

Deep eutectic solvent based on choline chloride and malonic acid as an efficient and reusable catalytic system for one-pot synthesis of functionalized pyrroles

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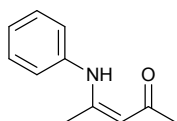
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### **(Z)-4-(Phenylamino)pent-3-en-2-one (intermediate A)**

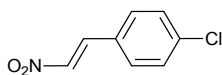
A mixture of acetylacetone (1 mmol), aniline (1 mmol) in ChCl-malonic acid (0.5 g) was stirred at 80 °C (monitored by TLC). Upon completion of the reaction, the reaction mixture was cooled to room temperature and water (5 mL) was added. The ChCl-malonic acid was dissolved in water and the products were extracted with EtOAc (3 × 5mL). The combined organic layers were dried over MgSO<sub>4</sub>, concentrated, and the resulting product was purified by column chromatography on SiO<sub>2</sub> with EtOAc-cyclohexane (2:8) to afford pure (Z)-4-(phenylamino)pent-3-en-2-one.



Yellow sticky liquid; IR (KBr): 3032, 2928, 2850, 1615, 1556, 1518, 1442, 1270, 1028 cm<sup>-1</sup>; <sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ 1.98 (s, 3H), 2.09 (s, 3H), 5.18 (s, 1H), 7.10 (d, *J* = 7.5 Hz, 2H), 7.18 (t, *J* = 7.5 Hz, 1H), 7.35 (t, *J* = 8.0 Hz, 2H), 12.46 (s, 1H) ppm; <sup>13</sup>C NMR (CDCl<sub>3</sub>, 125MHz) δ 19.8, 29.1, 97.6, 124.7, 125.5, 129.0, 138.7, 160.2, 196.1 ppm; Anal. Calcd for C<sub>11</sub>H<sub>13</sub>NO: C, 75.40; H, 7.48; N, 7.99; Found: C, 75.24; H, 7.38; N, 7.88; ESI-MS: *m/z* = 176 (M+1)<sup>+</sup>.

### **(E)-1-Chloro-4-(2-nitrovinyl)benzene (intermediate B)**

4-Chlorobenzaldehyde (6.2 mmol) was heated with ammonium acetate (1.2 g, 15.6 mmol) in a mixture of nitromethane (0.85 ml, 15.7 mmol) and glacial acetic acid (5.2 ml) at 100 °C. Upon completion of the reaction, the solvent was removed under reduced pressure leaving a brown residue which was extracted by addition of water (30 ml) and dichloromethane (2 × 30 ml). The combined organic layers were dried over MgSO<sub>4</sub>, concentrated, and pure products were obtained by column chromatography on silica gel using ethyl acetate/hexane as the eluent.



Yellow solid, mp 111-112 °C; IR (KBr): 3030, 1638, 1518, 1340, 1259 cm<sup>-1</sup>; <sup>1</sup>H NMR (CDCl<sub>3</sub>, 500 MHz) δ 7.43 (d, *J* = 8.5 Hz, 2H), 7.49 (d, *J* = 8.5 Hz, 2H), 7.55 (d, *J* = 13.5 Hz, 1H), 7.96 (d, *J* = 13.5 Hz, 1H) ppm; <sup>13</sup>C NMR (CDCl<sub>3</sub>, 125MHz) δ 128.5, 129.7, 130.3, 137.4,

137.7, 138.3 ppm; Calcd for C<sub>8</sub>H<sub>6</sub>ClNO<sub>2</sub>: C, 52.34; H, 3.29; N, 7.63; Found: C, 52.26; H, 3.20; N, 7.49; ESI-MS: m/z =184 (M+1)<sup>+</sup>.

## Crystallographic data

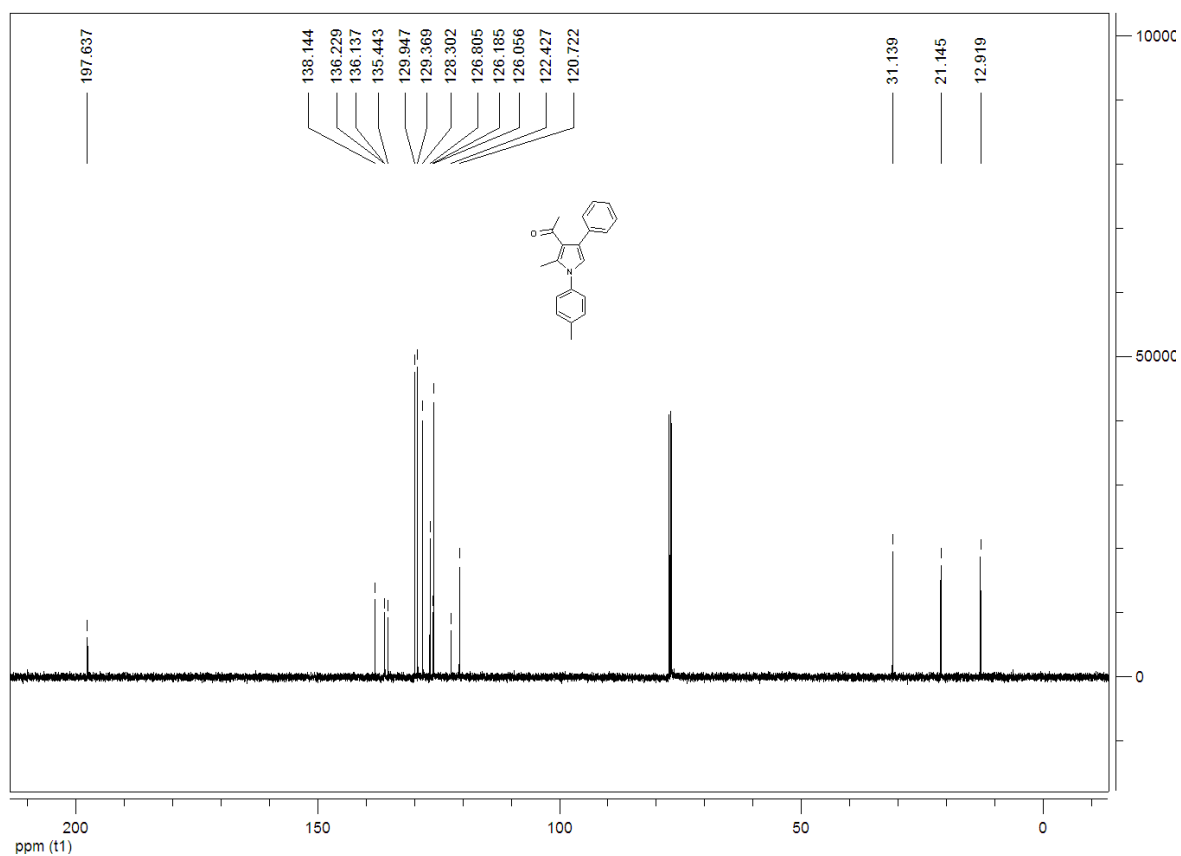
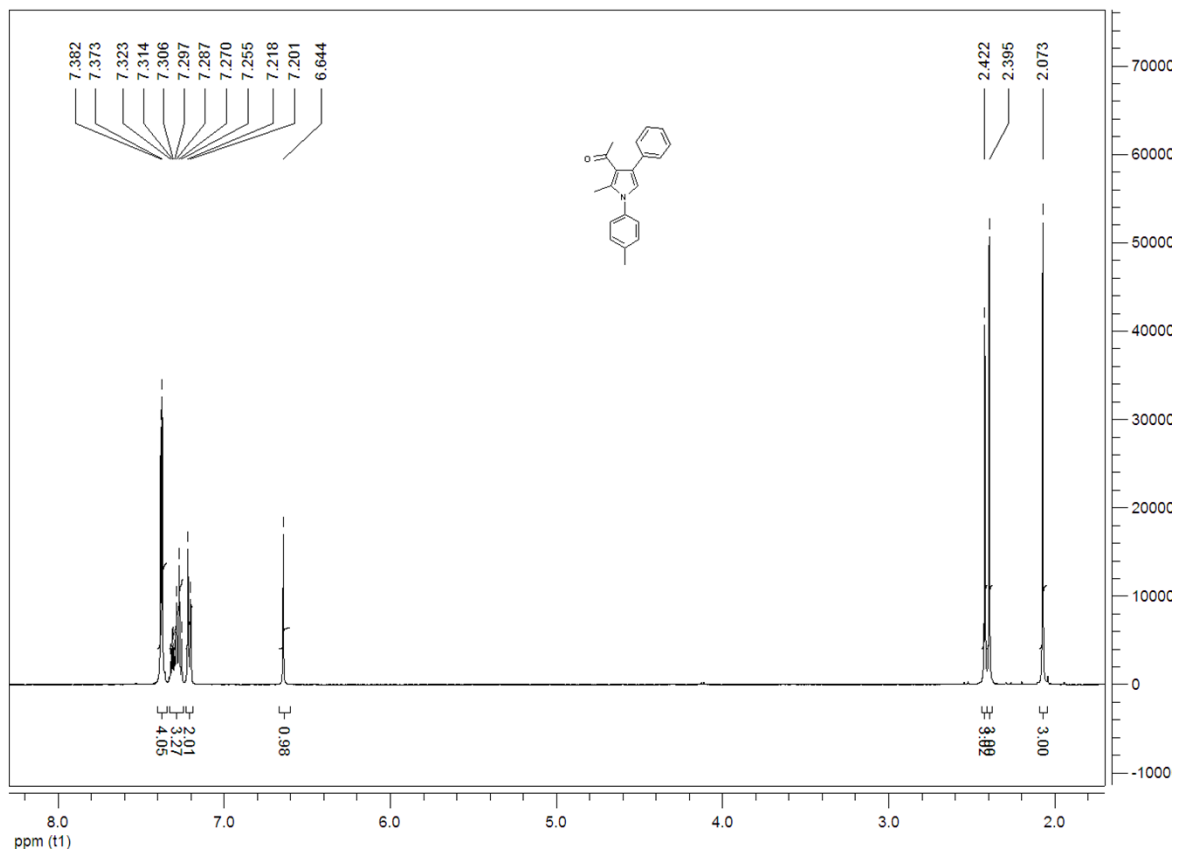
The product **5c** was crystallized by slow evaporation from ethyl acetate and hexane. The data were collected at room temperature with a Bruker Smart Apex CCD diffractometer with Mo Ka monochromated radiation ( $k = 0.71703 \text{ \AA}$ ). Routine Lorentz and polarization corrections were applied. The structure was solved by direct methods and refined by the full-matrix least-squares methods on F2 using the SHELXTL crystallographic software package.

Crystal data for **5c**:

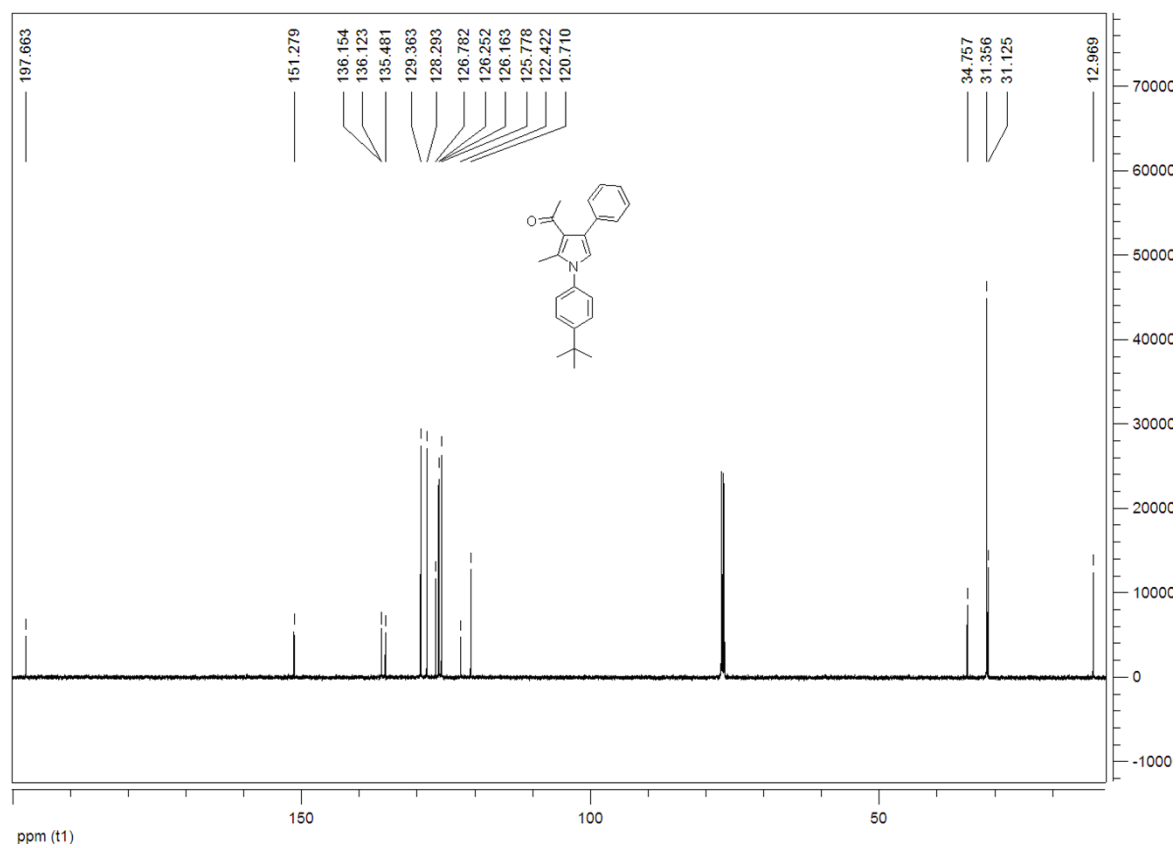
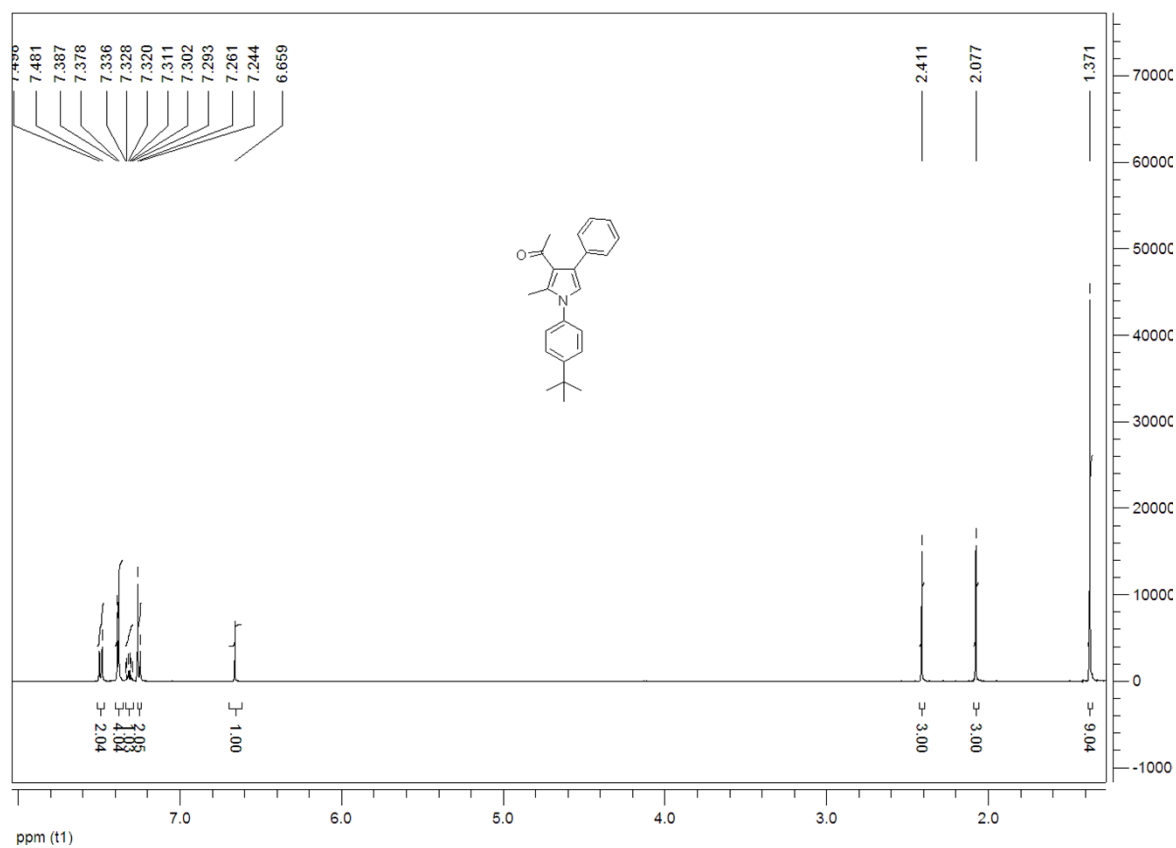
Empirical formula	C23H25NO
Formula weight	331.44
Wavelength	0.71073 A
Crystal system,	Monoclinic
Space group	P2(1)/c
a (Å)	10.7809(8)
b (Å)	16.0045(12)
c (Å)	11.2190(8)
$\alpha$ (°)	90
$\beta$ (°)	92.3110(10)
$\gamma$ (°)	90
Volume (Å <sup>3</sup> )	1934.2(2) A <sup>3</sup>
Z	4
Absorption coefficient (mm <sup>-1</sup> )	0.069
F(000)	712
Reflections collected	9650 [R(int) = 0.0258]
Completeness to theta = 25.02	99.9 %
Gof	1.023
Final R indices [I>2sigma(I)]	R <sub>1</sub> = 0.0523, wR <sub>2</sub> = 0.1430
R indices (all data)	R <sub>1</sub> = 0.0598, wR <sub>2</sub> = 0.1506
Extinction coefficient	0.043(4)



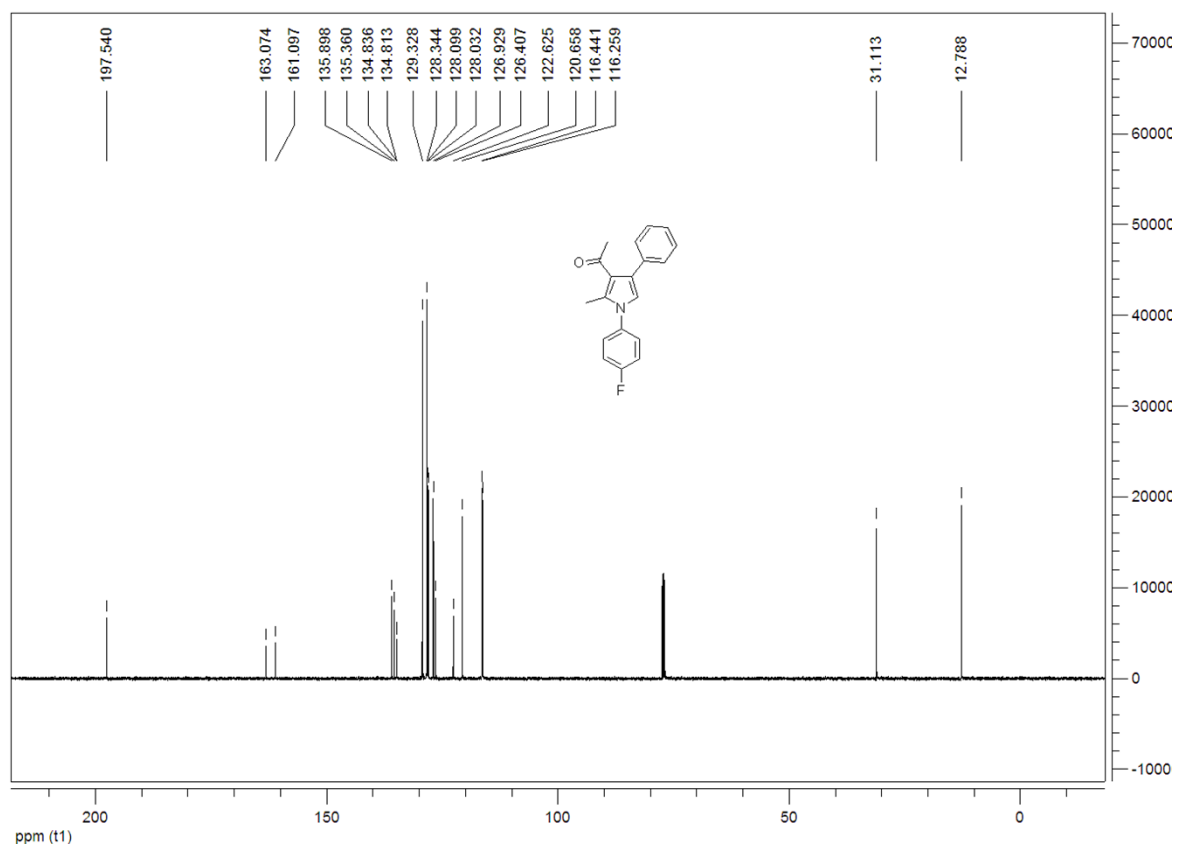
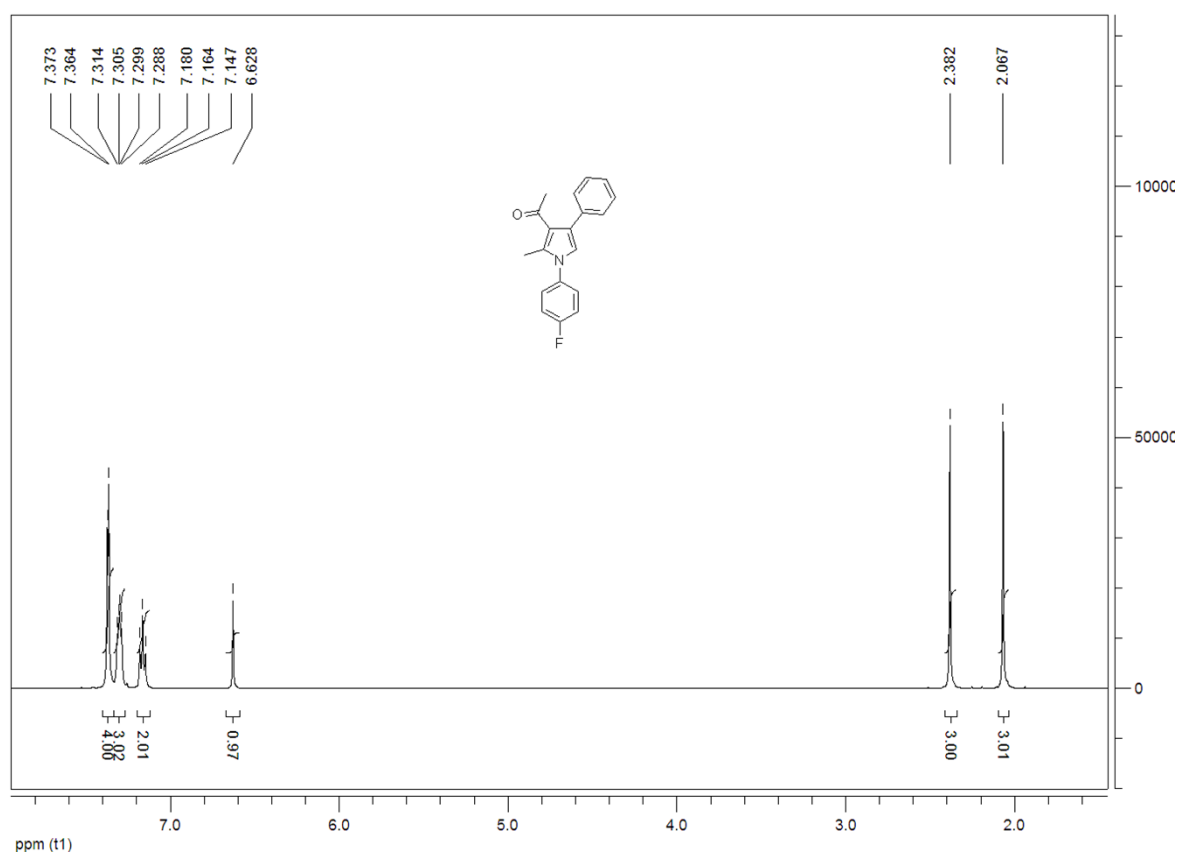
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5b**



# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5c**

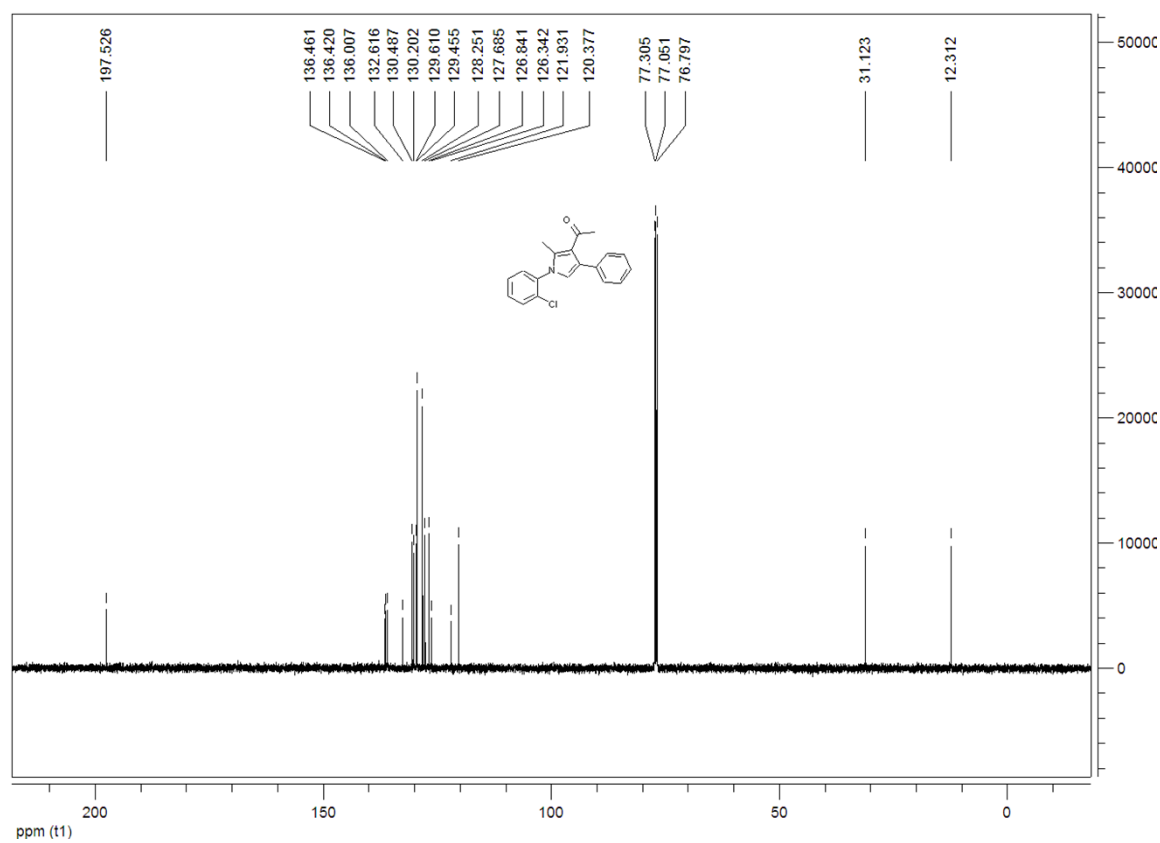
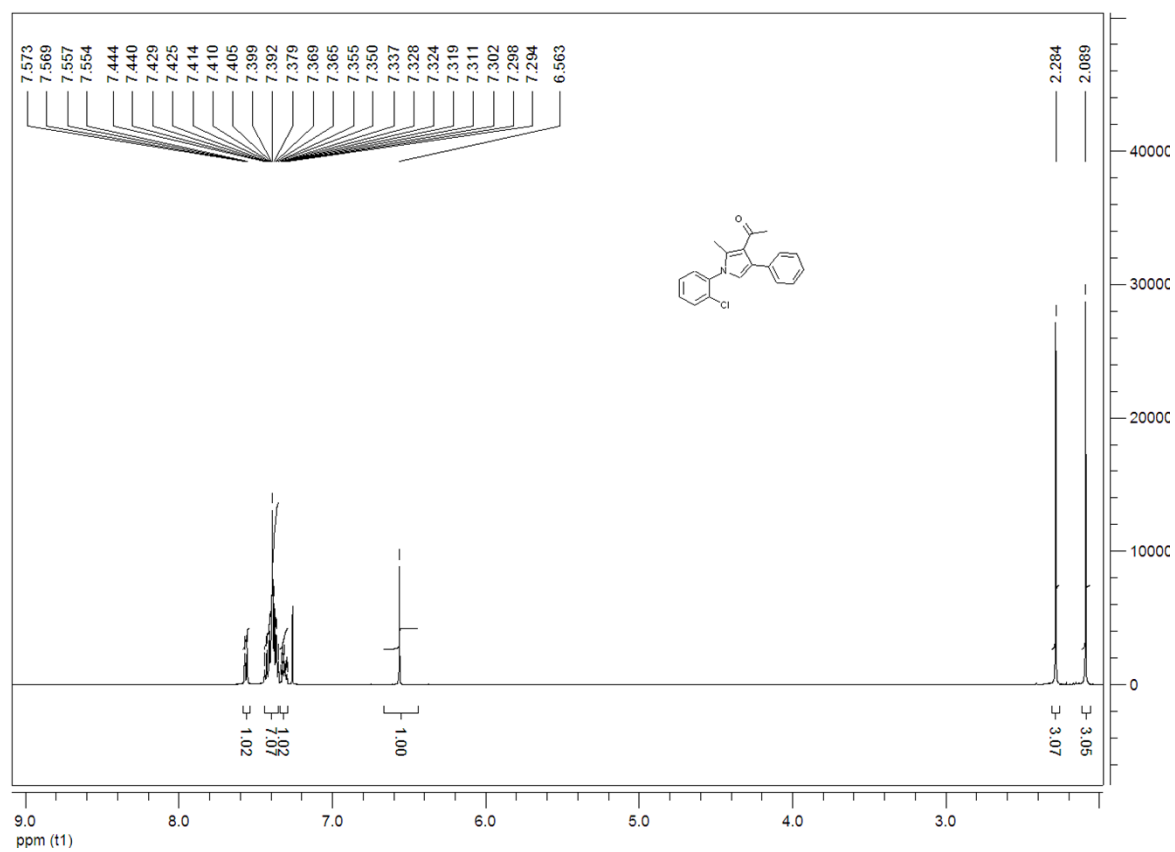


$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5d**

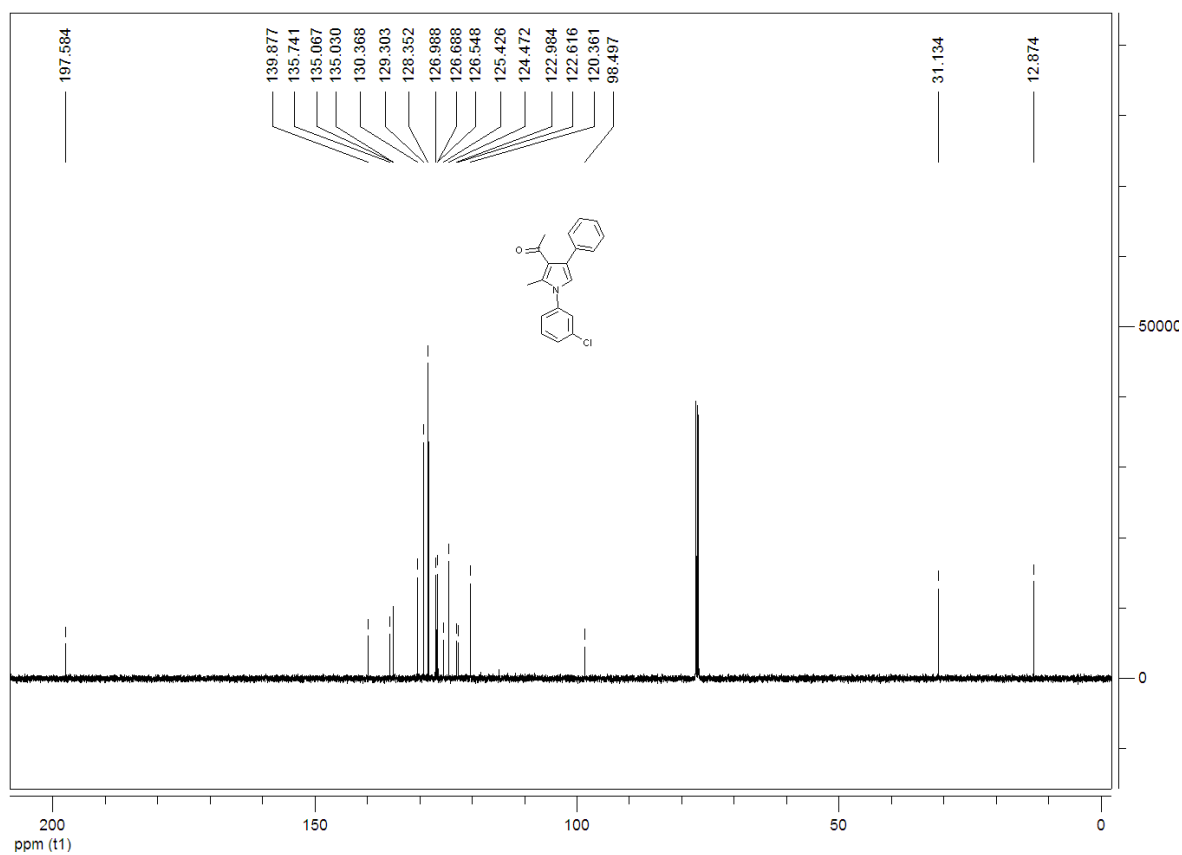
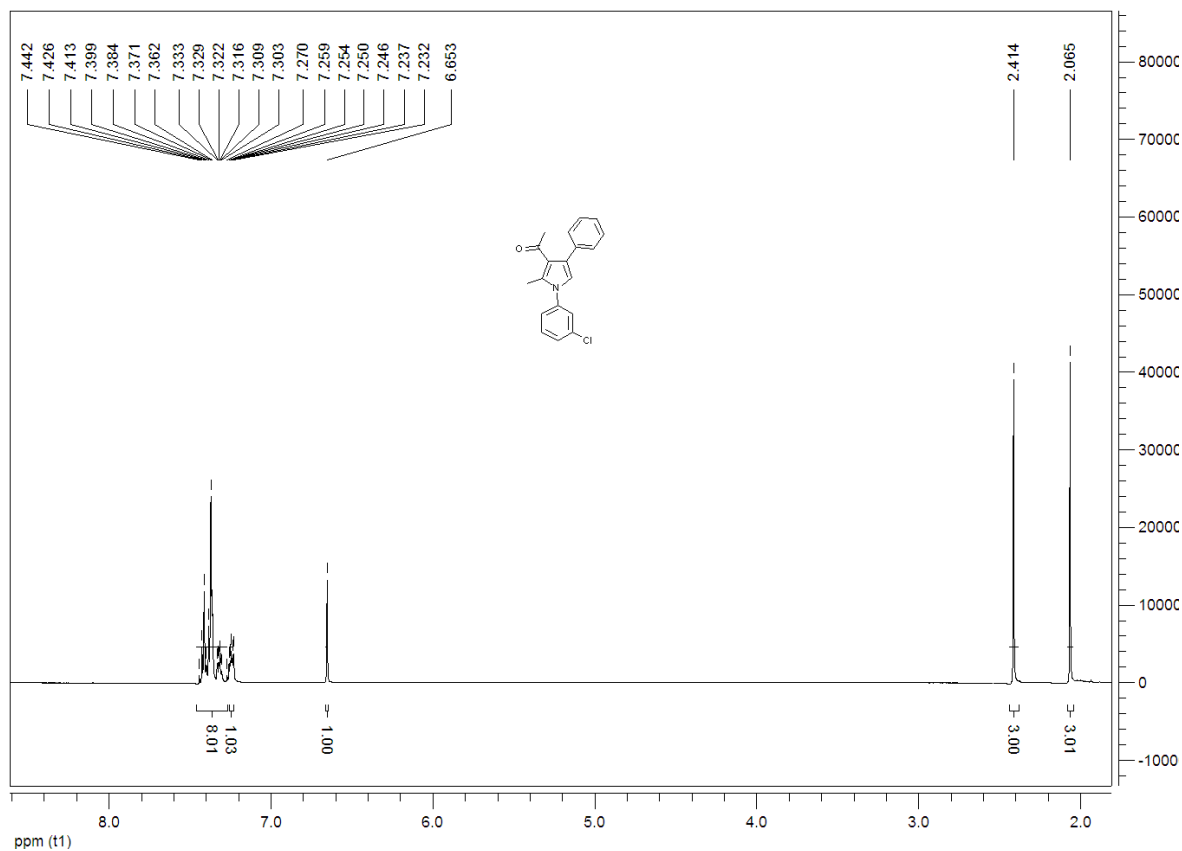




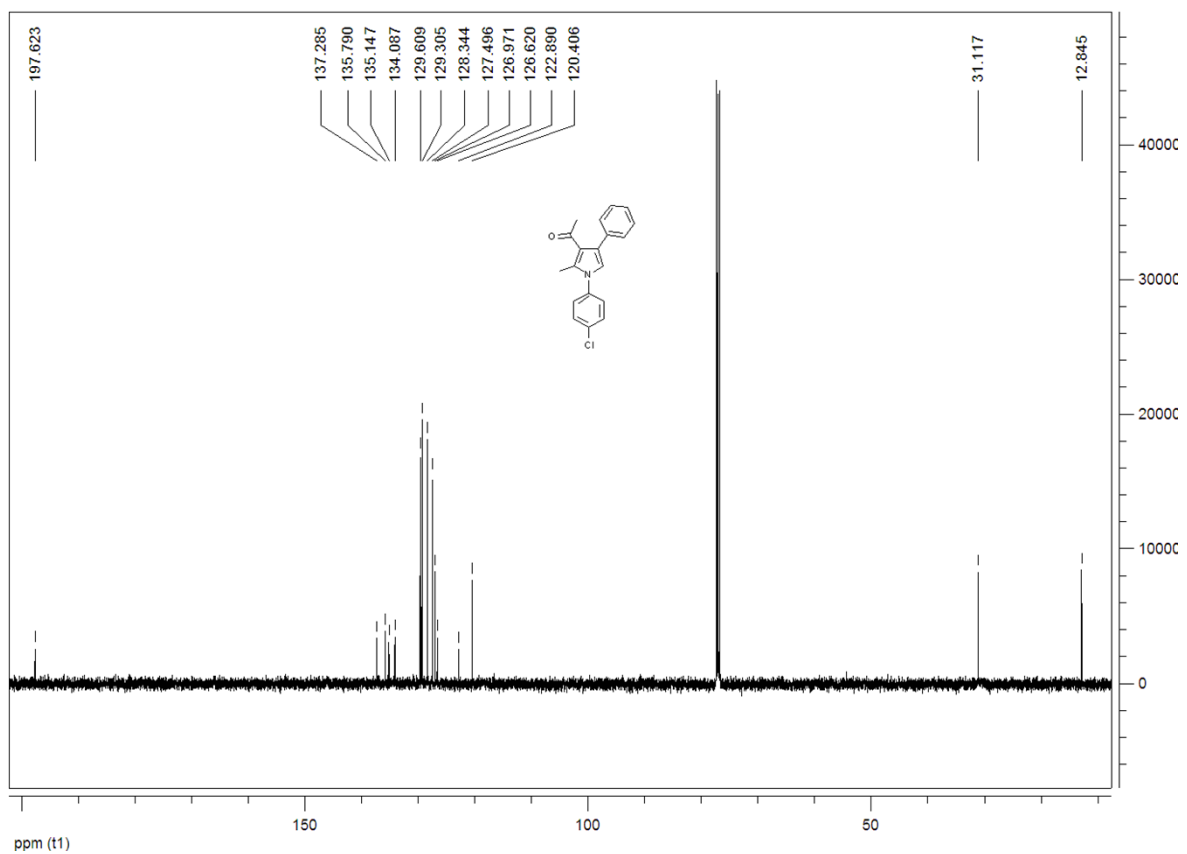
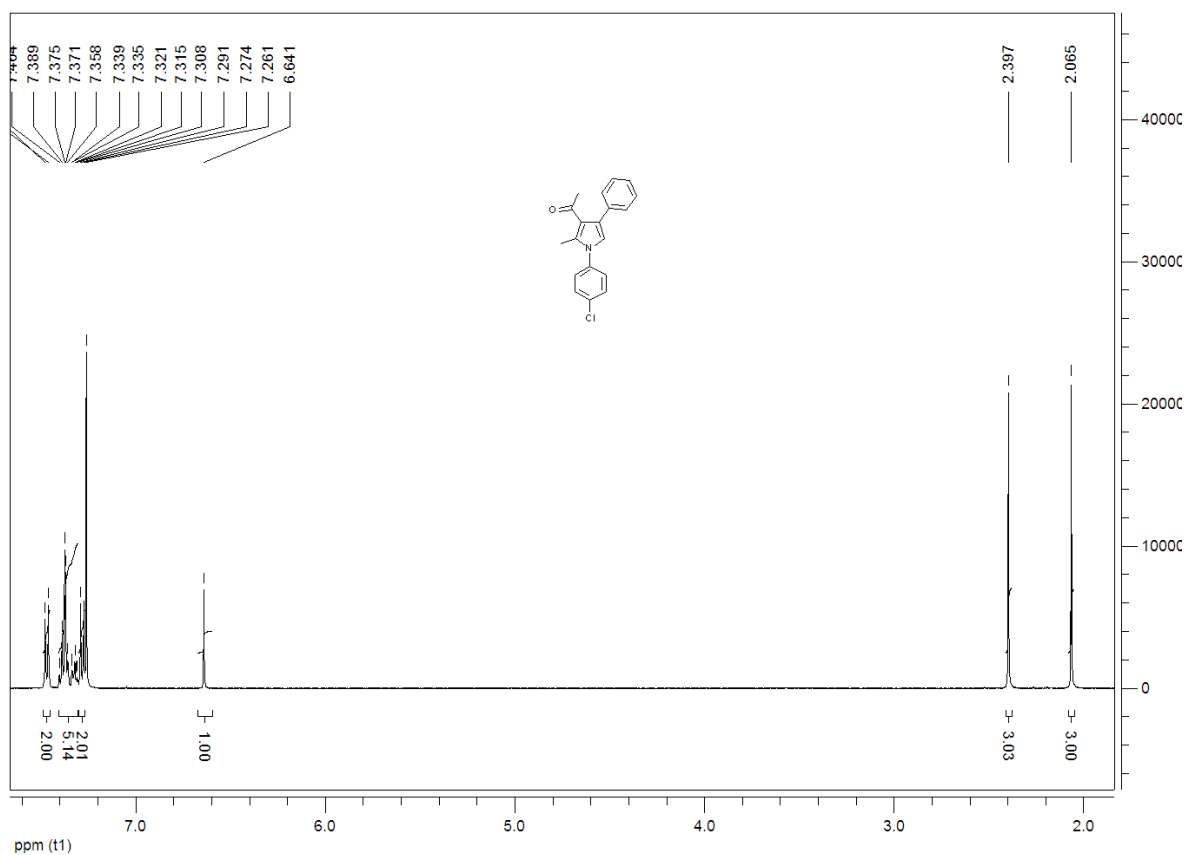
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5e**



