Facile synthesis of pyridopyrimidine and coumarin fused pyridine libraries over a Lewis base-surfactant-combined catalyst TEOA in aqueous medium

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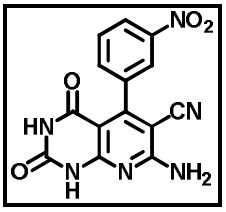
Materials and Instruments:

^{1}H-NMR and ^{13}C-NMR spectral analysis were carried out on Bruker-Advance Digital 300 MHz and 75 MHz instruments; tetramethylsilane (TMS) was used as internal standard. Infrared spectra were recorded in KBr pallets in reflection mode on a Perkin Elmer RX-1 FTIR spectrophotometer. Melting points were checked on a Köfler Block apparatus. Optical images were obtained using a CARL-ZEISS Axi-Observer optical microscope. DLS study was performed in a MALVERN Zetasizer DLS. Merck aluminum-blocked silica gel plates coated with silica gel G were used for analytical TLC and monitored under UV light and also by exposure to iodine vapor. Synthetic grade chemicals from Sigma-Aldrich, Spectrochem and E-Merck were used for the preparation of the catalyst and for carrying out the organic reactions. All the solvents used in the reaction were distilled and dried properly.

Representative physical data of the synthesized compounds:

7-amino-5-(3-nitrophenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4a):



Characteristic: White crystalline solid;

Mp: >300 ^{o}C;

IR (KBr): 3333, 3322, 2212, 1712, 1660 cm^{-1};

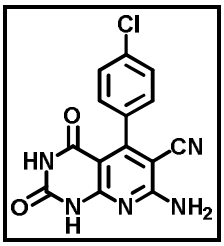
^{1}H NMR (300 MHz, DMSO-d_6): δ 8.12(6H, m), 10.84 (1H, s), 11.65 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 88.5, 115.3, 122.9, 123.3, 129.5, 134.6, 138.5, 147.3, 150.3, 155.6, 156.2, 160.3, 160.9;

Anal. Calcd for $C_{14}H_8N_6O_4$: C 51.86, H 2.49, N 25.92 %. Found: C 51.83, H 2.51, N 25.94 %.

HRMS of [$C_{14}H_8N_6O_4$ + H^+]: Calcd: 325.0680 Found: 325.0677

7-amino-5-(4-chlorophenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4b):



Characteristic: White crystalline solid;

Mp: >300 ^{o}C;

IR (KBr): 3400, 3330, 2224, 1695, 1644 cm^{-1};

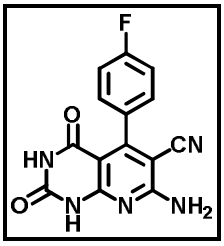
^{1}H NMR (300 MHz, DMSO-d_6): δ 7.63-7.71(2H, m), 7.81-7.89 (2H, m), 8.09 (2H, s), 11.37 (1H, s), 11.89 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 88.9, 115.8, 128.2, 130.0, 133.5, 136.1, 150.7, 156.0, 158.1, 160.6, 161.3;

Anal. Calcd for $C_{14}H_8ClN_5O_2$: C 53.60, H 2.57, N 22.33 %. Found: C 53.62, H 2.55, N 22.38 %.

HRMS of [$C_{14}H_8ClN_5O_2$ + H^+]: Calcd: 314.0439 Found: 314.0436

7-amino-5-(4-fluorophenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4c):



Characteristic: White crystalline solid;

Mp: >300 ^{o}C;

IR (KBr): 3391, 3176, 2225, 1709, 1667 cm^{-1};

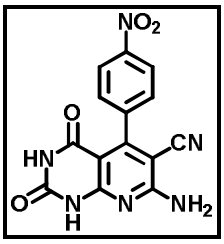
^{1}H NMR (300 MHz, DMSO-d_6): δ 6.71-7.10(2H, m), 7.19-7.33 (4H, m), 10.50 (1H, s), 10.93 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 98.9, 114.8, 114.9, 115.2, 115.9, 128.7, 128.8, 130.3, 130.4, 133.4, 135.9, 156.0, 158.5;

Anal. Calcd for $C_{14}H_8FN_5O_2$: C 56.57, H 2.71, N 23.56 %. Found: C 56.55, H 2.74, N 23.59 %.

HRMS of [$C_{14}H_8FN_5O_2 + H^+$]: Calcd: 298.0735 Found: 298.0736

7-amino-5-(4-nitrophenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4d):



Characteristic: White crystalline solid;

Mp: >300 ^oC;

IR (KBr): 3324, 3196, 2230, 1703, 1680 cm^{-1};

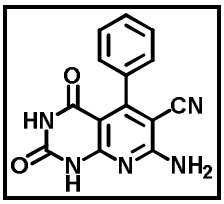
^1H NMR (300 MHz, DMSO-d_6): δ 7.73(2H, s), 7.95 (2H, d, J= 7.2 Hz), 8.20 (2H, d, J= 7.2 Hz), 10.98 (1H, s), 11.52 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 98.4, 115.1, 127.6, 128.4, 136.6, 140.2, 150.3, 155.3, 158.5, 159.9, 160.8;

Anal. Calcd for $C_{14}H_8N_6O_4$: C 51.86, H 2.49, N 25.92 %. Found: C 51.89, H 2.52, N 25.88 %.

HRMS of [$C_{14}H_8N_6O_4 + H^+$]: Calcd: 325.0680 Found: 325.0682

7-amino-2,4-dioxo-5-phenyl-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4e):



Characteristic: White crystalline solid;

Mp: >300 ^{o}C;

IR (KBr): 3318, 3184, 2227, 1707, 1674 cm^{-1};

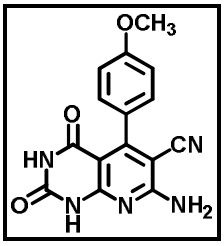
^{1}H NMR (300 MHz, DMSO-d_6): δ 7.15-7.18 (2H, 5), 7.33-7.35 (3H, m), 7.45 (2H, s), 10.82 (1H, s), 11.37 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 88.9, 115.3, 127.4, 128.1, 136.6, 150.3, 155.5, 158.8, 159.9, 160.9;

Anal. Calcd for $C_{14}H_9N_5O_2$: C 60.21, H 3.25, N 25.08 %. Found: C 60.19, H 3.28, N 25.05 %.

HRMS of [$C_{14}H_9N_5O_2$ + H^+]: Calcd: 280.0829 Found: 280.0826

7-amino-5-(4-methoxyphenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4f):



Characteristic: White crystalline solid;

Mp: >300 ^{o}C;

IR (KBr): 3361, 3131, 2220, 1709, 1665 cm^{-1};

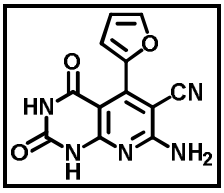
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.65 (3H, 5), 6.67-6.84 (4H, m), 6.85-6.94 (2H, m), 10.24 (1H, s), 10.44 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 32.2, 86.7, 113.6, 128.0, 129.8, 131.6, 150.2, 154.6, 157.3, 165.8;

Anal. Calcd for $C_{15}H_{11}N_5O_3$: C 58.25, H 3.58, N 22.64 %. Found: C 58.21, H 3.60, N 22.61 %.

HRMS of [$C_{15}H_{11}N_5O_3$ + H^+]: Calcd: 310.0935 Found: 310.0937

7-amino-5-(furan-2-yl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4g):



Characteristic: brown crystalline solid;

Mp: >300 ^oC (decomposes);

IR (KBr): 3361, 3167, 2228, 1711, 1663 cm^{-1};

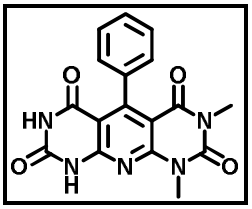
^1H NMR (300 MHz, DMSO-d_6): δ 6.18 (1H, 5), 6.62 (2H, m), 7.31-7.37 (1H, m), 8.20 (1H, s), 10.22 (1H, s), 10.41 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 85.8, 105.6, 11.5, 113.8, 115.0, 115.2, 148.5, 150.2, 152.4, 153.6, 154.2, 165.6;

Anal. Calcd for $C_{12}H_7N_5O_3$: C 53.54, H 2.62, N 26.01 %. Found: C 53.56, H 2.64, N 26.04 %.

HRMS of [$C_{12}H_7N_5O_3$ + H^+]: Calcd: 270.0622 Found: 270.0625

1,3-dimethyl-5-phenylpyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4h):



Characteristic: White crystalline solid;

Mp: 264 ^oC;

IR (KBr): 3317, 3219, 1698, 1664 cm^{-1};

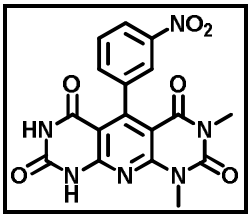
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.11 (3H, s), 3.32 (3H, s), 7.96-8.24 (5H, m), 10.15 (1H, s), 10.57 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.4, 30.4, 105.0, 109.3, 121.8, 122.3, 129.4, 133.5, 140.9, 147.7, 151.1, 153.6, 155.1, 159.4;

Anal. Calcd for $C_{19}H_{17}N_5O_4$: C 58.12, H 3.73, N 19.93 %. Found: C 58.14, H 3.76, N 19.91 %.

HRMS of [$C_{19}H_{17}N_5O_4$+ H^+]: Calcd: 352.1040 Found: 352.1042

1,3-dimethyl-5-(3-nitrophenyl)pyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4i):



Characteristic: White crystalline solid;

Mp: 268 ^{o}C;

IR (KBr): 3327, 3214, 1709, 1672 cm^{-1};

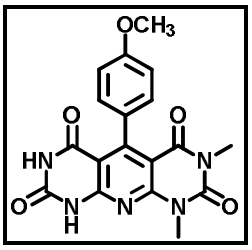
^{1}H NMR (300 MHz, DMSO-d_6): δ 2.99 (3H, s), 3.48 (3H, s), 7.59-7.71 (4H, m), 9.28 (1H, s), 9.72 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.6, 29.4, 95.5, 113.1, 113.6, 115.3, 128.2, 129.1, 135.3, 137.7, 151.2, 153.9, 158.6, 159.0;

Anal. Calcd for $C_{17}H_{12}N_6O_6$: C 51.52, H 3.05, N 21.21 %. Found: C 51.50, H 3.09, N 21.22 %.

HRMS of [$C_{19}H_{17}N_5O_4$+ H^+]: Calcd: 397.0891 Found: 397.0888

5-(4-methoxyphenyl)-1,3-dimethylpyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4j):



Characteristic: White crystalline solid;

Mp: 272 ^{o}C;

IR (KBr): 3314, 3221, 1696, 1668 cm^{-1};

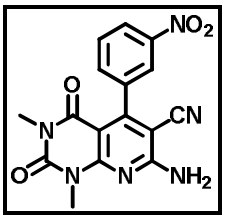
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.12 (3H, s), 3.38 (3H, s), 3.52 (3H, s), 7.79 (2H, d, J=8.7 Hz), 8.09 (2H, d, J=8.7 Hz), 10.06 (1H, s), 10.47 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.3, 30.2, 55.8, 91.9, 114.0, 115.3, 117.1, 128.3, 129.4, 137.2, 139.5, 151.2, 153.6, 158.4, 158.8, 160.7;

Anal. Calcd for $C_{18}H_{15}N_5O_5$: C 56.69, H 3.96, N 18.37 %. Found: C 56.70, H 3.99, N 18.37 %.

HRMS of [$C_{18}H_{15}N_5O_5$+ H^+]: Calcd: 382.1146 Found: 382.1149

7-amino-1,3-dimethyl-5-(3-nitrophenyl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4k):



Characteristic: White crystalline solid;

Mp: 284 ^{o}C;

IR (KBr): 3332, 3231, 2227, 1688, 1644 cm^{-1};

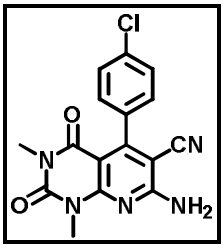
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.09 (3H, s), 3.52 (3H, s), 7.61-7.71 (4H, m), 8.07 (1H, s), 8.24 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.1, 30.0, 89.1, 115.2, 122.8, 123.4, 129.7, 134.2, 139.0, 147.8, 151.1, 154.0, 156.8, 159.1, 160.7;

Anal. Calcd for $C_{16}H_{12}N_6O_4$: C 54.55, H 3.43, N 23.85 %. Found: C 54.51, H 3.46, N 23.87 %.

HRMS of [$C_{16}H_{12}N_6O_4$ + H^+]: Calcd: 353.0993 Found: 353.0991

7-amino-5-(4-chlorophenyl)-1,3-dimethyl-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4l):



Characteristic: White crystalline solid;

Mp: 291 ^{o}C;

IR (KBr): 3319, 3218, 2219, 1684, 1657 cm^{-1};

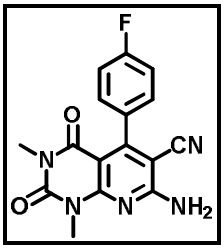
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.09 (3H, s), 3.49 (3H, s), 7.11 (2H, d, J=8.4 Hz), 7.32-7.38 (4H, m);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.0, 30.0, 89.4, 115.3, 128.2, 129.1, 134.1, 135.9, 151.1, 154.0, 158.4, 159.0, 160.7;

Anal. Calcd for $C_{16}H_{12}ClN_5O_2$: C 56.23, H 3.54, N 20.49 %. Found: C 56.26, H 3.55, N 20.46 %.

HRMS of [$C_{16}H_{12}ClN_5O_2$ + H^+]: Calcd: 342.0752 Found: 342.0755

7-amino-5-(4-fluorophenyl)-1,3-dimethyl-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4m):



Characteristic: White crystalline solid;

Mp: 276 ^oC;

IR (KBr): 3322, 3220, 2215, 1706, 1656 cm^{-1};

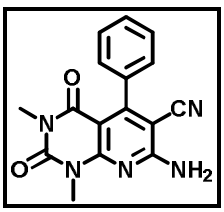
^1H NMR (300 MHz, DMSO-d_6): δ 3.09 (3H, s), 3.44 (3H, s), 6.94-7.41 (6H, m);

^{13}C NMR (75 MHz, DMSO-d_6): δ 27.6, 29.6, 89.2, 98.6, 113.2, 114.5, 114.8, 115.0, 115.2, 115.5, 129.1, 129.2, 132.9, 158.2, 158.5, 160.2, 160.5, 163.8;

Anal. Calcd for $C_{16}H_{12}FN_5O_2$: C 59.08, H 3.72, N 21.53 %. Found: C 59.11, H 3.74, N 21.50 %.

HRMS of [$C_{16}H_{12}FN_5O_2$ + H^+]: Calcd: 326.1048 Found: 326.1045

7-amino-1,3-dimethyl-2,4-dioxo-5-phenyl-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4n):



Characteristic: White crystalline solid;

Mp: 268 ^{o}C;

IR (KBr): 3318, 3227, 2228, 1711, 1662 cm^{-1};

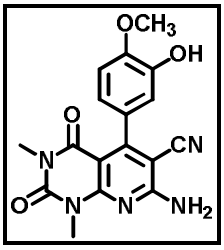
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.02 (3H, s), 3.49 (3H, s), 7.09-7.31 (5H, m), 8.28 (2H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 27.0, 28.9, 87.2, 113.6, 121.5, 123.5, 135.2, 137.4, 154.4, 156.8, 159.1, 165.6;

Anal. Calcd for $C_{16}H_{13}N_5O_2$: C 62.53, H 4.26, N 22.79 %. Found: C 62.55, H 4.22, N 22.82 %.

