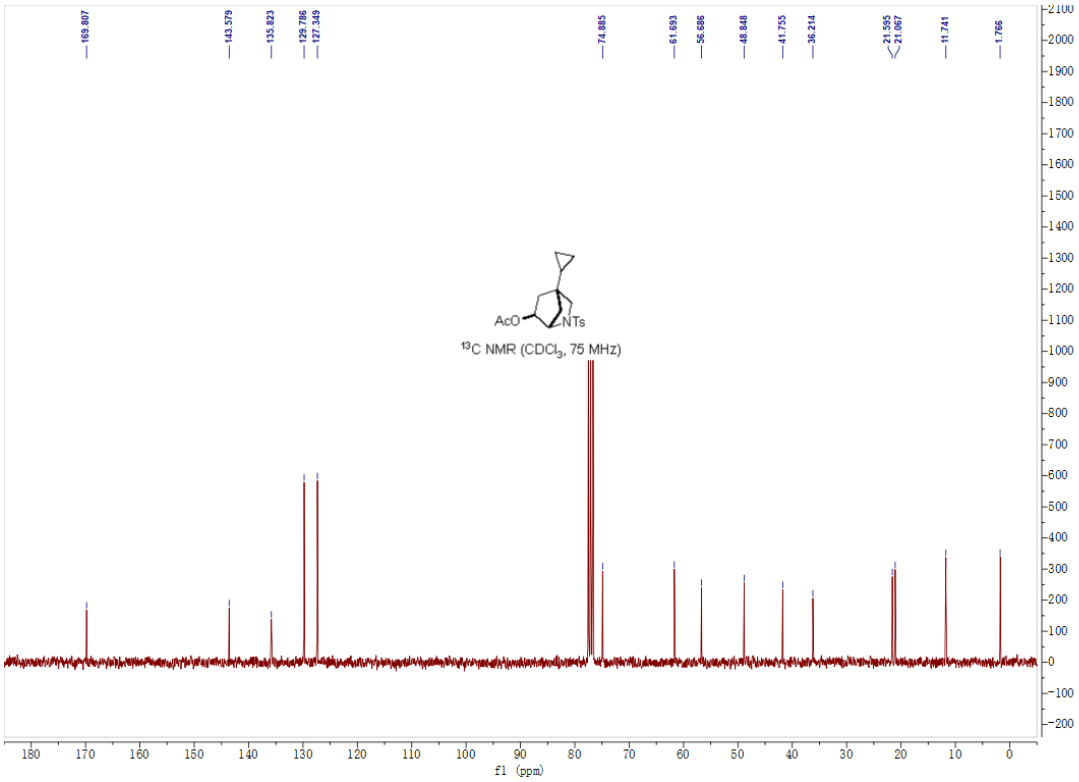
4-propyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3l)



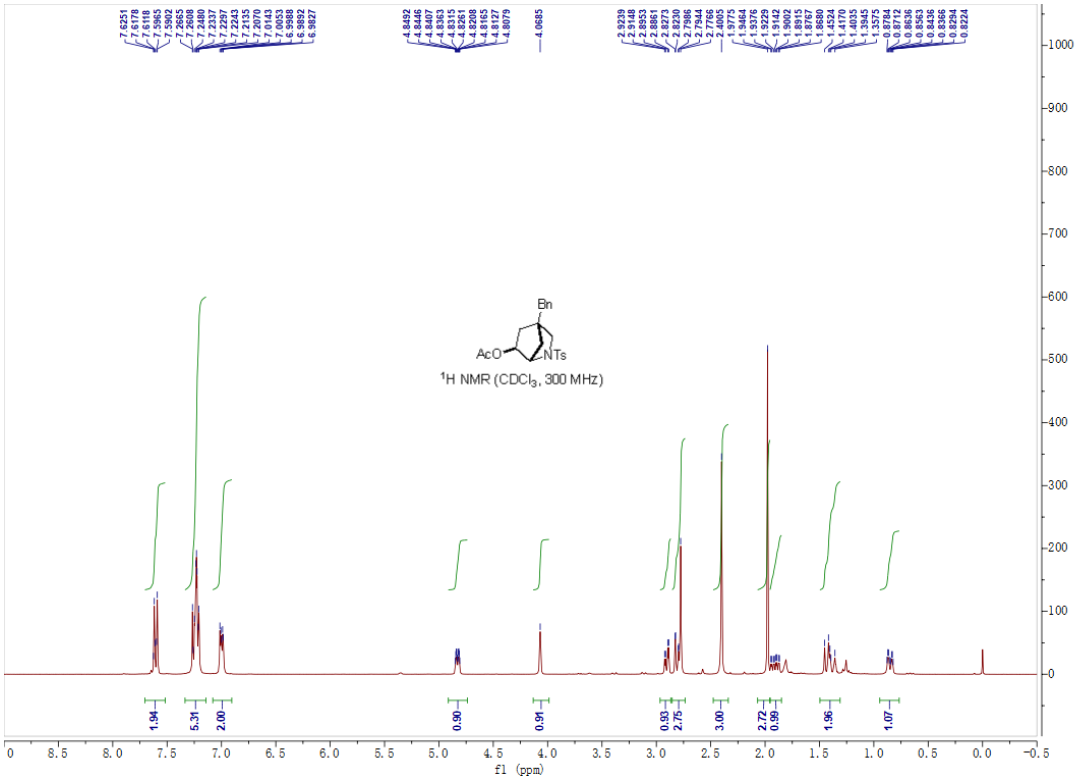


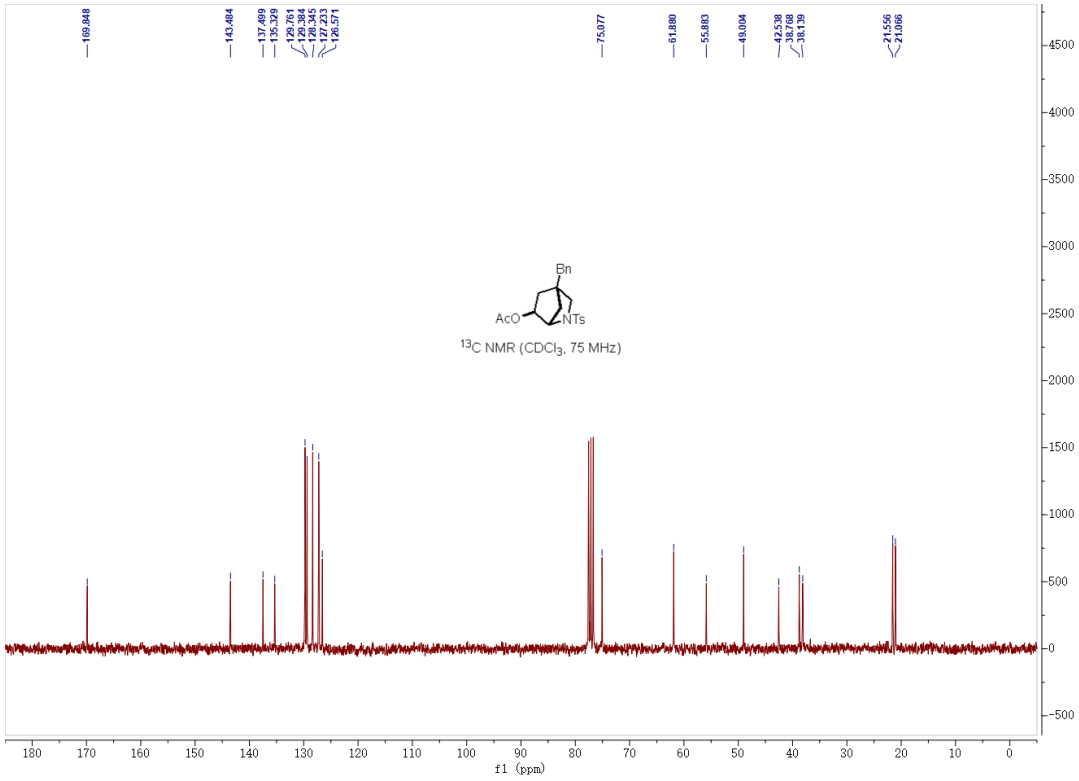
4-cyclopropyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3m)



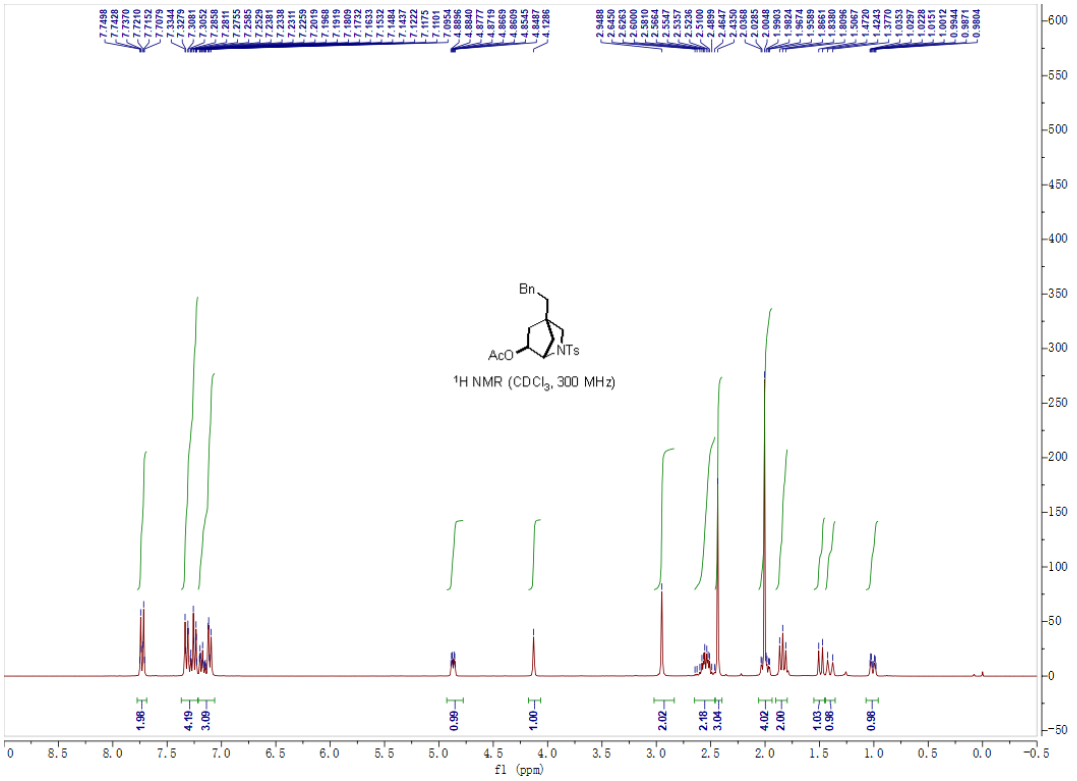


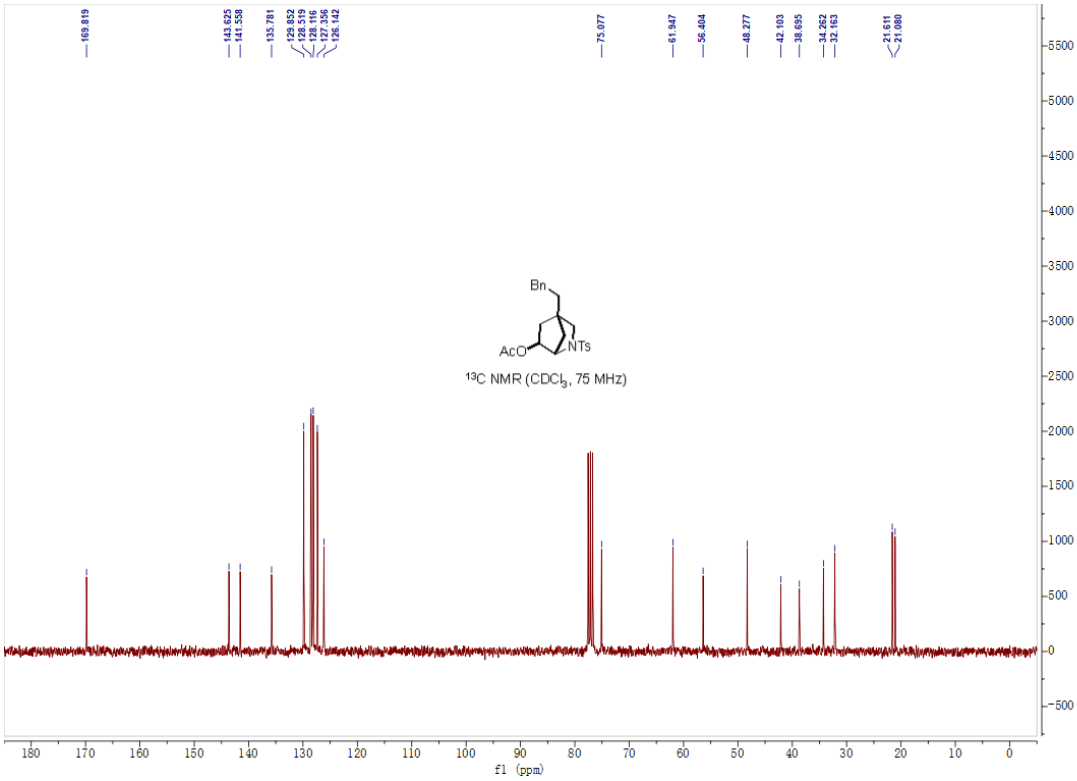
4-benzyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3n)



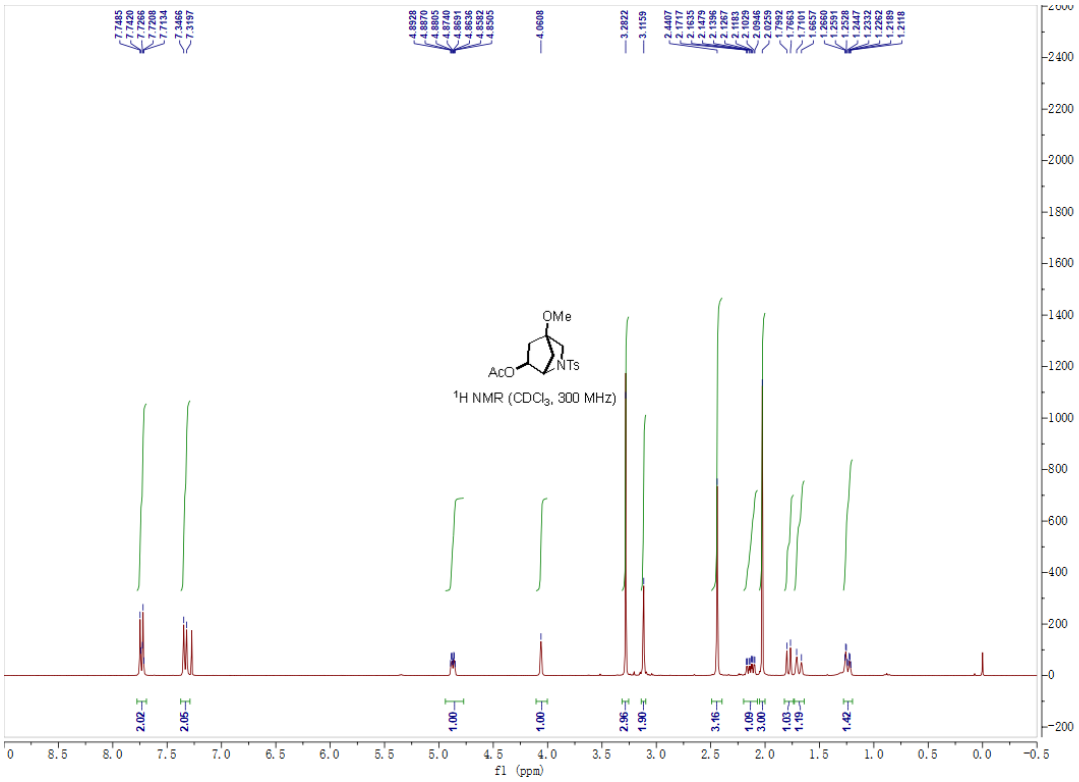


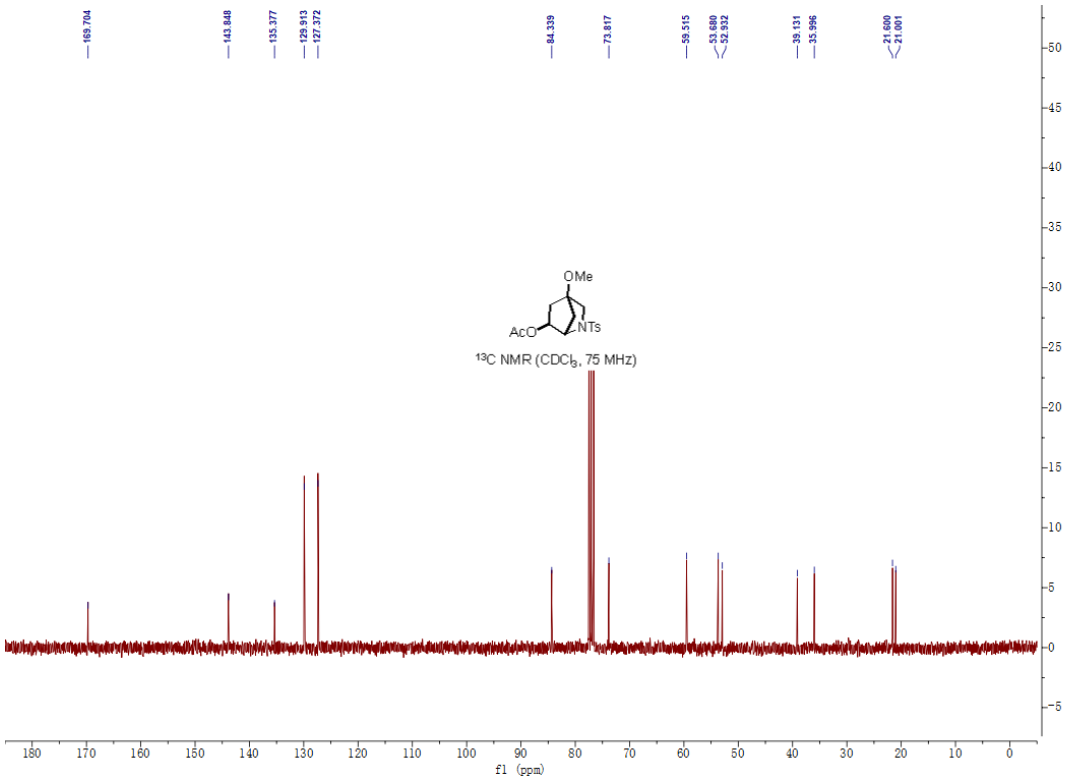
4-phenethyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3o)



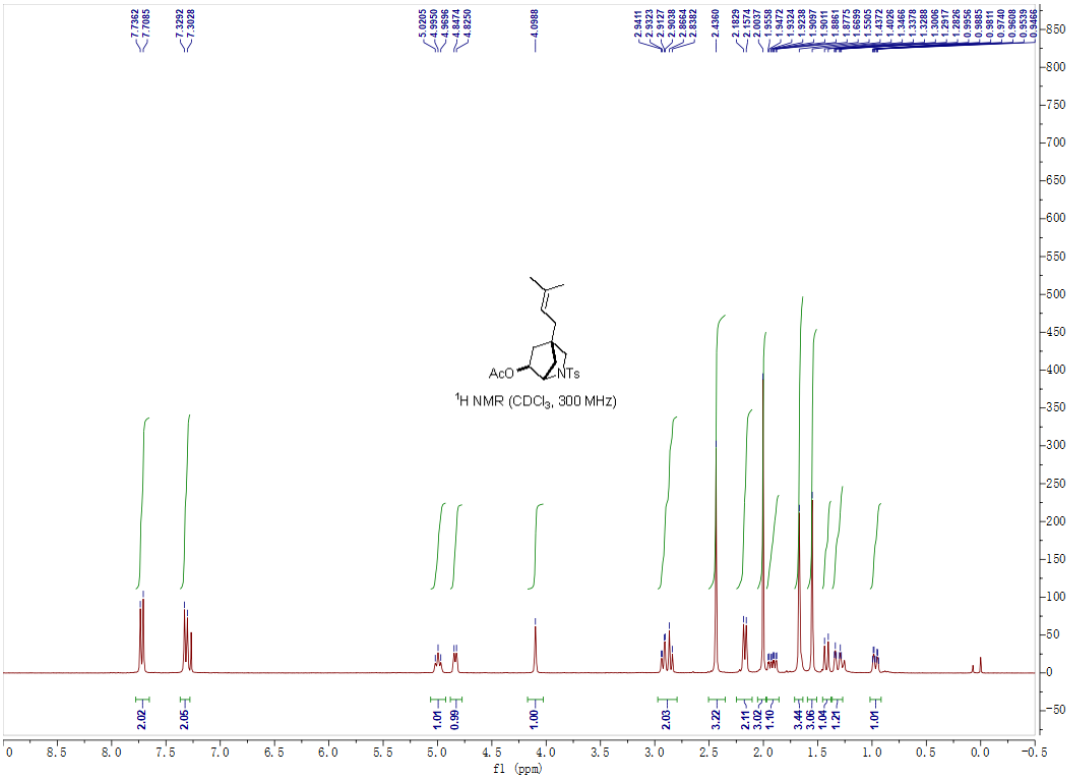


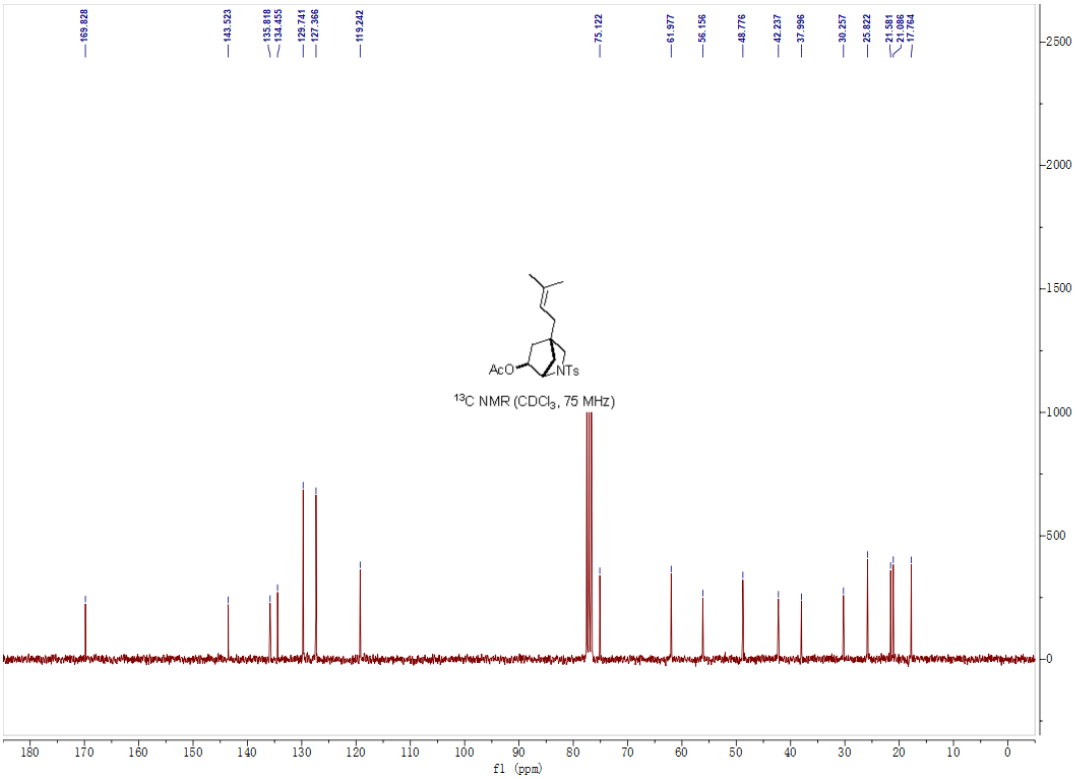
4-methoxy-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3p)



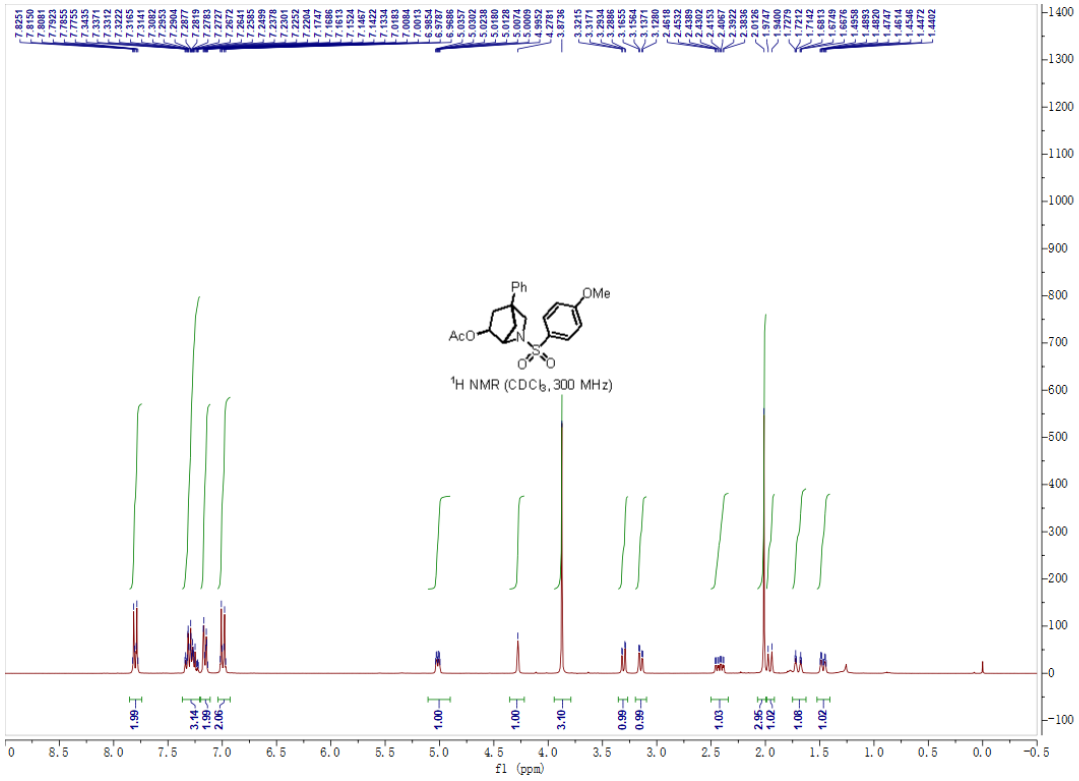


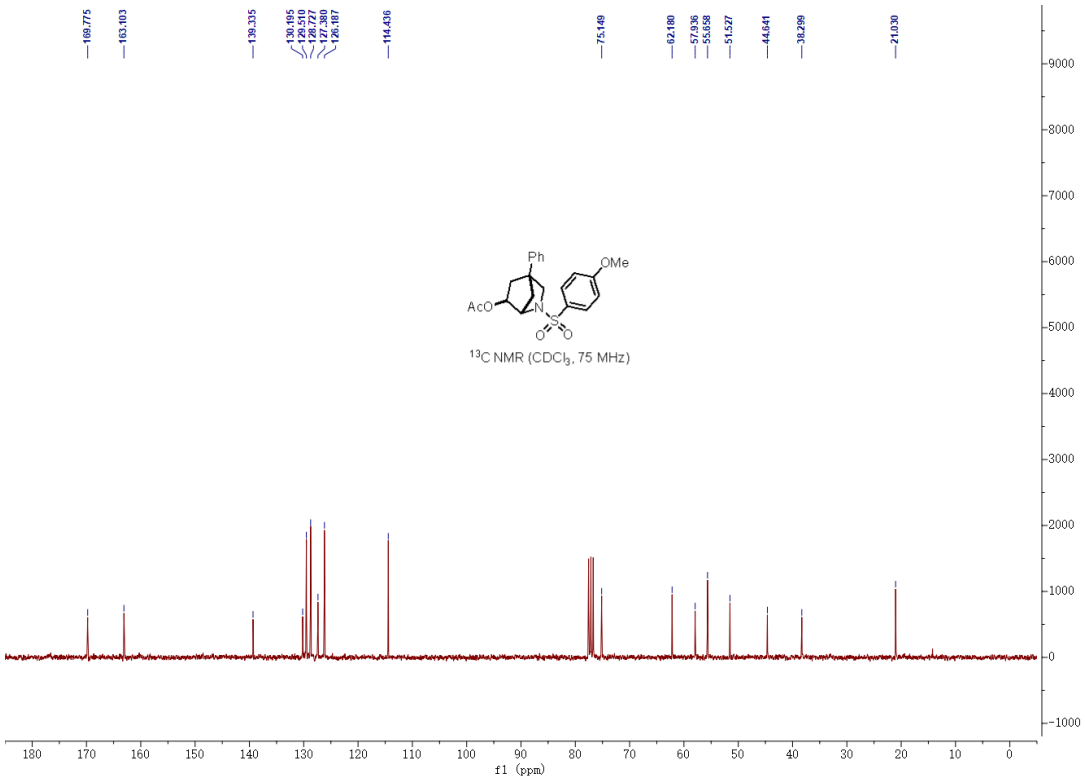
4-(3-methylbut-2-en-1-yl)-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3q)



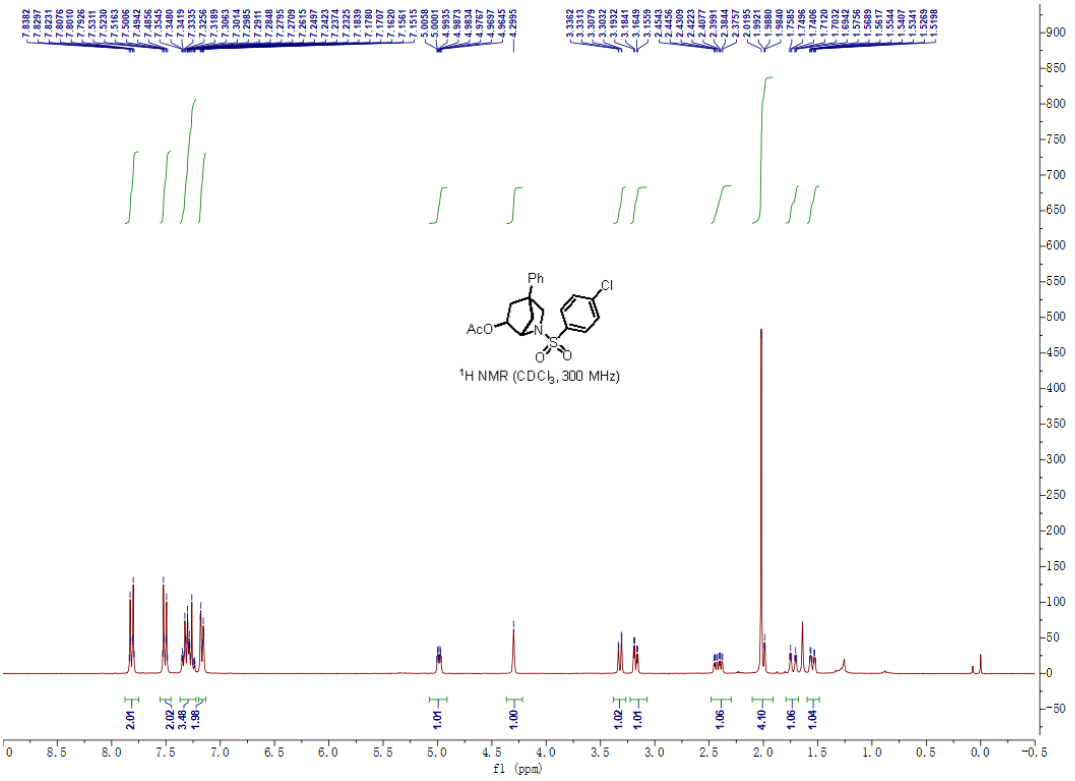


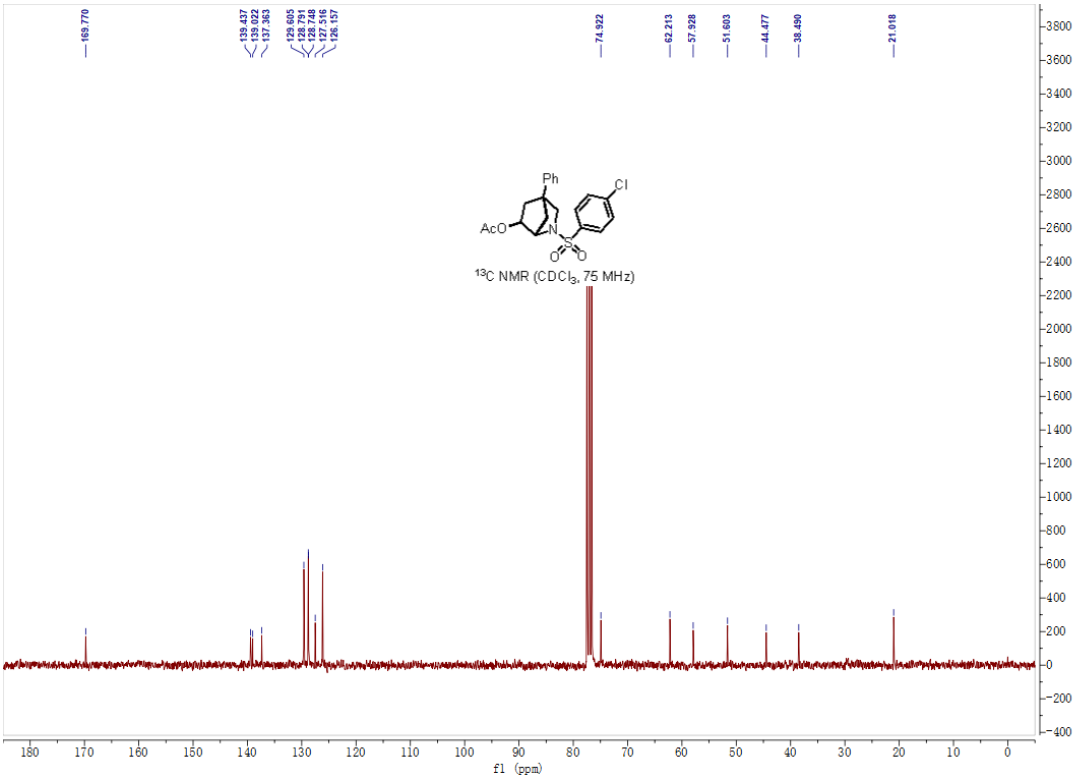
2-((4-methoxyphenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3r)



