BEILSTEIN JOURNAL OF ORGANIC CHEMISTRY

Supporting Information

for

Efficient method for propargylation of aldehydes promoted by allenylboron compounds under microwave irradiation

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Beilstein J. Org. Chem. **2020,** *16,* 168–174. doi:10.3762/bjoc.16.19

Experimental procedures and ^{1}H, ^{13}C, ^{11}B and ^{19}F NMR spectra for all synthesized compounds

1. General

1.1 Materials and methods

All reagents and solvents used were previously purified and dried in agreement with the literature [1]. The aldehydes and allenylboronic acid pinacol ester, **1** were purchased from Aldrich Chemical Co. and used as received. Reactions were monitored by thin-layer chromatography on 0.25 mm E. Merck silica gel 60 plates (F_{254}) using UV light, vanillin and *p*-anisaldehyde as visualizing agents. The reactions were performed using a microwave reactor CEM Focused Microwave Synthesis Discover System Model 908005 using a 10 mL IntelliVent reactor. The GC/FID analysis was performed on a Varian CP-3380 gas chromatograph system coupled with a flame ionization detector. The chromatographic column was a Chrompack CP-SPL5CB capillary column (30 m × 0.25 mm, 0.25 μm) using the initial temperature 60 °C then increased to 220 °C at 10 °C min^{-1}.^{1}H and ^{13}C NMR data were recorded in $CDCl_3$ or DMSO-d_6. The chemical shifts are reported as delta (δ) units in parts per million (ppm) relative to the solvent residual peak as the internal reference [$CDCl_3$ at δ 7.26 (^{1}H NMR) and δ 77.16 (^{13}C NMR) and DMSO-d_6 at δ 2.50 (^{1}H NMR) and δ 39.52 (^{13}C NMR)]. ^{11}B (128 MHz) and ^{19}F NMR (376 MHz) spectra were obtained in DMSO-d_6. Spectra were calibrated using BF_3•Et_2O (0.0 ppm) as external reference in the case of ^{11}B NMR and chemical shifts were referenced to external CF_3CO_2H (0.0 ppm) in the case of ^{19}F NMR. Coupling constants (*J*) for all spectra are reported in Hertz (Hz).

2. Experimental procedures

2.1 General procedure for the propargylation of aldehydes using allenylboronic acid pinacol ester (1) promoted by microwave irradiation: A vial containing the appropriate aldehyde (1 mmol) and allenylboronic acid pinacol ester, **1** (1.5 mmol, 250 mg) was irradiated at 300 W at 100 °C for 30 minutes. The vial contents were diluted with EtOAc (10 mL) and washed with water (2 × 15 mL). The combined organic phase was dried over $MgSO_4$, filtered, and the solvent was removed in vacuo followed by purification by a flash column chromatography [hexanes/EtOAc (8:2)] to yield **2a**–**t**.

1-(Naphth-2-yl)but-3-yn-1-ol (**2a**)*:* obtained 190 mg (97%) as a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79-7.75 (m, 4H, $H_{naphthyl}$), 7.44–7.39 (m, 2H, $H_{naphthyl}$), 7.18 (s, 1H, $H_{naphthyl}$), 4.98 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 2.68–2.65 (m, 2H, OCHC*H*$_2$), 2.01 (t, *J* = 2.8 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.8, 133.2, 133.1, 128.3, 128.0, 127.7, 126.2, 126.0, 124.6, 123.7, 80.6, 72.4, 71.1, 29.4. The data match with the previously described compound [2].

1-Phenyl-3-butyn-1-ol (**2b**)*:* obtained 108 mg (74%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42–7.32 (m, 5H, H_{aryl}), 4.90 (t, *J* = 6.3 Hz, 1H, OC*H*CH_2), 2.67–2.65 (m, 2H, OCHC*H*$_2$), 2.10 (t, *J* = 2.8 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.5, 128.4, 127.9, 125.7, 80.7, 72.2, 70.9, 29.4. The data match with the previously described compound [2].

1-(o-Tolyl)but-3-yn-1-ol (**2c**)*:* obtained 112 mg (70%) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.53–7.50 (m, 1H, H_{aryl}), 7.28–7.13 (m, 3H, H_{aryl}), 5.12 (dd, *J* = 6.0 and 5.7 Hz, 1H, OC*H*CH_2), 2.69–2.54 (m, 2H, OCHC*H*$_2$), 2.37 (s, 3H, C*H*$_3$), 2.12 (br s, 1H, O*H*), 2.09 (t, *J* = 2.4 Hz, 1H, C≡CH); ^{13}C NMR (75 MHZ, $CDCl_3$) δ 140.4, 134.6, 130.4, 127.7, 126.3, 125.0, 80.9, 70.7, 68.8, 28.2, 19.0. The data match with the previously described compound [3].

1-(2,5-Dimethylphenyl)but-3-yn-1-ol (**2d**)*:* obtained 130 mg (75%) as an oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (s, 1H, H_{aryl}), 7.06–7.01 (m, 2H, H_{aryl}), 5.12–5.08 (m, 1H, OC*H*CH_2), 2.66–2.55 (m, 2H, OCHC*H*$_2$), 2.34 (s, 3H, C*H*$_3$), 2.33 (s, 3H, C*H*$_3$), 2.10 (t, *J* = 2.8 Hz, 1H, C≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.2, 135.8, 131.4, 130.4, 128.4, 125.6, 80.0, 70.6, 68.9, 28.3, 21.1, 18.6. The data match with the previously described compound [4].

1-(p-Methoxyphenyl)but-3-yn-1-ol (**2e**)*:* obtained 135 mg (77%) as an oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 8.0 Hz, 2H, H_{aryl}), 6.91 (d, *J* = 8.8 Hz, 2H, H_{aryl}), 4.85 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 3.82 (s, 3H, OC*H*$_3$), 2.65–2.63 (m, 2H, OCHC*H*$_2$), 2.08 (t, *J* = 2.4 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3, 134.6, 127.0, 113.9, 80.8, 72.0, 70.9, 55.3, 29.4. The data match with the previously described compound [2].

1-(m-Methoxyphenyl)but-3-yn-1-ol (**2f**)*:* obtained 133 mg (76%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23–7.18 (m, 1H, H_{aryl}), 6.90–6.88 (m, 2H, H_{aryl}), 6.79–6.76 (m, 1H, H_{aryl}), 4.78 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 3.75 (s, 3H, OC*H*$_3$), 2.58–2.56 (m, 2H, OCHC*H*$_2$), 2.00 (t, *J* = 2.8 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 144.1, 129.5, 118.0, 113.4, 111.2, 80.6, 72.2, 70.9, 55.2, 29.4. The data match with the previously described compound [2].

1-(o-Methoxyphenyl)but-3-yn-1-ol (**2g**)*:* obtained 153 mg (87%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (dd, *J* = 7.6, 1.6 Hz, 1H, H_{aryl}), 7.31–7.26 (m, 1H, H_{aryl}), 6.99 (dt, *J* = 7.6, 0.8 Hz, 1H, H_{aryl}), 6.90 (d, *J* = 8.4 Hz, 1H, H_{aryl}), 5.10 (dd, *J* = 7.6, 5.2 Hz, 1H, OC*H*CH_2), 3.87 (s, 3H, OC*H*$_3$), 2.78 (ddd, *J* = 16.8, 5.2, 2.8 Hz, 1H, OCHC*H*$_2$), 2.65 (ddd, *J* = 16.8, 7.2, 2.8 Hz, 1H, OCHC*H*$_2$), 2.06 (t, *J* = 2.8 Hz, 1H, C≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 130.2, 128.7, 126.8, 120.7, 110.4, 81.3, 70.4, 68.9, 55.2, 27.4. The data match with the previously described compound [3].

1-(3,4,5-Trimethoxyphenyl)but-3-yn-1-ol (**2h**)*:* obtained 229 mg (97%) as an oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 6.64 (s, 2H, H_{aryl}), 4.83 (dt, *J* = 6.4 and 2.8 Hz, 1H, OC*H*CH_2), 3.88 (s, 6H, OC*H*$_3$), 3.85 (s, 3H, OC*H*$_3$), 2.68–2.59 (m, 2H, OCHC*H*$_2$), 2.41 (d, *J* = 3.2 Hz, 1H, OH), 2.11 (t, *J* = 2.8 Hz, 1H, C≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.4, 138.2, 137.6, 102.7, 80.7, 72.5, 71.1, 60.8, 56.1, 29.6. The data match with the previously described compound [5].

(E)-1-Phenylhex-1-en-5-yn-3-ol (**2i**)*:* obtained 156 mg (91%) as an oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, *J* = 7.6 Hz, 2H, H_{aryl}), 7.34 (t, *J* = 8.0 Hz, 1H, H_{aryl}), 7.28–7.24 (m, 2H, H_{aryl}), 6.68 (d, *J* = 16.0 Hz, 1H, C*H*=CH), 6.30 (dd, *J* = 16.0 6.0 Hz, 1H, CH=C*H*), 4.52–4.47 (m, 1H, OC*H*CH_2), 2.61 (ddd, *J* = 16.8, 5.6 2.8 Hz, 1H, OCHC*H*$_2$), 2.54 (ddd, *J*= 16.8, 6.0 and 2.4 Hz, 1H, OCHC*H*$_2$),

2.10 (t, *J* = 2.4 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.3, 131.4, 129.9, 128.6, 127.9, 126.6, 80.2, 71.1, 70.7, 27.7. The data match with the previously described compound.[2]

1-(p-Bromophenyl)but-3-yn-1-ol (**2j**)*:* obtained 157 mg (70%) as an oil.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.4 Hz, 2H, H_{aryl}), 7.29 (d, *J* = 8.4 Hz, 2H, H_{aryl}), 4.86 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 2.68–2.57 (m, 2H, OCHC*H*$_2$), 2.09 (t, *J* = 2.8 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.3, 131.6, 127.5, 121.8, 80.1, 71.6, 71.3, 29.4. The data match with the previously described compound [3].

1-(p-Fluorophenyl)but-3-yn-1-ol (**2k**)*:* obtained 84 mg (51%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40–7.36 (m, 2H, H_{aryl}), 7.08-7.04 (m, 2H, H_{aryl}), 4.88 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 2.65-2.62 (m, 2H, OCHC*H*$_2$), 2.09 (t, *J* = 2.8 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.4 (d, *J* = 244.7 Hz), 138.1 (d, *J* = 3.1 Hz), 127.4 (d, *J* = 8.5 Hz), 115.3 (d, *J* = 21.7 Hz), 80.3, 71.7, 71.2, 29.6. The data match with the previously described compound [2].

1-(o-Fluorophenyl)but-3-yn-1-ol (**2l**)*:* obtained 113 mg (69%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (t, *J* = 7.6 Hz, 1H, Ar), 7.22–7.19 (m, 1H, Ar), 7.10 (t, *J* = 7.6 Hz, 1H, Ar), 6.97 (t, *J* = 9.2 Hz, 1H, Ar), 5.13 (br, 1H, OC*H* CH_2), 2.71–2.67 (m, 1H, OCHC*H*$_2$), 2.59–2.54 (m, 1H, OCHC*H*$_2$), 2.10–1.91 (m, 1H, ≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6 (d, *J* = 244.8 Hz), 129.3 (d, *J* = 8.0 Hz), 127.2, 124.3, 115.3 (d, *J* = 22.0 Hz), 80.2, 71.1, 66.4, 28.3. The data match with the previously described compound [3].

1-(p-Nitrophenyl)but-3-yn-1-ol (**2m**)*:* obtained 187 mg (98%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (d, *J*= 8.8 Hz, 2H, H_{aryl}), 7.58 (d, *J* = 8.8 Hz, 2H, H_{aryl}), 4.99 (dd, 1H, *J* = 6.8 and 5.6 Hz, 1H, OC*H*CH_2), 2.70 (ddd, *J* = 16.8, 5.62.4 Hz, 1H, OCHC*H*$_2$), 2.63 (ddd, *J* = 16.8, 6.82.8 Hz, 1H, OCHC*H*$_2$), 2.11 (dd, *J* = 2.8 and 2.4 Hz, 1H, C≡CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.4, 147.5, 126.6, 123.7, 79.3, 72.0, 71.3, 29.5. The data match with the previously described compound [2].

1-(o-Nitrophenyl)but-3-yn-1-ol (**2n**)*:* obtained 177 mg (93%) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.97 (dd, *J* = 8.1, 1.2 Hz, 1H, H_{aryl}), 7.90 (dd, *J* = 8.4 and 1.2 Hz, 1H, H_{aryl}), 7.69 (dt, *J* = 7.8 1.2 Hz, 1H, H_{aryl}), 7.48 (dt, *J* = 7.2, 1.2 Hz, 1H, H_{aryl}), 5.48 (dd, *J* = 7.2, 4.8 Hz, 1H, OC*H*CH_2), 2.92 (ddd, *J* = 16.5, 4.8, 3.0 Hz, 1H, OCHC*H*$_2$), 2.68 (ddd, *J* = 3.0, 7.5 and 16.5 Hz, 1H, OCHC*H*$_2$), 2.12 (t, *J* = 3.0 Hz, 1H, ≡CH). ^{13}C NMR (75 MHz, $CDCl_3$) δ 147.6, 137.7, 133.6, 128.6, 128.2, 124.5, 79.7, 71.8, 67.4, 28.5. The data match with the previously described compound [3].

4-(1-Hydroxybut-3-ynyl)-2-methoxyphenol (**2o**)*:* obtained 178 mg (93%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95 (d, *J* = 2.0 Hz, 1H, H_{aryl}), 6.88 (d, *J* = 8.2 Hz, H_{aryl}), 6.85 (dd, *J* = 8.2, 1.6 Hz, 1H, H_{aryl}), 5.67 (br s, 1H, PhO*H*), 4.81 (t, *J* = 6.4 Hz, 1H, OC*H*CH_2), 3.89 (s, 3H, C*H*$_3$), 2.68–2.59 (m, 2H, OCHC*H*$_2$), 2.44 (br s, 1H, CHO*H*), 2.08 (t, *J* = 2.8 Hz, 1H, ≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.5, 145.3, 134.5, 118.8, 114.1, 108.2, 80.8, 72.2, 70.9, 55.9, 29.4. The data match with the previously described compound [6].

1-(5-Bromo-2-methoxyphenyl)but-3-yn-1-ol (**2p**)*:* obtained 228 mg (90%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 2.4 Hz, 1H, H_{aryl}), 7.36 (dd, *J* = 8.4 and 2.4 Hz, 1H, H_{aryl}), 6.75 (d, *J* =

8.8 Hz, 1H, H_{aryl}), 5.06 (dd, *J* = 7.6 and 4.8 Hz, 1 H, OC*H*CH_2), 3.83 (s, 3 H, CH_3), 2.75 (ddd, *J* = 16.8, 7.2 and 2.8 Hz, 1H, OCHCH_2), 2.56 (ddd, *J* = 16.8, 7.6 and 2.4 Hz, 1H, OCHCH_2), 2.08 (t, *J* = 2.8 Hz, 1H, C≡C*H*). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.1, 132.5, 131.2, 129.6, 113.1, 112.0, 80.7, 70.9, 67.7, 55.5, 27.4. The data match with the previously described compound [7].

Methyl 4-(1-Hydroxybut-3-ynyl)benzoate (**2q**)*:* obtained 195 mg (96%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 8.4 Hz, 2H, H_{aryl}), 7.46 (d, *J* = 8.0 Hz, 2H, H_{aryl}), 4.95–4.92 (m, 1H, OC*H*CH_2), 3.91 (s, 3H, CH_3), 2.71–2.59 (m, 2H, OCHCH_2), 2.59 (d, *J* = 3.6 Hz, 1H, OH), 2.08 (t, *J* = 2.8 Hz, 1H, C≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.8, 147.4, 129.7, 129.7, 125.7, 80.0, 71.8, 71.4, 52.1, 29.4. The data match with the previously described compound [8].

