[Supporting Information]

L-Proline: an efficient N,O-bidentate ligand for copper-catalyzed aerobic oxidation of primary and secondary benzylic alcohols at room temperature

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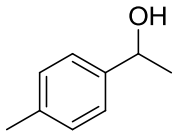
General Experimental

All reagents were purchased from commercial suppliers and used without purification unless otherwise stated. Copper salts, L-proline, L-valine, 8-hydroxyquinoline, glycine, 2-picolinic acid, benzyl alcohol, *p*-tolylmethanol, 4-methoxybenzyl alcohol, 3,4-dimethylbenzyl alcohol, 2-methoxybenzyl alcohol, 1-naphthalenemethanol, *p*-nitrobenzyl alcohol, 4-fluorobenzyl alcohol, 4-chlorobenzyl alcohol, 4-bromobenzyl alcohol, 2-chlorobenzyl alcohol, 3-chlorobenzyl alcohol, 2,4-dichlorobenzyl alcohol, cinnamyl alcohol, 2-thiophenemethanol, furfuryl alcohol, 3-pyridinemethanol, cyclohexanol and *n*-octyl alcohol were purchased from Aladdin reagent Co., LTD (Shanghai). 1-Phenethyl alcohol, diphenylmethanol, benzoin, 4-fluoro-α-methylbenzyl alcohol, 4-chloro-α-methylbenzyl alcohol, 4-bromo-α-methylbenzyl alcohol, 1-(2-furyl)ethanol, were purchased from Sigma-Aldrich Company. The other secondary alcohols were reduced from their corresponding acetophenones or acetylpyridine. Column chromatography was performed with silica gel (300-400 mesh) produced by Qingdao Marine Chemical Factory, Qingdao (China). GC-MS analysis of determination of conversion was performed on the instrument of Agilent 7890 GC-QQQ. NMR spectra were recorded on Bruker AVANCE III 500MHz instrument with TMS as internal standard.

Experimental Sections

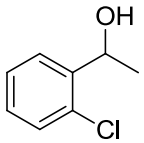
a) General procedures for preparation of secondary alcohol

To a solution of substrate (10.0 mmol) in C_2H_5OH (10.0 mL) was added $NaBH_4$ (0.9458 g, 25.0 mmol) at room temperature. After 12 h, the reaction mixture was diluted with H_2O (20.0 mL) and then partitioned between EtOAc (20.0 mL). The water layer was washed with EtOAc (3×15.0 mL). The combined organic layers were washed with brine (20.0 mL), dried with anhydrous Na_2SO_4, filtered, and concentrated in vacuo. The residue was purified by silica-gel column chromatography to give desired product.



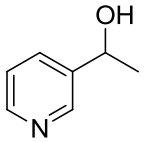
1-(4-Methylphenyl)ethanol

(1.2257 g, 90%) as a colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$): δ 1.49(d, *J* = 6.4 Hz, 3H), 2.38(s, 3H), 4.83-4.88(q, 1H), 7.18(d, *J* = 8.0 Hz, 2H), 7.28(d, *J* = 8.0 Hz, 2H).



1-(2-Chlorophenyl)ethanol

(1.4878 g, 95%) as a pale yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$): δ 1.49(d, *J* = 6.4 Hz, 3H), 5.26(t, *J* = 6.3 Hz, 1H), 7.18(t, *J* = 7.4 Hz, 1H), 7.26(d, *J* = 7.5 Hz, 1H), 7.56(d, *J* = 7.6 Hz, 1H).



1-(3-Pyridyl)ethanol

(1.1453 g, 93%) as a colorless oil. ^{1}H NMR (500 MHz, $CDCl_3$): δ 1.38(d, *J* = 6.5 Hz, 3H), 4.78-4.82(q, 1H), 7.13-7.17(q, 1H), 7.65 (t, *J* = 3.9 Hz, 1H), 8.21-8.24(q, 1H), 8.33(d, *J* = 2.0 Hz, 1H).

b) General procedures for copper-catalyzed secondary alcohol oxidation under air at room temperature (1-phenethyl alcohol).

A mixture of 1-phenethyl alcohol (0.1222 g, 1.0 mmol), L-proline (0.0058 g, 0.05

mmol), CuI (0.0095 g, 0.05 mmol), ^{t}BuOK (0.1122 g, 1.0 mmol), TEMPO (0.0078 g, 0.05 mmol), DMF (4.0 mL) were placed into a 50 mL flask equipped with a magnetic stirer. Then the resulting mixture was vigorously stirred under air at room temperature for 5 h. After the reaction, the residue was filtered off, and the solvent was removed under vacuum to give the crude product, which was purified by column chromatography on silica gel to give the pure product (0.1117 g, isolated yield 93%). ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.62(s, 3H), 7.47(t, *J* = 7.5 Hz, 2H), 7.57(t, *J* = 7.0, 1H), 7.97(d, *J* = 7.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.5, 128.2, 128.4, 133.0, 137.0, 198.0.

c) General procedures for copper-catalyzed primary alcohol oxidation under air at room temperture (benzyl alcohol).

A mixture of benzyl alcohol (0.1081 g, 1.0 mmol), L-proline (0.0078g, 0.05 mmol), CuBr (0.0072g, 0.05 mmol), Na_2CO_3 (0.1060 g, 1.0 mmol), TEMPO (0.0078 g, 0.05 mmol), CH_3OH (4.0 mL) were placed into a 50 mL flask equipped with a magnetic stirer. Then the resulting mixture was vigorously stirred under air at room temperature for 5 h. After the reaction, the residue was filtered off, and the solvent was removed under vacuum. Then the crude was purified by column chromatography on silica gel to give the pure product (0.0997 g, isolated yield 94%).^{1}H NMR (500 MHz, $CDCl_3$): δ 7.53(t, *J* = 7.8 Hz, 2H), 7.61-7.65(m, 1H), 7.87-7.90(m, 2H), 10.02(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 128.9, 129.7, 134.4, 136.4, 192.3.

d) The optimization of copper-catalyzed primary alcohol oxidation

Table S1 The optimization of copper-catalyzed primary alcohol oxidation[a]

Entry	Solvent	Copper salt	Ligand[b]	Conv.(%)[c]
1[d]	DMF	CuI	A	56
2	CH_3OH	CuCl	A	92
3	C_2H_5OH	CuCl	A	73
4	CH_3CN	CuCl	A	56
5	CH_2Cl_2	CuCl	A	69
6	toluene	CuCl	A	63
7	DMF	CuCl	A	61
8	CH_3OH	$CuCl_2$	A	88
9	CH_3OH	$CuBr_2$	A	71
10	**CH_3OH**	**CuBr**	**A**	**>99**
11	CH_3OH	$CuSO_4$	A	73
12	CH_3OH	$Cu(OAc)_2$	A	79
13	CH_3OH	CuI	A	93
14	CH_3OH	CuBr	B	87
15	CH_3OH	CuBr	C	79
16	CH_3OH	CuBr	D	30
17	CH_3OH	CuBr	E	90
18[e]	CH_3OH	-	A	8
19[f]	CH_3OH	CuBr	A	10
20[g]	CH_3OH	CuBr	-	28
21[h]	CH_3OH	CuBr	A	27

[a]Reaction condition: *p*-tolylmethanol (1.0 mmol), copper salt (5 mol%), TEMPO (5 mol%), Na_2CO_3 (1.0 mmol), L-proline (5 mol%), Solvent (4.0 mL), 5 h, 900r/min. [b]A is L-proline, B is L-valine, C is Glycine, D is 8-Quinolinol, E is 2-Picolinic acid. [c]Determined by GC-MS. [d] standard conditions for the aerobic oxidation of secondary alcohols. [e]Copper salt was omitted. [f]The reaction was carried out in the absence of TEMPO. [g]No L-proline was employed. [h]Base was omitted.

e) Effect of stirring rate on conversion of alcohol oxidation

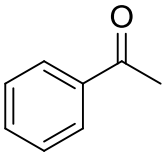
Condidering these reactions are categorized into gas-liquid phase reactions. The stirring rate should affect on the reaction rate. Hence we investigated the relationship between conversion with stirring rate. The corresponding results were summized in Table S2.

Table S2 Effect of stirring rate on conversion.

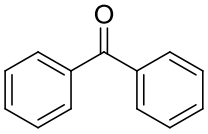
Stirring Rate (r/min)	500	700	900	1100
Conv. (%)[a]	88	96	>99	>99
Conv. (%)[b]	80	94	>99	>99

[a]Reaction condition: *p*-tolylmethanol (1.0 mmol), CuBr (5 mol%), TEMPO (5 mol%), Na_2CO_3 (1.0 mmol), L-proline (5 mol%), CH_3OH (4.0 mL), 5 h. [b]Reaction condition: 1-phenylethanol (1.0 mmol), CuI (5 mol%), TEMPO (5 mol%), ^{t}BuOK (1.0 mmol), L-proline (5 mol%), DMF (4.0 mL), 5 h.

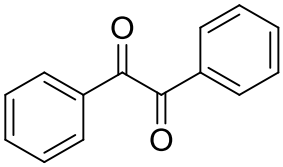
NMR Characterization Data and Figures



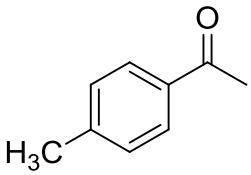
Acetophenone (Table 2, entry 1) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.62(s, 3H), 7.47(t, *J* = 7.5 Hz, 2H), 7.57(t, *J* = 7.5 Hz, 1H), 7.97(d, *J* = 7.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.5, 128.2, 128.4, 133.0, 137.0, 198.0.



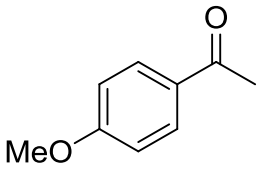
Benzophenone (Table 2, entry 2) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.50(t, *J* = 8.0 Hz, 4H), 7.61(t, *J* = 7.3 Hz, 2H), 7.82(d, *J* = 7.5 Hz, 4H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 128.2, 130.0, 132.4, 137.6, 196.7.



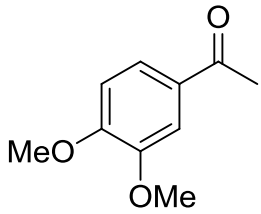
Benzil (Table 2, entry 3) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54(t, *J* = 7.8 Hz, 4H), 7.68(t, *J* = 7.0 Hz, 2H), 7.98-8.00(q, 4H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 129.0, 129.9, 133.0, 134.8, 194.6.



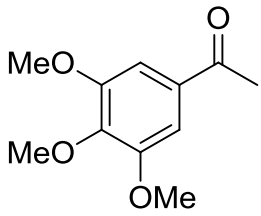
4-Methylacetophenone (Table 2, entry 4) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.40(s, 3H), 2.57(s, 3H), 7.25(d, *J* = 8.0 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.6, 26.4, 128.4, 129.2, 134.7, 143.8, 197.9.



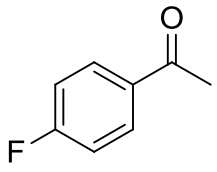
4-Methoxyacetophenone (Table 2, entry 5) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.57(s, 3H), 3.88(s, 3H), 6.95(d, *J* = 9.0 Hz, 2H), 7.95(d, *J* = 9.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.3, 55.4, 113.7, 130.4, 130.6, 163.5, 196.8.



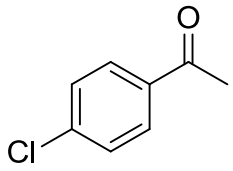
3,4-Diethoxyacetophenone (Table 2, entry 6) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.56(s, 3H), 3.94(d, *J* = 6.0 Hz, 6H), 6.89(d, *J* = 8.5 Hz, 1H), 7.53 (d, *J* = 2.5 Hz, 1H), 7.56-7.59(q, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.1, 55.9, 56.0, 109.9, 110.1, 123.2, 130.5, 149.0, 153.3, 196.7.



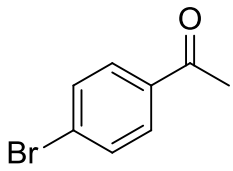
3,4,5-Trimethoxyacetophenone (Table 2, entry 7) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.59(s, 3H), 3.92(d, *J* = 2.5 Hz, 9H), 7.22(s, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.3, 56.3, 60.9, 105.9, 132.4, 153.0, 196.8.



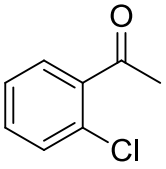
4-Fluoroacetophenone (Table 2, entry 8) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.58(s, 3H), 7.12(t, *J* = 8.8 Hz, 2H), 7.96-8.00(q, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.2, 115.5, 130.9, 133.6, 166.7, 196.4.



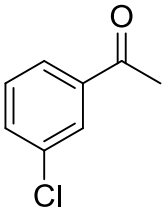
4-Chloroacetophenone (Table 2, entry 9) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.60(s, 3H), 7.45(d, *J* = 8.5 Hz, 2H), 7.91 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.5, 128.8, 129.7, 135.4, 139.5, 196.7.



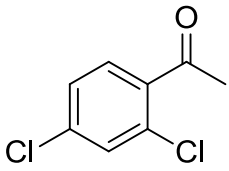
4-Bromoacetophenone (Table 2, entry 10) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.60(s, 3H), 7.62(d, *J* = 8.5 Hz, 2H), 7.83 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.5, 128.4, 129.8, 131.9, 135.7, 197.1.



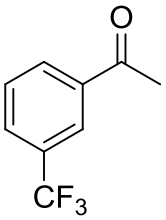
2-Chloroacetophenone (Table 2, entry 11) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.64(s, 3H), 7.31(td, *J* = 7.5, 1.5 Hz, 1H), 7.36-7.42(m, 2H), 7.54(dd, *J* = 1.5, 2.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 30.6, 126.9, 129.3, 130.6, 131.2, 131.9, 139.1, 200.4.



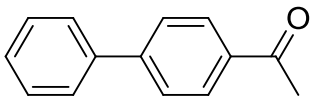
3-Chloroacetophenone (Table 2, entry 12) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.59(s, 3H), 7.41(t, *J* = 7.7 Hz, 1H), 7.52-7.55(m, 1H), 7.81-7.84(m, 1H), 7.91(t, *J* = 1.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.5, 126.3, 128.3, 129.9, 132.9, 134.9, 138.6, 196.6.



2,4-Dichloroacetophenone (Table 2, entry 13) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.64(s, 3H), 7.30-7.33(q, 1H), 7.44 (d, *J* = 2.0 Hz, 1H), 7.54(d, *J* = 8.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 30.6, 127.3, 130.5, 130.6, 132.5, 137.2, 137.7, 198.8.

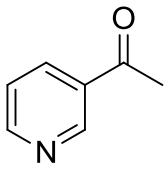


3-Trifluoromethylacetophenone (Table 2, entry 14) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.64(s, 3H), 7.61(t, *J* = 7.8 Hz, 1H), 7.81(d, *J* = 7.5 Hz, 1H), 8.13(d, *J* = 8.0 Hz, 1H), 8.19(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.4, 124.7, 125.0, 129.2, 129.5, 131.1, 131.4, 137.5, 196.6.

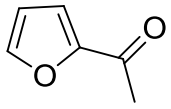


4-Phenylacetophenone (Table 2, entry 15) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.64(s, 3H), 7.41(t, *J* = 7.3 Hz, 1H), 7.48 (t, *J* = 7.5 Hz, 2H), 7.63(d,

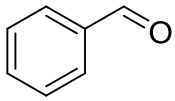
J = 7.0 Hz, 2H), 7.69(d, *J* = 9.0 Hz, 2H), 8.03(d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.6, 127.1, 127.2, 128.2, 128.8, 128.9, 135.8, 139.8, 145.8, 197.7.



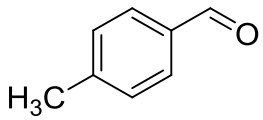
3-Acetylpyridine (Table 2, entry 16) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.52(s, 3H), 7.30-7.33(q, 1H), 8.10-8.13(m, 1H), 8.65-8.67(q, 1H), 9.05(d, *J* = 1.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 26.4, 123.3, 132.0, 135.2, 149.7, 153.3, 196.5.



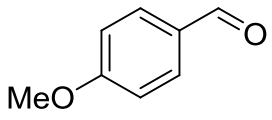
2-Acetylfuran (Table 2, entry 17) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.39(s, 3H), 6.45-6.47(q, 1H), 7.11 (d, *J* = 3.5 Hz, 1H), 7.51(t, *J* = 0.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 25.7, 112.0, 117.0, 146.2, 152.6, 186.5.



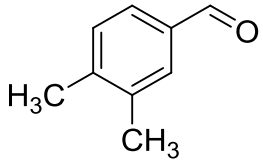
Benzaldehyde (Table 3, entry 1) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.53(t, *J* = 7.8 Hz, 2H), 7.61-7.65(m, 1H), 7.87-7.90(m, 2H), 10.02(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 128.9, 129.7, 134.4, 136.4, 192.3.



4-Methylbenzaldehyde (Table 3, entry 2) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.44(s, 3H), 7.34(d, *J* = 8.0 Hz, 2H), 7.78(d, *J* = 8.0 Hz, 2H), 9.97(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.8, 129.7, 129.8, 134.2, 145.5, 191.9.

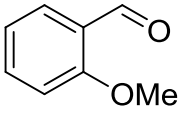


4-Methoxybenzaldehyde (Table 3, entry 3) ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.90(s, 3H), 7.00-7.03(m, 2H), 7.83-7.87(m, 2H), 9.89(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 55.5, 114.3, 129.9, 131.9, 164.6, 190.8.

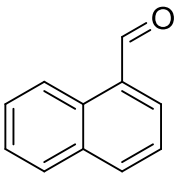


3,4-Dimethylbenzaldehyde (Table 3, entry 4) ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.30(d, *J* = 4.0 Hz, 6H), 7.25(d, *J* = 8.0 Hz, 1H), 7.58(t, *J* = 14.0 Hz, 2H), 9.89(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 19.4, 20.0, 127.5, 130.0, 130.4,

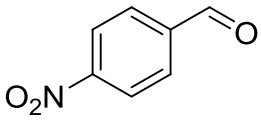
134.4, 137.3, 144.1, 192.0.



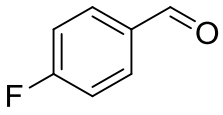
2-Methoxybenzaldehyde (Table 3, entry 5) ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.95(s, 3H), 7.00-7.07(m, 2H), 7.55-7.60(m, 1H), 7.84-7.86(q, 1H), 10.49(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 55.5, 111.6, 120.6, 125.0, 128.5, 135.9, 161.8, 189.8.



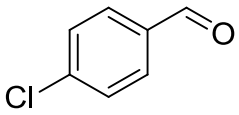
1-Naphthaldehyde (Table 3, entry 6) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.57(t, *J* = 7.5 Hz, 2H), 7.66-7.70(m, 1H), 7.89(d, *J* = 8.0 Hz, 1H), 7.93(dd, *J* = 8.0, 1.5 Hz, 1H), 9.26(d, *J* = 9.0 Hz, 1H), 10.37(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 124.7, 126.8, 128.3, 128.9, 130.3, 131.2, 133.5, 135.1, 136.4, 193.3.



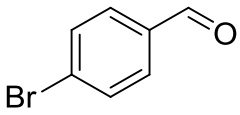
4-Nitrobenzaldehyde (Table 3, entry 7) ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.09(dd, *J* = 7.0, 2.0 Hz, 2H), 8.41(d, *J* = 8.5 Hz, 2H), 10.17(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 124.3, 130.4, 140.0, 151.1, 190.2.



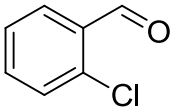
4-Fluorobenzaldehyde (Table 3, entry 8) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.16-7.20(m, 2H), 7.87-7.90(m, 2H), 9.94(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 116.3, 132.4, 133.0, 164.8, 191.6.



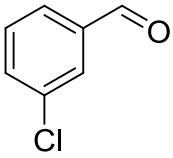
4-Clorobenzaldehyde (Table 3, entry 9) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.49-7.53(dt, *J* = 9.5, 7.5 Hz, 2H), 7.81-7.84(m, *J* = 13.0 Hz, 2H), 9.96(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 129.4, 130.8, 134.7, 140.9, 190.8.



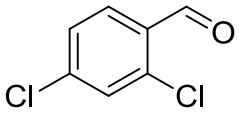
4-Bromobenzaldehyde (Table 3, entry 10) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.69-7.72(q, 2H), 7.75-7.78(m, 2H), 9.99(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 129.9, 131.0, 132.4, 135.0, 191.0.



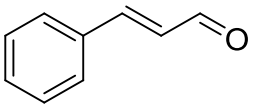
2-Clorobenzaldehyde (Table 3, entry 11) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.34(t, *J* = 7.5 Hz, 1H), 7.39-7.42(q, 1H), 7.47-7.51(m, 1H), 7.86-7.88(q, 1H), 10.43(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 127.1, 129.2, 130.4, 132.3, 135.0, 137.7, 189.5.



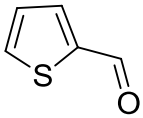
3-Clorobenzaldehyde (Table 3, entry 12) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.47(t, *J* = 7.8 Hz, 1H), 7.57-7.60(m, 1H), 7.74-7.77(m, 1H), 7.84(t, *J* = 1.7 Hz, 1H), 9.96(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 127.9, 129.2, 130.3, 134.3, 135.4, 137.8, 190.7.



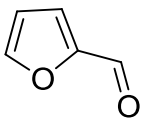
2,4-Diclorobenzaldehyde (Table 3, entry 13) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37(q, *J* = 10.0 Hz, 1H), 7.47(d, *J* = 2.0 Hz, 1H), 7.86(d, *J* = 8.5 Hz, 1H), 10.40(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 127.9, 130.3, 130.4, 130.9, 138.5, 141.0, 188.4.



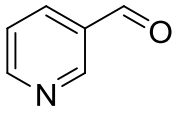
Cinnamaldehyde (Table 3, entry 14) ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.71(q, *J* = 7.5 Hz, 1H), 7.42(d, *J* = 2.0 Hz, 1H), 7.43(d, *J* = 2.0 Hz, 2H), 7.45(d, *J* = 2.5 Hz, 1H), 7.55(d, *J* = 2.5 Hz, 1H), 7.56(d, *J* = 2.0 Hz, 1H), 9.69(d, *J* = 7.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 128.5, 129.1, 131.2, 134.0, 152.7, 193.8.



2-Thiopheneformaldehyde (Table 2, entry 15) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.18-7.21(q, 1H), 7.74-7.75(q, 1H), 7.77(dd, *J* = 3.5, 1.5 Hz, 1H), 9.91(d, *J* = 1.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 128.2, 135.0, 136.3, 143.8, 182.9.

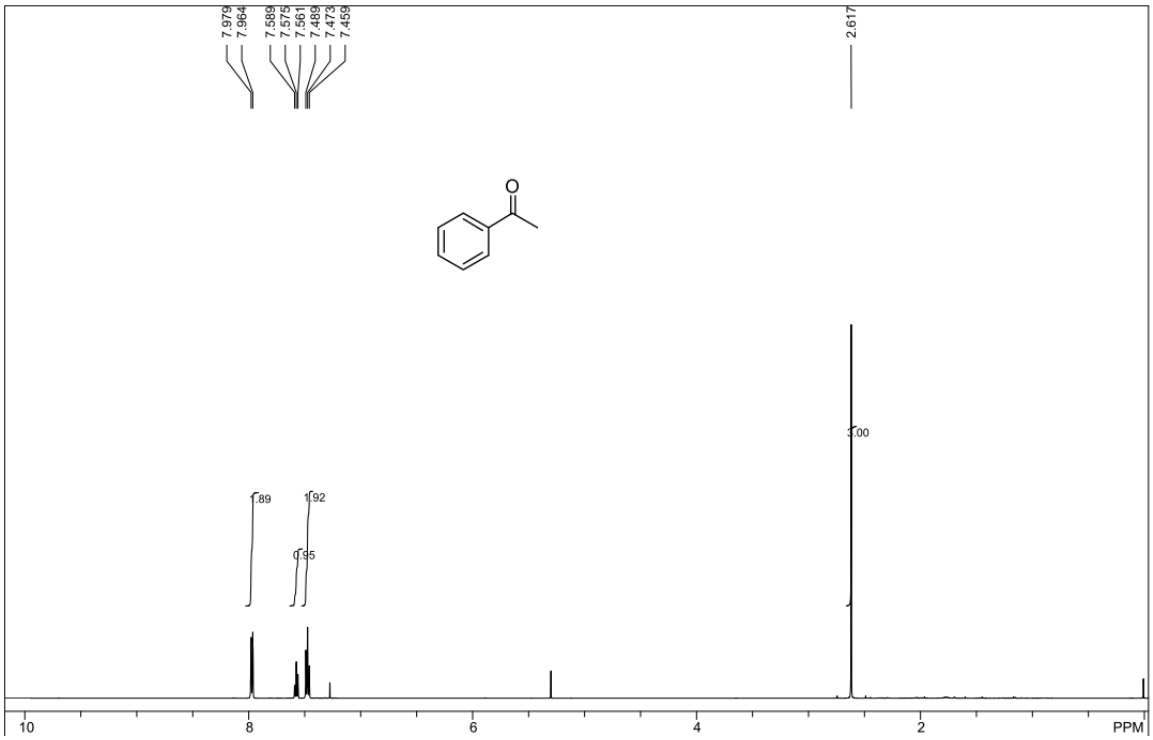


2-Furaldehyde (Table 2, entry 16) ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.53-6.55(q, 1H), 7.20(t, *J* = 1.8 Hz, 1H), 7.63(d, *J* = 1.0 Hz, 1H), 9.58(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 112.5, 121.2, 148.1, 152.9, 177.8.



