Diversity-Oriented Heterocyclic Synthesis using Divergent Reactivity of *N*-Substituted Iso(thio)cyanates

Jean-François Vincent-Rocan, Joshua S. Derasp, André M. Beauchemin*

Centre for Catalysis Research and Innovation, *Department of Chemistry and Biomolecular Sciences*, *University of Ottawa. 10 Marie-Curie*, *Ottawa*, *ON*, *K1N 6N5*, *Canada.*

Supplementary Information

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General Information.

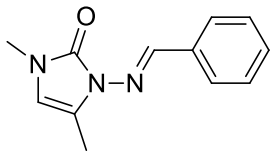
Purification of reaction products was carried out by flash column chromatography using Silicycle silica gel (40-63 μm), unless otherwise noted. Analytical thin layer chromatography (TLC) was performed on aluminum, cut to size. Visualization was accomplished with UV light followed by staining with a potassium permanganate solution and heating.

^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker AVANCE 300 MHz and 400 MHz spectrometers at ambient temperature, unless otherwise indicated. Spectral data was reported in ppm using solvent as the reference ($CDCl_3$ at 7.26 ppm, C_6D_6 at 7.15 ppm or DMSO-d_6 at 2.50 ppm for ^{1}H NMR and $CDCl_3$ at 77.0 ppm or DMSO-d_6 at 39.43 for ^{13}C NMR). ^{1}H NMR data was reported as: multiplicity (ap = apparent, br = broad, s = singlet, d = doublet, t = triplet, q = quartet, quint. = quintet, sext. = sextuplet, sept = septuplet, m = multiplet), integration and coupling constant(s) in Hz. Infrared (IR) spectra were obtained with neat thin films on a sodium chloride disk and were recorded on a Bomem Michelson 100 Fourier transform infrared spectrometer (FTIR). High-resolution mass spectroscopy (HRMS) was performed on a Kratos Concept-11A mass spectrometer with an electron beam of 70ev at the Ottawa-Carleton Mass Spectrometry Centre.

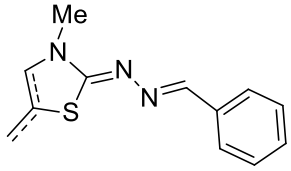
Materials

Unless otherwise noted, all commercially available materials were purchased from commercial sources and used without further purification.

General procedure A[a]: An oven-dried 5 mL microwave tube was charged with a stir bar, a carbarzone (1.0 equiv.), a propargylic amine (1.1 equiv.), Et_3N (20 mol %) and MeCN (0.3 M). The septum was removed and the tube was then quickly sealed with a microwave cap and heated for 2-6 hours at 100-150 °C in a microwave (μW) reactor. The tube was cooled to ambient temperature, concentrated under reduced pressure and purified by silica gel chromatography to give the corresponding products.

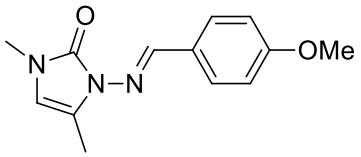


(E)-3-(Benzylideneamino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 1, 2a) : Synthesized according to general procedure A using carbazone **1a**[1] (0.144 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 35 % EtOAc/Hexane and the pure compound was obtained as an off-white solid (0.126 g, 87 %). TLC Rf = 0.21 in 35% EtOAc/Hexane. ^{1}H NMR (400 MHz; $CDCl_3$) δ 9.89 (s, 1H), 7.74-7.71 (m, 3H), 7.38-7.34 (m, 3H), 5.87 (q, *J*= 1.37 Hz, 1H), 3.17 (s, 3H), 2.13 (d, *J* = 1.4 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 150.9 (CH), 150.1 (C), 135.2 (C), 130.2 (CH), 128.6 (CH), 127.4 (CH), 120.0 (C), 106.0 (CH), 30.0 (CH_3), 10.0 (CH_3). IR (film): 2955, 2853, 1653, 1522, 1506, 1394, 903 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{12}H_{13}N_3O$ $[M]^+$: 215.1059. Found: 215.1056.

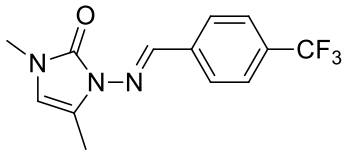


Equation 1 : Synthesized according to general procedure A using thiosemicarbazone **1n**[6] (0.180 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. NMR analysis showed a ratio of 63 / 37 of products with exocyclic and endocyclic double bonds. A 6 hours reaction gave 67 % (exo) and 27 % and 2 hours at 150 °C gave 70 % and 27 % while comparing to phenol production.

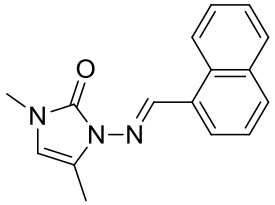
[a] During the optimization process, it has been observed that partial cyclization could also be obtained at 50 °C using DBU as base (20 mol%) in THF(0.3 M). Using **2a** under these conditions, 38% of product **2a** along with 62% of the uncyclized substitution product was observed after 18 hours.



(E)-3-((4-Methoxybenzylidene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2b): Synthesized according to general procedure A using carbazone **1b**[1] (0.162 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a off-white solid (0.126 g, 87 %). TLC Rf = 0.18 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ 9.84 (s, 1H), 7.74-7.69 (m, 2H), 6.96-6.91 (m, 2H), 5.91-5.90 (m, 1H), 3.85 (s, 3H), 3.23 (s, 3H), 2.16 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 161.3 (C), 151.1 (CH), 129.9 (CH), 127.9 (C), 120.0 (C), 114.0 (CH), 105.6 (CH), 55.3 (CH_3), 29.9 (CH_3), 9.9 (CH_3). IR (film): 1674, 1653, 1609, 1516, 1398, 1263, 1250, 1180, 1169, 1030 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{13}H_{15}N_3O_2$ $[M]^+$: 245.1164. Found: 245.1123.

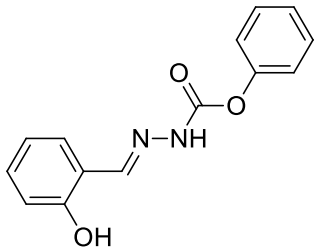


(E)-1,4-Dimethyl-3-((4-(trifluoromethyl)benzylidene)amino)-1H-imidazol-2(3H)-one (Table 2, 2c): Synthesized according to general procedure A using carbazone **1c**[2] (0.185 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow solid (0.141 g, 83 %). TLC Rf = 0.32 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ 10.00 (s, 1H), 7.87 (d, *J* = 8.1 Hz, 2H), 7.66 (d, *J* = 8.1 Hz, 2H), 5.98-5.92 (m, 1H), 3.24 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 148.8 (CH), 127.3 (CH), 125.5 (CH), 119.9 (C), 106.4 (CH), 29.9 (CH_3), 9.9 (CH_3). IR (film): 1680, 1560, 1429, 1400, 1321, 1255, 1180, 1166 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{13}H_{12}N_3OF_3$ $[M]^+$: 283.0932. Found: 283.0983.

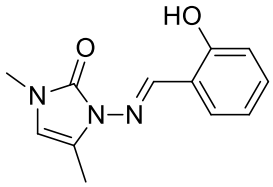


(E)-1,4-Dimethyl-3-((naphthalen-1-ylmethylene)amino)-1H-imidazol-2(3H)-one (Table 2, 2d) : Synthesized according to general procedure A using carbazone **1d**[1] (0.174 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow solid (0.146 g, 92 %). TLC Rf = 0.37 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ

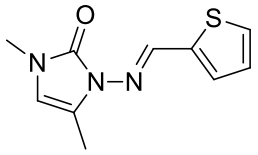
10.71 (s, 1H), 8.67 (dd, *J* = 8.3, 0.9 Hz, 1H), 8.06 (dd, *J* = 7.3, 1.0 Hz, 1H), 7.93-7.88 (m, 2H), 7.61-7.50 (m, 3H), 5.96 (q, *J* = 1.2 Hz, 1H), 3.27 (s, 3H), 2.25 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 150.6 (CH), 130.7 (CH), 130.7 (C), 128.6 (CH), 127.0 (C), 126.9 (CH), 126.4 (CH), 126.0 (CH), 125.3 (CH), 124.1 (CH), 120.1 (C), 29.9 (CH_3), 10.1 (CH_3). IR (film): 1693, 1564, 1539, 1472, 1420, 1288, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{16}H_{15}N_3O$ $[M]^+$: 265.1215. Found: 265.1224.



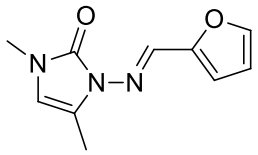
(E)-Phenyl 2-(2-hydroxybenzylidene)hydrazinecarboxylate (Table 2, 1e): Phenyl carbazate (2.53 g, 16.6 mmol) was dissolved in methanol (50.0 mL) completely in a round bottom flask charged with a stir bar. Salicylaldehyde (1.77 mL, 16.7 mmol) was then added to the mixtue. The mixture was stirred at room temperature for 1 hour. The precipitate was then filtered and recrystallized in boiling EtOAc followed by a few drops of hexanes yielding the title compound as thin colorless needles (1.372 g, 32% yield). ^{1}H NMR (300 MHz; DMSO-d_6): δ 11.81 (br s, 1H), 10.71 (br s, 1H), 8.40 (br s, 1H), 7.56 (dd, *J* = 7.7, 1.6 Hz, 1H) 7.47-7.40 (m, 2H) 7.30-7.21 (m, 4H), 6.93-6.86 (m, 2H). ^{13}C NMR (75 MHz; DMSO-d_6) δ 156.9 (C), 145.5 (C), 131.2 (CH), 139.5 (CH), 128.4 (CH) 125.6 (CH), 121.8 (CH), 119.4 (CH), 119.0 (C), 116.3 (CH), IR (film) 1684, 1675, 1663, 1649, 1514, 1456, 1393, 1307, 1248, 1166 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{14}H_{12}N_2O_3$l $[M]^+$: 256.0845 Found: 256.0850



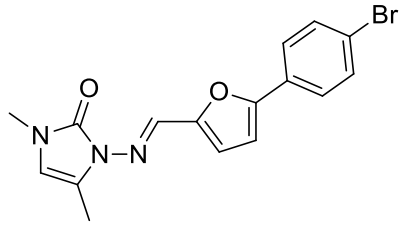
(E)-3-((2-Hydroxybenzylidene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2e) : Synthesized according to general procedure A using carbazone **1e** (0.154 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a white solid (0.122 g, 92 %). TLC Rf = 0.4 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ 10.87 (br s, 1H), 9.99 (s, 1H), 7.35-7.26 (m, 2H), 6.99-6.99 (m, 2H), 5.96 (s, 1H), 3.24 (s, 3H), 2.16 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 158.4 (C), 155.3 (CH), 132.1 (CH), 132.0 (CH), 119.7 (CH), 118.5 (C), 118.0 (C), 116.9 (CH), 106.5 (CH), 30.0 (CH_3), 9.9 (CH_3). IR (film): 1700, 1684, 1556, 1398, 1379, 1255 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{12}H_{13}N_3O_2$ $[M]^+$: 231.1008. Found: 231.1007.



(E)-1,4-Dimethyl-3-((thiophen-2-ylmethylene)amino)-1H-imidazol-2(3H)-one (Table 2, 2f) : Synthesized according to general procedure A using carbazone **1f**[l] (0.148 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a white solid (0.116 g, 87 %). TLC Rf = 0.29 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ 10.06 (s, 1H), 7.36 (dd, *J* = 9.4, 4.3 Hz, 2H), 7.08-7.05 (m, 1H), 5.93-5.89 (m, 1H) 3.22 (s, 3H), 2.14 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 145.7 (CH), 140.4 (C), 130.6 (CH), 128.1 (CH), 127.5 (CH), 119.8 (C), 118.5 (C), 105.9 (CH), 29.9 (CH_3), 9.8 (CH_3). IR (film): 1690, 1431, 1397, 1387, 1310, 1256 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{10}H_{11}N_3OS$ $[M]^+$: 221.0623. Found: 221.0599.

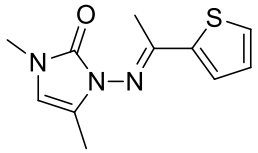


(E)-3-((Furan-2-ylmethylene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2g) : Synthesized according to general procedure A using carbazone **1g**[1] (0.138 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 2 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a white solid (0.105 g, 85 %). TLC Rf = 0.32 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$): δ 9.83 (s, 1H), 7.54 (d, *J* = 1.4 Hz, 1H), 6.76 (dd, *J* = 3.4, 0.5 Hz, 1H), 6.49 (dd, *J* = 3.4, 1.7 Hz, 1H), 5.91 (q, *J* = 1.2 Hz, 1H), 3.21 (s, 3H), 2.16 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 150.1 (C), 145.6 (CH), 140.8 (CH), 119.9 (C), 114.3 (CH), 111.8 (CH), 106.0 (CH), 29.9 (CH_3), 9.9 (CH_3). IR (film): 1695, 1653, 1558, 1433, 1398, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{10}H_{11}N_3O_2$ $[M]^+$: 205.0851. Found: 205.0866.

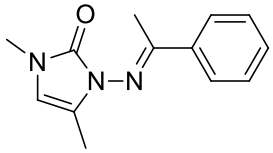


(E)-3-(((5-(4-Bromophenyl)furan-2-yl)methylene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2h) : Synthesized according to general procedure A using carbazone **1h**[3] (0.231 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by filtration and the pure compound was obtained as a light brown solid (0.175 g, 80 %). TLC Rf = 0.41 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; DMSO-d_6) δ 9.73 (s, 1H), 7.73-7.62 (m, 4H), 7.20-7.10 (m, 2H), 6.34 (s, 1H), 3.12 (s, 3H), 2.09 (s, 3H). ^{13}C NMR (100 MHz; DMSO-*d*6): δ

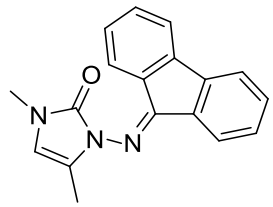
153.8 (C), 149.3 (C), 139.4 (CH), 131.9 (CH), 128.6 (C), 125.8 (CH), 121.3 (C), 118.3 (CH), 117.0 (C), 109.1 (CH), 107.1 (CH), 29.6 (CH_3), 9.6 (CH_3). IR (film): 1657, 1556, 1436, 1251, 1067, 1028 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{16}H_{14}N_3O_2Br$ $[M]^+$: 359.0269. Found: 359.0244.



(E)-1,4-Dimethyl-3-((1-(thiophen-2-yl)ethylidene)amino)-1H-imidazol-2(3H)-one (Table 2, 2i) : Synthesized according to general procedure A using carbazone **1i**[1] (0.156 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 40 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow oil (0.120 g, 85 %). TLC Rf = 0.16 in 40% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 7.51 (dd, *J* = 3.7, 1.2 Hz, 1H), 7.42 (dd, *J* = 5.1, 1.1 Hz, 1H), 7.07 (dd, *J* = 5.1, 3.7 Hz, 1H), 5.97 (q, *J* = 1.3 Hz, 1H), 3.24 (s, 3H), 2.42 (s, 3H), 2.03 (d, *J* = 1.2 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 165.6 (C), 142.2 (C), 129.9 (CH), 129.4 (CH), 127.3 (CH), 119.7 (C), 106.7 (CH), 30.4 (CH_3), 17.6 (CH_3), 10.0 (CH_3). IR (film): 1695, 1670, 1652, 1553, 1431, 1396, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{11}H_{13}N_3OS$ $[M]^+$: 235.0779. Found: 235.0803.

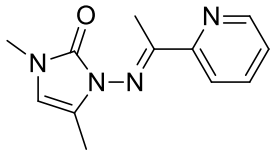


(E)-1,4-Dimethyl-3-((1-phenylethylidene)amino)-1H-imidazol-2(3H)-one (Table 2, 2j) : Synthesized according to general procedure A using carbazone **1j**[1] (0.153 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 40 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow oil (0.100 g, 73 %). TLC Rf = 0.3 in 40% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 7.96-7.90 (m, 2H), 7.47-7.34 (m, 3H), 5.98 (q, *J* = 1.3 Hz, 1H), 3.23 (s, 3H), 2.39 (s, 3H), 2.03 (d, *J* = 1.4 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 170.9 (C), 148.3 (C), 137.1 (C), 130.5 (CH), 128.2 (CH), 127.2 (CH), 119.5 (C), 106.7 (CH), 30.3 (CH_3), 17.6 (CH_3), 10.0 (CH_3). IR (film): 1680, 1558, 1506, 1433, 1398, 1385, 1355, 1265, 1180 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{13}H_{15}N_3O$ $[M]^+$: 229.1215. Found: 229.1220.

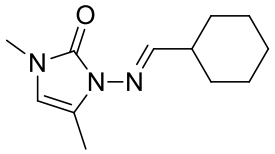


3-((9H-Fluoren-9-ylidene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2k) : Synthesized according to general procedure A using carbazone **1k**[4] (0.189 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0

mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/CH_2Cl_2 and the pure compound was obtained as an orange solid (0.130 g, 75 %). TLC Rf = 0.10 in 20% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 7.51 (dd, *J* = 3.7, 1.2 Hz, 1H), 7.92 (d, *J* = 7.5, 1H), 7.59 (dd, *J* = 7.4, 4.0 Hz, 2H), 7.42 (qd, *J* = 7.7, 1.1 Hz, 2H), 7.36 (d, *J* = 7.6 Hz, 1H), 7.32-7.27 (m, 1H), 7.24-7.19 (m, 1H) 6.10 (q, *J* = 1.4 Hz, 1H), 3.31 (s, 3H), 2.08 (d, *J* = 1.2 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 165.6 (C), 143.0 (C), 141.6 (C), 136.4 (C), 132.4 (CH), 131.9 (CH), 131.0 (C), 128.6 (CH), 128.2 (CH), 127.7 (CH), 123.6 (CH), 120.0 (CH), 119.8 (C), 119.7 (CH), 107.5 (CH), 30.6 (CH_3), 17.6 (CH_3), 10.2 (CH_3). IR (film): 1686, 1678, 1605, 1589, 1450, 1431, 1379, 1340, 1180 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{18}H_{15}N_3O$ $[M]^+$: 289.1215. Found: 289.1252.

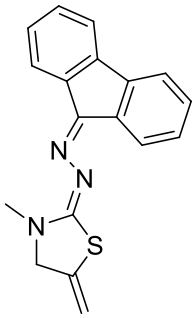


(E)-1,4-Dimethyl-3-((1-(pyridin-2-yl)ethylidene)amino)-1H-imidazol-2(3H)-one (Table 2, 2l) : Synthesized according to general procedure A using carbazone **1l**[1] (0.153 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow oil (0.119 g, 86 %). TLC Rf = 0.08 in 20% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.65 (d, *J* = 4.2 Hz, 1H), 8.16 (d, *J* = 8.0 Hz, 1H), 7.72 (td, *J* = 7.7, 1.6 Hz, 1H), 7.33 (dd, *J* = 6.4, 5.0 Hz, 1H) 6.00 (d, *J* = 1.2 Hz, 1H), 3.25 (s, 3H), 2.53 (s, 3H), 2.03 (d, *J* = 0.9 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 171.7 (C), 148.6 (CH), 136.2 (CH), 124.8 (CH), 122.0 (CH), 119.6 (C), 107.0 (CH), 30.4 (CH_3), 16.6 (CH_3), 10.0 (CH_3). IR (film): 1701, 1690, 1670, 1636, 1560, 1543, 1499, 1472, 1263, 1082 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{12}H_{14}N_4O$ $[M]^+$: 230.1168. Found: 230.1158.

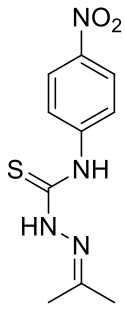


(E)-3-((Cyclohexylmethylene)amino)-1,4-dimethyl-1H-imidazol-2(3H)-one (Table 2, 2m) : Synthesized according to general procedure A using carbazone **1n**[5] (0.148 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 10 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a white solid (0.0900 g, 68 %). TLC Rf = 0.31 in 10% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ

8.98 (d, *J* = 5.5 Hz, 1H), 5.82 (q, *J* = 1.2 Hz, 1H), 3.16 (s, 3H), 2.33-2.22 (m, 1H), 2.05 (d, *J* = 1.4 Hz, 1H), 1.87-1.62 (m, 5H), 1.38-1.17 (m, 5H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 161.3 (CH), 150.0 (C), 119.7 (C), 105.1 (CH), 41.8 (CH_3), 29.9 (CH_2), 29.7 (CH), 25.9 (CH_2), 25.4 (CH_2), 9.8 (CH_3). IR (film): 1684, 1664, 1345, 1265, 1248 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{12}H_{19}N_3O$ $[M]^+$: 221.1528. Found: 221.1527.

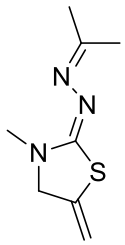


(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-methyl-5-methylenethiazolidine (Table 2, 2n) : Synthesized according to general procedure A using thiosemicarbazone **1n**[3] (0.225 g, 0.600 mmol), *N*-methylpropragylamine (0.0460 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/Hexanes and the pure compound was obtained as a yellow solid (0.139 g, 76 %). TLC Rf = 0.12 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.75-8.67 (m, 1H), 7.97-7.88 (m, 1H), 7.74-7.62 (m, 2H), 7.44-7.27 (m, 4H), 5.30-5.22 (m, 2H), 4.47-4.40 (m, 2H), 3.31-3.24 (m, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 141.3 (C), 140.1 (C), 137.7 (C), 132.0 (C), 129.7 (CH), 129.1 (CH), 129.0 (C), 127.6 (CH), 127.5 (CH), 121.7 (CH), 119.5 (CH), 119.5 (CH), 105.4 (CH_2), 59.2 (CH_2), 33.7 (CH_3). IR (film):1690, 1607, 1566, 1537, 1456, 1408, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{18}H_{15}N_3S$ $[M]^+$: 305.0987. Found: 305.1005.

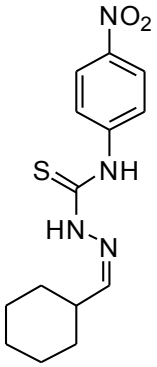


***N*-(4-Nitrophenyl)-2-(propan-2-ylidene)hydrazinecarbothioamide (Table 2, 1o):** To a solution of Acetone (0.15 mL, 2.00 mmol) in MeOH (10.0 mL) was added *N*-(4-nitrophenyl)hydrazinecarbothioamide (0.425 g. 2.00 mmol) and the solution was stirred at reflux for 3 hours. Upon cooling, a solid precipitated and was collected by filtration to afford the desired product as a orange solid (0.250 g, 50 %). TLC Rf = 0.29 in 10 % EtOAC/CH_2Cl_2. ^{1}H NMR (400 MHz; DMSO-d_6) δ 10.75 (br s, 1H), 10.25 (br s, 1H), 8.20 (d, *J* = 9.0 Hz, 2H), 8.07 (d, *J* = 9.2 Hz, 2H), 2.04 (s, 3H), 2.00 (s, 3H). ^{13}C NMR (100 MHz; DMSO-d_6): δ 175.8 (C), 154.5 (C), 145.5 (C), 143.1 (C), 123.7 (CH). 123.5 (CH), 25.1 (CH_3), 18.1 (CH_3). IR (film):1637,

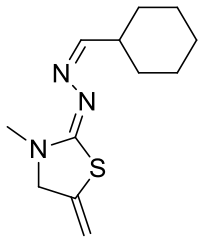
1596, 1558, 1523, 1330, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{10}H_{12}N_4O_2S$ $[M]^+$: 252.0681. Found: 252.0694.



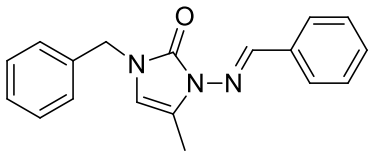
(E)-3-Methyl-5-methylene-2-(propan-2-ylidenehydrazono)thiazolidine (Table 2, 2o) : Synthesized according to general procedure A using thiosemicarbazone **1o** (0.0760 g, 0.300 mmol), *N*-methylpropragylamine (0.0230 g, 0.330 mmol), Et_3N (0.00600 g, 0.120 mmol) and MeCN (1.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/Hexanes and the pure compound was obtained as a yellow solid (0.0470 g, 85 %). TLC Rf = 0.24 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 5.18-5.13 (m, 2H), 4.23 (t, *J* = 2.3 Hz, 2H), 3.02 (s, 3H), 2.03 (s, 3H), 1.98 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 164.4 (C), 159.8 (C), 138.7 (C), 104.6 (CH_2), 58.7 (CH_2), 33.3 (CH_3), 24.7 (CH_3), 18.1 (CH_3). IR (film):1679, 1638, 1593, 1466, 1389, 1263, 1068 cm^{-1}. HRMS (EI): Exact mass calcd for $C_8H_{13}N_3S$ $[M]^+$: 183.0830. Found: 183.0835.



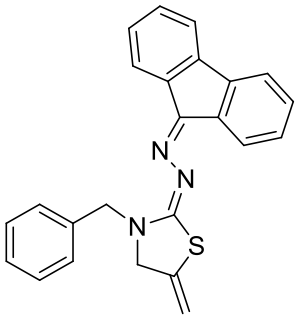
***N*-(4-Nitrophenyl)-2-(cyclohexylmethylene)hydrazinecarbothioamide (Table 2, 1p):** To a solution of cyclohexane carboxaldehyde (0.225 g, 2.00 mmol) in MeOH (10.0 mL) was added *N*-(4-nitrophenyl)hydrazinecarbothioamide (0.425 g. 2.00 mmol) and the solution was stirred at reflux for 3 hours. Upon cooling, a solid precipitated and was collected by filtration to afford the desired product as a yellow solid (0.375 g, 61 %). TLC Rf = 0.36 in 10 % EtOAC/CH_2Cl_2. ^{1}H NMR (400 MHz; DMSO-d_6) δ 8.25-8.14 (m, 3H), 8.05-8.02 (m, 2H), 7.45 (d, *J* = 5.7 Hz, 1H), 2.32-2.23 (m, 1H), 1.84-1.61 (m, 5H), 1.34-1.16 (m, 5H). ^{13}C NMR (100 MHz; DMSO-d_6): δ 175.0 (C), 152.8 (CH), 145.4 (C), 143.2 (C), 123.7 (CH). 40.1 (CH), 29.5 (CH_2), 25.4 (CH_2), 25.0 (CH_2). IR (film): 2941, 1641, 1585, 1552, 1450, 1332, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{14}H_{18}N_4O_2S$ $[M]^+$: 306.1150. Found: 306.1197.



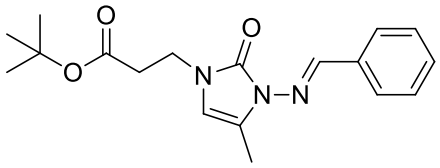
(E)-2-((Z)-(Cyclohexylmethylene)hydrazono)-3-methyl-5-methylenethiazolidine (Table 2, 2p) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.0920 g, 0.300 mmol), *N*-methylpropragylamine (0.0230 g, 0.330 mmol), Et_3N (0.00600 g, 0.120 mmol) and MeCN (1.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/Hexanes and the pure compound was obtained as a yellow oil (0.0430 g, 60 %). TLC Rf = 0.30 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 7.59 (d, J = 5.8 Hz, 1H), 5.20-5.14 (m, 2H), 4.27 (t, J = 2.3 Hz, 2H), 3.02 (s, 3H), 2.33-2.22 (m, 1H), 1.89-1.63 (m, 5H), 1.38-1.17 (m, 5H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 166.5 (C), 160.7 (CH), 138.3 (C), 104.7 (CH_2), 58.9 (CH_2), 40.7 (CH), 33.3 (CH_3), 30.2 (CH_2), 26.0 (CH_2), 25.4 (CH_2). IR (film): 2910, 1639, 1585, 1423, 1392, 1265, 951 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{12}H_{19}N_3S$ $[M]^+$: 237.1300. Found: 237.1329.



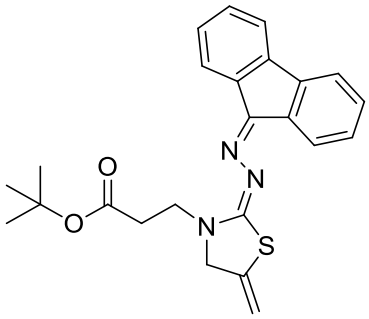
(E)-1-Benzyl-3-(benzylideneamino)-4-methyl-1H-imidazol-2(3H)-one (Table 3, 3a): Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), *n*-benzyl propargylamine (0.960 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using 5 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a off white solide (0.148 g, 85 %). TLC Rf = 0.3 in 5% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.98 (s, 1H), 7.81-7.78 (m, 2H), 7.45-7.30 (m, 8H), 5.90 (d, J = 1.2 Hz, 1H), 4.79 (s, 2H), 2.18 (d, J = 1.0 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 151.2 (CH), 149.8 (C), 136.7 (C), 135.1 (C), 130.2 (CH), 128.7 (CH), 128.6 (CH), 127.8 (CH), 127.8 (CH), 120.4 (C), 104.6 (CH), 46.7 (CH_2), 10.0 (CH_3). IR (film): 2953, 2853, 1679, 1647, 1456, 1398, 1362, 1327, 1258 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{18}H_{17}N_3O$ $[M]^+$: 291.1372. Found: 291.1387.



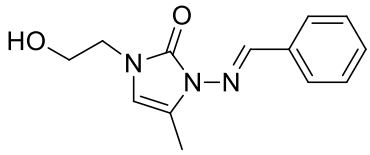
(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-benzyl-5-methylenethiazolidine (Table 3, 4a) : Synthesized according to general procedure A using thiosemicarbazone X (0.225 g, 0.600 mmol), *n*-benzyl propargylamine (0.0960 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by filtration and the pure compound was obtained as a yellow solid (0.155g, 68 %). TLC Rf = 0.27 in 40% CH_2Cl_2/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.64 (dt, *J* = 7.6, 0.6 Hz, 1H), 7.91-7.88 (m, 1H), 7.69-7.61 (m, 2H), 7.42-7.27 (m, 4H), 5.25-5.22 (m, 2H), 4.54 (t, *J* = 2.3 Hz, 2H), 3.93 (t, *J* = 6.6 Hz, 2H), 2.80 (t, *J* = 6.6 Hz, 2H), 1.48 (s, 9H) . ^{13}C NMR (100 MHz; $CDCl_3$): δ 171.0 (C), 169.9 (C), 153.1 (C), 141.4 (C), 140.1 (C), 137.7 (C), 131.9 (C), 129.7 (CH), 129.2 (CH), 128.8 (CH), 127.6 (CH), 127.5 (CH), 121.7 (CH), 119.5 (CH), 119.4 (CH), 105.4 (CH_2), 81.1 (C), 58.0 (CH_2), 43.0 (CH_2), 33.0 (CH_2), 28.0 (CH_3) . IR (film): 1684, 1647, 1554, 1506, 1107, 903 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{24}H_{19}N_3S$ $[M]^+$: 381.1300. Found: 381.1321.



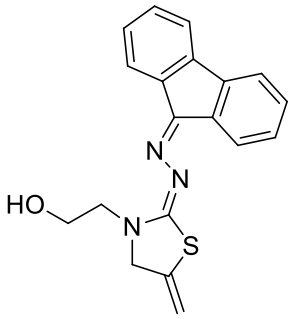
(E)-*tert*-Butyl 3-(3-(benzylideneamino)-4-methyl-2-oxo-2,3-dihydro-1H-imidazol-1-yl)propanoate (Table 3, 3b) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), the propargylic amine[7] (0.121 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by column chromatography using a gradient of CH_2Cl_2 to 5 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a yellow oil (0.140 g, 71 %). TLC Rf = 0.47 in 5% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.91 (s, 1H), 7.79-7.73 (m, 2H), 7.42-7.37 (m, 3H), 6.02 (d, *J* = 1.2 Hz, 1H), 3.85 (t, *J* = 6.6 Hz, 2H), 2.62 (t, *J* = 6.6 Hz, 2H), 2.17 (d, *J* = 1.2 Hz, 3H), 1.45 (s, 9H) . ^{13}C NMR (100 MHz; $CDCl_3$): δ 170.6 (C), 151.2 (CH), 135.1 (C), 130.2 (CH), 128.6 (CH), 127.3 (CH), 119.9 (C), 105.4 (CH), 81.1 (CH), 39.2 (CH_2), 35.2 (CH_2), 28.0 (CH_3), 9.9 (CH_3). IR (film): 1718, 1687, 1555, 1506, 1418, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{18}H_{23}N_3O_3$ $[M]^+$: 329.1739. Found: 329.1710.



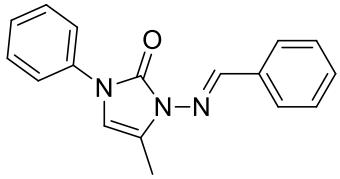
(E)- *tert*-Butyl 3-(2-((9H-fluoren-9-ylidene)hydrazono)-5-methylenethiazolidin-3-yl)propanoate (Table 3, 4b) : Synthesized according to general procedure A using thiosemicarbazone **1o** (0.225 g, 0.600 mmol), the propargylic amine[7] (0.121 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/Hexanes and the pure compound was obtained as a orange foam (0.200 g, 79 %). TLC Rf = 0.27 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.64 (dt, *J* = 7.6, 0.6 Hz, 1H), 7.91-7.88 (m, 1H), 7.69-7.61 (m, 2H), 7.42-7.27 (m, 4H), 5.25-5.22 (m, 2H), 4.54 (t, *J* = 2.3 Hz, 2H), 3.93 (t, *J* = 6.6 Hz, 2H), 2.80 (t, *J* = 6.6 Hz, 2H), 1.48 (s, 9H) . ^{13}C NMR (100 MHz; $CDCl_3$): δ 171.0 (C), 169.9 (C), 153.1 (C), 141.4 (C), 140.1 (C), 137.7 (C), 131.9 (C), 129.7 (CH), 129.2 (CH), 128.8 (CH), 127.6 (CH), 127.5 (CH), 121.7 (CH), 119.5 (CH), 119.4 (CH), 105.4 (CH_2), 81.1 (C), 58.0 (CH_2), 43.0 (CH_2), 33.0 (CH_2), 28.0 (CH_3) . IR (film): 1676, 1601, 1558, 1526, 1501, 1431, 1420, 1398, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{24}H_{25}N_3O_2S$ $[M]^+$: 419.1667. Found: 419.1666.



(E)-3-(Benzylideneamino)-1-(2-hydroxyethyl)-4-methyl-1H-imidazol-2(3H)-one (Table 3, 3c) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), ethanolpropagylamine[8] (0.0650 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 6 hours. After trying multiple purification methods and different reaction conditions that did not increase the yield or the purity of the obtained compound, a NMR yield was determined using ratio of phenol to the desired compound : 49-51 %

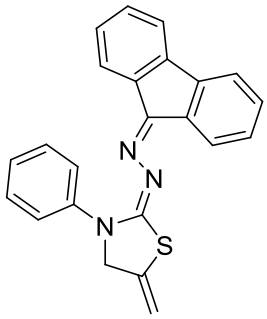


(E)-2-(2-((9H-Fluoren-9-ylidene)hydrazono)-5-methylenethiazolidin-3-yl)ethanol (Table 3, 4c) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.225 g, 0.600 mmol), ethanolpropargylamine[8] (0.0650 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 100 % EtOAc and the pure compound was obtained as a yellow solid (0.147 g, 73 %). TLC Rf = 0.20 in 100% EtOAc. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.55 (d, *J* = 7.4 Hz, 1H), 7.87 (d, *J* = 7.4 Hz, 1H), 7.66 (d, *J* = 7.4 Hz, 1H), 7.62 (d, *J* = 7.4 Hz, 1H), 7.40-7.29 (m, 4H), 5.25-5.20 (m, 2H), 4.55 (t, *J* = 2.2 Hz, 2H), 4.00 (t, *J* = 4.9 Hz, 2H), 3.84-3.82 (m, 2H) . ^{13}C NMR (100 MHz; $CDCl_3$): δ 171.8 (C), 153.0 (C), 153.1 (C), 141.5 (C), 140.1 (C), 137.6 (C), 137.5 (C), 131.7 (C), 129.9 (CH), 129.3 (CH), 128.5 (CH), 127.8 (CH), 127.5 (CH), 121.7 (CH), 119.6 (CH), 119.5 (CH), 106.4 (CH_2), 61.3 (CH_2), 58.8 (CH_2), 49.8 (CH_2). IR (film): 2960, 2853, 1535, 1495, 1416, 1265, 1141 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{24}H_{17}N_3OS$ $[M]^+$: 335.1092. Found: 335.1100.

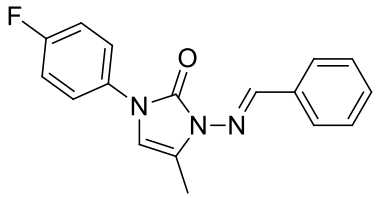


(E)-3-(Benzylideneamino)-4-methyl-1-phenyl-1H-imidazol-2(3H)-one (Table 3, 3d) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), *n*-phenylpropargylamine (0.0870 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by Et_3N treated[b] column chromatography using 25 % hexanes/CH_2Cl_2 and the pure compound was obtained as a yellow solid (0.0900 g, 54 %). TLC Rf = 0.25 in 25% hexanes/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.98 (s, 1H), 7.84-7.77 (m, 2H), 7.63-7.58 (m, 2H), 7.48-7.40 (m, 5H), 7.29-7.23 (m, 1H), 6.37 (q, *J* = 1.3 Hz, 1H), 2.18 (d, *J* = 1.4 Hz, 3H) . ^{13}C NMR (100 MHz; $CDCl_3$): δ 151.8 (C), 135.0 (C), 130.4 (C), 129.2 (CH), 128.6 (CH), 127.5 (CH), 125.8 (CH), 121.7 (C), 121.6 (CH), 104.2 (CH), 10.1 (CH_3). IR (film): 1693, 1684, 1506, 1398, 1376, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{17}H_{15}N_3O$ $[M]^+$: 277.1215. Found: 227.1228.

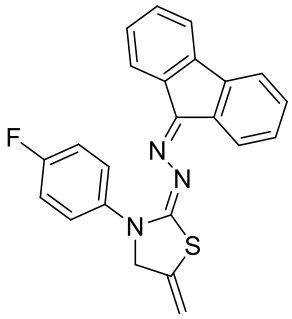
[b] Et_3N is crucial for separating product from phenol. Every solvent system without the use of Et_3N resulted in poor to no separation of the two compounds.



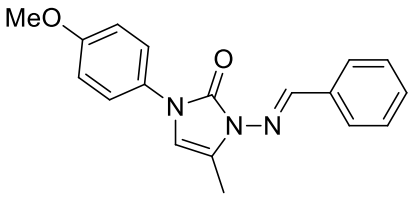
(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-5-methylene-3-phenylthiazolidine (Table 3, 4d) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.225 g, 0.600 mmol), *n*-phenylpropargylamine (0.0870 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified filtration and the pure compound was obtained as a orange solid (0.170 g, 78 %). TLC Rf = 0.12 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; DMSO-d_6) δ 8.34 (d, J = 7.6, 1H), 7.84-7.72 (m, 5H), 7.54 (t, J = 8.0 Hz, 2H), 7.45-7.30 (m, 4H), 7.22-7.19 (m, 1H), 5.43 (d, J = 15.1 Hz, 2H), 5.11 (s, 2H). ^{13}C NMR (100 MHz; DMSO-d_6): δ 169.0 (C), 152.8 (C), 140.6 (C), 139.7 (C), 136.5 (C), 135.8 (C), 130.6 (CH), 130.6 (C), 129.9 (CH), 128.9 (CH), 127.9 (CH), 125.7 (CH), 123.3 (CH), 121.2 (CH), 120.3 ($CH_)$, 120.3 (CH), 106.4 (CH_2), 58.8 (CH_2). IR (film): 1684, 1647, 1555, 1506, 1107 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{23}H_{17}N_3S$ $[M]^+$: 367.1143. Found: 367.1438.



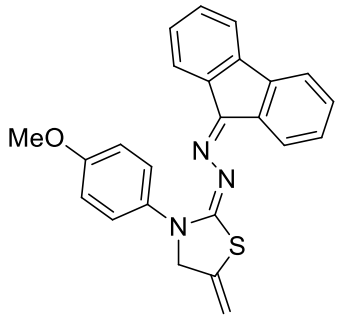
(E)-3-(Benzylideneamino)-1-(4-fluorophenyl)-4-methyl-1H-imidazol-2(3H)-one (Table 3, 3e) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), 4-fluoro-*n*-propargylaniline[9] (0.0980 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified column chromatography using 6% EtOAc/Hexane and the pure compound was obtained as a yellow solid (0.0660 g, 37 %). TLC Rf = 0.25 in 6% EtOAc/Hexane. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.95 (s, 1H), 7.81-7.78 (m, 2H), 7.57-7.53 (m, 2H), 7.44-7.41 (m, 3H), 7.15-7.09 (m, 2H), 6.29 (q, J = 1.2 Hz, 1H), 2.26 (d, J = 1.6 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 161.7 (C), 159.3 (C), 152.0 (CH), 148.6 (C), 135.0 (C), 133.0 (133.0 fluorine coupling) (C), 130.5 (CH), 128.7 (CH), 127.5 (CH), 123.6 (CH), 123.5 (CH), 121.8 (C), 116.1 (CH), 115.9 (CH), 10.1 (CH_3). IR (film): 2954, 2841, 1690, 1678, 1558, 1512, 1400, 1377, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{17}H_{14}N_3O$ $[M]^+$: 295.1121. Found: 295.1164.



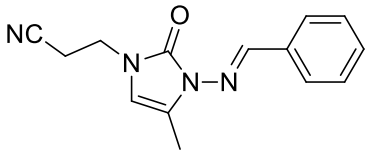
(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-(4-fluorophenyl)-5-methylenethiazolidine (Table 3, 4e) : Synthesized according to general procedure A using thiosemicarbazone **1p**(0.225 g, 0.600 mmol), 4-fluoro-*n*-propargylaniline[9] (0.0980 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified filtration and the pure compound was obtained as an orange solid (0.180 g, 78 %). TLC Rf = 0.11 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; DMSO-d_6) δ 8.26 (d, J = 7.6, 1H), 7.83-7.71 (m, 5H), 7.45-7.31 (m, 5H), 7.24-7.19 (m, 1H), 5.42 (d, J = 12.2 Hz, 2H), 5.08 (s, 2H). ^{13}C NMR (100 MHz; DMSO-d_6): δ 168.6 (C), 152.8 (C), 140.3 (C), 139.4 (C), 136.3 (C), 135.7 (C), 130.4 (CH), 130.0 (CH), 129.4 (CH), 127.7 (CH), 127.4 (CH) 127.3 (CH), 125.5 (CH), 125.4 (CH), 120.8 (CH), 119.6 (CH_2), 119.6 (CH), 115.3 (CH), 115.0 (CH), 105.8 (CH_2), 58.6 (CH_2). IR (film): 1690, 1670, 1609, 1595,1526, 1506, 1477, 1433, 1398 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{23}H_{16}N_3SF$ $[M]^+$: 385.1049. Found: 385.1015.