4-(1-Hydroxybut-3-yn-yl)benzonitrile (**2r**)*:* obtained 167 mg (98%) as an oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, *J* = 8.0 Hz, 2H, H_{aryl}), 7.52 (d, *J* = 8.0 Hz, 2H, H_{aryl}), 4.95 (dd, *J* = 7.8 and 1.8 Hz, 1H, OC*H*CH_2), 2.73–2.57 (m, 2H, OCHCH_2), 2.11 (t, *J* = 2.8 Hz, 1H, C≡CH). ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.5, 132.3, 126.5, 118.7, 111.8, 79.4, 71.9, 71.4, 29.4. The data match with the previously described compound [8].

1-(2-Furyl)but-3-yn-1-ol (**2s**)*:* obtained 82 mg (60%) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.39 (t, *J* = 1.2 Hz, 1H H_{furyl}), 6.34 (d, 2H, *J* = 1.2 Hz, 1H, H_{furyl}), 4.88 (t, *J* = 6.0 Hz, 1H, OC*H*CH_2), 2.77 (dd, *J* = 6.0, 2.4 Hz, 2H, OCHCH_2), 2.33 (s, 1H, OH), 2.07 (t, *J* = 2.4 Hz, 1H, C≡CH); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.6, 142.3, 110.3, 106.6, 79.8, 71.2, 66.1, 26.1. The data match with the previously described compound [2].

Dec-1-yn-4-ol (**2t**)*:* obtained 92 mg (60%) as an oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.80–3.72 (m, 1H, OC*H*CH_2), 2.44 (ddd, *J* = 16.5, 4.8, 3.0 Hz, 1H, OCHCH_2), 2.31 (ddd, *J* = 16.5, 6.3, 3.0 Hz, 1H, OCHCH_2), 2.06 (t, *J* = 3,0 Hz, 1H, C≡CH), 1.56–1.51 (m, 2H, CH_2), 1.36–1.29 (m, 8H, (CH_2)$_4$), 0.88 (t, *J* = 6.3 Hz, 3H, CH_3); ^{13}C NMR (75 MHz, $CDCl_3$) δ 80.9, 70.7, 69.9, 36.2, 31.7, 29.2, 27.3, 25.5, 22.6, 14.0. The data match with the previously described compound.[9]

2.2 Representative procedure for propargylation of 2-naphthaldehyde using potassium allenyltrifluoroborate (4) promoted by microwave irradiation: A vial containing 2-naphthaldehyde (1 mmol, 156 mg) and potassium allenyltrifluoroborate (**4**, 1.5 mmol, 250 mg) in acetone (500 μL) was irradiated at 300 W at 100 °C for 20 minutes. The vial contents were diluted with EtOAc (10 mL) and washed with water (2 × 15 mL). The organic phase was dried over $MgSO_4$ and filtered. The solvents were removed in vacuo to yield **2a** (137 mg, 70%) as a single isomer.

2.3 Synthesis of potassium allenyltrifluoroborate (4): A solution of KF (4 equiv, 11 mmol, 0.64 g) in H_2O (1.0 mL) was added to a suspension of the allenylboronic acid pinacol ester (**1**, 0.45 g, 2.75 mmol) in MeCN/MeOH (1:1) (3.0 mL). The mixture was stirred until complete dissolution (aprox. 1 min). *L*-(+)-tartaric acid [2.05 equiv, 5.64 mmol, 0.84 g in THF (4.0 mL)] was added dropwise to the rapidly stirring biphasic solution over a period of approximately 5 min, during which a white precipitate formed and rapidly flocculated. After 4.0 h stirring, the mixture was filtered, washed with more MeCN and filtered. The filtrate was concentrated in vacuo to give **4** as

a white solid (0.29 g, 74%) [10]. ^{1}H NMR (400 MHz, DMSO-d_6): δ 4.51 (br s, 1H, C*H*BF_3K), 3.98 (br s, 2H, CH_2=C); ^{13}C NMR (100 MHz, DMSO-d_6): δ 210.0, 65.8; ^{11}B NMR (128 MHz, DMSO-d_6): δ 0.59 (q, $J_{11B,19F}$ = 49.2 Hz, BF_3K); ^{19}F NMR (376 MHz, DMSO-d_6): δ -133.75 (q, $J_{19F,11B}$ = 49.2 Hz, BF_3K). The data match with the previously described compound [11].

2.4 Typical procedure to remove pinacol from obtained products: A vial containing 3,4,5-trimethoxybenzaldehyde (1 mmol, 196 mg) and allenylboronic acid pinacol ester, **1** (1.5 mmol, 250 mg) was irradiated at 300 W at 100 °C for 30 minutes. After this period, the vial contents were dissolved in 50% aqueous MeOH (10 mL) and the contents were transferred to a round-bottomed flask. All volatile materials were removed on a rotary evaporator (45–50 °C/25–15 mbar) and this procedure was repeated until the crude mixture displayed less than 1 mol % of pinacol remaining by gas chromatography analysis [11].

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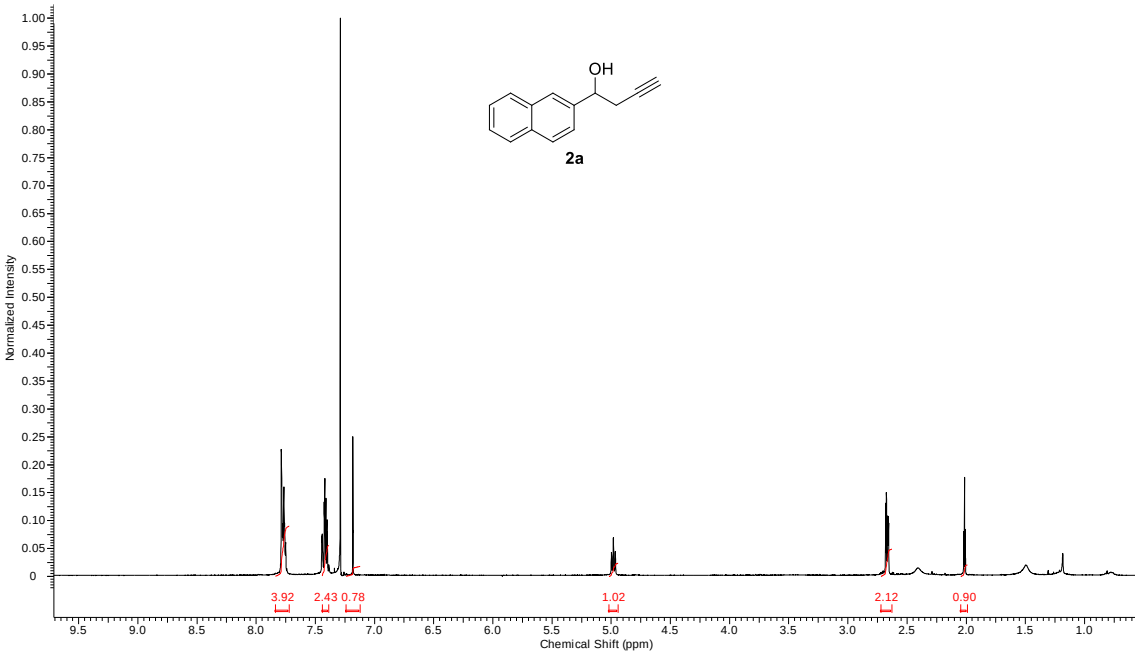
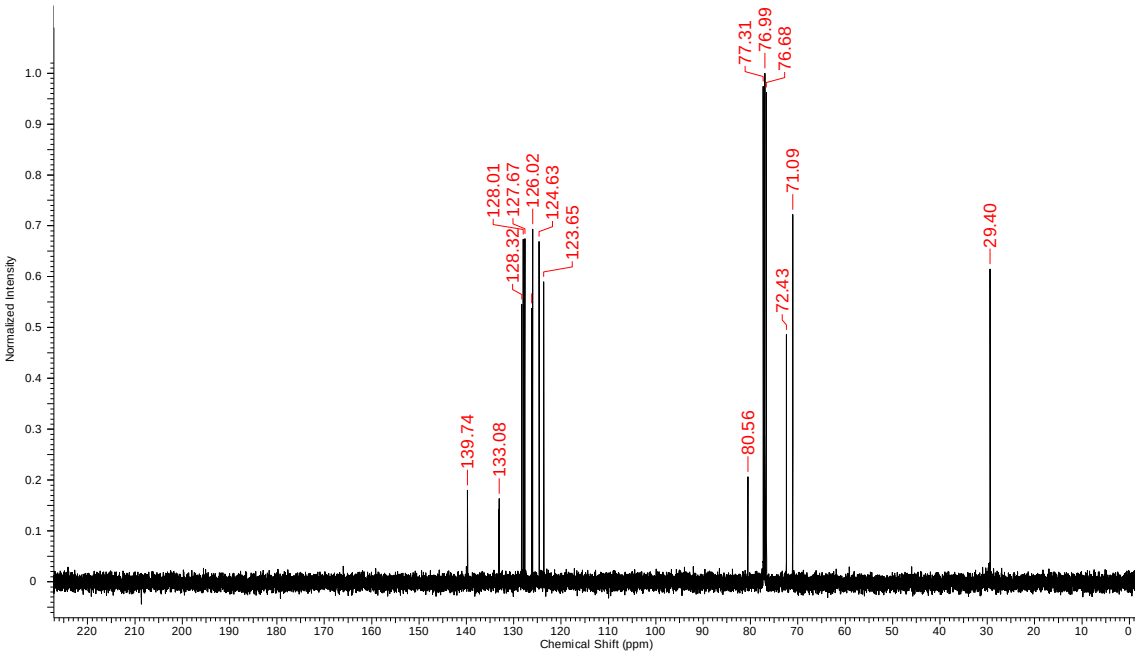
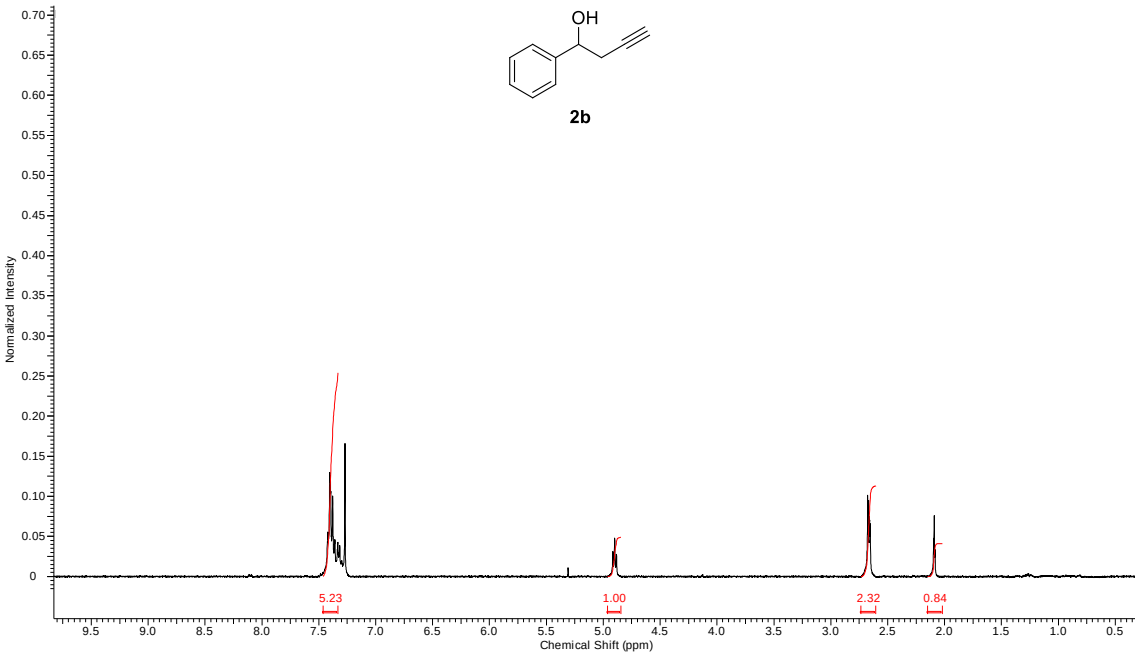
3. Spectra



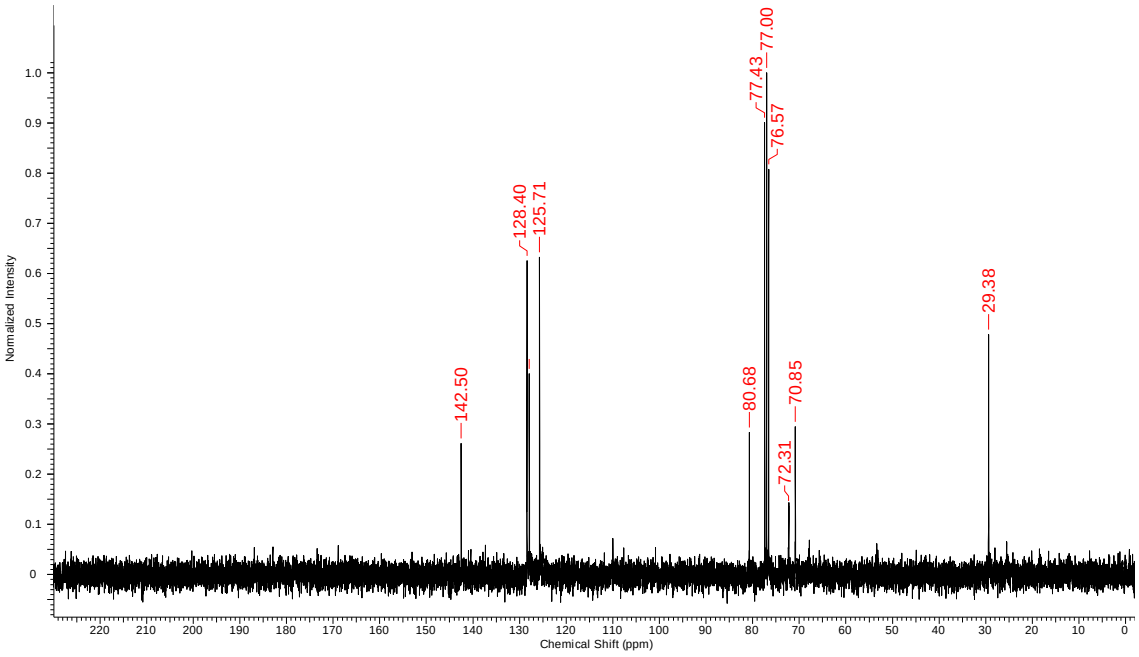
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2a**



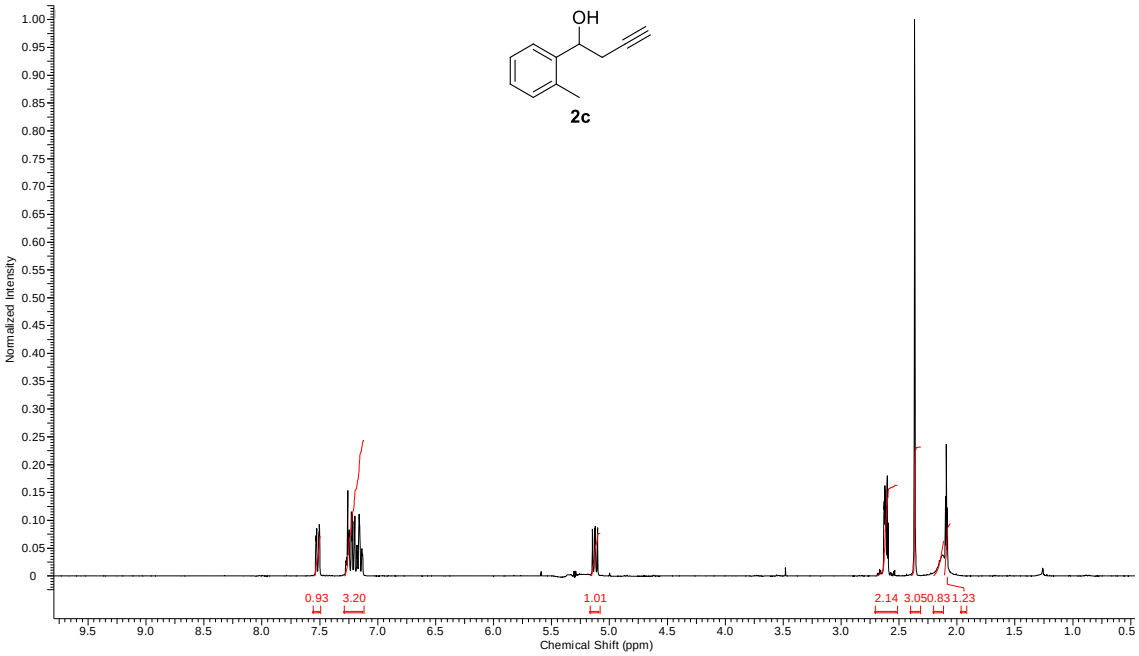
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2a**



