

# Supporting Information

## New multicomponent domino reaction (MDR) in water: highly chemo-, regio- and seteroselective synthesis of spiro{[1,3]dioxanes-pyridine}-4,6-diones and pyrazolo[3,4-*b*]pyridines

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### Experimental

#### General

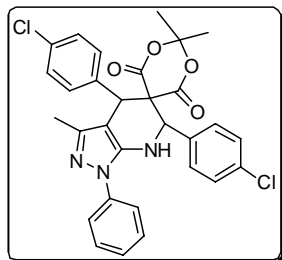
Microwave irradiation was carried out with microwave oven Emrys Creator from Personal Chemistry, Uppsala, Sweden. Melting points were determined in open capillaries and were uncorrected. IR spectra were taken on a FT-IR-Tensor 27 spectrometer in KBr pellets and reported in  $\text{cm}^{-1}$ . <sup>1</sup>H NMR spectra were measured on a Bruker DPX 400 MHz spectrometer in DMSO-*d*<sub>6</sub> with chemical shift ( $\delta$ ) given in ppm relative to TMS as internal standard. ESI-MS was determined by using the LCQ Advantage HPLC/MS instrument (Thermo Finnigan). HRMS (ESI) was determined by using microTOF-Q II HRMS/MS instrument (BRUKER). X-Ray crystallographic analysis was performed with a Siemens SMART CCD and a Siemens P4 diffractometer.

#### General procedure for the synthesis of compounds 4 and 5

**Preparation of compounds 4:** In a 10-mL Emrys reaction vial, a Meldrum's acid (**1**, 1 mmol), aromatic aldehydes (**2**, 2 mmol), 3-methyl-1-phenylpyrazol-5-amine (**3a**) or 3-methyl-isoxazol-5-amine (**3b**) (1.0 mmol) and water (2.0 mL) were mixed and then capped. The mixture was heated for a given min at 100 °C under microwave irradiation (initial power 100 W and maximum power 200 W). Upon completion, monitored by TLC, the reaction mixture was cooled to room temperature and then poured into cold water. The solid product was collected by Büchner filtration and subsequently purified recrystallized from EtOH (95%) to give the pure products **4**.

**Preparation of compounds 5:** In a 10-mL Emrys reaction vial, a Meldrum's acid (**1**, 1 mmol), aromatic aldehydes (**2**, 1 mmol), 3-methyl-pyrazol-5-amine (**3c**) or 3-methyl-1-methyl-pyrazol-5-amine (**3d**) (1.0 mmol) and water (2.0 mL) were mixed and then capped. The mixture was heated for a given min at 100 °C under microwave irradiation. Upon completion, monitored by TLC, the reaction mixture was cooled to room temperature and then poured into cold water. The subsequent work-up produce was the same as in the above reactions.

#### 4',6'-Bis(4-chlorophenyl)-2,2,3'-trimethyl-1'-phenyl-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (**4a**)



White solid, mp: 205.7-206.1 °C

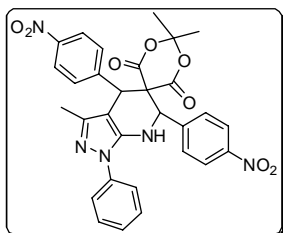
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 8.35 (d, 1H, *J* = 2.0 Hz, NH), 7.33 (d, 4H, *J* = 7.2 Hz, ArH), 7.26 (d, 2H, *J* = 5.6 Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H, *J* = 2.0 Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>), 0.55 (s, 3H, CH<sub>3</sub>).

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 195.1, 175.2, 167.7, 161.0, 157.5, 154.8, 152.6, .145.2, 143.9, 139.5, 135.5, 130.4, 129.1, 128.9, 128.6, 128.4, 128.3, 125.3, 122.2, 121.1, 112.7, 105.3, 101.1, 58.1, 47.1, 28.3, 27.3, 13.8.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3196, 3120, 3011, 2982, 2903, 1633, 1539, 1490, 1432, 1362, 1251, 1126, 1080, 954, 873, 827, 681.

HRMS (ESI): *m/z* calcd for: 562.1395 [M+H]<sup>+</sup>, found: 562.1352.

**2,2,3'-Trimethyl-4',6'-bis(4-nitrophenyl)-1'-phenyl-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (4b)**



White solid, mp: 204.1-205.6 °C

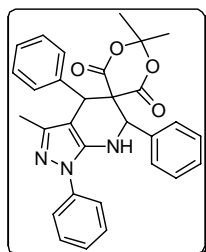
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.35 (d, 1H,  $J = 2.0$  Hz, NH), 7.33 (d, 4H,  $J = 7.2$  Hz, ArH), 7.26 (d, 2H,  $J = 5.6$  Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H,  $J = 2.0$  Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H,  $\text{CH}_3$ ), 0.64 (s, 3H,  $\text{CH}_3$ ), 0.55 (s, 3H,  $\text{CH}_3$ ).

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3338, 2954, 2930, 2857, 1764, 1734, 1598, 1524, 1498, 1458, 1351, 1291, 1211, 1041, 1015, 940, 860, 759.

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 167.1, 160.5, 157.7, 152.6, 148.0, 147.5, 145.1, 144.3, 143.6, 142.3, 139.2, 136.4, 131.9, 130.6, 130.4, 130.0, 129.0, 126.1, 125.6, 124.3, 123.7, 121.3, 112.7, 105.8, 100.2, 66.1, 57.8, 28.7, 27.4, 13.9.

HRMS (ESI):  $m/z$  calcd for: 584.1776  $[\text{M}+\text{H}]^+$ , found: 584.1788.

**2,2,3'-Trimethyl-1',4',6'-triphenyl-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (4c)**



White solid, mp: 211.6-212.8 °C

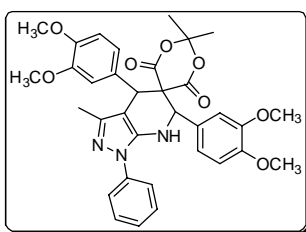
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.35 (d, 1H,  $J = 2.0$  Hz, NH), 7.33 (d, 4H,  $J = 7.2$  Hz, ArH), 7.26 (d, 2H,  $J = 5.6$  Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H,  $J = 2.0$  Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H,  $\text{CH}_3$ ), 0.64 (s, 3H,  $\text{CH}_3$ ), 0.55 (s, 3H,  $\text{CH}_3$ ).

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3311, 2923, 2900, 2829, 1758, 1719, 1598, 1513, 1465, 1456, 1304, 1247, 1144, 1077, 1045, 942, 839, 758.

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 221.5, 214.7, 195.0, 175.2, 167.7, 154.8, 145.2, 143.9, 139.5, 135.5, 130.4, 129.1, 128.9, 128.8, 128.8, 128.6, 128.5, 128.4, 128.3, 125.3, 122.2, 121.1, 112.7, 105.3, 101.1, 58.0, 47.1, 28.3, 27.3, 13.8.

HRMS (ESI):  $m/z$  calcd for: 494.2074  $[\text{M}+\text{H}]^+$ , found: 494.2092.

**4',6'-Bis(3,4-dimethoxyphenyl)-2,2,3'-trimethyl-1'-phenyl-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (4d)**



White solid, mp: 221.4-223.5 °C

$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.35 (d, 1H,  $J = 2.0$  Hz, NH), 7.33 (d, 4H,  $J = 7.2$  Hz, ArH), 7.26 (d, 2H,  $J = 5.6$  Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H,  $J = 2.0$  Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H,  $\text{CH}_3$ ), 0.64 (s, 3H,  $\text{CH}_3$ ), 0.55 (s, 3H,  $\text{CH}_3$ ).

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3308, 2956, 2942, 2864, 1761, 1725, 1597, 1515, 1461, 1424, 1389, 1296, 1140, 1030, 1030, 939, 809, 756.

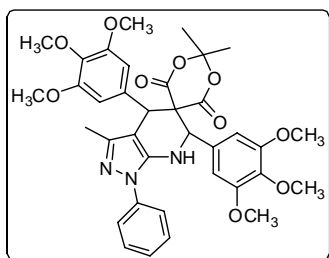
$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 167.5, 167.2, 165.9, 161.1, 157.2, 149.7, 149.0, 148.8, 148.6, 127.3, 126.6, 122.7, 121.0, 120.9, 120.8, 113.8, 112.7, 111.8, 111.4, 105.4, 88.9, 64.3, 64.2, 58.2, 55.7, 55.6, 55.5, 55.4, 40.5, 28.2, 27.5.

HRMS (ESI):  $m/z$  calcd for: 614.2497  $[\text{M}+\text{H}]^+$ , found: 614.2487.

**2,2,3'-Trimethyl-1'-phenyl-4',6'-bis(3,4,5-trimethoxyphenyl)-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (4e)**

White solid, mp: 222.9-224.1 °C

$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.35 (d, 1H,  $J = 2.0$  Hz, NH), 7.33 (d, 4H,  $J = 7.2$  Hz, ArH), 7.26 (d, 2H,  $J = 5.6$  Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H,  $J = 2.0$  Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H,  $\text{CH}_3$ ), 0.64 (s, 3H,  $\text{CH}_3$ ), 0.55 (s, 3H,  $\text{CH}_3$ ).



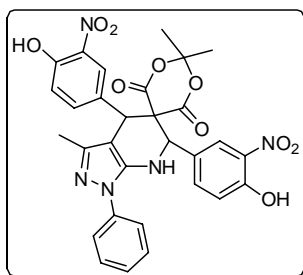
CH<sub>3</sub>), 0.55 (s, 3H, CH<sub>3</sub>).

IR (KBr,  $\nu$ , cm<sup>-1</sup>): 3337, 2961, 2940, 2841, 1758, 1722, 1594, 1509, 1468, 1428, 1300, 1249, 1130, 1048, 1007, 939, 829, 730.

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 161.6, 152.8, 143.7, 137.9, 133.1, 130.6, 128.9, 120.6, 106.3, 105.8, 105.3, 98.8, 98.0, 86.0, 85.7, 84.0, 83.0, 81.3, 80.3, 79.5, 77.7, 76.5, 64.8, 64.4, 64.1, 62.5, 60.8, 60.2, 60.0, 55.9, 55.8, 28.2, 27.3, 19.8, 13.8.

HRMS (ESI): *m/z* calcd for: 674.2708 [M+H]<sup>+</sup>, found: 674.2737.

**4',6'-Bis(4-hydroxy-3-nitrophenyl)-2,2,3'-trimethyl-1'-phenyl-1',4',6',7'-tetrahydrospiro[[1,3]dioxane-5,5'-pyrazolo[3,4-*b*]pyridine]-4,6-dione (4f)**



White solid, mp: 207.5-208.9 °C

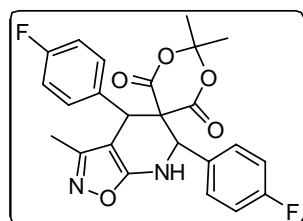
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 8.35 (d, 1H, *J* = 2.0 Hz, NH), 7.33 (d, 4H, *J* = 7.2 Hz, ArH), 7.26 (d, 2H, *J* = 5.6 Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H, *J* = 2.0 Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>), 0.55 (s, 3H, CH<sub>3</sub>).

IR (KBr,  $\nu$ , cm<sup>-1</sup>): 3336, 3279, 3277, 2957, 2935, 2864, 1758, 1722, 1594, 1509, 1468, 1428, 1300, 1249, 1130, 1048, 1007, 939, 829, 730.

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 222.0, 199.9, 196.7, 193.5, 189.2, 188.4, 177.6, 175.6, 174.2, 172.6, 162.0, 156.7, 152.7, 152.3, 150.9, 128.9, 121.2, 105.6, 102.1, 90.5, 89.0, 71.3, 68.6, 61.7, 59.4, 49.4, 36.6, 28.6, 22.3, 21.6.

HRMS (ESI): *m/z* calcd for: 616.1674 [M+H]<sup>+</sup>, found: 616.1697.

**4',6'-Bis(4-fluorophenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'-H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-*b*]pyridine]-4,6-dione (4g)**



White solid, mp: 195.2-195.8 °C

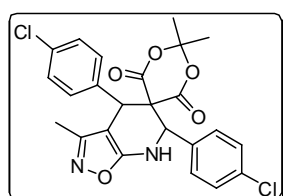
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 8.35 (d, 1H, *J* = 2.0 Hz, NH), 7.33 (d, 4H, *J* = 7.2 Hz, ArH), 7.26 (d, 2H, *J* = 5.6 Hz, ArH), 7.08 (s, 1H, ArH), 5.11 (d, 1H, *J* = 2.0 Hz, CH), 4.92 (s, 1H, CH), 1.54 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>), 0.55 (s, 3H, CH<sub>3</sub>).

IR (KBr,  $\nu$ , cm<sup>-1</sup>): 3366, 3077, 2900, 1769, 1733, 1632, 1551, 1511, 1455, 1380, 1223, 1159, 1099, 1044, 937, 850, 744.

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 166.9, 165.8, 161.4, 160.3, 157.1, 132.6, 132.5, 131.4, 131.3, 130.8, 130.7, 130.4, 130.3, 130.2, 115.8, 115.6, 105.6, 88.7, 63.6, 58.2, 45.7, 28.2, 27.5, 11.2.

HRMS (ESI): *m/z* calcd for: 455.1414 [M+H]<sup>+</sup>, found: 455.1411.

**4',6'-Bis(4-chlorophenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'-H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-*b*]pyridine]-4,6-dione (4h)**



white solid, mp: 192.4-193.9 °C

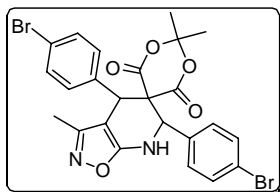
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 8.39 (d, 1H, *J* = 2.0 Hz, NH), 7.56 (d, 2H, *J* = 8.4 Hz, ArH), 7.52-7.47 (m, 2H, ArH), 7.30 (d, 2H, *J* = 8.4 Hz, ArH), 7.24-7.21 (m, 1H, ArH), 7.07-7.04 (m, 1H, ArH), 5.12 (d, 1H, *J* = 2.0 Hz, CH), 4.92 (s, 1H, CH), 1.56 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>), 0.56 (s, 3H, CH<sub>3</sub>).

IR (KBr,  $\nu$ , cm<sup>-1</sup>): 3363, 3070, 2944, 1767, 1732, 1647, 1539, 1489, 1416, 1380, 1239, 1199, 1092, 1050, 936, 827, 756.

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) ( $\delta$ , ppm): 166.8, 165.8, 161.2, 157.1, 134.3, 134.1, 133.4, 133.3, 132.3, 130.1, 129.0, 129.9, 105.7, 88.4, 63.6, 57.9, 47.8, 28.2, 27.4, 11.2.

HRMS (ESI): *m/z* calcd for: 487.0823 [M+H]<sup>+</sup>, found: 487.0820.

**4',6'-Bis(4-bromophenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4i)**



white solid, mp: 169.1-170.3 °C

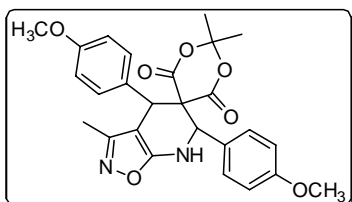
$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.39 (d, 1H,  $J = 1.6$  Hz, NH), 7.69 (d, 2H,  $J = 8.4$  Hz, ArH), 7.64-7.60 (m, 2H, ArH), 7.23 (d, 2H,  $J = 8.4$  Hz, ArH), 7.17-7.14 (m, 1H, ArH), 7.00-6.97 (m, 1H, ArH), 5.10 (d, 1H,  $J = 1.6$  Hz, CH), 4.90 (s, 1H, CH), 1.55 (s, 3H,  $\text{CH}_3$ ), 0.64 (s, 3H,  $\text{CH}_3$ ), 0.56 (s, 3H,  $\text{CH}_3$ ).

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3356, 3053, 2975, 1759, 1732, 1645, 1556, 1505, 1454, 1416, 1288, 1202, 1011, 1004, 935, 828, 741.

$^{13}\text{C NMR}$  (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 220.0, 216.1, 208.4, 207.7, 195.8, 186.9, 174.4, 160.1, 159.4, 133.8, 132.1, 131.9, 131.8, 131.8, 130.3, 118.8, 112.7, 105.7, 88.4, 77.9, 63.1, 77.9, 63.1, 57.8, 30.7, 11.2.

HRMS (ESI):  $m/z$  calcd for: 574.9812  $[\text{M}+\text{H}]^+$ , found: 574.9817.

**4',6'-Bis(4-methoxyphenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4j)**



white solid, mp: 196.4-197.7 °C

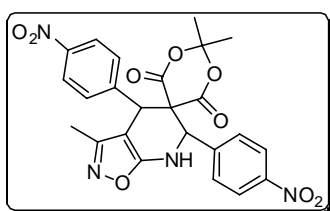
$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.17 (d, 1H,  $J = 1.6$  Hz, NH), 7.21 (d, 2H,  $J = 8.8$  Hz, ArH), 7.10 (d, 2H,  $J = 8.8$  Hz, ArH), 7.00-6.93 (m, 5H, ArH), 4.99 (d, 1H,  $J = 1.6$  Hz, CH), 4.79 (s, 1H, CH), 3.73 (d, 3H,  $J = 1.6$  Hz,  $\text{OCH}_3$ ), 1.54 (s, 3H,  $\text{CH}_3$ ), 0.62 (s, 3H,  $\text{CH}_3$ ), 0.53 (s, 3H,  $\text{CH}_3$ ).

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3206, 2967, 2935, 1761, 1731, 1646, 1531, 1517, 1444, 1394, 1260, 1204, 1098, 1039, 939, 845, 731.

$^{13}\text{C NMR}$  (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 167.3, 166.5, 165.9, 160.5, 160.1, 159.4, 157.6, 157.1, 153.2, 149.8, 129.4, 126.4, 114.5, 114.1, 88.9, 63.9, 58.3, 55.3, 55.2, 47.4, 46.0, 33.4, 28.2, 27.6, 11.2.

HRMS (ESI):  $m/z$  calcd for: 479.1813  $[\text{M}+\text{H}]^+$ , found: 479.1813.

**2,2,3'-Trimethyl-4',6'-bis(4-nitrophenyl)-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4k)**



White solid, mp: 186.8-199.7 °C

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-}d_6$ ): 8.63 (d, 1H,  $J = 1.6$  Hz, NH), 8.36 (d, 2H,  $J = 8.8$  Hz, ArH), 8.32-8.27 (m, 2H, ArH), 7.58 (d, 2H,  $J = 8.8$  Hz, ArH), 7.52-7.50 (m, 1H, ArH), 7.35-7.33 (m, 1H, ArH), 5.35 (d, 1H,  $J = 1.6$  Hz, CH), 5.16 (s, 1H, CH), 1.57 (s, 3H,  $\text{CH}_3$ ), 0.58 (s, 3H,  $\text{CH}_3$ ), 0.50 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C NMR}$  (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 192.3, 190.0, 189.9, 182.1, 178.0, 158.8, 152.6, 152.5, 123.9, 118.2, 111.0, 106.8, 106.3, 106.2, 100.1, 92.2, 92.0, 81.7, 81.6, 81.1, 66.0, 45.3, 30.7, 30.5.

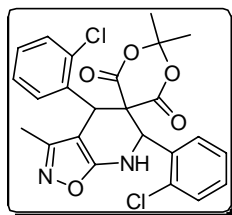
IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3370, 3113, 2936, 1768, 1735, 1645, 1522, 1476, 1417, 1348, 1228, 1208, 1092, 1045, 934, 860, 726.

HRMS (ESI):  $m/z$  calcd for: 509.1304  $[\text{M}+\text{H}]^+$ , found: 509.1330.

**4',6'-Bis(2-chlorophenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4l)**

white solid, mp: 189.2-190.0 °C

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.34 (d, 1H,  $J = 1.6$  Hz, NH), 7.56 (d, 2H,  $J = 8.4$  Hz, ArH), 7.51-7.47 (m, 2H, ArH), 7.22 (d, 3H,  $J = 8.4$  Hz, ArH), 7.06-7.04 (m, 1H, ArH), 5.12 (d, 1H,  $J = 1.6$  Hz, CH), 4.92 (s, 1H, CH),



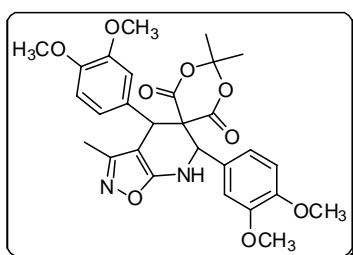
1.55 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>), 0.55 (s, 3H, CH<sub>3</sub>).

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 169.2, 166.8, 165.8, 162.3, 160.1, 141.4, 134.3, 134.1, 133.3, 132.3, 130.0, 128.8, 112.7, 105.7, 93.5, 88.4, 63.7, 57.9, 45.8, 32.1, 28.3, 27.4, 11.2, 9.9.

IR (KBr, ν, cm<sup>-1</sup>): 3277, 3053, 2974, 1766, 1732, 1648, 1540, 1490, 1414, 1393, 1289, 1200, 1093, 1014, 936, 827, 740.

HRMS (ESI): m/z calcd for: 487.0823 [M+H]<sup>+</sup>, found: 487.0811.

#### 4',6'-Bis(3,4-dimethoxyphenyl)-2,2,3'-trimethyl-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4m)



White solid, mp: 198.1-199.4 °C

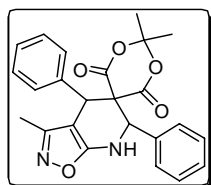
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 8.16 (d, 1H, *J* = 2.4 Hz, NH), 7.01-6.98 (m, 1H, ArH), 6.96 (d, 1H, *J* = 8.4 Hz, ArH), 6.86 (d, 1H, *J* = 5.6 Hz, ArH), 6.81 (t, 1H, *J* = 8.4 Hz, ArH), 6.74 (d, 1H, *J* = 8.8 Hz, ArH), 6.59-6.56 (m, 1H, ArH), 4.96 (d, 1H, *J* = 2.0 Hz, CH), 4.78 (s, 1H, CH), 4.96 (d, 1H, *J* = 2.0 Hz, CH), 3.73 (d, 10H, *J* = 9.6 Hz, OCH<sub>3</sub>), 3.60 (s, 2H, OCH<sub>3</sub>), 1.59 (s, 3H, CH<sub>3</sub>), 0.65 (s, 3H, CH<sub>3</sub>), 0.59 (s, 3H, CH<sub>3</sub>).

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 165.9, 161.1, 157.2, 149.6, 149.2, 148.9, 148.7, 148.5, 127.2, 126.5, 122.7, 120.9, 111.7, 111.273, 105.4, 88.9, 64.2, 58.2, 55.7, 55.5, 46.3, 46.2, 28.2, 27.6, 27.5, 11.3, 11.1.

IR (KBr, ν, cm<sup>-1</sup>): 3350, 2967, 2936, 1761, 1732, 1646, 1592, 1519, 1455, 1364, 1267, 1226, 1140, 1028, 933, 863, 733.

HRMS (ESI): m/z calcd for: 539.2025 [M+H]<sup>+</sup>, found: 539.2026.

#### 2,2,3'-Trimethyl-4',6'-diphenyl-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4n)



white solid, mp: 191.7-192.3 °C

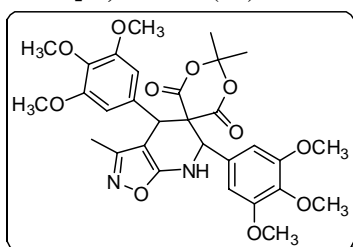
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 8.31 (d, 1H, *J* = 1.2 Hz, NH), 7.45-7.43 (m, 3H, ArH), 7.40-7.37 (m, 3H, ArH), 7.31-7.29 (m, 2H, ArH), 7.20 (d, 1H, *J* = 1.6 Hz, ArH), 7.06 (m, d, 1H, *J* = 6.8 Hz, ArH), 5.08 (d, 1H, *J* = 1.6 Hz, CH), 4.89 (s, 1H, CH), 1.54 (s, 3H, CH<sub>3</sub>), 0.53 (s, 3H, CH<sub>3</sub>), 0.44 (s, 3H, CH<sub>3</sub>).