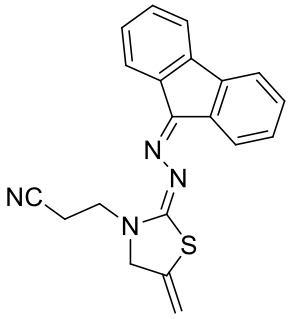
(E)-3-(Benzylideneamino)-1-(4-methoxyphenyl)-4-methyl-1H-imidazol-2(3H)-one (Table 3, 3f) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), 4-methoxy-*n*-propargylaniline[9] (0.106g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by filtration and the pure compound was obtained as a off white solid (0.0760 g, 41 %). TLC Rf = 0.20 in 50% hexanes/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.98 (s, 1H), 7.81-7.78 (m, 2H), 7.50-7.46 (m, 1H), 7.44-7.41 (m, 3H), 6.98-6.94 (m, 2H), 6.28 (q, J = 1.4 Hz, 1H), 3.83 (s, 3H), 2.26 (d, J = 1.2 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 157.6 (C), 151.6 (CH), 148.7 (C), 135.0 (C), 130.3 (CH), 130.0 (C), 128.6 (CH), 127.4 (CH), 123.5 (CH), 121.1 (C), 114.3 (CH), 104.7 (CH), 55.5 (CH_3), 10.0 (CH_3). IR (film): 2960, 2849, 1684, 1653, 1555, 1520, 1506, 1397, 1255, 1251 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{18}H_{17}N_3O_2$ $[M]^+$: 307.13208. Found: 307.13229



(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-(4-methoxyphenyl)-5-methylenethiazolidine (Table 3, 4f) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.225 g, 0.600 mmol), 4-methoxy-*n*-propargylaniline[9] (0.106 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified filtration and the pure compound was obtained as a brown solid (0.170 g, 78 %). TLC Rf = 0.3 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.38 (dt, *J* = 7.6, 0.9 Hz, 1H), 7.90 (dq, *J* = 7.4, 0.7 Hz, 1H), 7.63-7.57 (m, 4H), 7.38-7.27 (m, 3H), 7.15 (td, *J* = 7.6, 1.1 Hz, 1H), 7.03-6.99 (m, 2H), 5.31 (dq, *J* = 11.1, 2.1 Hz, 2H), 4.87 (t, *J* = 2.3 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 168.9 (C), 157.3 (C), 154.2 (C), 144.3 (C), 140.4 (C), 137.5 (C), 136.8 (C), 133.2 (C), 131.7 (C), 130.0 (CH), 129.4 (CH), 128.7 (CH), 127.7 (CH), 127.5 (CH), 125.0 ($CH_)$, 121.9 (CH), 119.5 (CH), 119.5 (CH), 114.1 (C), 105.6 (CH_2), 59.4 (CH_2), 55.6 (CH_3). IR (film): 2968, 2854, 1734, 1555, 1497, 1246, 1022 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{24}H_{19}N_3OS$ $[M]^+$: 397.1249. Found: 397.1224.



(E)-3-(3-(Benzylideneamino)-4-methyl-2-oxo-2,3-dihydro-1H-imidazol-1-yl)propanenitrile (Table 3, 3g) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), the propargylic amine[10] (0.0710 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 6 hours. The crude mixture was purified by column chromatography using 6 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a white solid (0.0920 g, 60 %). TLC Rf = 0.40 in 6% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.84 (s, 1H), 7.79-7.73 (m, 2H), 7.44-7.39 (m, 3H), 6.07 (d, *J* = 1.4 Hz, 1H), 3.88 (t, *J* = 6.4 Hz, 2H), 2.74 (t, *J* = 6.5 Hz, 2H), 2.18 (d, *J* = 1.2 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 151.8 (CH), 149.3 (C), 134.7 (C), 130.4 (CH), 128.6 (CH), 127.4 (CH), 121.0 (C), 117.4 (C), 104.7 (CH), 39.4 (CH_2), 18.0 (CH_2), 9.9 (CH_3). IR (film): 2360, 1730, 1701, 1553, 1433, 1398, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{14}H_{14}N_4O$ $[M]^+$: 254.1168. Found: 254.1155.



(E)-3-(2-((9H-Fluoren-9-ylidene)hydrazono)-5-methylenethiazolidin-3-yl)propanenitrile (Table 3, 4g) : Synthesized according to general procedure A using thiosemicarbazone **1p'**[c] (0.225 g, 0.600 mmol), the propargylic amine[10] (0.0710 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography using 20 % EtOAc/Hexanes and the pure compound was obtained as a orange solid (0.152 g, 74 %). TLC Rf = 0.27 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; DMSO-d_6) δ 8.59 (d, J = 7.2 Hz,1H), 7.84 (dd, J = 12.6, 7.3 Hz, 2H), 7.71 (d, J = 7.0 Hz, 1H), 7.49-7.30 (m, 4H), 5.39 (d, J = 12.3 Hz, 2H), 4.69-4.68 (m, 2H), 3.98 (t, J = 6.6 Hz, 2H), 3.06 (t, J = 6.6 Hz, 2H) .^{13}C NMR (100 MHz; DMSO- d_6): δ 170.2 (C), 151.8 (C), 140.6 (C), 139.5 (C), 136.7 (C), 136.6 (C), 131.0 (CH), 130.4 (CH), 129.7 (C), 128.6 (CH), 128.1 (CH), 127.8 (CH), 121.0 (CH), 120.2 (CH), 120.2 (CH), 119.1 (C), 106.6 (CH_2), 60.0 (CH_2), 42.4 (CH_2), 33.0 (CH_2), 15.1 (CH_2) . IR (film): 2314, 1684, 1601, 1458. 1420, 1398 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{20}H_{16}N_4S$ $[M]^+$: 344.1096. Found: 344.1126.

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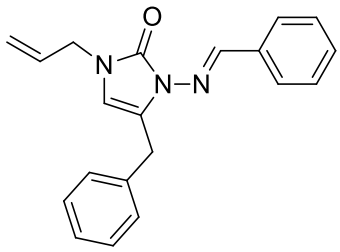
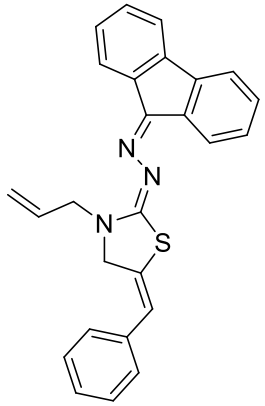
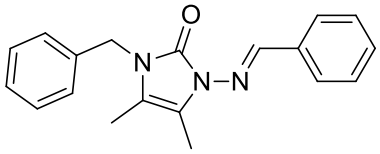


(E)-1-Allyl-4-benzyl-3-(benzylideneamino)-1H-imidazol-2(3H)-one (Table 3, 3h): Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), the propargylic amine[11] (0.113 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. Purifications were unsuccessful (product seems to degrade and equilibrate threw isomerization), therefore another reaction was performed and 0.0114 g of 1,3,5-trimethoxybenzene was added as NMR internal standard. 35 % of desired product (endocyclic alkene) was observed with 14 % of the exocyclic present.

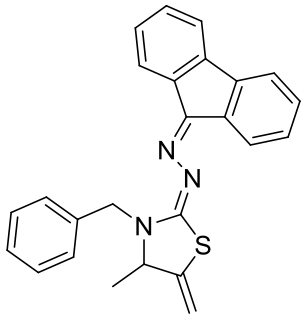
[c] *O*-Nitroaniline was used as leaving group to ensure good separation for the flash chromatography. For synthesis see: Lavergne, K.; MSc thesis, University of Ottawa, 2015



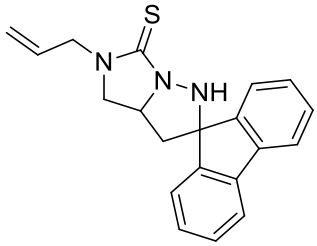
(2E,5E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-allyl-5-benzylidenethiazolidine (Table 3, 4h) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.225 g, 0.600 mmol), the propargylic amine[11] (0.113 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified filtration and the pure compound was obtained as an orange solid (0.223 g, 91 %). TLC Rf = 0.13 in 20% EtOAc/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.69 (d, *J* = 7.3, 1H), 7.99 (d, *J* = 7.0 Hz, 1H), 7.66 (dd, *J* = 11.8, 7.3 Hz, 2H), 7.46-7.27 (m, 9H), 7.22-7.19 (m, 1H), 6.55 (s, 1H), 6.00 (ddt, *J* = 16.9, 10.4, 6.2 Hz, 1H), 5.41-5.32 (m, 2H), 4.58 (d, *J* = 1.7 Hz, 2H), 4.35 (d, *J* = 6.1 Hz, 2H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 169.3 (C), 141.4 (C), 140.2 (C), 137.6 (C), 135.9 (C), 131.9 (C), 131.5 (CH), 129.9 (CH), 129.3 (CH), 129.1 (C), 129.0 (CH), 128.6 (CH), 128.0 (CH), 127.7 (CH), 127.5 (CH_2), 127.1 (CH), 121.9 (CH_2), 120.2 (CH), 119.5 (CH), 119.5 (CH), 119.0 (CH_2), 58.4 (CH_2), 49.5 (CH_2). IR (film): 1602, 1533, 1522, 1460, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{26}H_{21}N_3S$ $[M]^+$: 407.1456. Found: 407.1665.



(E)-1-Benzyl-3-(benzylideneamino)-4,5-dimethyl-1H-imidazol-2(3H)-one (Table 3, 3i) : Synthesized according to general procedure A using carbazone **1a** (0.146 g, 0.600 mmol), the propargylic amine[12] (0.105 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 100 °C for 6 hours. The crude mixture was purified by Et_3N treated silica gel column chromatography using 2% hexanes/CH_2Cl_2 and the pure compound was obtained as a white solid (0.150 g, 82 %). TLC Rf = 0.12 in 2% hexanes/CH_2Cl_2. ^{1}H NMR (300 MHz; $CDCl_3$) δ 9.96 (s, 1H), 7.80-7.75 (m, 2H), 7.46-7.39 (m, 3H), 7.37-7.31 (m, 2H), 7.30-7.25 (m, 3H), 4.87 (s, 2H), 2.16 (d, *J* = 1.1 Hz, 3H), 1.94 (d, *J* = 1.1 Hz, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 150.7 (CH), 150.0 (C), 137.5 (C), 135.4 (C), 130.0 (CH), 128.7 (CH), 128.6 (CH), 127.4 (CH), 127.4 (CH), 127.3 (CH), 127.0 (CH), 115.2 (C), 112.0 (C), 44.1 (CH_2), 8.8 (CH_3), 8.3 (CH_3). IR (film): 1701, 1664, 1653, 1558, 1387, 1265 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{19}H_{19}N_3O$ $[M]^+$: 305.1528. Found: 305.1522.

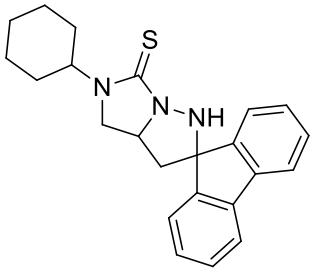


(E)-2-((9H-Fluoren-9-ylidene)hydrazono)-3-benzyl-4-methyl-5-methylenethiazolidine (Table 3, 4i) : Synthesized according to general procedure A using thiosemicarbazone **1p** (0.225 g, 0.600 mmol), the propargylic amine[12] (0.105 g, 0.660 mmol), Et_3N (0.0120 g, 0.120 mmol) and MeCN (2.0 mL) and heated at 120 °C for 2 hours. The crude mixture was purified by column chromatography and the pure compound was obtained as an orange foam (0.161 g, 68 %). TLC Rf = 0.26 in 25% CH_2Cl_2/hexanes. ^{1}H NMR (300 MHz; $CDCl_3$) δ 8.55-8.52 (m, 1H), 7.93-7.89 (m, 1H), 7.66-7.60 (m, 2H), 7.44-7.16 (m, 9H), 5.41 (d, *J* = 15.3, 1H), 5.23 (t, *J* = 1.97, 1H), 5.14 (t, *J* = 1.85, 1H), 4.53-4.43 (m, 2H), 1.45 (d, *J* = 6.40, 3H). ^{13}C NMR (100 MHz; $CDCl_3$): δ 170.2 (C), 153.2 (C), 143.7 (C), 141.4 (C), 140.2 (C), 137.8 (C), 136.3 (C), 131.9 (C), 129.8 (CH), 129.2 (CH), 128.9 (CH), 127.9 (CH), 127.8 (CH), 127.7 (CH), 127.5 (CH), 121.7 (CH), 119.5 (CH), 119.5 (CH), 105.3 (CH_2), 62.5 (CH), 48.8 (CH_2), 20.3 (CH_3) IR (film): 2854, 1599, 1521, 1506, 1423, 1398, 1244 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{25}H_{21}N_3S$ $[M]^+$: 395.1456. Found: 395.1432.

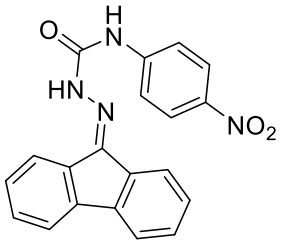


5'-Allyl-3',3a',4',5'-tetrahydrospiro[fluorene-9,2'-imidazo[1,5-b]pyrazole]-6'(1'H)-thione (Scheme 2, 6a) : Synthesized according to general procedure A using thiosemicarbazone **1n** (0.225 g, 0.600 mmol), diallylamine (0.0640 g, 0.660 mmol),) and MeCN (2.0 mL) and heated at 150 °C for 2 hours. The crude mixture was purified by column chromatography using 5 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a orange was obtained as a yellow solid (0.158 g, 79 %). TLC Rf = 0.4 in 5% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; DMSO- d_6) δ 7.73 (dd, *J* = 13.7, 7.2 Hz, 2H), 7.66 (d, *J* = 7.3 Hz, 1H), 7.43-7.23 (m, 5H), 5.94-5.82 (m, 2H), 5.31-5.26 (m, 2H), 4.58-4.50 (m, 1H), 4.45-4.25 (m, 2H), 3.87 (dd, *J* = 10.7, 7.9 Hz, 1H), 3.68 (d, *J* = 10.6 Hz, 1H), 2.50-2.43 (m, 1H), 2.20-2.12 (m, 1H). ^{13}C NMR (100 MHz; DMSO- d_6): δ 188.5 (C), 150.7 (C), 139.2 (C), 138.5 (C), 131.8 (CH), 128.7 (CH), 127.9 (CH), 127.8 (CH), 124.6 (CH), 123.8 (CH), 119.9 (CH), 119.6 (CH), 118.1 (CH_2), 74.7 (C), 60.6 (CH), 49.7 (CH_2), 49.6

(CH_2), 45.4 (CH_2). IR (film): 1680, 1610, 1553, 1379, 1360, 1310, 1255 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{20}H_{19}N_3S$ $[M]^+$: 333.1300. Found: 333.1292.



5'-Cyclohexyl-3',3a',4',5'-tetrahydrospiro[fluorene-9,2'-imidazo[1,5-b]pyrazole]-6'(1'H)-thione (Scheme 2, 6b : Synthesized according to general procedure A using thiosemicarbazone **1n** (0.225 g, 0.600 mmol), diallylamine (0.0640 g, 0.660 mmol),) and MeCN (2.0 mL) and heated at 150 °C for 4 hours. The crude mixture was purified by column chromatography using 5 % EtOAc/CH_2Cl_2 and the pure compound was obtained as a orange was obtained as a yellow solid (0.145 g, 64 %). TLC Rf = 0.26 in 5% EtOAc/CH_2Cl_2. ^{1}H NMR (300 MHz; DMSO-d_6) δ 7.74 (dd, J = 14.4, 7.0 Hz, 2H), 7.64 (d, J = 7.5 Hz, 1H), 7.42-7.22 (m, 5H), 5.85 (s, 1H), 4.51-4.41 (m, 2H), 3.85-3.79 (m, 1H), 3.70-3.67 (m, 1H), 2.42 (dd, J = 12.6, 6.7 Hz, 1H), 2.11-2.04 (m, 1H), 1.88-1.75 (m, 4H), 1.65 (d, J = 10.8 Hz, 1H), 1.55-1.28 (m, 4H), 1.19-1.08 (m, 1H). ^{13}C NMR (100 MHz; DMSO-d_6): δ 187.6 (C), 150.7 (C), 148.4 (C), 139.2 (C), 128.7 (CH), 128.0 (CH), 127.8 (CH), 124.6 (CH), 123.8 (CH), 119.9 (CH), 119.6 (CH), 74.6 (C), 60.5 (CH_2), 55.3 (CH), 46.2 (CH_2), 45.4 (CH_2), 28.9 (CH_2), 28.8 (CH_2), 25.1 (CH_2), 25.0 (CH_2), 24.9 (CH_2). IR (film): 1680, 1653, 1556, 1456, 1263, 1226, 1032 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{23}H_{25}N_3S$ $[M]^+$: 375.1769. Found: 375.1797.



2-(9H-Fluoren-9-ylidene)-N-(4-nitrophenyl)hydrazinecarbamide : To a solution of 9-fluorenone hydrazone (1.94 g, 10 mmol) in MeCN (50.0 mL) was slowly added 4-nitrophenyl isocyanate (1.62 g, 10 mmol). The solution was stirred at room temperature for 3 hours and the title compound was obtained by filtration as a yellow amorphous solid (3.44 g, 96 %). ^{1}H NMR (300 MHz; DMSO-d_6): δ 10.64 (br s, 1H), 10.02 (br s, 1H), 8.06-8.03 (m, 1H), 8.01-7.96 (m, 2H), 7.93-7.90 (m, 1H), 7.85-7.83 (m, 1H), 7.57-7.52 (m, 1H), 7.48-7.36 (m, 3H). ^{13}C NMR (75 MHz; DMSO-d_6) δ 153.2 (C), 145.7 (C), 145.5 (C), 145.3 (C), 141.8 (C), 141.3 (C), 139.0 (C), 136.7 (C), 131.2 (CH), 130.0 (CH), 128.1 (CH), 127.0 (CH), 124.9 (CH), 122.2(CH), 120.7 (CH), 120.2 (CH), 118.9 (CH). IR (film): 1684, 1649, 1541, 1529, 1263 cm^{-1}. HRMS (EI): Exact mass calcd for $C_{20}H_{14}N_4O_3$ $[M]^+$: 358.1060. Found: 358.1060.

References:

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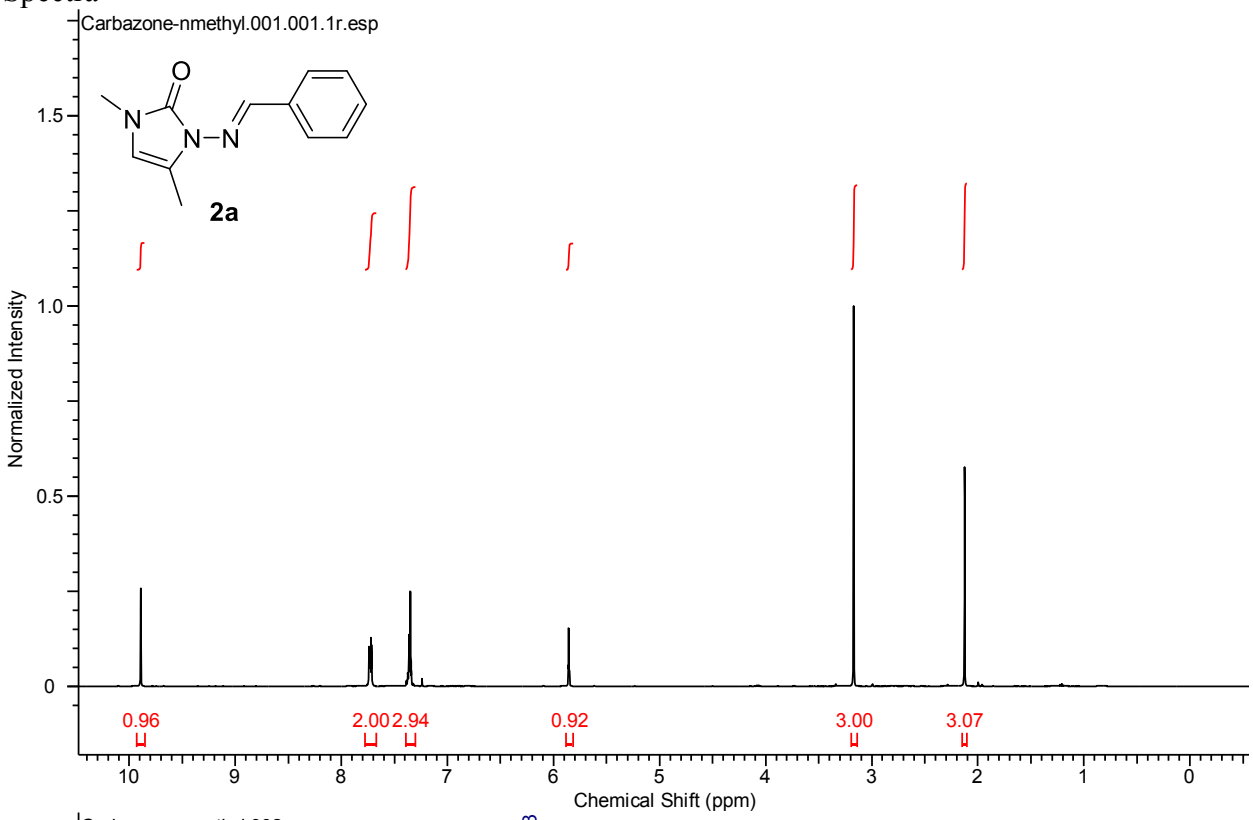
Spectra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3.07
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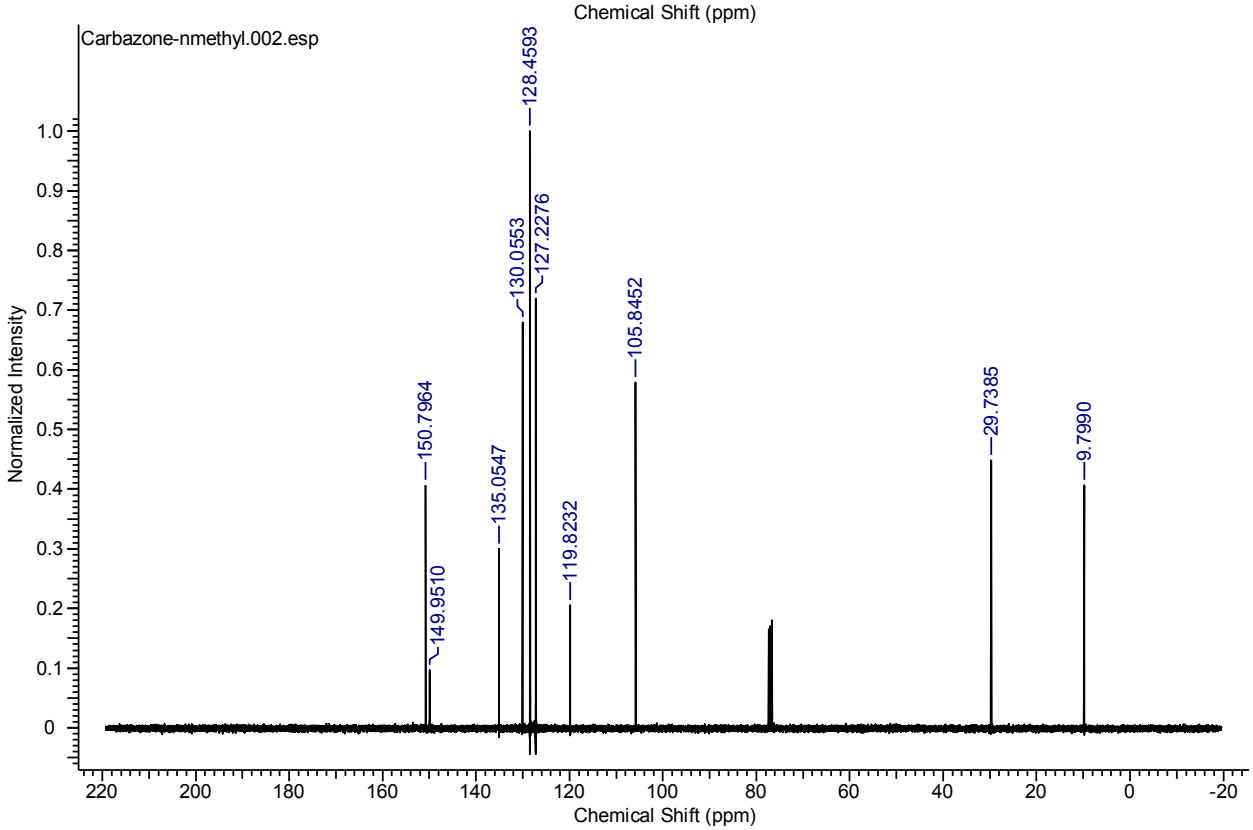
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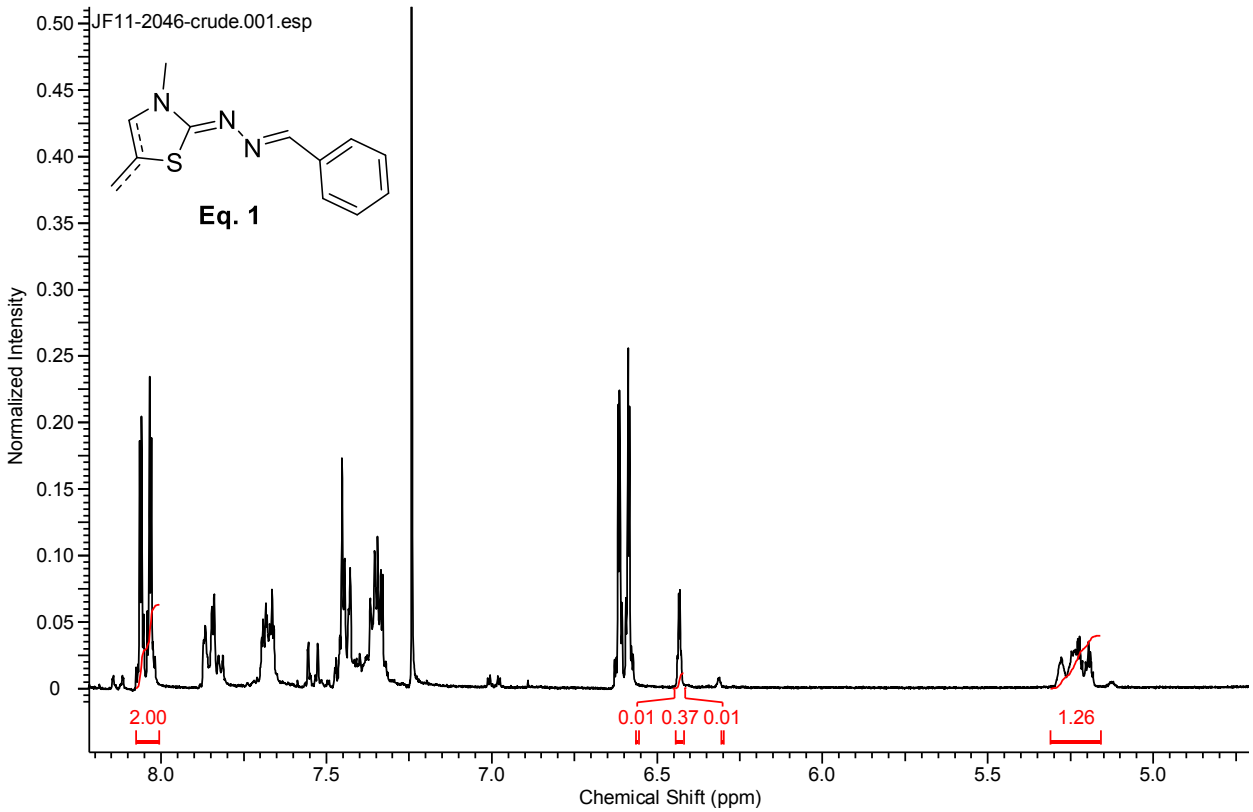
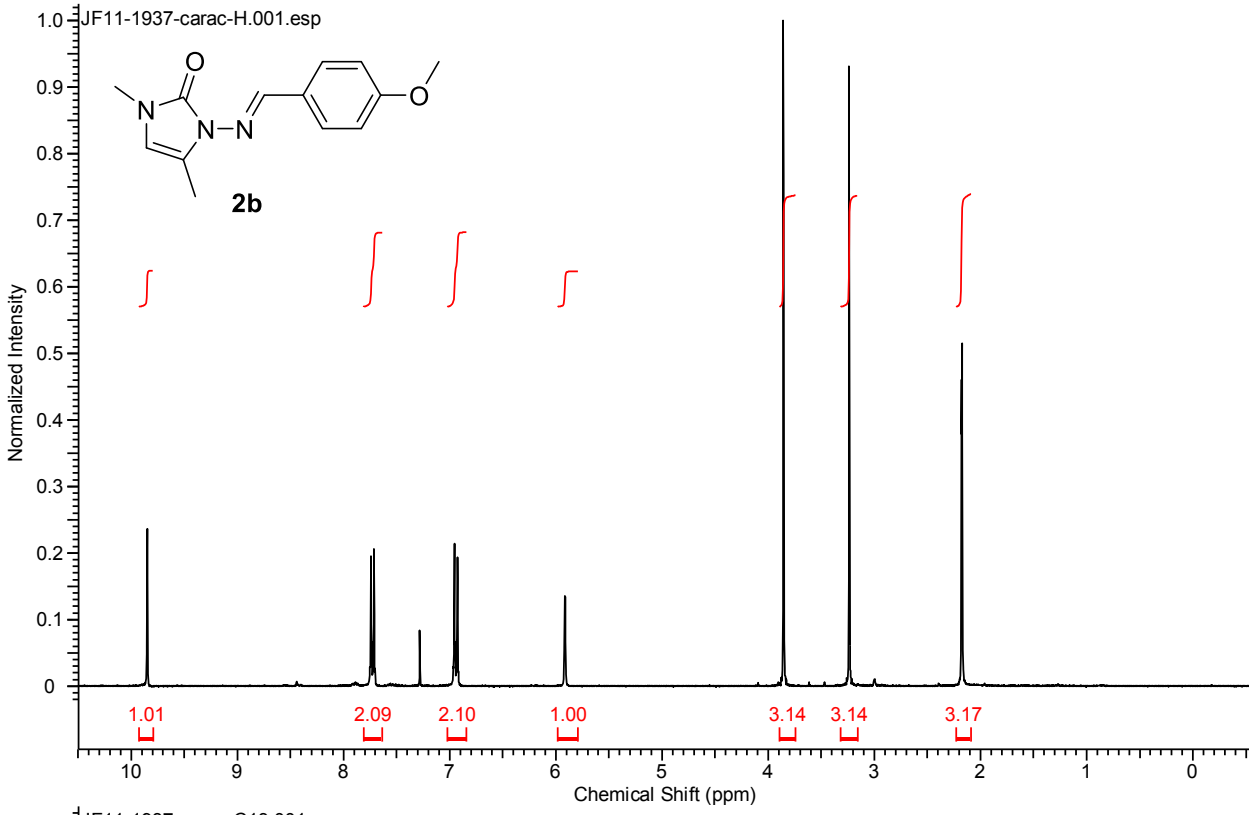
Chemical Shift (ppm)