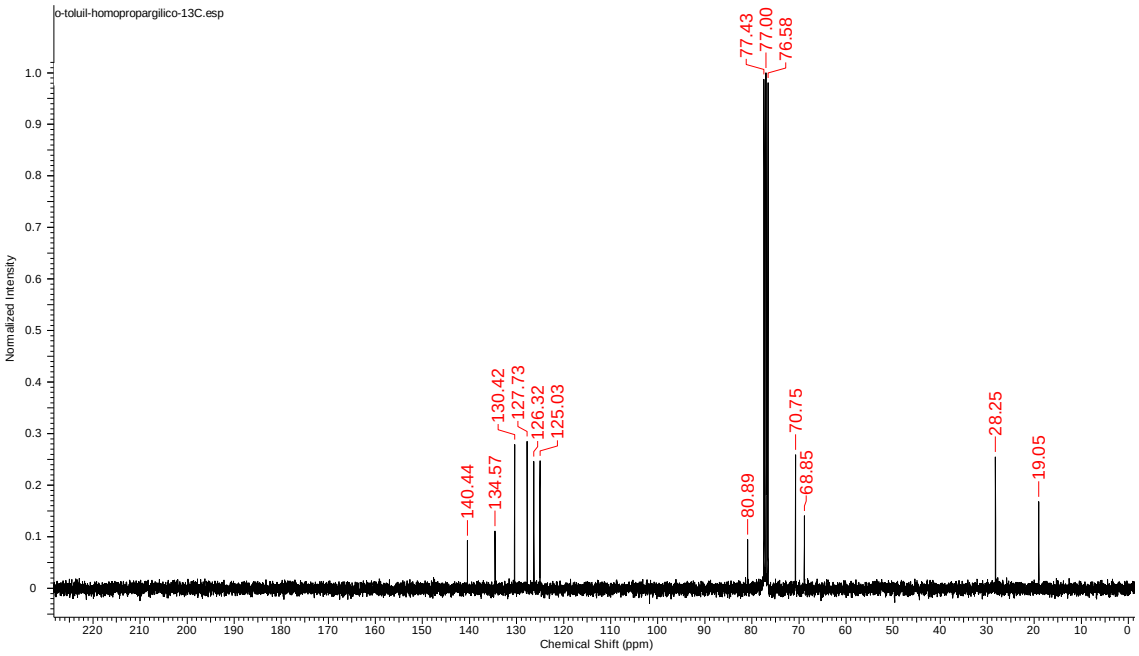
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2b**



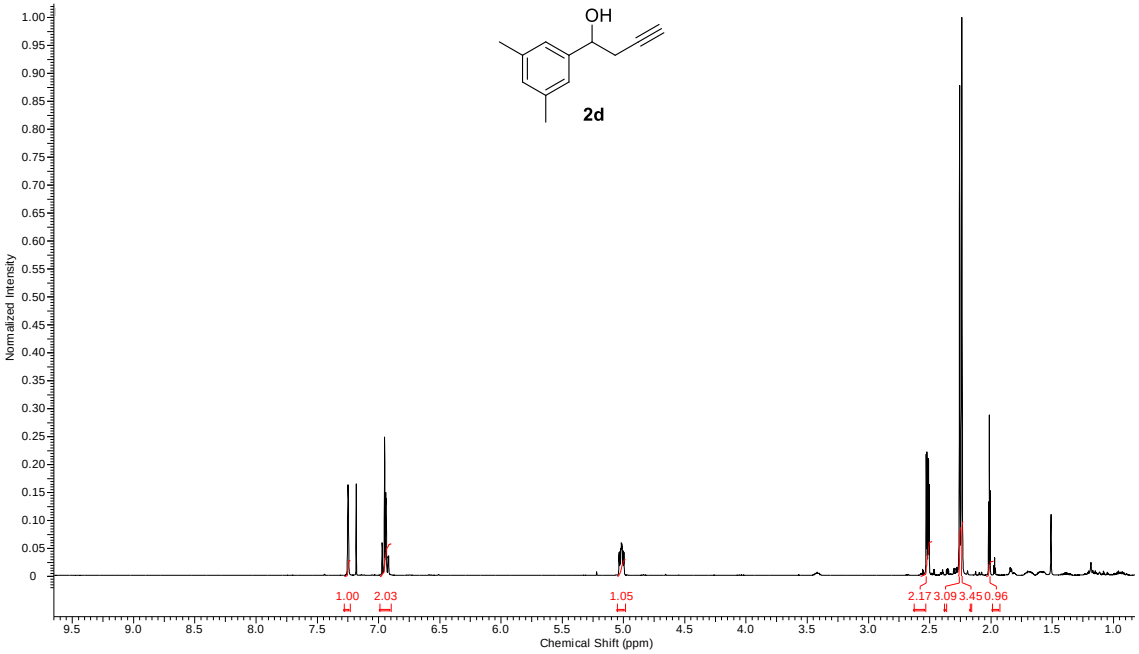
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2b**



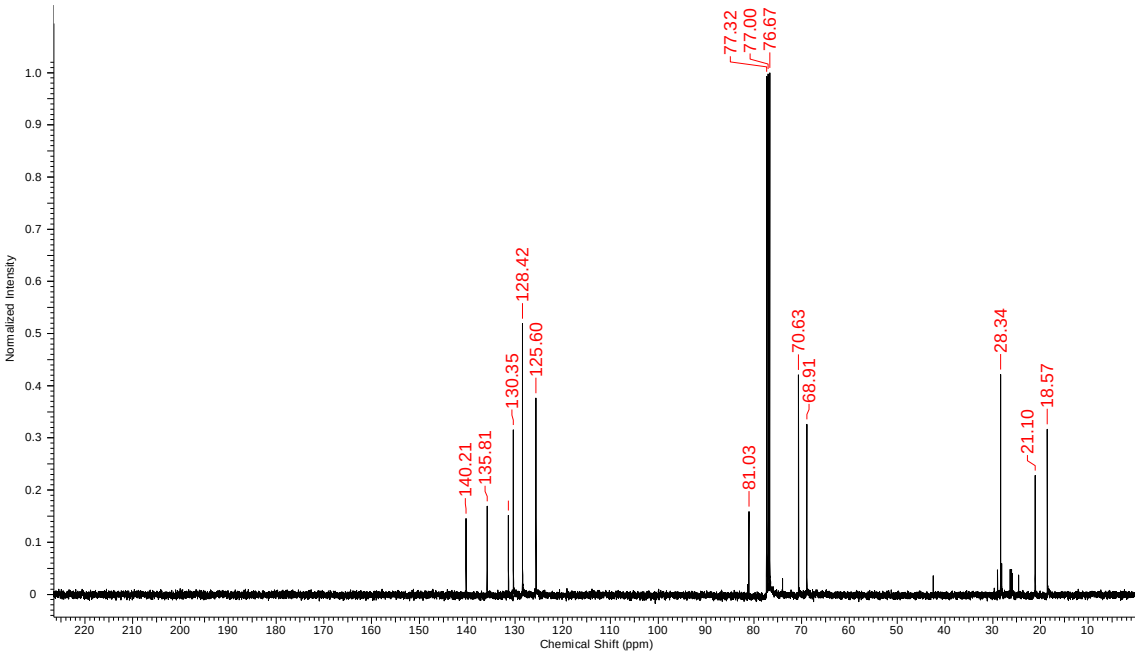
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2c**



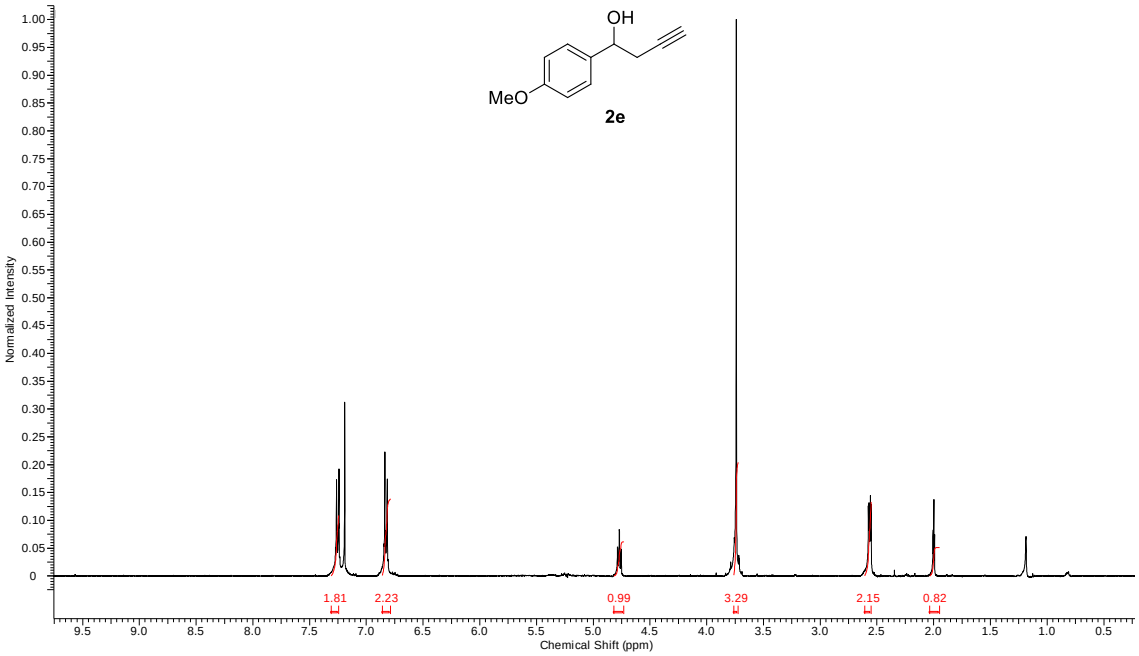
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2c**



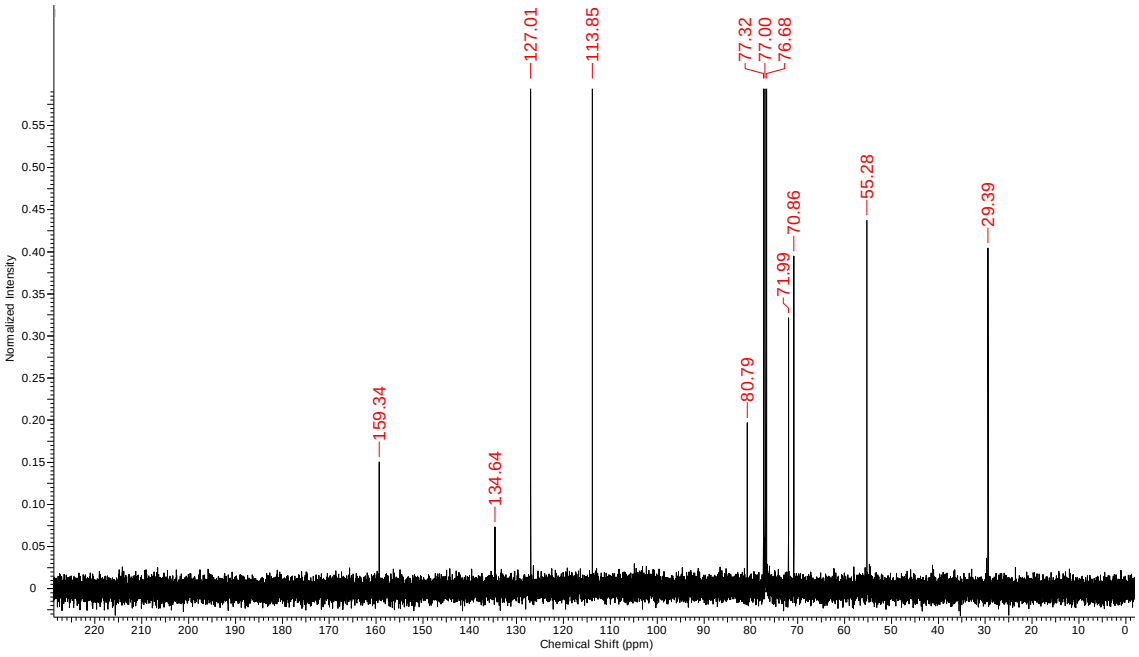
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2d**



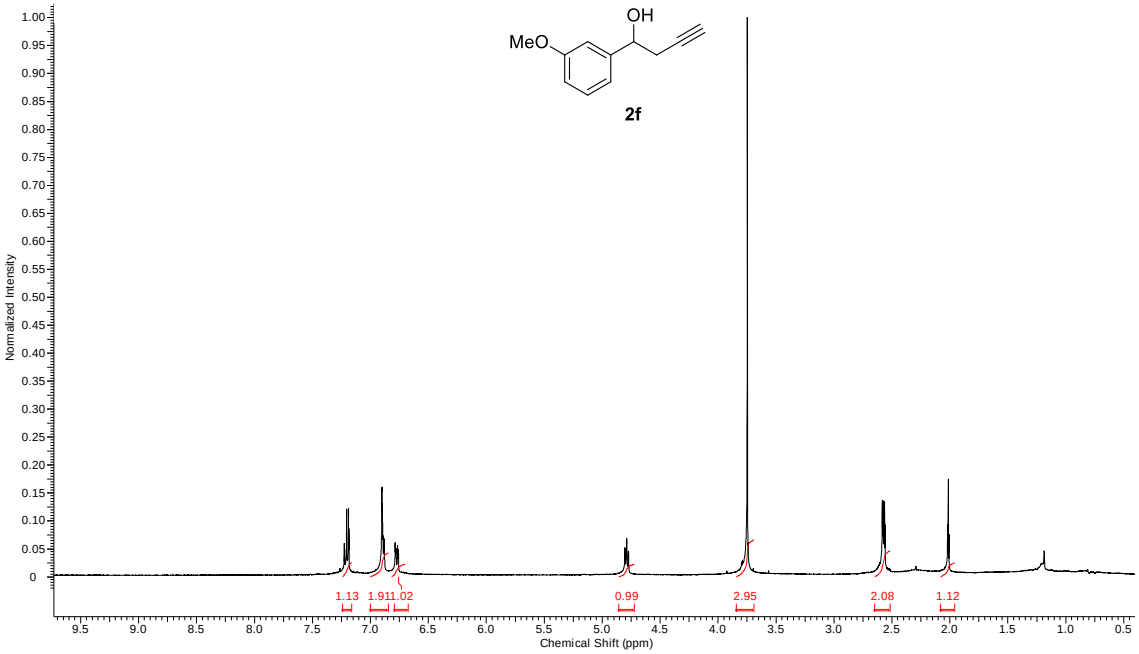
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2d**



