Electronic Supplementary Information

Facile Synthesis of Substituted 3-Aminofurans Through Tandem Reaction of N-Sulfonyl-1,2,3-triazoles and Propargyl Alcohols

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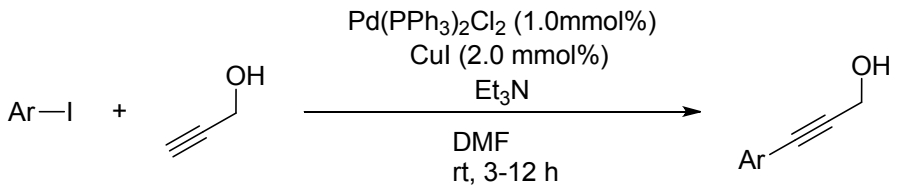
1. General information

Unless otherwise noted, all reactions were carried out under an Argon atmosphere underanhydrous conditions and all reagents were purchased from commercial suppliers without further purification. All solvents were distilled from appropriate drying agents prior to use.Reaction progress was monitored by thin layer chromatography (TLC) and components were visualized by observation under UV light at 254nm. Flash column chromatography was performed using silica gel 60 (200-300 mesh).

All ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra were given on Bruker AV-III 400 in $CDCl_3$. Chemical shifts were reported in parts per million (ppm, δ), referenced to the peak oftetramethylsilane,defined at δ = 0.00 (^{1}HNMR), or the solvent peak of $CDCl_3$, defined at δ = 77.0 (^{13}CNMR). Data are reported as follows: chemical shift, multiplicity (s = single, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet), coupling constants were quoted in Hz (*J*). Splitting patterns that could not be interpreted or easily visualized were designated as multiplet (m) or broad (br). Pressed KBr disks for infrared spectra were recorded using a Bruker-VERTEX 70 FT-IR spectrometer. Wavelengths (ν) are reported in cm^{-1}. Melting points were recorded using a SGW Melting Point thermometer (X-4).High-resolution mass spectra were obtained using a Thermo Fisher ScientificLTQ FT Ultra.

2. Synthesis

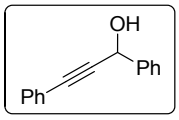
2.1 Preparation and Spectral Data of Propargyl Alcohols



Under an inert gas, to a solution of the appropriate aryl iodide (6.00 mmol) in 10

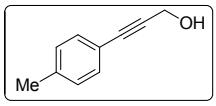
mL of DMF, 10 mL of TEA, propargylic alcohol (9.00 mmol, 1.5 eq), copper iodide (0.12 mmol, 0.02 eq) and $PdCl_2$ $(PPh_3)_2$ (0.06 mmol, 0.01 eq) were added, then the reaction was stirred at room temperature. After completion of the reaction as indicated by TLC, the reaction mixture was filtered through celite and the eluent was concentrated in vacuo and the raw product was purified by column chromatography on silica gel in 81-99% yield as a white solid or a colorless oil.[1]

1,3-diphenylprop-2-yn-1-ol (1a)



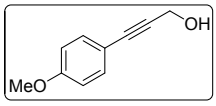
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.61 (d, J =7.2 Hz, 2H), 7.48-7.46 (m, 2H), 7.40 (t, J =7.2 Hz, 2H), 7.36-7.30 (m, 4H), 5.68 (s, 1H), 2.45 (s, 1H); ^{13}CNMR (100 MHz, $CDCl_3$) δ = 140.6, 131.7, 128.63, 128.57, 128.4, 128.3, 126.7, 122.4, 88.7, 86.6, 65.1.

3-(p-tolyl)prop-2-yn-1-ol (1m)



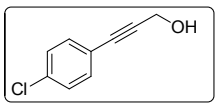
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.33 (d, *J* =7.6 Hz, 2H), 7.11 (d, *J* = 8.0 Hz, 2H), 4.49(d, *J* = 3.6 Hz, 2H), 2.34 (s, 3H), 2.02-1.98 (m, 1H); ^{13}CNMR (100 MHz, $CDCl_3$) δ = 138.6, 131.5, 129.0, 119.4, 86.5, 85.8, 51.6, 21.4.

3-(4-methoxyphenyl)prop-2-yn-1-ol (1n)



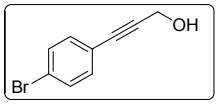
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.37 (d, *J* =8.0 Hz, 2H), 6.83 (d, *J* =8.0 Hz, 2H), 4.48 (s, 2H), 3.80 (s, 3H), 2.07 (s, 1H); ^{13}CNMR (100 MHz, $CDCl_3$) δ = 159.7, 133.1, 114.6, 113.9, 85.9, 85.6, 55.2, 51.6.

3-(4-chlorophenyl)prop-2-yn-1-ol (1o)



^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.35 (d, *J* =8.4 Hz, 2H), 7.27 (d, *J* =8.0 Hz, 2H), 4.49 (s, 2H), 2.28 (s, 1H); ^{13}CNMR (100 MHz, $CDCl_3$) δ = 134.5, 132.8, 128.6, 120.9, 88.1, 84.5, 51.4.

3-(4-bromophenyl)prop-2-yn-1-ol (1p)

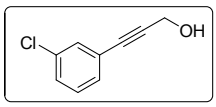


^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.35 (d, *J* =7.6 Hz, 2H), 7.19 (d, *J* =7.6 Hz, 2H), 4.40 (s, 2H), 2.32 (s, 1H); ^{13}CNMR (100 MHz,

[1] A. Pharma, S.A. *US6479476 B1*, 2002 .

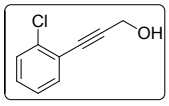
$CDCl_3$) δ = 133.0, 131.5, 122.7, 121.4, 88.3, 84.5, 51.4.

3-(3-chlorophenyl)prop-2-yn-1-ol (1q)



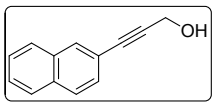
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.38 (s, 1H), 7.28-7.24 (m, 2H), 7.18 (d, *J* =8.0 Hz, 1H), 4.50 (s, 2H), 3.66(s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 133.9, 131.3, 129.6, 129.3, 128.5, 124.1, 88.3, 84.0, 51.0.

3-(2-chlorophenyl)prop-2-yn-1-ol (1r)



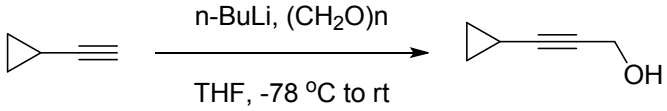
^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.44 (dd, *J* =7.2 Hz, 1.6 Hz, 1H), 7.34-7.32 (m, 1H), 7.18 (td, *J* =7.2 Hz, 1.6 Hz, 1H), 7.13 (td, *J* =7.2 Hz, 1.2Hz ,1H), 4.57(d, *J* = 4.4 Hz, 2H), 3.64 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 135.5, 133.3, 129.2, 128.9, 126.2, 122.2, 92.4, 81.9, 51.1.

3-(naphthalen-2-yl)prop-2-yn-1-ol (1s)



^{1}HNMR (400 MHz, $CDCl_3$) δ = 8.31 (d, *J* =8.4 Hz, 1H), 7.79 (t, *J* = 8.4 Hz, 2H), 7.64 (d, *J* =6.8 Hz, 1H), 7.53 (t, *J* =6.8 Hz, 1H), 7.47 (t, *J* =7.2 Hz, 1H), 7.36 (t, *J* = 7.6 Hz, 1H), 4.63 (s, 2H), 2.48 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 133.2, 133.0, 130.6, 128.9, 128.2, 126.7, 126.3, 126.0, 125.1, 120.1, 92.1, 83.6, 51.7.

3-cyclopropylprop-2-yn-1-ol (1v)[2]

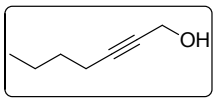


To a solution of cyclopropyl acetylene (5.0 g, 75.8 mmol) in THF (100 mL), at -78 ºC, was added n-BuLi (50 mL, 1.5 M in hexanes, 75 mmol) resulting in the formation of a thick white suspension which was warmed to room temperature over 1h. To the suspension was added paraformaldehyde (4.5 g, 152 mmol) and stirring continued at room temperature for 4h. The white suspension was quenched with 1N sodium bisulfate (200 mL) and the biphasic solution separated and the aqueous layer extracted with diethyl ether (2 × 100 mL). The combined diethyl ether extracts were dried

[2] I. B. Shredova, G. P. Okonnoshnikova, I. E. Dolgii, D. M. Nefedov, *J. Chem. Soc., Perkin Trans. 2,*1991, **12**, 1875.

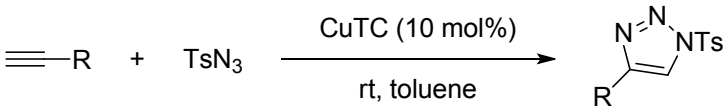
($MgSO_4$) and concentrated in vacuo and the raw product was purified by column chromatography on silica gelto afforded 3-cyclopropyl-prop-2-yn-1-ol (5.70 g, 78%) as a colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ = 4.21 (s, 2H), 3.22 (s, 1H), 1.29-1.24 (m, 1H), 0.80-0.75 (m, 2H), 0.71-0.68 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 89.0, 73.5, 50.7, 7.9, -0.8.

hept-2-yn-1-ol (1u)[3]



According to the general procedure described for **1v**. ^{1}H NMR (400 MHz, $CDCl_3$) δ = 4.18 (s, 2H), 2.15-2.13 (m, 2H), 2.08-1.93 (m, 1H), 1.44-1.31 (m, 4H), 0.86-0.82 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 86.4, 78.2, 51.2, 30.6, 21.8, 18.3, 13.5.

2.2 Preparation and Spectral Data of 1-Sulfonyl-1,2,3-triazoles



According to the procedure published by Fokin and co-workers:[4] A 50 mL of round bottom flask with a magnetic stir bar was added copper (I) thiophene-2-carboxylate (CuTC, 0.5 mmol, 0.1 eq in regards to alkyne), toluene (20 mL), and the alkyne (5 mmol, 1.0 eq). The reaction mixture was stirred at room temperature. Subsequently, the sulfonyl azide (5 mmol, 1.0 eq) was added slowly. After completion of the reaction as indicated by TLC, the reaction mixture was filtered through celite and the eluent was concentrated in vacuo and the residue was purified by column chromatography on silica gel (eluted with PE/EA = 8 :1) to give the 1-Sulfonyl-1,2,3-triazoles (**1a–k**).[5]

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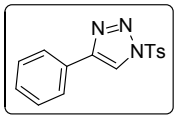
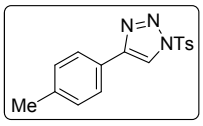
[3]J. G. Miller, A. C. Oehlshlager, *J. Org. Chem.*, 1984, **49**, 2332.
[4] J. Raushel, V. V. Forkin, *Org. Lett*., 2010, **12**, 4952.
[5] (a) E. J. Yoo, M. Ahlquist, S. H. Kim, I. Bae, V. V. Fokin, K. B. Sharpless, S. Chang, *Angew. Chem., Int. Ed*., 2007, **46**, 1730. (b) T. Miura, M.Yamauchi, M. Murakami, *Chem. Commun.,* 2009, 1470. (c) B. T. Parr, S. A. Green, H. M. L. Davies, *J. Am. Chem. Soc.,* 2013, **135**, 4716. (d) J. He, Z. Man, Y. Shi, C.-Y. Li,*J. Org. Chem.,* 2015 ,**80**, 4816.



4-phenyl-1-tosyl-1H-1,2,3-triazole (2a)

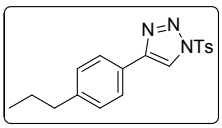
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.22 (s, 1H), 7.85 (d, *J* =8.4 Hz, 2H), 7.68 (d, *J* = 7.2 Hz, 2H), 7.27-7.17 (m, 5H), 2.24 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ =147.2, 132.8, 130.3, 128.9, 128.8, 128.7, 128.4, 125.8, 119.0, 21.5.

4-(p-tolyl)-1-tosyl-1H-1,2,3-triazole (2b)



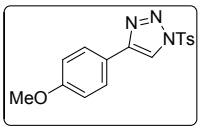
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.27 (s, 1H), 8.02(d, *J* =8.4 Hz, 2H), 7.71(d, *J* = 8.0 Hz, 2H), 7.38(d, *J* = 8.0 Hz, 2H), 7.23(d, *J* = 8.0 Hz, 2H), 2.44 (s, 3H), 2.37(s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.4, 147.3, 139.1, 133.1, 130.4, 129.6, 128.6, 126.0, 125.9, 118.5, 21.8, 21.3.

4-(4-propylphenyl)-1-tosyl-1H-1,2,3-triazole (2c)



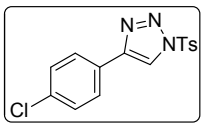
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.30 (s, 1H), 8.00(d, *J* =8.4 Hz, 2H), 7.73(d, *J* = 8.0 Hz, 2H), 7.35(d, *J* = 8.0 Hz, 2H), 7.22(d, *J* = 8.0 Hz, 2H), 2.61-2.57(m, 2H), 2.40 (s, 3H), 1.68-1.59(m, 2H), 0.94-0.91(m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.4, 147.2, 143.8, 133.0, 130.3, 129.0, 128.5, 126.2, 125.9, 118.5, 37.7, 24.3, 21.7, 13.6; IR (KBr) 3139, 1594, 1495, 1396, 1103, 996, 703, 675, 590 cm^{-1}. HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{18}H_{20}N_3O_2S$, 342.1276; found 342.1271.

4-(4-methoxyphenyl)-1-tosyl-1H-1,2,3-triazole (2d)



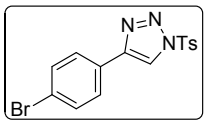
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.22 (s, 1H), 8.00(d, *J* =8.0 Hz, 2H), 7.74(d, *J* = 8.8 Hz, 2H), 7.36(d, *J* = 8.0 Hz, 2H), 6.94(d, *J* = 8.4 Hz, 2H), 3.82 (s, 3H),2.42 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.2, 147.22, 147.18, 133.1, 130.3, 128.5, 127.4, 121.4, 117.9, 114.3, 55.2, 21.7.

4-(4-chlorophenyl)-1-tosyl-1H-1,2,3-triazole (2e)



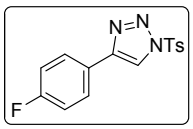
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.32 (s, 1H), 8.01(d, *J* =8.4 Hz, 2H), 7.76(d, *J* = 8.4 Hz, 2H), 7.40-7.37 (m, 4H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.5, 146.3, 134.9, 132.9, 130.5, 129.2, 128.7, 127.4, 127.3, 119.0, 21.8.

4-(4-bromophenyl)-1-tosyl-1H-1,2,3-triazole (2f)



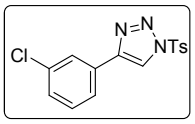
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.32 (s, 1H), 8.02(d, *J* =8.4 Hz, 2H), 7.70(d, *J* = 8.4 Hz, 2H), 7.55(d, *J* = 8.4 Hz, 2H), 7.39(d, *J* = 8.0 Hz, 2H), 2.45 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ= 147.5, 146.3, 132.9, 132.2, 130.5, 128.7, 127.9, 127.5, 123.1, 119.0, 21.8.

4-(4-fluorophenyl)-1-tosyl-1H-1,2,3-triazole (2g)



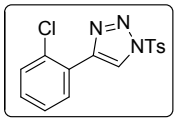
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.29 (s, 1H), 8.02(d,*J* =8.4 Hz,2H),7.82-7.78(m, 2H), 7.38(d, *J* =8.0 Hz, 2H),7.13-7.09 (m, 2H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 163.1 (d, $J_{C\text{-}F}$ = 247.4 Hz), 147.4, 146.4, 133.0, 130.4, 128.7.127.9 (d, $J_{C\text{-}F}$ = 8.3 Hz), 125.1 (d, $J_{C\text{-}F}$ = 3.3 Hz),118.7, 116.0 (d, $J_{C\text{-}F}$ = 21.8 Hz), 21.8.

4-(3-chlorophenyl)-1-tosyl-1H-1,2,3-triazole (2h)



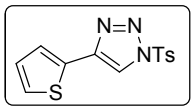
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.26 (s, 1H), 7.94(d, *J* =8.0 Hz, 2H),7.74 (s, 1H), 7.62(d, *J* = 6.8 Hz, 1H), 7.32-7.25 (m, 4H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.5, 146.0, 135.0, 132.9, 130.6, 130.5, 130.3, 129.1, 128.7, 126.1, 124.1, 119.4, 21.8.

4-(2-chlorophenyl)-1-tosyl-1H-1,2,3-triazole (2i)



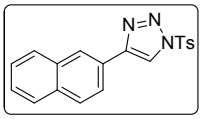
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.66 (s, 1H), 8.11(d, *J* =7.2 Hz, 1H), 7.95 (d, *J* =8.0 Hz, 2H), 7.36(d, *J* = 7.6 Hz, 1H), 7.31(d, *J* = 8.4 Hz, 2H), 7.27-7.18 (m, 2H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.4, 143.5, 133.0, 131.5, 130.4, 130.3, 130.0, 129.8, 128.7, 127.6, 127.2, 122.4, 21.8.

4-(thiophen-2-yl)-1-tosyl-1H-1,2,3-triazole (2j)



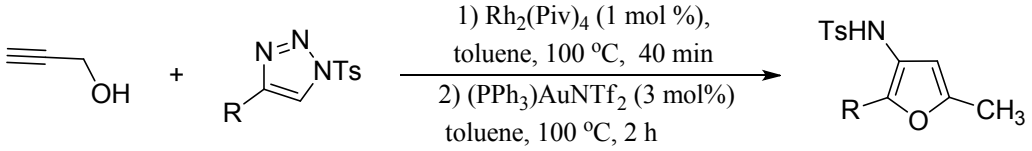
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.20 (s, 1H), 8.02(d, *J* =8.4 Hz, 2H), 7.44(dd, *J* = 3.6 Hz, 1.2 Hz, 1H), 7.39(d, *J* =8.4 Hz, 2H), 7.34(dd, *J* = 4.8 Hz, 1.2Hz, 1H), 7.08(dd, *J* = 4.8 Hz, 3.6Hz, 1H), 2.45 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ =147.4, 142.5, 132.9, 130.8, 130.4, 128.7, 127.8, 126.3, 125.6, 118.1, 21.8.

4-(naphthalen-2-yl)-1-tosyl-1H-1,2,3-triazole (2k)



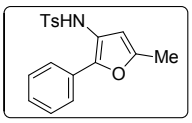
^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.43 (s, 1H), 8.36 (s, 1H), 8.05(d, *J* =8.4 Hz, 2H), 7.88-7.82 (m, 4H), 7.51-7.49(m, 2H),7.38 (d,*J* =8.0 Hz, 2H), 2.43 (s,3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.4, 147.3, 133.4, 133.3, 133.0, 130.4, 128.8, 128.7, 128.3, 127.8, 126.7, 126.6, 126.1, 125.2, 123.6, 119.2, 21.8.

2.3 General Procedure and Spectral Data of Products



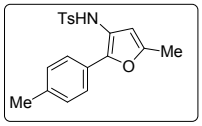
1-Sulfonyl-1,2,3-triazoles (0.50 mmol, 1.0 eq), 2-propyn-1-ol (0.75 mmol, 1.5 eq), $Rh_2(OCOtBu)_4$ (3.0 mg, 5.0 μmol, 1 mol%), and toluene (2.5 mL) were added to an oven-dried 10 mL pressure tube equipped with a stirrer bar in the Glove-box. The tube was sealed with a Teflon pressure cap. The mixture was heated at 100 °C for 40 min. After the resulting mixture was cooled, $(PPh_3)AuNTf_2$ (11.1 mg, 15 μmol, 3 mol%) was added. The reaction mixture was stirred at 100 °C for 2 h, and it was concentrated under reduced pressure. The resulting residue was purified by flash chromatography (petroleum ether /ethyl acetate 7:1) to give the trisubstituted furans as a white solid or colourless oil.

4-methyl-N-(5-methyl-2-phenylfuran-3-yl)benzenesulfonamide (5a)



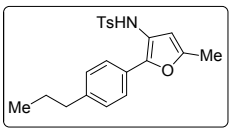
Compound **5a** was obtained as a white solid in 82% isolated yield, R_f = 0.35 (petroleum ether : ethyl acetate = 5 : 1); mp = 149-150 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.66 (d, *J* = 8.4 Hz, 2H), 7.38 (d, *J* = 7.2 Hz, 2H), 7.27-7.17 (m, 5H), 6.23 (s, 1H), 6.02 (s, 1H), 2.35 (s, 3H), 2.27 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.8, 144.7, 143.9, 136.2, 129.6, 129.4, 128.5, 127.4, 127.3, 124.7, 118.3, 107.4, 21.5, 13.8;IR (KBr) 3227, 1494, 1241, 906, 843, 769, 534, 489cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{18}H_{18}NO_3S$, 328.1007; found 328.1001.

4-methyl-N-(5-methyl-2-(p-tolyl)furan-3-yl)benzenesulfonamide (5b)



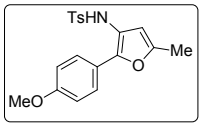
Compound **5b** was obtained as a white solid in 80% isolated yield, R_f = 0.44 (petroleum ether : ethyl acetate = 5 : 1); mp = 124-125ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.55 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.04 (d, *J* = 8.0 Hz, 2H) , 6.93 (d, *J* = 8.0 Hz, 2H), 6.45 (s, 1H), 5.84 (s, 1H), 2.22 (s, 3H), 2.18 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.1, 145.3, 143.6, 137.1, 136.2, 129.4, 129.0, 127.2, 126.6, 124.6, 117.4, 107.4, 21.3, 21.1, 13.7; IR (KBr) 3226, 2925, 1327, 1161, 1094, 900, 824, 716, 691, 665 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{19}H_{20}NO_3S$, 342.1164; found 342.1157.

4-methyl-N-(5-methyl-2-(4-propylphenyl)furan-3-yl)benzenesulfonamide (5c)



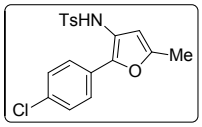
Compound **5c** was obtained as a white solid in 78% isolated yield, R_f = 0.53 (petroleum ether : ethyl acetate = 5 : 1); mp = 127-129 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.57 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.07 (d, *J* = 8.4 Hz, 2H) , 6.96 (d, *J* = 8.0 Hz, 2H), 6.32 (s, 1H), 5.89 (s, 1H), 2.44 (t, *J* = 7.6 Hz, 2H), 2.25 (s, 3H), 2.16 (s, 3H), 1.56-1.47 (m, 2H), 0.83 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.3, 145.2, 143.7, 142.0, 136.2, 129.4, 128.5, 127.2, 126.9, 124.6, 117.5, 107.4, 37.7, 24.3, 21.4, 13.72, 13.69;IR (KBr) 3215, 2953, 2918, 2858, 1330, 1153, 1093, 824, 697, 662, 530 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{21}H_{24}NO_3S$, 370.1477; found 370.1472.

N-(2-(4-methoxyphenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5d)



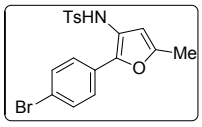
Compound **5d** was obtained as a white solid in 72% isolated yield, R_f = 0.30 (petroleum ether : ethyl acetate = 5 : 1); mp = 122-123ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.65 (d, *J* = 8.0 Hz, 2H), 7.36 (d, *J* = 8.8 Hz, 2H), 7.17 (d, *J* = 8.0 Hz, 2H) , 6.77 (d, *J* = 8.8 Hz, 2H), 6.33 (s, 1H), 5.90 (d,J = 0.8 Hz, 1H), 3.77 (s, 3H), 2.35 (s, 3H), 2.24 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.9, 149.9, 145.6, 143.7, 136.3, 129.4, 127.3, 126.3, 122.3, 116.6, 113.9, 107.4, 55.2, 21.4, 13.7; IR (KBr) 3251, 1508, 1326, 1300, 1250, 1180, 1162, 690 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{19}H_{20}NO_4S$, 358.1113; found 358.1108.

N-(2-(4-chlorophenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5e)



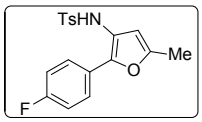
Compound **5e** was obtained as a white solid in 71% isolated yield, R_f = 0.44 (petroleum ether : ethyl acetate = 5 : 1); mp = 159-160 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.58 (d, *J* = 8.4 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 7.14-7.11 (m, 4H) , 6.09 (s, 1H), 5.86 (s, 1H), 2.31 (s, 3H), 2.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 151.1, 144.7, 144.1, 136.2, 133.1, 129.6, 128.6, 127.9, 127.3, 125.9, 118.4, 108.0, 21.5, 13.8; IR (KBr) 3260, 1556, 1488, 1329, 1161, 1092, 890, 737, 689, 597, 536 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{18}H_{17}ClNO_3S$, 362.0618; found 362.0611.

N-(2-(4-bromophenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5f)



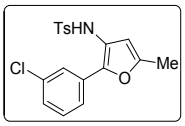
Compound **5f** was obtained as a white solid in 75% isolated yield, R_f = 0.44 (petroleum ether : ethyl acetate = 5 : 1); mp = 154-155 ºC; ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.55 (d, *J* = 8.0 Hz, 2H), 7.29-7.23 (m, 4H), 7.07 (d, *J* = 8.0 Hz, 2H) , 6.56 (s, 1H), 5.80 (s, 1H), 2.27 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 151.0, 144.8, 144.0, 136.2, 131.4, 129.5, 128.3, 127.2, 126.1, 121.0, 118.4, 108.1, 21.5, 13.7;IR (KBr) 3262, 1485, 1329, 1160, 724, 685, 534 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{18}H_{17}BrNO_3S$, 406.0113; found 406.0107.

N-(2-(4-fluorophenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5g)



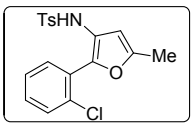
Compound **5g** was obtained as a white solid in 80% isolated yield, R_f = 0.41 (petroleum ether : ethyl acetate = 5 : 1); mp = 146-147 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.56 (d, *J* = 8.0 Hz, 2H), 7.40-7.36 (m, 2H), 7.08 (d, *J* = 8.0 Hz, 2H) , 6.83 (t, *J* = 8.8 Hz,2H), 6.50 (s, 1H),5.77 (d, *J* = 0.8 Hz ,1H), 2.26 (s, 3H), 2.15 (s, 3H);^{13}C NMR (100 MHz, $CDCl_3$) δ = 161.9 (d, J_{C-F} = 246.1 Hz), 150.5, 145.1143.9, 136.2, 129.5, 127.3, 126.7 (d, J_{C-F} = 8.0 Hz), 125.7 (d, J_{C-F} = 3.3 Hz), 117.5, 115.3 (d, J_{C-F} = 21.6 Hz), 107.8, 21.4, 13.7;^{19}F NMR (376 MHz, $CDCl_3$) δ = -113.5; IR (KBr) 3239, 1505, 1329, 1217, 1161, 1091, 839, 560 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{18}H_{17}FNO_3S$, 346.0913; found 346.0906.

N-(2-(3-chlorophenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5h)



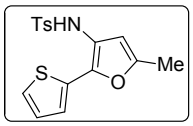
Compound **5h** was obtained as a white solid in 70% isolated yield, R_f = 0.46 (petroleum ether : ethyl acetate = 5 : 1); mp = 149-150 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.56 (d, *J* = 8.4 Hz, 2H), 7.29-7.23 (m, 2H), 7.09-7.02 (m, 4H) , 6.50 (s, 1H), 5.91 (d, *J* = 0.8 Hz, 1H), 2.25 (s, 3H), 2.18 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 151.3, 144.0, 143.9, 136.0, 134.3, 131.0, 129.62, 129.58, 127.2, 127.1, 124.4, 122.7, 119.0, 108.2, 21.4, 13.7; IR (KBr) 3243, 1595, 1556, 1406, 1326, 1158, 1091, 893, 573 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{18}H_{17}ClNO_3S$, 362.0618; found 362.0612.

N-(2-(2-chlorophenyl)-5-methylfuran-3-yl)-4-methylbenzenesulfonamide (5i)



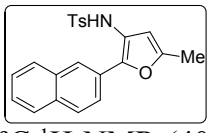
Compound **5i** was obtained as a colourless oil in 59% isolated yield, R_f = 0.48 (petroleum ether : ethyl acetate = 5 : 1); ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.43 (d, *J* = 8.0 Hz, 2H), 7.29 (dd, *J* = 8.0, 0.8 Hz, 1H),7.19 (td,*J* = 7.6, 1.6 Hz,1H) ,7.10 (td, *J* = 7.6, 0.8 Hz, 1H), 6.99 (d, *J* = 8.0 Hz, 2H), 6.92 (dd, *J* = 7.6, 1.6 Hz, 1H) , 6.38(s, 1H), 6.28(s, 1H),2.289 (s, 3H), 2.285 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 152.3, 143.4, 141.3, 135.4, 131.3, 130.8, 129.7, 129.4, 129.2, 128.2, 126.9, 126.5, 120.8, 107.0, 21.3, 13.8; IR (KBr) 3279, 1634, 1592, 1472, 1091, 1068, 814, 542 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{18}H_{17}ClNO_3S$, 362.0618; found 362.0612.

4-methyl-N-(5-methyl-2-(thiophen-2-yl)furan-3-yl)benzenesulfonamide (5j)

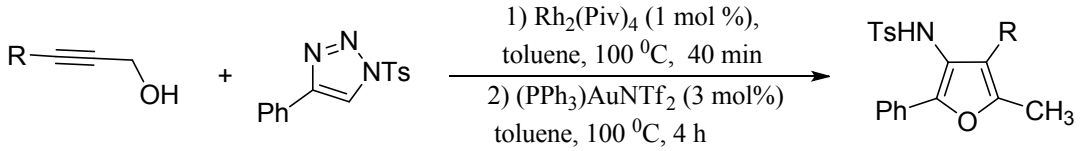


Compound **5j** was obtained as a white solid in 70% isolated yield, R_f = 0.35 (petroleum ether : ethyl acetate = 5 : 1); mp = 161-164 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.60 (d, *J* = 8.4 Hz, 2H), δ = 7.12 (d, *J* = 8.4 Hz, 2H),δ = 7.09 (d, *J* = 4.8 Hz, 1H), δ = 6.94 (d, *J* = 2.8 Hz, 1H), δ = 6.85 (dd, *J* = 4.8 Hz ,3.6 Hz, 1H), 6.23 (s, 1H), 5.96 (s, 1H), 2.28 (s, 3H), 2.18 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.8, 143.8, 140.9, 136.2, 130.8, 129.5, 127.3, 124.4, 123.2, 117.7, 107.0, 21.5, 13.8.;IR (KBr) 3215,1416,1329,1160,1092,981,893,718,691,665 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for$C_{16}H_{16}NO_3S_2$, 334.0572; found 334.0565.

4-methyl-N-(5-methyl-2-(naphthalen-2-yl)furan-3-yl)benzenesulfonamide (5k)

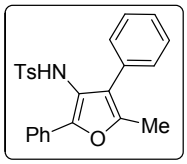


Compound **5k** was obtained as a white solid in 75% isolated yield, R_f = 0.40 (petroleum ether : ethyl acetate = 5 : 1); mp = 150-151 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.67-7.58 (m, 6H), δ = 7.47 (dd, *J* = 8.8, 1.6 Hz, 1H), δ = 7.38-7.33 (m, 2H), δ = 7.00 (d, *J* = 8.0 Hz, 2H), 6.33 (s, 1H), 6.03 (s, 1H), 2.24 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 151.1, 145.1, 143.9, 136.3, 133.1, 132.4, 129.5, 128.12, 128.08, 127.5, 127.2, 126.8, 126.3, 126.1, 123.3, 122.8, 118.6, 108.0, 21.3, 13.9; IR (KBr) 3280, 1321, 1161, 1093, 892, 822, 756, 694, 667, 567, 470 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{22}H_{20}NO_3S$, 378.1164; found 378.1157.



4-Phenyl-1-tosyl-1,2,3-triazole (0.55 mmol, 1.1 eq), propargyl alcohols (0.50 mmol, 1.0 eq), $Rh_2(OCOtBu)_4$ (3.0 mg, 5.0 μmol, 1 mol%), and toluene (2.5 mL) were added to an oven-dried 10 mL pressure tube equipped with a stirrer bar in the Glove-box. The tube was sealed with a Teflon pressure cap. The mixture was heated at 100 °C for 40 min. After the resulting mixture was cooled, $(PPh_3)AuNTf_2$ (11.1 mg, 15 μmol, 3 mol%) was added. The reaction mixture was stirred at 100 °C for 4h, and it was concentrated under reduced pressure. The resulting residue was purified by flash chromatography (petroleum ether /ethyl acetate 7:1) to give the tetrasubstituted furans as a white solid or colourless oil.

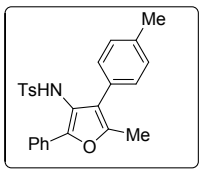
4-methyl-N-(5-methyl-2,4-diphenylfuran-3-yl)benzenesulfonamide (5l)



Compound **5l** was obtained as a yellow solid in 88% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1);mp = 153-154 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.82 (d, *J* = 7.6 Hz, 2H), 7.26-7.12 (m, 8H), 6.84-6.83 (m, 2H), 6.75 (d, *J* = 7.6 Hz, 2H), 6.33 (s, 1H), 2.20 (s, 3H), 2.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.1, 147.3, 143.0, 136.1, 131.0, 129.6, 129.0, 128.7, 128.3, 128.2, 127.5, 127.1, 126.6, 125.3, 122.0, 116.1, 21.4,

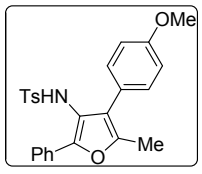
12.5;IR (KBr) 3247, 1495, 1428, 1333, 1162, 1093, 808, 763, 706, 666, 569cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for $C_{24}H_{22}NO_3S$, 404.1320; found 404.1312.

4-methyl-N-(5-methyl-2-phenyl-4-(p-tolyl)furan-3-yl)benzenesulfonamide (5m)



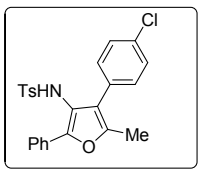
Compound **5m** was obtained as a yellow solid in 86% isolated yield, R_f= 0.52 (petroleum ether : ethyl acetate = 5 : 1); mp = 164-165 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.81 (d, *J* = 7.2 Hz, 2H), 7.25-7.13 (m, 5H), 6.93 (d, *J* = 7.6 Hz, 2H), 6.76-6.72 (m, 4H), 6.26 (s, 1H), 2.26 (s, 3H), 2.21 (s, 3H), 2.18(s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.0, 147.1, 143.0, 136.4, 129.7, 129.0, 128.9, 128.6, 128.2, 128.0, 127.5 127.1, 125.2, 121.9, 116.2, 21.4, 21.2, 12.5;IR (KBr) 3339, 1514, 1160, 963, 766, 692, 663, 565, 546 cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for$C_{25}H_{24}NO_3S$, 418.1477; found 418.1468.

N-(4-(4-methoxyphenyl)-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5n)



Compound **5n** was obtained as a white solid in 87% isolated yield, R_f = 0.30 (petroleum ether : ethyl acetate = 5 : 1); mp = 167-169 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.87 (d, *J* = 7.6 Hz, 2H), 7.32-7.28 (m, 4H), 7.22 (t, *J* = 7.2 Hz, 1H), 6.85 (d, J = 8.4 Hz, 4H), 6.73 (d, *J* = 8.4 Hz, 2H) , 6.44 (s, 1H), 3.80 (s, 3H), 2.29 (s, 3H), 2.25 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.5, 147.9, 147.0, 143.0, 136.5, 129.9, 129.7, 129.0, 128.2, 127.4, 127.1, 125.2, 123.3, 121.7, 116.3, 113.7, 55.2, 21.4, 12.5; IR (KBr) 3234, 1510, 1435, 1331, 1245, 1161, 837, 808, 670cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for $C_{25}H_{24}NO_4S$, 434.1426; found 434.1418.

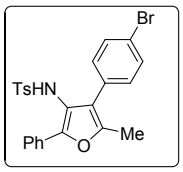
N-(4-(4-chlorophenyl)-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5o)



Compound **5o** was obtained as a pale yellow solid in 92% isolated yield, R_f = 0.52 (petroleum ether : ethyl acetate = 5 : 1); mp = 172-173 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS)δ = 7.80 (d, *J*= 7.6 Hz, 2H), 7.24-7.15 (m, 5H), 7.05 (d, *J* = 8.4 Hz, 2H),6.81 (d, *J* = 8.4 Hz,2H), 6.77 (d, *J* = 8.0 Hz, 2H), 6.68 (s, 1H), 2.23 (s, 3H), 2.17 (s, 3H);^{13}C NMR (100 MHz, $CDCl_3$) δ =

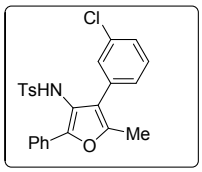
148.7, 147.4, 143.4, 136.5,132.7, 130.1, 129.6, 129.4, 129.0, 128.4, 128.3, 127.7, 127.0, 125.3, 121.2, 115.9, 21.4, 12,5;IR (KBr) 3245, 1495, 1325, 1160, 1091, 833, 725, 663, 574, 523cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for$C_{24}H_{21}ClNO_3S$, 438.0931; found 438.0922.

N-(4-(4-bromophenyl)-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5p)



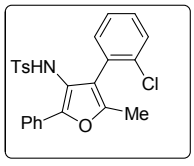
Compound **5p** was obtained as a yellow solid in 92% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1); mp = 172-173 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS)δ = 7.89 (d, *J* = 7.6 Hz, 2H), 7.35-7.26 (m, 7H), 6.87-6.80 (m, 5H), 2.32 (s, 3H), 2.24 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.7, 147.3, 143.4, 136.4, 131.3, 130.5, 130.1 129.4, 129.0, 128.3, 127.7, 126.9, 125.3, 121.2, 120.8, 115.8, 21.5, 12,5;IR (KBr) 3248, 1492, 1329, 1161, 1092, 716, 664, 572cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for $C_{24}H_{21}BrNO_3S$, 482.0426; found 482.0417.

N-(4-(3-chlorophenyl)-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5q)



Compound **5q** was obtained as a white solid in 91% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1); mp = 159-160 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ =7.86-7.84 (m, 2H), 7.29-7.18 (m, 5H), 7.09-7.07 (m, 2H), 6.83-6.81 (m,3H), 6.71 (s,1H), 6.39 (s, 1H), 2.25 (s, 3H), 2.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.6, 147.6, 143.5, 136.1,134.2, 133.0, 129.5, 129.4 129.1, 128.7, 128.3, 127.8, 127.1, 126.9, 126.8, 125.3, 120.9, 115.7, 21.5, 12,5; IR (KBr) 3259, 1596, 1494, 1336, 1165, 1093, 666, 571cm^{-1}; HRMS-(DART) (m/z): [M+H]$^{+}$calcd for $C_{24}H_{21}ClNO_3S$, 438.0931; found 438.0922.

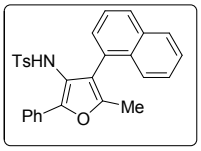
N-(4-(2-chlorophenyl)-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5r)



Compound **5r**was obtained as a pale yellow solid in 75% isolated yield, R_f = 0.43 (petroleum ether : ethyl acetate = 5 : 1); mp = 157-158 ºC; ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.89-7.87 (m, 2H),

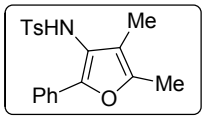
7.29-7.16 (m, 6H), 7.09 (td, *J* = 7.6 Hz, 1.6 Hz ,1H), 6.95 (td, *J* = 7.6 Hz, 1.2Hz,1H), 6.78 (d, *J* = 8.0 Hz, 2H), 6.63 (dd,*J* = 7.6 Hz, 1.6Hz, 1H), 6.14(s, 1H), 2.20 (s, 3H), 2.10 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.6, 147.9, 143.0, 136.4, 132.9, 132.0, 130.0, 129.41, 129.36, 129.2, 128.6, 128.2, 127.7, 126.8, 126.7, 125.2, 120.0, 116.6, 21.4, 12.6; IR (KBr) 3312, 1329, 1161, 1093, 818, 754, 691, 663, 569 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{24}H_{21}ClNO_3S$, 438.0931; found 438.0922.

4-methyl-N-(5-methyl-4-(naphthalen-1-yl)-2-phenylfuran-3-yl)benzenesulfonamide (5s)



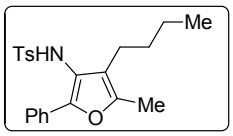
Compound **5s** was obtained as a white solid in 80% isolated yield, R_f = 0.43 (petroleum ether : ethyl acetate = 5 : 1); mp = 152-153 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.01 (d, *J* = 7.6 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 1H), 7.64 (d, *J* = 8.4 Hz, 1H), 7.42-7.32 (m, 5H), 7.25-7.17 (m , 2H), 6.93 (d, *J* = 8.0 Hz, 2H), 6.78 (d, *J* = 7.2 Hz, 1H), 6.54 (d, *J* = 8.0 Hz, 2H), 5.95 (s, 1H), 2.09 (s, 3H), 2.07 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.4, 148.1, 142.6, 136.1, 133.6, 131.4, 129.7, 128.9, 128.5, 128.3, 128.1, 127.8, 127.71, 127.66, 126.5, 125.8, 125.34, 125.28, 124.8, 119.9, 117.2, 21.4, 12.8;IR (KBr) 3242, 1329, 1161, 1092, 805, 780, 672, 570cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{28}H_{24}NO_3S$, 454.1477; found 454.1465.

N-(4,5-dimethyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5t)



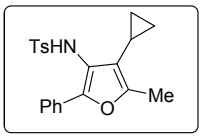
Compound **5t** was obtained as a white solid in 80% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1); mp = 155-157 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ =7.46 (d, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 6.8 Hz, 2H), 7.05 (d, *J* = 6.8 Hz, 3H), 6.93 (d, *J* = 7.6 Hz, 2H), 6.20 (s, 1H), 2.20 (s, 3H), 2.14 (s, 3H), 1.66 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 146.9, 146.4, 143.5, 136.6, 129.6, 129.2, 128.0, 127.3, 126.9, 124.7, 117.9, 116.3, 21.3, 12.0, 7.5;IR (KBr) 3221, 1598, 1329, 1158, 1092, 813, 769, 685, 544 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{19}H_{20}NO_3S$, 342.1164; found 342.1158.

N-(4-butyl-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5u)



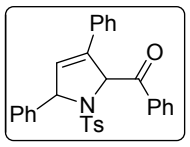
Compound **5u** was obtained as a oil in 88% isolated yield, R_f = 0.64 (petroleum ether : ethyl acetate = 5 : 1); ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.42 (d, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 7.2 Hz, 2H), 7.02-6.95 (m, 3H), 6.84 (d, *J* = 8.0 Hz, 2H), 6.63 (s, 1H), 2.12-2.08 (m, 8H), 1.34-1.27 (m, 2H), 1.20-1.11 (m, 2H), 0.79-0.76 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.0, 146.4, 143.3, 136.6, 129.6, 129.0, 127.8, 127.1, 126.7, 124.8, 120.9, 117.3, 31.7, 22.4, 22.0, 21.1, 13.7, 12.1; IR (KBr) 3270, 2855, 1599, 1494, 1155, 1093, 813, 763, 566 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{22}H_{26}NO_3S$, 384.1633; found 384.1625.

N-(4-cyclopropyl-5-methyl-2-phenylfuran-3-yl)-4-methylbenzenesulfonamide (5v)



Compound **5v** was obtained as a white solid in 72% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1); mp = 148-149 ºC;^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.62-7.59 (m, 4H), 7.20-7.12 (m, 3H), 7.07 (d, *J* = 8.0 Hz, 2H), 6.16 (d, *J* = 5.2 Hz, 1H), 2.31 (s, 3H), 2.25 (s, 3H), 0.90-0.84 (m, 1H), 0.68-0.64 (m, 2H), 0.39-0.35 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ =147.9, 146.6, 143.5, 136.9, 129.6, 129.2, 128.0, 127.5, 127.0, 124.8, 121.0, 118.6, 21.4, 12.5, 4.8, 3.5; IR (KBr) 3256, 1432, 1329, 1163, 1093, 815, 692, 667, 569, 544cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for $C_{21}H_{22}NO_3S$, 368.1320; found 368.1311.

