Supplementary Information

Efficient conjugate addition of 3-methyl-5-pyrazolones to chalcones in water extract rice straw ash (WERSA)

Shanta Raj Lakshmi, Vipin Singh & L Raju Chowhan*

Centre for Applied Chemistry, Central University of Gujarat, Sector 30, Gandhinagar 382 030, India

E-mail: rajuchowhan@gmail.com

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Experimental Section

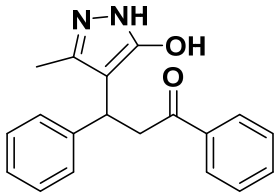
General experimental details

All commercially available chemicals were used without further purification. ^{1}H NMR spectra were obtained on Bruker 500 MHz FT-NMR spectrometers. ^{13}C NMR spectra were recorded at 125 MHz. Chemical shifts are reported in relative to the TMS signal. Multiplicity is indicated as follows: s (singlet); bs (broad singlet); d (doublet); t (triplet); q (quartet); m (multiplet); dd (doublet of doublets), etc. IR spectra were recorded on FT-IR-5700 instrument.TOF and quadrupole mass analyzer types are used for the HRMS measurements

General experimental procedure for the reaction

Chalcone **1a** (1 mmol), pyrazole**2** (1 mmol) was added in a round bottom flask containing 4 mL of WERSA: MeOH (1:1). The mixture was stirred for 2h at room temperature. Progress of the reaction was determined by thin-layer chromatography (TLC). After completion of the reaction, solid crude was filtered, washed with cold methanol and dried under vacuum to afford product **3a-k**as a solid.

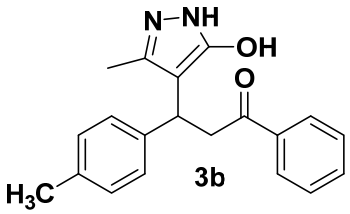
Spectral data for 3a-k



3a

3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1,3-diphenylpropan-1-one (3a)

TLC (SiO_2): R_f=0.7(70%EtOAc/Hexane); M.P.155-160°C; IR (KBr) υ_{max} (cm^{-1}): 3064, 3028,2924, 2612, 1594,1497,1388.84, 1359.48, 1312.51, 1157.79, 1134.85, 1094.30, 1021.79, 907.12, 867.89, 836.02, 802.17,cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ7.93 (d, J = 7.5 Hz, 2H), 7.53 (dd, J = 17.9, 11.4 Hz, 2H), 7.42 (d, J = 6.8 Hz, 4H), 7.30 – 7.20 (m, 3H), 7.18 – 7.11 (m, 1H), 4.50 (d, J = 6.1 Hz, 1H), 4.07 (dd, J = 17.1, 8.1 Hz, 1H), 3.58 (dd, J = 17.3, 5.9 Hz, 1H), 2.13 (s, 3H); ^{13}C NMR (126 MHz, DMSO)197.5, 159.1, 144.0, 135.9, 131.7, 127.3, 127.0, 126.7, 126.3, 124.6, 120.1, 117.3, 40.6, 24.5, 9.1.HRMS (ESI+): *m/z* calculated for $C_{19}H_{19}N_2O_2$ $[M+H]^+$: 307.1446; found: 307.1468.

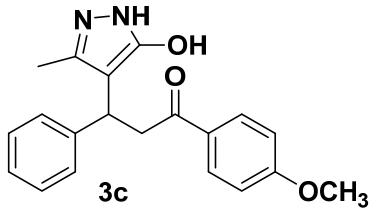


3b

3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenyl-3-(p-tolyl)propan-1-one (3b)

TLC (SiO_2): R_f=0.7(70%EtOAc/Hexane);M.P.148-152°C; IR (KBr) υ_{max} (cm^{-1}): 3326, 3138, 2925, 2561, 1894, 1684, 1335, 1308, 1285, 1253, 1158, 1088, 1039, 1014, 1001, 867, 826cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (d, J = 6.9 Hz, 2H), 7.42 (s, 1H), 7.29 (dd, J = 15.6, 11.6 Hz, 3H), 7.24 (d, J = 6.8 Hz, 2H), 6.97 (d, J = 6.9 Hz, 2H), 4.40 (s, 1H), 3.99 (d, J = 8.3 Hz, 1H), 3.48 (d, J = 12.6 Hz, 1H), 2.20 (s, 3H), 2.08 (d, J = 31.2 Hz, 3H);^{13}C NMR (126 MHz, DMSO) δ 198.4, 159.9, 141.5, 137.1, 136.6, 134.8, 134.5, 132.2, 128.2, 127.8, 127.3,

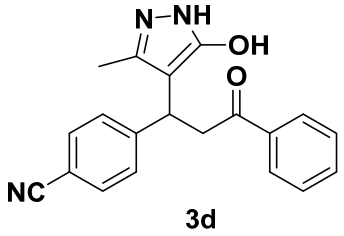
126.8, 102.8, 42.6, 20.3, 9.7.HRMS (ESI+): *m/z* calculated for $C_{20}H_{21}N_2O_2$ $[M+H]^+$:321.1603; found: 321.1632.



3c

3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-(4-methoxyphenyl)-3-phenylpropan-1-one (3c)

TLC (SiO_2): R_f=0.6 (70%EtOAc/Hexane);M.P.115-118°C; IR (KBr) υ_{max} (cm^{-1}): 3151, 3138, 3118, 3030, 2835, 1889, 1683, 1609, 1303, 1216, 1110, 1076, 1001,829, 802, cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, J = 7.8 Hz, 3H), 7.36 (d, J = 6.8 Hz, 4H), 7.26 (s, 2H), 6.80 (d, J = 8.1 Hz, 2H), 4.52 – 4.47 (m, 1H), 4.09 (dd, J = 17.4, 8.6 Hz, 1H), 3.75 (s, 3H), 3.71 (dd, J = 12.3, 6.1 Hz, 2H), 3.52 (dd, J = 17.4, 5.3 Hz, 1H), 2.16 (d, J = 9.8 Hz, 3H);^{13}C NMR (126 MHz, $CDCl_3$) δ 199.1, 160.6, 157.5, 137.1, 132.6, 128.4, 128.3, 127.8, 114.3, 113.7, 113.4, 103.5, 55.0, 43.5, 34.7, 10.2; HRMS (ESI+): *m/z* calculated for$C_{20}H_{21}N_2O_3$ $[M+H]^+$: 337.1552; found:337.1593.

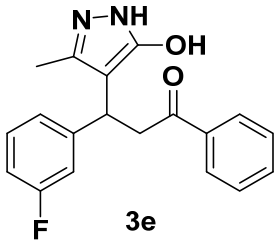


3d

4-(1-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-3-oxo-3-phenylpropyl)benzonitrile (3d)

TLC (SiO_2): R_f=0.7(70%EtOAc/Hexane);M.P.255-260°C; IR (KBr) υ_{max} (cm^{-1}): 3333, 3137, 2556, 2226, 1683, 1666,1370, 1315, 1288, 1253, 1180, 1038, 1013, 1001, 955, 987, 926, 873, 834cm^{-1}; ^{1}H NMR (500 MHz, DMSO) δ 7.94 (d, J = 7.3 Hz, 2H), 7.60-7.50 (m, 6H), 7.44 (t, J = 7.5 Hz, 2H), 4.55 (t, J = 6.9 Hz, 1H), 4.04 (dd, J = 17.7, 7.6 Hz, 1H), 3.66 (dd, J = 17.6, 6.6 Hz, 1H),2.15 (s, 3H);^{13}C NMR (126 MHz, $CDCl_3$) δ 196.5, 158.5, 149.5, 136.0, 135.4,

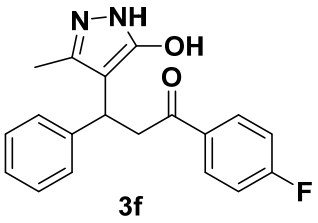
131.6, 130.5, 127.1, 126.4, 117.4, 107.6, 100.5, 40.9, 34.1, 8.7.HRMS (ESI+): *m/z* calculated for$C_{20}H_{18}N_3O_2$ $[M+H]^+$: 332.1399; found: 332.1407.



3e

3-(3-fluorophenyl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenylpropan-1-one (3e)

TLC (SiO_2): R_f=0.6(80%EtOAc/Hexane);M.P.185-190°C;IR (KBr) υ_{max} (cm^{-1}): 3342, 3151, 3138, 3119, 1679, 1639, 1611, 1598, 1586, 1529,1400, 1403, 1330, 1296, 1074, 1043, 1002,792, 769, 754, 741, 706cm^{-1};^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94 (d, J = 7.4 Hz, 2H), 7.58 – 7.47 (m, 2H), 7.43 (t, J = 7.3 Hz, 2H), 7.20 (d, J = 8.4 Hz, 3H), 6.83 (d, J = 7.5 Hz, 1H), 4.50 (t, J = 6.7 Hz, 1H), 4.03 (dd, J = 17.3, 8.0 Hz, 1H), 3.60 (dd, J = 17.3, 6.1 Hz, 1H), 2.16 (s, 3H),^{13}C NMR (126 MHz, $CDCl_3$) δ 197.7, 162.7, 159.6, 147.2, 136.1, 136.2, 132.1, 128.9, 127.7, 122.6, 113.5, 111.7, 101.9, 42.1, 34.5, 9.4.HRMS (ESI+): *m/z* calculated for$C_{19}H_{18}FN_2O_2$[M+H]$^+$: 325.1352; found: 325.1385.

