Electronic Supplementary Material (ESI) for Chemical Science.

Carbene-Catalyzed Enantioselective Annulation of Dinucleophilic Hydrazones and Bromoenals for Access to Aryl-Dihydropyridazinones and Related Drugs

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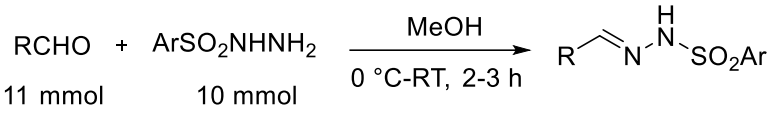
Part 1. General Information

Commercially available materials purchased from TCI or Sigma Aldrich were used as received. All reactions were carried out under nitrogen atmosphere with dry solvents under anhydrous conditions, unless otherwise noted. Ethyl acetate was dried by Na_2SO_4 and THF was distilled from sodium-benzophenone. Flash chromatography was performed using silica gel (200-300 mesh). Reactions were monitored by thin layer chromatography (TLC). Visualization was achieved under a UV lamp (254nm and 365 nm). ^{1}H, ^{13}C, and ^{19}F NMR were recorded on Bruker BBFO 400 MHz NMR, Bruker AV400 MHz NMR, Bruker AV300 MHz NMR Bruker AV500 MHz NMR spectrometer with tetramethylsilane as the internal standard and were calibrated using residual undeuterated solvent ($CDCl_3$: ^{13}C NMR = 77.16; CD_3OD: ^{13}C NMR = 49.00, ^{1}H NMR = 3.31) and tetramethylsilane (^{1}H NMR = 0.00) as internal references. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, dd = doublet of doublet t = triplet, q = quartet, m = multiplet, br = broad. Coupling constants (J) are reported in Hertz (Hz). High Resolution Mass spectra (HRMS) were recorded by using Finnigan MAT 95 XP mass spectrometer (Thermo Electron Corporation). The determination of er was performed via chiral HPLC analysis using Shimadzu LC-20AD HPLC workstation. Optical rotations were measured using a 1 mL cell with a 1 dm path length on a Jasco P-1030 polarimeter and are reported as follows: $[\alpha]_{rt}^{D}$ (c in g per 100 mL solvent). α-Bromoenals[1] were synthesized according to previous literature procedure. Catalyst G[2], H[2], and I[3] were prepared according to the reported procedure.

Part 2. Experimental Section

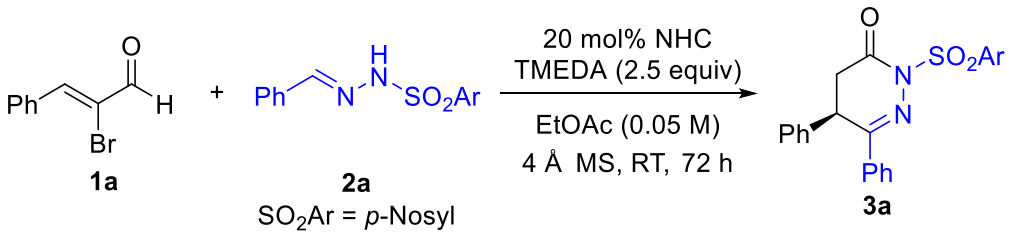
I. General Procedure to Synthesis of Hydrazones (2)

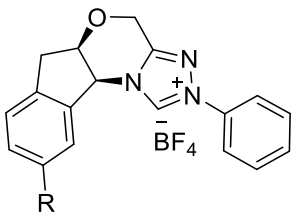


Literature procedure[4] was followed with slight modification. A round-bottom flask equipped with a stirring bar and aldehyde (11 mmol, 1.0 equiv) in MeOH (10 mL) was cooled down to 0 °C and sulfonyl hydrazide (10 mmol, 1.0 equiv) was added. Resulting mixture was stirred at room temperature for 2-3 hours. After the completion of the reaction (monitored by TLC analysis), precipitate was filtered and washed by 10 ml cold MeOH to afford pure hydrazone product in usually >80% yield.

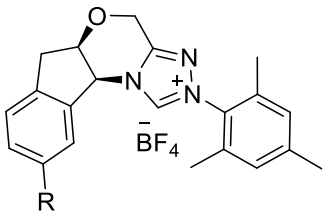
II. Reaction Conditions Optimization

Table S1. NHC Catalysts Screening[a, b]

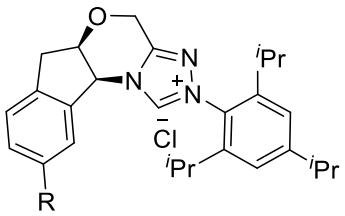




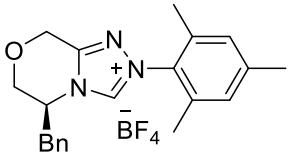
A: R = H; 44%, 78.5:21.5 e.r.
B: R = NO_2; 21%, 90:10 e.r.



C: R = H; 74%, 71:29 e.r.
D: R = Br; 64%, 87:13 e.r.
E: R = NO_2; 72%, 95:5 e.r.



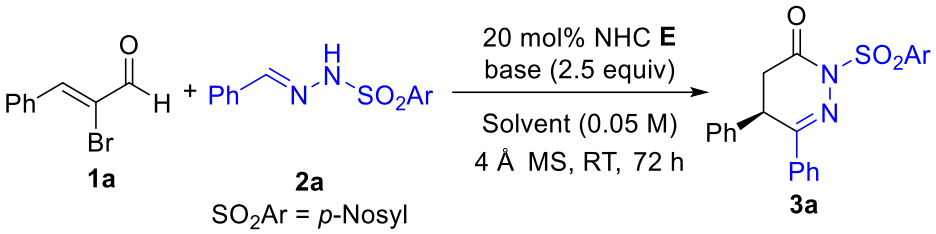
F: R = NO_2; 48%, 89.5:10.5
G: R = Br; 56%, 88:12
H: R = H; 58%, 61:39



I; 83%, 80:20

[a] Reaction condition: **1a** (0.1 mmol.), **2a** (0.05 mmol), **NHC** pre-cat. (20 mol%), TMEDA (2.5 equiv), EtOAc (0.05 M), MS (100 mg/ml) at RT for 72 h. [b] Yield determined by ^{1}H NMR, based on **2a**, by using 1,3,5-trimethoxybenzene as internal standard. The e.r. was determined via chiral-phase HPLC analysis. MS = molecular sieves, TMEDA = tetramethylethylenediamine.

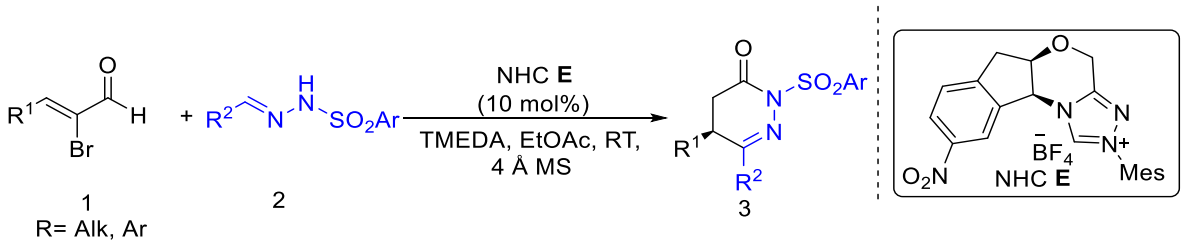
Table S2. Solvents, Bases and Amount of Catalyst Loading Screening[a, b]



Entry	Base	Solvent	Yield (%)	e.r.
1	TMEDA	DCM	51	93:7
2	TMEDA	MTBE	32	94:6
3	TMEDA	Et_2O	54	93:7
4	TMEDA	Tol.	74	93:7
5	TMEDA	PhCl	77	93.5:6.5
6	TMEDA	Dioxane	56	92.5:7.5
7	TMEDA	EtOAc	72	95:5
8	K_2CO_3	EtOAc	72	94:6
9	K_3PO_4	EtOAc	67	93.5:6.5
10	Cs_2CO_3	EtOAc	90	93:7
11	DABCO	EtOAc	83	93.5:6.5
12	DIPEA	EtOAc	64	94:6
13	DMAP	EtOAc	-[c]	-[c]
14[d]	TMEDA	EtOAc	72(**71**)	**95:5**
15[e]	TMEDA	EtOAc	57	95:5
16[f]	TMEDA	EtOAc	52	95.5:4.5

[a] Reaction condition: **1a** (0.1 mmol.), **2a** (0.05 mmol), Base (2.5 equiv), Solvent (.05 M), MS (100 mg/ml) at RT for 72 h. [b] Yield determined by ^{1}H NMR, based on **2a**, by using 1,3,5-trimethoxybenzene as internal standard. The e.r. was determined via chiral-phase HPLC analysis. [c] No cyclization product was detected. Only direct amide formation was detected. [d] 10 mol% NHC **E** and 0.075 mmol of **1a** were used. The yield in the parenthesis is the isolated yield. [e] 5 mol% NHC **E** was used. [f] 1 mol% NHC **E** was used, and the reaction was carried out using 1.0 mmol of **1a** and 0.5 mmol of **2a**. MS = molecular sieves, TMEDA = tetramethylenediamine.

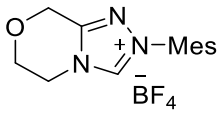
III. General Procedure for the Catalytic Reactions of Bromoenals (1) with Hydrazones (2) to Synthesize Product 3



A dry test tube with a stir bar was charged with bromoenal **1** (0.15 mmol, 1.5 equiv), hydrazone **2** (0.1 mmol, 1.0 equiv), NHC **E** (4.6 mg, 10 mol%), and molecular sieves (100 mg/ml solvent). The tube was evacuated and refilled with nitrogen for three times in a well manner. Then the mixture was dissolved in ethyl acetate (0.05 M). The reaction mixture

was cooled down to 0 °C and TMEDA (37.5 μL, 2.5 equiv) was added via a microliter syringe and stirred at room temperature for 72-84h until the hydrazone **2** was consumed completely (monitored by TLC). After the reaction was finished, the mixture was concentrated under vacuum and purified by column chromatography on silica gel (Hexane:EtOAc = 7:3 to 6:4 or Hexane:DCM = 6:4 to 3:7) to afford desired product **3**, which was confirmed by ^{1}H NMR, ^{13}C NMR, and ^{19}F NMR spectra, and the enantiomeric ratio was determined by chiral HPLC.

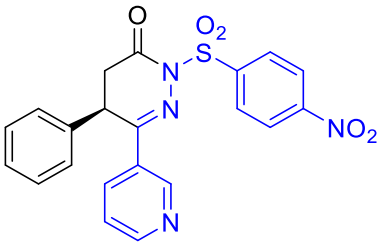
Note: Racemic samples for chiral phase HPLC analysis were prepared using NHC below as the NHC pre-catalyst according to the procedure as above.



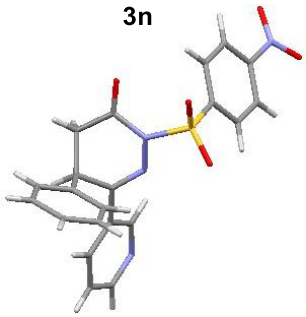
Achiral NHC

IV. Absolute Structure Determination

Product **3n** was crystallized as a colourless crystal via vaporization of a $CDCl_3$ solution, and its absolute configuration was determined by x-ray structure analysis. ***CCDC 2062761*** contains the supplementary crystallographic data that can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* www.ccdc.cam.ac.uk/data request/cif.

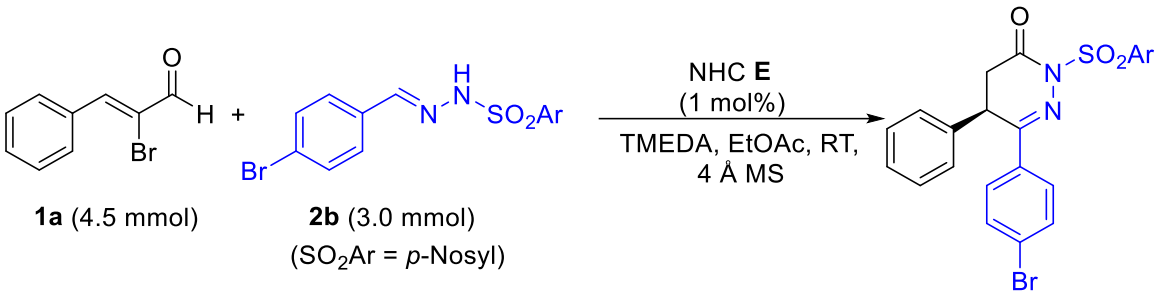


3n



3n

V. Procedure for Gram Scale Synthesis of 3b



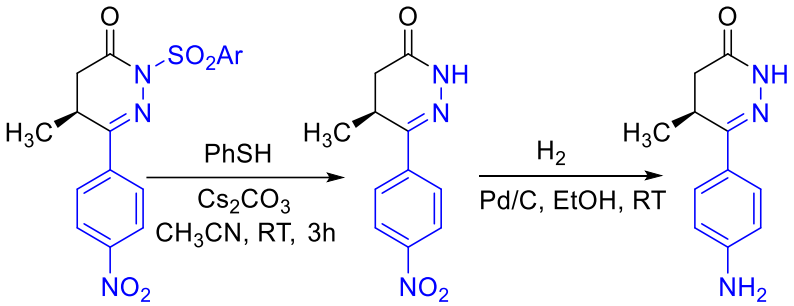
1a (4.5 mmol) **2b** (3.0 mmol)
(SO_2Ar = *p*-Nosyl)

3b: 65%, 99.5:0.5 e.r.

A dry 250 ml round bottom flask equipped with a stirring bar was charged with α-bromo cinnamaldehyde (**1a**) (949.8 mg, 4.5 mmol, 1.5 equiv), N'-(4-bromobenzylidene)-4-nitrobenzenesulfonohydrazide (**2b**) (1.1 g, 3.0 mmol, 1.0 equiv), NHC **E** (14.1 mg, 1 mol%), and molecular sieves (100 mg/ml solvent). The flask was evacuated and refilled with nitrogen for three times in a well manner. Then the mixture was dissolved in EtOAc (0.05 M). The reaction mixture was cooled down to 0 °C and TMEDA was added via a syringe (1.15 ml, 7.5 mmol, 2.5 equiv) and stirred at room temperature for 72-84h untill the hydrazone (**2b**) was consumed completely (monitored by TLC). The mixture was concentrated under vacuum and purified by column chromatography on silica gel (hexane/ethyl acetate = 7:3 to 1:1) to afford desired product **3b** in 74% yield (1.14 g) and 96:4 e.r. value.

VI. Transformation of Products

Scheme T1. Deprotection and Reduction of 4j to Form Levosimendan Precursor 5b



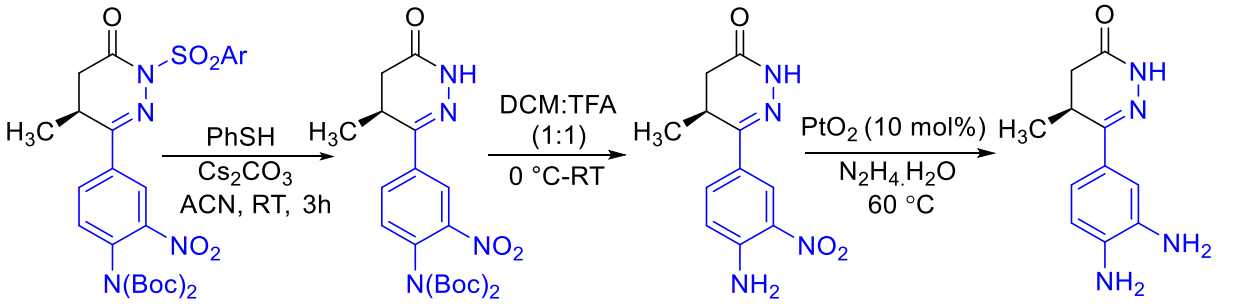
4j: 96:4 e.r. **5a**: 87% yield, 96:4 e.r. **5b:** 85% yield, 96:4 e.r.
Ar= 2-Nitrophenyl

(*S*)-5-methyl-6-(4-nitrophenyl)-4,5-dihydropyridazin-3(2H)-one (**5a**): A dry 10 ml round bottom flask equipped with a stirring bar was charged with **4j** (83.7 mg, 0.2 mmol, 96:4 e.r.), Cs_2CO_3 (228.1 mg, 0.7 mmol) and 5 ml acetonitrile. Then thiophenol (45 µL, 0.44 mmol) was added dropwise via a syringe. The mixture was stirred at room temperature for 3 hours. The reaction mixture was concentrated and purified by silica gel column

chromatography (hexane:ethylacetate = 1:1) to afford the product **5a** (40.6 mg, 87%, 96:4 e.r).

(*S*)-6-(4-aminophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (**5b**): A 10 ml round bottom flask equipped with a stirring bar was charged with **5a** (35 mg, 0.15 mmol, 96:4 e.r.) , 10% Pd on carbon (8.3 mg) and 3 ml ethanol. The resulting suspension was flushed with hydrogen thoroughly and was stirred with a hydrogen balloon for 1h. The crude reaction mixture was filtered through a cellite pad and washed with ethyl acetatate thoroughly. The filtrate was concentrated and purified by silica gel column chromatography (hexane:ethylacetate = 1:1 to 3:7) to give the product **5b** (25.9 mg, 85%, 96:4 e.r.).

Scheme T2. Transformation of 4k to 6c



4k: 96:4 e.r. Ar= 4-Nitrophenyl

6a: 90% yield, 96:4 e.r.

6b: 96% yield,96:4 e.r.

6c: 70% yield, 96:4 e.r.

(*S*)-6-(4-Di(tert-butyloxycarbonyl)amino-3-nitrophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (6a): A dry 10 ml round bottom flask equipped with a stirring bar was charged with **4k** (134.5 mg, 0.3 mmol, 96:4 e.r.), Cs_2CO_3 (342.1 mg , 1.05 mmol.) and 7.5 ml acetonitrile. Then thiophenol (67.5 µL, 0.66 mmol) was added dropwise via syringe. The mixture was stirred at room temperature for 3 hours. The reaction mixture was concentrated and purified by silica gel column chromatography (hexane:ethylacetate = 1:1) to afford the product **6a** (121.1 mg, 90%, 96:4 e.r.).

(*S*)-6-(4-amino-3-nitrophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (**6b**): In a 10 ml round bottom flask equipped with a stirring bar was charged with **6a** (89.6 mg, 0.2 mmol) and 1 ml dichloromethane. Then 1 ml trifluoroacetic acid was added dropwise via a syringe at 0 °C and the reaction mixture was stirred at room temperature until the starting material was consumed completely (monitored by TLC). After the reaction was finished the crude reaction mixture was concentrated and the product was purified by silica gel column chromatography (dichloromethane/hexane = 8:2) yielding the product **6b** (47.6 mg, 96%, 96:4 e.r.).

(*S*)-6-(3,4-diaminophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (**6c**): Literature method[5] for racemic substrate was used with slight modification. In a 4 ml vial **6b** (24.8 mg, 0.1 mmol), DMF (300 µL) and PtO_2 (10 mol%, 0.01 mmol, 2.3 mg) was added. Then 80 µL hydrazine monohydrate was added slowly and the mixture was stirred at 60 °C. Progress of the reaction was monitored by TLC. After the starting material was consumed, the reaction was filtered, and the filtrate was evaporated. The crude product was purified in silica gel column chromatography (dichloromethane/methanol = 49:1) yielding the product **6c** (15.3 mg, 70%, 96:4 e.r.).

VII. References

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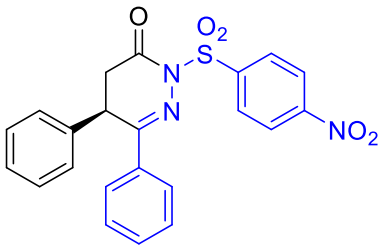
2. C. Zhao, F. Li, J. Wang, *Angew. Chem. Int. Ed.* 2016, **55**, 1820-1824.
3. I. Piel, M. Steinmetz, K. Hirano, R. Fröhlich, S. Grimme, F. Glorius, *Angew. Chem. Int. Ed*. 2011, **50**, 4983.
4. Z. Cao, S. Yan, C. Zhao, X. Sun, L. Tian, X. Meng, *Tetrahedron,* 2019, **75**, 130534.
5. Q. Tong, J. Chen, X. Cui, Z. Gong, B. Zhang, CN 107522663 A, 2017.

Part 3. Characterizations of products

I. Characterizations of Products



3a

(*R*)-2-((4-nitrophenyl)sulfonyl)-5,6-diphenyl-4,5-dihydropyridazin-3(2H)-one (3a)

Yield: 30.9 mg, 71%

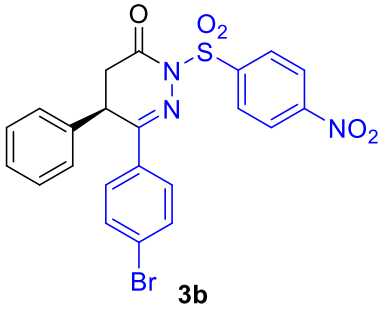
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.8 Hz, 2H), 8.30 (d, *J* = 8.8 Hz, 2H), 7.79 (d, *J* = 7.5 Hz, 2H), 7.46 - 7.43 (m, 1H), 7.42 - 7.39 (m, 2H), 7.24 - 7.21 (m, 3H), 7.03 (d, *J* = 6.5 Hz, 2H), 4.56 (d, *J* = 6.4 Hz, 1H), 3.00 (dd, *J* = 16.9, 7.0 Hz, 1H), 2.91 (d, *J* = 16.8 Hz, 1H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.6, 155.9, 151.0, 143.3, 135.8, 134.0, 131.3, 130.3, 129.7, 129.0, 128.5, 127.0, 126.8, 124.2, 40.2, 37.6 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 436.0967, found: 436.0963

IR ν_{max} (film, cm^{-1}): 1732,1606, 1531, 1131, 1186, 856, 825, 740.

HPLC analysis: 95:5 er, (CHIRALCEL AD-H column, 254 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 34.1 min, t_{minor} = 41.3 min), $[\alpha]_D^{25}$ = -34.8 (c = 1.3, acetone).



3b

(*R*)-6-(4-bromophenyl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3b)

Yield: 1.14 g, 74% [40.1 mg, 78% (0.1 mmol scale, 10 mol% catalyst loading)

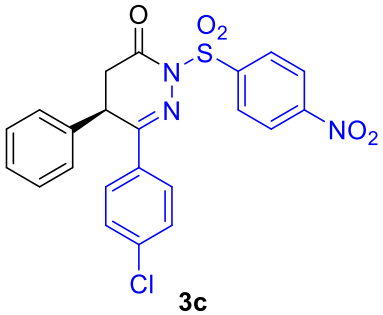
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.9 Hz, 2H), 8.29 (d, *J* = 8.9 Hz, 2H), 7.65 (d, *J* = 8.6 Hz, 2H), 7.52 (d, *J* = 8.6 Hz, 2H), 7.26 - 7.21 (m, 3H), 6.99 (d, *J* = 6.7 Hz, 2H), 4.51 (d, *J* = 5.8 Hz, 1H), 3.02 (dd, *J* = 16.9, 7.2 Hz, 1H), 2.90 (dd, *J* = 16.9, 1.8 Hz, 1H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.3, 154.6, 151.0, 143.2, 135.5, 132.9, 132.3, 130.3, 129.8, 128.6, 128.5, 126.7, 126.0, 124.2, 40.2, 37.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 514.0072, found: 514.0070

IR ν_{max} (film, cm^{-1}): 1732, 1607, 1531, 1186, 1008, 736.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, n-hexane/i-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 27.1 min, t_{minor} = 31.2 min), $[\alpha]_D^{25}$ = -23.2 (c = 1.0, acetone)



3c

(*R*)-6-(4-chlorophenyl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3c)

Yield: 33.8 mg, 72%

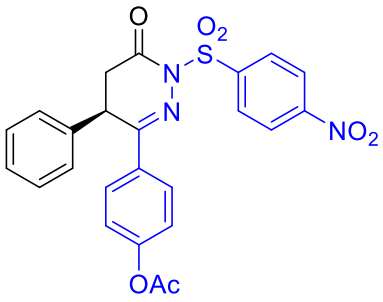
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.30 (d, *J* = 8.8 Hz, 2H), 7.73 (d, *J* = 8.6 Hz, 2H), 7.37 (d, *J* = 8.6 Hz, 2H), 7.28 – 7.21 (m, 3H), 6.99 (d, *J* = 6.8 Hz, 2H), 4.51 (d, *J* = 6.0 Hz, 1H), 3.01 (dd, *J* = 16.9, 7.1 Hz, 1H), 2.90 (dd, *J* = 16.9, 1.6 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.3, 154.6, 151.0, 143.2, 137.5, 135.5, 132.4, 130.3, 129.8, 129.3, 128.6, 128.3, 126.7, 124.2, 40.2, 37.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 470.0577, found: 470.0576

IR ν_{max} (film, cm^{-1}): 1714, 1606, 1531, 1186, 1089, 856, 837, 744.

HPLC analysis: 95.5:4.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 24.8 min, t_{minor}= 28.0 min), $[\alpha]_D^{25}$ = -31.8 (c = 0.6, acetone)



3d

(*R*)-4-(1-((4-nitrophenyl)sulfonyl)-6-oxo-4-phenyl-1,4,5,6-tetrahydropyridazin-3-yl)phenyl acetate (3d)

Yield: 37 mg, 75%

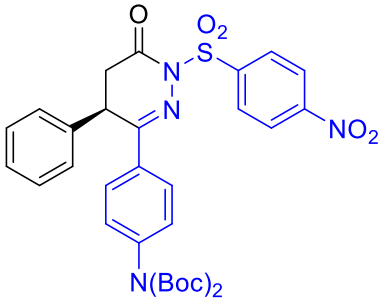
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.9 Hz, 2H), 8.30 (d, *J* = 8.9 Hz, 2H), 7.81 (d, *J* = 8.7 Hz, 2H), 7.24-7.20 (m, *J* = 11.1, 5.2 Hz, 3H), 7.13 (d, *J* = 8.7 Hz, 2H), 7.00 (d, *J* = 6.4 Hz, 2H), 4.53 (d, *J* = 5.6 Hz, 1H), 3.00 (dd, *J* = 16.8, 7.0 Hz, 1H), 2.90 (dd, *J* = 16.8, 1.8 Hz, 1H), 2.31 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.2, 164.4, 154.9, 153.0, 151.1, 143.3, 135.6, 131.6, 130.4, 129.8, 128.6, 128.3, 126.8, 124.2, 122.3, 40.4, 37.6, 21.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 494.1022, found: 494.1022

IR ν_{max} (film, cm^{-1}): 1761, 1718, 1604, 1529, 1188, 1087, 854,742.

HPLC analysis: 95.5:4.5 er, (CHIRALCEL IA column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 42.3 min, t_{major}= 48.4 min), $[\alpha]_D^{25}$ = -23.3 (c = 1.0, acetone)



3e

(*R*)-6-(4-Di(tert-butyloxycarbonyl)aminophenyl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3e)

Yield: 56.6 mg, 87%

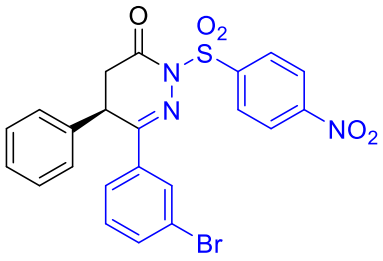
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.9 Hz, 2H), 8.29 (d, *J* = 8.9 Hz, 2H), 7.79 (d, *J* = 8.6 Hz, 2H), 7.25 – 7.18 (m, 5H), 7.01 – 6.99 (m, 2H), 4.54 (d, *J* = 5.7 Hz, 1H), 3.01 (dd, *J* = 16.9, 7.0 Hz, 1H), 2.89 (dd, *J* = 16.8, 1.6 Hz, 1H), 1.44 (s, 18H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.5, 154.9, 151.7, 151.0, 143.2, 141.9, 135.6, 132.9, 130.3, 129.7, 128.5, 128.4, 127.5, 126.7, 124.2, 83.4, 40.3, 37.5, 28.0 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 651.2125, found: 651.2125

IR ν_{max} (film, cm^{-1}): 1789, 1732, 1714, 1606, 1531, 1263, 1151, 1004, 856, 744.

HPLC analysis: 95.5:4.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 15.9 min, t_{major}= 23.9 min), $[\alpha]_D^{25}$ = -11.5 (c = 3.4, acetone)



3f

(*R*)-6-(3-bromophenyl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3f)

Yield: 38 mg, 74%

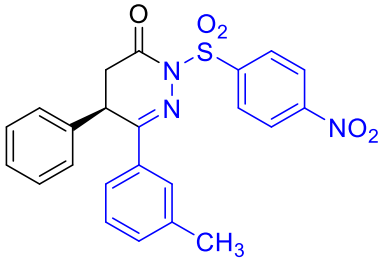
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 – 8.37 (m, 2H), 8.31 – 8.30 (m, 2H), 7.94 (t, *J* = 1.7 Hz, 1H), 7.66 (d, *J* = 7.9 Hz, 1H), 7.57 (dd, *J* = 8.0, 0.9 Hz, 1H), 7.28-7.24 (m, 4H), 7.01 – 7.00 (m, 2H), 4.50 (d, *J* = 5.5 Hz, 1H), 3.01 (dd, *J* = 16.9, 7.1 Hz, 1H), 2.91 (dd, *J* = 16.9, 1.9 Hz, 1H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.3, 154.3, 151.1, 143.2, 136.0, 135.4, 134.2, 130.5, 130.4, 129.9, 129.9, 128.7, 126.7, 125.6, 124.3, 123.3, 40.3, 37.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 514.0072, found: 514.0068

IR ν_{max} (film, cm^{-1}): 1732, 1606, 1558, 1531, 1186, 1088, 858, 829, 739.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 22.1 min, t_{minor}= 33.5 min), $[\alpha]_D^{25}$ = -38.5 (c = 0.4, acetone)



3g

(*R*)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-6-(m-tolyl)-4,5-dihydropyridazin-3(2H)-one (3g)

Yield: 37.7 mg, 84%

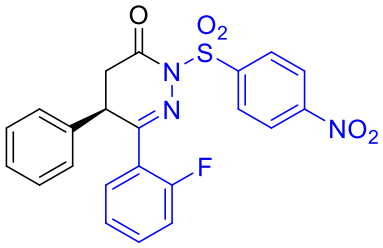
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (dd, *J* = 7.7, 5.3 Hz, 2H), 8.28 (dd, *J* = 8.8, 2.5 Hz, 2H), 7.63 (s, 1H), 7.55 (d, *J* = 7.1 Hz, 1H), 7.29 – 7.21 (m, 5H), 7.03 – 7.01 (m, 2H), 4.56 (d, *J* = 6.6 Hz, 1H), 2.98 (dd, *J* = 16.9, 6.9 Hz, 1H), 2.90 (d, *J* = 16.9 Hz, 1H), 2.37 (s, 3H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 164.8, 156.2, 151.0, 143.3, 138.8, 135.8, 135.8, 133.9, 132.1, 130.3, 129.6, 128.9, 128.4, 127.5, 126.8, 124.2, 124.2, 40.1, 37.5, 21.6 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 450.1124, found: 450.1121

IR ν_{max} (film, cm^{-1}): 1724, 1643, 1606, 1531, 1188, 1089, 854, 815, 742.

HPLC analysis: 95.5:4.5 er, (CHIRALCEL AD-H column, 220nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 21.6 min, t_{minor}= 36.5 min), $[\alpha]_D^{25}$ = -32.9 (c = 2.3, acetone)



3h

(*R*)-6-(2-fluorophenyl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3h)

Yield: 29 mg, 64%

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (dd, *J* = 8.5, 6.1 Hz, 2H), 8.30 (dd, *J* = 8.8, 3.5 Hz, 2H), 7.68 (td, *J* = 7.7, 1.4 Hz, 1H), 7.44-7.40 (m, 1H), 7.25 – 7.15 (m, 4H), 7.06 (ddd, *J* = 11.4, 8.5, 3.1 Hz, 1H), 7.00 (dd, *J* = 6.4, 2.8 Hz, 2H), 4.57 (dd, *J* = 7.0, 2.8 Hz, 1H), 3.06 (dd, *J* = 17.2, 7.1 Hz, 1H), 2.90 (dt, *J* = 17.1, 3.1 Hz, 1H) ppm.

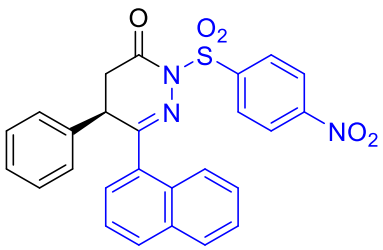
^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 160.7 (d, *J* = 252.3 Hz), 155.0, 151.1, 143.1, 135.5, 132.7 (d, *J* = 8.9 Hz), 130.4, 129.5, 128.3, 126.9, 124.9 (d, *J* = 3.4 Hz), 124.2, 122.9 (d, *J* = 11.0 Hz), 116.7 (d, *J* = 22.1 Hz), 42.2 (d, *J* = 6.3 Hz), 37.3.

^{19}F NMR (377 MHz, $CDCl_3$) δ -112.7 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 454.0873, found: 454.0877

IR ν_{max} (film, cm^{-1}): 1732, 1606, 1531, 1489, 1186, 1089, 856, 837, 742.

HPLC analysis: 92:8 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 26.3 min, t_{major}= 27.7 min), $[\alpha]_D^{25}$ = -46.9 (c = 1.7, acetone)



3i

(*R*)-6-(naphthalen-1-yl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3i)

Yield: 31.1 mg, 64%

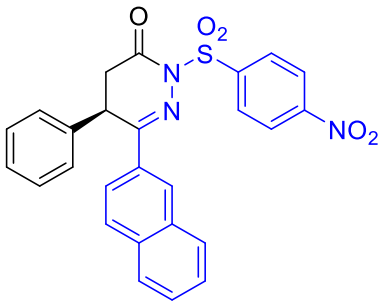
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 – 8.34 (m, 2H), 8.32 – 8.30 (m, 3H), 7.90-7.88 (m, 2H), 7.58 – 7.55 (m, 2H), 7.44 – 7.40 (m, 2H), 7.24 – 7.22 (m, 3H), 7.06-7.04 (m, 2H), 4.50 (dd, *J* = 7.0, 2.6 Hz, 1H), 3.19 (dd, *J* = 17.3, 7.0 Hz, 1H), 3.03 (dd, *J* = 17.3, 2.6 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 165.0, 158.7, 151.1, 143.1, 135.6, 134.1, 132.3, 131.2, 130.6, 130.5, 129.6, 128.9, 128.4, 127.7, 127.3, 127.1, 126.6, 125.2, 124.9, 124.2, 43.8, 37.4 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 486.1124, found: 486.1128

IR ν_{max} (film, cm^{-1}): 1732, 1647, 1533, 1184, 854, 740, 723.

HPLC analysis: 91.5:8.5 er, (CHIRALCEL AD-H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 32.7 min, t_{minor}= 55.4 min), $[\alpha]_D^{25}$ = -19.9 (c = 0.8, acetone)



3j

(*R*)-6-(naphthalen-2-yl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3j)

Yield: 35.9 mg, 74%

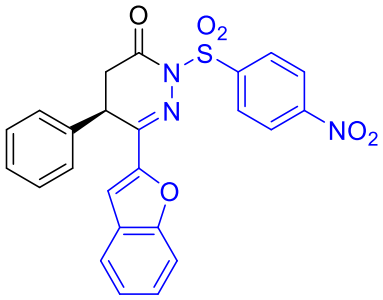
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 – 8.34 (m, 2H), 8.33 – 8.30 (m, 2H), 8.12 – 8.08 (m, 2H), 7.89 (d, *J* = 8.7 Hz, 1H), 7.85 (d, *J* = 8.1 Hz, 1H), 7.81 (d, *J* = 8.0 Hz, 1H), 7.52 (dtd, *J* = 14.8, 6.9, 1.3 Hz, 2H), 7.24 – 7.22 (m, 3H), 7.09-7.06 (m, 2H), 4.75 (dd, *J* = 6.6, 1.8 Hz, 1H), 3.06 (dd, *J* = 16.9, 6.7 Hz, 1H), 2.97 (dd, *J* = 16.9, 2.1 Hz, 1H) ppm

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.7, 155.8, 151.0, 143.3, 135.8, 134.6, 132.9, 131.3, 130.4, 129.7, 129.0, 129.0, 128.5, 128.0, 127.9, 127.7, 127.02, 126.8, 124.2, 123.4, 39.9, 37.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 486.1124, found: 486.1122

IR ν_{max} (film, cm^{-1}): 1732,1633, 1531, 1186, 1087, 854, 817, 740..

HPLC analysis: 95.5:4.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 37.3 min, t_{minor}= 42.9 min), $[\alpha]_D^{25}$ = 36.1 (c = 1.7, acetone)



3k

(*R*)-6-(benzofuran-2-yl)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-4,5-dihydropyridazin-3(2H)-one (3k)

Yield: 29.9 mg, 63%

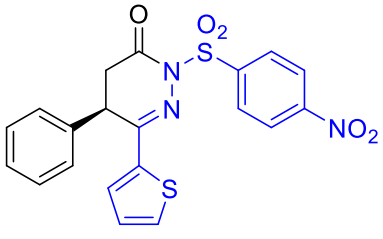
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.9 Hz, 2H), 8.31 (d, *J* = 9.0 Hz, 2H), 7.60 (d, *J* = 7.8 Hz, 1H), 7.55 (d, *J* = 8.4 Hz, 1H), 7.41 – 7.38 (m, 1H), 7.28 (t, *J* = 3.6 Hz, 2H), 7.25 – 7.20 (m, 3H), 7.06 – 7.05 (m, 2H), 4.63 (d, *J* = 5.7 Hz, 1H), 3.06 (dd, *J* = 16.9, 7.1 Hz, 1H), 2.96 (dd, *J* = 16.9, 1.8 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 155.8, 151.1, 149.8, 148.3, 143.1, 135.7, 130.5, 129.7, 128.6, 127.8, 127.4, 127.1, 126.7, 124.2, 124.0, 122.3, 112.2, 110.3, 39.6, 36.9 ppm

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 476.0916, found: 476.0914

IR ν_{max} (film, cm^{-1}): 1720, 1593, 1531, 1182, 1155, 1089, 1004, 941, 848, 817, 740.

HPLC analysis: 97.5:2.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 44.1 min, t_{minor}= 47.1 min), $[\alpha]_D^{25}$ = 17.4 (c = 1.2, acetone)



3l

(*R*)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-6-(thiophen-2-yl)-4,5-dihydropyridazin-3(2H)-one (3l)

Yield: 36.6 mg, 83%

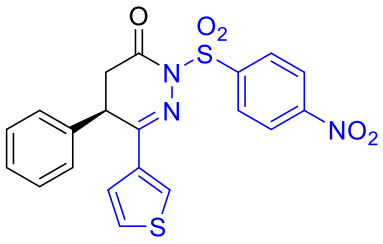
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.9 Hz, 2H), 8.29 (d, *J* = 8.9 Hz, 2H), 7.48 (d, *J* = 5.1 Hz, 1H), 7.30 (d, *J* = 3.6 Hz, 1H), 7.25 – 7.21 (m, 3H), 7.03-7.00 (m, 3H), 4.50 (d, *J* = 5.3 Hz, 1H), 3.03 (dd, *J* = 16.9, 7.0 Hz, 1H), 2.92 (dd, *J* = 16.9, 2.0 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 152.0, 151.0, 143.1, 138.8, 135.7, 130.9, 130.4, 129.7, 129.7, 128.5, 128.0, 126.8, 124.2, 41.0, 37.4 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 442.0531, found: 442.0528

IR ν_{max} (film, cm^{-1}): 1732, 1531, 1186, 854, 742, 721.

HPLC analysis: 97:3 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 39.7 min, t_{minor}= 52.3 min), $[\alpha]_D^{25}$ = -39.9 (c = 0.7, acetone)



3m

(*R*)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-6-(thiophen-3-yl)-4,5-dihydropyridazin-3(2H)-one (3m)

Yield: 37.1 mg, 84%

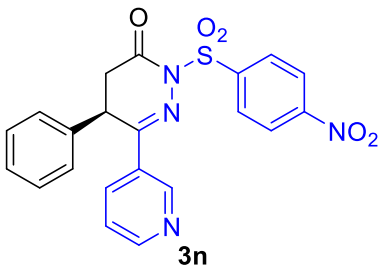
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.27 (d, *J* = 8.9 Hz, 2H), 7.62 (d, *J* = 5.1 Hz, 1H), 7.60 – 7.59 (m, 1H), 7.36 (dd, *J* = 5.1, 2.9 Hz, 1H), 7.22 - 7.21 (m, 3H), 7.02 – 7.00 (m, 2H), 4.46 (d, *J* = 5.5 Hz, 1H), 3.01 (dd, *J* = 16.9, 7.1 Hz, 1H), 2.89 (dd, *J* = 16.8, 1.9 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.6, 152.3, 151.0, 143.3, 137.0, 135.8, 130.3, 129.7, 128.5, 127.6, 127.2, 126.8, 126.1, 124.2, 41.1, 37.4.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 442.0531, found: 442.0529

IR ν_{max} (film, cm^{-1}): 1722, 1606, 1531, 1186, 1087, 856, 740.

HPLC analysis: 92:8 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 43.3 min, t_{minor}= 54.1 min), $[\alpha]_D^{25}$ = -14.7 (c = 1.5, acetone)



3n

(*R*)-2-((4-nitrophenyl)sulfonyl)-5-phenyl-6-(pyridin-3-yl)-4,5-dihydropyridazin-3(2H)-one (3n)

Yield: 30.1 mg, 69%

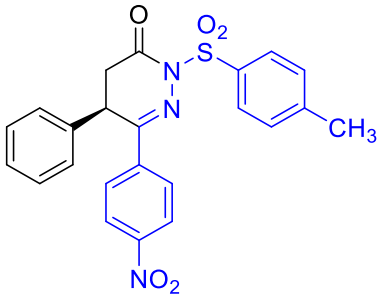
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.94 (d, *J* = 1.6 Hz, 1H), 8.66 (d, *J* = 3.7 Hz, 1H), 8.39 (d, *J* = 8.8 Hz, 2H), 8.32 (d, *J* = 8.8 Hz, 2H), 8.14 (d, *J* = 8.1 Hz, 1H), 7.36 (dd, *J* = 8.0, 4.8 Hz, 1H), 7.29 – 7.23 (m, 3H), 7.01 (d, *J* = 6.6 Hz, 2H), 4.54 (d, *J* = 6.1 Hz, 1H), 3.06 (dd, *J* = 16.9, 7.3 Hz, 1H), 2.92 (dd, *J* = 16.9, 1.7 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.1, 153.3, 151.9, 151.1, 148.2, 143.1, 135.3, 134.3, 130.4, 129.9, 128.8, 126.8, 124.3, 123.8, 40.4, 37.5.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 437.0920, found: 437.0921

IR ν_{max} (film, cm^{-1}): 1728, 1537, 1180, 1147, 1087, 983, 854, 853, 738, 704.

HPLC analysis: 92.5:7.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 36.8 min, t_{minor}= 45.6 min), $[\alpha]_D^{25}$ = -32.3 (c = 1.1, acetone)



3o

(*R*)-6-(4-nitrophenyl)-5-phenyl-2-tosyl-4,5-dihydropyridazin-3(2H)-one (3o)

Yield: 37 mg, 82%

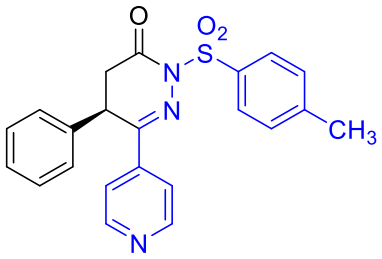
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.9 Hz, 2H), 8.01 (d, *J* = 8.3 Hz, 2H), 7.93 (d, *J* = 8.9 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 2H), 7.25 – 7.18 (m, 3H), 6.94 (d, *J* = 7.1 Hz, 2H), 4.51 (d, *J* = 6.4 Hz, 1H), 3.05 (dd, *J* = 16.6, 7.5 Hz, 1H), 2.84 (dd, *J* = 16.6, 1.5 Hz, 1H), 2.46 (s, 3H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 163.5, 151.5, 148.9, 145.9, 140.2, 135.7, 134.6, 129.9, 129.8, 129.0, 128.6, 127.8, 126.7, 124.0, 40.8, 37.7, 21.9 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 450.1124, found: 450.1122

IR ν_{max} (film, cm^{-1}): 1728, 1597, 1519, 1192, 1176, 856, 821, 744

HPLC analysis: 97:3 er, (CHIRALCEL AD-H column, 254 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 31.2 min, t_{minor}= 46.7 min), $[\alpha]_D^{25}$ = -41.5 (c = 2.3, acetone)



3p

(*R*)-5-phenyl-6-(pyridin-4-yl)-2-tosyl-4,5-dihydropyridazin-3(2H)-one (3p)

Yield: 34.9 mg, 86%

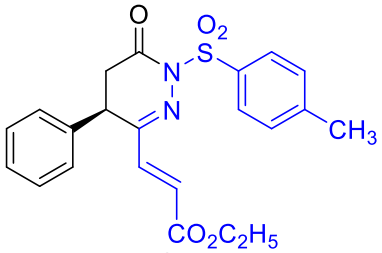
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 (brs, 2H), 8.02 (d, *J* = 8.3 Hz, 2H), 7.62 (d, *J* = 5.1 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 2H), 7.25 – 7.18 (m, 3H), 6.93 (d, *J* = 7.0 Hz, 2H), 4.45 (d, *J* = 6.2 Hz, 1H), 3.02 (dd, *J* = 16.6, 7.5 Hz, 1H), 2.83 (dd, *J* = 16.6, 1.7 Hz, 1H), 2.46 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.6, 151.4, 150.5, 145.8, 141.7, 135.8, 134.7, 129.9, 129.8, 129.0, 128.6, 126.8, 120.7, 40.5, 37.7, 21.9 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 406.1225, found: 406.1217

IR ν_{max} (film, cm^{-1}): 1722, 1593, 1190, 1174, 1143, 1089, 827, 704, 675, 551.