According to paranitroaniline production: 37 % isomerize and 63 % of desired product.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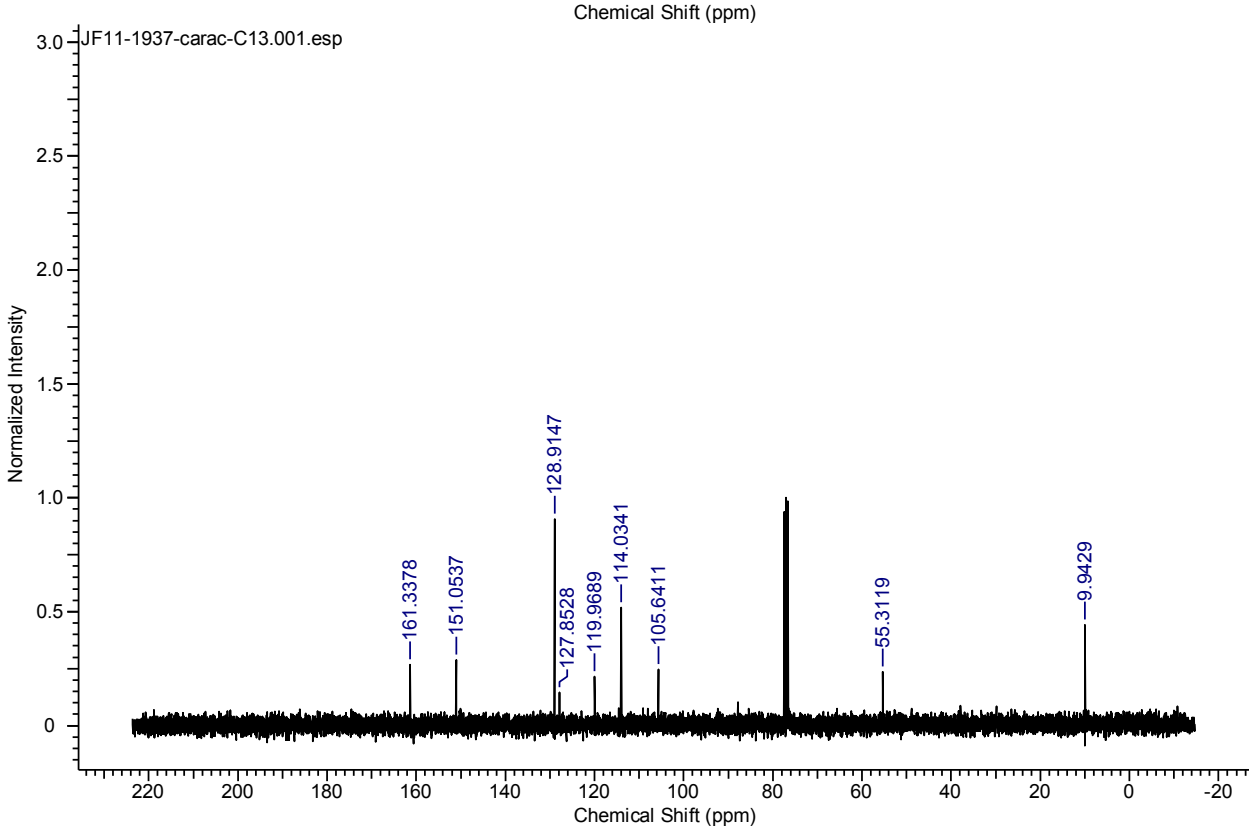
Chemical Shift (ppm)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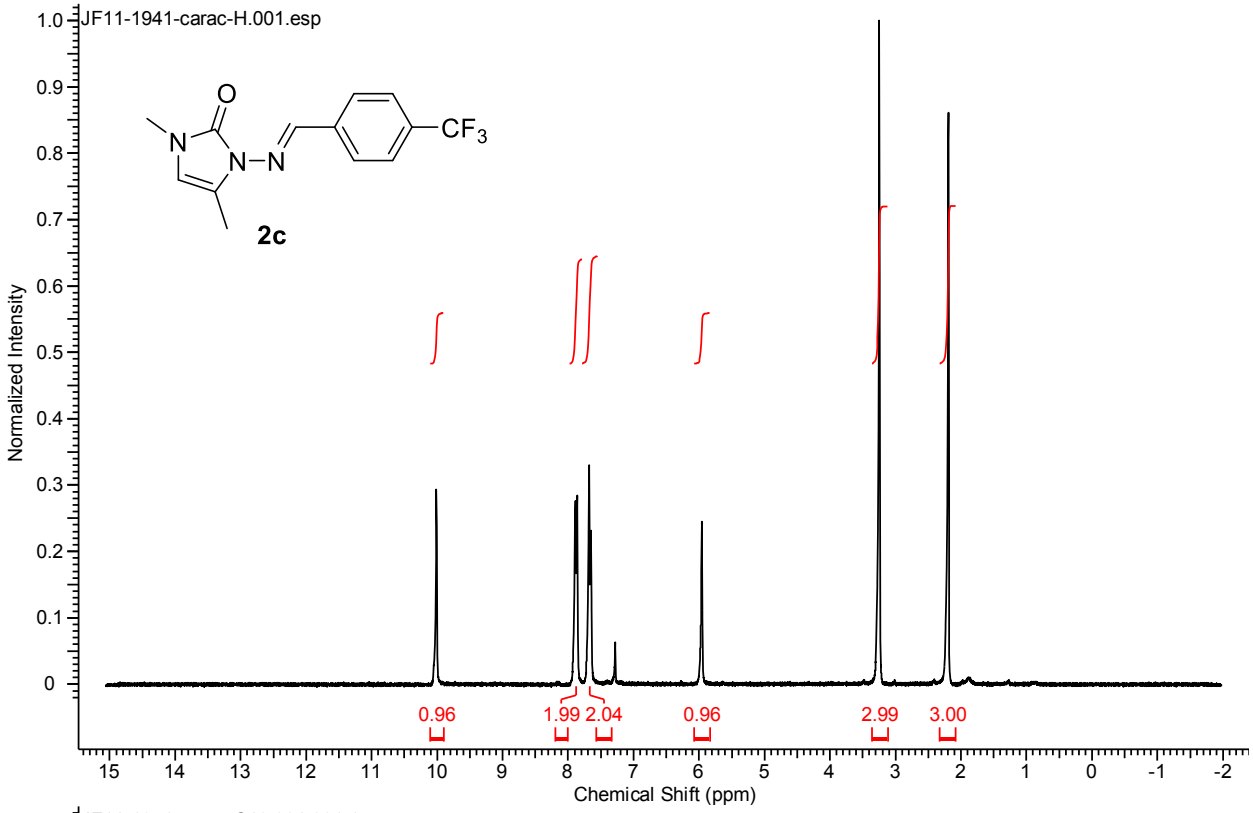
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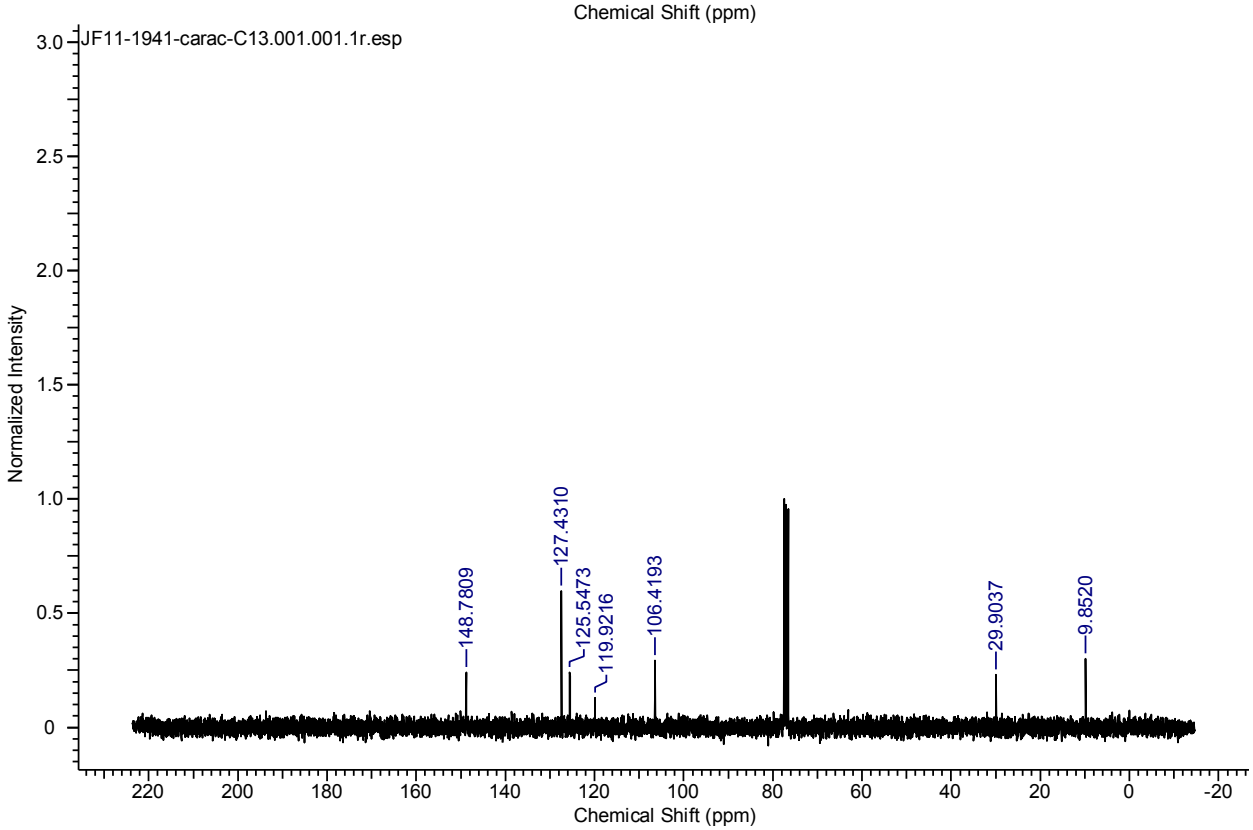
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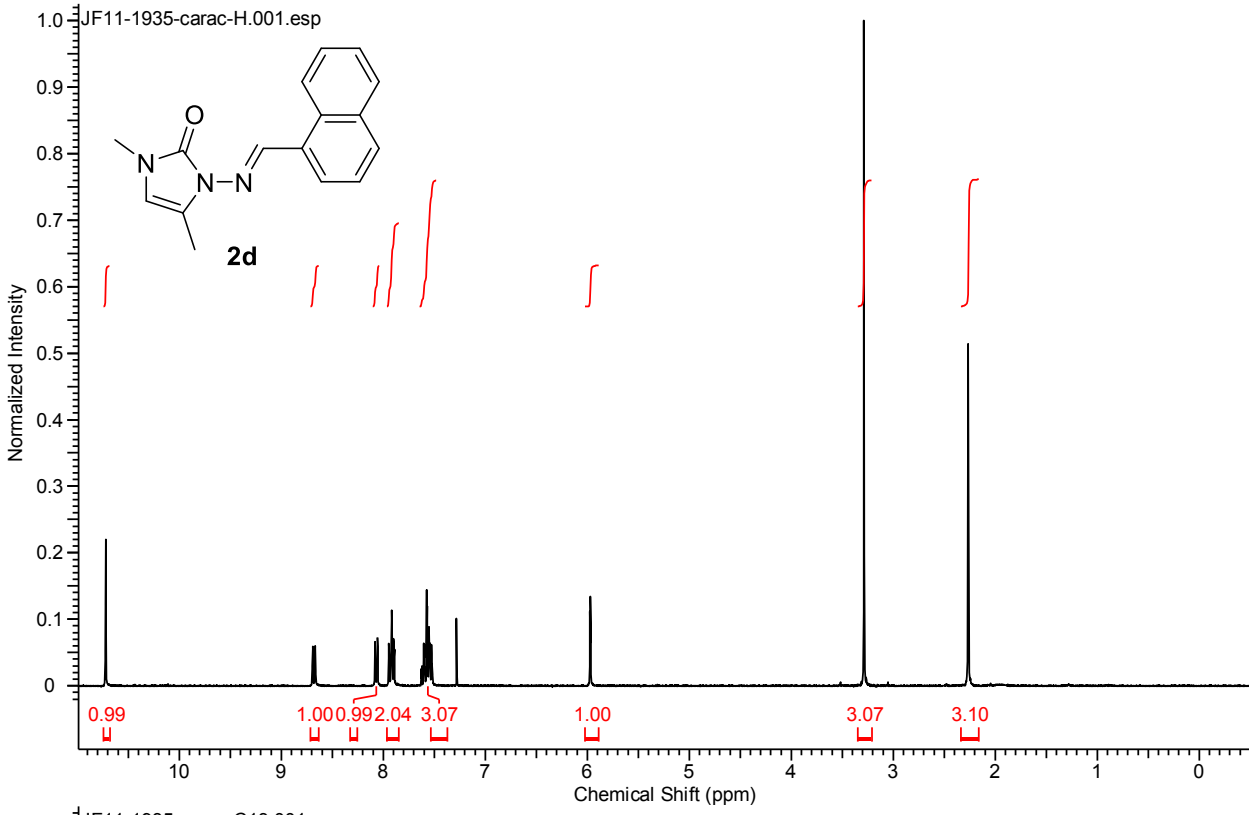
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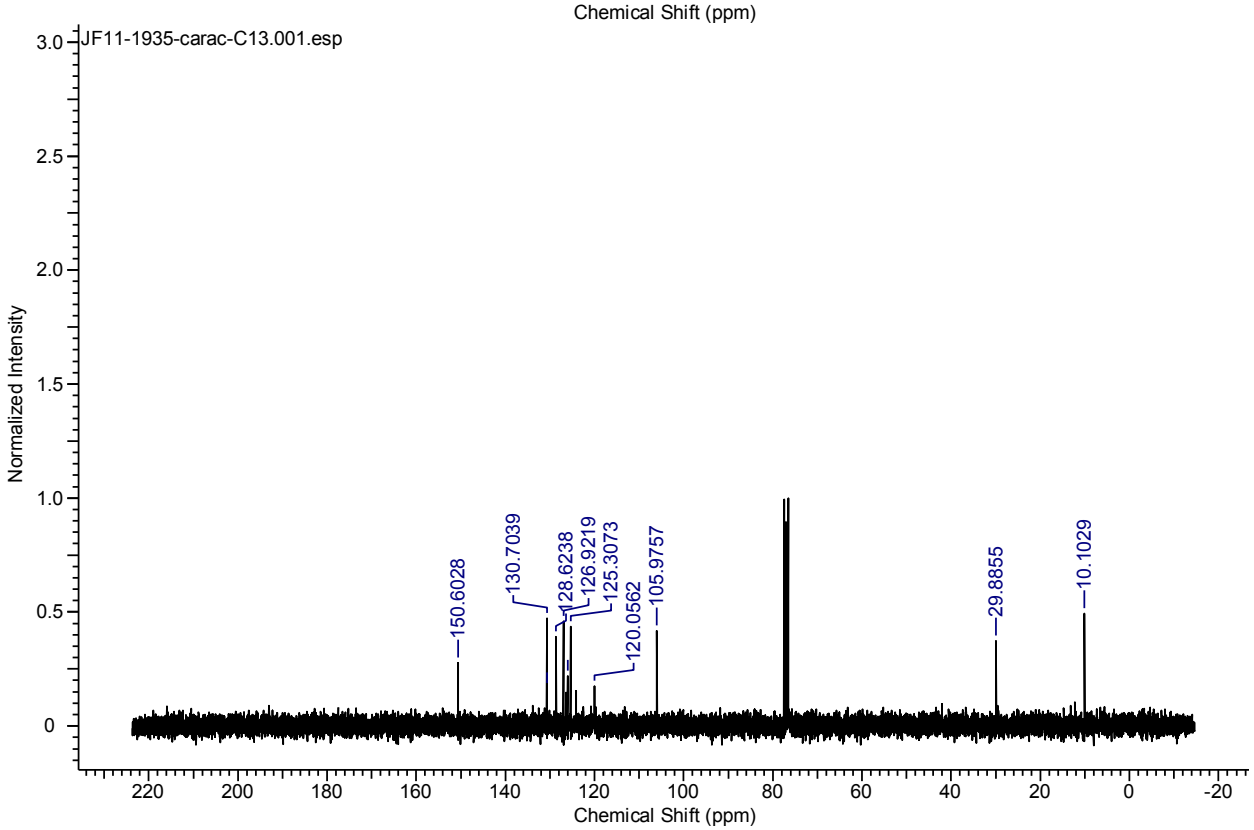
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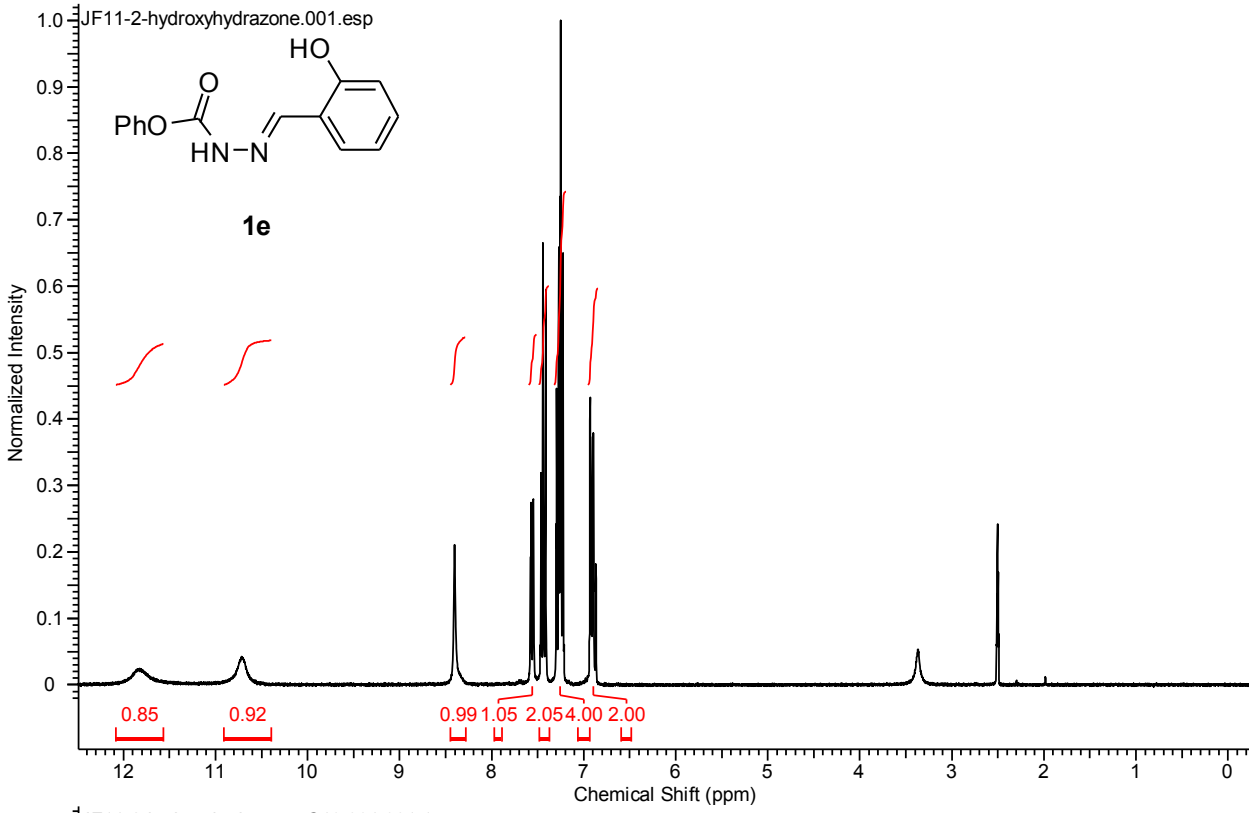
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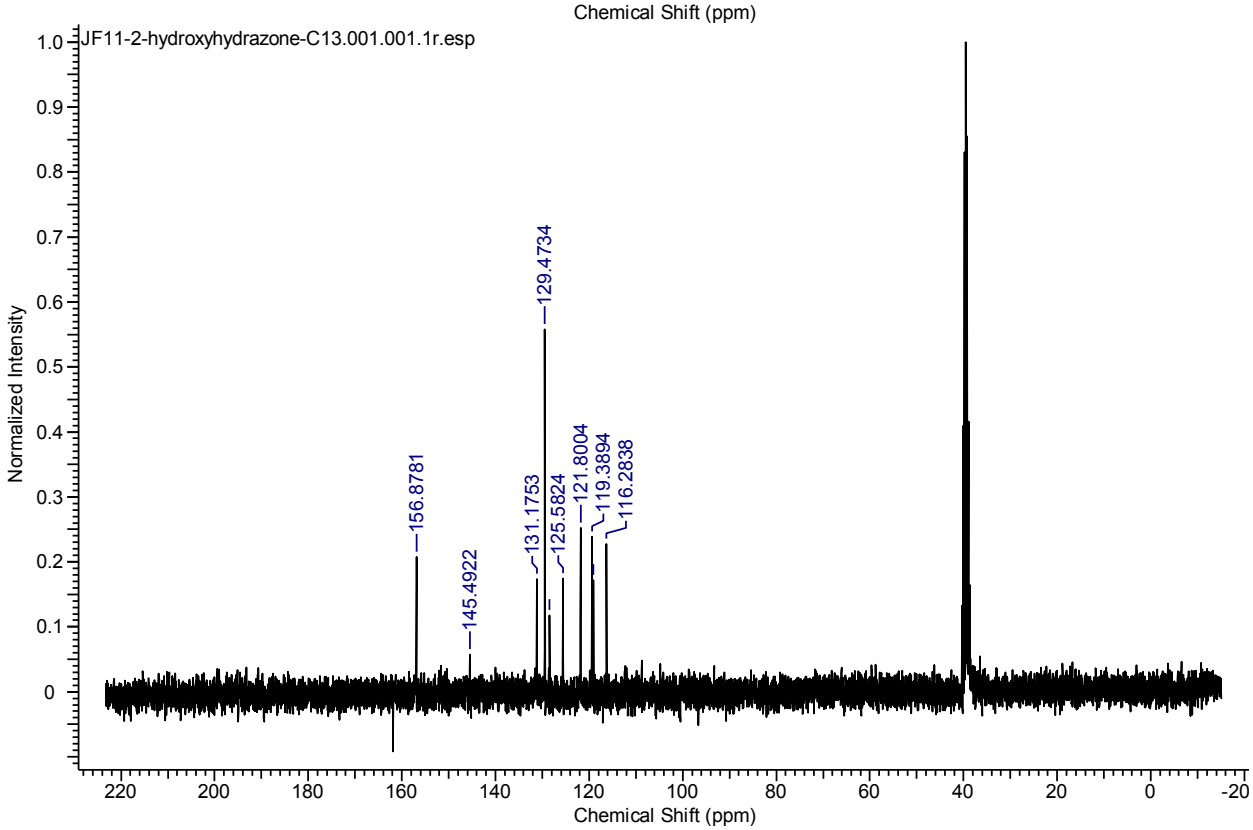
Chemical Shift (ppm)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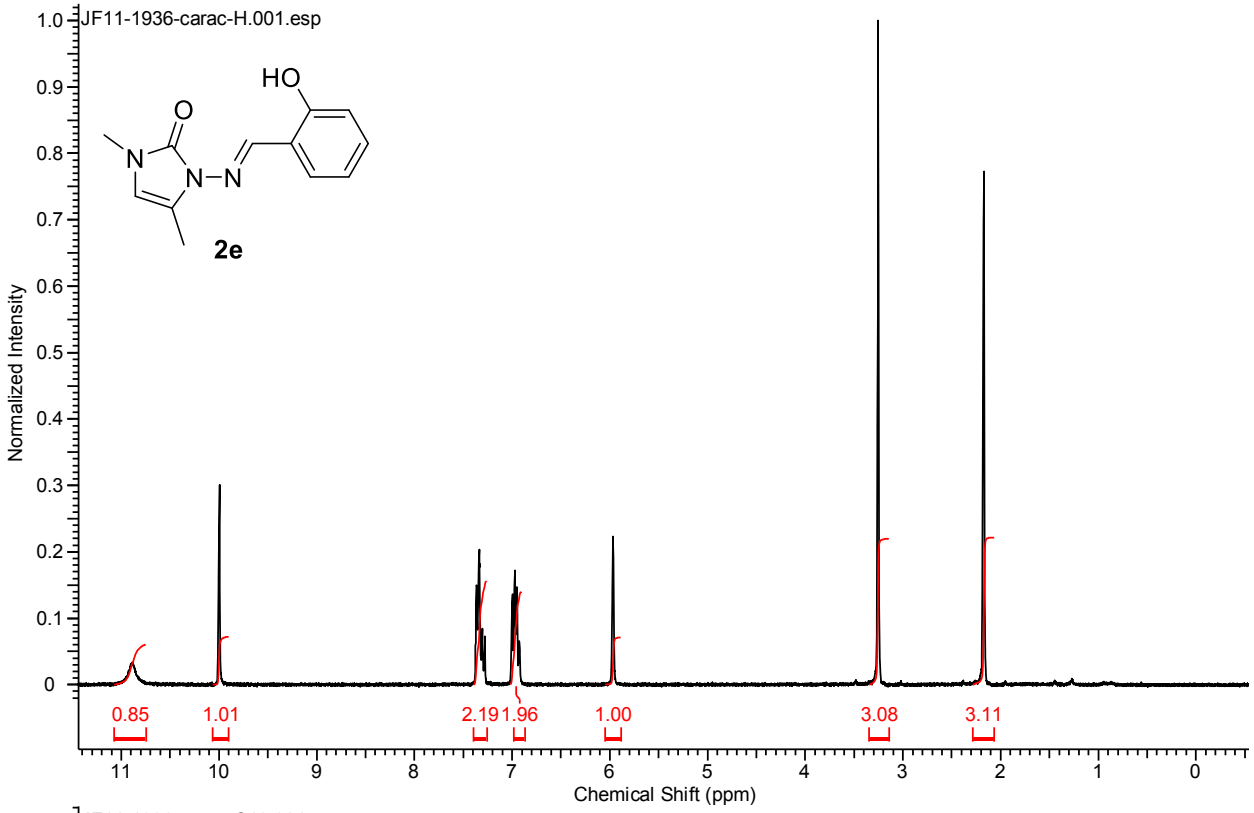
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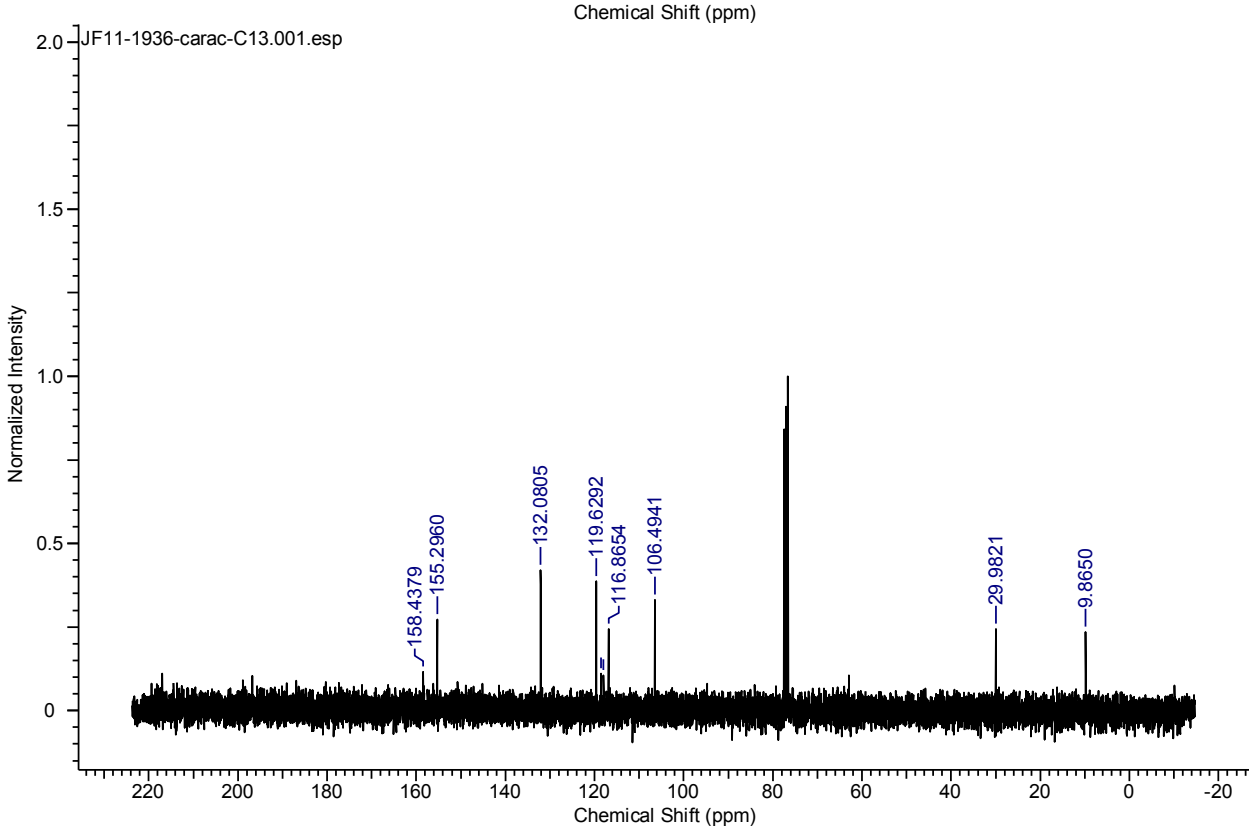
Chemical Shift (ppm)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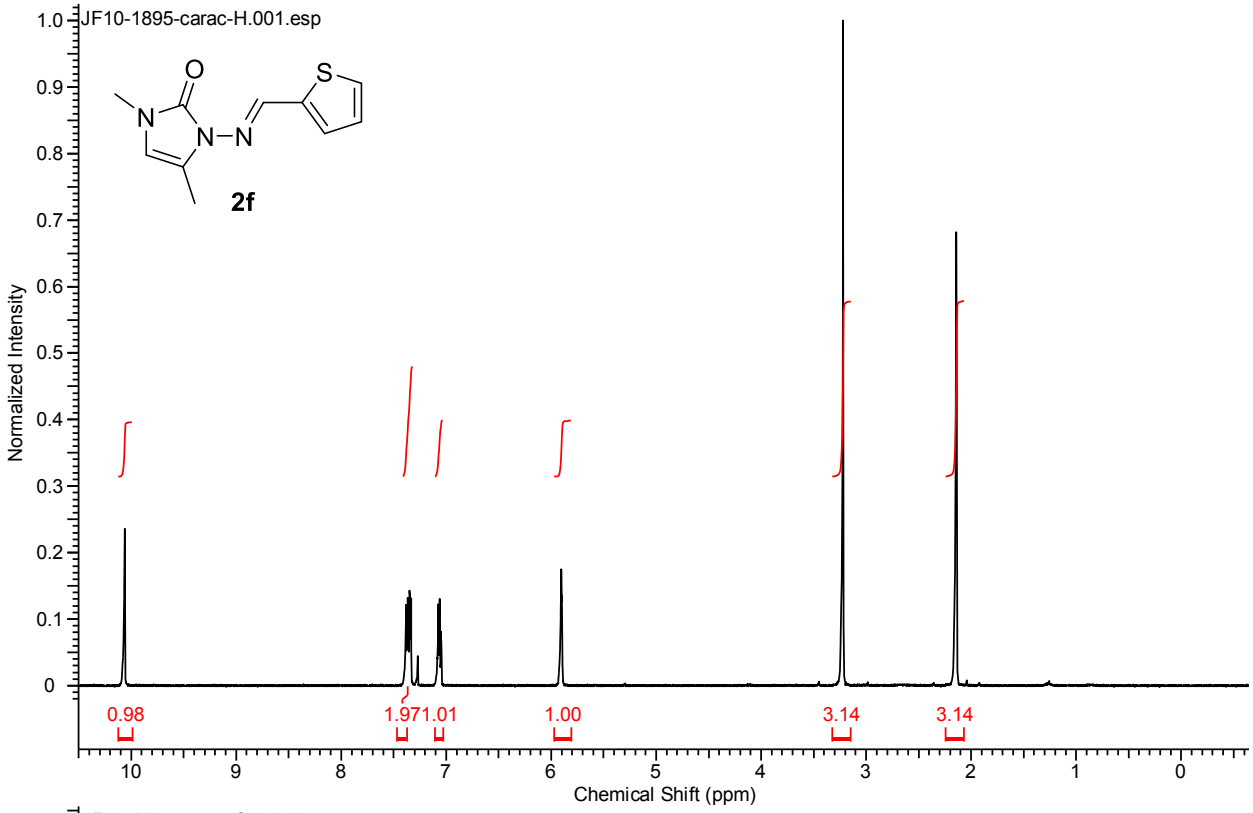
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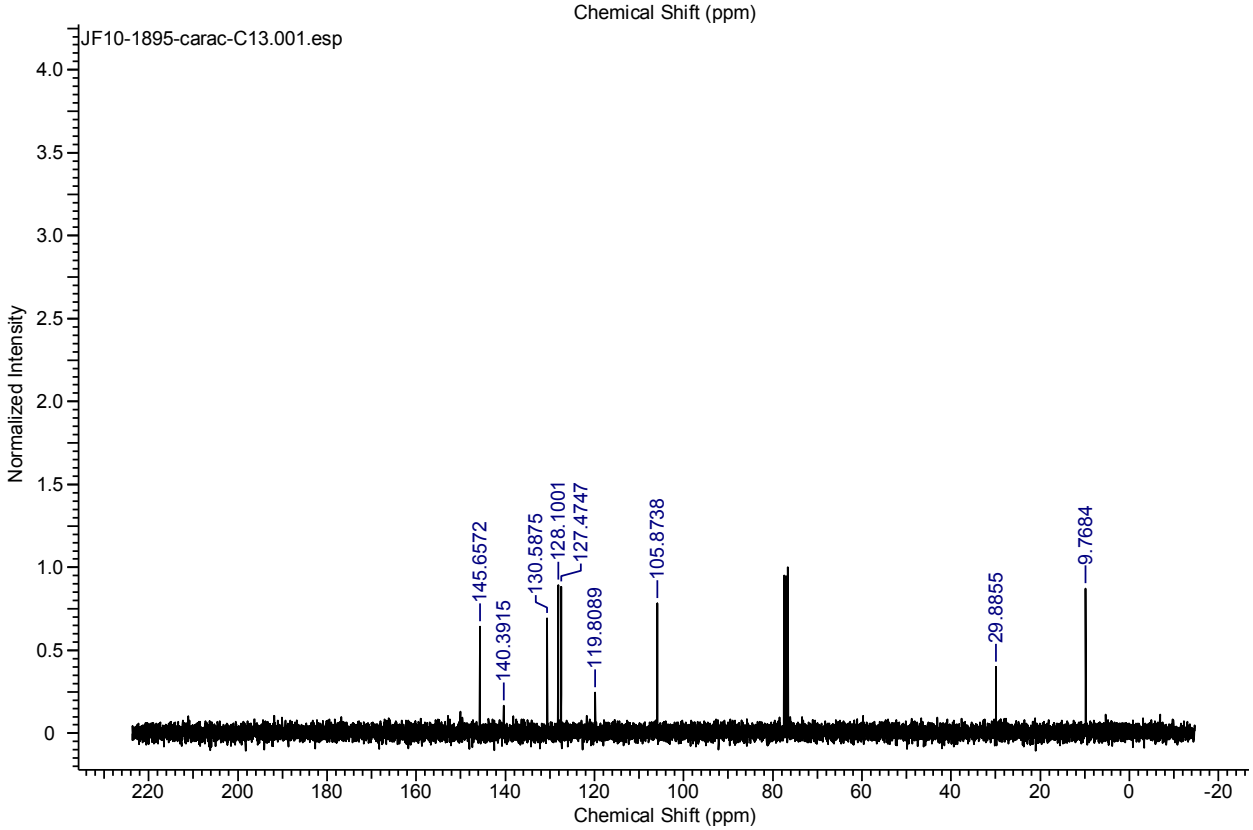
Chemical Shift (ppm)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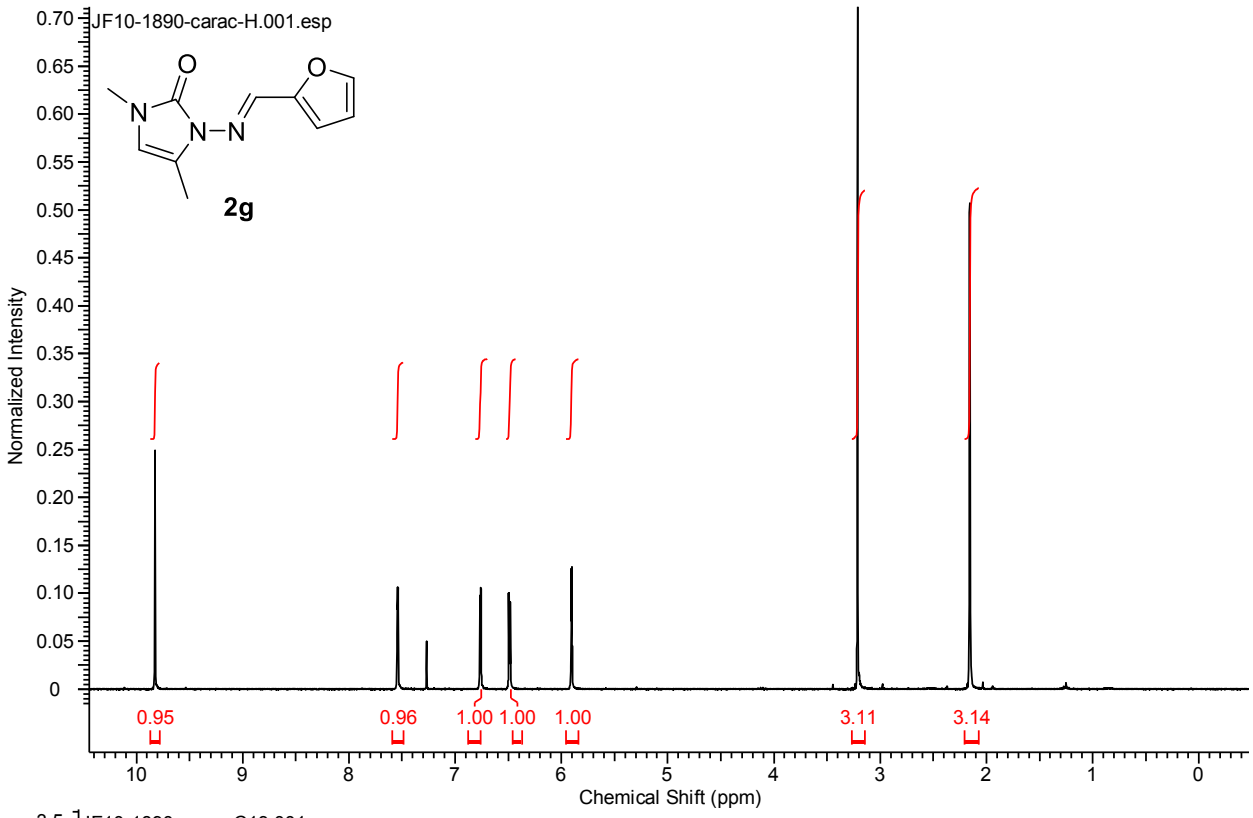
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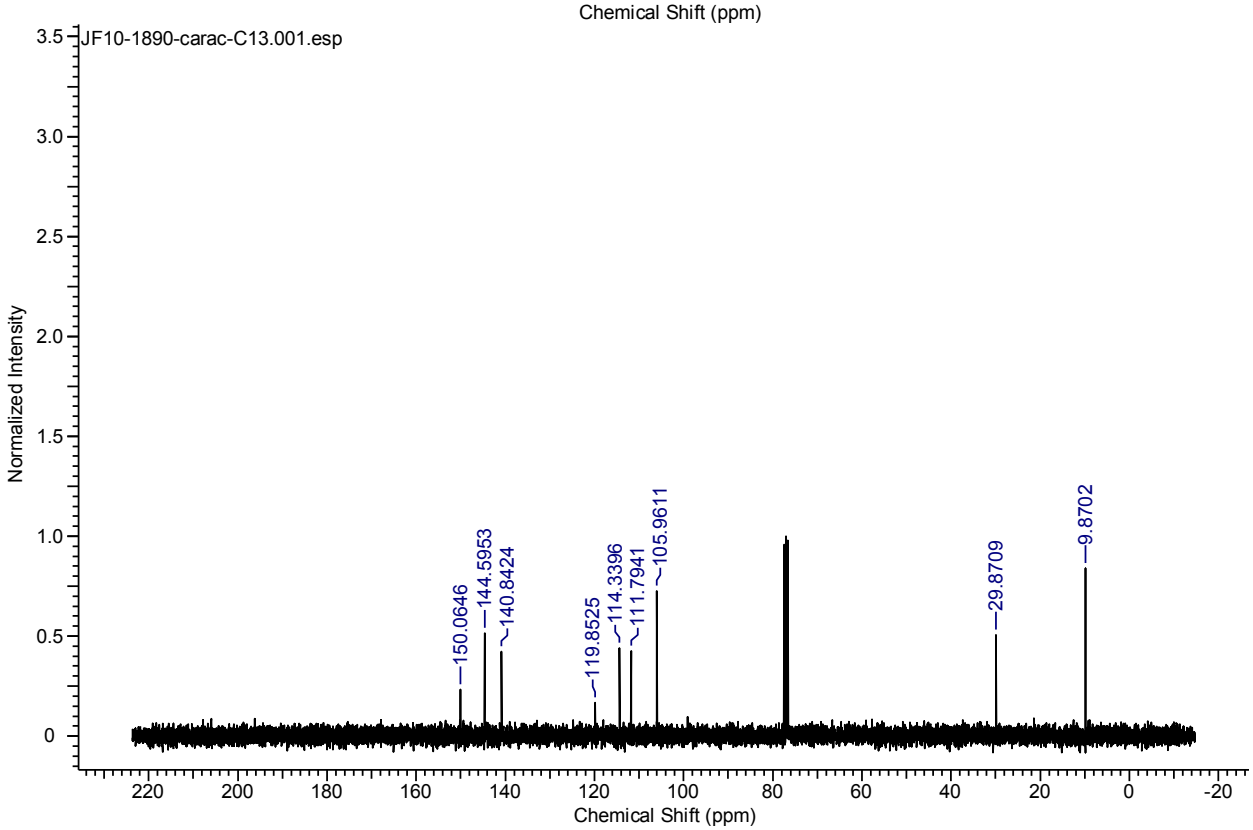
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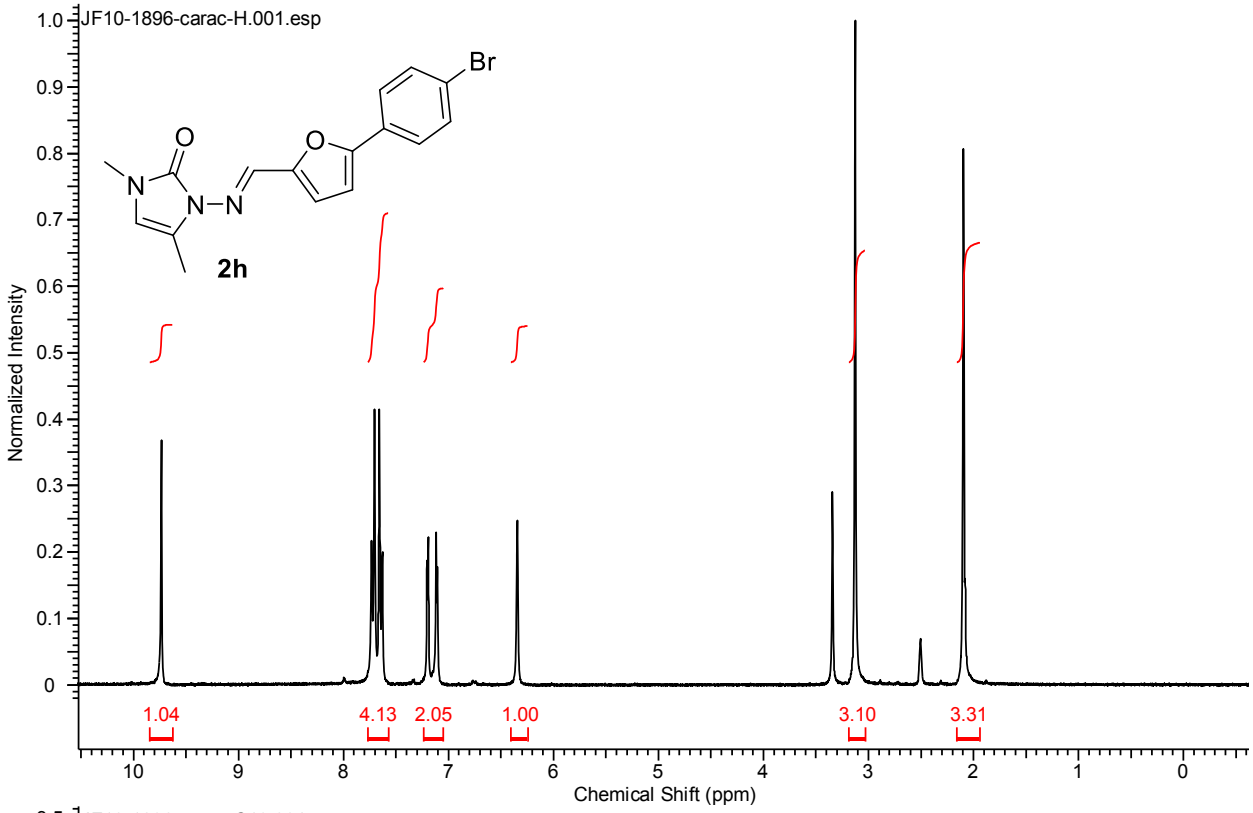
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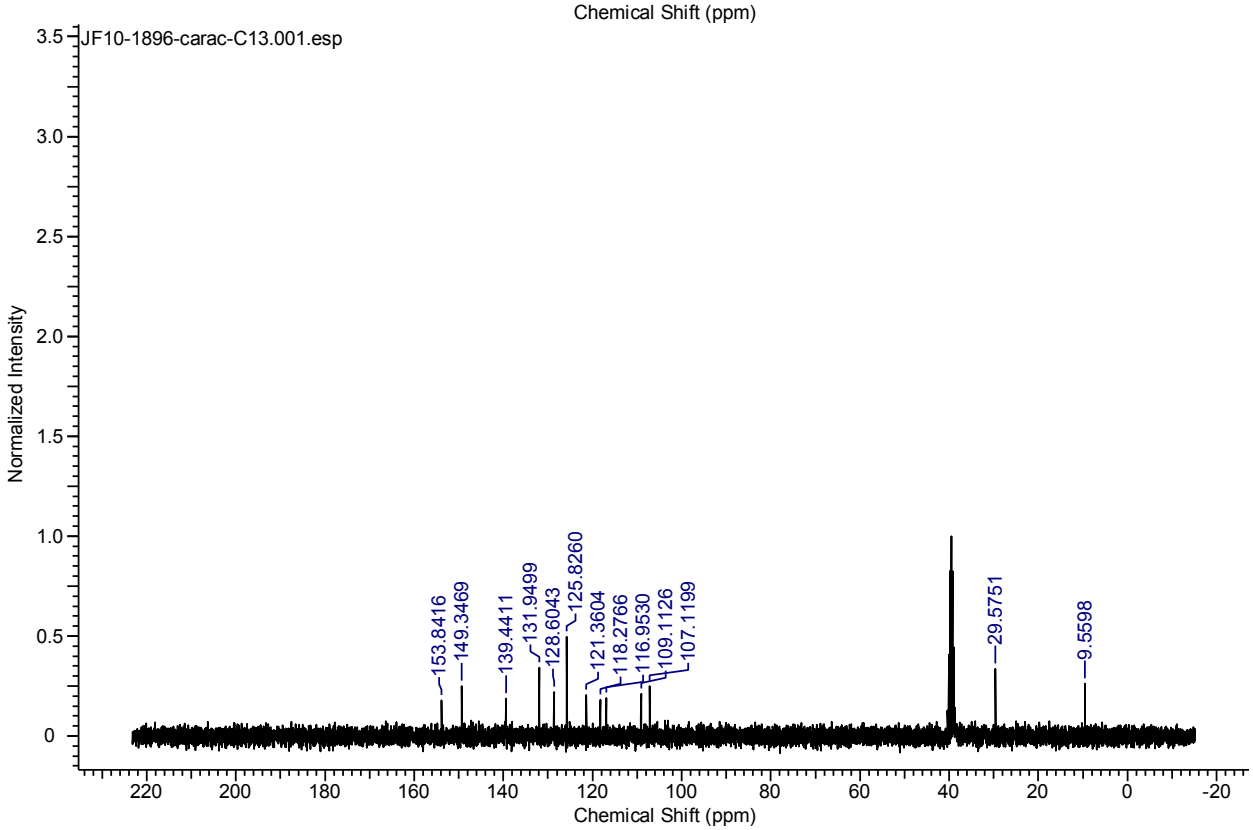
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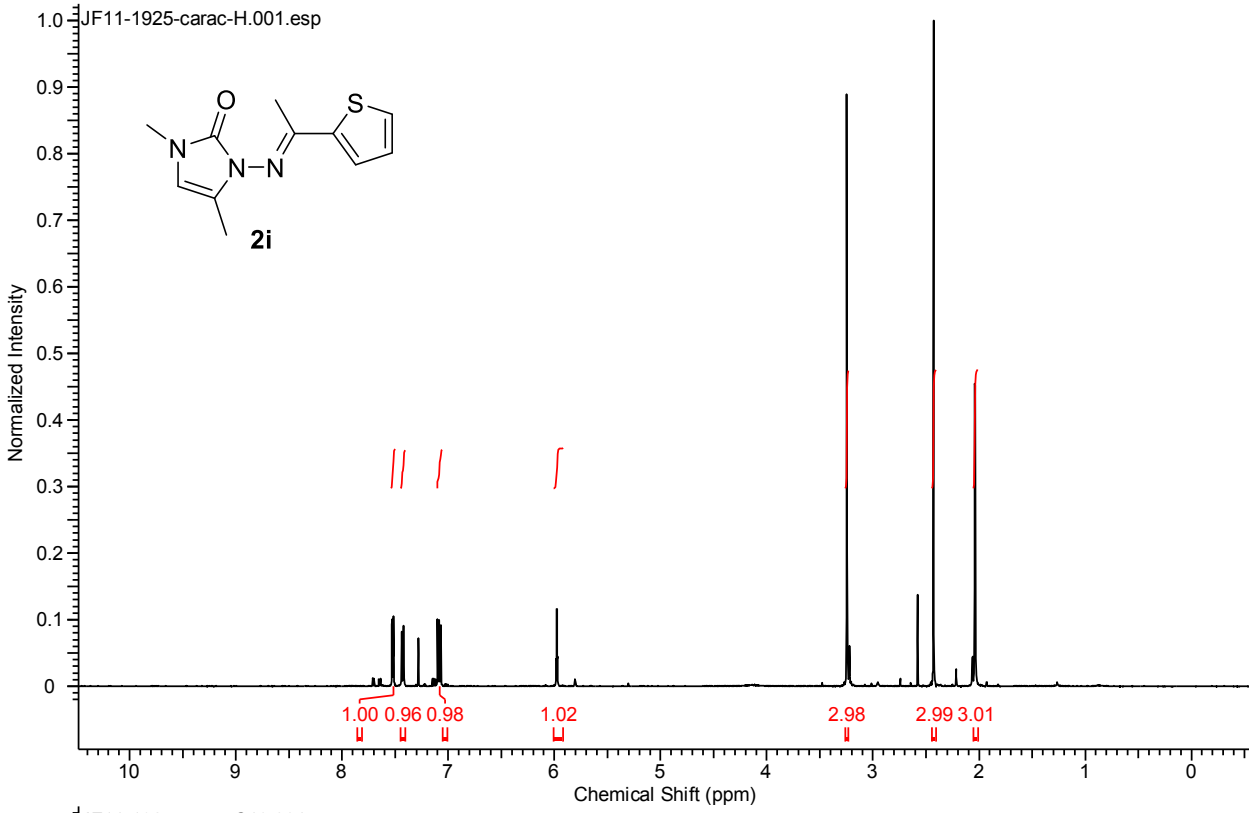
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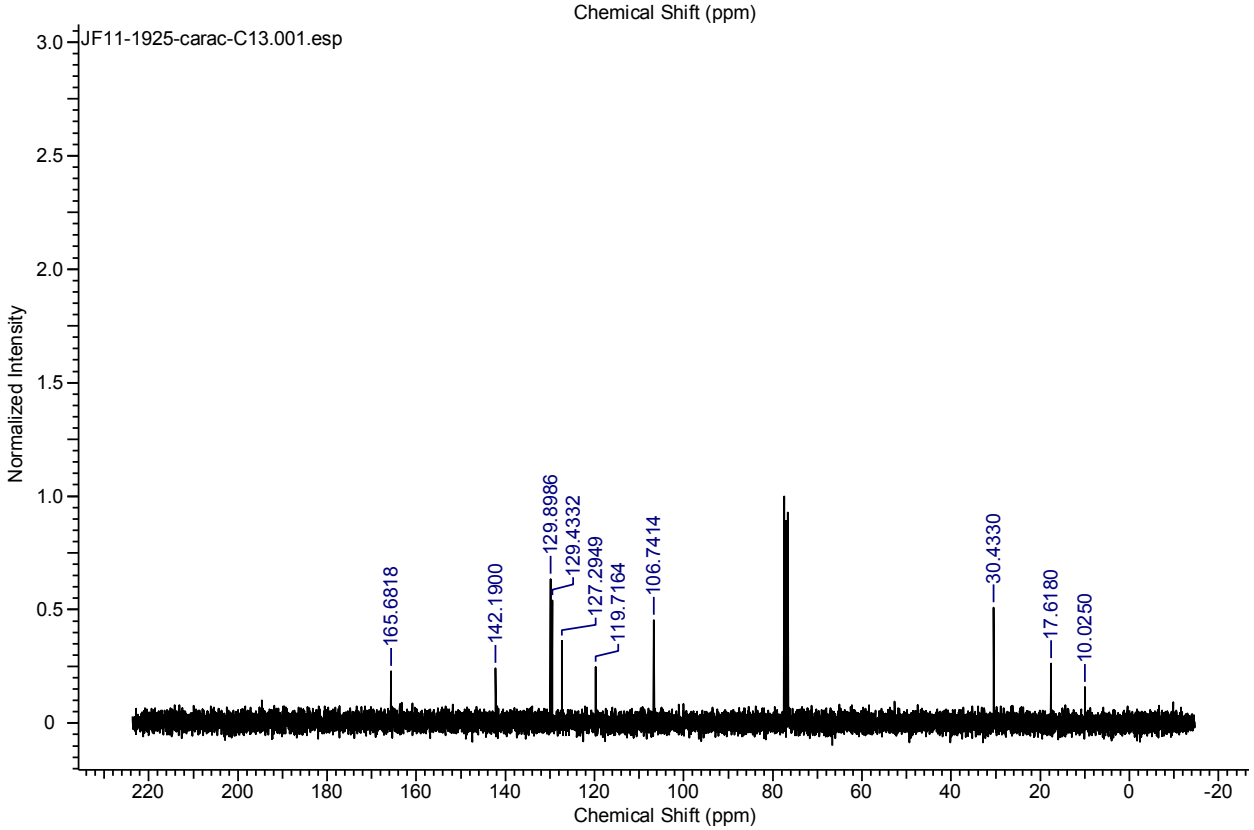
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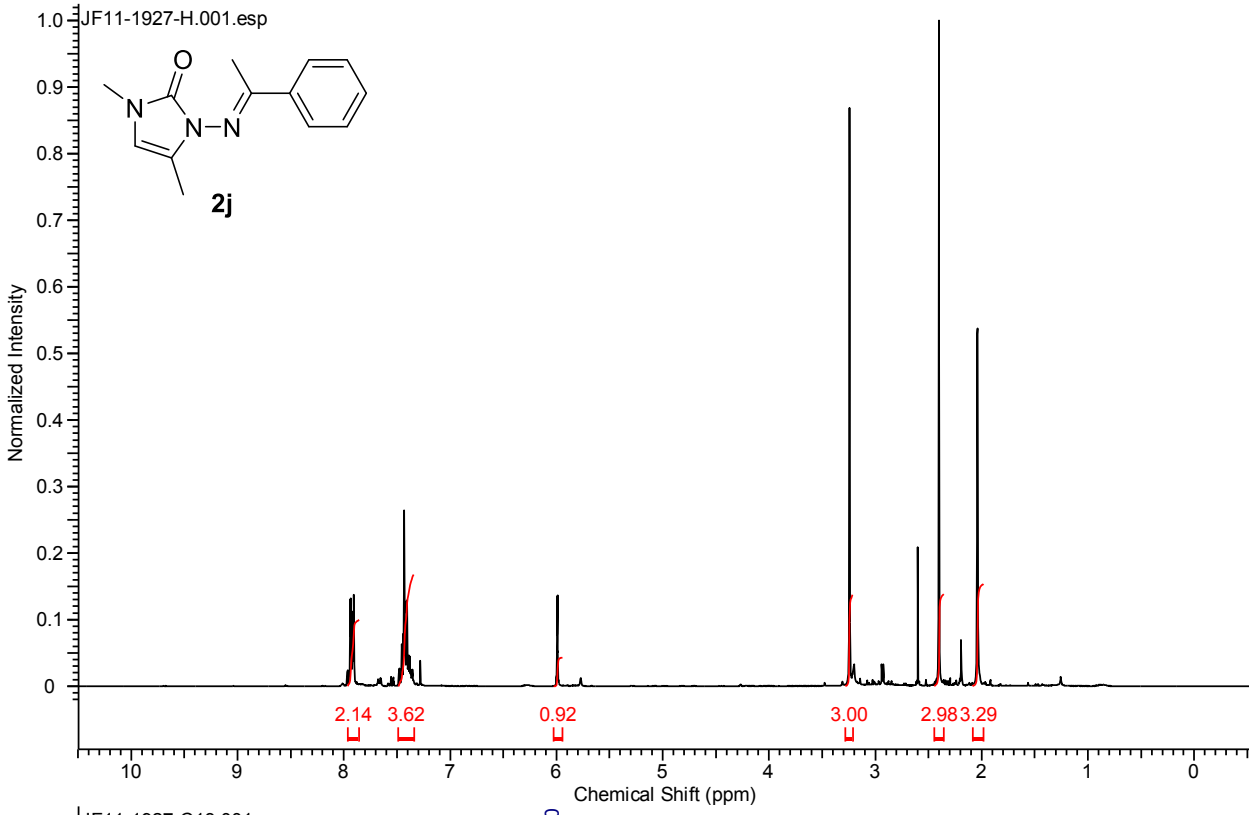
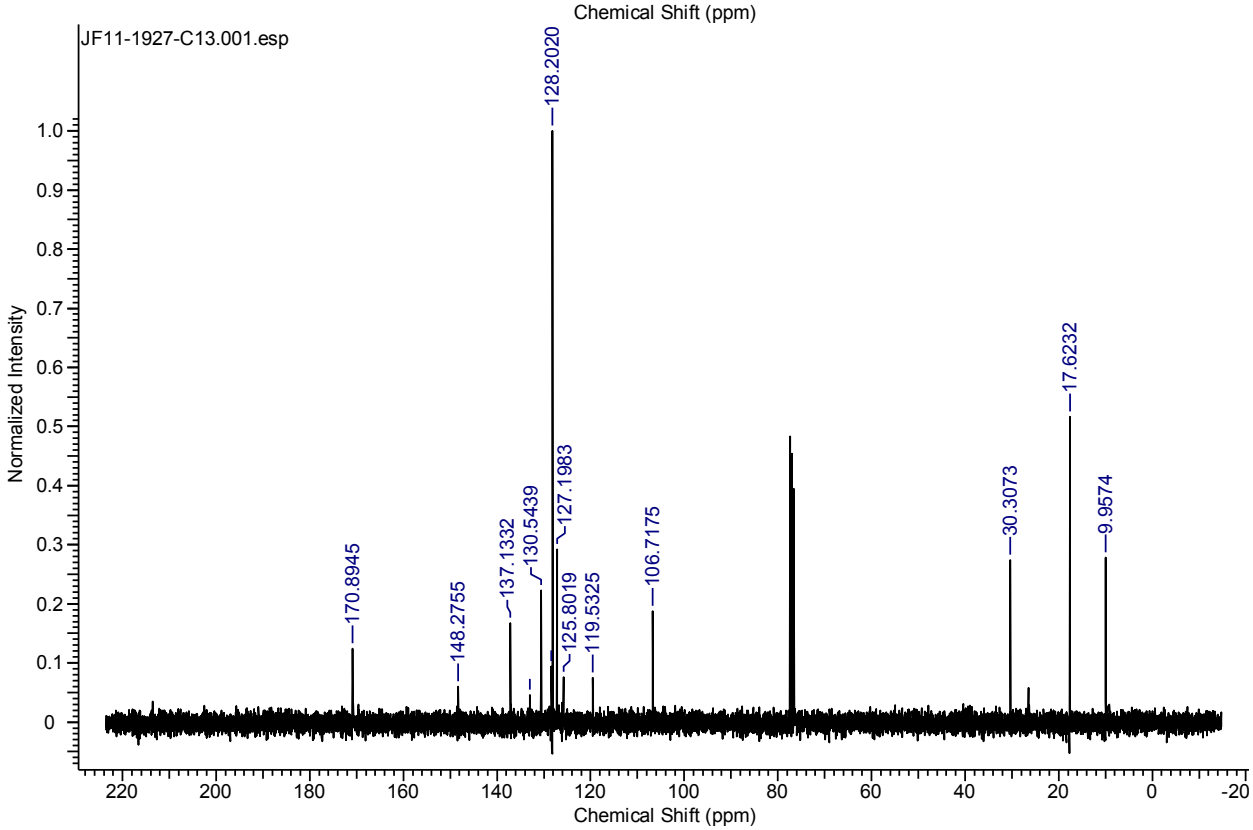
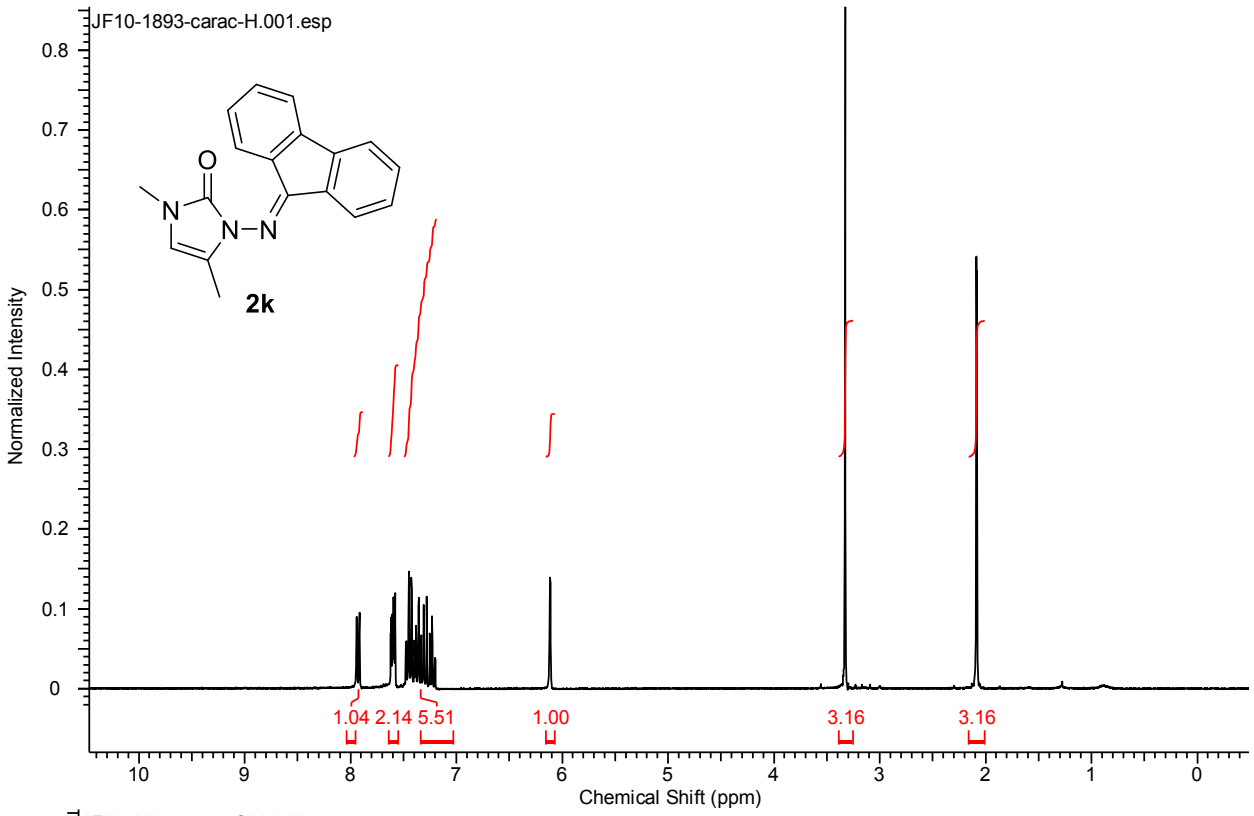
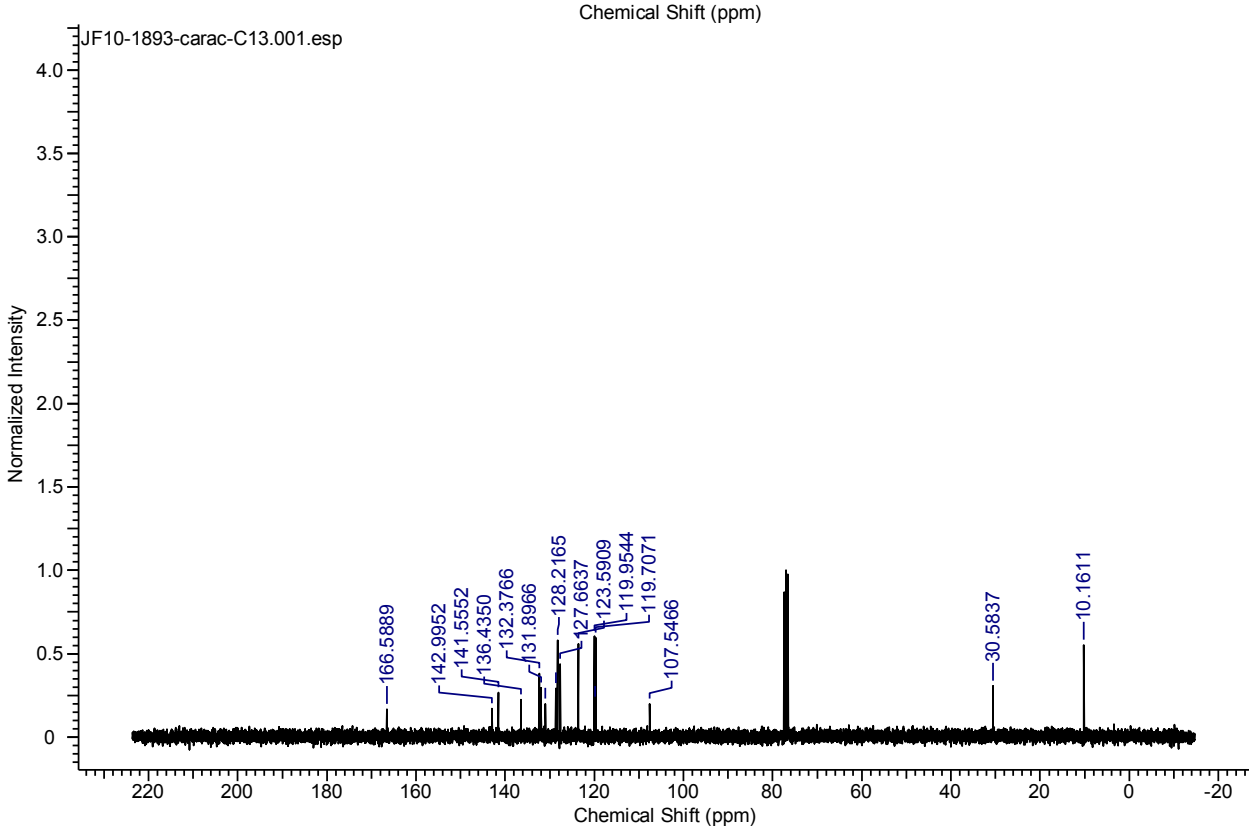
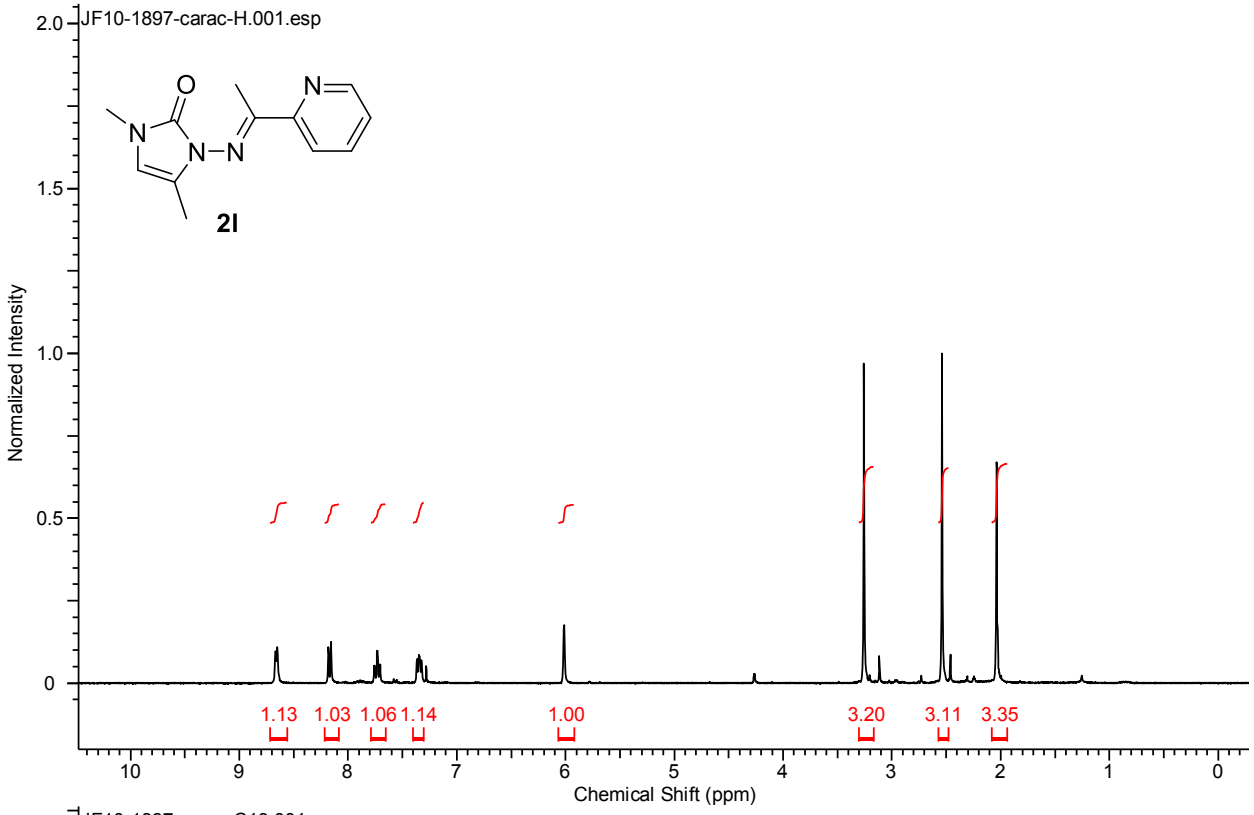
129.4332
127.2949
119.7164
106.7414
30.4330
17.6180
10.0250
Normalized Intensity
Chemical Shift (ppm)