3-Nicotinaldehyde (Table 3, entry 17) ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.46-7.50(q, 1H), 8.15-8.18(m, 1H), 8.82-8.84(q, 1H), 9.07(d, *J* = 2.0 Hz, 1H), 10.10(s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 124.0, 131.4, 135.7, 151.9, 154.6, 190.6.

Figure 1. ^{1}H NMR and ^{13}C NMR spectrum of acetophenone



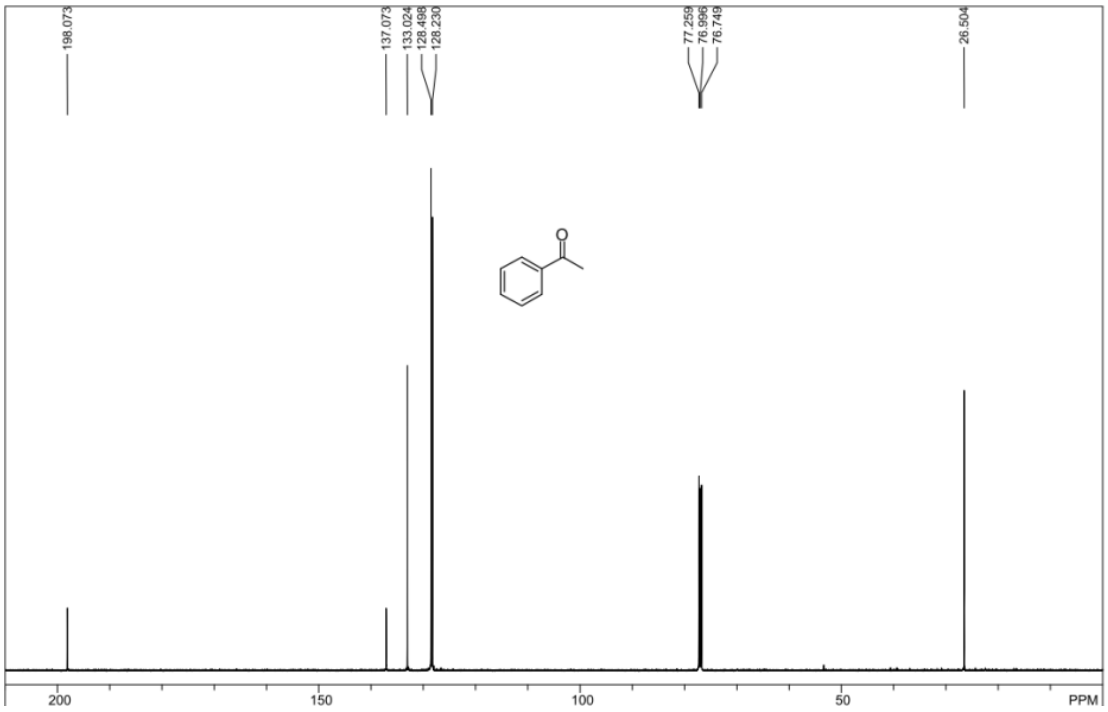
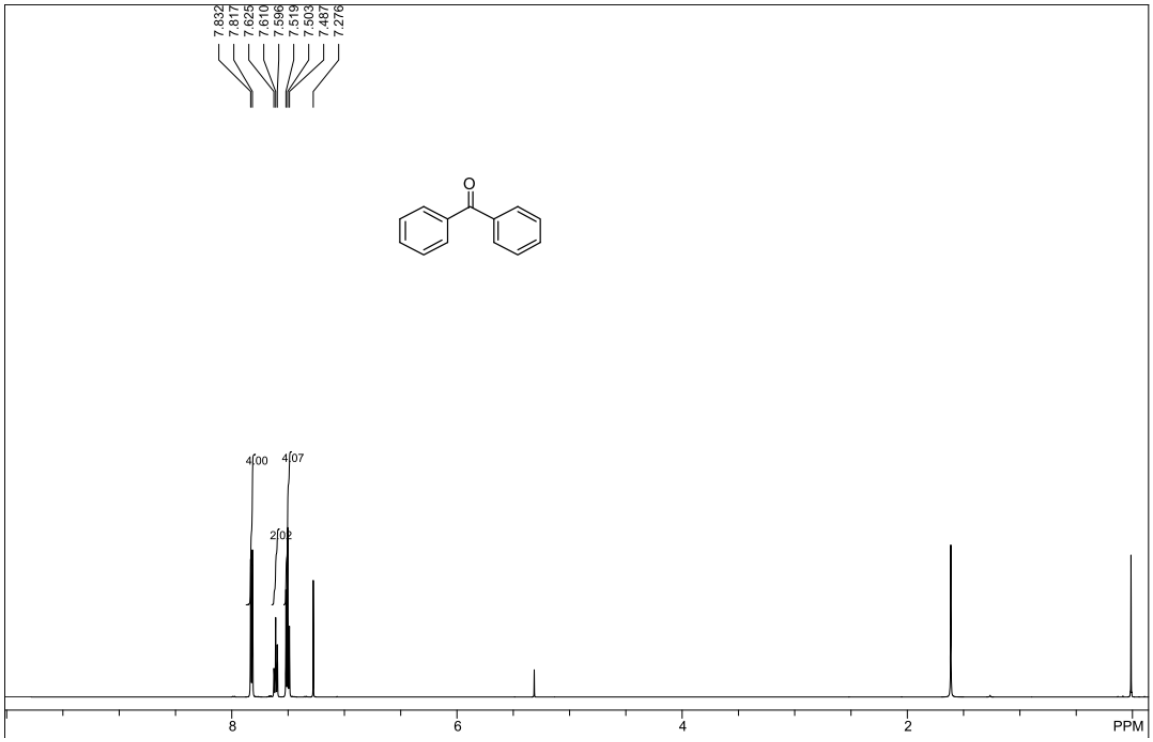


Figure 2. ^{1}H NMR and ^{13}C NMR spectrum of benzophenone



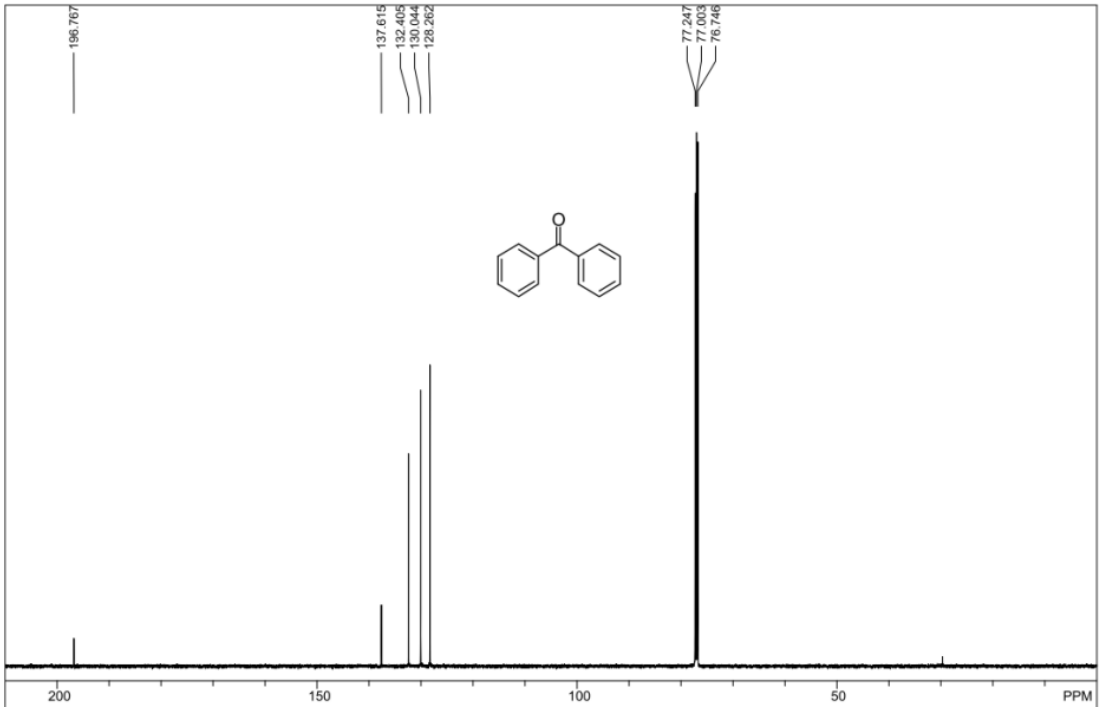
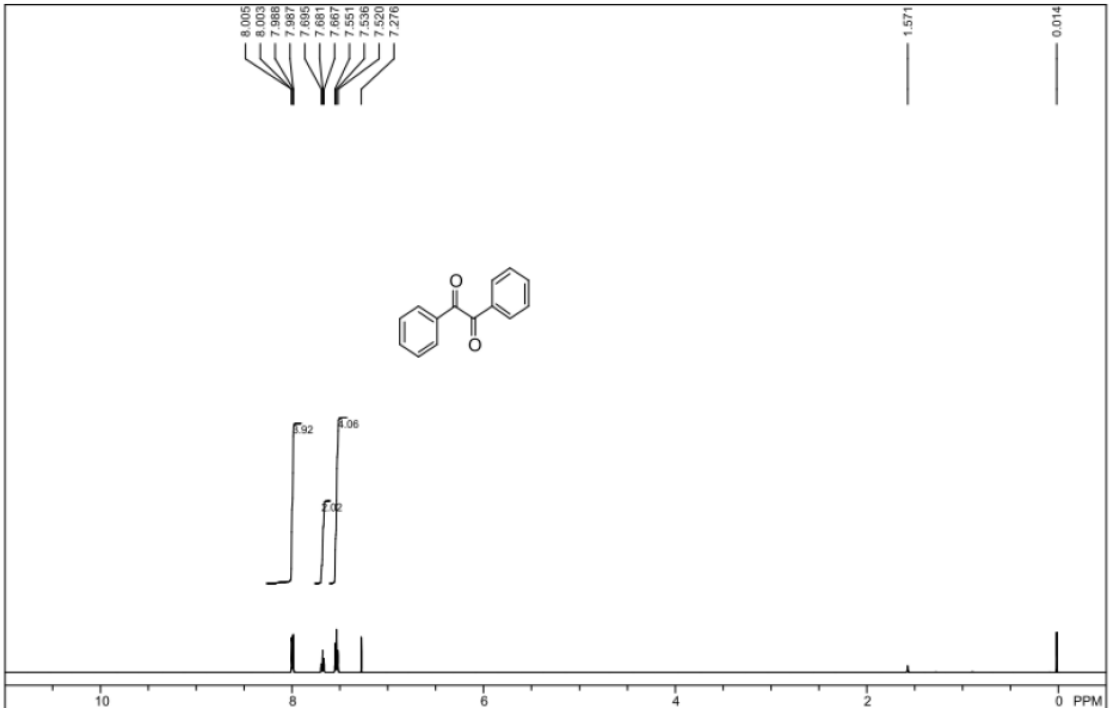


Figure 3. ^{1}H NMR and ^{13}C NMR spectrum of benzil



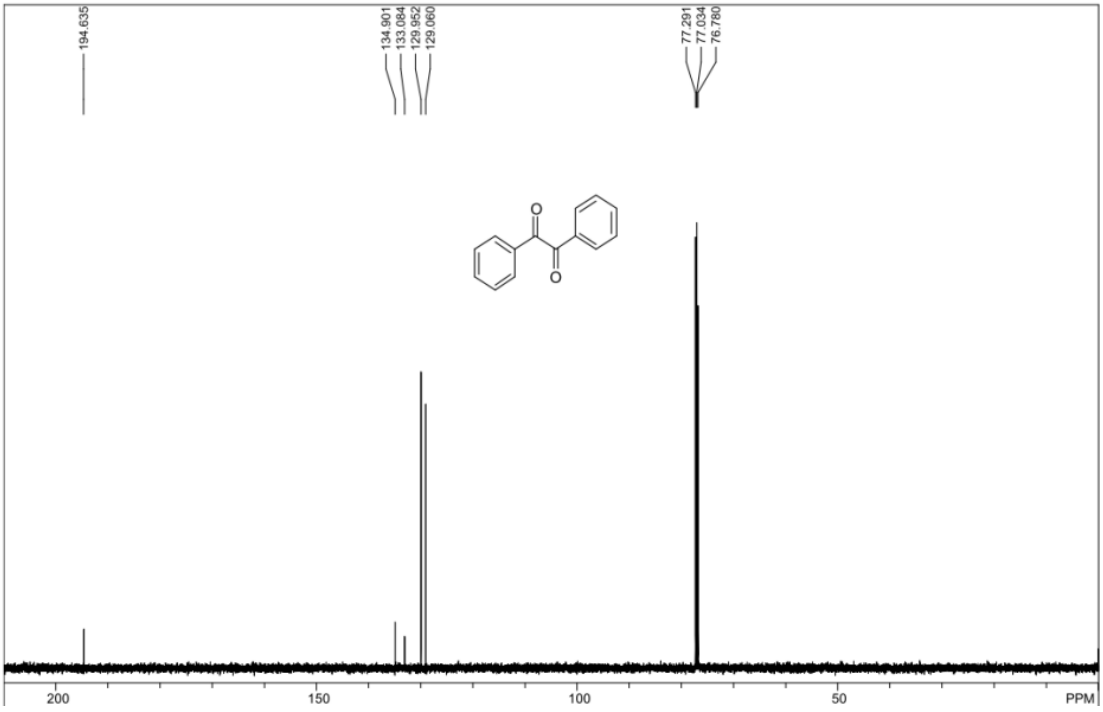
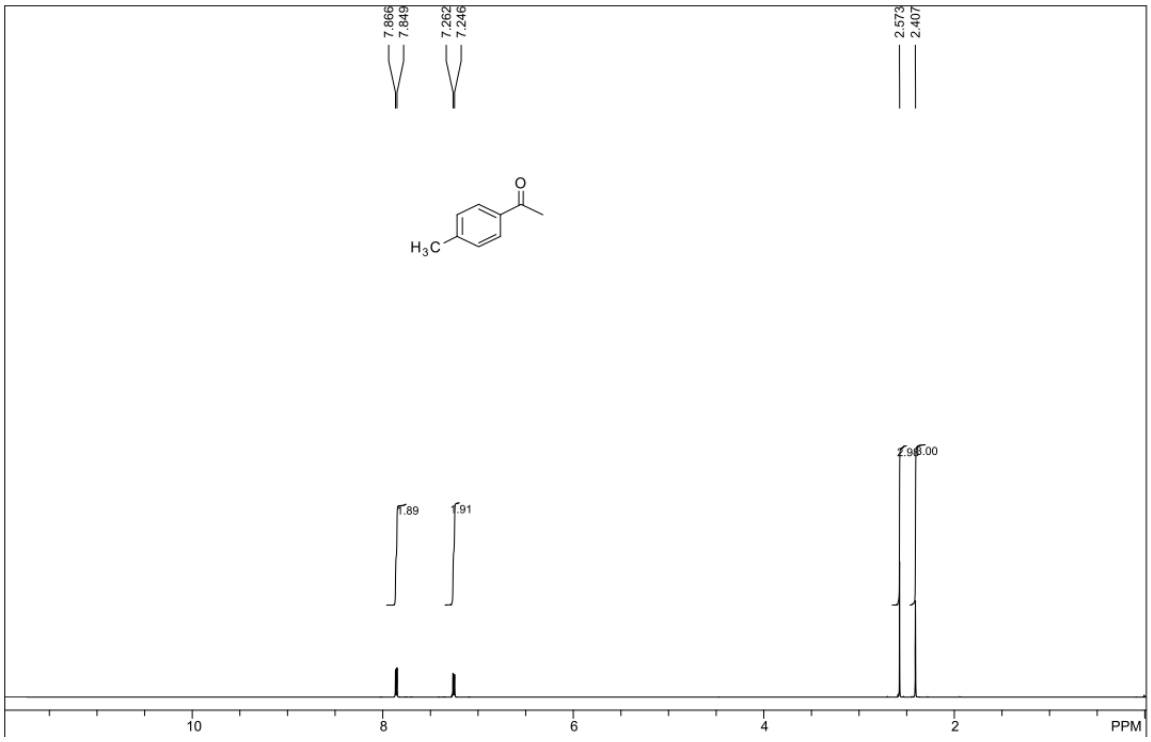


Figure 4. ^{1}H NMR and ^{13}C NMR spectrum of 4-methylacetophenone



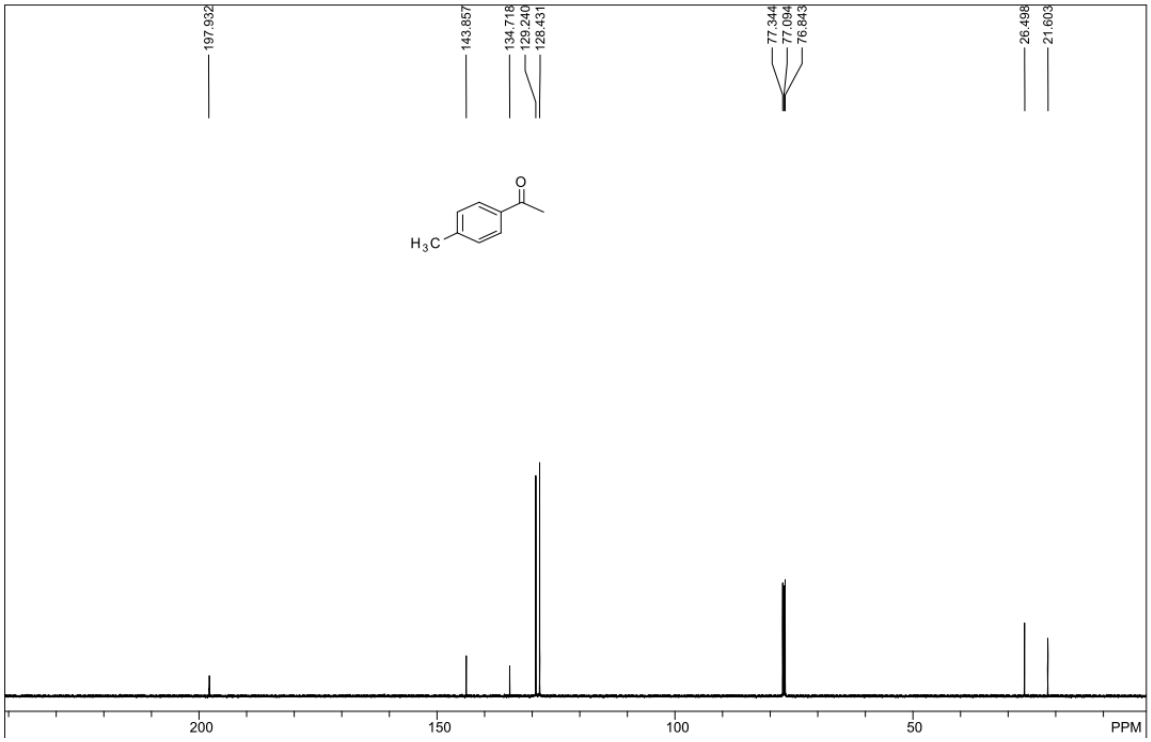
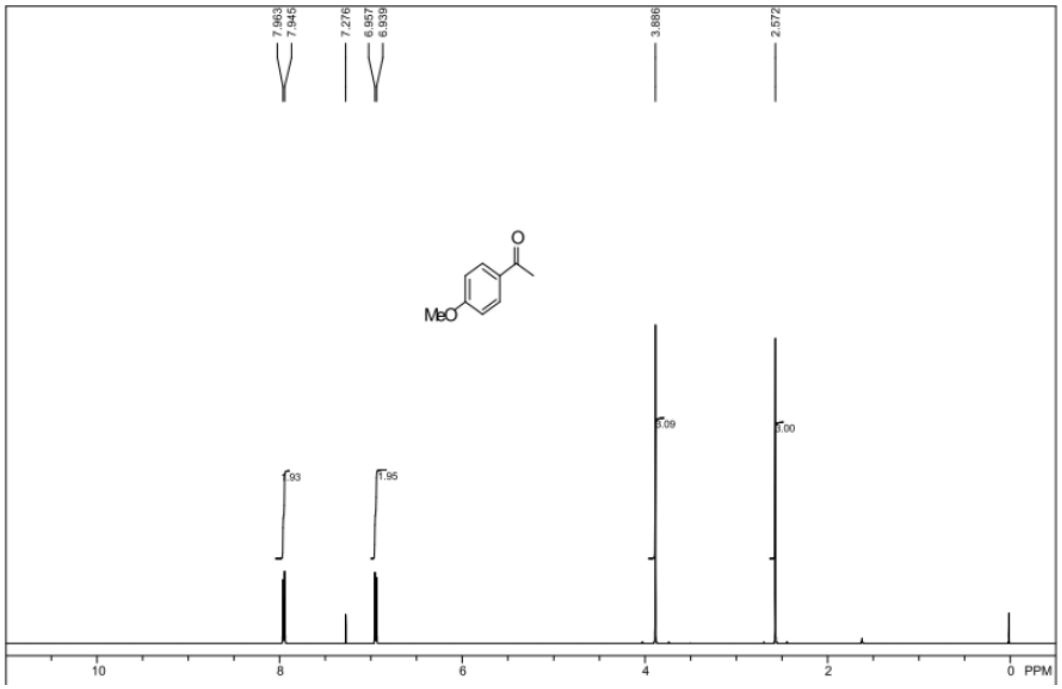


Figure 5. ^{1}H NMR and ^{13}C NMR spectrum of 4-methoxyacetophenone



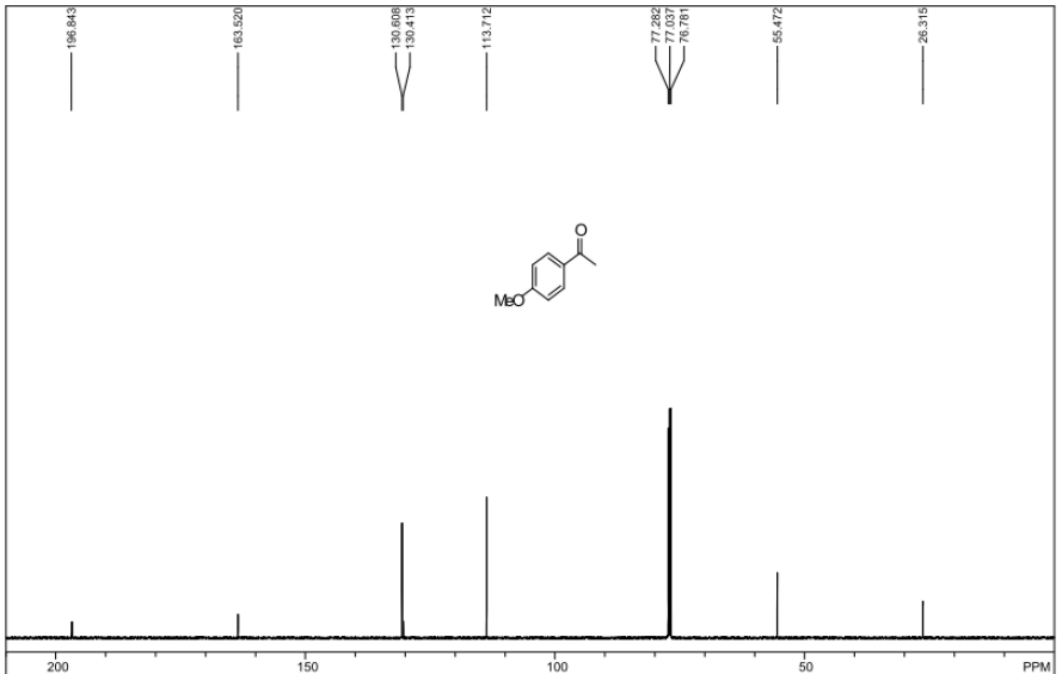
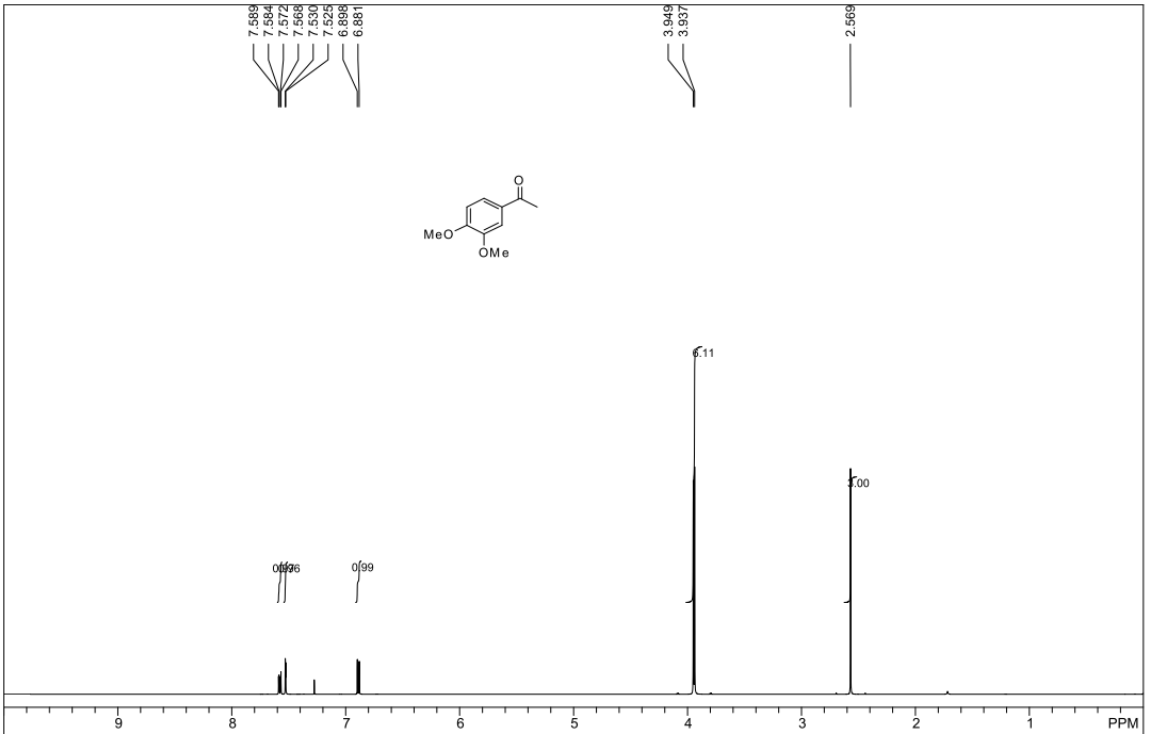