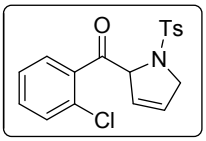
(3,5-diphenyl-1-tosyl-2,5-dihydro-1H-pyrrol-2-yl)(phenyl)methanone (4a)



Compound **4a** was obtained as a white solid in 72% isolated yield, R_f = 0.46 (petroleum ether : ethyl acetate = 5 : 1); mp = 188-190 ºC; ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ =8.05 (d, *J* = 7.6 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.36 (d, *J* = 3.6 Hz, 2H), 7.24-7.20 (m, 4H), 7.15 (t, *J* = 7.6 Hz, 2H), 7.11-7.06 (m, 4H), 6.97 (d, *J* = 8.0 Hz, 2H),6.17 (s, 1H), 6.12 (s, 1H),5.96 (dd, *J* = 5.6Hz, 1.6Hz,1H),2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ =197.4, 142.7, 138.7, 137.2, 136.4, 136.3, 132.8, 131.3, 128.9, 128.8, 128.7, 128.6, 128.4, 128.3, 127.9, 127.0, 126.6, 73.4, 71.0, 21.4;IR (KBr) 1695, 1685, 1343, 1162,

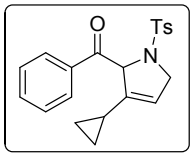
1150, 668, 602, 543cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$ calcd for $C_{30}H_{26}NO_3S$, 480.1633; found 480.1624.

(2-chlorophenyl)(1-tosyl-2,5-dihydro-1H-pyrrol-2-yl)methanone (5i')



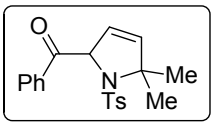
Compound **5i'** was obtained as a colourless oil in 23% isolated yield, R_f = 0.22 (petroleum ether : ethyl acetate= 5 : 1); ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.73 (d, *J* = 8.4 Hz, 2H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.42-7.30 (m, 5H), 5.86 (t, *J* = 2.4 Hz, 1H), 5.72 (s, 2H), 4.27-4.12 (m, 2H), 2.41 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 198.4, 143.8, 137.1, 134.7, 131.8, 130.9, 130.2, 129.7, 129.3, 128.6, 127.4, 126.6, 124.5, 74.5, 55.4, 21.4.

(3-cyclopropyl-1-tosyl-2,5-dihydro-1H-pyrrol-2-yl)(phenyl)methanone (5v')



Compound **5v'** was obtained as a white solid in 27% isolated yield, Rf = 0.23 (petroleum ether : ethyl acetate = 5 : 1); ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 8.00 (d, *J* = 7.6 Hz, 2H), 7.68 (d, *J* = 8.0 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 5.60 (t, *J* = 2.4 Hz, 1H), 5.33 (s, 1H), 4.29-4.18 (m, 2H), 2.40 (s, 3H), 1.00-0.97 (m, 1H), 0.61-0.56 (m, 1H),0.49-0.40 (m, 2H), 0.26-0.19 (m, 1H);^{13}C NMR (100 MHz, $CDCl_3$) δ = 197.5, 143.6, 142.3, 136.1, 134.3, 133.0, 129.6, 128.6, 128.4, 127.4, 118.1, 73.7, 54.3, 21.4, 8.9, 7.6, 5.8.

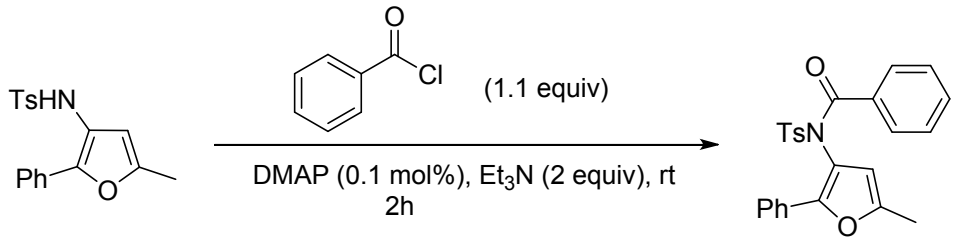
(5,5-dimethyl-1-tosyl-2,5-dihydro-1H-pyrrol-2-yl)(phenyl)methanone (4ma)



Compound **4ma** was obtained as a white solid in 70% isolated yield, R_f = 0.46 (petroleum ether : ethyl acetate = 5 : 1); mp = 148-149 ºC; ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.89 (d, *J* = 7.2 Hz, 2H), 7.68 (d, *J* = 8.0 Hz, 2H), 7.49 (t, *J* = 7.6 Hz, 1H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.15 (d, *J* = 8.0 Hz, 2H), 6.07 (s, 1H), 5.60 (dd, *J* = 6.0 Hz, 2.0Hz, 1H),5.52 (dd, *J* = 6.0 Hz, 2.0Hz, 1H),2.30 (s, 3H), 1.52 (s, 3H), 1.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 195.0, 143.1, 140.1, 138.7, 135.2, 133.3, 129.2, 128.6, 128.3, 127.7, 120.8, 72.2, 71.5, 28.9, 26.7, 21.4;IR (KBr) 1700, 1597, 1450, 1053, 859, 810, 714, 637, 594 cm^{-1}.

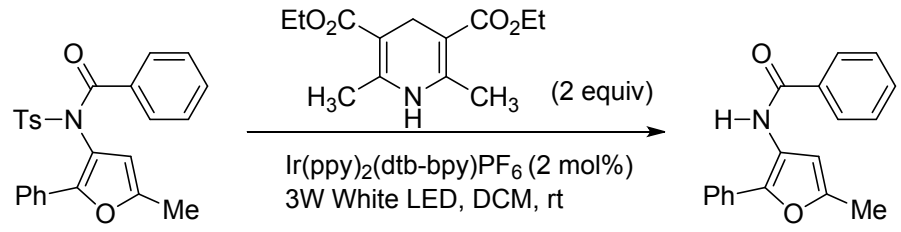
3.Representative synthetic application

N-(5-methyl-2-phenylfuran-3-yl)-N-tosylbenzamide[6]



To a mixture of the corresponding sulfonamide (0.5 mmol), DMAP (0.5 mmol%) and Et_3N (150ul, 1.0mmol) in CH_2Cl_2 (1 ml) was added slowly the benzoyl chloridein CH_2Cl_2 (1ml) at 0°C. The reaction mixture was stirred at room temperature for 2h.the solvent was removed under reduced pressure to give crude product, which was purified by column chromatography onsilica gel to affordN-tosylcarboxylic amideas a white solid in 95%.

N-(5-methyl-2-phenylfuran-3-yl)benzamide[7] (5a'')



To a 10 mL Schlenk flask equipped with a magnetic stir bar was added N-(5-methyl-2-phenylfuran-3-yl)-N-tosylbenzamide (0.2 mmol, 86.4 mg, 1.0 eq), $Ir(ppy)_2(dtb\text{-}bpy)PF_6$ (0.004 mmol, 3.4 mg, 2 mol%), Amine (0.4 mmol, 101.3 mg, 2.0 eq) and dry DCM (1.5 mL). The resulting mixture was degassed via 'freeze-pump-thaw' procedure (3 times). The solution was stirred at a distance of ~5 cm from a 3W white LED at room temperature for 2 days. Upon the completion of reaction monitored by TLC, the solvent was removed under reduced pressure. The crude product was purified by flash chromatography on silica gel (eluant: petroleum/ethyl

[6] M. C. McIntosh, S. M. Weinreb, *J. Org. Chem*., 1993 , **58,** 4823.
[7]J. Xuan, B. -J. Li, Z. -J. Feng, G. -D. Sun, H. -H. Ma, Z. -W. Yuan, J. -R. Chen, L.-Q. Lu, W.-J. Xiao, *Chem. Asian J.,* 2013*,* **8***,* 1090.

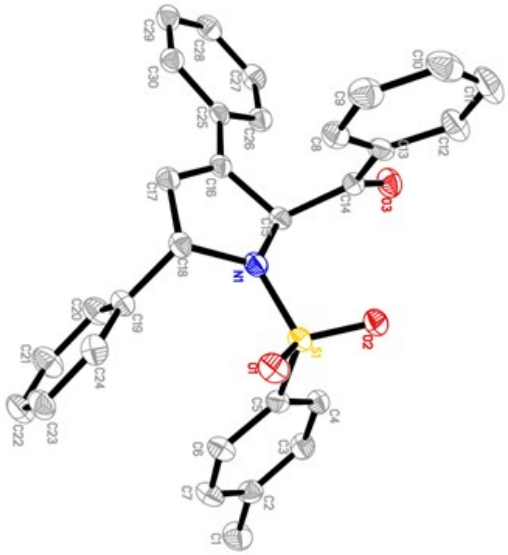
acetate (8;1) to provide pure product N-(5-methyl-2-phenylfuran-3-yl)benzamide as a white solid in 75% isolated yield, R_f = 0.50 (petroleum ether : ethyl acetate = 5 : 1); mp = 147-149 ºC; ^{1}H NMR (400 MHz, $CDCl_3$, TMS) δ = 7.85 (d, *J* = 7.2 Hz, 3H), 7.59-7.53 (m, 3H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.25 (t, *J* = 7.6 Hz, 1H), 6.69 (s, 1H), 2.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ =165.4, 151.0, 140.6, 134.1, 131.9, 130.6, 129.0, 128.8, 127.1, 127.0, 124.5, 120.9, 105.9, 13.8; IR (KBr) 3259, 1653, 1535, 1310, 1134, 803, 759, 711 cm^{-1}; HRMS-(DART) (m/z): $[M+H]^+$calcd for$C_{18}H_{16}NO_2$, 278.1181; found 278.1172.

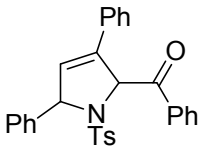
4.X-ray crystal structures

General procedure for preparation of the crystal(4a): The product (40 mg) was dissolved in ethyl acetate, and then filtered through a pad of filter paper. The filtrate was transferred into several test-tubes by different volumes. Then to these solution were added petroleum ether in dropwise. The samples prepared in this way were allowed to evaporate slowly at room temperature, which would eventually give colorless crystals on the surface of the tubes.

Crystals of 4a,5j,5n were prepared followed the method mentioned above.

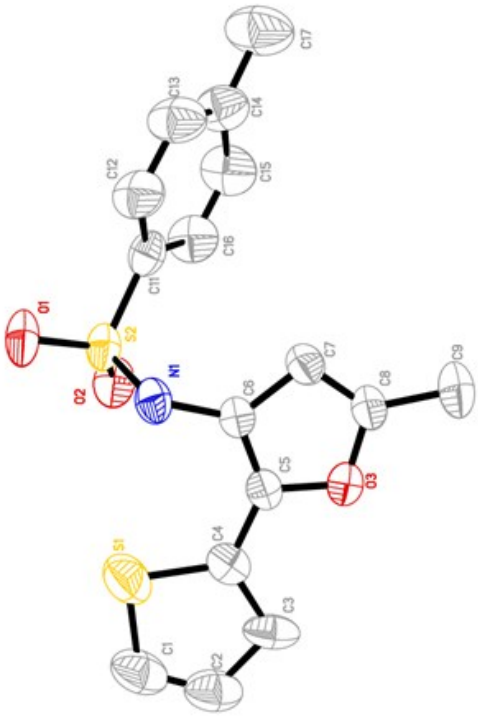
Colorless granular-shaped crystals **4a** was obtained from mixed solution (PE:EA =10:1).

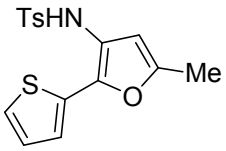




CCDC Nr. 1444605

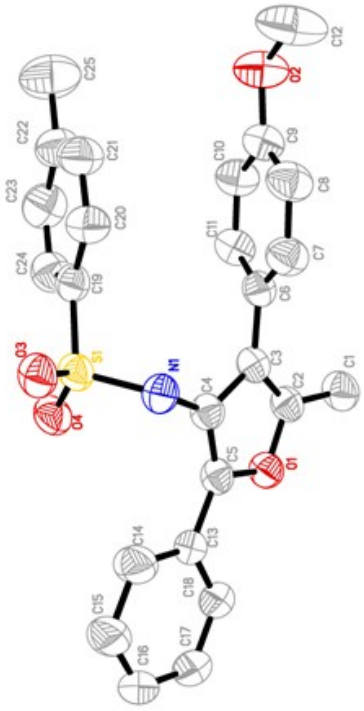
Colorless granular-shaped crystals **5j** was obtained from mixed solution (PE: EA = 10:1).

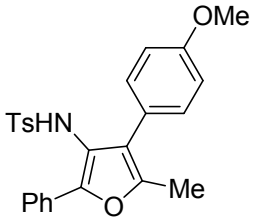




CCDC Nr. 1444603

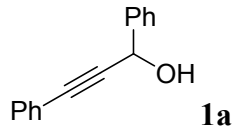
Colorless granular-shaped crystals **5n** was obtained from mixedsolution(PE:EA= 10:1).



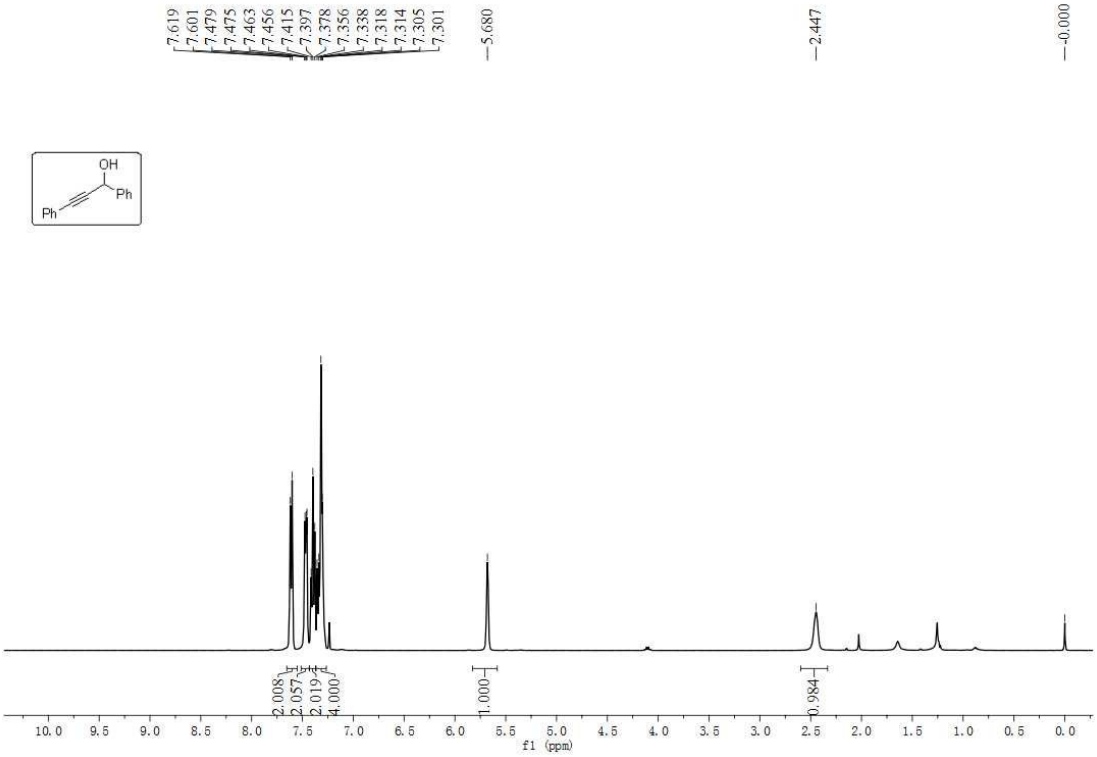


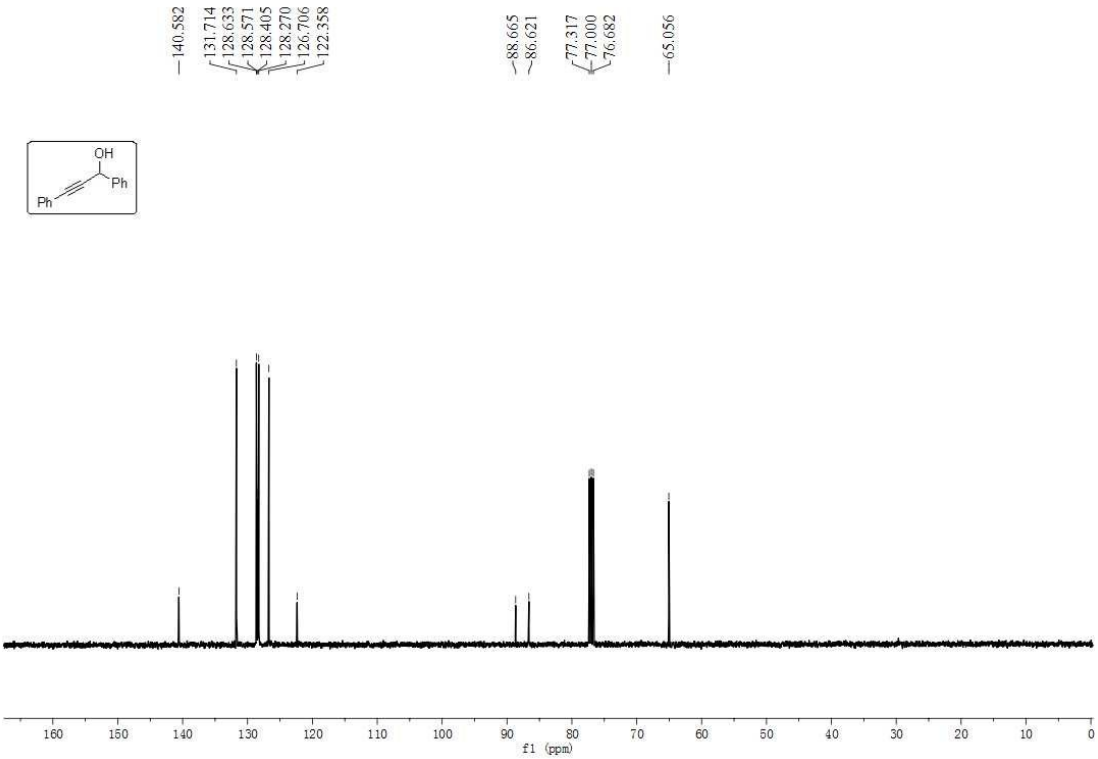
CCDC Nr. 1444604

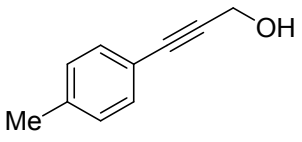
5. ^{1}H and ^{13}C NMR spectra of the products



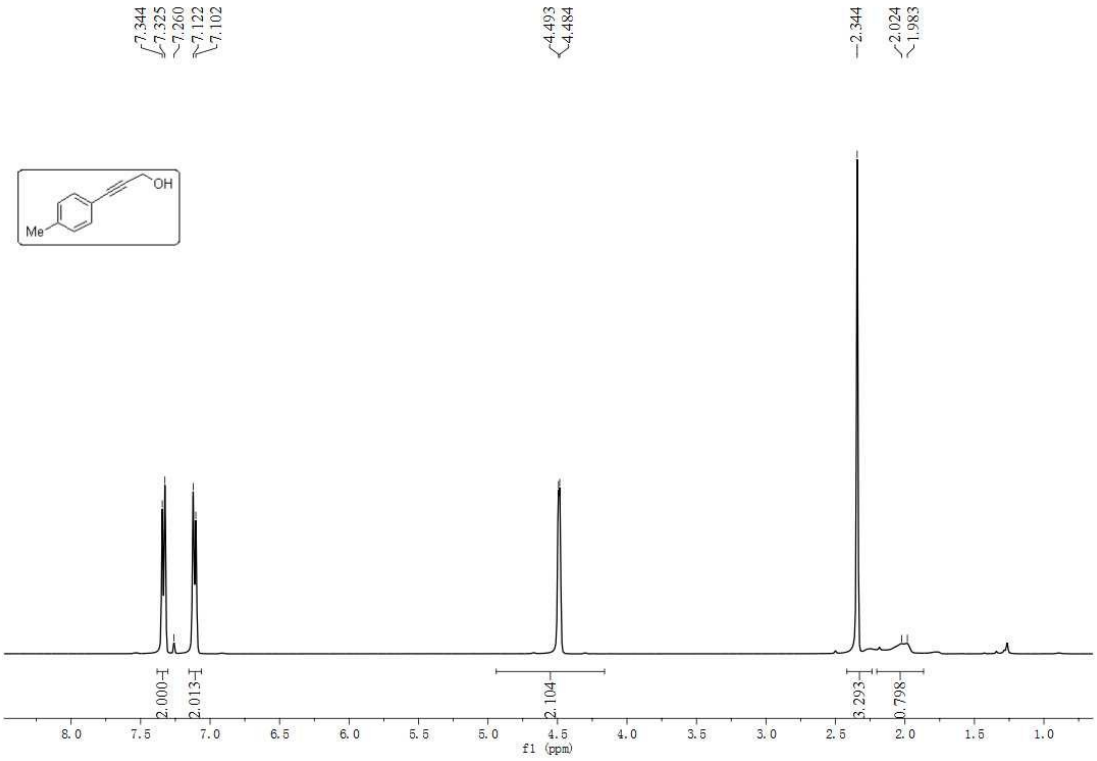
1a

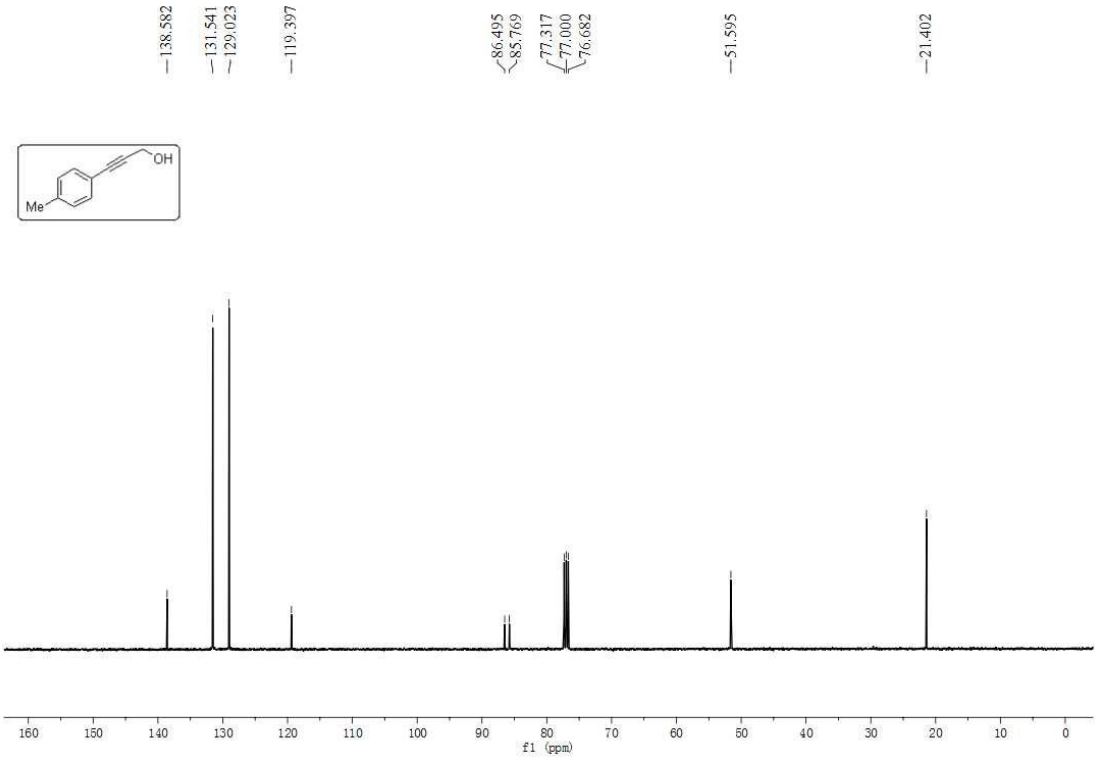


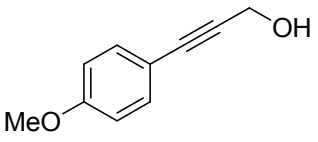



OH
Me

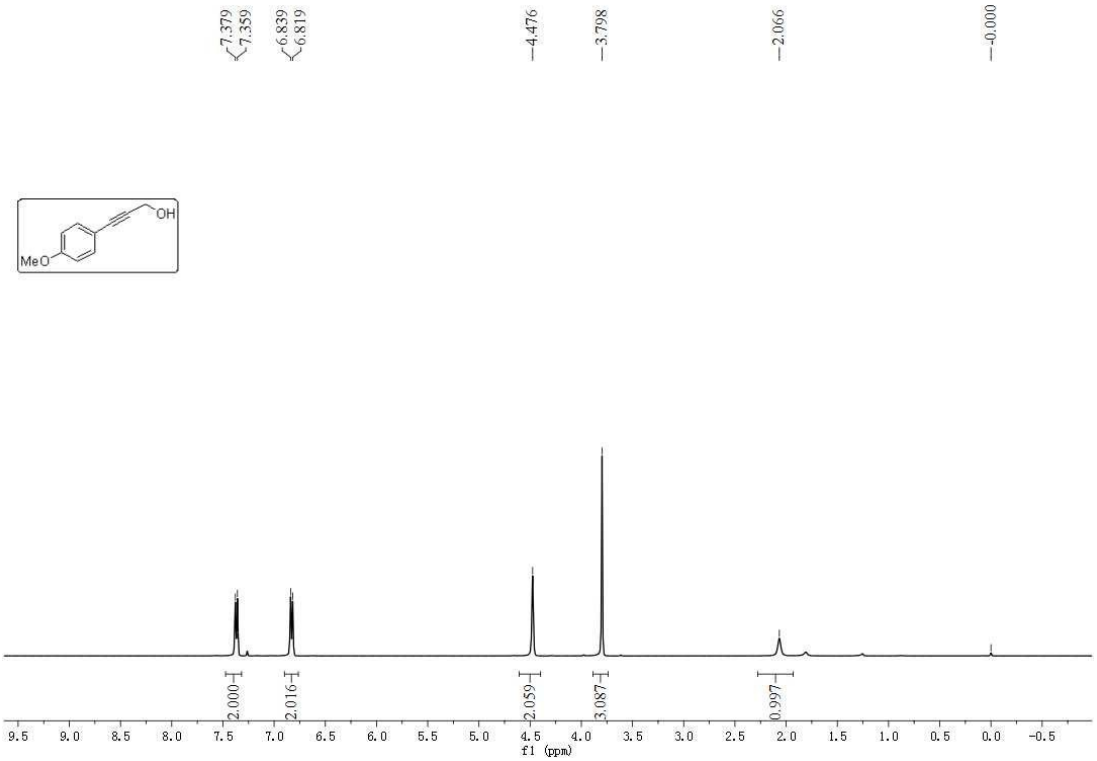
1m

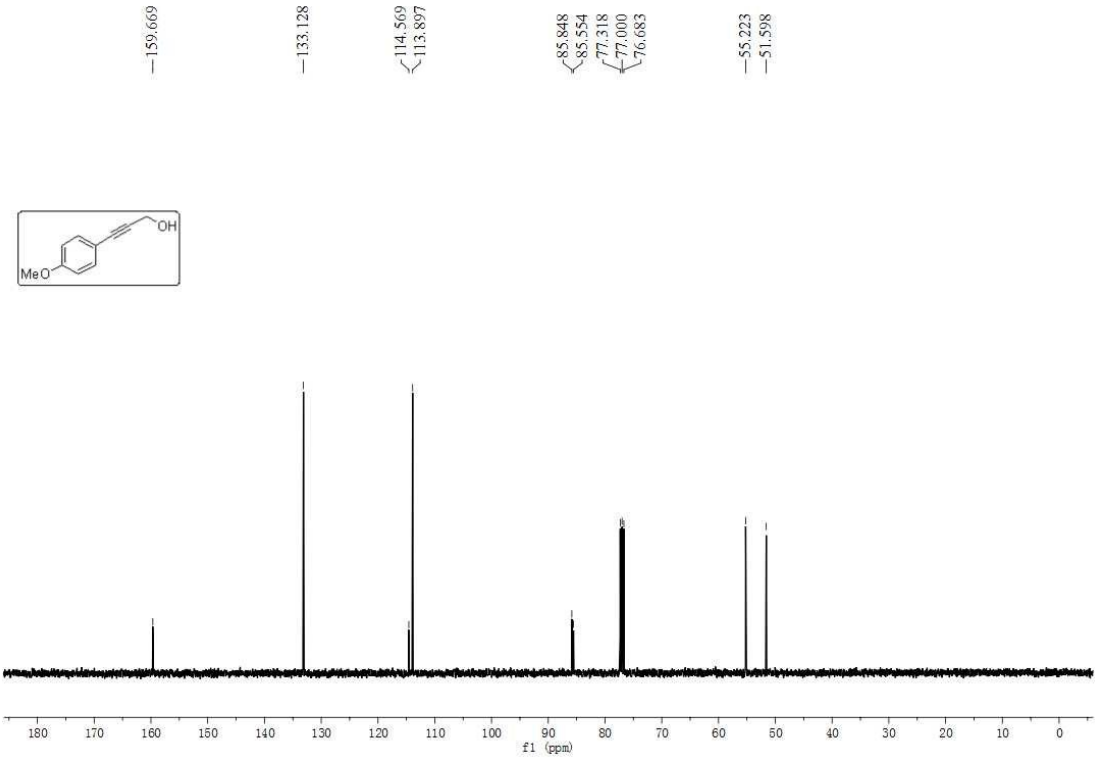

7.344
7.325
7.260
7.122
7.102
4.493
4.484
2.344
2.024
1.983
OH
Me
2.000
2.013
2.104
3.293
0.798
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

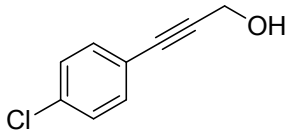

138.582
131.541
129.023
119.397
86.495
85.769
77.317
77.000
76.682
51.595
21.402
OH
Me
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


OH
MeO

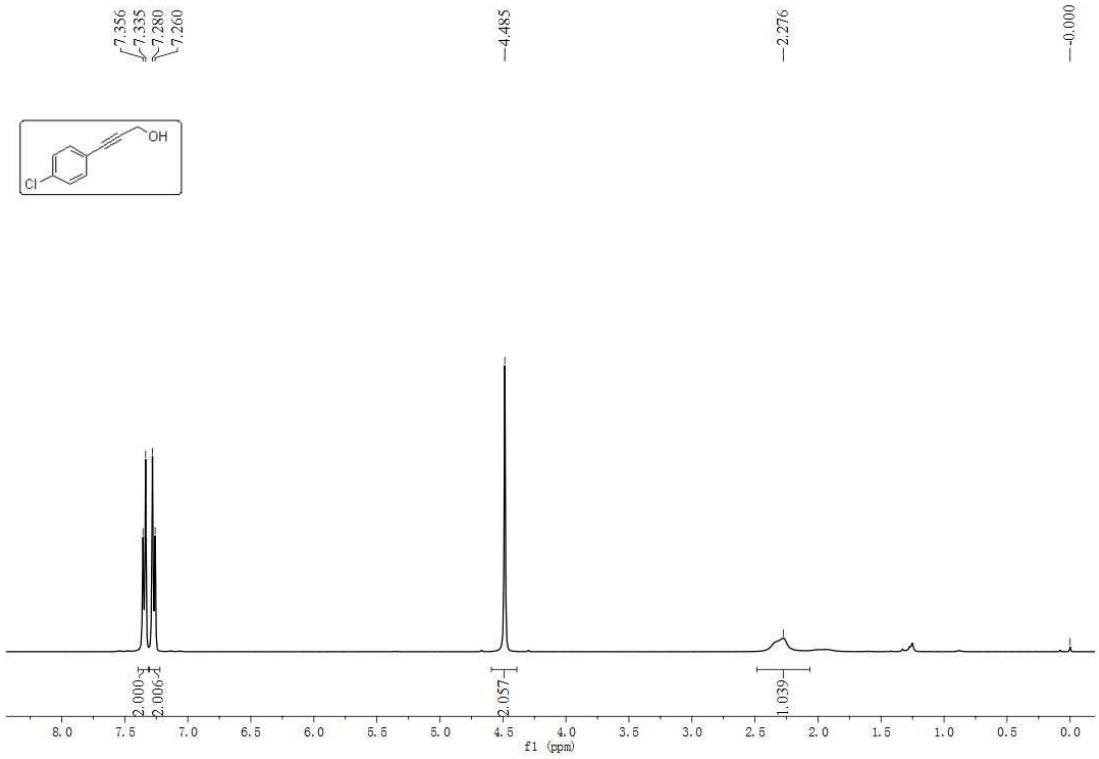
1n

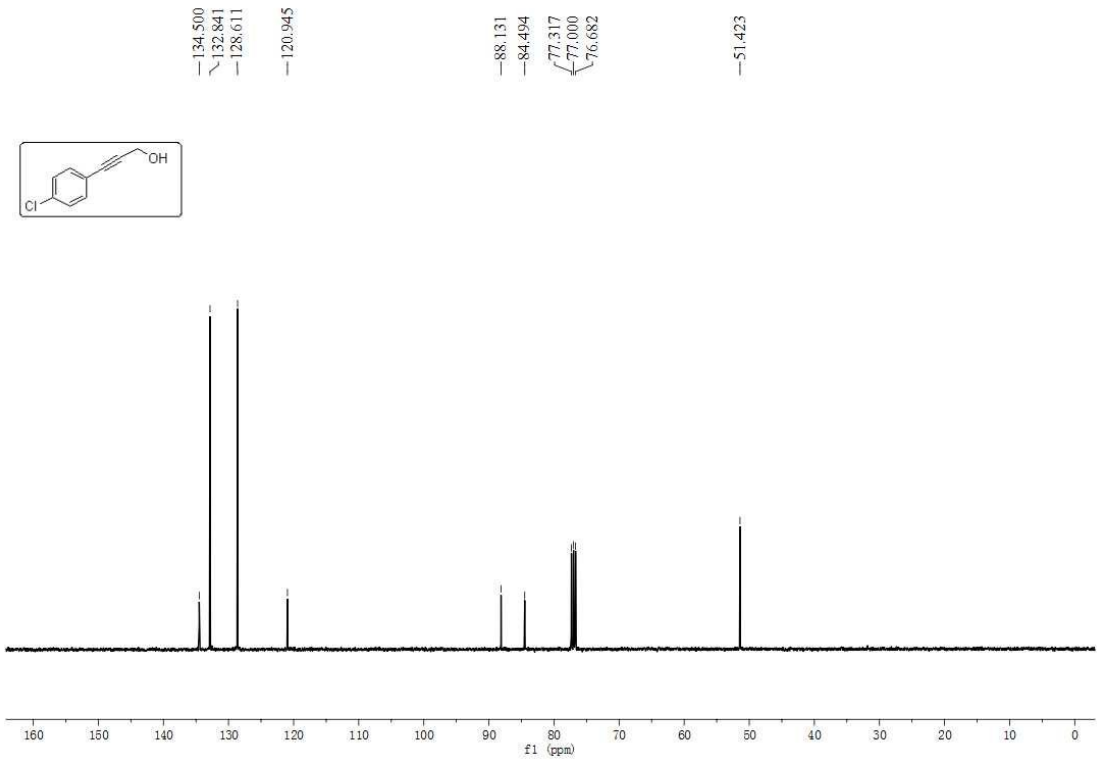

7.379
7.359
6.839
6.819
4.476
3.798
2.066
0.000
OH
MeO
2.000
2.016
2.059
3.087
0.997
f1 (ppm)

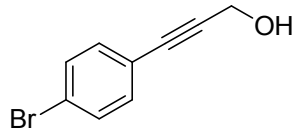

159.669
133.128
114.569
113.897
85.848
85.554
77.318
77.000
76.683
55.223
51.598
OH
MeO
f1 (ppm)


OH
Cl

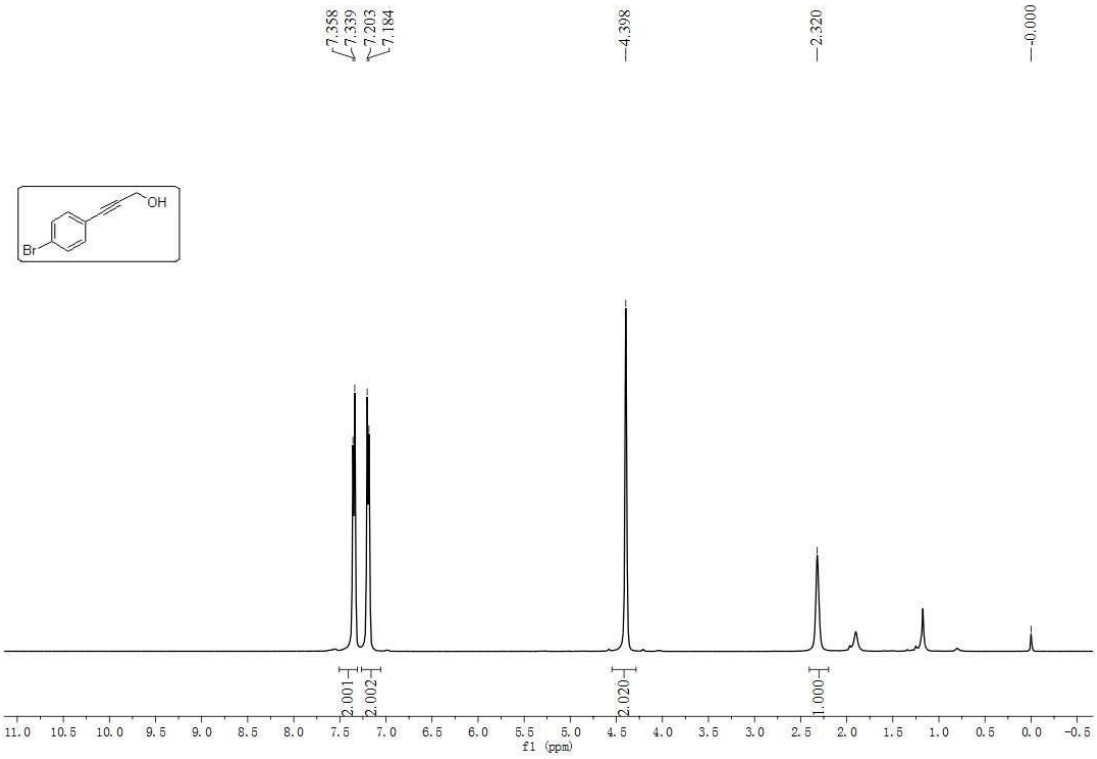
1o

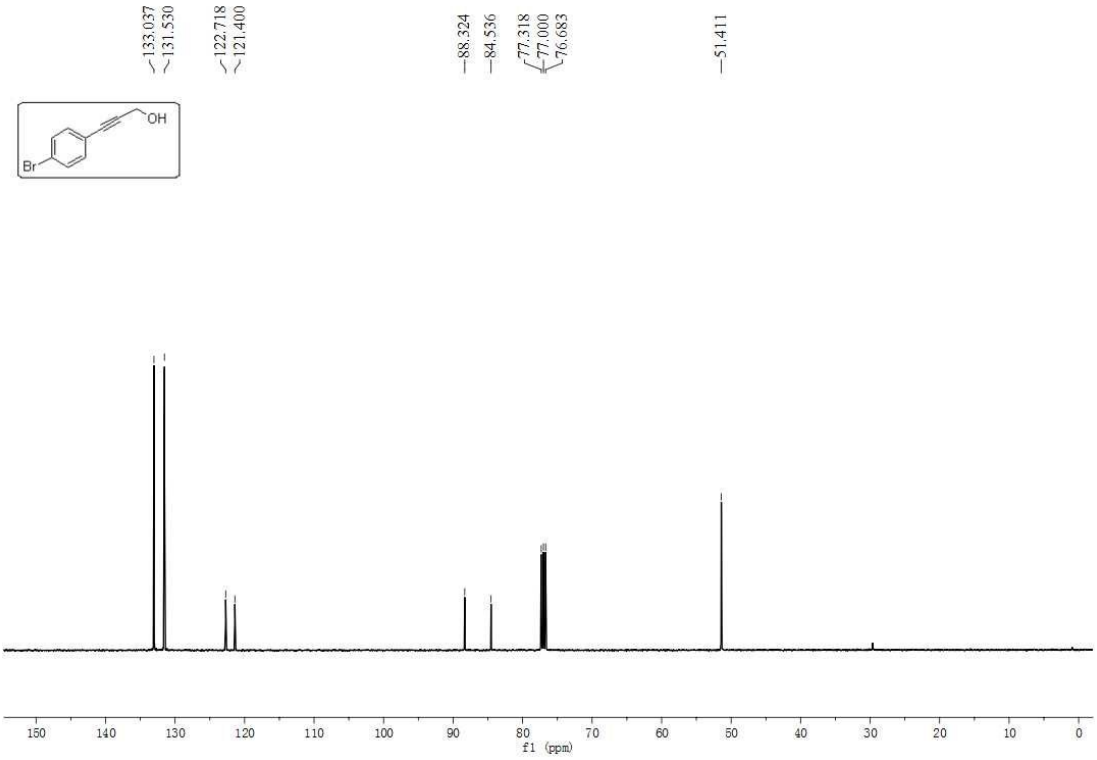

7.356
7.335
7.280
7.260
4.485
2.276
0.000
OH
Cl
2.000
2.006
2.057
1.039
f1 (ppm)

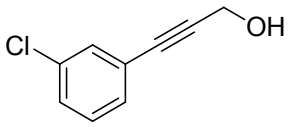

134.500
132.841
128.611
120.945
88.131
84.494
77.317
77.000
76.682
51.423
OH
Cl
f1 (ppm)


OH
Br

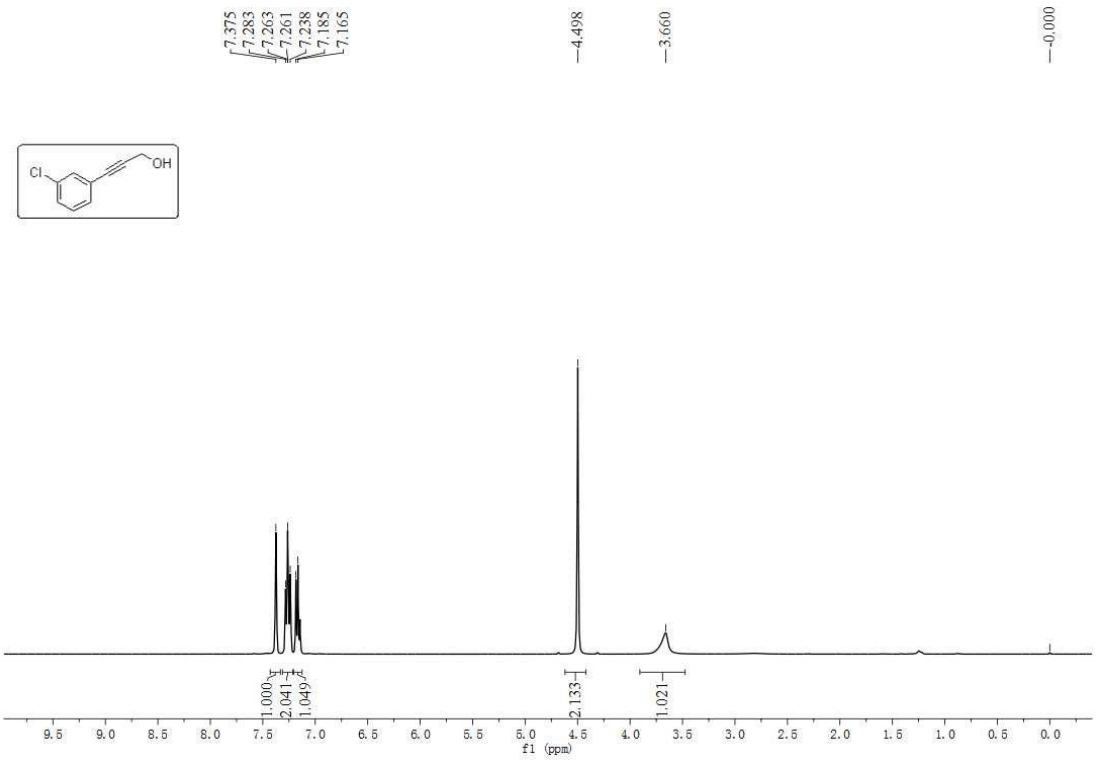
1p

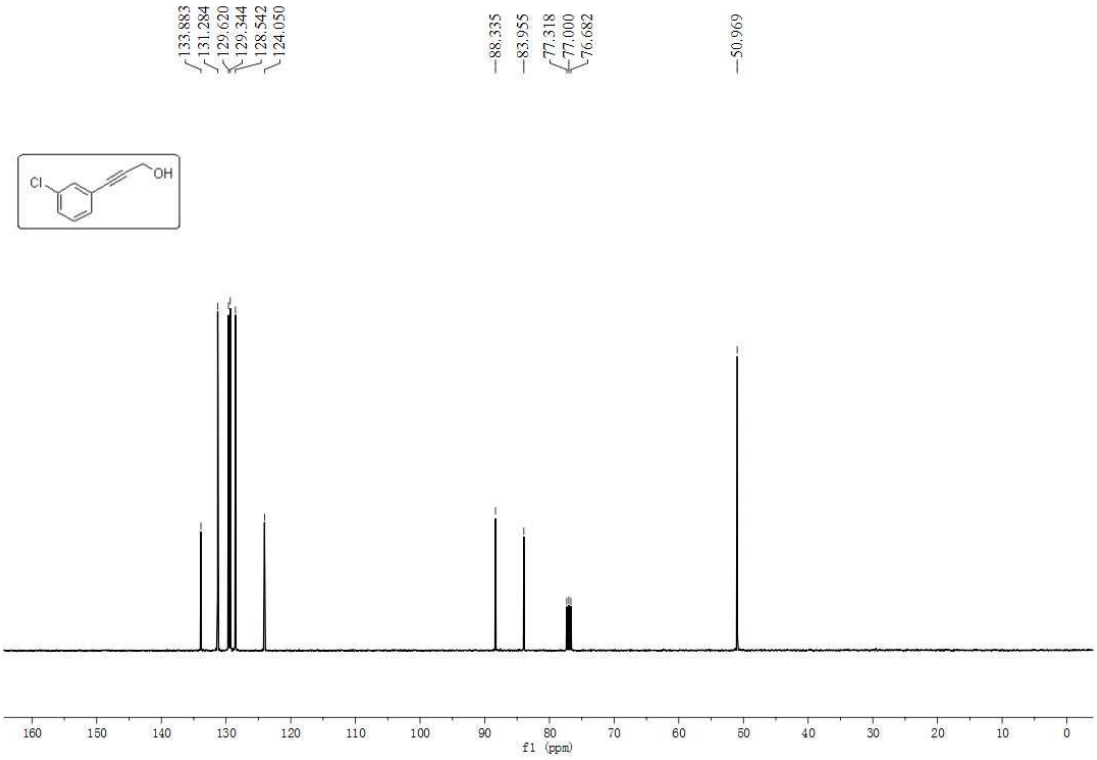

7.358
7.339
7.203
7.184
4.398
2.320
0.000
OH
Br
2.001
2.002
2.020
1.000
f1 (ppm)