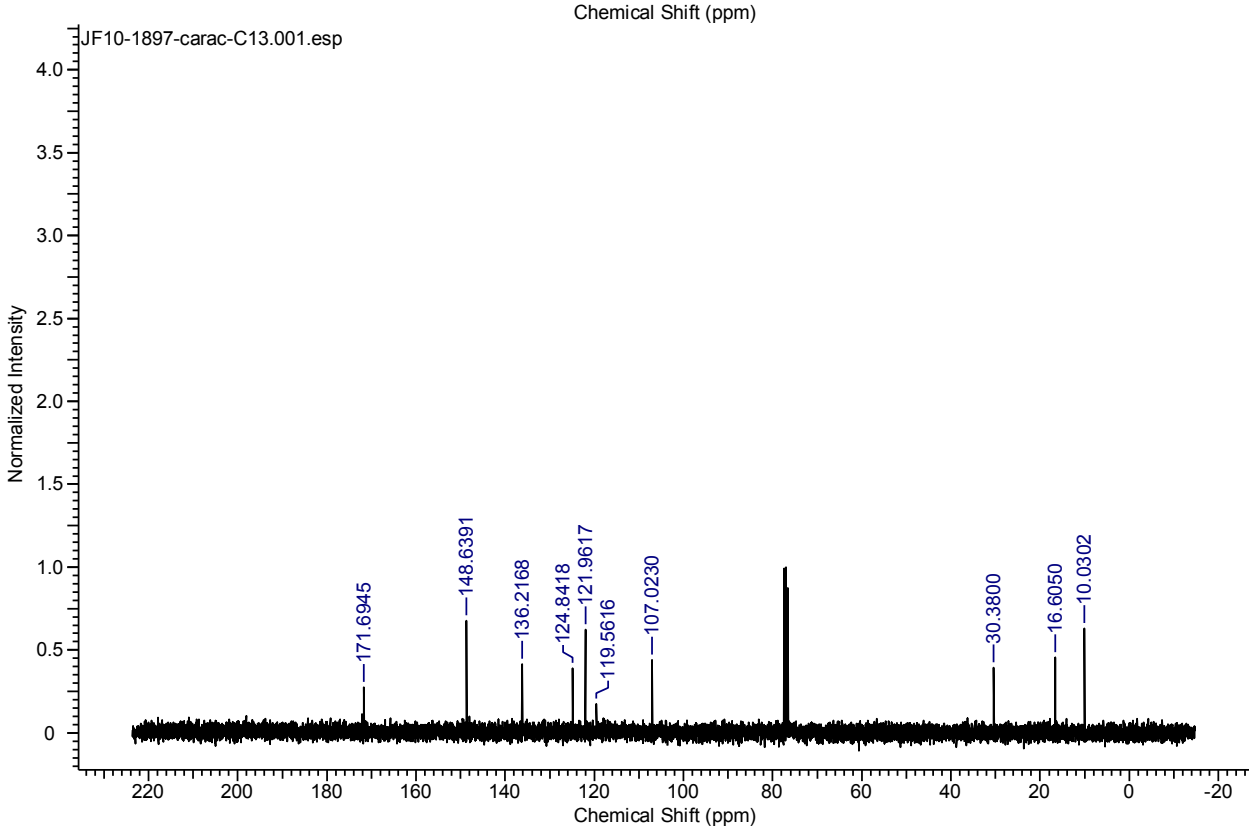

JF11-1927-H.001.esp
2j
Normalized Intensity
Chemical Shift (ppm)
2.14
3.62
0.92
3.00
2.98
3.29

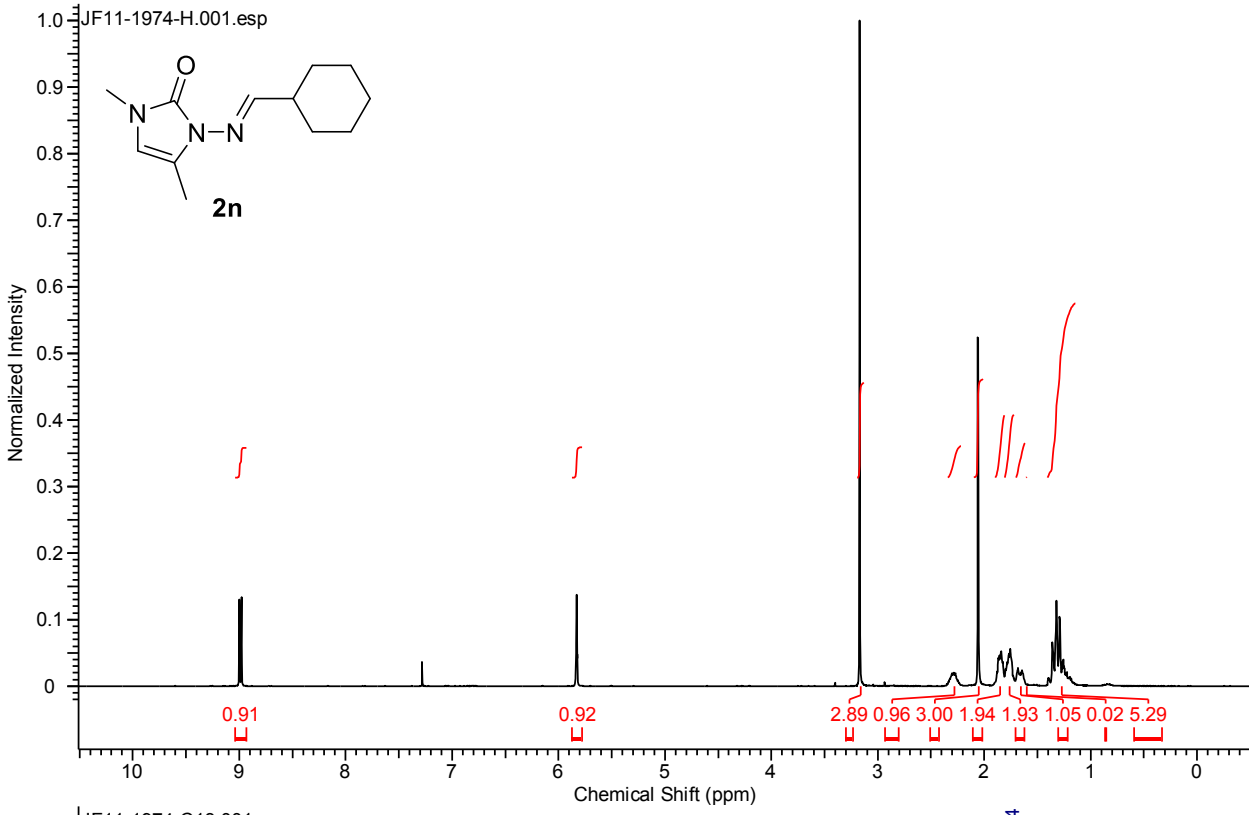

JF11-1927-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
170.8945
148.2755
137.1332
130.5439
128.2020
127.1983
125.8019
119.5325
106.7175
30.3073
17.6232
9.9574

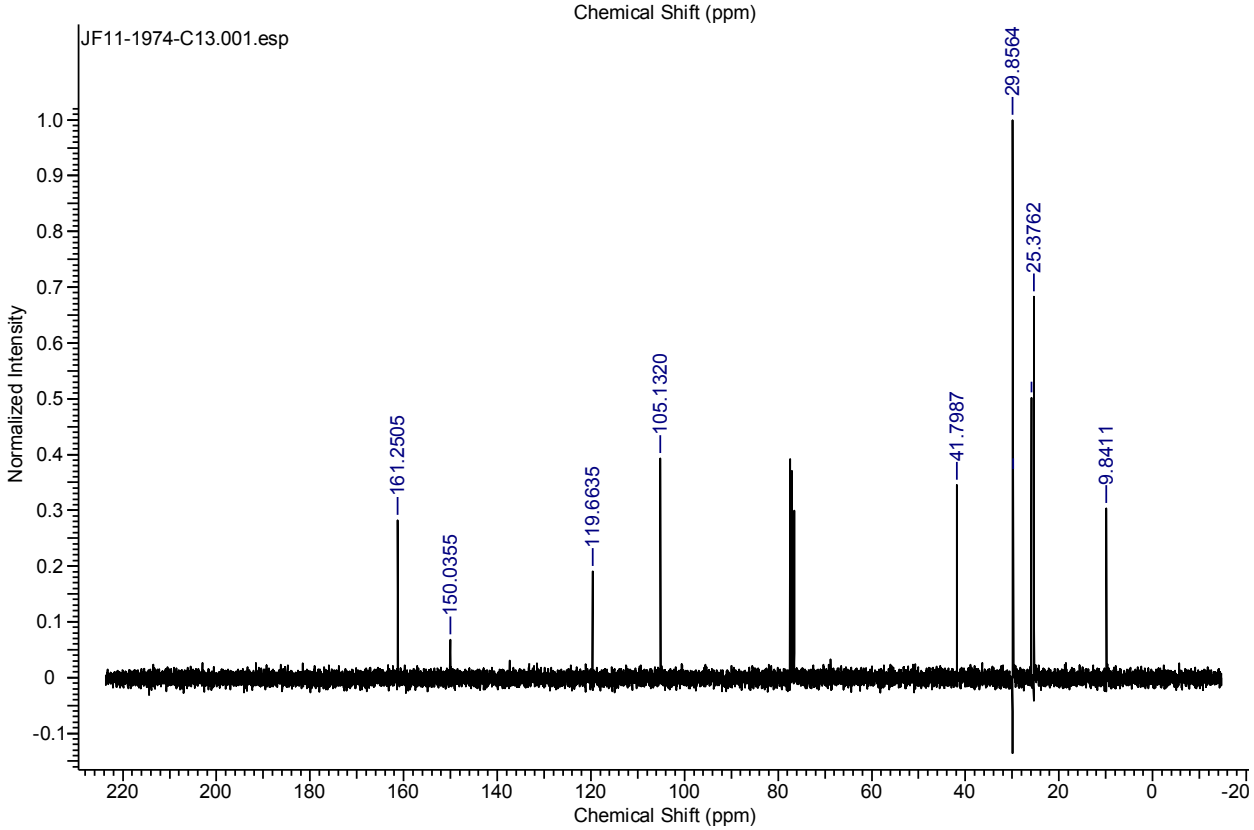

JF10-1893-carac-H.001.esp
Normalized Intensity
Chemical Shift (ppm)
1.04
2.14
5.51
1.00
3.16
3.16
2k

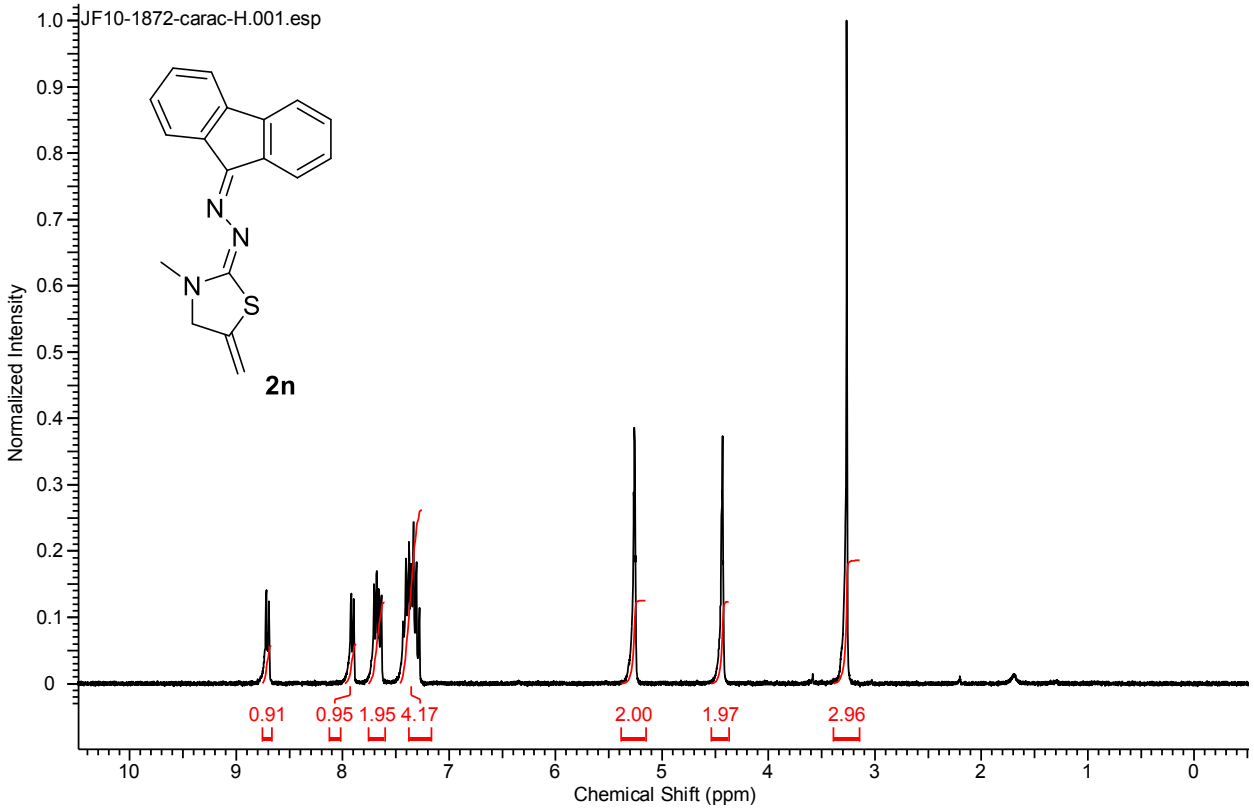

JF10-1893-carac-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
166.5889
142.9952
141.5552
136.4350
132.3766
131.8966
128.2165
127.6637
123.5909
119.9544
119.7071
107.5466
30.5837
10.1611

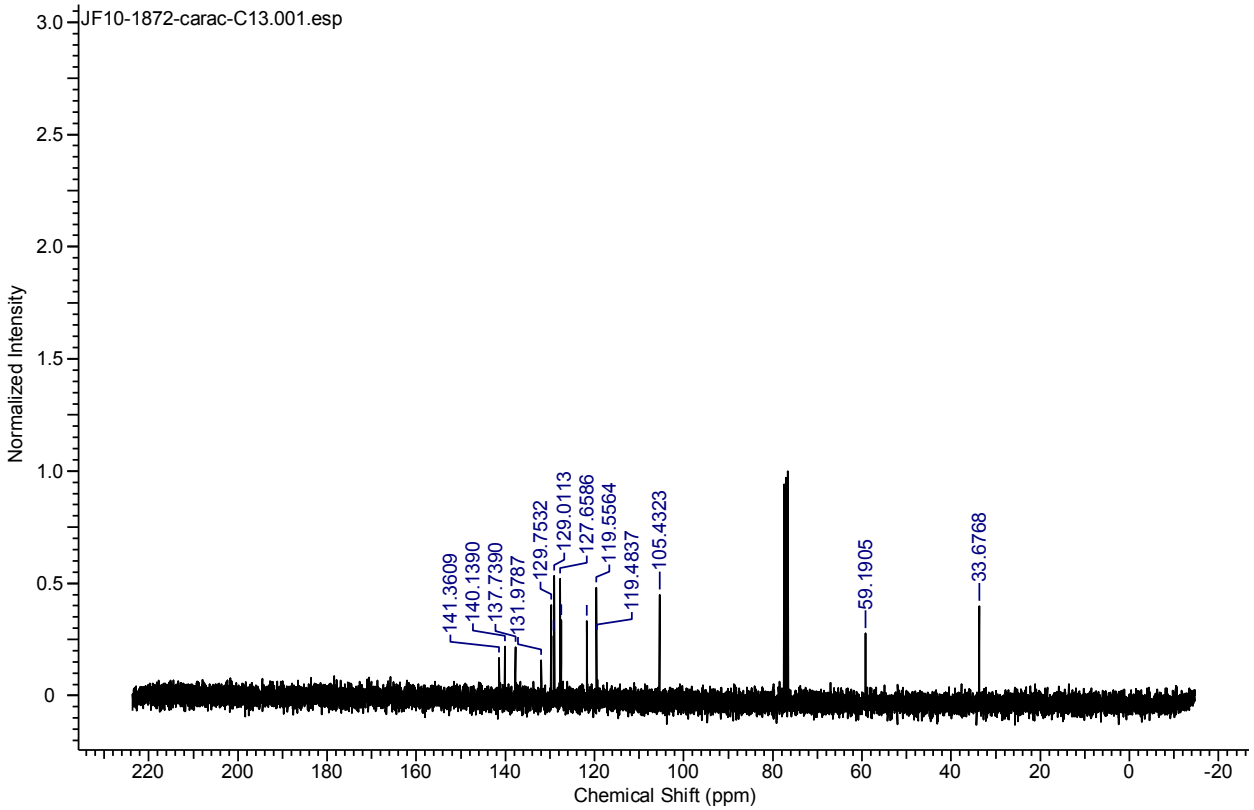

JF10-1897-carac-H.001.esp
O
N
N
N
N
2l
Normalized Intensity
Chemical Shift (ppm)
1.13
1.03
1.06
1.14
1.00
3.20
3.11
3.35

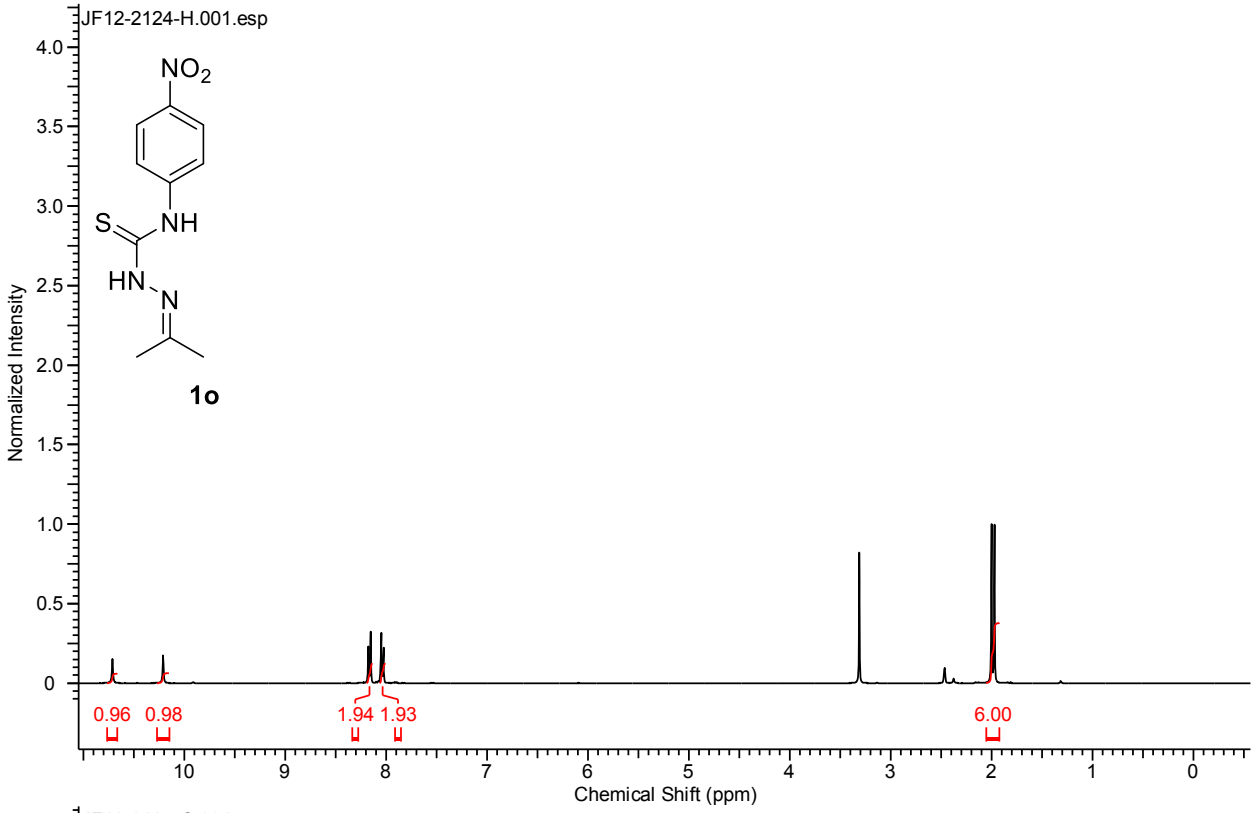

JF10-1897-carac-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
171.6945
148.6391
136.2168
124.8418
121.9617
119.5616
107.0230
30.3800
16.6050
10.0302

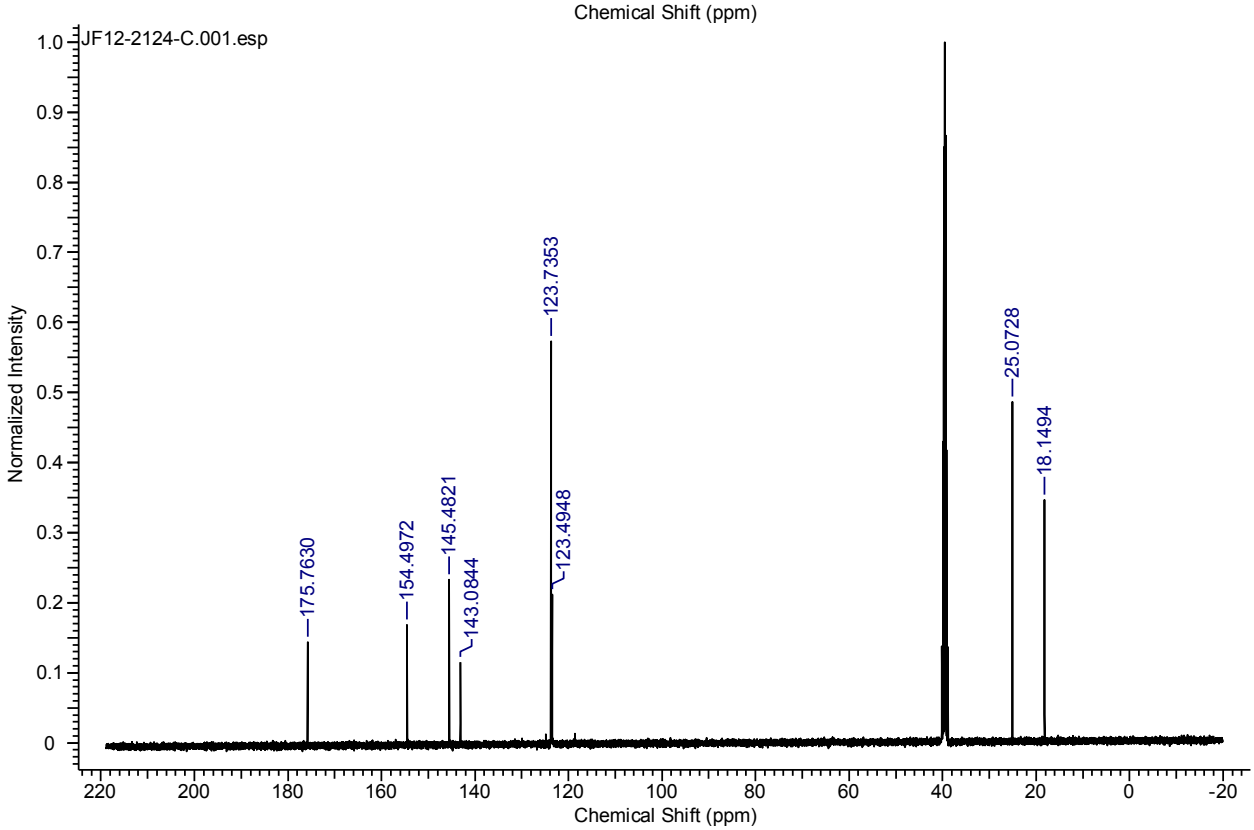

JF11-1974-H.001.esp
2n
Normalized Intensity
Chemical Shift (ppm)
0.91
0.92
2.89 0.96 3.00 1.94 1.93 1.05 0.02 5.29