HRMS of [$C_{16}H_{13}N_5O_2$ + H^+]: Calcd: 308.1142 Found: 308.1145

7-amino-1,3-dimethyl-2,4-dioxo-5-phenyl-1,2,3,4-tetrahydropyrido[2,3-d]pyrimidine-6-carbonitrile (4p):



Characteristic: Yellow crystalline solid;

Mp: 276 ^{o}C;

IR (KBr): 3342, 3222, 2219, 1708, 1678 cm^{-1};

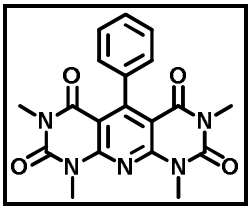
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.28 (6H, s), 3.79 (3H, s), 7.06 (1H, d, J=8.4 Hz), 7.35 (1H, d, J=8.7 Hz), 7.44 (1H, d, J=1.8 Hz), 9.76 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 26.4, 30.8, 56.6, 111.2, 112.6, 118.8, 126.8, 145.2, 148.5, 150.6, 153.7, 160.3;

Anal. Calcd for $C_{17}H_{15}N_5O_4$: C 57.79, H 4.28, N 19.82 %. Found: C 57.81, H 4.25, N 19.79 %.

HRMS of [$C_{17}H_{15}N_5O_4$ + H^+]: Calcd: 354.1197 Found: 354.1195

1,3,7,9-tetramethyl-5-phenylpyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4q):



Characteristic: White crystalline solid;

Mp: 228 ^oC;

IR (KBr): 3311, 1711, 1672 cm^{-1};

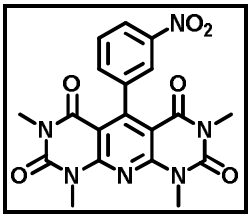
^1H NMR (300 MHz, DMSO-d_6): δ 3.26 (6H, s), 3.55 (6H, s), 6.95-7.25 (5H, m);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.7, 30.6112.1, 114.7, 123.3, 124.2, 126.4, 126.5, 136.2, 149.4, 157.3, 160.6, 166.9;

Anal. Calcd for $C_{19}H_{17}N_5O_4$: C 60.15, H 4.52, N 18.46 %. Found: C 60.19, H 4.49, N 18.48 %.

HRMS of [$C_{19}H_{17}N_5O_4$+ H^+]: Calcd: 380.1353 Found: 380.1355

1,3,7,9-tetramethyl-5-(3-nitrophenyl)pyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4r):



Characteristic: White crystalline solid;

Mp: 248 ^{o}C;

IR (KBr): 3317, 1721, 1686, 1592 cm^{-1};

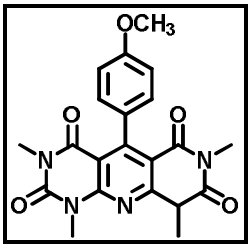
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.08 (6H, s), 3.64 (6H, s), 7.52 (2H, d, J=7.5 Hz), 7.62-7.67 (1H, m), 7.95 (1H, m), 8.22 (1H, d, J=7.8 Hz);

^{13}C NMR (75 MHz, DMSO-d_6): δ 28.5, 30.6, 105.0, 121.9, 122.2, 129.4, 133.9, 140.8, 147.7, 151.1, 153.4, 155.1, 159.5;

Anal. Calcd for $C_{19}H_{16}N_6O_6$: C 53.77, H 3.80, N 19.80 %. Found: C 53.75, H 3.83, N 19.81 %.

HRMS of [$C_{19}H_{16}N_6O_6$+ H^+]: Calcd: 425.1204 Found: 425.1207

5-(4-methoxyphenyl)-1,3,7,9-tetramethylpyrido[2,3-d:6,5-d']dipyrimidine-2,4,6,8(1H,3H,7H,9H)-tetraone (4s):



Characteristic: White crystalline solid;

Mp: 266 ^{o}C;

IR (KBr): 3309, 1711, 1689 cm^{-1};

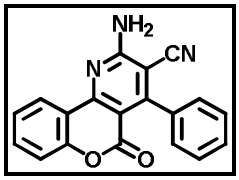
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.13 (6H, s), 3.57 (6H, s), 3.81 (3H, s), 7.37 (2H, d, J=7.5 Hz), 7.61(2H, d, J=7.5 Hz);

^{13}C NMR (75 MHz, DMSO-d_6): δ 32.2, 35.5, 50.2, 113.1, 113.3, 118.9, 126.3, 126.9, 128.0, 135.5, 157.6, 157.8, 160.9;

Anal. Calcd for $C_{20}H_{19}N_5O_5$: C 58.68, H 4.68, N 17.11 %. Found: C 58.70, H 4.71, N 17.13 %.

HRMS of [$C_{20}H_{19}N_5O_5$+ H^+]: Calcd: 410.1459 Found: 410.1457

2-amino-5-oxo-4-phenyl-5H-chromeno[4,3-b]pyridine-3-carbonitrile (4t):



Characteristic: White crystalline solid;

Mp: > 300 ^oC;

IR (KBr): 3309, 2229, 1731, 1693 cm^{-1};

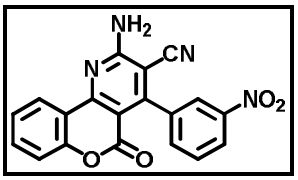
^1H NMR (300 MHz, DMSO-d_6): δ 7.32-7.39 (6H, m), 7.54-7.74 (3H, m), 8.02 (2H, d, J= 8.4 Hz);

^{13}C NMR (75 MHz, DMSO-d_6): δ 112.7, 114.0, 114.3, 118.7, 128.2, 128.3, 139.2, 142.8, 143.8, 147.9, 157.7, 159.0, 161.1, 162.2;

Anal. Calcd for $C_{19}H_{11}N_3O_2$: C 72.84, H 3.54, N 13.41 %. Found: C 72.82, H 3.52, N 13.43 %.

HRMS of [$C_{19}H_{11}N_3O_2$+ H^+]: Calcd: 314.0924 Found: 314.0926

2-amino-4-(3-nitrophenyl)-5-oxo-5H-chromeno[4,3-b]pyridine-3-carbonitrile (4u):



Characteristic: White crystalline solid;

Mp: > 300 ^oC;

IR (KBr): 3314, 2217, 1722, 1682 cm^{-1};

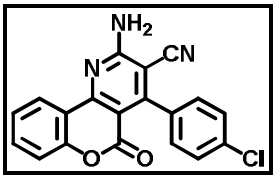
^1H NMR (300 MHz, DMSO-d_6): δ 7.36-7.47 (2H, m), 7.67-7.89 (4H, m), 8.33-8.40 (4H, m);

^{13}C NMR (75 MHz, DMSO-d_6): δ 89.1, 114.6, 119.3, 126.1, 126.7, 126.8, 128.7, 129.0, 129.3, 136.2, 140.5, 154.3, 157.7;

Anal. Calcd for $C_{19}H_{10}N_4O_4$: C 63.69, H 2.81, N 15.64 %. Found: C 63.71, H 2.78, N 15.68 %.

HRMS of [$C_{19}H_{10}N_4O_4$+ H^+]: Calcd: 359.0775 Found: 359.0771

2-amino-4-(4-chlorophenyl)-5-oxo-5H-chromeno[4,3-b]pyridine-3-carbonitrile (4v):



Characteristic: White crystalline solid;

Mp: > 300 ^oC;

IR (KBr): 3319, 2226, 1715, 1676 cm^{-1};

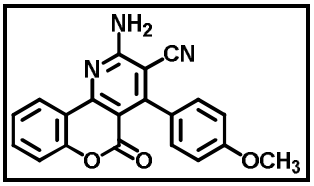
^{1}H NMR (300 MHz, DMSO-d_6): δ 7.31 (1H, d, J=8.1 Hz), 7.45 (1H, d, J=7.8 Hz), 7.62-7.65 (4H, m), 7.85-7.87 (4H, m), 8.30 (2H, d, J=7.5 Hz), 8.46 (1H, s);

^{13}C NMR (75 MHz, DMSO-d_6): δ 108.0, 114.1, 126.6, 127.6, 129.7, 132.8, 138.3, 145.5, 154.3, 156.8, 159.1, 163.0, 165.4;

Anal. Calcd for $C_{19}H_{10}ClN_3O_2$: C 65.62, H 2.90, N 12.08 %. Found: C 65.66, H 2.88, N 12.11 %.

HRMS of [$C_{19}H_{10}ClN_3O_2$+ H^+]: Calcd: 348.0534 Found: 348.0536

2-amino-4-(4-methoxyphenyl)-5-oxo-5H-chromeno[4,3-b]pyridine-3-carbonitrile (4w):



Characteristic: White crystalline solid;

Mp: > 300 ^{o}C;

IR (KBr): 3304, 2214, 1737, 1681 cm^{-1};

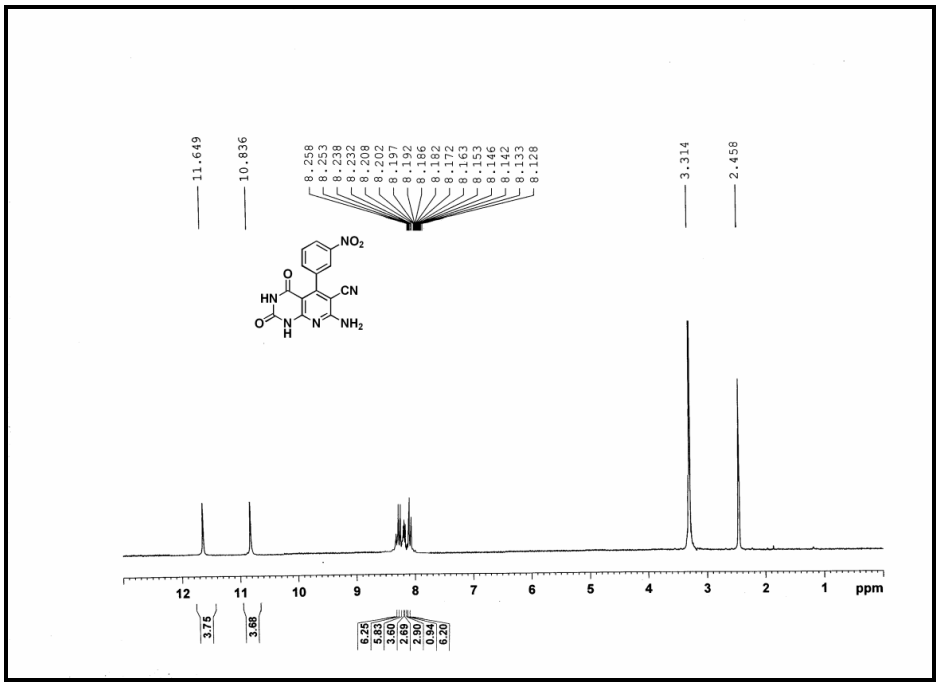
^{1}H NMR (300 MHz, DMSO-d_6): δ 3.69 (3H,s), 7.46-7.50 (2H, m), 7.67-7.68 (3H, m), 8.04-8.1 (5H, m);

^{13}C NMR (75 MHz, DMSO-d_6): δ 55.5, 113.2, 123.7, 123.8, 124.8, 124.9, 127.9, 129.5, 142.8, 155.9, 156.3, 157.5, 159.3, 160.8, 161.2;

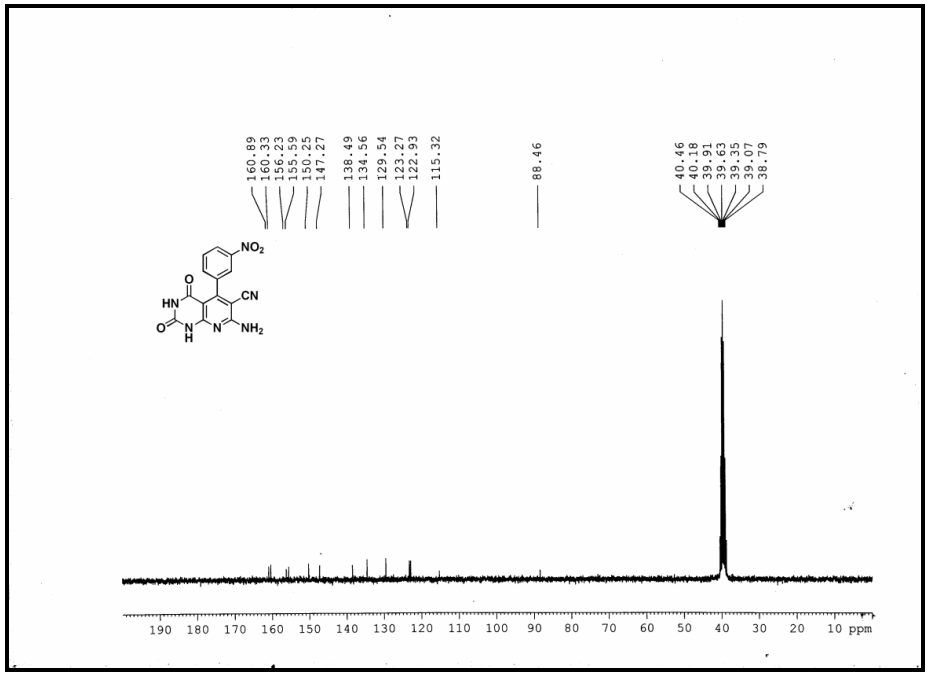
Anal. Calcd for $C_{20}H_{13}N_3O_3$: C 69.96, H 3.82, N 12.24 %. Found: C 69.93, H 3.79, N 12.26 %.

