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Supporting Information

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Regioselective Synthesis of γ-Amino-esters, -nitriles and -sulfones and Pyrrolidinones via Nickel-Catalyzed Reductive Coupling of Aldimines and Activated Alkenes

Chien-Hong Yeh, Rajendra Prasad Korivi, Chien-Hong Cheng*

Department of Chemistry, National Tsing Hua University, Hsinchu, 30013 Taiwan

chcheng@mx.nthu.edu.tw

Supporting Information

Table of Contents

General procedure for the preparation of substituted γ-aminoesters or γ-aminonitriles (3). A screw cap seal tube (15 mL) initially fitted with a septum containing Ni(phen)Br_2 (0.0125 mmol) and zinc powder (0.75 mmol) was evacuated and purged with nitrogen gas three times. Freshly distilled acetonitrile (1.0 mL), H_2O (9 μL, 0.50 mmol), benzaldimine (0.25 mmol) and acrylate or nitrile (0.75 mmol) were added to the system and the septum was replaced with a screw cap. The reaction mixture was stirred at 80 °C for the desired reaction time (20 h). The reaction mixture was cooled to room temperature and diluted with dichloromethane. The mixture was filtered through a silica gel pad (0.5 cm) and washed thoroughly with dichloromethane. The filtrate was concentrated in a rotary evaporator to get the crude product. Further separation of the crude product on a silica gel column using a mixture of hexanes and ethyl acetate as eluent afforded the desired pure product **3**. Compounds **3a-q** were synthesized according to this procedure and their spectral data were given below.

General procedure for the synthesis of pyrrolidinones (4). A screw cap seal tube (15 mL) initially fitted with a septum containing Ni(phen)Br_2 (0.01250 mmol) and zinc powder (49 mg, 0.750 mmol) was evacuated and purged with nitrogen gas three times. Freshly distilled acetonitrile (1.0 mL), H_2O (0.50 mmol), benzaldimine (0.25 mmol) and acrylate (0.75 mmol) were added to the system and the septum was replaced with a screw cap. The reaction mixture was stirred at 80 °C for 20 h. The reaction mixture was cooled to room temperature and diluted with dichloromethane. The mixture was filtered through silica gel pad and washed with dichloromethane. The solvent was removed under vacuum to give crude product **3**. To the crude product **3** were added toluene (2.0 ml) and catalytic amount of *p*-TSA (*p*-toluenesulfonic acid) (10%, 0.0250

mmol). The mixture was kept at 120 °C for 4 h. The mixture was cooled to room temperature and the solvent was removed under vacuum. Then the residue was separated on a silica gel column using a mixture of hexanes and ethyl acetate as eluent to afford the desired pure product **4**. Compounds **4a-j** were synthesized according to this procedure and the spectral data of these compounds were given below.

Procedure for the synthesis of amino derivatives 5a and 5b:. γ-Amino nitrile **3f** prepared as per the earlier procedure was treated with CAN in acetonitrile according to the procedure reported previously to give **5a**.[1] The Boc masked compound **5b** was obtained by treating **3f** with CAN and $(Boc)_2O$ by following the reported procedure.[2]

Procedure for the synthesis of Nickel complexes: Nickel catalysts $Ni(bpy)Cl_2$[3a], $Ni(phen)I_2$[3a], $Ni(phen)Br_2$[3a], $Ni(tmeda)Br_2$ [3b], $Ni(dppe)Br_2$[3c] and $Ni(PPh_3)_2Br_2$[3c] used for the study of ene-imine coupling were prepared according to the reported procedures.[3]

Reference:

1) G. Shang, Q. Yang, X. Zhang, *Angew. Chem. Int. Ed.* **2006**, *45*, 6360-6362.

2) A. Suzuki, M. Mae, H. Amii, K. Uneyama, *J. Org. Chem*. **2004**, *69,* 5132-5134.

3) a) M. Bialex, H. Cramail, A. Deffieux, S. M. Guillaume *Eur. Polym. J.* **2005**, *41*, 2678-2684. b) D. A. Handley, P. B. Hitchcock, G. J. Leigh, *Inorg. Chim. Acta* **2001**, *314*, 1-13. c) D. K. Rayabarapu, C-H. Yang, C-H. Cheng, *J. Org. Chem.* **2003**, *68*, 6726-6731.

Table 1. Results for the Formation of **3a** in the Presence of Various Catalysts and Solvents.[a]

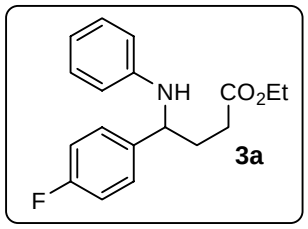
entry	catalyst	yield	entry	catalyst	yield
1	$Ni(dppe)Br_2$	trace	10	$Ni(phen)Cl_2$	81
2	$Co(dppe)I_2$	0	11	$Ni(bipy)\,Br_2$	75
3	$Co(dppe)Cl_2$	0	12	$Ni\,(tmeda)Br_2$	0
4	$Co(PPh_3)_2I_2$, 3 PPh_3	0	13	$Ni(bipy)Cl_2$	37
5	phen	0	14	$Ni(dppe)Br_2$, furan	trace
6	$Ni(cod)_2$, phen	0[b]			
7	$Ni(phen)I_2$	55			
8	$Ni(dppe)Br_2$, phen	90			
9	$Ni(phen)Br_2$	99			

[a]Except otherwise mentioned, all the reactions were carried out in nitrogen atmosphere using **1a**, (0.25 mmol), alkene **2a** (0.75 mmol), metal complex (0.01250 mmol), H_2O (0.50 mmol) and Zn (0.75 mmol) in CH_3CN or the solvent mentioned in each entry (1.0 mL) at 80 °C for 20 h. All the yields mentioned above are NMR yields using mesitylene as internal standard. [b]No zinc was added. (phen = 1,10-phenanthroline, bipy = 2,2'-bipyridine, tmeda = N,N,N',N'-tetramethylethylenediamine)

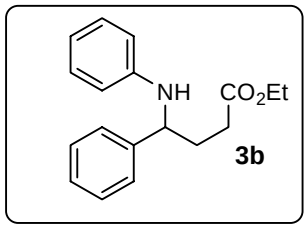
Table 2. Results for the Formation of **3a** in the Presence of Various Hydrogen Sources

entry	proton source	yield	entry	hydrogen source	yield
1	H_2O	99	4	$(Me)_3SiH$	0
2	none	0	5	$(Me)_3COOH$	0
3	AcOH	0	6	MeOH	8

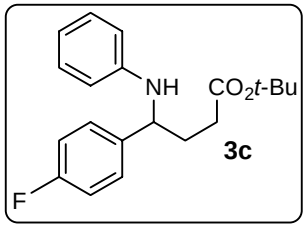
[a]All the reactions were carried out in nitrogen atmosphere using **1a**, (0.25 mmol), alkyne **2a** (0.75 mmol), Ni(phen)Br_2 (0.0125 mmol), proton source (0.50 mmol) and Zn (0.75 mmol) in CH_3CN (1.0 mL) at 80 °C for 20 h.



Ethyl 4-(4-fluorophenyl)-4-(phenylamino)butanoate (3a): light brown solid; mp = 57 °C; R_f = 0.34 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.24 (t, *J* = 7.0 Hz, 3H), 2.04-2.13 (m, 2H), 2.40 (t, *J* = 7.0 Hz, 2H), 4.12 (q, *J* = 7.2 Hz, 2H), 4.36 (t, *J* = 6.8 Hz, 1H), 6.47-6.49 (m, 2H), 6.64 (t, *J* = 7.2 Hz, 1H), 6.97-7.02 (m, 2H), 7.05-7.10 (m, 2H) and 7.28-7.32 (m, 2H); ^{13}C NMR δ 14.2, 31.2, 33.3, 57.1, 60.6, 113.2, 115.4, 115.6, 117.4, 127.8, 127.9, 129.1, 138.8, 138.9, 146.9, 160.9, 162.8 and 173.5; HRMS (EI^+) 301.1478 (cal. for $C_{18}H_{20}FNO_2$ 301.1478); IR 1501, 1605, 1728, 2931 and 3394 cm^{-1}.

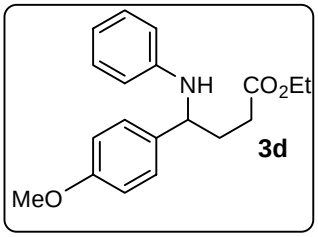


Ethyl 4-phenyl-4-(phenylamino)butanoate (3b): light brown solid; mp = 88 °C; R_f = 0.41 (20% ethyl acetate in hexanes);^{1}H NMR δ 1.24-1.28 (t, *J* = 7.2 Hz, 3H), 2.12-2.18 (m, 2H), 2.42 (t, *J* = 7.2 Hz, 2H), 4.14 (q, *J* = 7.2 Hz, 2H), 4.39 (t, *J* = 6.8 Hz, 1H), 6.52-6.54 (m, 2H), 6.65 (t, *J* = 7.6 Hz, 1H), 7.08-7.12 (m, 2H), 7.24-7.26 (m, 1H) and 7.31-7.37 (m, 4H); ^{13}C NMR δ 14.2, 31.3, 33.2, 57.7, 60.5, 113.2, 117.2, 126.3, 127.1, 128.6, 129.0, 143.1, 147.2 and 173.5; HRMS (EI^+) 283.1574 (cal. for $C_{18}H_{21}NO_2$ 283.1572); IR 1497, 1597, 1713, 3024 and 3394 cm^{-1}.

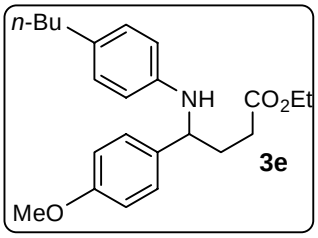


***tert*-Butyl 4-(4-fluorophenyl)-4-(phenylamino)butanoate (3c):** viscous liquid; R_f = 0.52 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.44 (s, 9H), 1.97-2.10 (m, 2H), 2.31 (dt, *J* =

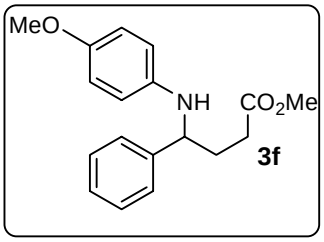
2.8 and 7.2 Hz, 2H), 4.31-4.34 (m, 1H), 6.45-6.47 (m, 2H), 6.63 (t, *J* = 7.2 Hz, 1H), 6.96-7.01 (m, 2H), 7.05-7.09 (m, 2H) and 7.28-7.31 (m, 2H); ^{13}C NMR δ 28.1, 32.4, 33.4, 57.3, 80.7, 113.2, 115.4, 115.5, 117.3, 127.8(2C), 129.1, 139.1(2C), 147.1, 160.9, 162.8 and 172.9; HRMS (EI^+) 329.1793 (cal. for $C_{20}H_{24}FNO_2$ 329.1791); IR 1227, 1501, 1605, 1720, 2977 and 3402 cm^{-1}.



Ethyl 4-(4-methoxyphenyl)-4-(phenylamino)butanoate (3d): viscous liquid; R_f = 0.23 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.26 (t, *J* = 7.0 Hz, 3H), 2.05-2.19 (m, 2H), 2.41 (t, *J* = 7.0 Hz, 2H), 3.81 (s, 3H), 4.16 (q, *J* = 7.2 Hz, 2H), 4.35(t, *J* = 6.8 Hz, 1H), 6.51-6.53 (m, 2H), 6.63 (dt, *J* = 1.0 and 7.2 Hz, 1H), 6.84-6.87 (m, 2H), 7.06-7.10 (m, 2H) and 7.24-7.26 (m, 2H); ^{13}C NMR δ 14.2, 31.2, 33.2, 55.2, 57.1, 60.5, 113.2, 114.0, 117.2, 127.4, 129.0, 135.0, 147.2, 158.6 and 173.6; HRMS (EI^+) 313.1676 (cal. for $C_{19}H_{23}NO_3$ 313.1678); IR 1512, 1605, 1728, 2931 and 3394 cm^{-1}.

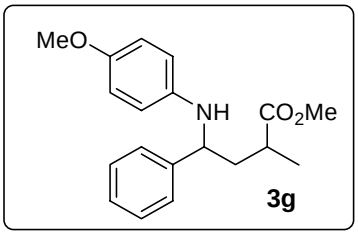


Ethyl 4-(4-butylphenylamino)-4-(4-methoxyphenyl)butanoate (3e): viscous liquid; R_f = 0.35 (20% ethyl acetate in hexanes); ^{1}H NMR δ 0.89 (t, *J* = 7.0 Hz, 3H), 1.24 (t, *J* = 7.2 Hz, 3H), 1.28-1.33 (m, 2H), 1.46-1.53 (m, 2H), 2.03-2.16 (m, 2H), 2.37(t, *J* = 7.2 Hz, 2H), 2.44(t, *J* = 7.6 Hz, 2H), 3.77 (s, 3H), 4.12 (q, *J* = 7.2 Hz, 2H), 4.29 (t, *J* = 6.8 Hz, 1H), 6.45 (d, *J* = 8.4 Hz, 2H), 6.85(d, *J* = 8.4Hz, 2H), 6.90 (d, *J* = 8.4Hz, 2H) and 7.25 (d, *J* = 8.8 Hz, 2H); ^{13}C NMR δ 13.9, 14.2, 22.3, 31.3, 33.3, 33.9, 34.6, 55.2, 57.3, 60.5, 113.3, 114.0, 127.4, 128.9, 131.6, 135.3, 145.1, 158.6 and 173.6; HRMS (EI^+) 369.2307 (cal. for $C_{23}H_{31}NO_3$ 369.2304); IR 1242, 1512, 1612, 1728, 2931 and 3394 cm^{-1}

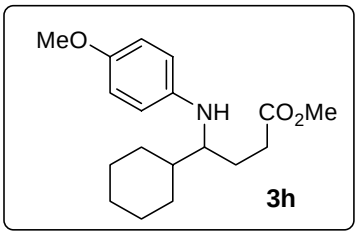


Methyl 4-(4-methoxyphenylamino)-4-phenylbutanoate (3f): viscous liquid; R_f = 0.28 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.99-2.09 (m, 2H), 2.33 (t, *J* = 7.2 Hz, 2H), 3.58 (s, 3H), 3.59 (s, 3H), 4.22 (t, *J* = 7.2 Hz, 1H), 6.38-6.42 (m, 2H), 6.58-6.62 (m, 2H), 7.13-7.16 (m, 1H) and 7.21-7.23 (m, 4H);^{13}C NMR δ 30.9, 33.2, 51.6, 55.6, 58.4, 114.5, 114.7, 126.4, 127.1, 128.6, 141.3, 143.2, 151.9 and 173.9; HRMS (EI^+) 299.1521 (cal. for $C_{18}H_{21}NO_3$ 299.1521); IR 1242, 1512, 1728, 2947 and 3386 cm^{-1}.

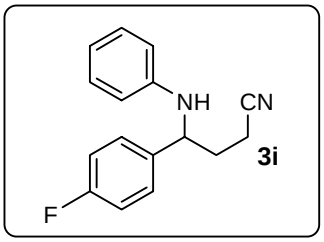
Methyl 4-(4-methoxyphenylamino)-4-phenyl-2-deutero-butanoate (3f-D: deuterium content 68%**).** ^{1}H NMR δ 2.04-2.18 (m, 2H), 2.36-2.41 (m, 2H), 3.65 (s, 3H), 3.67 (s, 3H), 4.29 (t, *J* = 6.5 Hz, 1H), 6.47 (d, *J* = 8.0 Hz, 2H), 6.66 (d, *J* = 8.5 Hz, 2H), 7.20-7.22 (m, 1H) and 7.28-7.31 (m, 4H); ^{13}C NMR δ 30.9, 33.2, 51.6, 55.6, 58.4, 114.5, 114.7, 126.4, 127.1, 128.6, 141.3, 143.2, 151.9 and 173.9; HRMS (EI^+) 300.1582 (cal. for $C_{18}H_{20}DNO_3$ 300.1584); IR 1242, 1512, 1728, 2947 and 3379 cm^{-1}



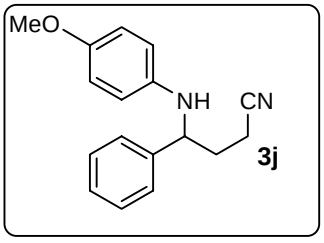
Methyl 4-(4-methoxyphenylamino)-2-methyl-4-phenylbutanoate (3g): viscous liquid; R_f = 0.35 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.17 (d, *J* = 7.0 Hz, 3H), 1.20 (d, *J* = 7.5 Hz, 3H), 1.73-1.78 (m, 1H), 1.83-1.89 (m, 1H), 2.18-2.26 (m, 1H), 2.54-2.63 (m, 1H), 3.61 (s, 3H), 3.65 (s, 3H), 3.66 (m, 3H), 4.32 (t, *J* = 7.0 Hz, 1H), 6.45 (d, *J* = 9.0 Hz, 2H), 6.66 (d, *J* = 8.5 Hz, 2H), 7.18-7.21 (m, 1H) and 7.27-7.31 (m, 4H);^{13}C NMR δ 17.7, 17.8, 36.5, 37.4, 42.1, 42.3, 51.7, 55.7, 57.2, 114.7, 114.9, 126.3, 126.4, 127.1, 128.6, 141.1, 143.3, 152.1 and 176.8; HRMS (EI^+) 313.1685 (cal. for $C_{19}H_{23}NO_3$ 313.1678); IR 1242, 1512, 1728, 2947 and 3379 cm^{-1}.



Methyl 4-(4-methoxyphenylamino)-4-cyclohexylbutanoate (3h): viscous liquid; R_f = 0.49 (20% ethyl acetate in hexanes); ^{1}H NMR δ 0.99-1.22 (m, 4H), 1.43-1.50 (m, 1H), 1.56-1.66 (m, 4H), 1.71-1.73 (m, 3H), 1.86-1.92 (m, 1H), 2.30-2.42 (m, 2H), 3.11 (m, 1H), 3.58 (s, 3H), 3.68 (m, 3H), 6.48 (d, *J* = 8.5 Hz, 2H) and 6.69 (d, J = 9.0 Hz, 2H);^{13}C NMR δ 26.8, 26.9, 27.0, 27.6, 29.3, 29.5, 31.6, 42.4, 51.7, 56.0, 58.7, 114.3, 115.2, 143.3, 151.8 and 174.6; HRMS (EI$^+$) 305.1993 (cal. for $C_{18}H_{27}NO_3$ 305.1991); IR 1242, 1512, 1736, 2360 and 3394 cm^{-1}.

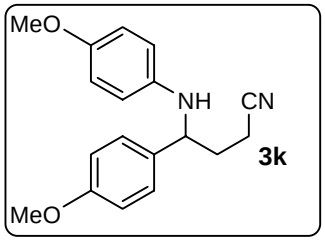


4-(4-Fluorophenyl)-4-(phenylamino)butanenitrile (3i): pale yellow solid; mp = 109 °C; R_f = 0.17 (20% ethyl acetate in hexanes); ^{1}H NMR δ 2.03-2.19 (m, 2H), 2.30-2.49 (m, 2H), 4.48 (t, *J* = 6.8 Hz, 1H), 6.55 (d, *J* = 8.0 Hz, 2H), 6.70 (t, *J* = 7.2, 1H), 7.03 (t, *J* = 8.4 Hz, 2H), 7.11(t, *J* = 7.6 Hz, 2H), and 7.24-7.32 (m, 2H); ^{13}C NMR δ 14.8, 33.9, 56.5, 113.9, 116.1, 116.3, 118.6, 119.5, 128.1, 128.2, 129.6, 137.7(2C), 146.6, 161.2 and 163.7; HRMS (EI$^+$) 254.1213 (cal. for $C_{16}H_{15}FN$ 254.1219); IR 1227, 1505, 1605, 2245, 2931 and 3387 cm^{-1}.

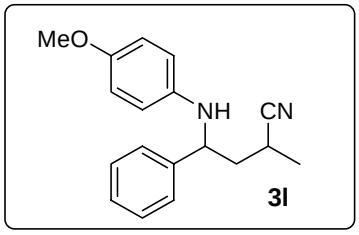


4-(4-Methoxyphenylamino)-4-phenylbutanenitrile (3j): light brown solid; mp = 92 °C; R_f = 0.18 (20% ethyl acetate in hexanes); ^{1}H NMR δ 2.06-2.18 (m, 2H), 2.30-2.36 (m,

1H), 2.41-2.47 (m, 1H), 3.68 (s, 3H), 4.40 (t, *J* = 7.0 Hz, 1H), 6.54 (d, *J* = 8.5 Hz, 2H), 6.70 (d, *J* = .9.0Hz, 2H), 7.24-7.27 (dt, *J* = 2.0 and 7.0 Hz, 1H) and 7.30-7.35 (m, 4H); ^{13}C NMR δ 14.4, 33.5, 55.6, 57.8, 114.7, 115.2, 119.4, 126.3, 127.7, 128.9, 140.5, 141.7 and 152.4; HRMS (EI^+) 266.1419 (cal. for $C_{17}H_{18}NO_2$ 266.1419); IR 1512, 2245, 2939 and 3387 cm^{-1}.



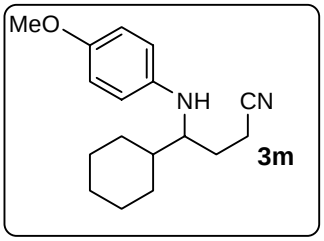
4-(4-Methoxyphenylamino)-4-(4-methoxyphenyl)butanenitrile (3k): viscous liquid; R_f = 0.14 (20% ethyl acetate in hexanes); ^{1}H NMR δ 2.00-2.07 (m, 1H), 2.11-2.19(m, 1H), 2.27-2.33 (m, 1H), 2.39-2.44 (m, 1H), 3.68 (s, 3H), 3.76 (s, 3H), 4.35 (t, *J* = 7.0 Hz, 1H), 6.30 (d, *J* = 9.0 Hz, 2H), 6.69 (d, *J* = .8.5 Hz, 2H), 6.85 (d, *J* = 9.0 Hz, 2H), and 7.21 (d, *J* = 9.0 Hz, 2H); ^{13}C NMR δ 14.4, 33.4, 55.2, 55.6, 57.4, 114.3, 114.8, 115.4, 119.4, 127.4, 133.5, 140.5, 152.6 and 159.1; HRMS (EI^+) 296.1549 (cal. for $C_{18}H_{20}N_2O_2$ 296.1525); IR 1512, 2245, 2939 and 3371 cm^{-1}.



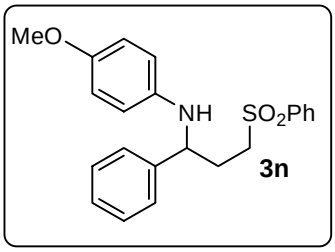
4-(4-Methoxyphenylamino)-2-methyl-4-phenylbutanenitrile (3l): pale brown solid; mp = 122 °C; R_f = 0.25 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.30 (d, *J* = 6.5 Hz, 3H), 1.80-1.86 (m, 1H), 2.20-2.26 (m, 1H), 2.42-2.50 (m, 1H), 3.68 (s, 3H), 4.45 (t, *J* = 7.5 Hz, 1H), 6.53 (dd, *J* = 3.5 and 9.0 Hz, 2H), 6.69 (d, *J* = .3.5 and 8.5 Hz, 2H), 7.24-7.27 (m, 1H) and 7.32-7.36 (4H); ^{13}C NMR δ 18.2, 22.9, 42.2, 55.7, 57.1, 114.8, 115.0, 122.7, 126.4, 127.8, 129.0, 140.6, 142.1 and 152.4; HRMS (EI^+) 280.1562 (cal. for $C_{18}H_{20}N_2O$ 280.1576); IR 1512, 2237, 2931 and 3379 cm^{-1}.

4-(4-Methoxyphenylamino)-2-methyl-4-phenylbutanenitrile (3l'): pale brown solid; mp = 121 °C; R_f = 0.23 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.35 (d, *J* = 7.0 Hz,

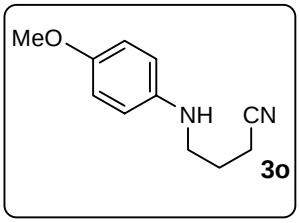
3H), 1.87-1.92 (m, 1H), 2.07-2.13 (m, 1H), 2.89-2.96 (m, 1H), 3.68 (s, 3H), 4.54-4.56 (m, 1H), 6.54 (d, *J* = 9.0 Hz, 2H), 6.68 (d, *J* = 9.5 Hz, 2H), 7.21-7.24 (m, 1H) and 7.27-7.35 (4H); ^{13}C NMR δ 18.1, 23.0, 42.8, 55.6, 57.0, 114.8, 115.5, 122.7, 126.1, 127.5, 128.9, 140.5, 142.3 and 152.6; HRMS (EI$^+$) 280.1572 (cal. for $C_{18}H_{20}N_2O$ 280.1576); IR 1512, 2237, 2924 and 3371 cm^{-1}.