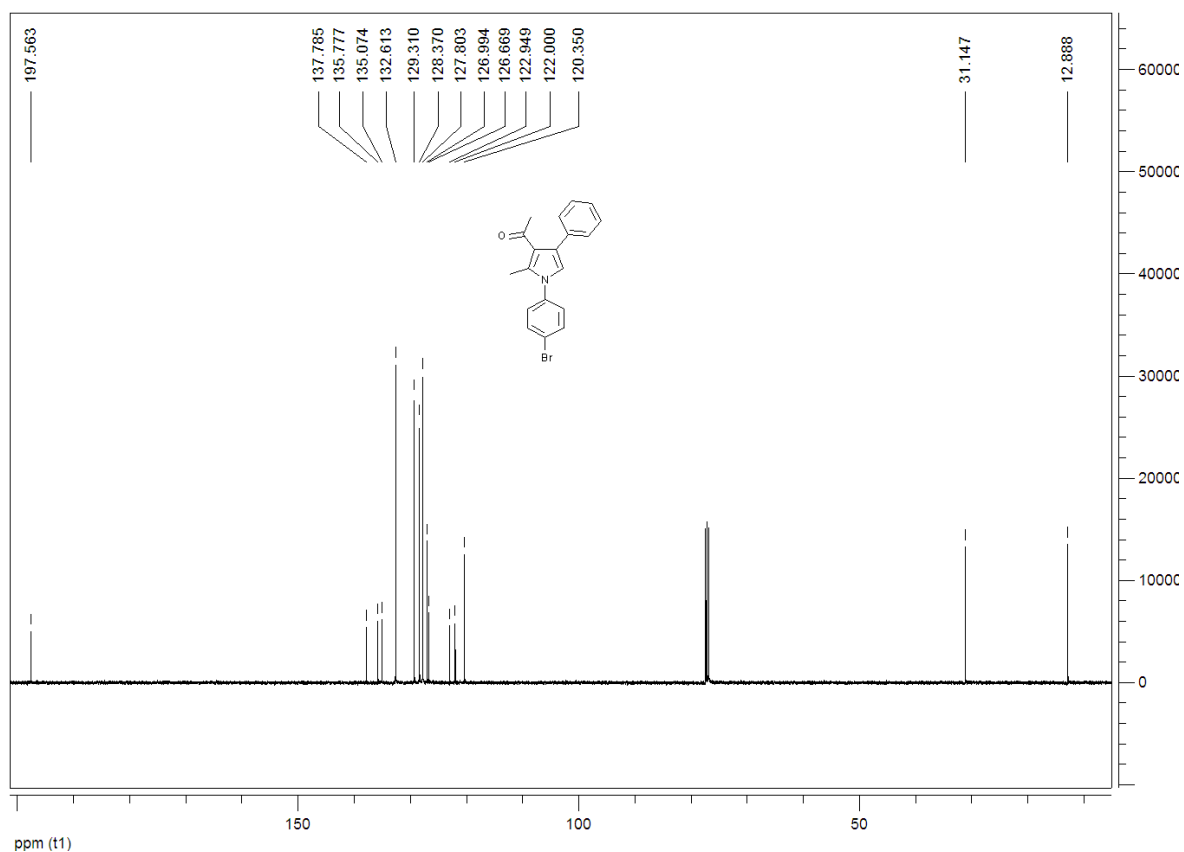
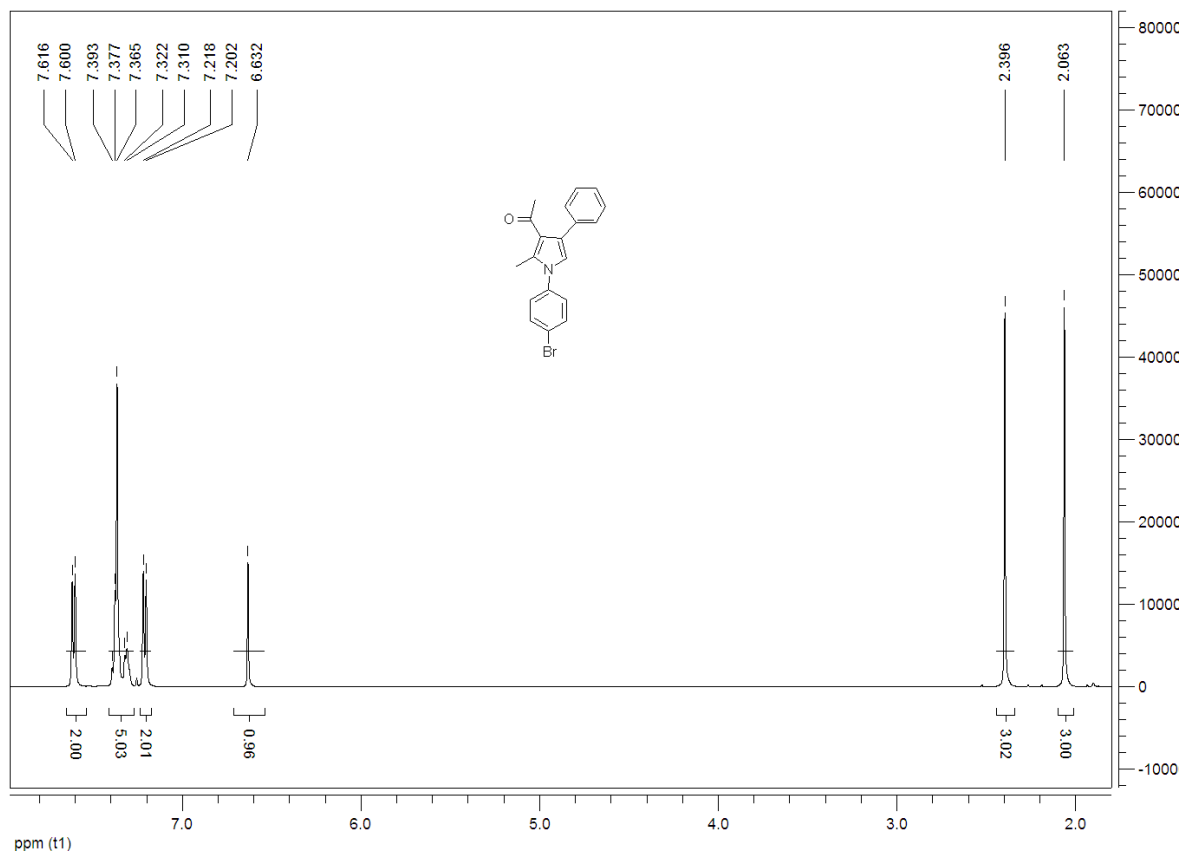
# <sup>1</sup>H NMR and <sup>13</sup>C NMR of compound **5f**



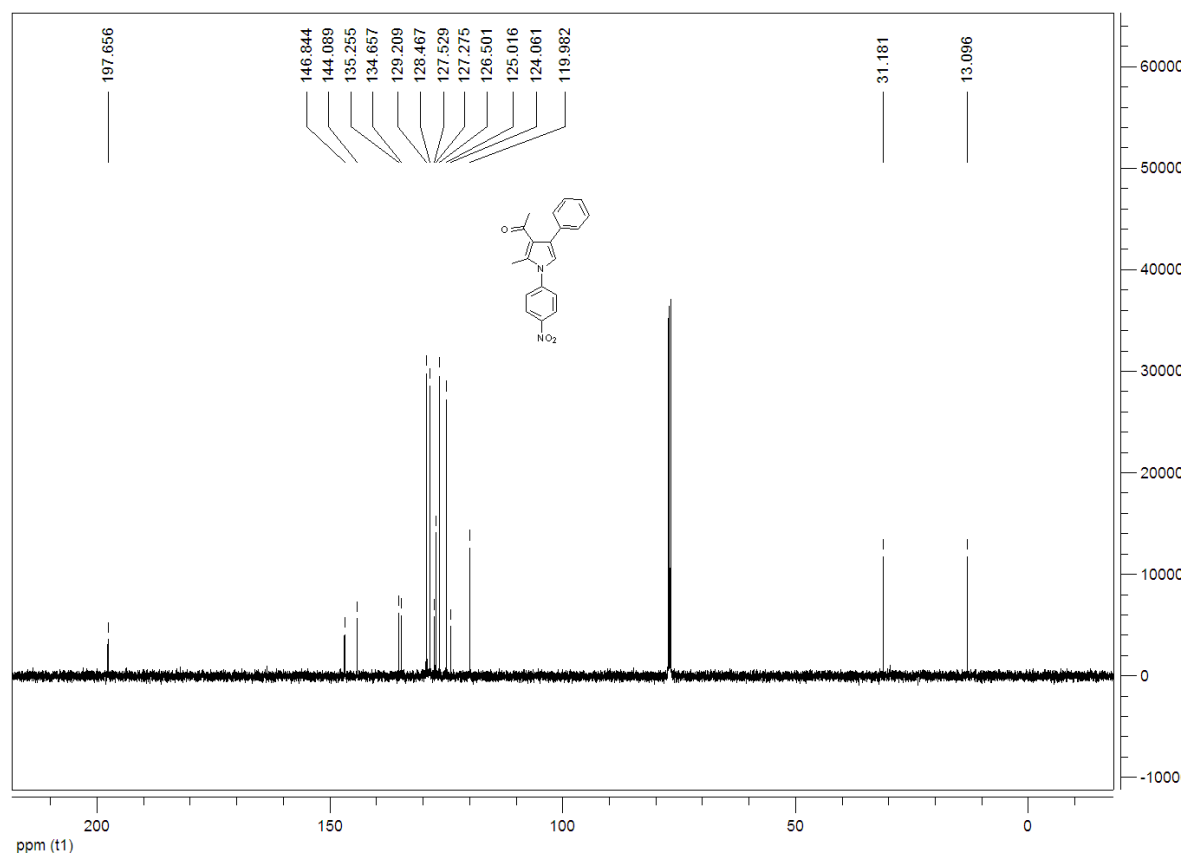
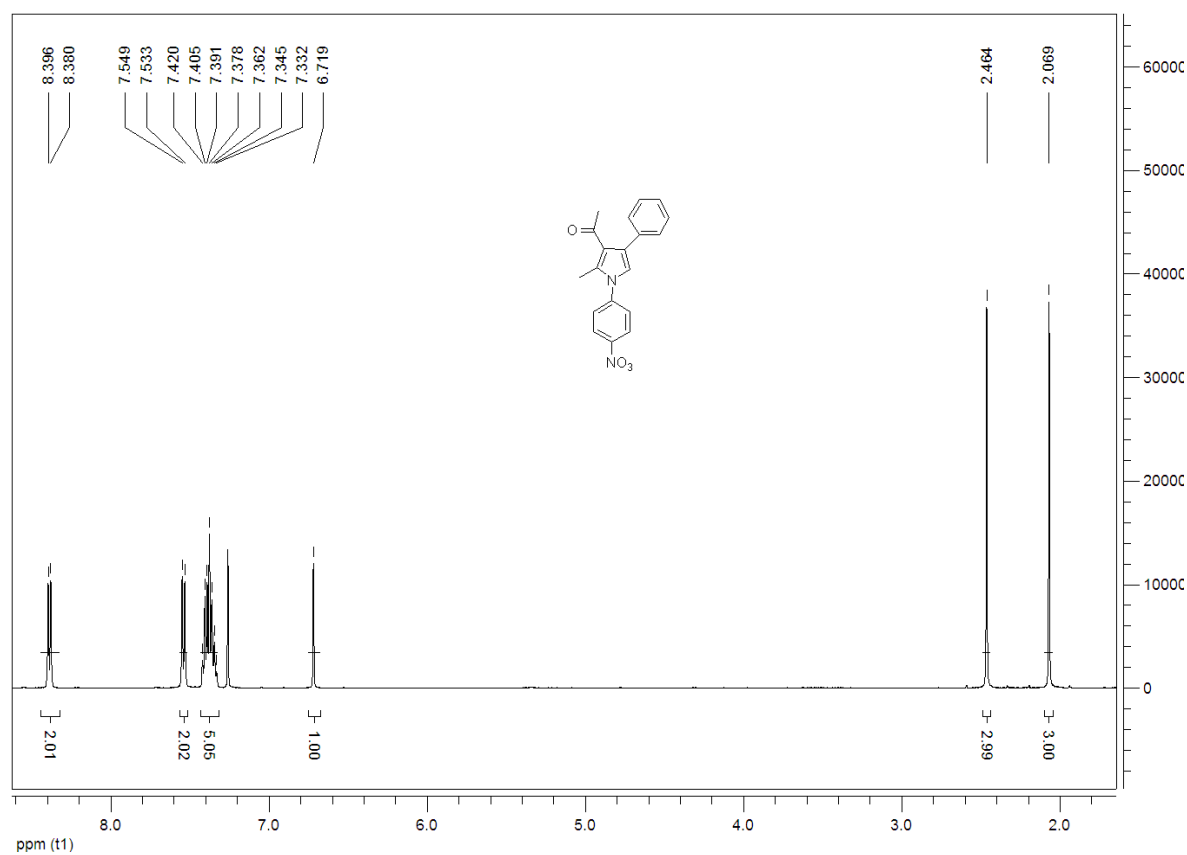
# <sup>1</sup>H NMR and <sup>13</sup>C NMR of compound 5g



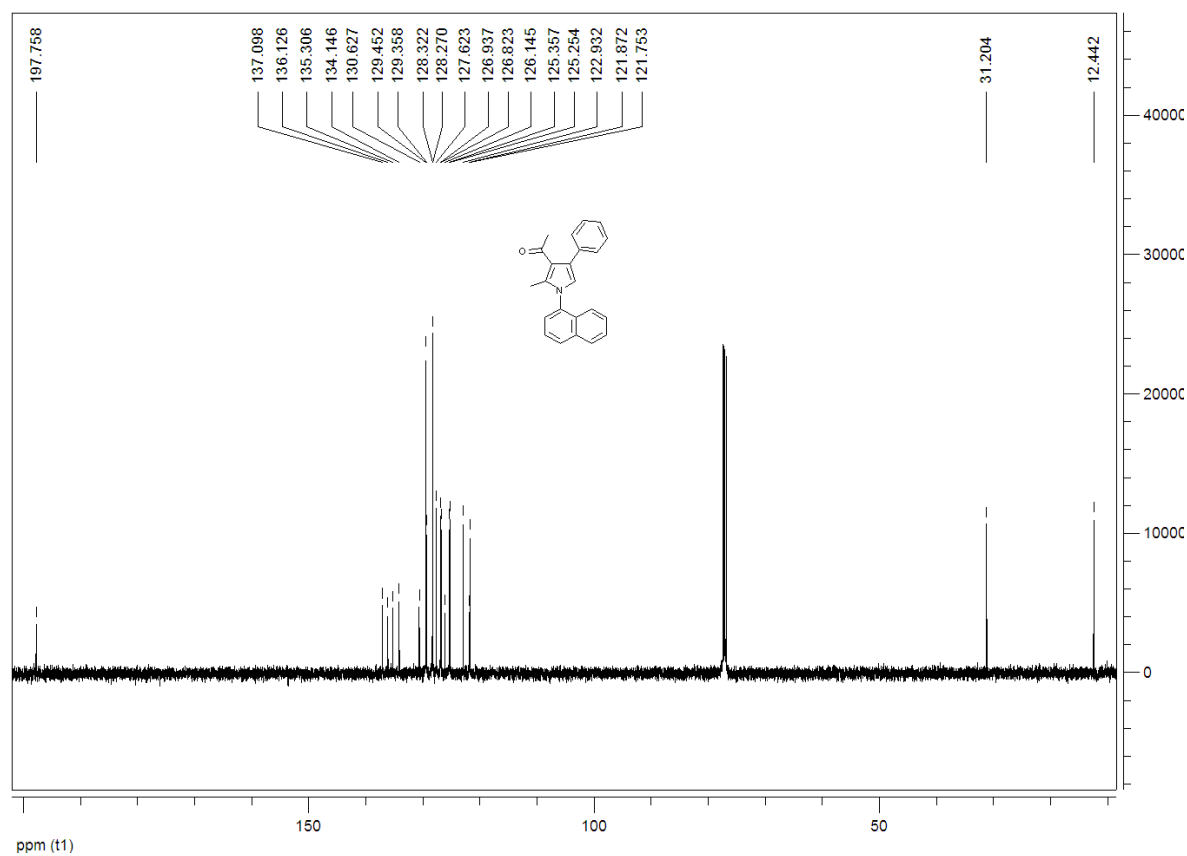
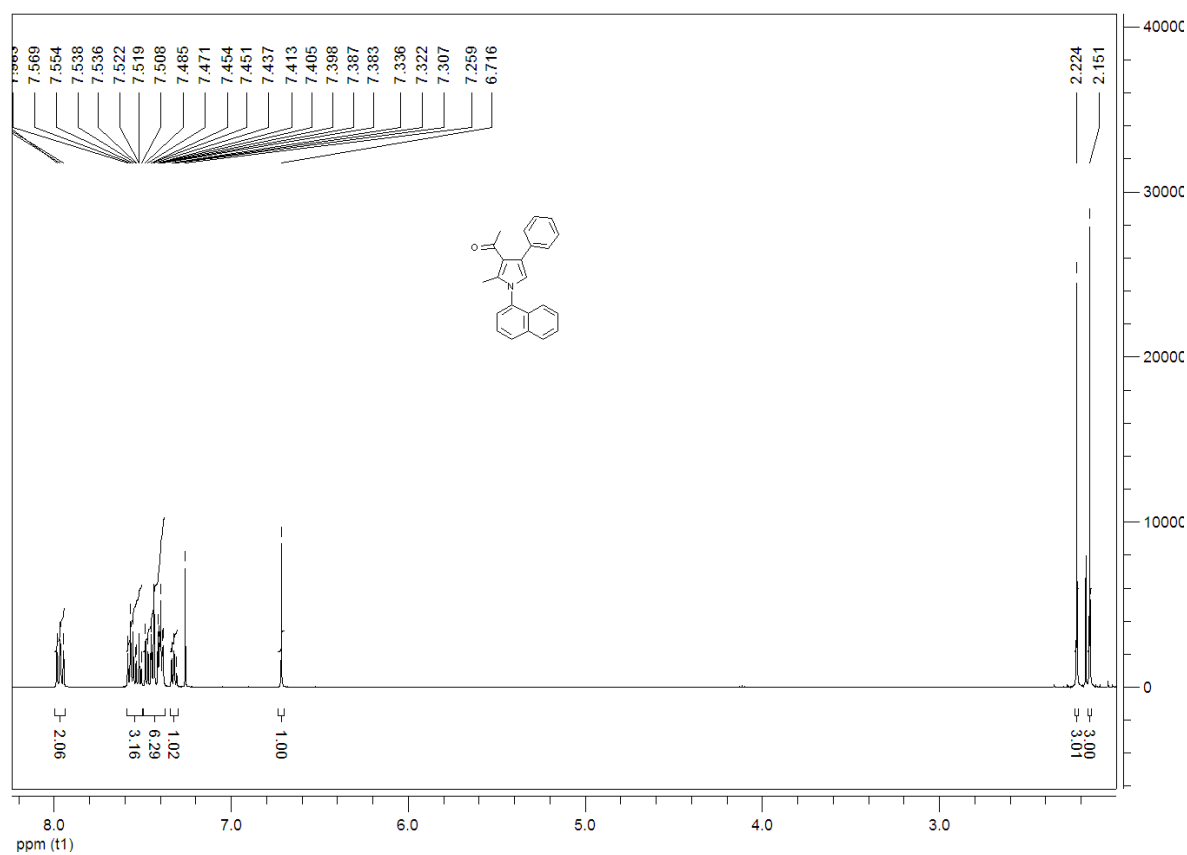
# <sup>1</sup>H NMR and <sup>13</sup>C NMR of compound **5h**



