Supplementary Information

One-Step Synthesis of Diazaspiro[4.5]decane Scaffolds with Exocyclic Double Bonds

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Contents

1. General Experimental Procedures

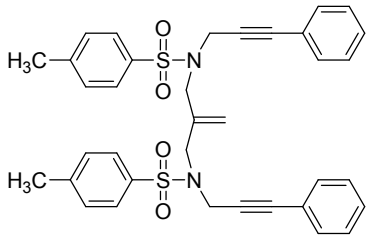
All the catalytic reactions were performed under an argon atmosphere using the oven-dried Schlenk flask. The chemicals were purchased from Alfa Aesar and Acros Chemicals. All solvents and materials were pre-dried, redistilled or recrystallized before use. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectra were recorded on a Bruker Avance 300 spectrometer with $CDCl_3$ as the solvent. Chemical shifts are reported in ppm by assigning TMS resonance in the ^{1}H NMR spectra as 0.00 ppm and $CDCl_3$ resonance in the ^{13}C spectra as 77.0 ppm. All coupling constants (*J* values) were reported in Hertz (Hz). Column chromatography was performed on silica gel 300–400 mesh. Melting points were determined using a Gallenkamp melting point apparatus and are uncorrected. The FT-IR spectra were recorded from KBr pellets or thin film from $CHCl_3$ on the NaCl window in the 4000-400 cm^{-1} ranges on a Nicolet 5DX spectrometer. All HRMS spectra were record using EI or APCI at 70 eV. X-ray Crystallography diffraction data of **fa**, **ga**, and **gb** were collected at room temperature with a Bruker SMART Apex CCD diffractometer with Mo-Kα radiation (λ = 0.71073 Å) with a graphite monochromator using the ω-scan mode. Data reductions and absorption corrections were performed with SAINT and SADABS software, respectively. The structure was solved by direct methods and refined on F^2 by full-matrix least squares using SHELXTL. All non-hydrogen atoms were treated anisotropically. The positions of hydrogen atoms were generated geometrically.

General procedures:

Substrate yne-en-yne[1] **a-g** (1.0 mmol), aryl halide (1.1 mmol), $Pd(OAc)_2$ (2 mol%), and PPh_3 (4 mol%) were added to the degassed solution of $(n\text{-}Bu)_3N$ (2 mmol) in DMF (10 mL). and the mixture was stirred at room temperature for half an hour, and then heated at 130°C for 20 h, The reaction mixture was cooled, and then quenched with water and extracted with EtOAc (3 × 5 mL). The combined organic layers were washed with hydrochloric acid (5%), sodium carbonate (5%), and saturated sodium chloride solution. After separation, the organic layer was dried over $MgSO_4$ and then concentrated. The residue was loaded onto a silica gel column and purified by flash column chromatography (eluent: petroleum ether/ethyl acetate) to give the corresponding product **aa-gd**.

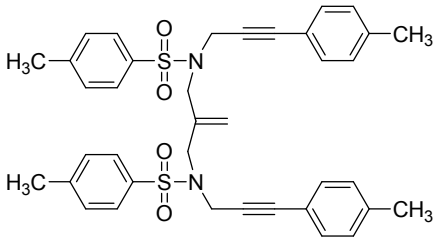
[1] T. J. Meng, Y. M. Hu, Q. S. Zhao, T. Yu, S. Wang, *Tetrahedron,* **2011**, *67*, 8710-8716.

2. Characterization Data for the New Compounds



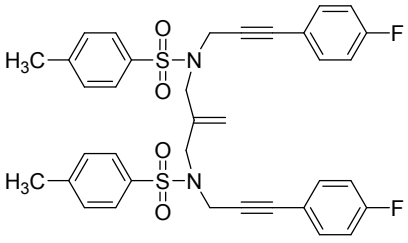
***N*, *N*'-2-methylenepropane-1,3-diyl)bis(4-methyl-*N*-(3-phenylprop-2-yn-1-yl)benzenesulfonamide (a)**

White solid; 82 % yield; m.p. 116-117 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.45; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.76 - 7.78 (d, 4H, J = 7.8 Hz; Ar-H), 7.23 (s, 10H, Ar-H), 7.05 - 7.07 (d, 4H, J = 6.3 Hz; Ar-H), 5.41 (s, 2H; C=CH_2), 4.33 (s, 4H; C≡C-CH_2), 3.92 (s, 4H; C=C-CH_2), 2.31 (s, 6H; Ar-CH_3); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 143.7, 137.3, 135.5, 131.6, 129.6, 128.5, 128.1, 127.9, 122.1, 117.6, 86.1, 81.4, 49.3, 37.4, 21.4 ppm; FT-IR (neat): ν 3053.3, 2993.5, 2908.7, 2862.4, 2337.4, 2198.9, 1595.1, 1442.8, 1350.2, 1329.0, 1163.1, 1089.8, 981.8, 904.6, 850.6, 758.0, 692.4, 659.7 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{36}H_{34}N_2O_4S_2$ $[M + H]^+$, 623.2033; found: 623.2028.



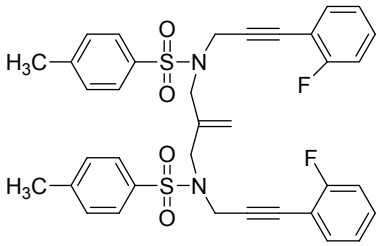
***N*, *N*'-2-methylenepropane-1,3-diyl)bis(4-methyl-*N*-(3-(p-tolyl)prop-2-yn-1-yl)benzenesulfon amide (b)**

White solid; 78 % yield; m.p. 127 - 128 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75 - 7.78 (d, 4H, J = 7.8 Hz; Ar-H), 7.23 - 7.25 (d, 4H, J = 5.7 Hz; Ar-H), 7.02 - 7.05 (d, 4H, J = 7.8 Hz; Ar-H), 6.94 - 6.97 (d, 4H, J = 8.1 Hz; Ar-H), 5.39 (s, 2H; C=CH_2), 4.32 (s, 4H; C≡C-CH_2), 3.91 (s, 4H; C=C-CH_2), 2.33 (s, 6H; Ar-CH_3), 2.32 (s, 6H; Ar-CH_3); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 143.6, 138.6, 137.4, 135.6, 131.5, 129.6, 128.9, 127.9, 119.0, 117.5, 86.2, 80.7, 49.3, 37.5, 21.5 ppm; FT-IR (neat): ν 3028.2, 2972.3, 2918.3, 2862.4, 2243.2, 1597.1, 1508.3, 1438.8, 1344.4, 1089.8, 902.7, 815.9, 744.5, 677.0, 657.7 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{38}H_{38}N_2O_4S_2$ $[M + H]^+$, 651.2346; found: 651.2336.



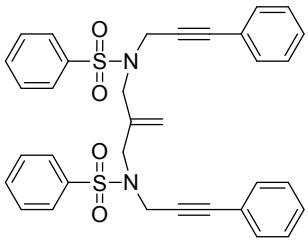
***N*, *N*'-2-methylenepropane-1,3-diyl)bis(*N*-(3-(4-fluorophenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (c)**

White solid; 83 % yield; m.p. 139 -140 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.48; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.74 - 7.77 (d, 4H, J = 8.7 Hz; Ar-H), 7.23 (s, 4H; Ar-H), 7.02 - 7.05 (m, 4H; Ar-H), 6.89 - 6.95 (t, 4H; Ar-H), 5.40 (s, 2H; C=CH_2), 4.30 (s, 4H; C≡C-CH_2), 3.92 (s, 4H; C=C-CH_2), 2.32 (s, 6H; Ar-CH_3); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 164.2, 143.7, 137.4, 135.6, 133.4, 129.6, 127.9, 118.0, 115.6, 115.3, 85.0, 81.1, 49.4, 37.4, 21.4 ppm; FT-IR (neat): ν 3049.5, 2980.0, 2908.7, 2858.5, 2250.9, 1599.0, 1442.8, 1354.0, 1305.8, 1213.2, 1091.7, 983.7, 910.4, 837.1, 814.0, 773.5, 655.8 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{36}H_{32}F_2N_2O_4S_2$ $[M + H]^+$, 659.1844; found: 659.1837.



***N*, *N*'-2-methylenepropane-1,3-diyl)bis(*N*-(3-(2-fluorophenyl)prop-2-yn-1-yl)-4-methylbenzenesulfonamide (d)**

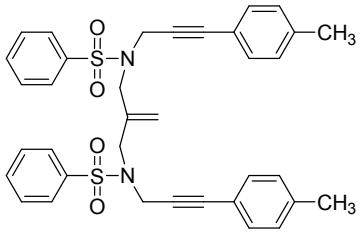
White solid; 71 % yield; m.p. 141 - 142 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.40; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75 - 7.77 (d, 4H, J = 8.4 Hz; Ar-H), 7.21 - 7.27 (m, 7H; Ar-H), 7.00 - 7.06 (m, 5H; Ar-H), 5.43 (s, 2H; C=CH_2), 4.36 (s, 4H; C≡C-CH_2), 3.92 (s, 4H; C=C-CH_2), 2.26 (s, 6H; Ar-CH_3); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 164.3, 143.7, 137.1, 135.4, 133.5, 130.2, 129.6, 127.8, 123.8, 117.9, 115.5, 115.2, 86.7, 79.6 49.3, 37.5, 21.4 ppm; FT-IR (neat): ν 3043.7, 2980.0, 2914.4, 2854.7, 1595.1, 1435.0, 1346.3, 1259.5, 1215.2, 1093.6, 941.3, 908.5, 817.8, 761.9, 734.9, 696.3, 661.6 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{36}H_{32}F_2N_2O_4S_2$ $[M + H]^+$, 659.1844; found: 659.1839.



***N, N'*-2-methylenepropane-1,3-diyl)bis(*N*-(3-phenylprop-2-yn-1-yl)benzenesulfonamide (e)**

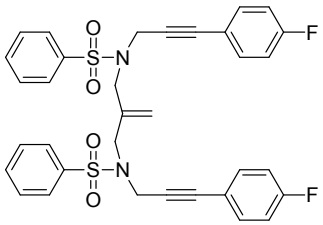
White solid; 75 % yield; m.p. 104 - 105 °C;TLC (petroleum ether/EtOAc = 5:1): R_f = 0.45; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.89 - 7.92 (d, 4H, J = 8.1 Hz; Ar-H), 7.45 - 7.53 (m, 6H,; Ar-H), 7.10 - 7.28 (m, 6H; Ar-H), 7.07 - 7.08 (d, 4H, J = 1.8 Hz; Ar-H), 5.42 (s, 2H; C=CH_2), 4.37 (s, 4H; C≡C-CH_2), 3.94 (s, 4H; C=C-CH_2); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 138.7, 137.2, 132.9, 131.6, 129.0, 128.6, 128.2, 127.8,

121.9, 117.8, 86.2, 81.3, 55.3, 49.3, 37.5 ppm; FT-IR (neat): ν 3055.2, 2968.5, 2908.7, 2858.5, 2239.4, 1597.1, 1491.0, 1446.6, 1330.9, 1093.6, 979.8, 898.8, 788.9, 814.0, 758.0, 721.4, 690.5 cm^{-1}; cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{34}H_{30}N_2O_4S_2$ $[M + H]^+$, 595.1720; found: 595.1713.



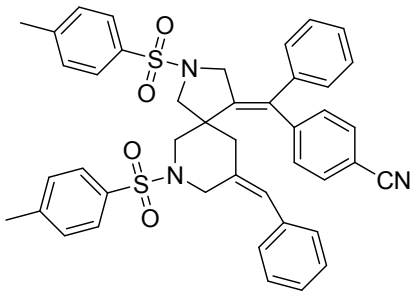
***N, N′*-2-methylenepropane-1,3-diyl)bis(*N*-(3-(p-tolyl)prop-2-yn-1-yl)benzenesulfonamide (f)**

White solid; 82 % yield; m.p. 109 - 110 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.45; ^1H NMR (300 MHz, $CDCl_3$): δ 7.88 - 7.90 (d, 4H, *J* = 5.4 Hz; Ar-H), 7.45 - 7.57 (m, 6H; Ar-H), 7.02 - 7.05 (d, 4H, *J* = 7.5 Hz; Ar-H), 6.96 - 6.99 (d, 4H, *J* = 8.4 Hz; Ar-H), 5.41 (s, 2H; C=CH_2), 4.35 (s, 4H; C≡C-CH_2), 3.93 (s, 4H; C=C-CH_2), 2.31 (s, 6H; Ar-CH_3); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 138.7, 138.6, 137.2, 132.8, 131.5, 129.0, 128.9, 127.8, 118.9, 117.7, 86.3, 80.5, 49.3, 37.5, 21.5 ppm; FT-IR (neat): ν 3072.6, 2974.2, 2912.5, 2862.4, 2241.3, 2206.6, 1604.8, 1508.3, 1446.6, 1334.7, 1091.7, 1062.8, 974.5, 896.9, 821.7, 814.0, 744.5, 686.7 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{36}H_{34}N_2O_4S_2$ $[M + H]^+$, 623.2033; found: 623.2023.



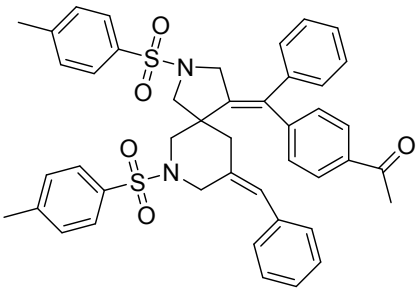
***N, N′*-2-methylenepropane-1,3-diyl)bis(*N*-(3-(4-fluorophenyl)prop-2-yn-1-yl)benzenesulfonamide (g)**

White solid; 87 % yield; m.p. 83 - 84 °C; TLC (petroleum ether/EtOAc = 5:1): R_f = 0.48; ^1H NMR (300 MHz, $CDCl_3$): δ 7.88 - 7.90 (d, 4H, *J* = 6.6 Hz; Ar-H), 7.45 - 7.87 (m, 6H; Ar-H), 7.04 - 7.08 (m, 4H; Ar-H), 6.89 - 6.95 (m, 4H; Ar-H), 5.41 (s, 2H; C=CH_2), 4.34 (s, 4H; C≡C-CH_2), 3.93 (s, 4H; C=C-CH_2); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 164.3, 138.6, 137.2, 133.6, 132.9, 129.0, 127.8, 117.8, 115.6, 115.3, 85.1, 81.0, 49.3, 37.4 ppm; FT-IR (neat): ν 3064.9, 2982.0, 2914.4, 2866.2, 2250.9, 2212.4, 1599.0, 1429.3, 1334.7, 1097.5, 981.8, 896.9, 842.9, 690.5, 661.6 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{34}H_{28}F_2N_2O_4S_2$ $[M + H]^+$, 631.1531; found: 631.1524.



4-((E)-((Z)-9-benzylidene-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)benzonitrile(aa)

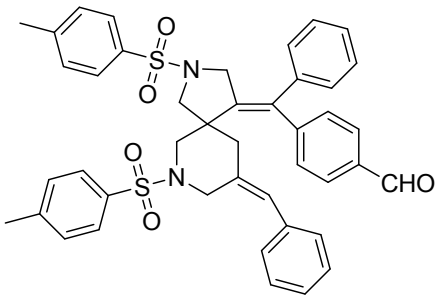
White solid; 623 mg (86 % yield); m.p. 252 - 253 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.64 - 7.67 (d , J = 7.8 Hz, 2H; Ar-H), 7.45 - 7.47 (d, J = 7.8 Hz, 2H; Ar-H), 7.25 - 7.35 (m, 8H; Ar-H), 7.24 - 7.25 (m, 6H; Ar-H), 7.04 - 7.11 (m, 4H; Ar-H), 6.34 (s, 1H; C=CH), 4.55 - 4.59 (d, J = 12.3 Hz, 1H; N-CH_2-C=C), 4.02 - 4.07 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.66 - 3.71 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.57 - 3.61 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.38 - 3.42 (d, J = 11.7 Hz, 1H; N-*CH_2*-C=CH), 2.91 - 2.94 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.53 - 2.57 (d, J = 13.8 Hz, 1H; C-*CH_2*-C=CH), 2.50 (s, 3H; Ar-CH_3), 2.43 (s, 3H; Ar-CH_3), 2.14 - 2.18 (d, J = 13.2 Hz, 1H; N-CH_2-C=C), 2.04 - 2.09 (d, J = 16.2 Hz, 1H; C-*CH_2*-C=CH), 1.72 - 1.76 (d, J = 11.1 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 145.4, 144.4, 144.1, 140.8, 139.1, 137.1, 135.6, 132.2, 132.1, 131.6, 130.3, 129.9, 129.7, 129.6, 129.4, 129.2, 128.7, 128.5, 128.2, 128.2, 128.0, 127.5, 127.4, 127.1, 118.2, 111.3, 56.4, 53.0, 52.7, 48.0, 47.3, 43.5, 21.7, 21.6 ppm; FT-IR (neat): ν 3055.2, 3028.2, 2926.0, 2873.9, 2837.3, 2227.8, 1597.1, 1564.3, 1491.0, 1442.8, 1334.7, 1091.7, 1010.7, 842.9, 815.9, 758.0, 702.1, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{39}N_3O_4S_2$ [M + H]$^+$, 726.2455; found: 726.2443.



1-(4-((E)-((Z)-9-benzylidene-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)phenyl)ethanone(ab)

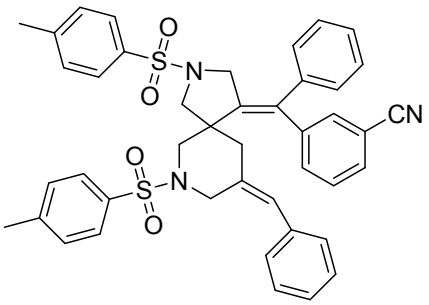
White solid; 564 mg (76 % yield); m.p. 254 - 255 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.40; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.76 - 7.78 (d , J = 9.9 Hz, 2H; Ar-H), 7.64 - 7.67 (d, J = 7.2 Hz, 2H; Ar-H), 7.31 - 7.33 (d, J = 5.1 Hz, 8H; Ar-H), 7.20 - 7.22(d, J = 9.3 Hz, 6H; Ar-H), 7.09 - 7.11 (d, J = 7.5 Hz, 4H; Ar-H), 6.34 (s, 1H; C=CH), 4.49 - 4.53 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 4.01 - 4.06 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.65 - 3.70 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.53 -

3.56 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 3.44 - 3.48 (d, J = 10.5 Hz, 1H; N-CH_2-C=CH), 2.92 - 2.95 (d, J = 9.3 Hz, 1H; N-CH_2-C-C=C), 2.50 - 2.54 (d, J = 13.5 Hz, 1H; C-CH_2-C=CH), 2.50 (s, 3H; O=C-CH_3), 2.43 (s, 3H; Ar-CH_3), 2.39 (s, 3H; Ar-CH_3), 2.12 - 2.15 (t, 2H; N-CH_2-C=C, C-CH_2-C=CH), 1.92 - 1.95 (d, J = 10.8 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.0, 145.5, 144.0, 143.9, 141.4, 138.2, 138.1, 135.8, 132.2, 131.9, 130.0, 129.9, 129.7, 129.1, 128.9, 128.8, 128.5, 128.4, 128.1, 127.8, 127.6, 127.3, 127.2, 56.6, 53.1, 52.8, 48.0, 47.2, 43.5, 26.6, 21.7, 21.5 ppm; FT-IR (neat): ν 3053.3, 3028.2, 2941.4, 2877.8, 2837.3, 1685.8 (C=O), 1599.0, 1492.9, 1460.1, 1400.3, 1350.2, 1265.3, 1091.7, 1012.6, 964.4, 815.9, 756.1, 704.0, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{42}N_2O_5S_2$ $[M + H]^+$, 743.2608; found: 743.2597.



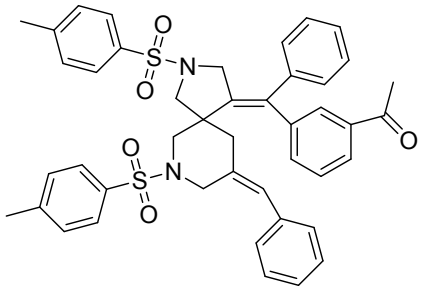
4-((E)-((Z)-9-benzylidene-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)benzaldehyde(ac)

White solid; 568 mg (78 % yield); m.p. 249 - 250 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.42; ^{1}H NMR (300 MHz, $CDCl_3$); δ 9.88 (s, 1H; CHO), 7.65 - 7.70 (t, 4H; Ar-H), 7.30 - 7.36 (t, 9H; Ar-H), 7.23 - 7.27 (t, 2H; Ar-H), 7.17 - 7.20 (d, J = 8.4 Hz, 3H; Ar-H), 7.07 - 7.12 (t, 4H; Ar-H), 6.36 (s, 1H; C=CH), 4.51 - 4.55 (d, J = 11.7 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.65 - 3.69 (d, J = 14.4 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.56 - 3.60 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.41 - 3.45 (d, J = 11.1 Hz, 1H; N-CH_2-C=CH), 2.89 - 2.93 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 2.53 - 2.58 (d, J = 13.2 Hz, 1H; C-CH_2-C=CH), 2.44 (s, 3H; Ar-CH_3), 2.40 (s, 3H; Ar-CH_3), 2.09 - 2.19 (t, 2H; N-CH_2-C=C, C-CH_2-C=CH), 1.82 - 1.85 (d, J = 11.1 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 191.1, 146.9, 143.9, 141.1, 138.6, 137.8, 135.7, 135.1, 132.4, 132.3, 131.8, 130.1, 129.8, 129.7, 129.5, 129.3, 129.2, 128.7, 128.5, 128.0, 127.9, 127.5, 127.3, 127.2, 56.5, 53.0, 52.7, 48.0, 47.2, 43.5, 21.6, 21.5 ppm; FT-IR (neat): ν 3053.3, 3026.3, 2962.7, 2931.8, 2873.9, 1699.3 (CHO), 1599.0, 1492.9, 1456.3, 1350.2, 1091.7, 1045.4, 815.9, 758.0, 702.1, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{40}N_2O_5S_2$ $[M + H]^+$, 729.2451; found: 729.2449.



3-((E)-((Z)-9-benzylidene-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)benzonitrile(ad)

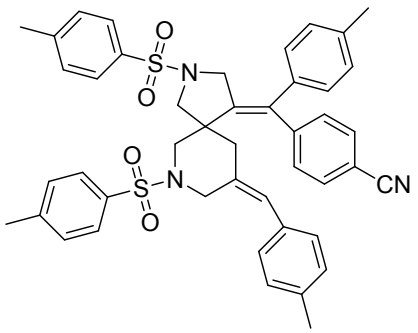
White solid; 558 mg (77 % yield); m.p. 133 - 134 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.48; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.67 (d, J = 7.8 Hz, 2H; Ar-H), 7.36 - 7.41 (m , 7H; Ar-H), 7.25 - 7.34 (m, 9H; Ar-H), 7.11 - 7.13 (d, J = 7.2 Hz, 2H; Ar-H), 7.03 - 7.06 (d, J = 6.9 Hz, 2H; Ar-H), 6.36 (s, 1H; C=CH), 4.55 - 4.59 (d , J = 12.0 Hz, 1H; N-CH_2-C=C), 4.00 - 4.05 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.66 - 3.71 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.52 - 3.55 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.45 - 3.48 (d, J = 11.1 Hz, 1H; N-CH_2-C=CH), 2.96 - 2.99 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 2.50 - 2.55 (d, J = 13.8 Hz, 1H; C-CH_2-C=CH), 2.45 (s, 3H; Ar-CH_3), 2.45 (s, 3H; Ar-CH_3), 2.19 - 2.23 (d, J = 12.6 Hz, 1H; N-CH_2-C=C), 2.06 - 2.11 (d, J = 12.9 Hz, 1H; C-CH_2-C=CH), 1.82 - 1.86 (d, J = 11.4 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 144.1, 143.9, 141.8, 141.0, 139.5, 136.7, 135.6, 133.0, 132.2, 131.9, 130.9, 130.2, 129.9, 129.8, 129.3, 129.3, 128.7, 128.5, 128.0, 127.4, 127.4, 127.1, 118.1, 112.7, 56.5, 52.9, 52.8, 48.1, 47.2, 43.6, 21.6 ppm; FT-IR (neat): ν 3055.2, 3026.3, 2955.0, 2924.1, 2870.1, 1597.1, 1492.9, 1462.0, 1442.8, 1348.2, 1091.7, 1043.5, 962.5, 814.0, 748.4, 706.0, 665.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{39}N_3O_4S_2$ $[M + H]^+$, 726.2455; found: 726.2462.



1-(3-((E)-((Z)-9-benzylidene-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)phenyl)ethanone(ae)

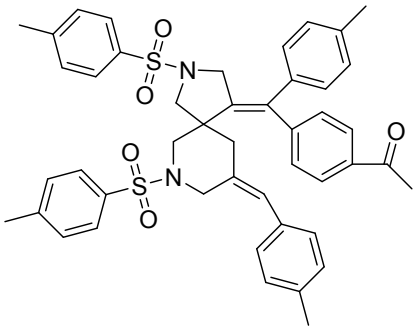
White solid; 527 mg (71 % yield); m.p. 239 - 240 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.48; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.74 (m, 4H; Ar-H), 7.32-7.42 (m, 8H; Ar-H), 7.14 - 7.20 (m, 6H; Ar-H), 7.05 - 7.10 (t, 4H; Ar-H), 6.32 (s, 1H; C=CH), 4.50 - 4.54 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 4.00 - 4.05 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.68 - 3.73 (d, J = 13.5 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.45 - 3.55 (t, 2H; N-CH_2-C-C=C, N-CH_2-C=CH), 2.96 - 2.99 (d, J = 9.0 Hz, 1H; N-CH_2-C-C=C), 2.51 (s, 4H; C-CH_2-C=CH, O=C-CH_3), 2.44 (s, 3H; Ar-CH_3), 2.43 (s, 3H; Ar-CH_3), 2.15 (s, 2H;

N-CH_2-C=C, C-*CH_2*-C=CH), 1.92 - 1.96 (d, *J* = 11.1 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.1, 144.0, 143.6, 141.7, 141.0, 138.3, 138.1, 136.8, 135.7, 133.2, 132.4, 132.3, 129.9, 129.6, 129.1, 128.7, 128.6, 128.5, 128.1, 128.0, 127.7, 127.5, 127.4, 127.3, 127.2, 56.5, 52.9, 52.8, 48.0, 47.1, 43.5, 26.7, 21.6, 21.6 ppm; FT-IR (neat): ν 3059.1, 3024.4, 2955.0, 2924.1, 2872.0, 2837.3, 1685.8 (C=O), 1597.1, 1491.0, 1423.5, 1352.1, 1249.9, 1091.7, 1043.5, 966.3, 815.9, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{42}N_2O_5S_2$ $[M + H]^+$, 743.2608; found: 743.2619.



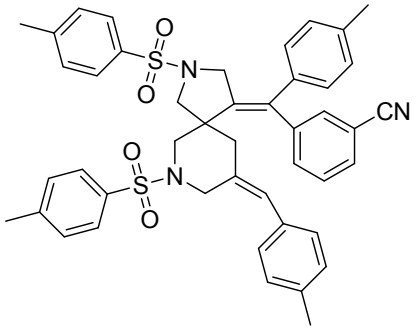
4-((E)-((Z)-9-(4-methylbenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)benzonitrile(ba)

White solid; 572 mg (76 % yield); m.p. 267 - 268 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.67 (d, *J* = 8.1 Hz, 2H; Ar-H), 7.44 - 7.46 (d, *J* = 7.8 Hz, 2H; Ar-H), 7.27 - 7.35 (m , 6H; Ar-H), 7.11 - 7.22 (m, 6H; Ar-H), 7.00 - 7.02 (d, *J* = 7.2 Hz, 2H; Ar-H), 6.91 - 6.93 (d, *J* = 7.8 Hz, 2H; Ar-H), 6.31 (s, 1H; C=CH), 4.55 - 4.59 (d, *J* = 12.0 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, *J* = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.66 - 3.71 (d, *J* = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.56 - 3.59 (d, *J* = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.35 - 3.39 (d, *J* = 11.1 Hz, 1H; N-*CH_2*-C=CH), 2.88 - 2.91 (d, *J* = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.50 - 2.55 (d, *J* = 14.4 Hz, 4H; C-*CH_2*-C=CH, Ar-CH_3), 2.44 (s, 3H; Ar-CH_3), 2.35 (s, 3H; Ar-CH_3), 2.32 (s, 3H; Ar-CH_3), 2.06 - 2.16 (t, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.70 - 1.74 (d, *J* = 14.7 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 145.7, 144.4, 144.0, 138.9, 137.9, 137.1, 137.0, 132.7, 132.3, 132.0, 131.7, 130.3, 129.9, 129.7, 129.4, 129.2, 128.6, 128.6, 128.0, 127.5, 127.0, 118.2, 111.2, 56.5, 53.1, 52.7, 47.9, 47.3, 43.6, 21.7, 21.6, 21.2, 21.2 ppm; FT-IR (neat): ν 3066.5, 3026.2, 2968.7, 2910.3, 2867.2, 2308.8, 1599.1, 1514.2, 1456.6, 1438.7, 1348.7, 1091.7, 1008.9, 850.1, 813.7, 753.7, 710.2, 665.6 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{45}H_{43}N_3O_4S_2$ $[M + H]^+$, 754.2768; found: 754.2756.



