Supporting Information for

Regioselective synthesis of arylsulfonyl heterocycles from bromoallyl sulfones via intramolecular Heck coupling reaction

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General Information

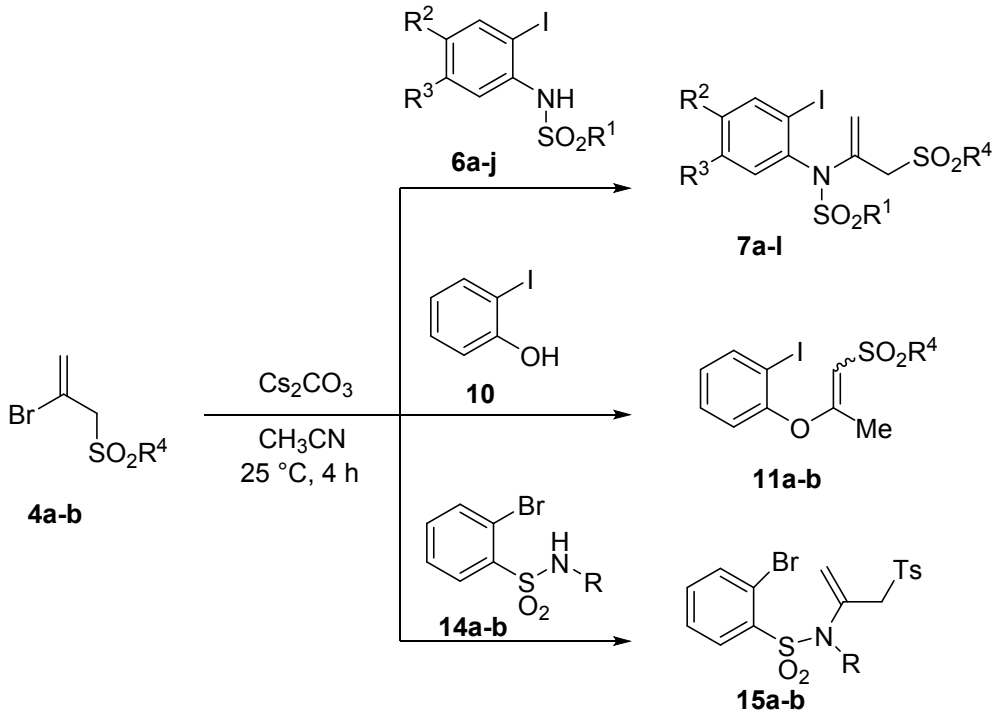
Solvents and reagents: All the reagents were used without further purification unless specified otherwise. Technical grade ethyl acetate and petroleum ether used for column chromatography were distilled prior to use. All reactions were performed in oven-dried glassware with magnetic stirring. HPLC grade acetonitrile and DMF were used as purchased.

Purification and chromatography: TLC analysis was performed on commercially prepared 60 F_{254} silica gel plates. Visualization of spots on TLC plate was accomplished with UV light (254 nm) and staining by $KMnO_4$ solution. Column chromatography was carried out using silica gel (60-120 mesh and 100- 200 mesh) packed in glass columns using distilled ethyl acetate and petroleum ether.

Characterisation: All ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were recorded in $CDCl_3$ solvent at ambient temperature, chemical shift δ are given in ppm on a scale downfield from TMS, and the coupling constant *J* are in Hz. The signal patterns are indicated as follows: s, Singlet; d, doublet; t, triplet; dd, doublet of doublet; m, multiplet; brs = broad, AB q, AB quartet). IR spectra were recorded on a Bruker Alfa FTIR spectrometer by dispersing samples in KBr pellets. Melting points were recorded on an electrothermal apparatus and are uncorrected.

The 2-bromoallylsulfones **4a-b**,[1] sulfonamides **6a-j**[2] and **14a-b**[3] were prepared as described previously.

General procedure A: Preparation of N-vinyl-o-halo sulfonamides 7a-j, enol ethers 11a-b and N-vinyl sulfonamides 15a-b



To a solution of the nucleophile (1.0 mmol) (N-sulfonyl-o-iodoaniline **6** or 2-iodophenol **10** or 2-bromobenzenesulfonamides **14)** and 2-bromoallyl sulfone **4** (1.5 mmol) in acetonitrile (10 mL), cesium carbonate (815 mg, 2.5 mmol) was added at room temperature and stirred the mixture for 4 hours. After completion of reaction, solvent was removed on a rotavapor and deionized water (20 mL) was added. The solution was extracted with ethyl acetate (3 X 15 mL). The combined extracts was washed with brine, dried over anhydrous sodium sulfate and concentrated on a rotavapor. Column chromatography of the residue on silica gel using petroleum ether-ethyl acetate as eluent afforded analytically pure products.

Spectroscopic data for N-vinyl-o-iodo sulfonamides 7a-j

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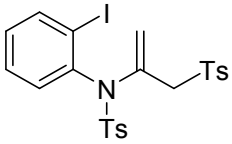
[1] S. Undeela, S. Thadkapally, J. B. Nanubolu, K. K. Singarapu and R. S. Menon, *Chem. Commun*., 2015, **51**, 13748-13751.
[2] C. Rossy, E. Fouquet and F.-X. Felpin, *Beilstein J. Org. Chem*., 2013, **9**, 1426-1431.
[3] S. Debnath and S. Mondal, . *J. Org. Chem*., 2015, **80**, 3940-3948.



*N-(2-iodophenyl)-4-methyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**7a**)*

White solid, 448 mg, 79%

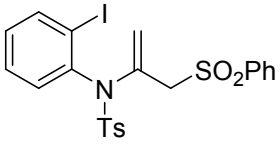
Melting point: 131-133 ˚C

IR (KBr) υ_{max}: 2922, 1620, 1595, 1460, 1346, 1311, 1157, 655, 586 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.0, 1.2 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.4 Hz, 2H), 7.34-7.21 (m, 4H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.05 (ddd, *J* = 8.0, 6.9, 2.2 Hz, 1H), 5.53 (d, *J* = 1.2 Hz, 1H), 5.29 (d, *J* = 1.2 Hz, 1H), 3.84 (AB q, *J* = 15.2 Hz, 2H), 2.45 (s, 3H), 2.42 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 144.5, 140.9, 140.0, 136.1, 135.1, 133.5, 132.5, 130.5, 129.7, 129.6, 129.2, 128.9, 128.7, 118.9, 102.3, 59.7, 21.7

HRMS calcd for $C_{23}H_{22}INO_4S_2$ (M+H) 568.0113 ; found 568.0116.



*N-(2-iodophenyl)-4-methyl-N-(3-(phenylsulfonyl)prop-1-en-2-yl)benzenesulfonamide (**7b**)*

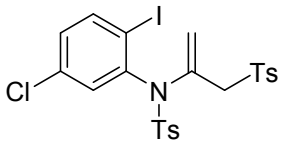
Colorless oil, 448 mg, 81%

IR (KBr) υ_{max}: 3062, 2924, 1591, 1496, 1315, 1153, 526 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.72-7.69 (m, 4H), 7.62-7.58 (m, 1H), 7.46 (t, *J* = 7.8 Hz, 2H), 7.36-7.29 (m, 4H), 7.05 (ddd, *J* = 8.0, 6.8, 2.0 Hz, 1H), 5.53, (d, *J* = 1.2 Hz, 1H), 5.28 (d, *J* = 1.2 Hz, 1H), 3.86 (AB q, *J* = 15.6 Hz, 2H), 2.45 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 141.0, 139.9, 138.1, 136.1, 133.9, 133.3, 132.5, 130.6, 129.6, 129.2, 129.1, 128.9, 128.7, 118.8, 102.2, 59.7, 21.7

HRMS calcd for $C_{22}H_{20}INO_4S_2$ (M+H) 553.9957 ; found 553.9977



*N-(5-chloro-2-iodophenyl)-4-methyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**7c**)*

White solid, 499 mg, 83%

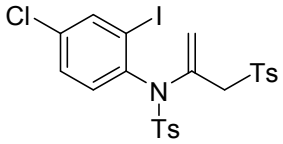
Melting point: 123-125 ˚C

IR (KBr) υ_{max}: 3244, 2924, 1620, 1595, 1448, 1309, 1157, 586, 516

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (t, *J* = 8.4 Hz, 3H), 7.57 (d, *J* = 8.4 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.0Hz, 2H), 7.14 (d, *J* = 2.4 Hz, 1H), 7.04 (dd, *J* = 8.4, 2.4 Hz, 1H), 5.55 (d, *J* = 1.2 Hz, 1H), 5.43 (d, *J* = 1.2 Hz, 1H), 3.85 (AB q, *J* = 15.6 Hz, 2H), 2.46 (s, 3H), 2.42 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 144.8, 141.3, 141.2, 135.7, 135.2, 134.9, 133.4, 132.2, 130.7, 129.8, 129.7, 128.9, 128.6, 119.7, 99.9, 59.9, 21.8, 21.7

HRMS calcd for $C_{23}H_{21}ClINO_4S_2$ (M+H) 601.9723; found 601.9737.



*N-(4-chloro-2-iodophenyl)-4-methyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**7d**)*

White solid, 469 mg, 78%

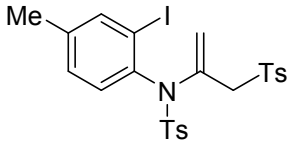
Melting point: 119-120 ˚C

IR (KBr) υ_{max}: 3091, 1597, 1577, 1463, 1334, 1163, 578

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 2.4 Hz, 1H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.33-7.28 (m, 3H), 7.23-7.19 (m, 3H), 5.55 (d, *J* = 1.2 Hz, 1H), 5.37 (d, *J* = 1.2 Hz, 1H), 3.81 (s, 2H), 2.46 (s, 3H), 2.43 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 144.7, 140.2, 138.6, 135.9, 135.6, 134.9, 133.2, 132.7, 129.7, 129.6, 129.3, 128.9, 128.7, 120.0, 102.7, 59.6, 21.7

HRMS calcd for $C_{23}H_{21}ClINO_4S_2$ (M+H) 601.9723 ; found 601.9748.



*N-(2-iodo-4-methylphenyl)-4-methyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**7e**)*

White solid, 442 mg, 76%

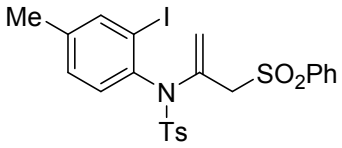
Melting point: 116-117 ˚C

IR (KBr) υ_{max}: 3041, 2924, 1624, 1595, 1477, 1319, 1159, 509 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.4 Hz, 2H), 7.64 (s, 1H), 7.55 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.16-7.10 (m, 2H), 5.52 (s, 1H), 5.25 (s, 1H), 3.82 (s, 2H), 2.45 (s, 3H), 2.42 (s, 3H), 2.31 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 144.4, 141.3, 141.1, 137.2, 136.2, 135.1, 133.5, 131.9, 130.0, 129.6, 129.5, 128.9, 128.7, 118.6, 102.0, 59.6, 21.7, 20.7

HRMS calcd for $C_{24}H_{24}INO_4S_2$ (M+H) 582.0270 ; found 582.0284.



*N-(2-iodo-4-methylphenyl)-4-methyl-N-(3-(phenylsulfonyl)prop-1-en-2-yl)benzenesulfonamide (**7f**)*

White solid, 419 mg, 74%

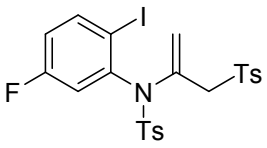
Melting point: 119-121 ˚C

IR (KBr) υ_{max}: 3040, 2922, 1620, 1585, 1440, 1307, 1153, 547 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72-7.69 (m, 4H), 7.65 (d, *J* = 1.2 Hz, 1H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.16 (d, *J* = 8.0 Hz, 1H), 7.12 (d, *J* = 8.0, 1.6 Hz, 1H), 5.52 (d, *J* = 1.2 Hz, 1H), 5.24 (d, *J* = 1.2 Hz, 1H), 3.85 (AB q, *J* = 15.2 Hz, 2H), 2.45 (s, 3H), 2.31 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 141.4, 141.1, 138.1, 137.1, 136.2, 133.8, 133.4, 131.9, 130.0, 129.5, 129.0, 128.9, 128.8, 118.4, 101.9, 59.7, 21.7, 20.6

HRMS calcd for $C_{23}H_{22}INO_4S_2$ (M+H) 568.0114 ; found 568.0131.



*N-(5-fluoro-2-iodophenyl)-4-methyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**7g**)*

White solid, 416 mg, 71%

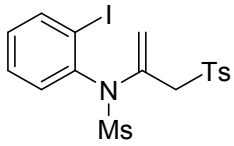
Melting point: 114-115 ˚C

IR (KBr) υ_{max}: 3099, 1589, 1460, 1354, 1292, 1159, 815, 580, 518 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (dd, *J* = 8.8, 6.0 Hz, 1H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.57 (d, *J* = 8.4 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.99 (dd, *J* = 8.8, 3.2 Hz, 1H), 6.85 (ddd, *J* = 8.8, 7.6, 3.2 Hz, 1H), 5.53 (s, *J* = 1.6 Hz, 1H), 5.35 (s, *J* = 1.6 Hz, 1H), 3.84 (AB q, *J* = 15.6 Hz, 2H), 2.46 (s, 3H), 2.42 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7 (d, *J* = 251.2 Hz), 144.9 (d, *J* = 20.9 Hz), 141.4, 141.3 (d, *J* = 8.3 Hz), 135.8, 135.1, 133.4, 129.8, 129.7, 128.9, 128.7, 119.8 (d, *J* = 22.8 Hz), 119.3, 118.2 (d, *J* = 21.6 Hz), 95.7 (d, *J* = 3.9 Hz), 59.9, 21.8, 21.7.

HRMS calcd for $C_{23}H_{21}FINO_4S_2$ (M+H) 586.0019 ; found 586.0026,



*N-(2-iodophenyl)-N-(3-tosylprop-1-en-2-yl)methanesulfonamide (**7h**)* [Spectroscopic data is in agreement with the previous report][4]

White solid, 354 mg, 72%

Melting point: 133-135 ˚C (Lit. 134-136 ˚C)[10b]

IR (KBr) υ_{max}: 2922, 1629, 1595, 1462, 1334, 1309, 1286, 1147, 765, 516 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.0 Hz, 1H), 7.76 (d, *J* = 8.0 Hz, 2H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 1H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.09 (t, *J* = 7.6 Hz, 1H), 5.83 (s, 1H), 5.11 (s, 1H), 3.66 (AB q, *J* = 15.2 Hz, 2H), 3.38 (s, 1H), 2.44 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.3, 141.0, 139.6, 135.4, 132.7, 132.5, 130.8, 130.0, 129.6, 128.5, 116.9, 102.3, 59.7, 41.2, 21.7.

HRMS calcd for $C_{17}H_{18}INO_4S_2$ (M+H) 491.9800; found 491.9811.

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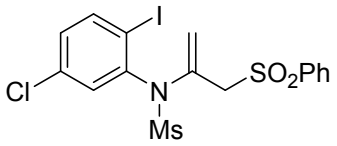
[4] S. Undeela, G. Ravikumar, J. B. Nanubolu, K. K. Singarapu and R. S. Menon, *Chem. Commun.,* 2016, **52**, 4824-4827.



*N-(5-chloro-2-iodophenyl)-N-(3-(phenylsulfonyl)prop-1-en-2-yl)methanesulfonamide (**7i**)*

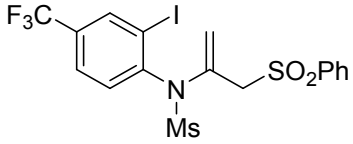
Pale yellow oil, 399 mg, 78%

IR (KBr) υ_{max}: 2931, 1579, 1469, 1315, 1149, 746, 518 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88-7.86 (m, 3H), 7.67 (t, *J* = 7.6 Hz, 1H), 7.58-7.51 (m, 3H), 7.42-7.39 (m, 1H), 5.84 (s, 1H), 5.16 (s, 1H), 3.68 (AB q, *J* = 15.2 Hz, 2H), 3.37 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 140.3, 138.4, 138.3, 136.0, 134.3, 132.9, 132.4, 129.9, 129.5, 128.5, 117.5, 102.5, 59.6, 41.3.

HRMS calcd for $C_{16}H_{15}ClINO_4S_2$ (M+H) 511.9254; found 511.9250.



*N-(2-iodo-4-(trifluoromethyl)phenyl)-N-(3-(phenylsulfonyl)prop-1-en-2- yl)methanesulfonamide (**7j**)*

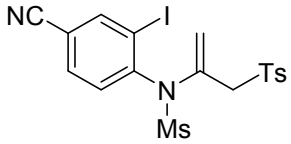
Brown viscous oil, 371 mg, 68%

Melting point: IR (KBr) υ_{max}: 2933, 1600, 1446, 1315, 1126, 524 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (s, 1H), 7.87 (d, *J* = 7.6 Hz, 2H), 7.73-7.64 (m, 3H), 7.56 (t, *J* = 7.6 Hz, 2H), 5.88 (s, 1H), 5.21 (s, 1H), 3.67 (AB q, *J* = 15.2 Hz, 2H), 3.40 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 143.1, 138.3, 137.9 (q, *J* = 3.7 Hz), 134.4, 132.7, 132.5 (q, *J* = 33.2 Hz), 132.2, 129.5, 128.4, 126.6, (q, *J* = 3.3 Hz), 123.7, 121.0, 118.0, 102.3, 59.7, 41.5.

HRMS calcd for $C_{17}H_{15}F_3INO_4S_2$ (M+H) 545.9518; found 545.9517.



*N-(4-cyano-2-iodophenyl)-N-(3-tosylprop-1-en-2-yl)methanesulfonamide (**7k**)*

Yellow solid, 325 mg, 63%

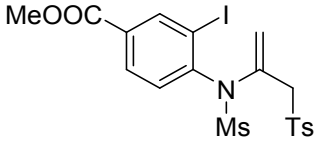
Melting point: 116-117 ˚C

IR (KBr) υ_{max}: 2924, 2233, 1629, 1595, 1469, 1315, 1149, 513 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (s, 1H), 7.73-7.71 (m, 4H), 7.34 (d, *J* = 8.4 Hz, 2H), 5.88 (s, 1H), 5.20 (s, 1H), 3.61 (AB q, *J* = 15.6 Hz, 2H), 3.40 (s, 3H), 2.44 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.6, 144.2, 144.0, 135.3, 133.0, 132.9, 132.1, 130.1, 128.4, 118.1, 116.2, 114.6, 102.6, 59.8, 41.5, 21.8.

HRMS calcd for $C_{18}H_{17}IN_2O_4S_2$ (M+H) 516.9753; found 516.9764.



*Methyl-3-iodo-4-(N-(3-tosylprop-1-en-2-yl)methylsulfonamido)benzoate (**7l**)*

Pale yellow solid, 379 mg, 69%

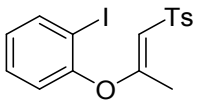
Melting point: 132-134 ˚C

IR (KBr) υ_{max}: 2927, 1639, 1593, 1429, 1340, 1149, 509 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.55 (s, 1H), 8.08 (dt, *J* = 8.4, 1.6 Hz, 1H), 7.74 (d, *J* = 8.0 Hz, 2H), 7.66 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.34 (d, *J* = 8.0 Hz, 2H), 5.88 (s, 1H), 5.20 (s, 1H), 3.94 (s, 3H), 3.65 (AB q, *J* = 15.6 Hz, 2H), 3.41 (s, 3H), 2.44 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 145.4, 143.7, 142.0, 135.4, 132.3, 132.2, 132.1, 130.6, 130.0, 128.4, 117.6, 101.9, 59.7, 52.8, 21.7.

HRMS calcd for $C_{19}H_{20}INO_6S_2$ (M+H) 549.9856; found 549.9858.



*1-iodo-2-((1-tosylprop-1-en-2-yl)oxy)benzene (**11a**)*

White solid, 265 mg, 64%

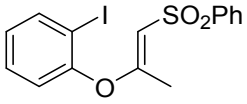
Melting point: 136-137 ˚C

IR (KBr) υ_{max}: 3068, 1627, 1462, 1284, 1130, 757 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.4 Hz, 2H), 7.76 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.30-7.25 (m, 3H), 6.92-6.88 (m, 1H), 6.85 (dd, *J* = 8.0, 1.2 Hz, 1H), 5.95 (d, *J* = 0.8 Hz, 1H), 2.39 (s, 3H), 1.75 (d, *J* = 0.8 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.7, 153.5, 143.8, 139.8, 139.5, 129.8, 129.4, 128.3, 127.1, 121.0, 113.7, 89.4, 21.6, 19.1.

HRMS calcd for $C_{16}H_{15}IO_3S$ (M+H) 414.9865; found 414.9887.



*1-iodo-2-((1-(phenylsulfonyl)prop-1-en-2-yl)oxy)benzene (**11b**)*

White solid, 268 mg, 67%

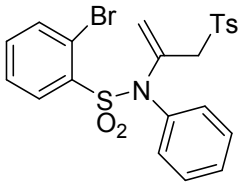
Melting point: 122-123 ˚C

IR (KBr) υ_{max}: 3070, 2924, 1627, 1458, 1436, 1286, 1126, 752, 567 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 7.6 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 1H), 7.57-7.54 (m, 1H), 7.48 (t, *J* = 7.2 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 1H), 6.92 (t, *J* = 7.6 Hz, 1H), 6.84 (d, *J* = 8.0 Hz, 1H), 5.96 (s, 1H), 1.77 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2, 153.4, 142.4, 139.8, 132.9, 129.8, 128.8, 128.3, 127.3, 121.2, 113.0, 89.5, 19.2

HRMS calcd for $C_{15}H_{13}IO_3S$ (M+H) 400.9708; found 400.9711.



*2-Bromo-N-phenyl-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**15a**)*

White solid, 349 mg, 69%

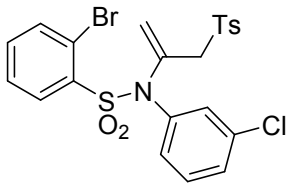
Melting point: 144-145 ˚C

IR (KBr) υ_{max}: 3062, 2924, 1593, 1489, 1448, 1317, 1149, 689, 513 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (dd, *J* = 7.2, 2.4 Hz, 1H), 7.70 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.58 (d, *J* = 8.4 Hz, 2H), 7.37-7.33 (m, 2H), 7.23-7.19 (m, 7H), 5.38 (s, 1H), 5.37 (s, 1H), 4.06 (s, 2H), 2.41 (s, 3H).

^{13}C NMR (101 MHz,) δ 144.8, 137.8 (2), 135.7, 135.3, 135.1, 134.2, 133.3, 129.7, 129.5, 129.2, 128.5, 128.4, 127.4, 120.9, 119.9, 60.4, 21.6.

HRMS calcd for $C_{22}H_{20}BrNO_4S_2$ (M+H) 506.0095; found 506.0093.



*2-bromo-N-(3-chlorophenyl)-N-(3-tosylprop-1-en-2-yl)benzenesulfonamide (**15b**)*

White solid, 384 mg, 71%

Melting point: 151-152 ˚C

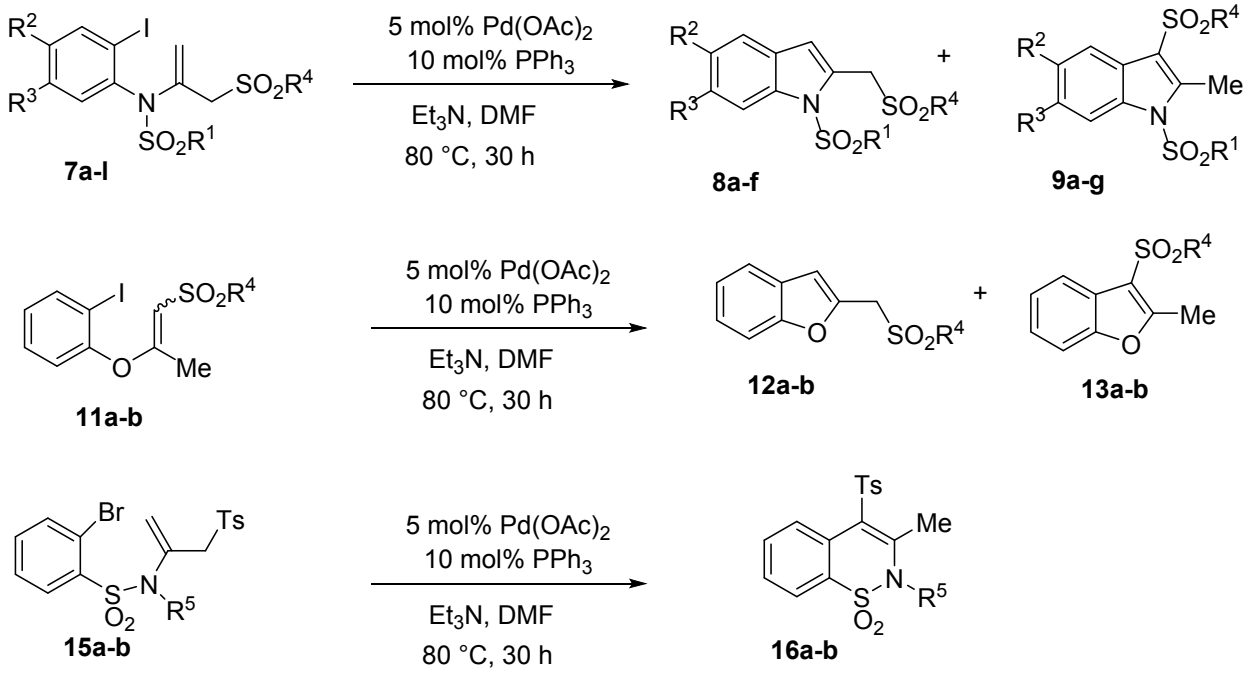
IR (KBr) υ_{max}: 3089, 2924, 1585, 1471, 1317, 1083, 684, 514 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (dd, *J* = 6.8, 2.4 Hz, 1H), 7.73 (d, *J* = 6.8 Hz, 1H), 7.58 (d, *J* = 8.0 Hz, 2H), 7.40 (t, *J* = 4.4 Hz, 2H), 7.26-7.23 (m, 3H), 7.17-7.13 (m, 3H), 5.50 (s, 1H), 5.35 (s, 1H), 4.08 (s, 2H), 2.43 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 139.0, 137.5, 135.8, 135.1, 134.9, 134.5 (2), 133.3, 129.9, 129.7, 129.3, 128.5, 128.4, 127.5 (2), 121.5, 120.8, 60.4, 21.7.

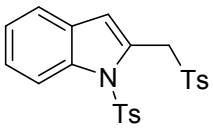
HRMS calcd for $C_{22}H_{19}BrClNO_4S_2$ (M+H) 539.9706; found 539.9700.

General procedure B: Intramolecular Heck coupling reaction of 7, 11 and 15



The halo alkenes (**7**, **11** or **15**) (0.4 mmol), $Pd(OAc)_2$ (5 mg, 5 mol%), PPh_3 (11 mg, 10 mol%) and triethylamine (0.17 ml, 1.2 mmol) were suspended in DMF (4 ml) in a reaction tube. The

mixture was heated at 80 ˚C in an oil bath for 30 h with stirring. Upon completion of reaction, the reaction mixture was diluted with saturated NH_4Cl (20 ml) and product was extracted with ethyl acetate (3×15 ml). The combined organic layer was washed with brine, dried over sodium sulfate and concentrated at rotavapor under reduced pressure. The residue was subjected to column chromatography on silica gel using petroleum ether-ethyl acetate as eluent to afford analytically pure sample of the products.



*1-tosyl-2-(tosylmethyl)-1H-indole (**8a**)*

White solid, 28 mg, 16%

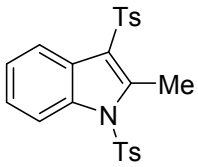
Melting point: 139-140 ˚C

IR (KBr) υ_{max}: 2935, 1593, 1490, 1446, 1367, 1309, 1147, 813, 651 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.4 Hz, 1H), 7.66 (d, *J* = 8.0 Hz, 2H), 7.55 (d, *J* = 8.0 Hz, 2H), 7.48 (d, *J* = 7.6 Hz, 1H), 7.30-7.20 (m, 4H), 7.14 (d, *J* = 8.4 Hz, 2H), 6.89 (s, 1H), 5.03 (s, 2H), 2.42 (s, 3H), 2.29 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.2, 145.1, 137.3, 135.4, 135.1, 129.9, 129.7, 129.2, 128.8, 127.6, 126.5, 125.4, 124.1, 121.3, 116.1, 115.2, 55.1, 21.8, 21.6

HRMS calcd for $C_{23}H_{21}NO_4S_2$ (M+H) 440.0990; found 440.0990.



*2-methyl-1,3-ditosyl-1H-indole (**9a**)*

White solid, 113 mg, 64%

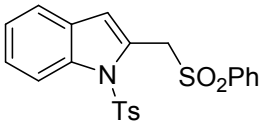
Melting point: 176-178 ˚C

IR (KBr) υ_{max}: 2922, 1593, 1543, 1442, 1371, 1153, 715, 534 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22-8.19 (m, 1H), 8.11-8.09 (m, 1H), 7.80 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 8.4 Hz, 2H), 7.34-7.31 (m, 2H), 7.25 (d, *J* = 8.0 Hz, 4H), 2.97 (s, 3H), 2.37 (s, 3H), 2.36 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.1, 144.2, 142.3, 139.8, 135.6, 135.4, 130.3, 129.9, 126.7, 126.5, 125.5, 125.4, 124.8, 120.4, 119.9, 114.4, 21.7, 21.6, 13.1

HRMS calcd for $C_{23}H_{21}NO_4S_2$ (M+H) 440.0990 ; found 440.1000.



*2-((phenylsulfonyl)methyl)-1-tosyl-1H-indole (**8b**)*

White solid, 27 mg, 16%

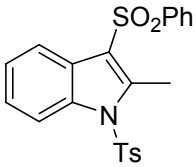
Melting point: 118-119 ˚C

IR (KBr) υ_{max}: 3014, 2947, 1565, 1448, 1361, 1300, 1145, 736, 538 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.4 Hz, 1H), 7.78 (d, *J* = 8.0 Hz, 2H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.49-7.45 (m, 3H), 7.30-7.22 (m, 2H), 7.13 (d, *J* = 8.4 Hz, 2H), 6.90 (s, 1H), 5.05 (s, 2H), 2.29 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.2, 138.3, 137.3, 135.0, 134.1, 129.9, 129.2, 129.1, 128.8, 127.4, 126.5, 125.5, 124.1, 121.3, 116.3, 115.2, 55.2, 21.6.

HRMS calcd for $C_{22}H_{19}NO_4S_2$ (M+H) 426.0834 ; found 426.0838



*2-methyl-3-(phenylsulfonyl)-1-tosyl-1H-indole (**9b**)*

White solid, 106 mg, 62%

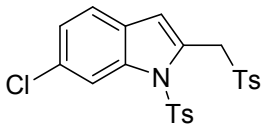
Melting point: 164-165 ˚C

IR (KBr) υ_{max}: 3057, 1544, 1442, 1373, 1313, 1182, 700, 542 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23-8.21 (m, 1H), 8.12-8.10 (m, 1H), 7.92 (d, *J* = 8.2 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.56-7.52 (m, 1H), 7.48-7.45 (m, 2H), 7.36-7.33 (m, 2H), 7.26 (d, *J* = 8.1 Hz, 2H), 2.98 (s, 3H), 2.38 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.1, 142.7, 142.6, 135.6, 135.4, 133.2, 130.4, 129.3, 126.7, 126.4, 125.6, 125.4, 124.9, 120.4, 119.5, 114.5, 21.7, 13.1

HRMS calcd for $C_{22}H_{19}NO_4S_2$ (M+H) 426.0834; found 426.0838



*6-chloro-1-tosyl-2-(tosylmethyl)-1H-indole (**8c**)*

White solid, 27mg, 14%

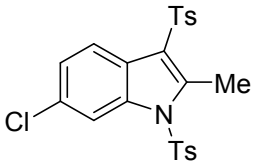
Melting point: 127-129 ˚C

IR (KBr) υ_{max}: 3107, 2924, 1563, 1452, 1369, 1317, 1153, 536 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, J = 1.6 Hz, 1H), 7.65 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.4 Hz, 2H), 7.40 (d, *J* = 8.4 Hz, 1H), 7.28 (d, J = 8.0 Hz, 2H), 7.22 (dd, *J* = 8.4, 2.0 Hz, 1H), 7.18 (d, *J* = 8.0 Hz, 2H), 6.88 (s, 1H), 4.99 (s, 2H), 2.44 (s, 3H), 2.32 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.6, 145.3, 137.6, 135.3, 134.9, 131.5, 130.0, 129.8, 128.7, 128.3, 127.6, 126.5, 124.8, 122.0, 115.4, 115.3, 55.0, 21.8, 21.6

HRMS calcd for $C_{23}H_{20}ClNO_4S_2$ (M+H) 474.0601; found 474.0610.



*6-chloro-2-methyl-1,3-ditosyl-1H-indole (**9c**)*

White solid, 131 mg, 69%

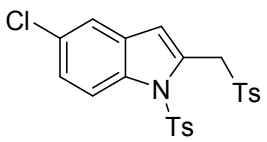
Melting point: 194-196 ˚C

IR (KBr) υ_{max}: 2922, 1544, 1417, 1373, 1311, 1151, 761, 535 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (d, *J* = 1.6 Hz, 1H), 8.02 (d, *J* = 8.8 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 8.4 Hz, 2H), 7.31-7.24 (m, 5H), 2.92 (s, 3H), 2.39 (s, 3H), 2.36 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.4, 144.4, 142.8, 139.5, 135.9, 135.1, 131.7, 130.5, 130.0, 126.7, 126.5, 125.5, 124.0, 121.2, 119.8, 114.6, 21.8, 21.6, 13.1.

HRMS calcd for $C_{23}H_{20}ClNO_4S_2$ (M+H) 474.0601; found 474.0608.



*5-chloro-1-tosyl-2-(tosylmethyl)-1H-indole (**8d**)*

White solid, 25 mg, 13%

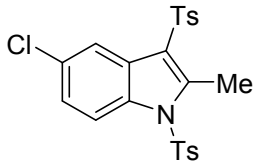
Melting point: 135-136 ˚C

IR (KBr) υ_{max}: 2922, 1595, 1442, 1371, 1317, 1155, 715, 536 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.8 Hz, 1H), 7.65 (d, *J* = 8.4 Hz, 2H), 7.53 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 2.0 Hz, 1H), 7.27 (d, *J* = 8.0 Hz, 2H), 7.23 (dd, *J* = 8.8, 2.0 Hz, 1H), 7.15 (d, *J* = 8.4 Hz, 2H), 6.81 (s, 1H), 5.00 (s, 2H), 2.42 (s, 3H), 2.30 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.5, 145.3, 135.6, 135.3, 134.9, 130.3, 130.0, 129.9, 129.8, 129.2, 128.8, 126.5, 125.7, 120.8, 116.2, 115.1, 55.0, 21.8, 21.6.

HRMS calcd for $C_{23}H_{20}ClNO_4S_2$ (M+H) 474.0601; found 474.0616.



*5-chloro-2-methyl-1,3-ditosyl-1H-indole (**9d**)*

White solid, 129 mg, 68%

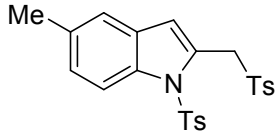
Melting point: 188-189 ˚C

IR (KBr) υ_{max}: 2924, 1541, 1436, 1373, 1315, 1149, 759, 532 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.8 Hz, 1H), 8.11 (d, *J* = 2.0 Hz, 1H), 7.78 (d, *J* = 8.4 Hz, 2H), 7.66 (d, *J* = 8.4 Hz, 2H), 7.31-7.25 (m, 5H), 2.93 (s, 3H), 2.38 (s, 3H), 2.37 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.4, 144.5, 143.5, 139.5, 135.1, 134.0, 130.8, 130.4, 130.0, 126.7, 126.5, 125.8, 120.0, 119.5, 115.5, 21.7, 21.6, 13.2

HRMS calcd for $C_{23}H_{20}ClNO_4S_2$ (M+H) 474.0601; found 474.0617.