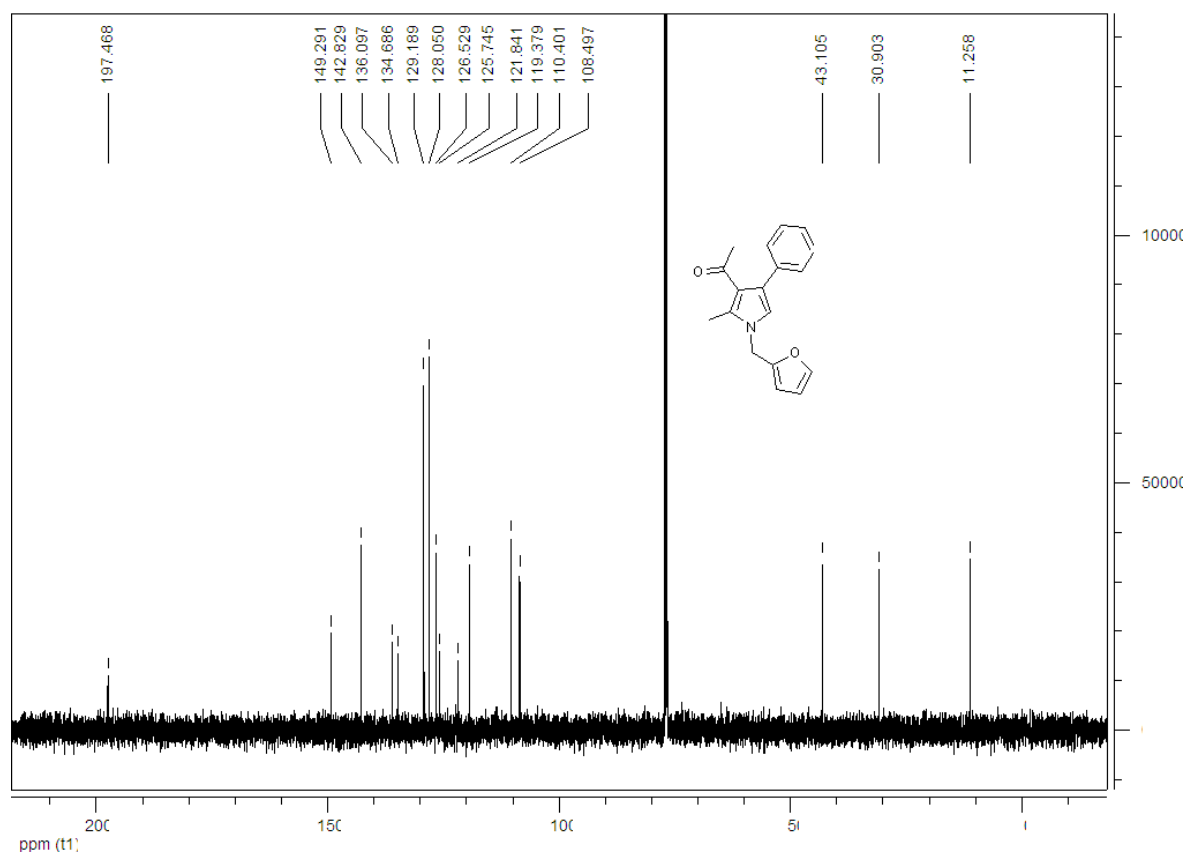
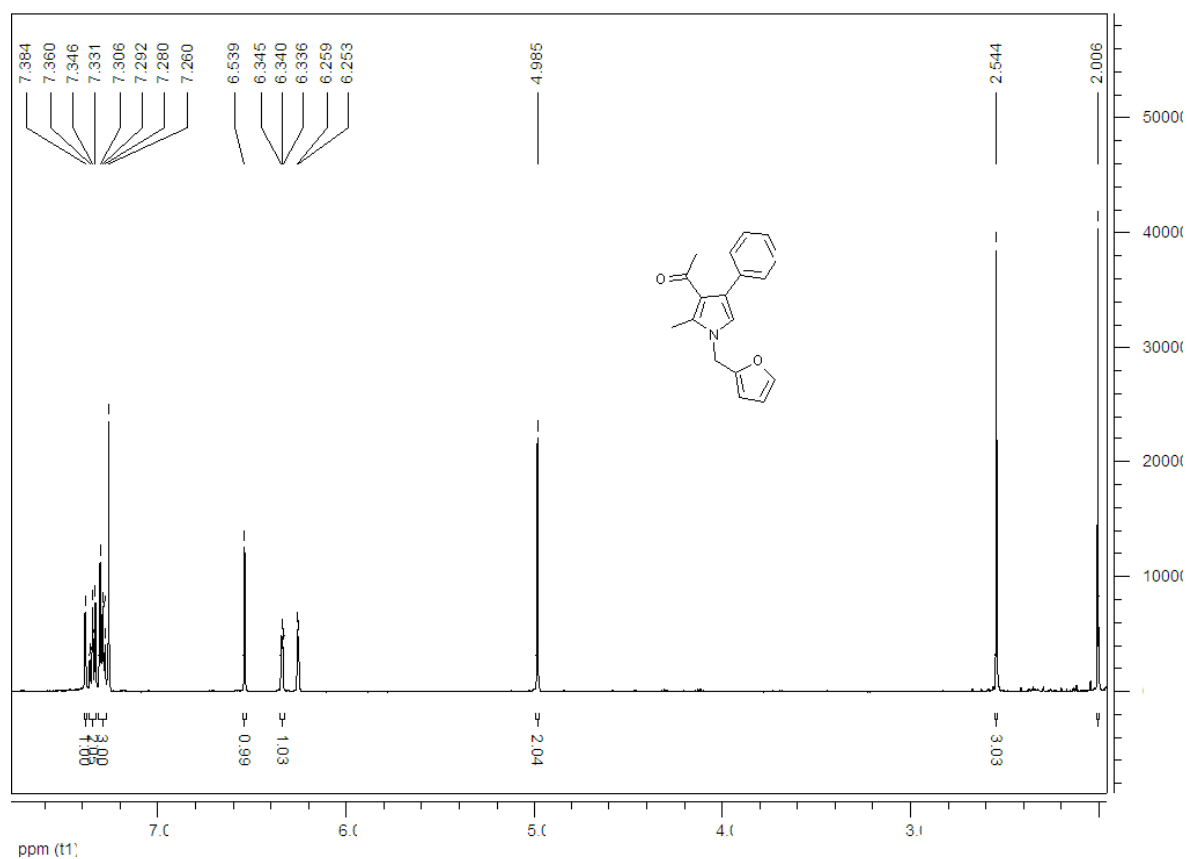
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5i**



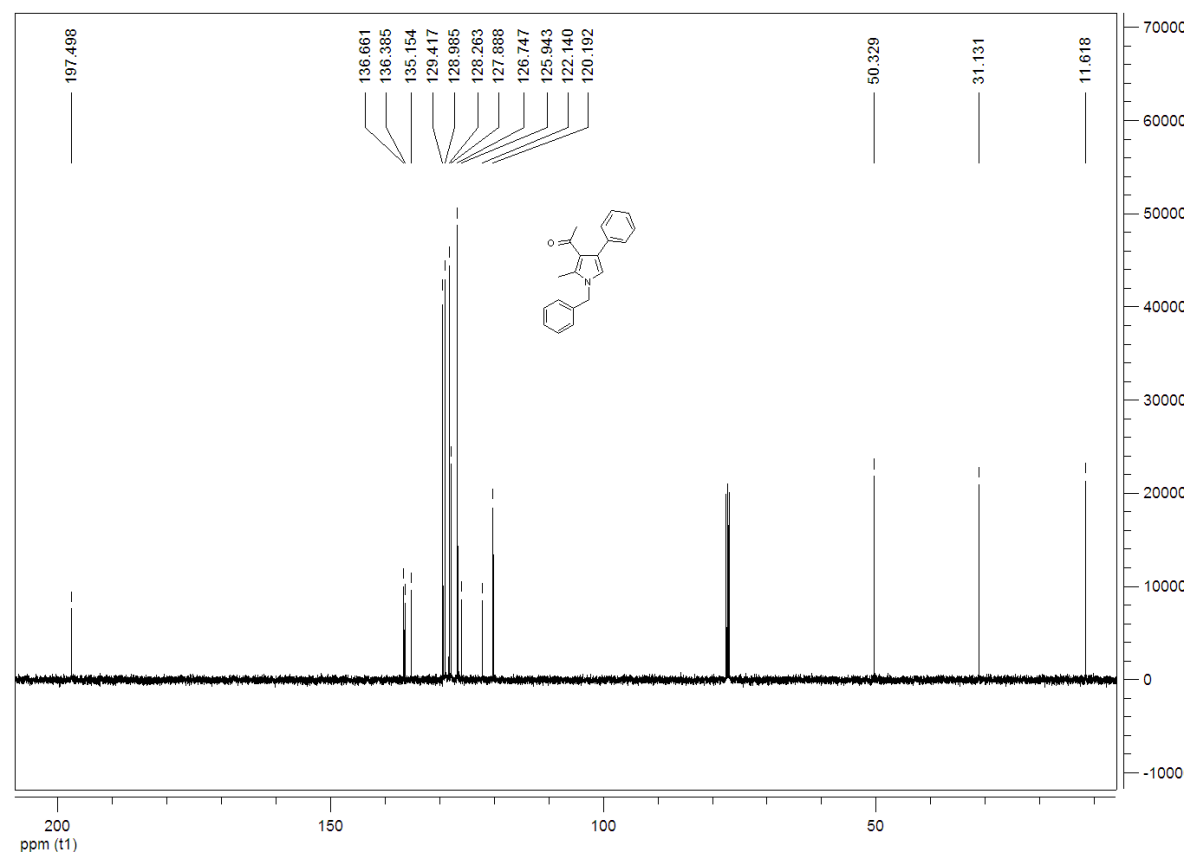
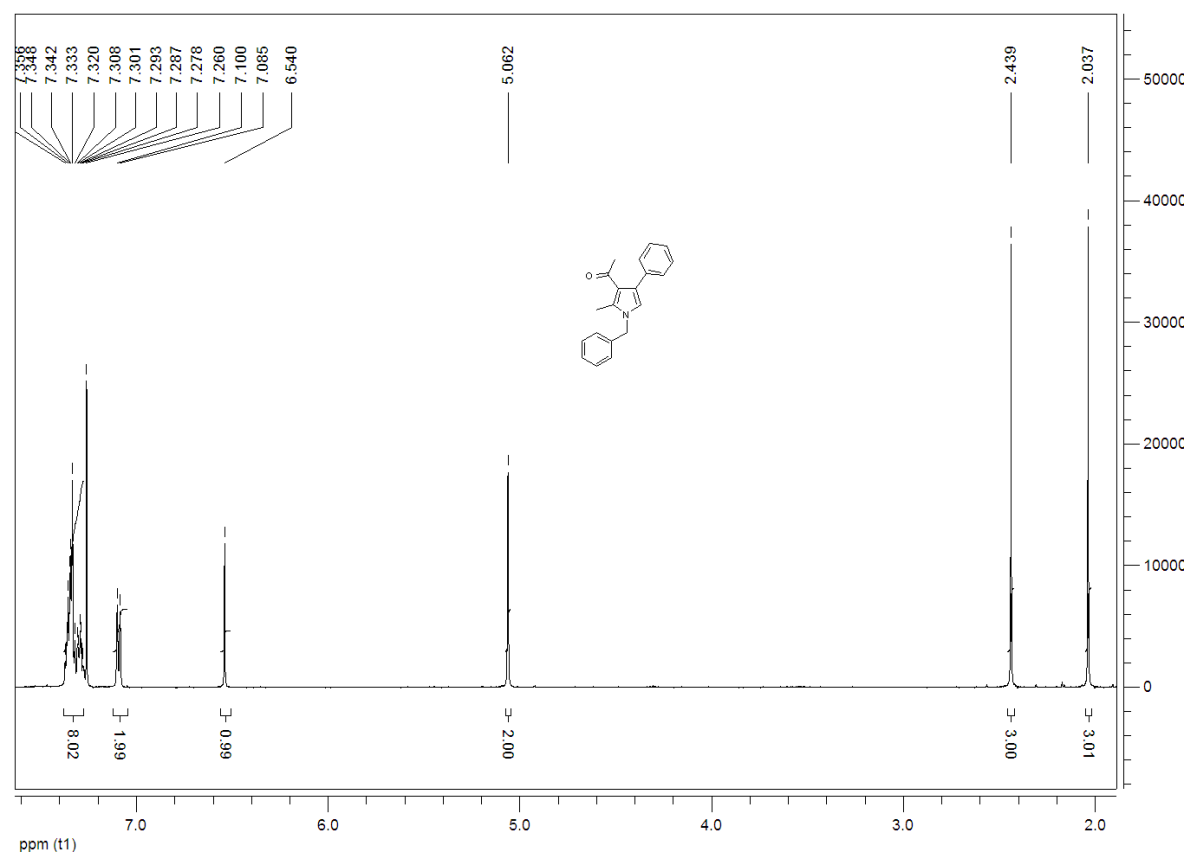
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5j**



$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5k**

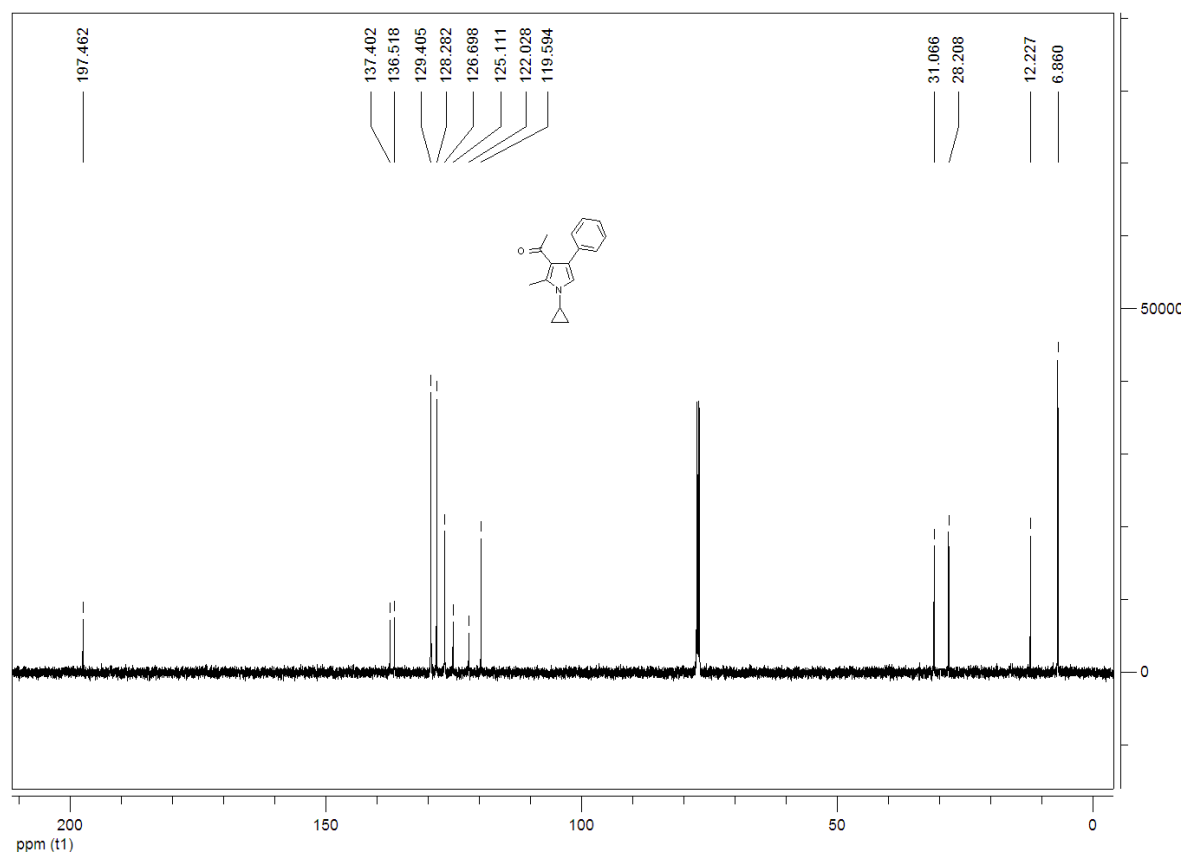
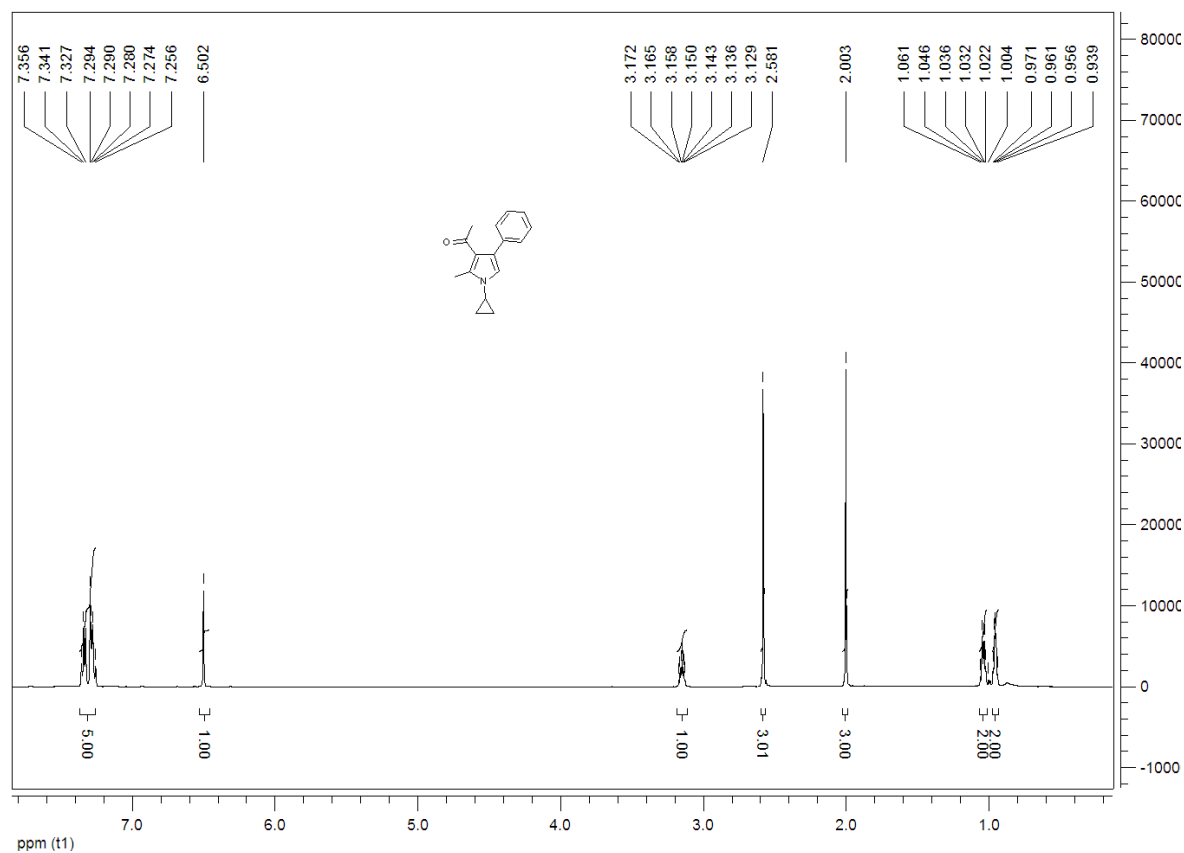


# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5I**

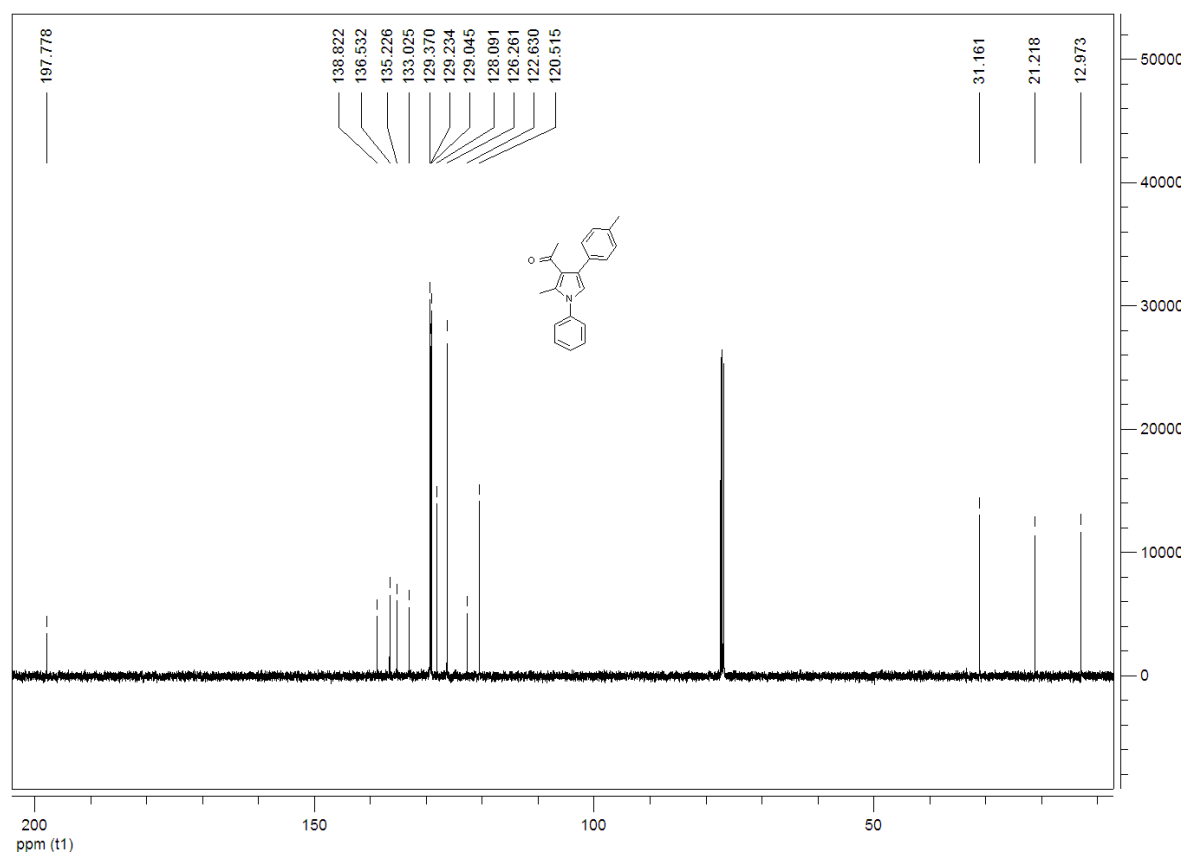
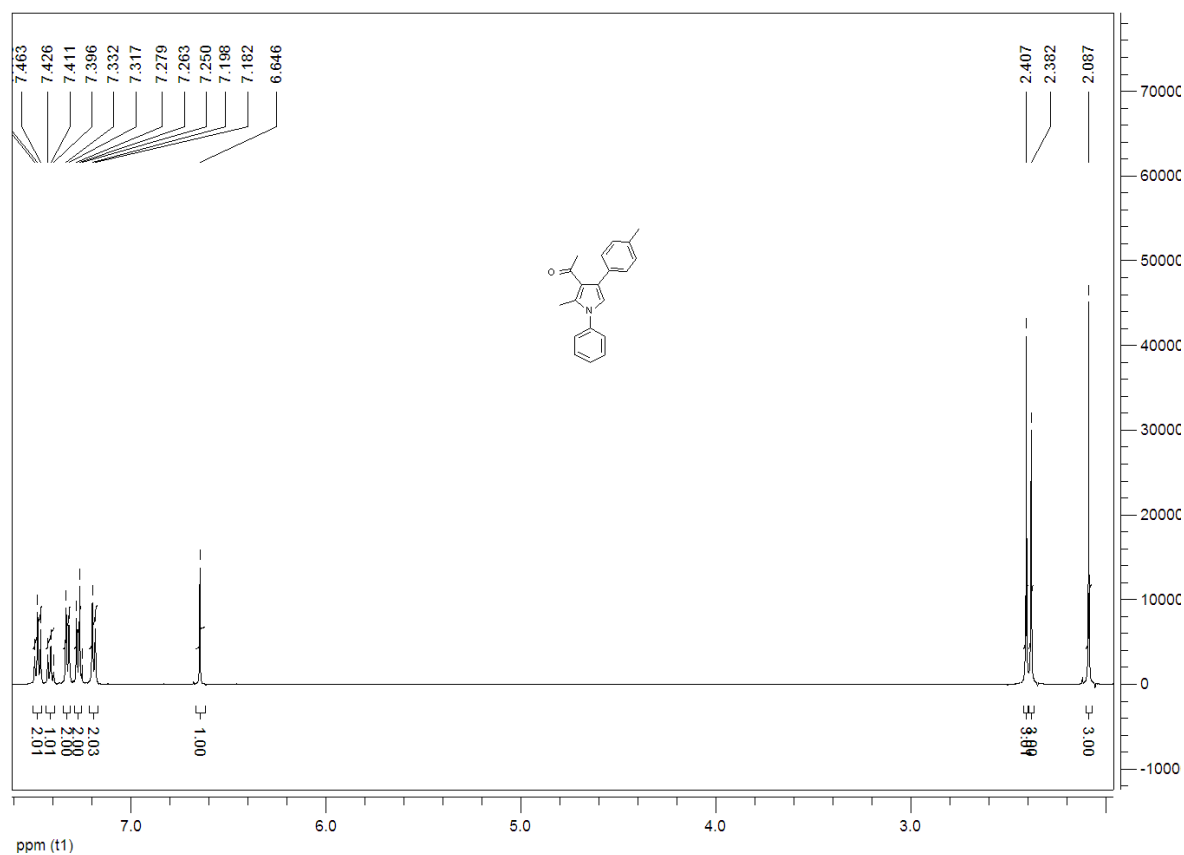