<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 193.6, 167.1, 165.9, 160.4, 157.5, 136.0, 134.7, 134.2, 130.4, 129.7, 129.5, 129.2, 128.9, 128.0, 126.6, 105.7, 88.7, 64.2, 58.0, 46.5, 28.0, 27.3, 11.1;

IR (KBr, ν, cm<sup>-1</sup>): 3306, 3065, 2994, 1769, 1731, 1645, 1533, 1494, 1457, 1394, 1276, 1228, 1086, 1048, 937, 845, 739.

HRMS (ESI): m/z calcd for: 419.1602 [M+H]<sup>+</sup>, found: 419.1631.

#### 2,2,3'-Trimethyl-4',6'-bis(3,4,5-trimethoxyphenyl)-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-b]pyridine]-4,6-dione (4o)



white solid, mp: 199.2-201.0 °C

<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 8.22 (d, 1H, *J* = 2.4 Hz, NH), 6.59 (s, 2H, ArH), 6.48 (d, 1H, *J* = 1.2 Hz, ArH), 6.29 (d, 1H, *J* = 1.2 Hz, ArH), 4.98 (d, 1H, *J* = 2.4 Hz, CH), 4.79 (s, 1H, CH), 3.74 (d, 9H, *J* = 4.0 Hz, OCH<sub>3</sub>), 3.61 (d, 9H, *J* = 5.6 Hz, OCH<sub>3</sub>), 1.67 (s, 3H, CH<sub>3</sub>), 0.71 (s, 3H, CH<sub>3</sub>), 0.64 (s, 3H, CH<sub>3</sub>).

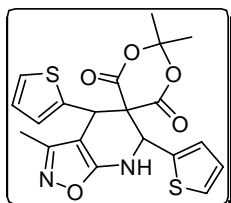
<sup>13</sup>C NMR (100MHz, DMSO-*d*<sub>6</sub>) (δ, ppm): 179.0, 178.7, 167.3, 167.1, 165.8, 160.8,

157.3, 152.9, 150.9, 150.5, 142.2, 138.5, 131.8, 130.5, 129.7, 129.2, 105.8, 105.5, 88.7, 67.2, 64.4, 60.1, 60.0, 58.2, 56.0, 55.9, 46.9, 28.0, 27.4, 11.2.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3363, 2961, 2940, 1758, 1722, 1645, 1594, 1509, 1468, 1391, 1249, 1130, 1047, 1008, 939, 839, 755.

HRMS (ESI):  $m/z$  calcd for: 599.2236  $[\text{M}+\text{H}]^+$ , found: 599.2218.

**2,2,3'-Trimethyl-4',6'-di(thiophen-2-yl)-6',7'-dihydro-4'H-spiro[[1,3]dioxane-5,5'-isoxazolo[5,4-*b*]pyridine]-4,6-dione (4p)**



white solid, mp: 164.2-166.0 °C

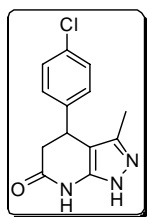
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 8.72 (d, 1H,  $J = 1.6$  Hz, NH), 8.42 (d, 1H,  $J = 1.6$  Hz, ArH), 8.38 (d, 1H,  $J = 5.2$  Hz, ArH), 8.27 (d, 1H,  $J = 4.0$  Hz, ArH), 7.62-7.61 (m, 1H, ArH), 7.39 (t, 1H,  $J_1 = J_2 = 4.8$  Hz, ArH), 7.09 (s, 1H, ArH), 5.37 (d, 1H,  $J = 2.0$  Hz, CH), 5.00 (s, 1H, CH), 1.61 (s, 3H,  $\text{CH}_3$ ), 0.81 (s, 3H,  $\text{CH}_3$ ), 0.71 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 208.1, 184.6, 169.4, 162.9, 148.6, 146.6, 143.3, 142.9, 138.2, 136.1, 129.1, 127.5, 127.4, 124.2, 106.7, 104.7, 94.8, 30.61, 26.8;

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3364, 2997, 2934, 1752, 1718, 1649, 1562, 1521, 1448, 1397, 1289, 1199, 1099, 1029, 932, 859, 703.

HRMS (ESI):  $m/z$  calcd for: 431.0730  $[\text{M}+\text{H}]^+$ , found: 431.0737.

**4-(4-Chlorophenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5a)**



White solid, mp: >300 °C

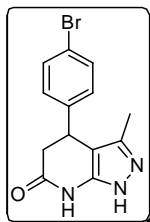
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 11.84 (s, 1H, NH), 10.32 (s, 1H, NH), 7.37 (d, 2H,  $J = 8.0$  Hz, ArH), 7.18 (d, 2H,  $J = 8.4$  Hz, ArH), 4.17 (t, 1H,  $J = 6.4$  Hz, CH), 2.80 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.53 (dd, 1H,  $J_1 = 5.6$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 1.84 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 169.3, 148.7, 142.8, 141.4, 134.7, 131.1, 128.8, 128.5, 112.7, 106.8, 101.5, 33.3, 9.4.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3179, 3132, 3049, 2985, 2905, 1638, 1539, 1489, 1414, 1365, 1230, 1087, 1015, 926, 883, 827, 678.

HRMS (ESI):  $m/z$  calcd for: 262.0742  $[\text{M}+\text{H}]^+$ , found: 262.0760.

**4-(4-Bromophenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5b)**



White solid, mp: >300 °C

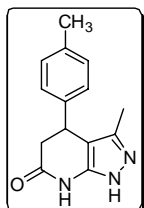
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 11.86 (s, 1H, NH), 10.35 (s, 1H, NH), 7.50 (d, 2H,  $J = 8.4$  Hz, ArH), 7.12 (d, 2H,  $J = 8.4$  Hz, ArH), 4.16 (t, 1H,  $J = 6.4$  Hz, CH), 2.80 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.53 (dd, 1H,  $J_1 = 5.6$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 1.84 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 183.2, 169.2, 143.2, 134.7, 131.4, 129.2, 119.5, 112.7, 104.9, 101.4, 82.9, 33.4, 9.43.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3174, 3129, 3049, 2982, 2904, 1644, 1538, 1487, 1411, 1366, 1228, 1072, 1010, 926, 883, 824, 675.

HRMS (ESI):  $m/z$  calcd for: 306.0237  $[\text{M}+\text{H}]^+$ , found: 306.0268.

**3-Methyl-4-p-tolyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5c)**



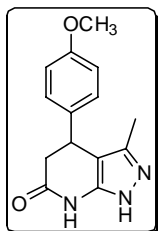
White solid, mp: 234.8-235.9 °C

$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) ( $\delta$ , ppm): 11.80 (s, 1H, NH), 10.28 (s, 1H, NH), 7.10 (d, 2H,  $J = 8.0$  Hz, ArH), 7.04 (d, 2H,  $J = 8.0$  Hz, ArH), 4.09 (t, 1H,  $J = 6.4$  Hz, CH), 2.76 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.53 (dd, 1H,  $J_1 = 6.0$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.26 (s, 3H,  $\text{CH}_3$ ), 1.82 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 169.4, 162.1, 158.2, 157.9, 134.2, 127.9, 114.2, 94.2, 55.1, 40.1, 31.9, 9.8.  
IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3181, 3130, 3047, 2986, 2900, 1627, 1534, 1514, 1493, 1366, 1265, 1179, 1038, 966, 874, 825, 683.

HRMS (ESI):  $m/z$  calcd for: 242.1288  $[\text{M}+\text{H}]^+$ , found: 242.1266.

#### 4-(4-Methoxyphenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5d)



White solid, mp: 223.8-224.9 °C

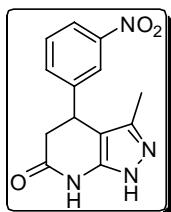
$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 11.79 (s, 1H, NH), 10.28 (s, 1H, NH), 7.08 (d, 2H,  $J = 8.4$  Hz, ArH), 6.86 (d, 2H,  $J = 8.4$  Hz, ArH), 4.06 (t, 1H,  $J = 6.8$  Hz, CH), 3.71 (s, 3H, OCH<sub>3</sub>), 2.74 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz, CH<sub>2</sub>), 2.54 (d, 1H,  $J = 6.4$  Hz, CH<sub>2</sub>), 1.82 (s, 3H, CH<sub>3</sub>).

$^{13}\text{C}$  NMR (100MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 169.6, 157.9, 148.7, 135.6, 134.5, 127.9, 113.9, 102.3, 88.1, 87.4, 55.0, 33.2, 9.4.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3180, 3133, 3057, 2997, 2907, 1637, 1541, 1512, 1475, 1371, 1258, 1171, 1036, 968, 884, 825, 681.

HRMS (ESI):  $m/z$  calcd for: 258.1238  $[\text{M}+\text{H}]^+$ , found: 258.1234.

#### 3-Methyl-4-(3-nitrophenyl)-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5e)



Yellow solid, mp: 186.6-188.2 °C

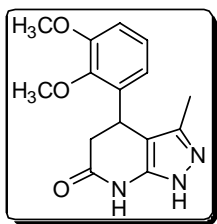
$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 11.93 (s, 1H, NH), 10.42 (s, 1H, NH), 8.11 (d, 2H,  $J = 7.6$  Hz, ArH), 8.01 (s, 1H, ArH), 7.65 (s, 1H, ArH), 4.40 (t, 1H,  $J = 6.4$  Hz, CH), 2.88 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz, CH<sub>2</sub>), 2.61 (dd, 1H,  $J_1 = 5.6$  Hz,  $J_2 = 15.6$  Hz, CH<sub>2</sub>), 1.86 (s, 3H, CH<sub>3</sub>).

$^{13}\text{C}$  NMR (100MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 213.9, 211.0, 169.0, 162.9, 159.2, 147.9, 146.1, 133.9, 130.2, 121.7, 121.5, 109.2, 100.9, 33.4, 9.5.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3206, 3109, 2982, 2907, 1669, 1529, 1456, 1418, 1351, 1206, 1096, 1046, 931, 867, 809, 734, 689.

HRMS (ESI):  $m/z$  calcd for: 273.0983  $[\text{M}+\text{H}]^+$ , found: 273.0994.

#### 4-(2,3-Dimethoxyphenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5f)



White solid, mp: 262.0-264.2 °C

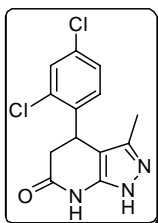
$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 11.81 (s, 1H, NH), 10.30 (s, 1H, NH), 6.99-6.91 (m, 2H, ArH), 6.51 (d, 2H,  $J = 7.6$  Hz, ArH), 4.41 (t, 1H,  $J = 6.0$  Hz, CH), 2.77 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz, CH<sub>2</sub>), 2.43 (dd, 1H,  $J_1 = 5.6$  Hz,  $J_2 = 15.6$  Hz, CH<sub>2</sub>), 1.80 (s, 3H, CH<sub>3</sub>).

$^{13}\text{C}$  NMR (100MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 169.4, 152.4, 149.1, 145.9, 136.8, 134.4, 124.0, 119.3, 111.3, 101.4, 60.3, 55.6, 35.7, 27.7, 9.3.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3217, 3100, 3039, 2998, 2907, 1655, 1525, 1477, 1429, 1360, 1276, 1169, 1079, 1002, 988, 826, 790, 745.

HRMS (ESI):  $m/z$  calcd for: 288.1343  $[\text{M}+\text{H}]^+$ , found: 288.1386.

#### 4-(2,4-Dichlorophenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-*b*]pyridin-6(7H)-one (5h)



White solid, mp: >300 °C

$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 11.97 (s, 1H, NH), 10.44 (s, 1H, NH), 7.66 (d, 1H,  $J = 2.0$  Hz, ArH), 7.39 (dd, 1H,  $J_1 = 2.0$  Hz,  $J_2 = 8.4$  Hz, ArH), 6.97 (d, 1H,  $J = 8.4$  Hz, ArH), 4.16 (t, 1H,  $J = 6.4$  Hz, CH), 2.80 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz, CH<sub>2</sub>), 2.53 (dd, 1H,  $J_1 = 5.6$  Hz,  $J_2 = 16.0$  Hz, CH<sub>2</sub>), 1.84 (s, 3H, CH<sub>3</sub>).

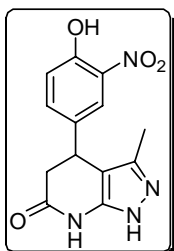
$^{13}\text{C}$  NMR (100MHz, DMSO- $d_6$ ) ( $\delta$ , ppm): 168.8, 149.2, 139.5, 134.7, 133.0, 132.1, 129.9, 127.9,

112.7, 100.0, 30.5, 9.3.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3201, 3120, 3049, 3003, 2913, 1654, 1527, 1465, 1373, 1270, 1201, 1140, 1079, 1049, 884, 820, 764, 679.

HRMS (ESI):  $m/z$  calcd for: 296.0352  $[\text{M}+\text{H}]^+$ , found: 296.0374.

#### 4-(4-Hydroxy-3-nitrophenyl)-3-methyl-4,5-dihydro-1H-pyrazolo[3,4-b]pyridin-6(7H)-one (5i)



Yellow solid, mp: 194.8-196.2 °C

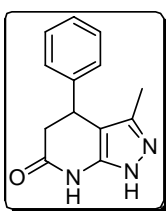
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 11.88 (s, 1H, NH), 10.90 (s, 1H, OH), 10.35 (s, 1H, NH), 7.64 (d, 1H,  $J = 2.0$  Hz, ArH), 7.37 (dd, 1H,  $J_1 = 2.0$  Hz,  $J_2 = 8.8$  Hz, ArH), 7.09 (d, 2H,  $J = 6.4$  Hz, ArH), 4.19 (t, 1H,  $J = 6.4$  Hz, CH), 2.78 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.55 (dd, 1H,  $J_1 = 6.0$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 1.86 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 169.2, 156.9, 150.8, 148.7, 136.4, 134.9, 134.1, 128.2, 123.0, 119.6, 101.3, 32.7, 9.5.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3196, 3120, 3011, 2982, 2903, 1633, 1539, 1490, 1432, 1362, 1251, 1126, 1080, 954, 873, 827, 681.

HRMS (ESI):  $m/z$  calcd for: 289.0932  $[\text{M}+\text{H}]^+$ , found: 289.0983.

#### 3-Methyl-4-phenyl-4,5-dihydro-1H-pyrazolo[3,4-b]pyridin-6(7H)-one (5j)



White solid, mp: 214.8-217.7 °C

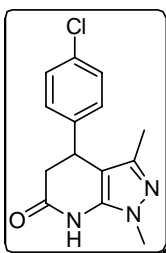
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 11.81 (s, 1H, NH), 10.29 (s, 1H, NH), 7.30 (t, 2H,  $J = 7.2$  Hz, ArH), 7.23-7.16 (m, 3H, ArH), 4.14 (t, 1H,  $J = 6.4$  Hz, ArH), 2.80 (dd, 1H,  $J_1 = 8.8$  Hz,  $J_2 = 15.6$  Hz,  $\text{CH}_2$ ), 2.56 (dd, 1H,  $J_1 = 6.0$  Hz,  $J_2 = 15.6$  Hz,  $\text{CH}_2$ ), 1.82 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 172.4, 169.5, 166.5, 158.8, 148.7, 143.8, 134.6, 128.6, 126.9, 126.5, 112.7, 101.9, 40.5, 33.9.

IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3165, 3133, 3040, 2974, 2832, 1681, 1581, 1479, 1396, 1219, 1119, 1090, 1010, 993, 825, 785, 735.

HRMS (ESI):  $m/z$  calcd for: 228.1131  $[\text{M}+\text{H}]^+$ , found: 228.1117.

#### 4-(4-Chlorophenyl)-1,3-dimethyl-4,5-dihydro-1H-pyrazolo[3,4-b]pyridin-6(7H)-one (5k)



White solid, mp: 214.8-217.7 °C

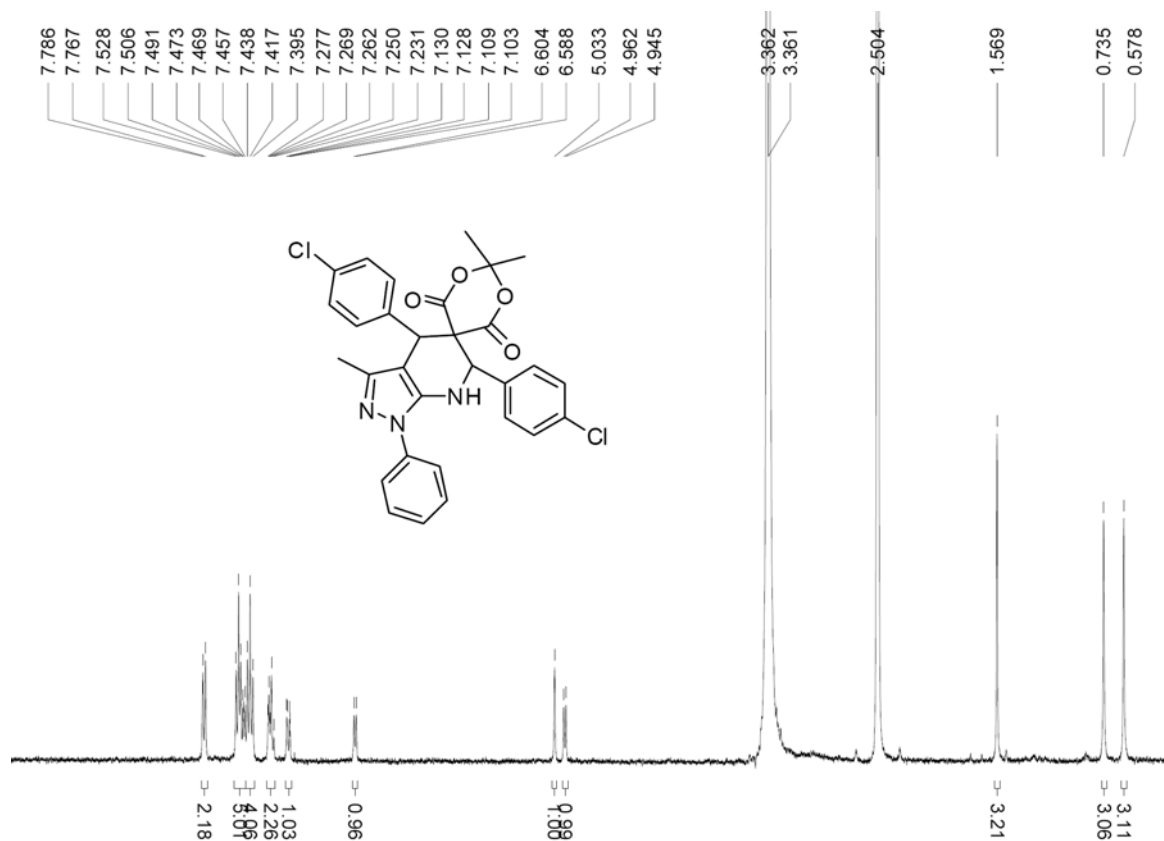
$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 10.74 (s, 1H, NH), 7.37 (d, 2H,  $J = 7.6$  Hz, ArH), 7.16 (d, 2H,  $J = 8.4$  Hz, ArH), 4.17-4.14 (m, 1H, CH), 3.60 (s, 3H,  $\text{CH}_3$ ), 2.91 (dd, 1H,  $J_1 = 7.2$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 2.55 (dd, 1H,  $J_1 = 4.8$  Hz,  $J_2 = 16.0$  Hz,  $\text{CH}_2$ ), 1.76 (s, 3H,  $\text{CH}_3$ ).

$^{13}\text{C}$  NMR (100MHz,  $\text{DMSO}-d_6$ ) ( $\delta$ , ppm): 169.5, 142.7, 142.6, 139.2, 131.1, 129.3, 128.8, 128.5, 100.0, 60.3, 55.6, 34.5, 33.6, 11.9.

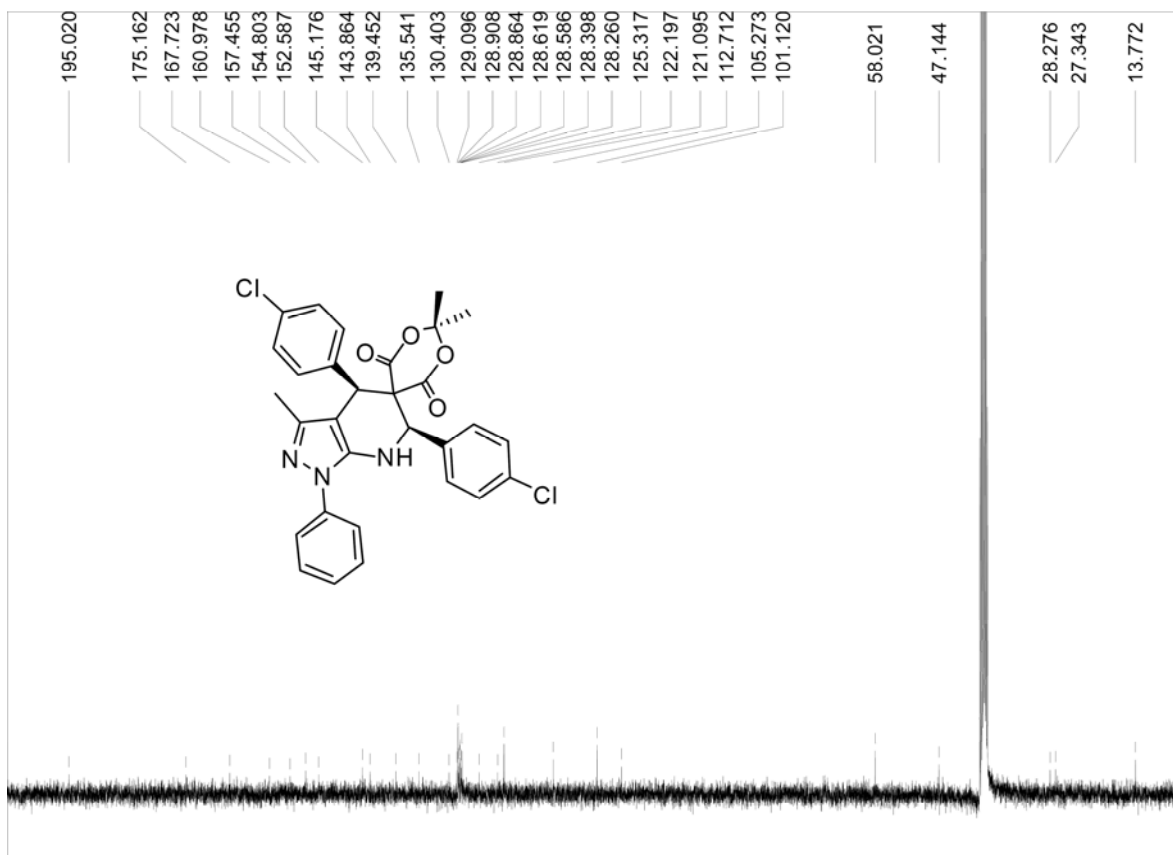
IR (KBr,  $\nu$ ,  $\text{cm}^{-1}$ ): 3166, 3041, 2977, 2833, 1681, 1581, 1491, 1397, 1286, 1219, 1090, 1010, 993, 825, 786, 735, 636.

HRMS (ESI):  $m/z$  calcd for: 276.0899  $[\text{M}+\text{H}]^+$ , found: 276.0912.