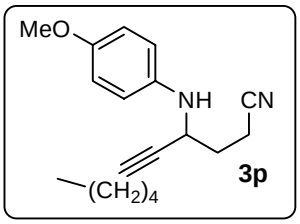
4-(4-Methoxyphenylamino)-4-cyclohexylbutanenitrile (3m): viscous liquid; R_f = 0.47 (20% ethyl acetate in hexanes); ^{1}H NMR δ 0.98-1.09 (m, 2H), 1.10-1.24 (m, 3H), 1.46-1.52 (m, 1H), 1.56-1.61 (m, 1H), 1.63-1.66 (m, 2H), 1.69-1.75 (m, 3H), 1.93-1.99 (m, 1H), 2.39-2.50 (m, 2H), 3.19-3.22 (m, 1H), 3.76 (s, 3H), 6.54 (d, *J* = 8.5 Hz, 2H) and 6.65 (d, *J* = .8.5 Hz, 2H); ^{13}C NMR δ 14.5, 26.2(2C), 26.4, 28.4, 28.8, 29.2, 42.0, 55.7, 57.9, 114.4, 115.0, 120.1, 142.1 and 151.9; HRMS (EI$^+$) 272.1893 (cal. for $C_{17}H_{24}N_2O$ 272.1889); IR 1512, 2245, 2924 and 3387 cm^{-1}.



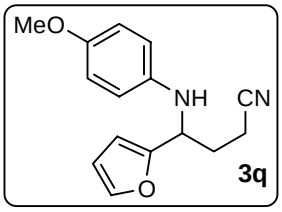
4-Methoxy-N-(1-phenyl-3-(phenylsulfonyl)propyl)benzenamine (3n): light brown solid; mp = 154 °C; R_f = 0.16 (20% ethyl acetate in hexanes); ^{1}H NMR δ 2.16-2.29 (m, 2H), 3.12-3.18 (m, 1H), 3.20-3.26 (m, 1H), 3.67 (s, 3H), 4.36 (t, *J* = 7.3 Hz, 1H), 6.48 (d, *J* = 8.5 Hz, 2H), 6.66 (d, *J* = .9.0 Hz, 2H), 7.20-7.24 (m, 3H), 7.28 (t, *J* = 7.5 Hz, 2H), 7.54 (t, *J* = 7.8 Hz, 2H), 7.64 (t, *J* = 7.8 Hz, 1H) and 7.87 (d, *J* = 8.0 Hz, 2H); ^{13}C NMR δ 30.6, 53.3, 55.6, 57.8, 114.7, 115.5, 126.4, 127.7, 128.0, 128.9, 129.3, 133.8, 139.0, 140.0, 141.6 and 152.7; HRMS (EI$^+$) 381.1408 (cal. for $C_{22}H_{23}NO_3S$ 381.1399); IR 1149, 1234, 1303, 1512, 2931 and 3379 cm^{-1}.



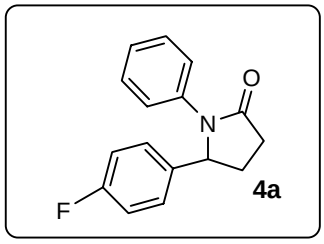
4-(4-Methoxyphenylamino)butanenitrile (3o): viscous liquid; R_f = 0.11 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.90-1.95 (m, 2H), 2.45 (t, *J* = 7.0 Hz, 2H), 3.24 (t, *J* = 7.0 Hz, 2H), 3.73 (s, 1H), 6.57 (d, *J* = 9.0 Hz, 2H) and 6.77 (d, *J* = .9.5 Hz, 2H); ^{13}C NMR δ 14.8, 25.4, 43.3, 55.8, 114.3, 115.0, 119.4, 141.6 and 152.5; HRMS (EI^+) 190.1104 (cal. for $C_{11}H_{14}N_2O$ 190.1106); IR 1234, 1512 and 2939 cm^{-1}.



4-(4-Methoxyphenylamino)-4-(1-heptyl)butanenitrile (3p): viscous liquid; R_f = 0.28 (20% ethyl acetate in hexanes); ^{1}H NMR δ 0.85 (t, *J* = 6.8 Hz, 3H), 1.21-1.30 (m, 4H), 1.39-1.46 (m, 2H), 1.96-2.09 (m, 2H), 2.12 (dt, *J* = 1.6 and 6.8 Hz, 2H), 2.56-2.60 (m, 2H), 3.74 (s, 3H), 4.11 (t, *J* = 6.8 Hz, 1H), 6.66 (d, J = 8.8 Hz, 2H) and 6.78 (d, 9.1 Hz, 2H);^{13}C NMR δ 13.8, 14.0, 18.5, 22.1, 28.2, 30.9, 31.8, 46.5, 55.6, 78.8, 85.3, 114.8, 116.3, 119.2, 140.2 and 153.3;HRMS (EI^+) 284.1887 (cal. for $C_{18}H_{24}N_2O$ 284.1889); IR 1242, 1458, 1512, 2245 and 2931 cm^{-1}.

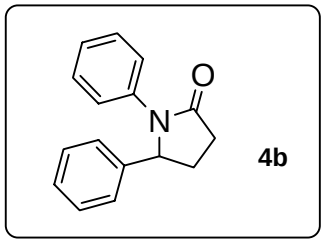


4-(4-Methoxyphenylamino)-4-(furan-2-yl)butanenitrile (3q): viscous liquid; R_f = 0.21 (20% ethyl acetate in hexanes); ^{1}H NMR δ 2.14-2.23 (m, 2H), 2.35-2.43 (m, 1H), 2.45-2.51 (m, 1H), 3.71 (s, 3H), 4.51 (t, *J* = 7.2 Hz, 1H), 6.18 (d, *J* = 3.2 Hz, 1H), 6.27 (m, 1H), 6.61 (d, *J* = 6.4 Hz, 1H), 6.62 (d, *J* = 6.8 Hz, 1H), 6.74 (d, *J* = 6.4 Hz, 1H), 6.75 (d, *J* = 6.8 Hz, 1H) and 7.33 (m, 1H);^{13}C NMR δ 14.1, 30.3, 52.1, 55.6, 107.0, 110.2, 114.8, 115.9, 119.2, 140.1, 142.1, 153.0 and 153.9;HRMS (EI$^+$) 256.1213 (cal. for $C_{15}H_{16}N_2O_2$ 256.1212); IR 1242, 1512, 2360 and 2939 cm^{-1}.



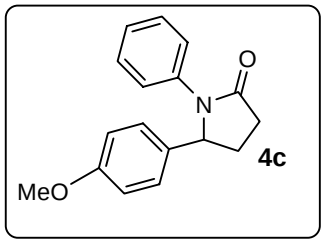
4a

5-(4-Fluorophenyl)-1-phenylpyrrolidin-2-one (4a): viscous liquid; R_f = 0.50 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.96-1.99 (m, 1H), 2.57-2.63 (m, 2H), 2.65-2.77 (m, 1H), 5.21-5.23 (m, 1H), 6.96 (t, *J* = 8.5 Hz, 2H), 7.05 (t, *J* = 7.5 Hz, 1H), 7.15-7.18(m, 2H), 7.21-7.24 (m, 2H) and 7.35 (d, *J* = 7.5 Hz, 2H);^{13}C NMR δ 29.2, 31.1, 63.2, 115.8, 116.0, 122.3, 125.1, 127.6(2C), 128.7, 136.9(2C), 137.9, 161.1, 163.1 and 174.7; HRMS (EI$^+$) 255.1056 (cal. for $C_{16}H_{14}FNO$ 255.1059); IR 1381, 1501, 1697 and 2947 cm^{-1}.

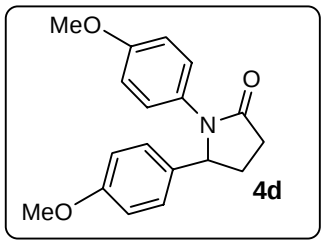


4b

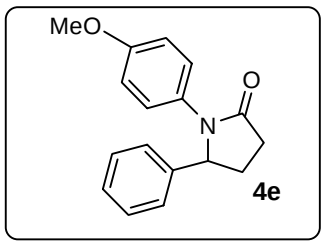
1,5-Diphenylpyrrolidin-2-one (4b): light brown solid; mp = 100 °C; R_f = 0.63 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.97-2.02 (m, 1H), 2.58-2.64 (m, 2H), 2.72-2.77 (m, 1H), 5.22-5.25 (m, 1H), 7.04 (t, *J* = 7.2 Hz, 1H), 7.19-7.24 (m, 5H), 7.29 (t, *J* = 7.2 Hz, 2H) and 7.39 (d, *J* = .8.0 Hz, 2H);^{13}C NMR δ 29.2, 31.2, 63.9, 122.2, 124.9, 125.9, 127.7, 128.6, 128.9, 138.1, 141.2 and 174.9; HRMS (EI$^+$) 237.1158 (cal. for $C_{16}H_{15}NO$ 237.1154); IR 1381, 1497, 1697 and 2947 cm^{-1}.



5-(4-Methoxyphenyl)-1-phenylpyrrolidin-2-one (4c): viscous liquid; R_f = 0.45 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.93-1.99 (m, 1H), 2.55-2.62(m, 2H), 2.70-2.76 (m, 1H), 3.73 (s, 3H), 5.17-5.19 (m, 1H), 6.80 (d, *J* = 8.5 Hz, 2H), 7.04 (t, *J* = 7.3 Hz, 1H), 7.11 (d, *J* = 8.5 Hz, 2H), 7.20-7.24 (m, 2H) and 7.37 (d, *J* = .8.0 Hz, 2H); ^{13}C NMR δ 29.3, 31.2, 55.2, 63.5, 114.3, 122.4, 124.9, 127.1, 128.6, 133.1, 138.1, 159.0 and 174.8; HRMS (EI^+) 267.1257 (cal. for $C_{17}H_{17}NO_2$ 267.1259); IR 1250, 1512 and 1697 cm^{-1}.

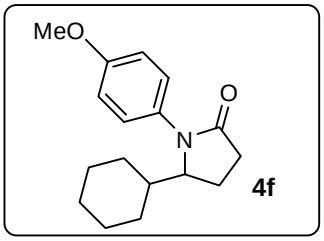


1,5-bis(4-Methoxyphenyl)pyrrolidin-2-one (4d): viscous liquid; R_f = 0.32 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.93-2.01 (m, 1H), 2.51-2.61 (m, 2H), 2.69-2.77 (m, 1H), 3.69 (s, 3H), 3.73 (s, 3H), 5.08-5.10 (m, 1H), 6.74 (d, *J* = 9.0 Hz, 2H), 6.79 (d, *J* = 8.0 Hz, 2H), 7.09 (d, *J* = 8.0 Hz, 2H) and 7.22 (d, *J* = 9.5 Hz, 2H); ^{13}C NMR δ 29.1, 31.1, 55.2(2C), 64.0, 113.9, 114.2, 124.4, 127.3, 131.0, 133.2, 156.8, 159.0, and 174.7; HRMS (EI^+) 297.1365 (cal. for $C_{18}H_{19}NO_3$ 297.1365); IR 1242, 1512, 1689 and 2947 cm^{-1}.

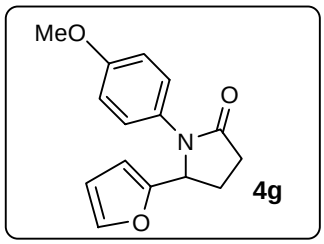


1-(4-Methoxyphenyl)-5-phenylpyrrolidin-2-one (4e): viscous liquid; R_f = 0.40 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.97-2.02 (m, 1H), 2.58-2.63 (m, 2H), 2.71-2.76 (m, 1H), 3.70 (s, 3H), 5.13-5.16 (m, 1H), 6.75 (d, *J* = 8.5 Hz, 2H), 7.18-7.21 (m, 2H) and 7.23-7.29 (m, 5H); ^{13}C NMR δ 29.1, 31.0, 55.3, 64.4, 114.0, 124.2, 126.1, 127.8, 128.9,

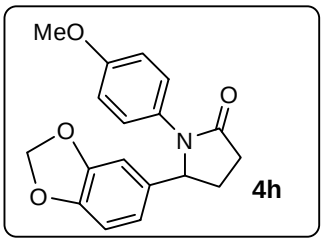
131.1, 141.4, 156.9 and 174.8; HRMS (EI^+) 267.1255 (cal. for $C_{17}H_{17}NO_2$ 267.1259); IR 1242, 1512, 1689 and 2947 cm^{-1}.



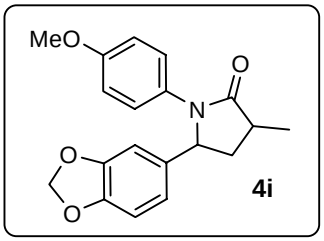
5-Cyclohexyl-1-(4-methoxyphenyl)pyrrolidin-2-one (4f): pale yellow solid; mp = 88 °C; R_f = 0.35 (40% ethyl acetate in hexanes);^{1}H NMR δ 0.92-1.16 (m, 4H), 1.44-1.47 (m, 1H), 1.52-1.56 (m, 2H), 1.58-1.63 (m, 1H), 1.63-1.73 (m, 3H), 1.89-1.96 (m, 1H), 2.07-2.15 (m, 1H), 2.44-2.57 (m, 2H), 3.79 (s, 3H), 4.03-4.06 (m, 1H), 6.90 (dd, *J* = 3.3 and 12.3 Hz, 2H), and 7.21 (dd, *J* = 3.3 and 12.3 Hz, 2H); ^{13}C NMR δ 19.2, 25.1, 25.7, 26.2, 26.5, 29.2, 31.5, 39.2, 55.4, 64.8, 114.3, 126.1, 130.5, 157.6 and 174.7; HRMS (EI^+) 273.1735 (cal. for $C_{17}H_{23}NO_2$ 273.1729); IR 1250, 1512, 1689 and 2923 cm^{-1}



5-(Furan-2-yl)-1-(4-methoxyphenyl)pyrrolidin-2-one (4g): pale yellow solid; mp = 75 °C; R_f = 0.32 (40% ethyl acetate in hexanes); ^{1}H NMR δ 2.25-2.30 (m, 1H), 2.47-2.61 (m, 2H), 2.77-2.85 (m, 1H), 3.77 (s, 3H), 5.07-5.10 (m, 1H), 6.09 (d, *J* = 8.0 Hz, 1H), 6.22-6.23 (m, 1H), 6.80 (d, *J* = 9.0 Hz, 2H), 7.11 (d, *J* = 8.5 Hz, 2H) and 7.32 (d, *J* = 1.5 Hz, 1H); ^{13}C NMR δ 25.2, 30.9, 55.3, 58.6, 108.0, 110.3, 114.1, 125.6, 130.6, 142.5, 153.0, 157.7 and 174.5; HRMS (EI^+) 257.1053 (cal. for $C_{15}H_{15}NO_3$ 257.1052); IR 1242, 1512, 1689 and 2939 cm^{-1}.

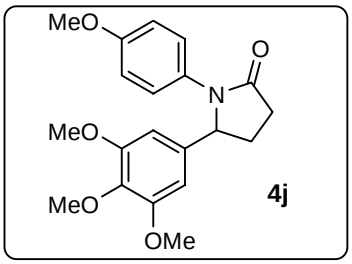


5-(Benzo[d][1,3]dioxol-6-yl)-1-(4-methoxyphenyl)pyrrolidin-2-one (4h): light brown solid; mp = 144 °C; R_f = 0.30 (10% ethyl acetate in hexanes); ^{1}H NMR δ 1.95-1.97 (m, 1H), 2.54-2.59 (m, 2H), 2.67-2.74 (m, 1H), 3.70 (s, 3H), 5.04-5.06 (m, 1H), 5.88 (s, 2H), 6.63-6.69 (m, 2H), 6.65 (s, 1H), 6.76 (d, *J* = 9.0 Hz, 2H) and 7.23 (d, *J* = 9.0 Hz, 2H); ^{13}C NMR δ 29.1, 31.0, 55.3, 64.2, 101.1, 106.3, 108.4, 113.9, 119.7, 124.3, 131.0, 135.3, 147.1, 148.2, 156.9 and 174.6; HRMS (EI^+) 311.1163 (cal. for $C_{18}H_{17}NO_4$ 311.1158); IR 1242, 1512, 1689 and 2939 cm^{-1}.

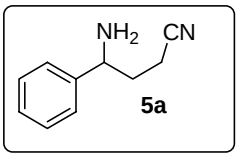


***trans*-5-(Benzo[d][1,3]dioxol-5-yl)-1-(4-methoxyphenyl)-3-methylpyrrolidin-2-one (4i):** yellow solid; mp = 114 °C; R_f = 0.39 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.27 (d, *J* = 7.0 Hz, 3H), 2.15-2.22 (m, 2H), 2.81 (q, *J* = 8.0 Hz, 1H), 3.72 (s, 3H), 5.01 (q, *J* = 3.5 Hz, 1H), 5.90 (s, 2H), 6.62-6.65 (m, 2H), 6.70 (d, *J* = 7.5 Hz, 1H), 6.77 (d, *J* = 9.5 Hz, 2H) and 7.36 (d, *J* = 9.0 Hz, 2H);^{13}C NMR δ 16.1, 35.7, 37.8, 55.3, 61.8, 101.2, 106.2, 108.5, 113.9, 119.2, 123.2, 131.7, 135.3, 147.0, 148.3, 156.6 and 176.9; HRMS (EI^+) 325.1307 (cal. for $C_{19}H_{19}NO_4$ 325.1314); IR 1250, 1512, 1689, 2360 and 2970 cm^{-1}.

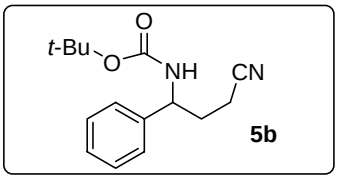
***cis*-5-(Benzo[d][1,3]dioxol-5-yl)-1-(4-methoxyphenyl)-3-methylpyrrolidin-2-one (4i'):** yellow solid; mp = 124 °C; R_f = 0.24 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.33 (d, *J* = 6.8 Hz, 3H), 1.56-1.61 (m, 1H), 2.64-2.76 (m, 2H), 3.70 (s, 3H), 4.95-4.99 (m, 1H), 5.87 (s, 2H), 6.61-6.65 (m, 3H), 6.74 (d, *J* = 9.5 Hz, 2H) and 7.15 (d, *J* = 9.0 Hz, 2H);^{13}C NMR δ 16.6, 37.4, 39.0, 55.3, 62.1, 101.1, 106.7, 108.2, 113.8, 120.4, 124.9, 130.9, 135.1, 147.0, 148.1, 156.8 and 177.1; HRMS (EI^+) 325.1311 (cal. for $C_{19}H_{19}NO_4$ 325.1314); IR 1249, 1512, 1689, 2360 and 2962 cm^{-1}.



5-(3,4,5-Trimethoxyphenyl)-1-(4-methoxyphenyl)pyrrolidin-2-one (4j): yellow solid; mp = 129 °C; R_f = 0.10 (40% ethyl acetate in hexanes); ^{1}H NMR δ 1.98-2.00 (m, 1H), 2.56-2.61 (m, 2H), 2.70-2.75 (m, 1H), 3.72 (s, 3H), 3.76 (s, 6H), 3.78 (s, 3H), 5.05-5.08 (m, 1H), 6.37 (s, 2H), 6.77 (d, *J* = 9.0 Hz, 2H) and 7.26 (d, *J* = 9.0 Hz, 2H); ^{13}C NMR δ 29.1, 31.0, 55.3, 56.1, 60.8, 64.5, 102.9, 114.0, 124.2, 131.2, 137.1, 153.6, 156.9 and 174.7; HRMS (EI^+) 357.1580 (cal. for $C_{20}H_{23}NO_5$ 357.1576); IR 1242, 1512, 1689 and 2939 cm^{-1}.



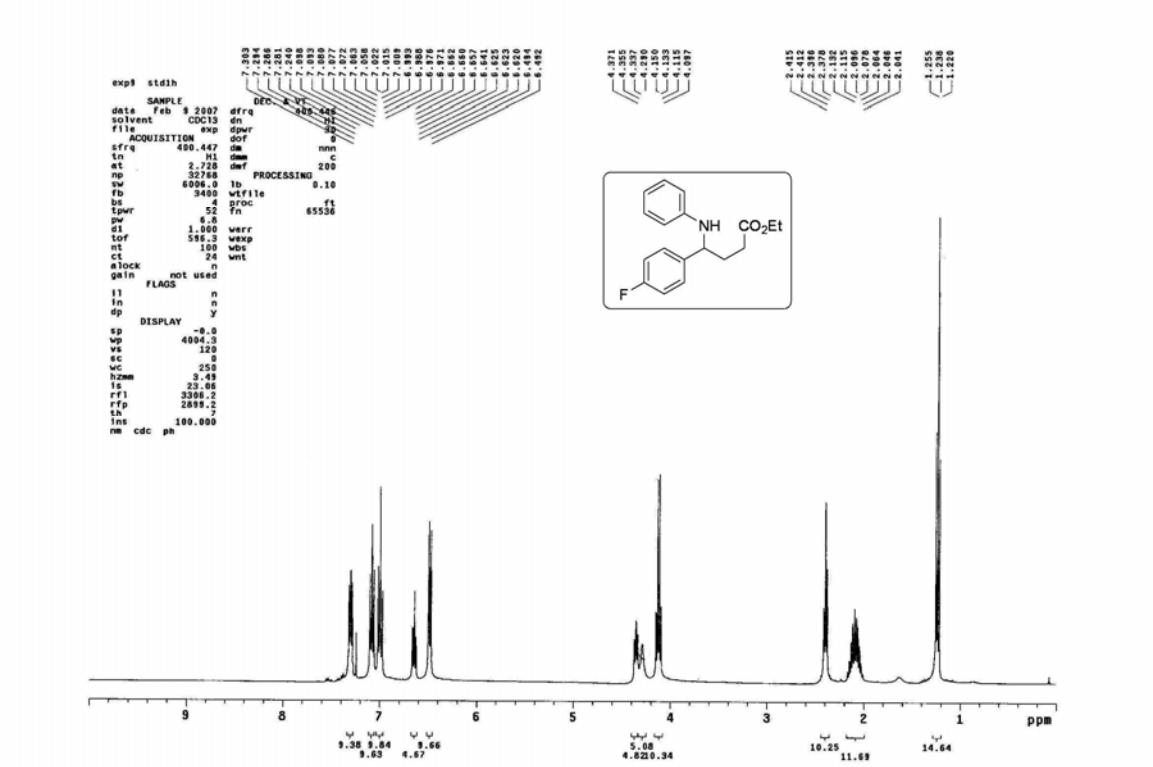
4-Amino-4-phenylbutanenitrile (5a): liquid; R_f = 0.39 (10% MeOH in CH_2Cl_2); ^{1}H NMR δ 1.93-2.00 (m, 1H), 2.03-2.10 (m, 1H), 2.25-2.31 (m, 1H), 2.36-2.42 (m, 1H), 3.92 (t, *J* = 7.0 Hz, 1H), 7.26-7.29 (m, 1H) and 7.32-7.36 (m, 4H); ^{13}C NMR δ 14.8, 35.3, 56.2, 120.8, 127.6, 128.7, 129.9 and 145.0; HRMS (EI^+) 160.0999 (cal. for $C_{10}H_{12}N_2$ 160.1000); IR 1666, 2360 and 2932 cm^{-1}.