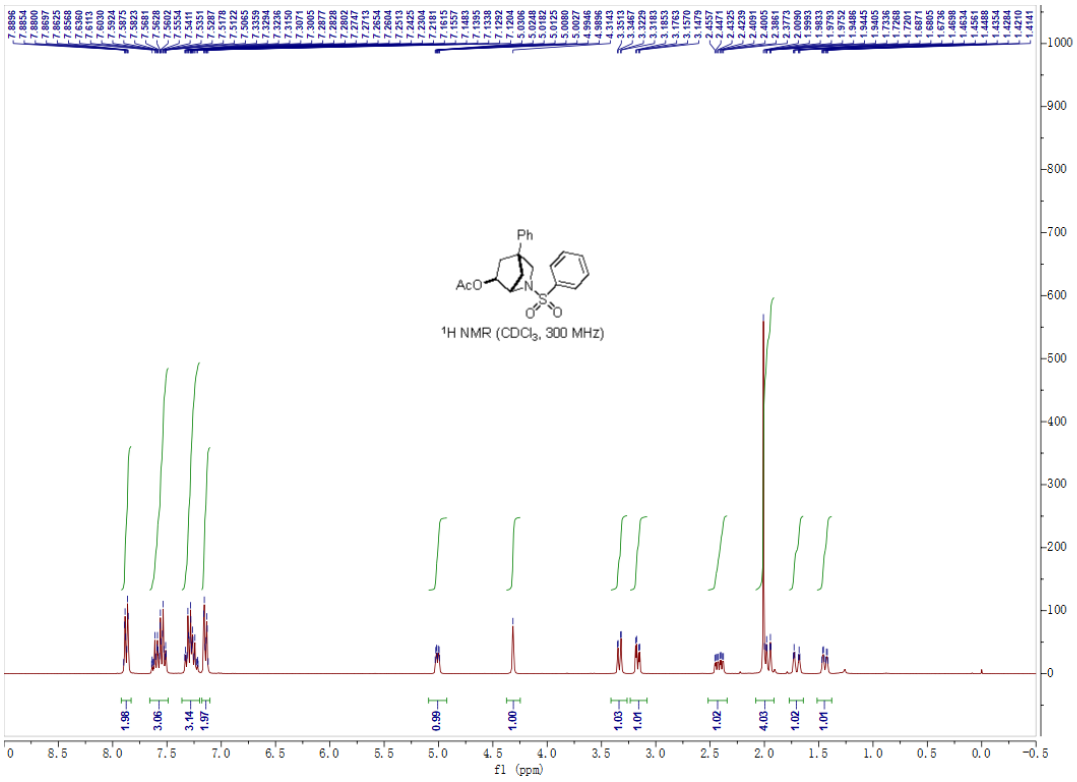


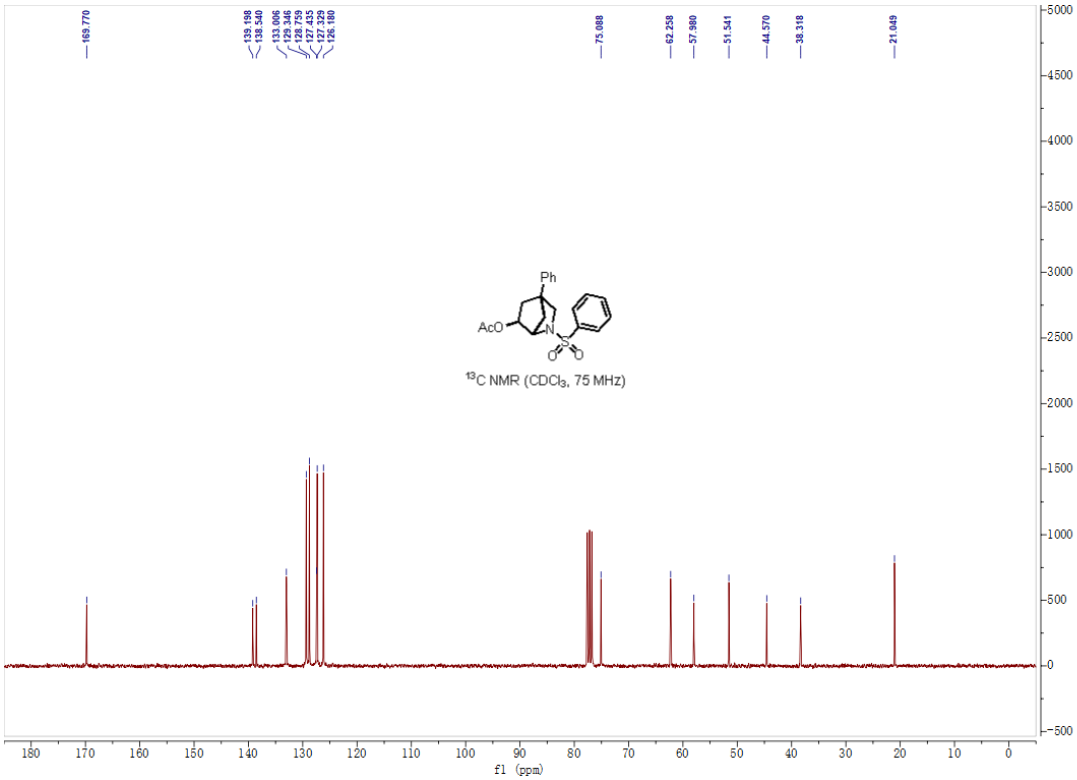
2-((4-chlorophenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3s)



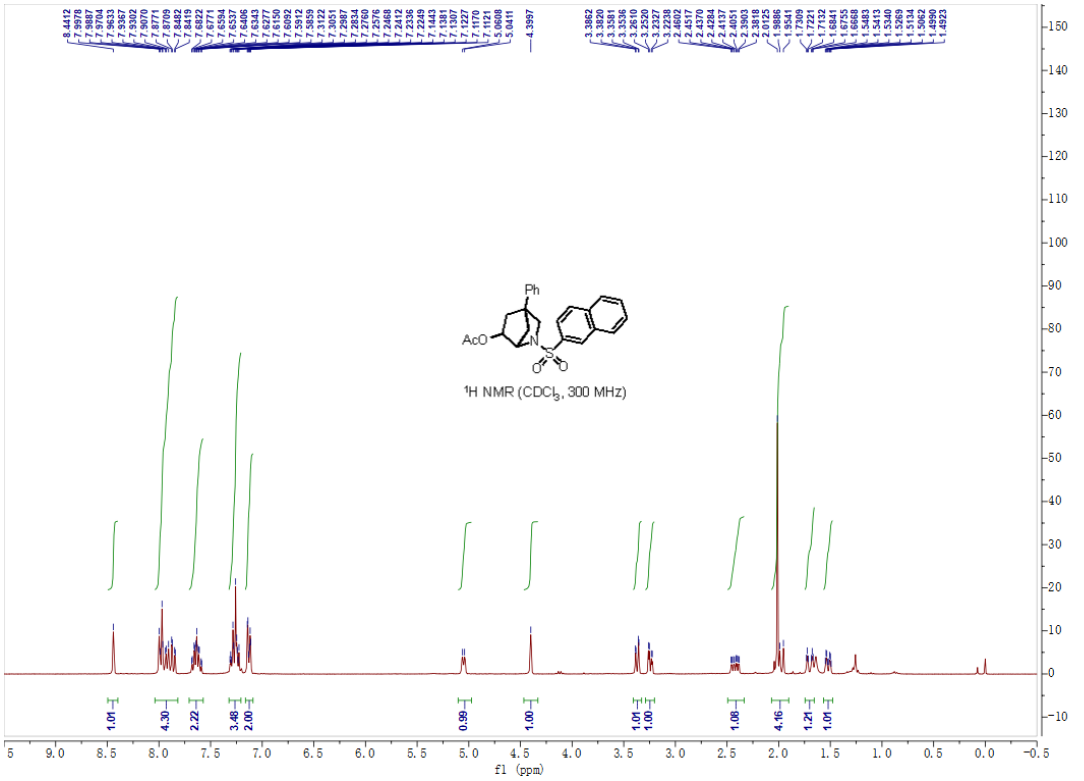


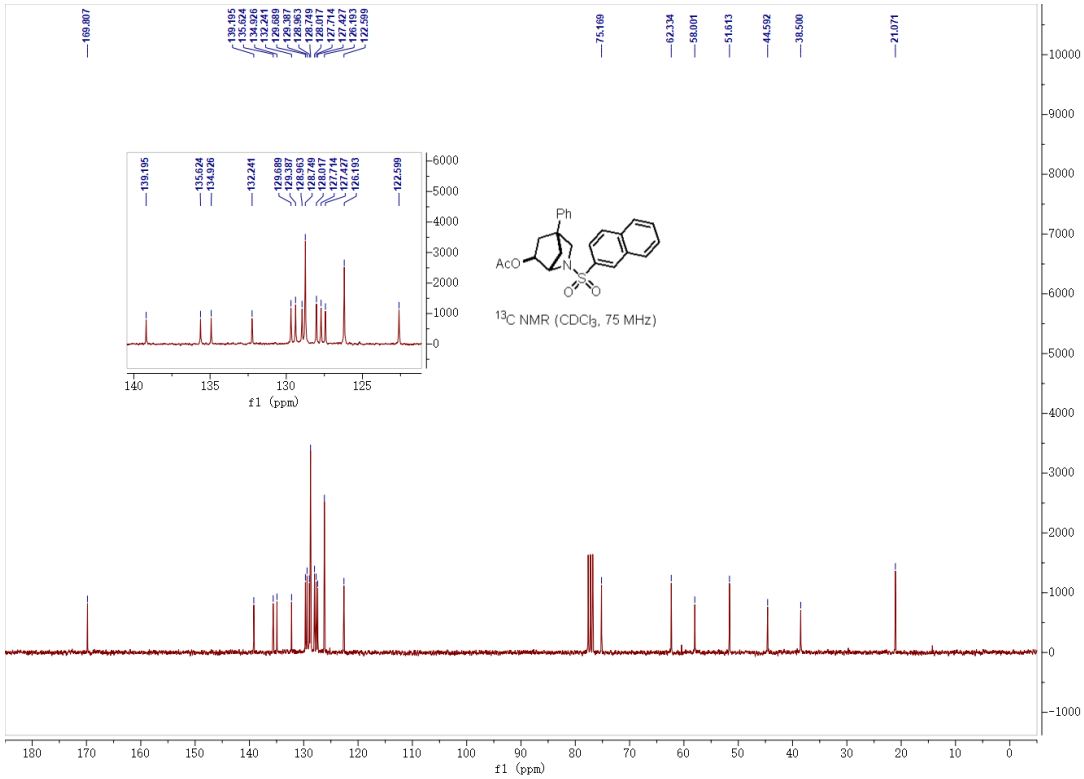
4-phenyl-2-(phenylsulfonyl)-2-azabicyclo[2.2.1]heptan-6-yl acetate (3t)



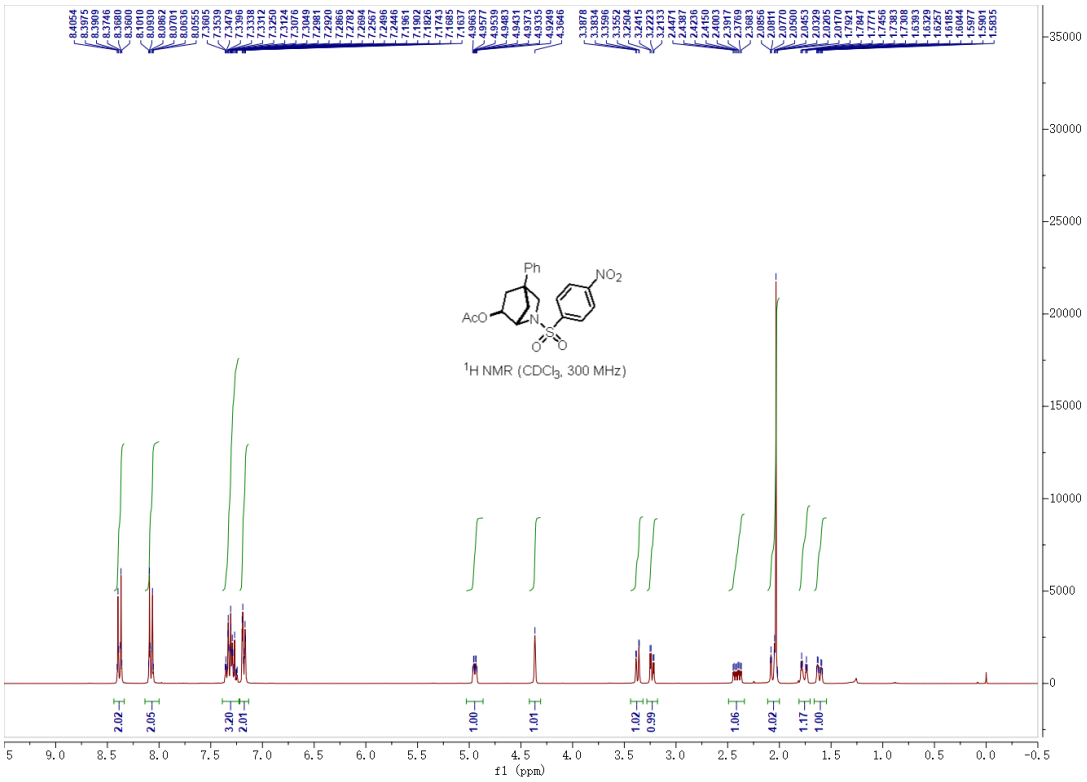


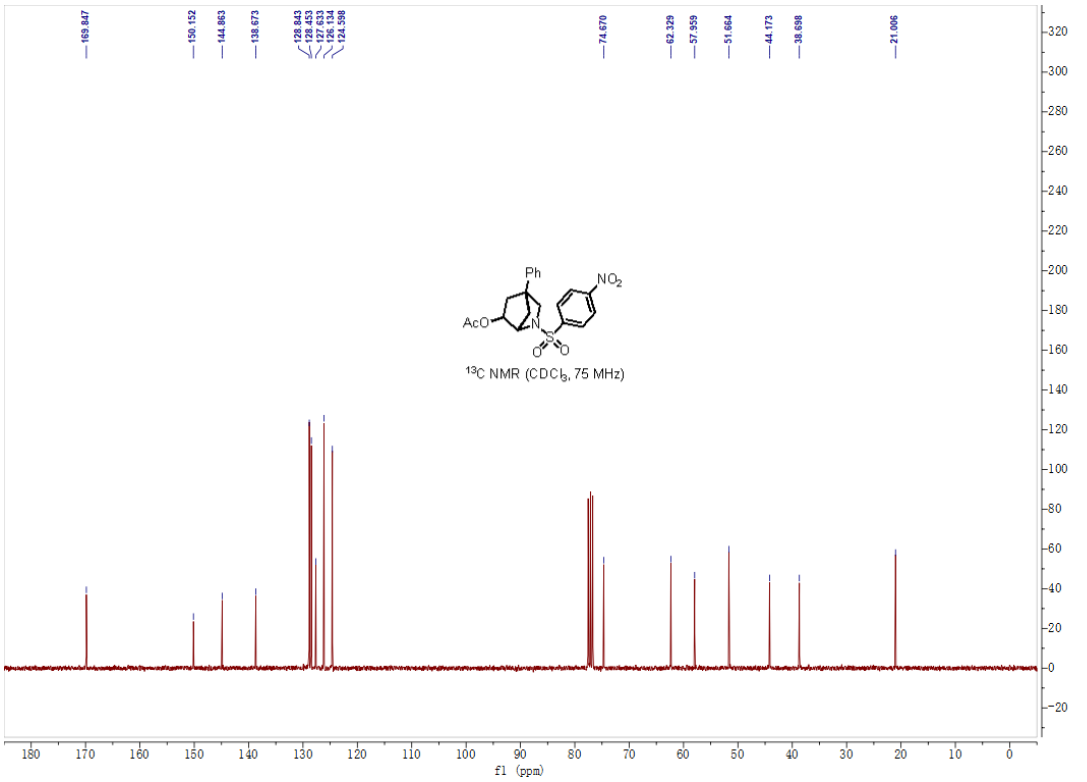
2-(naphthalen-2-ylsulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3u)



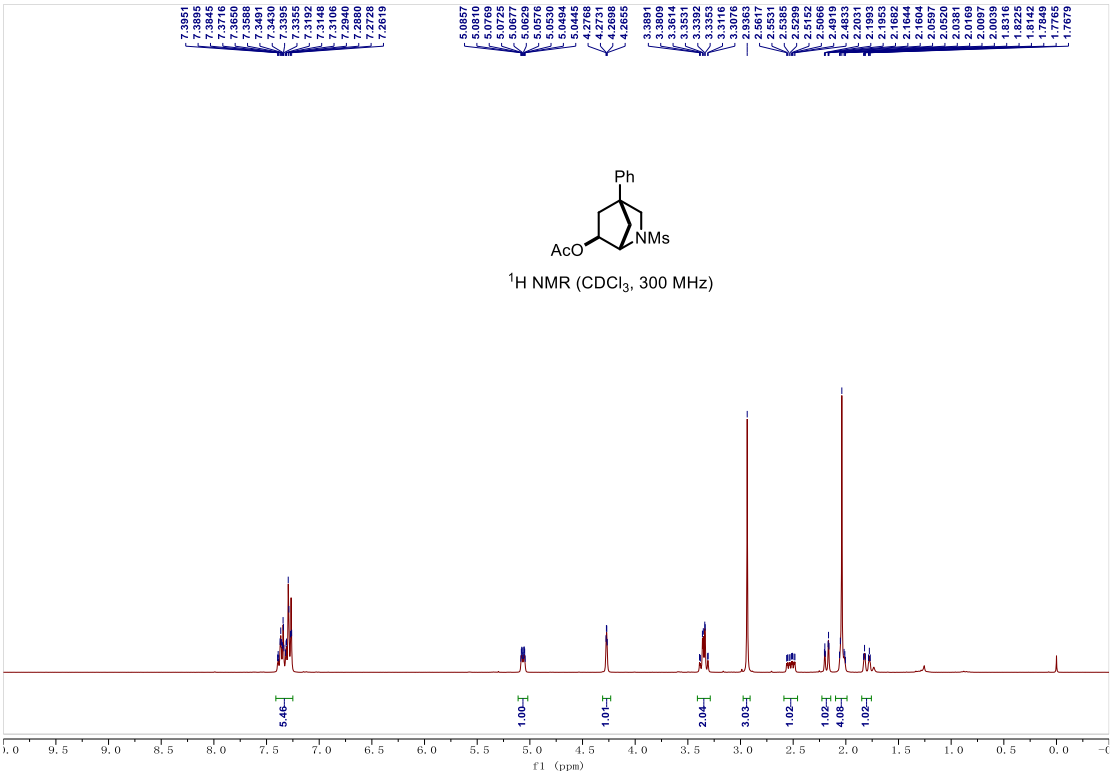


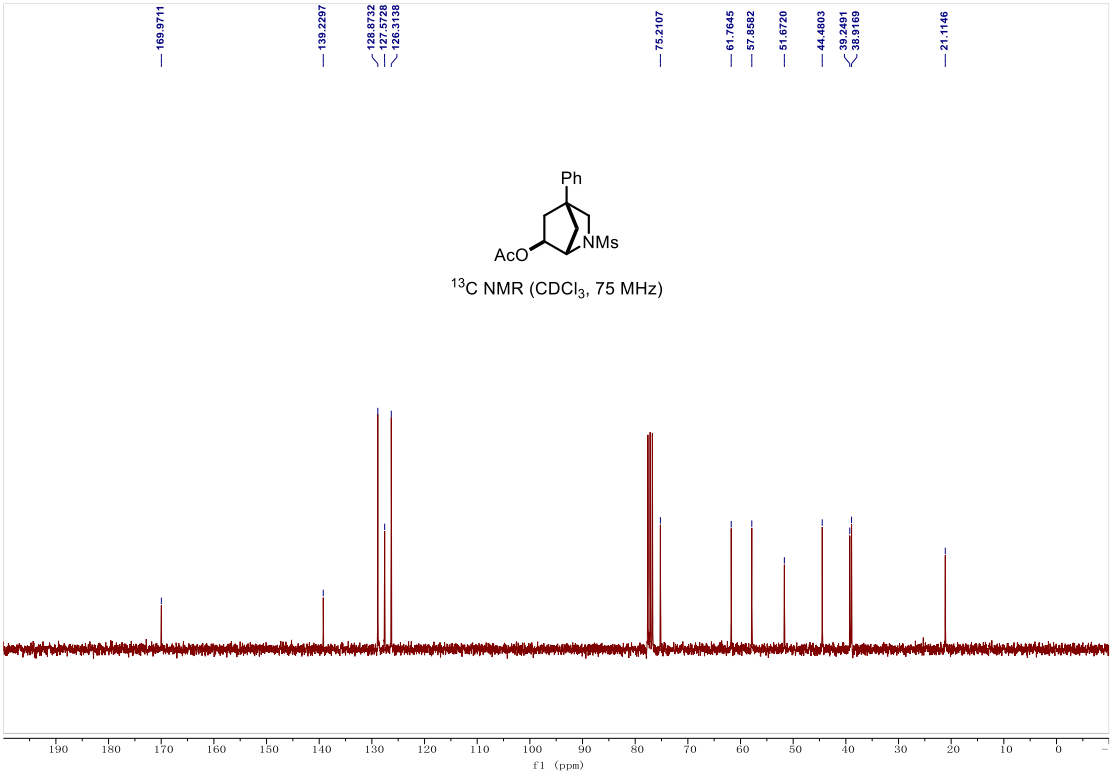
2-((4-nitrophenyl)sulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3v)



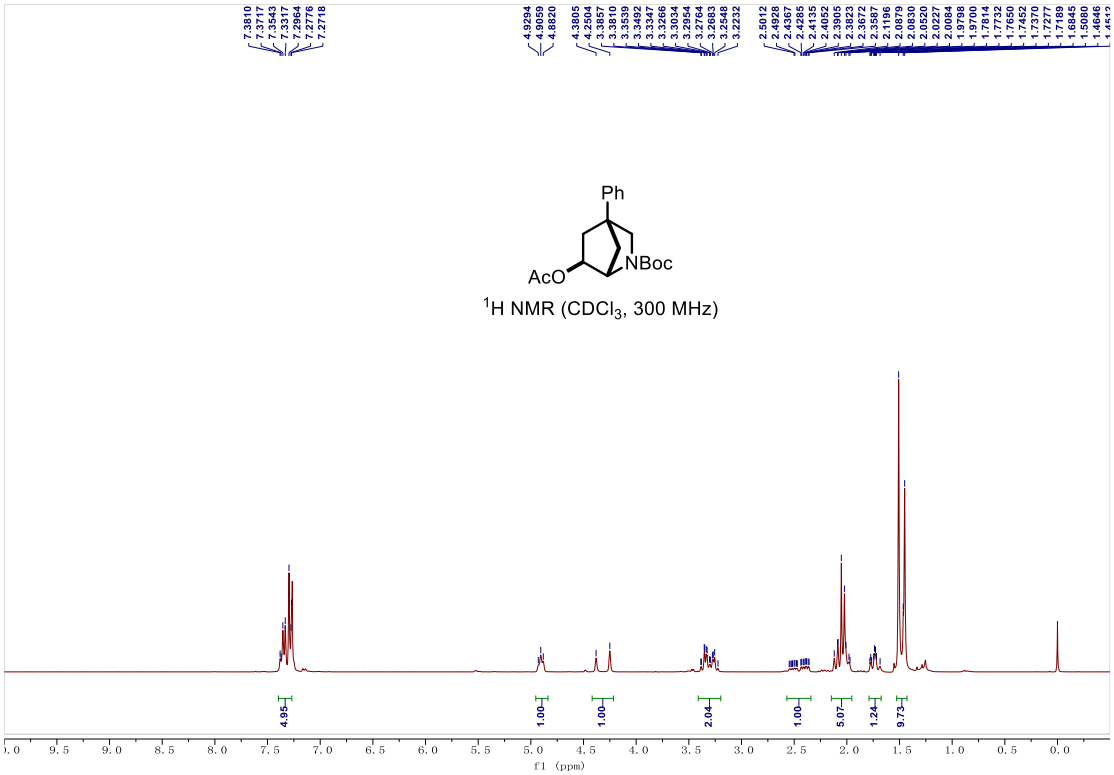


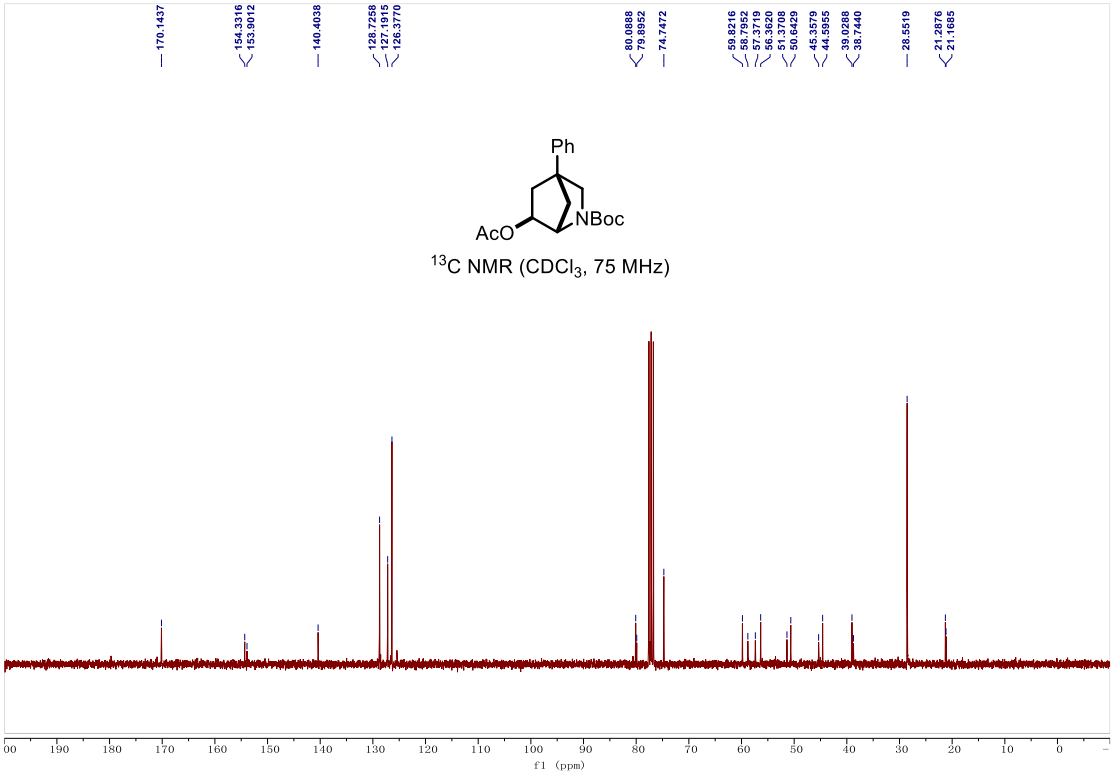
2-(methylsulfonyl)-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (3w)



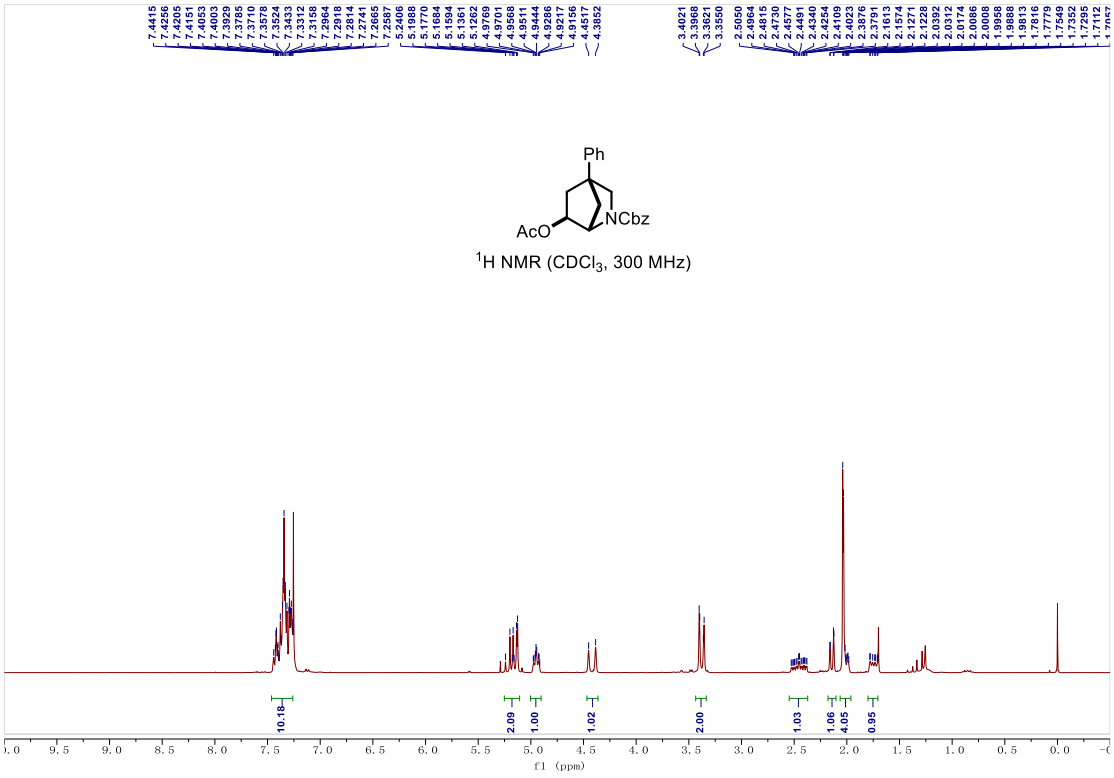


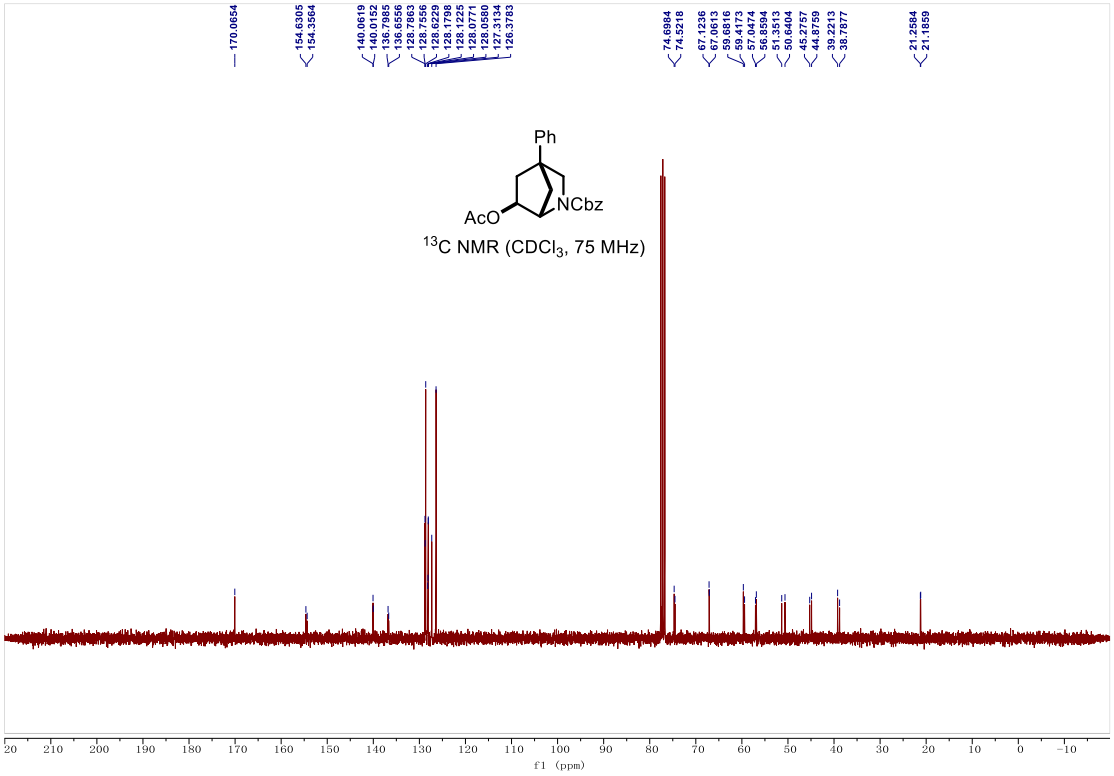
tert-butyl 6-acetoxy-4-phenyl-2-azabicyclo[2.2.1]heptane-2-carboxylate (3x)