HPLC analysis: 98:2 er, (CHIRALCEL OD column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 23.7 min, t_{major}= 55.9 min), $[\alpha]_D^{25}$ = -33.5 (c = 1.7, acetone)



3q

Ethyl (R,E)-3-(1-((4-nitrophenyl)sulfonyl)-6-oxo-4-phenyl-1,4,5,6-tetrahydropyridazin-3-yl)acrylate (3q)

Yield: 32 mg, 75%

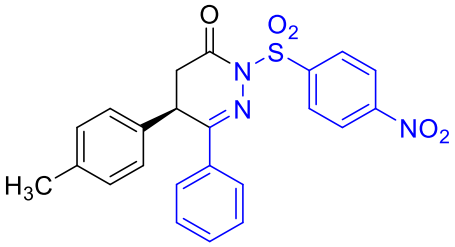
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.3 Hz, 2H), 7.48 (d, *J* = 16.3 Hz, 1H), 7.35 (d, *J* = 8.1 Hz, 2H), 7.21 (dt, *J* = 23.0, 7.2 Hz, 3H), 6.87 (d, *J* = 7.3 Hz, 2H), 6.18 (d, *J* = 16.3 Hz, 1H), 4.25 – 4.16 (m, 3H), 2.92 (dd, *J* = 16.6, 7.5 Hz, 1H), 2.76 (dd, *J* = 16.6, 1.7 Hz, 1H), 2.46 (s, 3H), 1.29 (t, *J* = 7.1 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 165.5, 163.7, 152.8, 145.8, 139.8, 135.7, 134.5, 129.8, 129.7, 129.0, 128.4, 126.6, 126.3, 61.3, 39.5, 37.3, 21.9, 14.3.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 427.1328, found: 427.1326

IR ν_{max} (film, cm^{-1}): 1728, 1635, 1597, 1190, 1033, 736, 702, 590.

HPLC analysis: 98.5:1.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 13.6 min, t_{minor}= 19.2 min), $[\alpha]_D^{25}$ = 0.6 (c = 2.5, acetone)



4a

(*R*)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-5-(p-tolyl)-4,5-dihydropyridazin-3(2H)-one (4a)

Yield: 26.9 mg, 60%

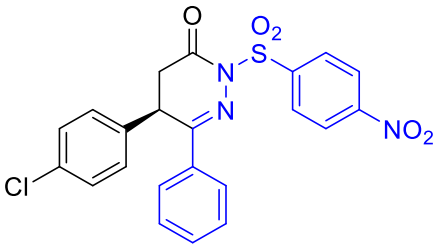
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.9 Hz, 2H), 8.30 (d, *J* = 8.9 Hz, 2H), 7.79 – 7.77 (m, 2H), 7.43 – 7.39 (m, 3H), 7.02 (d, *J* = 8.0 Hz, 2H), 6.90 (d, *J* = 8.1 Hz, 2H), 4.52 (d, *J* = 5.9 Hz, 1H), 2.98 (dd, *J* = 16.8, 6.8 Hz, 1H), 2.88 (dd, *J* = 16.8, 1.7 Hz, 1H), 2.27 (s, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.7, 157.8, 156.1, 151.0, 143.3, 138.3, 134.1, 132.7, 131.2, 130.3, 129.0, 127.0, 126.7, 124.2, 39.9, 37.6, 21.1 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 450.1124, found: 450.1122

IR ν_{max} (film, cm^{-1}): 1722, 1606, 1531, 1184, 1141, 1087, 856, 742, 682, 619, 596, 543.

HPLC analysis: 92:8 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 23.8 min, t_{major}= 31.4 min), $[\alpha]_D^{25}$ = -41.4 (c = 1.2, acetone)



4b

(*R*)-5-(4-chlorophenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4b)

Yield: 31 mg, 66%

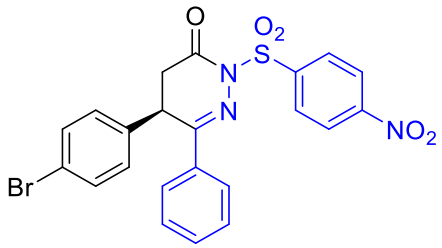
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.9 Hz, 2H), 8.31 (d, *J* = 8.9 Hz, 2H), 7.76 (d, *J* = 7.2 Hz, 2H), 7.48 – 7.39 (m, 3H), 7.23 (d, *J* = 8.5 Hz, 2H), 7.01 (d, *J* = 8.4 Hz, 2H), 4.54 (d, *J* = 5.4 Hz, 1H), 2.99 (dd, *J* = 17.1, 6.9 Hz, 1H), 2.89 (dd, *J* = 17.1, 1.9 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.4, 155.6, 151.1, 143.1, 134.5, 134.2, 133.7, 131.5, 130.4, 129.9, 129.1, 128.3, 126.9, 124.2, 39.5, 37.4 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 470.0577, found: 470.0580

IR ν_{max} (film, cm^{-1}): 1732, 1606, 1531, 1186, 1089, 856, 817, 736, 545.

HPLC analysis: 95:5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 27.7 min, t_{major}= 37.1 min), $[\alpha]_D^{25}$ = -24.1 (c = 1.9, acetone)



4c

(*R*)-5-(4-bromophenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4c)

Yield: 46.1 mg, 89%

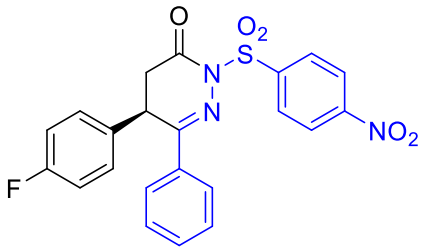
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.39 – 8.37 (m, 2H), 8.32 – 8.30 (m, 2H), 7.77 – 7.75 (m, 2H), 7.43 – 7.41 (m, 1H), 7.41 (dd, *J* = 15.4, 8.1 Hz, 4H), 6.96 (d, *J* = 8.4 Hz, 2H), 4.52 (d, *J* = 5.5 Hz, 1H), 2.99 (dd, *J* = 17.1, 7.0 Hz, 1H), 2.89 (dd, *J* = 17.1, 1.9 Hz, 1H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.4, 155.5, 151.1, 143.1, 134.7, 133.7, 132.9, 131.5, 130.4, 129.1, 128.6, 126.9, 124.3, 122.6, 39.6, 37.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 514.0072, found: 514.0067

IR ν_{max} (film, cm^{-1}): 1728, 1606, 1531, 1186, 1147, 1010, 856, 742.

HPLC analysis: 89:11 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 36.88 min, t_{minor}= 26.23 min), $[\alpha]_D^{25}$ = -27.1 (c = 2.6, acetone)



4d

(*R*)-5-(4-fluorophenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4d)

Yield: 38.9 mg, 86%

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.9 Hz, 2H), 8.32 (d, *J* = 8.9 Hz, 2H), 7.77 (d, *J* = 7.3 Hz, 2H), 7.46 (t, *J* = 7.3 Hz, 1H), 7.41 (t, *J* = 7.4 Hz, 2H), 7.05 (dd, *J* = 8.6, 5.1 Hz, 2H), 6.95 (t, *J* = 8.5 Hz, 2H), 4.55 (d, *J* = 6.1 Hz, 1H), 2.99 (dd, *J* = 17.1, 7.0 Hz, 1H), 2.89 (dd, *J* = 17.1, 1.8 Hz, 1H) ppm.

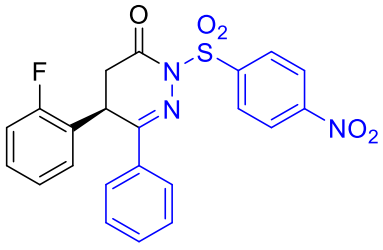
^{13}C NMR (126 MHz, $CDCl_3$) δ 164.5, 162.5 (d, *J* = 248.3 Hz), 155.8, 151.1, 143.1, 133.7, 131.5 (d, *J* = 3.5 Hz), 131.4, 130.4, 129.1, 128.7 (d, *J* = 8.2 Hz), 126.9, 124.2,116.7 (d, *J* = 21.8 Hz), 39.4, 37.6 ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -113.0 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 454.0873, found: 454.0874

IR ν_{max} (film, cm^{-1}): 1728, 1606, 1531, 1186, 856, 840, 817, 744, 684.

HPLC analysis: 95.5:4.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 22.0 min, t_{major}= 24.67 min), $[\alpha]_D^{25}$ = -16.8 (c = 1.9, acetone)



4e

(*R*)-5-(2-fluorophenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4e)

Yield: 33.1 mg, 73%

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (q, *J* = 9.0 Hz, 4H), 7.76 (d, *J* = 7.3 Hz, 2H), 7.45 (t, *J* = 7.2 Hz, 1H), 7.40 (t, *J* = 7.4 Hz, 2H), 7.29-7.25 (m, 1H), 7.12 – 7.08 (m, 1H), 6.94 (t, *J* = 7.5 Hz, 1H), 6.84 (t, *J* = 7.2 Hz, 1H), 4.84 (dd, *J* = 6.6, 2.0 Hz, 1H), 3.00 – 2.91 (m, 2H) ppm.

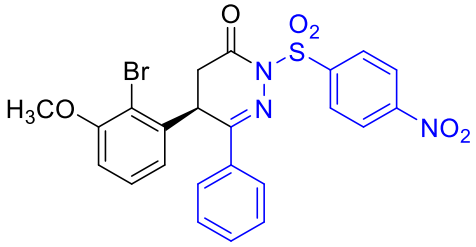
^{13}C NMR (101 MHz, $CDCl_3$) δ 164.4, 160.3 (d, *J* = 247.0 Hz), 154.6, 151.0, 143.1, 133.4, 131.3, 130.5 (d, *J* = 8.5 Hz), 130.3, 128.9, 127.8 (d, *J* = 2.9 Hz), 126.7, 125.1 (d, *J* = 3.6 Hz), 124.3, 122.7 (d, *J* = 14.1 Hz), 116.5 (d, *J* = 21.6 Hz), 36.0 (d, *J* = 1.1 Hz), 34.1 (d, *J* = 2.8 Hz) ppm.

^{19}F NMR (377 MHz, $CDCl_3$) δ -117.1 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 454.0873, found: 454.0872

IR ν_{max} (film, cm^{-1}): 1732, 1531, 1188, 1095, 856, 812, 740, 684, 555.

HPLC analysis: 97.5:2.5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 23.5 min, t_{major}= 27.3 min), $[\alpha]_D^{25}$ = -42.3 (c = 1.3, acetone)



4f

(*R*)-5-(3-methoxyphenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4f)

Yield: 33.1 mg, 61%

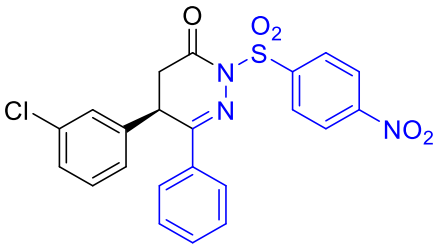
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.40 (d, *J* = 9.1 Hz, 2H), 8.36 (d, *J* = 9.0 Hz, 2H), 7.73 – 7.72 (m, 2H), 7.51 (d, *J* = 8.8 Hz, 1H), 7.44 (t, *J* = 7.2 Hz, 1H), 7.40 (t, *J* = 7.3 Hz, 2H), 6.65 (dd, *J* = 8.8, 2.9 Hz, 1H), 6.20 (d, *J* = 2.9 Hz, 1H), 4.90 (dd, *J* = 7.5, 1.5 Hz, 1H), 3.62 (s, 3H), 2.99 (dd, *J* = 16.8, 7.5 Hz, 1H), 2.91 (dd, *J* = 16.8, 1.7 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.1, 159.7, 154.7, 151.1, 143.1, 135.4, 134.9, 133.4, 131.4, 130.3, 129.1, 126.8, 124.4, 114.7, 114.4, 113.4, 55.5, 40.8, 35.7 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 544.0178, found: 544.0174

IR ν_{max} (film, cm^{-1}):1732, 1531, 1188, 1172, 856, 825, 738, 684.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 33.8 min, t_{major}= 38.0 min), $[\alpha]_D^{25}$ = -84.4 (c = 2.0, acetone)



4g

(*R*)-5-(3-chlorophenyl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4g)

Yield: 38.9 mg, 83%

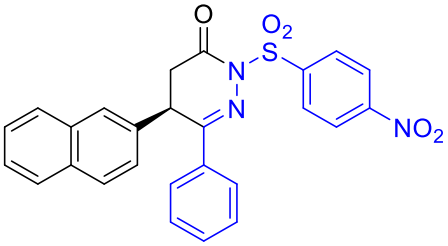
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (d, *J* = 8.9 Hz, 2H), 8.30 (d, *J* = 8.9 Hz, 2H), 7.78 – 7.76 (m, 2H), 7.46 (t, *J* = 7.3 Hz, 1H), 7.41 (t, *J* = 7.4 Hz, 2H), 7.23 – 7.18 (m, 2H), 6.96 (d, *J* = 7.4 Hz, 1H), 6.92 (s, 1H), 4.55 (d, *J* = 6.4 Hz, 1H), 3.04 (dd, *J* = 16.8, 7.2 Hz, 1H), 2.87 (dd, *J* = 16.8, 1.5 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.1, 154.7, 151.1, 143.2, 137.9, 135.5, 133.6, 131.5, 131.1, 130.3, 129.1, 128.8, 126.9, 126.9, 125.1, 124.4, 40.0, 37.4 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 470.0577, found: 470.0577

IR ν_{max} (film, cm^{-1}): 1728, 1606, 1593, 1573, 1531, 1263, 1087, 856, 773, 744, 623, 543.

HPLC analysis: 95:5 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 21.9 min, t_{minor}= 26.2 min), $[\alpha]_D^{25}$ = -45.4 (c = 2.1, acetone)



4h

(*R*)-5-(naphthalen-2-yl)-2-((4-nitrophenyl)sulfonyl)-6-phenyl-4,5-dihydropyridazin-3(2H)-one (4h)

Yield: 36.8 mg, 76%

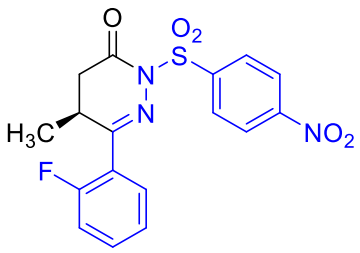
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 – 8.20 (m, 4H), 7.85– 7.83 (m, 2H), 7.76 (t, *J* = 7.9 Hz, 2H), 7.54 – 7.52 (m, 1H), 7.49 – 7.39 (m, 5H), 7.36 (s, 1H), 7.17 (dd, *J* = 8.5, 1.6 Hz, 1H), 4.71 (d, *J* = 4.7 Hz, 1H), 3.09 (dd, *J* = 16.7, 6.5 Hz, 1H), 3.02 (dd, *J* = 16.7, 2.2 Hz, 1H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 155.9, 150.9, 143.3, 134.1, 133.3, 133.0, 132.9, 131.3, 130.2, 129.9, 129.1, 127.8, 127.0, 127.0, 126.9, 125.5, 124.5, 124.1, 40.3, 37.2 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 486.1124, found: 486.1121

IR ν_{max} (film, cm^{-1}): 1722, 1184, 1170, 1136, 744, 723.

HPLC analysis: 92:8 er, (CHIRALCEL AD-H column, 254 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 38.7 min, t_{major}= 55.9 min), $[\alpha]_D^{25}$ = -100.4 (c = 1.3, acetone)



4i

(*S*)-6-(2-fluorophenyl)-5-methyl-2-((4-nitrophenyl)sulfonyl)-4,5-dihydropyridazin-3(2H)-one (4i)

Yield: 19.9 mg, 51%

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.41 – 8.38 (m, 2H), 8.35 – 8.33 (m, 2H), 7.68 (td, *J* = 7.7, 1.7 Hz, 1H), 7.50 – 7.45 (m, 1H), 7.27 – 7.24 (m, 1H), 7.17 – 7.13 (m, 1H), 3.37-3.30 (m, 1H), 2.74 (dd, *J* = 17.4, 6.2 Hz, 1H), 2.55 (dd, *J* = 17.4, 3.3 Hz, 1H), 1.23 (d, *J* = 7.3 Hz, 3H) ppm.

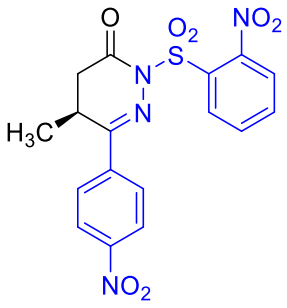
^{13}C NMR (101 MHz, $CDCl_3$) δ 165.9, 160.9 (d, *J* = 251.0 Hz), 158.5 (d, *J* = 2.0 Hz), 151.1, 143.2, 132.8 (d, *J* = 8.7 Hz), 130.5, 130.4 (d, *J* = 2.5 Hz), 125.0 (d, *J* = 3.3 Hz), 124.3, 122.7 (d, *J* = 11.8 Hz), 116.7 (d, *J* = 22.3 Hz), 36.5, 31.3 (d, *J* = 5.8 Hz), 15.6 (d, *J* = 2.5 Hz) ppm.

^{19}F NMR (376 MHz, $CDCl_3$) δ -113.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 392.0716, found: 392.0720

IR ν_{max} (film, cm^{-1}): 1730, 1614, 1531, 1188, 1163, 854, 767, 740.

HPLC analysis: 93:7 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 18.4 min, t_{major}= 20.2 min), $[\alpha]_D^{25}$ = 65.7 (c = 0.5, acetone)



4j

(*S*)-5-methyl-6-(4-nitrophenyl)-2-((2-nitrophenyl)sulfonyl)-4,5-dihydropyridazin-3(2H)-one (4j)

Yield: 20.1 mg, 48%

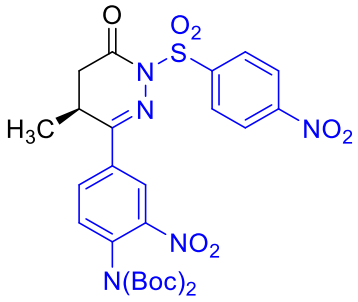
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.55 - 8.51 (m, 1H), 8.30 (d, *J* = 8.9 Hz, 2H), 8.03 (d, *J* = 8.9 Hz, 2H), 7.86-7.80 (m, 3H), 3.52-3.45 (m, 1H), 2.92 (dd, *J* = 16.7, 6.6 Hz, 1H), 2.61 (dd, *J* = 16.7, 1.4 Hz, 1H), 1.31 (d, *J* = 7.4 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.5, 153.6, 149.1, 148.4, 139.6, 135.5, 134.8, 132.2, 131.8, 127.8, 124.8, 124.2, 35.8, 29.1, 16.4.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 419.0661, found: 419.0657

IR ν_{max} (film, cm^{-1}): 1732, 1539, 1519, 1184, 852, 732, 576.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 43.8 min, t_{minor}= 60.3 min), $[\alpha]_D^{25}$ = -5.4 (c = 0.3, acetone)



4k

(*S*)-6-(4-Di(tert-butyloxycarbonyl)amino-3-nitrophenyl)-5-methyl-2-((4-nitrophenyl)sulfonyl)-4,5-dihydropyridazin-3(2H)-one (4k)

Yield: 41.1 mg, 65%

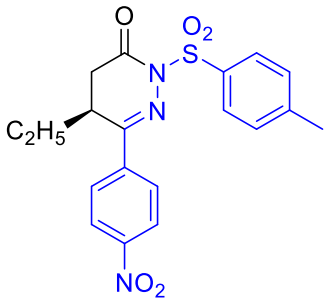
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.43 – 8.41 (m, 3H), 8.35 (d, *J* = 8.9 Hz, 2H), 8.17 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.46 (d, *J* = 8.3 Hz, 1H), 3.45 – 3.40 (m, 1H), 2.75 (dd, *J* = 17.3, 6.3 Hz, 1H), 2.65 (d, *J* = 17.2 Hz, 1H), 1.44 (s, 18H), 1.29 (d, *J* = 7.4 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.9, 155.1, 151.2, 150.2, 146.2, 143.0, 135.4, 134.1, 132.3, 131.3, 130.5, 124.4, 123.0, 84.5, 36.1, 28.7, 27.9, 16.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 634.1819, found: 634.1820

IR ν_{max} (film, cm^{-1}): 1797, 1766, 1732, 1714, 1531, 1274, 1188, 1120, 914, 854, 742, 686, 599.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 22.2 min, t_{major}= 32.4 min), $[\alpha]_D^{25}$ = 109.6 (c = 1.2, acetone)



4l

(*S*)-5-ethyl-6-(4-nitrophenyl)-2-tosyl-4,5-dihydropyridazin-3(2H)-one (4l)

Yield: 24.1 mg, 60%

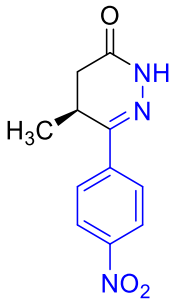
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 – 8.27 (m, 2H), 8.03 – 7.99 (m, 4H), 7.35 (d, *J* = 8.1 Hz, 2H), 3.24 - 3.19 (m, 1H), 2.74 (dd, *J* = 17.3, 1.9 Hz, 1H), 2.67 – 2.63 (m, 1H), 2.44 (s, 3H), 1.73 – 1.50 (m, 2H), 0.91 (t, *J* = 7.5 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 164.8, 154.0, 149.0, 145.8, 140.1, 134.6, 129.8, 129.0, 127.7, 124.1, 35.2, 33.5, 23.4, 21.9, 11.3.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 402.1124, found: 402.1129

IR ν_{max} (film, cm^{-1}):1724, 1597, 1591, 1174, 1087, 854, 721, 547.

HPLC analysis: 97:3 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 23.8 min, t_{major}= 35.5 min), $[\alpha]_D^{25}$ = 116.0 (c =1.3 , acetone)



5a

(*S*)-5-methyl-6-(4-nitrophenyl)-4,5-dihydropyridazin-3(2H)-one (5a)

Yield: 40.6 mg, 87%

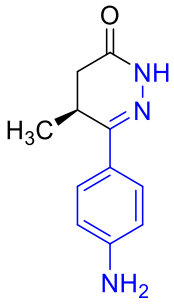
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (brs, 1H), 8.29 – 8.26 (m, 2H), 7.95 – 7.92 (m, 2H), 3.43 – 3.36 (m, 1H), 2.77 (dd, *J* = 17.0, 6.9 Hz, 1H), 2.55 (dd, *J* = 17.0, 0.9 Hz, 1H), 1.29 (d, *J* = 7.4 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 151.6, 148.5, 140.5, 126.8, 124.1, 33.9, 28.2, 16.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 234.0879, found: 234.0869

IR ν_{max} (film, cm^{-1}): 3226, 1681, 1645, 1597, 1514, 1192, 1035, 858, 756, 732.

HPLC analysis: 96:4 er, (CHIRALCEL OJ-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 20.7 min, t_{minor}= 24.3 min), $[\alpha]_D^{25}$ = 476.5 (c = 0.6, acetone)



5b

(*S*)-6-(4-aminophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (5b)

Yield: 25.9 mg, 85%

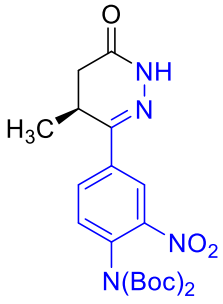
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.54 (brs, 1H), 7.58 (d, *J* = 8.6 Hz, 2H), 6.69 (d, *J* = 8.6 Hz, 2H), 3.92 (brs, 2H), 3.33-3.27 (m, 1H), 2.68 (dd, *J* = 16.9, 6.8 Hz, 1H), 2.44 (d, *J* = 16.8 Hz, 1H), 1.24 (d, *J* = 7.4 Hz, 3H) ppm.

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.9, 154.6, 148.3, 127.5, 124.6, 114.9, 34.0, 28.1, 16.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 204.1137, found: 204.1127

IR ν_{max} (film, cm^{-1}): 3369, 1645, 1608, 1033, 842, 721.

HPLC analysis: 96:4 er, (CHIRALCEL OJ-H column, 254 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 79.9 min, t_{major}= 84.5 min), $[\alpha]_D^{25}$ = 380.5 (c = 0.3, MeOH)



6a

(*S*)-6-(4-Di(tert-butyloxycarbonyl)amino-3-nitrophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (6a)

Yield: 121.1 mg, 90%

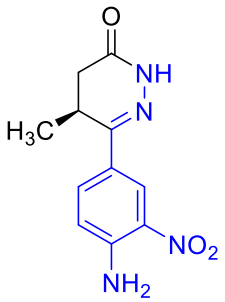
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.99 (bs, 1H), 8.46 (d, *J* = 1.9 Hz, 1H), 8.04 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.40 (d, *J* = 8.3 Hz, 1H), 3.43 - 3.47 (m, 1H), 2.79 (dd, *J* = 17.0, 6.9 Hz, 1H), 2.57 (d, *J* = 17.0 Hz, 1H), 1.44 (s, 18H), 1.31 (d, *J* = 6.9 Hz, 3H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.4, 150.8, 150.3, 146.1, 135.6, 134.0, 131.8, 130.5, 122.4, 84.3, 33.8, 28.0, 27.9, 16.3 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 449.2036, found: 449.2035

IR ν_{max} (film, cm^{-1}): 3419, 1797, 1697, 1683, 1593, 1274, 1151, 1120, 738.

HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 254 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 8.5 min, t_{major}= 10.6 min), $[\alpha]_D^{25}$ = 211.1 (c = 0.9, acetone)



6b

(*S*)-6-(4-amino-3-nitrophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (6b)

Yield: 47.6 mg, 96%

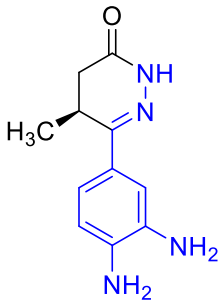
^{1}H NMR (400 MHz, CD_3OD) δ 8.42 (d, *J* = 2.1 Hz, 1H), 7.93 (dd, *J* = 9.0, 2.2 Hz, 1H), 7.01 (d, *J* = 9.0 Hz, 1H), 4.59 (brs, 2H), 3.43 – 3.39 (m, 1H), 2.74 (dd, *J* = 17.0, 7.0 Hz, 1H), 2.37 (dd, *J* = 17.0, 1.4 Hz, 1H), 1.18 (d, *J* = 7.4 Hz, 3H) ppm.

^{13}C NMR (101 MHz, MeOD) δ 169.4, 154.5, 148.3, 134.0, 131.9, 124.6, 123.9, 120.6, 34.5, 28.6, 16.4 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 249.0988, found: 249.0980

IR ν_{max} (film, cm^{-1}): 3444, 1633, 1265, 1076, 958, 721.

HPLC analysis: 96:4 er, (CHIRALCEL IA column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{major} = 12.3 min, t_{minor}= 18.9 min), $[\alpha]_D^{25}$ = 122.7 (c = 0.3, MeOH)



6c

(*S*)-6-(3,4-diaminophenyl)-5-methyl-4,5-dihydropyridazin-3(2H)-one (6c)

Yield: 15.3 mg, 70%

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (brs, 1H), 7.22 (d, *J* = 2.0 Hz, 1H), 7.07 (dd, *J* = 8.1, 2.0 Hz, 1H), 6.70 (d, *J* = 8.1 Hz, 1H), 3.54 (brs, 4H), 3.33 – 3.26 (m, 1H), 2.68 (dd, *J* = 16.9, 6.8 Hz, 1H), 2.43 (d, *J* = 16.8 Hz, 1H), 1.23 (d, *J* = 7.4 Hz, 3H) ppm.

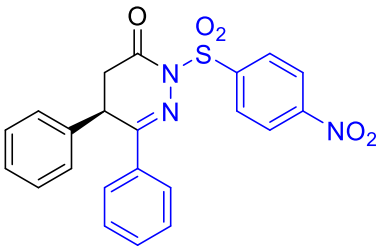
^{13}C NMR (101 MHz, $CDCl_3$) δ 166.8, 154.7, 137.5, 134.5, 126.1, 118.9, 115.7, 114.1, 33.9, 28.0, 16.5 ppm.

HRMS (ESI, m/z): calcd. for $[M+H]^+$: 219.1246, found: 219.1239

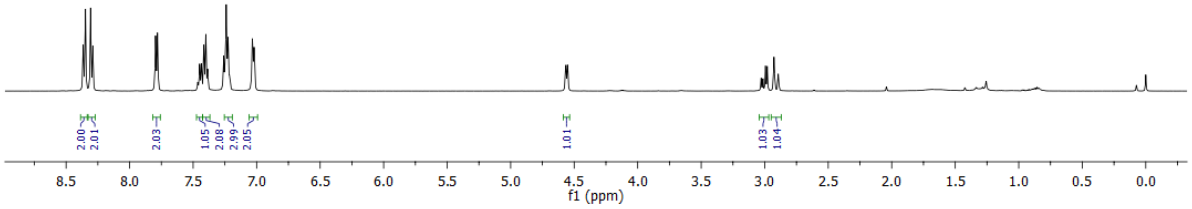
IR ν_{max} (film, cm^{-1}): 3417, 1645, 1078, 1037, 952, 721.

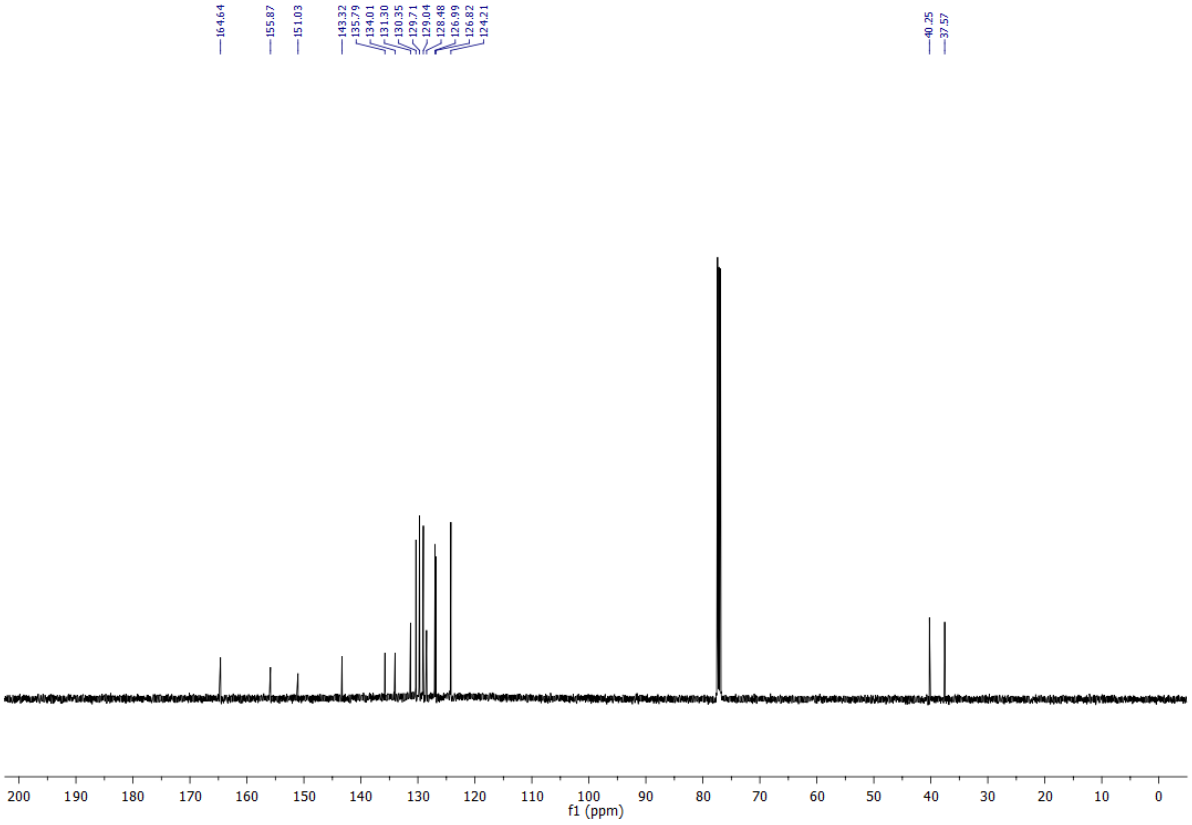
HPLC analysis: 96:4 er, (CHIRALCEL AD-H column, 220 nm, *n*-hexane/*i*-PrOH = 70/30, flow rate = 0.7 mL/min, t_{minor} = 29.8 min, t_{major}=31.4 min), $[\alpha]_D^{25}$ = 60.3 (c = 1.1, MeOH)

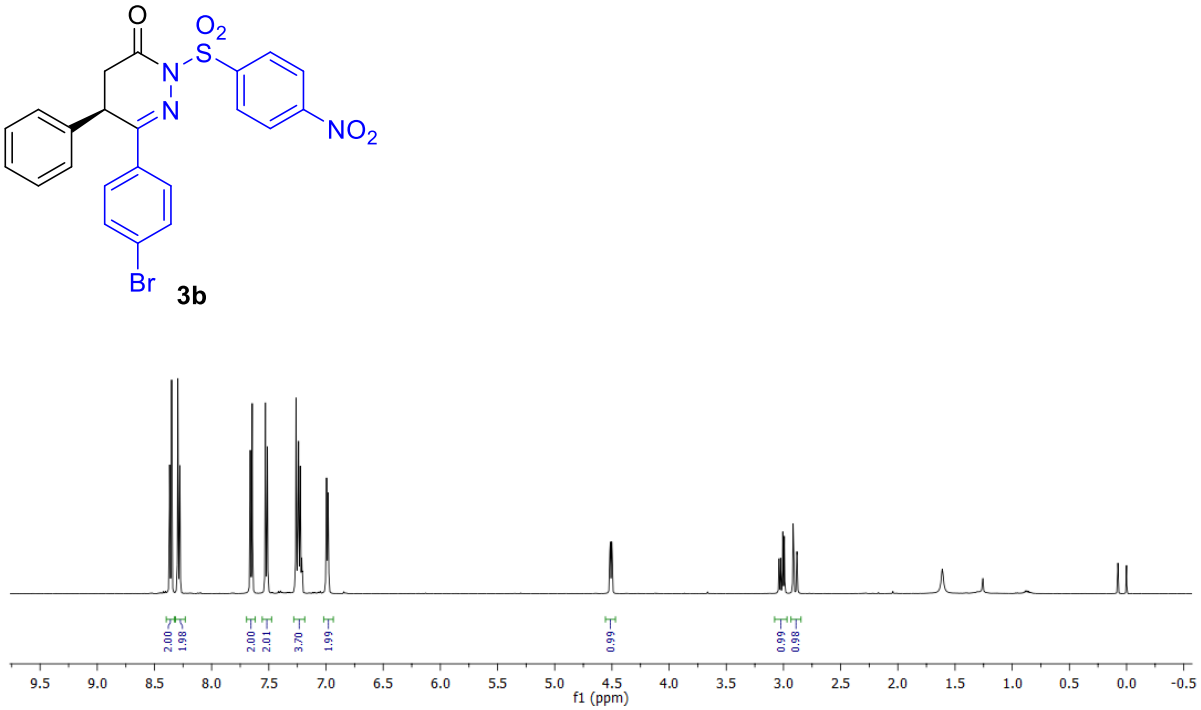
II. ^{1}H, ^{13}C, ^{19}F NMR and HPLC Spectra



3a



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7.22
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7.21
7.00
6.98
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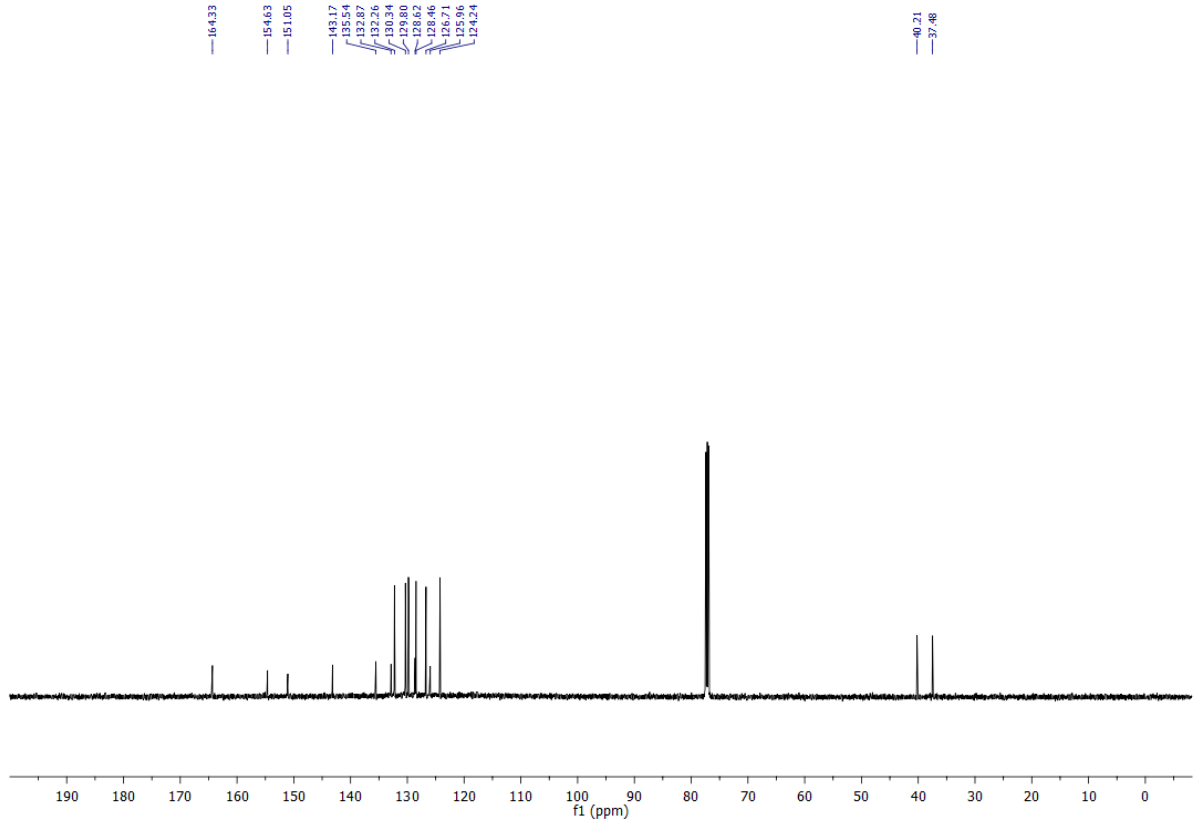
4.50
3.04
3.03
3.01
2.99
2.92
2.91
2.88
2.88
O
O2
S
N
N
NO2
Br
3b
2.00
1.98
2.00
2.01
3.70
1.99
0.99
0.99
0.98
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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128.62
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125.96
124.24
40.21
37.48
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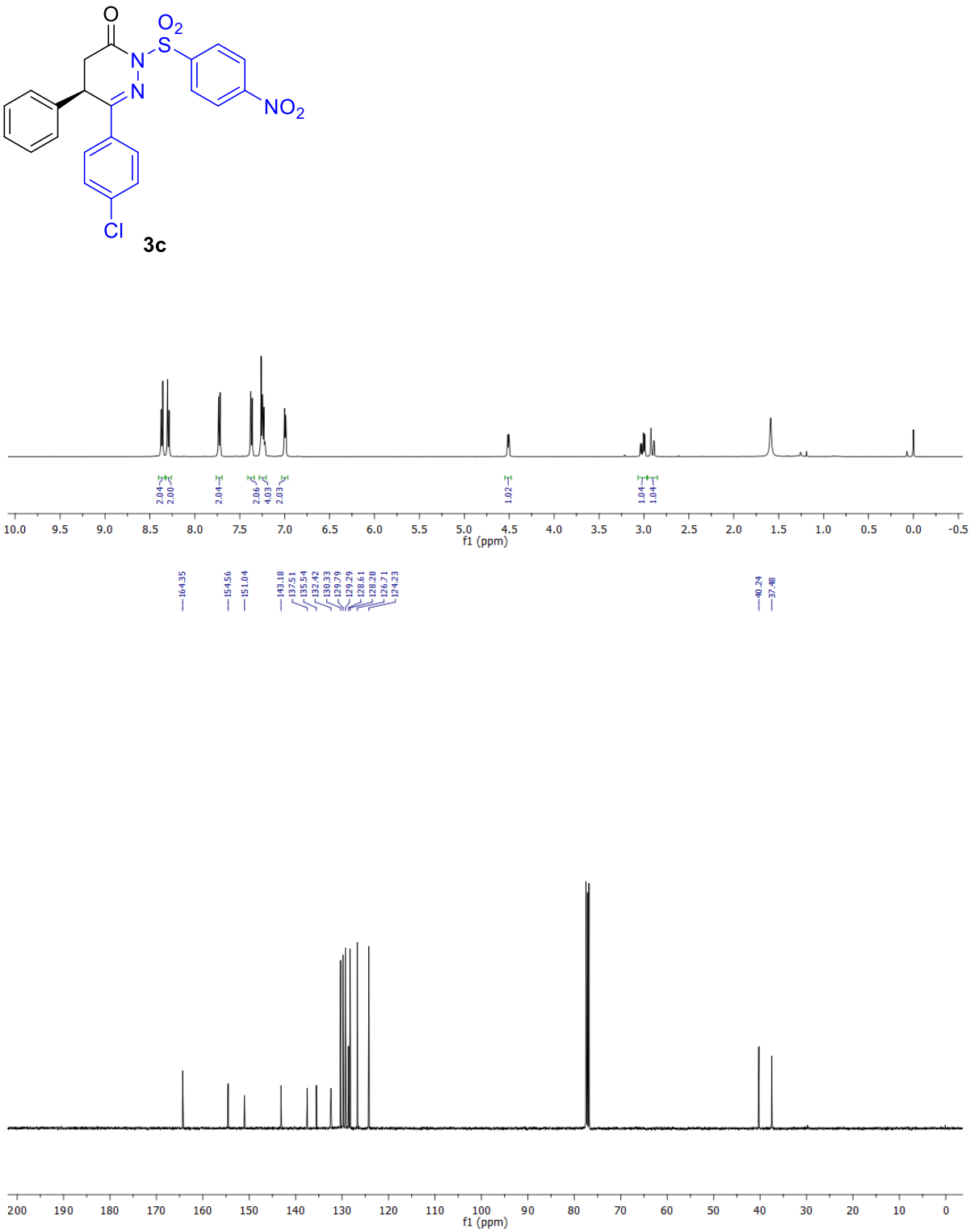
f1 (ppm)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4.50
3.04
3.02
3.00
2.99
2.92
2.92
2.89
2.89
O
O2
S
N
N
NO2
Cl
3c
2.04
2.00
2.04
2.06
4.03
2.03
1.02
1.04
1.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
164.35
154.56
151.04
143.18
137.51
135.54
132.42
130.33
129.79
129.29
128.61
128.28
126.71
124.23
40.24
37.48
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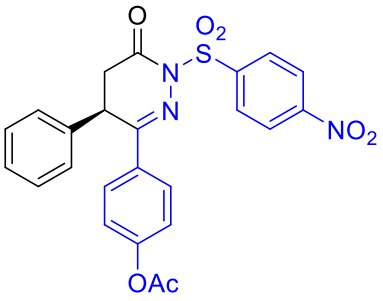
f1 (ppm)



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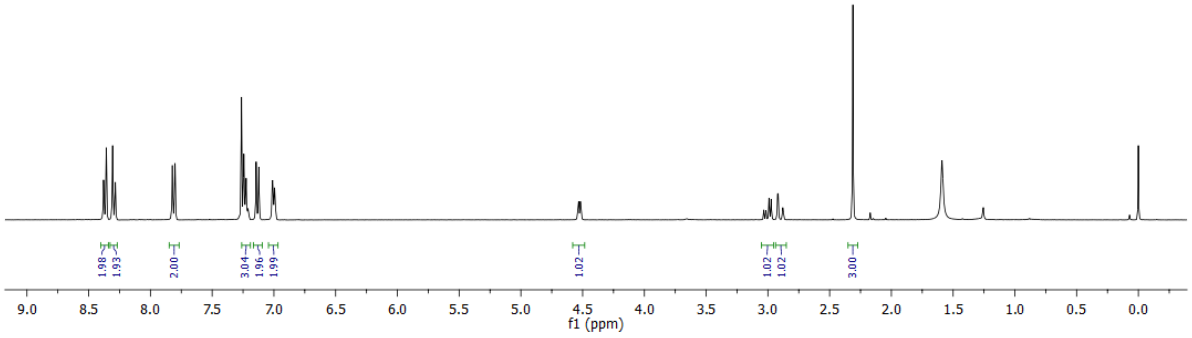

