

# European Journal of Organic Chemistry

## Supporting Information

### Synthesis of Lactams by Reductive Amination of Carbonyl Derivatives with $\omega$ -Amino Fatty Acids under Hydrosilylation Conditions

Satawat Tongdee<sup>+</sup>, Duo Wei<sup>+</sup>, Jiajun Wu<sup>+</sup>, Chakkrit Netkaew, and Christophe Darcel\*

## **Supporting Information**

### **Contents**

1- General information	S2
2- General procedure for reductive amination of carbonyl derivatives with $\omega$ -amino fatty acids	S2
3- Characterization data of cyclic amides	S3
4- NMR Spectra	S12
5- References	S42

## 1) General information

All reagents were obtained from commercial sources and used as received. All reactions were carried out with dried glassware using standard Schlenk techniques under ambient air atmosphere. Technical grade heptane and ethyl acetate were used for column chromatography. Analytical TLC was performed on Merck 60F254 silica gel plates (0.25 mm thickness). Column chromatography was performed on Acros Organics Ultrapure silica gel (mesh size 40-60 µm, 60Å).

Melting points of the new solid compounds were measured using Kofler hot-stage apparatus and are uncorrected.

FTIR-ATR spectra were recorded at room temperature on a Shimadzu IR Affinity-1 apparatus and are reported in cm<sup>-1</sup>.

<sup>1</sup>H NMR spectra were recorded in CDCl<sub>3</sub> at ambient temperature on Bruker AVANCE 400 spectrometers at 400.1 MHz, using the solvent as the internal standard (7.26 ppm,). <sup>13</sup>C NMR spectra were obtained at 100 MHz and referenced to the internal solvent signals (central peak is 77.16 ppm). <sup>19</sup>F NMR spectra were obtained at 376 MHz in CDCl<sub>3</sub>. Chemical shift ( $\delta$ ) and coupling constants ( $J$ ) are given in ppm and in Hz respectively. The peak patterns are indicated as follows: (s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet, and br. for broad).

GC analyses were performed with GC-2014 (Shimadzu) 2010 equipped with a 30-m capillary column (Supelco, SPBTM-20, fused silica capillary column, 30 M × 0.25 mm × 0.25 mm film thickness), which was used with argon as vector gas. The following GC conditions were used: Initial temperature 80 °C for 2 minutes, then rate 10 °C/min. until 220 °C and 220 °C for 15 minutes.

GC-MS were measured by GCMS-QP2010S (Shimadzu) with GC-2010 equipped with a 30-m capillary column (Supelco, SLBTM-5ms, fused silica capillary column, 30 M × 0.25 mm × 0.25 mm film thickness), which was used with helium as vector gas. The following GC-MS conditions were used: initial temperature 100 °C, for 2 minutes, then rate 10 °C/min. until 250 °C and 250 °C for 10 minutes.

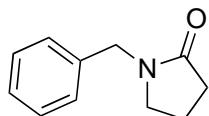
HR-MS spectra were performed using a time flight Agilent 6510 (Agilent Technologies Santa Clara (CA), USA) in Electrospray positive ionization mode at the Centre Régional de Mesures Physiques de l'Ouest, (CRMPO, ScanMAT, UMS 2001 CNRS - University Rennes 1).

## 2) General procedure for reductive amination of carbonyl derivatives with $\omega$ -amino fatty acids

In a 20 mL Schlenk tube under air,  $\omega$ -amino fatty acids **2**, **6** or **8** (0.5 mmol), carbonyl derivatives **1** (0.6 mmol), PhSiH<sub>3</sub> (123.4 µL, 2 equiv.) and ethanol (0.5 mL) were stirred at 40 °C for 18 h. After cooling to room temperature, the reaction mixture was dried under reduced pressure, and then the crude mixture was distilled using a bulb-to-bulb distillation apparatus at 200 °C. The distilled residue was then subjected to column chromatography (silica gel; ethyl acetate as the eluent) to afford the desired product.

### 3) Characterization data of cyclic amides

#### 1-Benzylpyrrolidin-2-one (**7a**)<sup>1</sup>



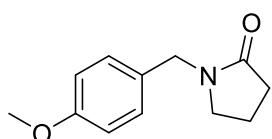
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), benzaldehyde (63.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7a** in 95% yield as a yellow oil.

**<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>)**  $\delta$  7.38 – 7.18 (m, 5H), 4.43 (s, 2H), 3.23 (t, *J* = 6.9 Hz, 2H), 2.42 (t, *J* = 8.1 Hz, 2H), 2.05 – 1.90 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (75 MHz, CDCl<sub>3</sub>)**  $\delta$  175.1, 136.7, 128.8, 128.3, 127.7, 46.7, 46.7, 31.1, 17.9.

**GC-MS, m/z(%)** = 175([M]+, 67), 146(40), 91(100), 77(39).

#### 1-(4-Methoxybenzyl)pyrrolidin-2-one (**7b**)<sup>2</sup>



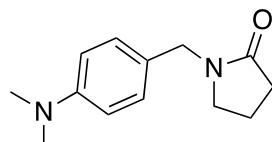
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), *p*-methoxybenzaldehyde (68.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7b** in 83% yield as a colorless solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.13 (d, *J* = 8.6 Hz, 2H), 6.81 (d, *J* = 8.6 Hz, 2H), 4.34 (s, 2H), 3.74 (s, 3H), 3.20 (t, *J* = 7.1 Hz, 2H), 2.37 (t, *J* = 8.1 Hz, 2H), 2.01 – 1.84 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.7, 159.0, 129.4, 128.7, 114.0, 55.2, 46.5, 45.9, 31.0, 17.7.

**GC-MS, m/z(%)** = 205([M]+, 53), 176(28), 121(100), 91(20), 77(35).

#### 1-(4-(Dimethylamino)benzyl)pyrrolidin-2-one (**7c**)



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), *p*-(*N,N*-dimethylamino)benzaldehyde (74.6 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7c** in 42% yield as a brown solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.12 (d, *J* = 8.4 Hz, 2H), 6.68 (d, *J* = 8.4 Hz, 2H), 4.35 (s, 2H), 3.23 (t, *J* = 7.1 Hz, 2H), 2.93 (s, 6H), 2.41 (t, *J* = 8.1 Hz, 2H), 1.99 – 1.90 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.8, 150.2, 129.5, 124.4, 112.7, 46.6, 46.2, 40.7, 31.3, 17.8.

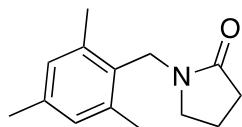
**GC-MS, m/z(%)** = 218([M]+, 65), 189(18), 134(100), 91(10), 77(4).

**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for C<sub>13</sub>H<sub>18</sub>N<sub>2</sub>ONa<sup>+</sup> 241.1311, found 241.1311.

**IR (ATR):**  $\bar{\nu}$  = 2919 (w), 2890 (w), 2861 (w), 1670 (vs), 1660 (s), 1614 (m), 1523 (m), 1475 (m), 1448 (m), 1430 (m), 1420 (m), 1360 (m), 1258 (s), 1230 (m), 1190 (m), 1164 (s), 1125 (w), 1063 (w), 946 (w), 802 (s), 657 (m) cm<sup>-1</sup>.

**Mp:** 63 °C.

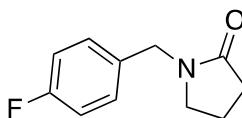
### 1-(2,4,6-Trimethylbenzyl)pyrrolidin-2-one (**7d**)



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 2,4,6-trimethylbenzaldehyde (71.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7d** in 67% yield as a colorless oil.  
<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  6.85 (s, 2H), 4.50 (s, 2H), 3.06 (t, *J* = 7.0 Hz, 2H), 2.40 (t, *J* = 8.1 Hz, 2H), 2.27 (s, 6H), 2.26 (s, 3H), 1.97 – 1.83 (m, 2H).

<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)  $\delta$  174.4, 137.8, 137.4, 129.3, 129.2, 45.7, 40.3, 31.1, 21.0, 20.0, 17.9.  
GC-MS, m/z(%) = 217([M]+, 25), 132(100), 117(28), 91(10), 77(4).  
HR-MS (ESI) *m/z*: [M+Na]<sup>+</sup> calcd for C<sub>14</sub>H<sub>19</sub>NONa<sup>+</sup> 240.1357, found 240.1357.  
IR (ATR):  $\bar{\nu}$  = 2950 (w), 2917 (w), 1678 (vs), 1605 (w), 1480 (w), 1450 (m), 1422 (s), 1285 (m), 1247 (m), 1225 (w), 1060 (w), 1028 (w), 1010 (w), 851 (m), 650 (m) cm<sup>-1</sup>.

### 1-(4-Fluorobenzyl)pyrrolidin-2-one (**7e**)



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), *p*-fluorobenzaldehyde (74.4 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7e** in 82% yield as a colorless oil. CAS 60736-96-1.

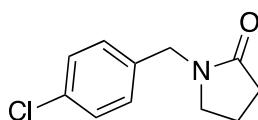
<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.22 (m, 2H), 7.01 (m, 2H), 4.42 (s, 2H), 3.25 (t, *J* = 7.1 Hz, 2H), 2.44 (t, *J* = 8.1 Hz, 2H), 2.04 – 1.96 (m, 2H).

<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)  $\delta$  175.1, 162.4 (d, *J* = 245.8 Hz), 132.6 (d, *J* = 3.1 Hz), 130.0 (d, *J* = 8.1 Hz), 115.7 (d, *J* = 21.3 Hz), 46.7, 46.1, 31.0, 17.9.

<sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>)  $\delta$  -114.9.

GC-MS, m/z(%) = 193([M]+, 60), 164(38), 109(100), 91(33), 77(5).

### 1-(4-Chlorobenzyl)pyrrolidin-2-one (**7f**)<sup>3</sup>



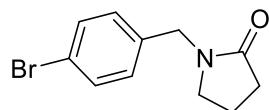
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), *p*-chlorobenzaldehyde (84.0 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7f** in 89% yield as a colorless oil.

<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.30 (d, *J* = 8.4 Hz, 2H), 7.18 (d, *J* = 8.4 Hz, 2H), 4.41 (s, 2H), 3.25 (t, *J* = 7.2 Hz, 2H), 2.44 (t, *J* = 8.1 Hz, 2H), 2.05 – 1.93 (m, 2H).

<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)  $\delta$  175.1, 135.3, 133.6, 129.6, 129.0, 46.7, 46.1, 31.0, 17.9.

GC-MS, m/z(%) = 211([M]+, 30), 209([M]+, 81), 180(10), 125(100), 91(17), 77(7).

**1-(4-Bromobenzyl)pyrrolidin-2-one (7g)<sup>4</sup>**



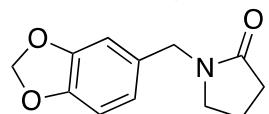
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), *p*-bromobenzaldehyde (92.5 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7g** in 84% yield as a colorless solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.38 (d, *J* = 8.4 Hz, 2H), 7.06 (d, *J* = 8.4 Hz, 2H), 4.33 (s, 2H), 3.19 (t, *J* = 7.2 Hz, 2H), 2.37 (t, *J* = 8.1 Hz, 2H), 2.00 – 1.87 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.9, 135.7, 131.7, 129.8, 121.4, 46.5, 45.9, 30.8, 17.7.

**GC-MS, m/z(%)** = 255([M]+, 84), 253([M]+, 84), 224(6), 169(48), 91(92), 77(16).

**1-(Benzo[*d*][1,3]dioxol-5-ylmethyl)pyrrolidin-2-one (7h)<sup>5</sup>**



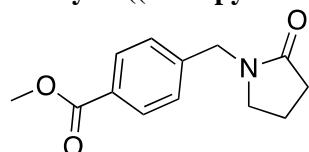
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 1,3-benzodioxole-5-carboxaldehyde (75.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7h** in 89% yield as a white solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  6.76 – 6.63 (m, 3H), 5.92 (s, 2H), 4.33 (s, 2H), 3.23 (t, *J* = 7.1 Hz, 2H), 2.40 (t, *J* = 8.1 Hz, 2H), 2.02 – 1.88 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.9, 148.0, 147.1, 130.6, 121.6, 108.6, 108.3, 101.1, 46.6, 46.4, 31.1, 17.8.

**GC-MS, m/z(%)** = 219([M]+, 80), 190(18), 135(100), 106(21), 77(57).

**Methyl 4-((2-oxopyrrolidin-1-yl)methyl)benzoate (7i)<sup>6</sup>**



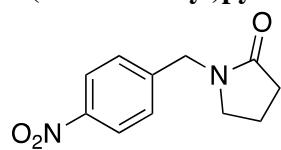
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), methyl 4-formylbenzoate (82.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7i** in 60% yield as a white solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.98 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.3 Hz, 2H), 4.48 (s, 2H), 3.89 (s, 3H), 3.25 (t, *J* = 7.1 Hz, 2H), 2.44 (t, *J* = 8.1 Hz, 2H), 2.07 – 1.94 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  175.2, 166.9, 141.9, 130.1, 129.6, 128.0, 52.2, 46.8, 46.4, 30.9, 17.9.

**GC-MS, m/z(%)** = 233([M]+, 100), 218(44), 174(41), 146(65), 91(40), 77(20).

**1-(4-Nitrobenzyl)pyrrolidin-2-one (7j)<sup>7</sup>**



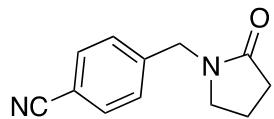
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 4-nitrobenzaldehyde (90.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7j** in 56% yield as a brown solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  8.18 (d, *J* = 8.7 Hz, 2H), 7.40 (d, *J* = 8.7 Hz, 2H), 4.54 (s, 2H), 3.29 (t, *J* = 7.1 Hz, 2H), 2.46 (t, *J* = 8.1 Hz, 2H), 2.16 – 1.89 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  175.4, 147.6, 144.3, 128.8, 124.1, 46.9, 46.2, 30.7, 17.9.

**GC-MS, m/z(%)** = 220([M]+, 100), 191(7), 136(18), 106(34), 91(32), 77(32).

**4-((2-Oxopyrrolidin-1-yl)methyl)benzonitrile (7k)<sup>8</sup>**



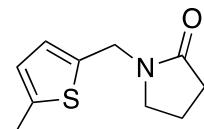
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 4-formylbenzonitrile (65.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7k** in 40% yield as a brown solid.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.60 (d, *J* = 8.3 Hz, 2H), 7.32 (d, *J* = 8.3 Hz, 2H), 4.47 (s, 2H), 3.26 (t, *J* = 7.1 Hz, 2H), 2.43 (t, *J* = 8.1 Hz, 2H), 2.17 – 1.95 (m, 2H).

**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  175.3, 142.2, 132.6, 128.6, 118.6, 111.5, 46.8, 46.3, 30.6, 17.8.

**GC-MS, m/z(%)** = 200([M]<sup>+</sup>, 87), 171(42), 116(100), 89(52), 77(5).

**1-((5-Methylthiophen-2-yl)methyl)pyrrolidin-2-one (7l)**



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 2-thiophenecarboxaldehyde (75.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7l** in 55% yield as a brown oil.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  6.72 (d, *J* = 3.4 Hz, 1H), 6.58 – 6.55 (m, 1H), 4.51 (s, 2H), 3.32 (t, *J* = 7.1 Hz, 2H), 2.42 (s, 3H), 2.39 (t, *J* = 8.1 Hz, 2H), 2.02 – 1.92 (m, 2H).

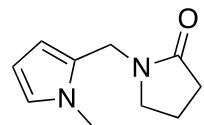
**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.6, 140.1, 136.7, 126.7, 124.9, 46.5, 41.3, 31.0, 17.8, 15.4.

**GC-MS, m/z(%)** = 195([M]<sup>+</sup>, 100), 166(10), 111(96), 97(17).

**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for C<sub>10</sub>H<sub>13</sub>NONa<sup>+</sup>S 218.0610, found 218.0608.