Figure 6. ^{1}H NMR and ^{13}C NMR spectrum of 3,4-dimethoxyacetophenone



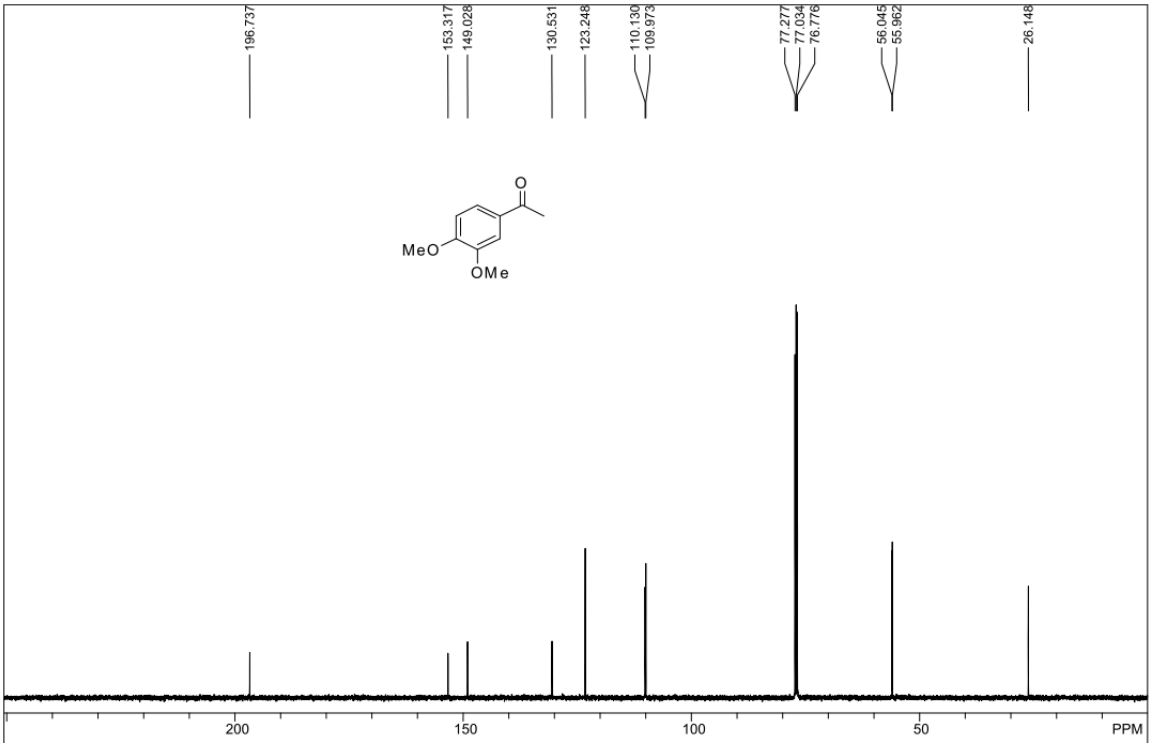
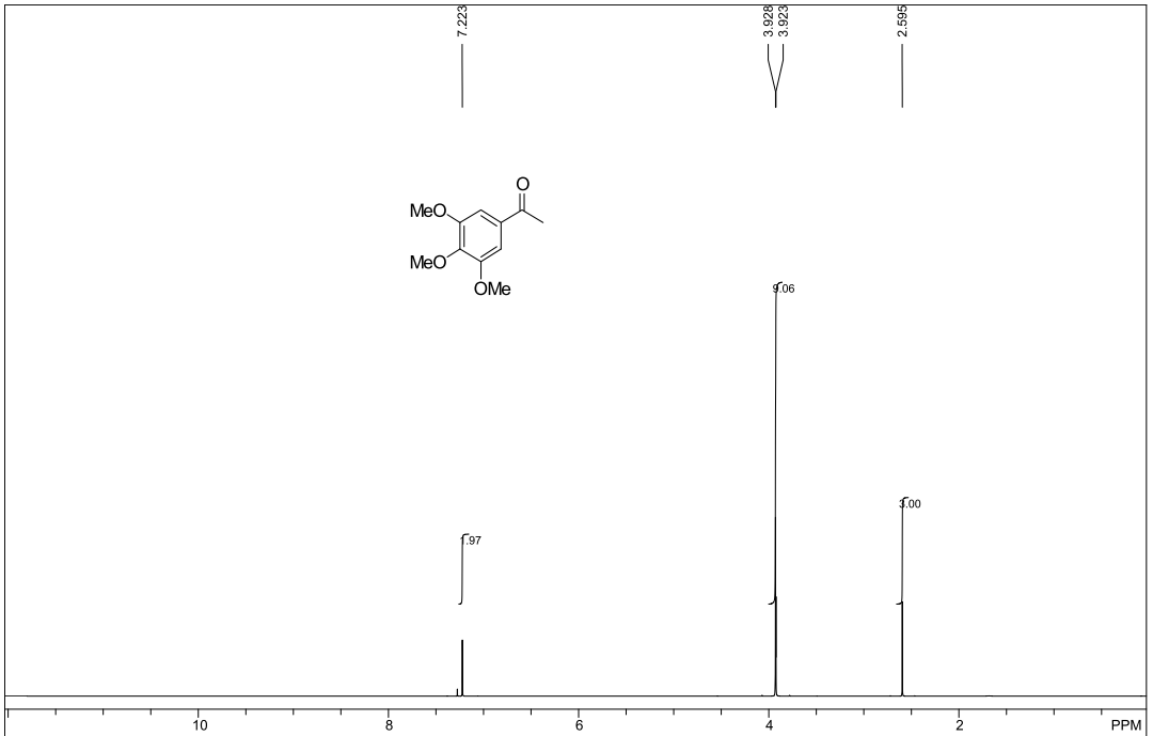


Figure 7. ^{1}H NMR and ^{13}C NMR spectrum of 3,4,5-trimethoxyacetophenone



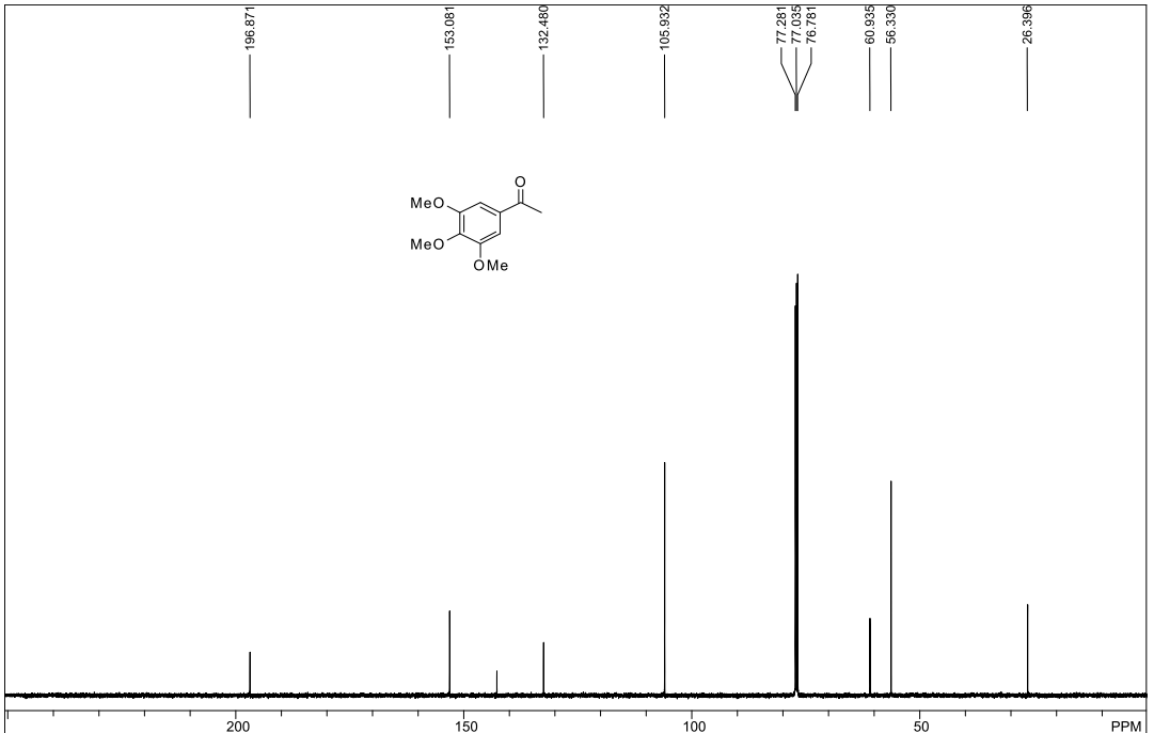
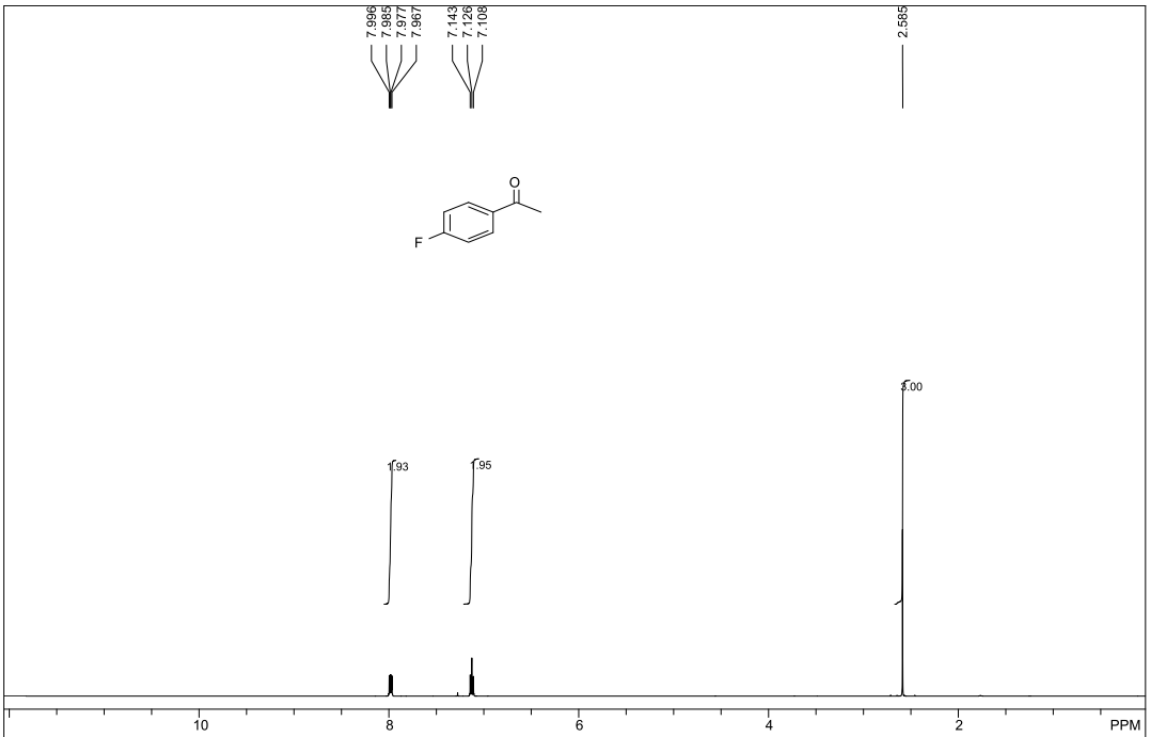


Figure 8. ^{1}H NMR and ^{13}C NMR spectrum of 4-fluoroacetophenone



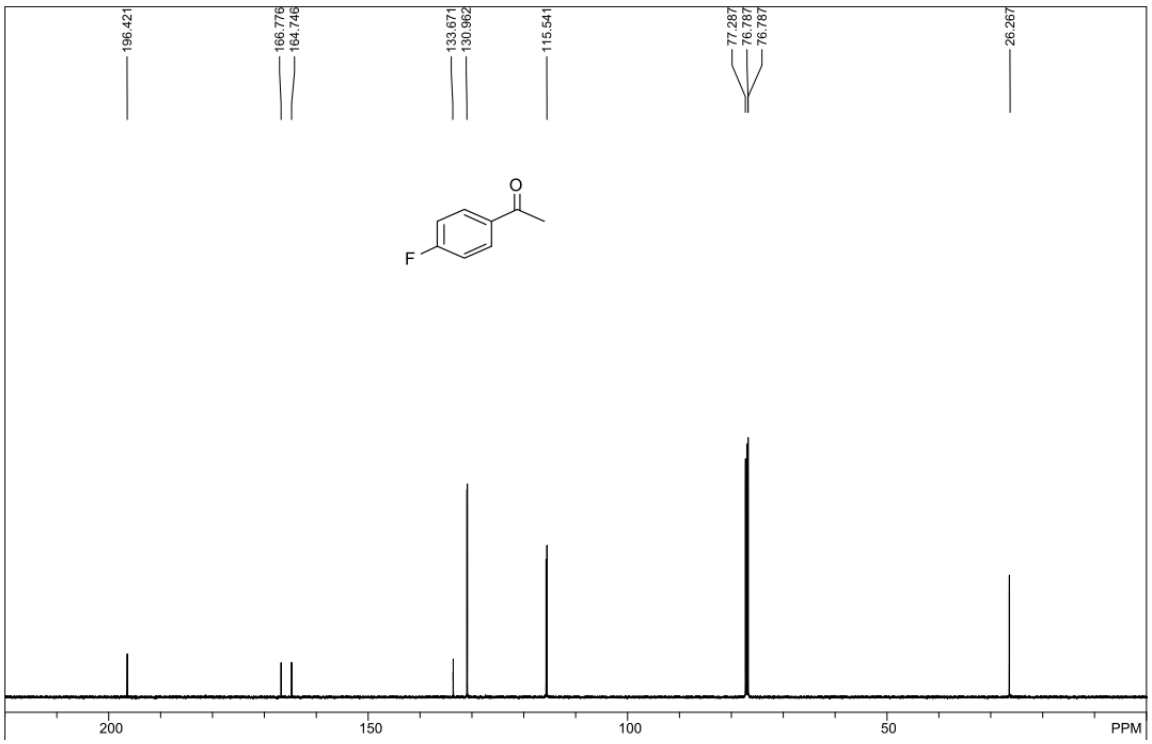
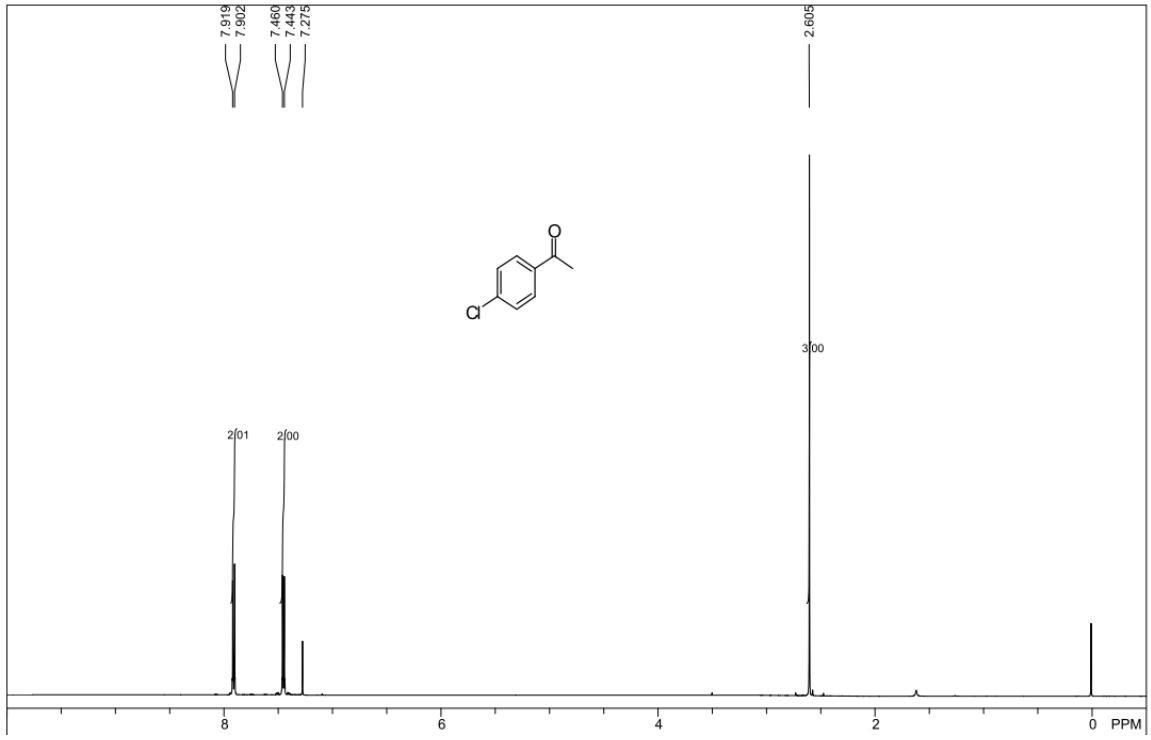


Figure 9. ^{1}H NMR and ^{13}C NMR spectrum of 4-chloroacetophenone



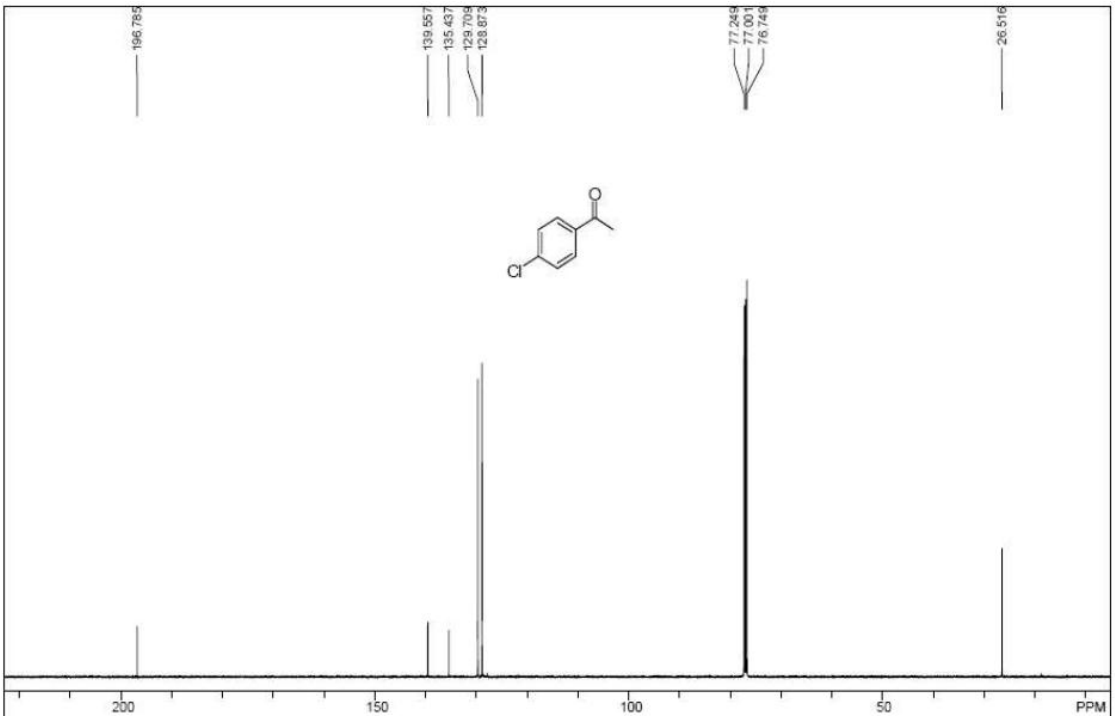
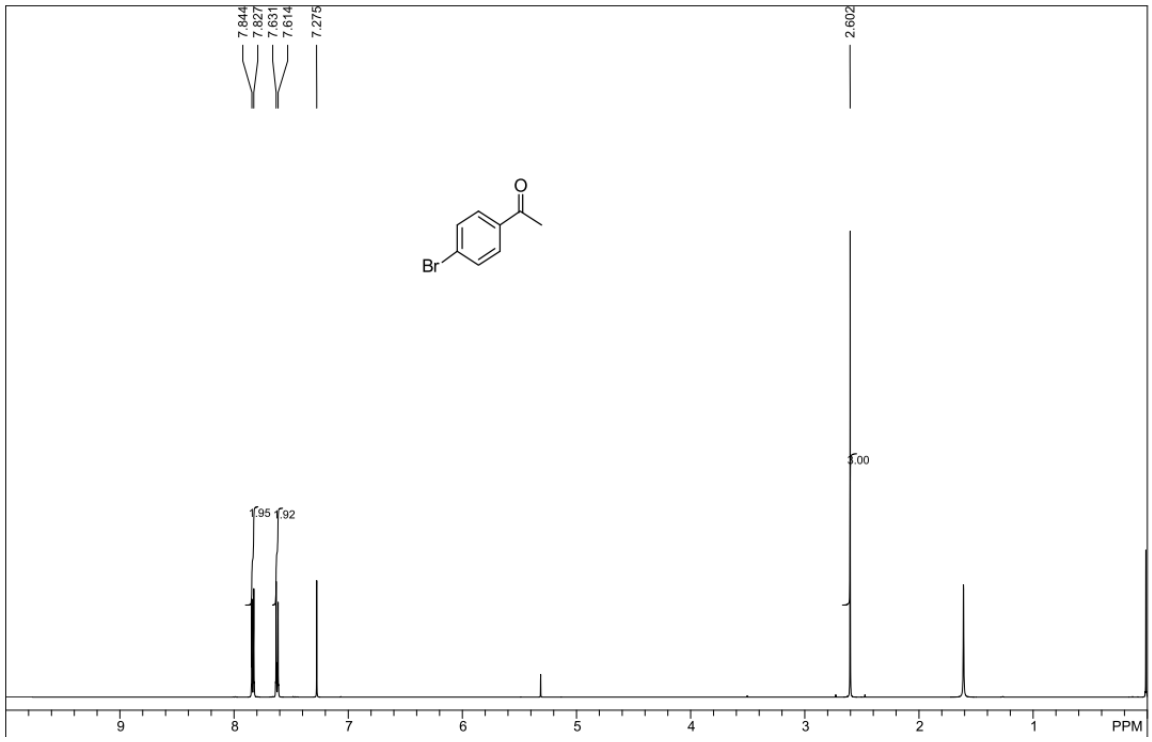