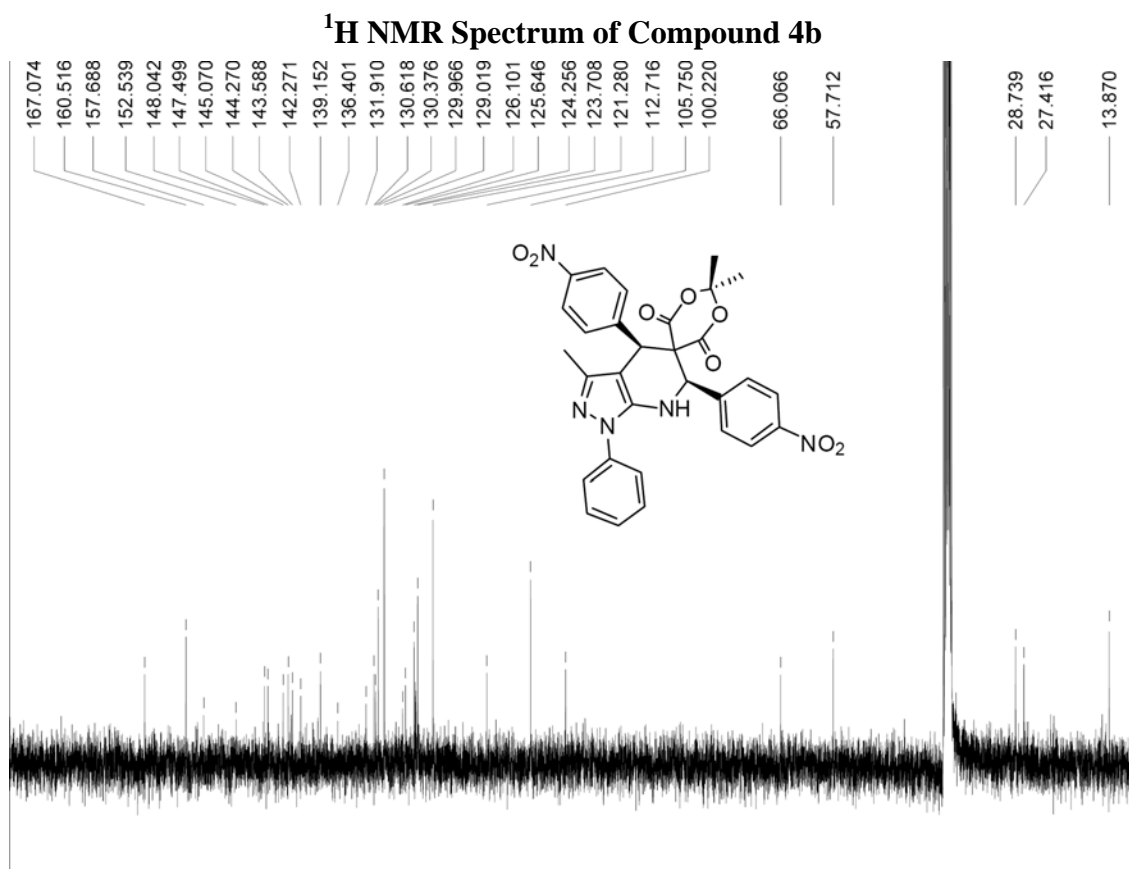
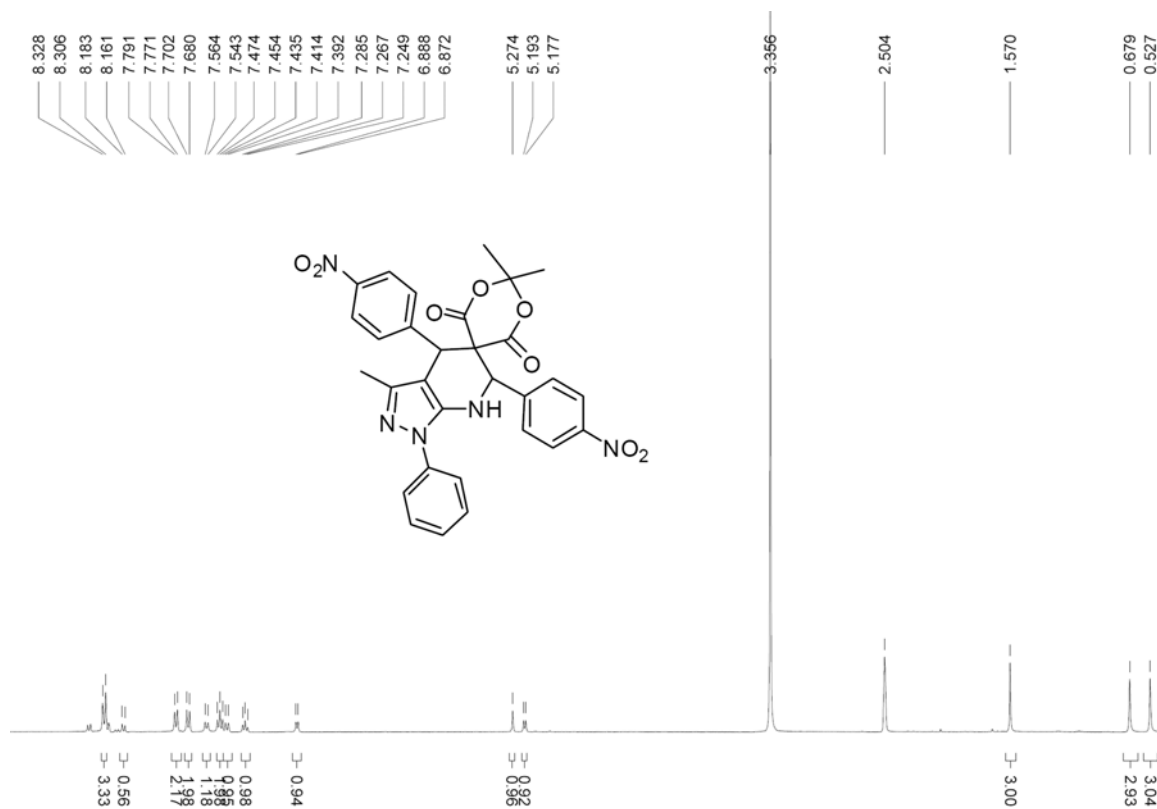




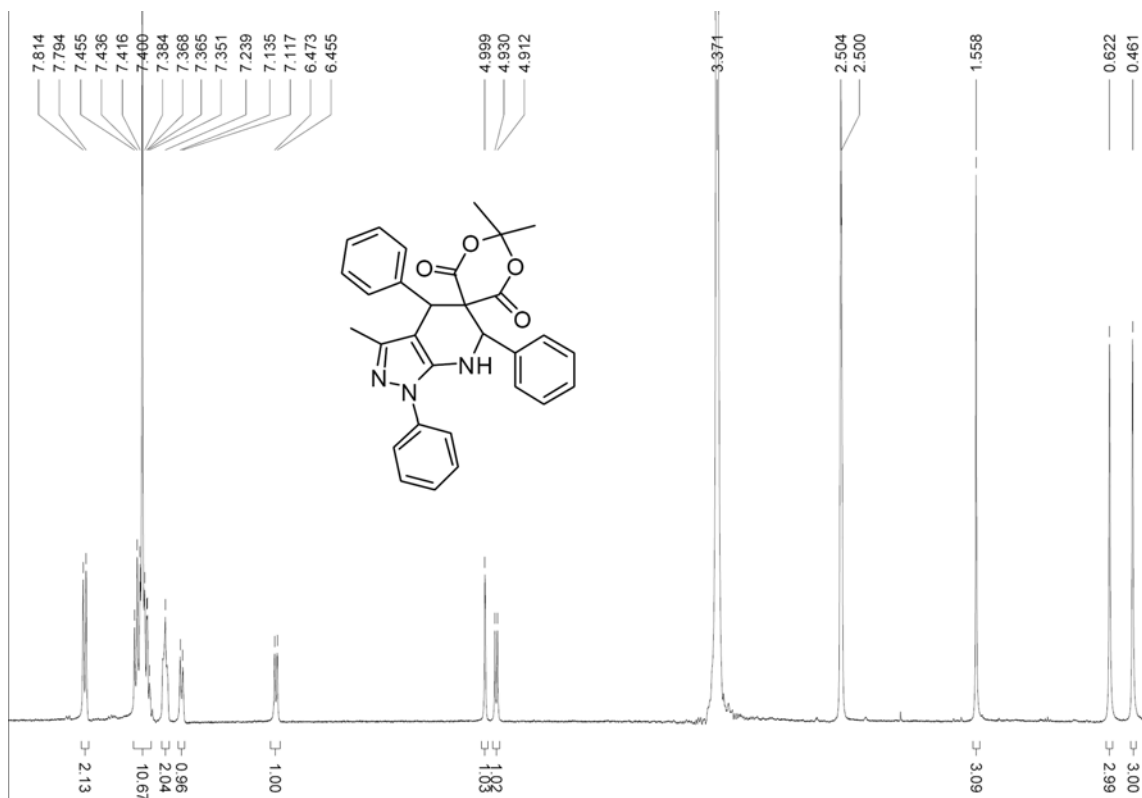
<sup>1</sup>H NMR Spectrum of Compound 4a



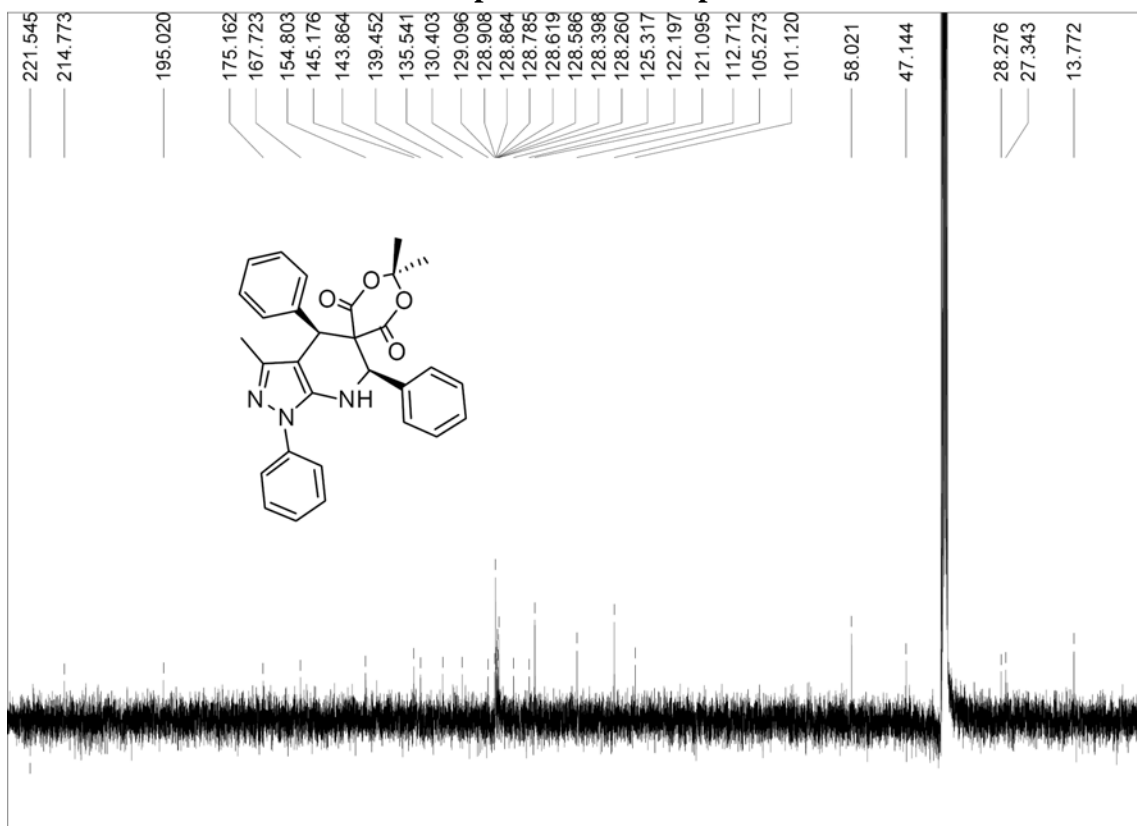
<sup>13</sup>C NMR Spectrum of Compound 4a



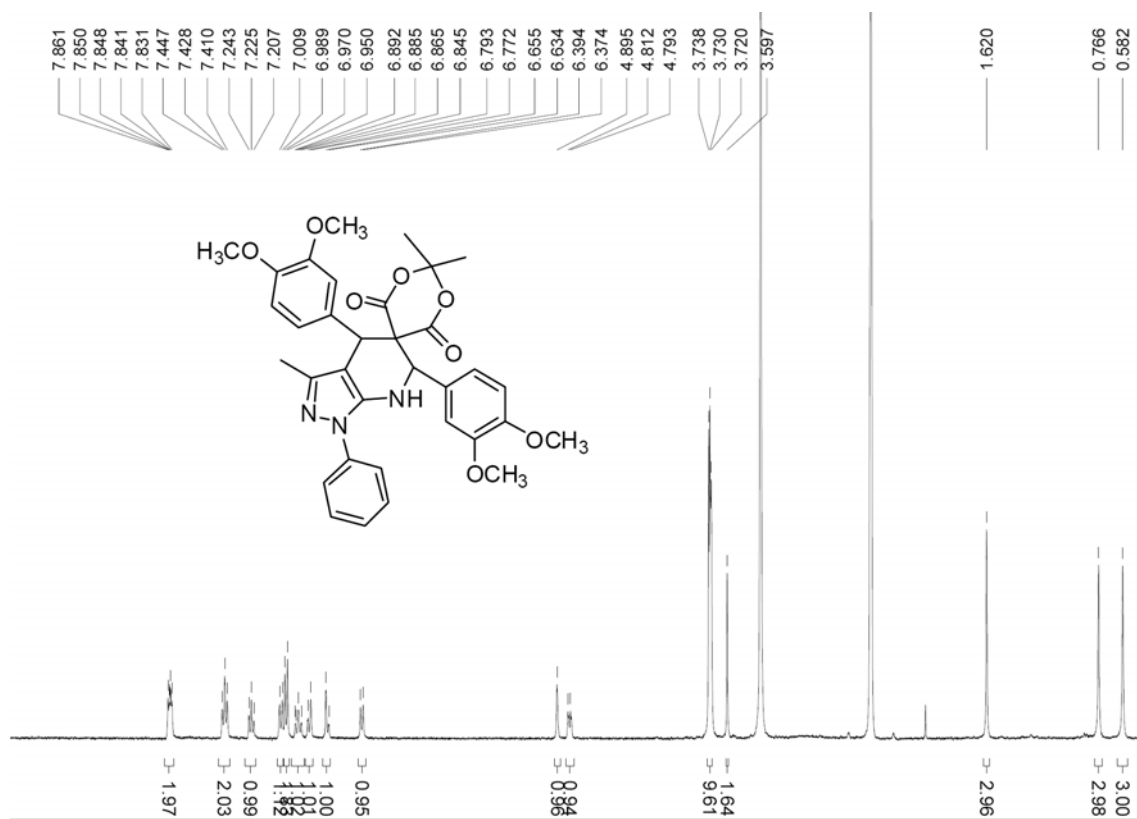
**<sup>13</sup>C NMR Spectrum of Compound 4b**



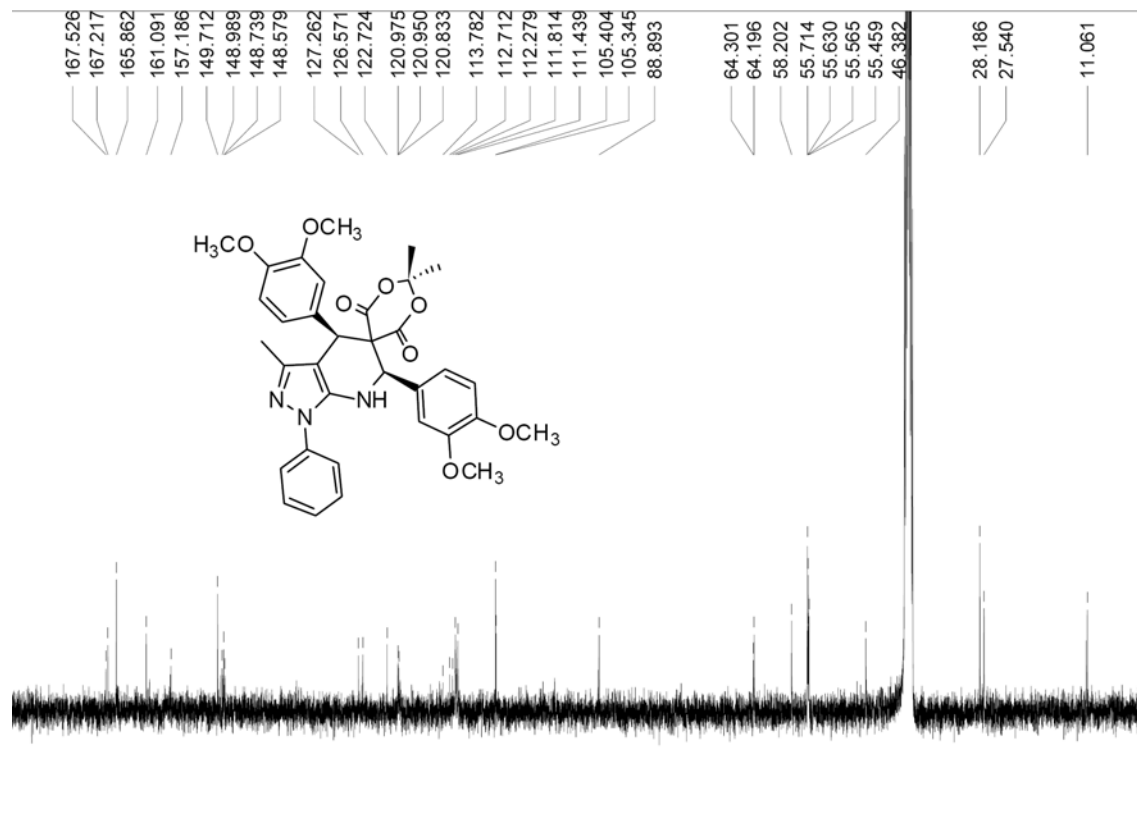
**<sup>1</sup>H NMR Spectrum of Compound 4c**



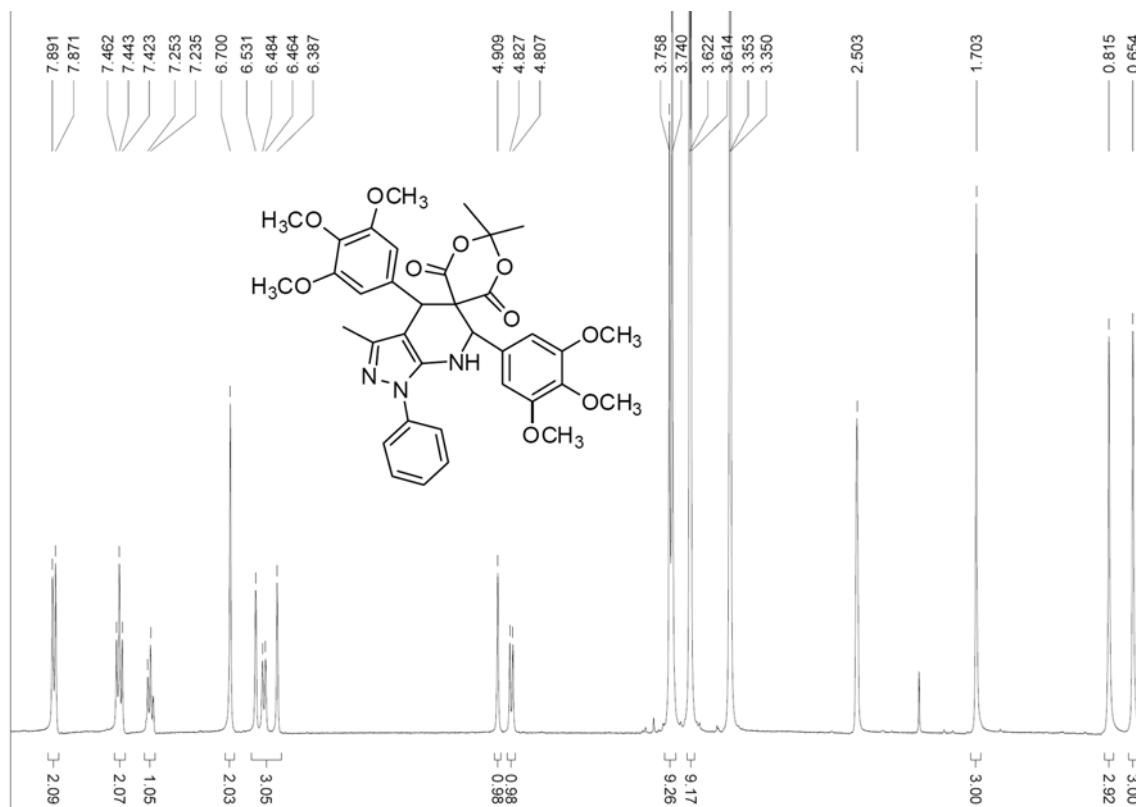
**<sup>13</sup>C NMR Spectrum of Compound 4c**



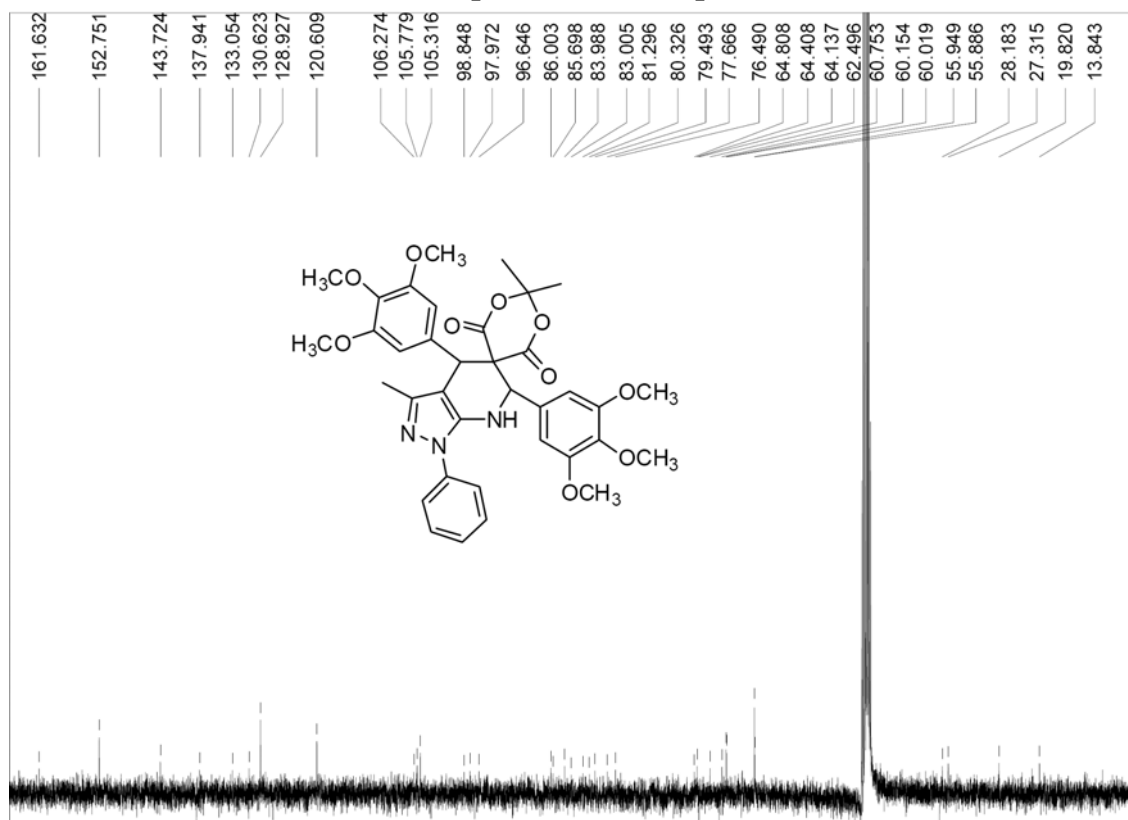
<sup>1</sup>H NMR Spectrum of Compound 4d



