Iron-catalyzed oxidative synthesis of N-heterocycles from primary alcohols

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Electronic Supplementary Information
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General information

All manipulations were carried out under air atmosphere unless otherwise specified. Melting points were measured with an X-4 melting point apparatus (Bei Jing Taike Co., Ltd.) and were uncorrected. ^{1}H-NMR and ^{13}C-NMR were determined in $CDCl_3$ or DMSO-d_6 on a Bruker DPX 300 MHz or a Bruker AVANCE III 400 MHz spectrometer at room temperature, respectively, and tetramethylsilane (TMS) served as an internal standard. Spin multiplicities are given as s (singlet), d (doublet), t (triplet), q (quartet) and m (multiplet) as well as brs (broad). Coupling constants (*J*) are given in hertz (Hz). ESI-MS was carried out on a LCMS-2020 (Shimadzu, Japan). HRMS were recorded on a LTQ-Orbitrap XL (Thermofisher, U.S.A.). All experiments were monitored by thin layer chromatography (TLC). TLC was performed on pre-coated silica gel plates (Qingdao Haiyang Chemical Co., Ltd).

Experimental section

General procedure for the synthesis of quinazolin-4(3H)-ones 3a–k:

A mixture of benzyl alcohol **1** (1.5 mmol), *o*-aminobenzamide **2** (0.5 mmol), 0.01 mmol $FeCl_3$ (0.1 M in DMSO, 100 μL) and 1.5 mmol TBHP (5.5 M in decane, 270 μL) in 2 mL DMSO was stirred in a Schlenk tube at 60 ^{o}C. After stirring for 7 h, the reaction mixture was cooled to the room temperature, and diluted with ethyl acetate, washed with brine, dried over anhydrous Na_2SO_4 and concentrated in vacuo. The residue was then purified by chromatography on silica gel with a eluent of petroleum ether and ethyl acetate. Products were characterized by Mp, ^{1}H-, ^{13}C-NMR and MS (ESI).

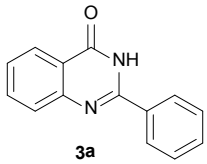
General procedure for the synthesis of quinazolines 5a–j:

A mixture of benzyl alcohol **1** (1.5 mmol), 0.01 mmol $FeCl_3$ (0.1 M in DMSO, 100 μL) and 1.5 mmol TBHP (5.5 M in decane, 270 μL) in 1 mL DMSO was stirred in a Schlenk tube at 60 ^{o}C under N_2. *O*-aminobenzylamine **4** (0.5 mmol) in 1mL DMSO was slowly added by syringe pump over 3h at 60 ^{o}C. After stirring for 6 h, the reaction mixture was cooled to the room temperature, and diluted with ethyl acetate, washed with brine, dried over anhydrous Na_2SO_4 and concentrated in vacuo. The residue was then purified by chromatography on silica gel with a eluent of petroleum ether and ethyl acetate. Products were characterized by Mp, ^{1}H-, ^{13}C-NMR and MS (ESI).

General procedure for the synthesis of 3,4-dihydro-2*H*-1,2,4-benzothiadiazine 1,1-dioxides 7a–k:

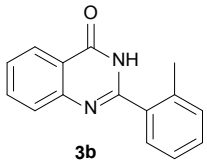
A mixture of benzyl alcohol **1** (1.5 mmol), *o*-aminobenzenesulfonamide **6** (0.5 mmol), 0.01 mmol $FeCl_3$ (0.1 M in DMSO, 100 μL) and 1.5 mmol TBHP (5.5 M in decane, 270 μL) in 2 mL DMSO was stirred in a Schlenk tube at 60 ^{o}C. After stirring for 12 h, the reaction mixture was cooled to the room temperature, and diluted with ethyl acetate, washed with brine, dried over anhydrous Na_2SO_4 and concentrated in vacuo. The residue was then purified by chromatography on silica gel with a eluent of dichloromethane and ethyl acetate. Products were characterized by Mp, ^{1}H-, ^{13}C-NMR and MS (ESI).

Product characterizations



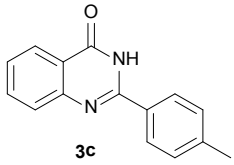
3a

2-phenylquinazolin-4(3H)-one (***3a***)[1]. white solid, 93% yield, mp. 235 – 237 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.53 (brs, 1H), 8.16 (t, J = 7.7 Hz, 3H), 7.83 (t, J = 7.1 Hz, 1H), 7.73 (d, J = 8.0 Hz, 1H), 7.65 – 7.41 (m, 4H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.2, 152.3, 148.7, 134.6, 132.7, 131.4, 128.6, 127.7, 127.5, 126.5, 125.8, 121.0; MS (ESI): 223.00 $[M+H]^+$.



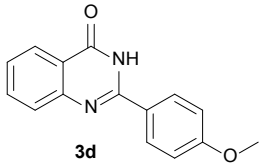
3b

2-(o-tolyl)quinazolin-4(3H)-one (***3b***)[2]. white solid, 57% yield, mp. 216 – 218 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.43 (brs, 1H), 8.16 (d, J = 7.9 Hz, 1H), 7.87 – 7.76 (m, 1H), 7.67 (d, J = 8.0 Hz, 1H), 7.59 – 7.46 (m, 2H), 7.45 – 7.37 (m, 1H), 7.37 – 7.25 (m, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.7, 154.3, 148.7, 136.1, 134.4, 134.2, 130.5, 129.9, 129.1, 127.3, 126.6, 125.8, 125.7, 121.0, 19.5; MS (ESI): 236.95 $[M+H]^+$.



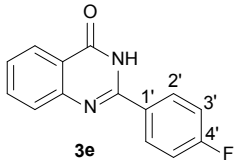
3c

2-(p-tolyl)quinazolin-4(3H)-one (***3c***)[1]. white solid, 66% yield, mp. 241 – 243 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.44 (brs, 1H), 8.13 (dd, J = 7.9, 1.0 Hz, 1H), 8.08 (d, J = 8.2 Hz, 2H), 7.87 – 7.75 (m, 1H), 7.70 (d, J = 7.8 Hz, 1H), 7.53 – 7.41 (m, 1H), 7.33 (d, J = 8.1 Hz, 2H), 2.37 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.3, 152.2, 148.8, 141.4, 134.5, 129.9, 129.1, 127.6, 127.4, 126.3, 125.8, 120.9, 20.9; MS (ESI): 237.00 $[M+H]^+$.



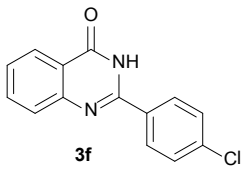
3d

2-(4-methoxyphenyl)quinazolin-4(3H)-one (***3d***)[1]. white solid, 37% yield, mp. 248 – 251 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.39 (brs, 1H), 8.18 (d, J = 8.9 Hz, 2H), 8.12 (dd, J = 7.9, 1.1 Hz, 1H), 7.86 – 7.75 (m, 1H), 7.69 (d, J = 7.7 Hz, 1H), 7.52 – 7.41 (m, 1H), 7.07 (d, J = 8.9 Hz, 2H), 3.83 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.3, 161.8, 151.8, 148.9, 134.5, 129.4, 127.3, 126.1, 125.8, 124.8, 120.7, 114.0, 55.4; MS (ESI): 253.00 $[M+H]^+$.



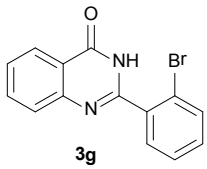
3e

2-(4-fluorophenyl)quinazolin-4(3H)-one (***3e***)[1]. white solid, 40% yield, mp. 284 – 287 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.56 (brs, 1H), 8.30 – 8.19 (m, 2H), 8.14 (dd, J = 7.9, 1.1 Hz, 1H), 7.87 – 7.78 (m, 1H), 7.72 (d, J = 7.7 Hz, 1H), 7.56 – 7.45 (m, 1H), 7.38 (t, J = 8.9 Hz, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 164.0 (d, $J_{C4'\text{-}F}$ = 249.5 Hz, C4'), 162.2, 151.4, 148.6, 134.6, 130.3 (d, $J_{C2'\text{-}F}$ = 9.0 Hz, C2'), 129.2 (d, $J_{C1'\text{-}F}$ = 2.9 Hz, C1'), 127.4, 126.6, 125.8, 120.9, 115.6 (d, $J_{C3'\text{-}F}$ = 21.9 Hz, C3'); MS (ESI): 240.95 $[M+H]^+$.



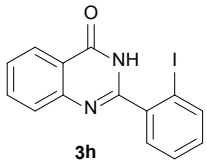
3f

2-(4-chlorophenyl)quinazolin-4(3H)-one (***3f***)[3]. white solid, 45% yield, mp. 298 – 300 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.58 (brs, 1H), 8.28 – 8.08 (m, 3H), 7.83 (t, J = 7.4 Hz, 1H), 7.73 (d, J = 7.7 Hz, 1H), 7.61 (d, J = 8.2 Hz, 2H), 7.52 (t, J = 7.3 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.2, 151.4, 148.5, 136.3, 134.6, 131.6, 129.6, 128.7, 127.4, 126.7, 125.9, 121.0; MS (ESI): 256.95 $[M+H]^+$.



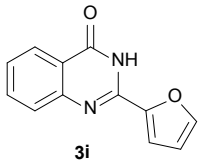
3g

2-(2-bromophenyl)quinazolin-4(3H)-one (***3g***)[4]. white solid, 84% yield, mp. 165 – 167 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.61 (brs, 1H), 8.17 (dd, J = 7.9, 1.2 Hz, 1H), 7.84 (ddd, J = 8.5, 7.2, 1.6 Hz, 1H), 7.76 (dd, J = 7.8, 1.3 Hz, 1H), 7.70 (d, J = 7.7 Hz, 1H), 7.64 (dd, J = 7.4, 1.9 Hz, 1H), 7.59 – 7.41 (m, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.4, 153.3, 148.5, 135.9, 134.5, 132.6, 131.6, 130.8, 127.6, 127.4, 127.0, 125.8, 121.3, 121.0; MS (ESI): 300.85 $[M+H]^+$.



3h

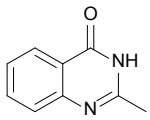
2-(2-iodophenyl)quinazolin-4(3H)-one (***3h***). yellow solid, 67% yield, mp. 217 – 219 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.55 (brs, 1H), 8.21 – 8.07 (m, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.89 – 7.78 (m, 1H), 7.69 (d, J = 8.0 Hz, 1H), 7.61 – 7.47 (m, 3H), 7.27 (td, J = 7.5, 2.1 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.5, 155.2, 148.5, 139.6, 138.8, 134.5, 131.4, 129.8, 128.1, 127.4, 126.9, 125.8, 121.2, 96.4; MS (ESI): 348.85 $[M+H]^+$; HRMS (ESI) m/z calcd for $C_{14}H_{10}IN_2O$ $[M+H]^+$ 348.9832, found 348.9833.



3i

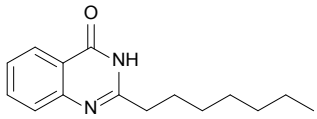
2-(furan-2-yl)quinazolin-4(3H)-one (***3i***)[1]. yellow solid, 76% yield, mp. 218 – 221 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.48 (brs, 1H), 8.11 (d, J = 7.5 Hz, 1H), 7.99 (s, 1H), 7.80 (t, J = 7.1 Hz, 1H), 7.67 (d, J = 8.0 Hz, 1H), 7.62 (d, J = 3.5 Hz, 1H), 7.48 (t, J = 7.5 Hz, 1H), 6.74 (dd, J = 3.4, 1.6 Hz, 1H);

^{13}C NMR (100 MHz, DMSO-d_6) δ 161.5, 148.6, 146.5, 146.1, 144.0, 134.6, 127.2, 126.4, 125.9, 121.1, 114.5, 112.5; MS (ESI): 212.95 $[M+H]^+$.



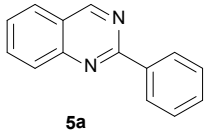
3j

2-methylquinazolin-4(3H)-one (***3j***)[5]. white solid, 42% yield, mp. 237 – 239 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.17 (brs, 1H), 8.05 (dd, J = 7.9, 1.0 Hz, 1H), 7.81 – 7.68 (m, 1H), 7.55 (d, J = 8.1 Hz, 1H), 7.43 (t, J = 7.5 Hz, 1H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.7, 154.2, 148.9, 134.2, 126.5, 125.8, 125.6, 120.6, 21.4; MS (ESI): 161.05 $[M+H]^+$.



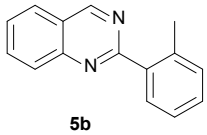
3k

2-heptylquinazolin-4(3H)-one (***3k***)[1]. white solid, 60% yield, mp. 133 – 135 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.14 (brs, 1H), 8.11 – 8.00 (m, 1H), 7.80 – 7.67 (m, 1H), 7.57 (d, J = 8.0 Hz, 1H), 7.43 (t, J = 7.5 Hz, 1H), 2.66 – 2.52 (m, 2H), 1.81 – 1.63 (m, 2H), 1.34 – 1.11 (m, 8H), 0.83 (t, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.8, 157.5, 148.9, 134.2, 126.7, 125.8, 125.6, 120.8, 34.5, 31.1, 28.4, 28.3, 26.7, 22.0, 13.9; MS (ESI): 245.05 $[M+H]^+$.



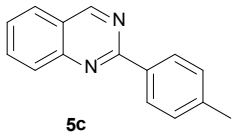
5a

2-phenylquinazoline (***5a***)[6]. white solid, 70% yield, mp. 94 – 95 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.47 (s, 1H), 8.71 – 8.54 (m, 2H), 8.16 – 8.04 (m, 1H), 7.97 – 7.86 (m, 2H), 7.66 – 7.58 (m, 1H), 7.58 – 7.46 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.1, 160.5, 150.8, 138.1, 134.1, 130.6, 128.7, 128.6, 127.3, 127.1, 123.6; MS (ESI): 207.10 $[M+H]^+$.



5b

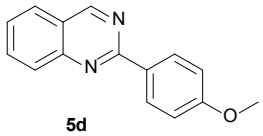
2-(o-tolyl)quinazoline (***5b***)[7]. yellow solid, 60% yield, mp. 36 – 37 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.50 (s, 1H), 8.10 (d, J = 8.5 Hz, 1H), 8.01 – 7.86 (m, 3H), 7.75 – 7.56 (m, 1H), 7.44 – 7.29 (m, 3H), 2.62 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.0, 160.1, 150.4, 138.6, 137.4, 134.1, 131.3, 130.7, 129.3, 128.6, 127.5, 127.1, 126.0, 122.9, 21.1; MS (ESI): 221.10 $[M+H]^+$.



5c

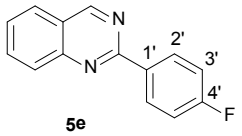
2-(p-tolyl)quinazoline (***5c***)[6]. yellow solid, 71% yield, mp. 103 – 104 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.45 (s, 1H), 8.52 (d, J = 8.2 Hz, 2H), 8.07 (d, J = 8.5 Hz, 1H), 7.89 (t, J = 7.9 Hz, 2H), 7.59 (t, J = 7.5 Hz, 1H), 7.35 (d, J = 8.2 Hz, 2H), 2.45 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2, 160.4, 150.8,

140.9, 135.4, 134.0, 129.4, 128.6, 127.1, 127.0, 123.5, 21.5; MS (ESI): 221.10 $[M+H]^+$.



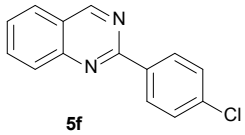
5d

*2-(4-methoxyphenyl)quinazoline (**5d**)*[6]. yellow solid, 71% yield, mp. 86 – 87 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.42 (s, 1H), 8.75 – 8.45 (m, 2H), 8.05 (d, J = 8.9 Hz, 1H), 7.93 – 7.83 (m, 2H), 7.65 – 7.44 (m, 1H), 7.13 – 6.88 (m, 2H), 3.90 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.9, 160.9, 160.4, 150.9, 134.0, 130.8, 130.23, 128.4, 127.1, 126.8, 123.3, 114.0, 55.4; MS (ESI): 237.10 $[M+H]^+$.



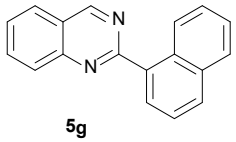
5e

*2-(4-fluorophenyl)quinazoline (**5e**)*[6]. yellow solid, 55% yield, mp. 121 – 123 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.45 (s, 1H), 8.63 (dd, J = 8.1, 5.9 Hz, 2H), 8.07 (d, J = 8.5 Hz, 1H), 7.91 (t, J = 7.9 Hz, 2H), 7.62 (t, J = 7.5 Hz, 1H), 7.21 (t, J = 8.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7 (d, $J_{C4'\text{-}F}$ = 250.4 Hz, C4'), 160.5, 160.1, 150.7, 134.2 (d, $J_{C1'\text{-}F}$ = 2.9 Hz, C1'), 134.2, 130.7 (d, $J_{C2'\text{-}F}$ = 8.7 Hz, C2'), 128.6, 127.3, 127.1, 123.5, 115.6 (d, $J_{C3'\text{-}F}$ = 21.6 Hz, C3'); MS (ESI): 225.05 $[M+H]^+$.



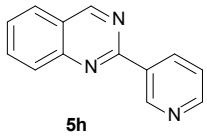
5f

*2-(4-chlorophenyl)quinazoline (**5f**)*[6]. white solid, 62% yield, mp. 123 – 124 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.45 (s, 1H), 8.58 (d, J = 8.6 Hz, 2H), 8.08 (d, J = 8.3 Hz, 1H), 7.92 (t, J = 7.7 Hz, 2H), 7.63 (t, J = 7.5 Hz, 1H), 7.50 (d, J = 8.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 160.0, 150.7, 136.8, 136.5, 134.2, 129.9, 128.8, 128.6, 127.4, 127.1, 123.6; MS (ESI): 241.05 $[M+H]^+$.



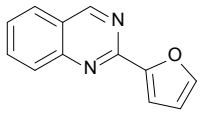
5g

*2-(naphthalen-1-yl)quinazoline (**5g**)*[7]. yellow solid, 65% yield, mp. 115 – 117 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.61 (s, 1H), 8.76 – 8.65 (m, 1H), 8.25 – 8.14 (m, 2H), 8.08 – 7.89 (m, 4H), 7.76 – 7.68 (m, 1H), 7.64 (dd, J = 8.1, 7.3 Hz, 1H), 7.60 – 7.49 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5, 160.4, 150.6, 136.3, 134.3, 134.2, 131.2, 130.4, 129.6, 128.7, 128.5, 127.7, 127.1, 126.9, 125.92, 125.89, 125.3, 123.1; MS (ESI): 257.05 $[M+H]^+$.



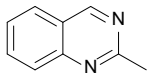
5h

*2-(pyridin-3-yl)quinazoline (**5h**)*[6]. yellow solid, 35% yield, mp. 93 – 95 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.81 (s, 1H), 9.46 (s, 1H), 8.86 (d, J = 8.0 Hz, 1H), 8.73 (d, J = 4.6 Hz, 1H), 8.09 (d, J = 8.3 Hz, 1H), 7.92 (t, J = 7.7 Hz, 2H), 7.64 (t, J = 7.5 Hz, 1H), 7.45 (dd, J = 8.0, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 159.2, 151.2, 150.6, 150.2, 135.8, 134.4, 133.6, 128.7, 127.8, 127.2, 123.8, 123.4; MS (ESI): 208.00 $[M+H]^+$.



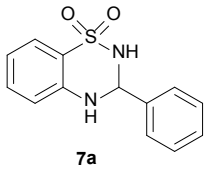
5i

2-(furan-2-yl)quinazoline (***5i***)[6]. yellow solid, 44% yield, mp. 130 – 133 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.37 (s, 1H), 8.09 (d, *J* = 9.0 Hz, 1H), 8.01 – 7.83 (m, 2H), 7.69 (d, *J* = 0.8 Hz, 1H), 7.64 – 7.54 (m, 1H), 7.52 – 7.40 (m, 1H), 6.61 (dd, *J* = 3.4, 1.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 154.1, 152.6, 150.5, 145.4, 134.5, 128.4, 127.3, 123.4, 114.1, 112.3; MS (ESI): 197.05 $[M+H]^+$.



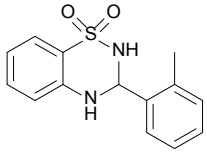
5j

2-methylquinazoline (***5j***)[8]. yellow oil, 53% yield. ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.29 (s, 1H), 7.92 (d, *J* = 8.8 Hz, 1H), 7.88 – 7.80 (m, 2H), 7.60 – 7.48 (m, 1H), 2.87 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 160.4, 150.4, 134.1, 127.7, 127.1, 127.0, 122.9, 26.4; MS (ESI): 145.00 $[M+H]^+$.



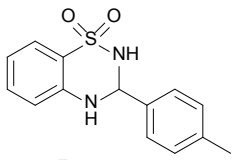
7a

3-phenyl-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (***7a***)[9]. white solid, 75% yield, mp. 129 – 132 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.87 (d, *J* = 12.0 Hz, 1H), 7.70 – 7.62 (m, 2H), 7.59 – 7.23 (m, 6H), 6.91 (d, *J* = 8.3 Hz, 1H), 6.76 (t, *J* = 7.5 Hz, 1H), 5.77 (d, *J* = 12.1 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.9, 137.3, 132.8, 129.1, 128.5, 127.5, 123.7, 121.6, 116.7, 116.4, 68.4; MS (ESI): 261.05 $[M+H]^+$.



7b

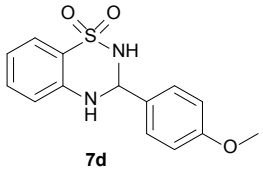
3-(o-tolyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (***7b***). white solid, 57% yield, mp. 179 – 181 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.78 (d, *J* = 12.0 Hz, 1H), 7.73 – 7.61 (m, 1H), 7.51 (d, *J* = 7.9 Hz, 1H), 7.44 – 7.15 (m, 5H), 6.93 (d, *J* = 8.3 Hz, 1H), 6.76 (t, *J* = 7.5 Hz, 1H), 5.95 (d, *J* = 12.0 Hz, 1H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 144.2, 135.8, 135.1, 132.7, 130.3, 128.8, 126.6, 126.0, 123.8, 121.7, 116.7, 116.5, 64.8, 18.4; MS (ESI): 274.95 $[M+H]^+$; HRMS (ESI) m/z calcd for $C_{14}H_{15}N_2O_2S$ $[M+H]^+$ 275.0849, found 275.0853.



7c

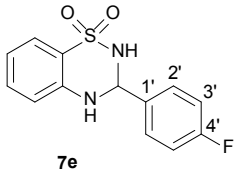
3-(p-tolyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (***7c***)[9]. white solid, 83% yield, mp. 150 – 153 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.81 (d, *J* = 12.1 Hz, 1H), 7.52 (t, *J* = 7.3 Hz, 3H), 7.38 – 7.20 (m, 4H), 6.89 (d, *J* = 8.2 Hz, 1H), 6.75 (t, *J* = 7.5 Hz, 1H), 5.72 (d, *J* = 12.1 Hz, 1H), 2.33

(s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.9, 138.5, 134.4, 132.8, 129.0, 127.4, 123.7, 121.6, 116.6, 116.3, 68.2, 20.8; MS (ESI): 274.95 $[M+H]^+$.



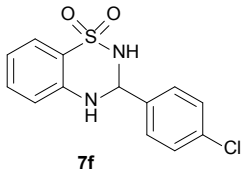
7d

*3-(4-methoxyphenyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7d**)*[9]. white solid, 58% yield, mp. 161 – 163 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.78 (d, J = 12.1 Hz, 1H), 7.57 (d, J = 8.7 Hz, 2H), 7.53 – 7.45 (m, 1H), 7.35 – 7.22 (m, 2H), 6.99 (d, J = 8.7 Hz, 2H), 6.88 (d, J = 8.2 Hz, 1H), 6.74 (t, J = 7.3 Hz, 1H), 5.71 (d, J = 12.0 Hz, 1H), 3.77 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 159.8, 143.9, 132.8, 129.5, 128.9, 123.7, 121.5, 116.6, 116.3, 113.8, 68.0, 55.2; MS (ESI): 290.95 $[M+H]^+$.



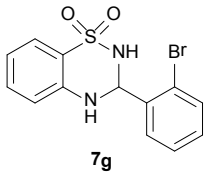
7e

*3-(4-fluorophenyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7e**)*[9]. white solid, 39% yield, mp. 184 – 186 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.89 (d, J = 12.0 Hz, 1H), 7.71 (dd, J = 8.6, 5.6 Hz, 2H), 7.52 (d, J = 7.4 Hz, 1H), 7.45 – 7.16 (m, 4H), 6.89 (d, J = 8.3 Hz, 1H), 6.76 (t, J = 7.5 Hz, 1H), 5.79 (d, J = 12.1 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.4 (d, $J_{C4'\text{-}F}$ = 245.2 Hz, C4'), 143.8, 133.7 (d, $J_{C1'\text{-}F}$ = 3.0 Hz, C1'), 132.9, 129.8 (d, $J_{C2'\text{-}F}$ = 8.5 Hz, C2'), 123.7, 121.6, 116.8, 116.3, 115.3 (d, $J_{C3'\text{-}F}$ = 21.6 Hz, C3'), 67.6; MS (ESI): 278.95 $[M+H]^+$.



7f

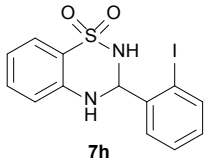
*3-(4-chlorophenyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7f**)*[9]. white solid, 47% yield, mp. 199 – 210 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.92 (d, J = 12.0 Hz, 1H), 7.68 (d, J = 8.5 Hz, 2H), 7.59 – 7.45 (m, 3H), 7.38 (s, 1H), 7.35 – 7.25 (m, 1H), 6.89 (d, J = 8.0 Hz, 1H), 6.76 (t, J = 7.2 Hz, 1H), 5.80 (d, J = 12.0 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.8, 136.2, 133.7, 132.9, 129.5, 128.5, 123.7, 121.7, 116.9, 116.4, 67.6; MS (ESI): 294.90 $[M+H]^+$.