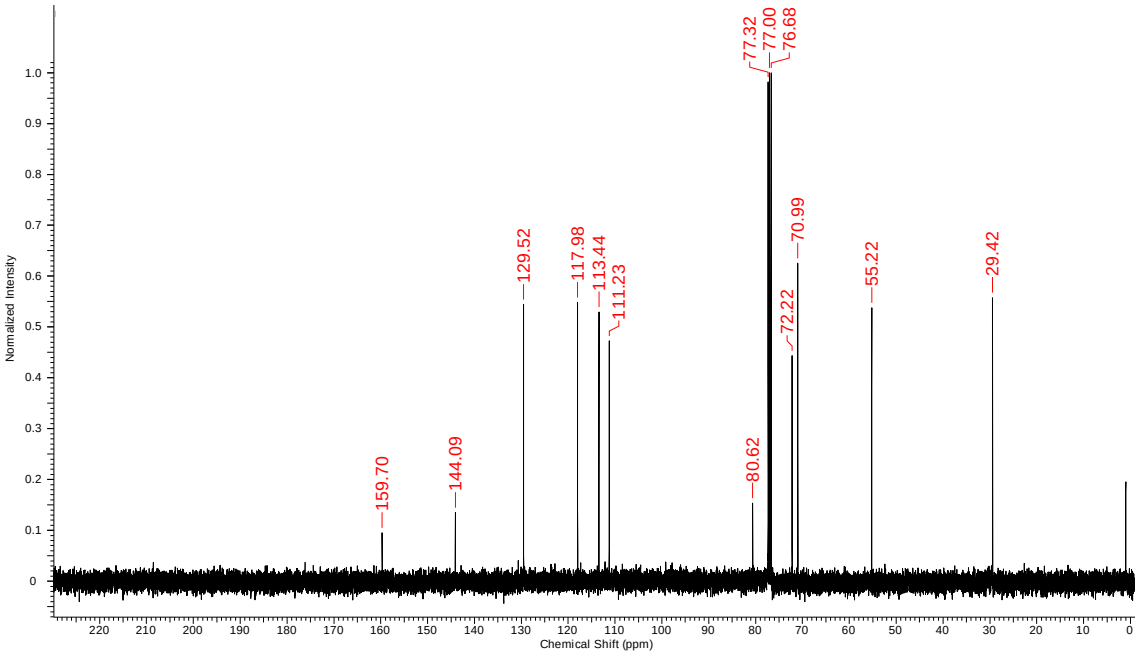
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2e**



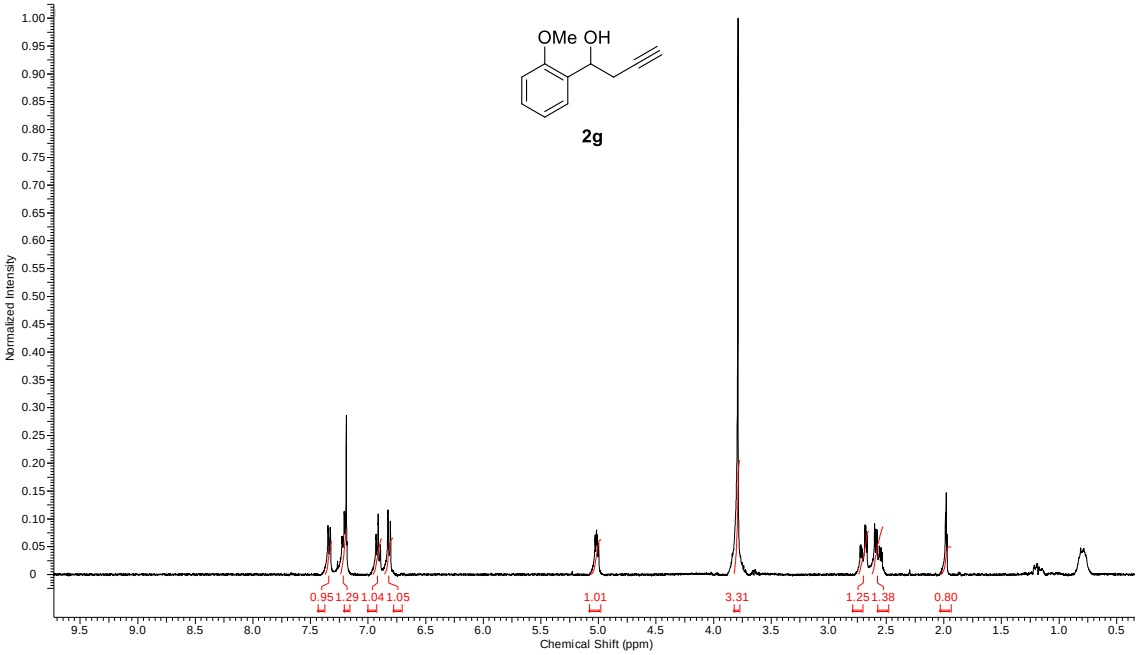
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2e**



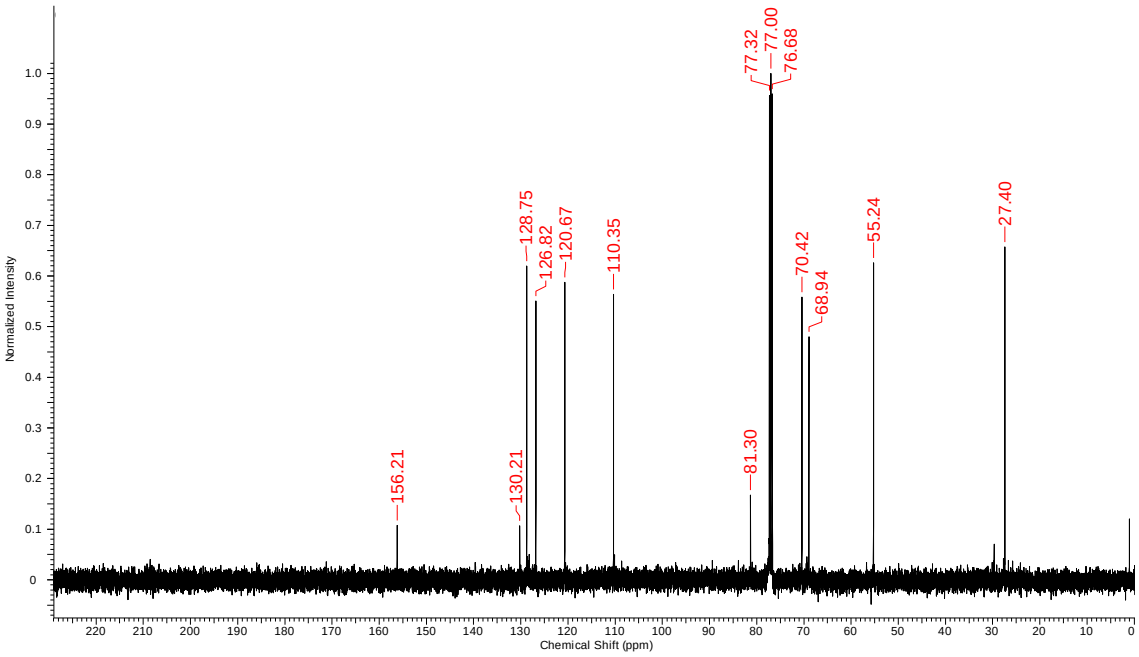
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2f**



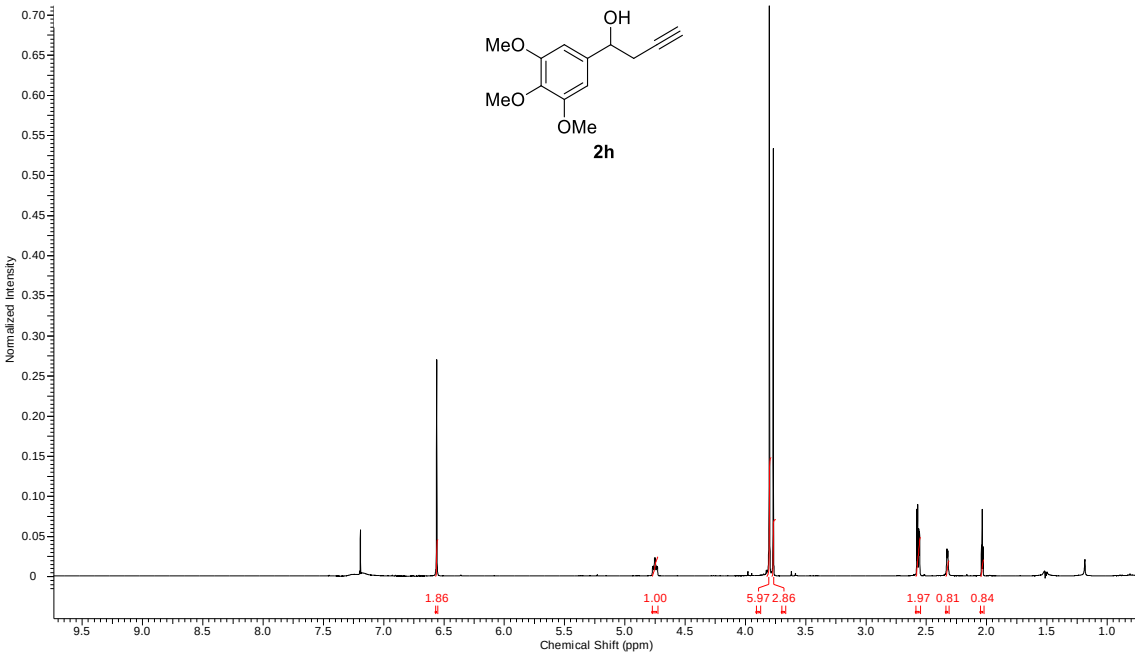
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2f**



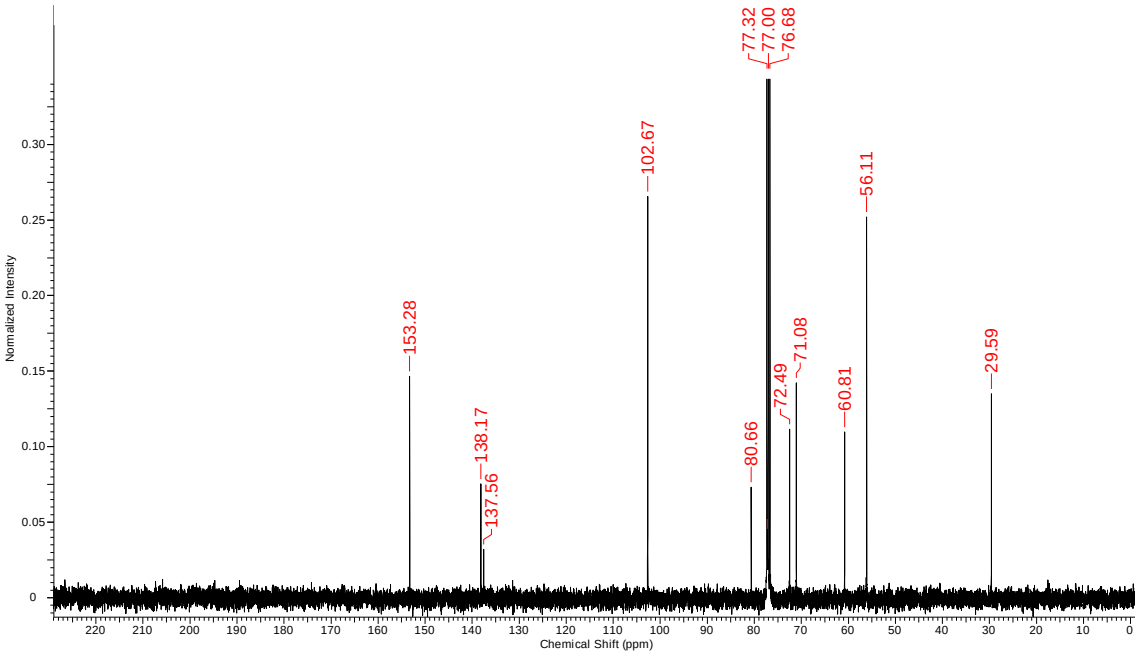
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2g**



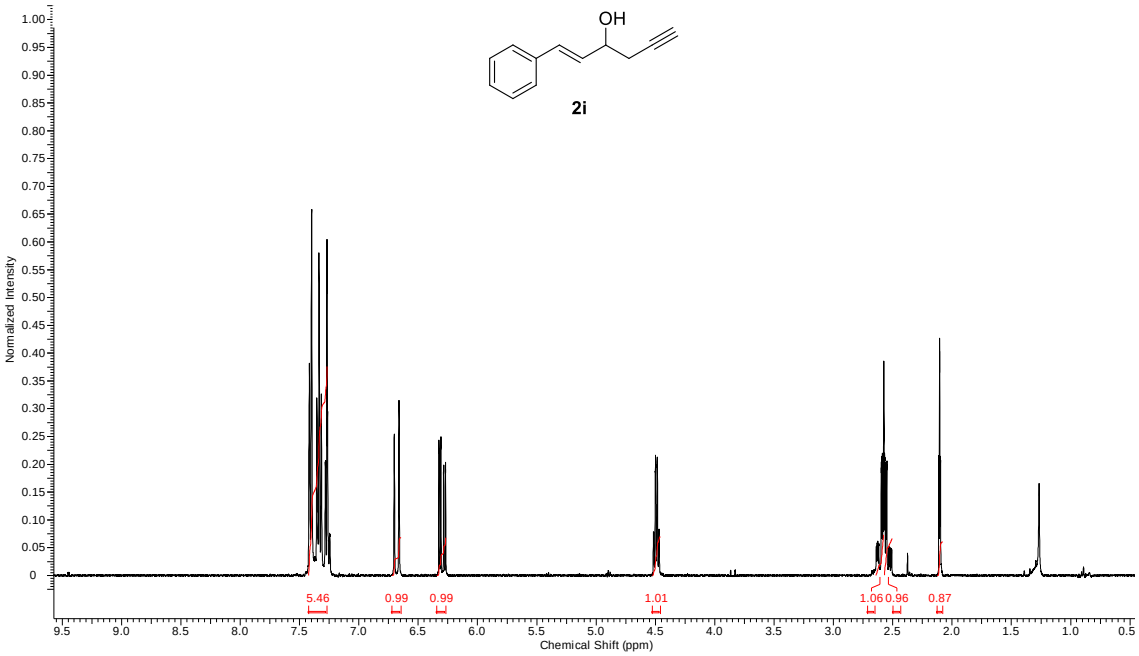
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2g**



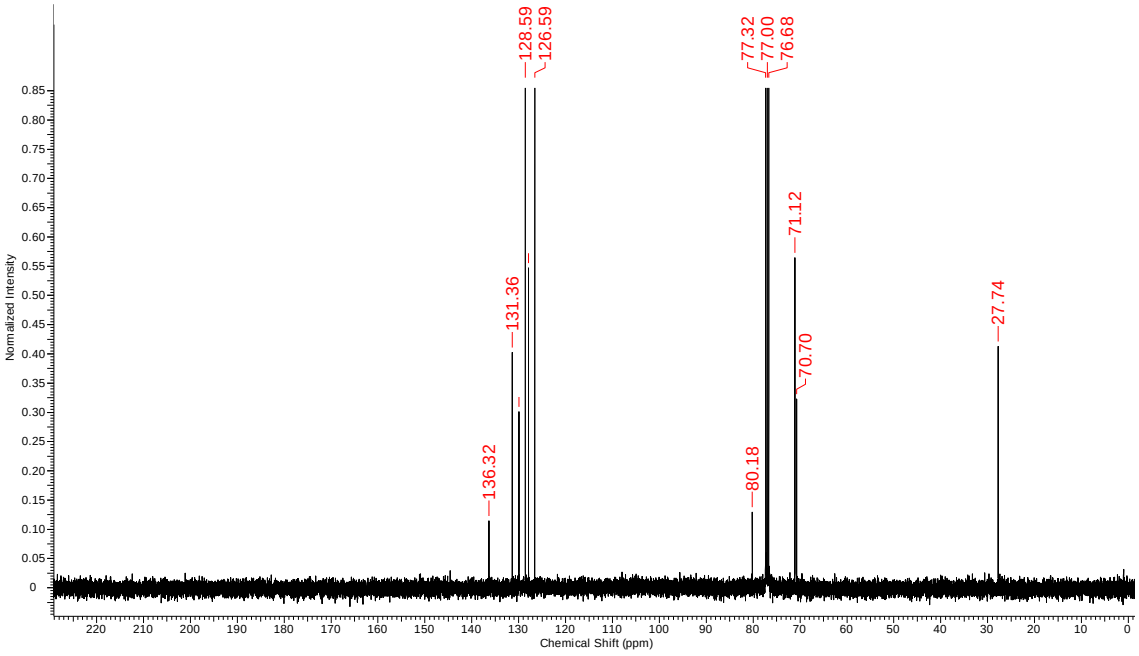
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2h**