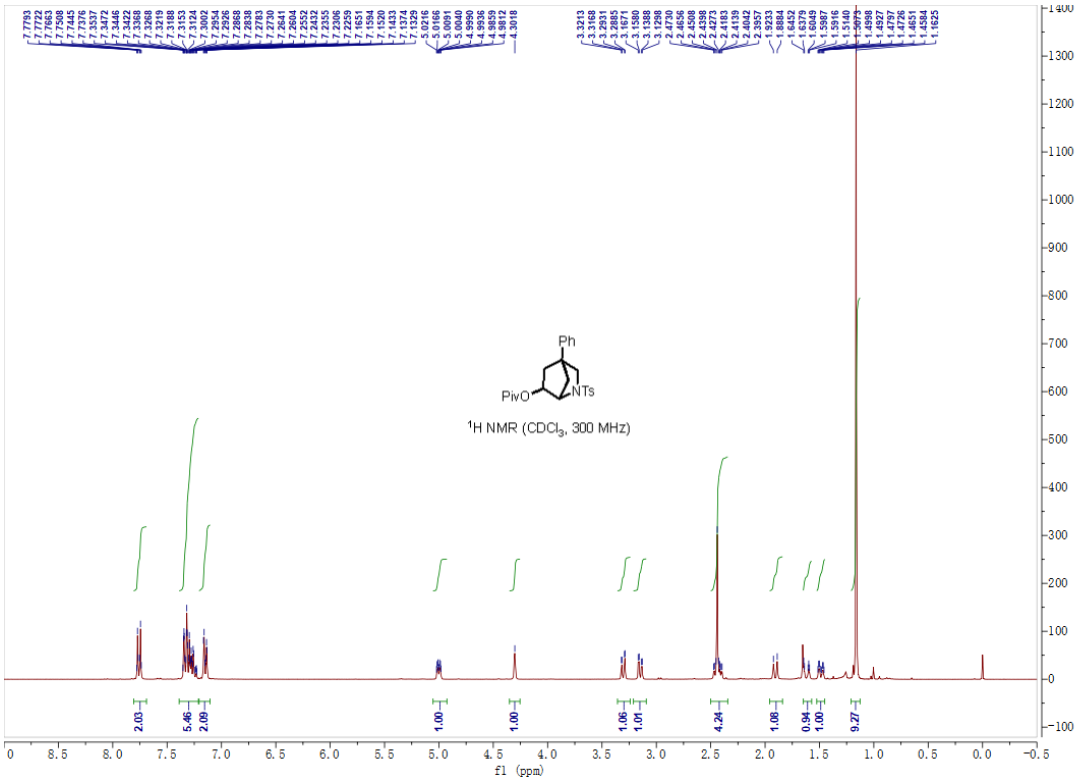


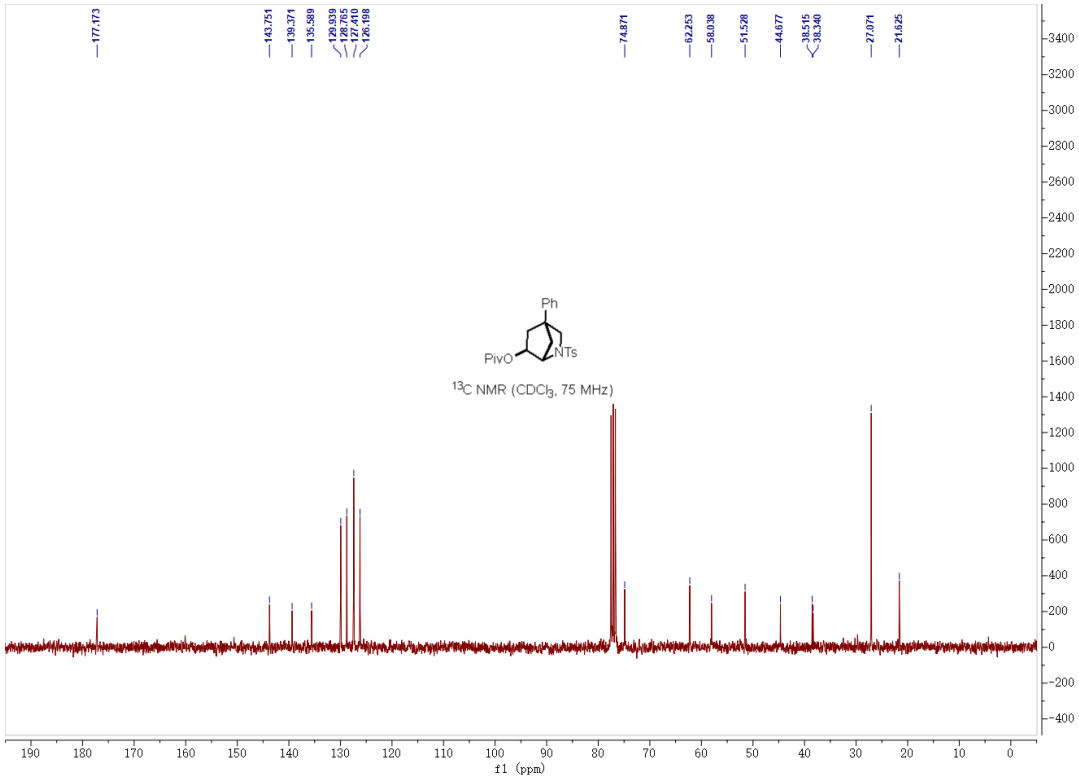
benzyl 6-acetoxy-4-phenyl-2-azabicyclo[2.2.1]heptane-2-carboxylate (3y)



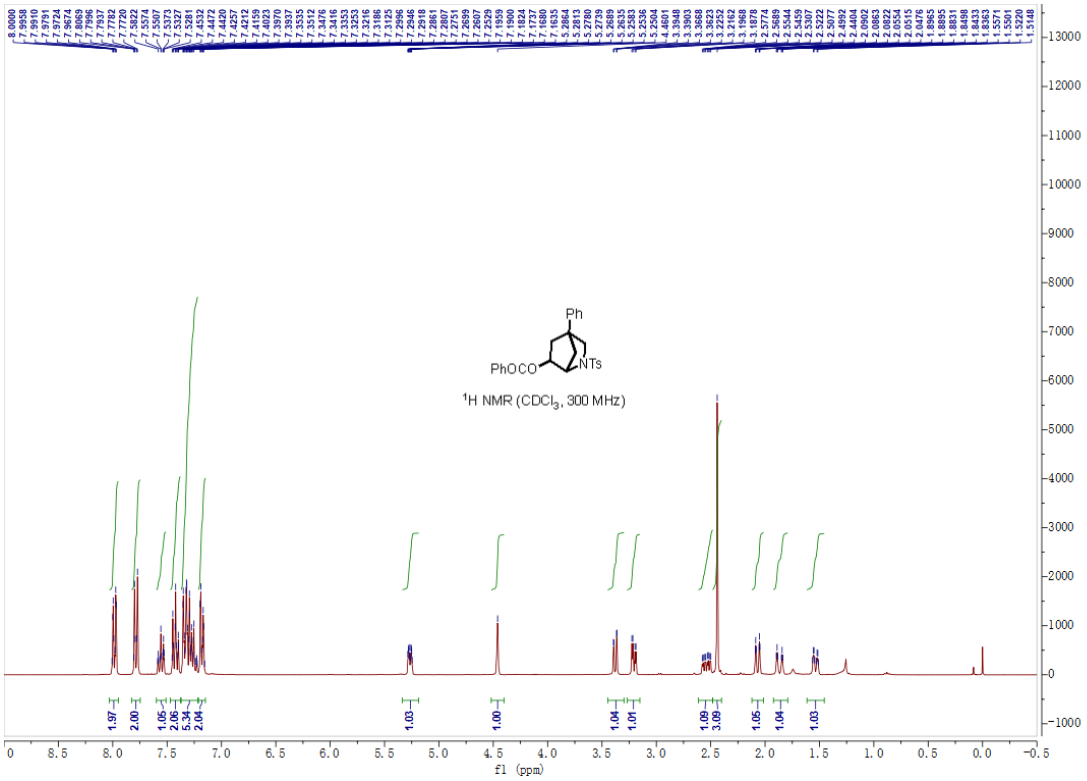


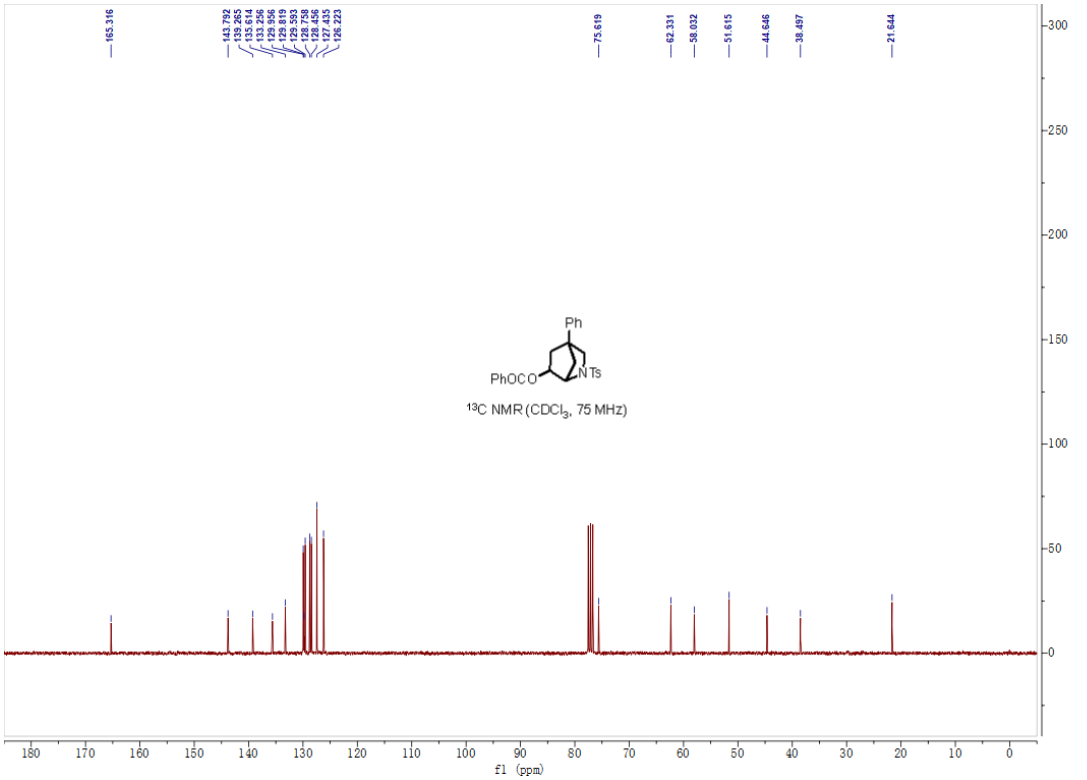
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl pivalate (3aa)



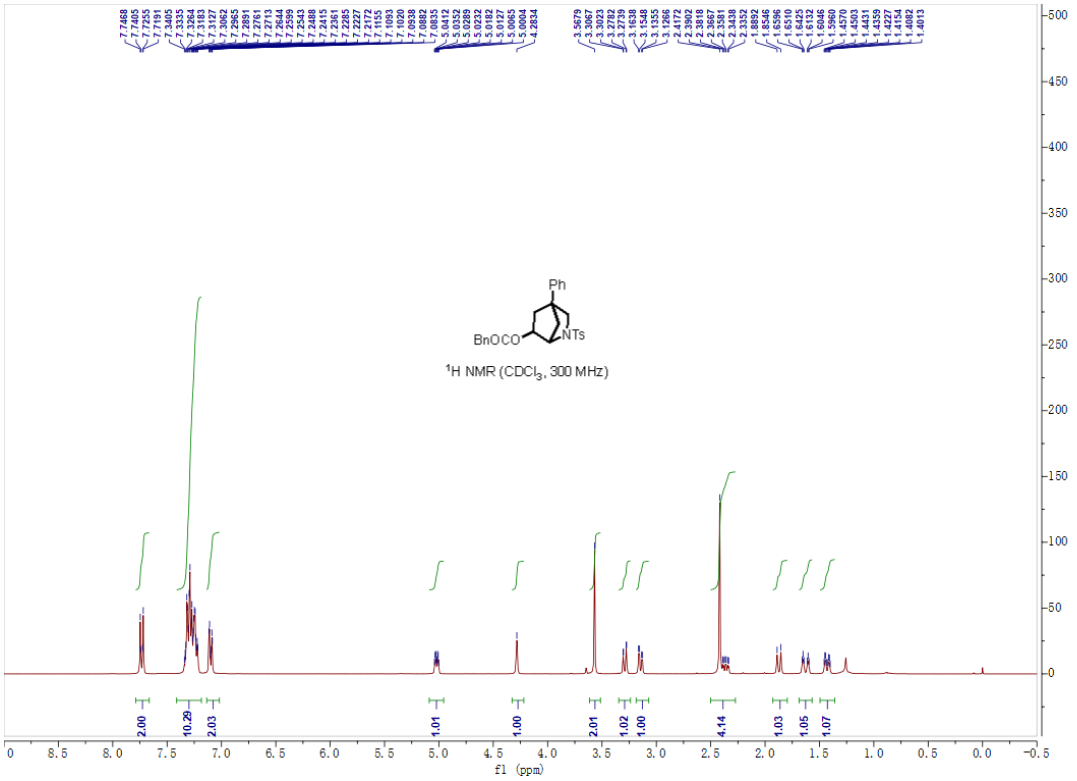


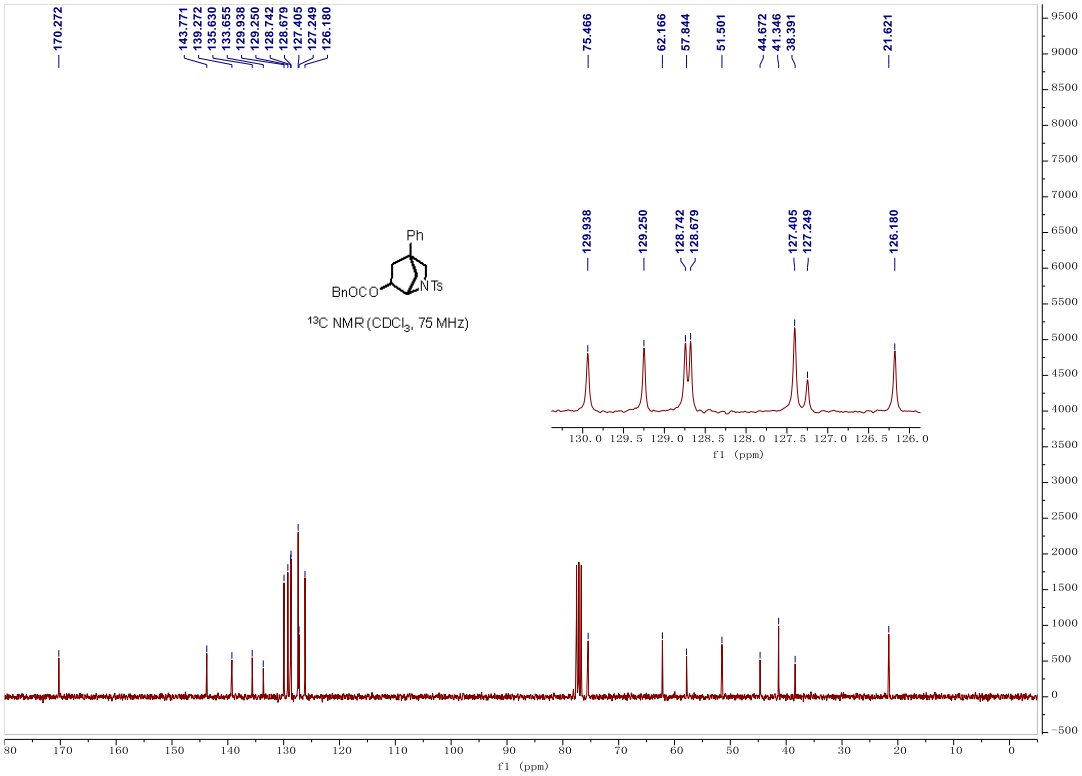
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzoate (3ab)



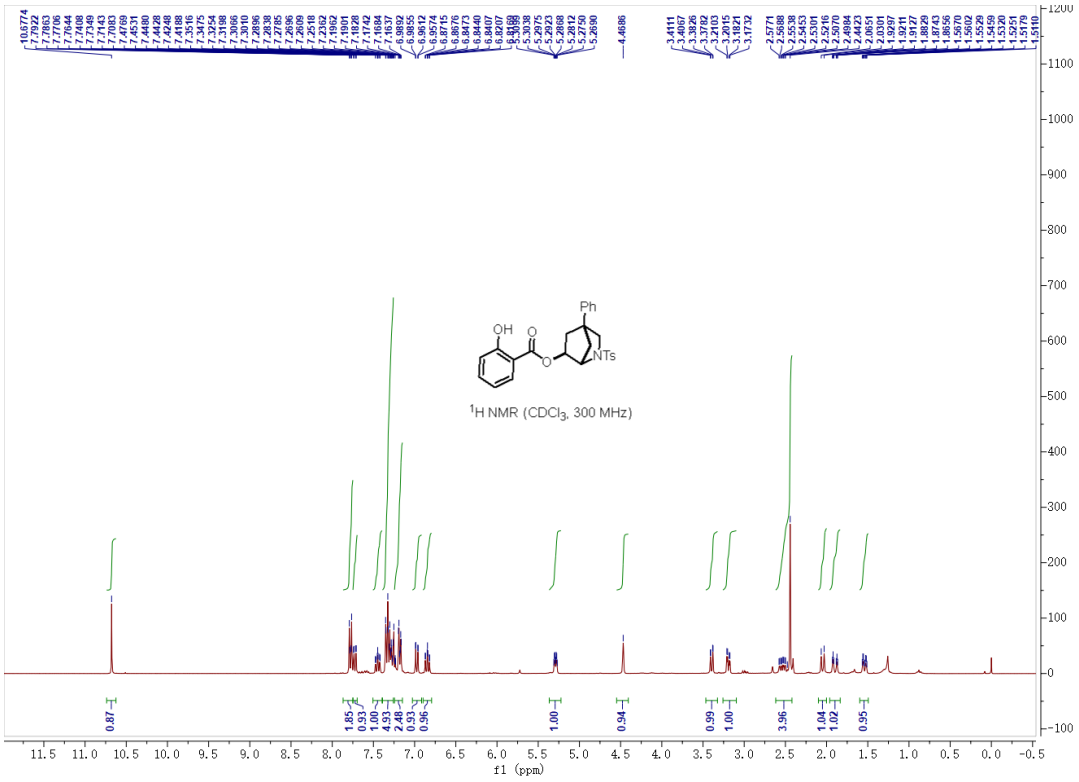


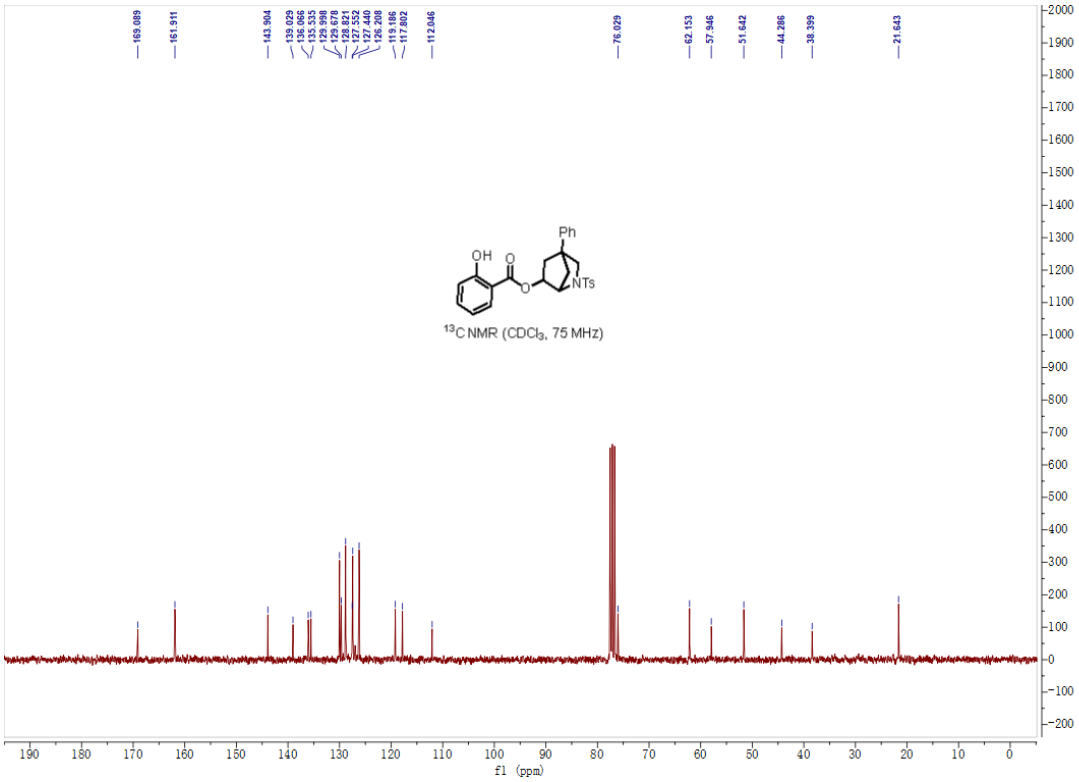
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-phenylacetate (3ac)



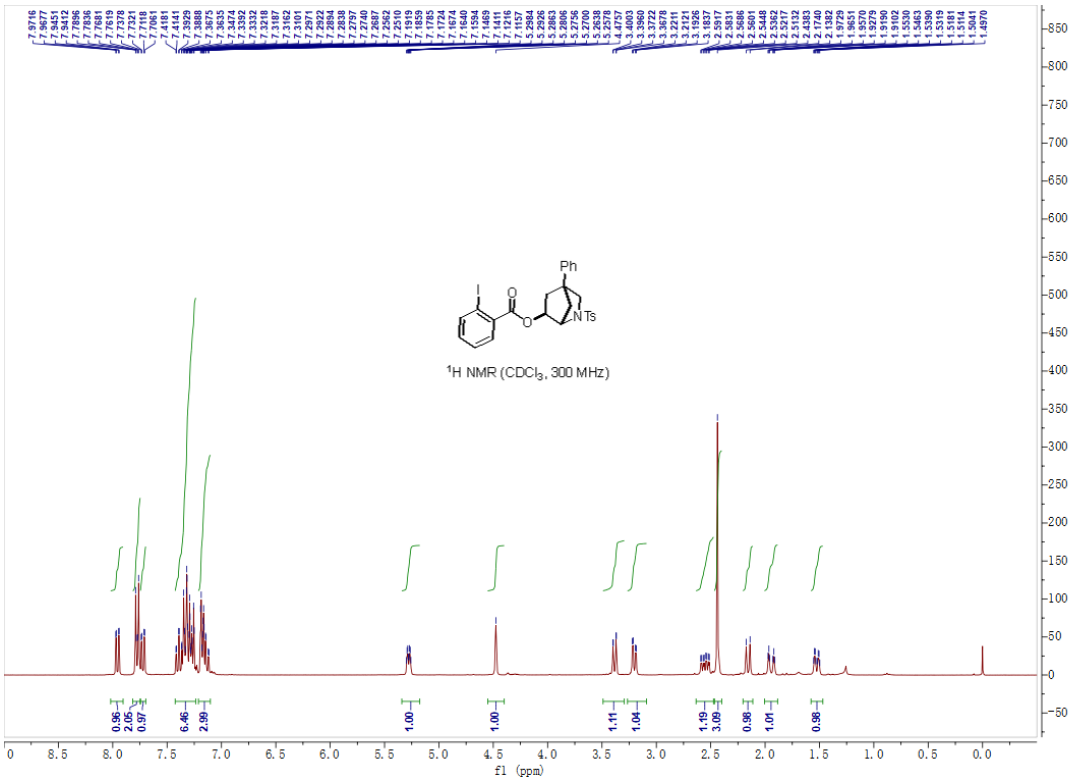


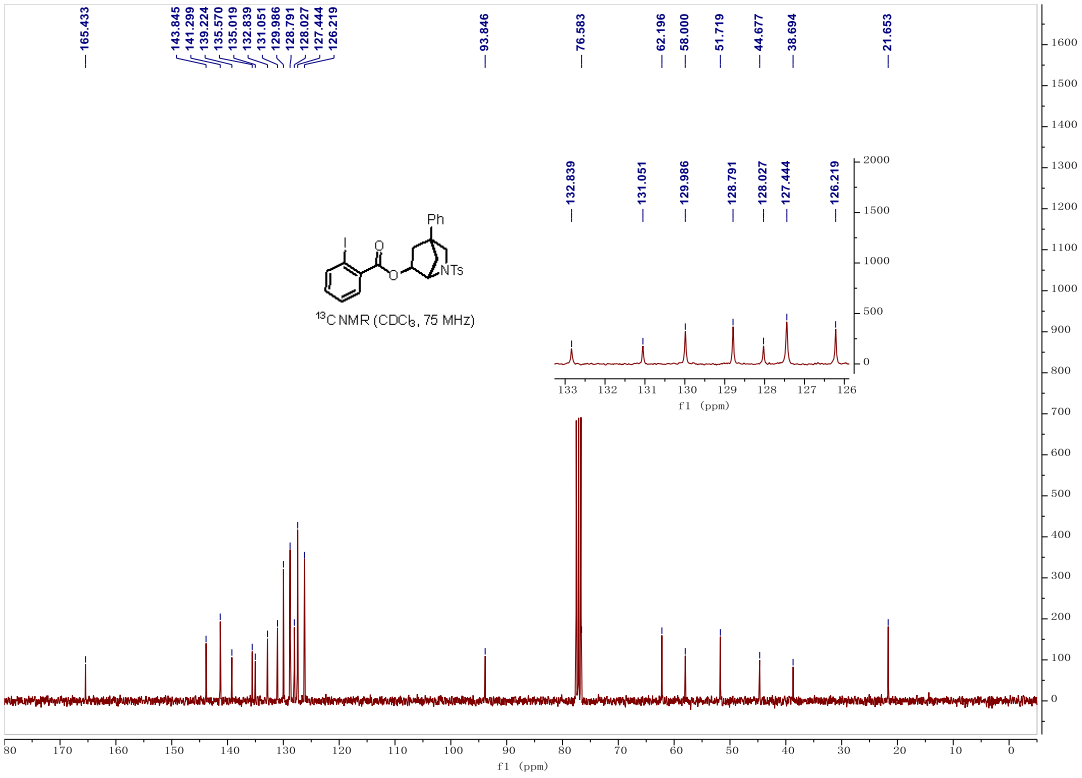
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-hydroxybenzoate (5a)



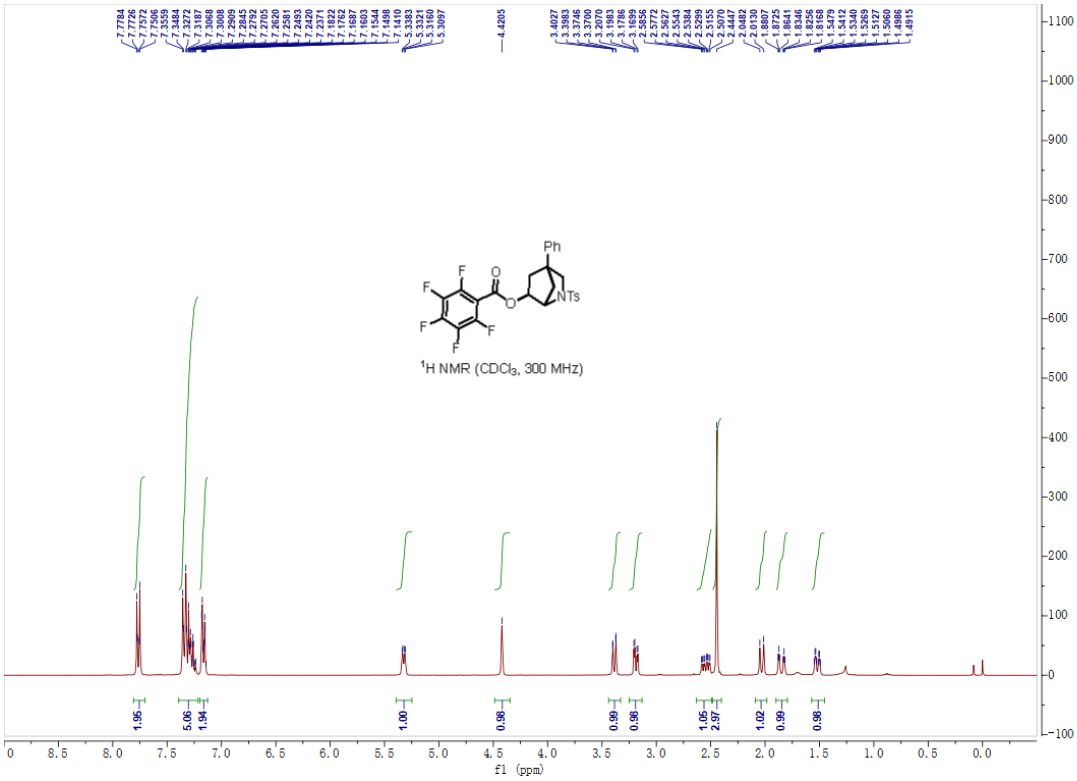


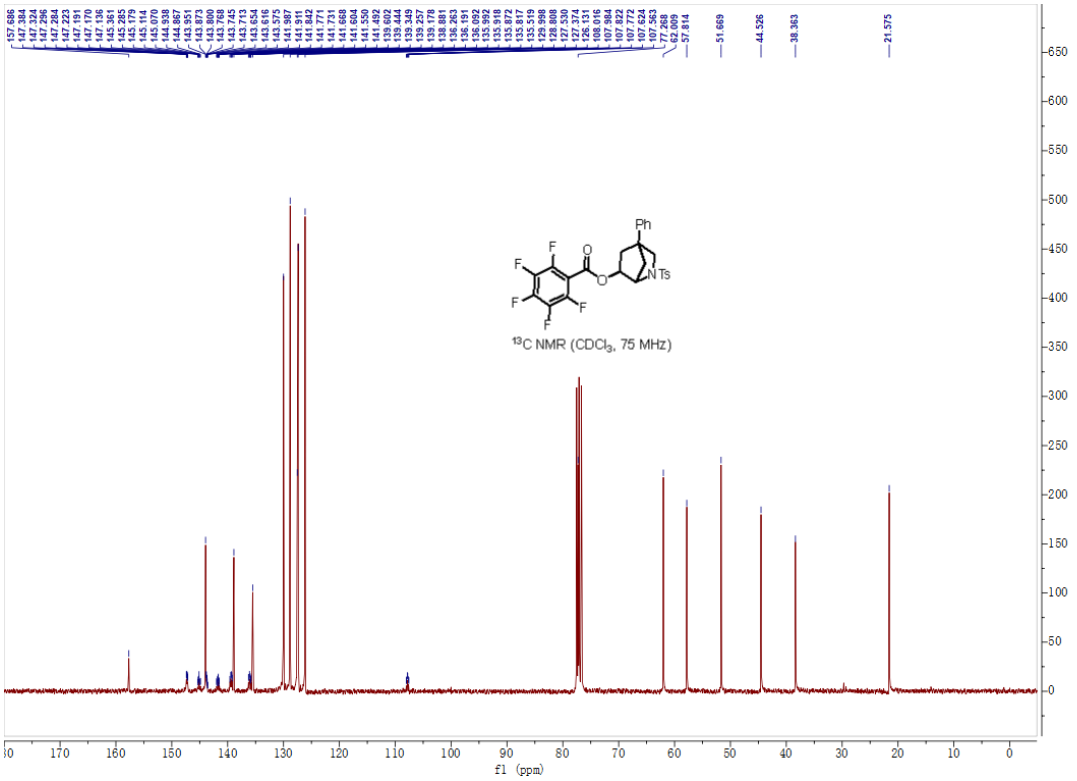
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-iodobenzoate (5b)