7g

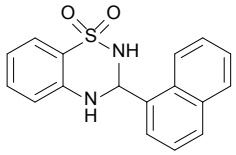
*3-(2-bromophenyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7g**)*. white solid, 51% yield, mp. 183 – 186 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.96 (d, J = 12.0 Hz, 1H), 7.87 (d, J = 7.7 Hz, 1H), 7.72 (d, J = 7.9 Hz, 1H), 7.52 (t, J = 8.1 Hz, 2H), 7.46 – 7.23 (m, 3H), 6.89 (d, J = 8.3 Hz, 1H), 6.78 (t, J = 7.5 Hz, 1H), 6.14 (d, J = 12.0 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.8, 135.9, 132.9, 132.8, 131.1, 129.4, 128.1, 123.8, 122.8, 121.8, 117.0, 116.4, 67.4; MS (ESI): 338.85 $[M+H]^+$;

HRMS (ESI) m/z calcd for $C_{13}H_{12}BrN_2O_2S$ $[M+H]^+$ 338.9797, found 338.9789.



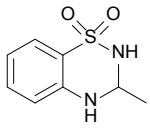
7h

*3-(2-iodophenyl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7h**)*. white solid, 52% yield, mp. 209 – 211 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.95 (d, J = 7.8 Hz, 1H), 7.89 (d, J = 12.0 Hz, 1H), 7.81 (d, J = 7.0 Hz, 1H), 7.51 (t, J = 8.0 Hz, 2H), 7.42 (s, 1H), 7.32 (t, J = 7.8 Hz, 1H), 7.19 (t, J = 7.1 Hz, 1H), 6.89 (d, J = 8.3 Hz, 1H), 6.78 (t, J = 7.5 Hz, 1H), 6.00 (d, J = 11.9 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.8, 139.4, 138.9, 132.9, 131.2, 128.9, 128.6, 123.8, 121.8, 116.9, 116.4, 99.8, 72.4; MS (ESI): 386.80 $[M+H]^+$; HRMS (ESI) m/z calcd for $C_{13}H_{12}IN_2O_2S$ $[M+H]^+$ 386.9659, found 386.9649.



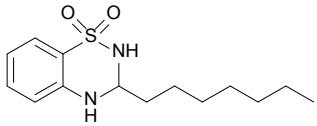
7i

*3-(naphthalen-1-yl)-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7i**)*. white solid, 44% yield, mp. 208 – 210 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.16 (d, J = 8.3 Hz, 1H), 8.10 – 7.97 (m, 3H), 7.95 (d, J = 7.2 Hz, 1H), 7.70 – 7.48 (m, 5H), 7.39 – 7.30 (m, 1H), 7.01 (d, J = 8.3 Hz, 1H), 6.80 (t, J = 7.4 Hz, 1H), 6.57 (d, J = 11.9 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 144.2, 133.3, 132.9, 132.2, 130.0, 129.5, 128.7, 126.9, 126.1, 125.2, 124.7, 123.8, 122.8, 121.8, 116.9, 116.8, 64.4; MS (ESI): 311.00 $[M+H]^+$; HRMS (ESI) m/z calcd for $C_{17}H_{15}N_2O_2S$ $[M+H]^+$ 311.0849, found 311.0843.



7j

*3-methyl-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7j**)*[10]. white solid, 24% yield, mp. 211 – 213 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.43 (d, J = 9.1 Hz, 2H), 7.32 – 7.20 (m, 1H), 7.08 (s, 1H), 6.75 (d, J = 8.3 Hz, 1H), 6.68 (t, J = 7.5 Hz, 1H), 4.80 (dq, J = 12.0, 6.0 Hz, 1H), 1.40 (d, J = 6.1 Hz, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.8, 132.7, 123.6, 120.8, 116.1, 115.7, 61.8, 20.0; MS (ESI): 198.95 $[M+H]^+$.



7k

*3-heptyl-3,4-dihydro-2H-benzo[e][1,2,4]thiadiazine 1,1-dioxide (**7k**)*. white solid, 29% yield, mp. 146 – 147 °C. ^{1}H NMR (300 MHz, DMSO-d_6) δ 7.42 (d, J = 7.9 Hz, 1H), 7.33 (d, J = 11.8 Hz, 1H), 7.29 – 7.19 (m, 1H), 6.97 (s, 1H), 6.78 (d, J = 8.3 Hz, 1H), 6.67 (t, J = 7.5 Hz, 1H), 4.75 – 4.47 (m, 1H), 1.79 – 1.64 (m, 2H), 1.44 (s, 2H), 1.34 – 1.21 (m, 8H), 0.91 – 0.82 (m, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 143.7, 132.6, 123.7, 121.2, 116.1, 115.8, 65.6, 33.4, 31.1, 28.6, 28.5, 24.1, 22.1, 13.9; MS (ESI):

283.00 $[M+H]^+$; HRMS (ESI) m/z calcd for $C_{14}H_{23}N_2O_2S$ $[M+H]^+$ 283.1475, found 283.1470.

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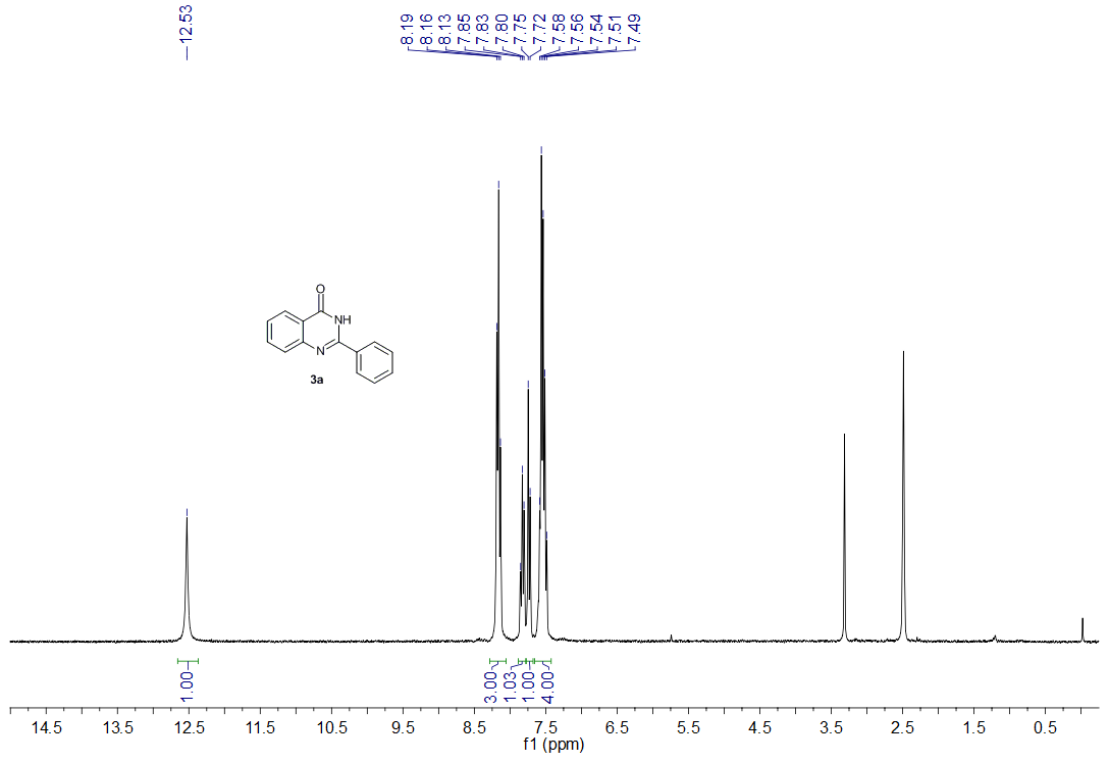
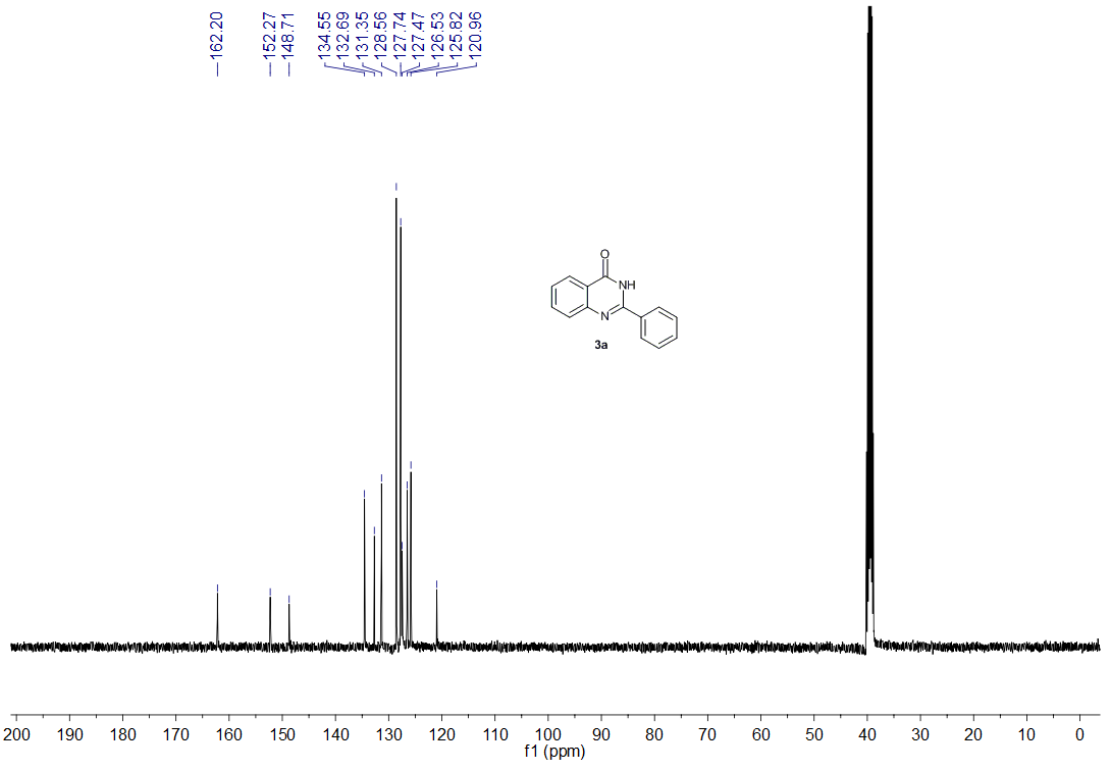
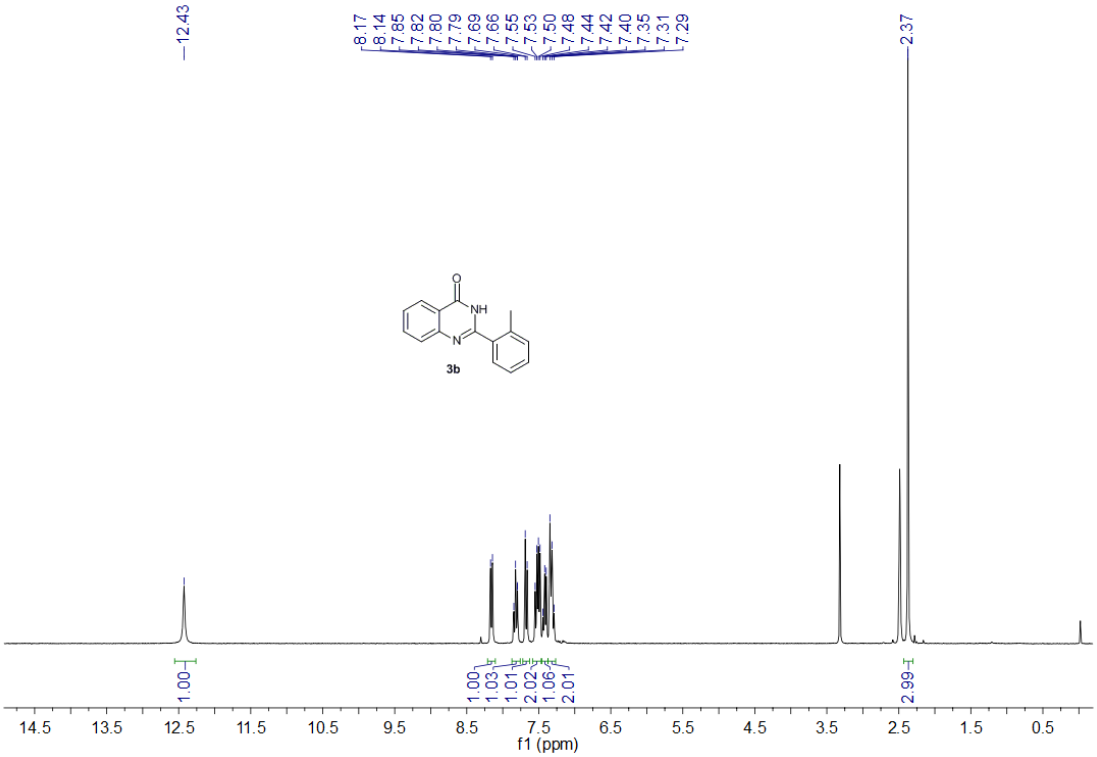
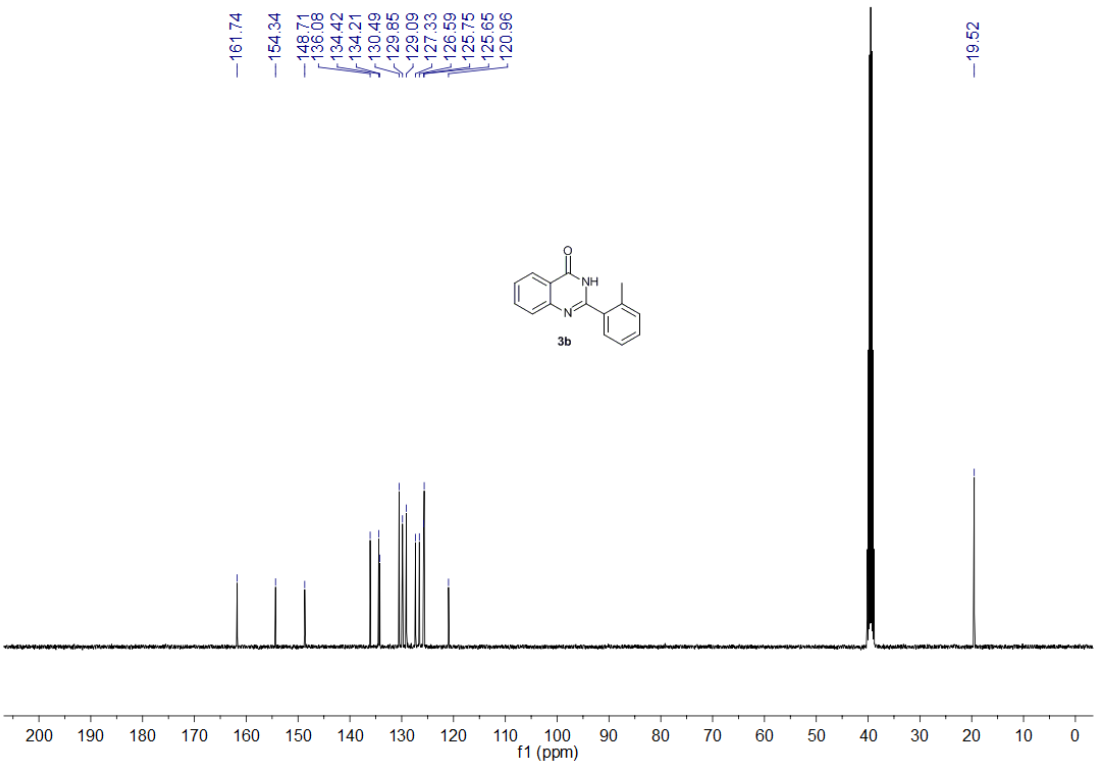
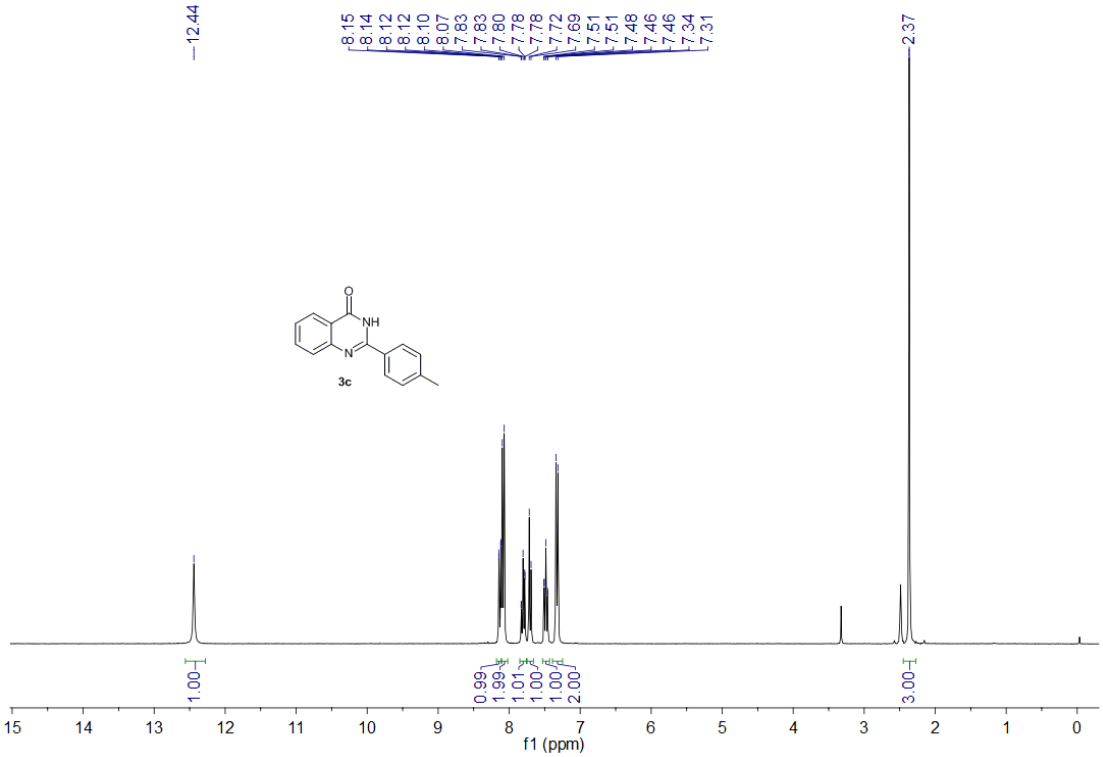
^{1}H- and ^{13}C-NMR spectral data for products







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7.51
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7.46
7.46
7.34
7.31
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NH
N
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1.00
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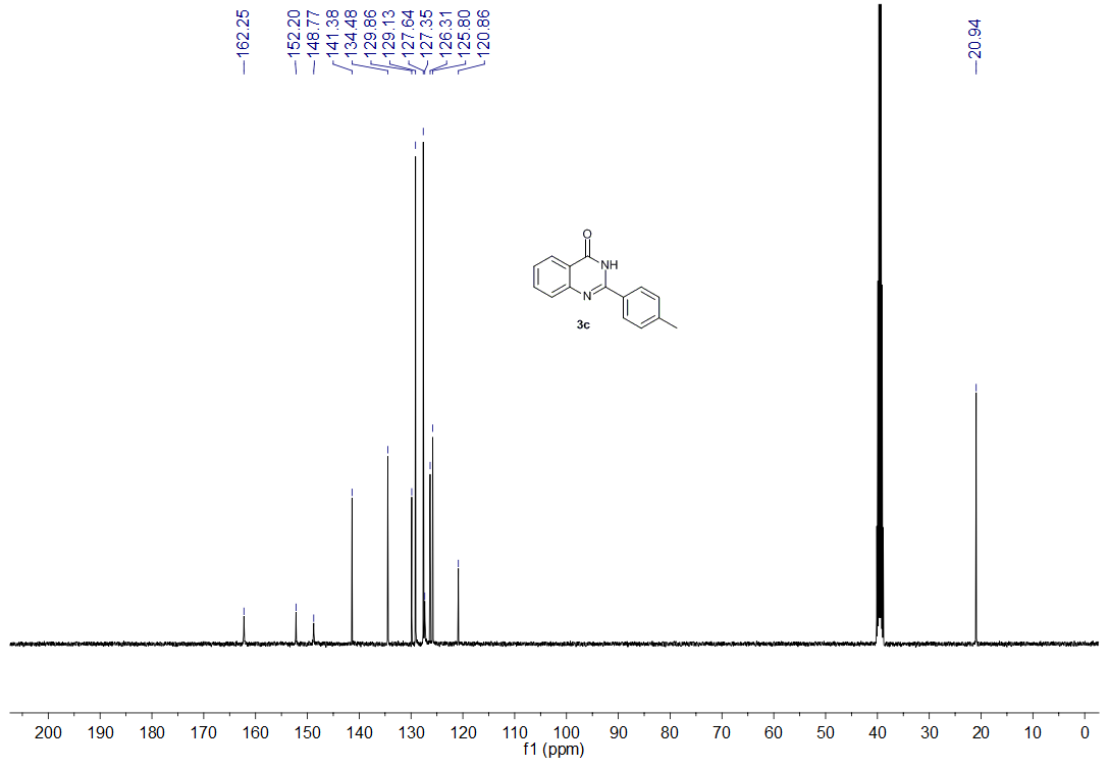
3.00
f1 (ppm)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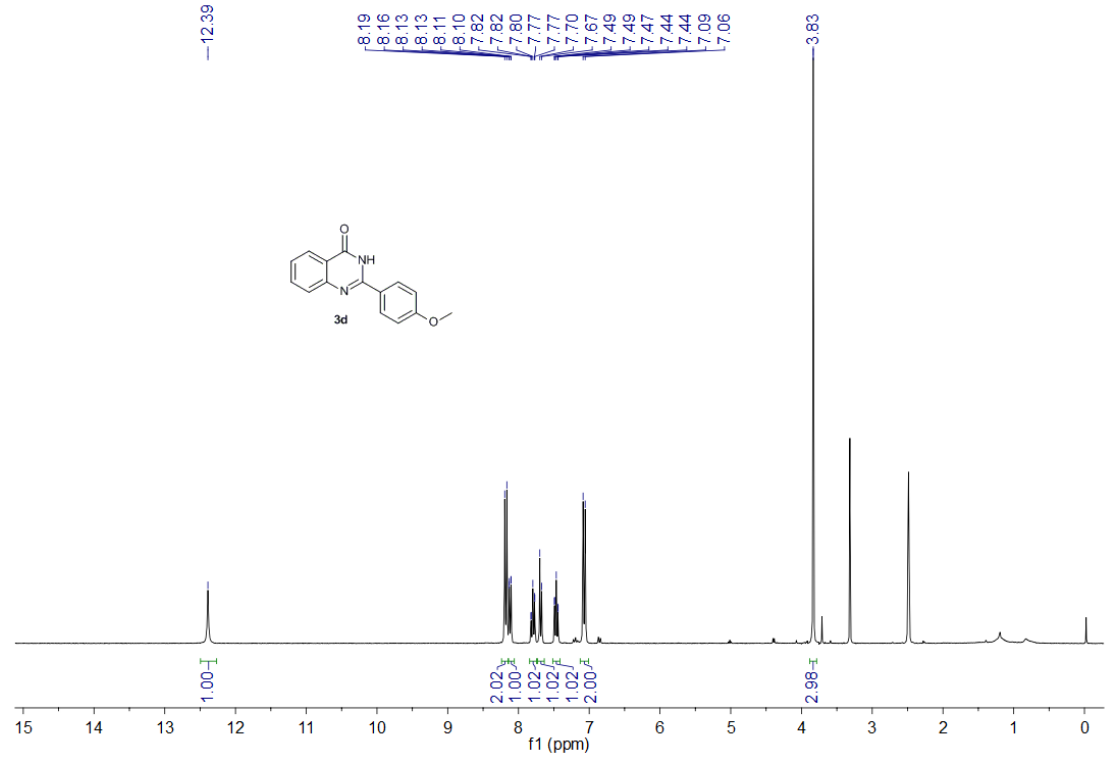
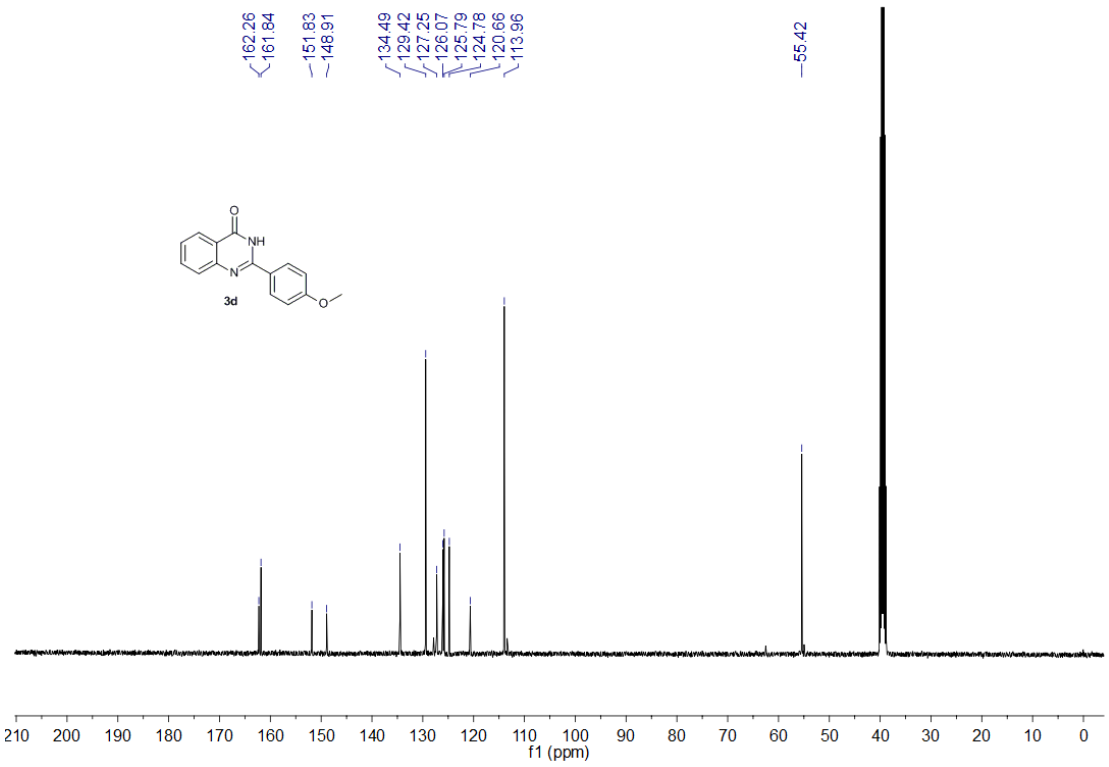
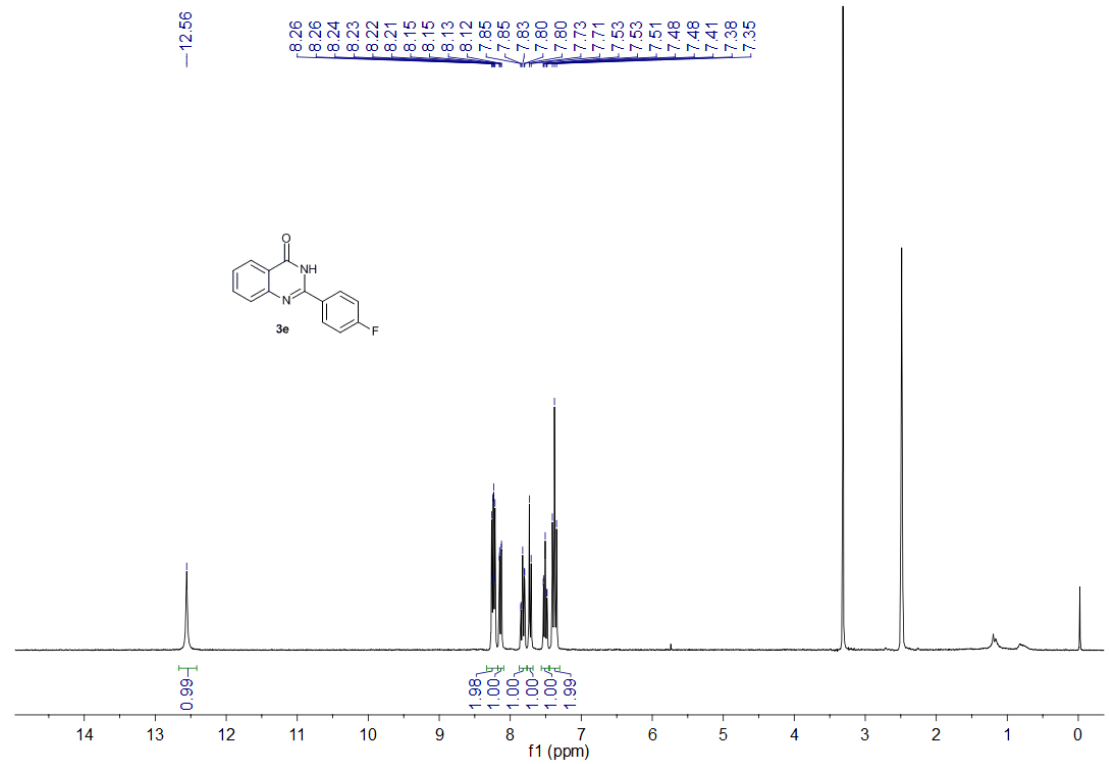
f1 (ppm)



