Supplementary Information

Direct difunctionalization of alkynes with sulfinic acids and melecular iodine: a simple and convenient approach to (*E*)-β-iodovinyl sulfones

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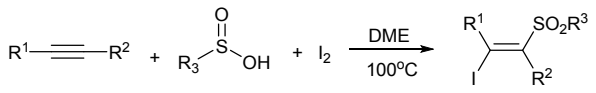
1. General information

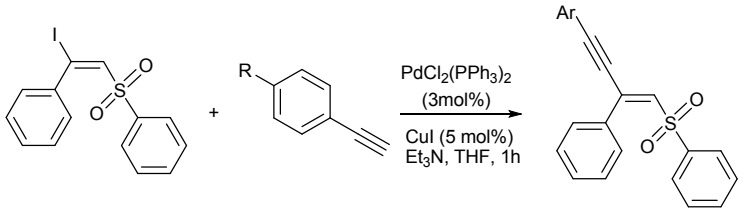
All commercially available reagent grade chemicals were purchased from Aldrich, Acros, Alfa Aesar and Beijing Ouhe Chemical Company and used as received without further purification unless otherwise stated. All solvents were dried according to standard procedures. ^{1}H NMR and ^{13}C NMR were recorded in $CDCl_3$ on a Bruker Avance III 400 spectrometer with TMS as internal standard (400 MHz ^{1}H, 100 MHz ^{13}C) at room temperature, the chemical shifts (δ) were expressed in ppm and J values were given in Hz. The following abbreviations are used to indicate the multiplicity: singlet (s), doublet (d), triplet (t), quartet (q), doublet of doublets (dd), doublet of triplets (dt), and multiplet (m). All first order splitting patterns were assigned on the basis of the appearance of the multiplet. Splitting patterns that could not be easily interpreted were designated as multiplet (m). Mass analyses and HRMS were obtained on a Finnigan-LCQDECA mass spectrometer and a Bruker Daltonics Bio-TOF-Q mass spectrometer by the ESI method, respectively. Column chromatography was performed on silica gel (200-300 mesh).

2. General procedure for direct synthesis of (*E*)-β-iodovinyl sulfones via difunctionalization of alkynes with sulfinic acids and melecular iodine.



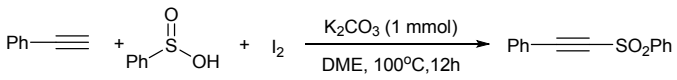
In a sealed tube, alkynes (0.5 mmol), sulfinic acids (1.0 mmol), molecular iodine (0.5 mmol), and DME (2 mL) were added. The mixture was allowed to stir at 100°C for 12-24h. After the reaction, the solvent was then removed under vacuum. The residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product.

3. The procedure (A) for the reaction of (*E*)-β-iodovinyl sulfone with alkynes leading to alkynylation products.



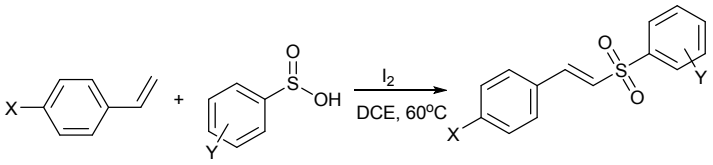
To a mixture of (*E*)-β-iodovinyl sulfone **3aa** (0.25 mmol), $PdCl_2(PPh_3)_2$ (3 mol%) CuI (5 mol%), Et_3N (0.25 mmol), and alkyne (0.75 mmol) in a 25 mL round-bottomed flack at room temperature, was added the THF (2 mL). The reaction vessel was allowed to stir at room temperature for 1 h. After the reaction, the solution was concentrated in vacuum. The residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired products.

4. The procedure (B) for the synthesis of acetylenic sulfone (5aa).



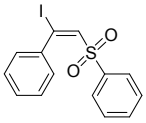
In a sealed tube, phenylacetylene **1a** (0.5 mmol)**,** benzenesulfinic acid **2a** (1.0 mmol), molecular iodine (0.5 mmol), K_2CO_3 (1 mmol), and DME (2 mL) were added. The mixture was allowed to stir at 100°C for 12h. After the reaction, the solvent was then removed under vacuum. The residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired product **5aa** (78%).

5. The procedure (C) for the synthesis of (*E*)-vinyl sulfones.

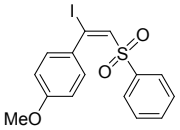


In a sealed tube, alkenes (0.5 mmol), sulfinic acids (1.0 mmol), molecular iodine (0.5 mmol), and DCE (2 mL) were added. The mixture was allowed to stir at 60°C for 12h. After the reaction, the solvent was then removed under vacuum. The residue was purified by flash column chromatography using a mixture of petroleum ether and ethyl acetate as eluent to give the desired (*E*)-vinyl sulfones.

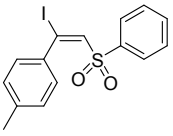
6. Characterization data of products 3aa-6af

(*E*)-(1-iodo-2-(phenylsulfonyl)vinyl)benzene[1] 

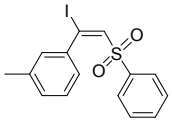
Compound **3aa** was obtained in 88% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.61-7.55 (m, 3H), 7.41 (s, 1H), 7.40 (t, J = 7.8 Hz, 2H), 7.34-7.28 (m, 3H), 7.25-7.23 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.1, 140.3, 139.6, 133.5, 129.8, 129.0, 128.0, 127.8, 127.7, 114.7; HRMS calc. for $C_{14}H_{11}IO_2SNa$ $(M+Na)^+$, 392.9422; found, 392.9424.

(*E*)-1-(1-iodo-2-(phenylsulfonyl)vinyl)-4-methoxybenzene[1] 

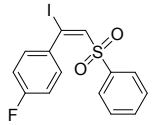
Compound **3ba** was obtained in 88% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.63 (d, J = 7.3 Hz, 2H), 7.56 (d, J = 7.4 Hz, 1H), 7.42 (t, J = 7.9 Hz, 2H), 7.33 (s, 1H), 7.27 (t, J = 6.6 Hz, 2H), 6.81 (d, J = 8.8 Hz, 2H), 3.84 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 160.9, 140.5, 140.2, 133.5, 131.8, 130.0, 129.0, 127.8, 115.5, 113.3, 55.4; HRMS calc. for $C_{15}H_{13}IO_3SNa$ $(M+Na)^+$, 422.9528; found, 422.9529.

(*E*)-1-(1-iodo-2-(phenylsulfonyl)vinyl)-4-methylbenzene[1] 

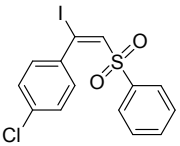
Compound **3ca** was obtained in 75% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.64-7.62 (m, 2H), 7.57 (t, J = 7.5 Hz, 1H), 7.41 (t, J = 8.1 Hz, 2H), 7.37 (s, 1H), 7.17 (d, J = 8.2 Hz, 2H), 7.10 (d, J = 8.0 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 140.6, 140.4, 140.3, 136.8, 133.5, 129.0, 128.6, 127.8, 115.4, 21.5; HRMS calc. for $C_{15}H_{13}IO_2SNa$ $(M+Na)^+$, 406.9579; found, 406.9577.

(*E*)-1-(1-iodo-2-(phenylsulfonyl)vinyl)-3-methylbenzene 

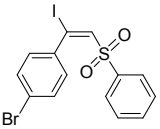
Compound **3da** was obtained in 90% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.59-7.53 (m, 3H), 7.41 (s, 1H), 7.39 (t, J = 8.3 Hz, 2H), 7.18 (t, J = 7.6 Hz, 1H), 7.11 (d, J = 7.6 Hz, 1H), 7.05 (d, J = 7.5 Hz, 1H), 6.93 (s, 1H), 2.28 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.1, 140.3, 139.5, 137.7, 133.4, 130.7, 128.9, 128.0, 127.9, 127.9, 124.8, 115.2, 21.3; HRMS calc. for $C_{15}H_{14}IO_2S$ $(M+H)^+$, 384.9759; found, 384.9759.

(*E*)-1-fluoro-4-(1-iodo-2-(phenylsulfonyl)vinyl)benzene[1] 

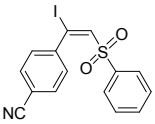
Compound **3ea** was obtained in 71% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.64-7.58 (m, 3H), 7.45 (t, J = 8.1 Hz, 2H), 7.40 (s, 1H), 7.28-7.25 (m, 2H), 6.99 (d, J = 8.6 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 163.2 (d, J = 250.1 Hz), 141.5, 140.2, 135.6 (d, J = 14.1 Hz), 133.7, 130.0 (d, J = 34.6 Hz), 129.1, 127.8, 115.1 (d, J = 22.0 Hz), 113.1; HRMS calc. for $C_{14}H_{10}FIO_2SNa$ $(M+Na)^+$, 410.9328; found, 410.9324.

(*E*)-1-chloro-4-(1-iodo-2-(phenylsulfonyl)vinyl)benzene[1] 

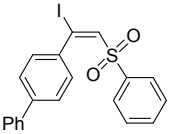
Compound **3fa** was obtained in 73% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.65-7.59 (m, 3H), 7.45 (t, J = 8.0 Hz, 2H), 7.39 (s, 1H), 7.28 (d, J = 8.6 Hz, 2H), 7.19 (d, J = 8.5 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.6, 140.1, 138.0, 136.0, 133.7, 129.2, 129.1, 128.3, 127.8, 112.7; HRMS calc. for $C_{14}H_{10}ClIO_2SNa$ $(M+Na)^+$, 426.9032; found, 426.9033.

(*E*)-1-bromo-4-(1-iodo-2-(phenylsulfonyl)vinyl)benzene[1] 

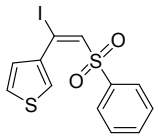
Compound **3ga** was obtained in 83% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.65-7.60 (m, 3H), 7.48-7.43 (m, 4H), 7.40 (s, 1H), 7.12 (d, J = 8.5 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.6, 140.1, 138.5, 133.7, 131.2, 129.3, 129.2, 127.8, 124.3, 112.6; HRMS calc. for $C_{14}H_{10}BrIO_2SNa$ $(M+Na)^+$, 470.8527; found, 470.8529.

(*E*)-4-(1-iodo-2-(phenylsulfonyl)vinyl)benzonitrile 

Compound **3ha** was obtained in 78% yield according to the general procedure (16h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.67-7.62 (m, 5H), 7.50 (t, J = 7.4 Hz, 2H), 7.41 (s, 1H), 7.36 (d, J = 8.5 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 144.1, 142.1, 139.9, 134.1, 131.8, 129.4, 128.2, 127.8, 118.0, 113.4, 110.4; HRMS calc. for $C_{15}H_{10}INO_2SNa$ $(M+Na)^+$, 417.9375; found, 417.9370.

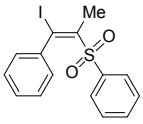
(*E*)-4-(1-iodo-2-(phenylsulfonyl)vinyl)biphenyl 

Compound **3ia** was obtained in 90% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.65-7.59 (m, 4H), 7.57 (t, J = 7.5 Hz, 1H), 7.52-7.48 (m, 4H), 7.45 (s, 1H), 7.44-7.38 (m, 3H), 7.32 (d, J = 8.3 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 142.7, 141.3, 140.3, 140.0, 138.4, 133.5, 129.0, 128.9, 128.4, 128.0, 127.9, 127.1, 126.6, 114.4; HRMS calc. for $C_{20}H_{15}IO_2SNa$ $(M+Na)^+$, 468.9735; found, 468.9729.



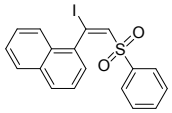
(*E*)-3-(1-iodo-2-(phenylsulfonyl)vinyl)thiophene

Compound **3ja** was obtained in 62% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.66-7.63 (m, 2H), 7.60 (dd, J_1 = 1.3 Hz, J_2= 3.0 Hz, 1H), 7.56 (t, J = 7.5 Hz, 1H), 7.42 (t, J = 8.1 Hz, 2H), 7.39 (s, 1H), 7.21 (dd, J_1 = 3.0 Hz, J_2= 5.0 Hz, 1H), 6.95 (dd, J_1 = 1.3 Hz, J_2= 5.0 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.3, 140.2, 138.8, 133.5, 129.0, 128.4, 127.6, 125.5, 108.0; HRMS calc. for $C_{12}H_9IO_2S_2Na$ $(M+Na)^+$, 398.8986; found, 398.8983.



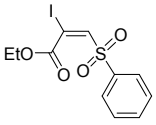
(*E*)-(1-iodo-1-phenylprop-1-en-2-ylsulfonyl)benzene

Compound **3ka** was obtained in 70% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.53-7.50 (m, 3H), 7.37 (t, J = 6.5 Hz, 2H), 7.25-7.22 (m, 3H), 7.12-7.10 (m, 2H), 2.56 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 144.0, 142.8, 140.4, 133.1, 128.9, 128.7, 127.7, 127.7, 127.6, 116.1, 27.0; HRMS calc. for $C_{15}H_{14}IO_2S$ $(M+H)^+$, 384.9759; found, 384.9757.



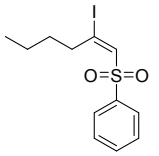
(*E*)-1-(1-iodo-2-(phenylsulfonyl)prop-1-enyl)naphthalene

Compound **3la** was obtained in 82% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.86-7.80 (m, 2H), 7.71 (s, 1H), 7.54 (d, J = 8.1 Hz, 1H), 7.47-7.38 (m, 4H), 7.32 (d, J = 7.3 Hz, 2H), 7.24 (t, J = 7.4 Hz, 1H), 7.06 (t, J = 8.0 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 143.7, 139.2, 136.1, 133.4, 133.1, 130.2, 128.5, 128.3, 127.8, 126.6, 126.3, 125.2, 125.0, 124.9, 112.4; HRMS calc. for $C_{18}H_{13}IO_2SNa$ $(M+Na)^+$, 442.9579; found, 442.9578.



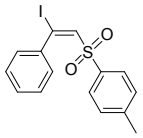
(*E*)-ethyl 2-iodo-3-(phenylsulfonyl)acrylate

Compound **3ma** was obtained in 36% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.00-7.98 (m, 2H), 7.71 (t, J = 7.4 Hz, 1H), 7.60 (t, J = 8.0 Hz, 2H), 6.98 (s, 1H), 4.45 (q, J = 7.2 Hz, 2H), 1.43 (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 164.6, 139.7, 139.0, 134.3, 129.6, 128.2, 100.4, 63.4, 13.8; HRMS calc. for $C_{11}H_{11}IO_4SNa$ $(M+Na)^+$, 388.9320; found, 388.9319.



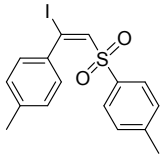
(*E*)-(2-iodohex-1-enylsulfonyl)benzene[1]

Compound **3na** was obtained in 12% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.95-7.92 (m, 2H), 7.69 (t, J = 7.4 Hz, 1H), 7.60 (t, J = 7.9 Hz, 2H), 7.04 (s, 1H), 3.06 (t, J = 7.4 Hz, 2H), 1.56-1.51 (m, 2H), 1.42-1.37 (m, 2H), 0.96 (t, J = 7.3 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.0, 138.6, 133.7, 129.5, 127.5, 126.2, 39.9, 32.0, 21.7, 13.8; HRMS calc. for $C_{12}H_{15}IO_2SNa$ $(M+Na)^+$, 372.9735; found, 372.9733.



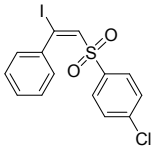
(*E*)-1-(2-iodo-2-phenylvinylsulfonyl)-4-methylbenzene[1]

Compound **3ab** was obtained in 88% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.48 (d, J = 8.3 Hz, 2H), 7.38 (s, 1H), 7.34-7.28 (m, 3H), 7.26-7.24 (m, 2H), 7.21 (d, J = 8.0 Hz, 2H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 144.6, 141.3, 139.7, 137.4, 129.8, 129.7, 127.9, 127.9, 127.7, 114.2, 21.6; HRMS calc. for $C_{15}H_{13}IO_2SNa$ $(M+Na)^+$, 406.9579; found, 406.9577.



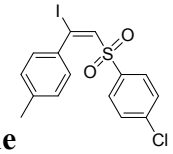
(*E*)-1-(2-iodo-2-p-tolylvinylsulfonyl)-4-methylbenzene[2]

Compound **3bb** was obtained in 74% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.52 (d, J = 8.3 Hz, 2H), 7.33 (s, 1H), 7.24-7.18 (m, 4H), 7.12 (d, J = 8.0 Hz, 2H), 2.42 (s, 3H), 2.38 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 144.5, 140.7, 140.2, 137.5, 136.9, 129.7, 128.6, 127.9, 127.8, 114.8, 21.6, 21.5; HRMS calc. for $C_{16}H_{15}IO_2SNa$ $(M+Na)^+$, 420.9735; found, 420.9736.



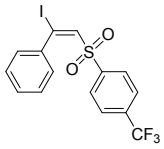
(*E*)-1-chloro-4-(2-iodo-2-phenylvinylsulfonyl)benzene

Compound **3ac** was obtained in 81% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.48 (d, J = 8.7 Hz, 2H), 7.41 (s, 1H), 7.37-7.28 (m, 5H), 7.22-7.20 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.0, 140.2, 139.5, 138.7, 130.0, 129.3, 129.3, 128.1, 127.7, 115.3; HRMS calc. for $C_{14}H_{10}ClIO_2SNa$ $(M+Na)^+$, 426.9032; found, 426.9037.