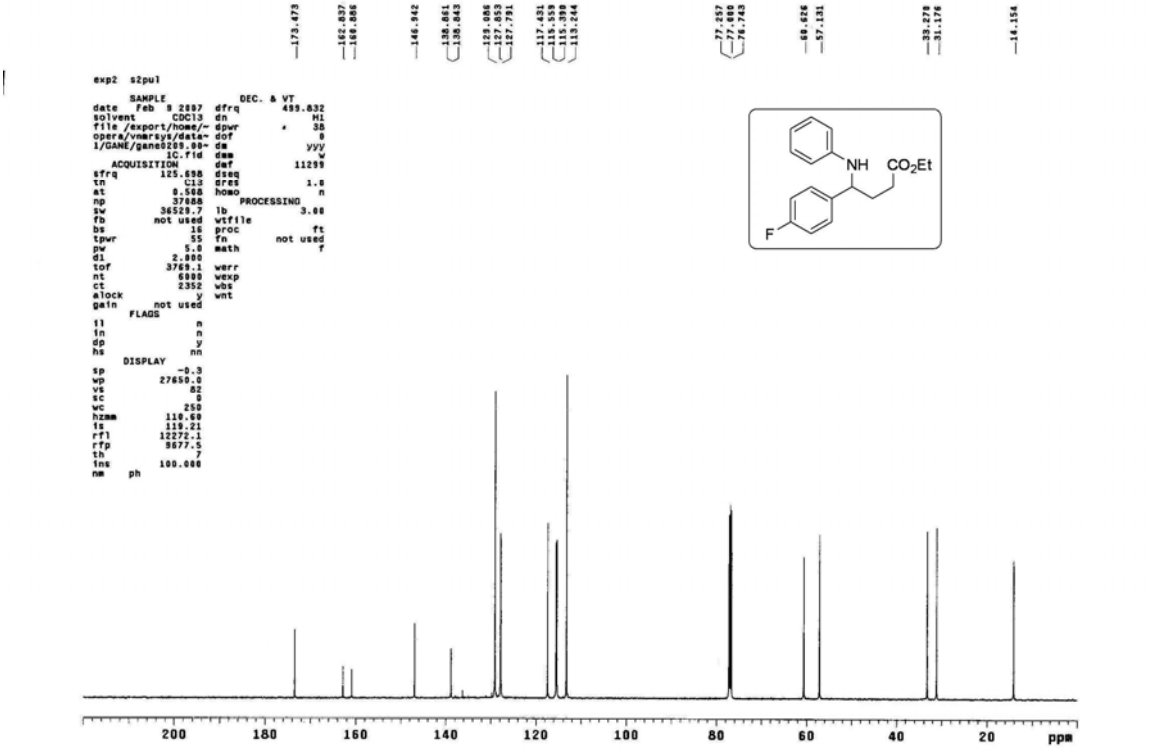


***tert*-Butyl 3-cyano-1-phenylpropylcarbamate (5b):** yellow solid; mp = 126 °C; R_f = 0.24 (20% ethyl acetate in hexanes); ^{1}H NMR δ 1.43 (s, 9H), 2.05-2.16 (m, 2H), 2.32-2.35 (m, 2H), 4.91-4.92 (m, 1H), 7.26-7.29 (m, 3H) and 7.31-7.38 (m, 2H);^{13}C NMR δ

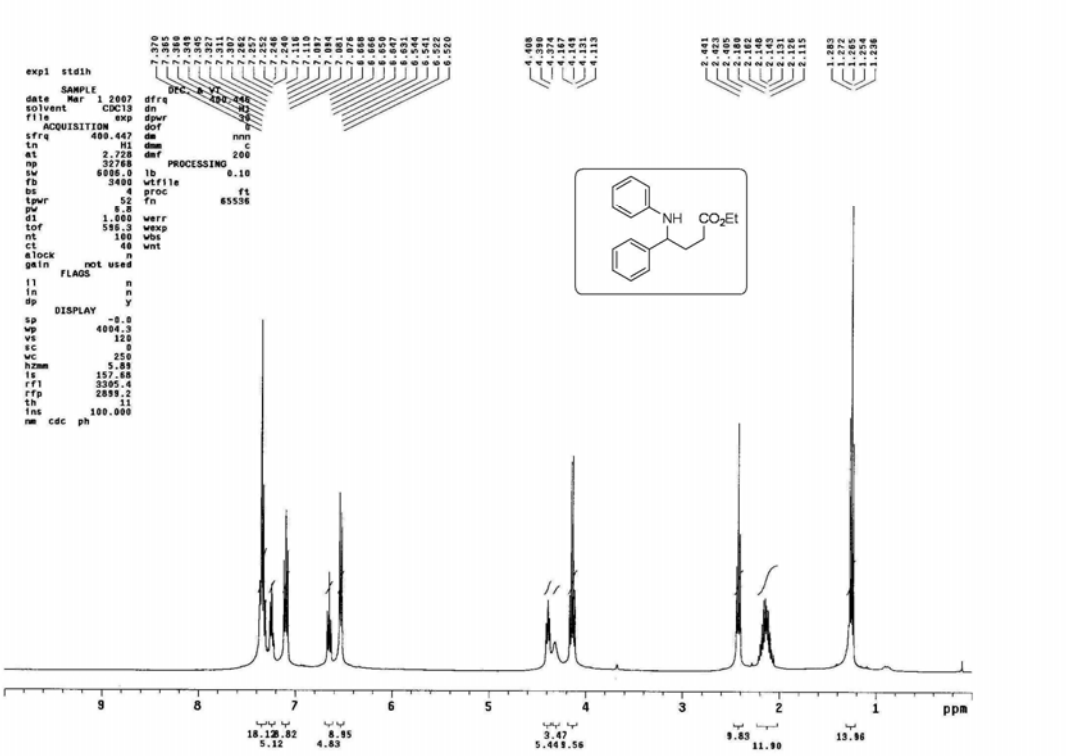
15.0, 28.6, 32.9, 54.6, 80.3, 119.7, 126.8, 128.4, 129.4, 141.4, and 155.6; HRMS (EI^+) 204.0893 (cal. for M-*t*-Bu, $C_{11}H_{12}N_2O_2$ 204.0899); IR 1520, 1682, 2360 and 3378 cm^{-1}.

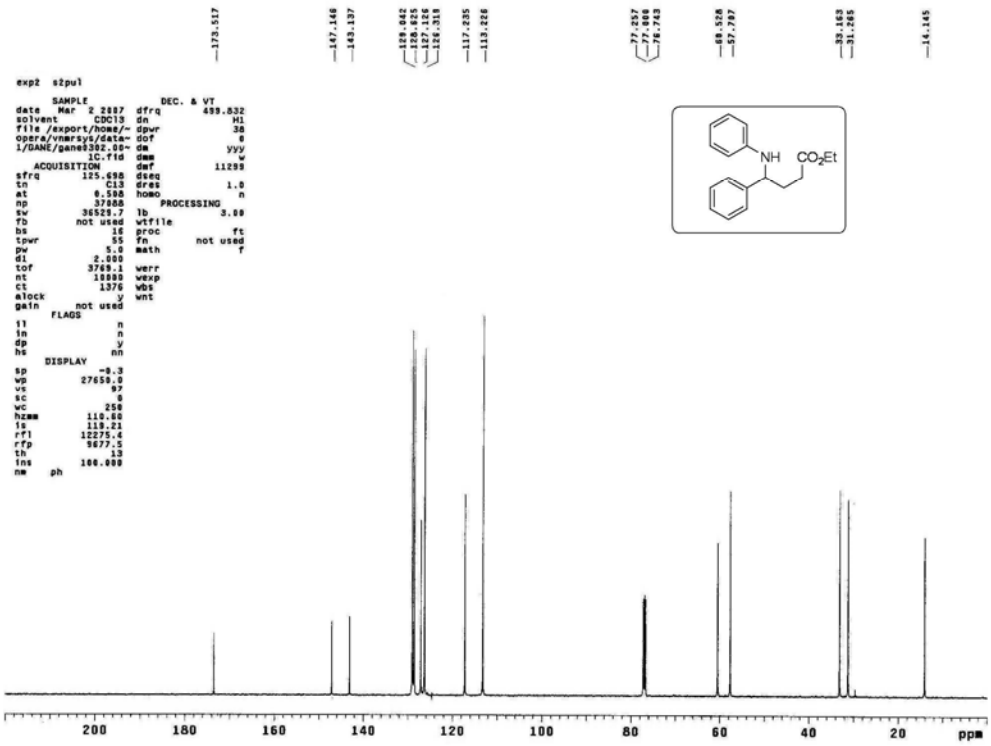
^{1}H and ^{13}C spectra of compound **3a**



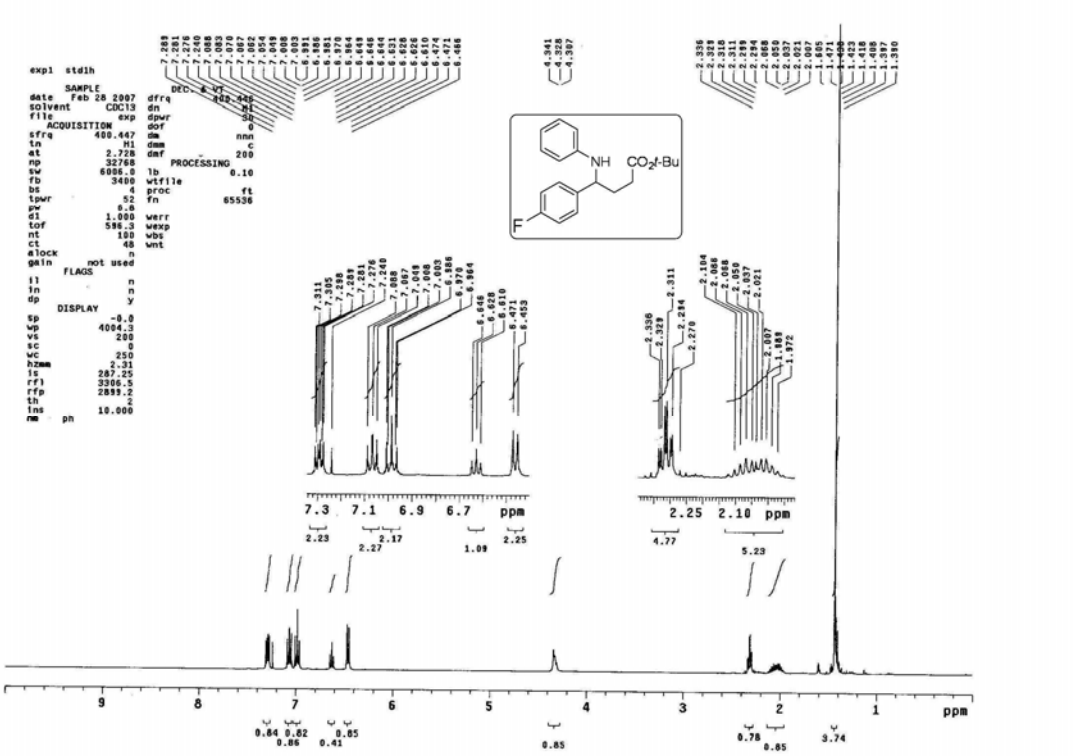


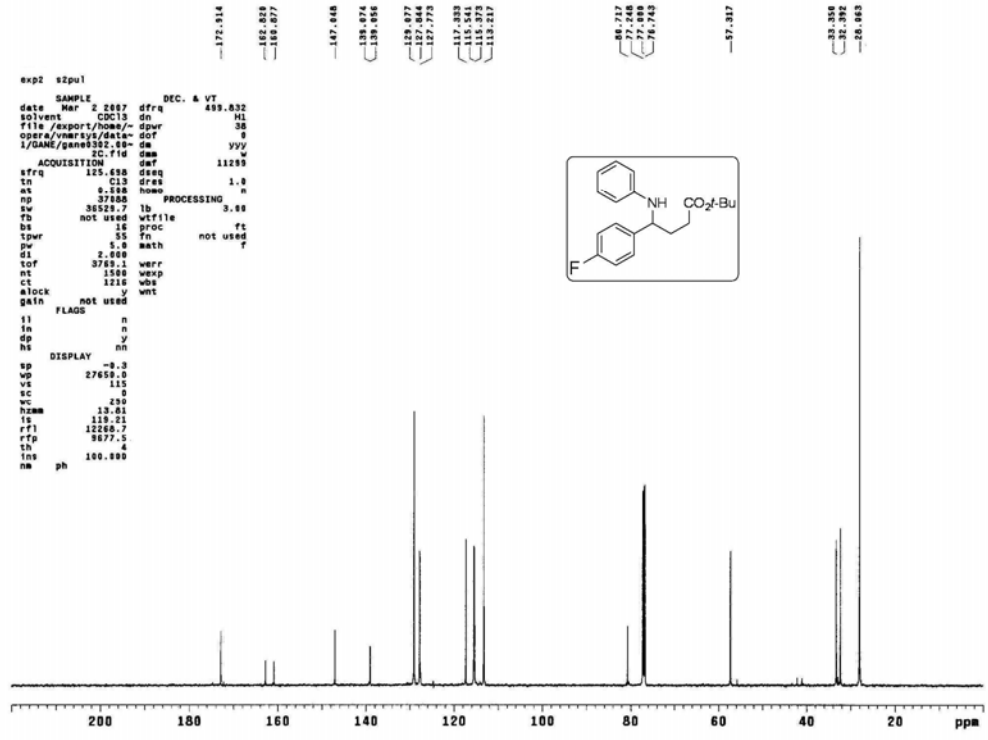
^{1}H and ^{13}C spectra of compound **3b**



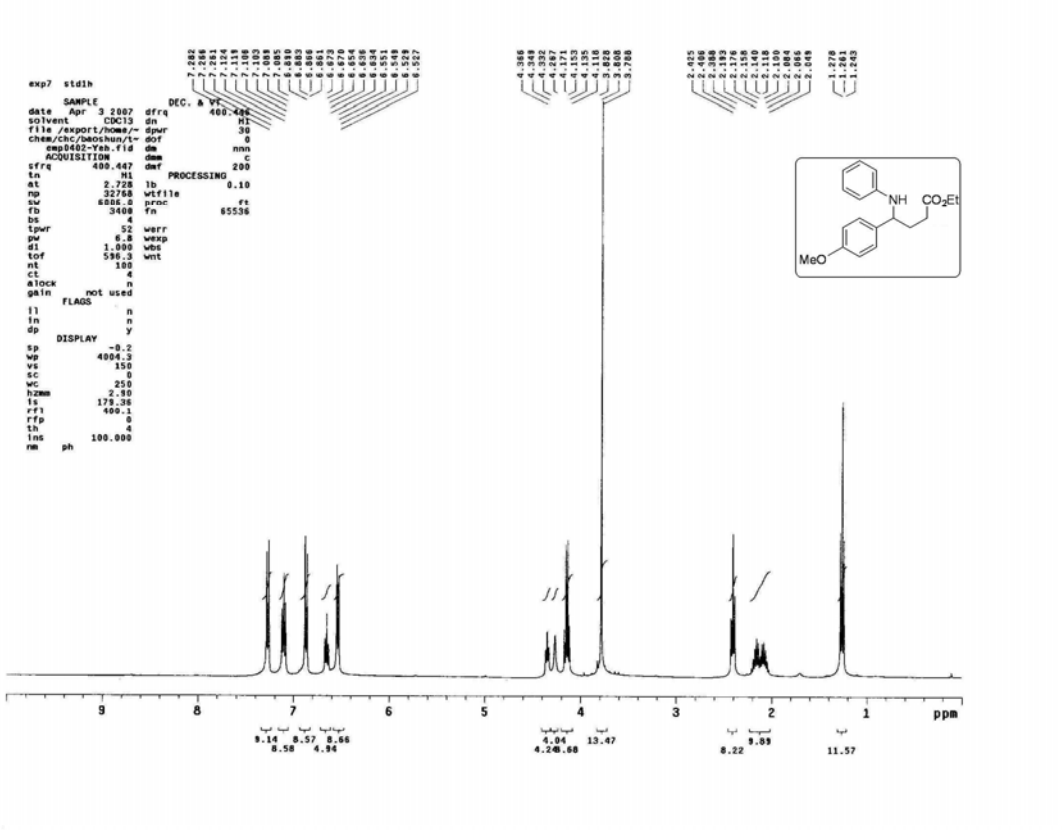


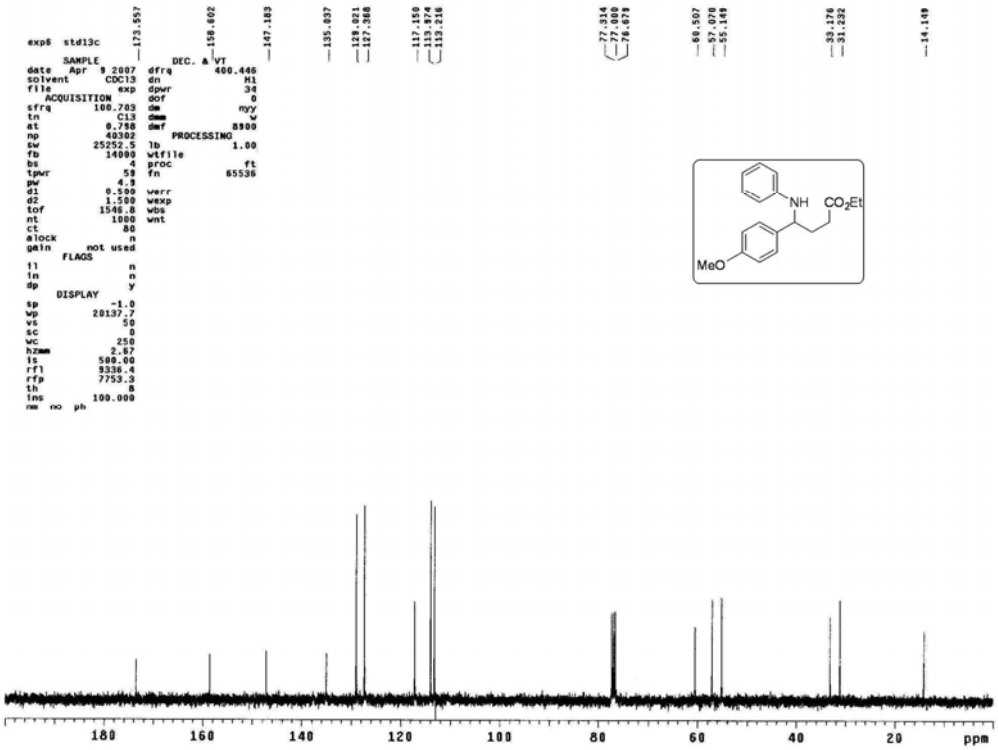
^{1}H and ^{13}C spectra of compound **3c**



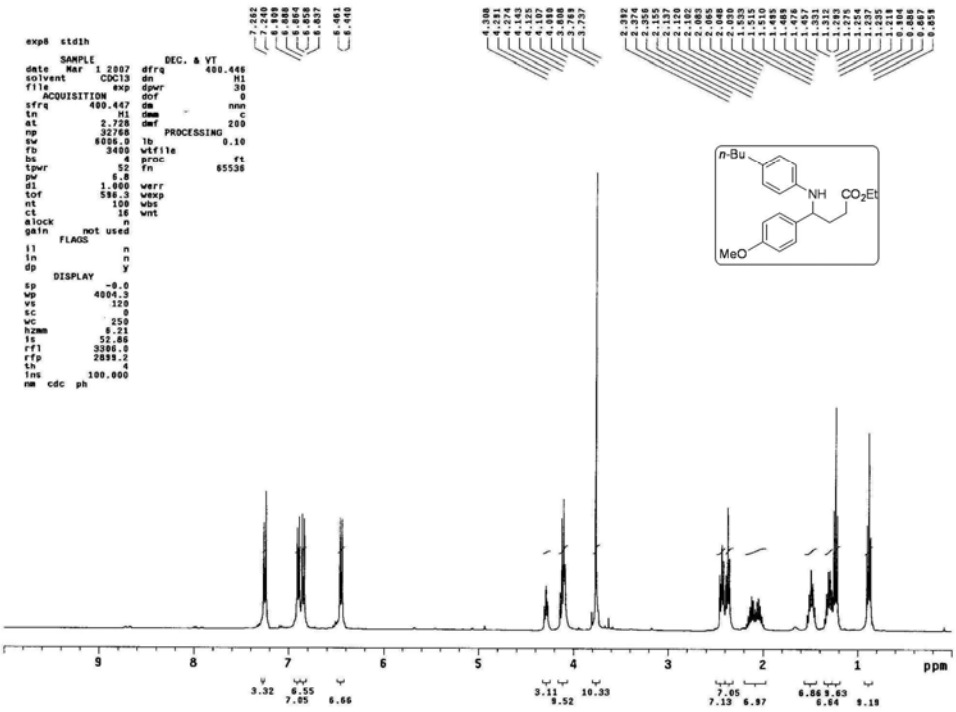


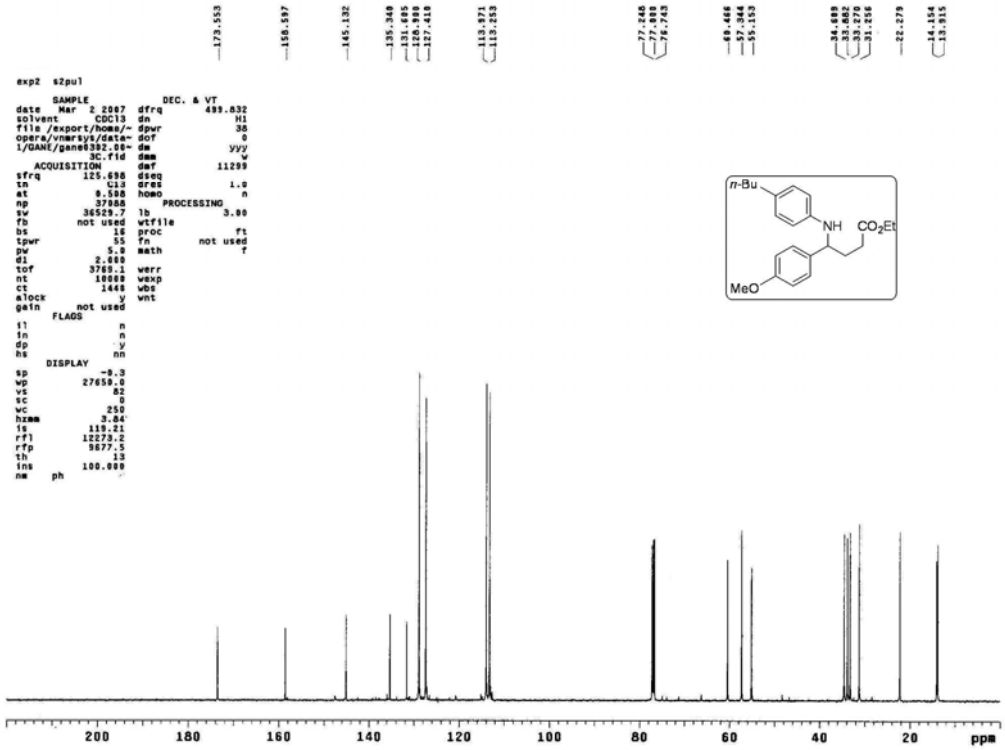
^{1}H and ^{13}C spectra of compound **3d**