*5-methyl-1-tosyl-2-(tosylmethyl)-1H-indole (**8e**)*

White solid, 24 mg, 13%

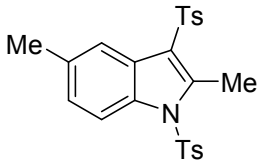
Melting point: 120-122 ˚C

IR (KBr) υ_{max}: 3035, 2922, 1581, 1435, 1365, 1292, 1130, 661 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.6 Hz, 1H), 7.65 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.27- 7.25 (m, 3H), 7.13-7.08 (m, 3H), 6.82 (s, 1H), 5.01 (s, 2H), 2.42 (s, 3H), 2.38 (s, 3H), 2.29 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 135.6, 135.4, 135.1, 133.8, 129.8, 129.7, 129.4, 128.8, 127.6, 126.9, 126.5, 121.1, 116.0, 114.9, 55.2, 21.8, 21.6, 21.2

HRMS calcd for $C_{24}H_{23}NO_4S_2$ (M+H) 454.1147 ; found 454.1149.



*2,5-dimethyl-1,3-ditosyl-1H-indole (**9e**)*

White solid, 131 mg, 72%

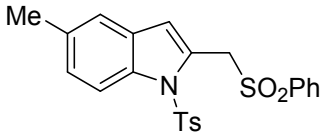
Melting point: 191-193 ˚C

IR (KBr) υ_{max}: 2924, 1591, 1544, 1456, 1369, 1315, 1145, 677, 534 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.8 Hz, 1H), 7.89 (d, *J* = 1.6 Hz, 1H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.66 (d, *J* = 8.4 Hz, 2H), 7.25-7.22 (m, 4H), 7.15 (dd, *J* = 8.8, 1.6 Hz, 1H), 2.94 (s, 3H), 2.43 (s, 3H), 2.36 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.0, 144.1, 142.3, 139.8, 135.4, 134.6, 133.8, 130.3, 129.9, 126.9, 126.6, 126.4, 125.6, 120.1, 119.6, 114.1, 21.7, 21.6, 21.5, 13.1.

HRMS calcd for $C_{24}H_{23}NO_4S_2$ (M+H) 454.1147; found 454.1147.



*5-methyl-2-((phenylsulfonyl)methyl)-1-tosyl-1H-indole (**8f**)*

White solid, 26 mg, 15%

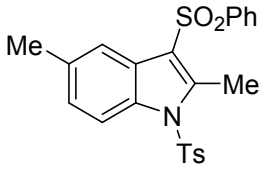
Melting point: 117-118 ˚C

IR (KBr) υ_{max}: 3010, 2941, 1585, 1450, 1359, 1298, 1170, 738, 578 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.8 Hz, 1H), 7.77 (dd, *J* = 8.4, 1.2 Hz, 2H), 7.66-7.11 (m, 1H), 7.52-7.45 (m, 4H), 7.25 (s, 1H), 7.13-7.09 (m, 3H), 6.83 (s, 1H), 5.03 (s, 2H), 2.38 (s, 3H), 2.29 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.1, 138.2, 135.6, 135.0, 134.0, 133.8, 129.8, 129.4, 129.0, 128.9, 127.4, 127.0, 126.4, 121.1, 116.2, 114.9, 55.2, 21.6, 21.1.

HRMS calcd for $C_{23}H_{21}NO_4S_2$ (M+H) 440.0990; found 440.1004.



*2,5-dimethyl-3-(phenylsulfonyl)-1-tosyl-1H-indole (**9f**)*

White solid, 121 mg, 69%

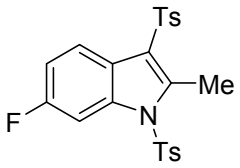
Melting point: 172-173 ˚C

IR (KBr) υ_{max}: 2924, 1593, 1544, 1444, 1373, 1313, 1147, 678, 538 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.4 Hz, 1H), 7.92-7.89 (m, 3H), 7.67 (d, *J* = 8.4 Hz, 2H), 7.55-7.51 (m, 1H), 7.48-7.44 (m, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.16 (dd, *J* = 8.8, 1.6 Hz, 1H), 2.94 (s, 3H), 2.43 (s, 3H), 2.37 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.0, 142.7, 142.6, 135.4, 134.7, 133.8, 133.2, 130.3, 129.2, 127.0, 126.6, 126.4, 125.6, 120.1, 119.2, 114.1, 21.7, 21.5, 13.1.

HRMS calcd for $C_{23}H_{21}NO_4S_2$ (M+H) 440.0990; found 440.1005.



*6-fluoro-2-methyl-1,3-ditosyl-1H-indole (**9g**)*

White solid, 111 mg, 61%

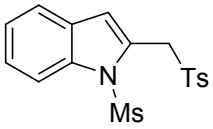
Melting point: 187-188 ˚C

IR (KBr) υ_{max}: 2922, 1591, 1546, 1483, 1373, 1317, 1149, 806, 532 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (dd, *J* = 8.8, 5.6 Hz, 1H), 7.96 (dd, *J* = 10.4, 2.0 Hz, 1H), 7.78 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 2H), 7.27 (t, *J* = 8.4 Hz, 4H), 7.09 (td, *J* = 8.8, 2.0 Hz, 1H), 2.93 (s, 3H), 2.39 (s, 3H), 2.36 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1 (d, *J* = 243 Hz), 146.4, 144.4, 142.6 (d, *J* = 4.2 Hz), 139.6, 135.8 (d, *J* = 12.5 Hz), 135.1, 130.5, 130.0, 126.7, 126.5, 121.7, 121.4 (d, *J* = 2.5 Hz), 119.7, 113.2 (d, *J* = 24.0 Hz), 102.0 (d, *J* = 30.0 Hz), 21.7, 21.6, 13.1

HRMS calcd for $C_{23}H_{20}FNO_4S_2$ (M+H) 458.0896; found 458.0921.



*1-(methylsulfonyl)-2-(tosylmethyl)-1H-indole (**8g**)*

White solid, 108 mg, 74%

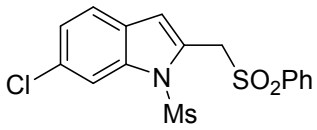
Melting point: 146-147 ˚C

IR (KBr) υ_{max}: 3014, 2926, 1565, 1446, 1355, 1309, 1151, 536 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.4 Hz, 1H), 7.79 (d, *J* = 8.0 Hz, 2H), 7.56 (d, *J* = 7.6 Hz, 1H), 7.37-7.34 (m, 3H), 7.30 (d, *J* = 7.6 Hz, 1H), 6.65 (s, 1H), 4.97 (s, 2H), 3.42 (s, 3H), 2.46 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.3, 147.0, 135.9, 130.0, 128.5, 126.7, 125.6, 123.8, 121.5, 114.4, 114.0, 54.8, 41.2, 21.8.

HRMS calcd for $C_{17}H_{17}NO_4S_2$ (M+H) 364.0677; found 364.0681.



*6-chloro-1-(methylsulfonyl)-2-((phenylsulfonyl)methyl)-1H-indole (**8h**)*

White solid, 112 mg, 73%

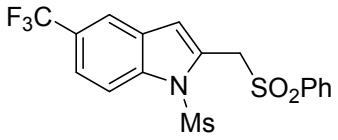
Melting point: 186-187 ˚C

IR (KBr) υ_{max}: 2953, 1583, 1444, 1361, 1309, 1161, 543 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.6 Hz, 2H), 7.87 (d, *J* = 8.8 Hz, 1H), 7.70 (t, *J* = 7.6 Hz, 1H), 7.59 (t, *J* = 7.6 Hz, 2H), 7.53 (s, 1H), 7.34 (dd, *J* = 7.2, 1.6 Hz, 1H), 6.58 (s, 1H), 4.98 (s, 2H), 3.43 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.6, 135.3, 134.4, 129.7, 129.6, 129.5, 128.5, 127.9, 125.9, 121.0, 115.1, 113.7, 54.6, 41.5.

HRMS calcd for $C_{16}H_{14}ClNO_4S_2$ (M+H) 384.0131; found 384.0149.



*1-(methylsulfonyl)-2-((phenylsulfonyl)methyl)-5-(trifluoromethyl)-1H-indole (**8i**)*

White solid, 102 mg, 61%

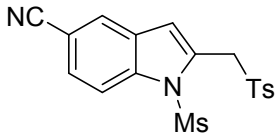
Melting point: 204-205 ˚C

IR (KBr) υ_{max}: 3008, 2953, 1620, 1448, 1356, 1313, 1159, 542 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (d, *J* = 8.8 Hz, 1H), 7.93 (d, *J* = 8.4 Hz, 2H), 7.86 (d, *J* = 0.8 Hz, 1H), 7.73-7.69 (m, 1H), 7.63-7.58 (m, 3H), 6.71 (s, 1H), 5.02 (s, 2H), 3.49 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 138.6, 138.4, 134.4, 129.5, 128.6, 128.5, 128.1, 126.4 (q, *J* = 32.5 Hz), 125.7, 123.0, 122.3(q, *J* = 3.1 Hz)), 119.0(q, *J* = 4.1 Hz), 114.5, 114.2, 54.6, 41.8

HRMS calcd for $C_{17}H_{14}F_3NO_4S_2$ (M+H) 418.0395; found 418.0415.



*1-(methylsulfonyl)-2-(tosylmethyl)-1H-indole-5-carbonitrile (**8j**)*

White solid, 90 mg, 58%

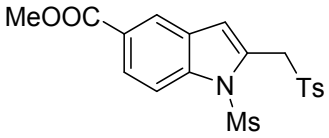
Melting point: 180-181 ˚C

IR (KBr) υ_{max}: 3020, 2926, 2223, 1595, 1456, 1363, 1303, 1138, 509 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.91 (d, *J* = 1.6 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 2H), 7.63 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.39 (d, *J* = 8.0 Hz, 2H), 6.69 (s, 1H), 4.98 (s, 2H), 3.53 (s, 3H), 2.48 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.7, 138.6, 135.5, 130.2, 129.4, 128.5, 128.4, 128.3, 126.3, 119.0, 115.0, 113.5, 107.6, 54.6, 42.0, 21.8.

HRMS calcd for $C_{18}H_{16}N_2O_4S_2$ (M+H) 389.0630; found 389.0631.



*Methyl-1-(methylsulfonyl)-2-(tosylmethyl)-1H-indole-5-carboxylate (**8k**)*

White solid, 106 mg, 63%

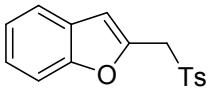
Melting point: 178-179 ˚C

IR (KBr) υ_{max}: 3014, 2958, 1716, 1606, 1438, 1354, 1136, 538 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 (s, 1H), 8.08 (d, *J* = 8.8 Hz, 1H), 7.99 (d, *J* = 8.8 Hz, 1H), 7.80 (d, *J* = 7.6 Hz, 2H), 7.39 (d, *J* = 7.6 Hz, 2H), 6.68 (s, 1H), 4.99 (s, 2H), 3.95 (s, 3H), 3.51 (s, 3H), 2.48 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 145.5, 139.4, 135.6, 130.1, 128.5, 128.3, 128.2, 126.6, 125.9, 123.7, 114.5, 113.8, 54.7, 52.3, 41.7, 21.8.

HRMS calcd for $C_{19}H_{19}NO_6S_2$ (M+H) 422.0732; found 422.0749.



*2-(tosylmethyl)benzofuran (**12a**)*

White solid, 72 mg, 63%

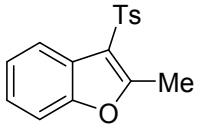
Melting point: 196-197 ˚C

IR (KBr) υ_{max}: 2987, 1591, 1448, 1303, 1286, 1145, 719, 520 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.4 Hz, 2H), 7.53-7.51 (m, 1H), 7.37-7.35 (m, 1H), 7.29-7.27 (m, 3H), 7.22 (td, *J* = 7.6, 1.2 Hz, 1H), 6.67 (d, *J* = 0.8 Hz, 1H), 4.53 (s, 2H), 2.43 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 145.3, 145.2, 135.3, 129.8, 128.6, 128.0, 125.0, 123.1, 121.3, 111.3, 108.9, 56.5, 21.7

HRMS calcd for $C_{16}H_{14}O_3S$ (M+H) 287.0742; found 287.0746.



*2-methyl-3-tosylbenzofuran (**13a**)*

White solid, 18 mg, 16%

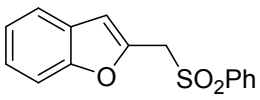
Melting point: 122-123 ˚C

IR (KBr) υ_{max}: 2922, 1583, 1446, 1296, 1143, 758, 580 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90-7.85 (m, 3H), 7.42-7.39 (m, 1H), 7.31-7.28 (m, 4H), 2.80 (s, 3H), 2.38 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 153.2, 144.3, 139.7, 129.9, 126.7, 125.2, 124.4, 124.3, 120.3, 118.2, 111.2, 21.6, 13.6.

HRMS calcd for $C_{16}H_{14}O_3S$ (M+H) 287.0742; found 287.0740.



*2-((phenylsulfonyl)methyl)benzofuran (**12b**)*

White solid, 70 mg, 64%

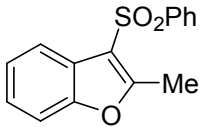
Melting point: 162-163 ˚C

IR (KBr) υ_{max}: 2880, 1581, 1448, 1305, 1141, 735, 569 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 8.0Hz, 2H), 7.63 (t, *J* = 7.6Hz, 1H), 7.52-7.45 (m, 3H), 7.33 (d, *J* = 8.0Hz, 1H), 7.24-7.19 (m, 2H), 6.63 (s, 1H), 4.54 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 145.1, 138.2, 134.1, 129.2, 128.6, 127.9, 125.0, 123.2, 121.3, 111.3, 109.0, 56.5

HRMS calcd for $C_{15}H_{12}O_3S$ (M+H) 273.0585; found 273.0589.



*2-methyl-3-(phenylsulfonyl)benzofuran (**13b**)*

White solid, 17 mg, 16%

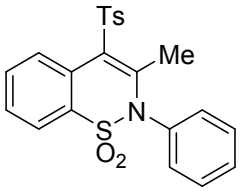
Melting point: 106-107 ˚C

IR (KBr) υ_{max}: 3064, 2920, 1577, 1444, 1309, 1149, 750, 545 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.4 Hz, 2H), 7.88-7.86 (m, 1H), 7.56 (t, *J* = 7.8 Hz, 1H), 7.50 (t, *J* = 7.6 HZ, 2H), 7.42-7.39 (m, 1H), 7.31-7.28 (m, 2H), 2.80 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 160.9, 153.3, 142.5, 133.3, 129.3, 126.7, 125.3, 124.5, 124.4, 120.3, 117.9, 111.3, 13.7

HRMS calcd for $C_{15}H_{12}O_3S$ (M+H) 273.0585; found 273.0589.



*3-methyl-2-phenyl-4-tosyl-2H-benzo[e][1,2]thiazine 1,1-dioxide (**16a**)*

White solid, 97 mg, 57%

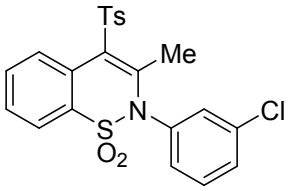
Melting point: 168-169 ˚C

IR (KBr) υ_{max}: 3064, 2924, 1570, 1541, 1492, 1346, 1282, 1139, 1083, 665, 565 cm^{-1}

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.42 (d, *J* = 8.4Hz, 1H), 7.74 (d, *J* = 8.0Hz, 3H), 7.59 (t, *J* = 4.0Hz, 1H), 7.47 (d, *J* = 7.6Hz, 1H), 7.44-7.39 (m, 3H), 7.24 (d, *J* = 8.0Hz, 2H), 7.14-7.12 (m, 2H), 2.41 (s, 3H), 2.35 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 149.7, 144.2, 139.0, 134.9, 132.3, 132.2, 129.8, 129.7, 129.6, 128.8, 128.3, 127.6, 126.9, 123.1, 122.0, 21.6, 20.7

HRMS calcd for $C_{22}H_{19}NO_4S_2$ (M+H) 426.0834; found 426.0833.



*2-(3-chlorophenyl)-3-methyl-4-tosyl-2H-benzo[e][1,2]thiazine 1,1-dioxide (**16b**)*

White solid, 109 mg, 59%

Melting point: 184-185 ˚C

IR (KBr) υ_{max}: 2960, 1571, 1546, 1469, 1357, 1284, 1143, 1083, 671, 565 cm^{-1}

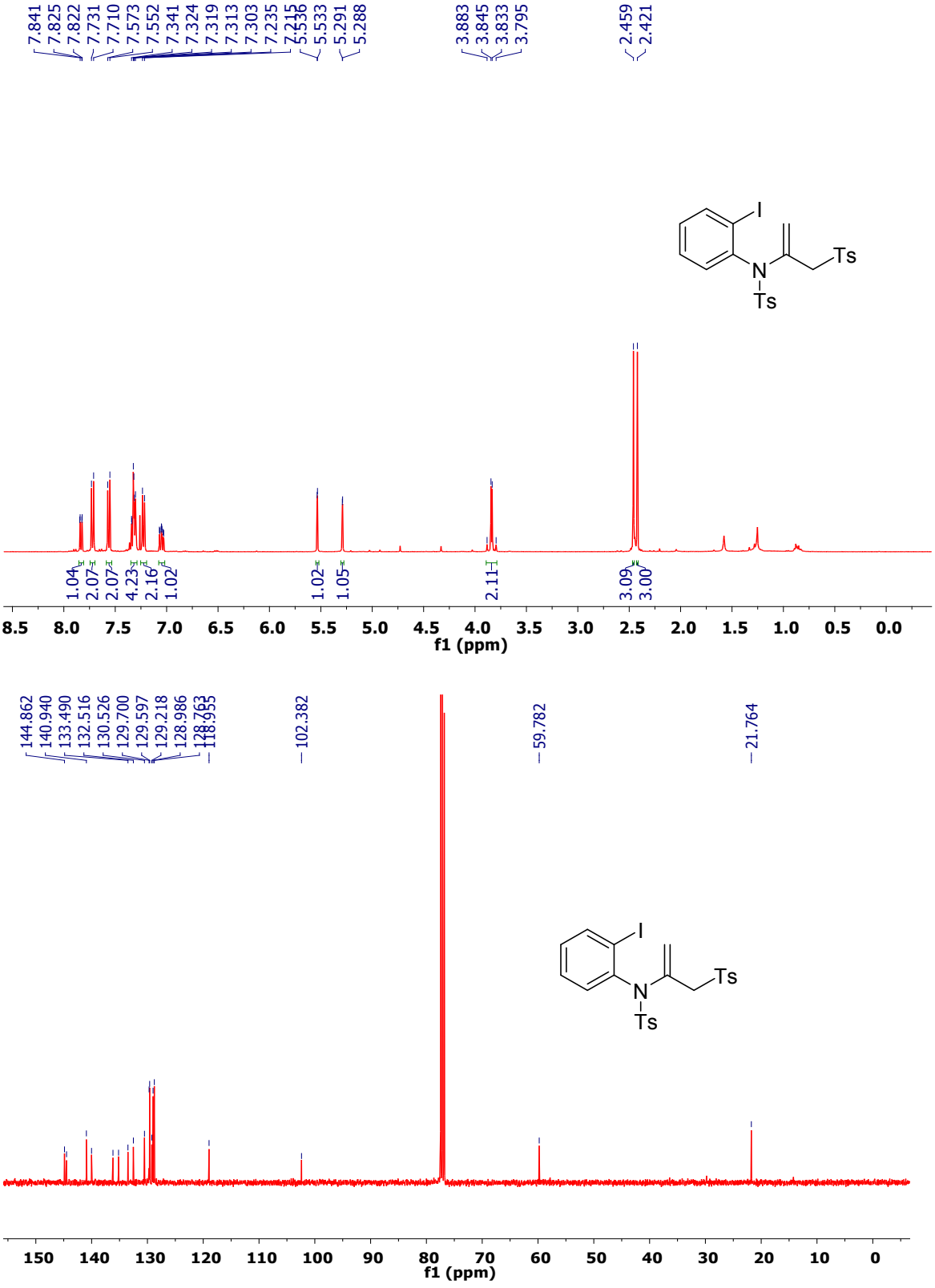
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 8.4 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 3H), 7.61-7.57 (m, 1H), 7.46 (td, *J* = 8.0, 0.8 Hz, 1H), 7.38 (dt, *J* = 8.0, 1.6 Hz, 1H), 7.32 (t, *J* = 8.0 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.11 (t, *J* = 2.0 Hz, 1H), 7.05-7.02 (m, 1H), 2.41 (s, 3H), 2.34 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 149.0, 144.3, 138.7, 135.9, 135.3, 132.4, 130.5, 129.8, 129.7, 129.4, 128.8, 128.6, 127.8, 127.0, 124.0, 122.1, 21.6, 20.7.

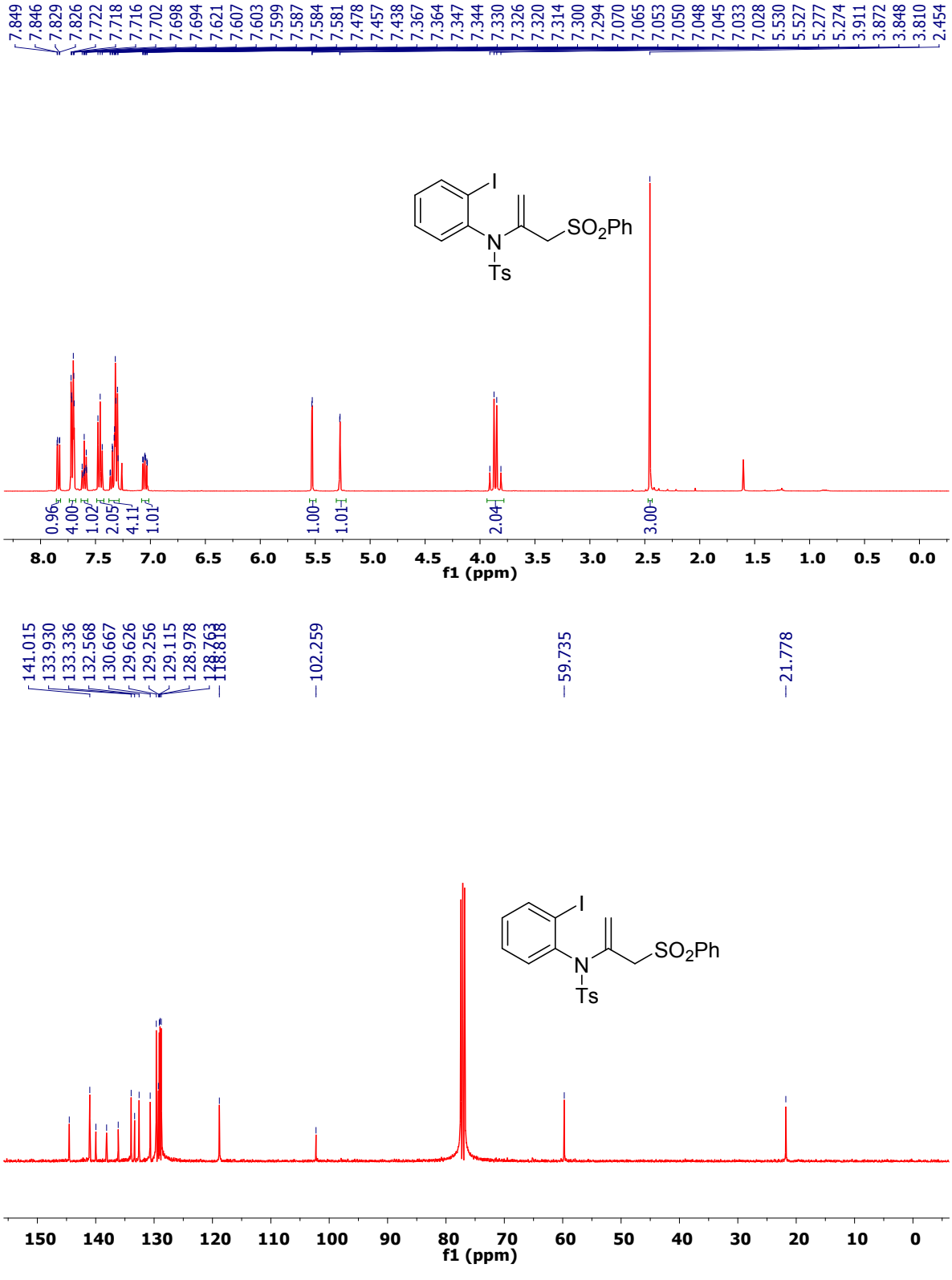
HRMS calcd for $C_{22}H_{18}ClNO_4S_2$ (M+H) 460.0444; found 460.0436.

NMR spectra of new compounds

7a, $CDCl_3$



7b, **$CDCl_3$**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7.826
7.722
7.718
7.716
7.702
7.698
7.694
7.621
7.607
7.603
7.599
7.587
7.584
7.581
7.478
7.457
7.438
7.367
7.364
7.347
7.344
7.330
7.326
7.320
7.314
7.300
7.294
7.070
7.065
7.053
7.050
7.048
7.045
7.033
7.028
5.530
5.527
5.277
5.274
3.911
3.872
3.848
3.810
2.454
I
N
Ts
SO2Ph
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4.00
1.02
2.05
4.11
1.01
1.00
1.01
2.04
3.00
f1 (ppm)
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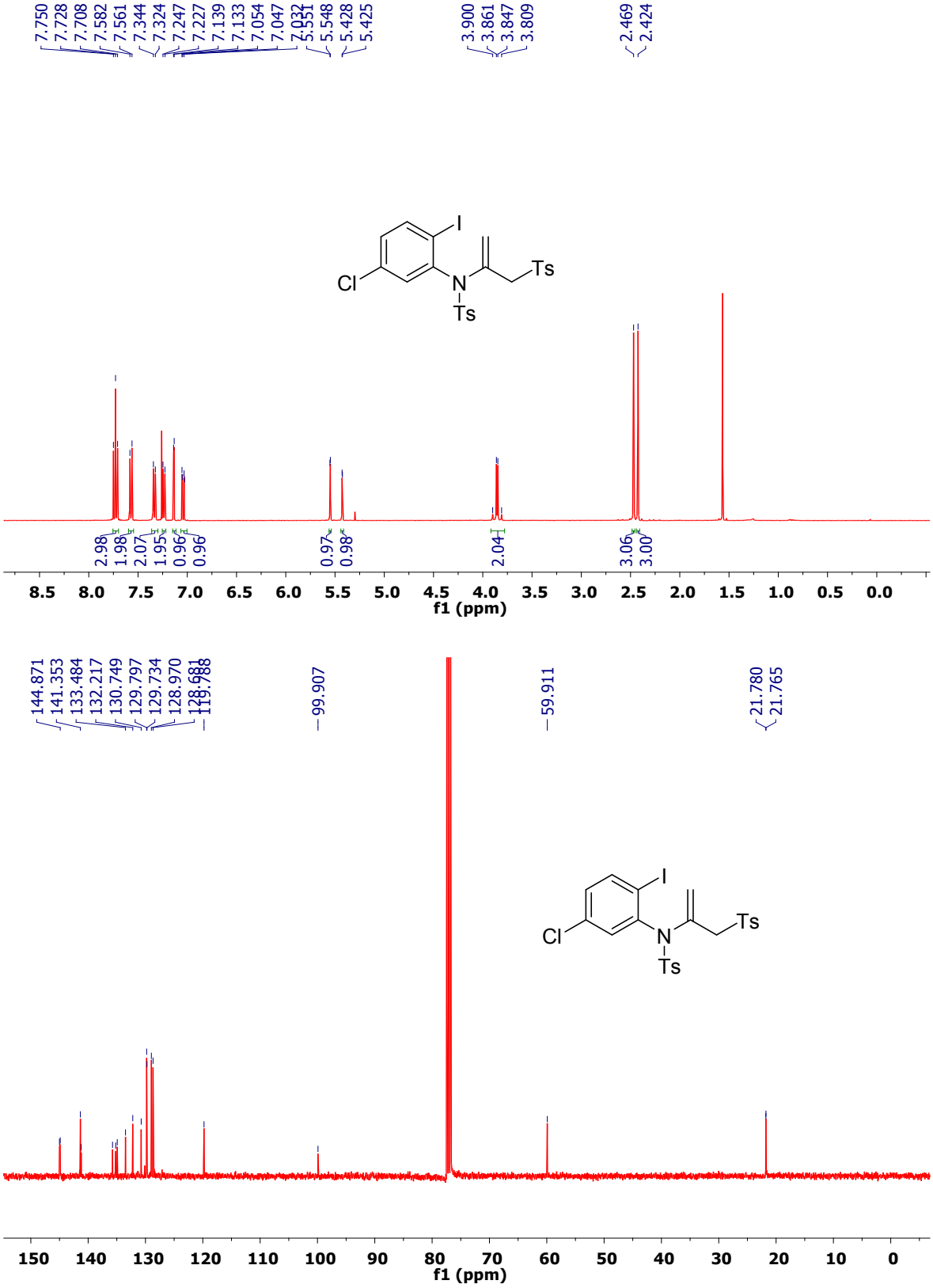
133.930
133.336
132.568
130.667
129.626
129.256
129.115
128.978
128.763
128.618
102.259
59.735
21.778
I
N
Ts
SO2Ph
f1 (ppm)

7c, **$CDCl_3$**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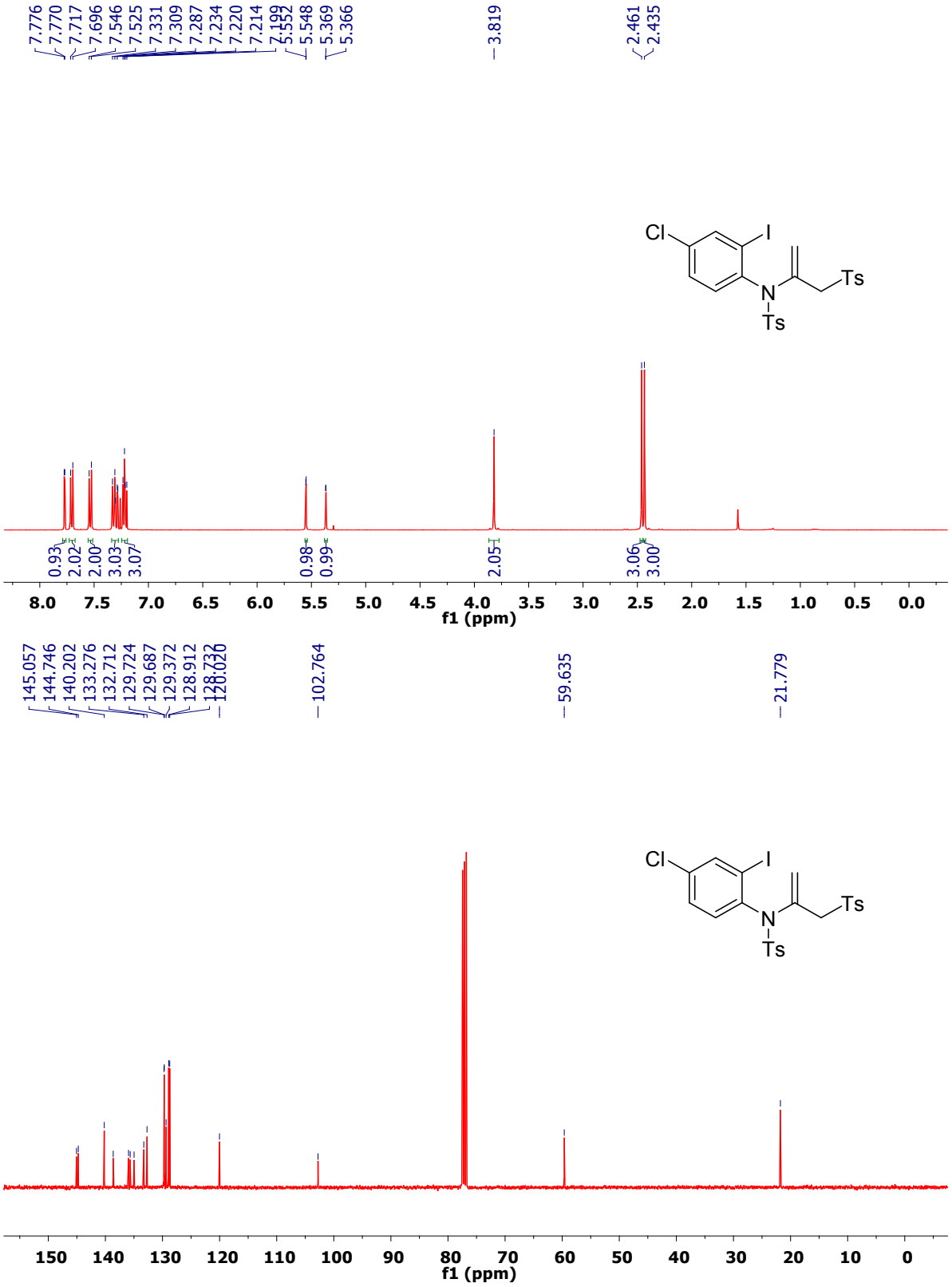
7.728
7.708
7.582
7.561
7.344
7.324
7.247
7.227
7.139
7.133
7.054
7.047
5.551
5.548
5.428
5.425
3.900
3.861
3.847
3.809
2.469
2.424
I
Cl
N
Ts
Ts
2.98
1.98
2.07
1.95
0.96
0.96
0.97
0.98
2.04
3.06
3.00
f1 (ppm)
144.871
141.353
133.484
132.217
130.749
129.797
129.734
128.970
99.907
59.911
21.780
21.765
f1 (ppm)

7d, **$CDCl_3$**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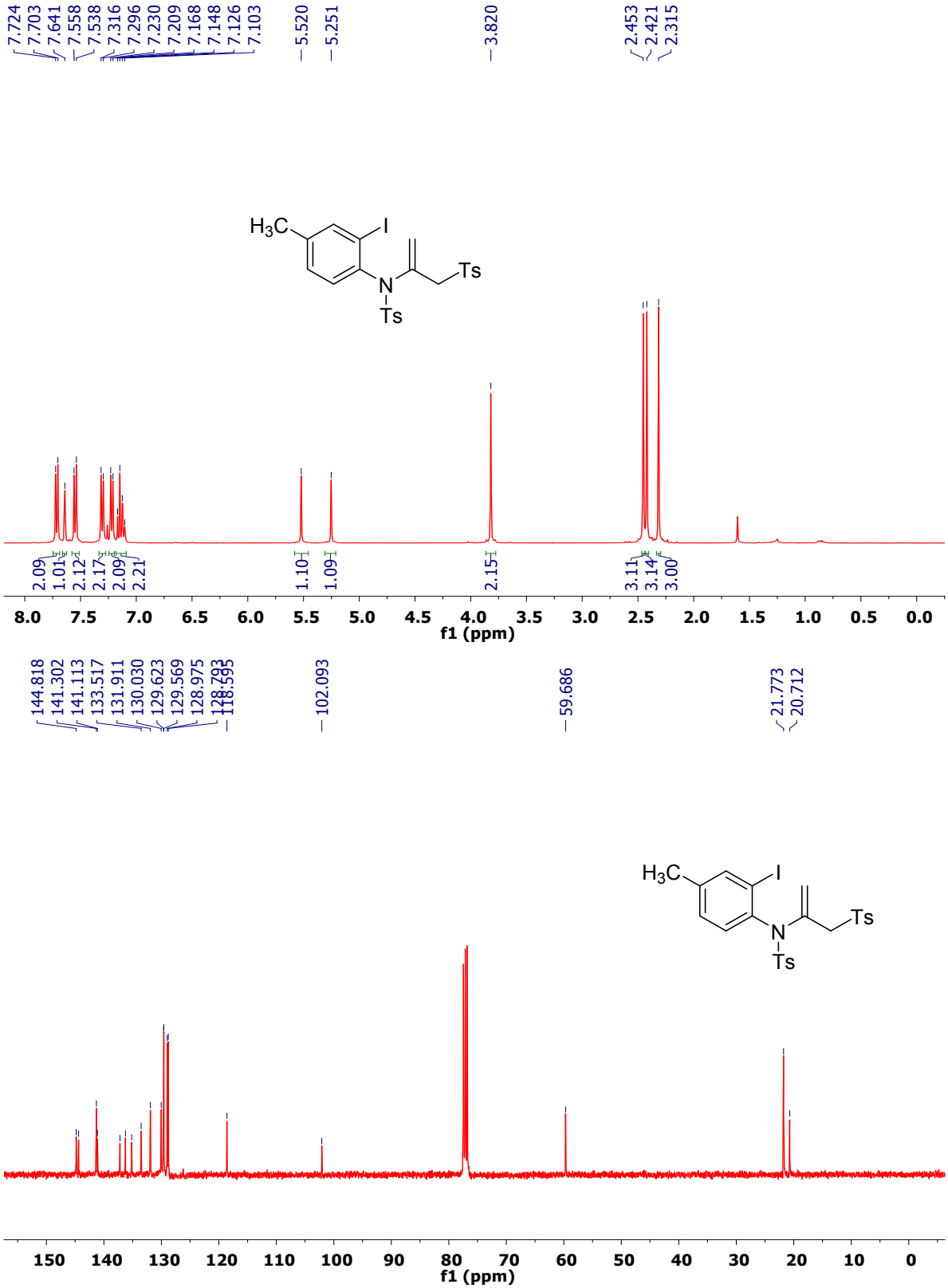
7.309
7.287
7.234
7.220
7.214
7.199
5.552
5.548
5.369
5.366
3.819
2.461
2.435
Cl
I
Ts
N
Ts
0.93
2.02
2.00
3.03
3.07
0.98
0.99
2.05
3.06
3.00
f1 (ppm)
145.057
144.746
140.202
133.276
132.712
129.724
129.687
129.372
128.912
128.732
120.020
102.764
59.635
21.779
Cl
I
Ts
N
Ts
f1 (ppm)