HRMS of [$C_{20}H_{13}N_3O_3$+ H^{+}]: Calcd: 344.1030 Found: 344.1032

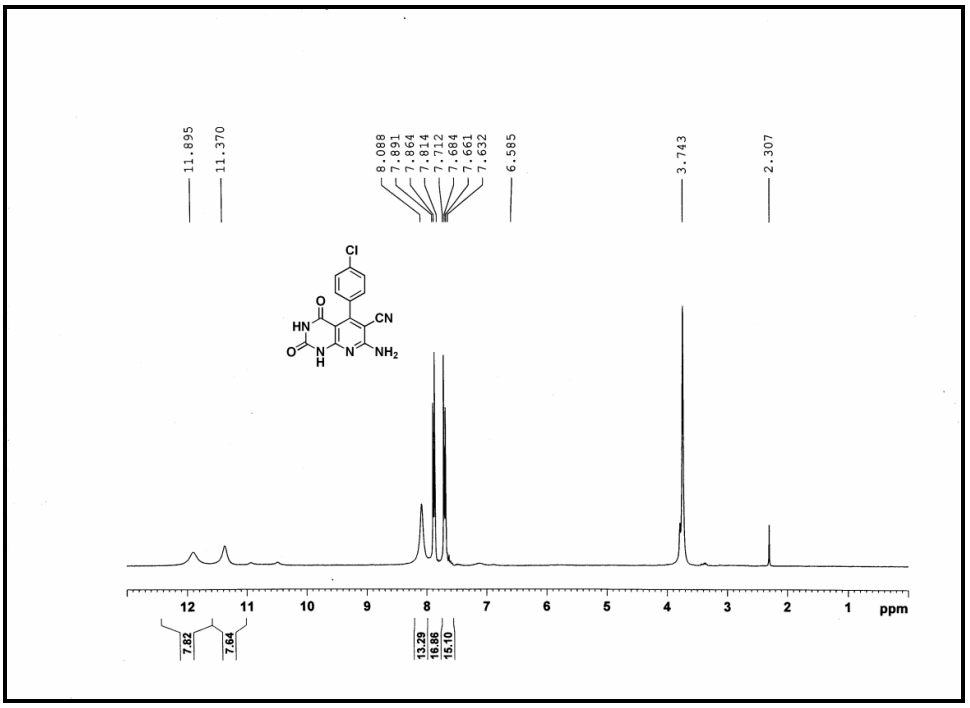
Spectra of representative synthesized compounds:



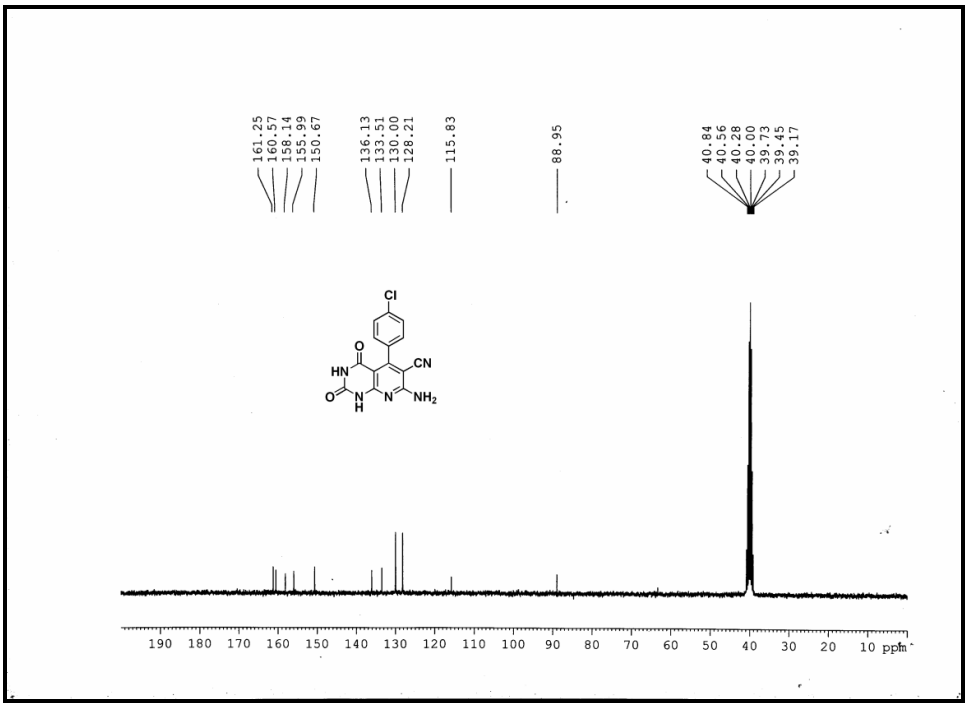
^{1}H NMR spectra of compound 4a



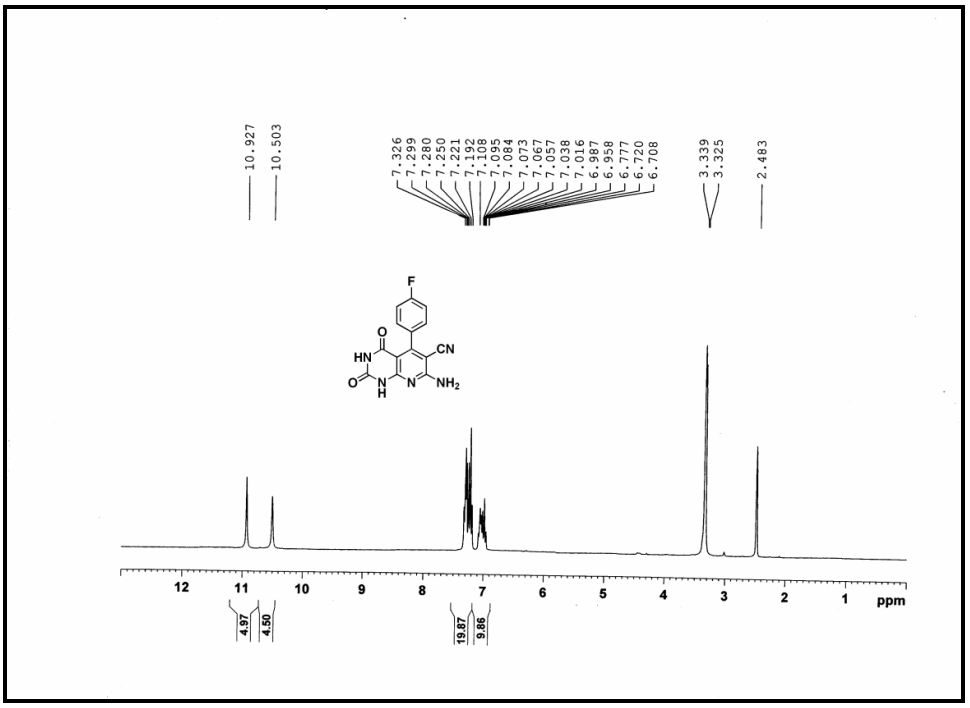
^{13}C NMR spectra of compound 4a



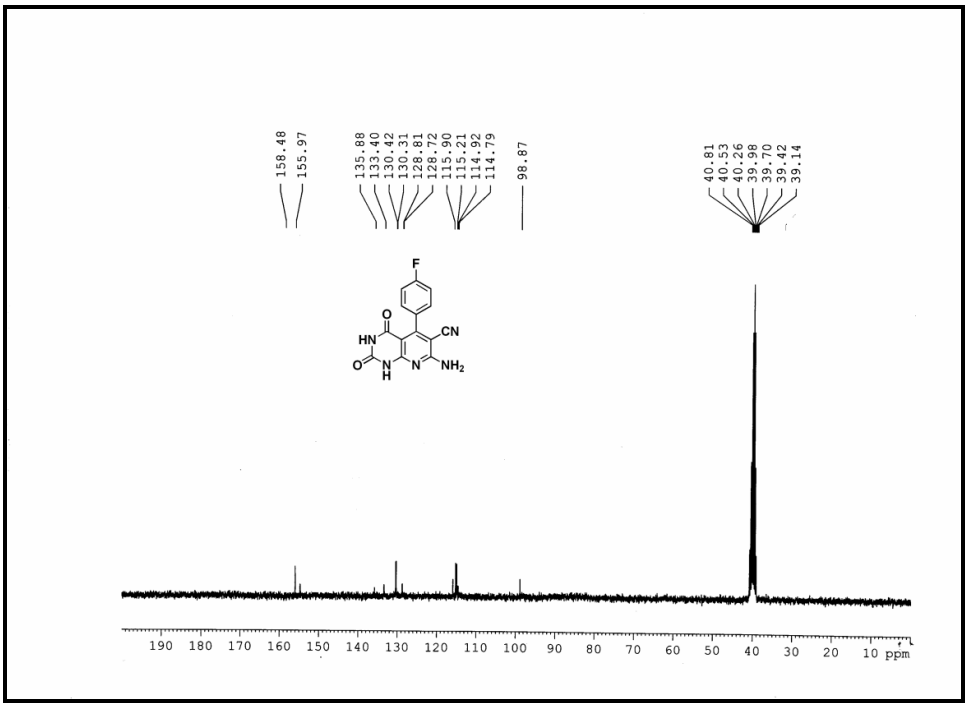
^{1}H NMR spectra of compound 4b



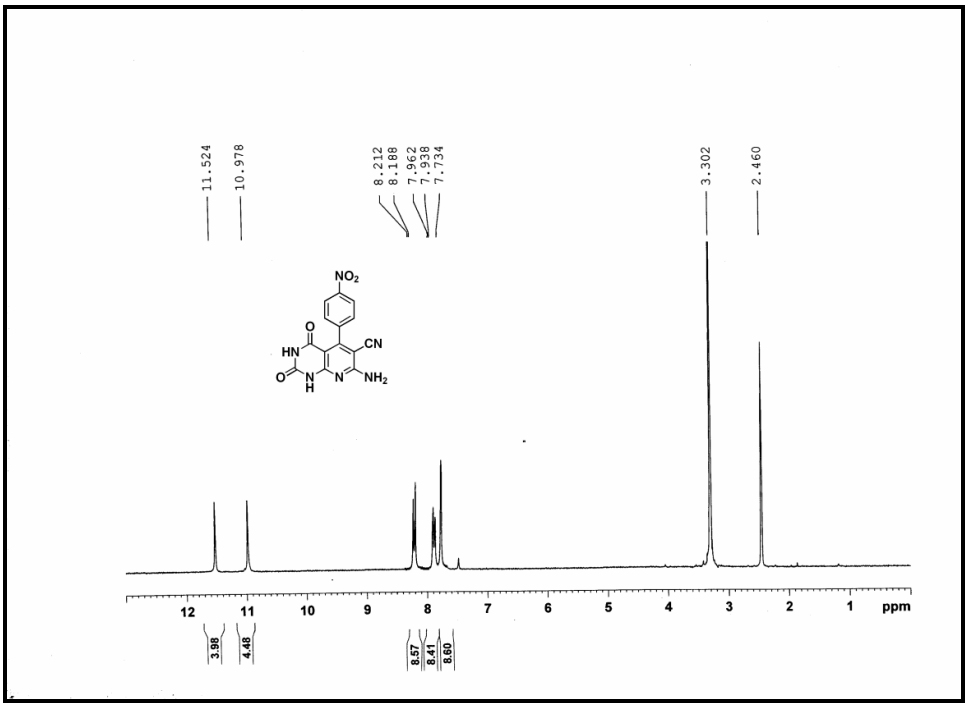
^{13}C NMR spectra of compound 4b



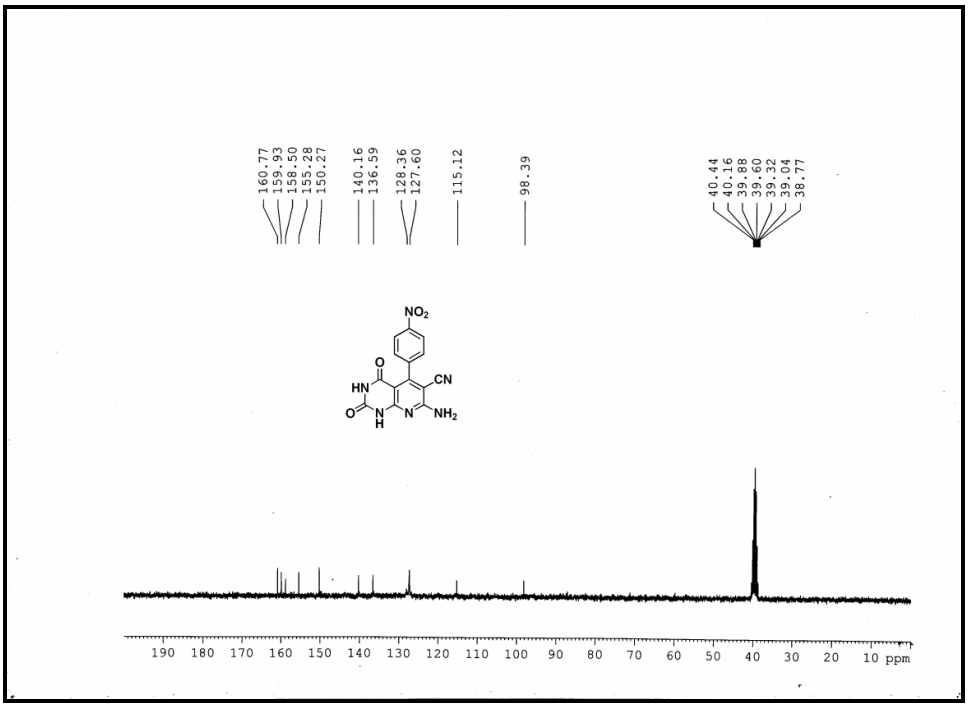
^{1}H NMR spectra of compound 4c



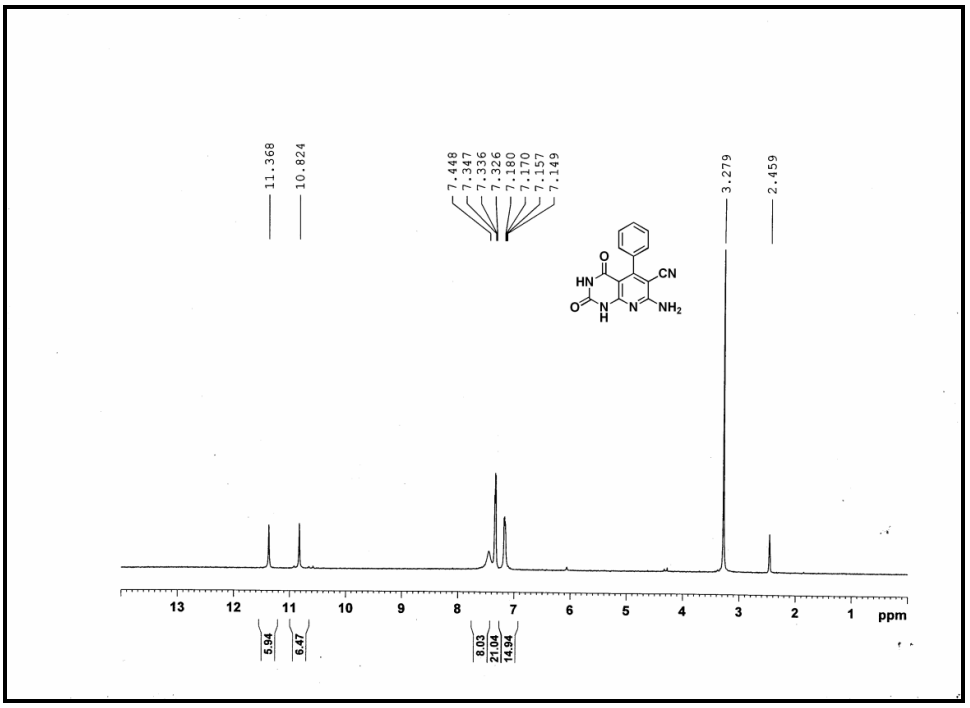
^{13}C NMR spectra of compound 4c



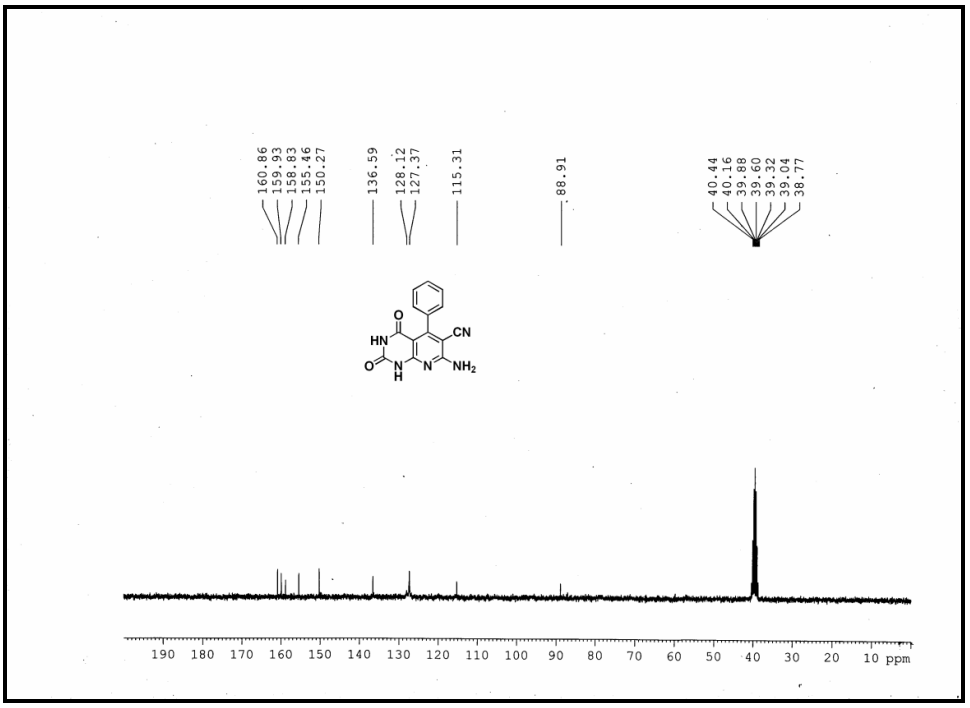
^{1}H NMR spectra of compound 4d



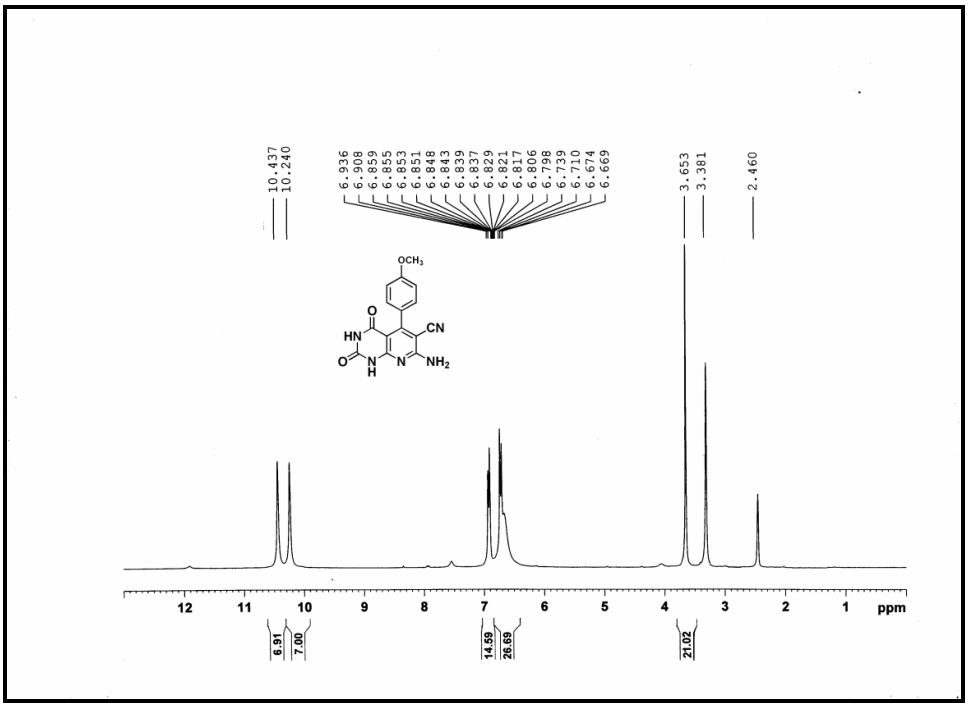
^{13}C NMR spectra of compound 4d



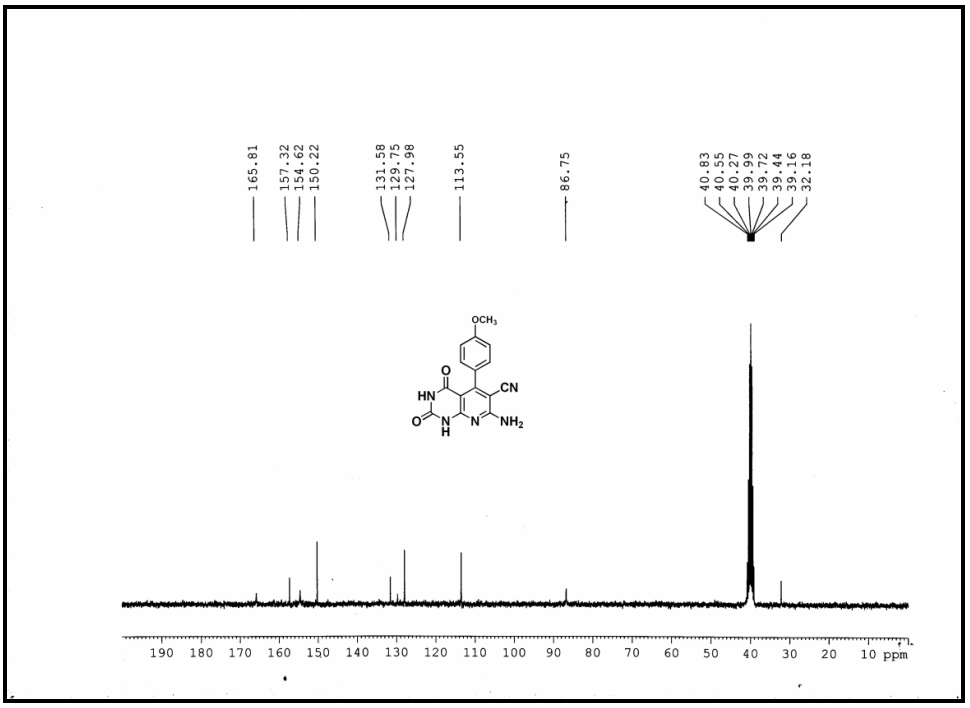