Figure 10. ^{1}H NMR and ^{13}C NMR spectrum of 4-bromoacetophenone



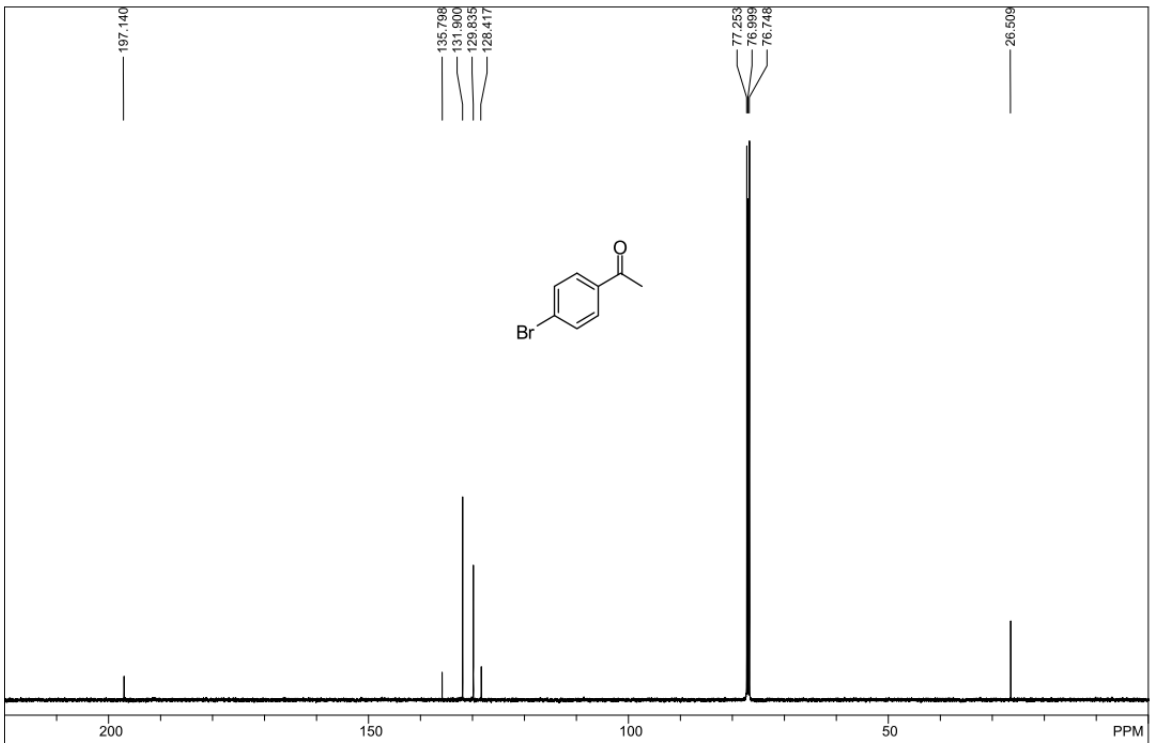
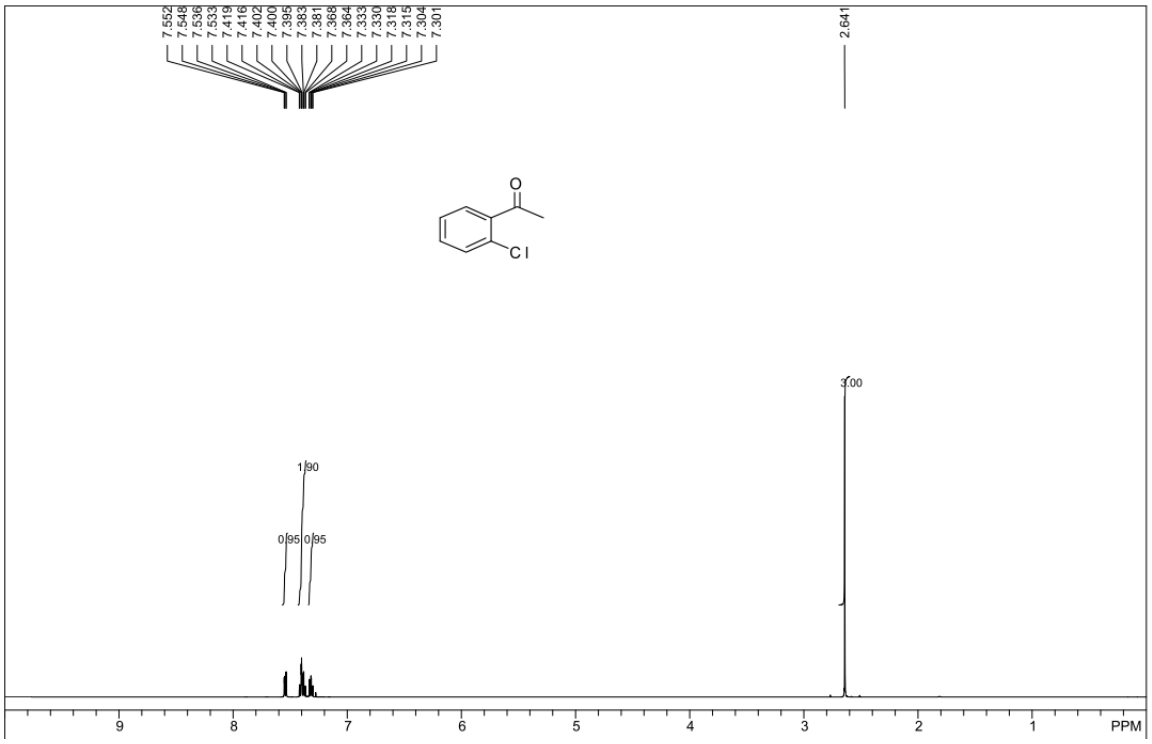


Figure 11. ^{1}H NMR and ^{13}C NMR spectrum of 2-chloroacetophenone



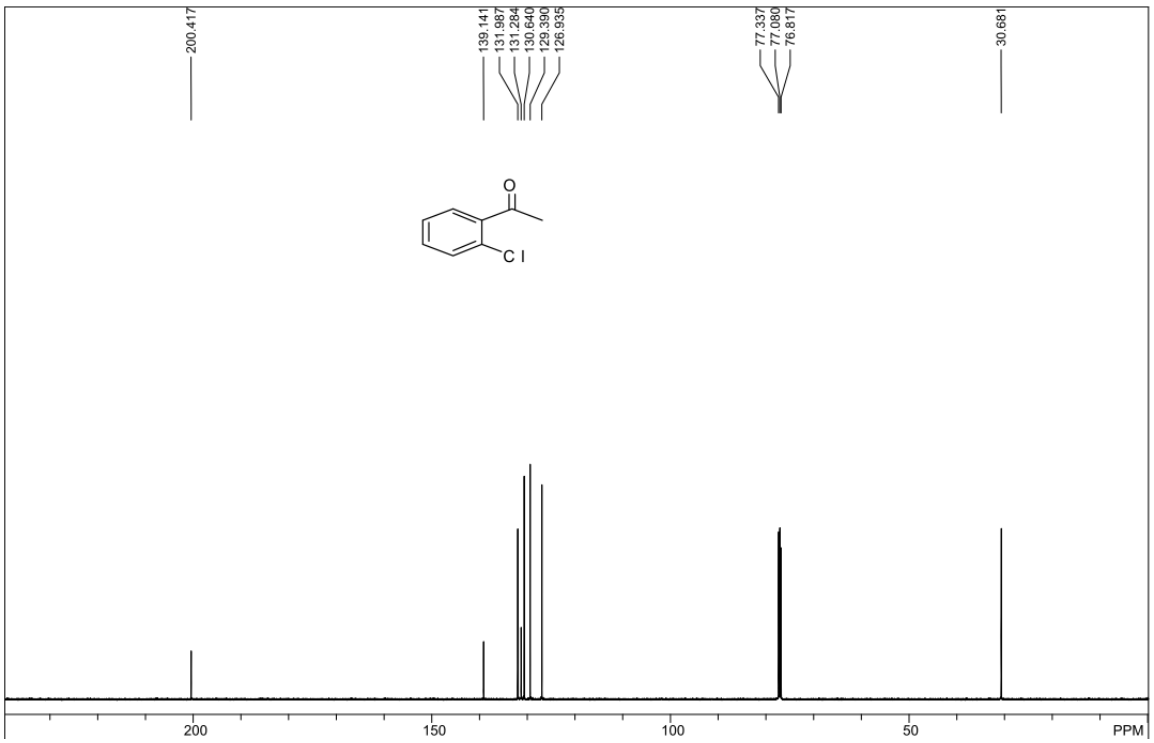
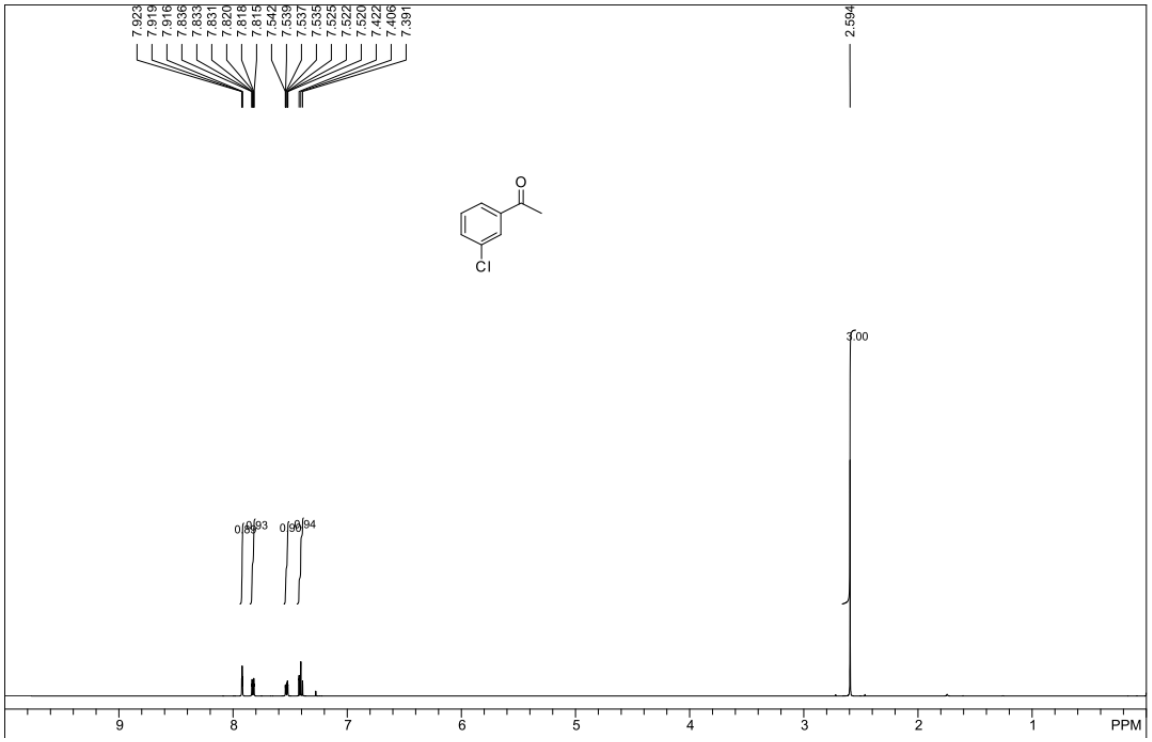


Figure 12. ^{1}H NMR and ^{13}C NMR spectrum of 3-chloroacetophenone



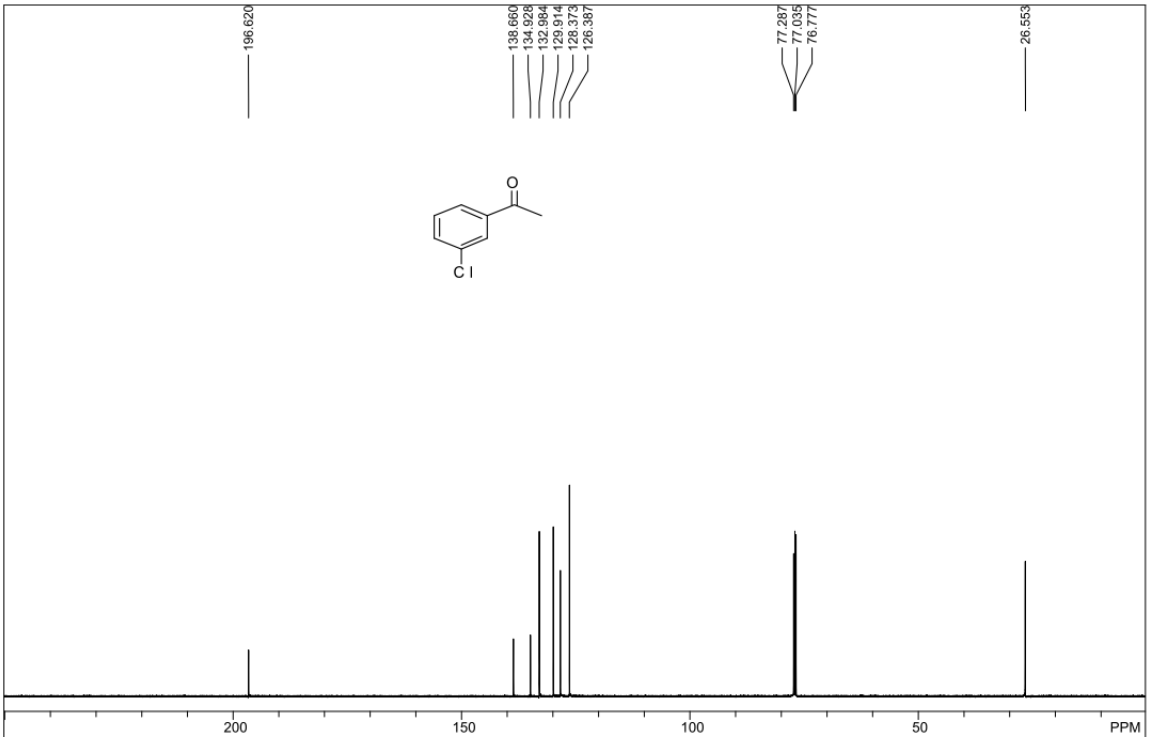
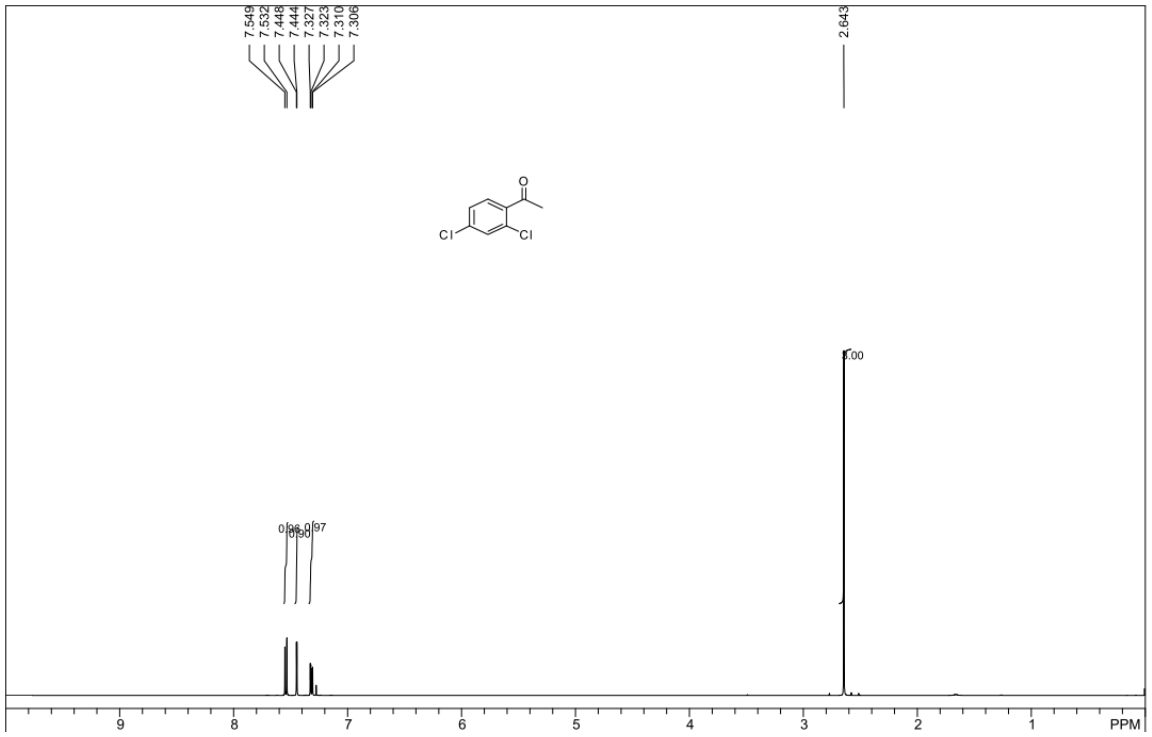


Figure 13. ^{1}H NMR and ^{13}C NMR spectrum of 2,4-dichloroacetophenone



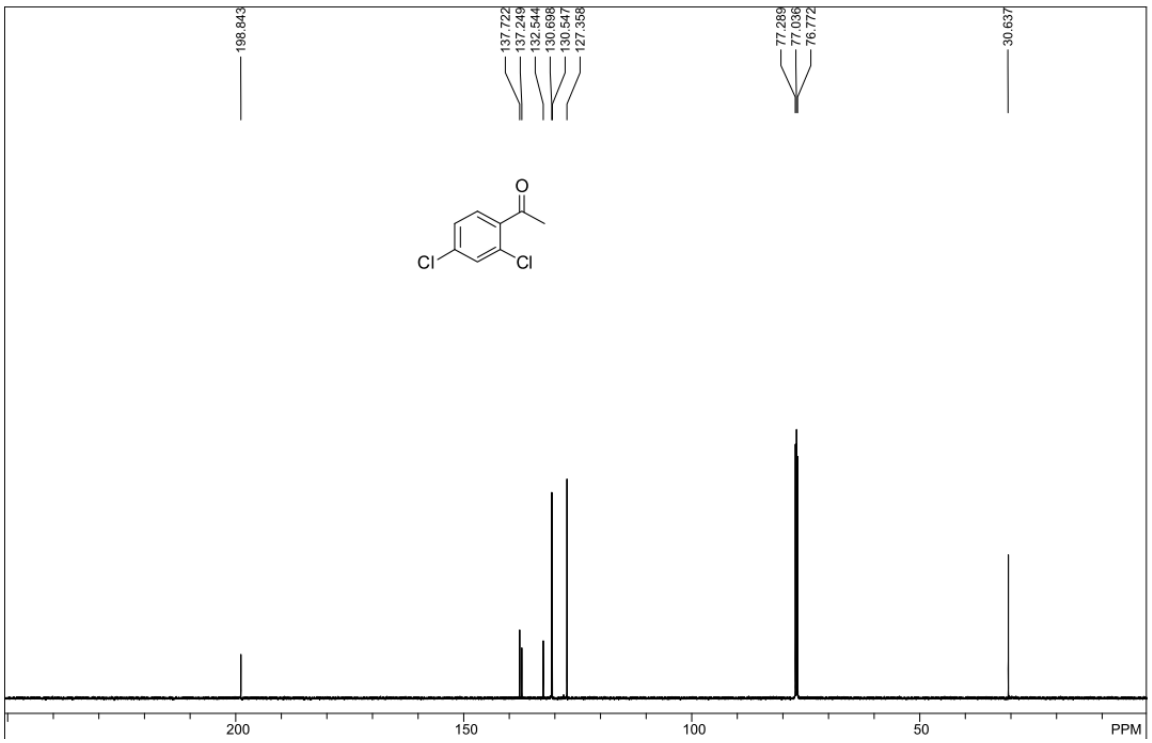
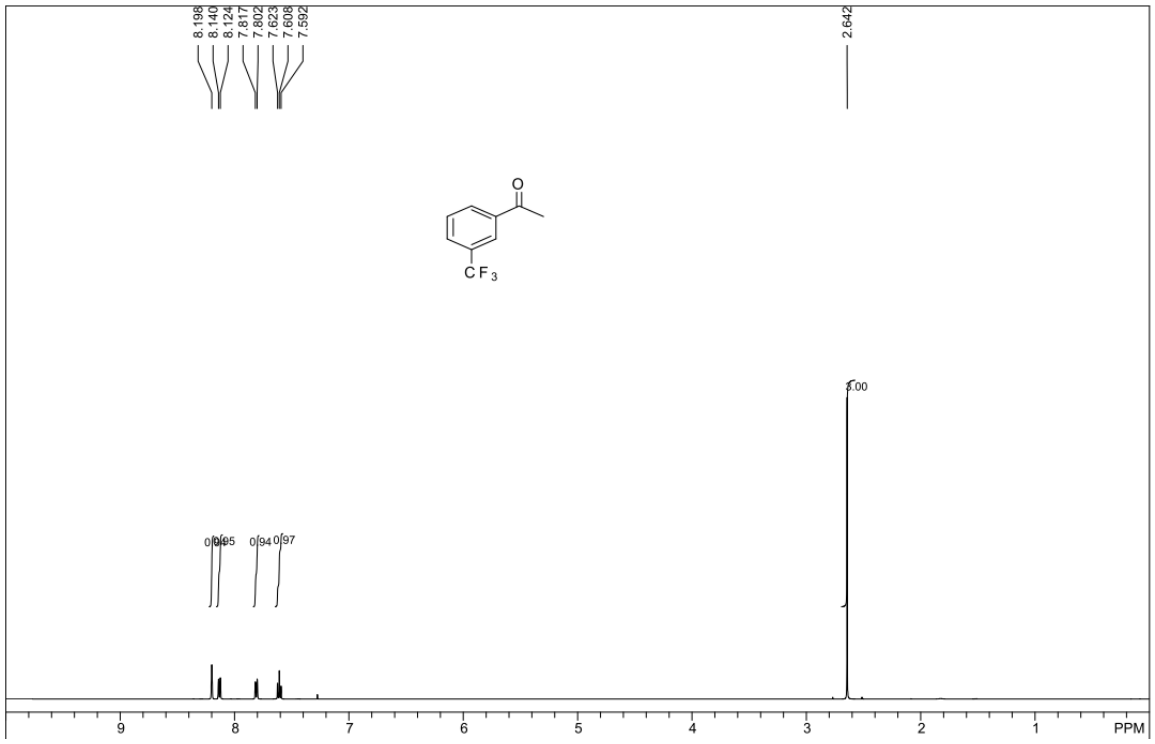