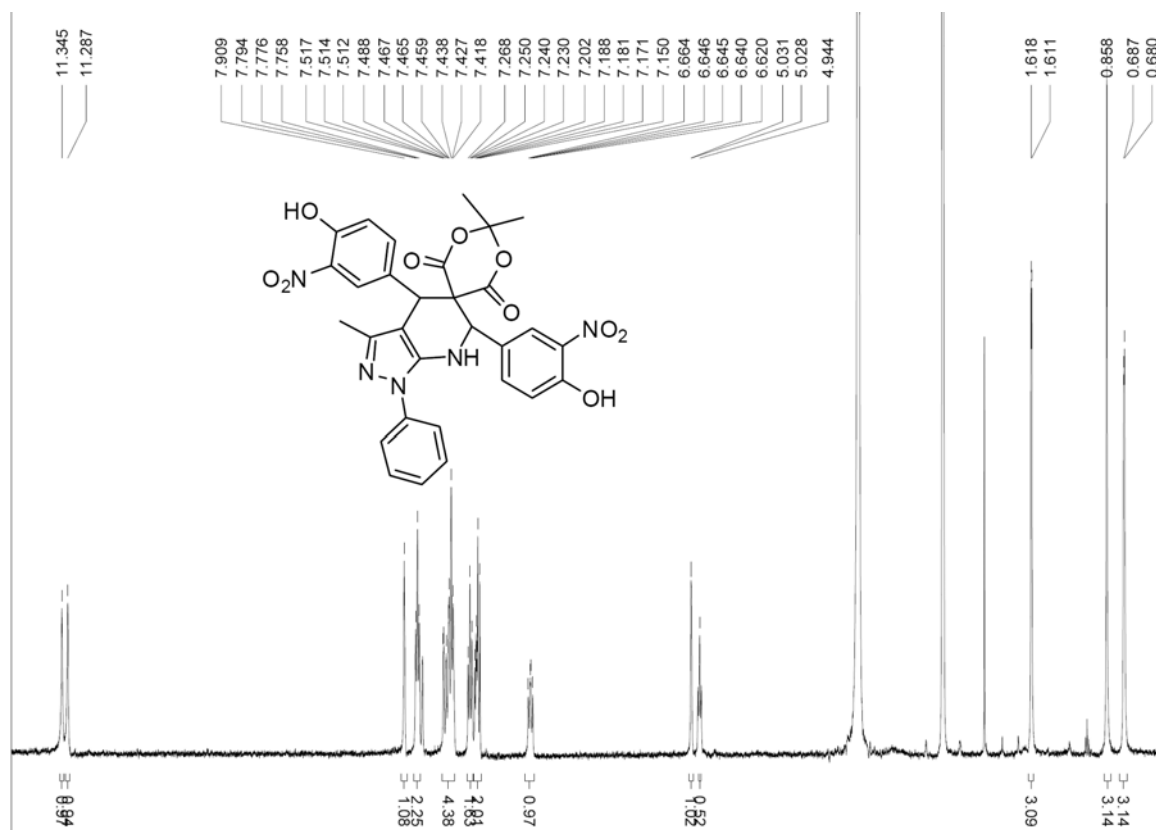
<sup>13</sup>C NMR Spectrum of Compound 4d



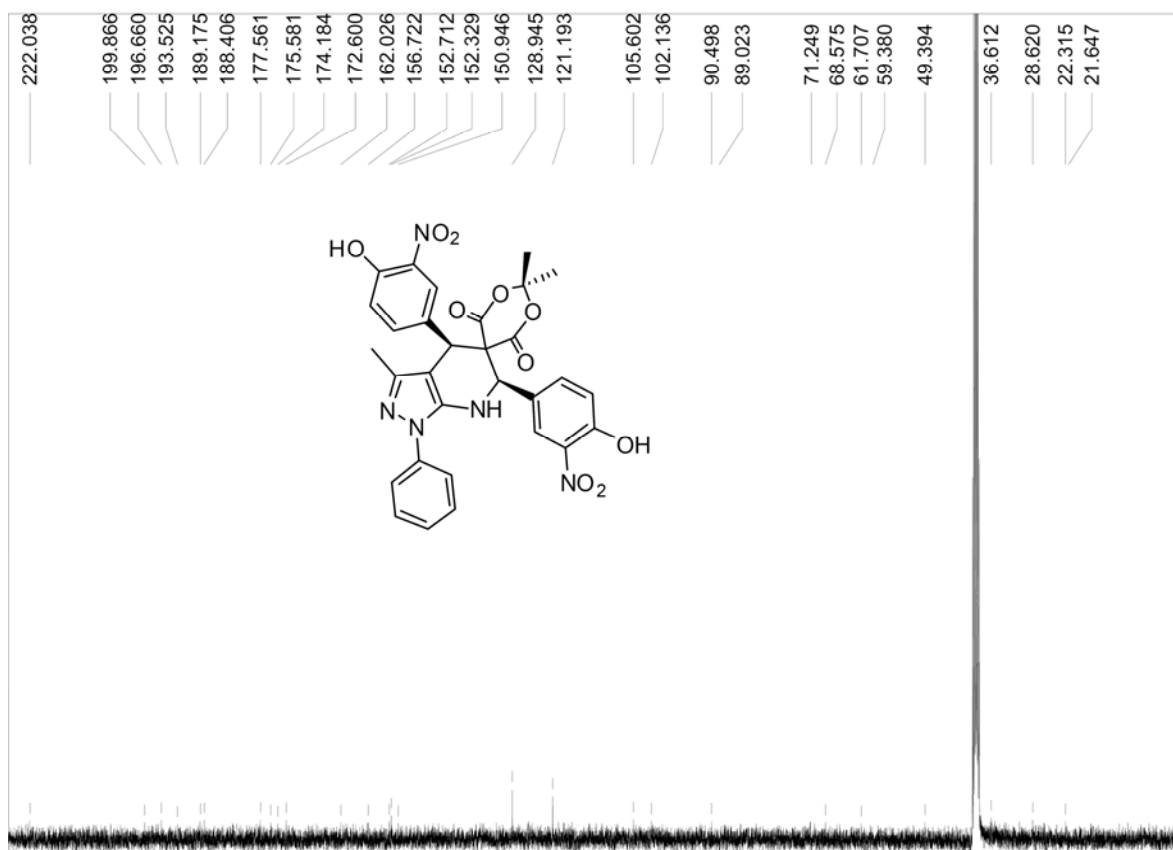
**<sup>1</sup>H NMR Spectrum of Compound 4e**



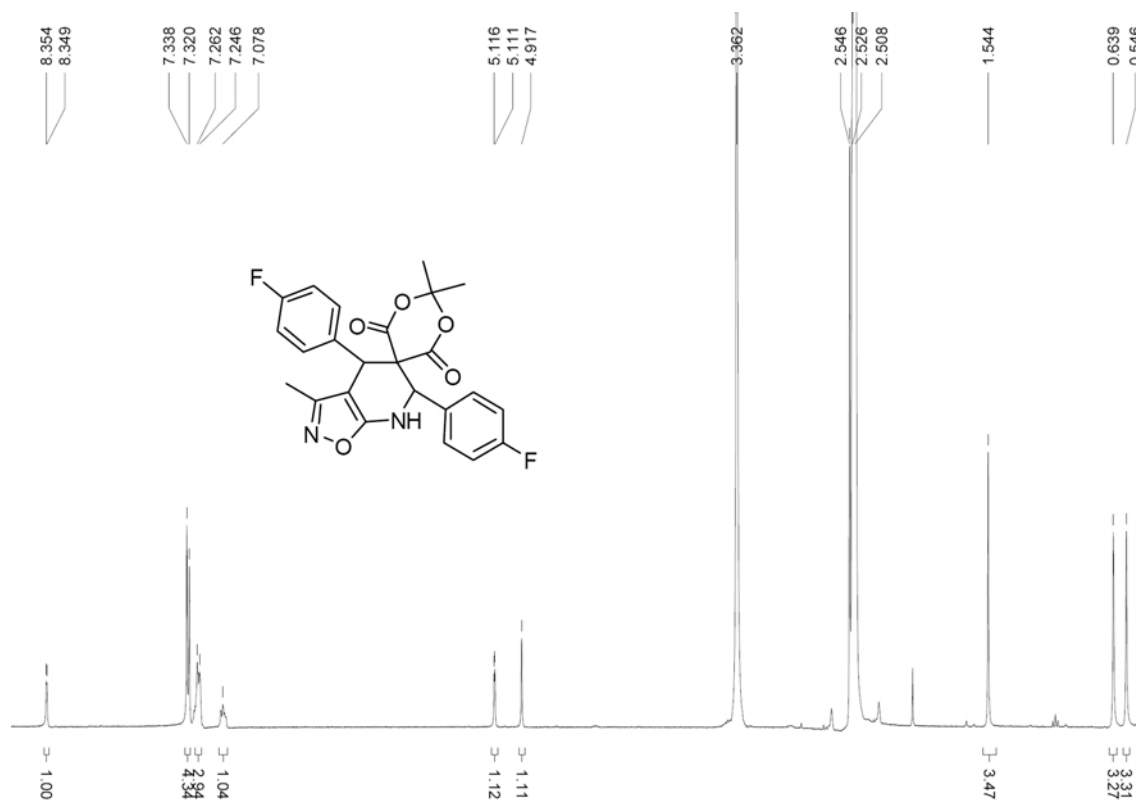
**<sup>13</sup>C NMR Spectrum of Compound 4e**



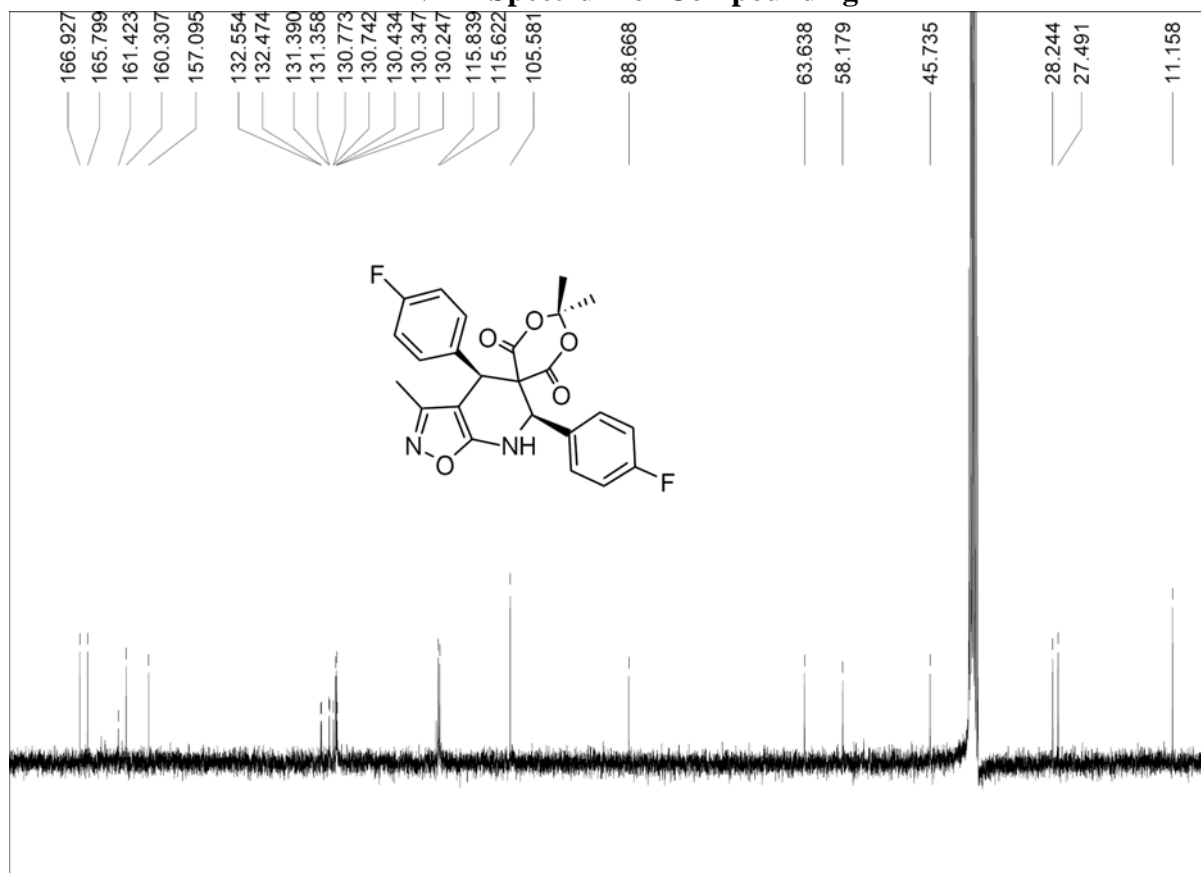
<sup>1</sup>H NMR Spectrum of Compound 4f



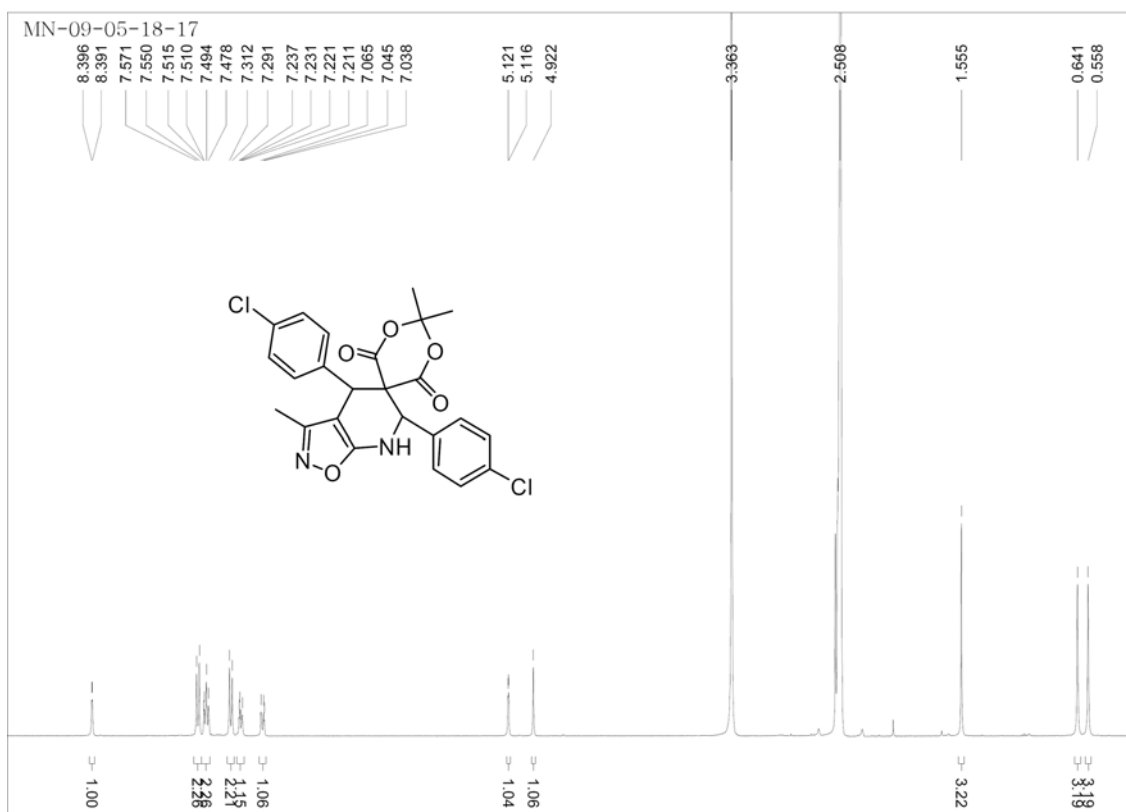
<sup>13</sup>C NMR Spectrum of Compound 4f



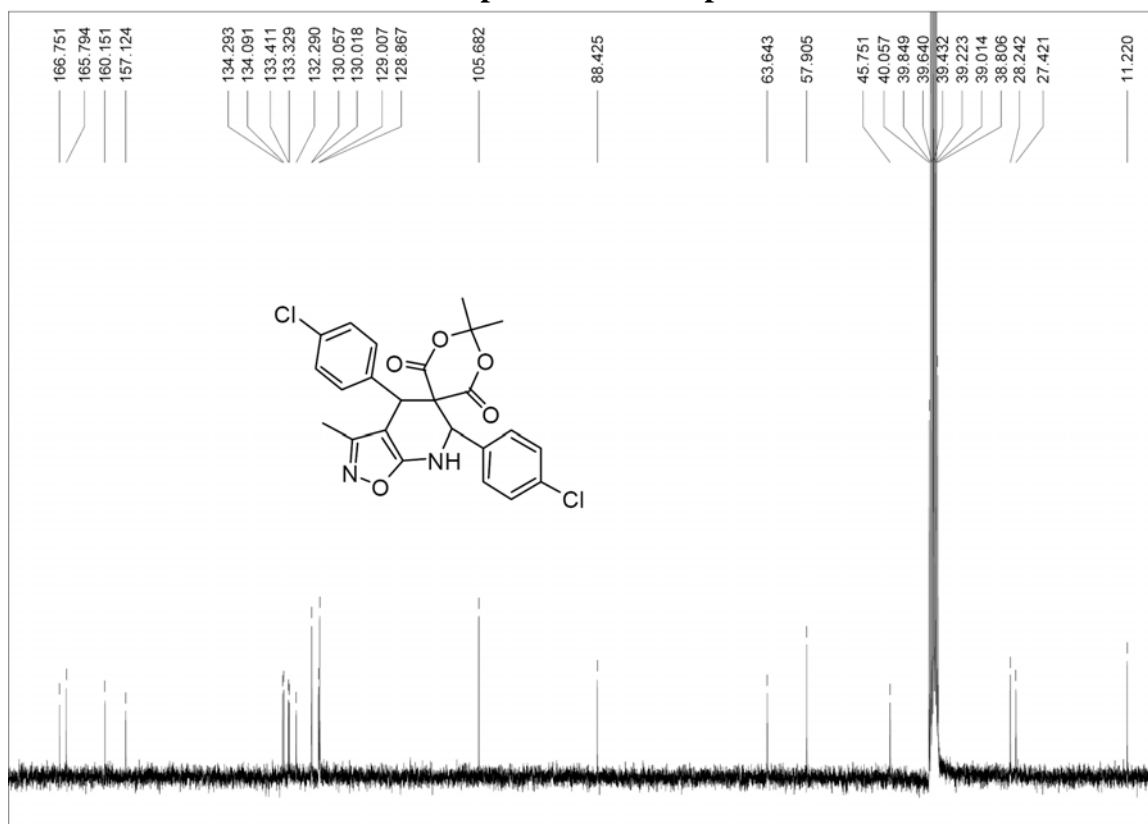
<sup>1</sup>H NMR Spectrum of Compound 4g