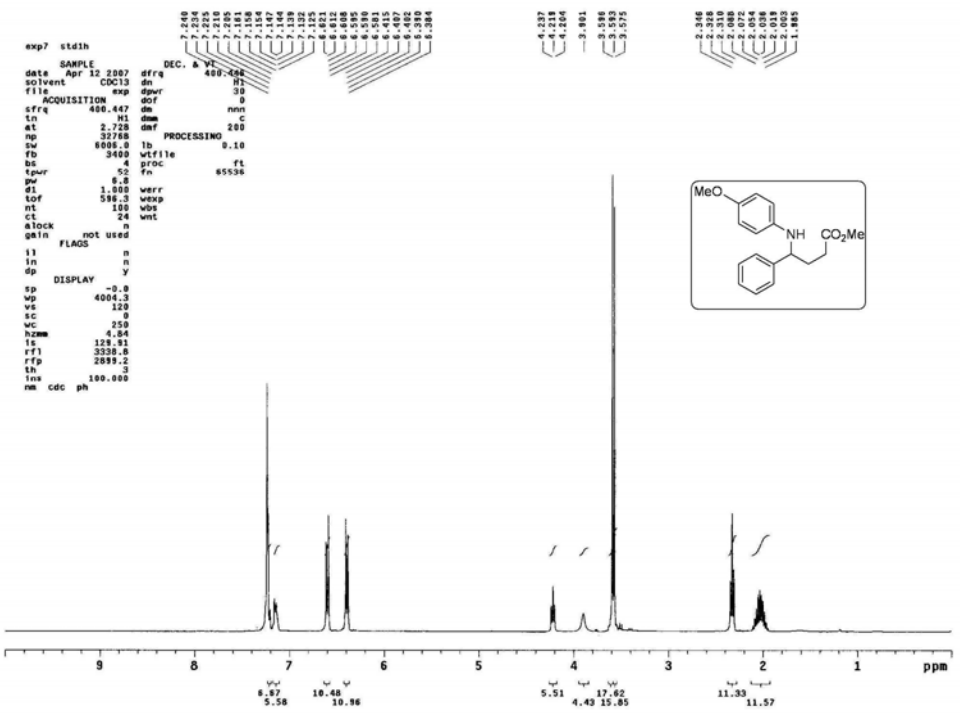


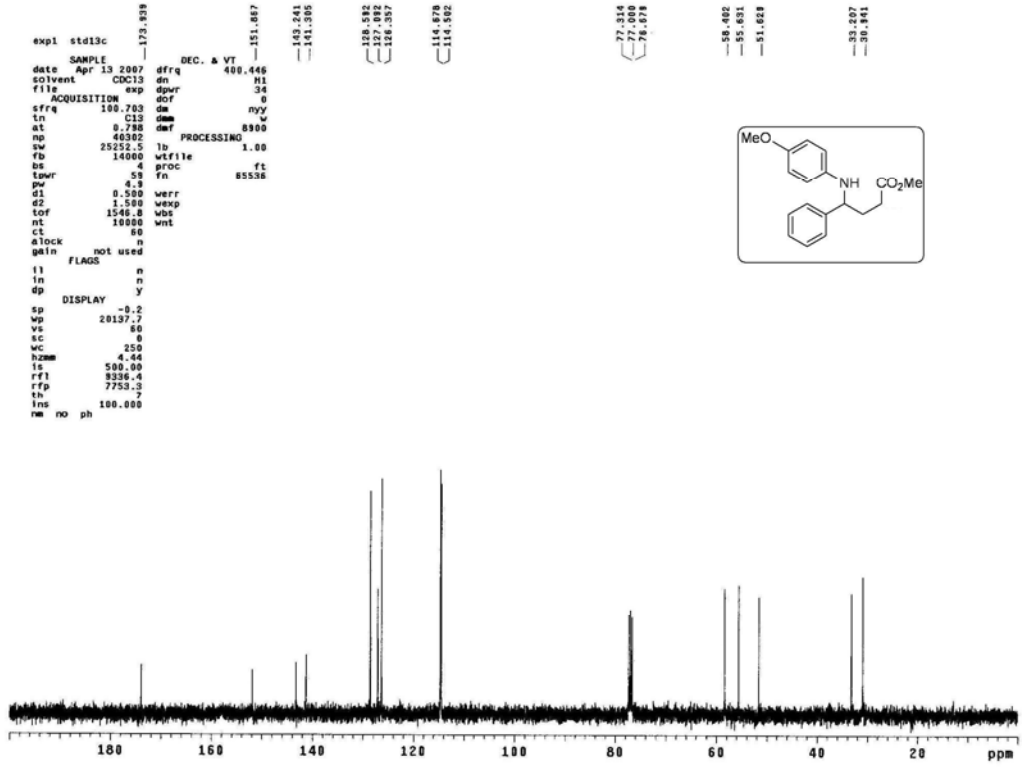
^{1}H and ^{13}C spectra of compound **3e**



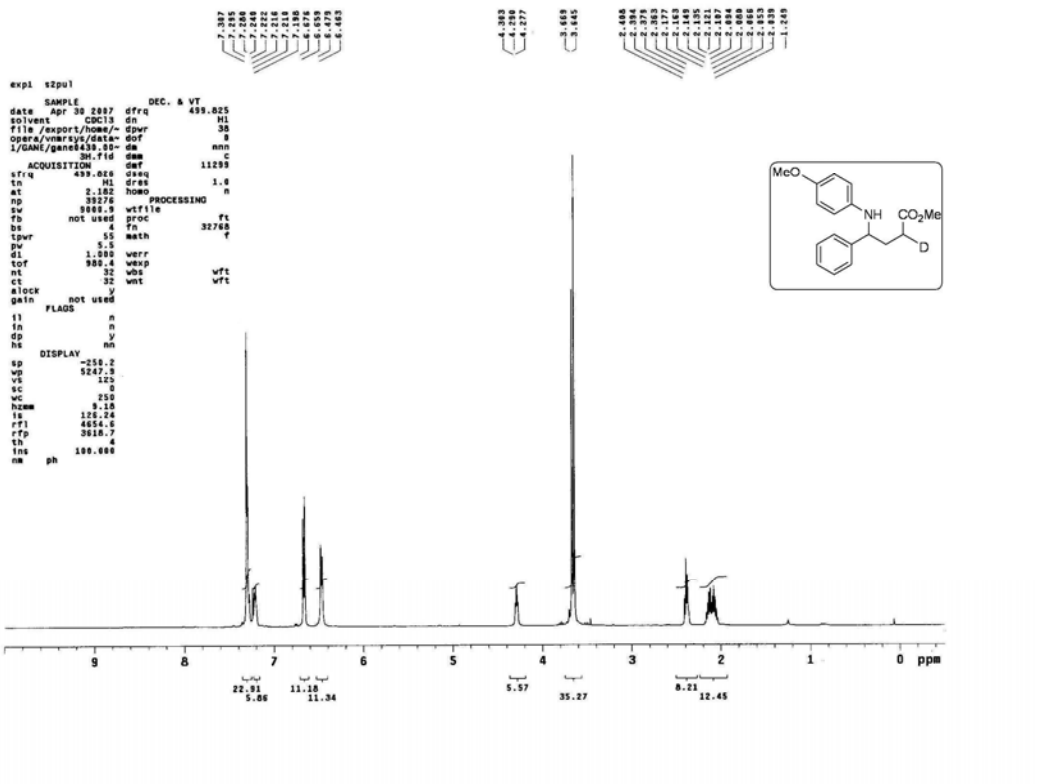


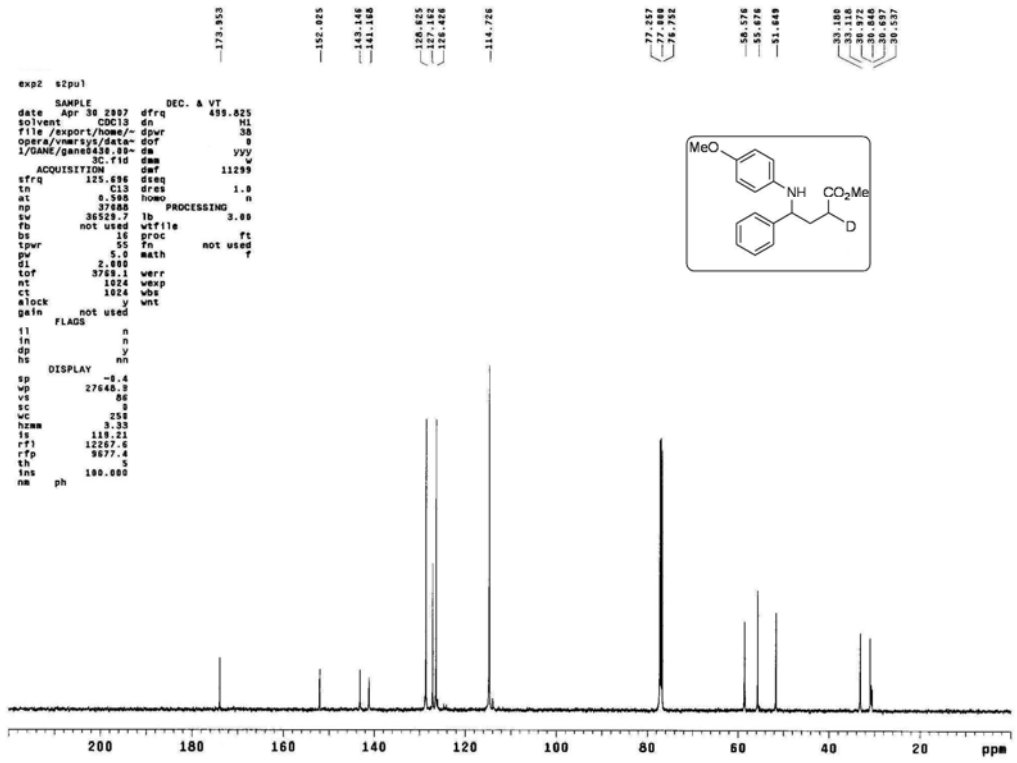
^{1}H and ^{13}C spectra of compound **3f**



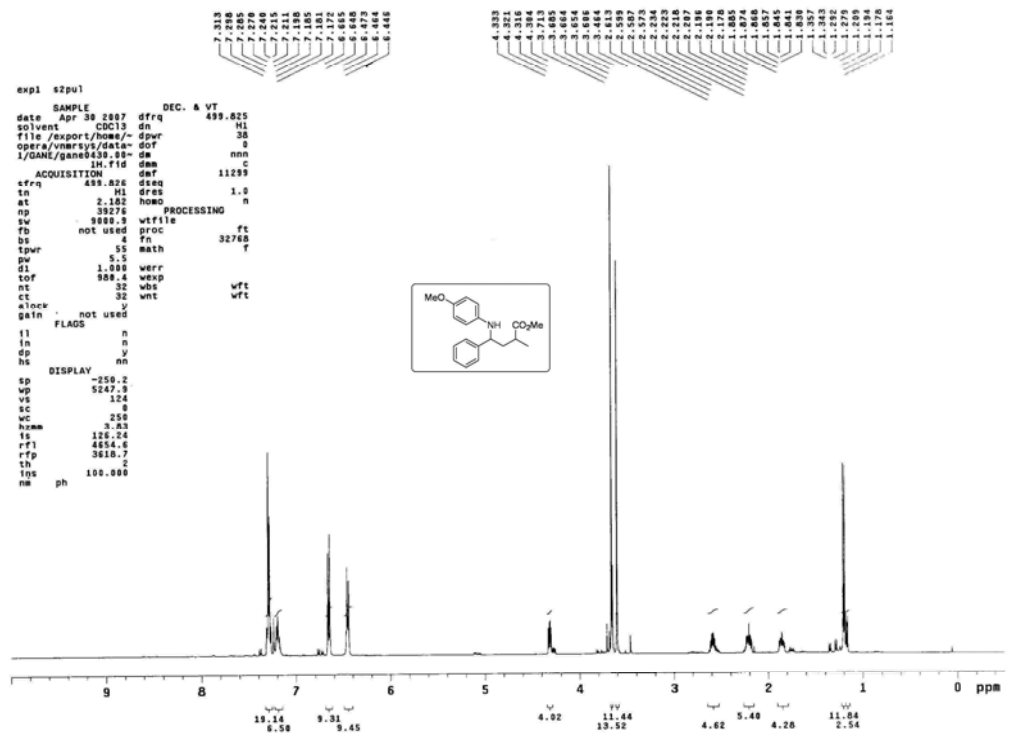


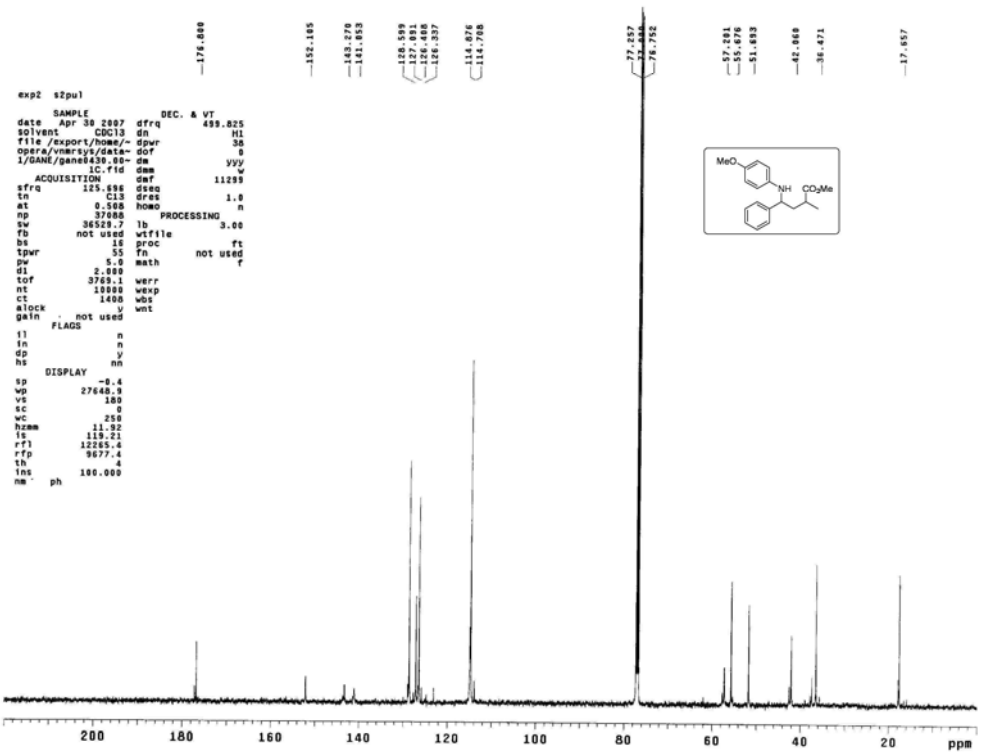
^{1}H and ^{13}C spectra of compound **3f-D**



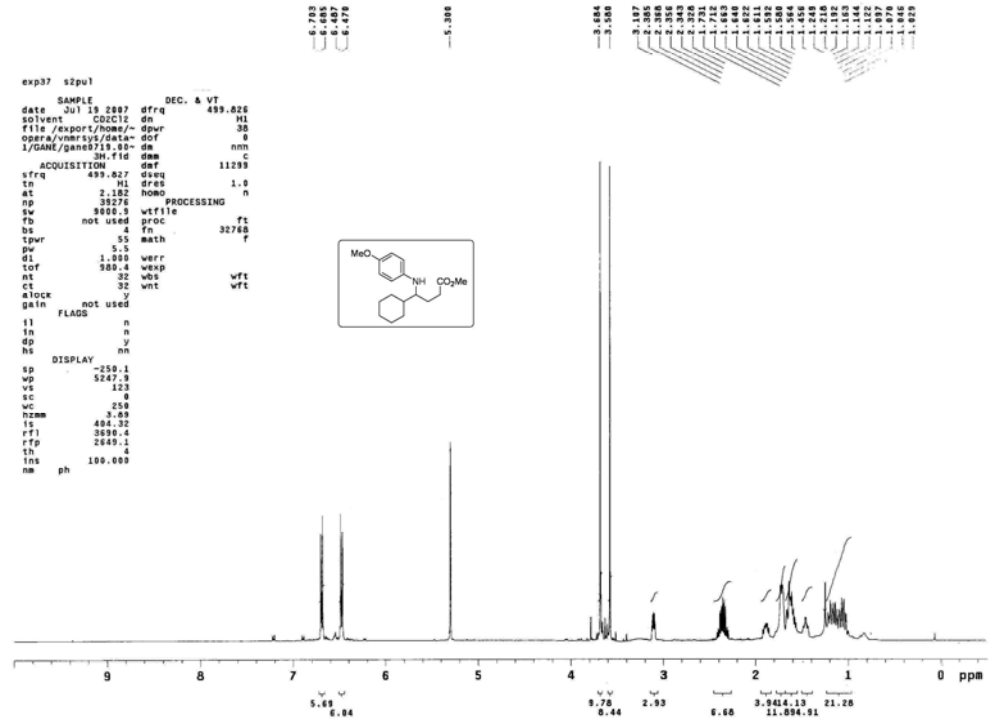


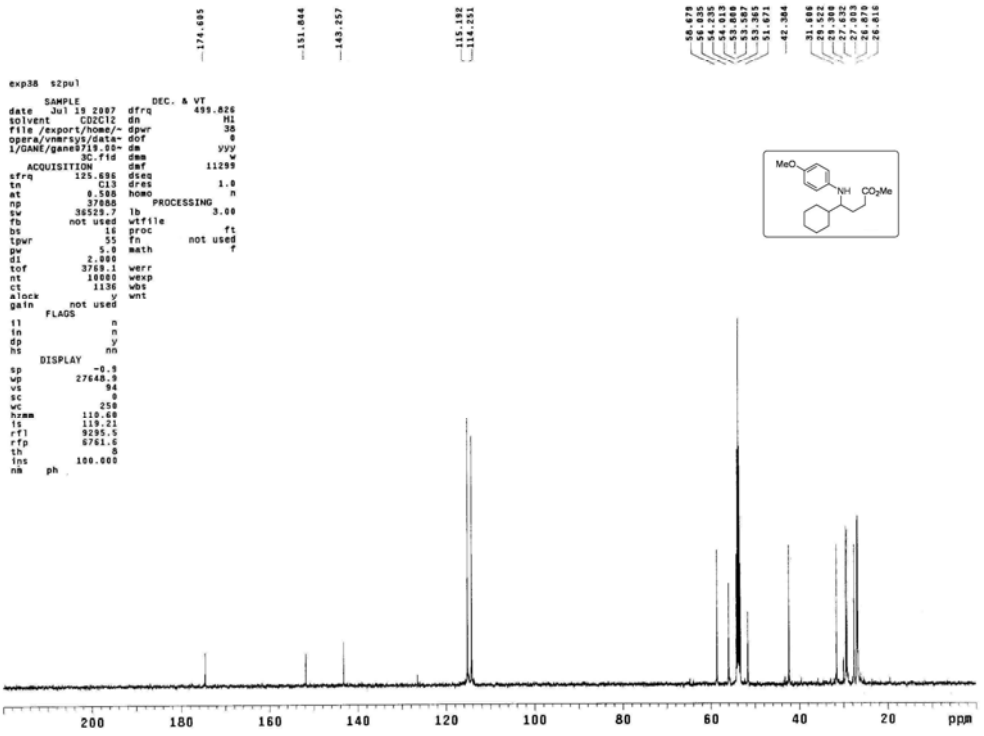
^{1}H and ^{13}C spectra of compound **3g**



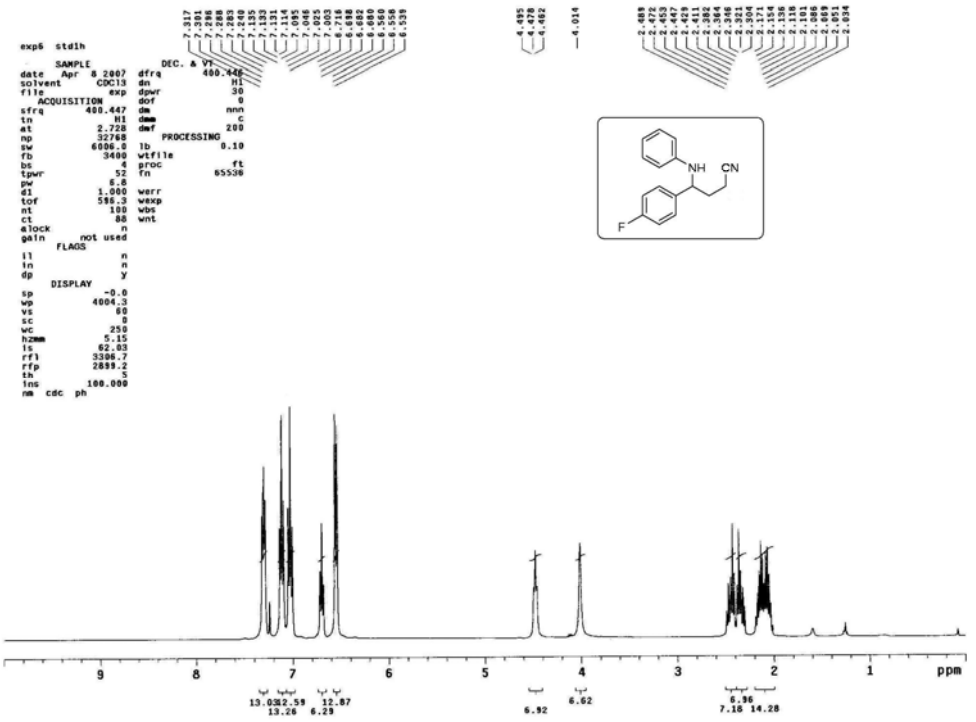


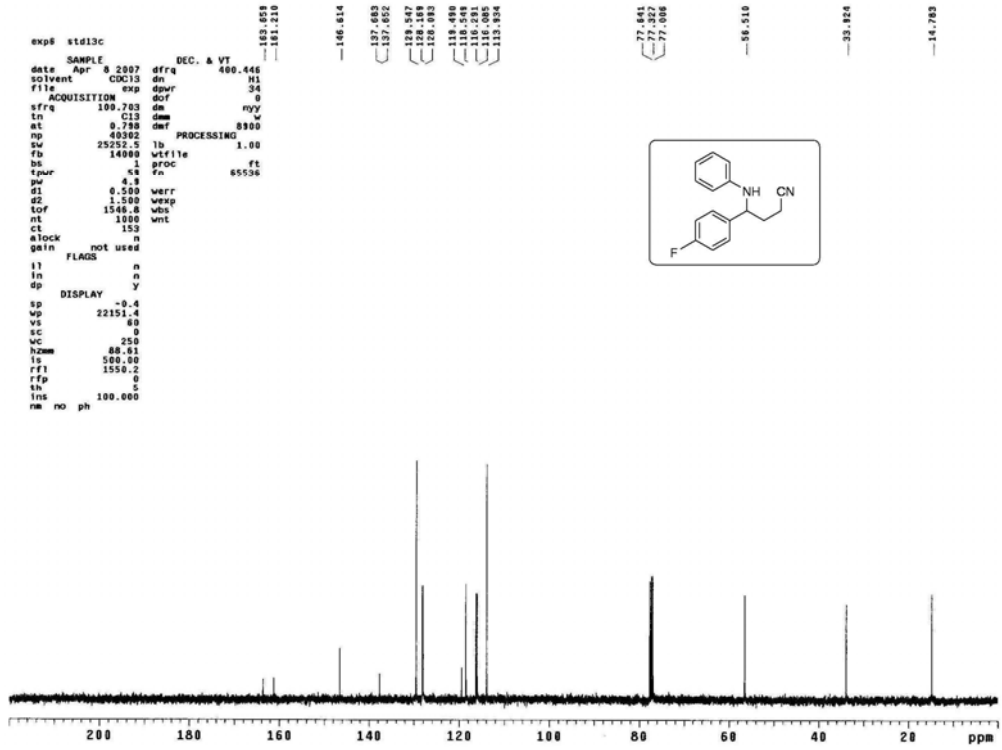
^{1}H and ^{13}C spectra of compound **3h**



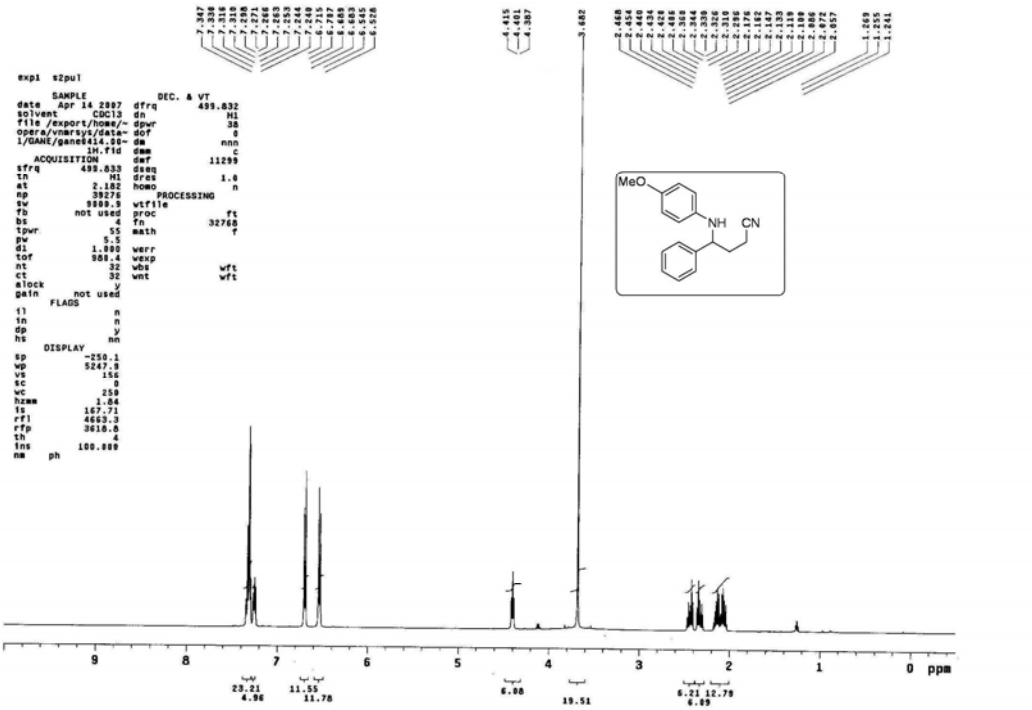


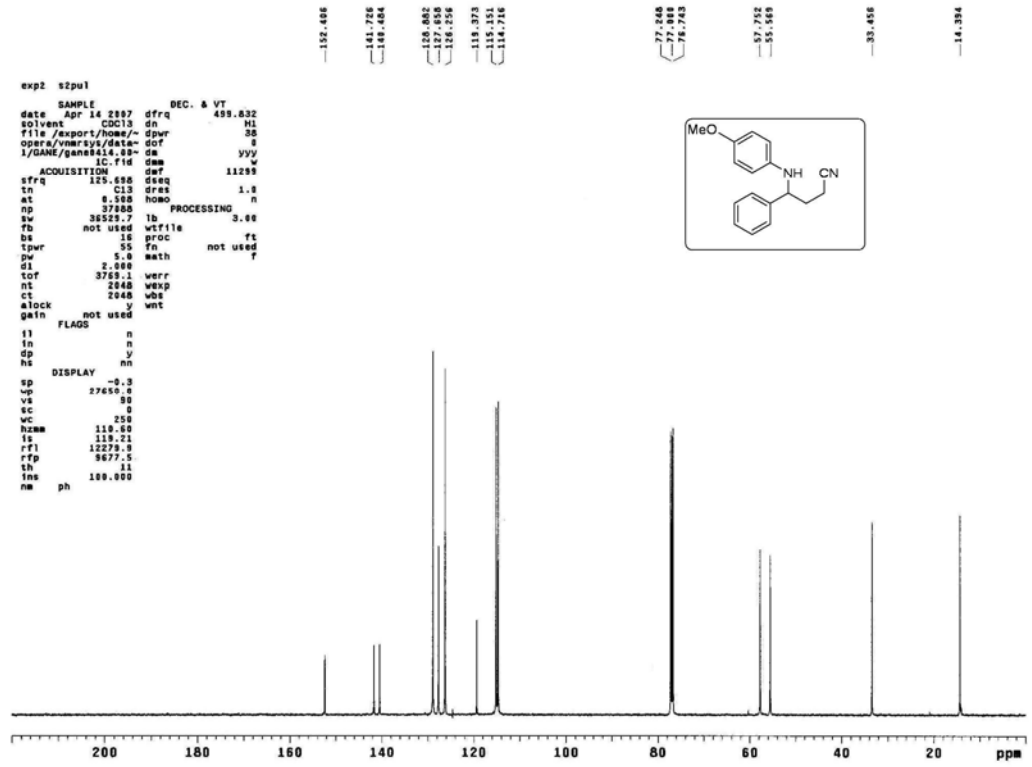
^{1}H and ^{13}C spectra of compound **3i**