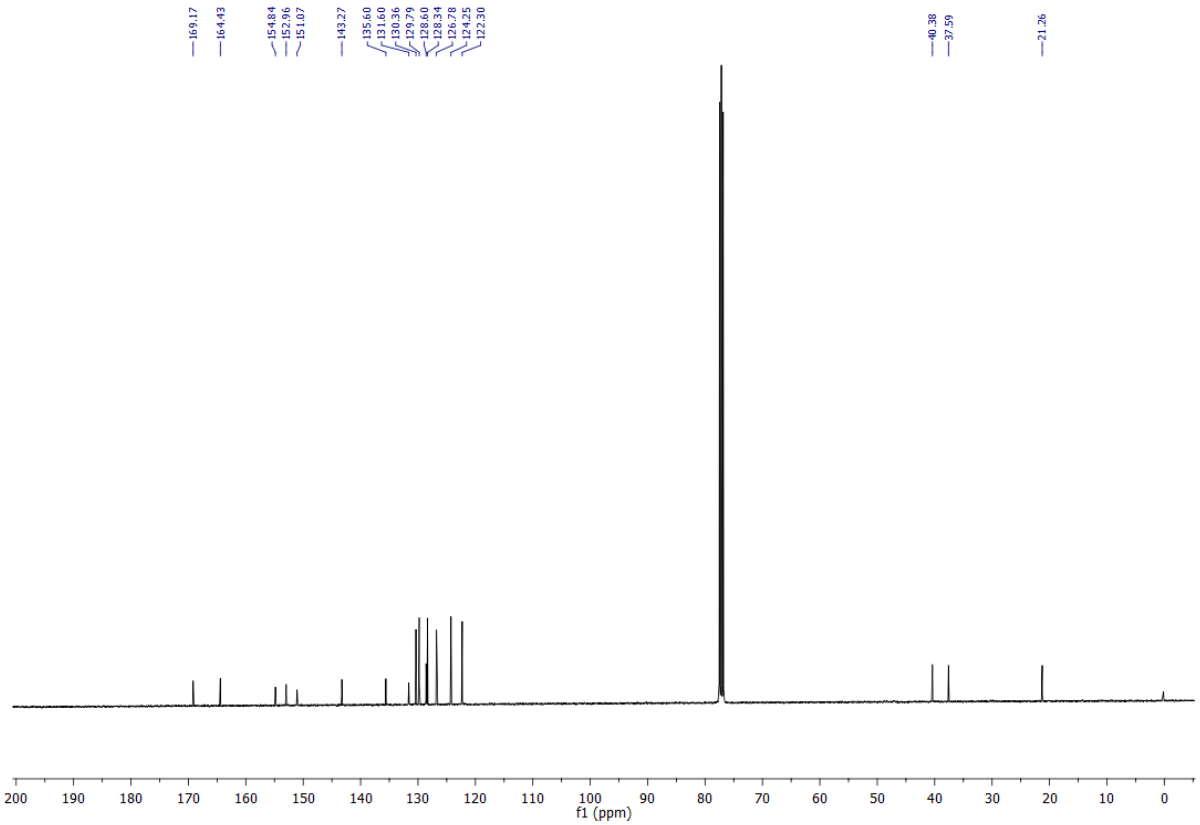

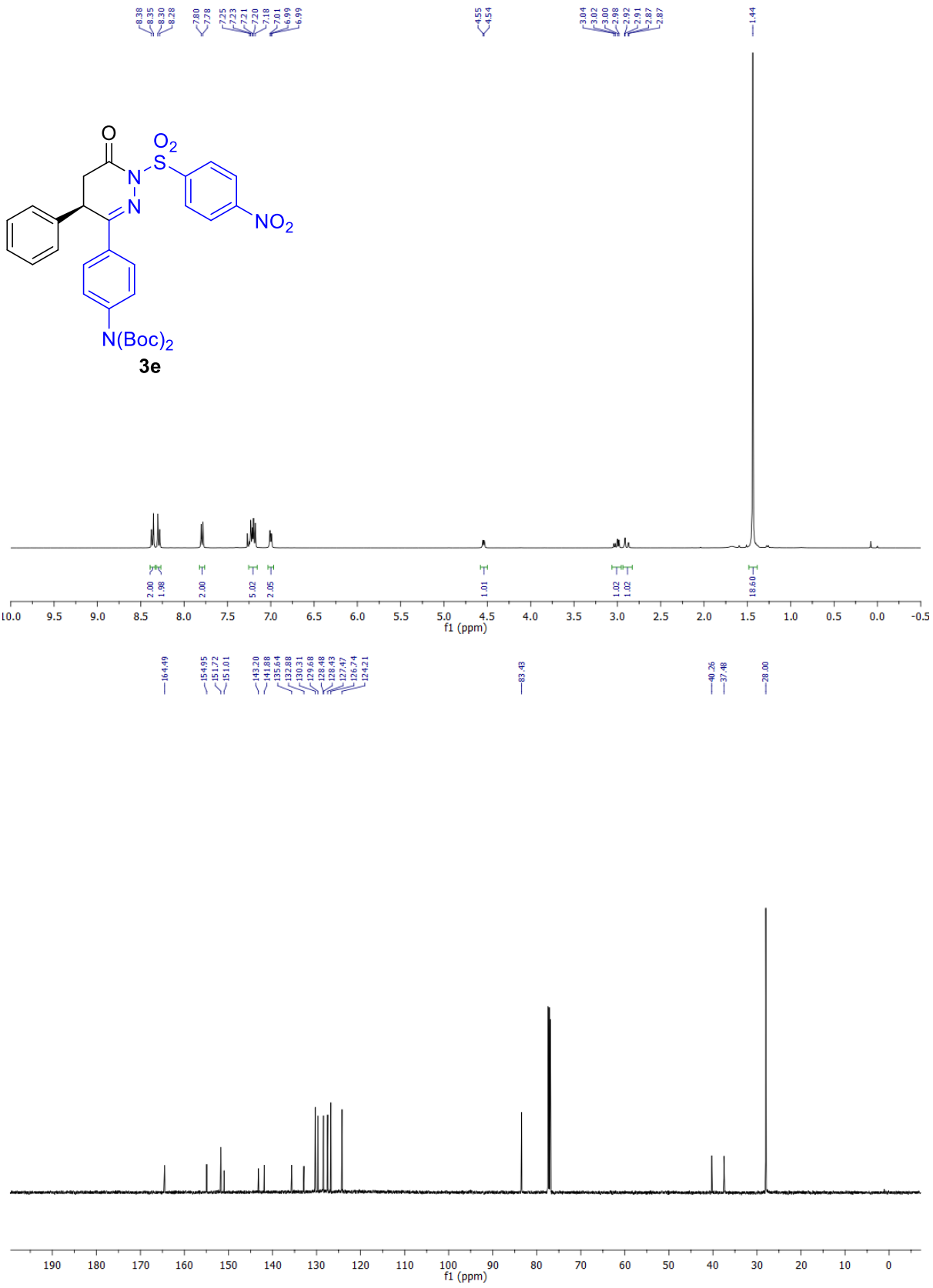
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7.78
7.25
7.23
7.21
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5.02
2.05
1.01
1.02
1.02
18.60
f1 (ppm)
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154.95
151.72
151.01
143.20
141.88
135.64
132.88
130.31
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128.43
127.47
126.74
124.21
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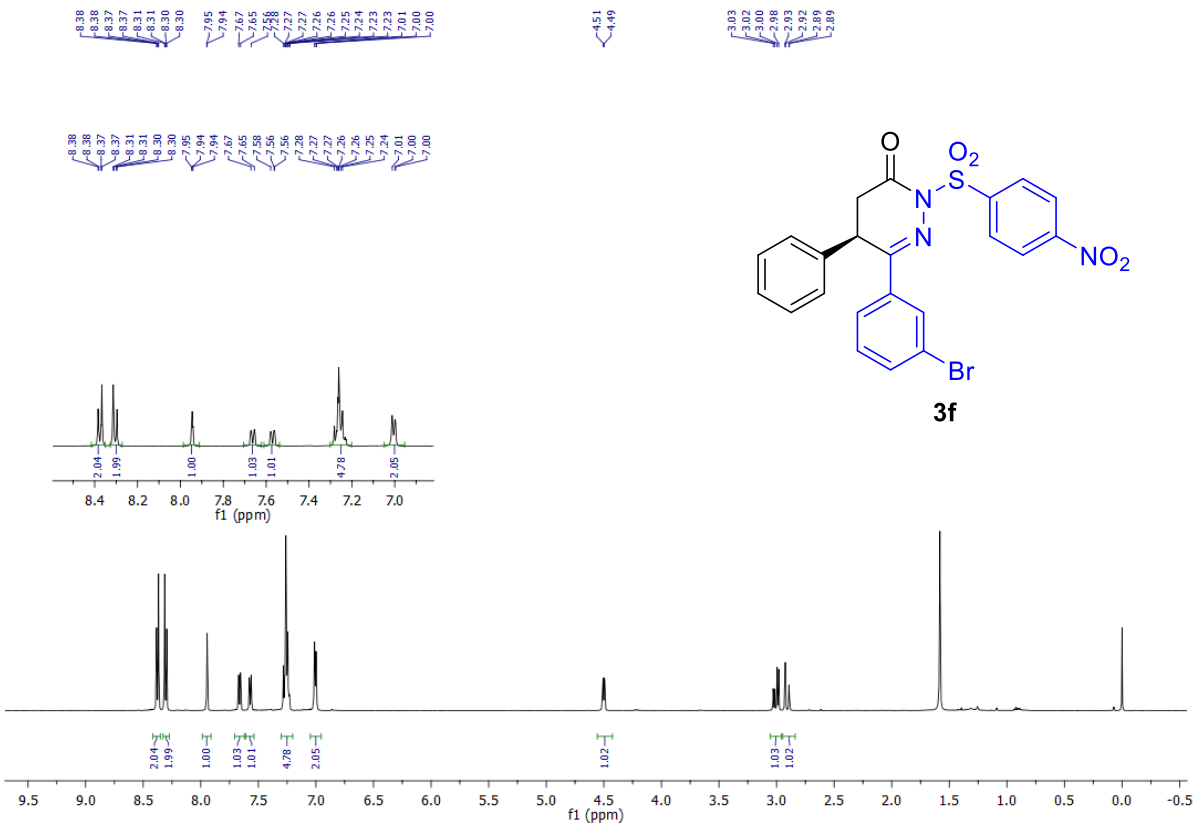
37.48
28.00
f1 (ppm)



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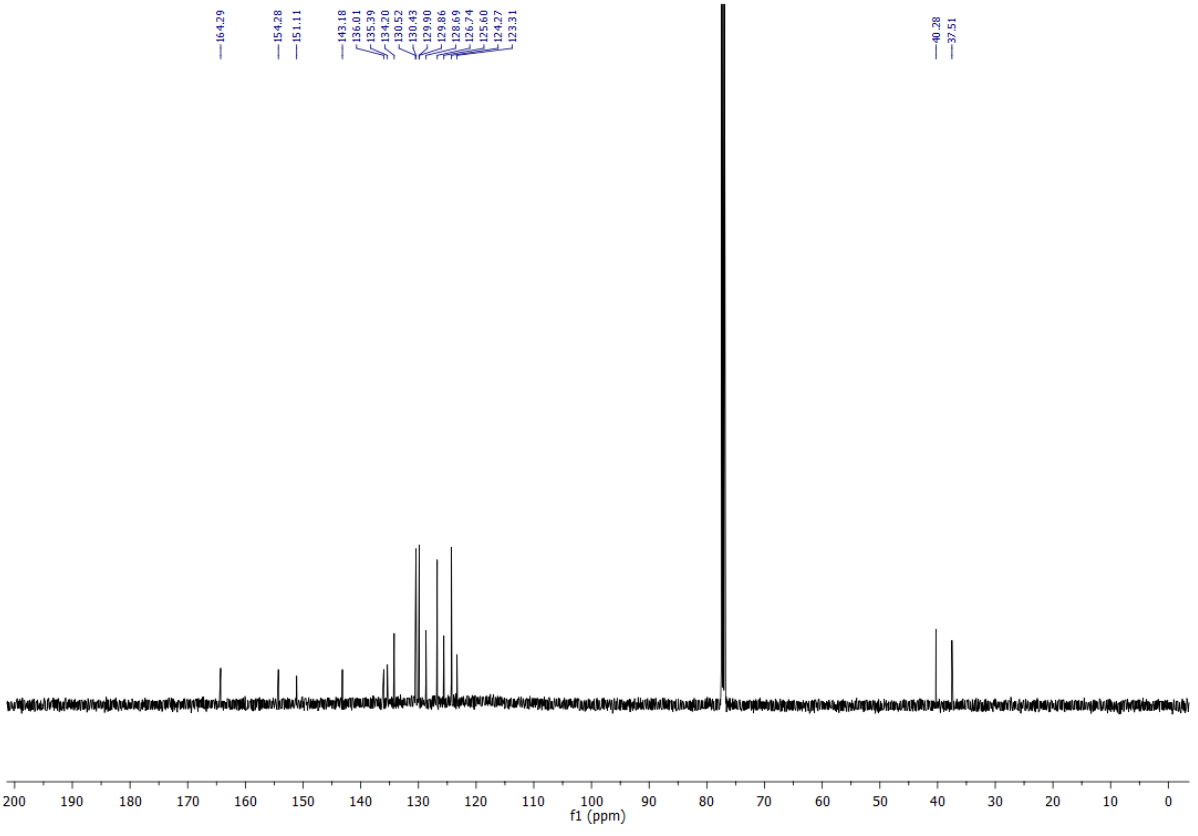

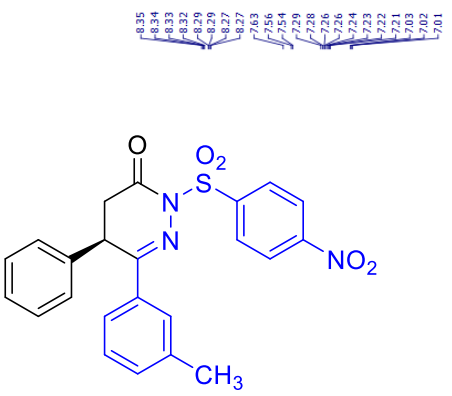

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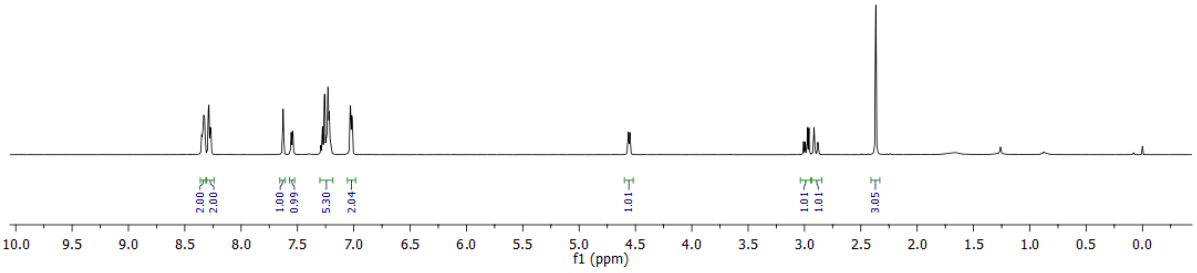
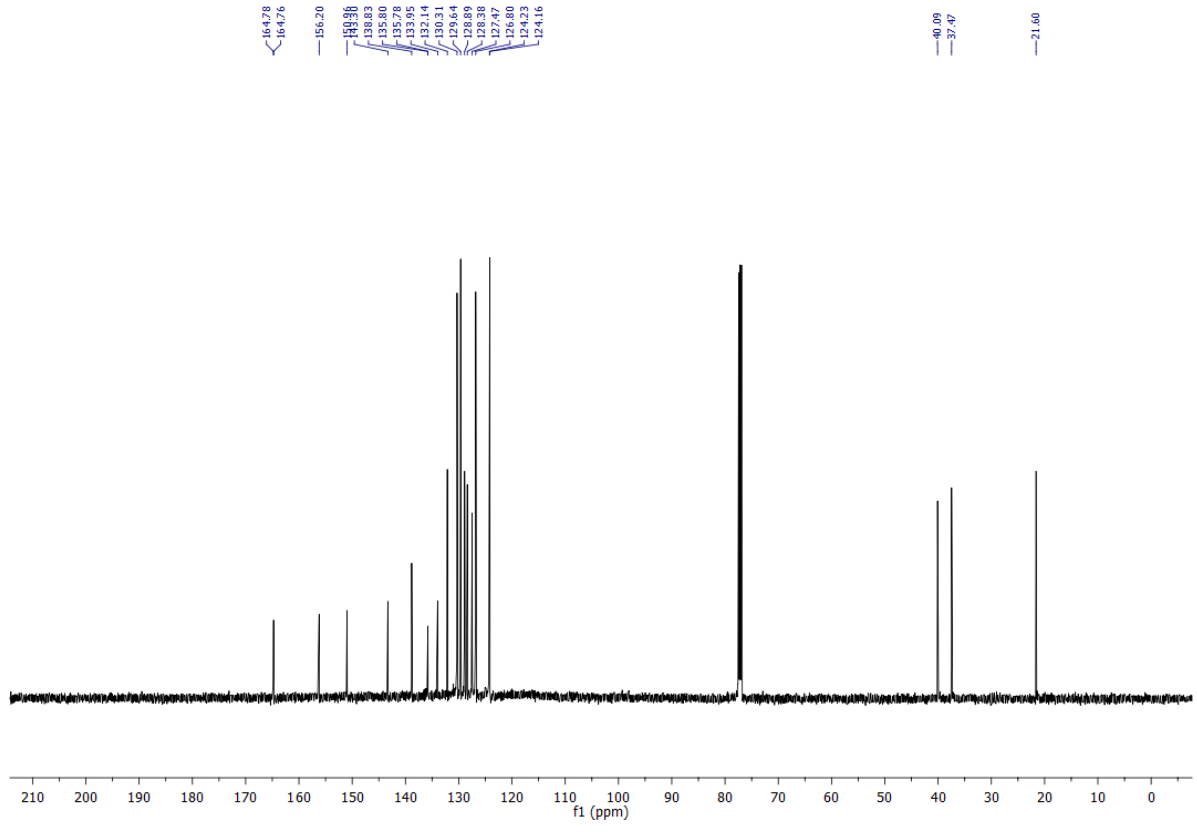
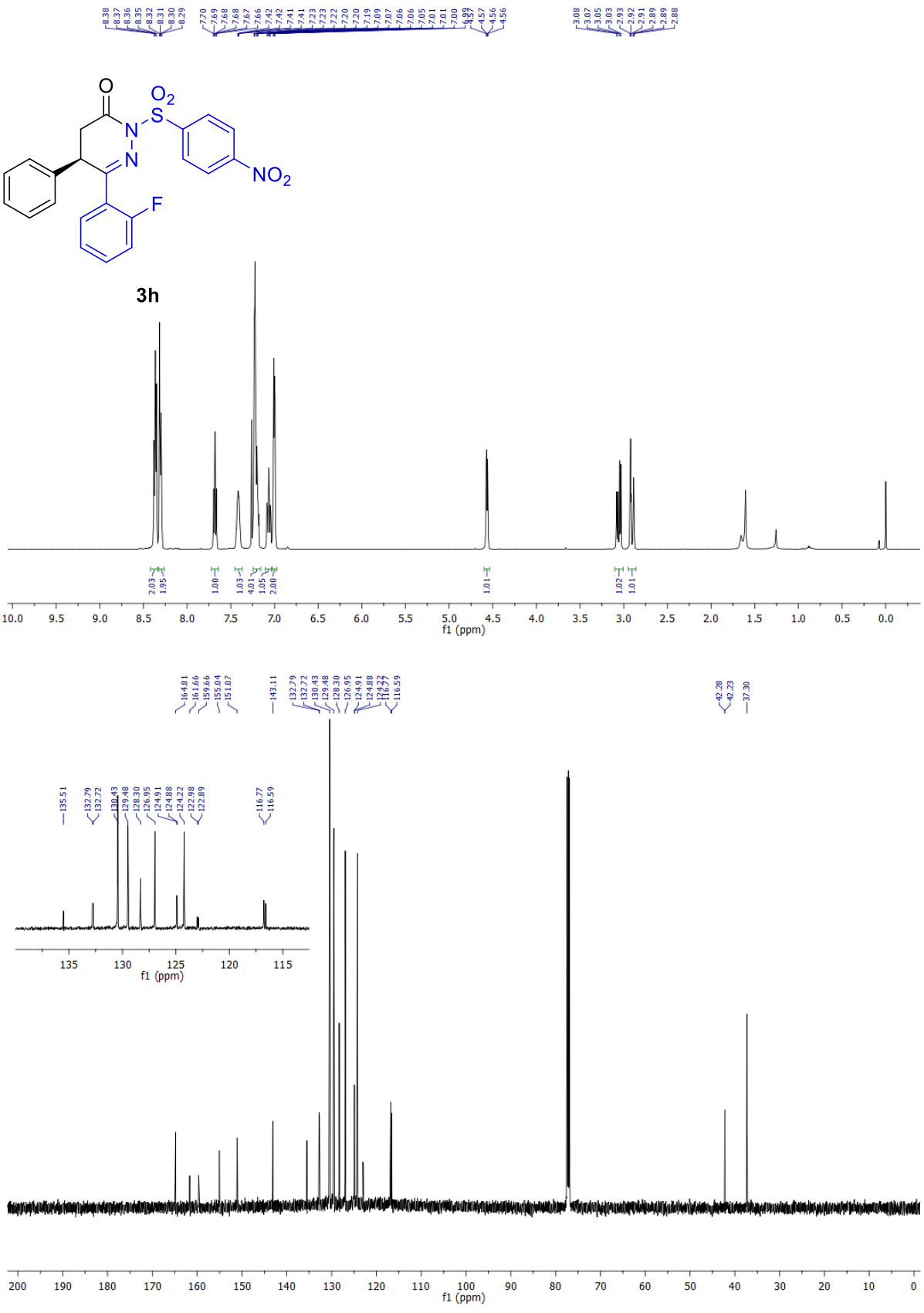
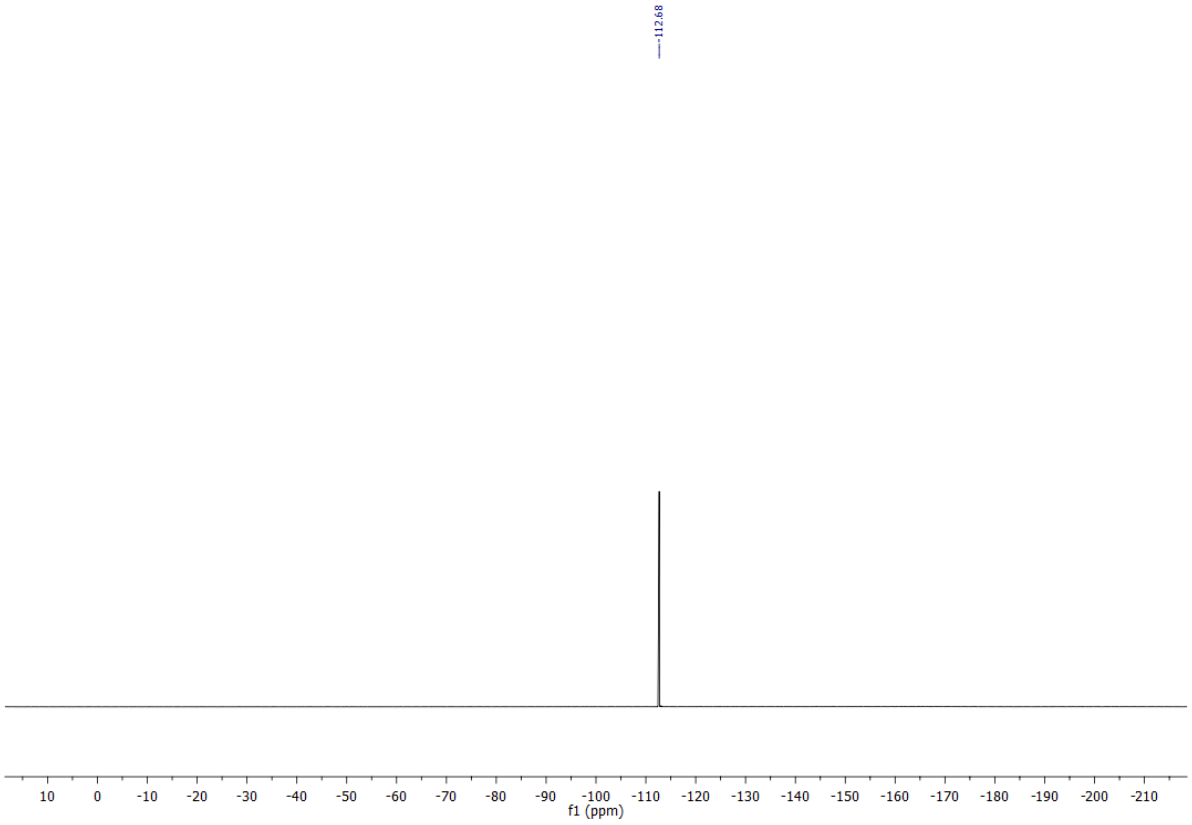





3h
f1 (ppm)
f1 (ppm)


-112.68
10
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-30
-40
-50
-60
-70
-80
-90
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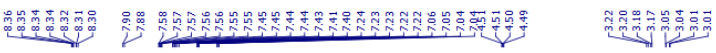
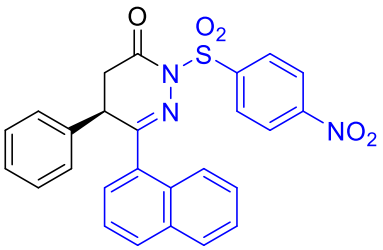
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)





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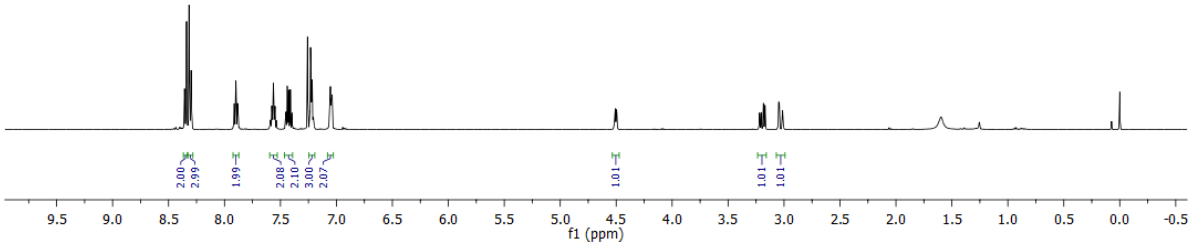

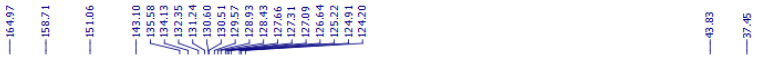

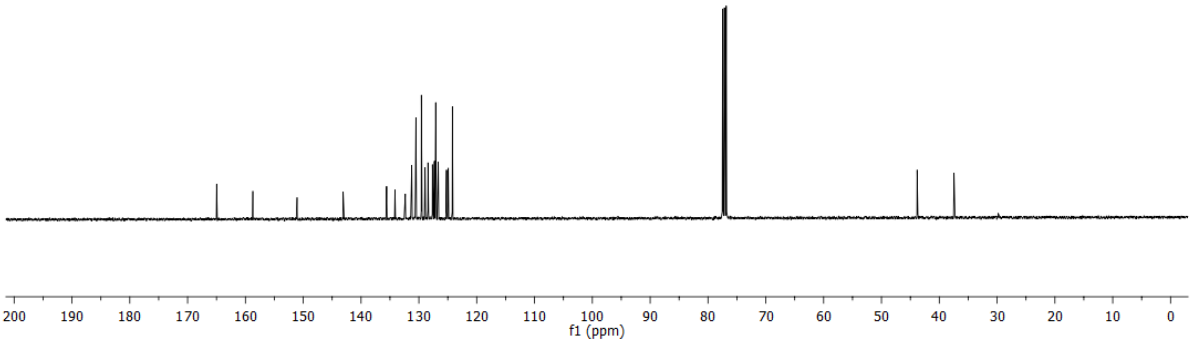

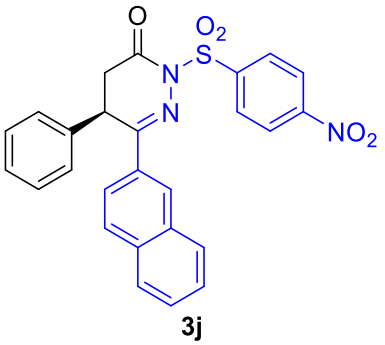

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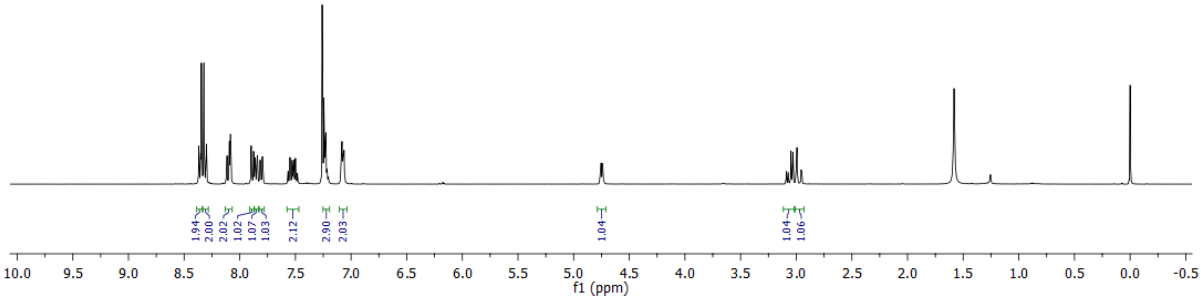

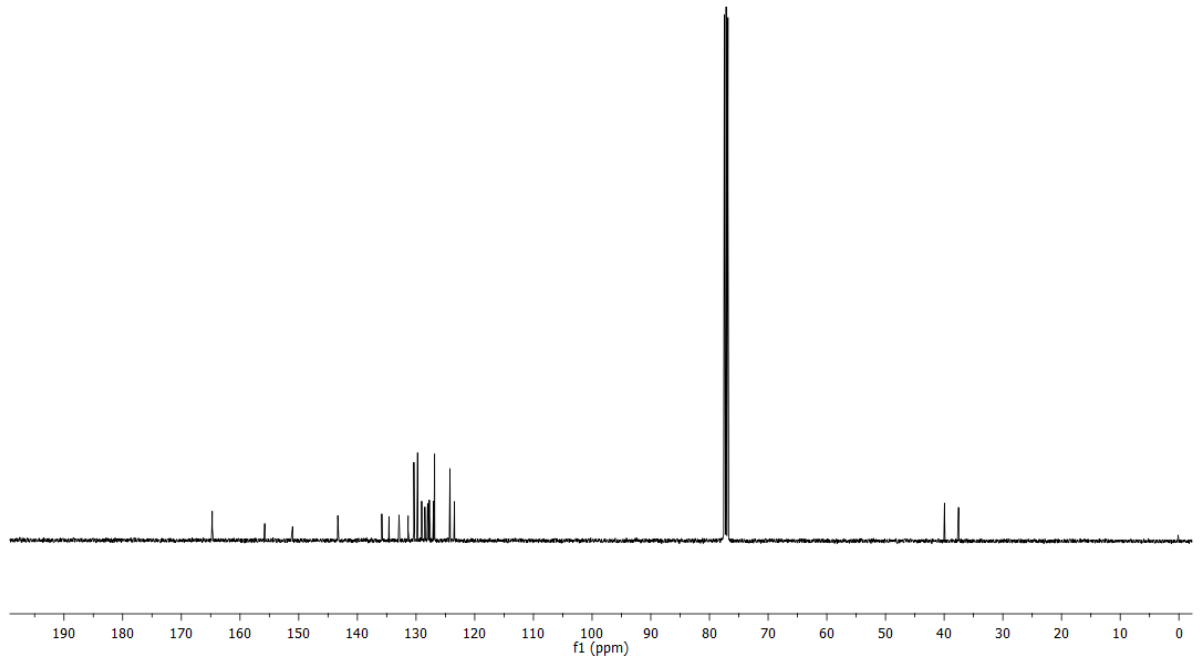

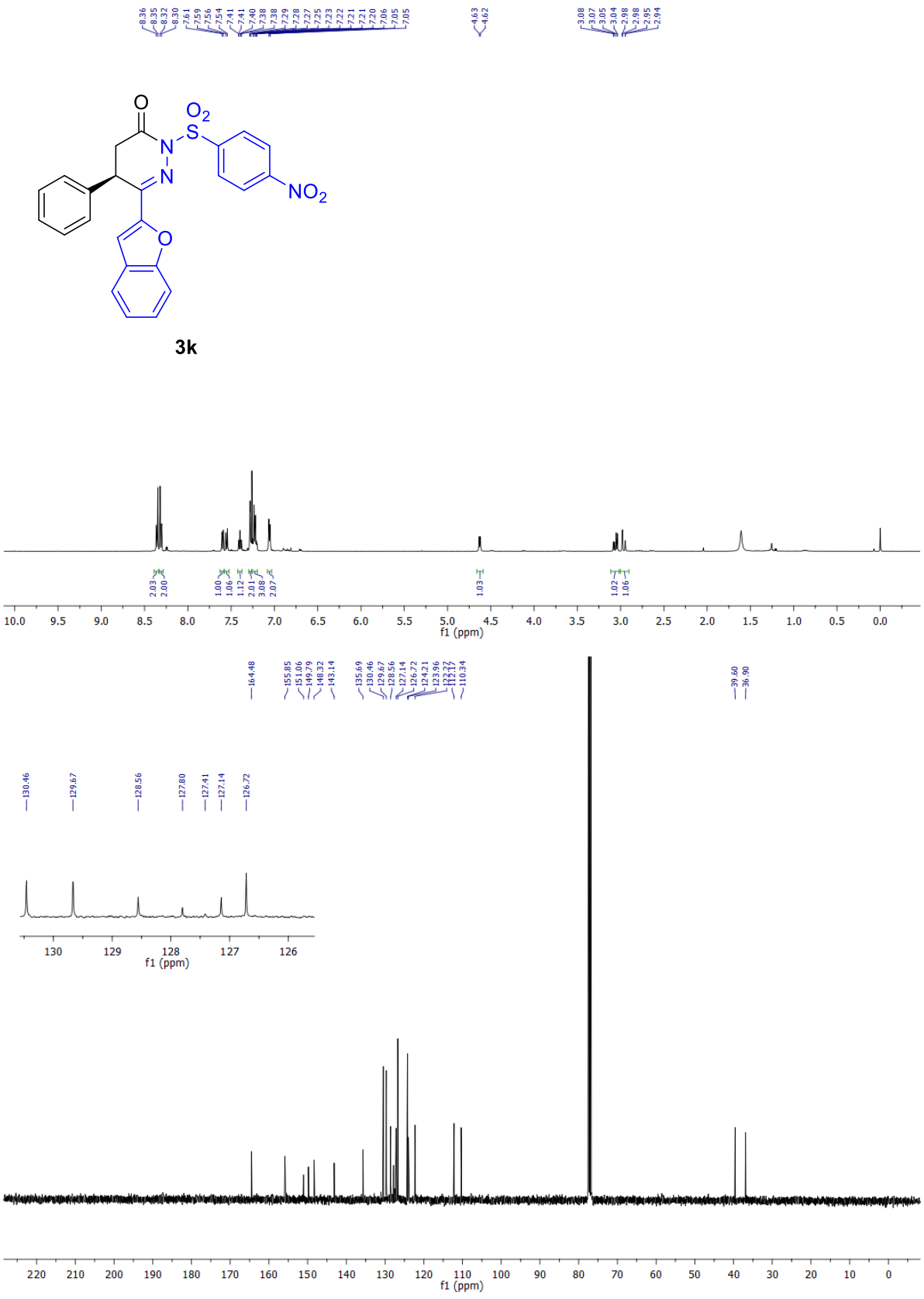

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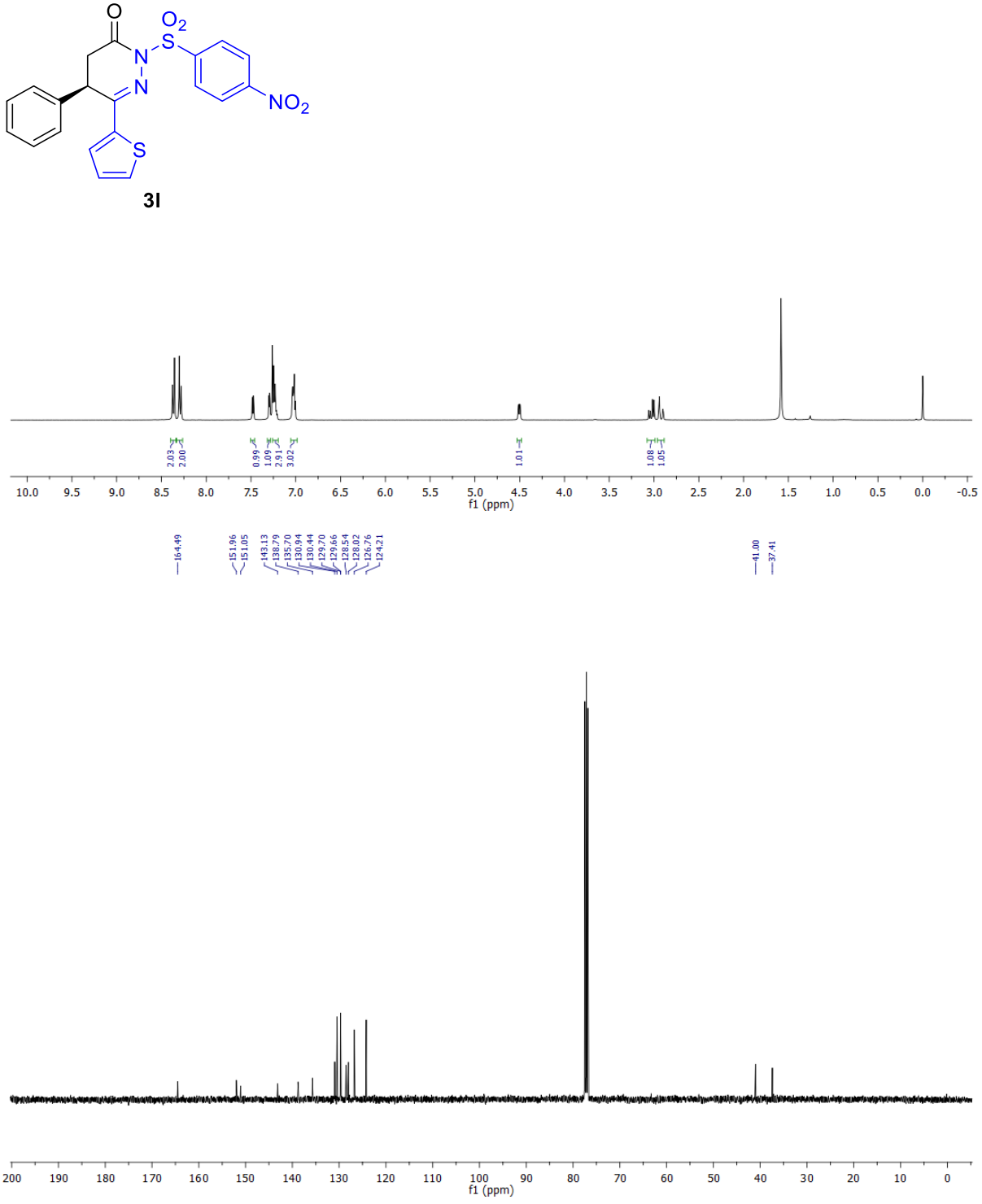
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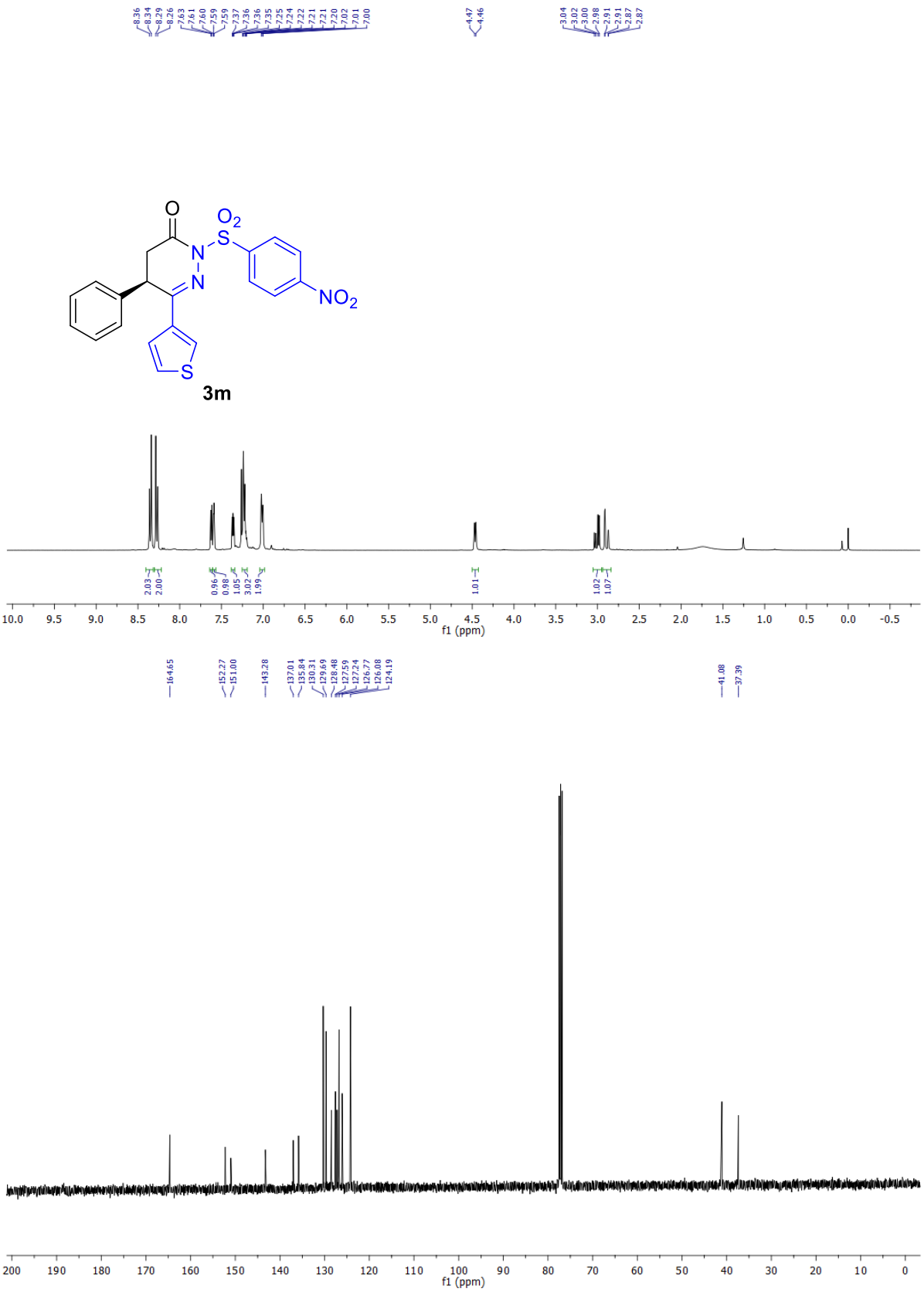
7.29
7.25
7.23
7.22
7.22
7.21
7.03
7.03
7.02
7.00
4.51
4.50
3.06
3.04
3.02
3.00
2.94
2.94
2.90
2.90
O
O2
S
N
N
NO2
S
2.03
2.00
0.99
1.09
2.91
3.02
1.01
1.08
1.05
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
164.49
151.96
151.05
143.13
138.79
135.70
130.94
130.44
129.70
129.66
128.54
128.02
126.76
124.21
41.00
37.41
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3l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8.34
8.29
8.26
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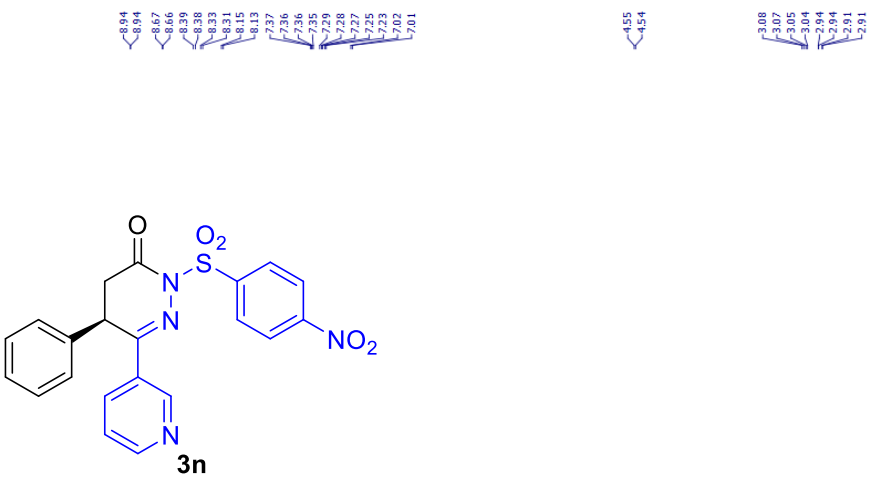
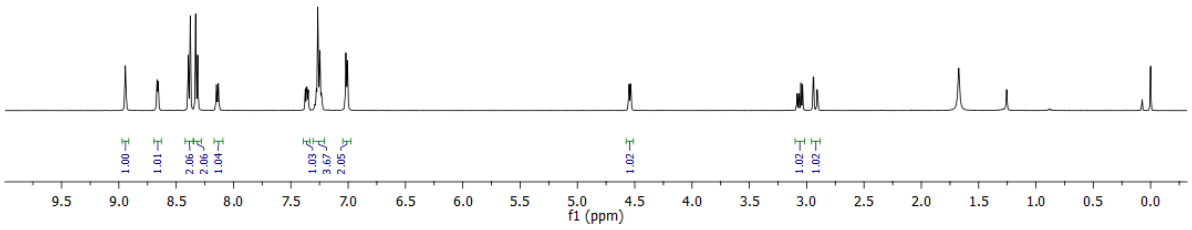
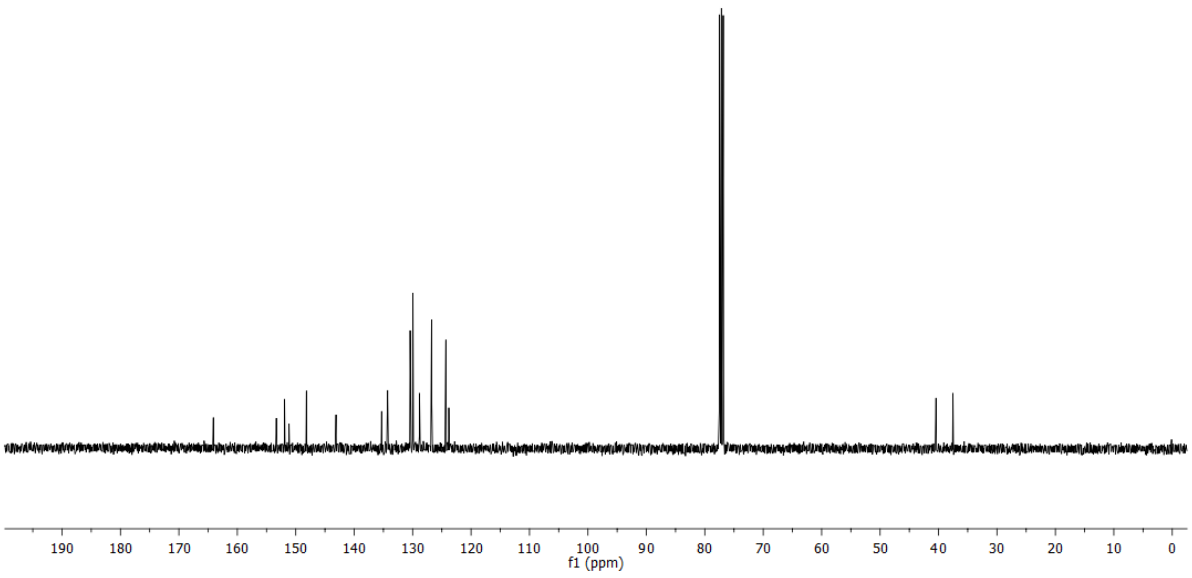
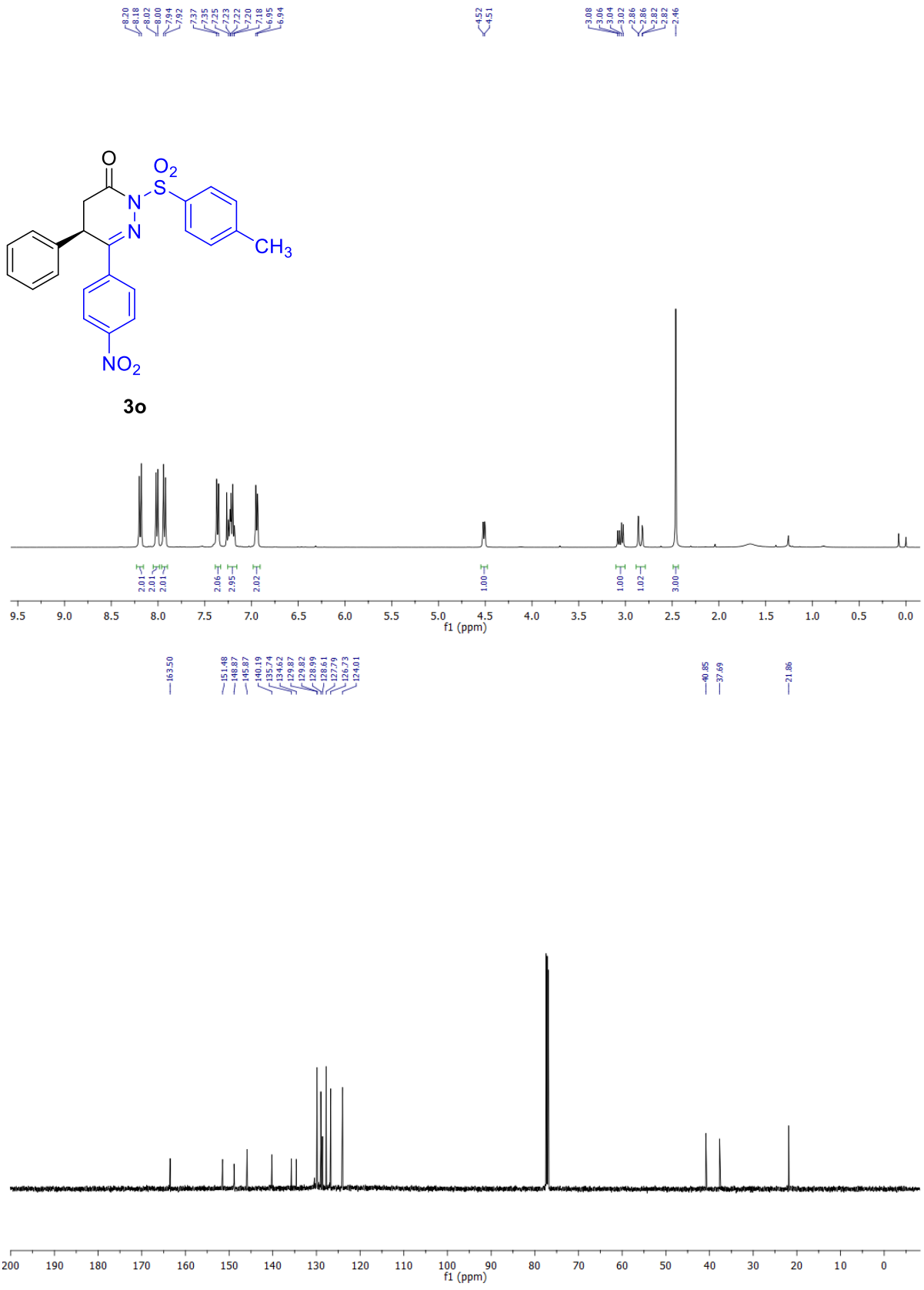
7.61
7.60
7.59
7.59
7.37
7.36
7.36
7.35
7.25
7.24
7.22
7.21
7.21
7.20
7.02
7.01
7.00
4.47
4.46
3.04
3.02
3.00
2.98
2.91
2.91
2.87
2.87
O
O2
S
N
N
NO2
S
3m
2.03
2.00
0.96
0.98
1.05
3.02
1.99
1.01
1.02
1.07
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
164.65
152.27
151.00
143.28
137.01
135.84
130.31
129.69
128.48
127.59
127.24
126.77
126.08
124.19
41.08
37.39
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