7e, **$CDCl_3$**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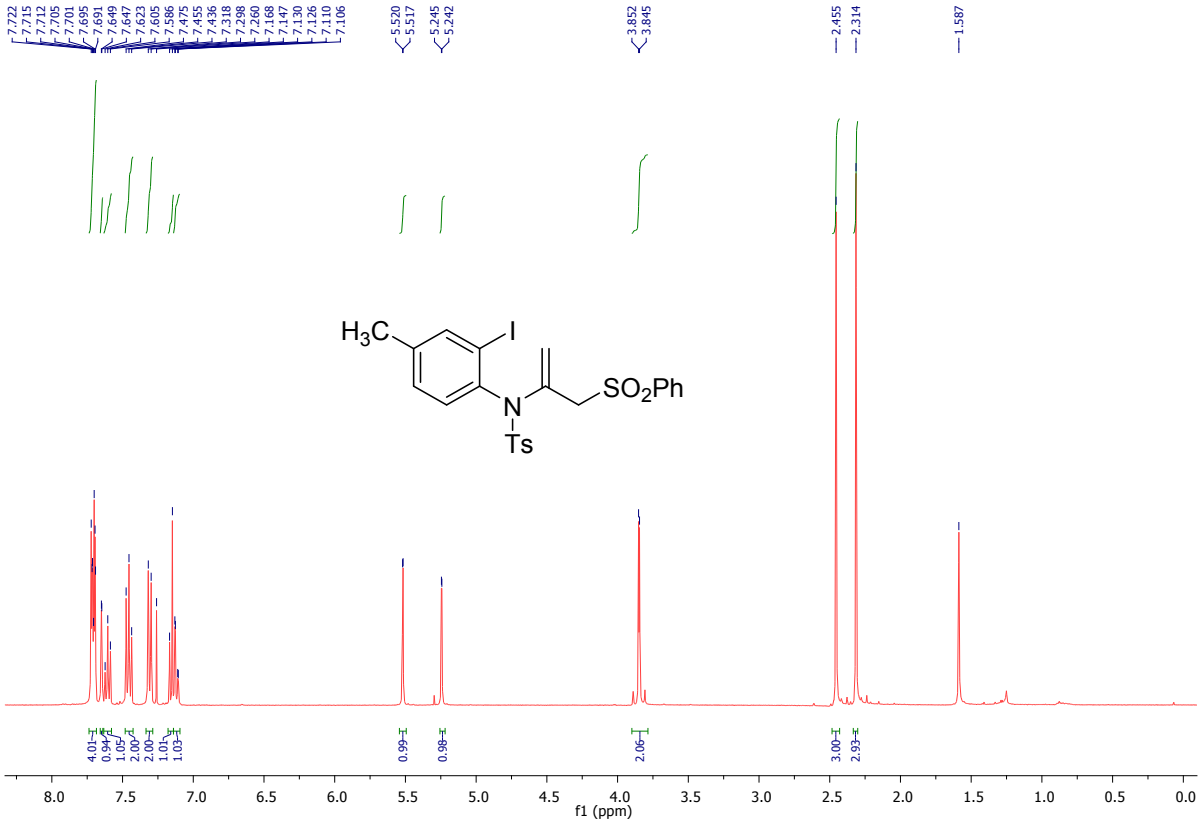
7.558
7.538
7.316
7.296
7.230
7.209
7.168
7.148
7.126
7.103
5.520
5.251
3.820
2.453
2.421
2.315
H3C
I
Ts
N
Ts
2.09
1.01
2.12
2.17
2.09
2.21
1.10
1.09
2.15
3.11
3.14
3.00
f1 (ppm)
144.818
141.302
141.113
133.517
131.911
130.030
129.623
129.569
128.975
128.793
128.595
102.093
59.686
21.773
20.712
f1 (ppm)

7f, $CDCl_3$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7.712
7.705
7.701
7.695
7.691
7.649
7.647
7.623
7.605
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7.475
7.455
7.436
7.318
7.298
7.260
7.168
7.147
7.130
7.126
7.110
7.106
5.520
5.517
5.245
5.242
3.852
3.845
2.455
2.314
1.587
H3C
I
SO2Ph
N
Ts
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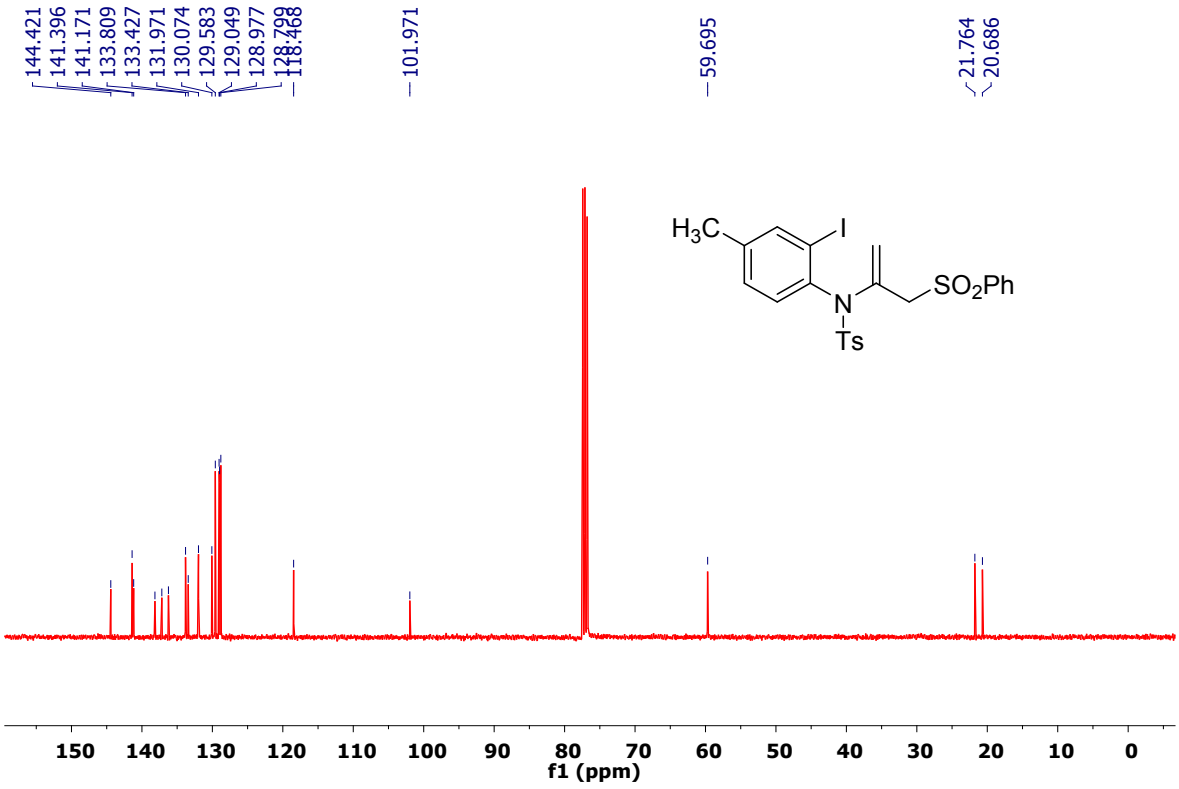
0.94
1.05
2.00
1.01
1.03
0.99
0.98
2.06
3.00
2.93
f1 (ppm)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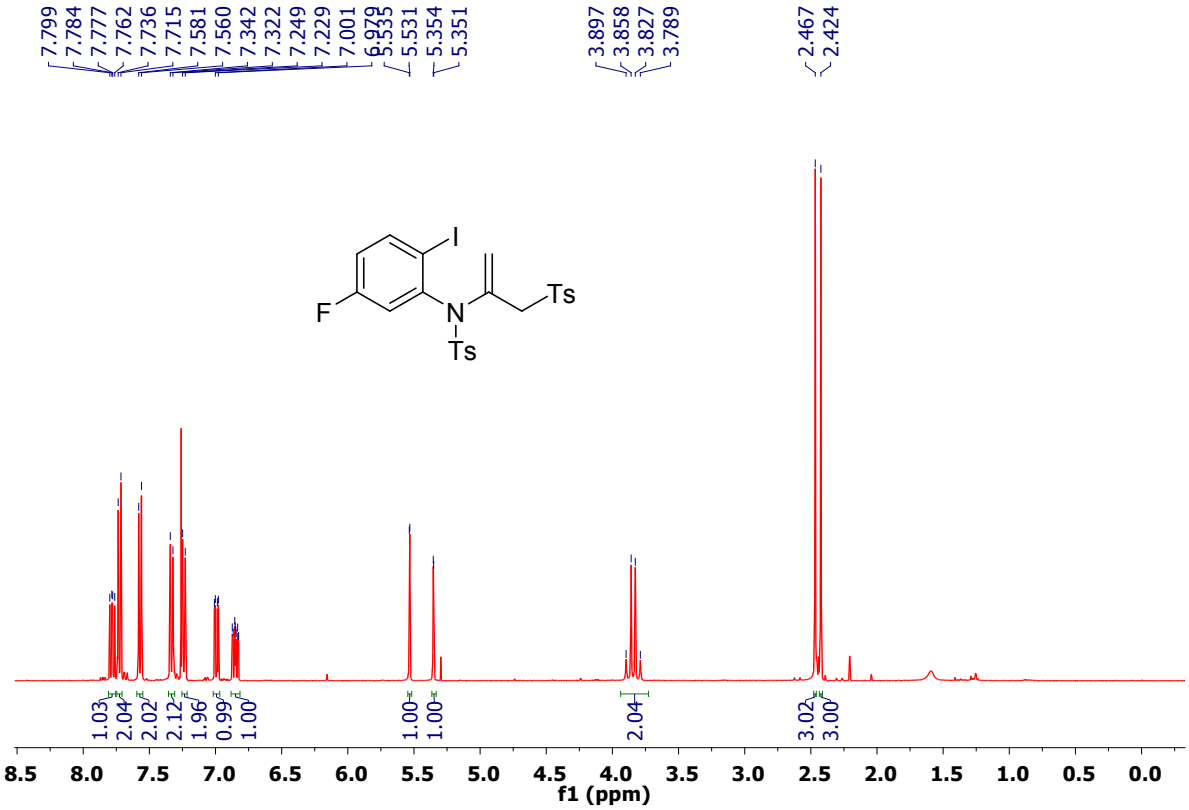
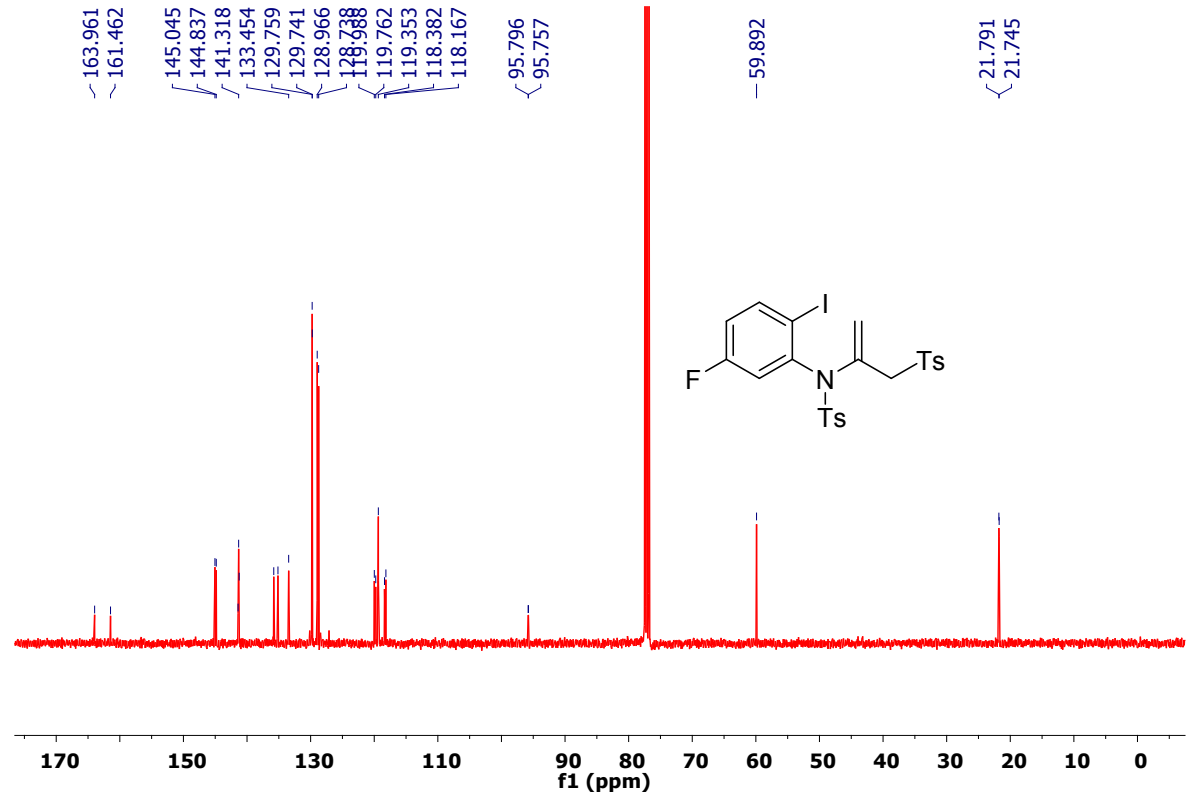
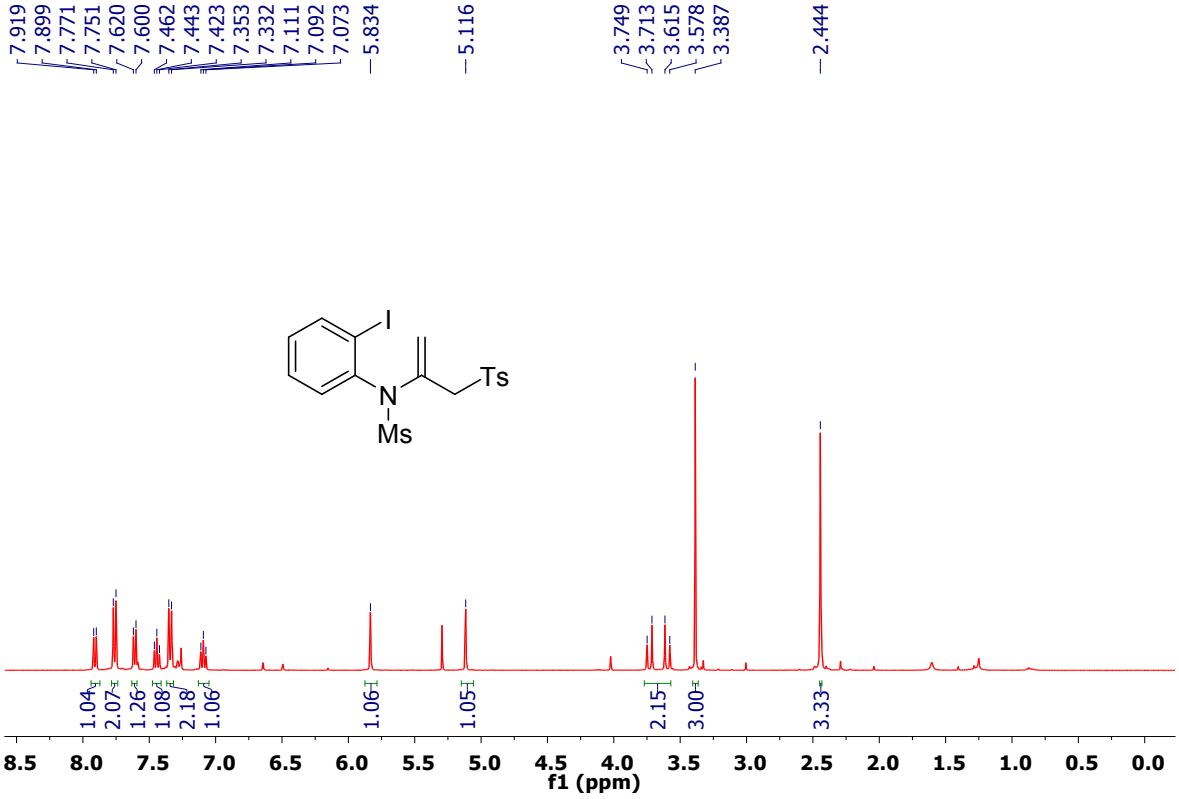
133.809
133.427
131.971
130.074
129.583
129.049
128.977
128.799
128.468
101.971
59.695
21.764
20.686
H3C
I
SO2Ph
N
Ts
f1 (ppm)

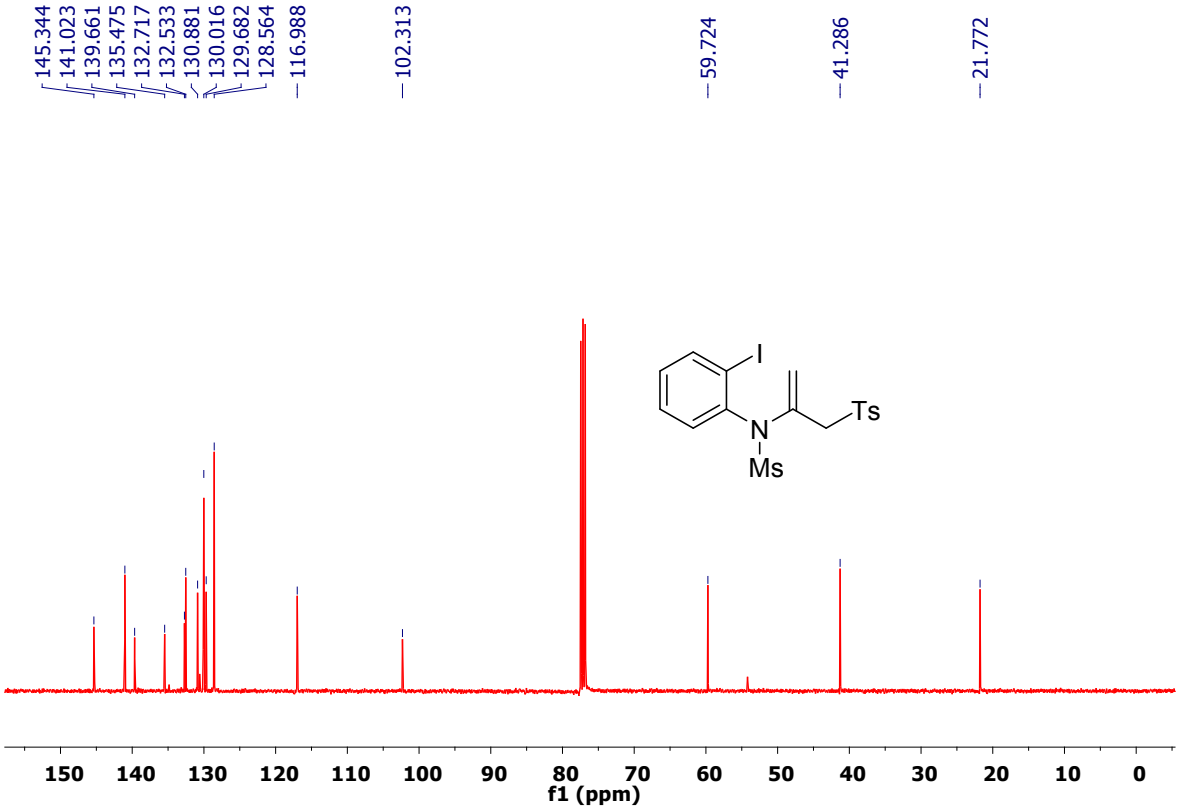
7g, **$CDCl_3$**


7.799
7.784
7.777
7.762
7.736
7.715
7.581
7.560
7.342
7.322
7.249
7.229
7.001
6.979
6.535
5.531
5.354
5.351
3.897
3.858
3.827
3.789
2.467
2.424
I
F
N
Ts
Ts
1.03
2.04
2.02
2.12
1.96
0.99
1.00
1.00
1.00
2.04
3.02
3.00
f1 (ppm)


163.961
161.462
145.045
144.837
141.318
133.454
129.759
129.741
128.966
119.762
119.353
118.382
118.167
95.796
95.757
59.892
21.791
21.745
I
F
N
Ts
Ts
f1 (ppm)

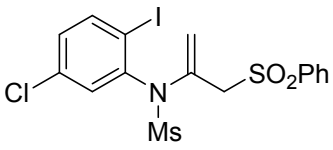
7h, **$CDCl_3$**

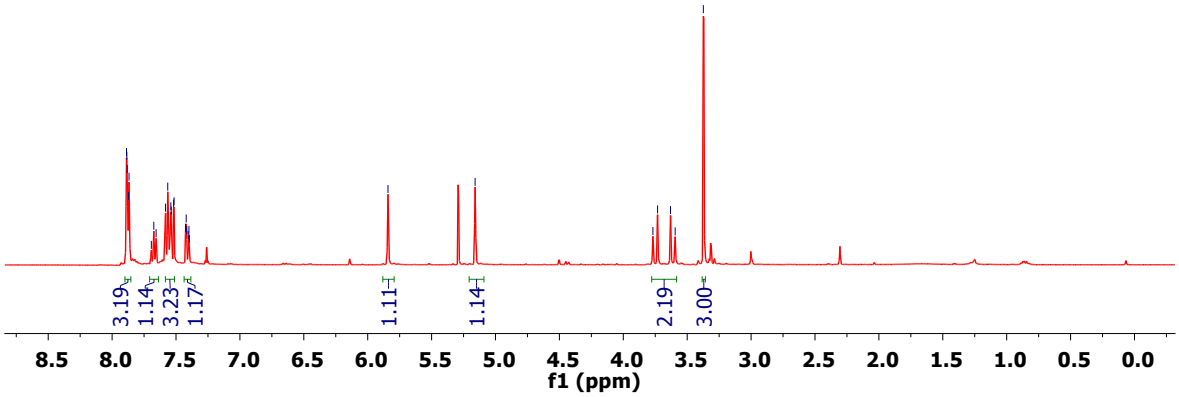

7.919
7.899
7.771
7.751
7.620
7.600
7.462
7.443
7.423
7.353
7.332
7.111
7.092
7.073
5.834
5.116
3.749
3.713
3.615
3.578
3.387
2.444
I
N
Ms
Ts
1.04
2.07
1.26
1.08
2.18
1.06
1.06
1.05
2.15
3.00
3.33
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


145.344
141.023
139.661
135.475
132.717
132.533
130.881
130.016
129.682
128.564
116.988
102.313
59.724
41.286
21.772
I
N
Ms
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

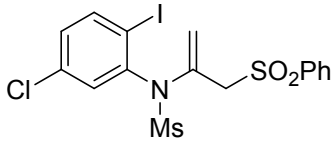
7i, **$CDCl_3$**

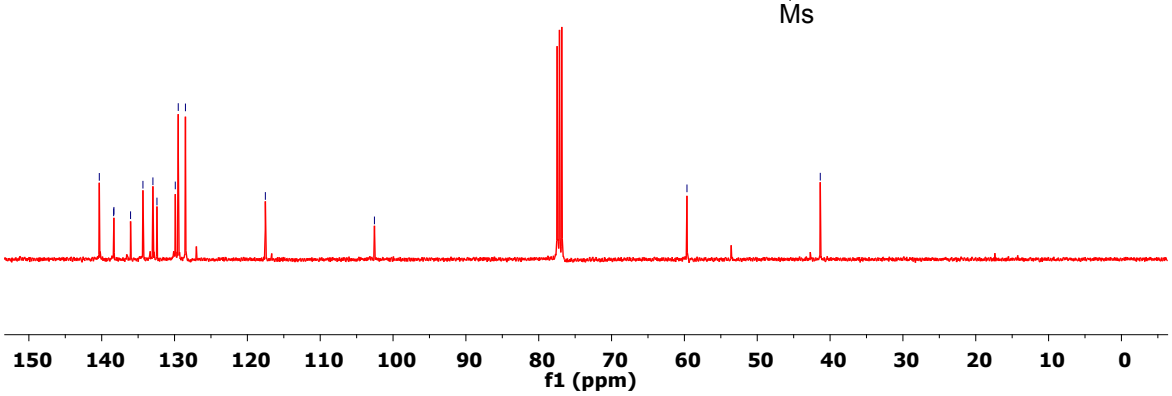

7.887
7.885
7.882
7.871
7.868
7.674
7.582
7.565
7.540
7.538
7.519
7.515
7.426
7.420
5.841
5.160
3.768
3.732
3.631
3.594
3.374


I
Cl
N
Ms
SO2Ph

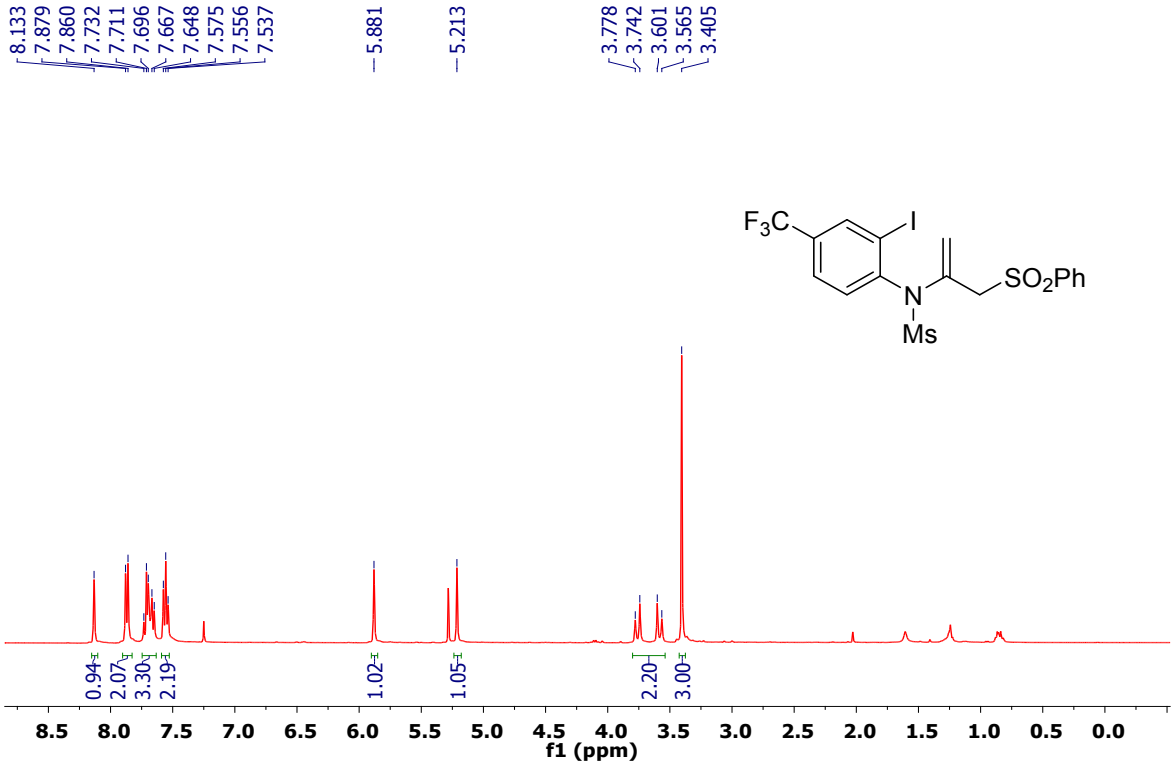

3.19
1.14
3.23
1.17
1.11
1.14
2.19
3.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

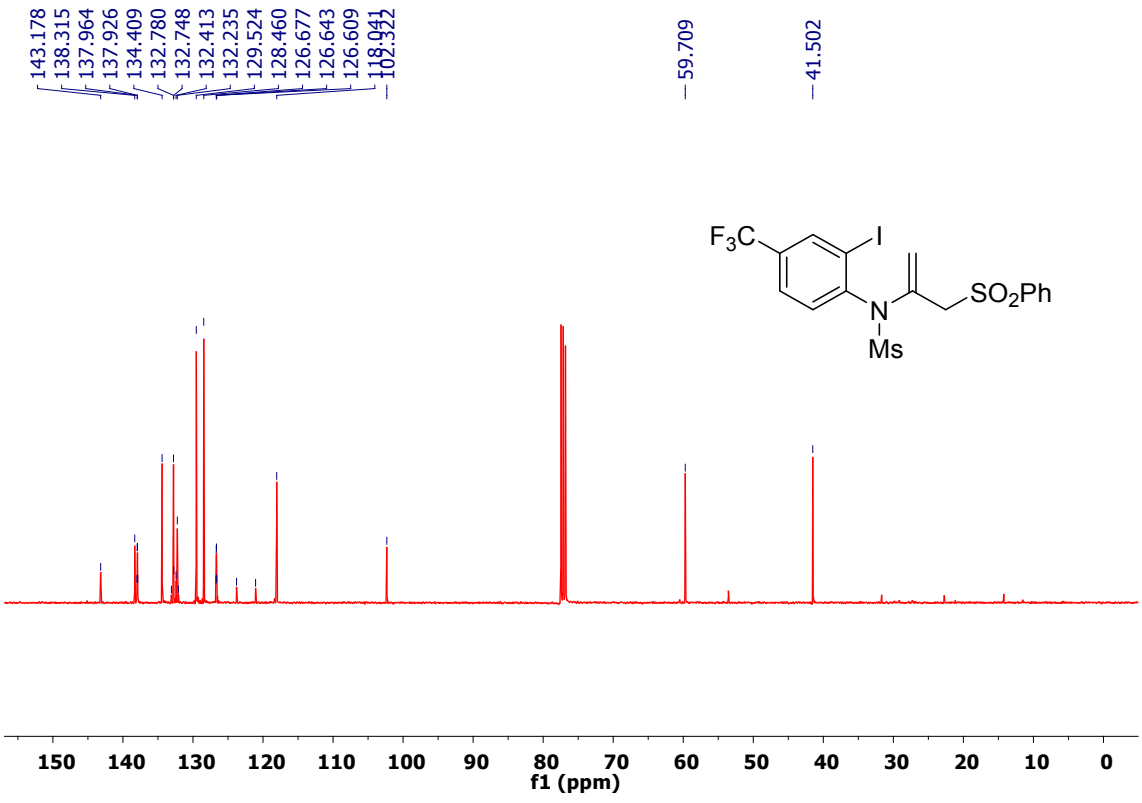

140.329
138.363
138.324
136.039
134.339
132.970
132.415
129.898
129.490
128.502
117.531
102.555
59.648
41.346


I
Cl
N
Ms
SO2Ph

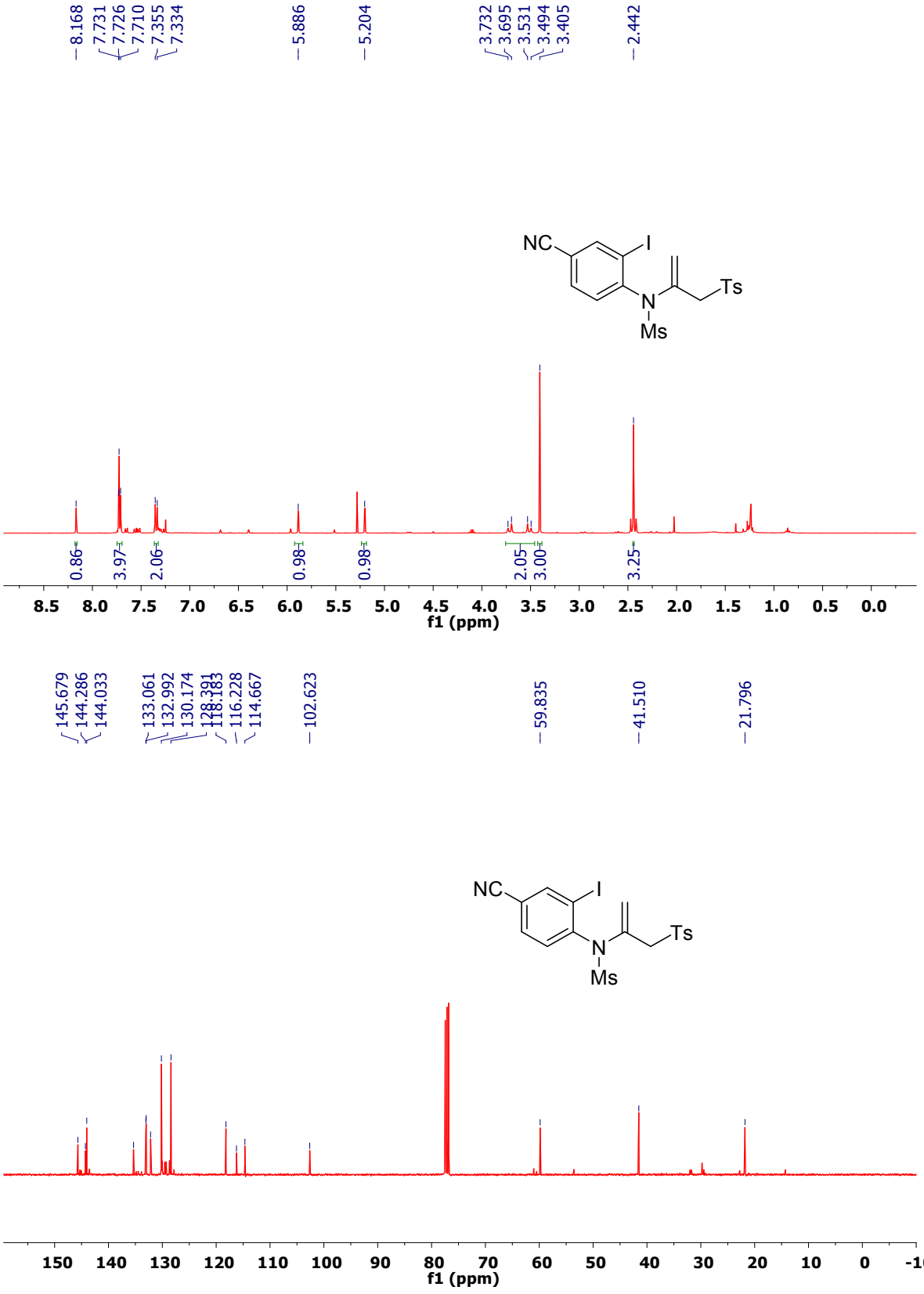

150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

7j, $CDCl_3$

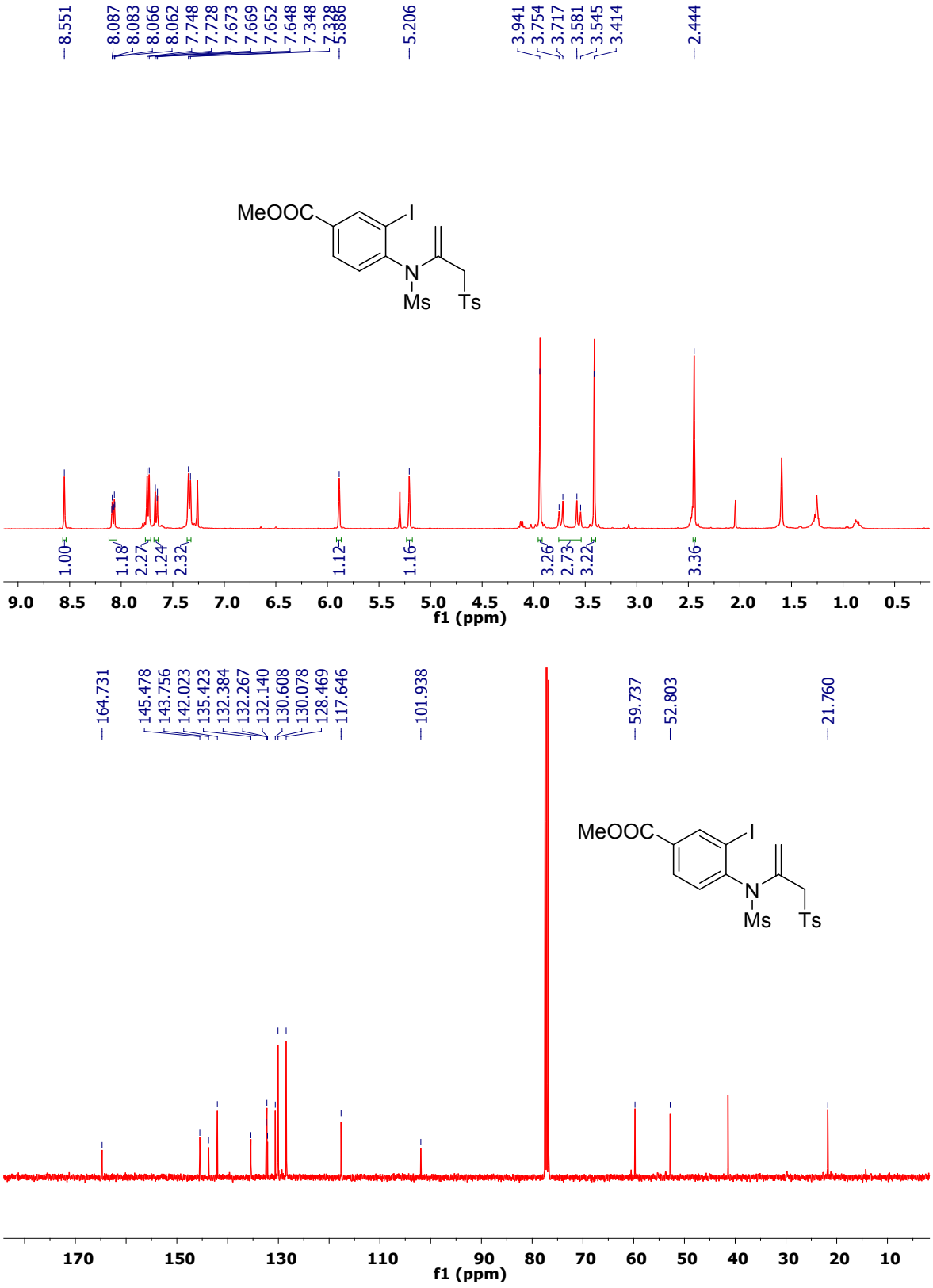

8.133
7.879
7.860
7.732
7.711
7.696
7.667
7.648
7.575
7.556
7.537
5.881
5.213
3.778
3.742
3.601
3.565
3.405
F3C
I
SO2Ph
N
Ms
0.94
2.07
3.30
2.19
1.02
1.05
2.20
3.00
f1 (ppm)