<sup>13</sup>C NMR Spectrum of Compound 4g

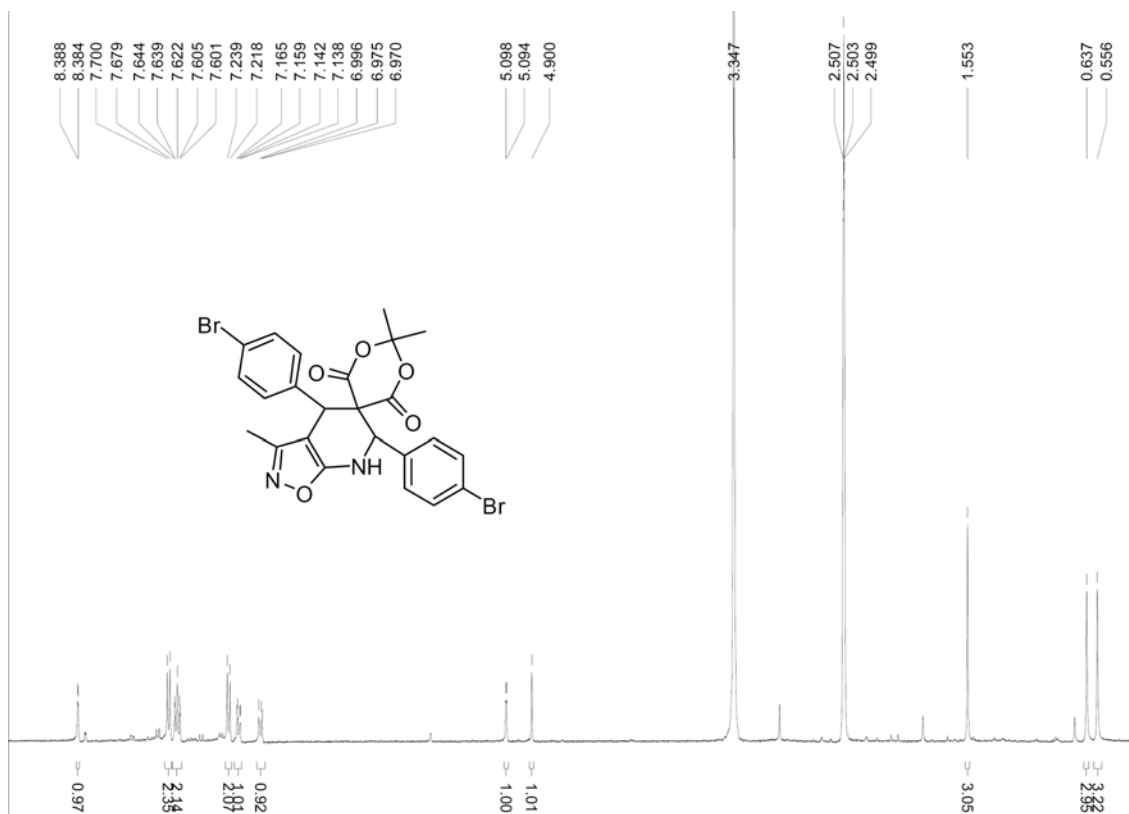


**<sup>1</sup>H NMR Spectrum of Compound 4h**

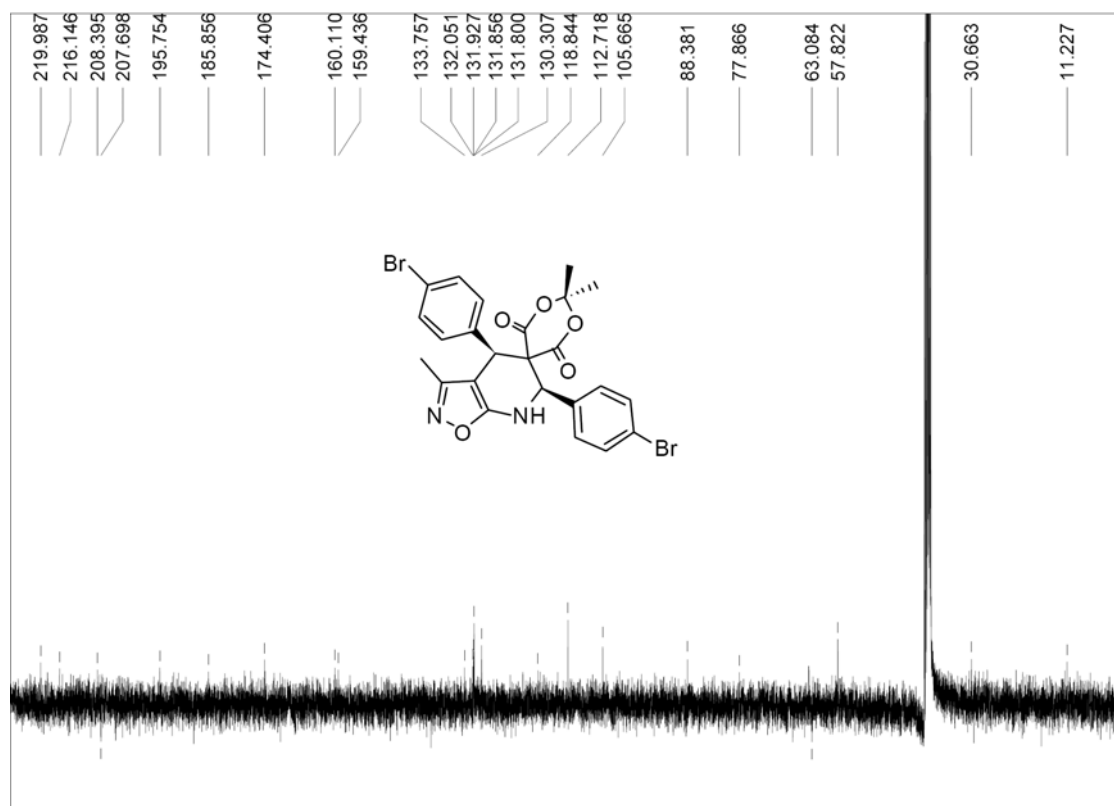


**<sup>13</sup>C NMR Spectrum of Compound 4h**

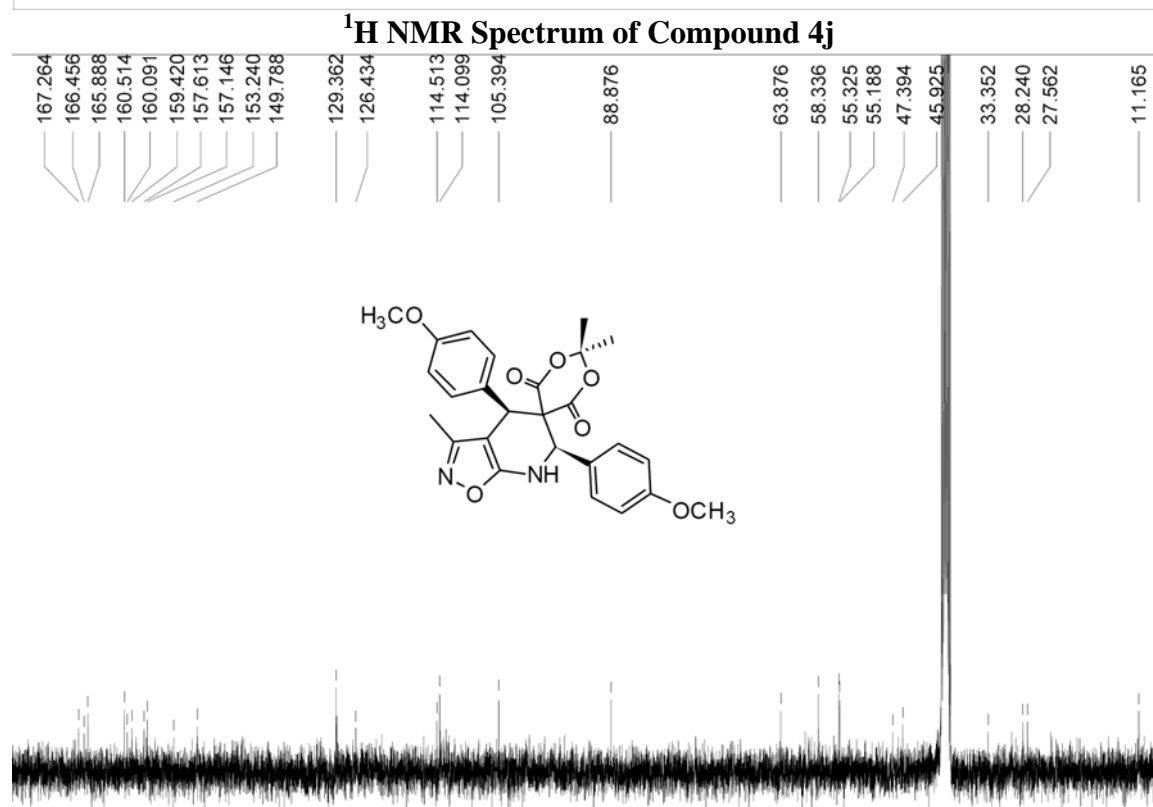
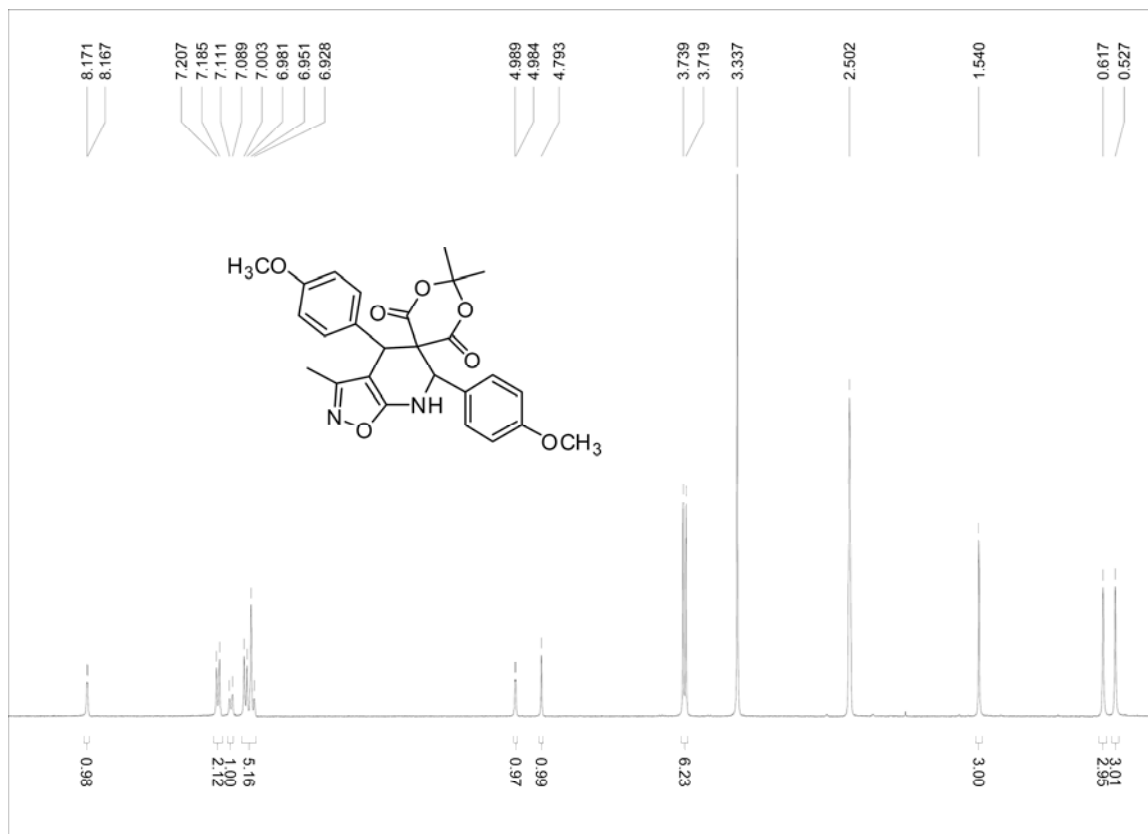




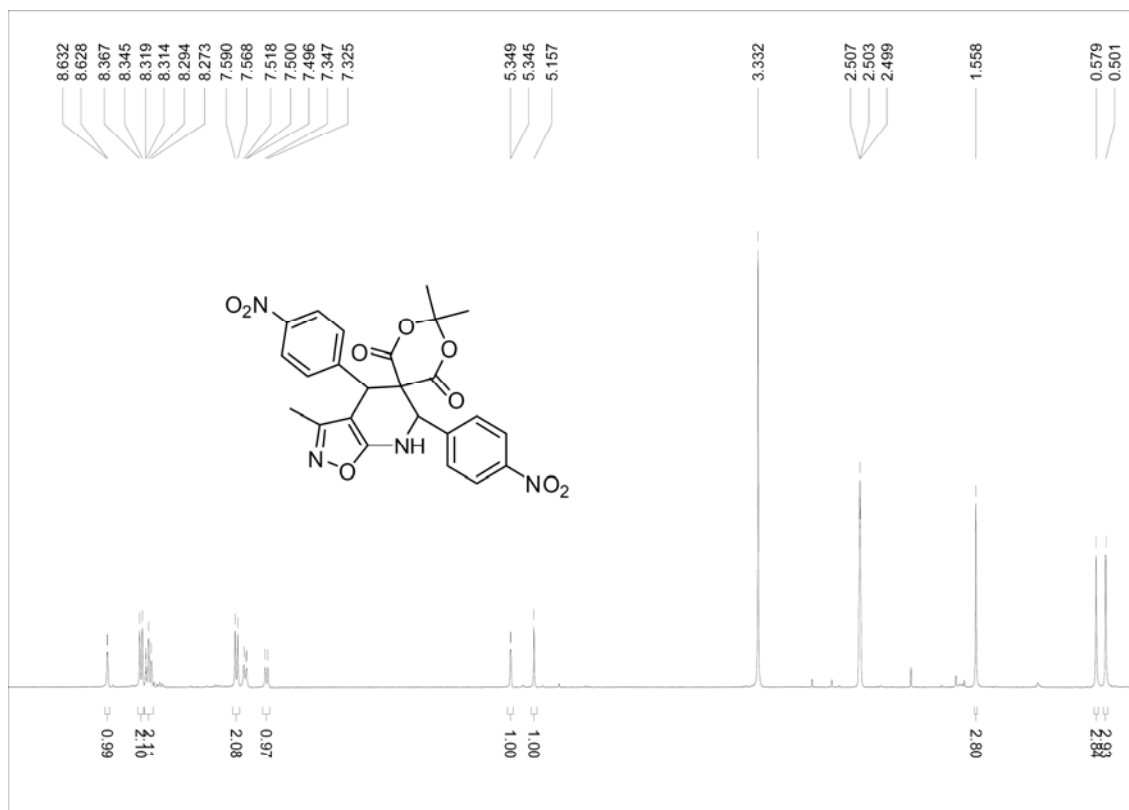
**<sup>1</sup>H NMR Spectrum of Compound 4i**



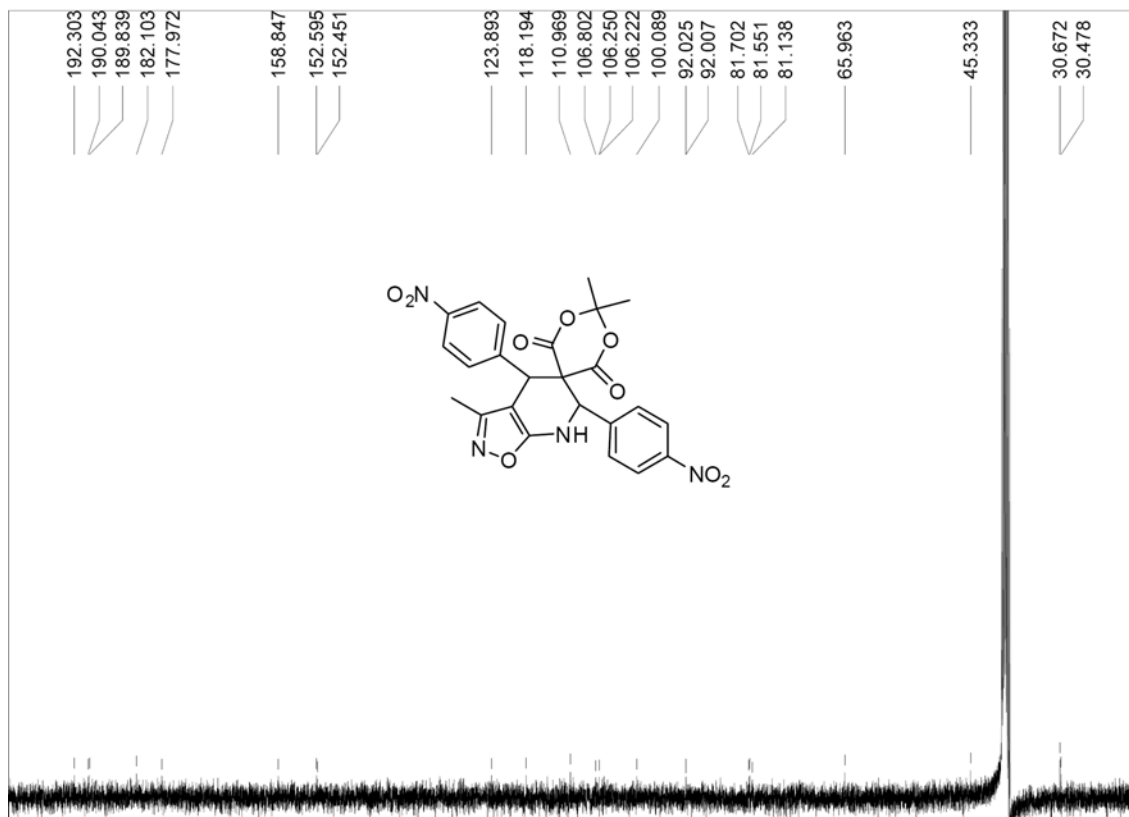
**<sup>13</sup>C NMR Spectrum of Compound 4i**



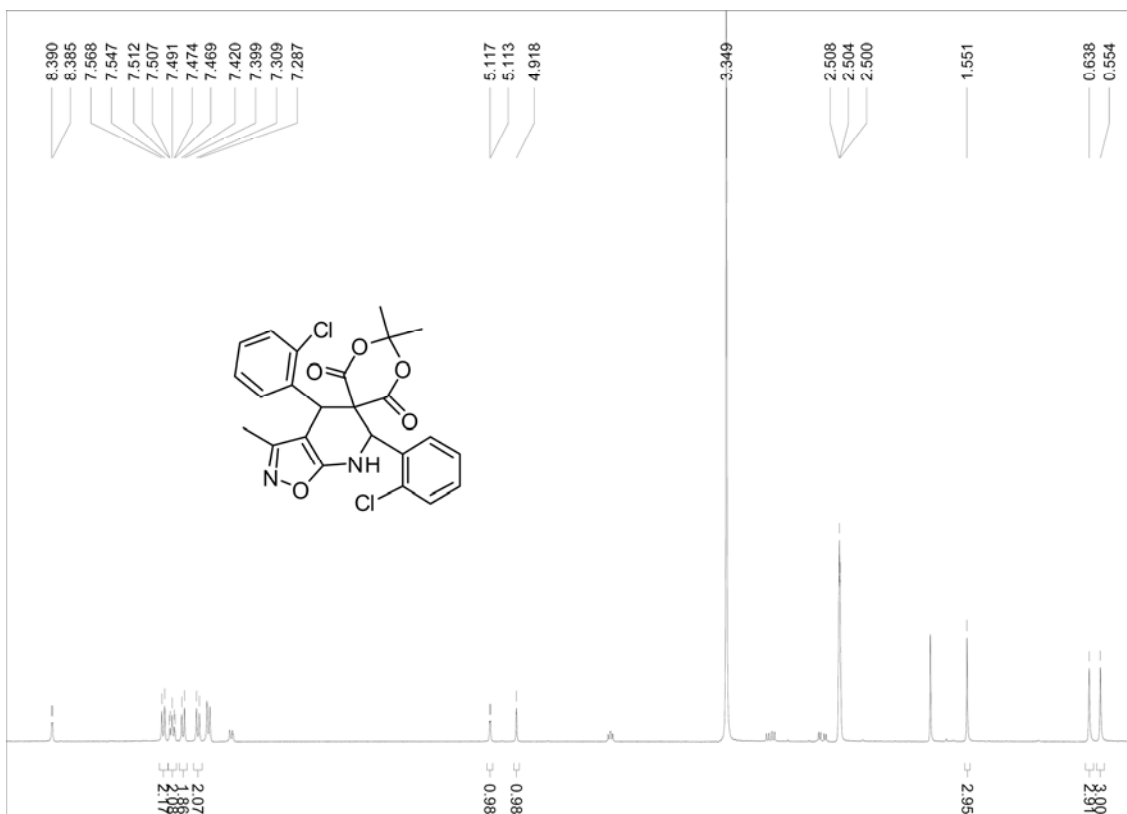
**<sup>13</sup>C NMR Spectrum of Compound 4j**



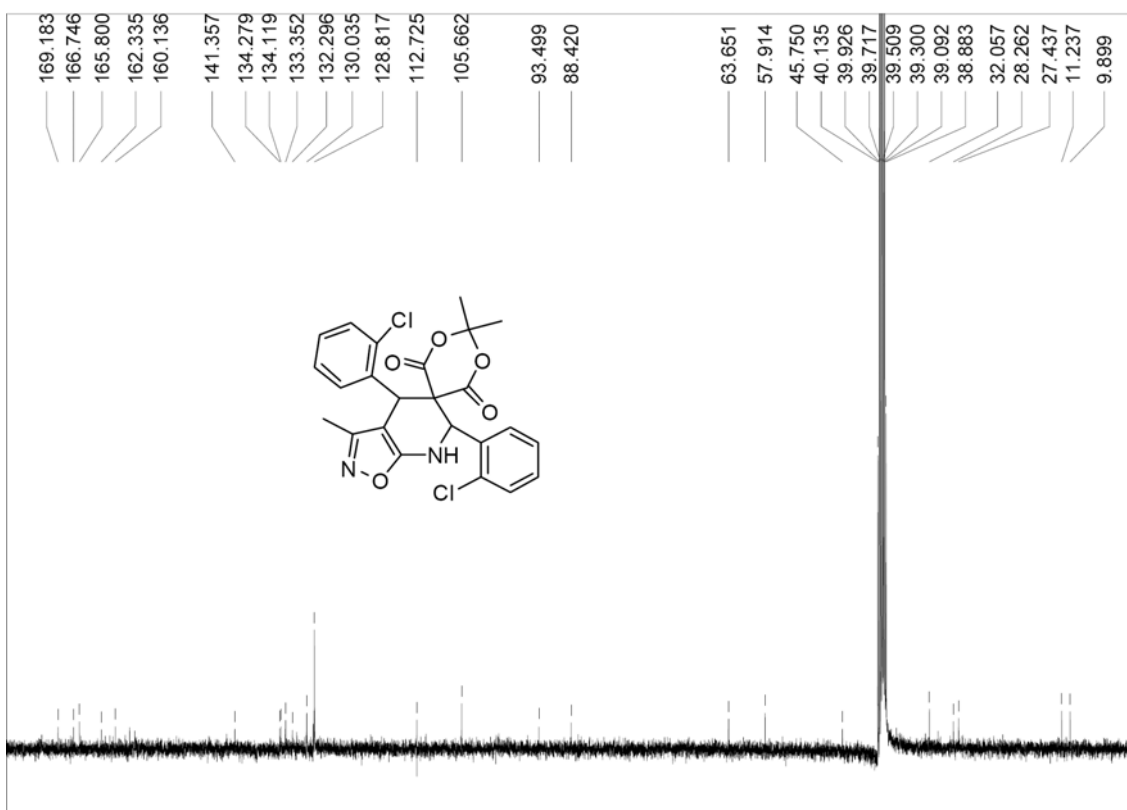
**<sup>1</sup>H NMR Spectrum of Compound 4k**



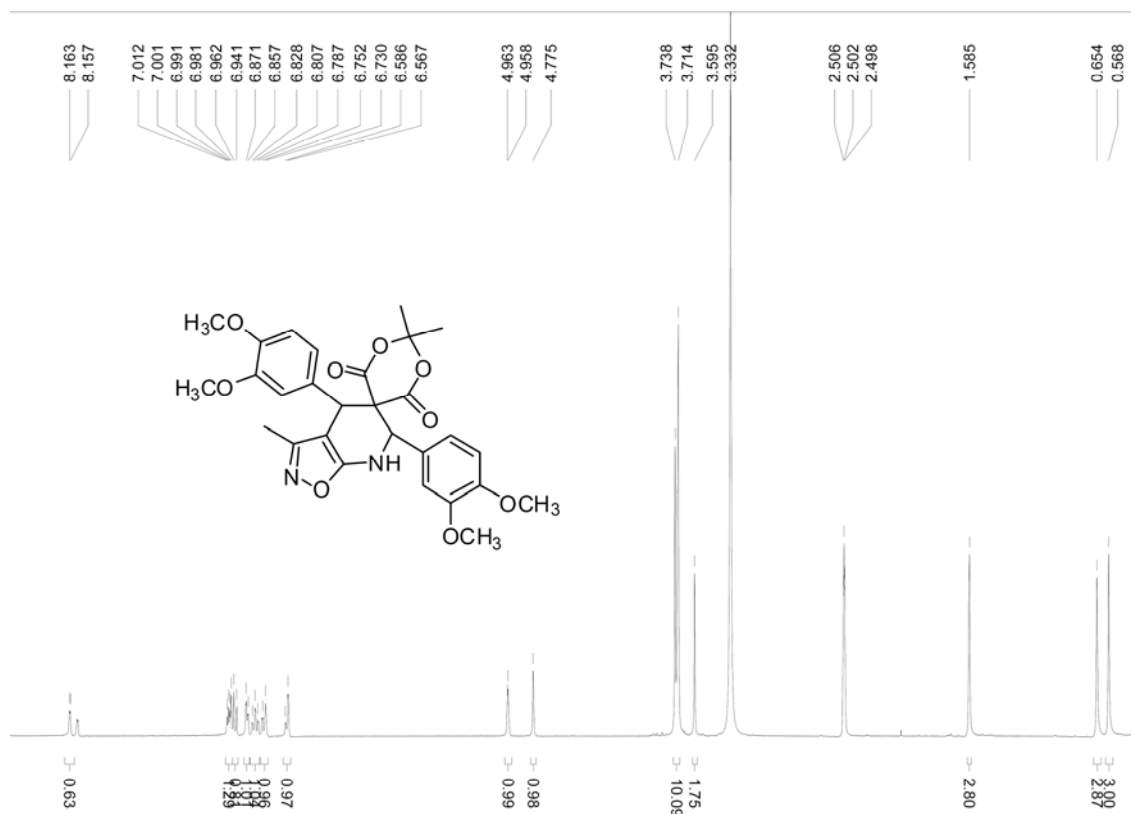
**<sup>13</sup>C NMR Spectrum of Compound 4k**



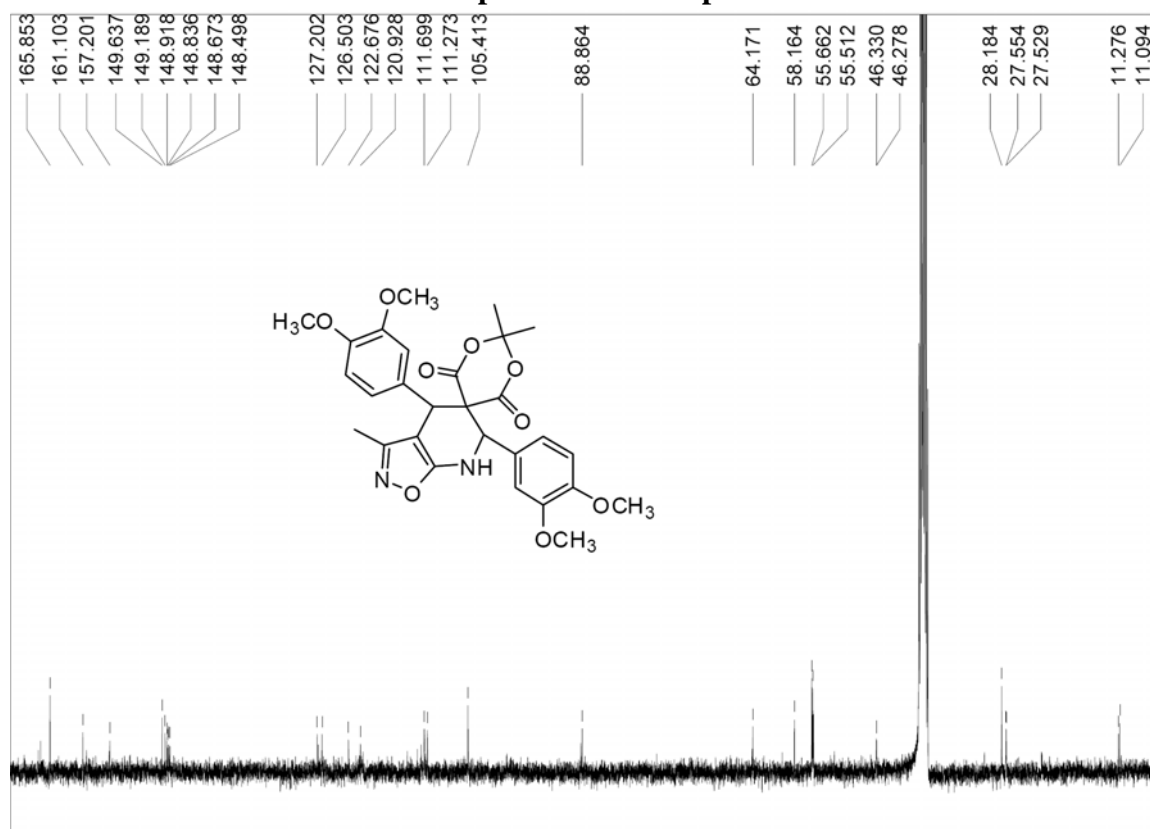
**<sup>1</sup>H NMR Spectrum of Compound 4l**