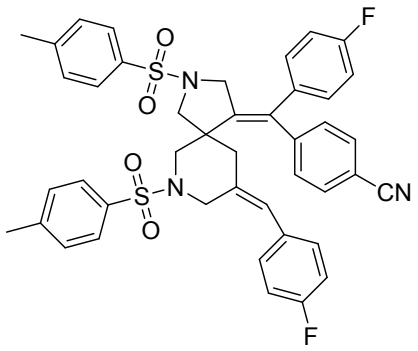
1-(4-((E)-((Z)-9-(4-methylbenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)phenyl)ethanone(bb)

White solid; 570 mg (74 % yield); m.p. 142 - 143 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.41; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.74 - 7.77 (d, J = 8.7 Hz, 2H; Ar-H), 7.65 - 7.68 (d, J = 8.1 Hz, 2H; Ar-H), 7.31 - 7.36 (m, 4H; Ar-H), 7.10 - 7.20 (m, 8H; Ar-H), 6.93 - 7.10 (m, 4H; Ar-H), 6.30 (s, 1H; C=CH), 4.50 - 4.54 (d, J = 9.3 Hz, 1H; N-CH_2-C=C), 4.02 - 4.07 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.67 - 3.71 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.52 - 3.55 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 3.42 - 3.45 (d, J = 10.5 Hz, 1H; N-*CH_2*-C=CH), 2.91 - 2.95 (d, J = 11.1 Hz, 1H; N-CH_2-C-C=C), 2.47 - 2.50 (t, 4H; C-*CH_2*-C=CH, O=C-CH_3), 2.44 (s, 3H; Ar-CH_3), 2.39 (s, 3H; Ar-CH_3), 2.34 (s, 3H; Ar-CH_3), 2.31 (s, 3H; Ar-CH_3), 2.10 - 2.17 (t, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.90 - 1.93 (d, J = 9.0 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 196.9, 145.8, 143.9, 143.8, 138.5, 138.0, 137.9, 137.6, 137.0, 135.7, 132.8, 132.3, 131.9, 129.9, 129.8, 129.7, 129.6, 129.2, 129.0, 128.9, 128.6, 128.3, 128.0, 127.6, 127.0, 56.6, 53.0, 52.8, 47.9, 47.2, 43.4, 26.5, 21.6, 21.4, 21.2, 21.1 ppm; FT-IR (neat): ν 3066.7, 3023.6, 2957.8, 2906.2, 2865.3, 1683.9 (C=O), 1599.7, 1508.2, 1446.7, 1415.6, 1352.6, 1265.5, 1091.7, 1010.8, 959.4, 817.8, 756.5, 708.2, 669.7 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{46}H_{46}N_2O_5S_2$ $[M + H]^+$, 771.2921; found: 771.2911.



3-((E)-((Z)-9-(4-methylbenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)benzonitrile(bc)

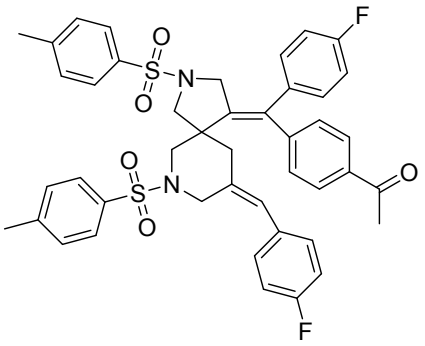
White solid; 587 mg (78 % yield); m.p. 138 - 140 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.48; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.68 (d, J = 8.1 Hz, 2H; Ar-H), 7.37 - 7.38 (t, 4H; Ar-H), 7.28 - 7.35 (m, 6H; Ar-H), 7.12 - 7.16 (m, 4H; Ar-H), 7.00 - 7.03 (d, J = 8.1 Hz, 2H; Ar-H), 6.91 - 6.93 (d, J = 8.1 Hz, 2H; Ar-H), 6.31 (s, 1H; C=CH), 4.55 - 4.59 (d, J = 12.9 Hz, 1H; N-CH_2-C=C), 4.00 - 4.05 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.67 - 3.72 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.49 - 3.54 (d, J = 12.9 Hz, 1H; N-CH_2-C-C=C), 3.42 - 3.45 (d, J = 9.6 Hz, 1H; N-CH_2-C=CH), 2.94 - 2.98 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.45 - 2.50 (d, 7H; C-CH_2-C=CH, Ar-CH_3), 2.35 (s, 3H; Ar-CH_3), 2.33 (s, 3H; Ar-CH_3), 2.16 - 2.20 (d, J = 12.0 Hz, 1H; N-CH_2-C-C=C), 2.03 - 2.08 (d, J = 12.9 Hz, 1H; C-CH_2-C=CH), 1.79 - 1.83 (d , J = 11.1 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 144.0, 143.9, 142.1, 139.2, 138.2, 137.9, 137.1, 136.6, 133.0, 132.7, 132.2, 131.9, 130.8, 130.1, 129.9, 129.8, 129.2, 128.7, 128.7, 128.1, 127.4, 127.0, 118.1, 112.6, 56.5, 53.0, 52.9, 47.9, 47.2, 43.6, 21.6, 21.6, 21.2, 21.2 ppm; FT-IR (neat): ν 3055.2, 3020.5, 2953.0, 2881.7, 2310.7, 1595.1, 1535.3, 1489.1, 1456.3, 1338.6, 1159.2, 1085.9, 1014.6, 839.0, 808.2, 754.2, 688.6 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{45}H_{43}N_3O_4S_2$ $[M + H]^+$, 754.2768; found: 754.2780.



4-((Z)-((Z)-9-(4-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)benzonitrile(ca)

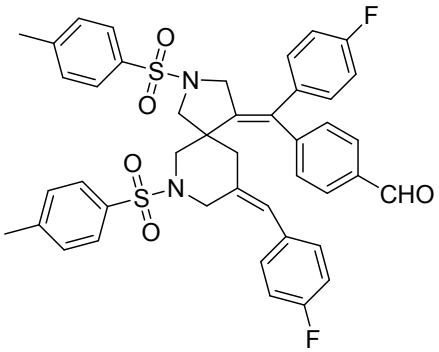
White solid; 646 mg (85 % yield); m.p. 257 - 258 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.52; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.66 - 7.68 (d, J = 8.0 Hz, 2H; Ar-H), 7.47 - 7.49 (d, J = 8.4 Hz, 2H; Ar-H), 7.26 - 7.36 (m, 6H; Ar-H), 7.20 - 7.22 (d, J = 8.4 Hz, 2H; Ar-H), 7.06 - 7.12 (m, 4H; Ar-H), 7.02 - 7.04 (d, J = 6.8 Hz, 2H; Ar-H), 6.33 (s, 1H; C=CH), 4.48 - 4.51 (d, J = 12.4 Hz, 1H; N-CH_2-C=C), 4.03 - 4.06 (d, J = 14.8 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.59 - 3.66 (t, 2H; C-CH_2-N-CH_2-C=CH, N-CH_2-C-C=C), 3.38 - 3.41 (d, J = 11.2 Hz, 1H; N-CH_2-C=CH), 2.89 - 2.91 (d, J = 10.0 Hz, 1H; N-CH_2-C-C=C), 2.51 - 2.55 (d, J = 11.6 Hz, 1H; C-CH_2-C=CH), 2.51 (s, 3H; Ar-CH_3), 2.45 (s, 3H; Ar-CH_3), 2.12 - 2.17 (t, 2H; N-CH_2-C-C=C, C-CH_2-C=CH), 1.73 - 1.76 (d, J = 11.2 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 163.8 (d, $J_{C\text{-}F}$ =249.2 Hz), 163.6 (d, $J_{C\text{-}F}$ =247.4 Hz), 145.2, 144.5, 144.2, 139.7, 136.7, 136.7, 136.2, 132.1, 131.7, 130.5, 130.4, 129.9, 129.8, 129.4, 129.3, 129.1, 129.0, 128.0, 127.5, 118.1, 116.4, 116.2, 115.6, 115.4, 111.6, 56.4, 52.9, 52.6, 48.1, 47.2, 43.4, 21.6,

21.6 ppm; FT-IR (neat): ν 3074.5, 3045.6, 2974.2, 2937.6, 2881.7, 2308.8, 2227.8, 1600.9, 1508.3, 1338.6, 1222.9, 1161.2, 1091.7, 815.9, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{37}F_2N_3O_4S_2$ $[M + H]^+$, 762.2266; found: 762.2252.



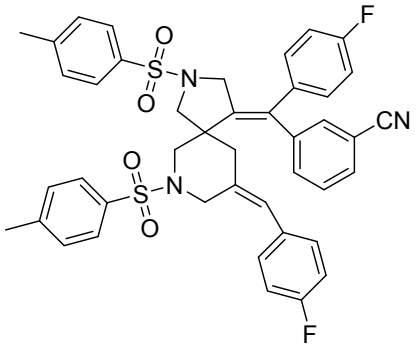
1-(4-((Z)-((Z)-9-(4-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)phenyl)ethanone(cb)

White solid; 646 mg (83 % yield); m.p. 137 - 138 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.42; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.77 - 7.79 (d, J = 7.8 Hz, 2H; Ar-H), 7.65 - 7.67 (d, J = 8.1 Hz, 2H; Ar-H), 7.30 - 7.36 (t, 5H; Ar-H), 7.17 - 7.21 (m, 5H; Ar-H), 6.98 - 7.07 (m, 6H; Ar-H), 6.32 (s, 1H; C=CH), 4.41 - 4.45 (d, J = 12.6 Hz, 1H; N-CH_2-C=C), 4.00 - 4.05 (d, J = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.59 - 3.64 (d, J = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.54 - 3.57 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 3.42 - 3.46 (d, J = 10.2 Hz, 1H; N-*CH_2*-C=CH), 2.89 - 2.92 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 2.56 - 2.61 (d, J = 16.2 Hz, 1H; C-*CH_2*-C=CH), 2.51 (s, 3H; O=C-CH_3), 2.44 (s, 3H; Ar-CH_3), 2.39 (s, 3H; Ar-CH_3), 2.07 - 2.17 (t, 2H; N-CH_2-C-C=C, C-*CH_2*-C=CH), 1.89 - 1.93 (d, J = 11.4 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 196.8, 163.7 (d, $J_{C\text{-}F}$ =248.3 Hz), 163.5 (d, $J_{C\text{-}F}$ =247.0 Hz), 145.2, 144.1, 144.0, 138.7, 137.1, 135.9, 132.1, 131.8, 130.5, 130.4, 129.9, 129.7, 129.7, 129.1, 128.9, 128.8, 128.4, 128.0, 127.5, 116.3, 116.0, 115.6, 115.3, 56.5, 52.9, 52.7, 48.0, 47.0, 43.3, 26.5, 21.6, 21.4 ppm; FT-IR (neat): ν 3063.0, 3043.7, 2956.9, 2926.0, 2870.1, 2351.2, 2308.8, 1683.9 (C=O), 1600.9, 1508.3, 1350.2, 1265.3, 1226.7, 1091.7, 1041.6, 958.6, 815.9, 663.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{40}F_2N_2O_5S_2$ $[M + H]^+$, 779.2420; found: 779.2404.



4-((Z)-((Z)-9-(4-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)benzaldehyde(cc)

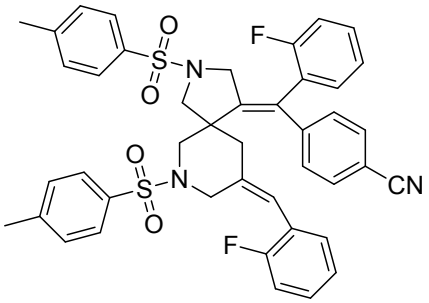
White solid; 581 mg (76 % yield); m.p. 146 - 147 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.48; ^{1}H NMR (300 MHz, $CDCl_3$); δ 9.88 (s, 1H; CHO), 7.68 - 7.71 (d, J = 8.7 Hz, 2H; Ar-H), 7.65 -7.67 (d, J = 8.4 Hz, 2H; Ar-H), 7.29 -7.36 (m, 6H; Ar-H), 7.17 - 7.26 (m, 2H; Ar-H), 7.01 - 7.11 (m, 8H; Ar-H), 6.33 (s, 1H; C=CH), 4.43 - 4.47 (d, J = 13.2 Hz, 1H; N-CH_2-C=C), 4.02 - 4.06 (d, J = 14.4 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.56 - 3.64 (t, 2H; C-CH_2-N-CH_2-C=CH, N-CH_2-C-C=C), 3.39 - 3.42 (d, J = 10.2 Hz, 1H; N-CH_2-C=CH), 2.87 - 2.90 (d, J = 9.0 Hz, 1H; N-CH_2-C-C=C), 2.53 - 2.57 (d, J = 11.1 Hz, 1H; C-CH_2-C=CH), 2.44 (s, 3H; Ar-CH_3), 2.39 (s, 3H; Ar-CH_3), 2.07 - 2.16 (t, 2H; N-CH_2-C=C, C-CH_2-C=CH), 1.79 - 1.83 (d, J = 13.2 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 190.9, 163.7 (d, $J_{C\text{-}F}$ =248.1 Hz), 163.6 (d, $J_{C\text{-}F}$ =247.0 Hz), 146.6, 144.0, 139.2, 136.9, 135.3, 132.3, 131.9, 131.6, 130.5, 130.3, 129.9, 129.7, 129.3, 129.1, 129.0, 128.0, 127.5, 116.4, 116.1, 115.6, 115.3, 56.5, 52.9, 52.7, 48.1, 47.1, 43.3, 21.6, 21.5 ppm; FT-IR (neat): ν 3066.8, 3047.5, 2956.9, 2926.0, 2870.1, 2374.4, 1701.2(CHO), 1600.9, 1506.4, 1348.2, 1226.7, 1091.7, 815.9, 663.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{38}F_2N_2O_5S_2$ $[M + H]^+$, 765.2263; found: 765.2256.



3-((E)-((Z)-9-(4-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)benzonitrile(cd)

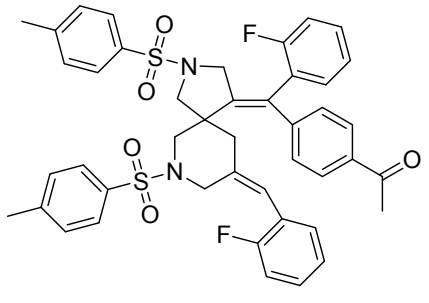
White solid; 594 mg (78 % yield); m.p. 149 - 150 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.68 (d, J = 8.1 Hz, 2H; Ar-H), 7.36 - 7.37 (d, J = 4.5 Hz, 4H; Ar-H), 7.29 - 7.34 (m, 6H; Ar-H), 7.06 - 7.09 (t, 3H; Ar-H), 7.01 - 7.04 (t, 5H; Ar-H), 6.33 (s, 1H; C=CH), 4.67 - 4.51 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 3.99 - 4.04 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.61 - 3.66 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.52 - 3.55 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.43 - 3.46 (d, J = 7.8 Hz, 1H; N-CH_2-C=CH), 2.94 - 2.97 (d, J = 9.3 Hz, 1H; N-CH_2-C-C=C), 2.48 - 2.54 (d, J = 18.6 Hz, 4H; C-CH_2-C=CH, Ar-CH_3), 2.45 (s, 3H; Ar-CH_3), 2.16 - 2.20 (d, J = 12.0 Hz, 1H; N-CH_2-C-C=C), 2.04 - 2.08 (d, J = 14.1 Hz, 1H; C-CH_2-C=CH), 1.78 - 1.84 (d , J = 17.8 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 163.8 (d, $J_{C\text{-}F}$ =258.8 Hz), 163.6 (d, $J_{C\text{-}F}$ =271.0

Hz), 144.2, 144.1, 141.6, 140.0, 136.9, 135.8, 132.9, 131.9, 131.0, 130.5, 130.4, 129.9, 129.8, 129.5, 129.4, 129.1, 129.0, 128.0, 127.4, 118.0, 116.5, 116.2, 115.7, 115.4, 112.8, 56.5, 52.8, 48.1, 47.1, 43.4, 21.6, 21.6 ppm; FT-IR (neat): ν 3064.9, 3043.7, 2956.9, 2926.0, 2872.0, 2378.2, 2308.8, 1599.0, 1508.3, 1458.2, 1350.2, 1220.9, 1153.4, 1091.7, 1043.5, 1010.7, 964.4, 815.9, 771.5, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{37}F_2N_3O_4S_2$ $[M + H]^+$, 762.2266; found: 762.2274.



4-((Z)-((Z)-9-(2-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(2-fluorophenyl)methyl)benzonitrile(da)

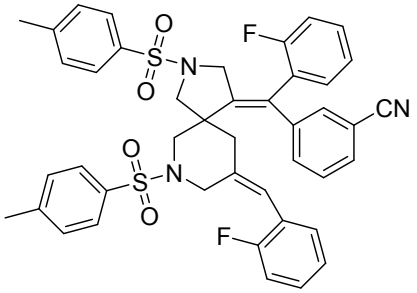
White solid; 632 mg (83 % yield); m.p. 265 - 266 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.42; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.64 - 7.67 (d, *J* = 8.1 Hz, 2H; Ar-H), 7.45 - 7.48 (d, *J* = 8.1 Hz, 2H; Ar-H), 7.29-7.35 (t, 6H; Ar-H), 7.27 (s, 4H; Ar-H), 7.03 - 7.15 (m, 6H; Ar-H), 6.26 (s, 1H; C=CH), 4.31 - 4.35(d, *J* = 12.6 Hz, 1H; N-CH_2-C=C), 3.96 - 4.00 (d, *J* = 14.7Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.58 - 3.63 (t, 2H; C-*CH_2*-N-CH_2-C=CH, N-CH_2-C-C=C), 3.39 - 3.42 (d, *J* = 11.1 Hz, 1H; N-*CH_2*-C=CH), 2.92 - 2.95 (d, *J* = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.58 - 2.63(d, *J* = 13.5 Hz, 1H; C-*CH_2*-C=CH), 2.50 (s, 3H; Ar-CH_3), 2.43 (s, 3H; Ar-CH_3), 2.11 - 2.25 (t, 2H; N-CH_2-C-C=C, C-*CH_2*-C=CH), 1.69 - 1.73 (d, *J* = 11.4 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 161.5 (d, $J_{C\text{-}F}$ =247.6 Hz), 159.7 (d, $J_{C\text{-}F}$ =246.6 Hz), 144.5, 144.3, 144.1, 141.7, 132.1, 131.4, 130.8, 130.6, 130.4, 130.3, 129.9, 129.8, 129.6, 129.4, 129.1, 127.9, 127.5, 125.1, 124.3, 124.2, 123.3, 118.2, 116.7, 116.5, 115.8, 115.5, 111.6, 56.4, 52.8, 52.6, 48.0, 47.6, 43.3, 21.7, 21.6 ppm; FT-IR (neat): ν 3061.0, 3030.2, 2926.0, 2877.8, 2833.4, 2349.3, 2306.9, 1595.1, 1487.1, 1452.4, 1340.5, 1093.6, 1012.6, 916.2, 815.9, 765.7, 707.9, 665.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{37}F_2N_3O_4S_2$ $[M + H]^+$, 762.2266; found: 762.2257.



1-(4-((Z)-((Z)-9-(2-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(2-

fluorophenyl)methyl)phenyl)ethanone(db)

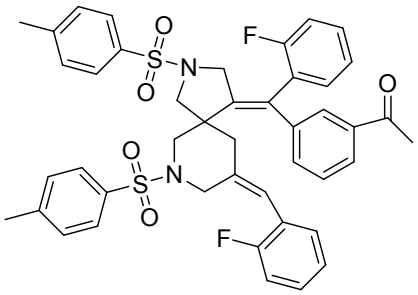
White solid; 654 mg (84 % yield); m.p. 235 - 236 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.36; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.76 - 7.79 (d, J = 8.1 Hz, 2H; Ar-H), 7.65 - 7.67 (d, J = 8.1 Hz, 2H; Ar-H), 7.32 - 7.35 (d, J = 8.7 Hz, 4H; Ar-H), 7.25 - 7.29 (t, 4H; Ar-H), 7.17 - 7.19 (d, J = 7.8 Hz, 2H; Ar-H), 7.00 - 7.14 (m, 6H; Ar-H), 6.25 (s, 1H; C=CH), 4.27 - 4.31(d, J = 12.3 Hz, 1H; N-CH_2-C=C), 3.95 - 4.00 (d, J = 14.4 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.59 - 3.64 (d, J = 14.4 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.53 - 3.56 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 3.45 - 3.49 (d, J = 11.4 Hz, 1H; N-CH_2-C=CH), 2.96 - 2.99 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.55 - 2.59 (d, J = 13.5 Hz, 1H; C-CH_2-C=CH), 2.50 (s, 3H; O=C-CH_3), 2.43 (s, 3H; Ar-CH_3), 2.38 (s, 3H; Ar-CH_3), 2.12 - 2.21 (t, 2H; N-CH_2-C-C=C, C-CH_2-C=CH), 1.89 - 1.92 (d, J = 11.1 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 196.8, 161.5 (d, $J_{C\text{-}F}$ =246.8 Hz), 159.7 (d, $J_{C\text{-}F}$ =245.8 Hz), 144.4, 144.1, 143.9, 140.8, 135.9, 132.2, 131.8, 131.7, 131.4, 130.9, 130.8, 129.9, 129.7, 129.5, 129.1, 128.9, 128.4, 128.0, 127.5, 125.0, 124.2, 122.9, 116.6, 116.4, 115.7, 115.4, 56.5, 52.8, 52.7, 48.0, 47.4, 43.2, 26.5, 21.6, 21.4 ppm; FT-IR (neat): ν 3078.4, 3032.1, 2941.4, 2877.8, 2833.4, 2349.3, 2308.8, 1685.8 (C=O), 1600.9, 1487.1, 1450.5, 1400.3, 1352.1, 1265.3, 1091.7, 1010.7, 964.4, 814.0, 754.2, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{40}F_2N_2O_5S_2$ $[M + H]^+$, 779.2420; found: 779.2410.



3-((Z)-((Z)-9-(2-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(2-fluorophenyl)methyl)benzonitrile(dc)

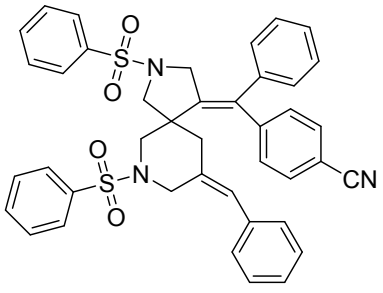
White solid; 517 mg (68 % yield); m.p. 149 - 150 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.38; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.65 - 7.68 (d, J = 8.1 Hz, 2H; Ar-H), 7.40 - 7.44 (t, 3H; Ar-H), 7.36-7.41 (t, 3H; Ar-H), 7.28 -7.33 (m, 6H; Ar-H), 7.11 - 7.17 (m, 3H; Ar-H), 7.02 - 7.08 (m, 3H; Ar-H), 6.27 (s, 1H; C=CH), 4.33 - 4.38 (d, J = 12.6 Hz, 1H; N-CH_2-C=C), 3.94 - 3.98 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.59 - 3.64 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.50 - 3.55 (d, J = 15.0 Hz, 1H; N-CH_2-C-C=C), 3.46 - 3.48 (d, J = 7.2 Hz, 1H; N-CH_2-C=CH), 3.00 - 3.03 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 2.54 - 2.59 (d, J = 13.5 Hz, 1H; C-CH_2-C=CH), 2.45 (s, 3H; Ar-CH_3), 2.44 (s, 3H; Ar-CH_3), 2.20 - 2.24 (d, J = 13.5 Hz, 1H; N-CH_2-C-C=C), 2.08 - 2.12 (d, J = 13.2 Hz, 1H; C-CH_2-C=CH), 1.77 - 1.83 (d, J = 18.0 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 161.5 (d, $J_{C\text{-}F}$ =241.3

Hz), 159.1 (d, $J_{C\text{-}F}$ =249.7 Hz), 144.1, 144.0, 142.1, 140.8, 133.0, 131.9, 131.5, 131.1, 130.8, 130.3, 130.2, 129.9, 129.8, 129.5, 129.4, 129.3, 129.0, 128.0, 127.4, 125.2, 124.2, 123.1, 118.1, 116.8, 116.5, 115.8, 115.7, 115.4, 56.5, 52.7, 48.2, 47.5, 43.3, 21.6 ppm; FT-IR (neat): ν 3063.0, 3030.2, 2955.0, 2924.1, 2873.9, 2308.8, 1597.1, 1573.9, 1487.1, 1450.5, 1340.5, 1238.3, 1163.1, 1091.7, 1045.4, 815.9, 758.0, 663.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{37}F_2N_3O_4S_2$ $[M + H]^+$, 762.2266; found: 762.2275.



1-(3-((Z)-((Z)-9-(2-fluorobenzylidene)-2,7-ditosyl-2,7-diazaspiro[4.5]decan-4-ylidene)(2-fluorophenyl)methyl)phenyl)ethanone(dd)

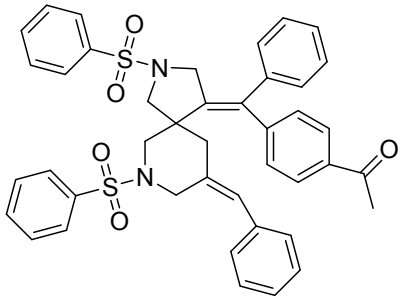
White solid; 513 mg (66 % yield); m.p. 246 - 247 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.35; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.66 - 7.72 (t, 4H; Ar-H), 7.30 - 7.35 (t, 8H; Ar-H), 7.13 - 7.19 (t , 6H; Ar-H), 7.04 - 7.07 (d, J = 9.0 Hz, 2H; Ar-H), 6.24 (s, 1H; C=CH), 4.29 - 4.34 (d, J = 12.3 Hz, 1H; N-CH_2-C=C), 3.94 - 3.99 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.62 - 3.66 (d, J = 14.1 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.50 (s, 2H; N-CH_2-C-C=C, N-*CH_2*-C=CH), 3.01 - 3.04 (d, J = 9.3 Hz, 1H; N-CH_2-C-C=C), 2.56 - 2.60 (d, J = 13.2 Hz, 1H; C-*CH_2*-C=CH), 2.51 (s , 3H;, O=C-CH_3), 2.43 (s, 6H; Ar-CH_3), 2.16 (s, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.90 - 1.94 (d, J = 10.5 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.0, 163.3 (d, $J_{C\text{-}F}$ = 265.1 Hz), 161.7 (d, $J_{C\text{-}F}$ = 247.3 Hz), 144.0, 143.6, 141.0, 140.0, 136.9, 133.2, 131.9, 130.8, 130.0, 129.9, 129.7, 129.7, 129.1, 128.7, 128.2, 128.0, 127.5, 127.5, 125.0, 124.2, 122.8, 116.6, 116.7, 115.7, 115.4, 56.5, 52.8, 52.7, 48.1, 47.4, 43.2, 26.6, 21.6 ppm; FT-IR (neat): ν 3066.8, 3030.2, 2935.7, 2872.0, 2837.3, 2349.3, 2308.8, 1685.8 (C=O), 1597.1, 1575.8, 1487.1, 1452.4, 1423.5, 1346.3, 1093.6, 1010.7, 968.3, 817.8, 761.9, 704.0, 663.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{40}F_2N_2O_5S_2$ $[M + H]^+$, 779.2420; found: 779.2433.



4-((E)-((Z)-9-benzylidene-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-

ylidene)(phenyl)methyl)benzonitrile(ea)

White solid; 425 mg (57 % yield); m.p. 240 - 241 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.45; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.77 - 7.79 (d , J = 6.6Hz, 2H; Ar-H), 7.56 - 7.68 (m , 4H; Ar-H), 7.43 - 7.53 (m, 6H; Ar-H), 7.25 - 7.35 (m, 6H; Ar-H), 7.20 - 7.22 (d, J = 7.5Hz, 2H; Ar-H), 7.12 - 7.14 (d, J = 6.9Hz, 2H; Ar-H), 7.03 - 7.05 (d, J = 6.0 Hz, 2H; Ar-H), 6.37 (s, 1H; C=CH), 4.59 - 4.63 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 4.04 - 4.09 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.68 - 3.73 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.59 - 3.62 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C,), 3.39 - 3.42 (d, J = 11.1 Hz, 1H; N-*CH_2*-C=CH), 2.97 - 3.00 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 2.51 - 2.56 (d, J = 12.9 Hz, 1H; C-*CH_2*-C=CH), 2.19 - 2.23 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 2.09 - 2.13 (d, J = 13.5 Hz, 1H; C-*CH_2*-C=CH), 1.73 - 1.77 (d, J = 11.7 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 145.3, 140.7, 138.9, 137.3, 135.5, 134.8, 133.3, 133.1, 132.1, 130.4, 129.3, 129.3, 129.1, 129.1, 128.8, 128.6, 128.1, 127.9, 127.4, 127.1, 118.1, 111.5, 56.4, 52.9, 52.6, 48.0, 47.3, 43.5 ppm; FT-IR (neat): ν 3053.3, 3026.3, 2873.9, 2225.9, 1597.1, 1491.0, 1462.0, 1440.8, 1352.1, 1334.7, 1163.1, 1091.7, 815.9, 758.0, 702.1, 667.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{41}H_{35}N_3O_4S_2$ $[M + H]^+$, 698.2142; found: 698.2137.

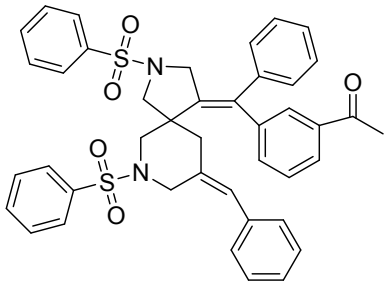


1-(4-((E)-((Z)-9-benzylidene-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-

ylidene)(phenyl)methyl)phenyl)ethanone(eb)

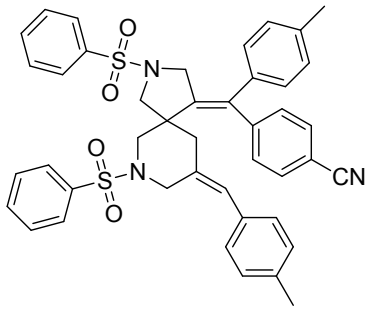
White solid; 443 mg (62 % yield); m.p. 136 - 137 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.43; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.74 - 7.80 (t, 4H; Ar-H), 7.49 - 7.67 (m, 4H; Ar-H), 7.40 - 7.47 (m, 4H; Ar-H), 7.23 - 7.37 (m, 4H; Ar-H), 7.18 - 7.21 (d, J = 8.4 Hz, 2H; Ar-H), 7.05 - 7.13 (m, 6H; Ar-H), 6.36 (s, 1H; C=CH), 4.54 - 4.58 (d, J = 12.6 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, J = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.68 - 3.73 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.56 - 3.59 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.44 - 3.47 (d, J = 11.1 Hz, 1H; N-*CH_2*-C=CH), 2.97 - 3.01 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 2.54 - 2.56 (d, J = 7.5 Hz, 1H; C-*CH_2*-C=CH), 2.49 (s , 3H; O=C-CH_3), 2.16 - 2.20 (d, J = 12.3 Hz, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.90 - 1.94 (d, J = 11.7 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.0, 145.4, 141.3, 138.1, 135.6, 135.2, 133.1, 132.8, 130.1, 129.5, 129.2, 129.1, 129.0, 128.8, 128.7, 128.5, 128.4, 128.1, 127.9, 127.8, 127.5, 127.5, 127.3, 127.1, 56.5, 52.9, 52.7, 48.0, 47.2, 43.4, 26.5 ppm; FT-IR (neat): ν 3057.2, 3024.4, 2956.9, 2829.9, 2850.8, 2347.4,

2308.8, 1681.9 (C=O), 1600.9, 1462.0, 1444.7, 1350.2, 1265.3, 1166.9, 1091.7, 1014.6, 960.6, 925.8, 823.6, 752.2, 690.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{42}H_{38}N_2O_5S_2$ $[M + H]^+$, 715.2295; found: 715.2296.