143.178
138.315
137.964
137.926
134.409
132.780
132.748
132.413
132.235
129.524
128.460
126.677
126.643
126.609
59.709
41.502
F3C
I
SO2Ph
N
Ms
f1 (ppm)

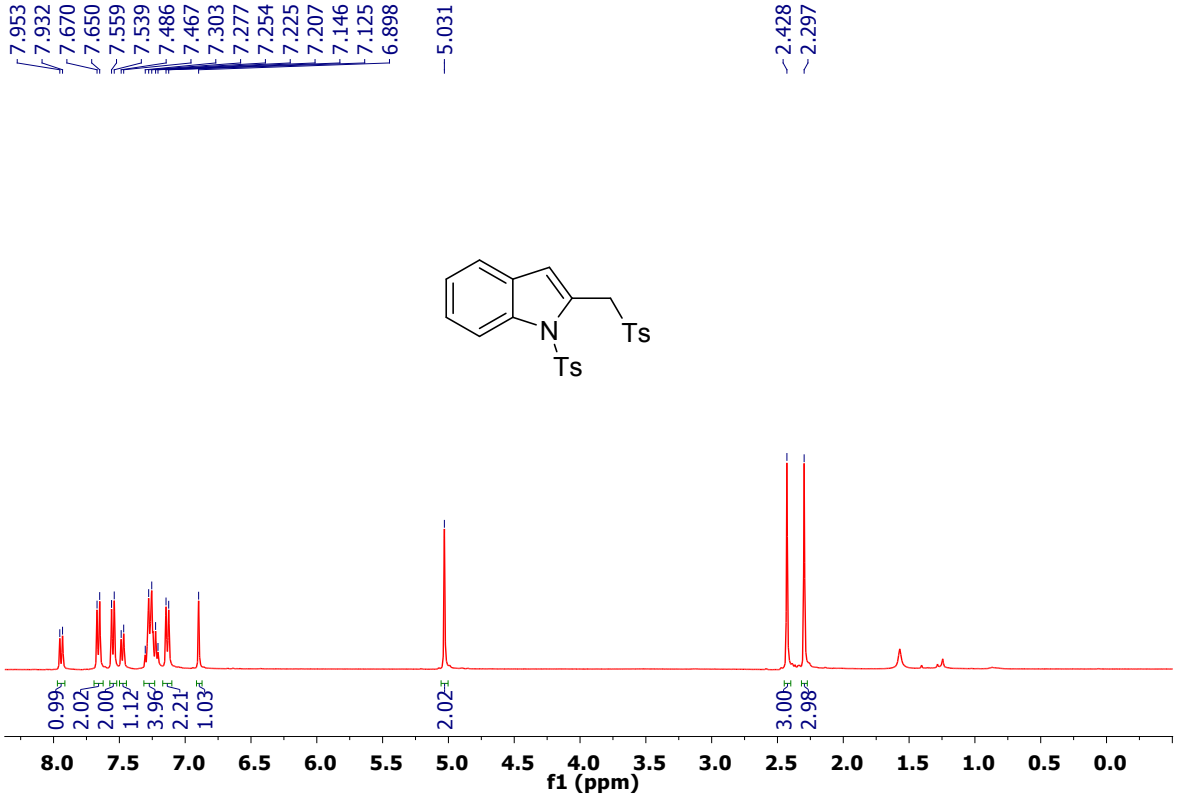
7k, **$CDCl_3$**

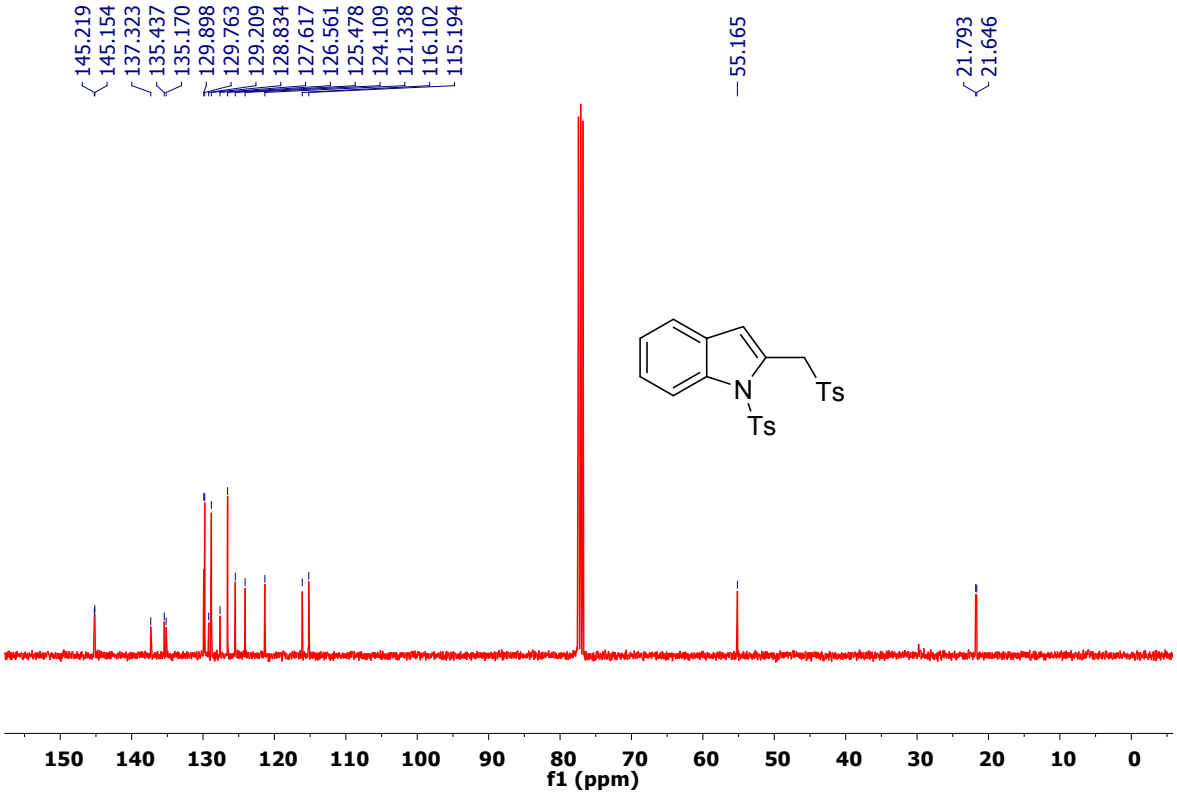

8.168
7.731
7.726
7.710
7.355
7.334
5.886
5.204
3.732
3.695
3.531
3.494
3.405
2.442
NC
I
Ts
N
Ms
0.86
3.97
2.06
0.98
0.98
2.05
3.00
3.25
f1 (ppm)
145.679
144.286
144.033
133.061
132.992
130.174
128.391
128.183
116.228
114.667
102.623
59.835
41.510
21.796
f1 (ppm)

7l, $CDCl_3$

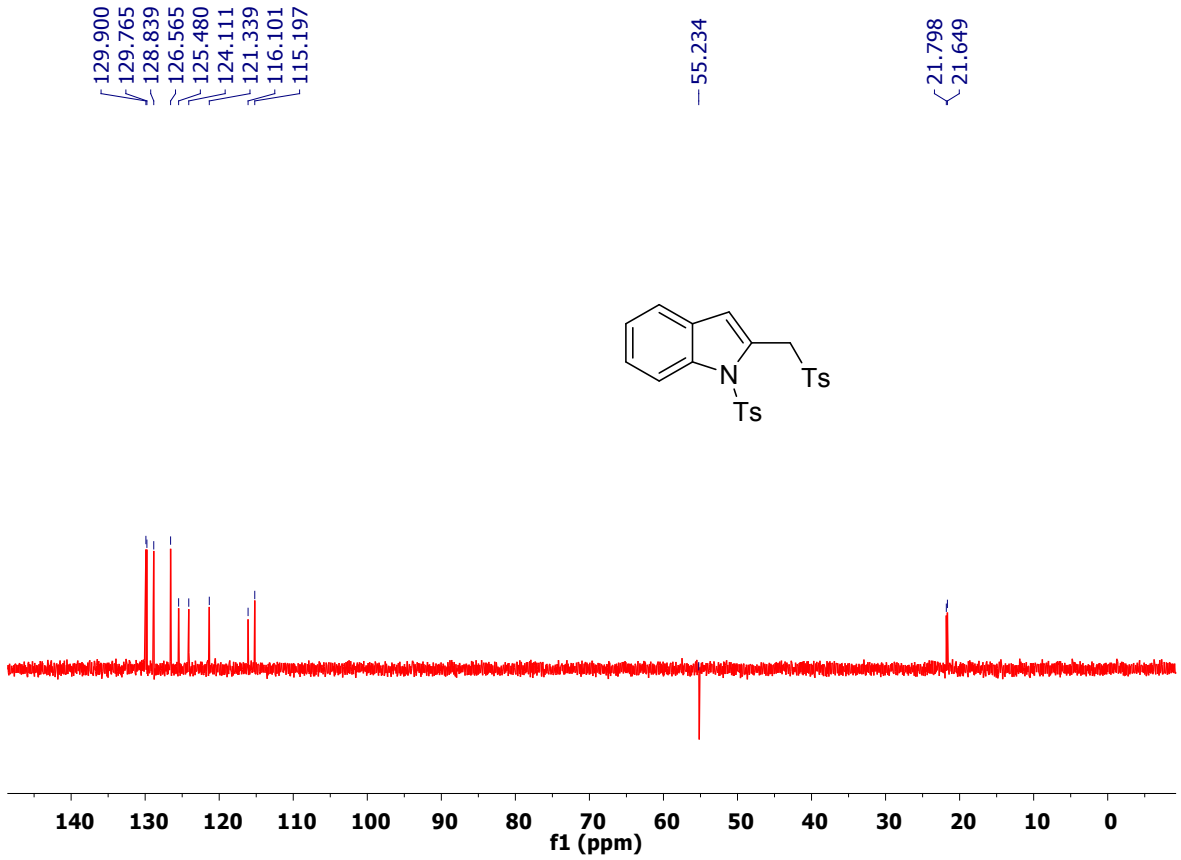

8.551
8.087
8.083
8.066
8.062
7.748
7.728
7.673
7.669
7.652
7.648
7.348
5.206
3.941
3.754
3.717
3.581
3.545
3.414
2.444
MeOOC
I
N
Ms
Ts
1.00
1.18
2.27
1.24
2.32
1.12
1.16
3.26
2.73
3.22
3.36
f1 (ppm)
164.731
145.478
143.756
142.023
135.423
132.384
132.267
132.140
130.608
130.078
128.469
117.646
101.938
59.737
52.803
21.760
f1 (ppm)

8a, **$CDCl_3$**

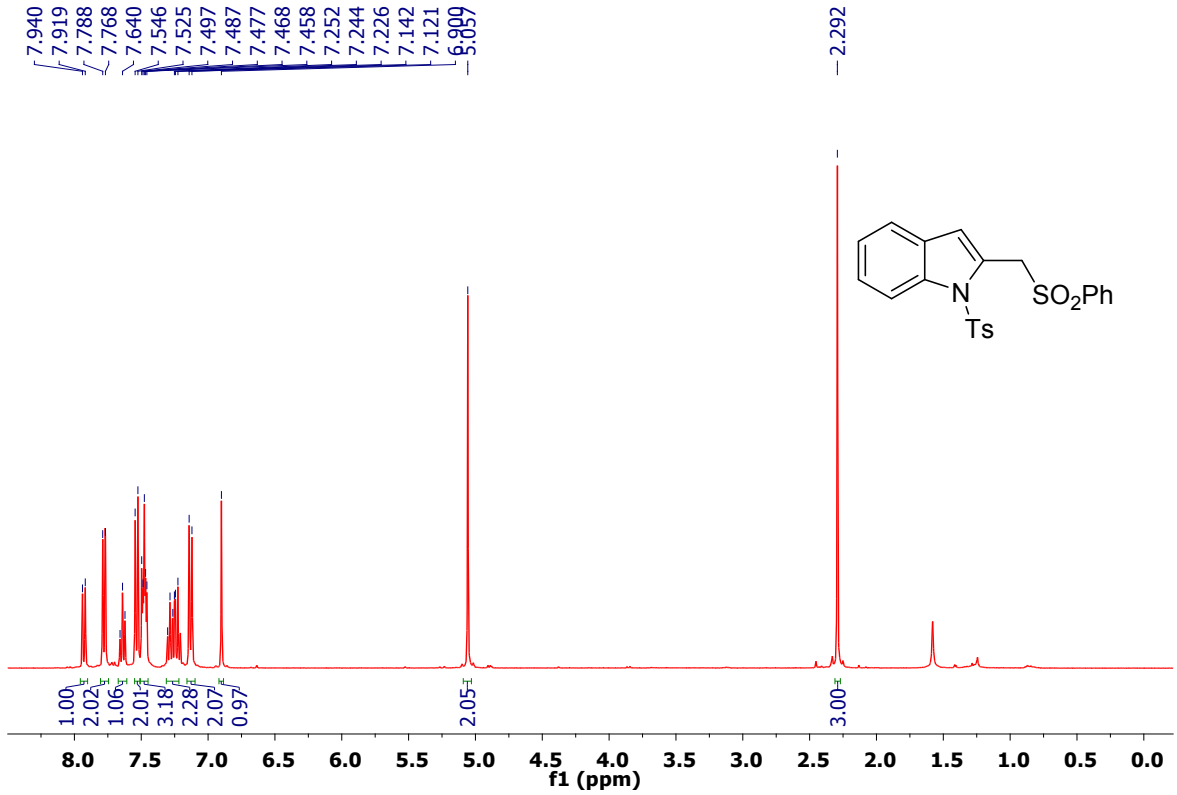

7.953
7.932
7.670
7.650
7.559
7.539
7.486
7.467
7.303
7.277
7.254
7.225
7.207
7.146
7.125
6.898
5.031
2.428
2.297
N
Ts
Ts
0.99
2.02
2.00
1.12
3.96
2.21
1.03
2.02
3.00
2.98
f1 (ppm)

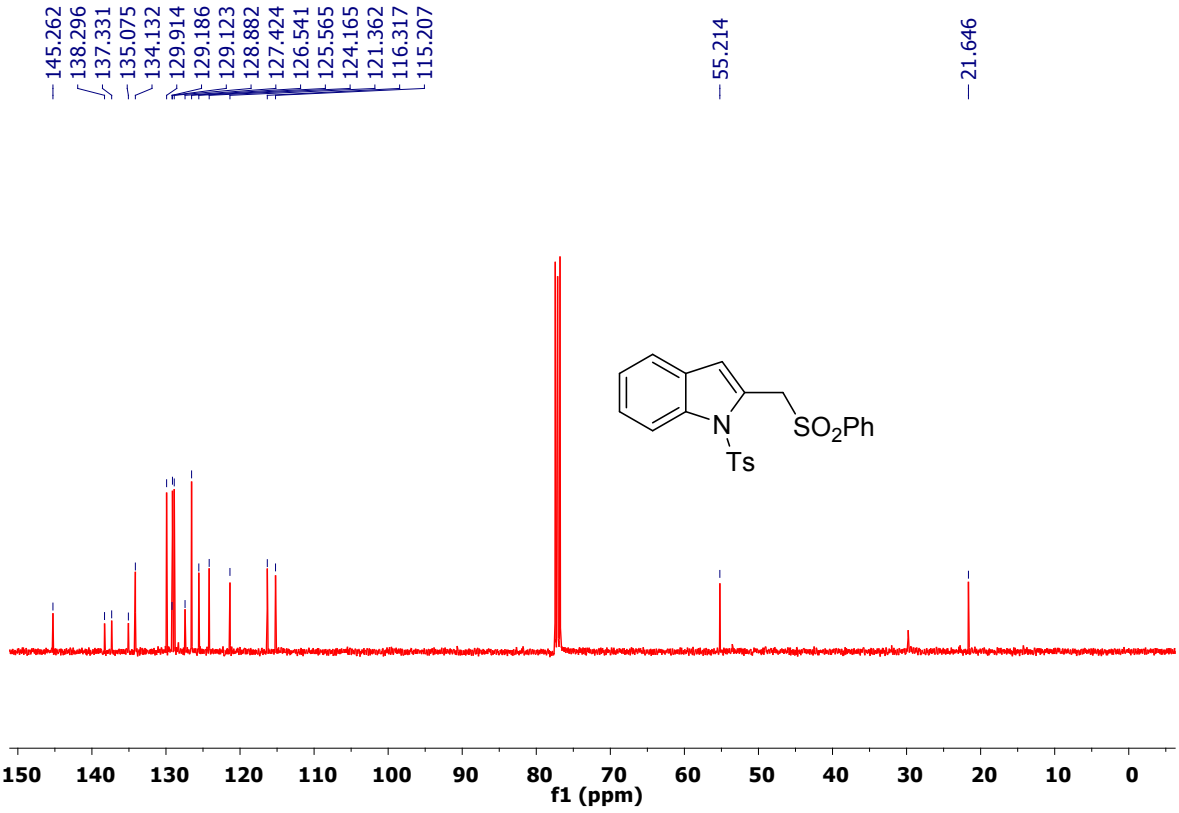

145.219
145.154
137.323
135.437
135.170
129.898
129.763
129.209
128.834
127.617
126.561
125.478
124.109
121.338
116.102
115.194
55.165
21.793
21.646
N
Ts
Ts
f1 (ppm)

8a, **$CDCl_3$**, **DEPT-135**

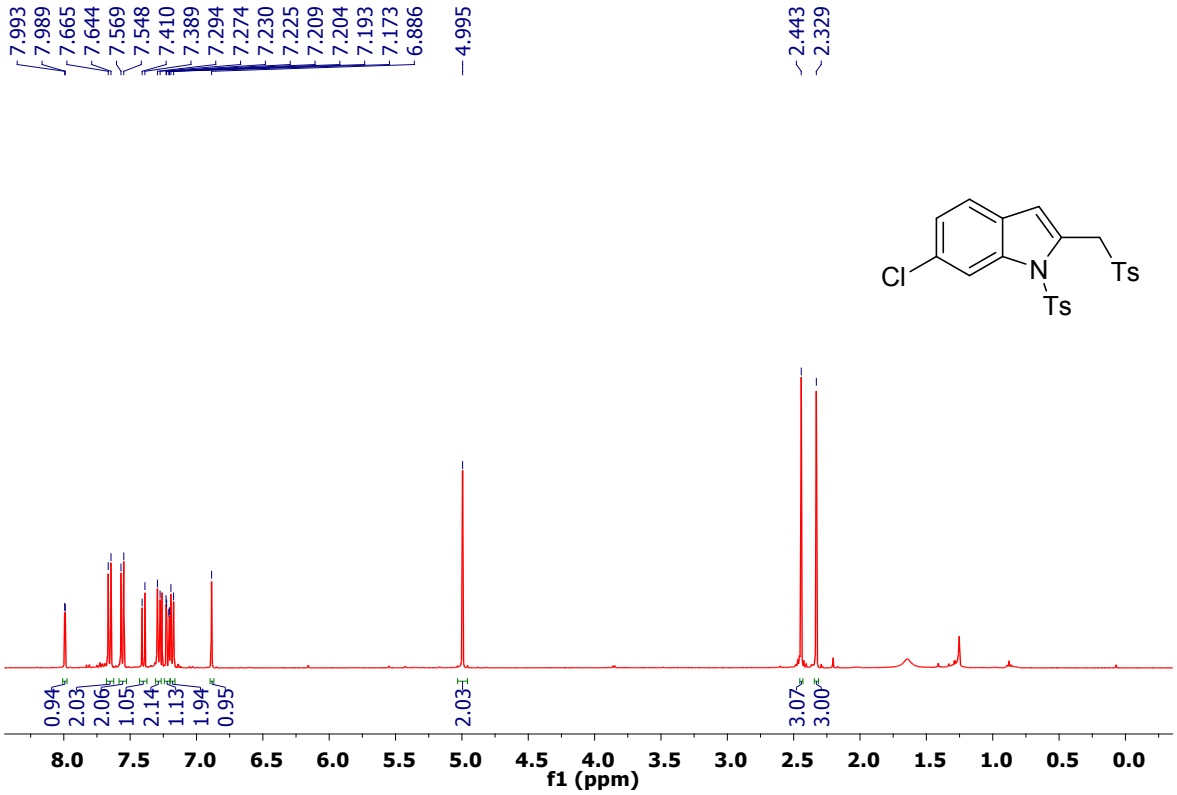


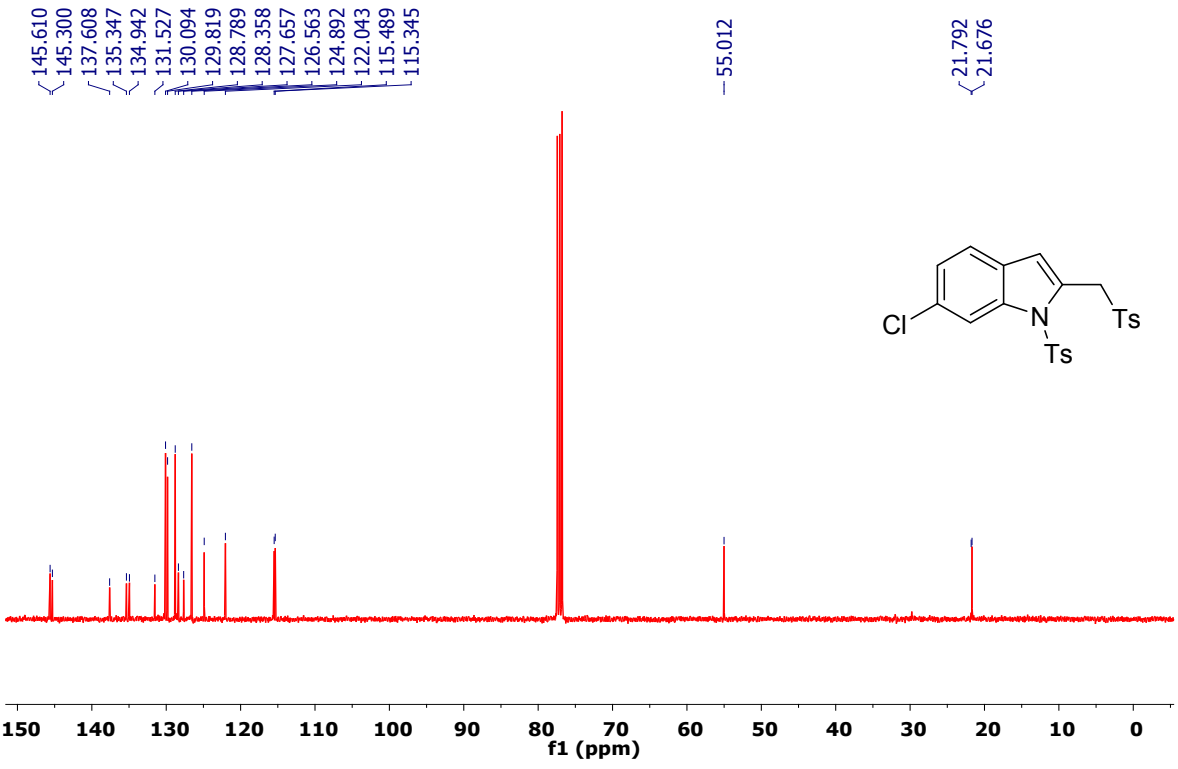
8b, $CDCl_3$


7.940
7.919
7.788
7.768
7.640
7.546
7.525
7.497
7.487
7.477
7.468
7.458
7.252
7.244
7.226
7.142
7.121
6.909
6.857
2.292
N
Ts
SO2Ph
1.00
2.02
1.06
2.01
3.18
2.28
2.07
0.97
2.05
3.00
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)

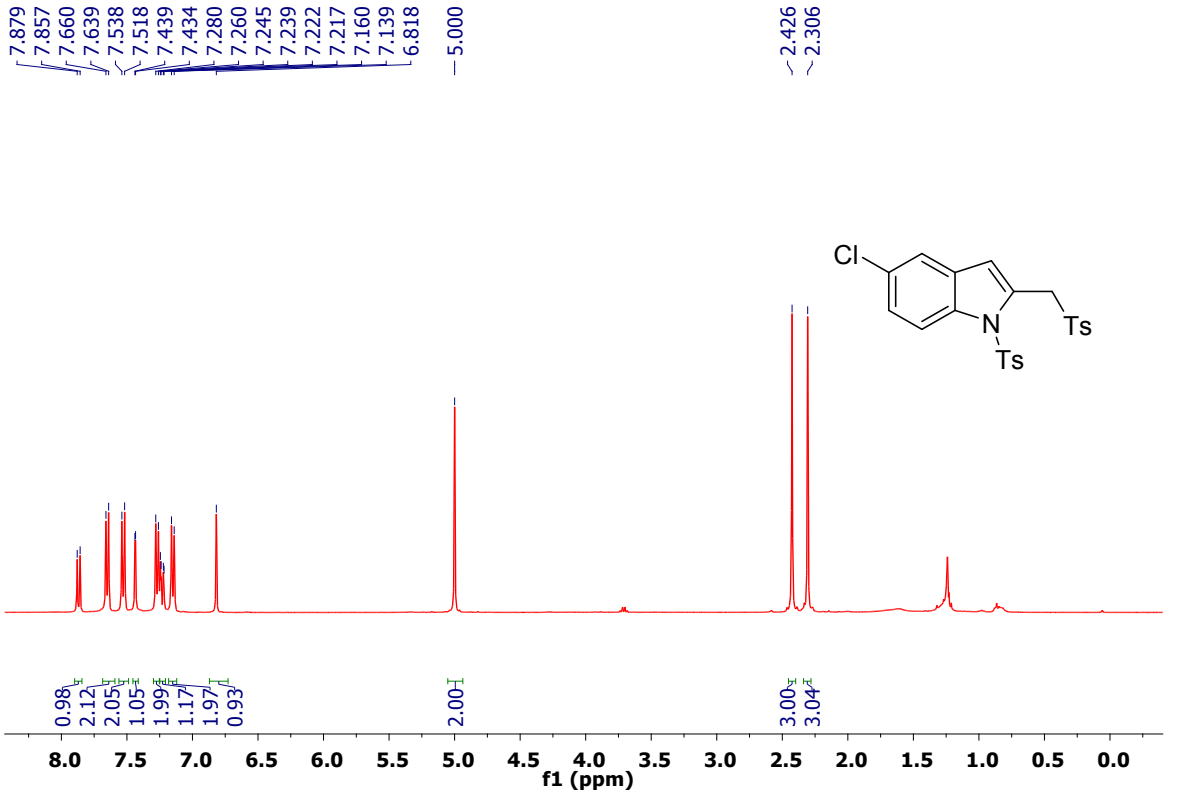

145.262
138.296
137.331
135.075
134.132
129.914
129.186
129.123
128.882
127.424
126.541
125.565
124.165
121.362
116.317
115.207
55.214
21.646
N
Ts
SO2Ph
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

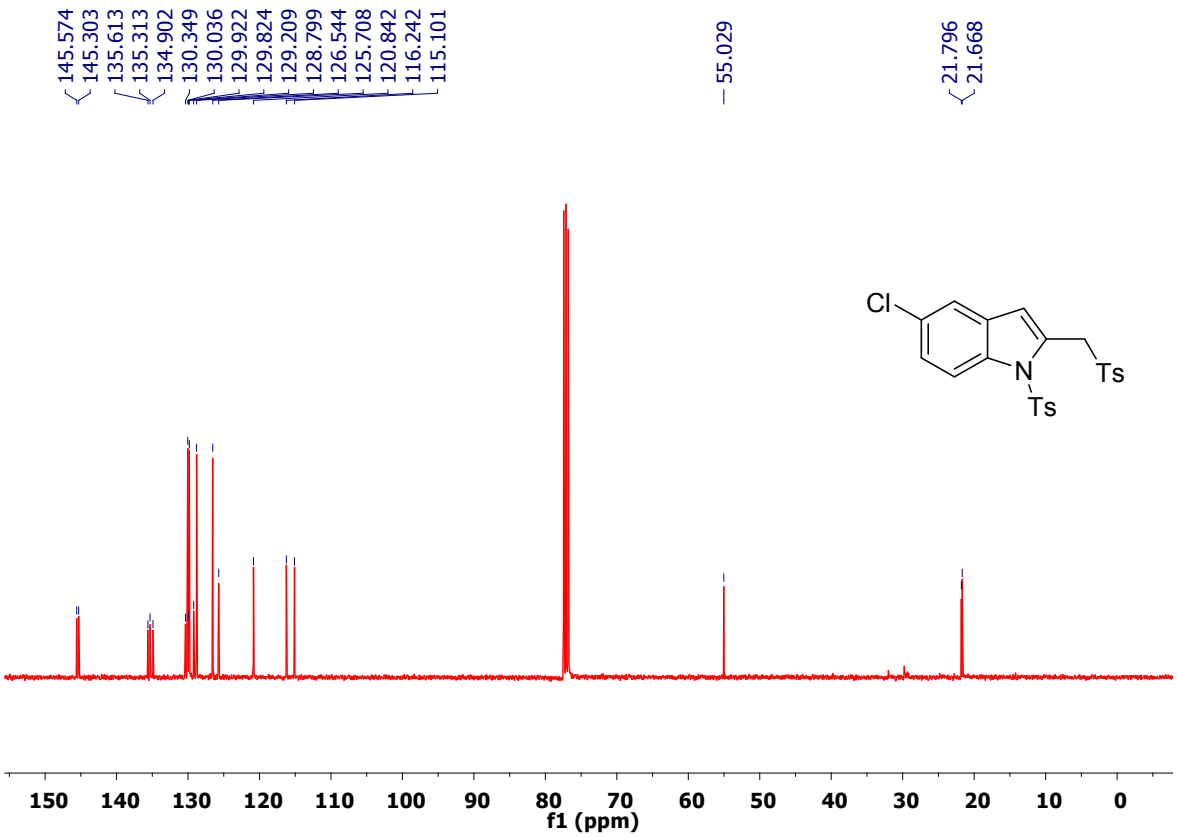
8c, $CDCl_3$


7.993
7.989
7.665
7.644
7.569
7.548
7.410
7.389
7.294
7.274
7.230
7.225
7.209
7.204
7.193
7.173
6.886
4.995
2.443
2.329
Cl
N
Ts
Ts
0.94
2.03
2.06
1.05
2.14
1.13
1.94
0.95
2.03
3.07
3.00
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)

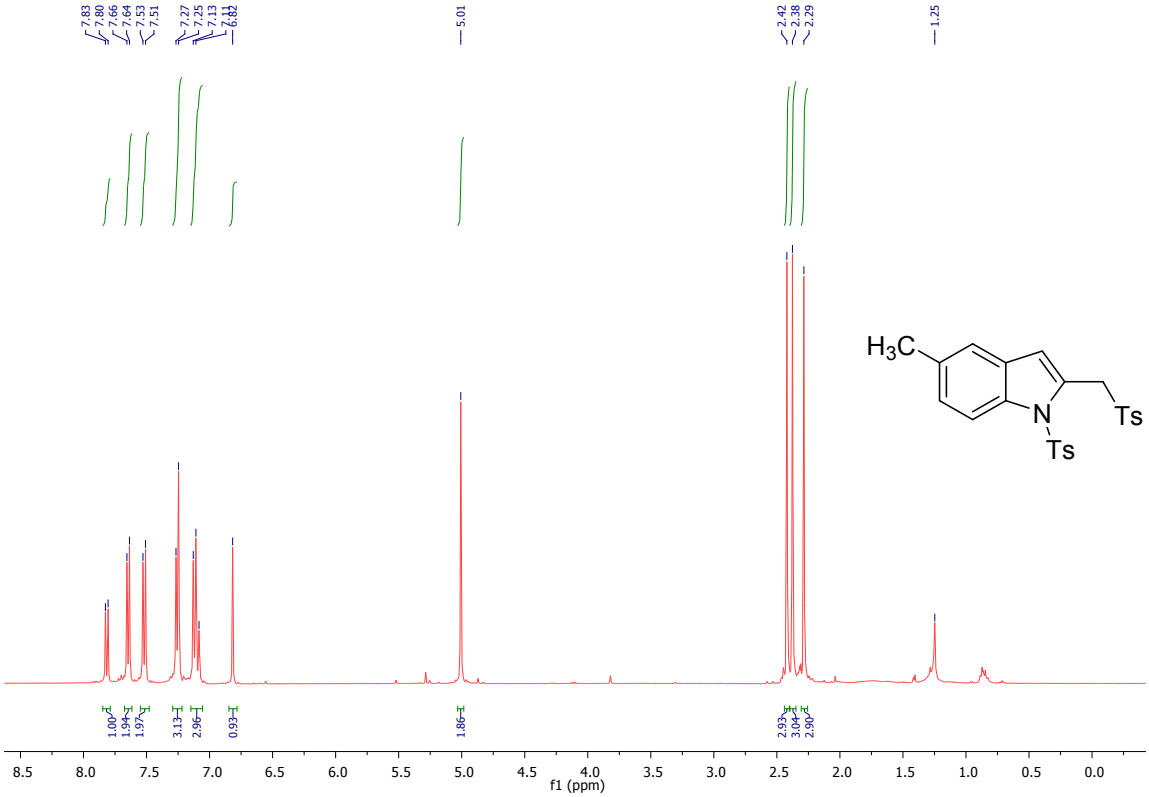

145.610
145.300
137.608
135.347
134.942
131.527
130.094
129.819
128.789
128.358
127.657
126.563
124.892
122.043
115.489
115.345
55.012
21.792
21.676
Cl
N
Ts
Ts
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