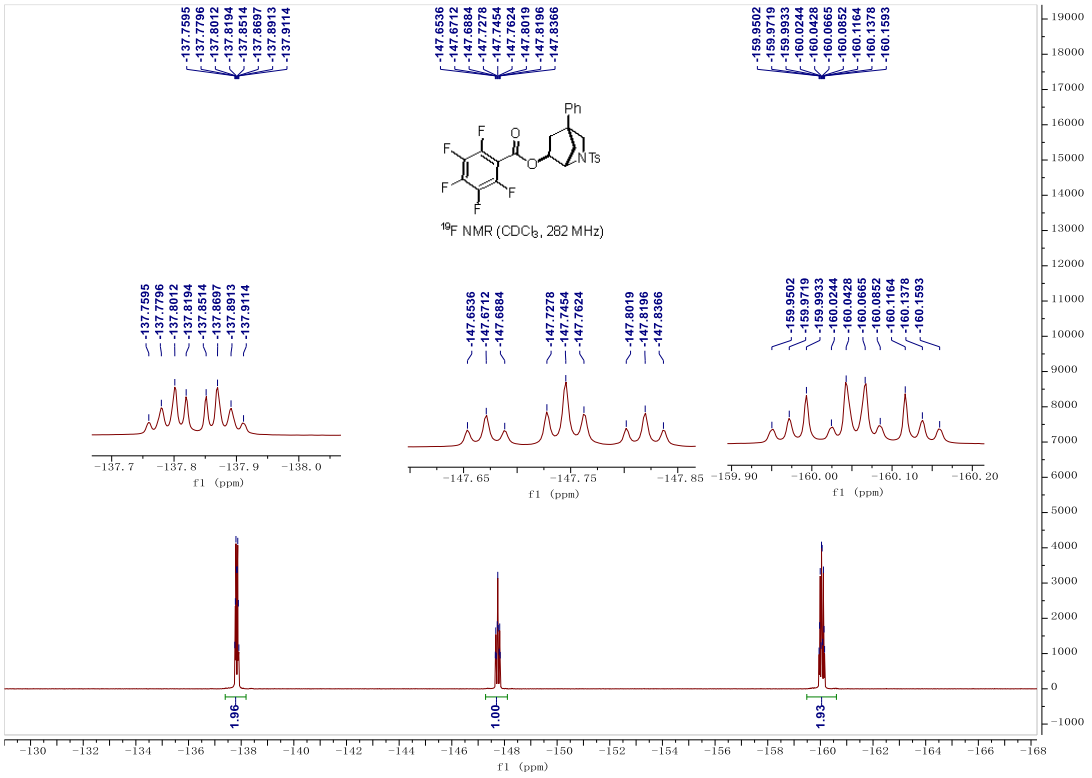




4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2,3,4,5,6-pentafluorobenzoate (5c)



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-137.8012
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-147.7278
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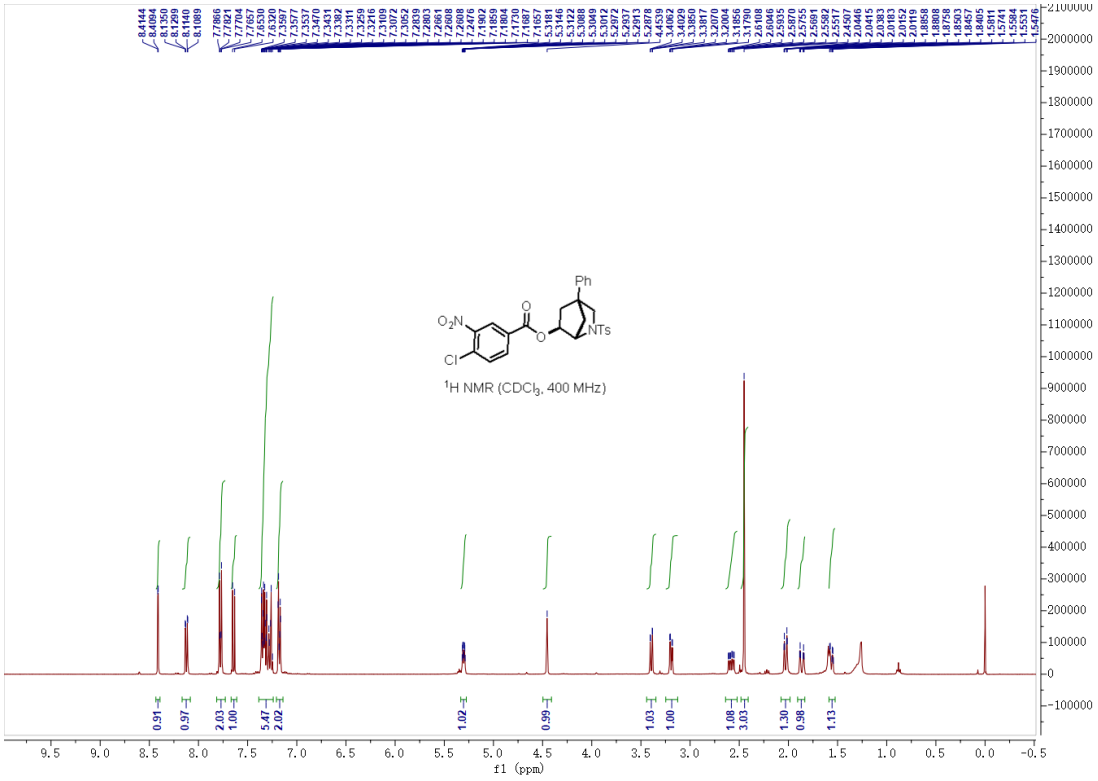
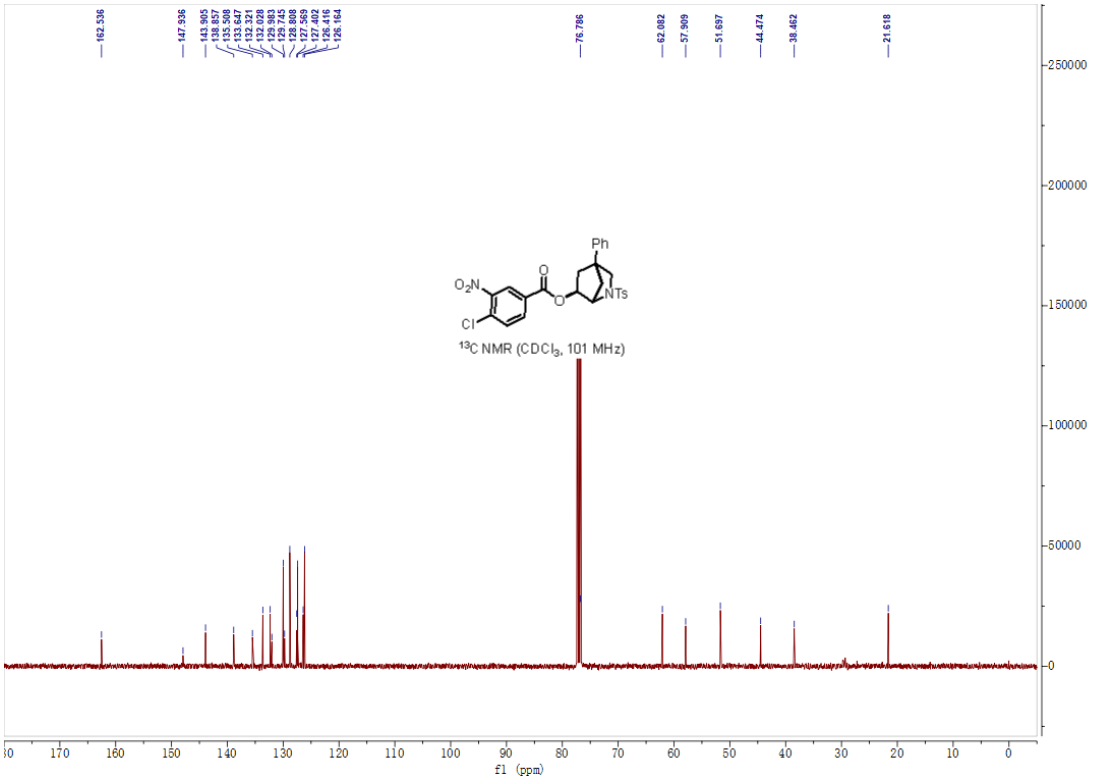
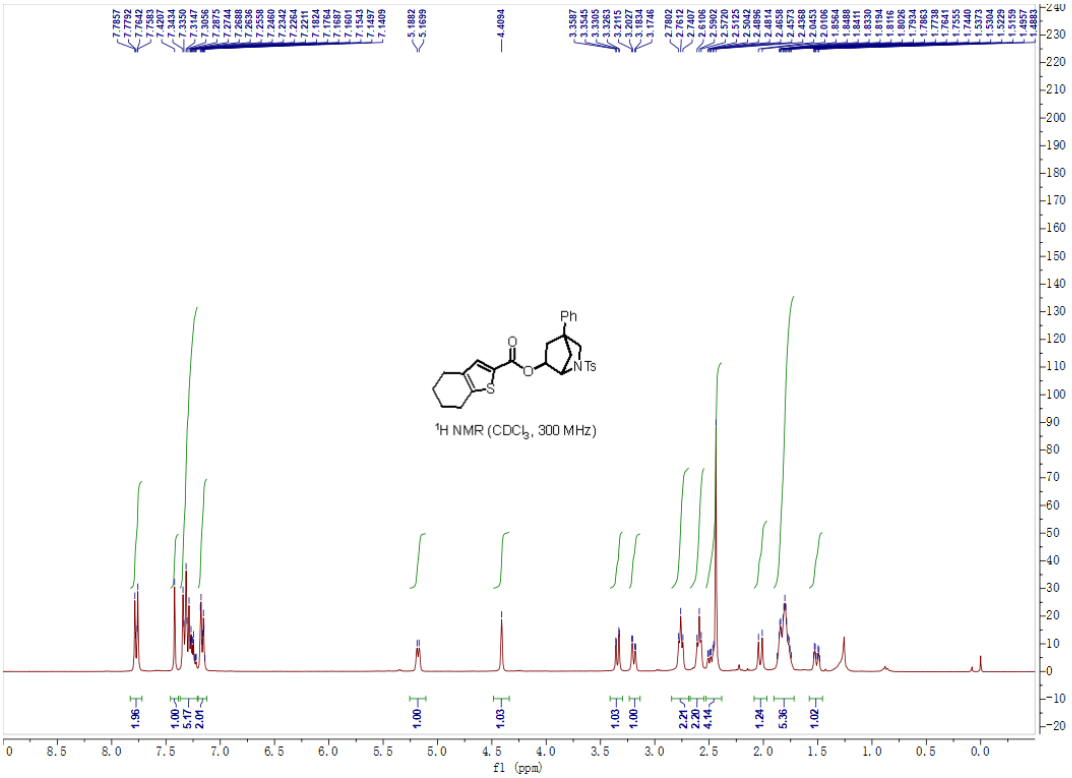
-147.7624
-147.8019
-147.8196
-147.8366
-159.9502
-159.9719
-159.9933
-160.0244
-160.0428
-160.0665
-160.0852
-160.1164
-160.1378
-160.1593
Ph
N Ts
F
O
19F NMR (CDCl3, 282 MHz)
f1 (ppm)
1.96
1.00
1.93

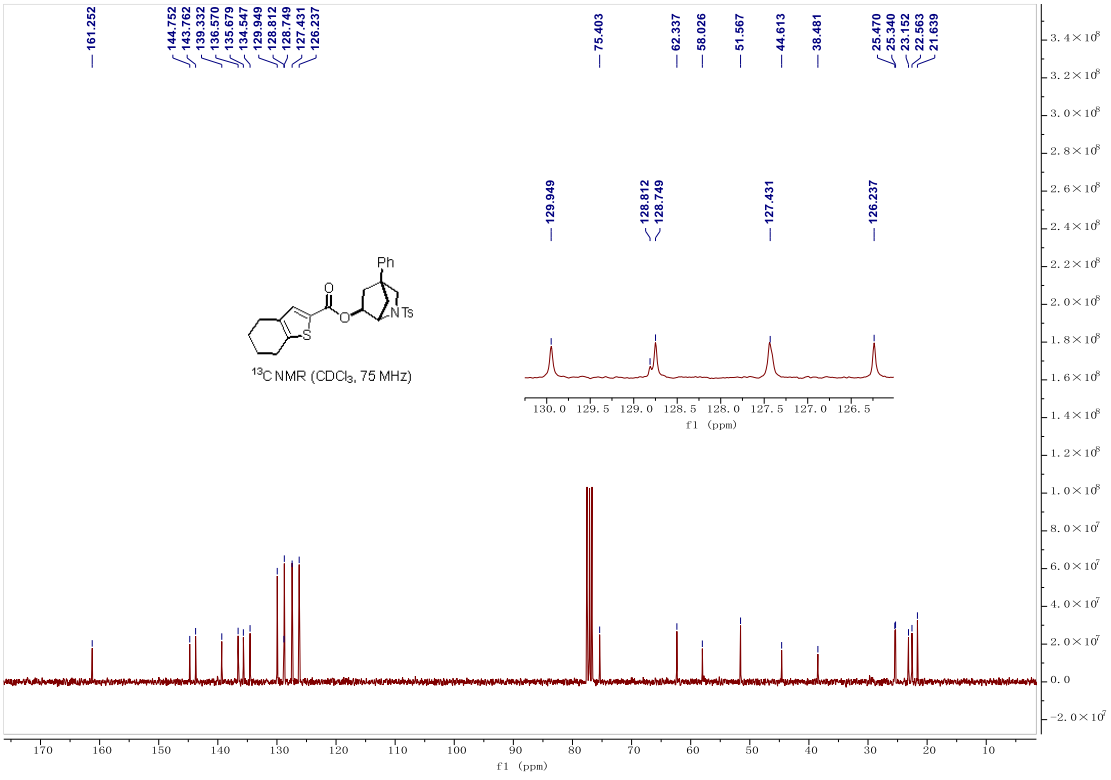
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 4-chloro-3-nitrobenzoate (5d)



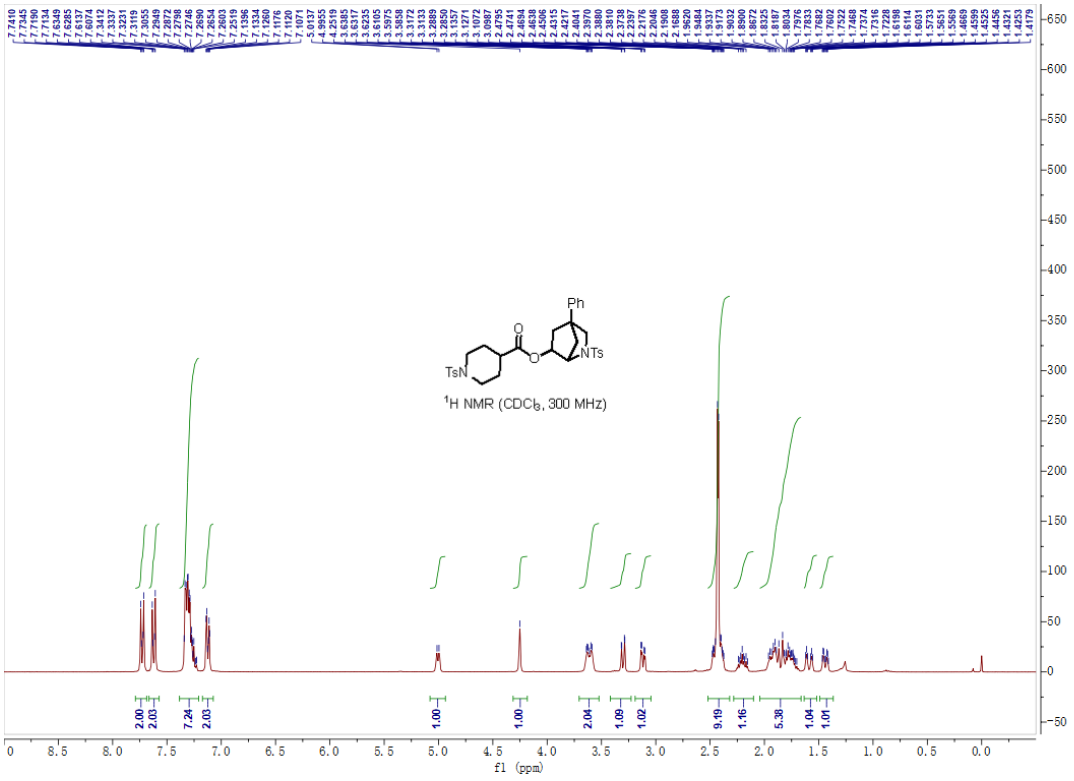


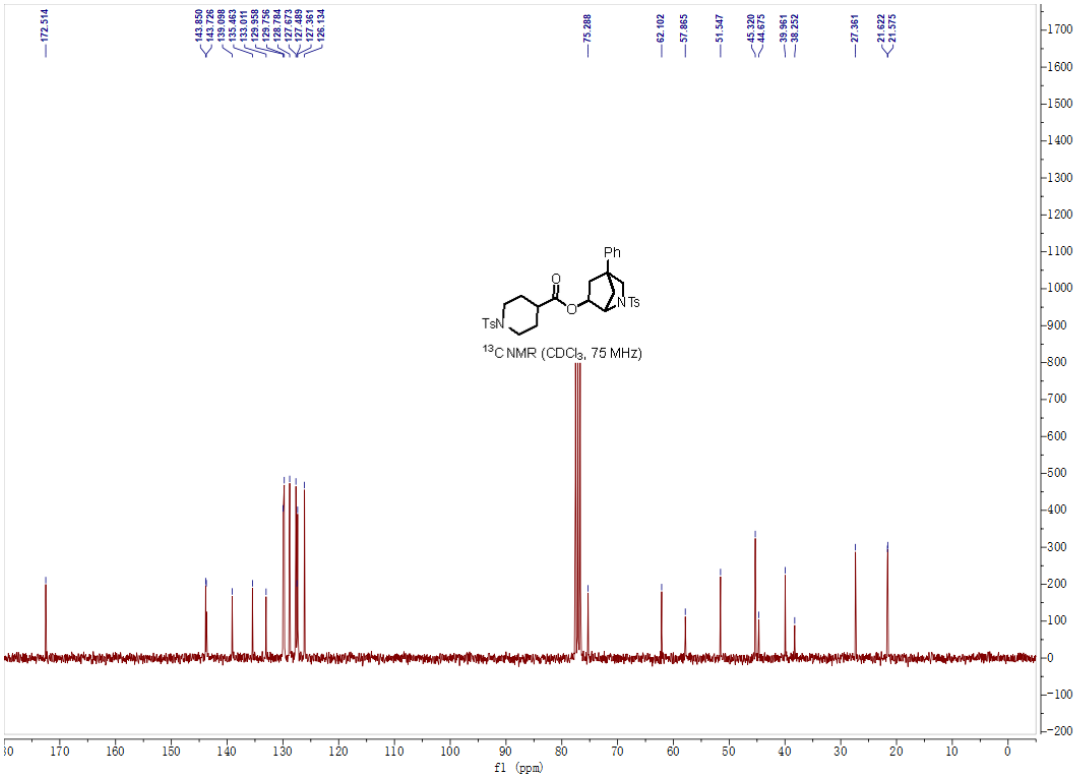
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 4,5,6,7-tetrahydrobenzo[b]thiophene-2-carboxylate (5e)



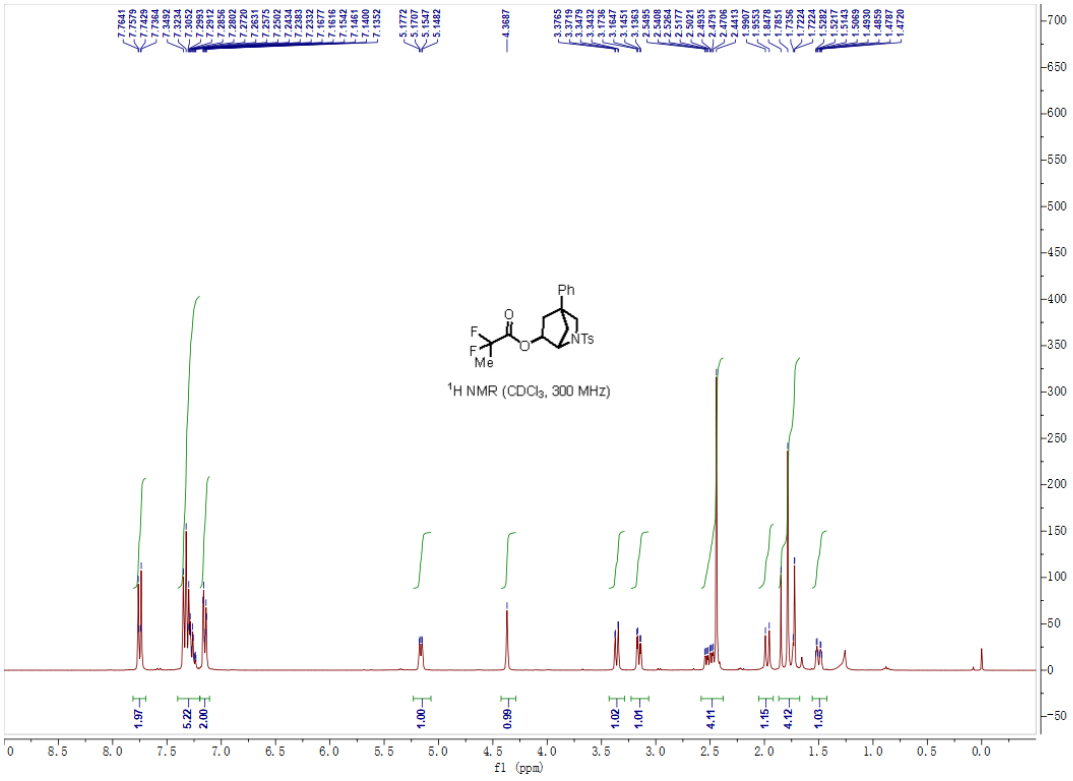


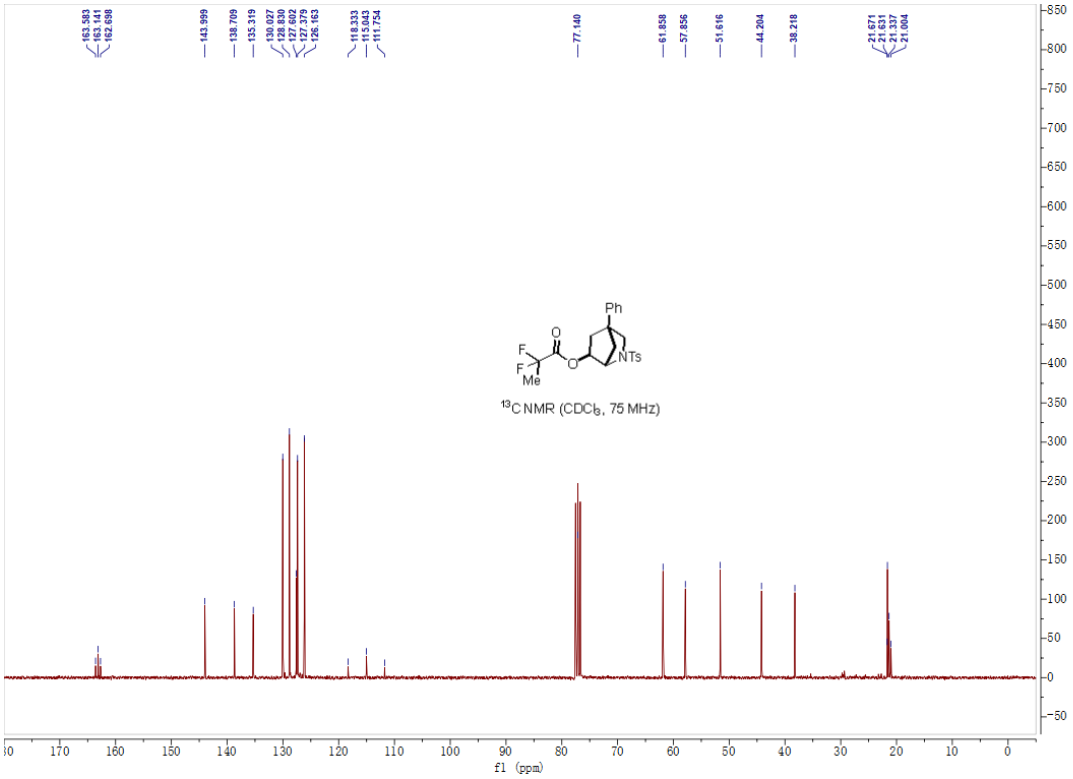
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 1-tosylpiperidine-4-carboxylate (5f)

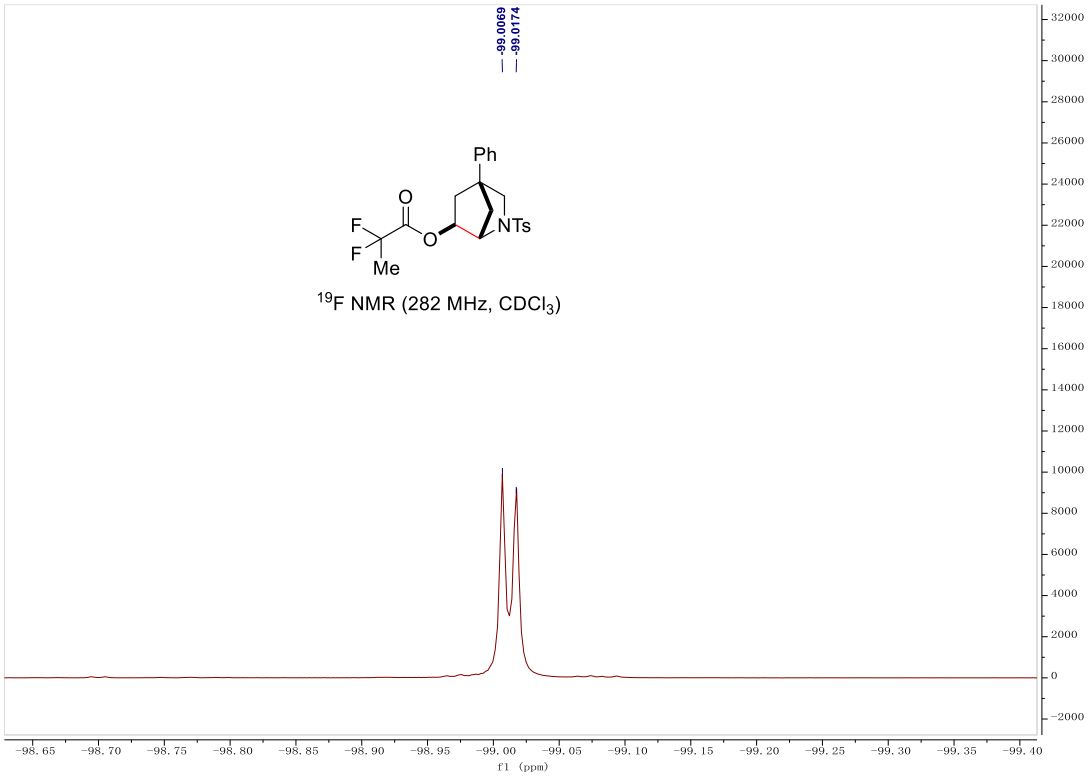




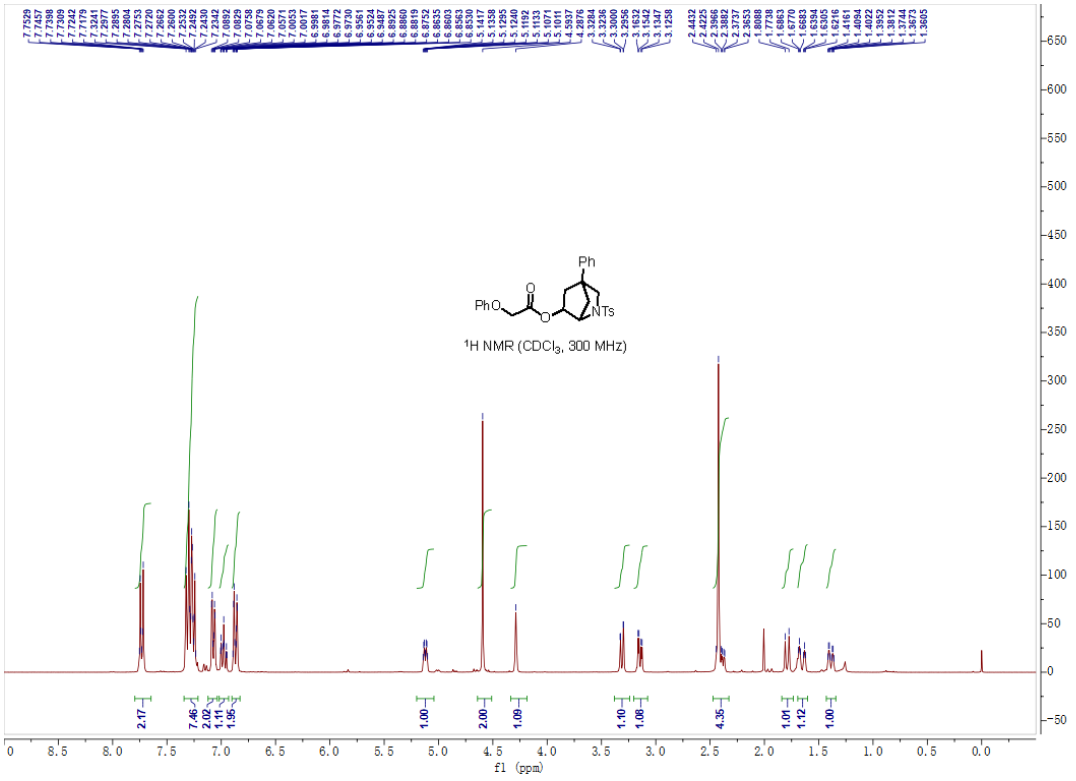
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2,2-difluoropropanoate (5g)

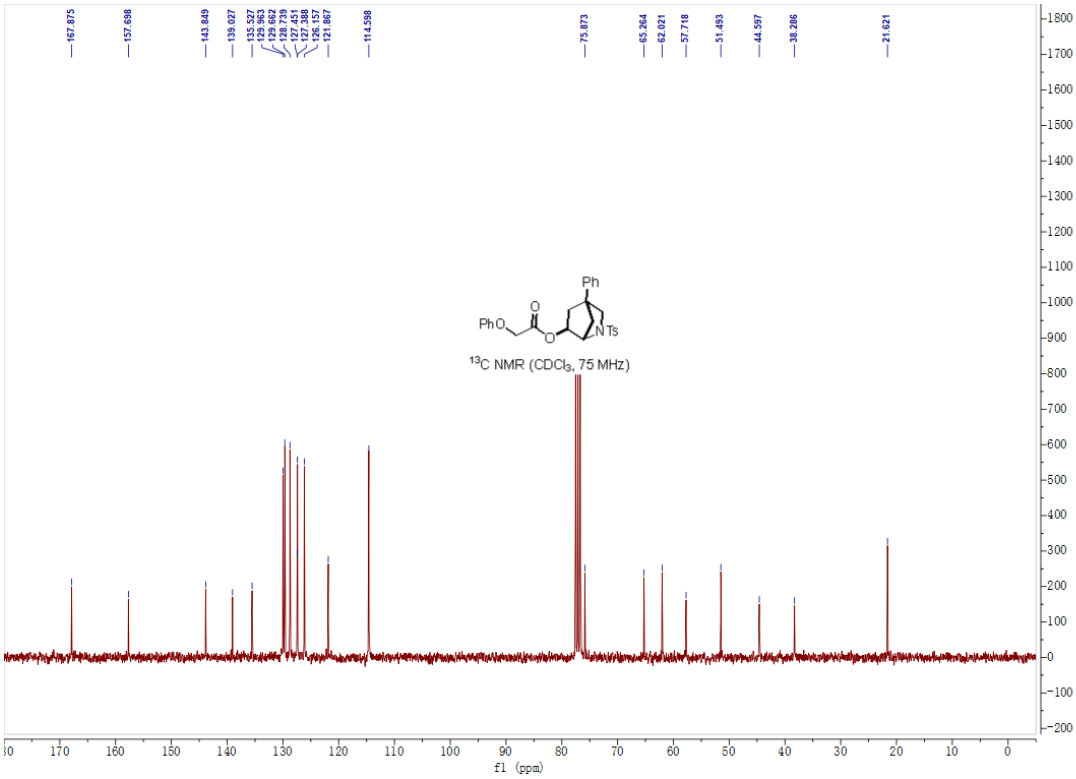




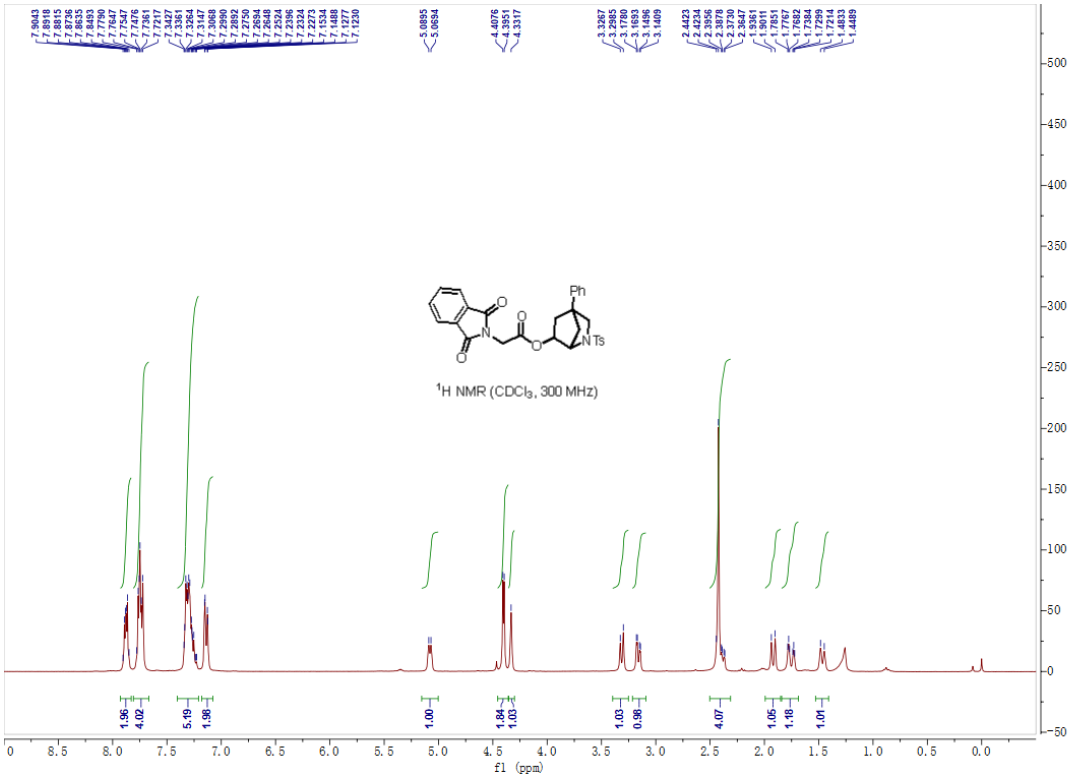

-99.0069
-99.0174
Ph
O
F
F
O
NTs
Me
^{19}F NMR (282 MHz, $CDCl_3$)
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
-98.65
-98.70
-98.75
-98.80
-98.85
-98.90
-98.95
-99.00
-99.05
-99.10
-99.15
-99.20
-99.25
-99.30
-99.35
-99.40
f1 (ppm)