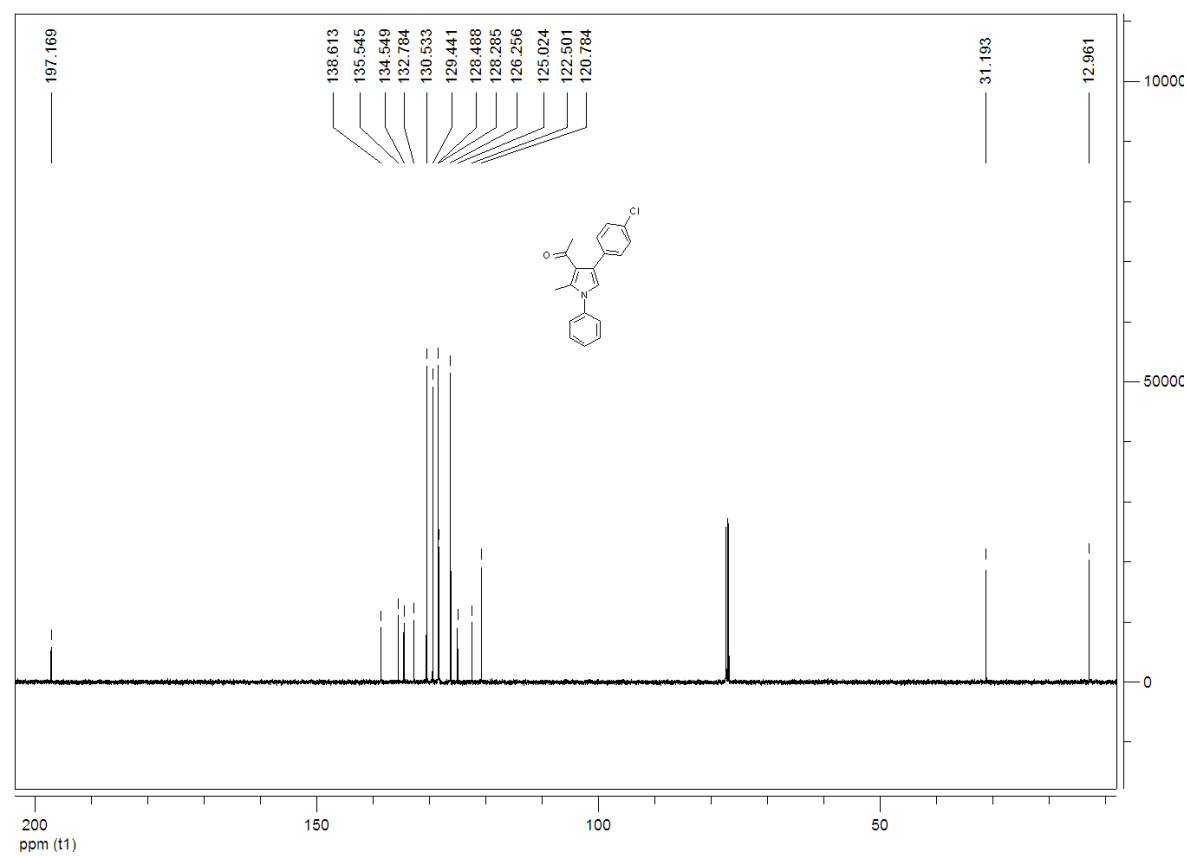
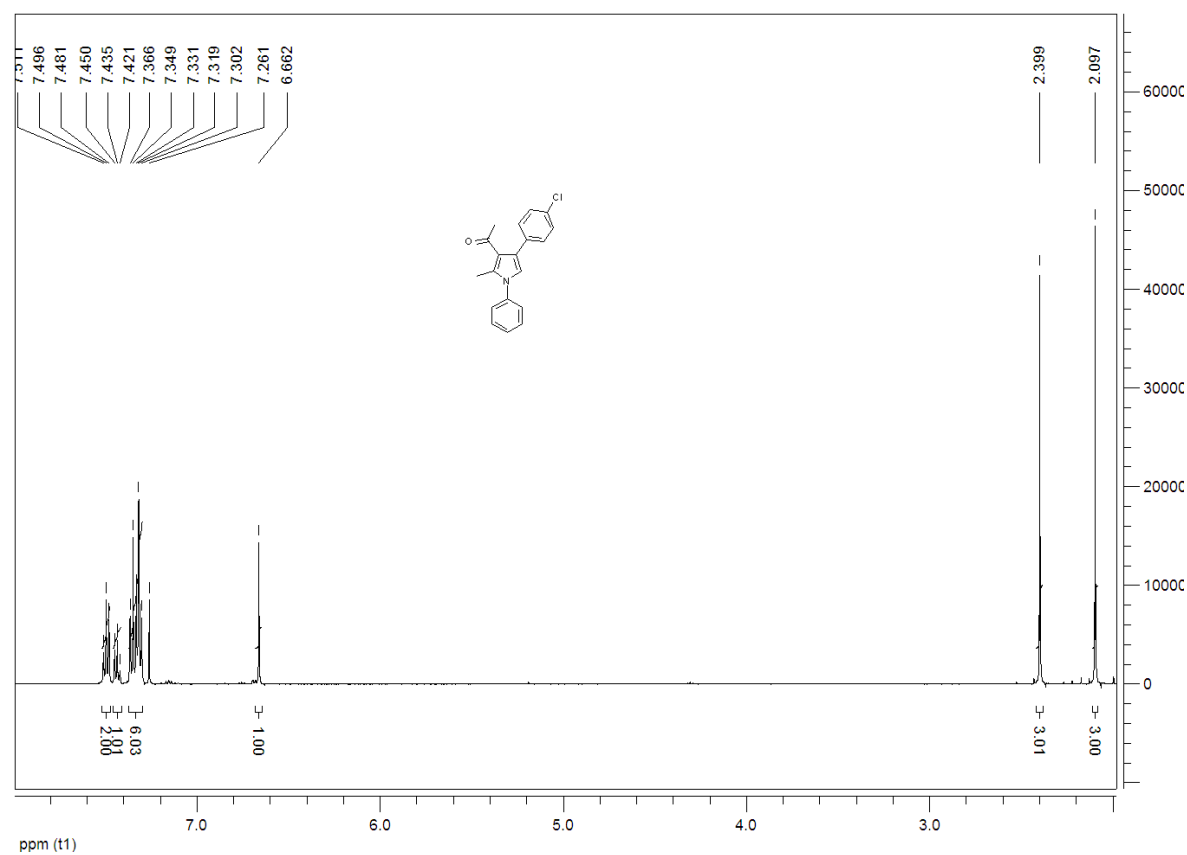
# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5m**



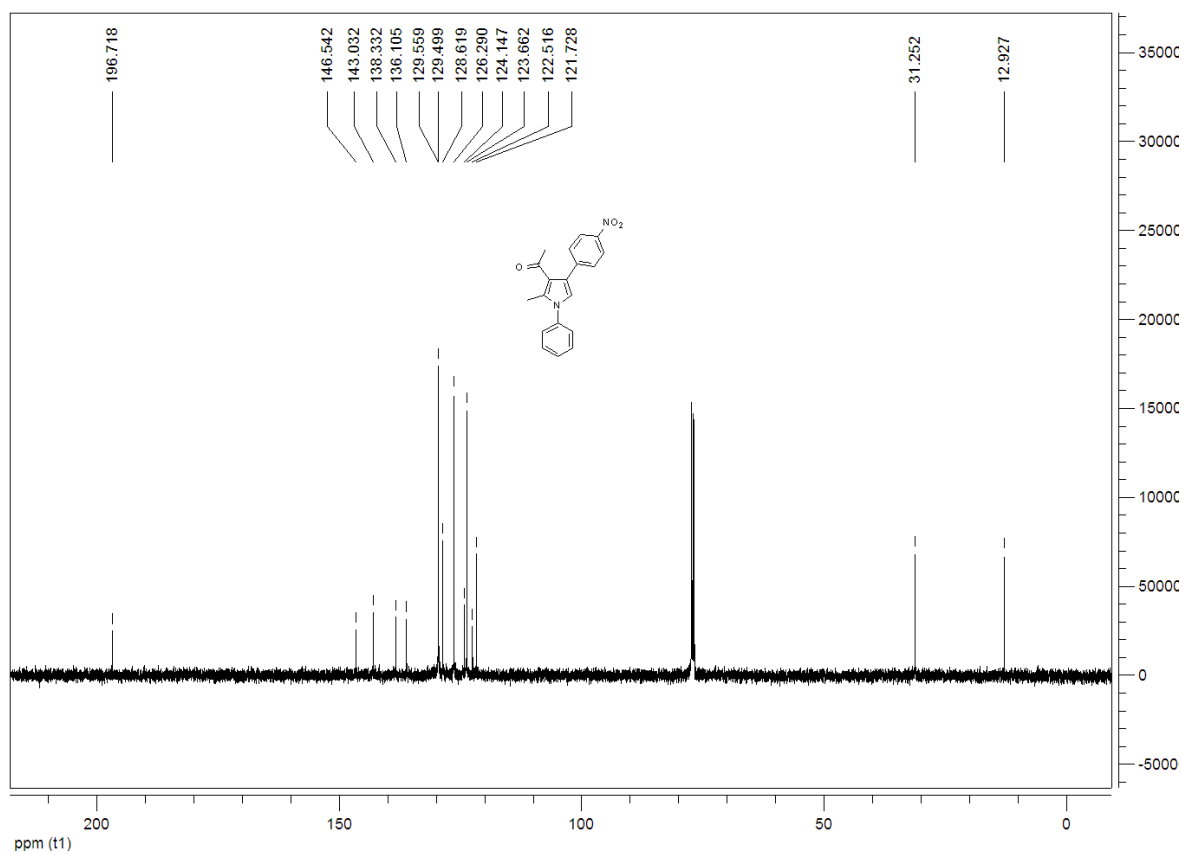
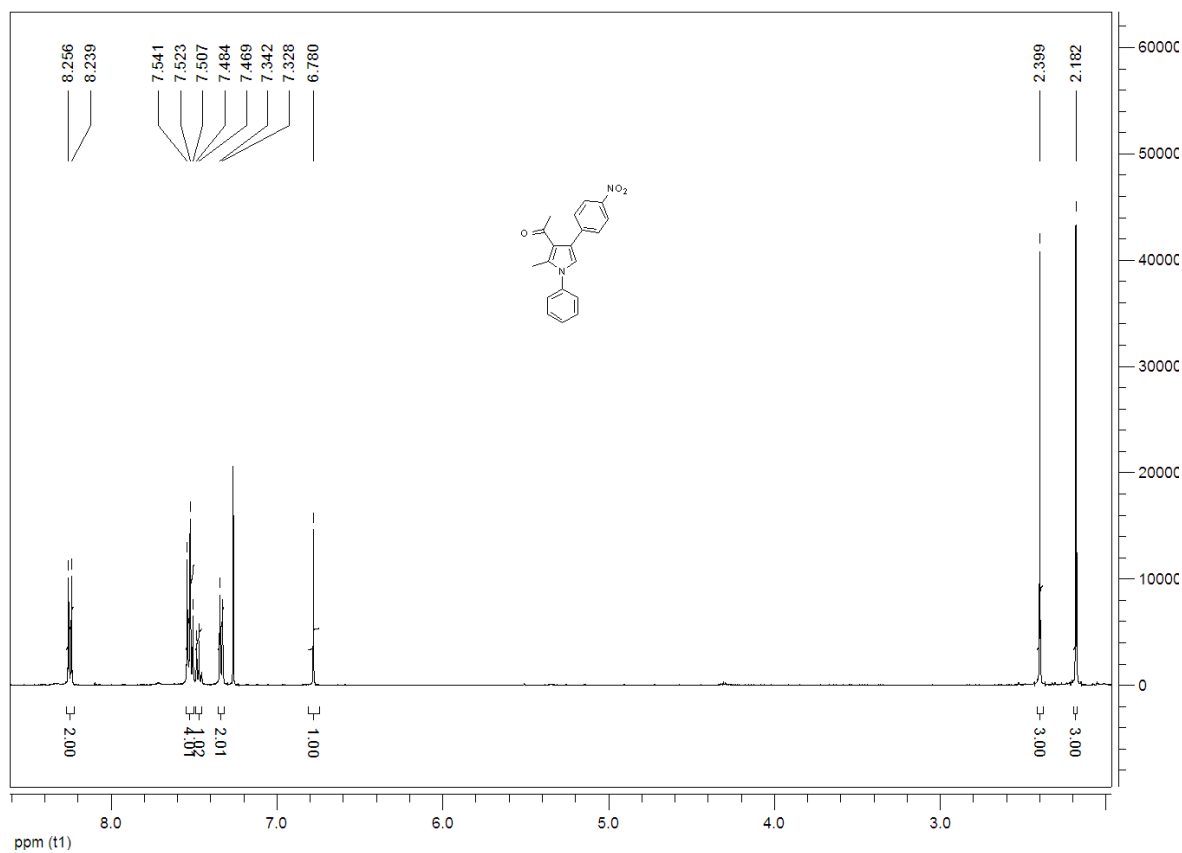
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5n**