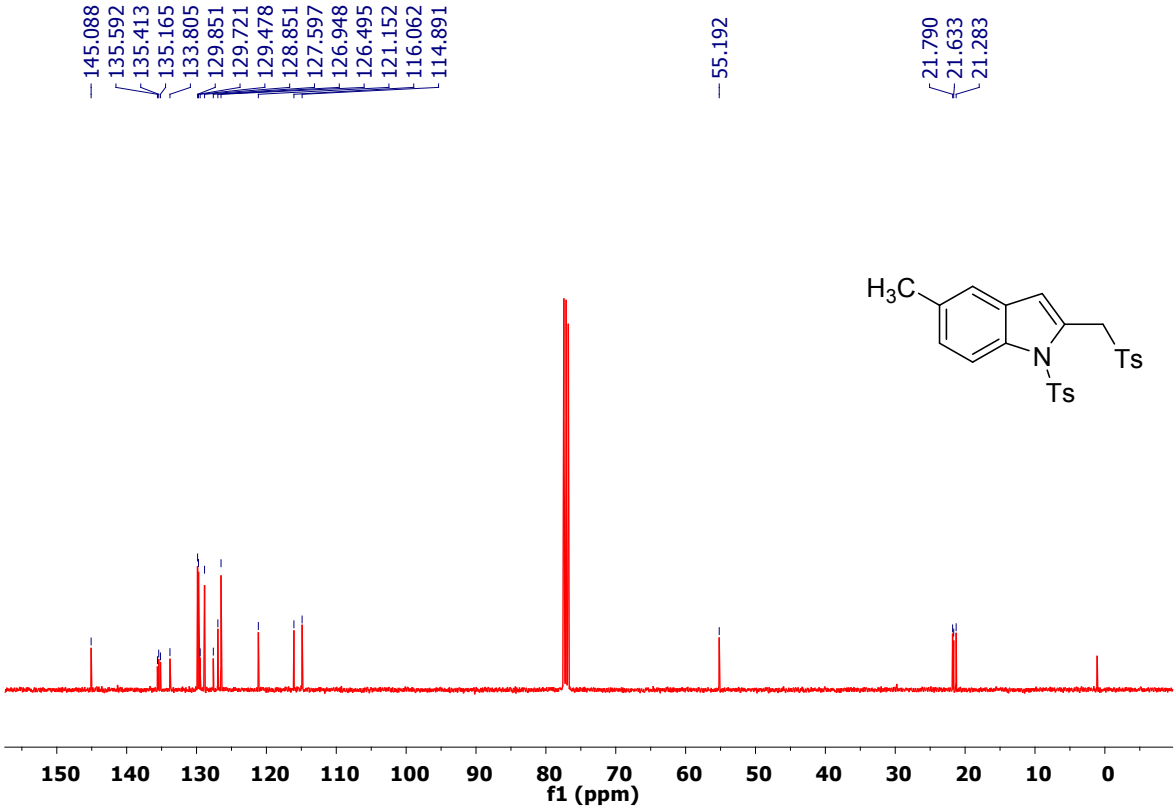
8d, $CDCl_3$


7.879
7.857
7.660
7.639
7.538
7.518
7.439
7.434
7.280
7.260
7.245
7.239
7.222
7.217
7.160
7.139
6.818
5.000
2.426
2.306
Cl
N
Ts
Ts
0.98
2.12
2.05
1.05
1.99
1.17
1.97
0.93
2.00
3.00
3.04
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)

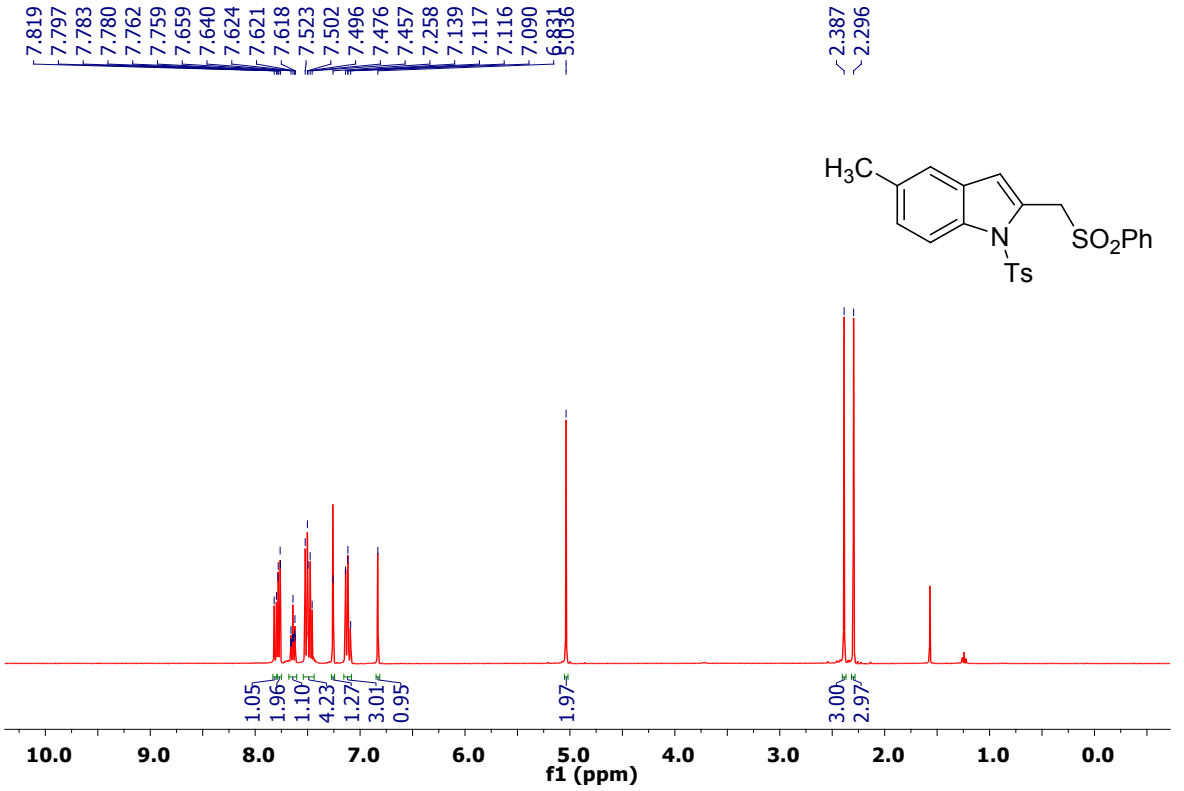

145.574
145.303
135.613
135.313
134.902
130.349
130.036
129.922
129.824
129.209
128.799
126.544
125.708
120.842
116.242
115.101
55.029
21.796
21.668
Cl
N
Ts
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

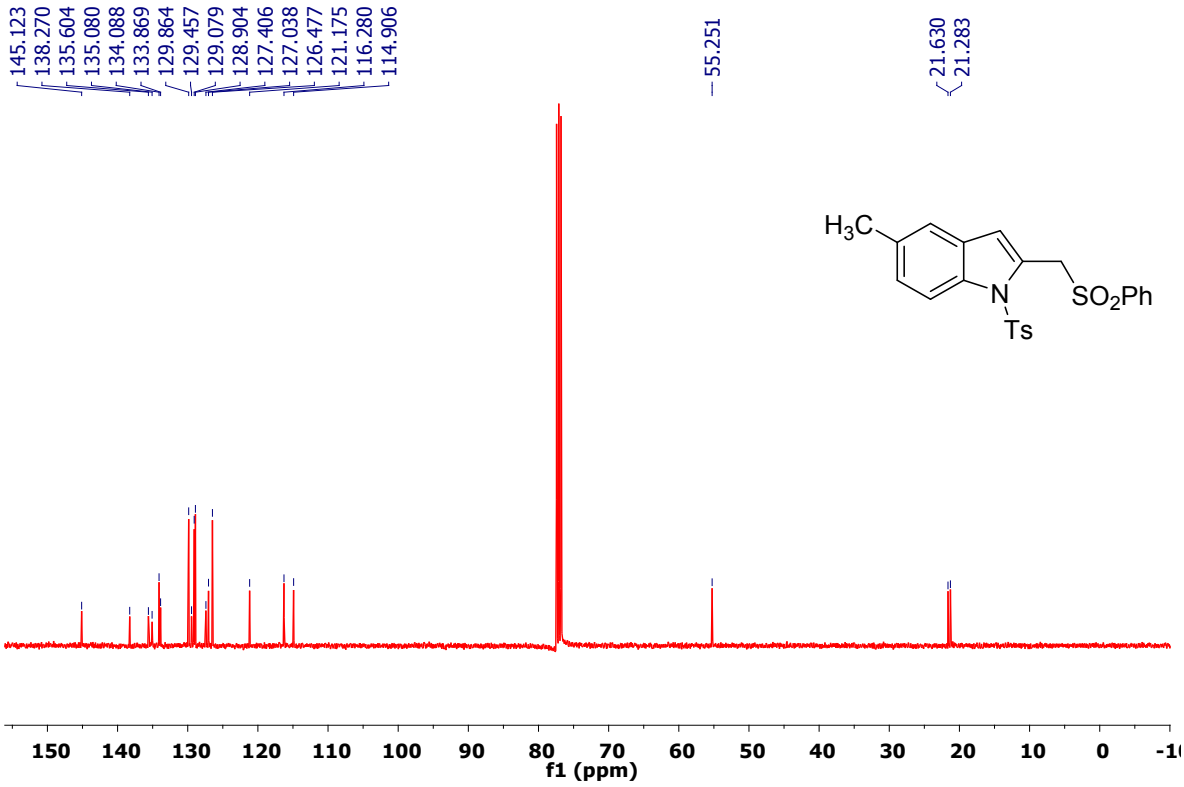
8e, $CDCl_3$


7.83
7.80
7.66
7.64
7.53
7.51
7.27
7.25
7.13
7.11
6.82
5.01
2.42
2.38
2.29
1.25
1.00
1.94
1.97
3.13
2.96
0.93
1.86
2.93
3.04
2.90
f1 (ppm)
H3C
N
Ts
Ts

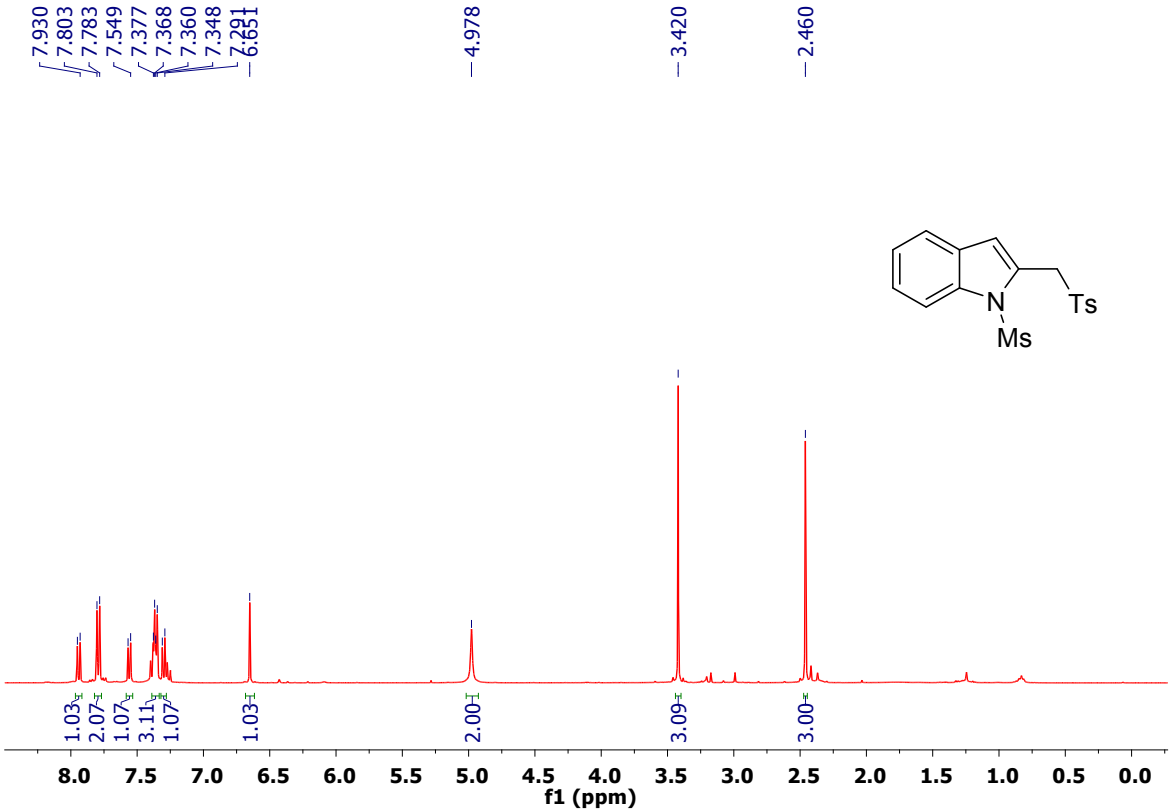

145.088
135.592
135.413
135.165
133.805
129.851
129.721
129.478
128.851
127.597
126.948
126.495
121.152
116.062
114.891
55.192
21.790
21.633
21.283
H3C
N
Ts
Ts
f1 (ppm)

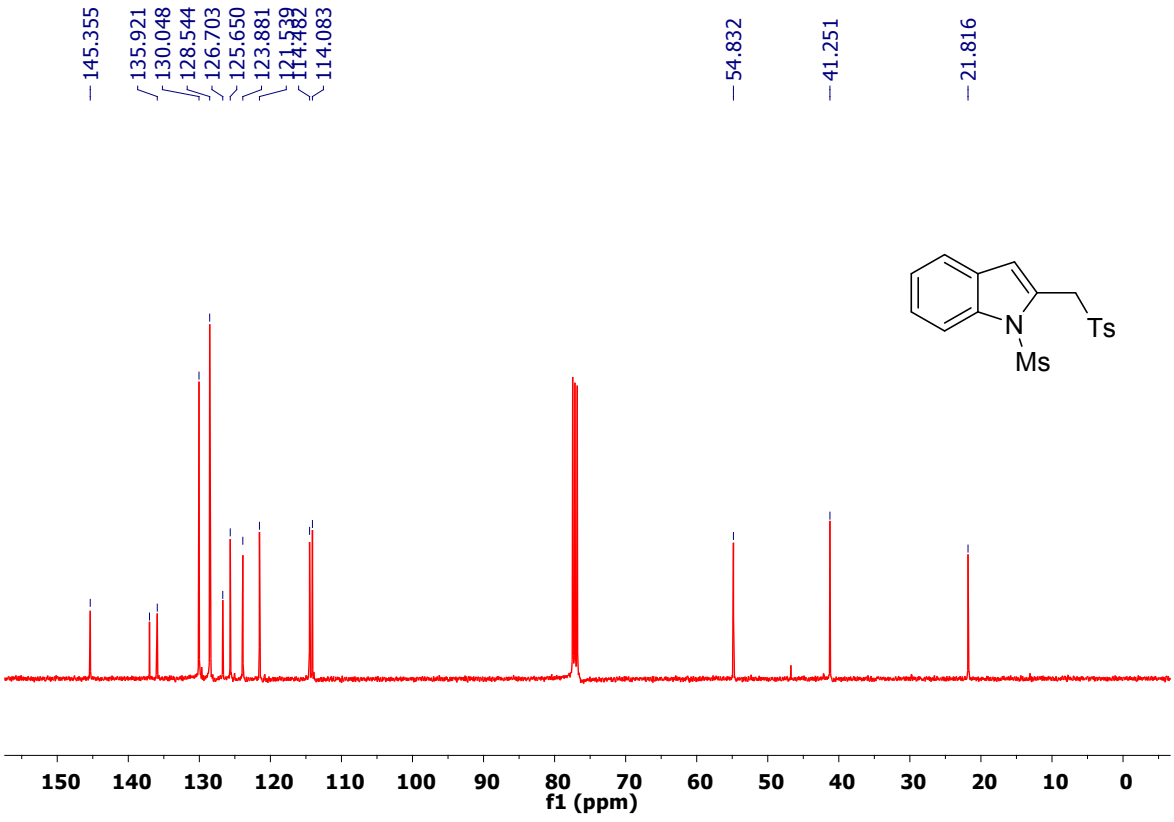
8f, $CDCl_3$


7.819
7.797
7.783
7.780
7.762
7.759
7.659
7.640
7.624
7.621
7.618
7.523
7.502
7.496
7.476
7.457
7.258
7.139
7.117
7.116
7.090
6.831
5.036
2.387
2.296
H3C
N
Ts
SO2Ph
1.05
1.96
1.10
4.23
1.27
3.01
0.95
1.97
3.00
2.97
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)

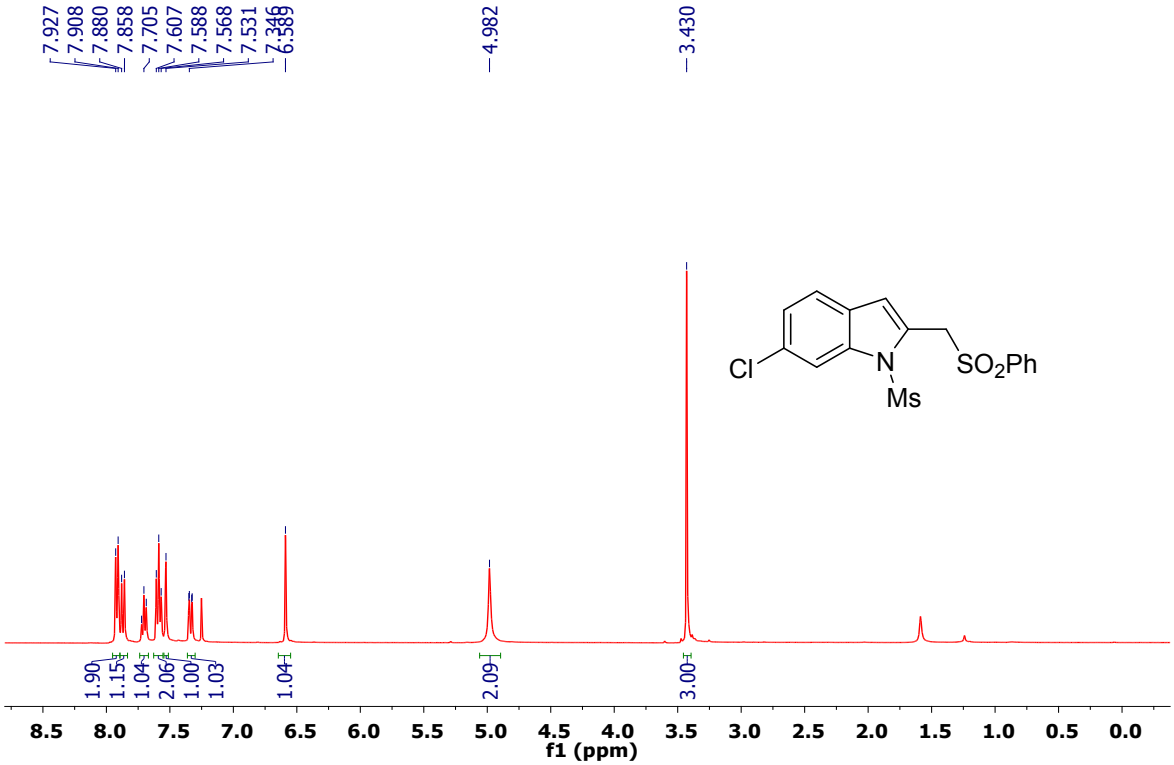

145.123
138.270
135.604
135.080
134.088
133.869
129.864
129.457
129.079
128.904
127.406
127.038
126.477
121.175
116.280
114.906
55.251
21.630
21.283
H3C
N
Ts
SO2Ph
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

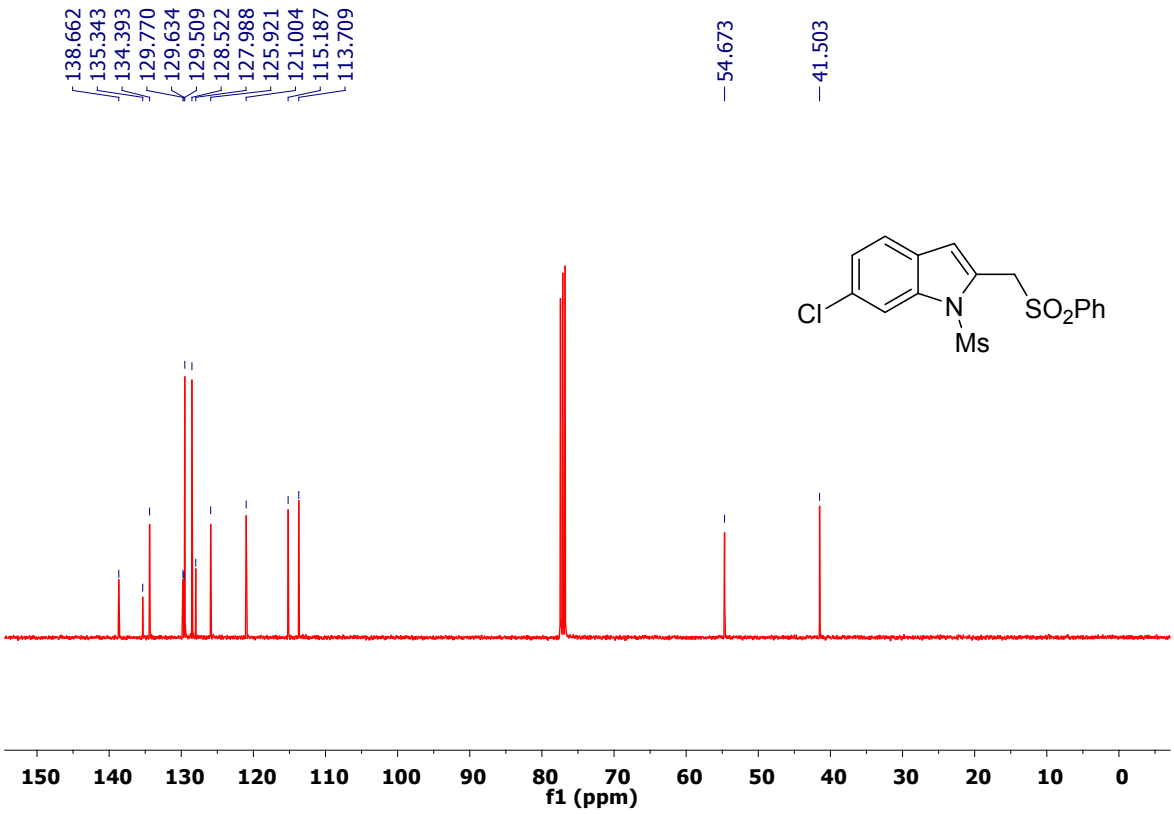
8g, **$CDCl_3$**


7.930
7.803
7.783
7.549
7.377
7.368
7.360
7.348
7.291
6.651
4.978
3.420
2.460
N
Ts
Ms
1.03
2.07
1.07
3.11
1.07
1.03
2.00
3.09
3.00
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)

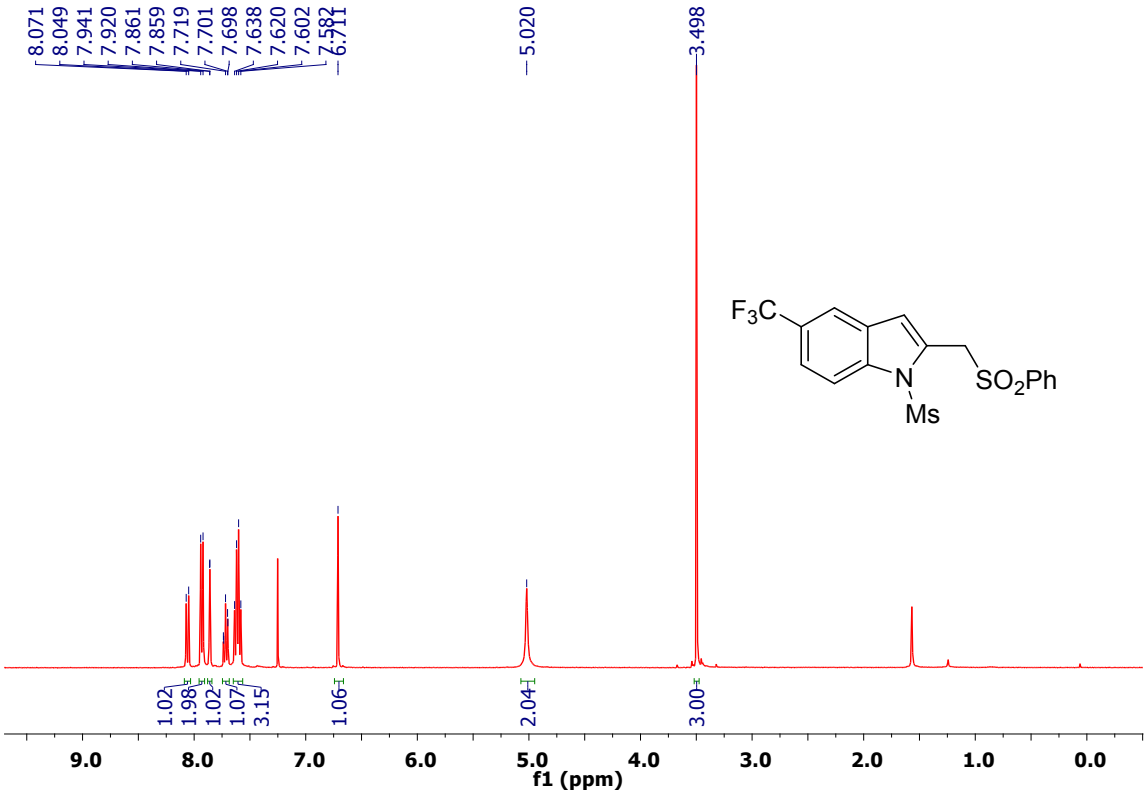

145.355
135.921
130.048
128.544
126.703
125.650
123.881
121.539
114.482
114.083
54.832
41.251
21.816
N
Ts
Ms
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

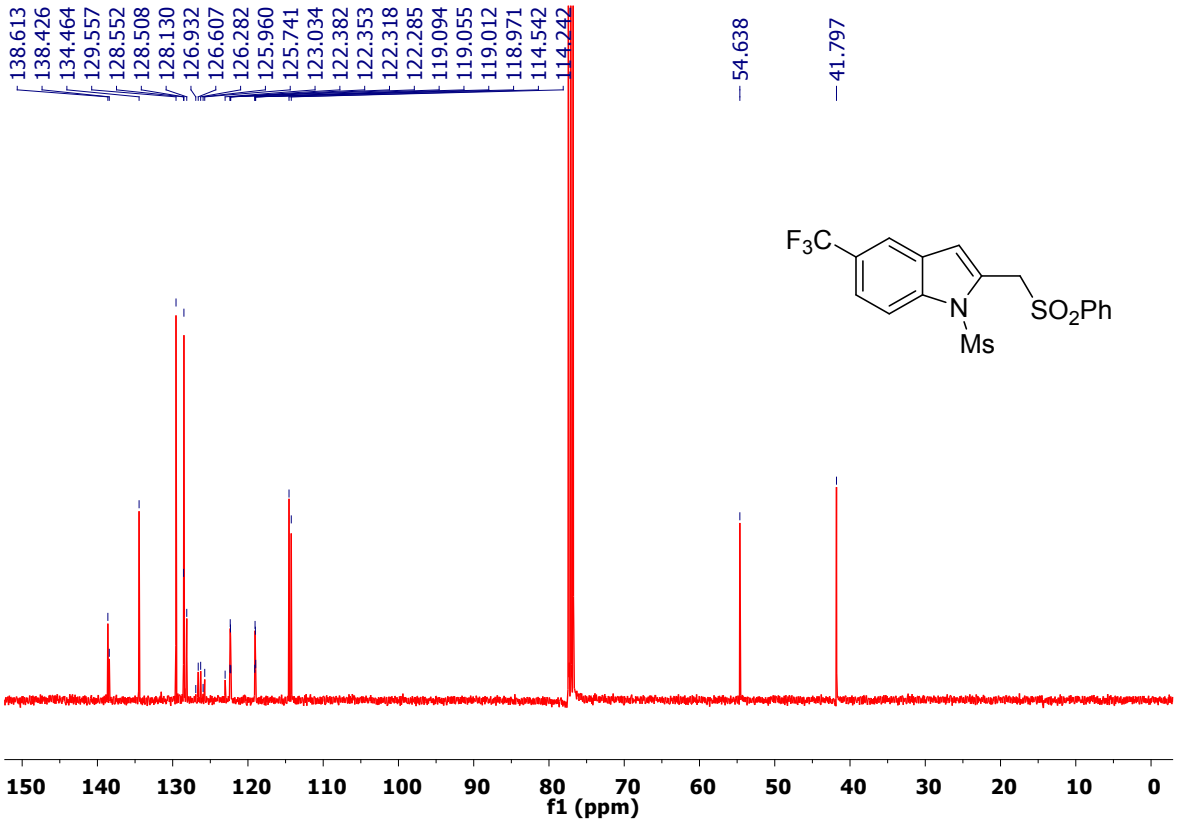
8h, $CDCl_3$


7.927
7.908
7.880
7.858
7.705
7.607
7.588
7.568
7.531
7.346
6.589
4.982
3.430
Cl
N
Ms
SO2Ph
1.90
1.15
1.04
2.06
1.00
1.03
1.04
2.09
3.00
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)

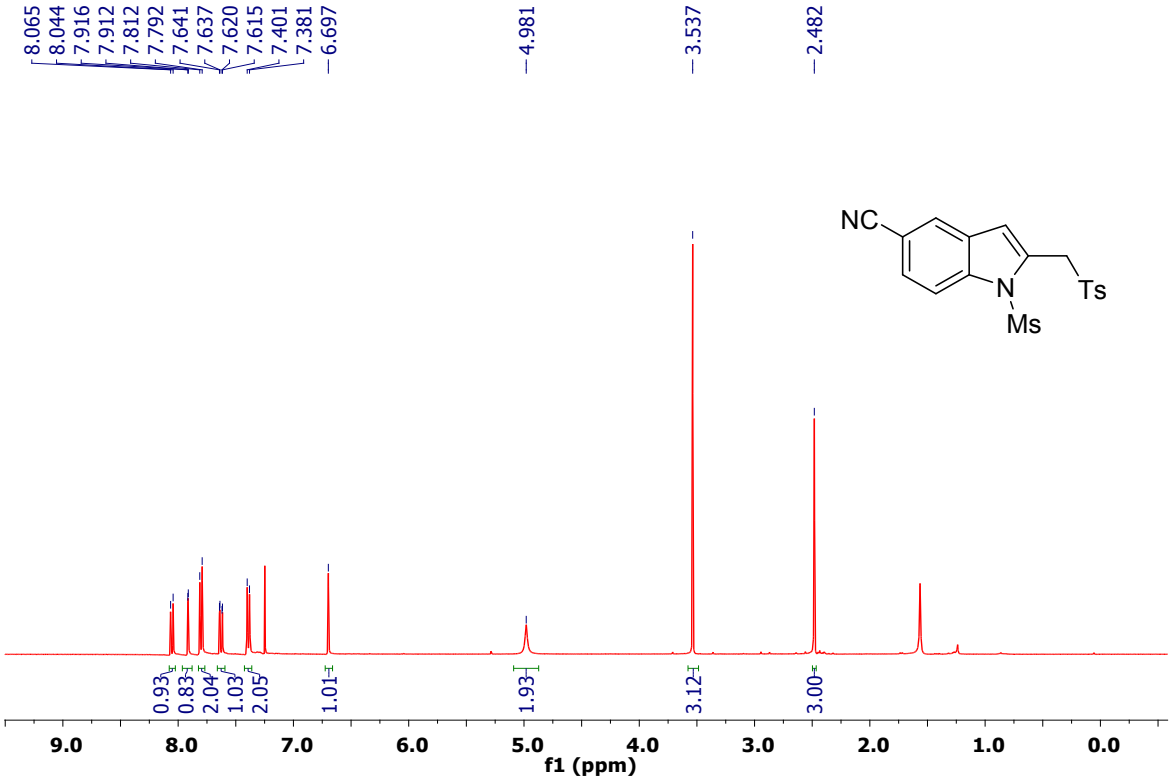

138.662
135.343
134.393
129.770
129.634
129.509
128.522
127.988
125.921
121.004
115.187
113.709
54.673
41.503
Cl
N
Ms
SO2Ph
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

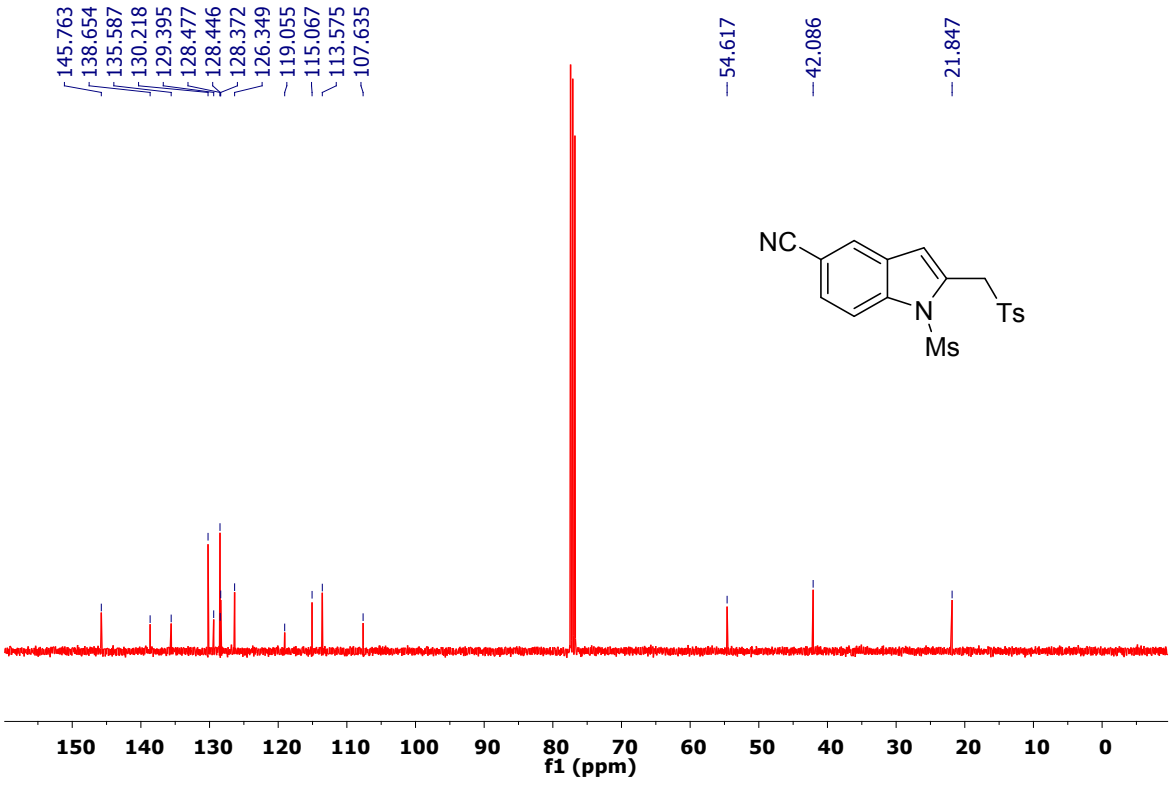
8i, **$CDCl_3$**


8.071
8.049
7.941
7.920
7.861
7.859
7.719
7.701
7.698
7.638
7.620
7.602
7.582
7.711
5.020
3.498
F3C
N
Ms
SO2Ph
1.02
1.98
1.02
1.07
3.15
1.06
2.04
3.00
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)