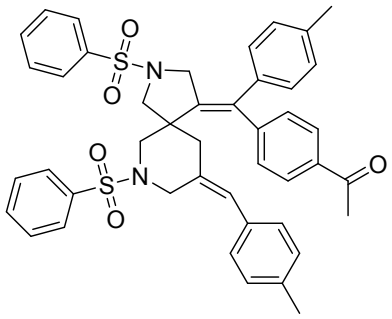
1-(3-((E)-((Z)-9-benzylidene-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(phenyl)methyl)phenyl)ethanone(ec)

White solid; 364 mg (51 % yield); m.p. 204 - 205 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.45; ^1H NMR (300 MHz, $CDCl_3$); δ 7.77 - 7.80 (d , *J* = 7.2 Hz, 2H; Ar-H), 7.65 - 7.68 (t, 3H; Ar-H), 7.54 - 7.59 (m, 3H; Ar-H), 7.41 - 7.47 (m, 4H; Ar-H), 7.24 - 7.36 (m, 8H; Ar-H), 7.08 - 7.13 (t, 4H; Ar-H), 6.34 (s, 1H; C=CH), 4.54 - 4.58 (d, *J* = 12.3 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, *J* = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.71 - 3.76 (d, *J* = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.48 - 3.55 (t, 2H; N-CH_2-C-C=C, N-*CH_2*-C=CH), 3.02 - 3.06 (d, *J* = 10.2 Hz, 1H; N-CH_2-C-C=C), 2.46 - 2.50 (d, *J* = 12.9 Hz, 1H; C-*CH_2*-C=CH), 2.46 (s, 3H;, O=C-CH_3), 2.11 - 2.21 (t, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.93 - 1.97 (d, *J* = 11.4 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.1, 141.6, 140.9, 138.2, 136.9, 135.7, 135.6, 135.5, 133.1, 132.7, 129.9, 129.5, 129.2, 129.1, 129.0, 128.7, 128.5, 128.1, 127.9, 127.7, 127.5, 127.4, 127.3, 127.2, 56.5, 52.9, 52.7, 48.1, 47.1, 43.5, 26.7 ppm; FT-IR (neat): ν 3057.2, 3026.3, 2958.8, 2933.7, 2877.8, 2345.4, 1685.8 (C=O), 1597.1, 1491.0, 1444.7, 1346.3, 1249.9, 1168.9, 1091.7, 1014.6, 964.4, 927.8, 819.8, 754.2, 692.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{42}H_{38}N_2O_5S_2$ $[M + H]^+$, 715.2295; found: 715.2304.



4-((E)-((Z)-9-(4-methylbenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)benzonitrile(fa)

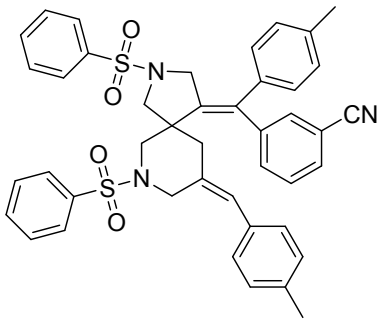
White solid; 537 mg (74 % yield); m.p. 154 - 155 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.77 - 7.79 (d , J = 7.2 Hz, 2H; Ar-H), 7.53 - 7.68 (m , 4H; Ar-H), 7.42 - 7.50 (m, 6H; Ar-H), 7.11 - 7.19 (m, 6H; Ar-H), 7.01 - 7.04 (d, J = 7.8 Hz, 2H; Ar-H), 6.90 - 6.92 (d, J = 8.1 Hz, 2H; Ar-H), 6.32 (s, 1H; C=CH), 4.59 - 4.63 (d, J = 11.4 Hz, 1H; N-CH_2-C=C), 4.04 - 4.08 (d, J = 14.1 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.69 - 3.74 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.57 - 3.60 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.35 - 3.39 (d, J = 11.7 Hz, 1H; N-*CH_2*-C=CH), 2.95 - 2.98 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 2.48 - 2.52 (d, J = 14.4 Hz, 1H; C-*CH_2*-C=CH), 2.35 (s, 3H; Ar-CH_3), 2.32 (s, 3H; Ar-CH_3), 2.16 - 2.20 (d, J = 14.4 Hz, 1H; N-CH_2-C=C), 2.04 - 2.10 (d, J = 18.9 Hz, 1H; C-*CH_2*-C=CH), 1.70 - 1.73 (d, J = 11.1 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 145.5, 138.6, 137.9, 137.9, 137.2, 137.2, 135.5, 134.8, 133.3, 132.7, 132.1, 130.3, 129.9, 129.3, 129.3, 129.1, 128.7, 128.5, 127.9, 127.5, 127.0, 118.2, 111.3, 56.4, 53.0, 52.7, 48.0, 47.4, 43.6, 21.3, 21.2 ppm; FT-IR (neat): ν 3057.2, 3022.5, 2953.0, 2922.2, 2868.2, 2380.2, 2308.8, 1602.9, 1446.6, 1350.2, 1165.0, 1091.7, 1041.6, 1012.6, 823.6, 719.5, 690.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{39}N_3O_4S_2$ [M + H]$^+$, 726.2455; found: 726.2456.



1-(4-((E)-((Z)-9-(4-methylbenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)phenyl)ethanone(fb)

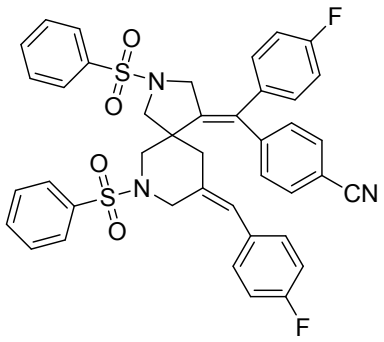
White solid; 497 mg (67 % yield); m.p. 161 - 162 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.42; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.76 - 7.80 (d, J = 7.2 Hz, 2H; Ar-H), 7.72-7.75 (d, J = 7.8 Hz, 2H; Ar-H), 7.51-7.65 (m, 5H; Ar-H), 7.40-7.46 (m, 3H; Ar-H), 7.10 - 7.18 (m, 5H; Ar-H), 7.00 - 7.02 (d, J = 7.5 Hz, 2H; Ar-H), 6.93 - 6.95 (d, J = 7.2 Hz, 2H; Ar-H), 6.31 (s, 1H; C=CH), 4.53 - 4.59 (d, J = 19.2 Hz, 1H; N-CH_2-C=C), 4.04 - 4.09 (d, J = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.70 - 3.75 (d, J = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.54 - 3.57 (d, J =9.9 Hz, 1H; N-CH_2-C-C=C), 3.41 - 3.45 (d, J = 7.8 Hz, 1H; N-*CH_2*-C=CH), 2.96 - 3.00 (d, J =10.2 Hz, 1H; N-CH_2-C-C=C), 2.46 - 2.49 (d, J = 9.9 Hz, 4H; C-*CH_2*-C=CH, O=C-CH_3), 2.34 (s, 3H; Ar-CH_3), 2.31 (s, 3H; Ar-CH_3), 2.14 - 2.17 (d, J =10.5 Hz, 2H; N-CH_2-C=C, C-*CH_2*-C=CH), 1.87 - 1.91 (d, J =9.6 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.0, 145.6, 138.4, 138.0, 137.8, 137.6, 137.1, 135.7, 135.5, 135.0, 133.1, 132.8, 130.0,

129.7, 129.2, 129.0, 128.8, 128.7, 128.5, 128.3, 128.1, 128.0, 127.7, 127.5, 127.0, 56.5, 53.0, 52.8, 47.9, 47.2, 43.4, 26.5, 21.2, 21.1 ppm; FT-IR (neat): ν 3061.0, 3024.4, 2953.0, 2920.2, 2868.2, 2349.3, 2306.9, 1683.9 (C=O), 1602.9, 1510.3, 1446.6, 1348.2, 1265.3, 1166.9, 1091.7, 1008.8, 964.4, 821.7, 754.2, 692.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{44}H_{42}N_2O_5S_2$ $[M + H]^+$, 743.2608; found: 743.2604.



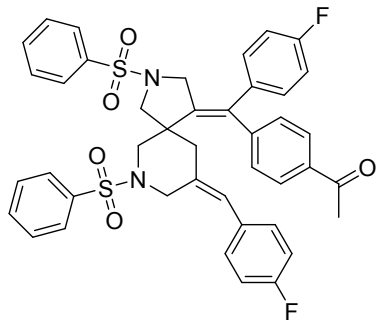
3-((E)-((Z)-9-(4-methylbenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(p-tolyl)methyl)benzonitrile(fc)

White solid; 500 mg (69 % yield); m.p. 141 - 142 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.78 - 7.80 (d, *J* = 6.9 Hz, 2H; Ar-H), 7.51 - 7.65 (m , 8H; Ar-H), 7.27 - 7.38 (m, 4H; Ar-H), 7.12 - 7.17 (t, 4H; Ar-H), 7.01 - 7.04 (d, *J* = 7.8 Hz, 2H; Ar-H), 6.91 - 6.93 (d, *J* = 8.1 Hz, 2H; Ar-H), 6.33 (s, 1H; C=CH), 4.59 - 4.63 (d, *J* = 12.3 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, *J* = 15.0 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.70 - 3.75 (d, *J* = 14.4 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.53 - 3.56 (d, *J* = 9.6 Hz, 1H; N-CH_2-C-C=C), 3.44 - 3.48 (d, *J* = 11.1 Hz, 1H; N-*CH_2*-C=CH), 3.01 - 3.04 (d, *J* = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.45 - 2.50 (d, *J* = 13.2 Hz, 1H; C-*CH_2*-C=CH), 2.35 (s, 3H; Ar-CH_3), 2.31 (s, 3H; Ar-CH_3), 2.19 - 2.23 (d, *J* = 12.6 Hz, 1H; N-CH_2-C=C), 2.03 - 2.08 (d, *J* = 12.9 Hz, 1H; C-*CH_2*-C=CH), 1.80 - 1.83 (d, *J* = 10.8 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 142.0, 139.0, 138.1, 137.9, 137.2, 136.8, 135.2, 134.8, 133.1, 133.1, 132.9, 132.7, 131.9, 131.0, 129.9, 129.3, 129.2, 128.6, 128.5, 127.9, 127.4, 127.0, 118.1, 112.6, 56.5, 53.0, 52.8, 48.1, 47.3, 43.6, 21.2, 21.2 ppm; FT-IR (neat): ν 3063.0, 3024.4, 2955.0, 2922.2, 2866.2, 2378.2, 2229.7, 1610.6, 1510.3, 1446.6, 1350.2, 1091.7, 1043.5, 1012.6, 962.5, 825.5, 804.3, 756.1, 719.5, 690.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{43}H_{39}N_3O_4S_2$ $[M + H]^+$, 726.2455; found: 726.2463.



4-((Z)-((Z)-9-(4-fluorobenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)benzonitrile(ga)

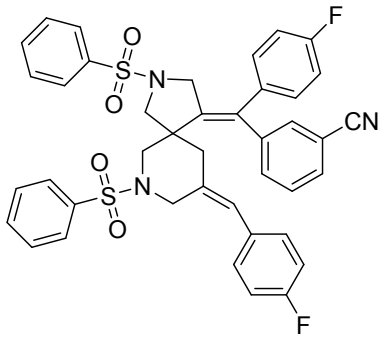
White solid; 564 mg (77 % yield); m.p. 168 - 169 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.78 (s, 2H; Ar-H), 7.63 - 7.67 (t, 5H; Ar-H), 7.48 - 7.57 (m , 6H; Ar-H), 7.18 - 7.20 (d, J = 6.3 Hz, 2H; Ar-H), 7.02 - 7.20 (m , 7H; Ar-H), 6.34 (s, 1H; C=CH), 4.52 - 4.55 (d, J = 14.7 Hz, 1H; N-CH_2-C=C), 4.03 - 4.08 (d, J = 14.7 Hz, 1H; C-*CH_2*-N-CH_2-C=CH), 3.60 - 3.69 (t, 2H; C-*CH_2*-N-CH_2-C=CH, N-CH_2-C-C=C), 3.37 - 3.41 (d, J = 10.8 Hz, 1H; N-*CH_2*-C=CH), 2.94 - 2.97 (d, J = 9.0 Hz, 1H; N-CH_2-C-C=C), 2.52 - 2.56 (d, J = 12.6 Hz, 1H; C-*CH_2*-C=CH), 2.17 - 2.21 (d, J = 12.0 Hz, 1H; N-CH_2-C-C=C), 2.06 - 2.11 (d, J = 13.8 Hz, 1H; C-*CH_2*-C=CH), 1.71 - 1.75 (d, J = 10.5 Hz, 1H; N-*CH_2*-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 163.8 (d, $J_{C\text{-}F}$ = 249.0 Hz), 163.6 (d, $J_{C\text{-}F}$ = 247.4 Hz), 145.0, 139.4, 136.3, 135.4, 134.7, 133.4, 133.2, 131.5, 130.5, 130.4, 129.3, 129.2, 129.1, 129.0, 128.0, 127.9, 127.4, 118.0, 116.5, 116.2, 115.7, 115.4, 111.7, 56.4, 52.8, 52.6, 48.1, 47.2, 43.4 ppm; FT-IR (neat): ν 3056.6, 2957.3, 2871.5, 2347.9, 2308.8, 1600.7, 1504.4, 1438.2, 1346.3, 1223.7, 1163.8, 1091.7, 1008.4, 962.6, 815.9, 742.7, 714.6, 692.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{41}H_{33}F_2N_3O_4S_2$ $[M + H]^+$, 734.1953; found: 734.1943.



1-(4-((Z)-((Z)-9-(4-fluorobenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)phenyl)ethanone(gb)

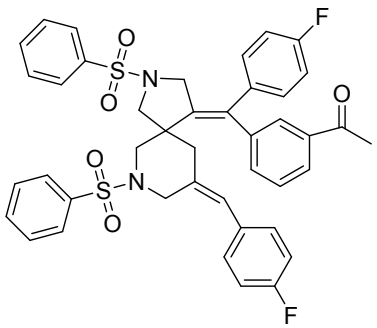
White solid; 540 mg (72 % yield); m.p. 150 - 151 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.44; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.74 - 7.80 (t, 4H; Ar-H), 7.50 - 7.65 (m, 4H; Ar-H), 7.41 - 7.47 (m, 4H; Ar-H), 7.15 - 7.18 (d, J = 8.1 Hz, 2H; Ar-H), 7.00 - 7.08 (m, 8H; Ar-H), 6.32 (s, 1H; C=CH), 4.46 -

4.50 (d, J = 12.3 Hz, 1H; N-CH_2-C=C), 4.02 - 4.07 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.65 - 3.70 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.56 - 3.59 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 3.42 - 3.46 (d, J = 11.7 Hz, 1H; N-CH_2-C=CH), 2.97 - 3.00 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.49 - 2.53 (d, J = 9.6 Hz, 4H; C-CH_2-C=CH, O=C-CH_3), 2.14 - 2.18 (d, J = 12.6 Hz, 2H; N-CH_2-C-C=C, C-CH_2-C=CH), 1.88 - 1.92 (d, J = 14.4 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 196.9, 163.7 (d, $J_{C\text{-}F}$ = 248.3 Hz), 163.6 (d, $J_{C\text{-}F}$ = 246.7 Hz), 145.1, 138.5, 137.2, 135.9, 134.9, 133.2, 132.9, 130.5, 130.4, 129.6, 129.3, 129.1, 129.0, 128.9, 128.8, 128.4, 127.9, 127.4, 116.3, 116.0, 115.7, 115.4, 56.5, 52.9, 52.6, 48.1, 47.1, 43.3, 26.5 ppm; FT-IR (neat): ν 3064.9, 2955.0, 2872.0, 2310.7, 1687.7 (C=O), 1602.9, 1506.4, 1446.6, 1348.2, 1265.3, 1226.7, 1165.0, 1091.7, 1012.6, 960.6, 817.8, 748.4, 719.5, 690.5 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{42}H_{36}F_2N_2O_5S_2$ $[M + H]^+$, 751.2107; found: 751.2105.



3-((E)-((Z)-9-(4-fluorobenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)benzonitrile(gc)

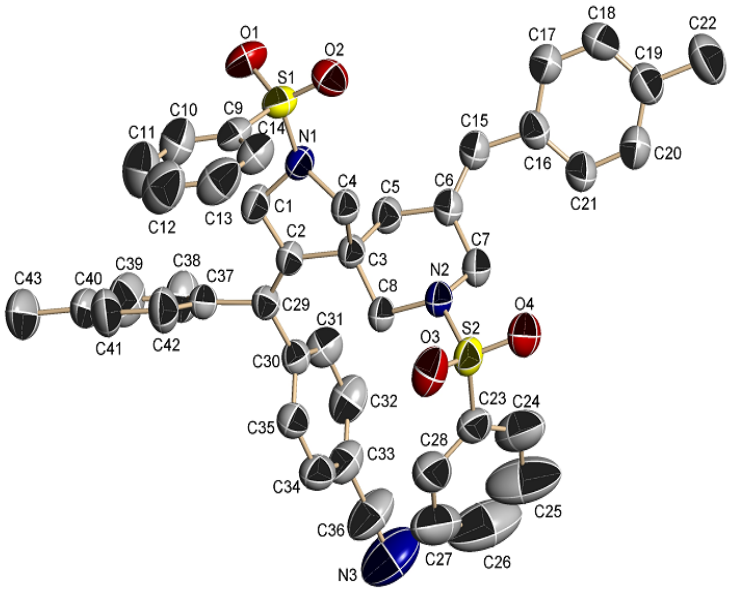
White solid; 550 mg (75 % yield); m.p. 153 - 154 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.50; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.78 - 7.80 (d, J = 6.9 Hz, 2H; Ar-H), 7.58 - 7.66 (m, 5H; Ar-H), 7.51 - 7.55 (m, 4H; Ar-H), 7.30 - 7.38 (m , 4H; Ar-H), 7.07 - 7.11 (m, 3H; Ar-H), 7.02 - 7.04 (d, J = 6.9 Hz, 4H; Ar-H), 6.34 (s, 1H; C=CH), 4.51 - 4.55 (d, J = 12.0 Hz, 1H; N-CH_2-C=C), 4.01 - 4.07 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.64 - 3.69 (d, J = 15.0 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.55 - 3.59 (d, J = 10.2 Hz, 1H; N-CH_2-C-C=C), 3.45 - 3.49 (d, J = 11.4 Hz, 1H; N-CH_2-C=CH), 2.99 - 3.03 (d, J = 9.9 Hz, 1H; N-CH_2-C-C=C), 2.50 - 2.54 (d, J = 13.5 Hz, 1H; C-CH_2-C=CH), 2.18 - 2.22 (d, J = 12.6 Hz, 1H; N-CH_2-C-C=C), 2.04 - 2.08 (d, J = 13.5 Hz, 1H; C-CH_2-C=CH), 1.80 - 1.83 (d, J = 11.1 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 164.1 (d, $J_{C\text{-}F}$ = 273.4 Hz), 163.7 (d, $J_{C\text{-}F}$ = 269.9 Hz), 141.5, 139.8, 135.9, 135.3, 135.1, 133.3, 133.2, 132.9, 131.8, 131.2, 130.5, 130.4, 129.3, 129.3, 129.0, 128.9, 127.9, 127.4, 118.0, 116.5, 116.2, 115.7, 115.4, 112.8, 56.4, 52.8, 52.7, 48.2, 47.1, 43.4 ppm; FT-IR (neat): ν 3066.8, 2955.0, 2935.7, 2875.9, 2380.2, 2208.8, 1600.9, 1506.4, 1446.6, 1348.2, 1222.9, 1166.9, 1091.7, 1010.7, 964.4, 927.8, 875.7, 817.8, 756.1, 717.5, 692.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{41}H_{33}F_2N_3O_4S_2$ $[M + H]^+$, 734.1953; found: 734.1965.



1-(3-((E)-((Z)-9-(4-fluorobenzylidene)-2,7-bis(phenylsulfonyl)-2,7-diazaspiro[4.5]decan-4-ylidene)(4-fluorophenyl)methyl)phenyl)ethanone(gd)

White solid; 503 mg (67 % yield); m.p. 159 - 160 °C; TLC (petroleum ether/EtOAc = 3:1): R_f = 0.44; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.78 - 7.81 (d, J = 7.5 Hz, 2H; Ar-H), 7.55 - 7.68 (m, 6H; Ar-H), 7.42 - 7.47 (m, 4H; Ar-H), 7.28 - 7.30 (d, J = 6.0 Hz, 2H; Ar-H), 6.98 - 7.08 (m, 8H; Ar-H), 6.31 (s, 1H; C=CH), 4.46 - 4.50(d, J = 12.6 Hz, 1H; N-CH_2-C=C), 4.02 - 4.07 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.67 - 3.72 (d, J = 14.7 Hz, 1H; C-CH_2-N-CH_2-C=CH), 3.53 - 3.57 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 3.46 - 3.50 (d, J = 12.9 Hz, 1H; N-CH_2-C=CH), 3.00 - 3.03 (d, J = 9.6 Hz, 1H; N-CH_2-C-C=C), 2.49 - 2.53 (d, J = 12.0 Hz, 4H; C-CH_2-C=CH, O=C-CH_3), 2.10 - 2.18 (t, 2H; N-CH_2-C-C=C, C-CH_2-C=CH), 1.91 - 1.95 (d, J = 11.4 Hz, 1H; N-CH_2-C=CH); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 197.1, 163.6 (d, $J_{C\text{-}F}$ = 255.0 Hz), 163.4 (d, $J_{C\text{-}F}$ = 247.1 Hz), 140.7, 138.6, 137.3, 136.9, 135.4, 133.2, 133.0, 132.8, 131.6, 130.5, 130.4, 129.7, 129.3, 129.1, 128.9, 128.9, 128.7, 127.9, 127.7, 127.4, 116.3, 116.0, 115.7, 115.4, 56.5, 52.8, 52.7, 48.1, 47.0, 43.3, 26.7 ppm; FT-IR (neat): 3070.7, 2935.7, 2885.5, 2812.2, 2351.2, 2306.9, 1681.9 (C=O), 1600.9, 1446.6, 1348.2, 1226.7, 1170.8, 1091.7, 1012.6, 966.3, 817.8, 760.0, 719.5, 694.4 cm^{-1}; HRMS (APCI): *m/z* calcd for $C_{42}H_{36}F_2N_2O_5S_2$ $[M + H]^+$, 751.2107; found: 751.2101.

3. X-Ray Structure for fa, ga, and gb


O1
O2
S1
C10
C9
C14
N1
C11
C12
C13
C1
C4
C5
C6
C15
C16
C17
C18
C19
C20
C21
C22
C2
C3
C7
N2
C8
C43
C40
C39
C38
C37
C29
C31
O4
O3
S2
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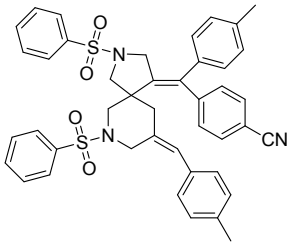
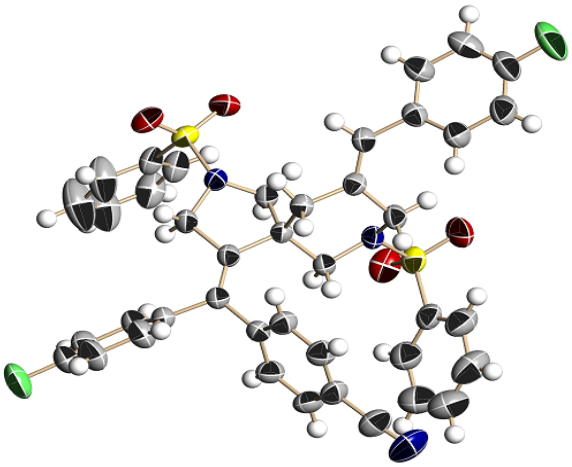
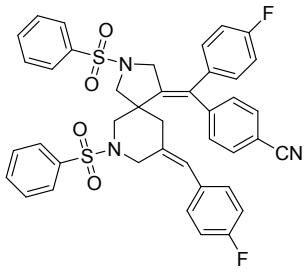
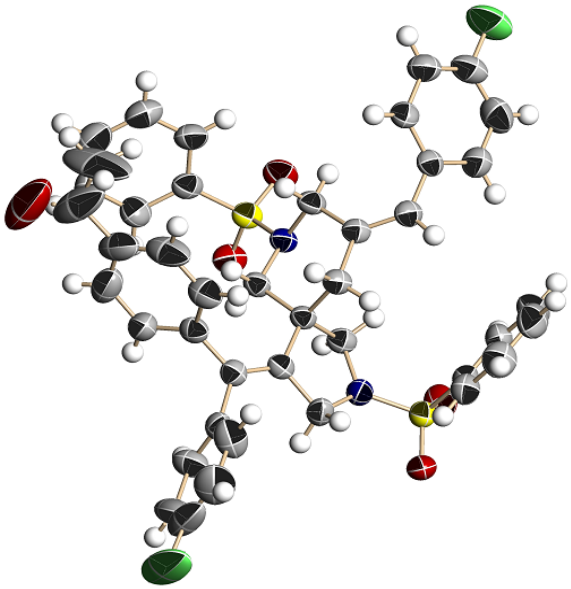
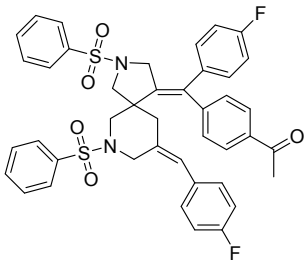
C33
C34
C25
C36
C27
C26
N3