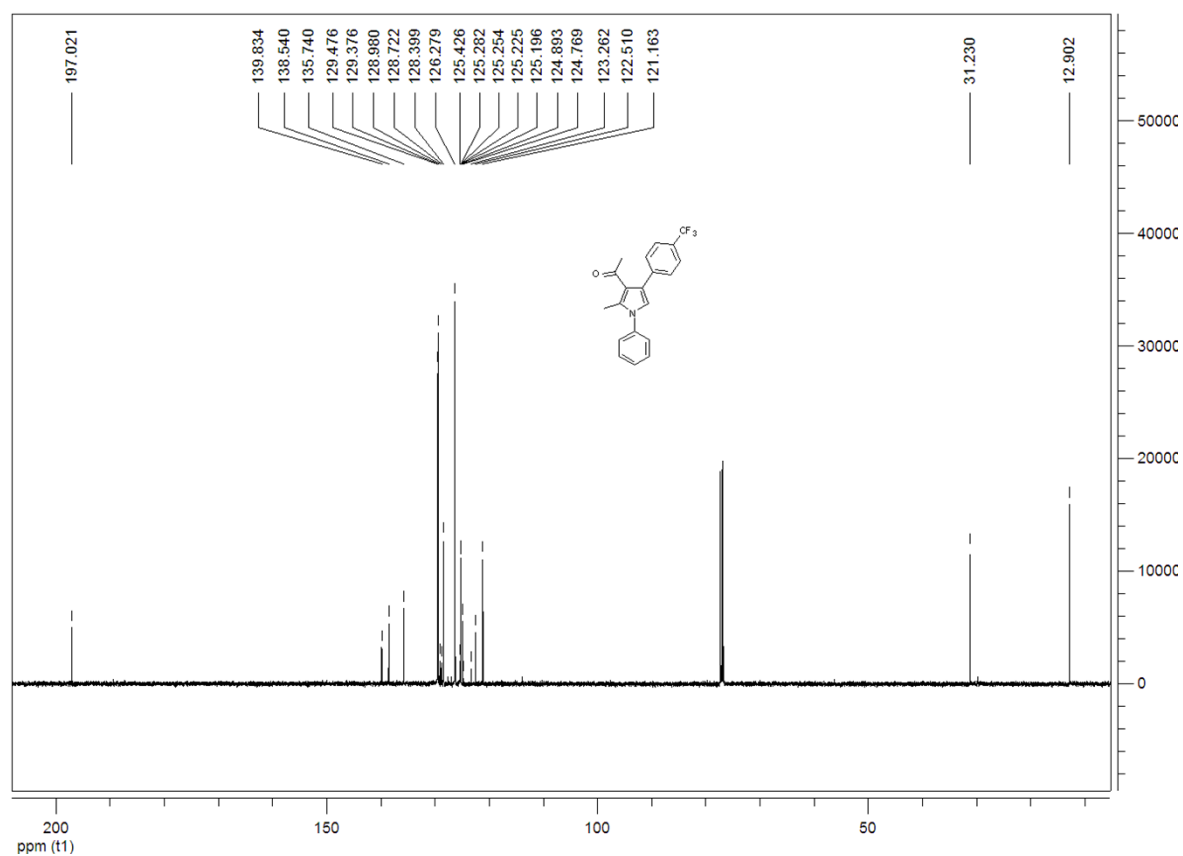
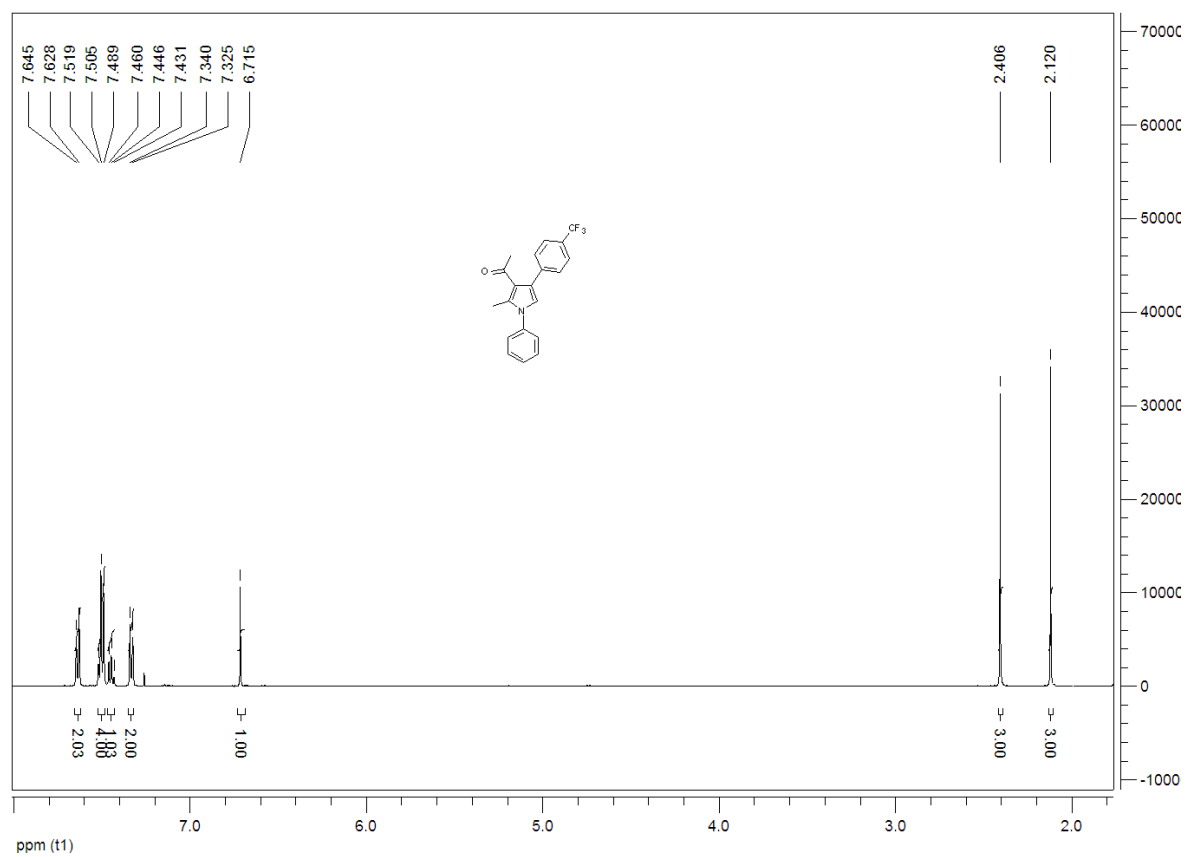
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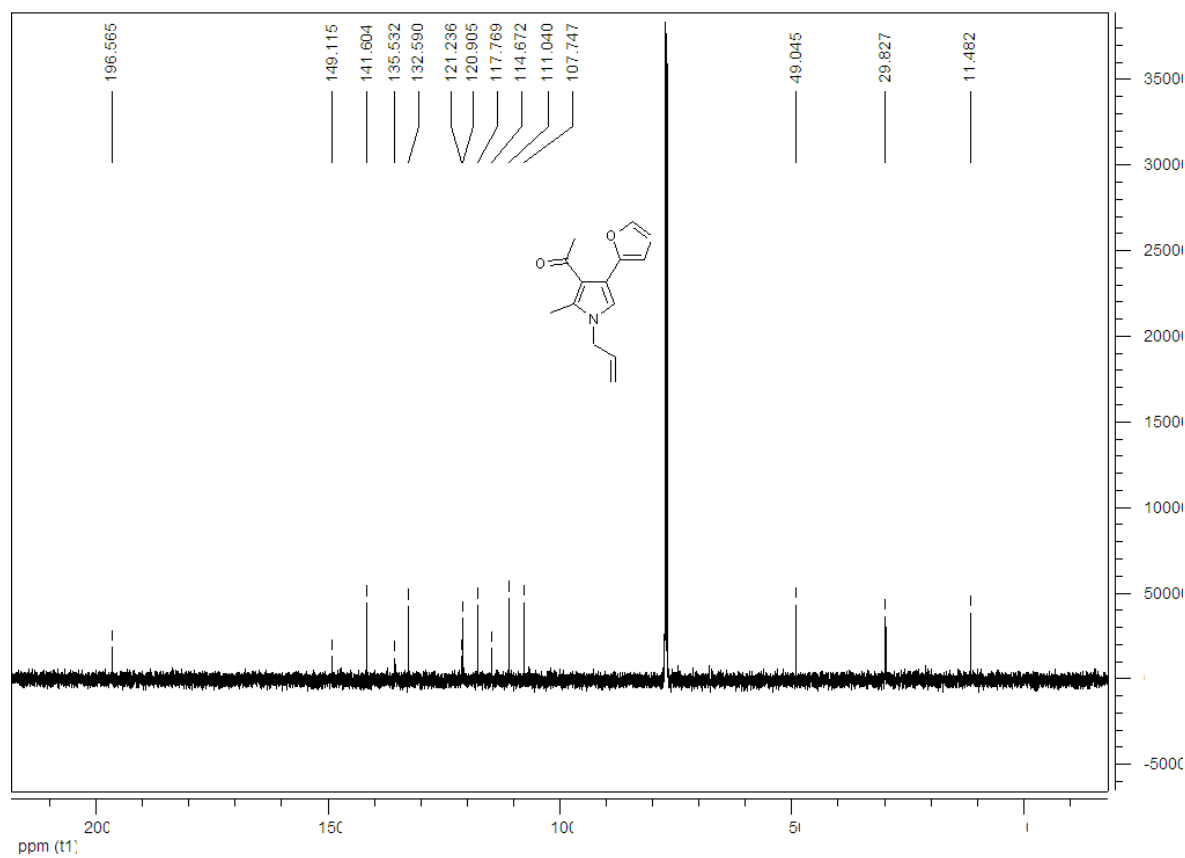
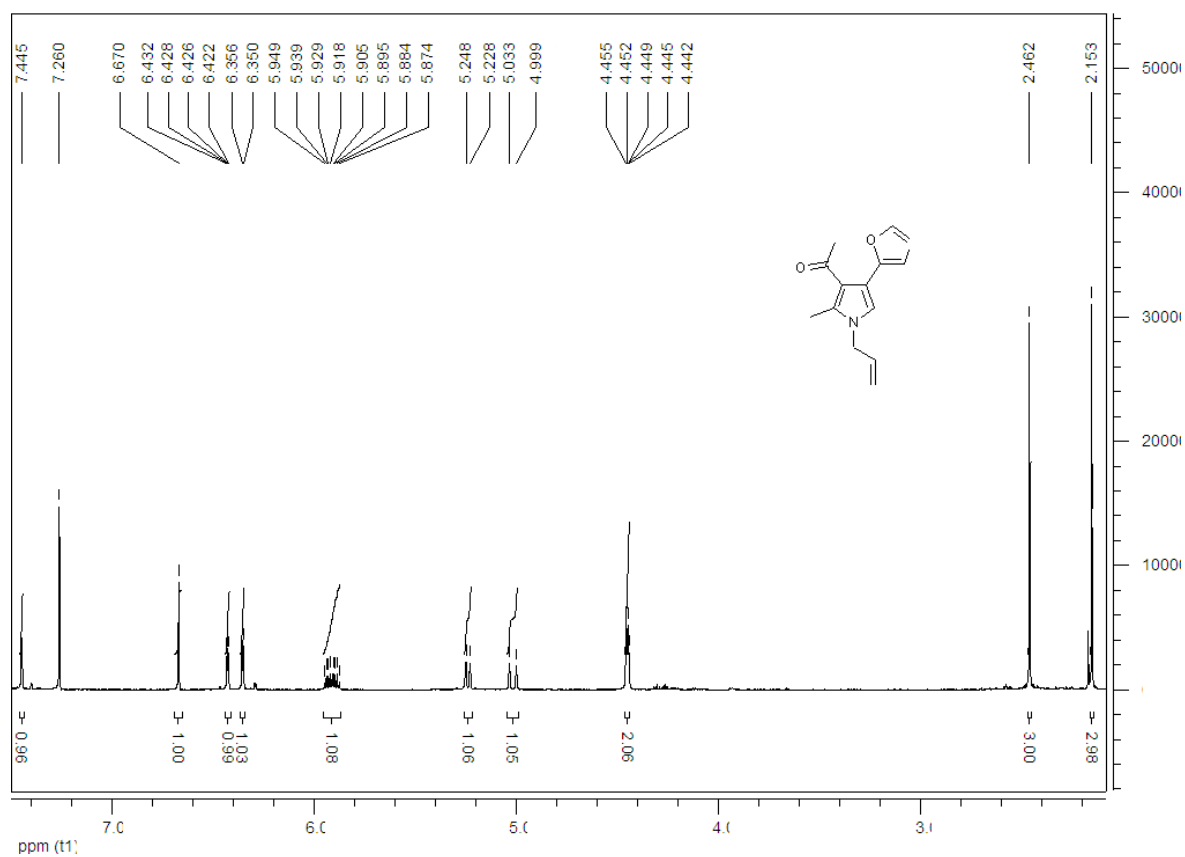
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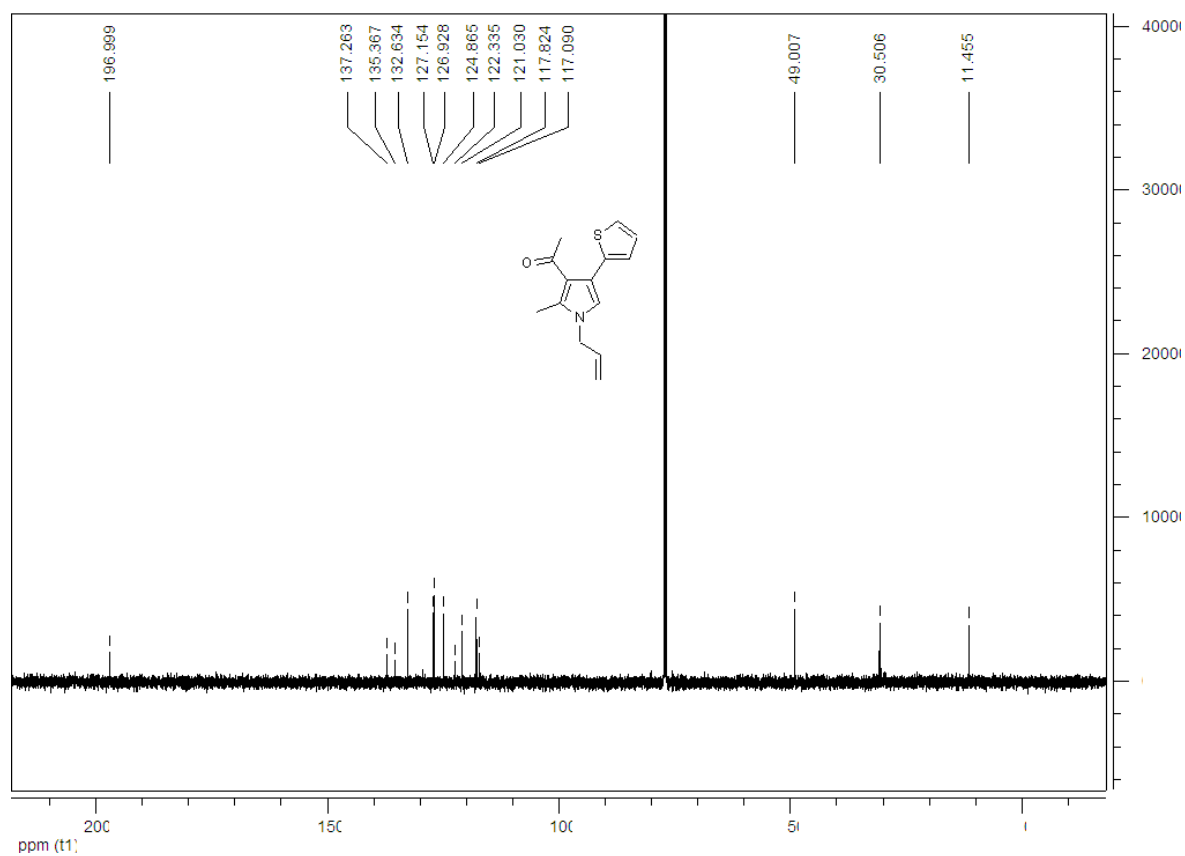
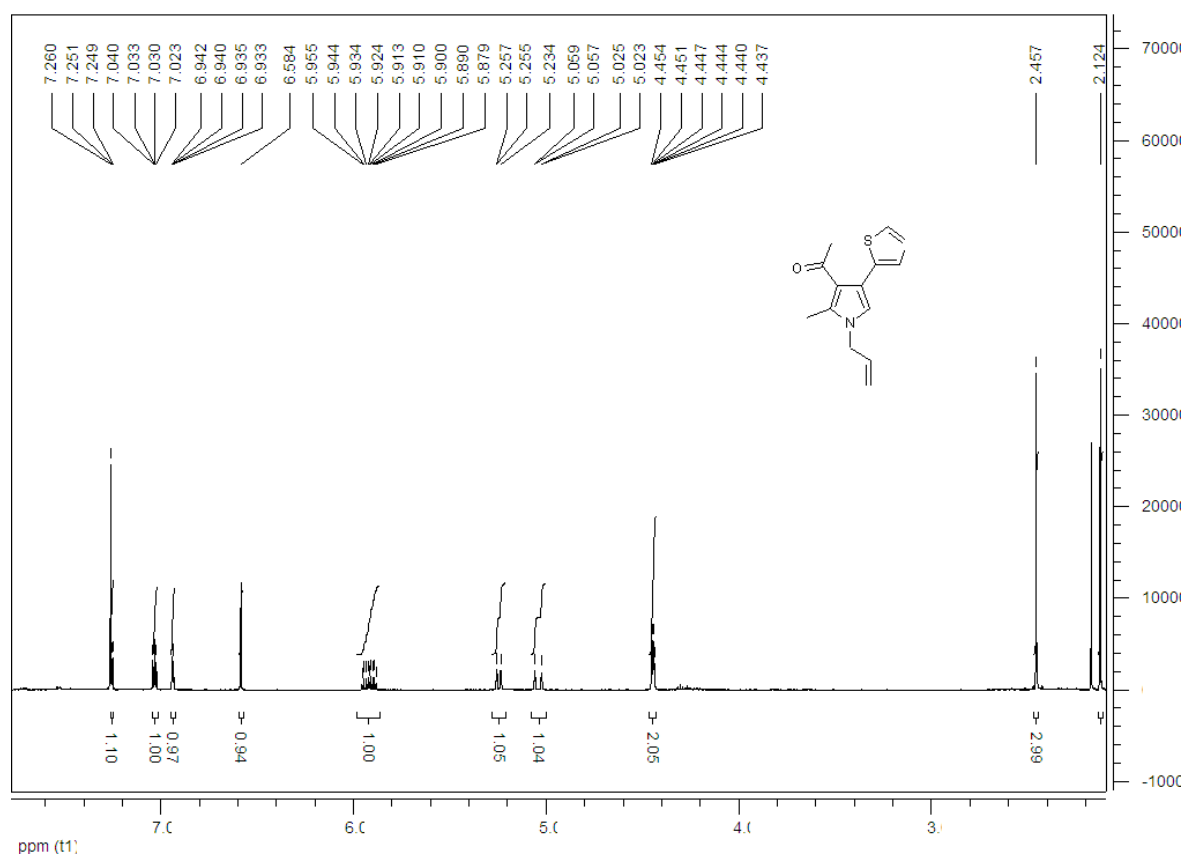
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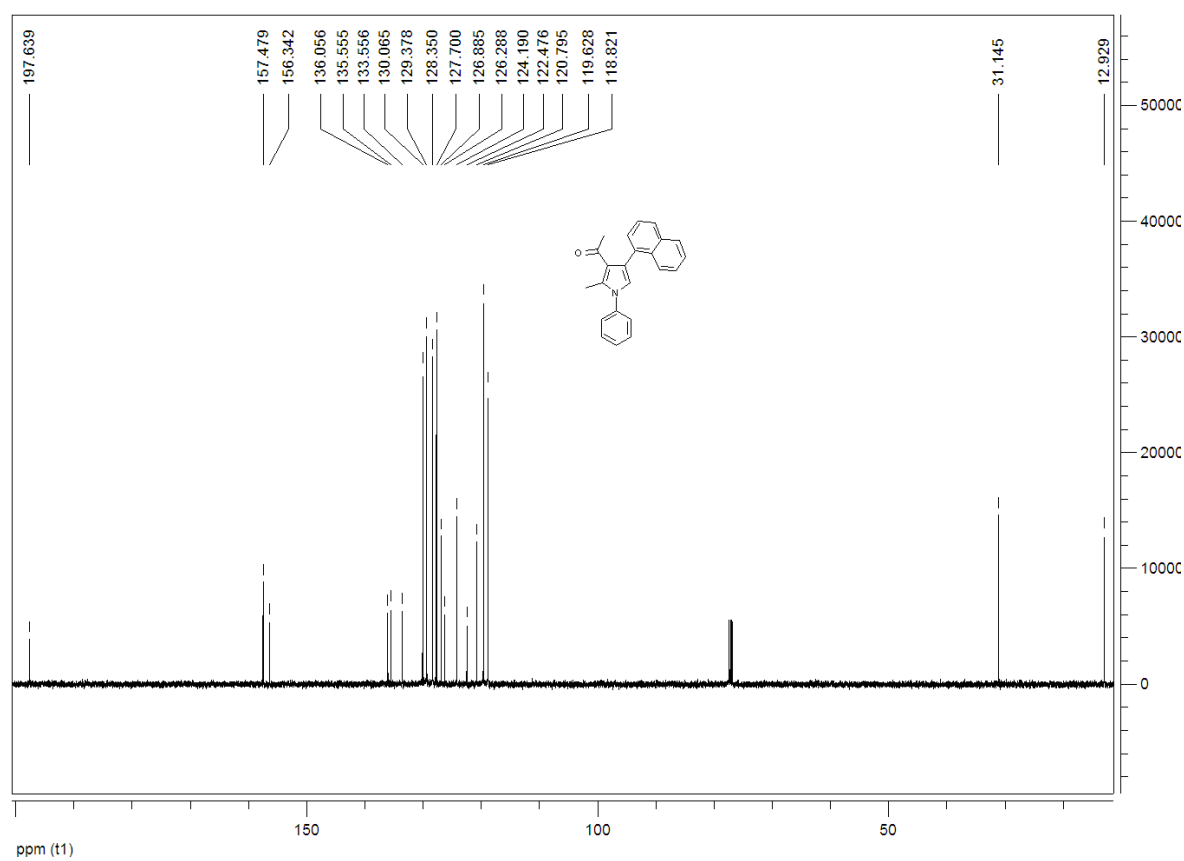
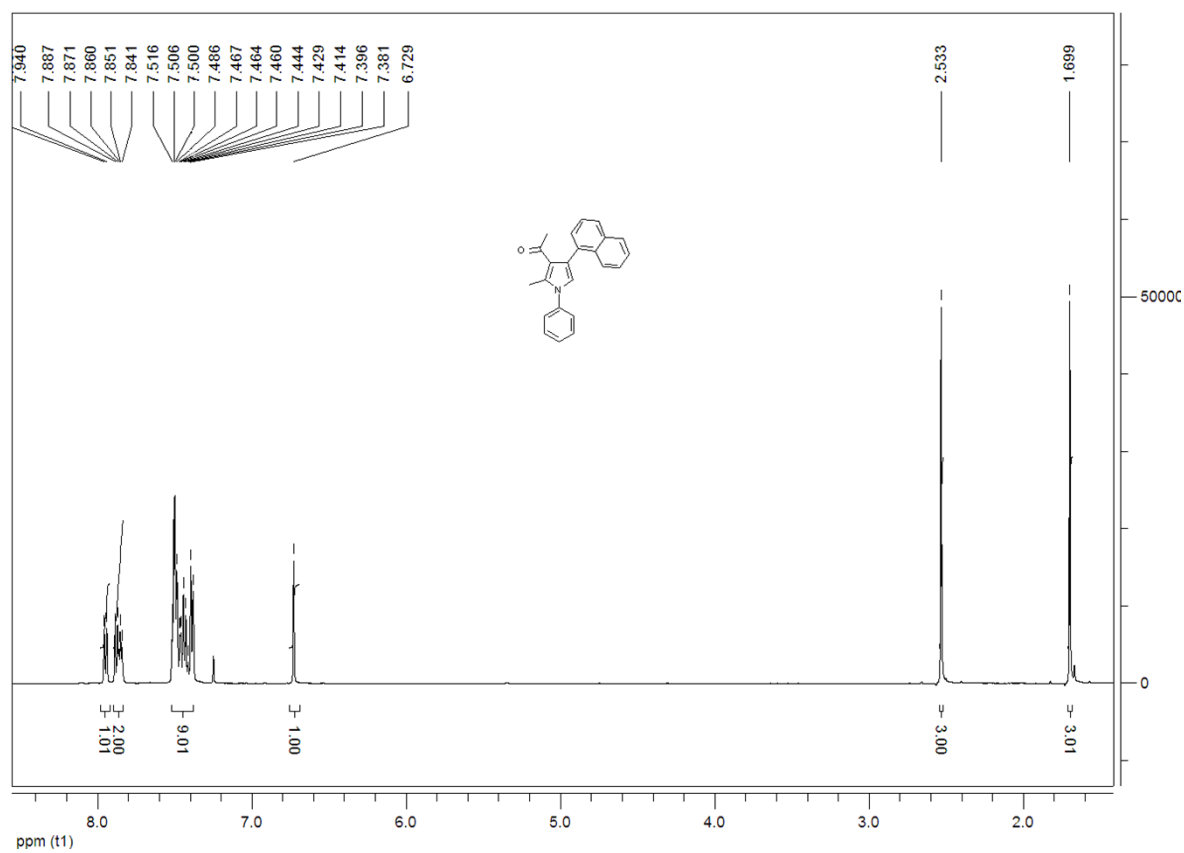
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# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5s**