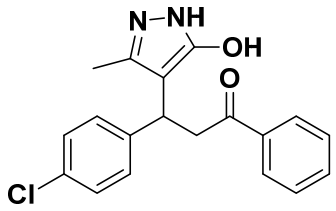


3f

1-(4-fluorophenyl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-3-phenylpropan-1-one (3f)

TLC (SiO_2): R_f=0.7 (80%EtOAc/Hexane);M.P.182-187°C; IR (KBr) υ_{max} (cm^{-1}): 3342, 3151, 3138, 3119, 1679, 1639, 1611,1330, 1296, 1074, 1043, 1002, 986, 934, 916, 897, 837, 807cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, J = 7.3 Hz, 2H), 7.57 – 7.46 (m, 2H), 7.40 (dd, J = 20.5, 13.4 Hz, 3H), 7.26 (s, 1H), 7.19 (s, 3H), 6.85 (d, J = 6.7 Hz, 1H), 4.52 (s, 1H), 4.11 (dt, J = 17.1, 7.4 Hz, 1H), 3.55 (dd, J = 17.5, 4.6 Hz, 1H), 2.15 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 197.3, 158.7, 139.9, 135.8, 131.7, 127.9, 127.9, 127.3, 126.7, 126.6, 113.6,

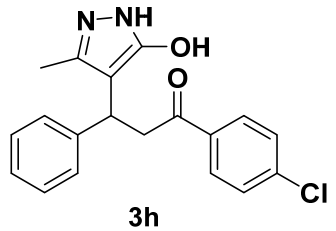
113.5, 41.9, 33.7,9.0.HRMS (ESI+): *m/z* calculated for$C_{19}H_{18}FN_2O_2[M+H]^+$: 325.1352; found: 325.1385.



3g

3-(4-chlorophenyl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenylpropan-1-one (3g)

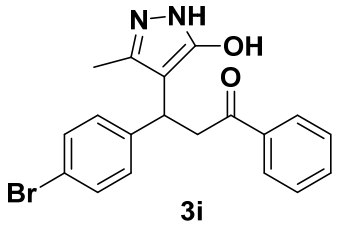
TLC (SiO_2): R_f=0.6 (80%EtOAc/Hexane);M.P.206-208°CIR (KBr) υ_{max} (cm^{-1}): 3151, 3138, 1676, 1612, 1508, 1403, 1400, 1324, 1277, 1258, 1147, 1095, 9867, 939, 874, 835cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, J = 7.5 Hz, 2H), 7.63 (s, 1H), 7.54 (t, J = 7.1 Hz, 1H), 7.49 – 7.36 (m, 4H), 7.19 (d, J = 8.2 Hz, 2H), 4.46 (t, J = 7.0 Hz, 1H), 4.01 (dd, J = 17.3, 7.9 Hz, 1H), 3.58 (dd, J = 17.3, 6.4 Hz, 1H),2.13 (s, 3H);^{13}C NMR (126 MHz, DMSO) δ 197.6, 159.4, 143.0, 136.8, 136.1, 132.0, 130.2, 128.2, 127.6, 127.2, 126.1, 101.9, 42.0, 34.1, 9.4.HRMS (ESI+): *m/z* calculated for$C_{19}H_{18}ClN_2O_2[M+H]^+$:341.1056; found: 341.1085.



3h

1-(4-chlorophenyl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-3-phenylpropan-1-one (3h)

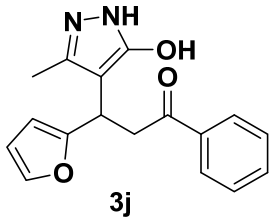
TLC (SiO_2): R_f=0.7(80%EtOAc/Hexane);M.P.205-209°C; IR (KBr) υ_{max} (cm^{-1}): 3151, 3138,1676, 1612, 1508, 1403, 1400, 1324,1095, 9867, 939, 874, 835cm^{-1}; ^1H NMR (500 MHz, DMSO) δ 7.87 (dd, J = 29.5, 9.0 Hz, 2H), 7.40 (dd, J = 17.4, 7.7 Hz, 4H), 7.22 (t, J = 7.2 Hz, 2H), 7.12 (t, J = 7.0 Hz, 1H), 4.43 (t, J = 6.7 Hz, 1H), 4.03 (dd, J = 17.1, 8.4 Hz, 1H), 3.51 (dd, J = 17.1, 5.6 Hz, 1H),2.10 (s, 3H);^{13}C NMR (126 MHz, DMSO) δ 196.5, 159.1, 143.9, 137.6, 136.5, 134.4, 128.4, 127.6, 127.1, 126.4, 124.8, 101.9, 41.8, 34.5, 9.2.HRMS (ESI+): *m/z* calculated for$C_{19}H_{18}ClN_2O_2[M+H]^+$:341.1056; found: 341.1085.



3i

3-(4-bromophenyl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenylpropan-1-one (3i)

TLC (SiO_2): R_f=0.8 (80%EtOAc/Hexane);M.P.203-205°C;IR (KBr) υ_{max} (cm^{-1}): 3389.07,2956.82,2923.84,2852.75,1609.28,1547.55,1377.19,1261.55,1222.90,1146.41,1075.94,1023.24,857.93,803.73, cm^1; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, J = 17.6 Hz, 2H), 7.52 (s, 1H), 7.42 (d, J = 6.1 Hz, 4H), 7.34 (s, 3H), 7.18 – 7.04 (m, 1H), 4.49 (s, 1H), 4.05 (s, 1H), 3.66 – 3.46 (m, 1H), 2.14 (s, 3H);^{13}C NMR (126 MHz, DMSO) δ 198.5, 160.1, 144.7, 136.7, 132.4,128.0, 127.8, 127.5, 127.1, 125.4, 107.0, 102.9, 42.7, 35.2, 9.9.HRMS (ESI+): *m/z* calculated for$C_{19}H_{18}BrN_2O_2$ $[M+H]^+$:385.0551; found: 385.0856.

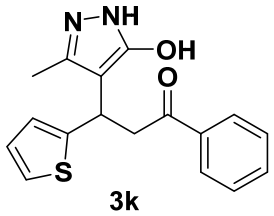


3j

3-(furan-2-yl)-3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenylpropan-1-one (3j)

TLC (SiO_2): R_f=0.6 (80%EtOAc/Hexane);M.P.270-272°C; IR (KBr) υ_{max} (cm^{-1}): 3370, 3148, 3124, 3025, 2904, 2807, 2769, 2567, 1676, 1613, 1407, 1356, 1319, 1303, 1223, 1207, 1178, 1170, 1146, 1082, 1064, 1001, 884, 869, 802cm^{-1}; ^{1}H NMR (500 MHz, DMSO) δ 7.94 (d, J = 7.4 Hz, 2H), 7.57 (t, J = 7.0 Hz, 1H), 7.47 (t, J = 7.4 Hz, 2H), 7.33 (s, 1H), 6.25 (s, 1H), 6.01 (s, 1H), 4.53 (t, J = 6.7 Hz, 1H), 3.78 (dd, J = 17.0, 8.0 Hz, 1H), 3.61 (dd, J = 17.1, 6.0 Hz, 1H),2.09 (s, 3H);^{13}C NMR (126 MHz, DMSO) δ 196.3, 158.0, 155.4, 139.1, 135.8, 135.2,

131.4, 126.1, 126.3,108.6, 103.2, 99.0, 39.2, 27.4, 8.5.HRMS (ESI+): *m/z* calculated for$C_{17}H_{17}N_2O_3$ $[M+H]^+$: 297.1239; found: 297.1266.