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7.53
7.51
7.48
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NH
N
O
F
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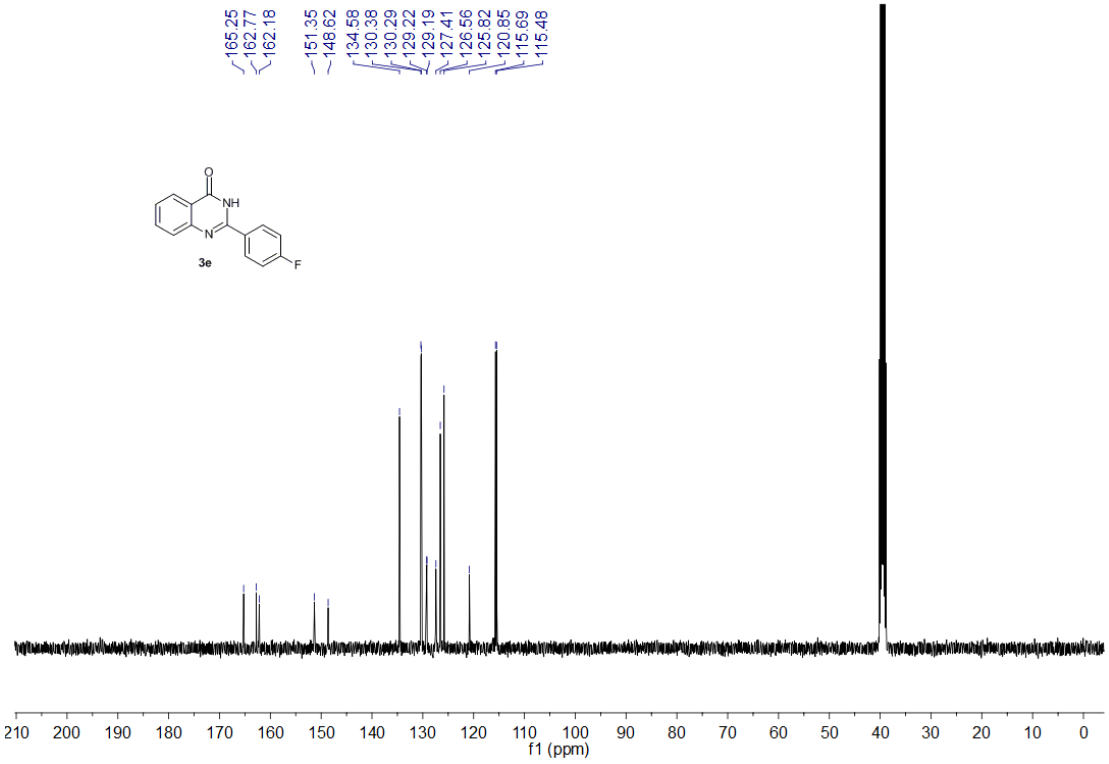
1.99
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)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130.29
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127.41
126.56
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120.85
115.69
115.48
NH
N
O
F
3e
210
200
190
180
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130
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110
100
90
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70
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50
40
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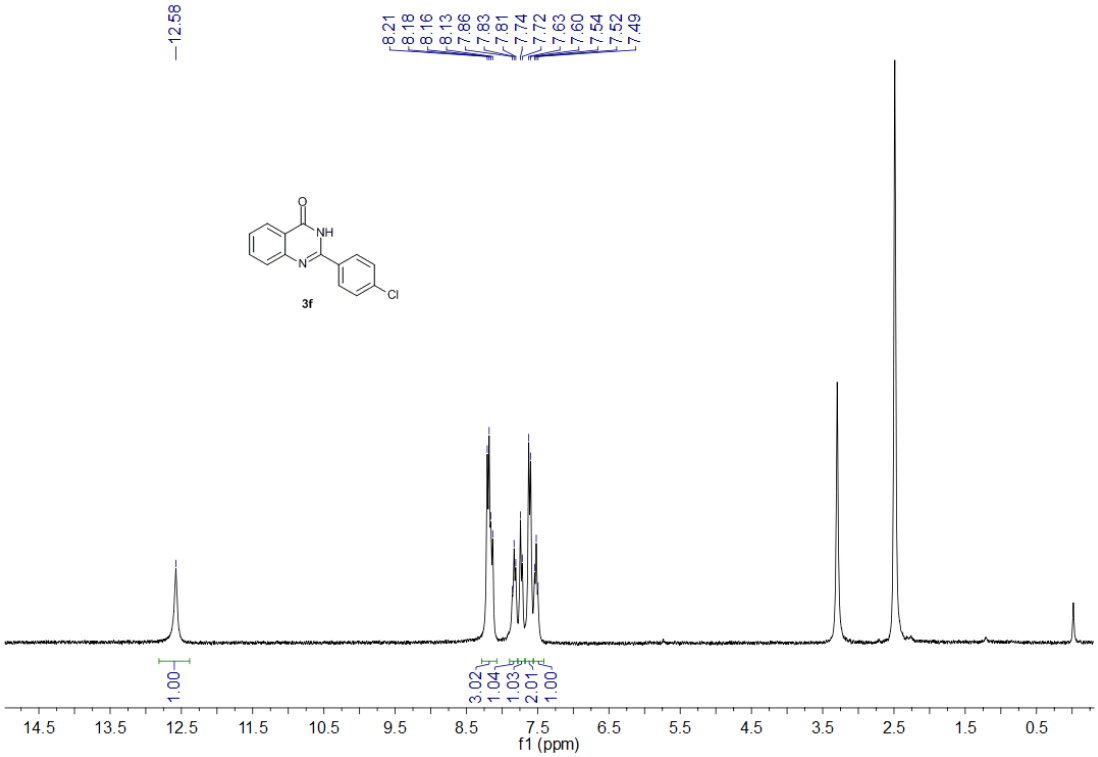
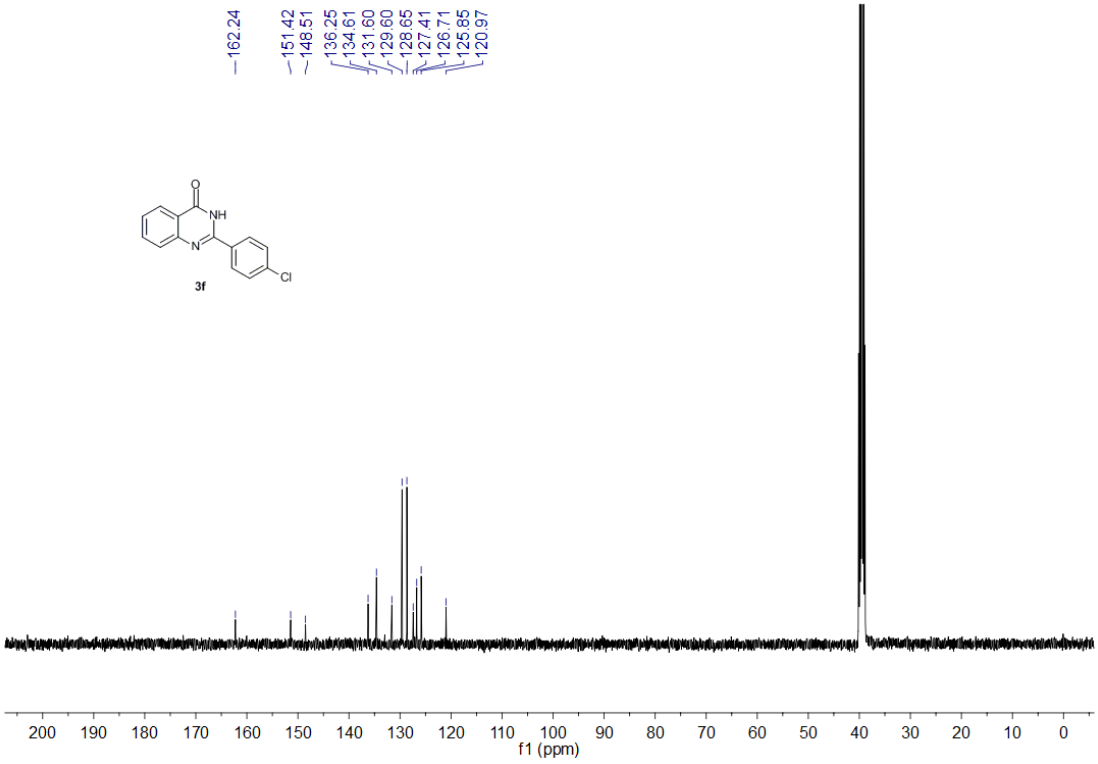
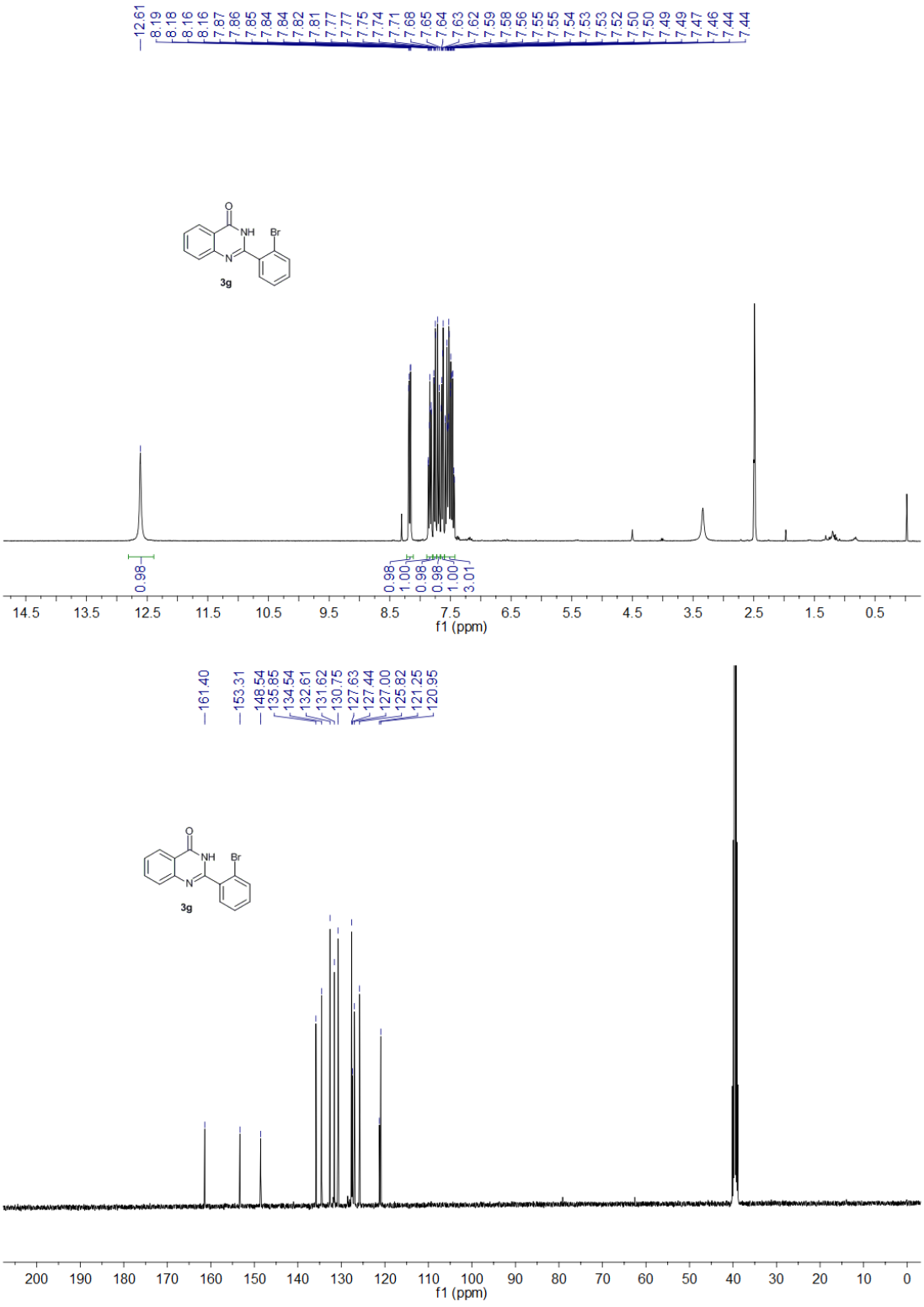
f1 (ppm)



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7.81
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7.77
7.75
7.74
7.71
7.68
7.65
7.64
7.63
7.62
7.59
7.58
7.56
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7.54
7.53
7.53
7.52
7.50
7.50
7.49
7.49
7.47
7.46
7.44
7.44
O
NH
Br
N
3g
0.98
0.98
1.00
0.98
0.98
1.00
3.01
14.5
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)
161.40
153.31
148.54
135.85
134.54
132.61
131.62
130.75
127.63
127.44
127.00
125.82
121.25
120.95
O
NH
Br
N
3g
200
190
180
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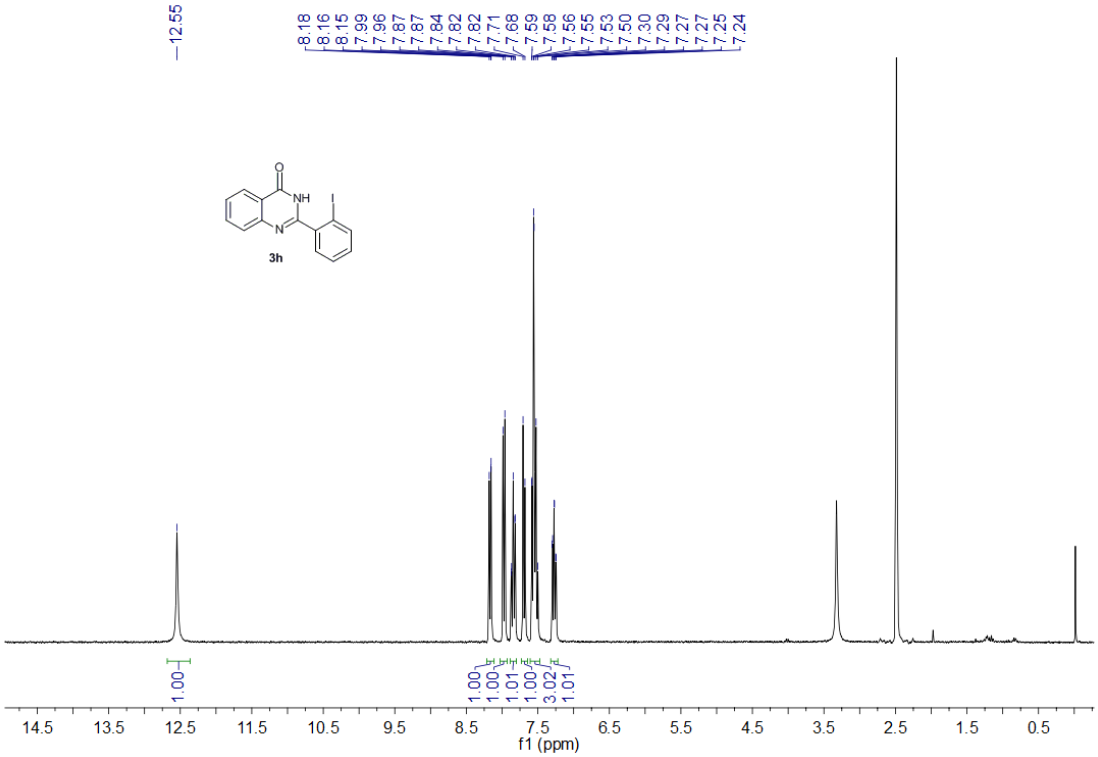
f1 (ppm)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7.68
7.59
7.58
7.56
7.55
7.53
7.50
7.30
7.29
7.27
7.27
7.25
7.24
O
NH
N
I
3h
1.00
1.00
1.00
1.01
1.00
3.02
1.01
14.5
13.5
12.5
11.5
10.5
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7.5
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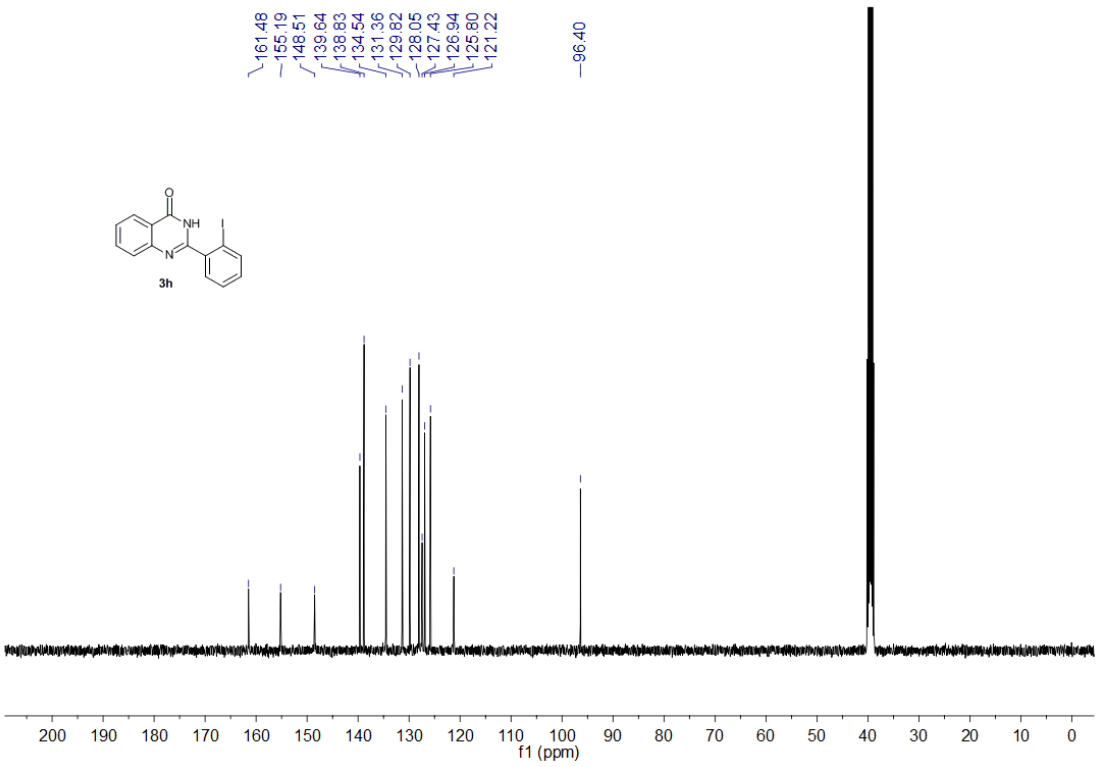
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)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134.54
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129.82
128.05
127.43
126.94
125.80
121.22
96.40
O
NH
N
I
3h
200
190
180
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130
120
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90
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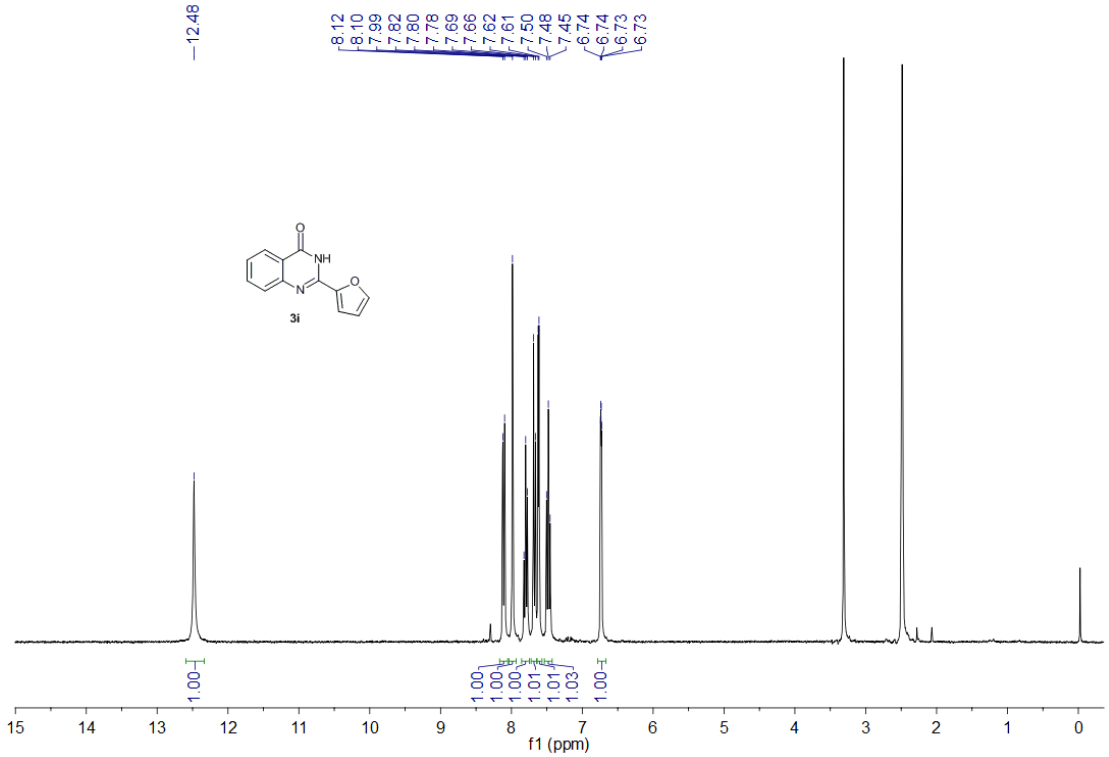
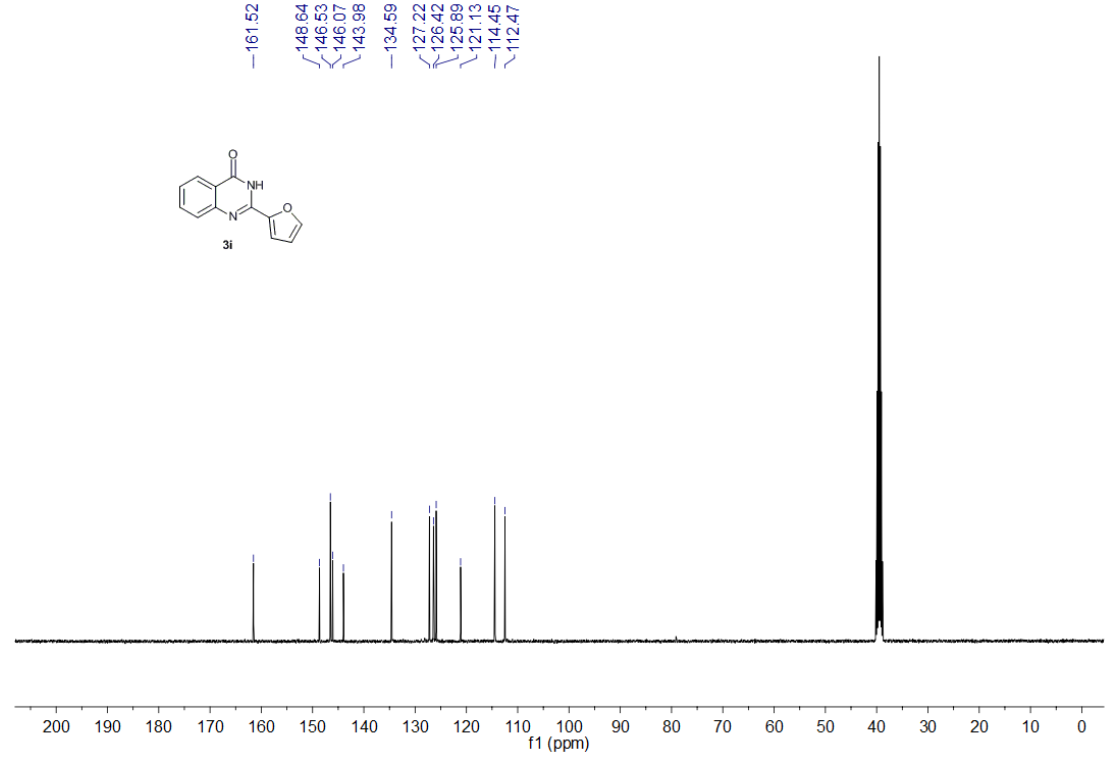
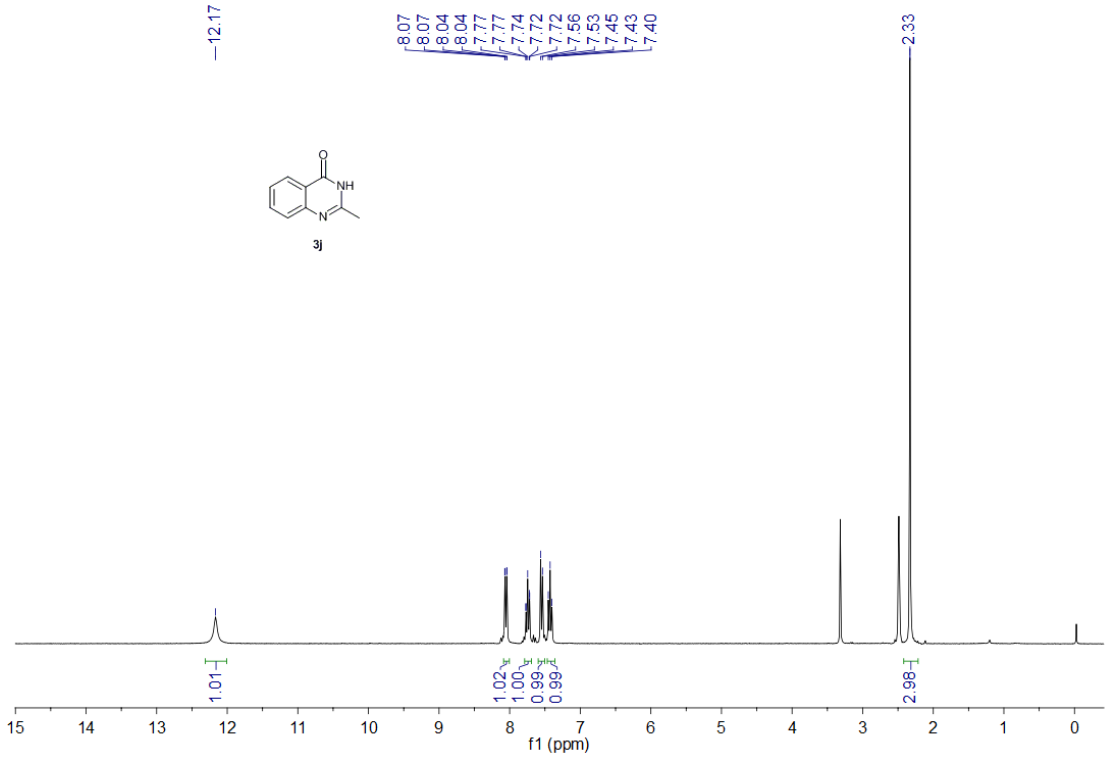
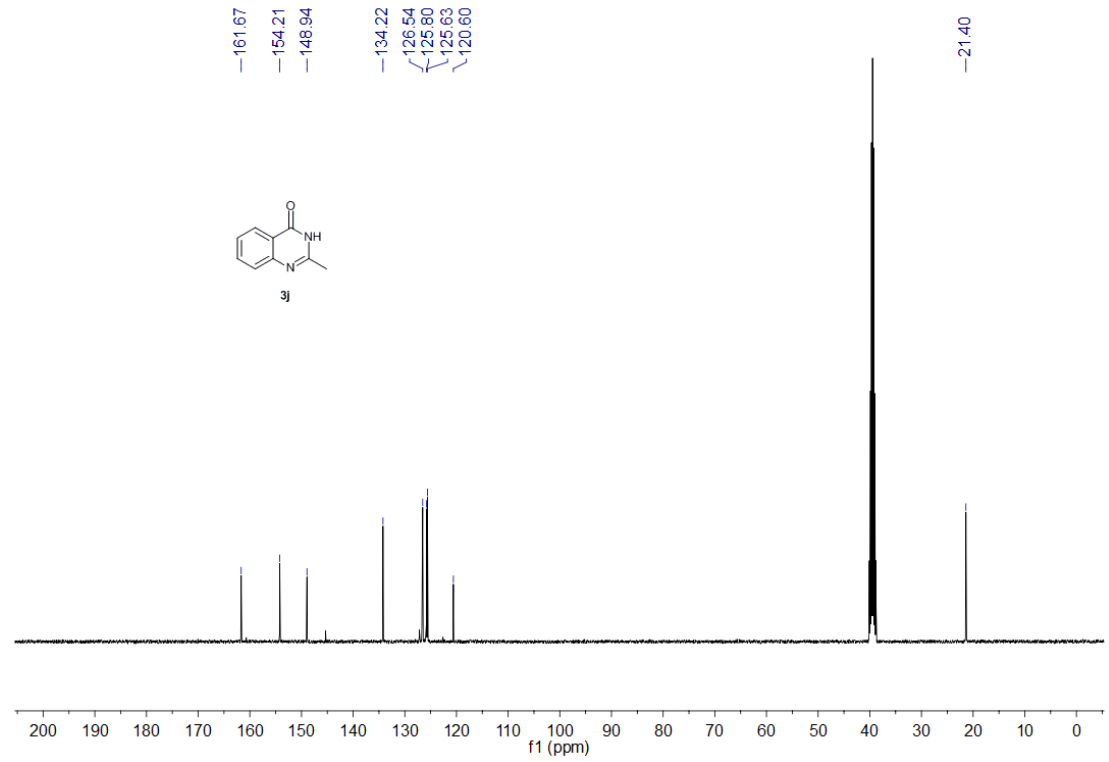
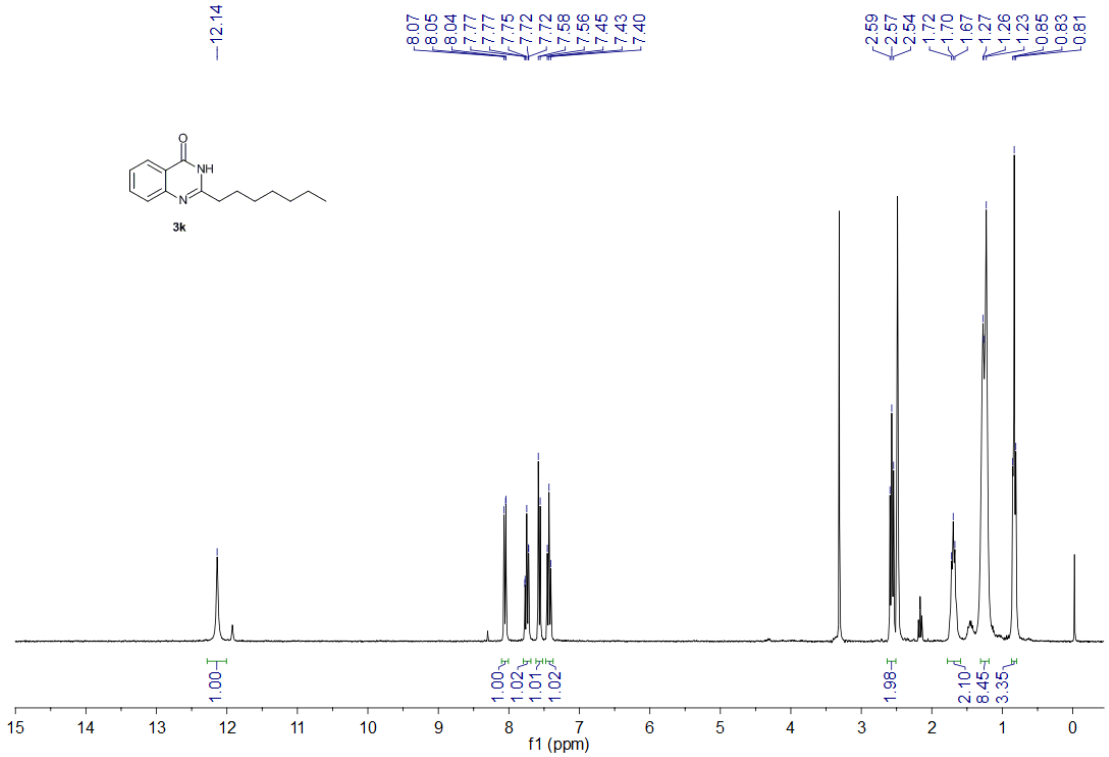
70
60
50
40
30
20
10
0
f1 (ppm)