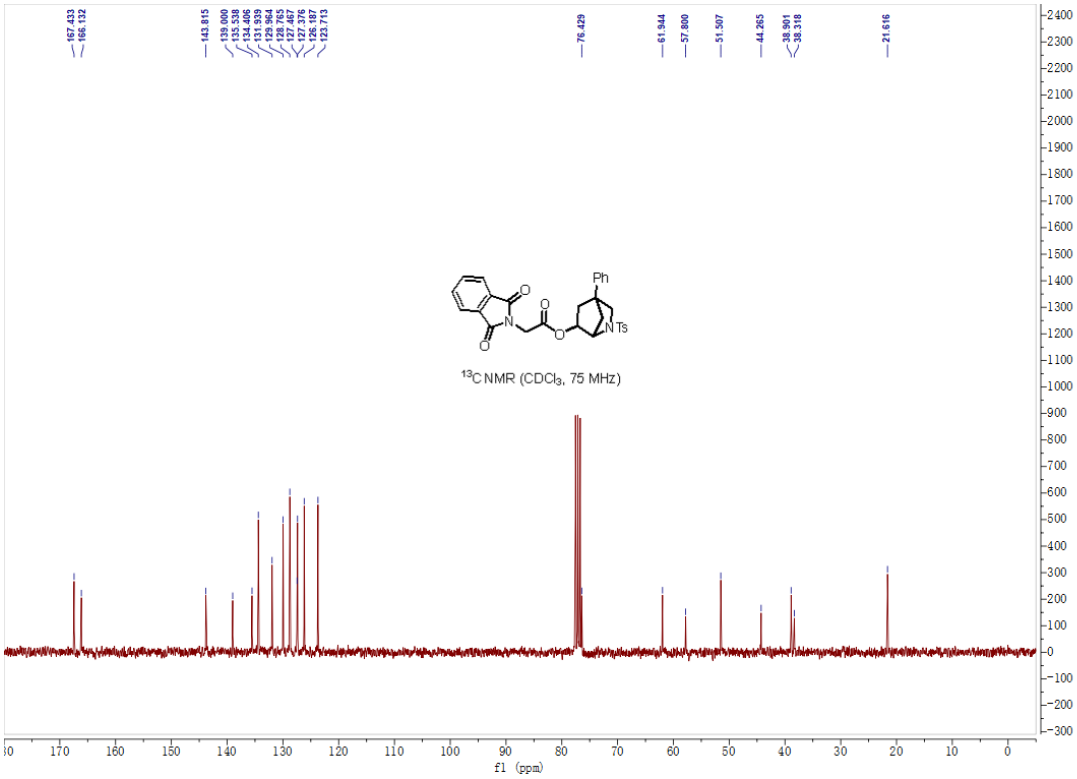
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-phenoxyacetate (5h)



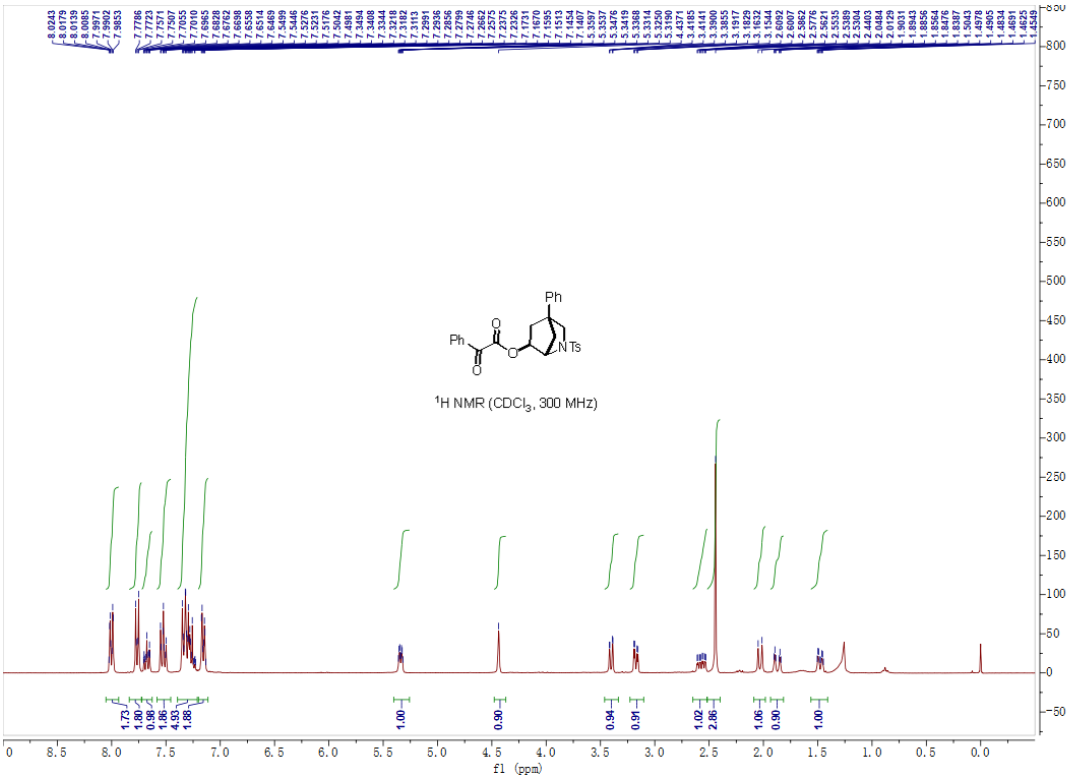


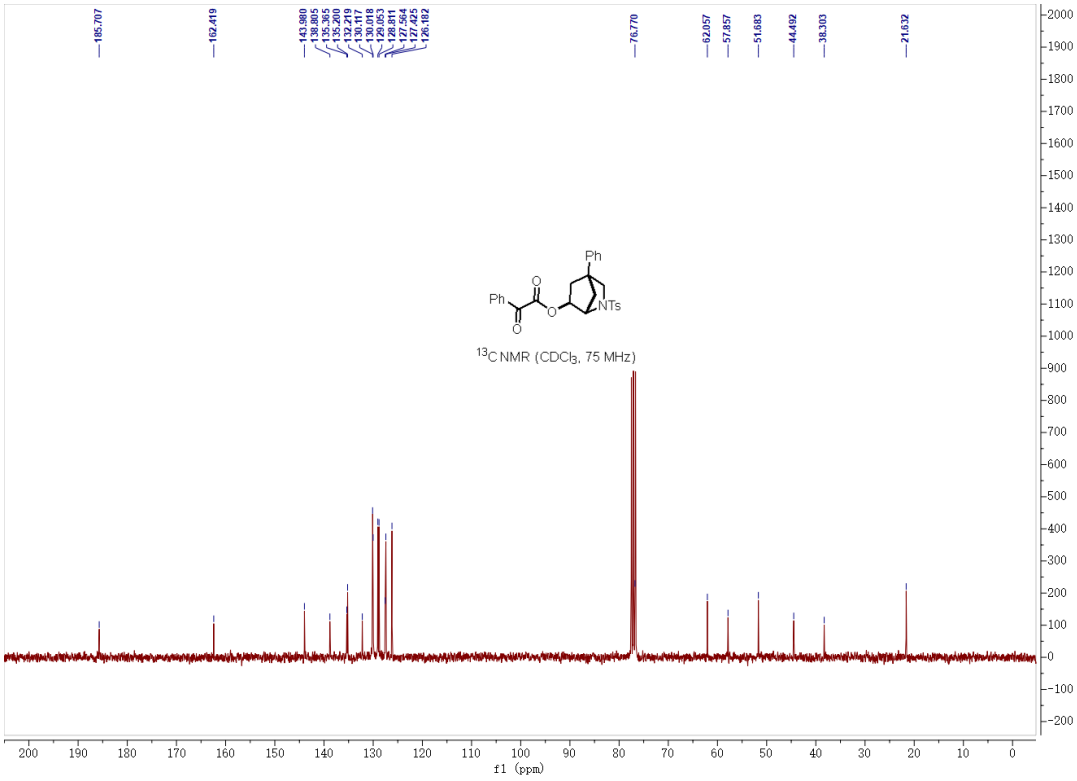
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-(1,3-dioxoisoindolin-2-yl)acetate (5i)



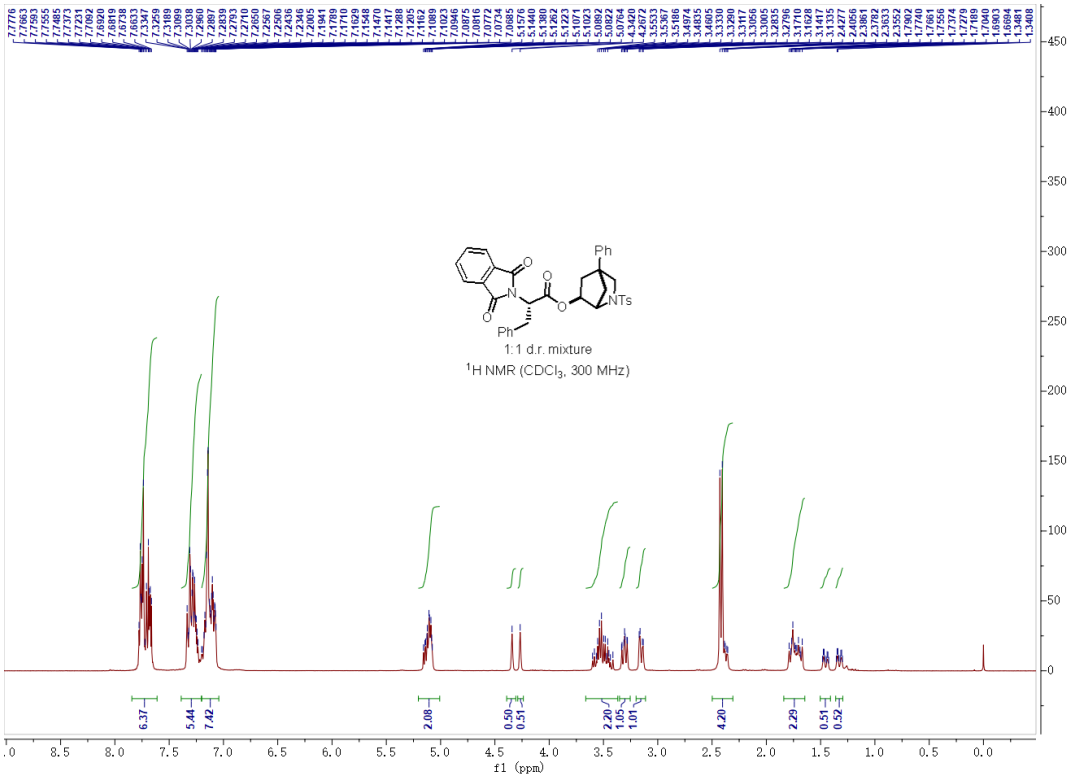


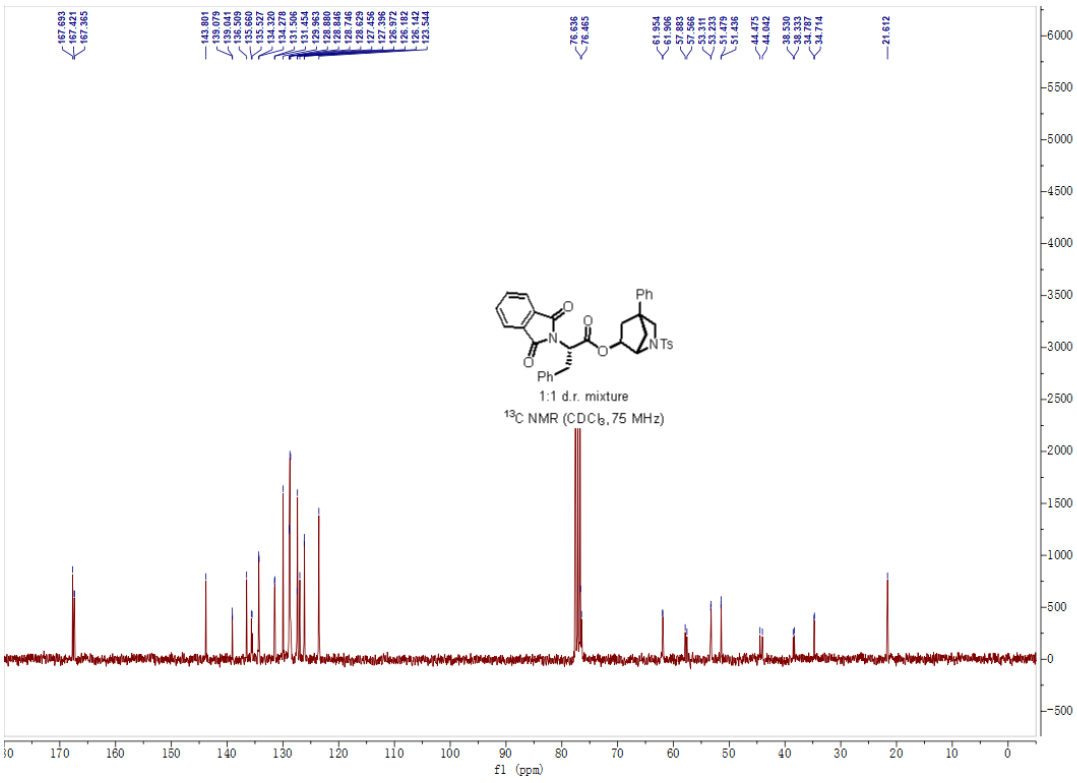
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-oxo-2-phenylacetate (5j)



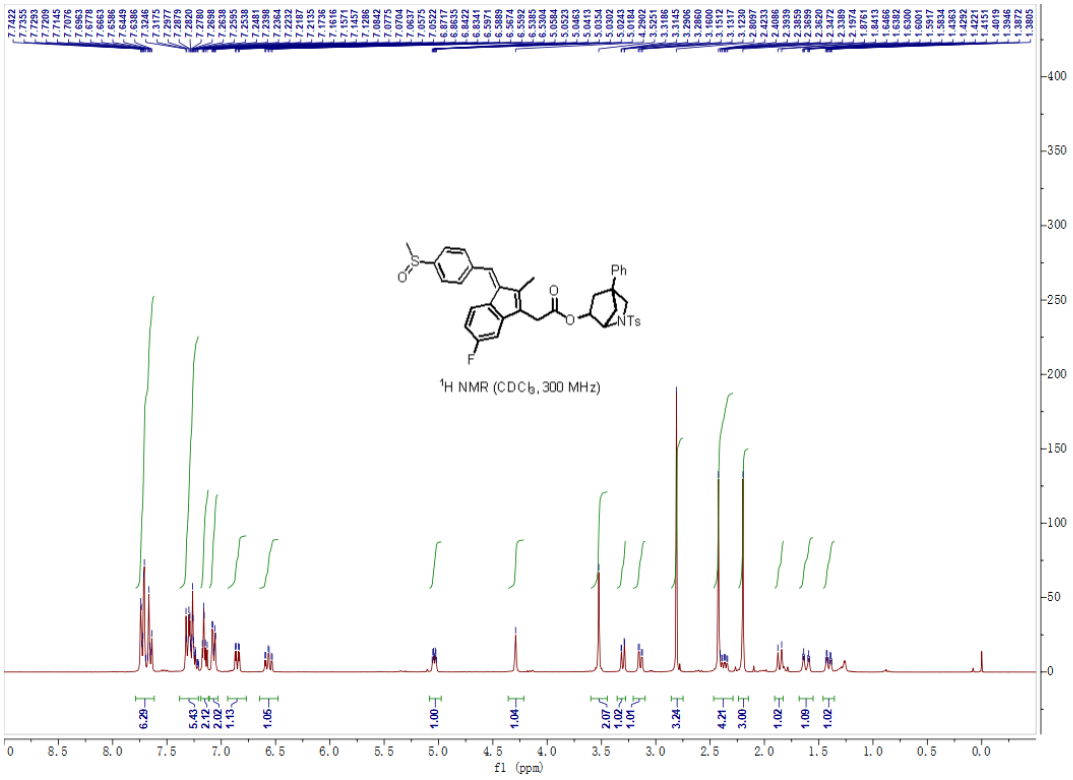


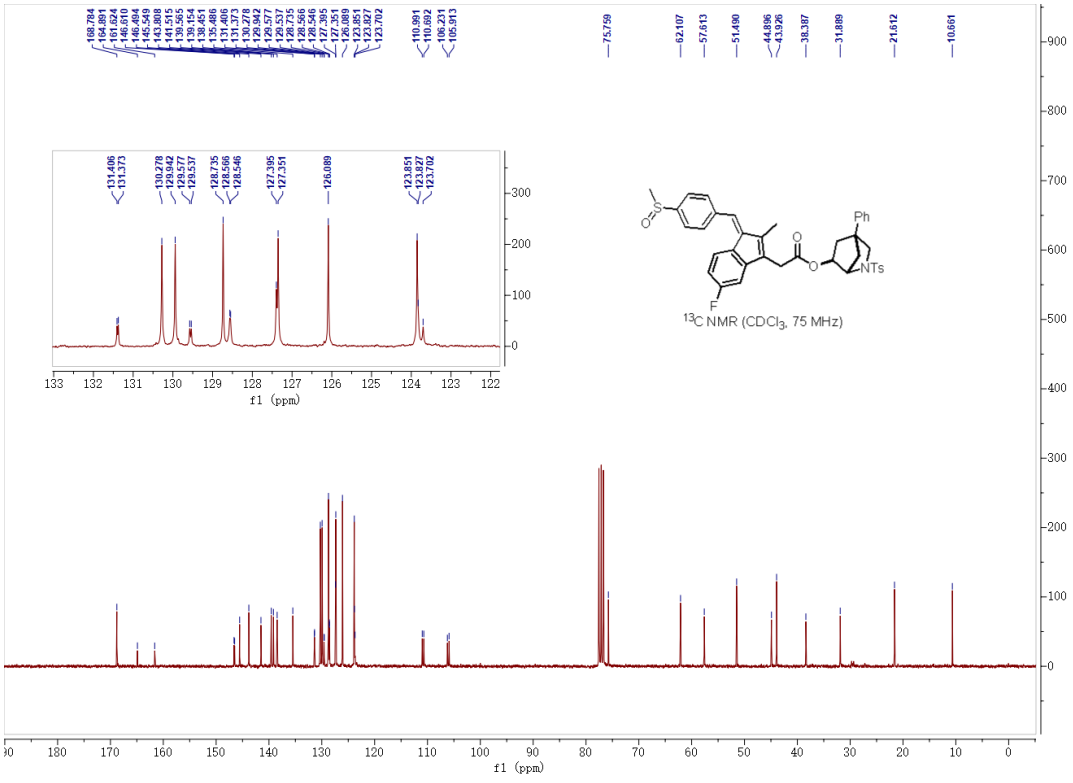
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl (S)-2-(1,3-dioxoisoindolin-2-yl)-3-phenylpropanoate (5k)

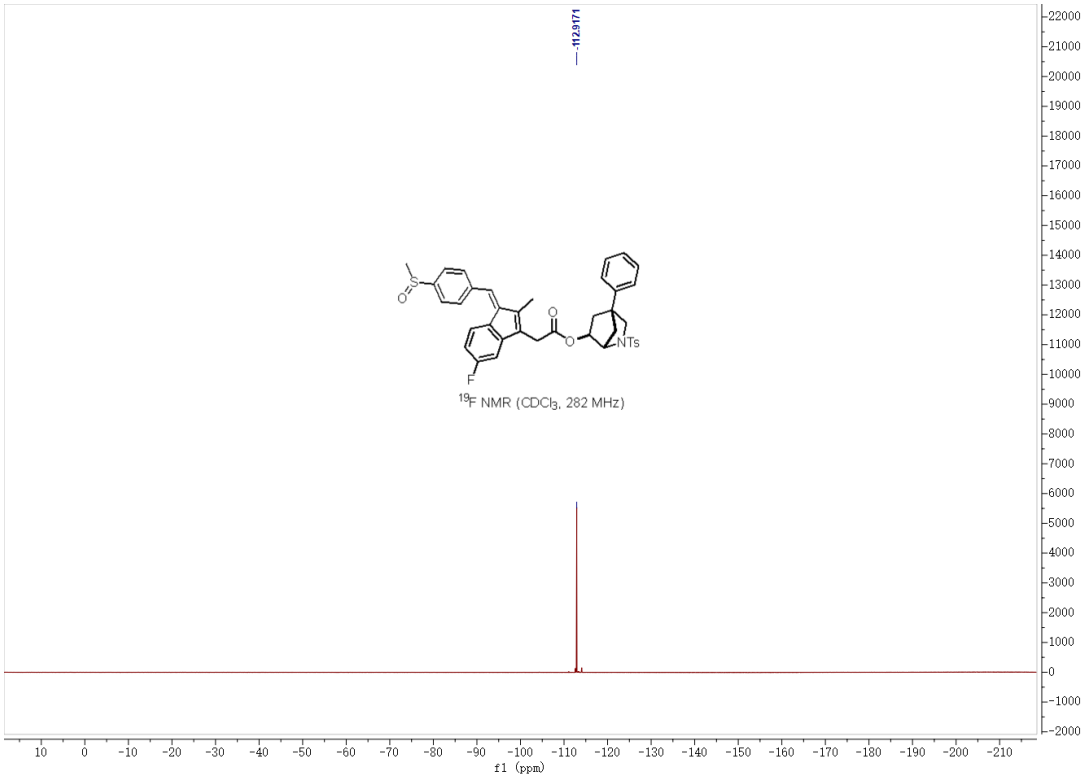




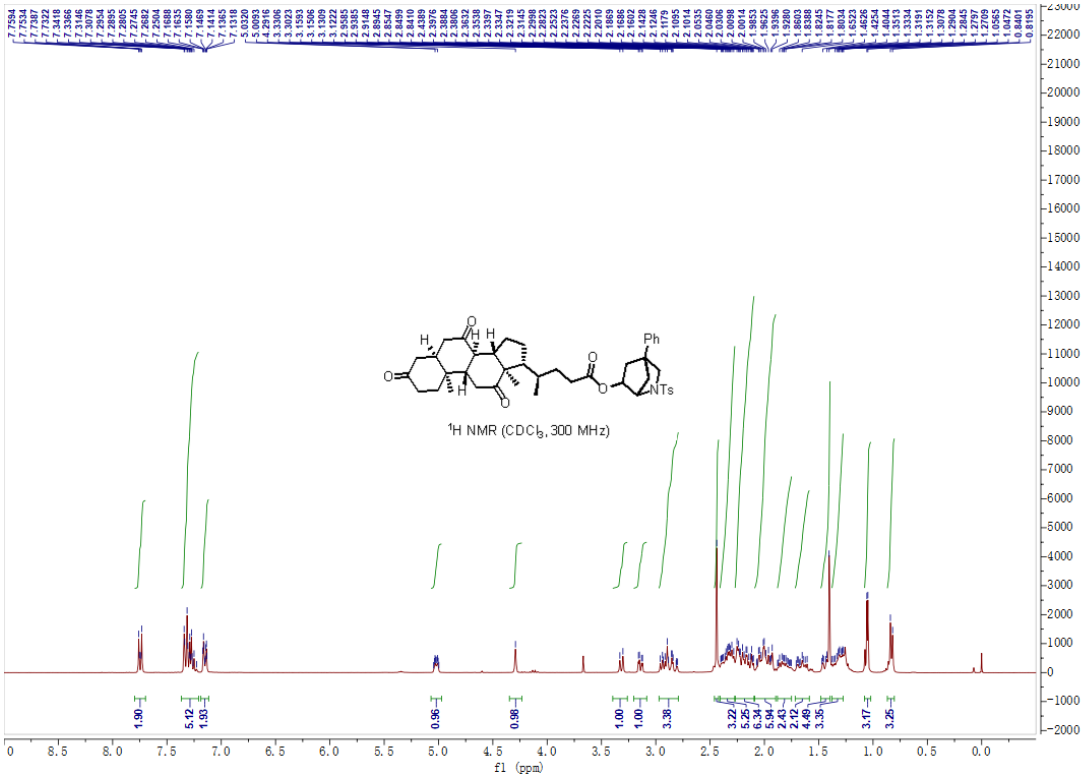
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl 2-(5-fluoro-2-methyl-1-((Z)-4-(methylsulfinyl)benzylidene)-1H-inden-3-yl)acetate (5l)

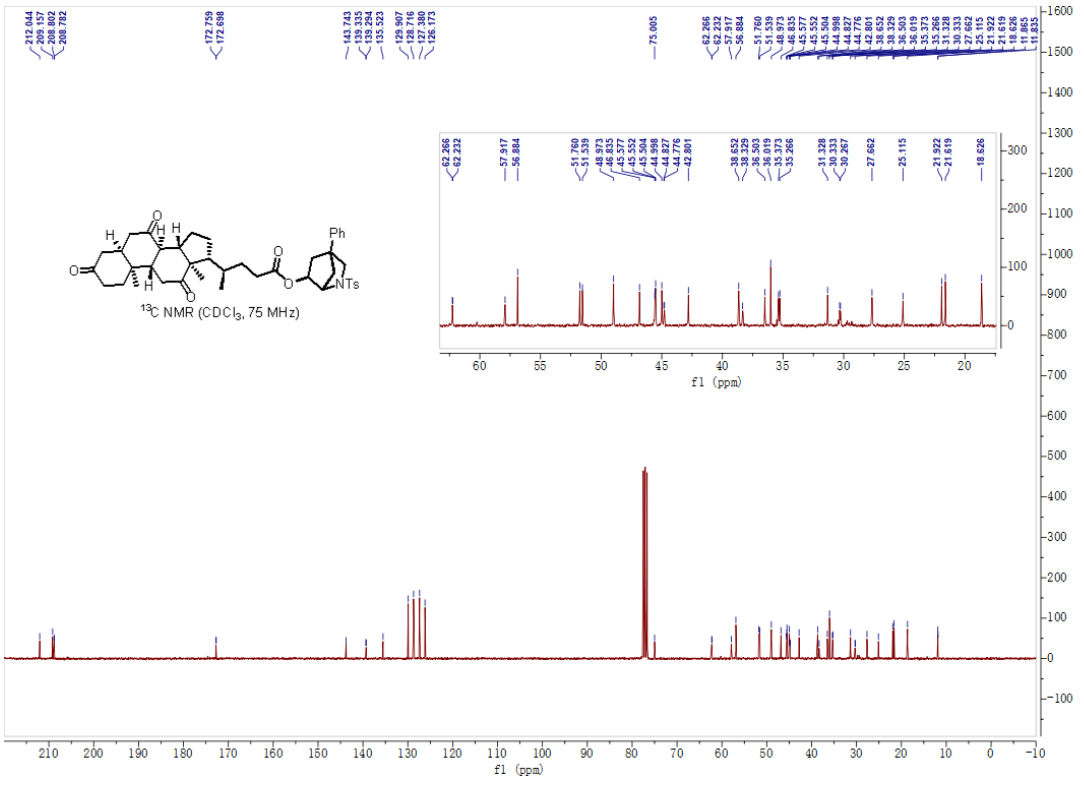




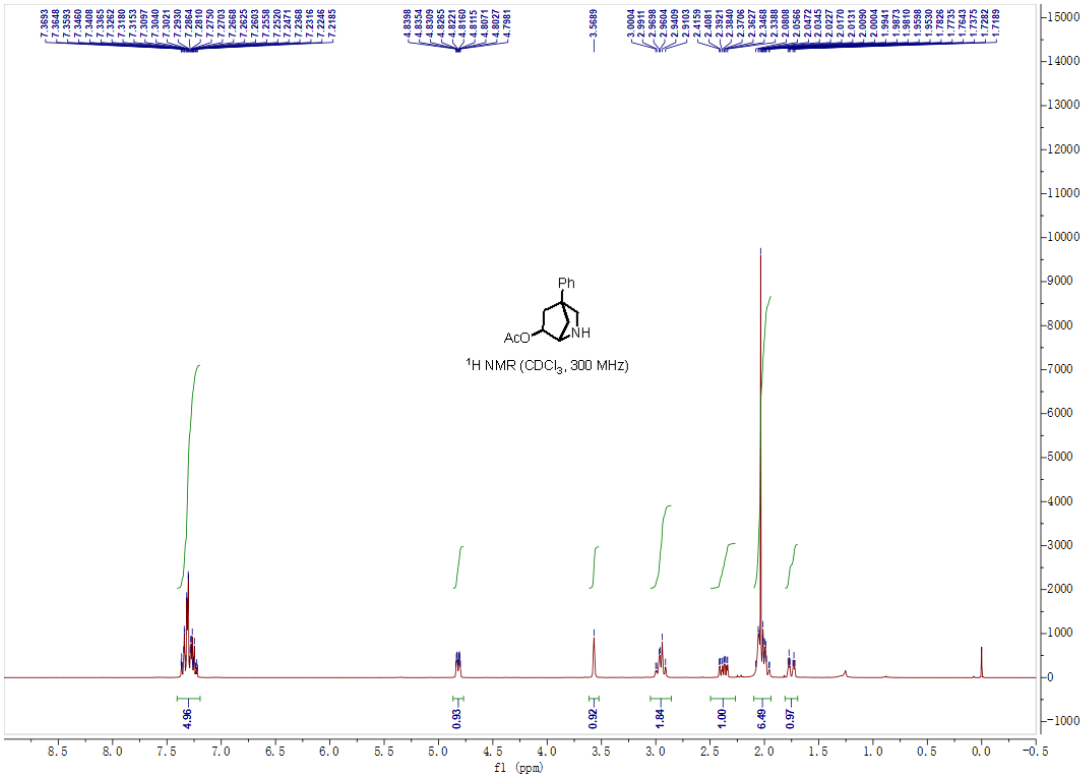

1123171
O
S
O
O
O
NTs
F
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

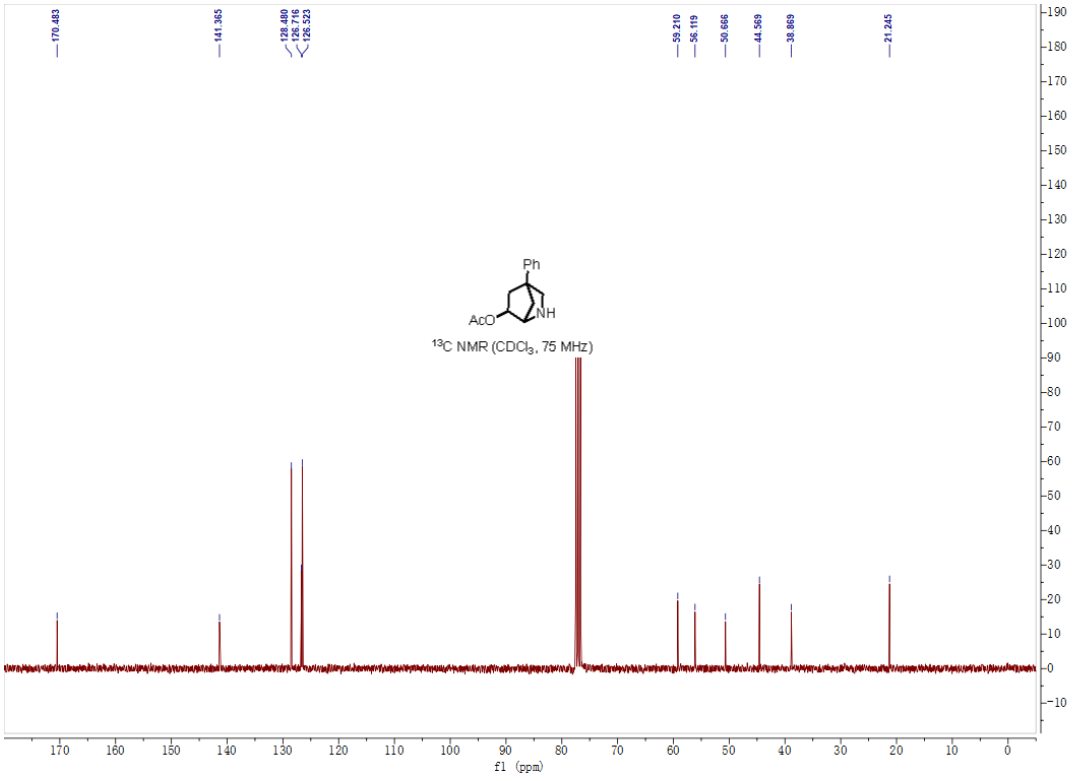
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl (R)-4-((5S,8R,9S,10S,13R,14S,17R)-10,13-dimethyl-3,7,12-trioxohexadecahydro-1H-cyclopenta[a]phenanthren-17-yl)pentanoate (5m)