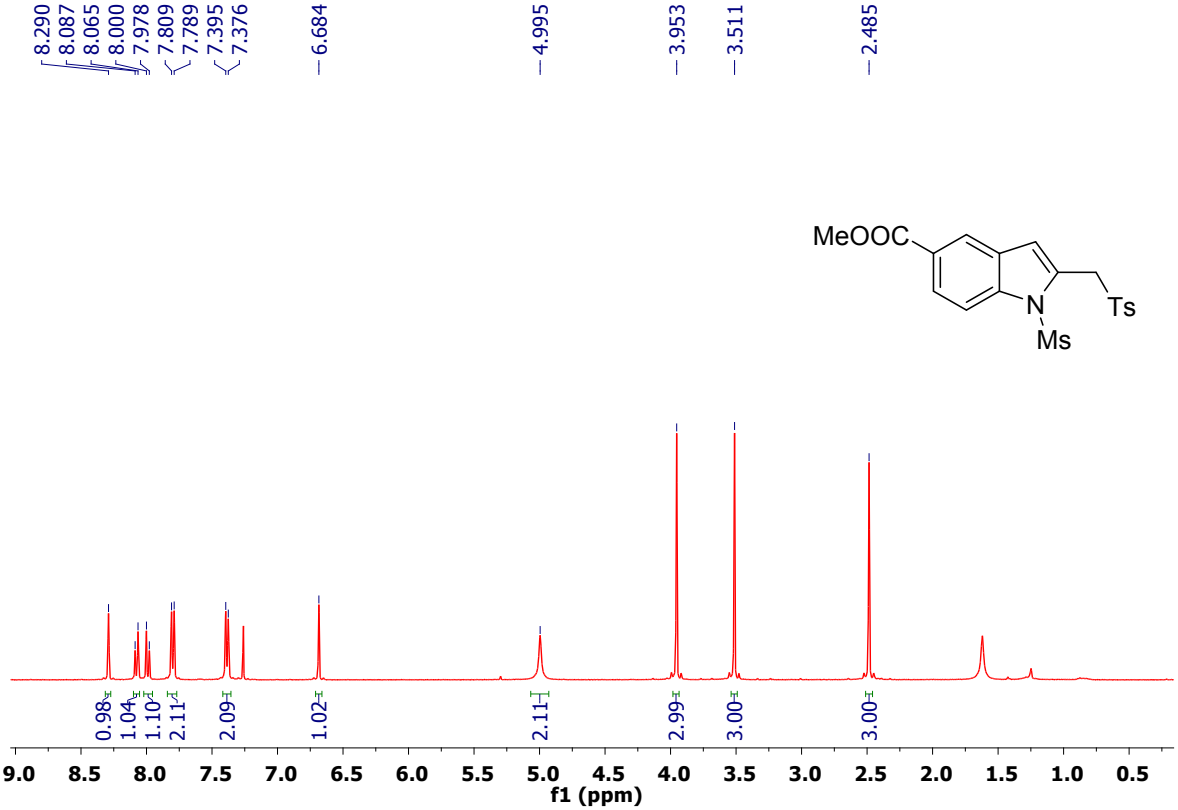

138.613
138.426
134.464
129.557
128.552
128.508
128.130
126.932
126.607
126.282
125.960
125.741
123.034
122.382
122.353
122.318
122.285
119.094
119.055
119.012
118.971
114.542
114.242
54.638
41.797
F3C
N
Ms
SO2Ph
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

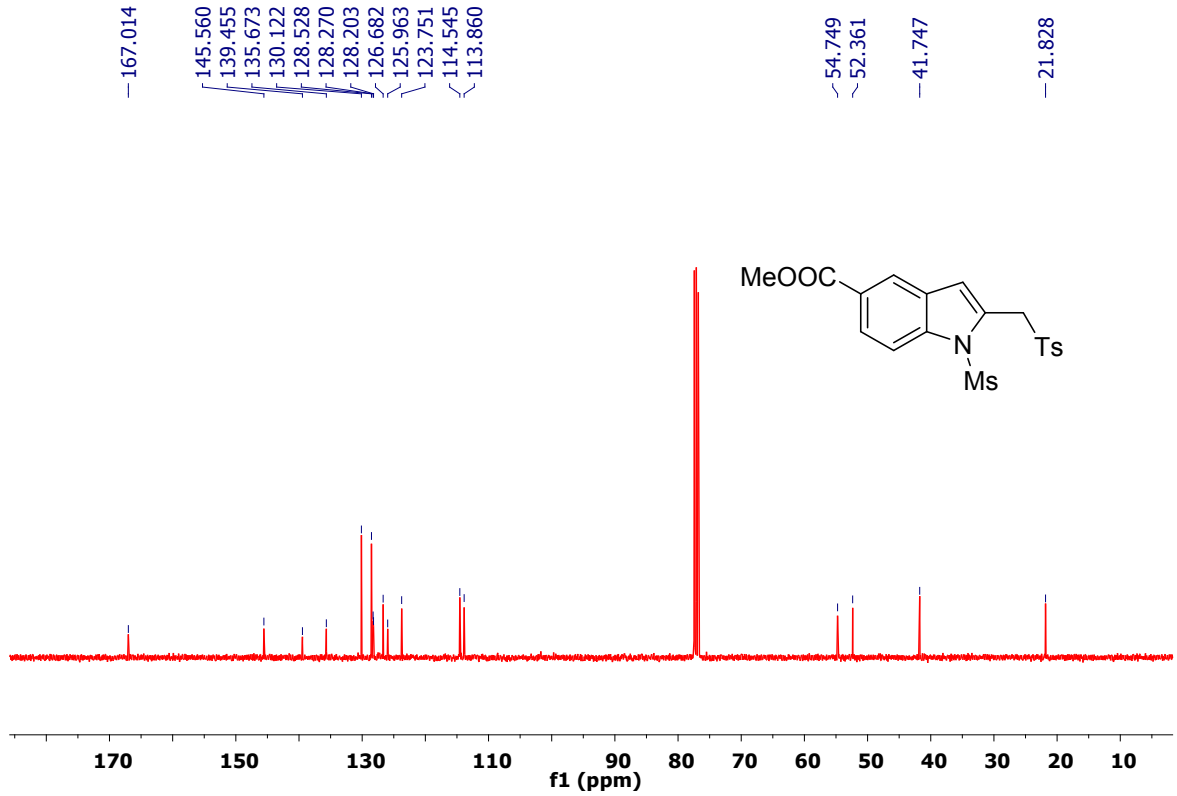
8j, $CDCl_3$


8.065
8.044
7.916
7.912
7.812
7.792
7.641
7.637
7.620
7.615
7.401
7.381
6.697
4.981
3.537
2.482
NC
N
Ts
Ms
0.93
0.83
2.04
1.03
2.05
1.01
1.93
3.12
3.00
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)

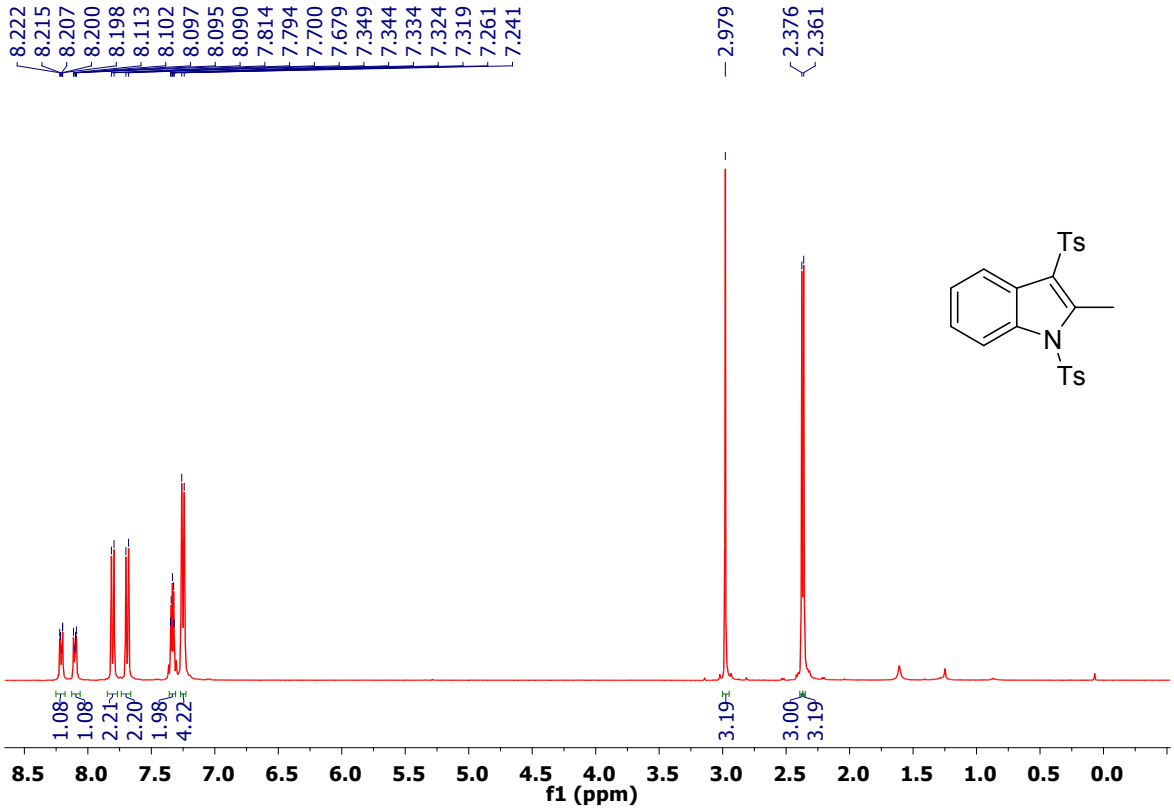

145.763
138.654
135.587
130.218
129.395
128.477
128.446
128.372
126.349
119.055
115.067
113.575
107.635
54.617
42.086
21.847
NC
N
Ts
Ms
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

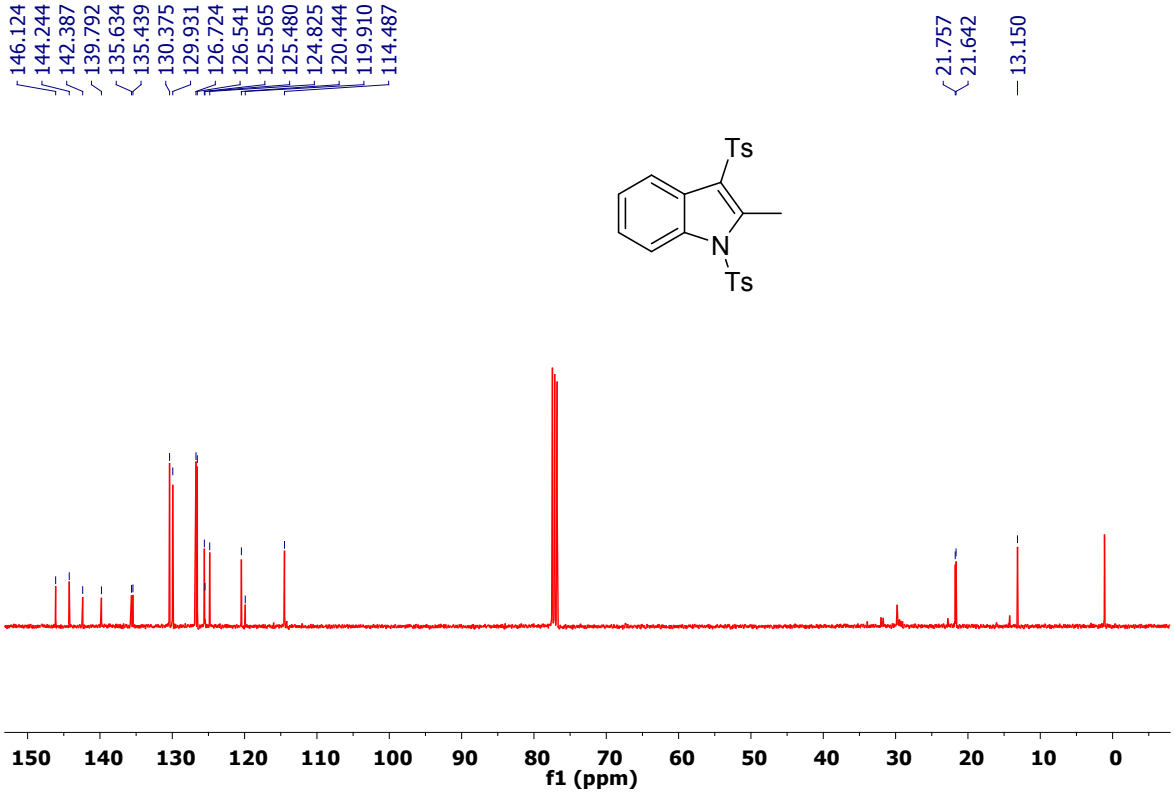
8k, **$CDCl_3$**


8.290
8.087
8.065
8.000
7.978
7.809
7.789
7.395
7.376
6.684
4.995
3.953
3.511
2.485
MeOOC
N
Ts
Ms
0.98
1.04
1.10
2.11
2.09
1.02
2.11
2.99
3.00
3.00
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)

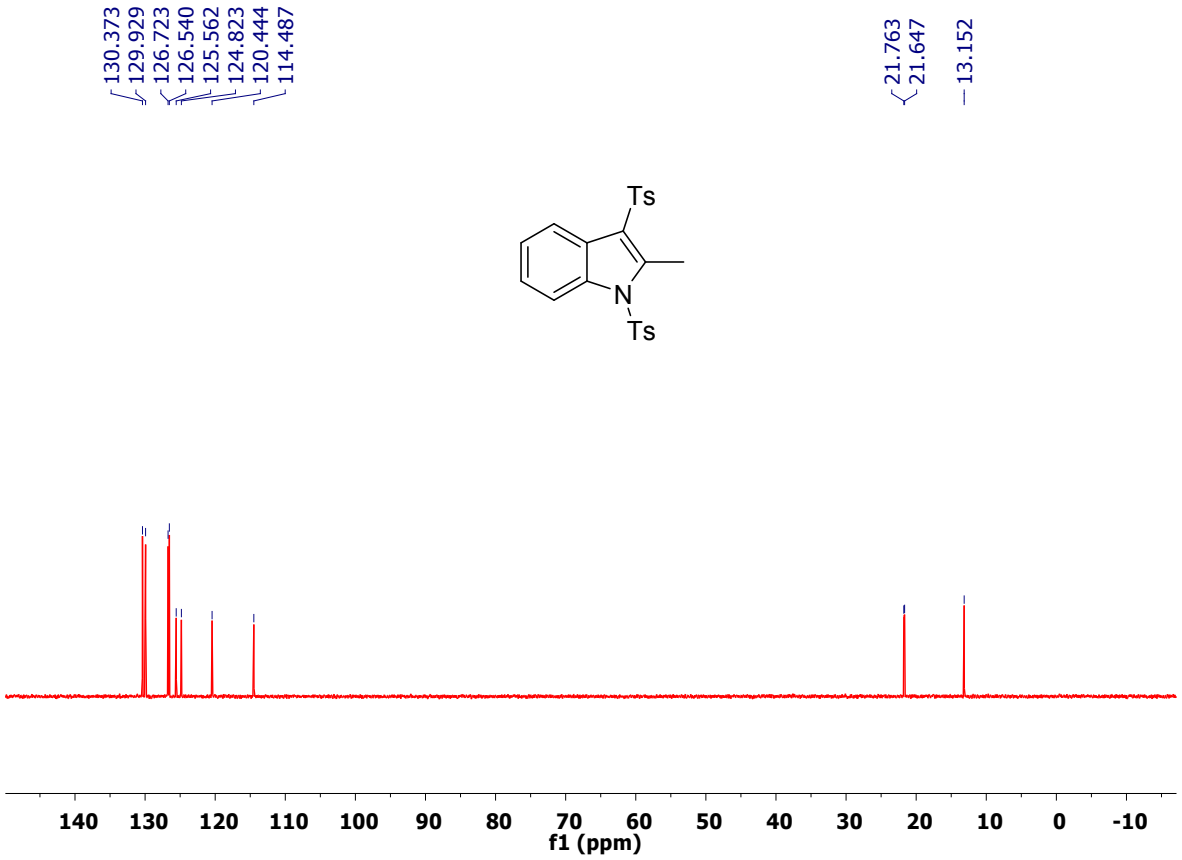

167.014
145.560
139.455
135.673
130.122
128.528
128.270
128.203
126.682
125.963
123.751
114.545
113.860
54.749
52.361
41.747
21.828
MeOOC
N
Ts
Ms
170 150 130 110 90 80 70 60 50 40 30 20 10
f1 (ppm)

9a, **$CDCl_3$**

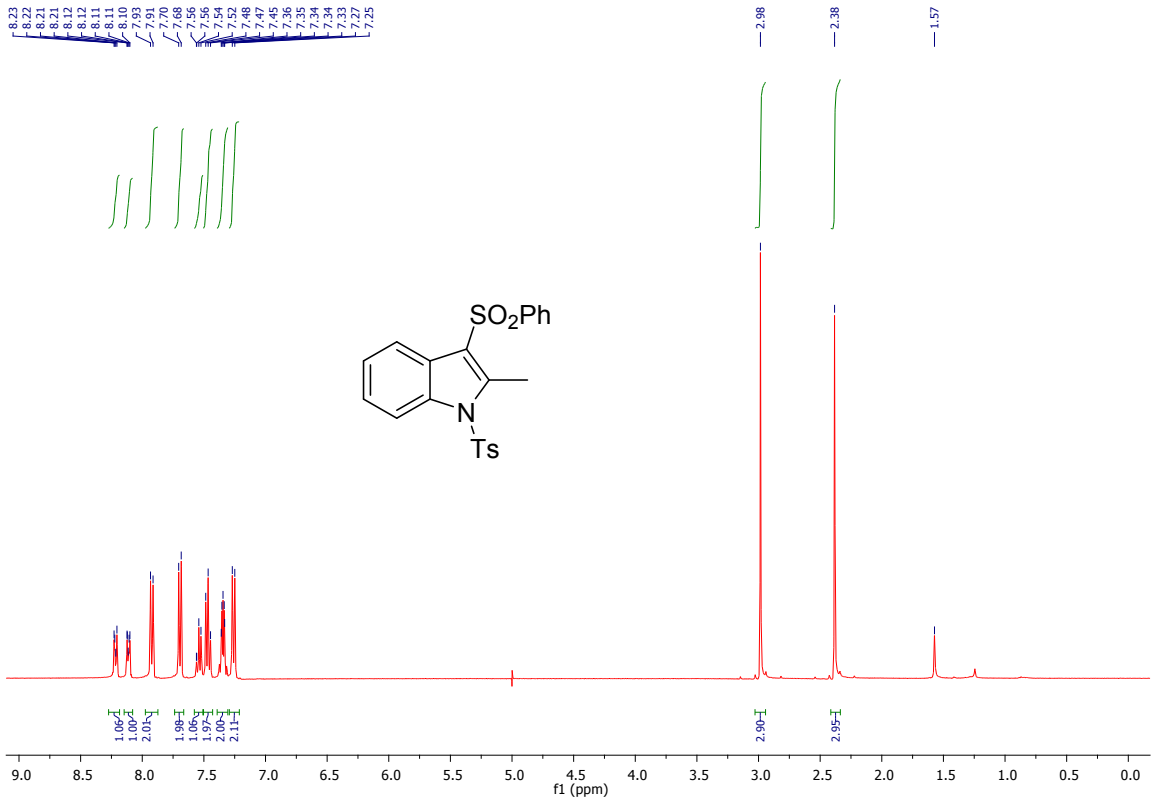

8.222
8.215
8.207
8.200
8.198
8.113
8.102
8.097
8.095
8.090
7.814
7.794
7.700
7.679
7.349
7.344
7.334
7.324
7.319
7.261
7.241
2.979
2.376
2.361
Ts
N
Ts
1.08
1.08
2.21
2.20
1.98
4.22
3.19
3.00
3.19
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

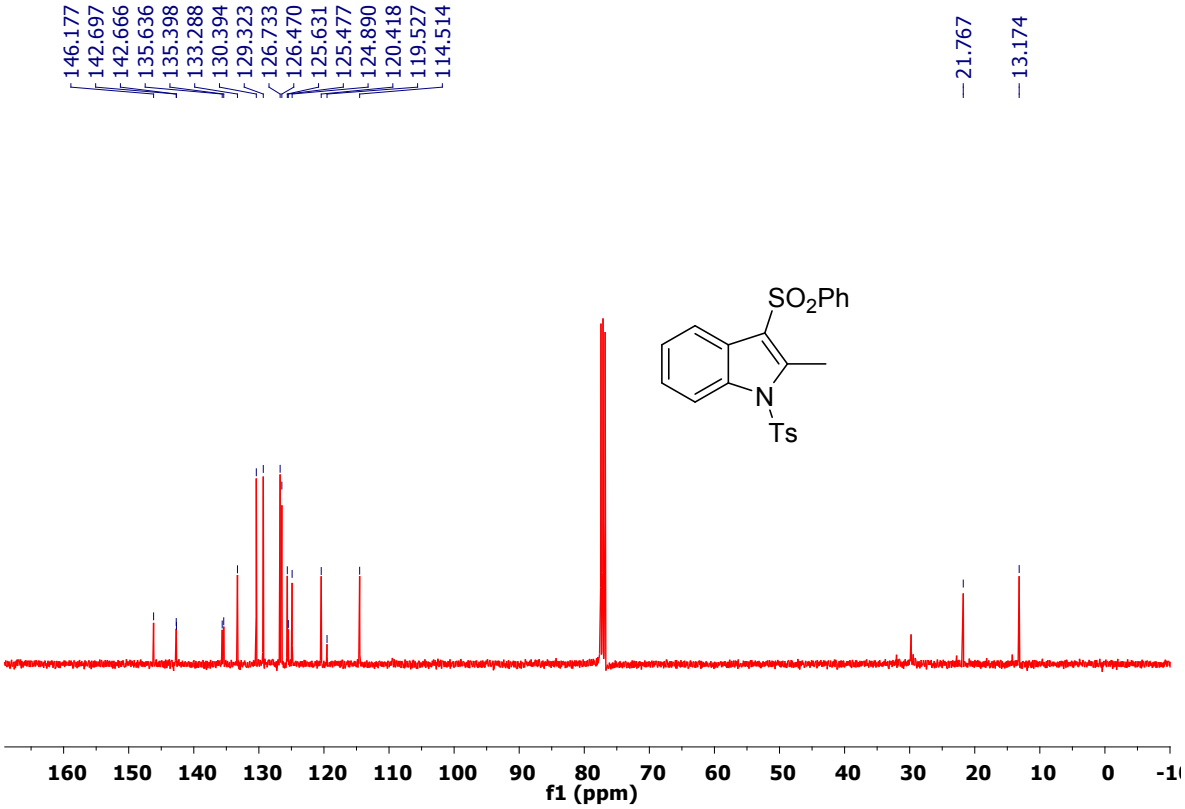

146.124
144.244
142.387
139.792
135.634
135.439
130.375
129.931
126.724
126.541
125.565
125.480
124.825
120.444
119.910
114.487
21.757
21.642
13.150
Ts
N
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

9a, **$CDCl_3$, DEPT-135**

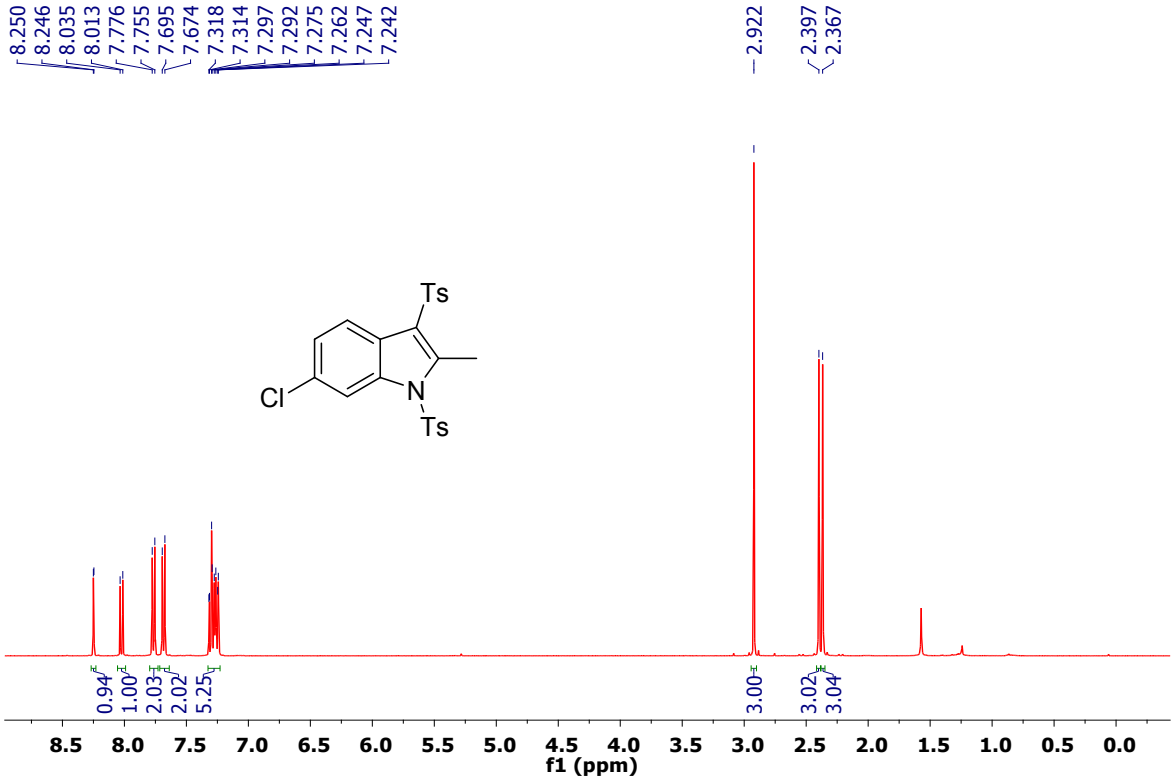


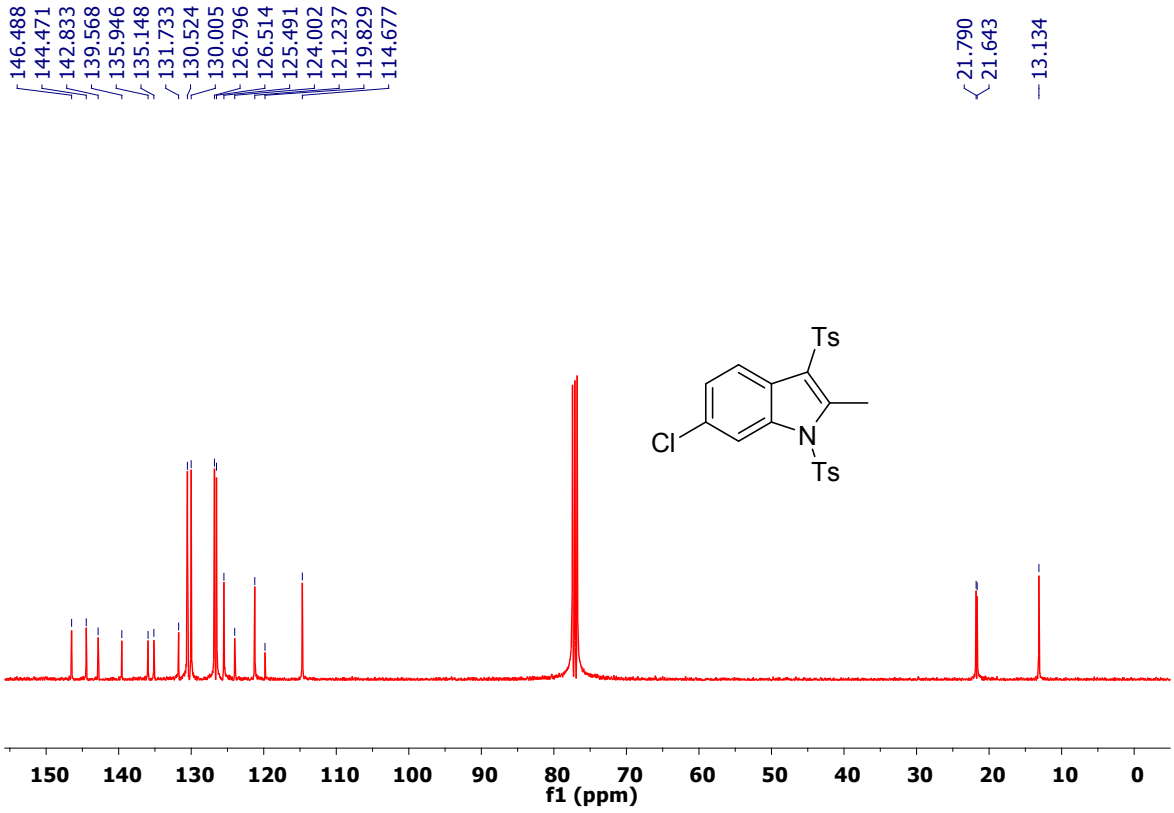
9b, $CDCl_3$


8.23
8.22
8.21
8.21
8.12
8.12
8.11
8.11
8.10
7.93
7.91
7.70
7.68
7.56
7.56
7.54
7.52
7.48
7.47
7.45
7.36
7.35
7.34
7.34
7.33
7.27
7.25
2.98
2.38
1.57
SO2Ph
N
Ts
1.06
1.00
2.01
1.98
1.06
1.97
2.00
2.11
2.90
2.95
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)

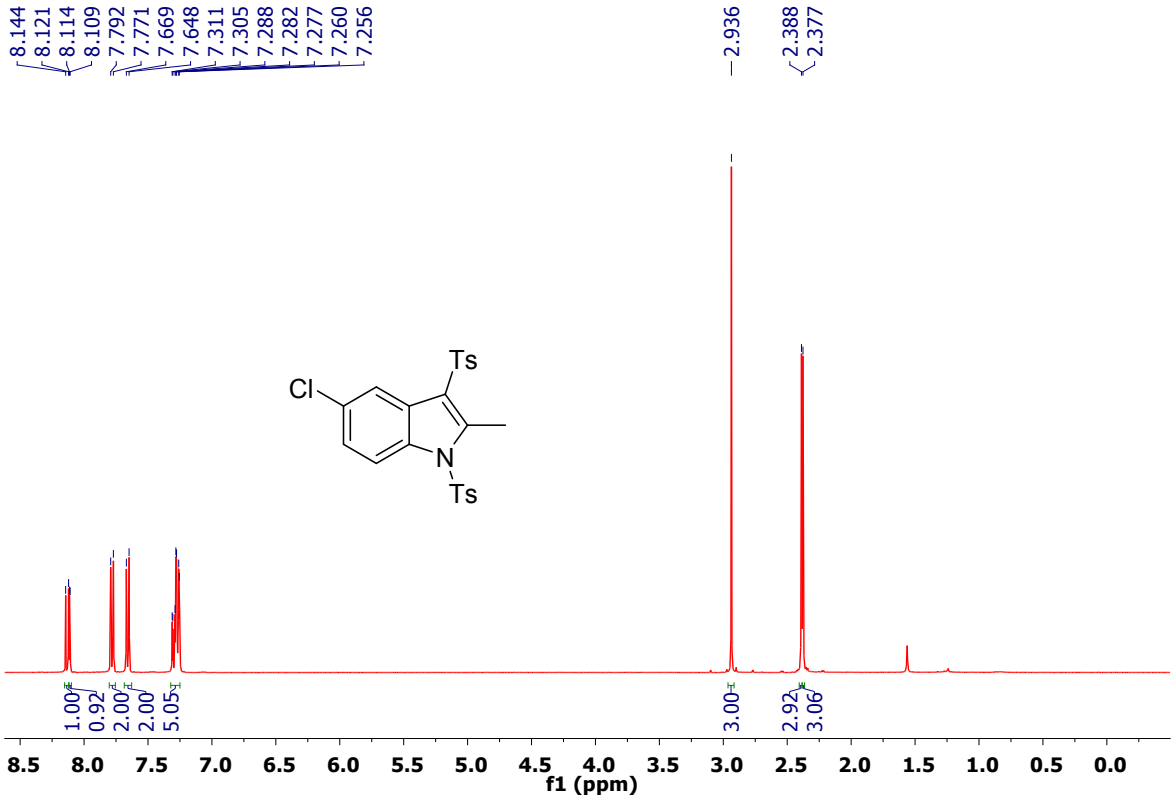

146.177
142.697
142.666
135.636
135.398
133.288
130.394
129.323
126.733
126.470
125.631
125.477
124.890
120.418
119.527
114.514
21.767
13.174
SO2Ph
N
Ts
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1
f1 (ppm)

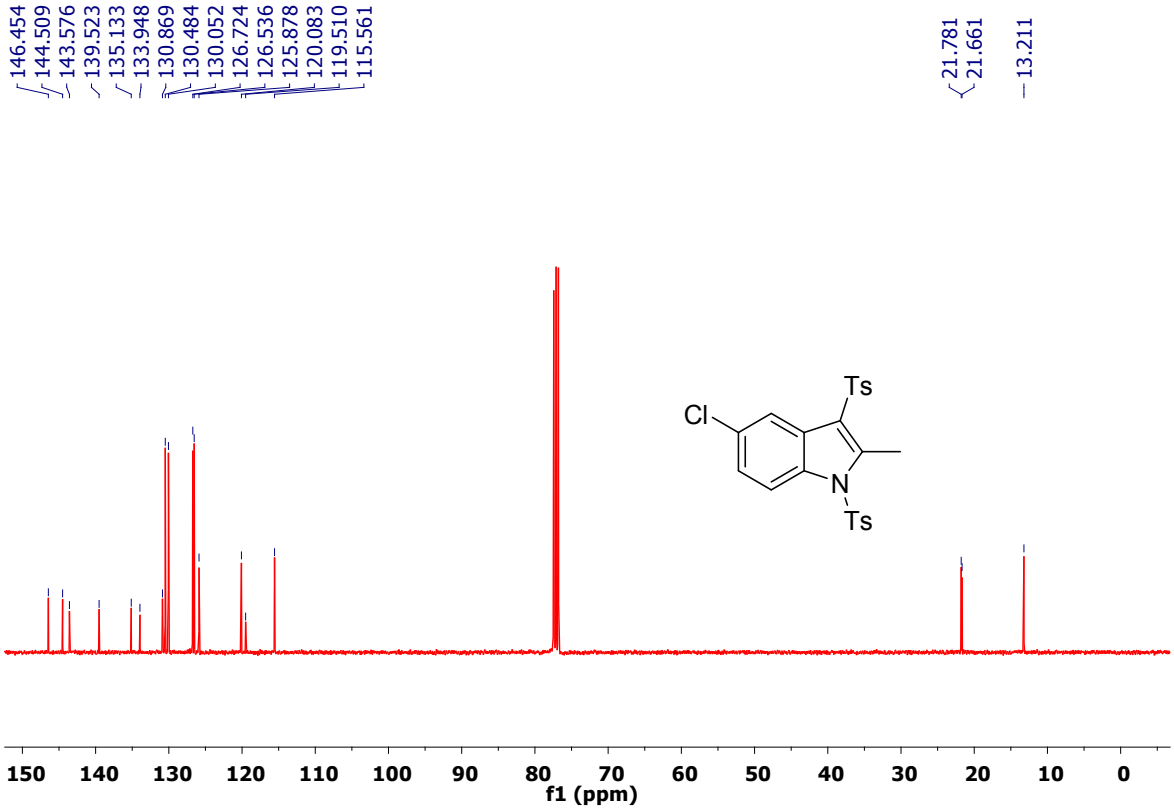
9c, **$CDCl_3$**


8.250
8.246
8.035
8.013
7.776
7.755
7.695
7.674
7.318
7.314
7.297
7.292
7.275
7.262
7.247
7.242
2.922
2.397
2.367
Ts
Cl
N
Ts
0.94
1.00
2.03
2.02
5.25
3.00
3.02
3.04
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)

