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TBAI-catalyzed selective synthesis of sulfonamides and *β*-aryl sulfonyl Enamines: coupling of arenesulfonyl chlorides and sodium sulfinates with *tert*-amines

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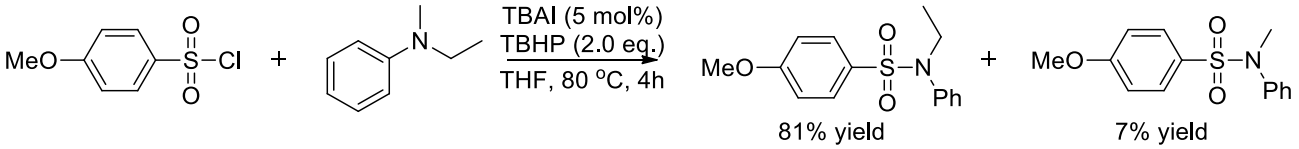
Contents of Supporting Information:

1. General Information

All reactions were carried out in anhydrous solvent using commercially available reagents that were purchased and used as received. Analytical thin layer chromatography (TLC) was performed on pre-coated 0.25 mm thick silica gel 60-F_{254} plates (*Merck* or *Whatman PE SIL G/UV*); visualized using U V light and by treatment with a $KMnO_4$, followed by heating. All compounds were purified by flash chromatography using silica gel 100-200 (Greagent G72651J) and gave spectroscopic data consistent with being ≥95% the assigned structure. ^{1}H NMR and ^{13}C NMR spectra were recorded on a *Bruker Avance 400* spectrometer in $CDCl_3$ at ambient temperature; chemical shifts (δ) are given in ppm and calibrated using the signal of residual undeuterated solvent as internal reference (δ_H = 7.26 ppm and δ_C = 77.16 ppm). IR spectra were recorded on an Agilent Technologies Cary 630 FT-IR (ATR) or P erkin-Elmer FT-IR Spectrum 100 (ATR) spectrometer; wavenumbers (ν) are given in cm^{-1}.

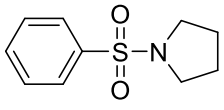
The reaction of *N*-methyl-*N*-ethyl aniline with 4-methoxybenzenesulfonyl chloride

Using *N*-methyl-*N*-ethyl aniline as the substrate, we examined the regioselectivity and generality of this reaction. As shown in Scheme S1, the reaction of 4-methoxybenzenesulfonyl chloride with *N*-methyl-*N*-ethyl aniline gave a mixture of sulfonamides in THF.



Scheme S1, The reaction of 4-methoxybenzenesulfonyl chloride with N-methyl-N-ethyl aniline

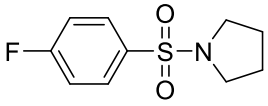
2. Spectral Data for the Spectral Data for the sulfonamides 3a-r and 4a-h



1-(phenylsulfonyl)pyrrolidine(3a)[a]

Color and State: Yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.0 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.54 (t, *J* = 8.0 Hz, 2H), 3.24 (t, *J* = 8.0 Hz, 4H), 1.74 (t, *J* = 4.0 Hz, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 136.7, 132.6, 129.0, 127.3, 47.9, 25.1.
IR (Neat): 3055, 2850, 1311, 1149, 720 cm^{-1}
MS: m/z $C_{10}H_{13}NO_2S$ 211.3 (M+)



1-((4-fluorophenyl)sulfonyl)pyrrolidine (3b)[b]

Color and State: White solid. m.p. 67-68 ^{o}C

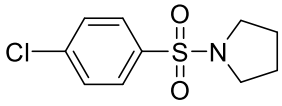
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79-7.76 (m, 2H), 7.14 (t, *J* = 8.0 Hz, 2H), 3.15 (t, *J* = 8.0 Hz, 4H), 1.78 (t, J = 4.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 163.8, 133.1, 133.0, 130.1, 130.0, 116.3, 116.1, 47.9, 25.2.

^{19}F NMR (376 MHz, $CDCl_3$) δ -105.6.

IR (Neat): 2963, 2858, 1347, 1159, 1112, 721 cm^{-1}

MS: m/z $C_{10}H_{12}FNO_2S$ 229.3 (M+)



1-((4-chlorophenyl)sulfonyl)pyrrolidine (3c)[c]

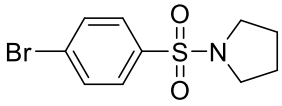
Color and State: Brown solid. m.p. 78-79 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 2H), 3.15 (t, *J* = 4.0 Hz, 4H), 1.69 (s, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 138.9, 135.4, 129.3, 128.8, 47.9, 25.2.

IR (Neat): 2977, 2865, 1454, 1350, 1161, 720 cm^{-1}

MS: m/z $C_{10}H_{12}ClNO_2S$ 245.7 (M+)



1-((4-bromophenyl)sulfonyl)pyrrolidine (3d)[c]

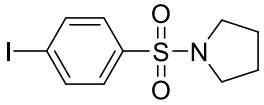
Color and State: White solid. m.p. 102-104 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63-7.58 (m, 4H), 3,15 (t, *J* = 8.0 Hz, 4H), 1.70 (d, *J* = 4.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 136.0, 132.3, 128.9, 127.5, 47.9, 25.2.

IR (Neat): 2982, 1448, 1334, 1162, 761 cm^{-1}

MS: m/z $C_{10}H_{12}BrNO_2S$ 290.2 (M+)



1-((4-iodophenyl)sulfonyl)pyrrolidine (3e)[d]

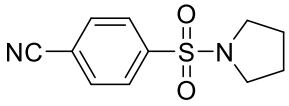
Color and State: Yellow solid. m.p. 141-143 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 4.0 Hz, 2H), 7.46 (d, *J* = 8.0 Hz, 2H), 3.15 (t, *J* = 8.0 Hz, 4H), 1.69 (d, *J* = 8.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 138.2, 136.6, 128.8, 99.9, 47.9, 25.2.

IR (Neat): 2954, 2856, 1472, 13647, 1165, 728 cm^{-1}

MS: m/z $C_{10}H_{12}INO_2S$ 337.2 (M+)



4-(pyrrolidin-1-ylsulfonyl)benzonitrile (3f)

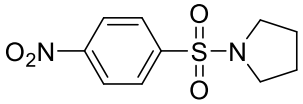
Color and State: White solid. m.p. 111-113 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.0 Hz, 2H), 7.88 (d, *J* = 8.0 Hz, 2H), 3.28 (s, 4H), 1.8 (d, *J* = 2.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 141.2, 132.9, 127.9, 117.4, 116.1, 48.0, 25.2.

IR (Neat): 2953, 2862, 1488, 1456, 1165, 845 cm^{-1}

HRMS(ESI):Cald for $C_{11}H_{13}N_2O_2S[MH]^+$:m/z 237.0692; found: 237.0688.



1-((4-nitrophenyl)sulfonyl)pyrrolidine (3g)[e]

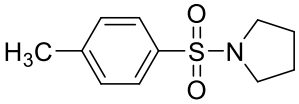
Color and State: White solid. m.p. 131-132 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, *J* = 12.0 Hz, 2H), 8.04 (d, *J* = 8.0 Hz, 2H), 3.30 (t, *J* = 8.0 Hz, 4H), 1.83 (t, *J* = 8.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 150.1, 143.1, 128.6, 124.4, 48.1, 25.4.

IR (Neat): 2974, 2936, 1600, 1518, 1465, 1349, 1152, 771cm^{-1}

MS: m/z $C_{10}H_{12}N_2O_4S$ 256.3 (M+)



1-tosylpyrrolidine (3h)[a]

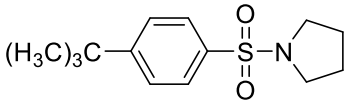
Color and State: White solid. m.p. 133-134 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 3.22 (t, *J* = 8.0 Hz, 4H), 2.43 (s, 3H), 1.75 (d, *J* = 4.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.3, 133.8, 129.6, 127.5, 47.9, 25.1, 21.4.

IR (Neat): 3010, 2845, 1456, 1327, 729 cm^{-1}

MS: m/z $C_{11}H_{15}NO_2S$ 225.3 (M+)



1-((4-(tert-butyl)phenyl)sulfonyl)pyrrolidine (3i)[f]

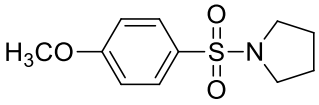
Color and State: White solid. m.p. 138-139 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 4.0 Hz, 2H), 7.53 (d, *J* = 8.0 Hz, 2H), 3.25 (s, 4H), 1.76 (d, *J* = 1.6 Hz, 4H), 1.35 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 133.8, 127.4, 126.0, 47.9, 35.1, 31.1, 25.2.

IR (Neat): 3010, 2838, 1448, 1325, 725 cm^{-1}

MS: m/z $C_{14}H_{21}NO_2S$ 267.4 (M+)



1-((4-methoxyphenyl)sulfonyl)pyrrolidine (3j)[a]

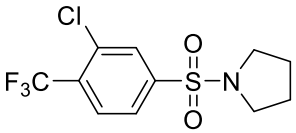
Color and State: White solid. m.p. 165-166 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.87 (s, 3H), 3.21 (s, 4H), 1.74 (d, *J* = 1.6 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 129.4, 128.2, 114.1, 55.5, 47.8, 25.0.

IR (Neat): 2975, 2853, 1454, 1347, 1162, 719 cm^{-1}

MS: m/z $C_{11}H_{15}NO_3S$ 241.3 (M+)



1-((3-chloro-4-(trifluoromethyl)phenyl)sulfonyl)pyrrolidine (3k)

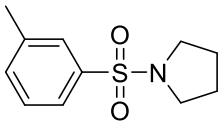
Color and State: Yellow solid. m.p. 87-89 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 1.95 (d, *J* = 8.0 Hz, 1H), 1.71 (d, *J* = 12.0 Hz, 1H), 3.17 (t, *J* =8.0 Hz, 4H), 1.85 (d, *J* =4.0 Hz, 4H).

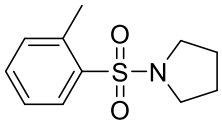
^{13}C NMR (101 MHz, $CDCl_3$) δ 137.1, 136.8, 132.5, 131.6, 129.6, 129.3, 126.7, 126.7, 126.6, 126.6, 123.5, 120.8, 48.1, 25.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ -63.0.

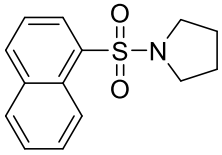
IR (Neat): 2929, 1405, 1323, 1134, 711 cm^{-1}
HRMS(ESI):Cald for $C_{11}H_{12}ClF3NO_2S[MH]^+$:m/z 314.0224; found: 314.0222.



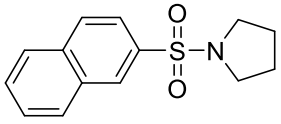
1-(m-tolylsulfonyl)pyrrolidine (3l)
Color and State: Brown solid. m.p. 134-135 ^oC
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.0 Hz, 2H), 7.41 (t, *J* = 12.0 Hz, 2H), 3.24 (s, 4H), 2.43 (s, 3H), 1.75 (s, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 139.14, 136.55, 133.42, 128.87, 127.79, 124.58, 47.92, 25.18, 21.37.
IR (Neat): 2971, 2852, 1451, 1346, 1165, 721cm^{-1}
HRMS(ESI):Cald for $C_{11}H_{16}NO_2S[MH]^+$:m/z 226.0896; found: 226.0892.



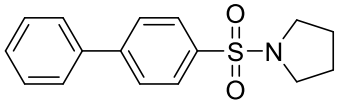
1-(o-tolylsulfonyl)pyrrolidine (3m)
Color and State: Yellow oil.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.0 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 1H), 7.31 (t, *J* = 4.0 Hz, 2H), 3.30 (t, *J* = 4.0 Hz, 4H), 2.64 (s, 3H), 1.89 (m, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 137.8, 137.0, 132.6, 129.4, 127.5, 126.0, 47.3, 25.5, 20.6.
IR (Neat): 2980, 2857, 1455, 1346, 723 cm^{-1}
MS: m/z $C_{11}H_{15}NO_2S$ 225.3 (M+)



1-(naphthalen-1-ylsulfonyl)pyrrolidine (3n)[g]
Color and State: White solid. m.p. 79-81 ^oC
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, *J* = 12.0 Hz, 1H), 8.09 (d, *J* = 4.0 Hz, 1H), 1.90 (d, *J* = 8.0 Hz, 1H), 7.87 (d, *J* = 8.0 Hz, 1H), 7.51 (t, *J* = 8.0 Hz, 1H), 7.45-7.37 (m, 2H), 3,21 (t, *J* = 8.0 Hz, 4H), 1.65 (t, *J* = 4.0 Hz, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 134.3, 134.1, 133.8, 129.5, 129.0, 128.8, 127.9, 126.7, 125.2, 124.1, 47.5, 25.4.
IR (Neat): 2970, 2864, 1367, 1151, 726 cm^{-1}
MS: m/z $C_{14}H_{15}NO_2S$ 261.3 (M+)



1-(naphthalen-2-ylsulfonyl)pyrrolidine (3o)[g]
Color and State: White solid. m.p. 106-107 ^oC
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (s, 1H), 7.97 (d, *J* = 8.0 Hz, 2H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.84 (d, *J* = 8.0 Hz, 1H), 7.64-7.58 (m, 2H), 3.30 (s, 4H), 1.71 (s, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 134.69, 133.85, 132.07, 129.19, 129.09, 128.60, 128.58, 127.82, 127.44, 122.83, 47.96, 25.16.
IR (Neat): 2955, 2860, 1367, 1150, 723 cm^{-1}
MS: m/z $C_{14}H_{15}NO_2S$ 261.3 (M+)



1-([1,1'-biphenyl]-4-ylsulfonyl)pyrrolidine (3p)

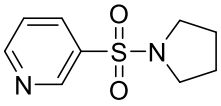
Color and State: White solid. m.p. 139-141 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 8.0 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.46 (t, *J* = 8.0 Hz, 2H), 7.40 (d, *J* = 8.0 Hz, 1H), 3.27 (t, *J* = 8.0 Hz, 4H), 1.75 (t, *J* = 8.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.3, 139.1, 135.4, 129.0, 128.4, 128.0, 127.5, 127.2, 47.9, 25.2.

IR (Neat): 2955, 2846, 1355, 1156, 760 cm^{-1}

HRMS(ESI):Cald for $C_{16}H_{18}NO_2S[MH]^+$:m/z 288.1053; found: 288.1048.



3-(pyrrolidin-1-ylsulfonyl)pyridine (3q)[h]

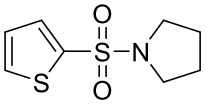
Color and State: Yellow solid. m.p. 75-76 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.97 (s, 1H), 8.76 (d, *J* = 4.0 Hz, 1H), 8.06 (d, *J* = 8.0 Hz, 1H), 7.46 (t, *J* = 8.0 Hz, 1H), 3.20 (t, *J* =8.0 Hz, 4H), 1.72 (s, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 153.06, 147.86, 134.92, 133.60,123.78, 47.84, 25.13.

IR (Neat): 3052, 2976, 2839, 1426, 1151, 746 cm^{-1}

MS: m/z $C_9H_{12}N_2O_2S$ 212.3 (M+)



1-(thiophen-2-ylsulfonyl)pyrrolidine (3r)

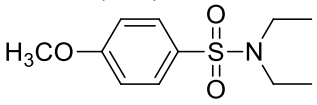
Color and State: Brown solid. m.p. 75-77 ^{o}C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 4.0 Hz,1H), 7.59 (d, *J* = 4.0 Hz, 1H), 7.16 (t, *J* = 4.0 Hz, 1H), 3.29 (t, *J* = 8.0 Hz, 4H), 1.77 (t, *J* = 8.0 Hz, 4H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 136.6, 132.0, 131.7, 127.5, 48.2, 25.2.

IR (Neat): 3114, 1964, 1334, 1150 1017, 742 cm^{-1}

HRMS(ESI):Cald for $C_8H_{12}NO_2S_2[MH]^+$:m/z 218.0304; found: 218.0300.



***N*,*N*-diethyl-4-methoxybenzenesulfonamide (4a)**[j]

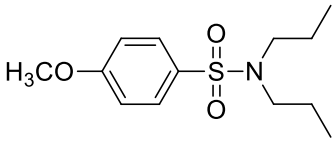
Color and State: Yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 8.0 Hz, 2H), 6.96 (d, *J* = 8.0 Hz, 2H), 3.86 (s, 3H), 3.24-3.19 (m, 4H), 1.12 (t, *J* = 8.0 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7, 132.1, 129.2, 114.2, 55.7, 42.0, 14.2.

IR (Neat): 2978, 2942, 1498, 1324, 1156, 736 cm^{-1}

MS: m/z $C_{11}H_{17}NO_3S$ 243.3 (M+)



4-methoxy-*N*,*N*-dipropylbenzenesulfonamide (4b)

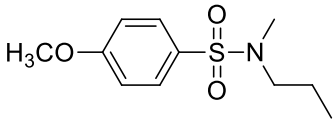
Color and State: Yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.0 Hz, 2H), 6.97 (d, *J* = 8.0 Hz, 2H), 3.86 (s, 3H), 3.05 (t, *J* = 8.0 Hz, 4H), 1.57-1.52 (m, 4H), 0.87 (t, *J* = 8.0 Hz ,6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.6, 131.7, 129.1, 114.1, 50.0, 32.9, 22.0, 11.2.

IR (Neat): 2980, 2942, 1495, 1340, 1156, 736 cm^{-1}

HRMS(ESI):Cald for $C_{13}H_{22}NO_3S[MH]^+$:m/z 272.1315; found: 272.1311.



4-methoxy-*N*-methyl-*N*-propylbenzenesulfonamide (4c)

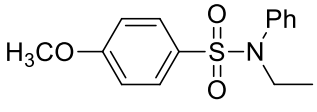
Color and State: Yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 2H), 6.90 (d, *J* = 8.0 Hz, 2H), 3.76 (s, 3H), 2.84 (t, *J* = 8.0 Hz, 2H), 2.59 (s, 3H), 1.49-1.40 (m, 2H), 0.82 (t, *J* = 4.0 Hz, 3H)

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.7, 129.3, 129.1, 114.1, 55.5, 51.7, 34.5, 20.8, 11.0.

IR (Neat): 2984, 2940, 1498, 1145, 737cm^{-1}

HRMS(ESI):Cald for $C_{11}H_{18}NO_3S[MH]^+$:m/z 244.1002; found: 244.1002.



***N*-ethyl-4-methoxy-*N*-phenylbenzenesulfonamide (4d)**

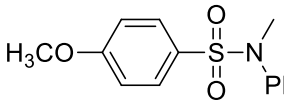
Color and State: Brown oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 4.0 Hz, 3H), 7.05 (d, *J* = 8.0 Hz, 2H), 6.91 (d, *J* = 8.0 Hz, 2H), 3.86 (s, 3H), 3.62-3.57 (m, 2H), 1.07 (t, *J* = 8.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.9, 139.1, 130.3, 129.9, 129.1, 129.1, 127.9, 114.0, 55.7, 45.6, 14.1.

IR (Neat): 3025, 1446, 1341, 1166, 741 cm^{-1}

HRMS(ESI):Cald for $C_{15}H_{18}NO_3S[MH]^+$:m/z 292.1002; found: 292.1000.



4-methoxy-*N*-methyl-*N*-phenylbenzenesulfonamide (4e)

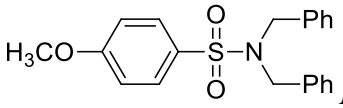
Color and State: Brown oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.0 Hz, 2H), 7.24-7.16 (m, 3H), 7.03 (d, *J* = 8.0 Hz, 2H), 6.83 (d, *J* = 8.0 Hz, 2H), 3.78 (s, 3H), 3.08 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1, 141.8, 130.1, 128.9, 128.3, 127.4, 126.8, 114.0, 55.7, 38.2.

IR (Neat): 3020, 1449, 1340, 1162, 732 cm^{-1}

HRMS(ESI):Cald for $C_{14}H_{16}NO_3S[MH]^+$:m/z 278.0845; found: 278.0840.



***N*,*N*-dibenzyl-4-methoxybenzenesulfonamide (4f)**

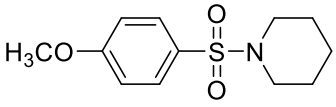
Color and State: Yellow solid. m.p. 63-65 ^oC

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.27 (d, *J* = 8.0 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 7.13 (s, 3H), 6.99 (s, 4H), 6.89 (d, *J* = 8.0 Hz, 2H), 4.23 (s, 4H), 3.80 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.9, 135.9, 132.5, 129.4, 128.7, 128.5, 127.7, 114.3, 55.8, 50.6.

IR (Neat): 2994, 1456, 1346, 1166, 723 cm^{-1}

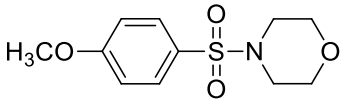
MS: m/z $C_{21}H_{21}NO_3S$ 367.5 (M+)



1-((4-methoxyphenyl)sulfonyl)piperidine (4g)[k]

Color and State: Brown solid. m.p. 105-108 ^oC

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.87 (s, 3H), 2.95 (t, *J* = 4.0 Hz, 4H), 1.63 (t, *J* = 4.0 Hz, 4H),1.42 (d,*J* = 4.0 Hz ,2H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 129.6, 127.6, 114.1, 55.6, 46.9, 25.1, 23.4.
IR (Neat): 3055, 2855, 1440, 1320, 1050, 763 cm^{-1}
MS: m/z $C_{12}H_{17}NO_3S$ 255.3 (M+)

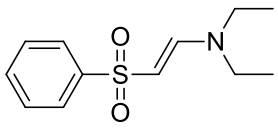


4-((4-methoxyphenyl)sulfonyl)morpholine (4h)[k]

Color and State: Brown solid. m.p. 155-156 °C

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.02 (d, *J* = 8.0 Hz, 2H), 3.88 (s, 3H), 3.73 (s, 4H), 2.97 (s, 4H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 163.2, 129.9, 126.4, 114.3, 66.0, 55.6, 46.0.
IR (Neat): 2921, 2856, 1449, 1350, 1169, 935 cm^{-1}
MS: m/z $C_{11}H_{15}NO_4S$ 257.3 (M+)

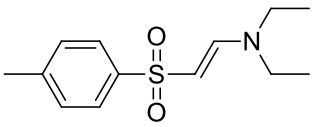
3. Spectral Data for the β-aryl sulfonyl Enamines 5a-o



(*E*)-*N*,*N*-diethyl-2-(phenylsulfonyl)ethenamine (5a)[j]

Color and State: white solid. m.p. 45-46 °C

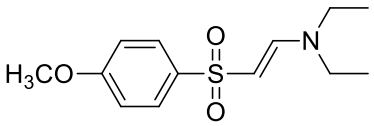
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86-7.85 (m, 2H), 7.47-7.46 (m, 3H), 7.32 (d, *J* = 12.6 Hz, 1H), 4.91 (d, *J* = 12.6 Hz, 1H), 3.24 (broad doublet, 4H), 1.15 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.2, 145.4, 131.6, 128.9, 126.2, 91.3, 50.2, 42.5,14.6, 11.2.
IR (Neat): 3069, 2977, 2936, 2875, 1614, 1452, 1468 cm^{-1}
MS: m/z $C_{12}H_{17}NO_2S$ 239.3 (M+)



(*E*)-*N*,*N*-diethyl-2-tosylethen-1-amine (5b)[j]

Color and State: Brown oil.

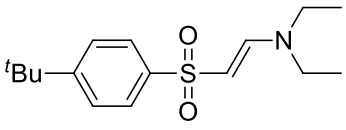
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.0 Hz, 2H), 7.20-7.16 (m, 3H), 4.82 (d, *J* = 12.7 Hz, 1H), 3.08 (broad doublet, 4H), 2.31 (s, 3H), 1.06 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 148.8, 142.6, 142.1, 129.5, 126.2, 91.8, 50.0, 42.6, 21.5, 14.6, 11.5.
IR (Neat): 3076, 2977, 2935, 2876, 1617, 1493, 1450 cm^{-1}
MS: m/z $C_{13}H_{19}NO_2S$ 253.4 (M+)



(*E*)-*N*,*N*-diethyl-2-((4-methoxyphenyl)sulfonyl)ethen-1-amine (5c)[j]

Color and State: Brown oil.

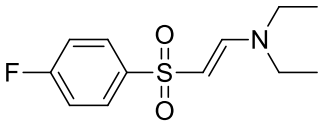
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 12.7 Hz, 1H), 6.97 (d, *J* = 8.0 Hz, 2H), 4.93 (d, *J* = 12.7 Hz, 1H), 3.88 (s, 3H), 3.17 (broad doublet, 4H), 1.18 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 162.1, 148.6, 137.4, 128.3, 114.0, 92.1, 55.6, 50.1, 42.8, 14.8, 13.8.
IR (Neat): 3069, 2975, 2934, 2872, 1612, 1495, 1460 cm^{-1}
MS: m/z $C_{13}H_{19}NO_3S$ 269.4 (M+)



(*E*)-2-((4-(tert-butyl)phenyl)sulfonyl)-*N*,*N*-diethylethen-1-amine (5d)[j]

Color and State: Brown oil.

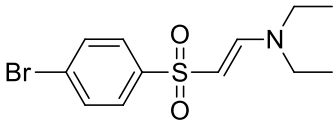
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 8.0 Hz, 2H), 7.21 (d, *J* = 12.7 Hz, 1H), 4.84 (d, *J* = 12.7 Hz, 1H), 3.11 (broad doublet, 4H), 1.26 (s, 9H), 1.08 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 155.2, 148.9, 142.4, 126.1, 125.9, 91.7, 50.0, 42.8, 35.1, 31.3, 14.8, 11.3.
IR (Neat): 3077, 2982, 2932, 2870, 1613, 1494, 1456 cm^{-1}
MS: m/z $C_{16}H_{25}NO_2S$ 295.4 (M+)



(*E*)-*N*,*N*-diethyl-2-((4-fluorophenyl)sulfonyl)ethen-1-amine (5e)[j]

Color and State: Brown oil.

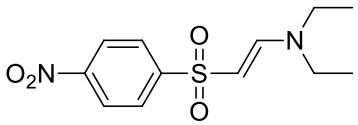
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79-7.76 (dd, *J* = 8.0 Hz, *J* = 4.0 Hz, 2H), 7.24 (d, *J* = 12.6 Hz, 1H), 7.05 (t, *J* = 8.0 Hz, 2H), 4.81 (d, *J* = 12.6 Hz, 1H), 3.10 (broad doublet, 4H), 1.13 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 165.7, 163.2, 149.2, 141.6, 128.2, 128.7, 116.0, 115.8, 91.1, 49.9, 43.0, 14.7, 11.0.
^{19}F NMR (376 MHz, $CDCl_3$) δ -107.7.
IR (Neat): 3073, 2979, 2934, 2881, 1615, 1493, 1469 cm^{-1}
MS: m/z $C_{12}H_{16}FNO_2S$ 257.3 (M+)



(*E*)-2-((4-bromophenyl)sulfonyl)-*N*,*N*-diethylethen-1-amine (5f)[j]

Color and State: Brown solid. m.p. 75-76 °C

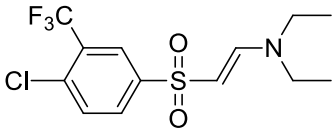
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.0 Hz, 2H), 7.51 (d, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 12.7 Hz,1H), 4.80 (d, *J* = 12.7 Hz,1H), 3.18 (broad doublet, 4H), 1.12 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.4, 144.6, 132.1, 127.9, 126.2, 90.9, 50.2, 42.8, 14.8, 11.2.
IR (Neat): 3069, 2969, 2920, 2850, 1610, 1569 cm^{-1}
MS: m/z $C_{12}H_{16}BrNO_2S$ 318.2 (M+)



(*E*)-*N*,*N*-diethyl-2-((4-nitrophenyl)sulfonyl)ethen-1-amine (5g)[l]

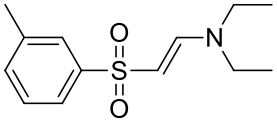
Color and State: Yellow solid. m.p. 111-112 °C

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.0 Hz, 2H), 7.95, (d, *J* = 8.0 Hz, 2H), 7.27 (d, *J* = 12.7 Hz, 1H), 4.82 (d, *J* = 12.7 Hz, 1H), 3.15 (broad doublet, 4H), 1.13 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 151.4, 150.4, 149.4, 127.4, 124.3, 89.8, 50.5, 43.0, 14.8, 11.2.
IR (Neat): 3364, 2920, 1535, 1348, 1147 cm^{-1}
MS: m/z $C_{12}H_{16}N_2O_4S$ 284.3 (M+)



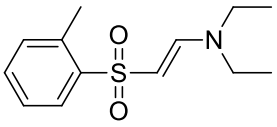
(*E*)-2-((4-chloro-3-(trifluoromethyl)phenyl)sulfonyl)-*N*,*N*-diethylethen-1-amine (5h)
Color and State: Brown solid. m.p. 90-91 ^oC

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.88 (d, *J* = 8.0 Hz, 1H), 7.54-7.51 (m, 1H), 7.25 (d, *J* = 12.6 Hz, 1H), 4.80 (d, *J* = 12.6 Hz, 1H), 3.14 (broad doublet, 4H), 1.10 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 150.1, 144.9, 132.2, 130.5, 125.8, 125.7, 123.7, 121.0, 90.0, 50.4, 43.0, 14.8, 11.2.
^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9.
IR (Neat): 3064, 2976, 2935, 2872, 1615, 1468 cm^{-1}
HRMS(ESI):Cald for $C_{13}H_{16}ClF_3NO_3S[MH]^+$:m/z 342.0537; found: 342.0532.