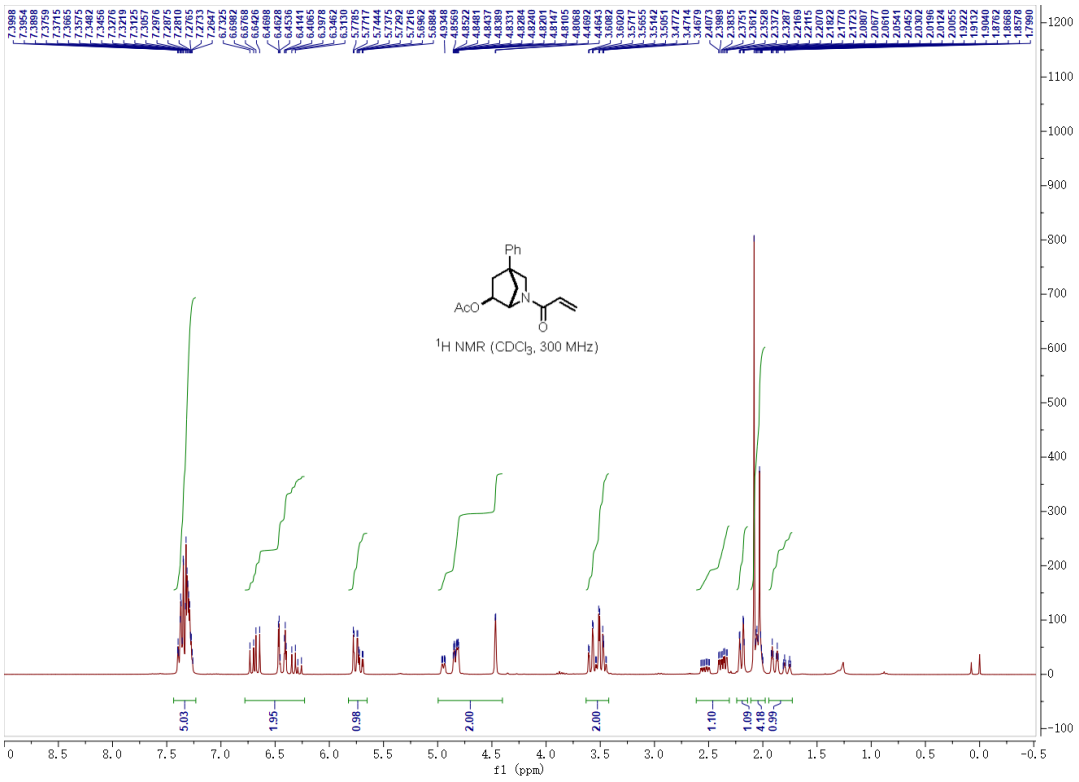


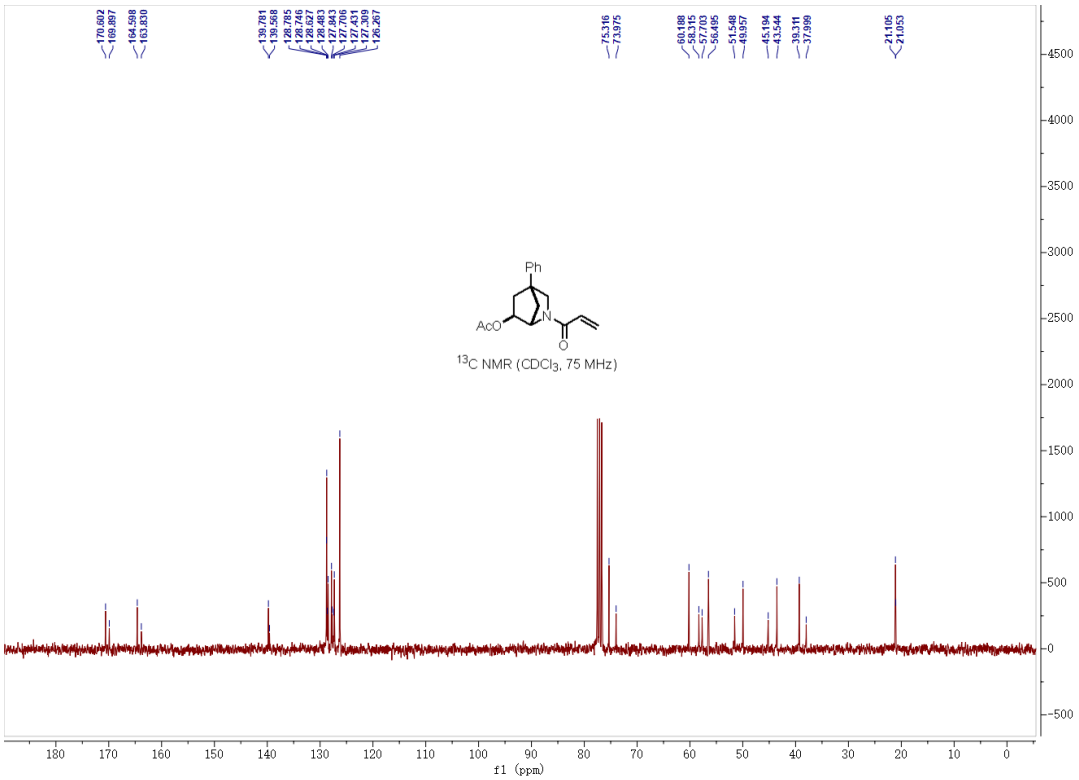
4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (6)



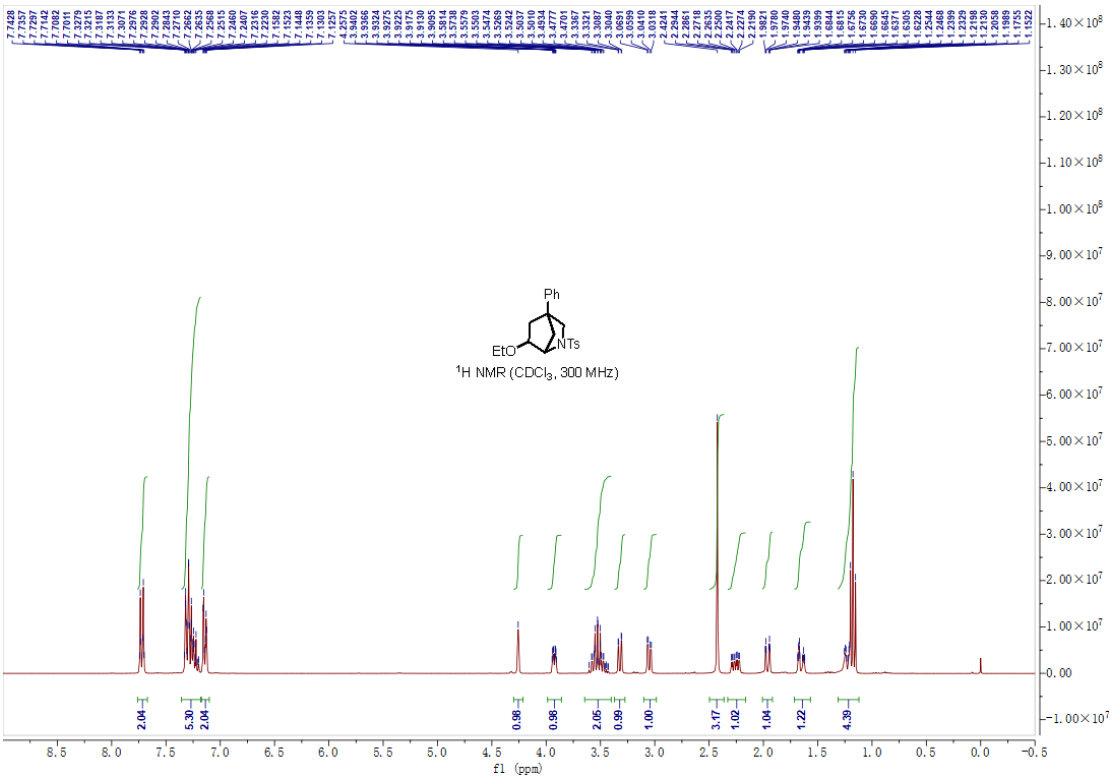


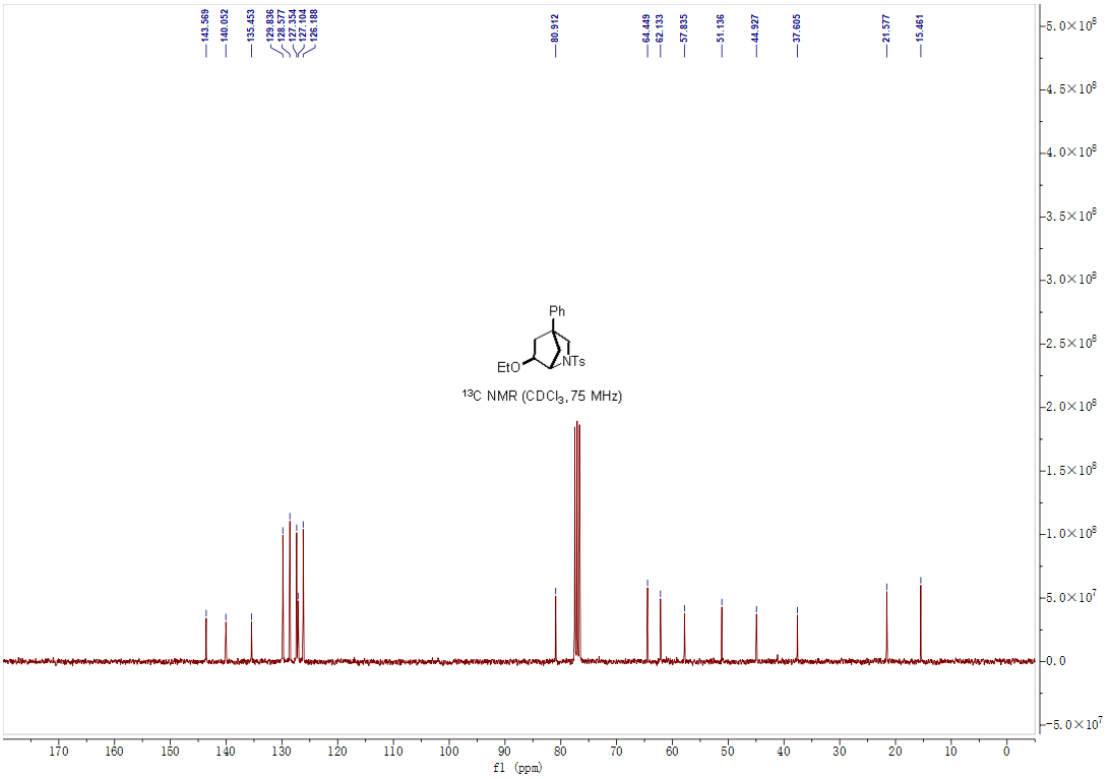
2-acryloyl-4-phenyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (7)



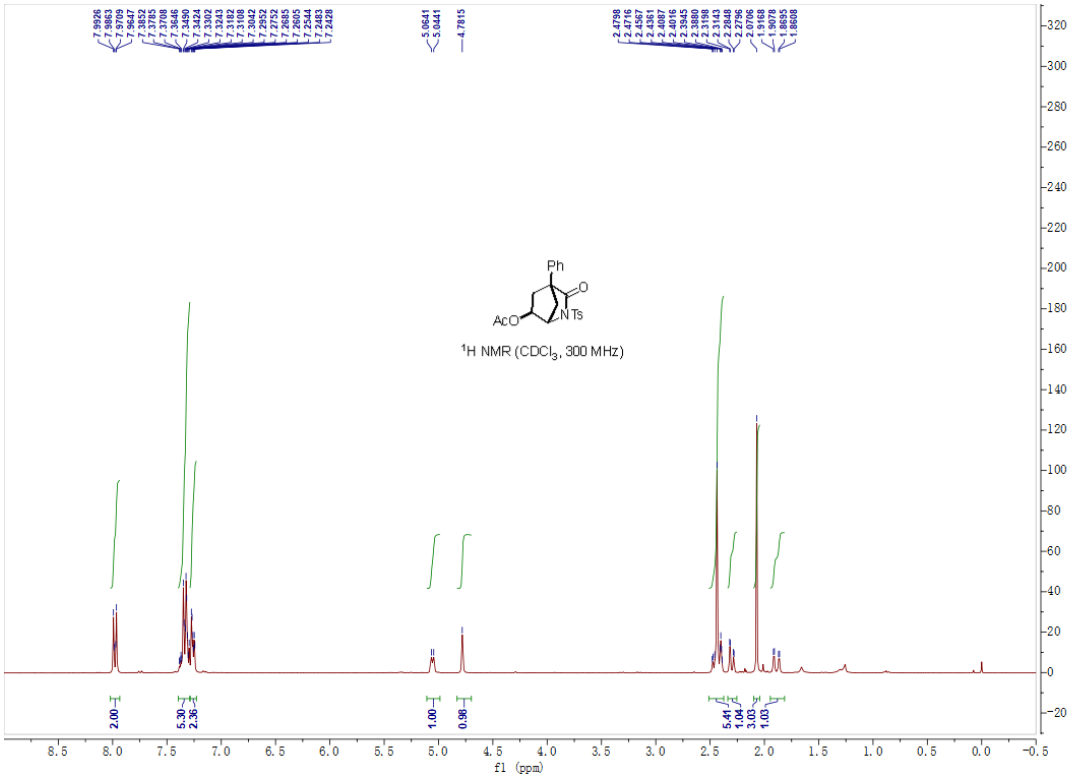


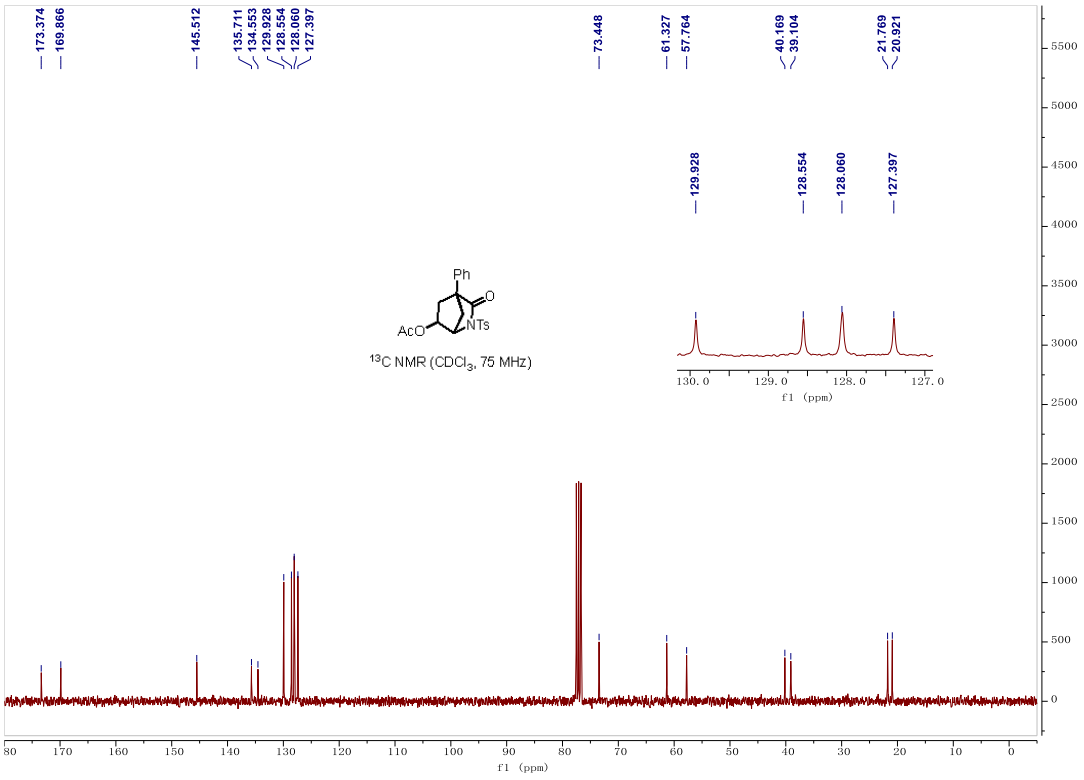
6-ethoxy-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (8)



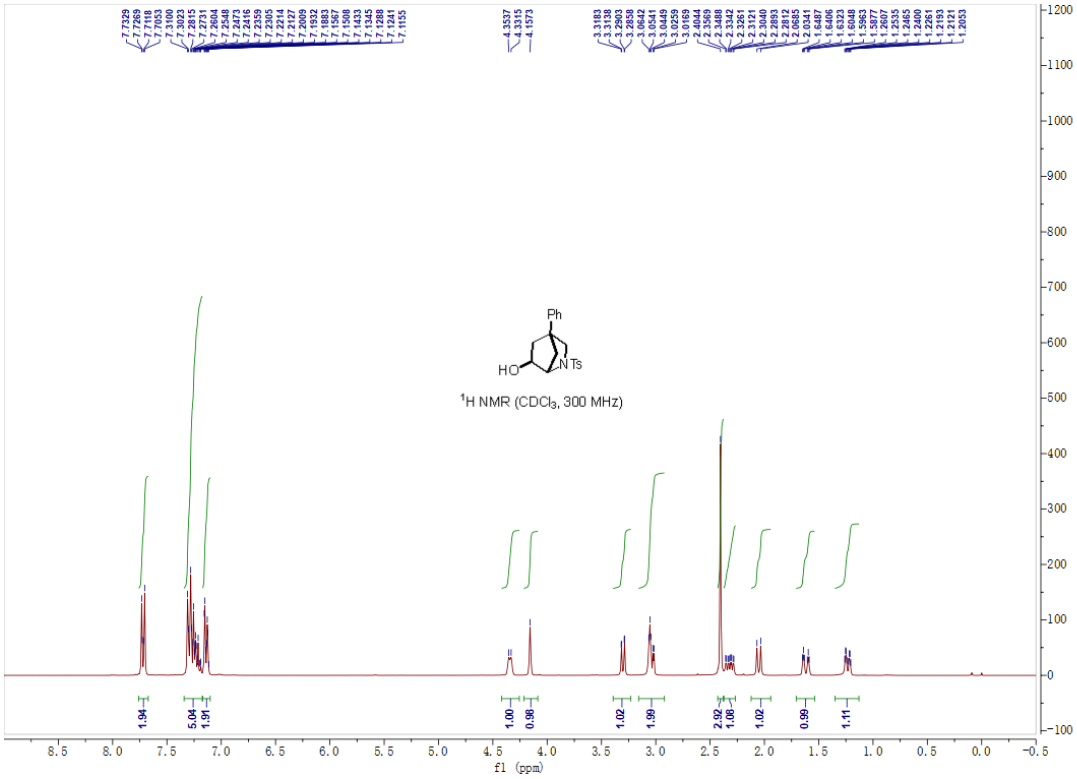


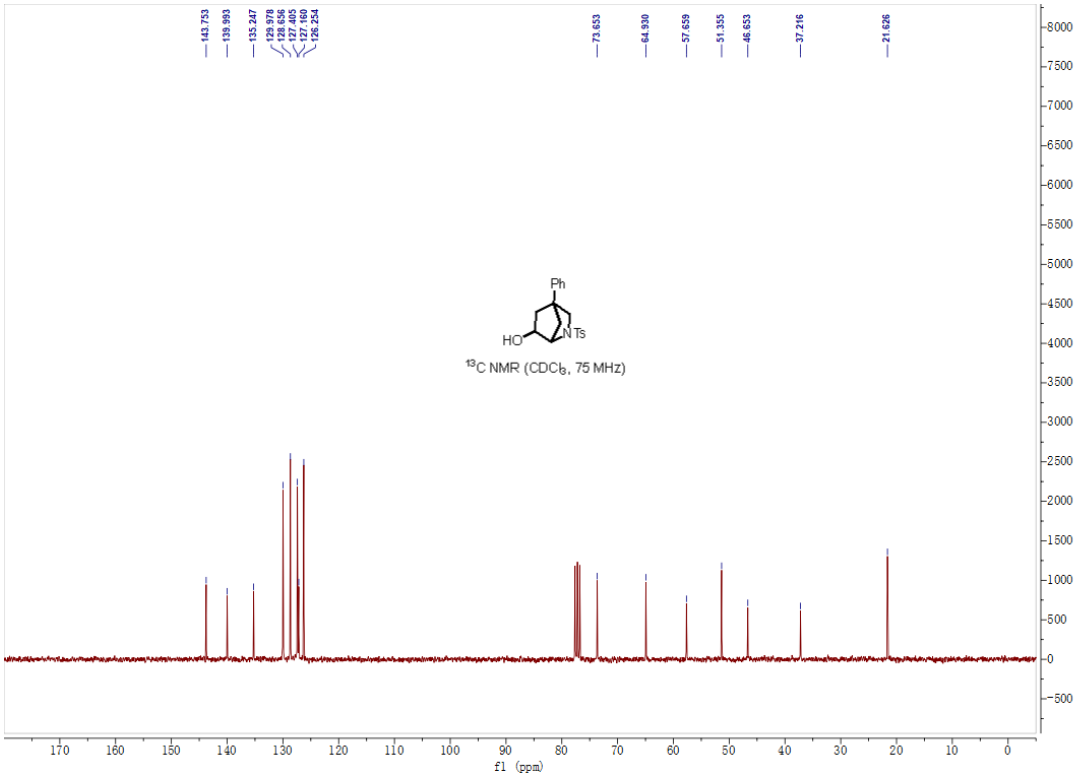
3-oxo-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl acetate (9)



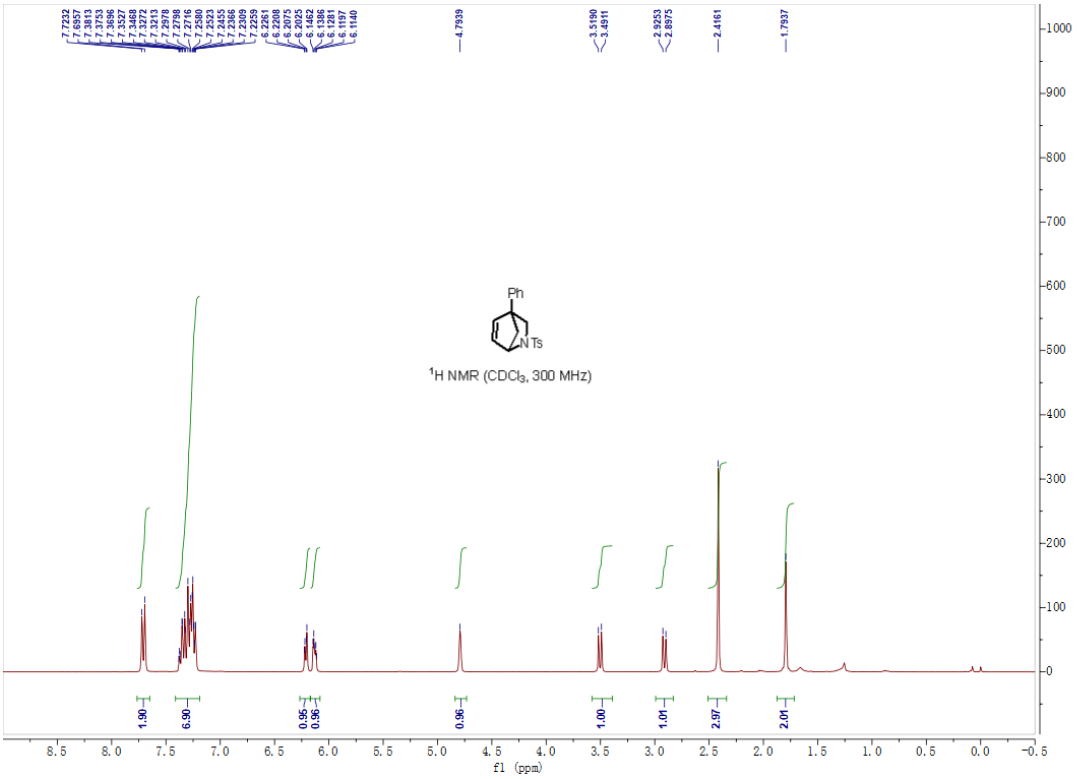


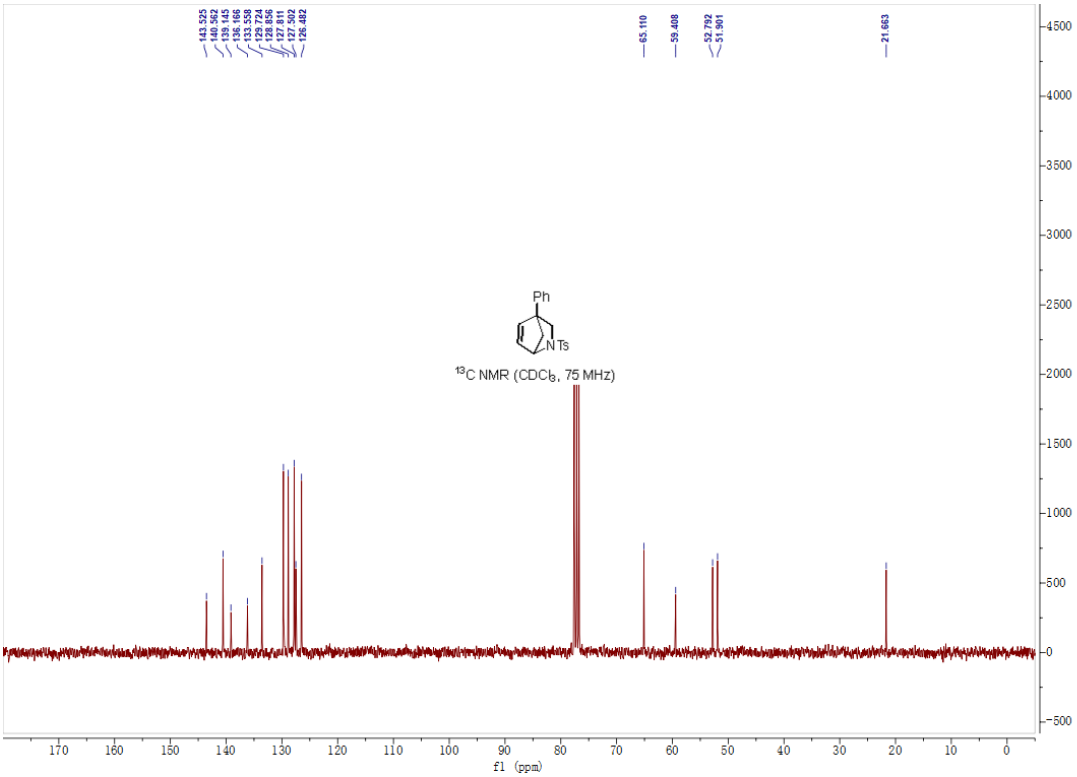
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-ol (10)



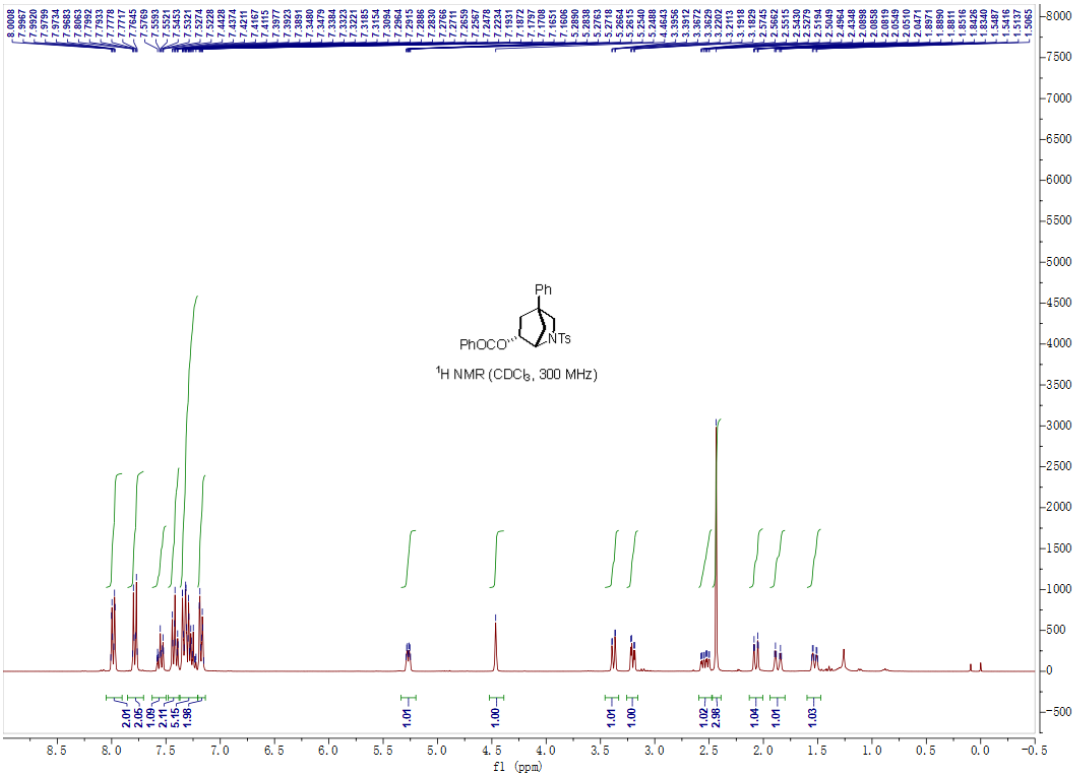


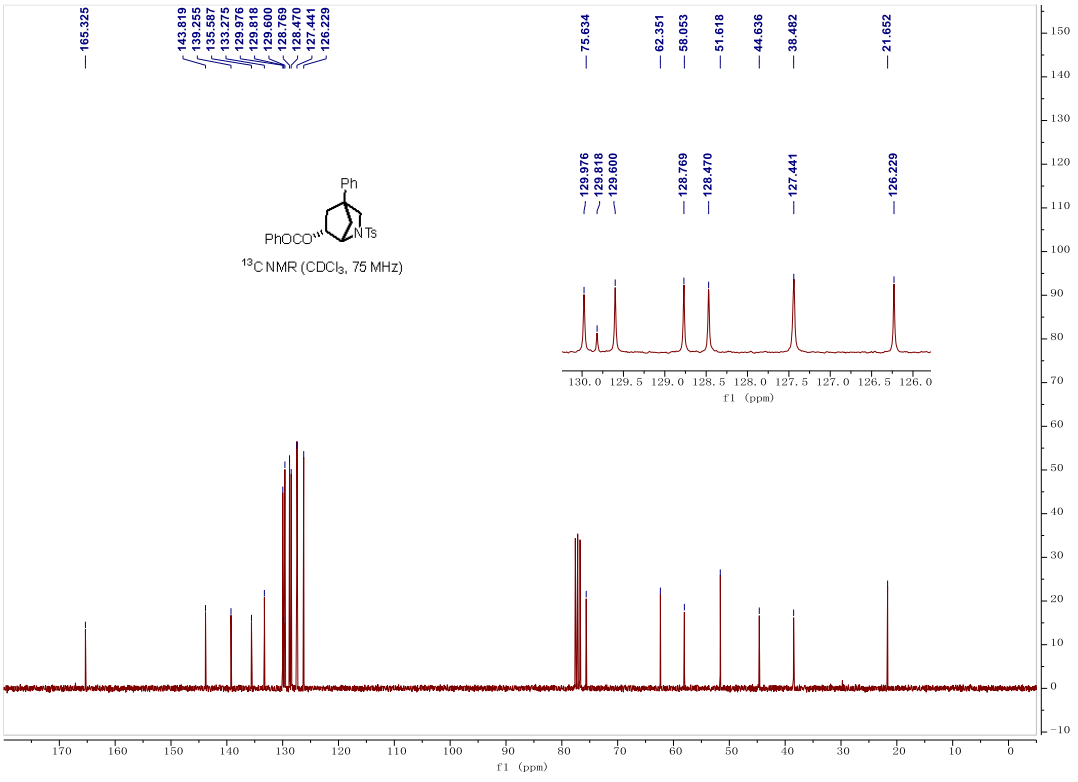
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]hept-5-ene (11)