Figure 14. ^{1}H NMR and ^{13}C NMR spectrum of 3-trifluoromethylacetophenone



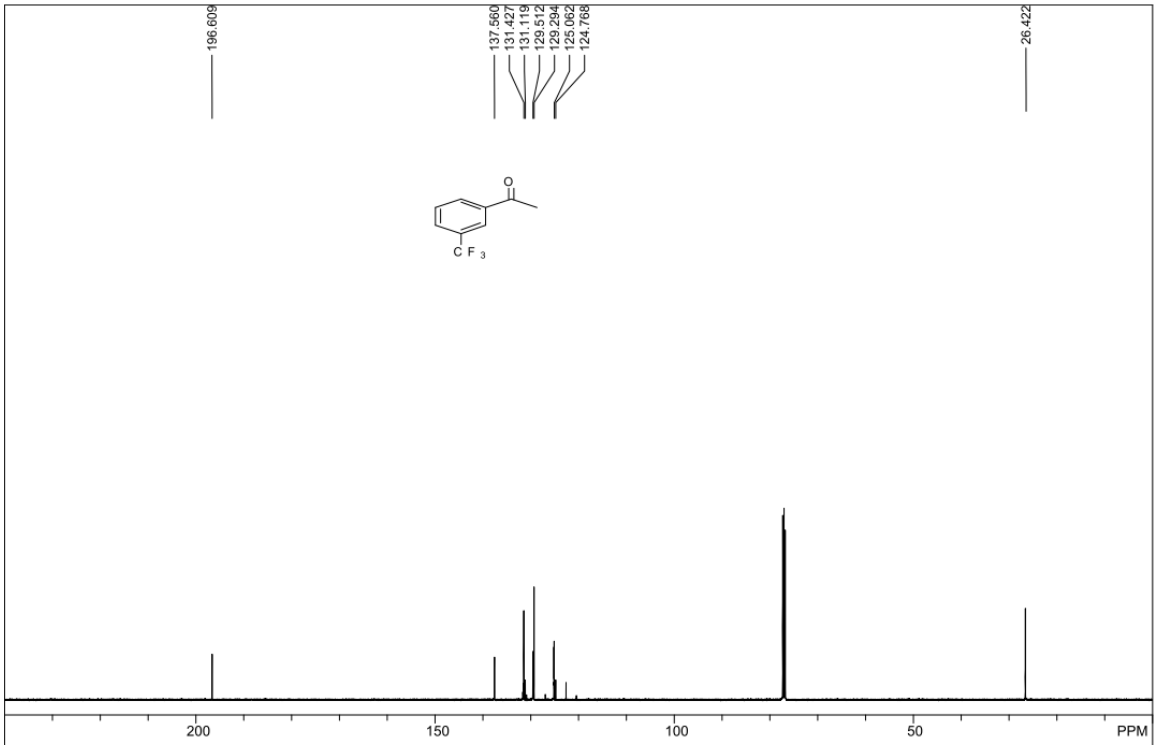
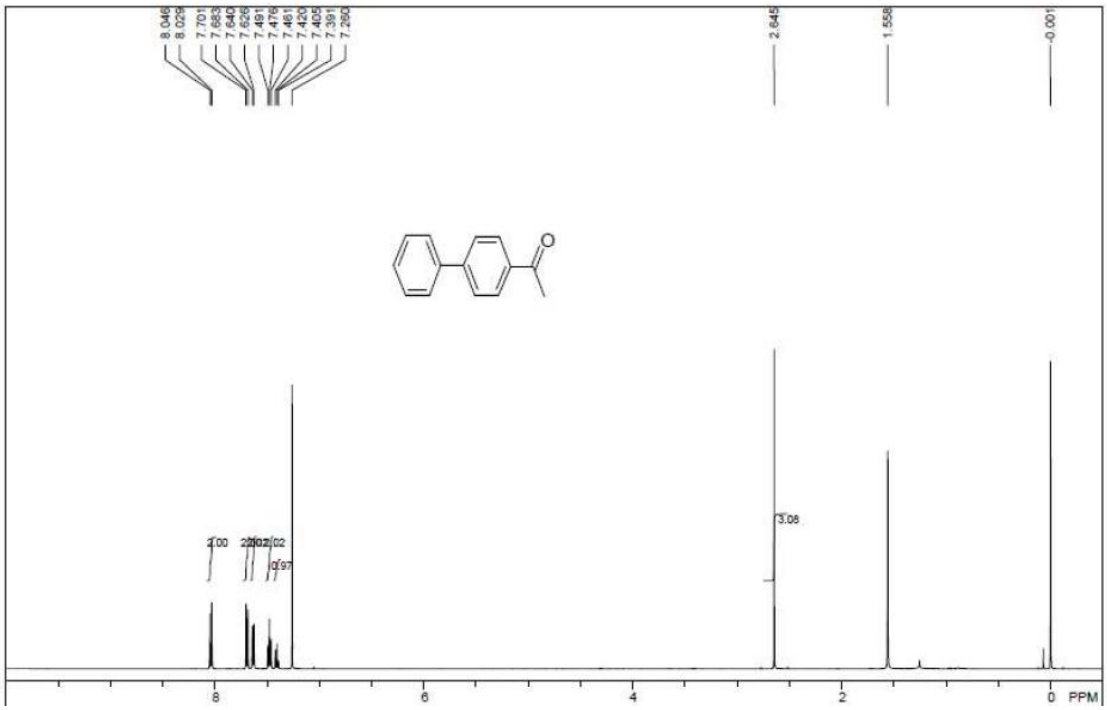


Figure 15. ^{1}H NMR and ^{13}C NMR spectrum of 4-acetylbiphenyl



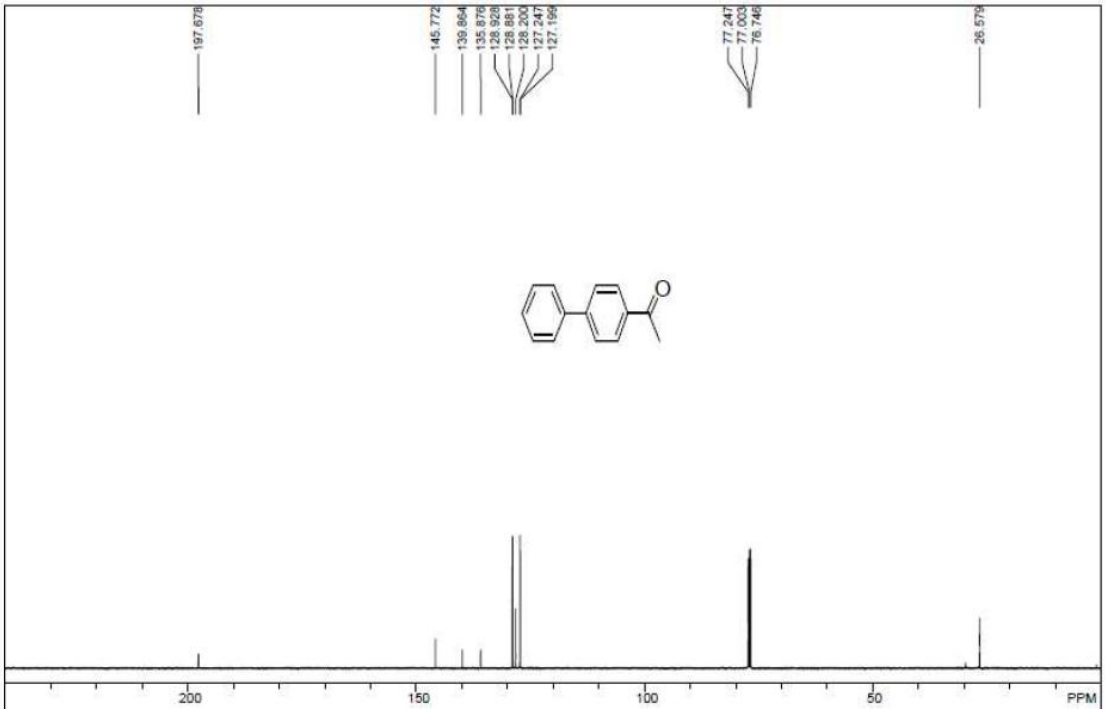
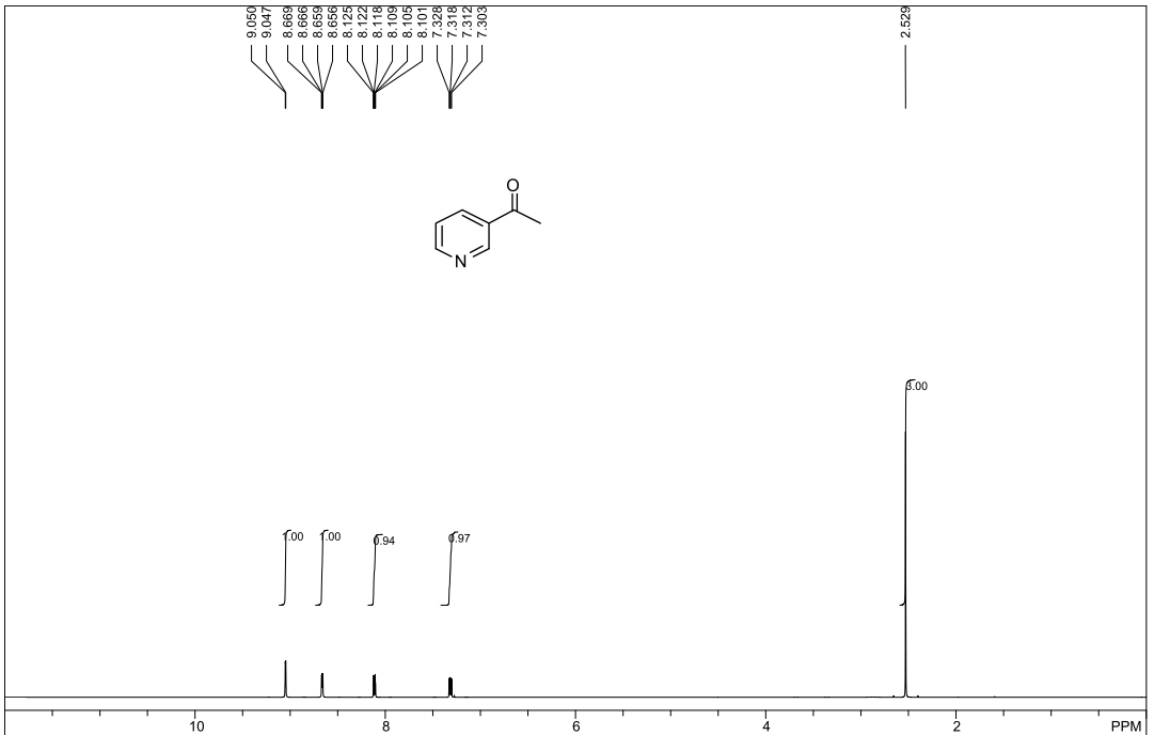


Figure 16. ^{1}H NMR and ^{13}C NMR spectrum of 3-acetylpyridine



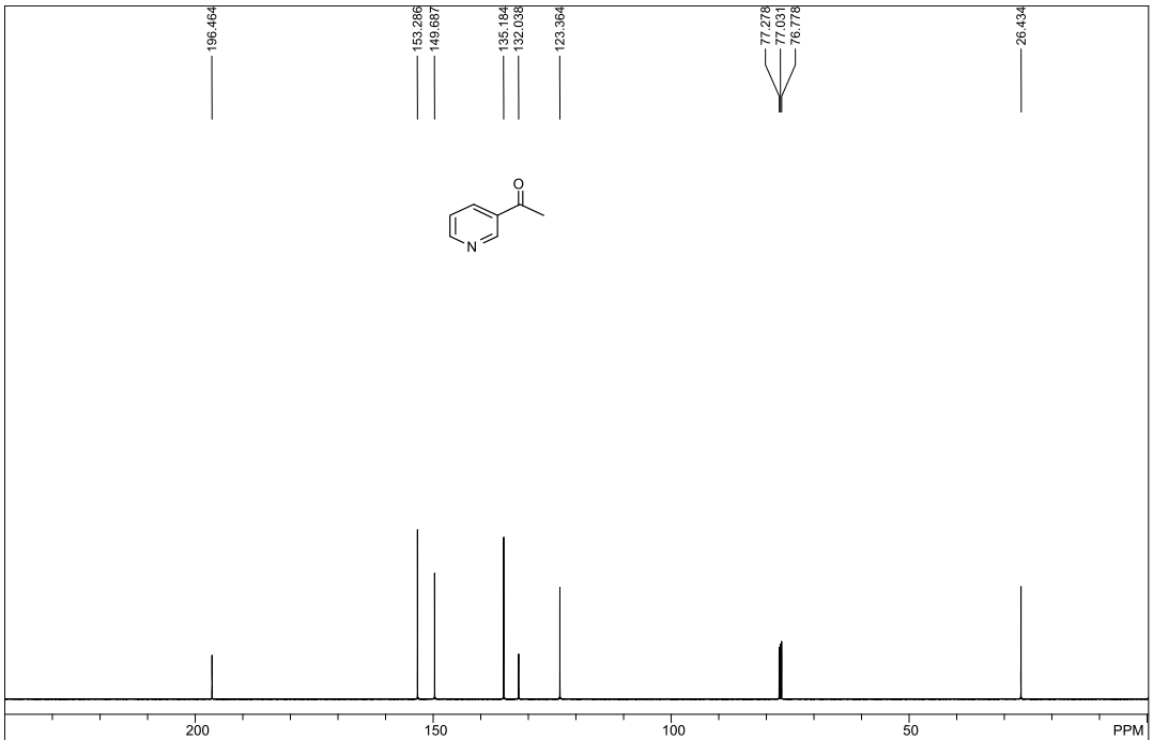
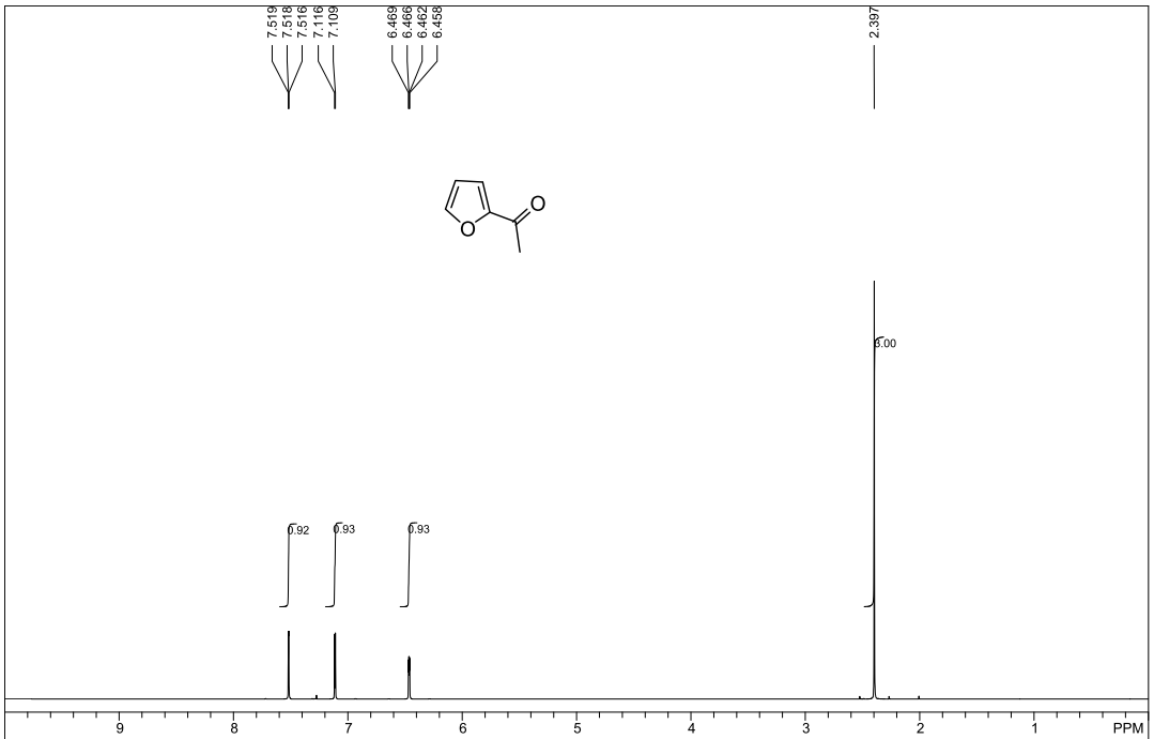


Figure 17. ^{1}H NMR and ^{13}C NMR spectrum of 2-acetylfuran



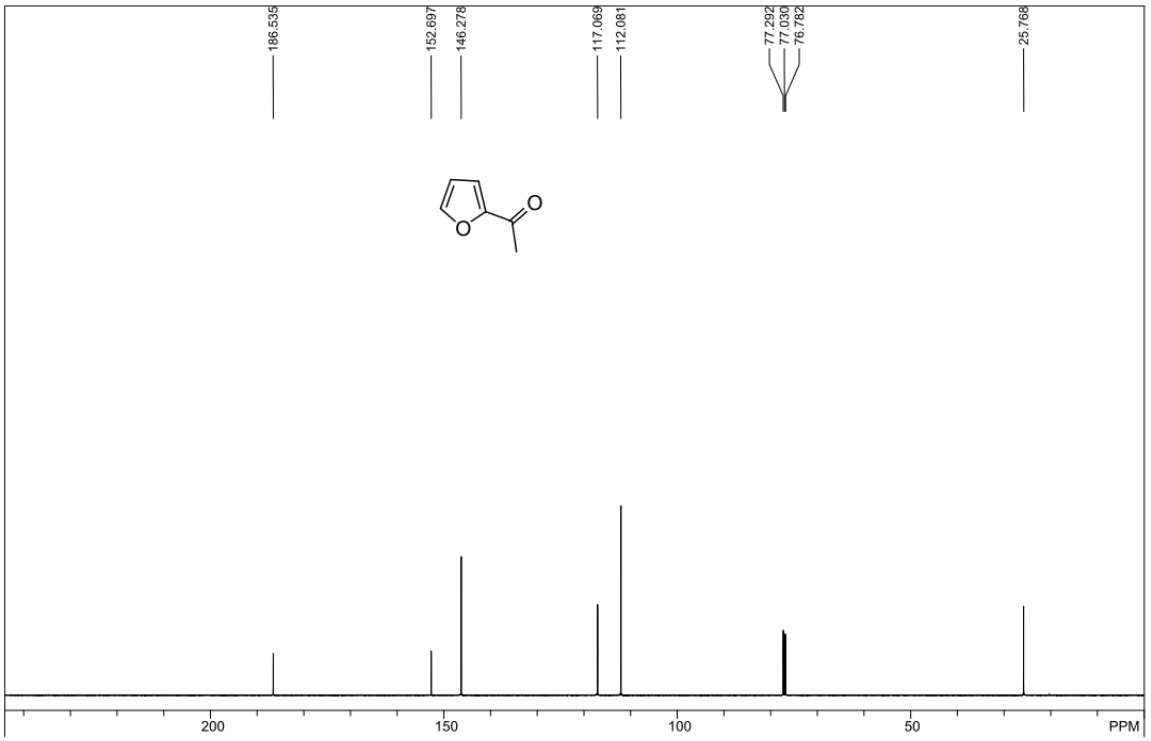


Figure 18. ^{1}H NMR and ^{13}C NMR spectra of benzaldehyde.

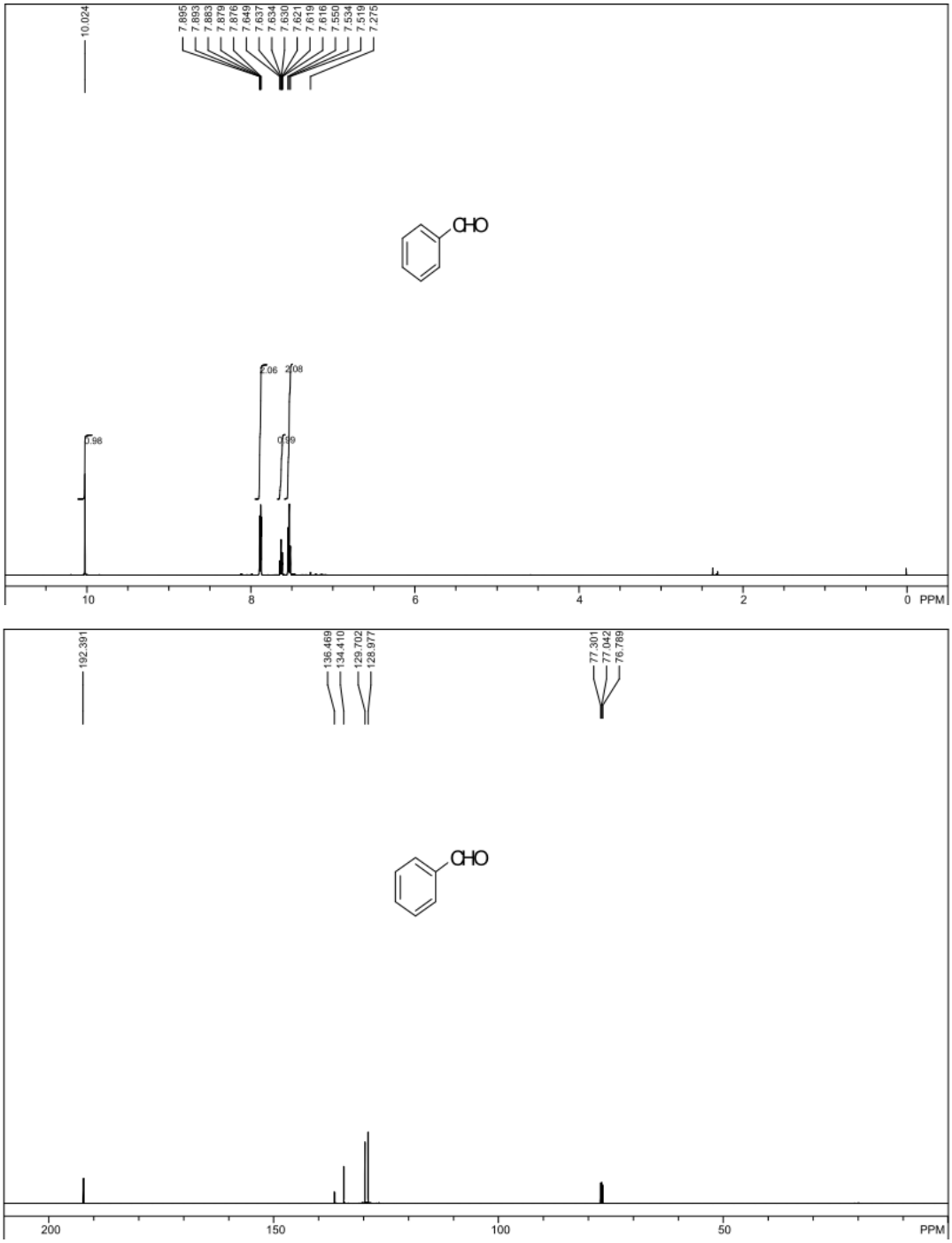


Figure 19. ^{1}H NMR and ^{13}C NMR spectra of 4-methylbenzaldehyde.

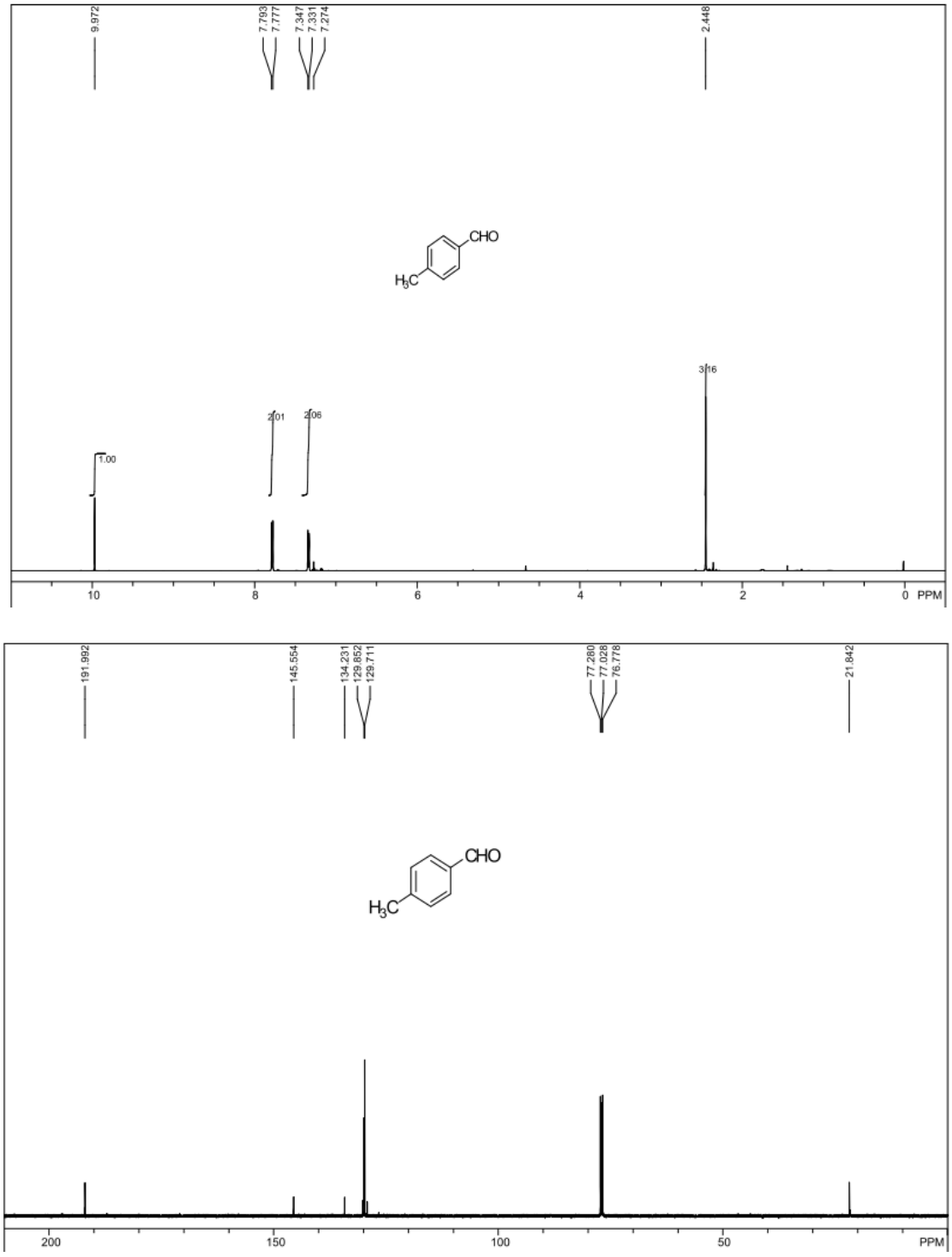
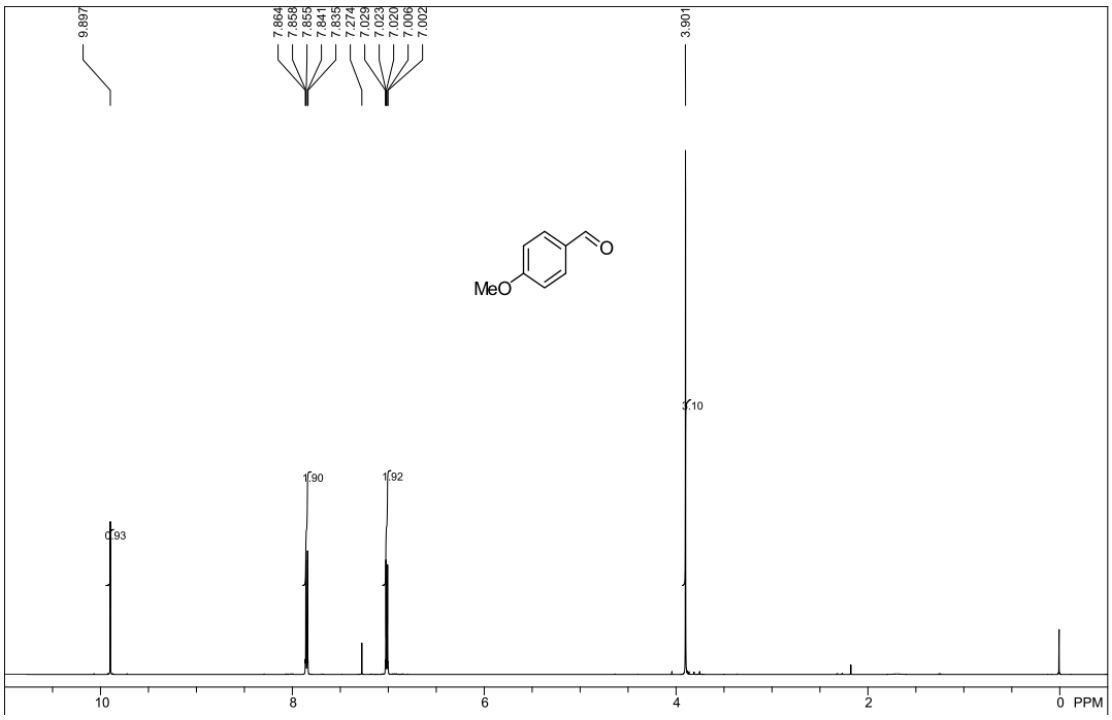


Figure 20. ^{1}H NMR and ^{13}C NMR spectra of 4-methoxybenzaldehyde.