**IR (ATR):**  $\bar{\nu}$  = 2918 (w), 1671 (vs), 1485 (w), 1450 (w), 1430 (m), 1421 (s), 1355 (w), 1263 (s), 1230 (m), 1130 (w), 1052 (w), 801 (m), 743 (w), 680 (m) cm<sup>-1</sup>.

**1-((1-Methyl-1*H*-pyrrol-2-yl)methyl)pyrrolidin-2-one (7m)**



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 1-methyl-1*H*-pyrrole-2-carboxaldehyde (65.5 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7m** in 69% yield as a brown oil.

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  6.62 – 6.56 (m, 1H), 6.06 (dd, *J* = 3.5, 1.8 Hz, 1H), 6.03 (t, *J* = 3.1 Hz, 1H), 4.42 (s, 2H), 3.56 (s, 3H), 3.23 (t, *J* = 7.1 Hz, 2H), 2.39 (t, *J* = 8.1 Hz, 2H), 1.98 – 1.91 (m, 2H).

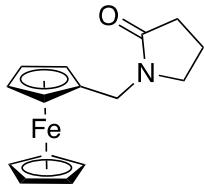
**<sup>13</sup>C- NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  174.2, phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7m** in 69% yield as a brown oil. 127.0, 123.1, 109.9, 106.8, 46.3, 38.1, 34.0, 31.3, 17.6.

**GC-MS, m/z(%)** = 178([M]<sup>+</sup>, 33), 149(6), 94(100), 80(5).

**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for C<sub>10</sub>H<sub>14</sub>N<sub>2</sub>ONa<sup>+</sup> 201.0998, found 201.0998.

**IR (ATR):**  $\bar{\nu}$  = 2947 (w), 2925 (w), 2880 (w), 1655 (vs), 1499 (m), 1460 (m), 1421 (s), 1353 (w), 1305 (s), 1264 (s), 1225 (m), 1200 (m), 1149 (w), 1089 (w), 1050 (w), 1021 (w), 1010 (w), 940 (w), 925 (w), 890 (w), 854 (w), 790 (w), 713 (s), 658 (m), 606 (m) cm<sup>-1</sup>.

### 1-(Ferrocenylmethyl)pyrrolidine-2-one (**7n**)



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), ferrocenylcarboxaldehyde (107.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7n** in 64% yield as an orange solid.

**$^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  4.24 (s, 2H), 4.20 – 4.17 (m, 2H), 4.18 (s, 5H), 4.13 – 4.10 (m, 2H), 3.27 (t,  $J$  = 7.1 Hz, 2H), 2.37 (t,  $J$  = 8.1 Hz, 2H), 1.98 – 1.89 (m, 2H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  174.3, 82.6, 69.4, 68.8, 68.4, 46.6, 42.2, 31.2, 17.7.

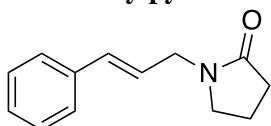
**GC-MS**, m/z(%) = 283([M]+, 92), 218(100), 189(6), 135(27), 121(23), 56(15).

**HR-MS (ESI)** m/z: [M+Na]<sup>+</sup> calcd for  $\text{C}_{15}\text{H}_{17}\text{NONa}^{+56}\text{Fe}$  306.0552, found 306.0551.

**IR (ATR):**  $\bar{\nu}$  = 2969 (w), 2930 (w), 2890 (w), 1666 (vs), 1530 (w), 1508 (m), 1459 (m), 1420 (w), 1390 (w), 1340 (m), 1263 (m), 1230 (w), 1150 (w), 1106 (m), 1042 (w), 1005 (w), 845 (w), 813 (m), 775 (w).

Mp: 137 °C

### 1-Cinnamylpyrrolidin-2-one (**7o**)



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), cinnamaldehyde (79.3 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7o** in 40% yield as a colorless oil.

**$^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.38 – 7.29 (m, 4H), 7.26 – 7.22 (m, 1H), 6.53 (d,  $J$  = 15.9 Hz, 1H), 6.11 (dt,  $J$  = 15.9, 6.6 Hz, 1H), 4.05 (d,  $J$  = 6.6 Hz, 2H), 3.39 (t,  $J$  = 7.1 Hz, 2H), 2.43 (t,  $J$  = 8.1 Hz, 2H), 2.09 – 1.94 (m, 2H).

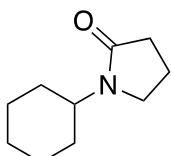
**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  174.9, 136.6, 133.4, 128.8, 128.0, 126.5, 124.1, 46.9, 44.9, 31.2, 17.9.

**GC-MS**, m/z(%) = 201([M]+, 30), 172(10), 117(42), 77(14).

**HR-MS (ESI)** m/z: [M+Na]<sup>+</sup> calcd for  $\text{C}_{13}\text{H}_{15}\text{NONa}^{+}$  224.1046, found 224.1048.

**IR (ATR):**  $\bar{\nu}$  = 2918 (w), 2970 (w), 2880 (w), 1651 (vs), 1505 (w), 1494 (m), 1450 (w), 1422 (m), 1287 (m), 1265 (m), 1225 (w), 1175 (w), 1066 (w), 1027 (w), 968 (w), 745 (m), 697 (s)  $\text{cm}^{-1}$ .

### 1-Cyclohexylpyrrolidin-2-one (**7p**)<sup>9</sup>



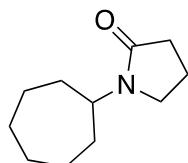
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), cyclohexanone (58.9 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7p** in 63% yield as a colorless oil.

**$^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  4.00 – 3.86 (m, 1H), 3.31 (t,  $J$  = 7.0 Hz, 2H), 2.35 (t,  $J$  = 8.1 Hz, 2H), 2.02 – 1.89 (m, 2H), 1.80 – 1.73 (m, 2H), 1.70 – 1.59 (m, 3H), 1.46 – 1.26 (m, 4H), 1.15 – 0.98 (m, 1H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  174.3, 50.6, 43.0, 31.7, 30.4, 25.6, 25.6, 18.3.

**GC-MS**, m/z(%) = 167([M]+, 18), 124(53), 86(100), 56(20).

**1-Cycloheptylpyrrolidin-2-one (7q)**



4-Aminobutanoic acid (51.6 mg, 0.5 mmol), cycloheptanone (67.3 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7q** in 74% yield as a colorless oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  4.17 – 4.07 (m, 1H), 3.34 (t,  $J$  = 7.0 Hz, 2H), 2.34 (t,  $J$  = 8.1 Hz, 2H), 2.00 – 1.91 (m, 2H), 1.79 – 1.42 (m, 12H).

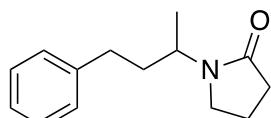
**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  173.7, 52.4, 42.9, 32.6, 31.6, 27.9, 24.9, 18.3.

**GC-MS**, m/z(%) = 181([M]+, 9), 124(59), 86(100), 56(12).

**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for  $\text{C}_{11}\text{H}_{19}\text{NONa}^+$  204.1359, found 204.1357.

**IR (ATR):**  $\bar{\nu}$  = 2921 (s), 2856 (s), 1661 (vs), 1500 (w), 1470 (w), 1450 (m), 1422 (s), 1370 (w), 1325 (w), 1305 (w), 1285 (s), 1260 (s), 1217 (m), 1162 (m), 640 (w)  $\text{cm}^{-1}$ .

**1-(4-Phenylbutan-2-yl)pyrrolidin-2-one (7r)<sup>10</sup>**



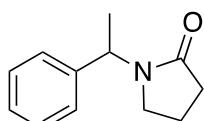
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 4-phenylbutan-2-one (88.9 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7r** in 68% yield as a colorless oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.31 – 7.26 (m, 2H), 7.21 – 7.15 (m, 3H), 4.38 – 4.22 (m, 1H), 3.37 – 3.19 (m, 2H), 2.68 – 2.48 (m, 2H), 2.42 – 2.33 (m, 2H), 2.05 – 1.64 (m, 4H), 1.16 (d,  $J$  = 6.8 Hz, 3H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  174.8, 141.8, 128.5, 128.3, 126.0, 46.8, 41.9, 35.8, 33.1, 31.7, 18.4, 18.1.

**GC-MS**, m/z(%) = 217([M]+, 30), 112(100), 98(33), 69(38).

**1-(1-Phenylethyl)pyrrolidin-2-one (7s)<sup>11</sup>**



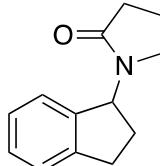
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), acetophenone (72.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7s** in 22% yield as a colorless oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.38 – 7.24 (m, 5H), 5.50 (q,  $J$  = 7.2 Hz, 1H), 3.36 – 3.29 (m, 1H), 3.02 – 2.95 (m, 1H), 2.49 – 2.34 (m, 2H), 2.04 – 1.82 (m, 2H), 1.52 (d,  $J$  = 7.2 Hz, 3H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  174.6, 140.4, 128.7, 127.6, 127.2, 49.1, 42.4, 31.6, 18.1, 16.4.

**GC-MS**, m/z(%) = 189([M]+, 86), 160(35), 105(100), 91(34), 77(65).

**1-(2,3-Dihydro-1*H*-inden-1-yl)pyrrolidin-2-one (7t)<sup>12</sup>**



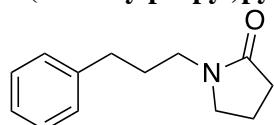
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 1-indanone (79.3 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7t** in 10% yield as a brown solid.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.26 – 7.09 (m, 4H), 5.80 (t,  $J = 7.7$  Hz, 1H), 3.25 – 3.17 (m, 1H), 3.06 – 3.01 (m, 1H), 3.01 – 2.86 (m, 2H), 2.50 – 2.45 (m, 2H), 2.44 – 2.34 (m, 1H), 2.06 – 1.89 (m, 3H).

**$^{13}\text{C}\{^1\text{H}\} \text{NMR}$  (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  175.2, 143.7, 140.9, 128.0, 126.8, 125.0, 124.3, 56.4, 42.8, 31.7, 30.7, 29.3, 18.3.

**GC-MS**, m/z(%) = 201([M]+, 13), 172(1), 116(70), 77(5).

**1-(3-Phenylpropyl)pyrrolidin-2-one (7u)<sup>13</sup>**



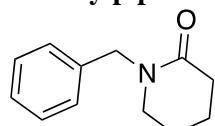
4-Aminobutanoic acid (51.6 mg, 0.5 mmol), 3-phenylpropanal (80.5 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **7u** in 10% yield as a colorless oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.31 – 7.26 (m, 2H), 7.24 – 7.13 (m, 3H), 3.34 (t,  $J = 7.0$  Hz, 4H), 2.63 (t,  $J = 8.1$  Hz, 2H), 2.36 (t,  $J = 8.1$  Hz, 2H), 2.01 – 1.93 (m, 2H), 1.89 – 1.81 (m, 2H).

**$^{13}\text{C}\{^1\text{H}\} \text{NMR}$  (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  175.1, 141.6, 128.5, 128.4, 126.1, 47.2, 42.5, 33.4, 31.1, 29.1, 18.0.

**GC-MS**, m/z(%) = 203([M]+, 30), 99(100), 70(15).

**1-Benzylpiperidin-2-one (3a)<sup>14</sup>**



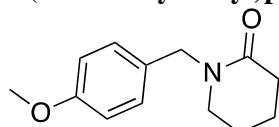
5-Aminopentanoic acid (58.6 mg, 0.5 mmol), benzaldehyde (63.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **3a** in 90% yield as an orange oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.33 – 7.23 (m, 5H), 4.60 (s, 2H), 3.20 (t,  $J = 5.6$  Hz, 2H), 2.47 (t,  $J = 6.2$  Hz, 2H), 1.83 – 1.72 (m, 4H).

**$^{13}\text{C}\{^1\text{H}\} \text{NMR}$  (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  170.0, 137.5, 128.7, 128.2, 127.4, 50.2, 47.4, 32.6, 23.4, 21.6.

**GC-MS**, m/z(%) = 189([M]+, 63), 105(28), 160(7), 91(100), 77(7).

**1-(4-Methoxybenzyl)piperidin-2-one (3b)<sup>15</sup>**



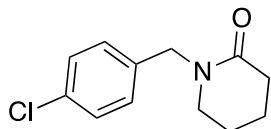
5-Aminopentanoic acid (58.6 mg, 0.5 mmol), *p*-methoxybenzaldehyde (68.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **3b** in 62% yield as a colorless oil.

**$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )**  $\delta$  7.17 (d,  $J = 8.6$  Hz, 2H), 6.83 (d,  $J = 8.6$  Hz, 2H), 4.51 (s, 2H), 3.77 (s, 3H), 3.16 (t,  $J = 5.4$  Hz, 2H), 2.42 (t,  $J = 6.3$  Hz, 2H), 1.85 – 1.62 (m, 4H).

**$^{13}\text{C}\{^1\text{H}\} \text{NMR}$  (101 MHz,  $\text{CDCl}_3$ )**  $\delta$  169.8, 159.0, 129.5, 129.5, 114.0, 55.3, 49.5, 47.1, 32.5, 23.3, 21.5.

**HR-MS (ESI)**  $m/z$ : [M+Na]<sup>+</sup> calcd for  $\text{C}_{13}\text{H}_{17}\text{NO}_2\text{Na}^+$  242.1151, found 242.1152.

**1-(4-chlorobenzyl)piperidin-2-one (3c)<sup>2</sup>**



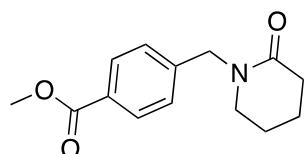
5-Aminopentanoic acid (58.6 mg, 0.5 mmol), *p*-chlorobenzaldehyde (84.0 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **3c** in 65% yield as a colorless solid.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.26 (d, *J* = 8.4 Hz, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 4.53 (s, 2H), 3.16 (t, *J* = 6.2 Hz, 2H), 2.43 (t, *J* = 6.2 Hz, 2H), 1.82 – 1.71 (m, 4H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  170.0, 136.0, 133.2, 129.6, 128.8, 49.6, 47.4, 32.5, 23.3, 21.4.

**GC-MS, m/z(%)** = 225([M]<sup>+</sup>, 25), 223([M]<sup>+</sup>, 65), 139(40), 125(100), 91(13), 77(10).

**Methyl 4-((2-oxopiperidin-1-yl)methyl)benzoate (3d)**



5-Aminopentanoic acid (58.6 mg, 0.5 mmol), methyl 4-formylbenzoate (82.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **3d** in 51% yield as a white solid.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.97 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.3 Hz, 2H), 4.63 (s, 2H), 3.89 (s, 3H), 3.18 (t, *J* = 5.5 Hz, 2H), 2.47 (t, *J* = 6.3 Hz, 2H), 1.84 – 1.73 (m, 4H).

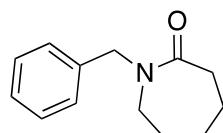
**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  170.1, 167.0, 142.8, 130.0, 129.4, 128.0, 52.2, 50.1, 47.7, 32.5, 23.3, 21.5.

**HR-MS (ESI) m/z:** [M+H]<sup>+</sup> calcd for C<sub>14</sub>H<sub>18</sub>NO<sub>3</sub><sup>+</sup> 248.1281, found 248.1283.

**IR (ATR):**  $\bar{\nu}$  = 2960 (w), 2939 (w), 2900 (w), 1716 (vs), 1633 (s), 1610 (w), 1508 (m), 1435 (w), 1417 (m), 1339 (w), 1278 (s), 1260 (m), 1250 (m), 1176 (m), 1112 (m), 1090 (w), 1019 (w), 958 (w), 900 (w), 870 (w), 800 (w), 761 (s), 725 (m), 696 (m), 657 (w) cm<sup>-1</sup>.