O
S
O
N
O
S
O
N
CN

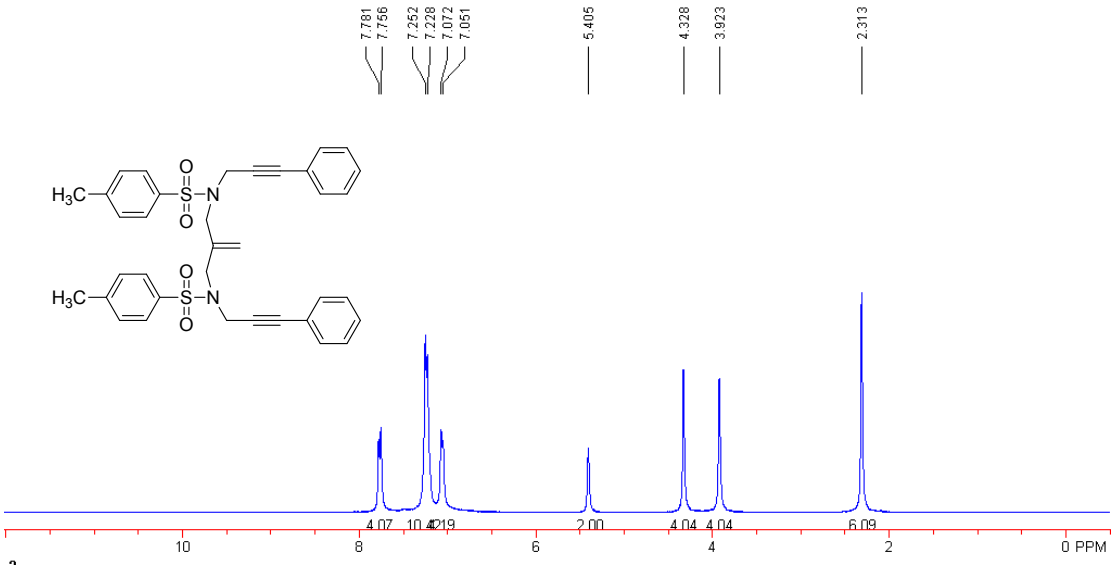



O
S
O
N
O
S
O
N
F
CN
F





4. ^{1}H NMR & ^{13}C NMR Spectra for New Compounds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7.252
7.228
7.072
7.051
5.405
4.328
3.923
2.313
4.07
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2.19
2.00
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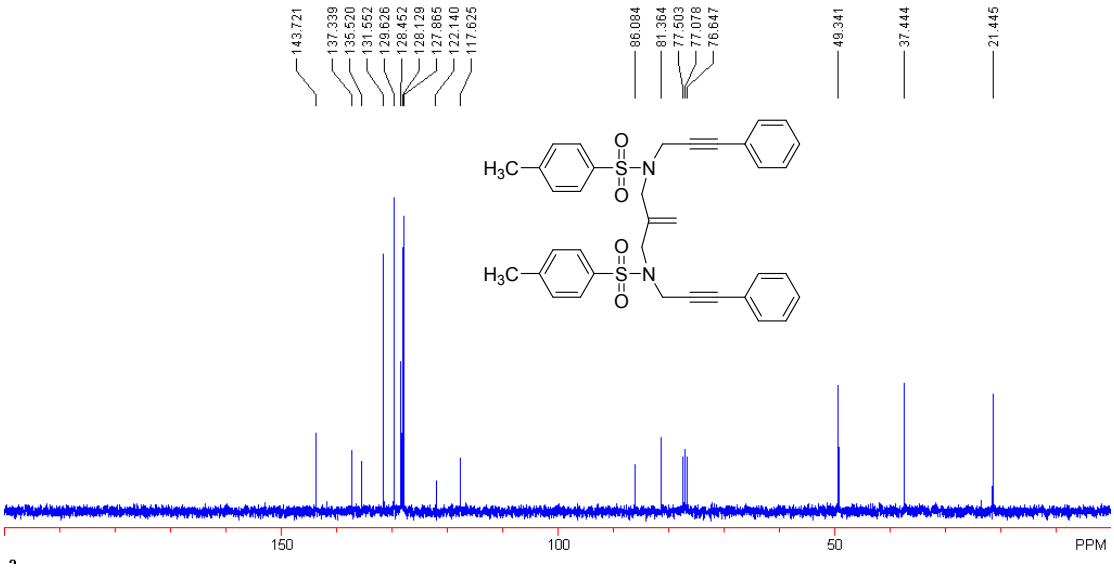
4.04
6.09
10
8
6
4
2
0 PPM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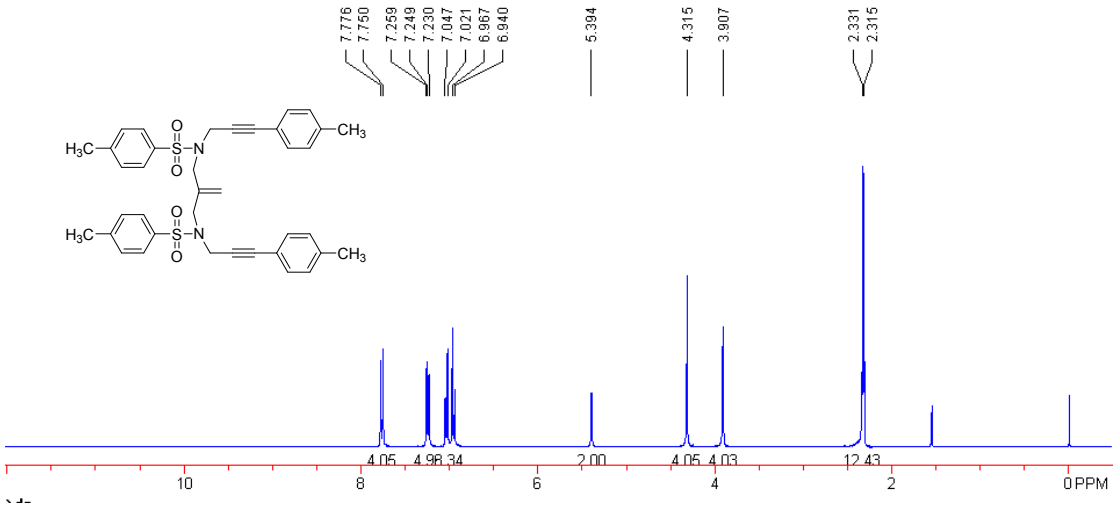
137.339
135.520
131.552
129.626
128.452
128.129
127.885
122.140
117.625
86.084
81.364
77.503
77.078
76.647
49.341
37.444
21.445
150
100
50
PPM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7.259
7.249
7.230
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7.021
6.967
6.940
5.394
4.315
3.907
2.331
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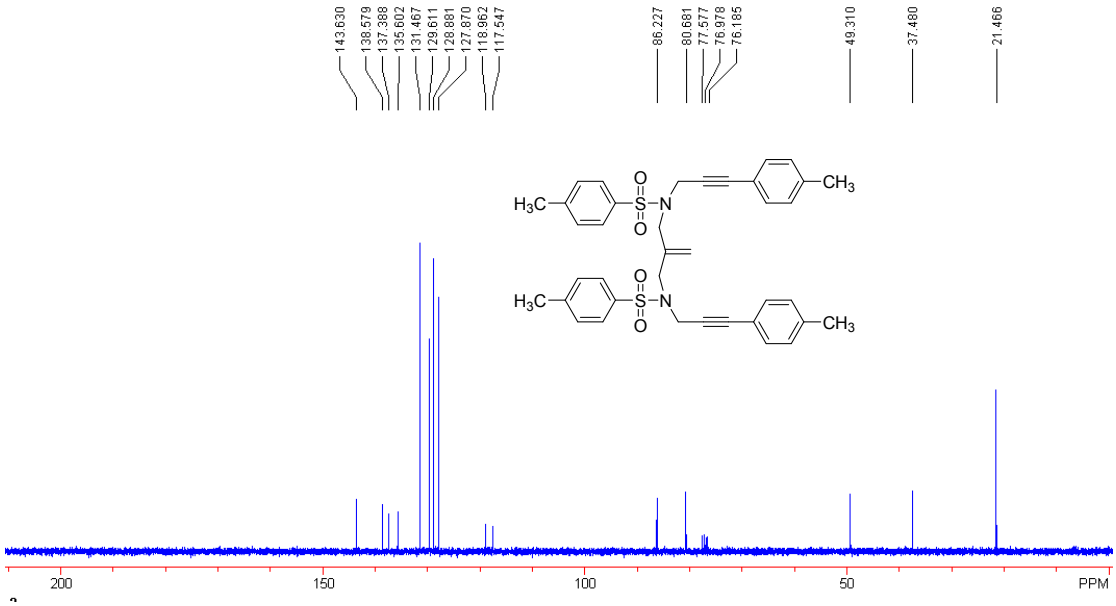
4.05
4.03
12.43
10
8
6
4
2
0 PPM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138.579
137.388
135.602
131.467
129.611
128.881
127.870
118.962
117.547
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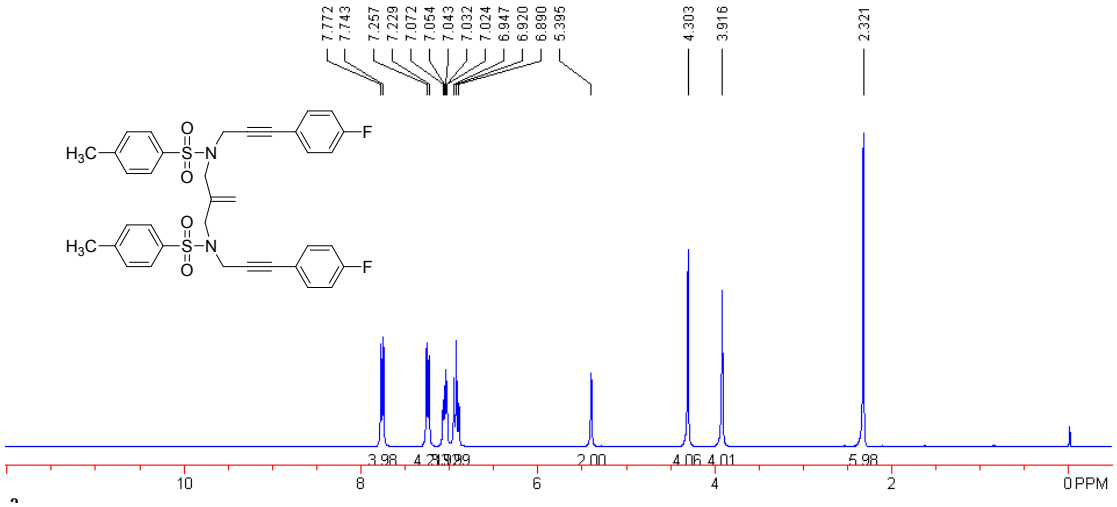
80.681
77.577
76.978
76.185
49.310
37.480
21.466
200
150
100
50
PPM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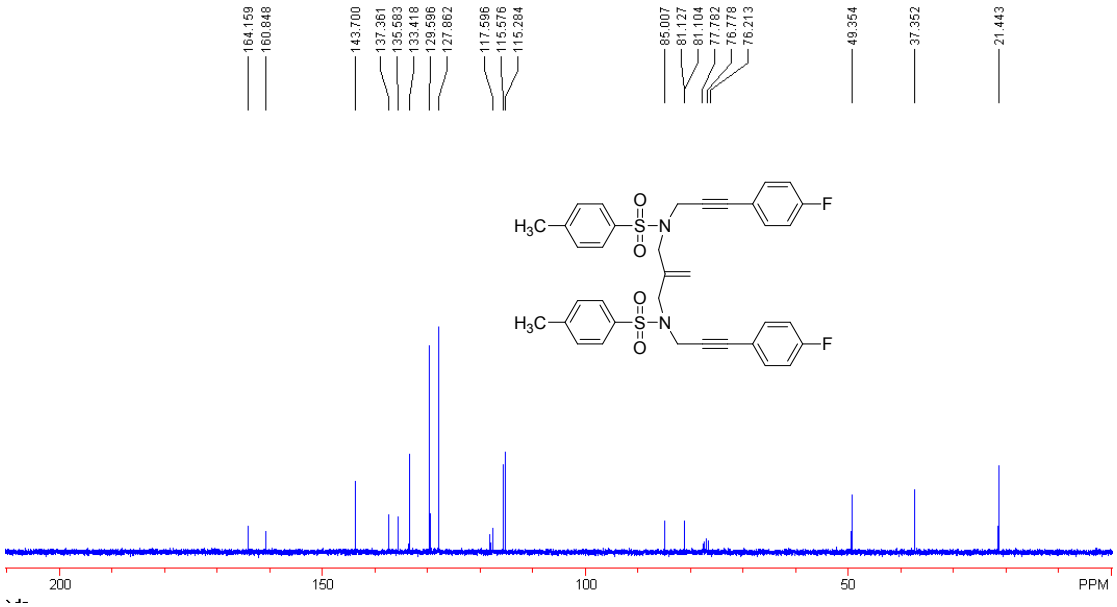
7.743
7.257
7.229
7.072
7.054
7.043
7.032
7.024
6.947
6.920
6.890
5.395
4.303
3.916
2.321
3.98
2.00
4.06
4.01
5.98
10
8
6
4
2
0 PPM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135.583
133.418
129.596
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115.576
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76.213
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37.352
21.443
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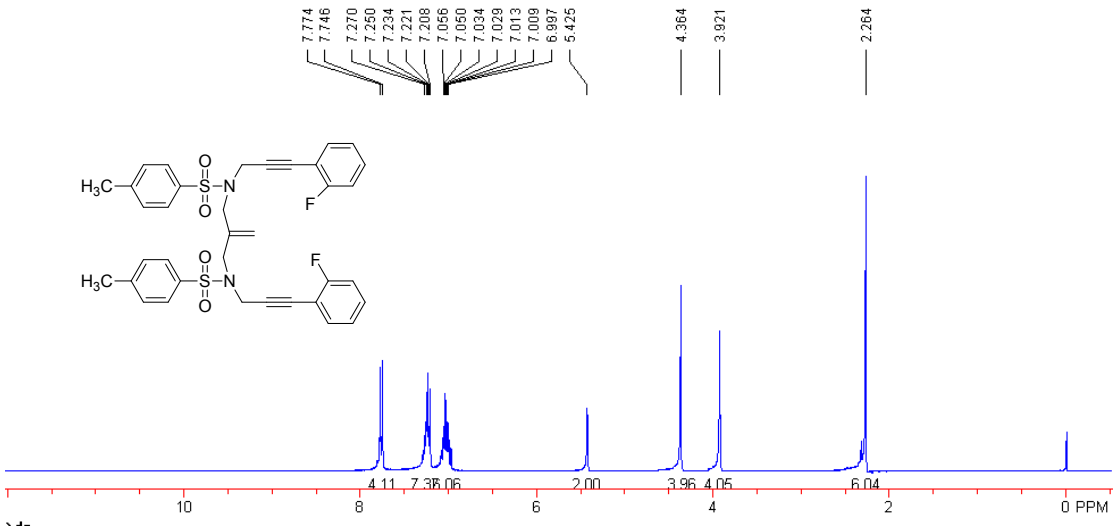
150
100
50
PPM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7.250
7.234
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7.056
7.050
7.034
7.029
7.013
7.009
6.997
5.425
4.364
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7.36
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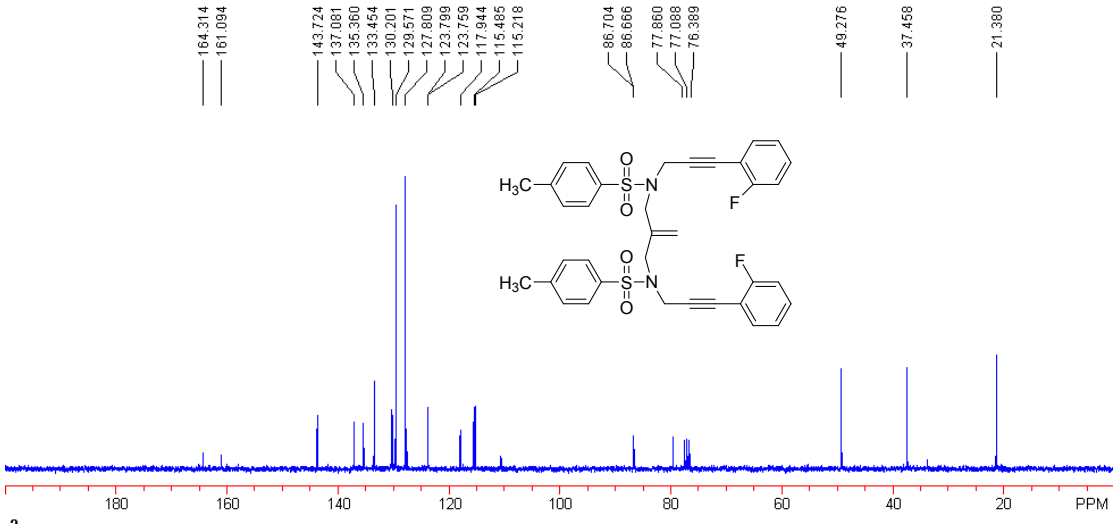
3.96
4.05
6.04
10
8
6
4
2
0 PPM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129.571
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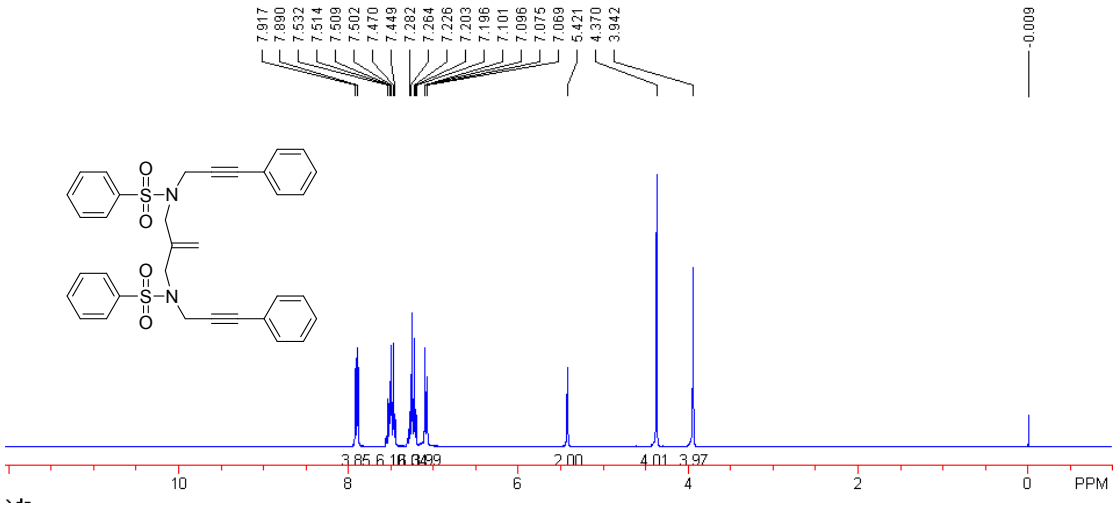
123.799
123.759
117.944
115.485
115.218
86.704
86.666
77.860
77.088
76.389
49.276
37.458
21.380
180
160
140
120
100
80
60
40
20
PPM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7.509
7.502
7.470
7.449
7.282
7.264
7.226
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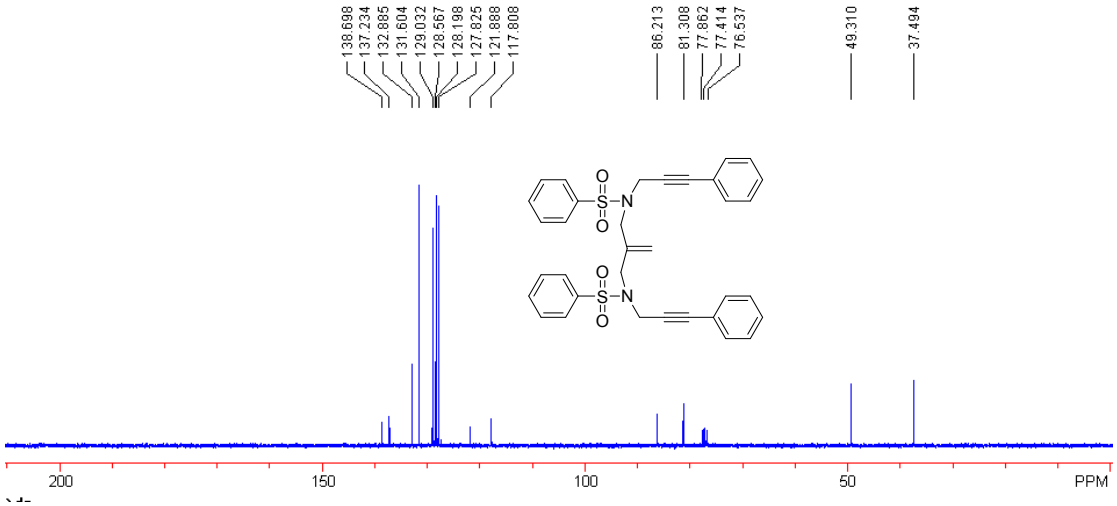
7.196
7.101
7.096
7.075
7.069
5.421
4.370
3.842
-0.009
3.85
6.16
16.04
2.00
4.01
3.97
10
8
6
4
2
0
PPM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128.198
127.825
121.888
117.808
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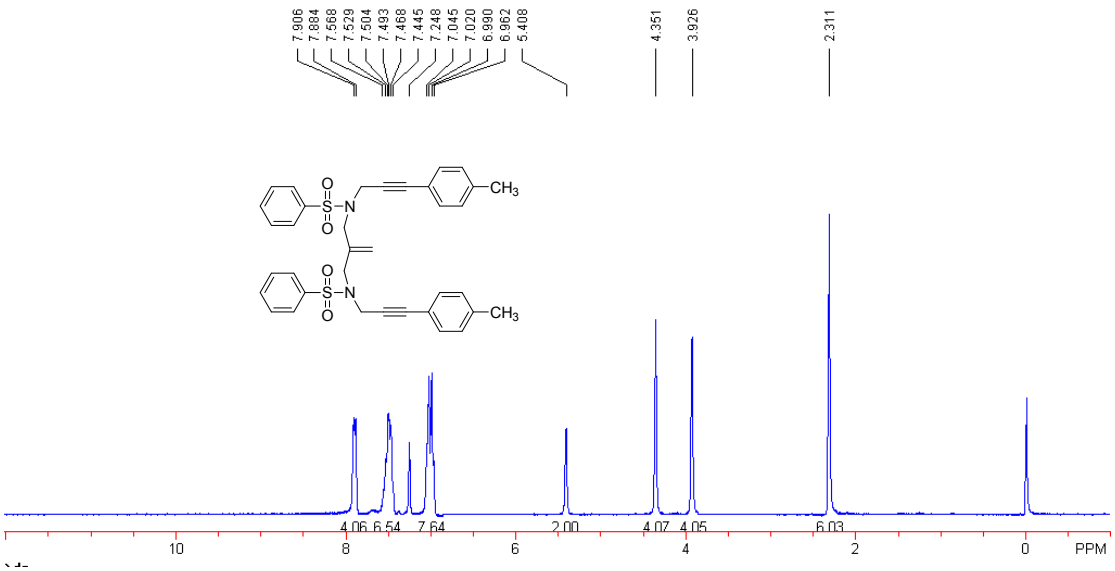
81.308
77.862
77.414
76.537
49.310
37.494
200
150
100
50
PPM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7.529