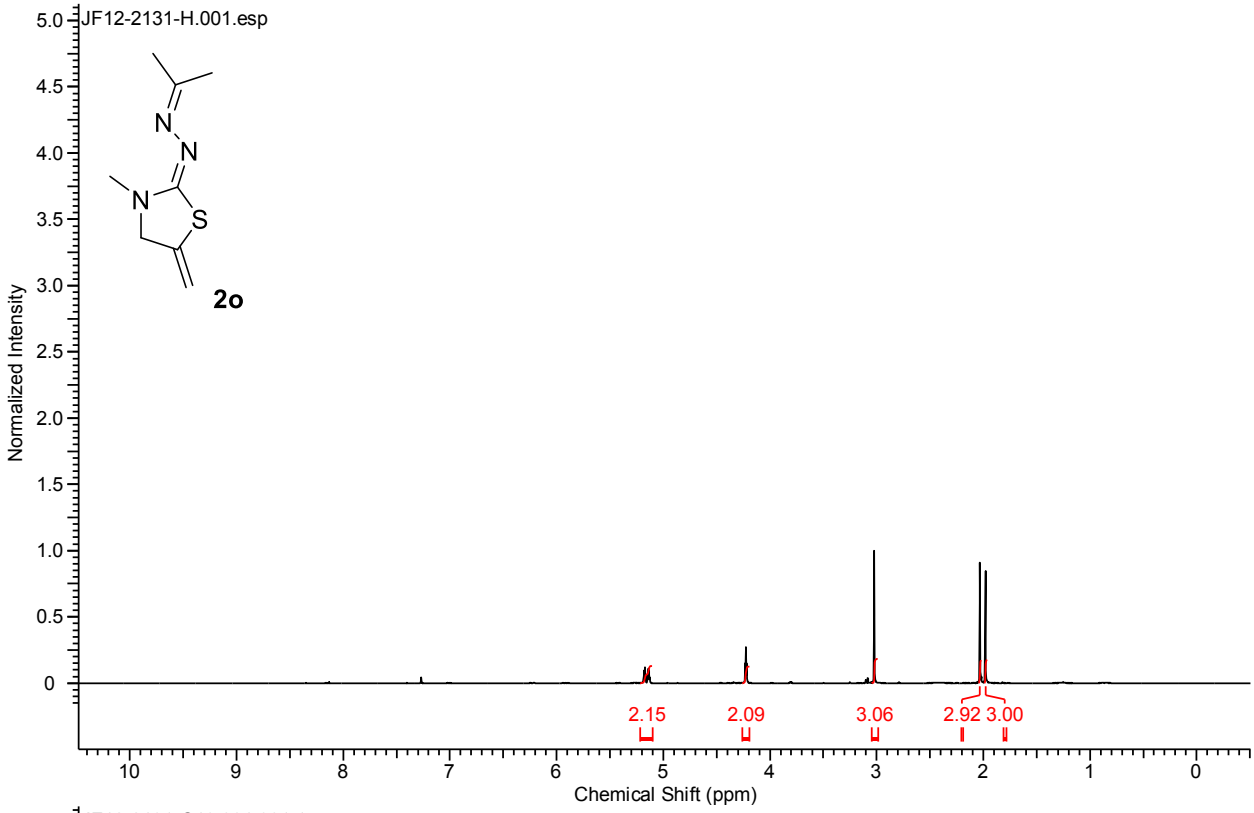

JF11-1974-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
161.2505
150.0355
119.6635
105.1320
41.7987
29.8564
25.3762
9.8411

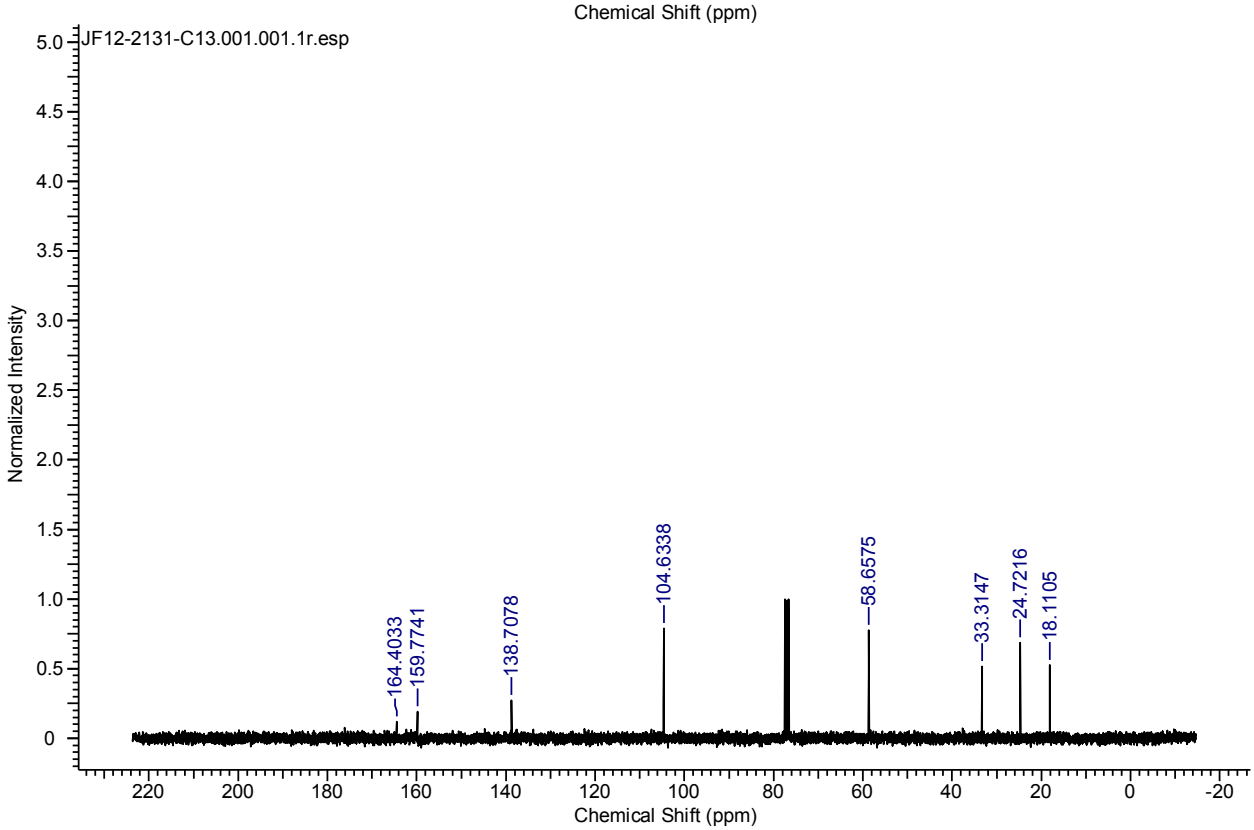

JF10-1872-carac-H.001.esp
2n
Normalized Intensity
Chemical Shift (ppm)
0.91
0.95
1.95
4.17
2.00
1.97
2.96

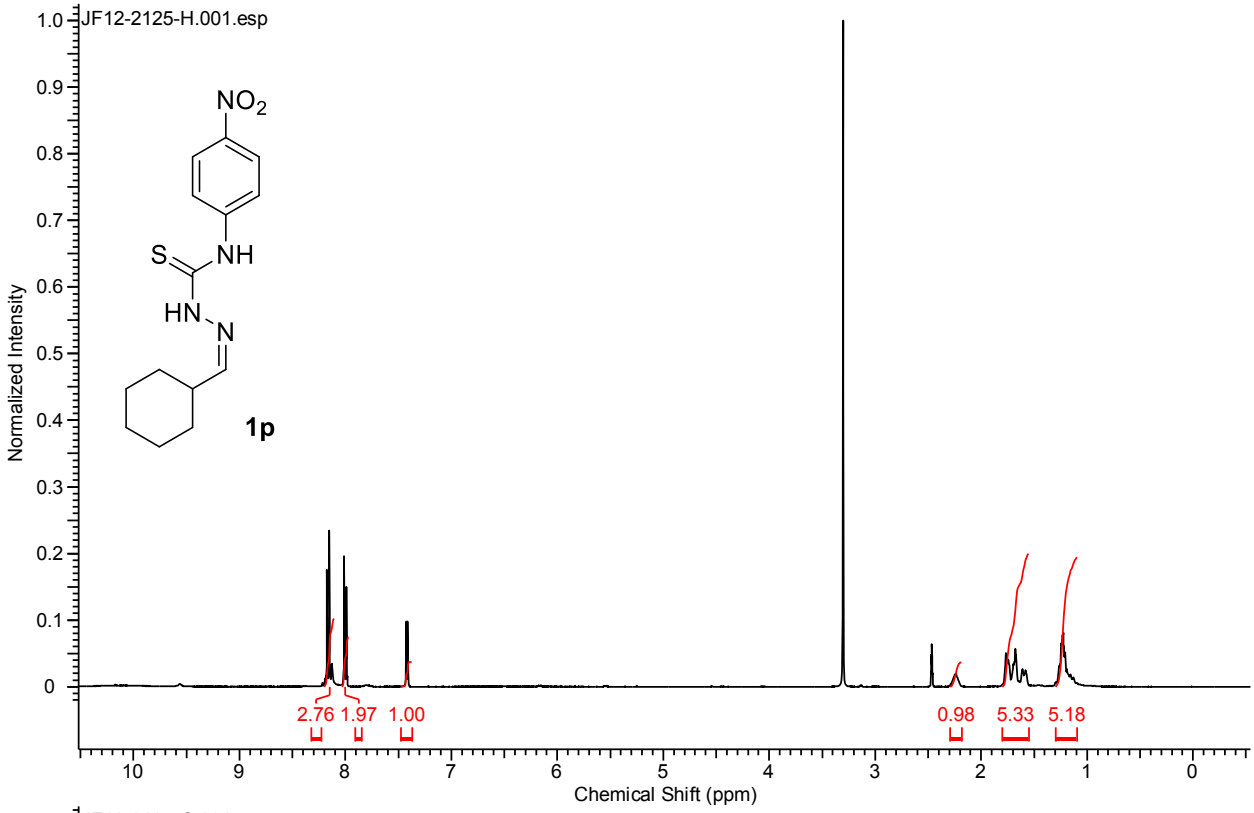

JF10-1872-carac-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
141.3609
140.1390
137.7390
131.9787
129.7532
129.0113
127.6586
119.5564
119.4837
105.4323
59.1905
33.6768

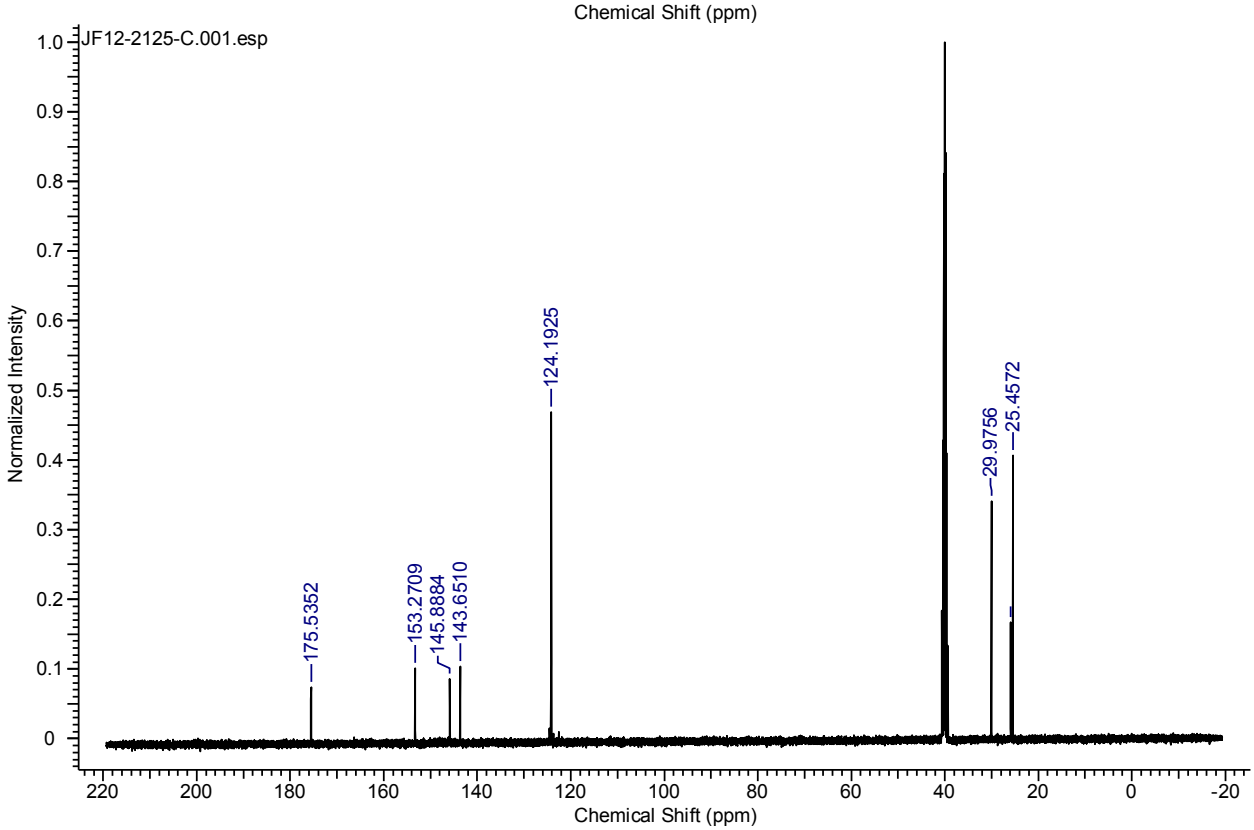

JF12-2124-H.001.esp
NO2
NH
S
HN
N
1o
Normalized Intensity
0.96
0.98
1.94
1.93
6.00
Chemical Shift (ppm)

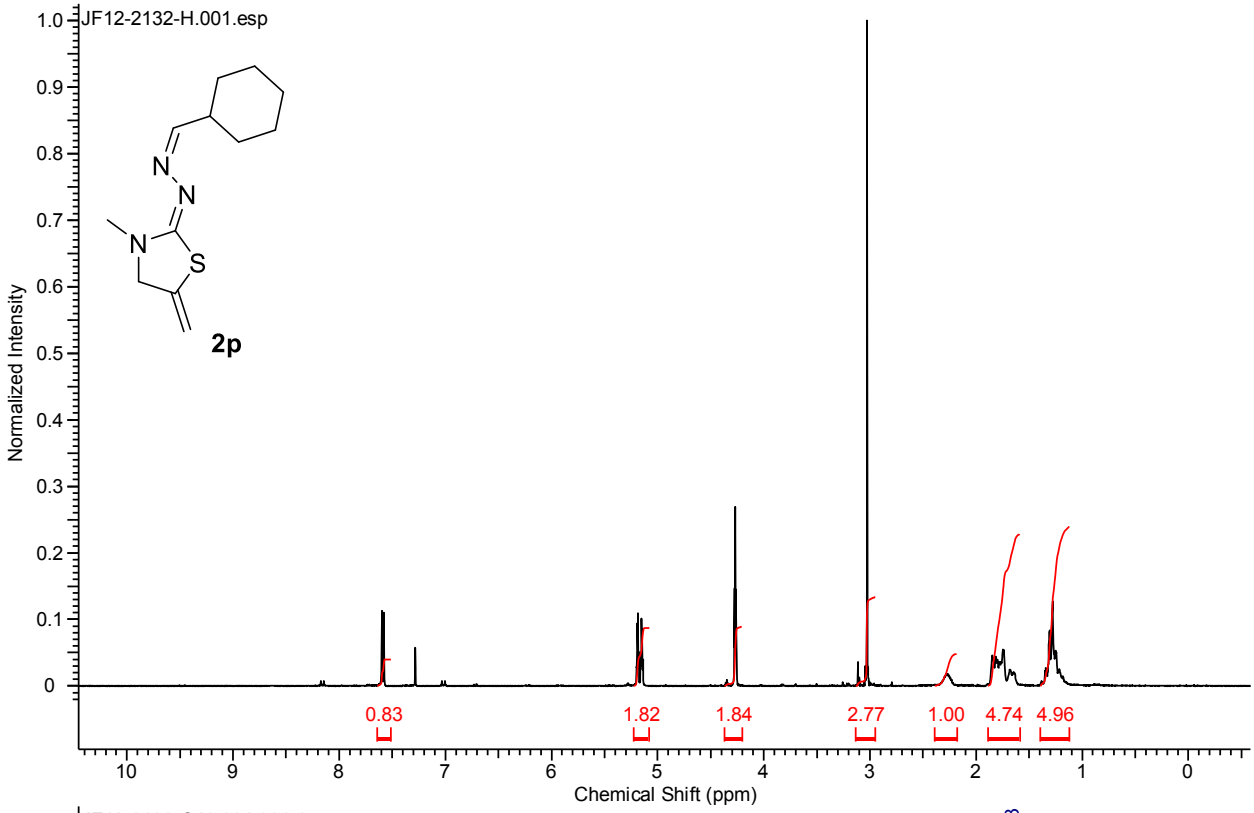

JF12-2124-C.001.esp
Normalized Intensity
175.7630
154.4972
145.4821
143.0844
123.7353
123.4948
25.0728
18.1494
Chemical Shift (ppm)

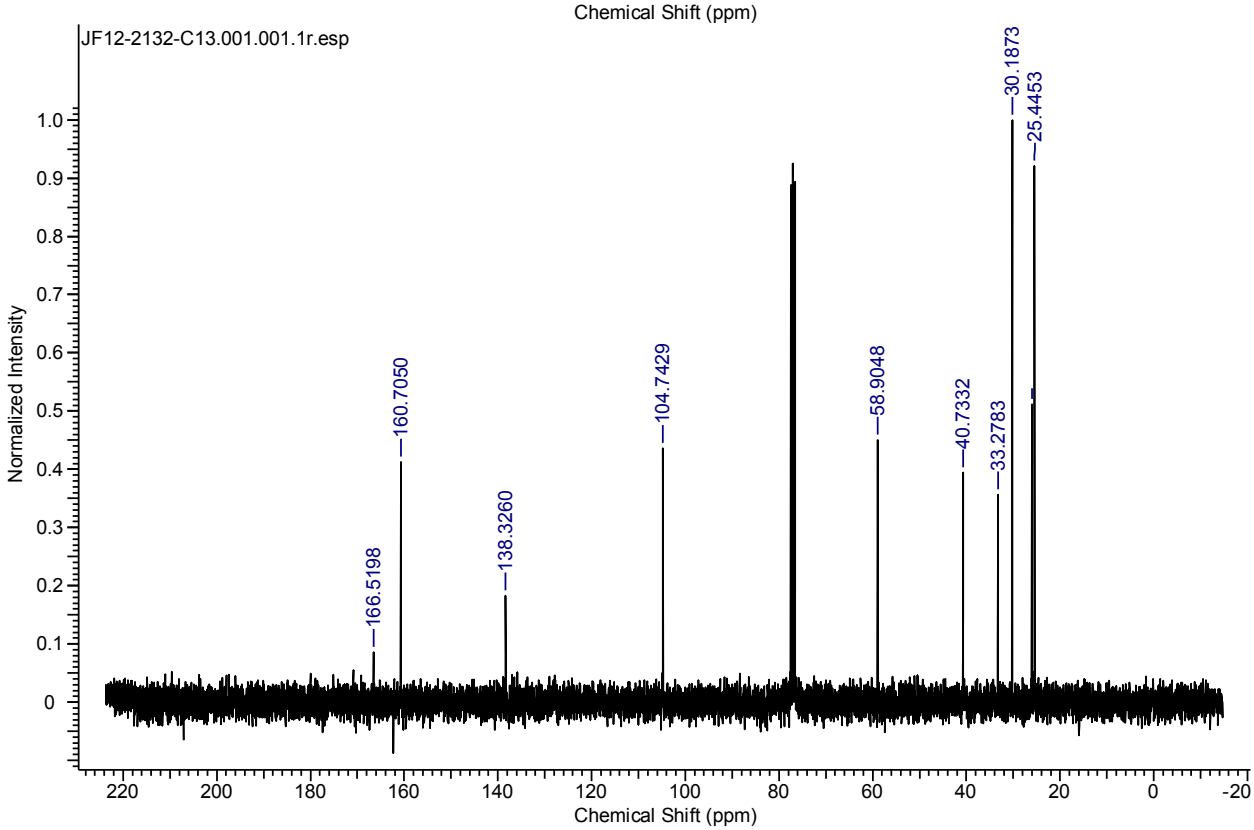

JF12-2131-H.001.esp
2o
Normalized Intensity
Chemical Shift (ppm)
2.15
2.09
3.06
2.92
3.00

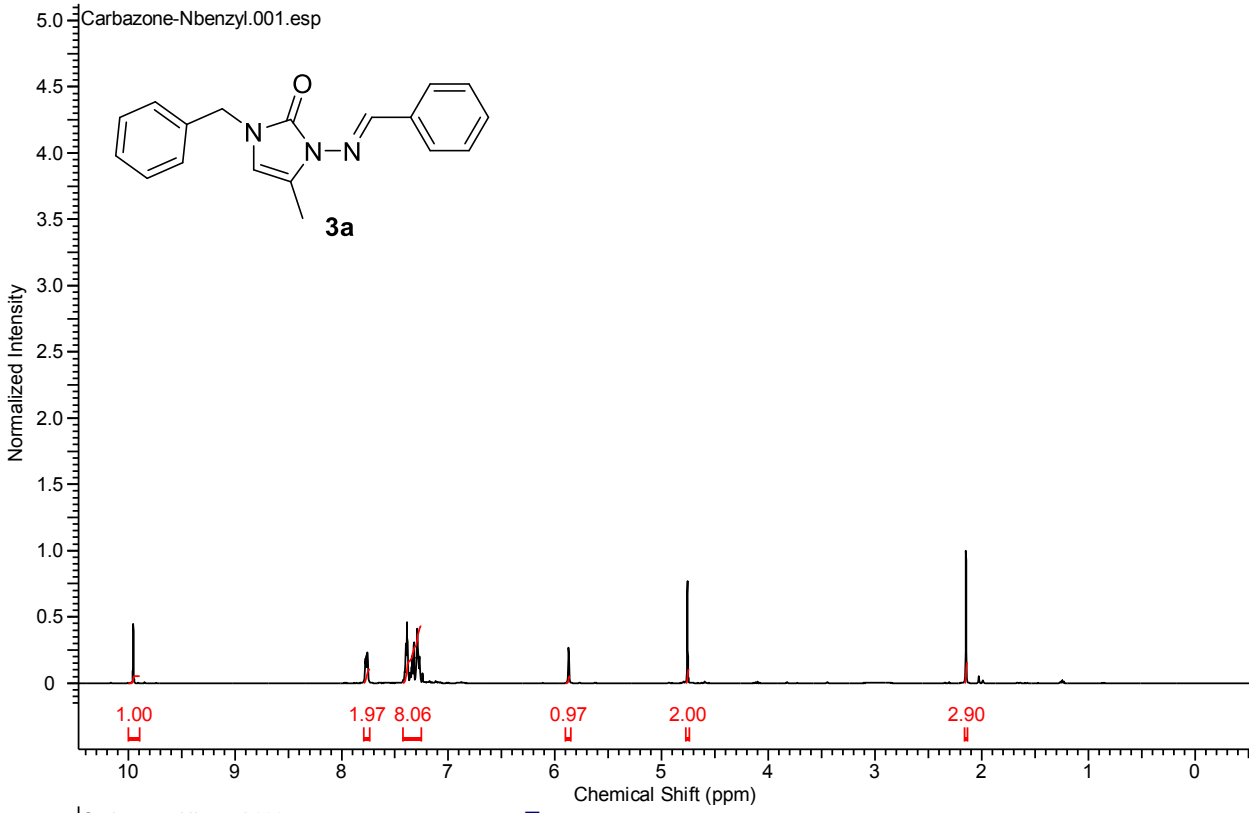

JF12-2131-C13.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
164.4033
159.7741
138.7078
104.6338
58.6575
33.3147
24.7216
18.1105

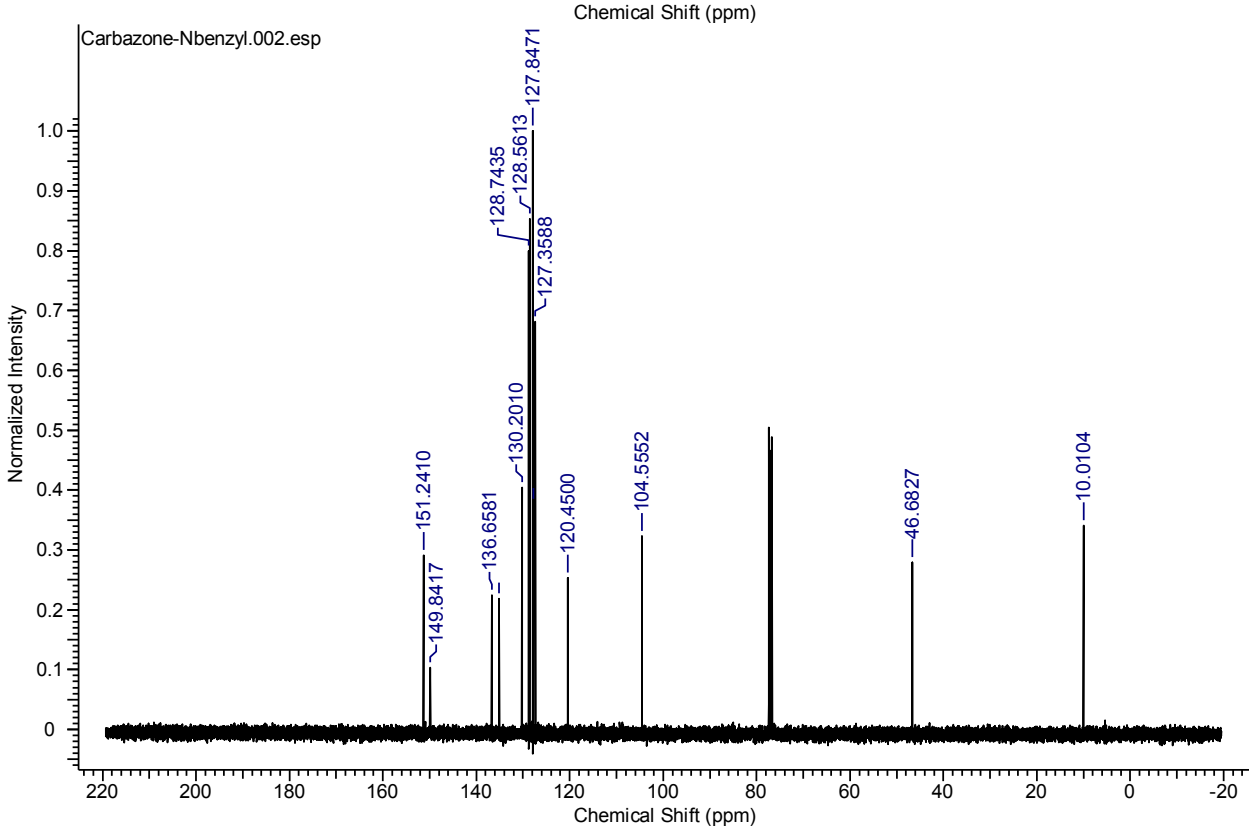

JF12-2125-H.001.esp
NO2
S
NH
HN
N
1p
Normalized Intensity
2.76
1.97
1.00
0.98
5.33
5.18
Chemical Shift (ppm)

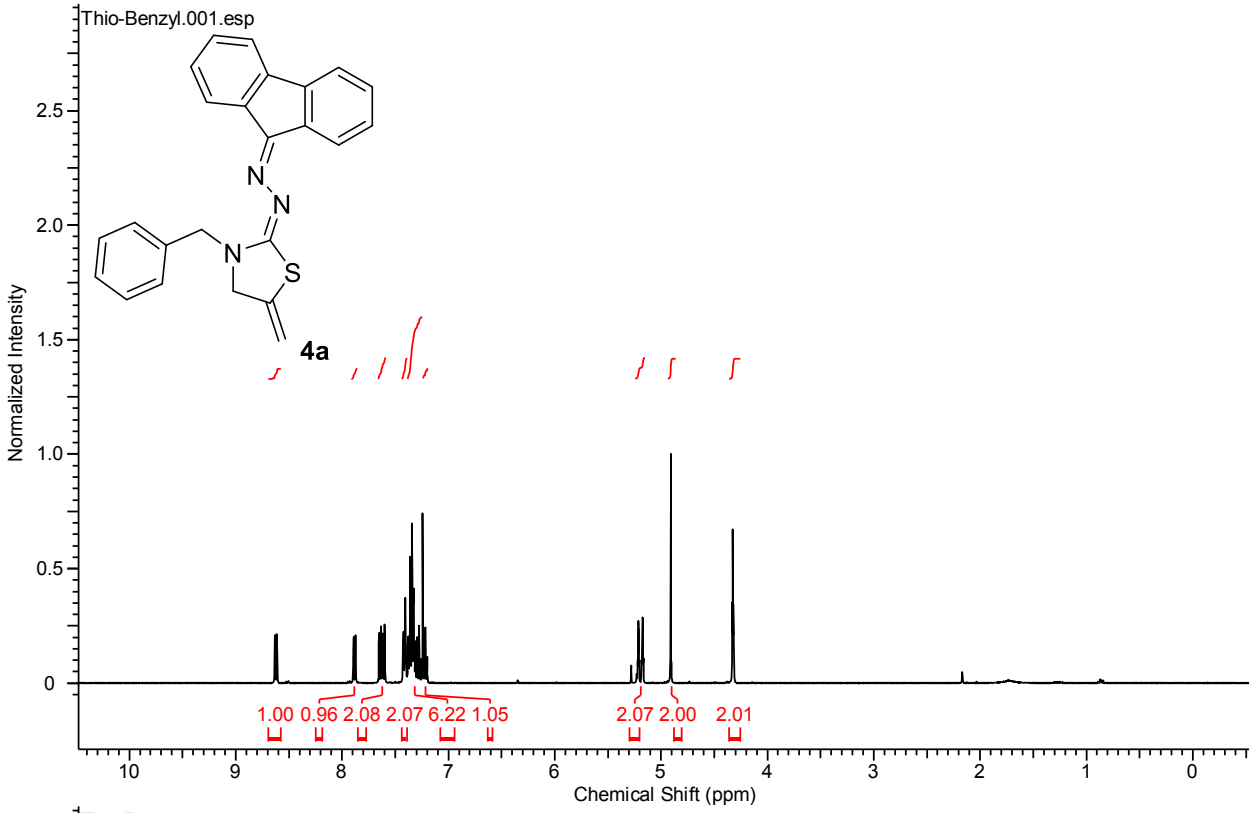

JF12-2125-C.001.esp
Normalized Intensity
175.5352
153.2709
145.8884
143.6510
124.1925
29.9756
25.4572
Chemical Shift (ppm)

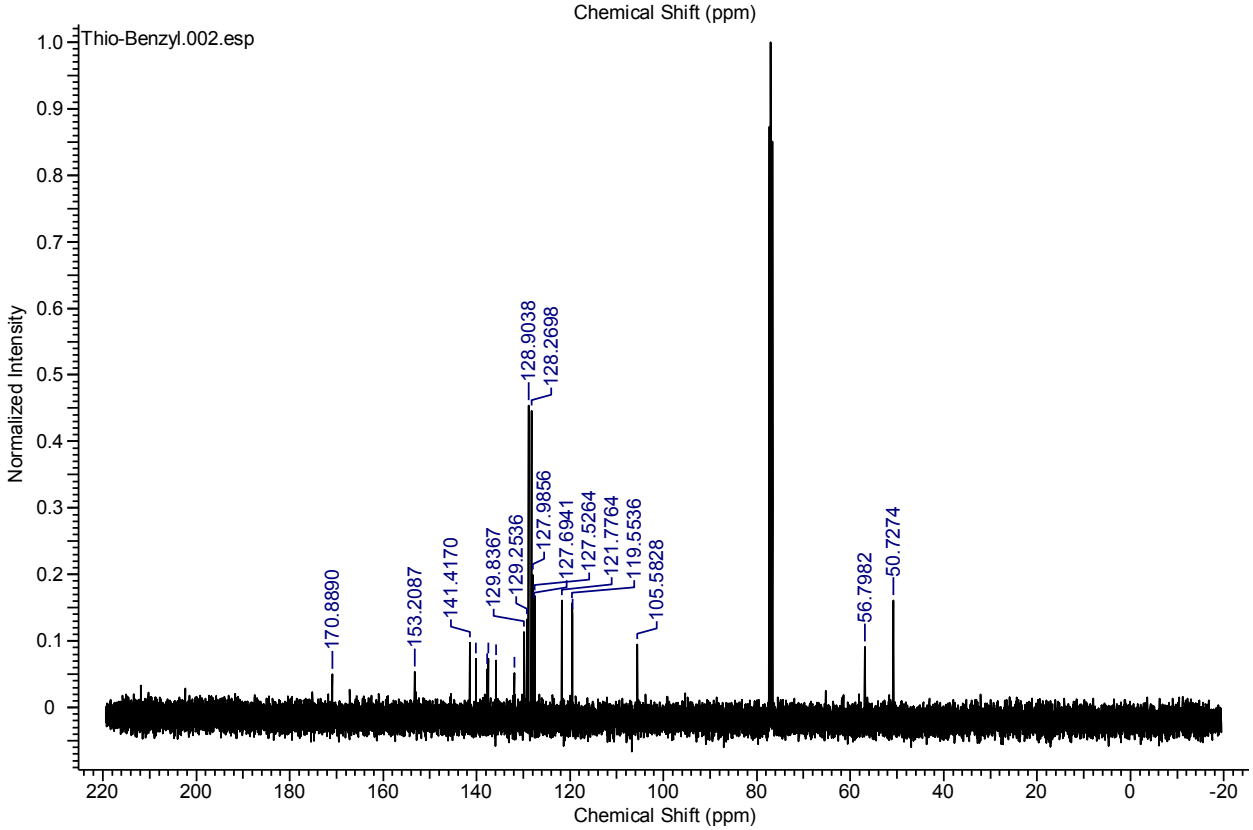

JF12-2132-H.001.esp
2p
Normalized Intensity
Chemical Shift (ppm)
0.83
1.82
1.84
2.77
1.00
4.74
4.96

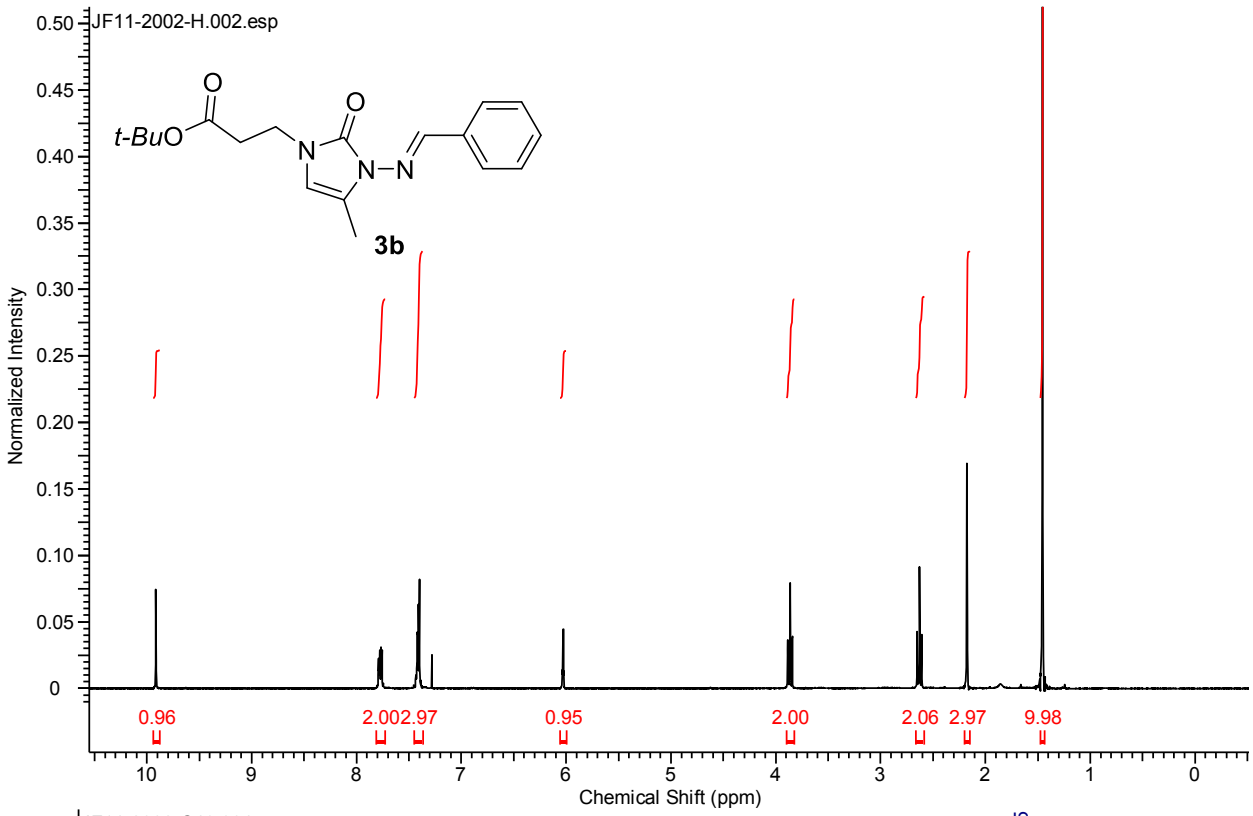

JF12-2132-C13.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
166.5198
160.7050
138.3260
104.7429
58.9048
40.7332
33.2783
30.1873
25.4453

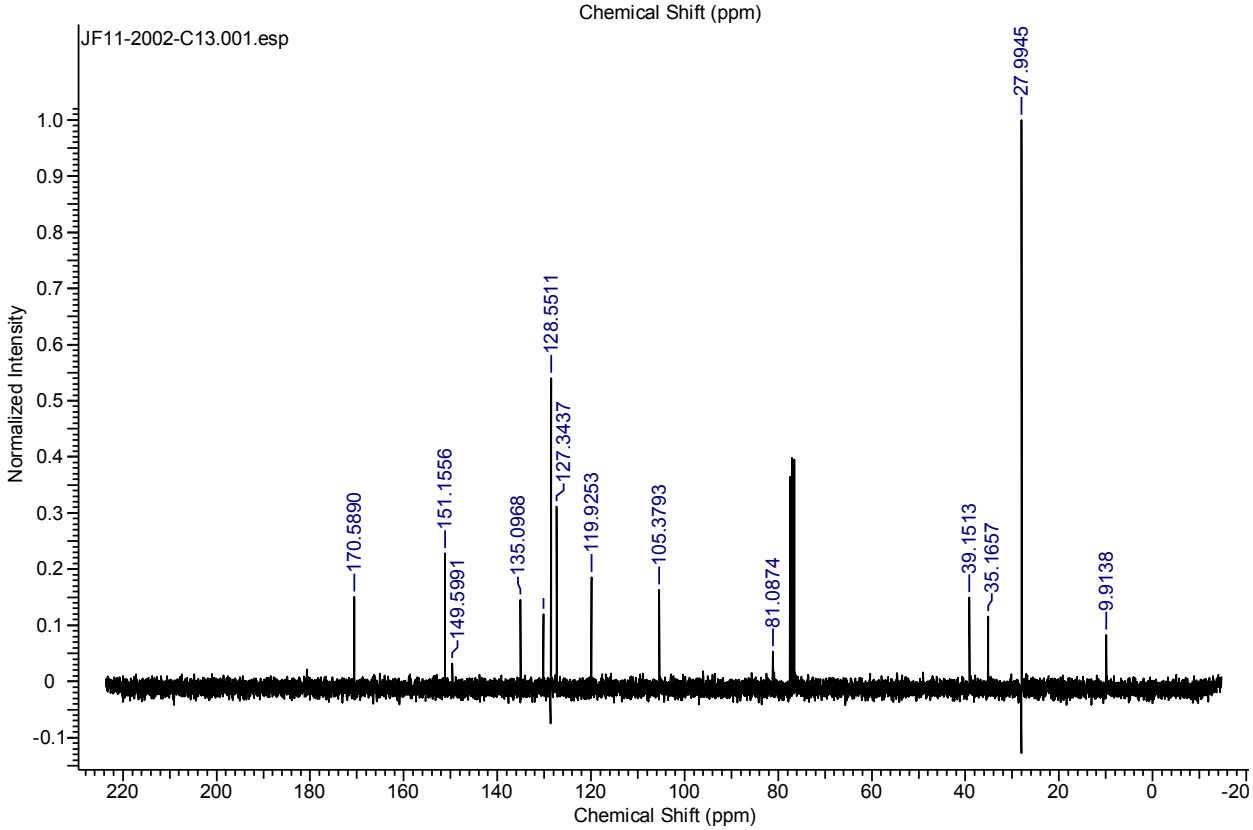

Carbazone-Nbenzyl.001.esp
O
N
N–N
3a
Normalized Intensity
1.00
1.97
8.06
0.97
2.00
2.90
Chemical Shift (ppm)