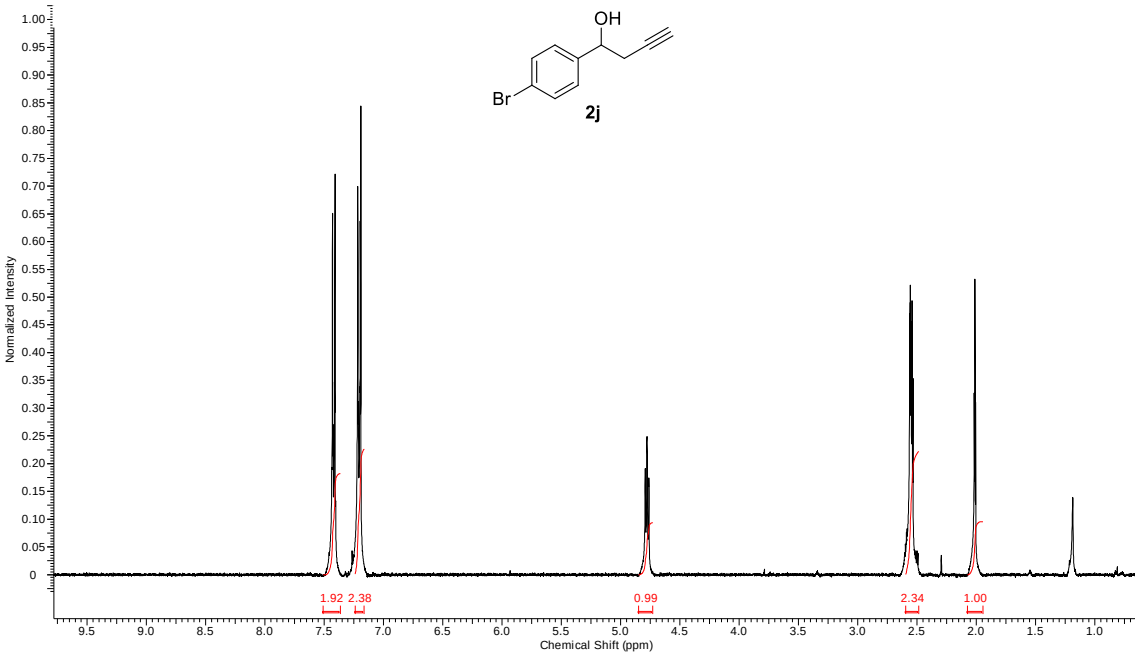
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2h**



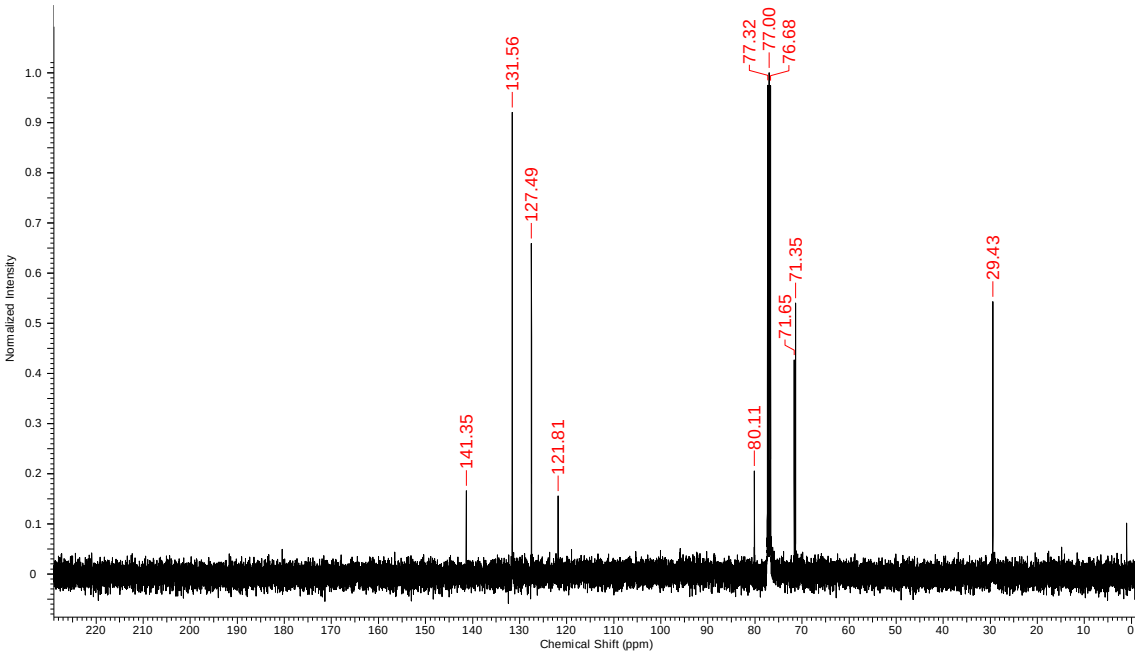
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2i**



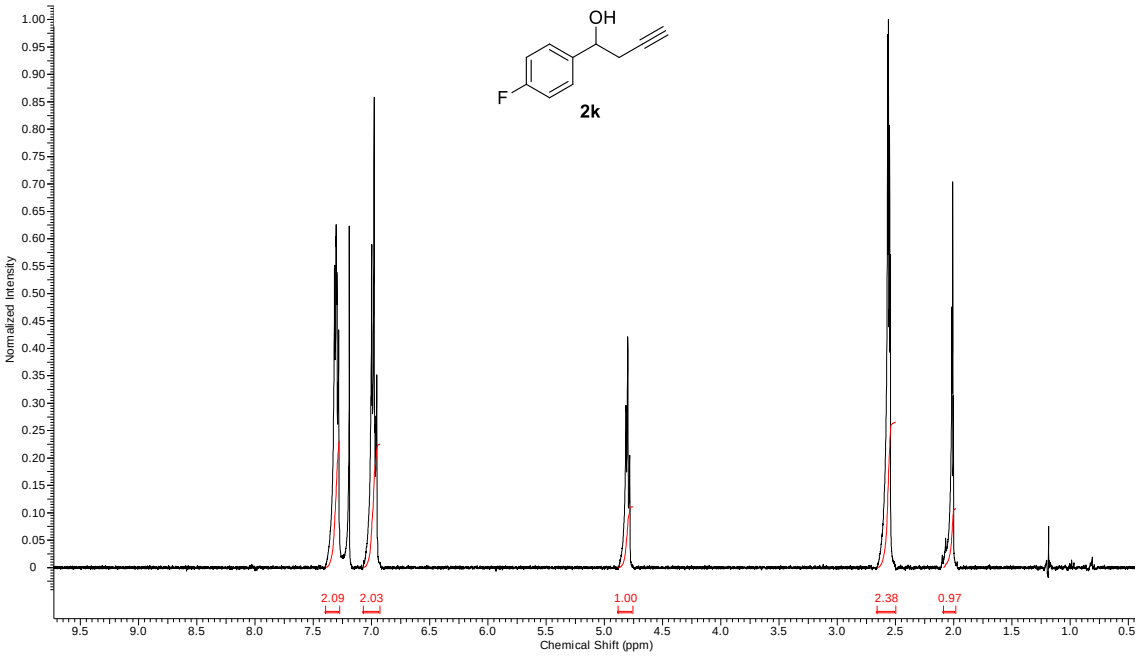
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2i**



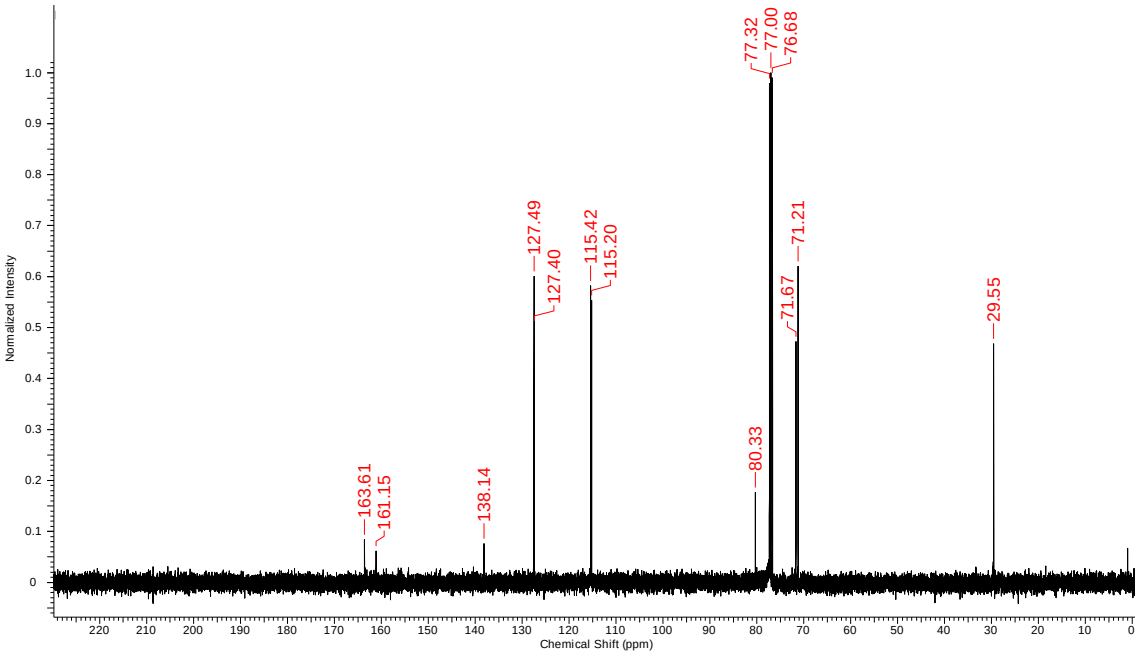
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2j**



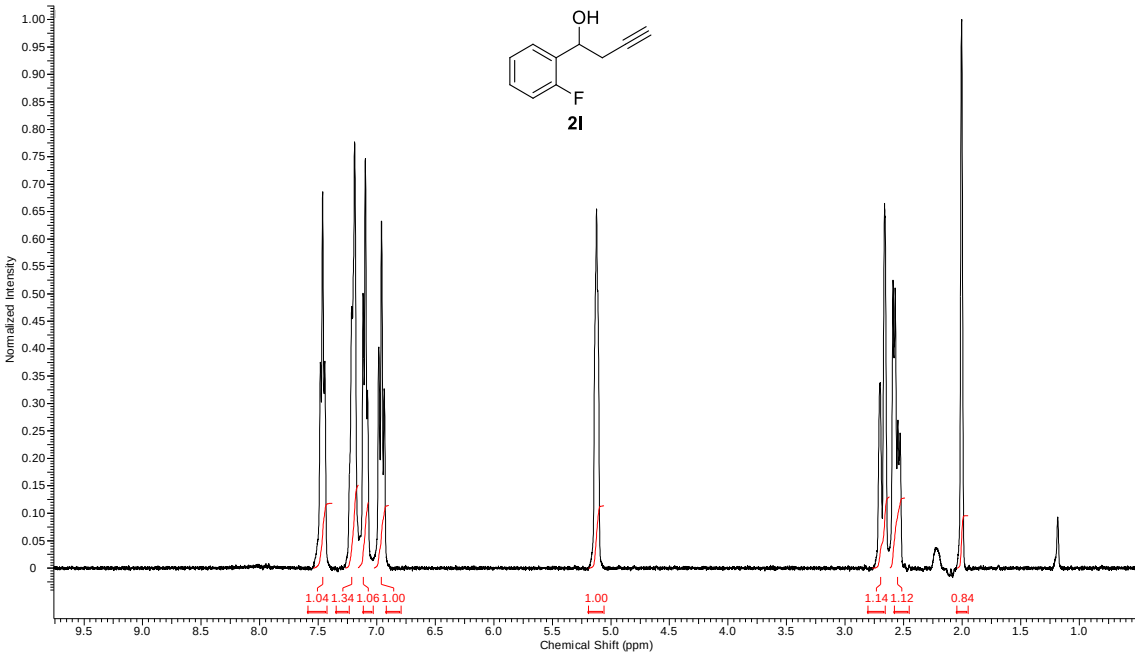
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2j**



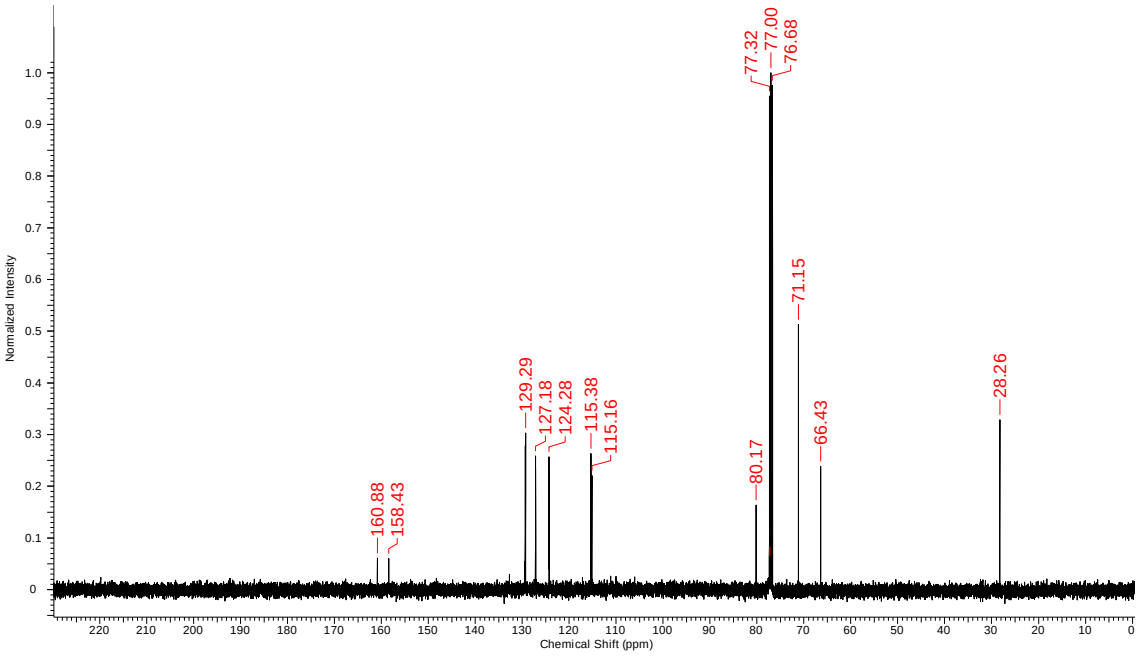
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2k**