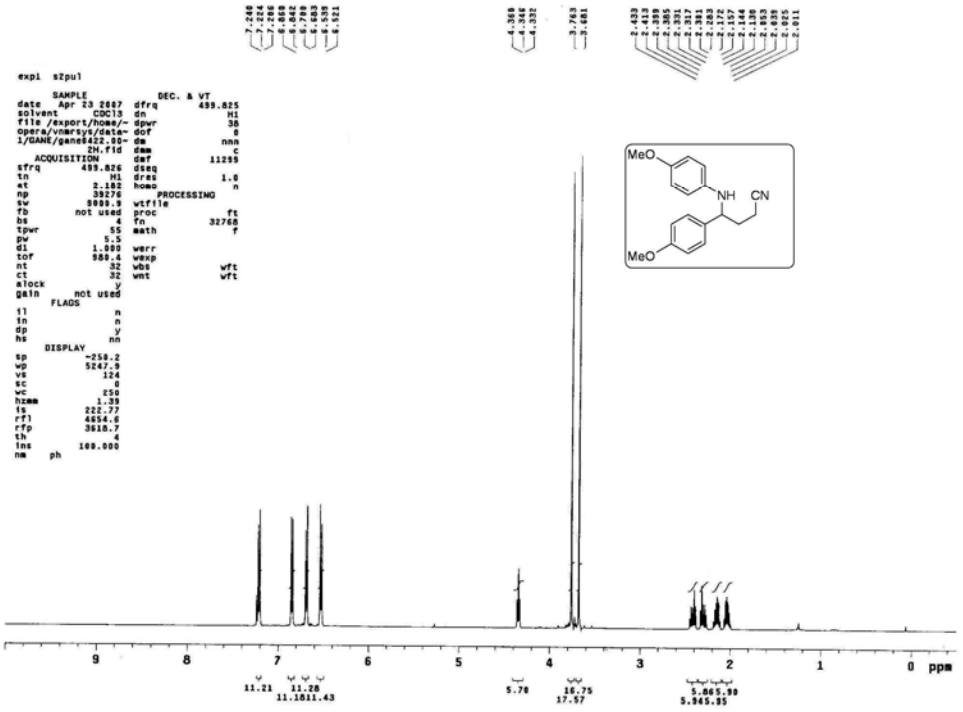


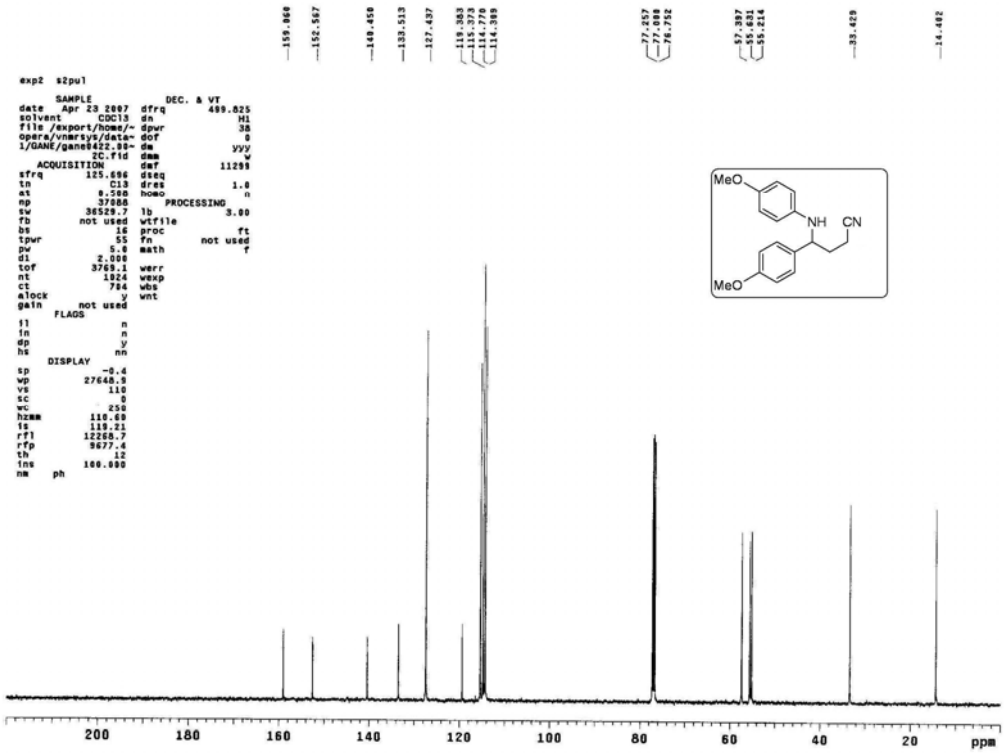
^{1}H and ^{13}C spectra of compound **3j**



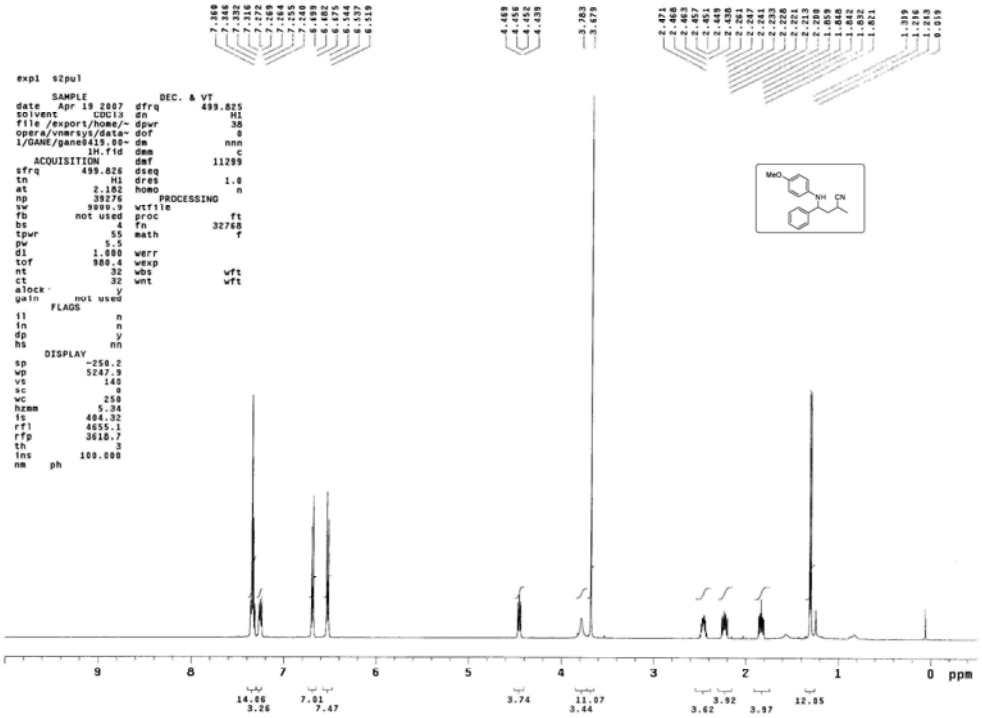


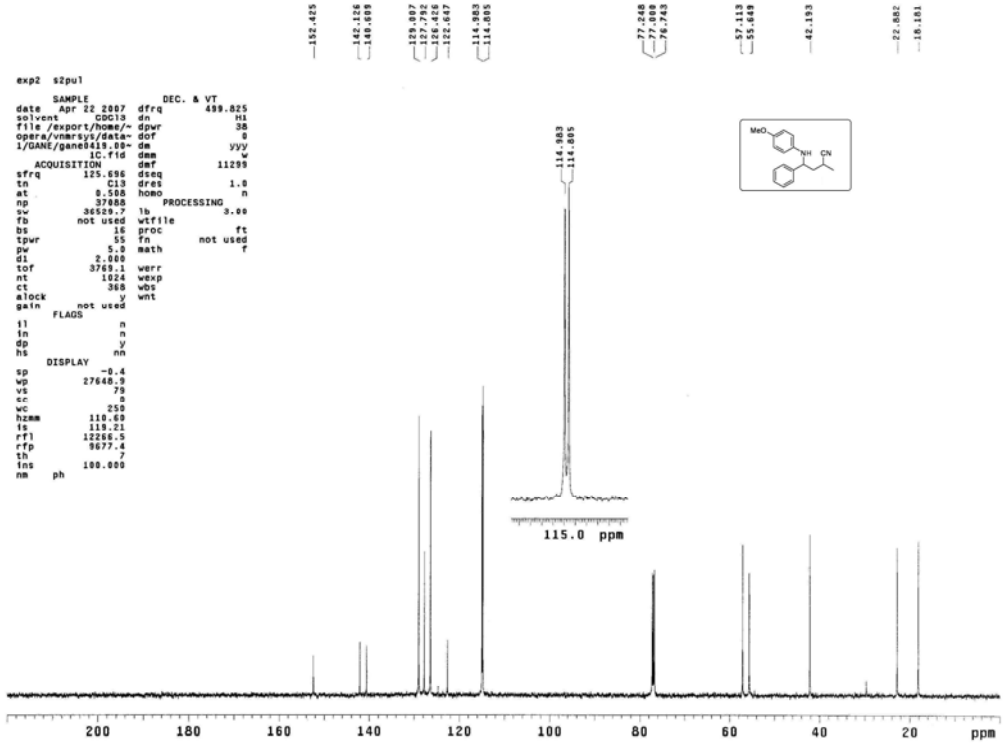
^{1}H and ^{13}C spectra of compound **3k**



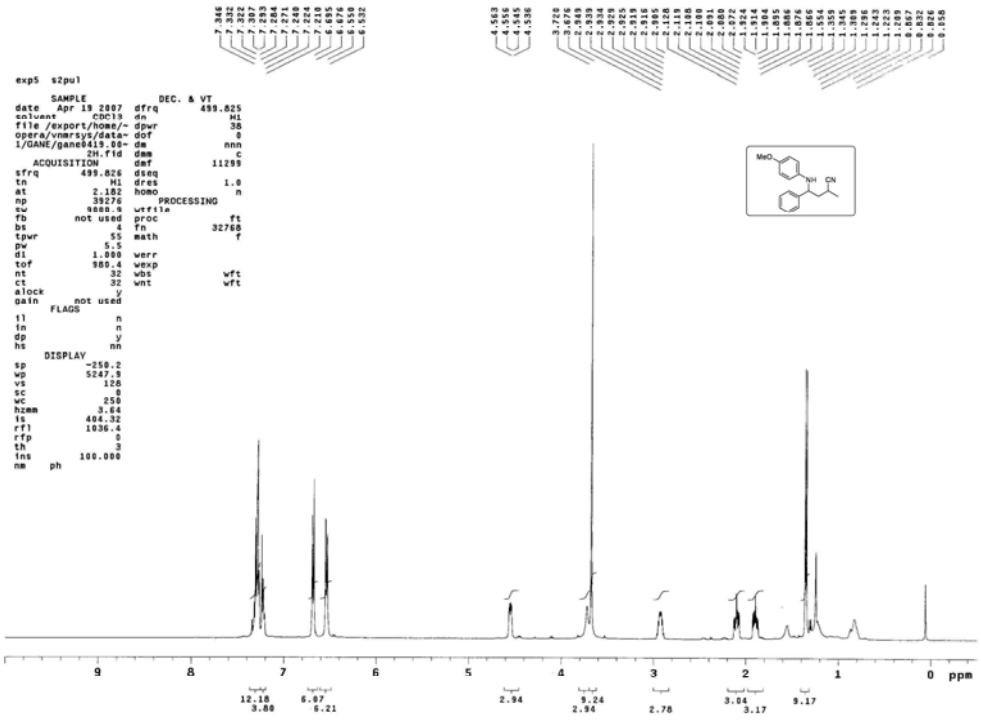


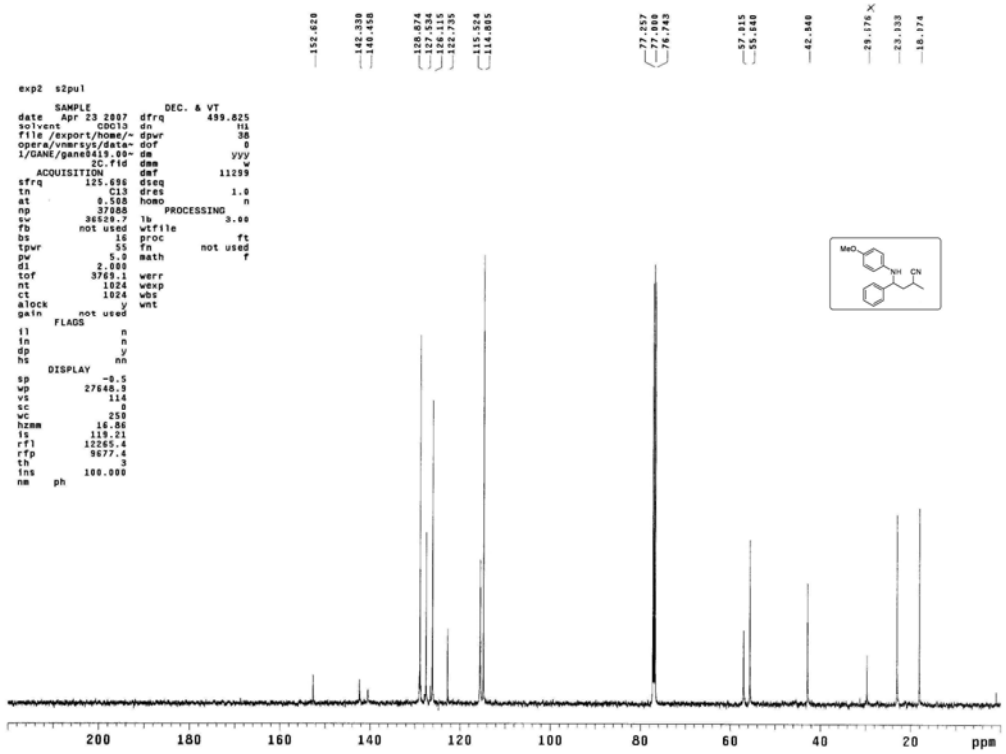
^{1}H and ^{13}C spectra of compound **3l**



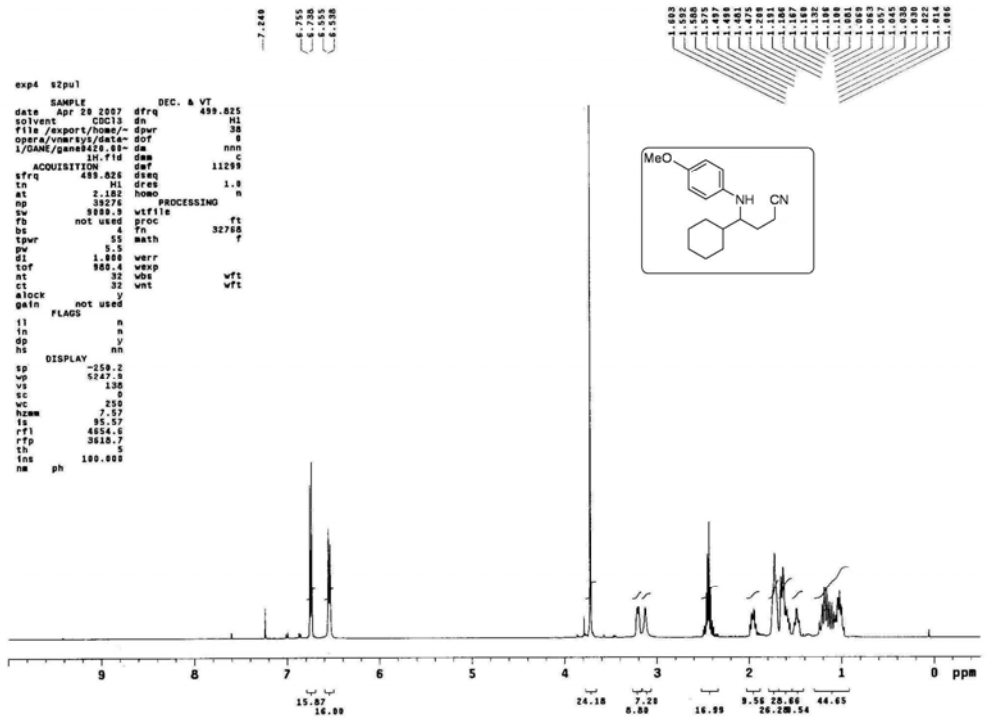


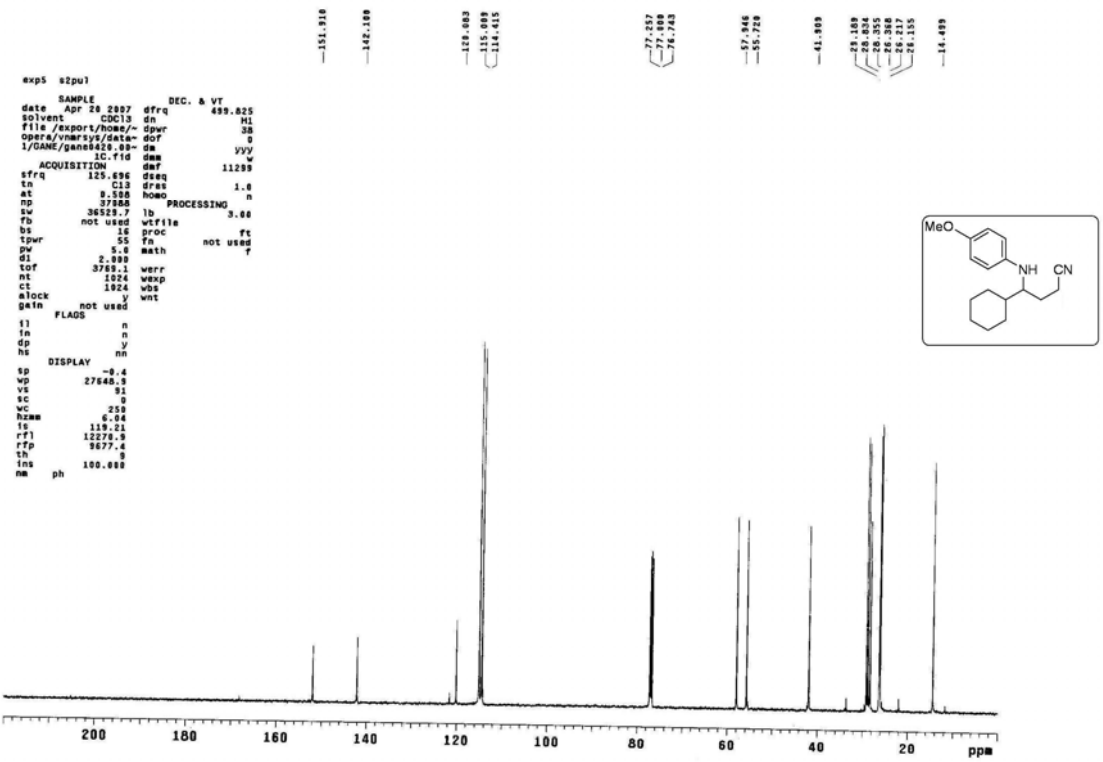
^{1}H and ^{13}C spectra of compound **3l'**



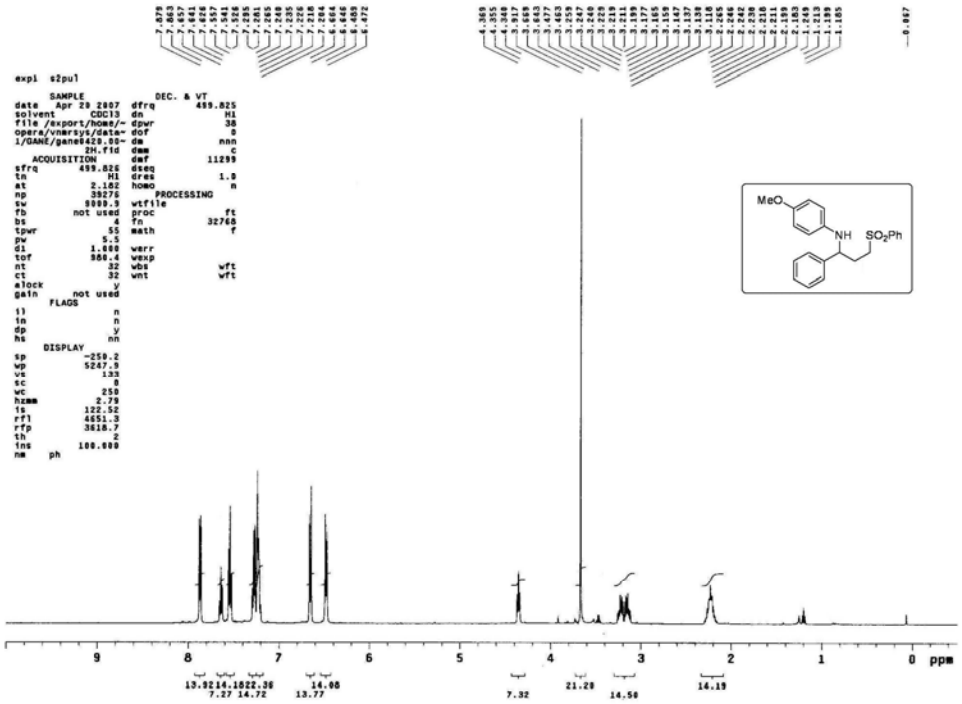


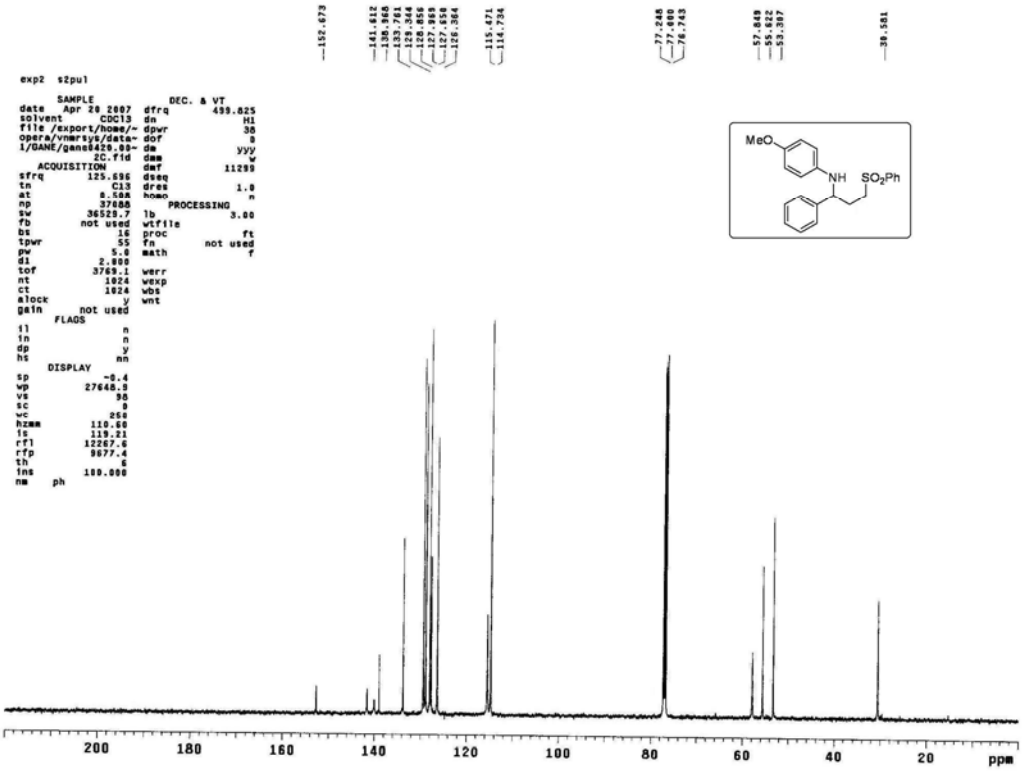
^{1}H and ^{13}C spectra of compound **3m**