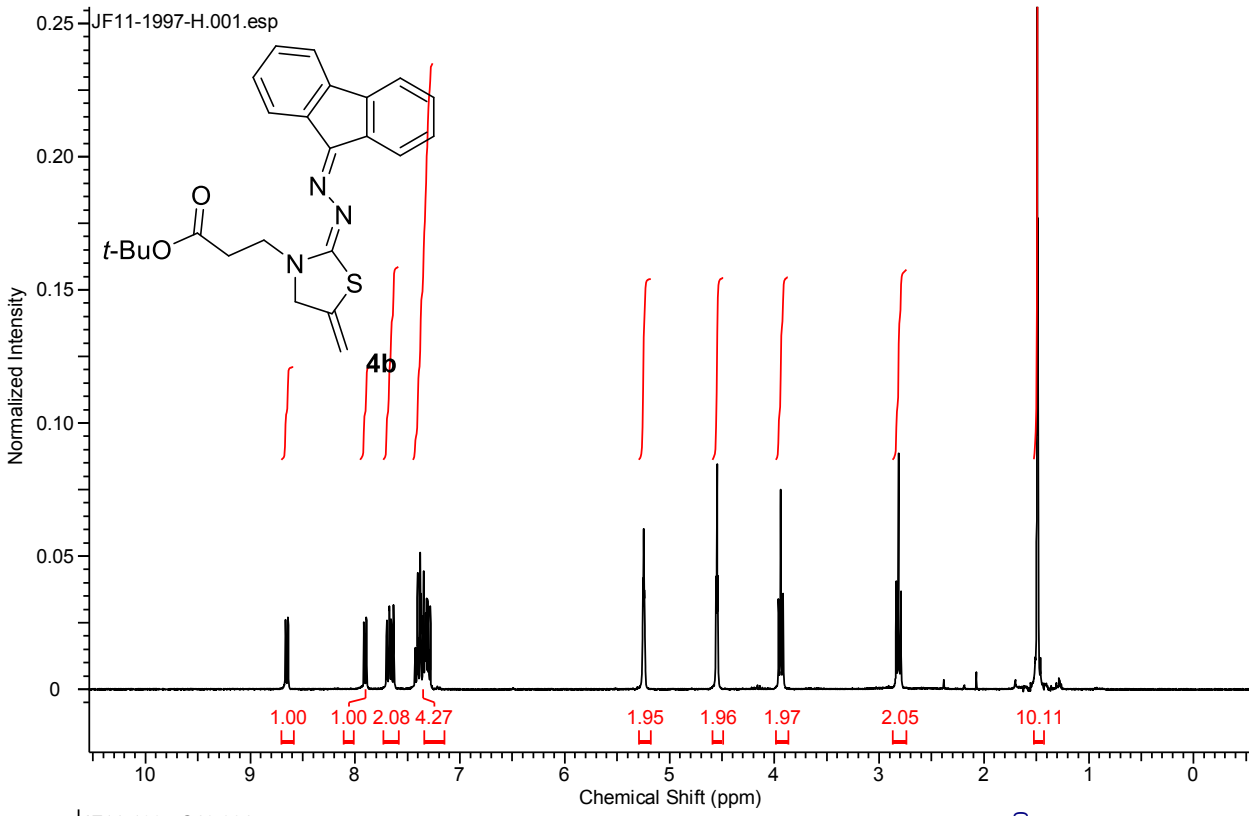

Carbazone-Nbenzyl.002.esp
127.8471
128.7435
128.5613
127.3588
130.2010
151.2410
149.8417
136.6581
120.4500
104.5552
46.6827
10.0104
Normalized Intensity
Chemical Shift (ppm)

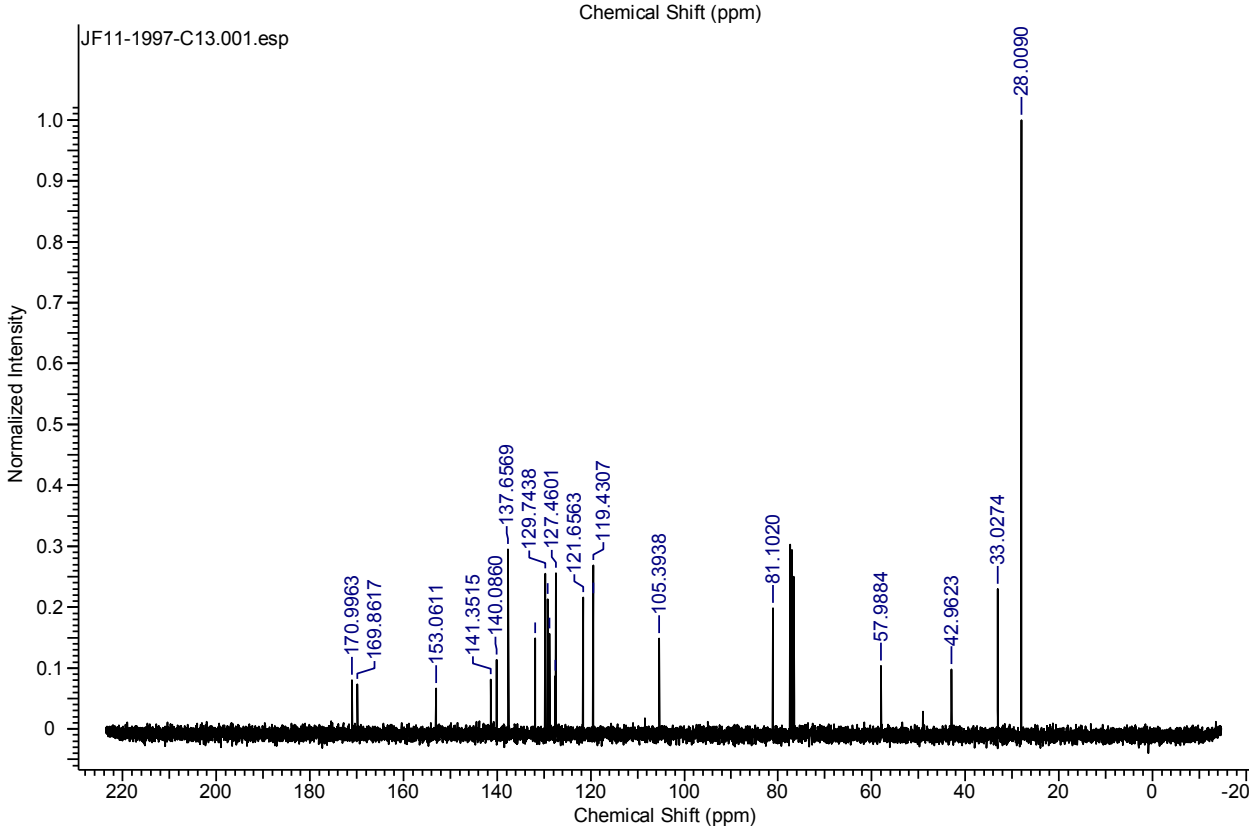

Thio-Benzyl.001.esp
4a
Normalized Intensity
1.00 0.96 2.08 2.07 6.22 1.05
2.07 2.00 2.01
Chemical Shift (ppm)

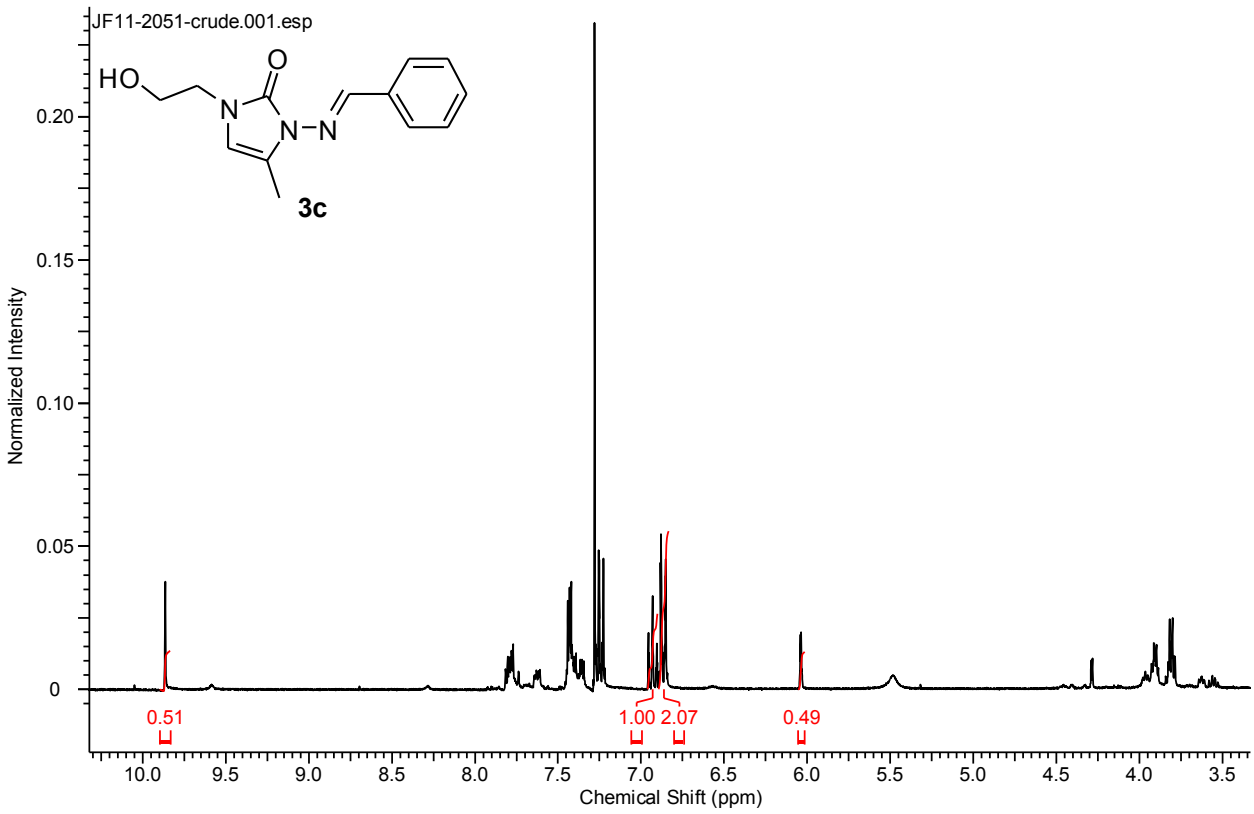

Thio-Benzyl.002.esp
Normalized Intensity
170.8890
153.2087
141.4170
129.8367
129.2536
128.9038
128.2698
127.9856
127.6941
127.5264
121.7764
119.5536
105.5828
56.7982
50.7274
Chemical Shift (ppm)

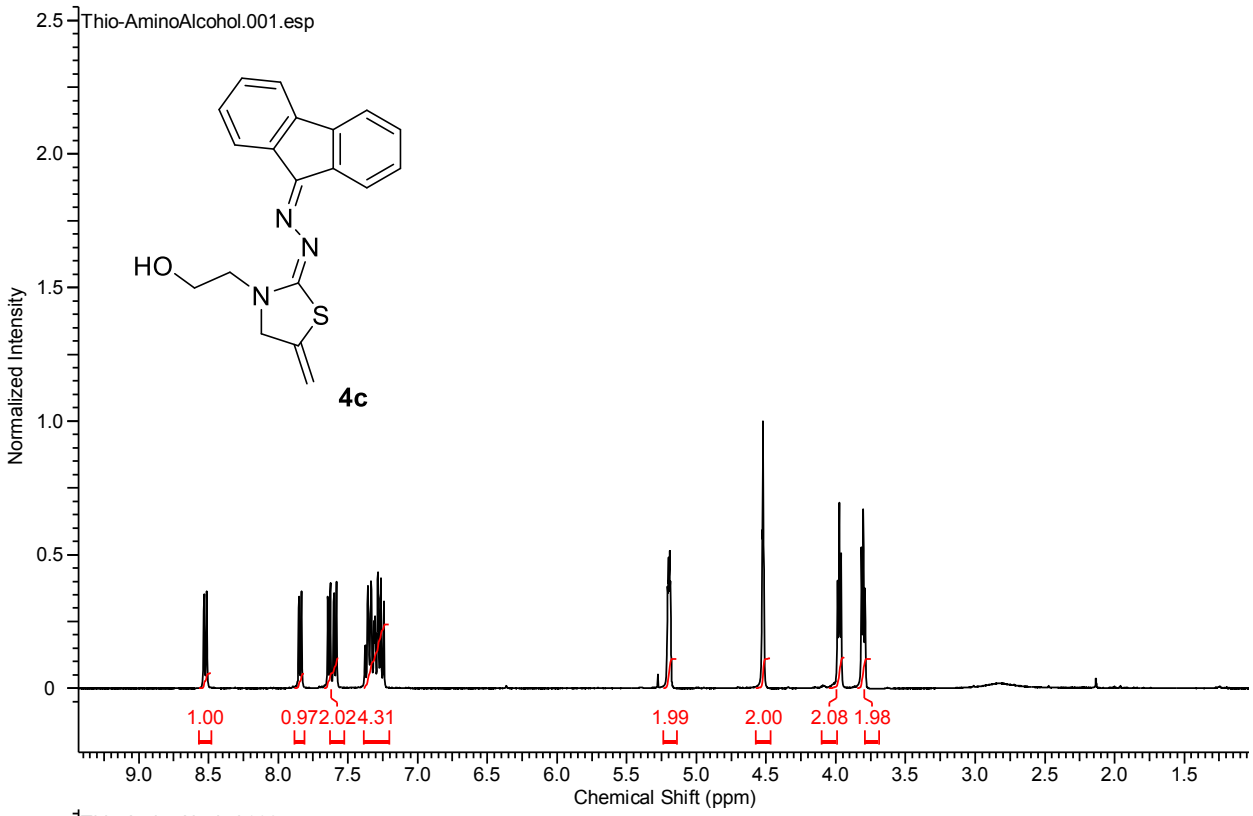

JF11-2002-H.002.esp
t-BuO
O
O
N
N–N
3b
Normalized Intensity
0.96
2.00
2.97
0.95
2.00
2.06
2.97
9.98
Chemical Shift (ppm)

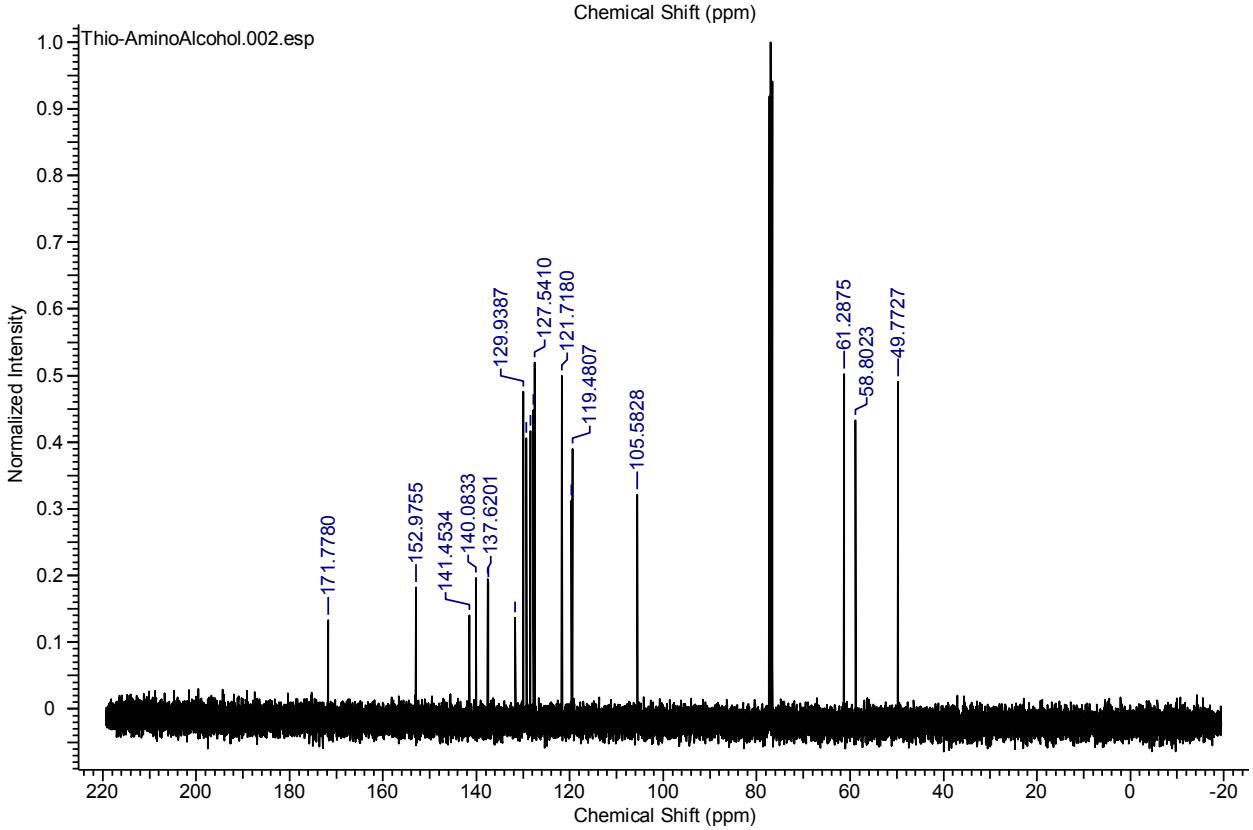

JF11-2002-C13.001.esp
Normalized Intensity
170.5890
151.1556
149.5991
135.0968
128.5511
127.3437
119.9253
105.3793
81.0874
39.1513
35.1657
27.9945
9.9138
Chemical Shift (ppm)

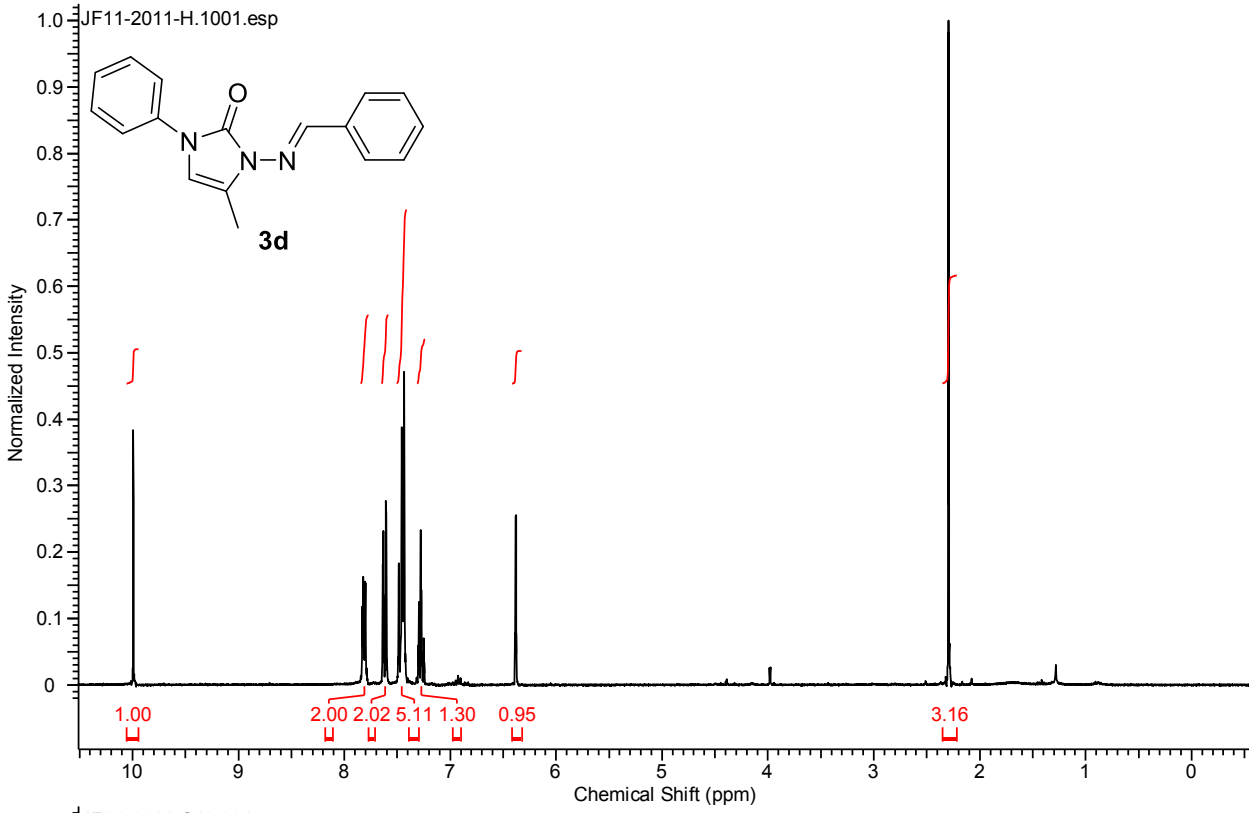

JF11-1997-H.001.esp
Normalized Intensity
Chemical Shift (ppm)
1.00
1.00
2.08
4.27
1.95
1.96
1.97
2.05
10.11
t-BuO
O
N
N
N
S
4b

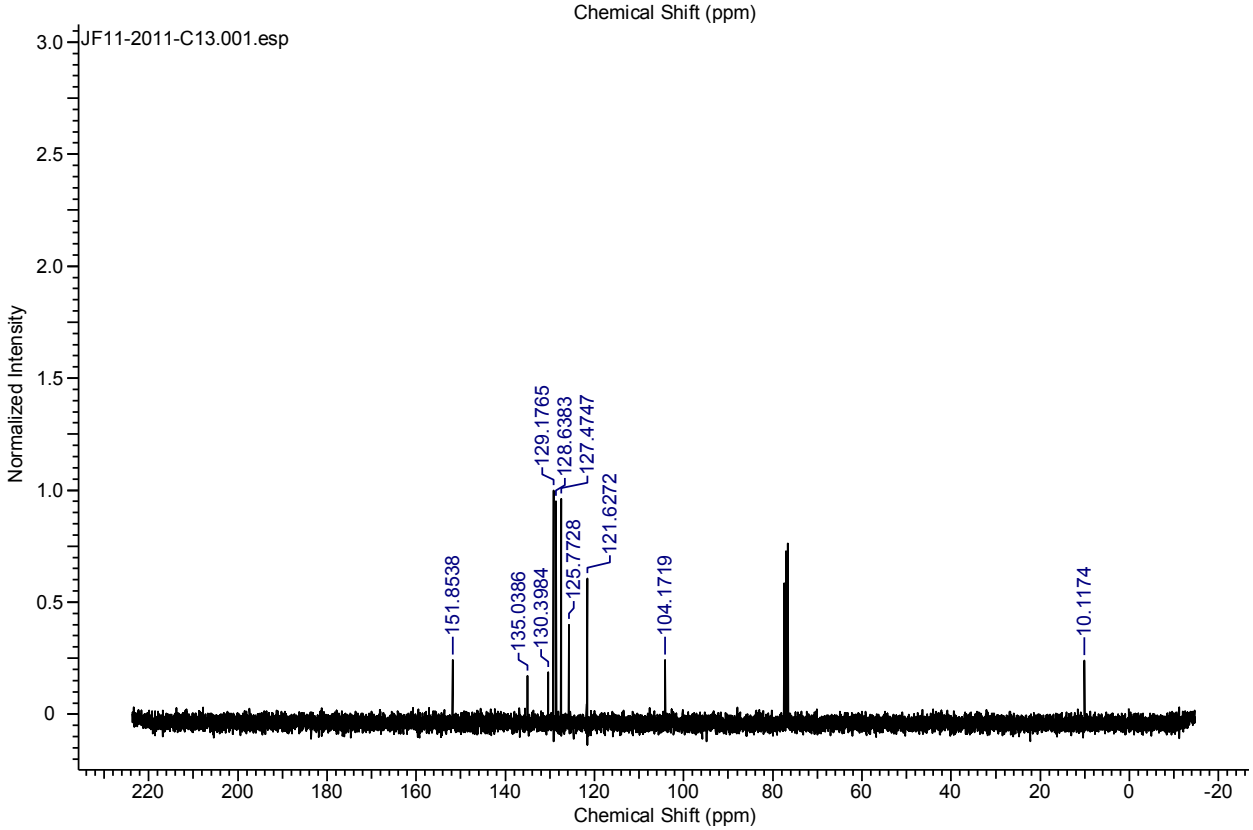

JF11-1997-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
170.9963
169.8617
153.0611
141.3515
140.0860
137.6569
129.7438
127.4601
121.6563
119.4307
105.3938
81.1020
57.9884
42.9623
33.0274
28.0090

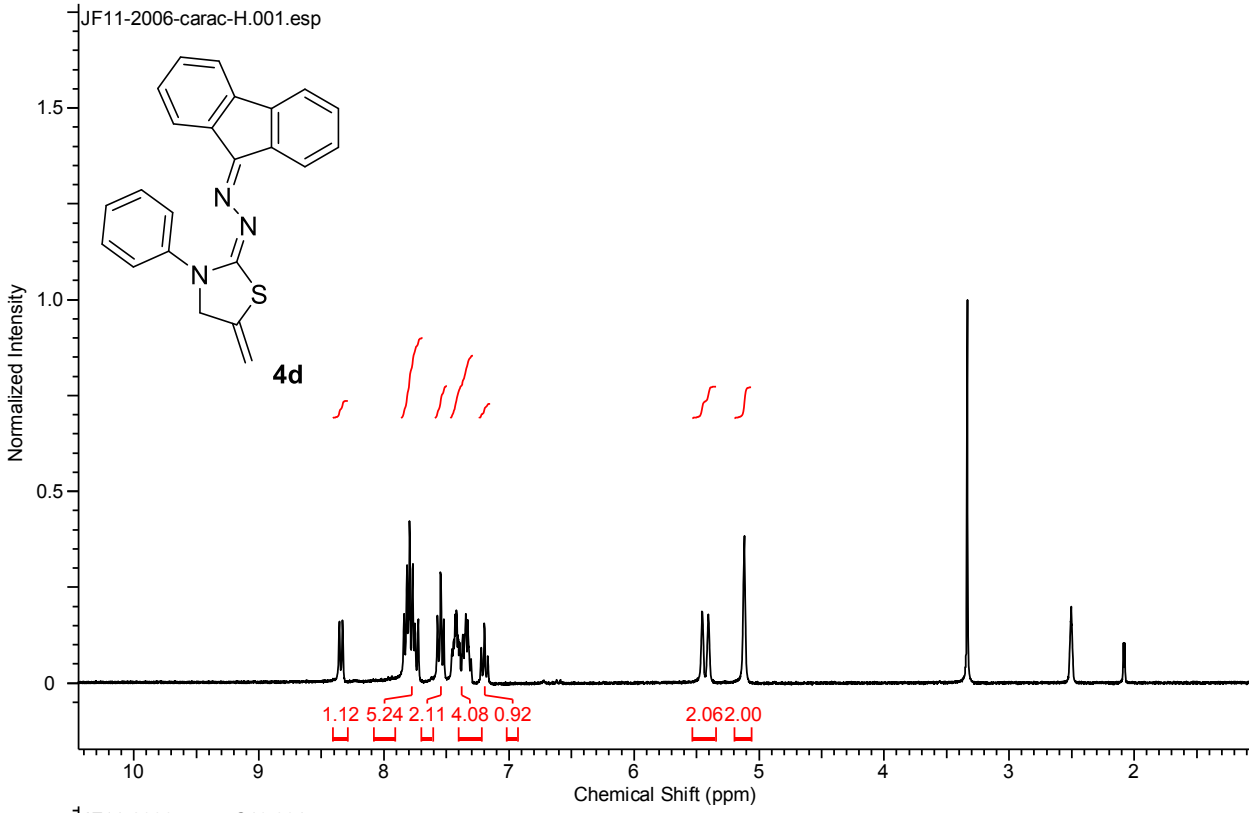

JF11-2051-crude.001.esp
HO
O
N
N–N
3c
Normalized Intensity
0.20
0.15
0.10
0.05
0
0.51
1.00
2.07
0.49
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
Chemical Shift (ppm)

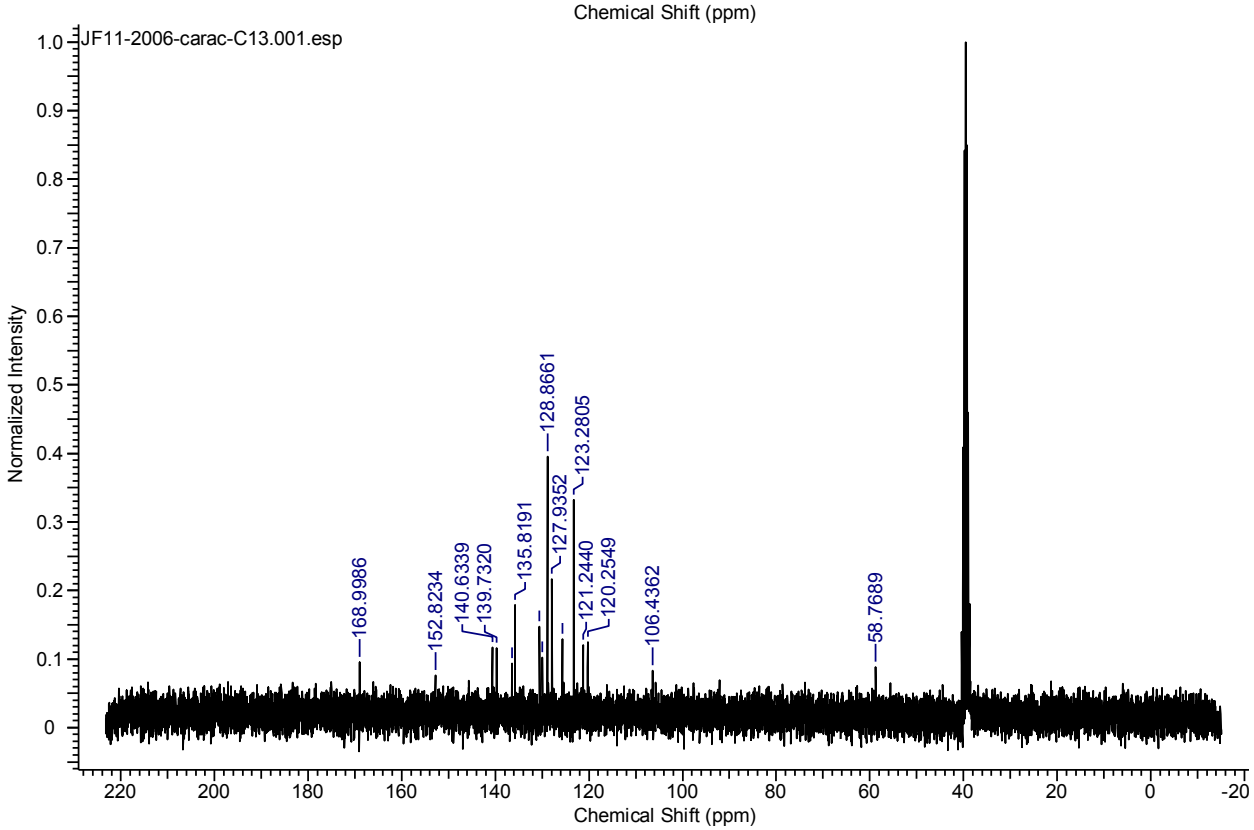

Thio-AminoAlcohol.001.esp
Normalized Intensity
Chemical Shift (ppm)
HO
N
N
N
S
4c
1.00
0.97
2.02
4.31
1.99
2.00
2.08
1.98

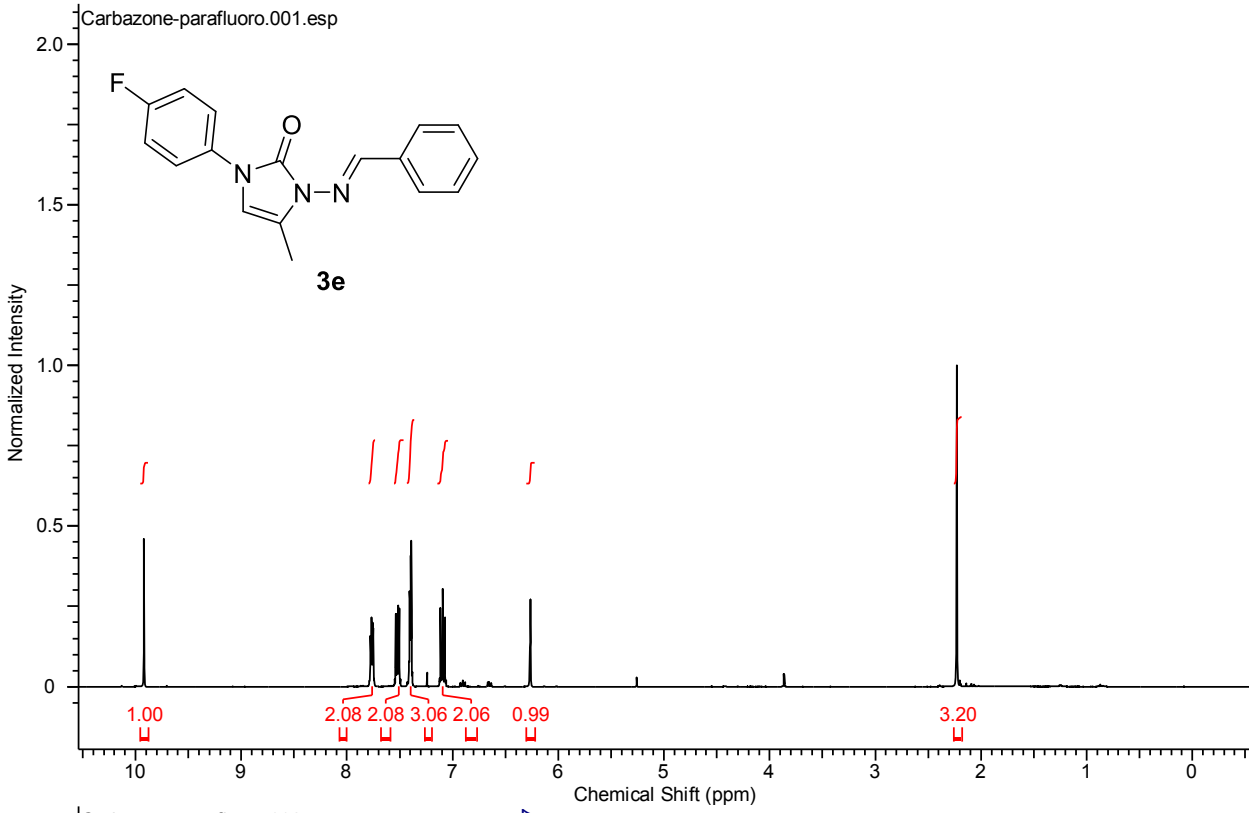

Thio-AminoAlcohol.002.esp
Normalized Intensity
Chemical Shift (ppm)
171.7780
152.9755
141.4534
140.0833
137.6201
129.9387
127.5410
121.7180
119.4807
105.5828
61.2875
58.8023
49.7727

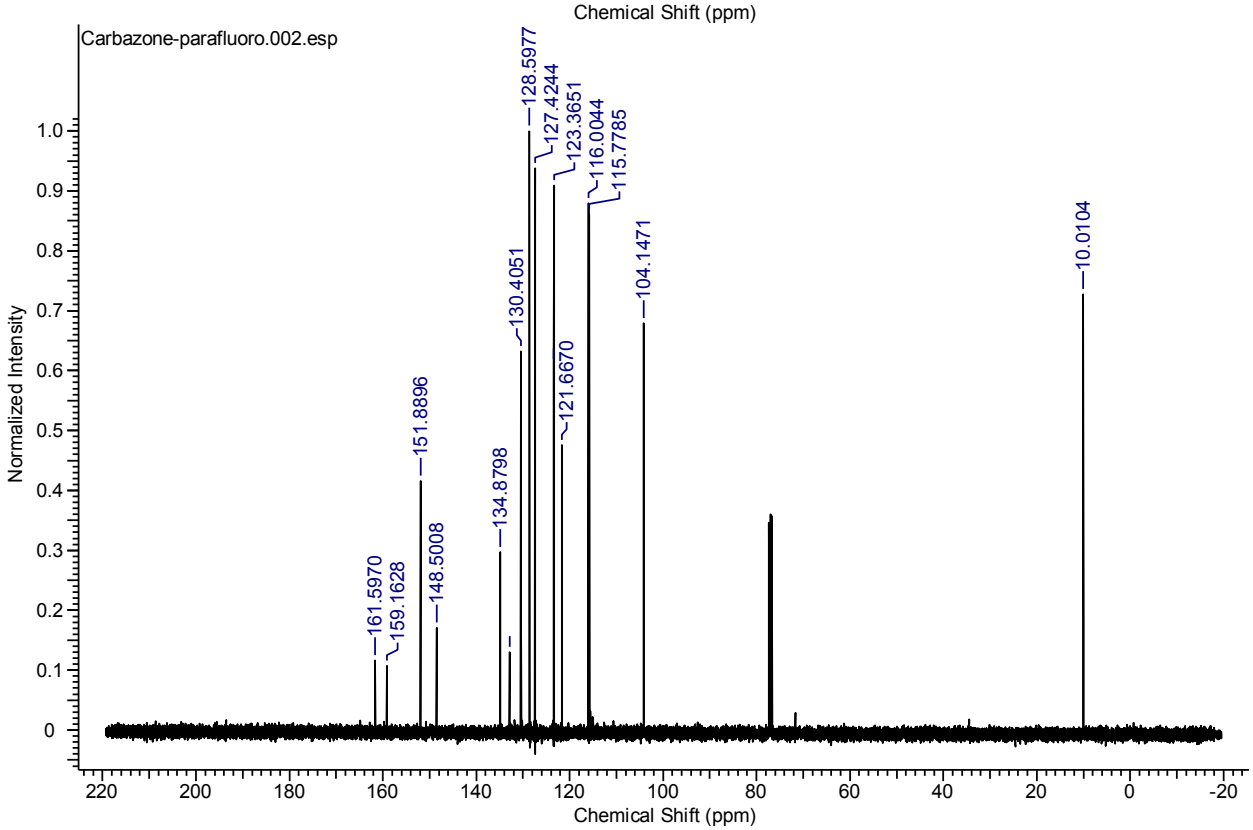

JF11-2011-H.1001.esp
O
N
N–N
3d
Normalized Intensity
1.00
2.00
2.02
5.11
1.30
0.95
3.16
Chemical Shift (ppm)

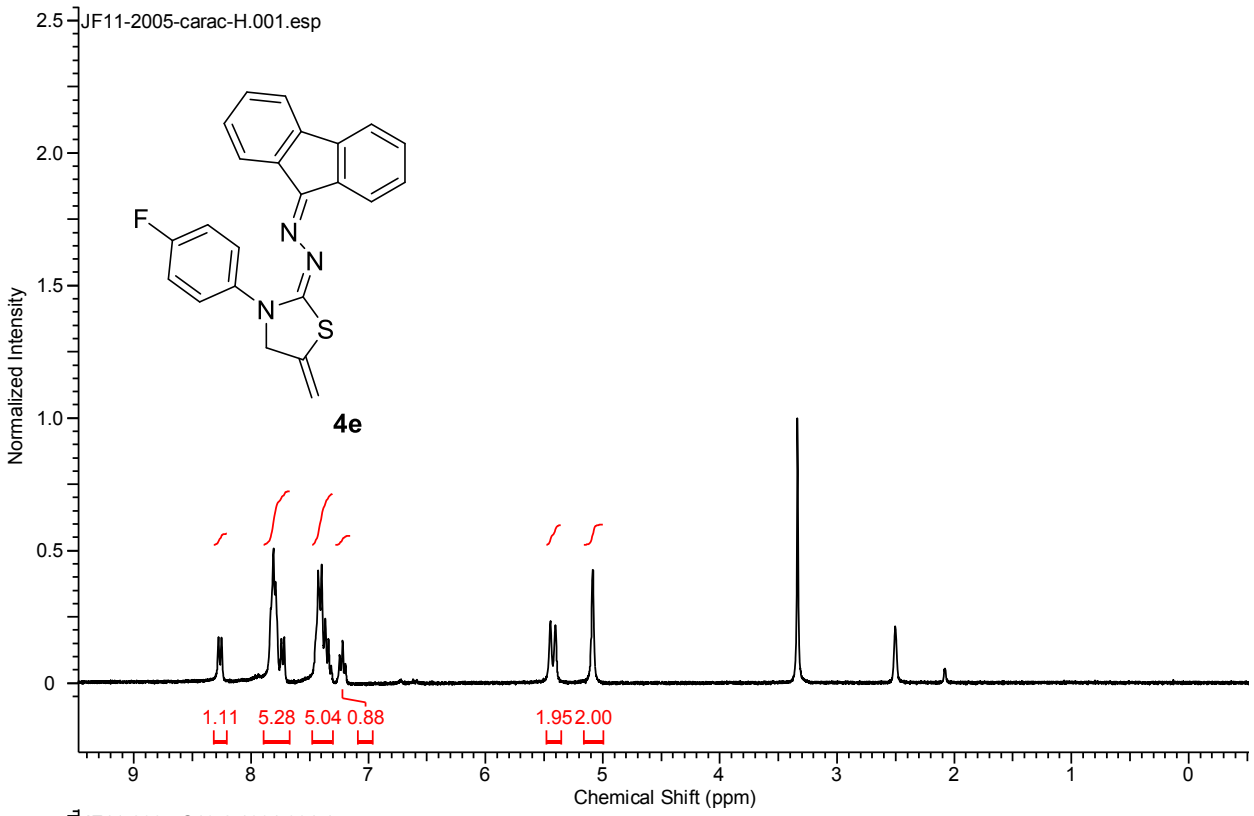

JF11-2011-C13.001.esp
Normalized Intensity
151.8538
135.0386
130.3984
129.1765
128.6383
127.4747
125.7728
121.6272
104.1719
10.1174
Chemical Shift (ppm)