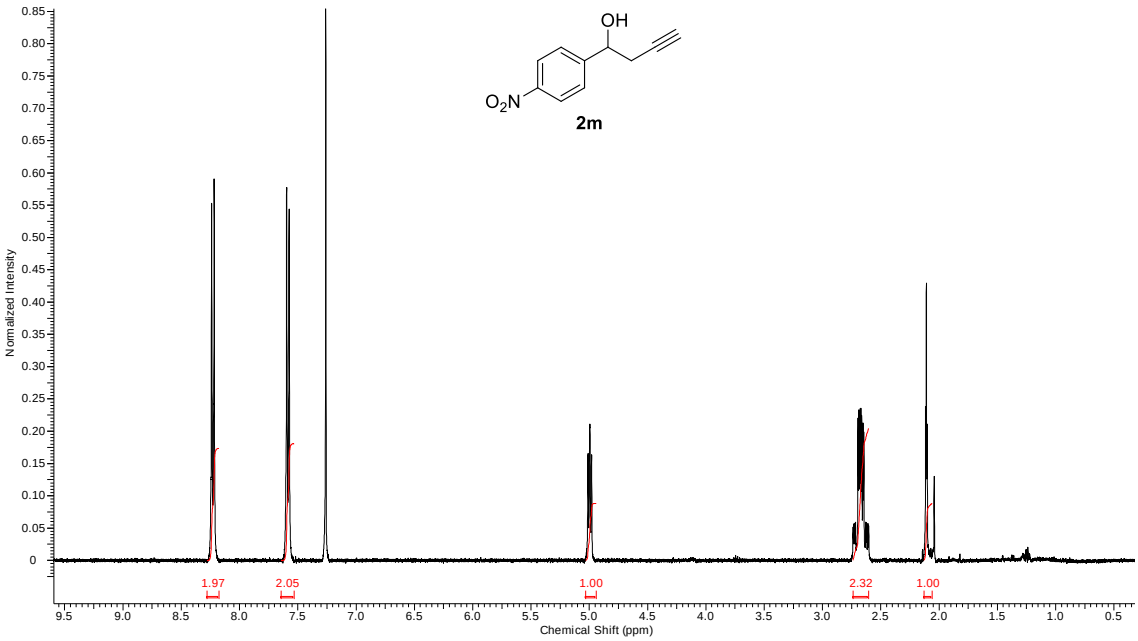
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2k**



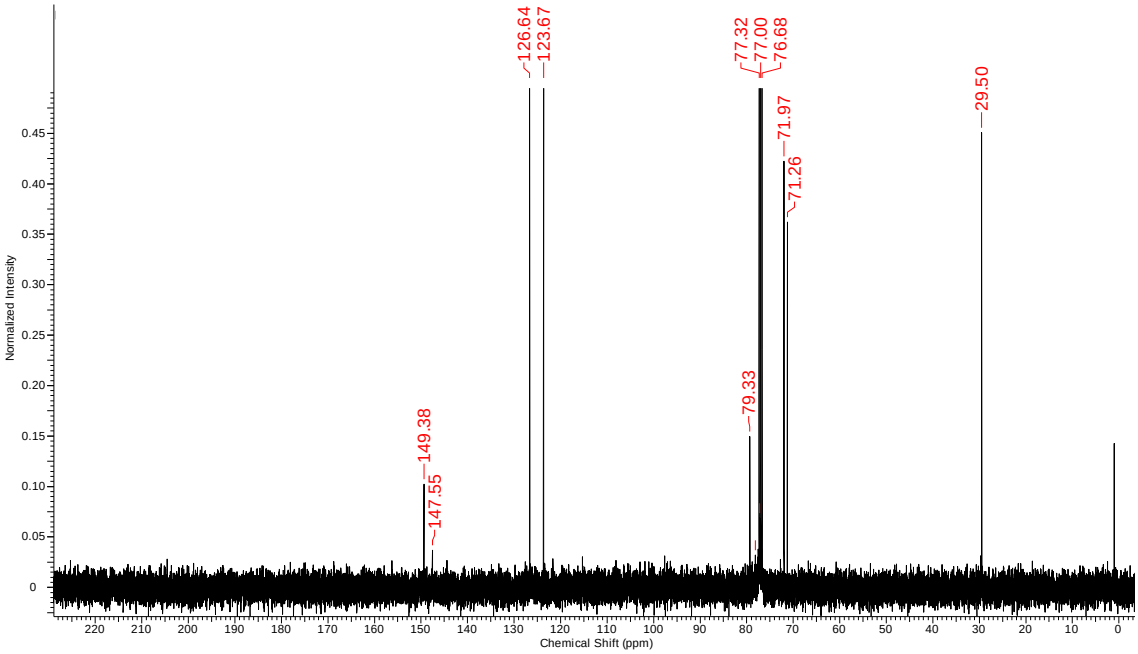
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2l**



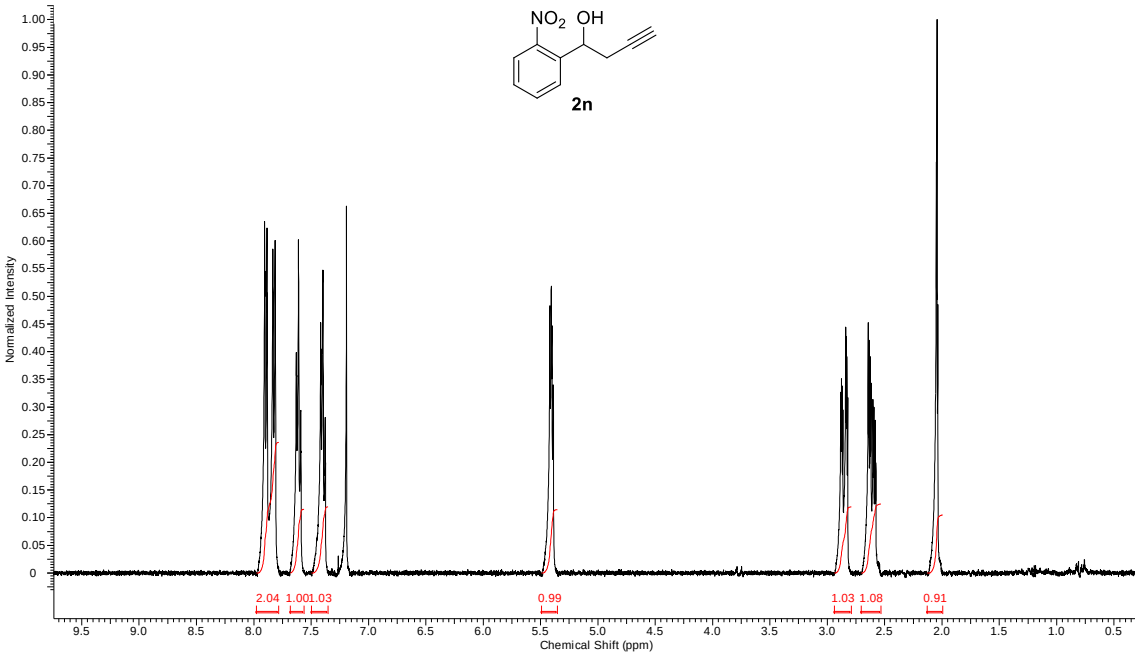
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2l**



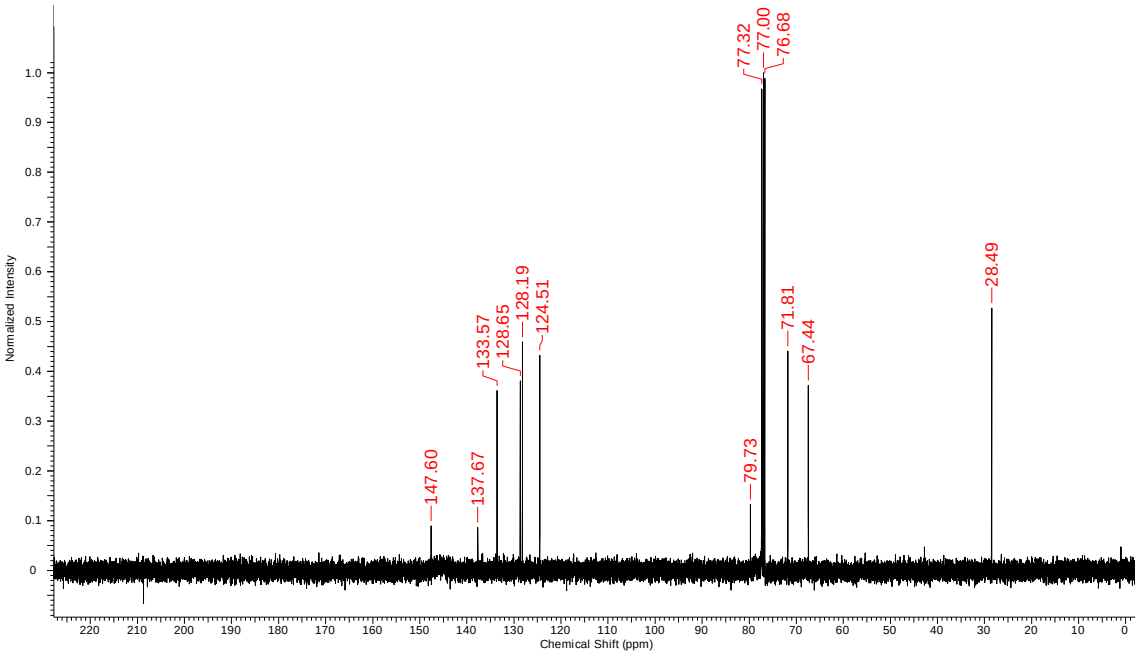
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2m**



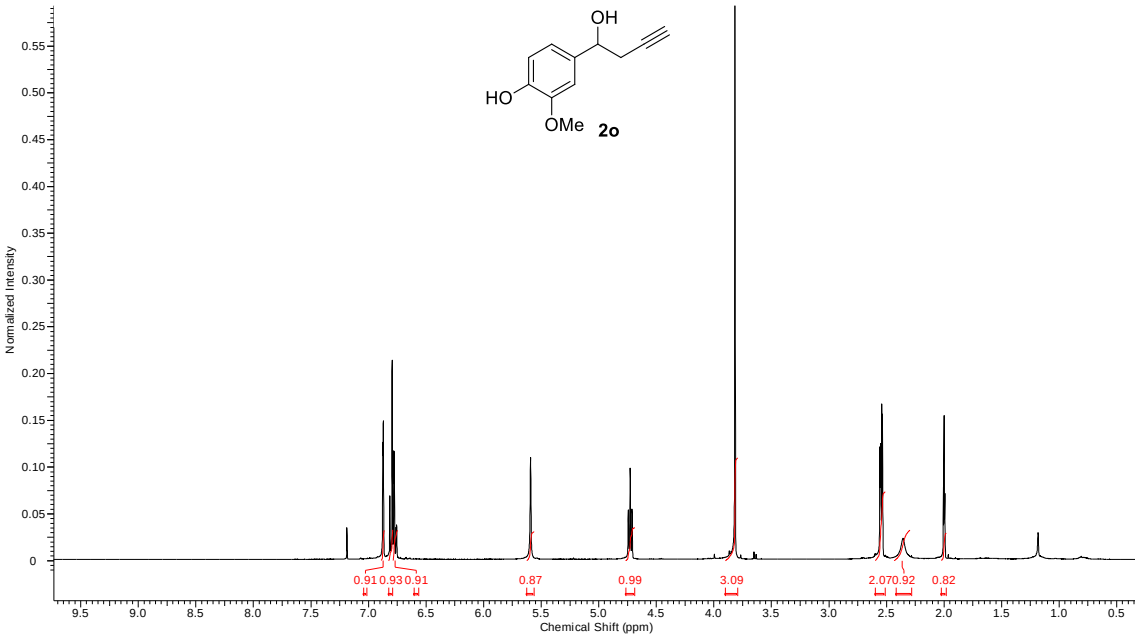
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2m**



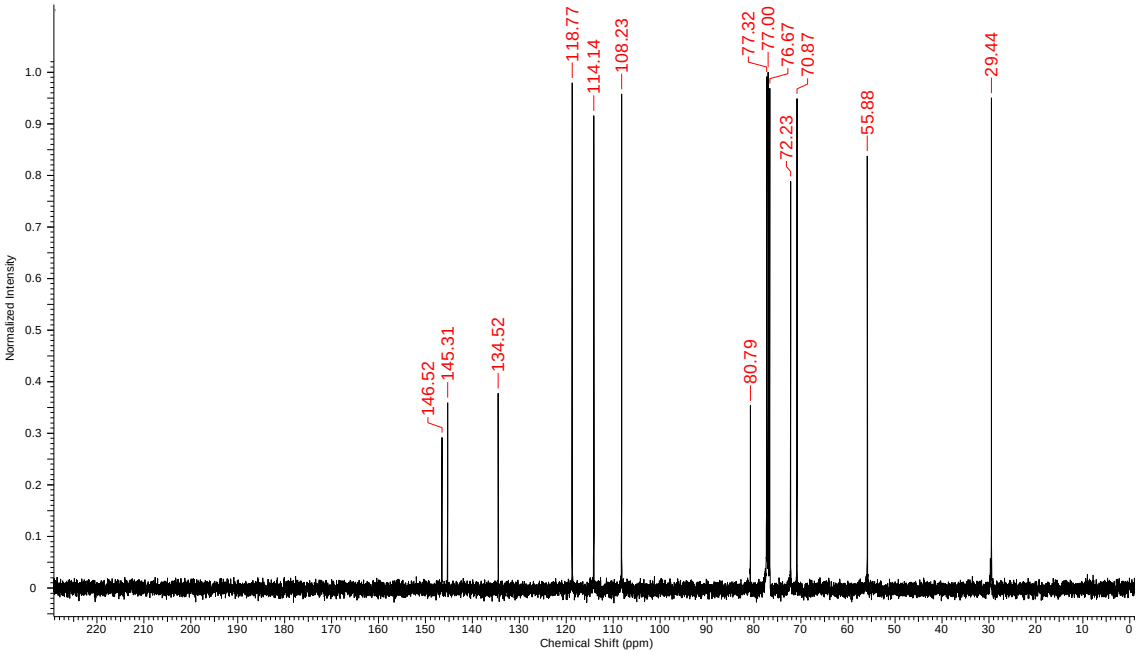
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2n**



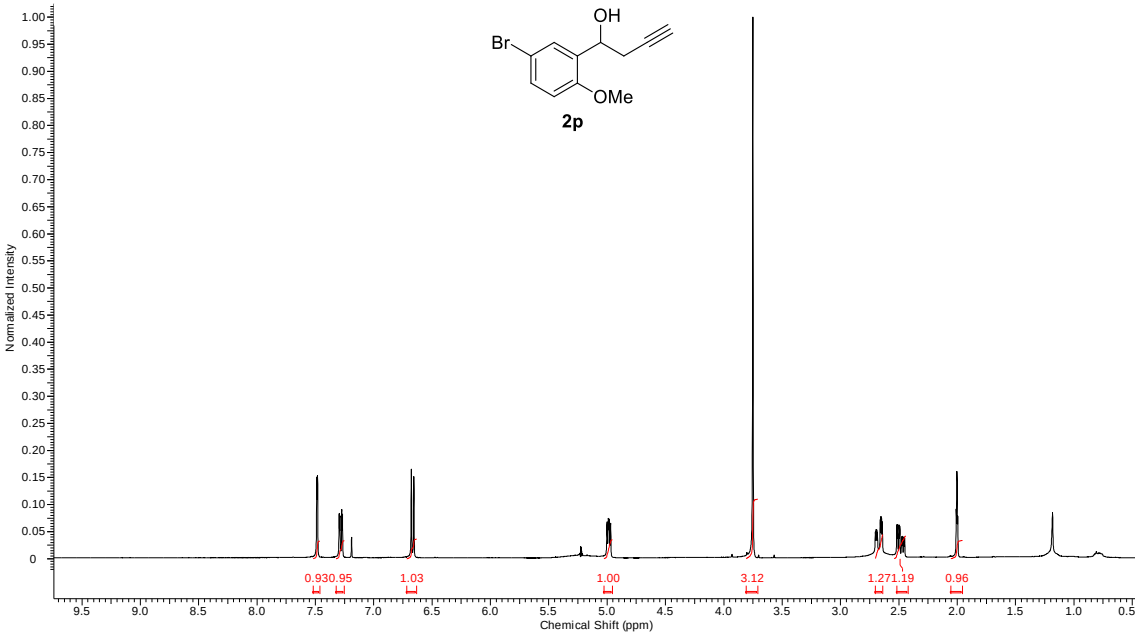
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2n**