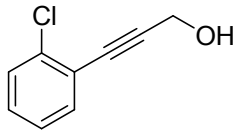

133.037
131.530
122.718
121.400
88.324
84.536
77.318
77.000
76.683
51.411
OH
Br
f1 (ppm)


Cl
OH

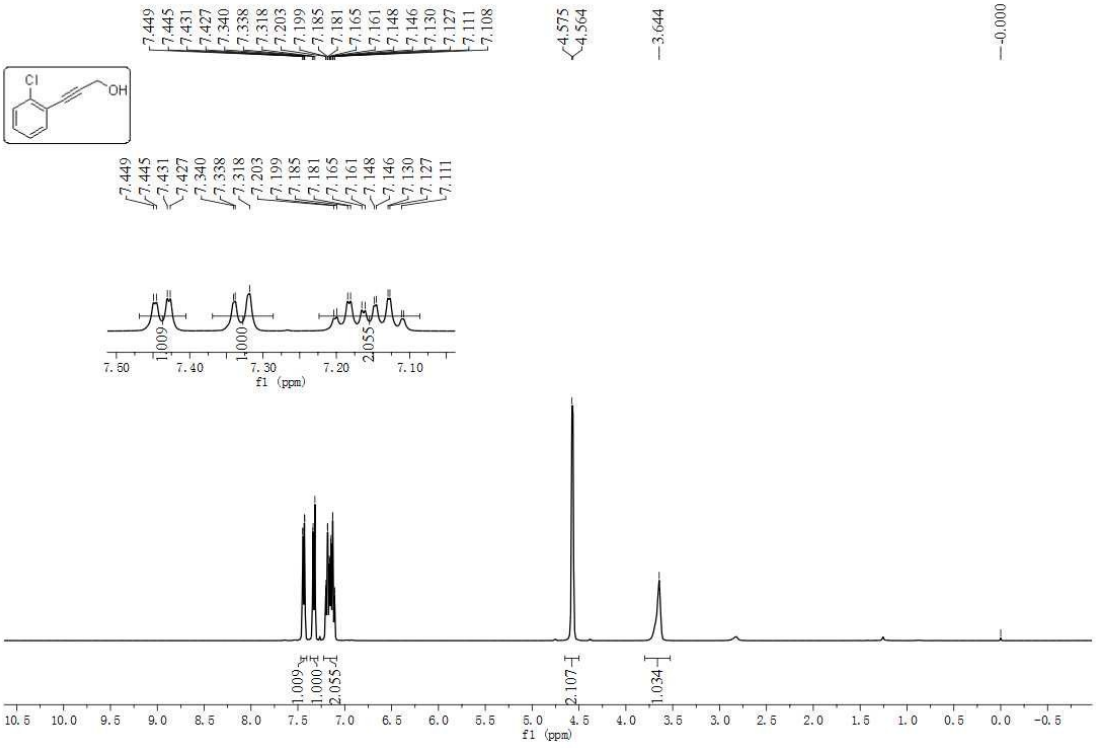
1q

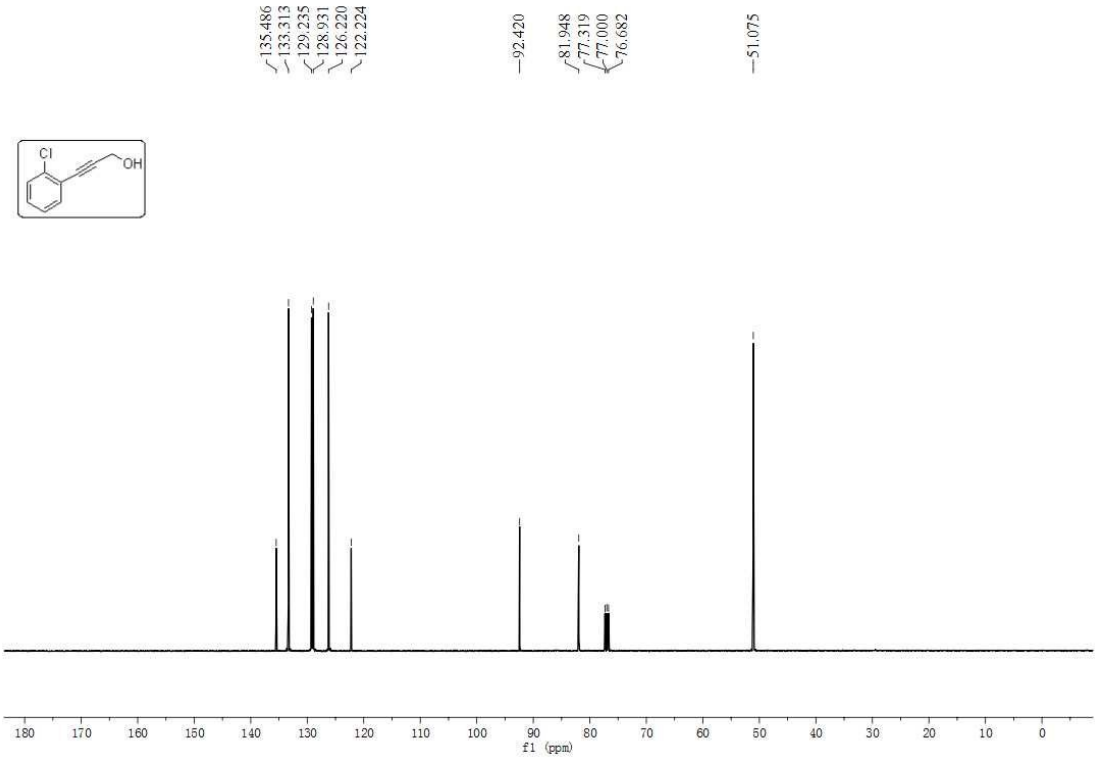

7.375
7.283
7.263
7.261
7.238
7.185
7.165
4.498
3.660
0.000
Cl
OH
1.000
2.041
1.049
2.133
1.021
f1 (ppm)

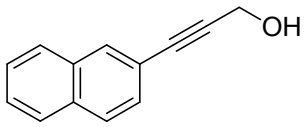

133.883
131.284
129.620
129.344
128.542
124.050
88.335
83.955
77.318
77.000
76.682
50.969
Cl
OH
f1 (ppm)


Cl
OH

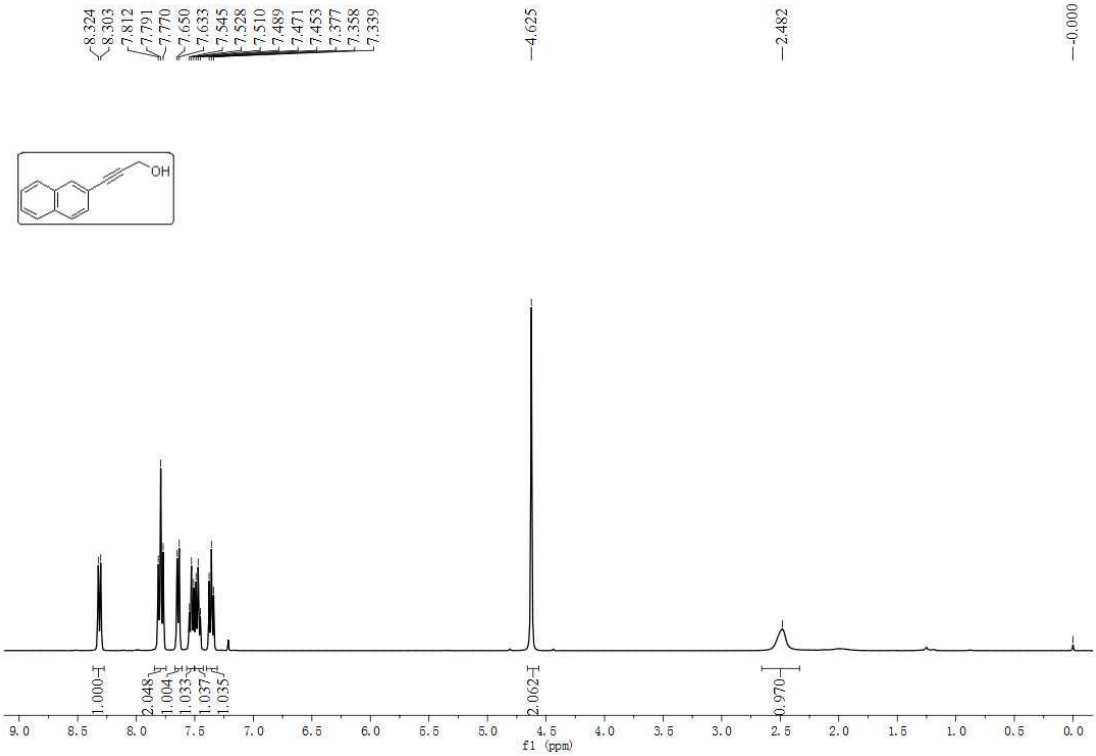
1r


7.449
7.445
7.431
7.427
7.340
7.338
7.318
7.203
7.199
7.185
7.181
7.165
7.161
7.148
7.146
7.130
7.127
7.111
7.108
4.575
4.564
3.644
0.000
Cl
OH
1.009
1.000
2.055
2.107
1.034
f1 (ppm)


135.486
133.313
129.235
128.931
126.220
122.224
92.420
81.948
77.319
77.000
76.682
51.075
Cl
OH
f1 (ppm)


OH

1s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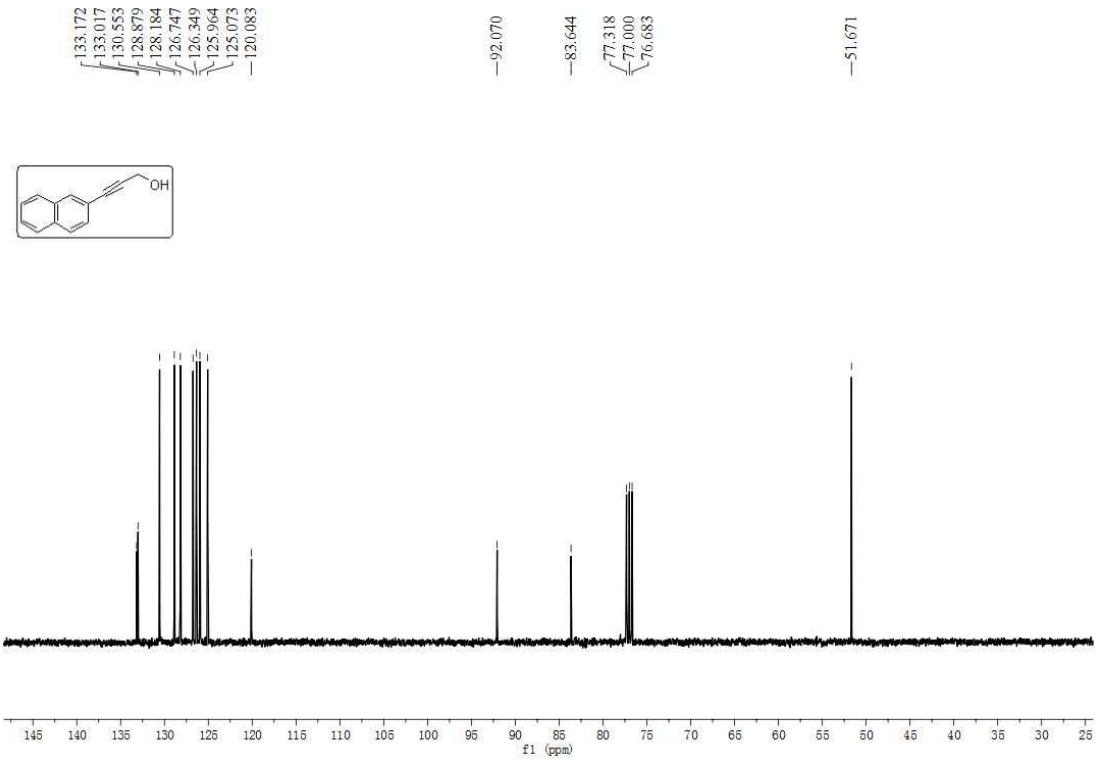
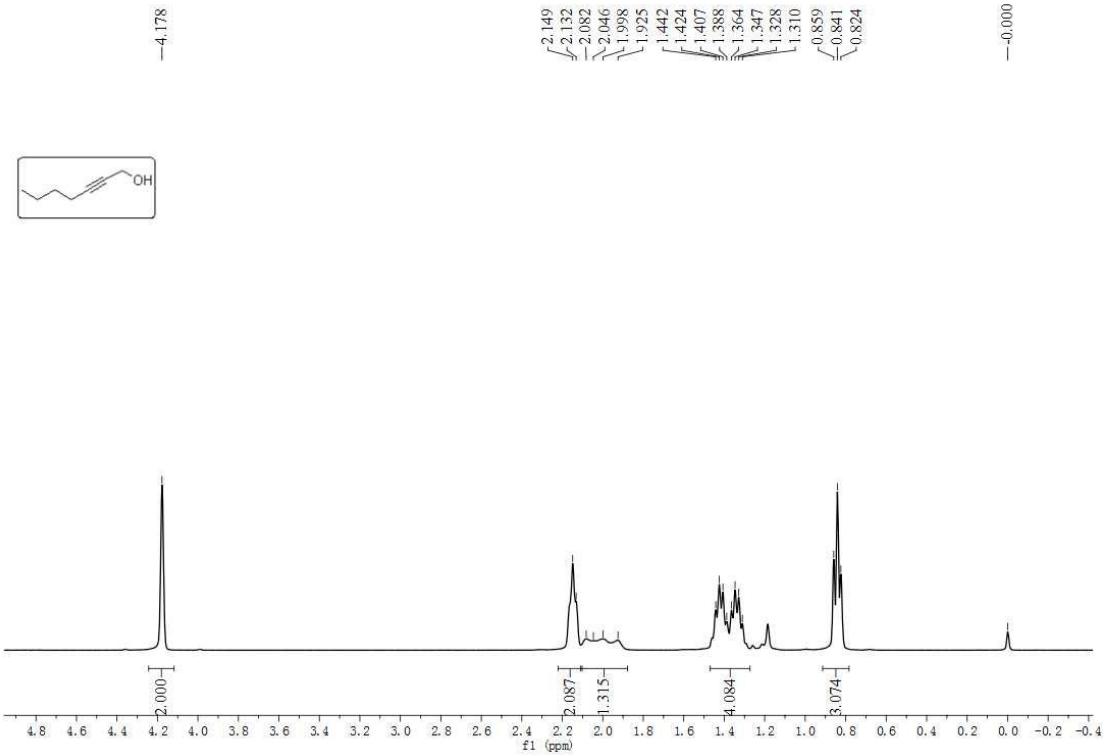
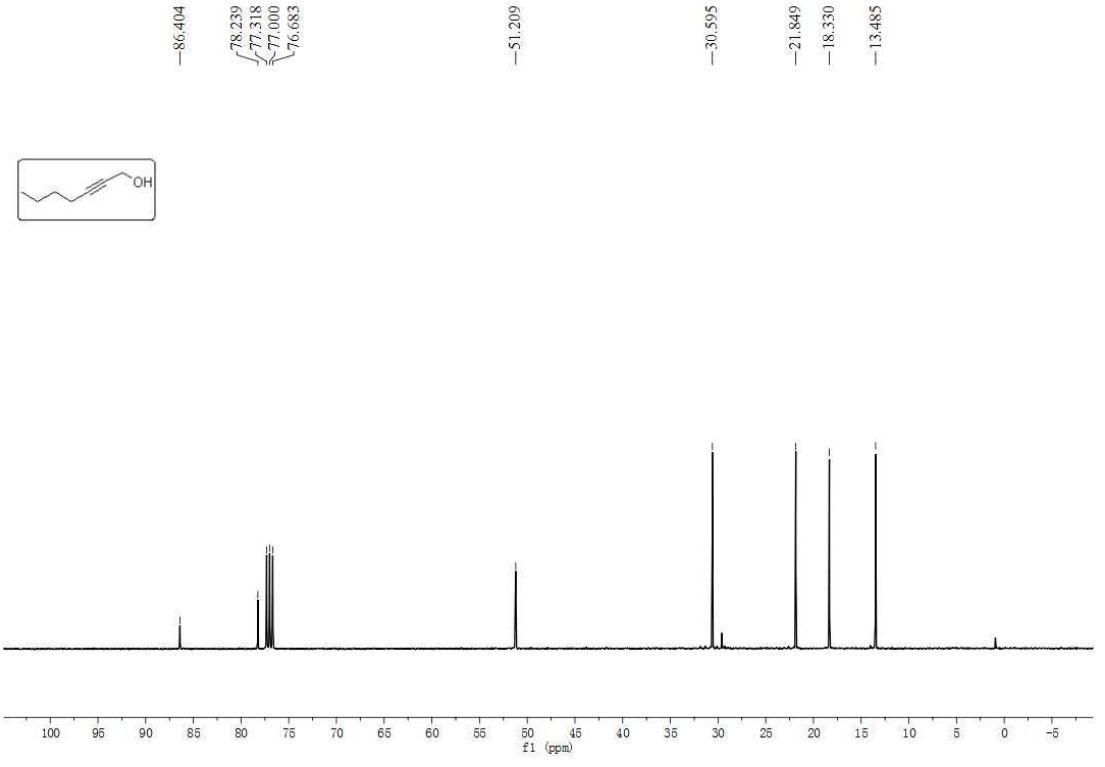
8.303
7.812
7.791
7.770
7.650
7.633
7.545
7.528
7.510
7.489
7.471
7.453
7.377
7.358
7.339
4.625
2.482
0.000
OH
1.000
2.048
1.004
1.033
1.037
1.035
2.062
0.970
f1 (ppm)

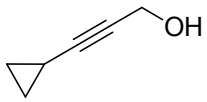

133.172
133.017
130.553
128.879
128.184
126.747
126.349
125.964
125.073
120.083
92.070
83.644
77.318
77.000
76.683
51.671
OH
f1 (ppm)


OH

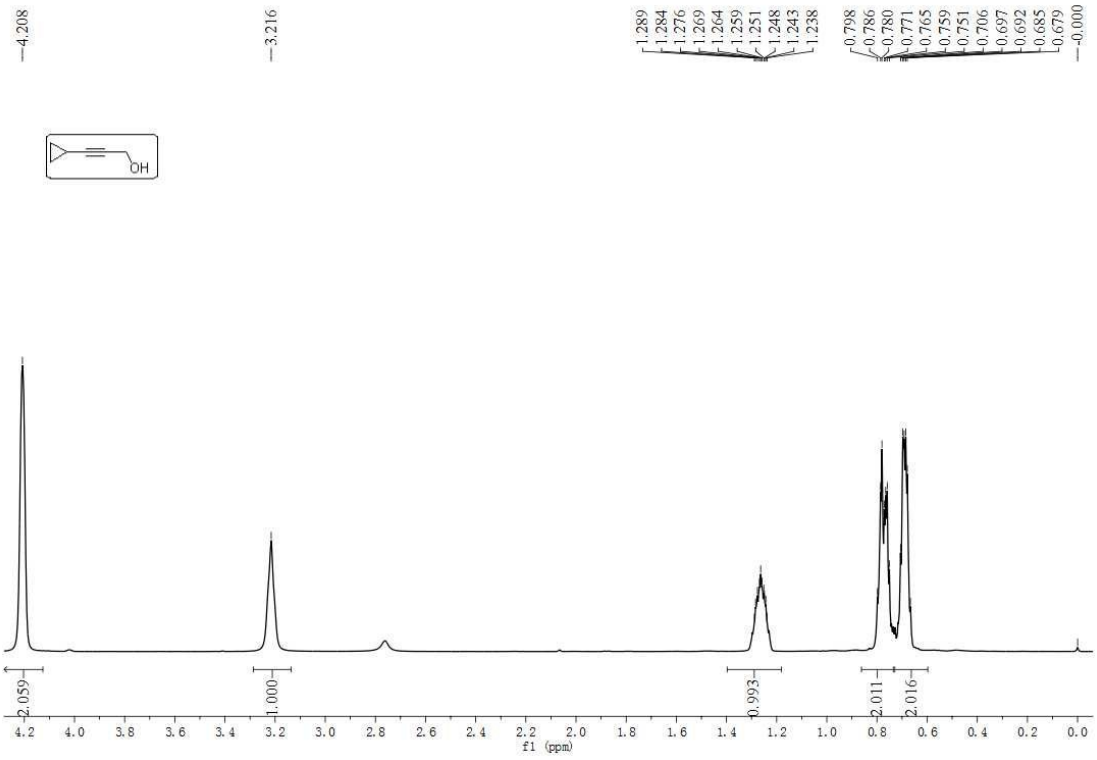
1u

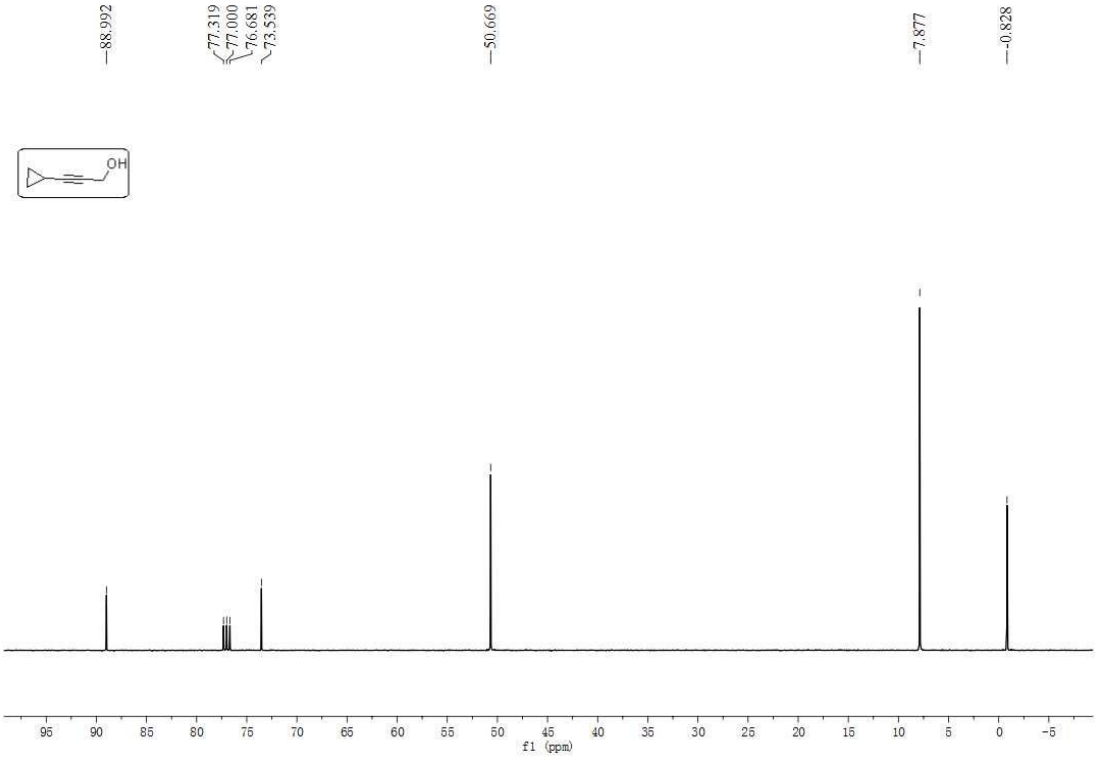

4.178
2.149
2.132
2.082
2.046
1.998
1.925
1.442
1.424
1.407
1.388
1.364
1.347
1.328
1.310
0.859
0.841
0.824
0.000
OH
2.000
2.087
1.315
4.084
3.074
f1 (ppm)

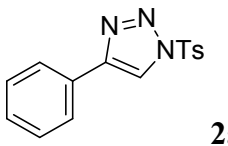

86.404
78.239
77.318
77.000
76.683
51.209
30.595
21.849
18.330
13.485
OH
f1 (ppm)


OH

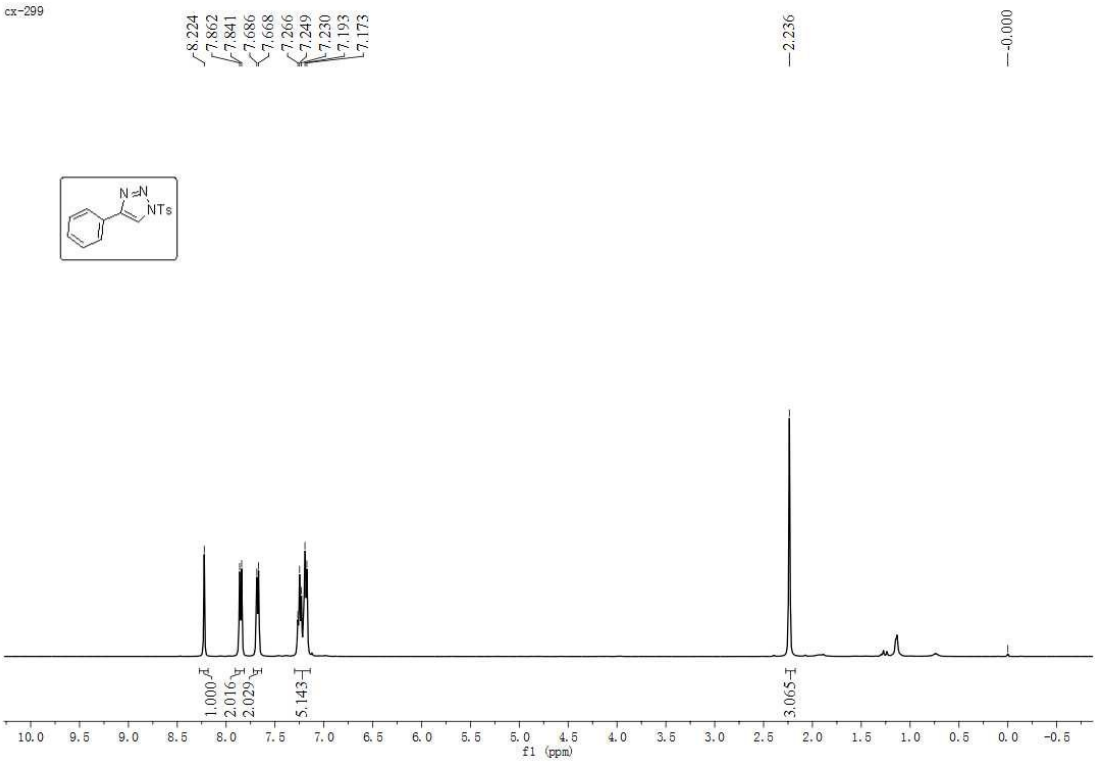
1v

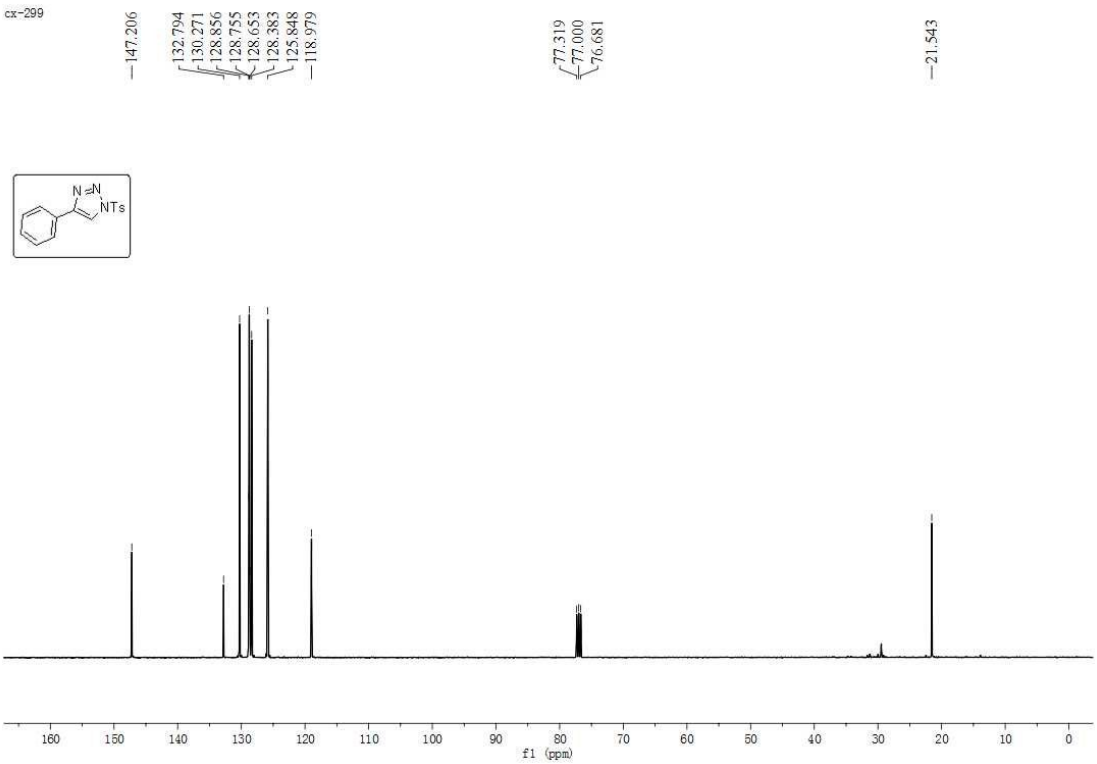

4.208
3.216
1.289
1.284
1.276
1.269
1.264
1.259
1.251
1.248
1.243
1.238
0.798
0.786
0.780
0.771
0.765
0.759
0.751
0.706
0.697
0.692
0.685
0.679
0.000
OH
2.059
1.000
0.993
2.011
2.016
f1 (ppm)

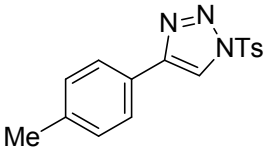

88.992
77.319
77.000
76.681
73.539
50.669
7.877
0.828
OH
f1 (ppm)


N=N
NTs

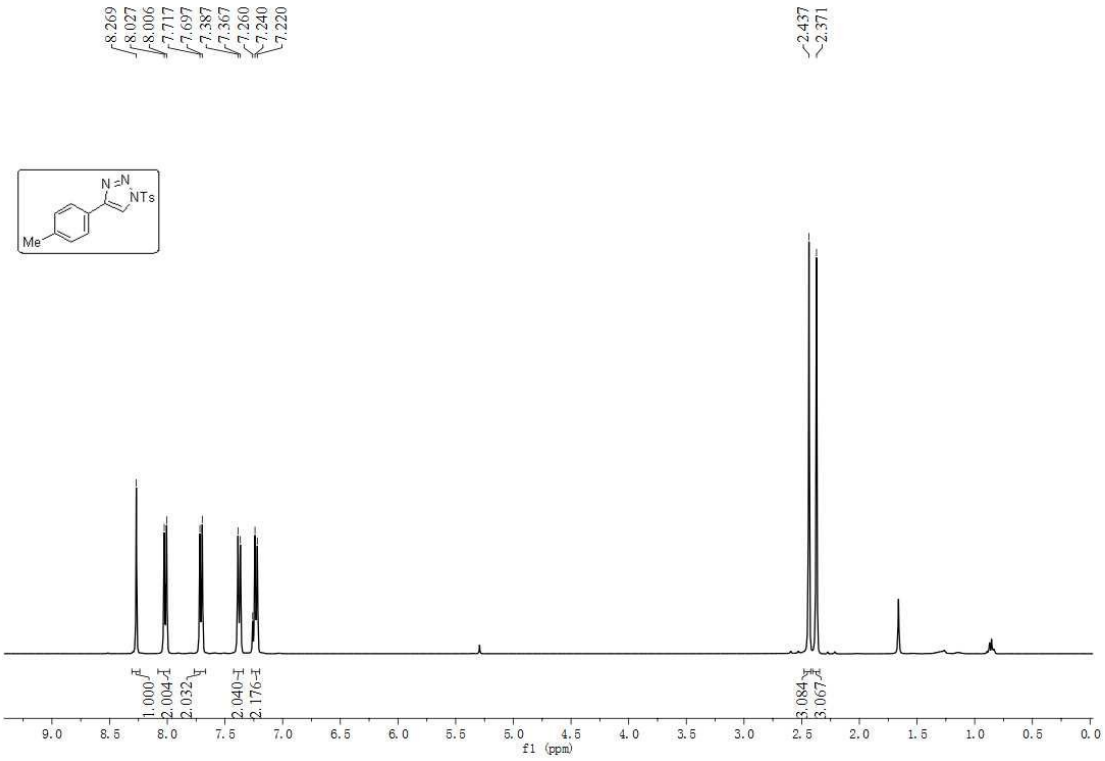
2a

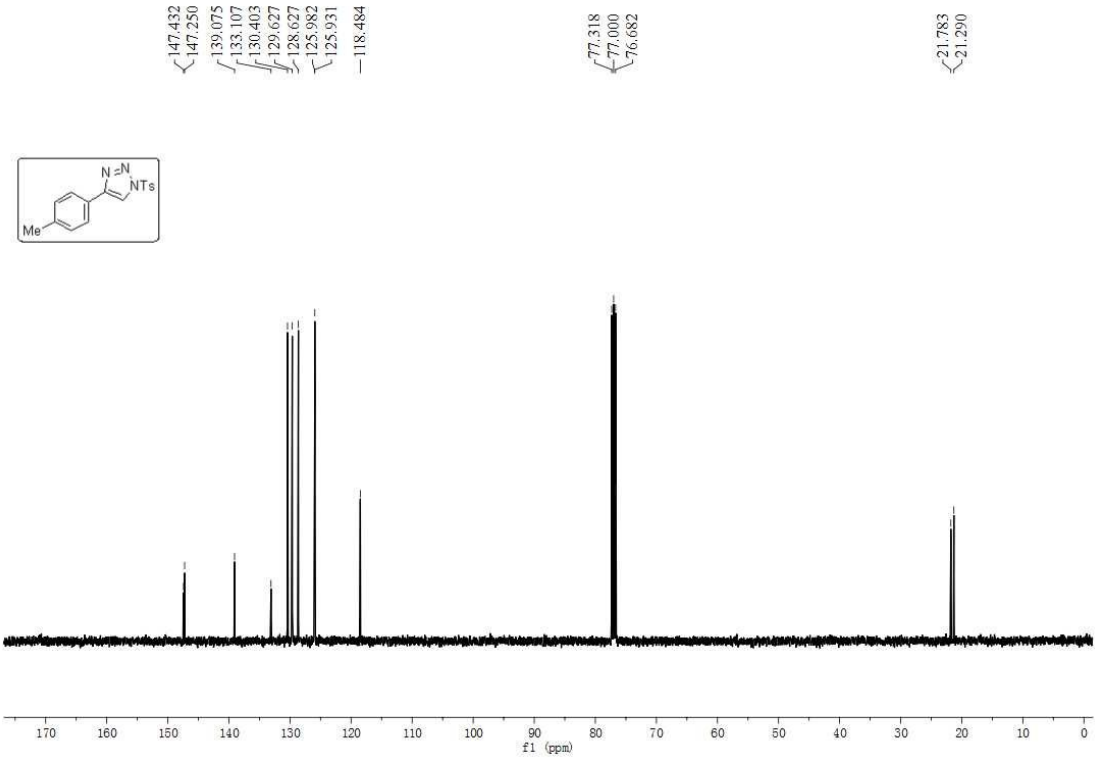

cx-299
8.224
7.862
7.841
7.686
7.668
7.266
7.249
7.230
7.193
7.173
2.236
-0.000
1.000
2.016
2.029
5.143
3.065
f1 (ppm)

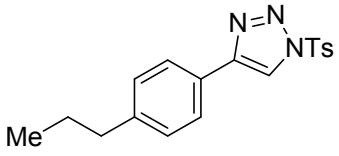

cx-299
147.206
132.794
130.271
128.856
128.755
128.653
128.383
125.848
118.979
77.319
77.000
76.681
21.543
f1 (ppm)


N=N
NTs
Me

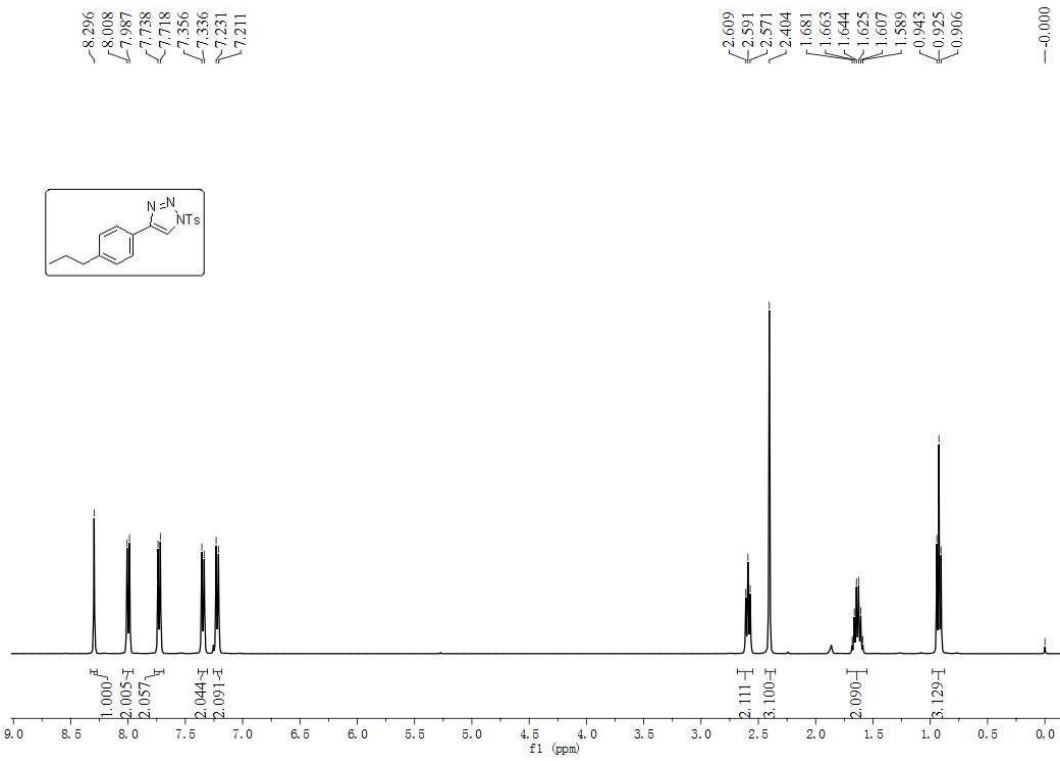
2b

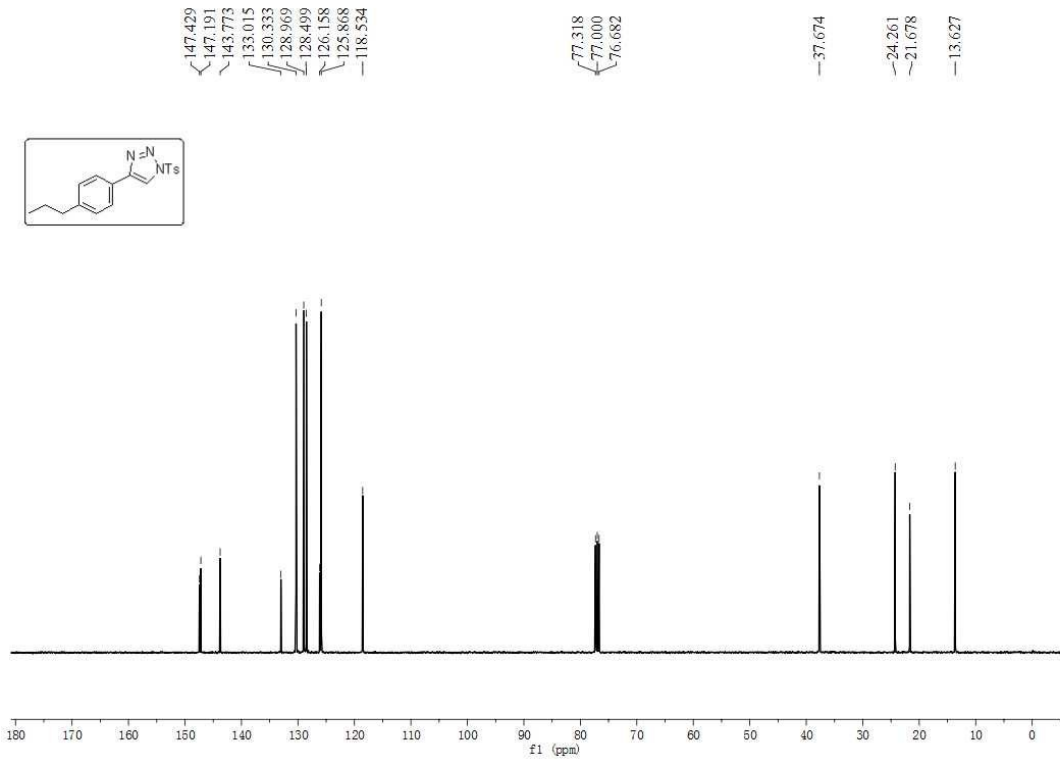

8.269
8.027
8.006
7.717
7.697
7.387
7.367
7.260
7.240
7.220
2.437
2.371
N=N
NTs
Me
1.000
2.004
2.032
2.040
2.176
3.084
3.067
f1 (ppm)

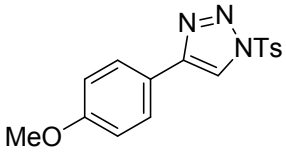

147.432
147.250
139.075
133.107
130.403
129.627
128.627
125.982
125.931
118.484
77.318
77.000
76.682
21.783
21.290
N=N
NTs
Me
f1 (ppm)