^{1}H NMR spectra of compound 4e



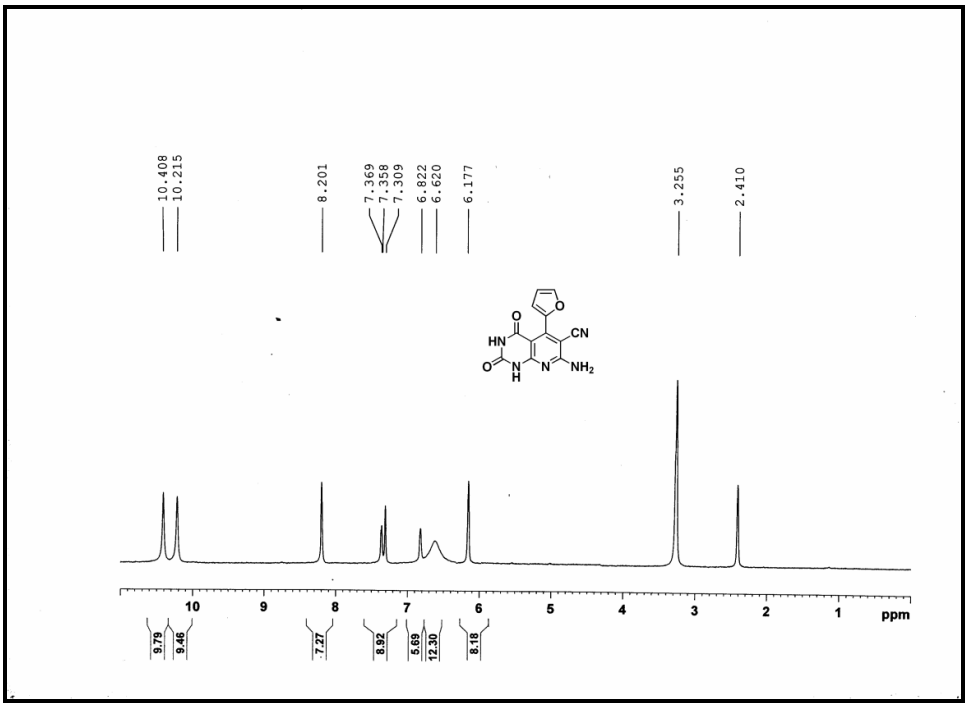
^{13}C NMR spectra of compound 4e



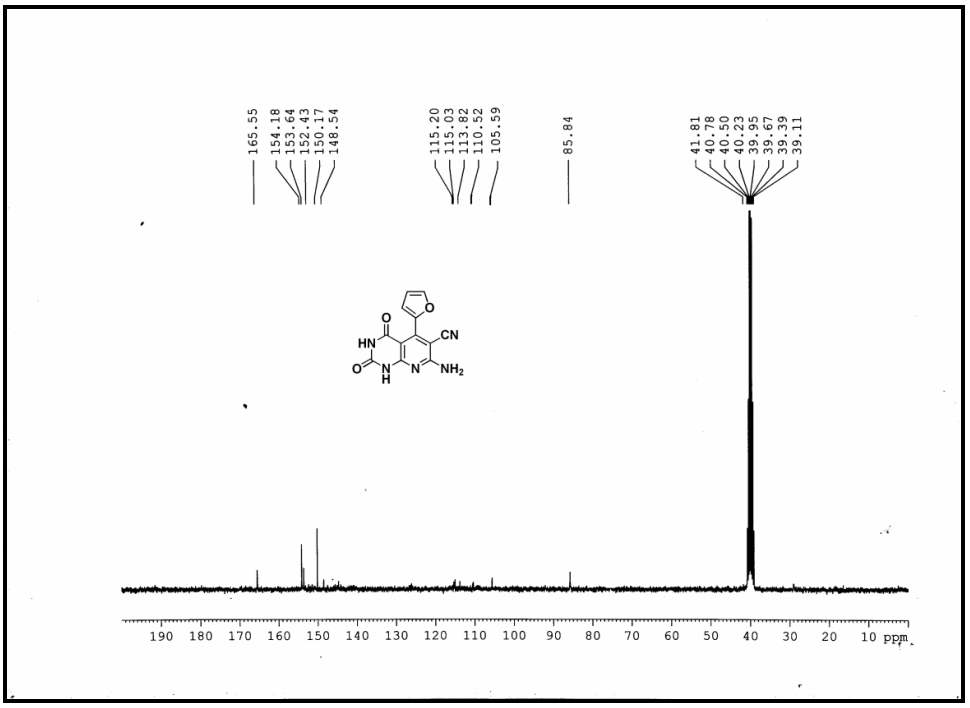
^{1}H NMR spectra of compound 4f



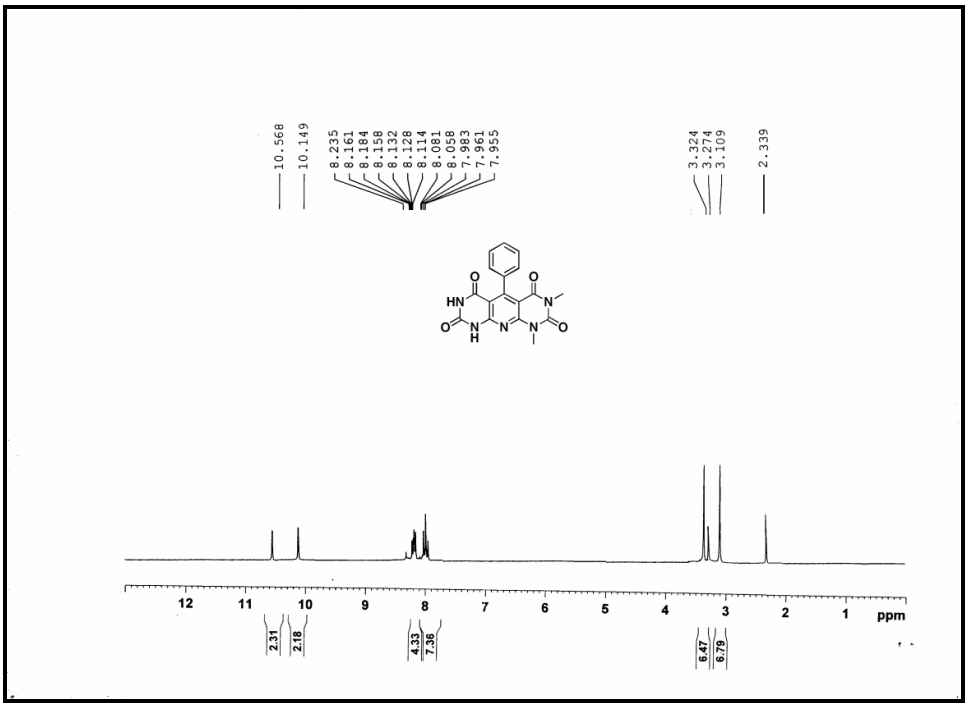
^{13}C NMR spectra of compound 4f



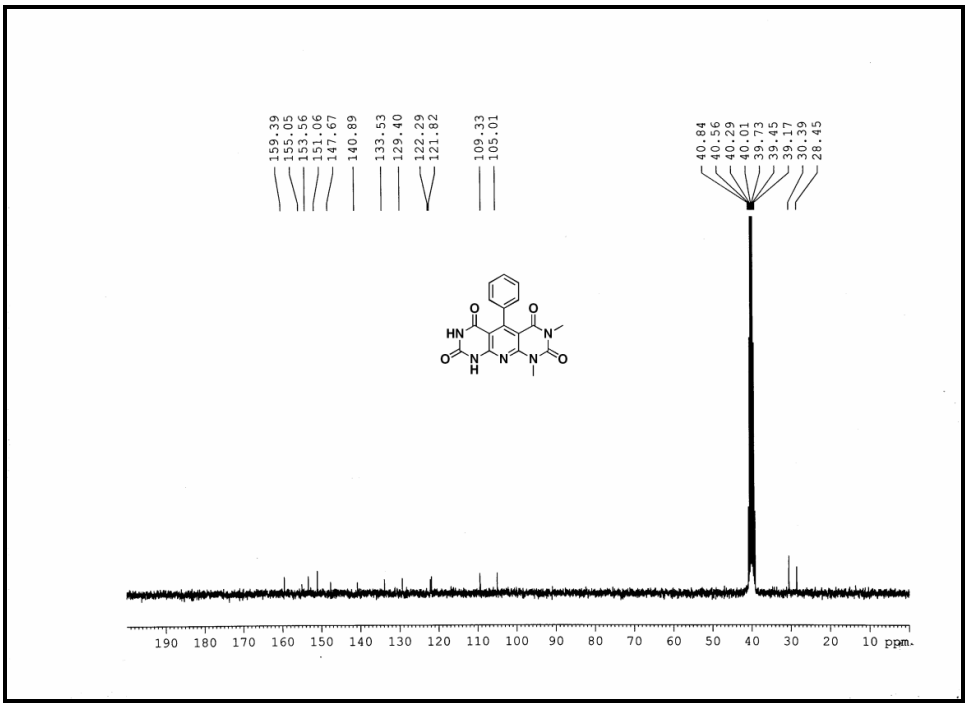
^{1}H NMR spectra of compound 4g



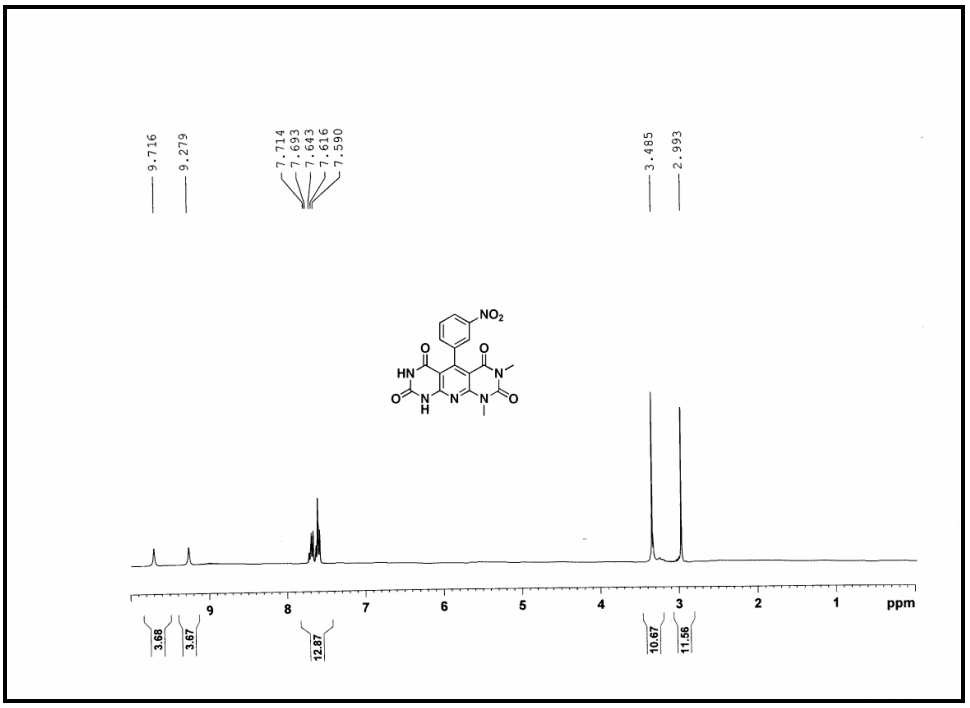
^{13}C NMR spectra of compound 4g



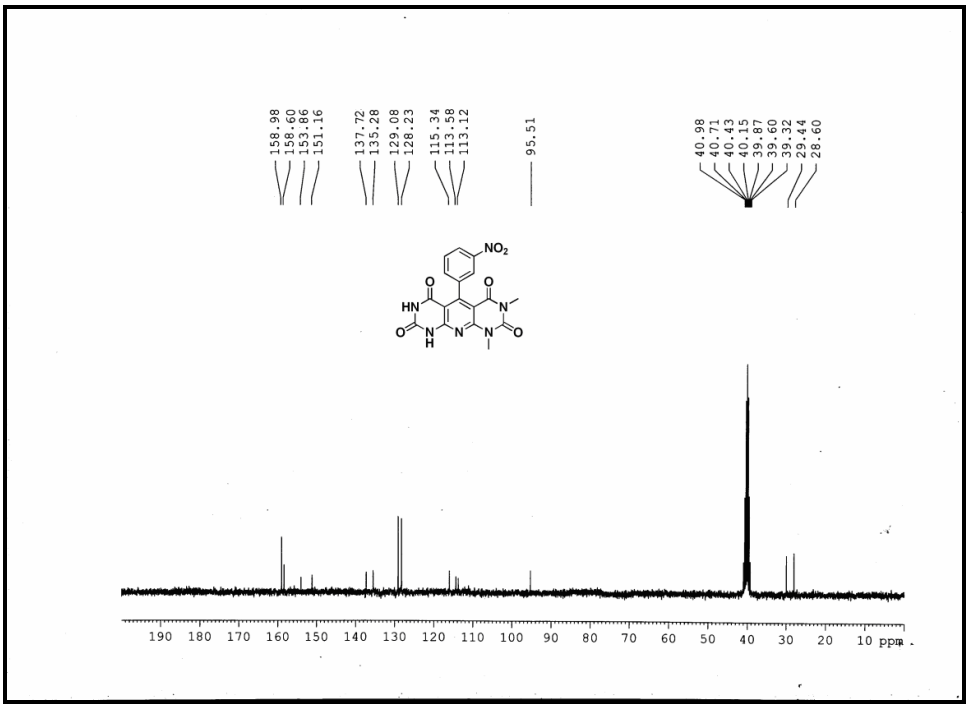
^{1}H NMR spectra of compound 4h



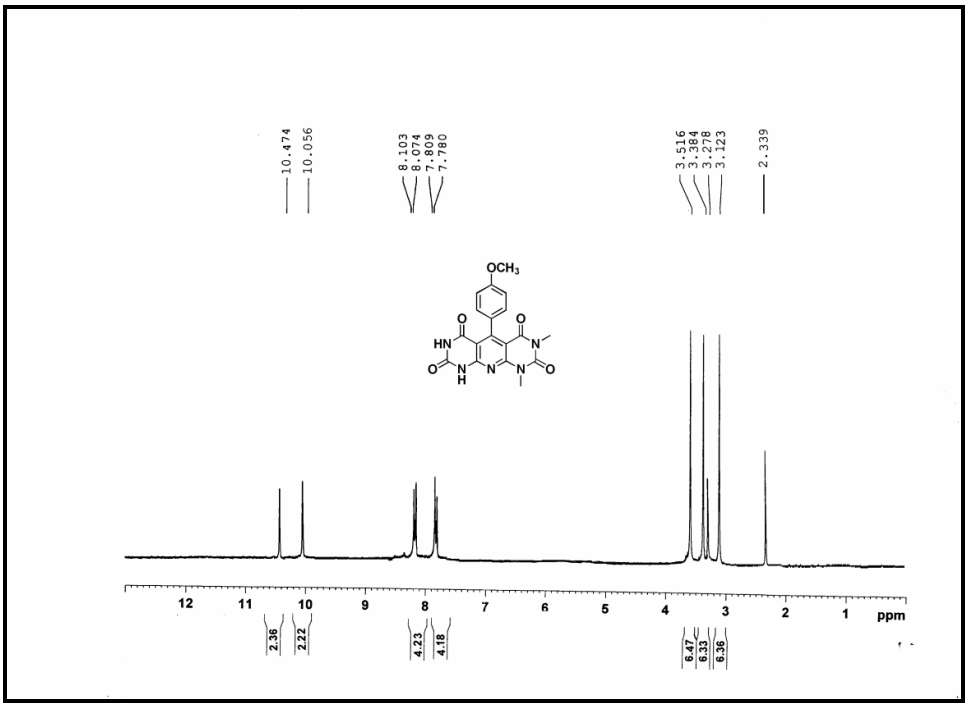
^{13}C NMR spectra of compound 4h



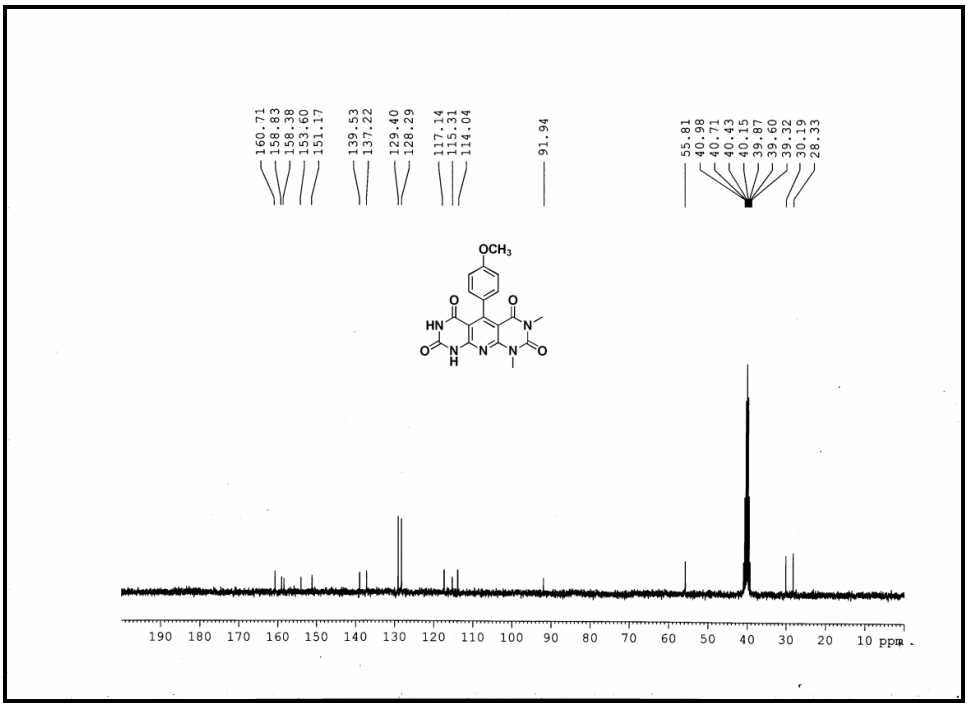
^{1}H NMR spectra of compound 4i