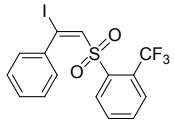
(*E*)-1-chloro-4-(2-iodo-2-p-tolylvinylsulfonyl)benzene

Compound **3bc** was obtained in 70% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.51 (d, J = 8.3Hz, 2H), 7.37 (s, 1H), 7.29-7.24 (m, 4H), 7.00 (t, J =8.6 Hz, 2H), 2.43 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 164.5, 162.0, 144.8, 141.7, 137.3, 135.7, 130.1, 130.0, 129.8, 127.8, 115.2, 115.0, 112.6, 21.6; HRMS calc. for $C_{15}H_{12}ClIO_2SNa$ $(M+Na)^+$, 440.9189; found, 440.9187.



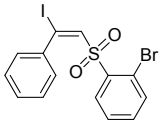
(*E*)-1-(2-iodo-2-phenylvinylsulfonyl)-4-(trifluoromethyl)benzene

Compound **3ad** was obtained in 77% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.69-7.62 (m, 4H), 7.45 (s, 1H), 7.34 (t, J = 7.3 Hz, 1H), 7.30-7.26 (m, 2H), 7.18 (d, J = 7.1 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 143.7, 140.7, 139.4, 135.0 (d, J = 32.9 Hz), 130.1, 128.4, 128.1, 127.6, 126.0 (q, J = 3.6 Hz), 123.0 (q, J = 256.1 Hz), 116.0; HRMS calc. for $C_{15}H_{10}F_3IO_2SNa$ $(M+Na)^+$, 460.9296; found, 460.9299.



(*E*)-1-(2-iodo-2-phenylvinylsulfonyl)-2-(trifluoromethyl)benzene

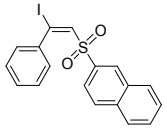
Compound **3ae** was obtained in 86% yield according to the general procedure (16h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.82 (d, J = 7.8 Hz, 1H), 7.64 (t, J = 7.6 Hz, 1H), 7.57 (d, J = 7.9 Hz, 1H), 7.51 (d, J = 1.4 Hz, 1H), 7.40 (t, J = 7.4 Hz, 1H), 7.28 (t, J = 7.2 Hz, 1H), 7.22 (t, J = 7.6 Hz, 2H), 7.16-7.14 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.7 (q, J = 22.4 Hz), 139.5, 138.7, 133.5, 132.0, 132.0, 129.8, 128.5 (d, J = 33.3 Hz), 128.2 (q, J = 6.0 Hz), 128.0, 127.5, 122.6 (q, J = 272.7 Hz), 114.5; HRMS calc. for $C_{15}H_{10}F_3IO_2SNa$ $(M+Na)^+$, 460.9296; found, 460.9297.



(*E*)-1-bromo-2-(2-iodo-2-phenylvinylsulfonyl)benzene

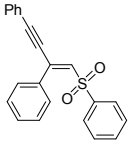
Compound **3af** was obtained in 87% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.65 (dd, J_1 = 1.1 Hz, J_2 = 8.0 Hz, 1H), 7.62 (s, 1H), 7.48 (dd, J_1 = 1.6 Hz, J_2 = 7.9 Hz, 1H), 7.32-7.28 (m, 1H), 7.20-7.17 (m, 1H),

7.15-7.10 (m, 5H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 140.4, 139.8, 139.3, 134.9, 134.2, 131.2, 129.8, 127.8, 127.4, 127.4, 120.6, 114.7; ^{1}HRMS calc. for $C_{14}H_{10}BrIO_2SNa$ $(M+Na)^+$, 470.8527; found, 470.8529.



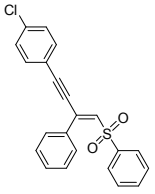
(*E*)-2-(2-iodo-2-phenylvinylsulfonyl)naphthalene

Compound **3ag** was obtained in 74% yield according to the general procedure (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.03 (d, J = 1.5 Hz, 1H), 7.89 (t, J = 8.8 Hz, 2H), 7.81 (t, J = 8.1 Hz, 1H), 7.69-7.58 (m, 3H), 7.49 (s, 1H), 7.26-7.23 (m, 1H), 7.21(d, J = 4.3 Hz, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.3, 139.5, 136.9, 135.1, 132.0, 130.0, 129.9, 129.4, 129.3, 127.9, 127.7, 127.6, 122.4, 114.8; HRMS calc. for $C_{18}H_{13}IO_2SNa$ $(M+Na)^+$, 442.9579; found, 442.9578.



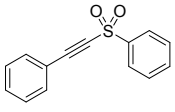
(*E*)-(4-(phenylsulfonyl)but-3-en-1-yne-1,3-diyl)dibenzene

Compound **4aa** was obtained in 92% yield according to the procedure A (1h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.70-7.67 (m, 2H), 7.54 (t, J = 7.5 Hz, 1H), 7.49-7.43 (m, 5H), 7.42-7.34 (m, 7H), 7.00 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.0, 137.4, 135.3, 134.2, 133.3, 132.0, 129.7, 129.6, 129.1, 128.9, 128.5, 128.0, 127.8, 121.6, 97.7, 88.3; HRMS calc. for $C_{22}H_{17}O_2S$ $(M+H)^+$, 345.0949; found, 345.0943.



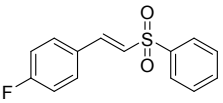
(*E*)-1-chloro-4-(3-phenyl-4-(phenylsulfonyl)but-3-en-1-ynyl)benzene

Compound **4af** was obtained in 84% yield according to the procedure A (1h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.69-7.67 (m, 2H), 7.55 (t, J = 7.5 Hz, 1H), 7.47-7.45 (m, 3H), 7.43-7.36 (m, 6H), 7.35-7.31 (m, 2H), 6.99 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 140.8, 137.0, 135.9, 135.7, 134.0, 133.3, 133.2, 129.7, 129.0, 128.9, 128.9, 128.1, 127.8, 120.0, 96.3, 89.1; HRMS calc. for $C_{22}H_{15}ClO_2SNa$ $(M+Na)^+$, 401.0379; found, 401.0383.

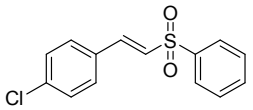


(phenylethynylsulfonyl)benzene 5aa[3]

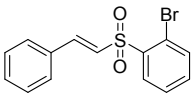
Compound **5aa** was obtained in 78% yield according to the procedure B (12h). ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.12-8.10 (m, 2H), 7.72 (t, J = 7.4 Hz, 1H), 7.65-7.61 (t, J = 7.9 Hz, 2H), 7.56-7.54 (m, 2H), 7.49 (t, J = 7.6 Hz, 1H), 7.39 (t, J = 7.7 Hz, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.8, 134.2, 132.8, 131.6, 129.4, 128.7, 127.4, 117.9, 93.5, 85.4; HRMS calc. for $C_{14}H_{10}O_2SNa$ $(M+Na)^+$, 265.0299; found, 265.0293.

(*E*)-1-fluoro-4-(2-(phenylsulfonyl)vinyl)benzene (6ea)[4] 

Compound **6ea** was obtained in 73% yield according to the procedure C. ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.97 (d, J = 7.7 Hz, 2H), 7.69-7.63 (m, 2H), 7.57 (t, J = 7.9 Hz, 2H), 7.52-7.49 (m, 2H), 7.10 (t, J = 8.5 Hz, 2H), 6.82 (d, J = 15.4 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 165.6 (d, J = 251.5Hz), 141.2, 140.7, 133.5, 130.6 (d, J = 8.7 Hz), 129.4, 128.7, 127.7, 127.1 (d, J = 2.4 Hz), 116.3 (d, J = 22.0 Hz); HRMS calc. for $C_{14}H_{11}FO_2SNa$ $(M+Na)^+$, 285.0361; found, 285.0366.

(*E*)-1-chloro-4-(2-(phenylsulfonyl)vinyl)benzene (6fa)[4] 

Compound **6fa** was obtained in 74% yield according to the procedure C. ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.97 (d, J = 7.2 Hz, 2H), 7.68-7.63 (m, 2H), 7.57 (t, J = 7.8 Hz, 2H), 7.45-7.37 (m, 4H), 6.87 (d, J = 15.4 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 141.0, 140.5, 137.3, 133.5, 130.9, 129.8, 129.4, 129,4, 128.0, 127.7; HRMS calc. for $C_{14}H_{11}ClO_2SNa$ $(M+Na)^+$, 301.0066; found, 301.0065.

(*E*)-1-bromo-2-(styrylsulfonyl)benzene (6af) 

Compound **6af** was obtained in 77% yield according to the procedure C. ^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.28 (dd, J_1 = 1.7 Hz, J_2 = 7.9 Hz, 1H), 7.81 (d, J = 15.4 Hz, 1H), 7.71 (d, J_1 = 1.1 Hz, J_2 = 7.9 Hz, 1H), 7.55-7.53 (m, 3H), 7.49-7.43 (m, 4H), 7.14 (d, J = 15.4 Hz, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 145.5, 139.9, 135.5, 134.5, 132.4, 131.5, 131.1, 129.2, 128.7, 128.1, 125.0, 121.0; HRMS calc. for $C_{14}H_{11}O_2BrSNa$ $(M+Na)^+$, 344.9561; found, 344.9563.

7. Reference

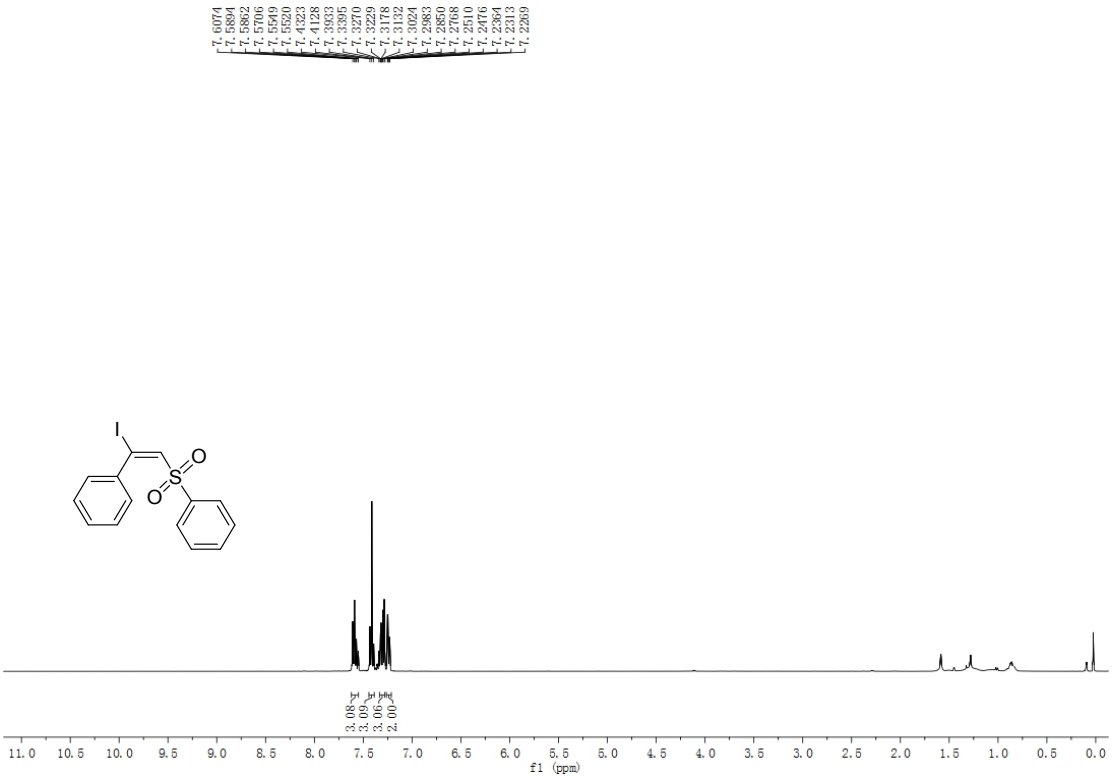
[1] X. Q. Li, X. S. Xu and X. H. Shi, *Tetrahedron Lett*; 2013, **54**, 3071.

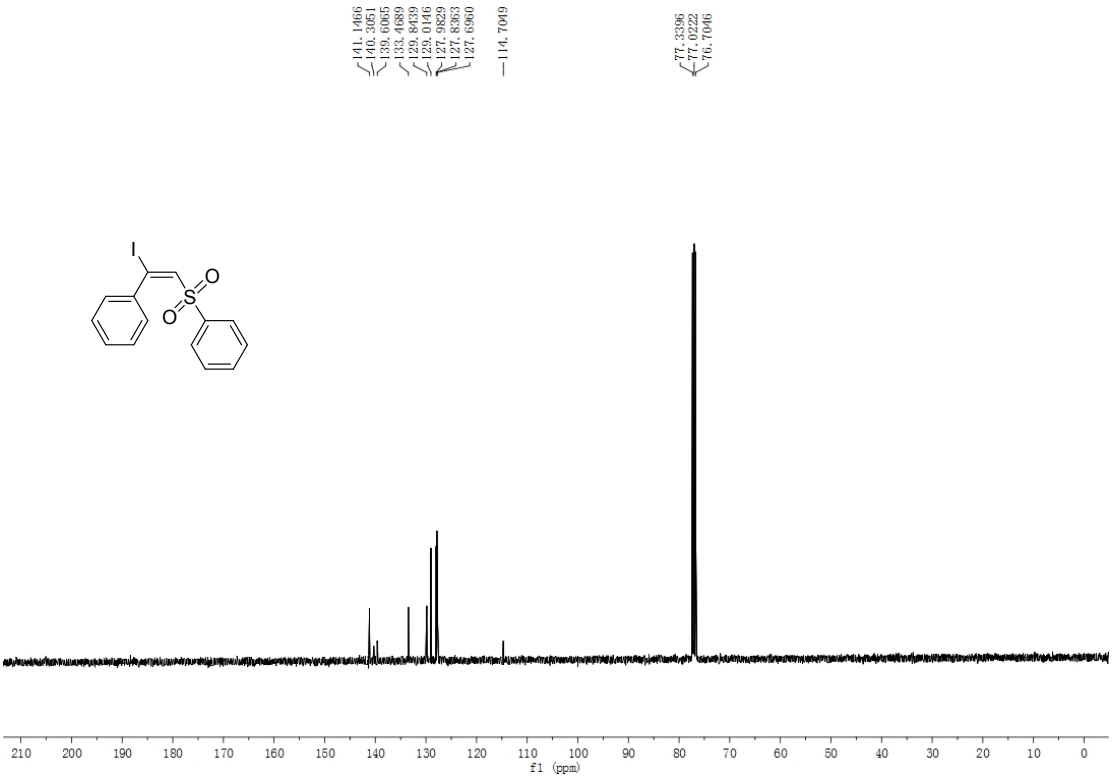
[2] V. Nair, A. Augustine and T. D. Suja, *Synthesis*, 2002, 2259.

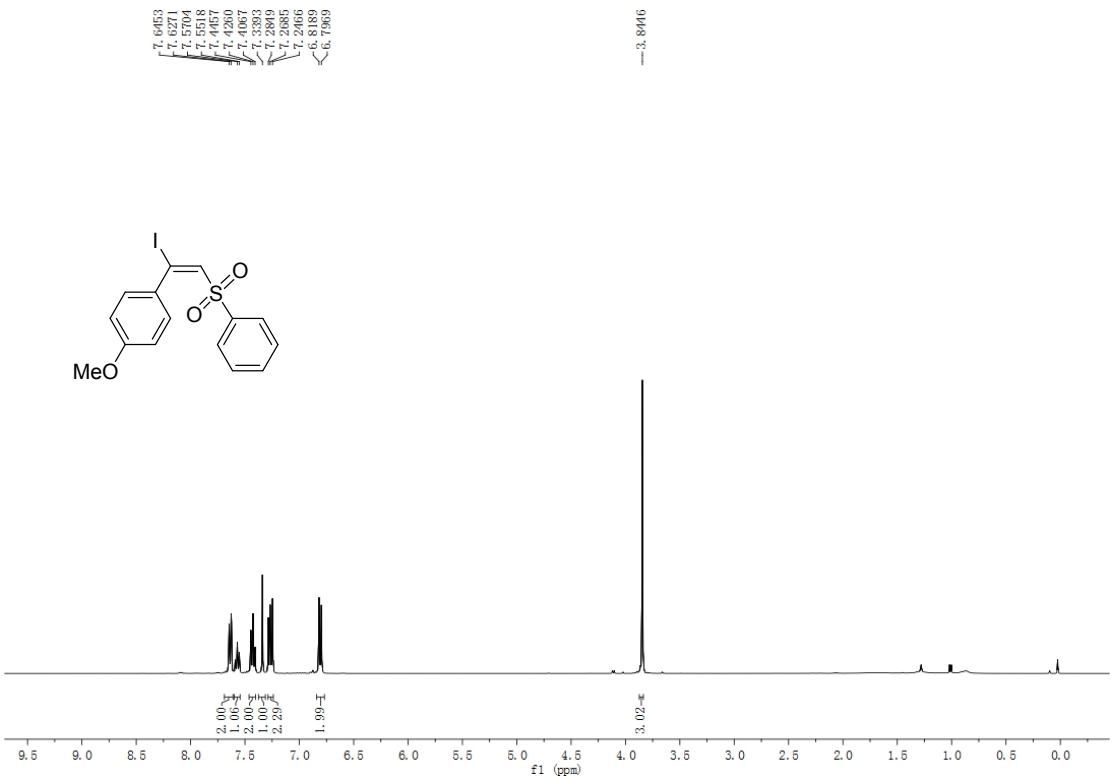
[3] H. Qian and X. Huang, *Tetrahedron Lett* 2002, **43**, 1059.

[4] (a) M. Bian, F. Xu and C. Ma, *Synthesis*, 2007, 2951. **(b)** A. Battace, T. Zair, H. Doucet and M. Santelli, *Synthesis*, 2006, 3495.