N=N
NTs
Me

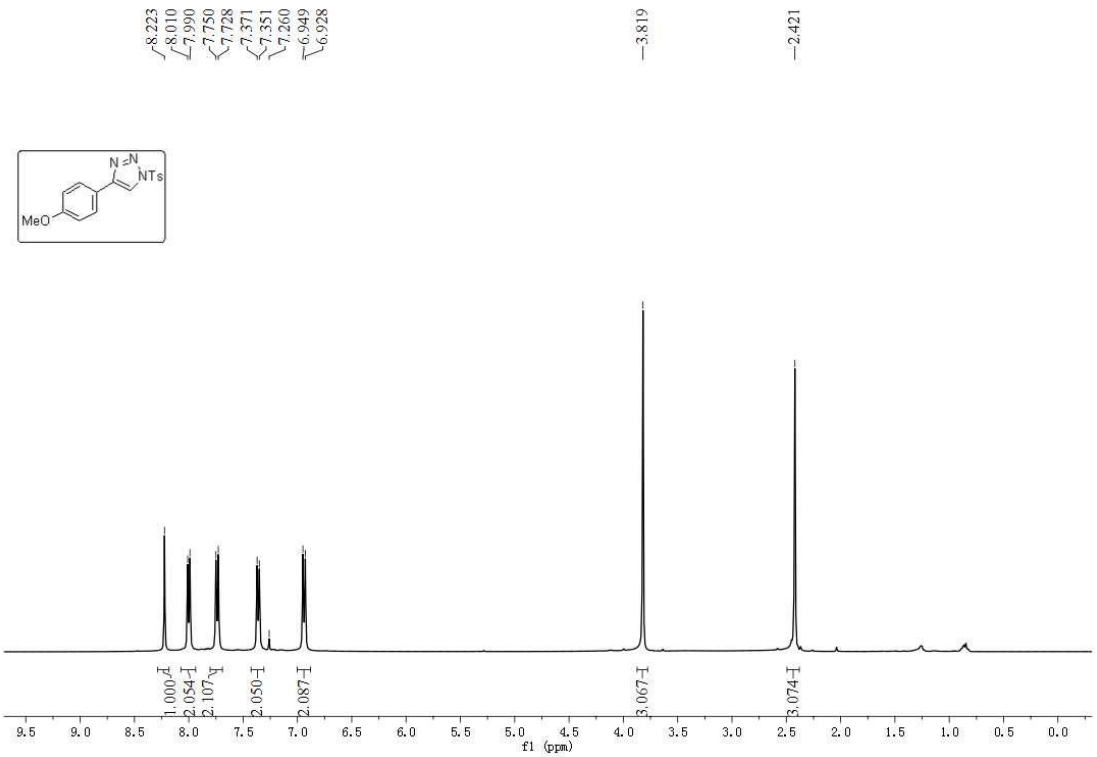
2c

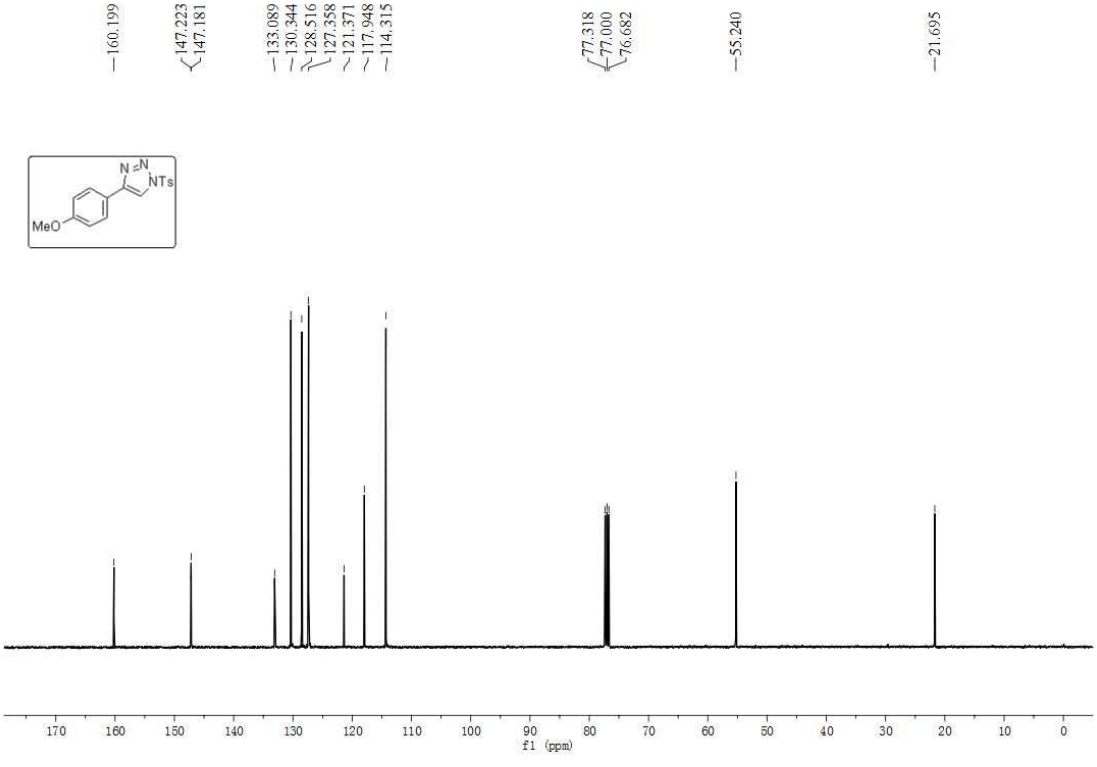

8.296
8.008
7.987
7.738
7.718
7.356
7.336
7.231
7.211
2.609
2.591
2.571
2.404
1.681
1.663
1.644
1.625
1.607
1.589
0.943
0.925
0.906
-0.000
1.000
2.005
2.057
2.044
2.091
2.111
3.100
2.090
3.129
f1 (ppm)

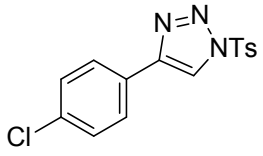

147.429
147.191
143.773
133.015
130.333
128.969
128.499
126.158
125.868
118.534
77.318
77.000
76.682
37.674
24.261
21.678
13.627
f1 (ppm)


N=N
NTs
MeO

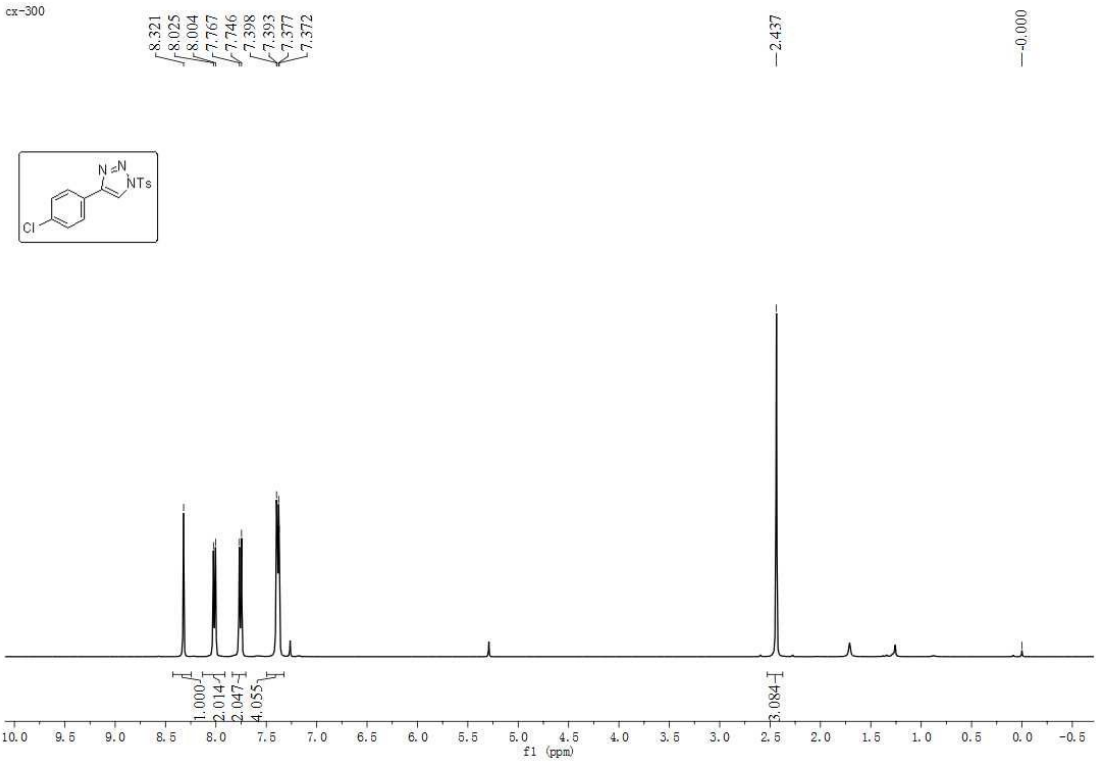
2d

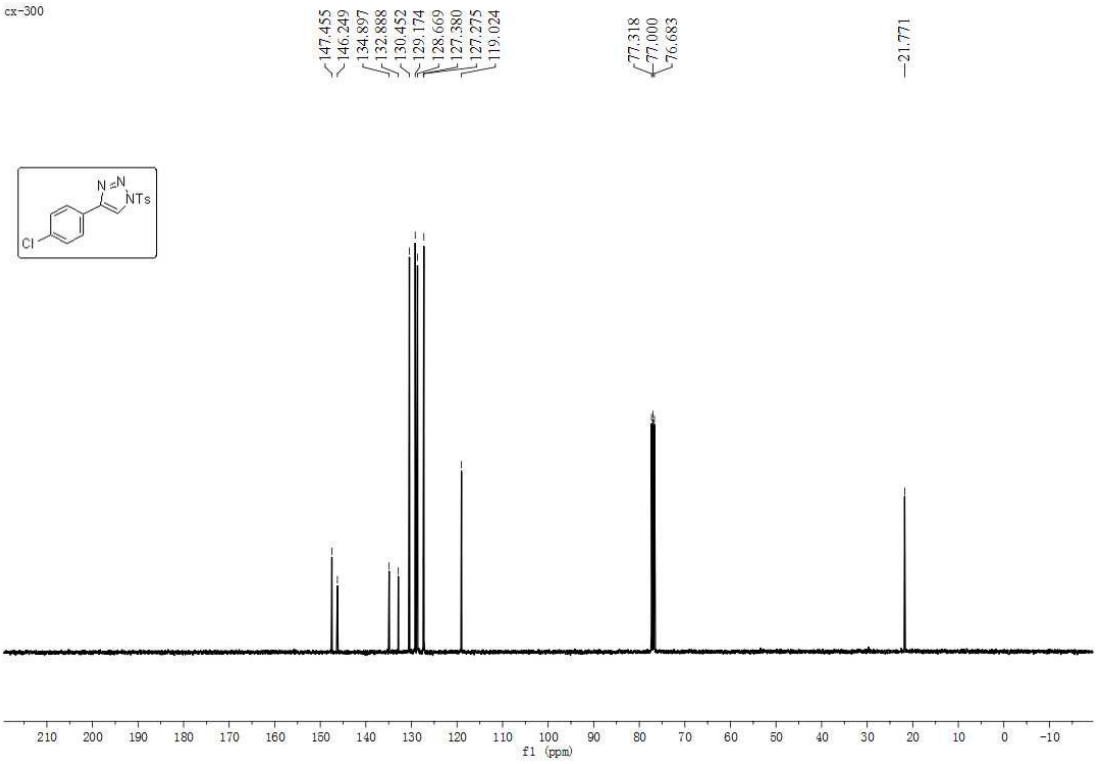

8.223
8.010
7.990
7.750
7.728
7.371
7.351
7.260
6.949
6.928
3.819
2.421
1.000
2.054
2.107
2.050
2.087
3.067
3.074
f1 (ppm)

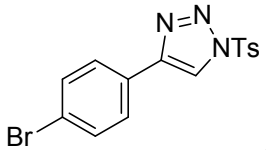

160.199
147.223
147.181
133.089
130.344
128.516
127.358
121.371
117.948
114.315
77.318
77.000
76.682
55.240
21.695
f1 (ppm)


N=N
NTs
Cl

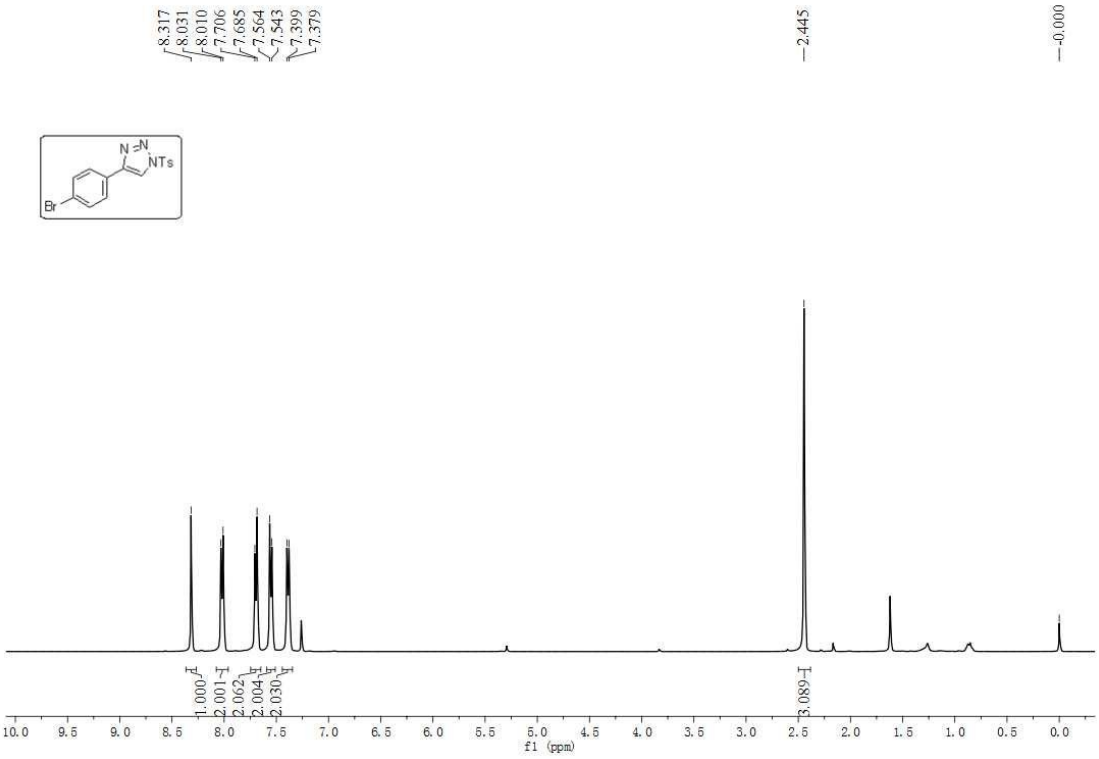
2e

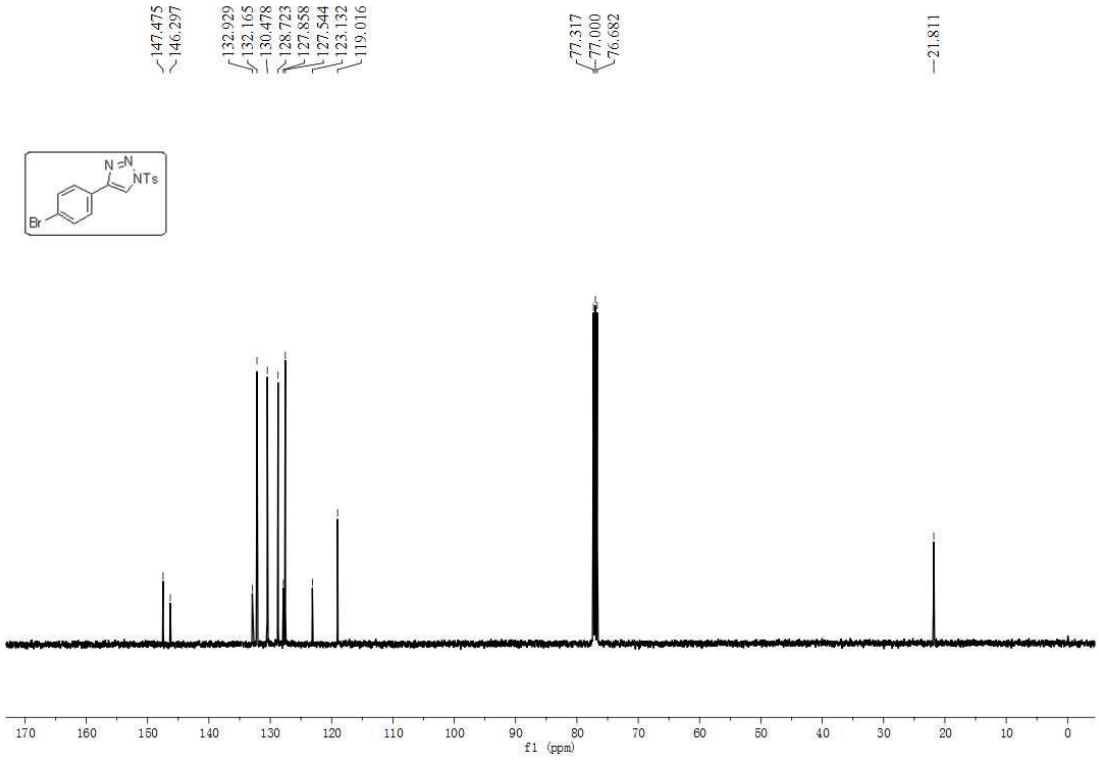

cx-300
8.321
8.025
8.004
7.767
7.746
7.398
7.393
7.377
7.372
2.437
-0.000
1.000
2.014
2.047
4.055
3.084
f1 (ppm)

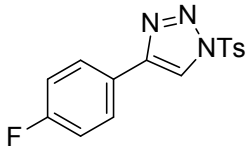

cx-300
147.455
146.249
134.897
132.888
130.452
129.174
128.669
127.380
127.275
119.024
77.318
77.000
76.683
21.771
f1 (ppm)


N=N
NTs
Br

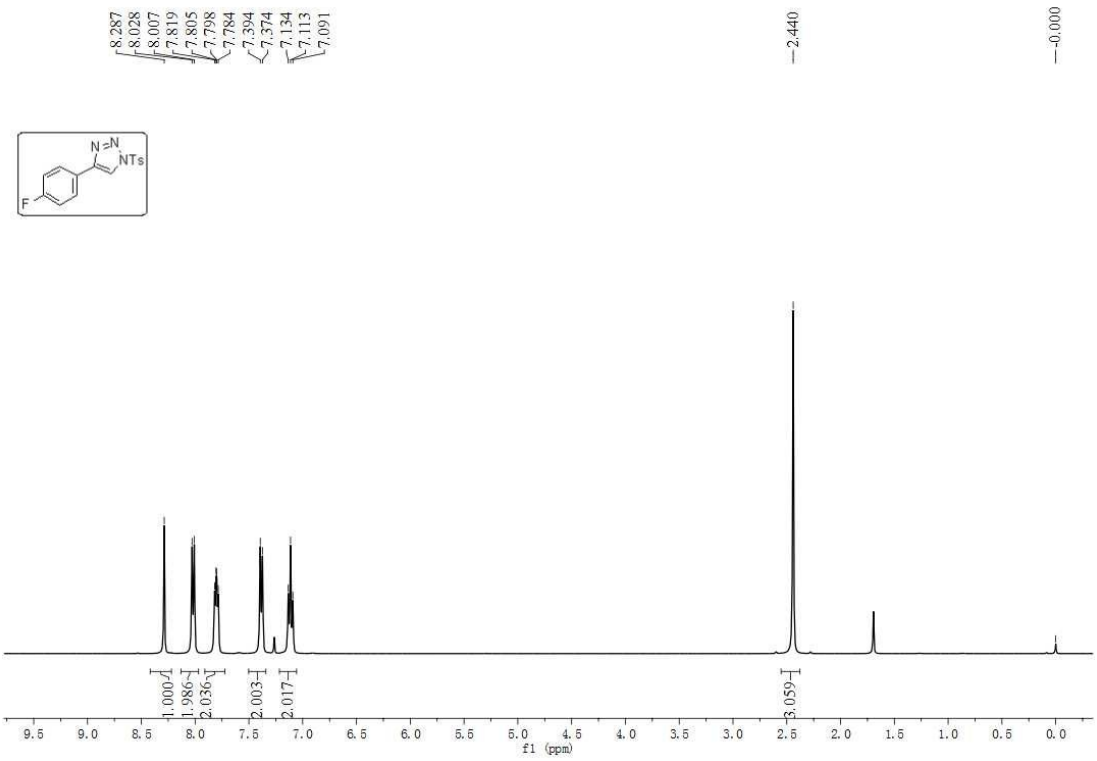
2f

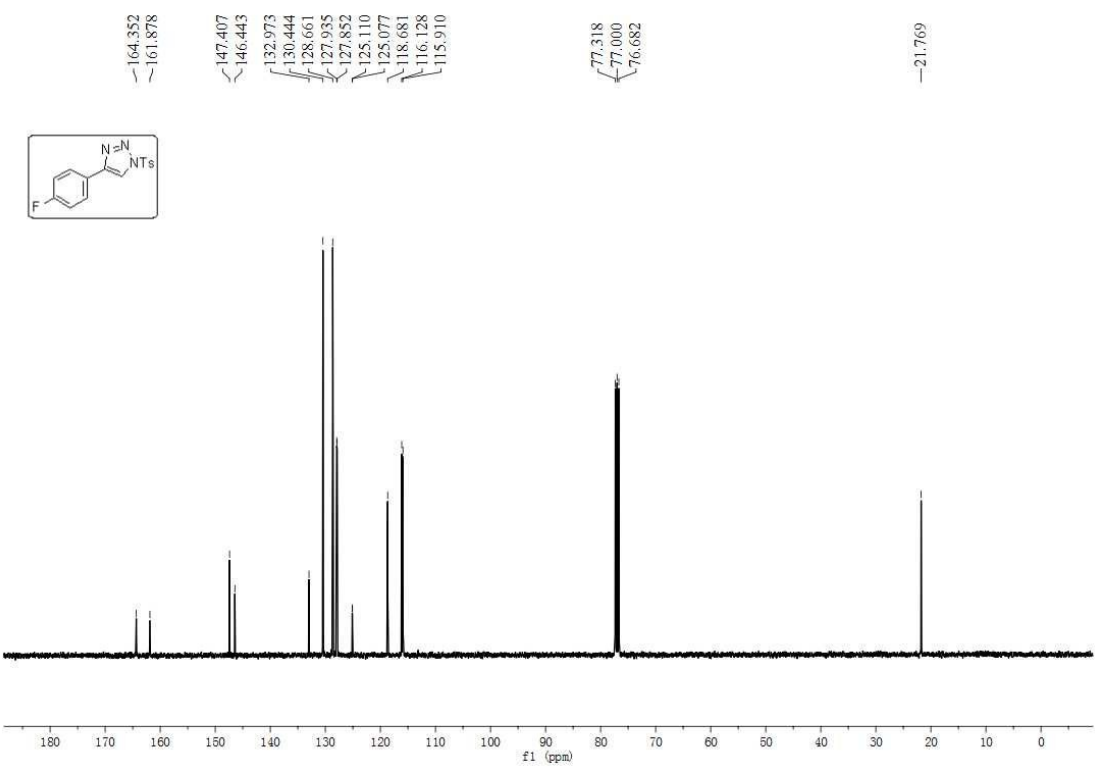

8.317
8.031
8.010
7.706
7.685
7.564
7.543
7.399
7.379
2.445
0.000
1.000
2.001
2.062
2.004
2.030
3.089
f1 (ppm)

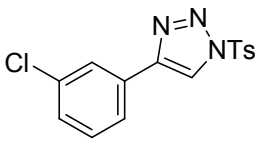

147.475
146.297
132.929
132.165
130.478
128.723
127.858
127.544
123.132
119.016
77.317
77.000
76.682
21.811
f1 (ppm)


N=N
NTs
F

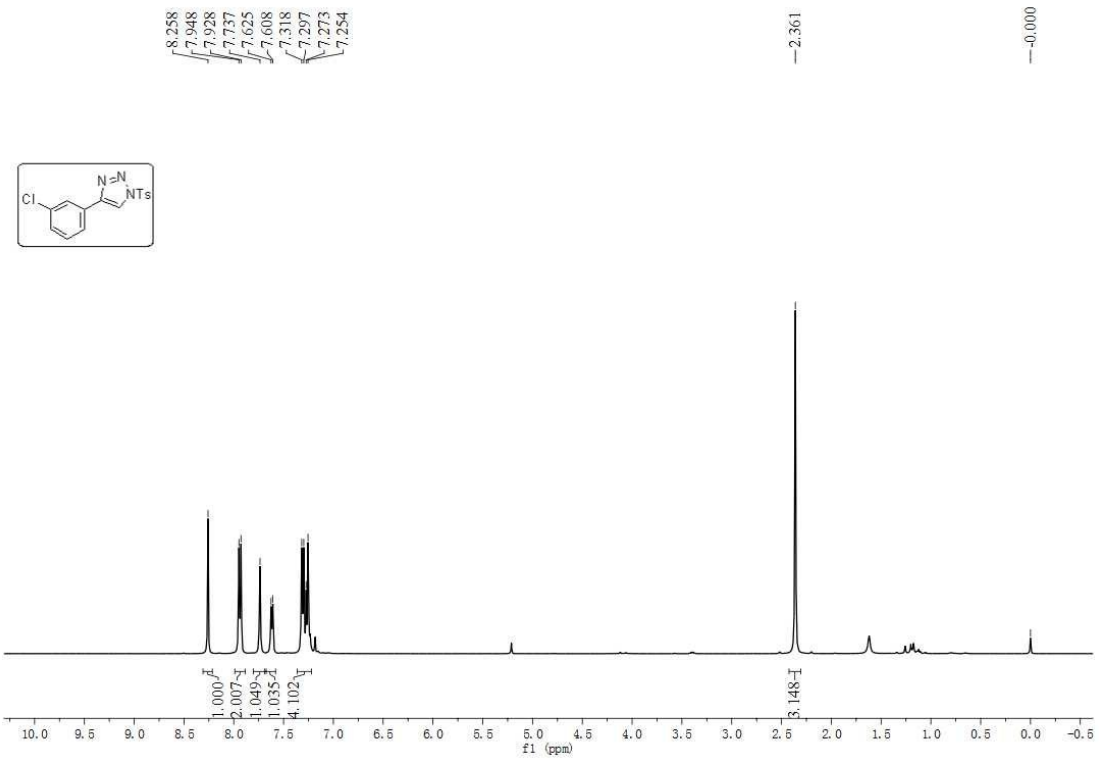
2g

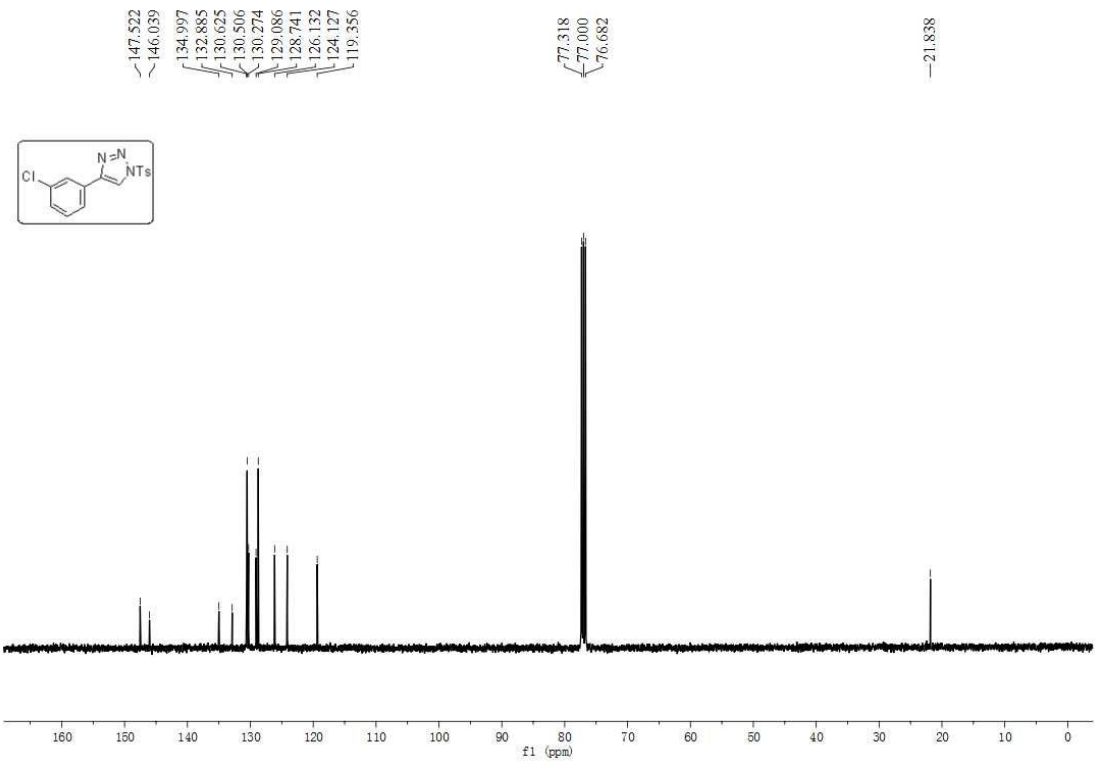

8.287
8.028
8.007
7.819
7.805
7.798
7.784
7.394
7.374
7.134
7.113
7.091
2.440
0.000
1.000
1.986
2.036
2.003
2.017
3.059
f1 (ppm)

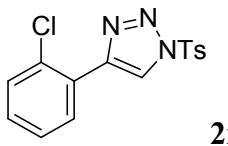

164.352
161.878
147.407
146.443
132.973
130.444
128.661
127.935
127.852
125.110
125.077
118.681
116.128
115.910
77.318
77.000
76.682
21.769
f1 (ppm)


N=N
NTs
Cl

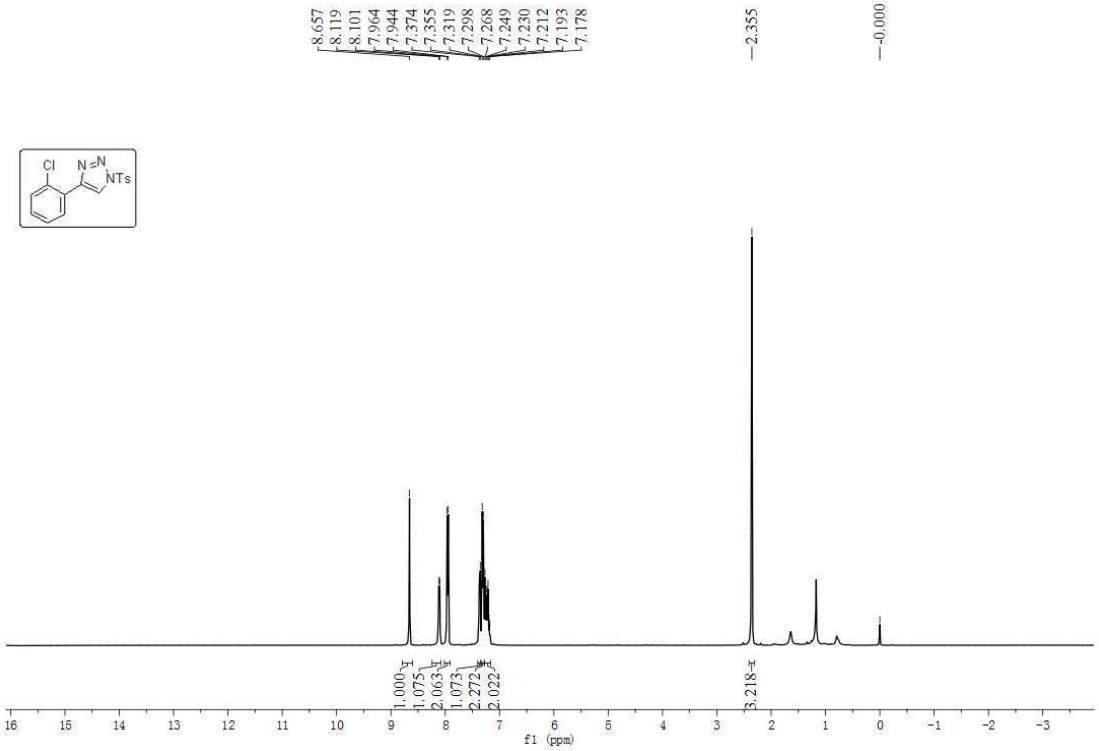
2h

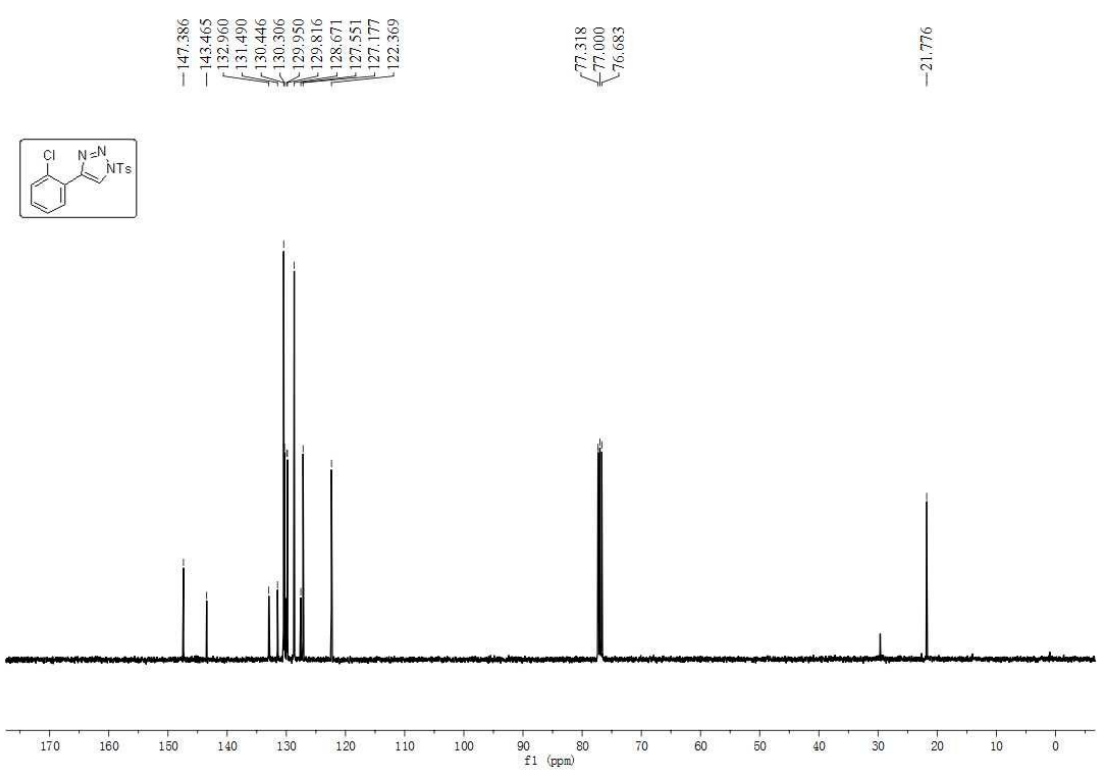

8.258
7.948
7.928
7.737
7.625
7.608
7.318
7.297
7.273
7.254
2.361
0.000
1.000
2.007
1.049
1.035
4.102
3.148
f1 (ppm)

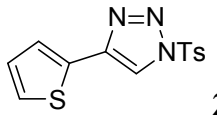

147.522
146.039
134.997
132.885
130.625
130.506
130.274
129.086
128.741
126.132
124.127
119.356
77.318
77.000
76.682
21.838
f1 (ppm)


Cl
N=N
NTs

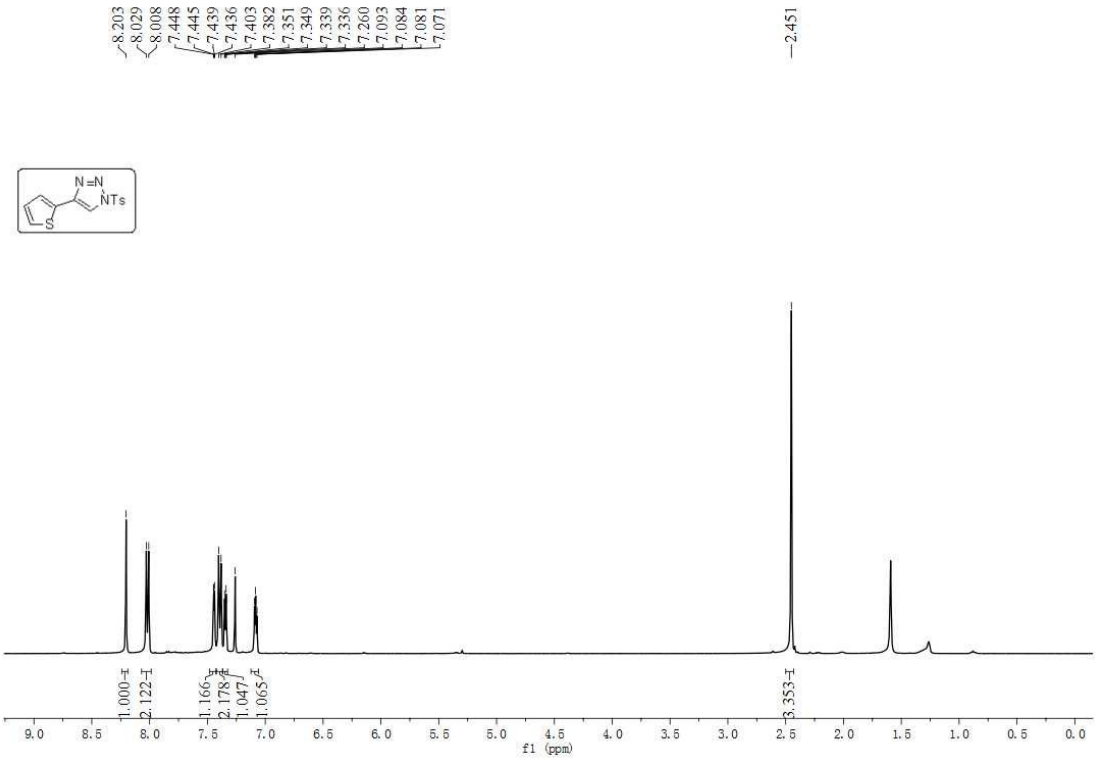
2i

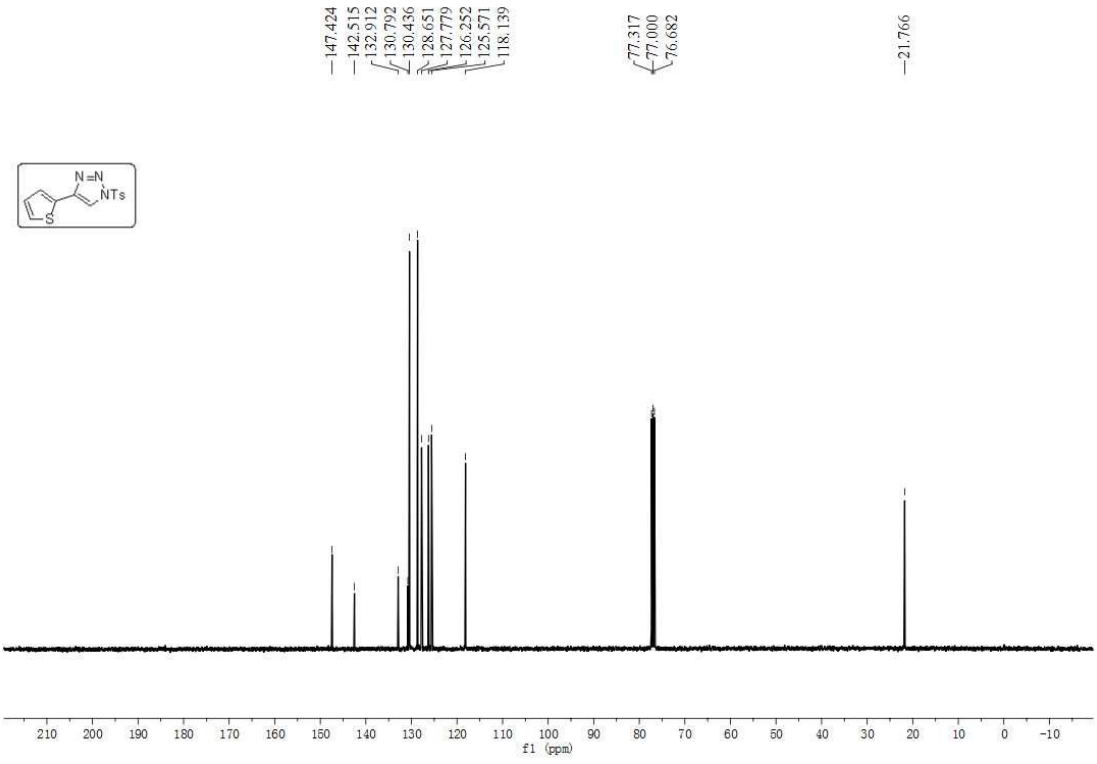

8.657
8.119
8.101
7.964
7.944
7.374
7.355
7.319
7.298
7.268
7.249
7.230
7.212
7.193
7.178
2.355
0.000
1.000
1.075
2.063
1.073
2.272
2.022
3.218
f1 (ppm)

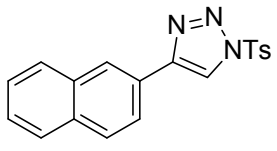

147.386
143.465
132.960
131.490
130.446
130.306
129.950
129.816
128.671
127.551
127.177
122.369
77.318
77.000
76.683
21.776
f1 (ppm)


N=N
NTs
S

2j

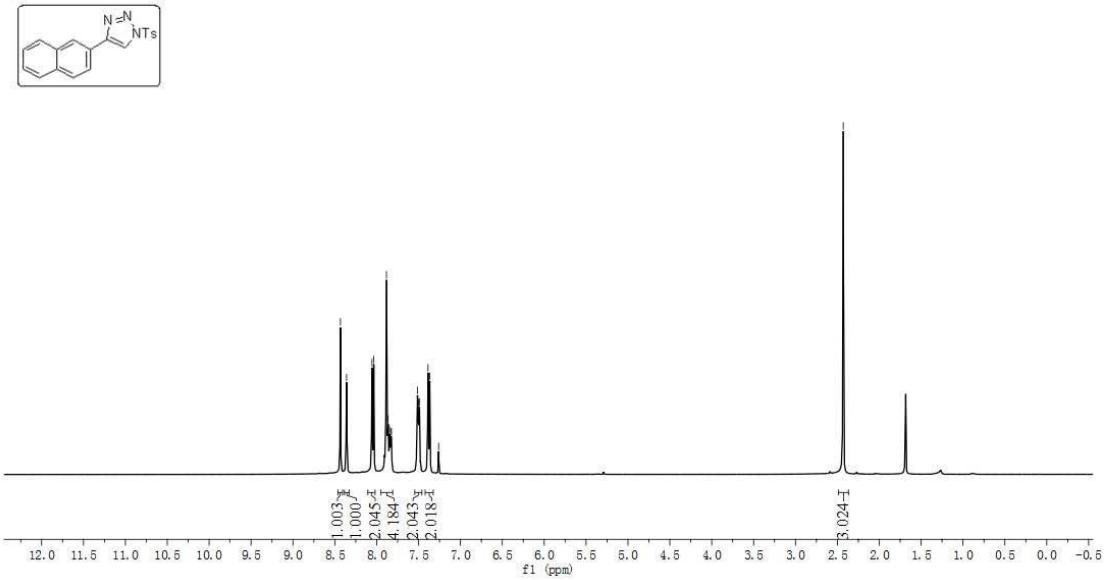

8.203
8.029
8.008
7.448
7.445
7.439
7.436
7.403
7.382
7.351
7.349
7.339
7.336
7.260
7.093
7.084
7.081
7.071
2.451
1.000
2.122
1.166
2.178
1.047
1.065
3.353
f1 (ppm)


147.424
142.515
132.912
130.792
130.436
128.651
127.779
126.252
125.571
118.139
77.317
77.000
76.682
21.766
f1 (ppm)

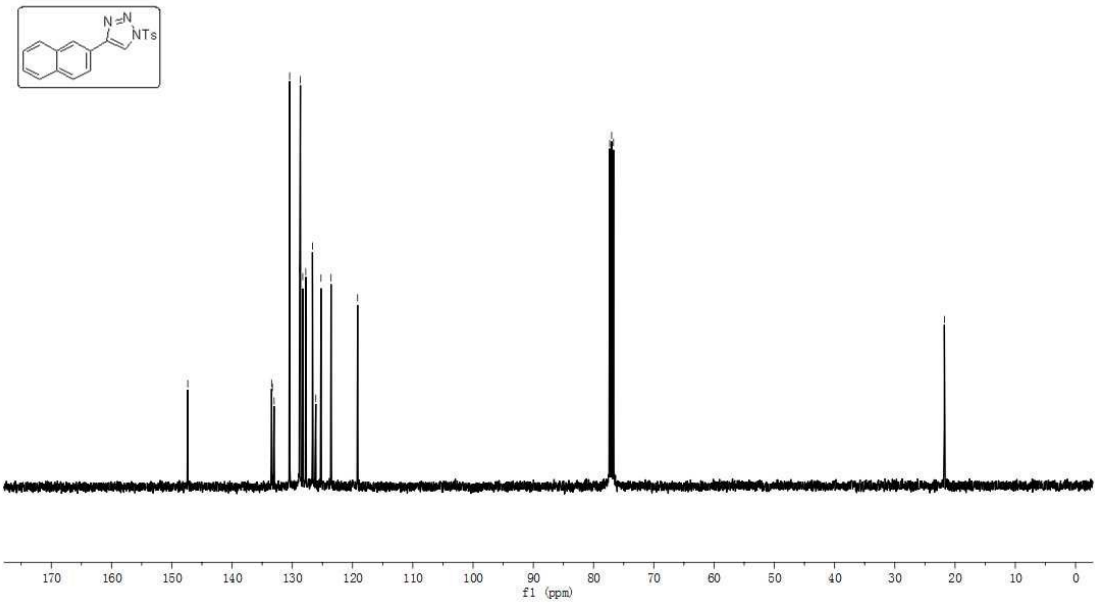


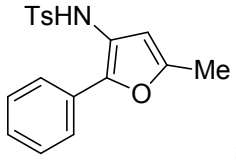
2k


8.433
8.359
8.056
8.035
7.883
7.863
7.847
7.834
7.824
7.512
7.508
7.502
7.494
7.489
7.387
7.367
7.260
2.430