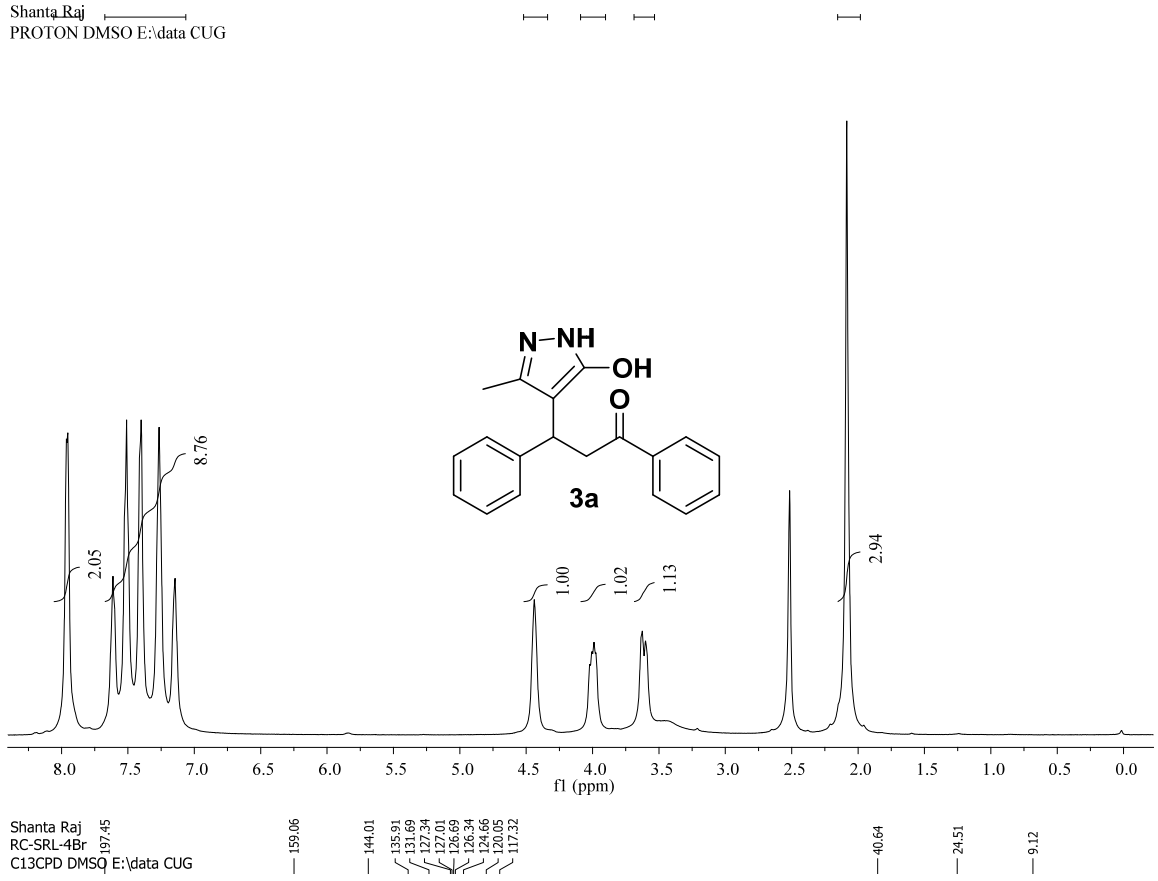


3k

3-(5-hydroxy-3-methyl-1H-pyrazol-4-yl)-1-phenyl-3-(thiophen-2-yl)propan-1-one (3k)

TLC (SiO_2): R_f=0.7 (80%EtOAc/Hexane);M.P. 265-268°C; IR (KBr) υ_{max} (cm^{-1}): 3138, 3032, 2954, 1847, 1712, 1607, 1309, 1277, 1202, 1175, 1114, 1082, 1046, 985, 957, 920, 882cm^{-1}; ^{1}H NMR (500 MHz, DMSO) δ 7.94 (d, J = 4.9 Hz, 2H), 7.56 (s, 1H), 7.46 (d, J = 5.0 Hz, 2H), 7.09 (s, 1H), 6.87 (d, J = 13.8 Hz, 2H), 4.72 (s, 1H), 3.99 (dd, J = 16.0, 7.2 Hz, 1H), 3.62 (d, J = 17.0 Hz, 1H),2.14 (s, 3H);^{13}C NMR (126 MHz, DMSO) δ 196.4, 158.0, 147.6, 135.6, 135.3, 131.4, 127.0, 126.3, 124.9, 121.7, 121.5, 101.4, 42.0, 28.9, 8.6.HRMS (ESI+): *m/z* calculated for$C_{17}H_{17}N_2O_2S$ $[M+H]^+$: 313.1010; found: 313.1032.