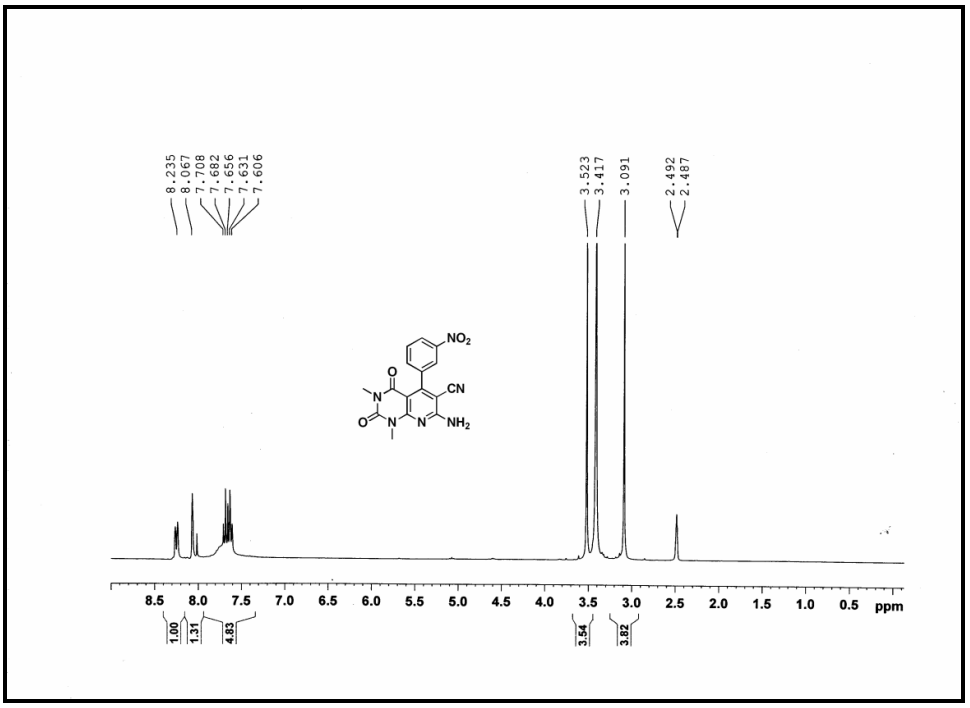
^{13}C NMR spectra of compound 4i



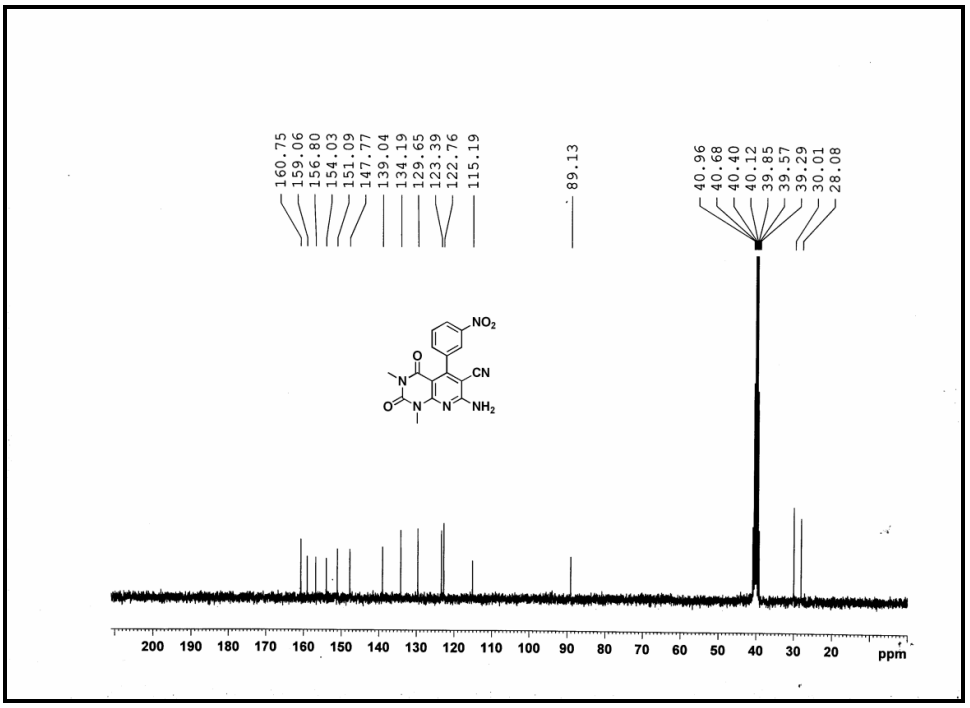
^{1}H NMR spectra of compound 4j



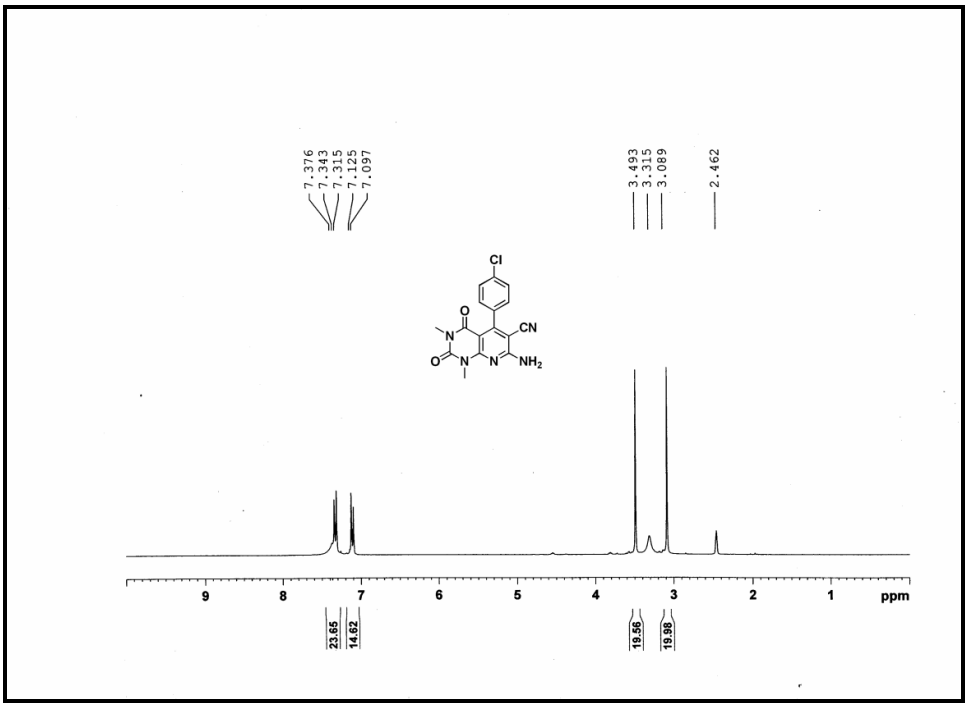
^{13}C NMR spectra of compound 4j



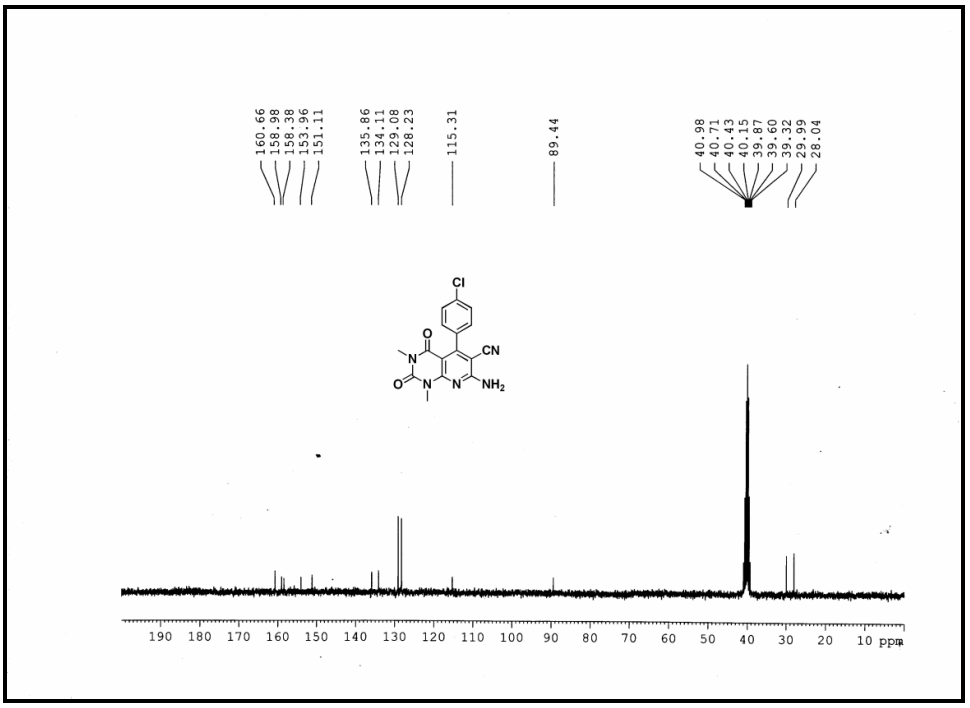
^{1}H NMR spectra of compound 4k



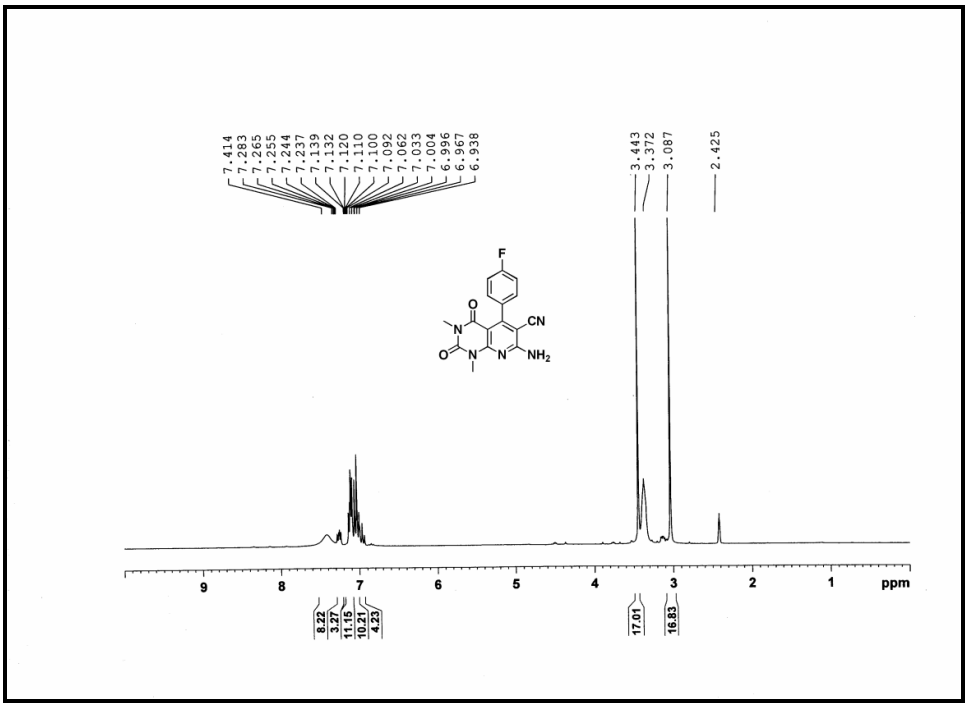
^{13}C NMR spectra of compound 4k



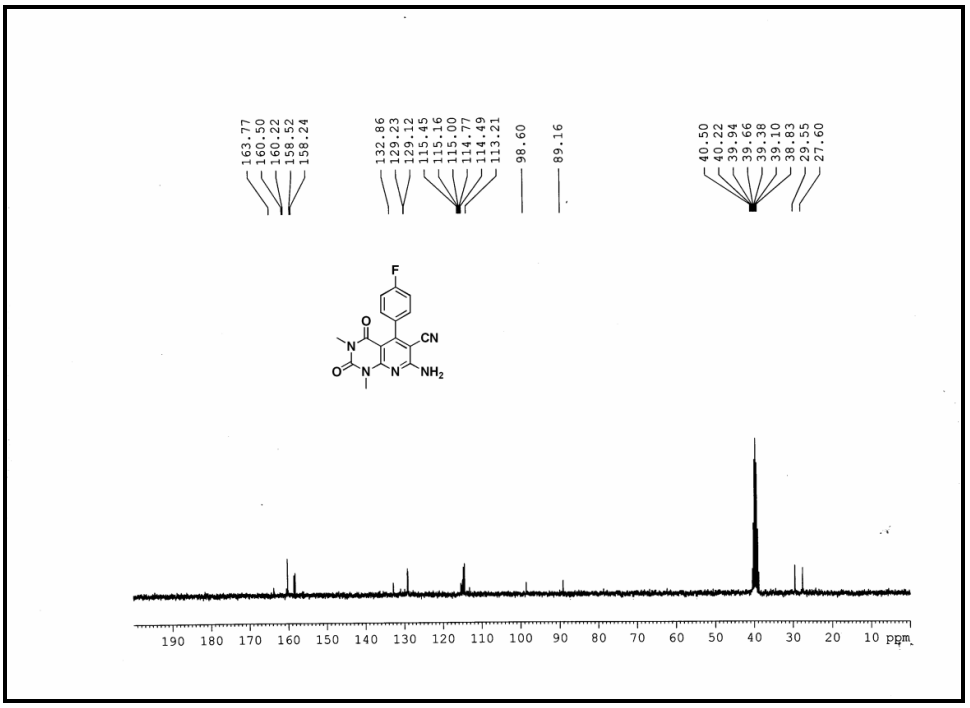
^{1}H NMR spectra of compound 4l



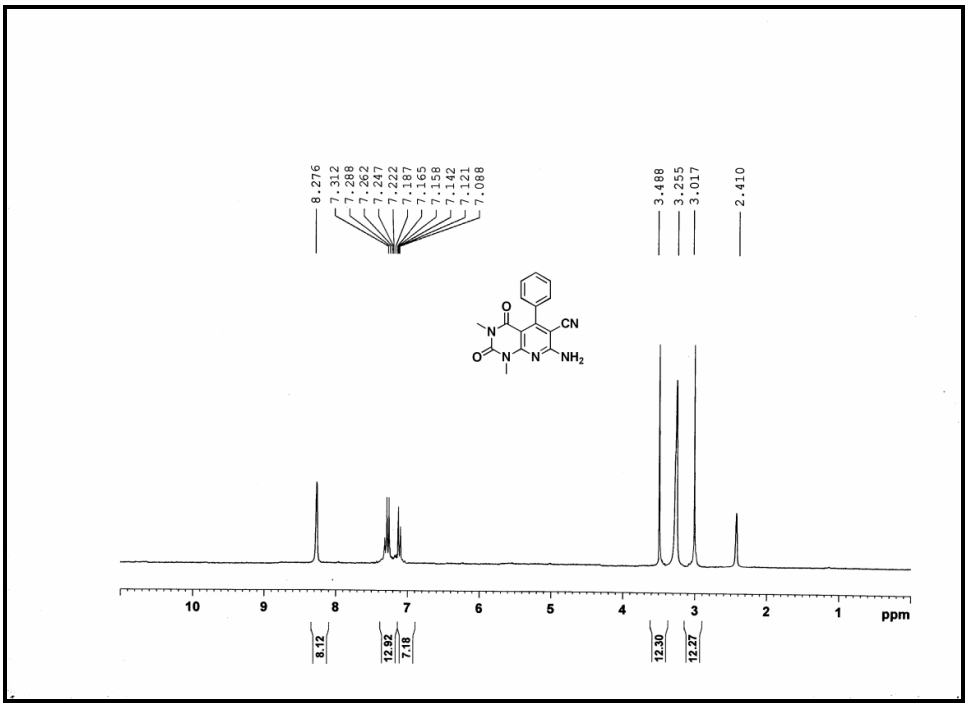
^{13}C NMR spectra of compound 4l



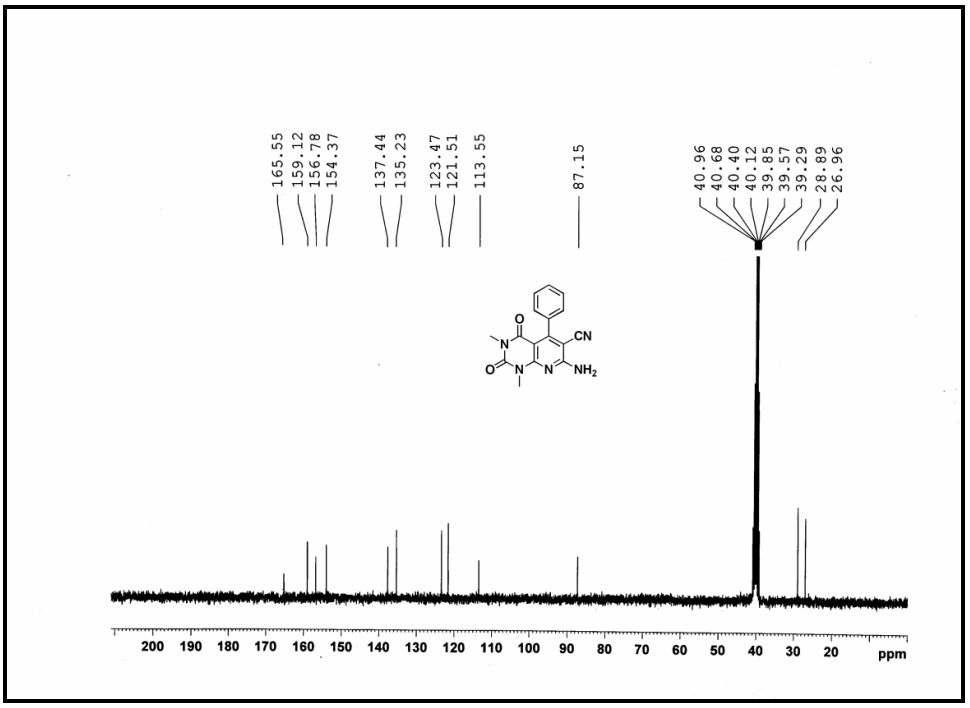
^{1}H NMR spectra of compound 4m



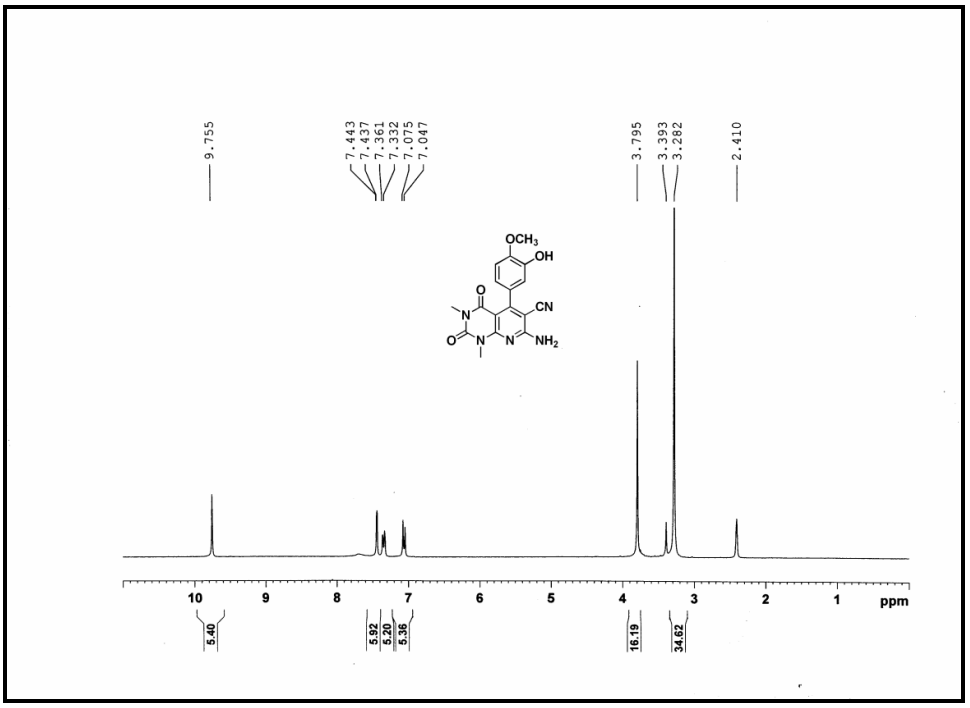