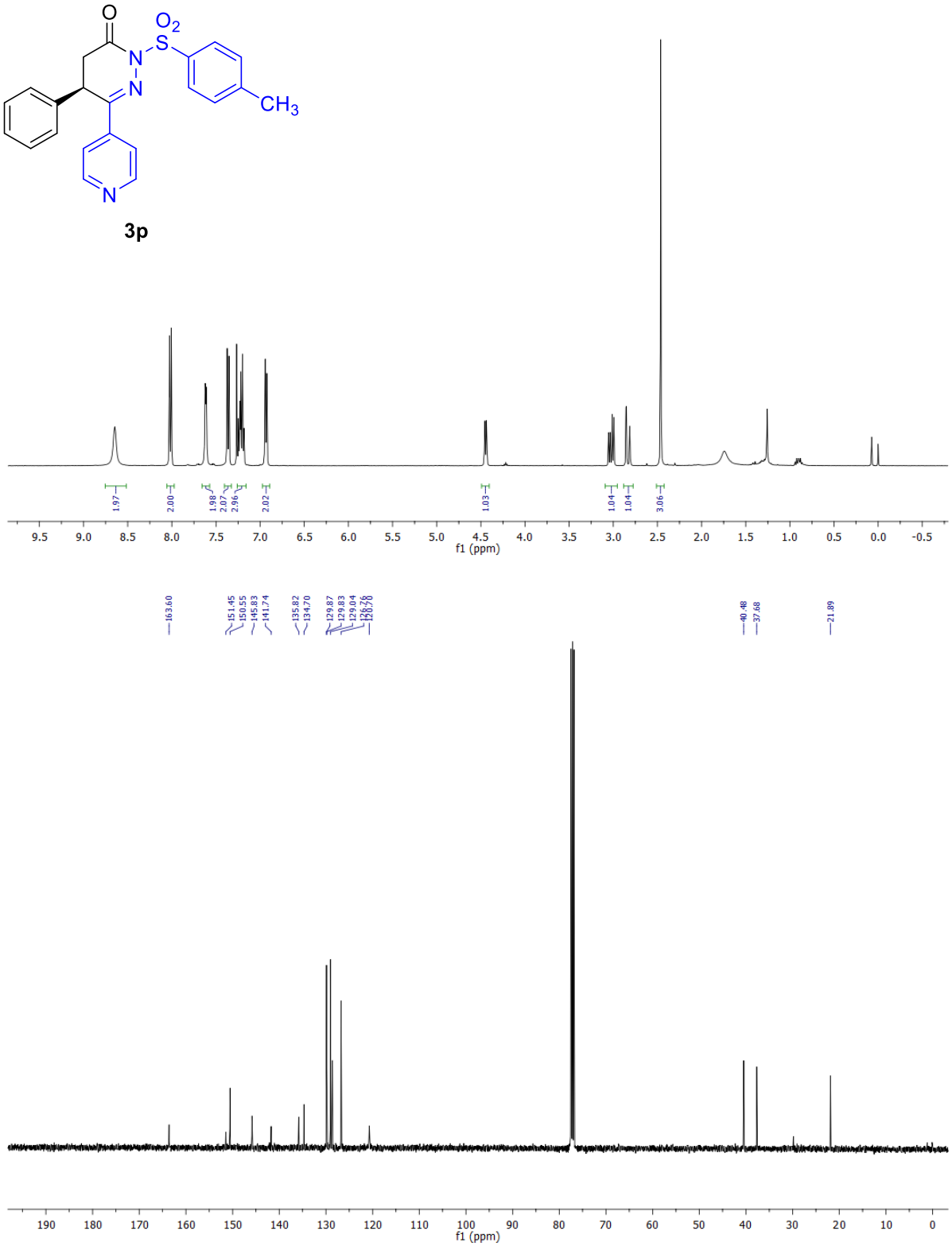

O
O2
S
N
N
NO2
N
3n


f1 (ppm)

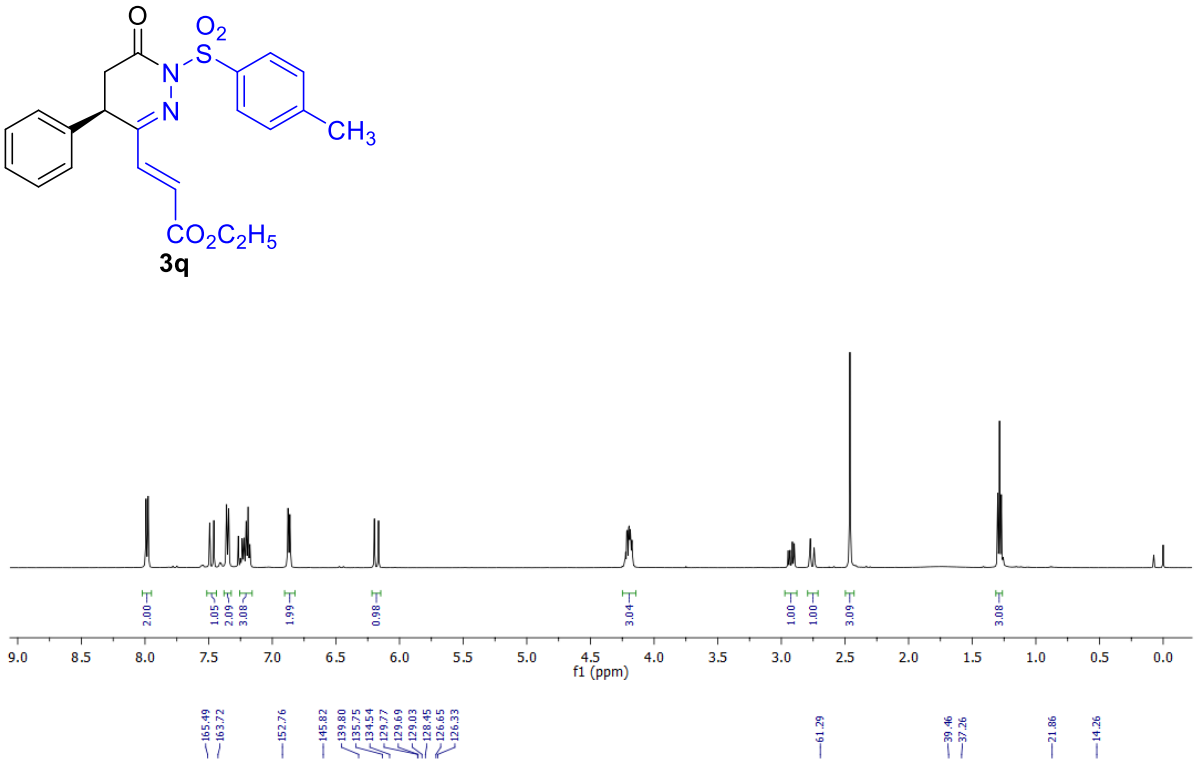

f1 (ppm)

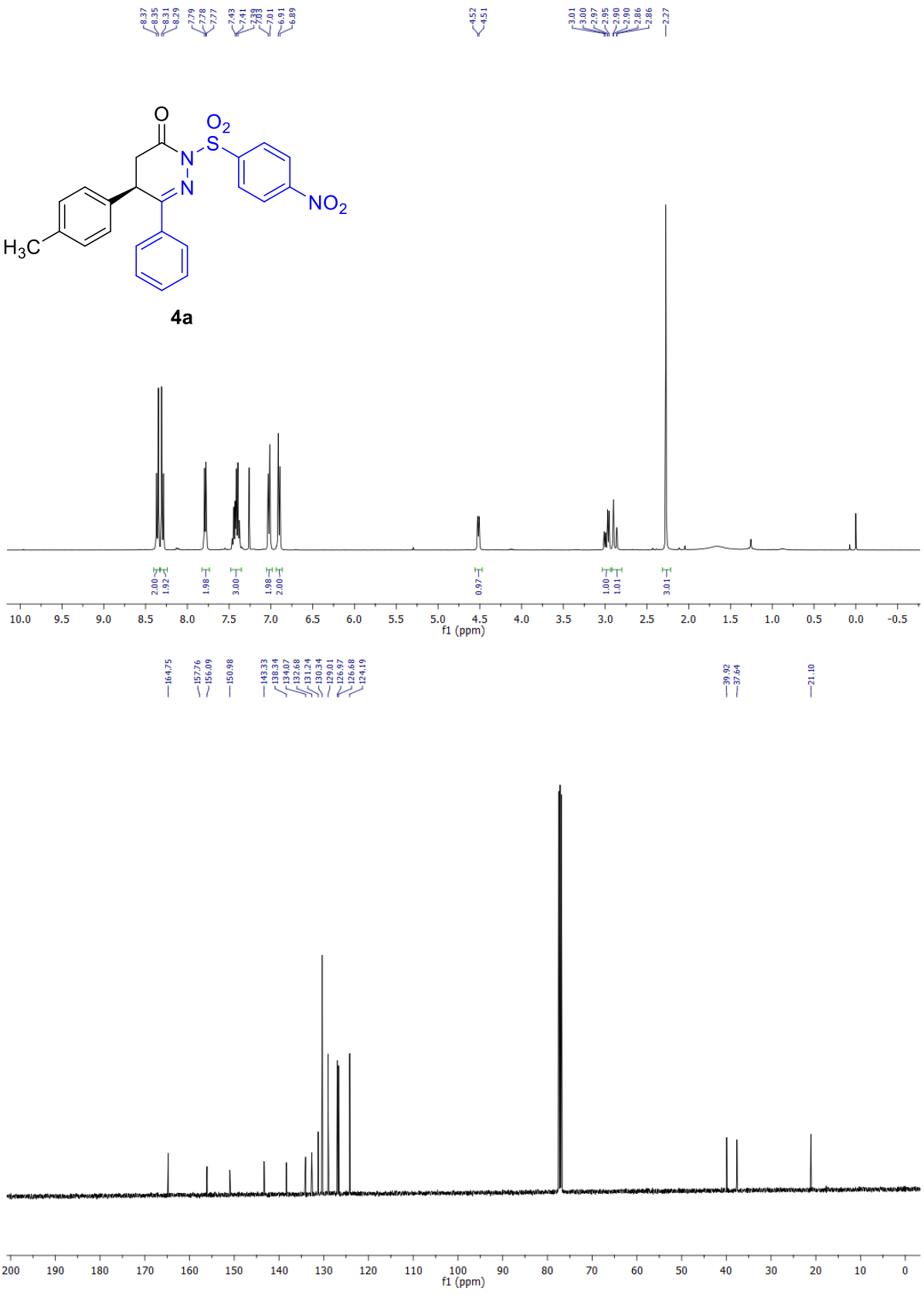

8.20
8.18
8.02
8.00
7.94
7.92
7.37
7.35
7.25
7.23
7.22
7.20
7.18
6.95
6.94
4.52
4.51
3.08
3.06
3.04
3.02
2.86
2.86
2.82
2.82
2.46
O
O2
S
N
N
CH3
NO2
2.01
2.01
2.01
2.06
2.95
2.02
1.00
1.00
1.02
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
163.50
151.48
148.87
145.87
140.19
135.74
134.62
129.87
129.82
128.99
128.61
127.79
126.73
124.01
40.85
37.69
21.86
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3o


8.65
8.03
8.01
7.62
7.61
7.37
7.35
7.26
7.25
7.24
7.23
7.22
7.20
7.18
6.94
6.92
4.45
4.44
3.05
3.04
3.01
2.99
2.86
2.85
2.81
2.81
2.46
O
O2
S
N
N
CH3
N
1.97
2.00
1.98
2.07
2.96
2.02
1.03
1.04
1.04
3.06
f1 (ppm)
163.60
151.45
150.55
145.83
141.74
135.82
134.70
129.87
129.83
129.04
40.48
37.68
21.89
f1 (ppm)

3p


7.99
7.98
7.49
7.46
7.36
7.34
7.24
7.22
7.21
6.88
6.86
6.20
6.17
4.25
4.24
4.23
4.22
4.21
4.21
4.20
4.20
4.19
4.18
4.17
4.16
2.95
2.93
2.91
2.90
2.78
2.77
2.74
2.74
2.46
1.30
1.29
1.27
O
O2
S
N
N
CH3
CO2C2H5
3q
2.00
1.05
2.09
3.08
1.99
0.98
3.04
1.00
1.00
3.09
3.08
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
165.49
163.72
152.76
145.82
139.80
135.75
134.54
129.77
129.69
129.03
128.45
126.65
126.33
61.29
39.46
37.26
21.86
14.26
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.31
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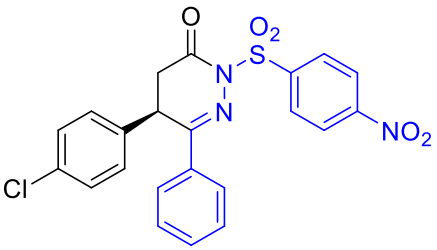
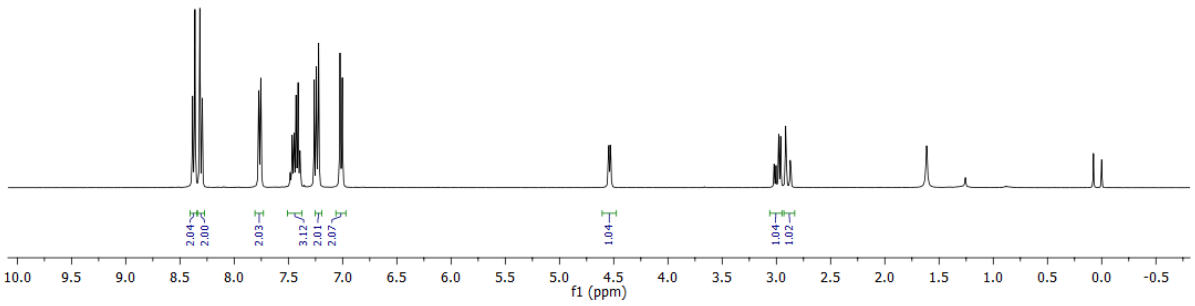
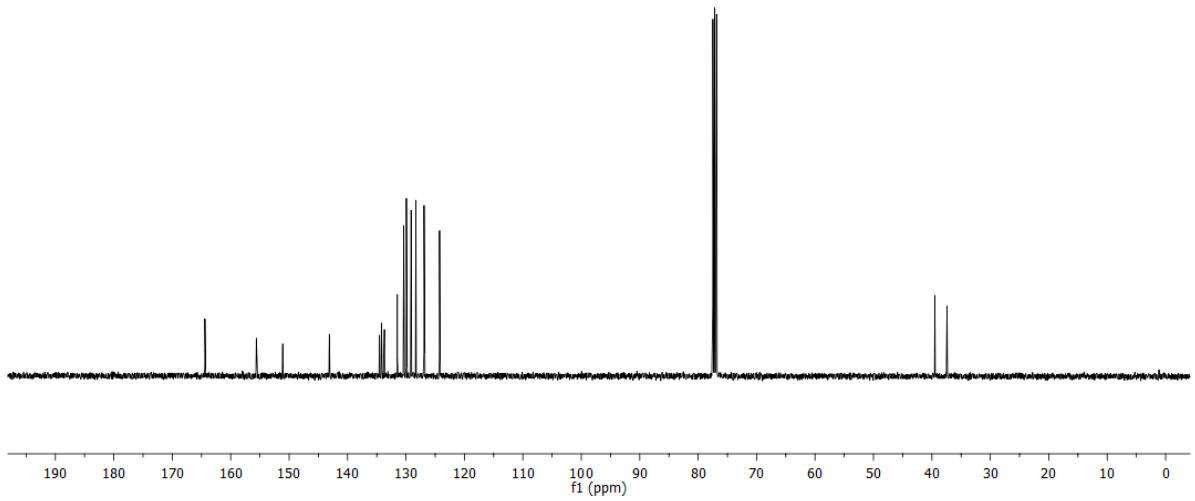
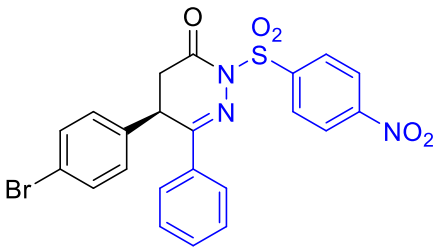
7.78
7.77
7.43
7.41
7.03
7.01
6.91
6.89
4.52
4.51
3.01
3.00
2.97
2.95
2.90
2.90
2.86
2.86
2.27
O
O2
S
N
N
NO2
H3C
4a
2.00
1.92
1.98
3.00
1.98
2.00
0.97
1.00
1.01
3.01
f1 (ppm)
164.75
157.76
156.09
150.98
143.33
138.34
134.07
132.68
131.24
130.34
129.01
126.97
126.68
124.19
39.92
37.64
21.10
f1 (ppm)



4b







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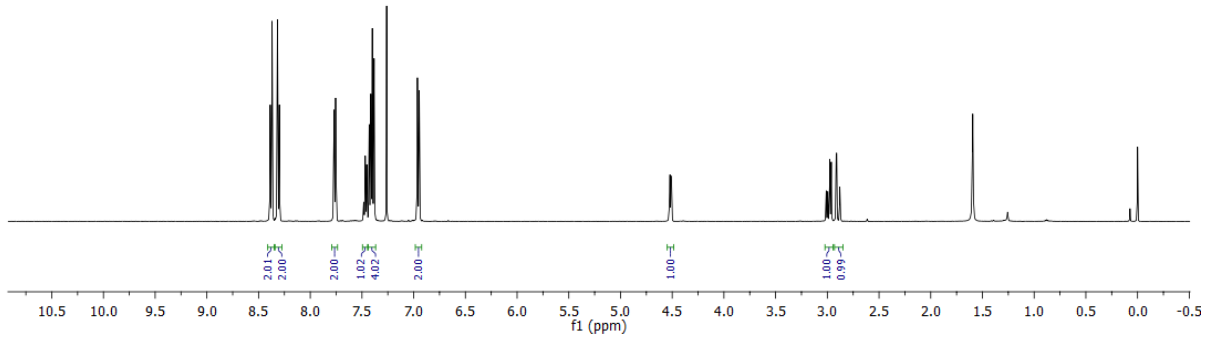
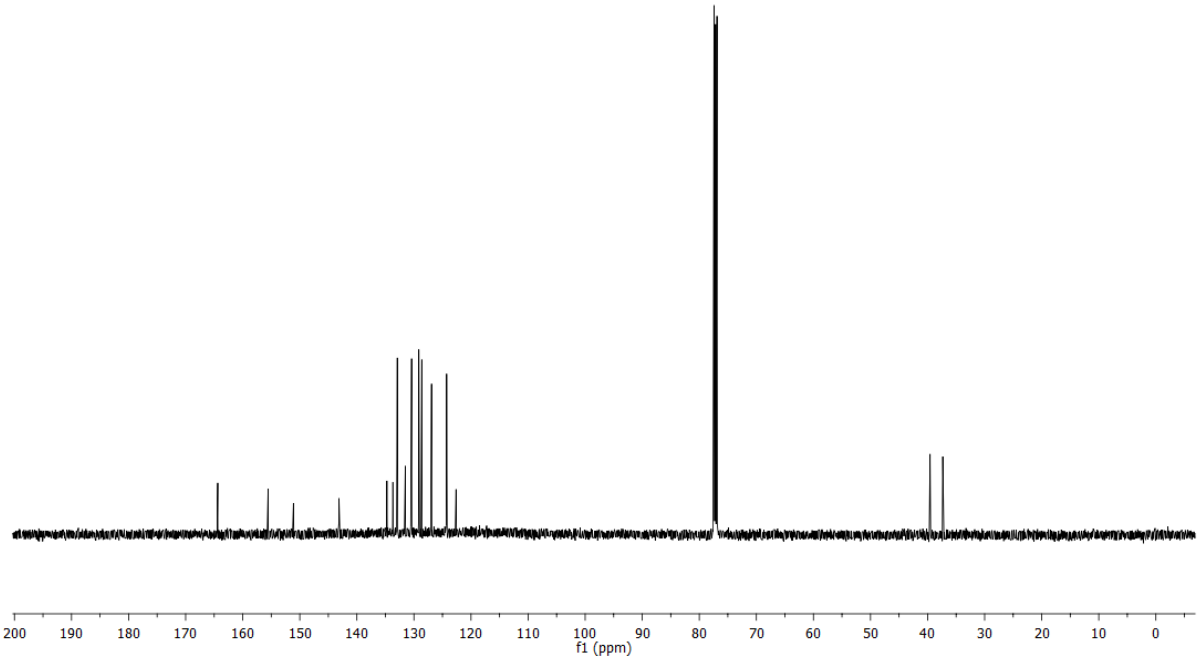
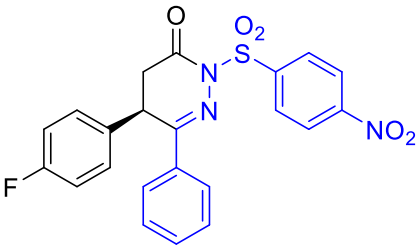
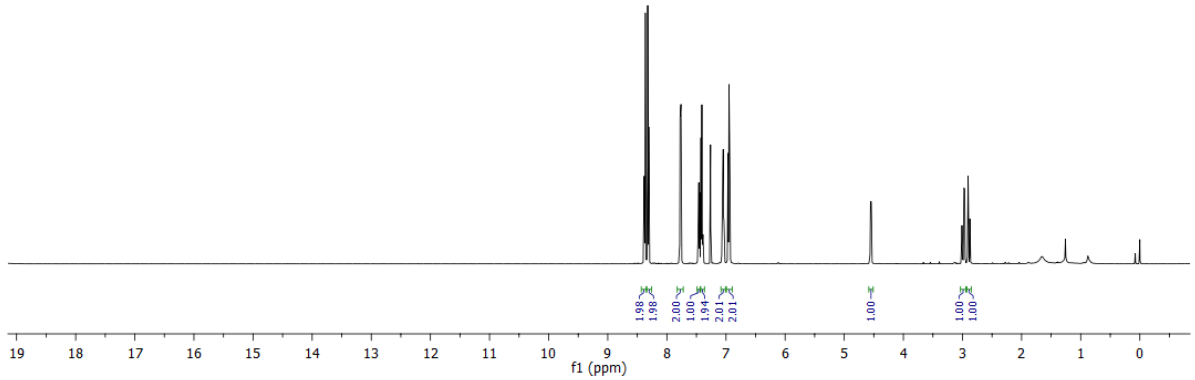
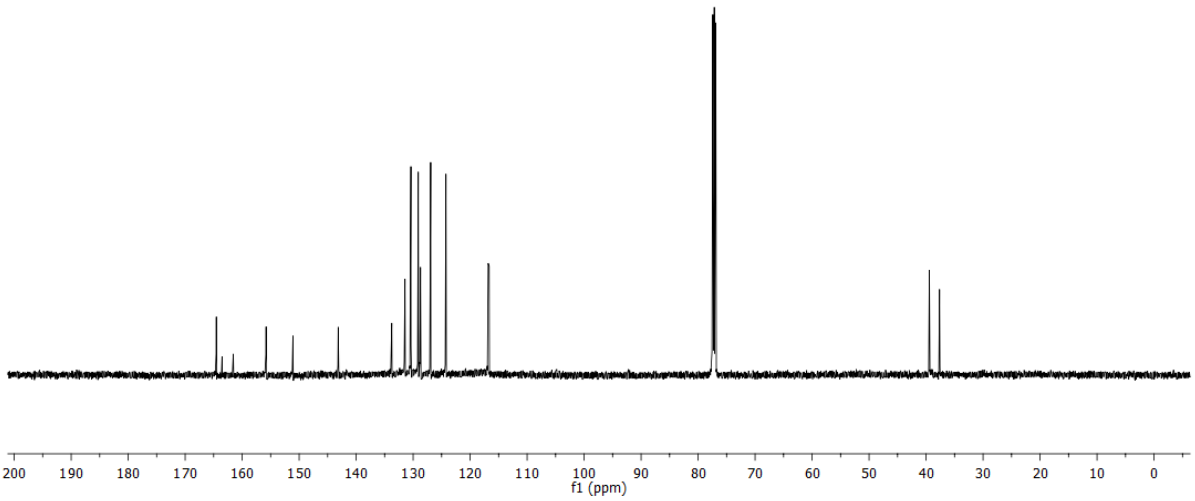


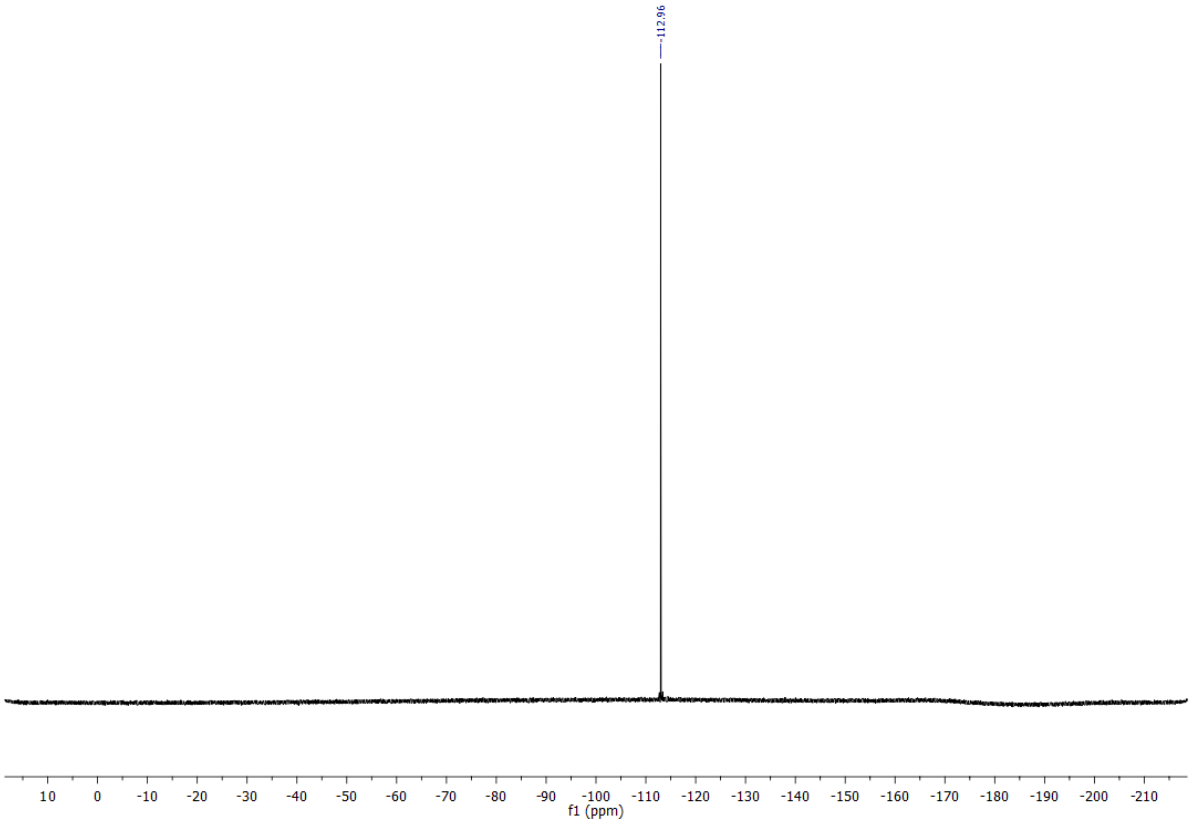


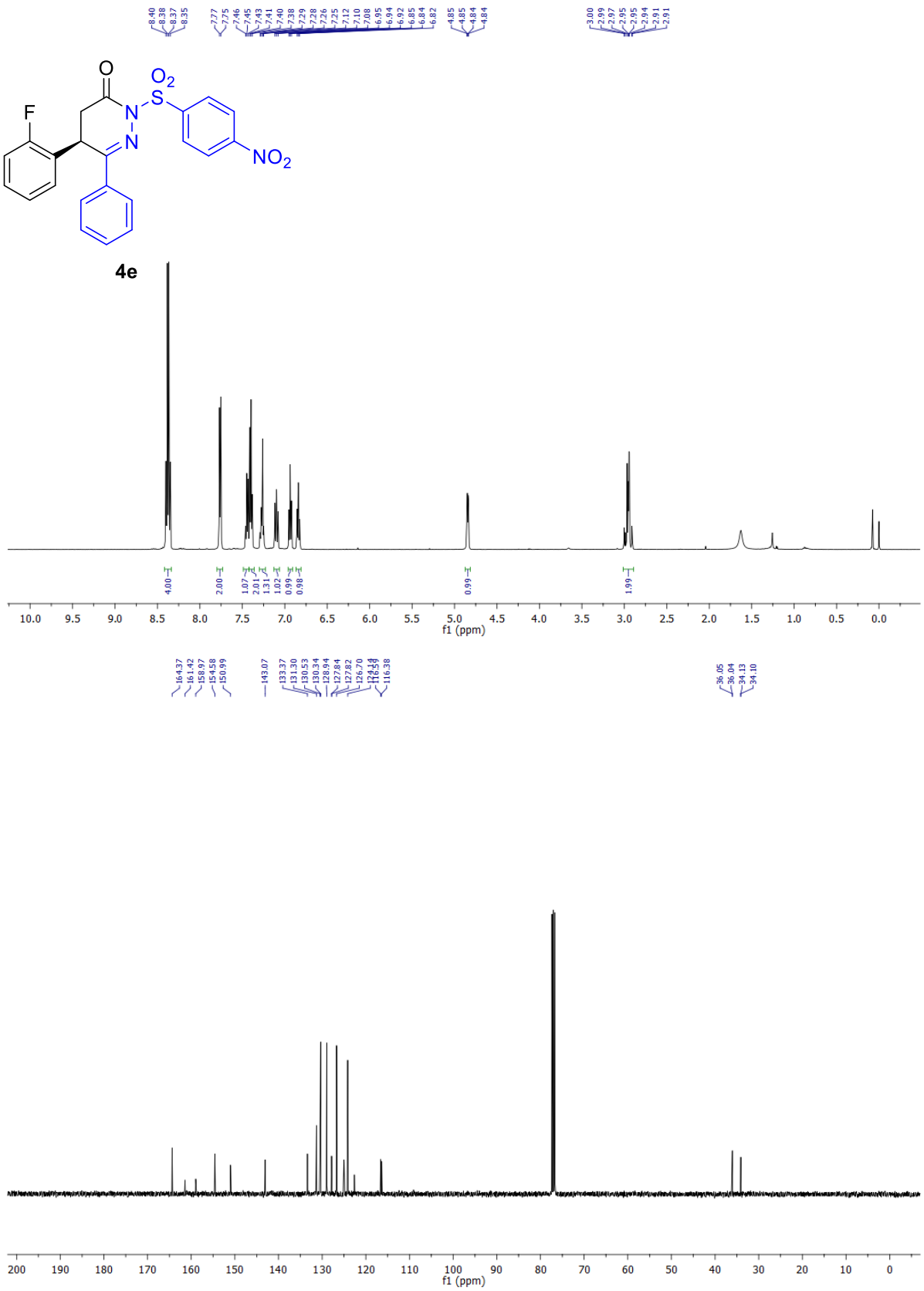


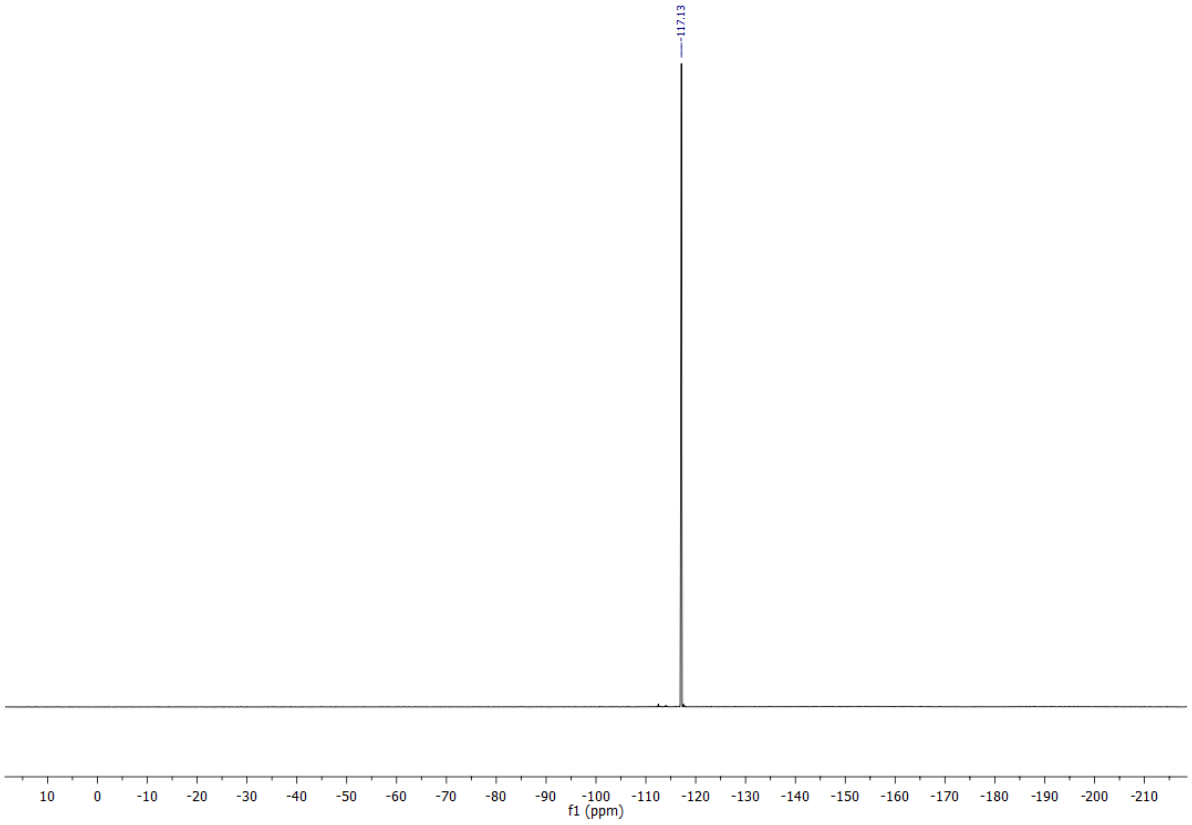
4d






-112.96
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)


4e
f1 (ppm)
f1 (ppm)


-117.13
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
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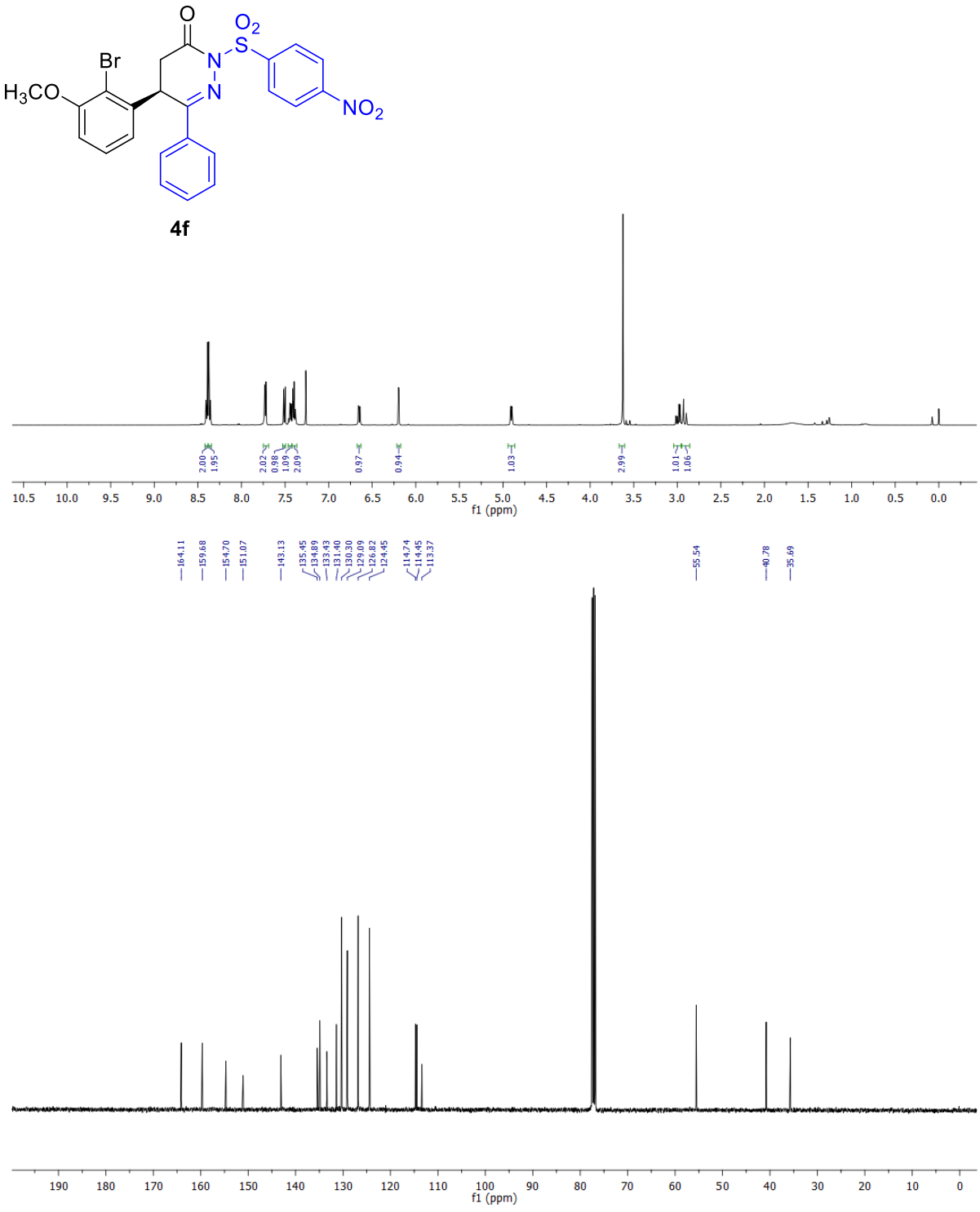
-170
-180
-190
-200
-210
f1 (ppm)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7.72
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7.43
7.41
7.40
6.66
6.65
6.64
6.64
6.20
6.19
4.91
4.91
4.90
4.89
3.62
3.02
3.00
2.98
2.97
2.93
2.93
2.90
2.89
O
O2
S
N
N
Br
H3CO
NO2
4f
2.00
1.95
2.02
0.98
1.09
2.09
0.97
0.94
1.03
2.99
1.01
1.06
f1 (ppm)
164.11
159.68
154.70
151.07
143.13
135.45
134.89
133.43
131.40
130.30
129.09
126.82
124.45
114.74
114.45
113.37
55.54
40.78
35.69
f1 (ppm)