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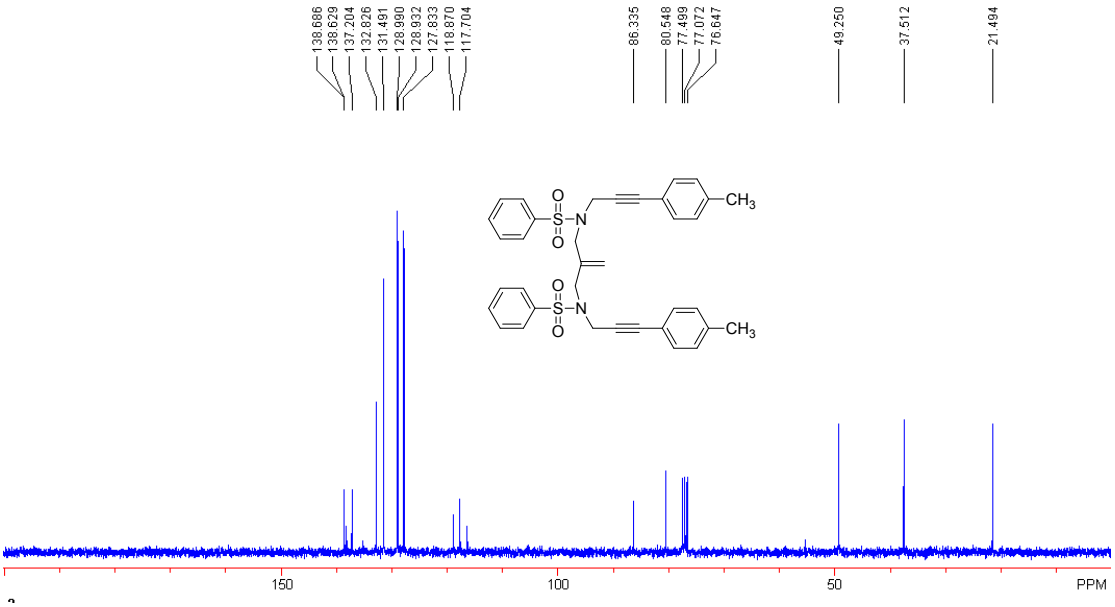
7.493
7.468
7.445
7.248
7.045
7.020
6.990
6.962
5.408
4.351
3.926
2.311
CH3
CH3
4.06 6.54 7.64 2.00 4.07 4.05 6.03
10
8
6
4
2
0
PPM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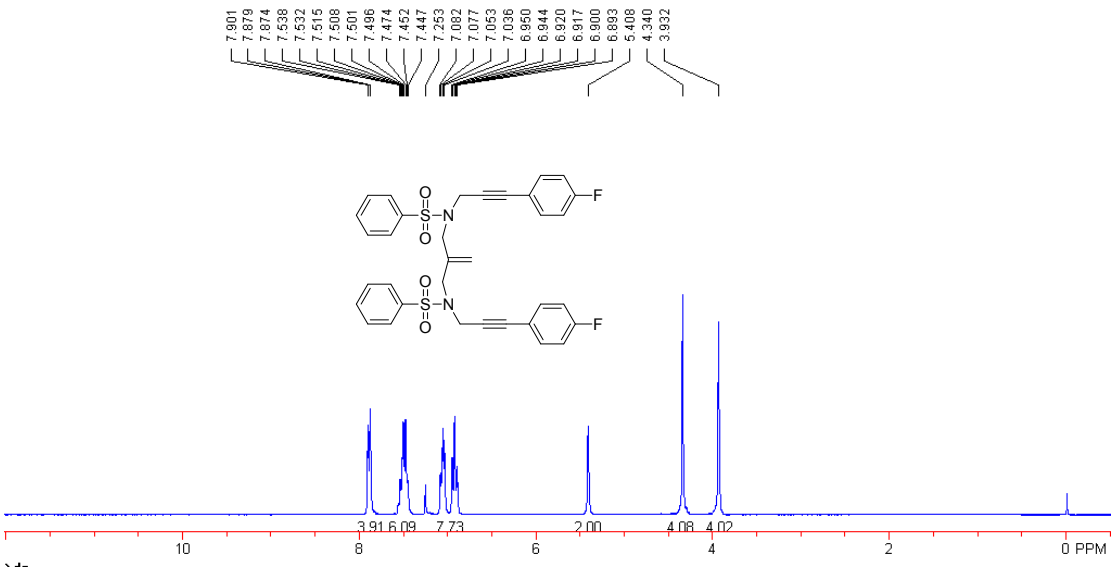
77.072
76.647
49.250
37.512
21.494
CH3
CH3
150
100
50
PPM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7.501
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7.447
7.253
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7.077
7.053
7.036
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6.944
6.920
6.917
6.900
6.893
5.408
4.340
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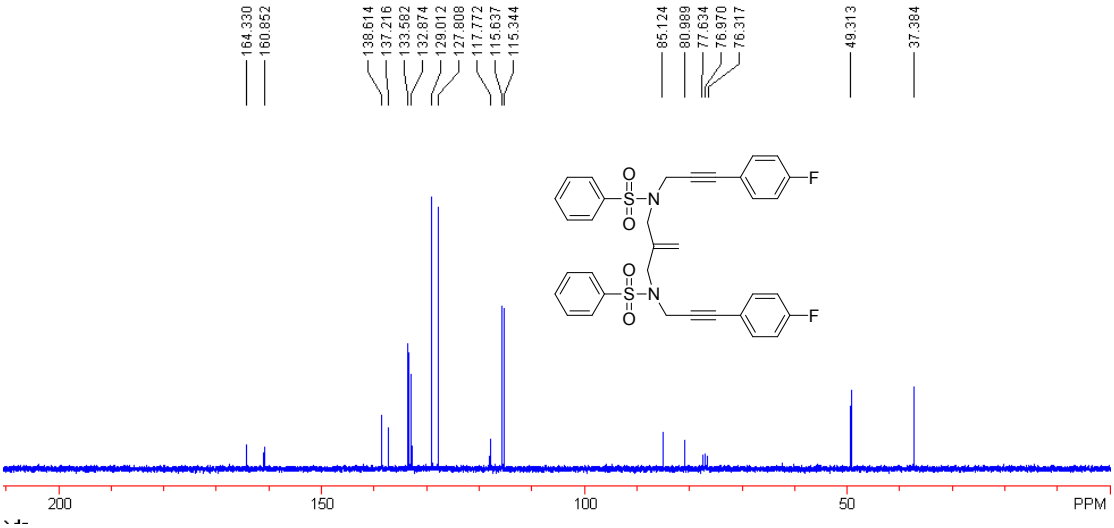
4.08
4.02
10
8
6
4
2
0 PPM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77.634
76.970
76.317
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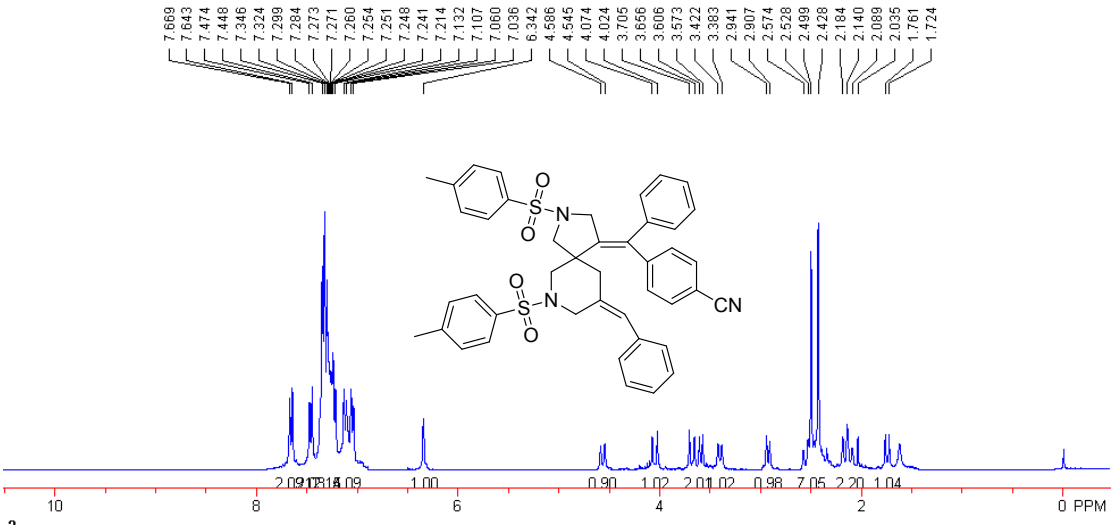
F
F
200
150
100
50
PPM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7.251
7.248
7.241
7.214
7.132
7.107
7.060
7.036
6.342
4.586
4.545
4.074
4.024
3.705
3.656
3.606
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3.383
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2.574
2.528
2.499
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2.184
2.140
2.089
2.035
1.761
1.724
CN
1.00
0.90
1.02
2.01
1.02
0.98
7.05
2.20
1.04
10
8
6
4
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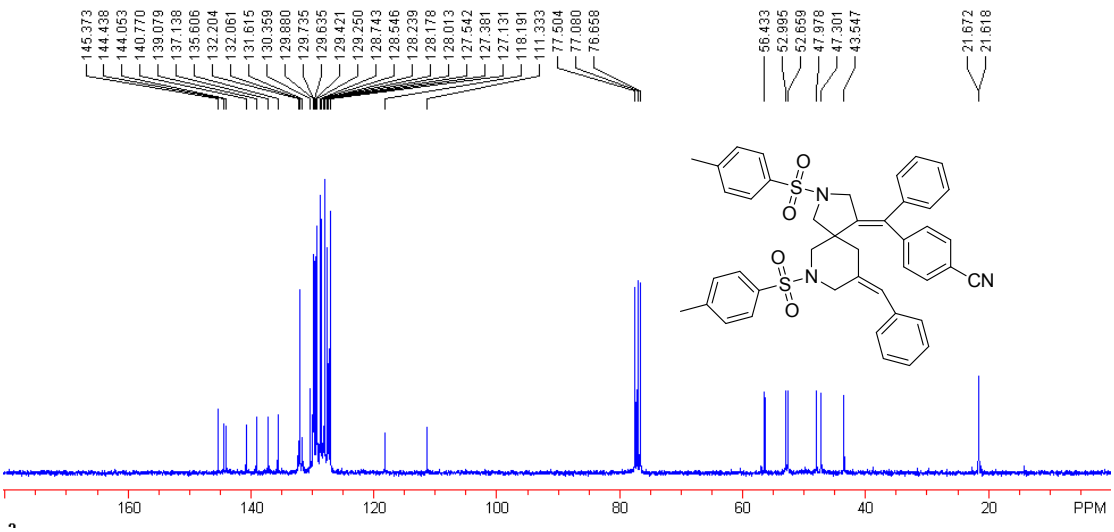
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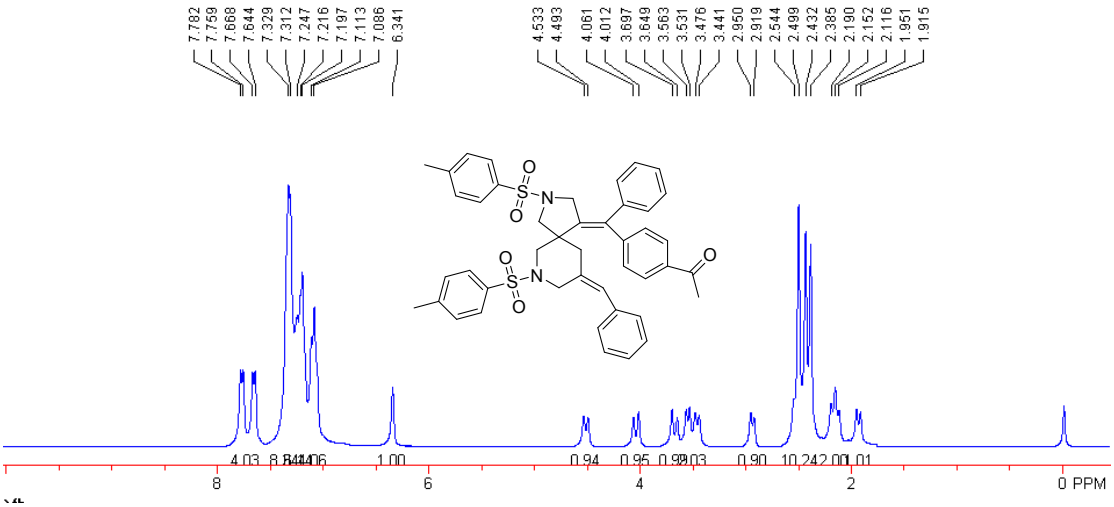
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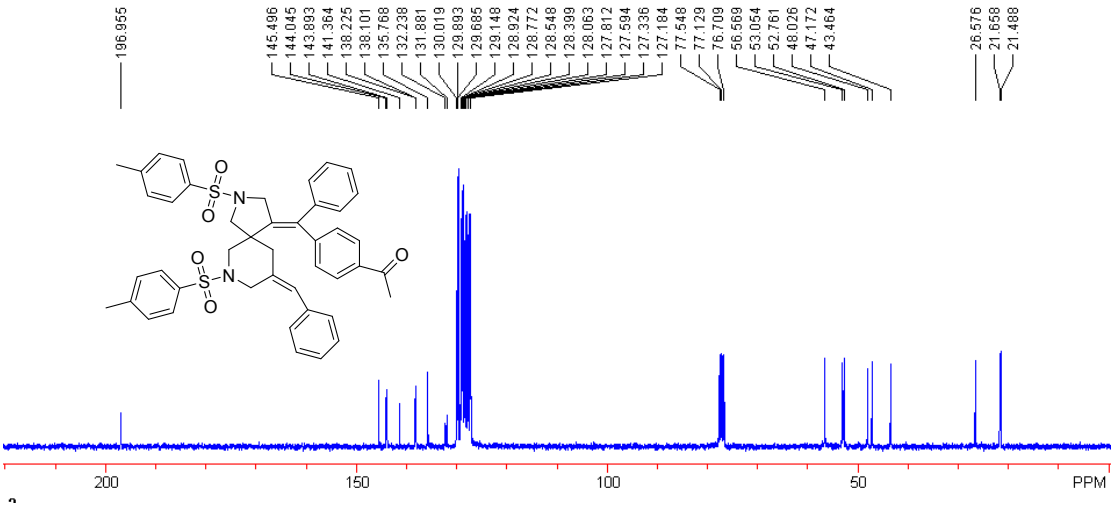
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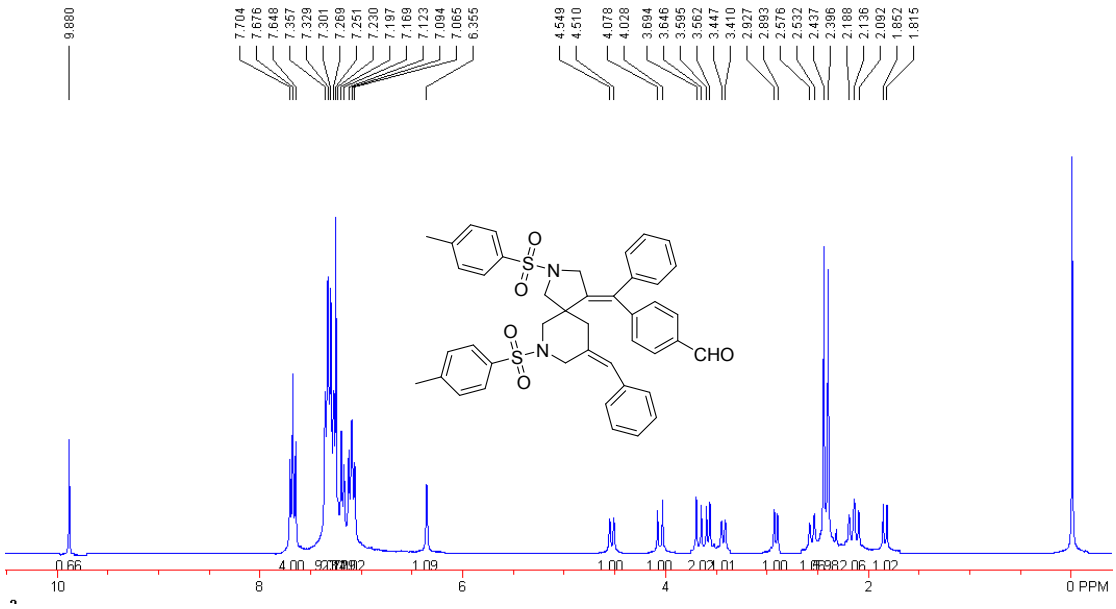
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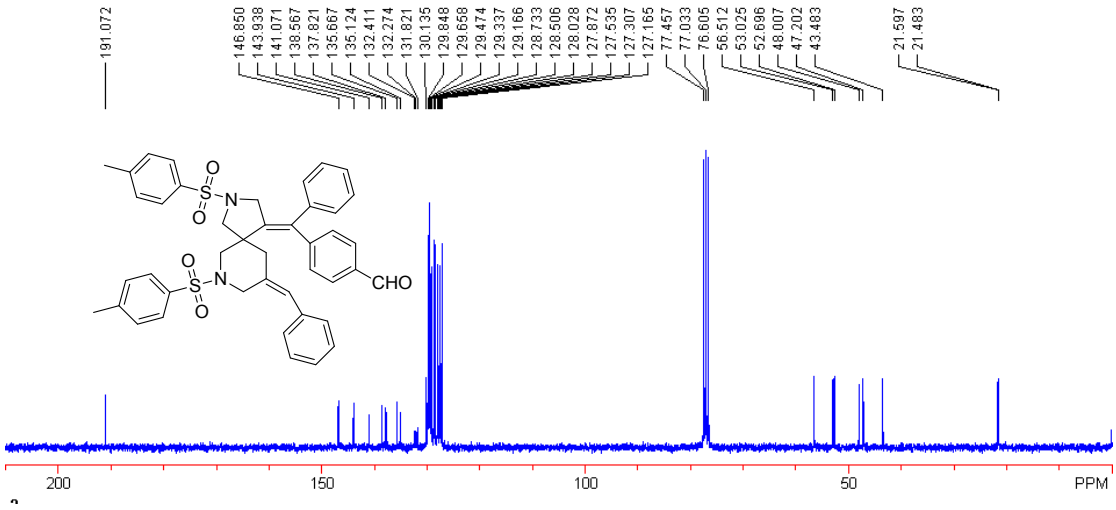
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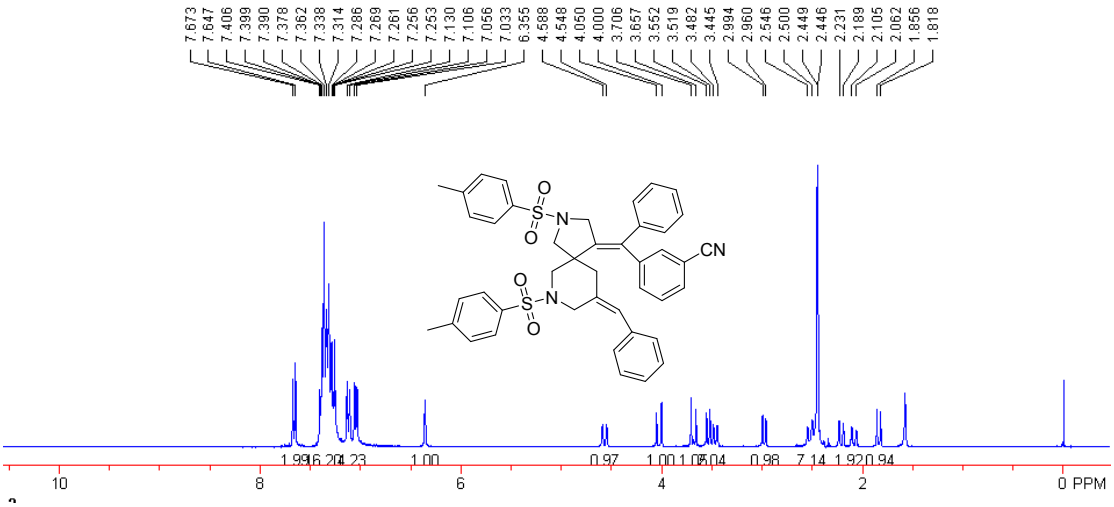
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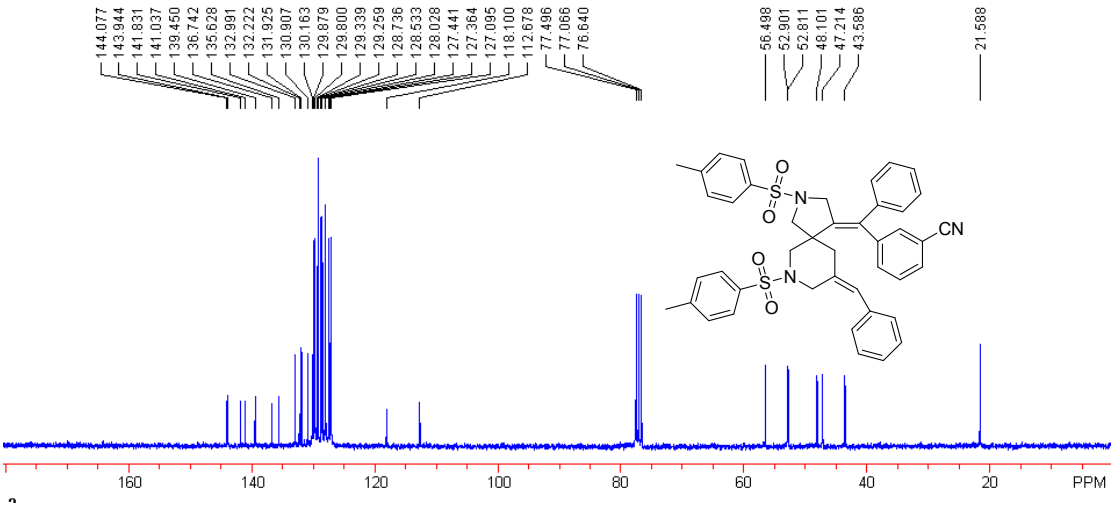
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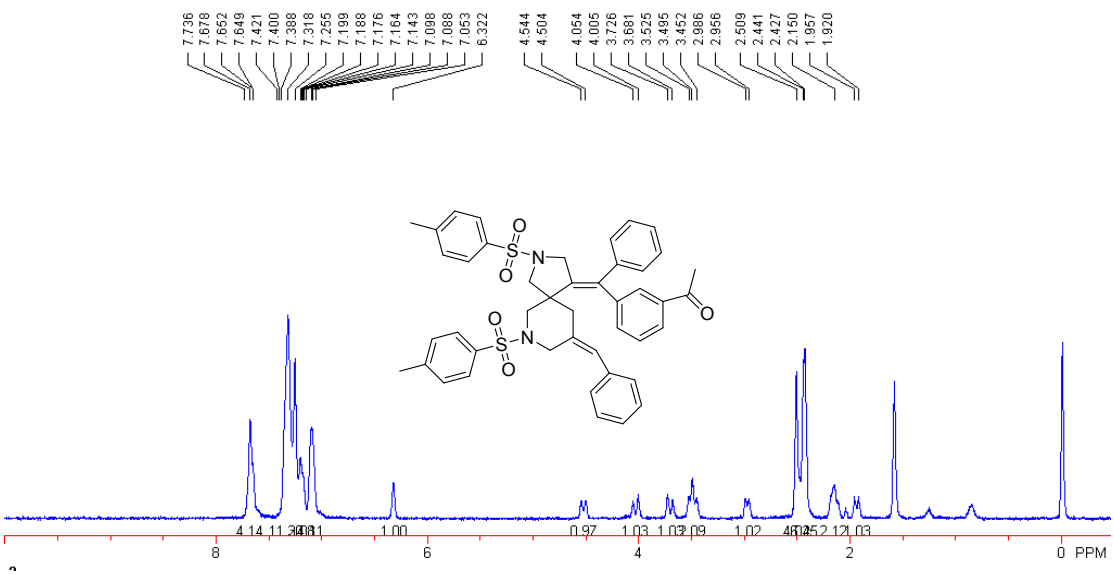
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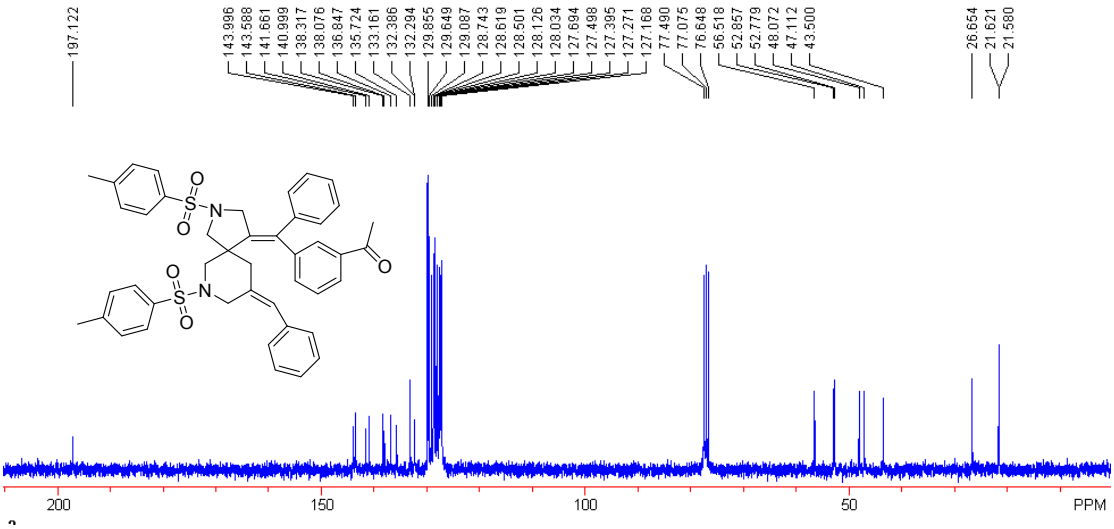
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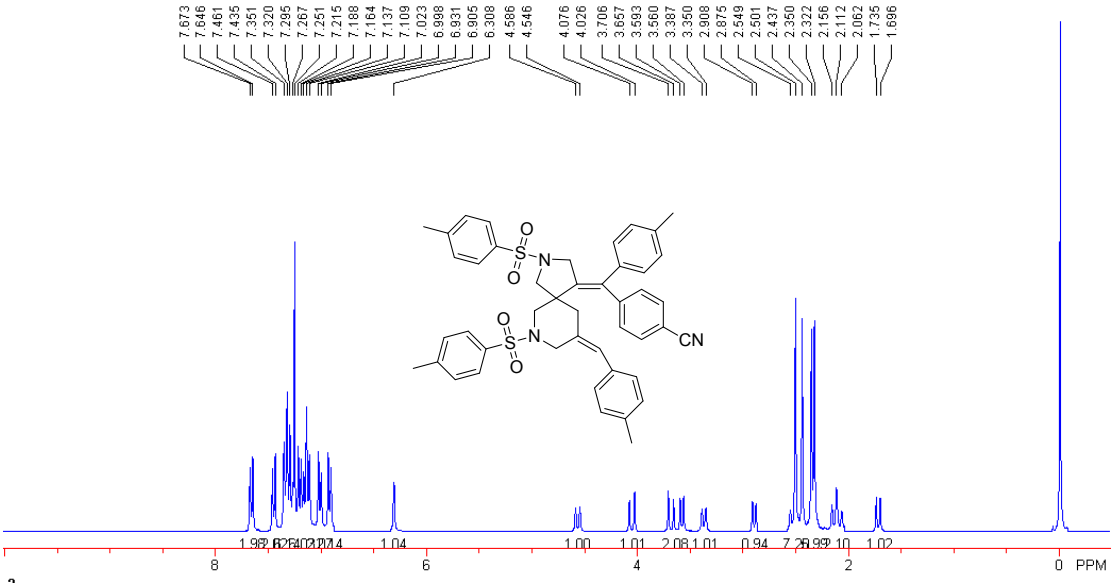
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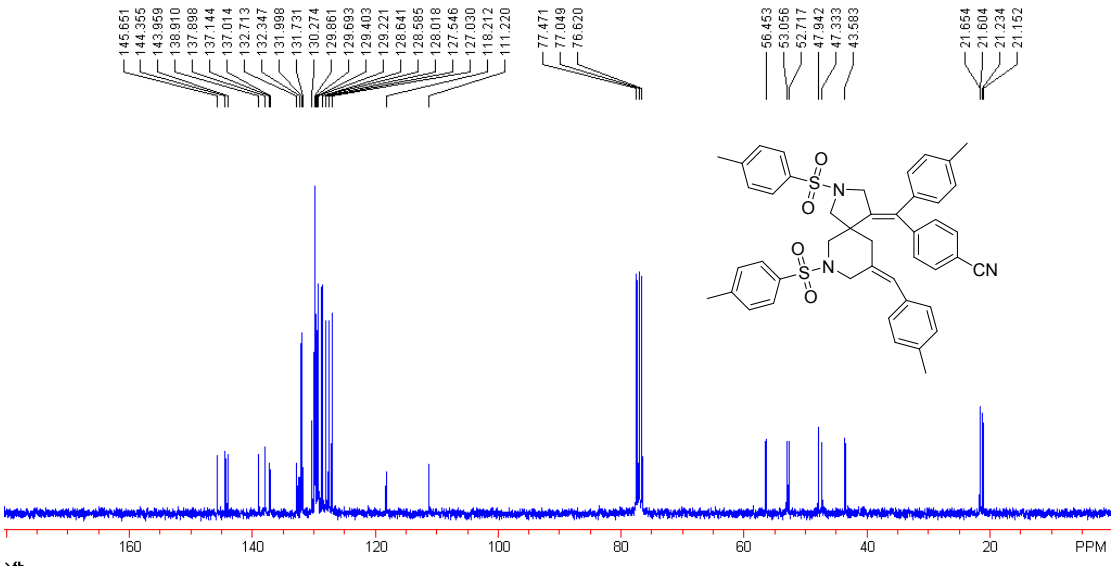
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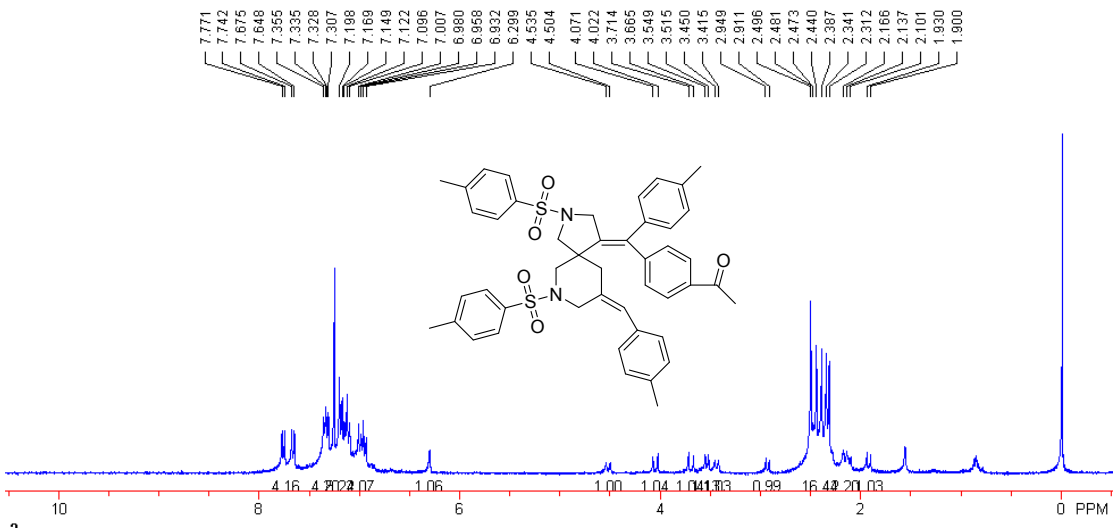
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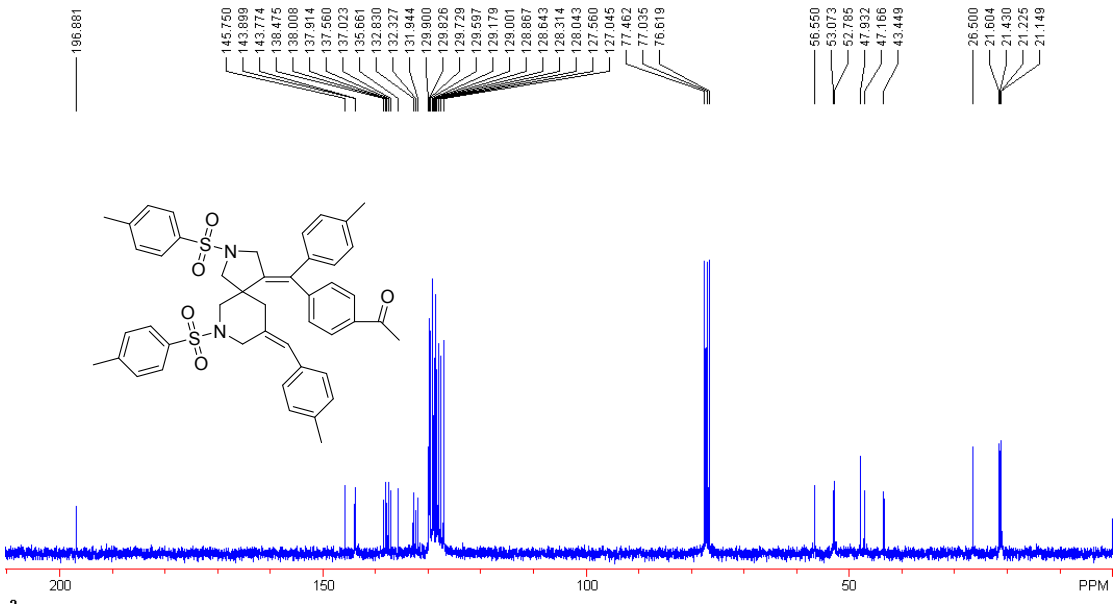
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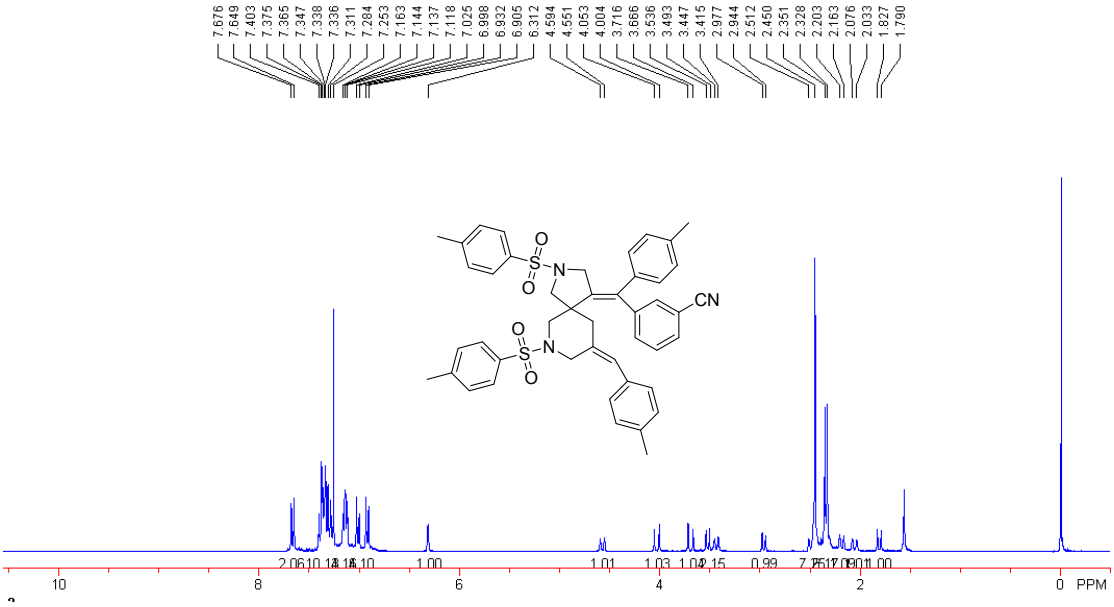
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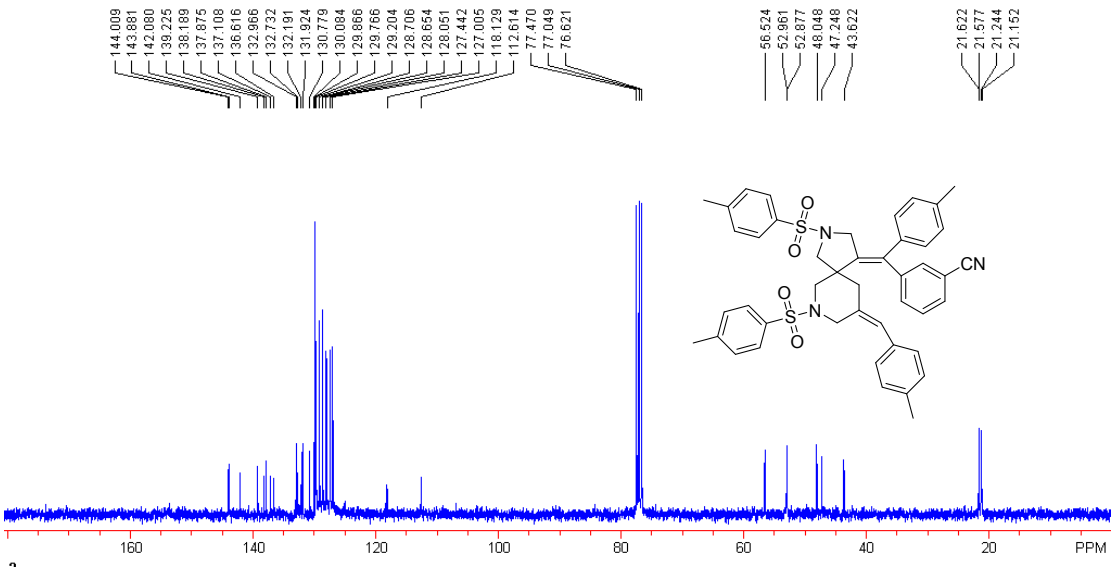
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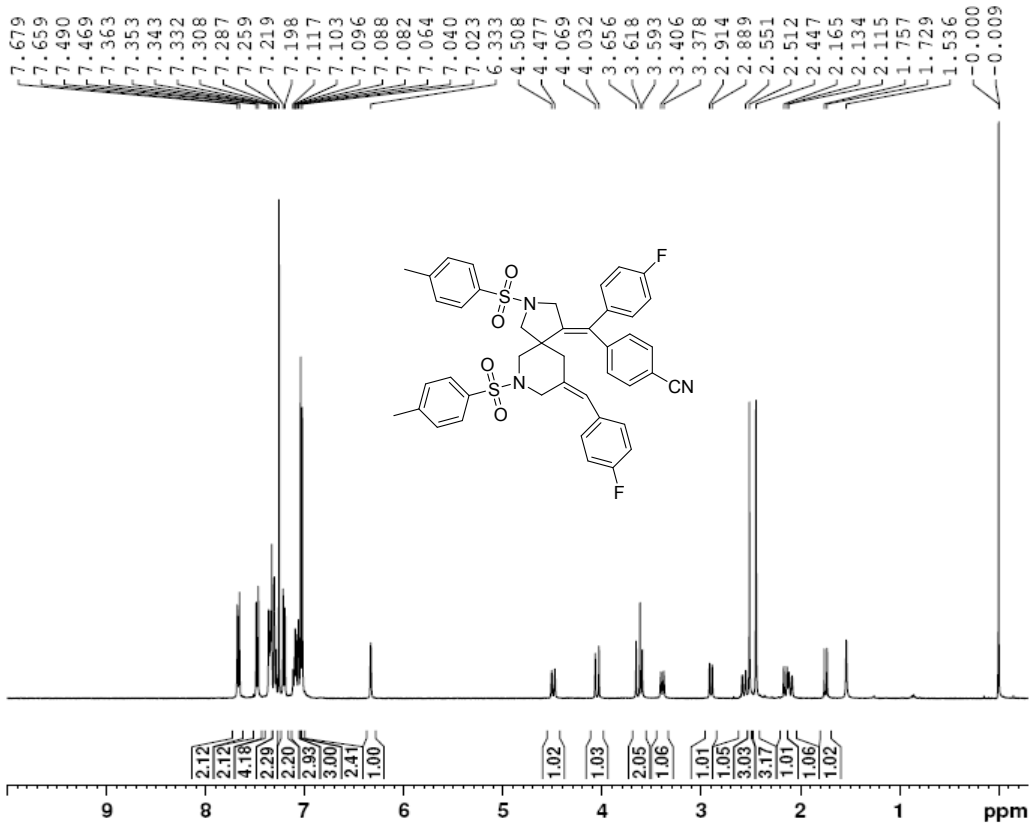
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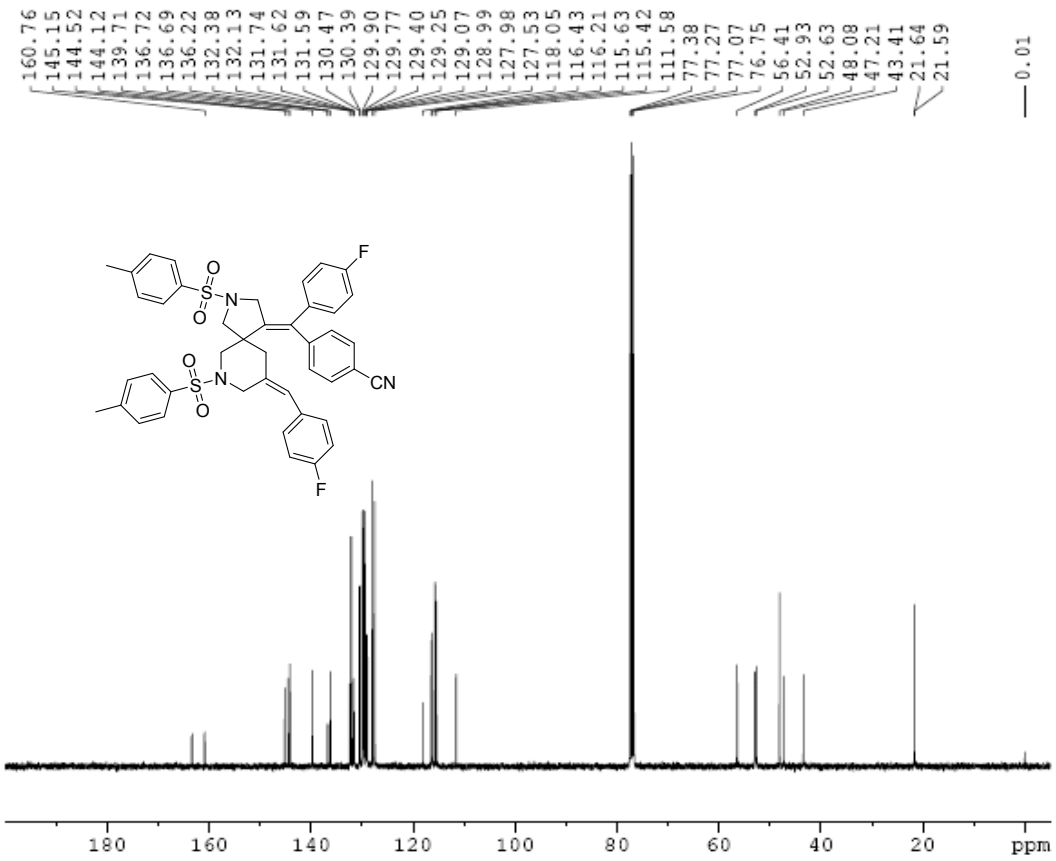
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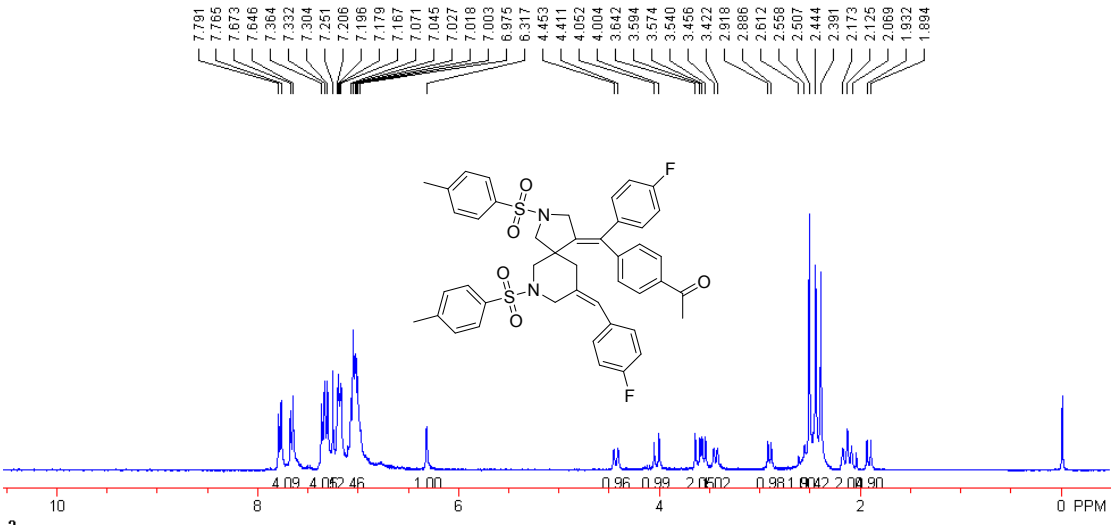