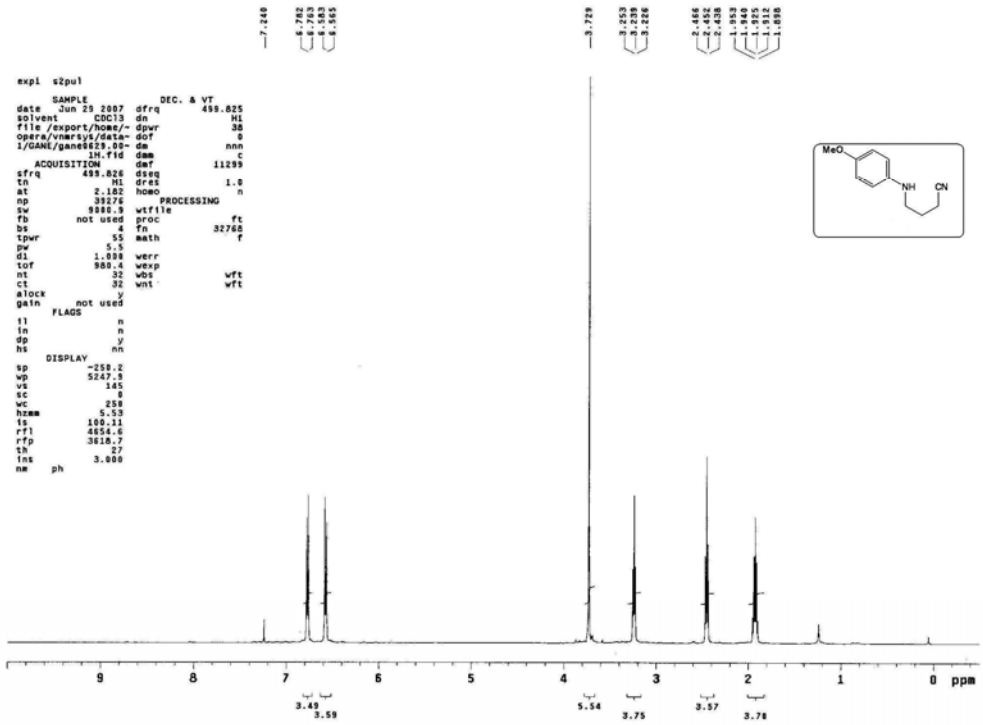


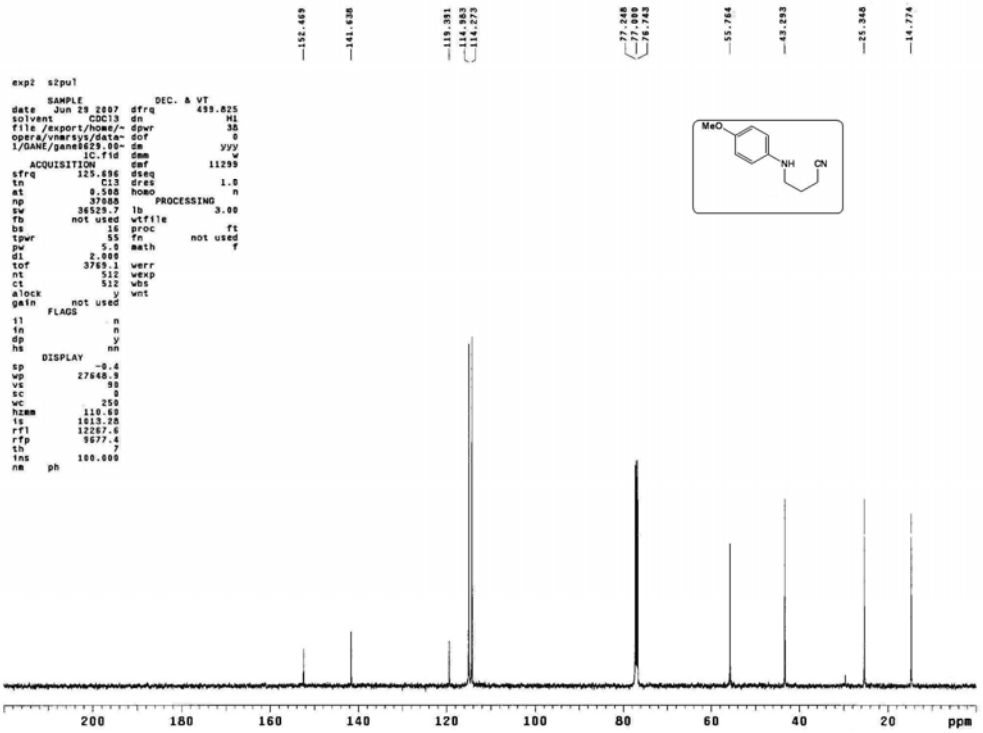
^{1}H and ^{13}C spectra of compound **3n**



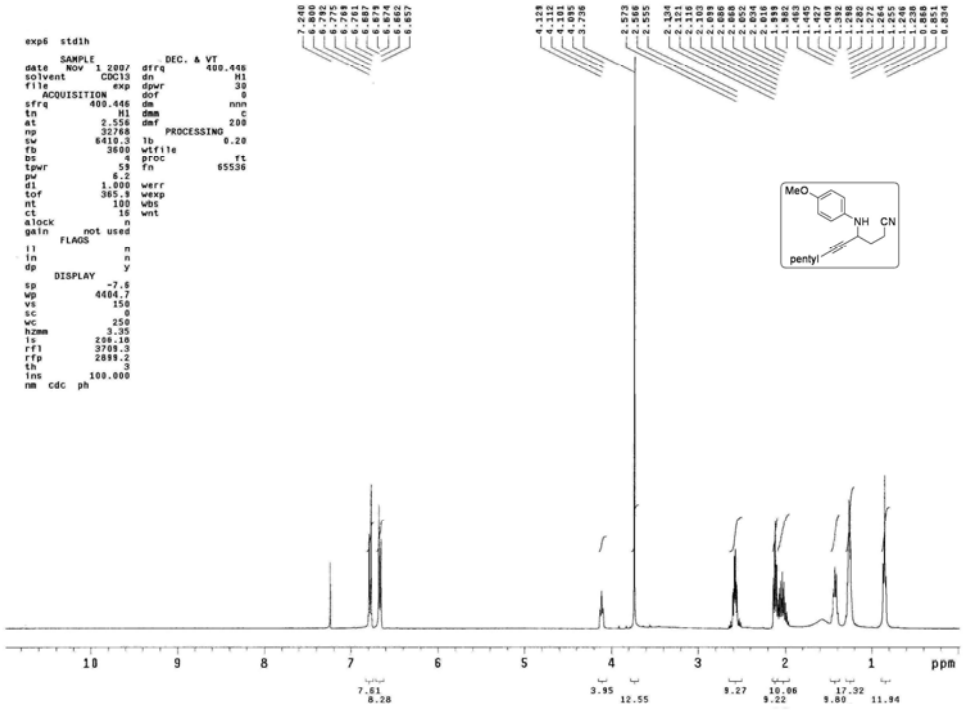


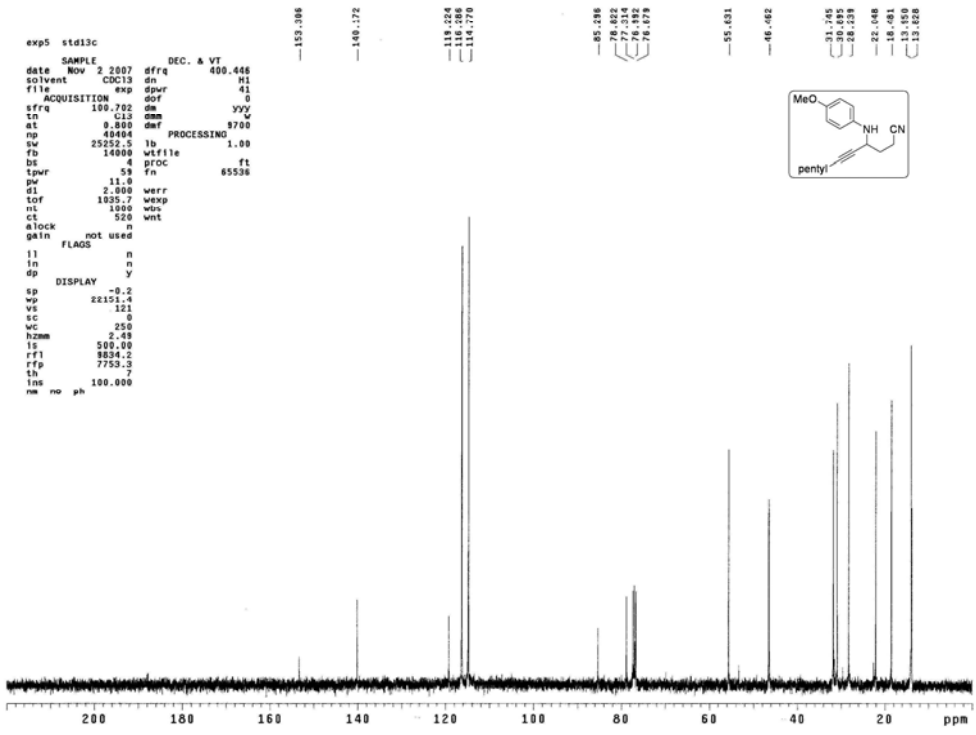
^{1}H and ^{13}C spectra of compound **3o**



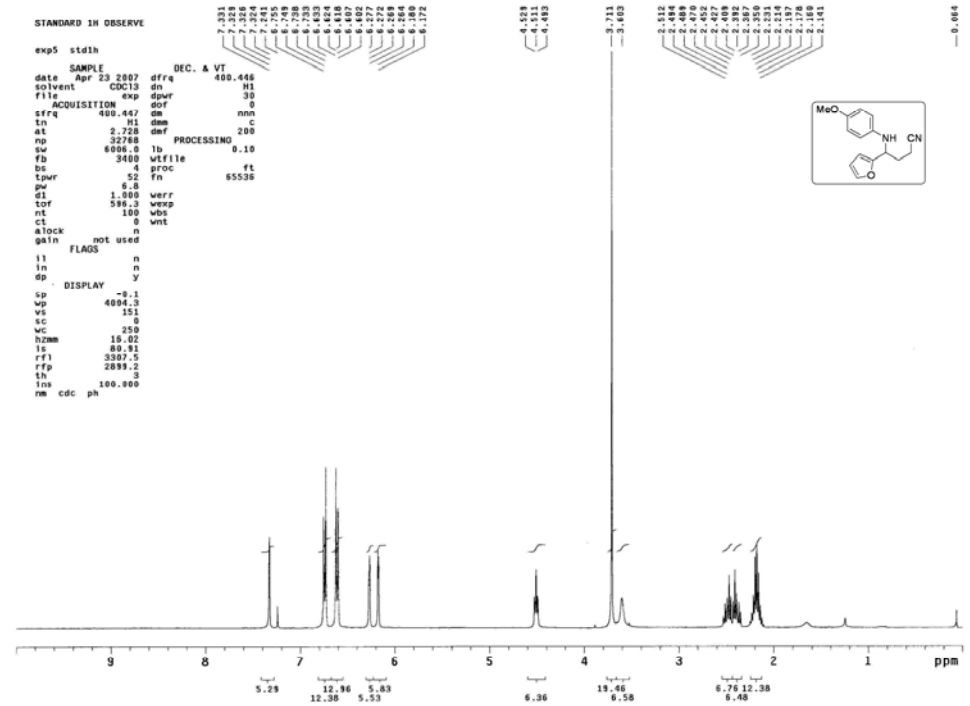


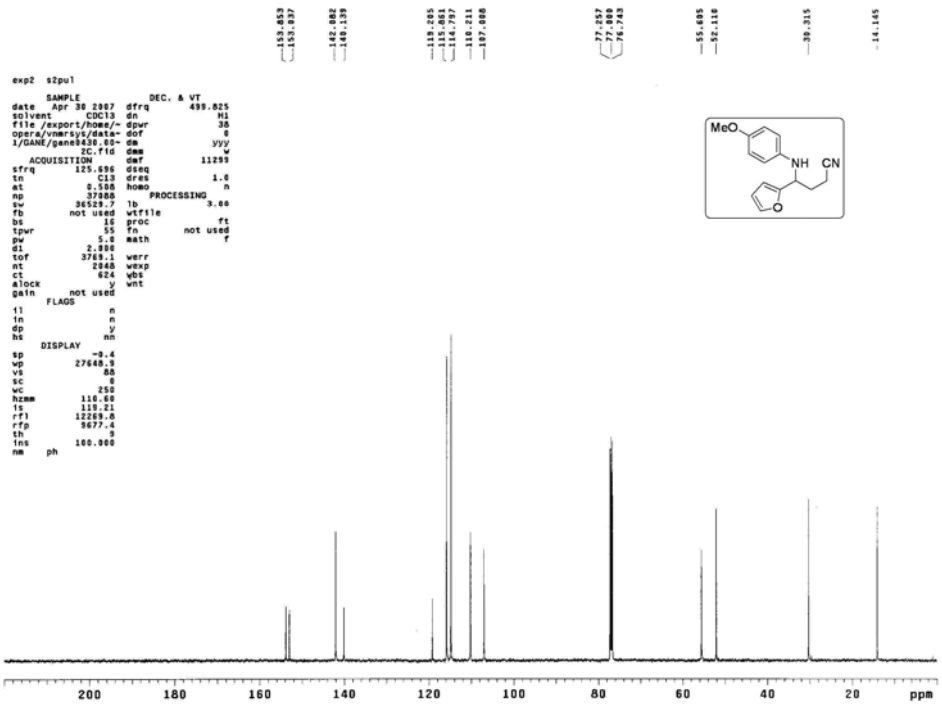
^{1}H and ^{13}C spectra of compound **3p**



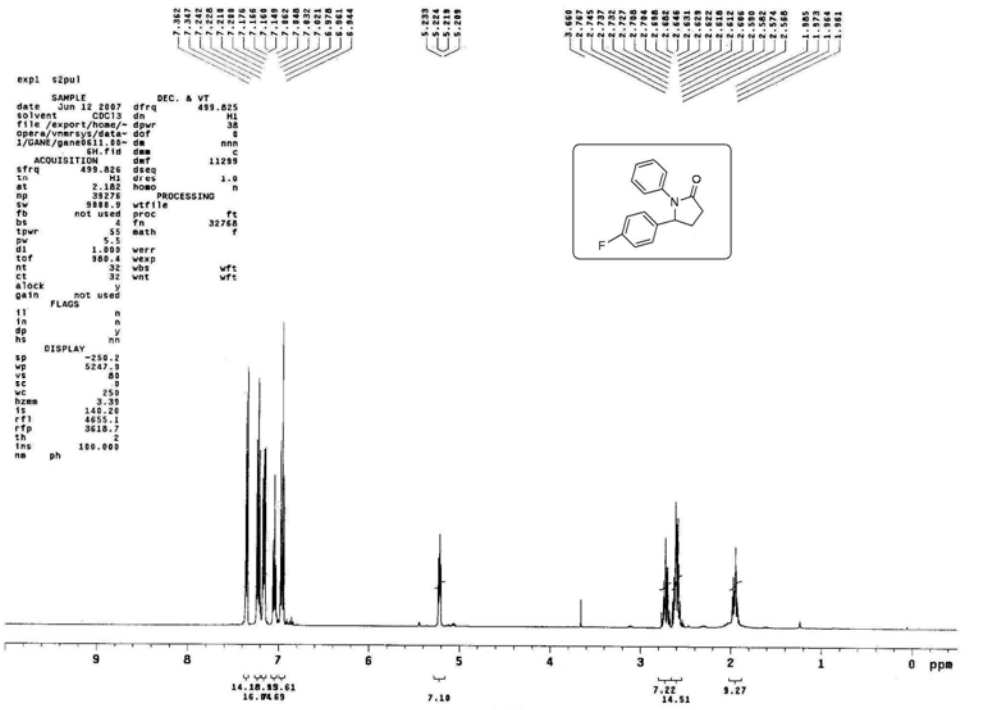


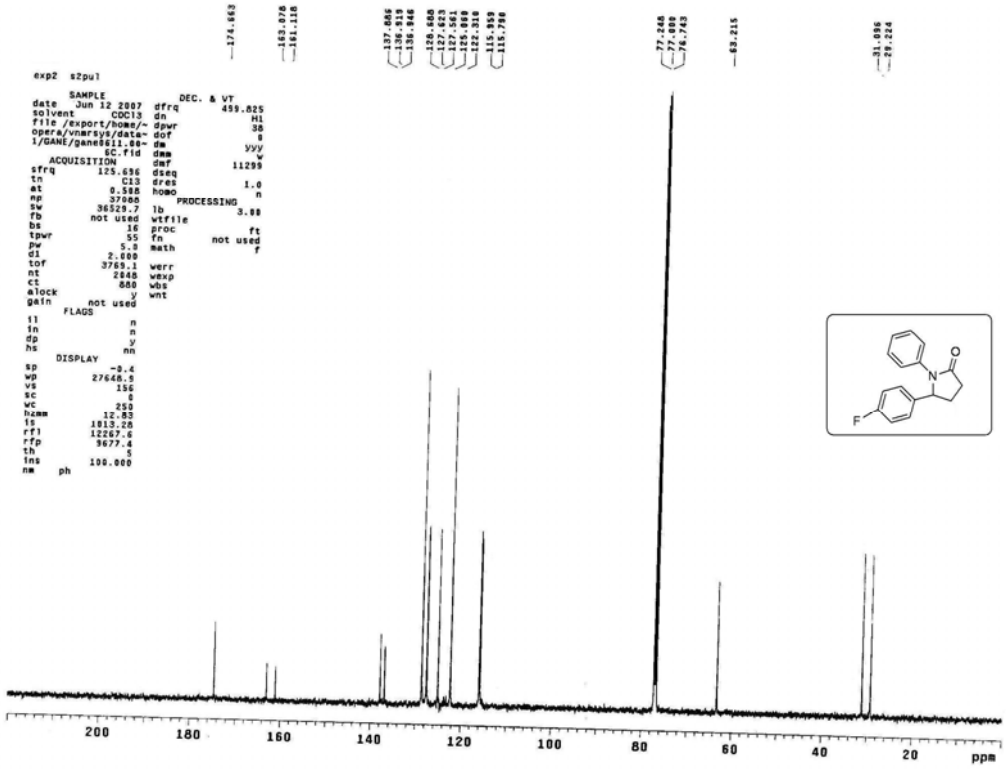
^{1}H and ^{13}C spectra of compound **3q**



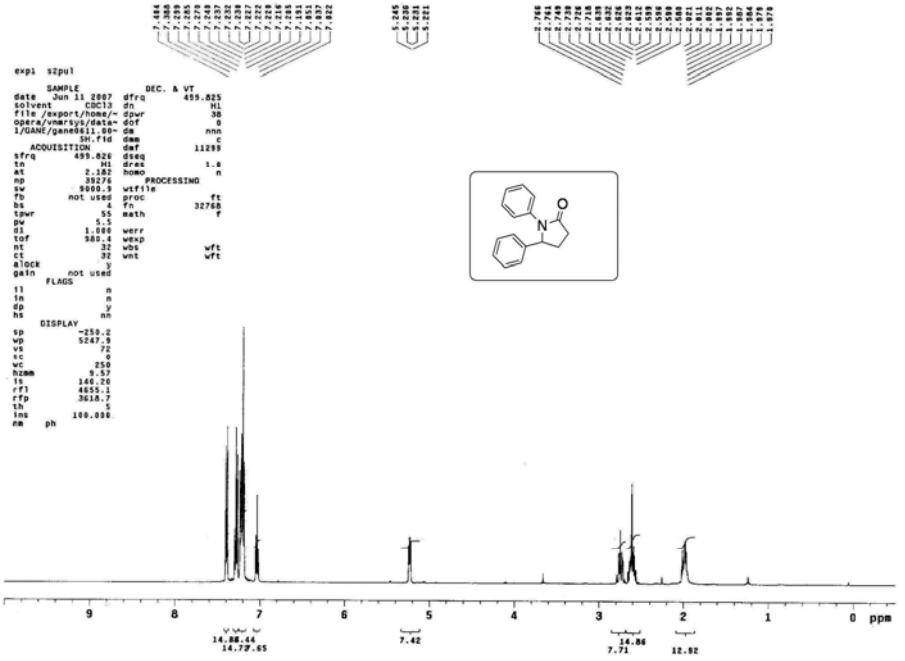


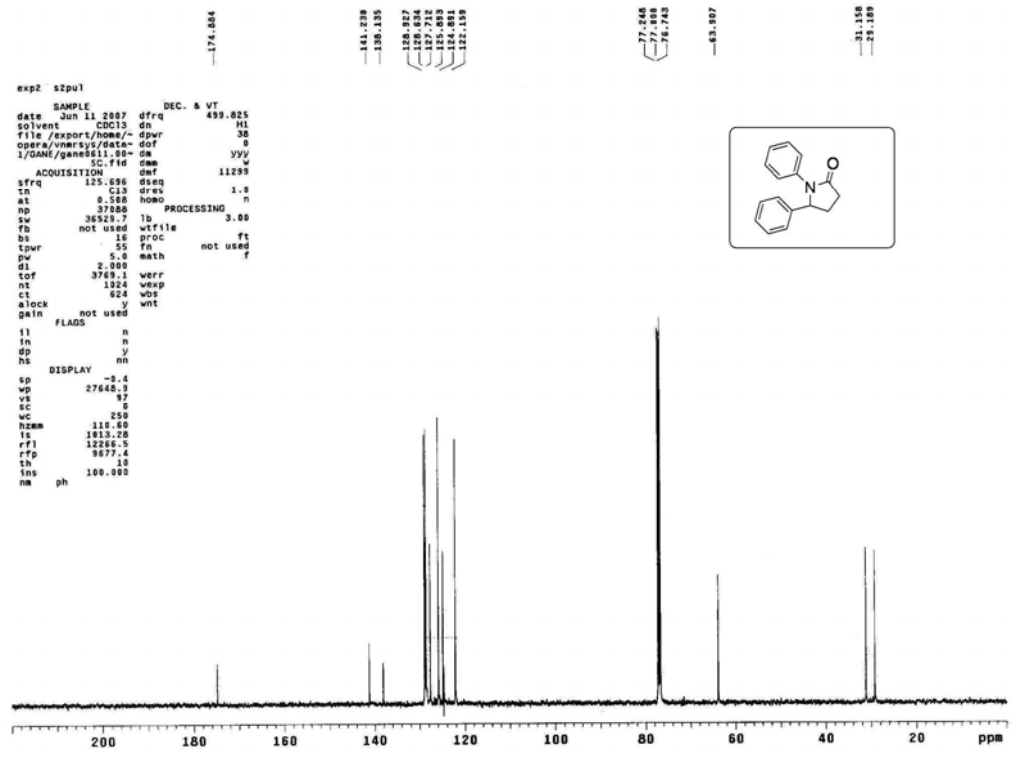
^{1}H and ^{13}C spectra of compound **4a**