^{13}C NMR spectra of compound 4m



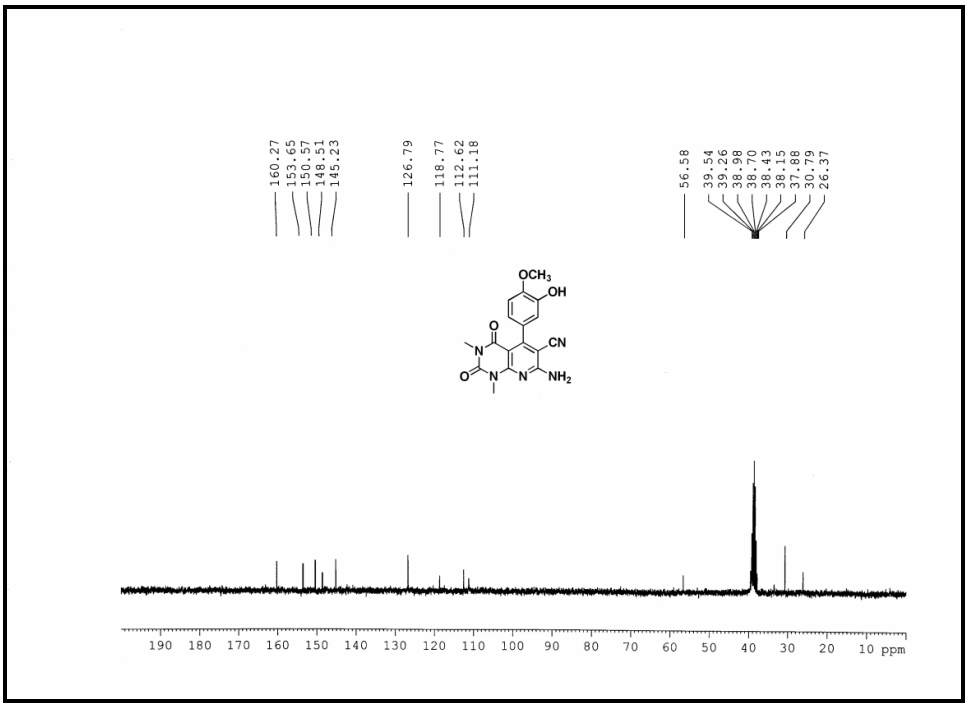
^{1}H NMR spectra of compound 4n



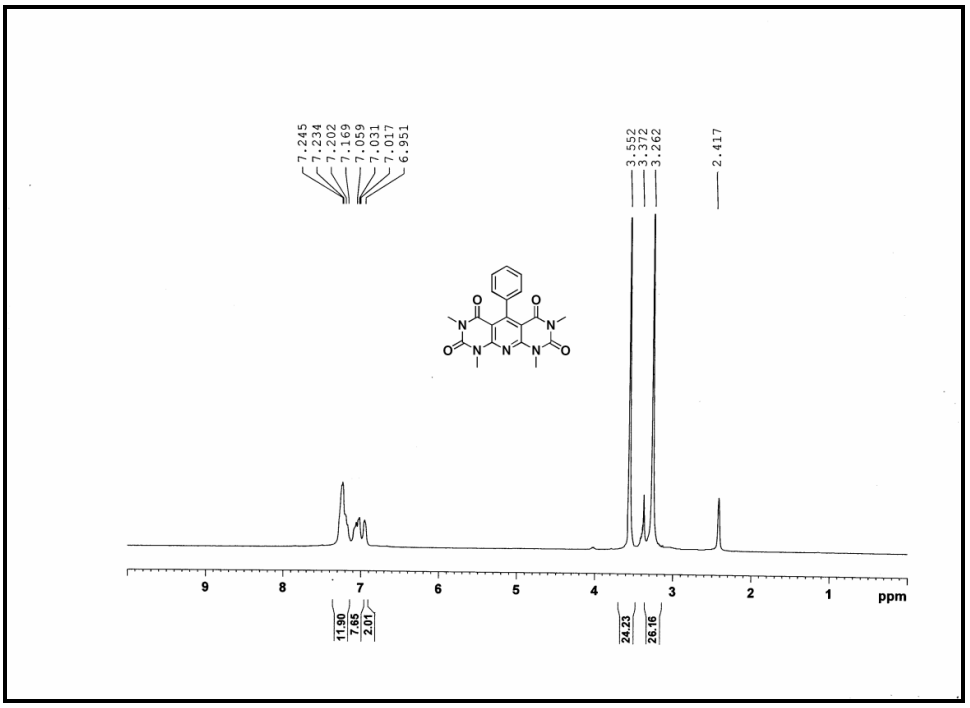
^{13}C NMR spectra of compound 4n



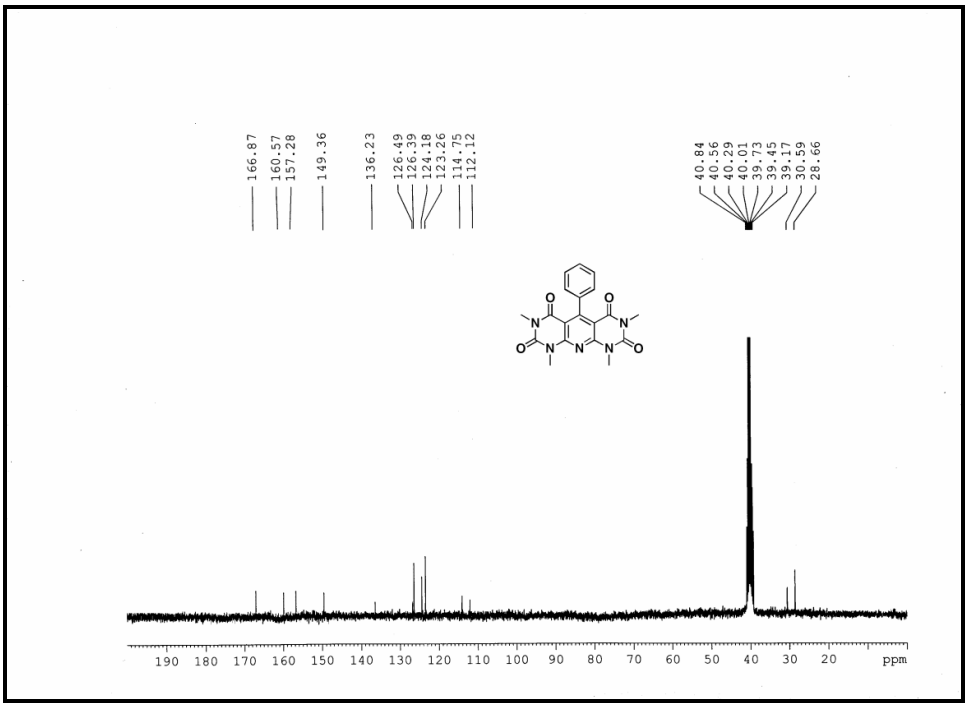
^{1}H NMR spectra of compound 4p



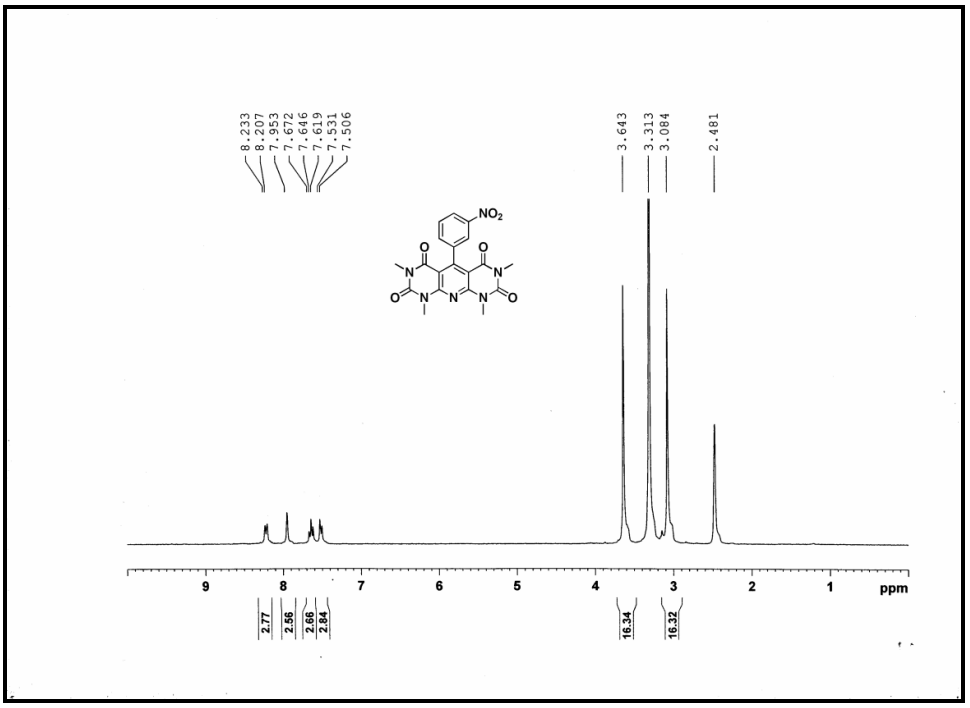
^{13}C NMR spectra of compound 4p



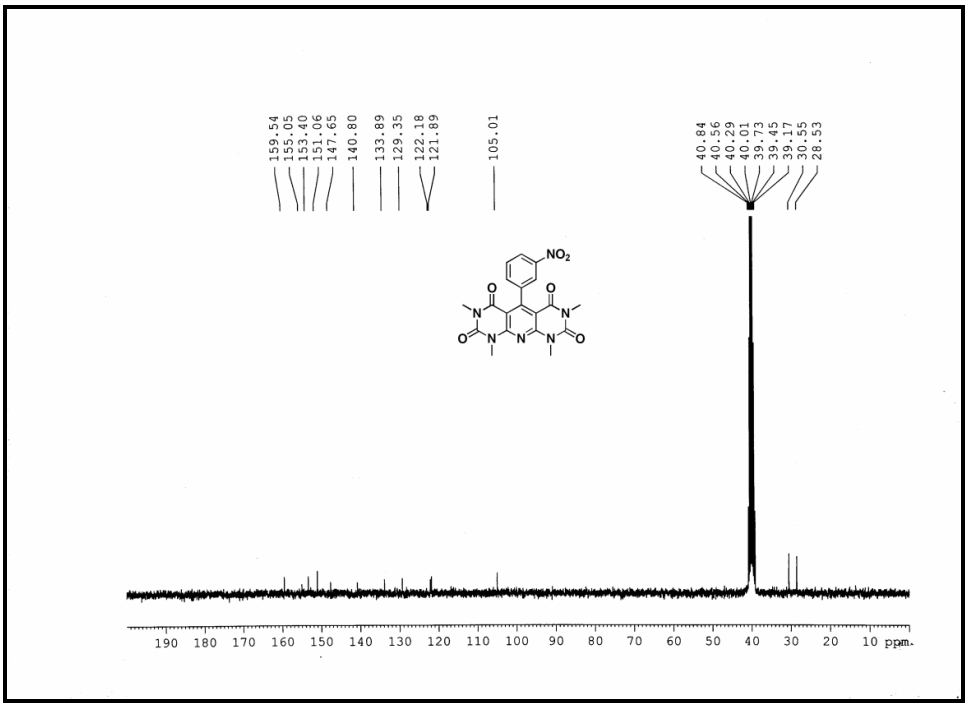
^{1}H NMR spectra of compound 4q



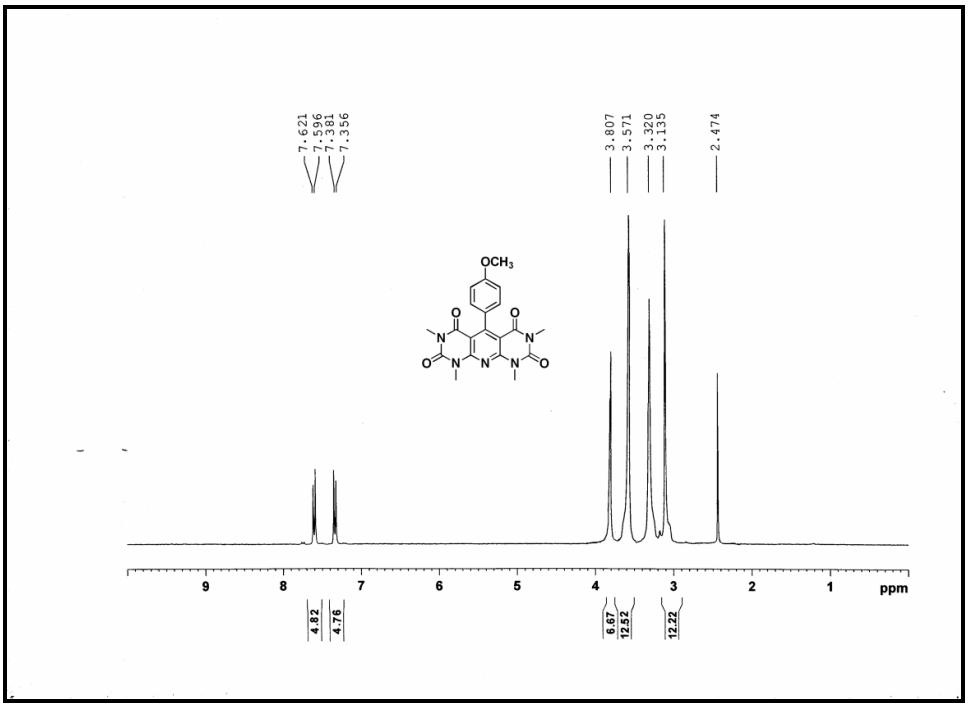
^{13}C NMR spectra of compound 4q



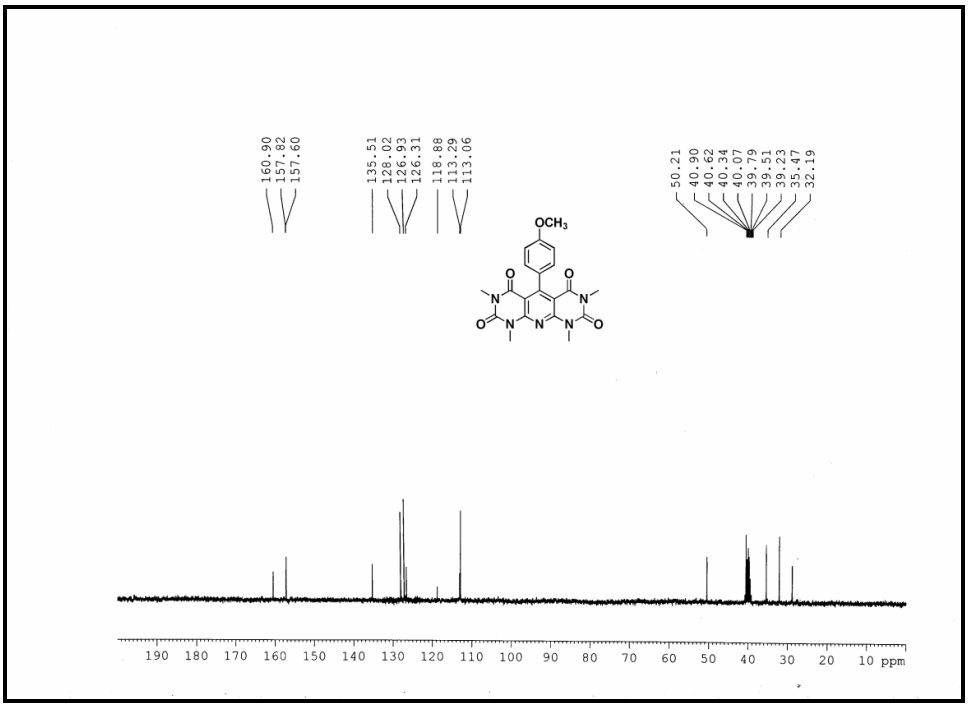
^{1}H NMR spectra of compound 4r



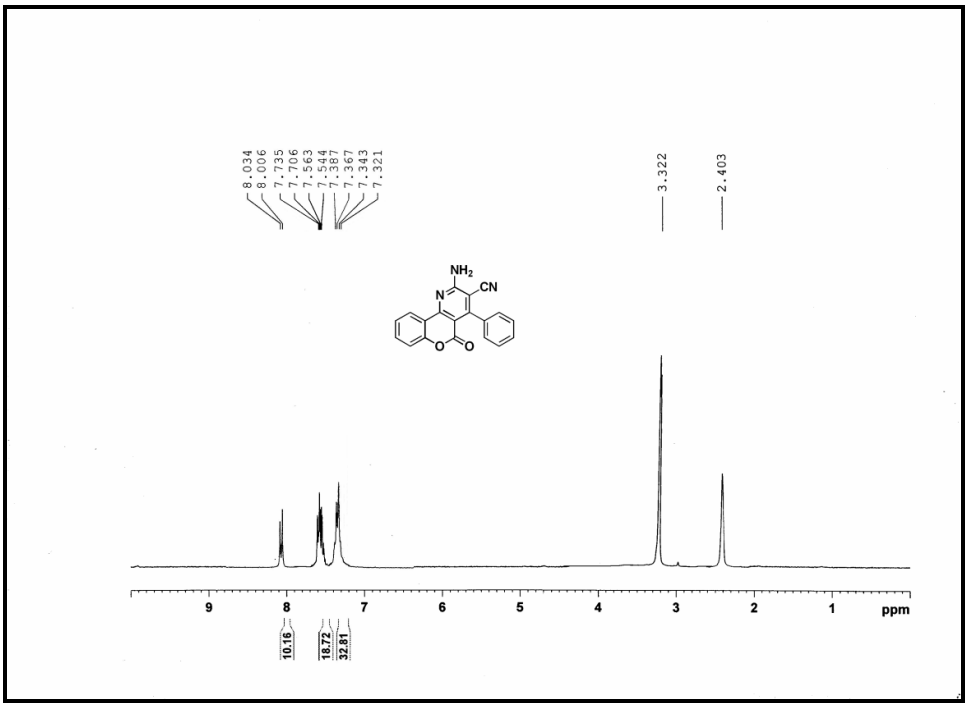
^{13}C NMR spectra of compound 4r