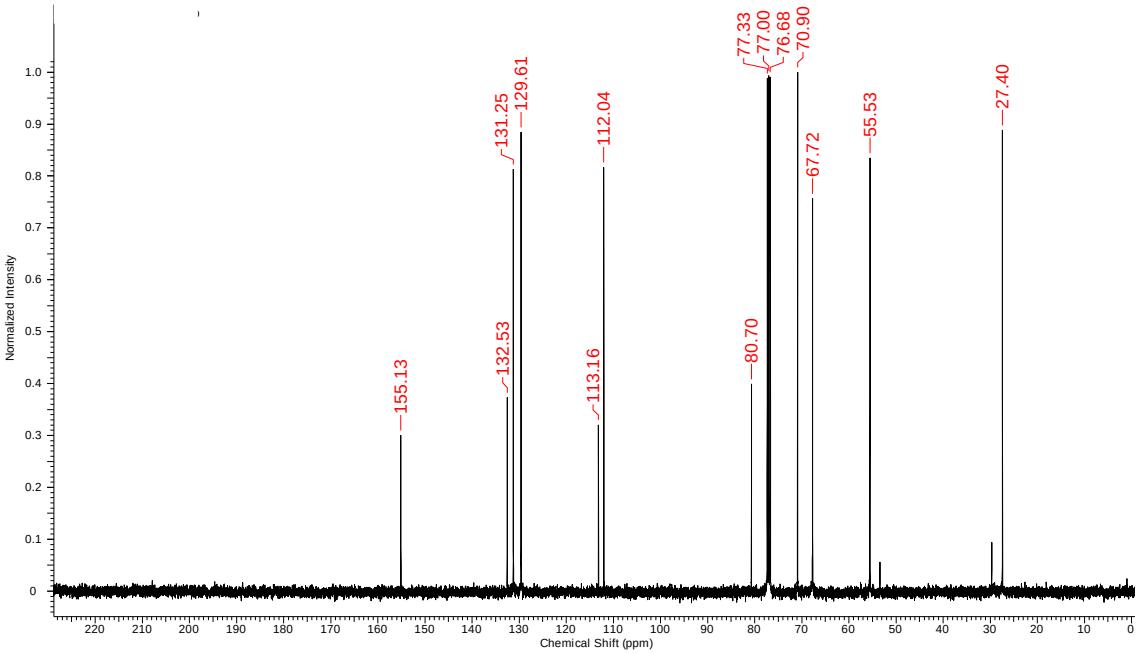
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2o**



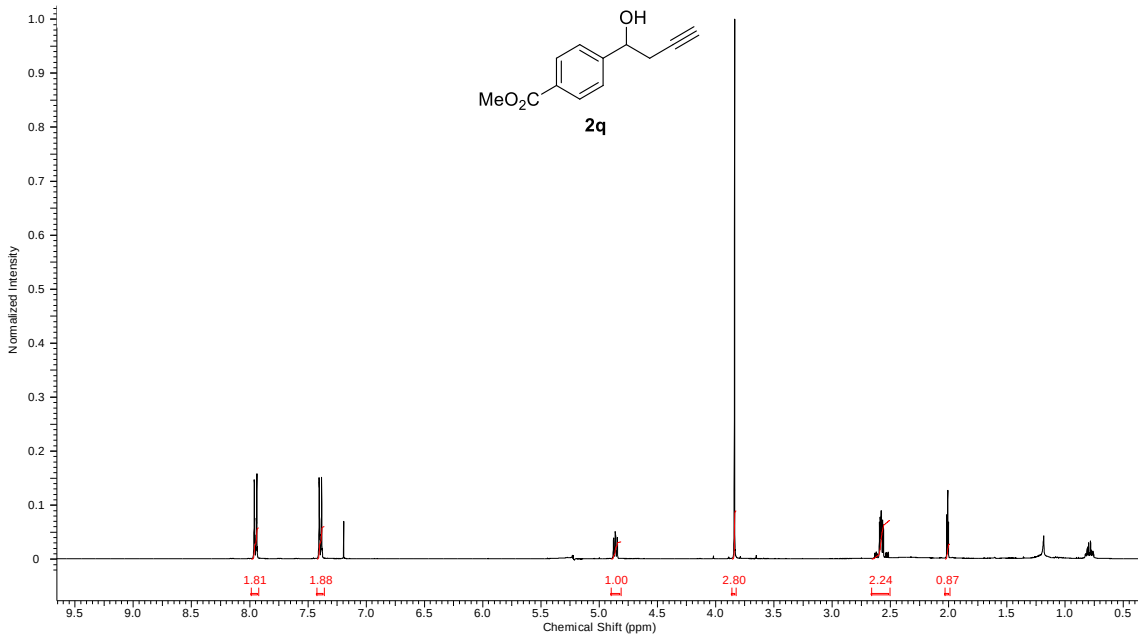
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2o**



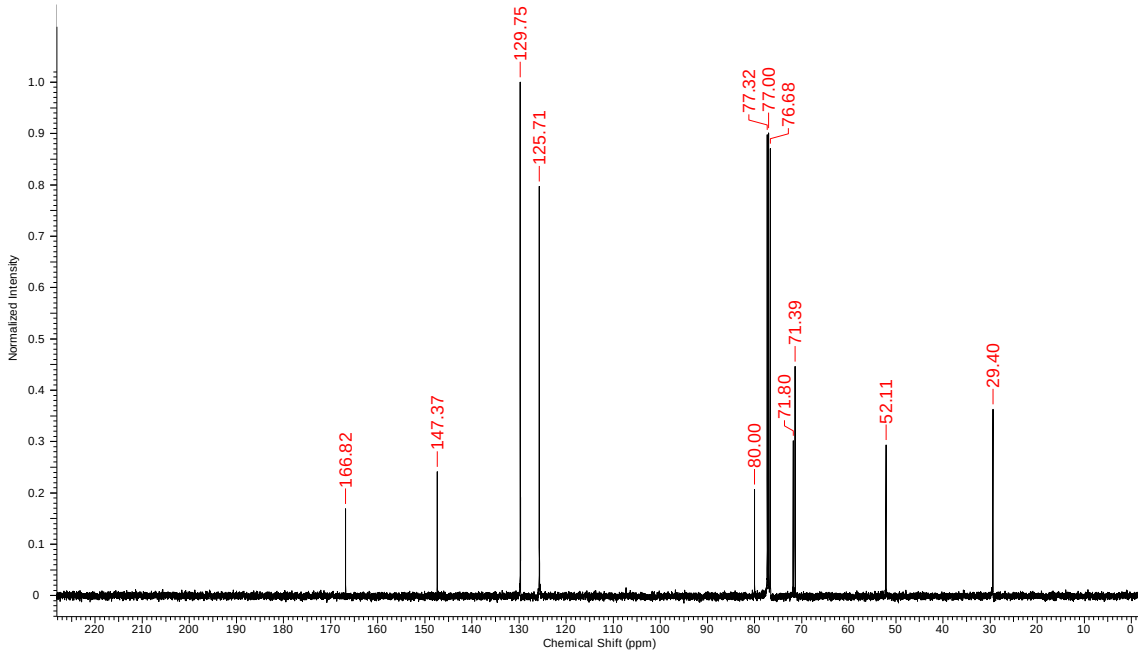
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2p**



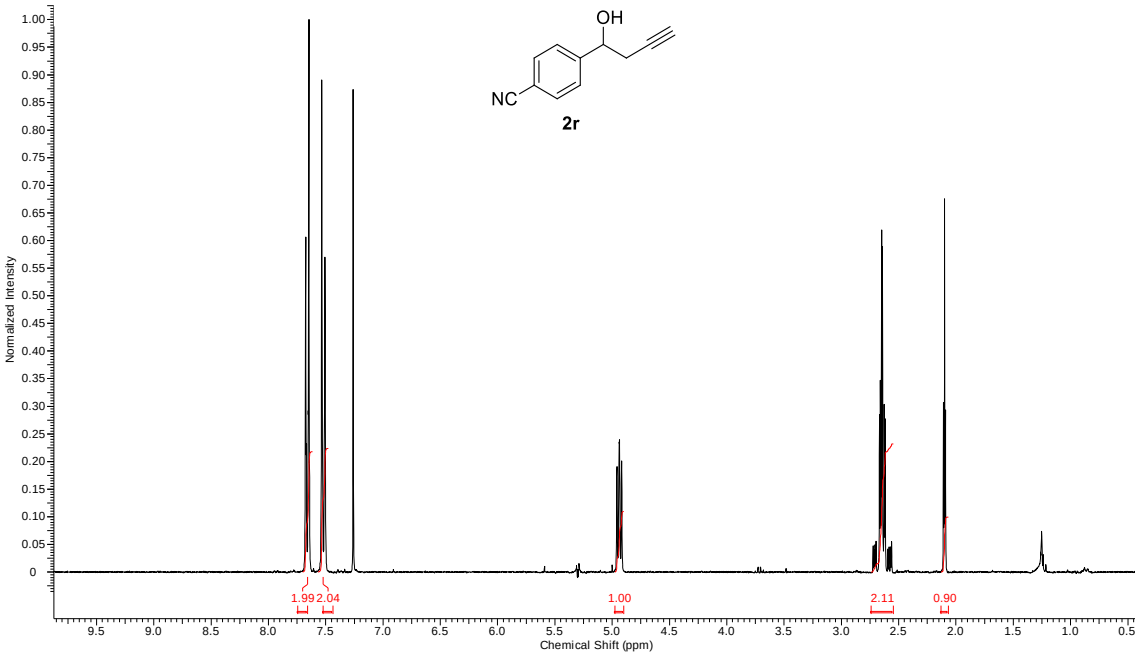
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2p**



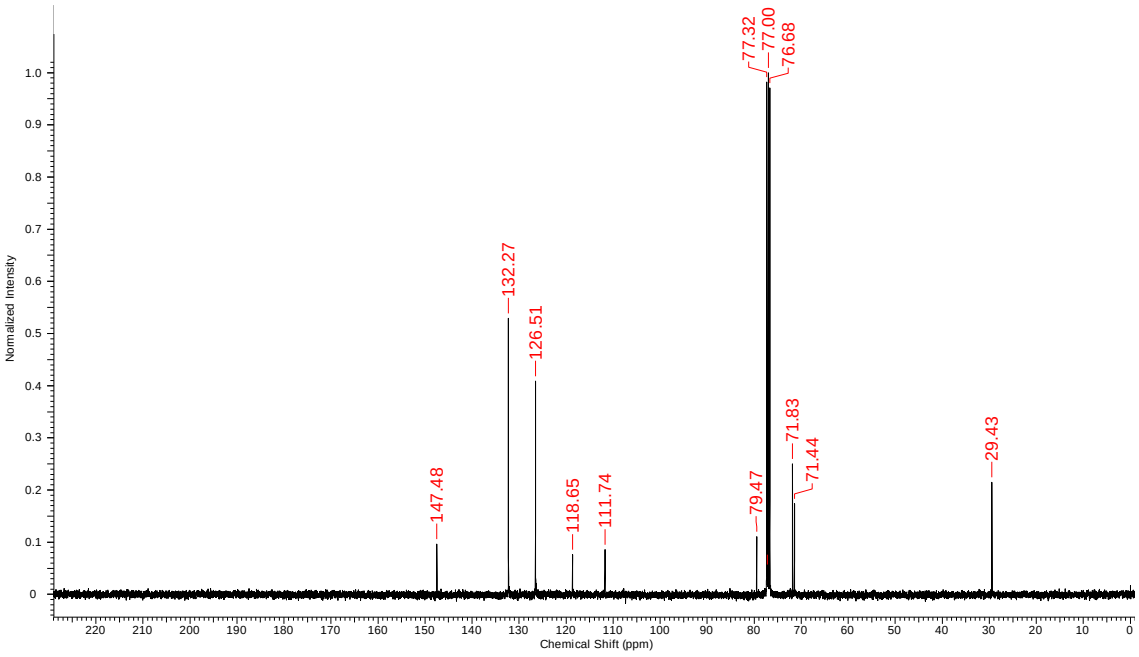
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2q**



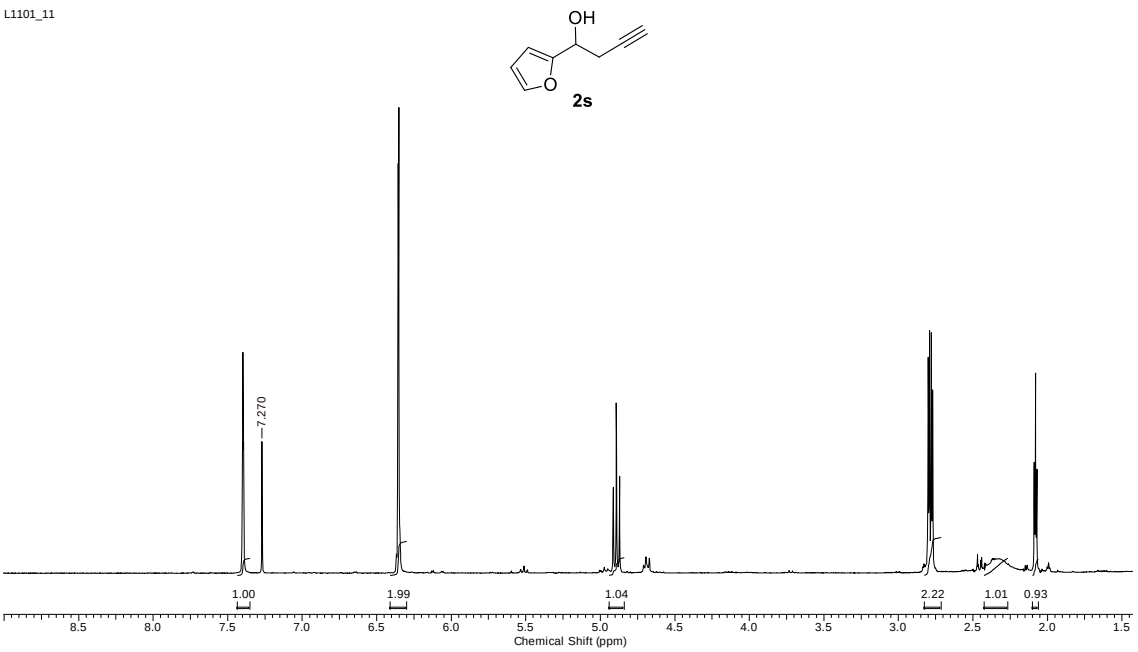
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2q**



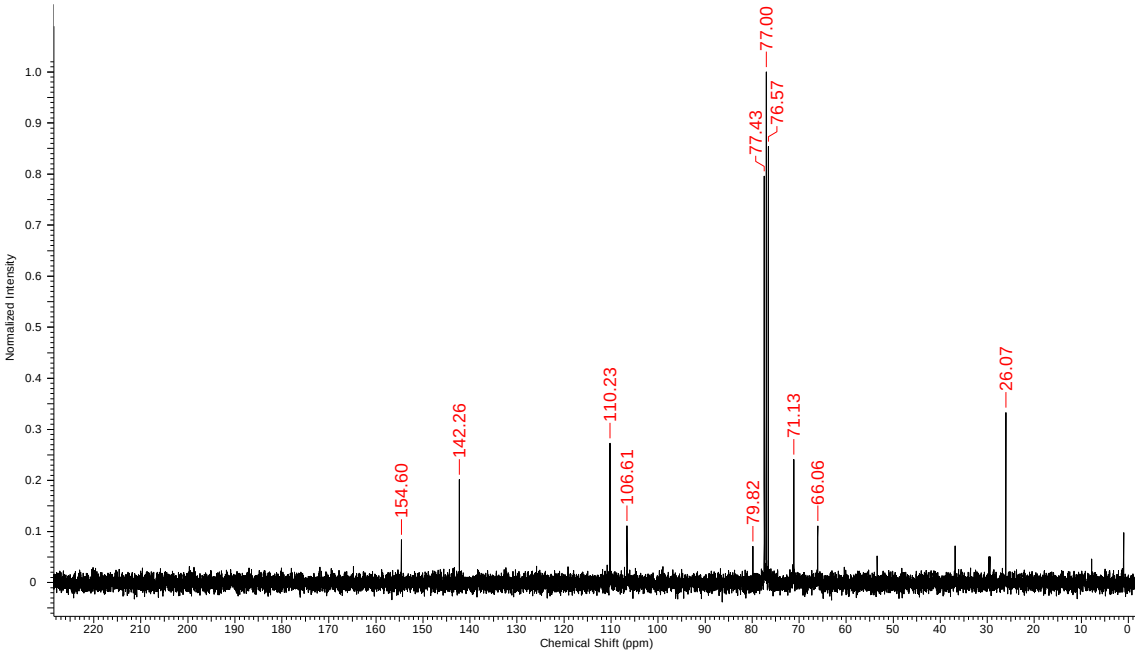
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2r**