Mp: 87 °C

**1-Benzylazepan-2-one (9a)<sup>16</sup>**



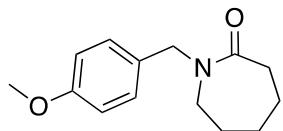
6-Aminohexanoic acid (65.6 mg, 0.5 mmol), benzaldehyde (63.7 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **9a** in 43% yield as a white solid.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.35 – 7.23 (m, 5H), 4.60 (s, 2H), 3.33 – 3.27 (m, 2H), 2.65 – 2.58 (m, 2H), 1.75 – 1.66 (m, 4H), 1.53 – 1.46 (m, 2H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  176.0, 138.0, 128.6, 128.2, 127.4, 51.2, 49.0, 37.3, 30.1, 28.2, 23.5.

**GC-MS, m/z(%)** = 203([M]<sup>+</sup>, 40), 106(37), 91(100), 77(14).

**1-(4-Methoxybenzyl)azepan-2-one (**9b**)<sup>17</sup>**



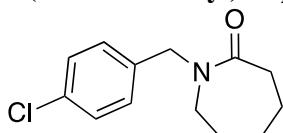
6-Aminohexanoic acid (65.6 mg, 0.5 mmol), *p*-methoxybenzaldehyde (68.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **9b** in 40% yield as a colorless solid.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.18 (d, *J* = 8.6 Hz, 2H), 6.83 (d, *J* = 8.6 Hz, 2H), 4.51 (s, 2H), 3.78 (s, 3H), 3.35 – 3.18 (m, 2H), 2.60 – 2.51 (m, 2H), 1.71 – 1.64 (m, 4H), 1.49 – 1.42 (m, 2H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  176.0, 159.0, 130.2, 129.6, 114.0, 55.4, 50.5, 48.8, 37.4, 30.1, 28.3, 23.6.

**GC-MS, m/z(%) =** 233([M]+, 34), 136(34), 121(100), 91(10), 77(13).

**1-(4-Chlorobenzyl)azepan-2-one (**9c**)**



6-Aminohexanoic acid (65.6 mg, 0.5 mmol), *p*-chlorobenzaldehyde (84.0 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **9c** in 35% yield as a colorless oil.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.28 (d, *J* = 8.4 Hz, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 4.54 (s, 2H), 3.46 – 3.16 (m, 2H), 2.80 – 2.46 (m, 2H), 1.75 – 1.64 (m, 4H), 1.57 – 1.41 (m, 2H).

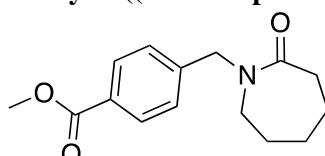
**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  176.1, 136.7, 133.3, 129.7, 128.8, 50.7, 49.2, 37.3, 30.1, 28.3, 23.5.

**GC-MS, m/z(%) =** 239([M]+, 11), 237([M]+, 35), 125(100), 89(32), 77(5).

**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for C<sub>13</sub>H<sub>16</sub>NO<sup>35</sup>ClNa<sup>+</sup> 206.0813, found 206.0812.

**IR (ATR):**  $\bar{\nu}$  = 2970 (w), 2927 (m), 2856 (w), 1633 (vs), 1489 (s), 1430 (m), 1420 (m), 1406 (s), 1353 (m), 1275 (w), 1260 (m), 1225 (w), 1191 (m), 1142 (w), 1083 (m), 1014 (m), 975 (m), 965 (w), 930 (w), 841 (m), 796 (s), 733 (w), 655 (w) cm<sup>-1</sup>.

**Methyl 4-((2-oxoazepan-1-yl)methyl)benzoate (**9d**)**



6-Aminohexanoic acid (65.6 mg, 0.5 mmol), methyl 4-formylbenzoate (82.1 mg, 0.6 mmol, 1.2 equiv.) and phenylsilane (123.4  $\mu$ L, 1.0 mmol, 2 equiv.) gave the title compound **9d** in 48% yield as a white solid.

**$^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>)**  $\delta$  7.98 (d, *J* = 8.3 Hz, 2H), 7.32 (d, *J* = 8.3 Hz, 2H), 4.63 (s, 2H), 3.90 (s, 3H), 3.36 – 3.20 (m, 2H), 2.70 – 2.51 (m, 2H), 1.73 – 1.66 (m, 4H), 1.52 – 1.45 (m, 2H).

**$^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>)**  $\delta$  176.2, 167.0, 143.4, 130.0, 129.4, 128.1, 52.2, 51.1, 49.3, 37.2, 30.0, 28.3, 23.5.

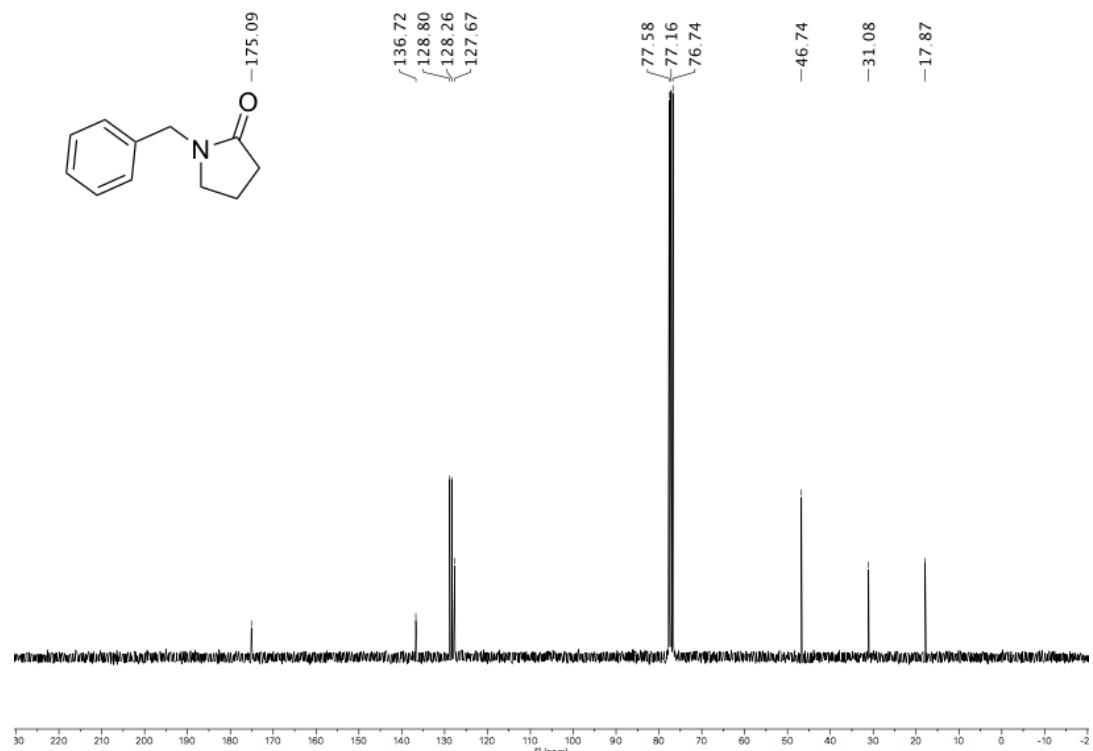
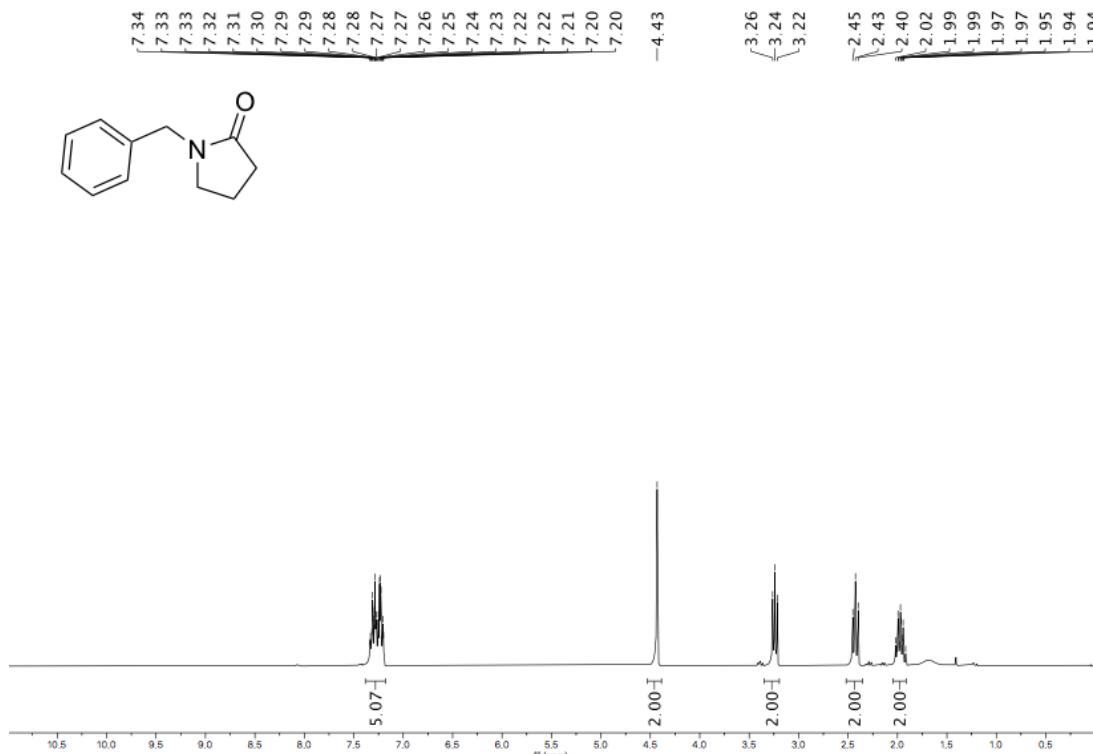
**GC-MS, m/z(%) =** 261([M]+, 91), 164(43), 149(100), 91(21), 77(15).

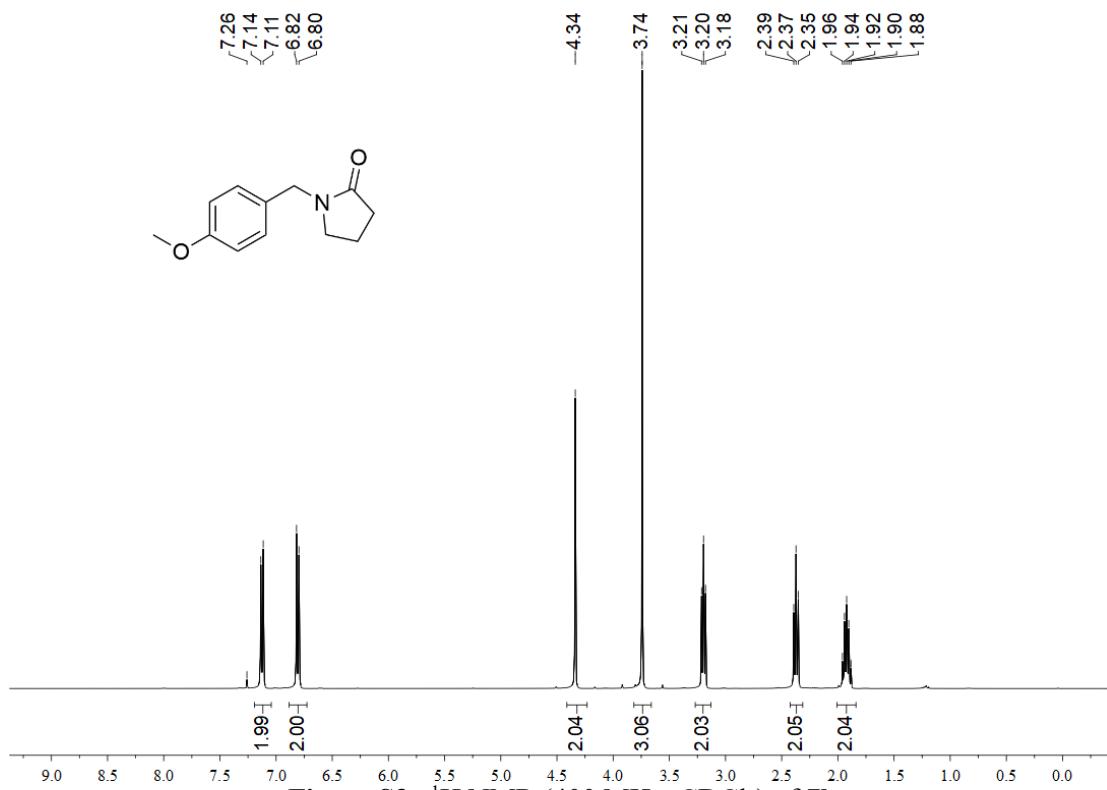
**HR-MS (ESI) m/z:** [M+Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>19</sub>NO<sub>3</sub>Na<sup>+</sup> 284.1257, found 284.1256.

**IR (ATR):**  $\bar{\nu}$  = 2955 (w), 2931 (m), 2855 (w), 1713 (vs), 1640 (vs), 1610 (m), 1500 (w), 1486 (w), 1430 (w), 1416 (m), 1272 (m), 1198 (m), 1112 (m), 1090 (w), 1018 (w), 960 (m), 862 (w), 802 (w), 761 (s), 716 (m), 685 (m), 635 (w) cm<sup>-1</sup>.

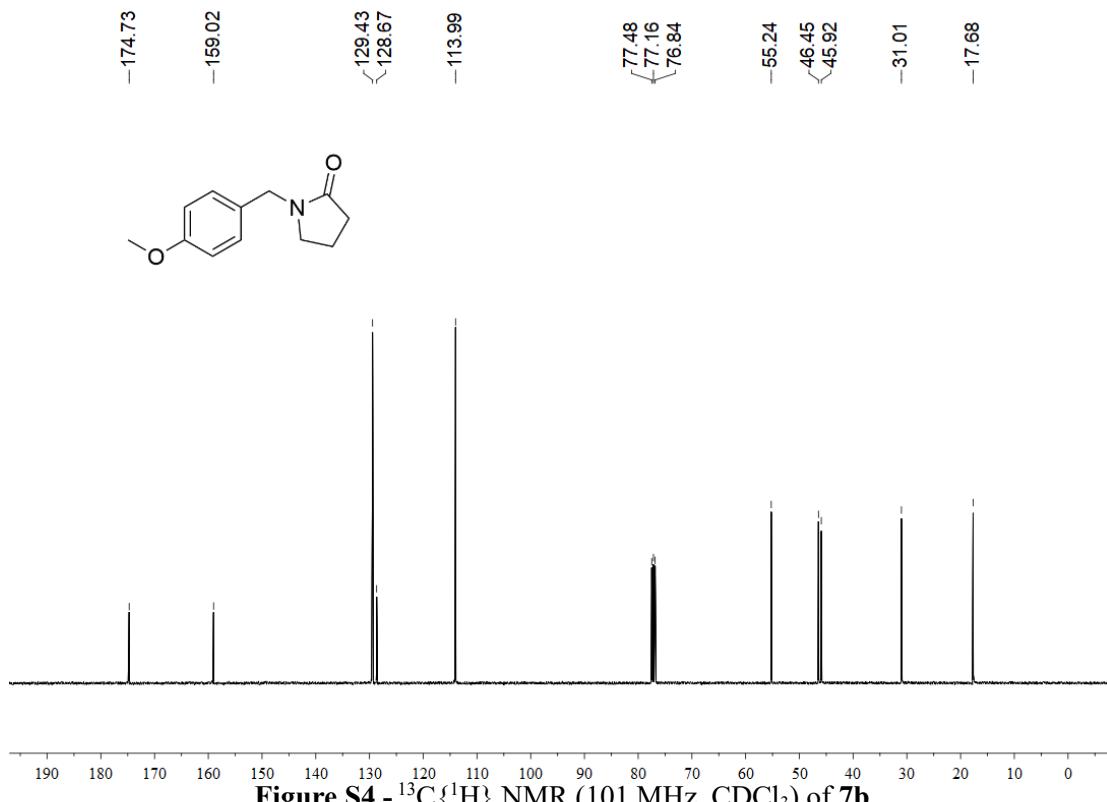
**Mp:** 99 °C.