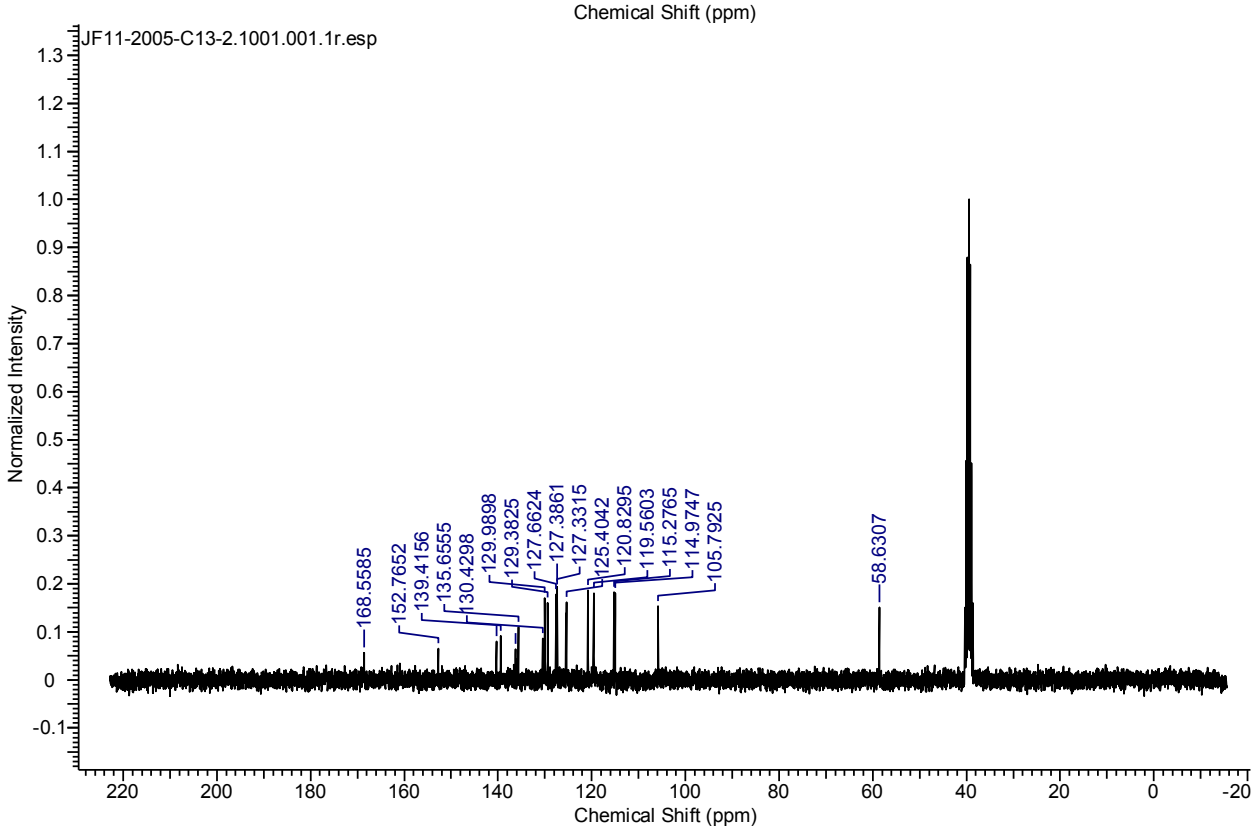

JF11-2006-carac-H.001.esp
4d
Normalized Intensity
1.12 5.24 2.11 4.08 0.92
2.06 2.00
Chemical Shift (ppm)

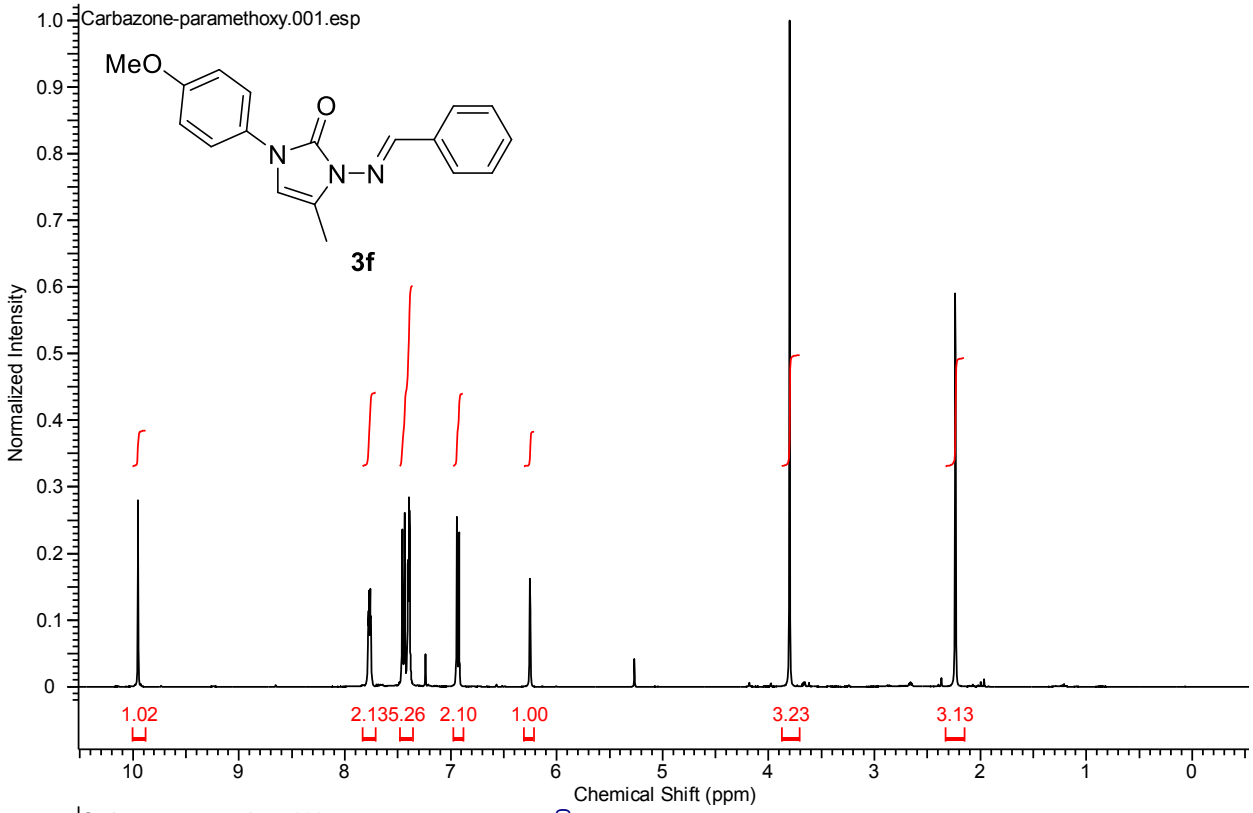

JF11-2006-carac-C13.001.esp
Normalized Intensity
168.9986
152.8234
140.6339
139.7320
135.8191
128.8661
127.9352
123.2805
121.2440
120.2549
106.4362
58.7689
Chemical Shift (ppm)

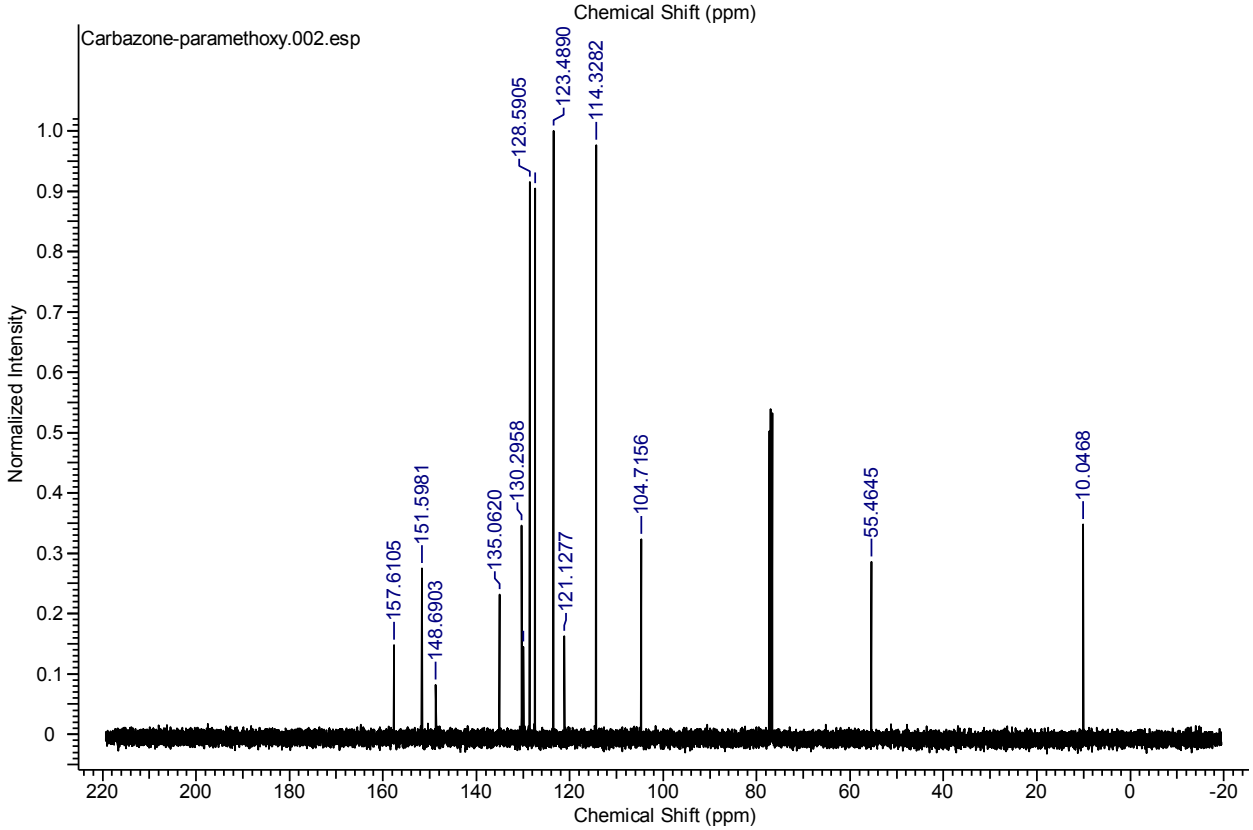

Carbazone-parafluoro.001.esp
F
O
N
N–N
3e
Normalized Intensity
1.00
2.08
2.08
3.06
2.06
0.99
3.20
Chemical Shift (ppm)

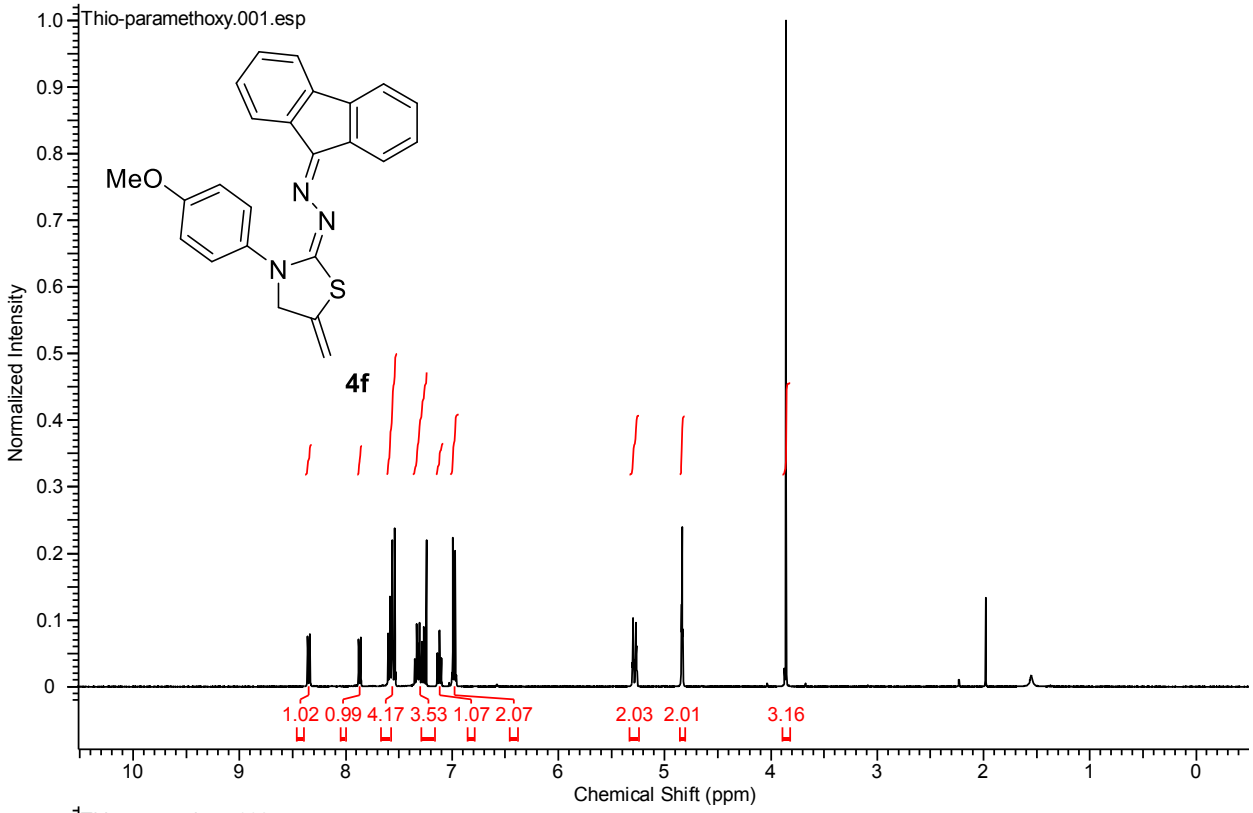

Carbazone-parafluoro.002.esp
128.5977
127.4244
123.3651
116.0044
115.7785
130.4051
104.1471
10.0104
151.8896
134.8798
121.6670
161.5970
159.1628
148.5008
Normalized Intensity
Chemical Shift (ppm)

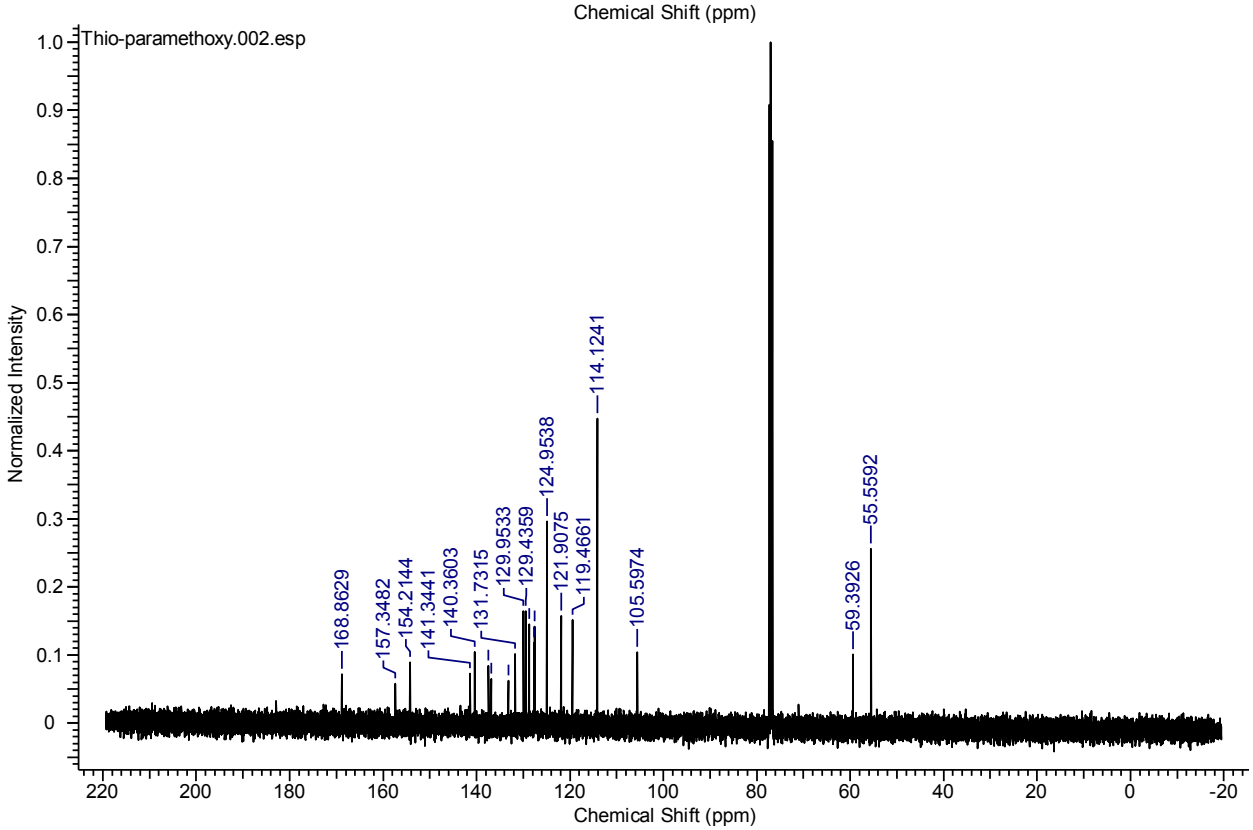

JF11-2005-carac-H.001.esp
Normalized Intensity
Chemical Shift (ppm)
1.11
5.28
5.04
0.88
1.95
2.00
F
N
N
N
S
4e

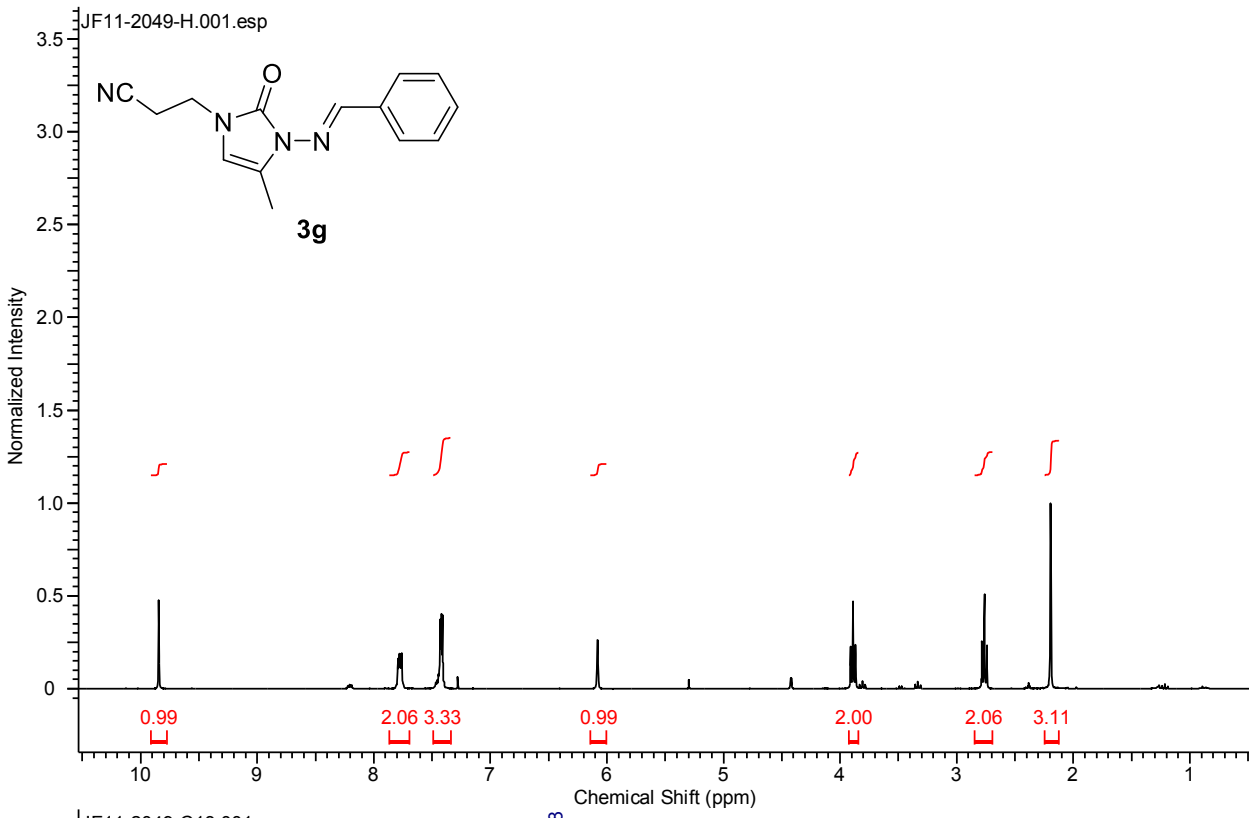

JF11-2005-C13-2.1001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
168.5585
152.7652
139.4156
135.6555
130.4298
129.9898
129.3825
127.6624
127.3861
127.3315
125.4042
120.8295
119.5603
115.2765
114.9747
105.7925
58.6307

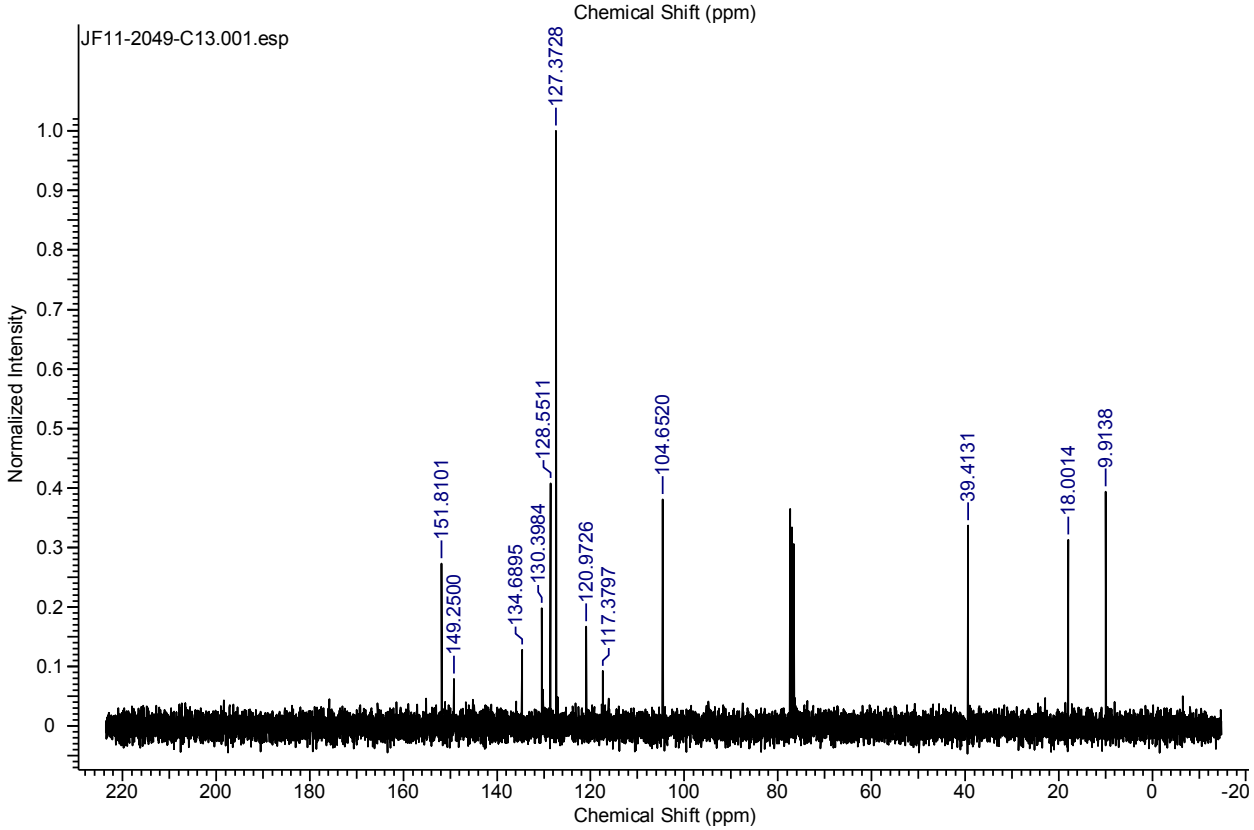

Carbazone-paramethoxy.001.esp
MeO
O
N
N–N
3f
Normalized Intensity
1.02
2.13
5.26
2.10
1.00
3.23
3.13
Chemical Shift (ppm)

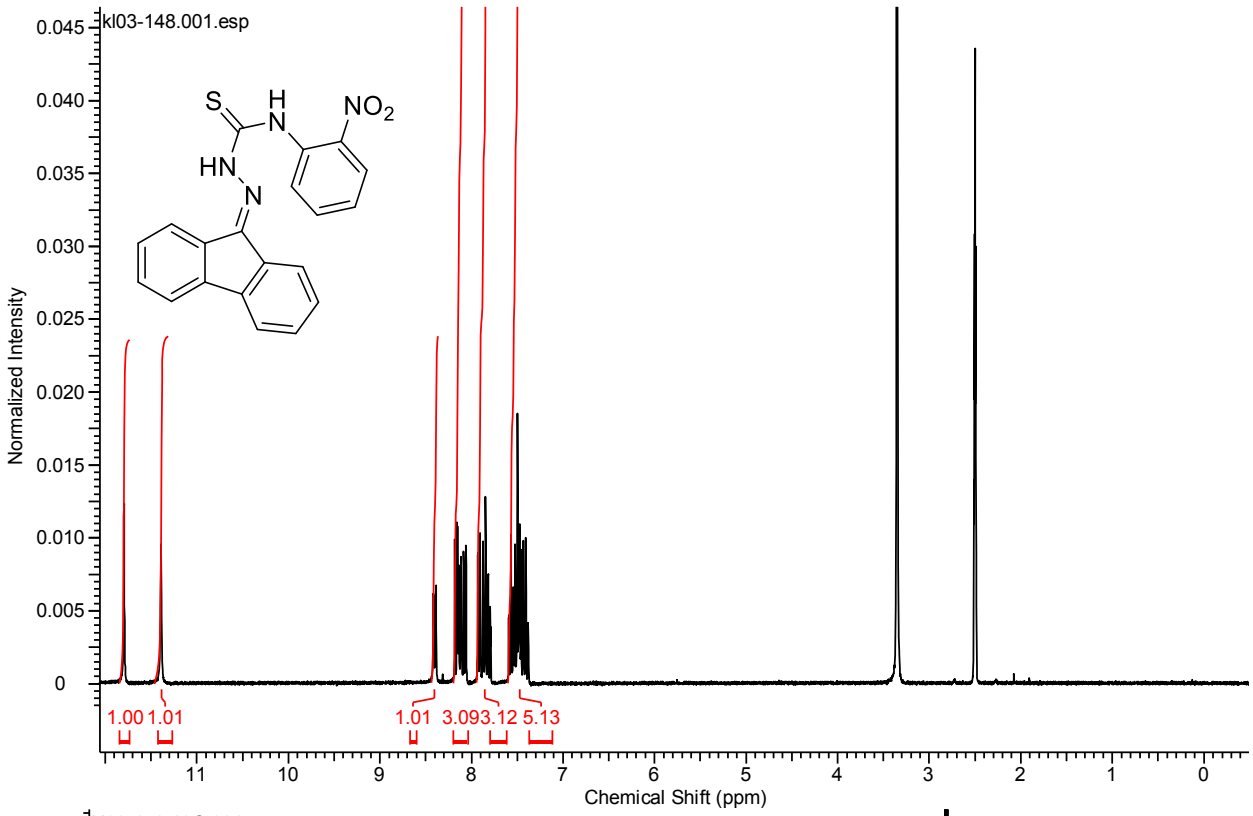

Carbazone-paramethoxy.002.esp
157.6105
151.5981
148.6903
135.0620
130.2958
128.5905
123.4890
121.1277
114.3282
104.7156
55.4645
10.0468
Normalized Intensity
Chemical Shift (ppm)

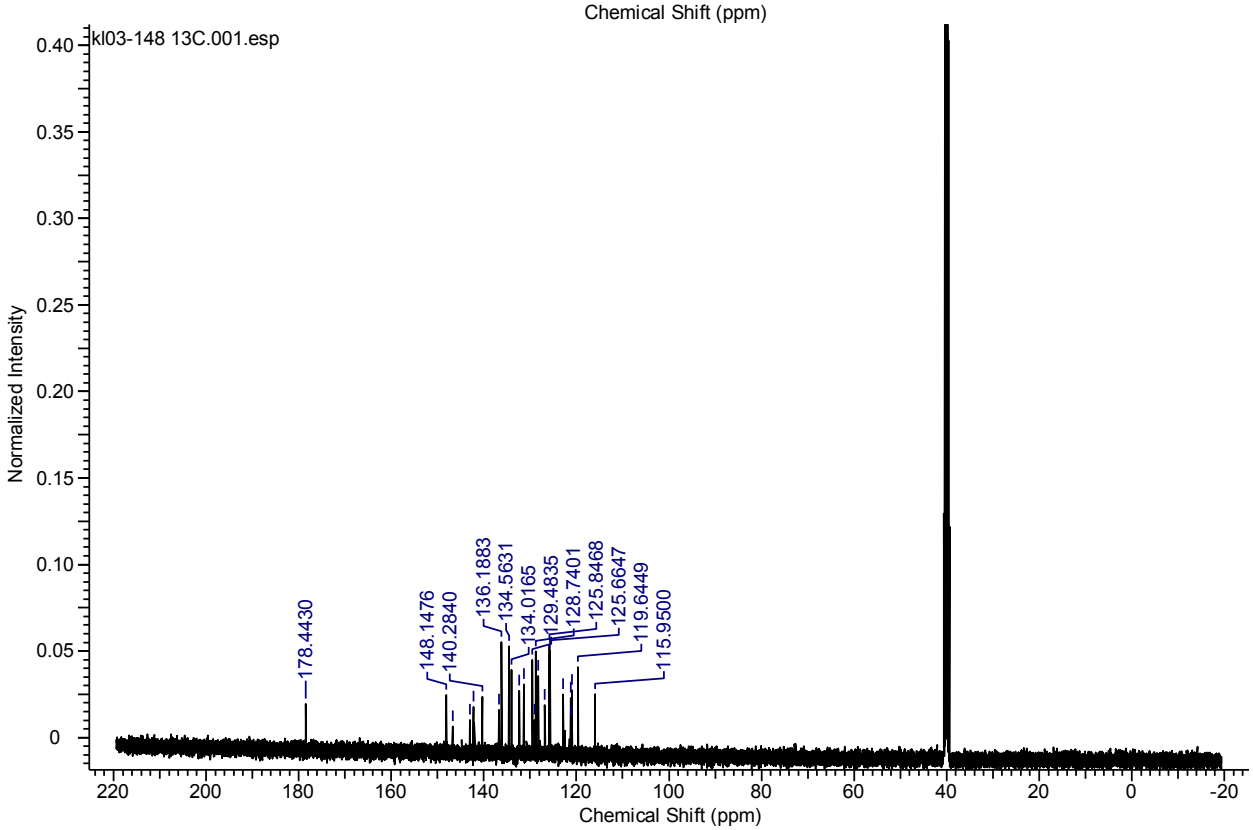

Thio-paramethoxy.001.esp
MeO
N
N
N
S
4f
Normalized Intensity
1.02 0.99 4.17 3.53 1.07 2.07
2.03 2.01
3.16
Chemical Shift (ppm)

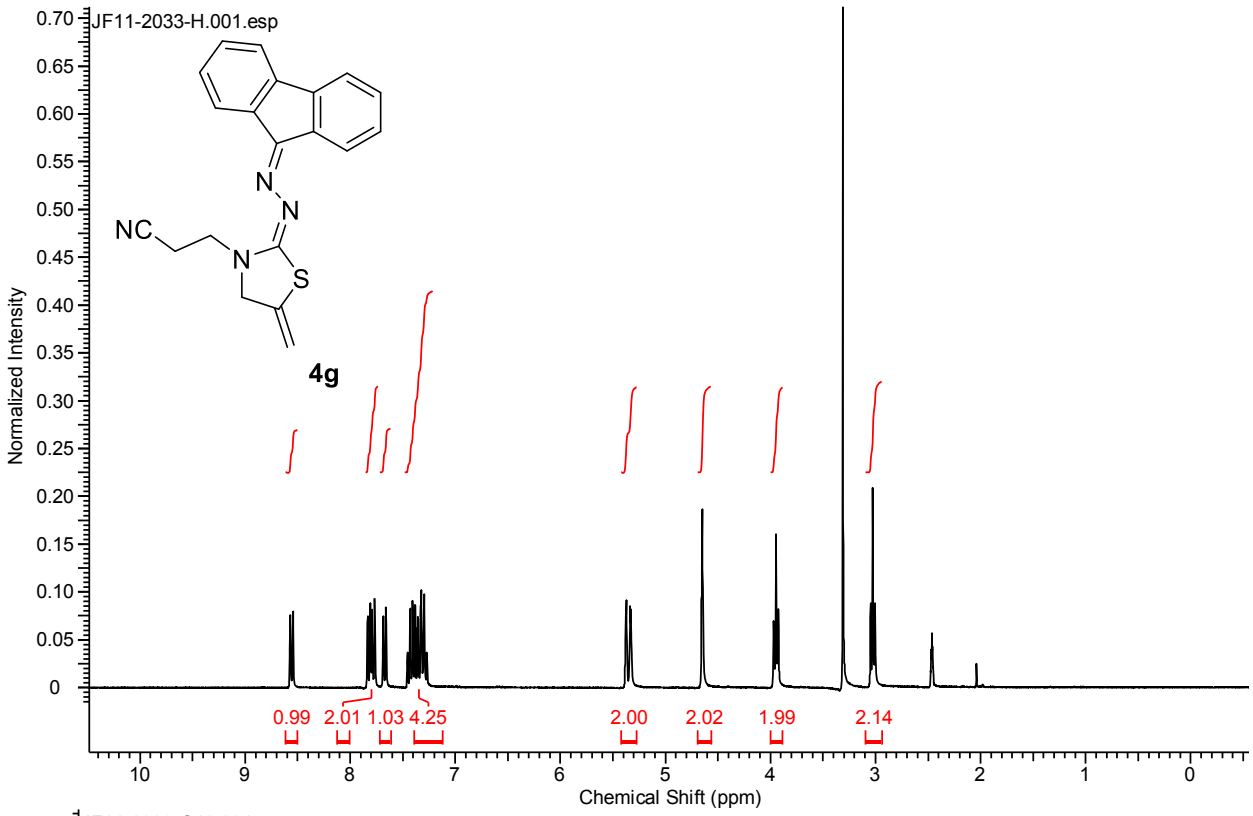

Thio-paramethoxy.002.esp
Normalized Intensity
168.8629
157.3482
154.2144
141.3441
140.3603
131.7315
129.9533
129.4359
124.9538
121.9075
119.4661
114.1241
105.5974
59.3926
55.5592
Chemical Shift (ppm)

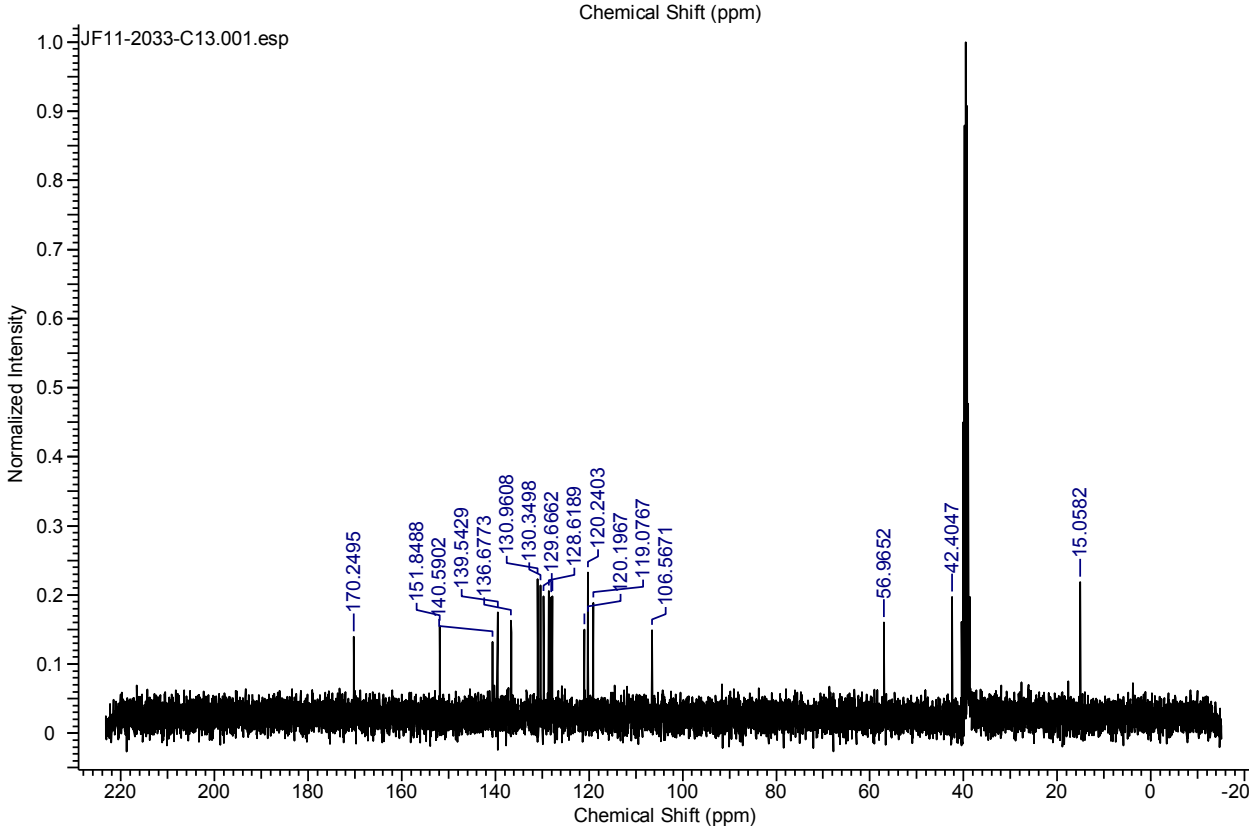

JF11-2049-H.001.esp
NC
O
N
N
N
3g
Normalized Intensity
0.99
2.06
3.33
0.99
2.00
2.06
3.11
Chemical Shift (ppm)

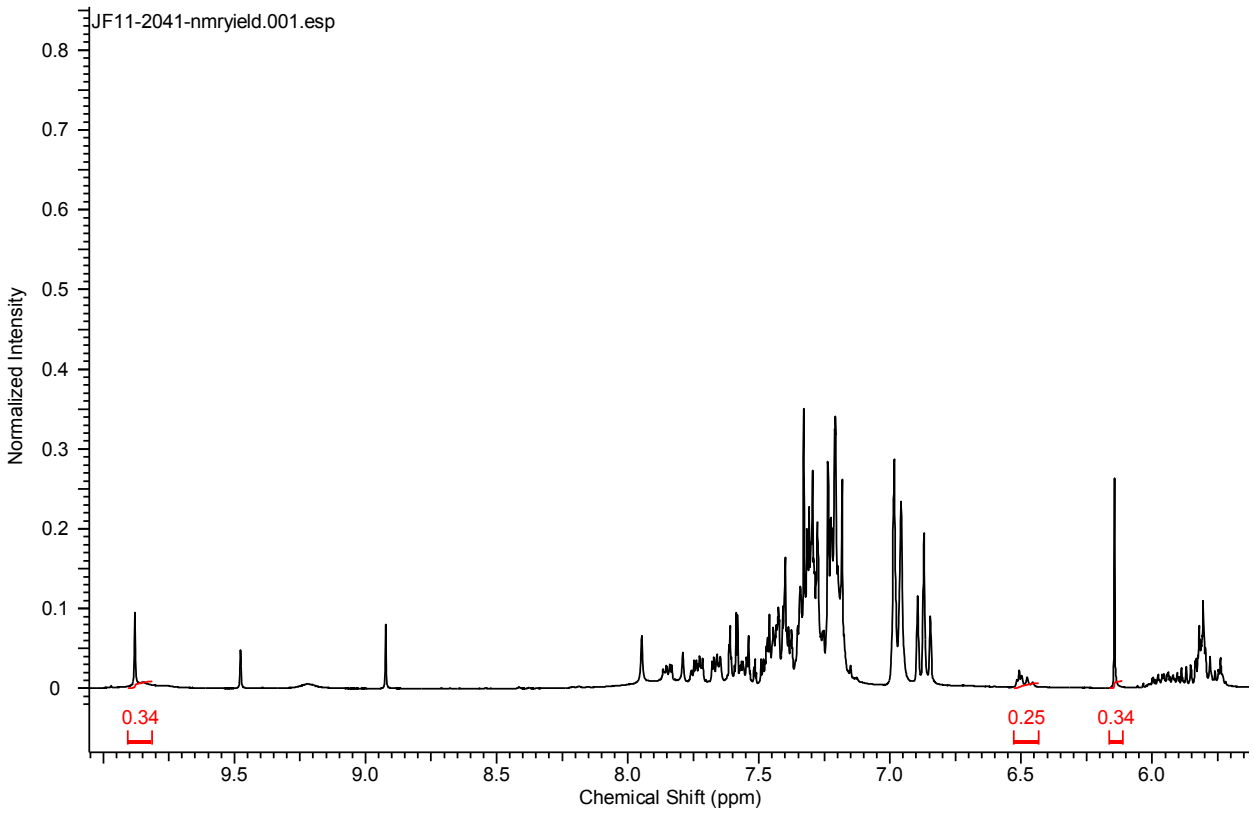

JF11-2049-C13.001.esp
127.3728
128.5511
151.8101
149.2500
134.6895
130.3984
120.9726
117.3797
104.6520
39.4131
18.0014
9.9138
Normalized Intensity
Chemical Shift (ppm)


kl03-148.001.esp
Normalized Intensity
Chemical Shift (ppm)
1.00 1.01
1.01 3.09 3.12 5.13