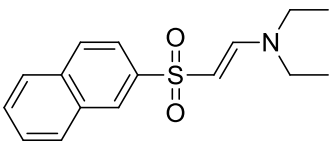
(*E*)-*N*,*N*-diethyl-2-(m-tolylsulfonyl)ethen-1-amine (5i)[j]
Color and State: Brown oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70-7.63 (m, 2H), 7.36-7.29 (m, 3H), 4.90 (d, *J* = 12.7 Hz, 1H), 3.18 (broad doublet, 4H), 2.40 (s, 3H), 1.14 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.0, 145,2, 139.0, 132.4, 128.8, 126.6, 123.3, 91.5, 50.2, 42.7, 21.5, 15.0, 11.1.
IR (Neat): 3080, 2935, 2876, 1615, 1490, 1455 cm^{-1}
MS: m/z $C_{13}H_{19}NO_2S$ 253.4 (M+)



(*E*)-*N*,*N*-diethyl-2-(o-tolylsulfonyl)ethen-1-amine (5j)[j]
Color and State: Brown oil.

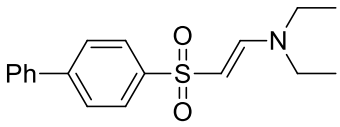
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 8.0 Hz, 1H), 7.41-7.37 (m, 1H), 7.31-7.25 (m, 3H), 4.92 (d, *J* = 12.7 Hz, 1H), 4.18 (broad doublet, 4H), 2.62 (s, 3H), 1.16 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.6, 142.8, 132,3, 131.9, 129.5, 127.8, 126.2, 90.6, 50.1, 42.9, 20.3, 14.9, 11.2.
IR (Neat): 3066, 2976, 2922, 2871, 1613, 1493, 1468 cm^{-1}
MS: m/z $C_{13}H_{19}NO_2S$ 253.4 (M+)



(*E*)-*N*,*N*-diethyl-2-(naphthalen-2-ylsulfonyl)ethen-1-amine (5k)

Color and State: Yellow solid. m.p. 124-125 ^{o}C

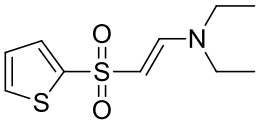
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (s, 1H), 7.85-7.82 (m, 2H), 7.80-7.73 (m, 2H), 7.53-7.45 (m, 2H), 7.29 (d, *J* = 12.7 Hz, 1H), 4.89 (d, *J* = 12.7 Hz, 1H), 3.11 (broad doublet, 4H), 1.07 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.2, 142.3, 134.5, 132.5, 129.3, 129.2, 128.3, 127.9, 127.3, 126.6, 122.5, 50.2, 42.8, 14.9, 11.2.
IR (Neat): 3070, 2975, 2930, 2872, 1612, 1495, 1465 cm^{-1}
HRMS(ESI):Cald for $C_{16}H_{20}NO_2S[MH]^+$:m/z 290.1209; found: 290.1205.



(*E*)-2-([1,1'-biphenyl]-4-ylsulfonyl)-*N*,*N*-diethylethen-1-amine (5l)

Color and State: Yellow solid. m.p. 102-104 ^{o}C

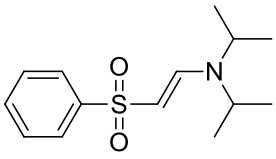
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.0 Hz, 2H), 7.59 (d, *J* = 8.0 Hz, 2H), 7.51 (d, *J* = 8.0 Hz, 2H), 7.38 (t, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.0 Hz, 1H), 7.27 (d, *J* = 12.7 Hz, 1H), 4.88 (d, *J* = 12.7 Hz, 1H), 3.11 (broad doublet, 4H), 1.09 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.2, 144.5, 144.1, 139.9, 129.1, 128.3, 127.6, 127.4, 126.8, 91.6, 50.2, 42.8, 14.9, 11.3.
IR (Neat): 3071, 2976, 2922, 2871, 1613, 1493, 1468 cm^{-1}
HRMS(ESI):Cald for $C_{18}H_{21}NO_2S[MH]^+$:m/z 316.1366; found: 316.1362.



(*E*)-*N*,*N*-diethyl-2-(thiophen-2-ylsulfonyl)ethen-1-amine (5m)[m]

Color and State: Brown oil

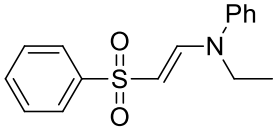
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (d, *J* = 4.0 Hz, 1H), 7.41 (d, *J* = 4.0 Hz, 1H), 7.27 (d, *J* = 12.6 Hz, 1H), 6.94 (t, *J* = 4.0 Hz, 1H), 4.96 (d, *J* = 12.6 Hz, 1H), 3.12 (broad doublet, 4H), 1.10 (bs, 6H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 149.3, 148.3, 130.6, 130.0, 127.2, 92.5, 50.2, 43.0, 14.9, 11.3.
IR (Neat): 3078, 2976, 2934, 2875, 1613, 1507 cm^{-1}
MS: m/z $C_{10}H_{15}NO_2S_2$ 245.4 (M+)



(*E*)-*N*-isopropyl-*N*-(2-(phenylsulfonyl)vinyl)propan-2-amine (5n)[l]

Color and State: Brown oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.40-7.38 (m, 3H), 7.33 (d, *J* = 12.8 Hz, 1H), 4.90 (d, *J* = 12.8 Hz, 1H), 3.53 (broad doublet, 2H), 1.14 (bs, 12H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 145.6, 145.4, 131.5, 128.9, 126.2, 92.4, 49.4, 47.7, 23.6, 19.8.
IR (Neat): 3074, 2976, 2925, 2869, 1607, 1542 cm^{-1}
MS: m/z $C_{14}H_{21}NO_2S$ 267.4 (M+)



(*E*)-*N*-ethyl-*N*-(2-(phenylsulfonyl)vinyl)aniline (5o)

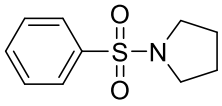
Color and State: Brown oil.

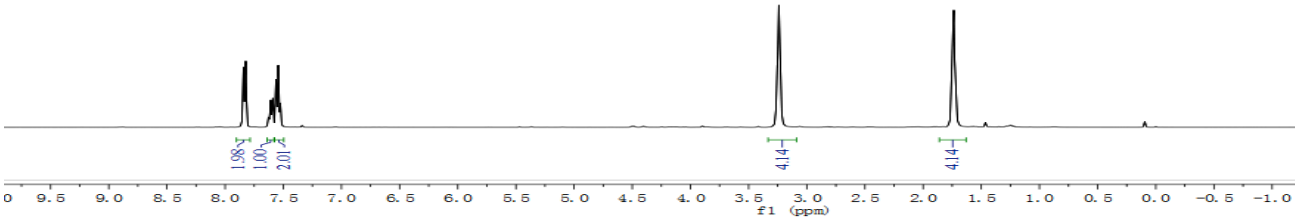
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.0 Hz, 2H), 7.53 (d, *J* = 12.2 Hz, 1H), 7.53-7.46 (m, 3H), 7.37 (t, *J* = 8.0 Hz, 2H), 7.20 (t, *J* = 8.0 Hz, 1H), 7.14 (d, *J* = 8.0 Hz, 2H), 5.27 (d, *J* = 12.2 Hz, 1H), 3.67-3.61 (m, 2H), 1.20 (t, *J* = 8.0 H, 3H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.5, 132.0, 129.8, 129.7, 129.0, 127.0, 126.4, 125.8, 124.3, 97.5, 40.2, 13.1.
IR (Neat): 3068, 2970, 2903, 2852, 1610, 1492, 1467 cm^{-1}
HRMS(ESI):Cald for $C_{16}H_{18}NO_2S[MH]^+$:m/z 288.1053; found: 288.1051.

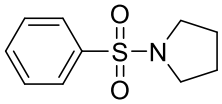
4. References

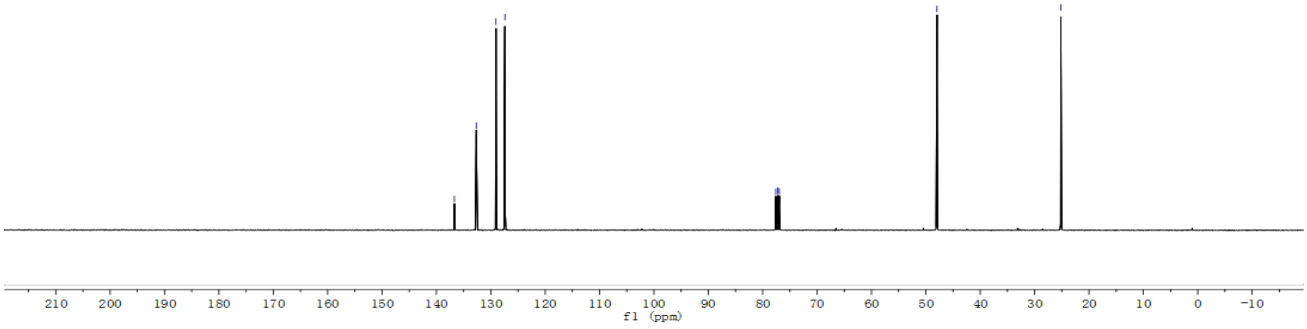
(a) S. Yotphan, L. Sumunnee, D. Beukeaw, C. Buathongjan, V. Reutrakul, *Org. Biomol. Chem.* **2016**, *14*, 590; (b) M. K. Narayanam, G. Ma, P. A. Champagne, K. N. Houk, J. M. Murphy, *Angew. Chem. Int. Ed.* **2017**, *56*, 13006; (c) X. Tang, L. Huang, C. Qi, W. Wu, H. Jiang, *Chem. Commun.* **2013**, *49*, 6102; (d) G. Cheng, S. Muench, Y. Zhou, G. A. Afanador, E. J. Mui, A. Fomovska, B. S. Lai, S. T. Prigge, C. W. Roberts, M. R. Hickman, P. J. Lee, S. E. Leed, J. M. Auschwitz, D. W. Rice, R. Meleod, *Bio. Med. Chem. Lett.* **2013**, *23*, 2035; (e) T.-Y. Xu, S.-L. Zhang, G.-Q. Dong, X.-Z. Liu, X. Wang, X.-Q. Lv, Q.-J. Qian, R.-Y. Zhang, C.-Q. Sheng, C.-Y. Miao, *Scientific Reports*, **2015**, *5*, 10043; (f) H. Zhu, Y. Shen, Q. Deng, C. Huang, T. Tu, *Chem. Asian J.* **2017**, *12*, 706; (g) V. Hojat, *Bulletin Korean Chem. Society*, **2012**, *33*, 383; (h) H. Wollven, C. González-Rodríguez, I. Marco, A. L. Thompson, M. C. Wills, *Org. Lett.* **2011**, *13*, 4876; (j) J. Lai, L. Chang, G. Yuan, Org. Lett. 2016, 18, 3194; (k) S. K. R. Parumala, R. K. Peddinti, *Tetrahedron Lett.* **2016**, *57*, 1232; (l) Y. Cai, R. Zhang, D. Sun, S. Xu, Q. Zhou, *Synlett*, **2017**, *28*, 1630; (m) M. Chen, Z.-T. Huang, Q.-Y. Zheng, *Org. Biomol. Chem.* **2014**, *12*, 9337.