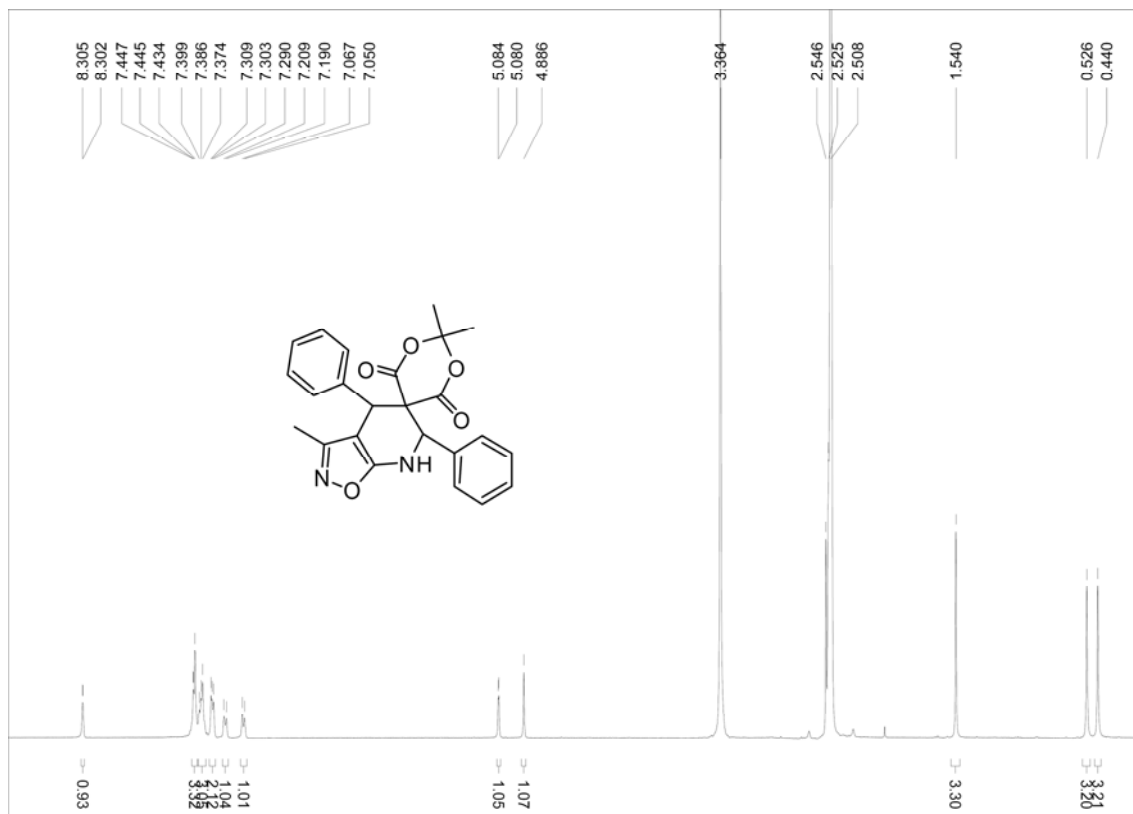
**<sup>13</sup>C NMR Spectrum of Compound 4l**



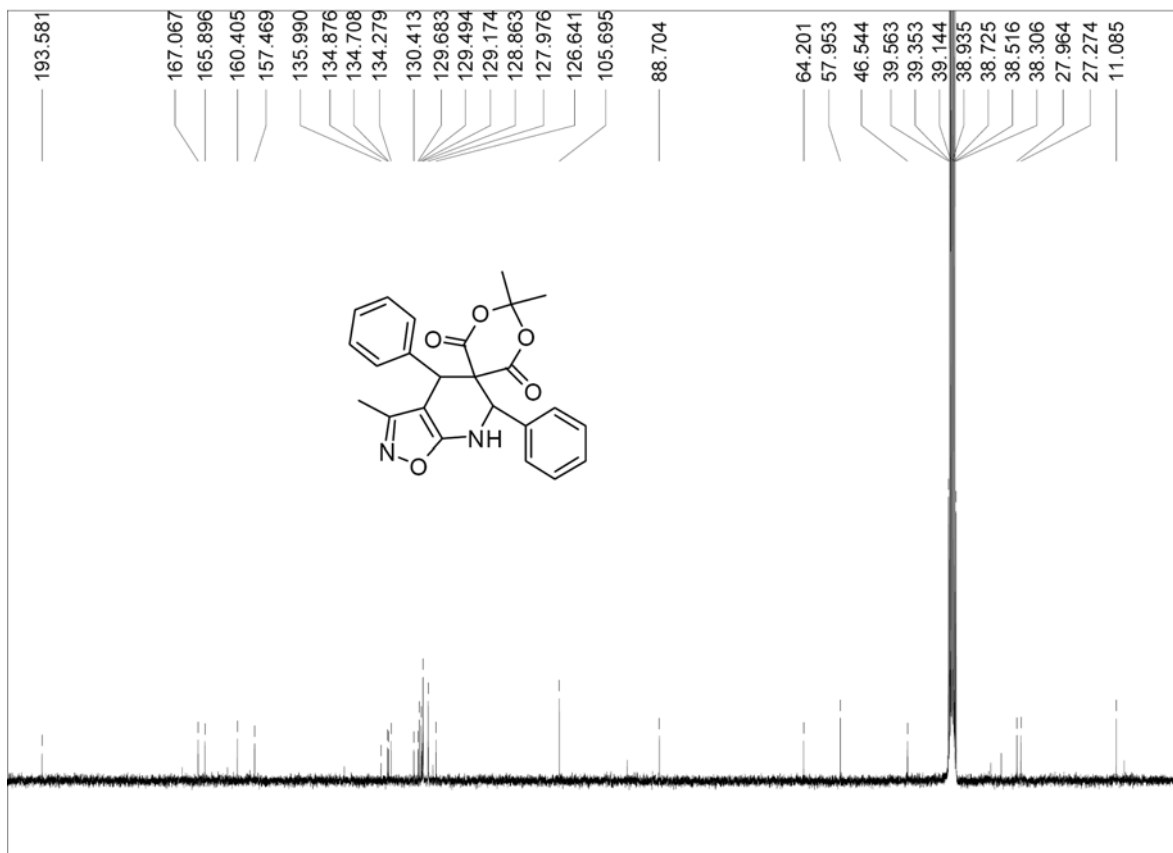
<sup>1</sup>H NMR Spectrum of Compound 4m



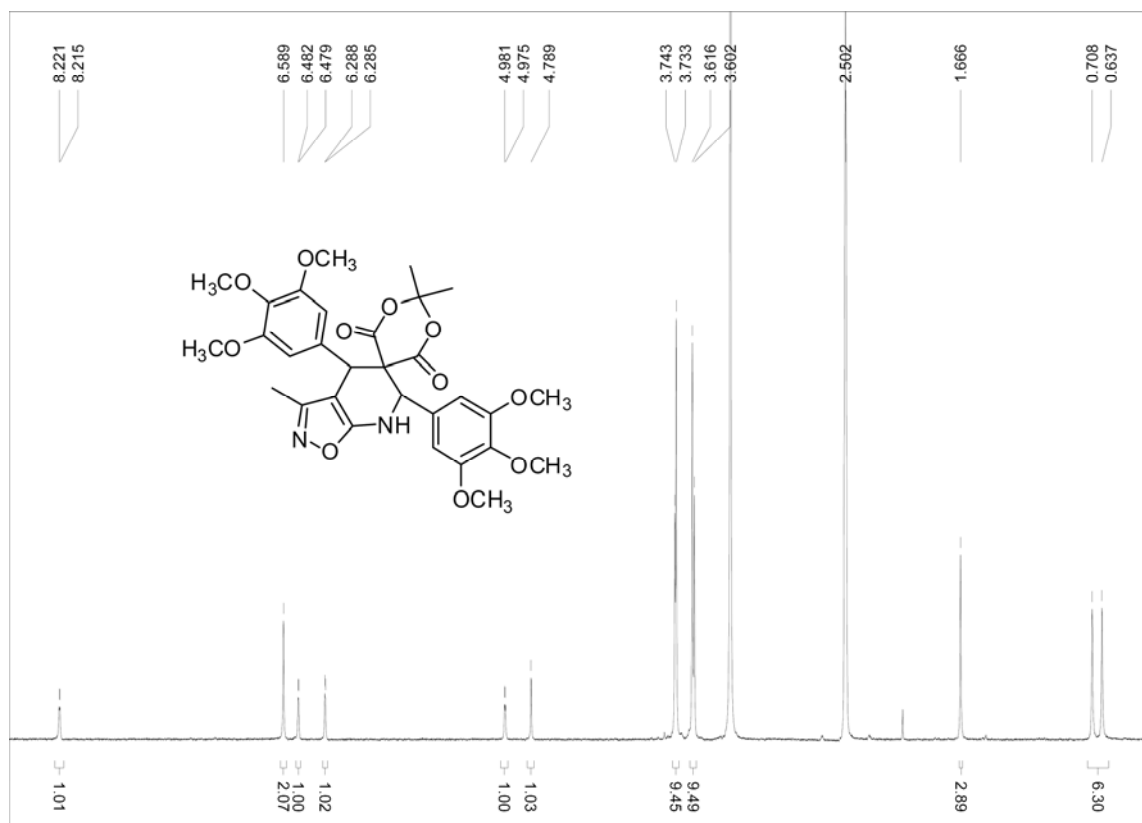
<sup>13</sup>C NMR Spectrum of Compound 4m



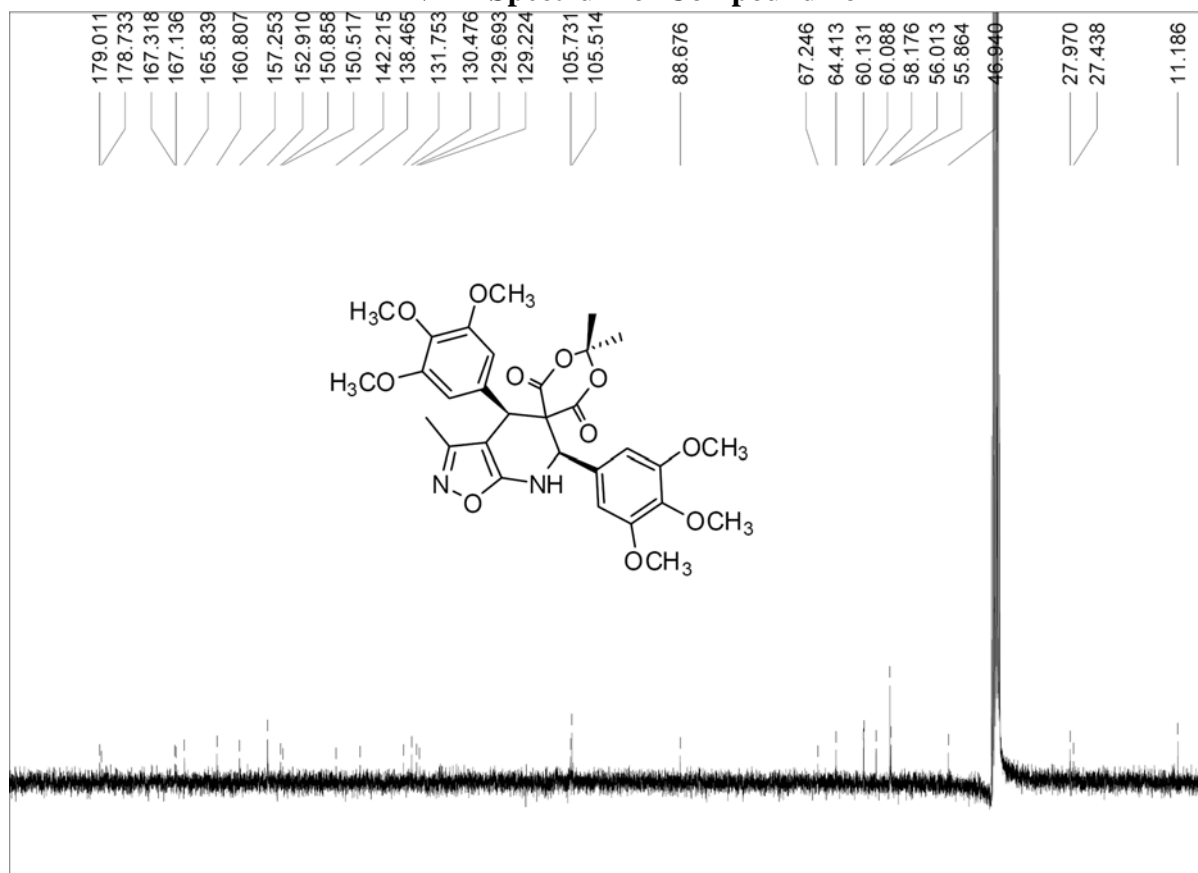
<sup>1</sup>H NMR Spectrum of Compound 4n



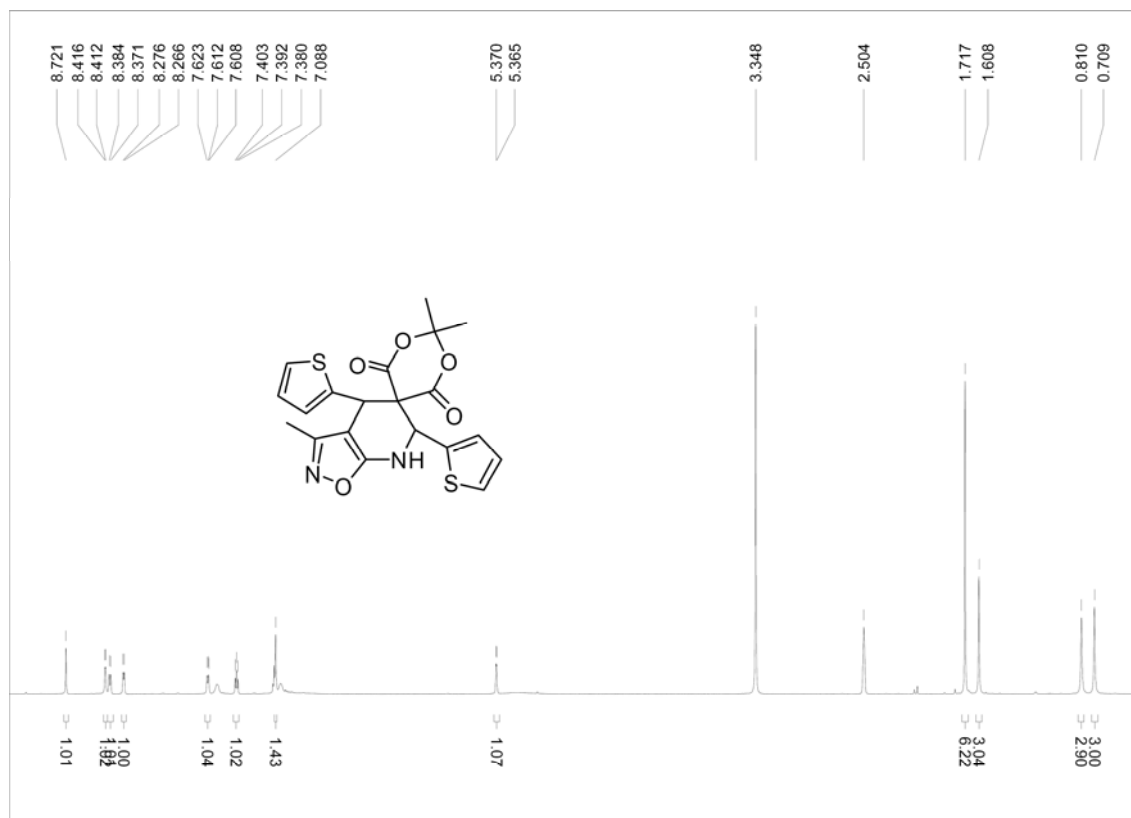
<sup>13</sup>C NMR Spectrum of Compound 4n



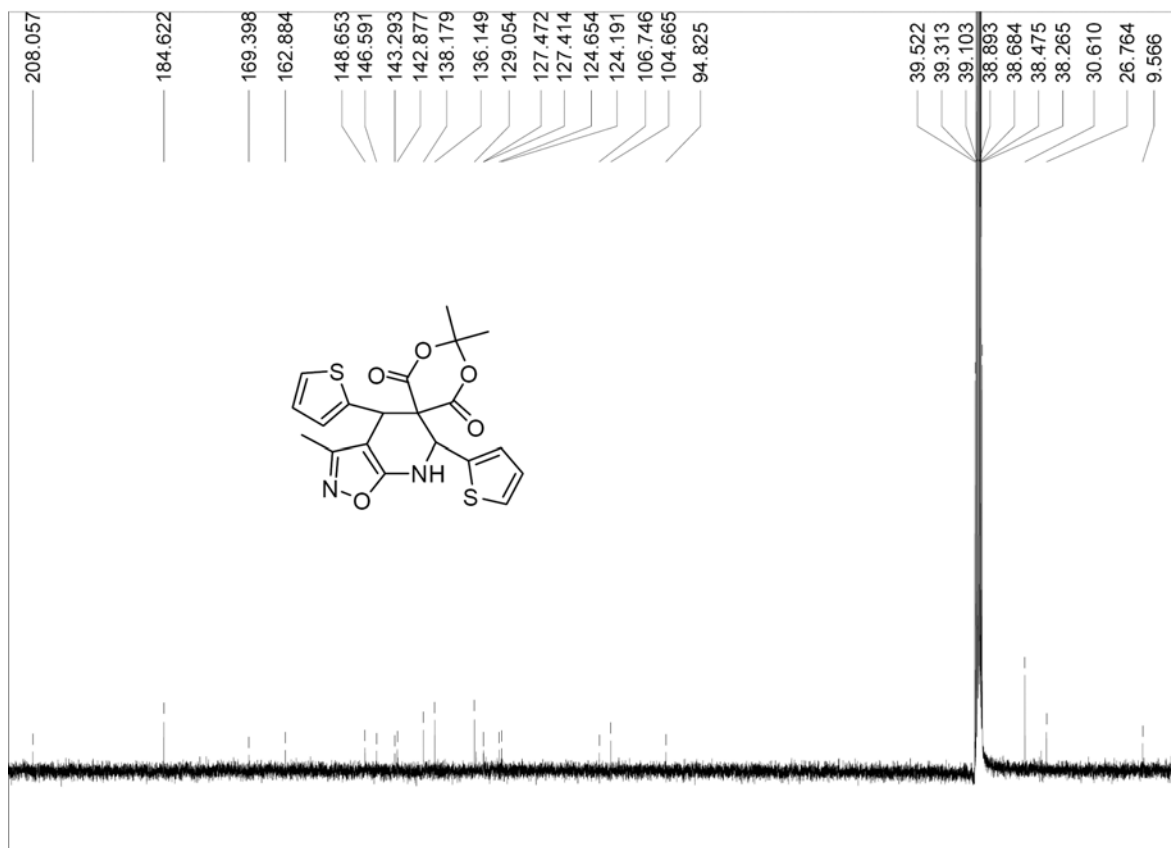
<sup>1</sup>H NMR Spectrum of Compound 4o