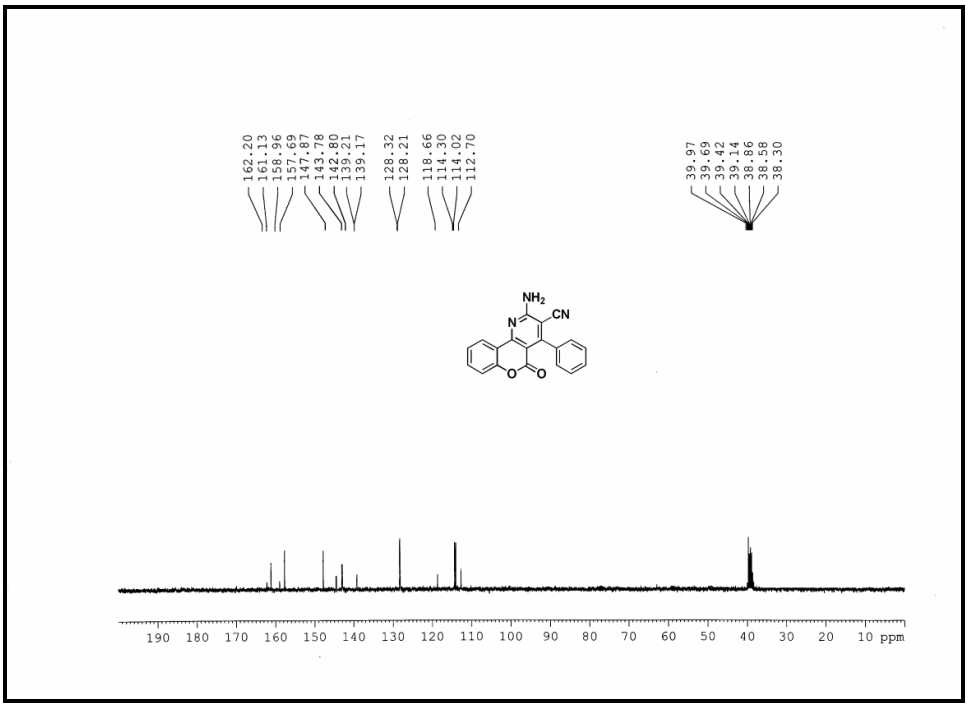
^{1}H NMR spectra of compound 4s



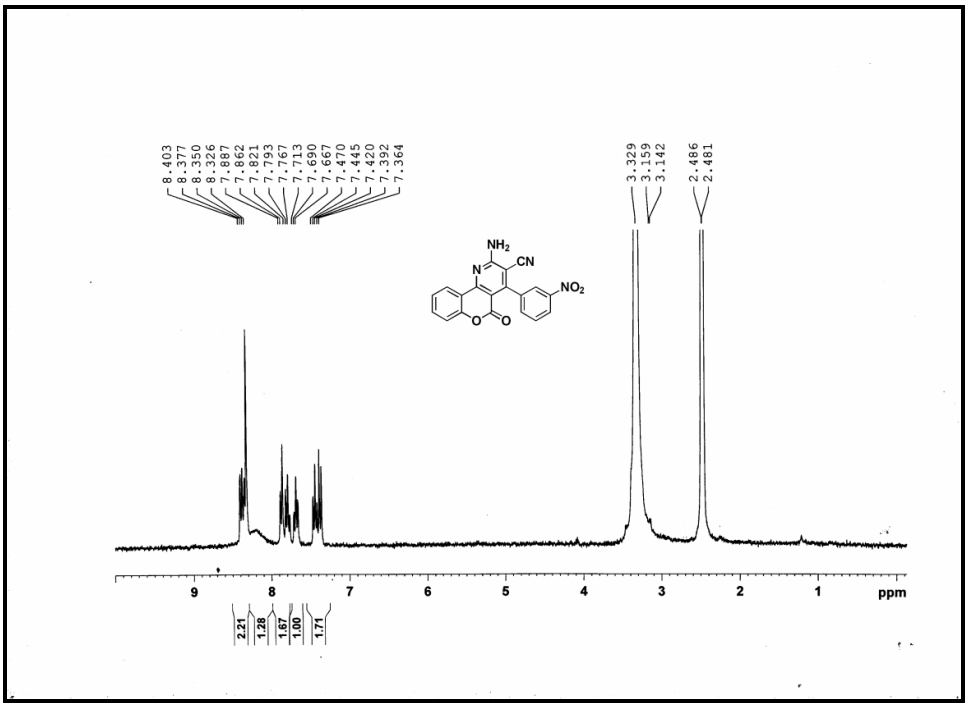
^{13}C NMR spectra of compound 4s



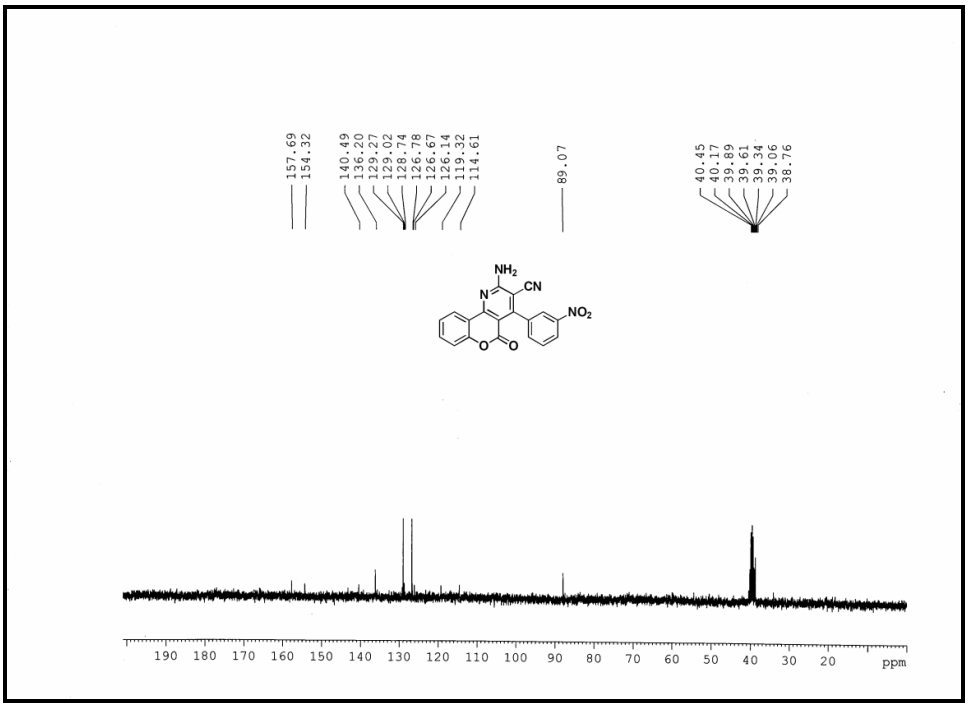
^{1}H NMR spectra of compound 4t



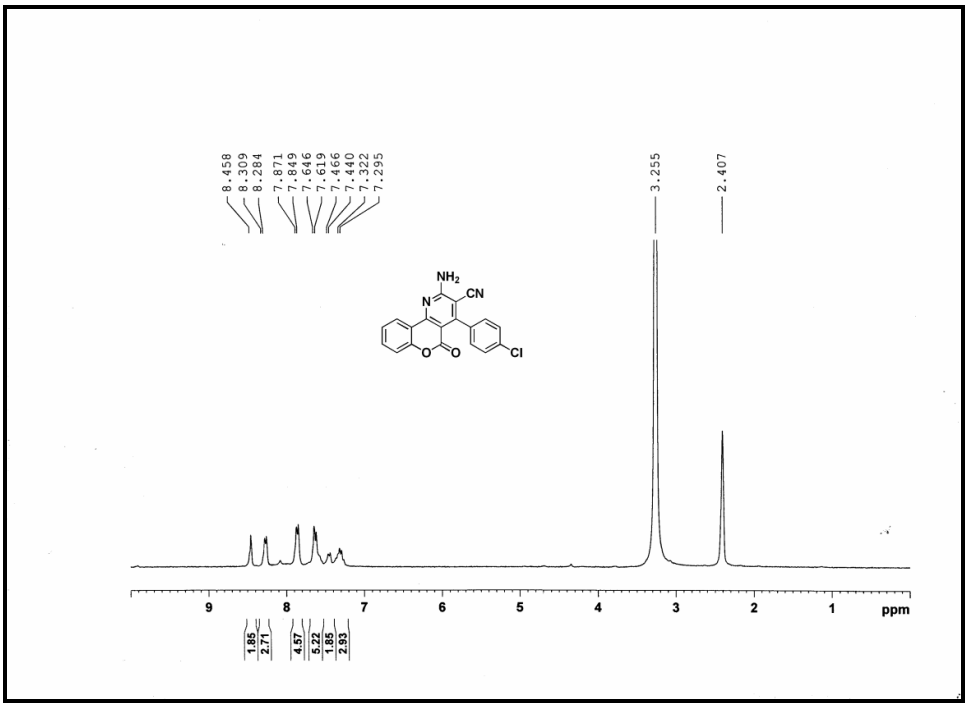
^{13}C NMR spectra of compound 4t



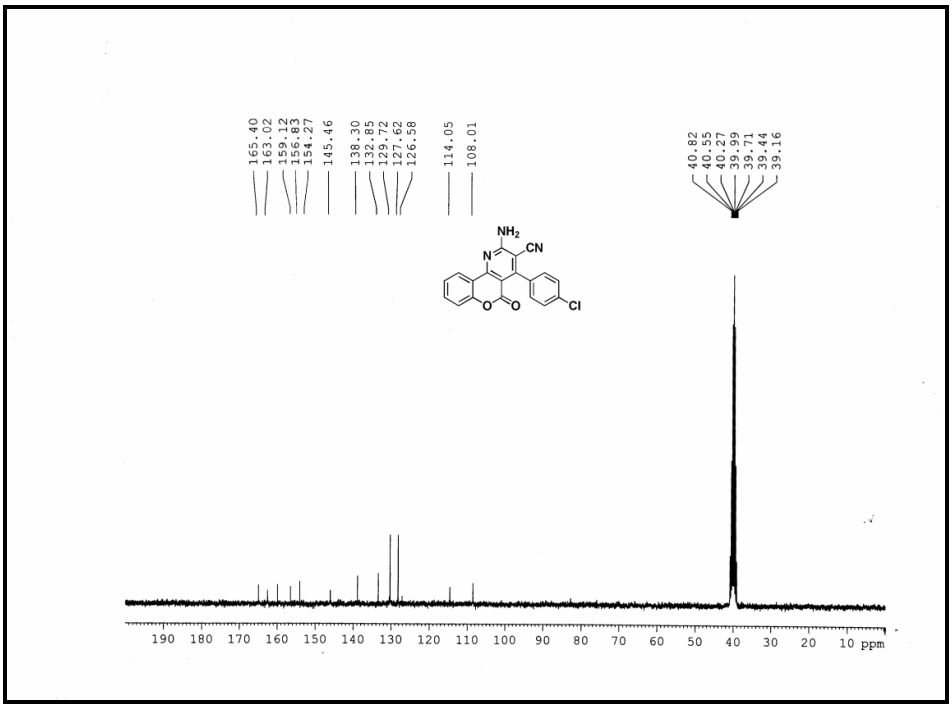
^{1}H NMR spectra of compound 4u



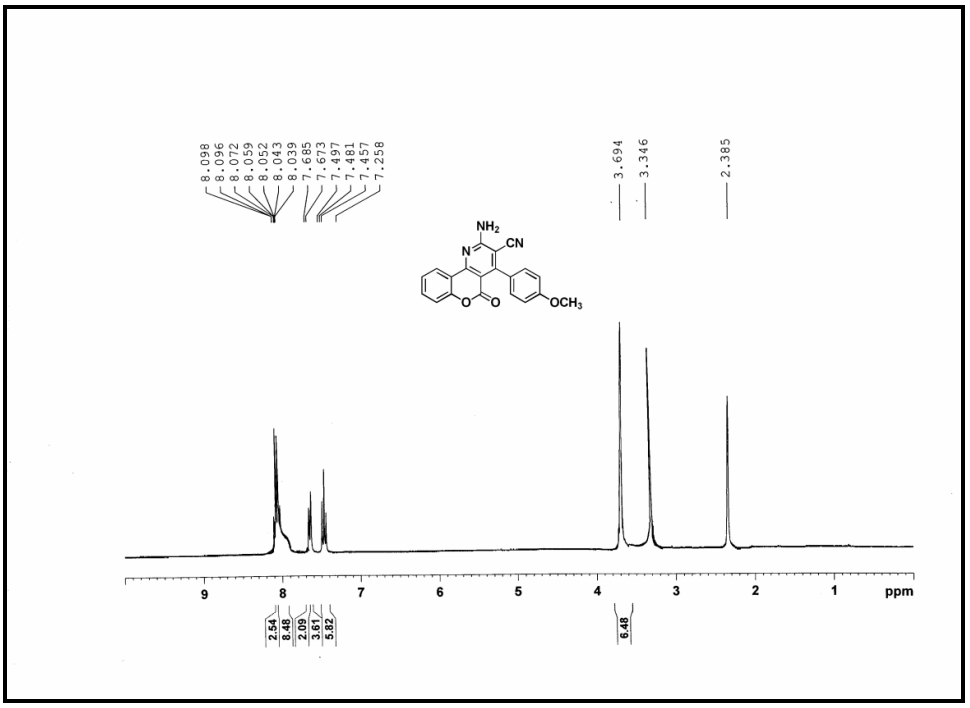
^{13}C NMR spectra of compound 4u



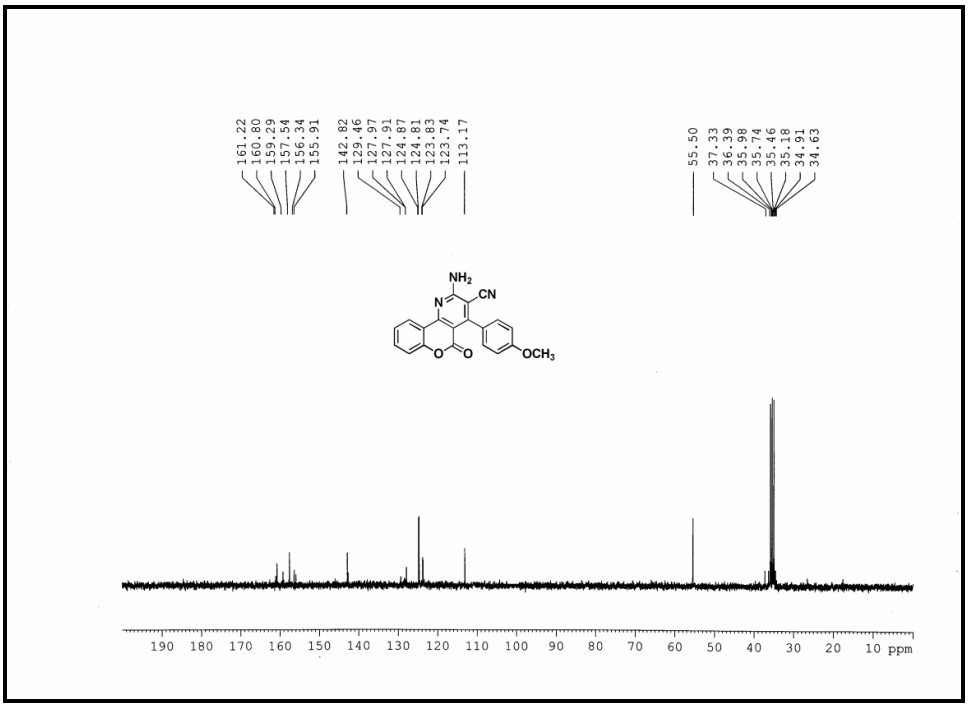
[1]H NMR spectra of compound 4v



[13]C NMR spectra of compound 4v



^{1}H NMR spectra of compound 4w



^{13}C NMR spectra of compound 4w