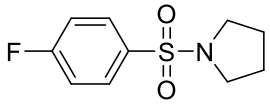
5. Proton and Carbon NMR Spectra







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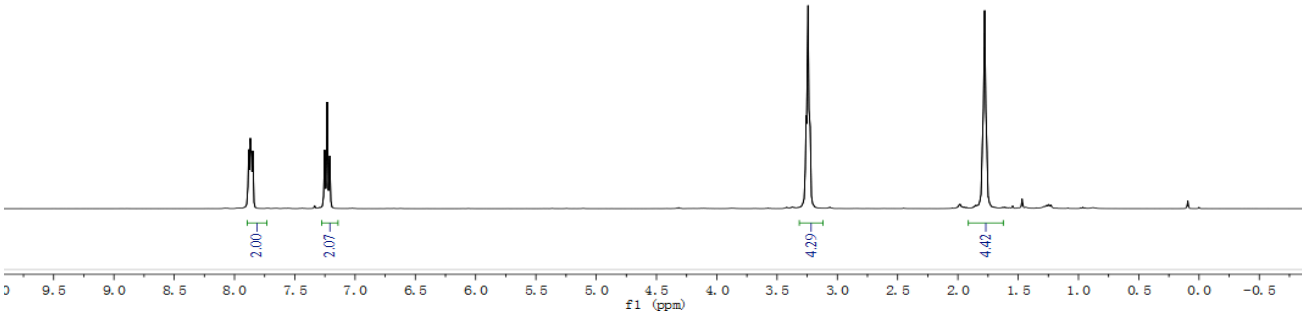
S
N
O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4.29
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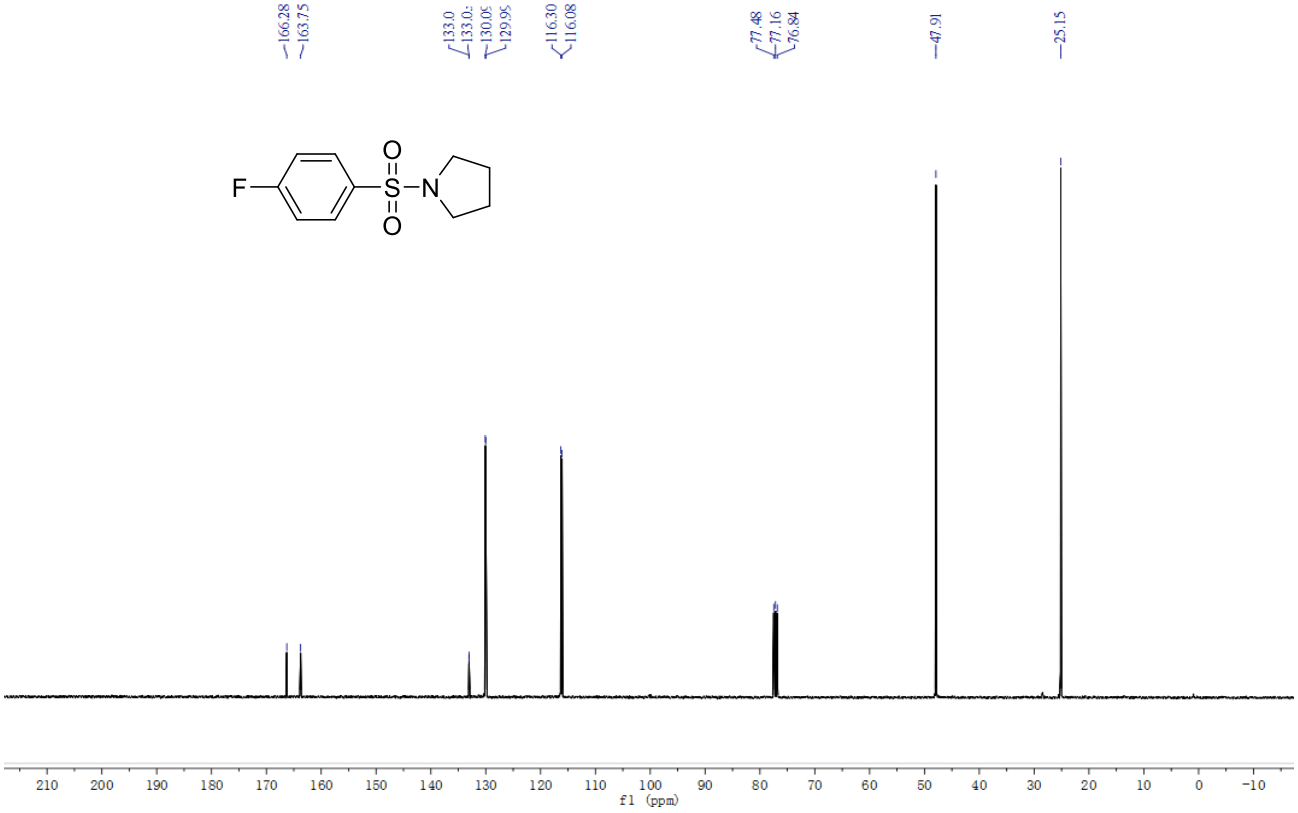
166.28
163.75
133.0
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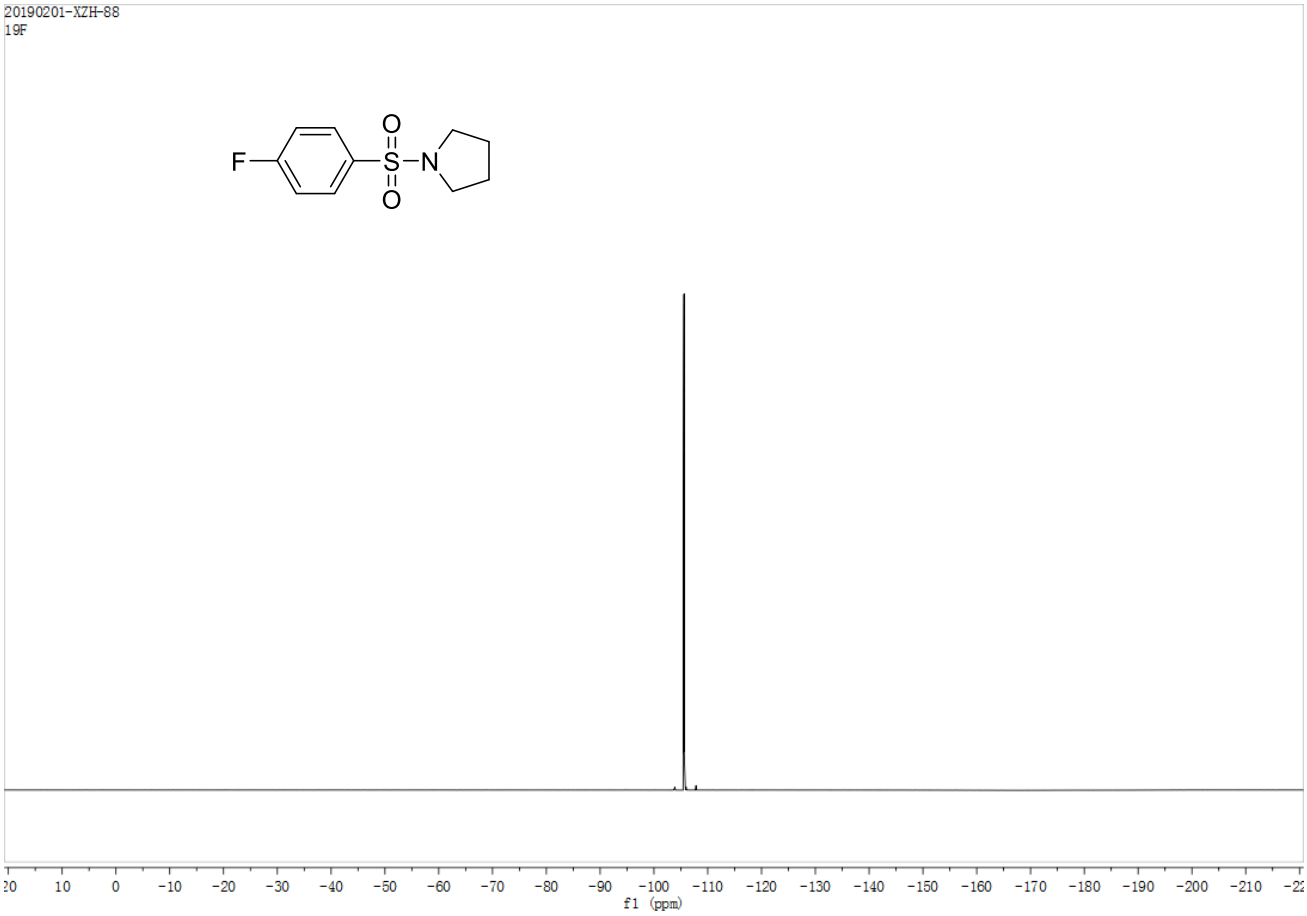
130.0
129.9
116.30
116.08
77.48
77.16
76.84
47.91
25.15
f1 (ppm)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F
O
S
N
O
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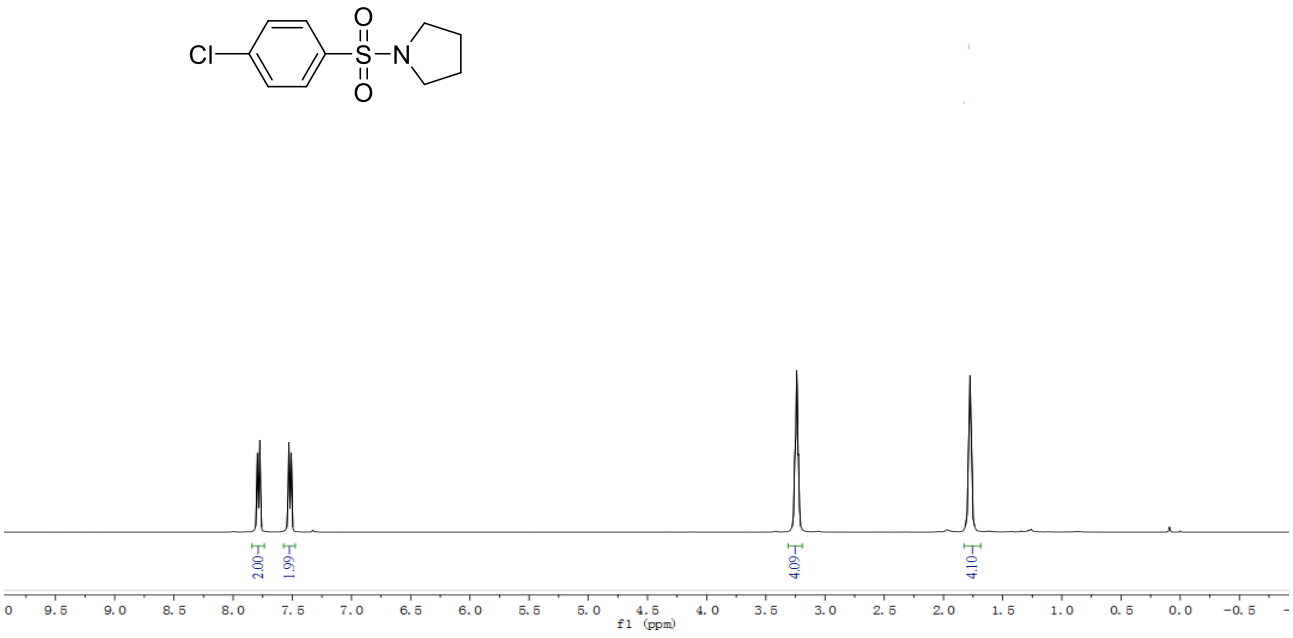
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O
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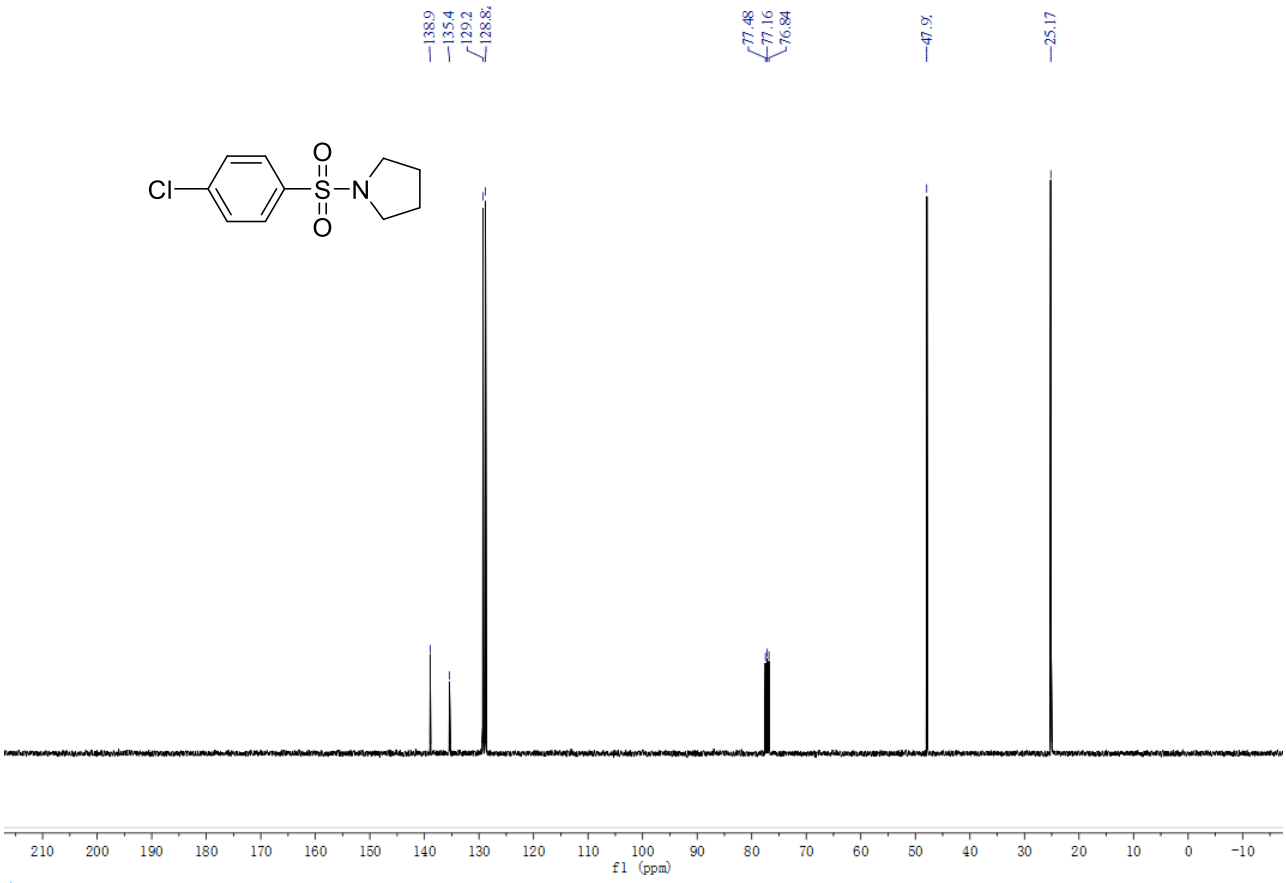
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135.4
129.2
128.8
77.48
77.16
76.84
47.9
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N
O
O
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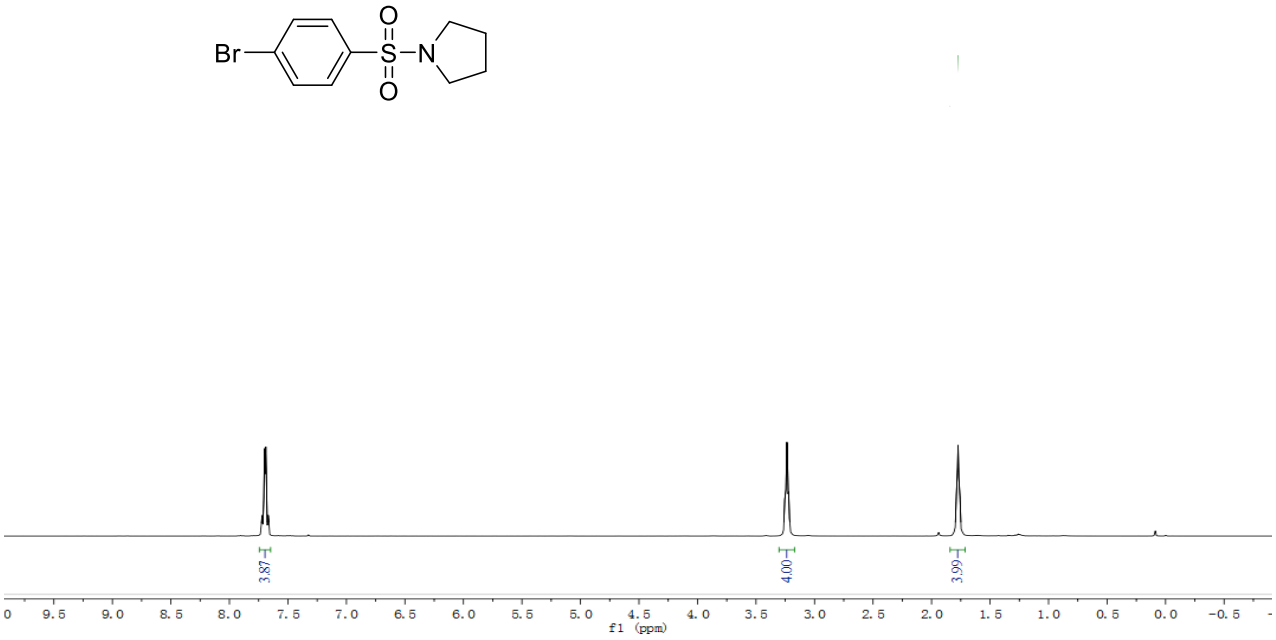
f1 (ppm)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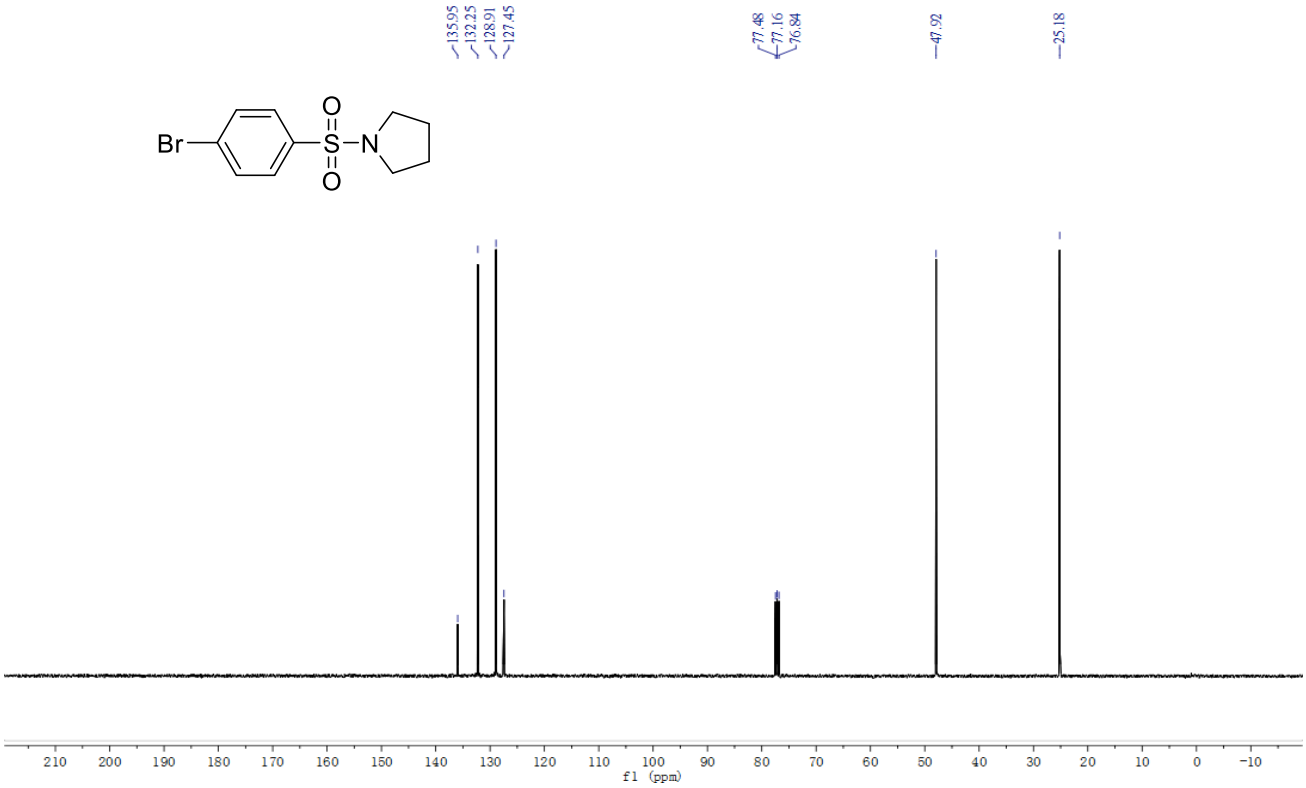
S
N
O
O
3.87
4.00
3.99
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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S
N
O
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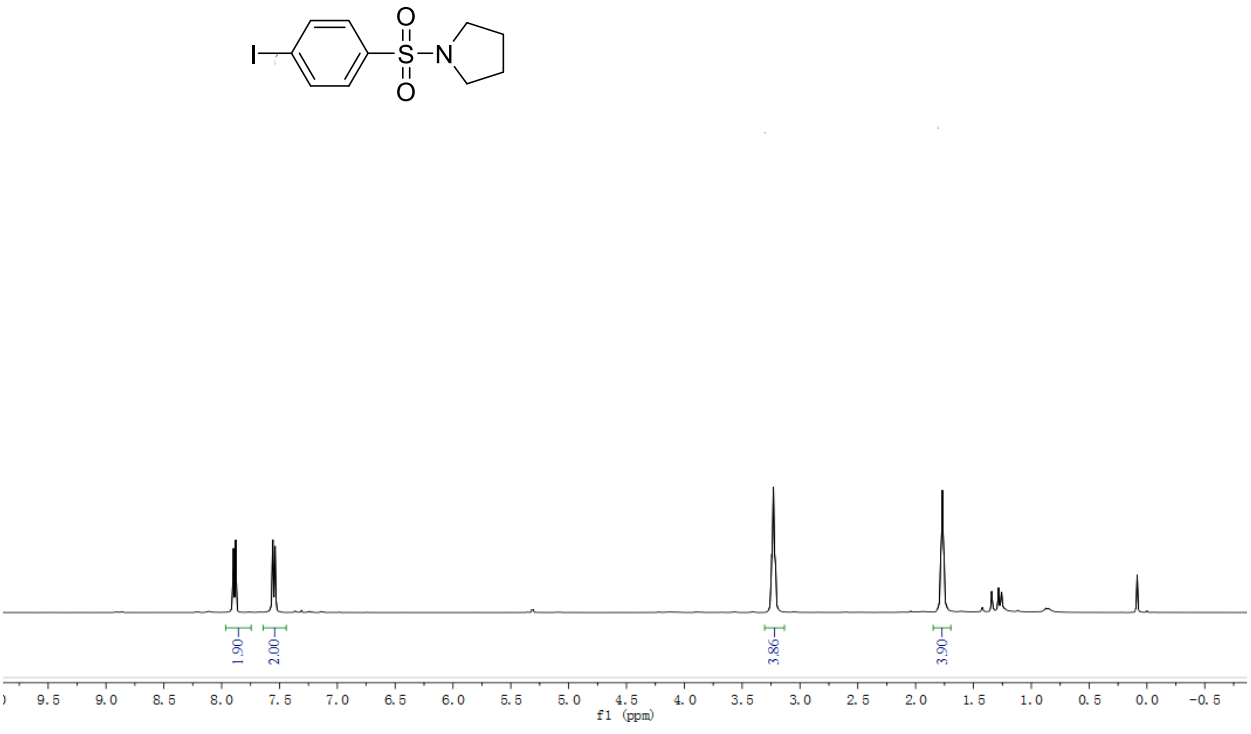
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S
N
O
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3.90
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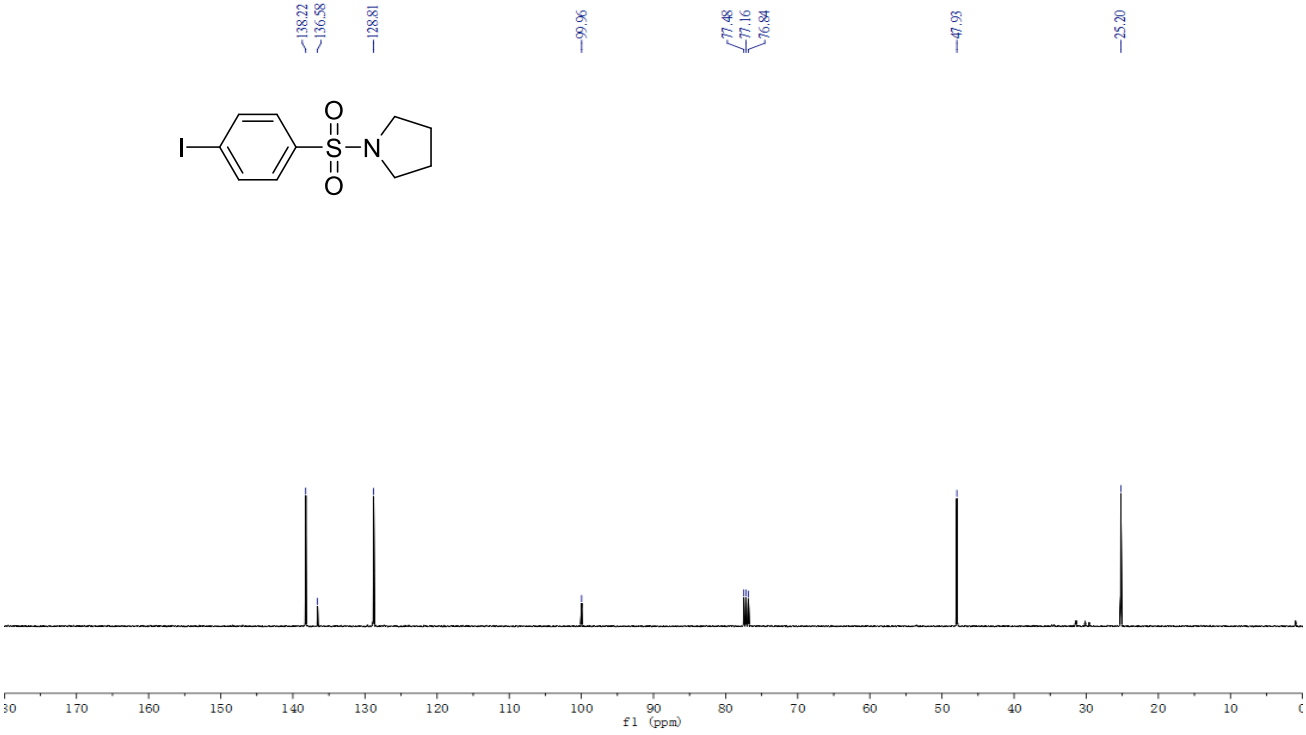
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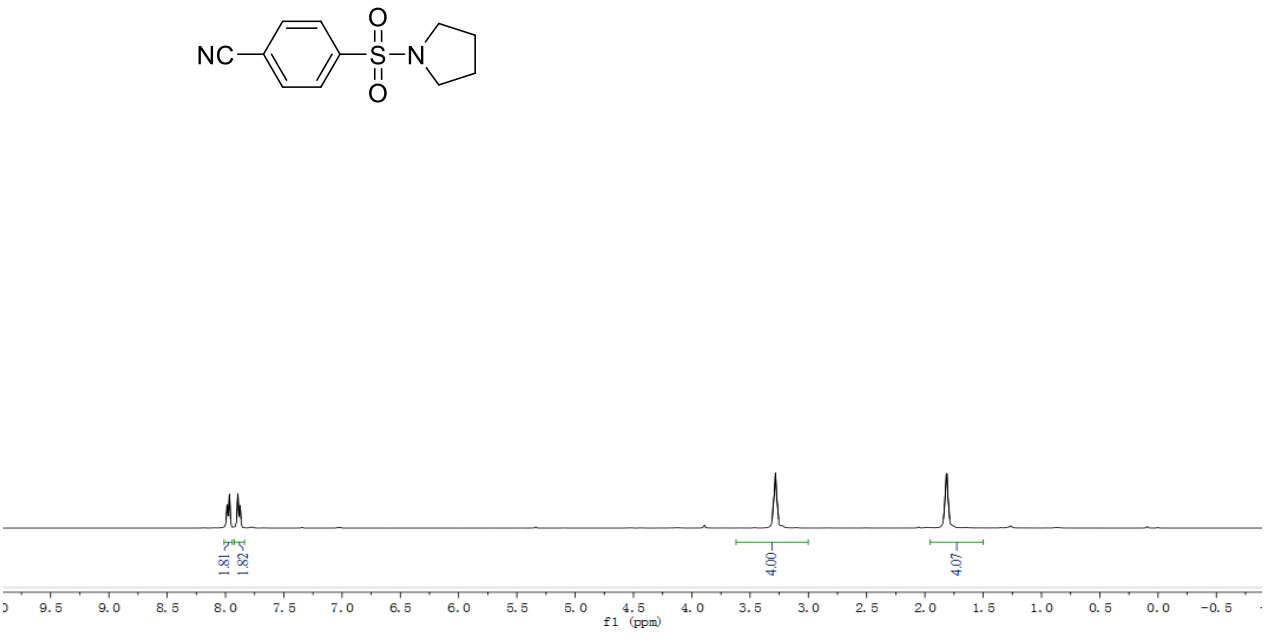
77.16
76.84
47.93
25.20
I
O
S
N
O
f1 (ppm)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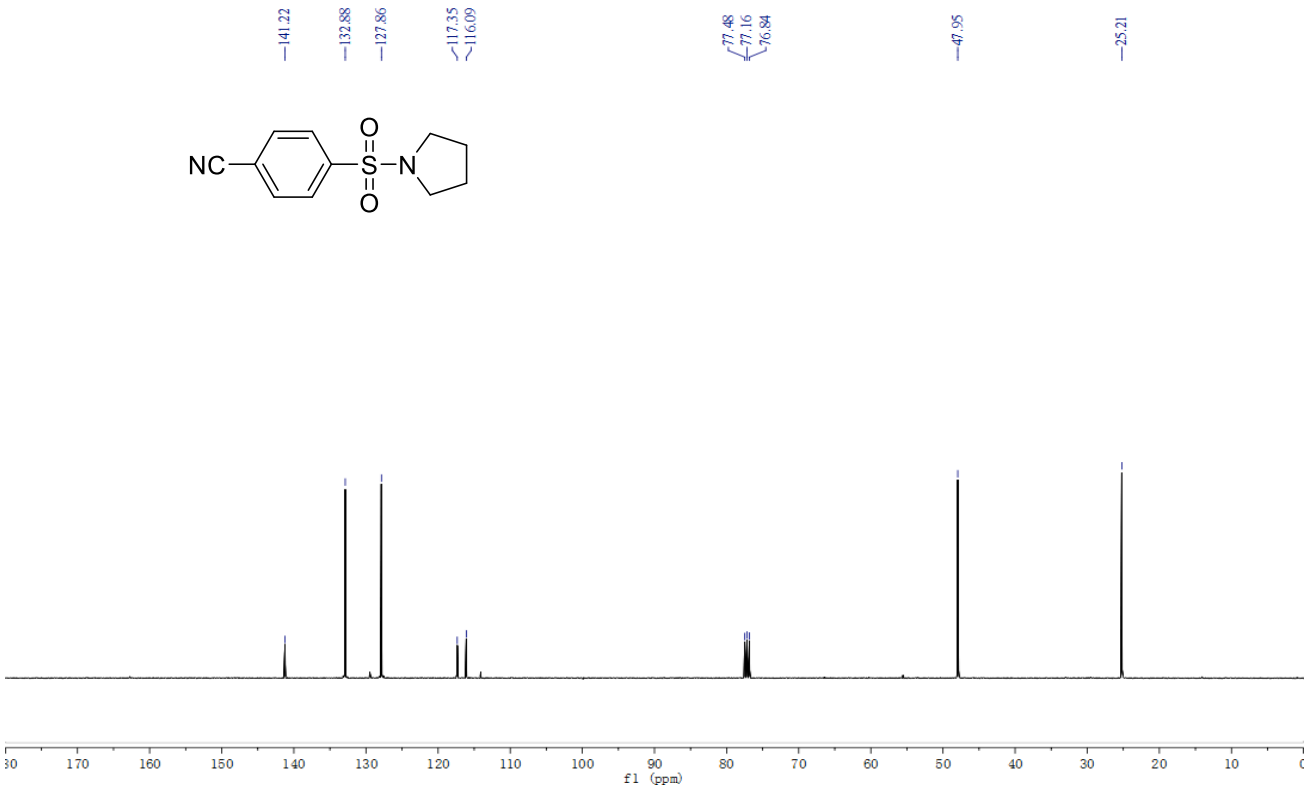
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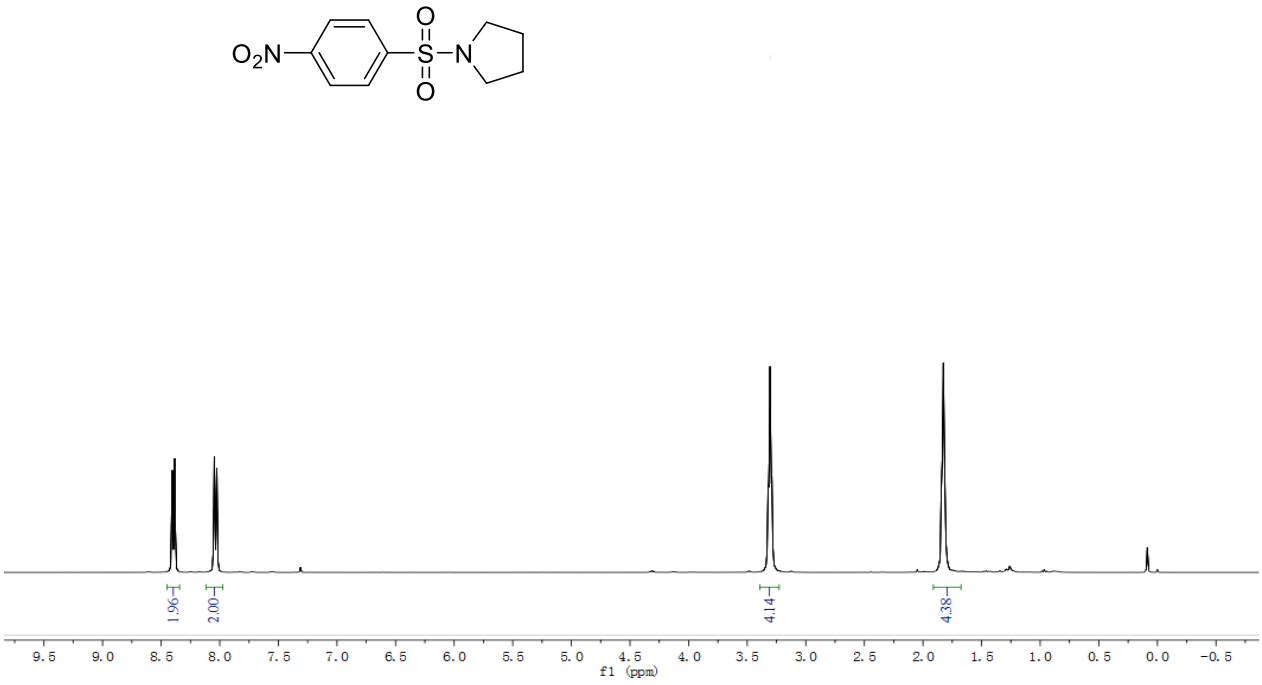
NC
S
N
O
O
f1 (ppm)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O
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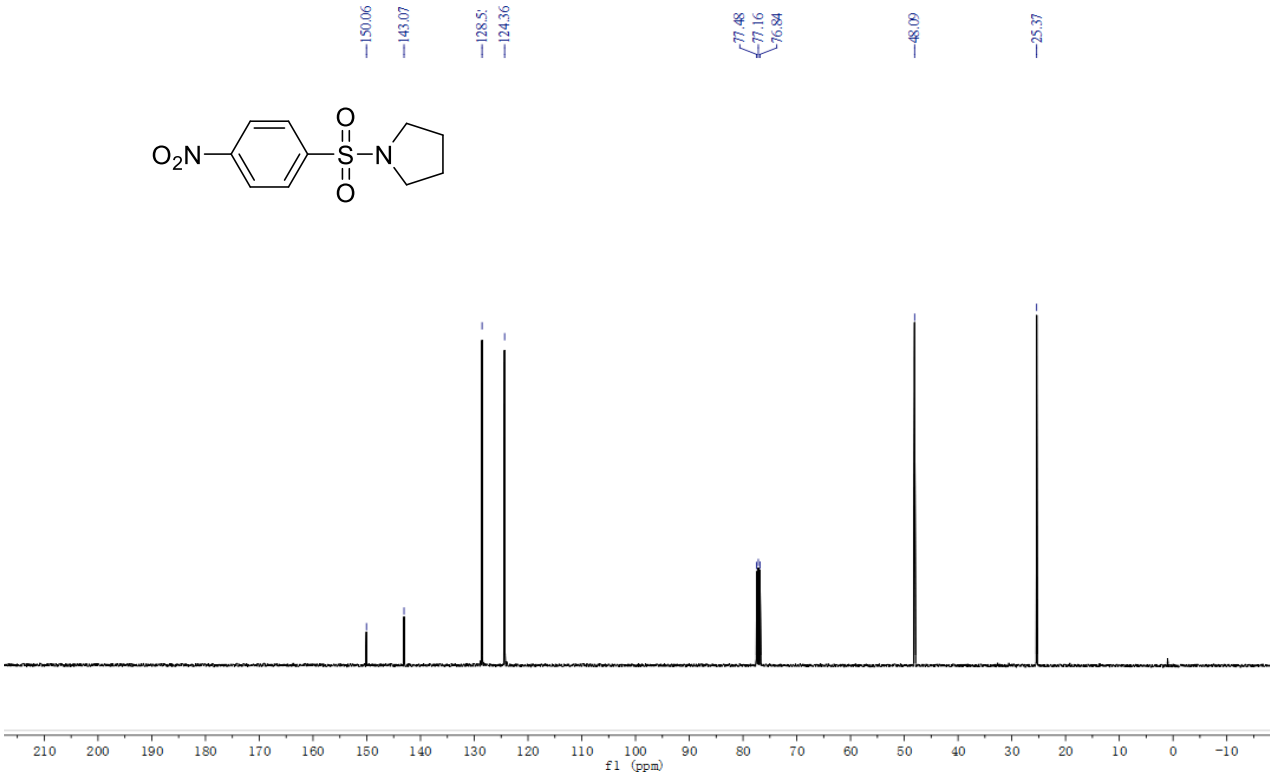
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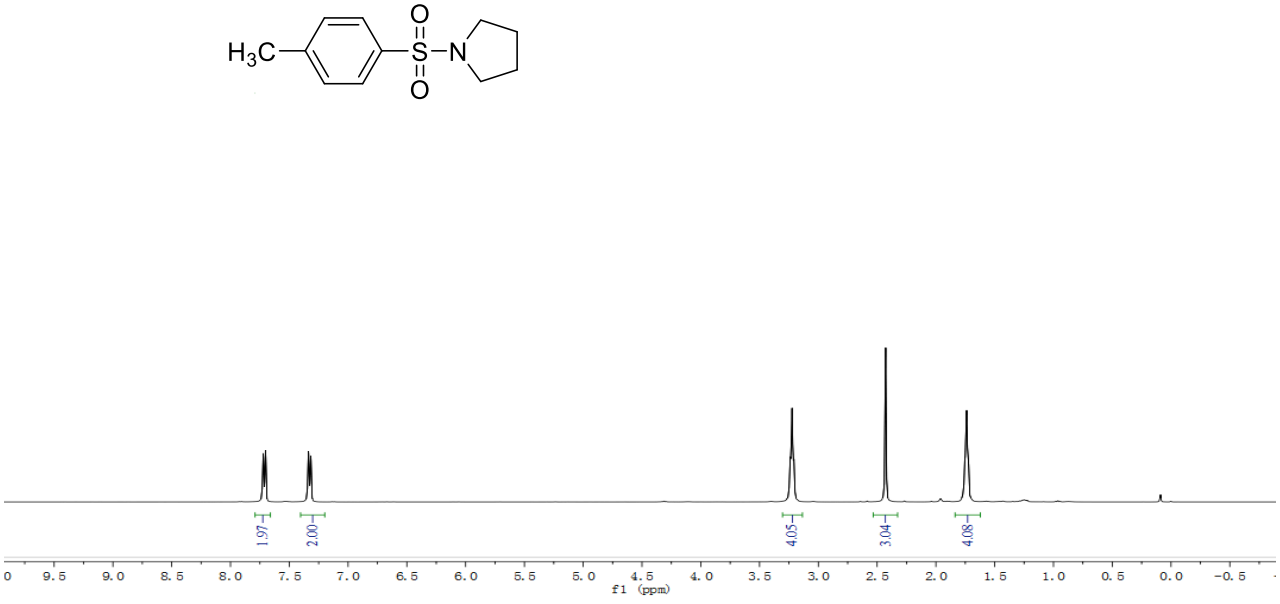
N
O
O
f1 (ppm)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O
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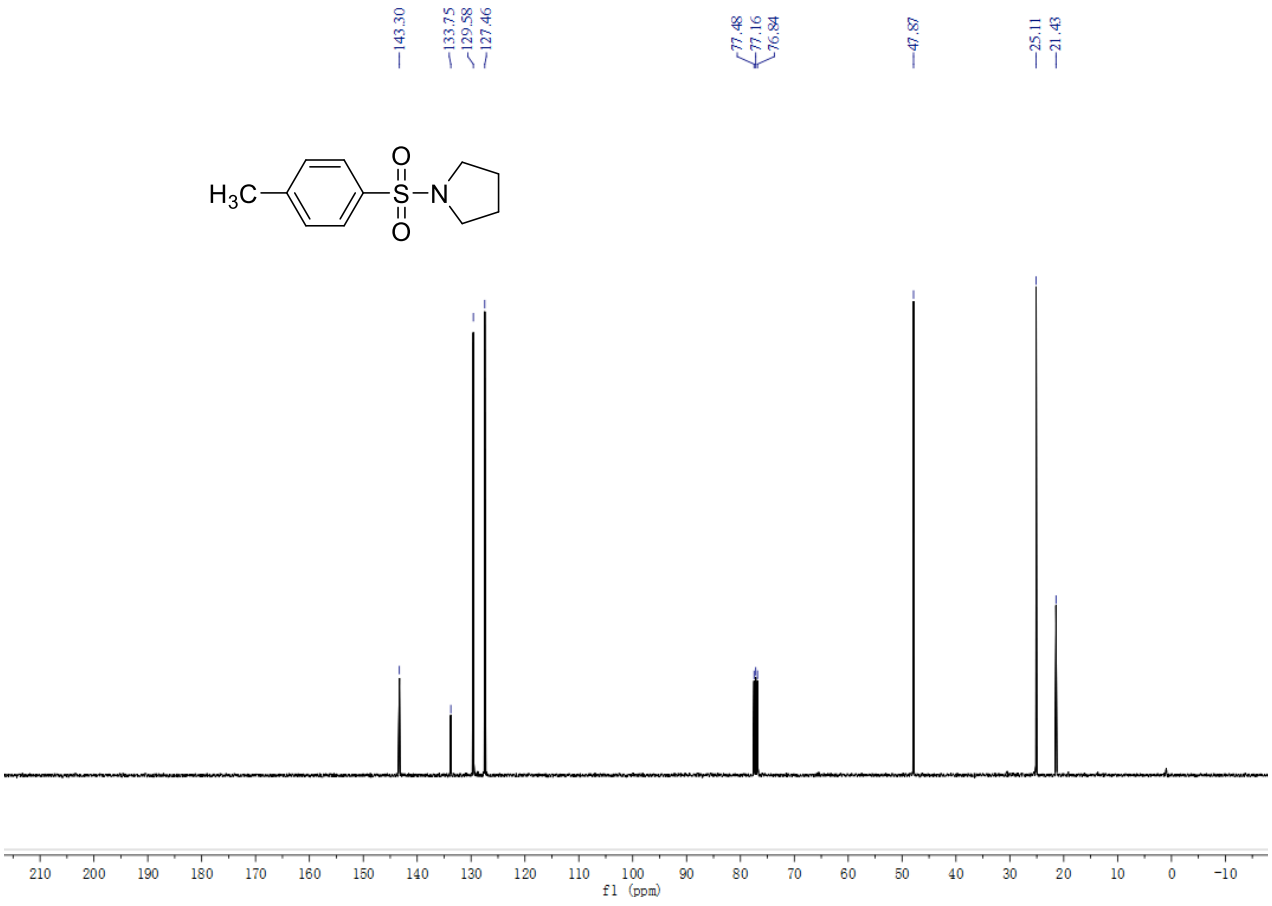
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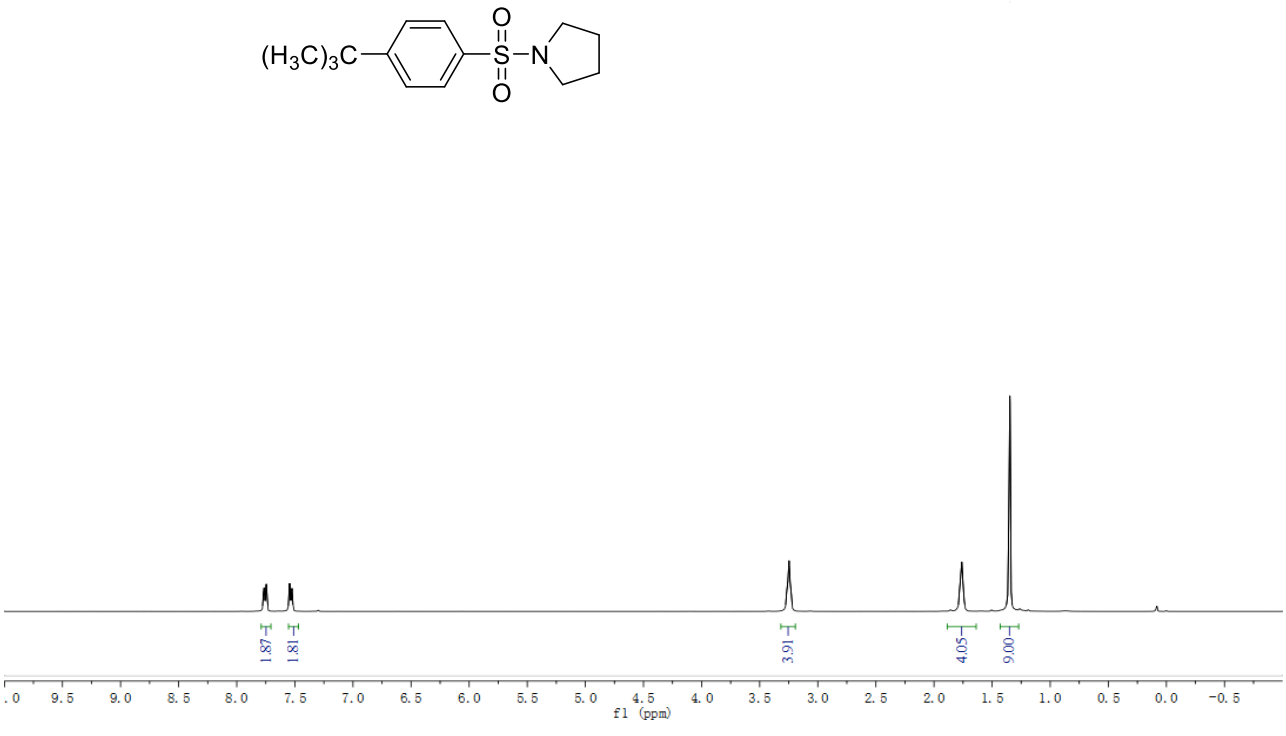
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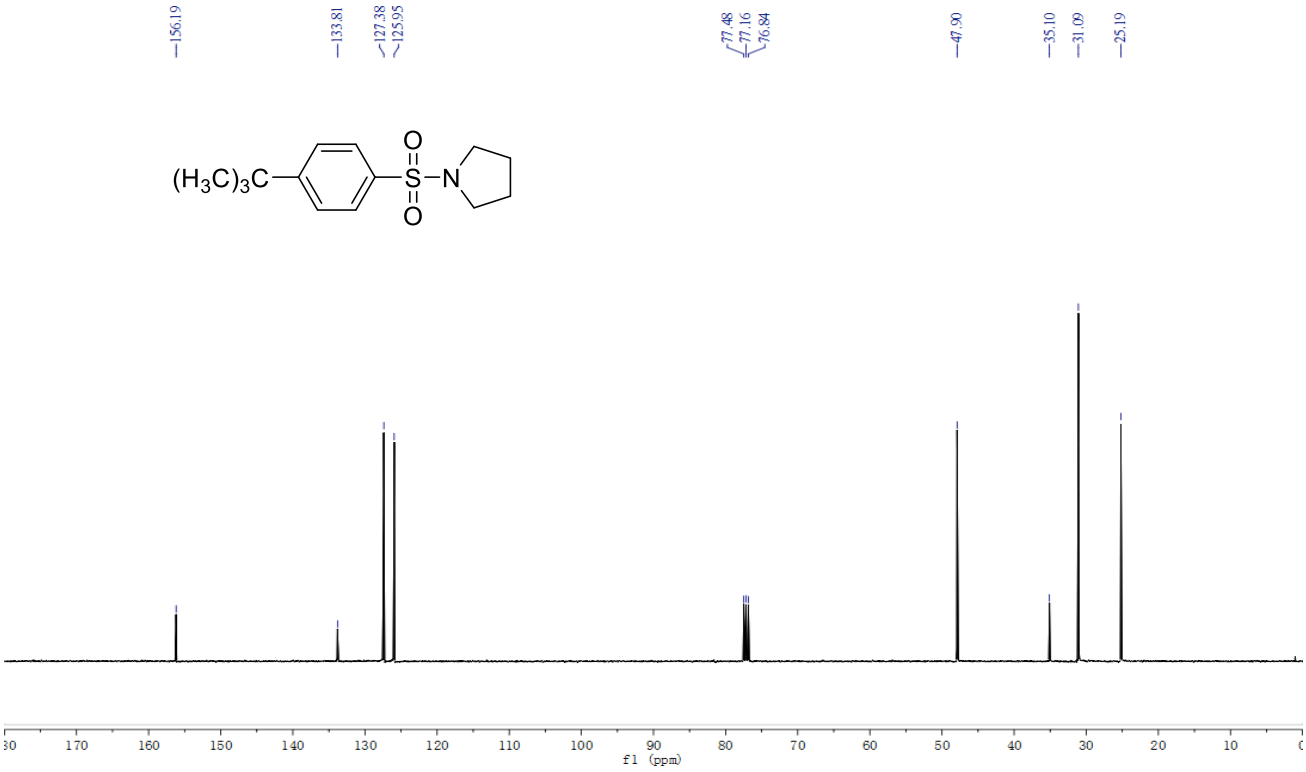
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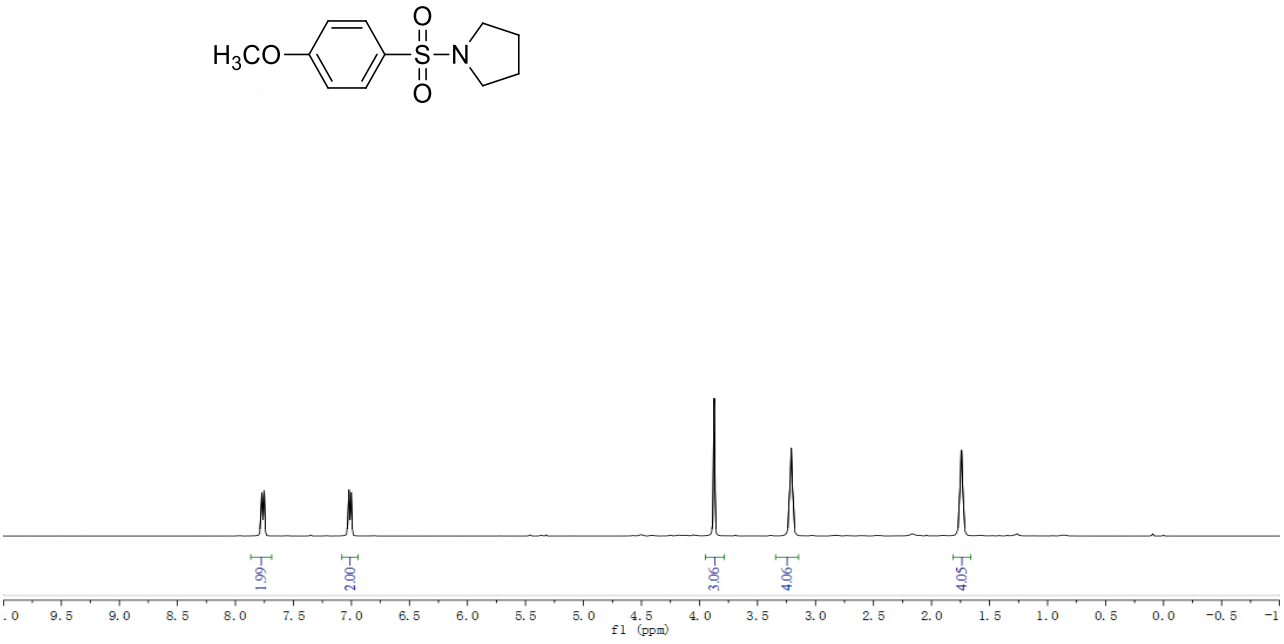
O
f1 (ppm)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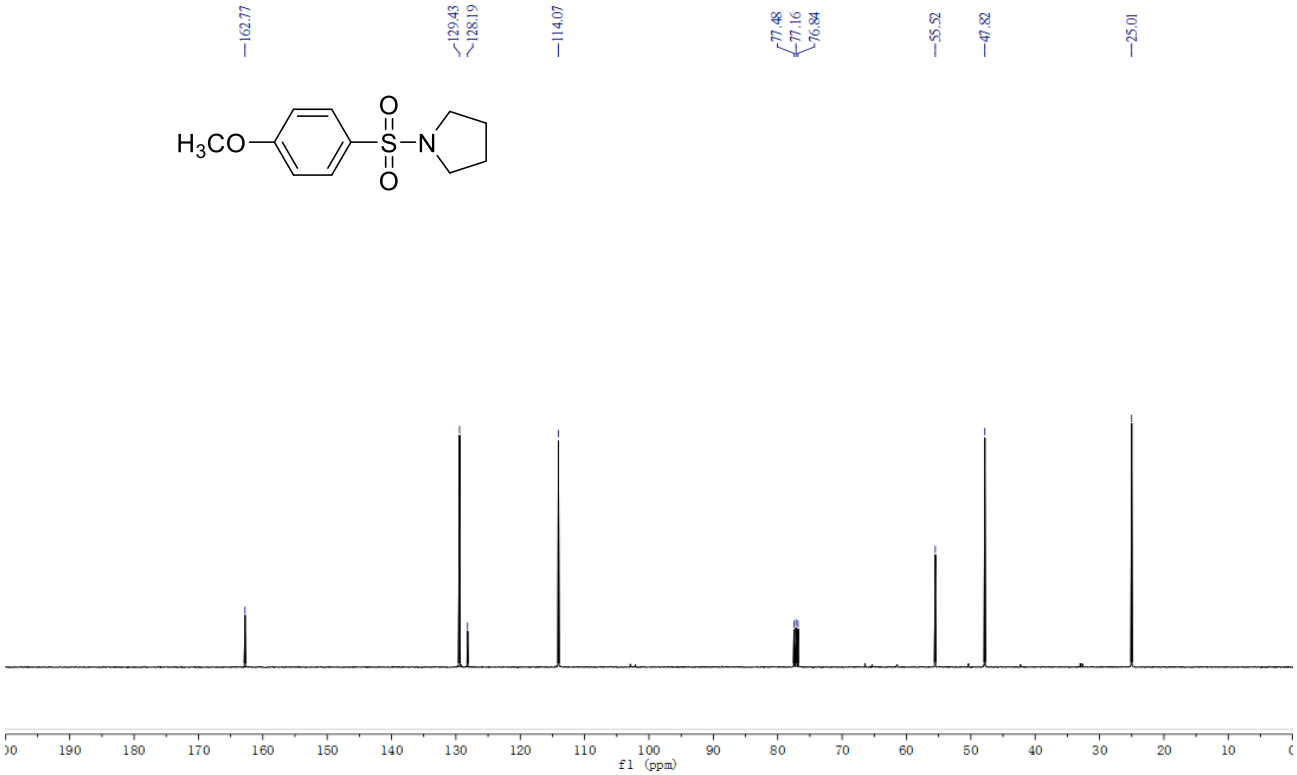
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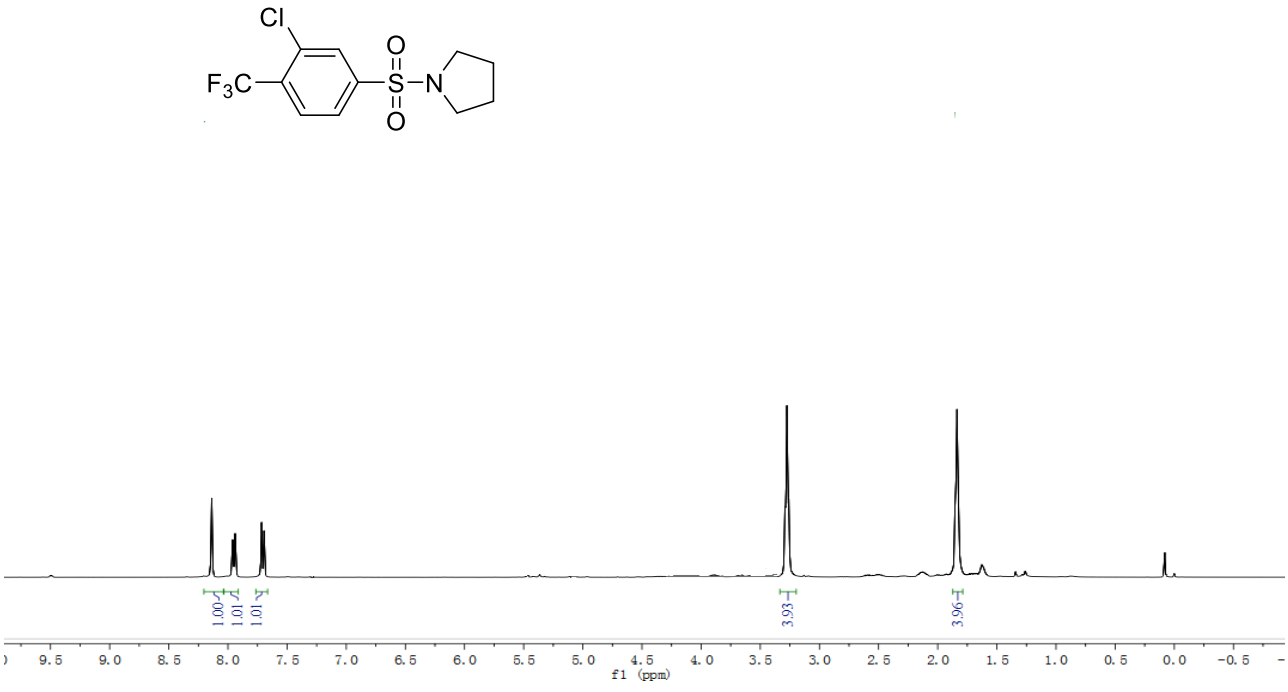
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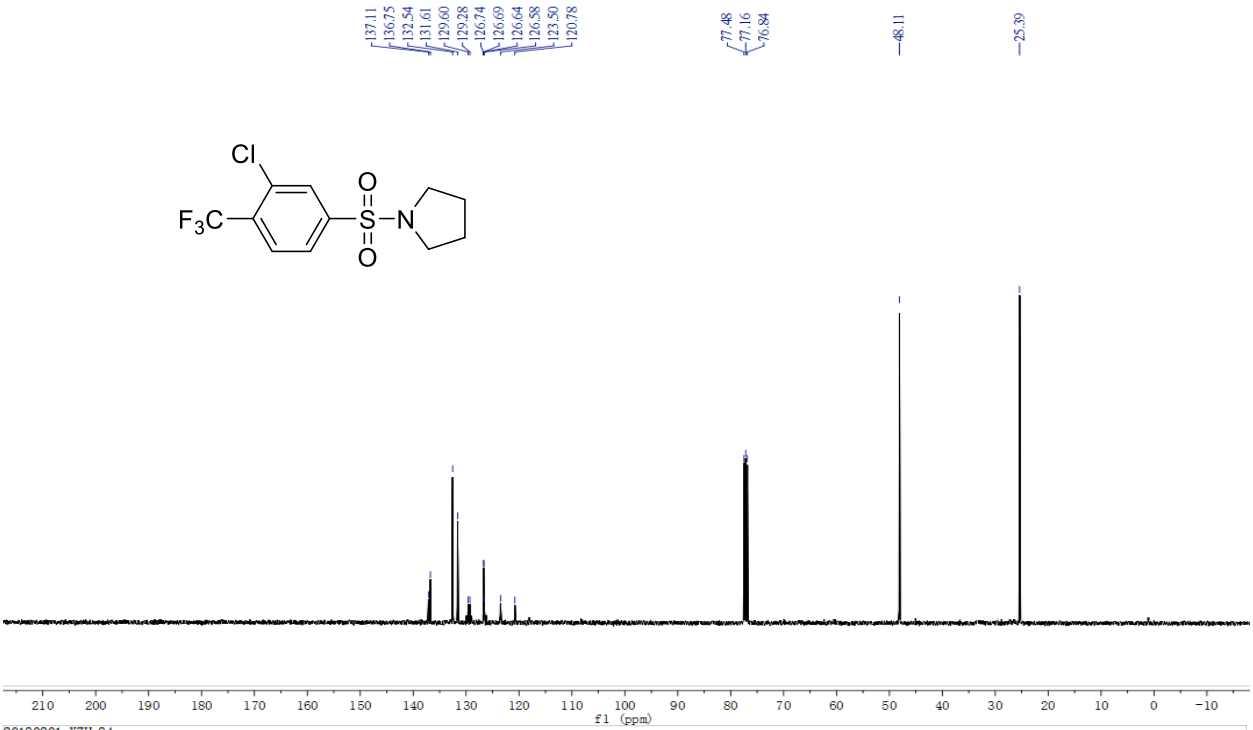
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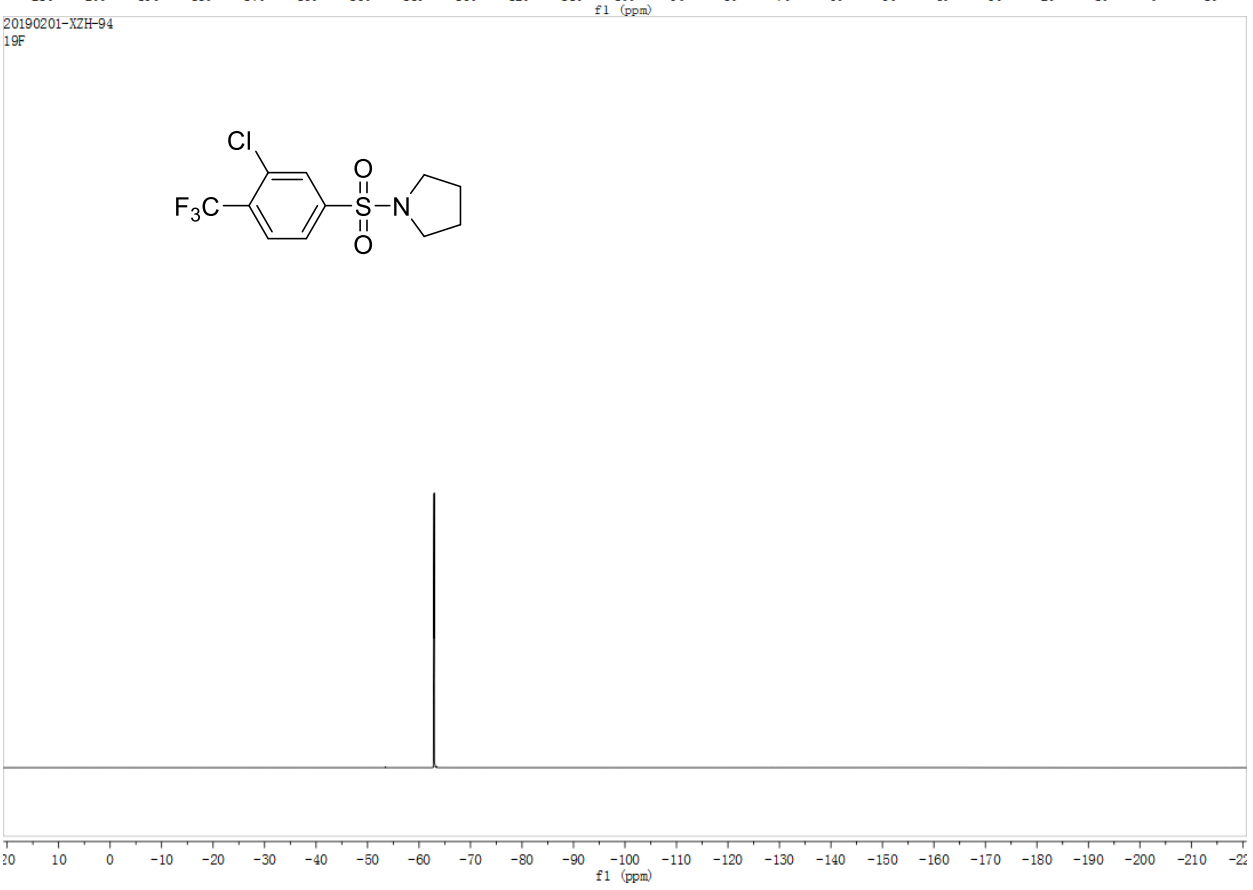
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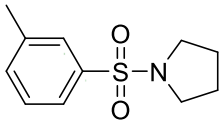