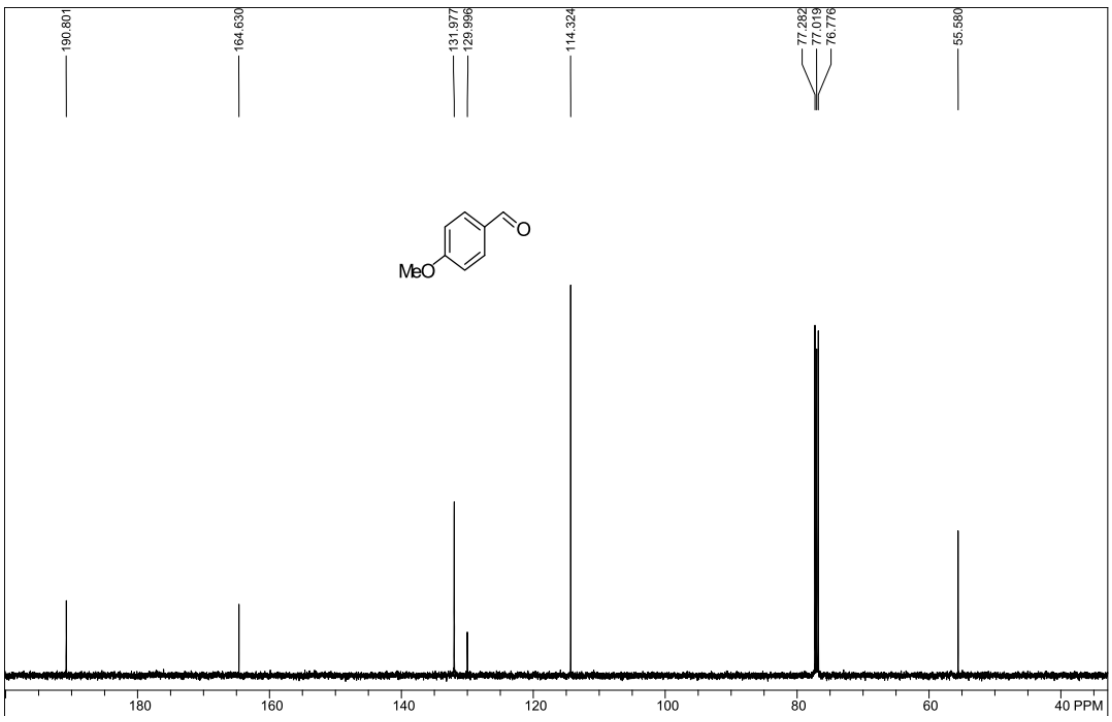
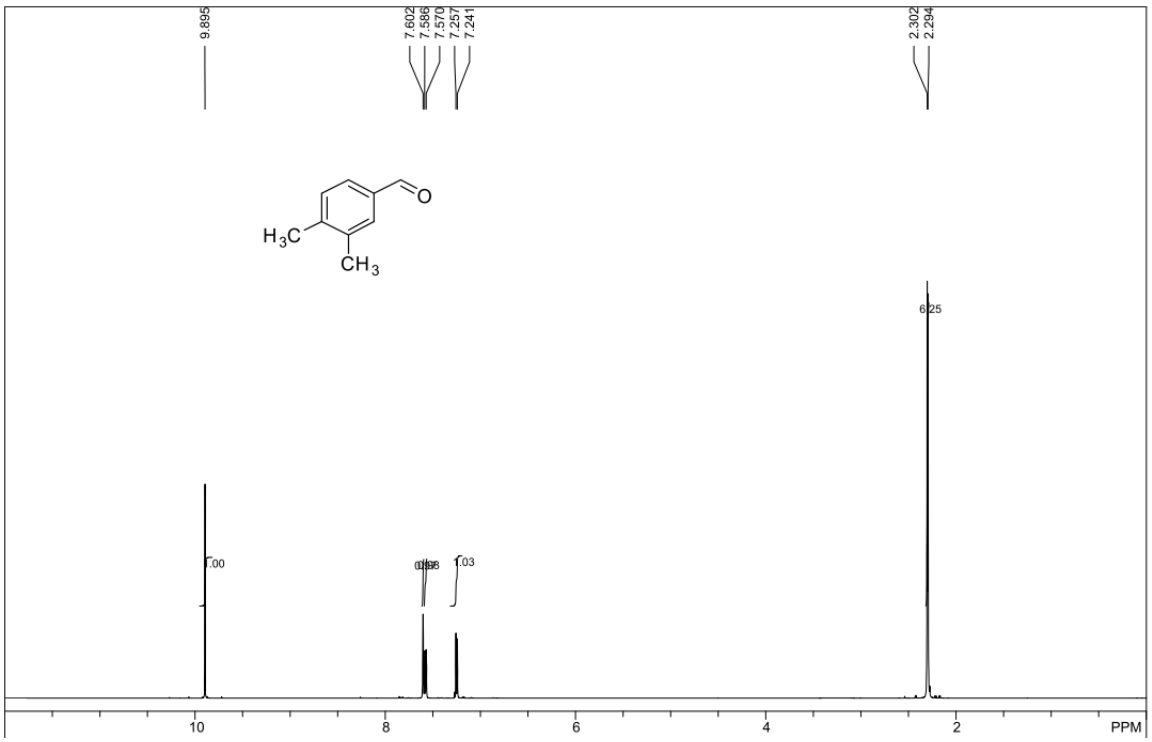


Figure 21. ^{1}H NMR and ^{13}C NMR spectra of 3,4-dimethylbenzaldehyde



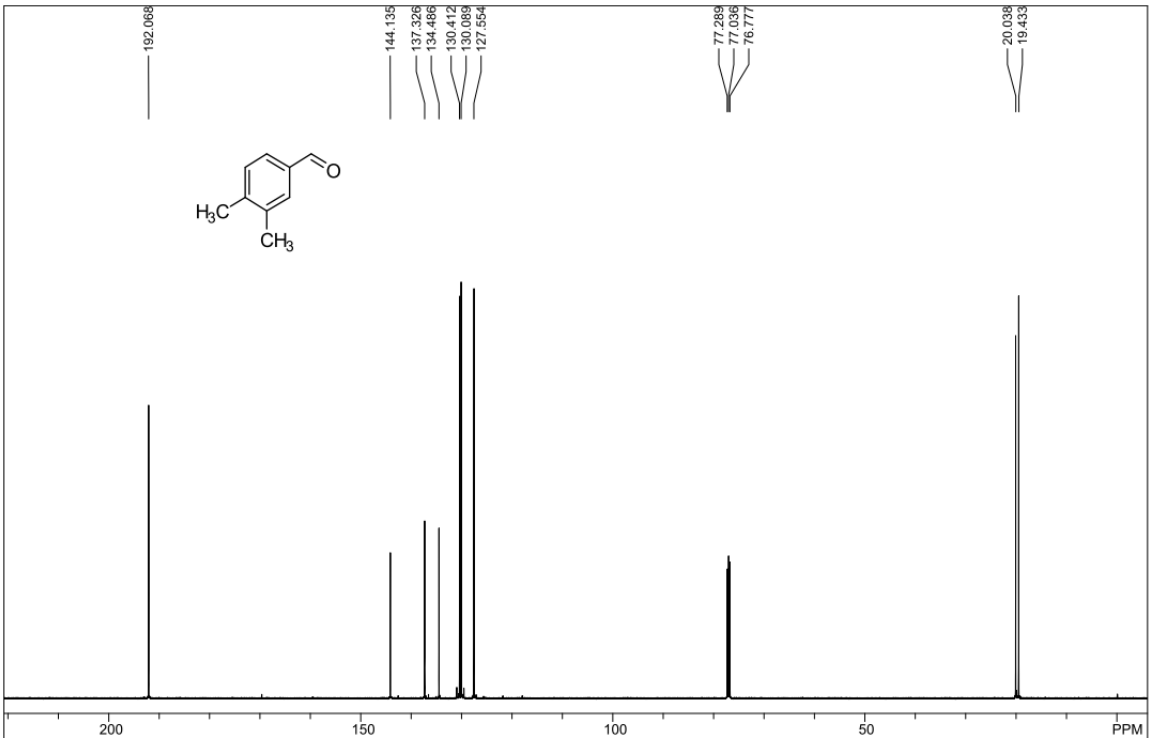
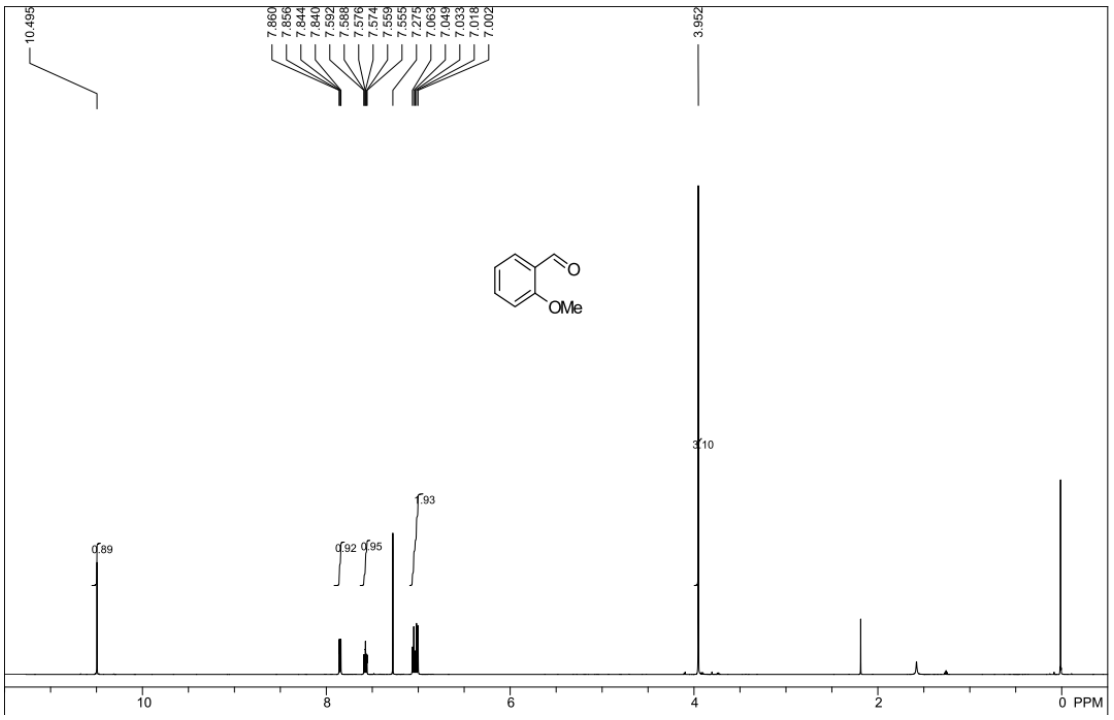


Figure 22. ^{1}H NMR and ^{13}C NMR spectra of 2-methoxybenzaldehyde.



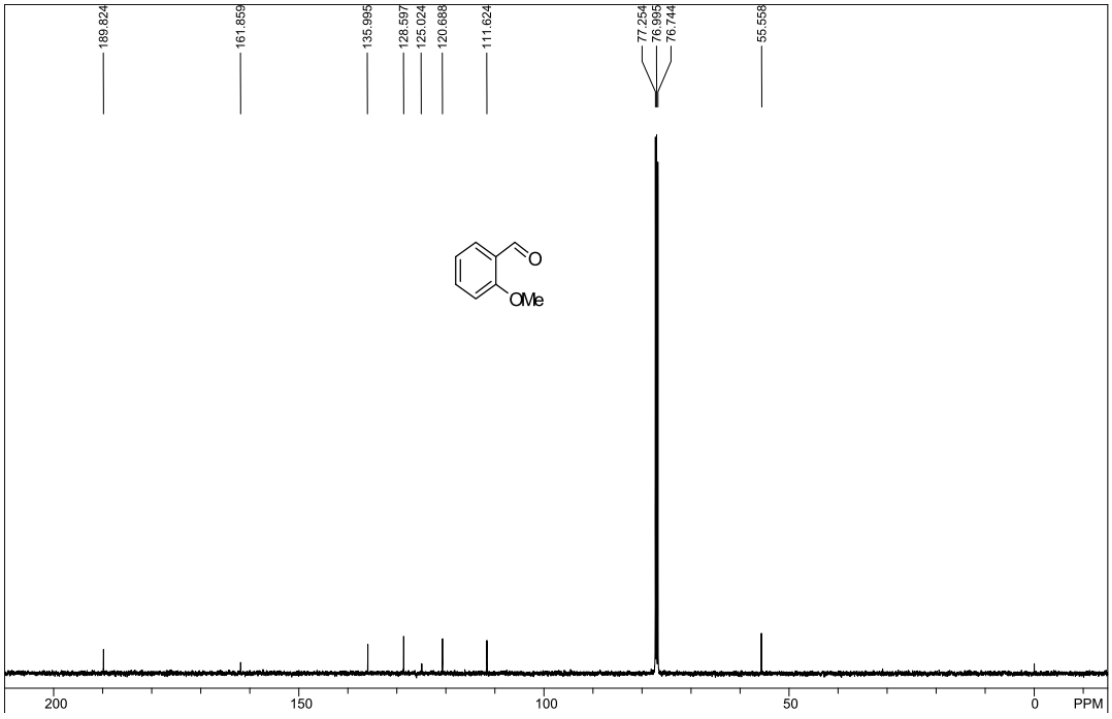
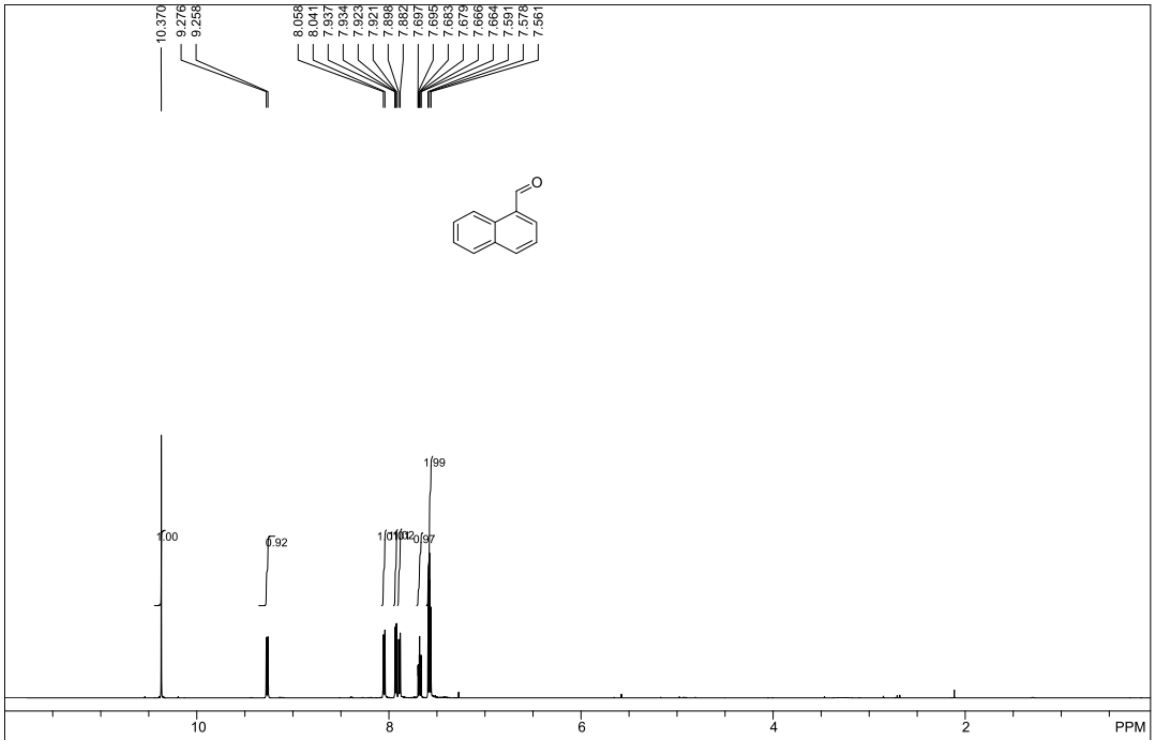


Figure 23. ^{1}H NMR and ^{13}C NMR spectra of 1-naphthaldehyde



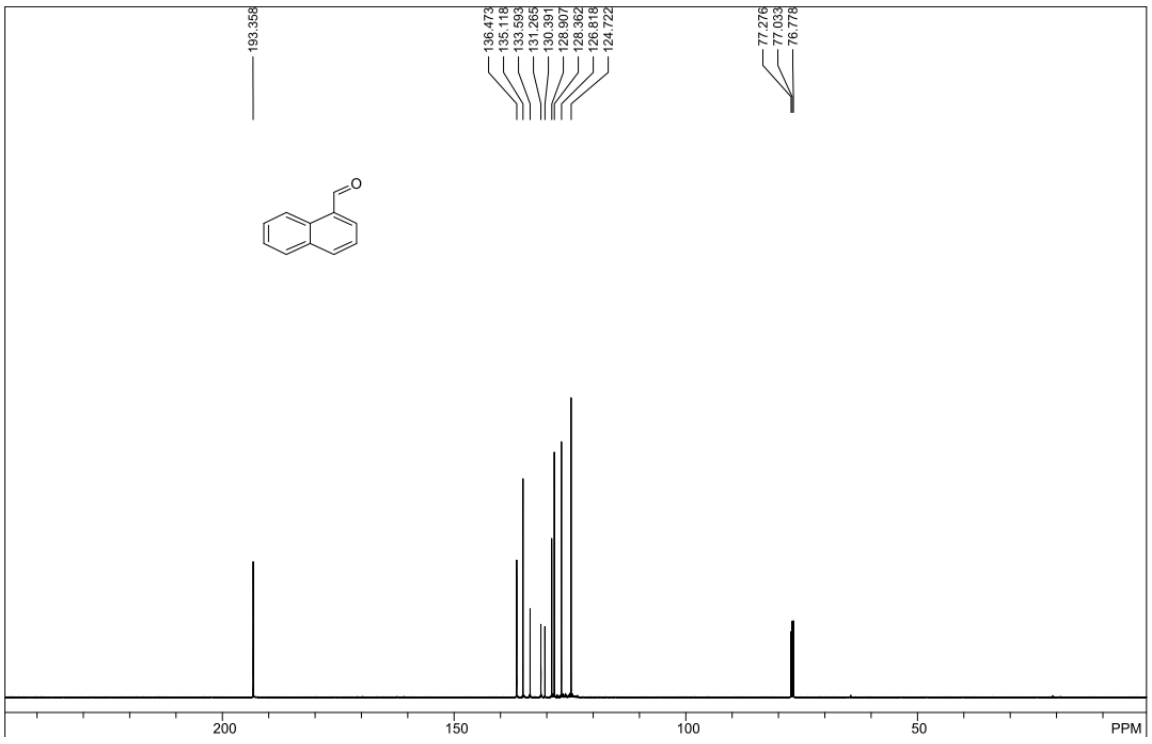
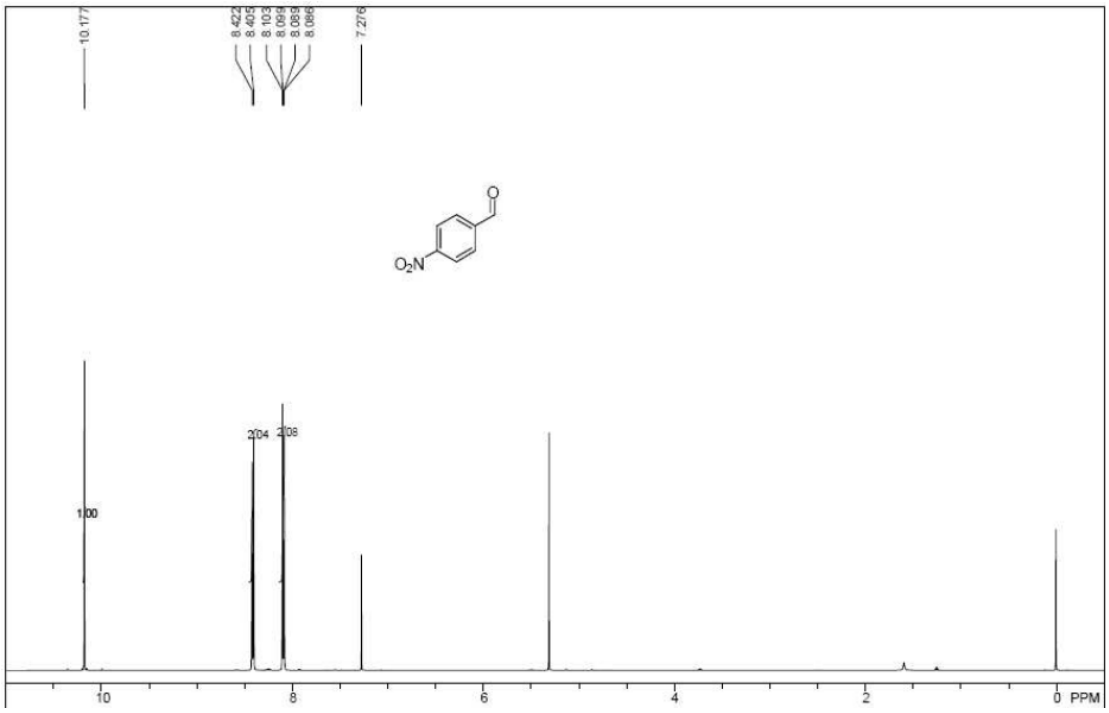


Figure 24. ^{1}H NMR and ^{13}C NMR spectra of 4-nitrobenzaldehyde.