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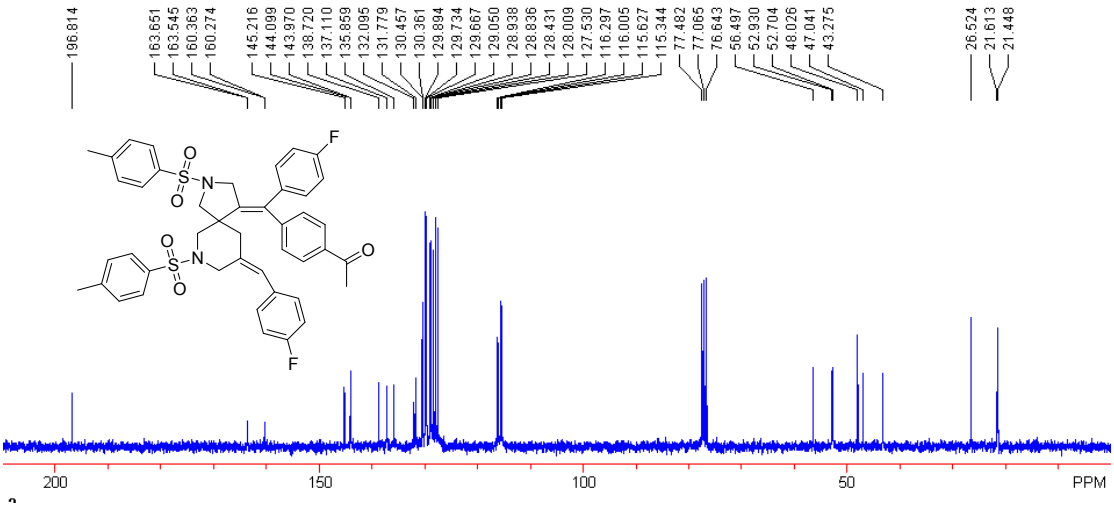
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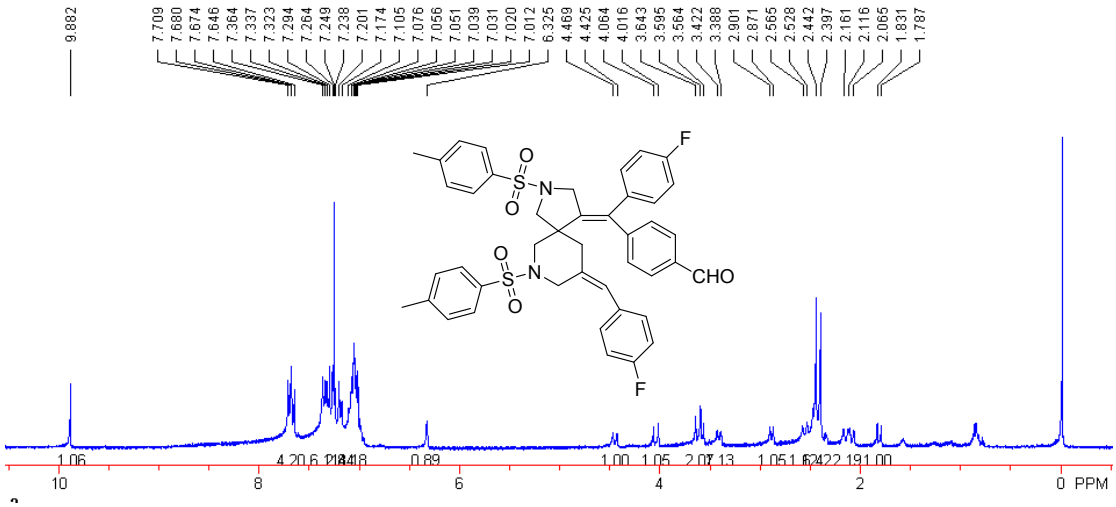
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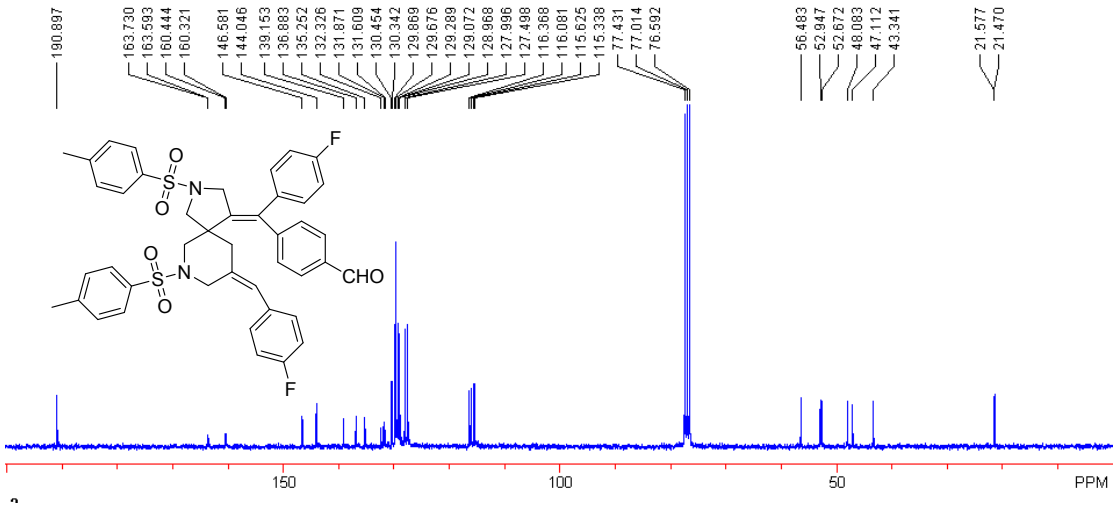
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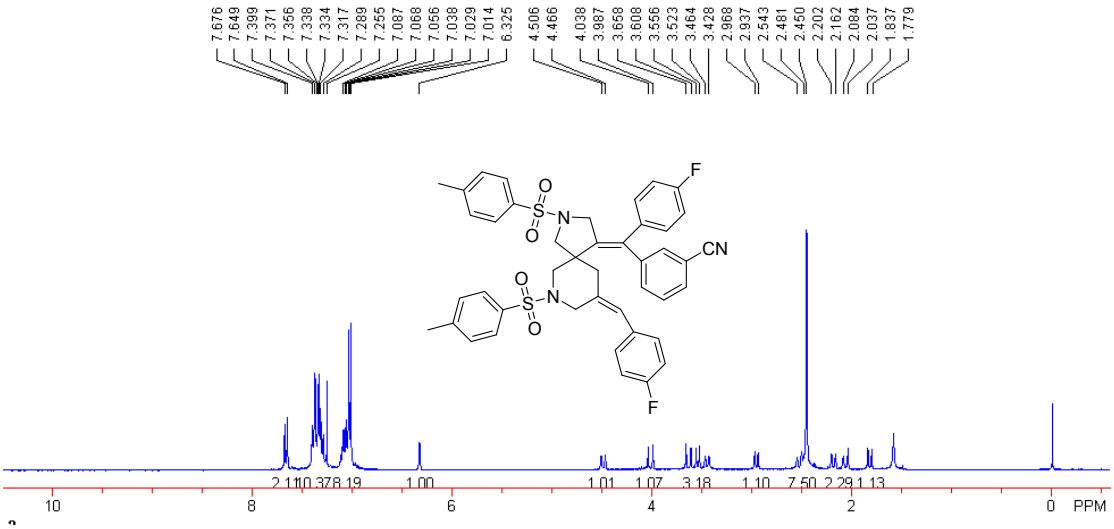
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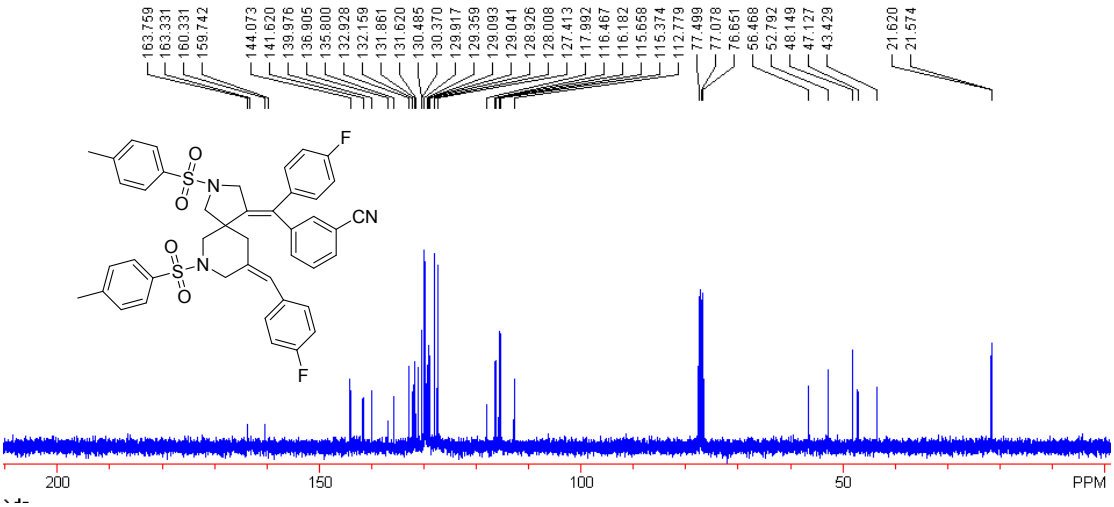
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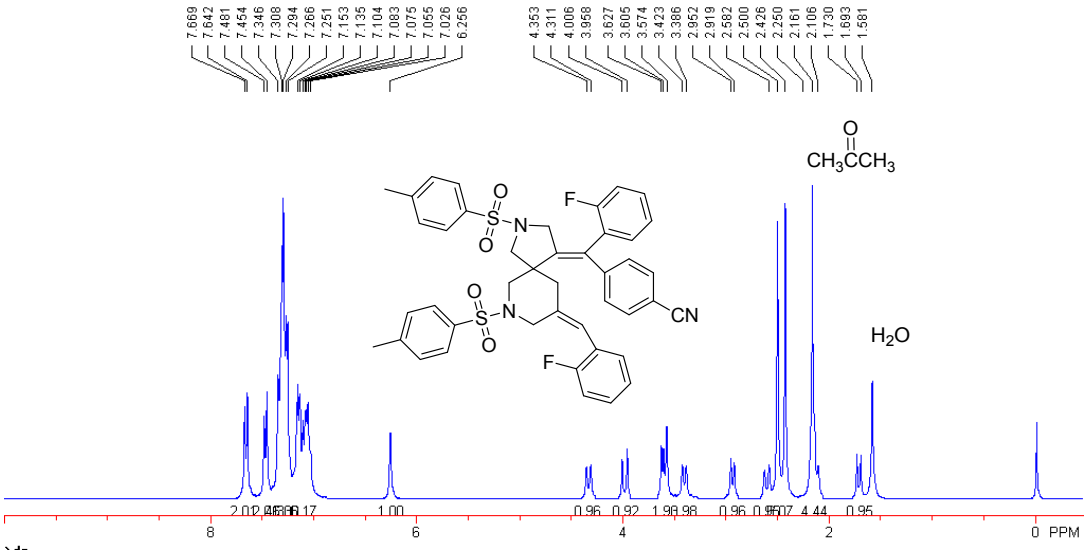
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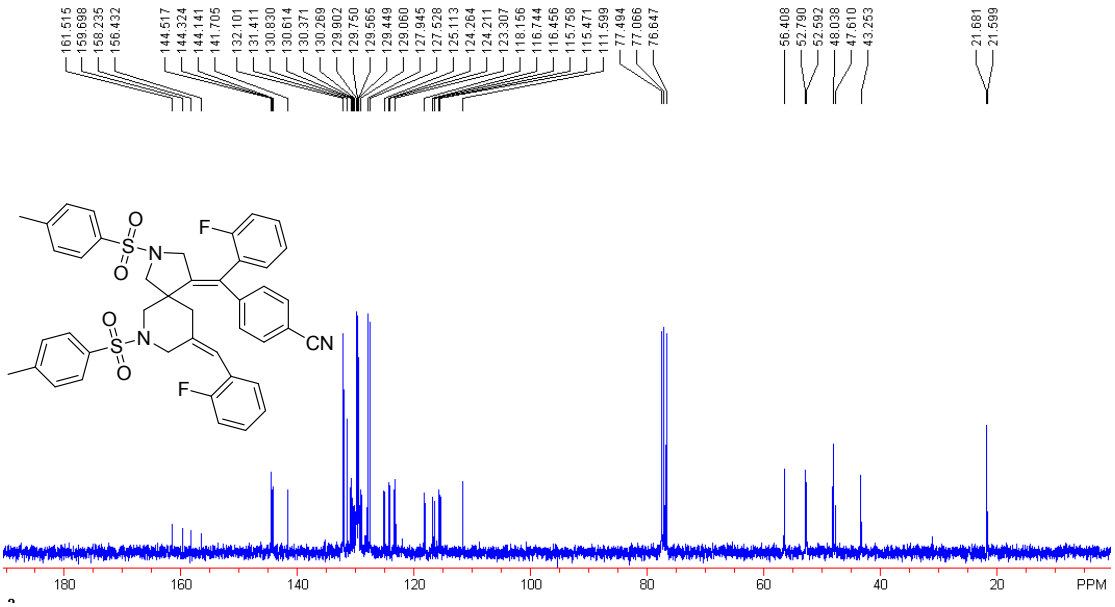
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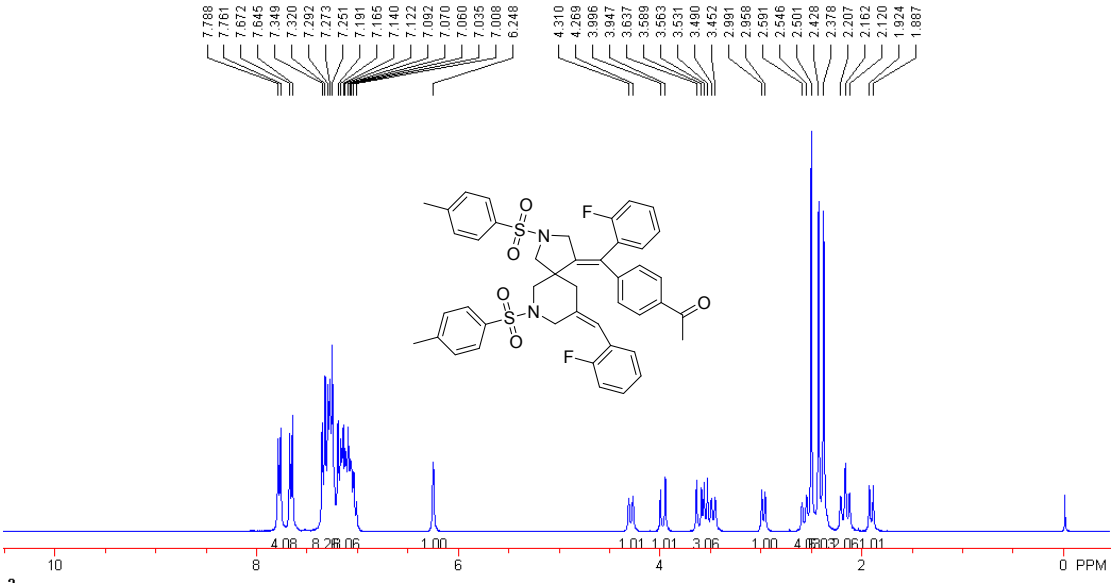
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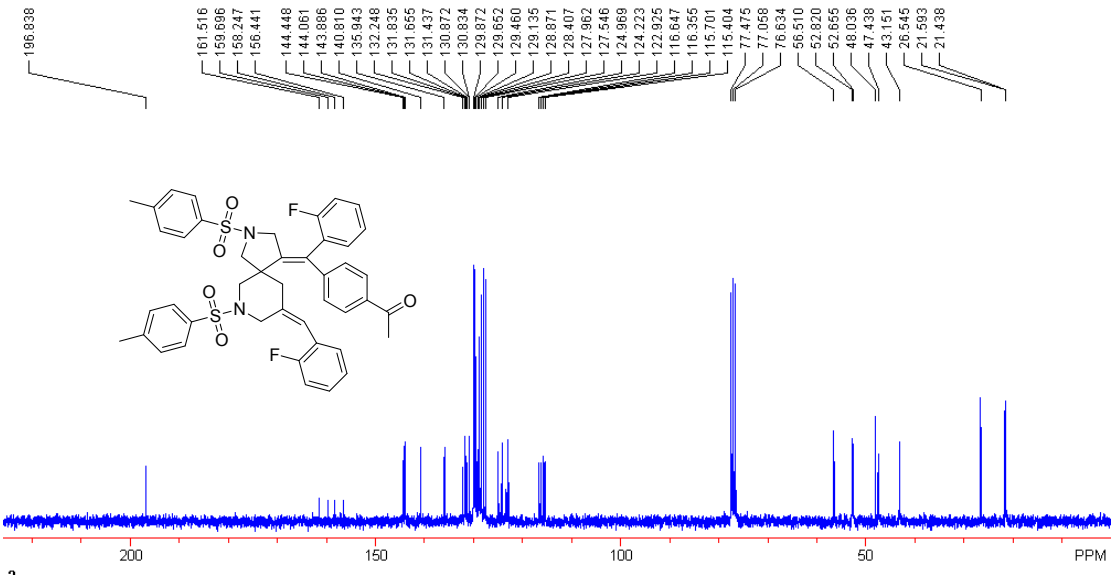
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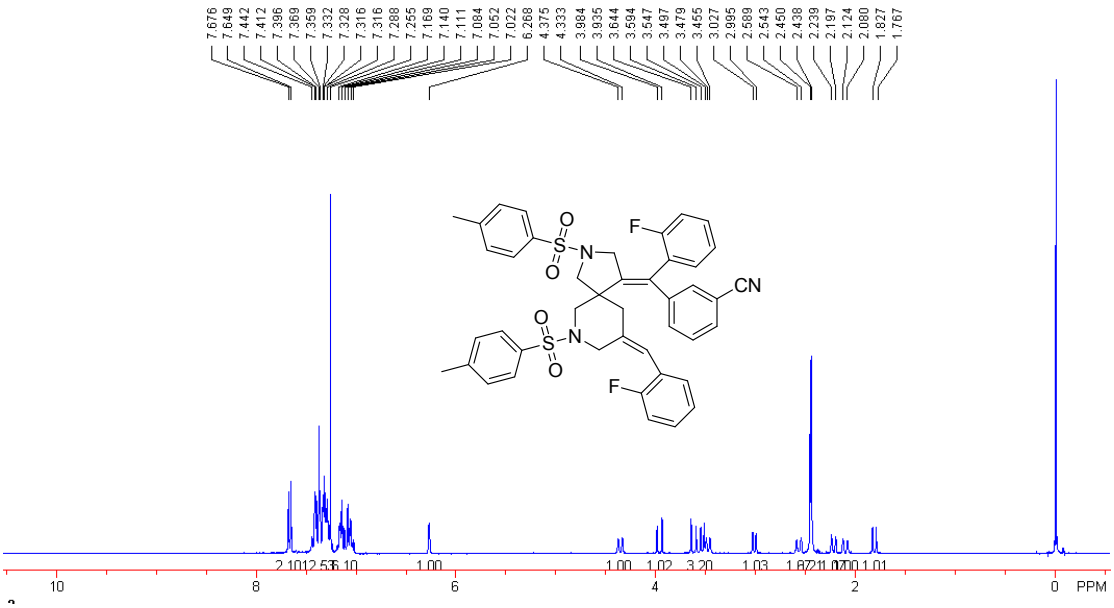
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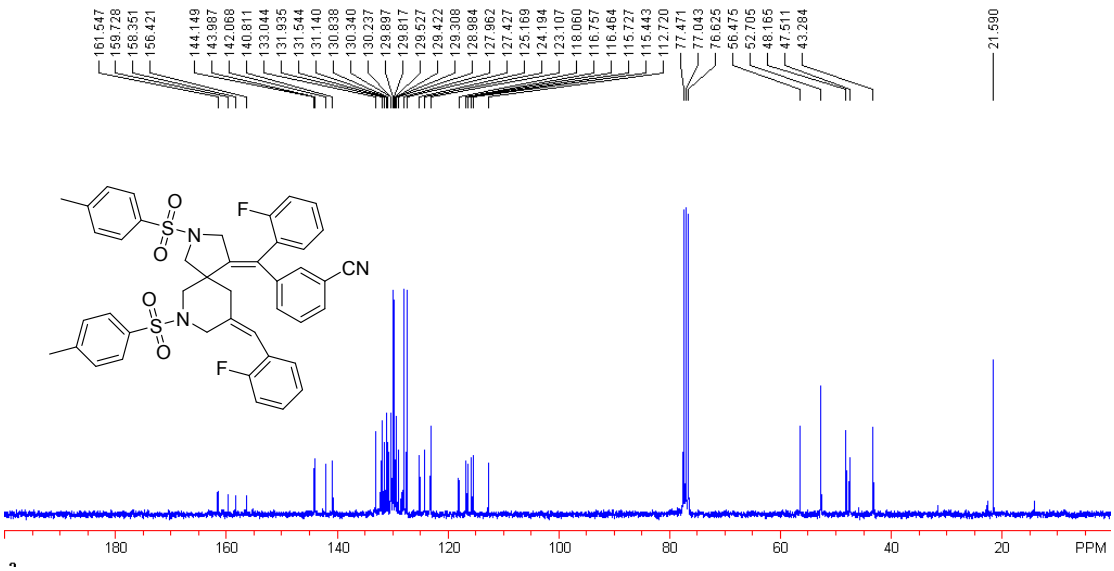
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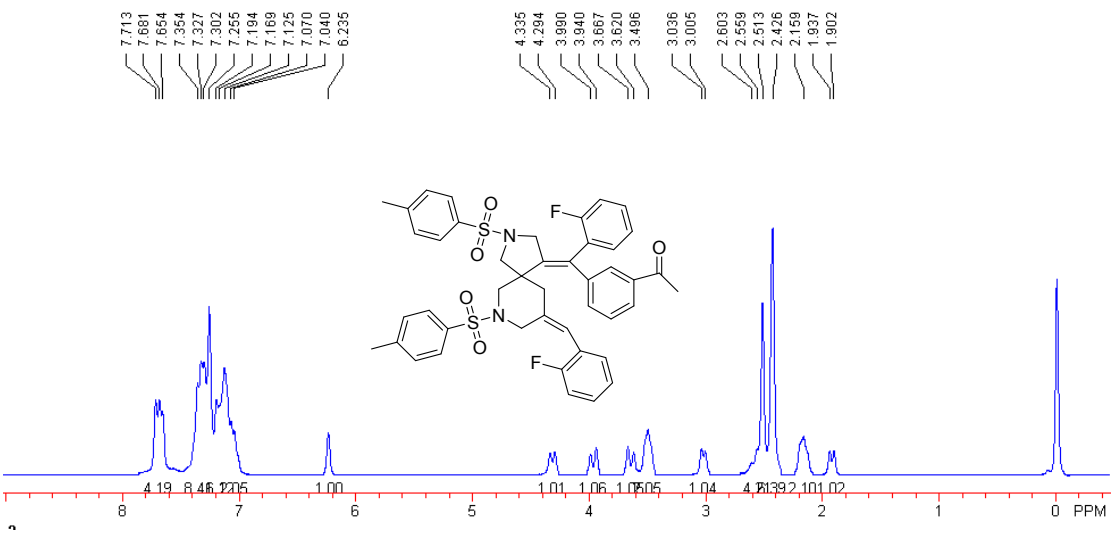
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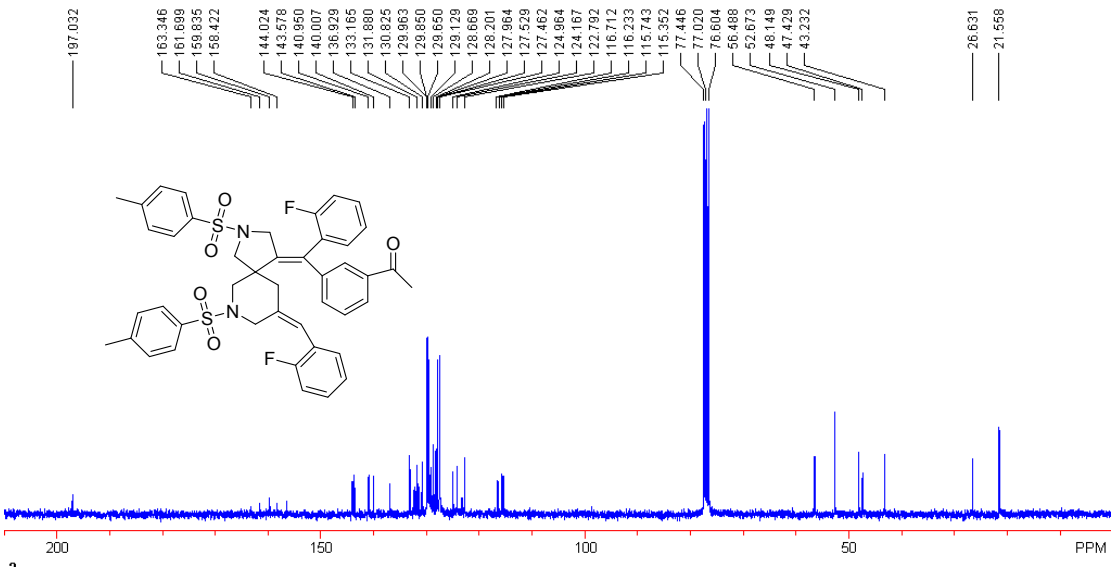
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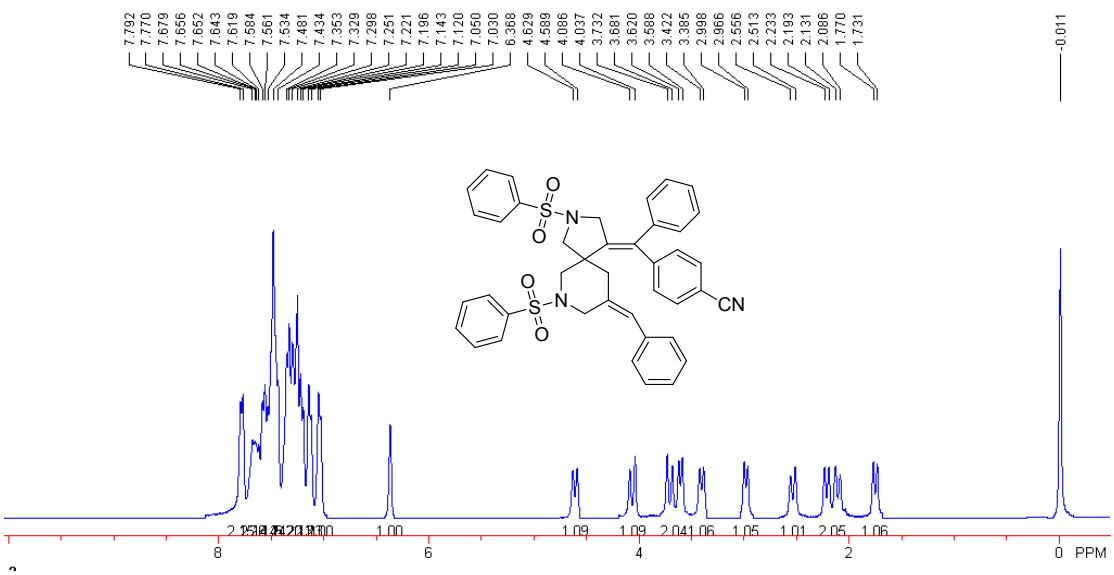
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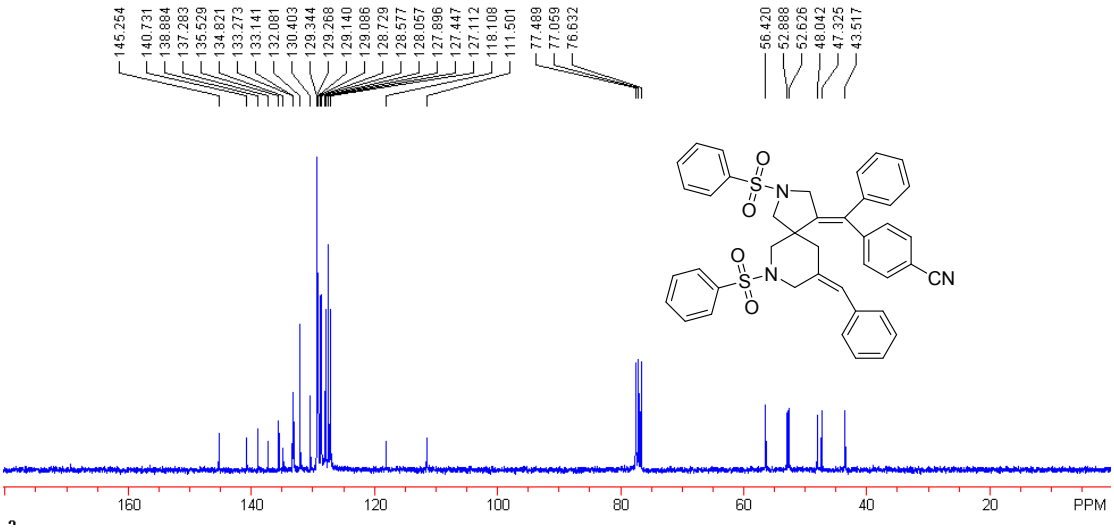
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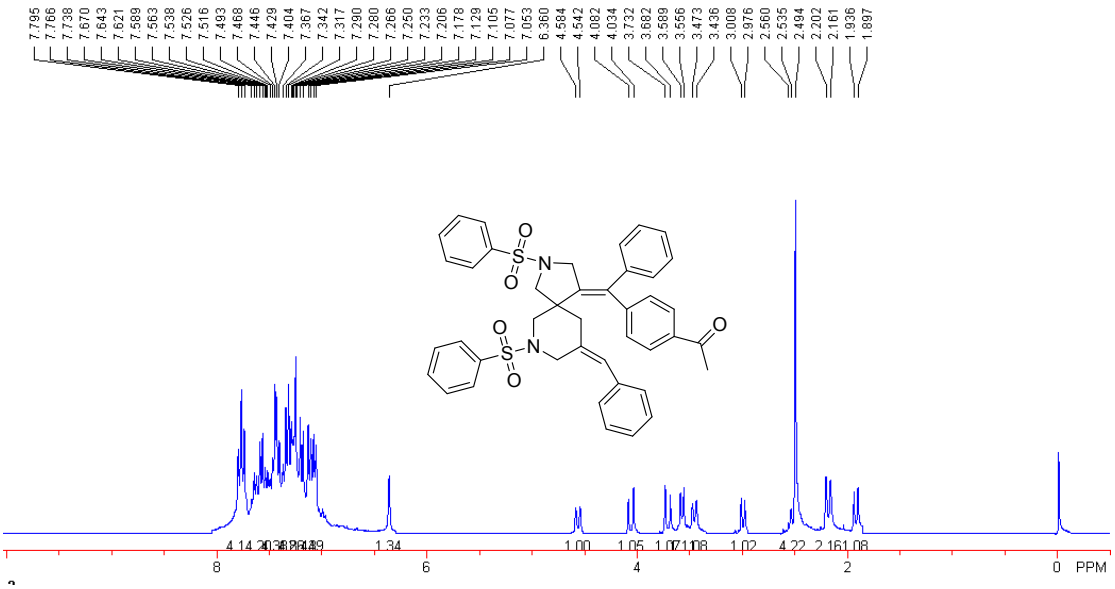
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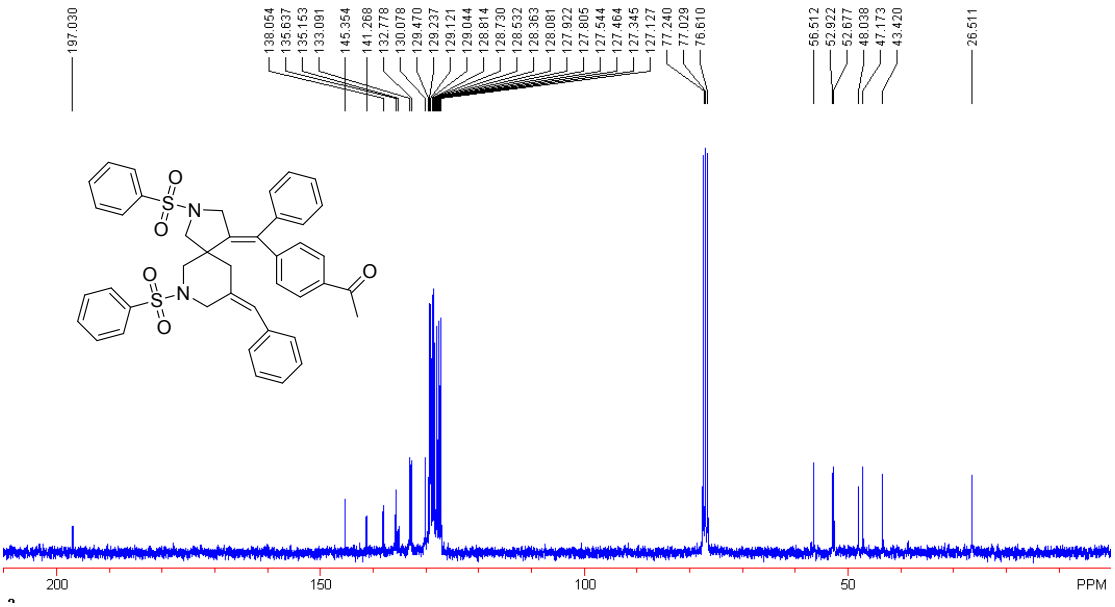
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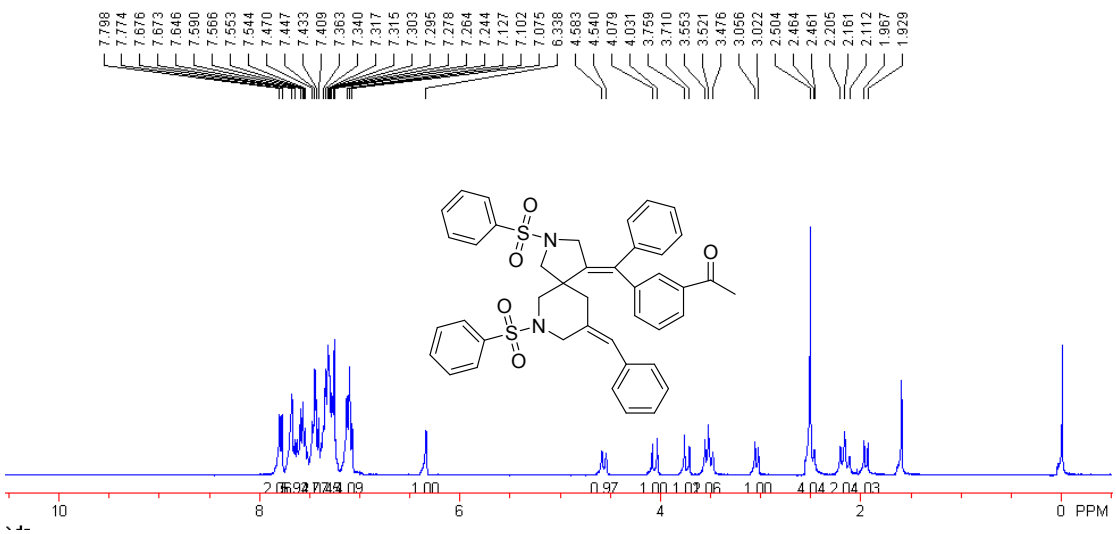
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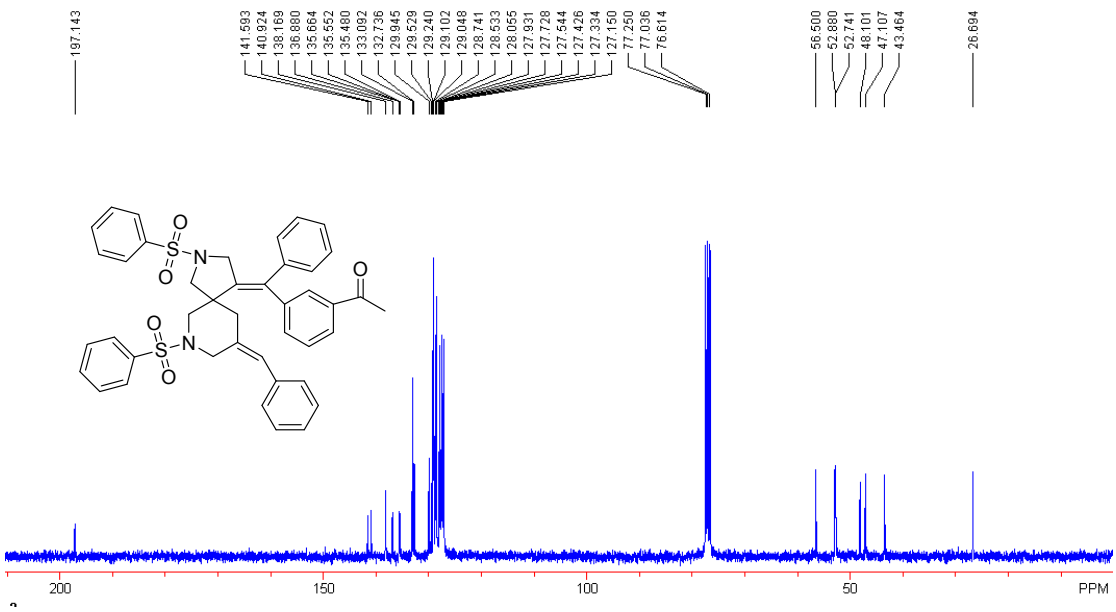
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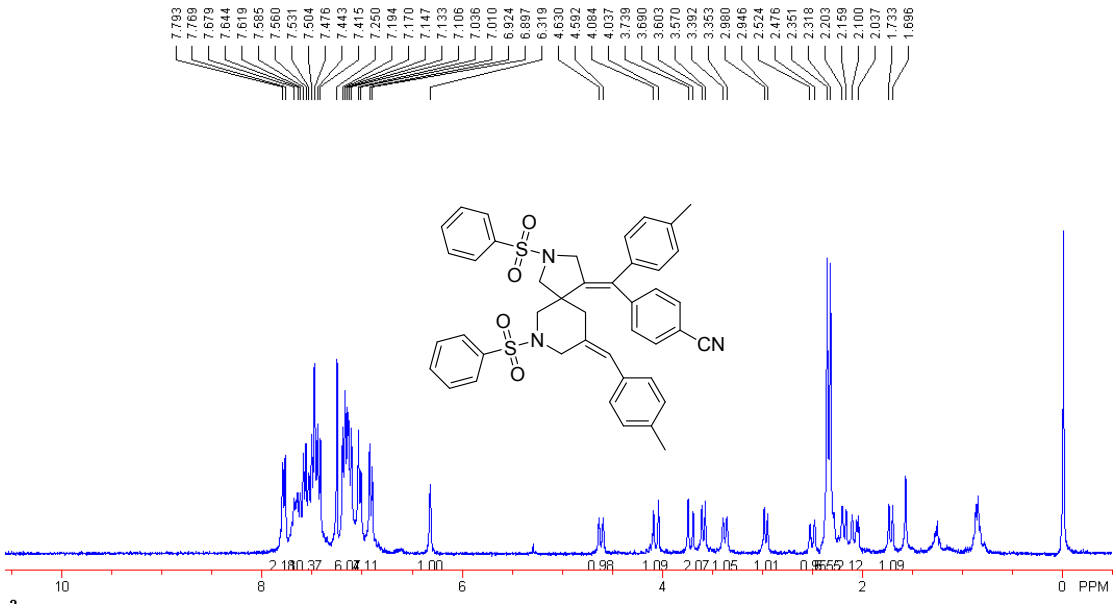
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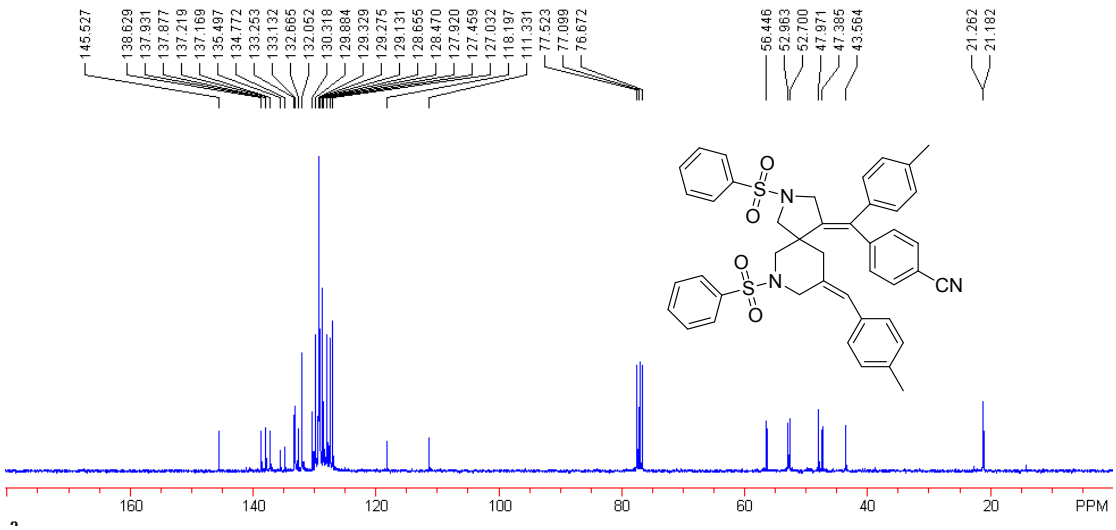
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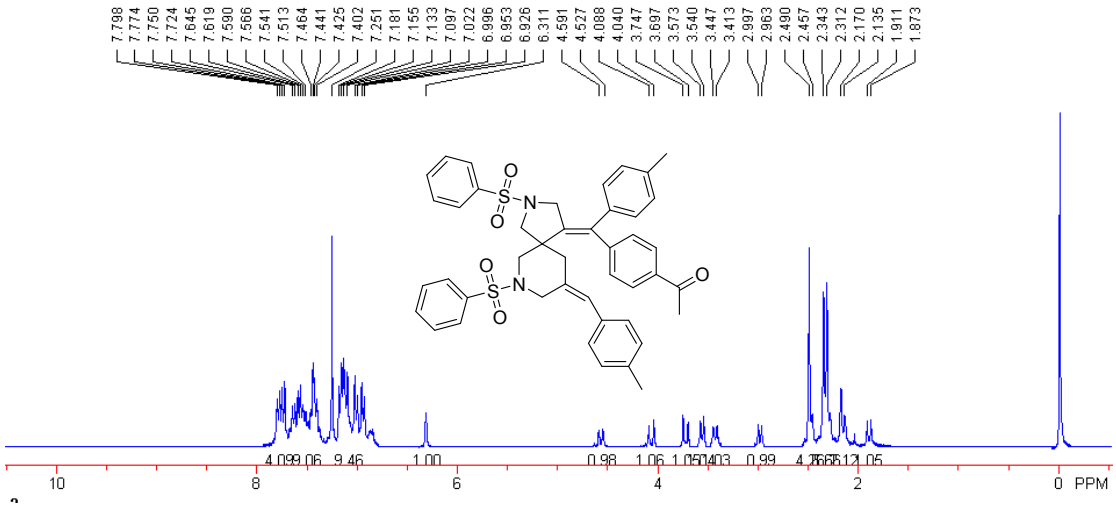
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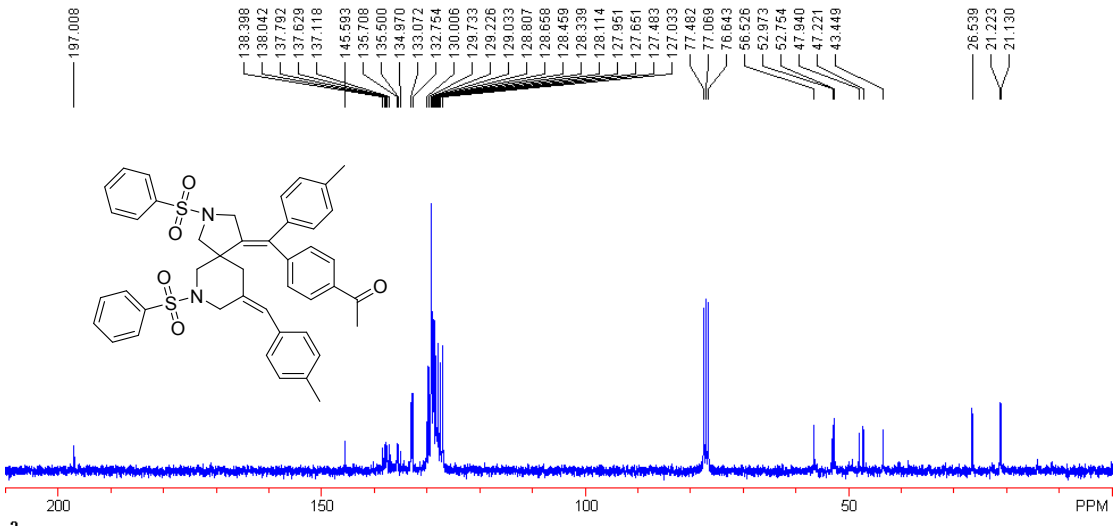
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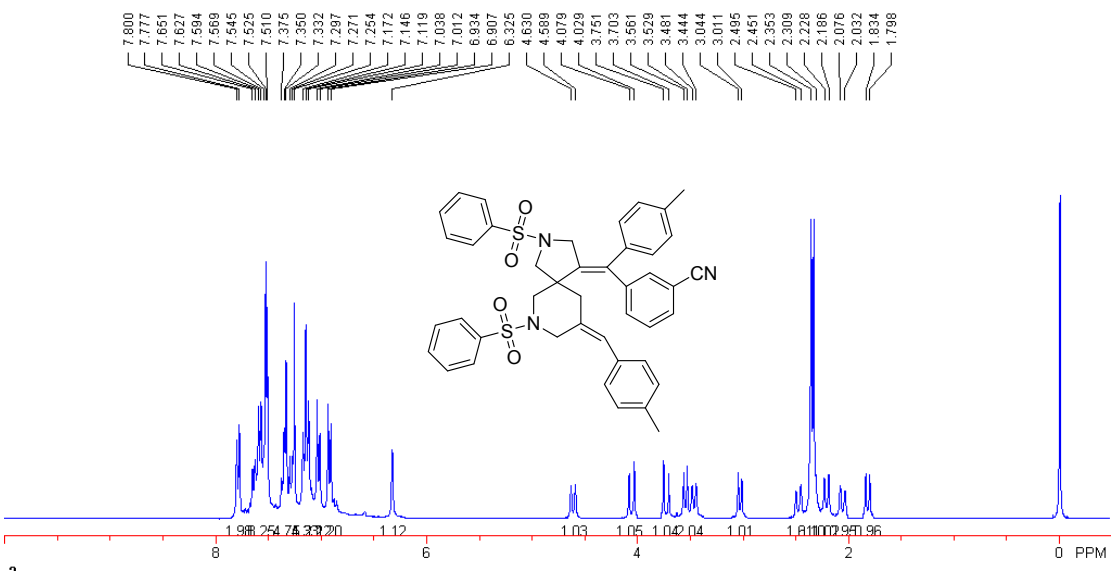
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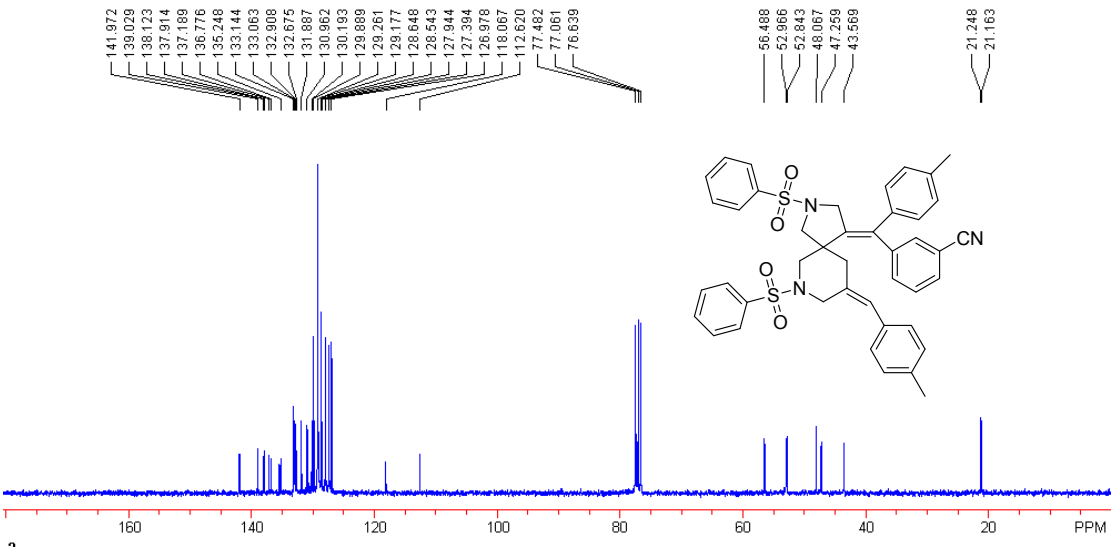
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80
60
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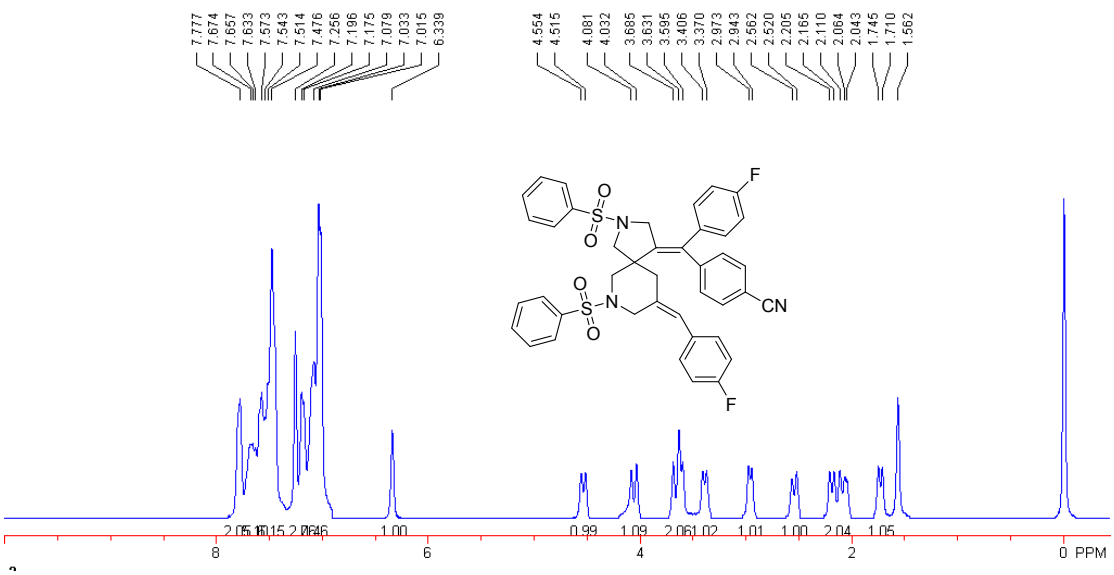
PPM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7.015
6.339
4.554
4.515
4.081
4.032
3.685
3.631
3.595
3.406
3.370
2.973
2.943
2.562
2.520
2.205
2.165
2.110
2.064
2.043
1.745
1.710
1.562
F
CN
F
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2.06
1.02
1.01
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2.04
1.05
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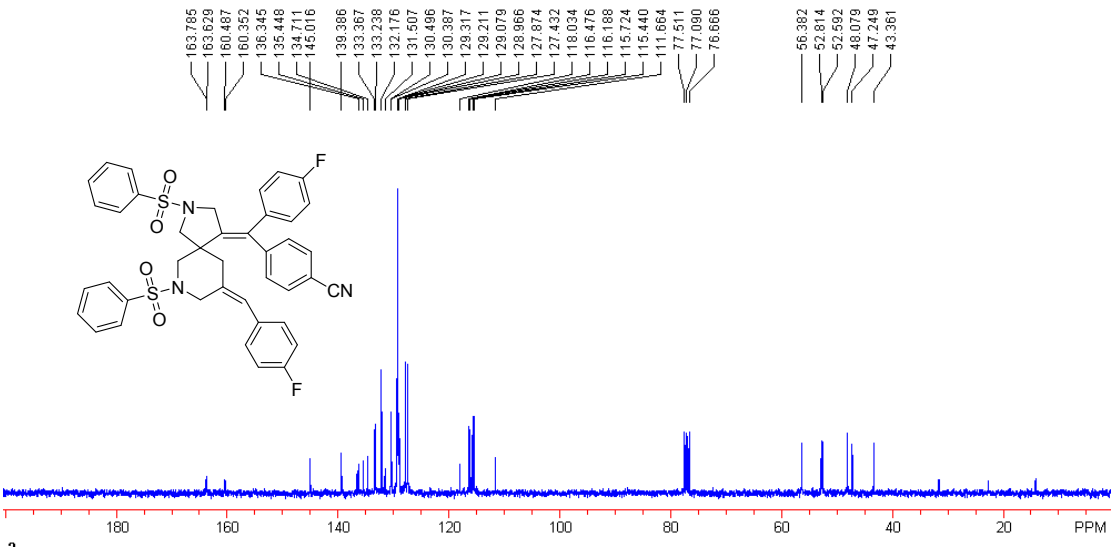
4
2
0 PPM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131.507
130.496
130.387
129.317