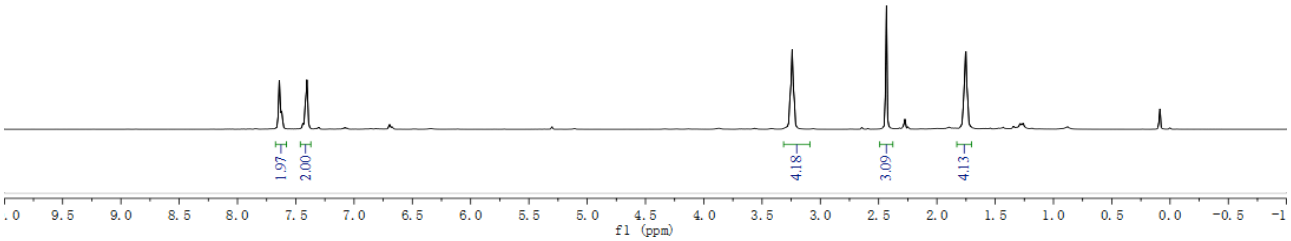
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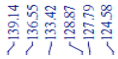
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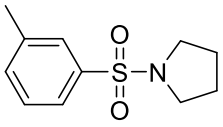

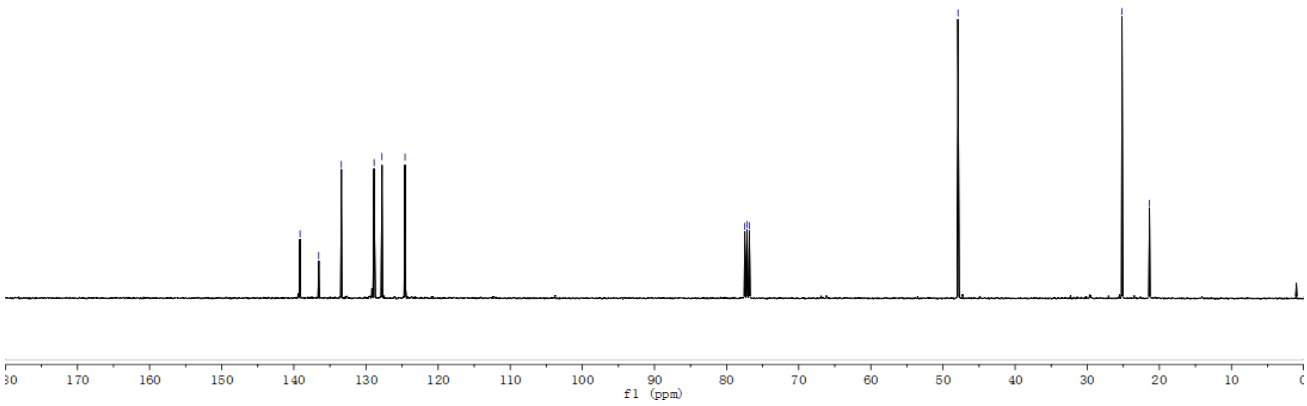
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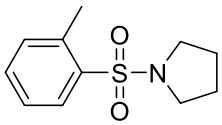

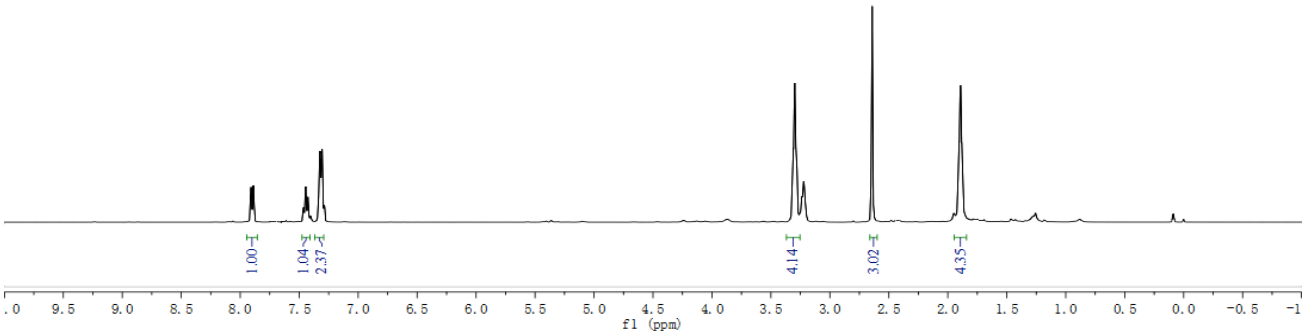
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4.14
3.02
4.35
f1 (ppm)


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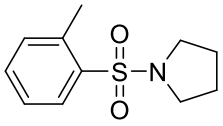
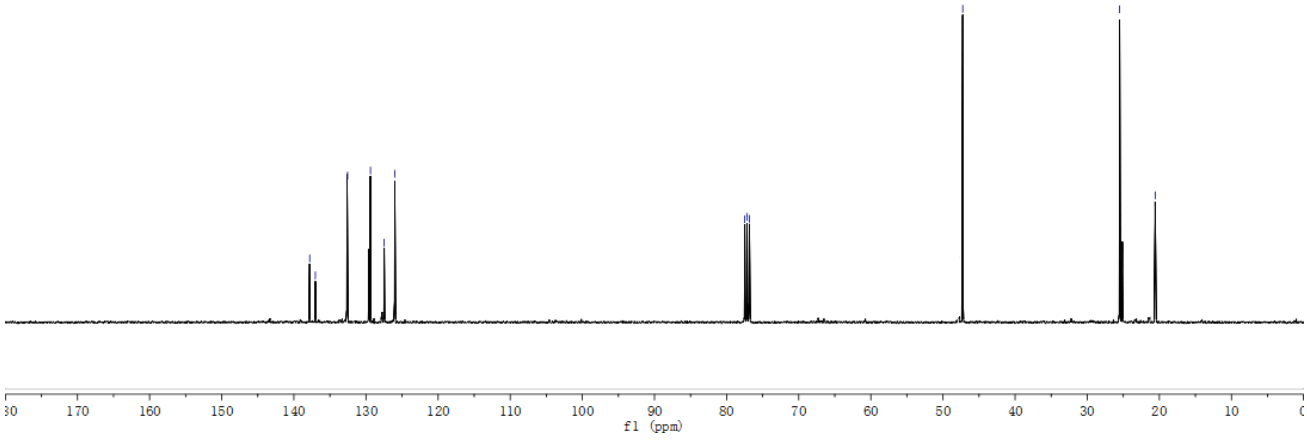
25.51
20.98

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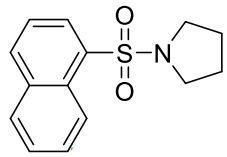

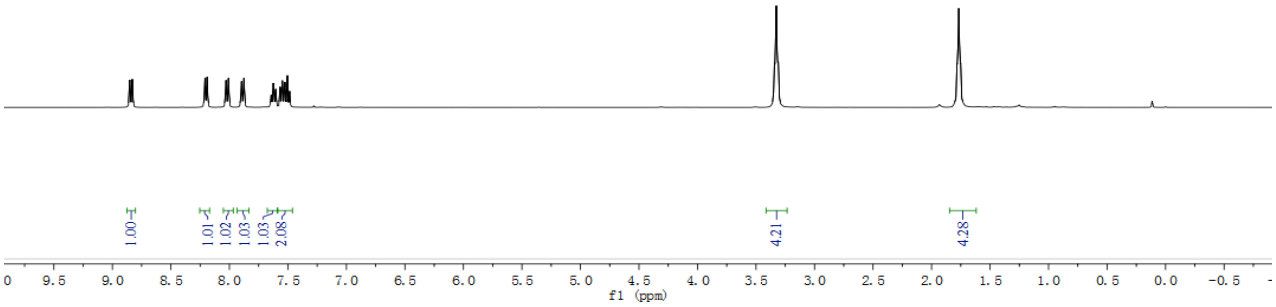
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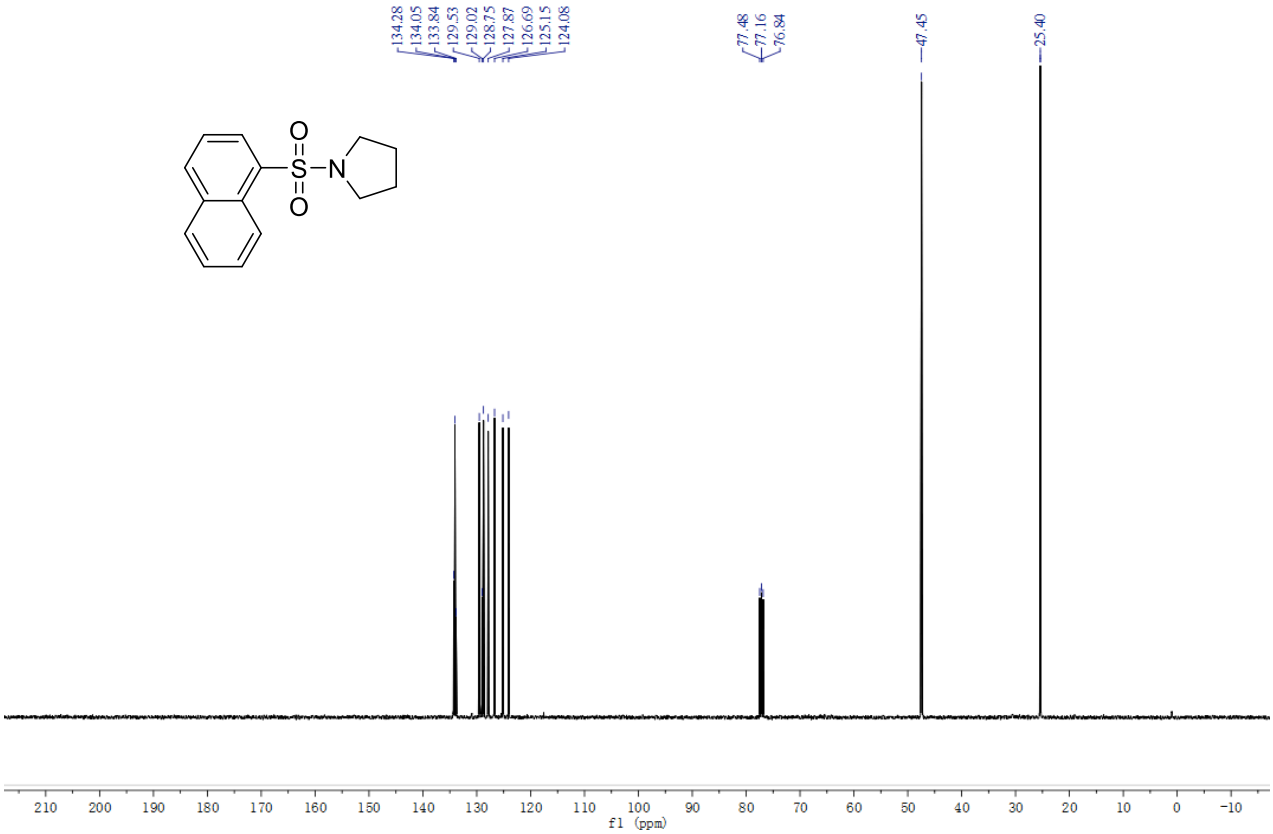
1.03
1.03
2.08
4.21
4.28
f1 (ppm)