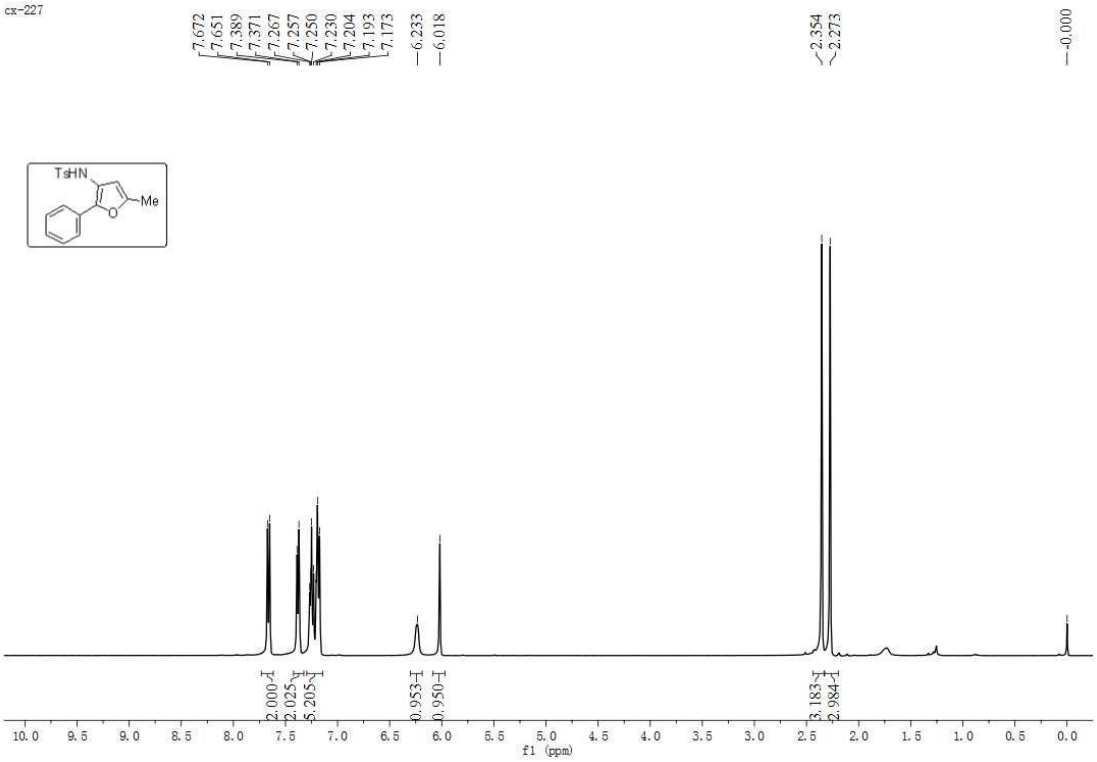

1.003
1.000
2.045
4.184
2.043
2.018
3.024
f1 (ppm)

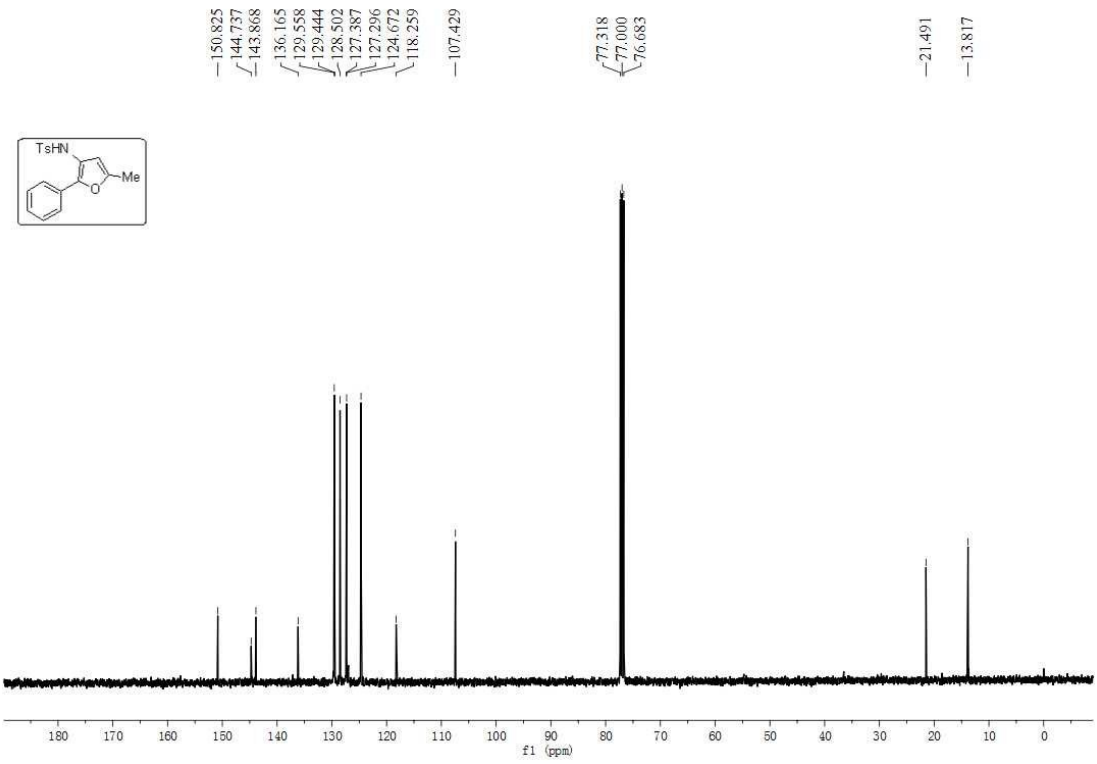

147.393
147.346
133.439
133.297
133.020
130.436
128.784
128.656
128.261
127.760
126.656
126.633
126.100
125.235
123.567
119.159
77.318
77.000
76.682
21.775

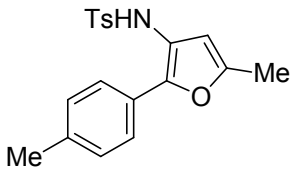

f1 (ppm)


TsHN
Me
O

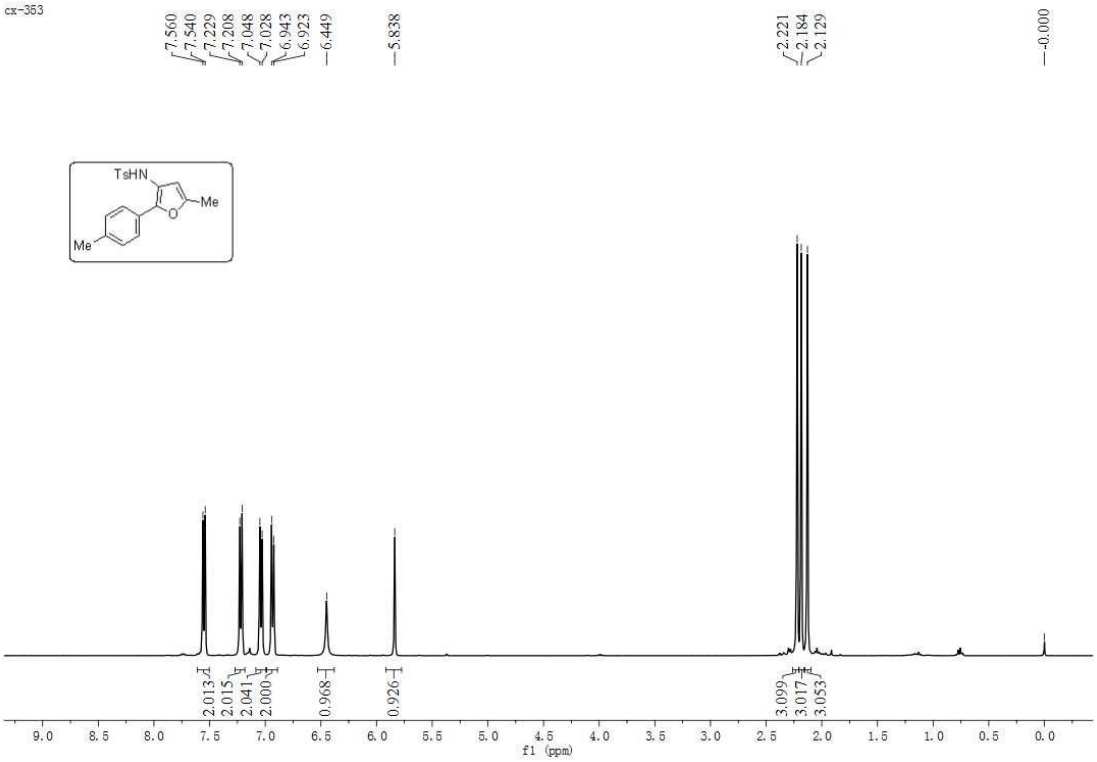
5a

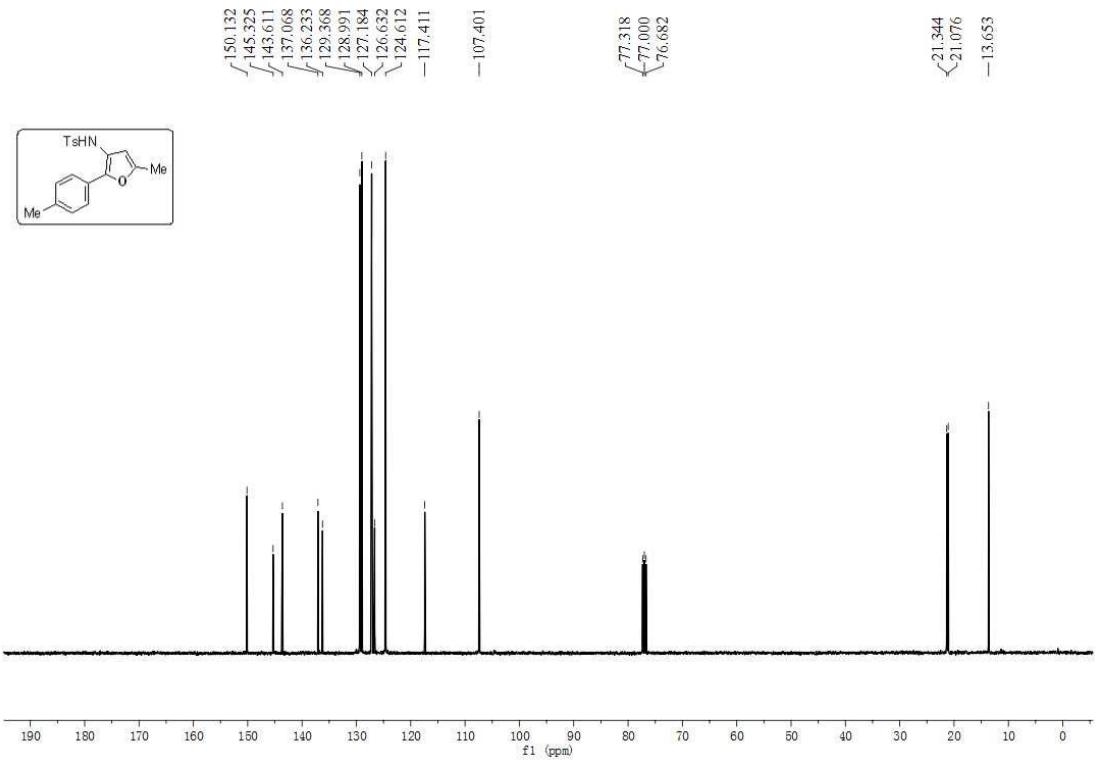

cx-227
7.672
7.651
7.389
7.371
7.267
7.257
7.250
7.230
7.204
7.193
7.173
6.233
6.018
2.354
2.273
-0.000
TsHN
Me
2.000
2.025
5.205
0.953
0.950
3.183
2.984
f1 (ppm)

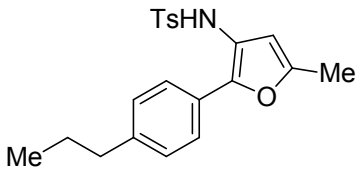

150.825
144.737
143.868
136.165
129.558
129.444
128.502
127.387
127.296
124.672
118.259
107.429
77.318
77.000
76.683
21.491
13.817
TsHN
Me
f1 (ppm)


TsHN
Me
O
Me

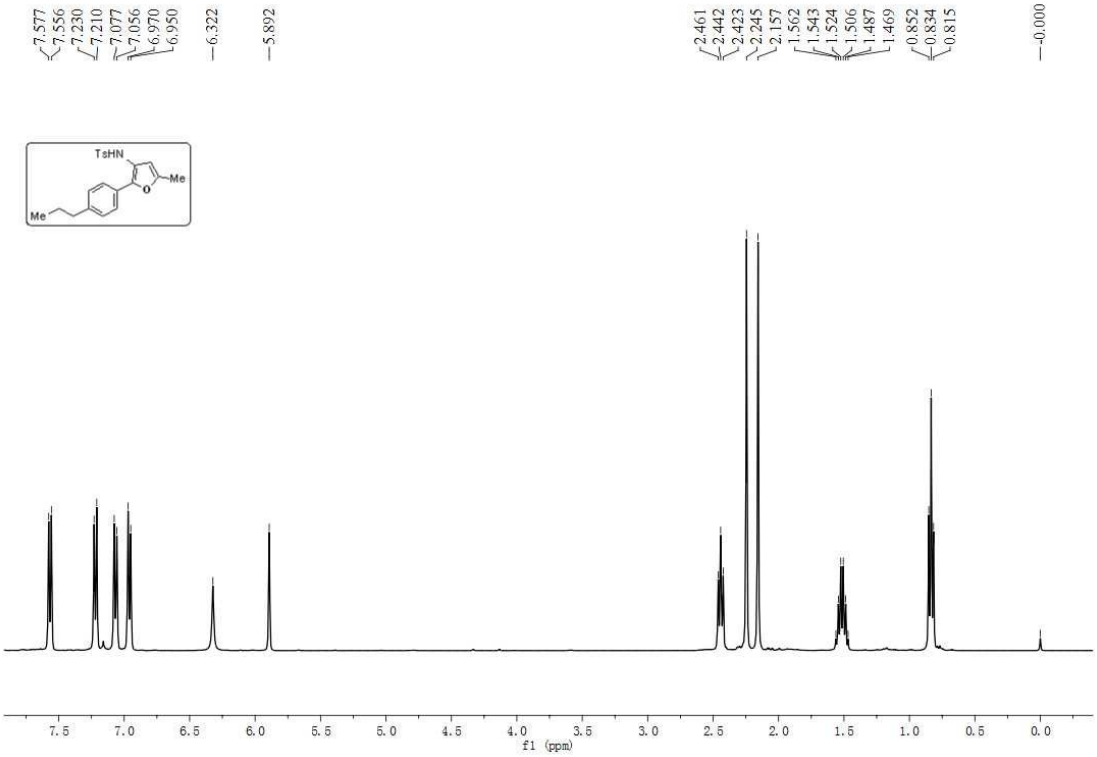
5b

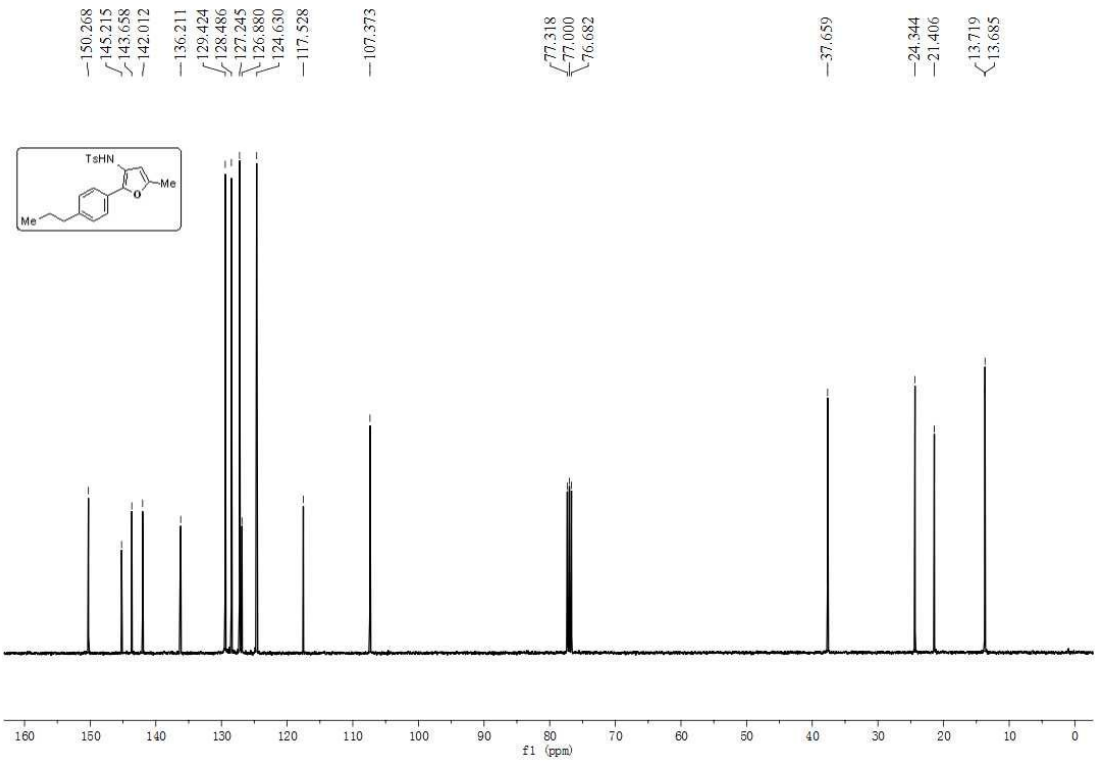

cx-353
7.560
7.540
7.229
7.208
7.048
7.028
6.943
6.923
6.449
5.838
2.221
2.184
2.129
0.000
TsHN
Me
Me
2.013
2.015
2.041
2.000
0.968
0.926
3.099
3.017
3.053
f1 (ppm)

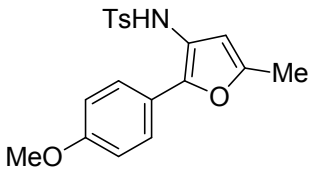

150.132
145.325
143.611
137.068
136.233
129.368
128.991
127.184
126.632
124.612
117.411
107.401
77.318
77.000
76.682
21.344
21.076
13.653
TsHN
Me
Me
f1 (ppm)


TsHN
Me
O
Me

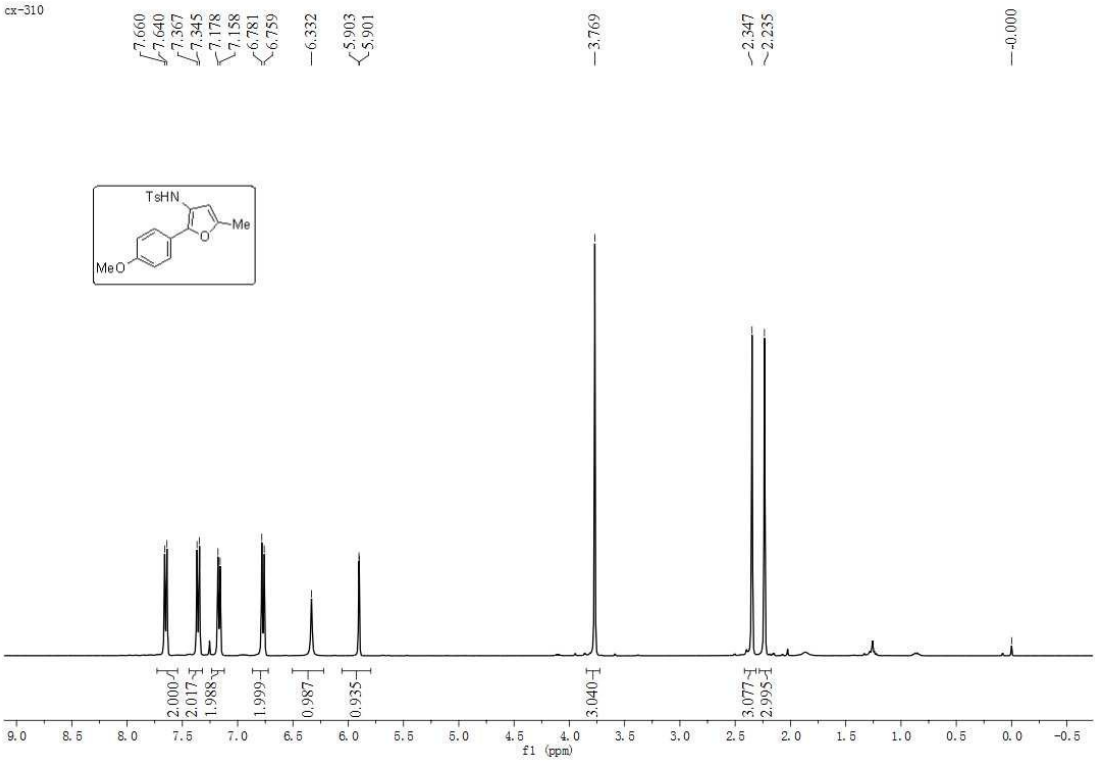
5c

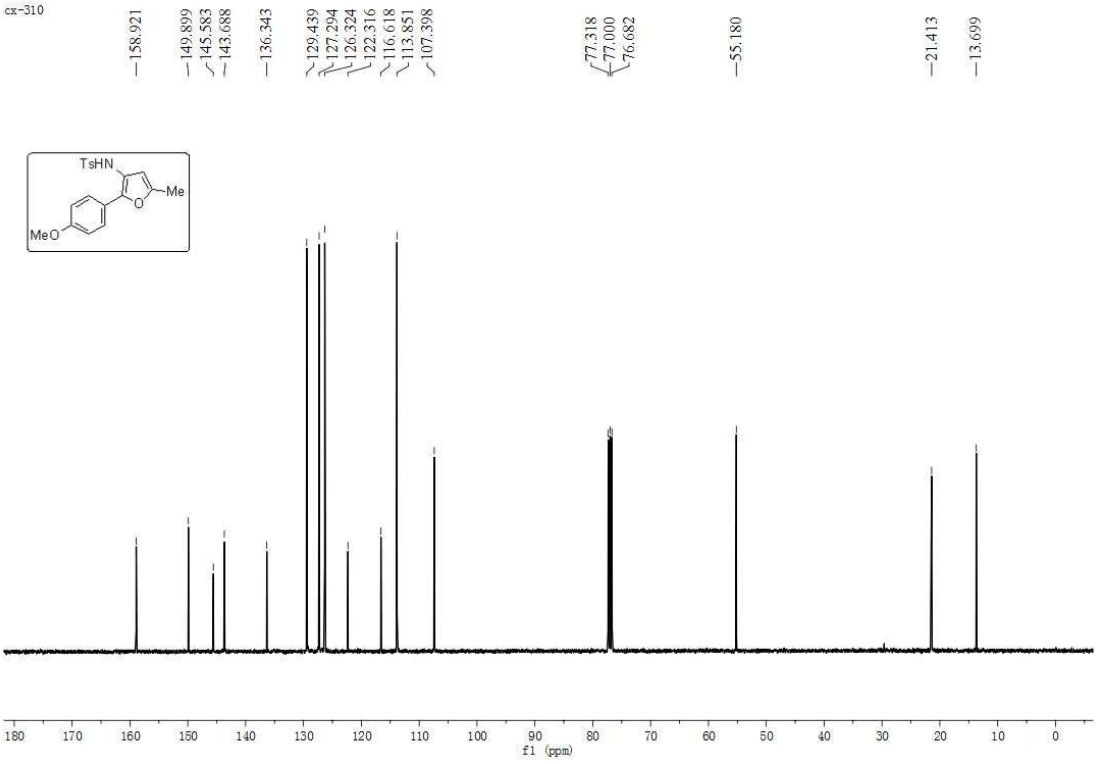

7.577
7.556
7.230
7.210
7.077
7.056
6.970
6.950
6.322
5.892
2.461
2.442
2.423
2.245
2.157
1.562
1.543
1.524
1.506
1.487
1.469
0.852
0.834
0.815
0.000
TsHN
Me
Me
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

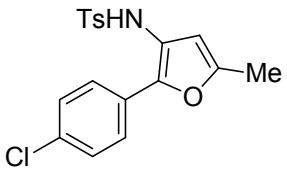

150.268
145.215
143.658
142.012
136.211
129.424
128.486
127.245
126.880
124.630
117.528
107.373
77.318
77.000
76.682
37.659
24.344
21.406
13.719
13.685
TsHN
Me
Me
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


TsHN
Me
O
MeO

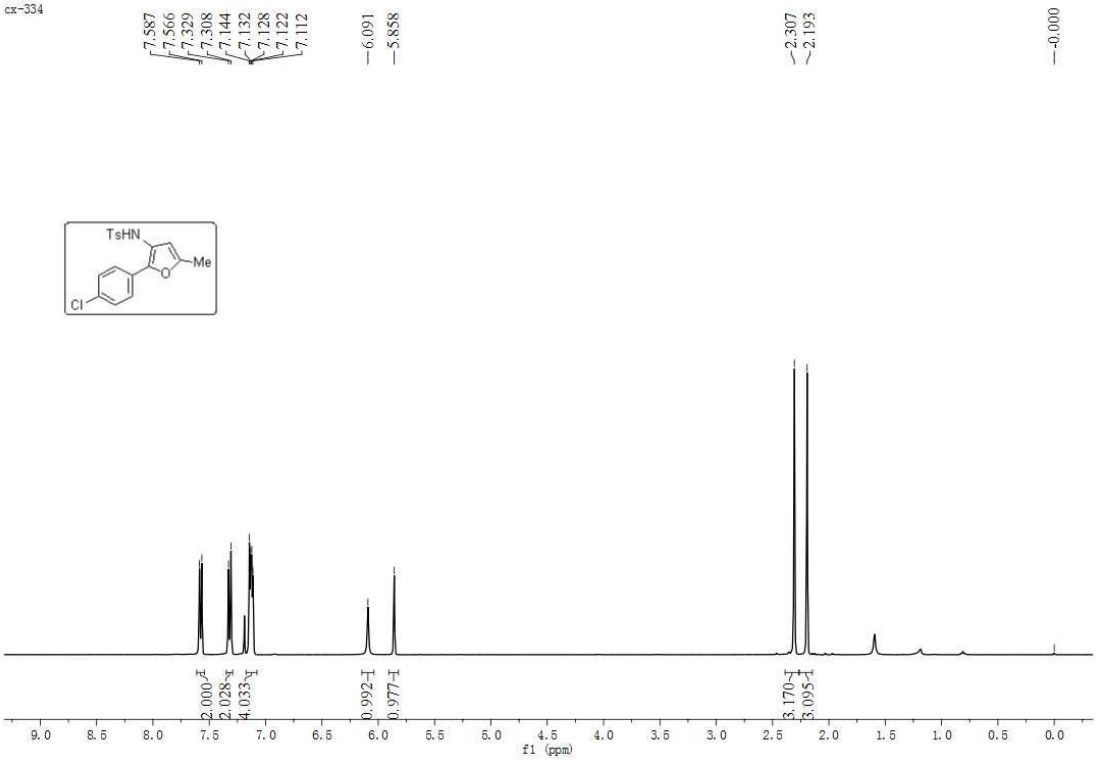
5d

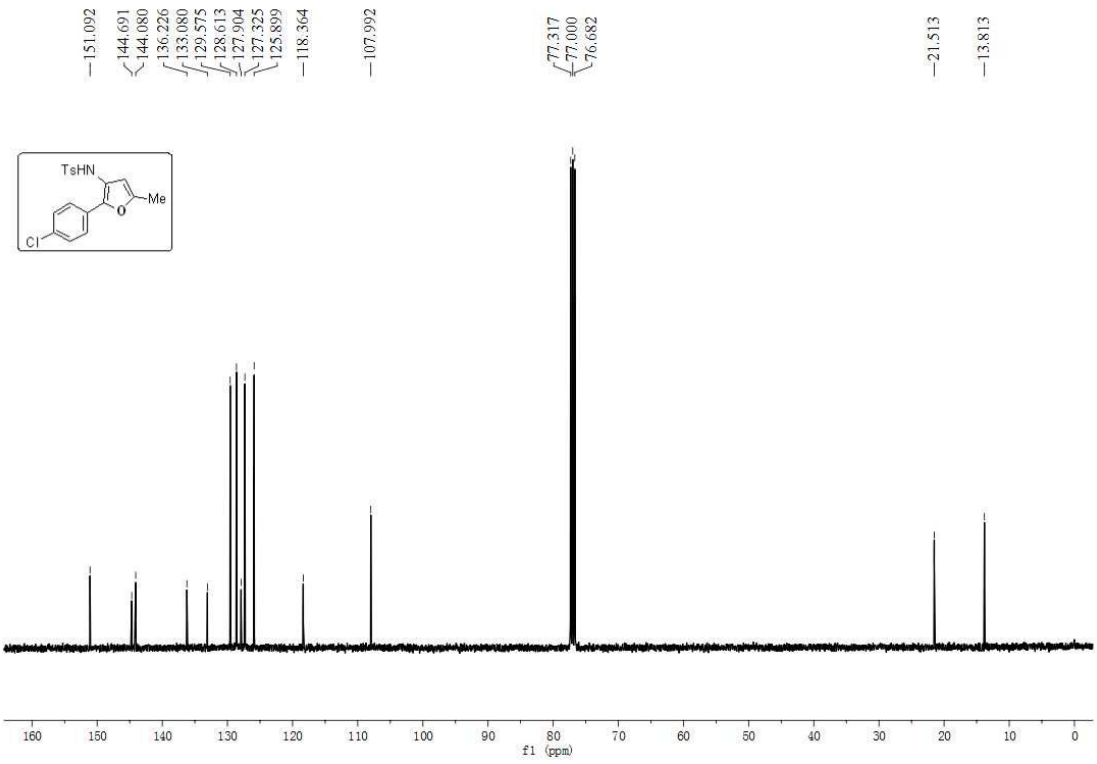

cx-310
7.660
7.640
7.367
7.345
7.178
7.158
6.781
6.759
6.332
5.903
5.901
3.769
2.347
2.235
-0.000
TsHN
Me
MeO
2.000
2.017
1.988
1.999
0.987
0.935
3.040
3.077
2.995
f1 (ppm)

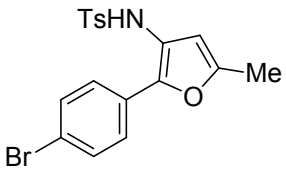

cx-310
158.921
149.899
145.583
143.688
136.343
129.439
127.294
126.324
122.316
116.618
113.851
107.398
77.318
77.000
76.682
55.180
21.413
13.699
TsHN
Me
MeO
f1 (ppm)


TsHN
Me
O
Cl

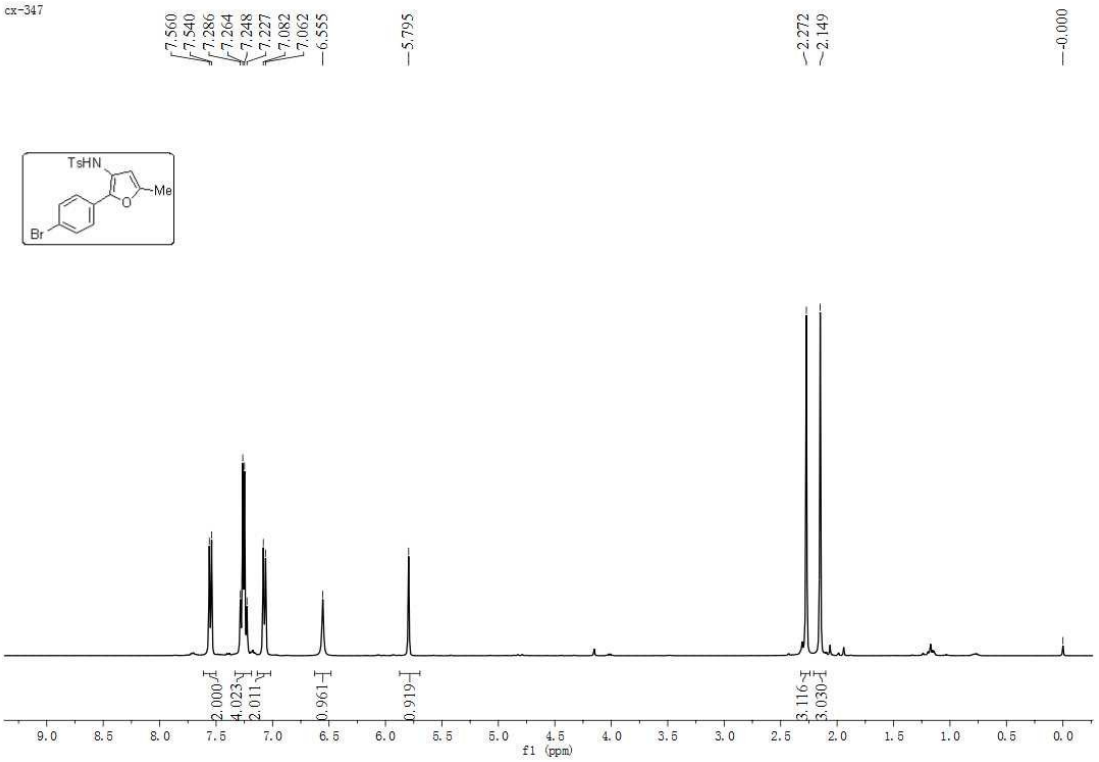
5e

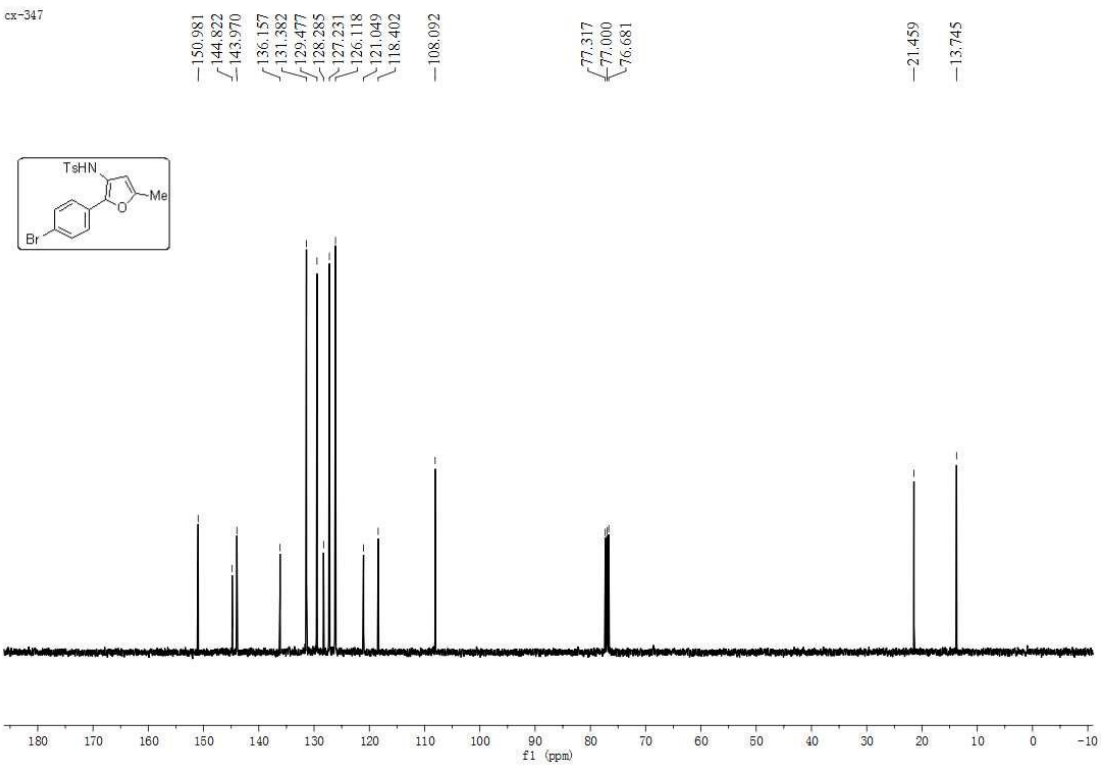

cx-334
7.587
7.566
7.329
7.308
7.144
7.132
7.128
7.122
7.112
6.091
5.858
2.307
2.193
0.000
TsHN
Me
Cl
2.000
2.028
4.033
0.992
0.977
3.170
3.095
f1 (ppm)

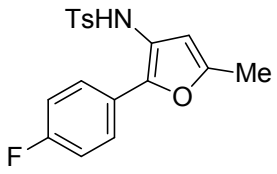

151.092
144.691
144.080
136.226
133.080
129.575
128.613
127.904
127.325
125.899
118.364
107.992
77.317
77.000
76.682
21.513
13.813
TsHN
Me
Cl
f1 (ppm)


TsHN
Me
O
Br

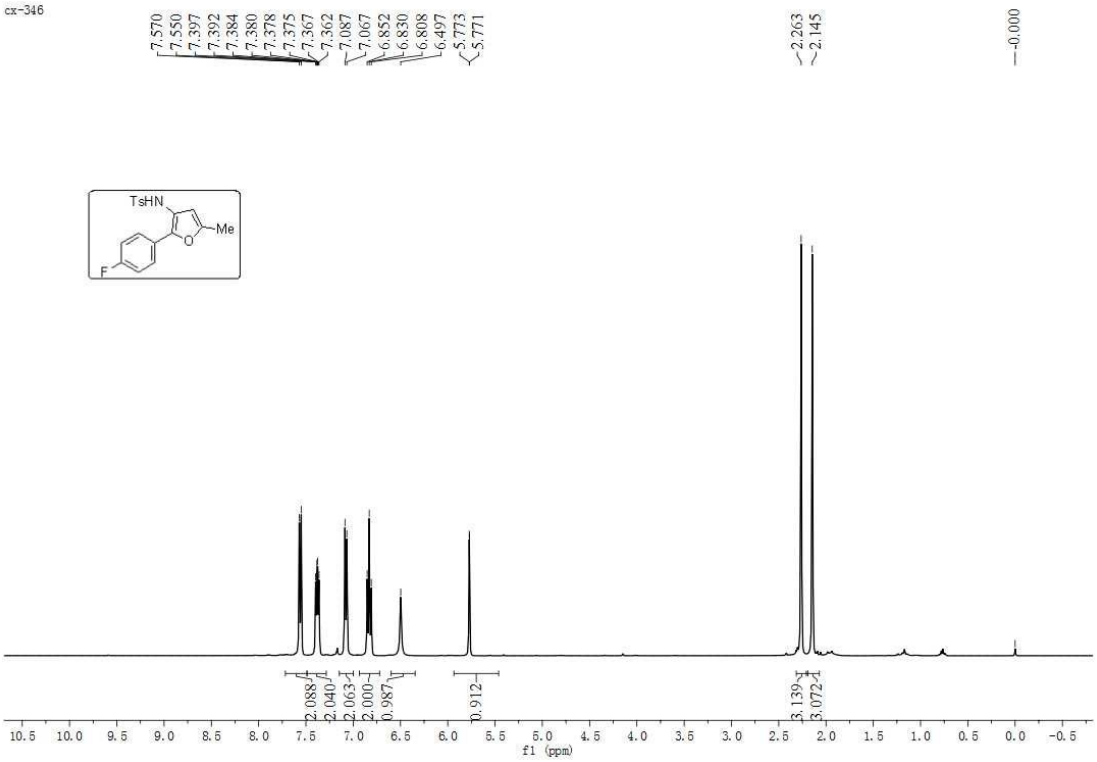
5f

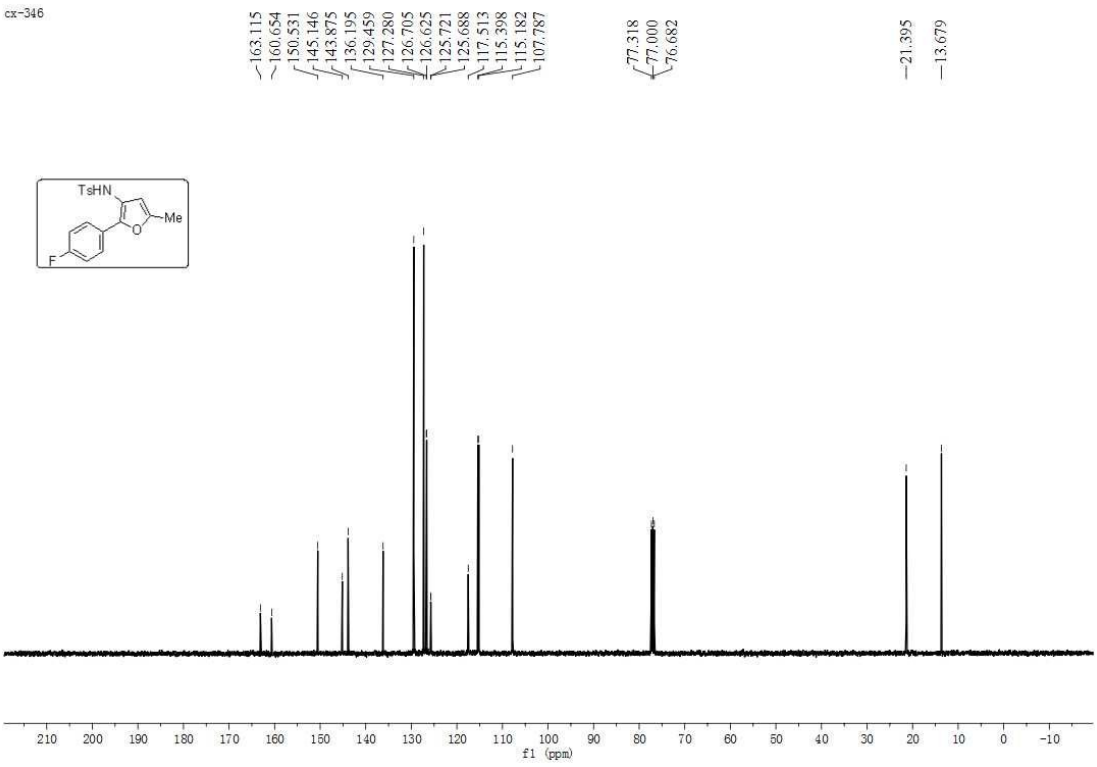

cx-347
7.560
7.540
7.286
7.264
7.248
7.227
7.082
7.062
6.555
5.795
2.272
2.149
0.000
TsHN
Me
Br
2.000
4.023
2.011
0.961
0.919
3.116
3.030
f1 (ppm)

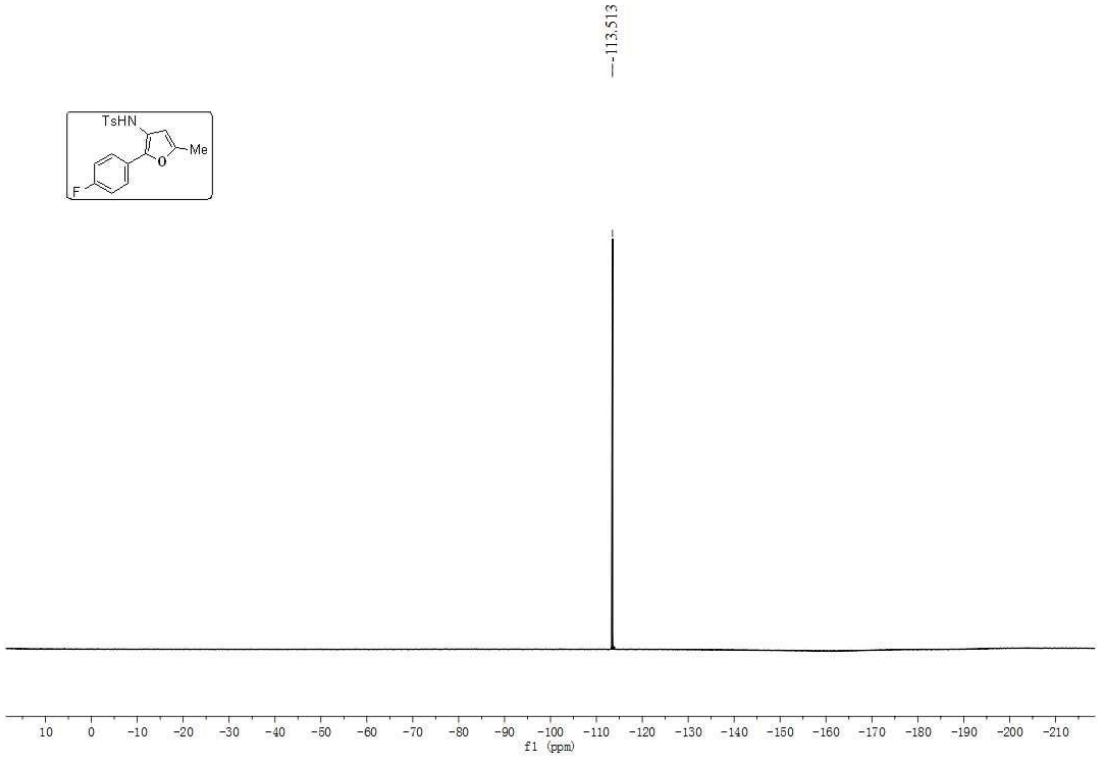

cx-347
150.981
144.822
143.970
136.157
131.382
129.477
128.285
127.231
126.118
121.049
118.402
108.092
77.317
77.000
76.681
21.459
13.745
TsHN
Me
Br
f1 (ppm)