Fig. S1 ^{1}H &^{13}Cspectra for Compound (**3a)**



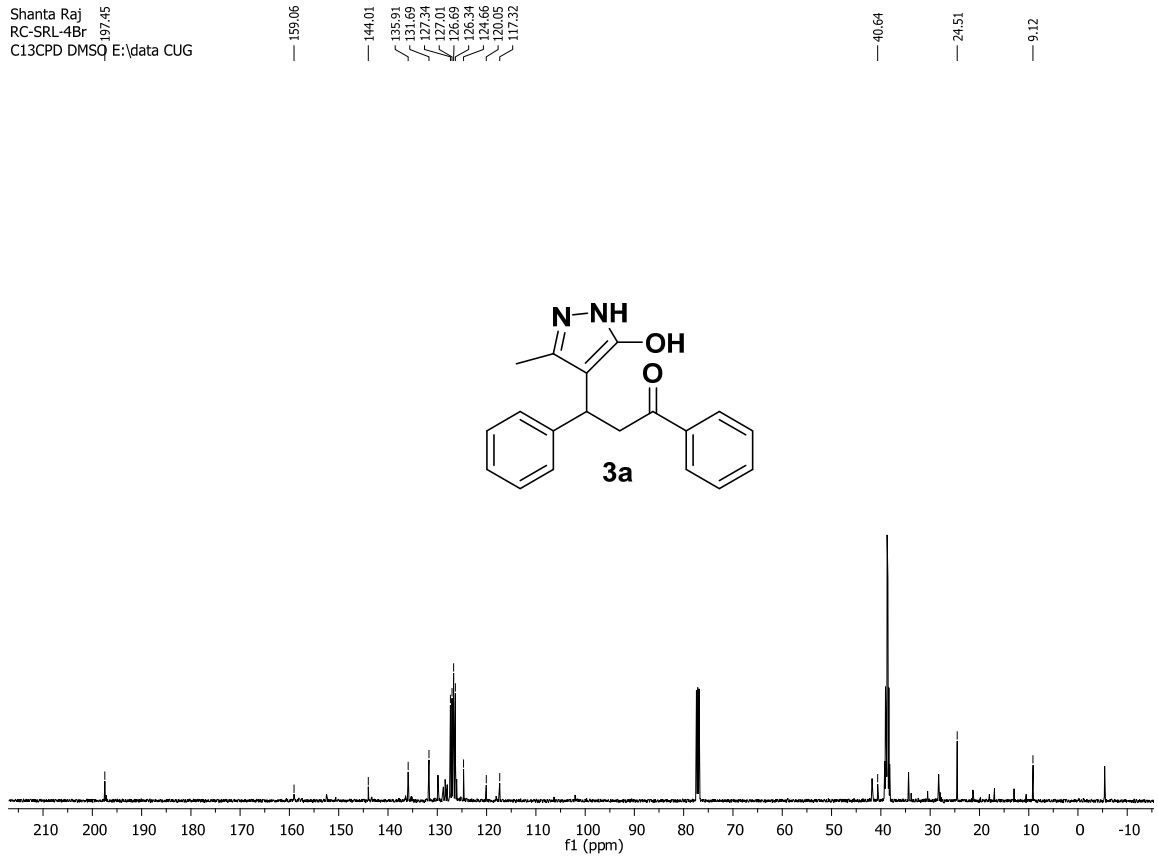


Fig. S2 ^{1}H&^{13}C spectra for Compound (**3b)**

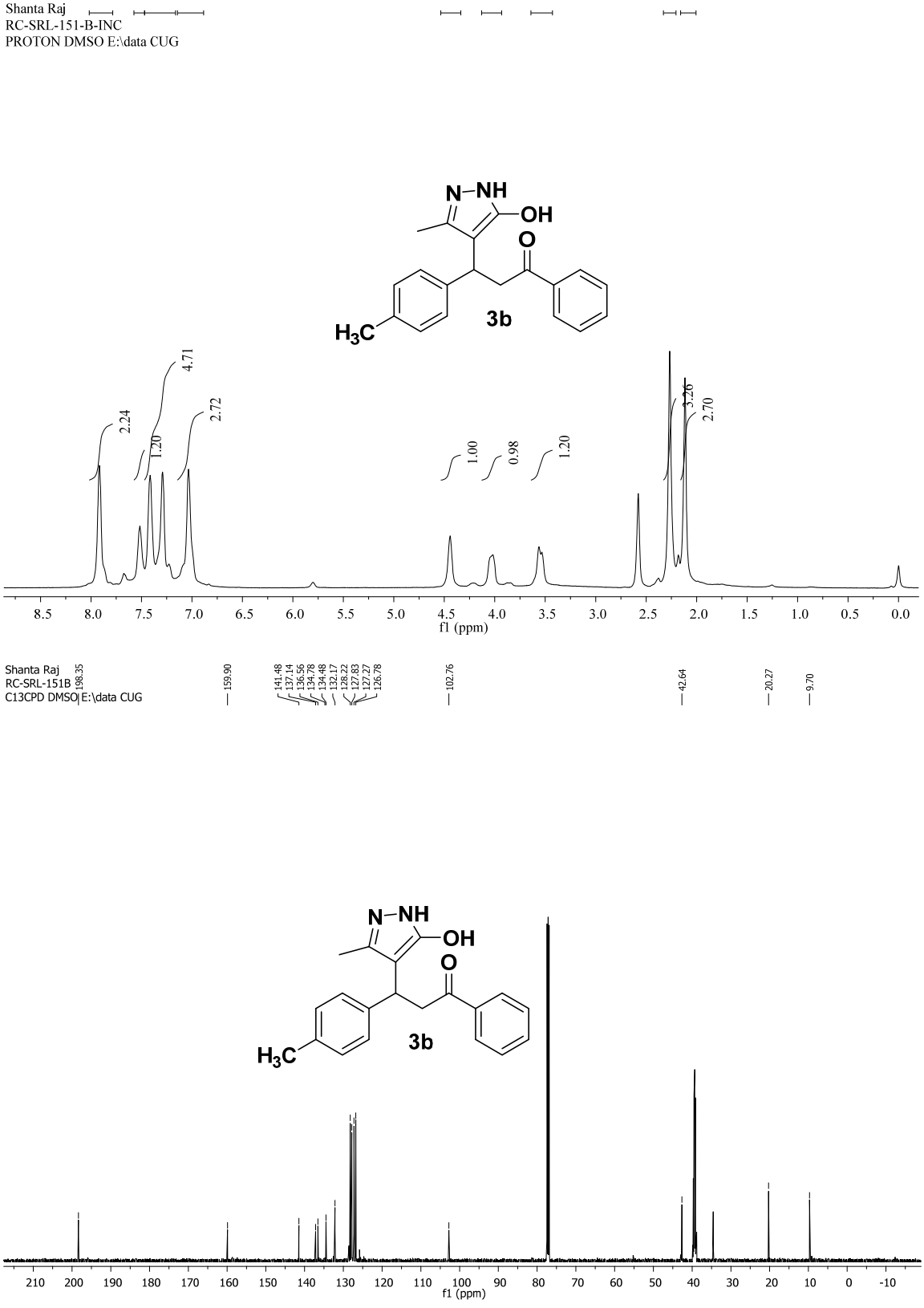
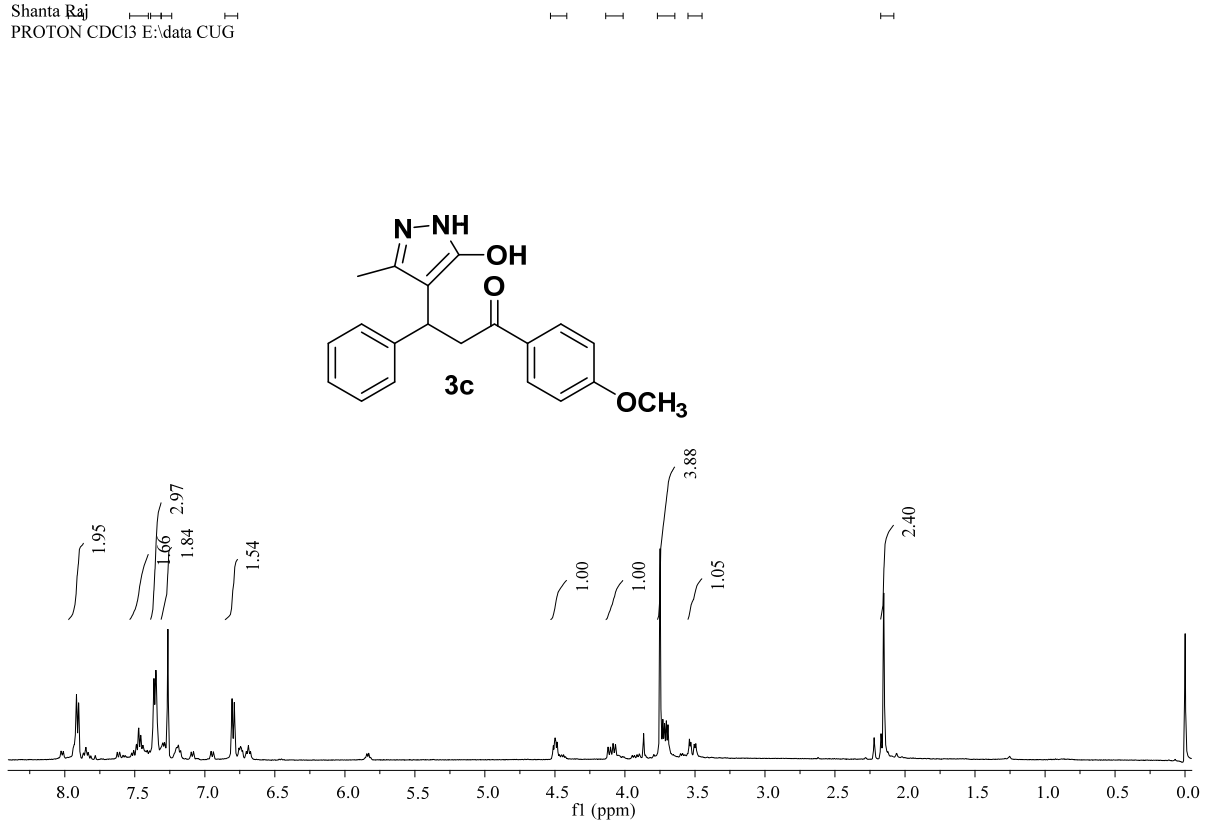


Fig. S3 ^{1}H&^{13}C spectra for Compound (**3c)**



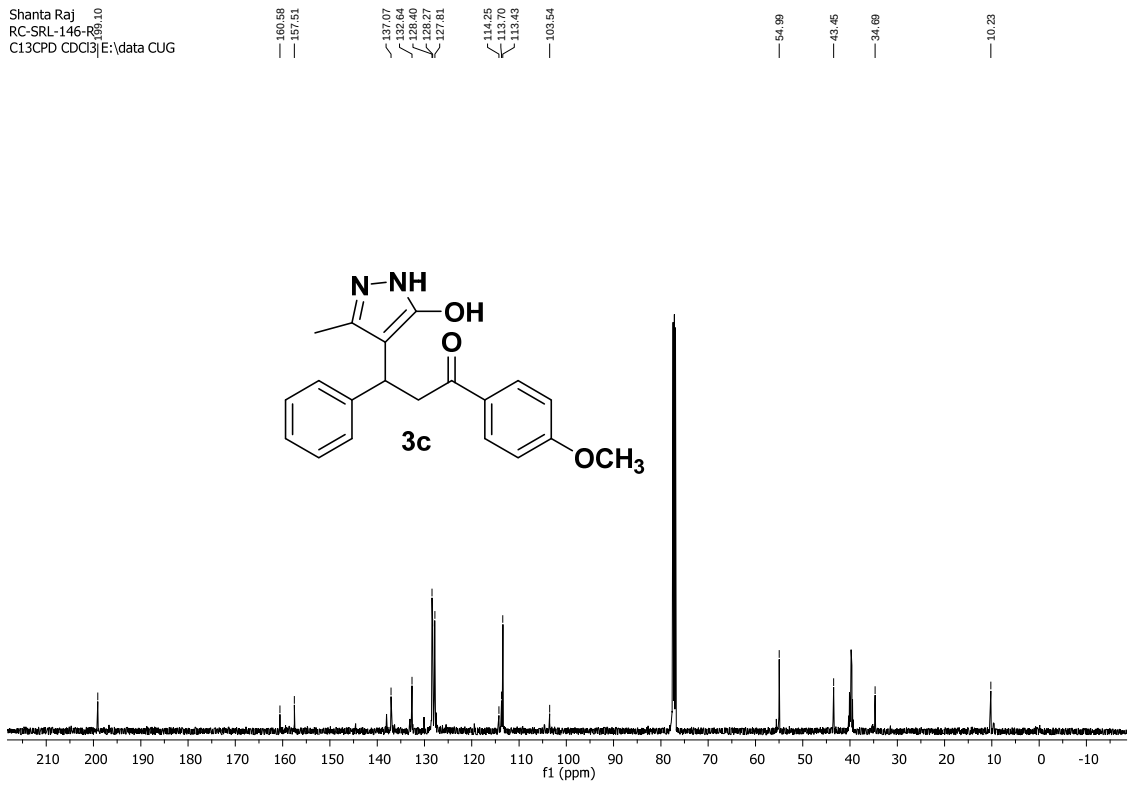
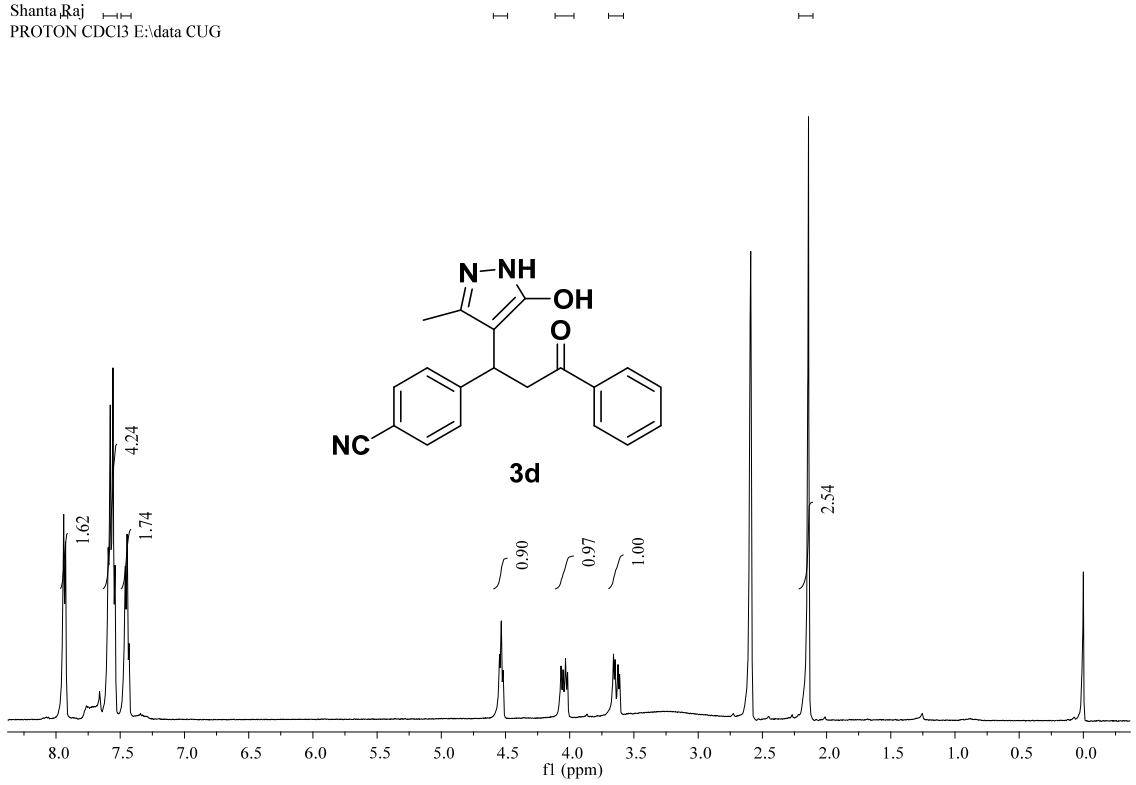