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7.77
7.75
7.72
7.72
7.58
7.56
7.45
7.43
7.40
2.59
2.57
2.54
1.72
1.70
1.67
1.27
1.26
1.23
0.85
0.83
0.81
3k
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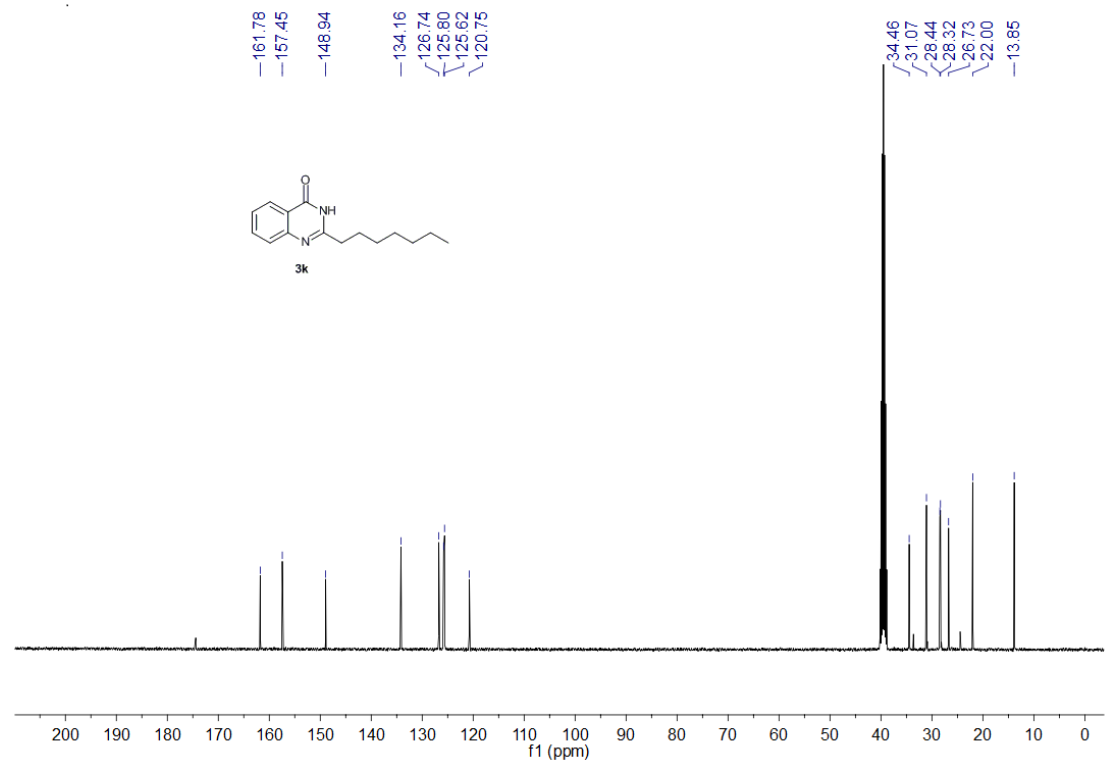
1.00
1.02
1.01
1.02
1.98
2.10
8.45
3.35
f1 (ppm)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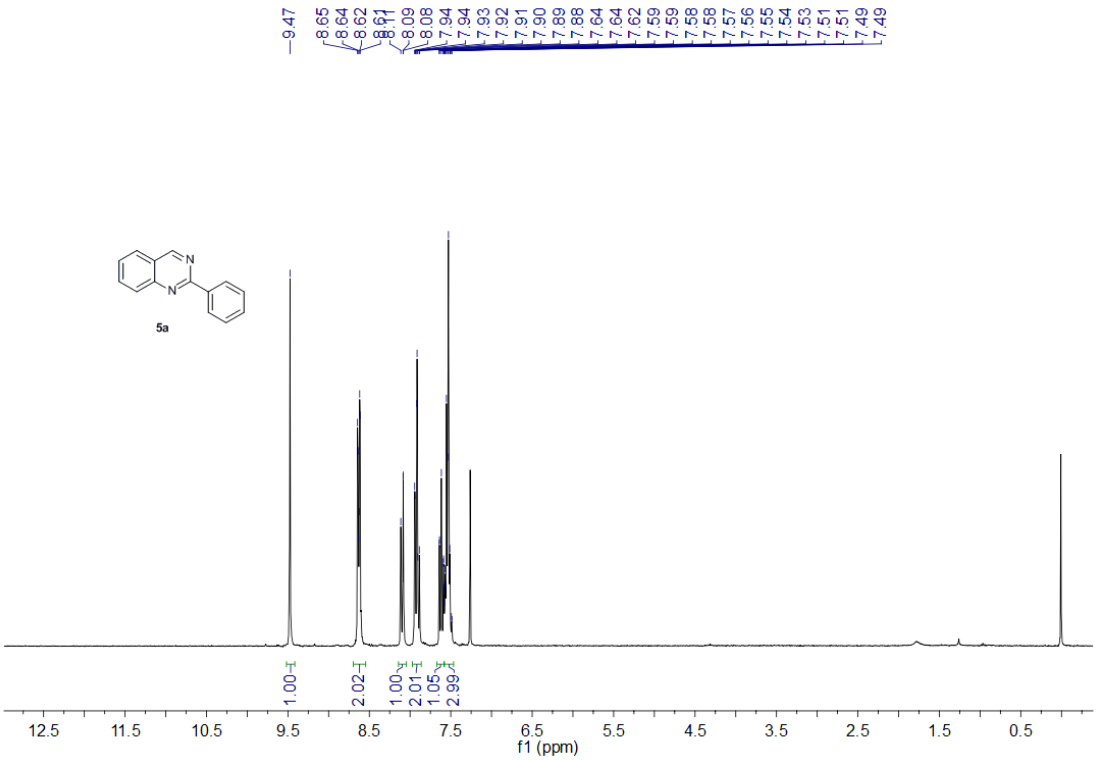
26.73
22.00
13.85
3k
f1 (ppm)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7.91
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7.64
7.62
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7.58
7.58
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7.56
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7.54
7.53
7.51
7.51
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2.01
1.05
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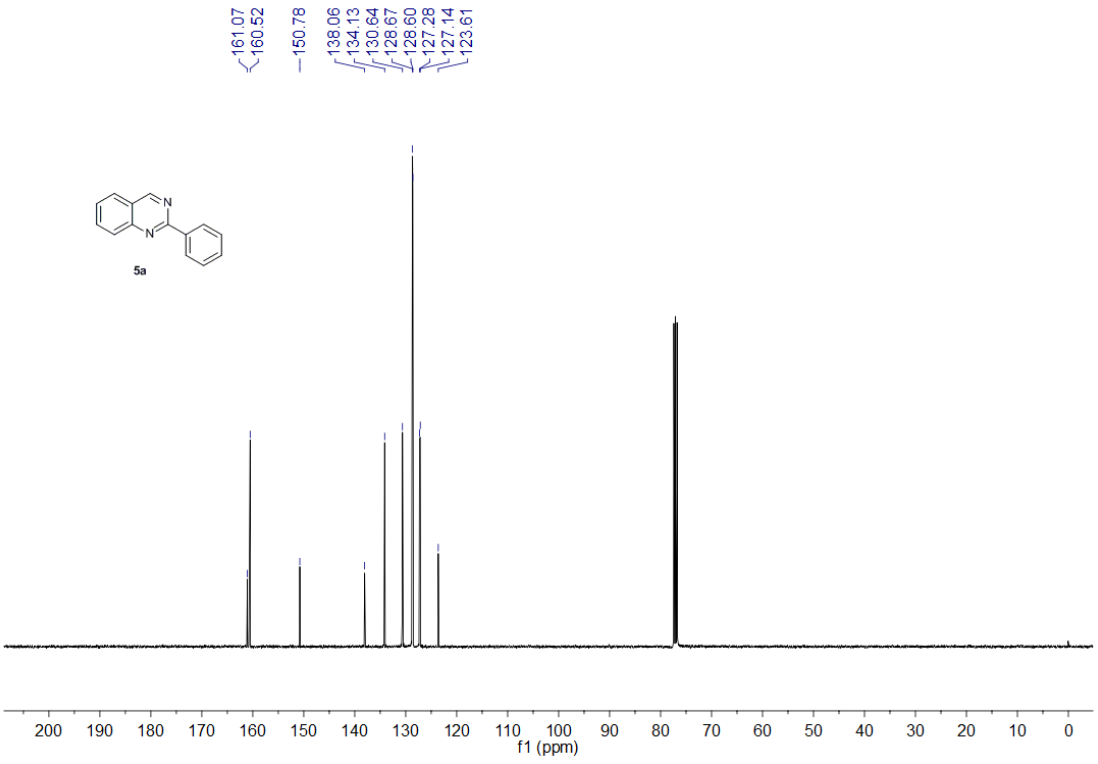
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)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128.67
128.60
127.28
127.14
123.61
5a
200
190
180
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150
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130
120
110
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90
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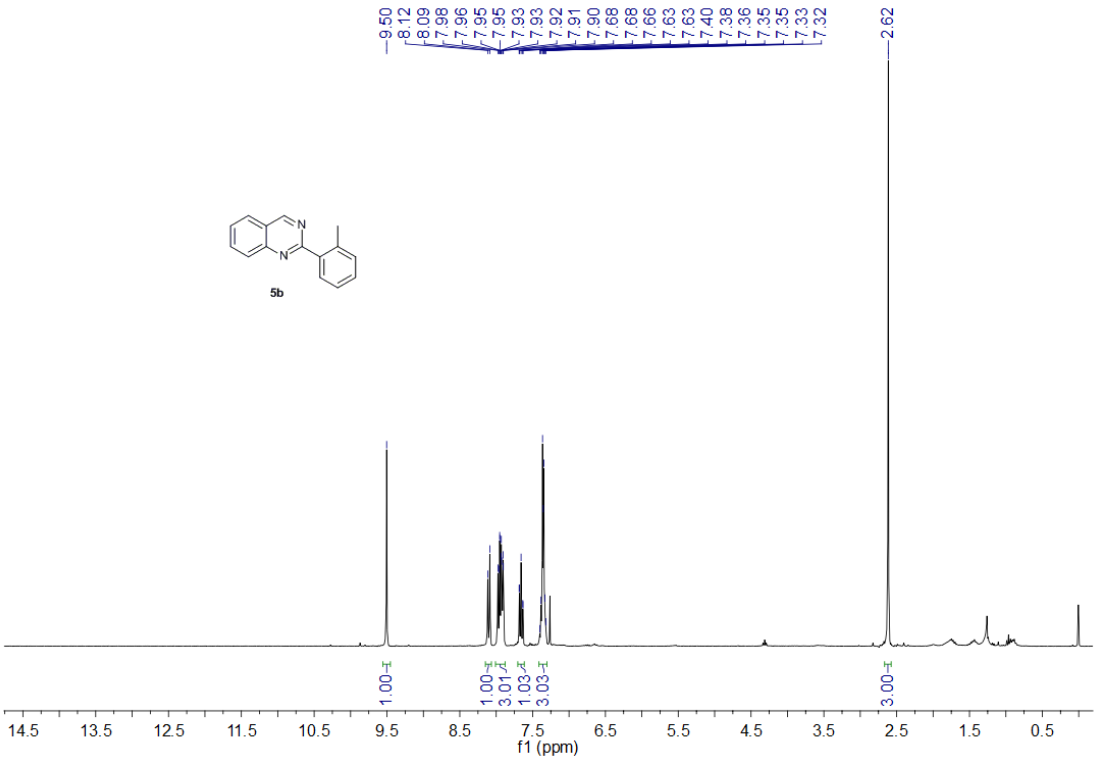
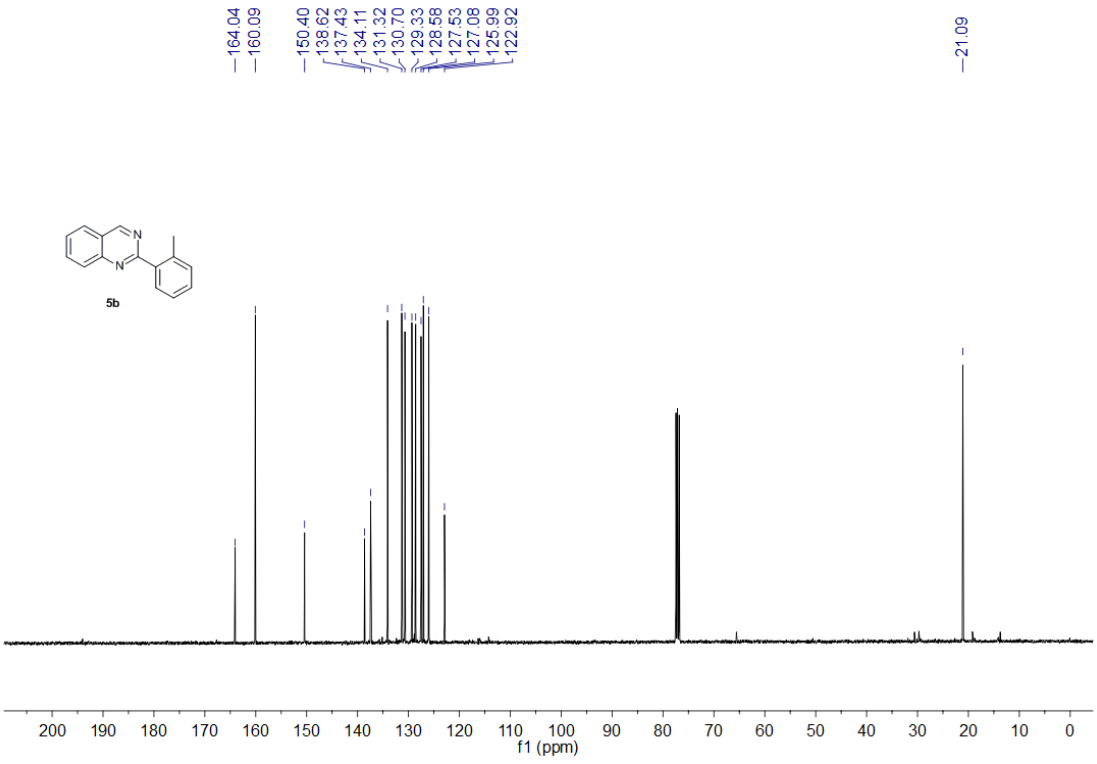
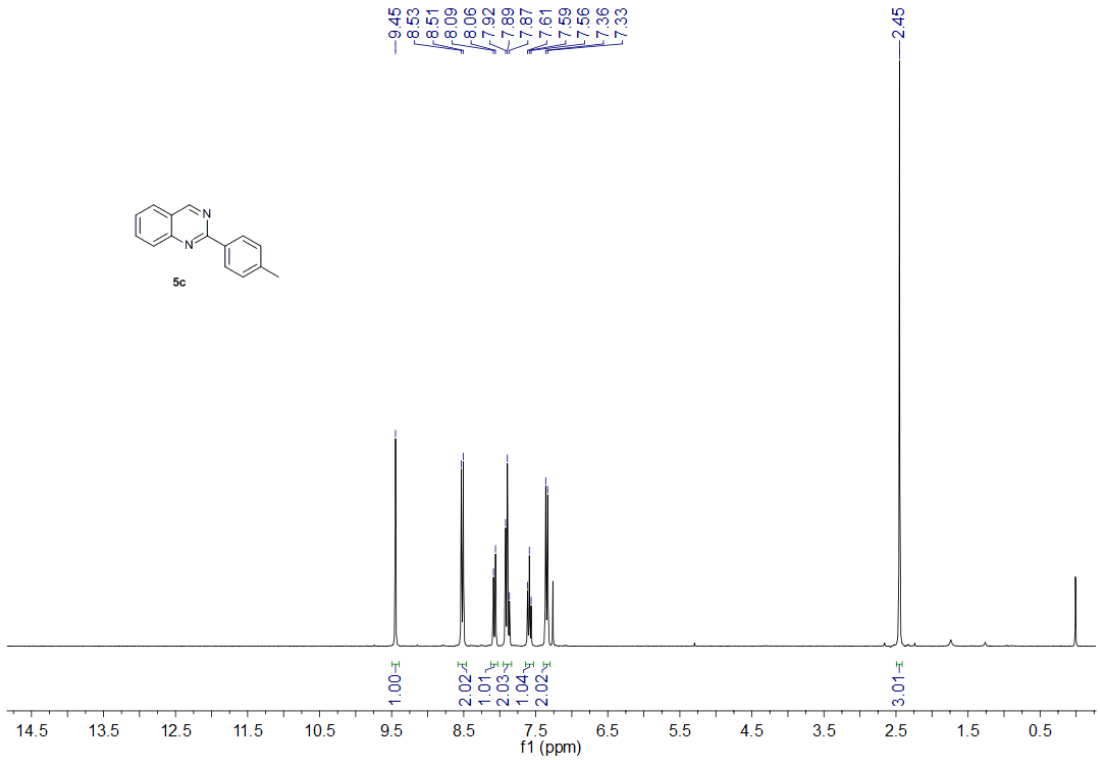
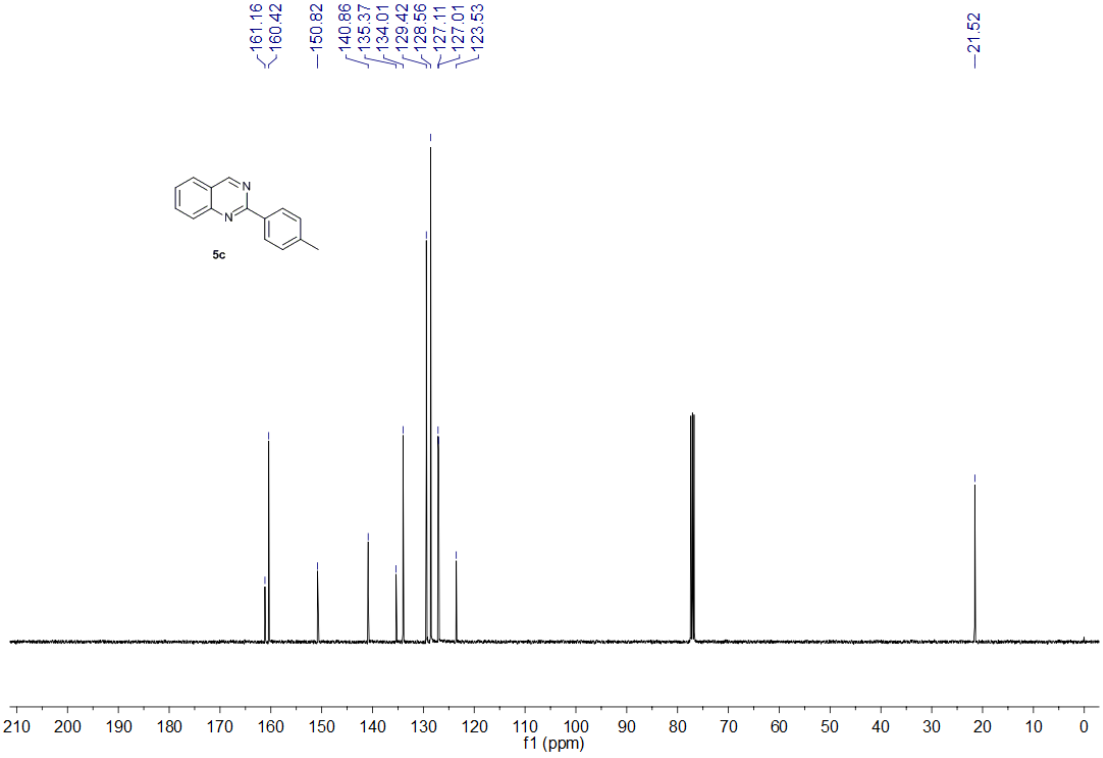
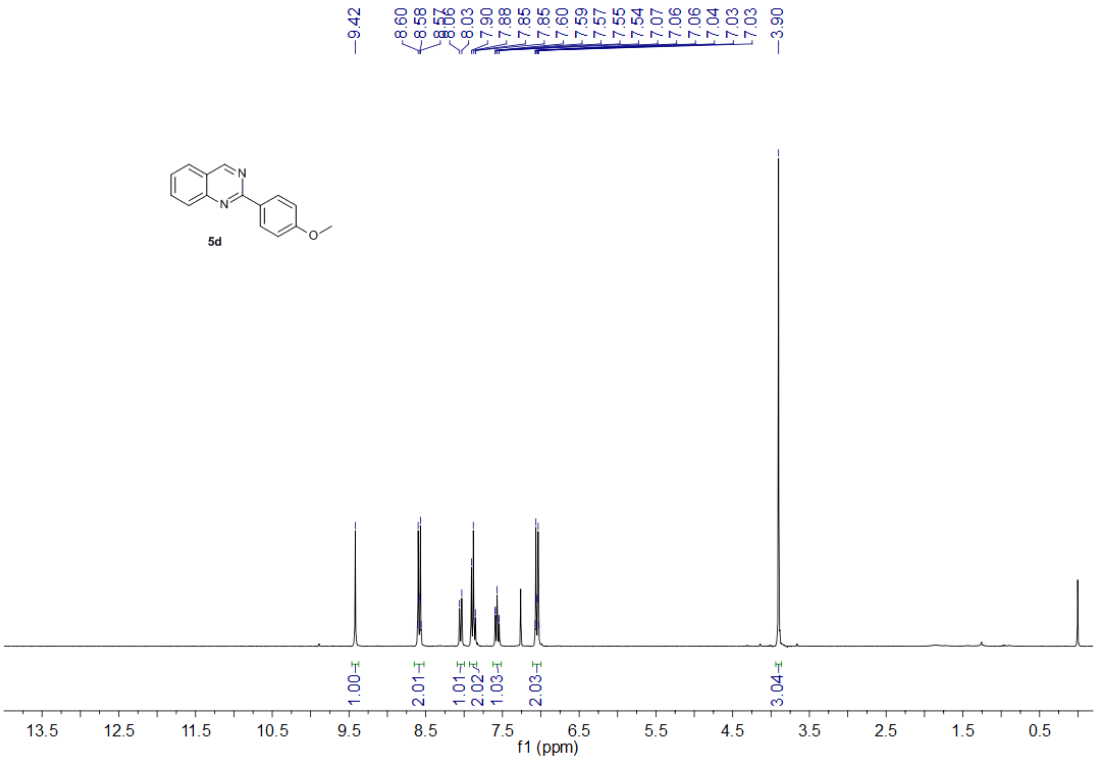
50
40
30
20
10
0
f1 (ppm)