134.28
134.05
133.84
129.53
129.02
128.75
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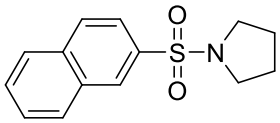
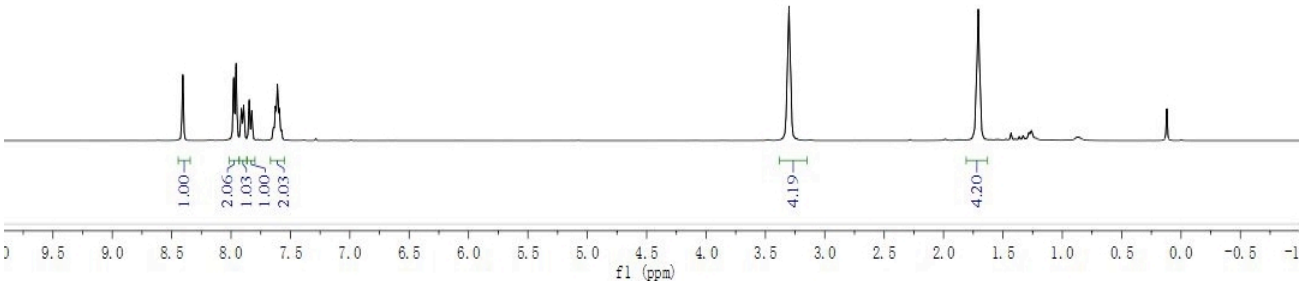
126.69
125.15
124.08
77.48
77.16
76.84
47.45
25.40
f1 (ppm)

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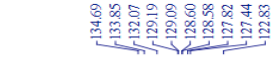
2.06
1.03
1.00
2.03
4.19
4.20
f1 (ppm)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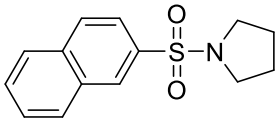
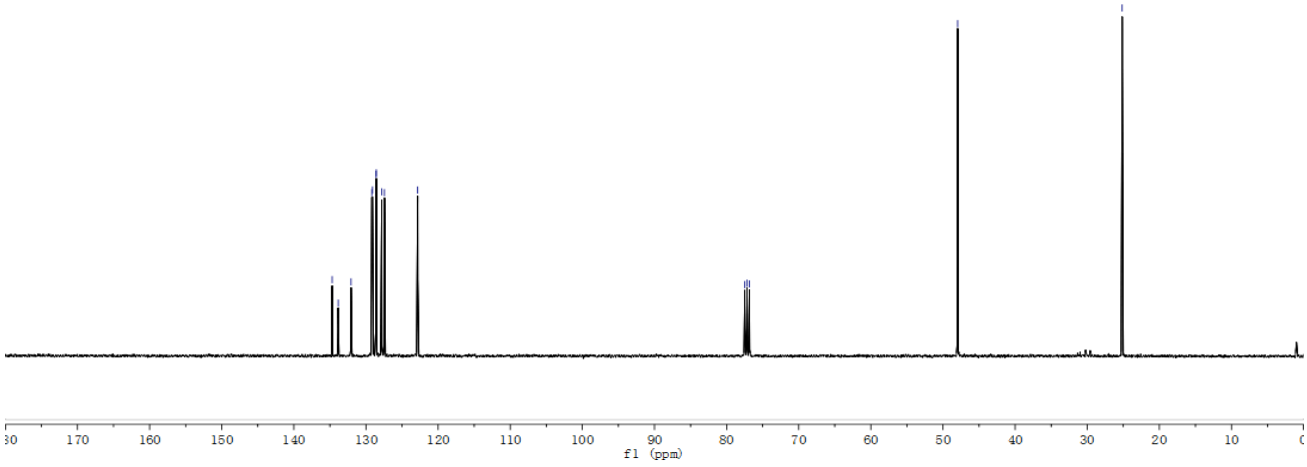
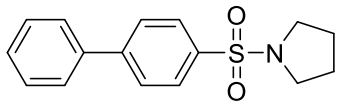
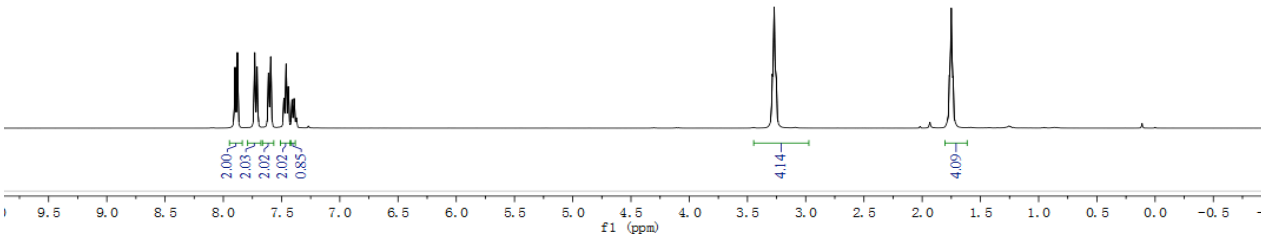
122.83
77.48
77.16
76.84
47.96
25.16




f1 (ppm)

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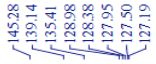
2.02
2.02
0.85
4.14
4.09
f1 (ppm)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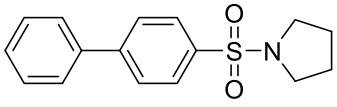
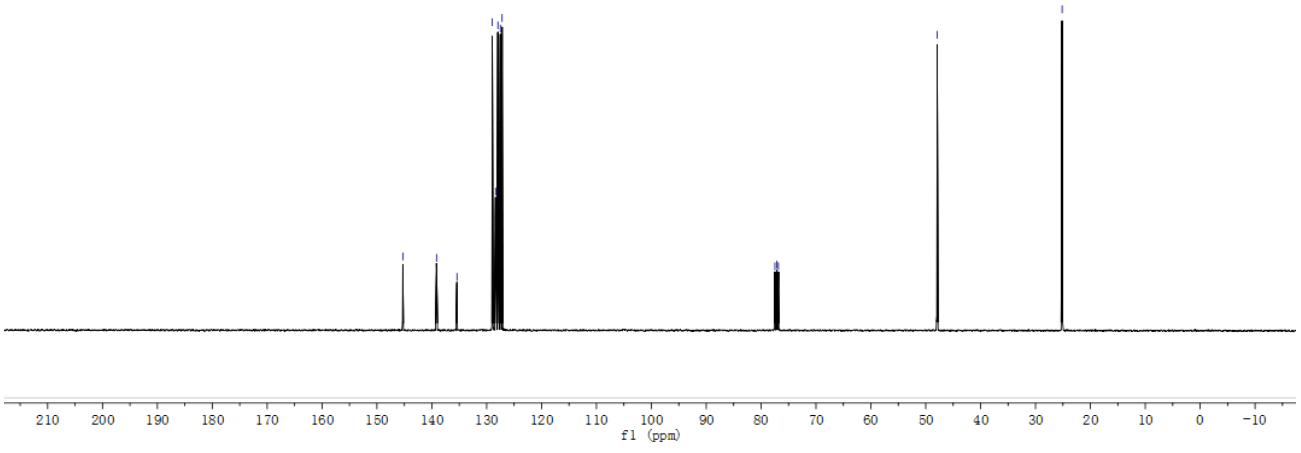
127.50
127.19


77.48
77.16
76.84


47.92


25.15

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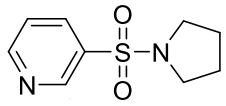
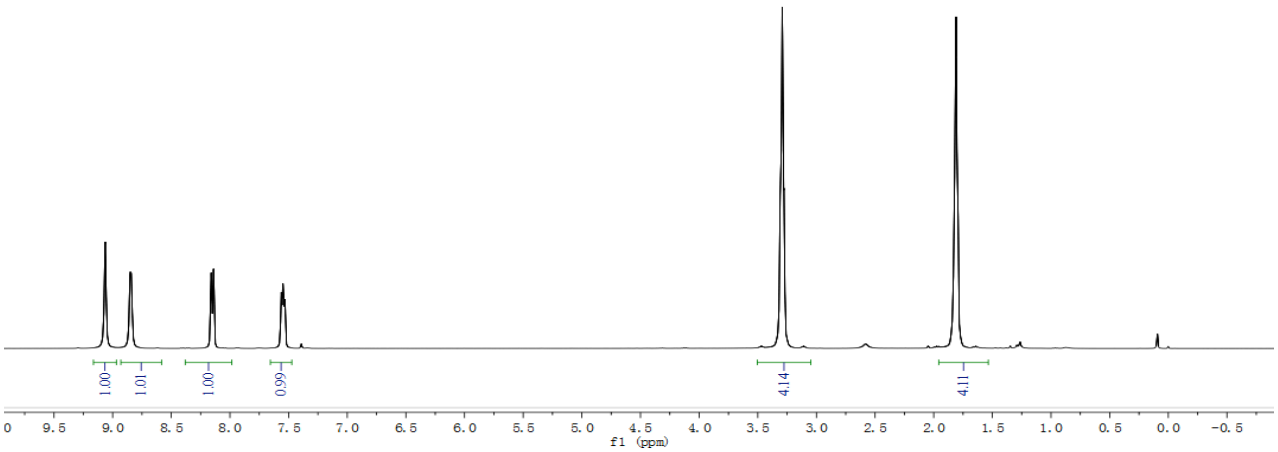
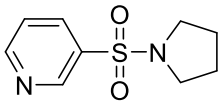
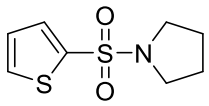
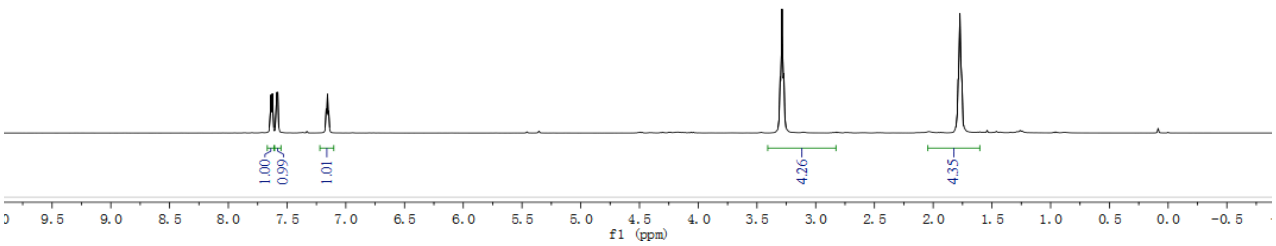



1.00
1.01
1.00
0.99
4.14
4.11
f1 (ppm)



153.06
147.86
134.92
133.60
123.78
77.48
77.16
76.84
47.84
25.13
f1 (ppm)

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0.99
1.01
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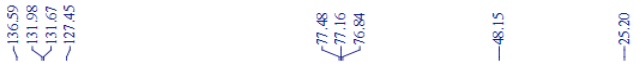
4.35
f1 (ppm)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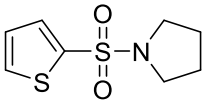
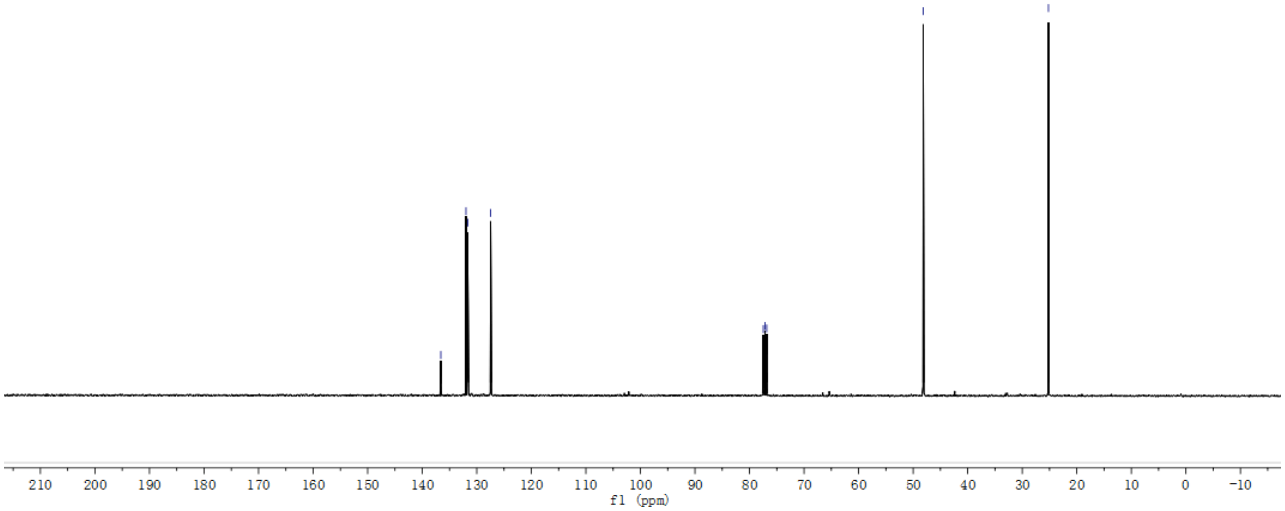
127.45
77.48
77.16
76.84
48.15
25.20

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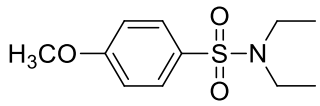
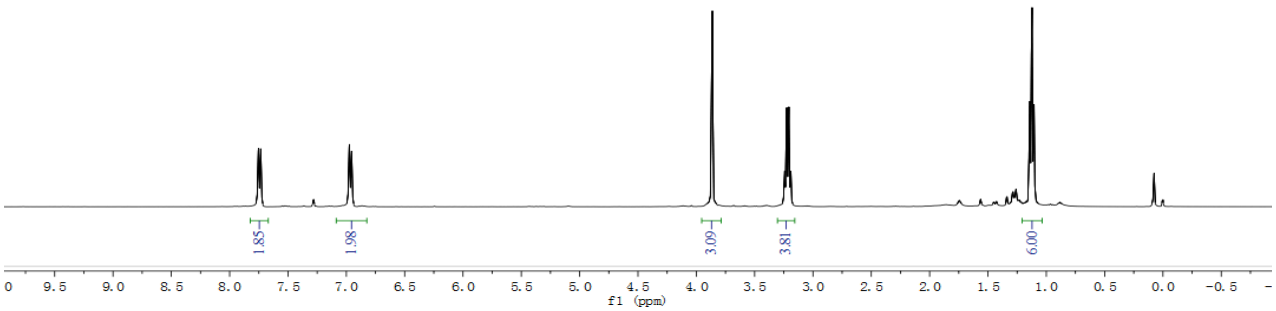

H3CO
O
S
N
O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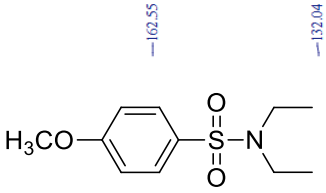
1.98
3.09
3.81
6.00
f1 (ppm)


H3CO
O
S
N
O

162.55
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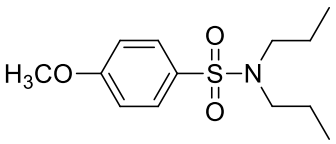
129.05
114.11
77.38
77.06
76.74
55.56
41.93
14.11
f1 (ppm)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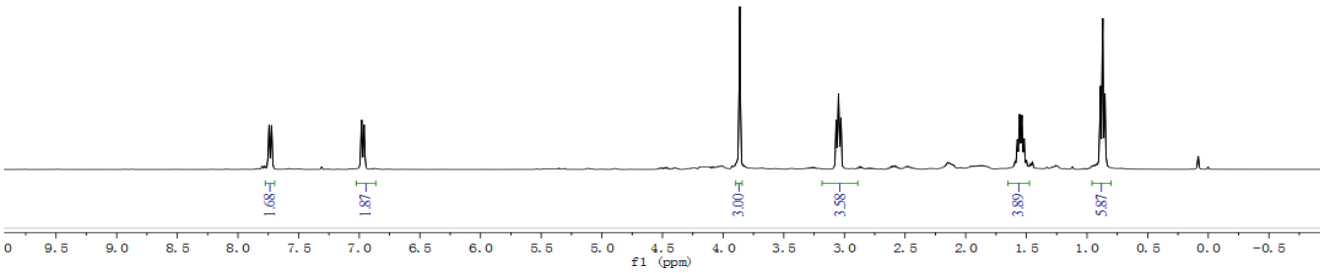
O
S
N
O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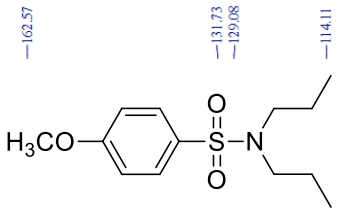
f1 (ppm)


H3CO
O
S
N
O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77.48
77.16
76.84
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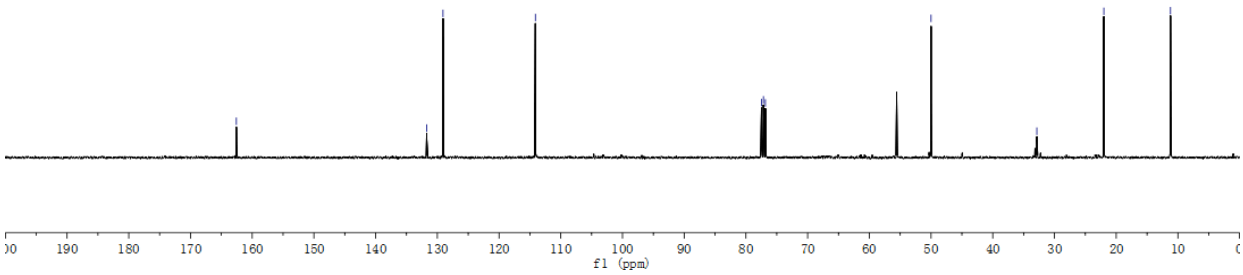
32.86
22.00
11.20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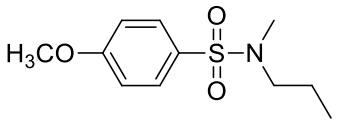
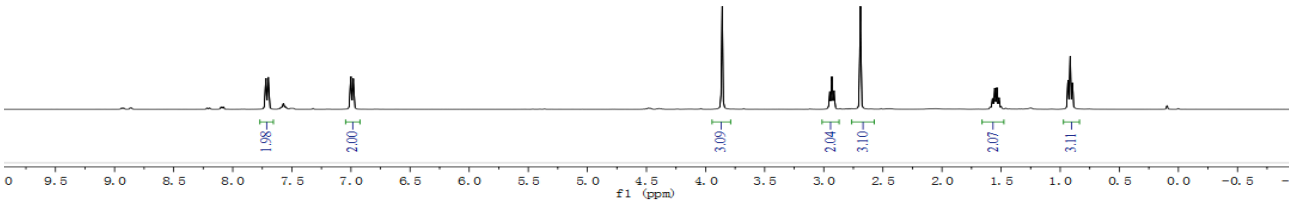

H3CO
O
S
N
O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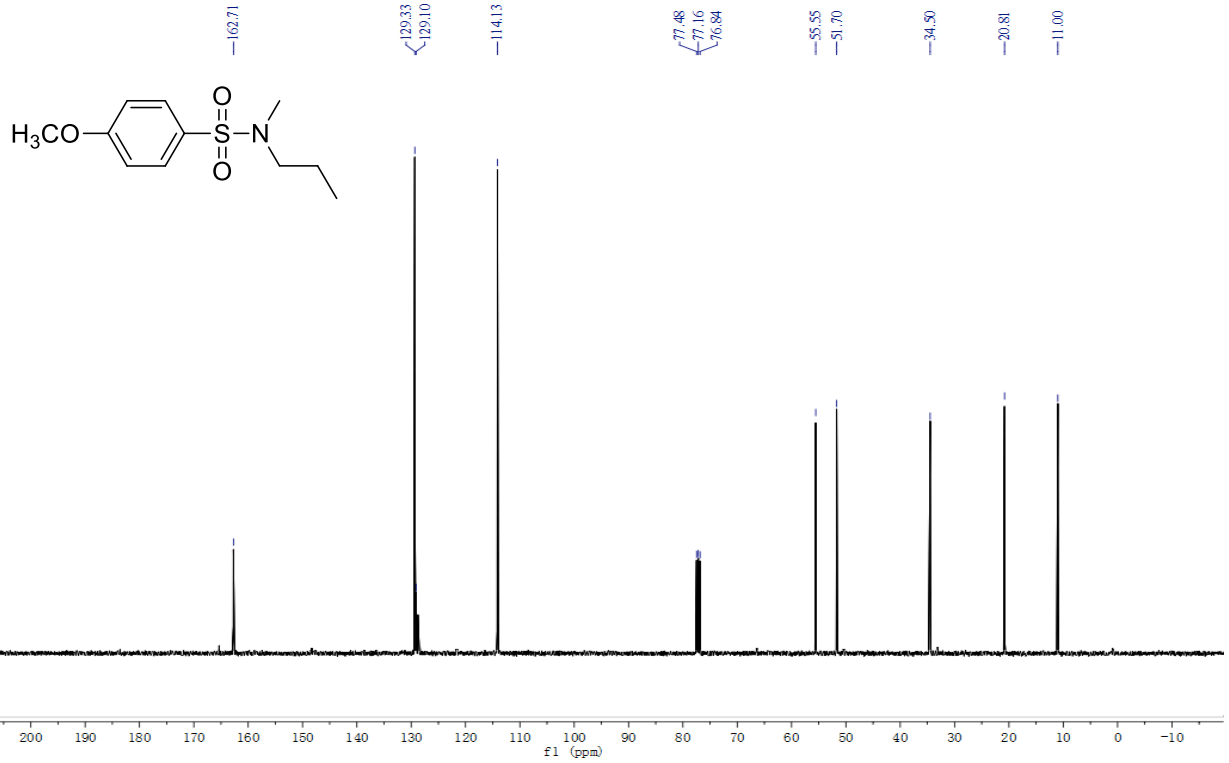
2.00
3.09
2.04
3.10
2.07
3.11
f1 (ppm)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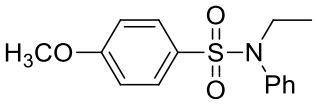
114.13
77.48
77.16
76.84
55.55
51.70
34.50
20.81
11.00
H3CO
f1 (ppm)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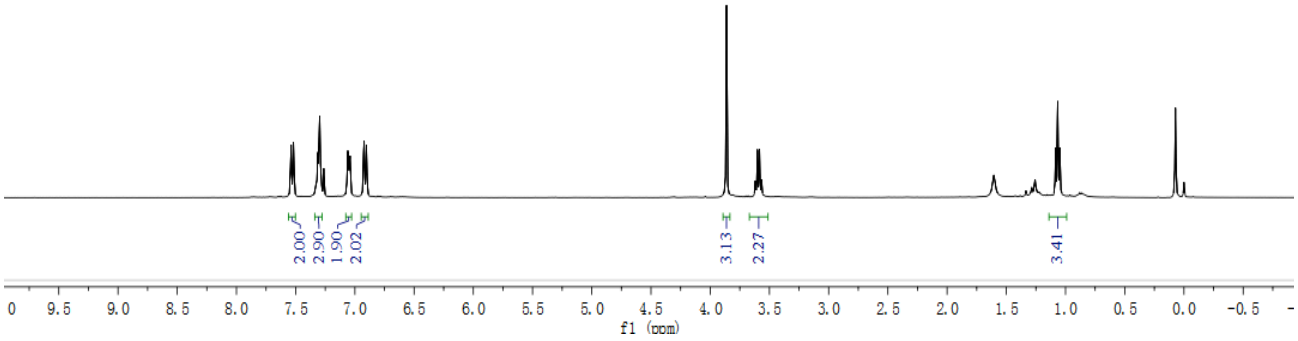
O
S
N
Ph
O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1.90
2.02
3.13
2.27
3.41
0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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4.0
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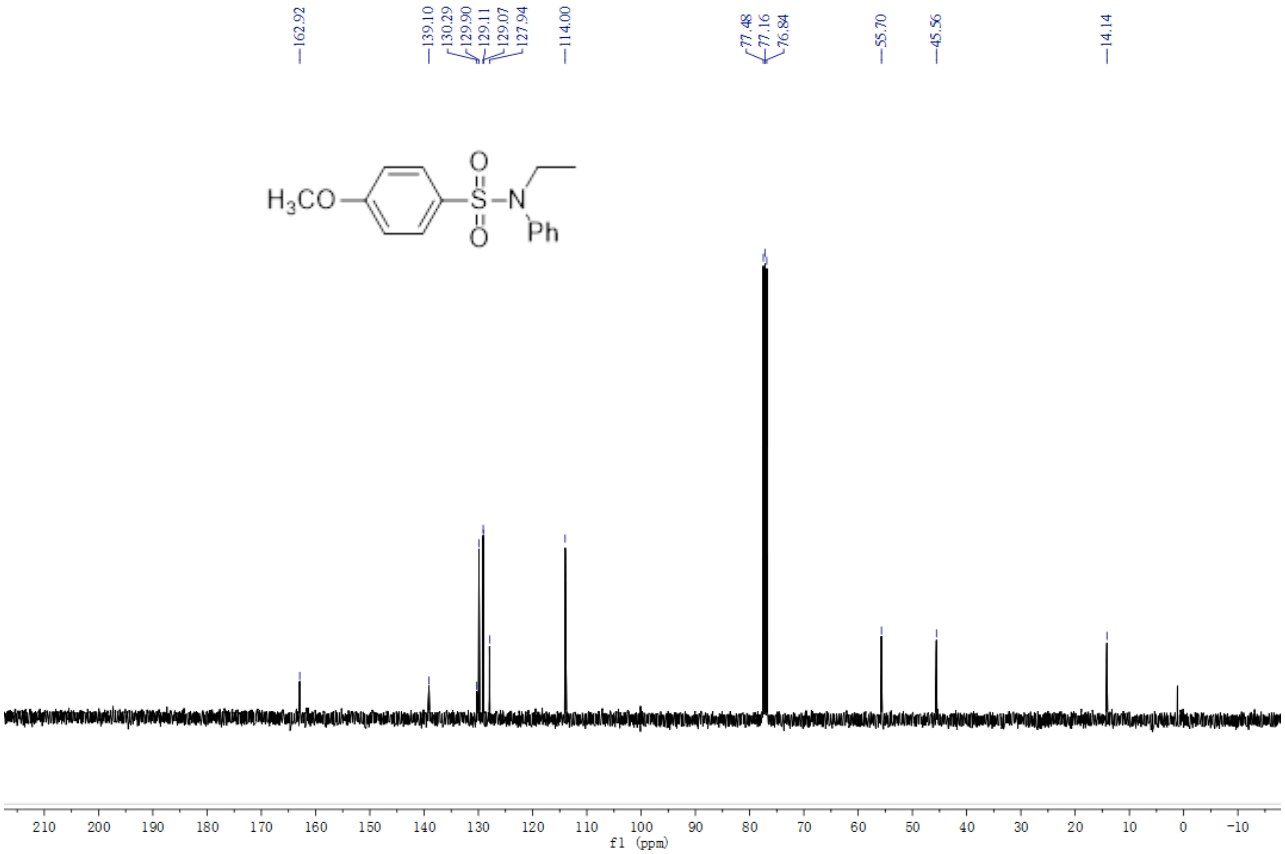
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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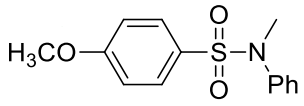
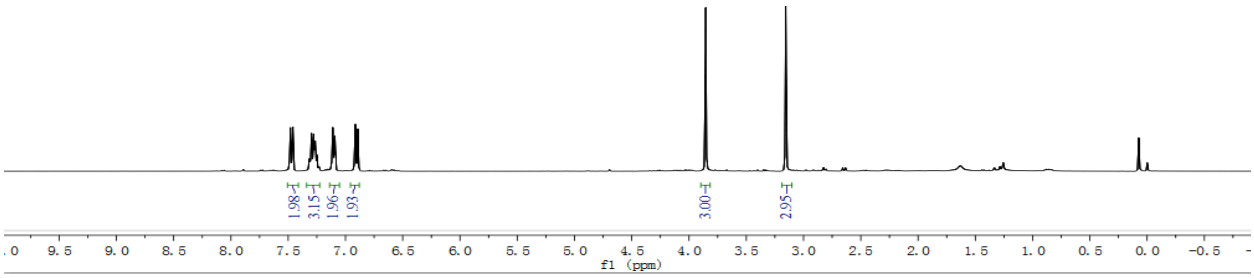
130.29
129.90
129.11
129.07
127.94
114.00
77.48
77.16
76.84
55.70
45.56
14.14
H3CO
O
S
N
Ph
O
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


H3CO
O
S
N
Ph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3.15
1.96
1.93
3.00
2.95
f1 (ppm)