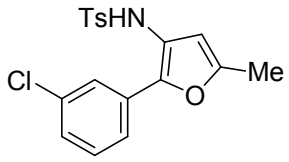

TsHN
Me
O
F

5g

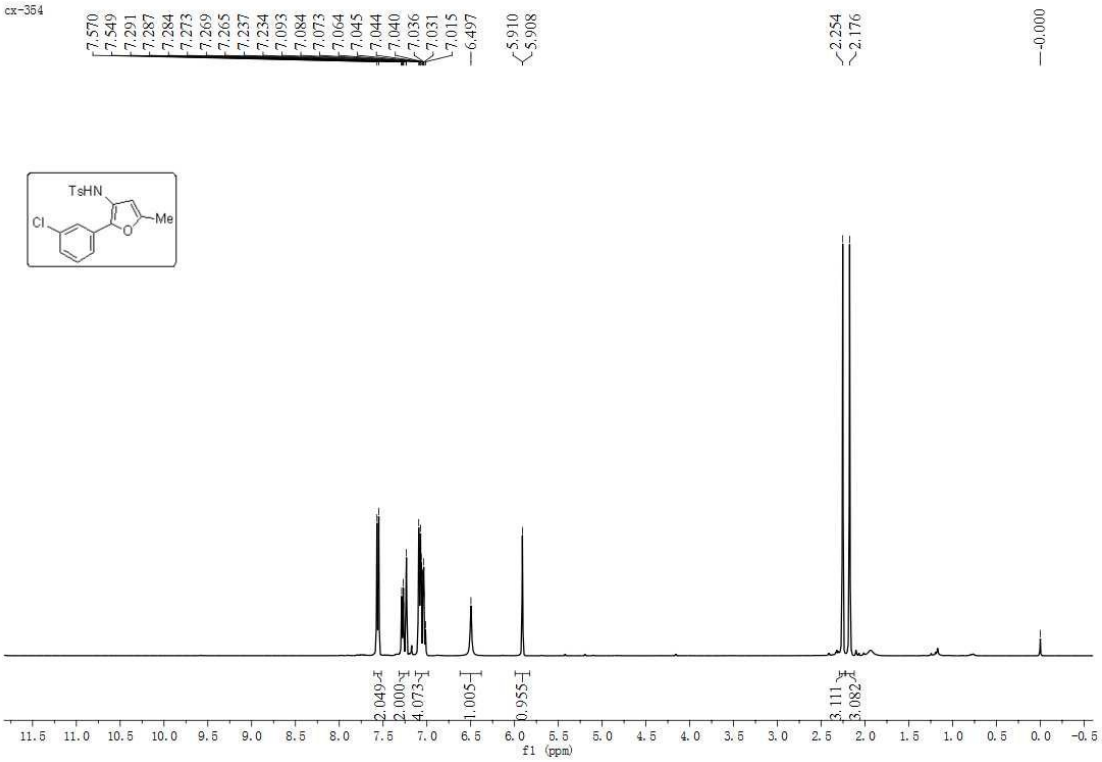

cx-346
7.570
7.550
7.397
7.392
7.384
7.380
7.378
7.375
7.367
7.362
7.087
7.067
6.852
6.830
6.808
6.497
5.773
5.771
2.263
2.145
0.000
TsHN
Me
F
2.088
2.040
2.063
2.000
0.987
0.912
3.139
3.072
f1 (ppm)

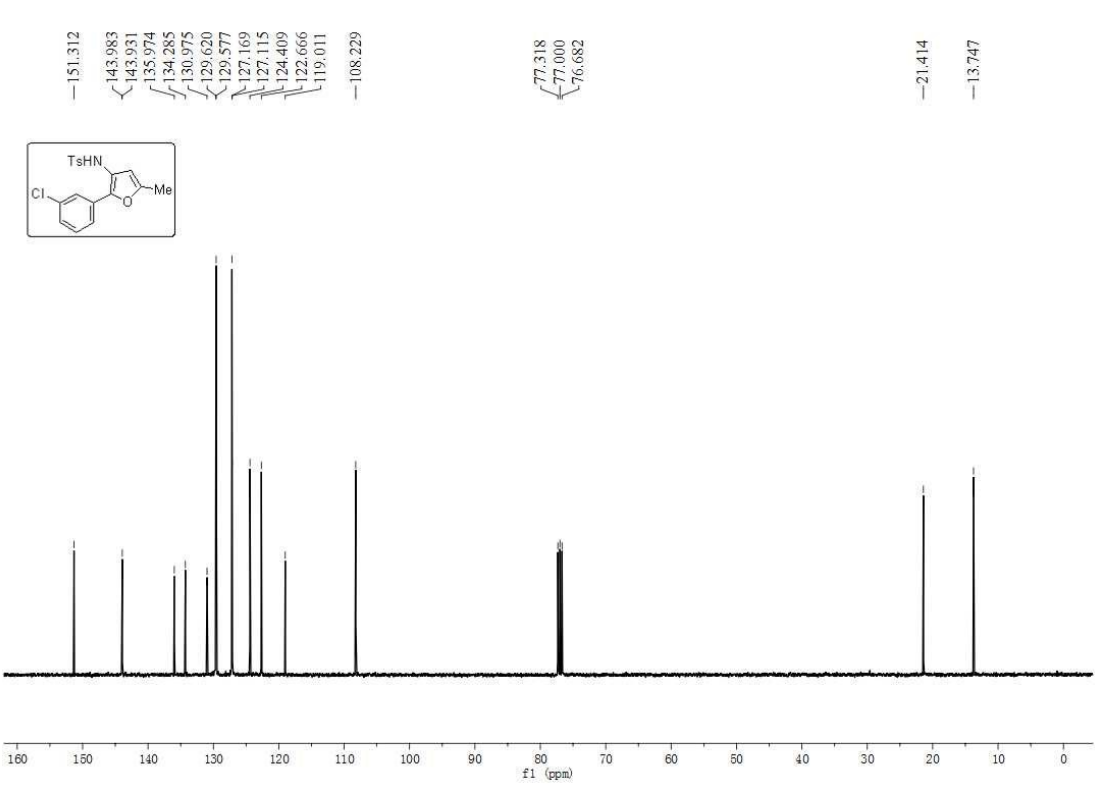

cx-346
163.115
160.654
150.531
145.146
143.875
136.195
129.459
127.280
126.705
126.625
125.721
125.688
117.513
115.398
115.182
107.787
77.318
77.000
76.682
21.395
13.679
TsHN
Me
F
f1 (ppm)

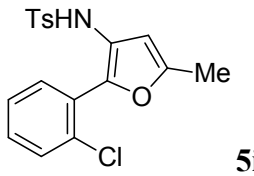

-113.513
TsHN
Me
O
F
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)


TsHN
Cl
Me
O

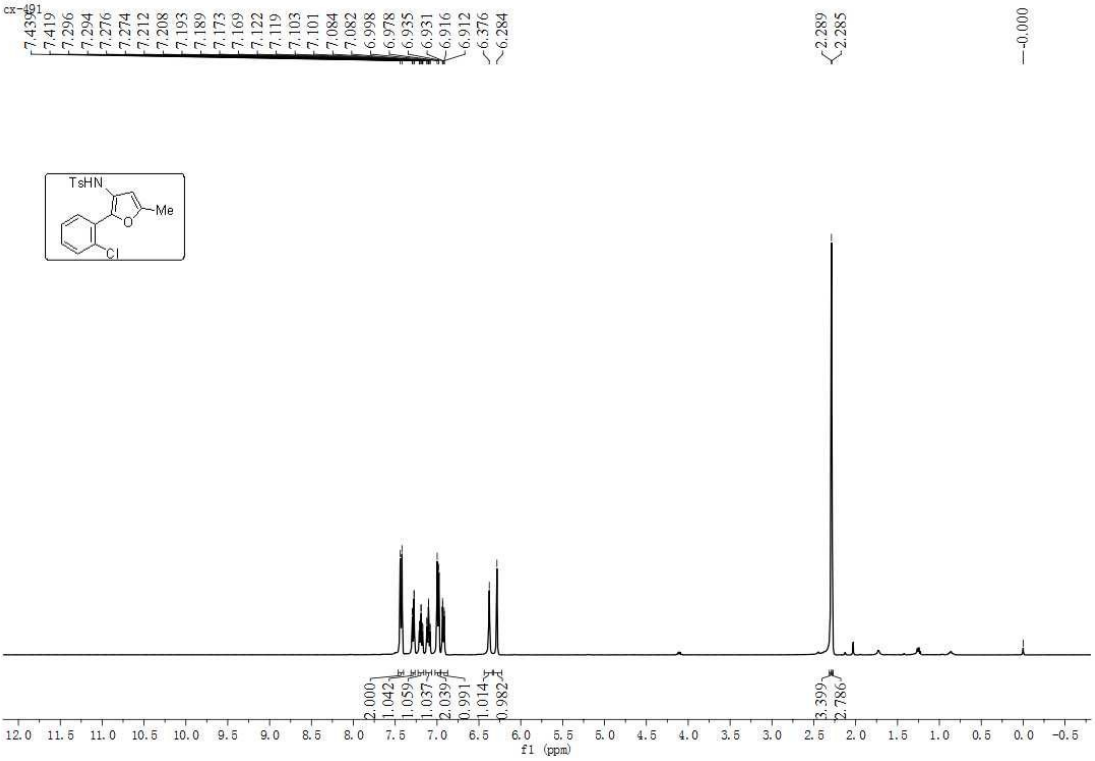
5h

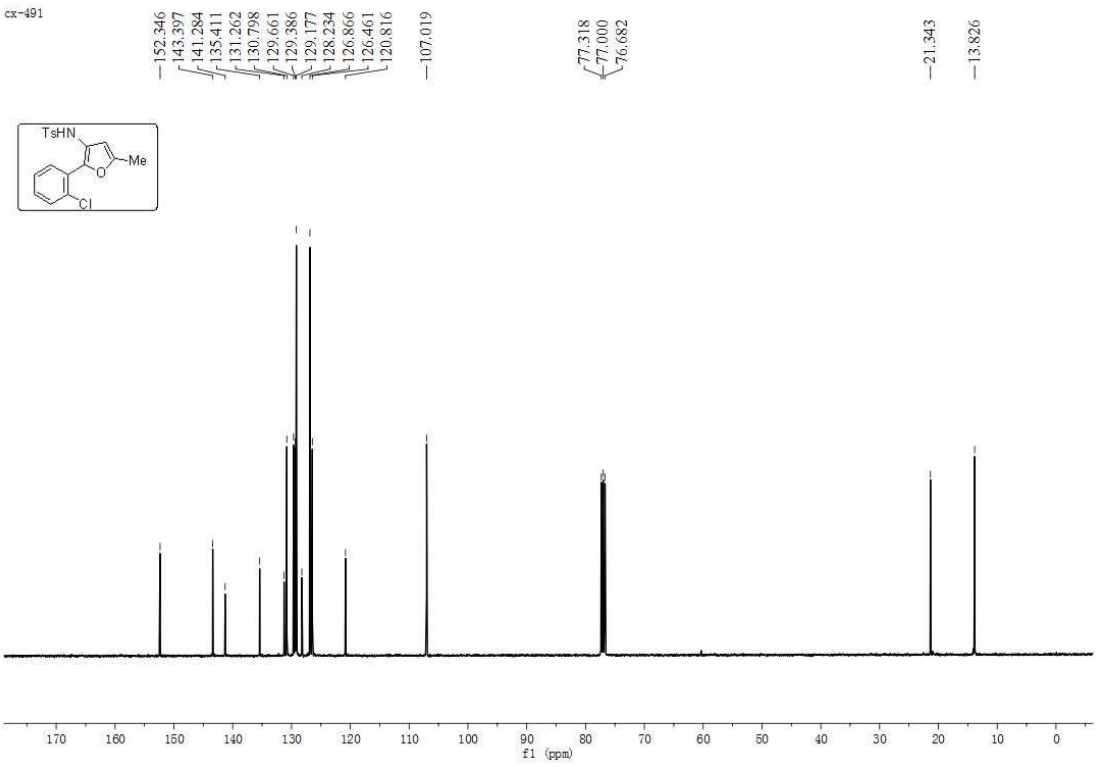

cx-354
7.570
7.549
7.291
7.287
7.284
7.273
7.269
7.265
7.237
7.234
7.093
7.084
7.073
7.064
7.045
7.044
7.040
7.036
7.031
7.015
6.497
5.910
5.908
2.254
2.176
-0.000
TsHN
Cl
Me
O
2.049
2.000
4.073
1.005
0.955
3.111
3.082
f1 (ppm)

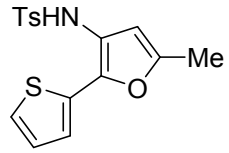

151.312
143.983
143.931
135.974
134.285
130.975
129.620
129.577
127.169
127.115
124.409
122.666
119.011
108.229
77.318
77.000
76.682
21.414
13.747
TsHN
Cl
Me
O
f1 (ppm)


TsHN
Me
O
Cl

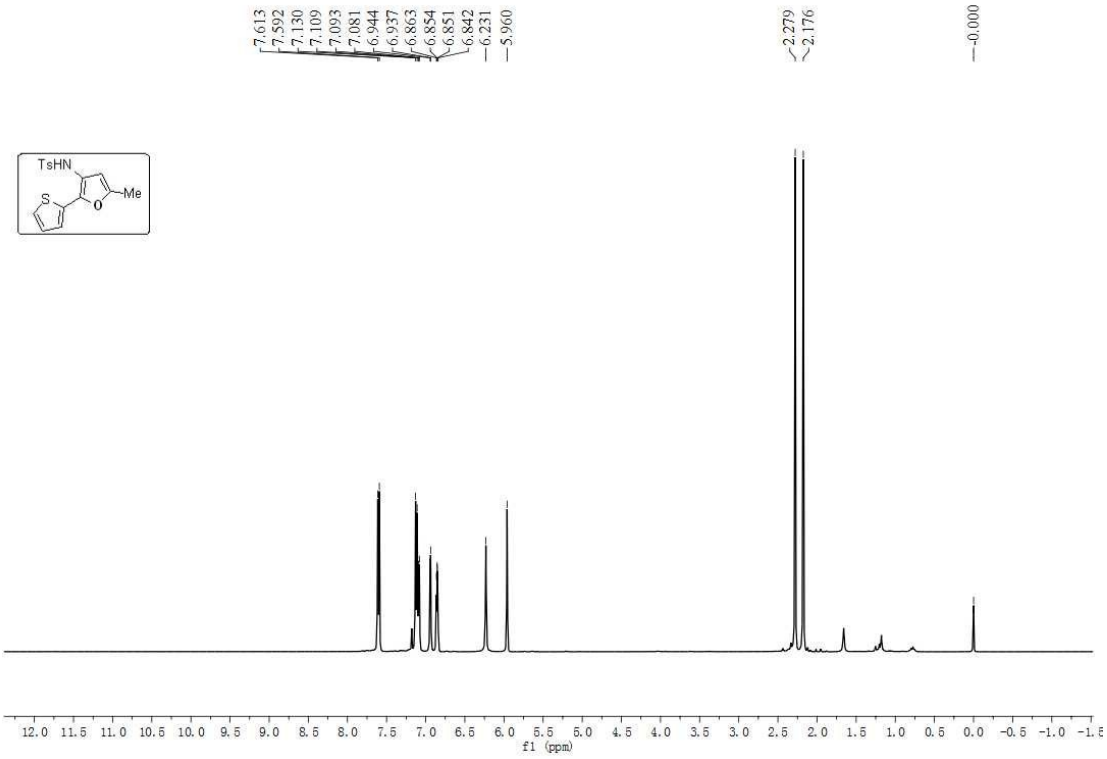
5i

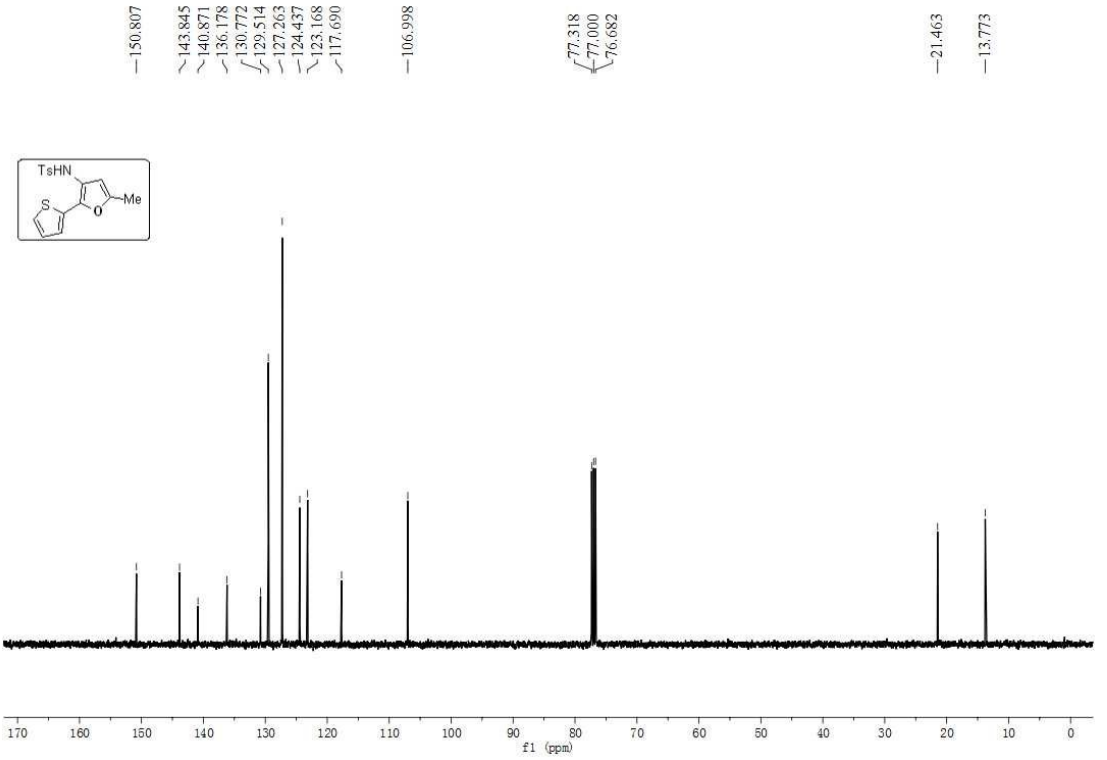

cx-491
7.439
7.419
7.296
7.294
7.276
7.274
7.212
7.208
7.193
7.189
7.173
7.169
7.122
7.119
7.103
7.101
7.084
7.082
6.998
6.978
6.935
6.931
6.916
6.912
6.376
6.284
2.289
2.285
-0.000
TsHN
Me
Cl
2.000
1.042
1.059
1.037
2.039
0.991
1.014
0.982
3.399
2.786
f1 (ppm)

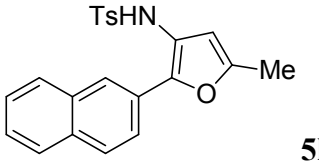

cx-491
152.346
143.397
141.284
135.411
131.262
130.798
129.661
129.386
129.177
128.234
126.866
126.461
120.816
107.019
77.318
77.000
76.682
21.343
13.826
TsHN
Me
Cl
f1 (ppm)


TsHN
Me
S
O

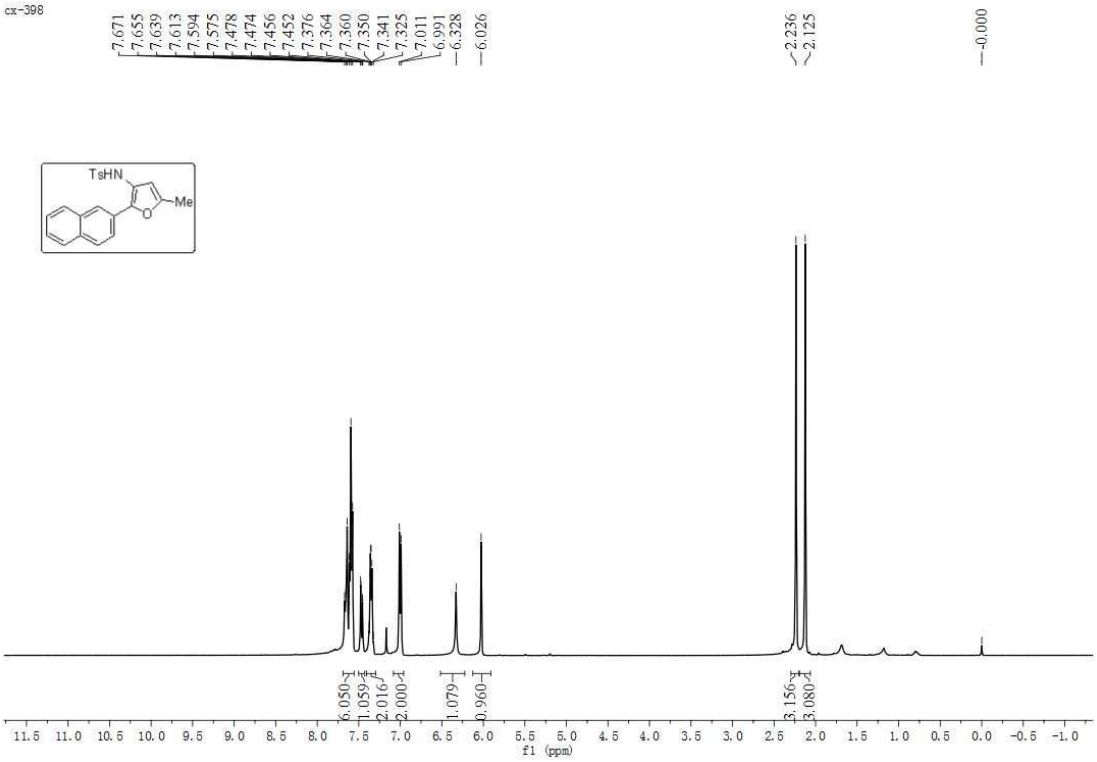
5j

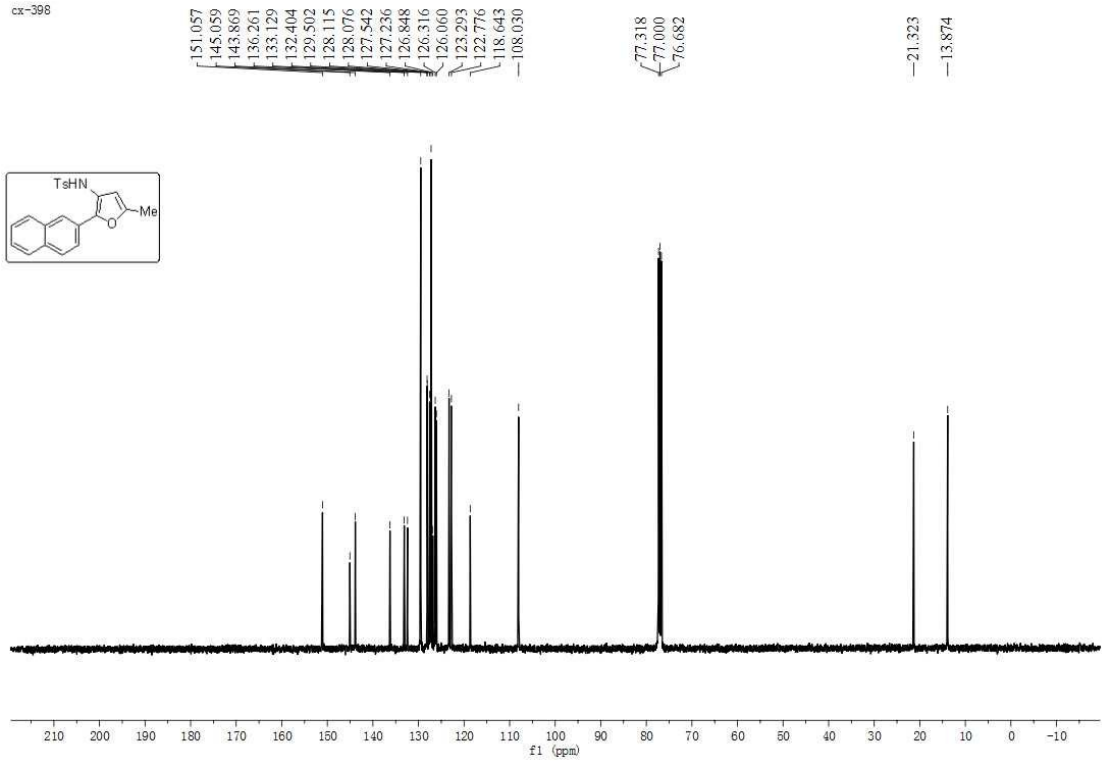

7.613
7.592
7.130
7.109
7.093
7.081
6.944
6.937
6.863
6.854
6.851
6.842
6.231
5.960
2.279
2.176
0.000
TsHN
Me
f1 (ppm)

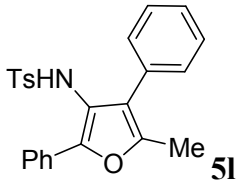

150.807
143.845
140.871
136.178
130.772
129.514
127.263
124.437
123.168
117.690
106.998
77.318
77.000
76.682
21.463
13.773
TsHN
Me
f1 (ppm)


TsHN
Me
O

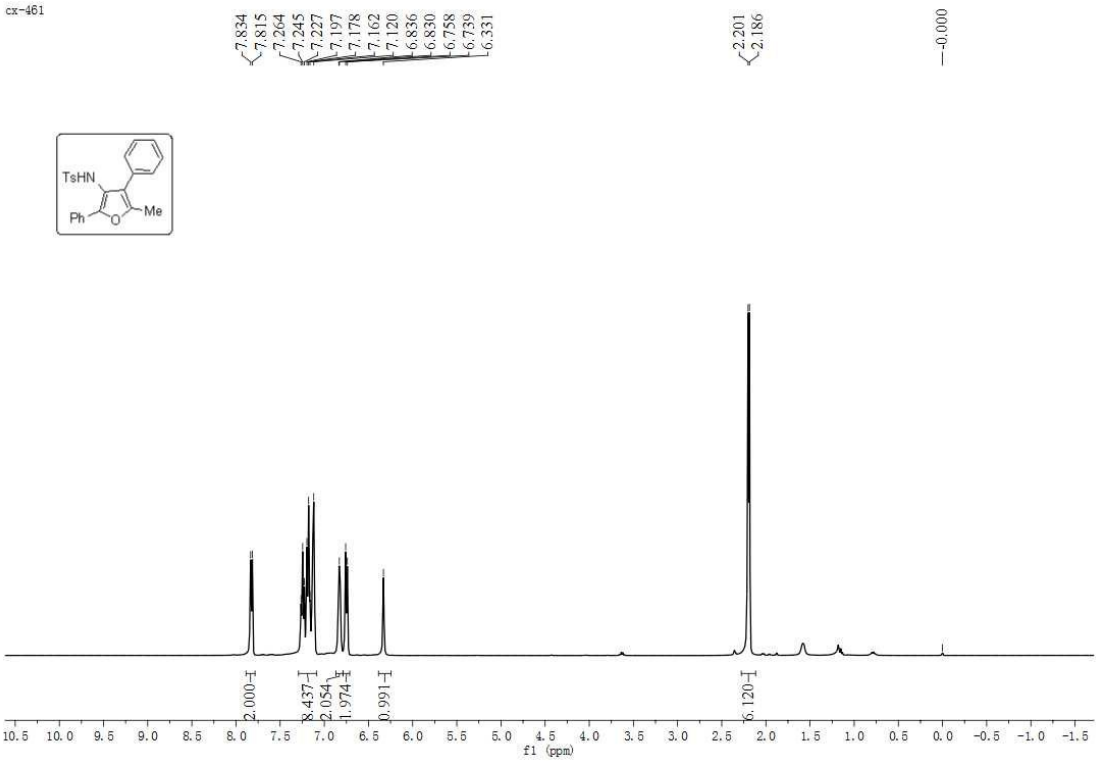
5k

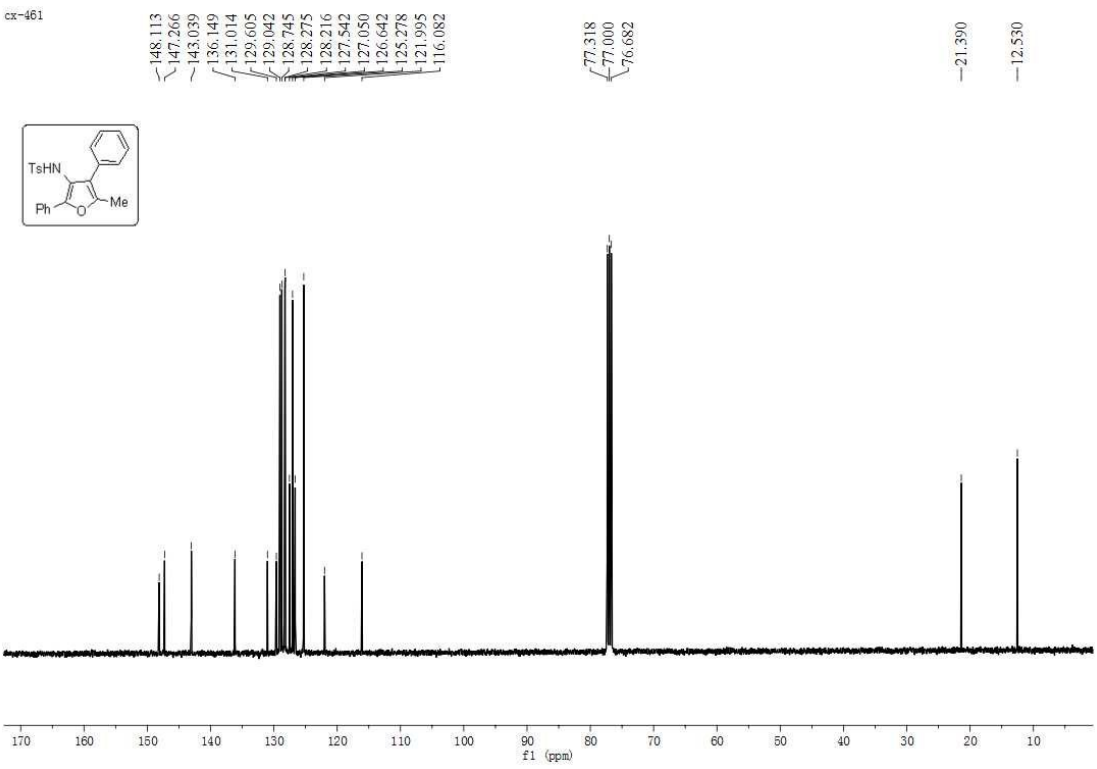

cx-398
7.671
7.655
7.639
7.613
7.594
7.575
7.478
7.474
7.456
7.452
7.376
7.364
7.360
7.350
7.341
7.325
7.011
6.991
6.328
6.026
2.236
2.125
-0.000
TsHN
Me
6.050
1.059
2.016
2.000
1.079
0.960
3.156
3.080
f1 (ppm)

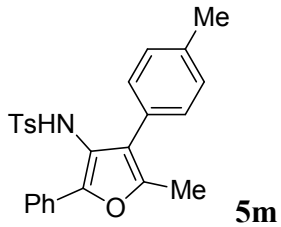

cx-398
151.057
145.059
143.869
136.261
133.129
132.404
129.502
128.115
128.076
127.542
127.236
126.848
126.316
126.060
123.293
122.776
118.643
108.030
77.318
77.000
76.682
21.323
13.874
TsHN
Me
f1 (ppm)


TsHN
Ph
O
Me

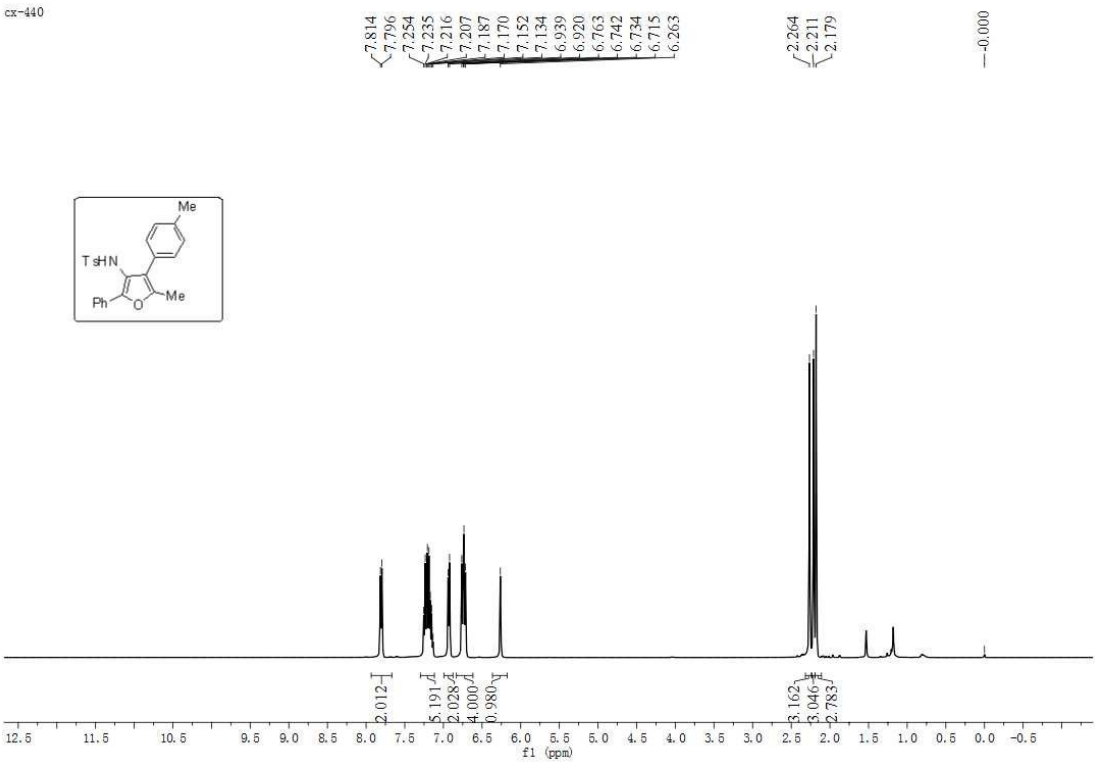
5l

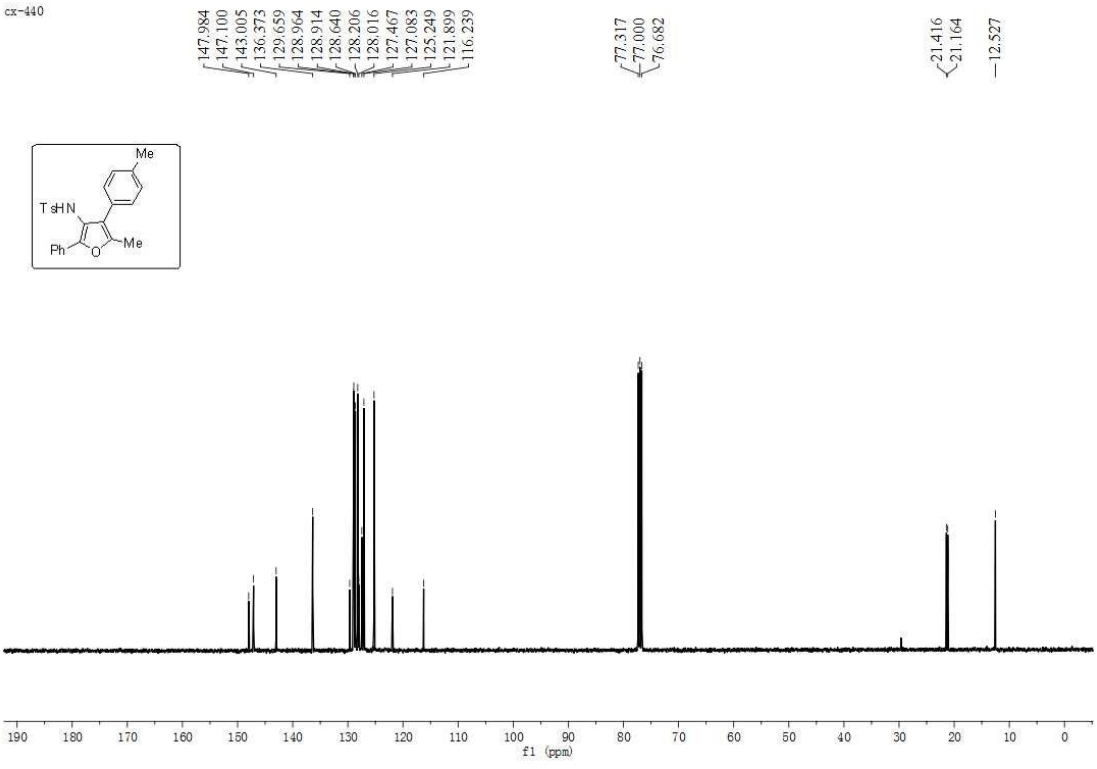

cx-461
7.834
7.815
7.264
7.245
7.227
7.197
7.178
7.162
7.120
6.836
6.830
6.758
6.739
6.331
2.201
2.186
-0.000
TsHN
Ph
O
Me
2.000
8.437
2.054
1.974
0.991
6.120
f1 (ppm)

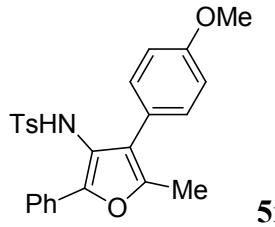

cx-461
148.113
147.266
143.039
136.149
131.014
129.605
129.042
128.745
128.275
128.216
127.542
127.050
126.642
125.278
121.995
116.082
77.318
77.000
76.682
21.390
12.530
TsHN
Ph
O
Me
f1 (ppm)


Me
TsHN
Ph
O
Me

5m

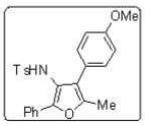

cx-440
7.814
7.796
7.254
7.235
7.216
7.207
7.187
7.170
7.152
7.134
6.939
6.920
6.763
6.742
6.734
6.715
6.263
2.264
2.211
2.179
-0.000
Me
TsHN
Ph
O
Me
2.012
5.191
2.028
4.000
0.980
3.162
3.046
2.783
f1 (ppm)

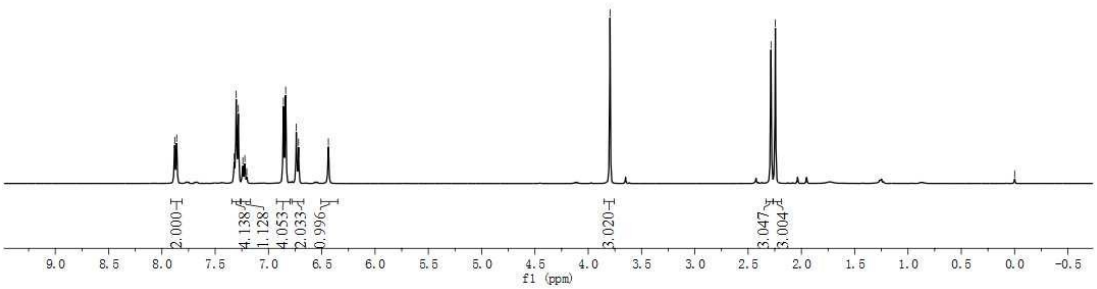

cx-440
147.984
147.100
143.005
136.373
129.659
128.964
128.914
128.640
128.206
128.016
127.467
127.083
125.249
121.899
116.239
77.317
77.000
76.682
21.416
21.164
12.527
Me
TsHN
Ph
O
Me
f1 (ppm)


OMe
TsHN
Ph
O
Me

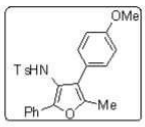
5n

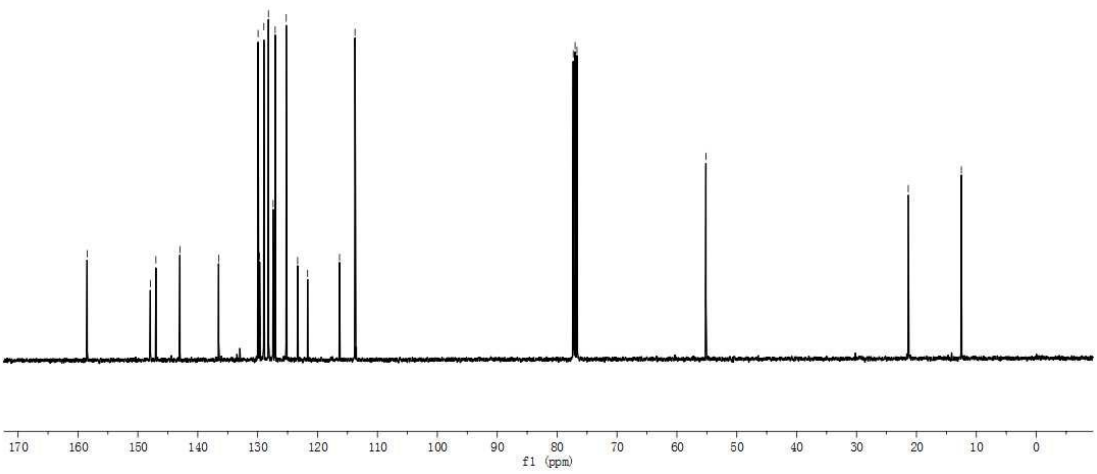

7.880
7.861
7.322
7.303
7.283
7.240
7.222
7.204
6.860
6.839
6.739
6.718
6.438
3.796
2.286
2.245
0.000

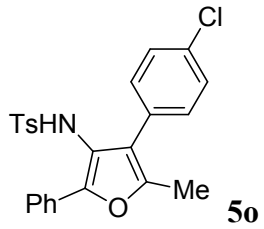

OMe
TsHN
Ph
O
Me


2.000
4.138
1.128
4.053
2.033
0.996
3.020
3.047
3.004
f1 (ppm)

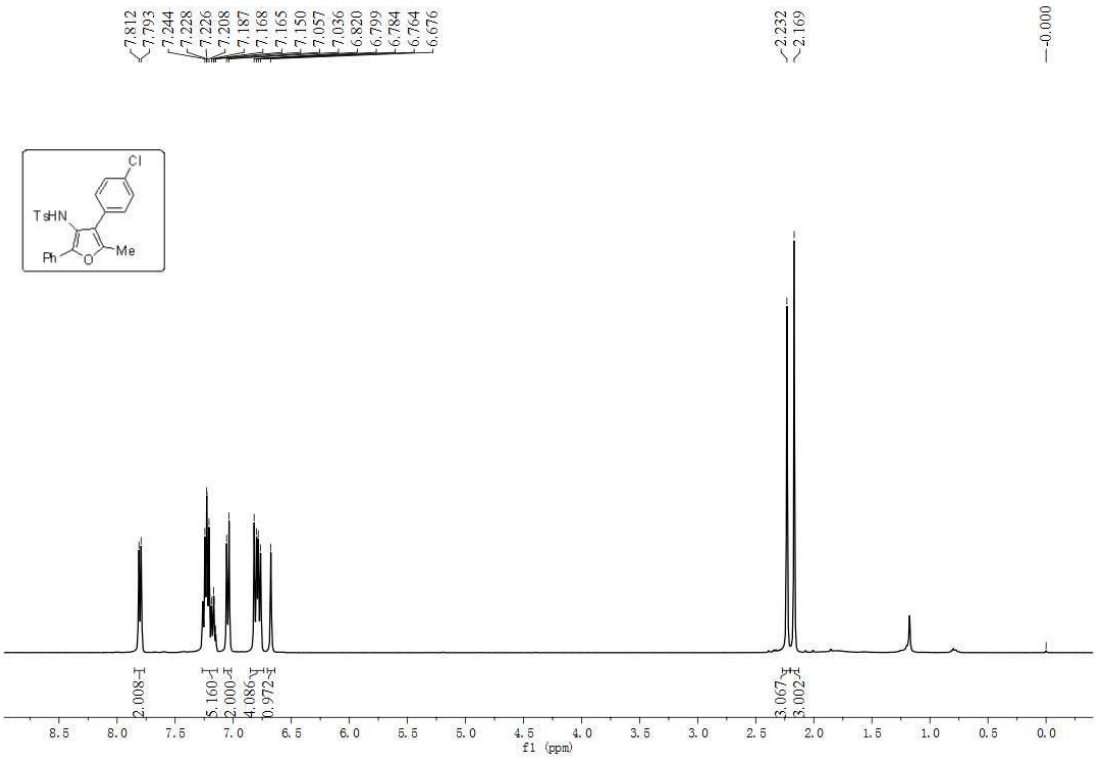

158.473
147.922
146.992
142.984
136.512
129.922
129.672
128.960
128.197
127.424
127.069
125.222
123.322
121.657
116.326
113.744
77.318
77.000
76.683
55.154
21.367
12.504