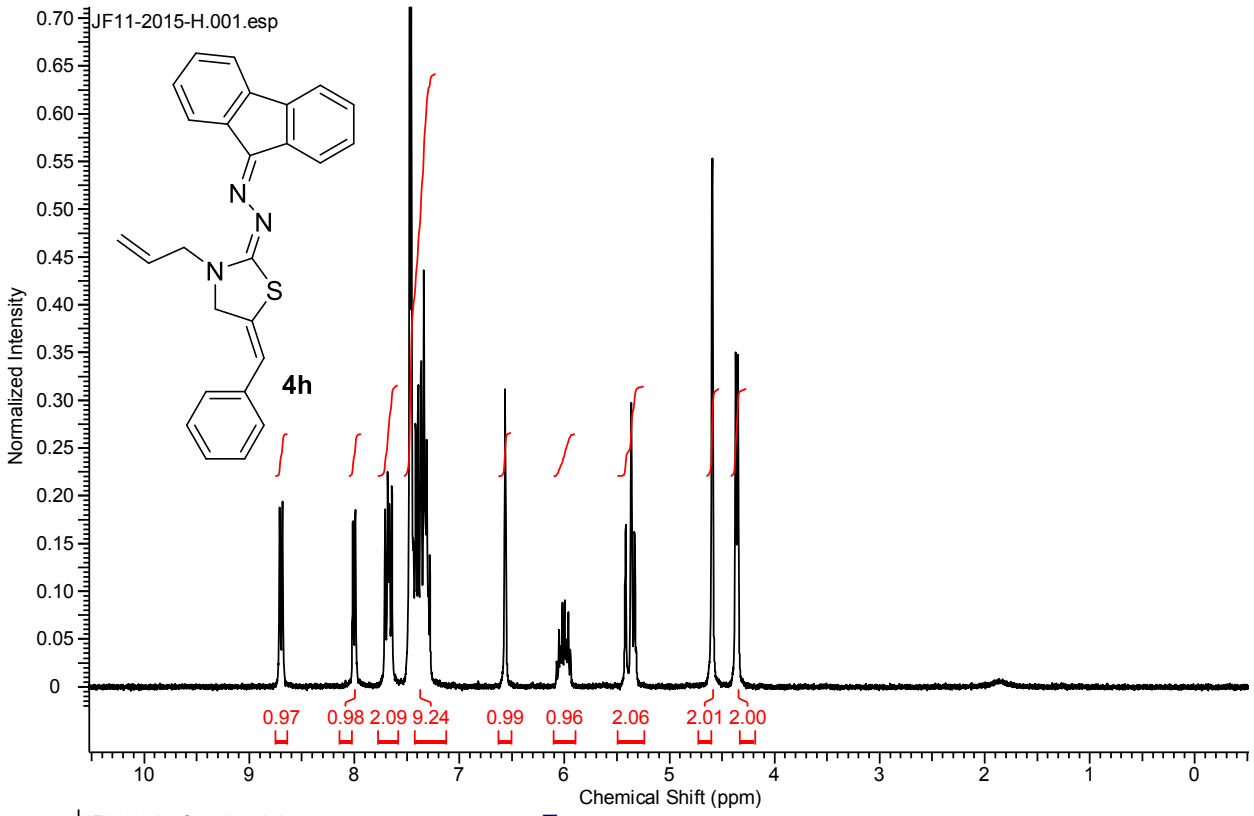

kl03-148 13C.001.esp
Normalized Intensity
Chemical Shift (ppm)
178.4430
148.1476
140.2840
136.1883
134.5631
134.0165
129.4835
128.7401
125.8468
125.6647
119.6449
115.9500

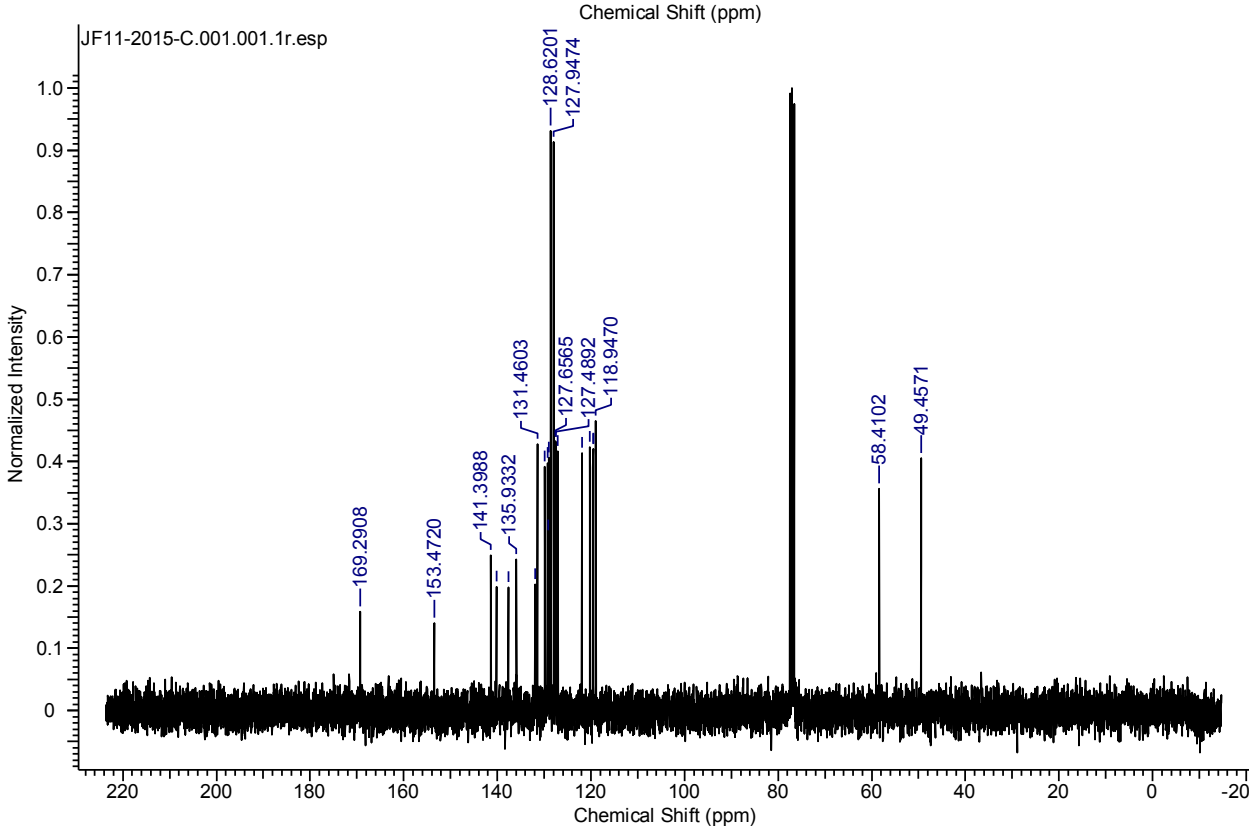

JF11-2033-H.001.esp
NC
N
N
N
S
4g
Normalized Intensity
Chemical Shift (ppm)
0.99
2.01
1.03
4.25
2.00
2.02
1.99
2.14


JF11-2033-C13.001.esp
Normalized Intensity
Chemical Shift (ppm)
170.2495
151.8488
140.5902
139.5429
136.6773
130.9608
130.3498
129.6662
128.6189
120.2403
120.1967
119.0767
106.5671
56.9652
42.4047
15.0582

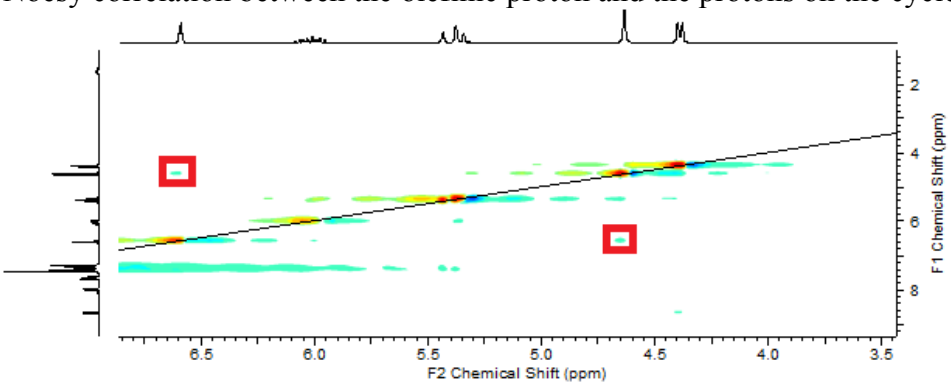


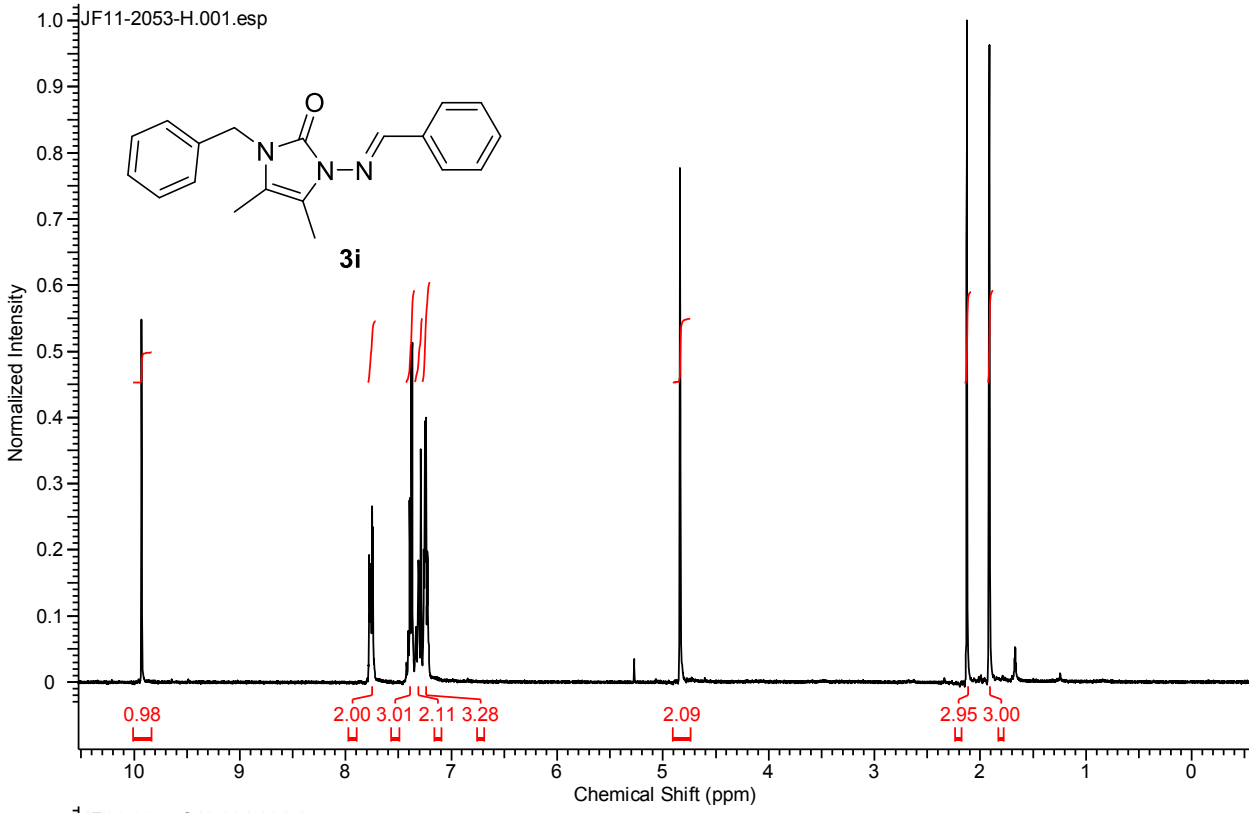
11.4 mg of TMB = 0.0678 mmol
0.600 mmol/ 0.0678 mmol = 8.34
3 proton (tmd signal)/8.34 = 0.34 proton

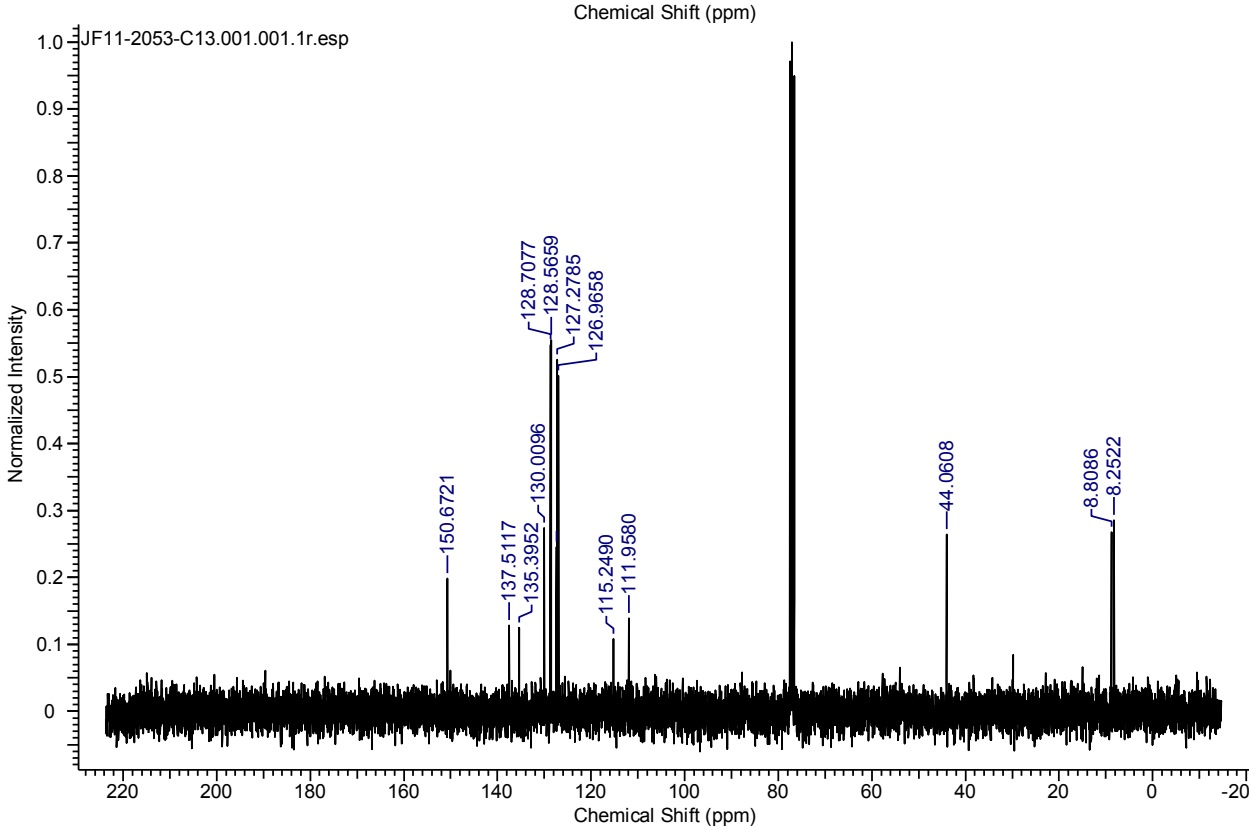

JF11-2015-H.001.esp
4h
Normalized Intensity
0.97
0.98
2.09
9.24
0.99
0.96
2.06
2.01
2.00
Chemical Shift (ppm)

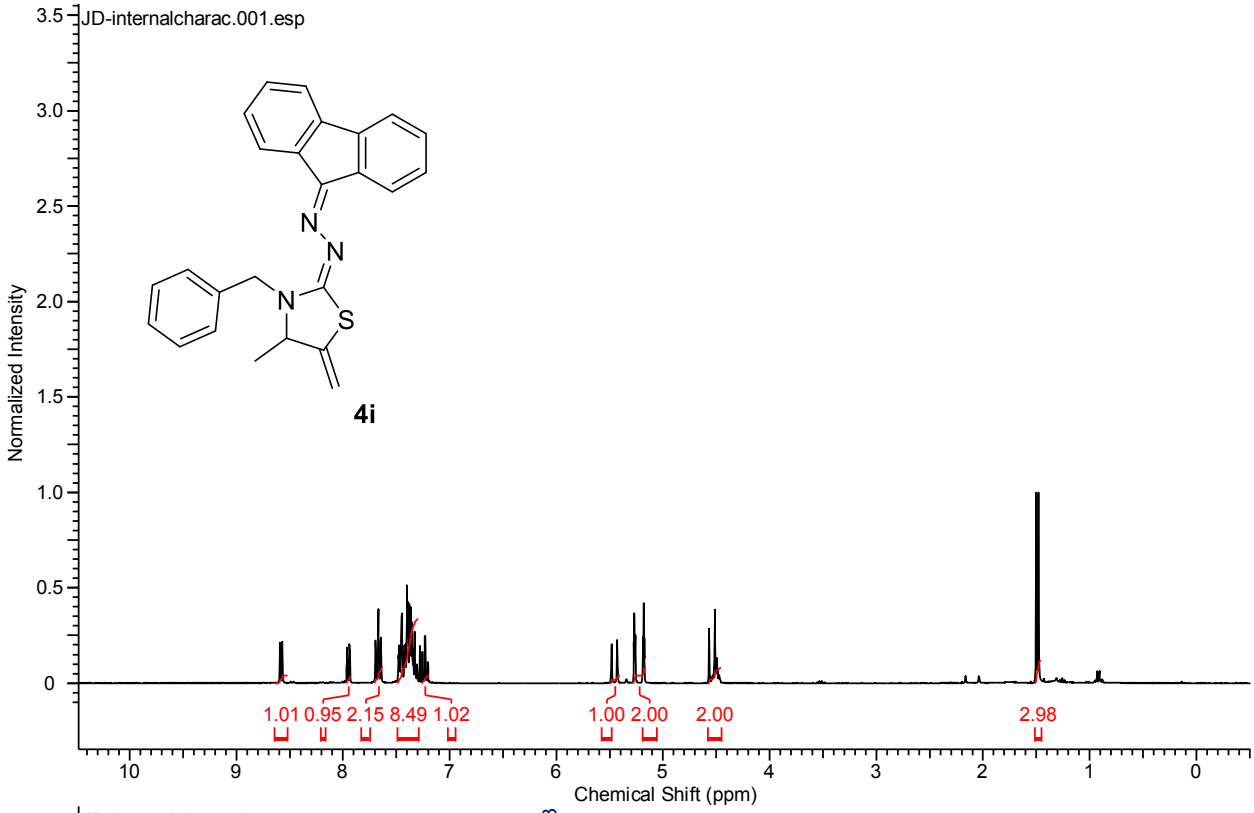

JF11-2015-C.001.001.1r.esp
Normalized Intensity
128.6201
127.9474
131.4603
127.6565
127.4892
118.9470
141.3988
135.9332
169.2908
153.4720
58.4102
49.4571
Chemical Shift (ppm)

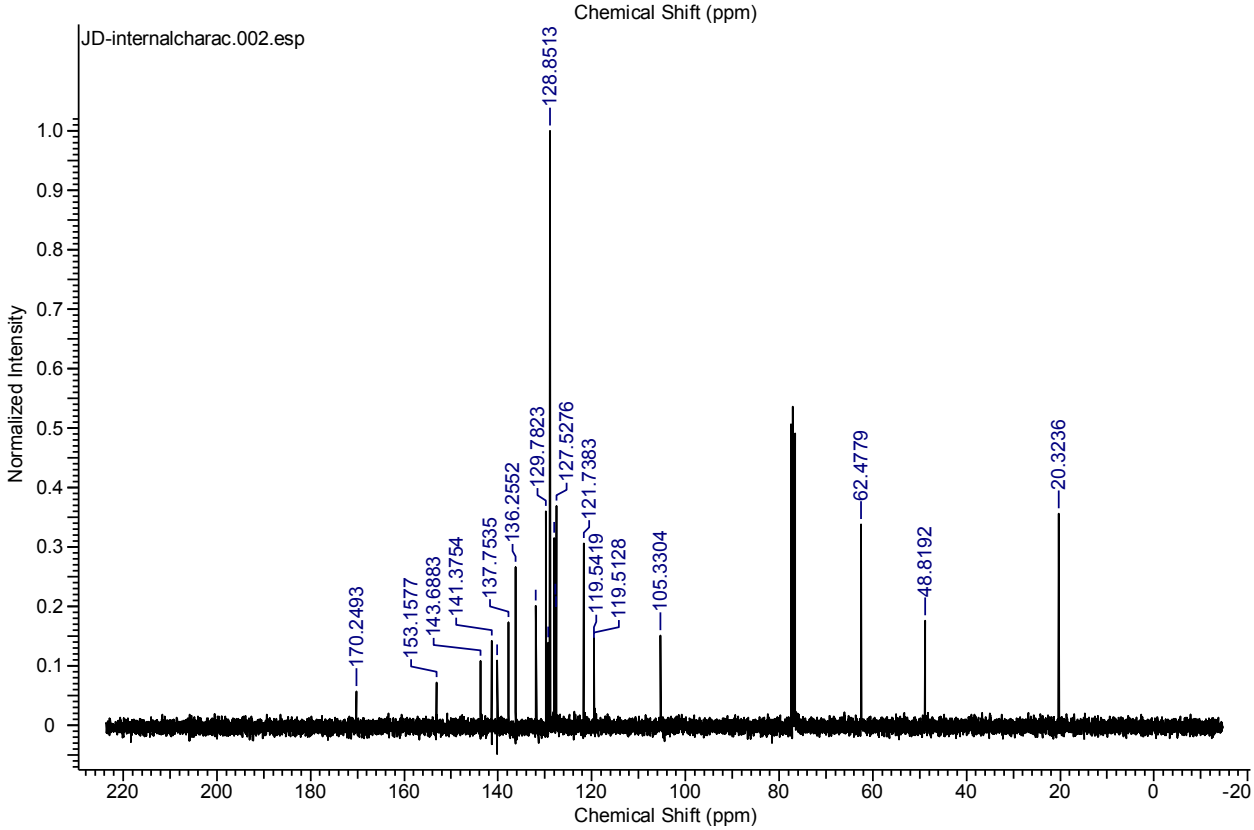
Noesy correlation between the olefinic proton and the protons on the cycle

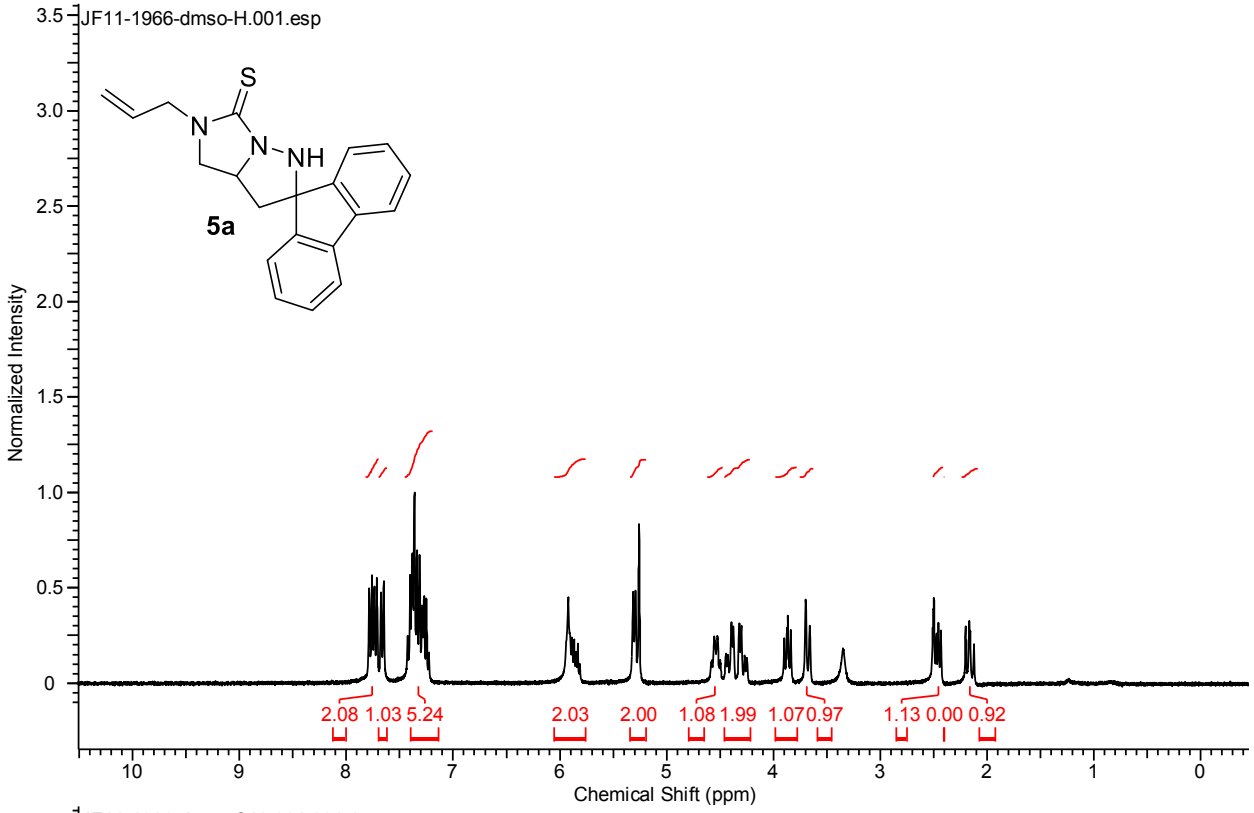


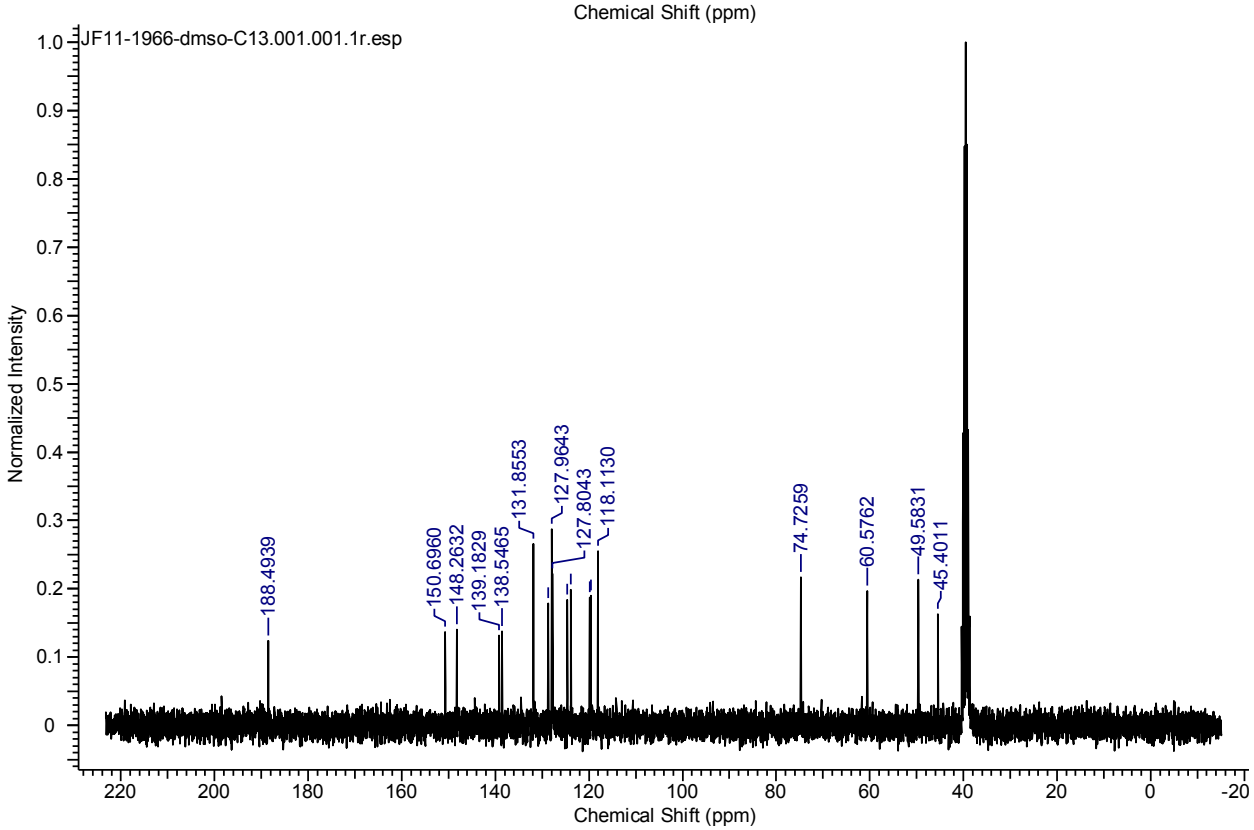

JF11-2053-H.001.esp
O
N
N–N
3i
Normalized Intensity
Chemical Shift (ppm)
0.98
2.00
3.01
2.11
3.28
2.09
2.95
3.00

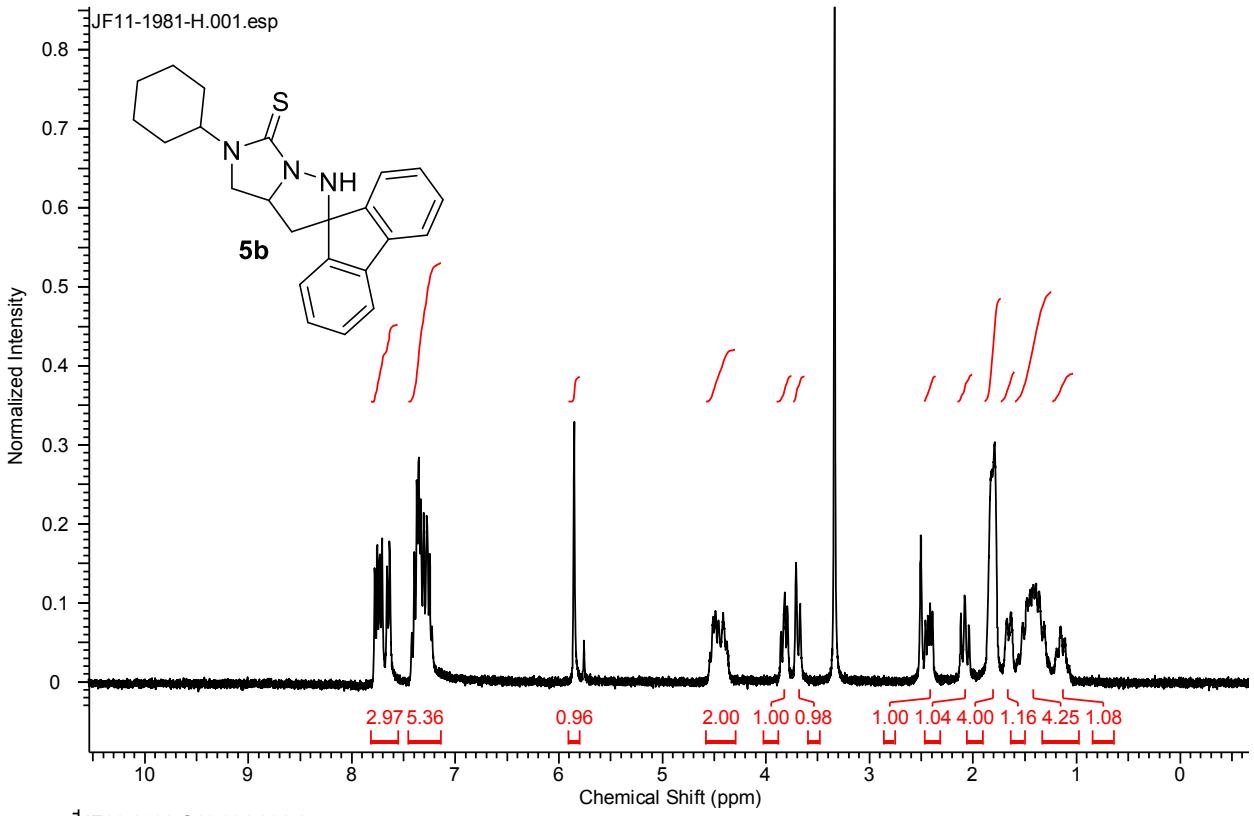

JF11-2053-C13.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
150.6721
137.5117
135.3952
130.0096
128.7077
128.5659
127.2785
126.9658
115.2490
111.9580
44.0608
8.8086
8.2522

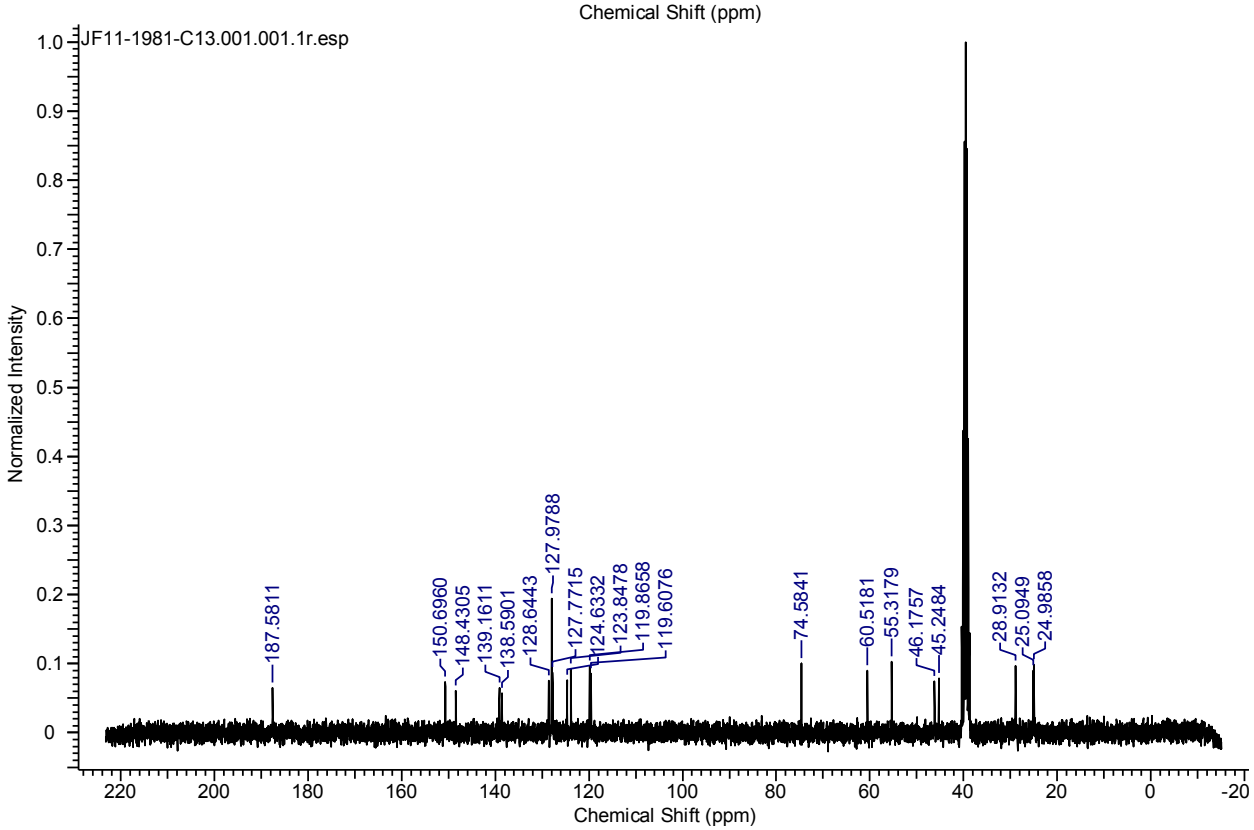

JD-internalcharac.001.esp
Normalized Intensity
Chemical Shift (ppm)
1.01 0.95 2.15 8.49 1.02
1.00 2.00
2.00
2.98
4i

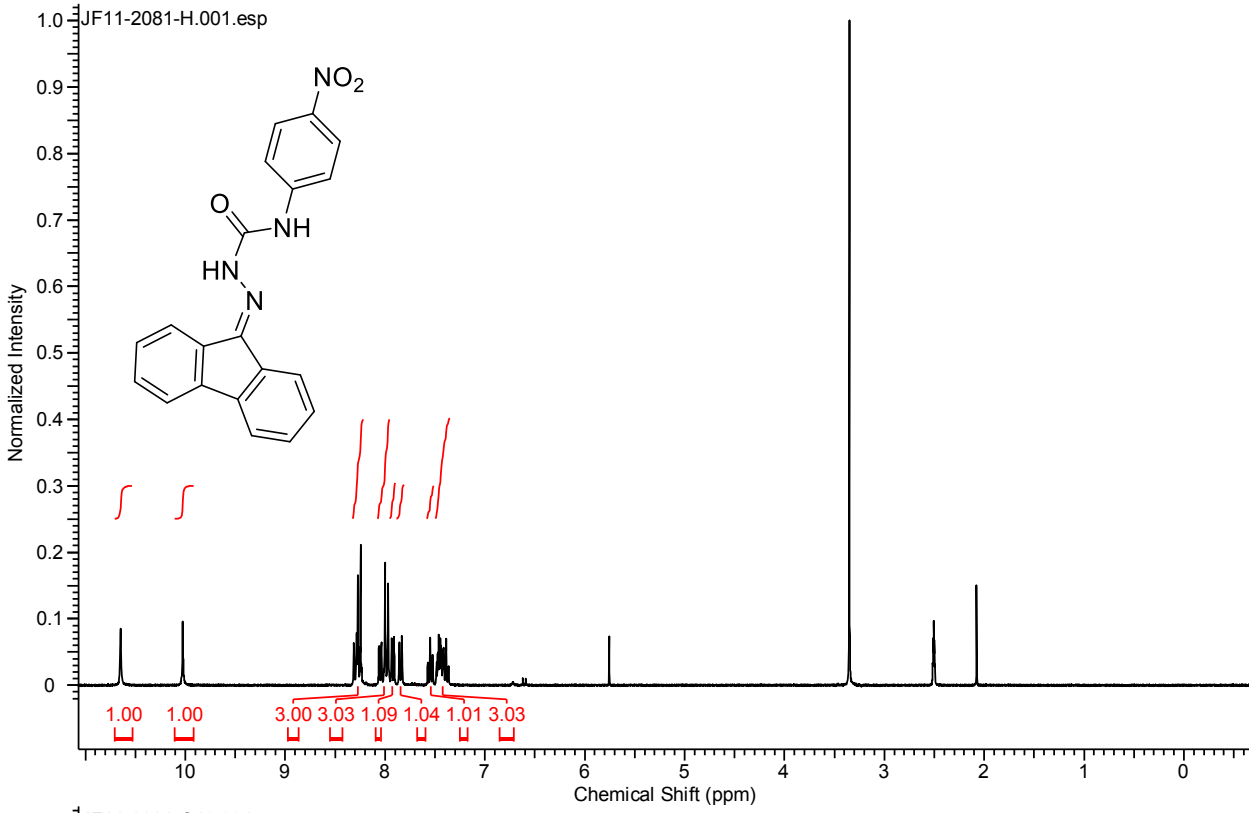

JD-internalcharac.002.esp
Normalized Intensity
Chemical Shift (ppm)
128.8513
129.7823
127.5276
121.7383
119.5419
119.5128
105.3304
62.4779
48.8192
20.3236
170.2493
153.1577
143.6883
141.3754
137.7535
136.2552

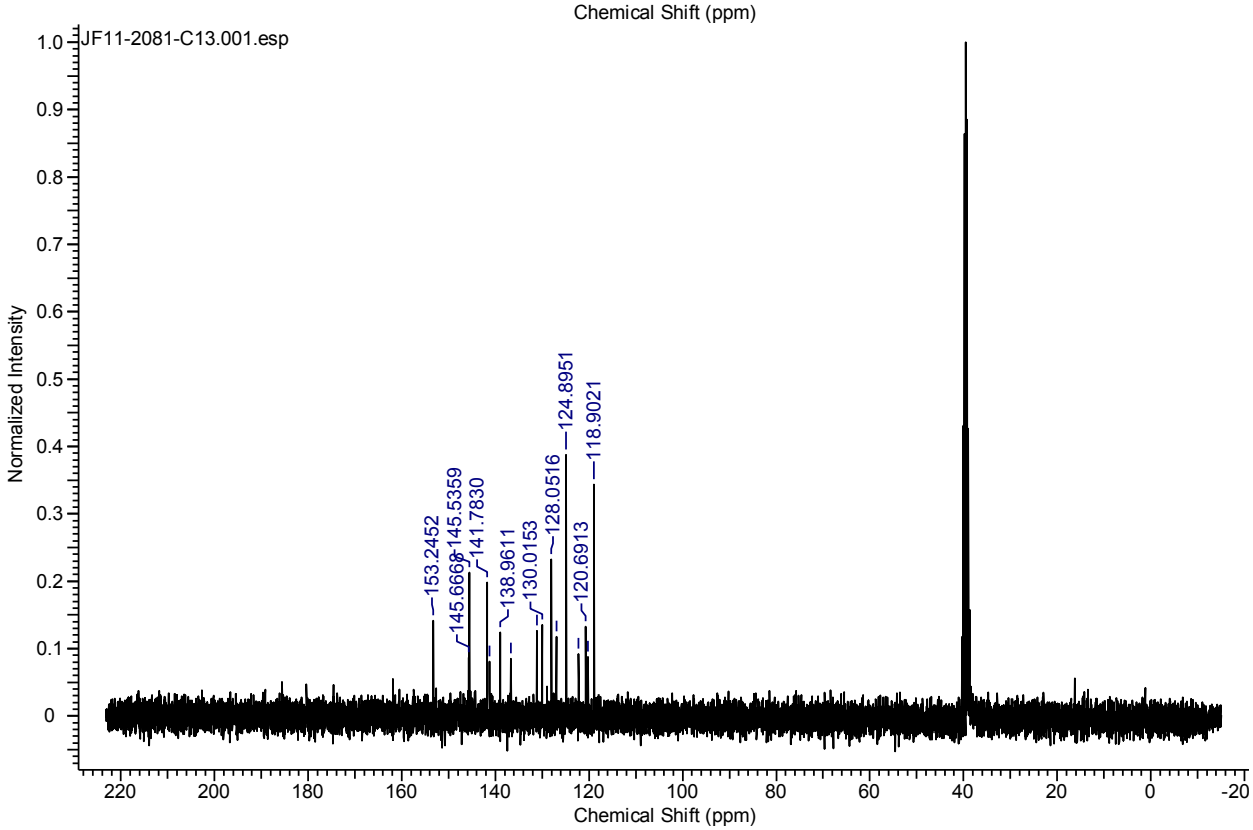

JF11-1966-dmso-H.001.esp
S
N
N
NH
5a
Normalized Intensity
2.08 1.03 5.24
2.03
2.00
1.08 1.99
1.07 0.97
1.13 0.00 0.92
Chemical Shift (ppm)


JF11-1966-dmso-C13.001.001.1r.esp
Normalized Intensity
188.4939
150.6960
148.2632
139.1829
138.5465
131.8553
127.9643
127.8043
118.1130
74.7259
60.5762
49.5831
45.4011
Chemical Shift (ppm)


JF11-1981-H.001.esp
S
N
N
NH
5b
Normalized Intensity
Chemical Shift (ppm)
2.97 5.36
0.96
2.00
1.00 0.98
1.00 1.04 4.00 1.16 4.25 1.08


JF11-1981-C13.001.001.1r.esp
Normalized Intensity
Chemical Shift (ppm)
187.5811
150.6960
148.4305
139.1611
138.5901
128.6443
127.9788
127.7715
124.6332
123.8478
119.8658
119.6076
74.5841
60.5181
55.3179
46.1757
45.2484
28.9132
25.0949
24.9858


JF11-2081-H.001.esp
NO2
O
NH
HN
N
Normalized Intensity
1.00 1.00 3.00 3.03 1.09 1.04 1.01 3.03
Chemical Shift (ppm)


JF11-2081-C13.001.esp
Normalized Intensity
153.2452
145.6668
145.5359
141.7830
138.9611
130.0153
128.0516
124.8951
120.6913
118.9021
Chemical Shift (ppm)