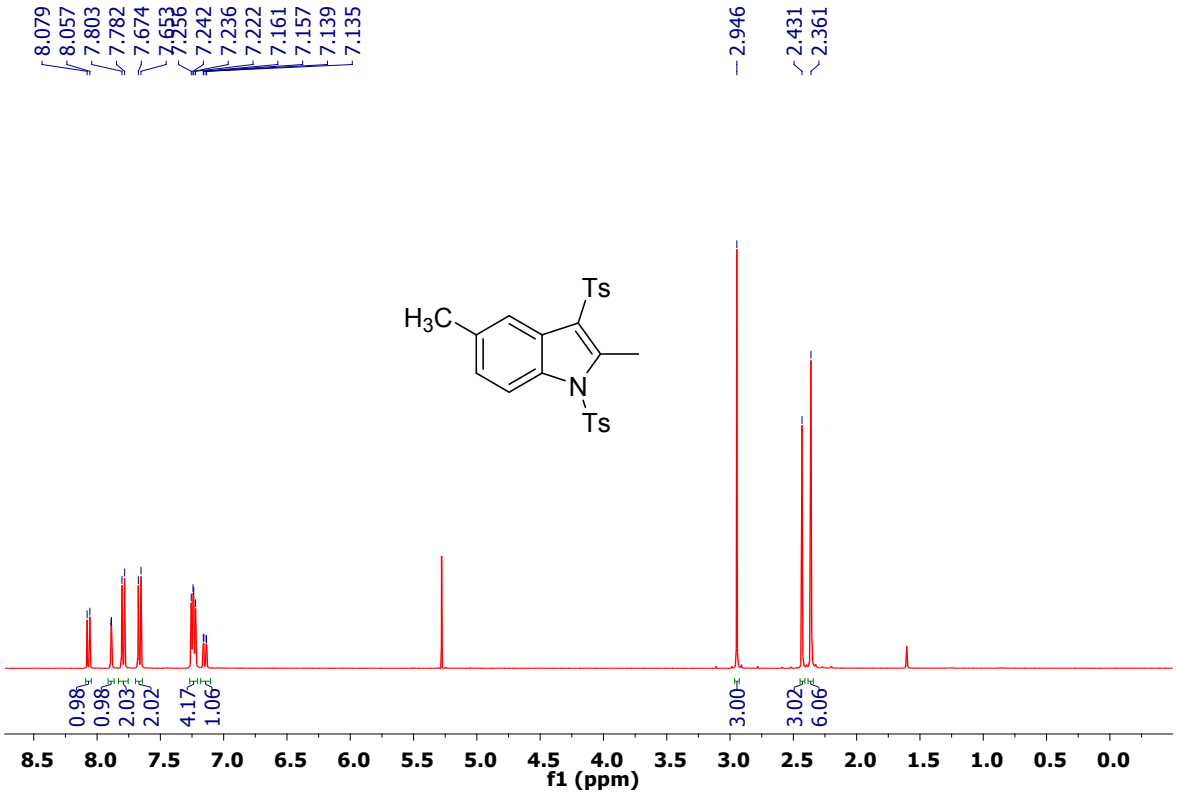

146.488
144.471
142.833
139.568
135.946
135.148
131.733
130.524
130.005
126.796
126.514
125.491
124.002
121.237
119.829
114.677
21.790
21.643
13.134
Ts
Cl
N
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

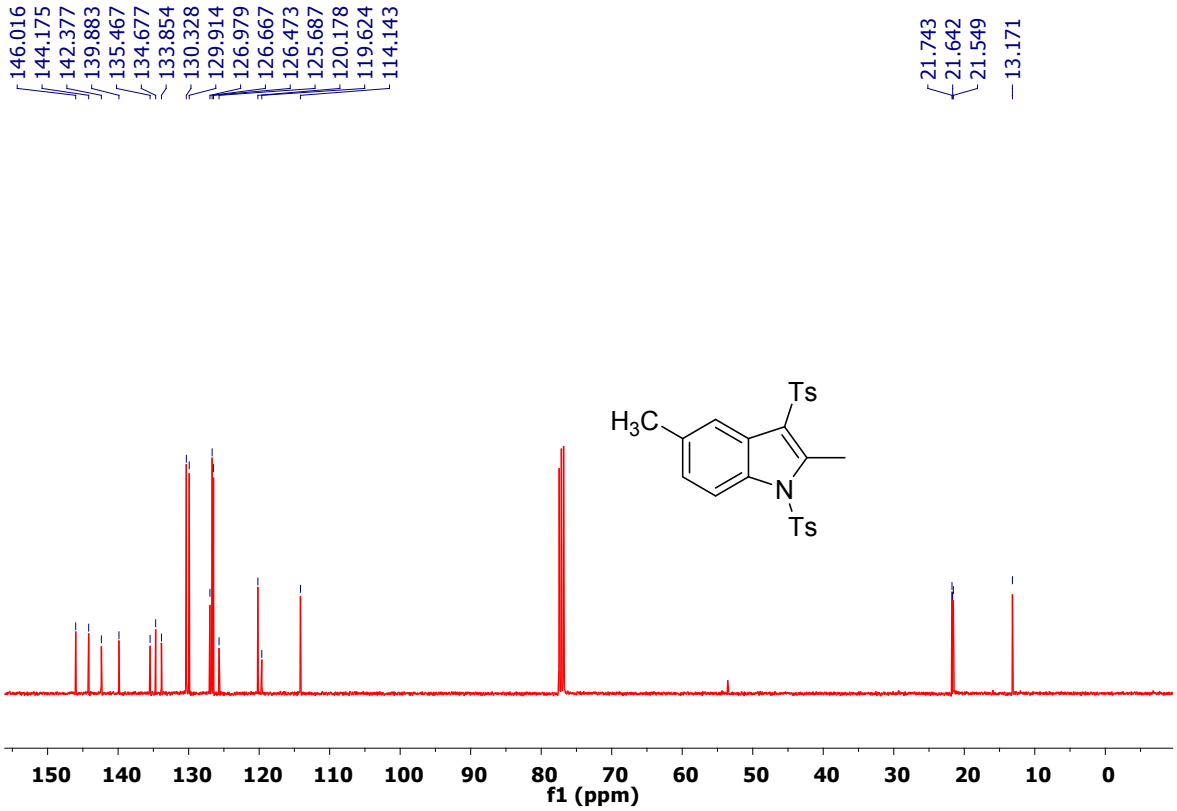
9d, **$CDCl_3$**


8.144
8.121
8.114
8.109
7.792
7.771
7.669
7.648
7.311
7.305
7.288
7.282
7.277
7.260
7.256
2.936
2.388
2.377
Ts
Cl
N
Ts
1.00
0.92
2.00
2.00
5.05
3.00
2.92
3.06
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)

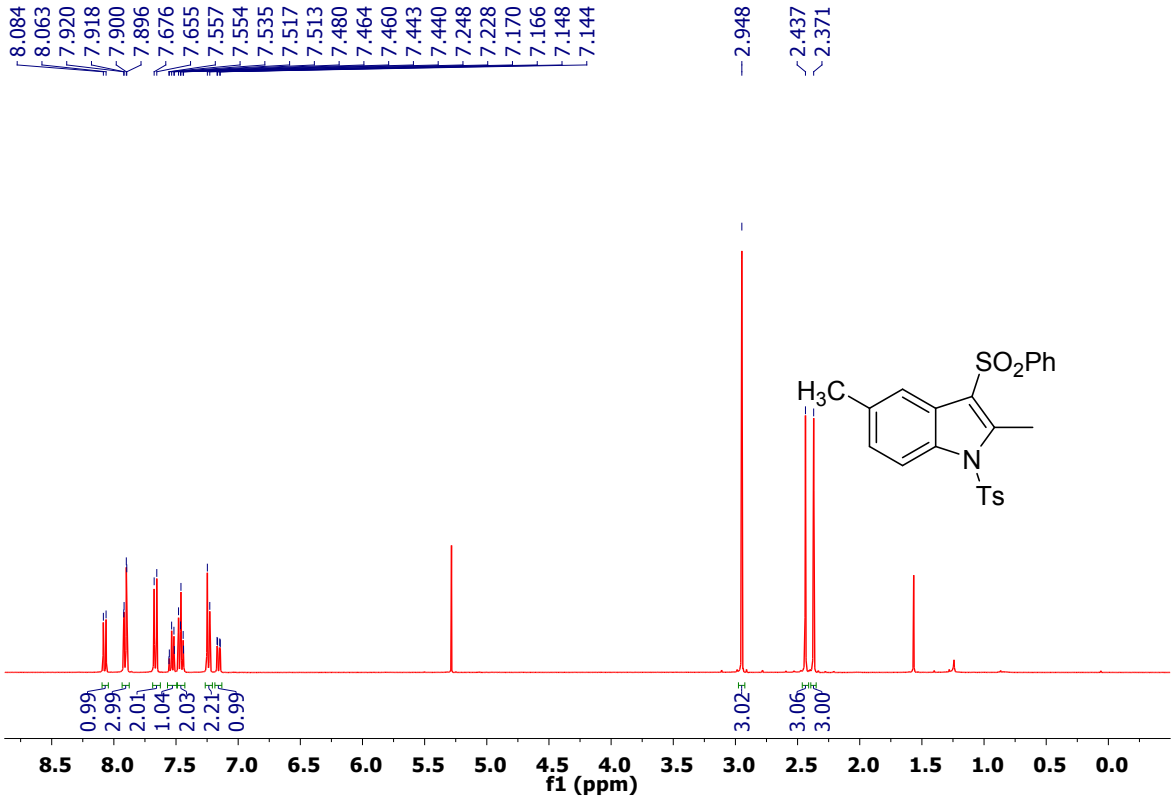

146.454
144.509
143.576
139.523
135.133
133.948
130.869
130.484
130.052
126.724
126.536
125.878
120.083
119.510
115.561
21.781
21.661
13.211
Ts
Cl
N
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

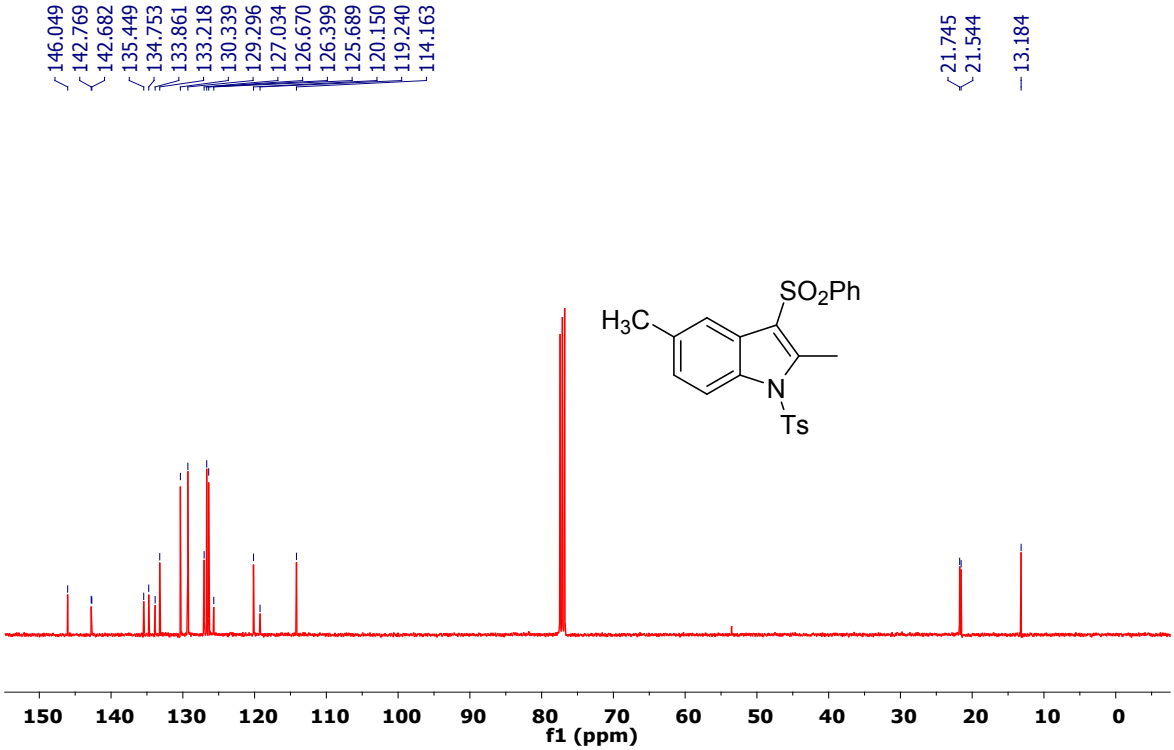
9f, **$CDCl_3$**


8.079
8.057
7.803
7.782
7.674
7.242
7.236
7.222
7.161
7.157
7.139
7.135
2.946
2.431
2.361
Ts
H3C
N
Ts
0.98
0.98
2.03
2.02
4.17
1.06
3.00
3.02
6.06
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)

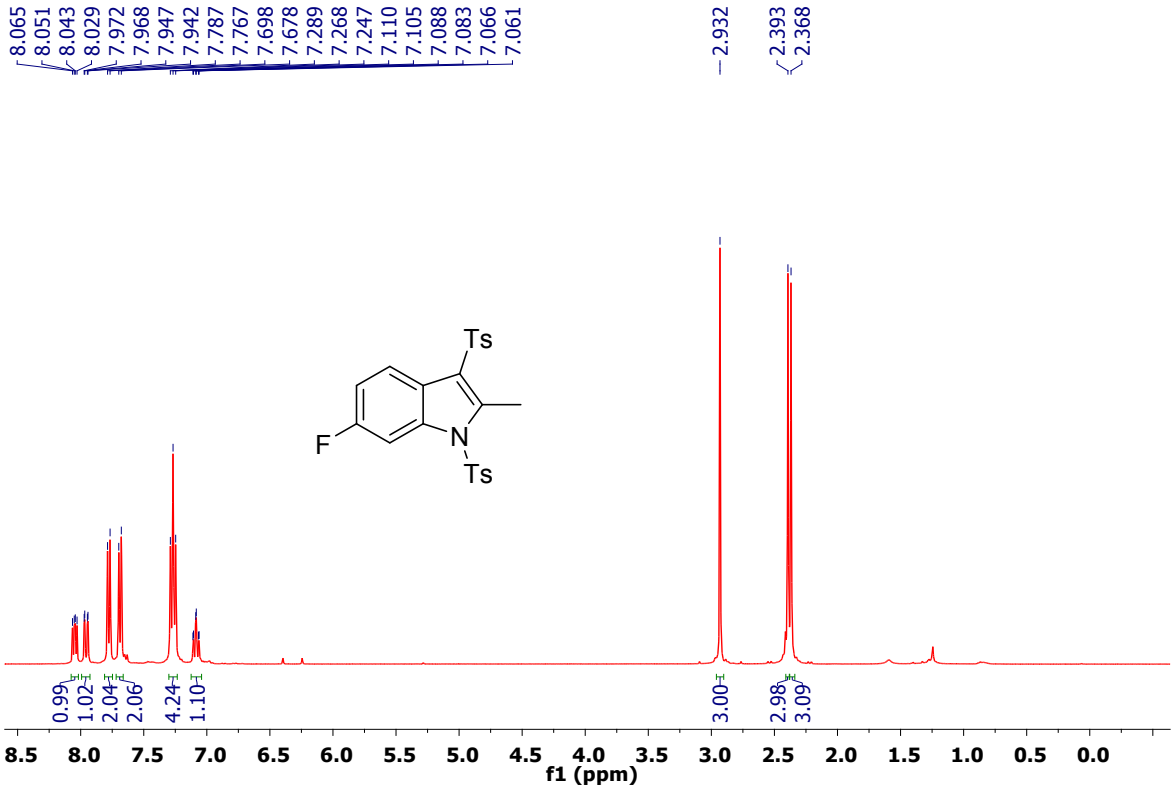

146.016
144.175
142.377
139.883
135.467
134.677
133.854
130.328
129.914
126.979
126.667
126.473
125.687
120.178
119.624
114.143
21.743
21.642
21.549
13.171
Ts
H3C
N
Ts
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

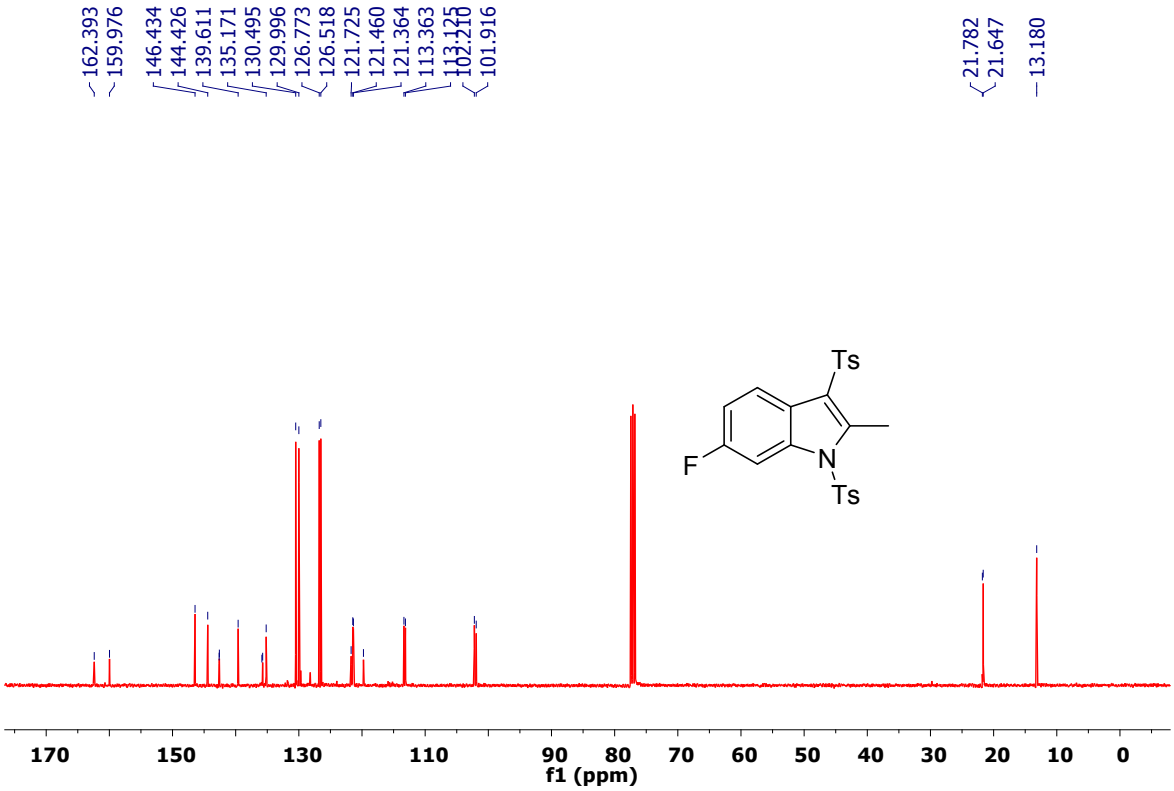
9g, **$CDCl_3$**


8.084
8.063
7.920
7.918
7.900
7.896
7.676
7.655
7.557
7.554
7.535
7.517
7.513
7.480
7.464
7.460
7.443
7.440
7.248
7.228
7.170
7.166
7.148
7.144
2.948
2.437
2.371
SO2Ph
H3C
N
Ts
0.99
2.99
2.01
1.04
2.03
2.21
0.99
3.02
3.06
3.00
f1 (ppm)

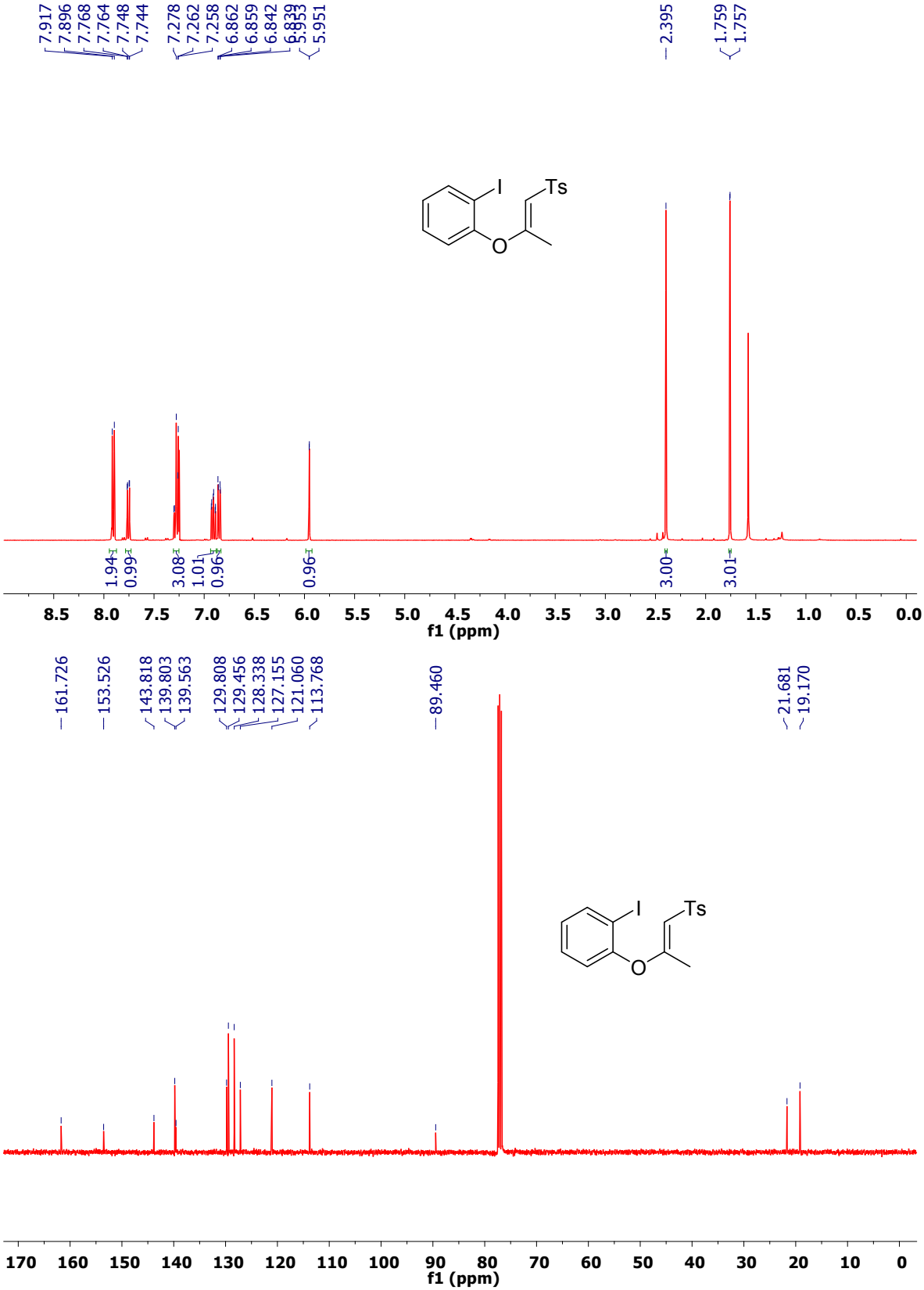

146.049
142.769
142.682
135.449
134.753
133.861
133.218
130.339
129.296
127.034
126.670
126.399
125.689
120.150
119.240
114.163
21.745
21.544
13.184
SO2Ph
H3C
N
Ts
f1 (ppm)

9h, **$CDCl_3$**

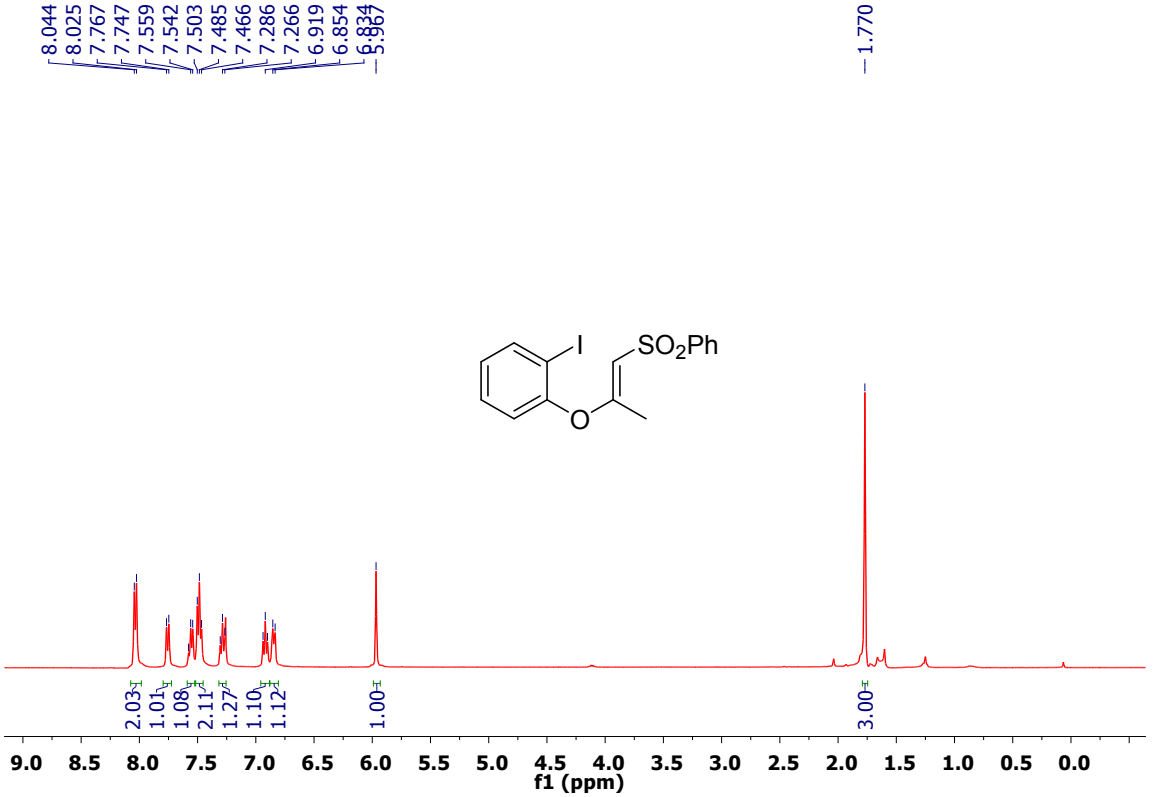

8.065
8.051
8.043
8.029
7.972
7.968
7.947
7.942
7.787
7.767
7.698
7.678
7.289
7.268
7.247
7.110
7.105
7.088
7.083
7.066
7.061
2.932
2.393
2.368
Ts
F
N
Ts
0.99
1.02
2.04
2.06
4.24
1.10
3.00
2.98
3.09
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

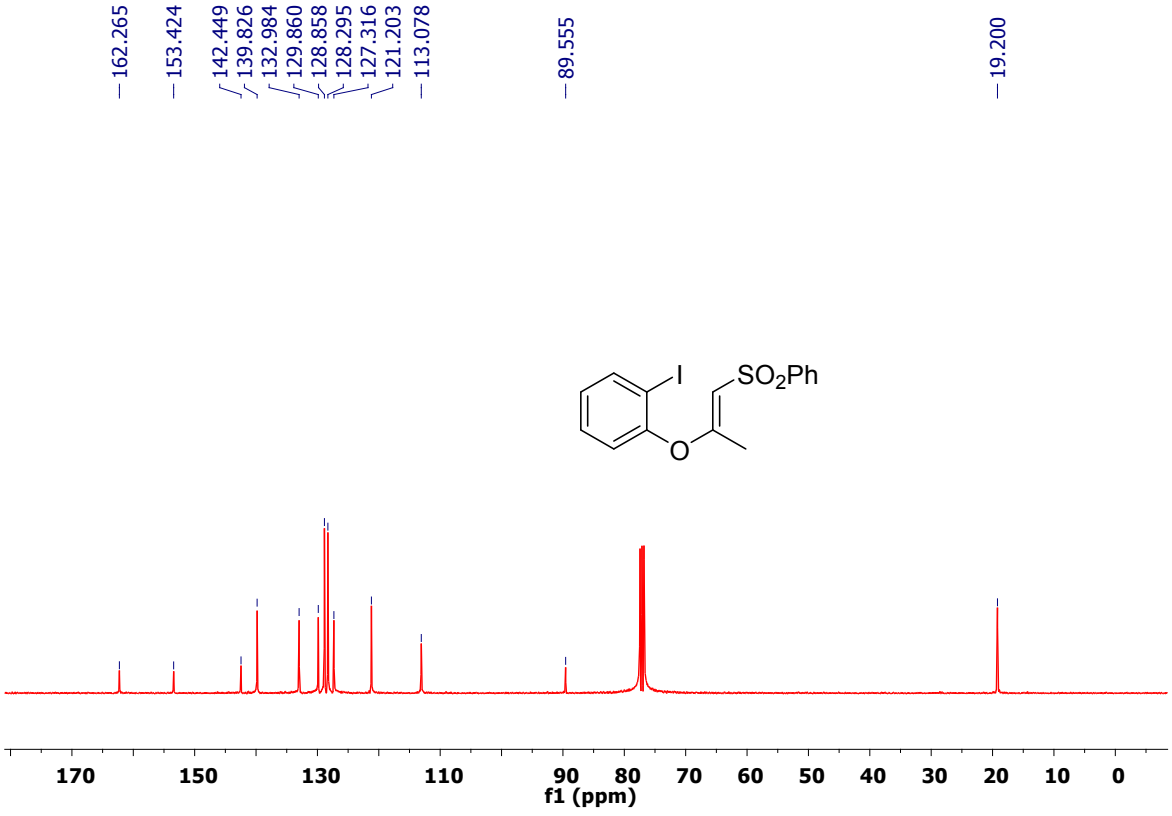

162.393
159.976
146.434
144.426
139.611
135.171
130.495
129.996
126.773
126.518
121.725
121.460
121.364
113.363
113.125
102.210
101.916
21.782
21.647
13.180
Ts
F
N
Ts
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

11a, $CDCl_3$

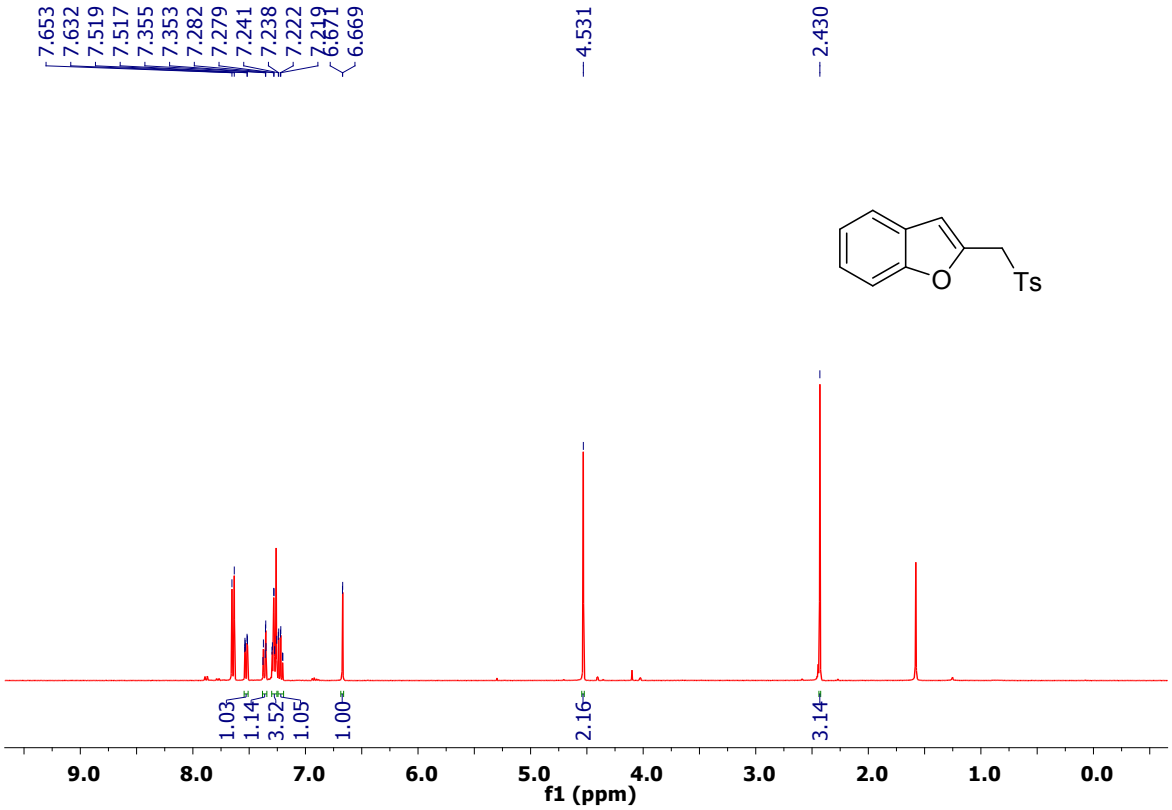

7.917
7.896
7.768
7.764
7.748
7.744
7.278
7.262
7.258
6.862
6.859
6.842
6.839
5.953
5.951
2.395
1.759
1.757
I
Ts
O
1.94
0.99
3.08
1.01
0.96
0.96
3.00
3.01
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
161.726
153.526
143.818
139.803
139.563
129.808
129.456
128.338
127.155
121.060
113.768
89.460
21.681
19.170
I
Ts
O
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

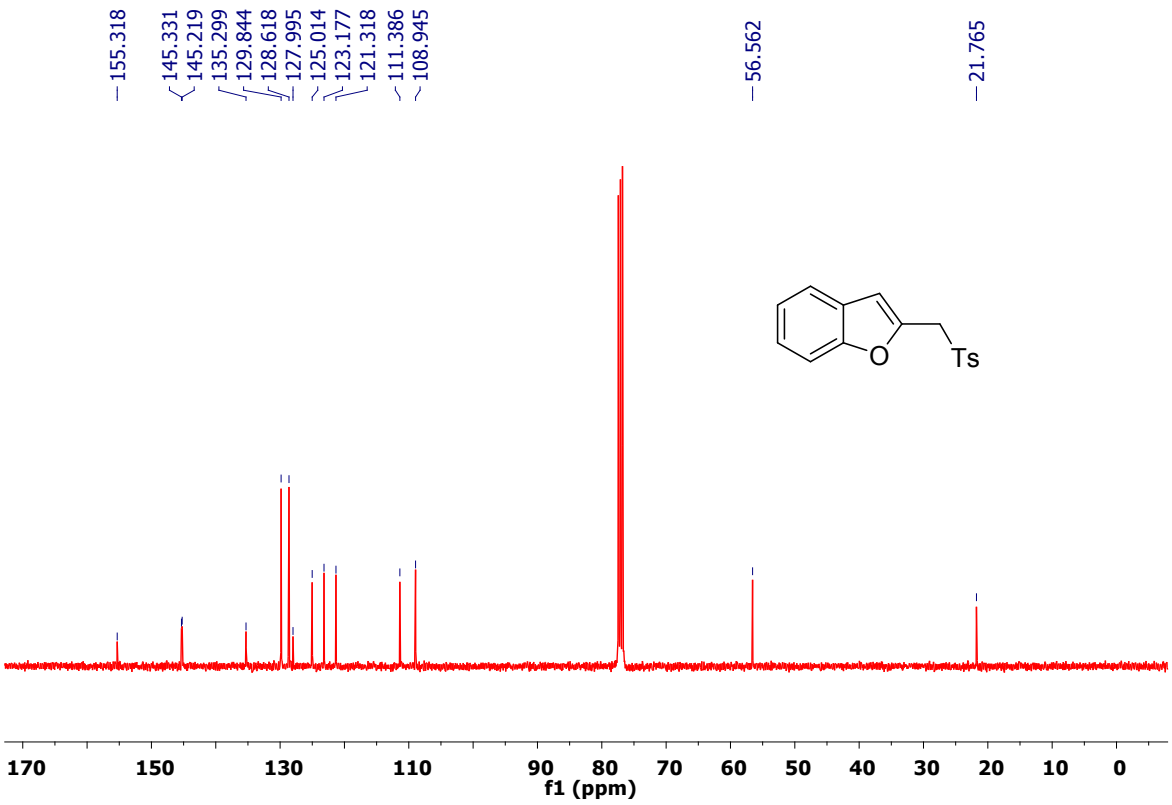
11b, **$CDCl_3$**


8.044
8.025
7.767
7.747
7.559
7.542
7.503
7.485
7.466
7.286
7.266
6.919
6.854
6.834
5.967
1.770
I
SO2Ph
O
2.03
1.01
1.08
2.11
1.27
1.10
1.12
1.00
3.00
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)