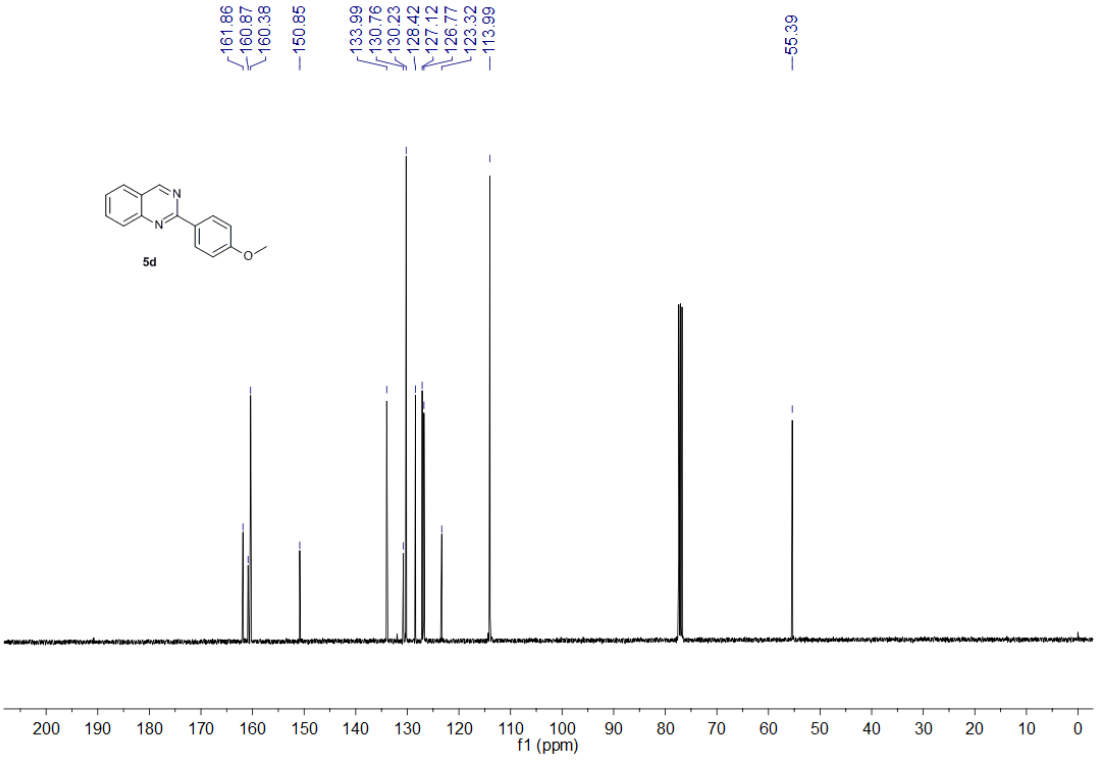


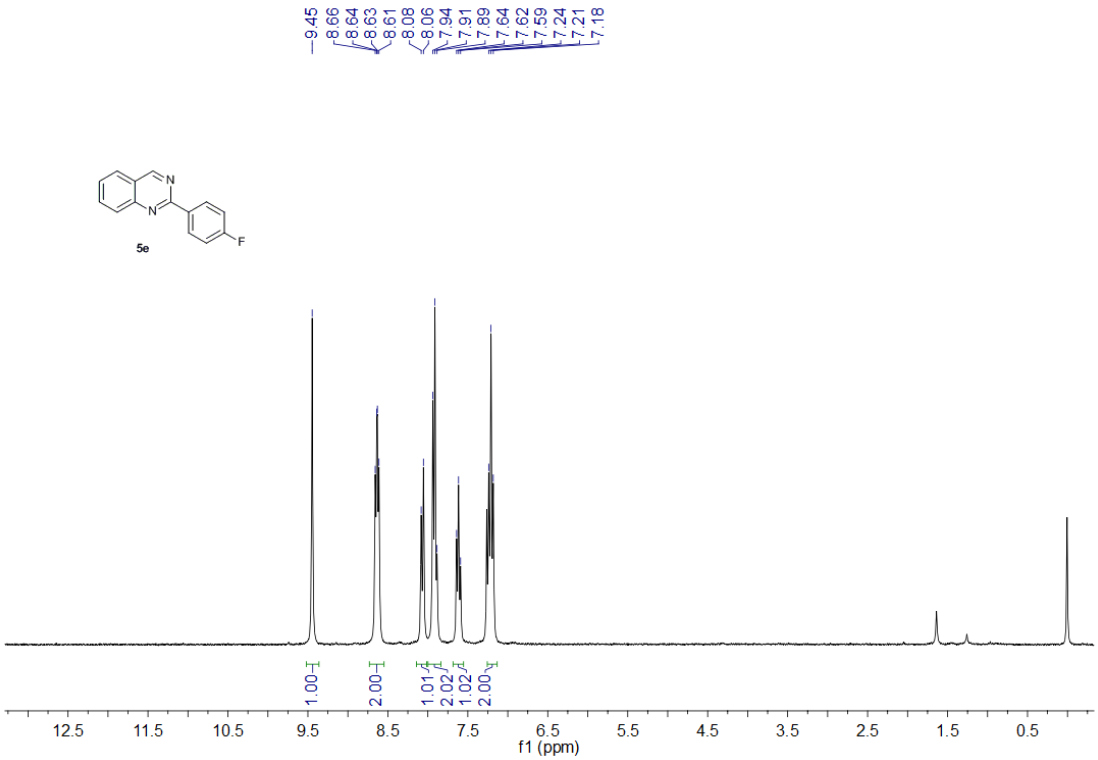








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7.62
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7.24
7.21
7.18
5e
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2.00
1.01
2.02
1.02
2.00
12.5
11.5
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7.5
6.5
5.5
4.5
3.5
2.5
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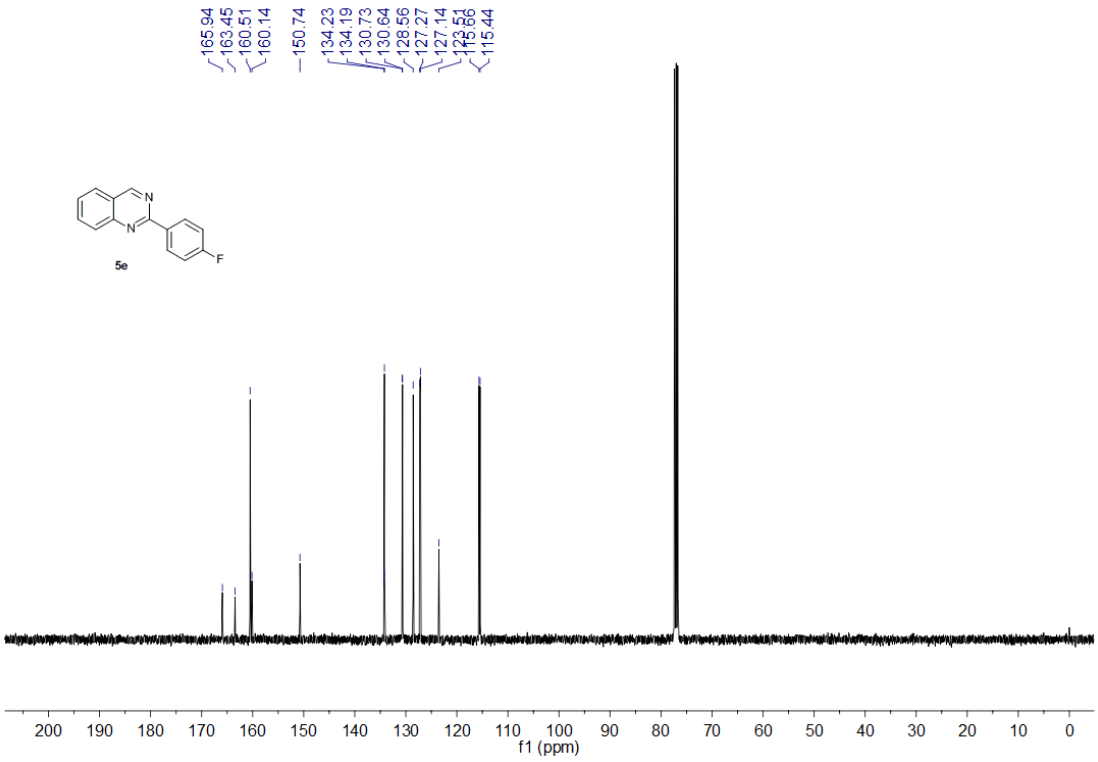
0.5
f1 (ppm)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130.73
130.64
128.56
127.27
127.14
123.51
115.66
115.44
5e
200
190
180
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130
120
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90
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70
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50
40
30
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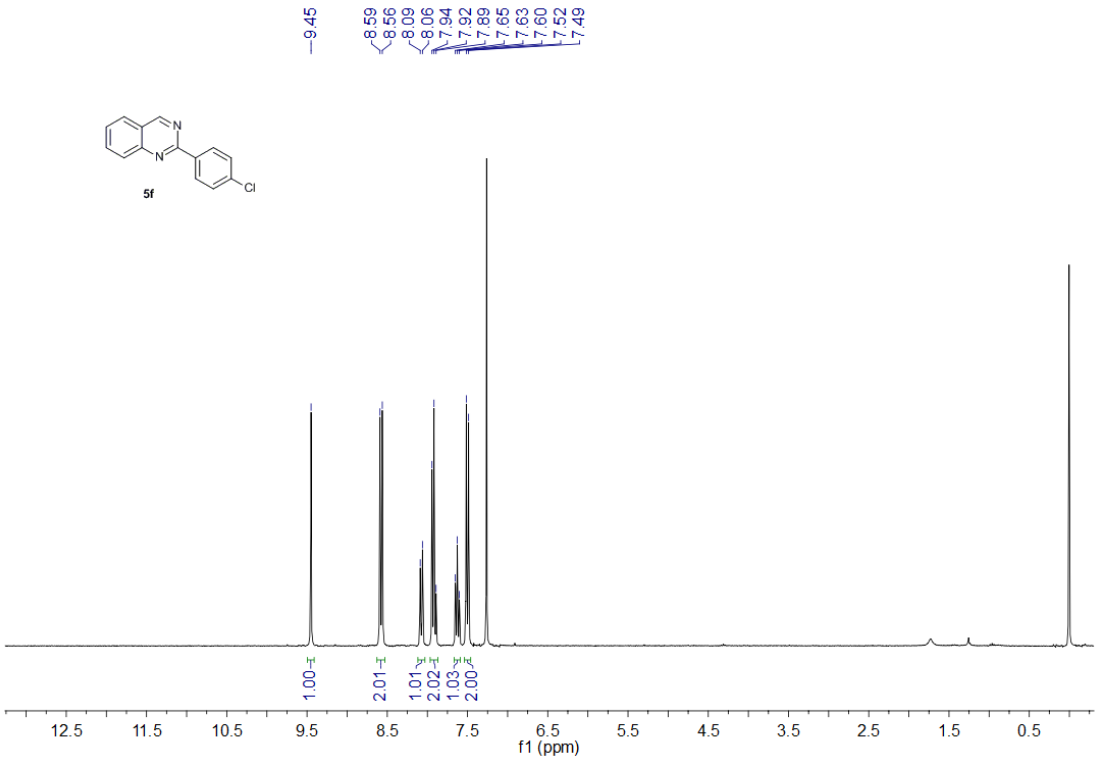
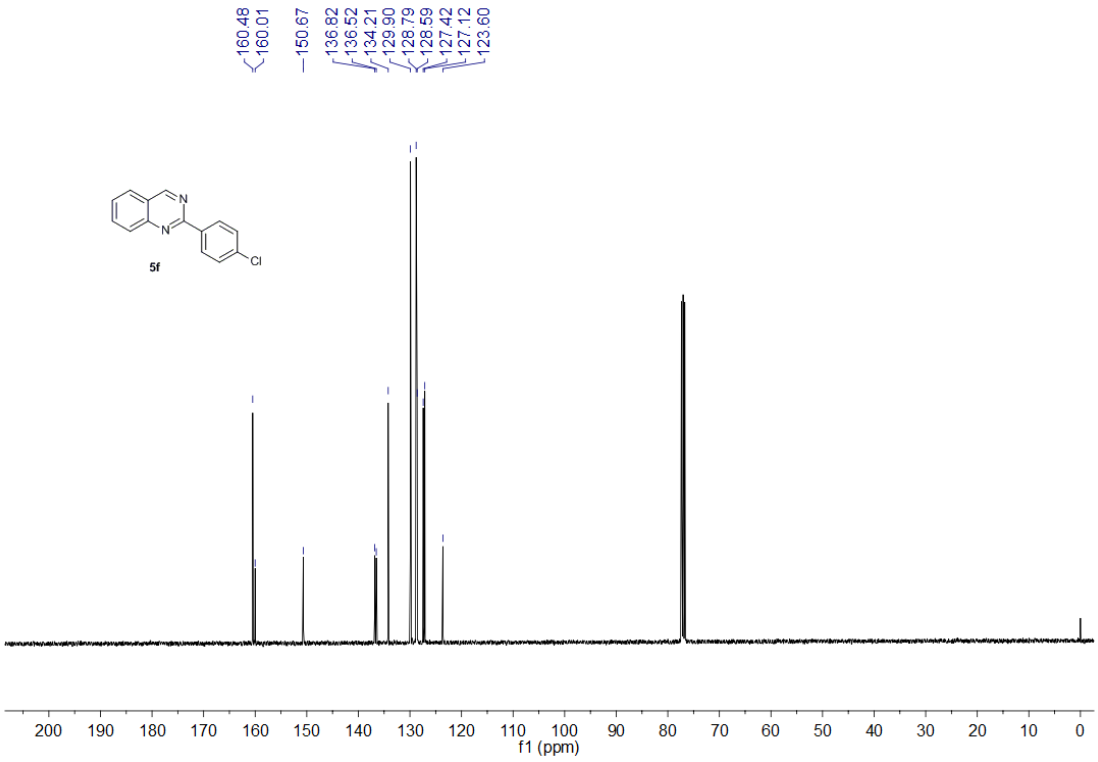
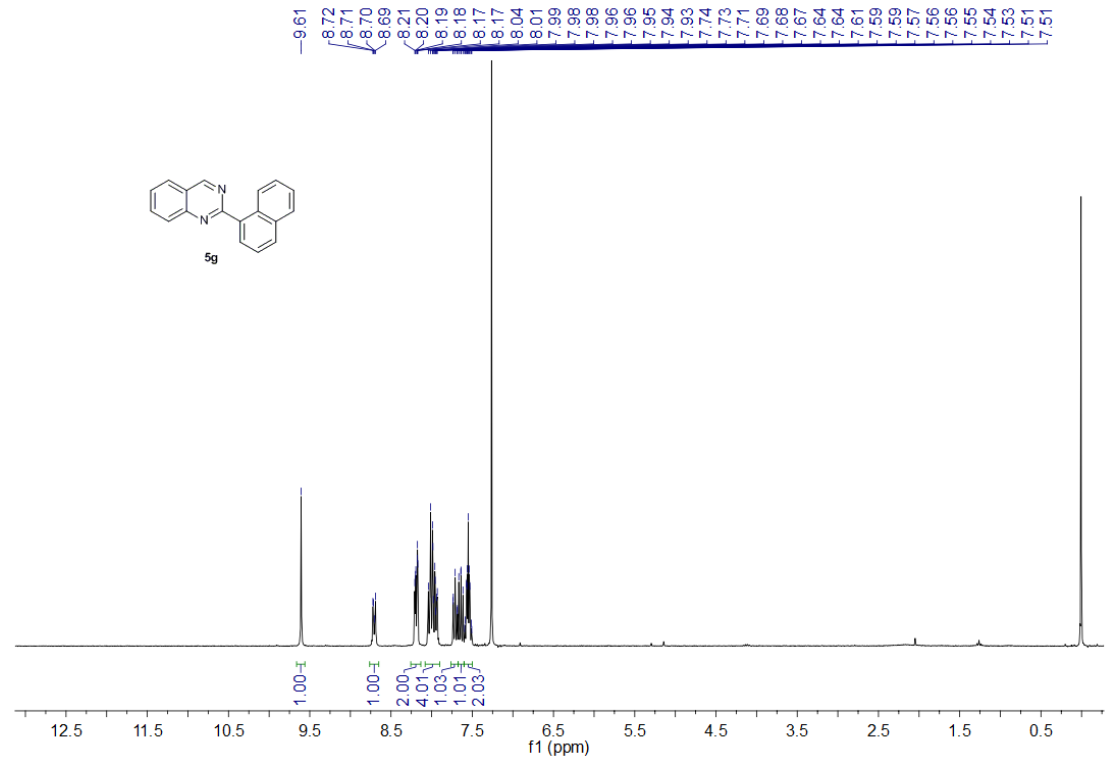
10
0
f1 (ppm)