Fig. S4 ^{1}H& ^{13}C spectra for Compound (**3d)**



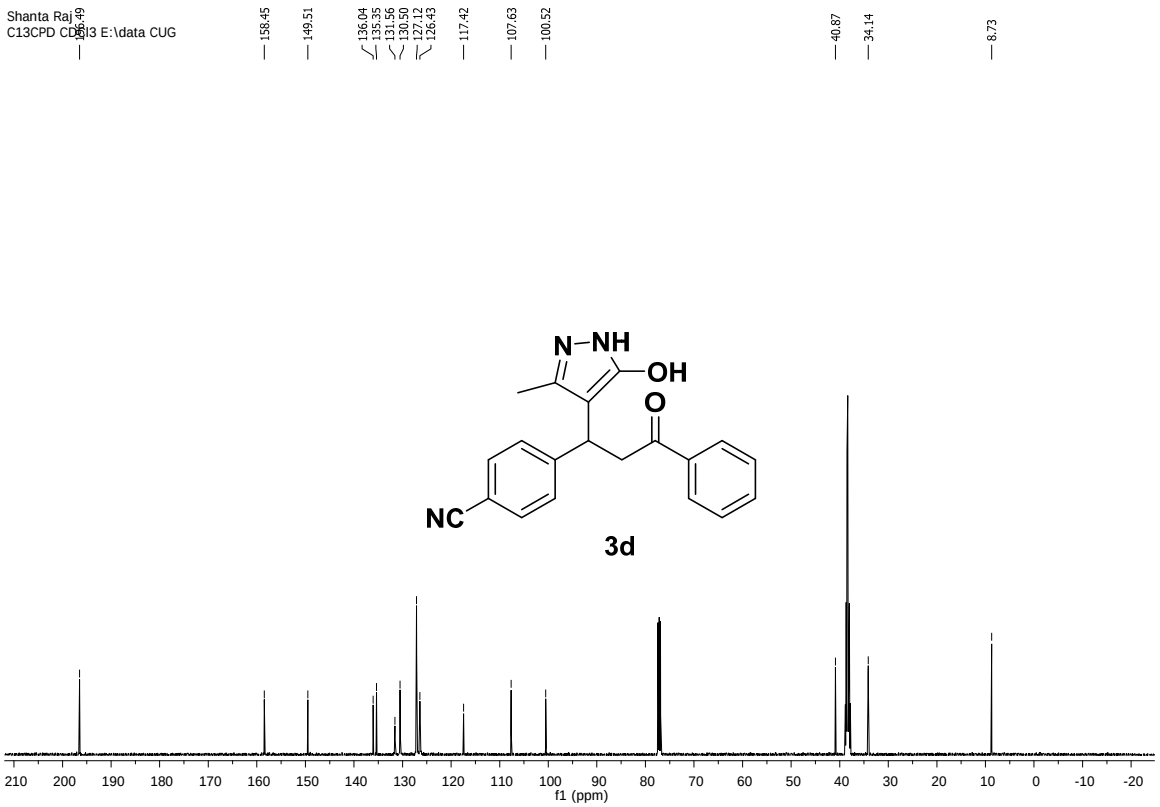

Shanta Raj
C13CPD CDCl3 E:\data CUG
196.49
158.45
149.51
136.04
133.55
131.56
130.50
127.72
126.43
117.42
107.63
100.52
40.87
34.14
8.73
N–NH
OH
O
NC
3d
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

Fig. S5 ^{1}H&^{13}C spectra for Compound (**3e)**

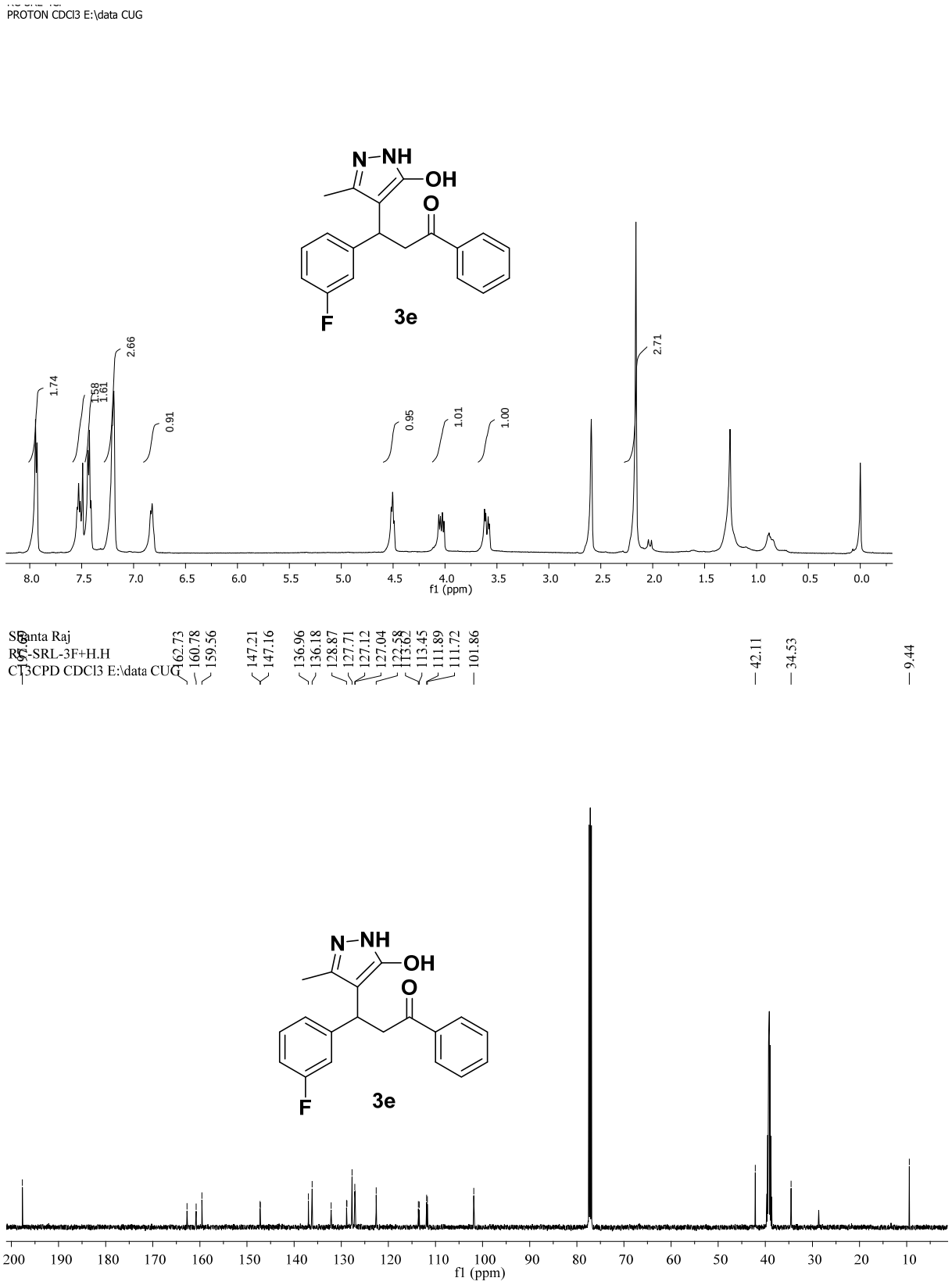
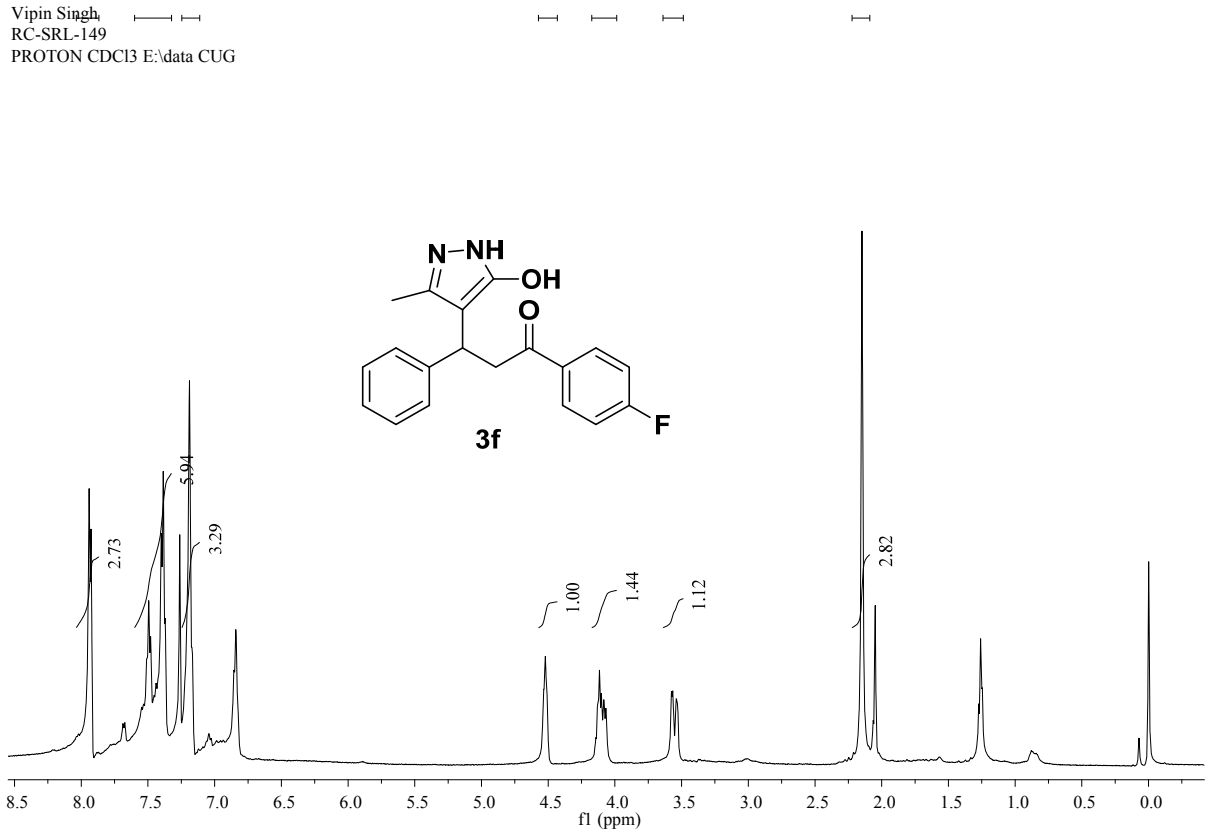