163.10
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130.10
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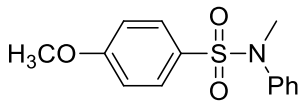
128.30
127.35
126.77
113.98
55.69
38.16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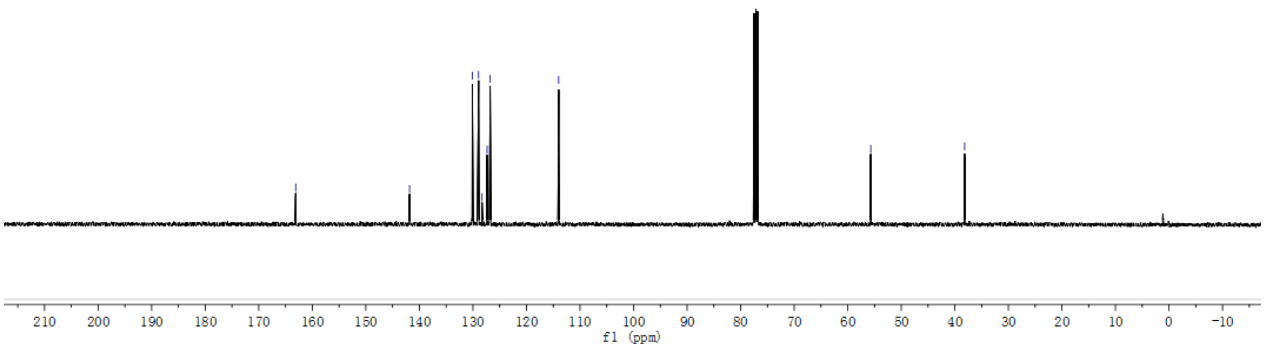
O
S
N
Ph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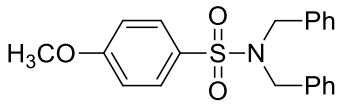
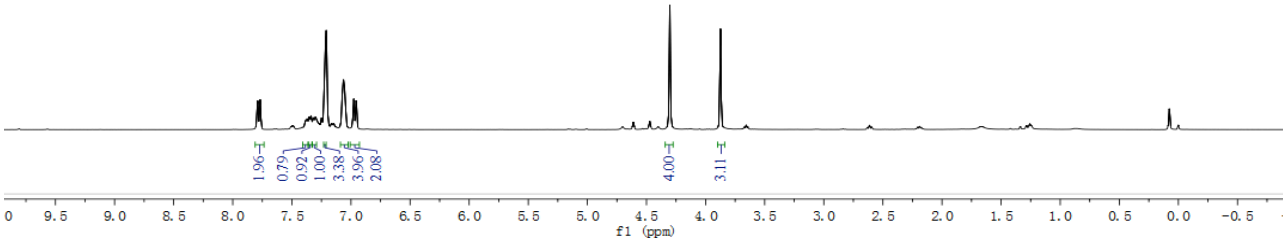

H3CO
O
S
O
N
Ph
Ph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0.79
0.92
1.00
3.38
3.96
2.08
4.00
3.11
f1 (ppm)


162.89
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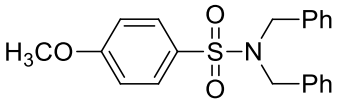
129.44
128.68
128.52
127.72
114.33
77.48
77.16
76.84
55.75
50.57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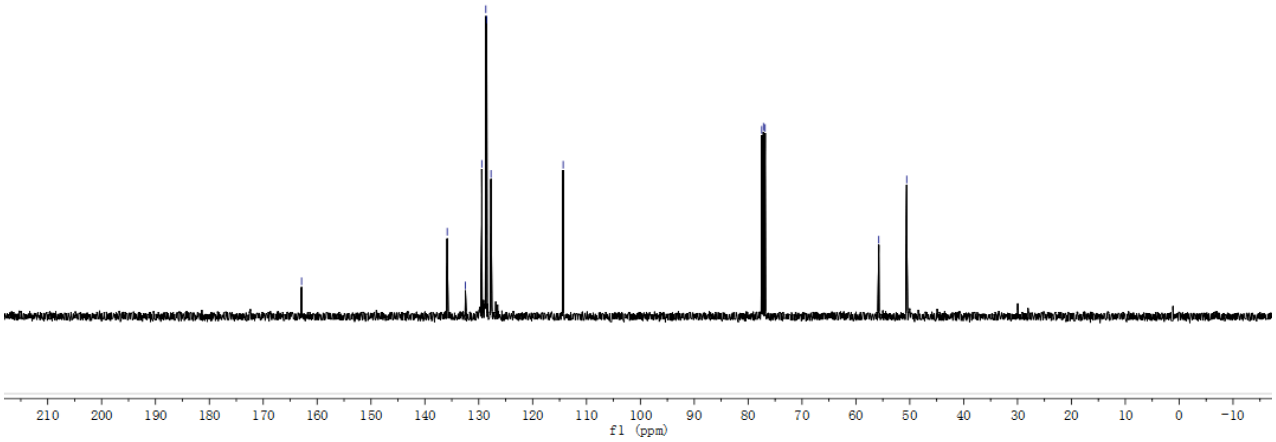
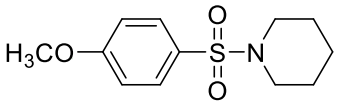
O
S
O
N
Ph
Ph


f1 (ppm)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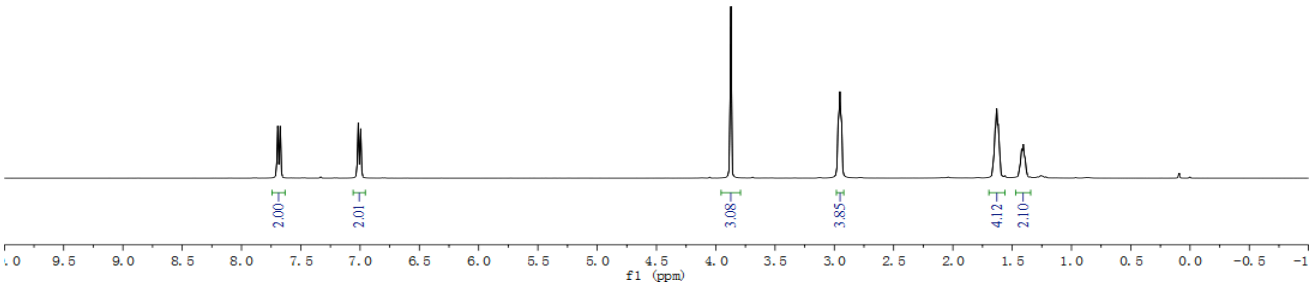
O
S
N
O


2.00
2.01
3.08
3.85
4.12
2.10
f1 (ppm)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127.64
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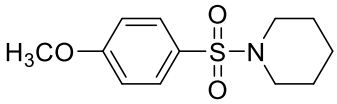
77.16
76.84
55.56
46.87
25.06
23.40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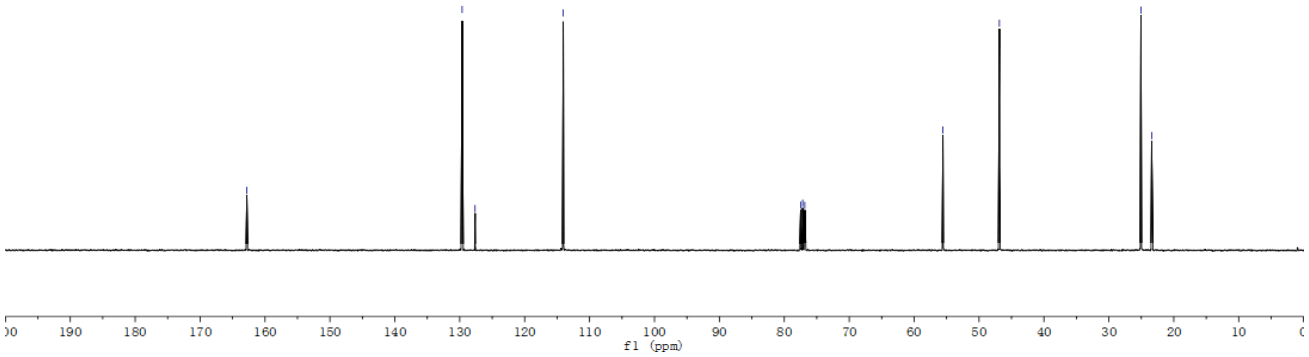
S
N
O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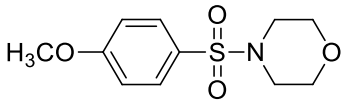
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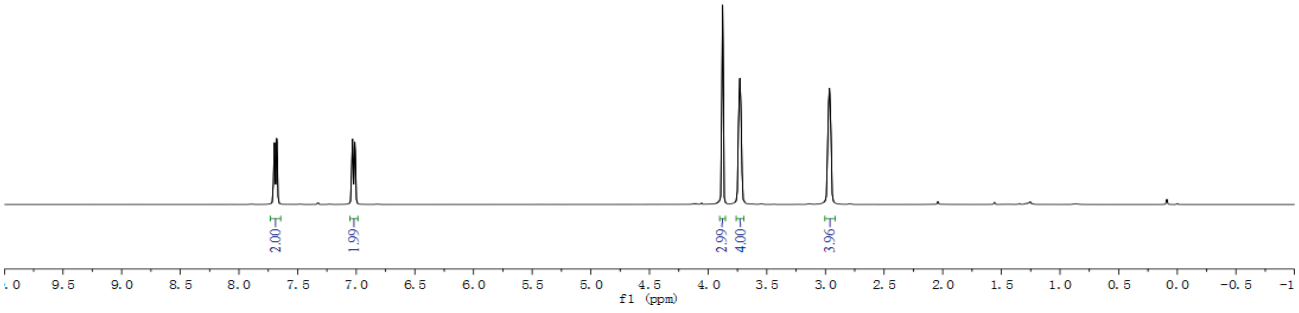
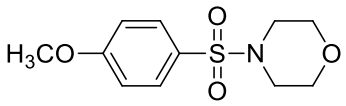
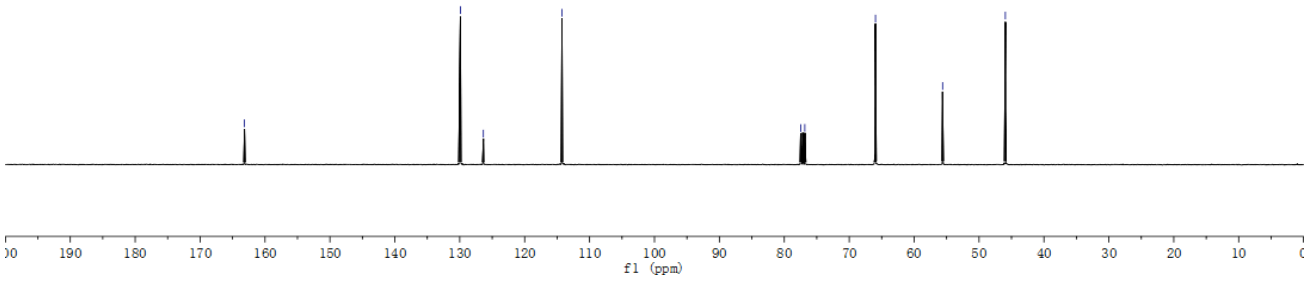
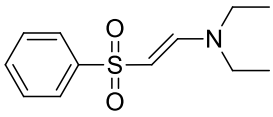
O
S
N
O
O
O

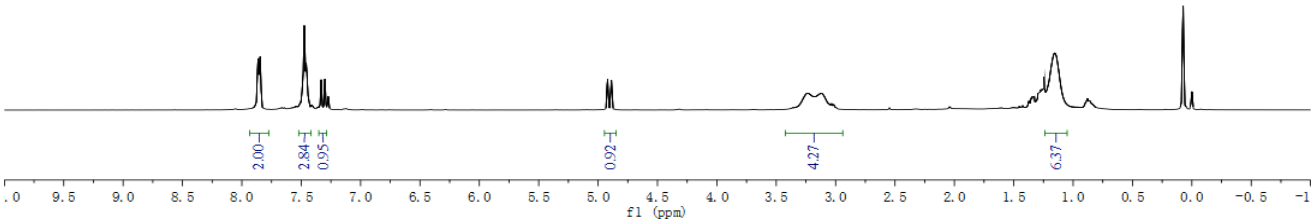

2.00
1.99
2.99
4.00
3.96
f1 (ppm)

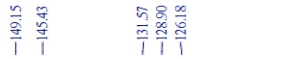

163.16
129.90
126.36
114.25
77.48
76.84
65.95
55.62
45.95

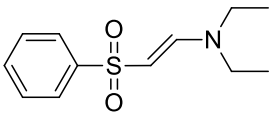

H3CO
O
S
N
O
O
O

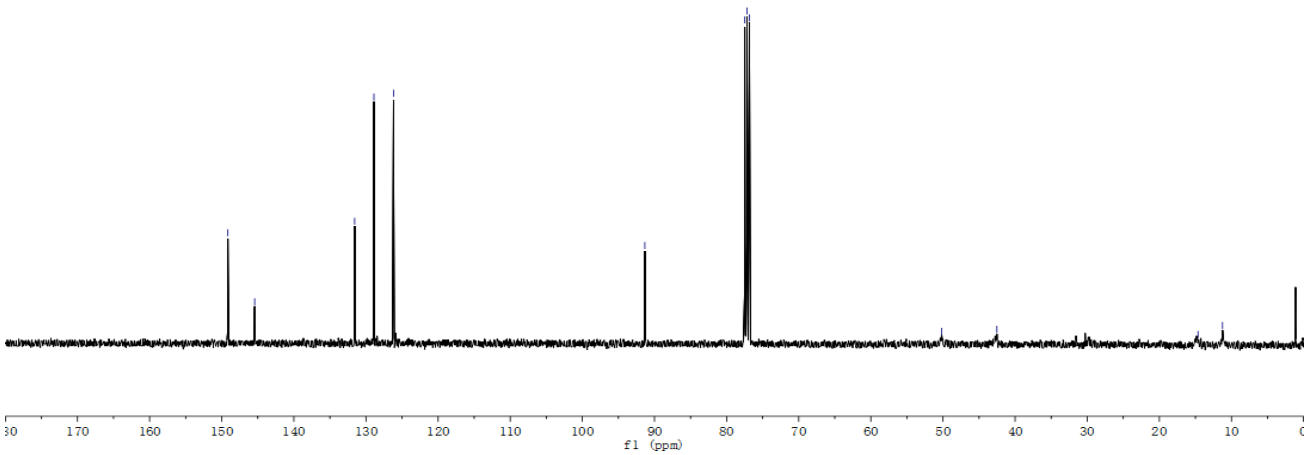

f1 (ppm)

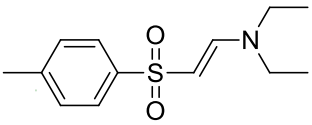


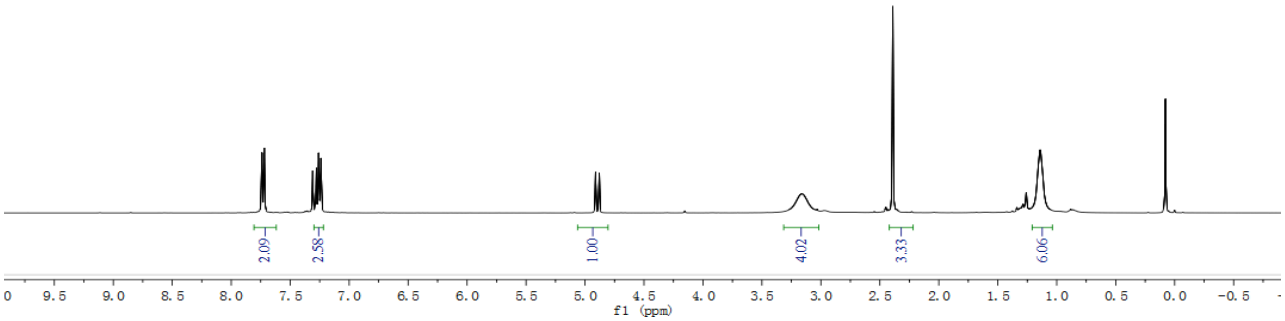

2.00
2.84
0.95
0.92
4.27
6.37
f1 (ppm)


149.15
145.43
131.57
128.90
126.18
91.34
77.48
77.16
76.84
50.21
42.53
14.64
11.24




f1 (ppm)

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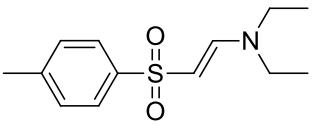
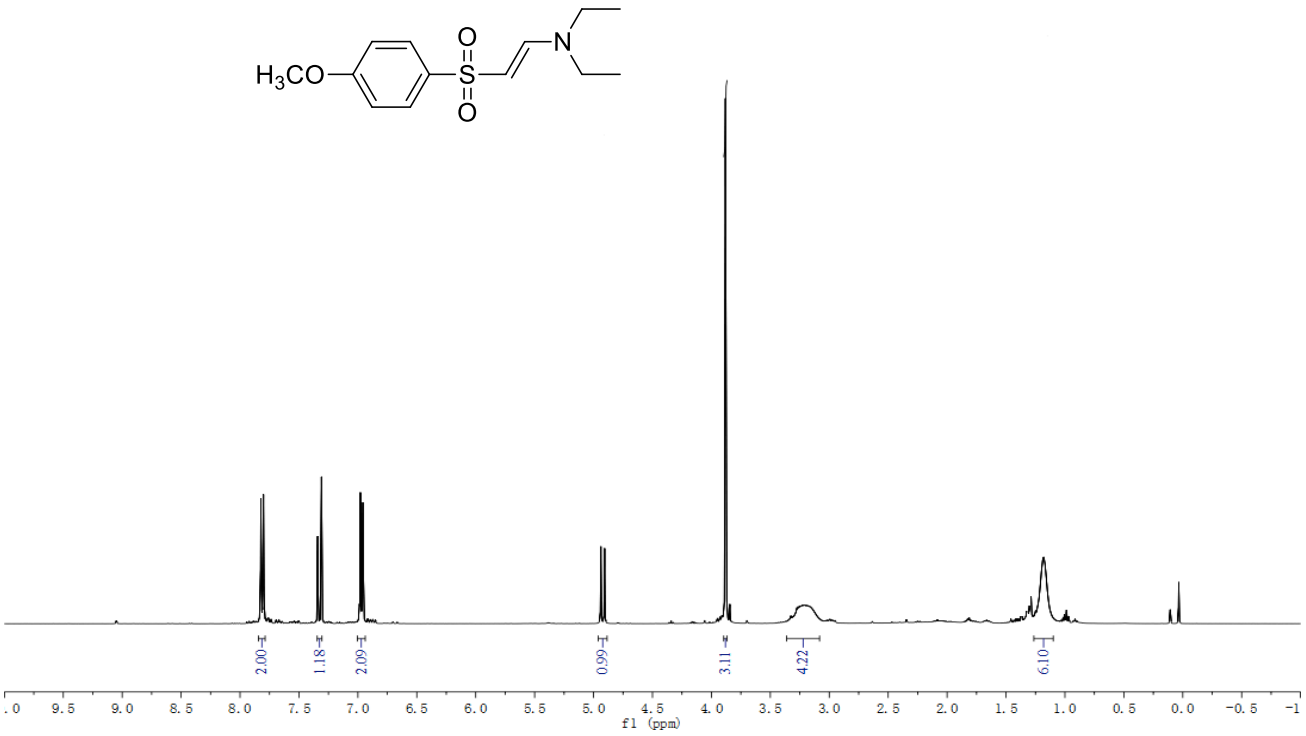
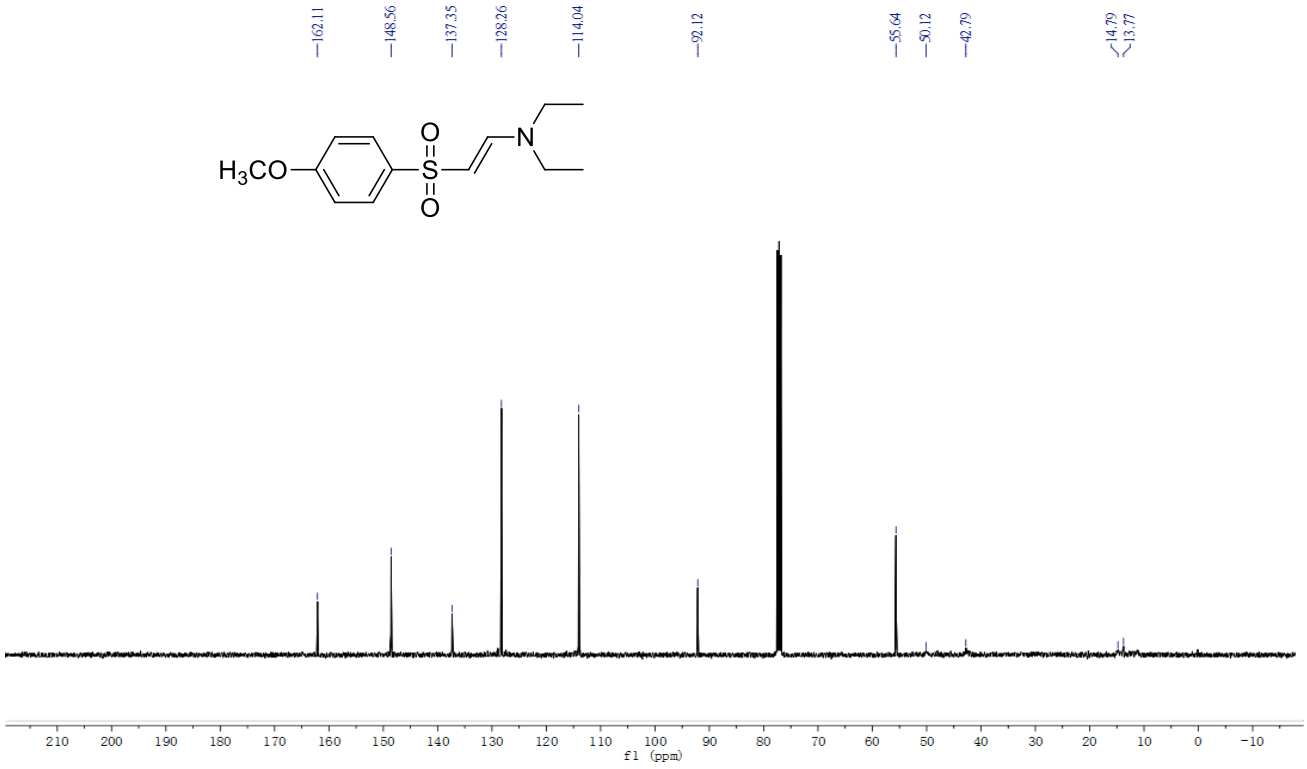
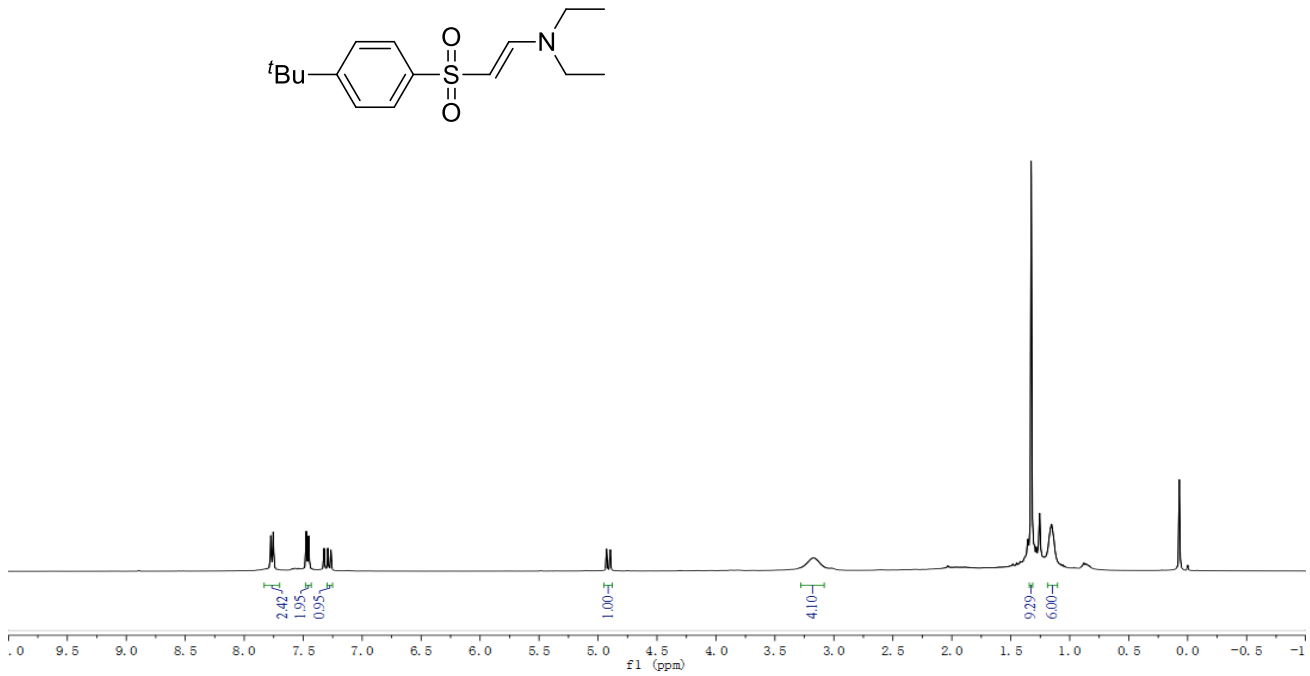
2.58
1.00
4.02
3.33
6.06
f1 (ppm)

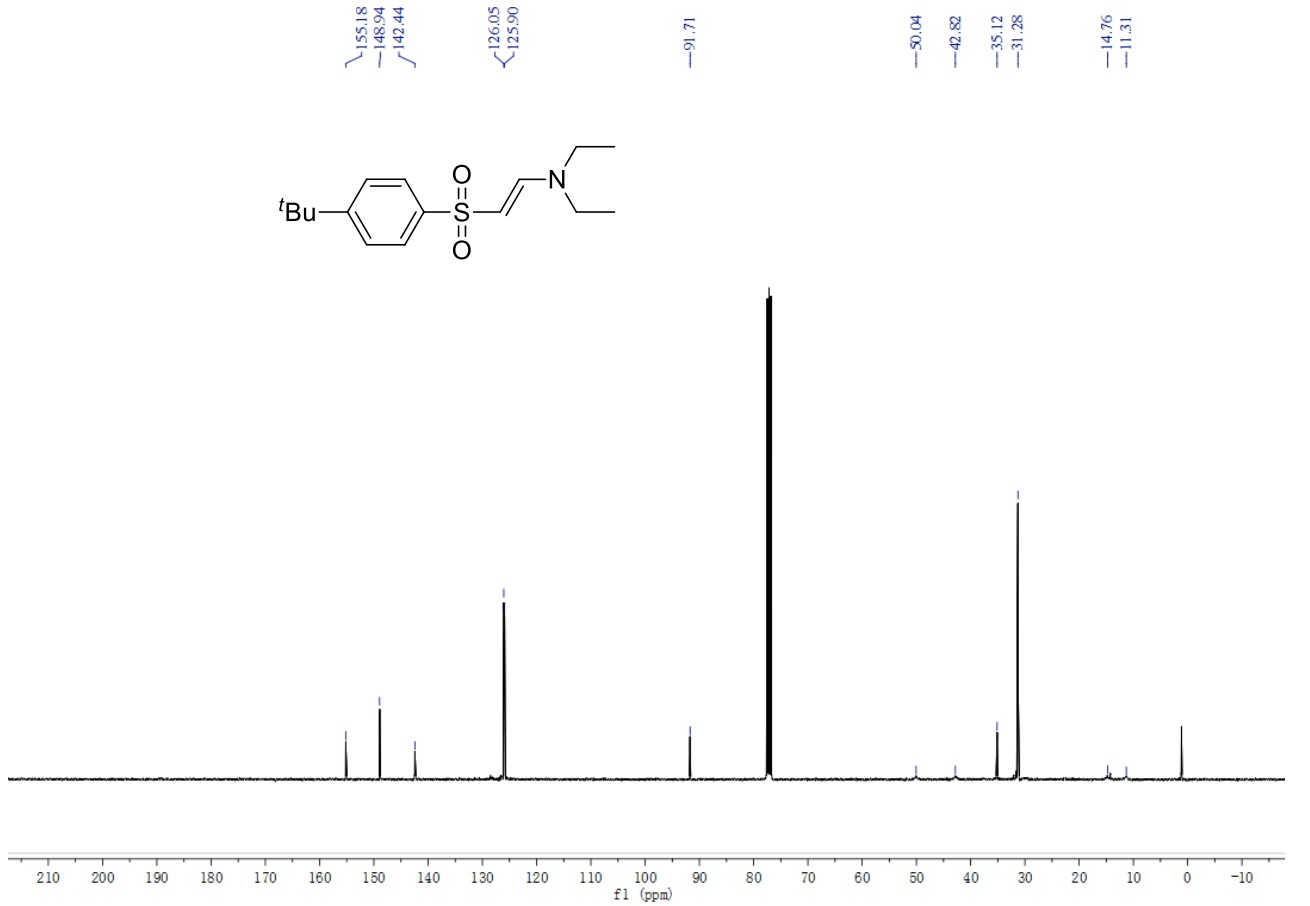


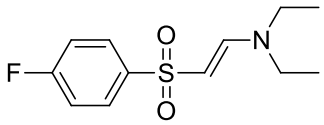
148.80
142.60
142.05
129.45
126.17
91.78
50.01
42.57
21.46
14.62
11.45
f1 (ppm)