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8.04
8.01
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7.98
7.98
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7.96
7.95
7.94
7.93
7.74
7.73
7.71
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7.68
7.67
7.64
7.64
7.61
7.59
7.59
7.57
7.56
7.56
7.55
7.54
7.53
7.51
7.51
5g
1.00
1.00
2.00
4.01
1.03
1.01
2.03
12.5
11.5
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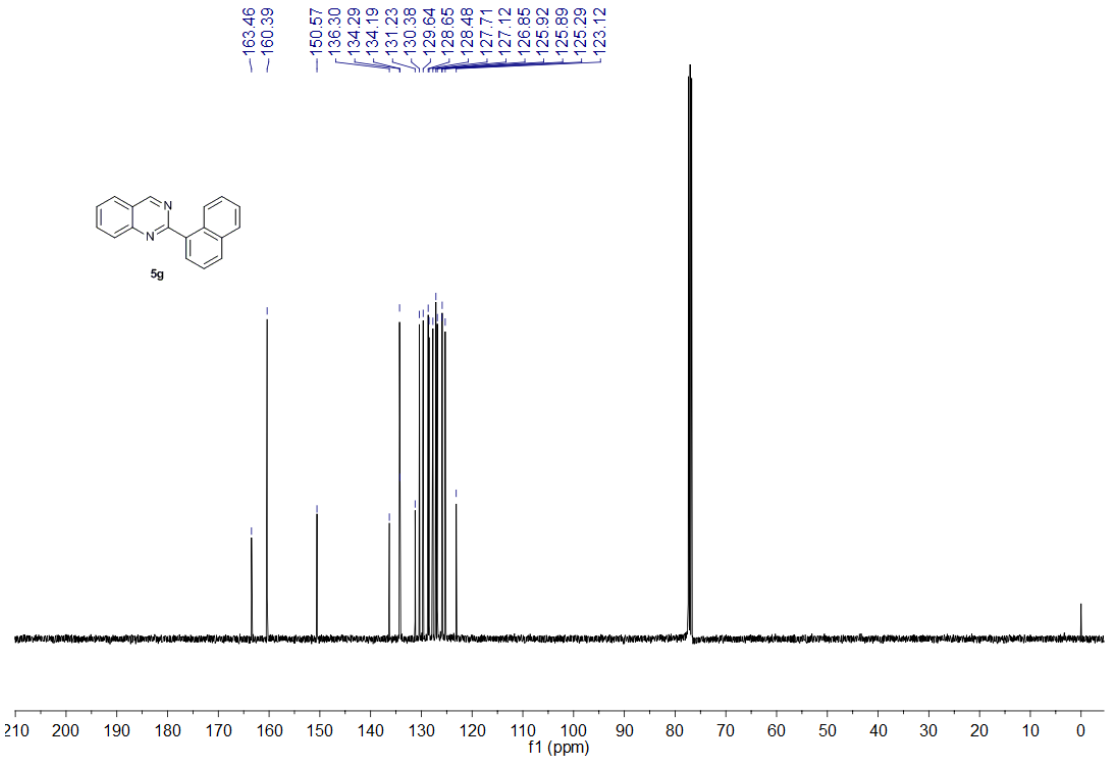
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)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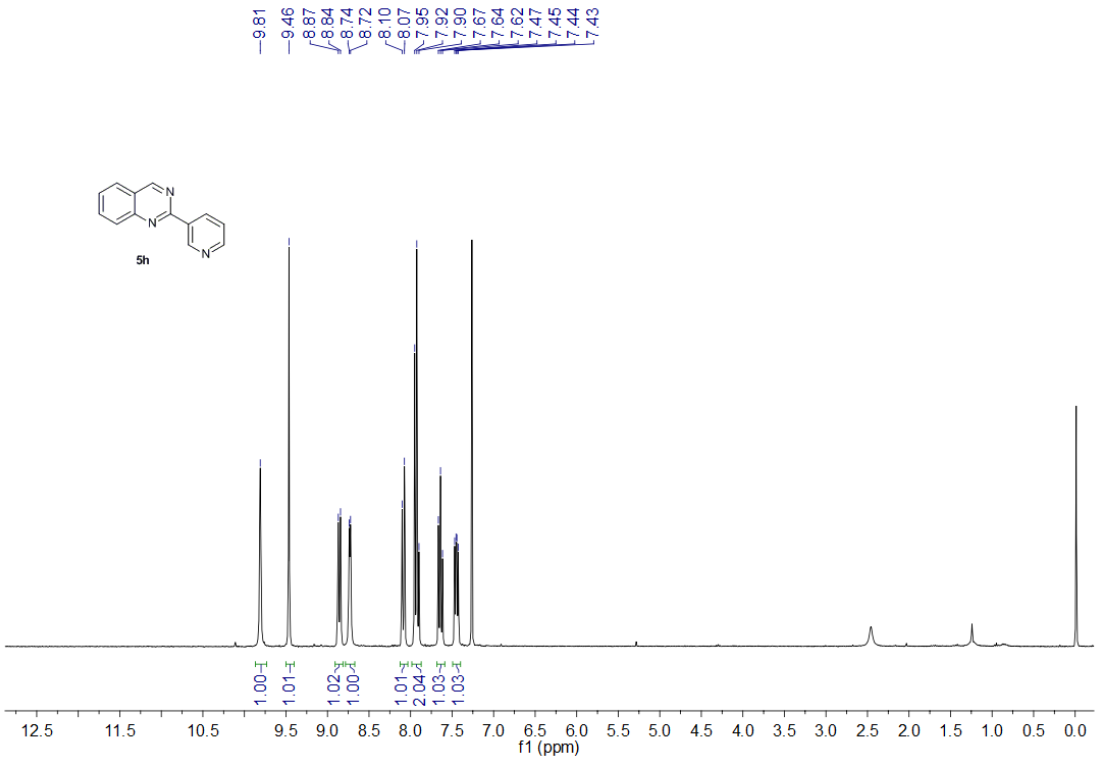
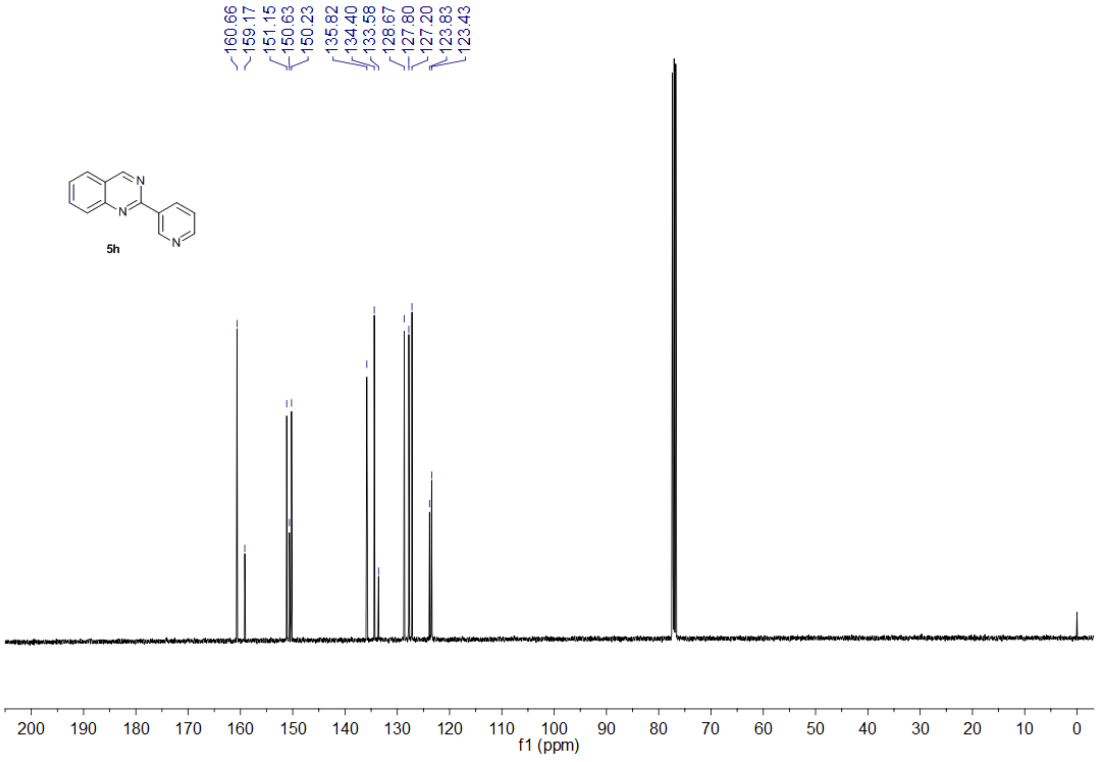
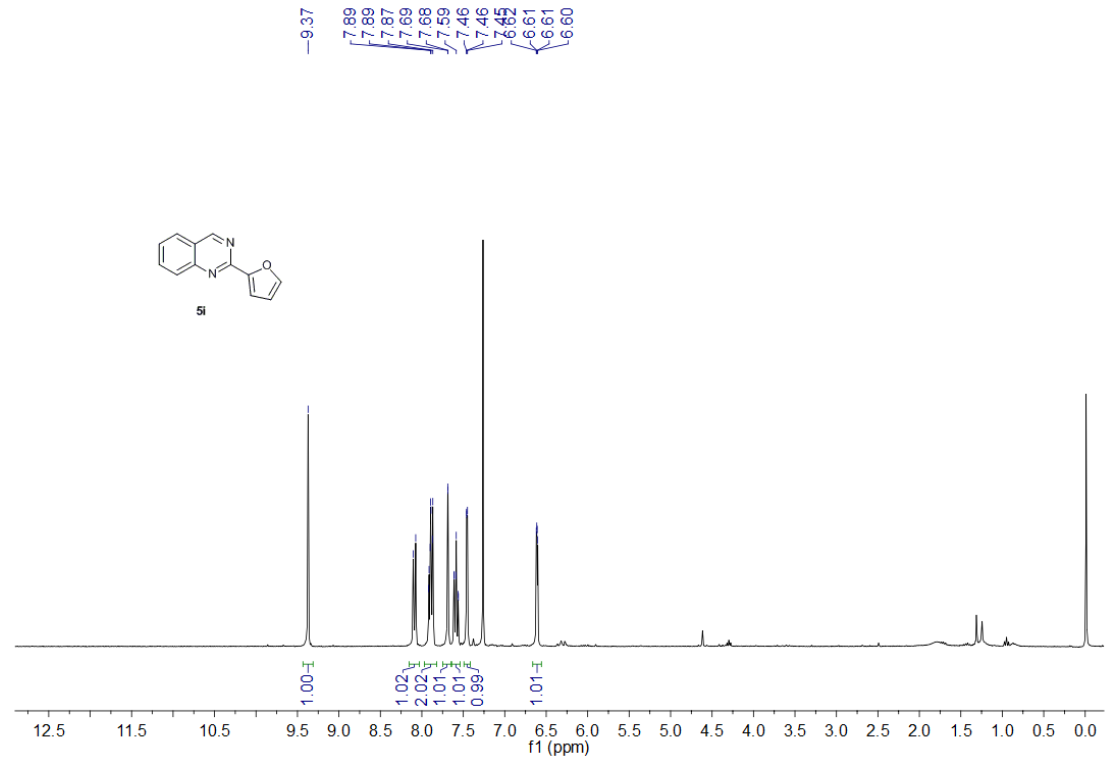
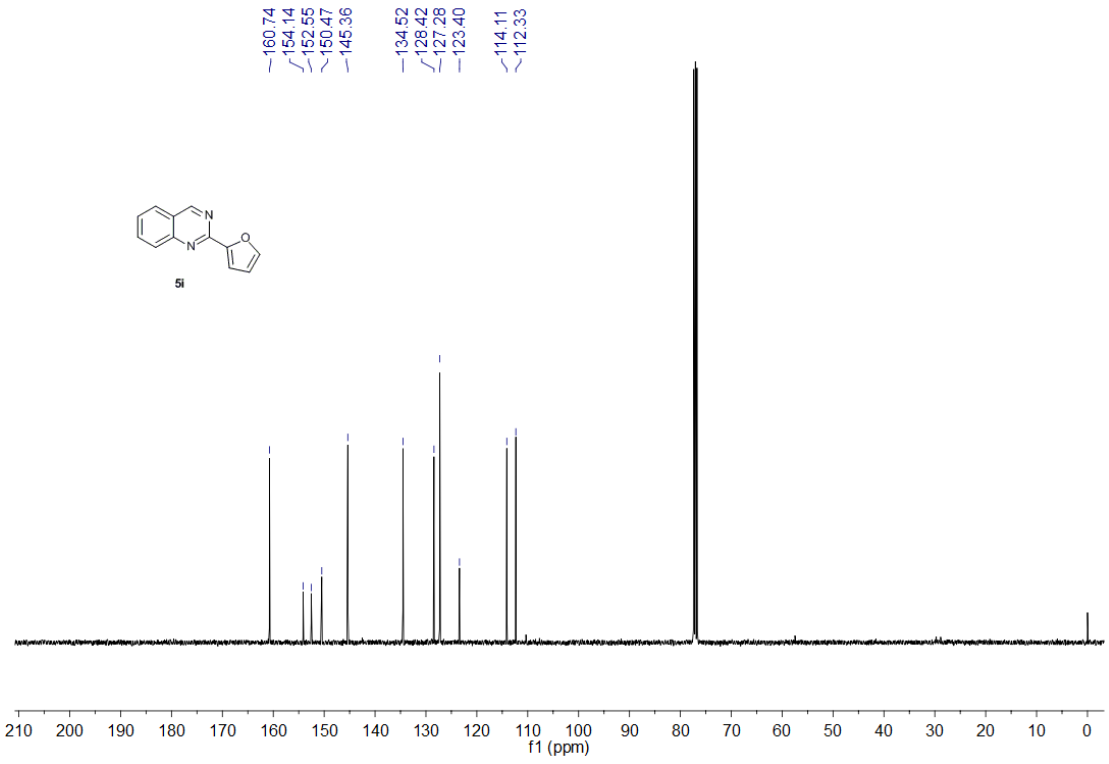
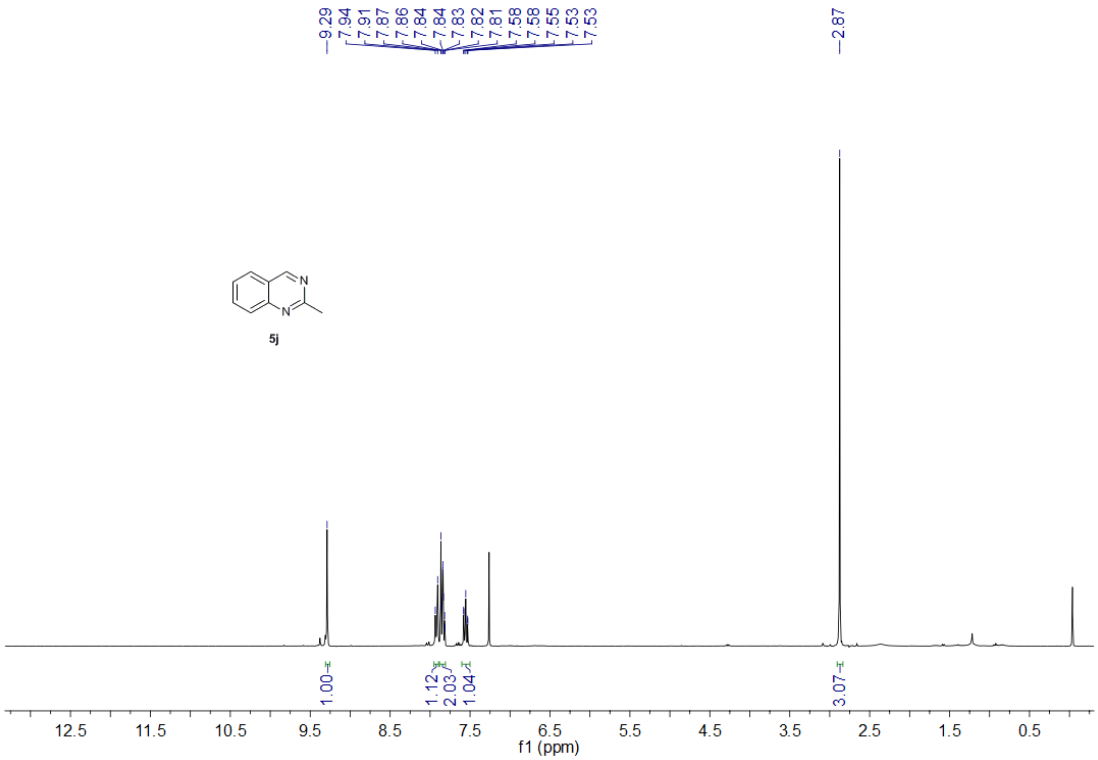
127.71
127.12
126.85
125.92
125.89
125.29
123.12
5g
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