Fig. S6 ^{1}H& ^{13}C spectra for Compound (**3f)**



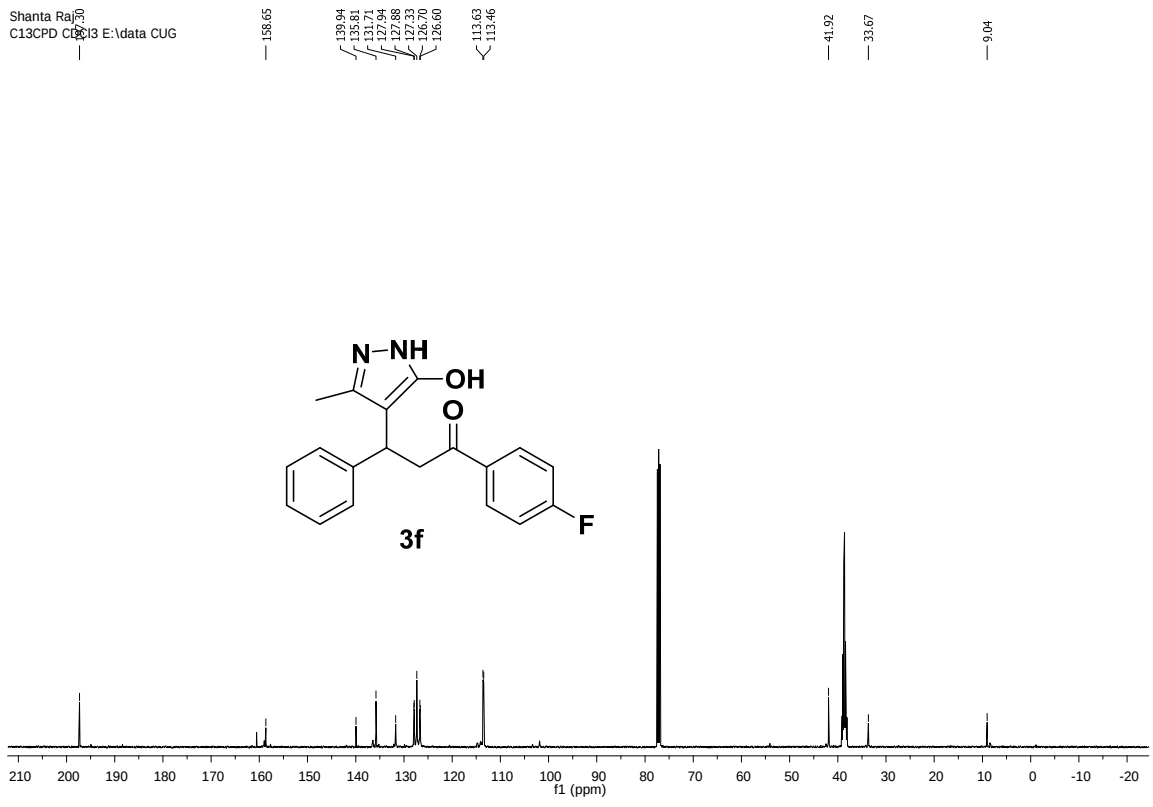
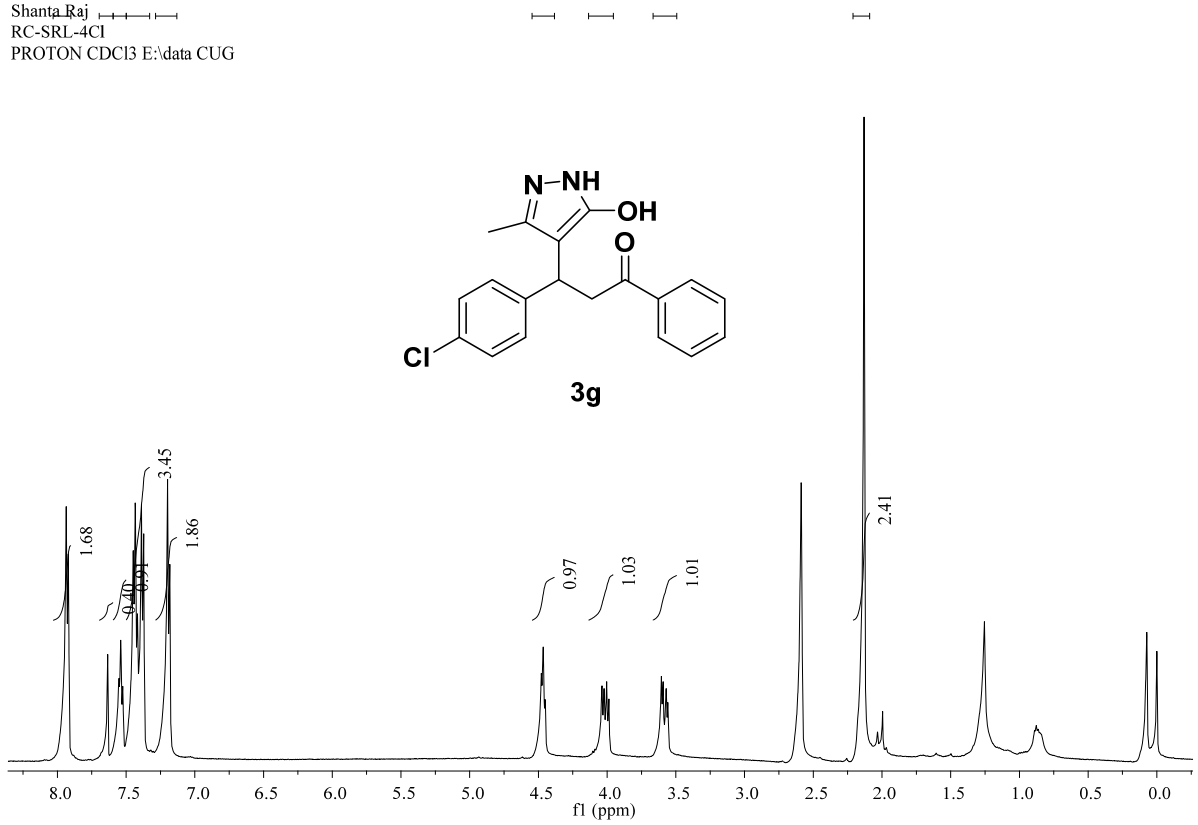