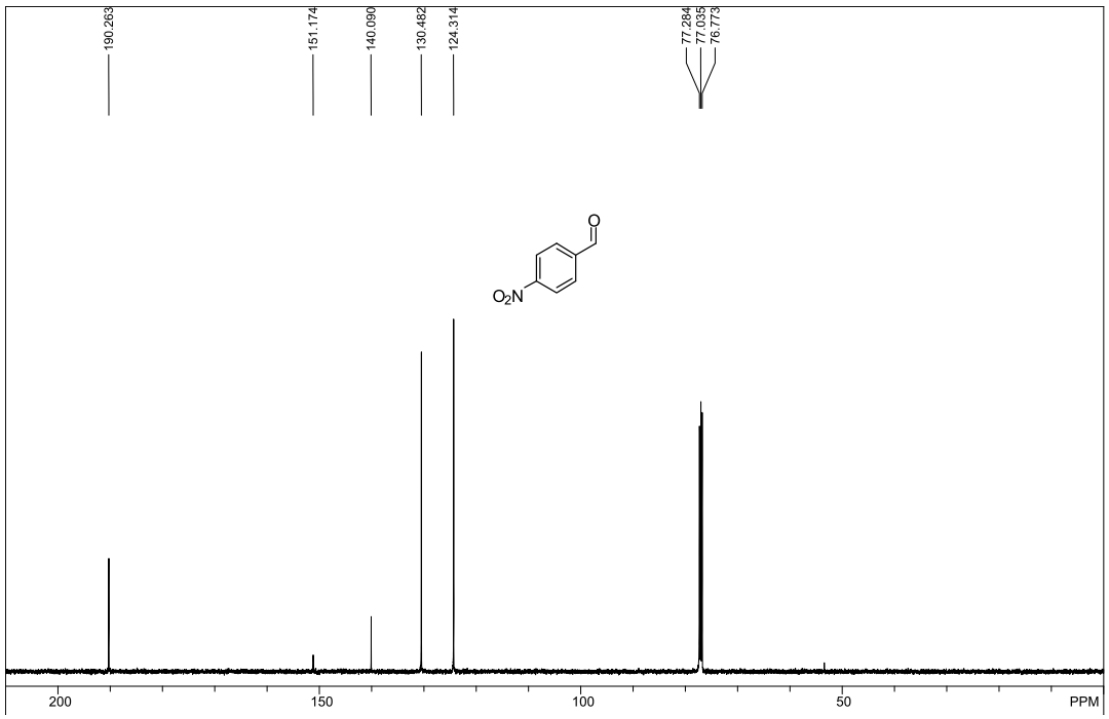


Figure 25. ^{1}H NMR and ^{13}C NMR spectra of 4-fluorobenzaldehyde.

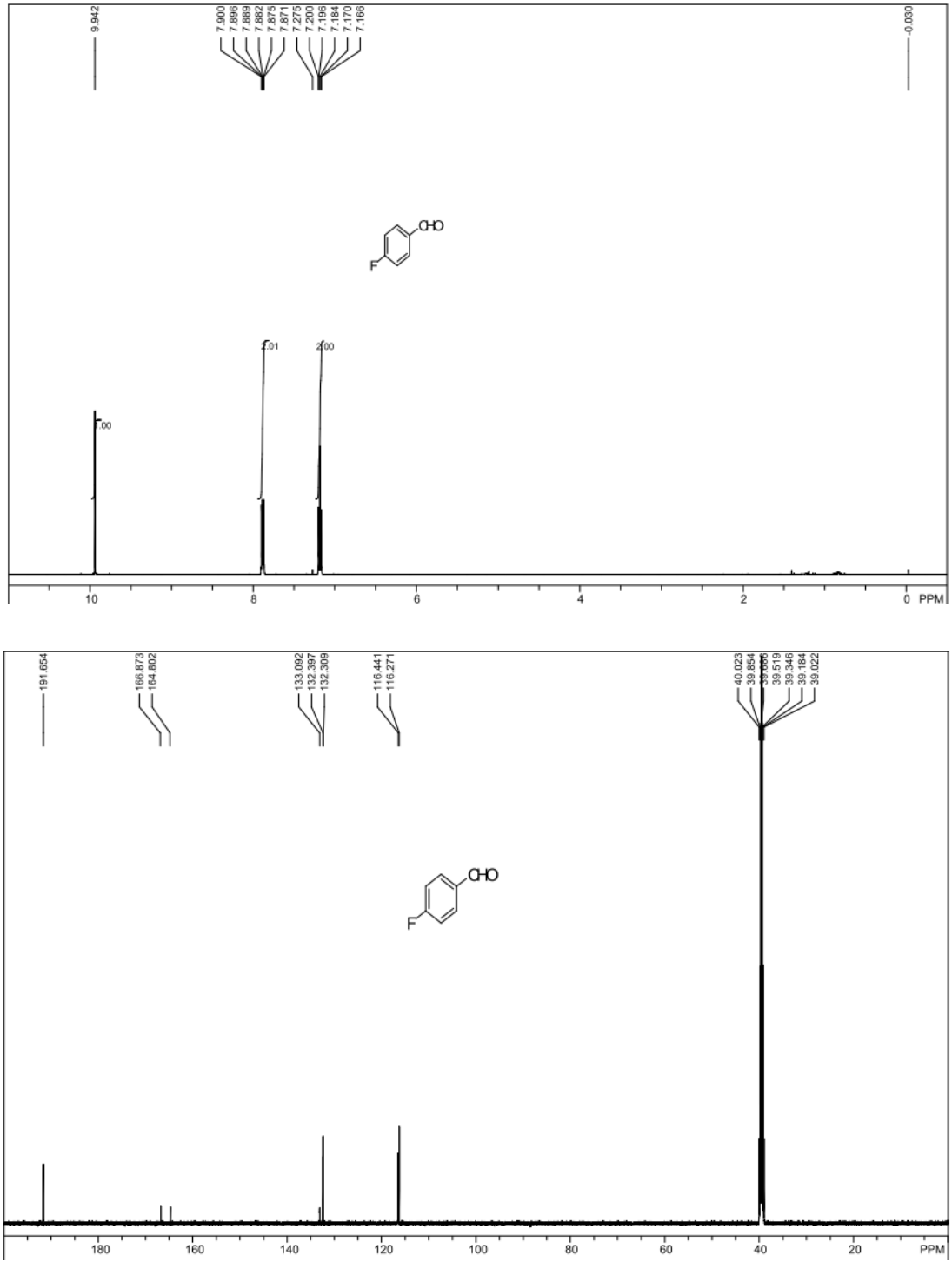
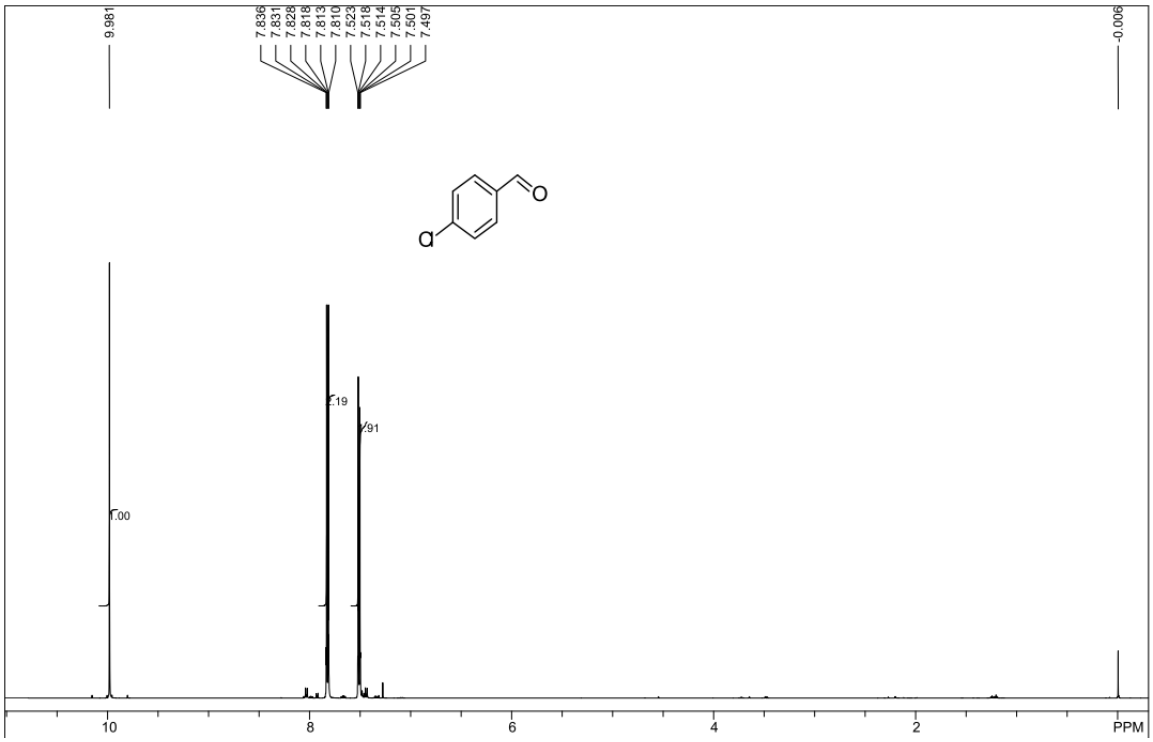


Figure 26. ^{1}H NMR and ^{13}C NMR spectra of 4-chlorobenzaldehyde.



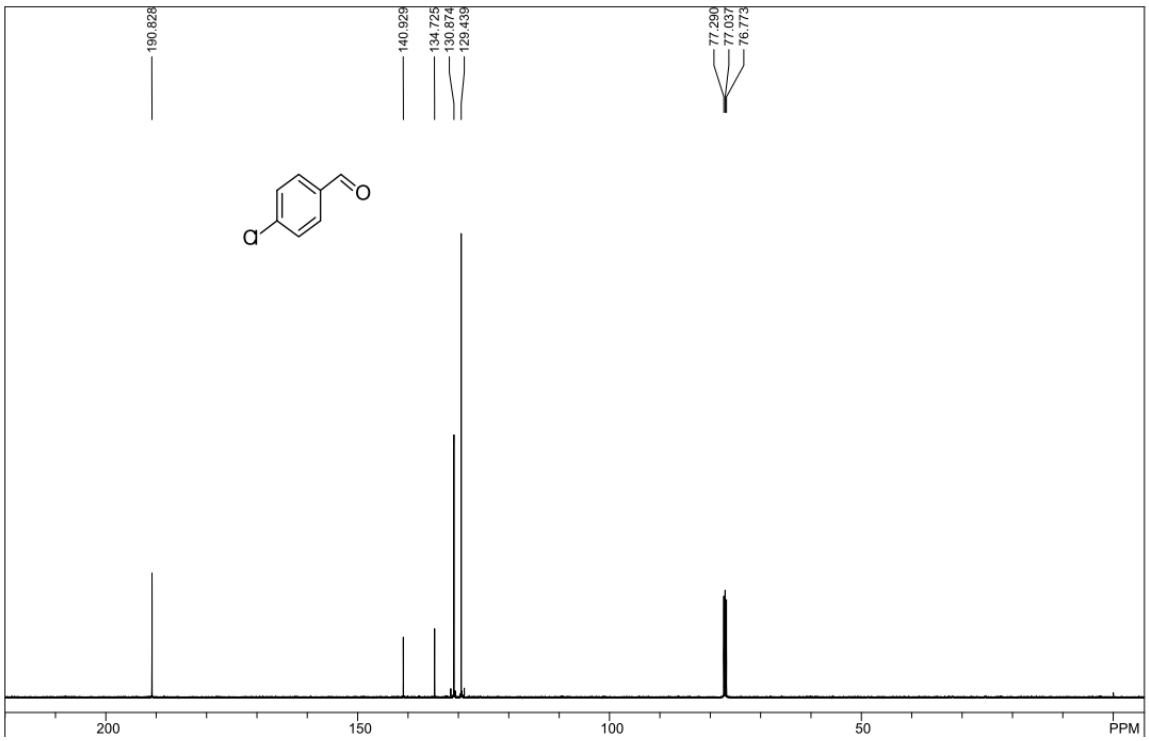
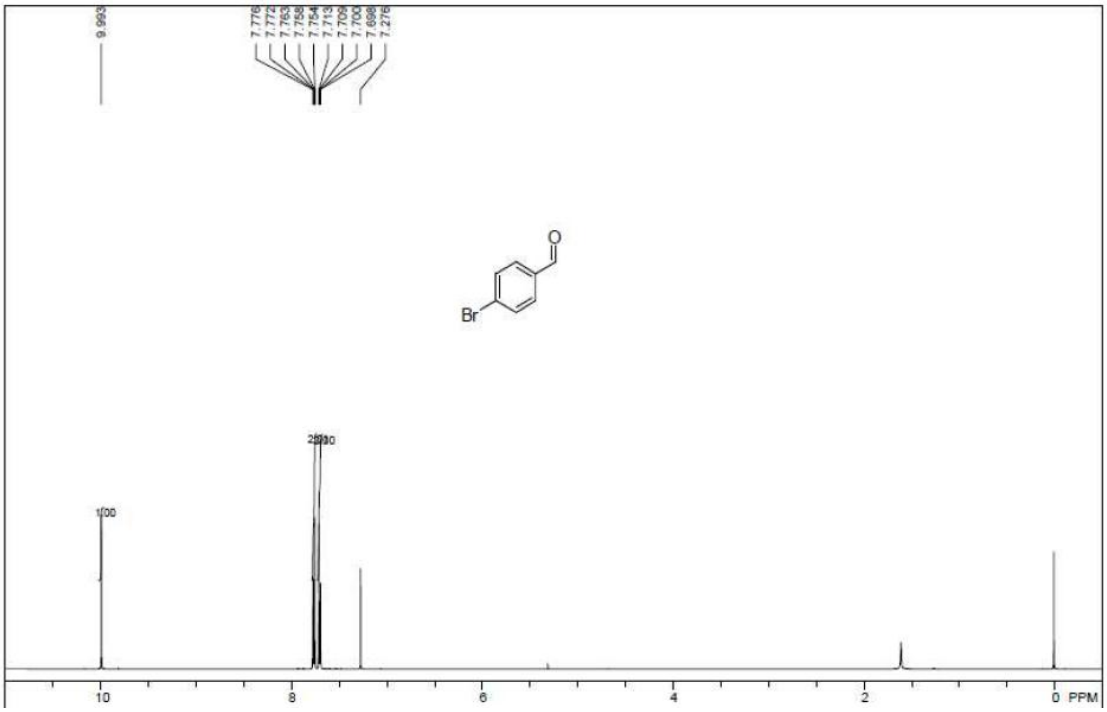


Figure 27. ^{1}H NMR and ^{13}C NMR spectra of 4-bromobenzaldehyde.



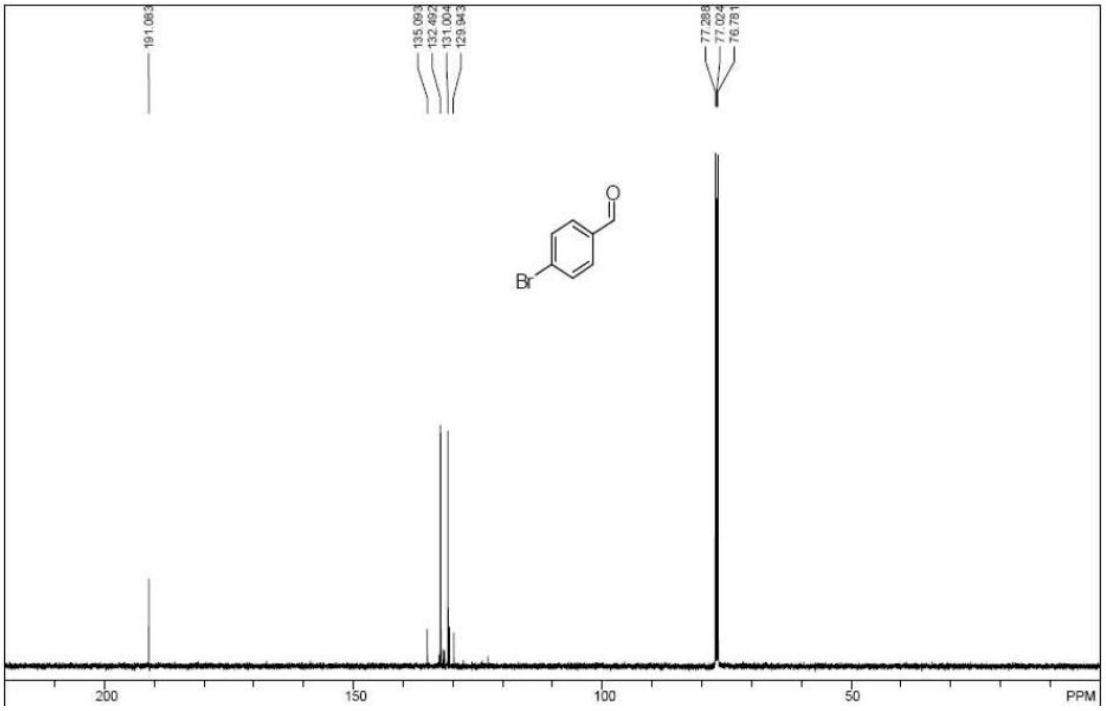
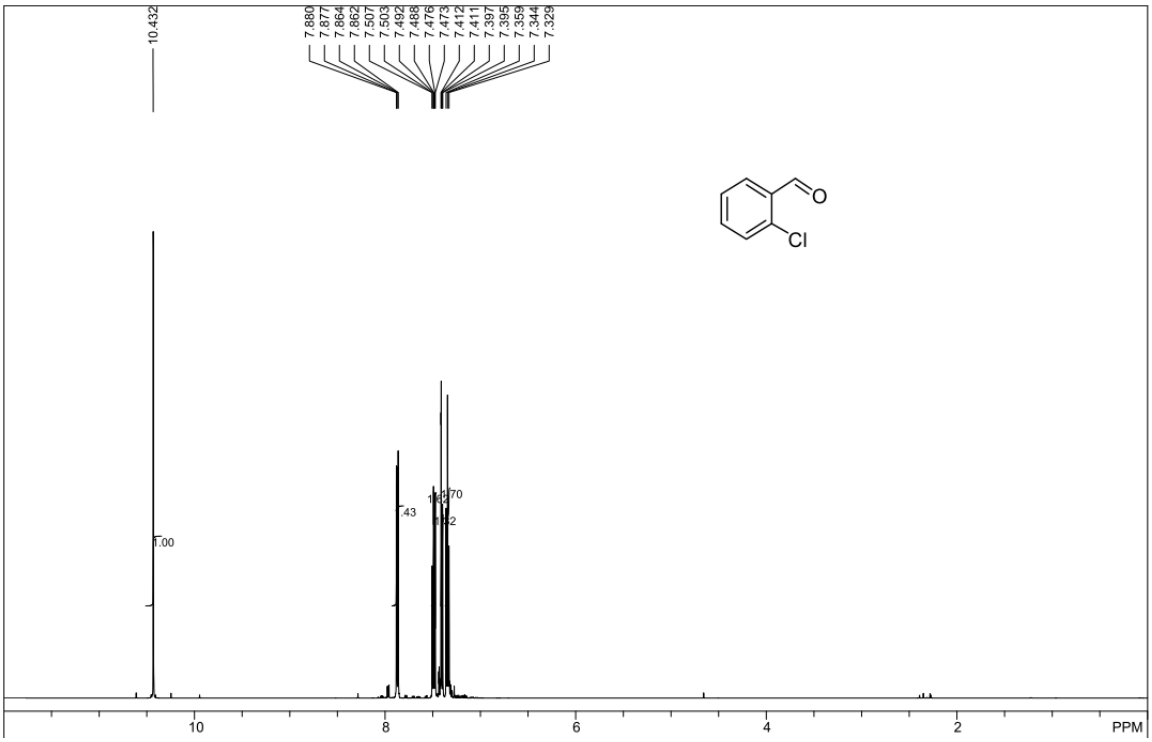


Figure 28. ^{1}H NMR and ^{13}C NMR spectra of 2-chlorobenzaldehyde



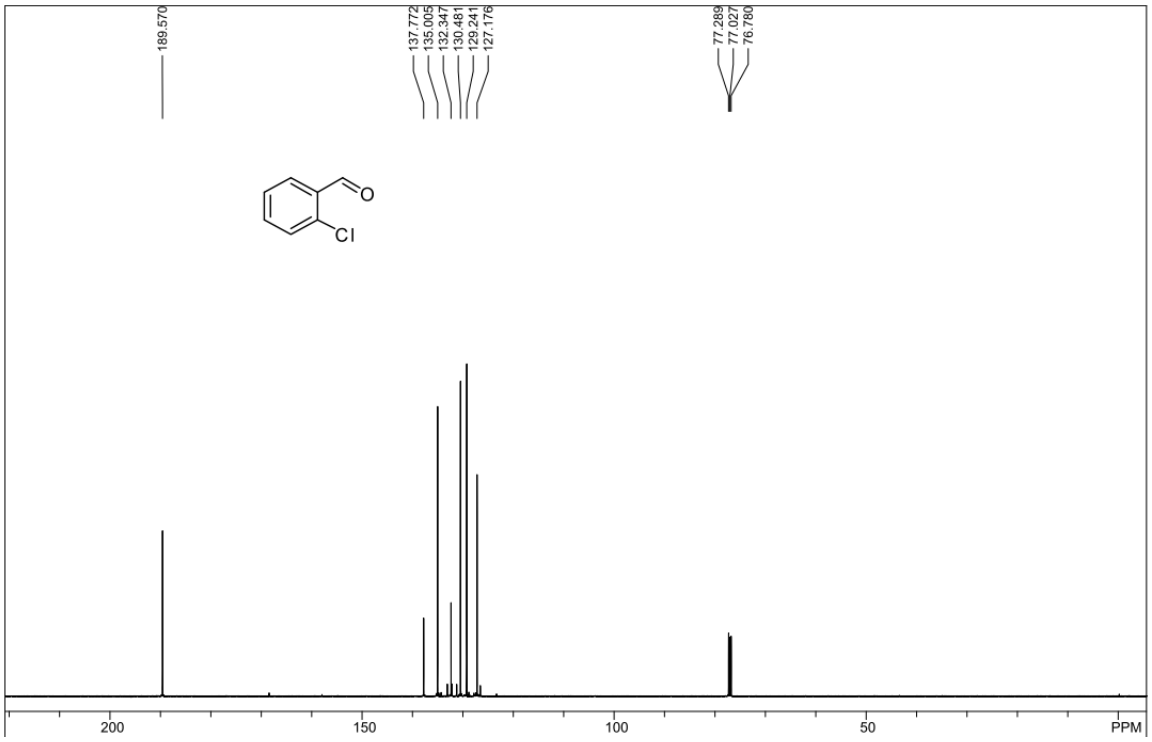
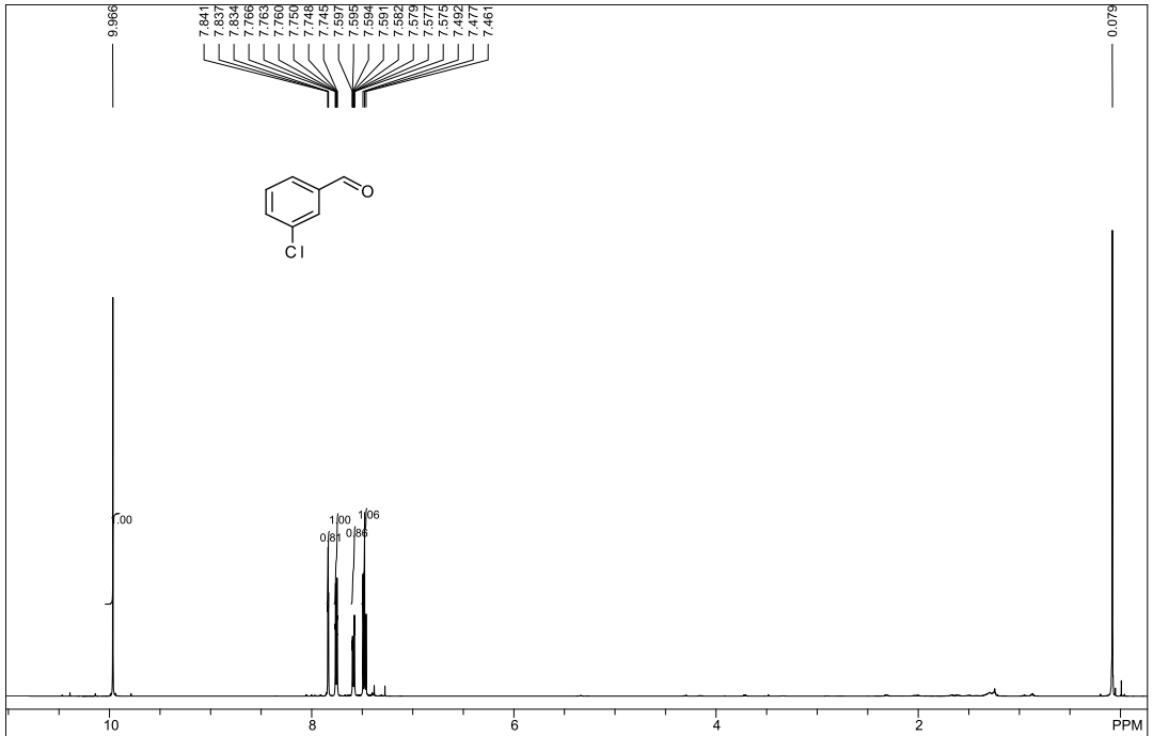