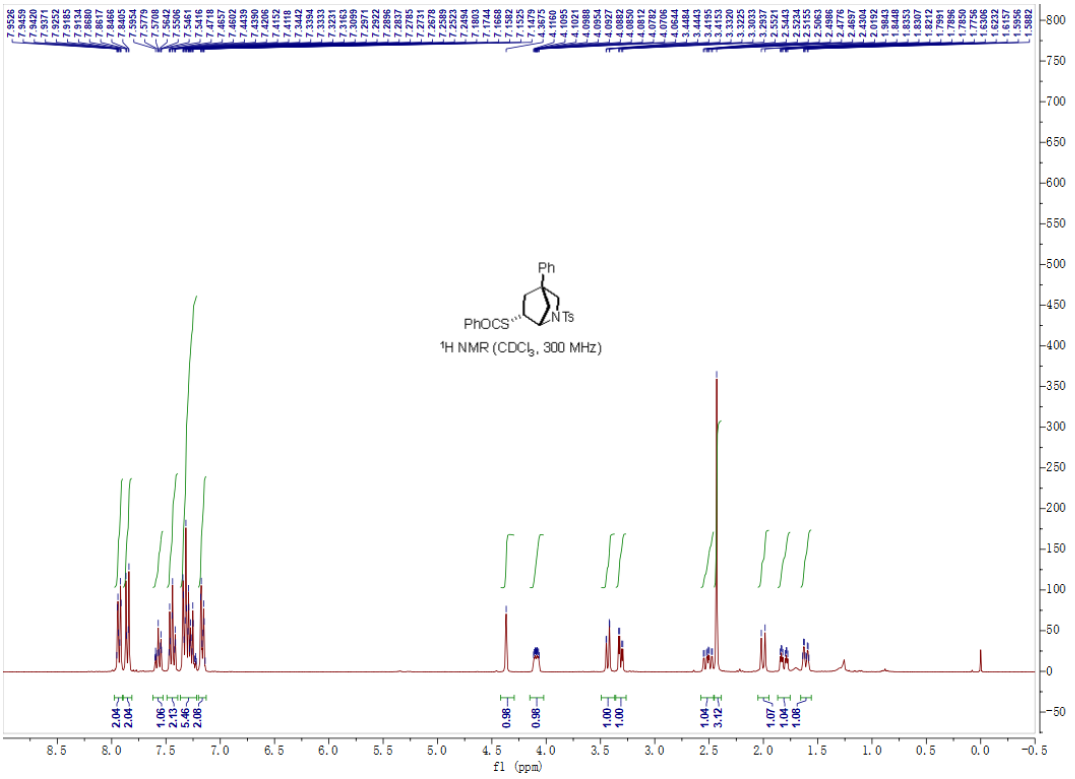


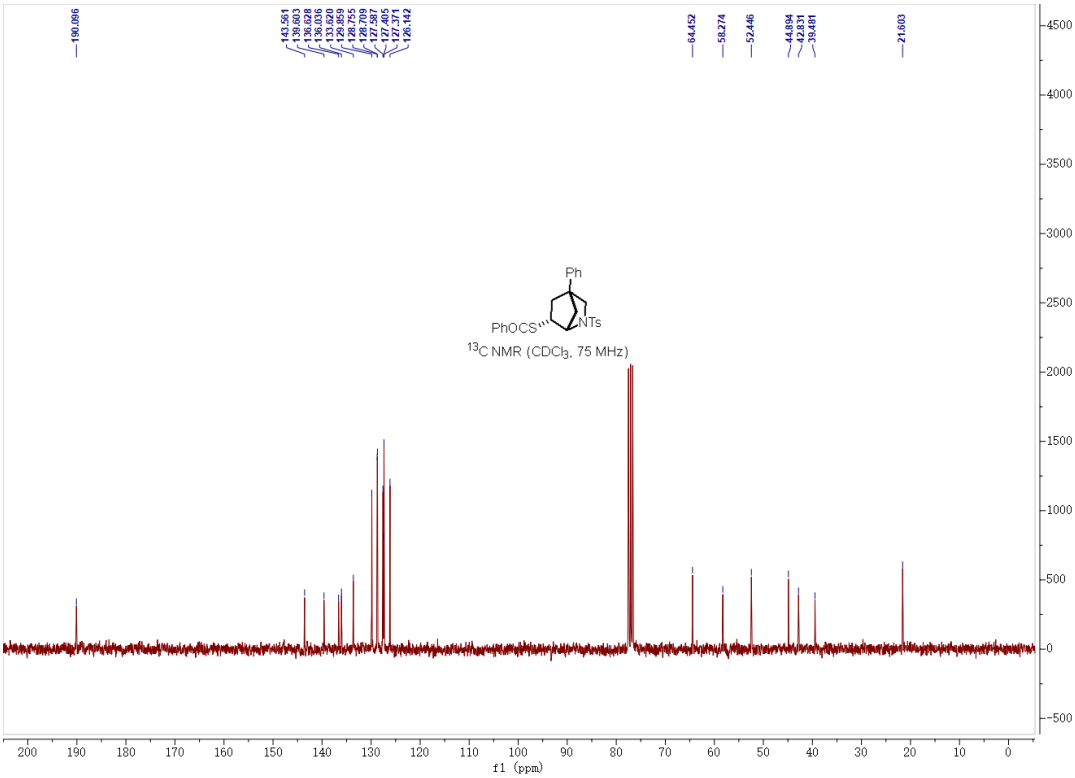
endo-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl benzoate (12)



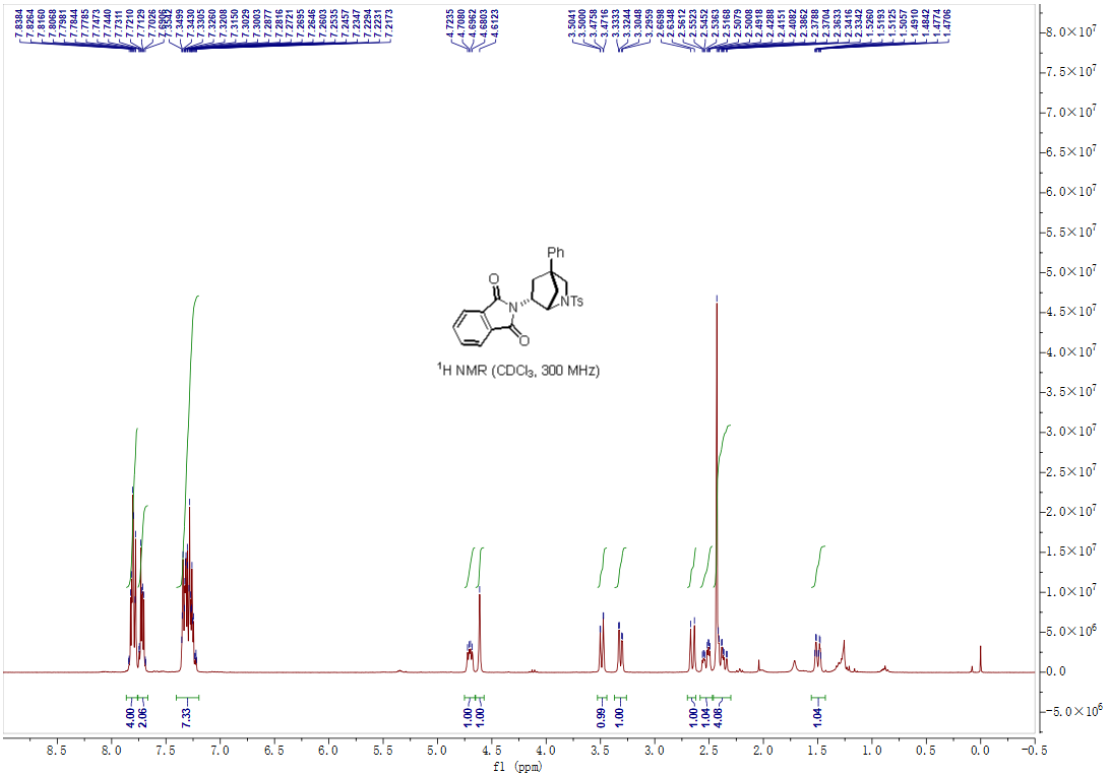


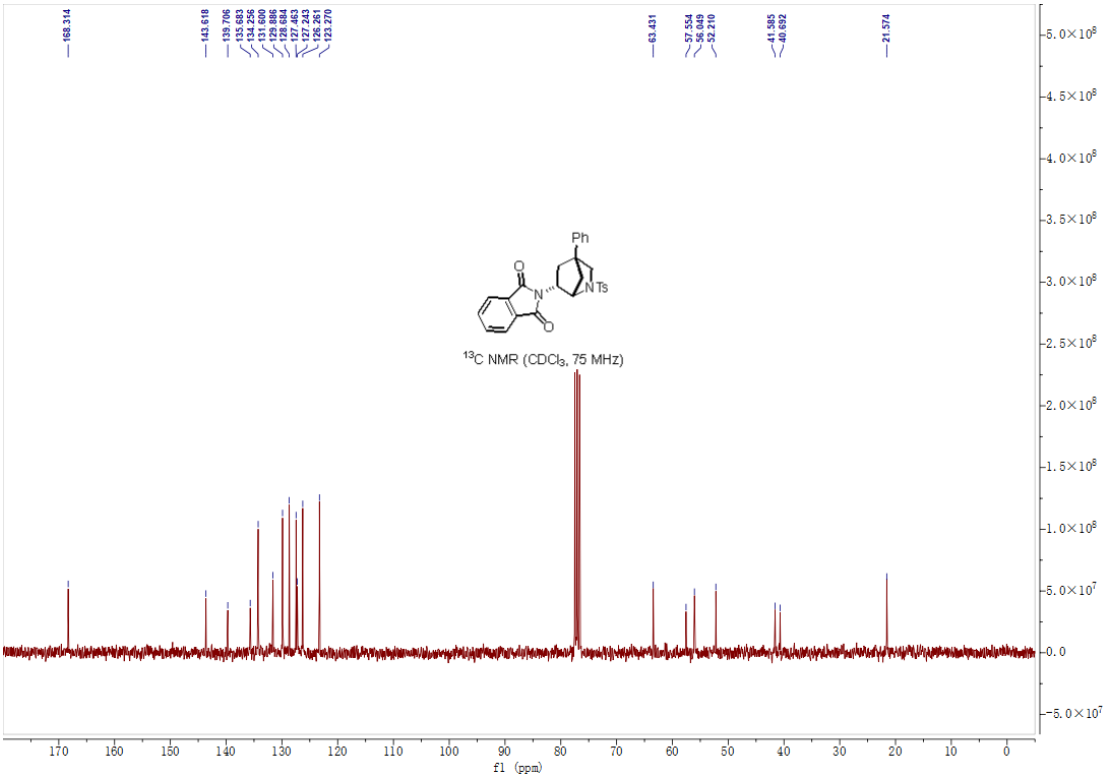
endo-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl) benzothioate (13)



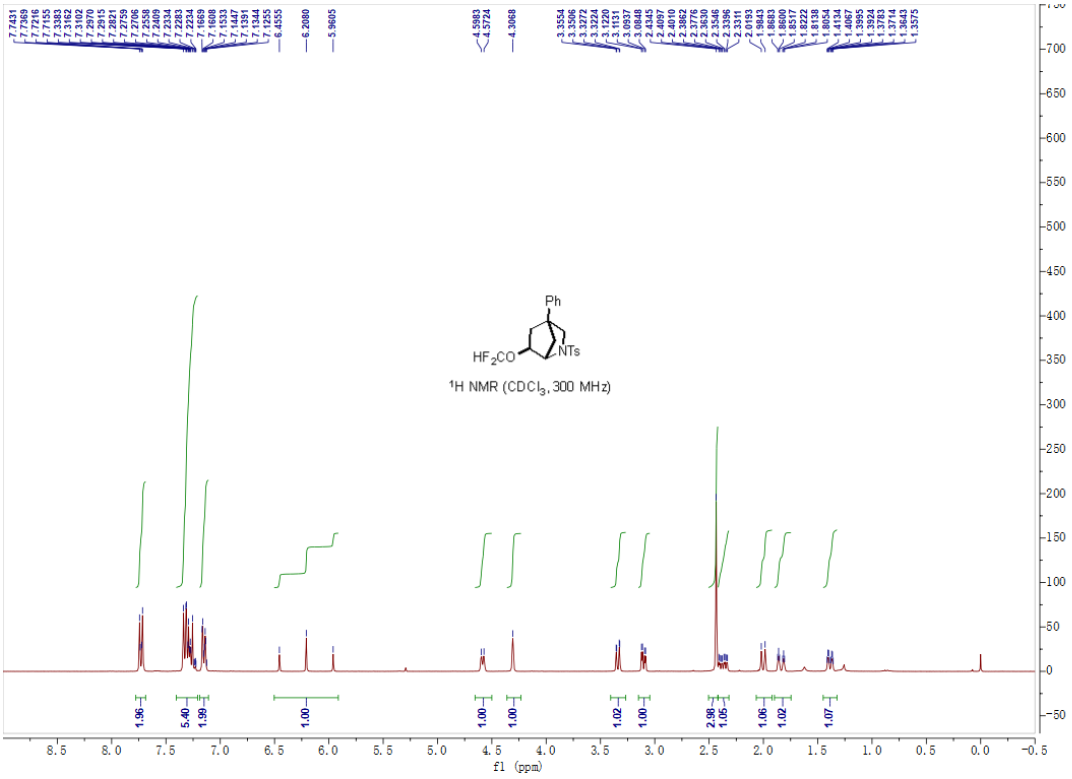


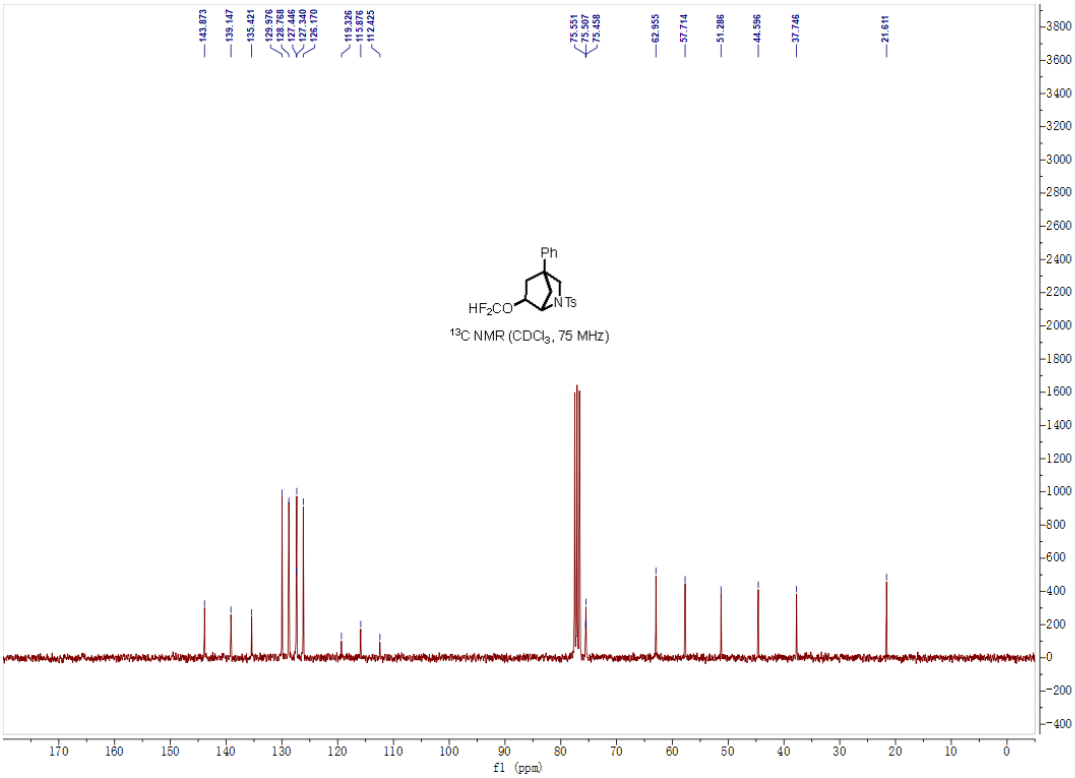
endo-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-yl)isoindoline-1,3-dione (14)

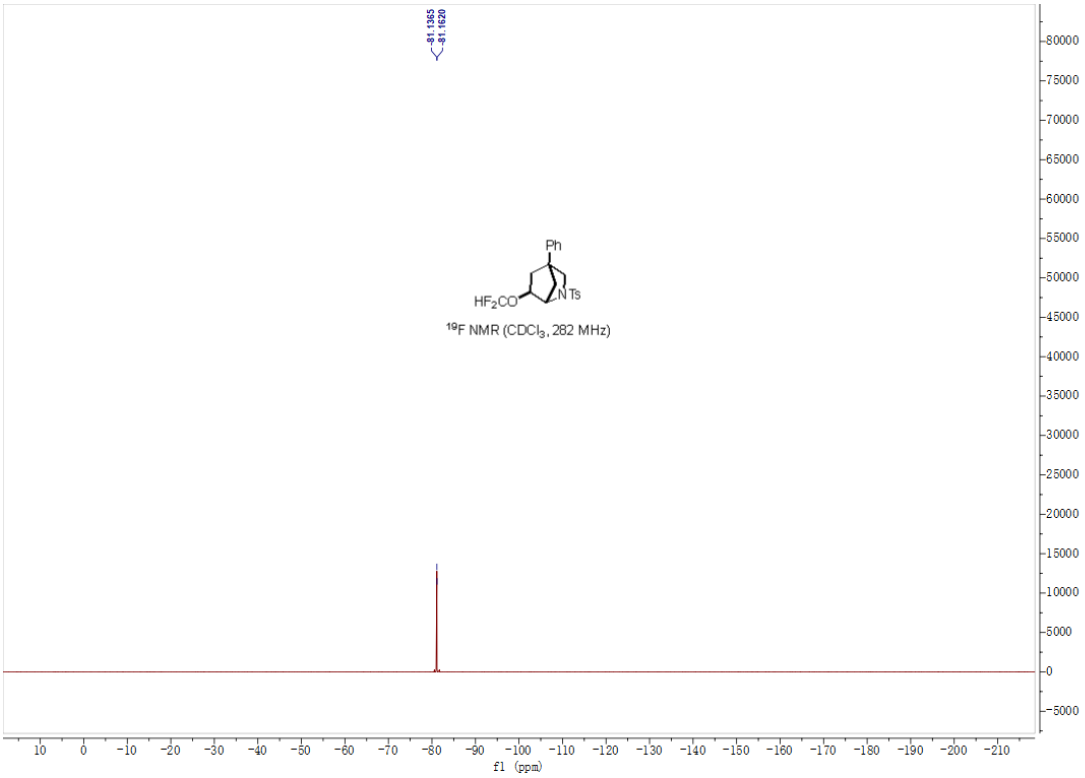




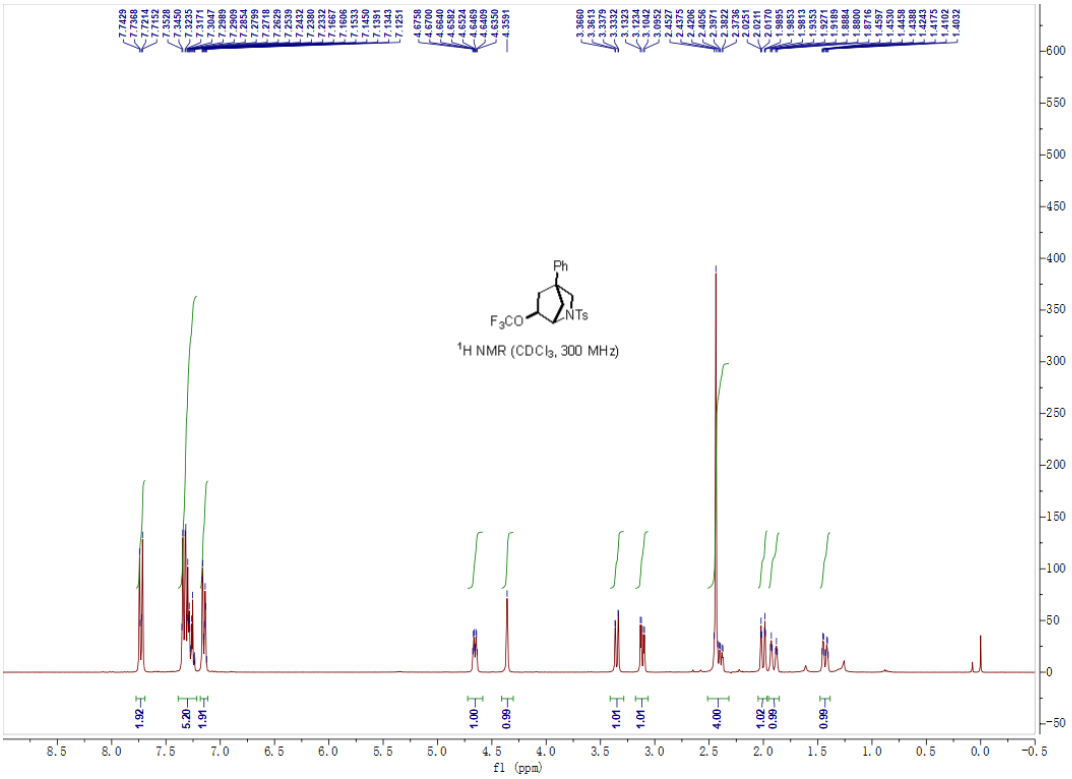
6-(difluoromethoxy)-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (15)

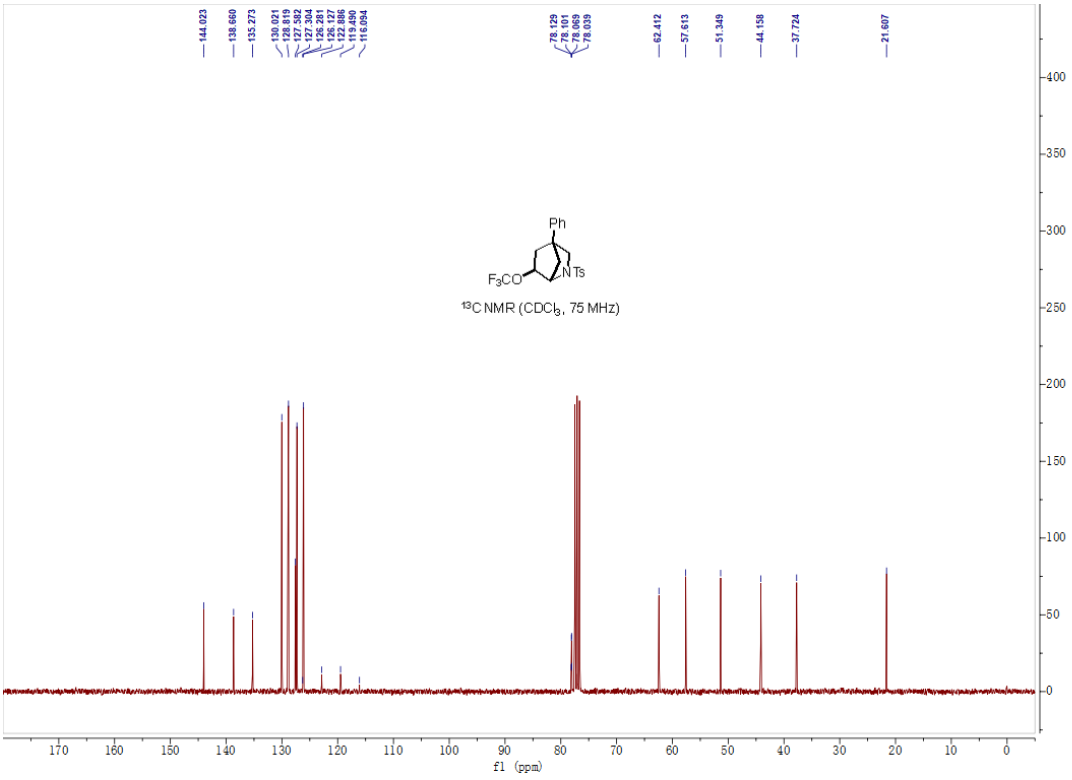


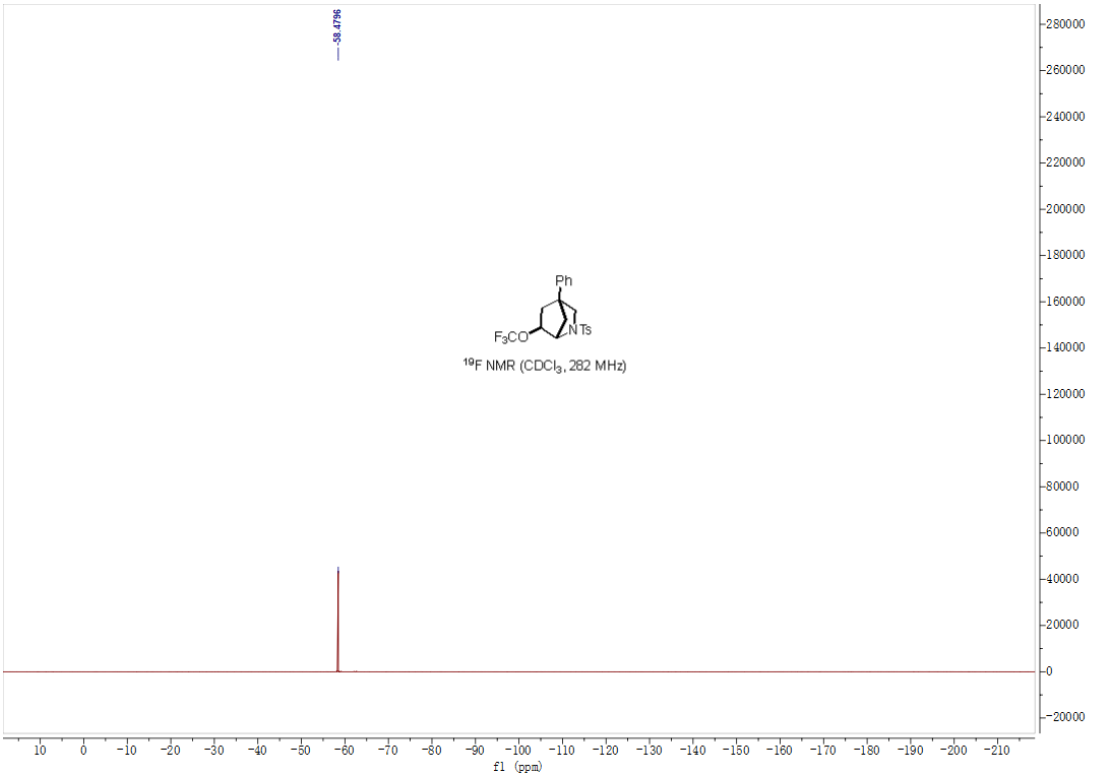



-81.1365
-81.1620
Ph
HF2CO
NTs
19F NMR (CDCl3, 282 MHz)
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

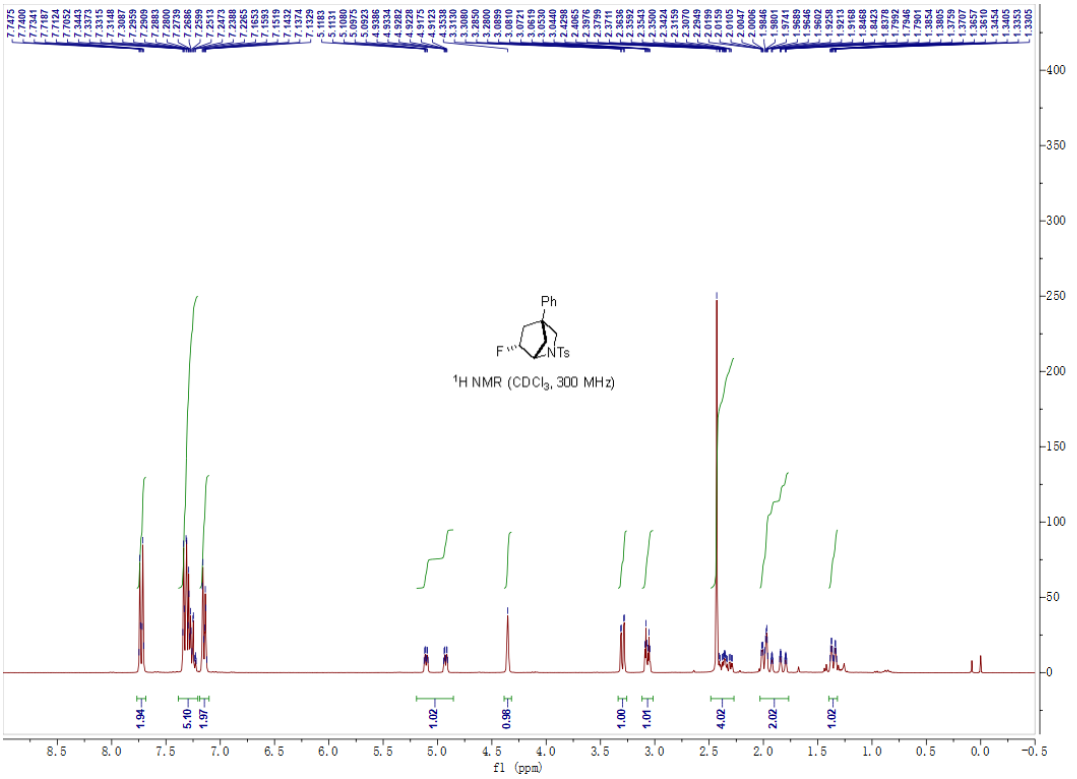
4-phenyl-2-tosyl-6-(trifluoromethoxy)-2-azabicyclo[2.2.1]heptane (16)