8.38
8.36
8.31
8.29
7.78
7.76
7.76
7.76
7.48
7.46
7.45
7.43
7.41
7.40
7.23
7.22
7.21
7.19
7.18
6.97
6.95
6.92
4.55
4.54
3.06
3.05
3.03
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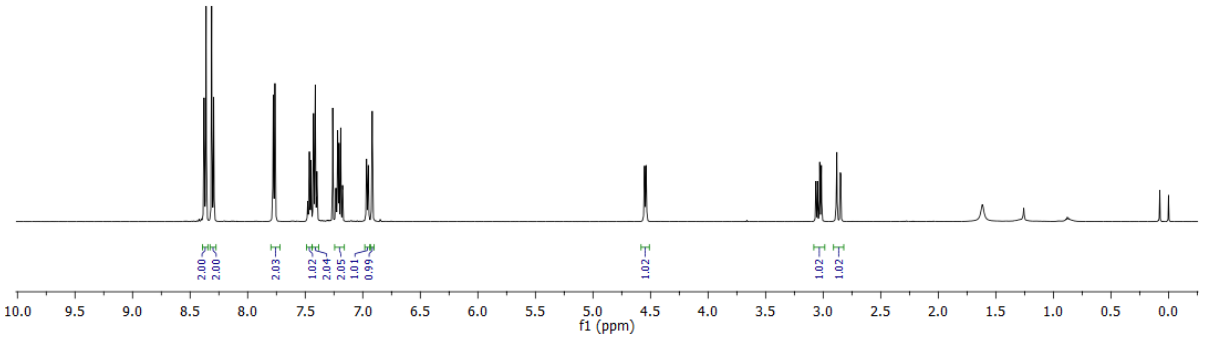
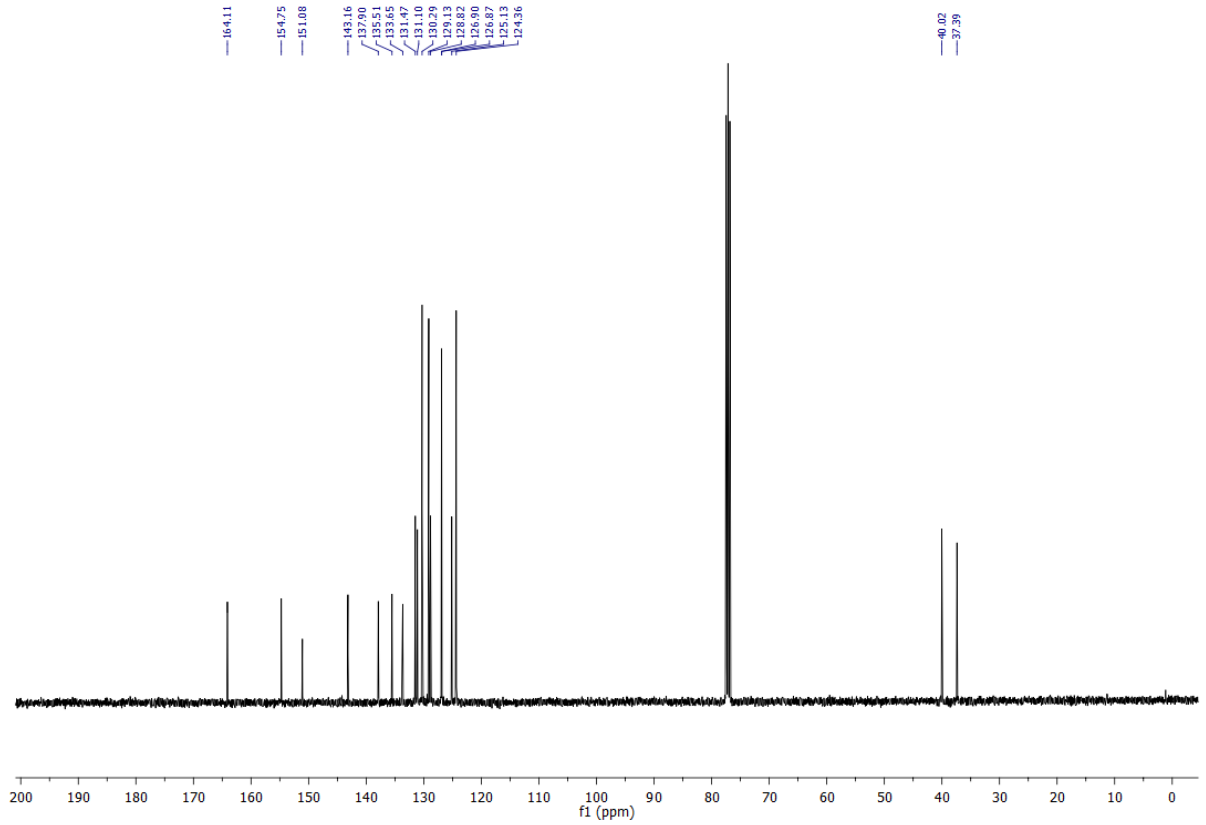
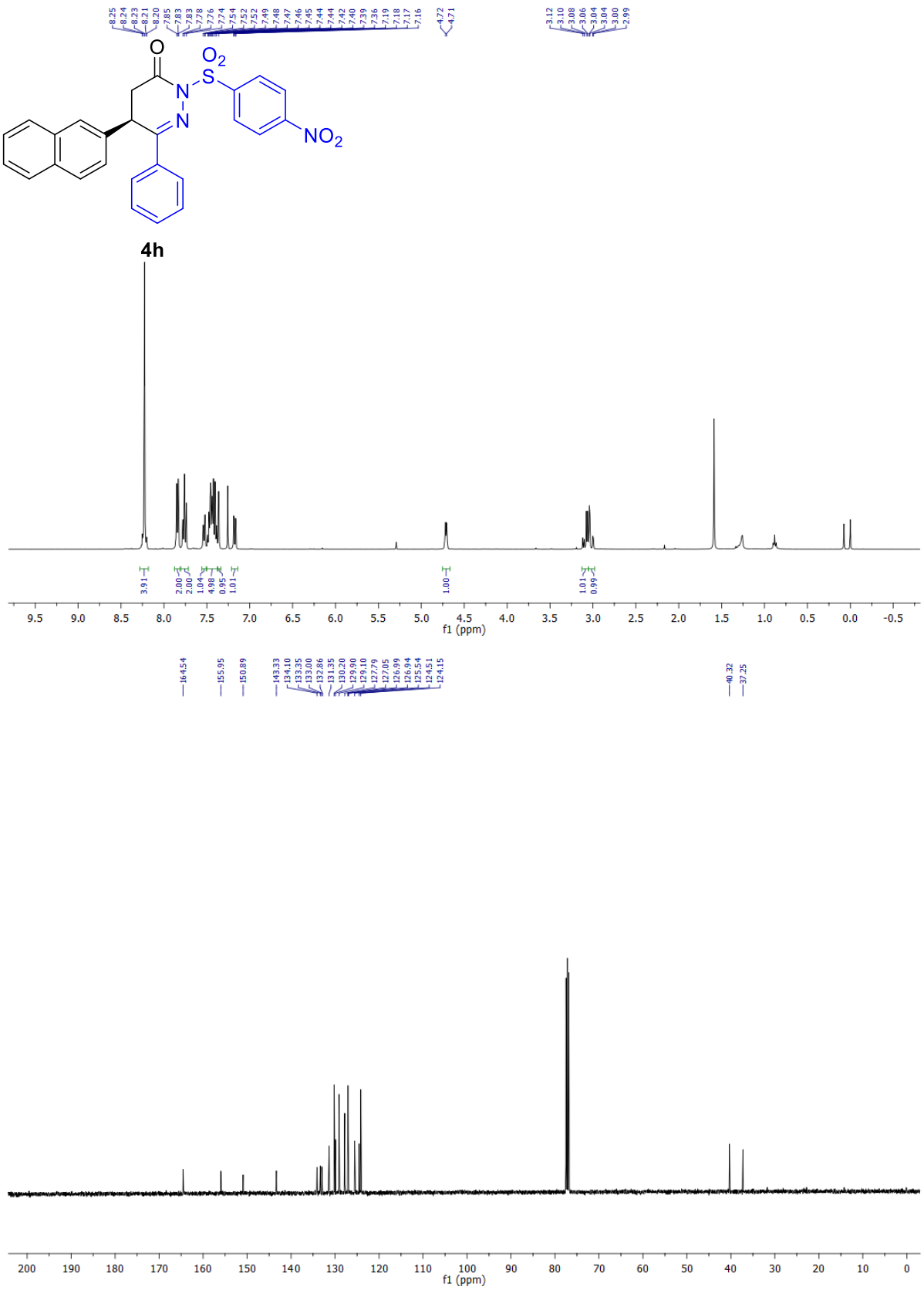
2.88
2.85
2.85
O
O2
S
N
N
Cl
NO2

4g


2.00
2.00
2.03
1.02
2.04
2.05
1.01
0.99
1.02
1.02
1.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


164.11
154.75
151.08
143.16
137.90
135.51
133.65
131.47
131.10
130.29
129.13
128.82
126.90
126.87
125.13
124.36
40.02
37.39
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.25
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7.85
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7.83
7.78
7.76
7.74
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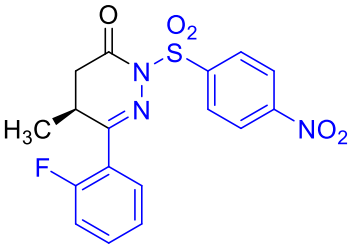
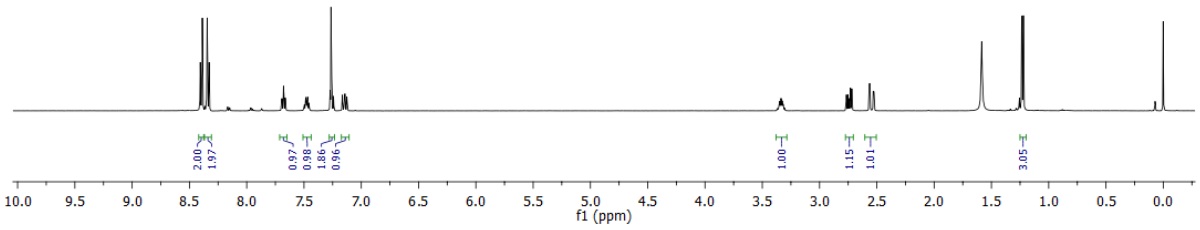
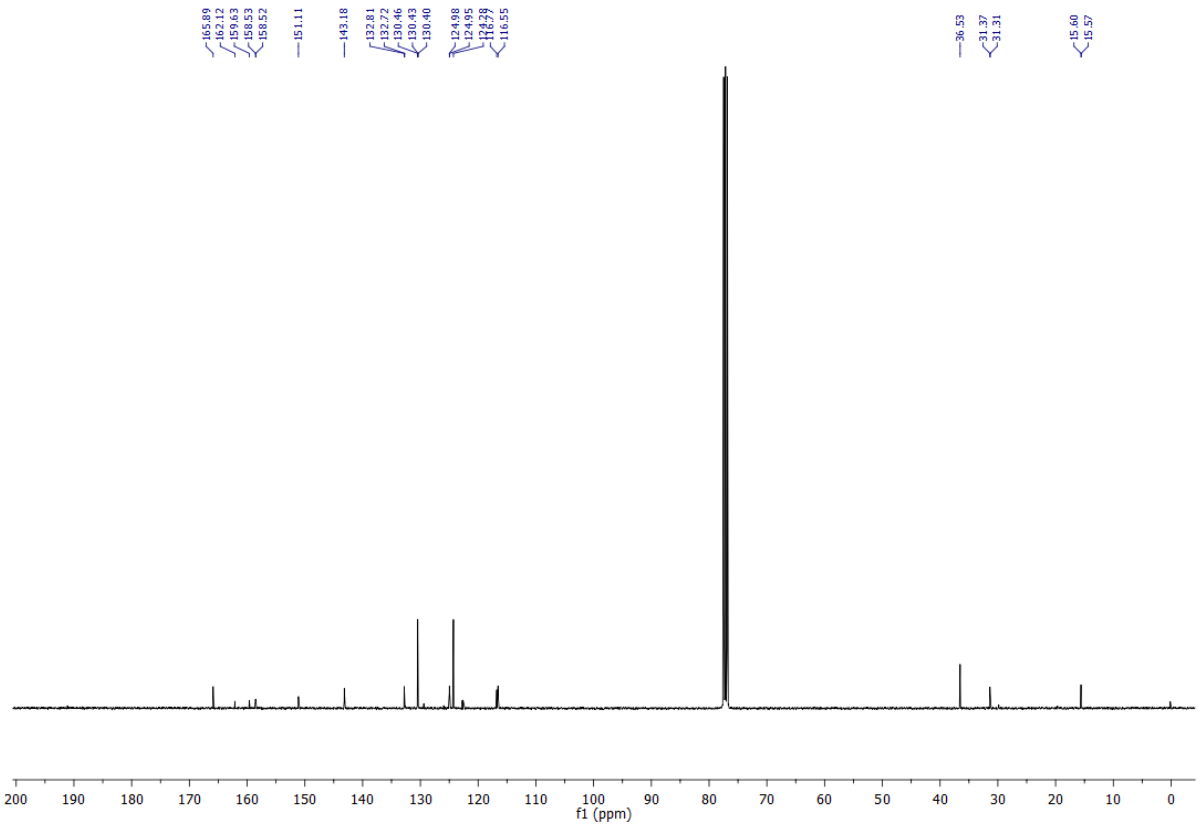
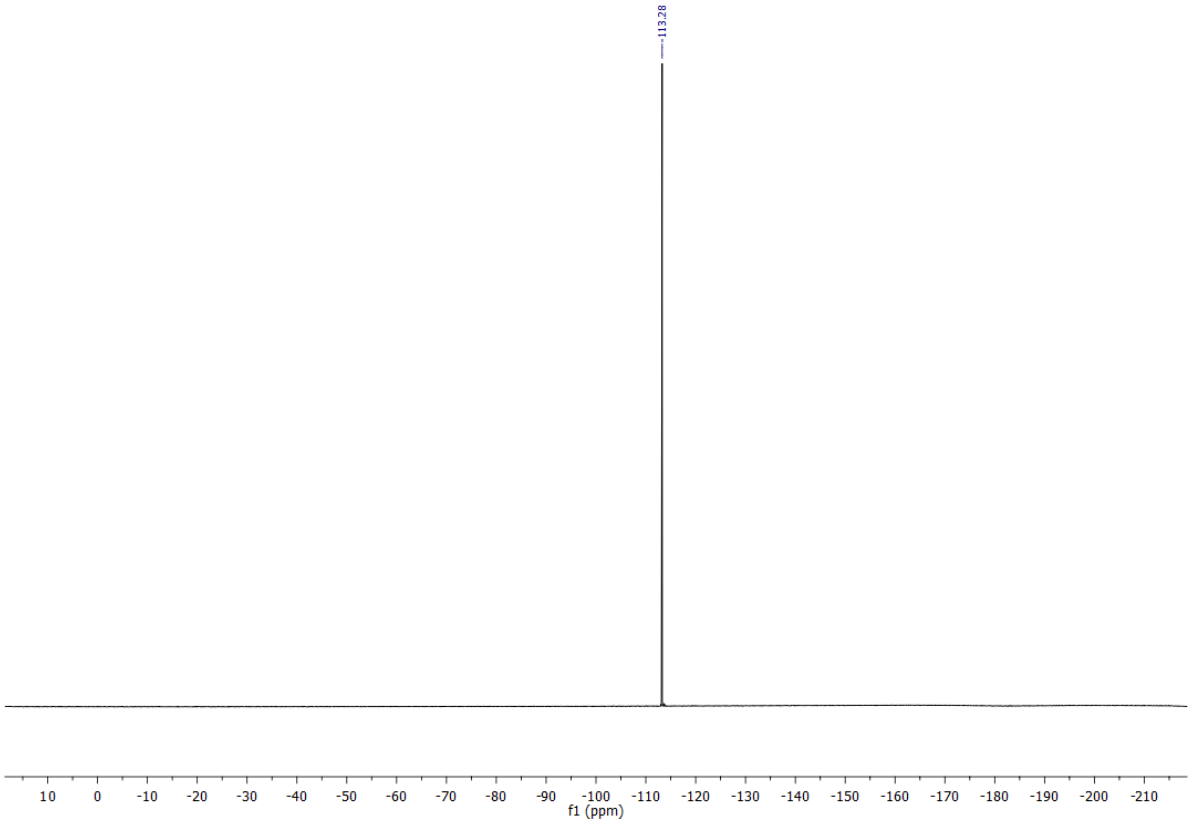
7.52
7.52
7.49
7.48
7.47
7.46
7.45
7.44
7.44
7.42
7.40
7.39
7.36
7.19
7.18
7.17
7.16
4.72
4.71
3.12
3.10
3.08
3.06
3.04
3.04
3.00
2.99
O
O2
S
N
N
NO2
4h
3.91
2.00
2.00
1.04
4.98
0.95
1.01
1.00
1.01
0.99
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
164.54
155.95
150.89
143.33
134.10
133.35
133.00
132.86
131.35
130.20
129.90
129.10
127.79
127.05
126.99
126.94
125.54
124.51
124.15
40.32
37.25
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



4i






-113.28
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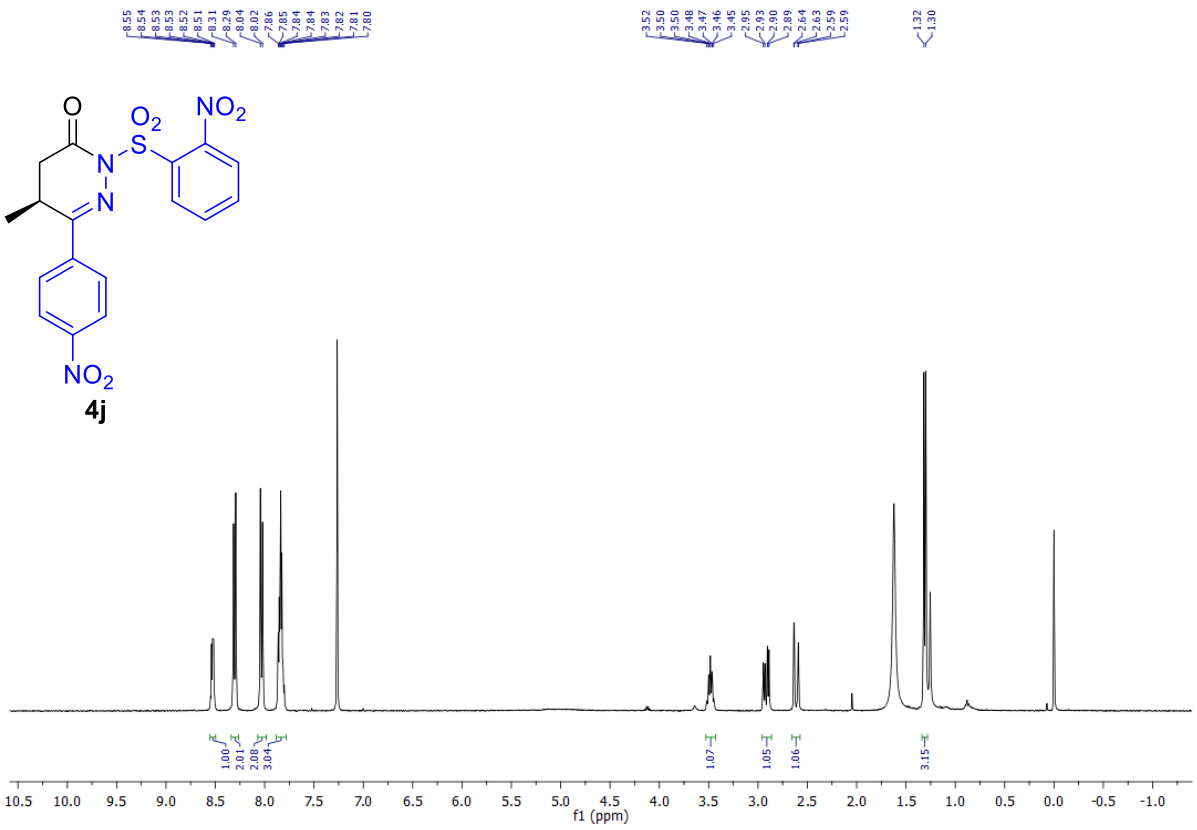
f1 (ppm)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8.29
8.04
8.02
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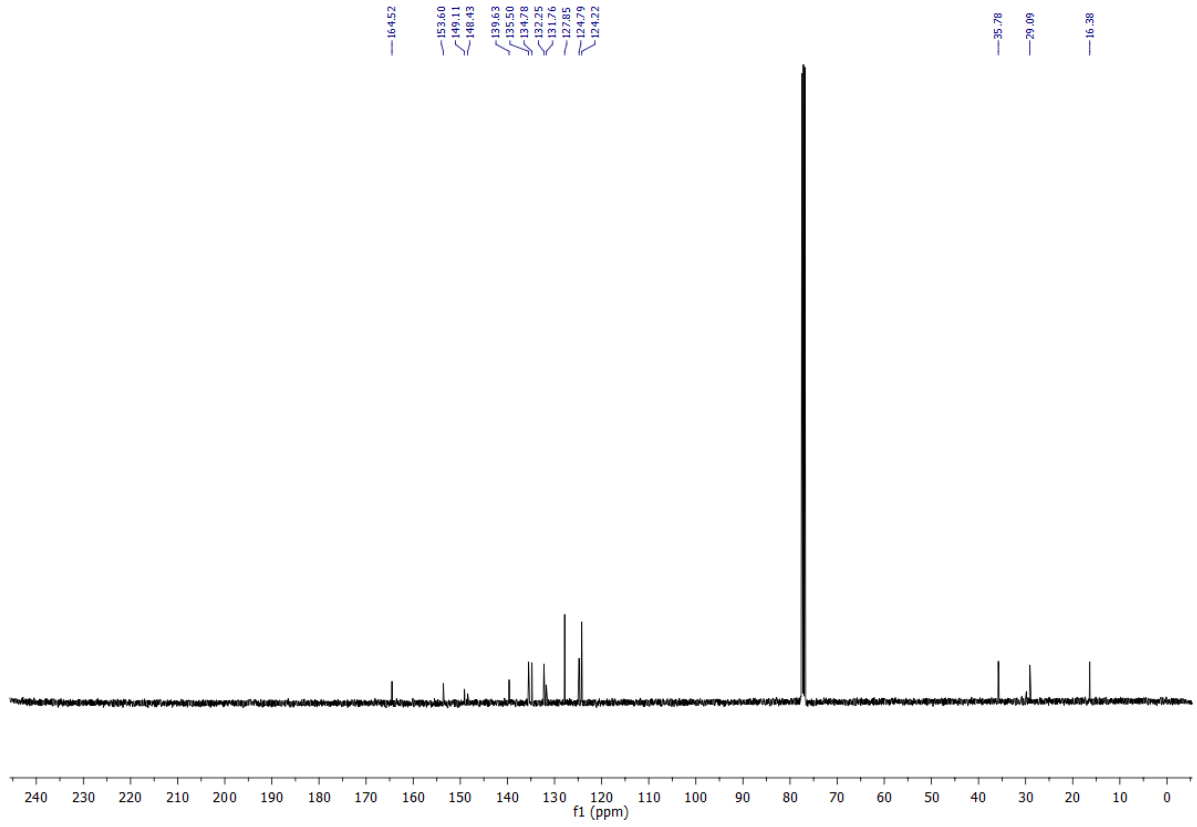
7.85
7.84
7.84
7.83
7.82
7.81
7.80
3.52
3.50
3.50
3.48
3.47
3.46
3.45
2.95
2.93
2.90
2.89
2.64
2.63
2.59
2.59
1.32
1.30
O
O2
NO2
N
S
N
NO2
4j
1.00
2.01
2.08
3.04
1.07
1.05
1.06
3.15
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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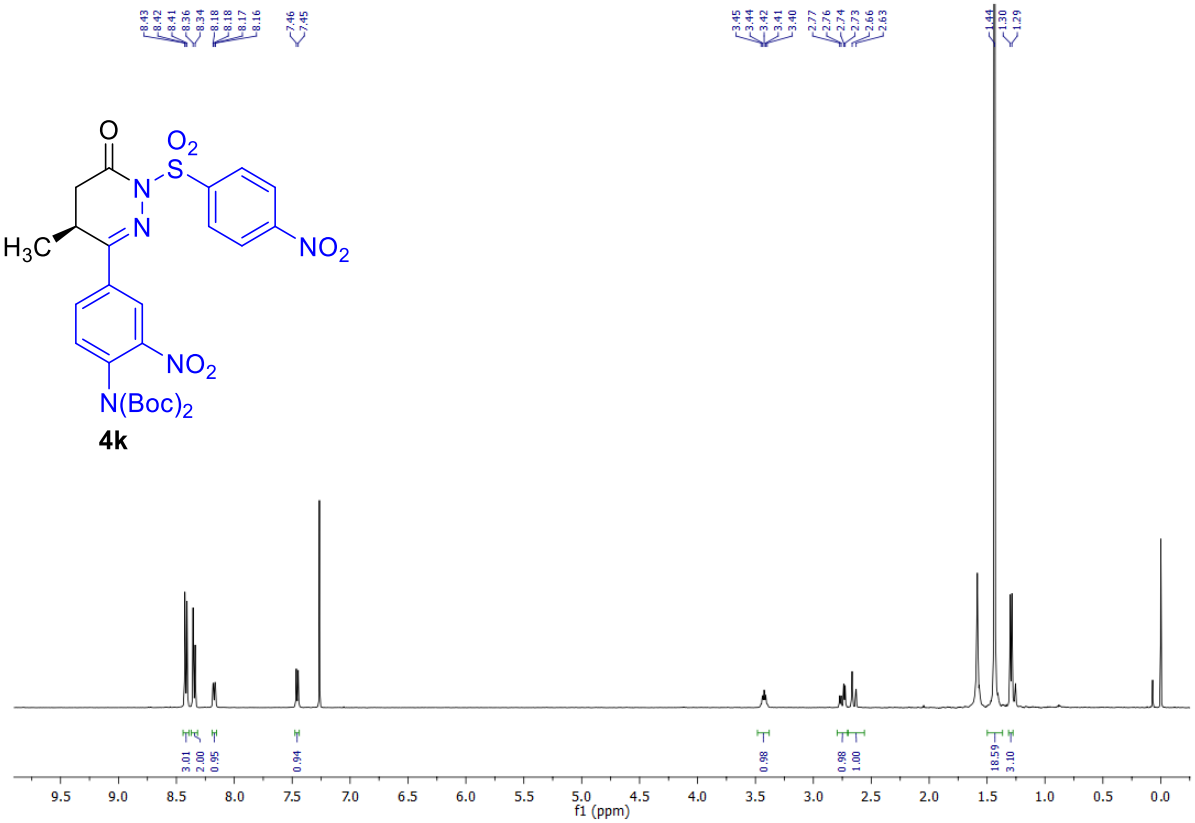
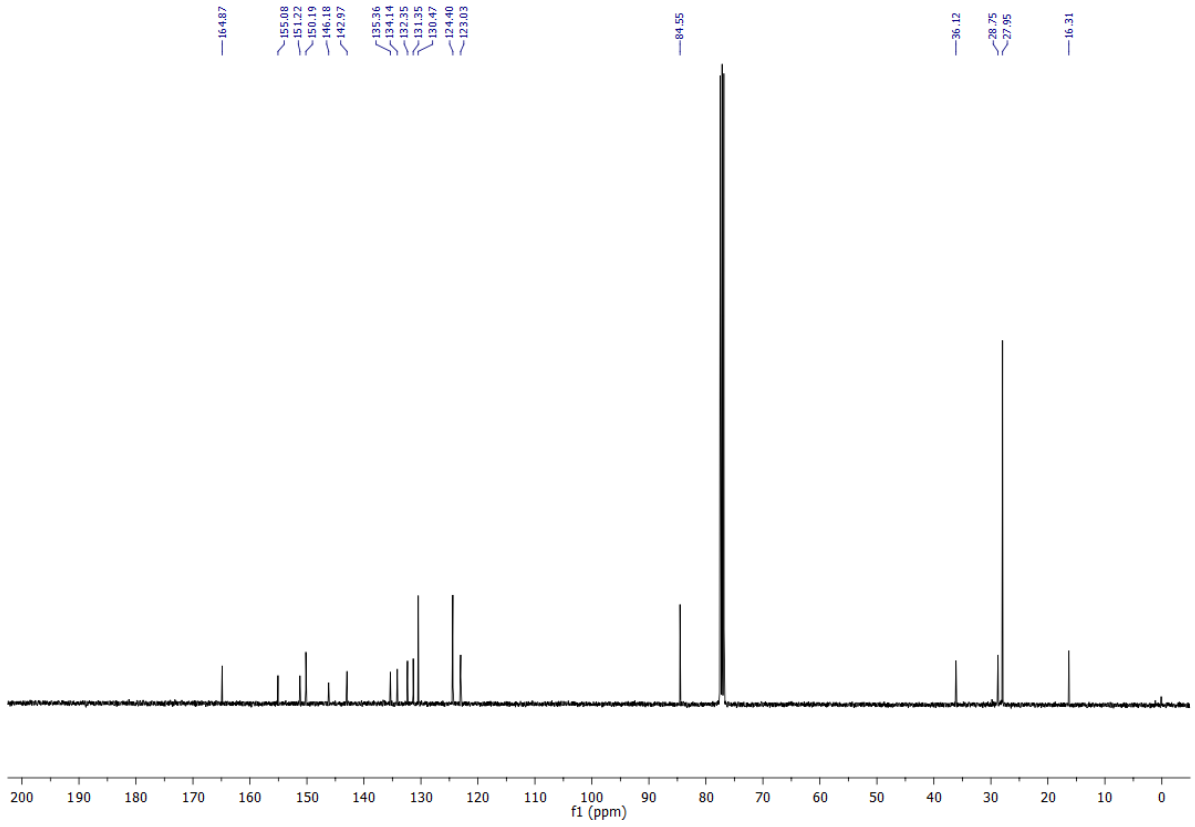
153.60
149.11
148.43
139.63
135.50
134.78
132.25
131.76
127.85
124.79
124.22
35.78
29.09
16.38
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


O
O2
S
N
N
H3C
NO2
NO2
N(Boc)2
4k
f1 (ppm)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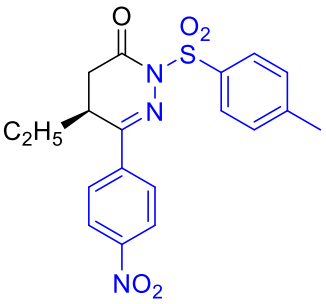

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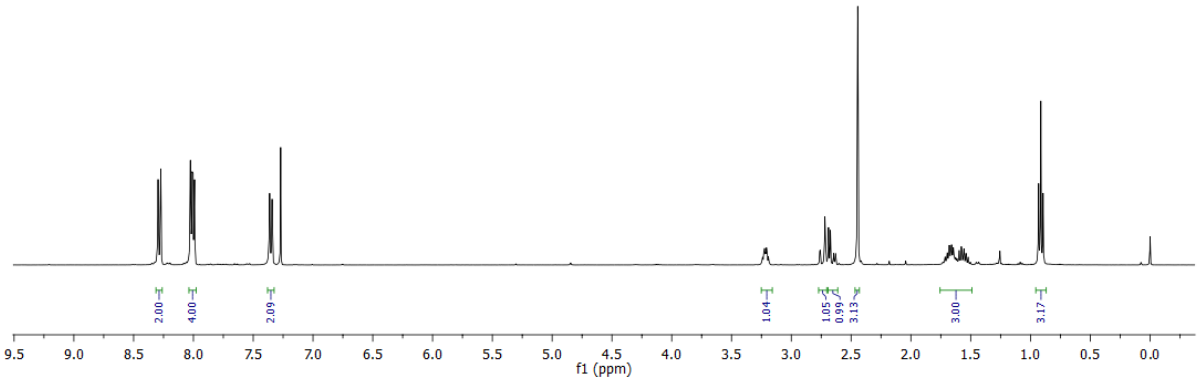

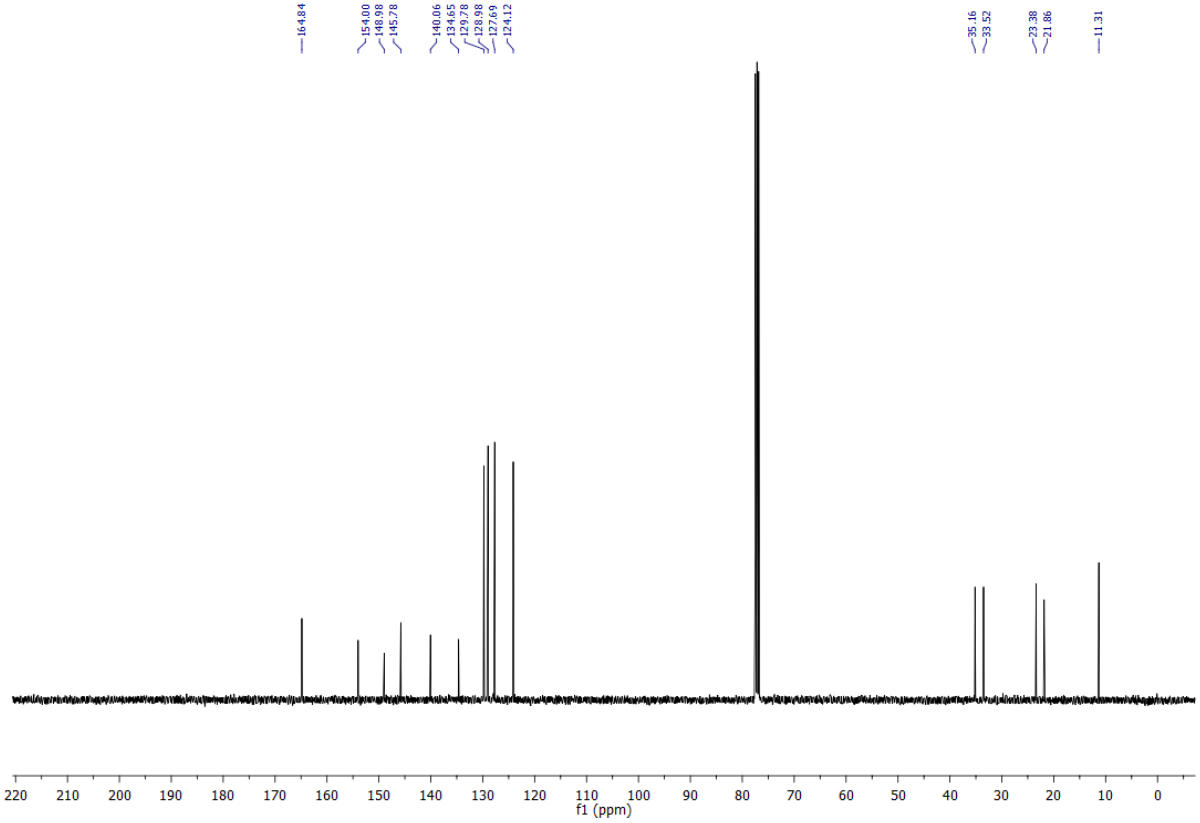

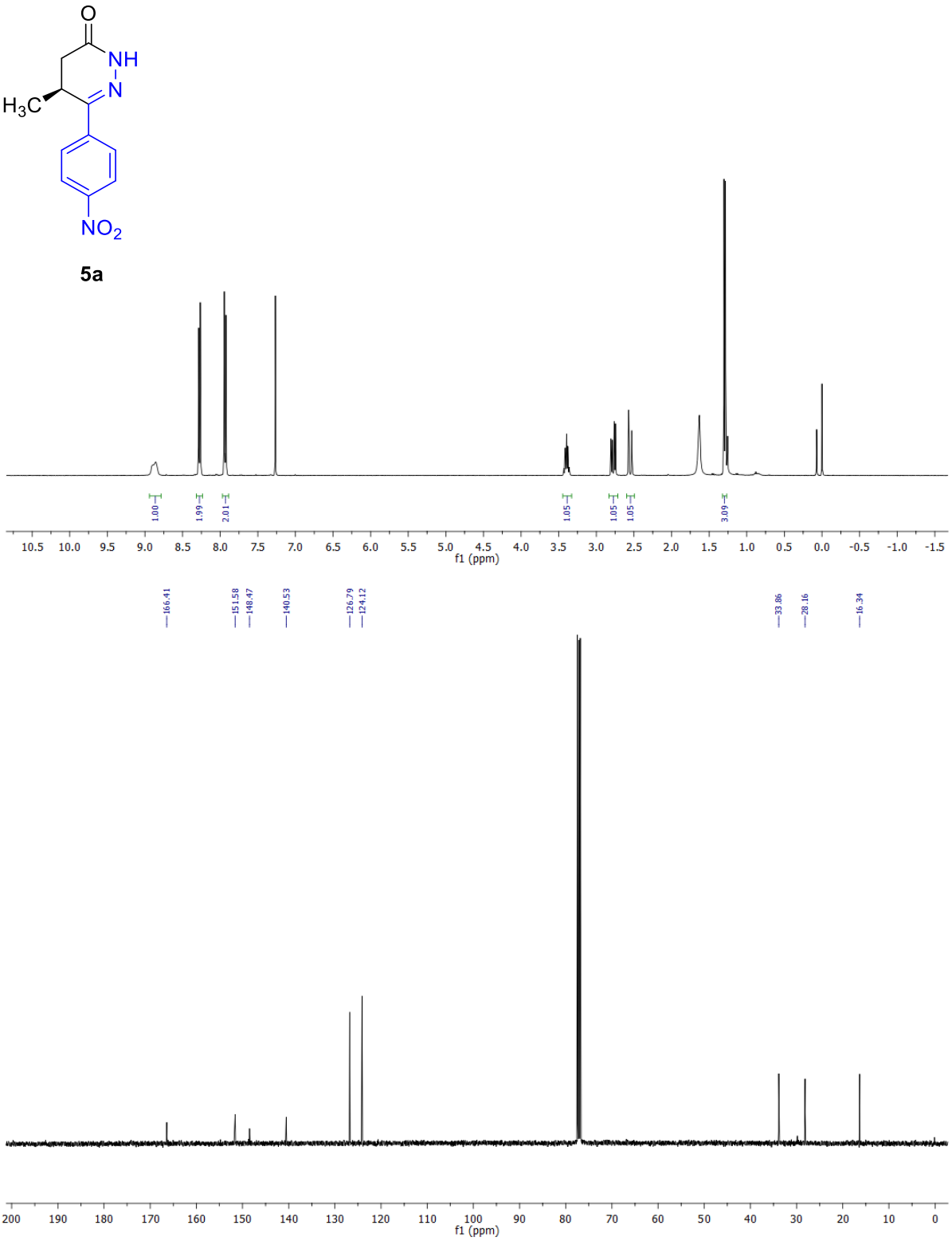
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7.94
7.93
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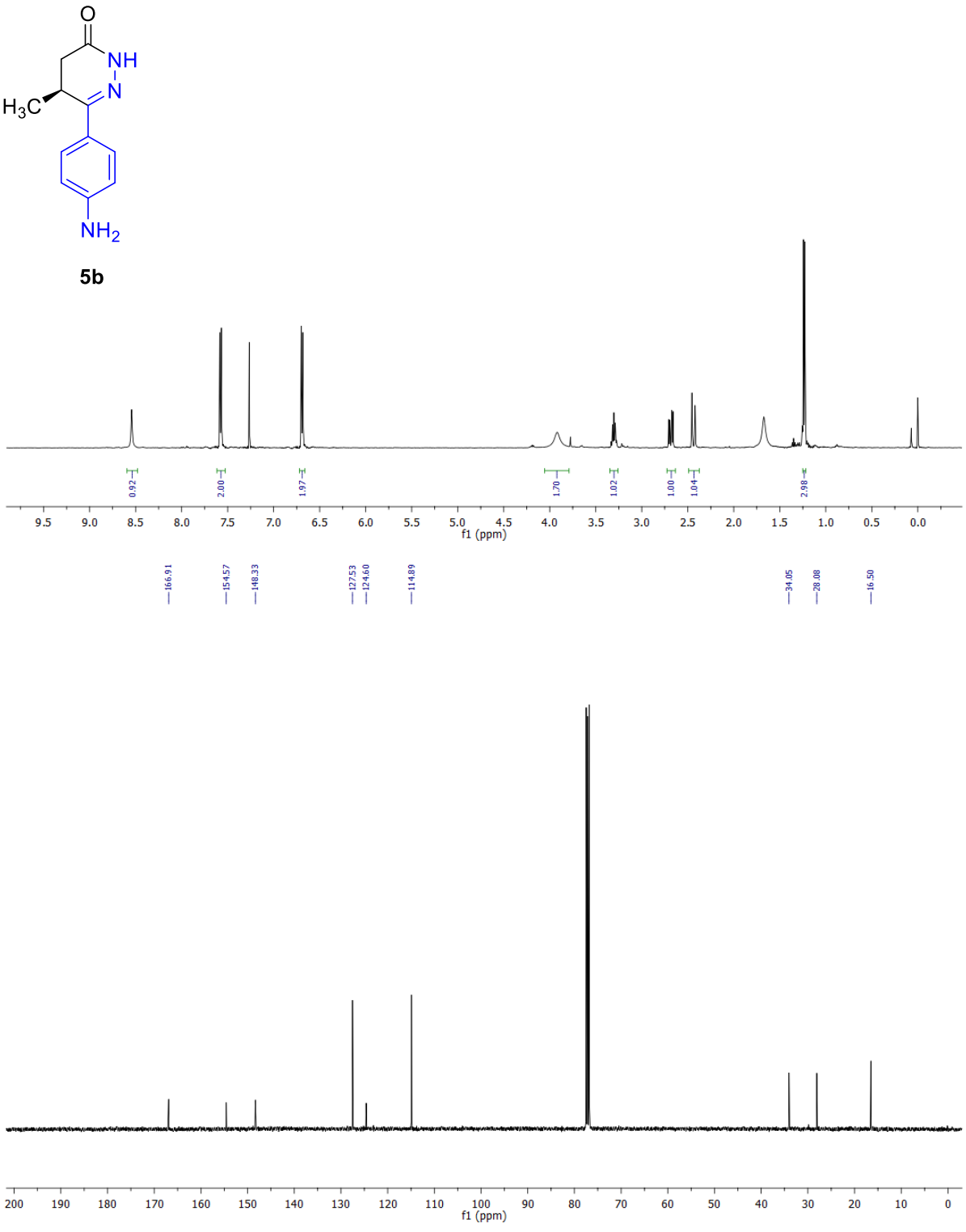
3.39
3.38
3.38
3.36
3.36
2.80
2.79
2.76
2.74
2.57
2.57
2.53
2.53
1.30
1.28
O
NH
N
H3C
NO2
5a
1.00
1.99
2.01
1.05
1.05
1.05
3.09
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5
f1 (ppm)
166.41
151.58
148.47
140.53
126.79
124.12
33.86
28.16
16.34
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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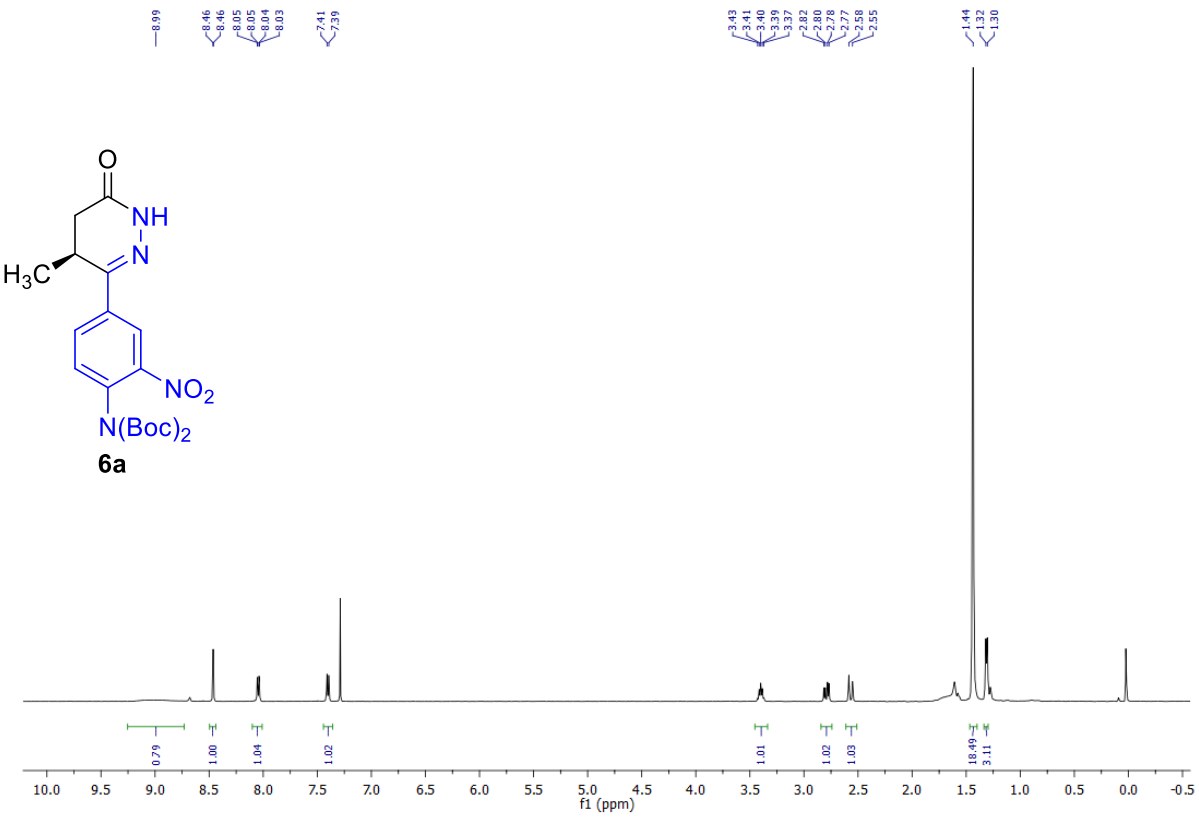
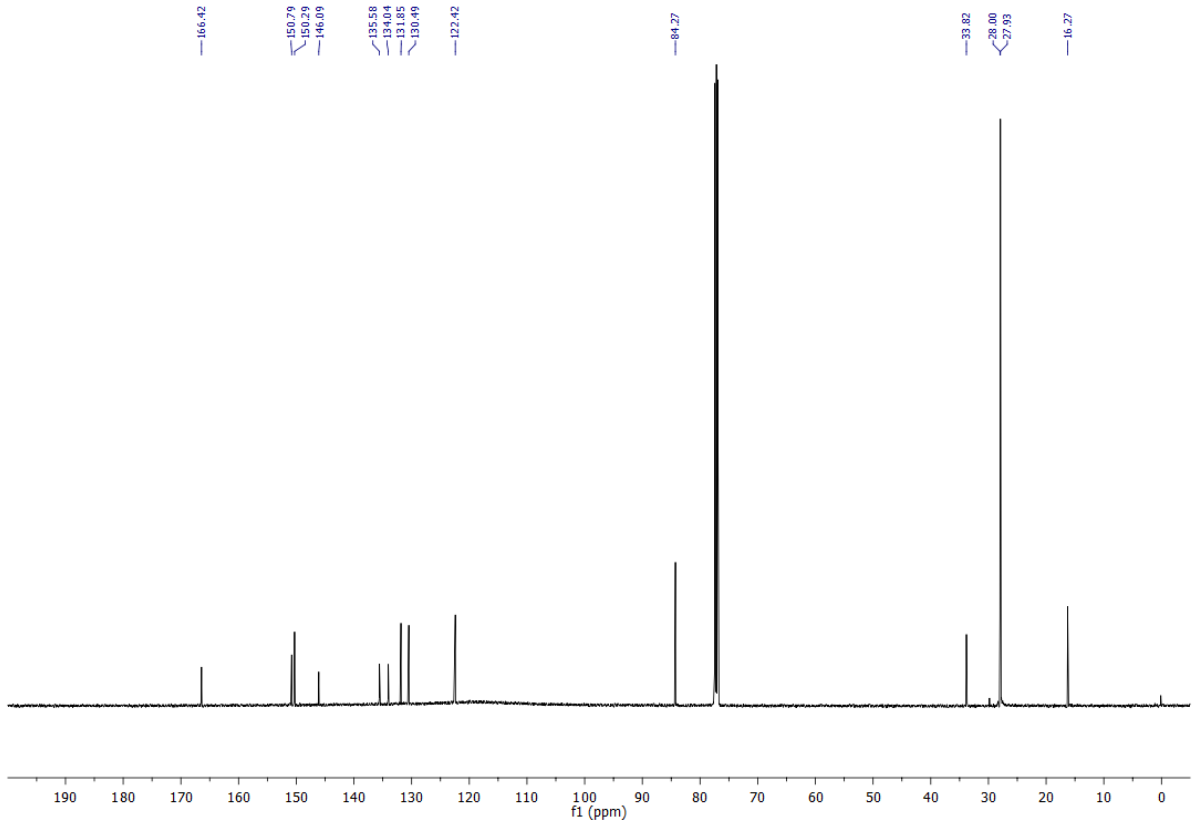
3.32
3.30
3.29
3.27
2.71
2.69
2.67
2.66
2.45
2.42
1.24
1.23
O
NH
N
H3C
NH2
0.92
2.00
1.97
1.70
1.02
1.00
1.04
2.98
f1 (ppm)
166.91
154.57
148.33
127.53
124.60
114.89
34.05
28.08
16.50
f1 (ppm)