**4) NMR Spectra**

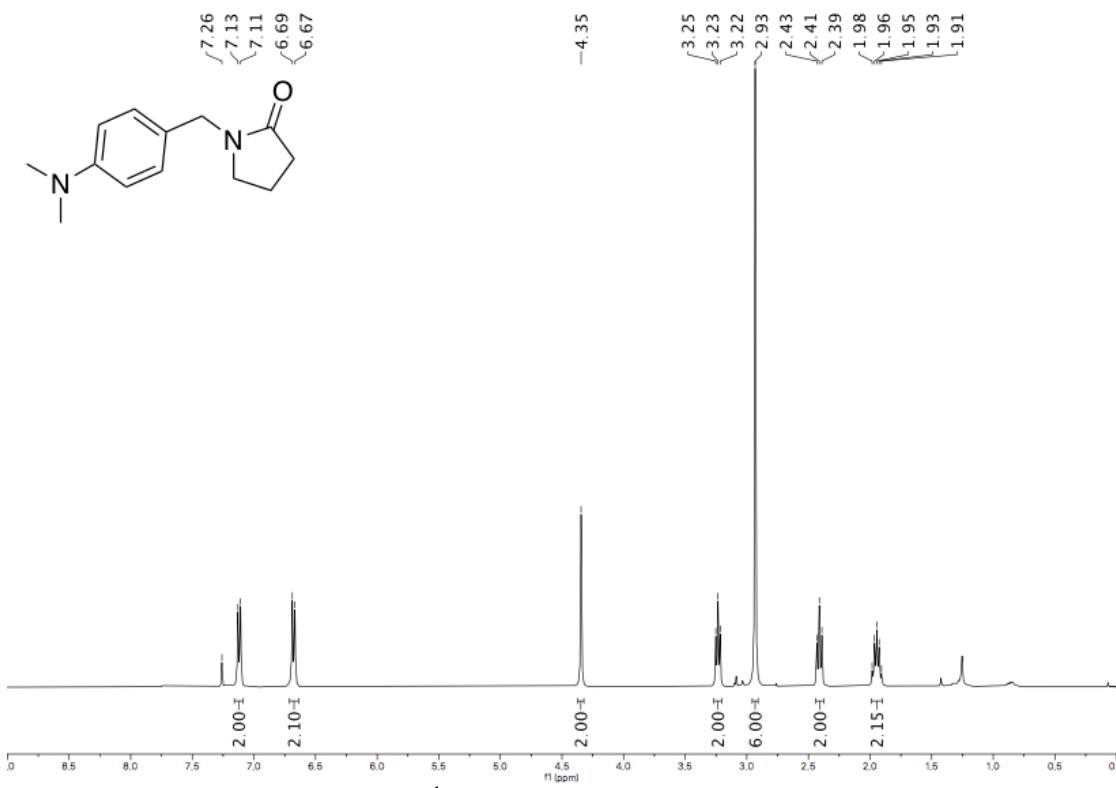




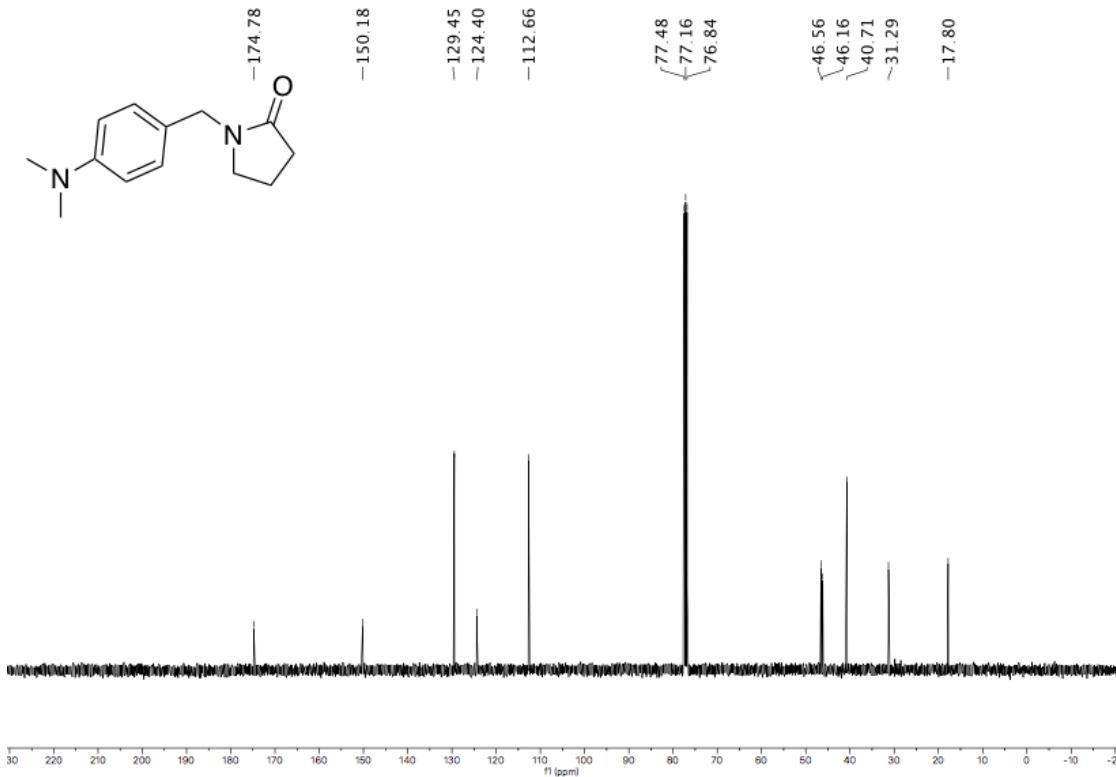
**Figure S3 -  $^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>) of 7b**



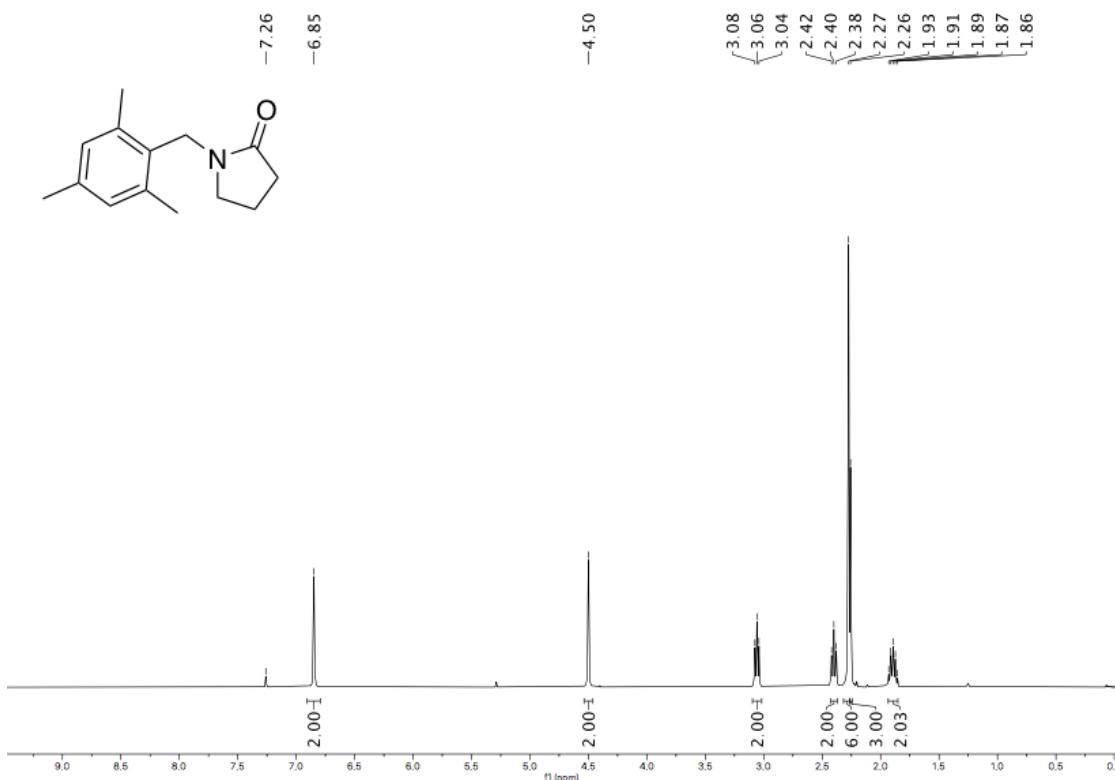
**Figure S4 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>) of 7b**



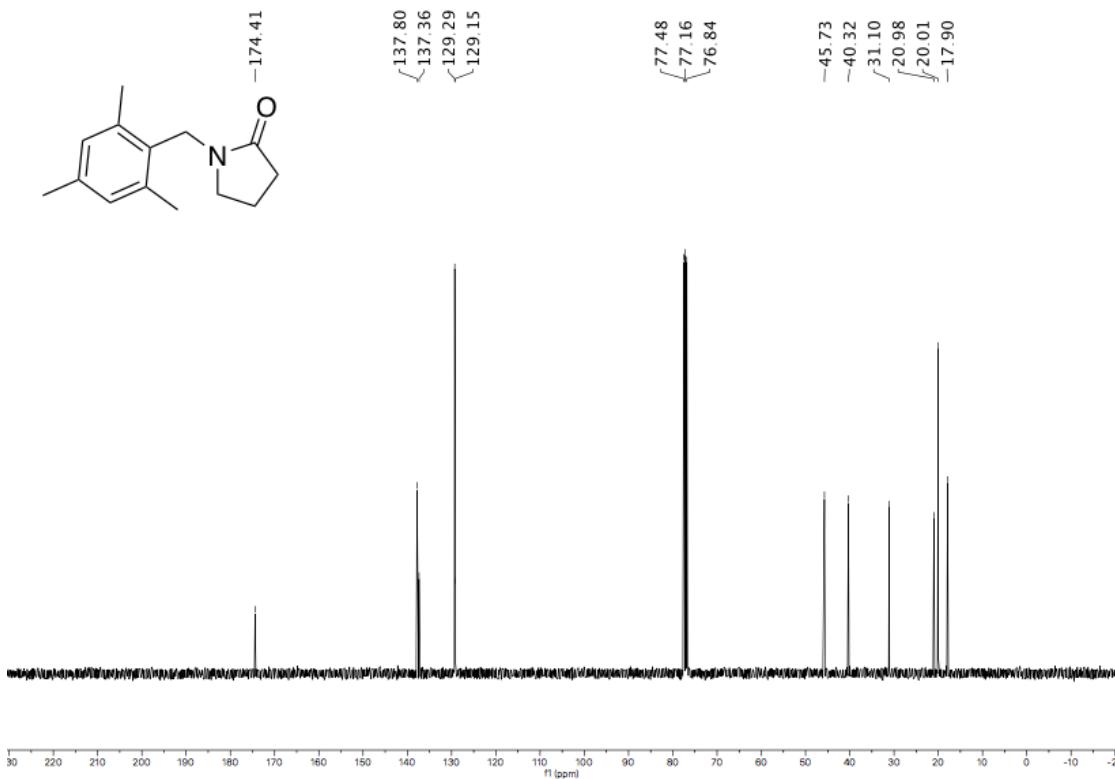
**Figure S5 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7c**



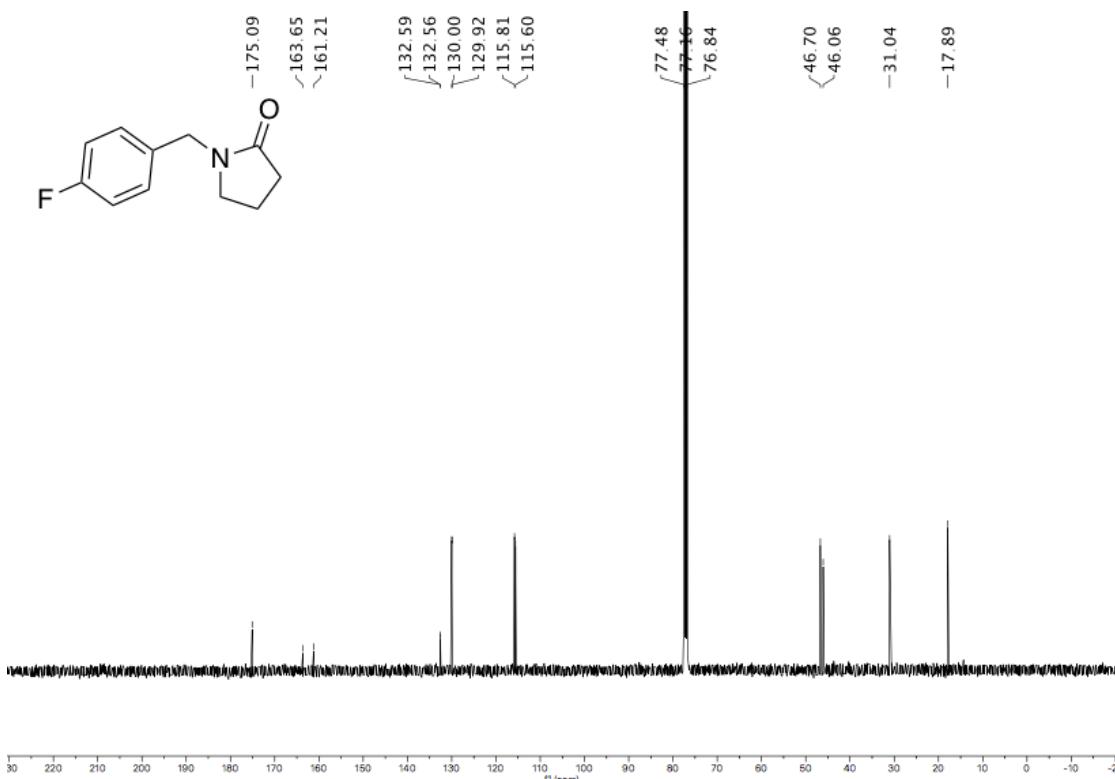
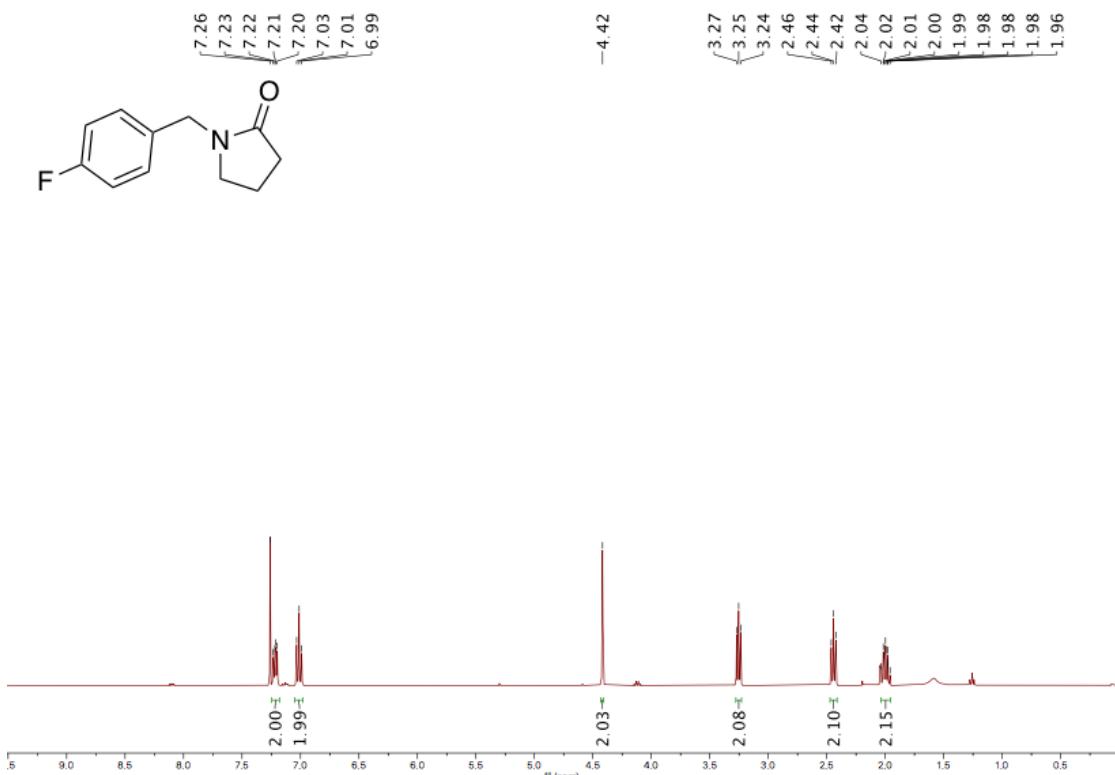
**Figure S6 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7c**