<sup>13</sup>C NMR Spectrum of Compound 4o

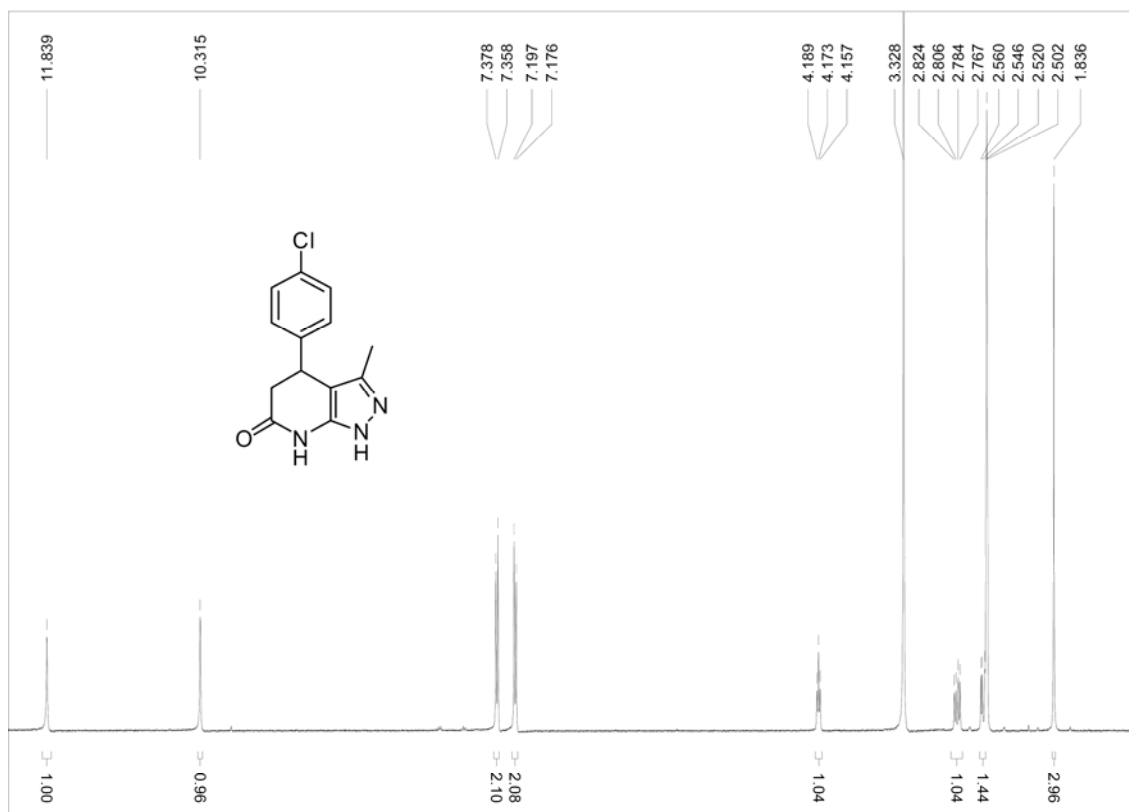


**<sup>1</sup>H NMR Spectrum of Compound 4p**

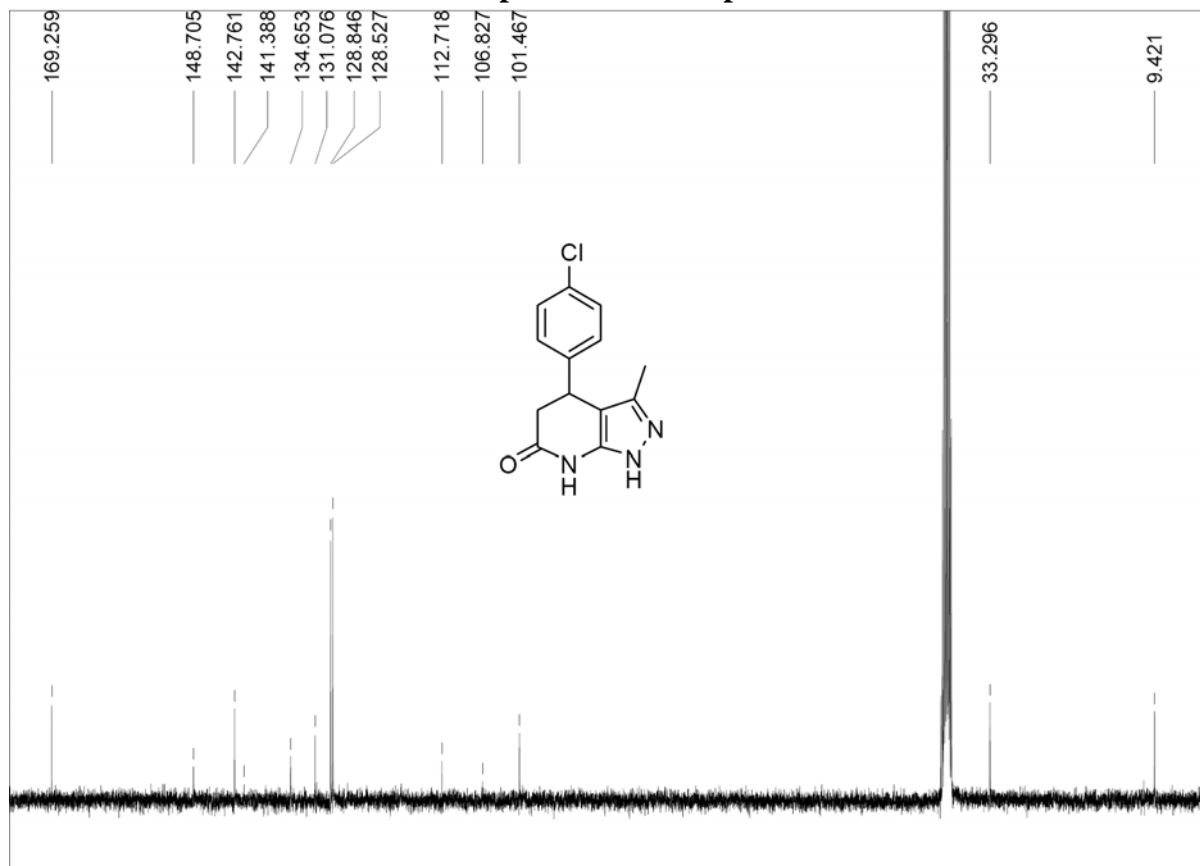


**<sup>13</sup>C NMR Spectrum of Compound 4p**

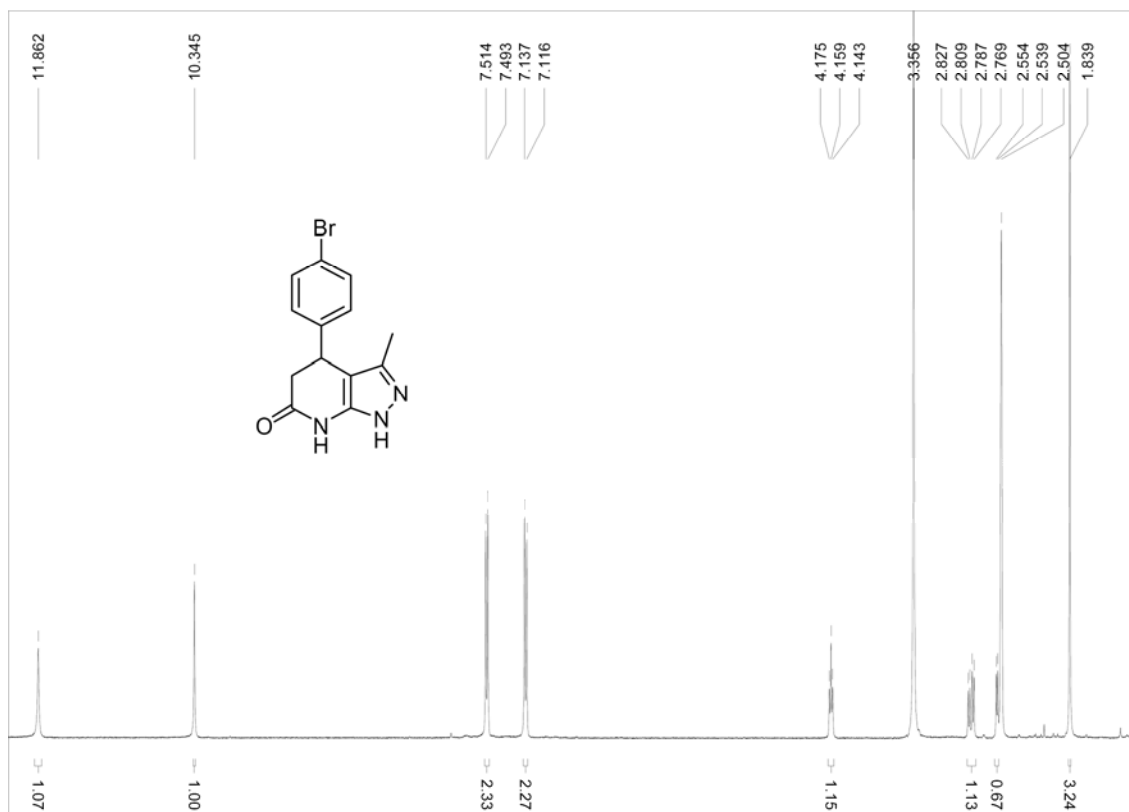




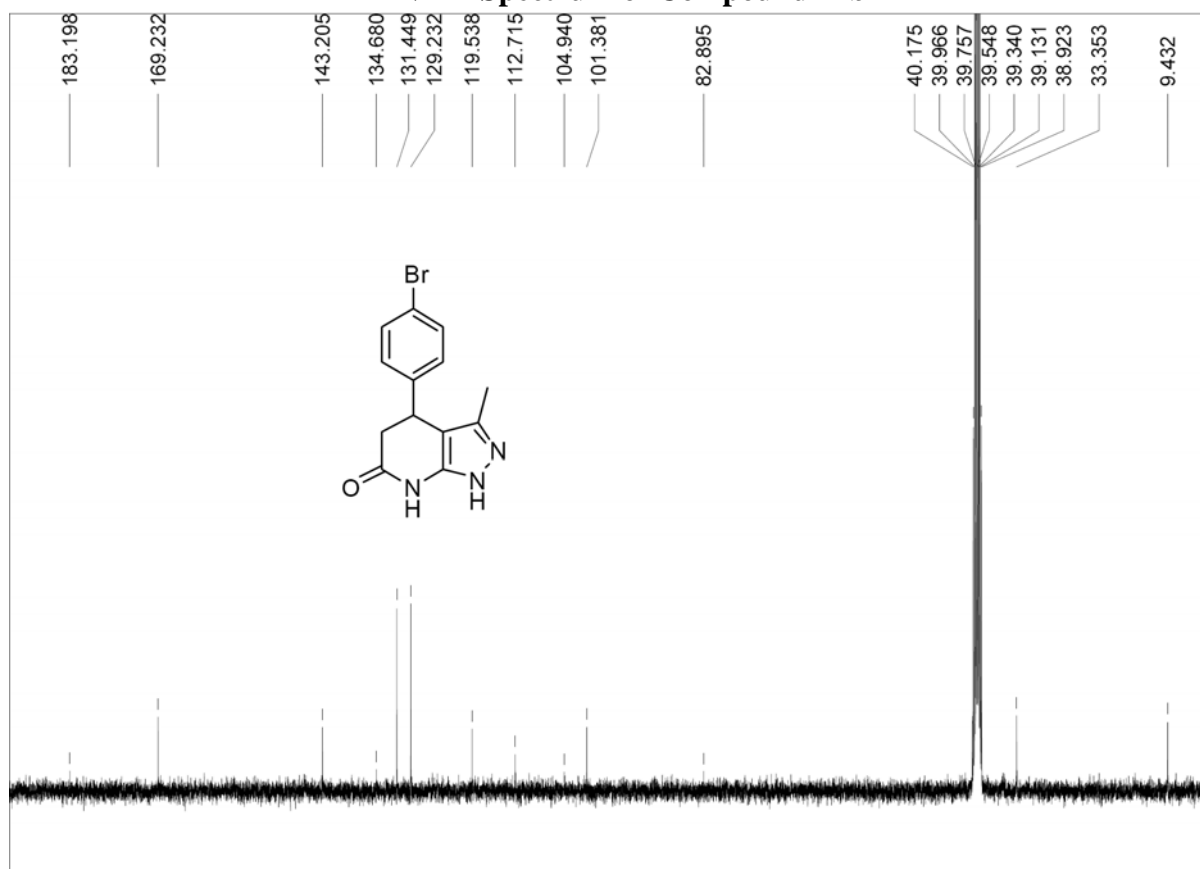
**<sup>1</sup>H NMR Spectrum of Compound 12a**



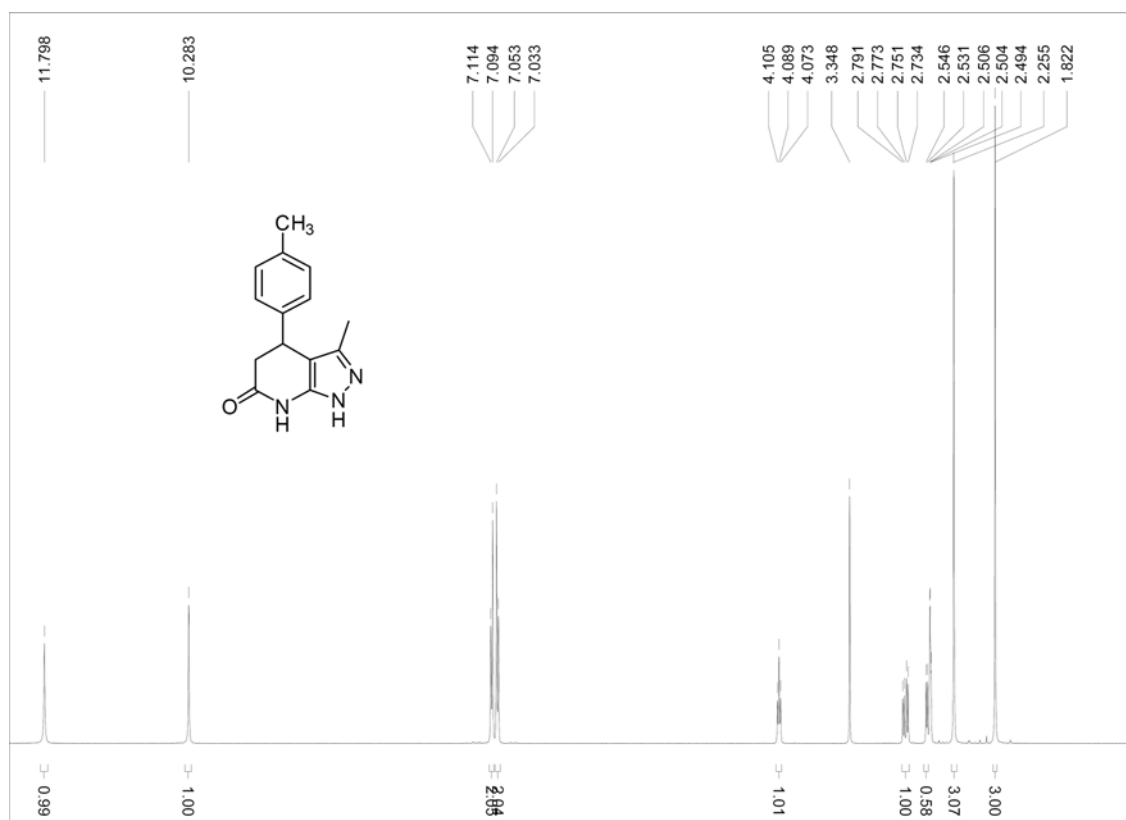
**<sup>13</sup>C NMR Spectrum of Compound 12a**



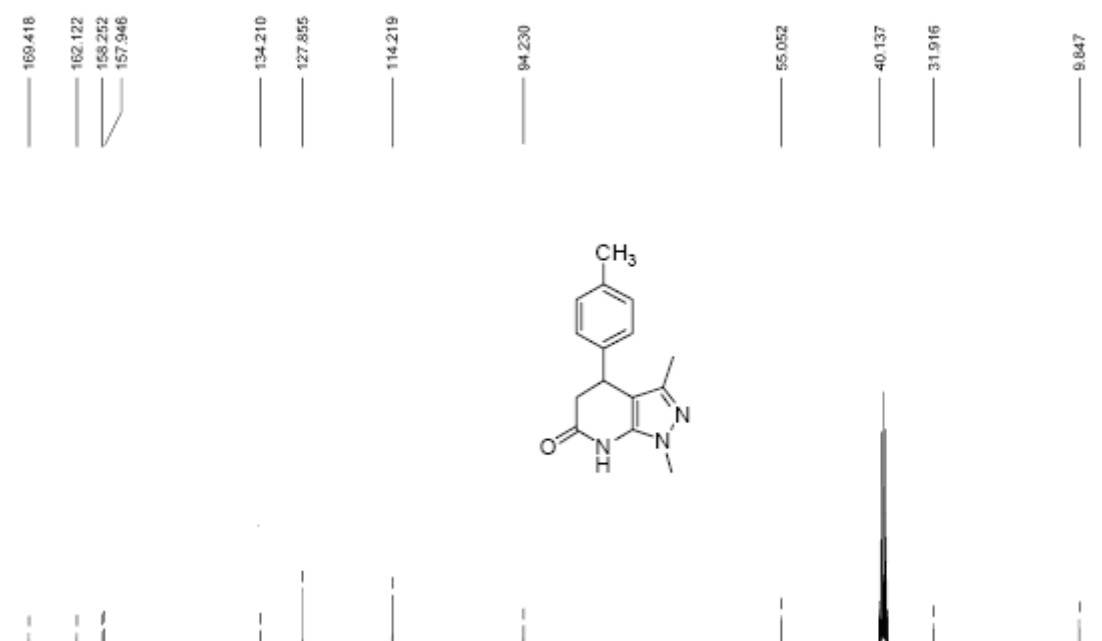
<sup>1</sup>H NMR Spectrum of Compound 12b



<sup>13</sup>C NMR Spectrum of Compound 12b

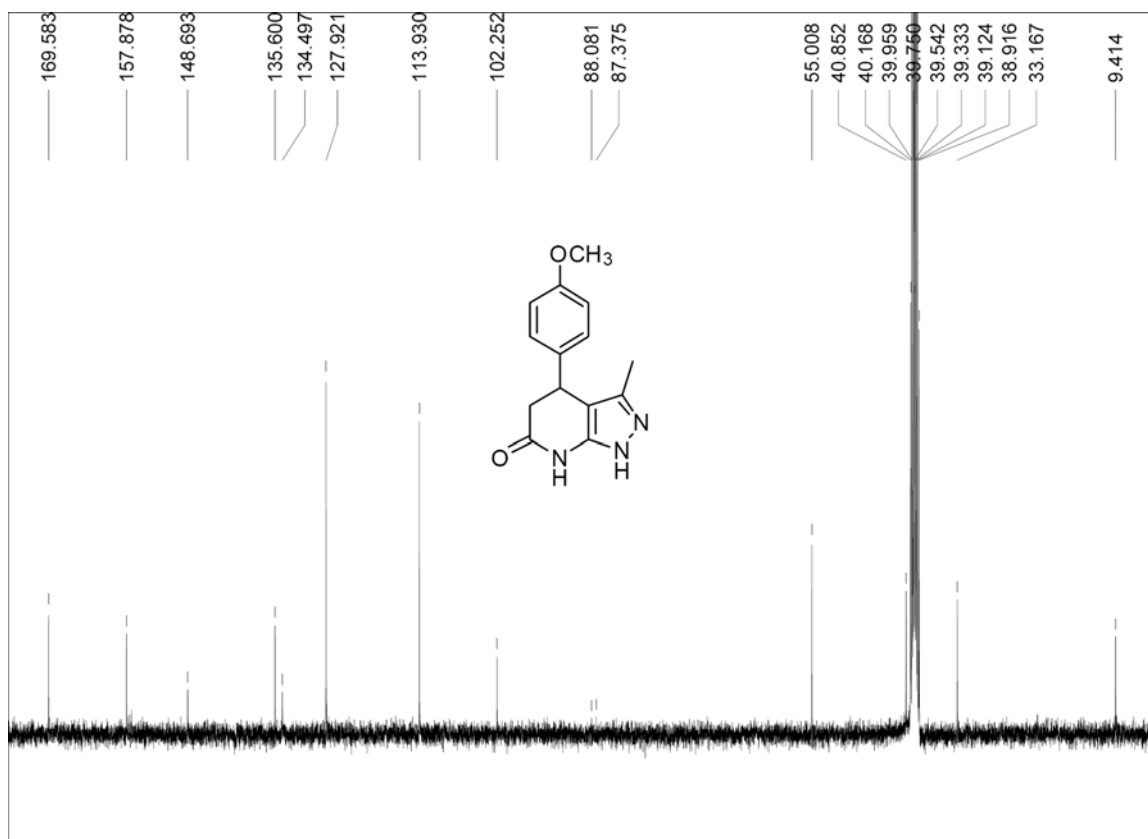


**<sup>1</sup>H NMR Spectrum of Compound 12c**

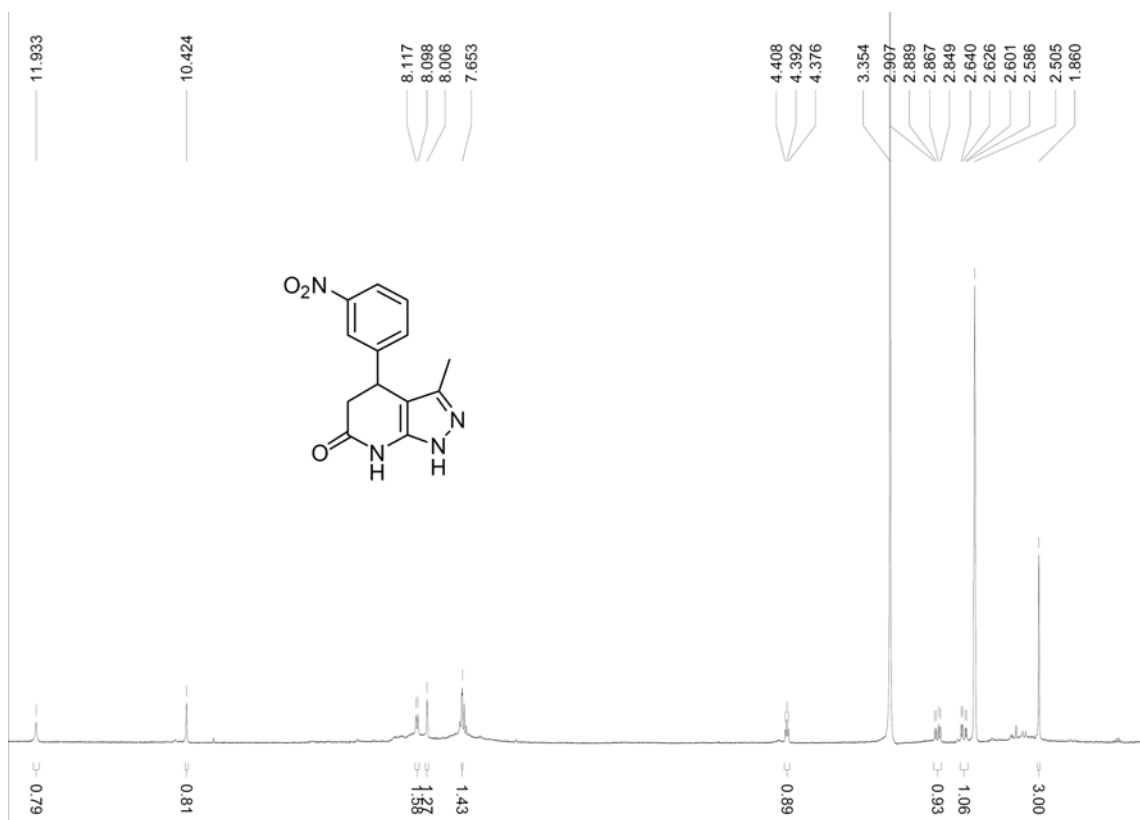


**<sup>13</sup>C NMR Spectrum of Compound 12c**

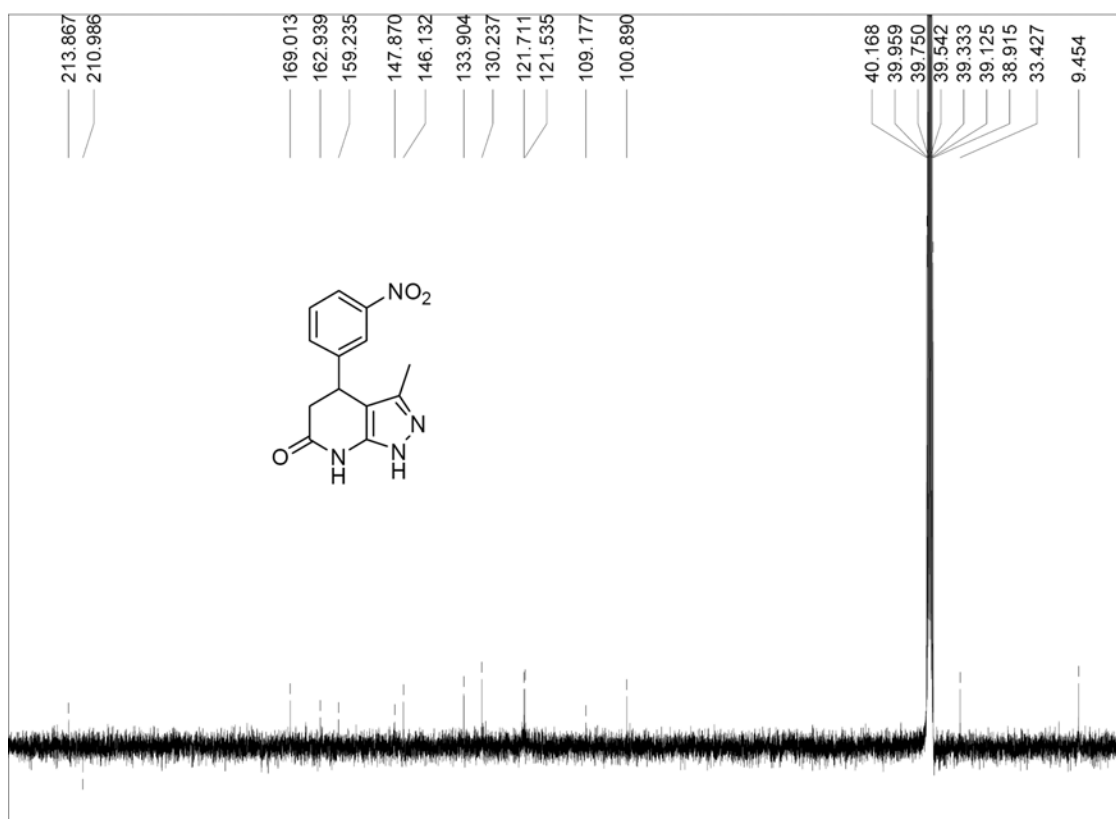
### <sup>1</sup>H NMR Spectrum of Compound 12d



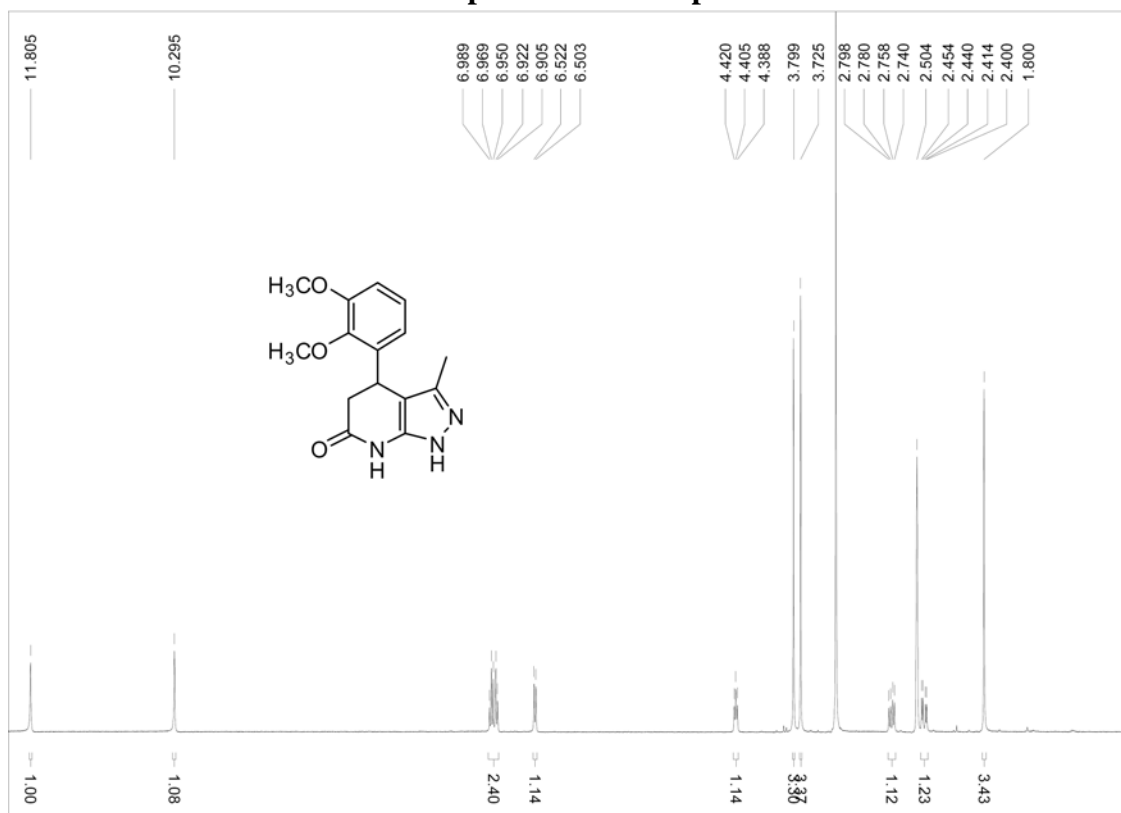
### <sup>13</sup>C NMR Spectrum of Compound 12d