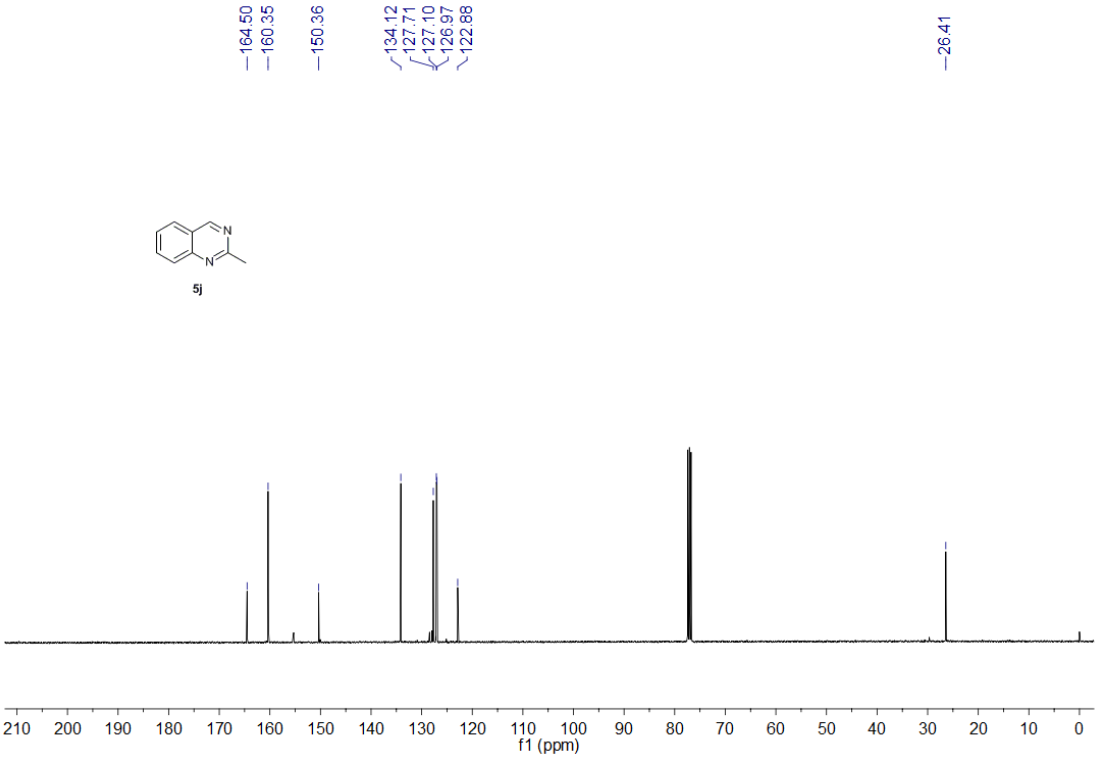


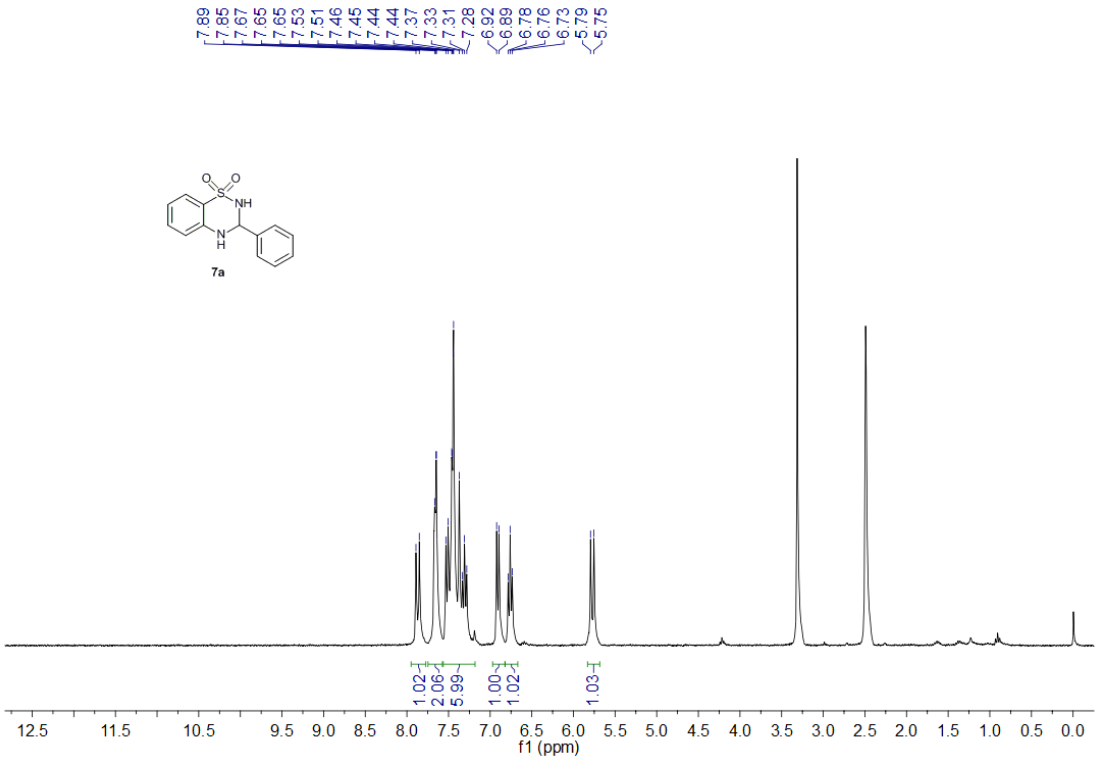








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7.31
7.28
6.92
6.89
6.78
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5.75
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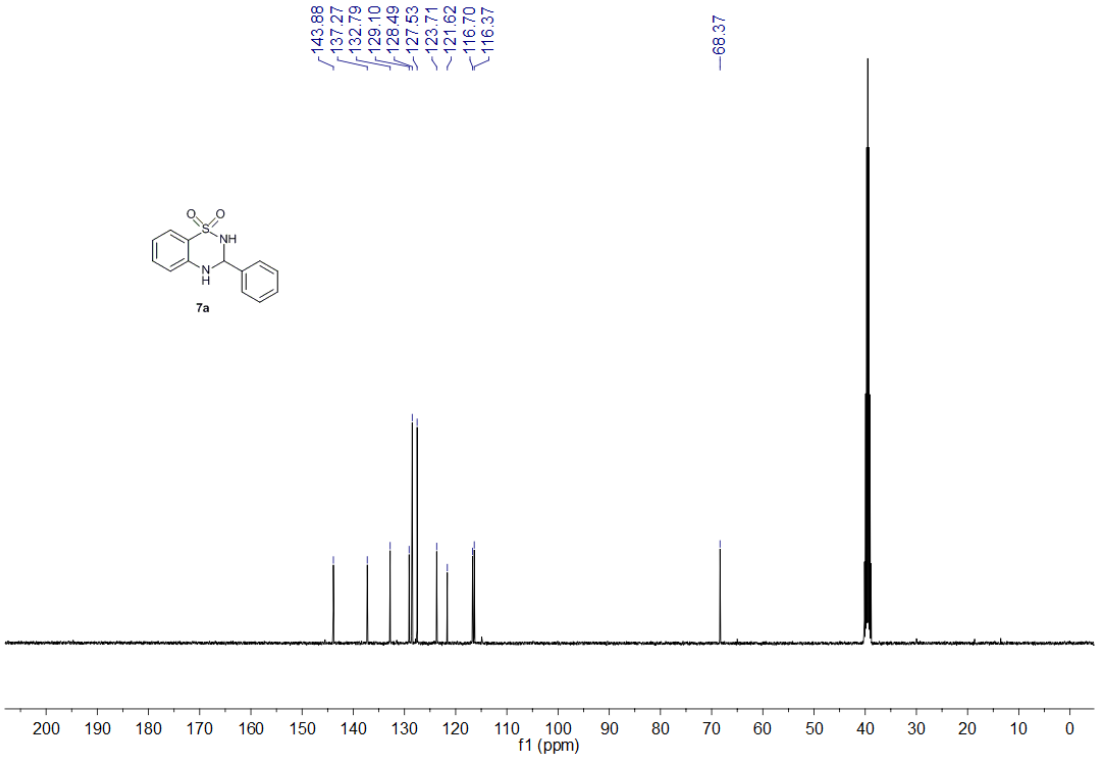
5.99
1.00
1.02
1.03
f1 (ppm)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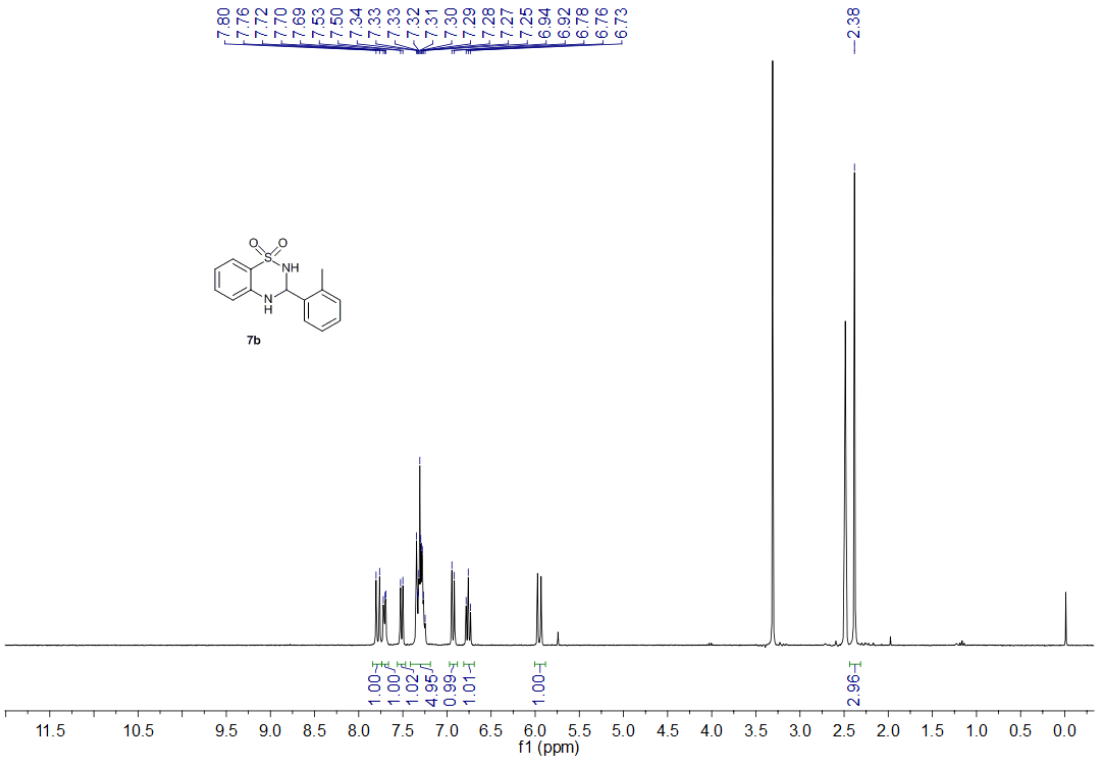
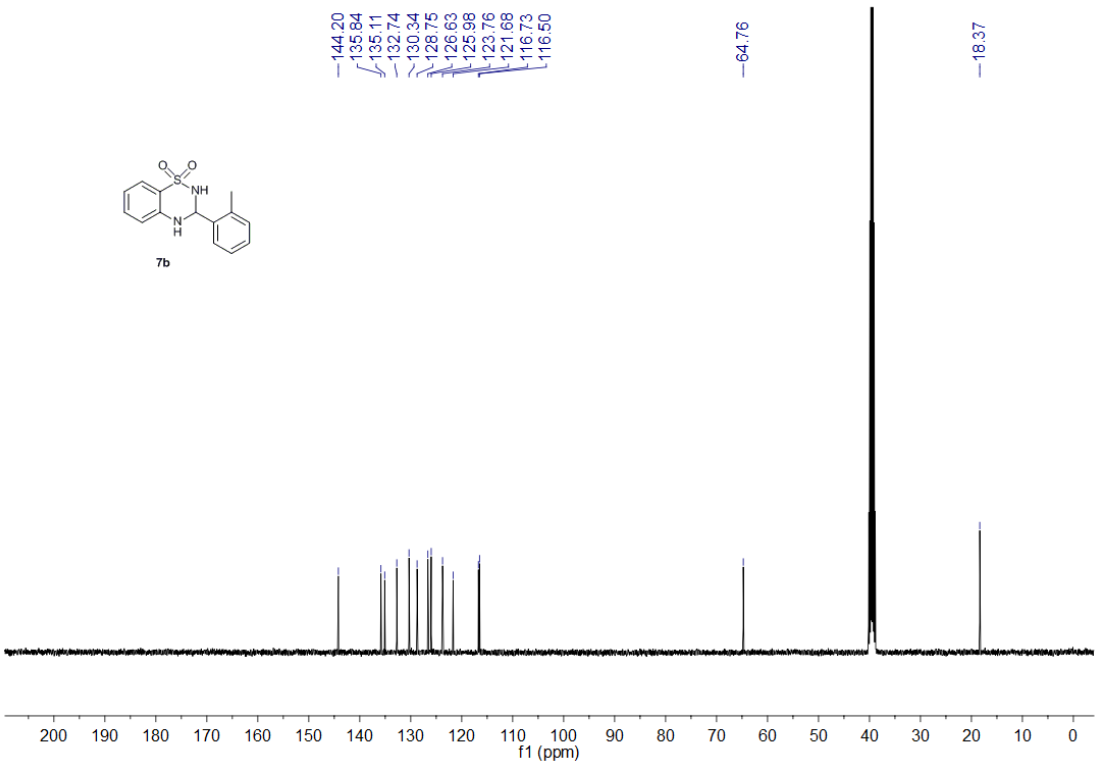
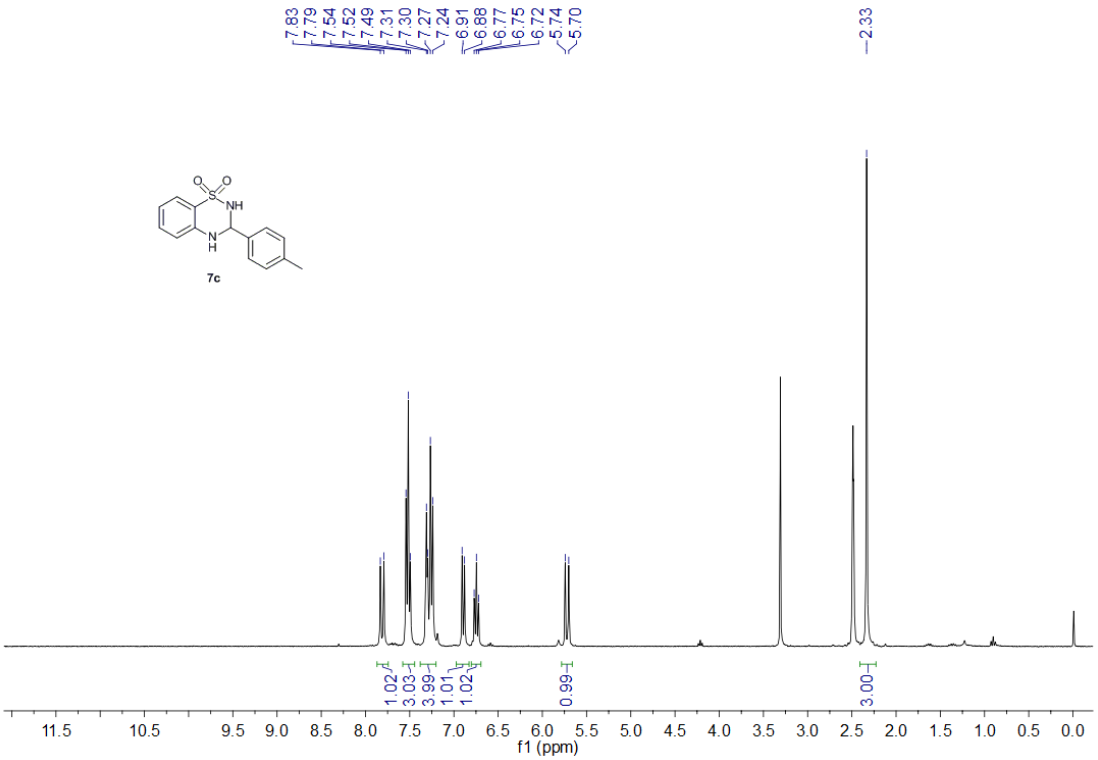
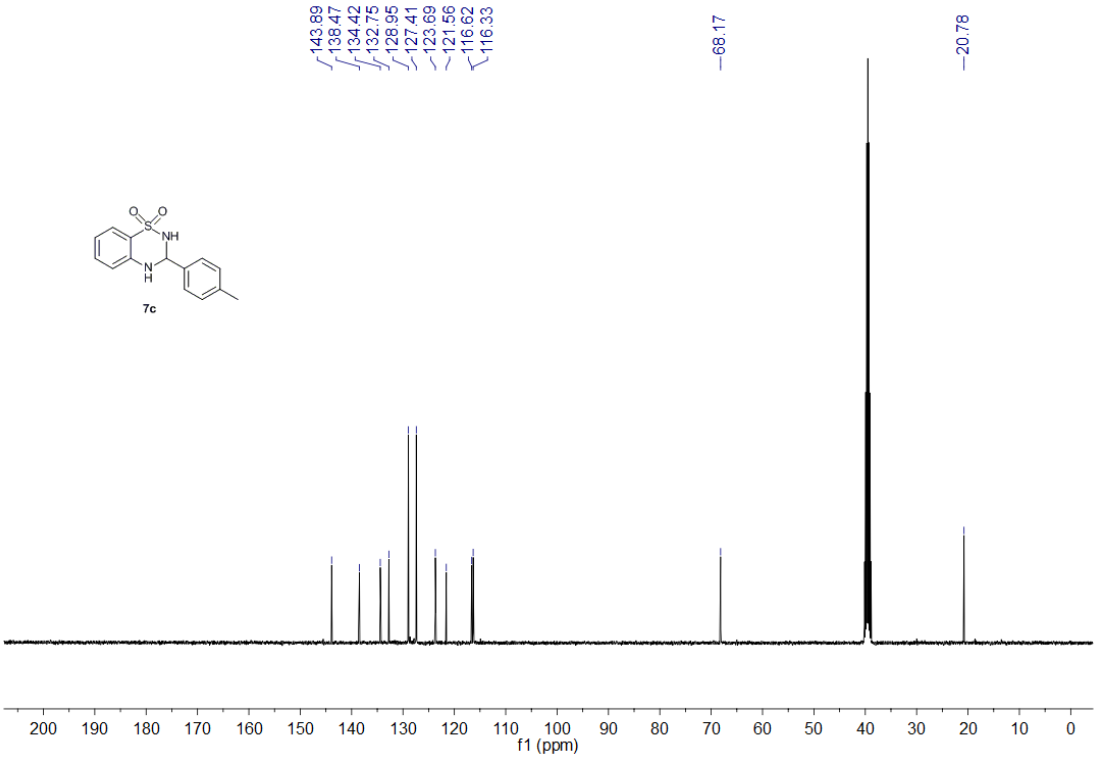
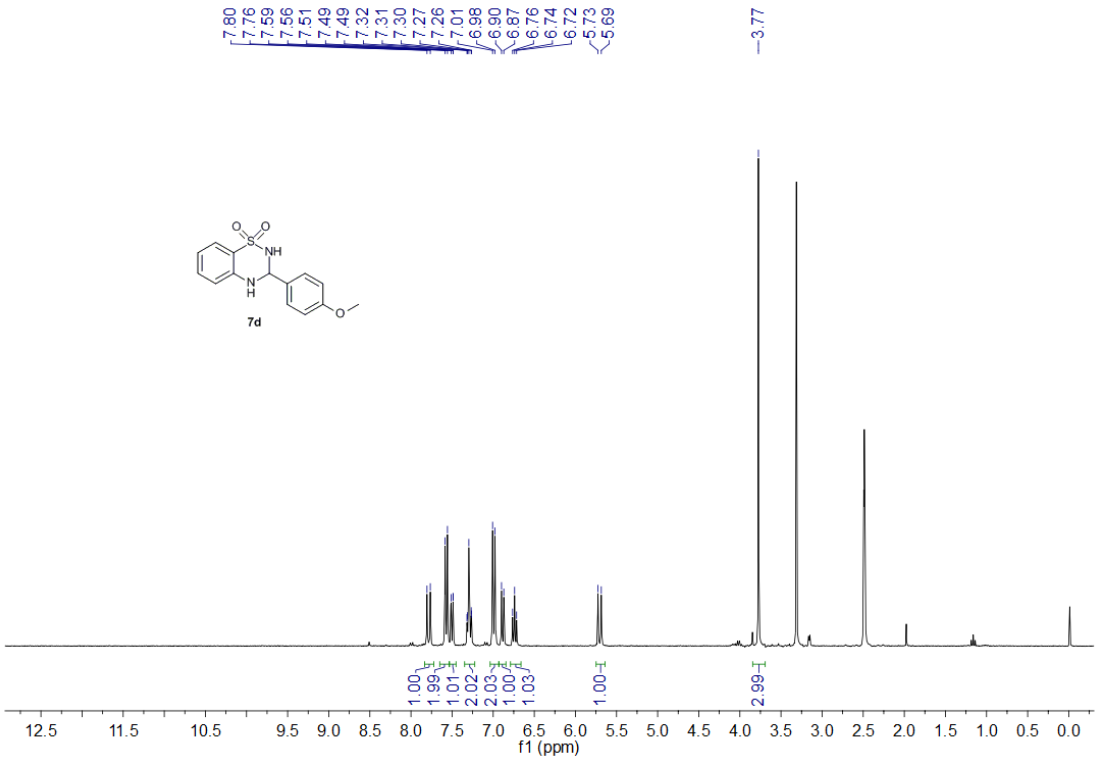
121.62
116.70
116.37
68.37
7a
f1 (ppm)







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6.90
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6.76
6.74
6.72
5.73
5.69
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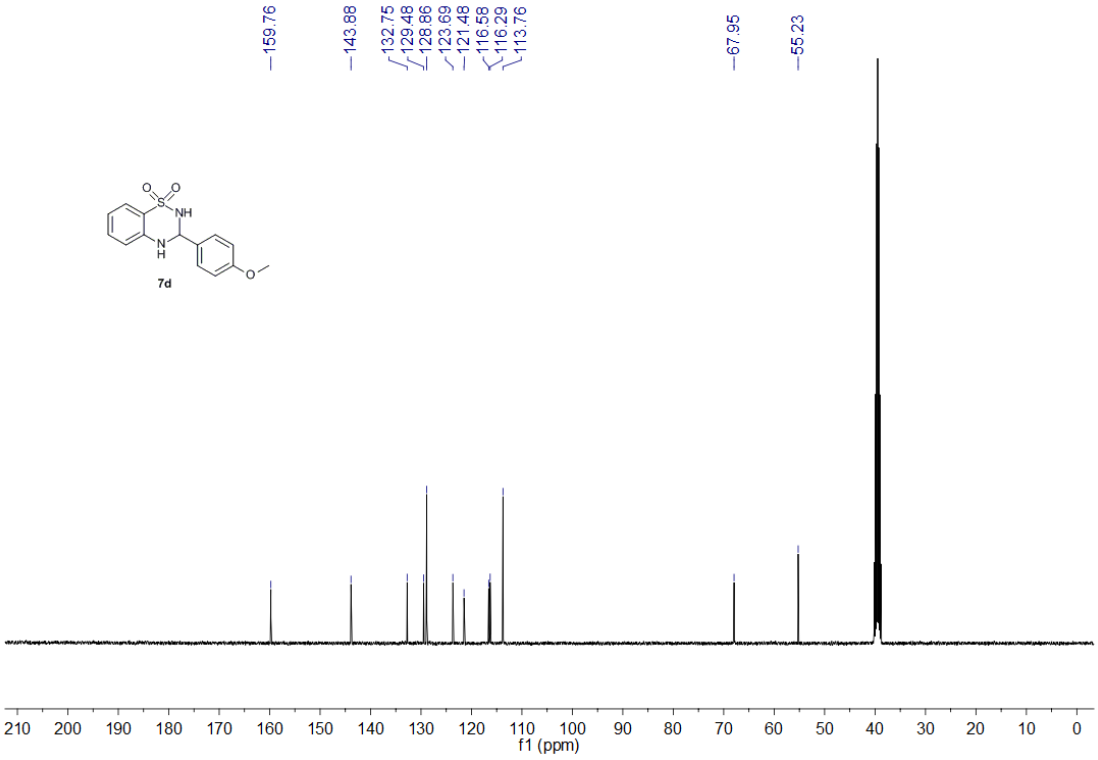
2.02
2.03
1.00
1.03
1.00
2.99
f1 (ppm)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128.86
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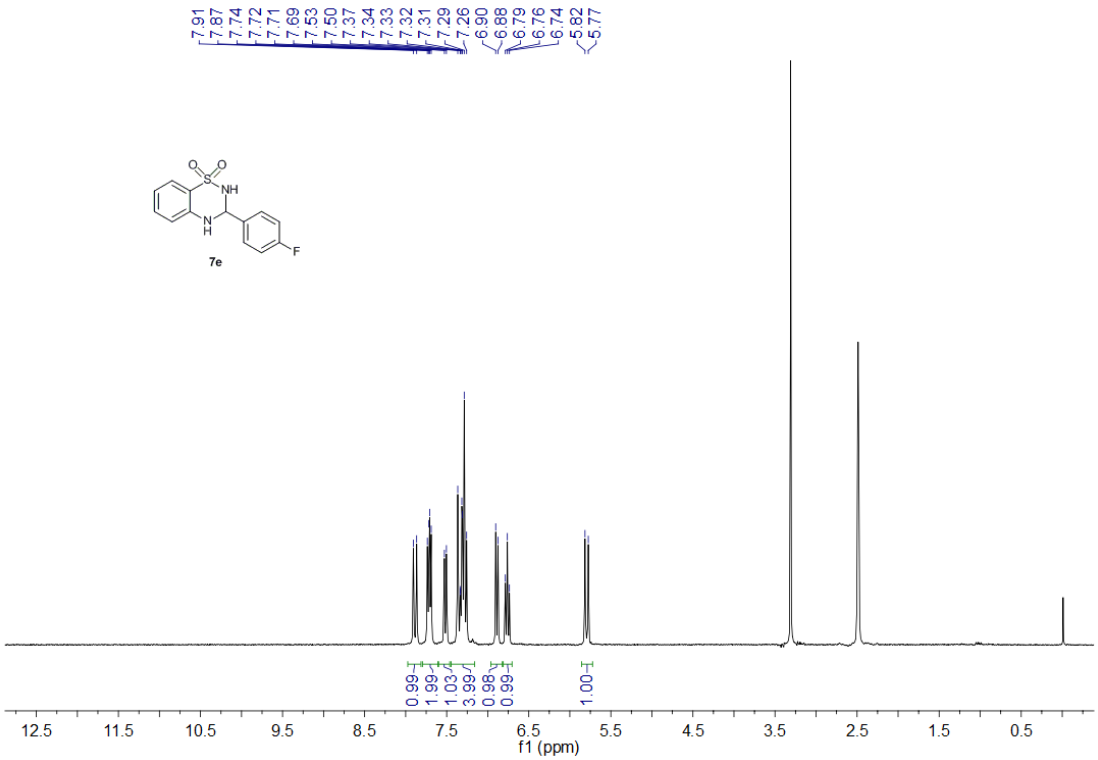
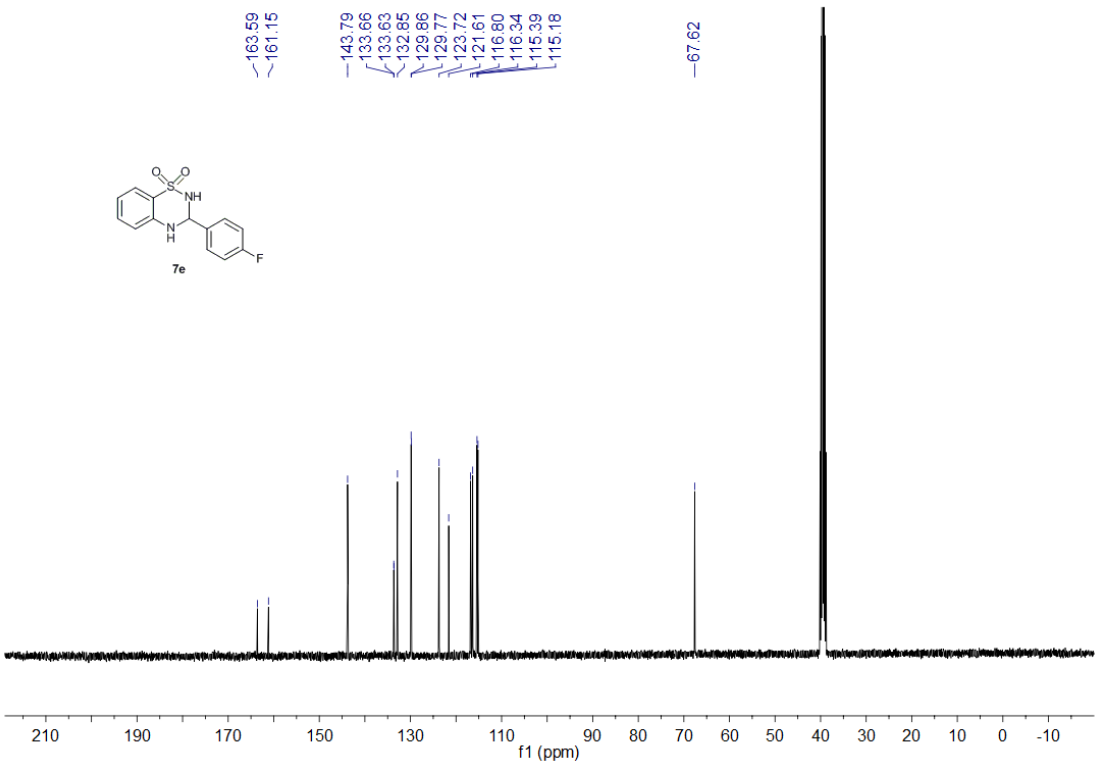
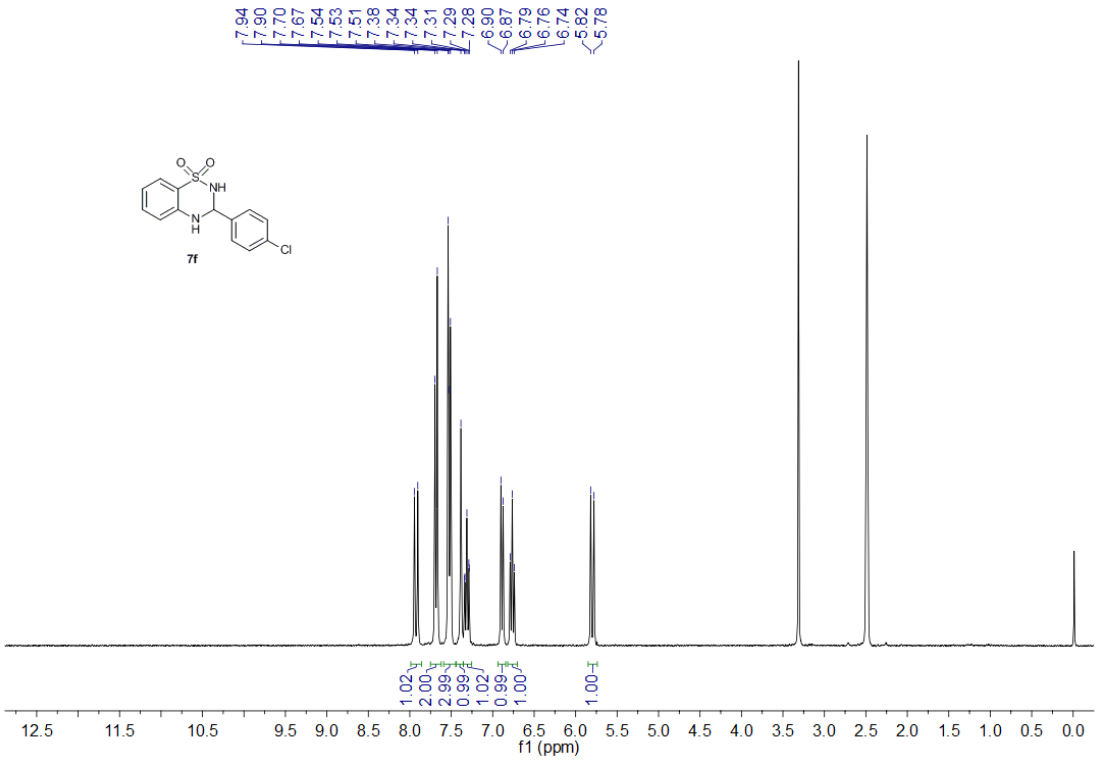
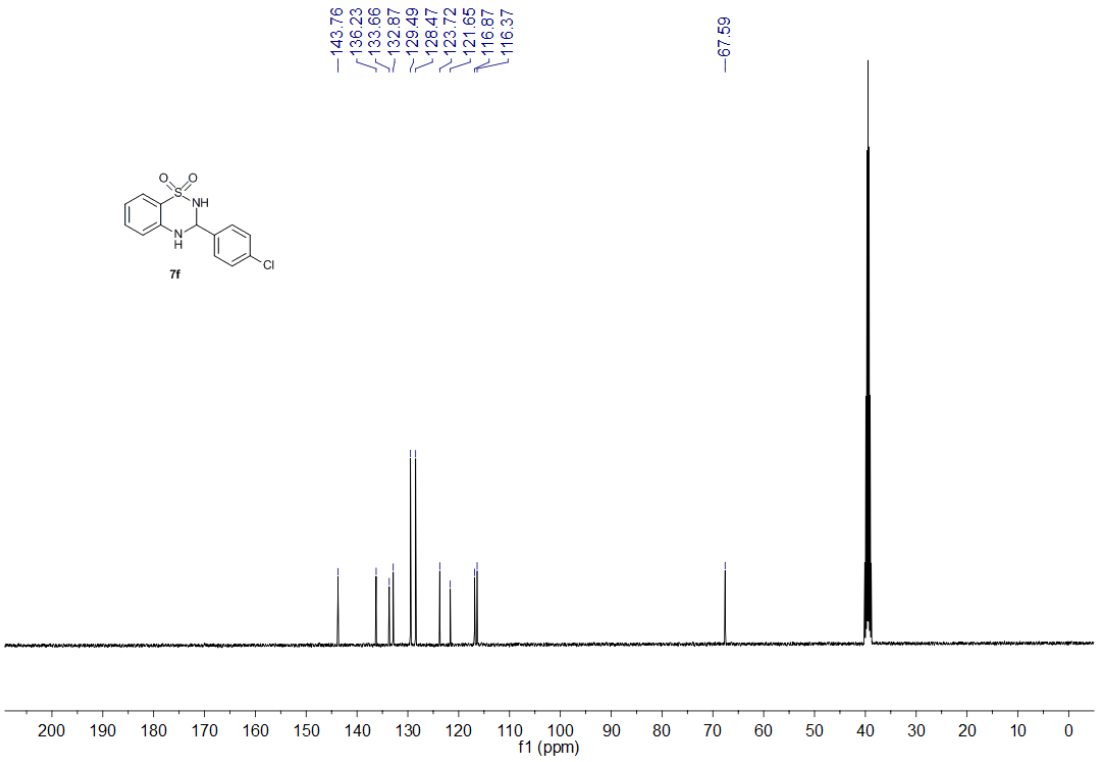
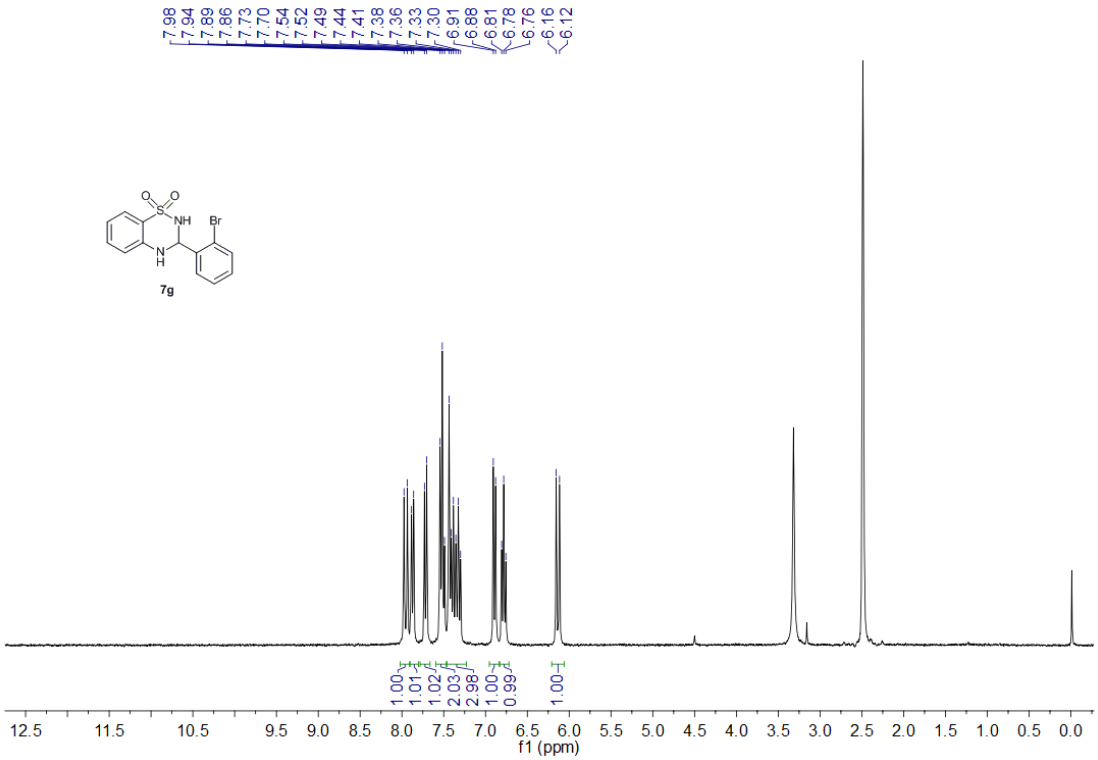
121.48
116.58
116.29
113.76
67.95
55.23
7d
f1 (ppm)