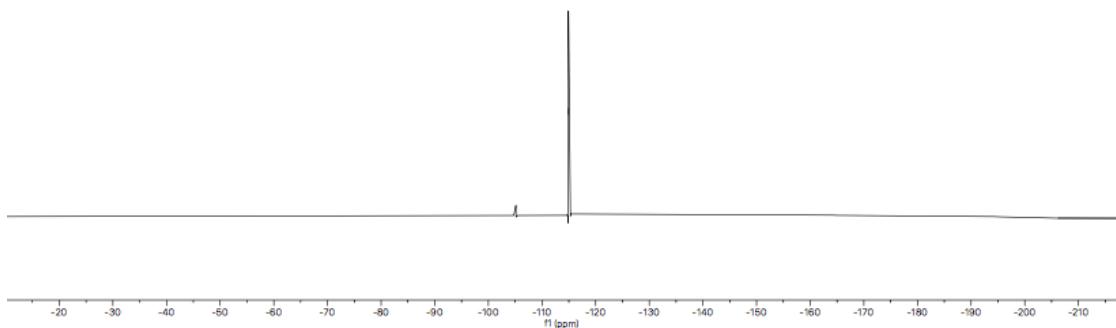
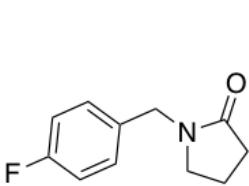


**Figure S7 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7d**

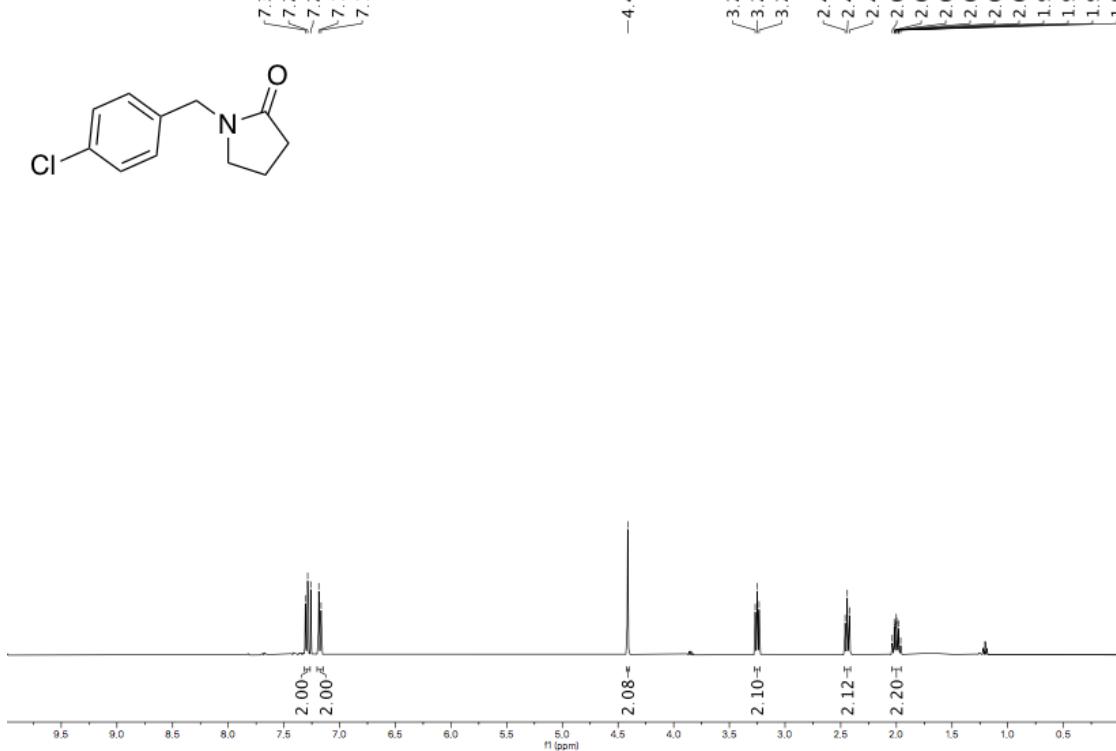
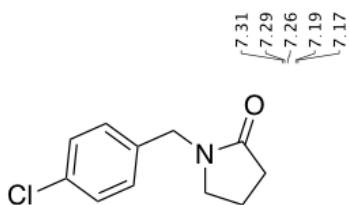


**Figure S8 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7d**

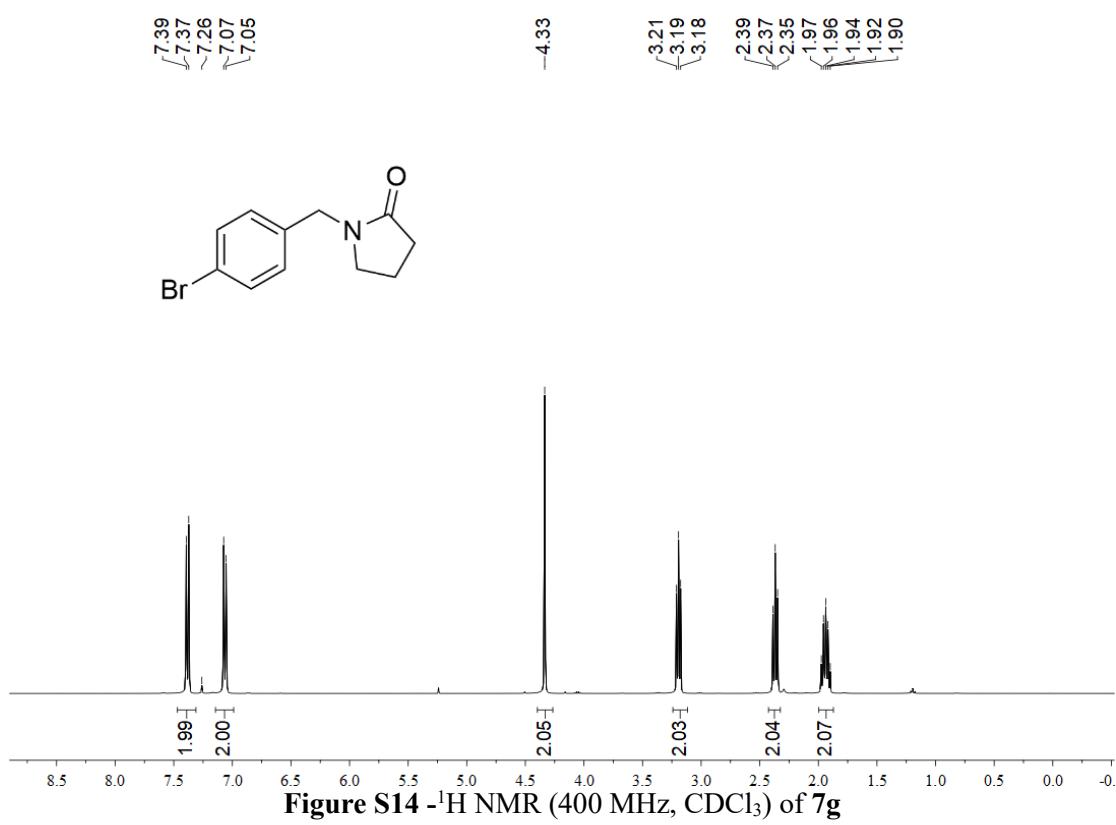
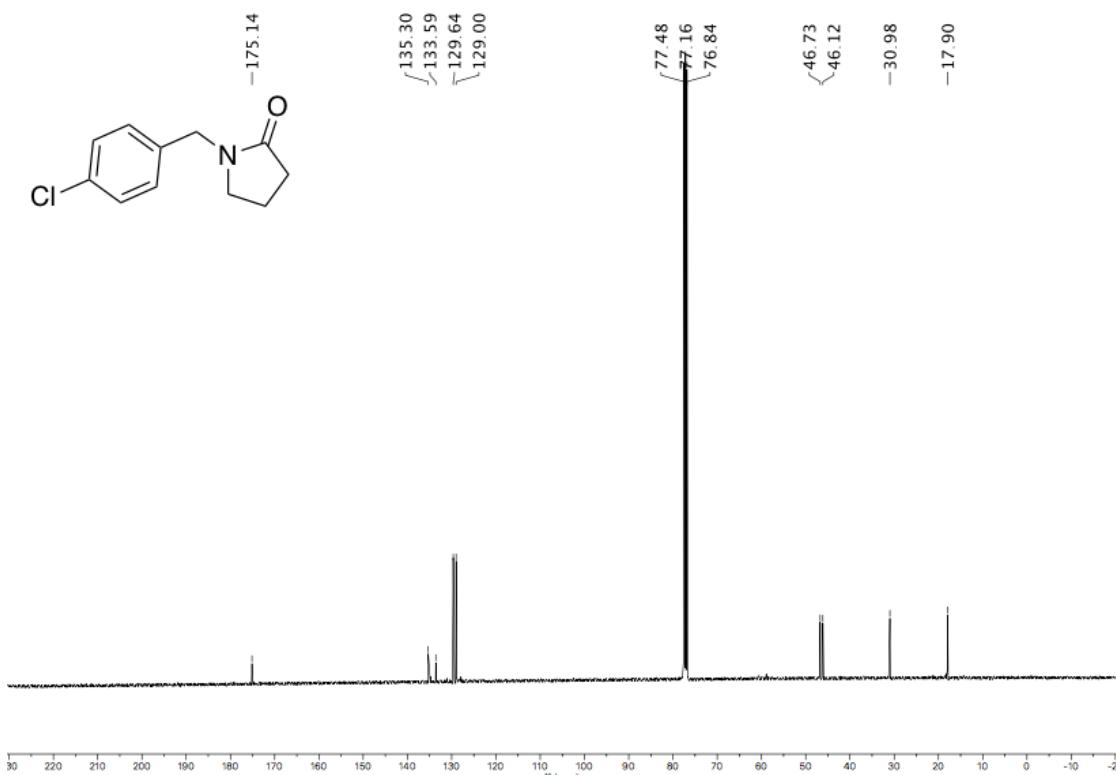