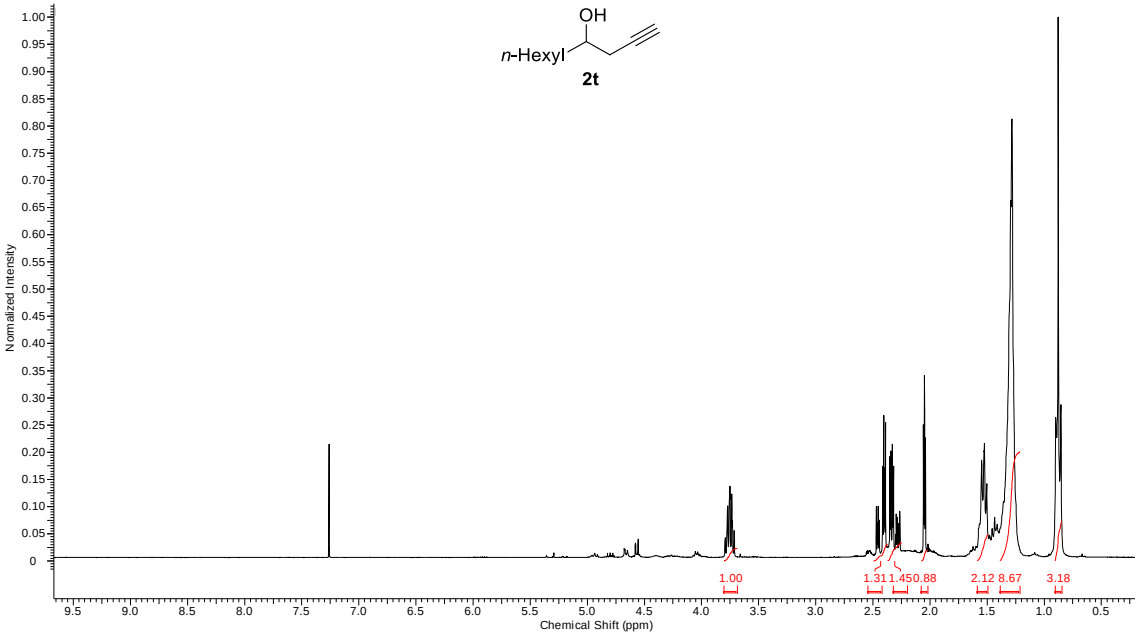
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2r**



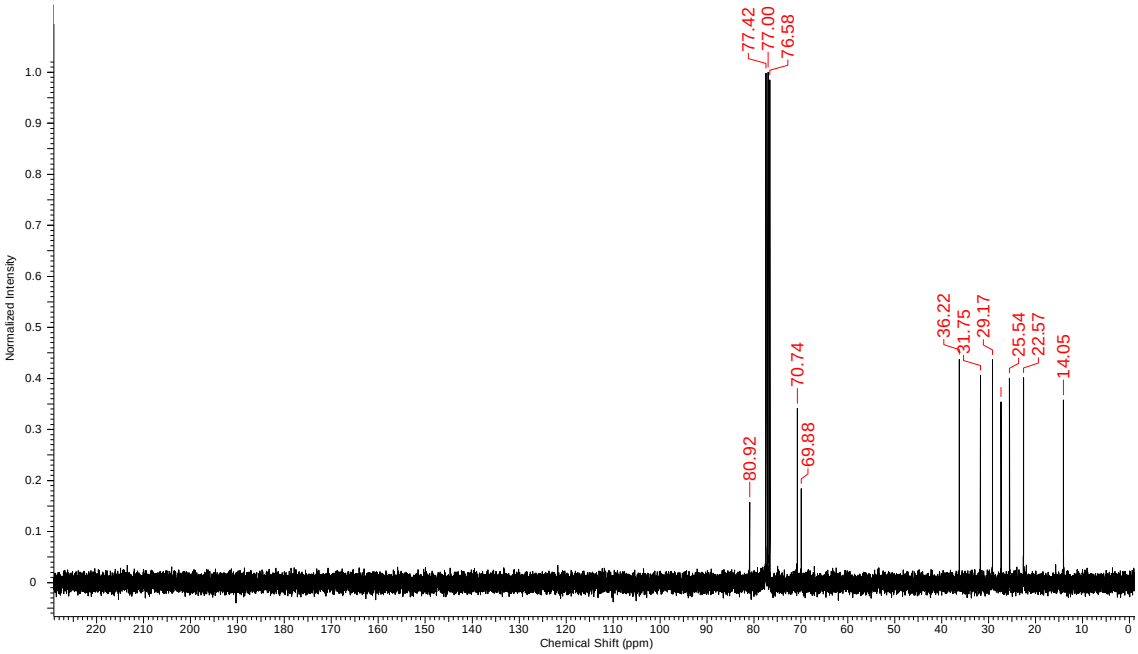
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2s**



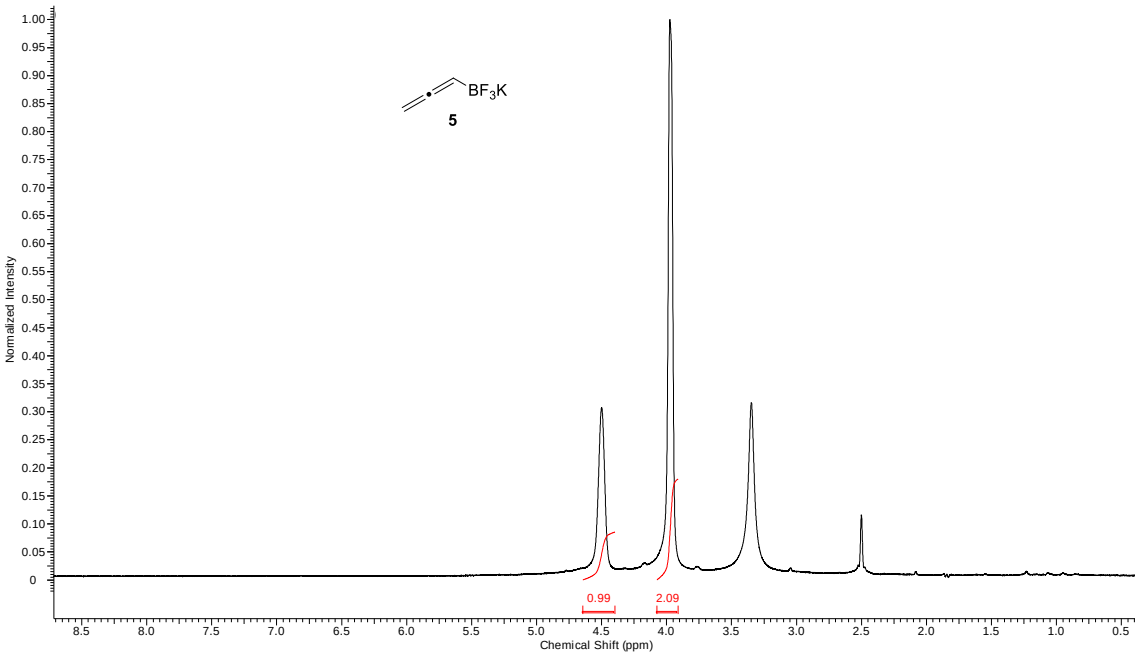
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2s**



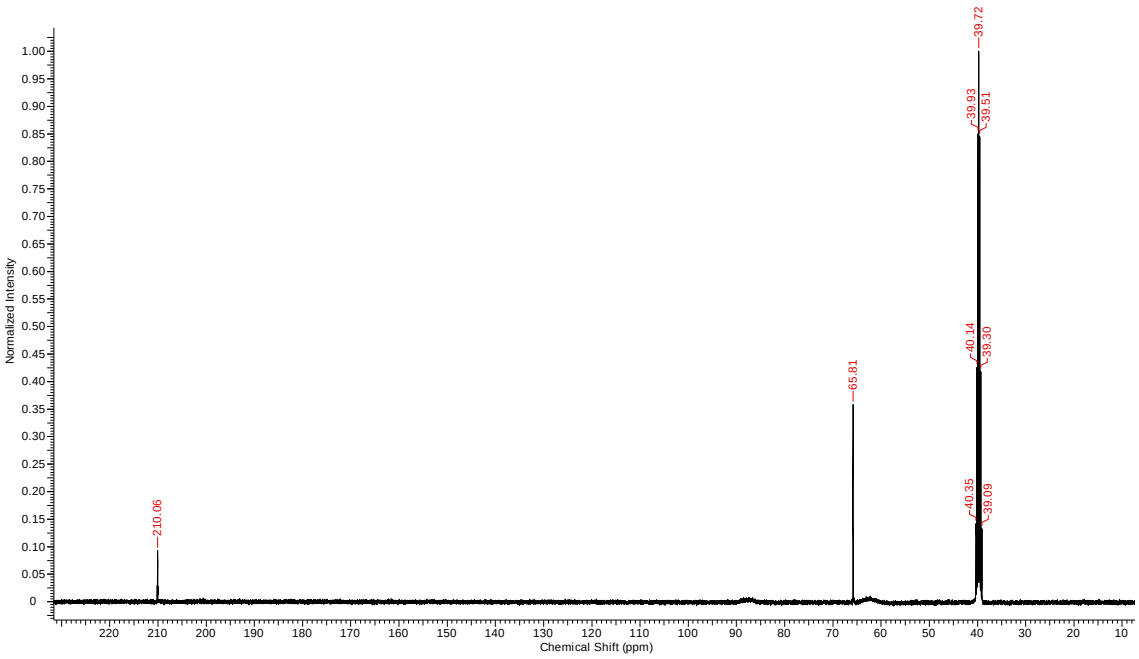
^{1}H NMR spectrum (300 MHz, $CDCl_3$) of compound **2t**



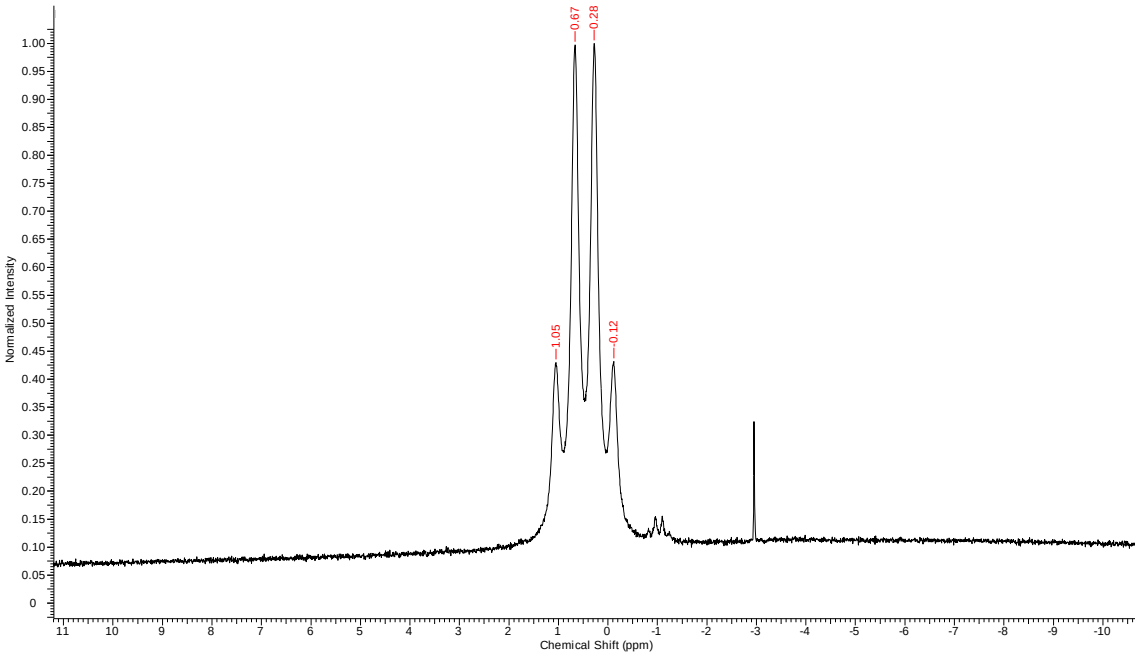
^{13}C NMR spectrum (75 MHz, $CDCl_3$) of compound **2t**



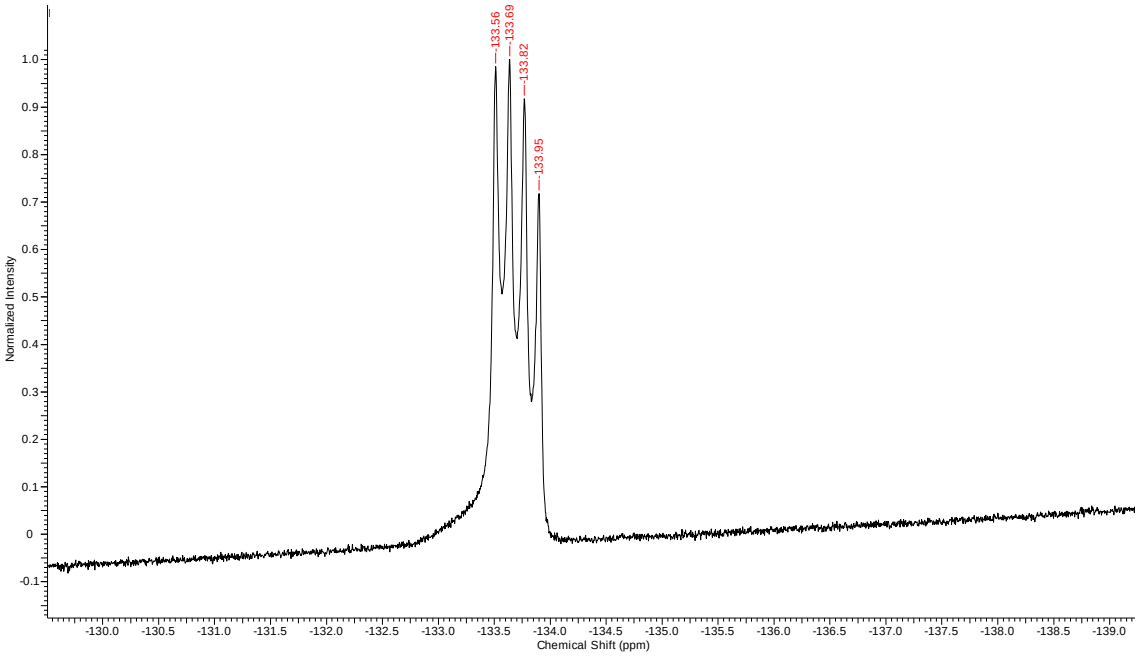
^{1}H NMR spectrum (400 MHz, DMSO-d_6) of compound **4**



^{13}C NMR spectrum (100 MHz, DMSO-d_6) of compound **4**



^{19}F NMR spectrum (376 MHz, DMSO-d_6) of compound **4**



^{11}B NMR spectrum (128 MHz, DMSO-d_6) of compound **4**