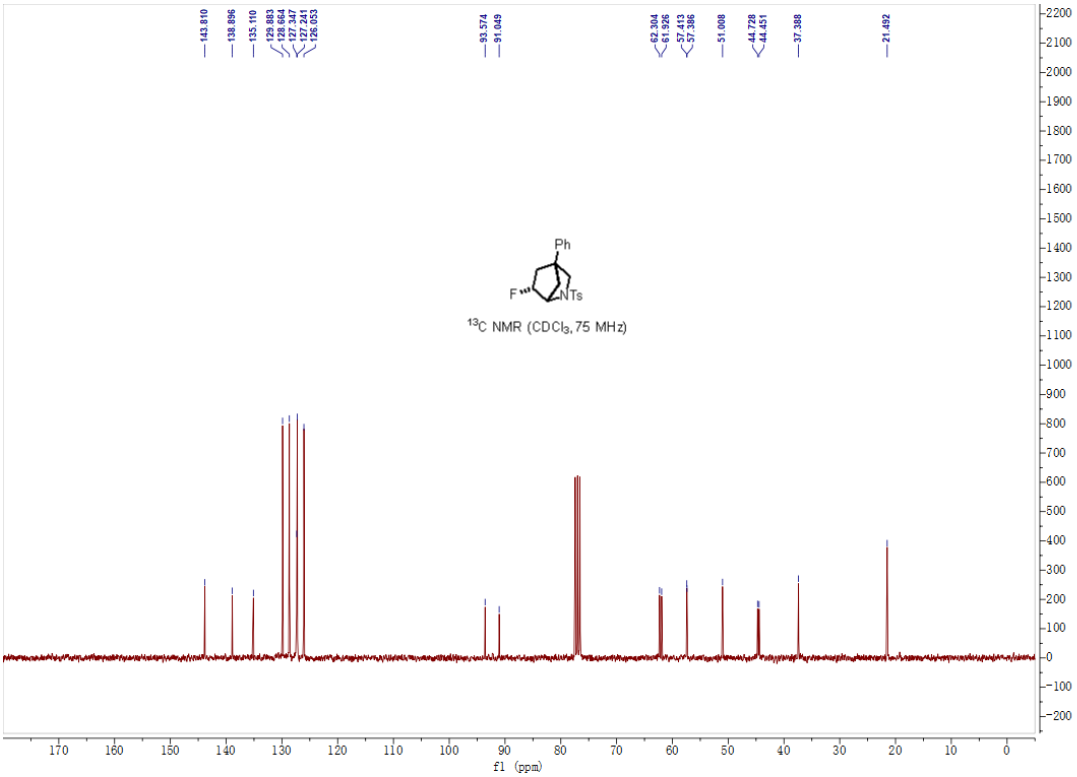


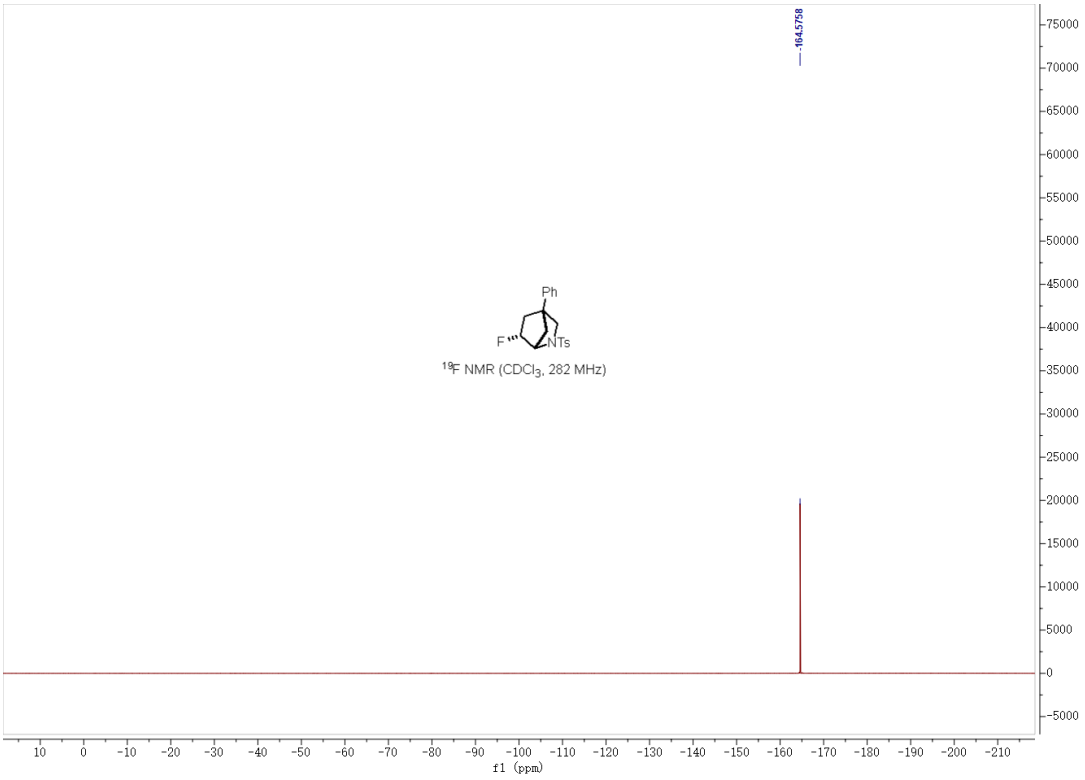



-58.4796
Ph
F3CO
NTs
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

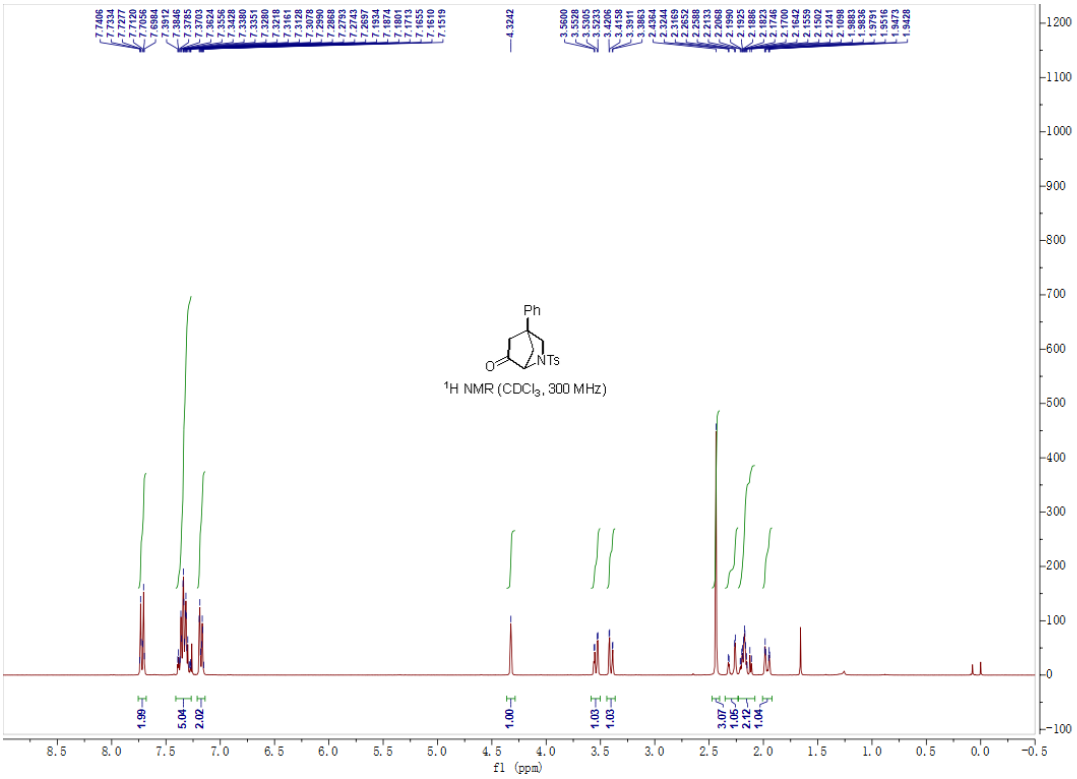
endo-6-fluoro-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (17)

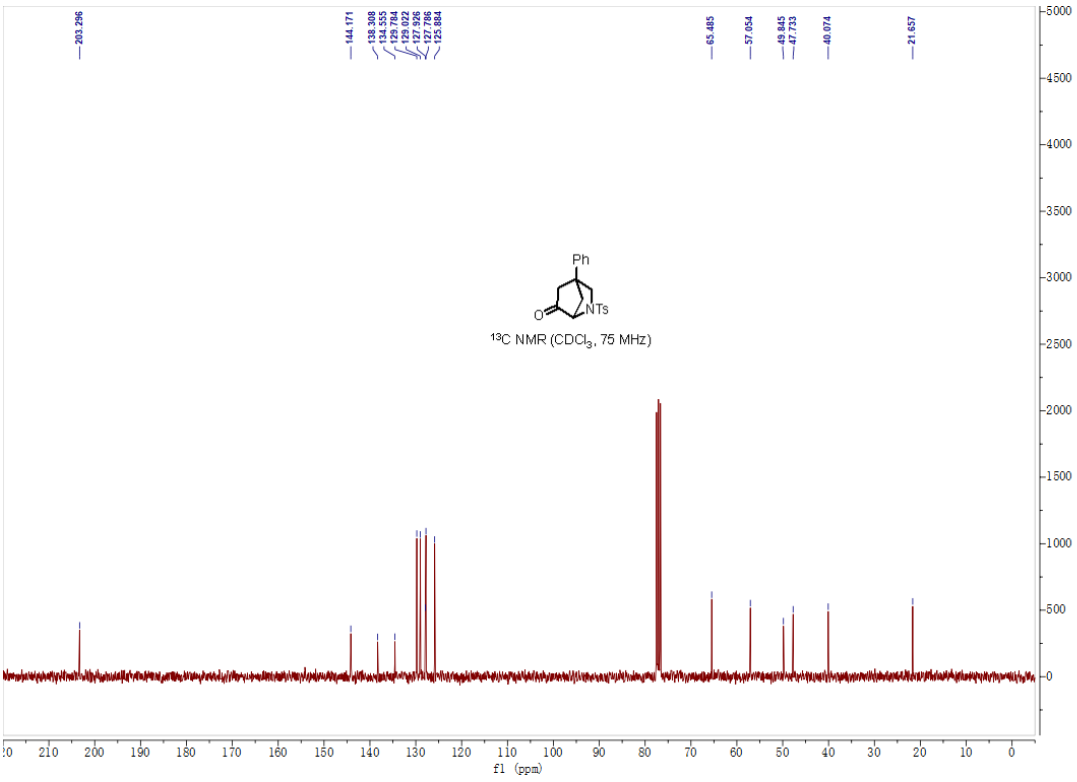




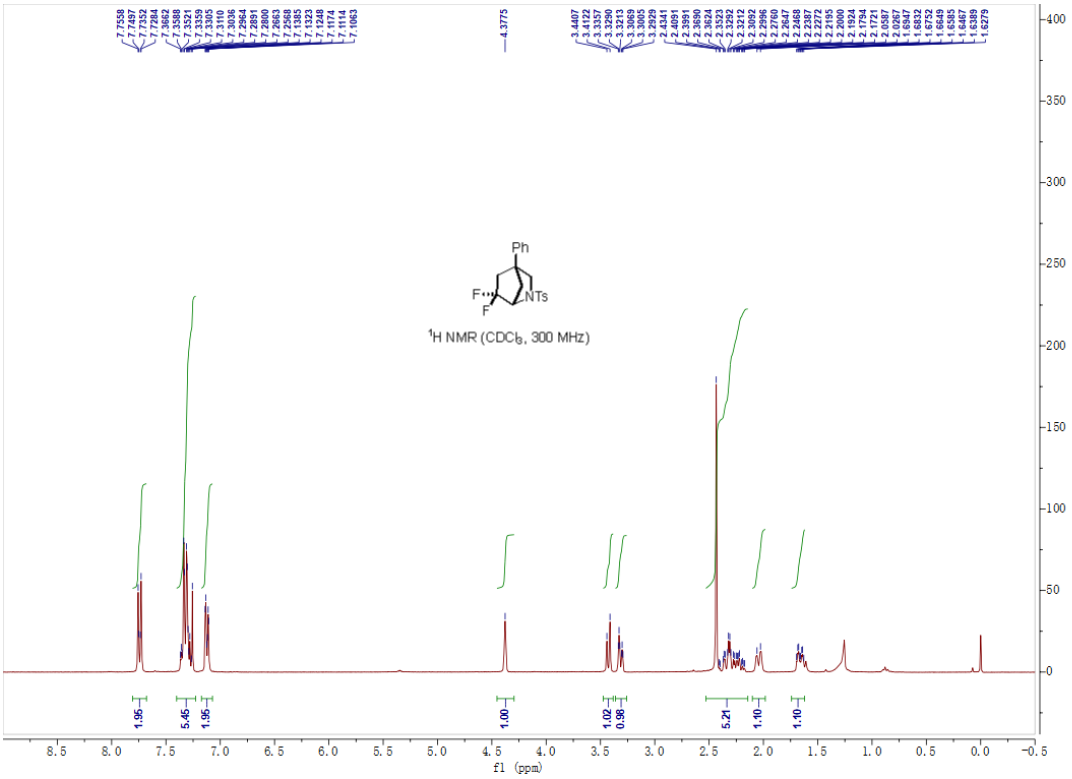

-164.5758
Ph
F
NTs
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

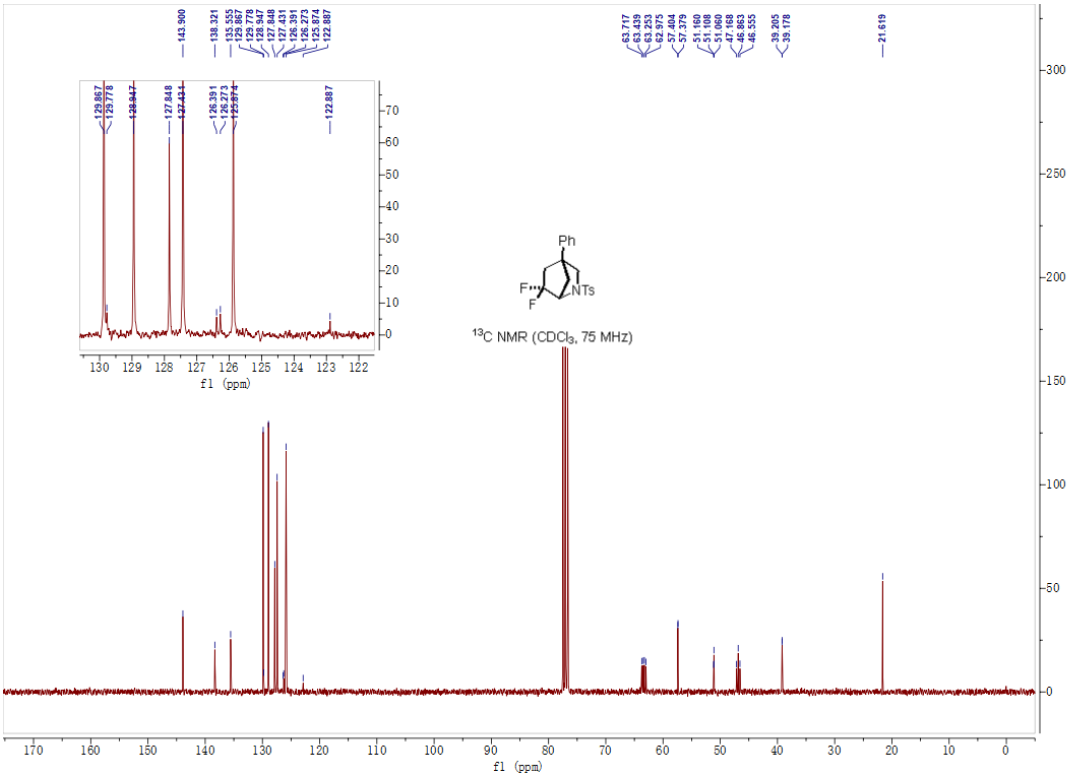
4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptan-6-one (18)

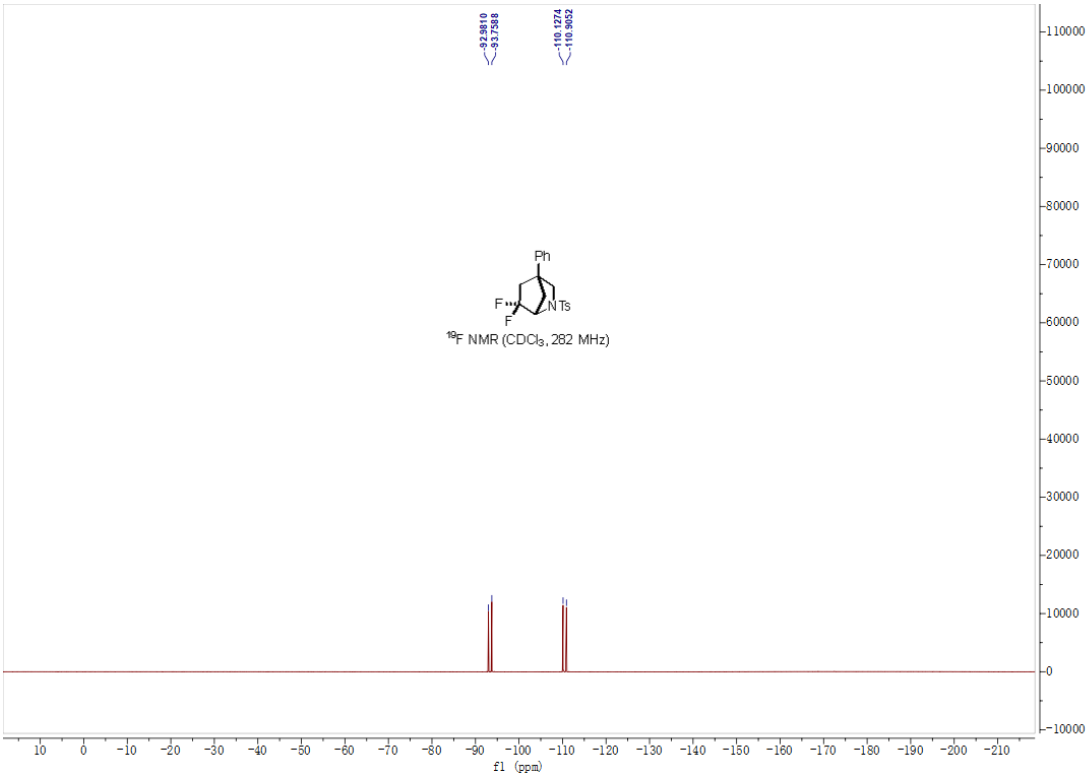




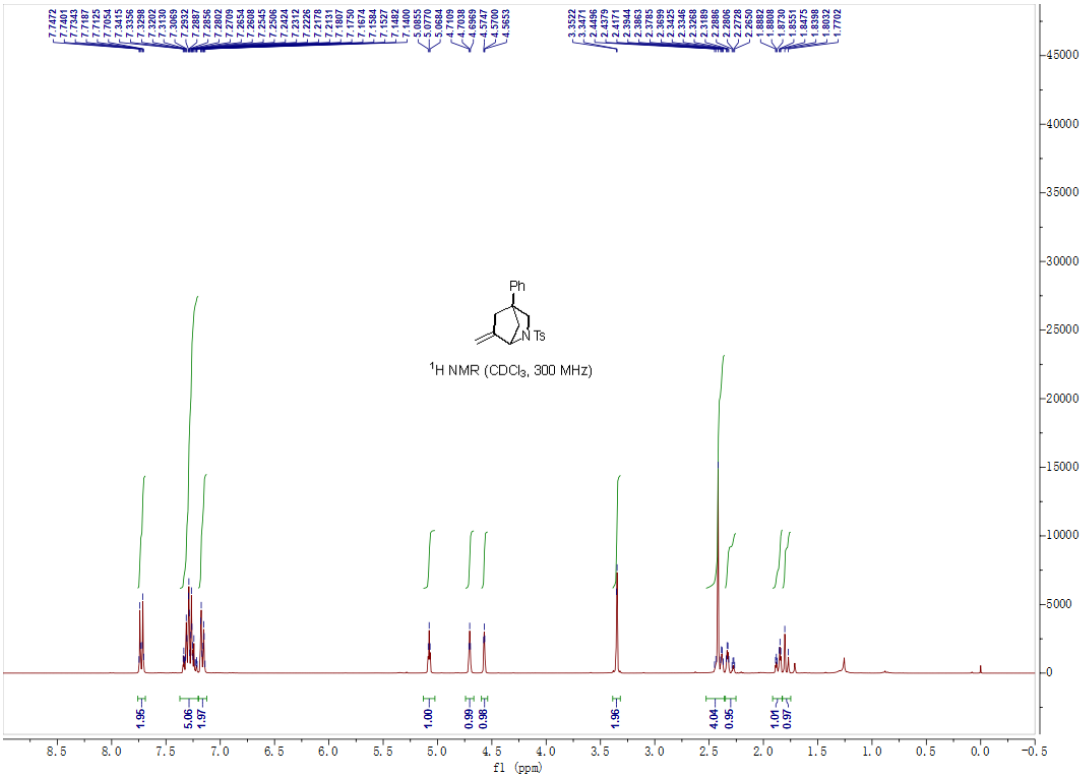
6,6-difluoro-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (19)

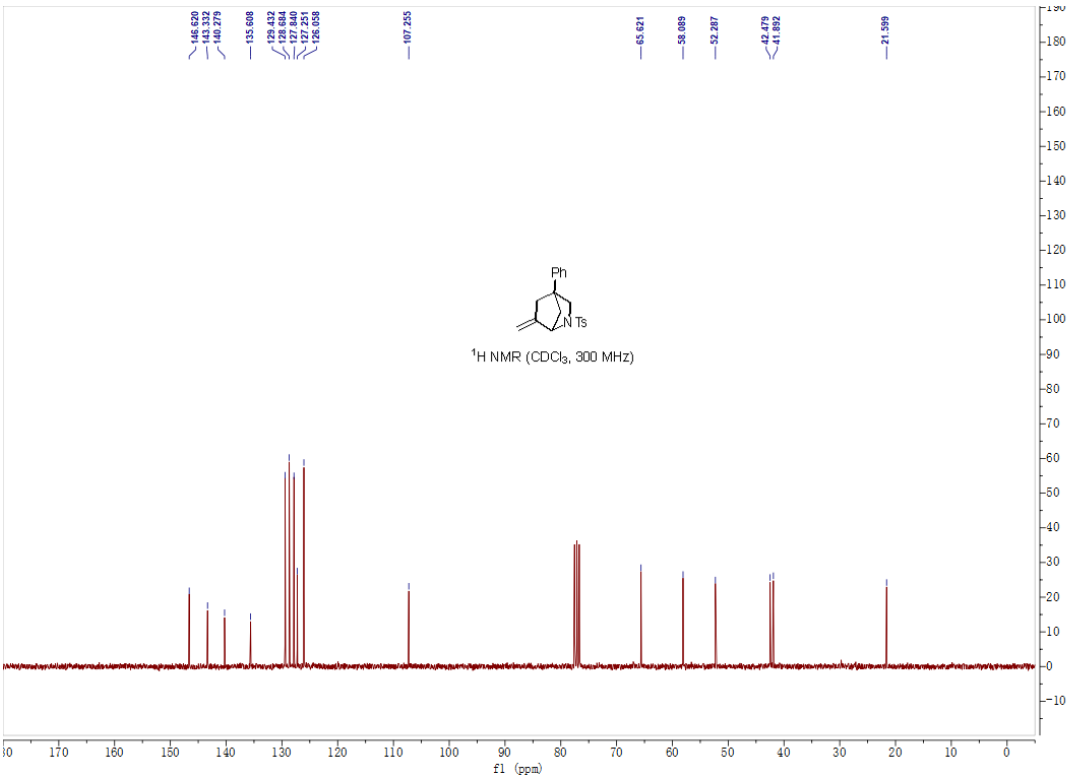




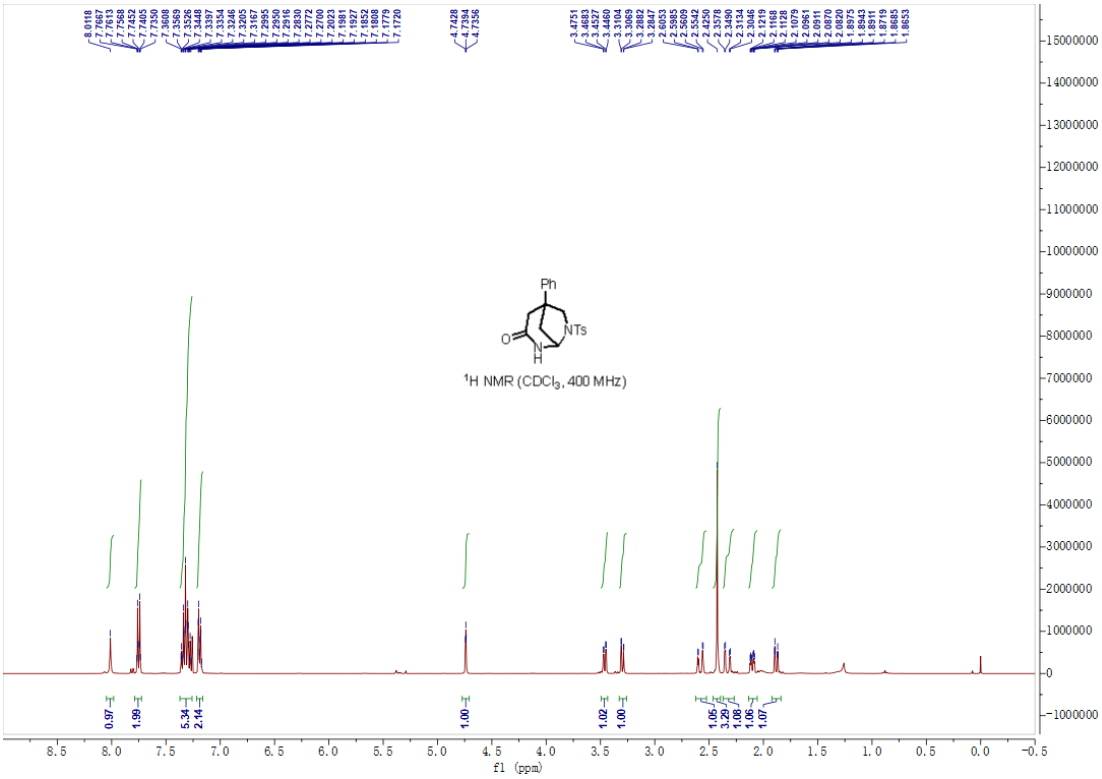

-92.9810
-93.7588
-110.1274
-110.9052
Ph
F
F
N Ts
19F NMR (CDCl3, 282 MHz)
f1 (ppm)

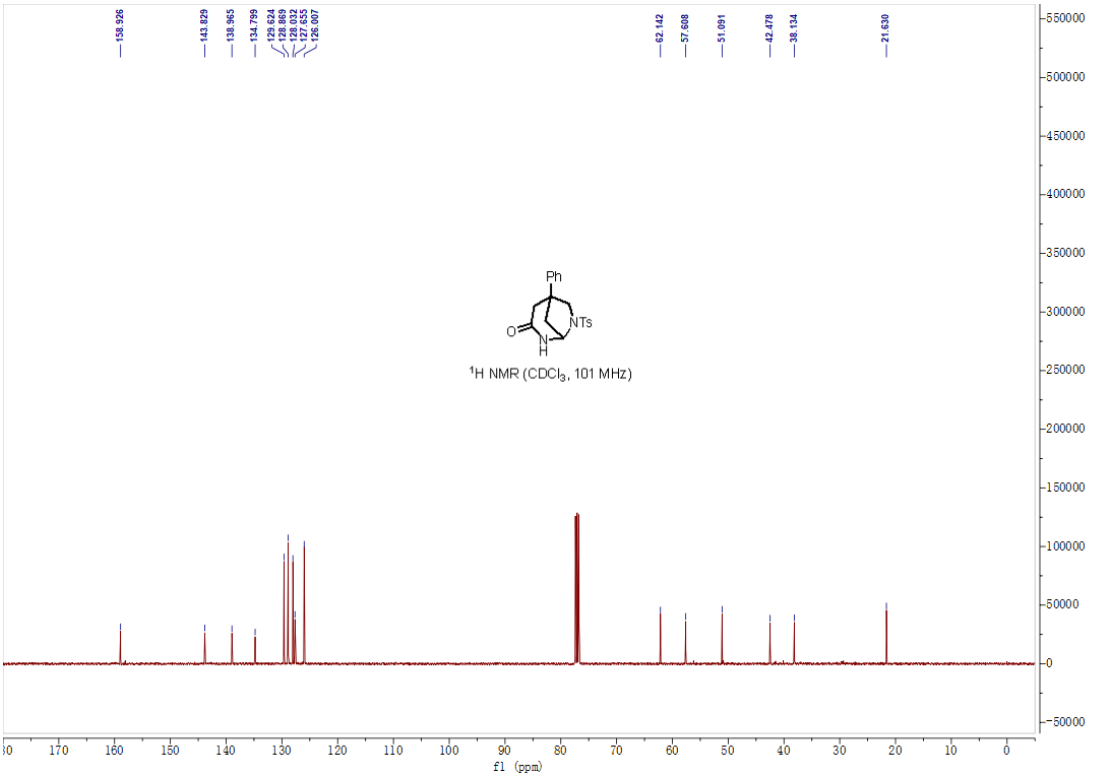
6-methylene-4-phenyl-2-tosyl-2-azabicyclo[2.2.1]heptane (20)



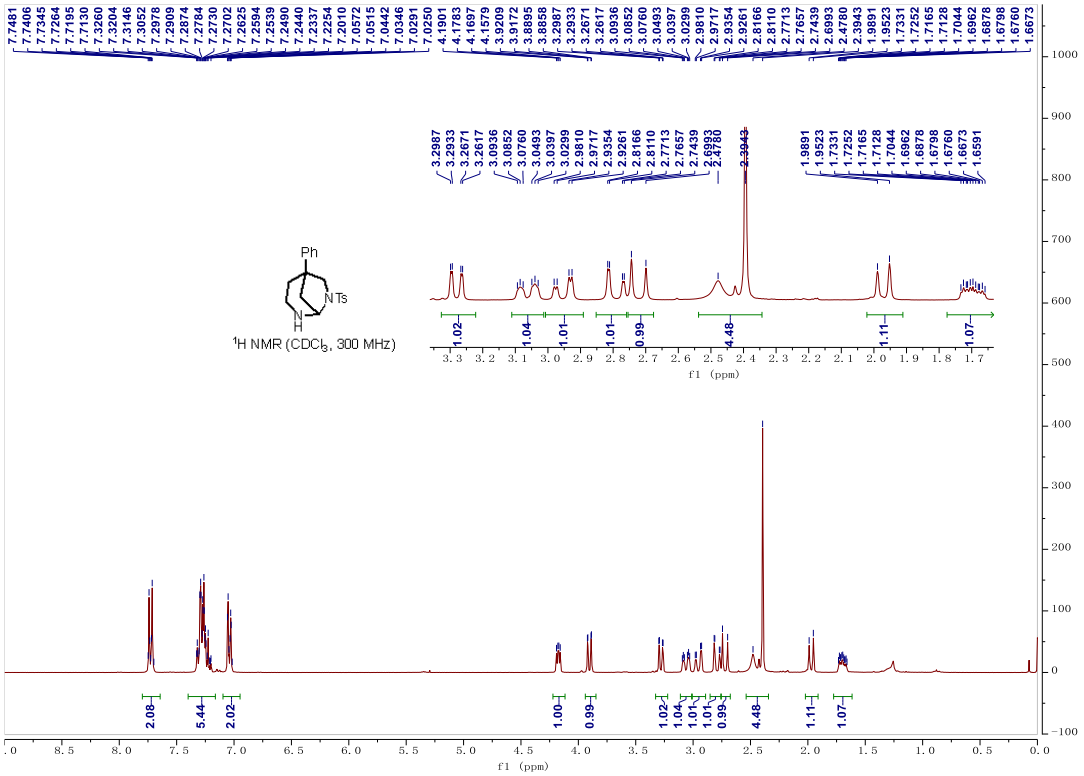


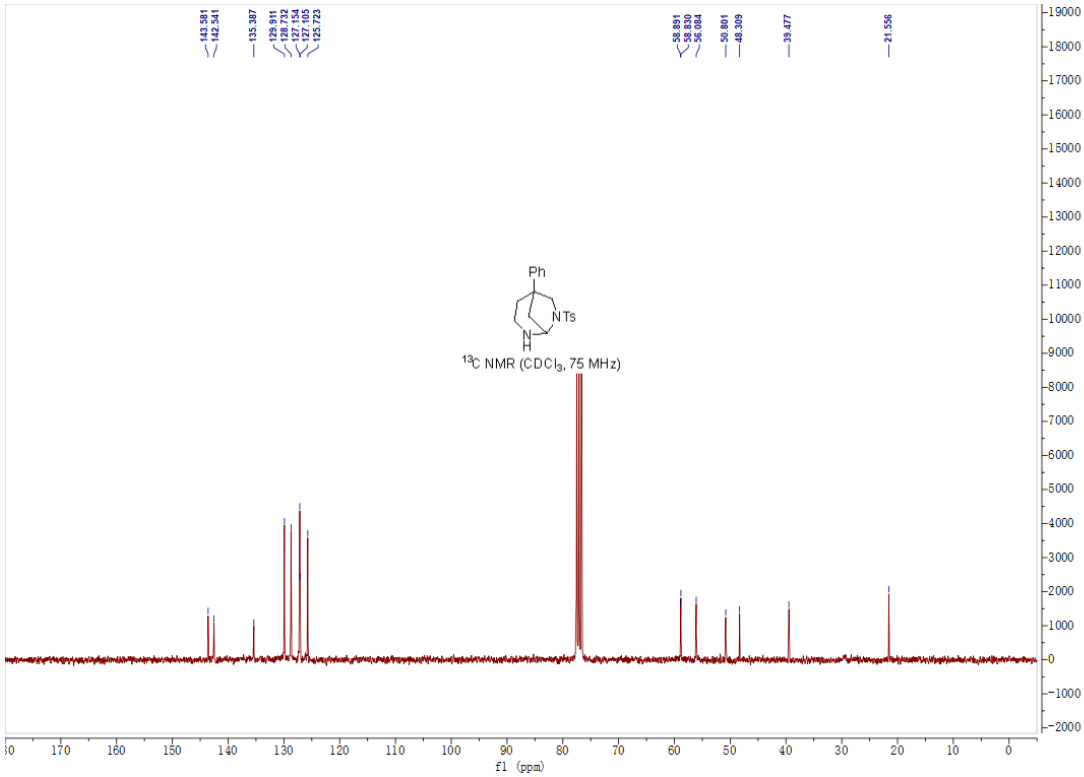
5-phenyl-7-tosyl-2,7-diazabicyclo[3.2.1]octan-3-one (21)





5-phenyl-7-tosyl-2,7-diazabicyclo[3.2.1]octane (22)





5-phenyl-7-tosyl-2-oxa-7-azabicyclo[3.2.1]octan-3-one (23)