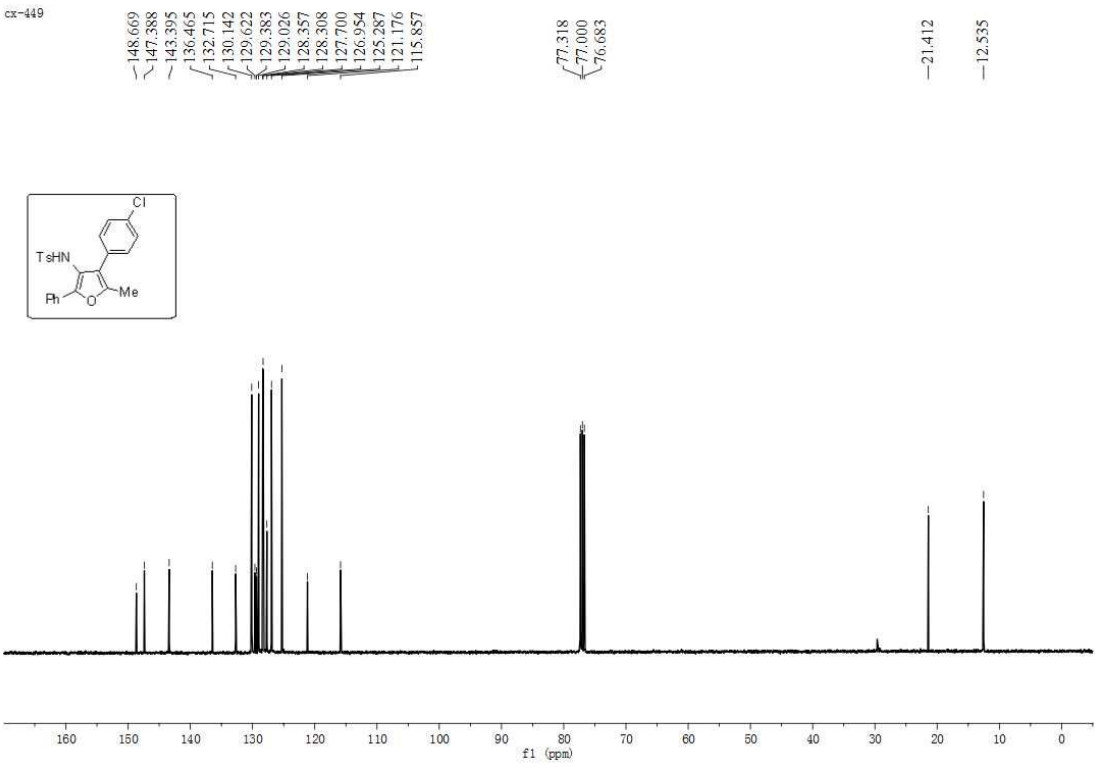

OMe
TsHN
Ph
O
Me

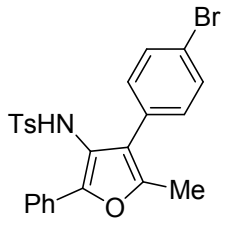

f1 (ppm)


Cl
TsHN
Me
Ph
O

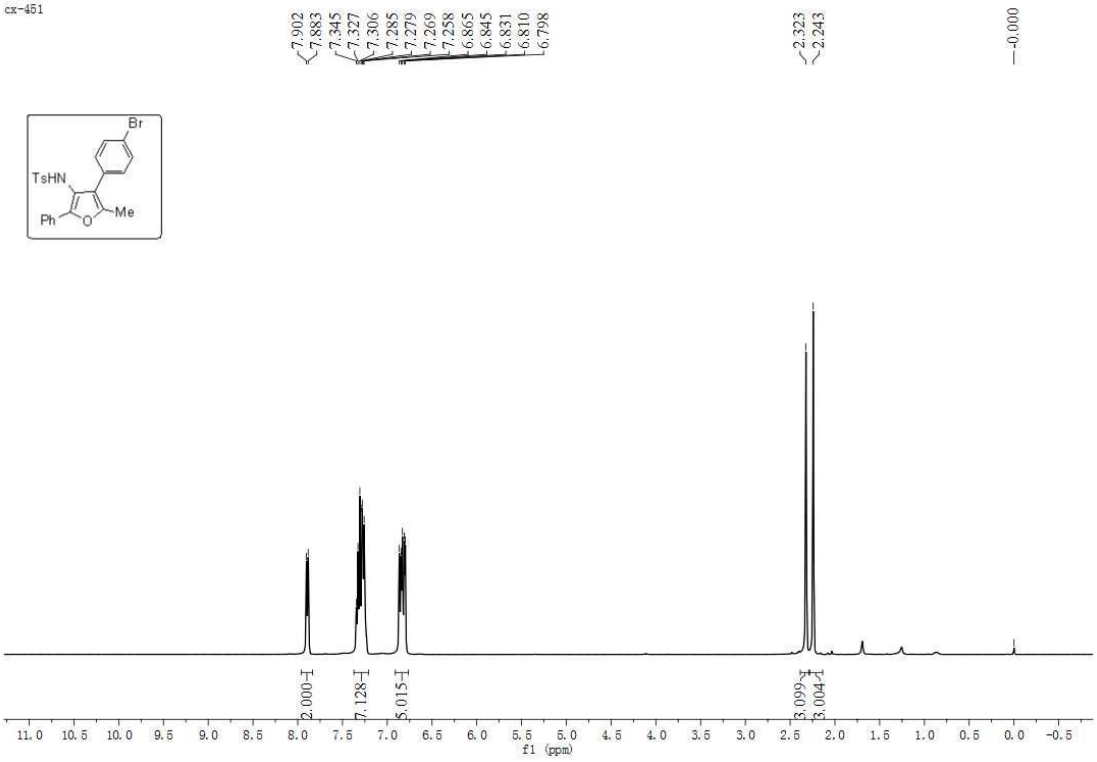
5o

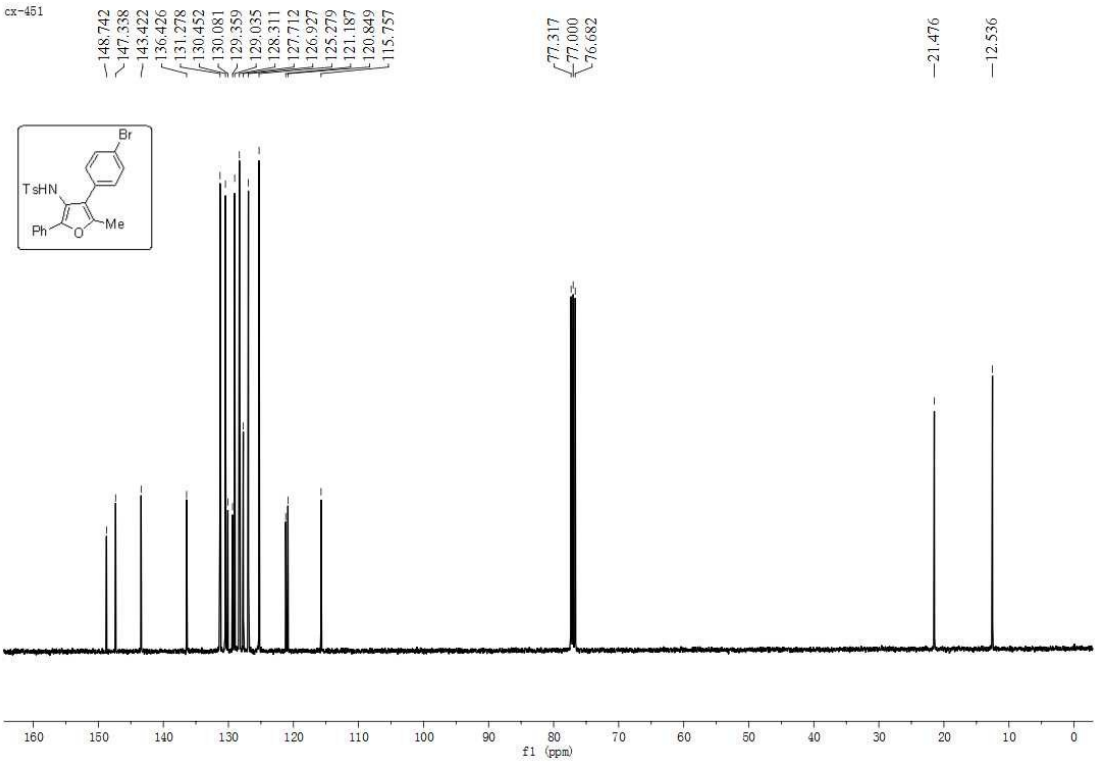

7.812
7.793
7.244
7.228
7.226
7.208
7.187
7.168
7.165
7.150
7.057
7.036
6.820
6.799
6.784
6.764
6.676
2.232
2.169
0.000
Cl
TsHN
Ph
Me
2.008
5.160
2.000
4.086
0.972
3.067
3.002
f1 (ppm)

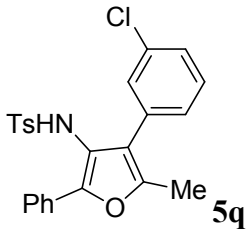

cx-449
148.669
147.388
143.395
136.465
132.715
130.142
129.622
129.383
129.026
128.357
128.308
127.700
126.954
125.287
121.176
115.857
77.318
77.000
76.683
21.412
12.535
Cl
TsHN
Ph
Me
f1 (ppm)


Br
TsHN
Ph
O
Me

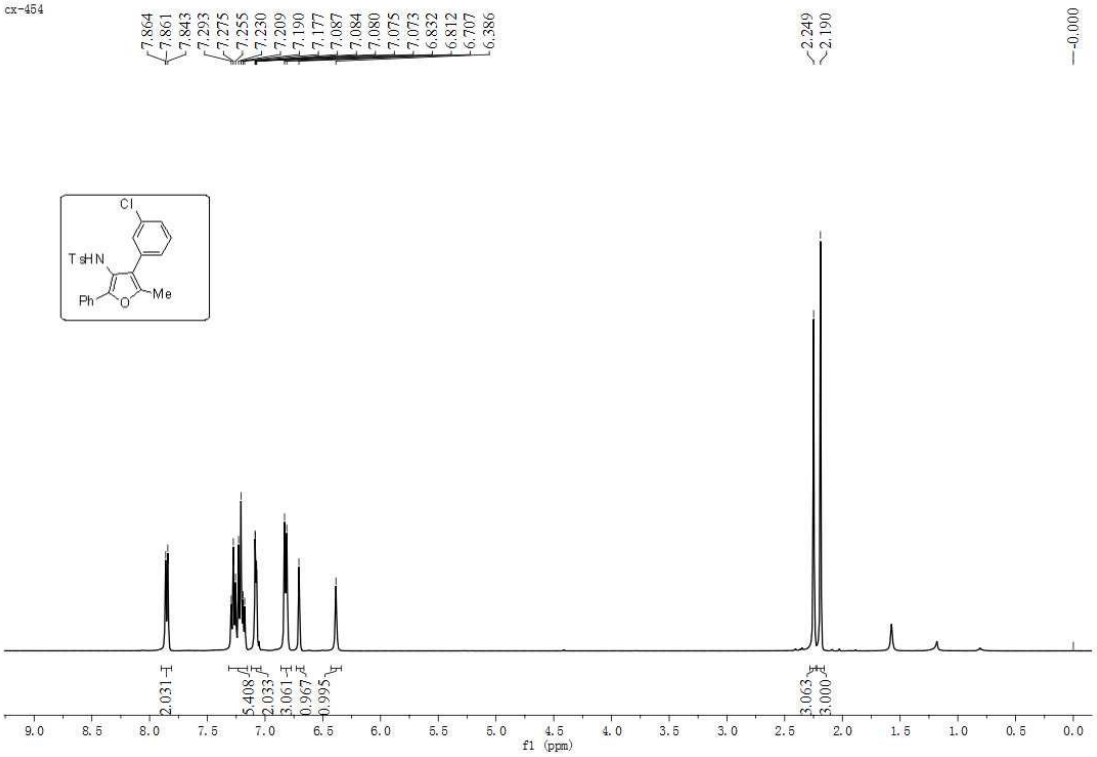
5p

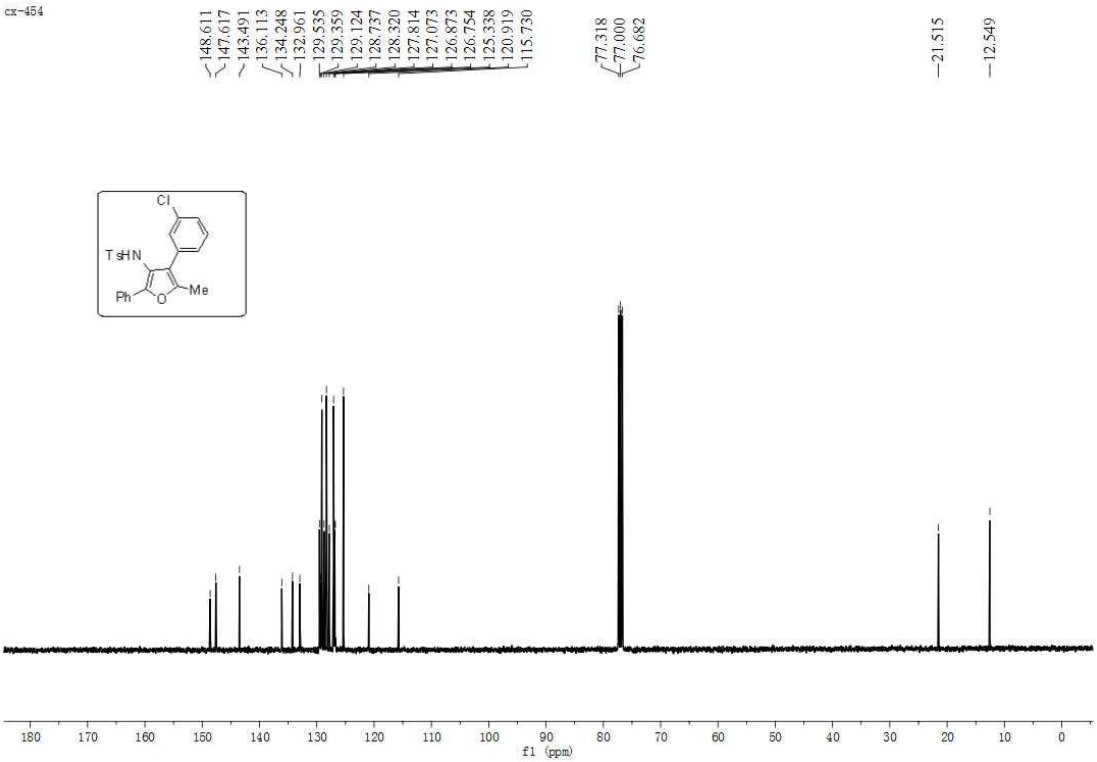

cx-451
7.902
7.883
7.345
7.327
7.306
7.285
7.279
7.269
7.258
6.865
6.845
6.831
6.810
6.798
2.323
2.243
0.000
Br
TsHN
Ph
O
Me
2.000
7.128
5.015
3.099
3.004
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

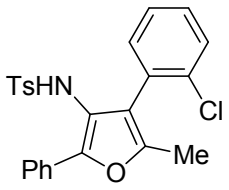

cx-451
148.742
147.338
143.422
136.426
131.278
130.452
130.081
129.359
129.035
128.311
127.712
126.927
125.279
121.187
120.849
115.757
77.317
77.000
76.682
21.476
12.536
Br
TsHN
Ph
O
Me
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


Cl
TsHN
Ph
O
Me

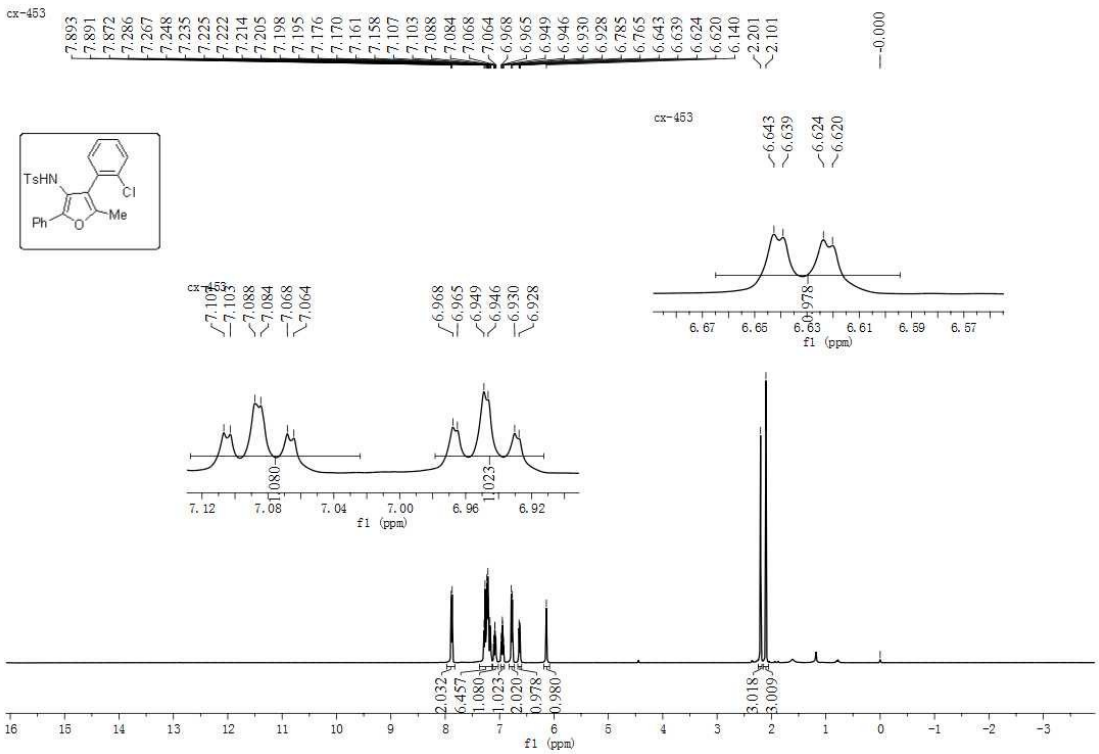
5q

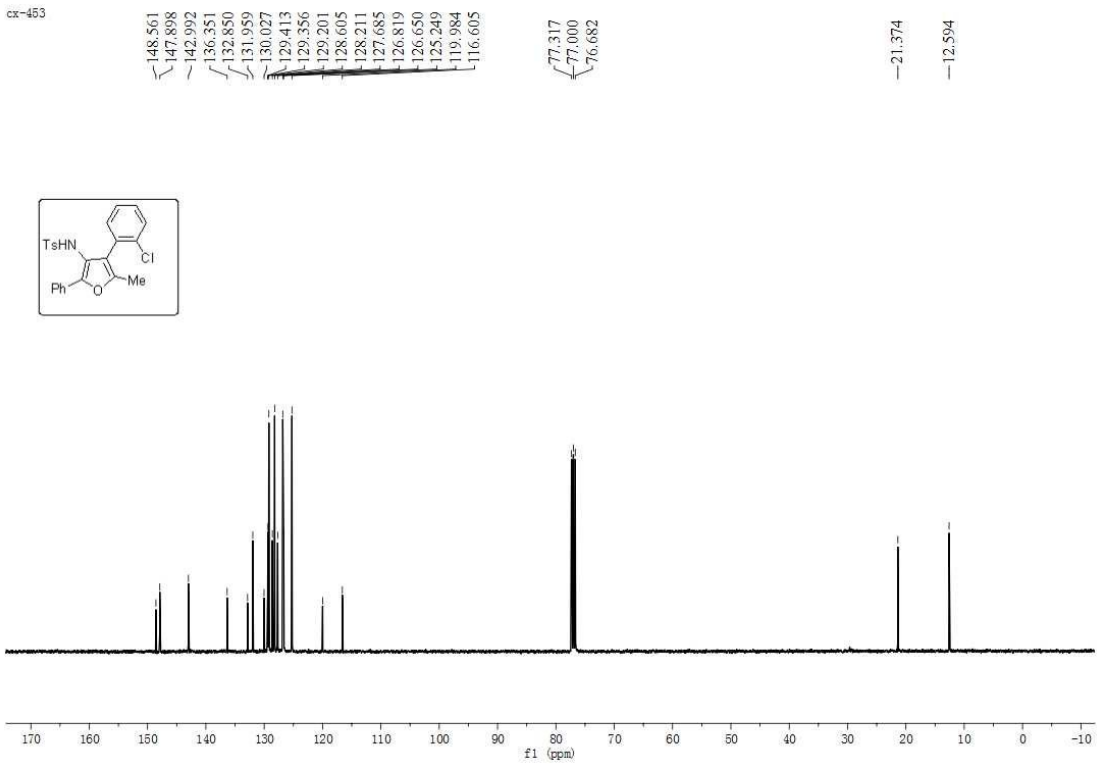

cx-454
7.864
7.861
7.843
7.293
7.275
7.255
7.230
7.209
7.190
7.177
7.087
7.084
7.080
7.075
7.073
6.832
6.812
6.707
6.386
2.249
2.190
0.000
Cl
TsHN
Ph
O
Me
2.031
5.408
2.033
3.061
0.967
0.995
3.063
3.000
f1 (ppm)

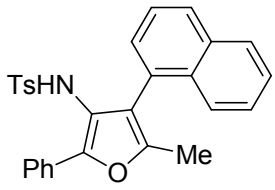

cx-454
148.611
147.617
143.491
136.113
134.248
132.961
129.535
129.359
129.124
128.737
128.320
127.814
127.073
126.873
126.754
125.338
120.919
115.730
77.318
77.000
76.682
21.515
12.549
Cl
TsHN
Ph
O
Me
f1 (ppm)


TsHN
Cl
Ph
O
Me

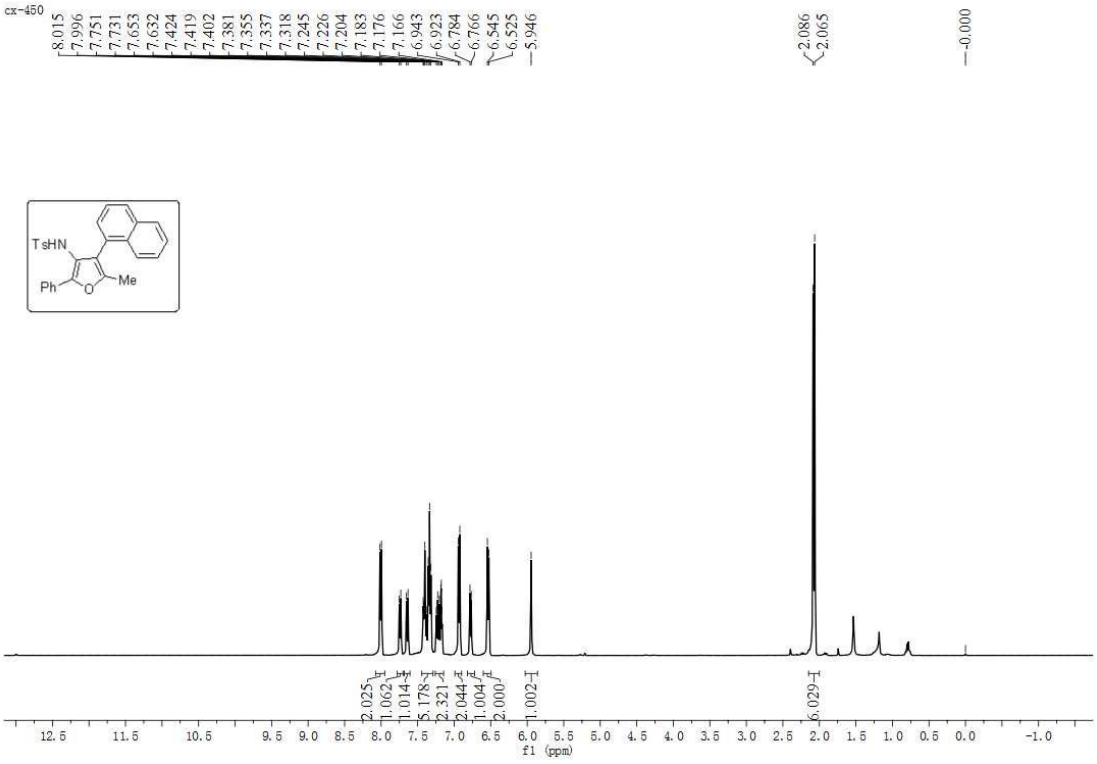
5r

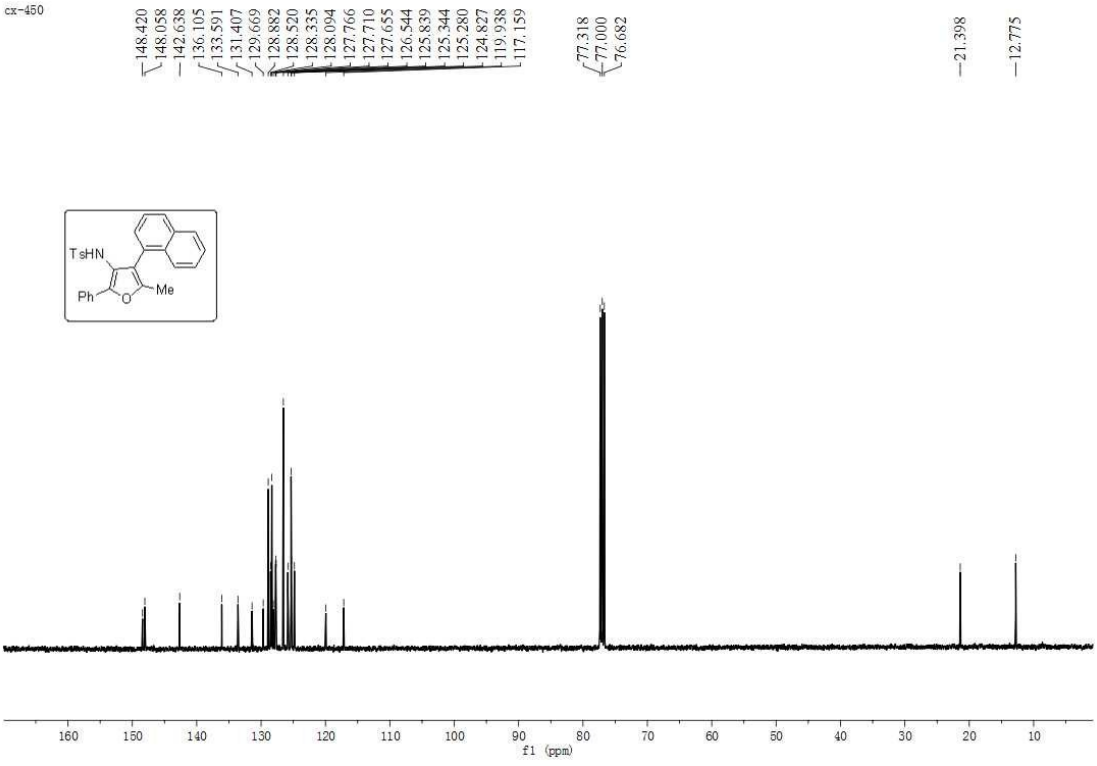

cx-453
7.893
7.891
7.872
7.286
7.267
7.248
7.235
7.225
7.222
7.214
7.205
7.198
7.195
7.176
7.170
7.161
7.158
7.107
7.103
7.088
7.084
7.068
7.064
6.968
6.965
6.949
6.946
6.930
6.928
6.785
6.765
6.643
6.639
6.624
6.620
6.140
2.201
2.101
0.000
TsHN
Cl
Ph
O
Me
cx-453
6.643
6.639
6.624
6.620
1.078
6.67
6.65
6.63
6.61
6.59
6.57
f1 (ppm)
cx-453
7.104
7.103
7.088
7.084
7.068
7.064
6.968
6.965
6.949
6.946
6.930
6.928
1.080
1.023
7.12
7.08
7.04
7.00
6.96
6.92
f1 (ppm)
2.032
6.457
1.080
1.023
2.020
0.978
0.980
3.018
3.009
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

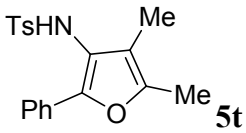

cx-453
148.561
147.898
142.992
136.351
132.850
131.959
130.027
129.413
129.356
129.201
128.605
128.211
127.685
126.819
126.650
125.249
119.984
116.605
77.317
77.000
76.682
21.374
12.594
TsHN
Cl
Ph
O
Me
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


TsHN
Ph
O
Me

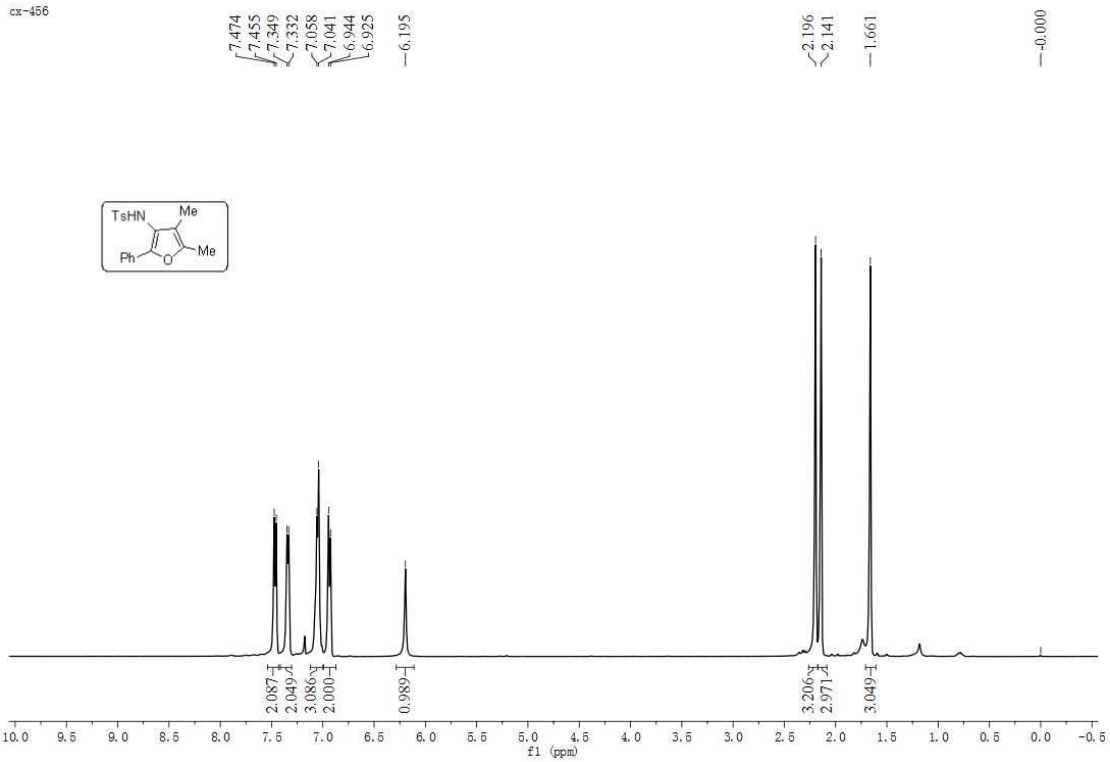
5s

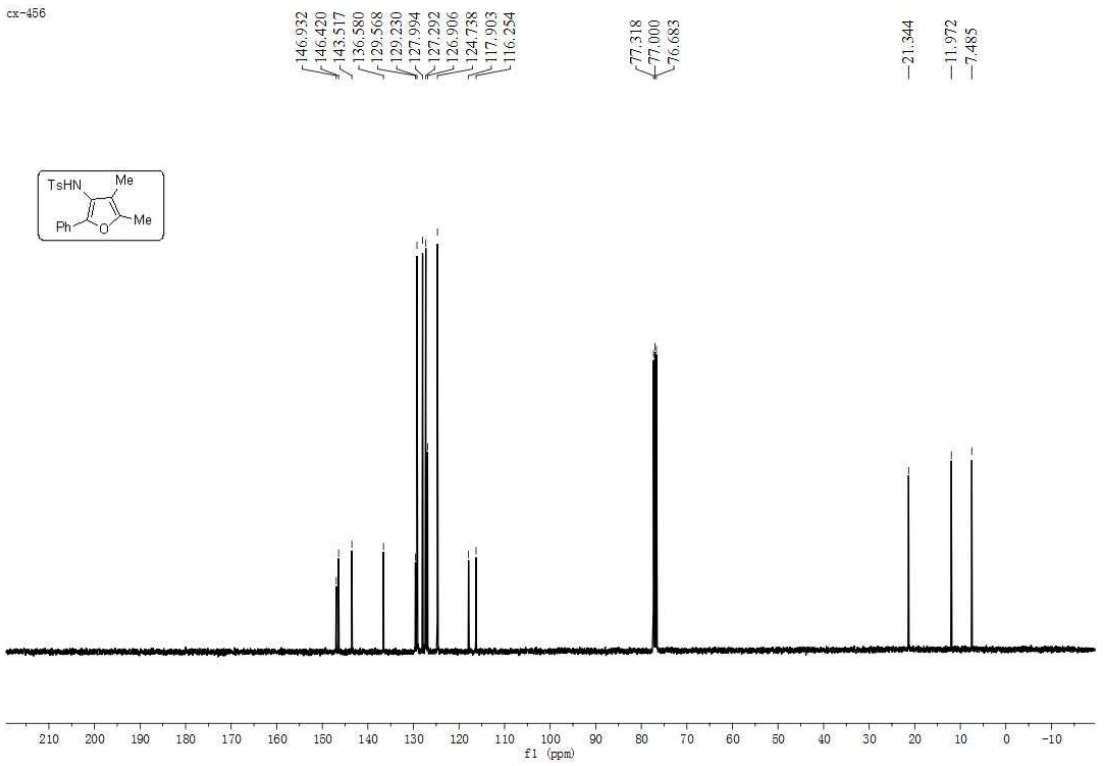

cx-450
8.015
7.996
7.751
7.731
7.653
7.632
7.424
7.419
7.402
7.381
7.355
7.337
7.318
7.245
7.226
7.204
7.183
7.176
7.166
6.943
6.923
6.784
6.766
6.545
6.525
5.946
2.086
2.065
-0.000
TsHN
Ph
O
Me
2.025
1.062
1.014
5.178
2.321
2.044
1.004
2.000
1.002
6.029
f1 (ppm)

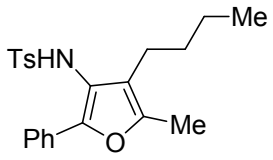

cx-450
148.420
148.058
142.638
136.105
133.591
131.407
129.669
128.882
128.520
128.335
128.094
127.766
127.710
127.655
126.544
125.839
125.344
125.280
124.827
119.938
117.159
77.318
77.000
76.682
21.398
12.775
TsHN
Ph
O
Me
f1 (ppm)


TsHN
Me
Me
Ph
O

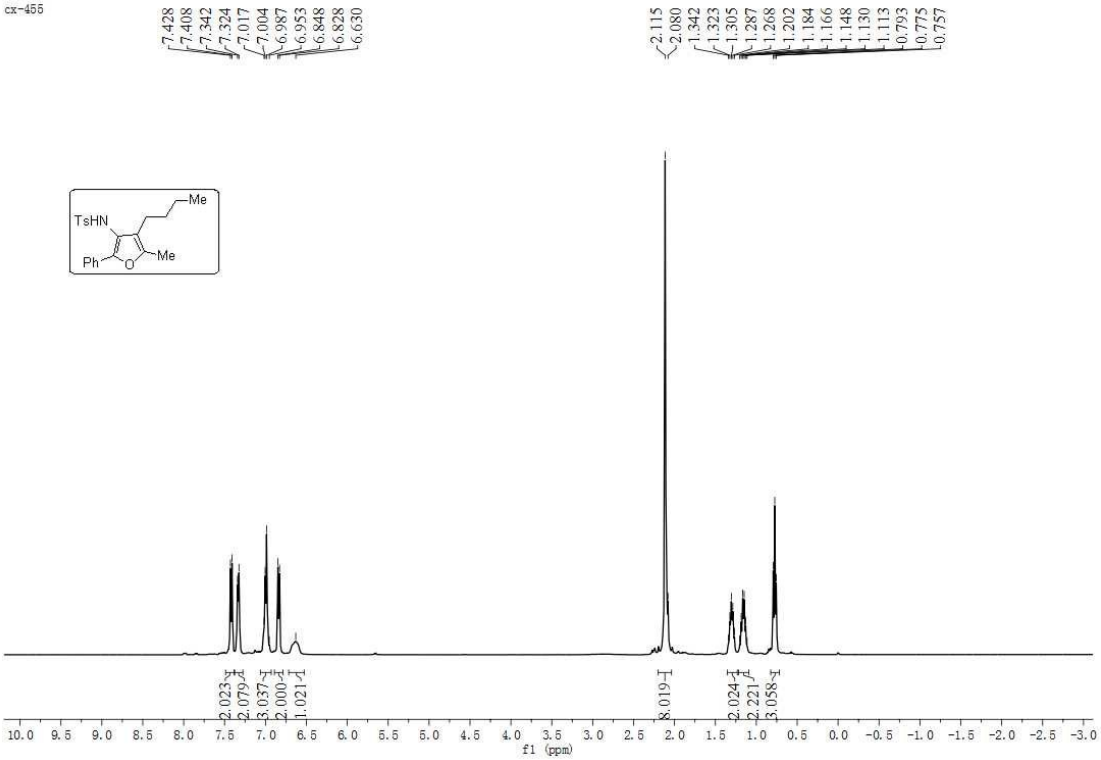
5t

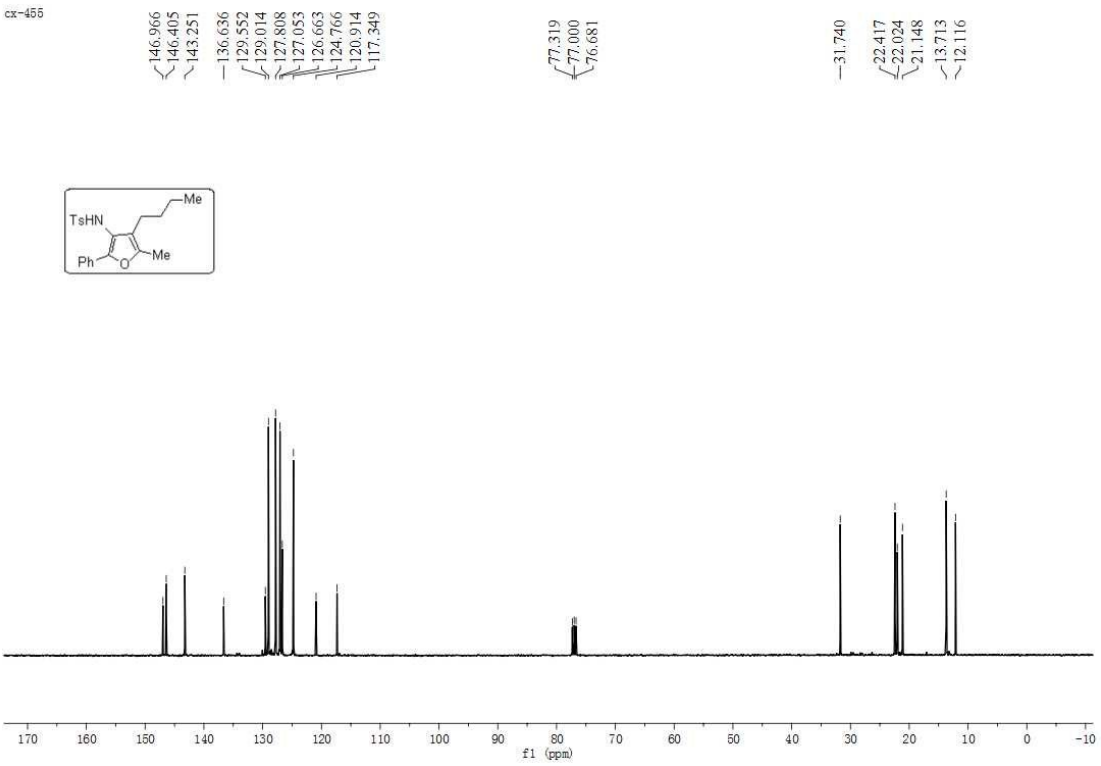

cx-456
7.474
7.455
7.349
7.332
7.058
7.041
6.944
6.925
6.195
2.196
2.141
1.661
0.000
TsHN
Me
Ph
Me
2.087
2.049
3.086
2.000
0.989
3.206
2.971
3.049
f1 (ppm)

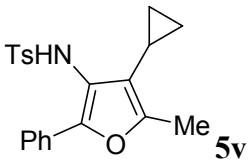

cx-456
146.932
146.420
143.517
136.580
129.568
129.230
127.994
127.292
126.906
124.738
117.903
116.254
77.318
77.000
76.683
21.344
11.972
7.485
TsHN
Me
Ph
Me
f1 (ppm)


Me
TsHN
Ph
O
Me

5u

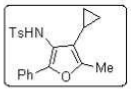

cx-456
7.428
7.408
7.342
7.324
7.017
7.004
6.987
6.953
6.848
6.828
6.630
2.115
2.080
1.342
1.323
1.305
1.287
1.268
1.202
1.184
1.166
1.148
1.130
1.113
0.793
0.775
0.757
Me
TsHN
Ph
O
Me
2.023
2.079
3.037
2.000
1.021
8.019
2.024
2.221
3.058
f1 (ppm)

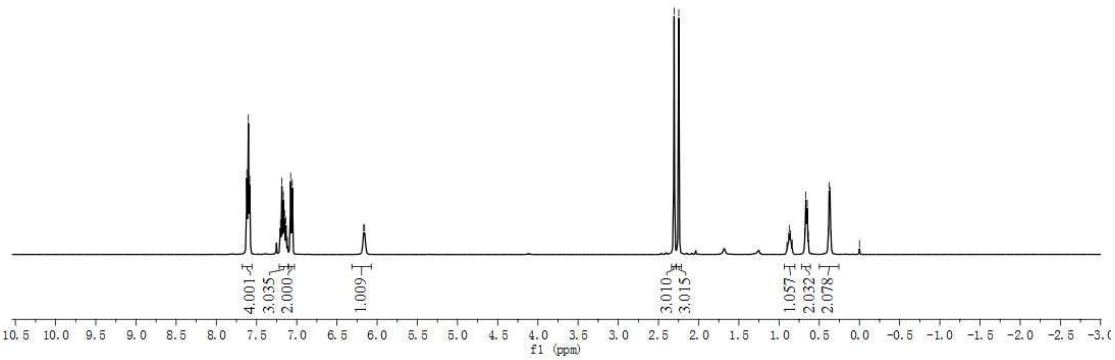

cx-456
146.966
146.405
143.251
136.636
129.552
129.014
127.808
127.053
126.663
124.766
120.914
117.349
77.319
77.000
76.681
31.740
22.417
22.024
21.148
13.713
12.116
Me
TsHN
Ph
O
Me
f1 (ppm)


TsHN
Ph
O
Me

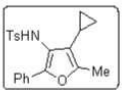
5v

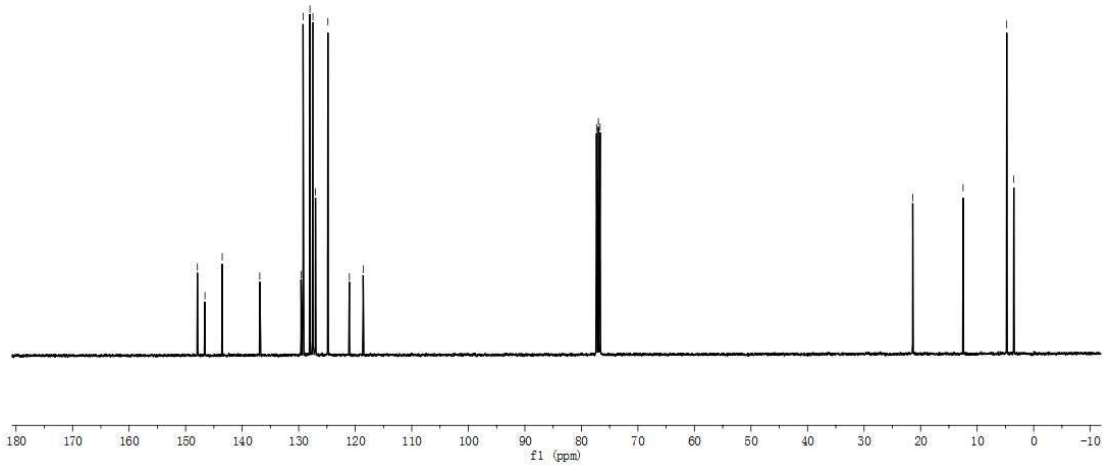

cx-463
7.621
7.602
7.585
7.202
7.185
7.166
7.151
7.134
7.116
7.075
7.055
6.169
6.156
2.305
2.247
0.902
0.880
0.869
0.857
0.836
0.681
0.667
0.657
0.649
0.636
0.389
0.376
0.366
0.352
-0.000