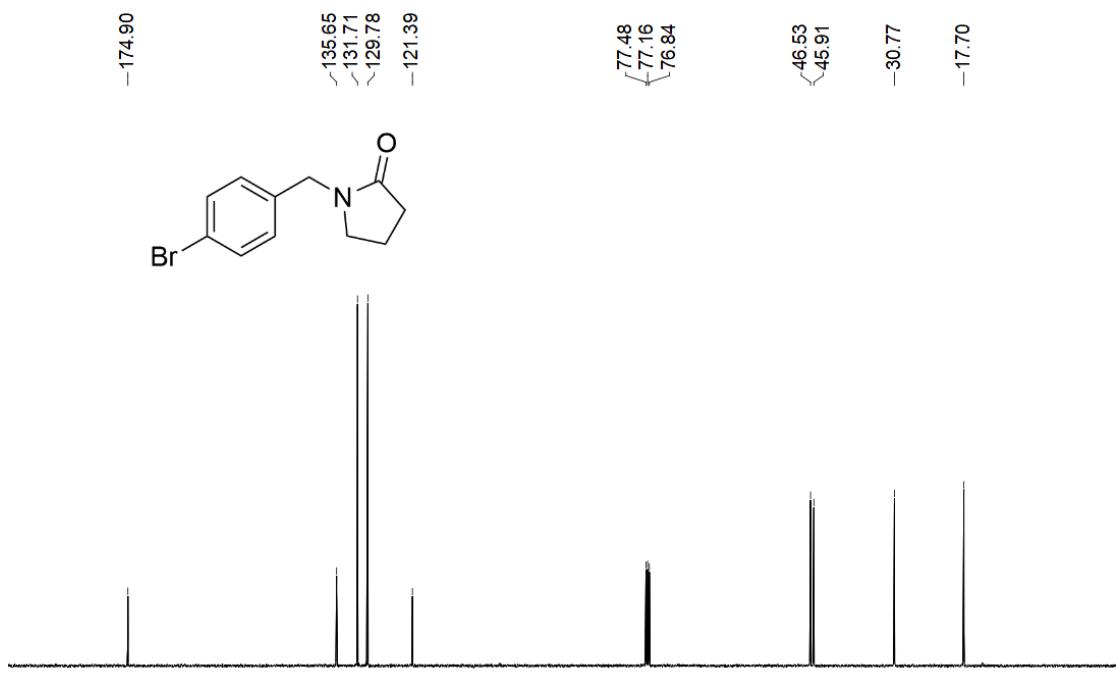


**Figure S11 -  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ) of 7e**

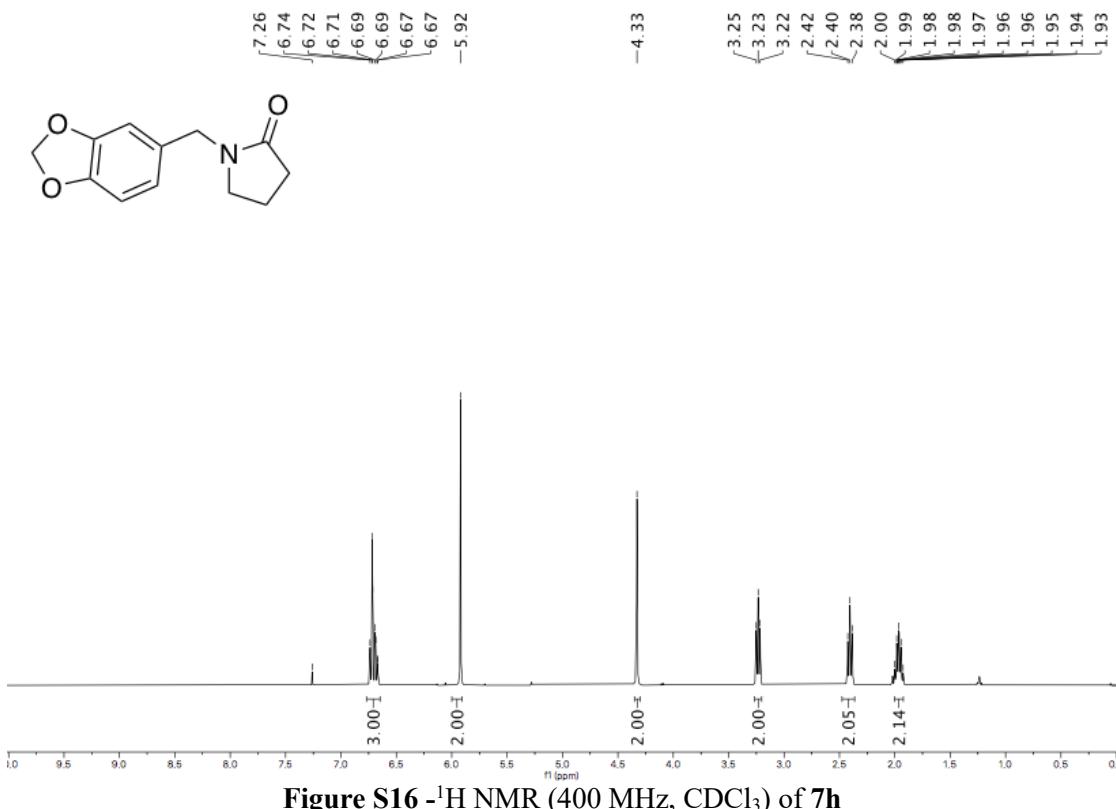


**Figure S12 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7f**

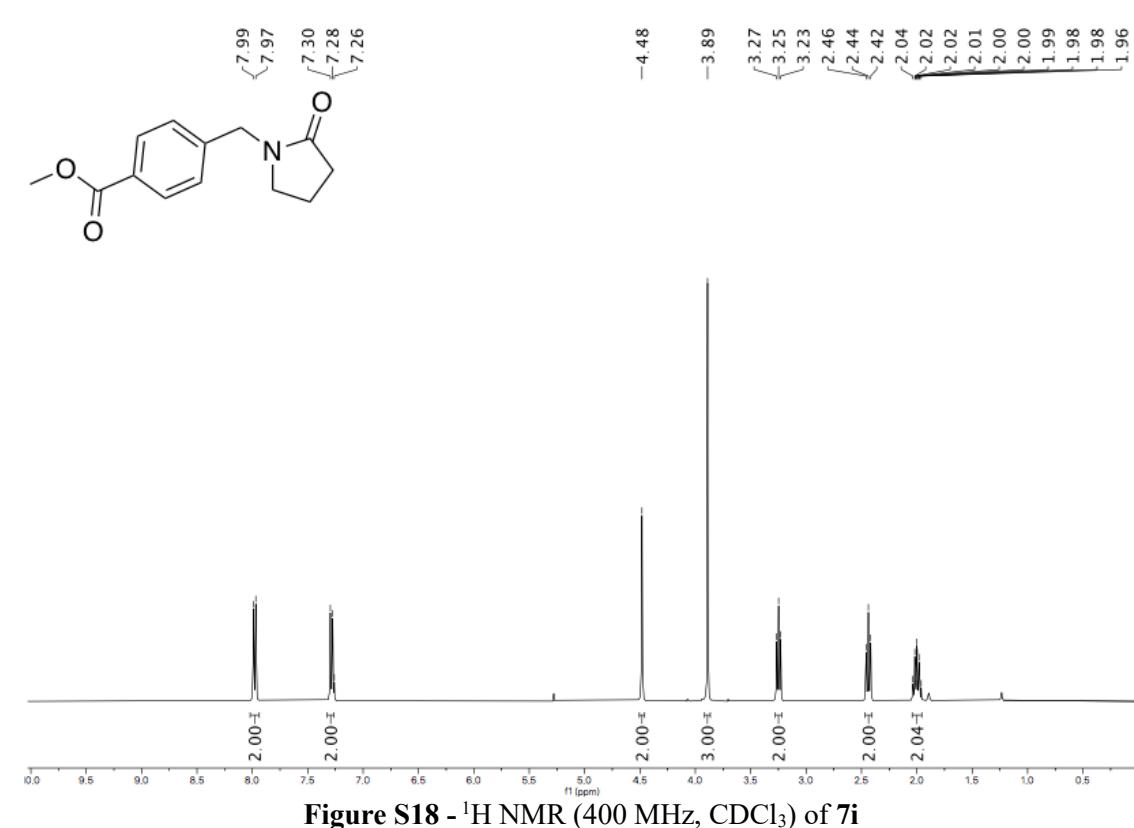
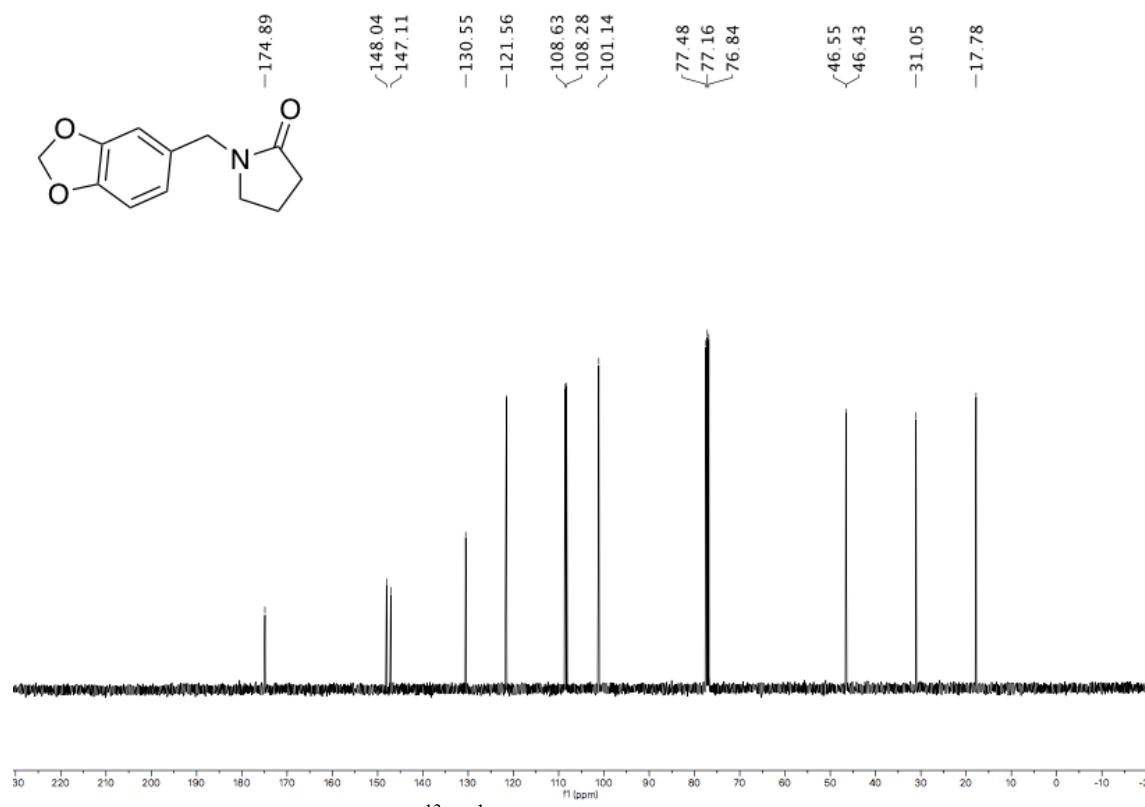


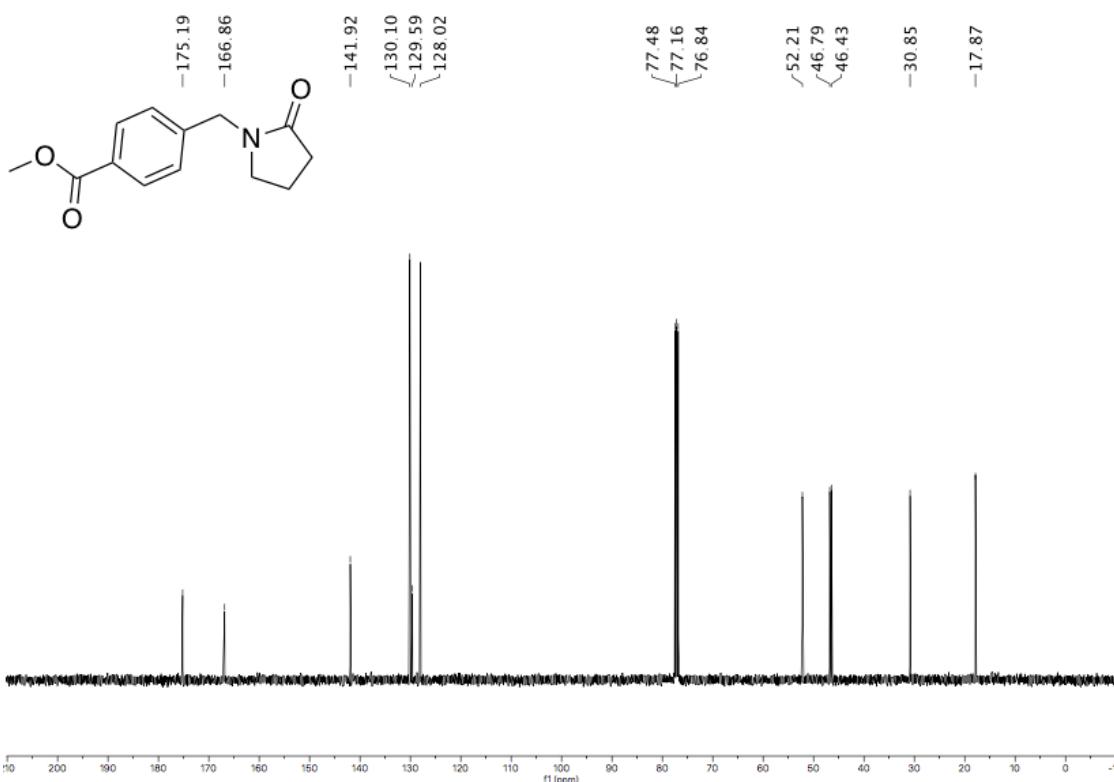


**Figure S15 -**  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>) of 7g

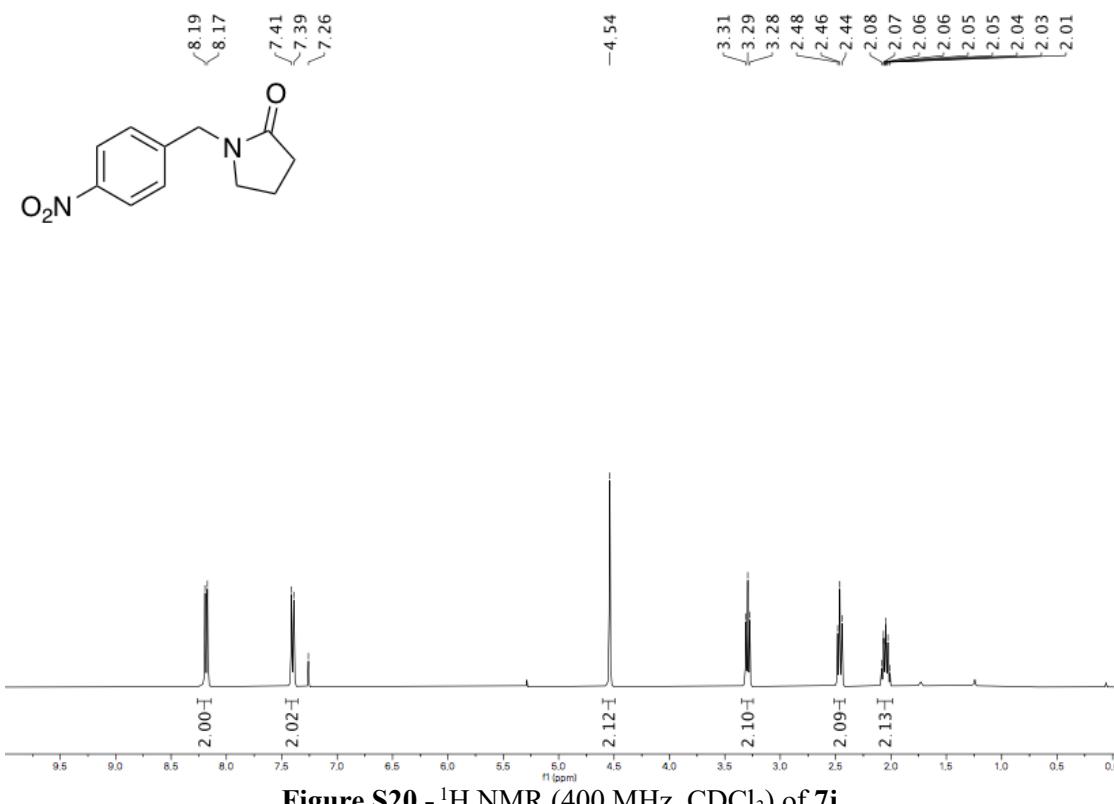


**Figure S16 -**  $^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>) of 7h

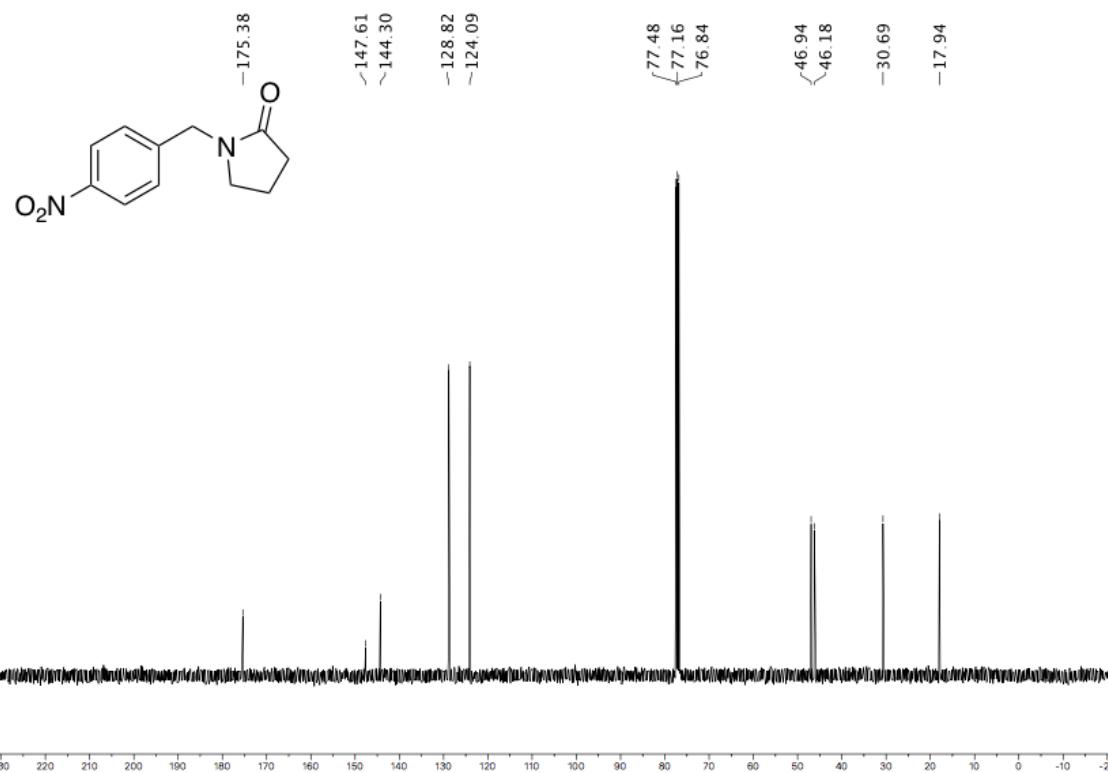




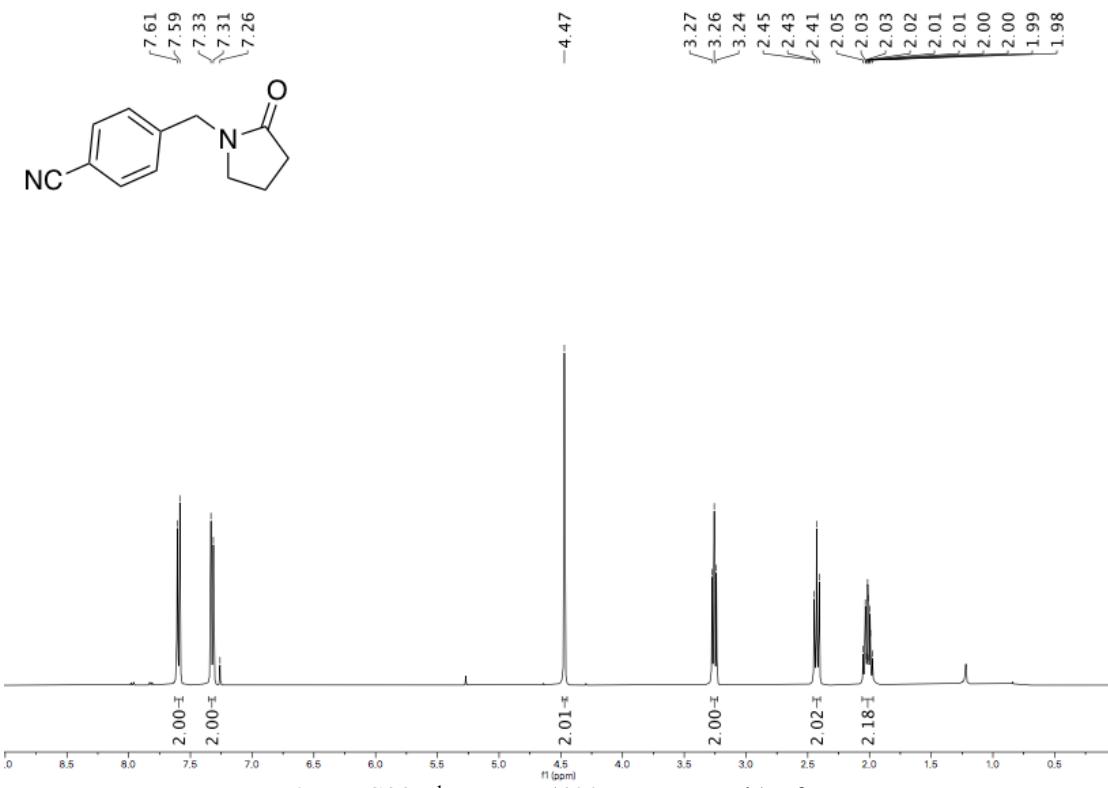
**Figure S19 -**  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7i