8. Copies of NMR Spectra for 3aa-6af.



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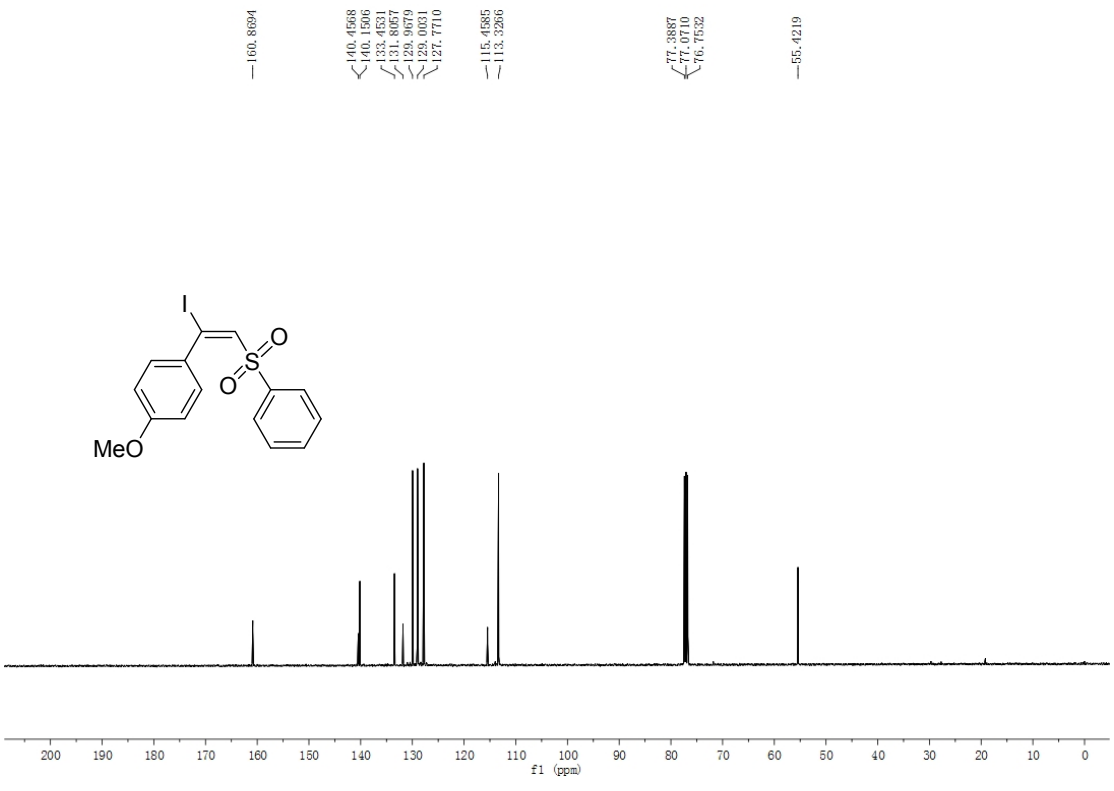
6.8189
6.7969
3.8446
I
O
S
O
MeO
2.00
1.06
2.00
1.00
2.29
1.99
3.02
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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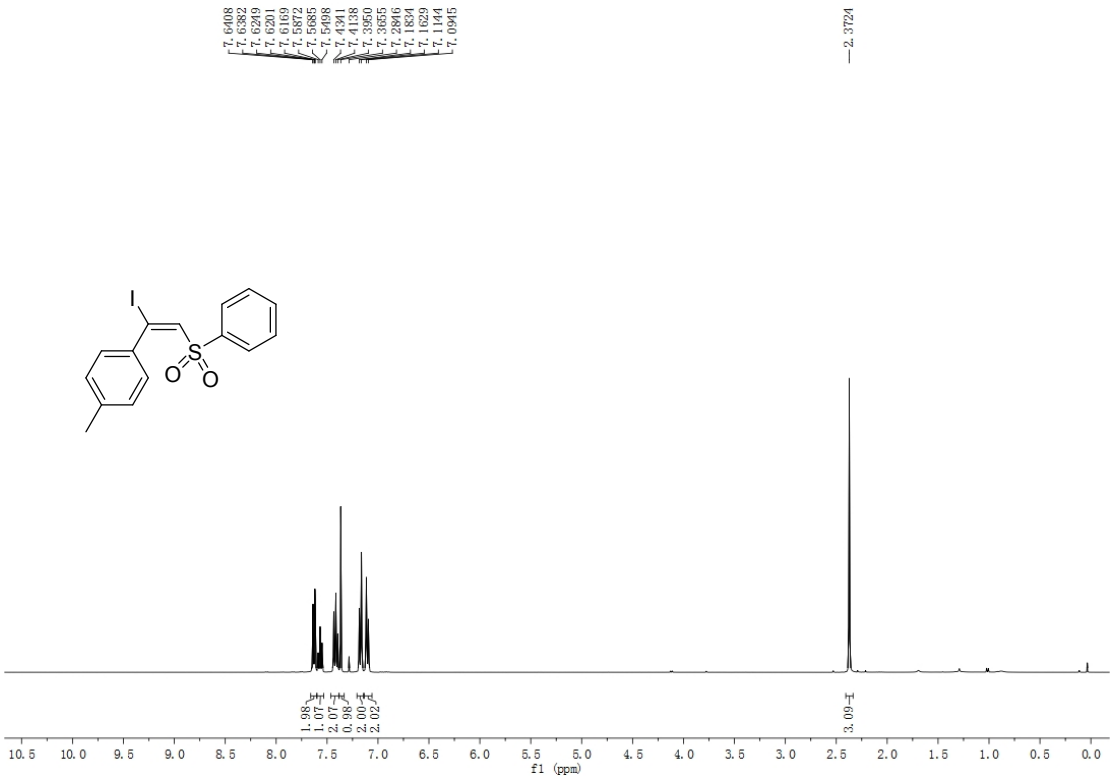
f1 (ppm)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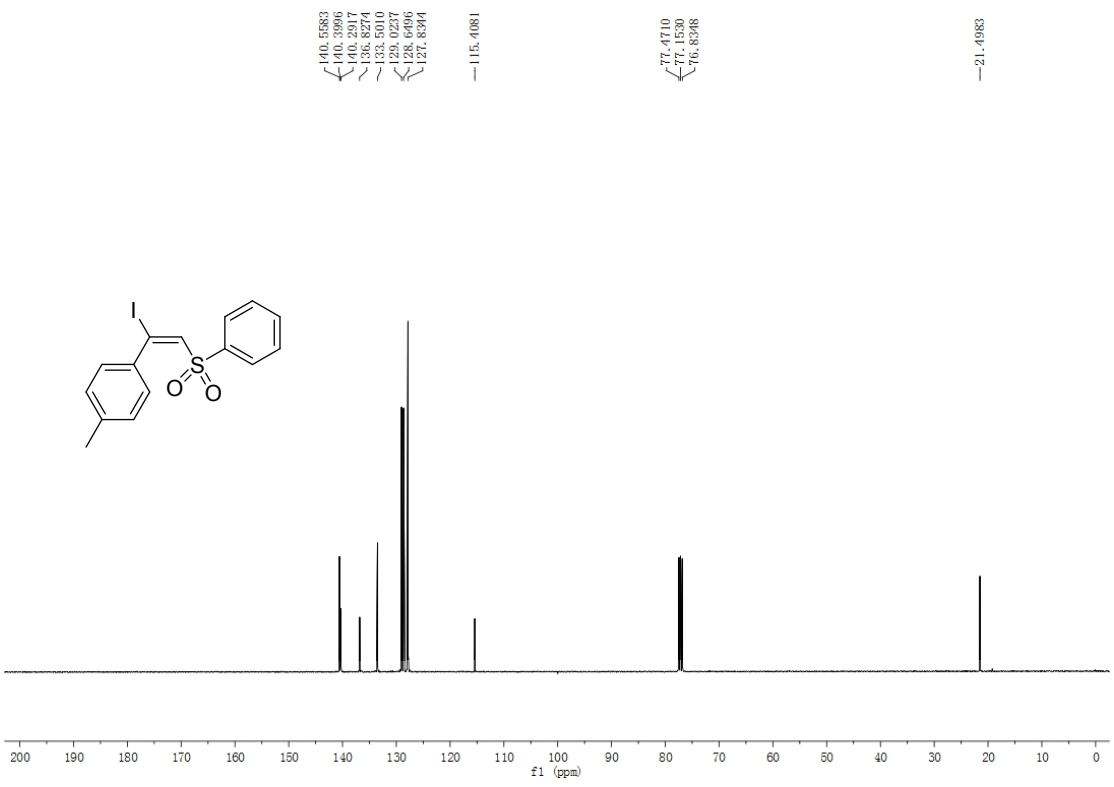
f1 (ppm)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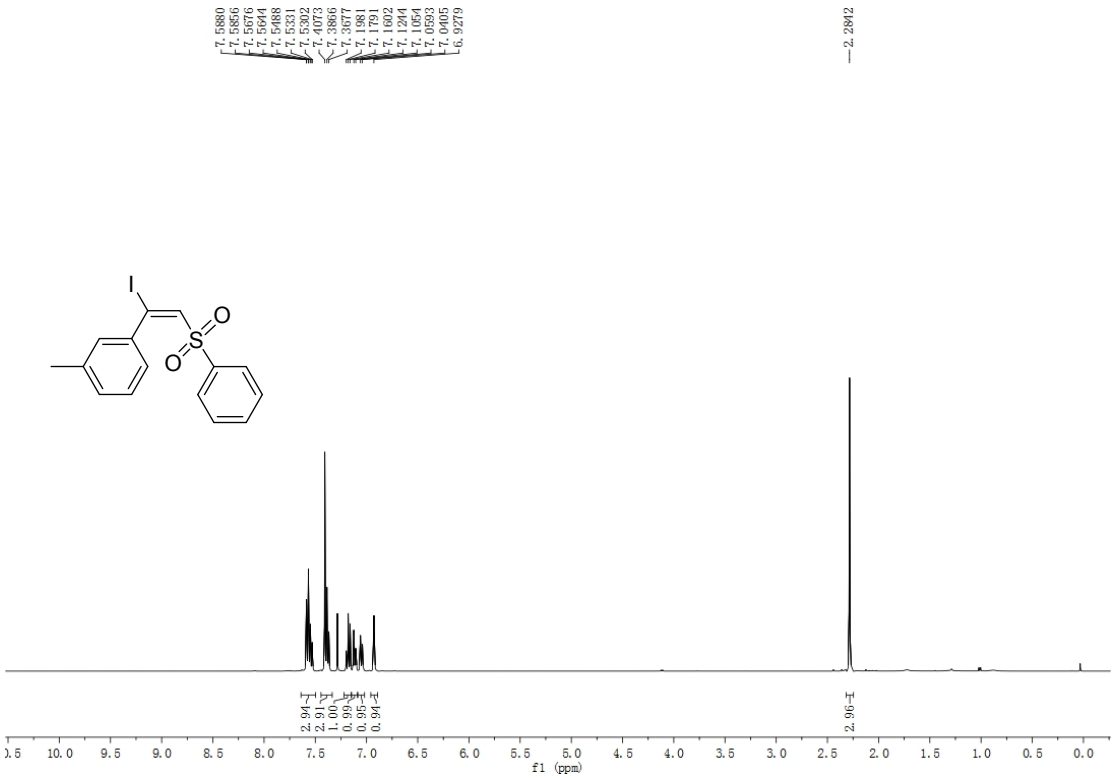
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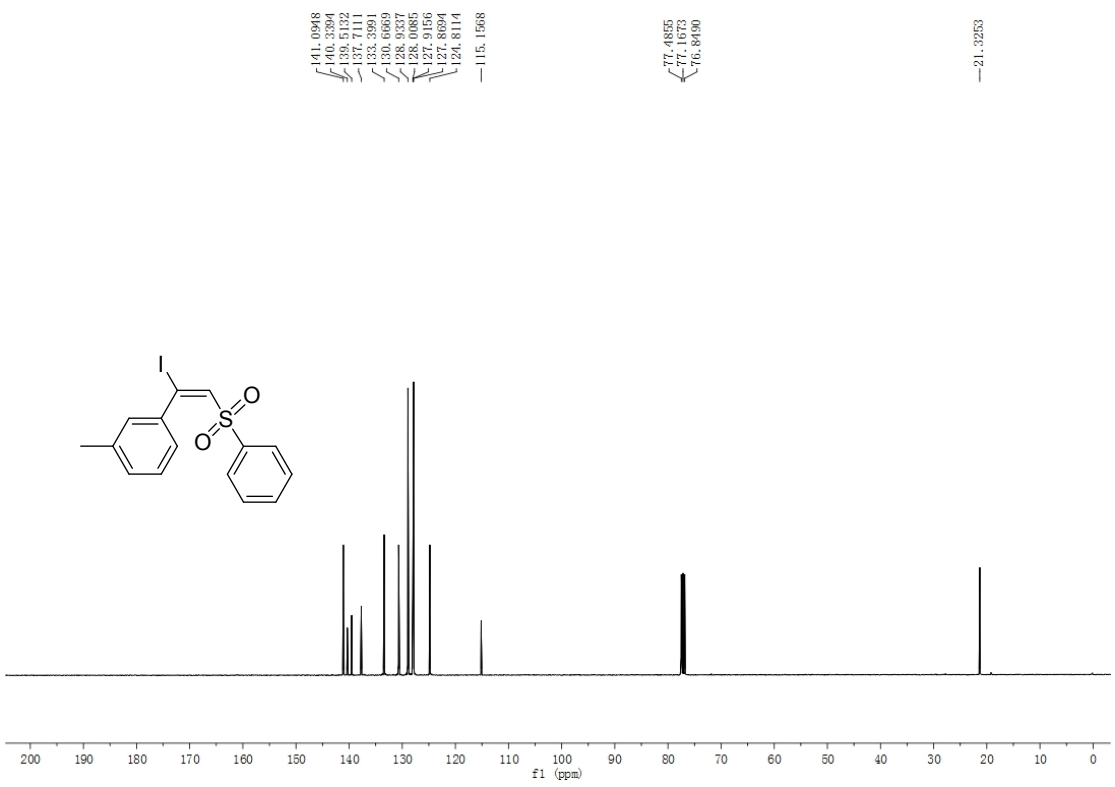
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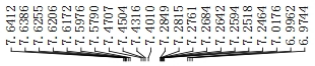
f1 (ppm)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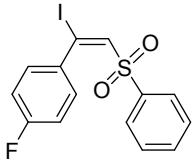
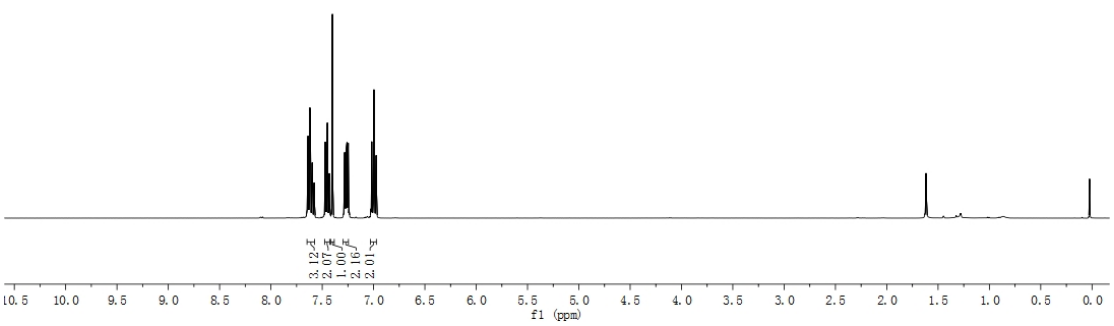

I
O
O
S
F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2.16
2.01
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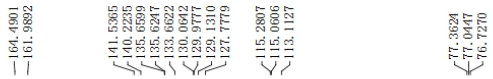
f1 (ppm)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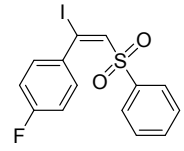
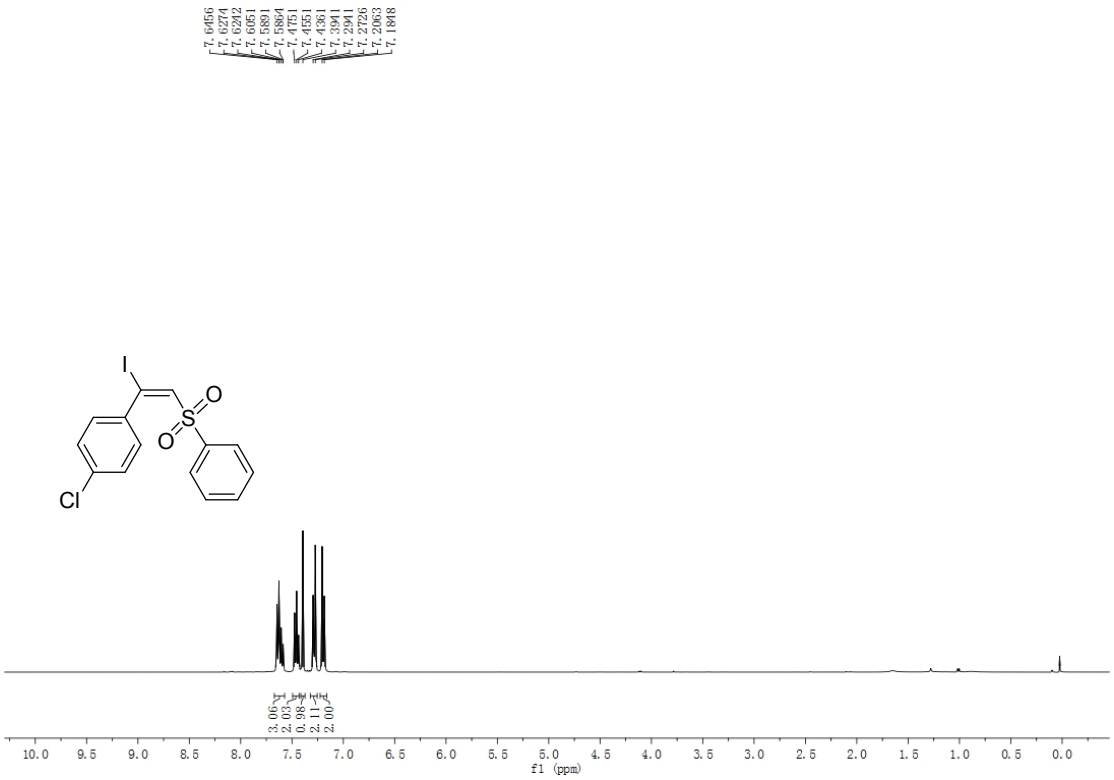