129.211
129.079
128.966
127.874
127.432
118.034
116.476
116.188
115.724
115.440
111.664
77.511
77.090
76.666
56.382
52.814
52.592
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47.249
43.361
F
CN
F
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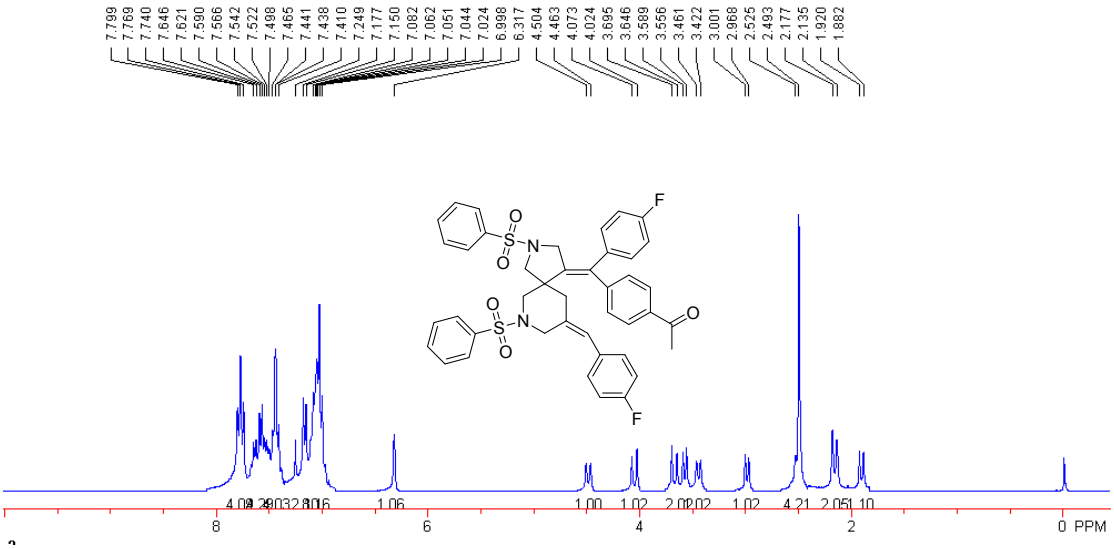
140
120
100
80
60
40
20
PPM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7.522
7.498
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7.438
7.410
7.249
7.177
7.150
7.082
7.062
7.051
7.044
7.024
6.998
6.317
4.504
4.463
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3.461
3.422
3.001
2.968
2.525
2.493
2.177
2.135
1.920
1.882
F
O
S
N
O
O
O
S
N
O
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1.10
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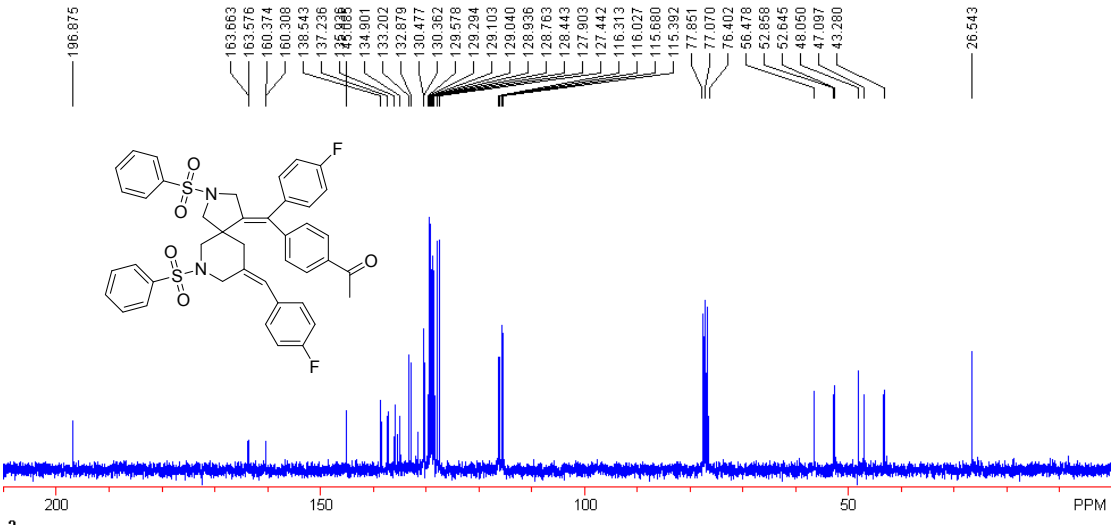
4
2
0 PPM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129.103
129.040
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128.763
128.443
127.903
127.442
116.313
116.027
115.680
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77.851
77.070
76.402
56.478
52.858
52.645
48.050
47.097
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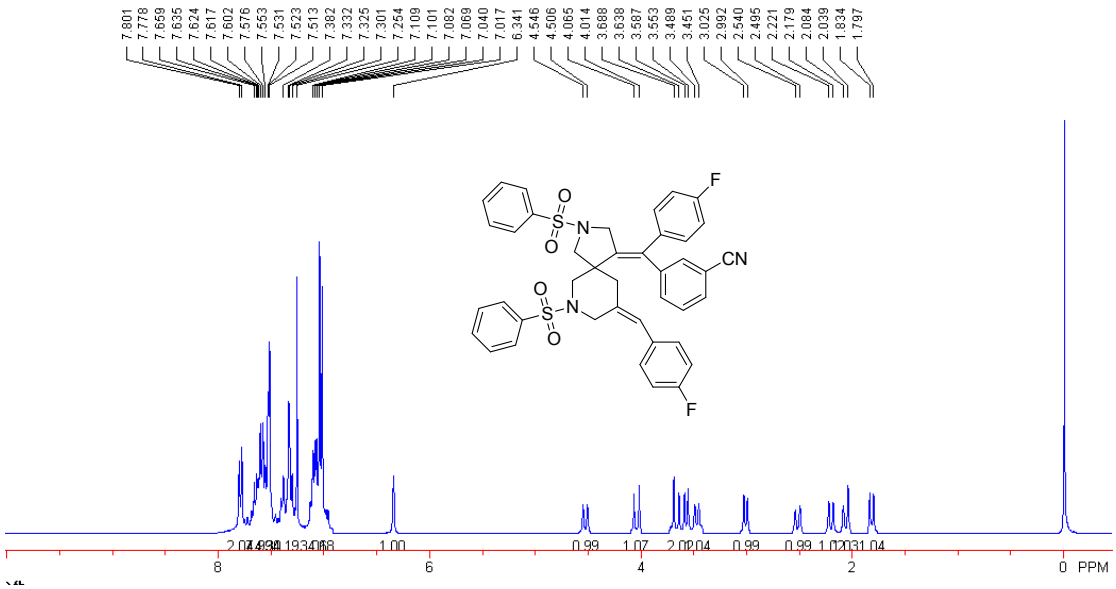
F
O
S
N
O
O
O
S
N
O
F
200
150
100
50
PPM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7.602
7.576
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7.531
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7.513
7.382
7.332
7.325
7.301
7.254
7.109
7.101
7.082
7.069
7.040
7.017
6.341
4.546
4.506
4.065
4.014
3.688
3.638
3.587
3.553
3.489
3.451
3.025
2.992
2.540
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2.221
2.179
2.084
2.039
1.834
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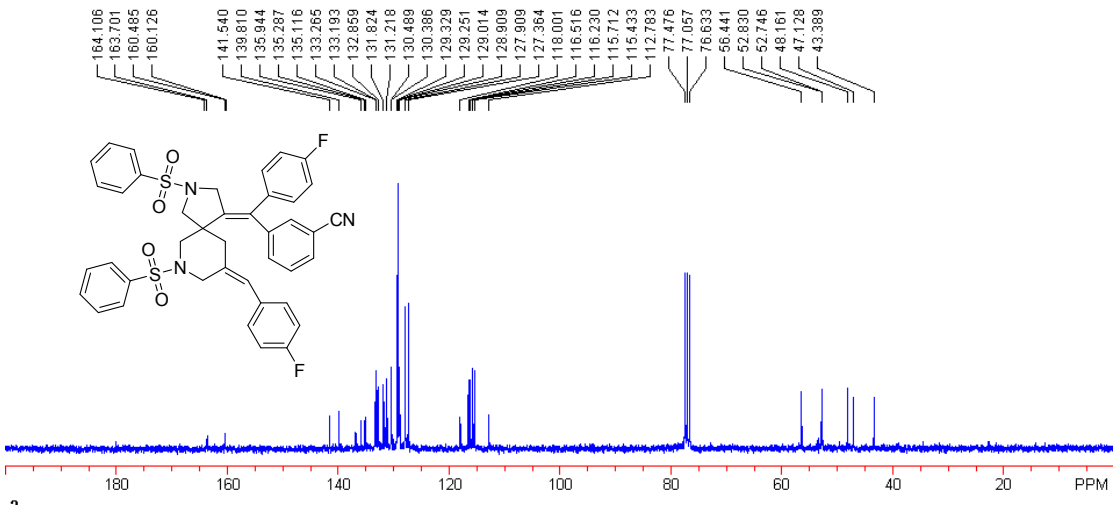
PPM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135.287
135.116
133.265
133.193
132.859
131.824
131.218
130.489
130.386
129.329
129.251
129.014
128.909
127.909
127.364
118.001
116.516
116.230
115.712
115.433
112.783
77.476
77.057
76.633
56.441
52.830
52.746
48.161
47.128
43.389
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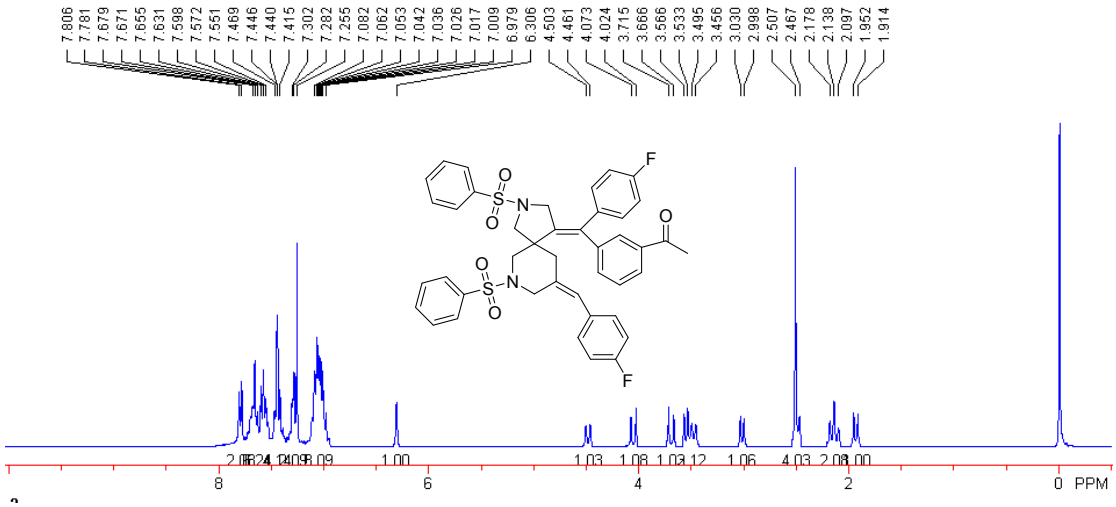
CN
F
180
160
140
120
100
80
60
40
20
PPM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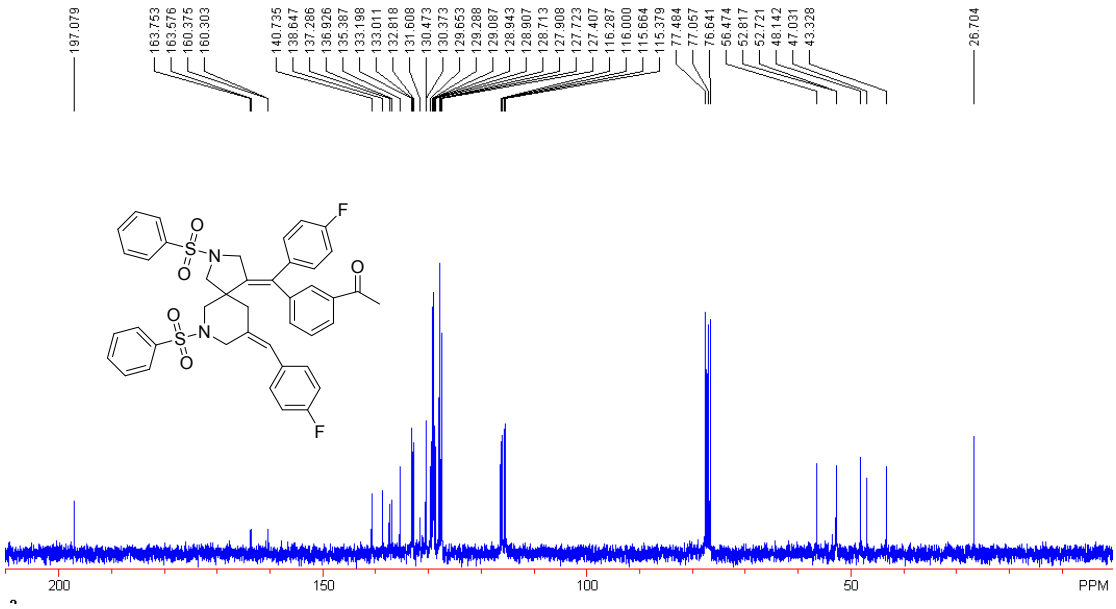
7.631
7.598
7.572
7.551
7.469
7.446
7.440
7.415
7.302
7.282
7.255
7.082
7.062
7.053
7.042
7.036
7.026
7.017
7.009
6.979
6.306
4.503
4.461
4.073
4.024
3.715
3.666
3.566
3.533
3.495
3.456
3.030
2.998
2.507
2.467
2.178
2.138
2.097
1.952
1.914
F
O
S
N
O
O
O
S
N
O
F
1.00
1.03
1.08
1.03
1.12
1.06
4.03
8.00
8
6
4
2
0
PPM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140.735
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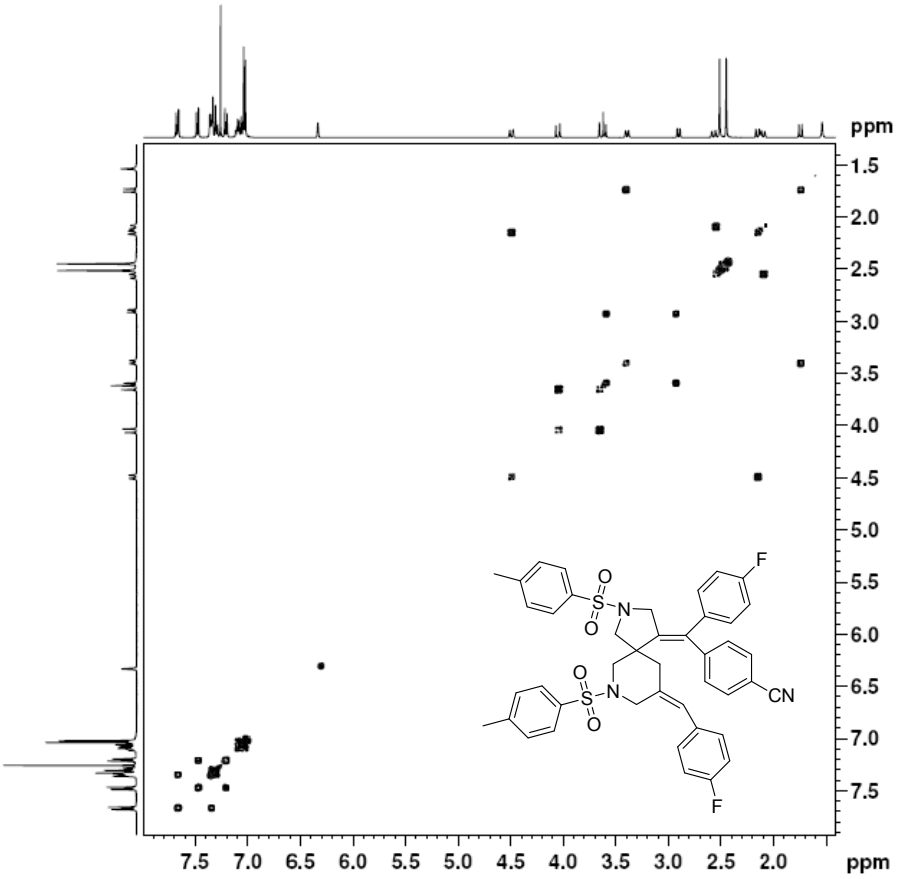
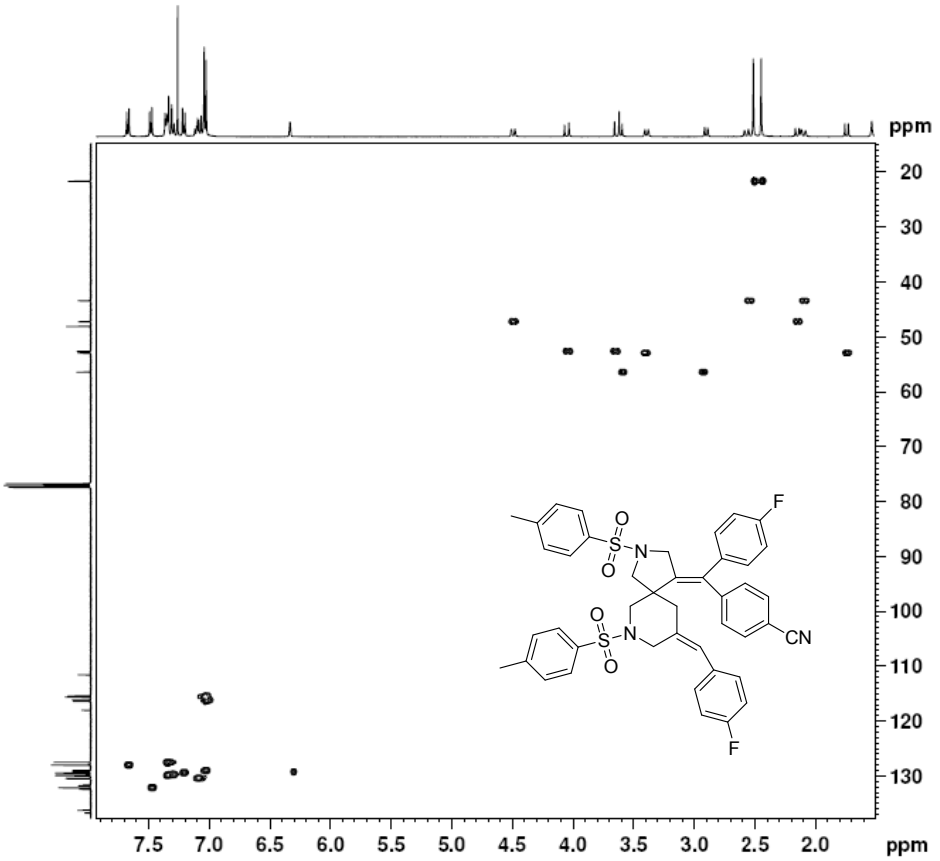
137.286
136.926
135.387
133.198
133.011
132.818
131.608
130.473
130.373
129.653
129.288
129.087
128.943
128.907
128.713
127.908
127.723
127.407
116.287
116.000
115.664
115.379
77.484
77.057
76.641
56.474
52.817
52.721
48.142
47.031
43.328
26.704
F
O
S
N
O
O
O
S
N
O
F
200
150
100
50
PPM