Figure 29. ^{1}H NMR and ^{13}C NMR spectra of 3-chlorobenzaldehyde



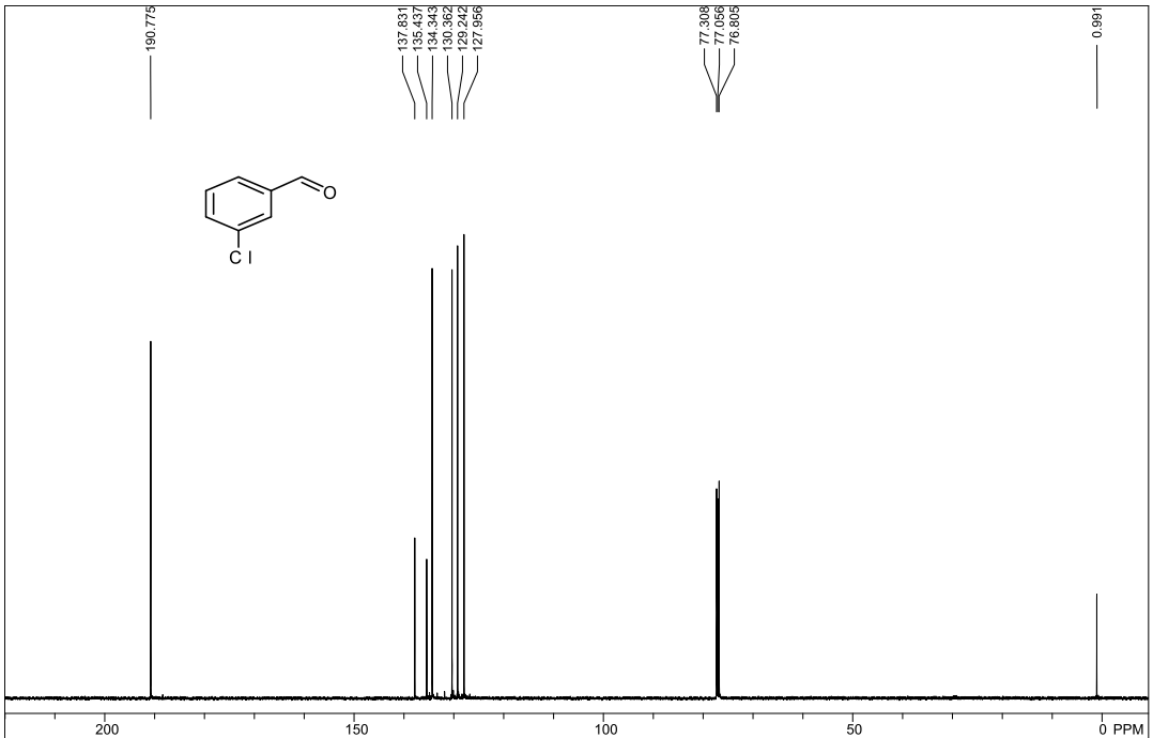
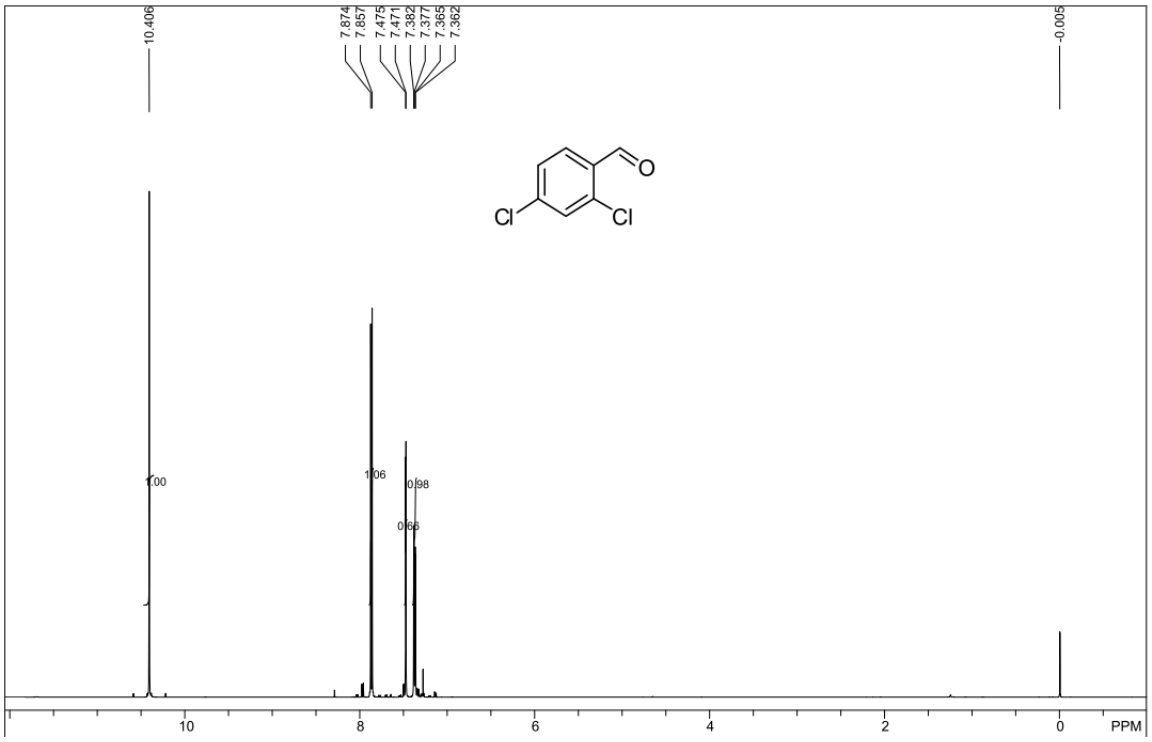


Figure 30. ^{1}H NMR and ^{13}C NMR spectra of 2,4-dichlorobenzaldehyde.



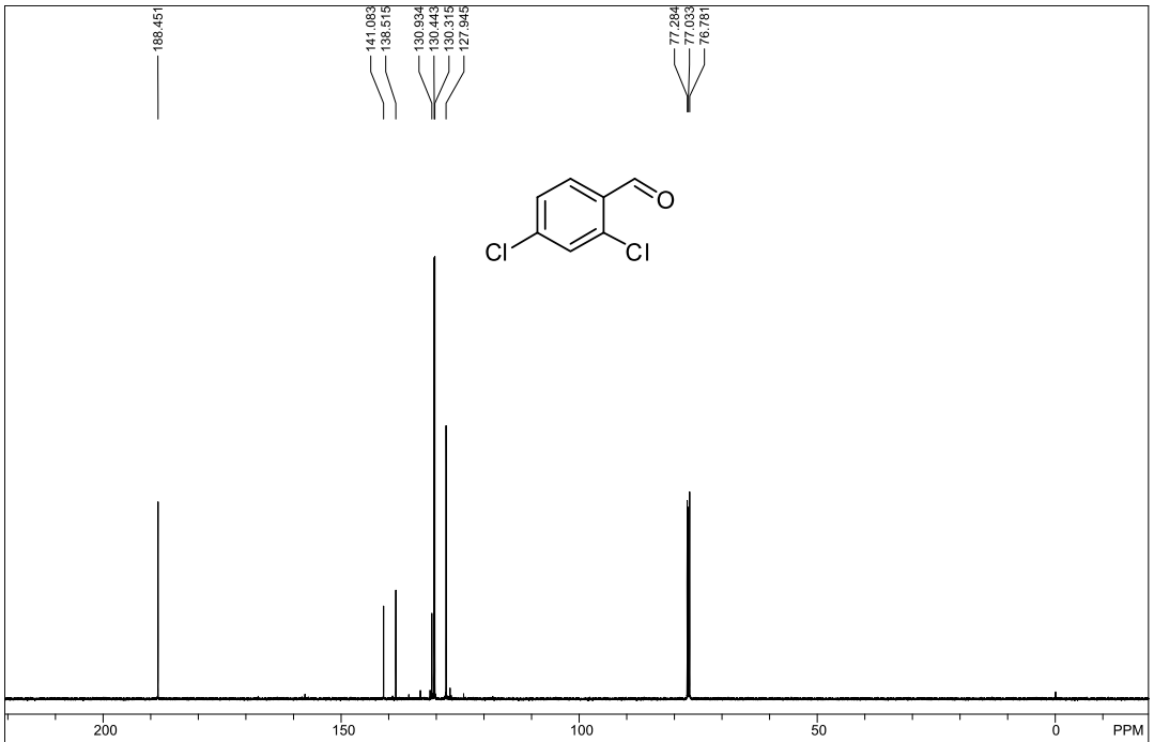
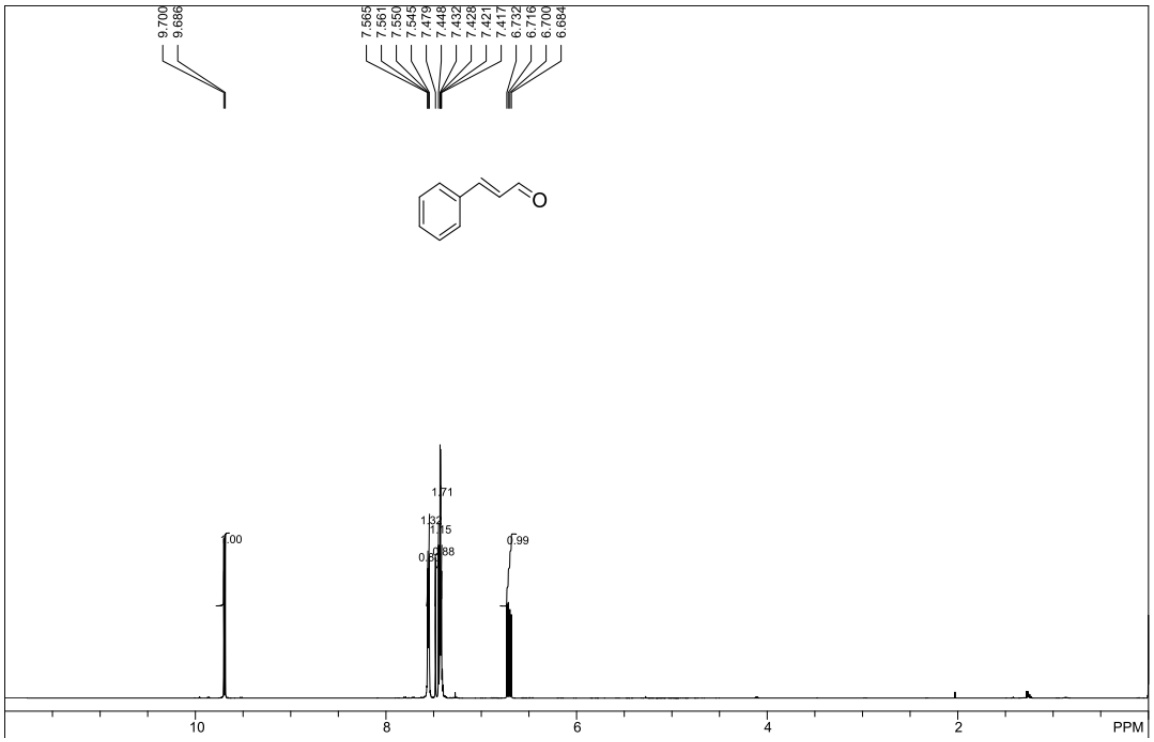


Figure 31. ^{1}H NMR and ^{13}C NMR spectra of cinnamaldehyde.



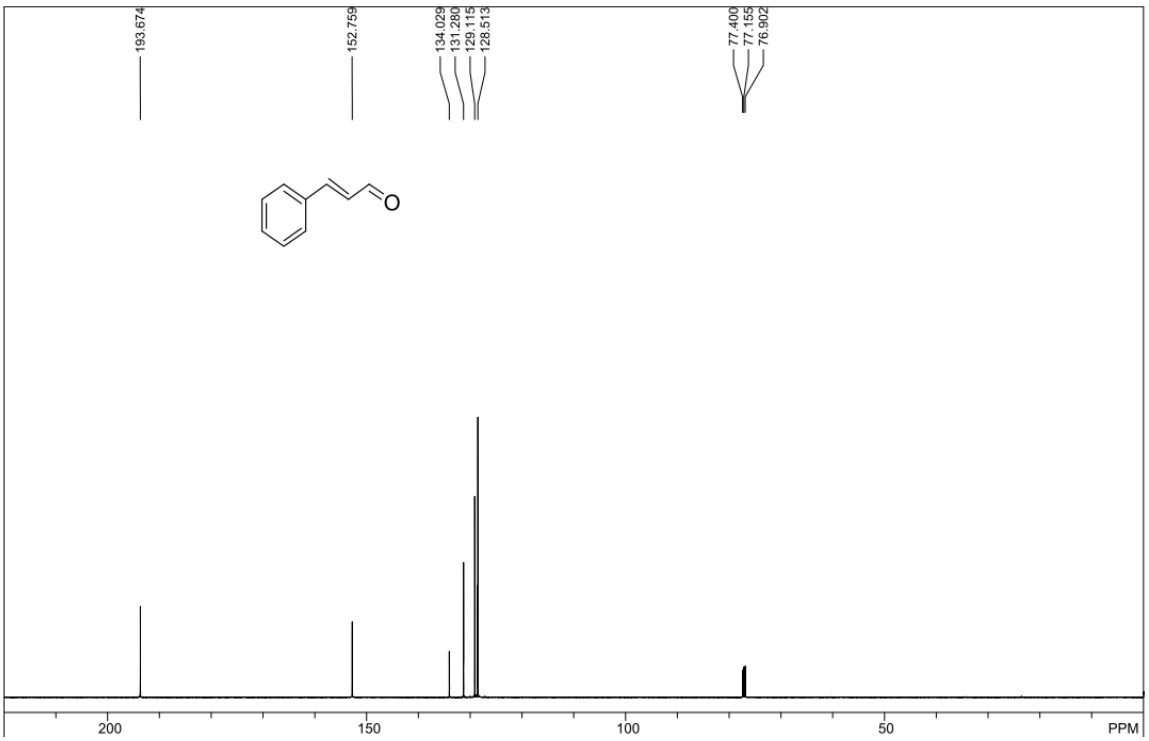
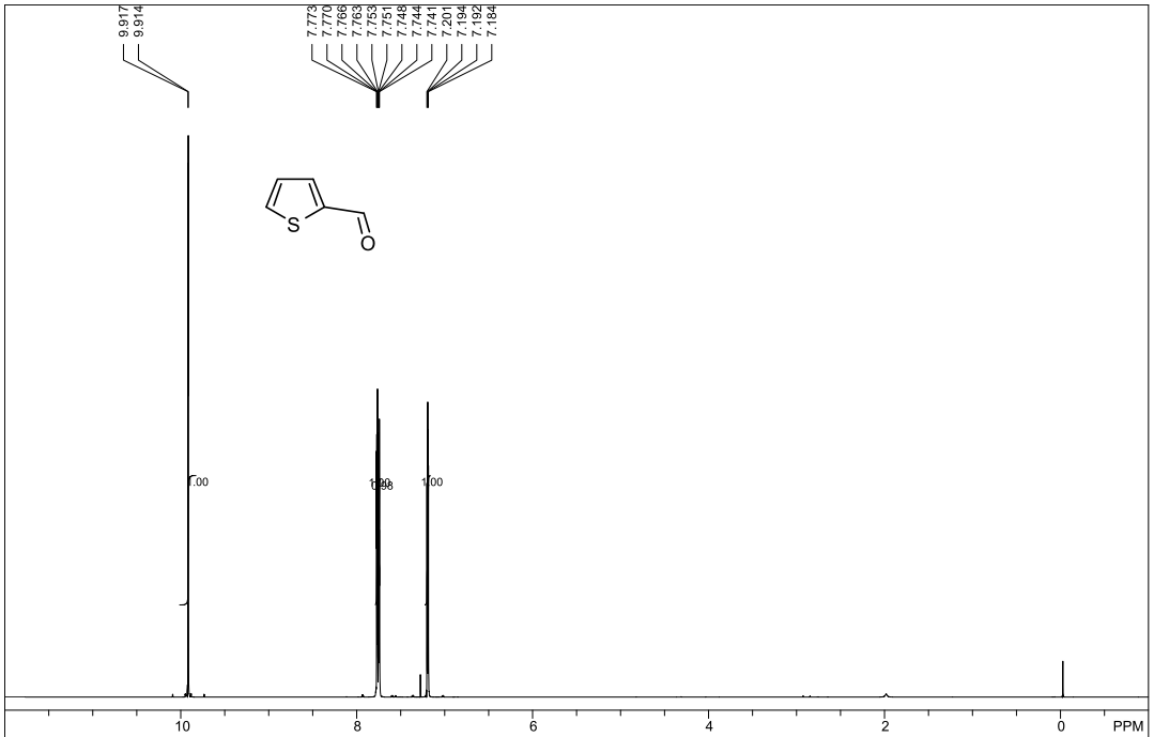


Figure 32. ^{1}H NMR and ^{13}C NMR spectra of 2-thiopheneformaldehyde.



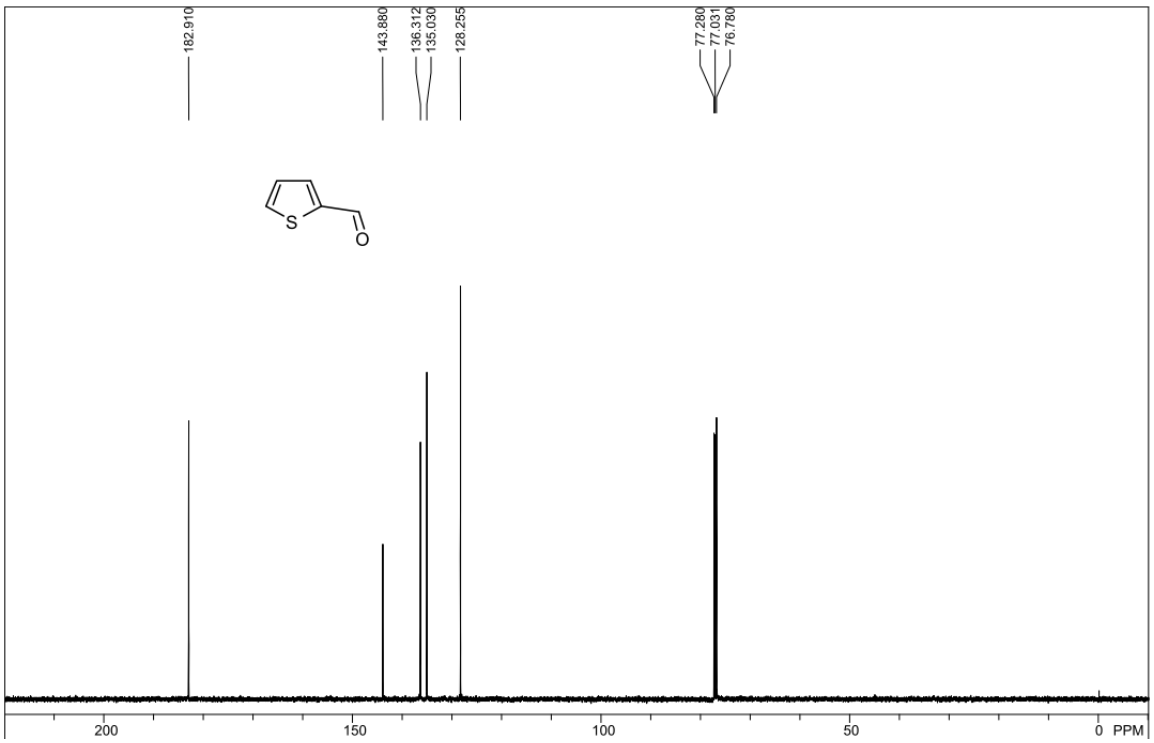
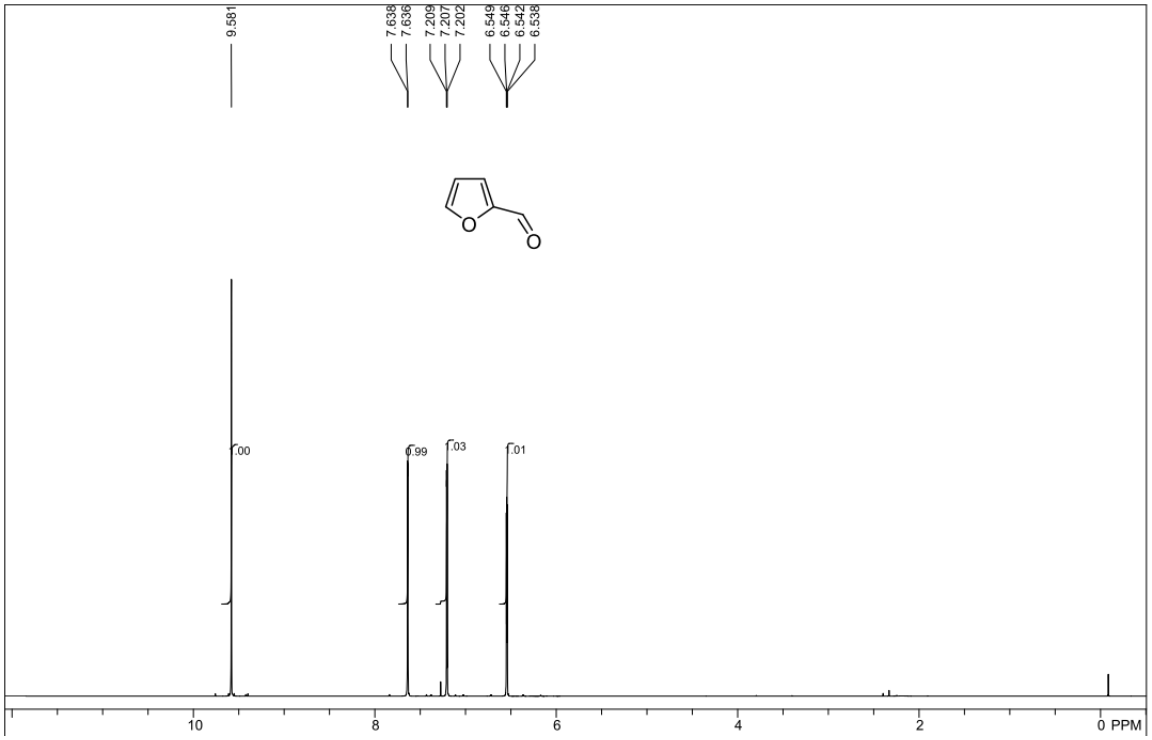


Figure 33. ^{1}H NMR and ^{13}C NMR spectra of 2-furaldehyde.



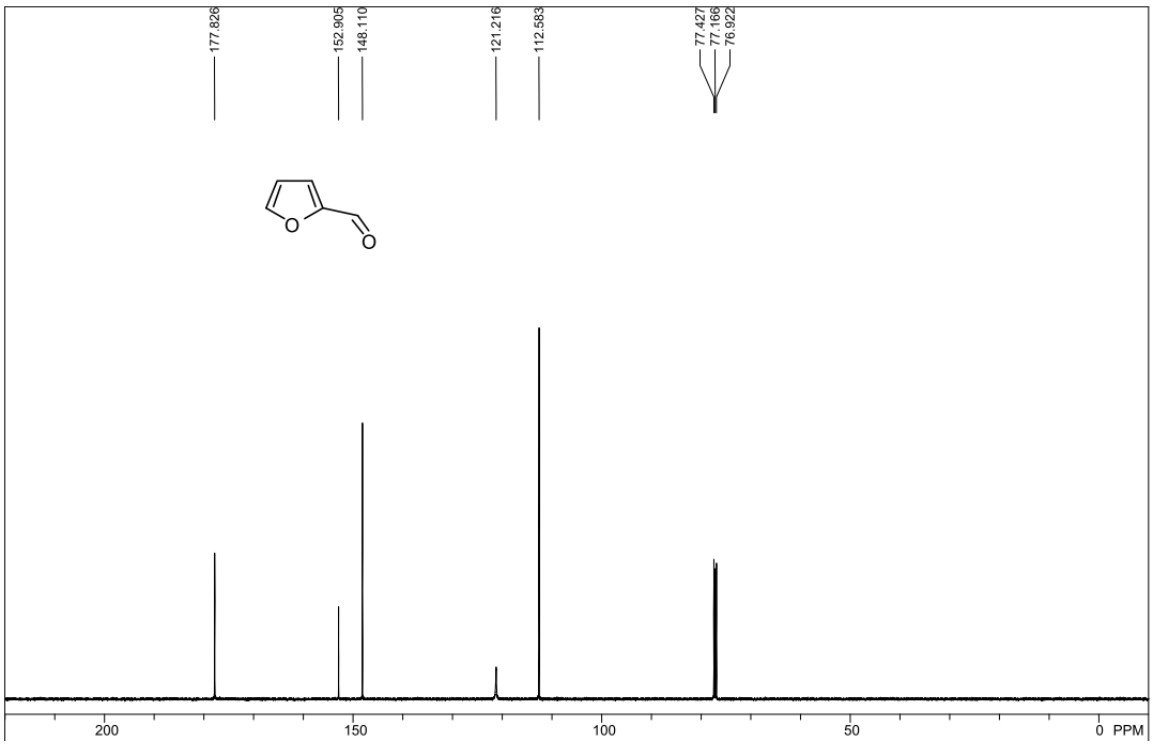


Figure 34. ^{1}H NMR and ^{13}C NMR spectra of 3-nicotinaldehyde.