I
O
O
S
F

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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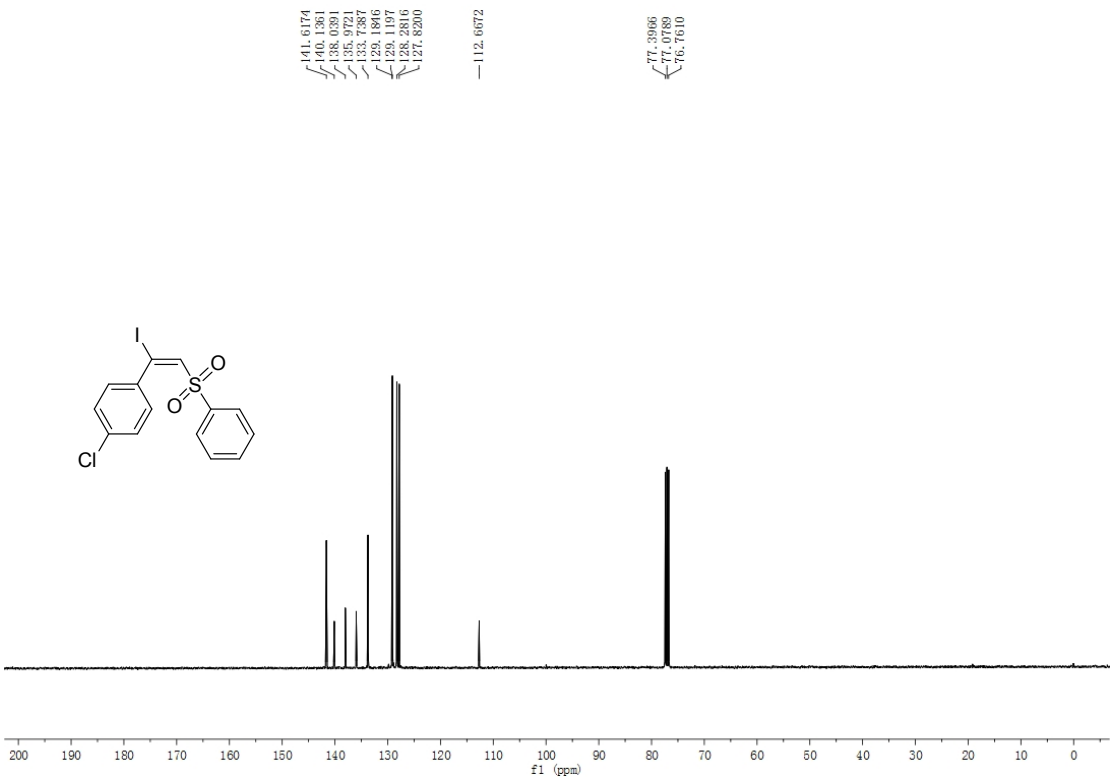
7.6242
7.6051
7.5891
7.5864
7.4751
7.4551
7.4361
7.3991
7.2991
7.2726
7.2063
7.1848
I
O
S
O
Cl
3.06
2.03
0.98
2.11
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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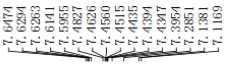
138.0391
135.9721
133.7387
129.1846
129.1197
128.2816
127.8200
112.6672
77.3966
77.0789
76.7610
I
O
S
O
Cl
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.6294
7.6263
7.6141
7.5955
7.4827
7.4626
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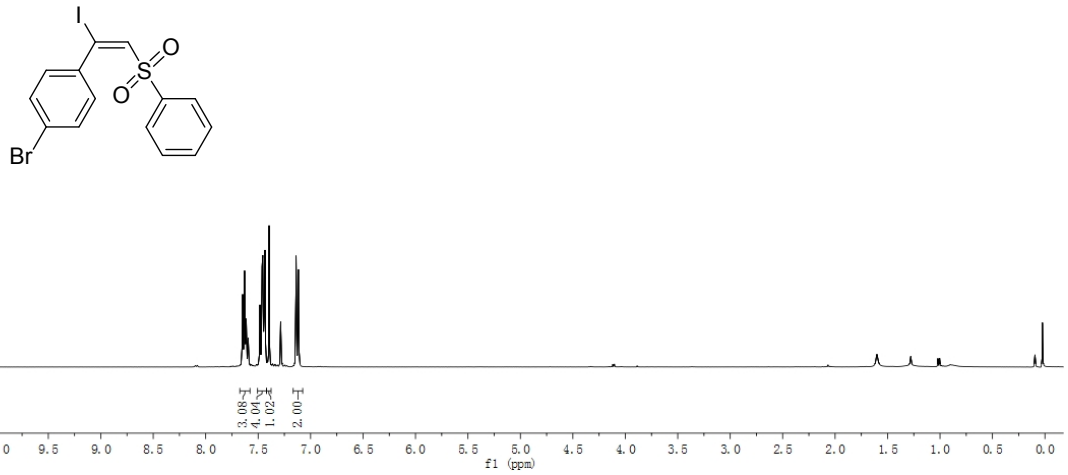
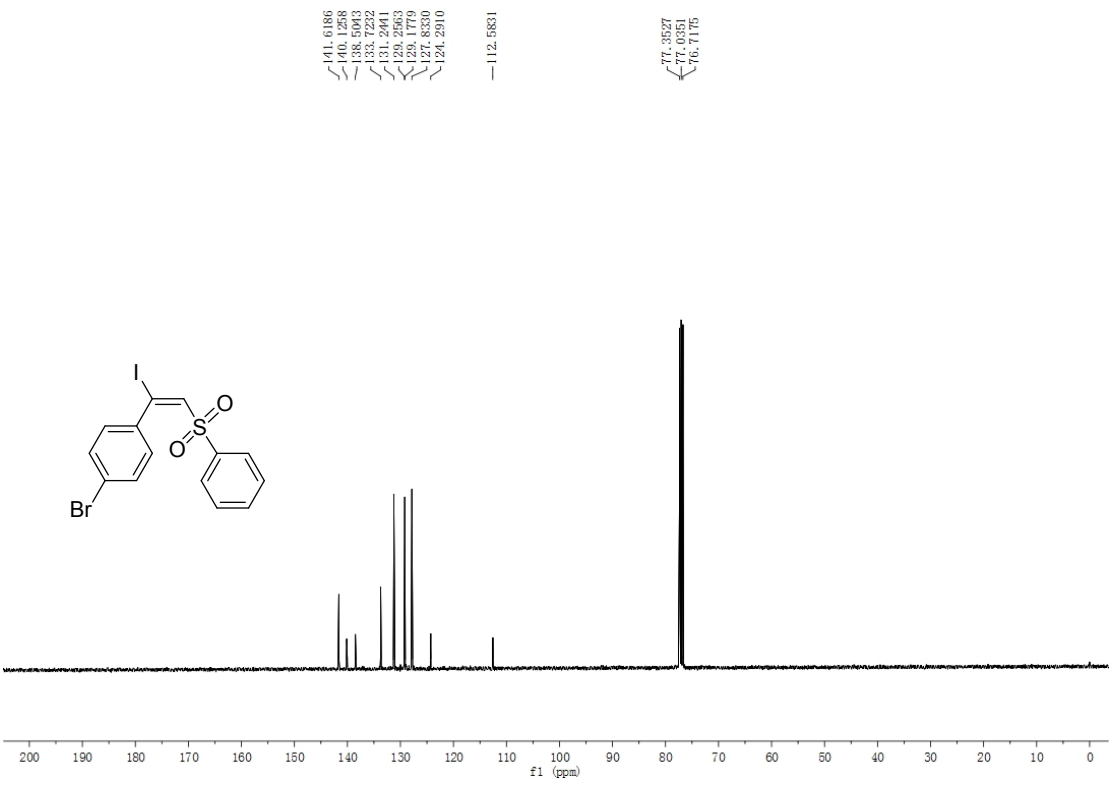
7.4515
7.4435
7.4394
7.4347
7.3954
7.2851
7.1381
7.1169


I
O
S
O
Br
3.08
4.04
1.02
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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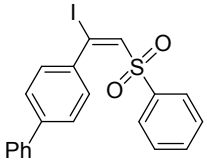
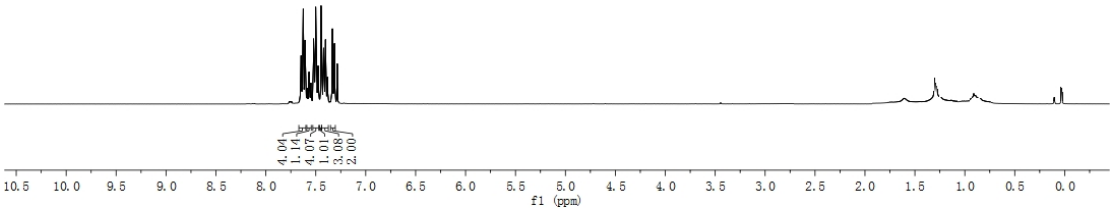
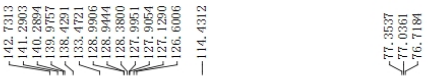
140.1258
138.5043
133.7232
131.2441
129.2563
129.1779
127.8330
124.2910
112.5831
77.3527
77.0351
76.7175
I
O
S
O
Br
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.6472
7.6290
7.6258
7.6076
7.5863
7.5676
7.5491
7.5217
7.5170
7.5007
7.4964
7.4769
7.4475
7.4412
7.4382
7.4220
7.4026
7.3836
7.3335
7.3127
7.2850


I
O
S
O
Ph


4.04
1.14
4.07
1.08
3.00
2.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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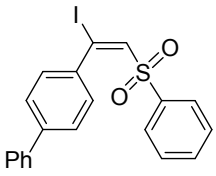
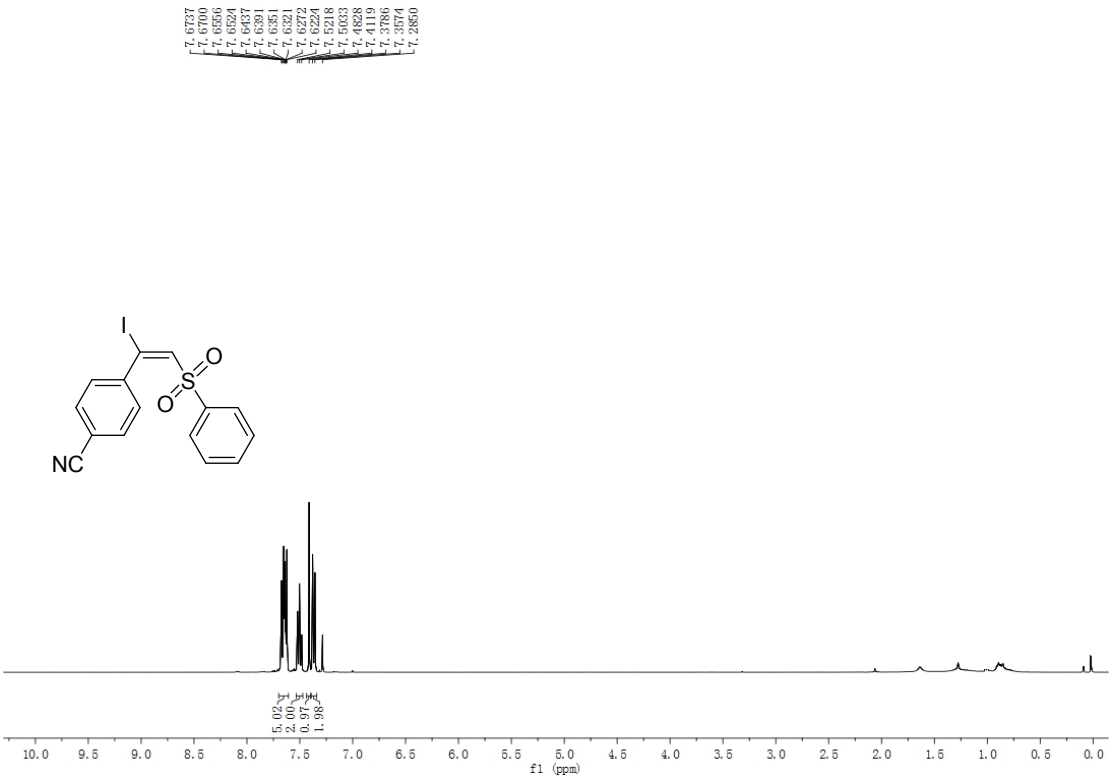
141.2903
140.2894
139.9757
138.4291
133.4721
128.9906
128.9444
128.3800
127.9951
127.9054
127.1290
126.6006
114.4312
77.3537
77.0361
76.7184