5b


O
NH
N
H3C
NO2
N(Boc)2

6a

8.99
8.46
8.46
8.05
8.05
8.04
8.03
7.41
7.39
3.43
3.41
3.40
3.39
3.37
2.82
2.80
2.78
2.77
2.58
2.55
1.44
1.32
1.30
0.79
1.00
1.04
1.02
1.01
1.02
1.03
18.49
3.11
f1 (ppm)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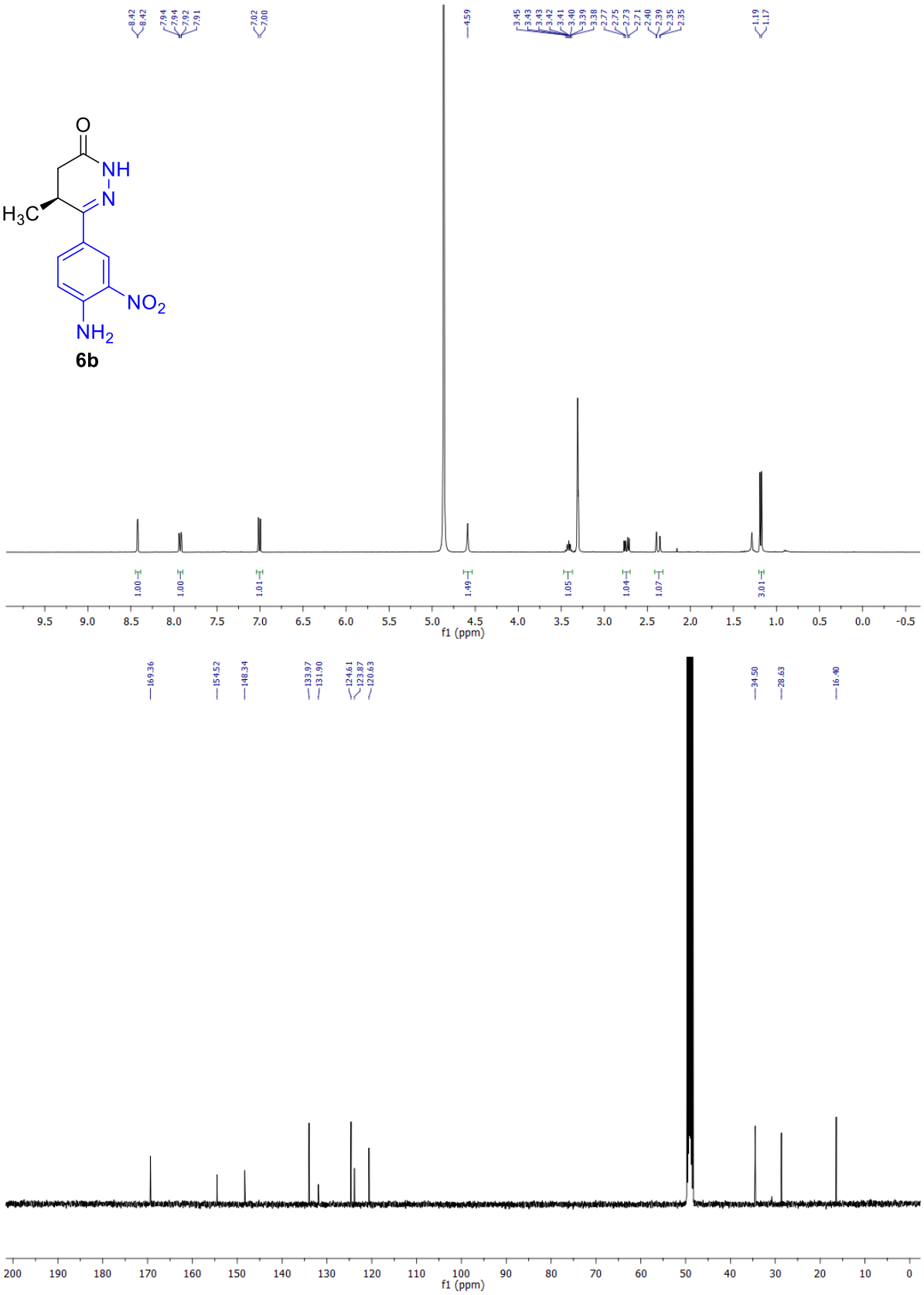
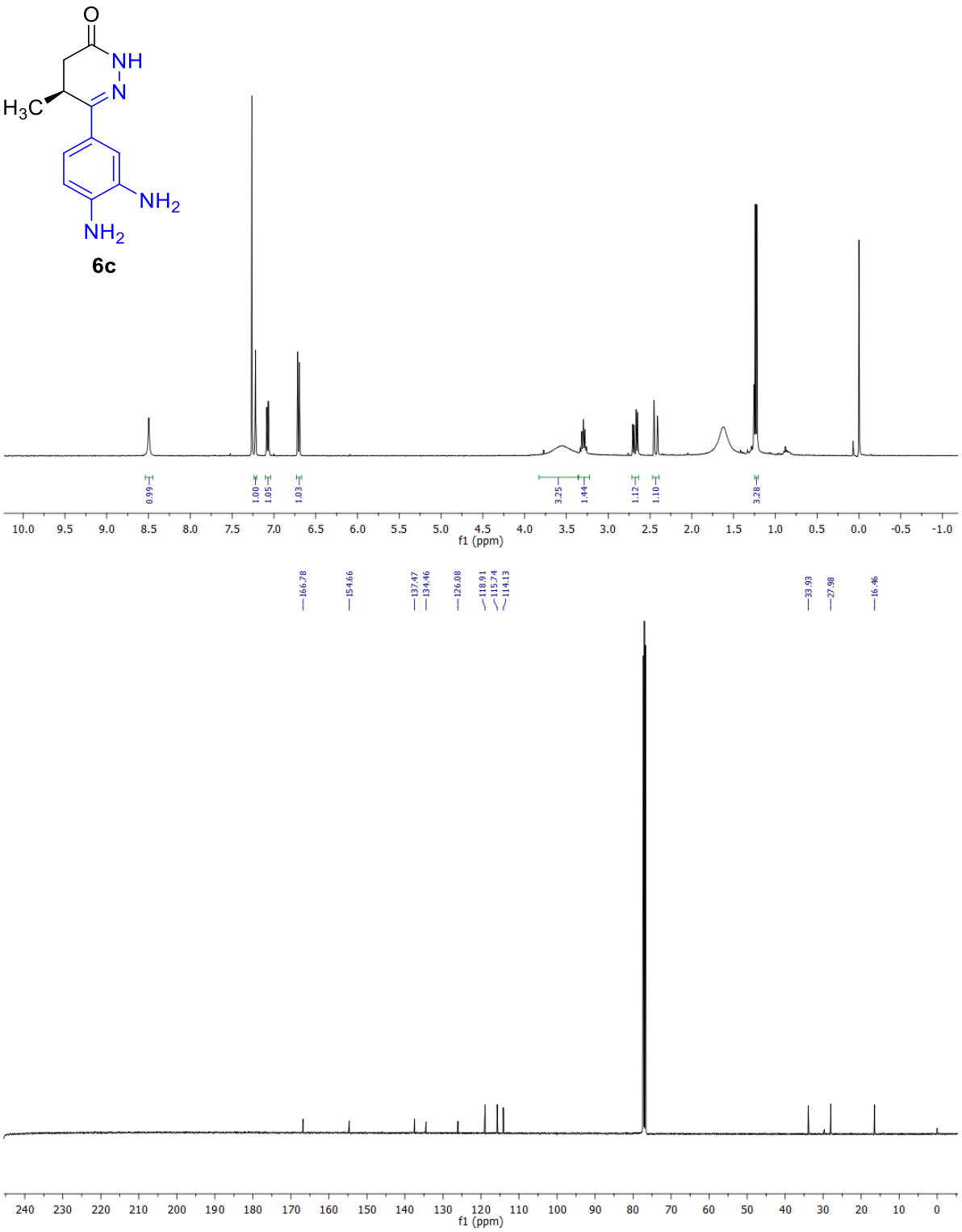
150.79
150.29
146.09
135.58
134.04
131.85
130.49
122.42
84.27
33.82
28.00
27.93
16.27
f1 (ppm)


O
NH
N
H3C
NO2
NH2
6b
f1 (ppm)
f1 (ppm)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7.07
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6.71
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3.54
3.33
3.31
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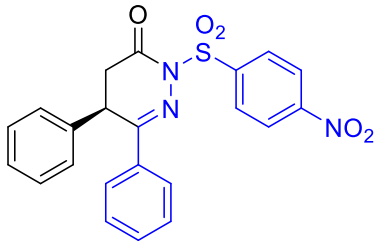
3.28
3.26
2.71
2.69
2.66
2.65
2.45
2.41
1.24
1.22
O
NH
N
H3C
NH2
NH2
6c
0.99
1.00
1.05
1.03
3.25
1.44
1.12
1.10
3.28
f1 (ppm)
166.78
154.66
137.47
134.46
126.08
118.91
115.74
114.13
33.93
27.98
16.46
f1 (ppm)

HPLC Data:



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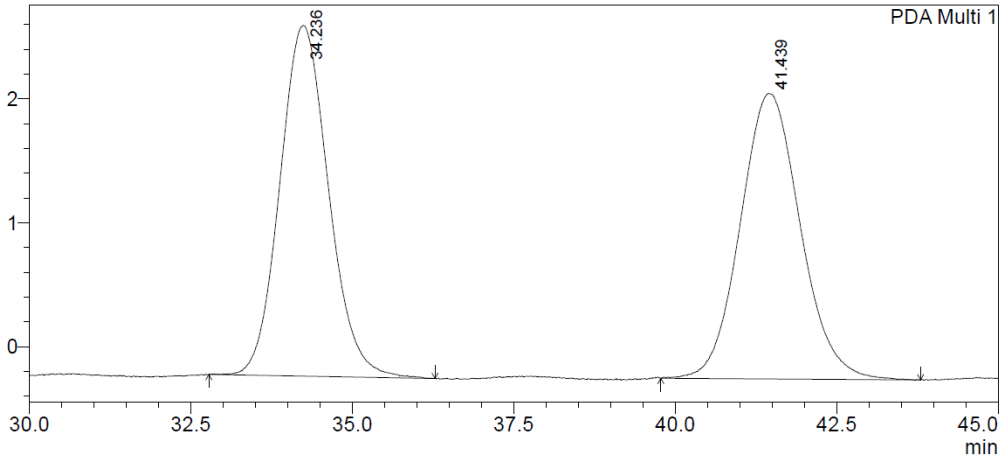
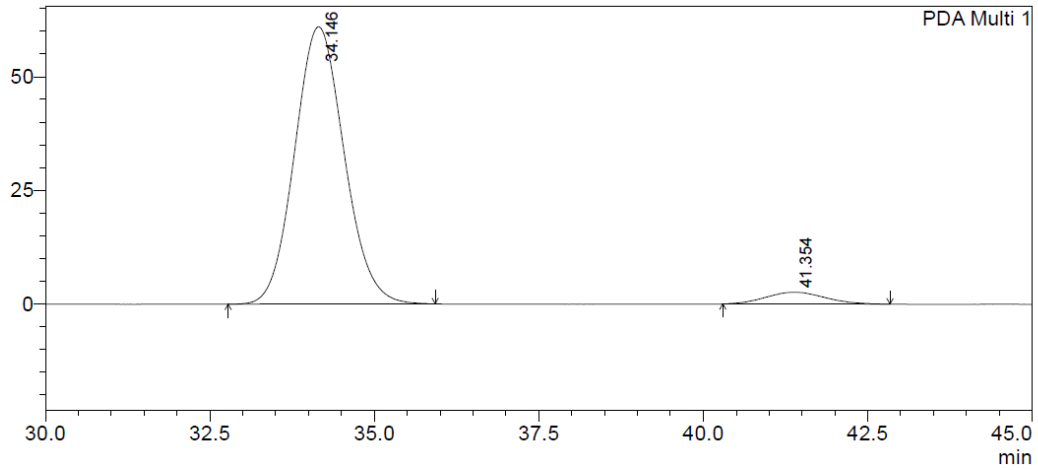


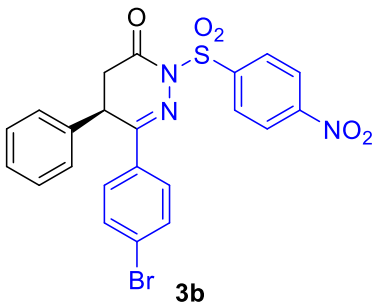
PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	34.236	149016	2834	50.026	55.146
2	41.439	148863	2305	49.974	44.854
Total		297879	5139	100.000	100.000

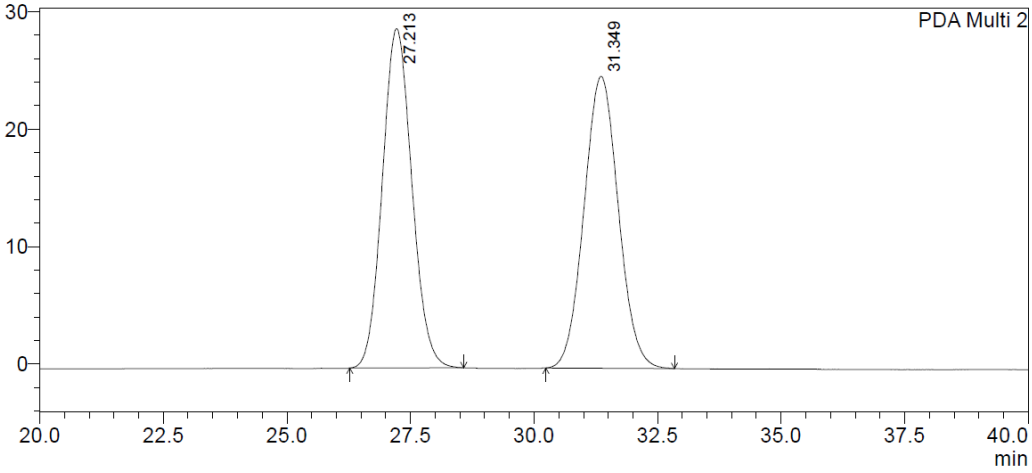


PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	34.146	3203812	61014	95.219	95.923
2	41.354	160880	2593	4.781	4.077
Total		3364692	63608	100.000	100.000

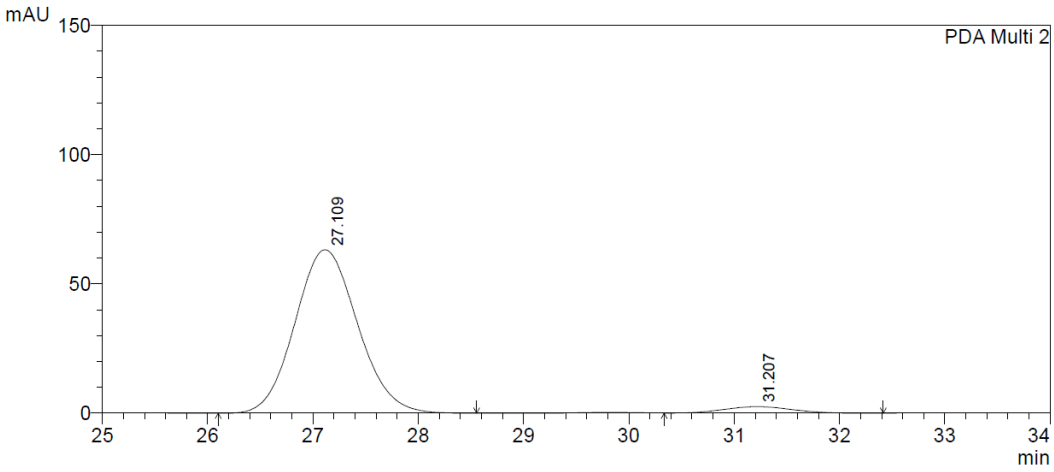


3b



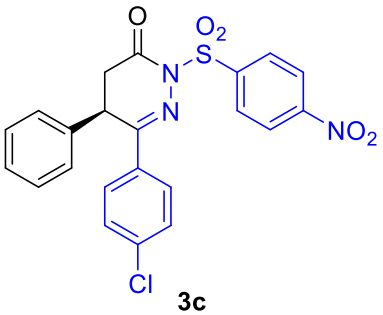
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	27.213	1201235	28897	49.994	53.769
2	31.349	1201518	24846	50.006	46.231
Total		2402753	53743	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	27.109	2629341	63321	95.736	96.146
2	31.207	117104	2538	4.264	3.854
Total		2746445	65860	100.000	100.000



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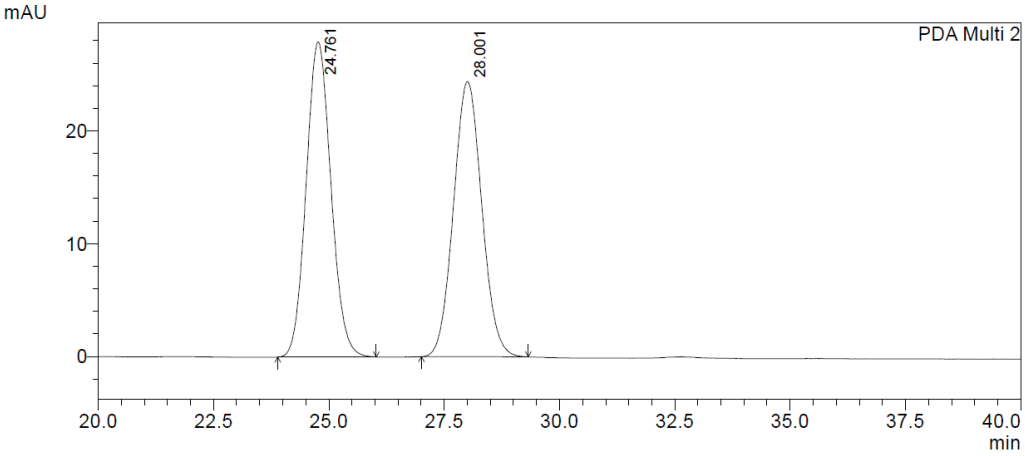
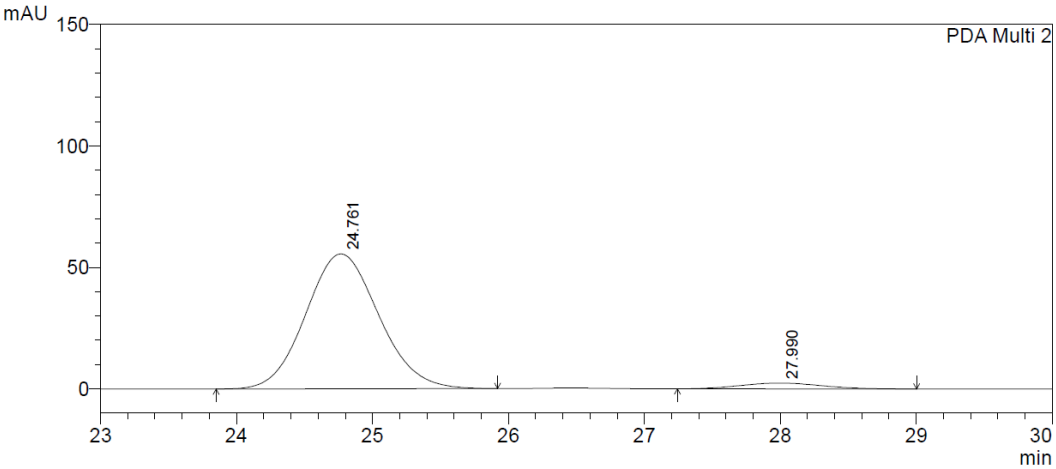


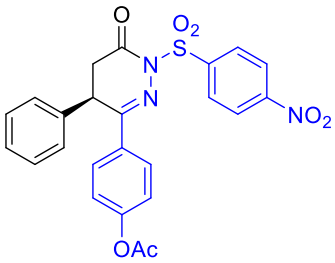
PDA Ch2 220nm 4nm

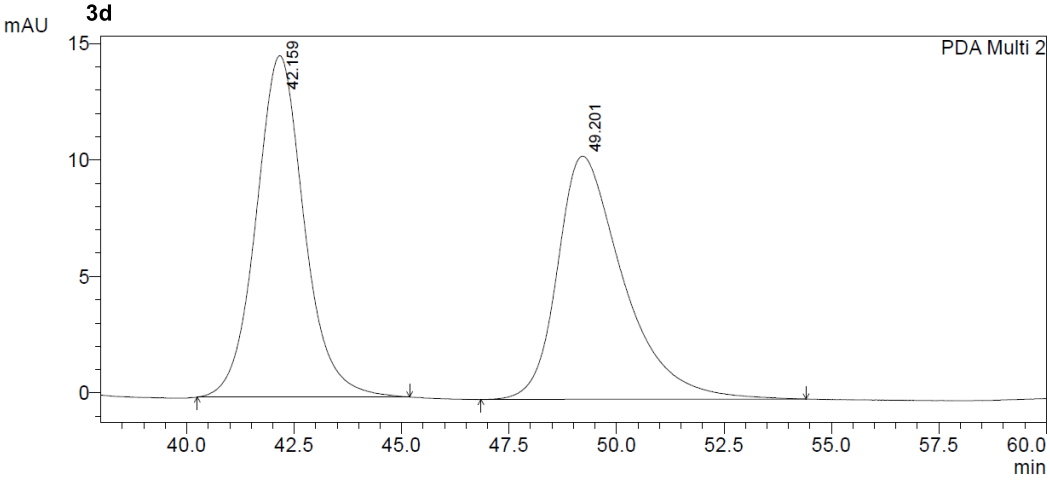
Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.761	1046360	27926	50.137	53.375
2	28.001	1040643	24395	49.863	46.625
Total		2087004	52321	100.000	100.000



PDA Ch2 220nm 4nm

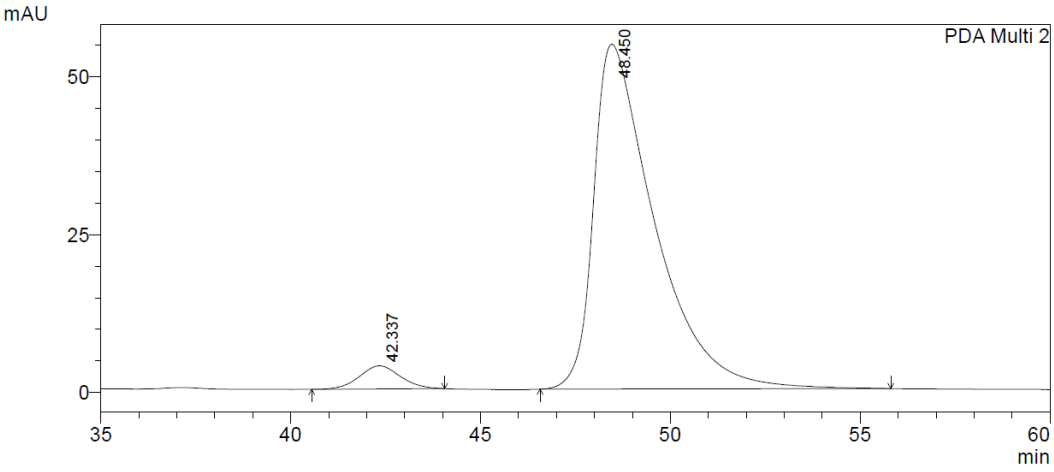
Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.761	2077861	55503	95.379	95.814
2	27.990	100669	2425	4.621	4.186
Total		2178530	57928	100.000	100.000





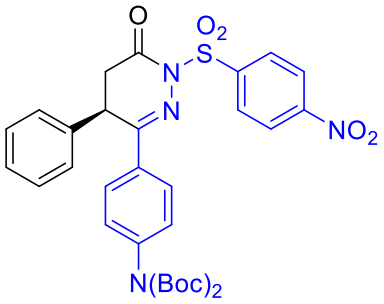
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	42.159	1140260	14648	50.563	58.372
2	49.201	1114889	10446	49.437	41.628
Total		2255149	25095	100.000	100.000

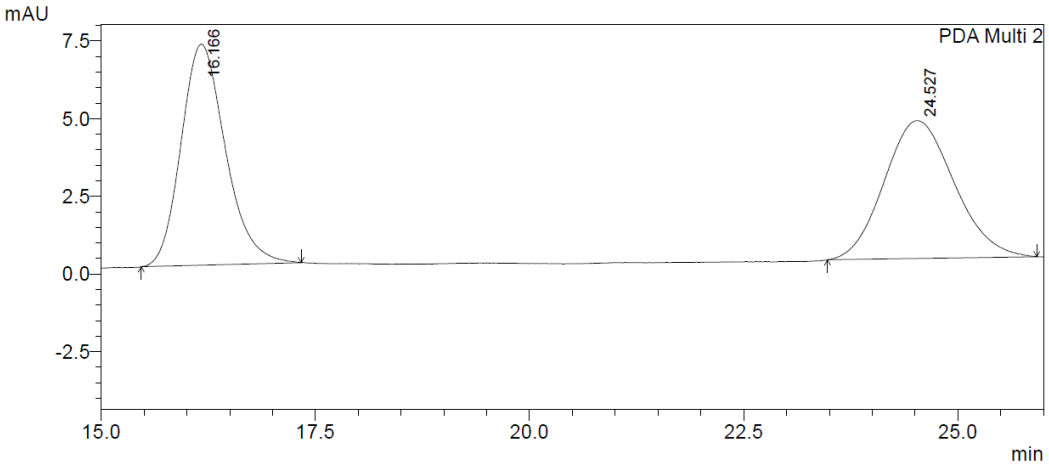


PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	42.337	275457	3660	4.322	6.276
2	48.450	6098519	54658	95.678	93.724
Total		6373976	58318	100.000	100.000

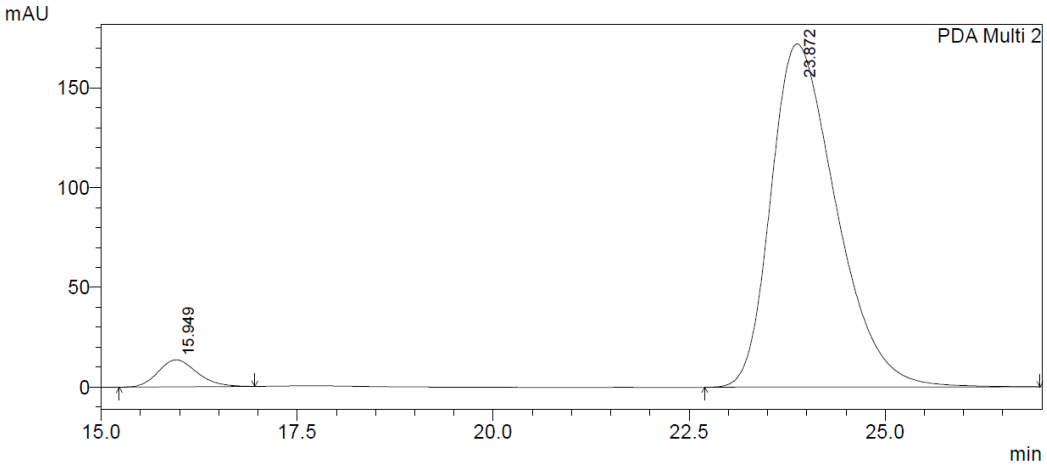


3e



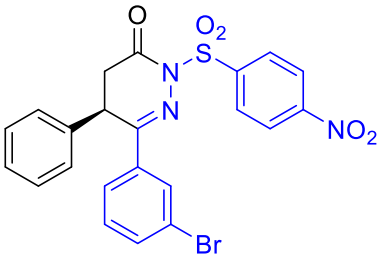
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	16.166	255957	7119	50.414	61.605
2	24.527	251754	4437	49.586	38.395
Total		507711	11556	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	15.949	464167	13521	4.454	7.283
2	23.872	9957048	172125	95.546	92.717
Total		10421215	185645	100.000	100.000



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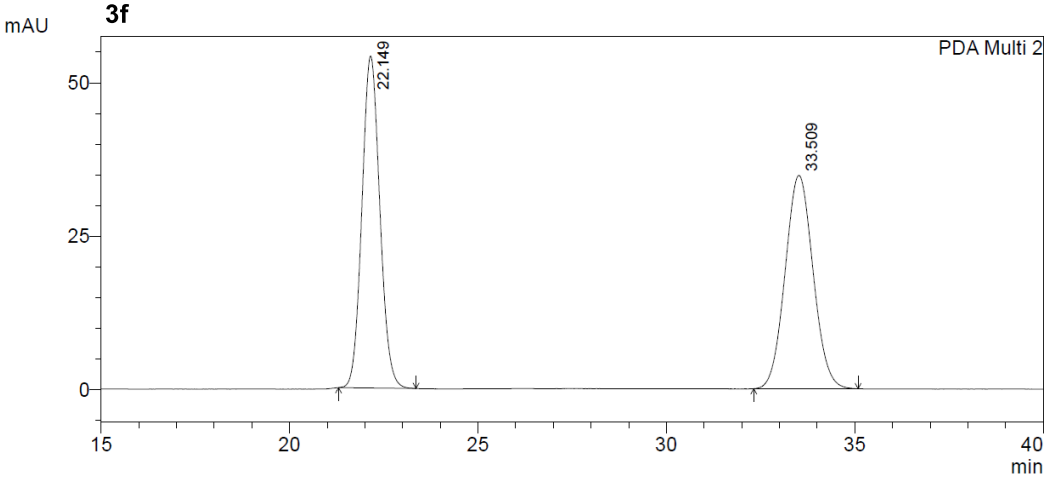
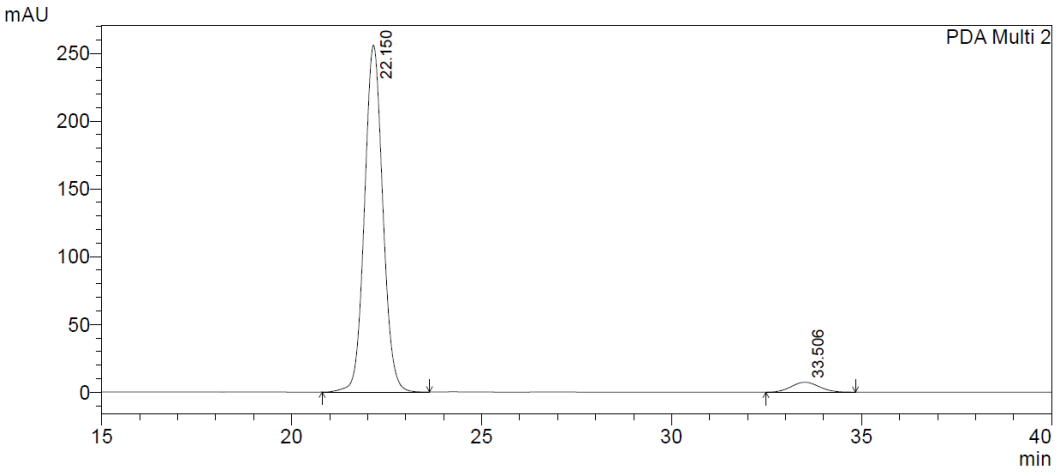


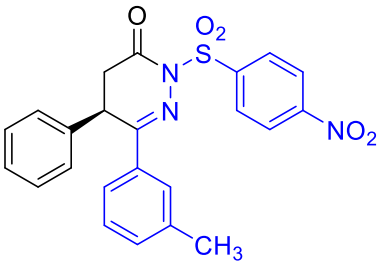
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.149	1786665	54114	49.931	60.881
2	33.509	1791631	34771	50.069	39.119
Total		3578296	88885	100.000	100.000

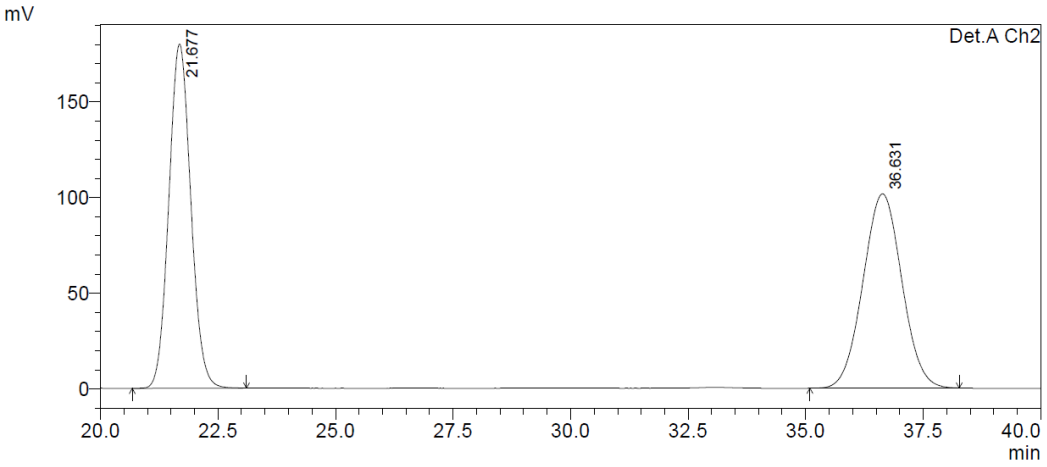


PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.150	8587493	256001	95.807	97.205
2	33.506	375862	7361	4.193	2.795
Total		8963355	263361	100.000	100.000

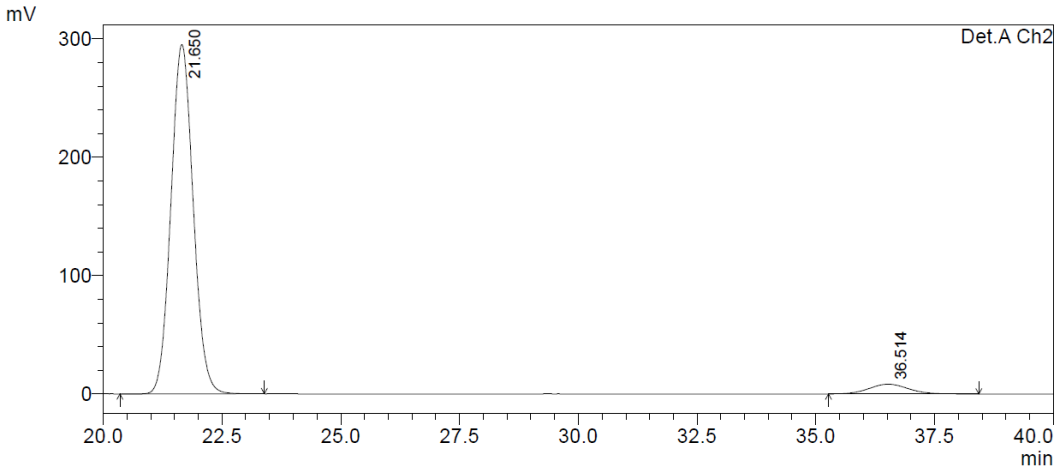


3g



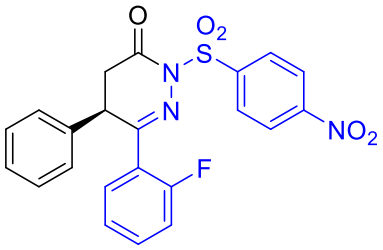
Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.677	5854046	179838	50.077	63.915
2	36.631	5836040	101532	49.923	36.085
Total		11690086	281370	100.000	100.000

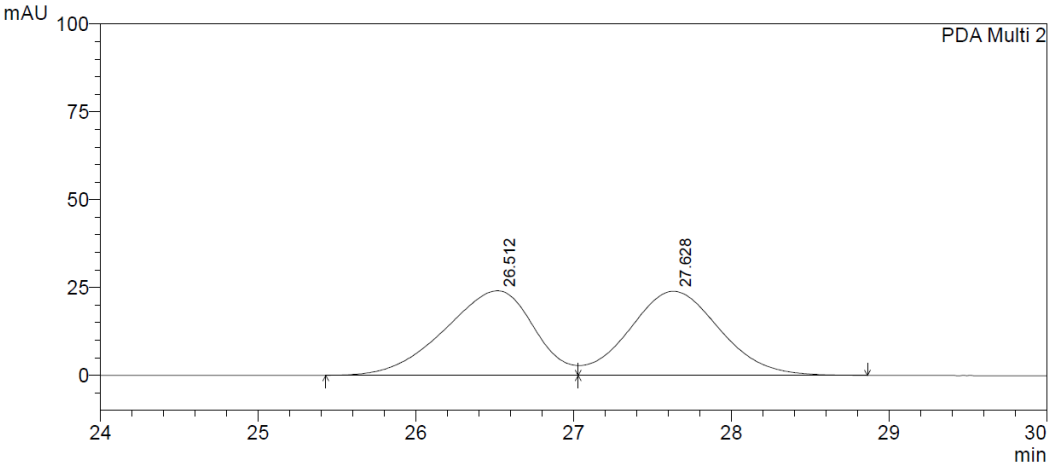


Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.650	9611700	294976	95.308	97.280
2	36.514	473228	8246	4.692	2.720
Total		10084928	303223	100.000	100.000

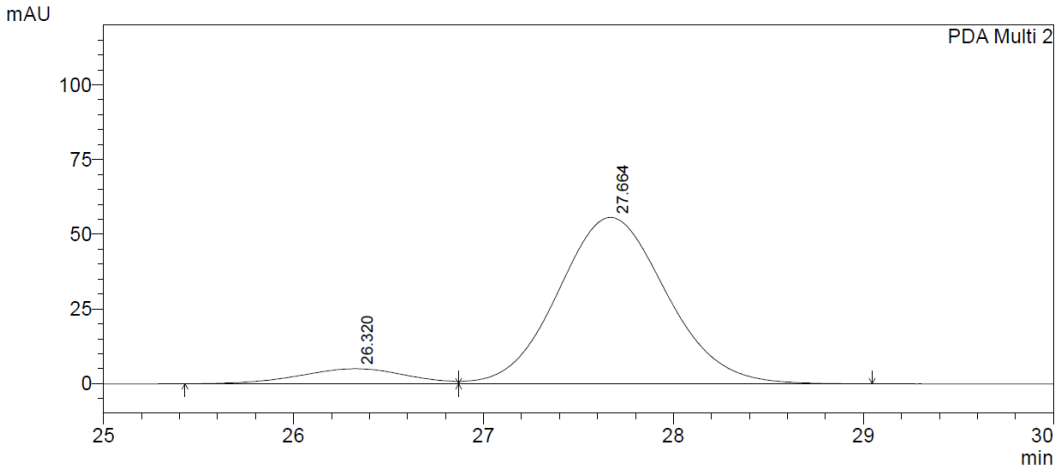


3h



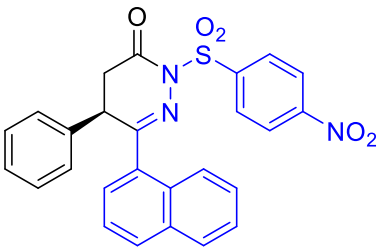
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	26.512	945785	24092	49.833	50.162
2	27.628	952126	23936	50.167	49.838
Total		1897910	48029	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	26.320	197021	5052	8.161	8.312
2	27.664	2217128	55726	91.839	91.688
Total		2414149	60778	100.000	100.000



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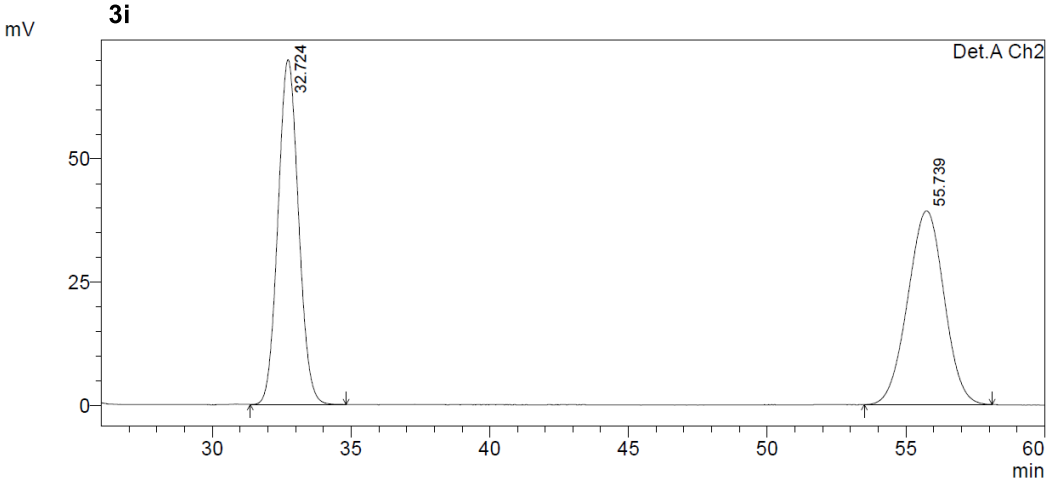
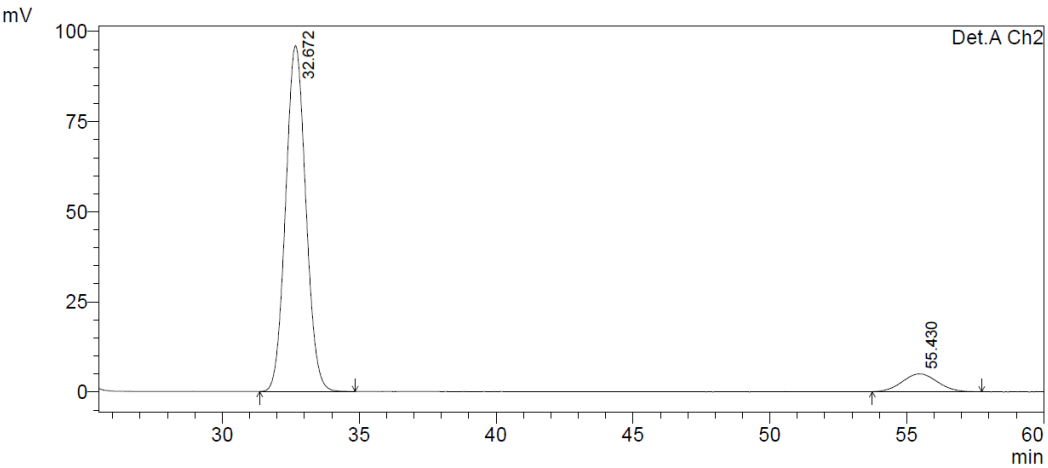


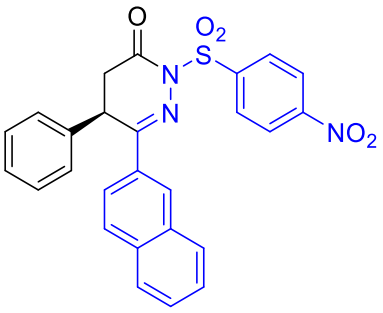
Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.724	3601758	69966	50.126	64.008
2	55.739	3583682	39343	49.874	35.992
Total		7185440	109309	100.000	100.000



Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.672	4930802	96014	91.601	95.054
2	55.430	452082	4996	8.399	4.946
Total		5382884	101010	100.000	100.000