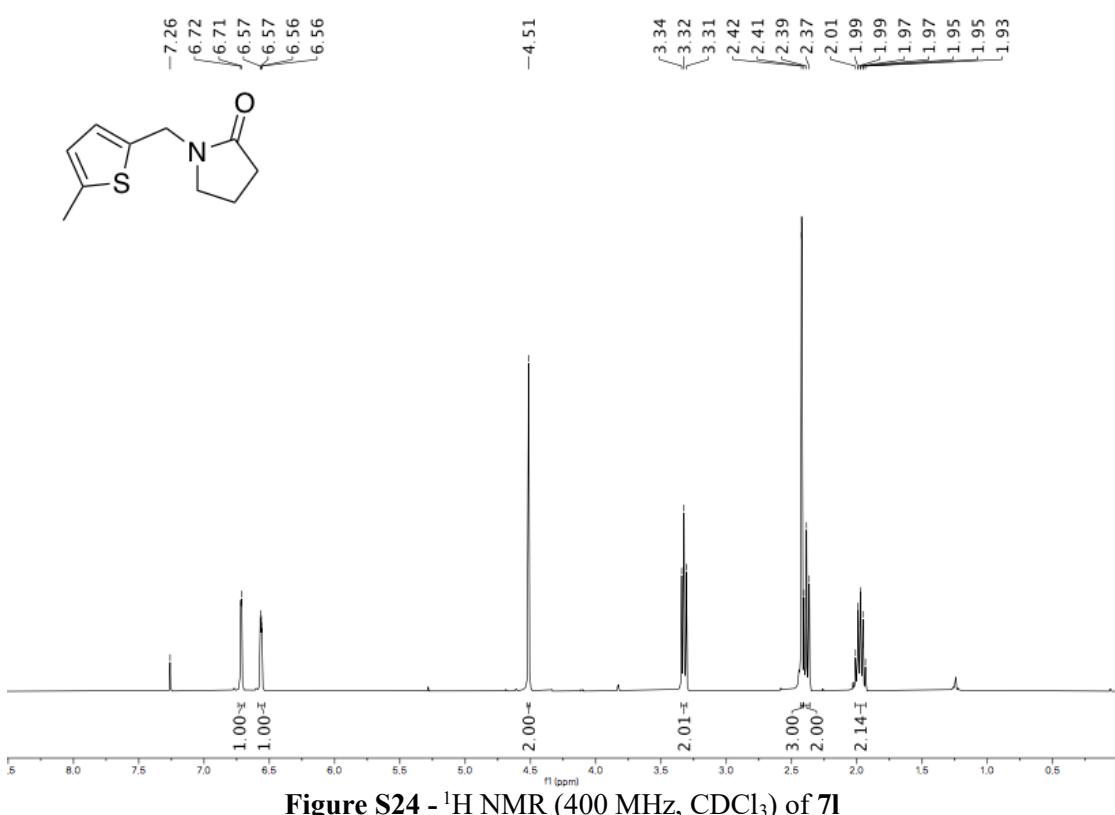
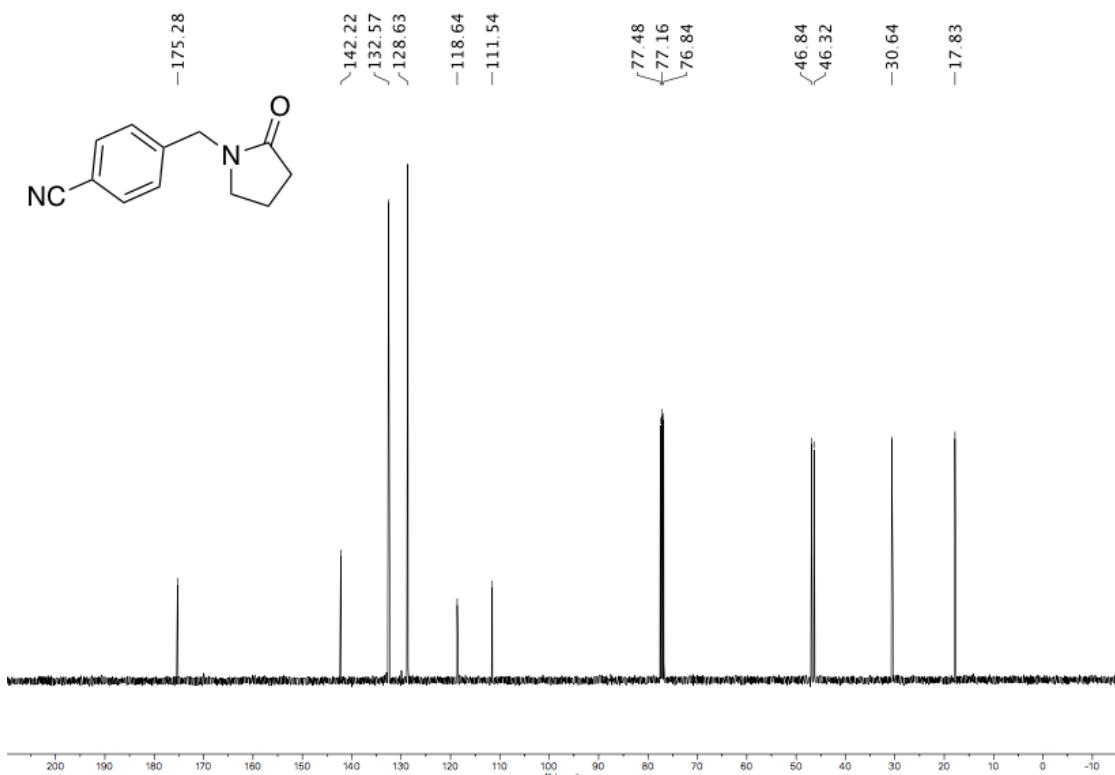
**Figure S20 -**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7j

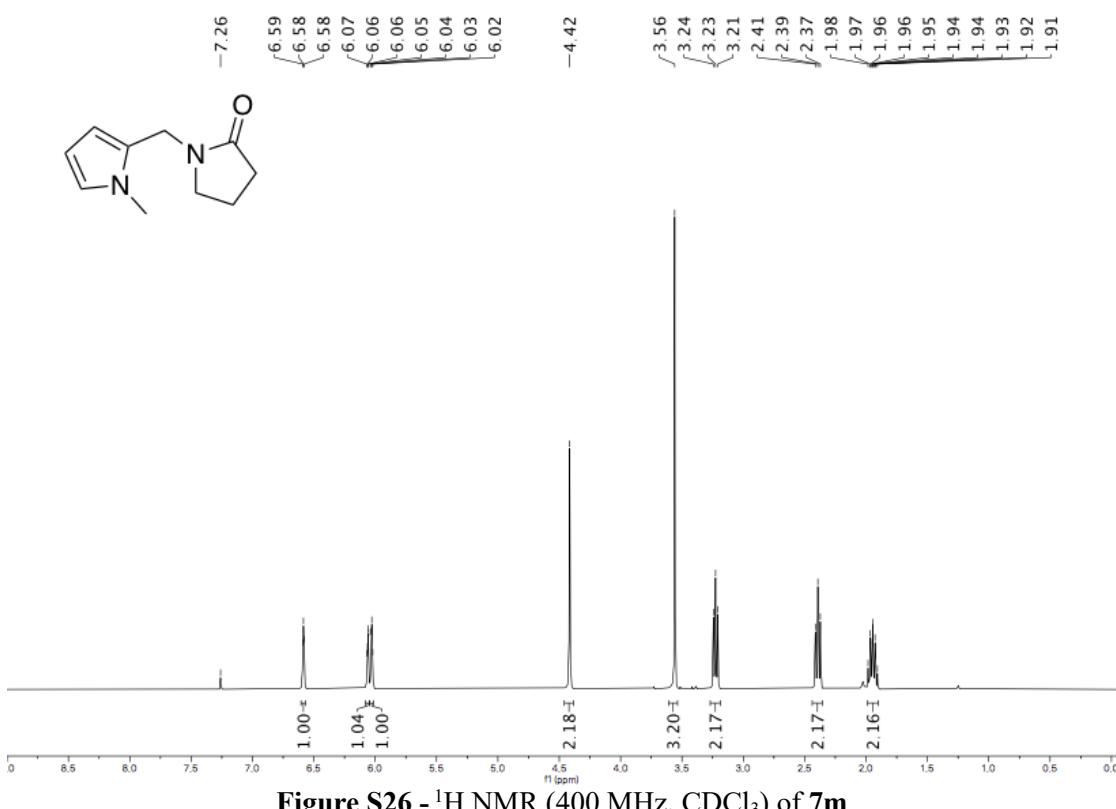
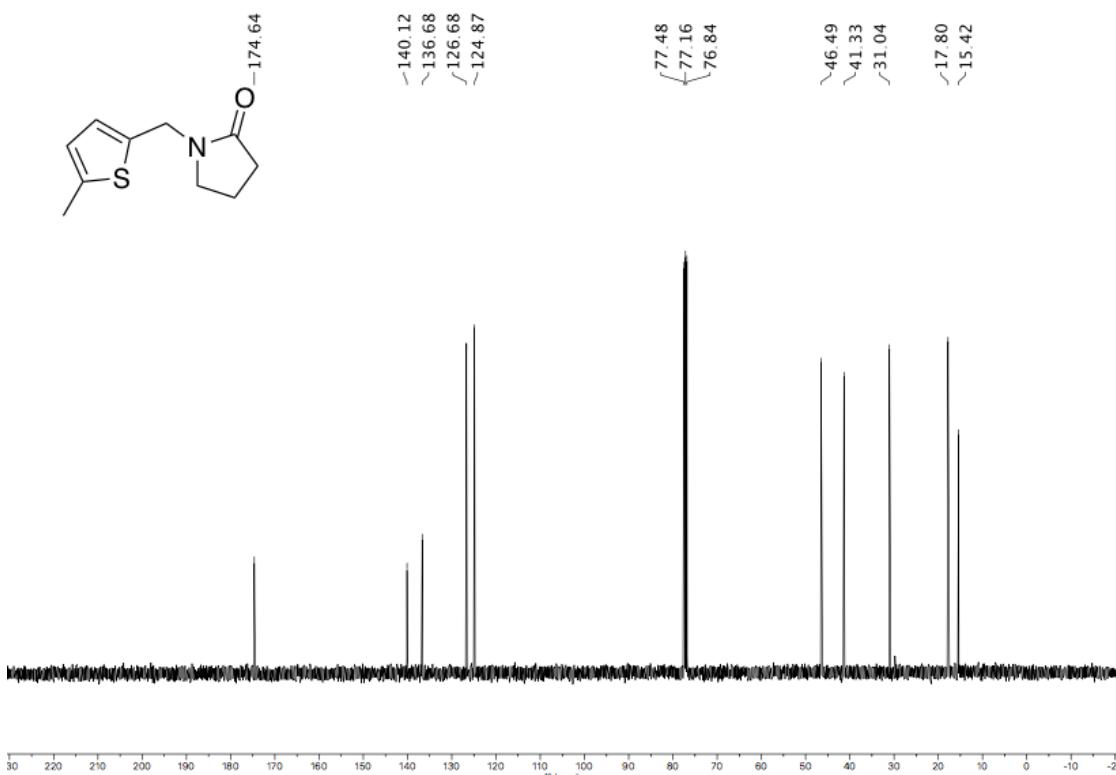


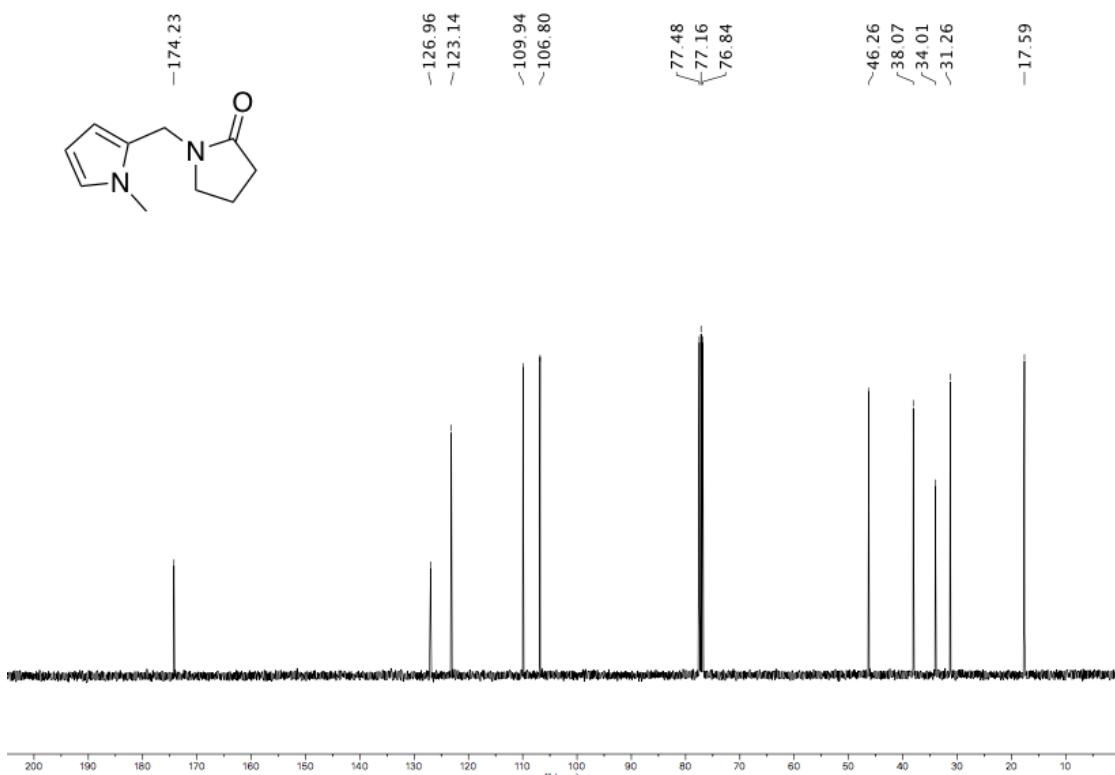
**Figure S21 -**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of 7j