I
O
S
O
Ph

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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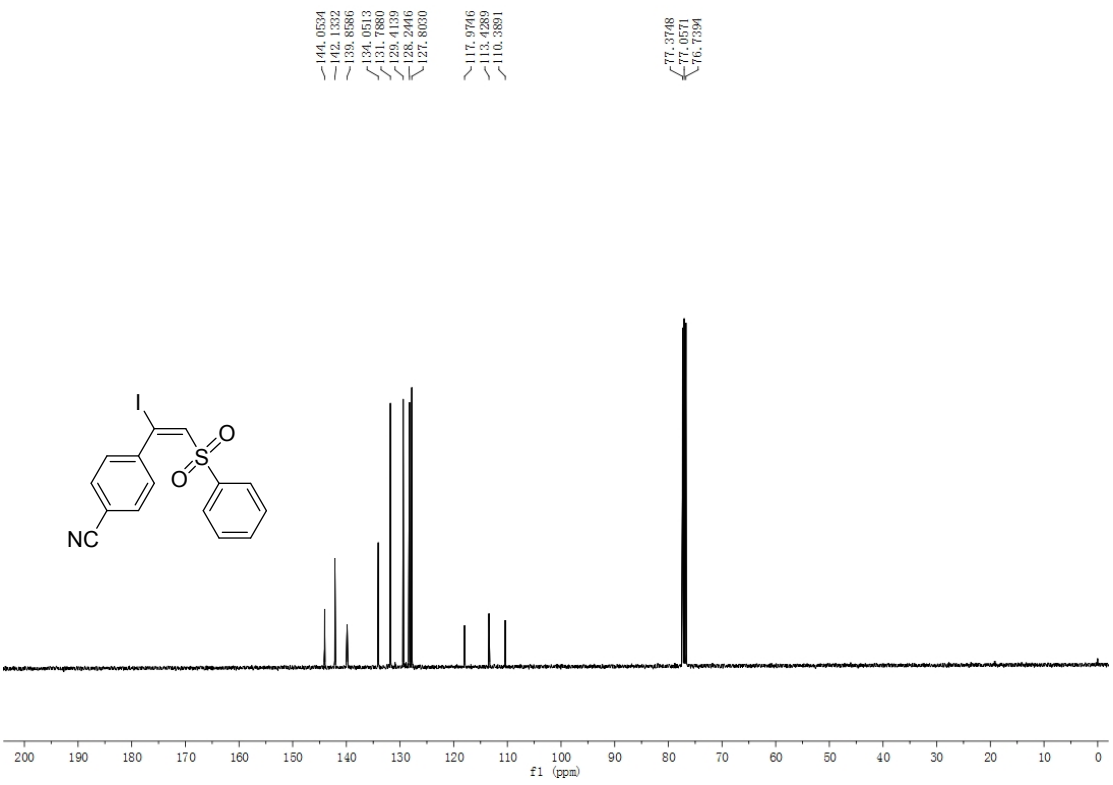
7.6700
7.6556
7.6524
7.6437
7.6391
7.6351
7.6321
7.6272
7.6224
7.5218
7.5033
7.4828
7.4119
7.3786
7.3574
7.2850
I
O
S
O
NC
5.02
2.00
0.97
1.98
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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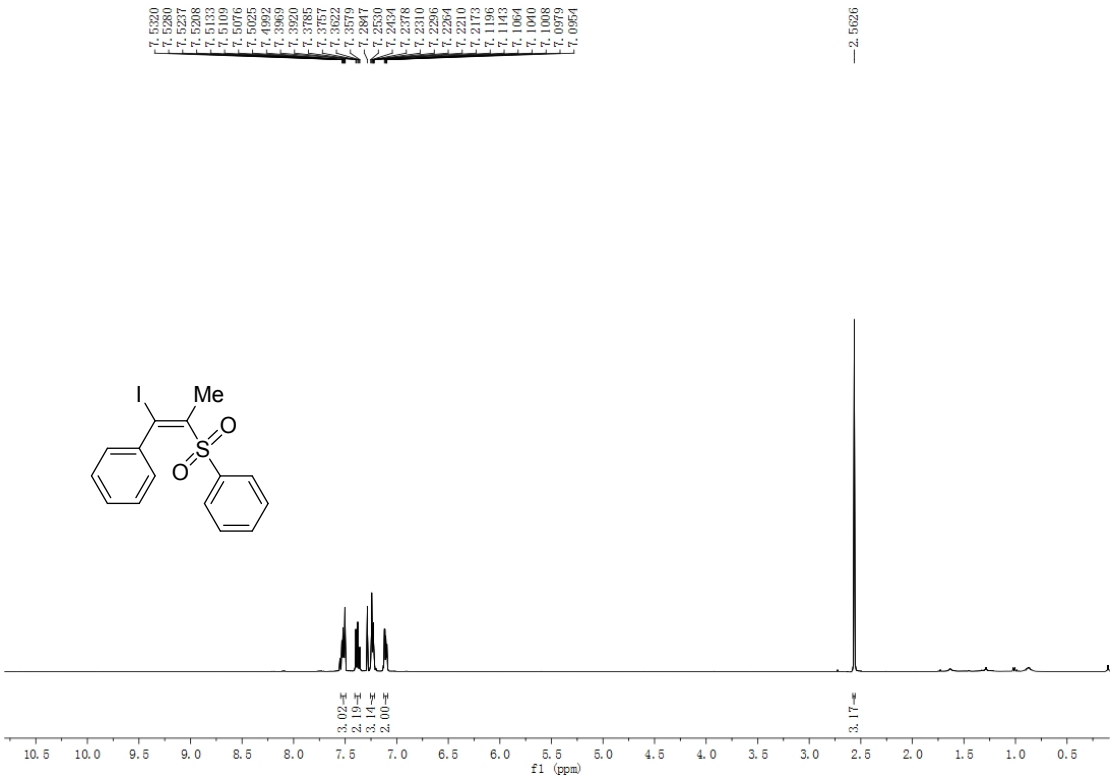
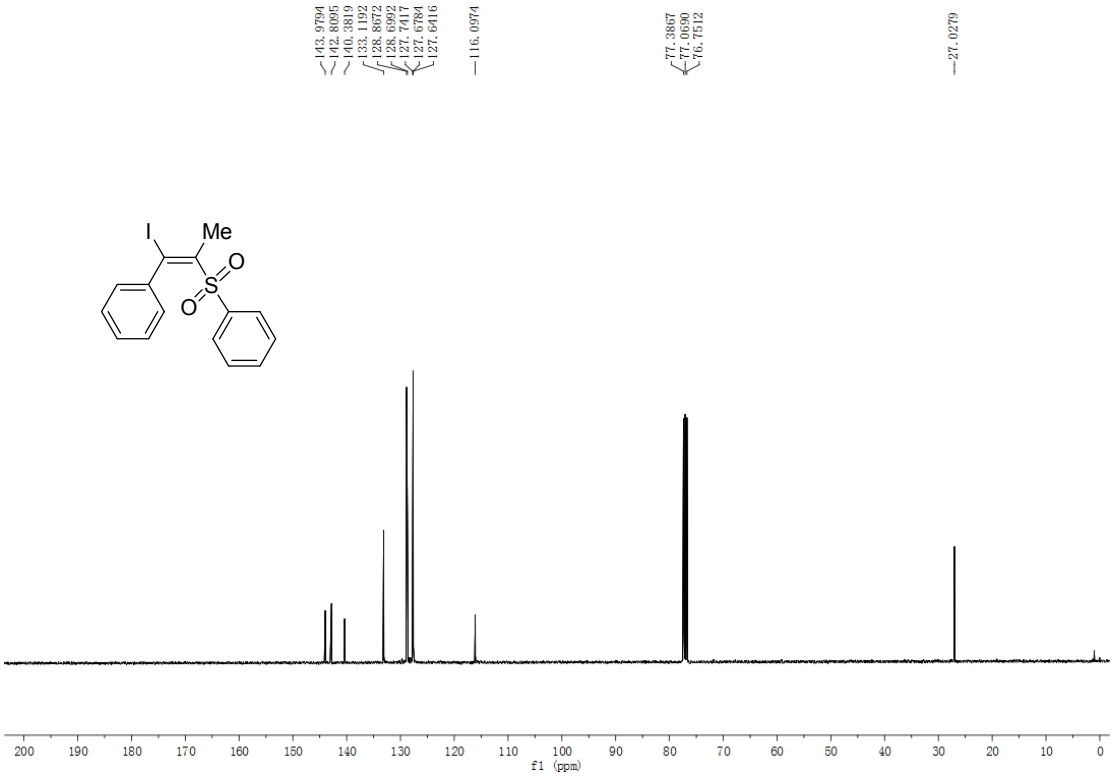
142.1332
139.8586
134.0513
131.7880
129.4139
128.2946
127.8630
117.9746
113.4289
110.3891
77.3748
77.0571
76.7394
I
O
S
O
NC
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.5320
7.5280
7.5237
7.5208
7.5133
7.5109
7.5076
7.5025
7.4992
7.3969
7.3920
7.3785
7.3757
7.3622
7.3579
7.2847
7.2530
7.2434
7.2378
7.2310
7.2296
7.2264
7.2210
7.2173
7.1196
7.1143
7.1064
7.1040
7.1008
7.0979
7.0954
2.5626
I
Me
O
S
O
3.02
2.19
3.14
2.00
3.17
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)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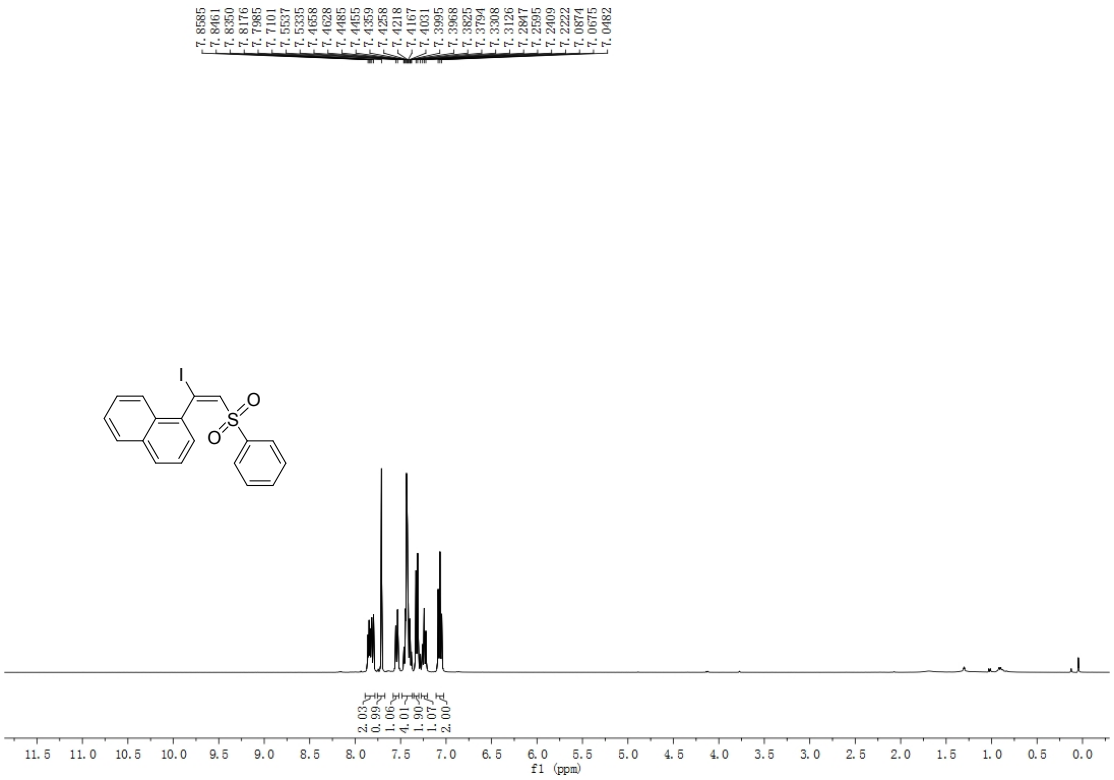
142.8095
140.3819
133.1192
128.8672
128.6992
127.7417
127.6784
127.6416
116.0974
77.3867
77.0690
76.7512
27.0279
I
Me
O
S
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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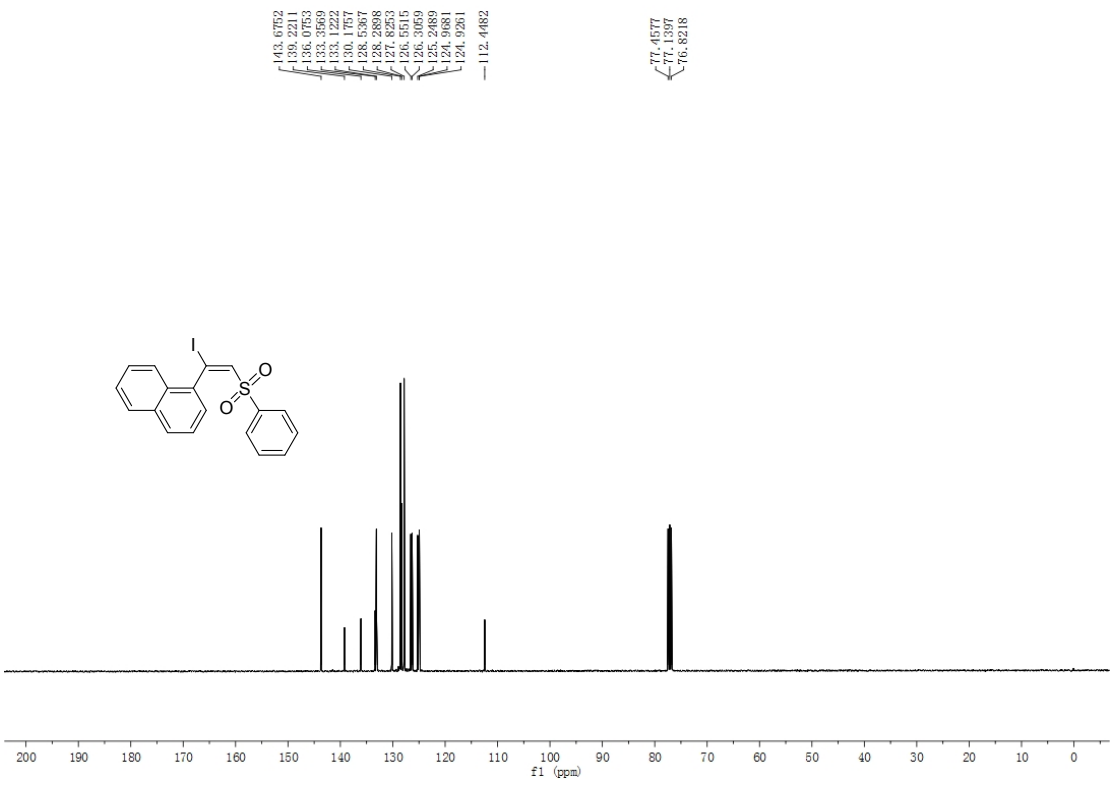
7.8350
7.8176
7.7985
7.7101
7.5537
7.5335
7.4658
7.4628
7.4485
7.4455
7.4359
7.4258
7.4218
7.4167
7.4031
7.3995
7.3968
7.3825
7.3794
7.3308
7.3126
7.2947
7.2595
7.2409
7.2222
7.0874
7.0675
7.0482
I
O
S
O
2.03
0.99
1.06
4.01
1.90
1.07
2.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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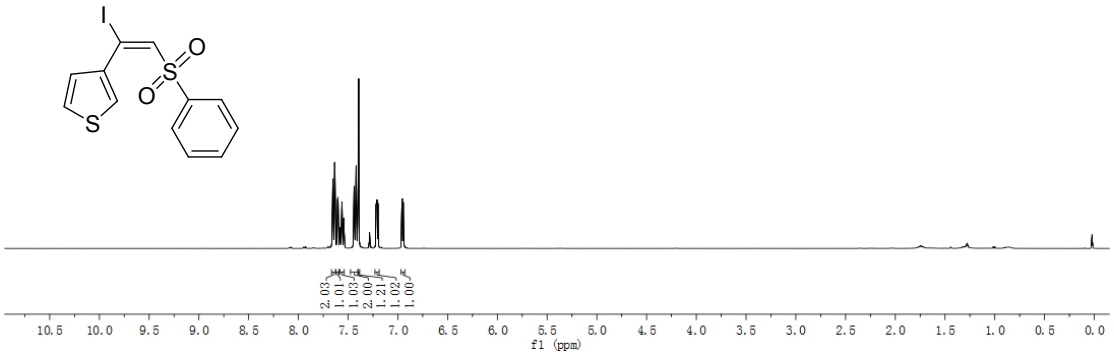
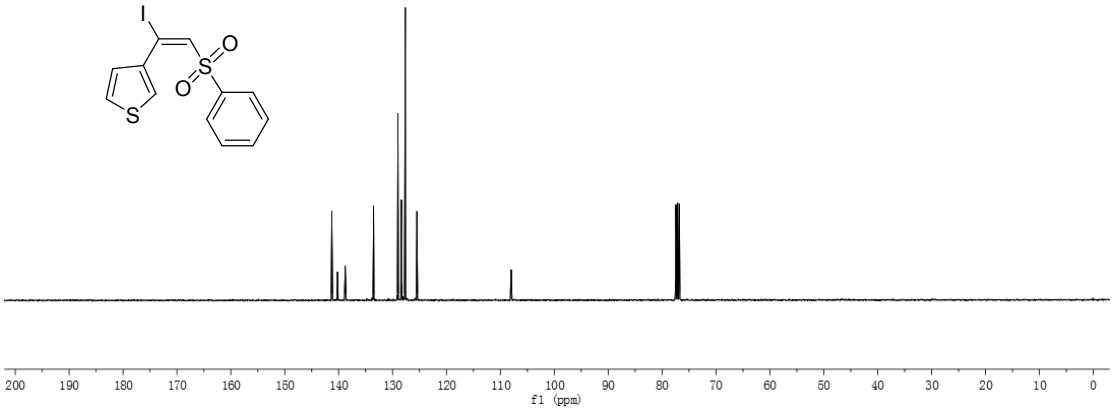
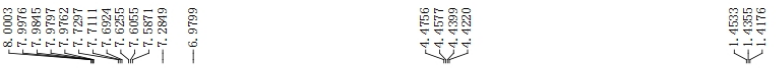
136.0753
133.3569
133.1222
130.1757
128.5367
128.2898
127.8253
126.5515
126.3059
125.2489
124.9681
124.9261
112.4482
77.4577
77.1397
76.8218
I
O
S
O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.6561
7.6535
7.6402
7.6355
7.6322
7.6096
7.6064
7.6021
7.5989
7.5808
7.5621
7.5465
7.5435
7.4399
7.4197
7.4008
7.3944
7.2849
7.2207
7.2131
7.2080
7.2005
6.9589
6.9557
6.9463
6.9431


I
O
S
O
S
2.03
1.01
1.03
2.00
1.21
1.02
1.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


141.2723
140.1974
138.7897
133.5228
129.0945
128.3765
127.6494
125.4733
108.0001
77.4208
77.1088
76.7909


I
O
S
O
S
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.0003
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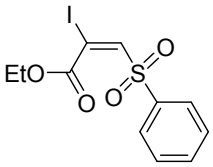
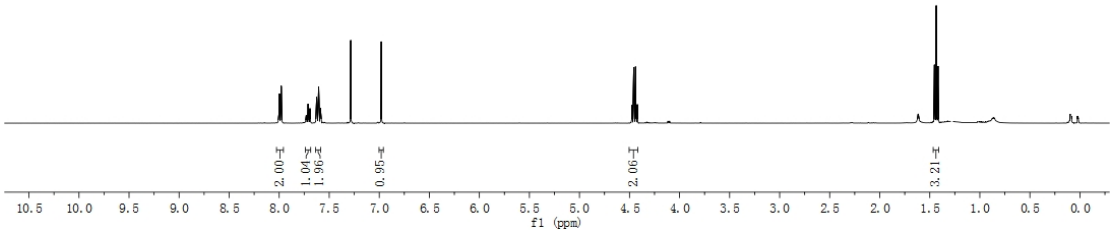
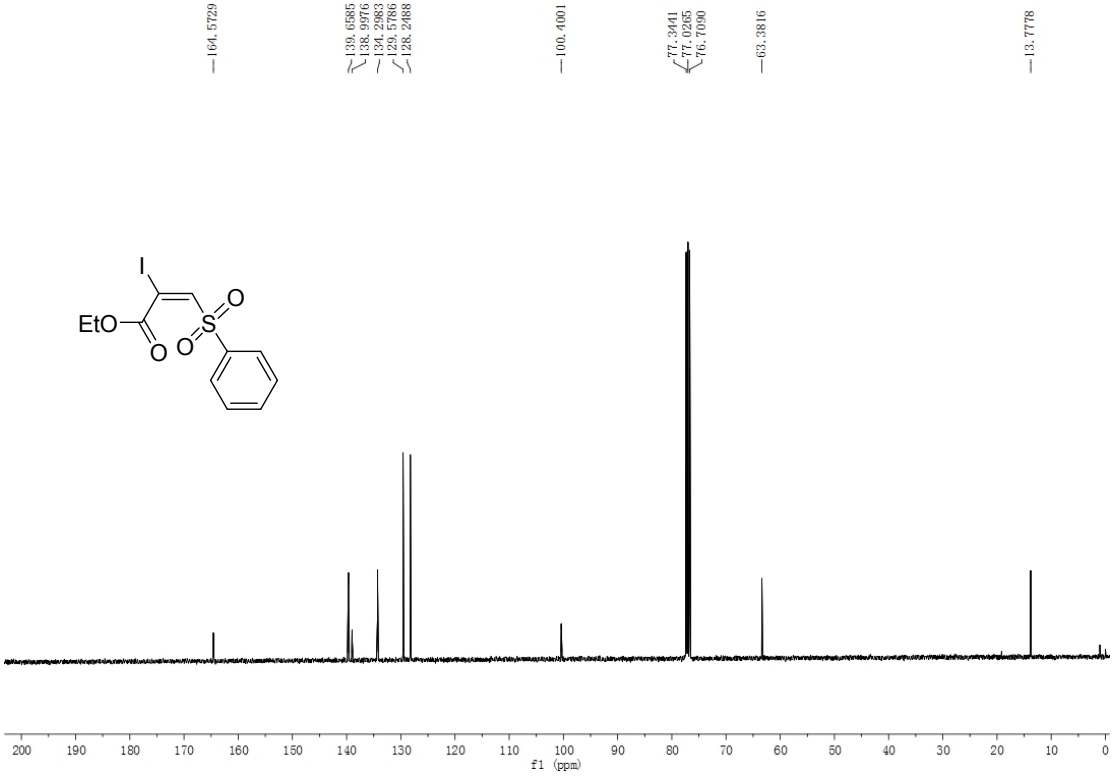
7.9845
7.9797
7.9762
7.7297
7.7111
7.6924
7.6255
7.6055
7.5871
7.2849
6.9799
4.4756
4.4577
4.4399
4.4220
1.4533
1.4355
1.4176