Fig. S7 ^{1}H&^{13}C spectra for Compound (**3g)**



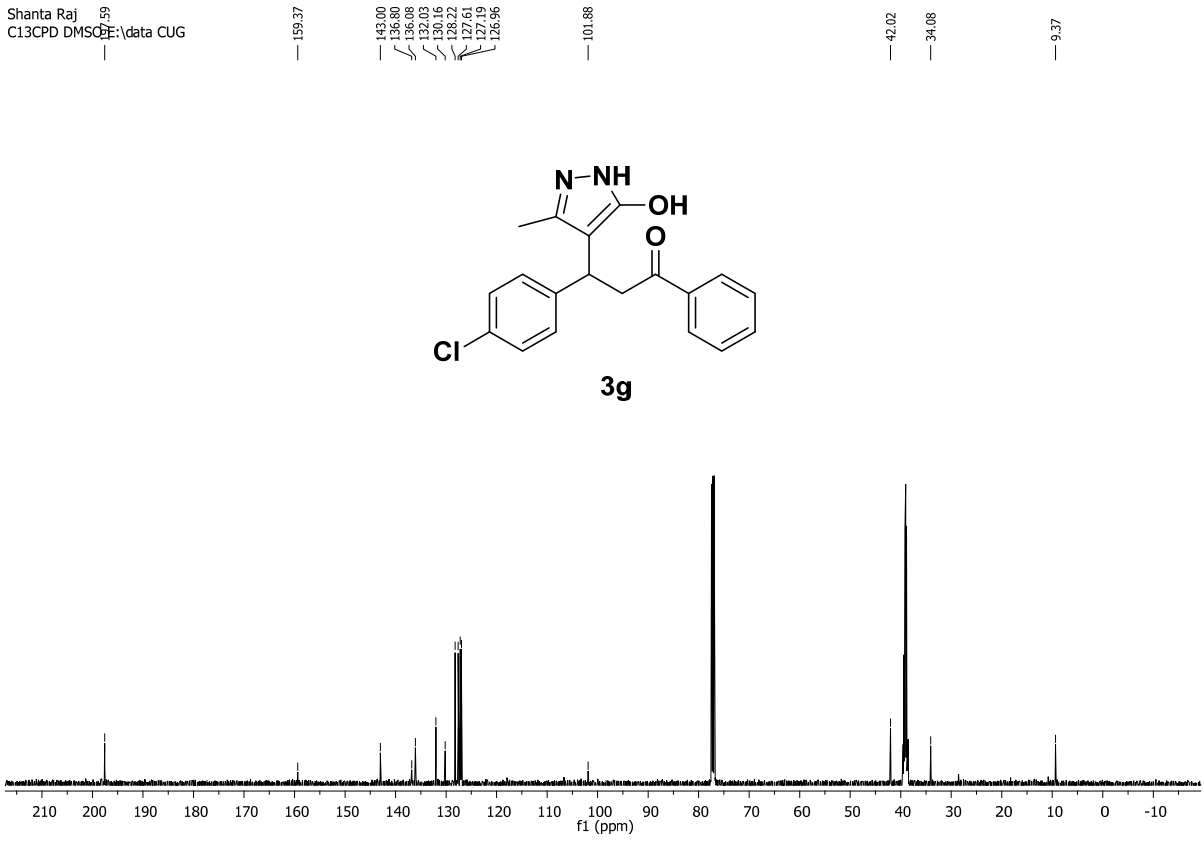
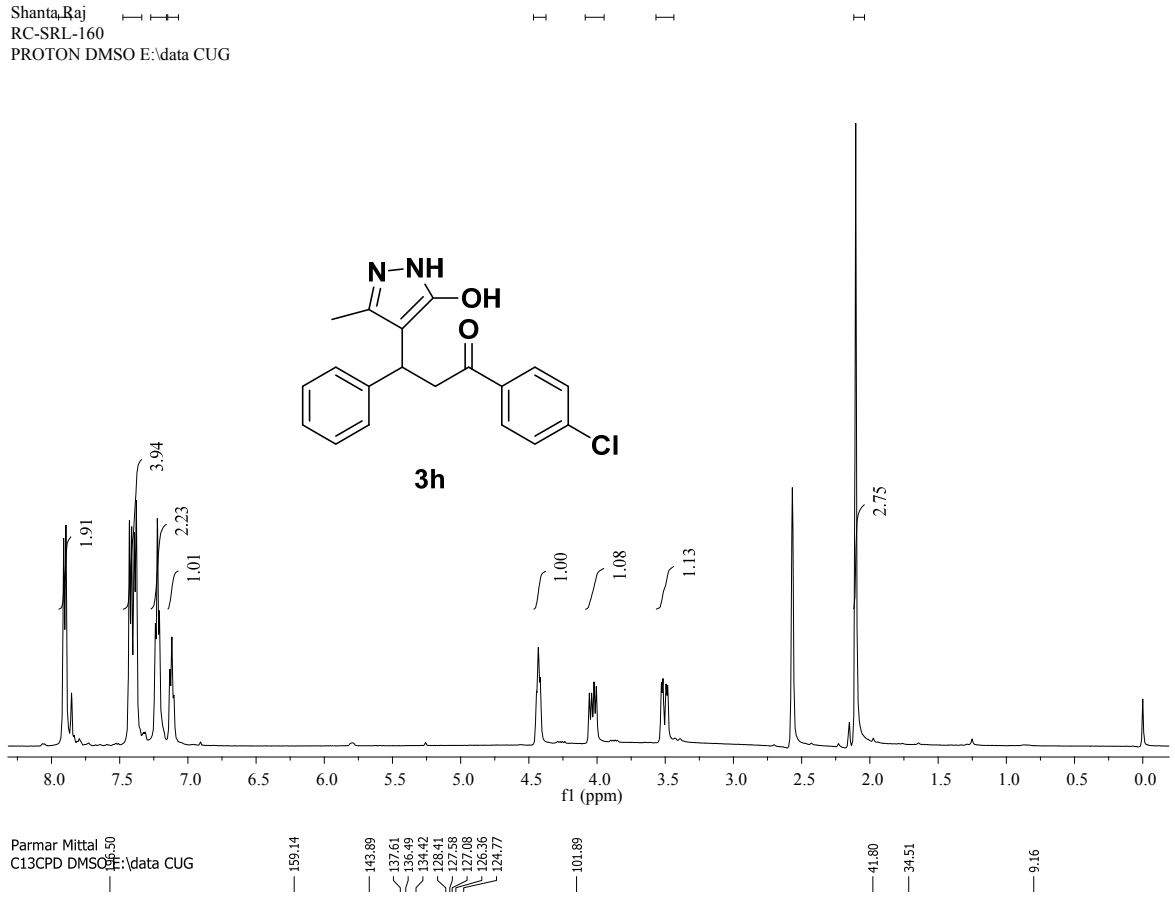

Shanta Raj
C13CPD DMSO E:\data CUG
197.59
159.37
143.00
136.80
136.08
132.03
130.16
128.22
127.61
127.19
126.96
101.88
42.02
34.08
9.37
N
NH
OH
O
Cl
3g
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Fig. S8 ^{1}H & ^{13}C spectra for Compound (**3h)**