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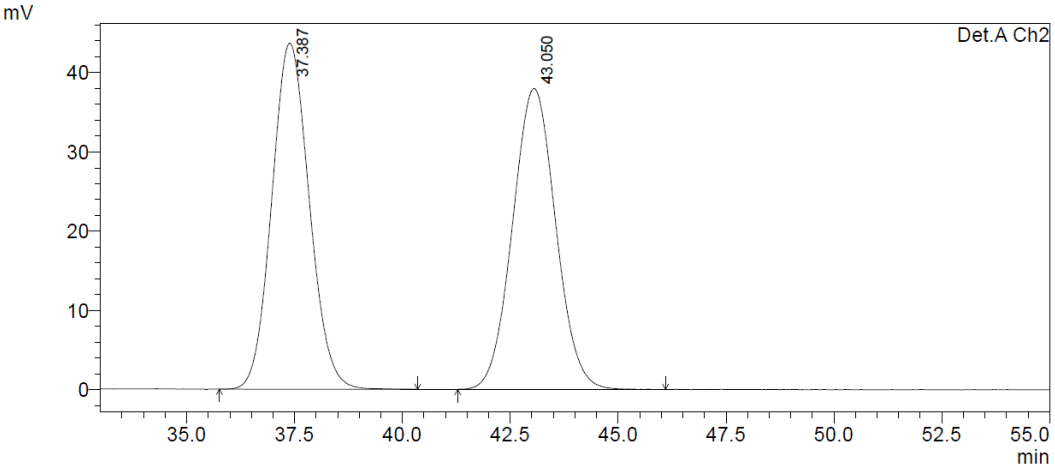
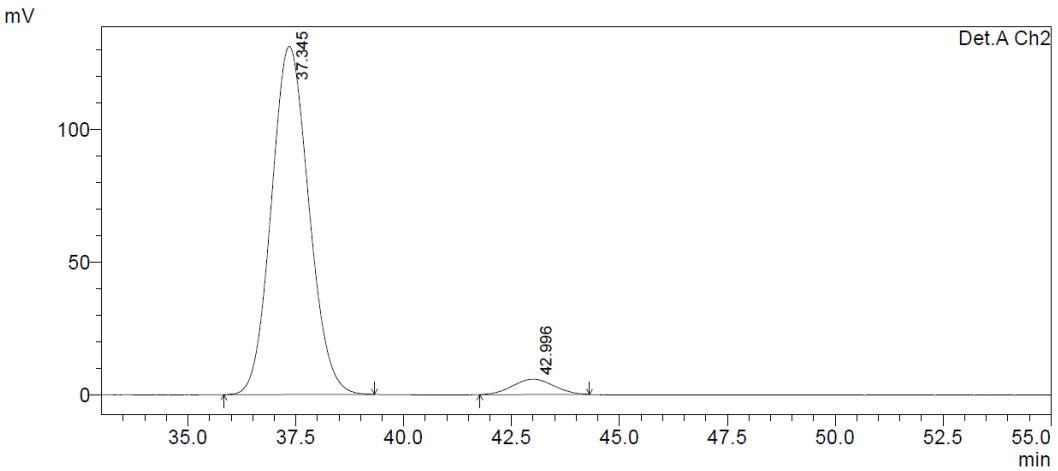


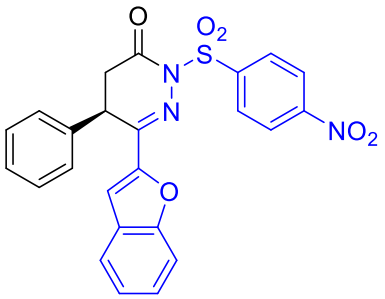
Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.387	2643770	43663	49.981	53.486
2	43.050	2645822	37971	50.019	46.514
Total		5289591	81633	100.000	100.000



Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	37.345	7909117	131063	95.365	95.784
2	42.996	384400	5768	4.635	4.216
Total		8293516	136832	100.000	100.000



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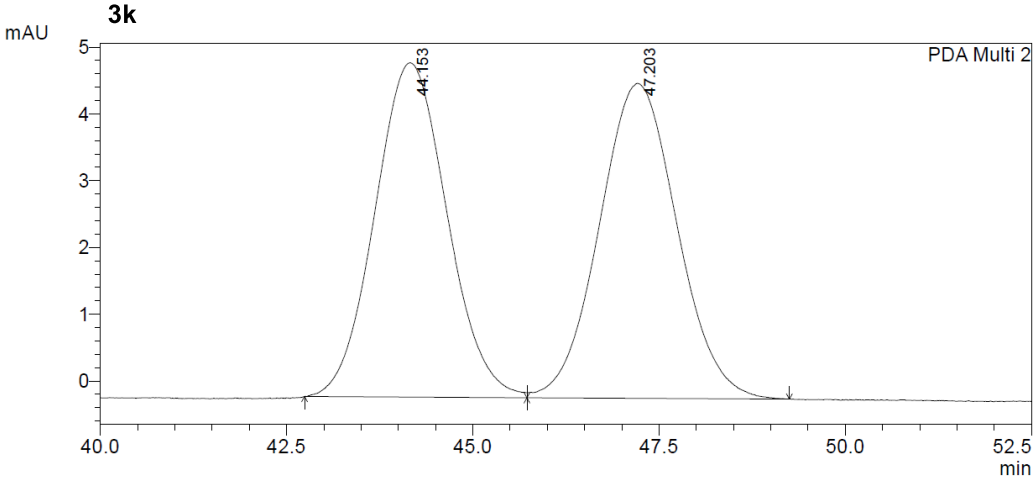
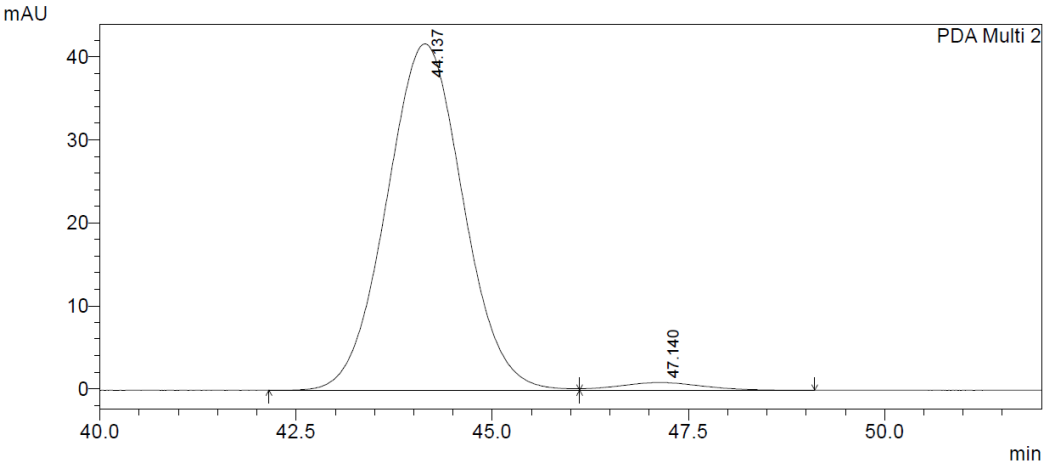


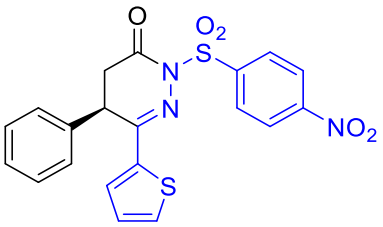
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	44.153	337249	5009	49.657	51.504
2	47.203	341903	4717	50.343	48.496
Total		679152	9726	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	44.137	2827003	41743	97.653	97.844
2	47.140	67946	920	2.347	2.156
Total		2894949	42663	100.000	100.000



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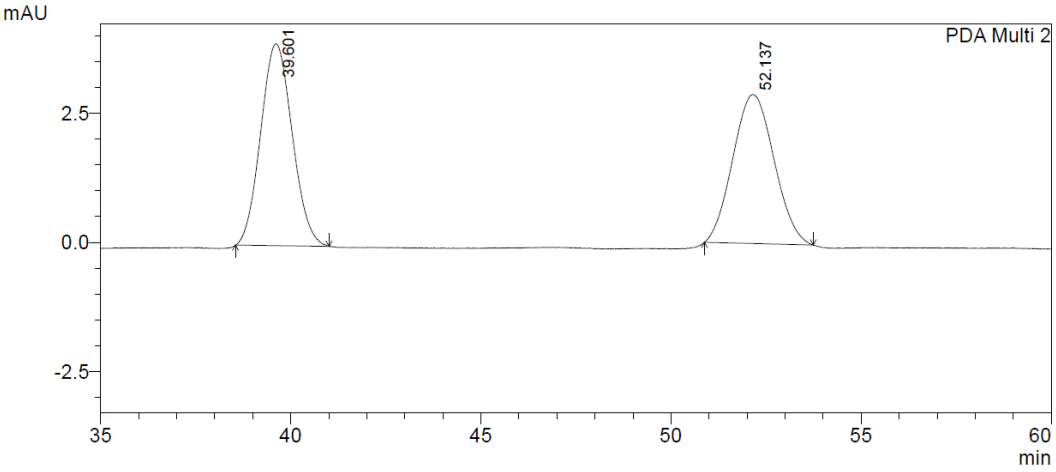
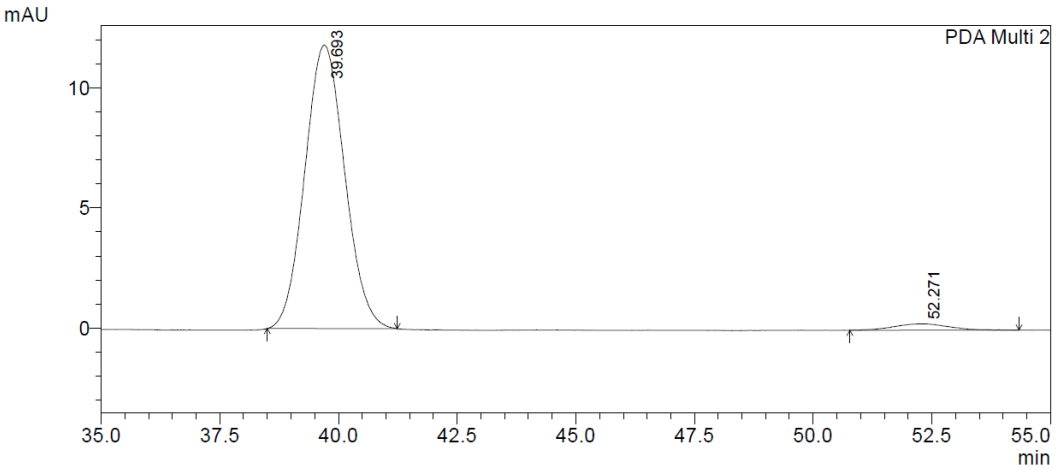


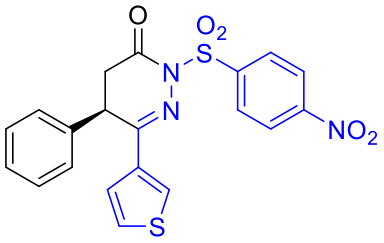
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	39.601	225337	3909	50.899	57.547
2	52.137	217379	2884	49.101	42.453
Total		442716	6793	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	39.693	690195	11796	97.111	97.788
2	52.271	20536	267	2.889	2.212
Total		710731	12063	100.000	100.000



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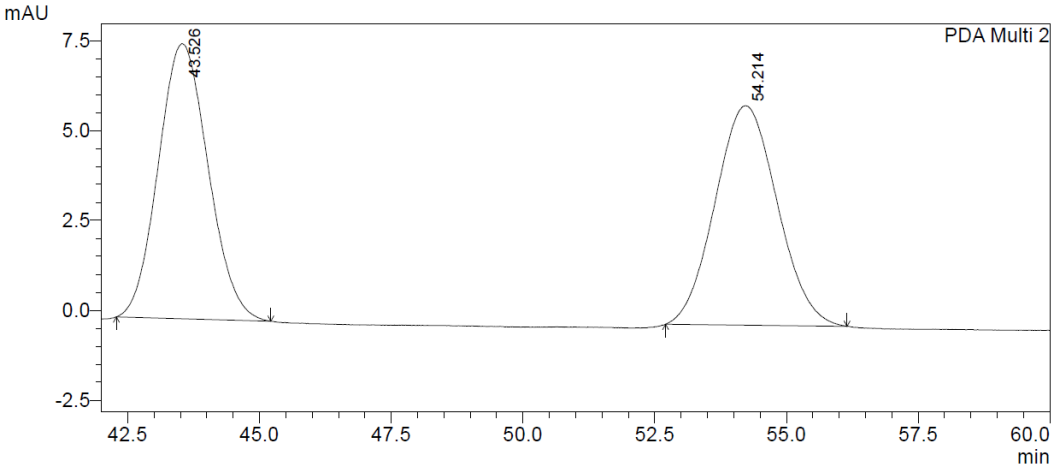
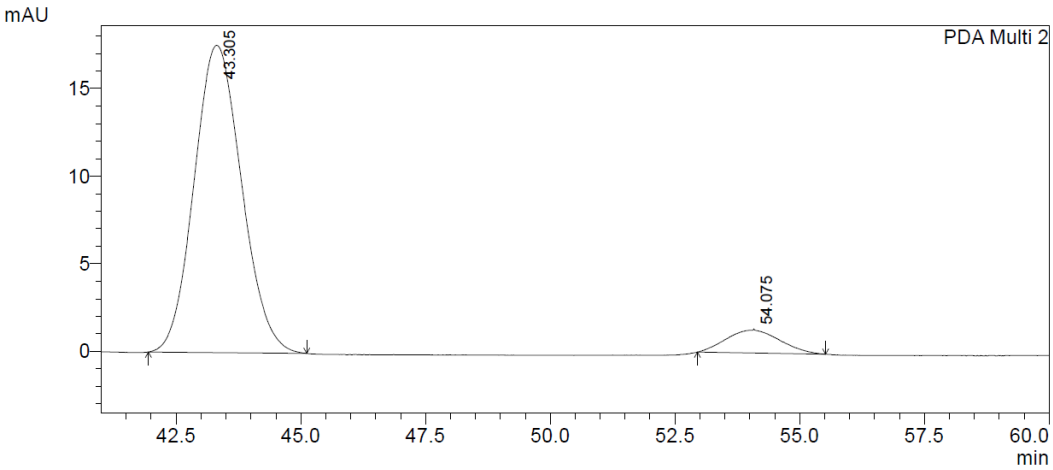


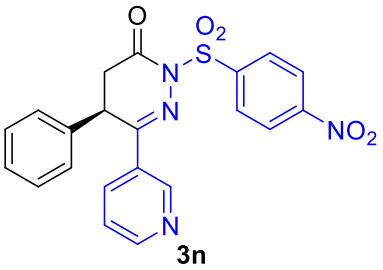
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.526	504252	7655	50.177	55.627
2	54.214	500701	6106	49.823	44.373
Total		1004953	13761	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.305	1162428	17543	92.238	92.687
2	54.075	97818	1384	7.762	7.313
Total		1260247	18927	100.000	100.000



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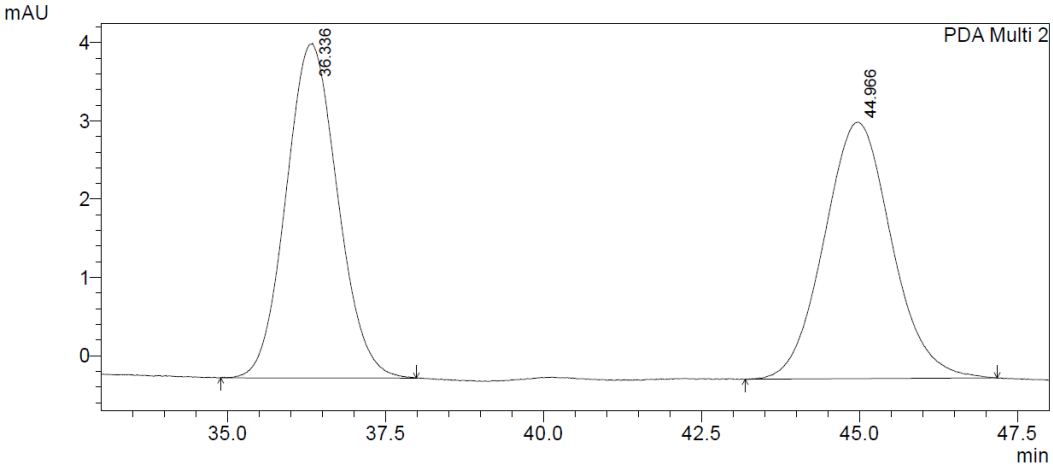
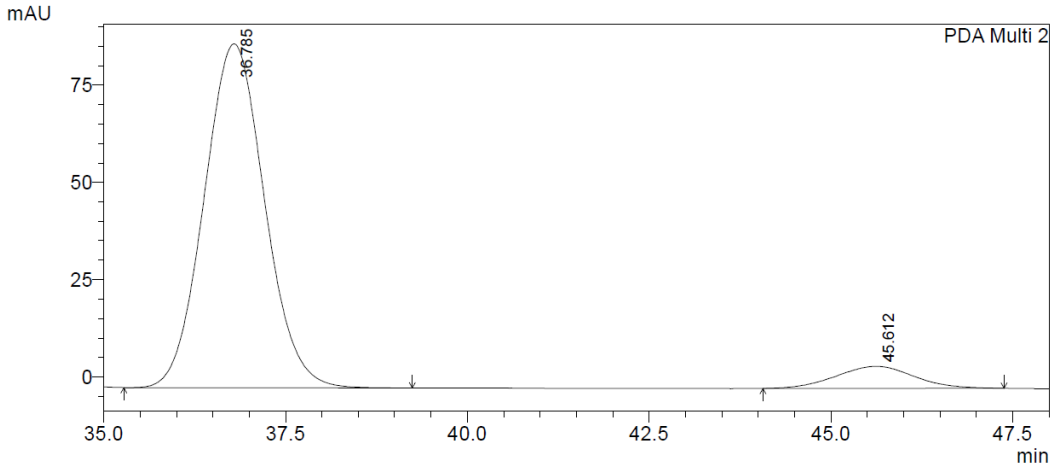


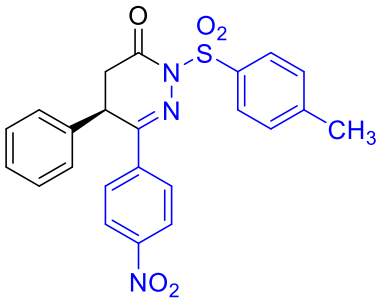
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	36.336	242949	4274	49.993	56.625
2	44.966	243018	3274	50.007	43.375
Total		485968	7548	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	36.785	5113340	88402	92.363	93.987
2	45.612	422766	5656	7.637	6.013
Total		5536106	94058	100.000	100.000



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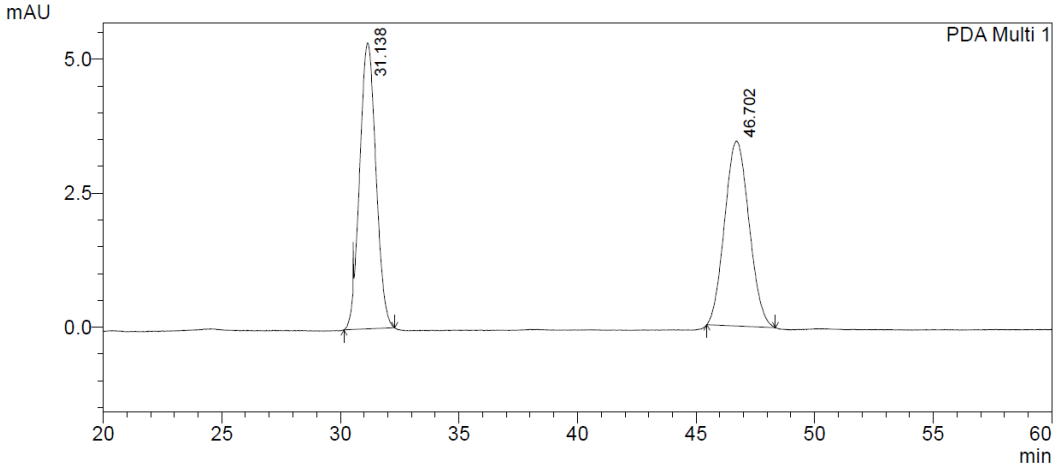
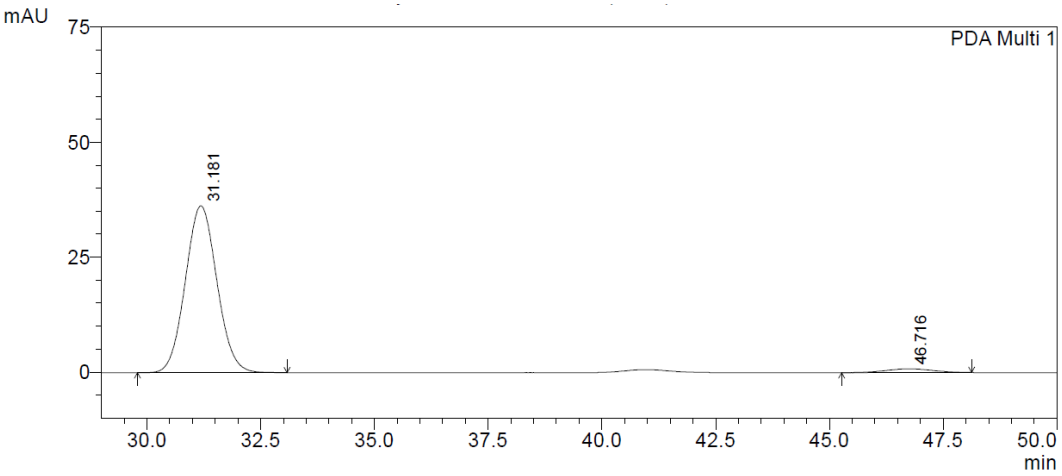


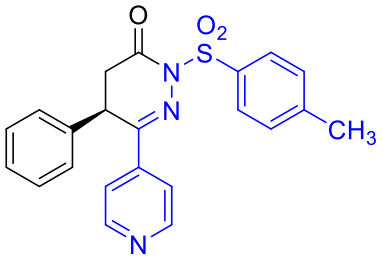
PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	31.138	255806	5335	50.806	60.709
2	46.702	247687	3453	49.194	39.291
Total		503493	8788	100.000	100.000



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	31.181	1756020	36303	96.761	97.781
2	46.716	58782	824	3.239	2.219
Total		1814802	37127	100.000	100.000



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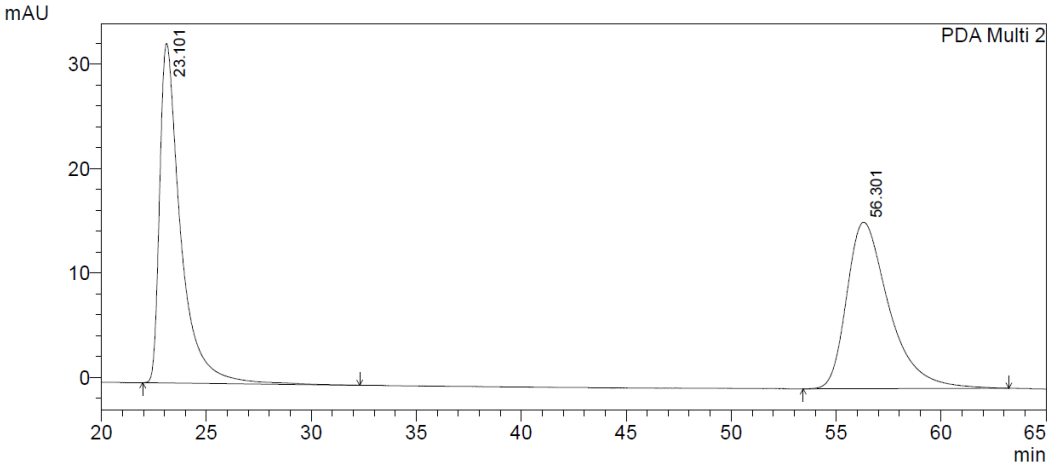
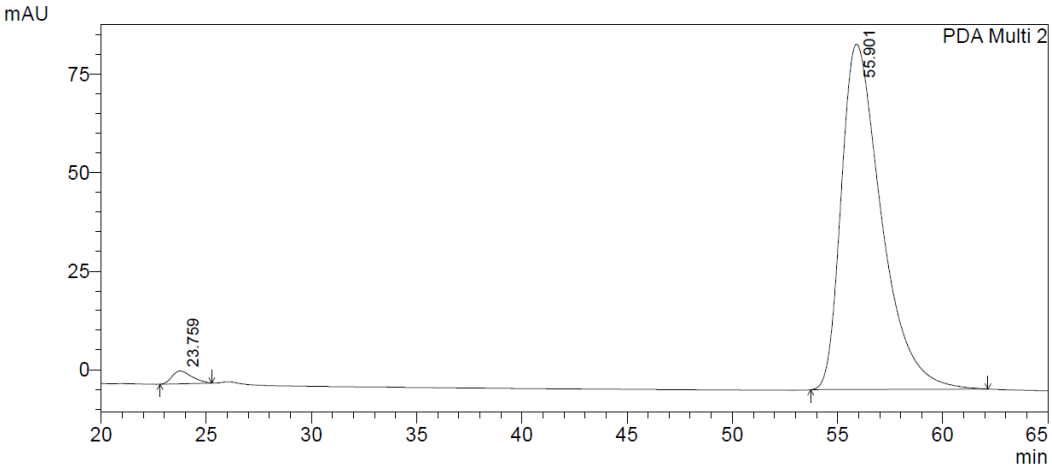


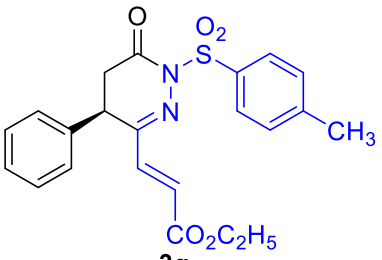
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.101	2264668	32494	50.316	67.106
2	56.301	2236202	15928	49.684	32.894
Total		4500870	48422	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.759	215667	3258	1.817	3.582
2	55.901	11652752	87709	98.183	96.418
Total		11868419	90967	100.000	100.000



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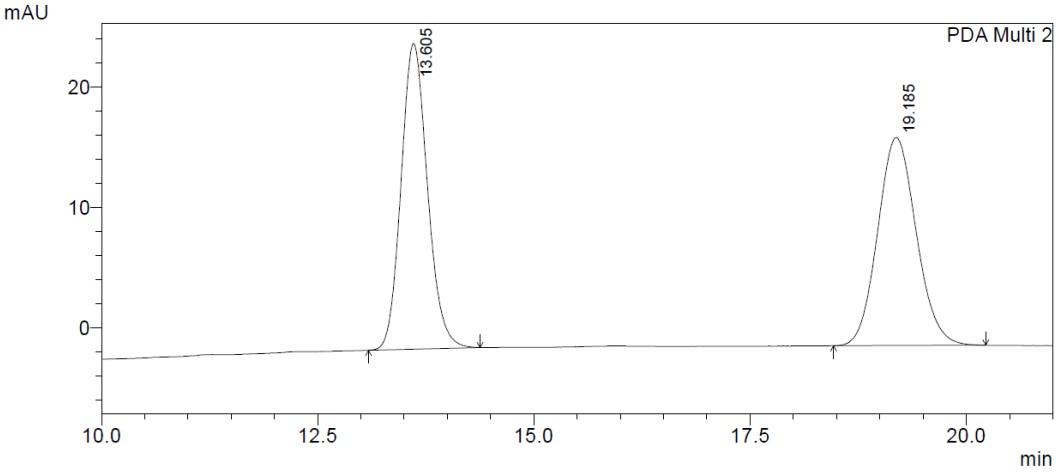
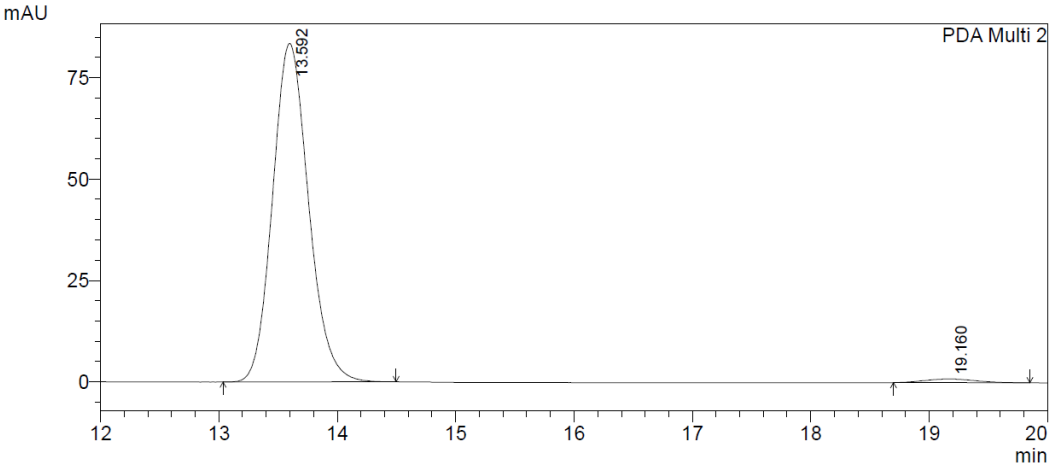


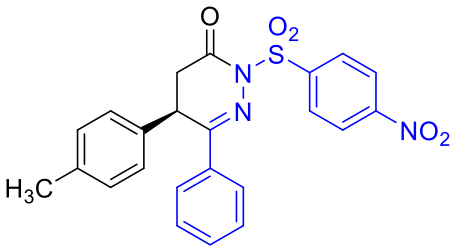
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.605	539342	25425	50.069	59.504
2	19.185	537854	17304	49.931	40.496
Total		1077195	42729	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.592	1767715	83535	98.474	98.903
2	19.160	27399	927	1.526	1.097
Total		1795114	84462	100.000	100.000



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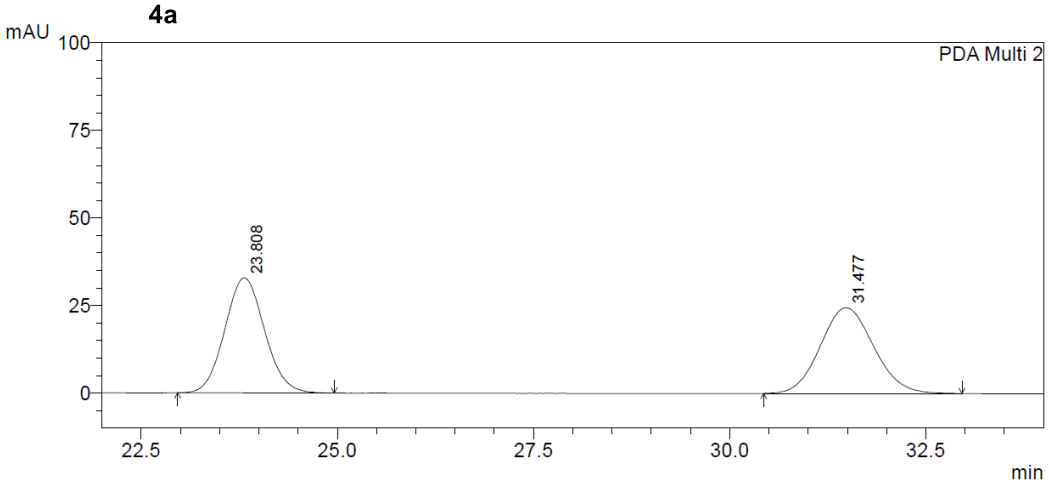
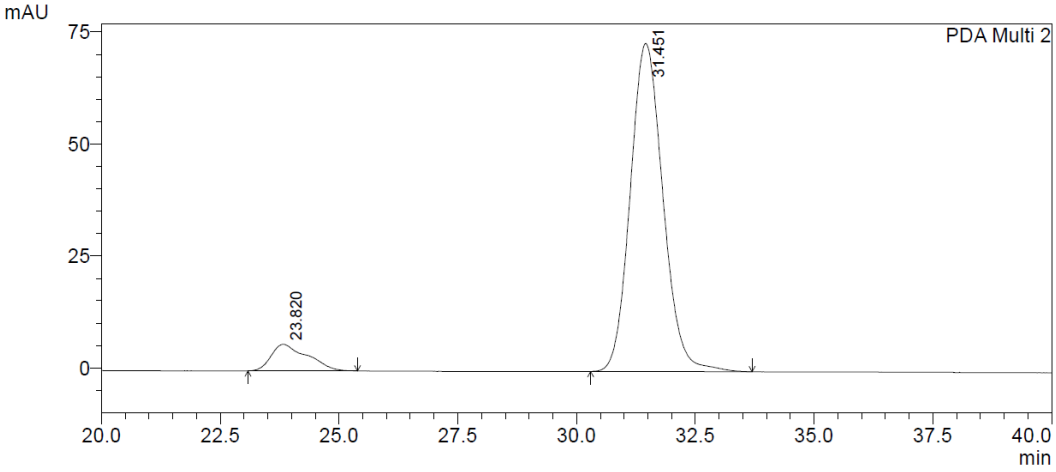


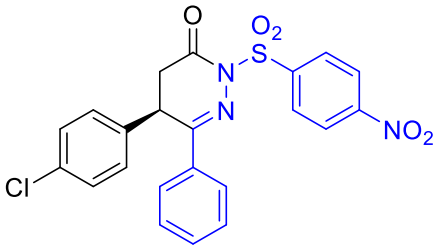
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.808	1157830	32818	50.035	57.262
2	31.477	1156217	24494	49.965	42.738
Total		2314047	57312	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.820	313470	5923	8.188	7.484
2	31.451	3514844	73217	91.812	92.516
Total		3828314	79140	100.000	100.000



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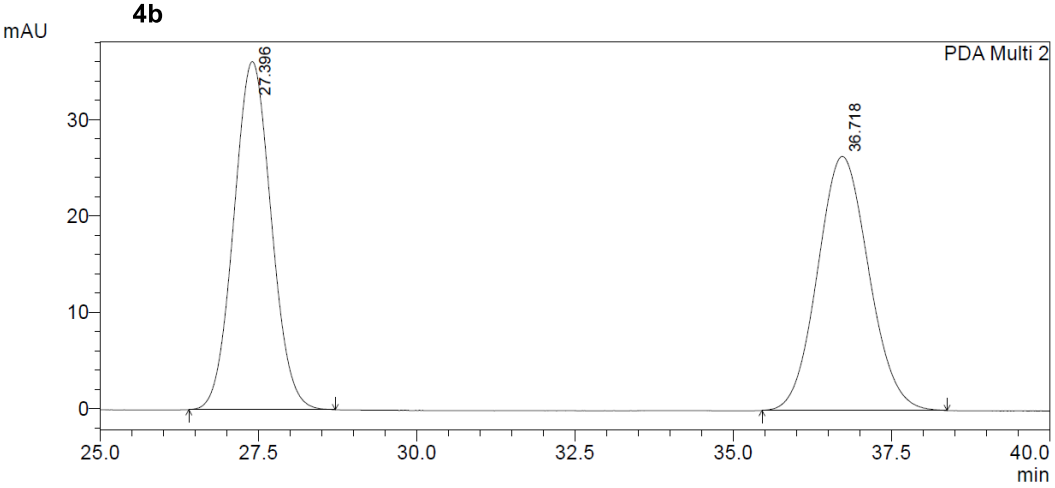
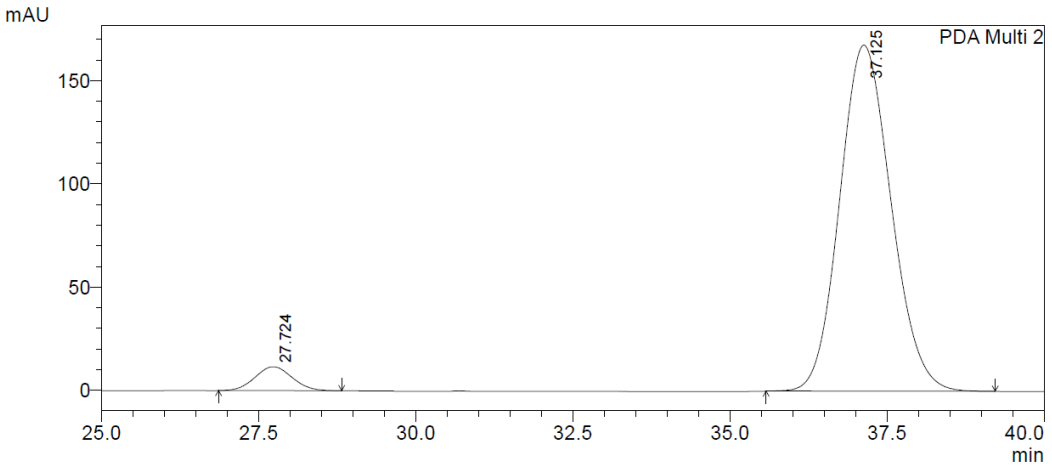


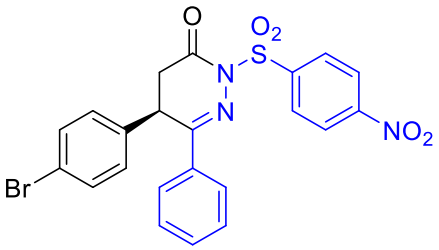
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	27.396	1485993	36103	50.073	57.818
2	36.718	1481654	26339	49.927	42.182
Total		2967647	62442	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	27.724	474612	11585	4.729	6.463
2	37.125	9561517	167658	95.271	93.537
Total		10036129	179242	100.000	100.000



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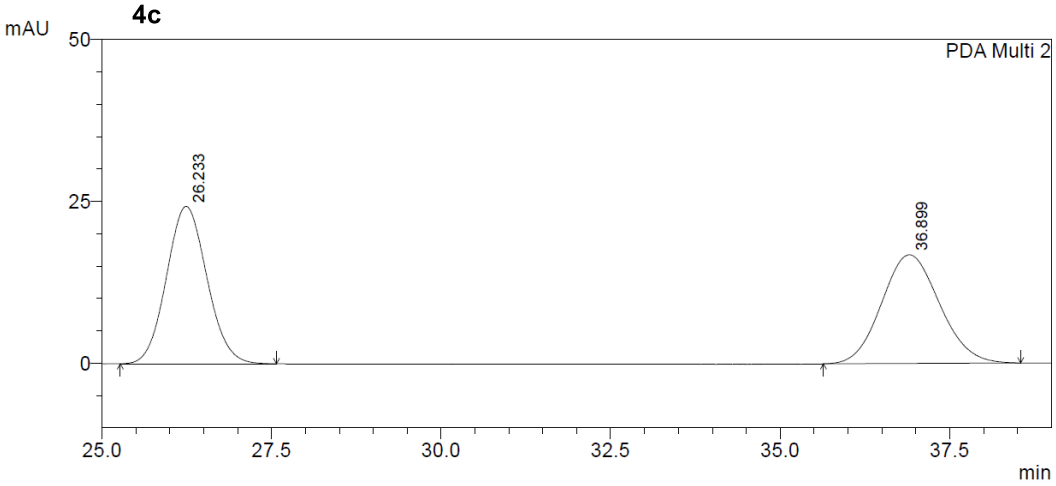
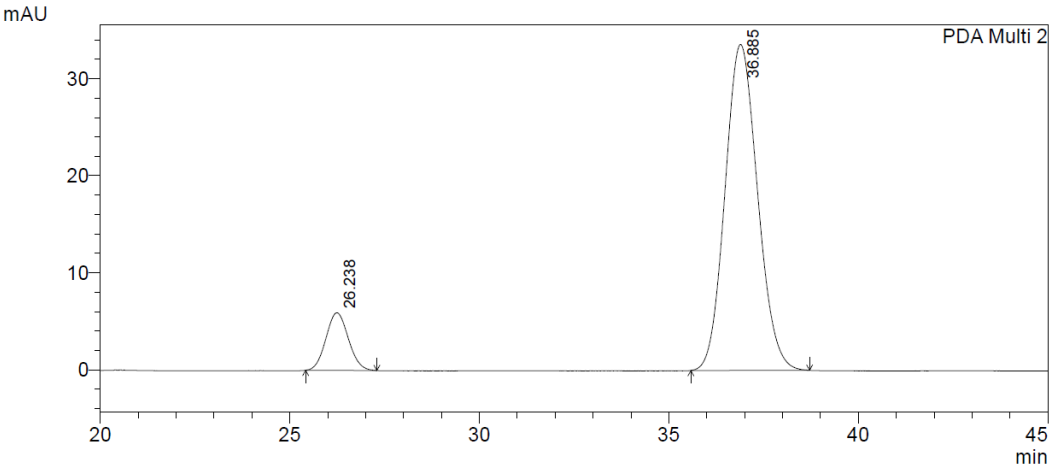


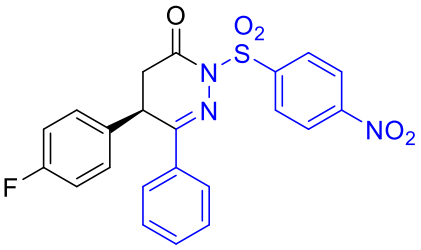
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	26.233	1009975	24312	50.295	59.146
2	36.899	998111	16793	49.705	40.854
Total		2008086	41105	100.000	100.000

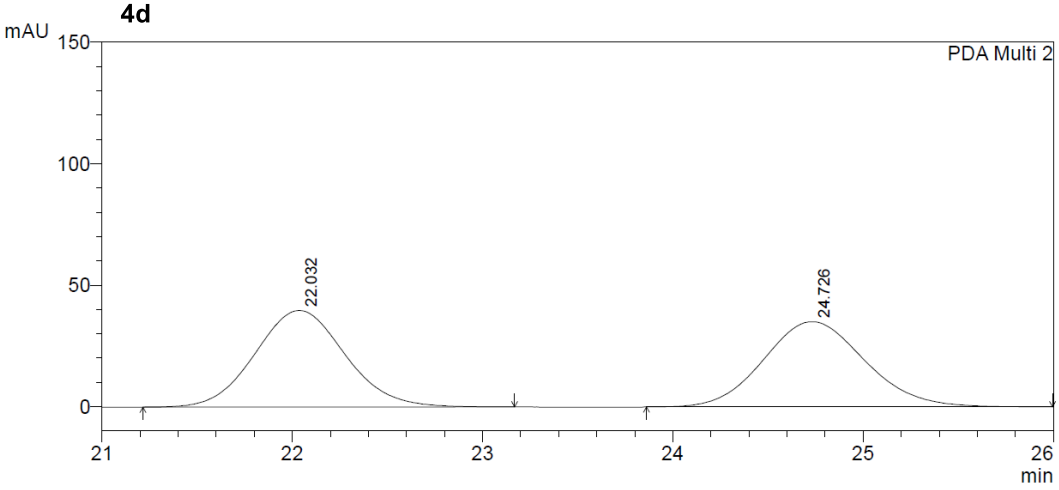


PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	26.238	244821	5947	10.891	15.044
2	36.885	2003132	33584	89.109	84.956
Total		2247953	39531	100.000	100.000

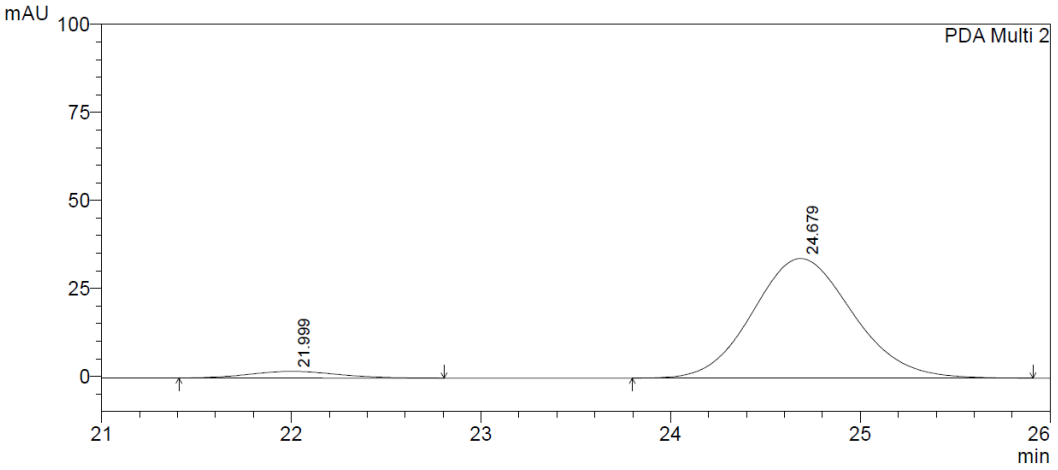


4d



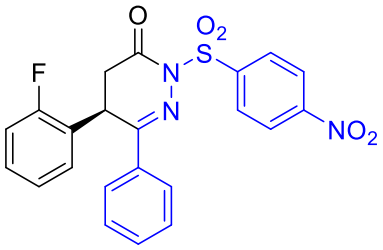
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.032	1309202	39715	50.102	53.090
2	24.726	1303875	35092	49.898	46.910
Total		2613078	74807	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.999	60408	1877	4.617	5.238
2	24.679	1247871	33962	95.383	94.762
Total		1308279	35839	100.000	100.000



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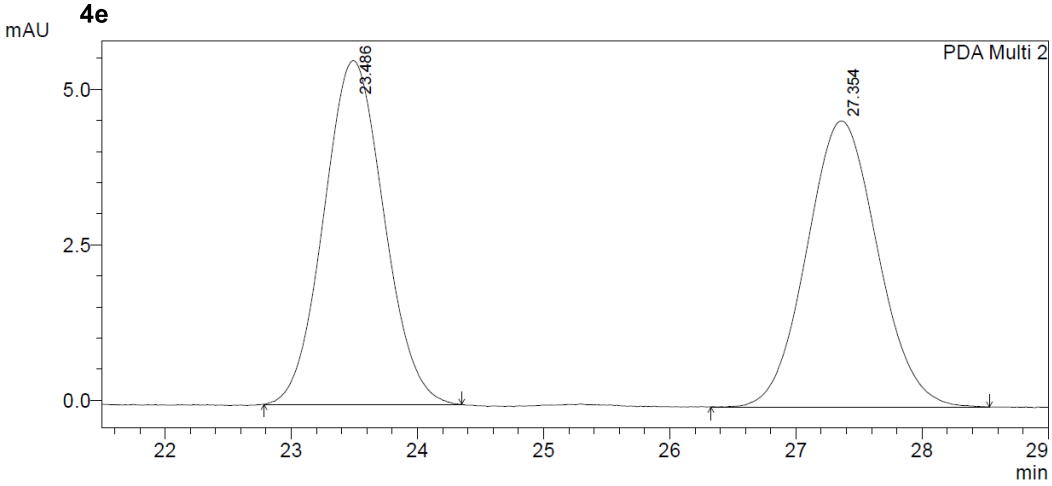
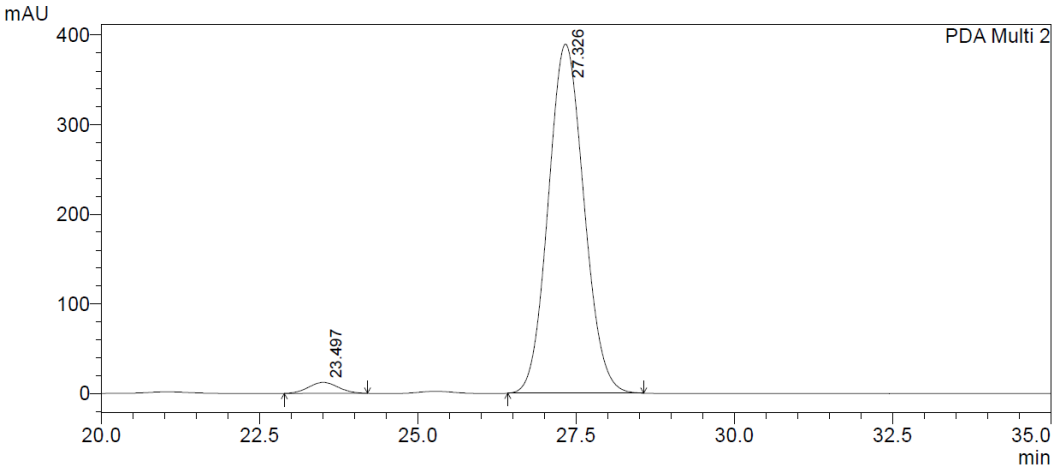