I
EtO
O
O
S
O


2.00
1.04
1.96
0.95
2.06
3.21
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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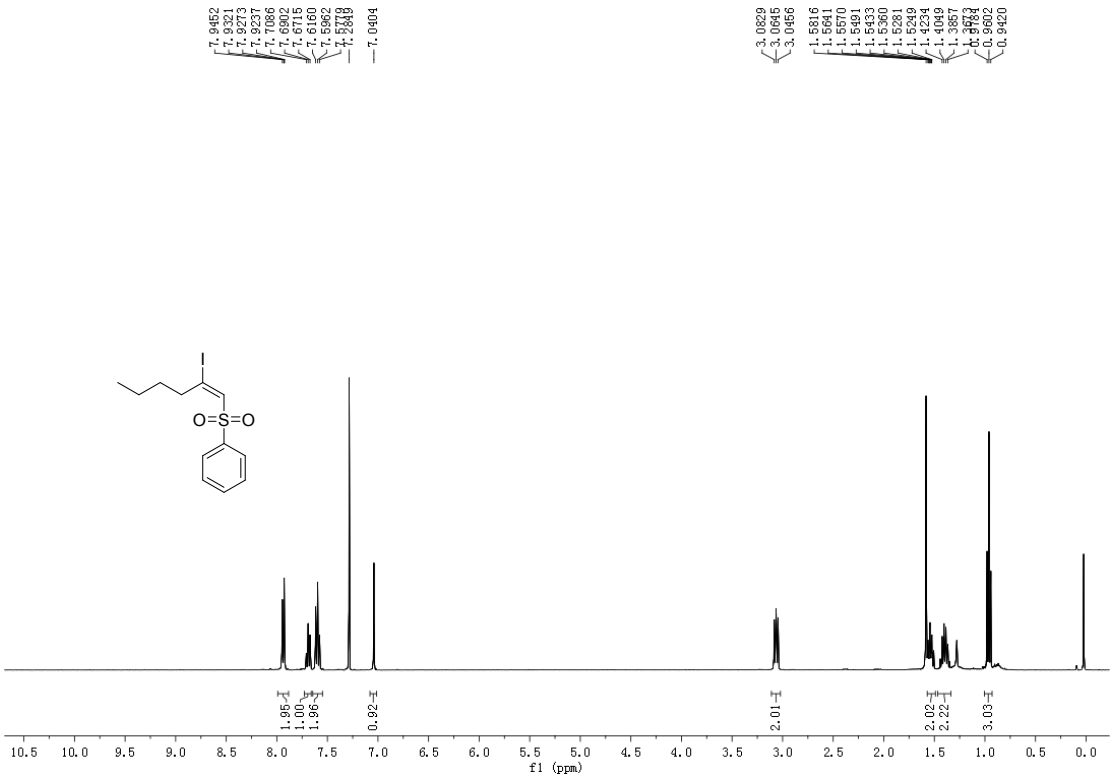
139.6585
138.9976
134.2983
129.5786
128.2488
100.4001
77.3441
77.0265
76.7090
63.3816
13.7778
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

I
EtO
O
O
S
O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7.9273
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7.6902
7.6715
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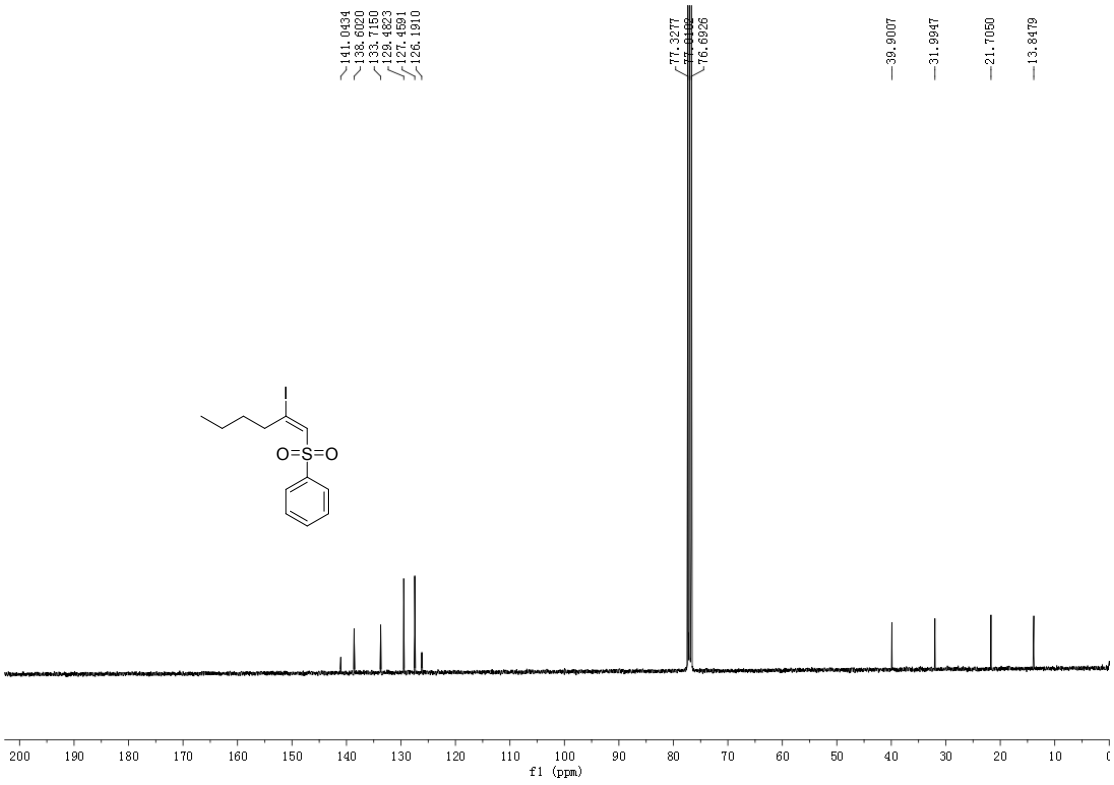
7.5962
7.5779
7.5618
7.2849
7.0404
3.0829
3.0645
3.0456
1.5816
1.5641
1.5570
1.5491
1.5433
1.5360
1.5281
1.5249
1.4234
1.4049
1.3957
1.3673
0.9783
0.9602
0.9420
O=S=O
1.95
1.00
1.96
0.92
2.01
2.02
2.22
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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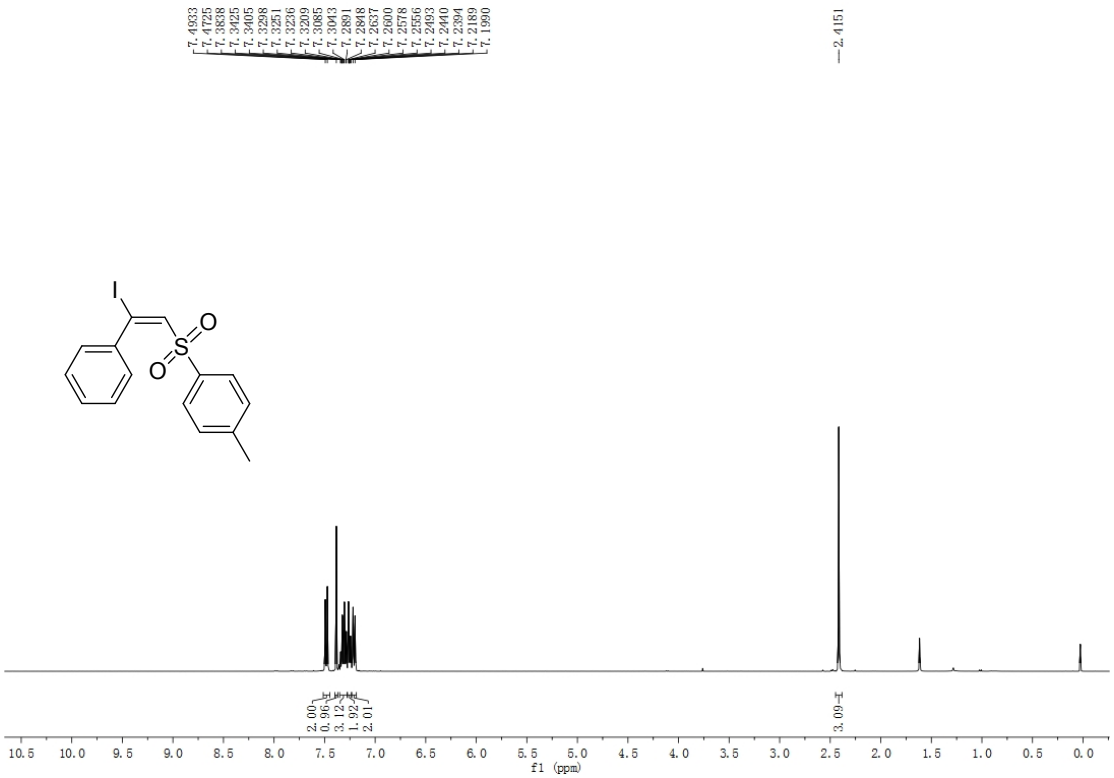
138.6020
133.7150
129.4823
127.4591
126.1910
77.3277
77.0102
76.6926
39.9007
31.9947
21.7050
13.8479
O=S=O
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)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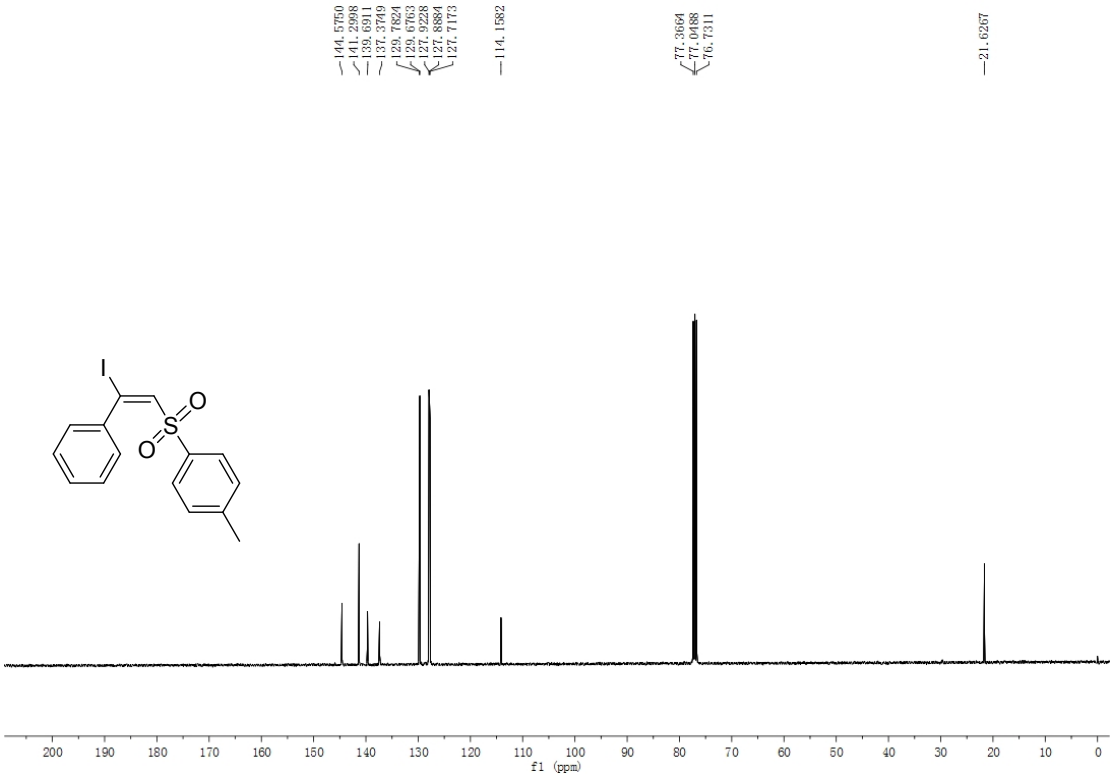
7.4725
7.3838
7.3425
7.3405
7.3298
7.3251
7.3236
7.3209
7.3085
7.3043
7.2891
7.2848
7.2637
7.2600
7.2578
7.2556
7.2493
7.2440
7.2394
7.2189
7.1990
2.4151
I
O
O
S
2.00
0.96
3.12
1.92
2.01
3.09
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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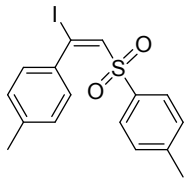
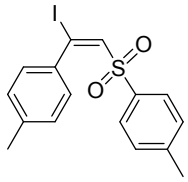
141.2998
139.6911
137.3749
129.7624
129.6763
127.9228
127.8884
127.7173
114.1582
77.3664
77.0488
76.7311
21.6267
I
O
O
S
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


I
O
S
O


I
O
S
O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7.4696
7.4102
7.3675
7.3617
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7.3493
7.3448
7.3399
7.3356
7.3318
7.3277
7.3207
7.3172
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7.3024
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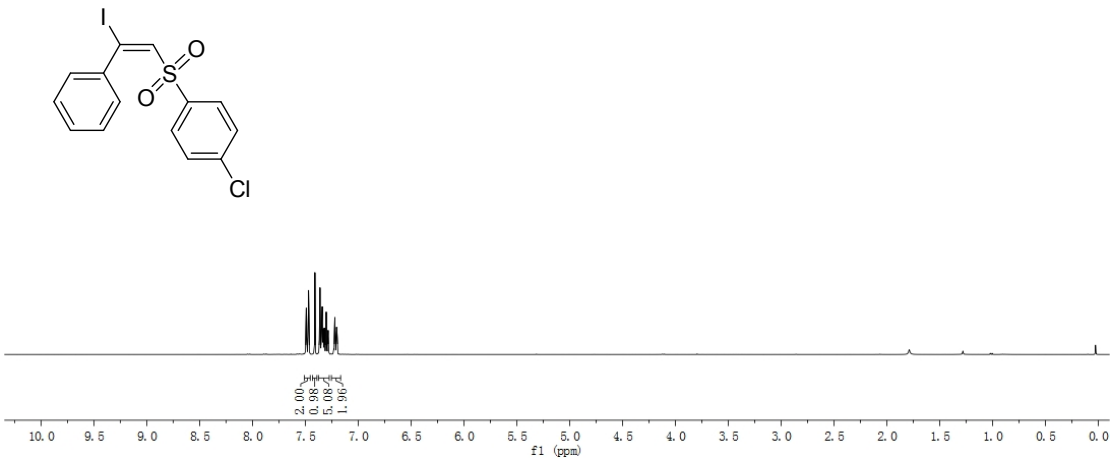
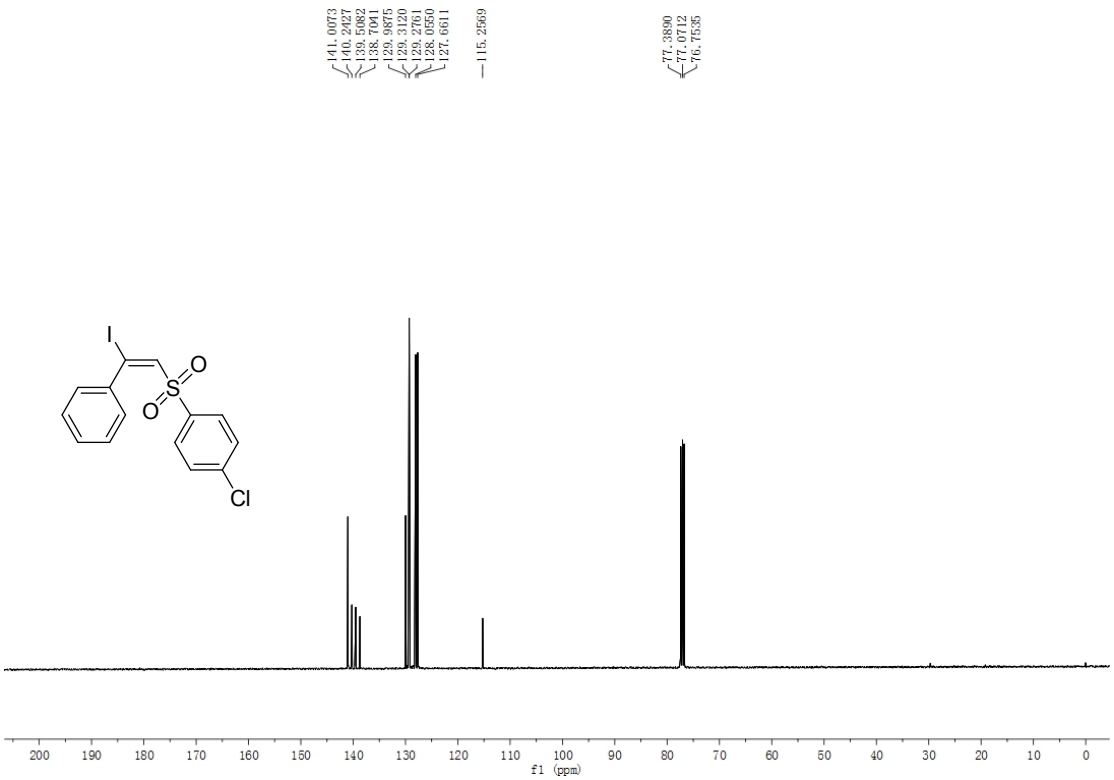
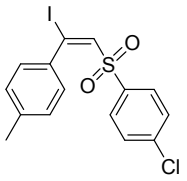
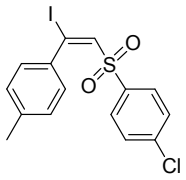
7.2046
7.2004