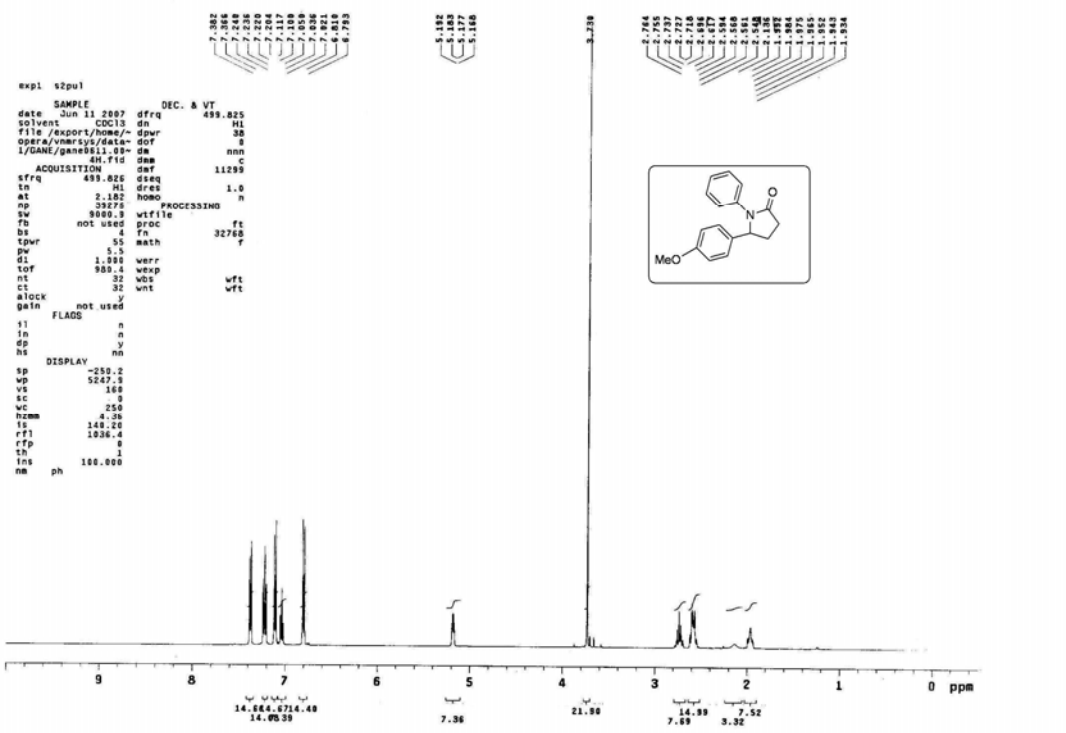


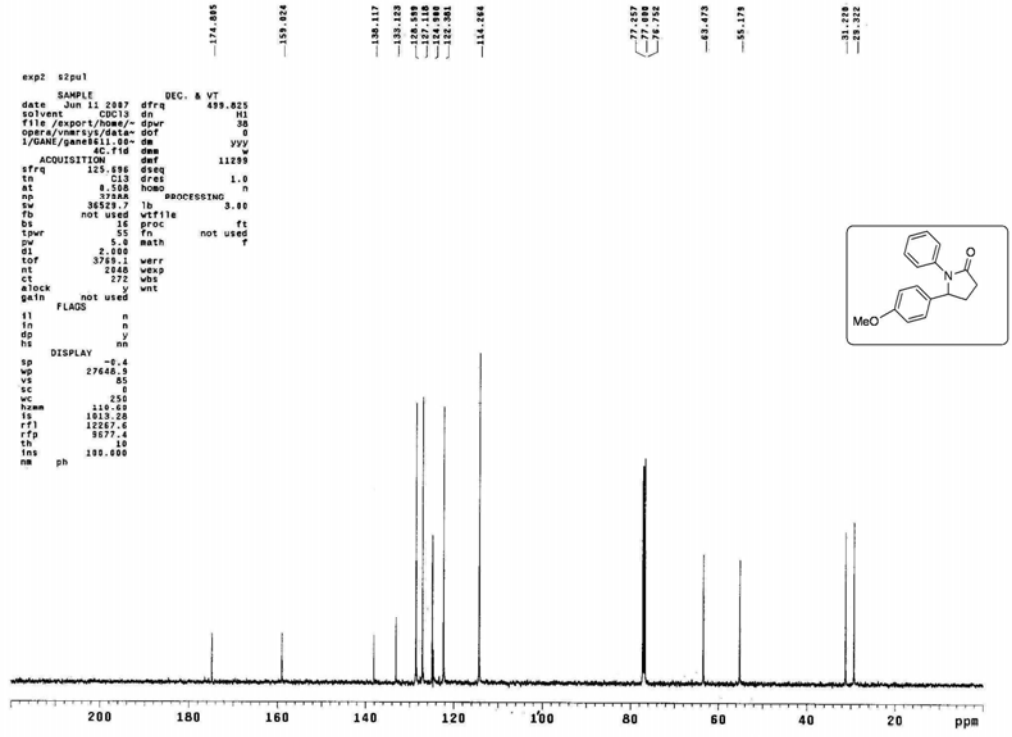
^{1}H and ^{13}C spectra of compound **4b**



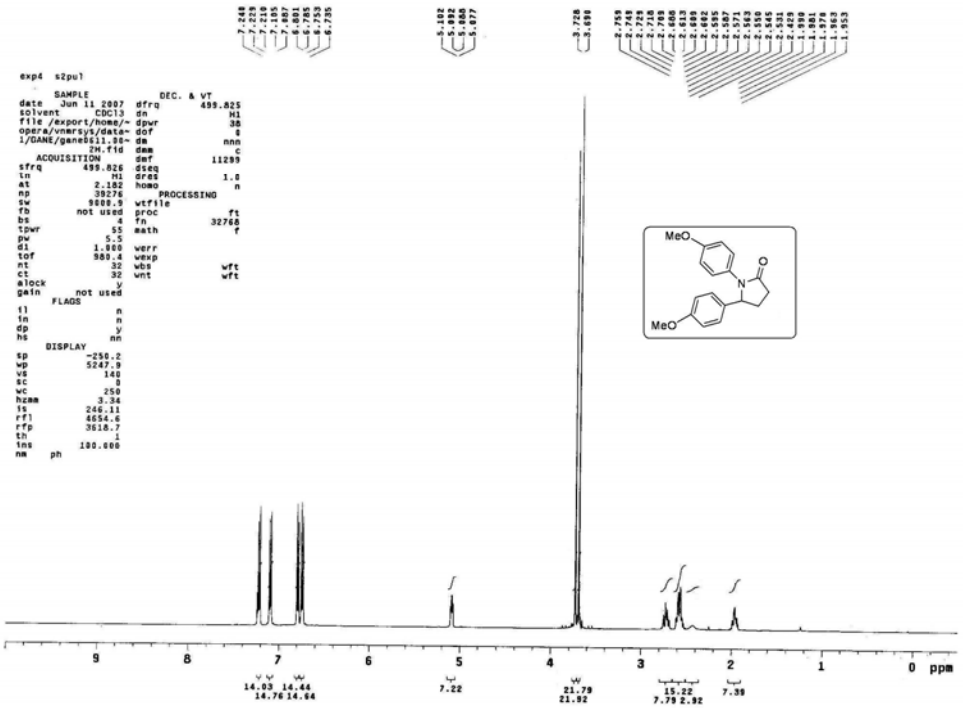


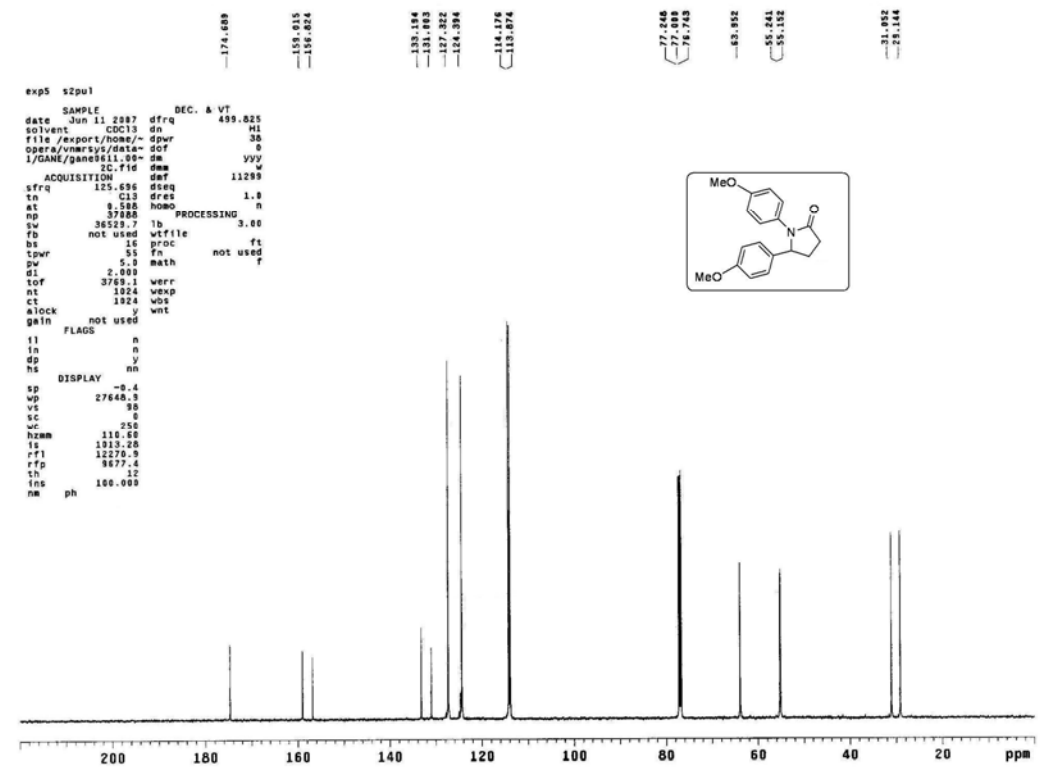
^{1}H and ^{13}C spectra of compound **4c**



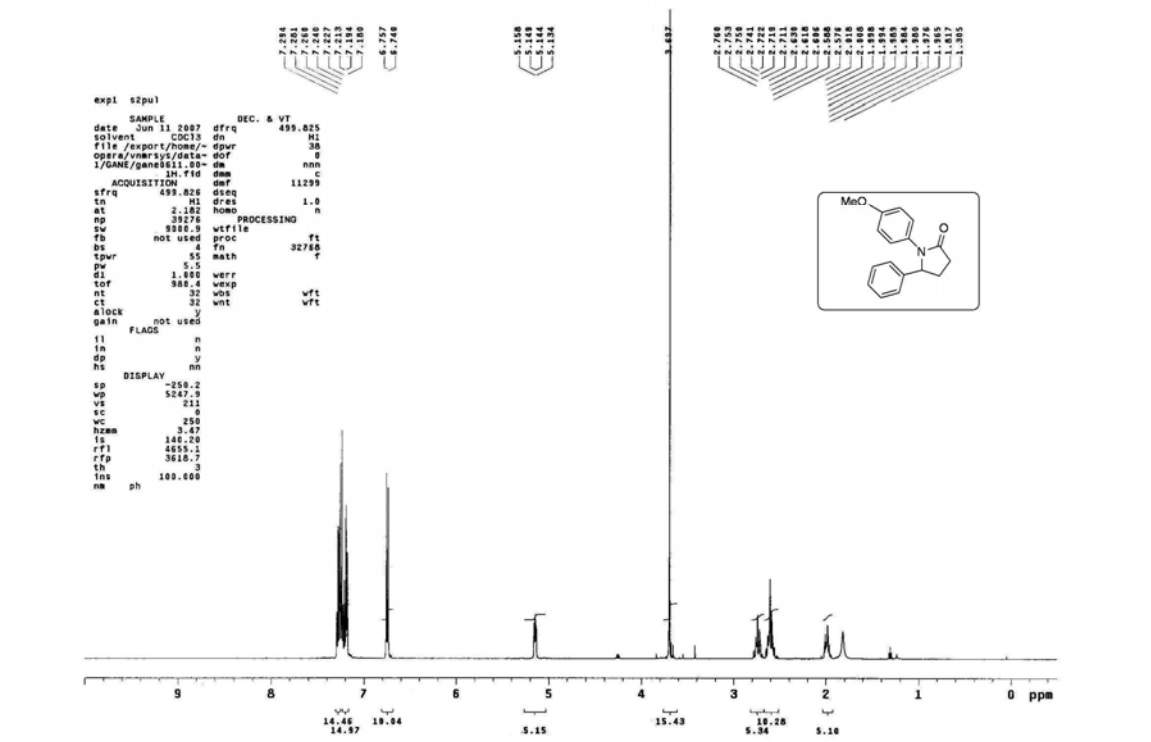


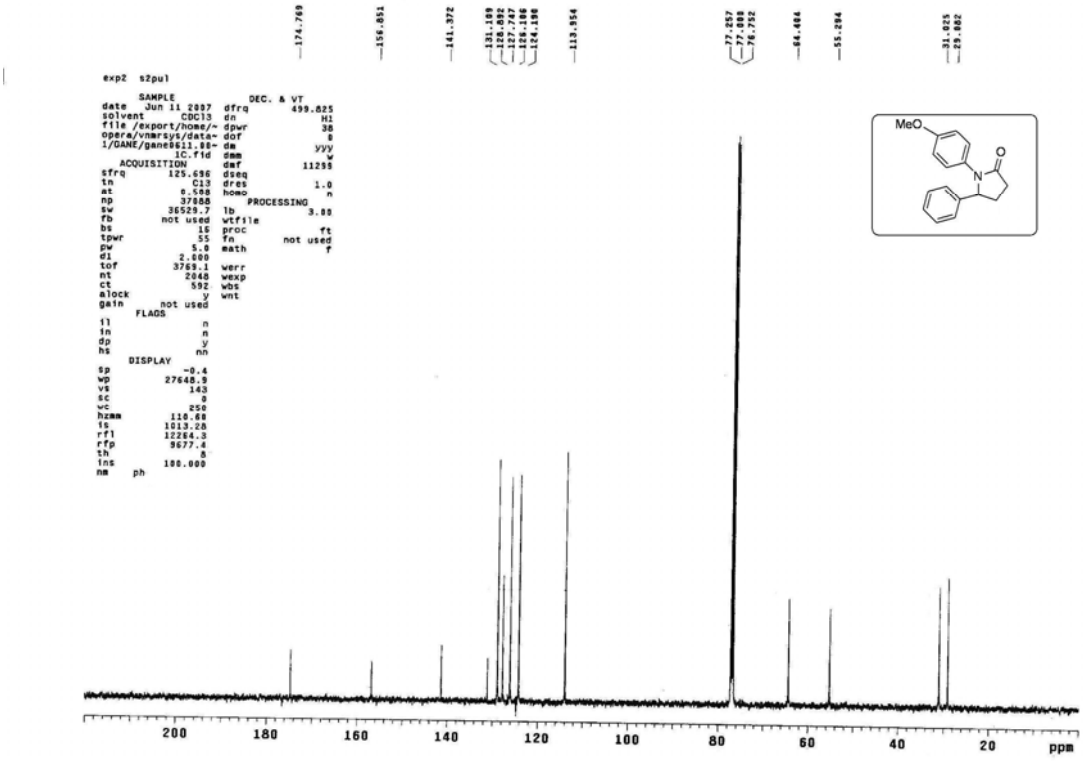
^{1}H and ^{13}C spectra of compound **4d**



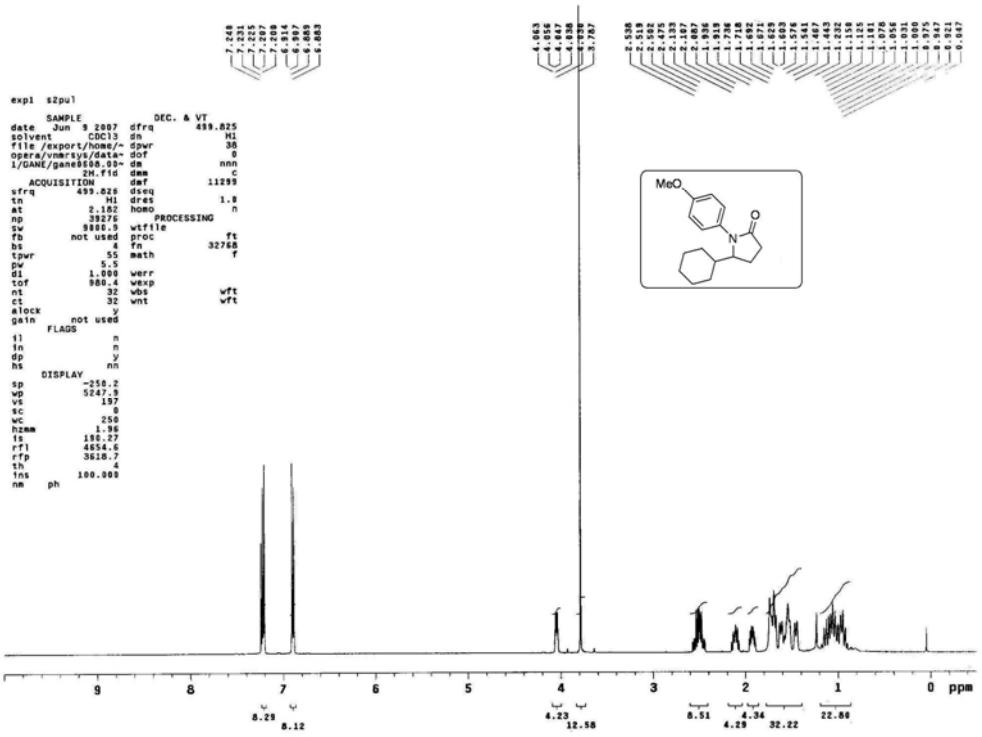


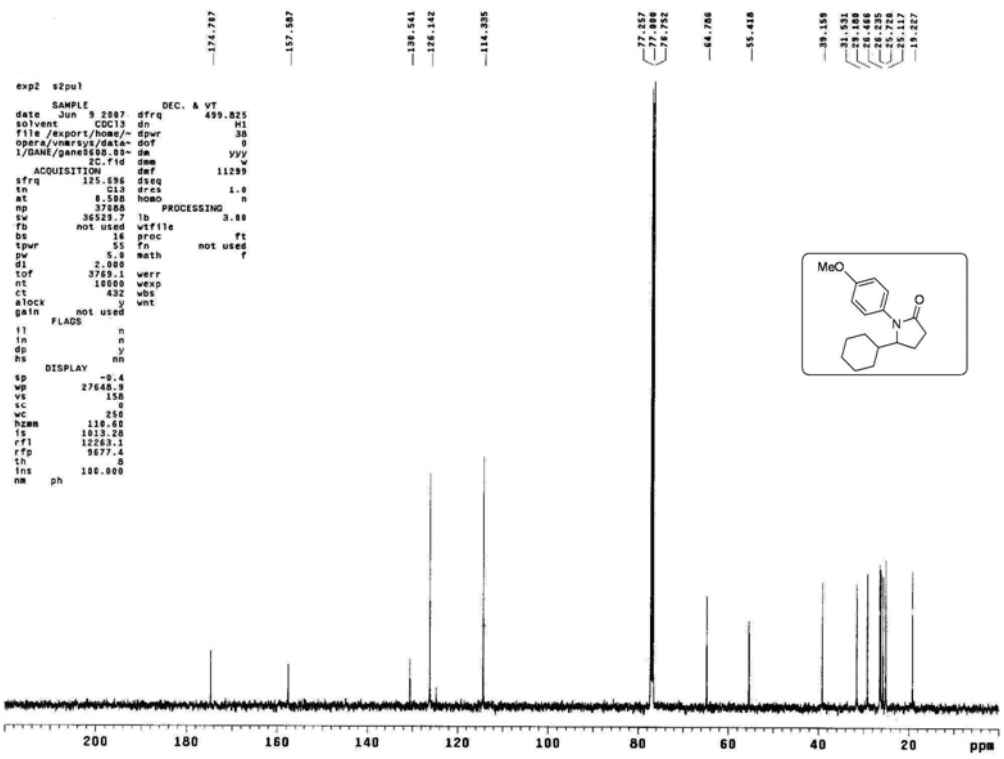
^{1}H and ^{13}C spectra of compound **4e**



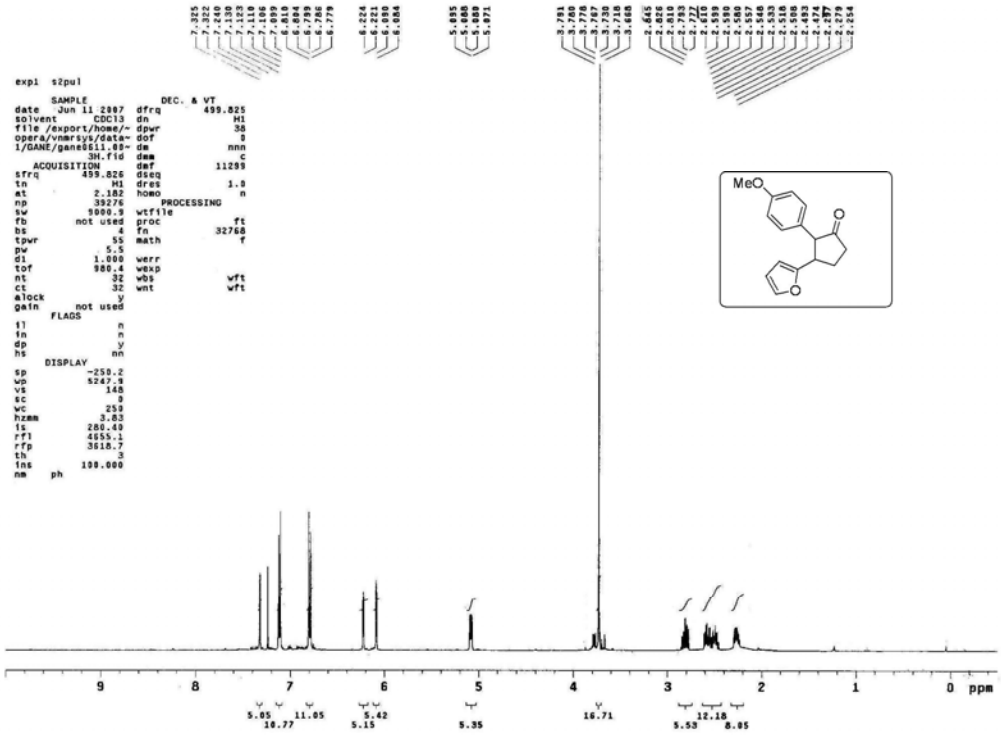


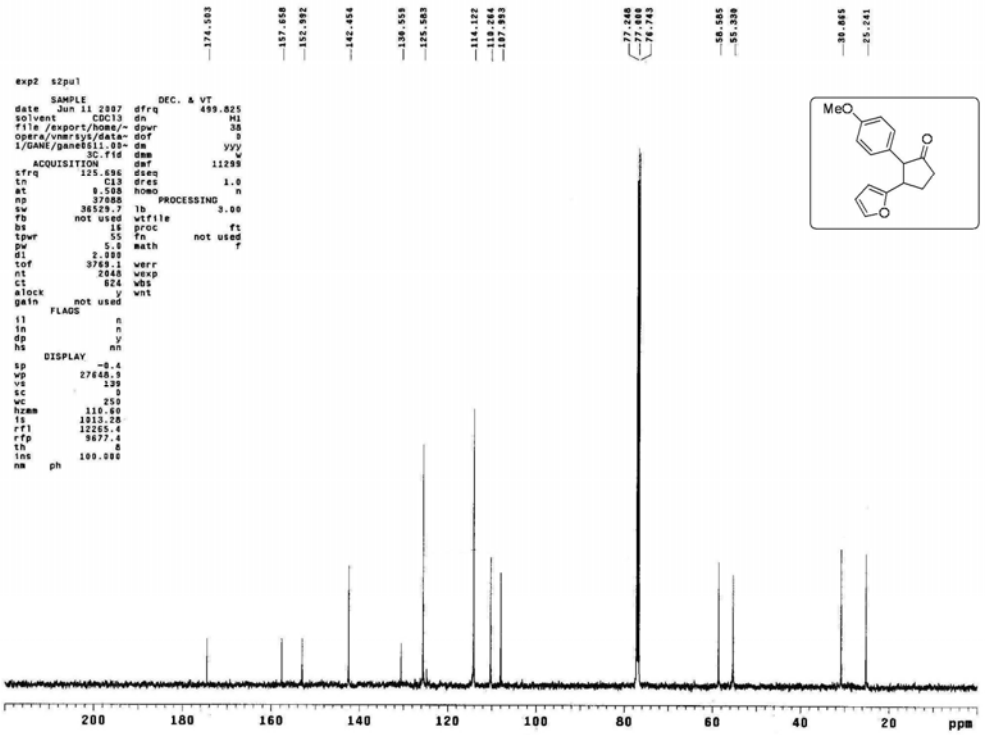
^{1}H and ^{13}C spectra of compound **4f**