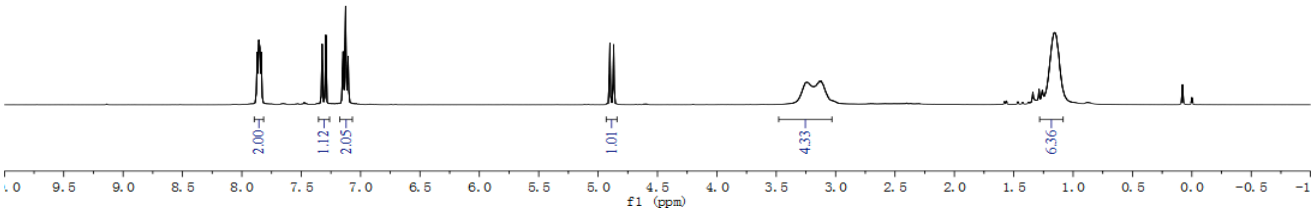

H3CO
O
S
O
N
2.00
1.18
2.09
0.99
3.11
4.22
6.10
f1 (ppm)


162.11
148.56
137.35
128.26
114.04
92.12
55.64
50.12
42.79
14.79
13.77
H3CO
O
S
O
N
f1 (ppm)

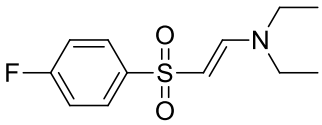

tBu
O
S
O
N
2.42
1.95
0.95
1.00
4.10
9.29
6.00
f1 (ppm)

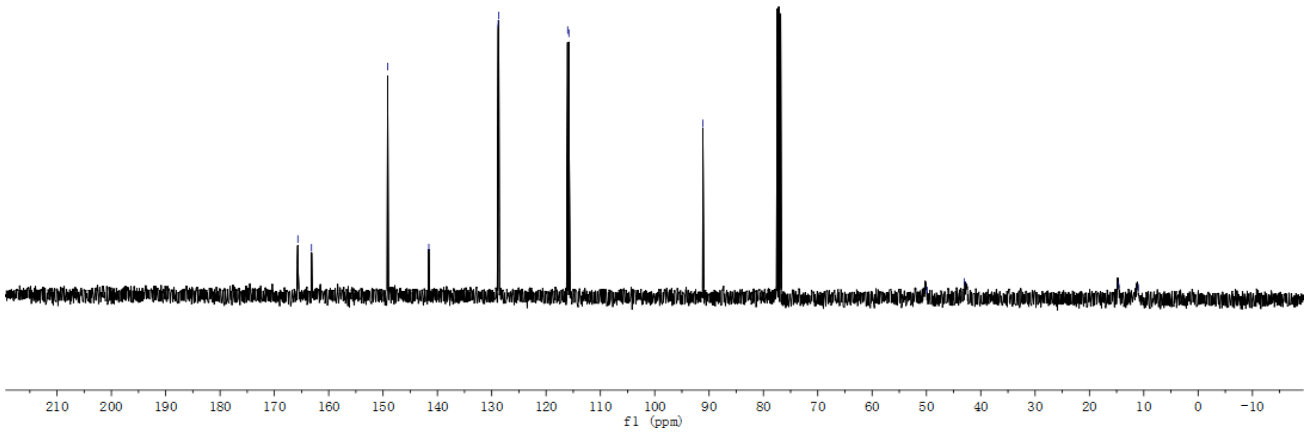

155.18
148.94
142.44
126.05
125.90
91.71
50.04
42.82
35.12
31.28
14.76
11.31
tBu
O
S
O
N
f1 (ppm)

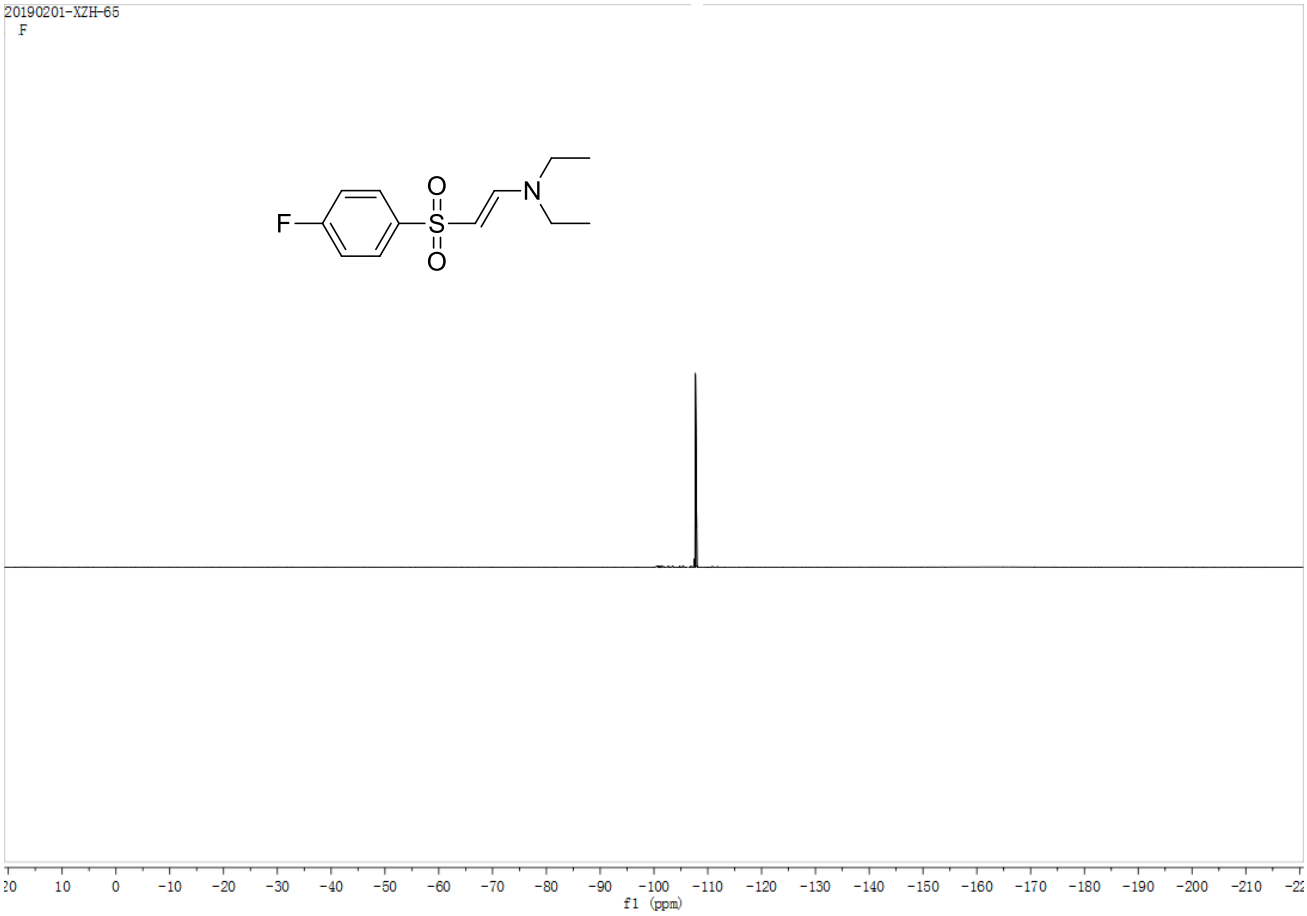

F
O
S
O
N

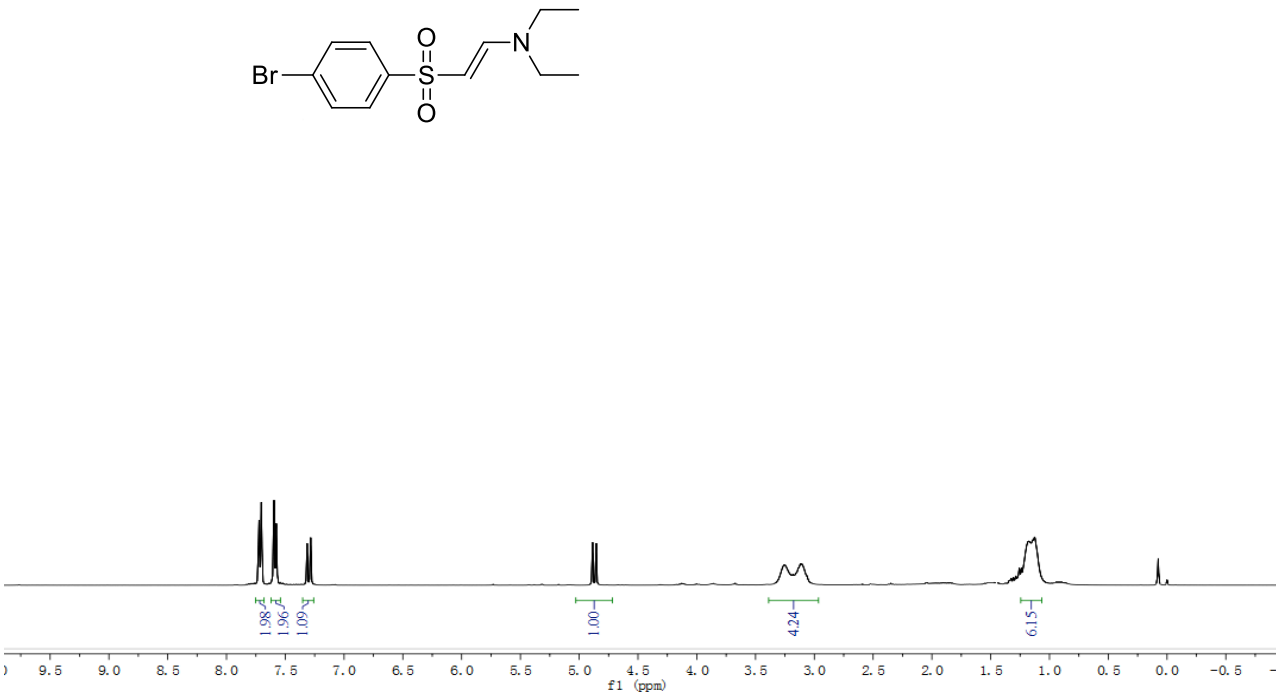

2.00
1.12
2.05
1.01
4.33
6.36
f1 (ppm)

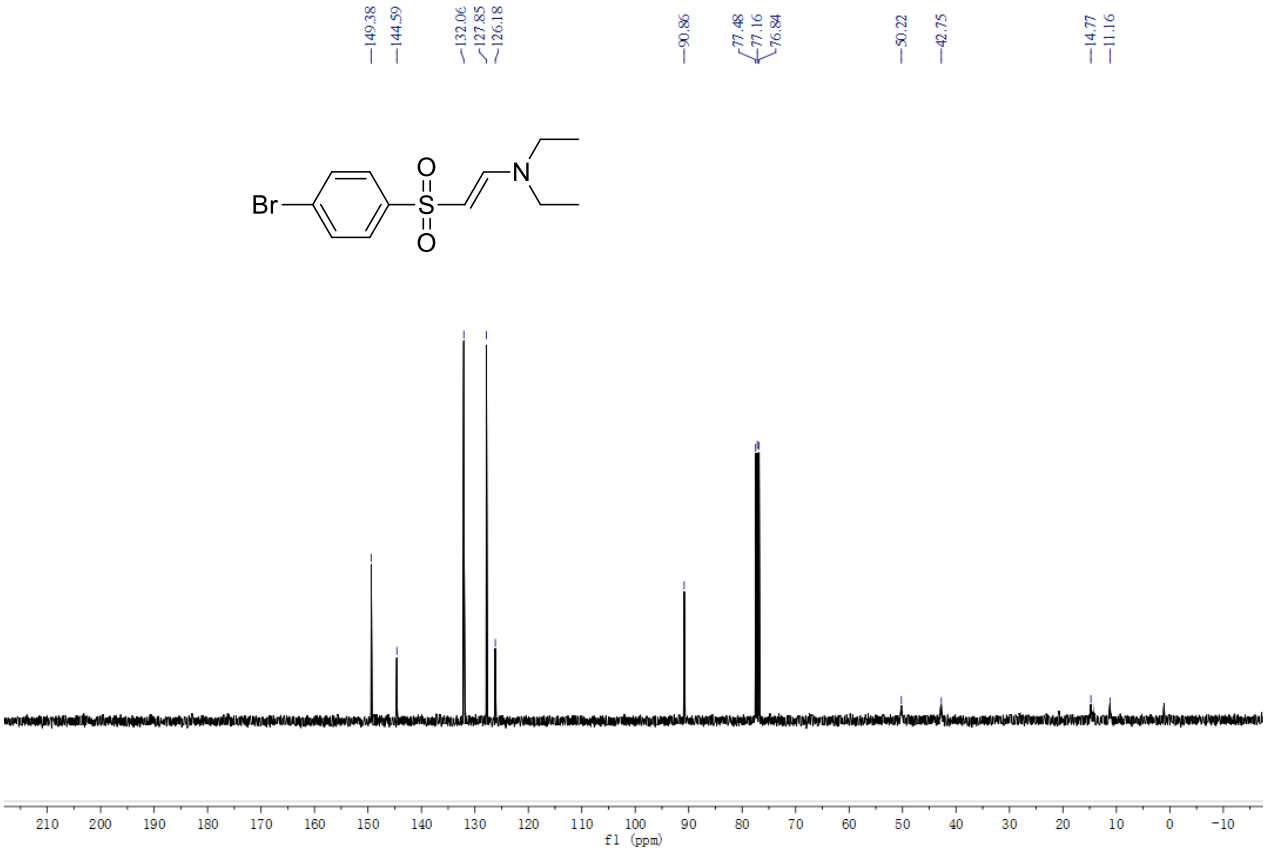

165.68
163.17
149.15
141.58
128.81
128.72
116.02
115.80
91.14
49.88
43.02
14.65
11.03

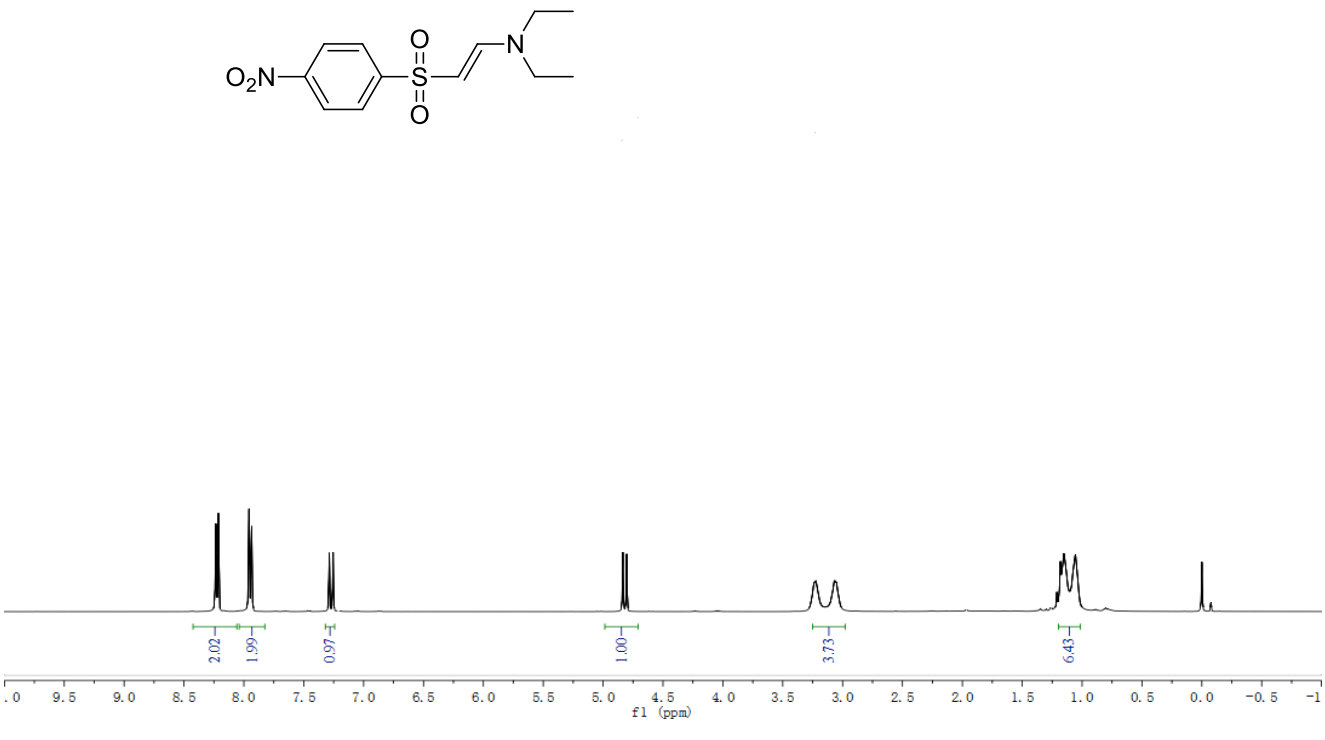

F
O
S
O
N

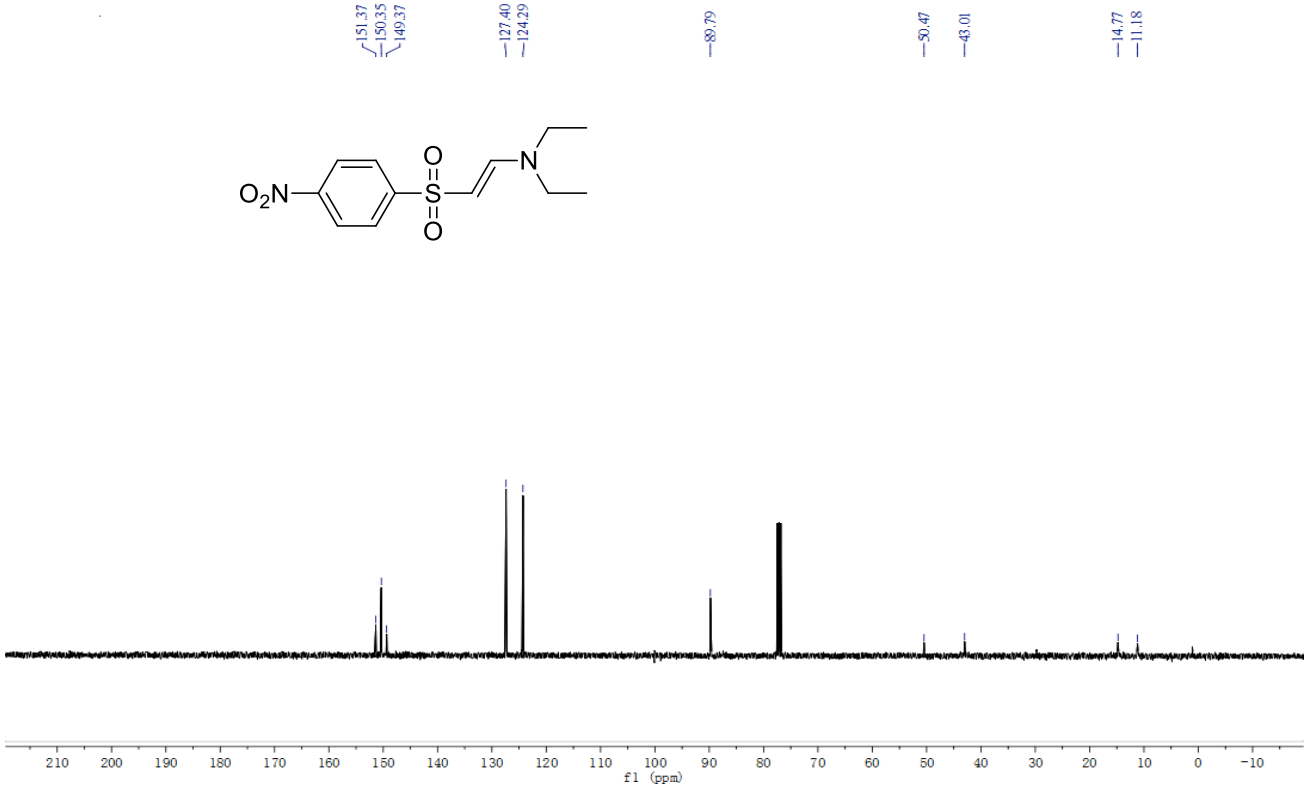

f1 (ppm)

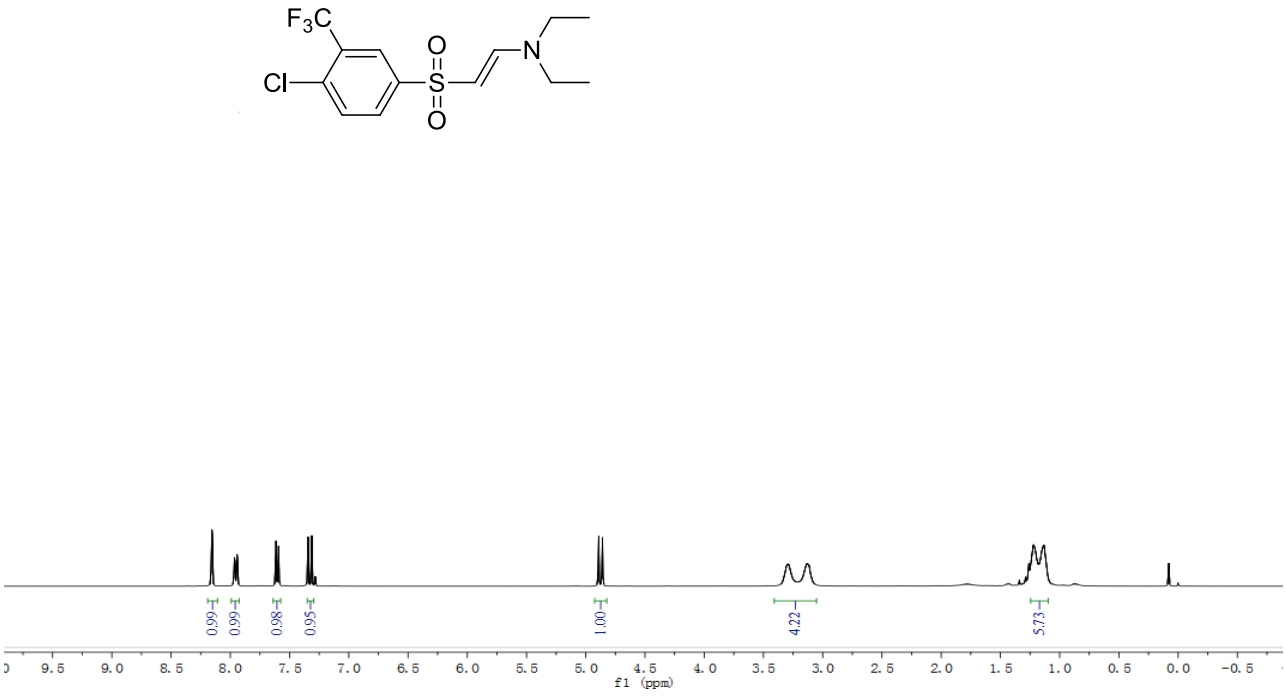

20190201-XZH-65
F
O
S
O
N
F
f1 (ppm)

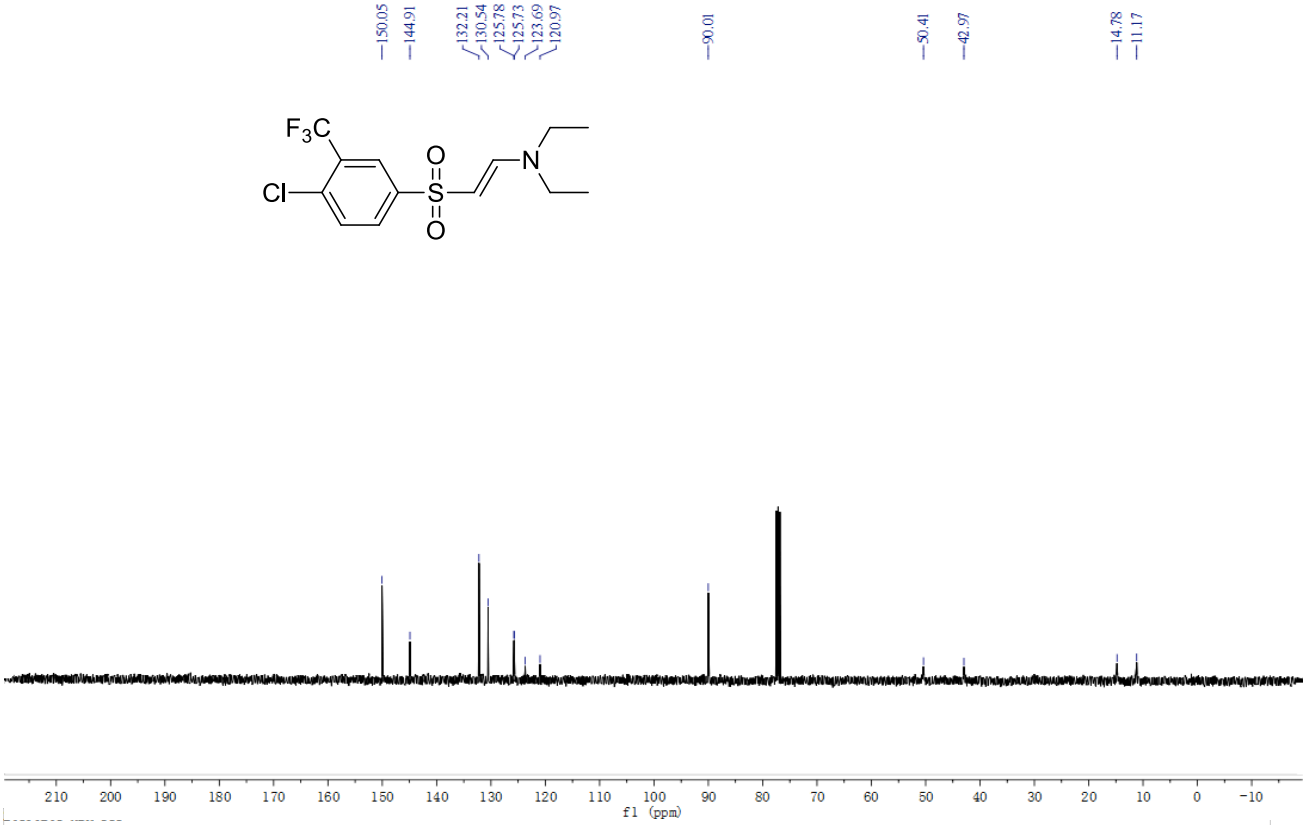

Br
O
S
O
N
1.98
1.96
1.09
1.00
4.24
6.15
f1 (ppm)

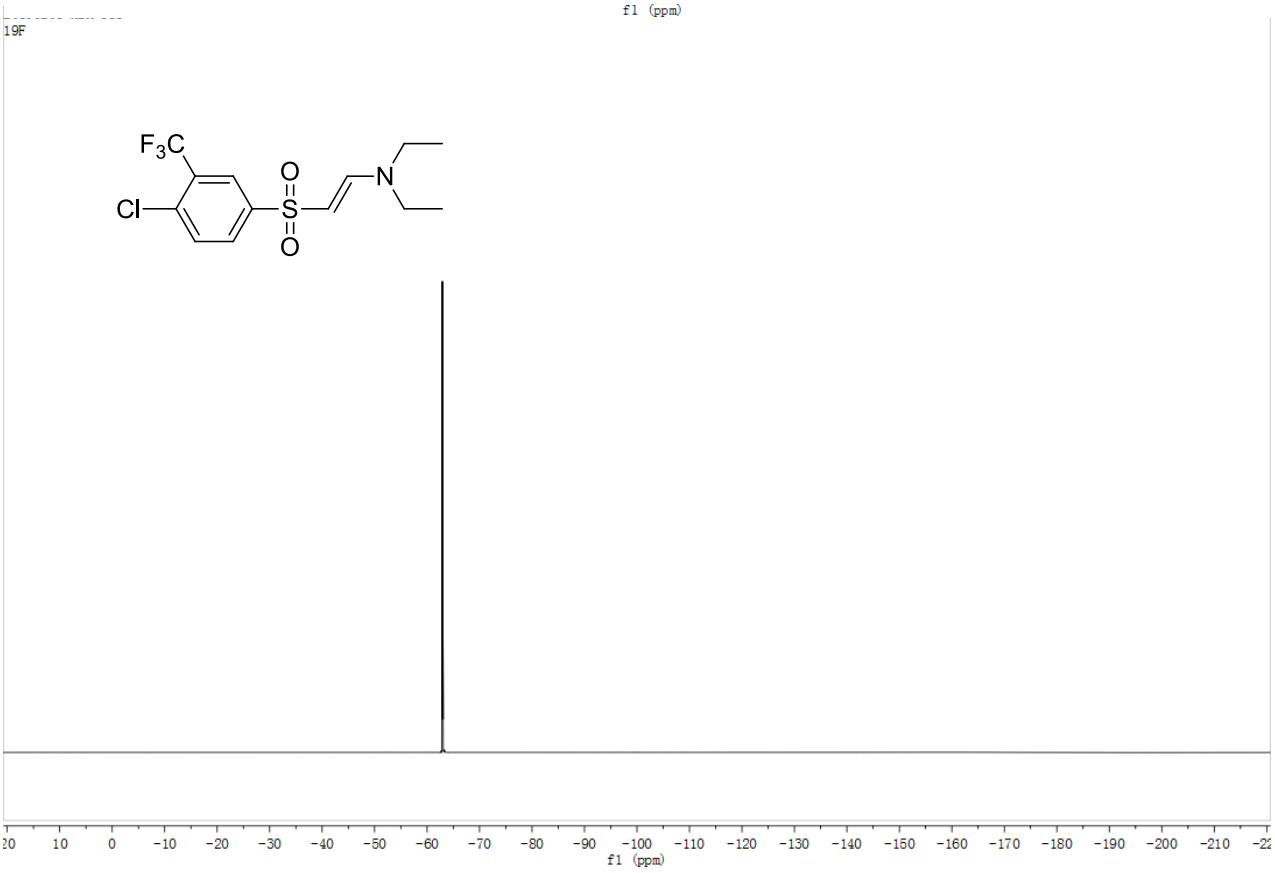

149.38
144.59
132.06
127.85
126.18
90.86
77.48
77.16
76.84
50.22
42.75
14.77
11.16
Br
O
S
O
N
f1 (ppm)