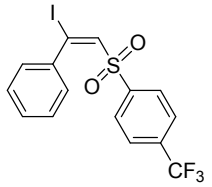

I
O
O
S
Cl
2.00
0.98
5.08
1.96
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

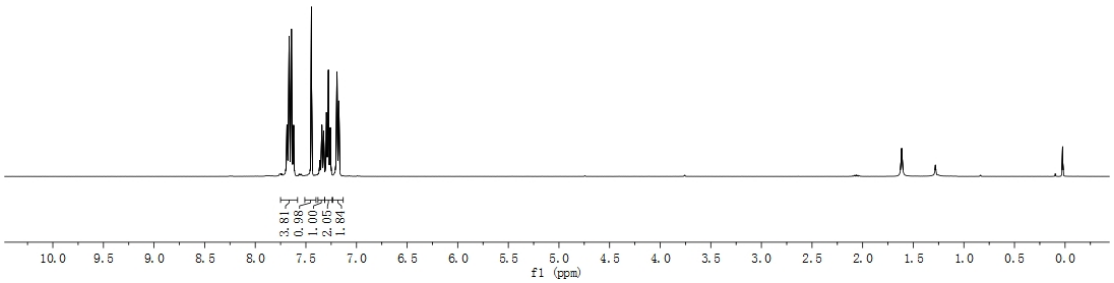

141.0073
140.2427
139.5082
138.7041
129.9875
129.3120
129.2761
128.0550
127.6611
115.2569
77.3890
77.0712
76.7535
I
O
O
S
Cl
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


I
O
S
O
Cl

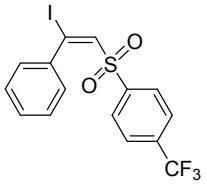

I
O
S
O
Cl

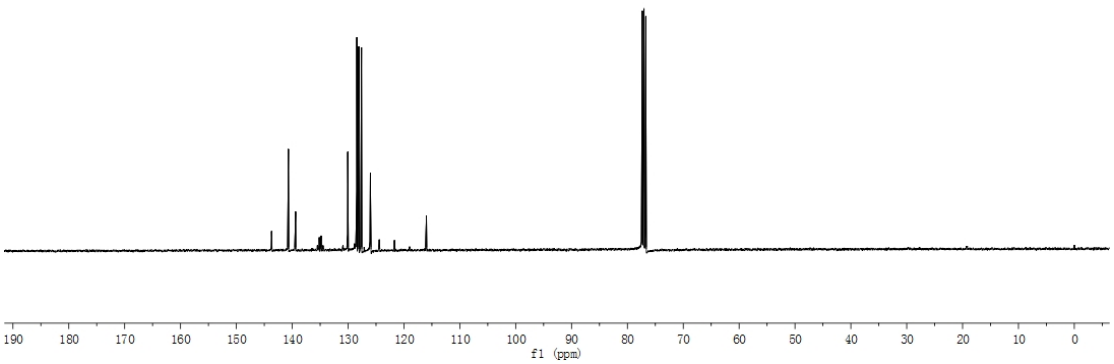

7.6867
7.6655
7.6430
7.6216
7.4451
7.3908
7.3425
7.3242
7.2961
7.2846
7.2804
7.2768
7.2390
7.1928
7.1750


I
O
O
S
CF3

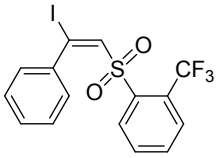

3.81
0.98
1.00
2.05
1.84
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

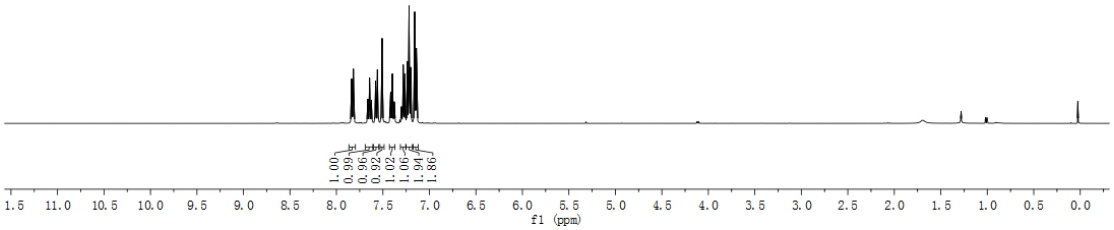

143.6936
140.6919
139.4018
135.1604
134.8308
130.0553
128.4287
128.0816
127.6052
126.0514
126.0151
125.9782
125.9414
124.2612
121.7002
115.9765
77.3432
77.0256
76.7081


I
O
O
S
CF3

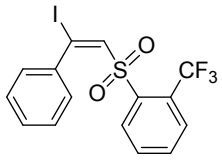

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.8372
7.8177
7.6624
7.6433
7.6242
7.5791
7.5593
7.5124
7.5090
7.4168
7.3982
7.3793
7.3001
7.2820
7.2638
7.2383
7.2192
7.2014
7.1694
7.1577
7.1453
7.1404
7.1363

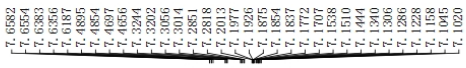

I
O
S
O
CF3

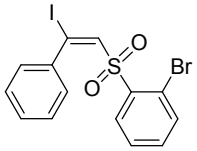

1.00
0.99
0.96
0.92
1.02
1.06
1.94
1.86
1.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

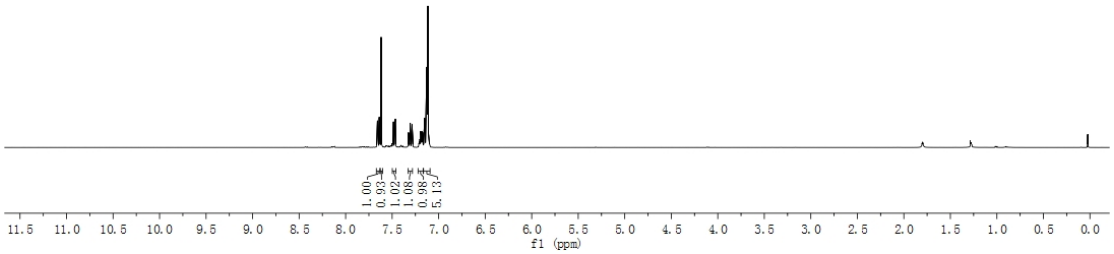

141.6818
141.6594
139.4692
138.6973
133.4684
132.0208
131.9603
129.7814
129.0598
128.7277
128.3945
128.3482
128.2884
128.2289
128.1687
128.0838
127.9921
127.4945
126.7377
123.9726
121.2456
118.5187
114.4922
77.3804
77.0627
76.7449

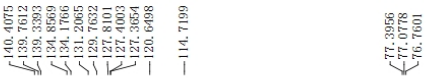

I
O
S
O
CF3

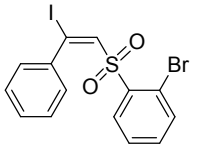
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

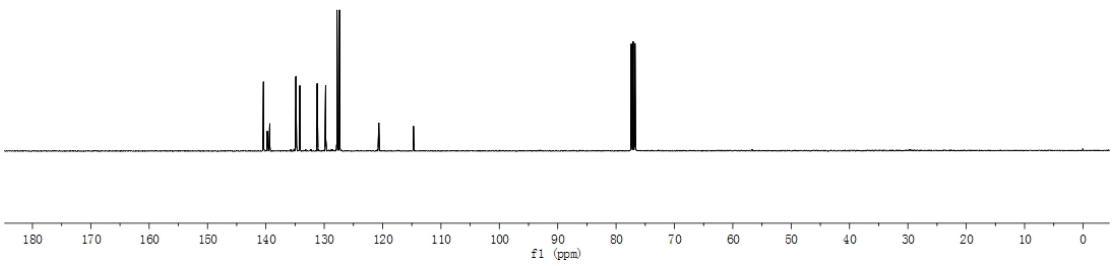

7.6582
7.6554
7.6383
7.6356
7.6187
7.4895
7.4854
7.4697
7.4656
7.3244
7.3202
7.3056
7.3014
7.2851
7.2818
7.2013
7.1977
7.1926
7.1875
7.1854
7.1837
7.1772
7.1707
7.1538
7.1510
7.1444
7.1340
7.1306
7.1286
7.1228
7.1158
7.1045
7.1020

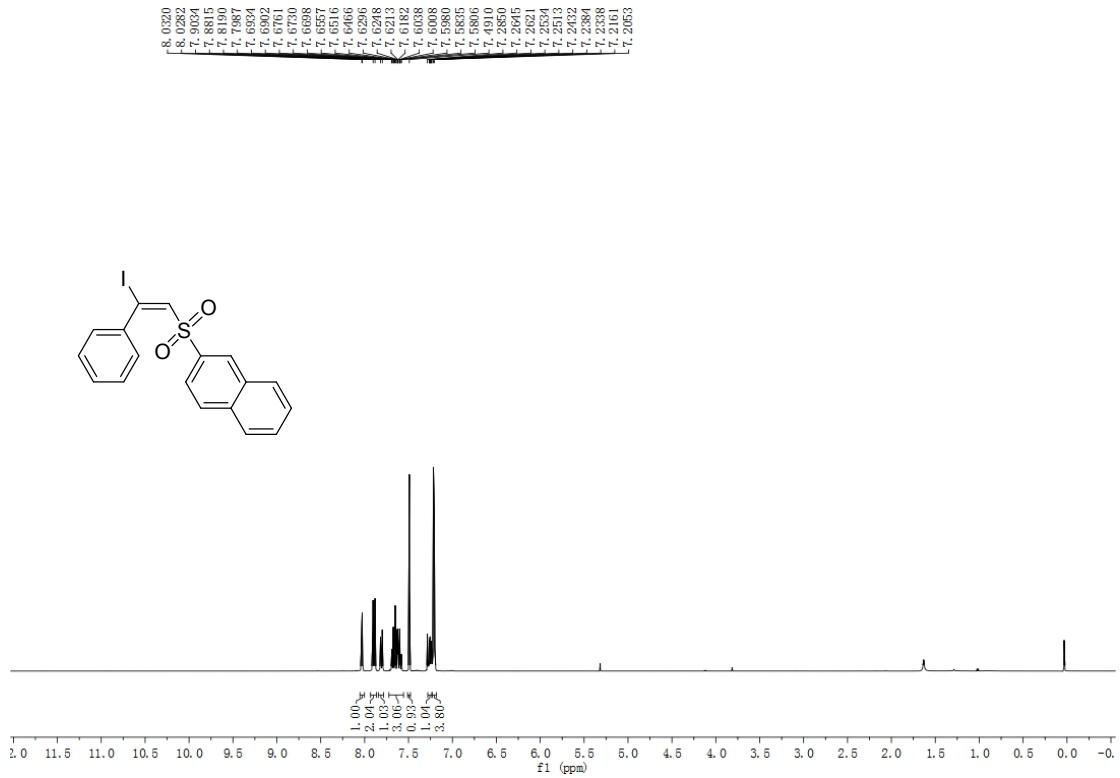

I
O
S
O
Br

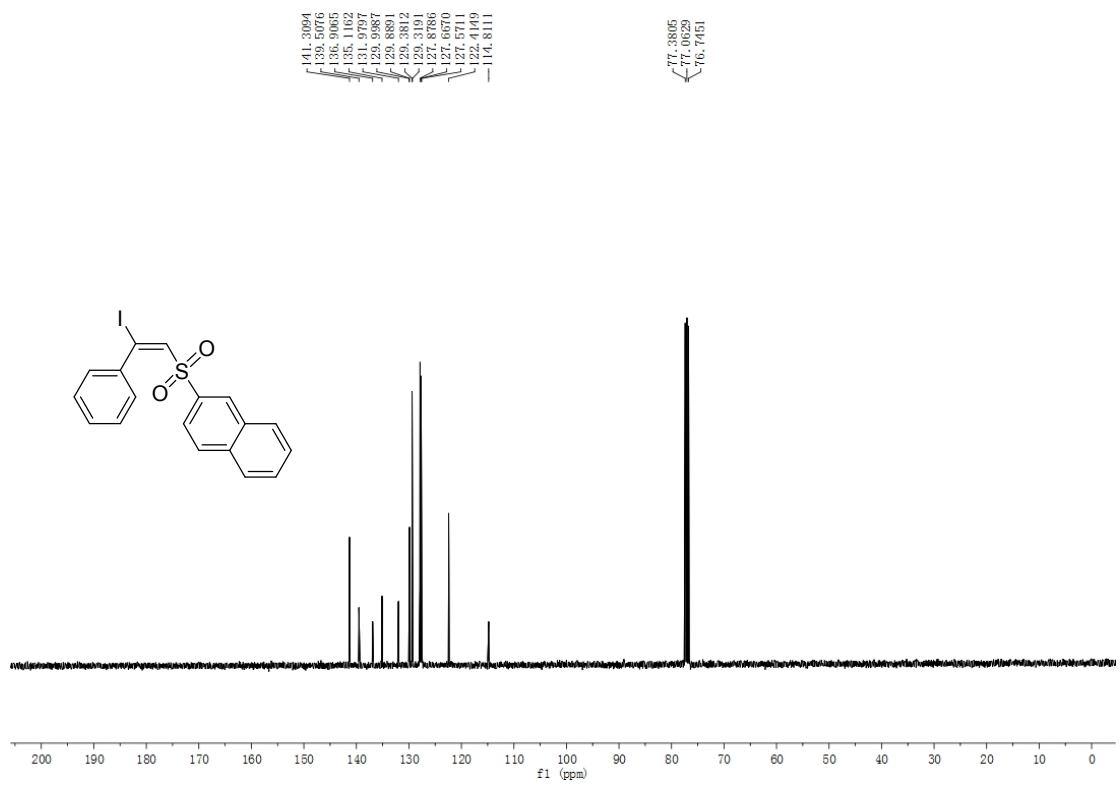

1.00
0.93
1.02
1.08
0.98
5.13
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


140.4075
139.7612
139.3393
134.8569
134.1766
131.2065
129.7632
127.8101
127.4003
127.3654
120.6498
114.7199
77.3956
77.0778
76.7601

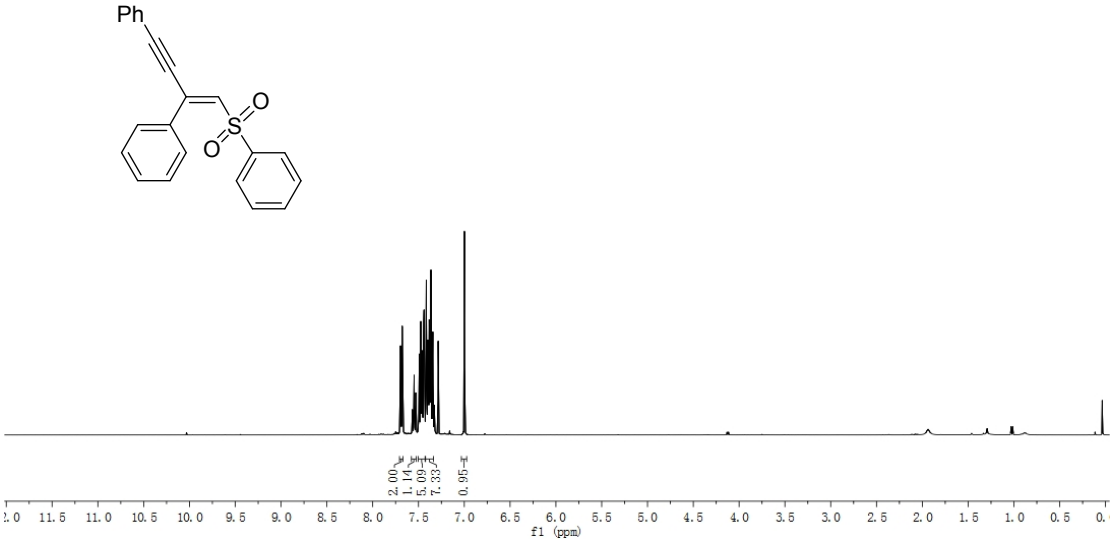

I
O
S
O
Br


180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

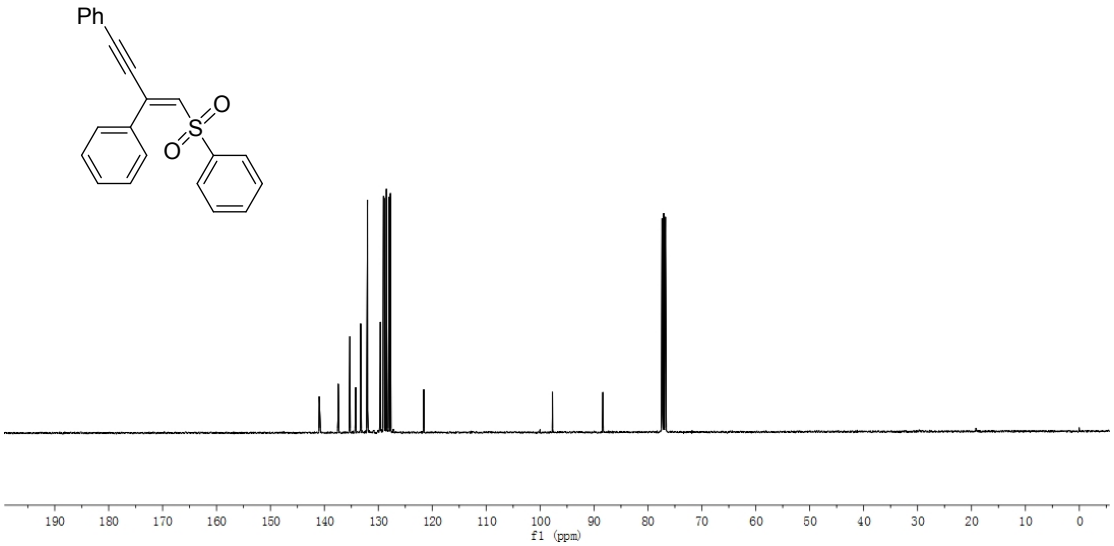

8.0320
8.0282
7.9034
7.8815
7.8190
7.7987
7.6934
7.6902
7.6761
7.6730
7.6698
7.6557
7.6516
7.6466
7.6296
7.6248
7.6213
7.6182
7.6038
7.6008
7.5980
7.5835
7.5806
7.4910
7.2850
7.2645
7.2621
7.2534
7.2513
7.2432
7.2384
7.2338
7.2161
7.2053
I
O
O
S
1.00
2.04
1.03
3.06
0.93
1.04
3.80
f1 (ppm)