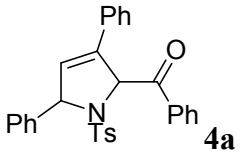

TsHN
Ph
O
Me


4.001
3.035
2.000
1.009
3.010
3.015
1.057
2.032
2.078
f1 (ppm)

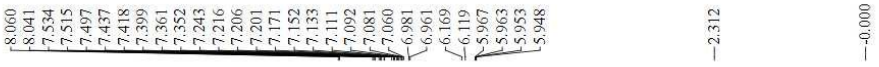

147.919
146.584
143.524
136.887
129.585
129.225
128.014
127.486
127.031
124.834
121.044
118.595
77.318
77.000
76.682
21.393
12.480
4.769
3.516

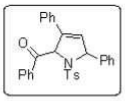

TsHN
Ph
O
Me

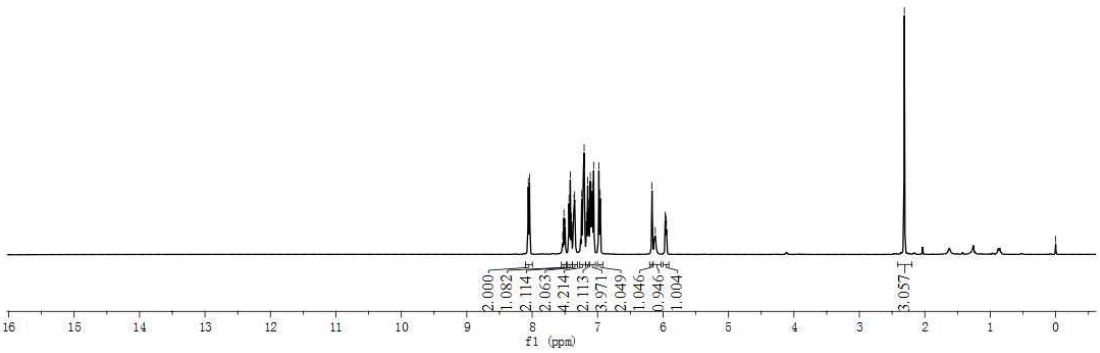

f1 (ppm)

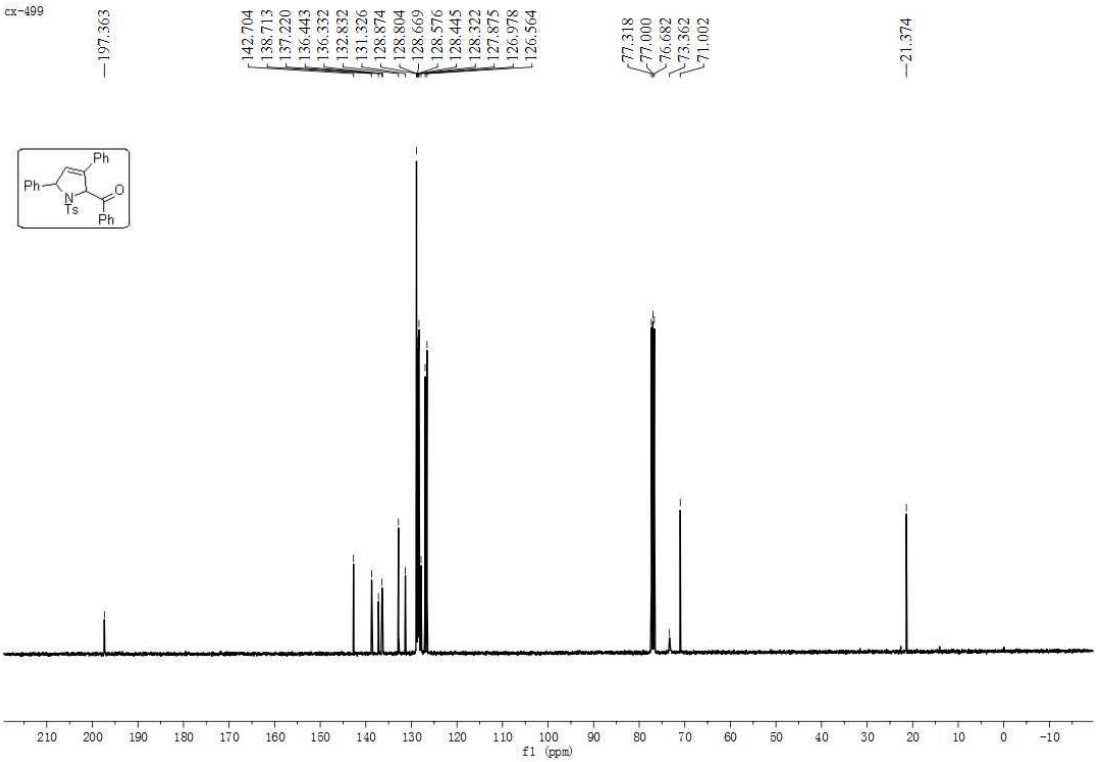

Ph
O
Ph
N
Ts
Ph

4a

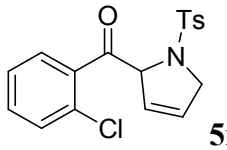

8.060
8.041
7.534
7.515
7.497
7.437
7.418
7.399
7.361
7.352
7.243
7.216
7.206
7.201
7.171
7.152
7.133
7.111
7.092
7.081
7.060
6.981
6.961
6.169
6.119
5.967
5.963
5.953
5.948
2.312
-0.000


Ph
O
Ph
N
Ts
Ph

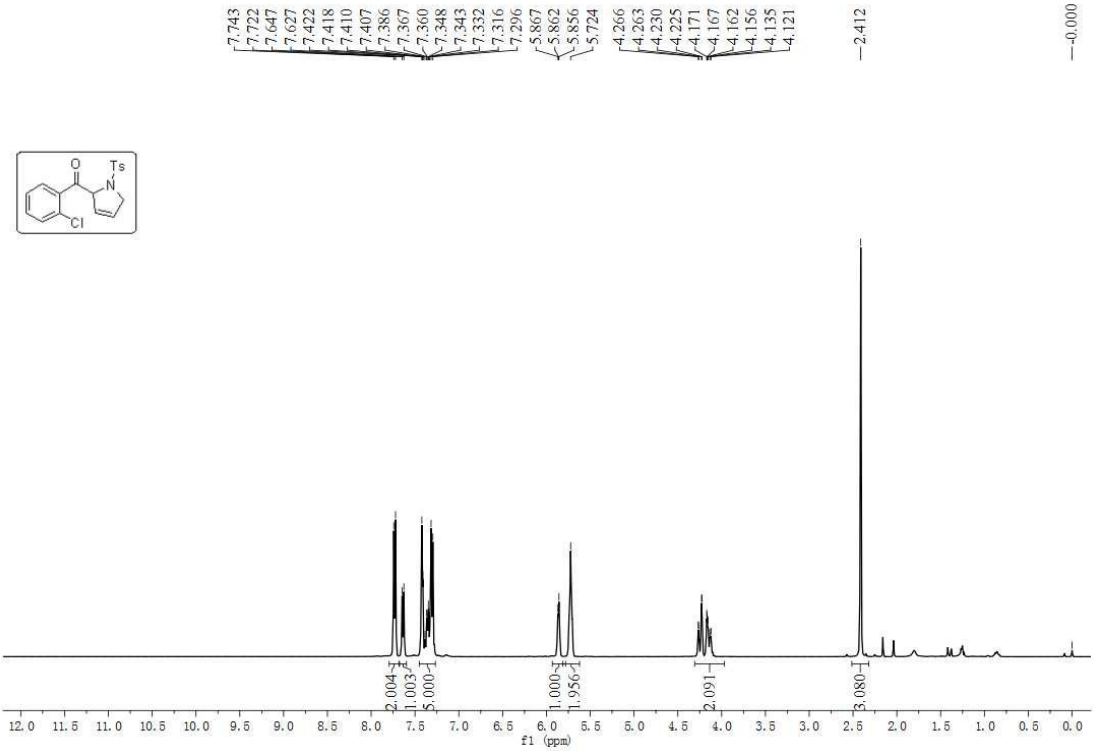

2.000
1.082
2.114
2.063
4.214
2.113
3.971
2.049
1.046
0.946
1.004
3.057
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

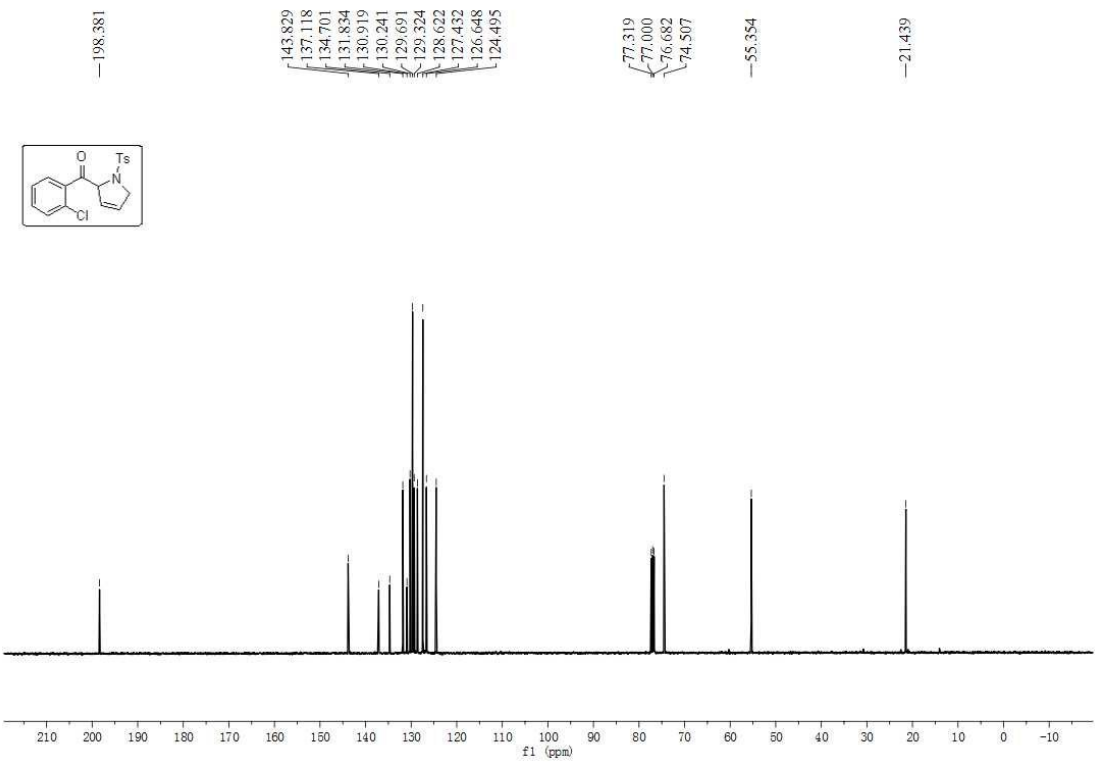

cx-499
197.363
142.704
138.713
137.220
136.443
136.332
132.832
131.326
128.874
128.804
128.669
128.576
128.445
128.322
127.875
126.978
126.564
77.318
77.000
76.682
73.362
71.002
21.374
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

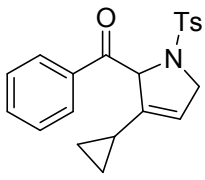
Ph
Ph
N
Ts
O
Ph


O
Ts
N
Cl

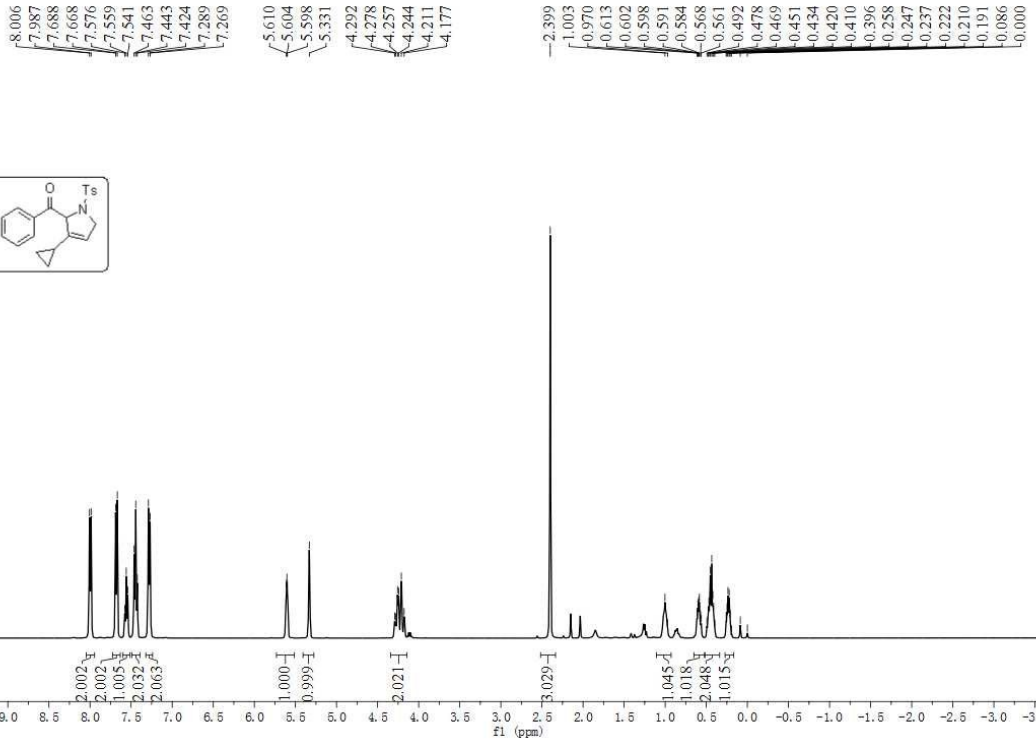
5i'

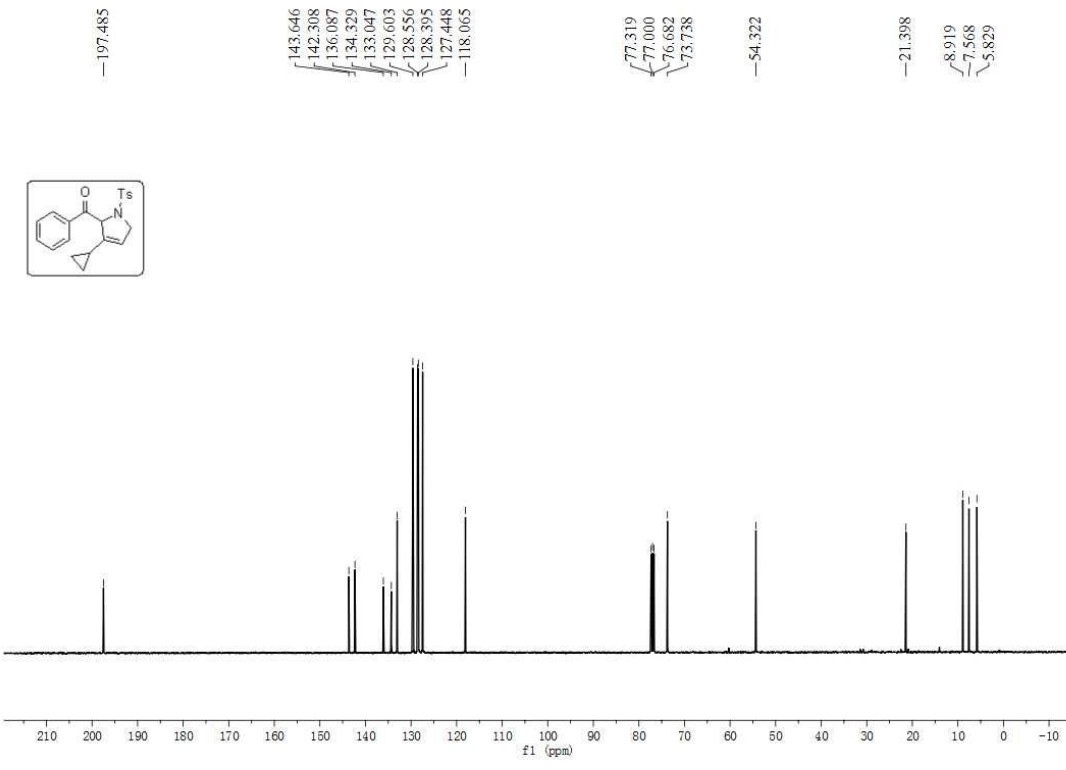

7.743
7.722
7.647
7.627
7.422
7.418
7.410
7.407
7.386
7.367
7.360
7.348
7.343
7.332
7.316
7.296
5.867
5.862
5.856
5.724
4.266
4.263
4.230
4.225
4.171
4.167
4.162
4.156
4.135
4.121
2.412
0.000
2.004
1.003
5.000
1.000
1.956
2.091
3.080
f1 (ppm)

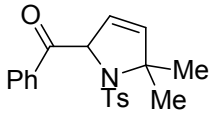

198.381
143.829
137.118
134.701
131.834
130.919
130.241
129.691
129.324
128.622
127.432
126.648
124.495
77.319
77.000
76.682
74.507
55.354
21.439
f1 (ppm)


O
Ts
N

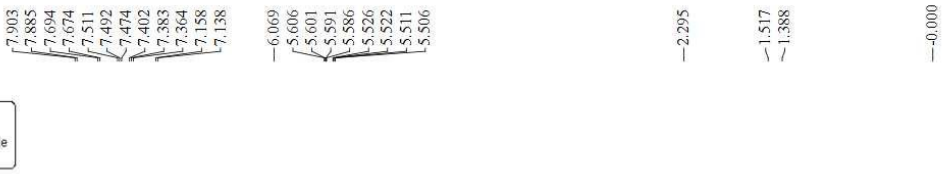
5v'

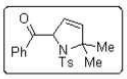

8.006
7.987
7.688
7.668
7.576
7.559
7.541
7.463
7.443
7.424
7.289
7.269
5.610
5.604
5.598
5.331
4.292
4.278
4.257
4.244
4.211
4.177
2.399
1.003
0.970
0.613
0.602
0.598
0.591
0.584
0.568
0.561
0.492
0.478
0.469
0.451
0.434
0.420
0.410
0.396
0.258
0.247
0.237
0.222
0.210
0.191
0.086
0.000
O
Ts
N
2.002
2.002
1.005
2.032
2.063
1.000
0.999
2.021
3.029
1.045
1.018
2.048
1.015
f1 (ppm)

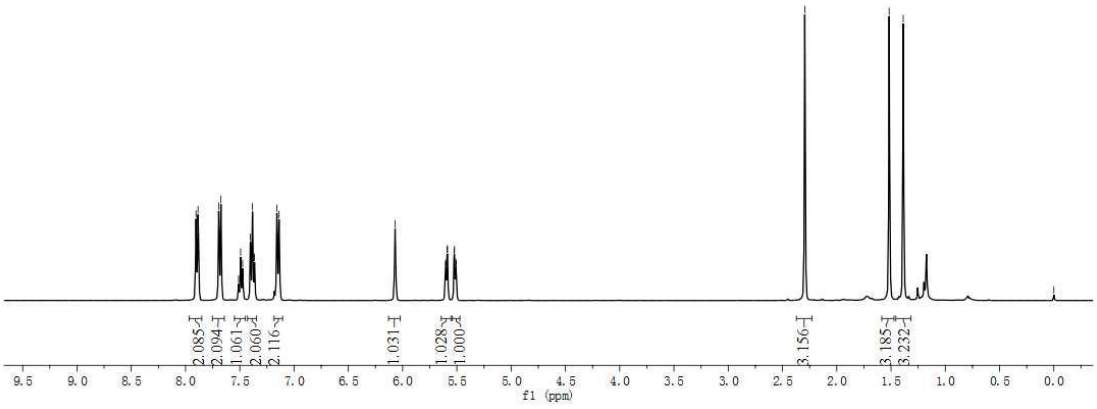

197.485
143.646
142.308
136.087
134.329
133.047
129.603
128.556
128.395
127.448
118.065
77.319
77.000
76.682
73.738
54.322
21.398
8.919
7.568
5.829
O
Ts
N
f1 (ppm)


O
Ph
N
Ts
Me
Me

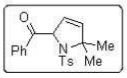
4ma

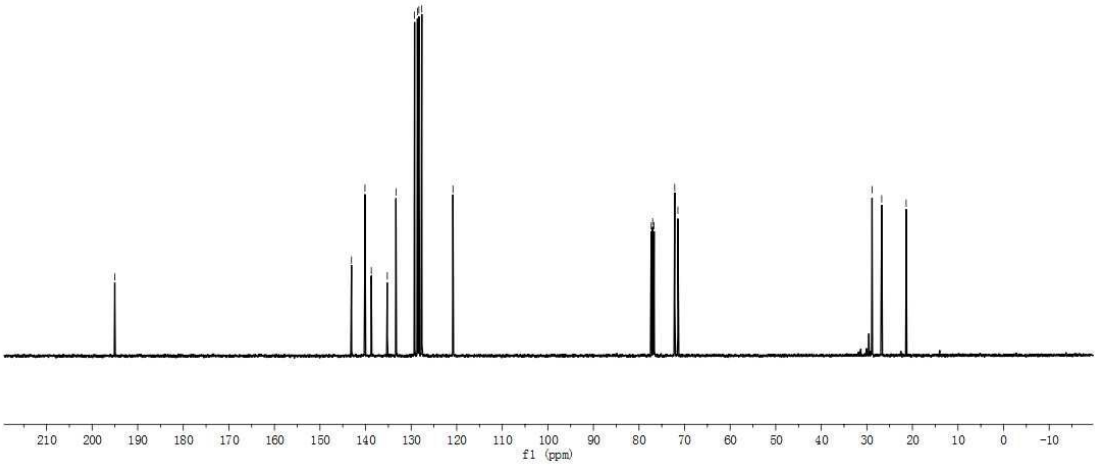

7.903
7.885
7.694
7.674
7.511
7.492
7.474
7.402
7.383
7.364
7.158
7.138
6.069
5.606
5.601
5.591
5.586
5.526
5.522
5.511
5.506
2.295
1.517
1.388
0.000

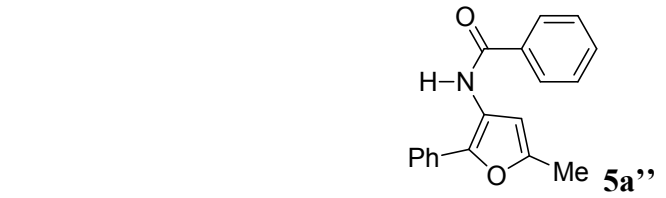



2.085
2.094
1.061
2.060
2.116
1.031
1.028
1.000
3.156
3.185
3.232
f1 (ppm)


195.031
143.089
140.137
138.740
135.234
133.331
129.247
128.622
128.292
127.661
120.828
77.318
77.000
76.682
72.158
71.461
28.853
26.738
21.369

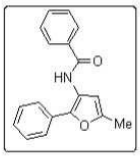


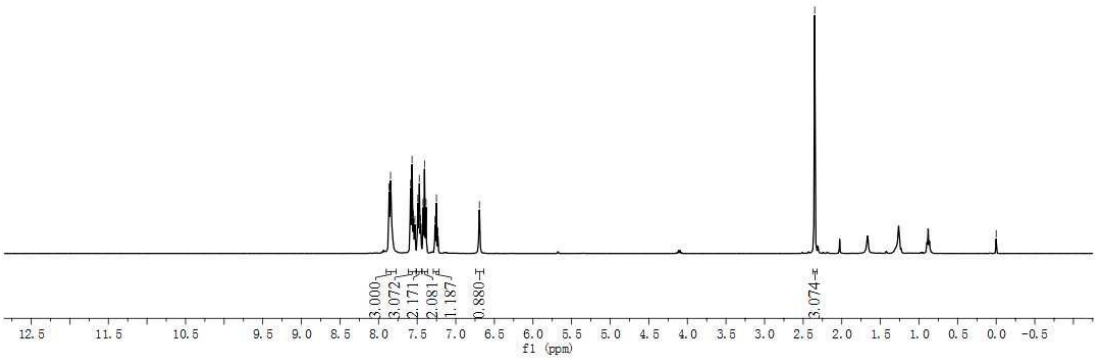

f1 (ppm)

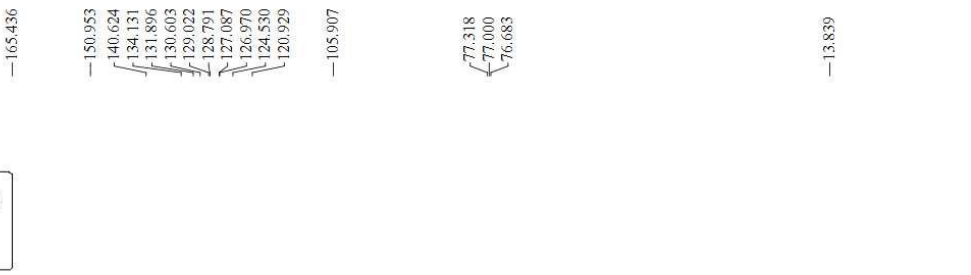

O
H–N
Ph
O
Me

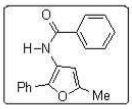
5a''

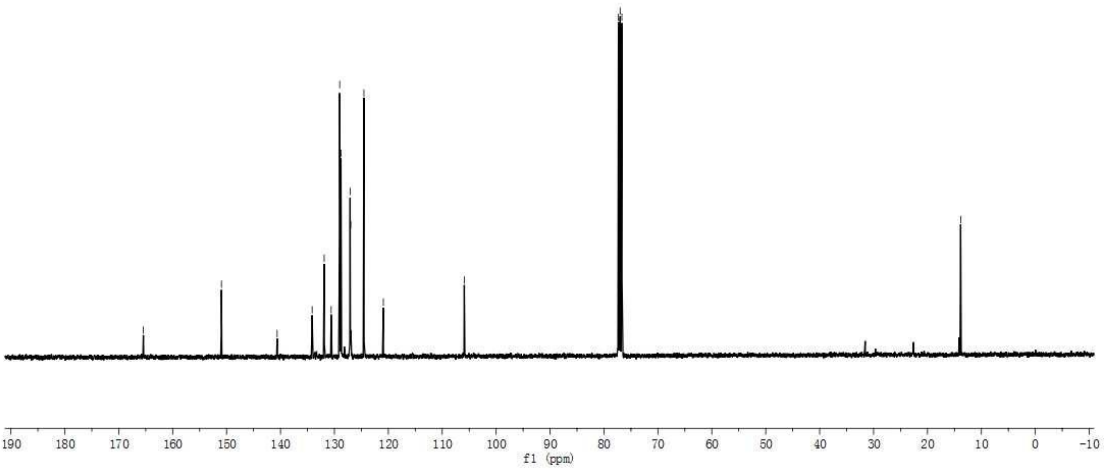

7.863
7.845
7.585
7.566
7.548
7.530
7.492
7.473
7.454
7.424
7.405
7.385
7.268
7.250
7.231
6.694
2.351
0.000

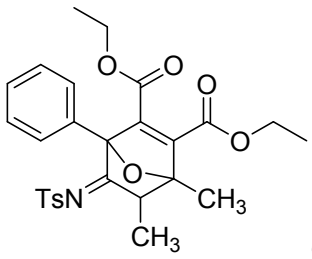

HN
O
Me


3.000
3.072
2.171
2.081
1.187
0.880
3.074
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

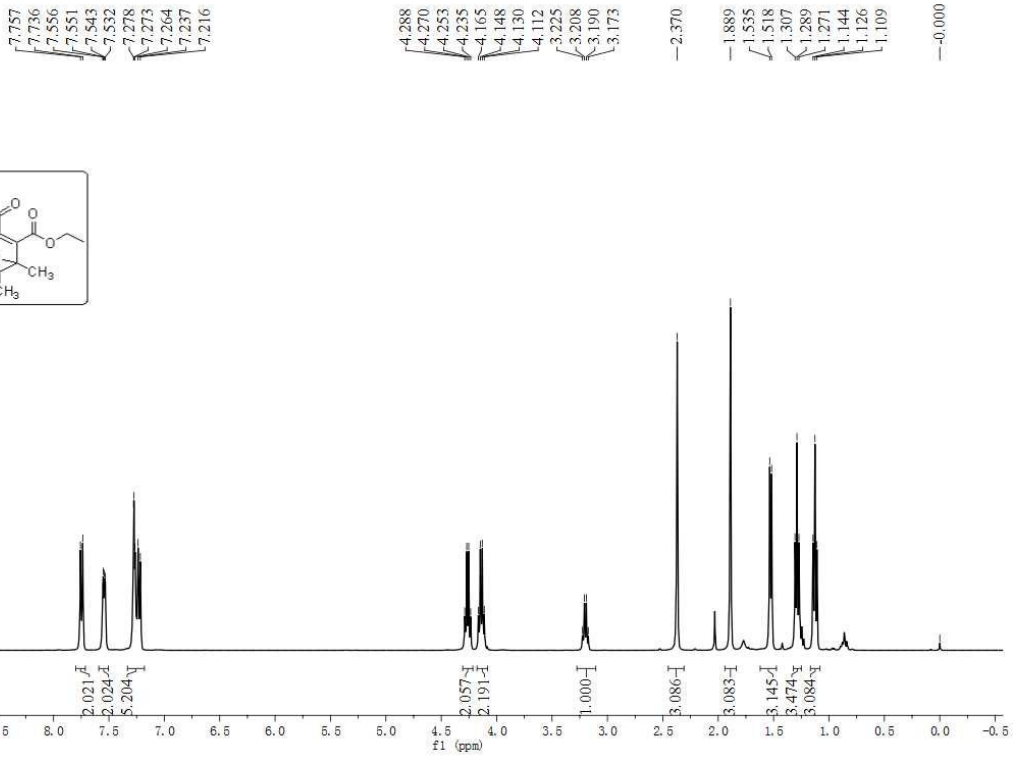

165.436
150.953
140.624
134.131
131.896
130.603
129.022
128.791
127.087
126.970
124.530
120.929
105.907
77.318
77.000
76.683
13.839

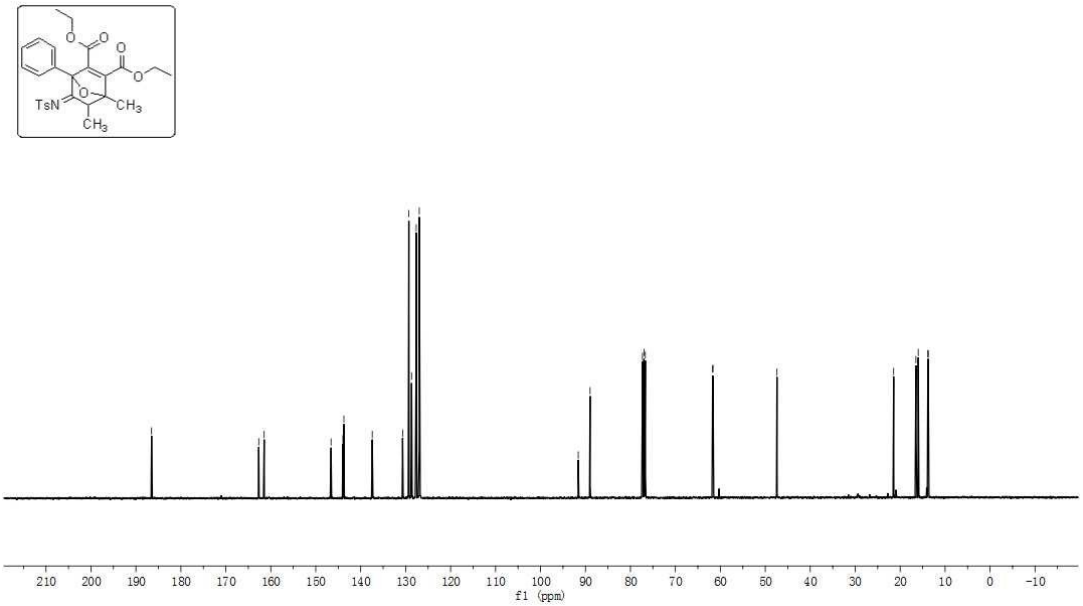

O
H–N
Ph
O
Me

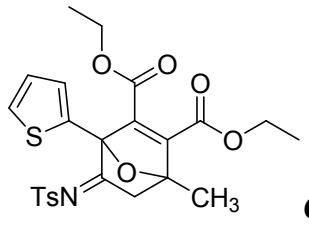

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



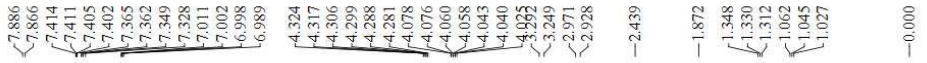
6t

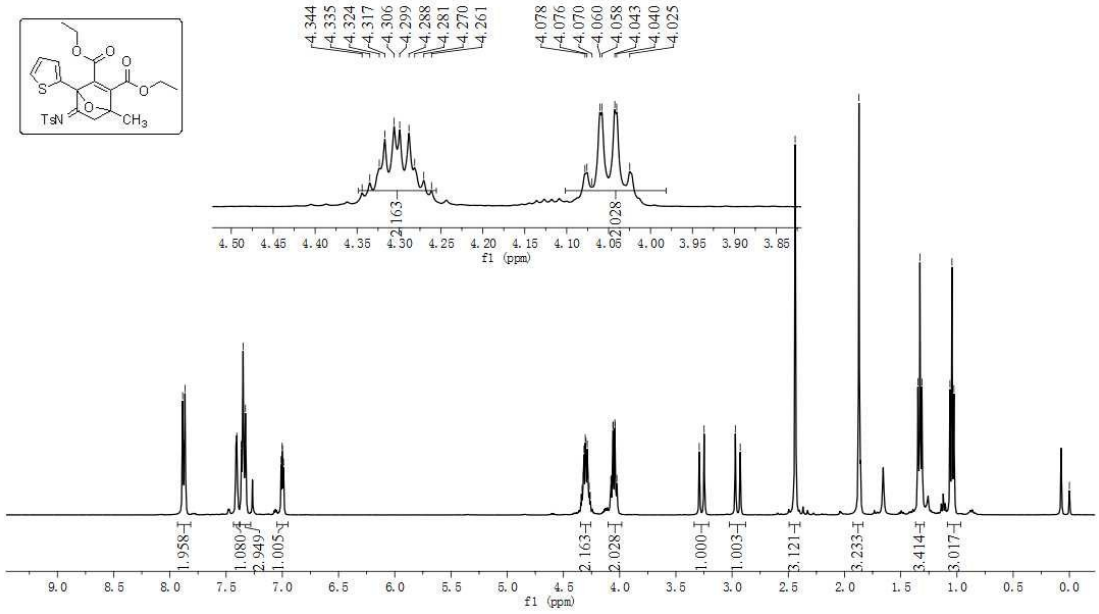


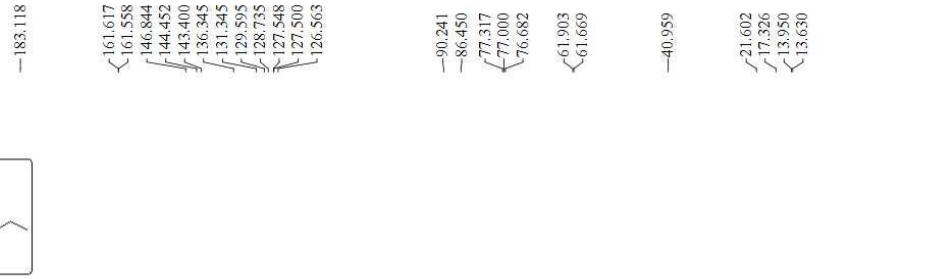


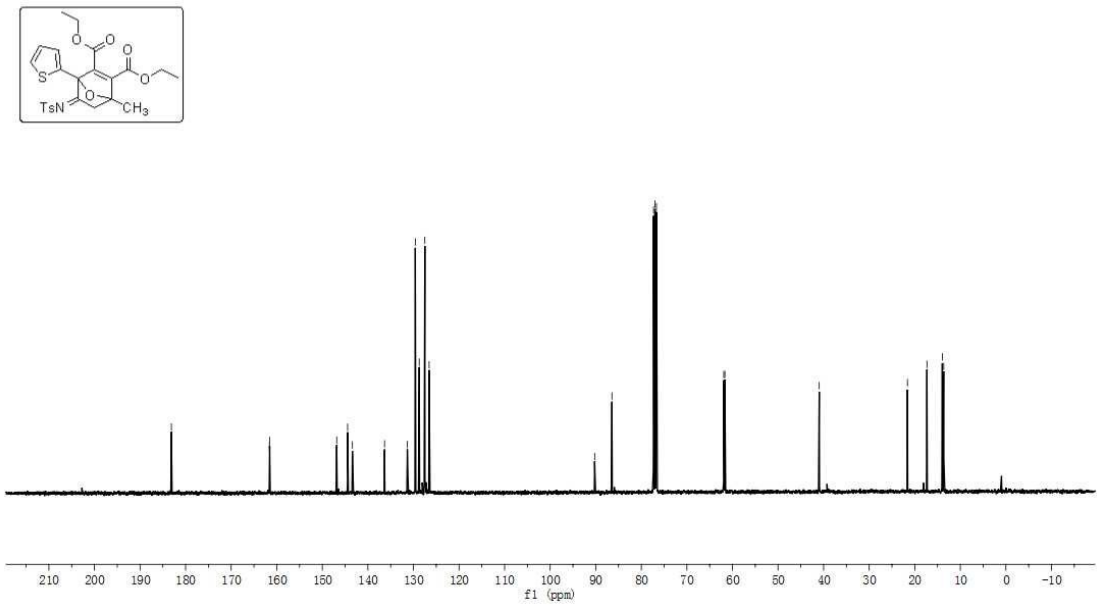

O
O
O
O
S
O
TsN
CH3

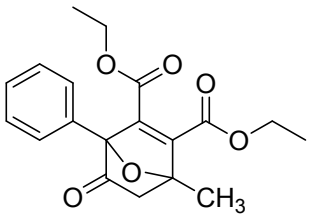
6j


7.886
7.866
7.414
7.411
7.405
7.402
7.365
7.362
7.349
7.328
7.011
7.002
6.998
6.989
4.324
4.317
4.306
4.299
4.288
4.281
4.078
4.076
4.060
4.058
4.043
4.040
4.025
3.249
2.971
2.928
2.439
1.872
1.348
1.330
1.312
1.062
1.045
1.027
0.000

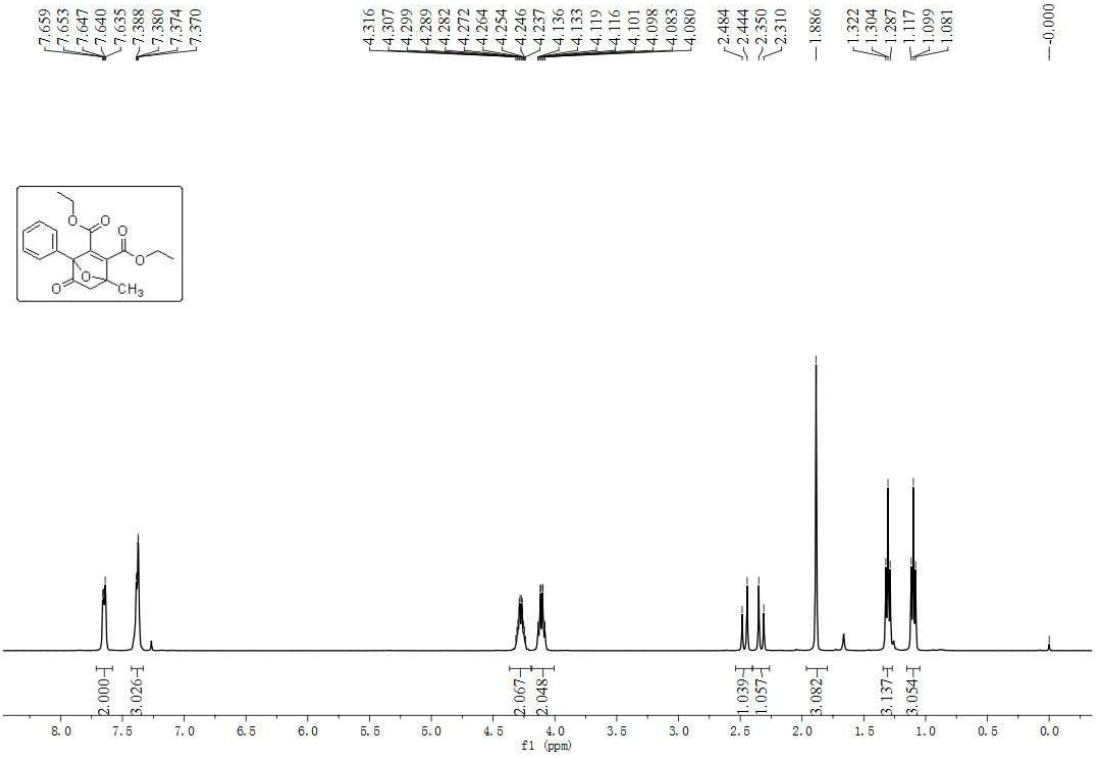

4.344
4.335
4.324
4.317
4.306
4.299
4.288
4.281
4.270
4.261
4.078
4.076
4.070
4.060
4.058
4.043
4.040
4.025
2.163
2.028
4.50 4.45 4.40 4.35 4.30 4.25 4.20 4.15 4.10 4.05 4.00 3.95 3.90 3.85
f1 (ppm)
1.958
1.080
2.949
1.005
2.163
2.028
1.000
1.003
3.121
3.233
3.414
3.017
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

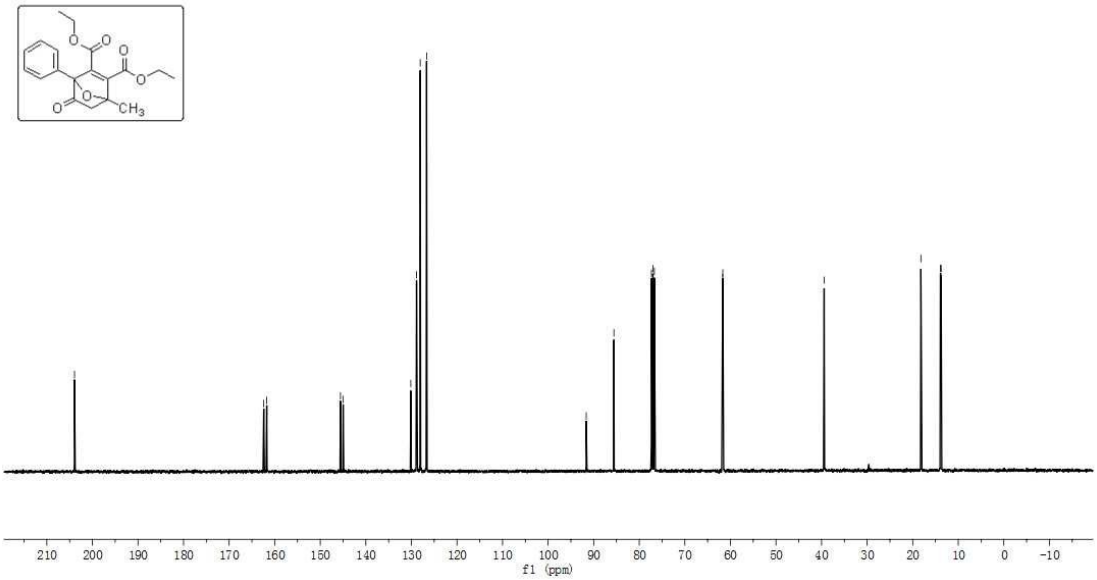

183.118
161.617
161.558
146.844
144.452
143.400
136.345
131.345
129.595
128.735
127.548
127.500
126.563
90.241
86.450
77.317
77.000
76.682
61.903
61.669
40.959
21.602
17.326
13.950
13.630


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



6a


7.659
7.653
7.647
7.640
7.635
7.388
7.380
7.374
7.370
4.316
4.307
4.299
4.289
4.282
4.272
4.264
4.254
4.246
4.237
4.136
4.133
4.119
4.116
4.101
4.098
4.083
4.080
2.484
2.444
2.350
2.310
1.886
1.322
1.304
1.287
1.117
1.099
1.081
0.000
2.000
3.026
2.067
2.048
1.039
1.057
3.082
3.137
3.054
f1 (ppm)


203.922
162.404
161.748
145.566
144.978
130.131
128.876
128.063
126.663
91.634
85.563
77.318
77.000
76.682
61.698
61.664
39.423
18.197
13.916
13.750
f1 (ppm)