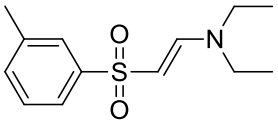

O2N
O
S
O
N
2.02
1.99
0.97
1.00
3.73
6.43
f1 (ppm)

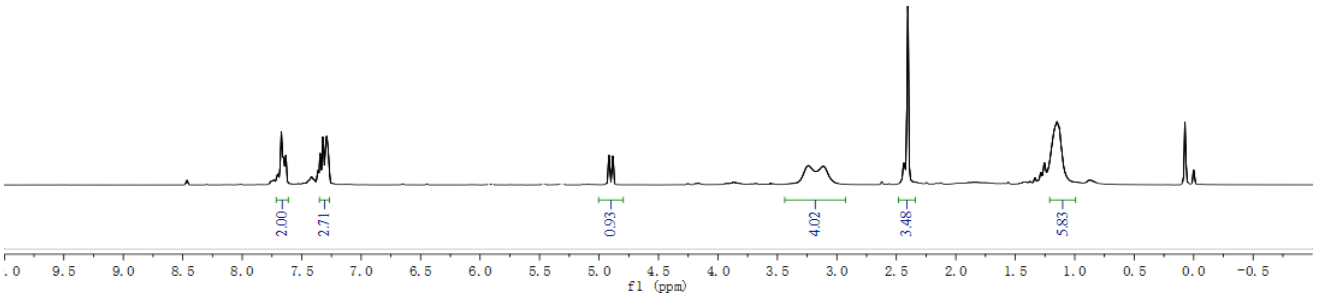

151.37
150.35
149.37
127.40
124.29
89.79
50.47
43.01
14.77
11.18
O2N
O
S
O
N
f1 (ppm)


F3C
Cl
O
S
O
N
0.99
0.99
0.98
0.95
1.00
4.22
5.73
f1 (ppm)


150.05
144.91
132.21
130.54
125.78
125.73
123.69
120.97
90.01
50.41
42.97
14.78
11.17
F3C
Cl
O
S
O
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


19F
F3C
Cl
O
S
O
N
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

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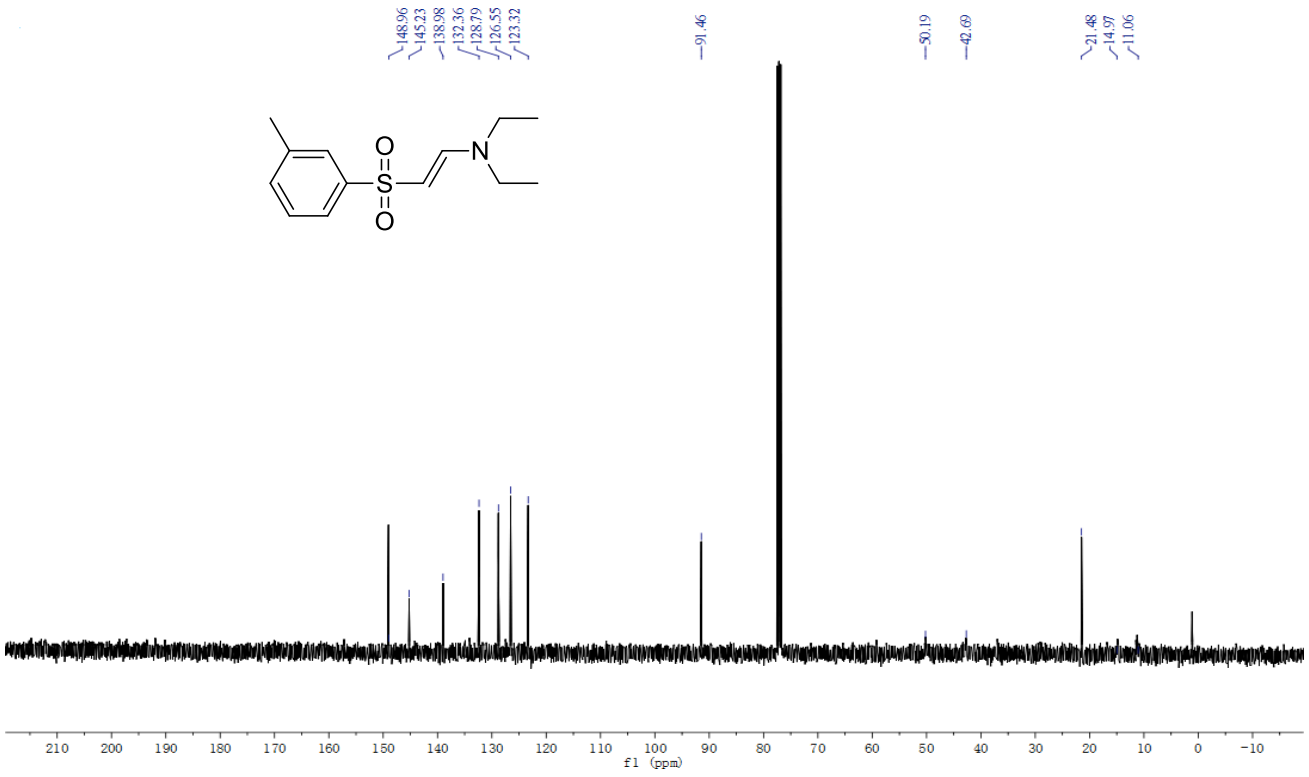
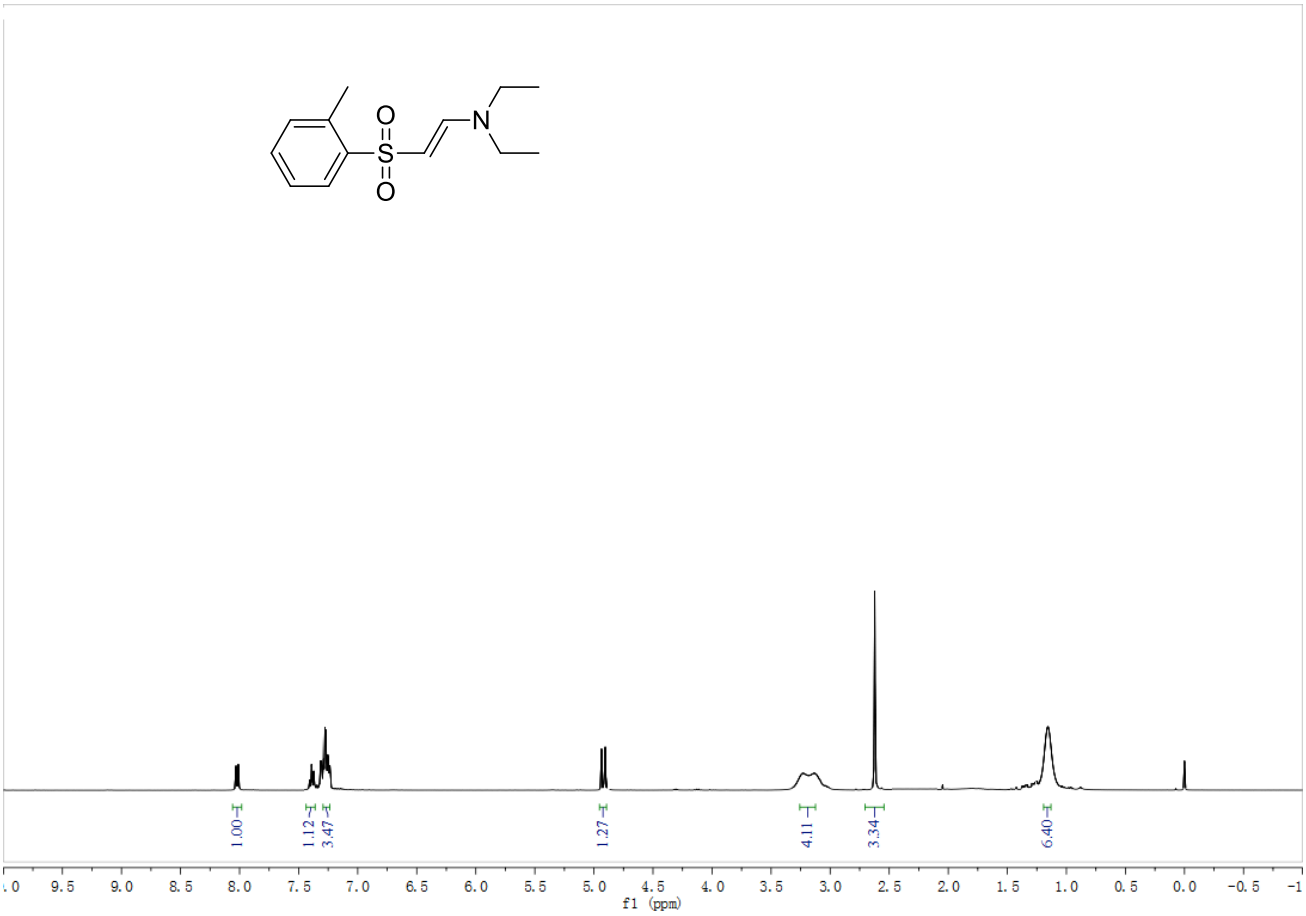
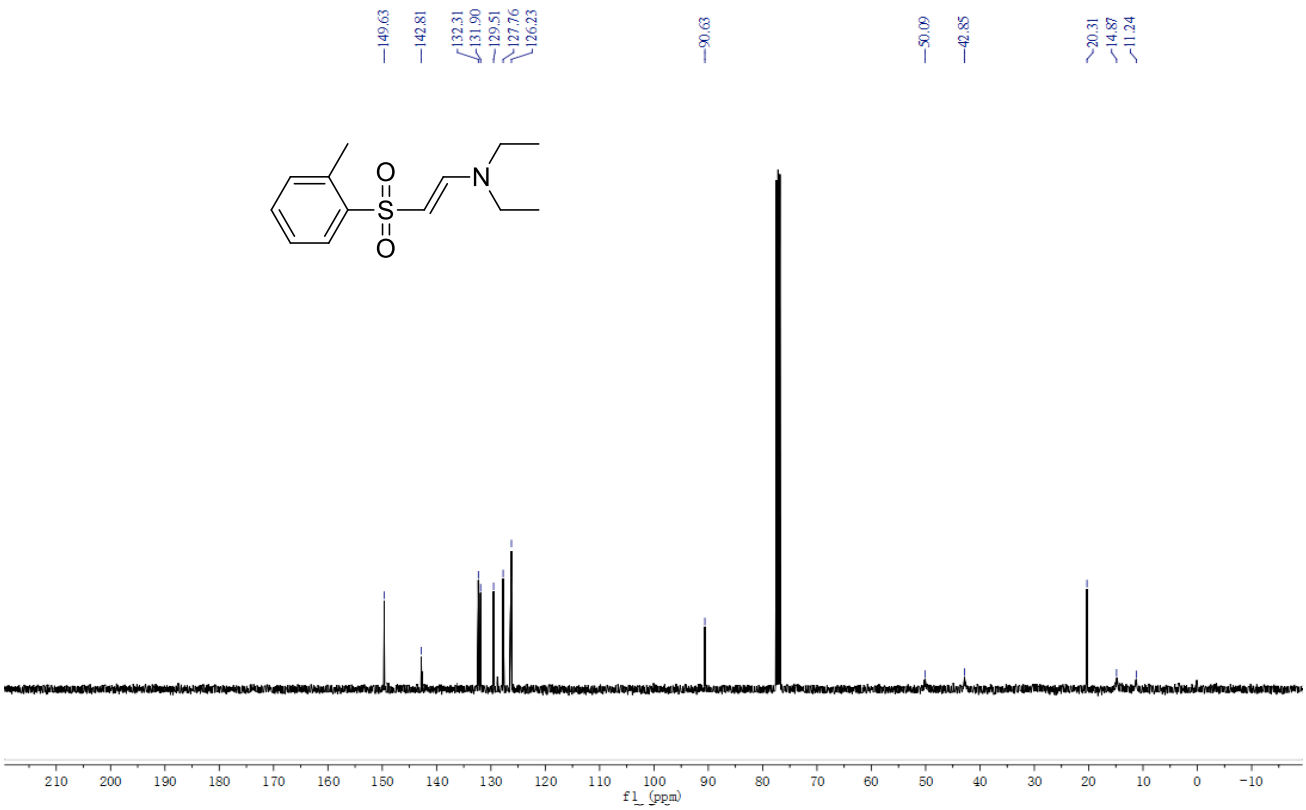
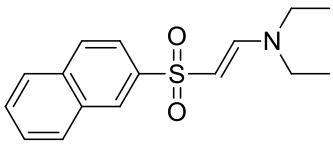
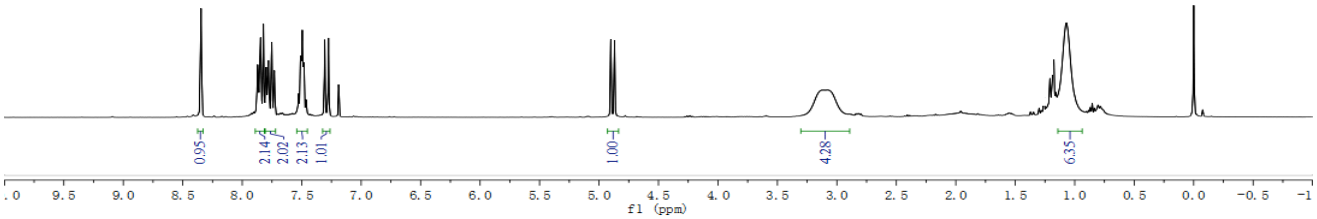
2.71
0.93
4.02
3.48
5.83
f1 (ppm)


148.96
145.23
138.98
132.36
128.79
126.55
123.32
91.46
50.19
42.69
21.48
14.97
11.06
f1 (ppm)


1.00
1.12
3.47
1.27
4.11
3.34
6.40
f1 (ppm)


149.63
142.81
132.31
131.90
129.51
127.76
126.23
90.63
50.09
42.85
20.31
14.87
11.24
f1 (ppm)





149.22
142.27
134.47
132.49
129.27
129.20
128.26
127.91
127.28
126.62
122.49
91.55
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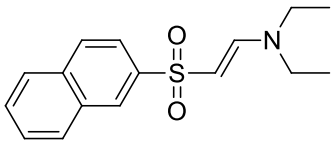
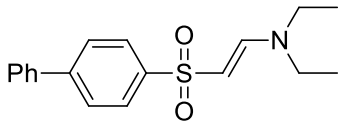
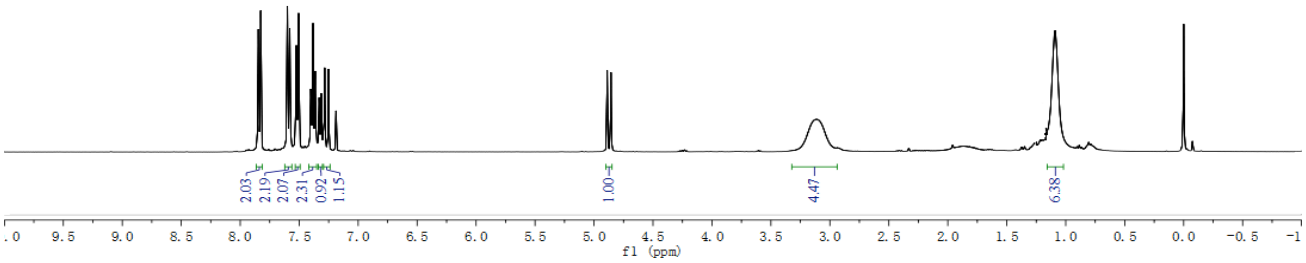
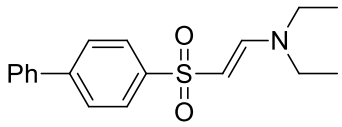
77.16
76.84
50.20
42.83
14.87
11.22

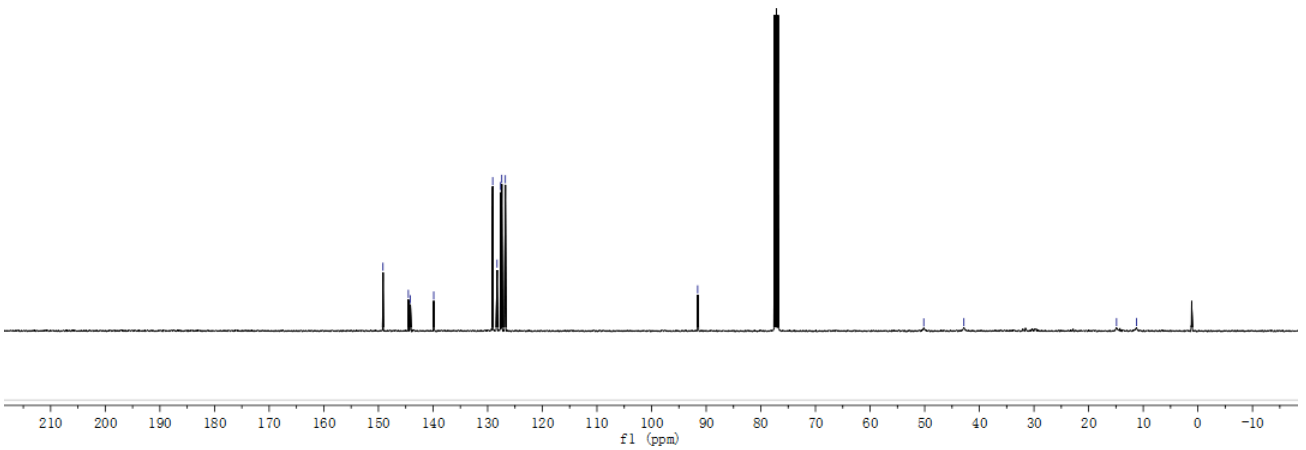


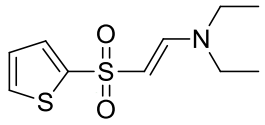

Ph
O
S
O
N

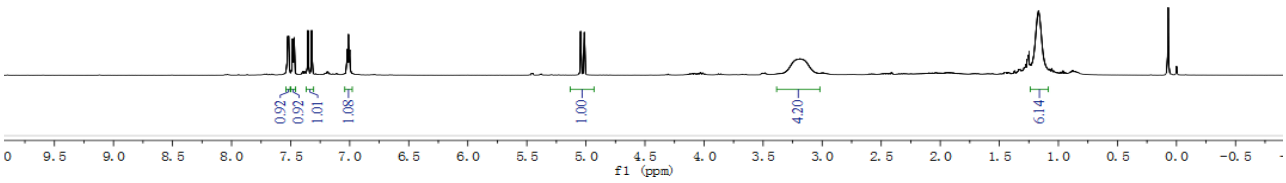

2.03
2.19
2.07
2.31
0.92
1.15
1.00
4.47
6.38
f1 (ppm)

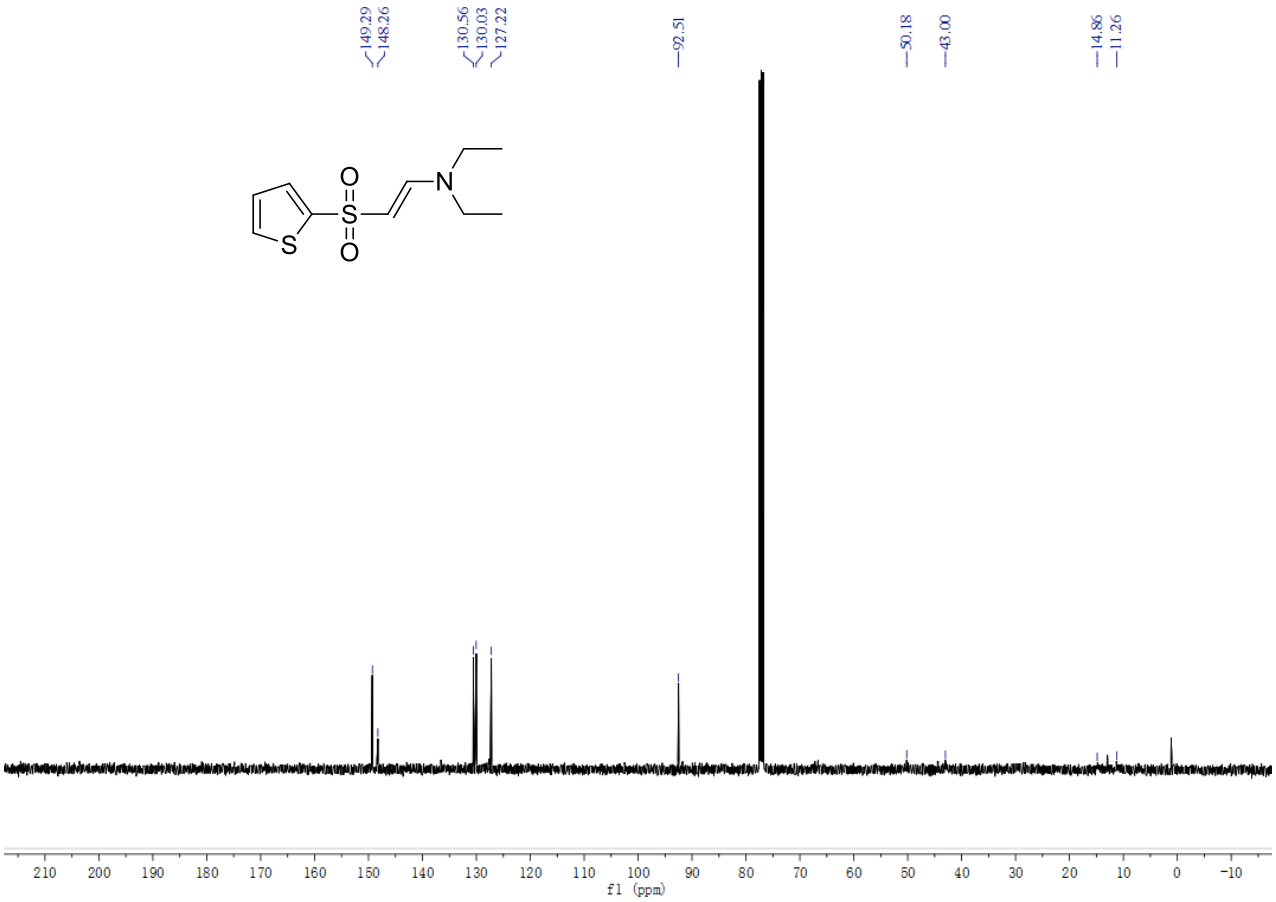

149.16
144.52
144.14
139.87
129.08
128.28
127.63
127.42
126.76
91.56
50.18
42.83
14.89
11.25


Ph
O
S
O
N


f1 (ppm)




0.92
0.92
1.01
1.08
1.00
4.20
6.14
f1 (ppm)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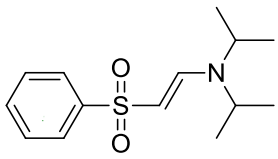
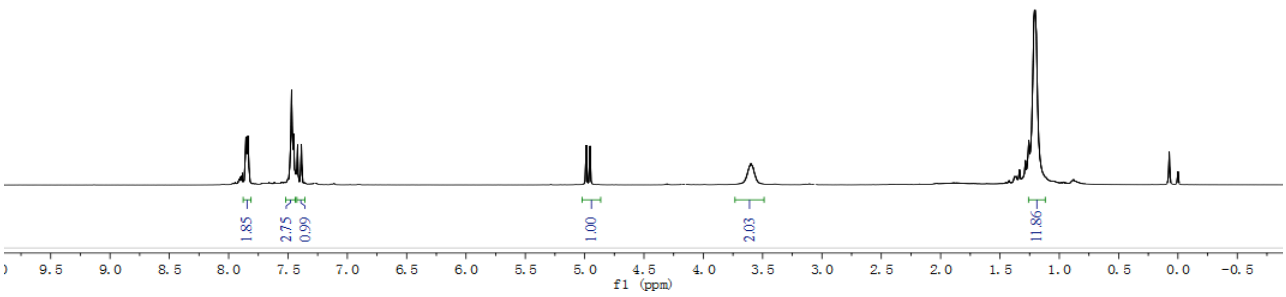
148.26
130.56
130.03
127.22
92.51
50.18
43.00
14.86
11.26
f1 (ppm)

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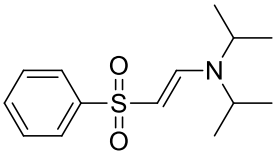
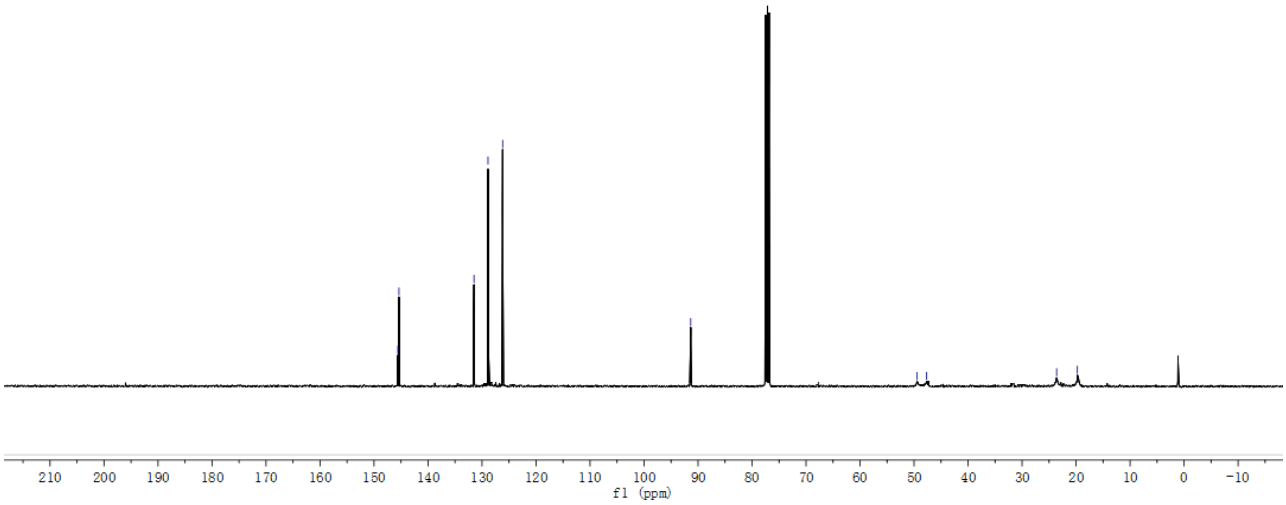
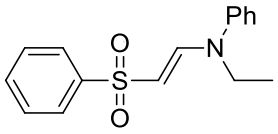
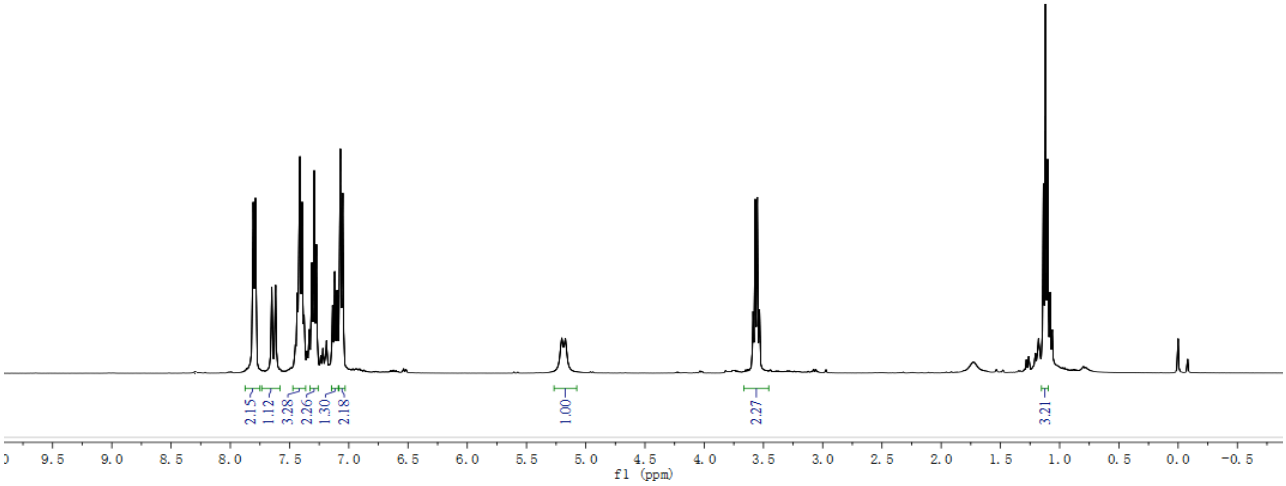
2.75
0.99
1.00
2.03
11.86
f1 (ppm)




145.58
145.38
131.48
128.89
126.18
91.35
49.44
47.66
23.60
19.76
f1 (ppm)





144.52
131.96
129.77
129.71
129.01
126.95
126.42
125.77
124.33
97.52
77.48
77.16
76.84
40.15
13.11