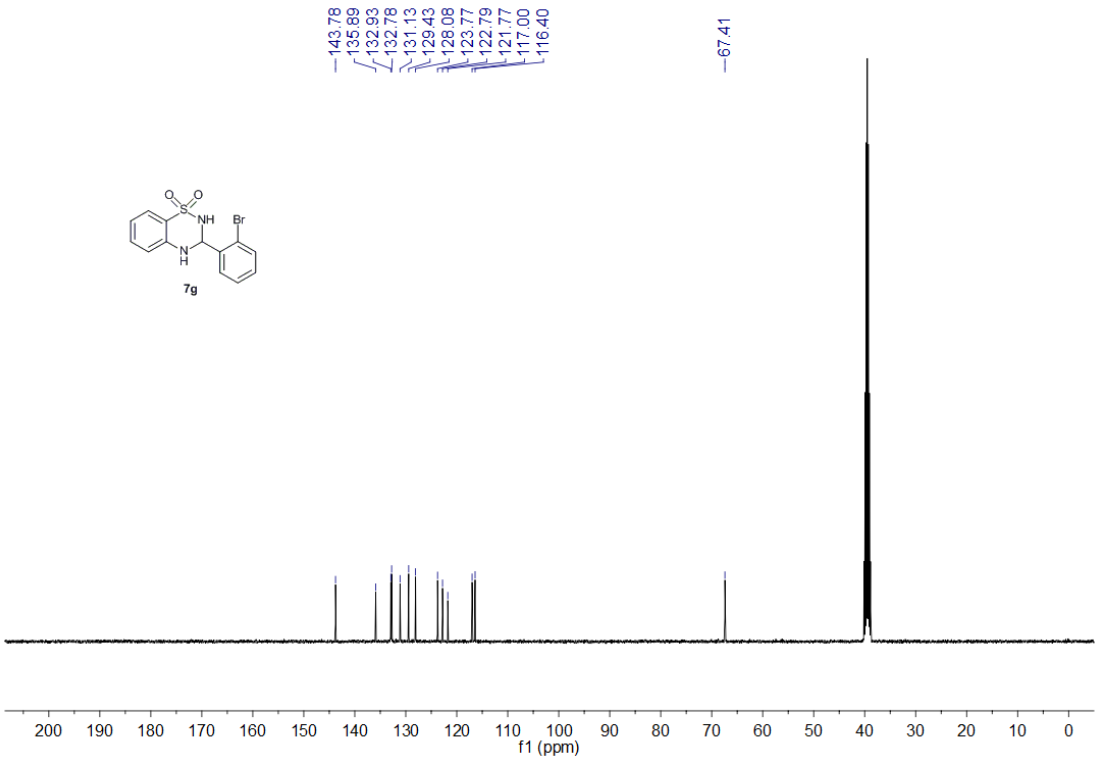









7.98
7.94
7.89
7.86
7.73
7.70
7.54
7.52
7.49
7.44
7.41
7.38
7.36
7.33
7.30
6.91
6.88
6.81
6.78
6.76
6.16
6.12
O
O
S
NH
Br
N
H
7g
1.00
1.01
1.02
2.03
2.98
1.00
0.99
1.00
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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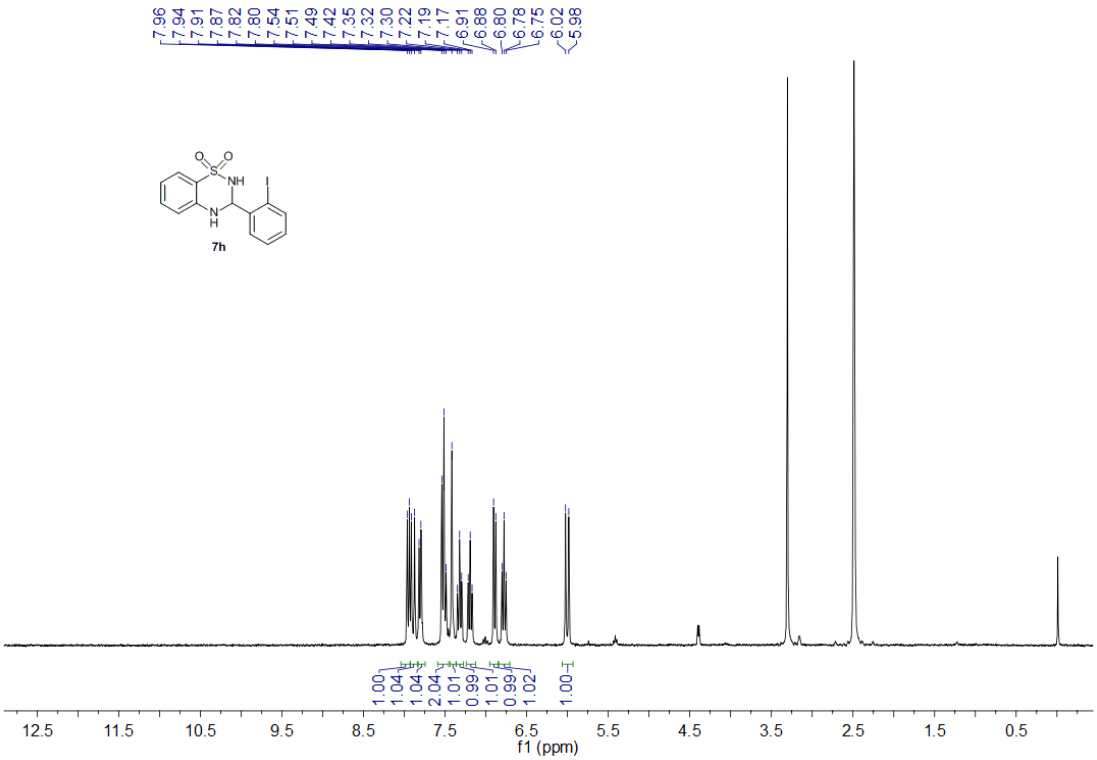
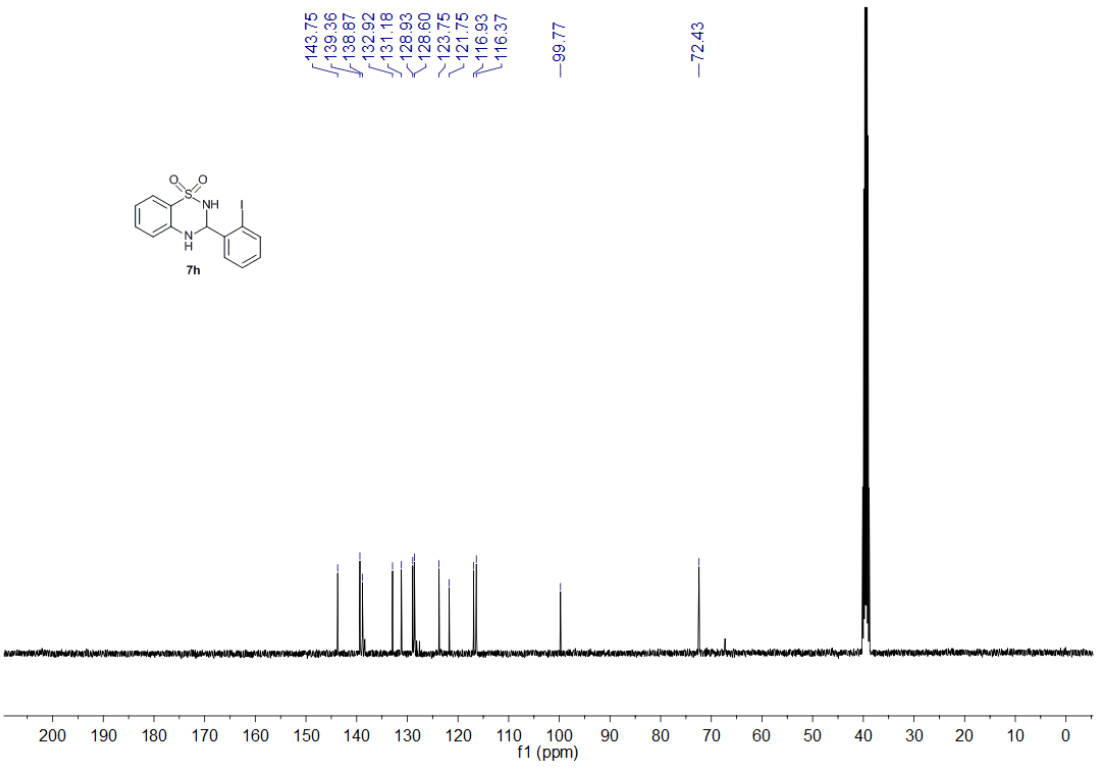
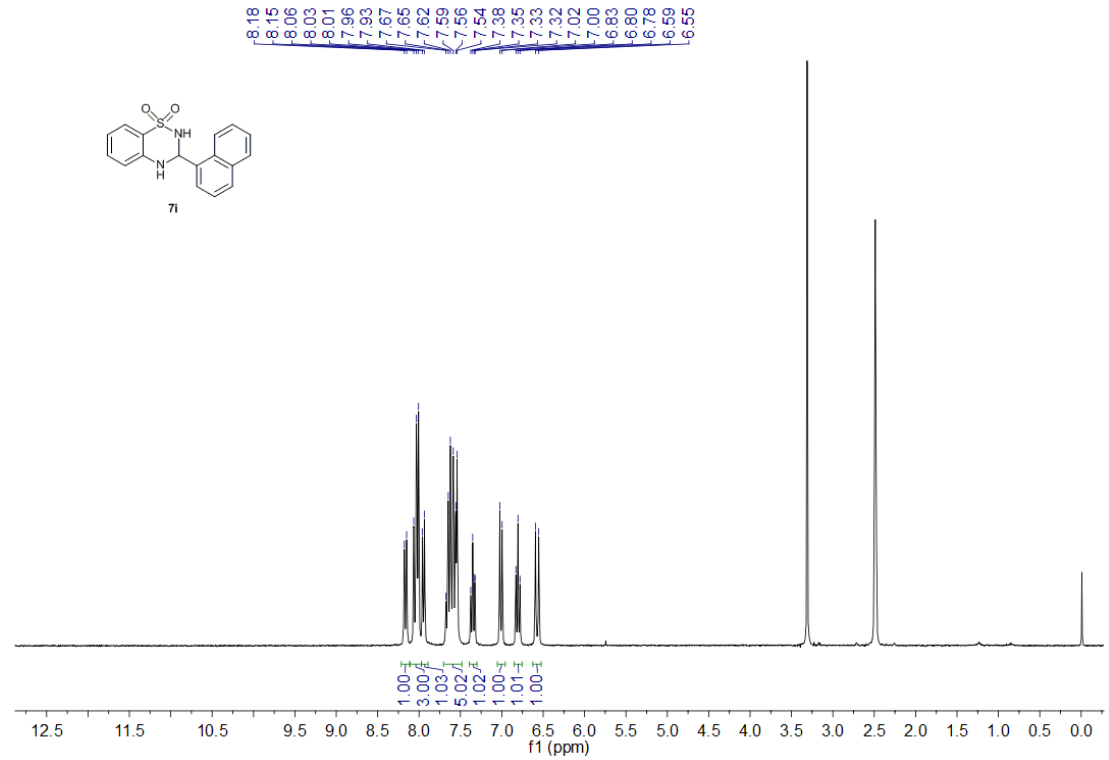
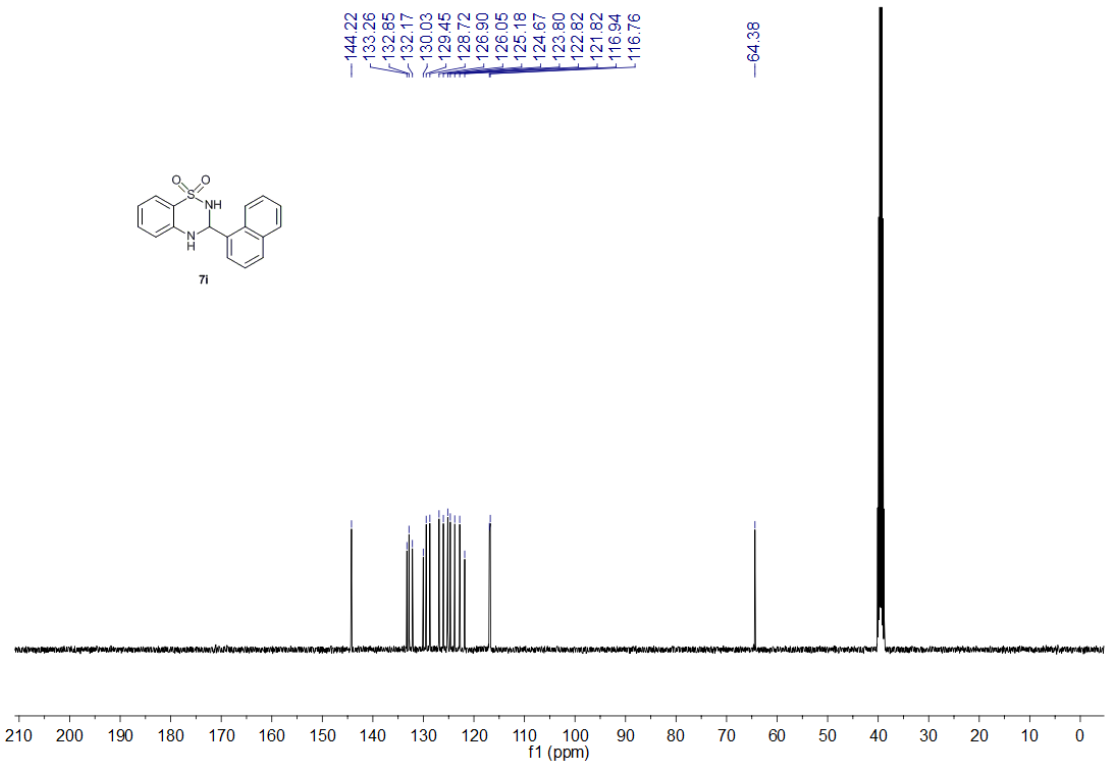
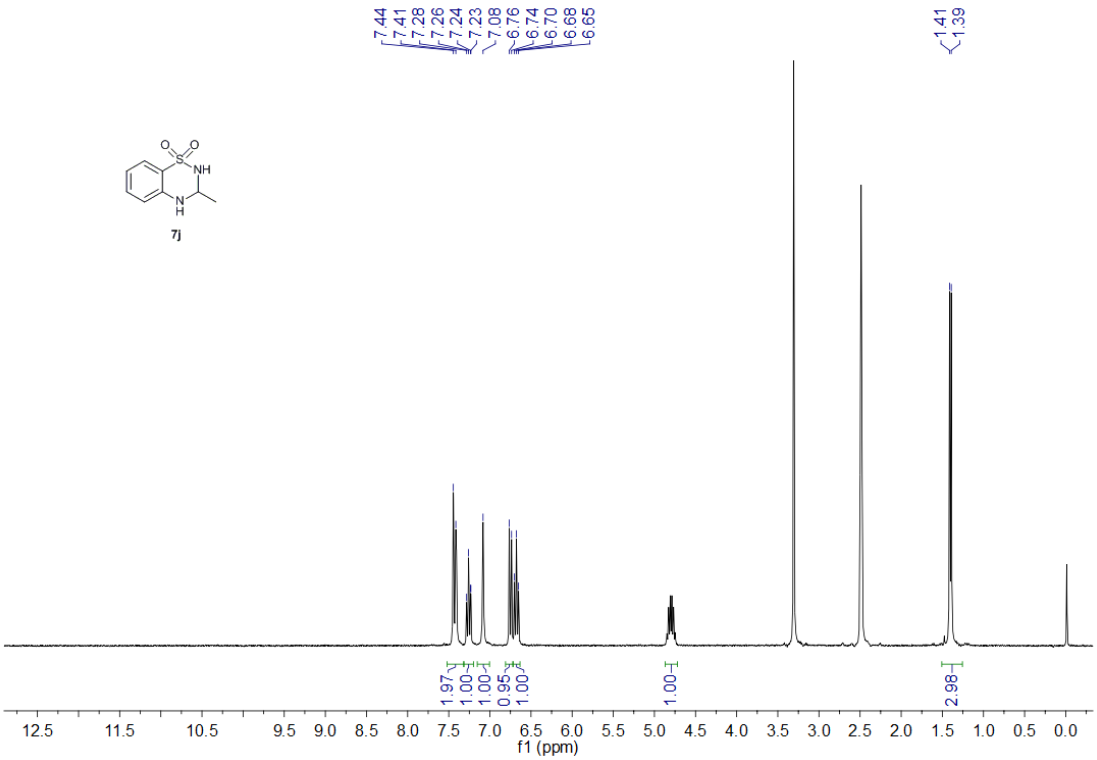
135.89
132.93
132.78
131.13
129.43
128.08
123.77
122.79
121.77
117.00
116.40
67.41
O
O
S
NH
Br
N
H
7g
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

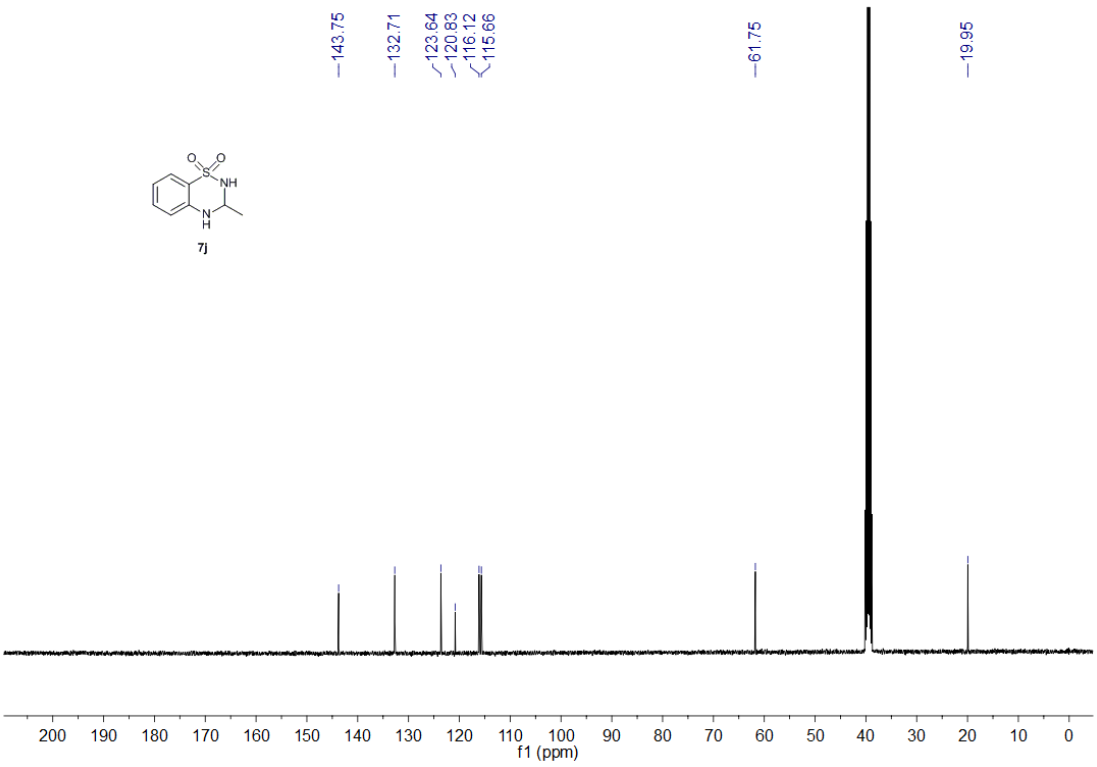

7.96
7.94
7.91
7.87
7.82
7.80
7.54
7.51
7.49
7.42
7.35
7.32
7.30
7.22
7.19
7.17
6.91
6.88
6.80
6.78
6.75
6.02
5.98
7h
1.00
1.04
1.04
2.04
1.01
0.99
1.01
0.99
1.02
1.00
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
f1 (ppm)

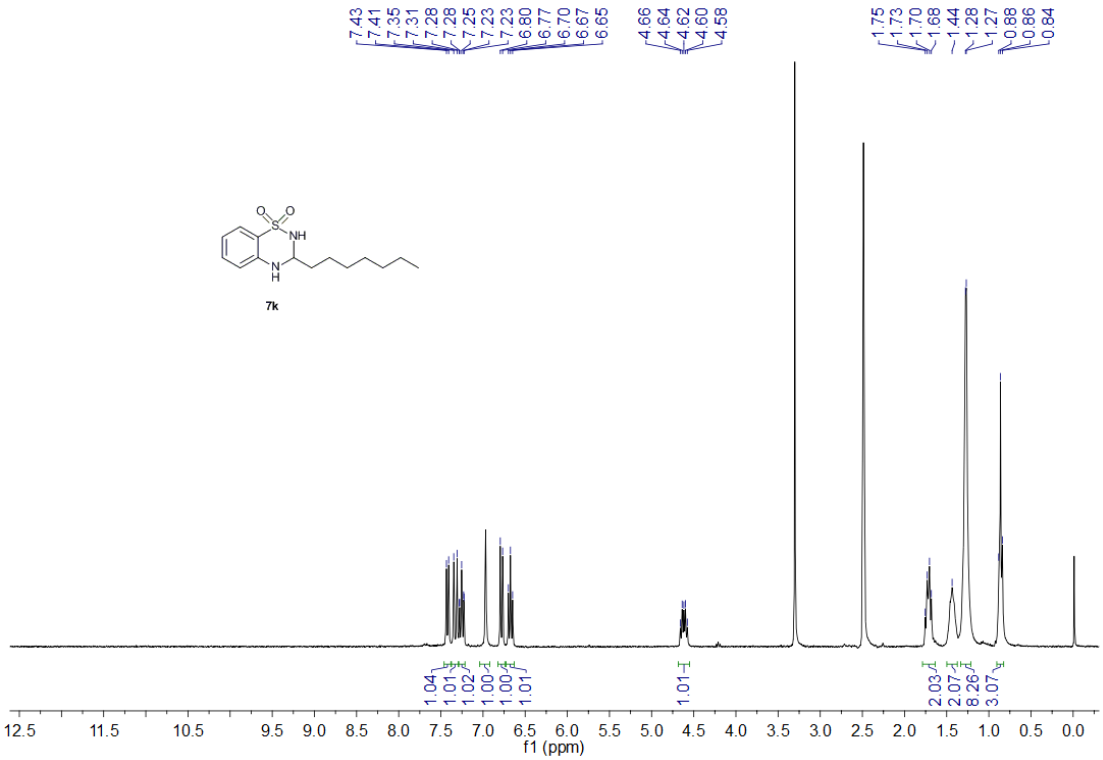

143.75
139.36
138.87
132.92
131.18
128.93
128.60
123.75
121.75
116.93
116.37
99.77
72.43
7h
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.18
8.15
8.06
8.03
8.01
7.96
7.93
7.67
7.65
7.62
7.59
7.56
7.54
7.38
7.35
7.33
7.32
7.02
7.00
6.83
6.80
6.78
6.59
6.55
7i
1.00
3.00
1.03
5.02
1.02
1.00
1.01
1.00
f1 (ppm)


144.22
133.26
132.85
132.17
130.03
129.45
128.72
126.90
126.05
125.18
124.67
123.80
122.82
121.82
116.94
116.76
64.38
7i
f1 (ppm)






7.43
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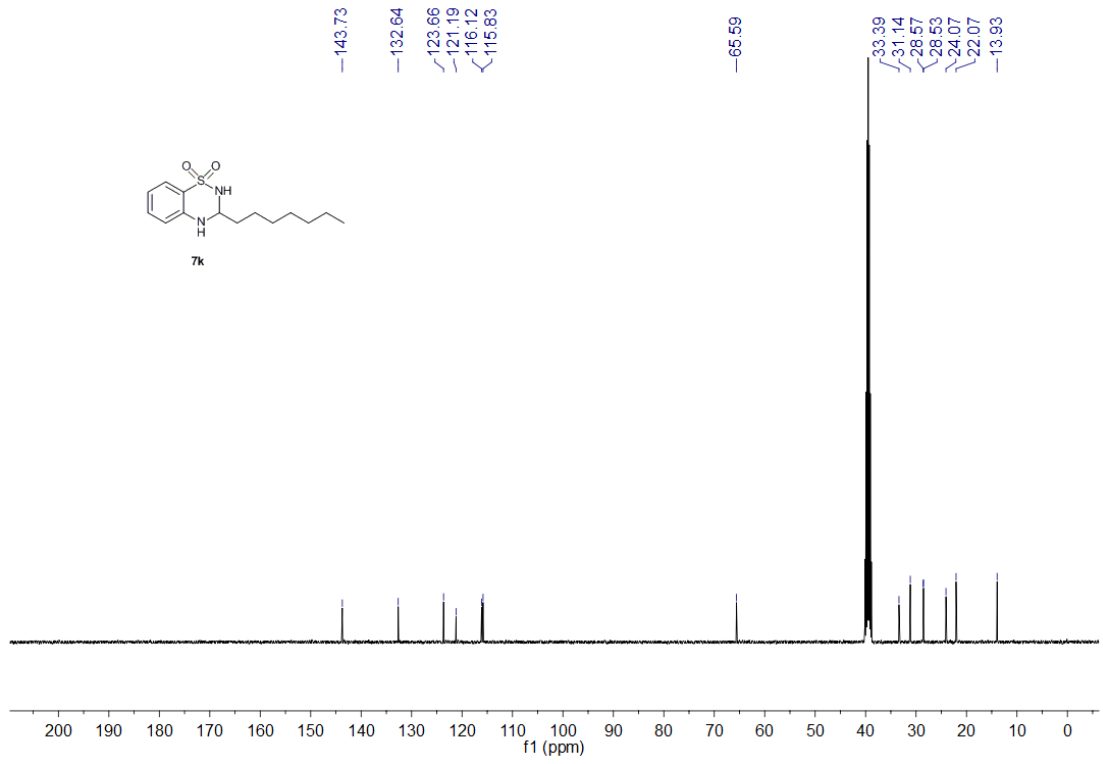
7.35
7.31
7.28
7.28
7.25
7.23
7.23
6.80
6.77
6.70
6.67
6.65
4.66
4.64
4.62
4.60
4.58
1.75
1.73
1.70
1.68
1.44
1.28
1.27
0.88
0.86
0.84
NH
N
H
7k
1.04
1.01
1.02
1.00
1.00
1.01
1.01
2.03
2.07
8.26
3.07
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


143.73
132.64
123.66
121.19
116.12
115.83
65.59
33.39
31.14
28.57
28.53
24.07
22.07
13.93
NH
N
H
7k
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)