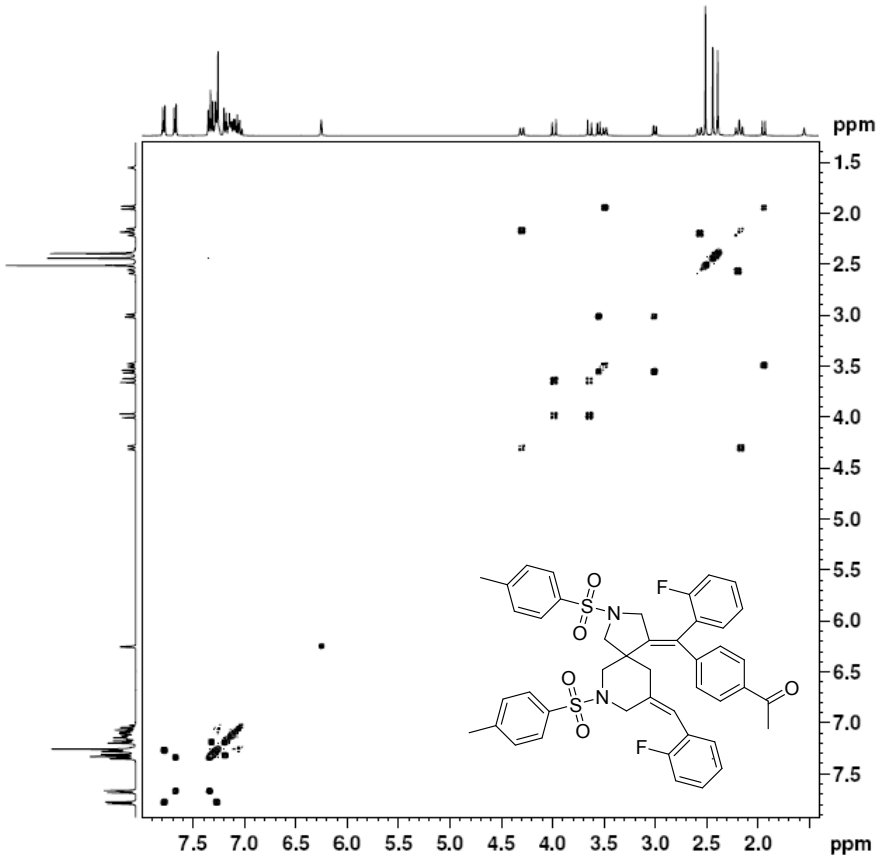
5. 2D COSY Spectra for ca and db



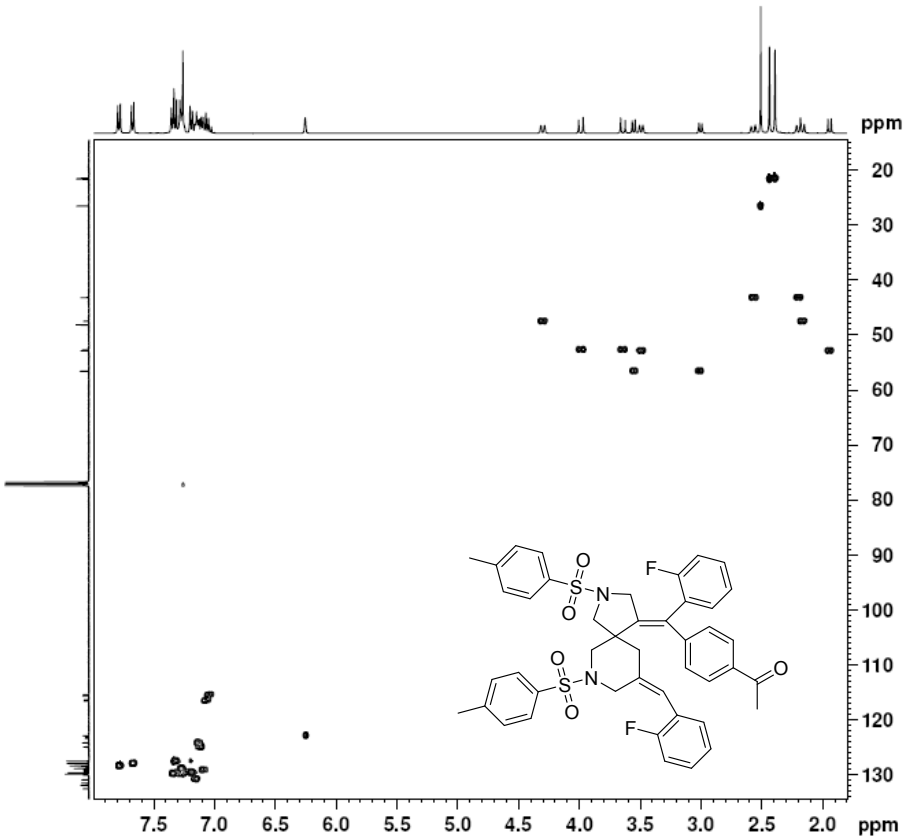

```
NAME          106W13_M_40
EXPNO                   3
PROCNO                  1
Date_            20130419
Time                20.11
INSTRUM             spect
PROBHD    5 mm PABBO BB-
PULPROG          cosygpqf
TD                   2048
SOLVENT              CDCl3
NS                      8
DS                      8
SWH              3546.099 Hz
FIDRES           1.731494 Hz
AQ               0.2888180 sec
RG                     57
DW                141.000 usec
DE                  6.50 usec
TE                 300.0 K
D0              0.00000300 sec
D1              1.38981700 sec
D13             0.00000400 sec
D16             0.00020000 sec
IN0             0.00028200 sec

-------- CHANNEL f1 --------
NUC1                   1H
P0                  12.80 usec
P1                  12.80 usec
PL1                 -1.00 dB
PL1W           17.70875549 W
SFO1           400.2315373 MHz

------ GRADIENT CHANNEL -----
GPNAM1           SINE.100
GPZ1                10.00 %
P16               1000.00 usec
ND0                     1
TD                    128
SFO1             400.2315 MHz
FIDRES           27.703901 Hz
SW                   8.860 ppm
FnMODE                 QF
SI                   1024
SF             400.2300127 MHz
WDW                  SINE
SSB                     0
LB                   0.00 Hz
GB                      0
PC                   1.40
SI                   1024
MC2                    QF
SF             400.2300127 MHz
WDW                  SINE
SSB                     0
LB                   0.00 Hz
GB                      0
```




```
NAME          106W13_M_40
EXPNO                   4
PROCNO                  1
Date_          20130419
Time              20.42
INSTRUM            spect
PROBHD   5 mm PABBO BB-
PULPROG        hsqcetgp
TD                  1024
SOLVENT             CDCl3
NS                    16
DS                    16
SWH            3546.099 Hz
FIDRES         3.462988 Hz
AQ             0.1444340 sec
RG                   203
DW              141.000 usec
DE                6.50 usec
TE               300.1 K
CNST2          145.0000000
D0              0.00000300 sec
D1              1.45146203 sec
D4              0.00172414 sec
D11             0.03000000 sec
D13             0.00000400 sec
D16             0.00020000 sec
IN0             0.00003000 sec
ZGOPTNS

======== CHANNEL f1 ========
NUC1                    1H
P1                   12.80 usec
P2                   25.60 usec
P28                   1.00 usec
PL1                  -1.00 dB
PL1W           17.70875549 W
SF01           400.2315373 MHz

======== CHANNEL f2 ========
CPDPRG2                 garp
NUC2                    13C
P3                   11.70 usec
P4                   23.40 usec
PCPD2                80.00 usec
PL2                   3.00 dB
PL12                 19.70 dB
PL2W           41.92221451 W
PL12W           0.89628094 W
SF02           100.6454196 MHz

====== GRADIENT CHANNEL =====
GPNAM1              SINE.100
GPNAM2              SINE.100
GPZ1                 80.00 %
GPZ2                 20.10 %
P16                1000.00 usec
MD0                     2
TD                    256
SF01            100.6454 MHz
FIDRES          65.120438 Hz
SW                165.639 ppm
FnMODE      Echo-Antiecho
SI                   1024
SF             400.2300127 MHz
WDW                  QSINE
SSB                     2
LB                   0.00 Hz
GB                      0
PC                   1.40
SI                   1024
WDW2        echo-antiecho
SF              100.6378140 MHz
WDW                  QSINE
SSB                     2
LB                   0.00 Hz
GB                      0
```



NAME	106W13_M_26
EXPNO	3
PROCNO	1
Date_	20130419
Time	13.47
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	cosygpqf
TD	2048
SOLVENT	CDCl3
NS	8
DS	8
SWH	2958.580 Hz
FIDRES	1.444619 Hz
AQ	0.3461620 sec
RG	64
DW	169.000 usec
DE	6.50 usec
TE	300.0 K
D0	0.00000300 sec
D1	1.33247304 sec
D13	0.00000400 sec
D16	0.00020000 sec
IN0	0.00033800 sec
-------- CHANNEL f1 --------	
NUC1	1H
P0	12.80 usec
P1	12.80 usec
PL1	-1.00 dB
PL1W	17.70875549 W
SFO1	400.2318812 MHz
------ GRADIENT CHANNEL -----	
GPNAM1	SINE.100
GPZ1	10.00 %
P16	1000.00 usec
ND0	1
TD	128
SFO1	400.2319 MHz
FIDRES	23.113905 Hz
SW	7.392 ppm
FnMODE	QF
SI	1024
SF	400.2300127 MHz
WDW	SINE
SSB	0
LB	0.00 Hz
GB	0
PC	1.40
SI	1024
MC2	QF
SF	400.2300127 MHz
WDW	SINE
SSB	0
LB	0.00 Hz
GB	0




```
NAME          106M13_M_26
EXPNO                   4
PROCNO                  1
Date_          20130419
Time                14.17
INSTRUM             spect
PROBHD   5 mm PABBO BB-
PULPROG         hsqcetgp
TD                   1024
SOLVENT              CDCl3
NS                     16
DS                     16
SWH              2958.580 Hz
FIDRES           2.889238 Hz
AQ               0.1731060 sec
RG                    203
DW                169.000 usec
DE                  6.50 usec
TE                 300.0 K
CNST2          145.0000000
D0               0.00000300 sec
D1               1.42279005 sec
D4               0.00172414 sec
D11              0.03000000 sec
D13              0.00000400 sec
D16              0.00020000 sec
IN0              0.00003000 sec
ZGOPTNS

======== CHANNEL f1 ========
NUC1                    1H
P1                   12.80 usec
P2                   25.60 usec
P28                   1.00 usec
PL1                  -1.00 dB
PLLW           17.70875549 W
SFO1          400.2318812 MHz

======== CHANNEL f2 ========
CPDPRG2               garp
NUC2                    13C
P3                   11.70 usec
P4                   23.40 usec
PCPD2                80.00 usec
PL2                   3.00 dB
PL12                 19.70 dB
PL2W          41.92221451 W
PL12W          0.89628094 W
SFO2          100.6454196 MHz

====== GRADIENT CHANNEL ======
GPNAM1             SINE.100
GPNAM2             SINE.100
GPZ1                 80.00 %
GPZ2                 20.10 %
P16                1000.00 usec
ND0                     2
TD                    256
SFO1           100.6454 MHz
FIDRES          65.120438 Hz
SW                165.639 ppm
FnMODE      Echo-Antiecho
SI                   1024
SF           400.2300127 MHz
WDW                 QSINE
SSB                     2
LB                   0.00 Hz
GB                      0
PC                   1.40
SI                   1024
WDW2        echo-antiecho
SF            100.6379140 MHz
WDW                 QSINE
SSB                     2
LB                   0.00 Hz
GB                      0
```