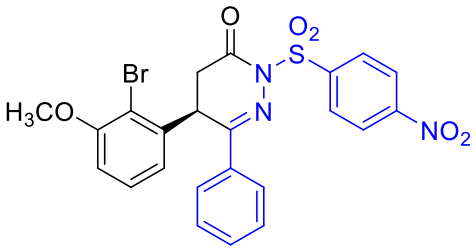
PDA Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.486	183433	5534	50.498	54.576
2	27.354	179817	4606	49.502	45.424
Total		363250	10140	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.497	396067	12178	2.527	3.032
2	27.326	15278953	389513	97.473	96.968
Total		15675020	401691	100.000	100.000



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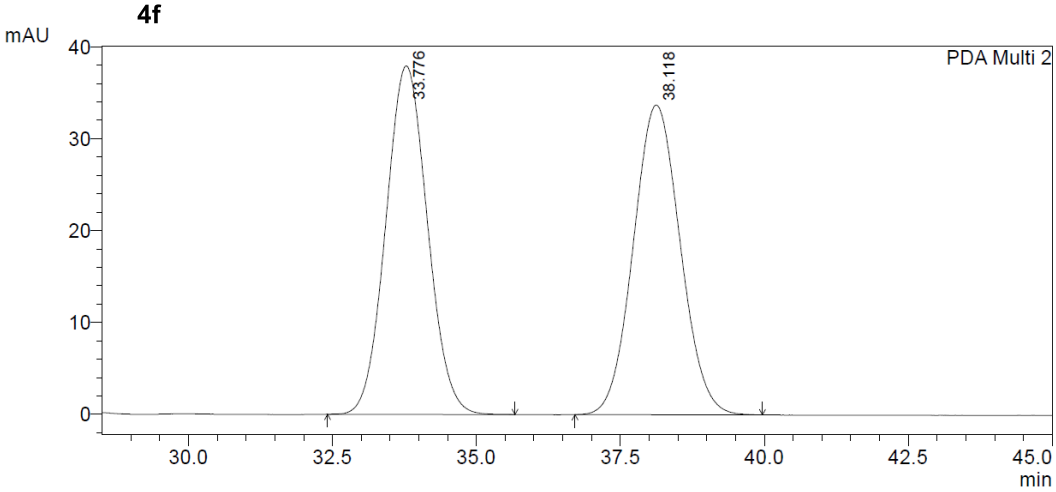
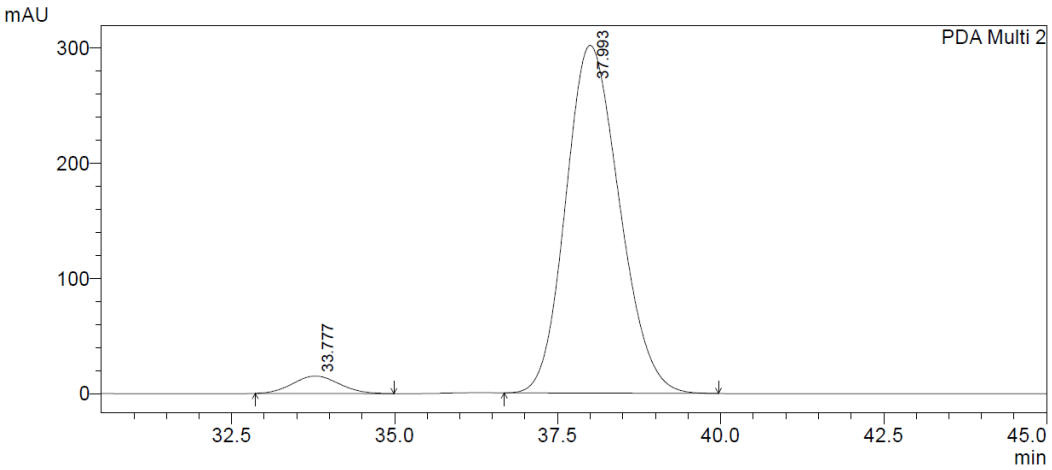


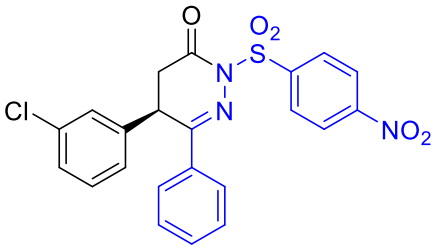
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	33.776	1906124	37916	49.950	52.950
2	38.118	1909957	33691	50.050	47.050
Total		3816081	71607	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	33.777	745686	15088	4.140	4.764
2	37.993	17267160	301657	95.860	95.236
Total		18012846	316745	100.000	100.000



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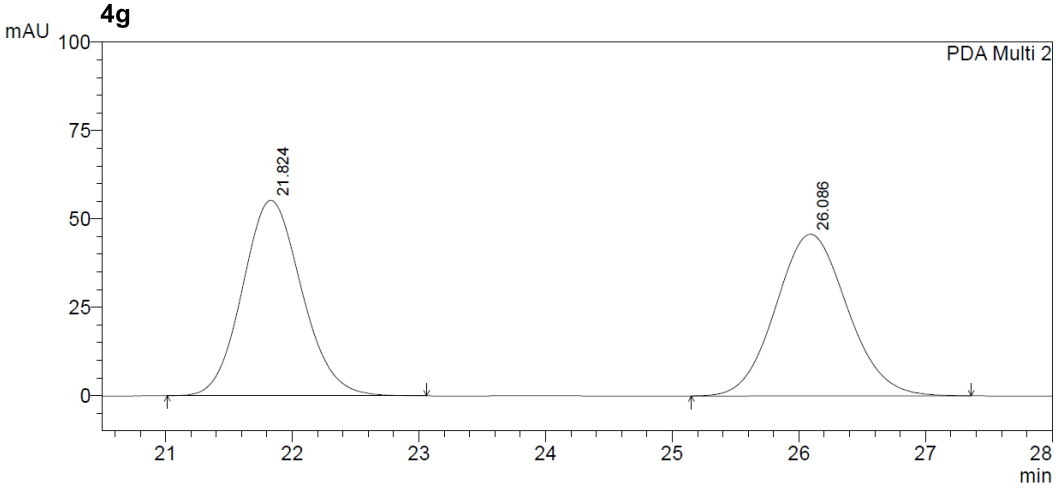
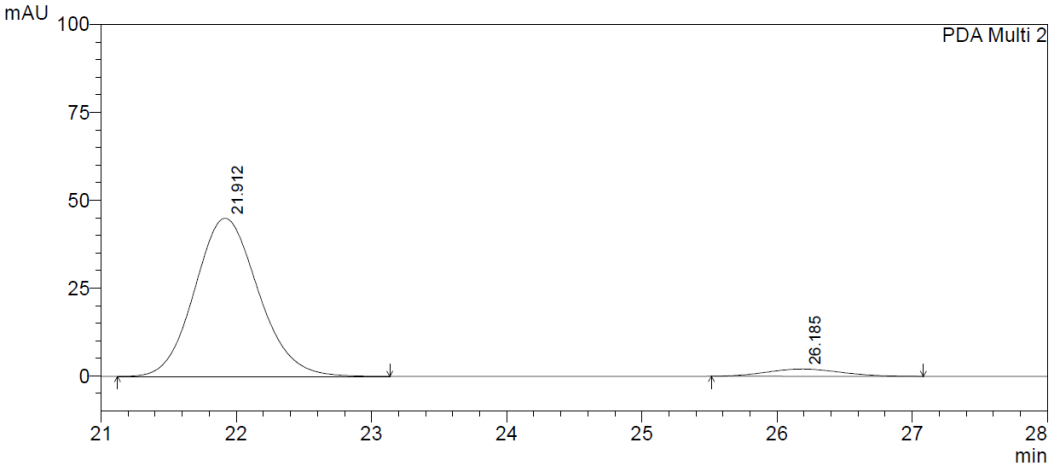


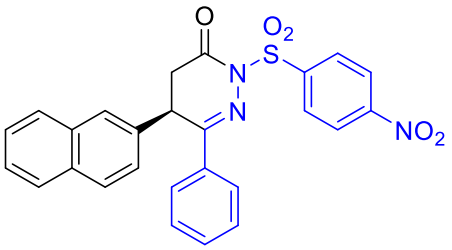
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.824	1799900	55284	50.052	54.736
2	26.086	1796138	45718	49.948	45.264
Total		3596038	101002	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.912	1472386	44981	94.911	95.608
2	26.185	78946	2066	5.089	4.392
Total		1551332	47047	100.000	100.000



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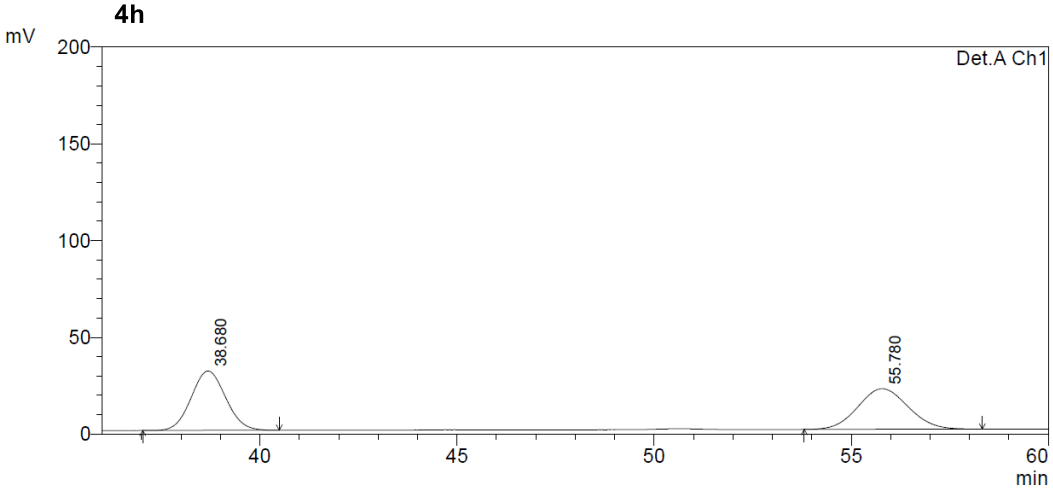
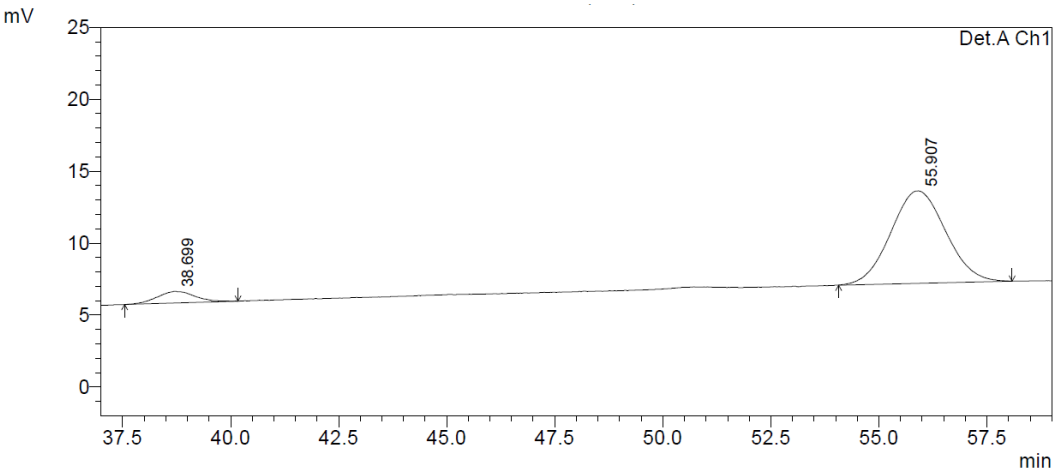


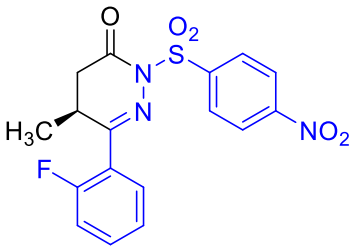
Detector A Ch1 254 nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	38.680	1868276	30699	50.098	59.399
2	55.780	1860957	20983	49.902	40.601
Total		3729233	51682	100.000	100.000



Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	38.699	48934	805	7.896	11.117
2	55.907	570806	6437	92.104	88.883
Total		619740	7242	100.000	100.000



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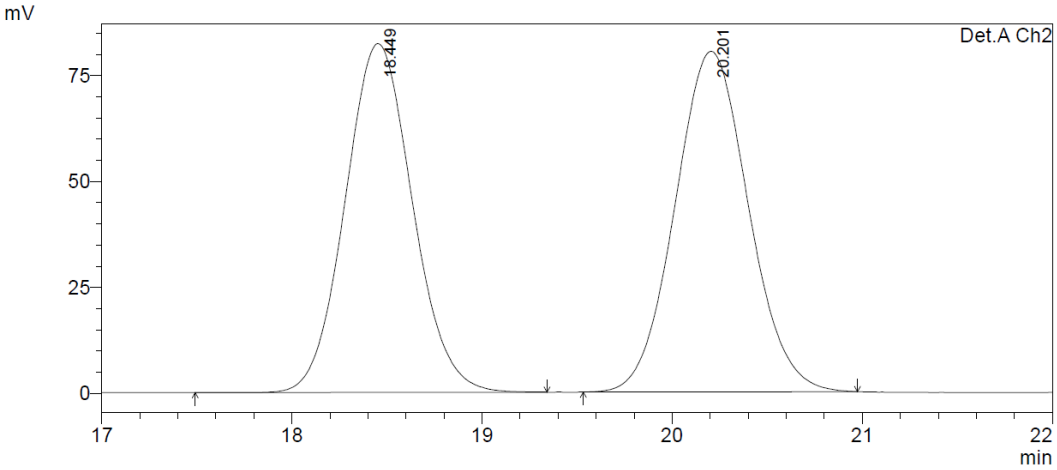
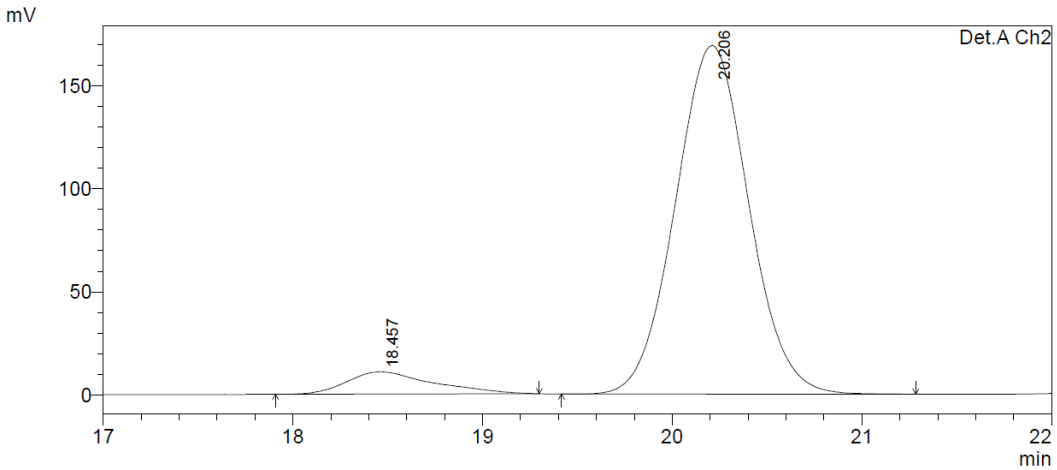


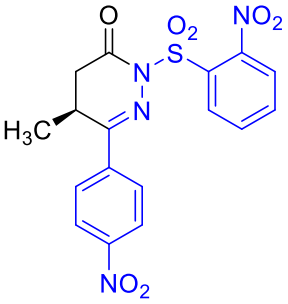
Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	18.449	2022758	82279	48.457	50.598
2	20.201	2151557	80335	51.543	49.402
Total		4174314	162613	100.000	100.000



Detector A Ch2 220nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	18.457	341637	10825	6.988	6.015
2	20.206	4547420	169151	93.012	93.985
Total		4889057	179977	100.000	100.000



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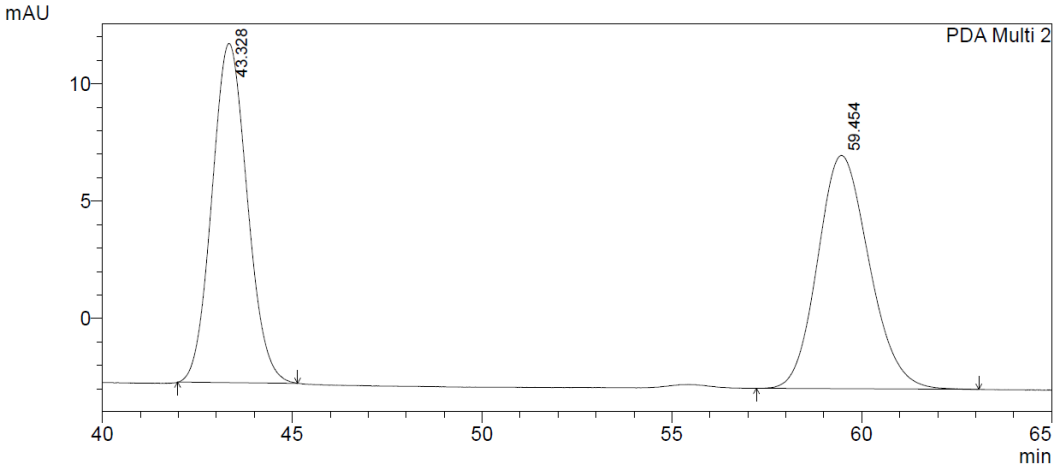
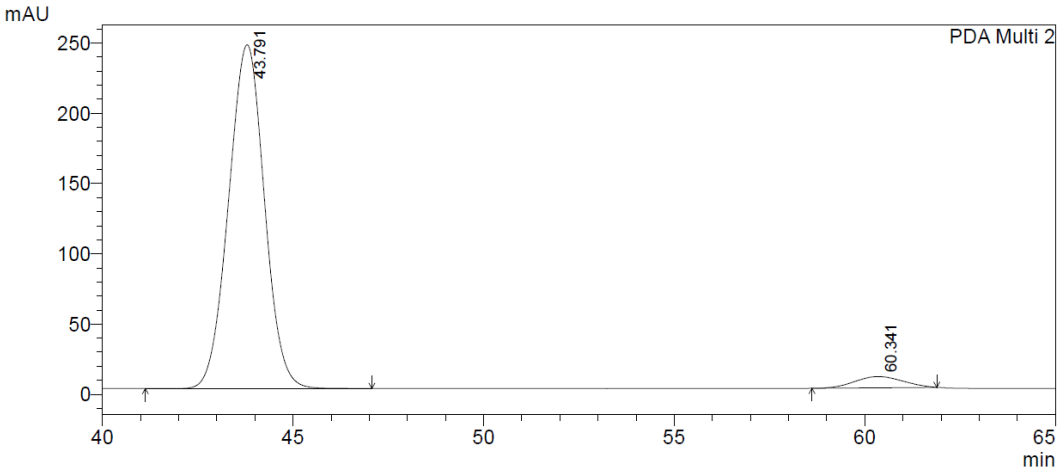


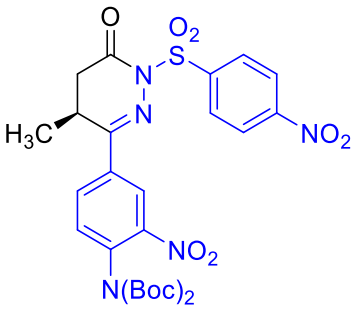
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.328	934900	14454	49.869	59.247
2	59.454	939804	9942	50.131	40.753
Total		1874704	24396	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.791	15972931	244585	95.778	96.828
2	60.341	704134	8013	4.222	3.172
Total		16677065	252598	100.000	100.000



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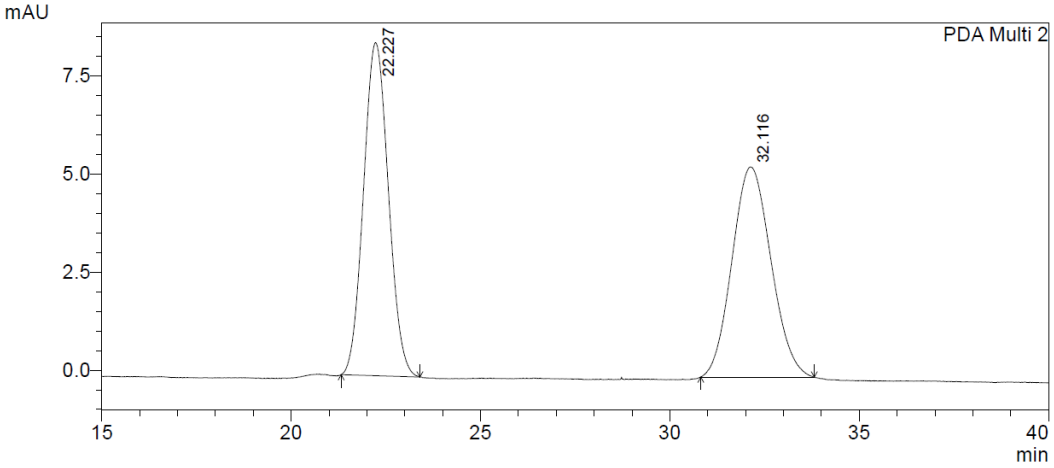
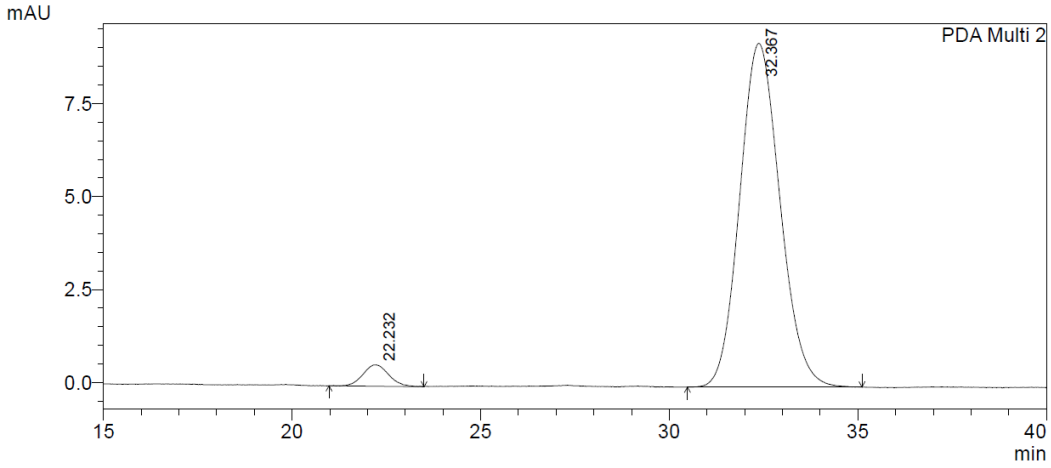


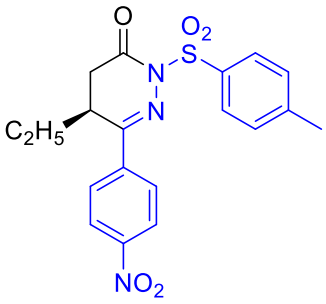
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.227	387432	8484	50.350	61.336
2	32.116	382044	5348	49.650	38.664
Total		769475	13832	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.232	27294	575	3.824	5.850
2	32.367	686401	9246	96.176	94.150
Total		713694	9820	100.000	100.000



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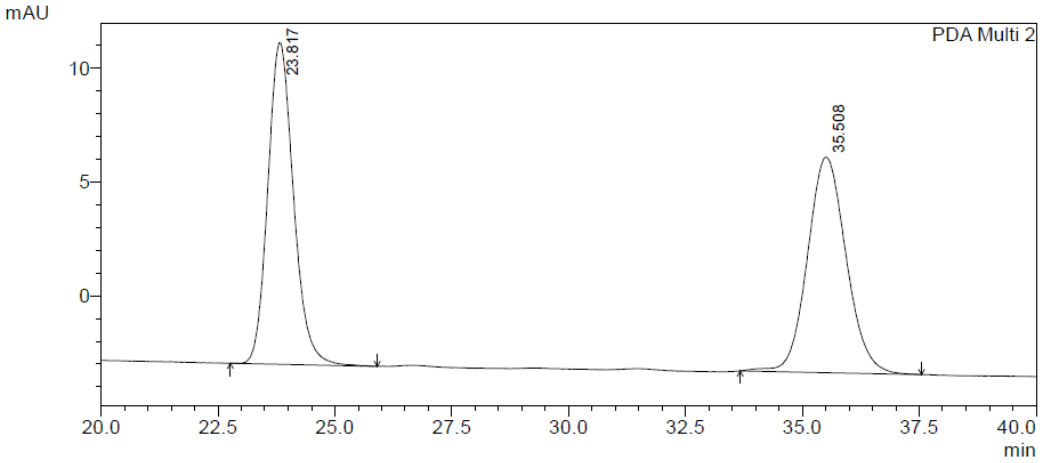
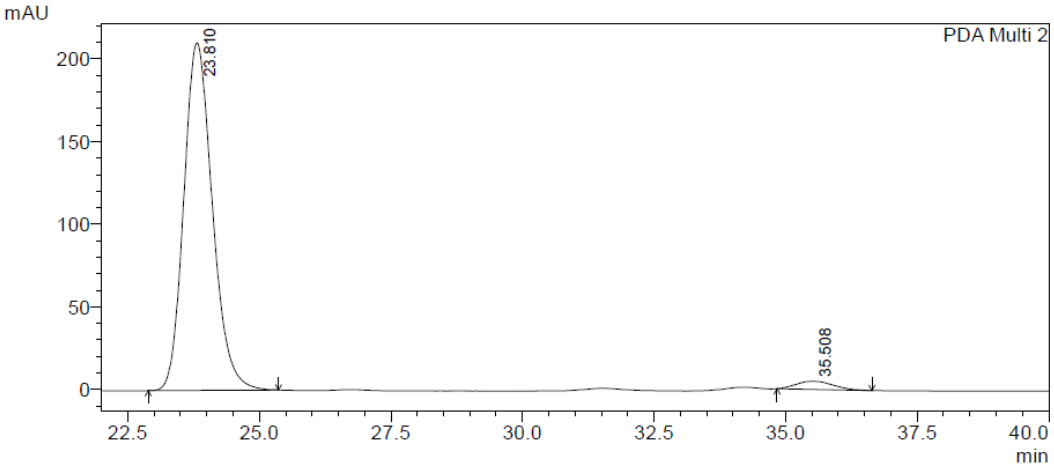


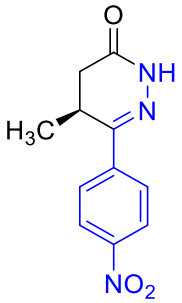
PDA Ch2 220nm 4nm

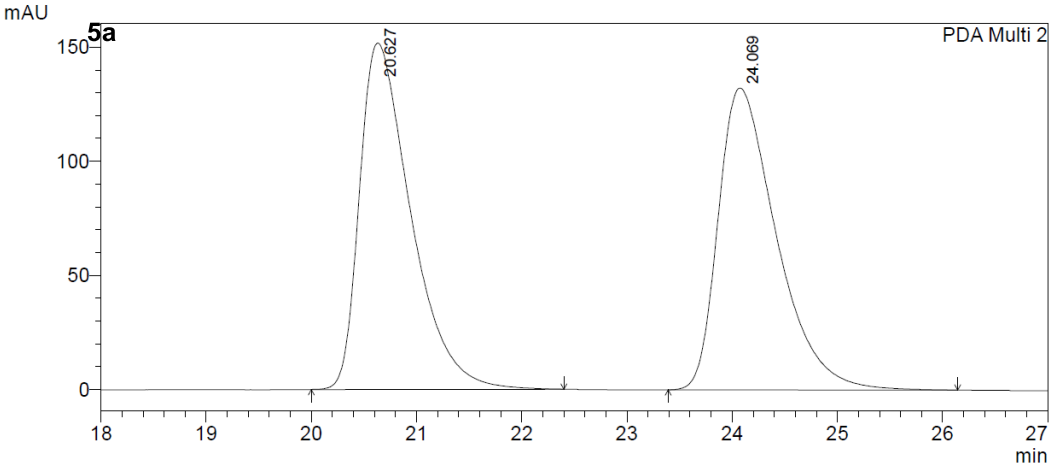
Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.817	541269	14138	49.818	59.897
2	35.508	545223	9466	50.182	40.103
Total		1086493	23604	100.000	100.000



PDA Ch2 220nm 4nm

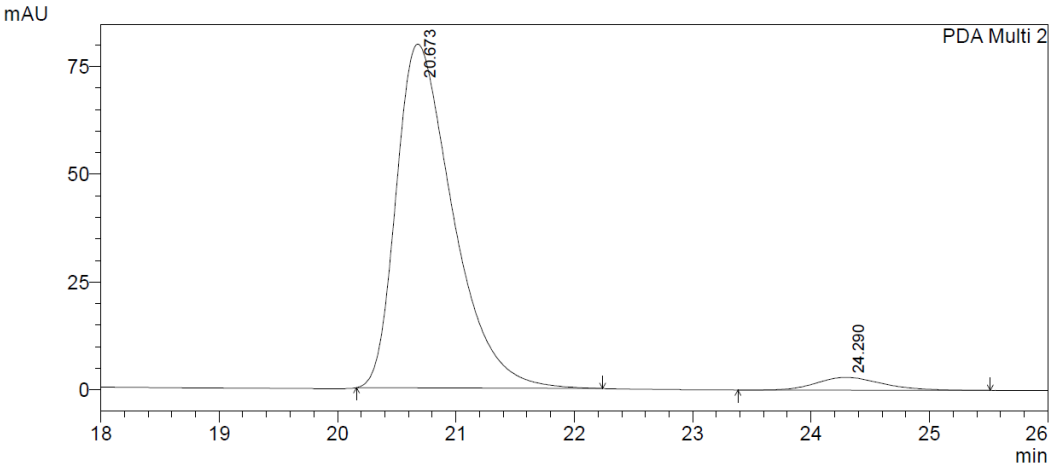
Peak#	Ret. Time	Area	Height	Area %	Height %
1	23.810	7959730	210163	97.079	97.708
2	35.508	239506	4930	2.921	2.292
Total		8199236	215093	100.000	100.000





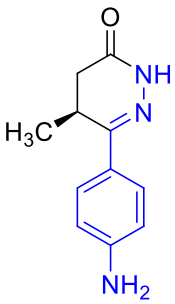
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	20.627	5140691	151758	50.242	53.431
2	24.069	5091269	132268	49.758	46.569
Total		10231960	284026	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	20.673	2649759	79706	95.852	96.405
2	24.290	114670	2972	4.148	3.595
Total		2764430	82679	100.000	100.000



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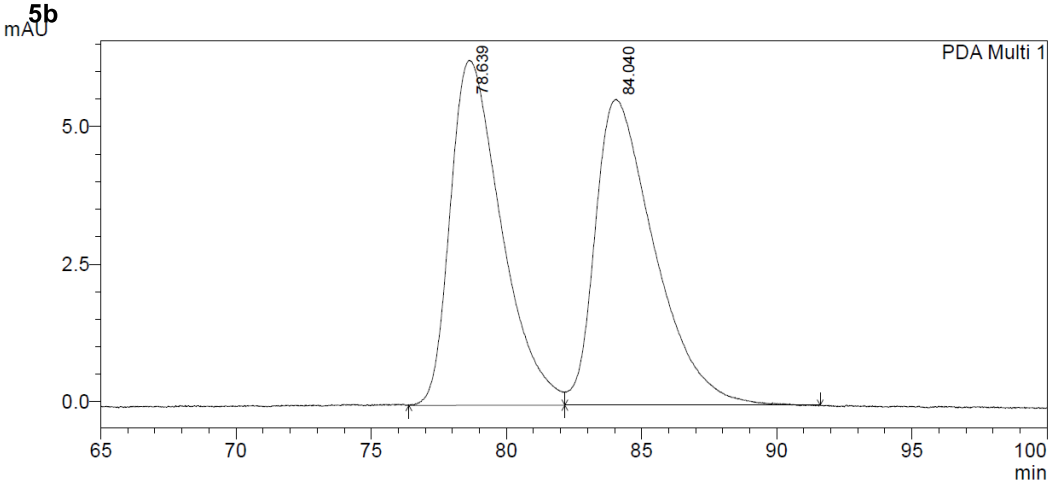
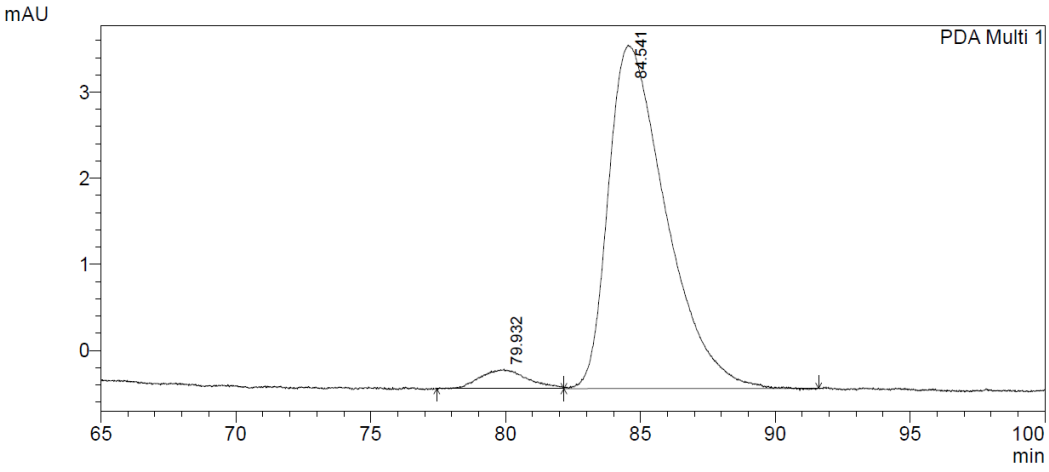


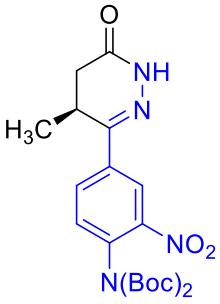
PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	78.639	823425	6269	49.205	53.011
2	84.040	850047	5557	50.795	46.989
Total		1673472	11827	100.000	100.000



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	79.932	26383	226	4.279	5.363
2	84.541	590160	3986	95.721	94.637
Total		616543	4212	100.000	100.000



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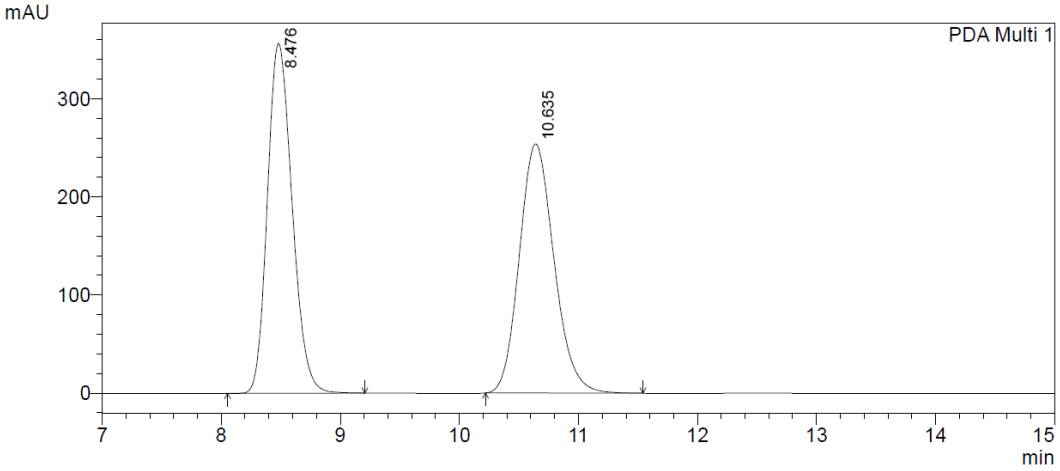
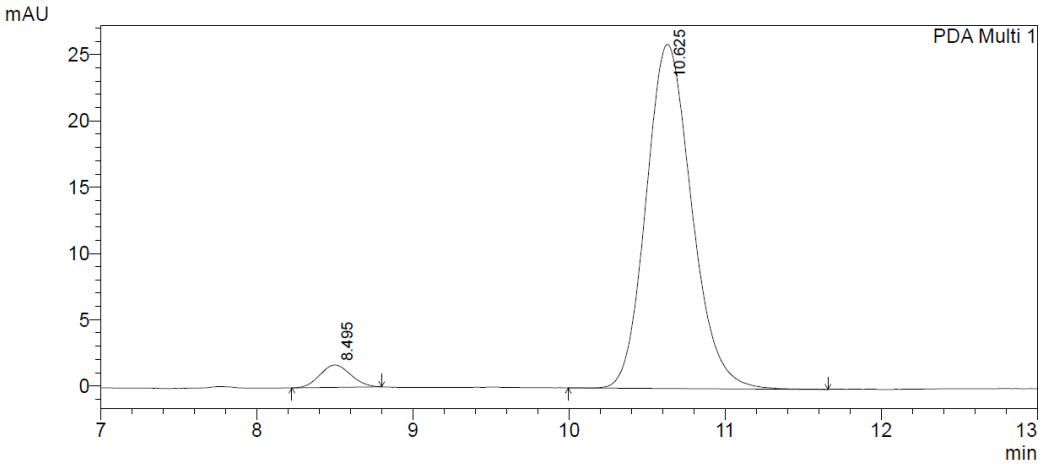


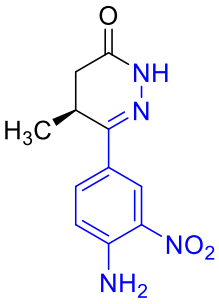
PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	8.476	5151368	356799	50.022	58.440
2	10.635	5146828	253740	49.978	41.560
Total		10298196	610539	100.000	100.000



PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	8.495	23267	1687	4.233	6.103
2	10.625	526444	25950	95.767	93.897
Total		549711	27636	100.000	100.000



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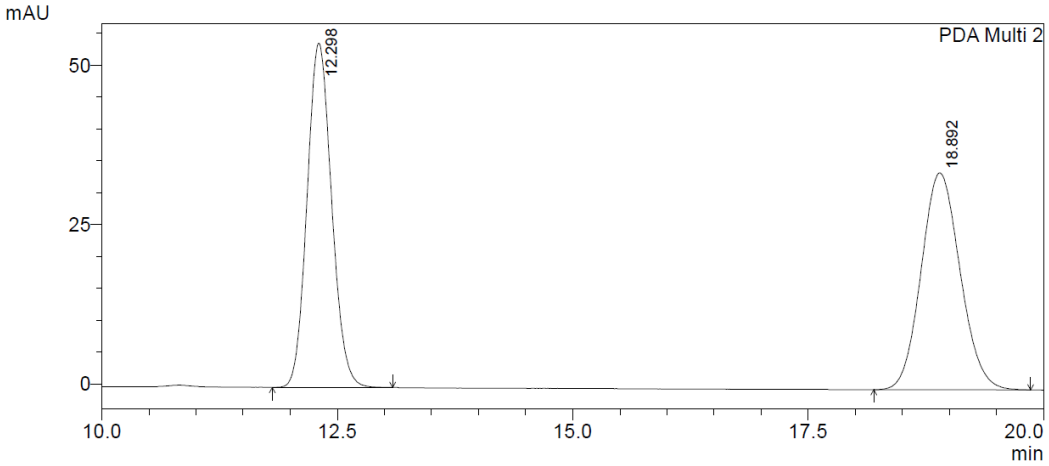
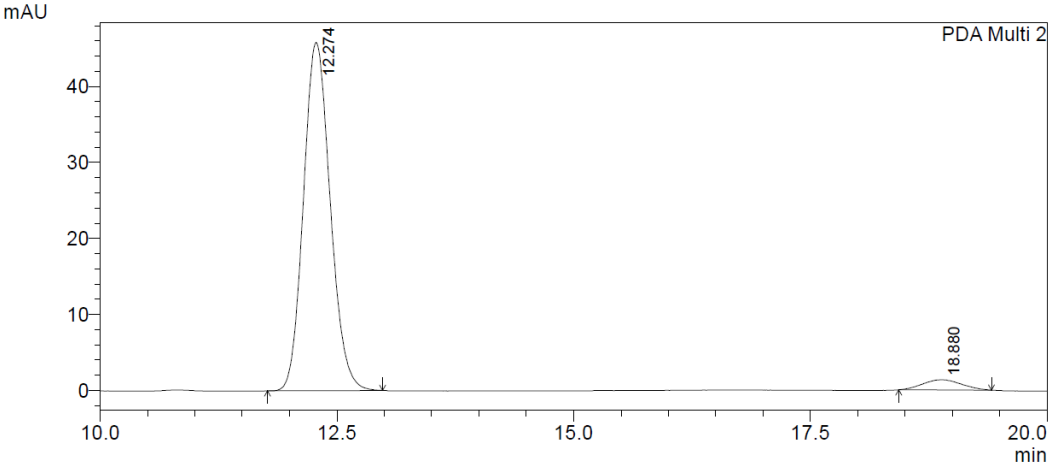


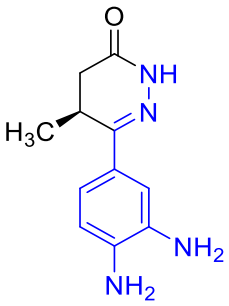
PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.298	981174	53968	50.054	61.359
2	18.892	979065	33987	49.946	38.641
Total		1960239	87955	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.274	903351	45839	95.954	97.154
2	18.880	38087	1343	4.046	2.846
Total		941438	47182	100.000	100.000



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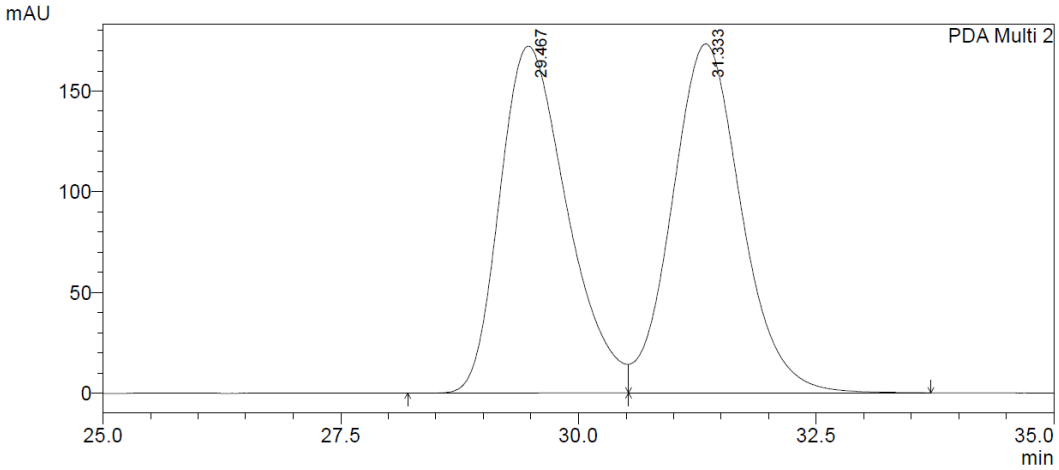
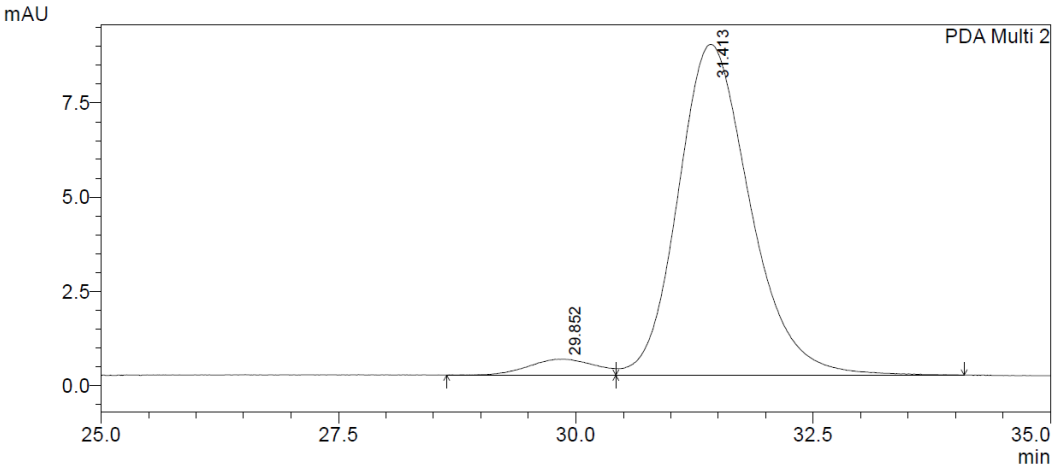


PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.467	8487755	172142	49.175	49.847
2	31.333	8772702	173200	50.825	50.153
Total		17260457	345342	100.000	100.000



PDA Ch2 220nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.852	20296	419	4.203	4.565
2	31.413	462624	8765	95.797	95.435
Total		482920	9184	100.000	100.000