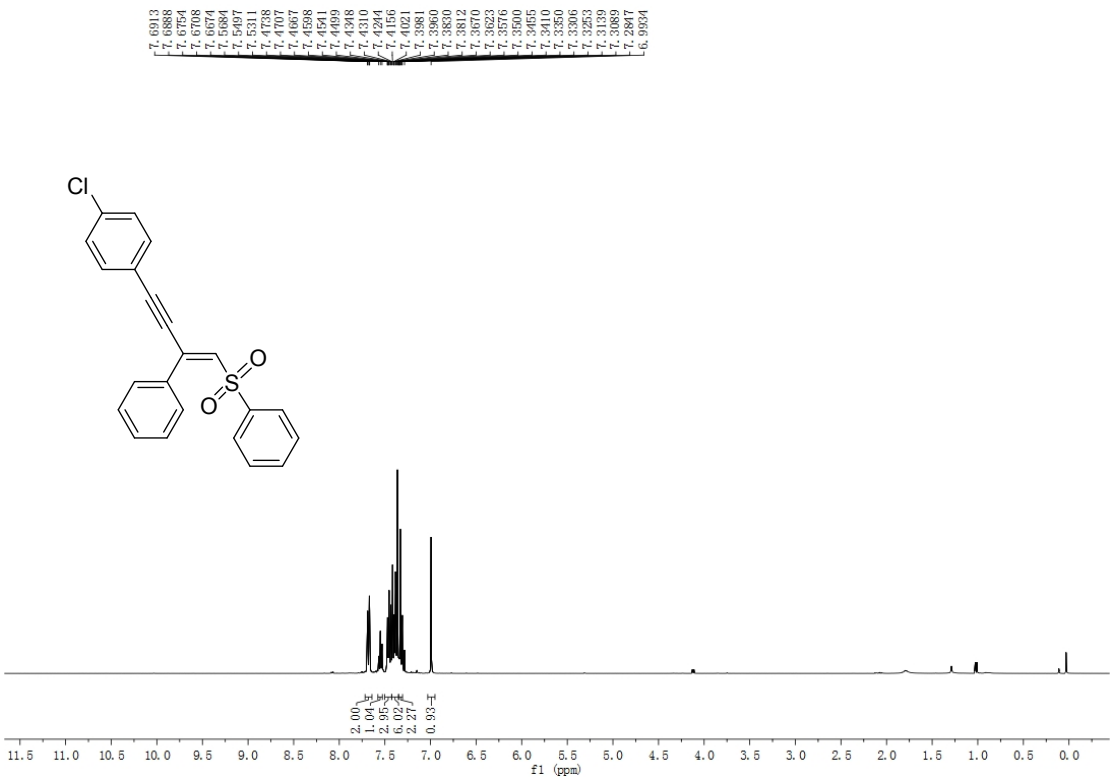

141.3094
139.5076
136.9065
135.1162
131.9797
129.9987
129.8891
129.3812
129.3191
127.8786
127.6670
127.5711
122.4149
114.8111
77.3805
77.0629
76.7451
I
O
O
S
f1 (ppm)

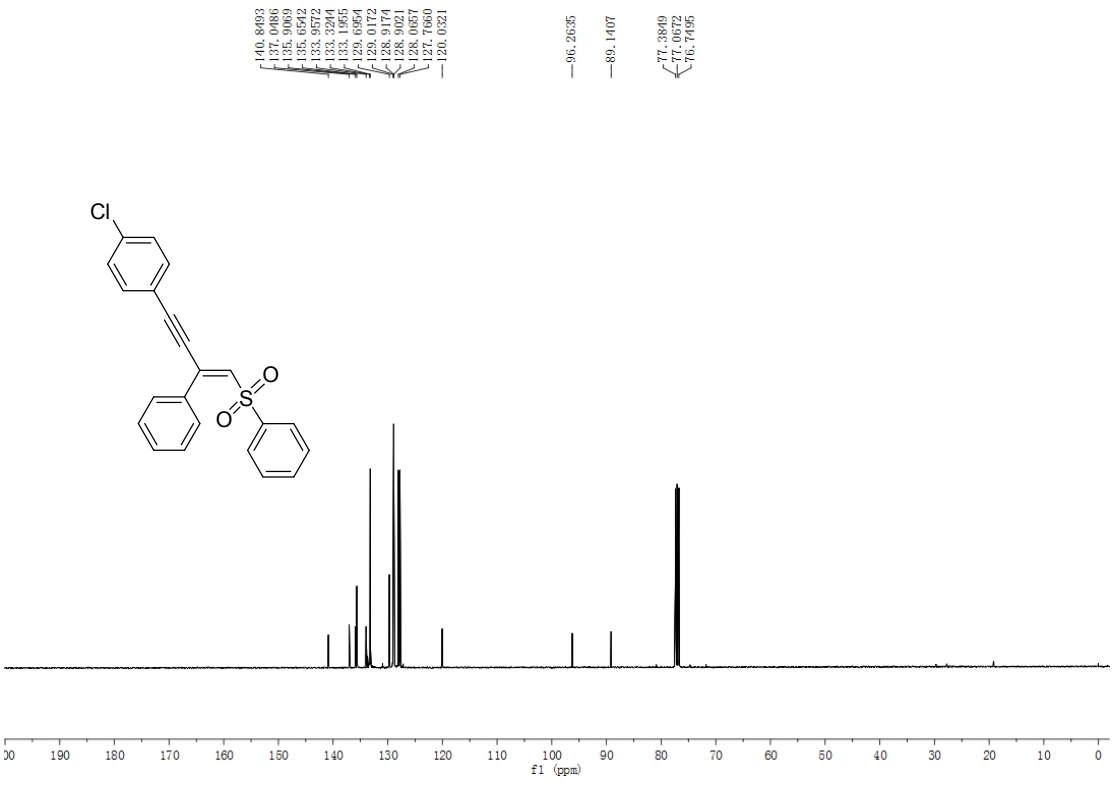

7.6985
7.6958
7.6826
7.6777
7.6744
7.5664
7.5477
7.5291
7.4943
7.4910
7.4869
7.4745
7.4702
7.4628
7.4591
7.4550
7.4485
7.4430
7.4385
7.4352
7.4310
7.4150
7.4095
7.4015
7.3978
7.3907
7.3825
7.3783
7.3734
7.3687
7.3641
7.3624
7.3586
7.3474
7.3437
7.3385
7.3271
7.2847
6.9986


Ph
O
O
S
2.00
2.14
5.09
7.33
0.95
f1 (ppm)

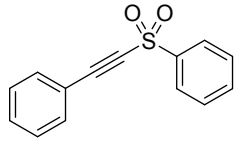

140.9526
137.4395
135.2681
134.1817
133.2637
131.9984
129.6910
129.6213
129.0537
128.8757
128.4998
128.0166
127.7557
121.5571
97.6915
88.3476
77.3813
77.2665
77.0636
76.7459

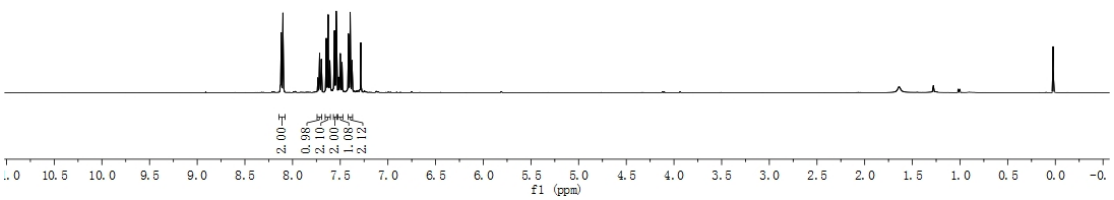

Ph
O
O
S
f1 (ppm)


7.6913
7.6888
7.6754
7.6708
7.6674
7.5684
7.5497
7.5311
7.4738
7.4707
7.4667
7.4598
7.4541
7.4499
7.4348
7.4310
7.4244
7.4156
7.4021
7.3981
7.3960
7.3830
7.3812
7.3670
7.3623
7.3576
7.3500
7.3455
7.3410
7.3350
7.3306
7.3253
7.3139
7.3089
7.2847
6.9934
Cl
O
S
O
2.00
1.04
2.95
6.02
2.27
0.93
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

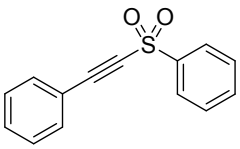

140.8493
137.0486
135.9069
135.6542
133.9572
133.3244
133.1955
129.6954
129.0172
128.9174
128.9021
128.0657
127.7660
120.0321
96.2635
89.1407
77.3849
77.0672
76.7495
Cl
O
S
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.1222
8.1207
8.1194
8.1159
8.1065
8.1015
8.0980
7.7352
7.7168
7.6981
7.6512
7.6465
7.6427
7.6301
7.6267
7.6126
7.6085
7.6062
7.5633
7.5602
7.5570
7.5478
7.5427
7.5391
7.5187
7.4998
7.4810
7.4145
7.3952
7.3768
7.2848


O
O
S

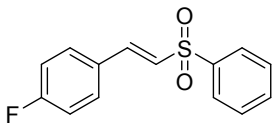

2.00
0.98
2.10
2.00
1.08
2.12
f1 (ppm)

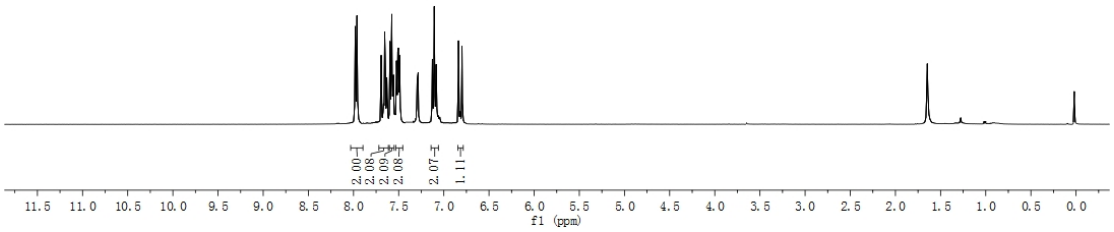

141.8463
134.1537
132.7608
131.5738
129.3752
128.6908
127.4039
117.8890
93.5125
85.3522
77.3383
77.0207
76.7031

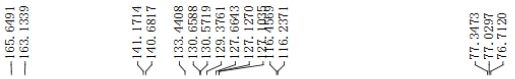

O
O
S

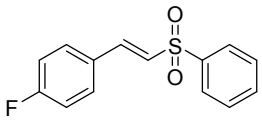
f1 (ppm)


7.9809
7.9616
7.6936
7.6550
7.6311
7.5960
7.5762
7.5580
7.5237
7.5102
7.5023
7.4889
7.2848
7.1272
7.1060
7.0846
6.8371
6.7985


O
S
O
F

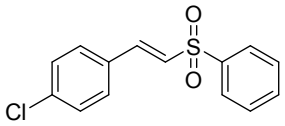

2.00
2.08
2.09
2.08
2.07
1.11
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

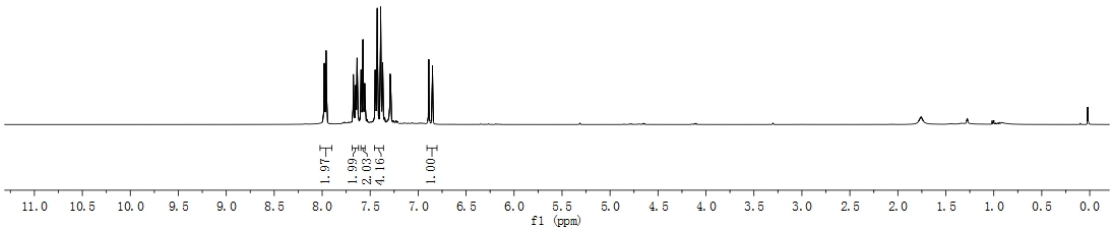

165.6491
163.1539
141.1714
140.6817
133.4408
130.6588
130.5719
129.3761
127.6643
127.1270
116.2371
77.3473
77.0297
76.7120

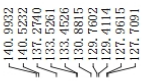

O
S
O
F

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

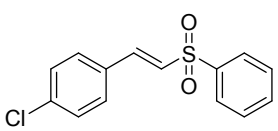

7.9779
7.9598
7.6753
7.6692
7.6506
7.6451
7.6364
7.6323
7.5946
7.5751
7.5571
7.4473
7.4259
7.3909
7.3695
7.2919
6.8895
6.8510


O
S
O
Cl

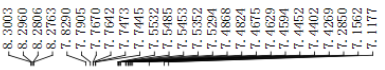

1.97
1.99
2.03
4.16
1.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

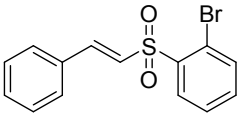

140.9932
140.5232
137.2740
133.5261
133.4526
130.8815
129.7602
129.4114
127.9615
127.7091

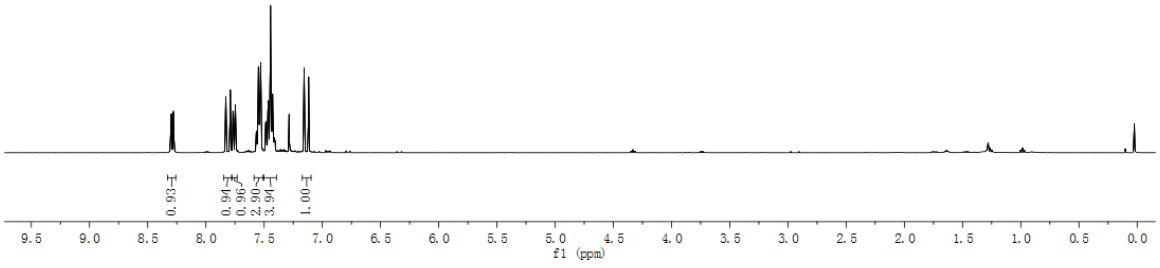

77.3754
77.0575
76.7398


O
S
O
Cl

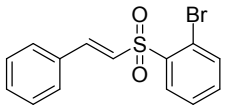
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

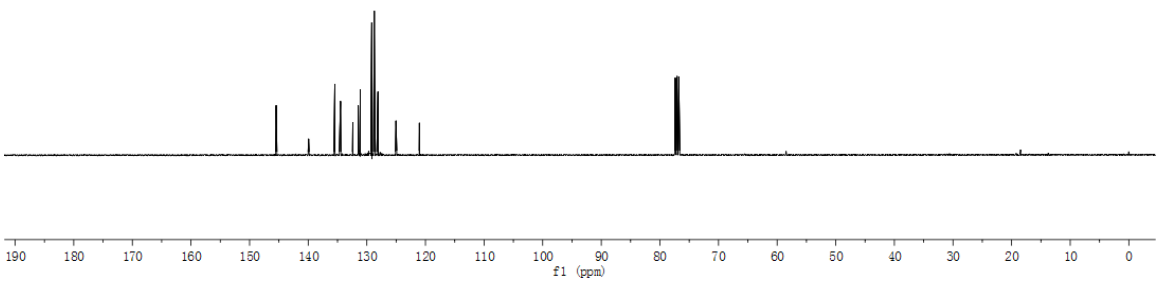

8.3003
8.2960
8.2806
8.2763
7.8290
7.7905
7.7670
7.7642
7.7473
7.7445
7.5532
7.5485
7.5453
7.5362
7.5294
7.4868
7.4824
7.4675
7.4629
7.4594
7.4452
7.4402
7.4269
7.2850
7.1562
7.1177


O
S
O
Br


0.93
0.94
0.96
2.90
3.94
1.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


145.46
139.93
135.46
134.49
132.39
131.45
131.11
129.16
128.73
128.09
125.02
121.03
77.39
77.07
76.75


O
S
O
Br


190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)