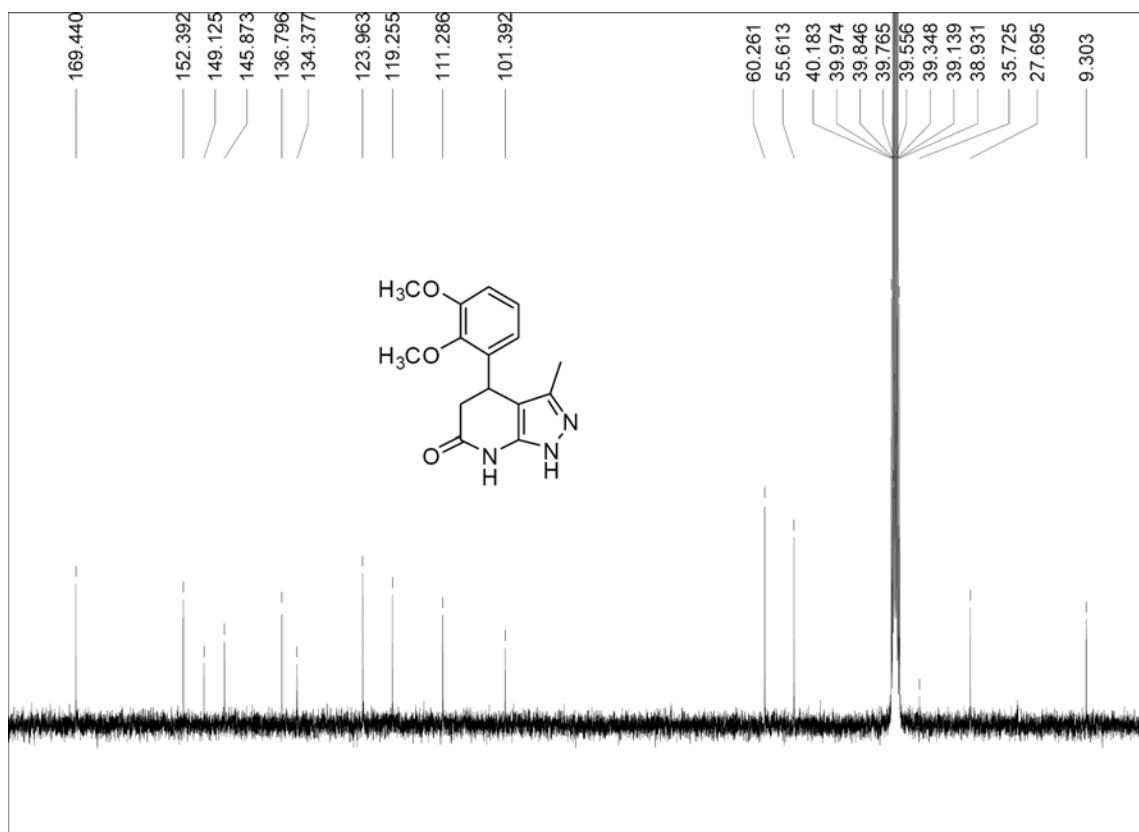
### <sup>1</sup>H NMR Spectrum of Compound 12e



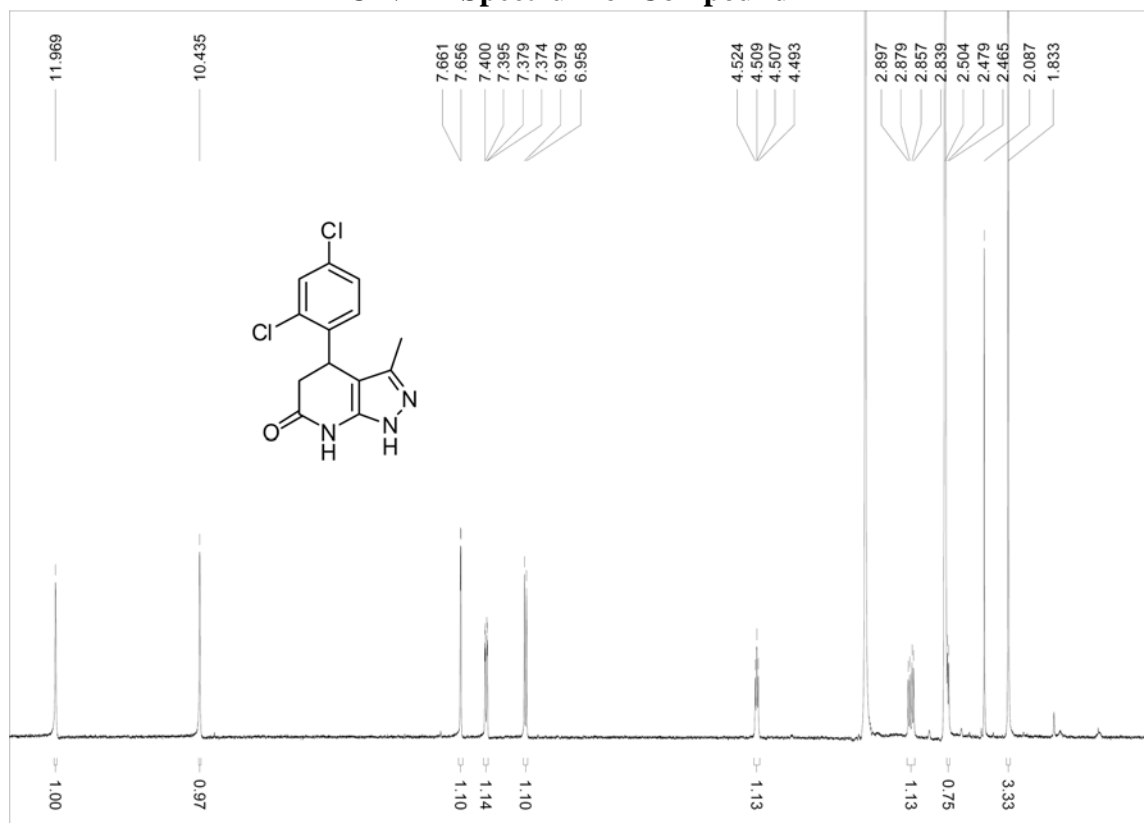
### <sup>13</sup>C NMR Spectrum of Compound 12e



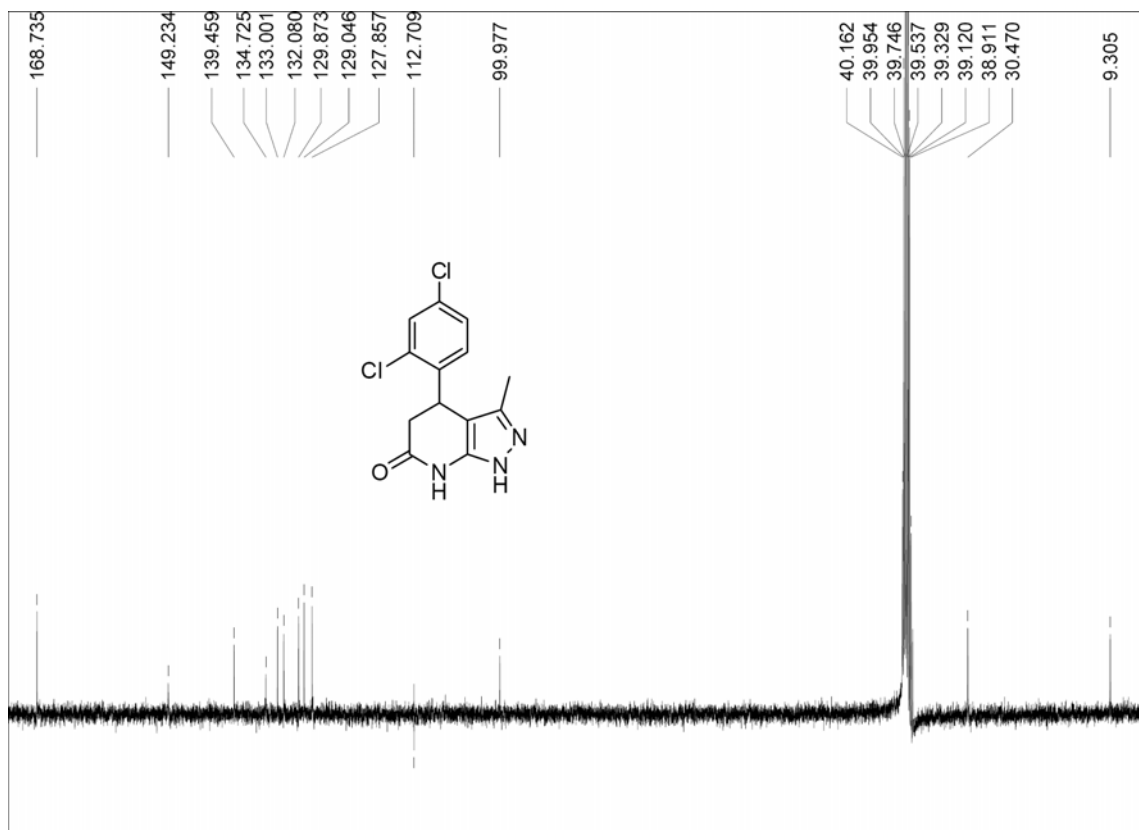
### <sup>1</sup>H NMR Spectrum of Compound 12f



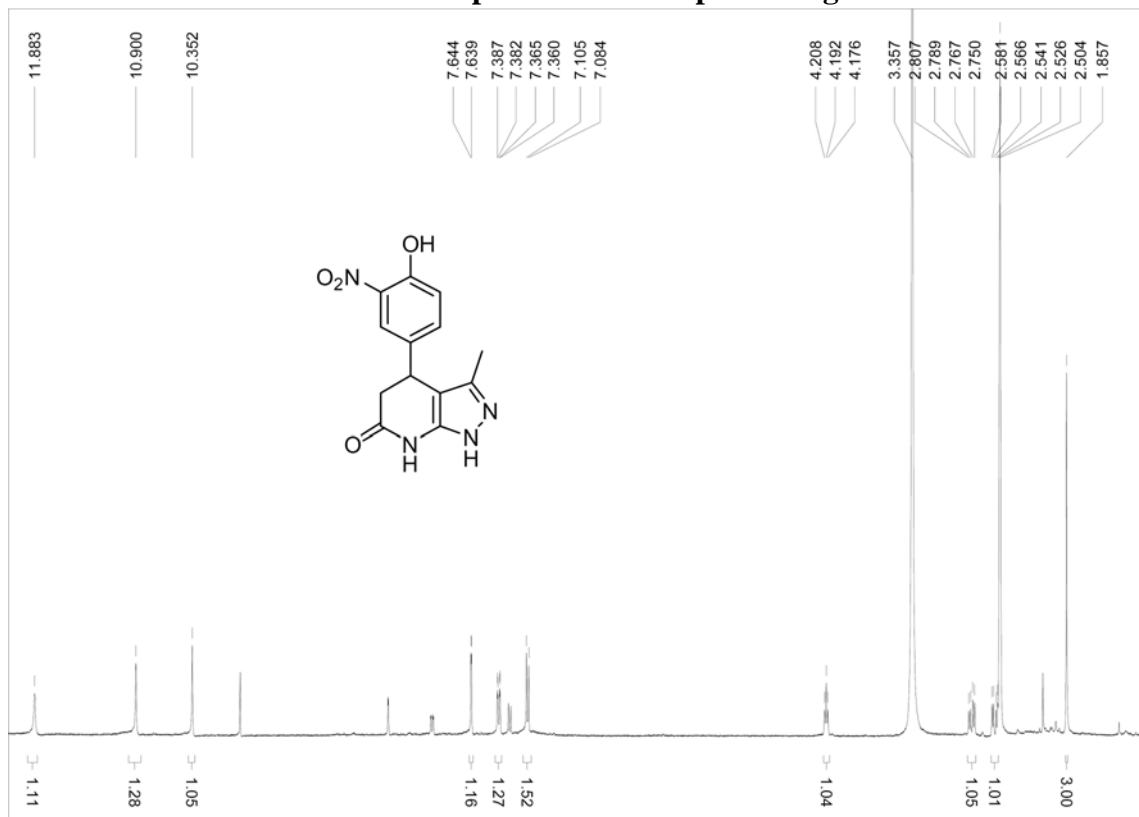
**<sup>13</sup>C NMR Spectrum of Compound 12f**



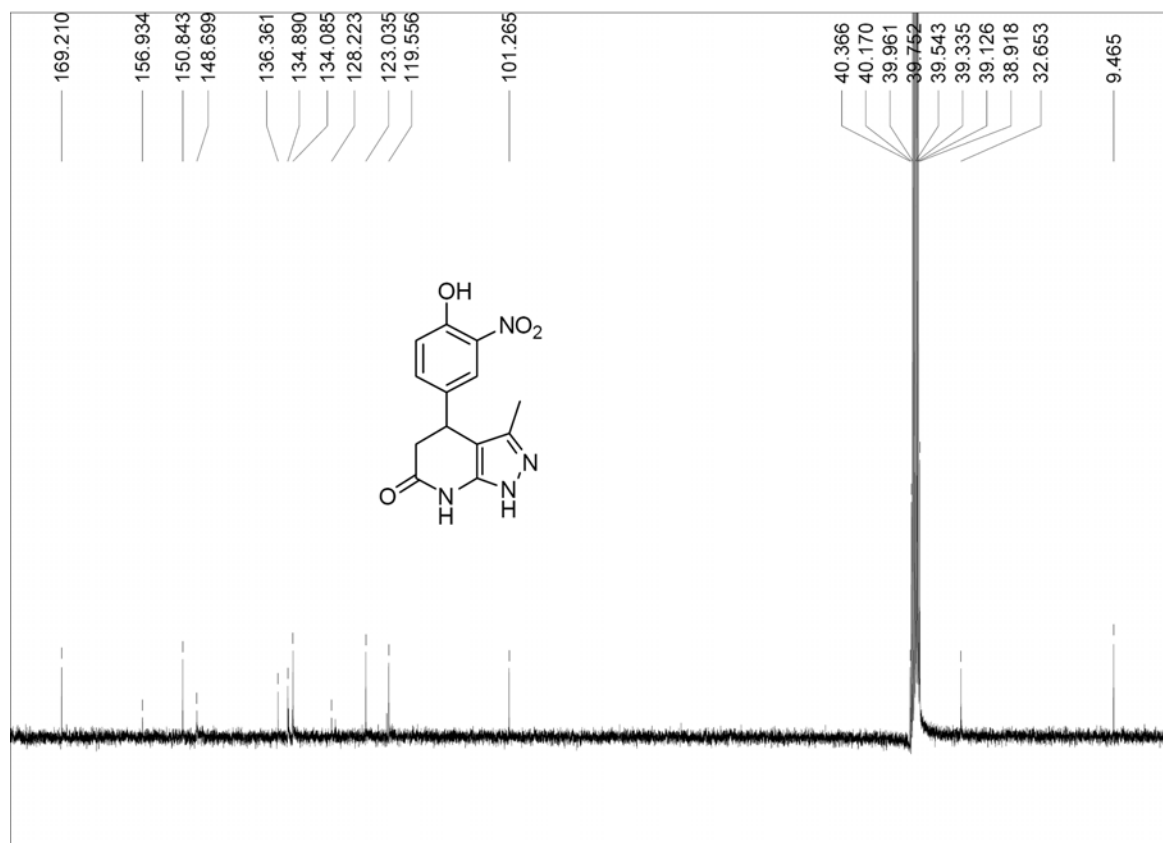
**<sup>1</sup>H NMR Spectrum of Compound 12g**



**<sup>13</sup>C NMR Spectrum of Compound 12g**



**<sup>1</sup>H NMR Spectrum of Compound 12h**

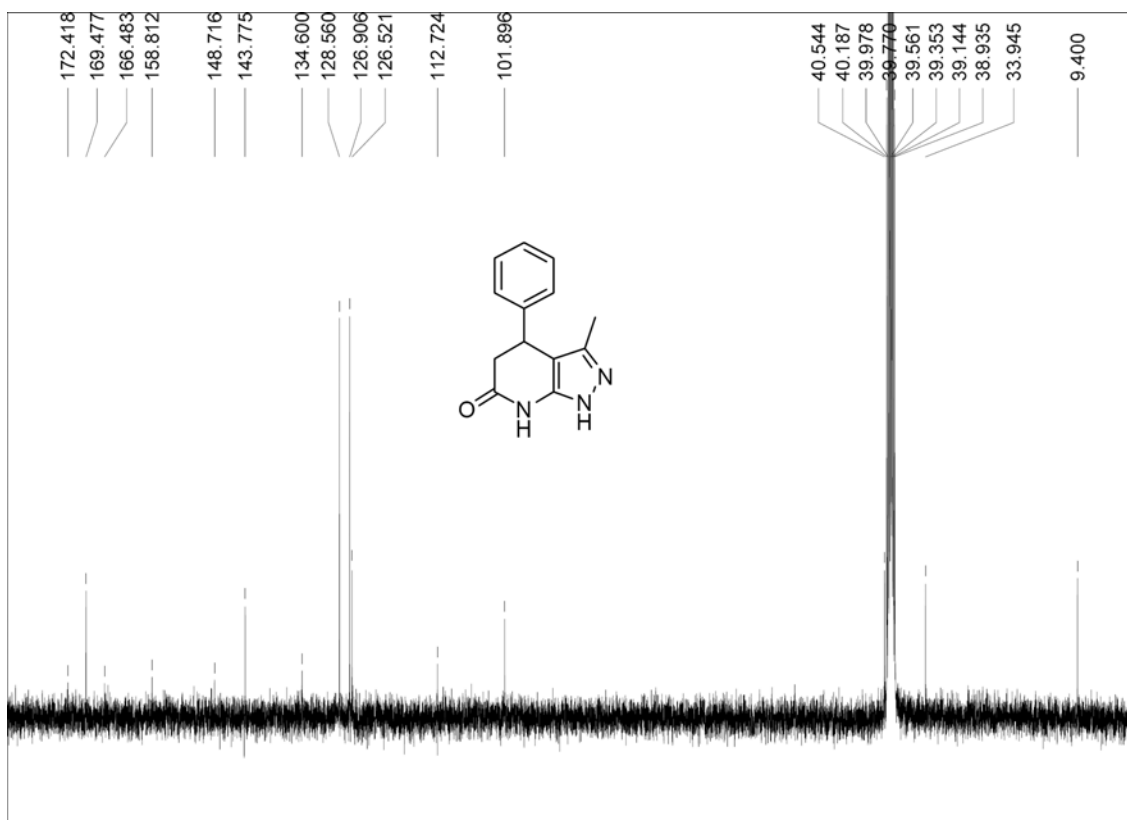


<sup>13</sup>C NMR Spectrum of Compound 12h



<sup>1</sup>H NMR Spectrum of Compound 12i

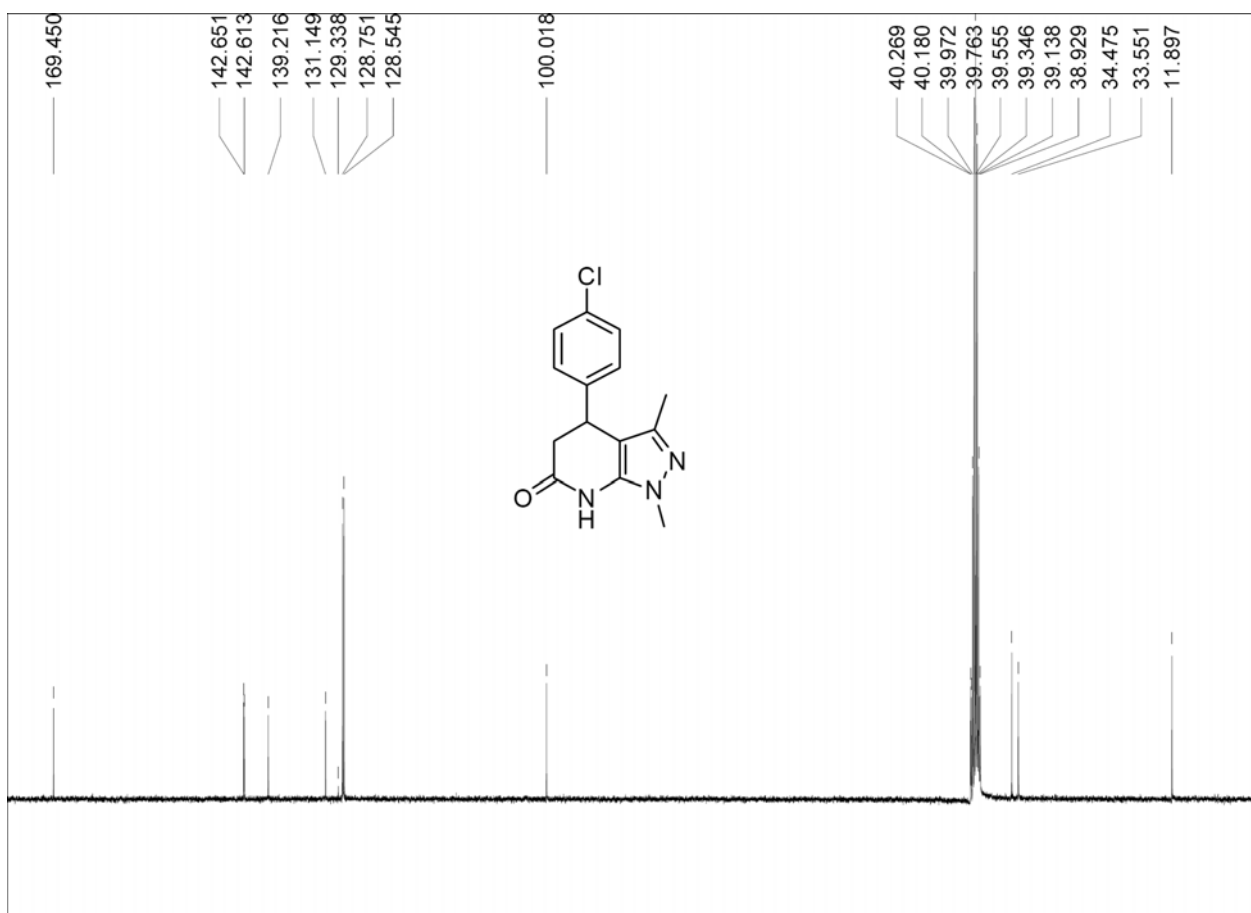




**<sup>13</sup>C NMR Spectrum of Compound 12i**



**<sup>1</sup>H NMR Spectrum of Compound 12j**



$^{13}\text{C}$ NMR Spectrum of Compound 12j