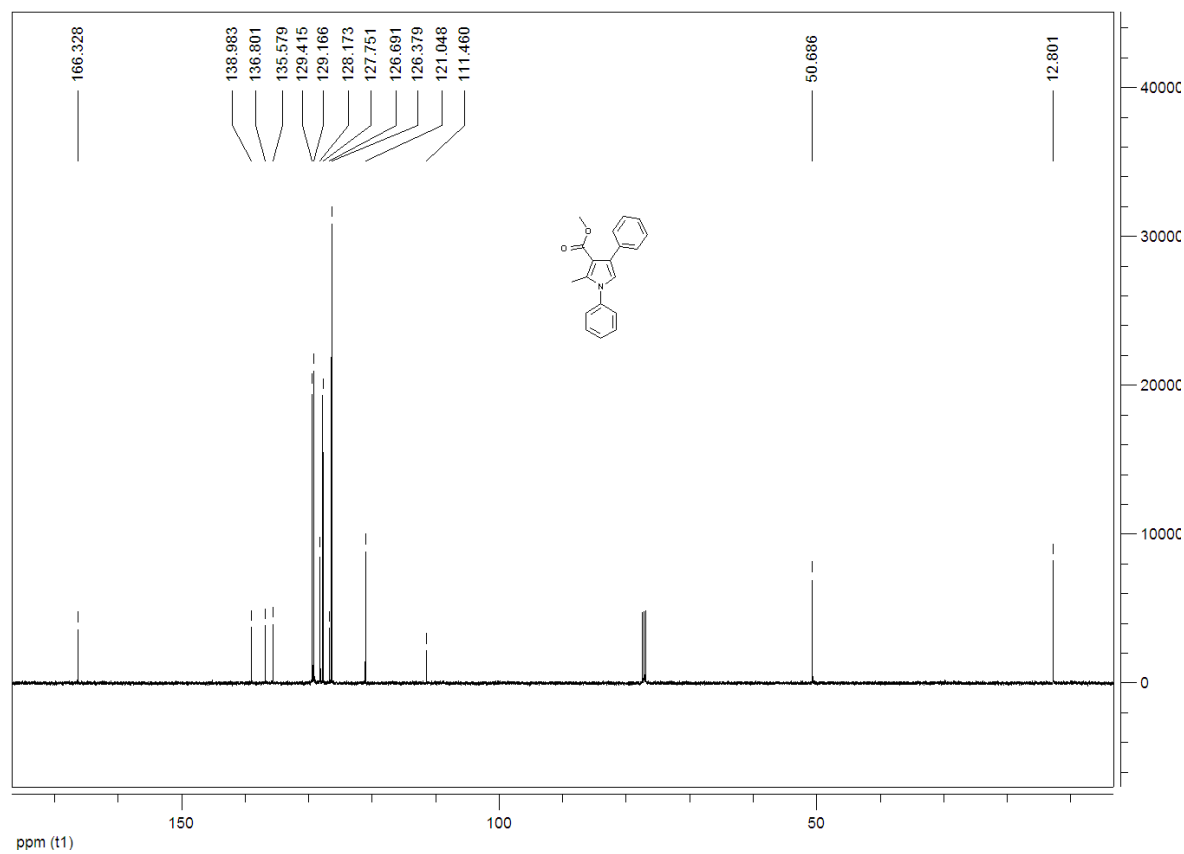
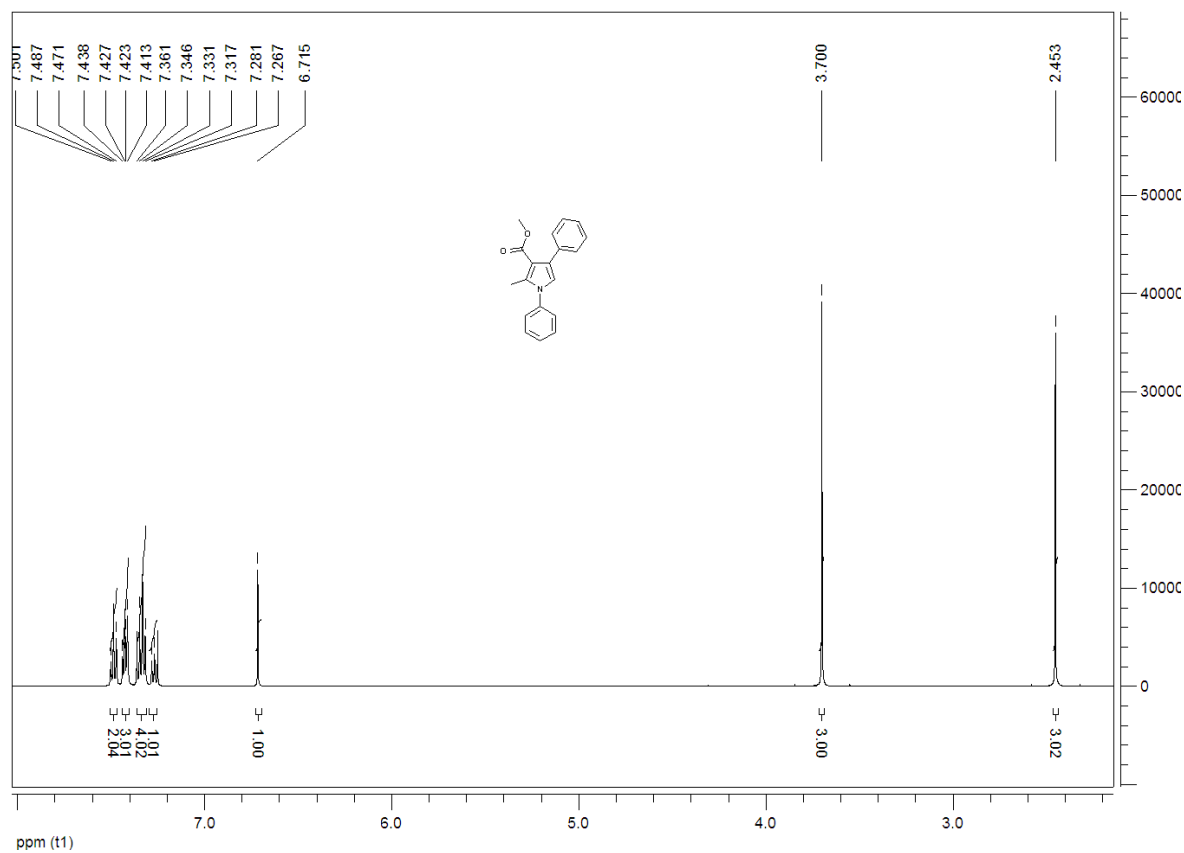


$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5t**

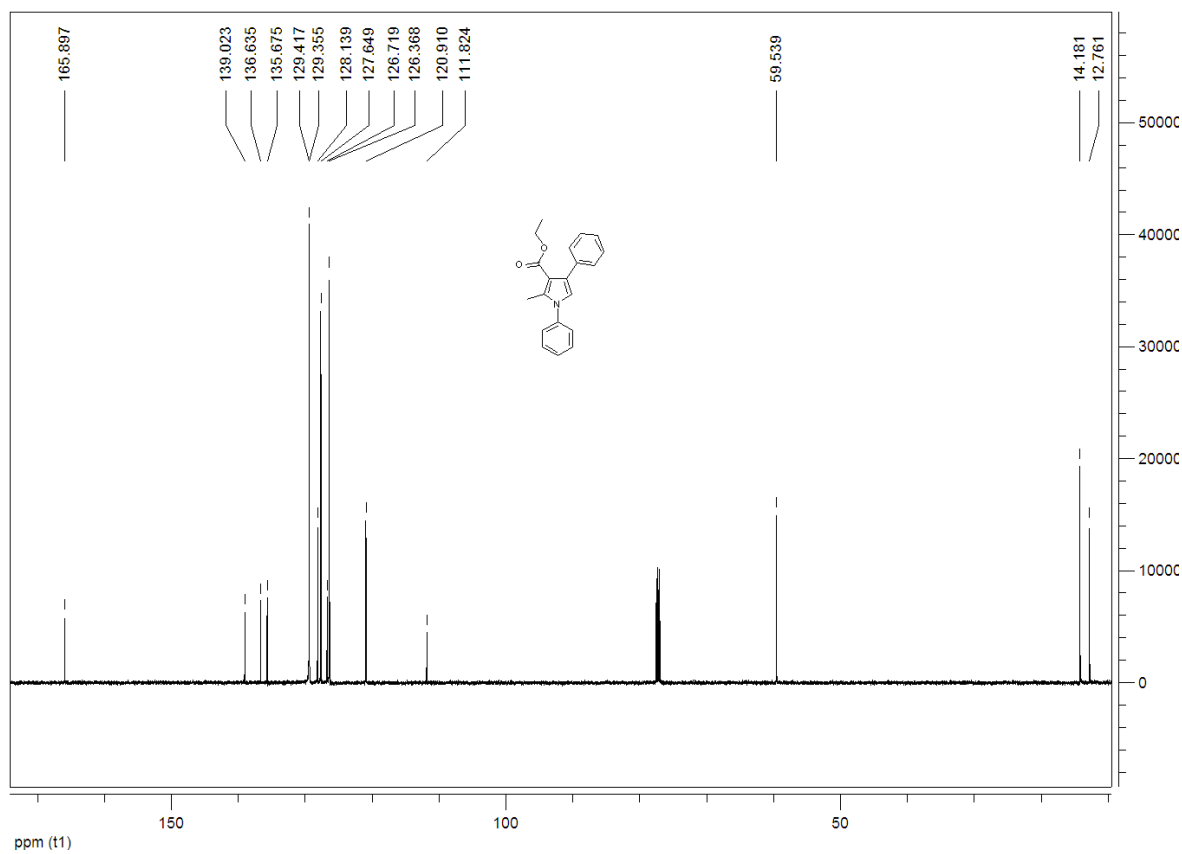
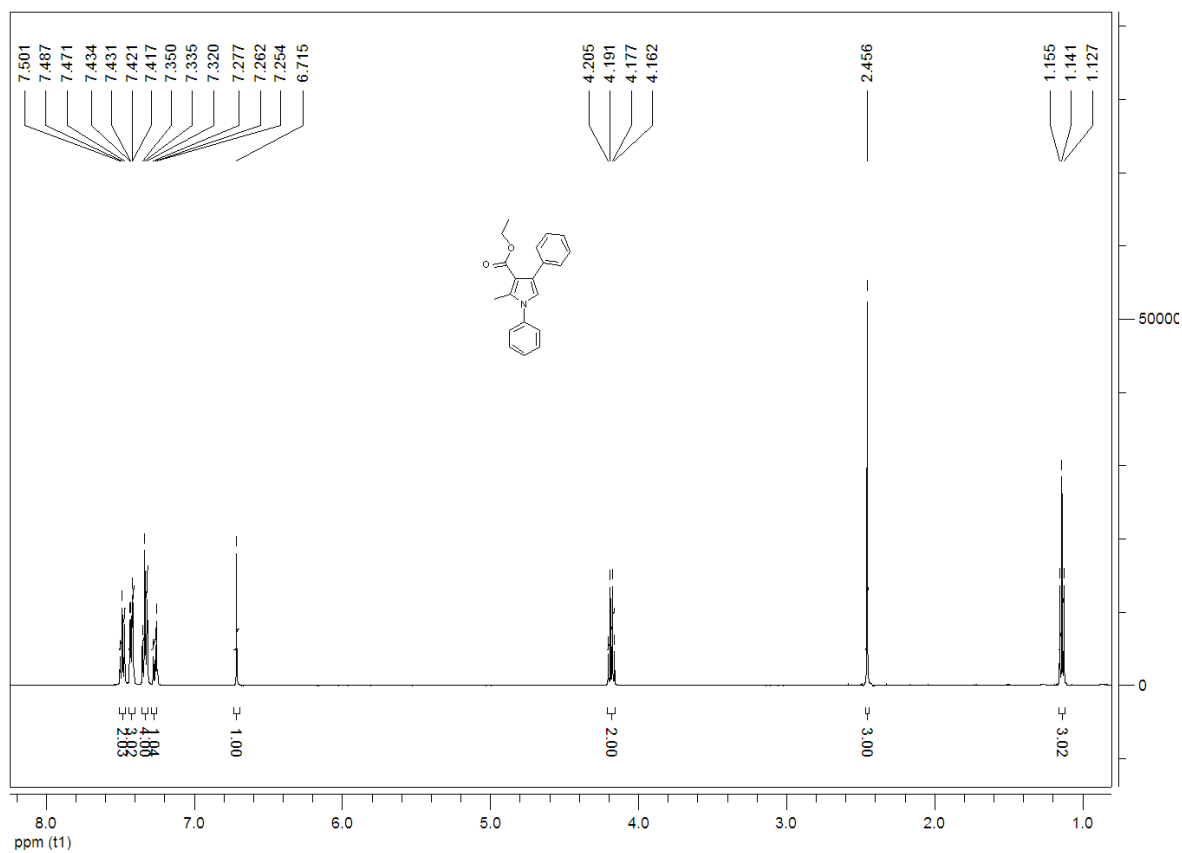




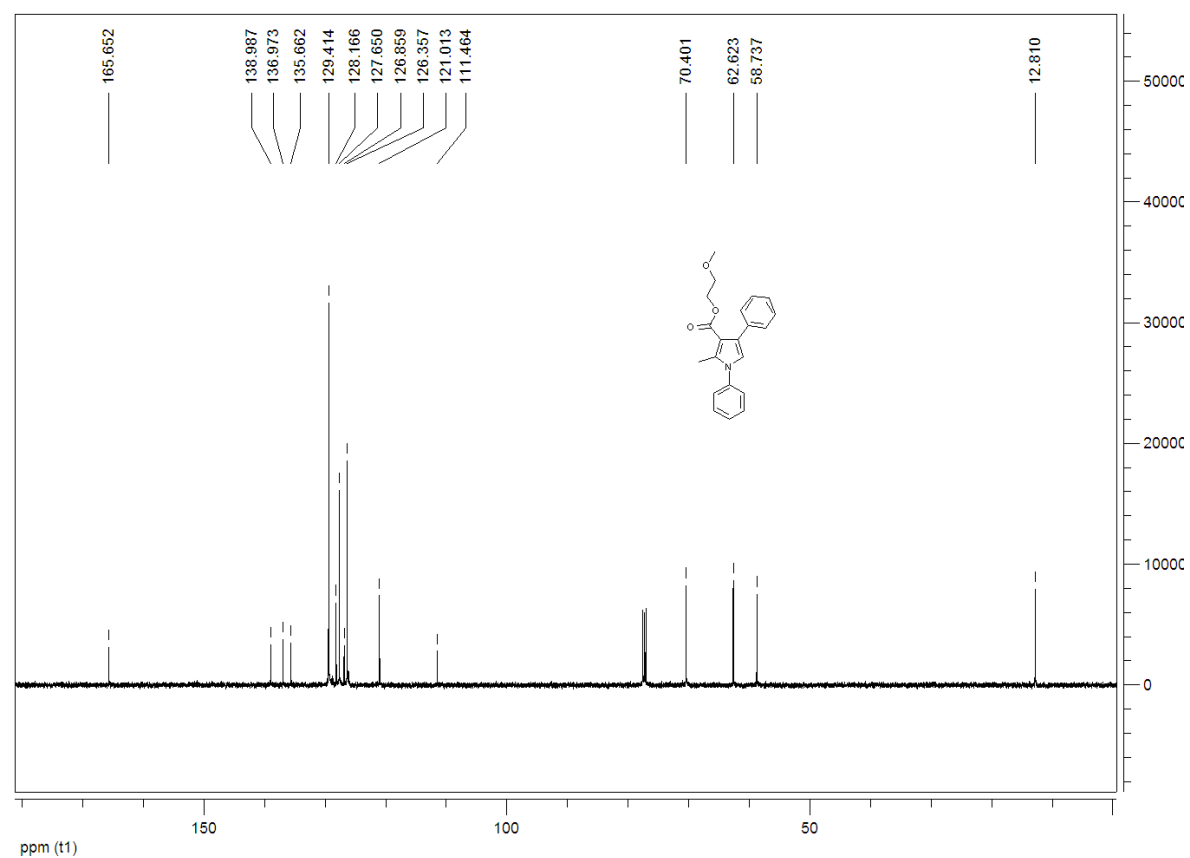
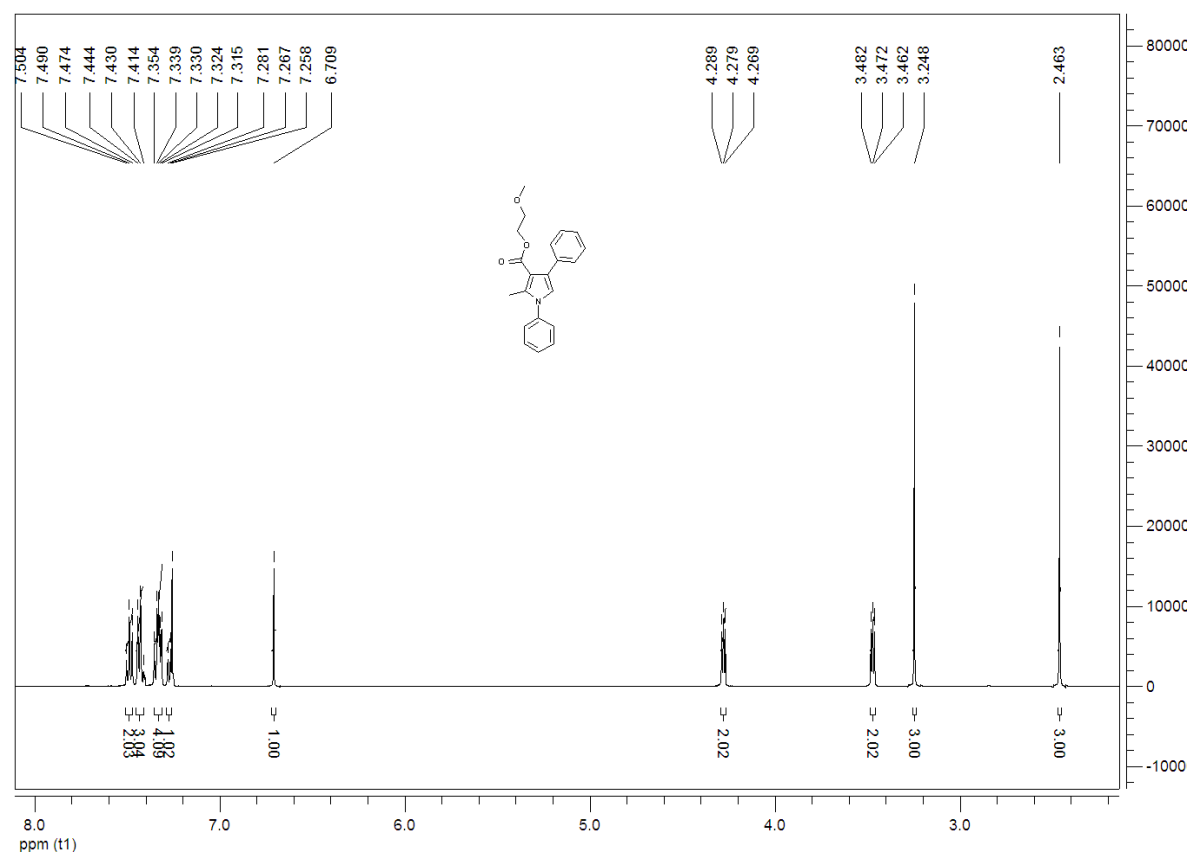
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5u**



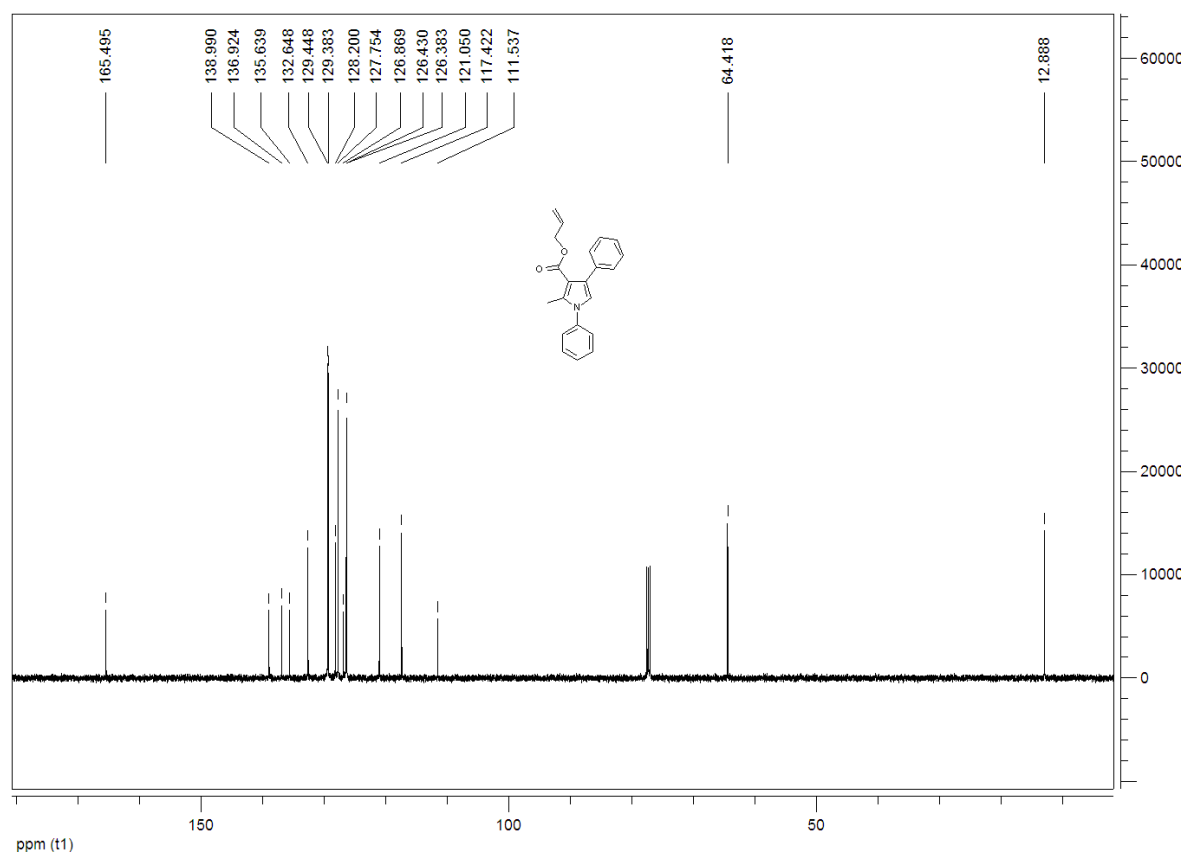
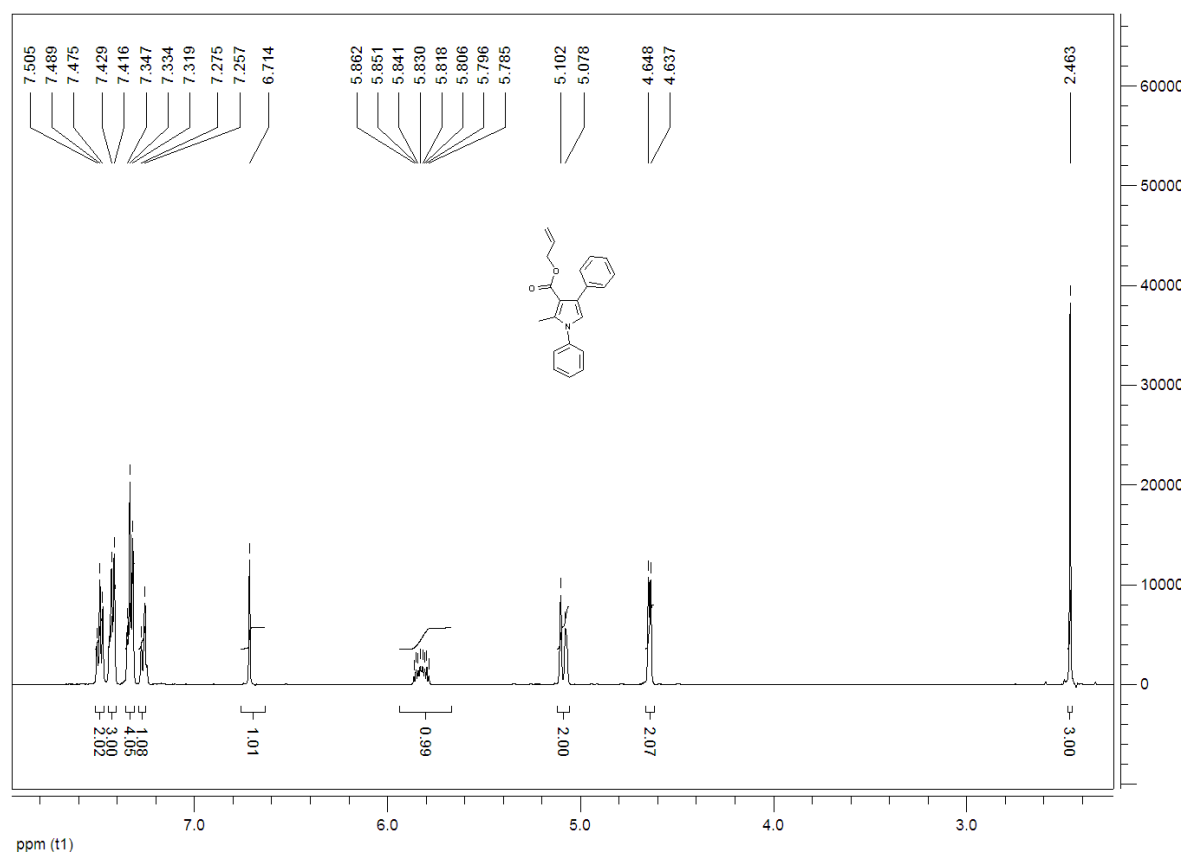
# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound 5v



# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5w**

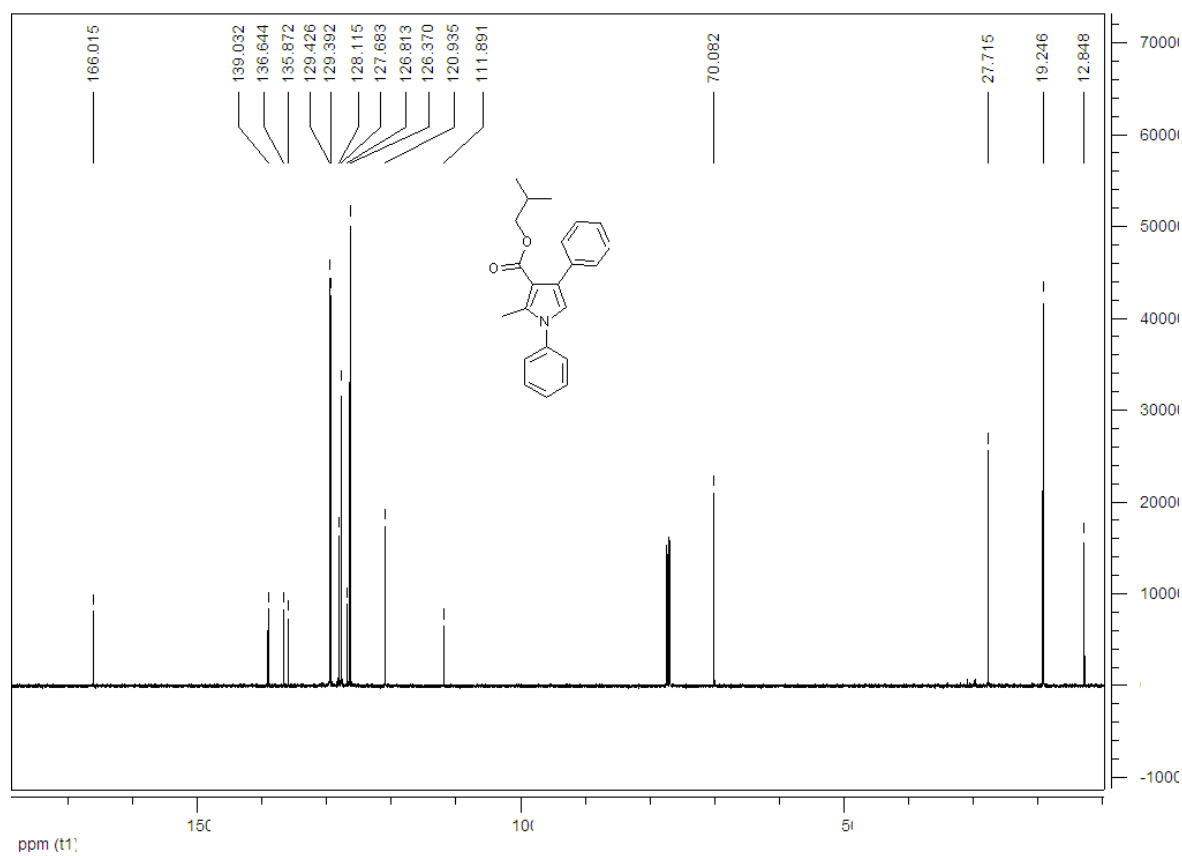
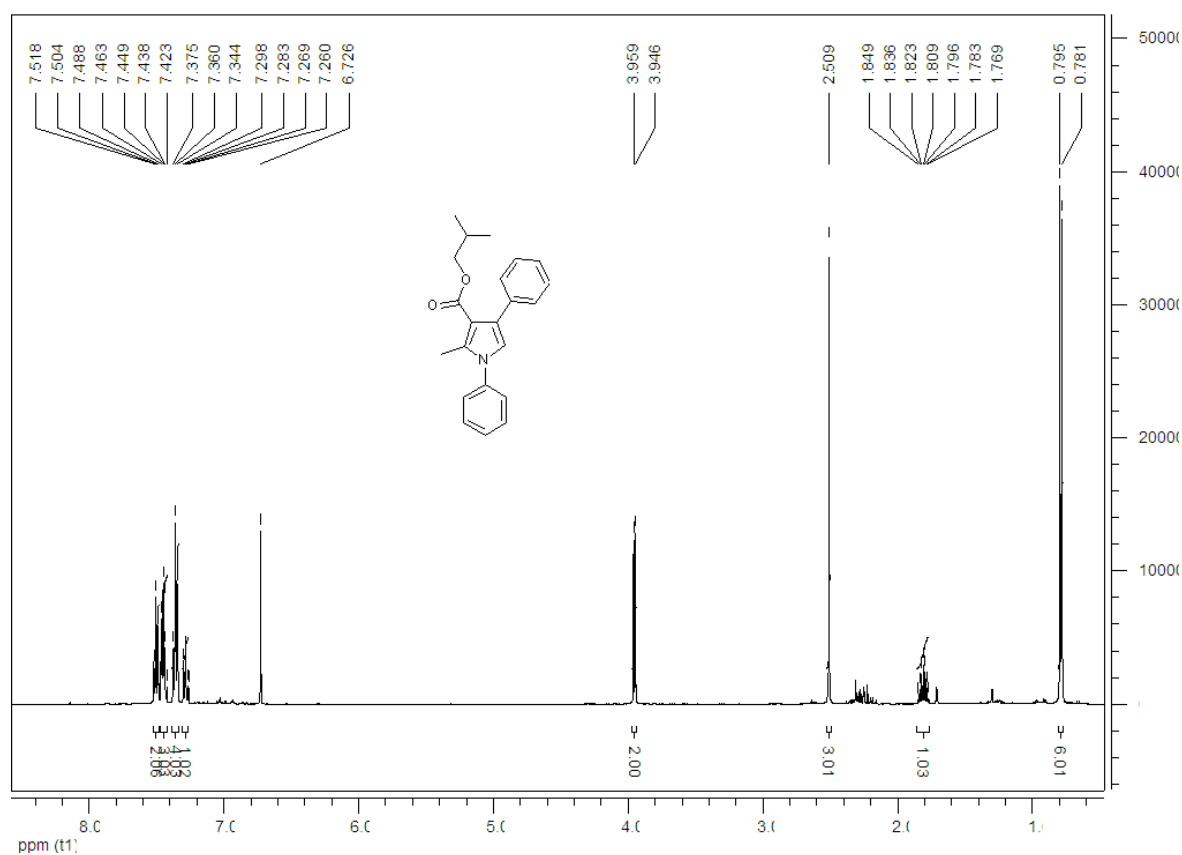


# $^1\text{H}$ NMR and $^{13}\text{C}$ NMR of compound **5x**

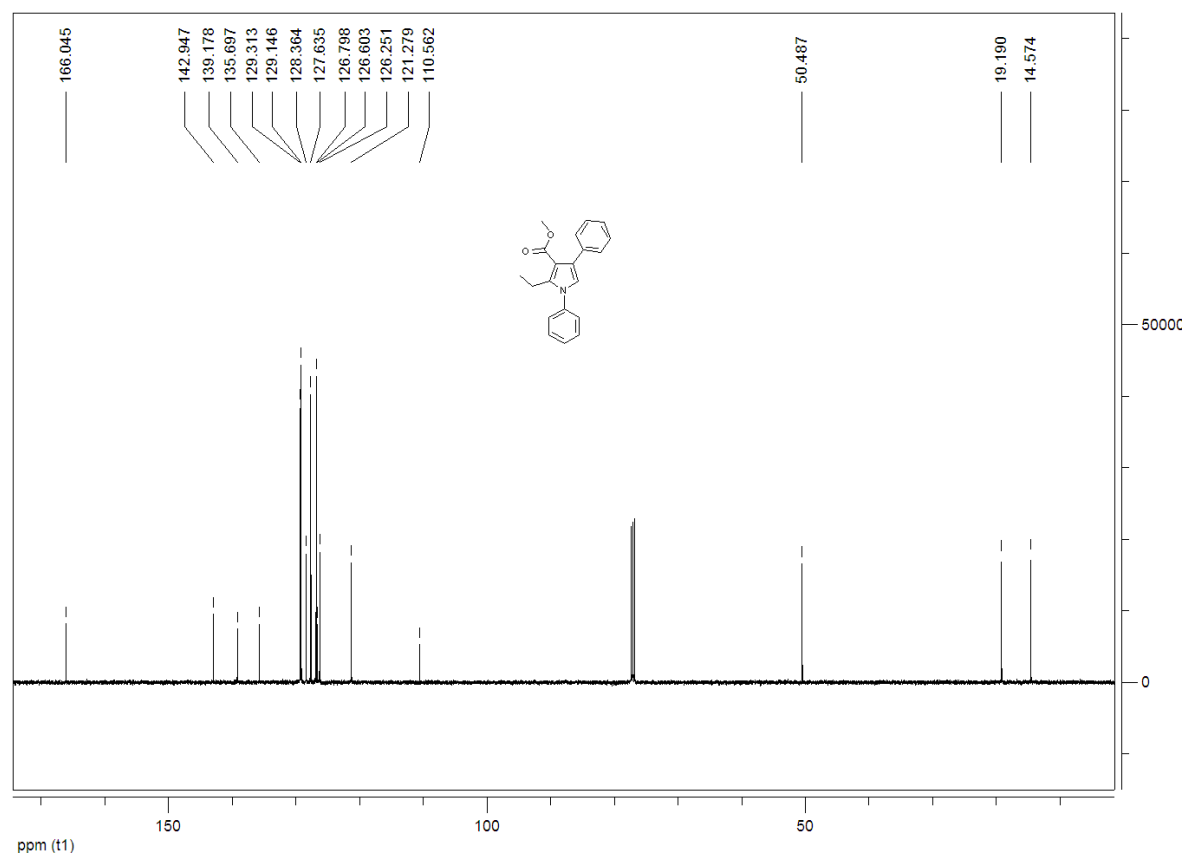
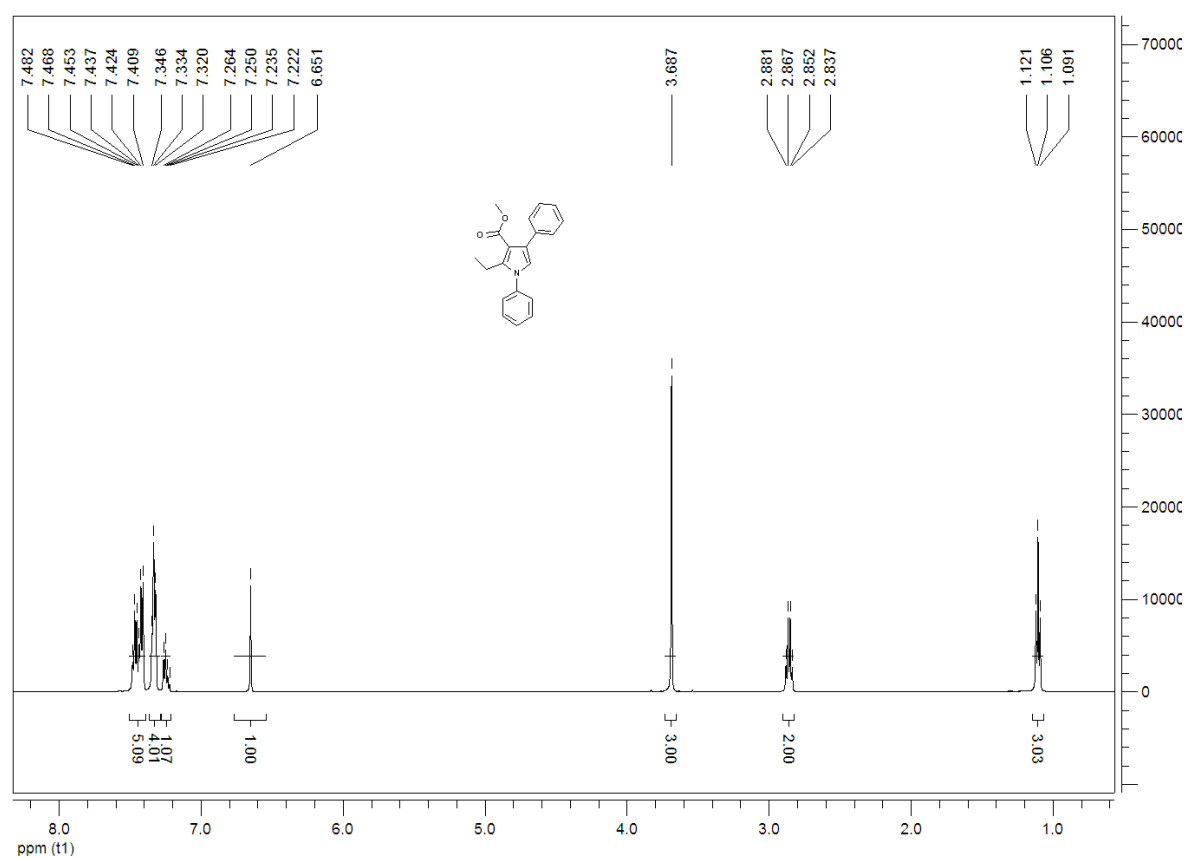




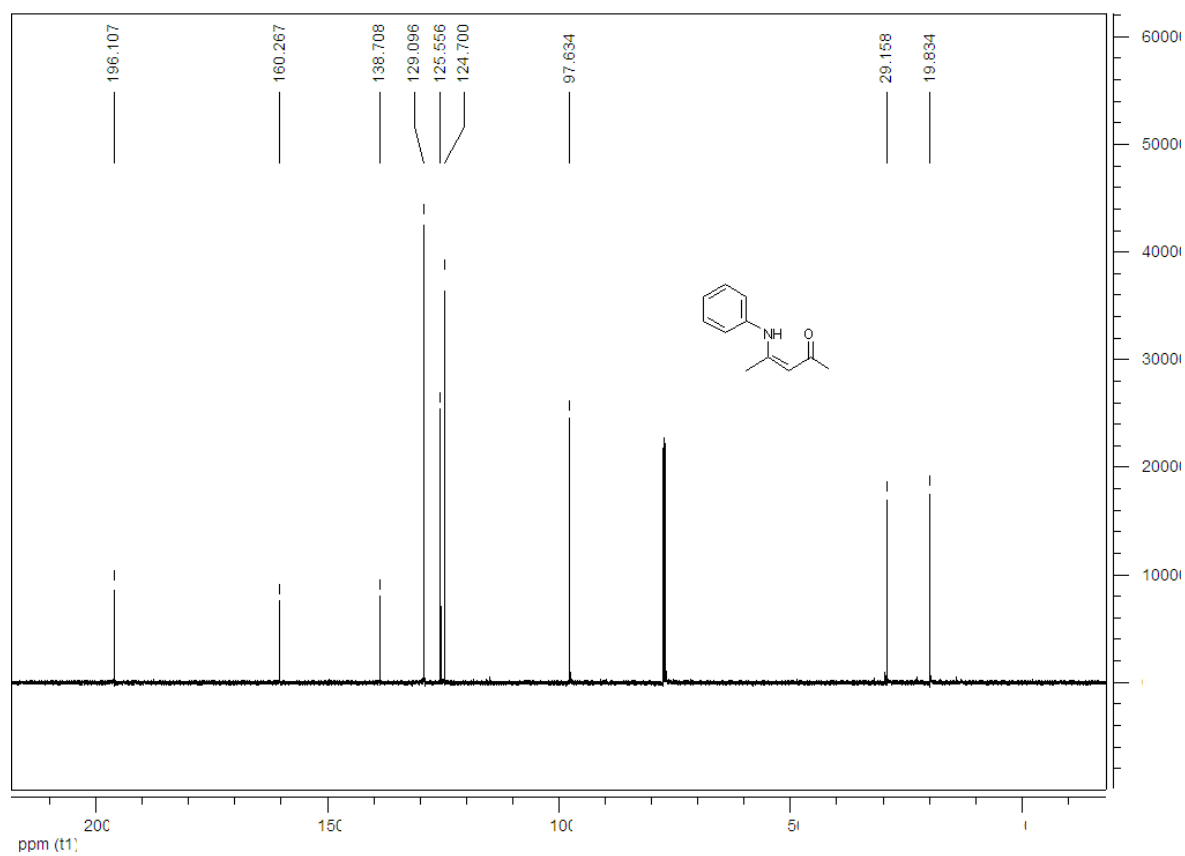
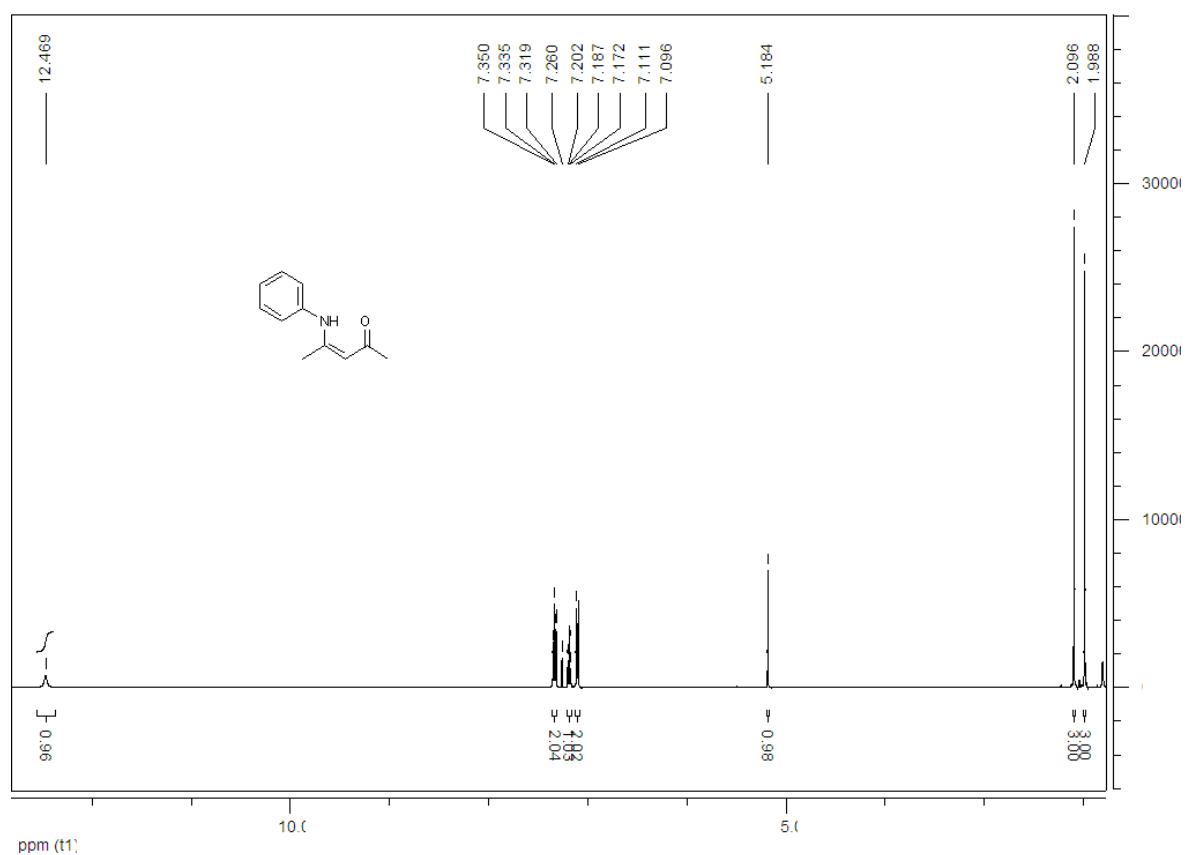
$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **5z**



# <sup>1</sup>H NMR and <sup>13</sup>C NMR of compound **5aa**



$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **intermediate A**





$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR of compound **intermediate B**