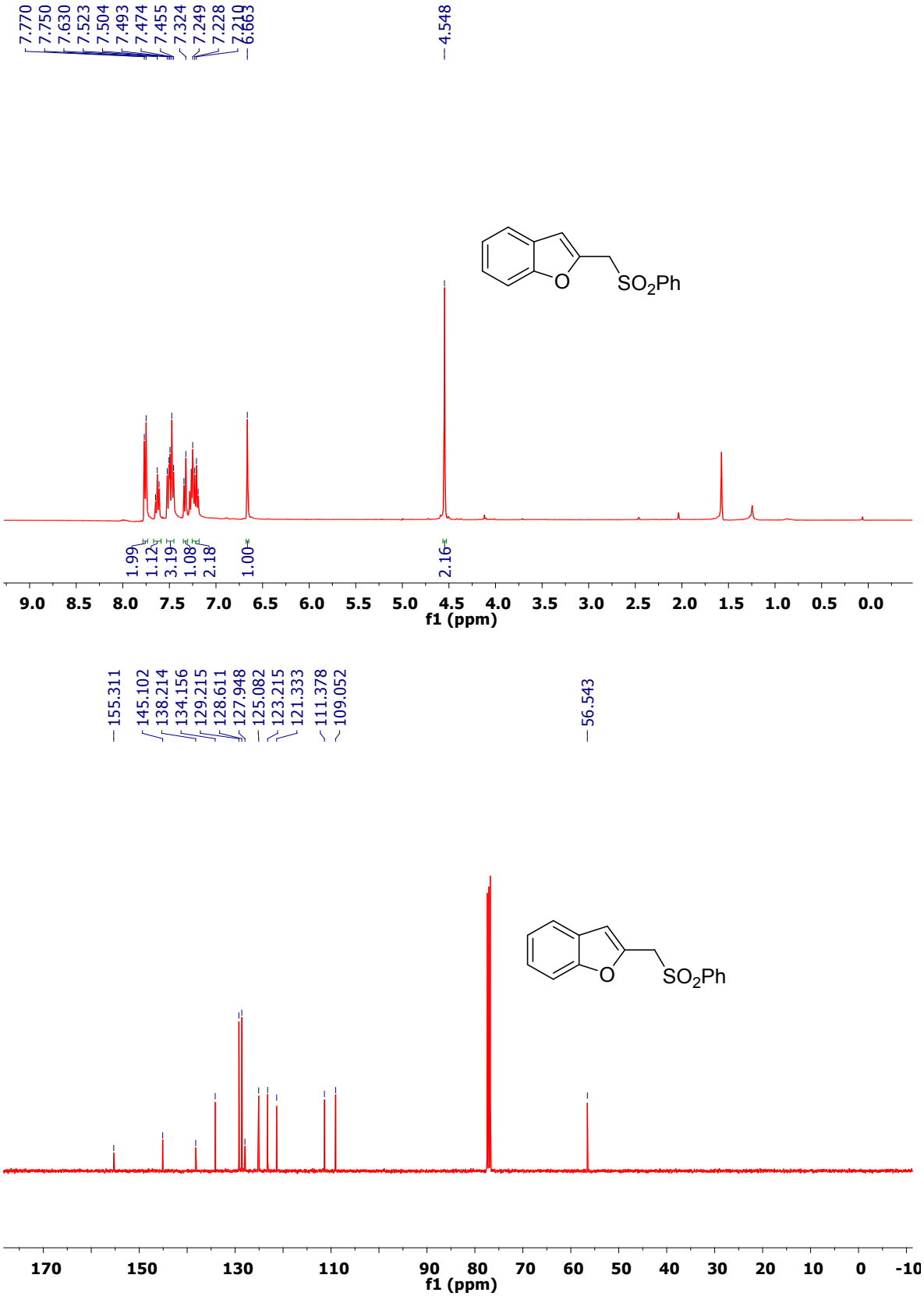

162.265
153.424
142.449
139.826
132.984
129.860
128.858
128.295
127.316
121.203
113.078
89.555
19.200
I
SO2Ph
O
170 150 130 110 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

12a, $CDCl_3$

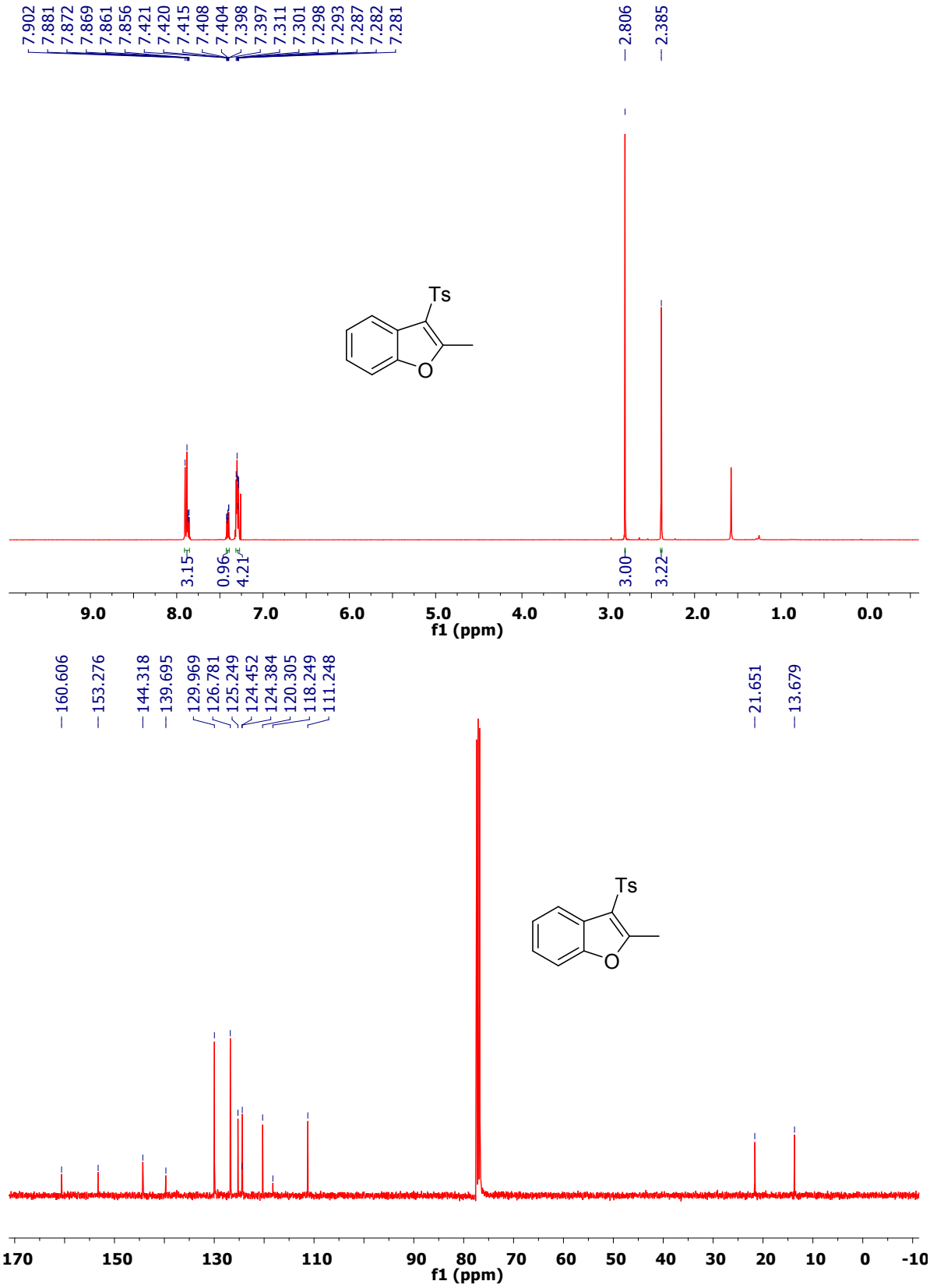

7.653
7.632
7.519
7.517
7.355
7.353
7.282
7.279
7.241
7.238
7.222
7.219
6.671
6.669
4.531
2.430
O
Ts
1.03
1.14
3.52
1.05
1.00
2.16
3.14
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)


155.318
145.331
145.219
135.299
129.844
128.618
127.995
125.014
123.177
121.318
111.386
108.945
56.562
21.765
O
Ts
170
150
130
110
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

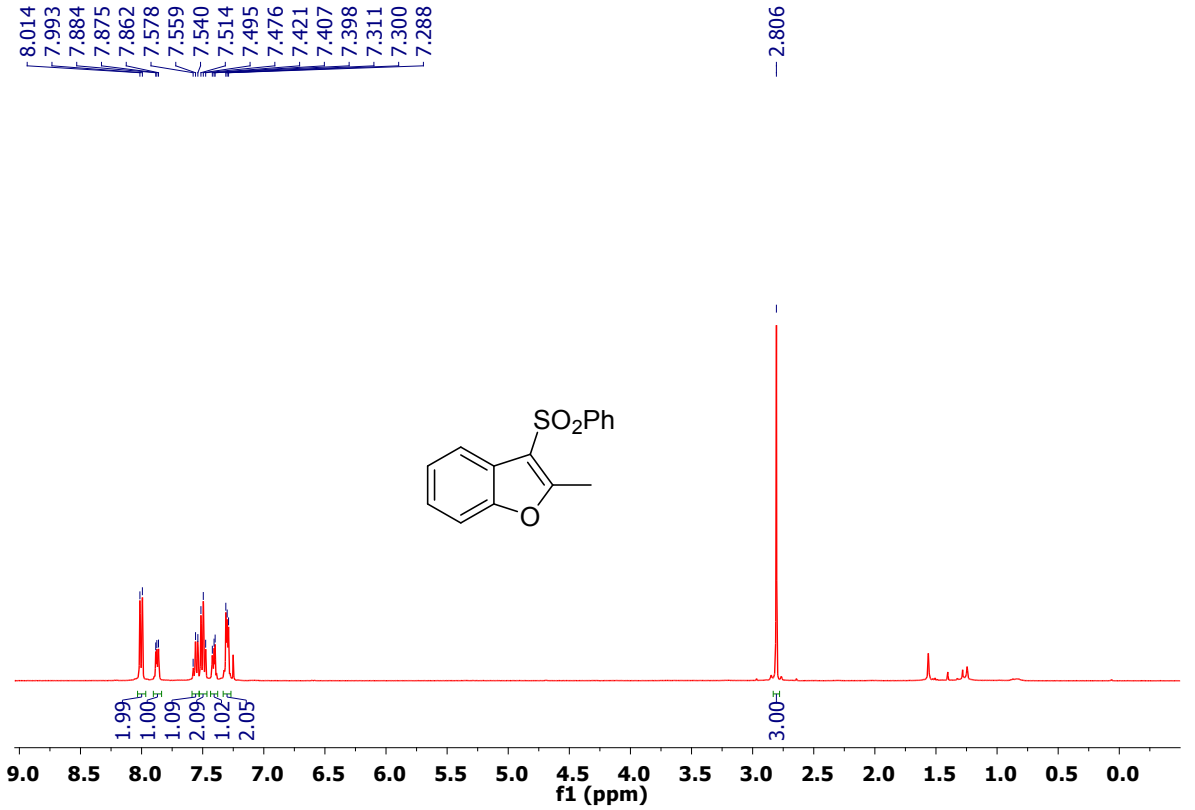
12b, $CDCl_3$

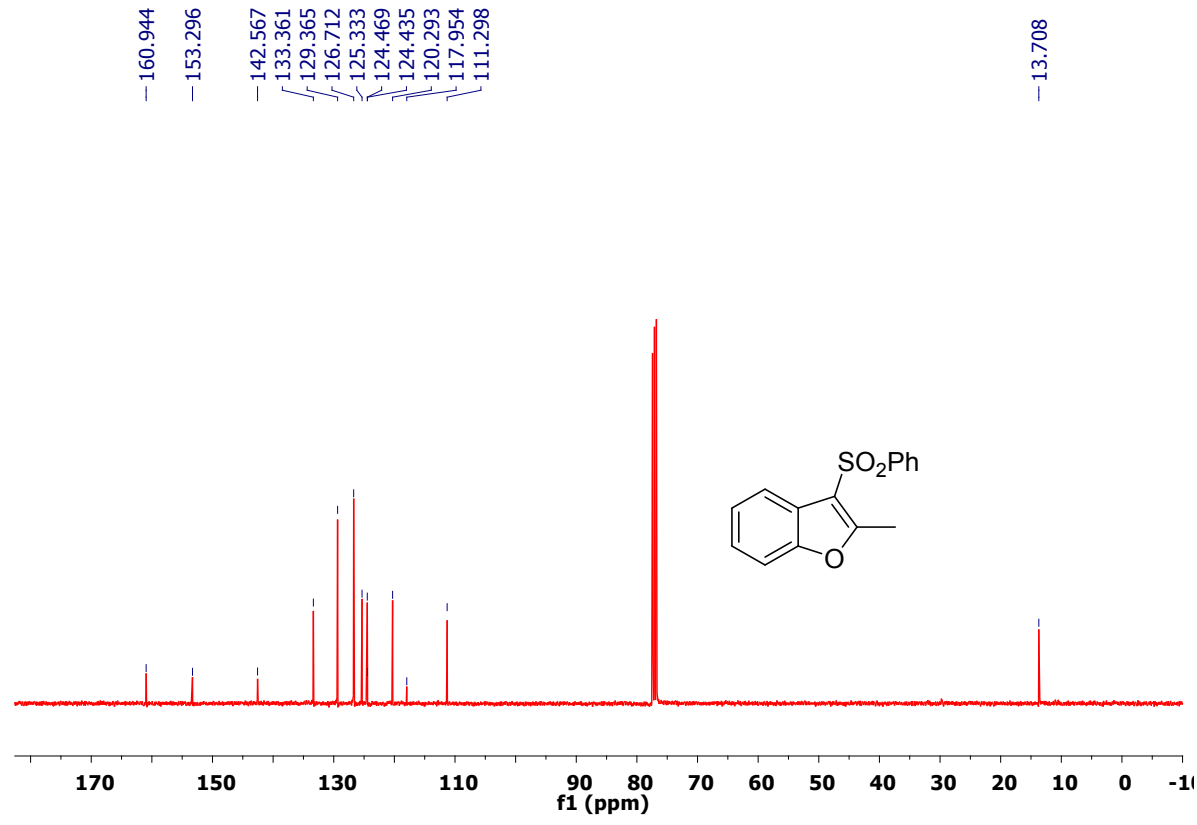

7.770
7.750
7.630
7.523
7.504
7.493
7.474
7.455
7.324
7.249
7.228
7.219
6.663
4.548
O
SO2Ph
1.99
1.12
3.19
1.08
2.18
1.00
2.16
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
155.311
145.102
138.214
134.156
129.215
128.611
127.948
125.082
123.215
121.333
111.378
109.052
56.543
O
SO2Ph
170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

13a, $CDCl_3$

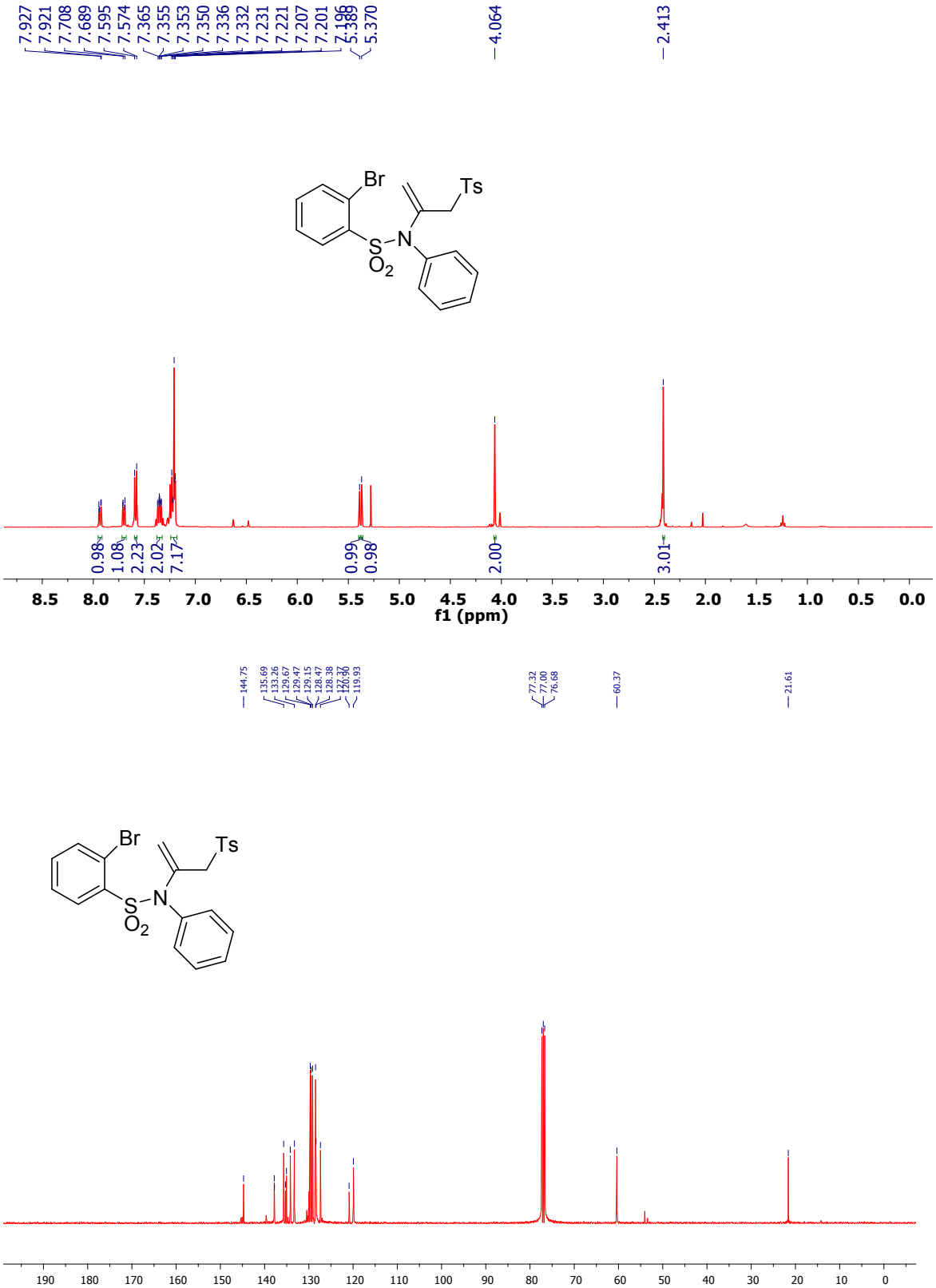

7.902
7.881
7.872
7.869
7.861
7.856
7.421
7.420
7.415
7.408
7.404
7.398
7.397
7.311
7.301
7.298
7.293
7.287
7.282
7.281
2.806
2.385
Ts
O
3.15
0.96
4.21
3.00
3.22
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)
160.606
153.276
144.318
139.695
129.969
126.781
125.249
124.452
124.384
120.305
118.249
111.248
21.651
13.679
Ts
O
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

13b, $CDCl_3$

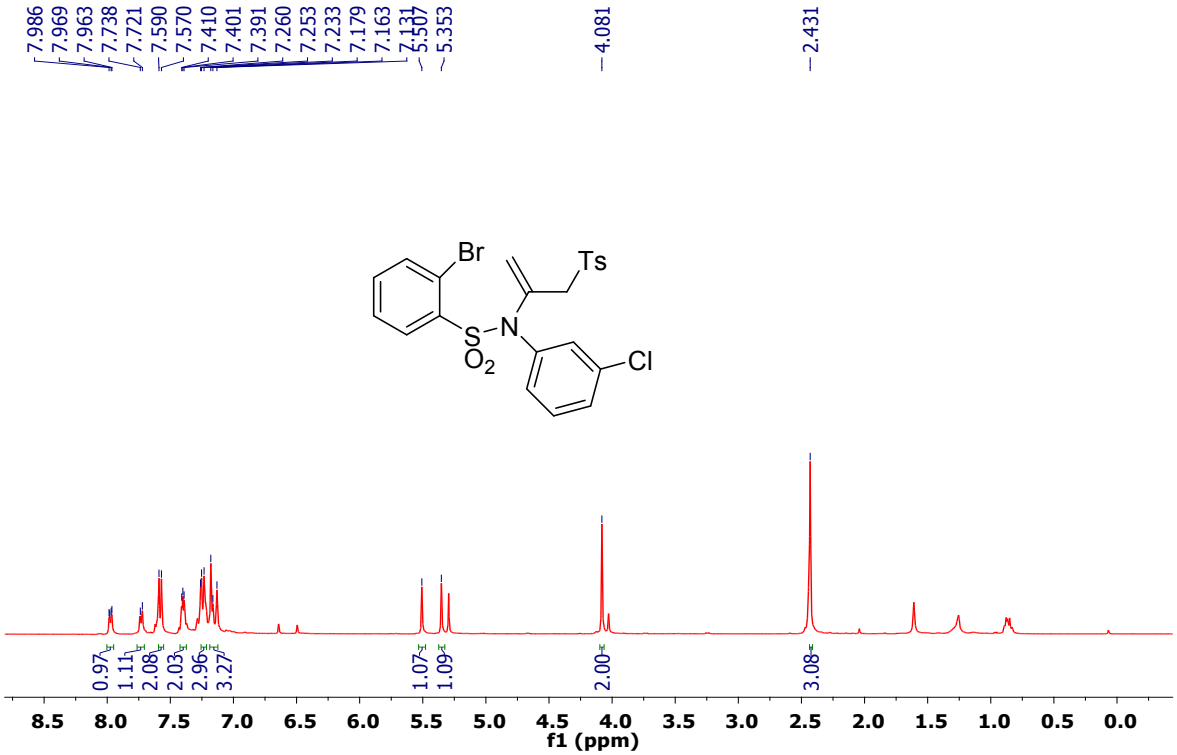

8.014
7.993
7.884
7.875
7.862
7.578
7.559
7.540
7.514
7.495
7.476
7.421
7.407
7.398
7.311
7.300
7.288
2.806
SO2Ph
O
1.99
1.00
1.09
2.09
1.02
2.05
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

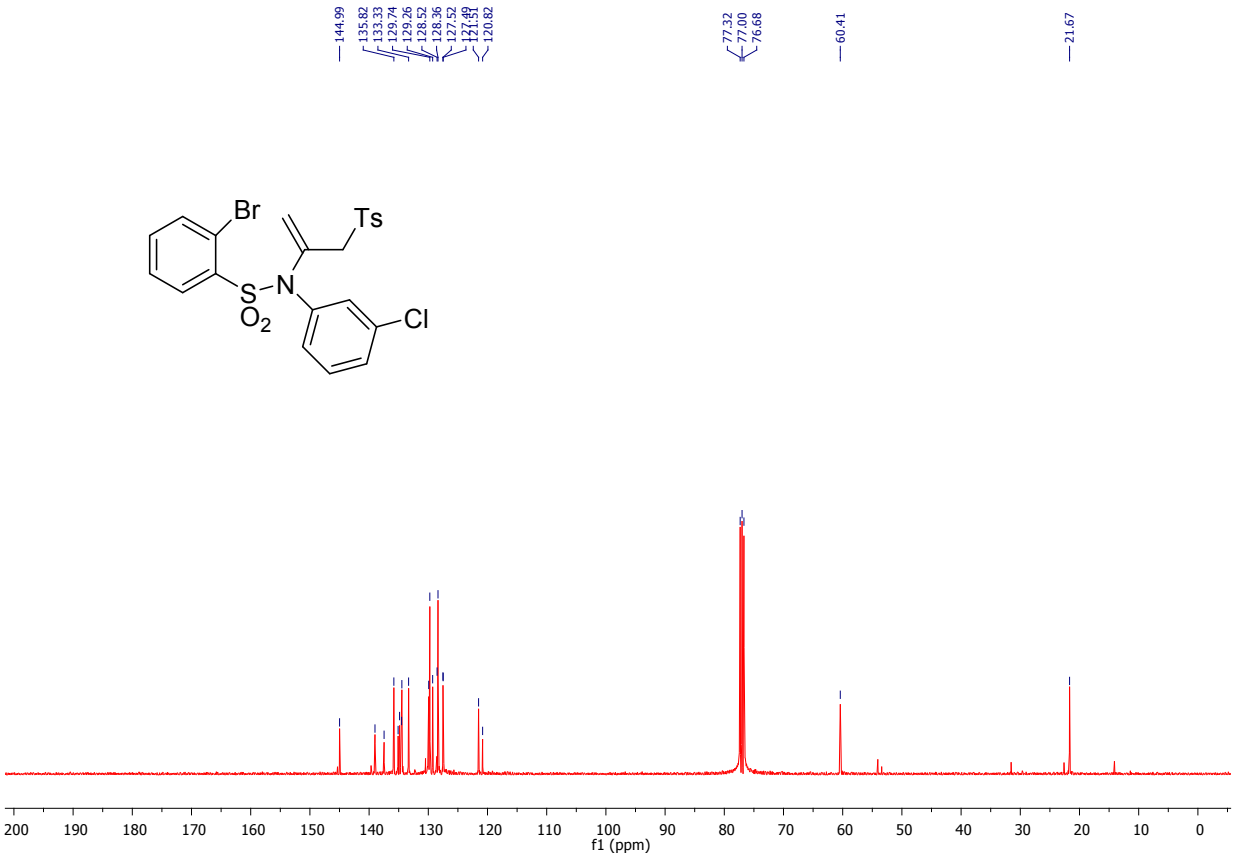

160.944
153.296
142.567
133.361
129.365
126.712
125.333
124.469
124.435
120.293
117.954
111.298
13.708
SO2Ph
O
170 150 130 110 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)

15a, $CDCl_3$

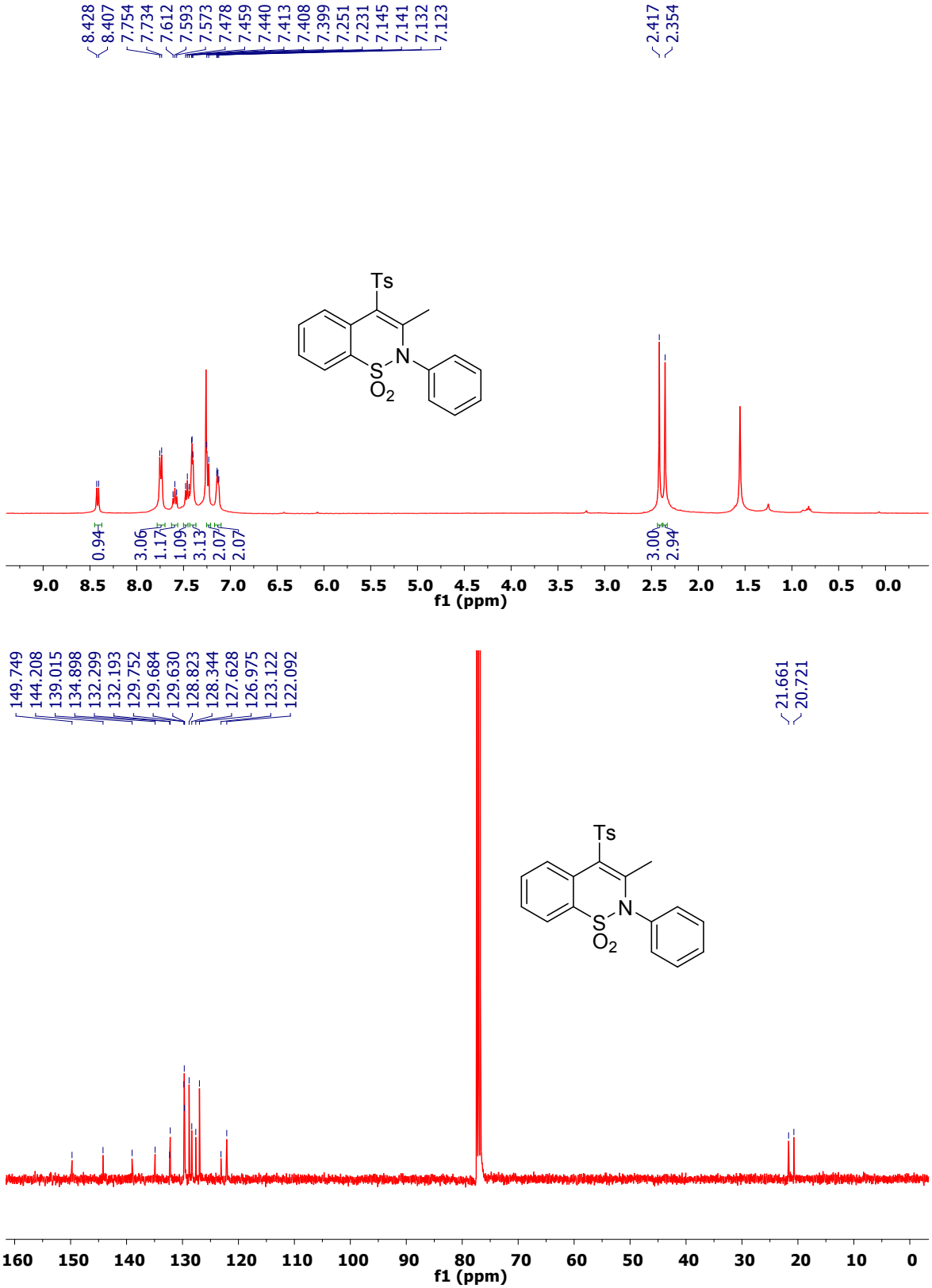

7.927
7.921
7.708
7.689
7.595
7.574
7.365
7.355
7.353
7.350
7.336
7.332
7.231
7.221
7.207
7.201
5.389
5.370
4.064
2.413
Br
Ts
S
N
O2
0.98
1.08
2.23
2.02
7.17
0.99
0.98
2.00
3.01
f1 (ppm)
144.75
135.69
133.26
129.67
129.47
129.15
128.47
128.38
127.27
120.96
119.93
77.32
77.00
76.68
60.37
21.61

15b, $CDCl_3$

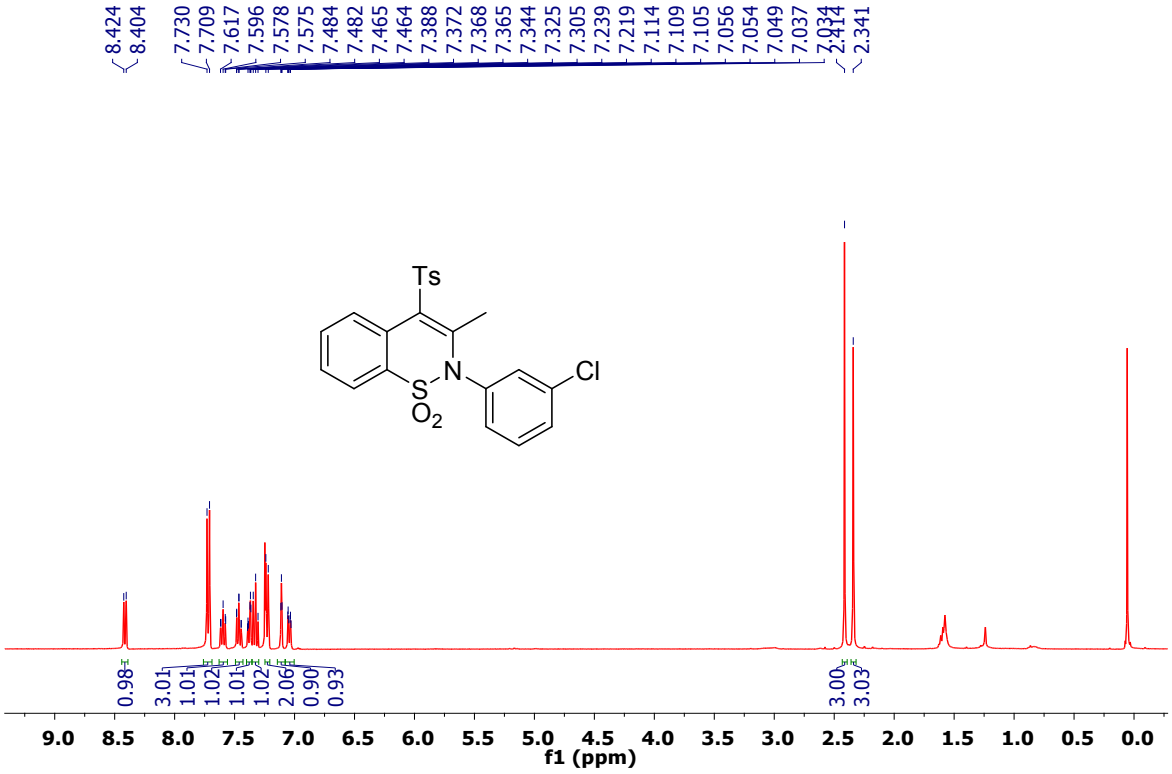

7.986
7.969
7.963
7.738
7.721
7.590
7.570
7.410
7.401
7.391
7.260
7.253
7.233
7.179
7.163
5.507
5.353
4.081
2.431
Br
Ts
S
N
O2
Cl
0.97
1.11
2.08
2.03
2.96
3.27
1.07
1.09
2.00
3.08
f1 (ppm)

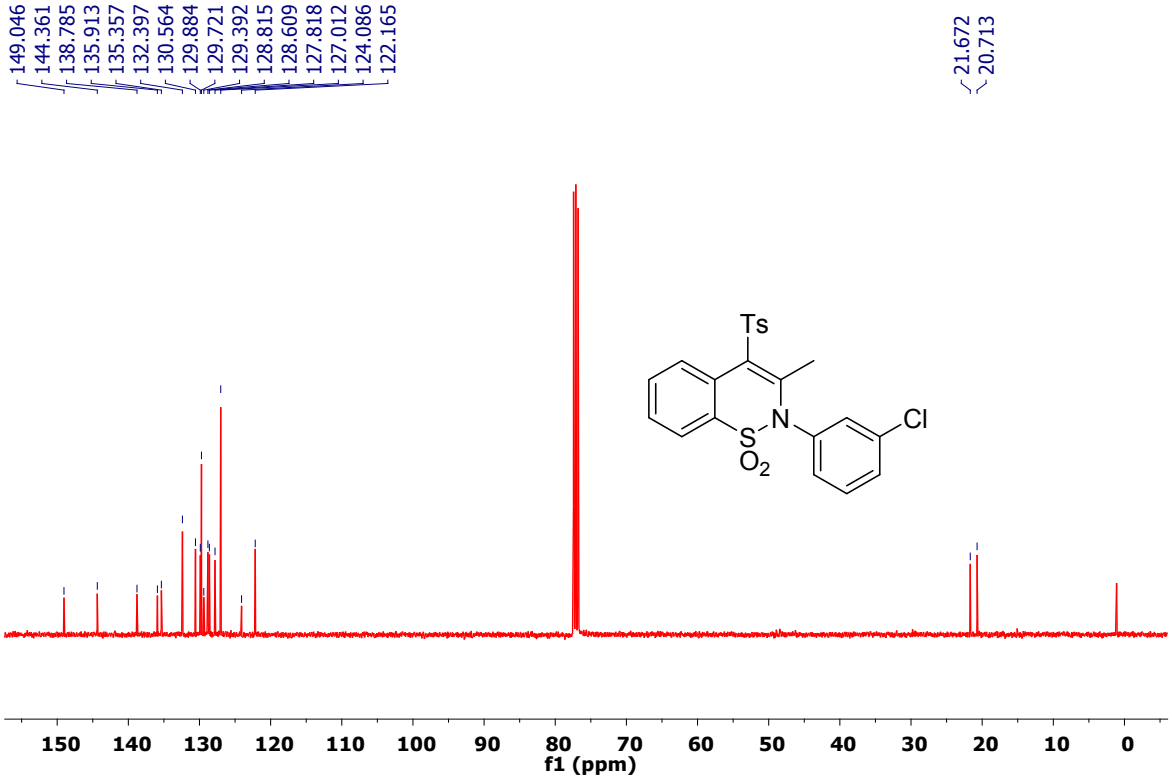

144.99
135.82
133.33
129.74
129.26
128.52
128.36
127.52
127.49
121.51
120.82
77.32
77.00
76.68
60.41
21.67
Br
Ts
S
N
O2
Cl
f1 (ppm)

16a, $CDCl_3$


8.428
8.407
7.754
7.734
7.612
7.593
7.573
7.478
7.459
7.440
7.413
7.408
7.399
7.251
7.231
7.145
7.141
7.132
7.123
2.417
2.354
Ts
N
S
O2
0.94
3.06
1.17
1.09
3.13
2.07
2.07
3.00
2.94
f1 (ppm)
149.749
144.208
139.015
134.898
132.299
132.193
129.752
129.684
129.630
128.823
128.344
127.628
126.975
123.122
122.092
21.661
20.721
Ts
N
S
O2
f1 (ppm)

16b, $CDCl_3$


8.424
8.404
7.730
7.709
7.617
7.596
7.578
7.575
7.484
7.482
7.465
7.464
7.388
7.372
7.368
7.365
7.344
7.325
7.305
7.239
7.219
7.114
7.109
7.105
7.056
7.054
7.049
7.037
2.414
2.341
Ts
N
S
O2
Cl
0.98
3.01
1.01
1.02
1.01
1.02
2.06
0.90
0.93
3.00
3.03
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)


149.046
144.361
138.785
135.913
135.357
132.397
130.564
129.884
129.721
129.392
128.815
128.609
127.818
127.012
124.086
122.165
21.672
20.713
Ts
N
S
O2
Cl
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)