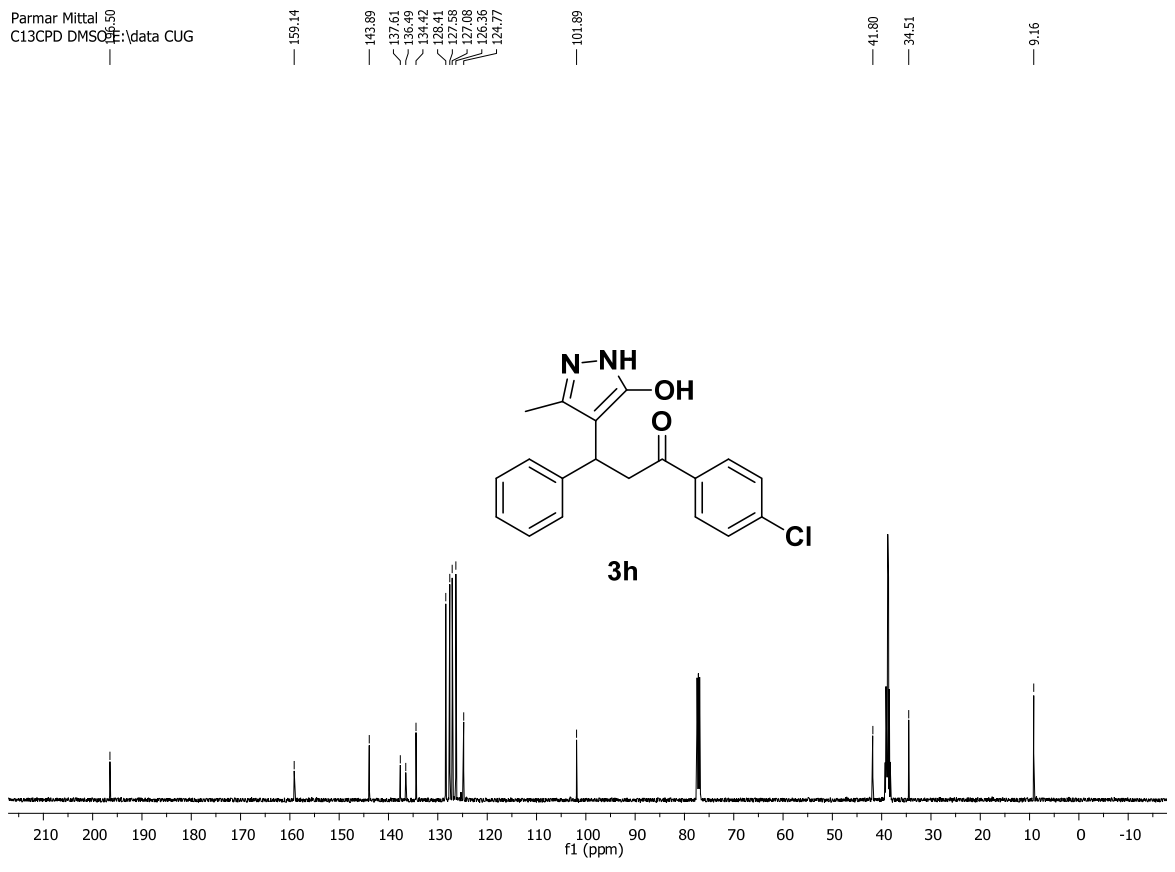


Fig. S9 ^{1}H&^{13}C spectra for Compound (**3i)**

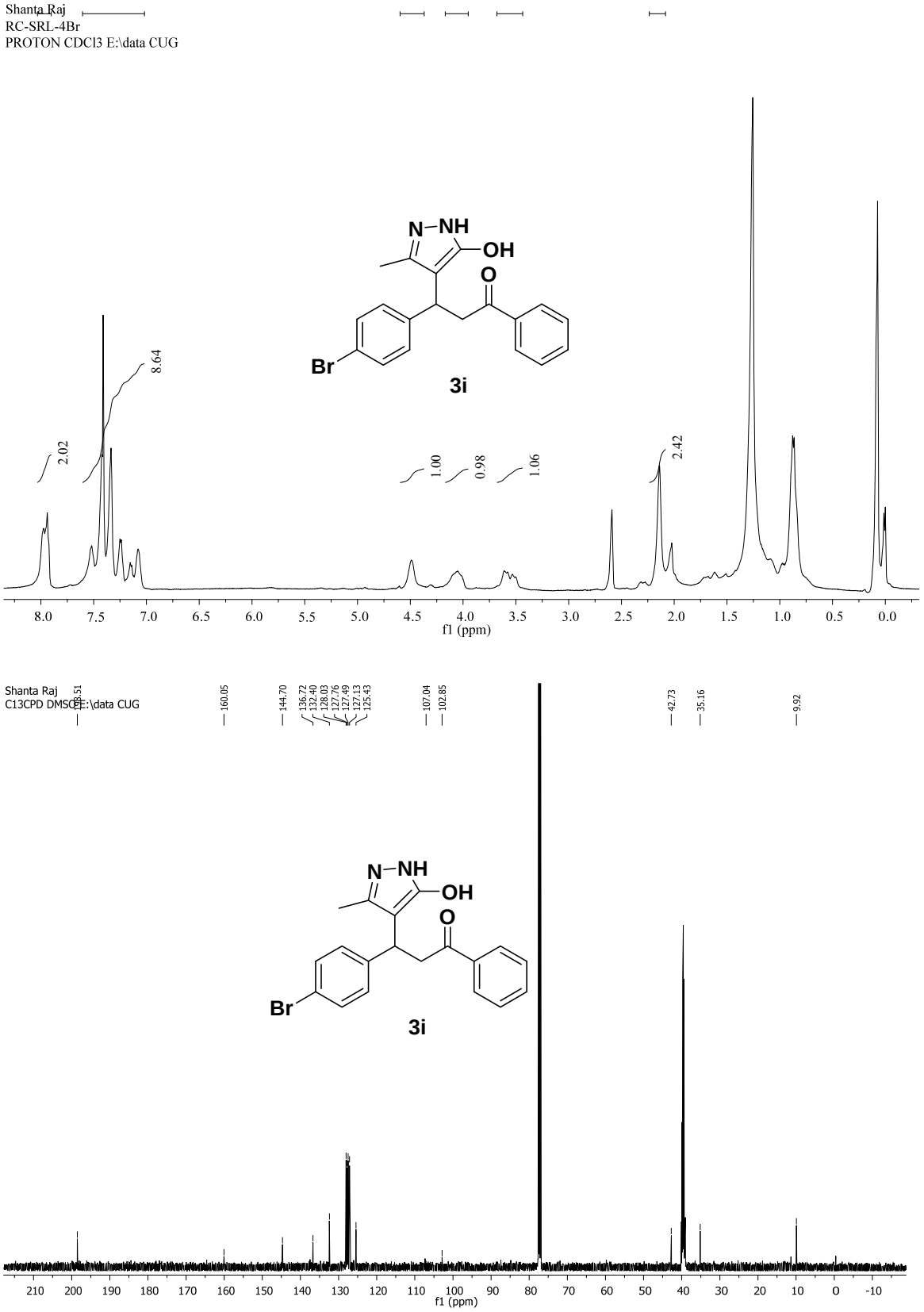


Fig. S10 ^{1}H&^{13}C spectra for Compound (**3j)**

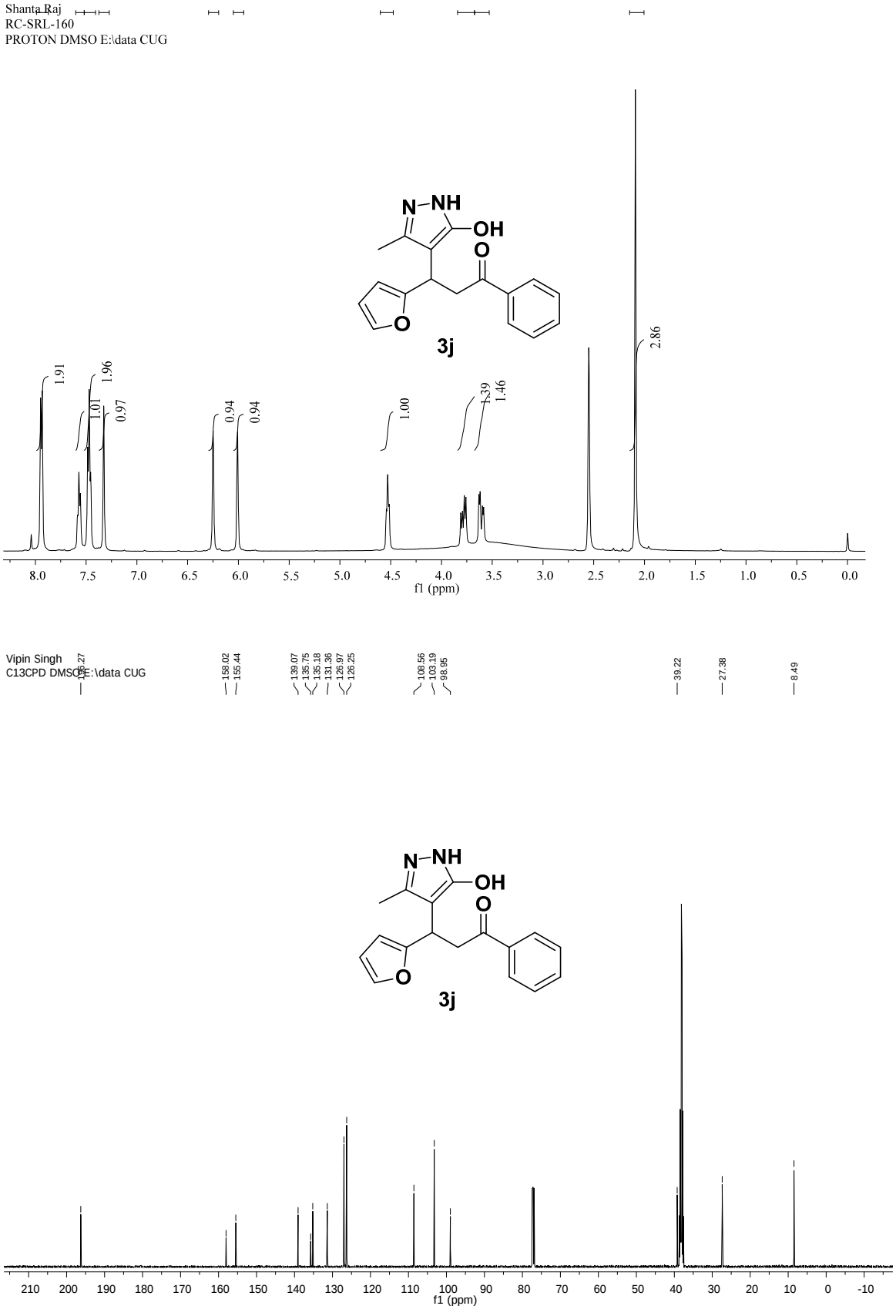


Fig. S11 ^{1}H&^{13}C spectra for Compound (**3k)**