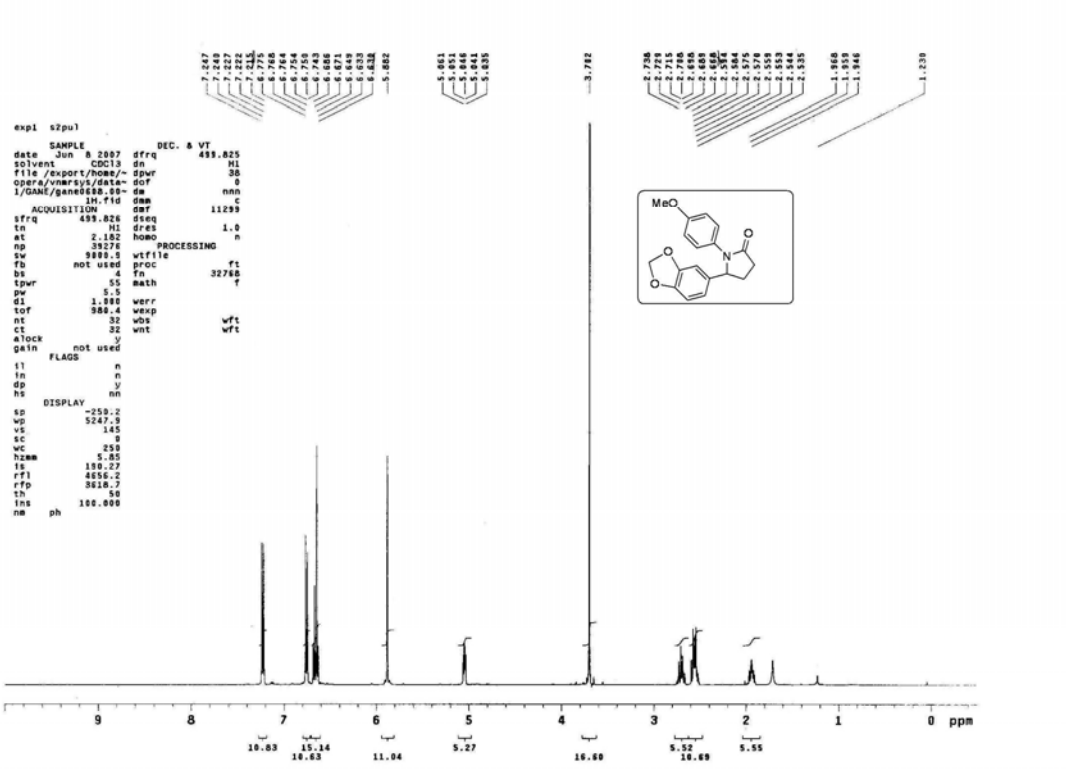


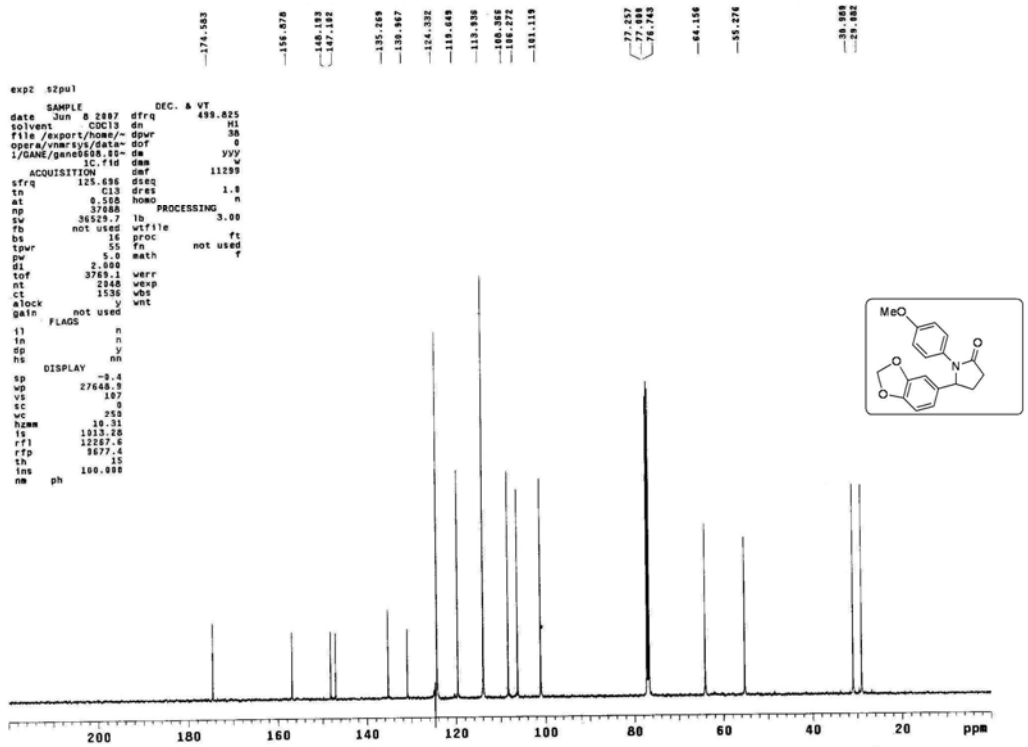
^{1}H and ^{13}C spectra of compound **4g**



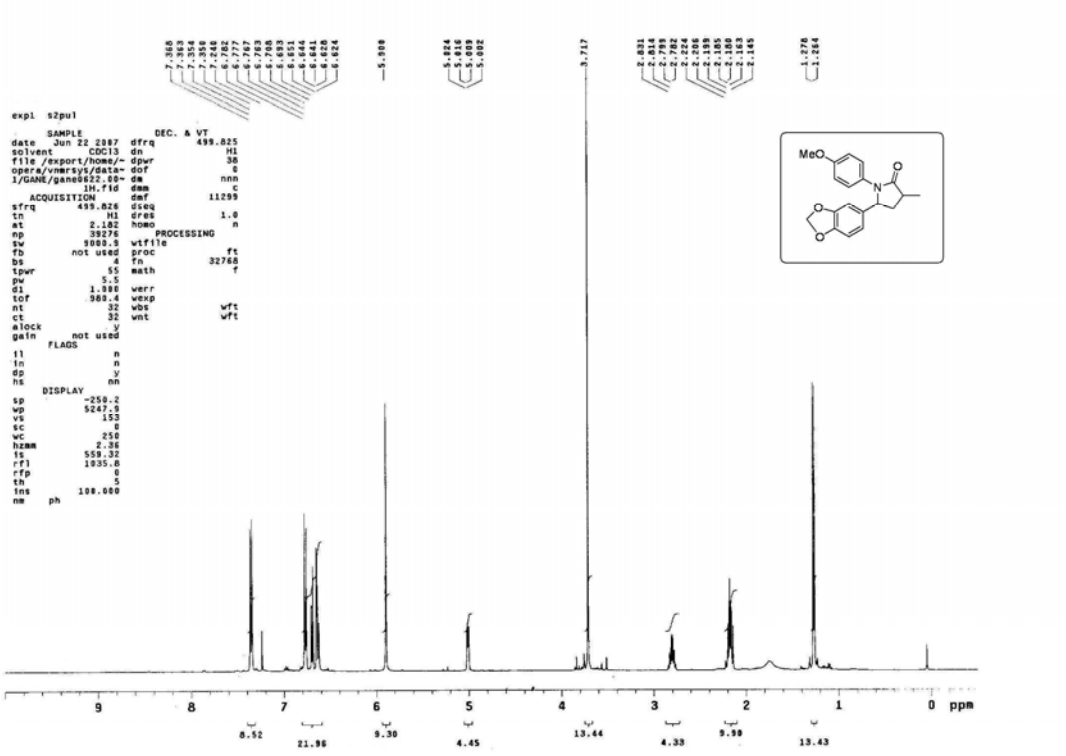


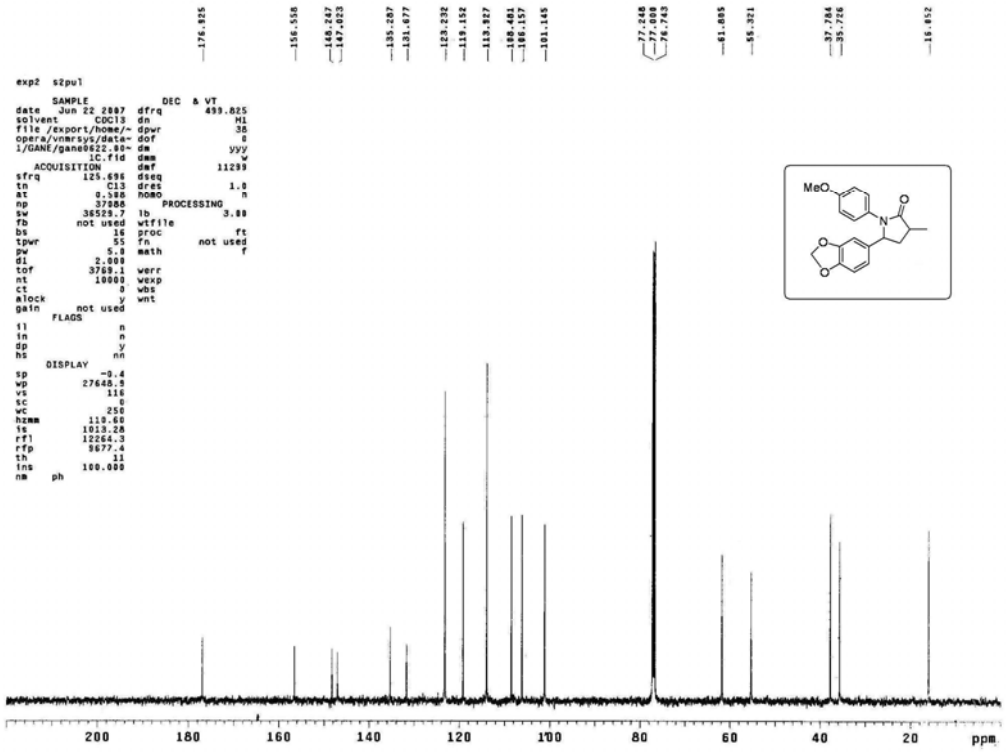
^{1}H and ^{13}C spectra of compound **4h**



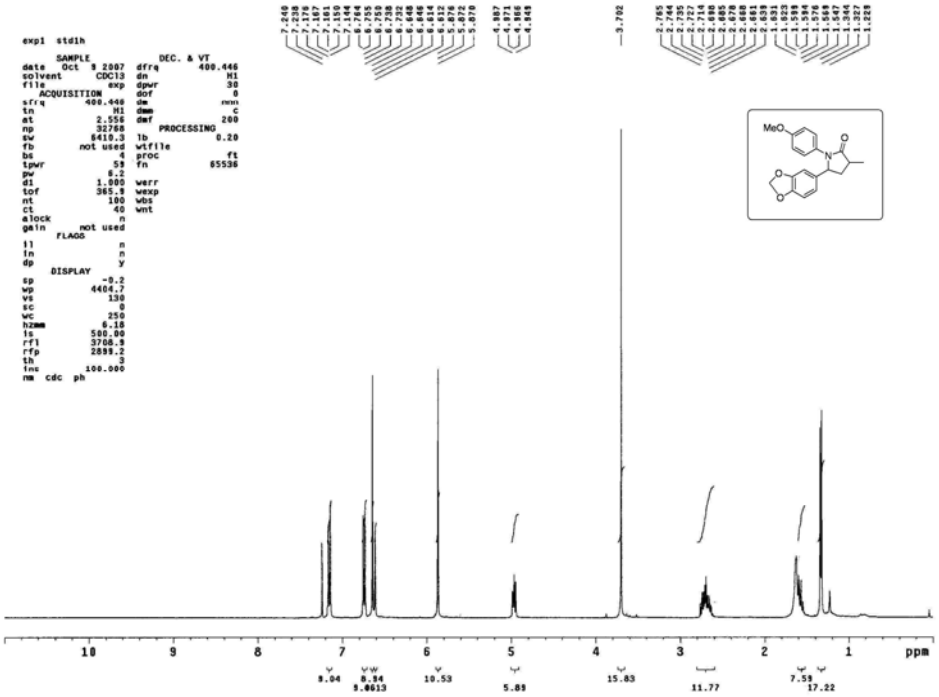


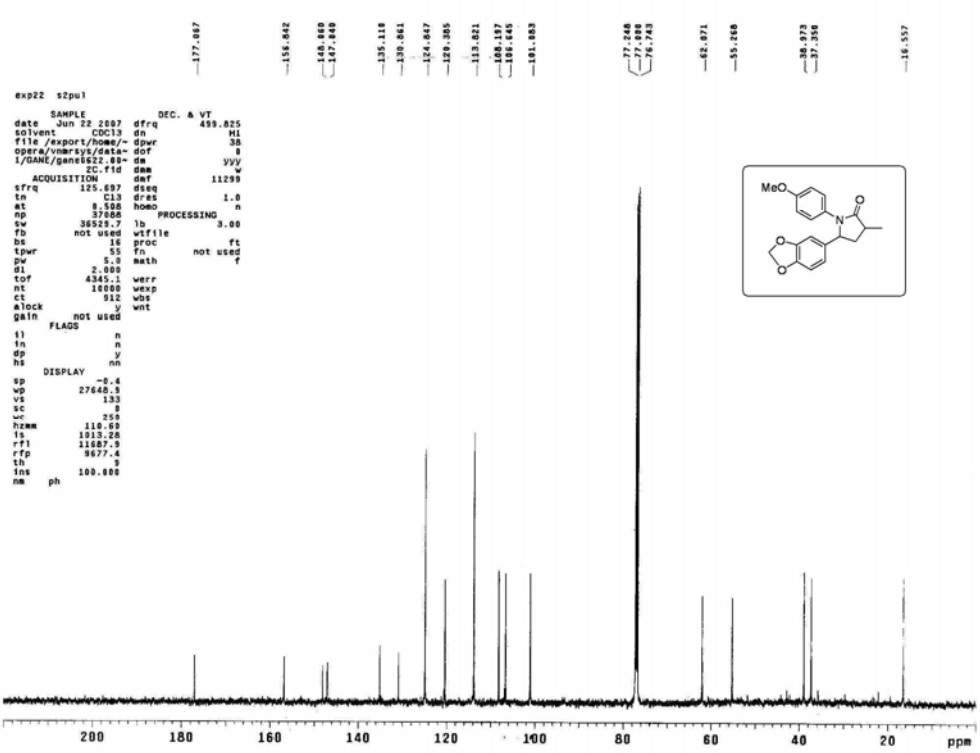
^{1}H and ^{13}C spectra of compound *trans*-**4i**



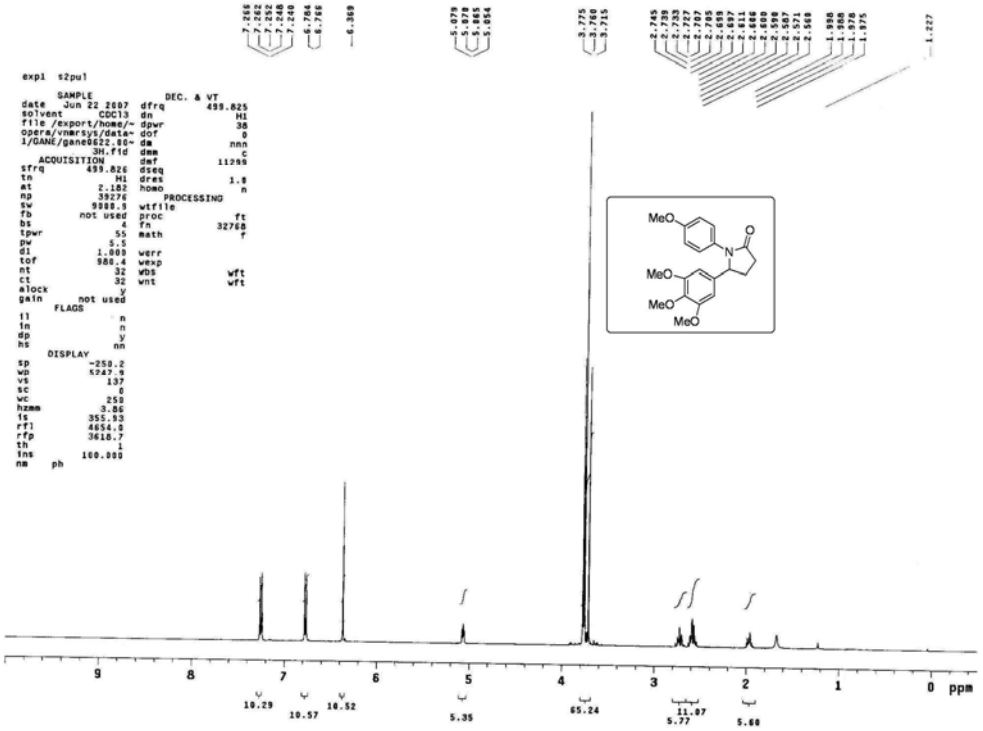


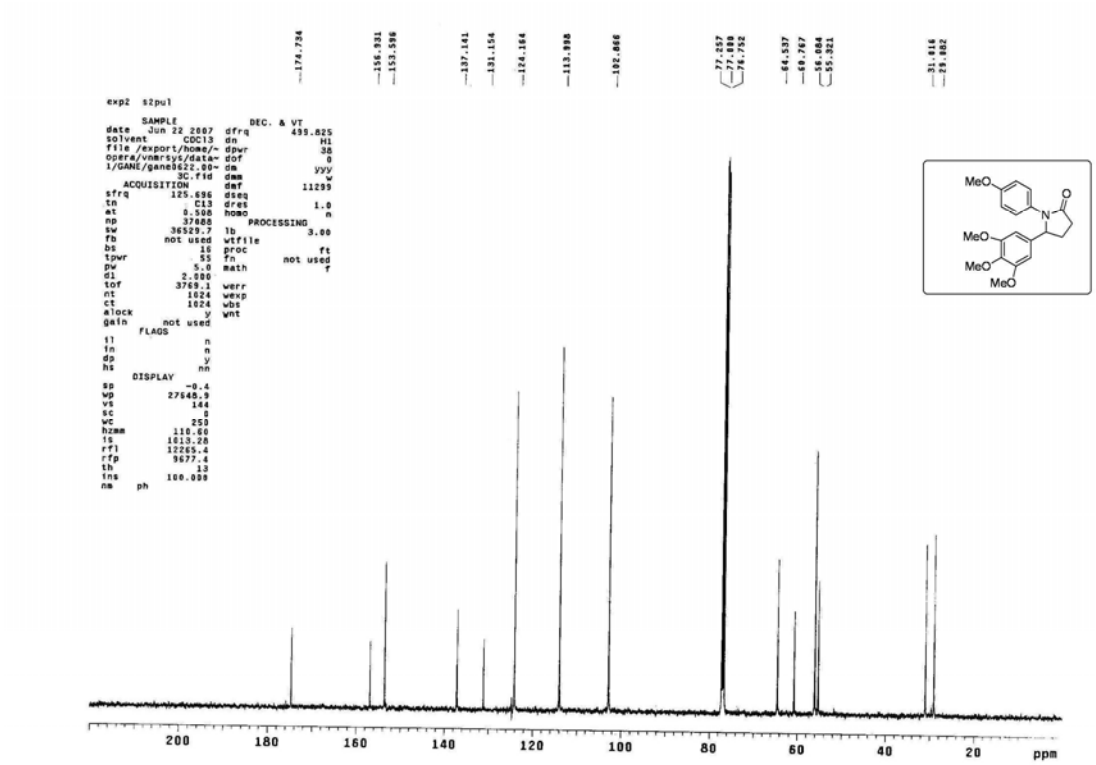
^{1}H and ^{13}C spectra of compound *cis*-**4i'**



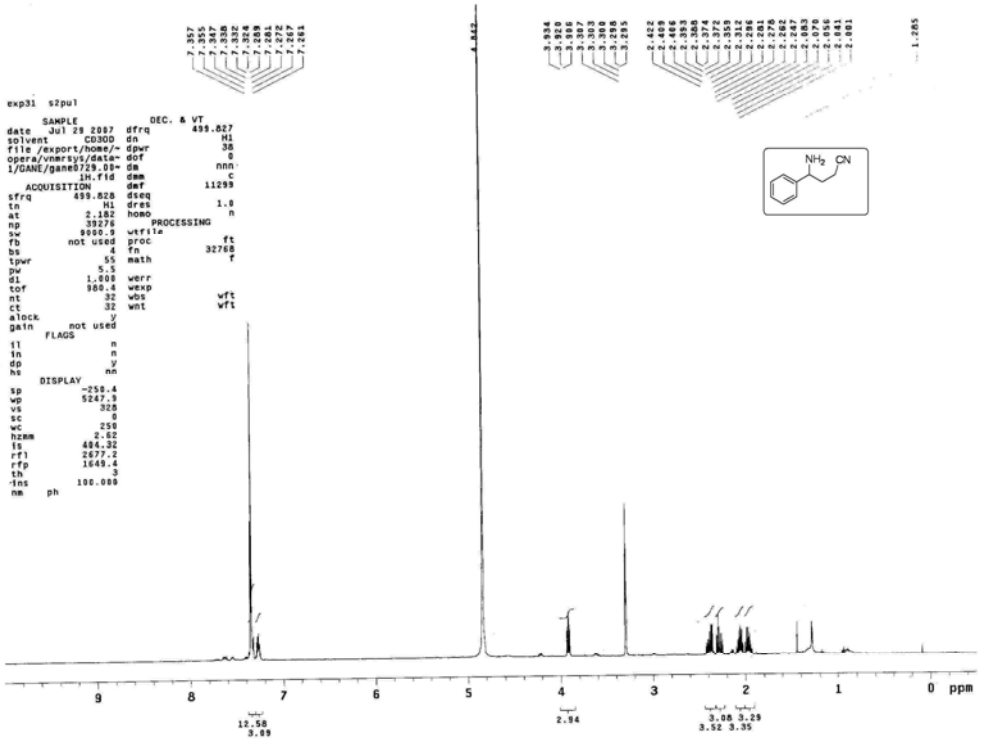


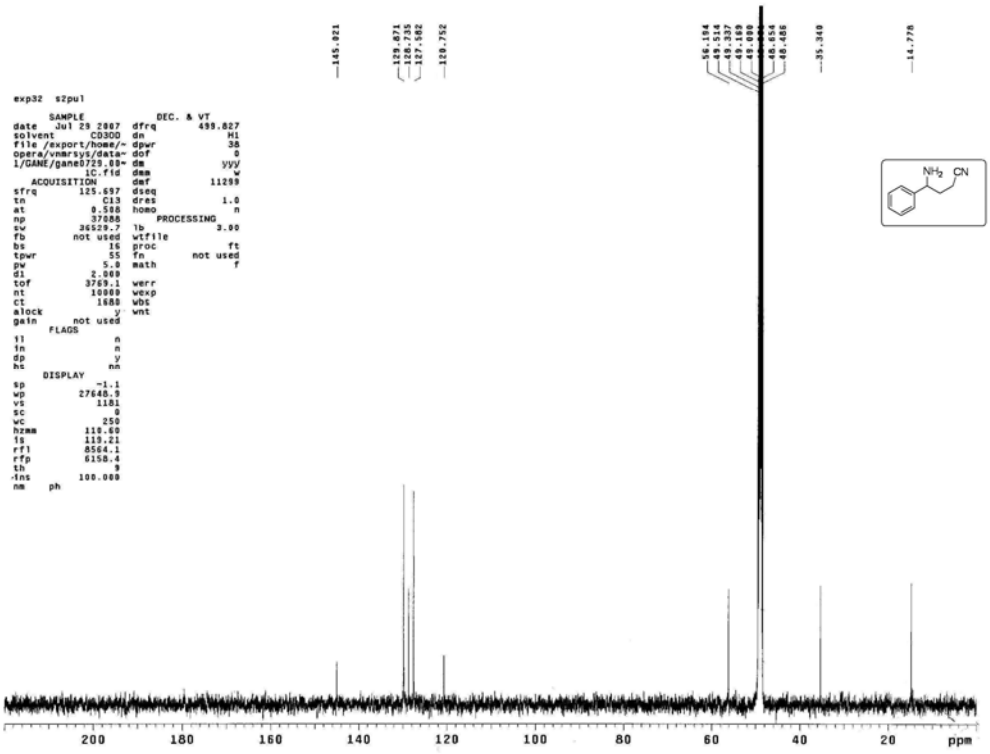
^{1}H and ^{13}C spectra of compound **4j**





^{1}H and ^{13}C spectra of compound **5a**





^{1}H and ^{13}C spectra of compound **5b**