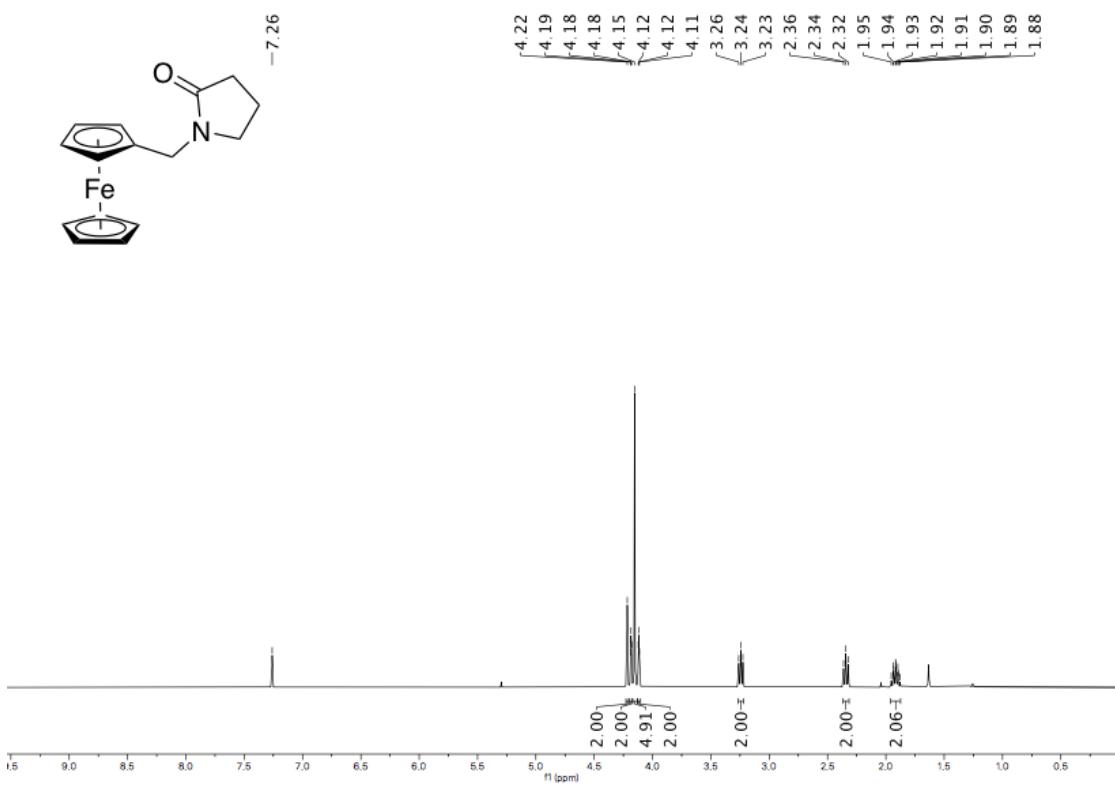
**Figure S22 -**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of 7k



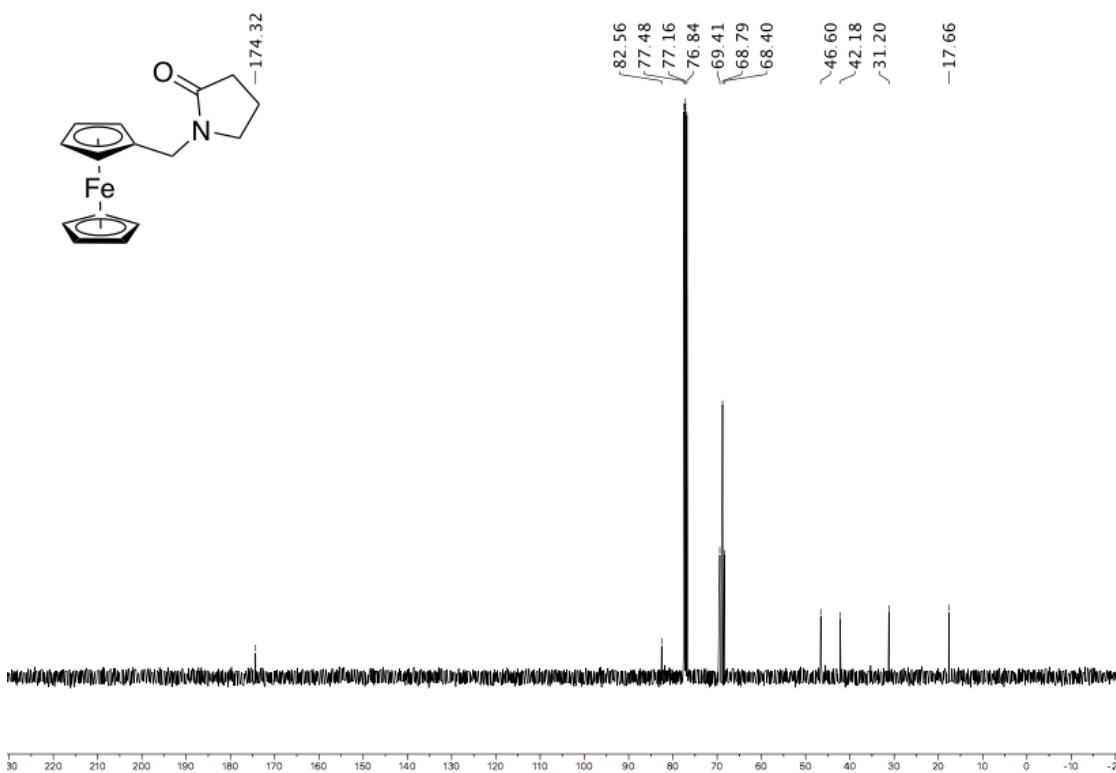




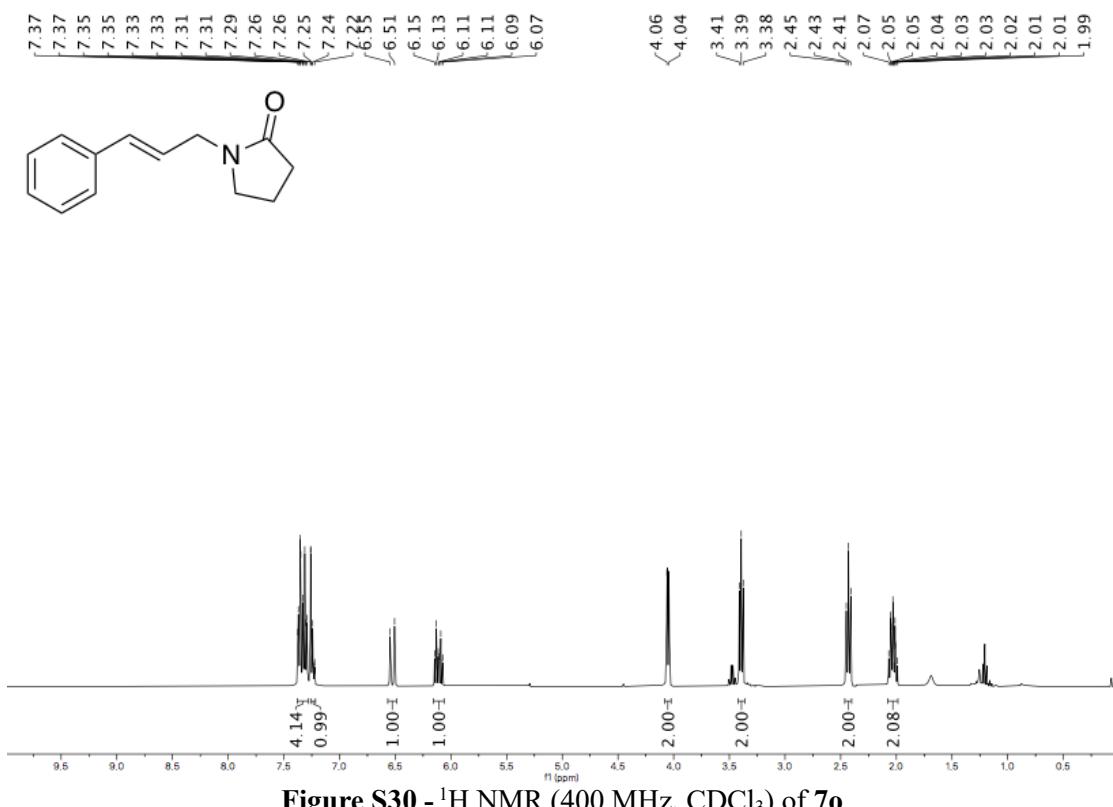
**Figure S27 -**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of 7m



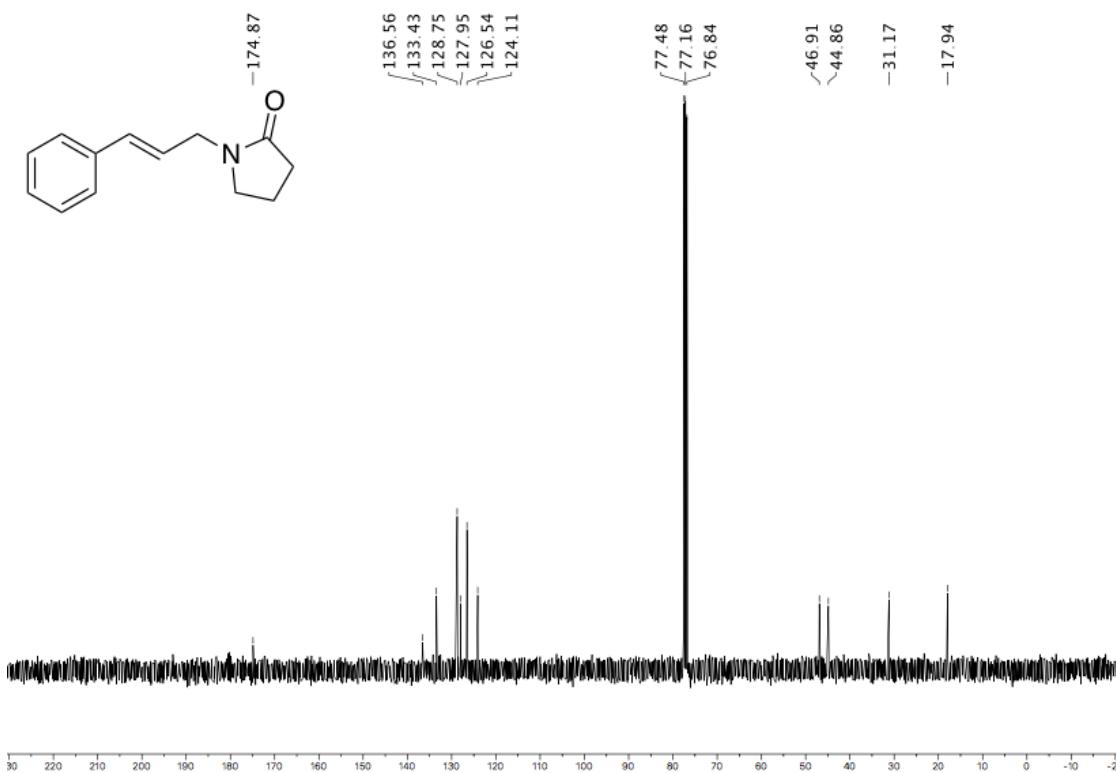
**Figure S28 -**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of 7n



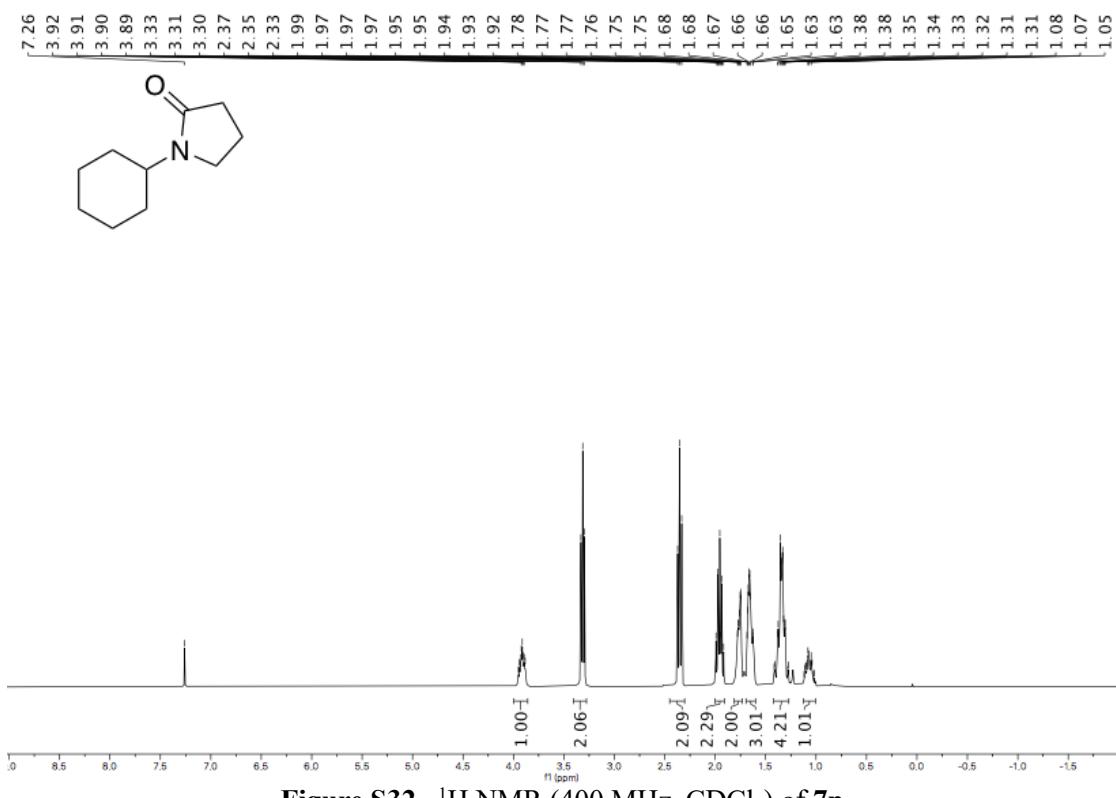
**Figure S29 -**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of **7n**



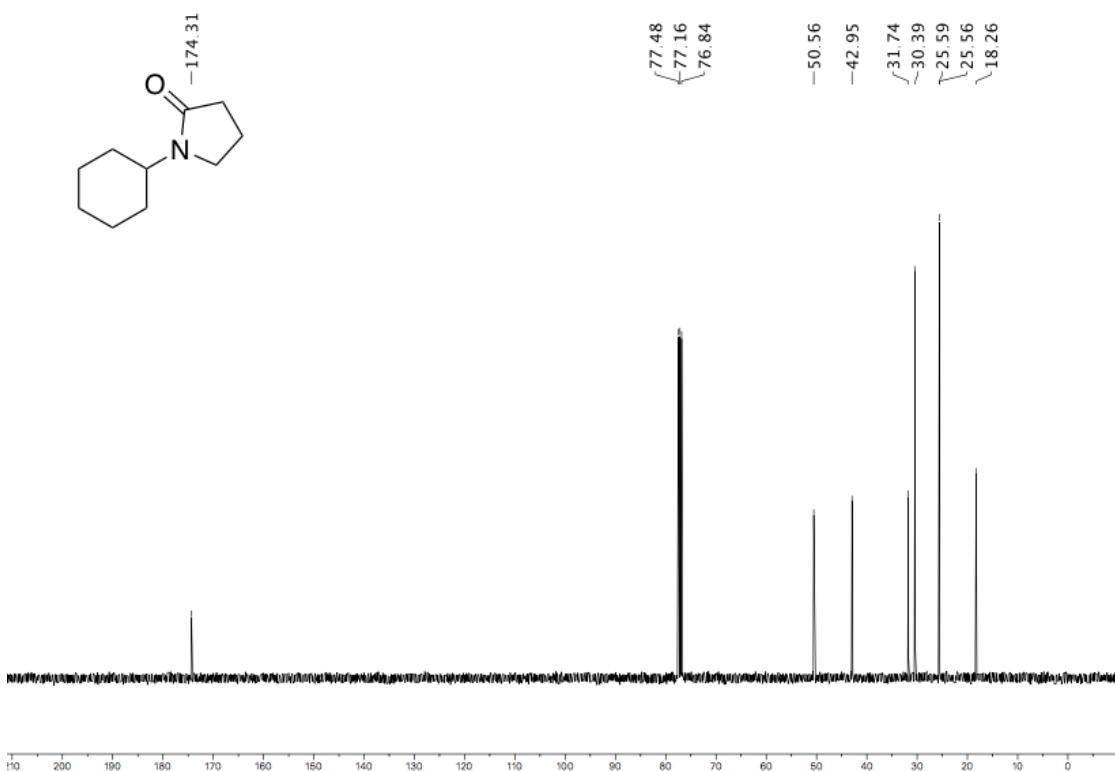
**Figure S30 -**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of **7o**



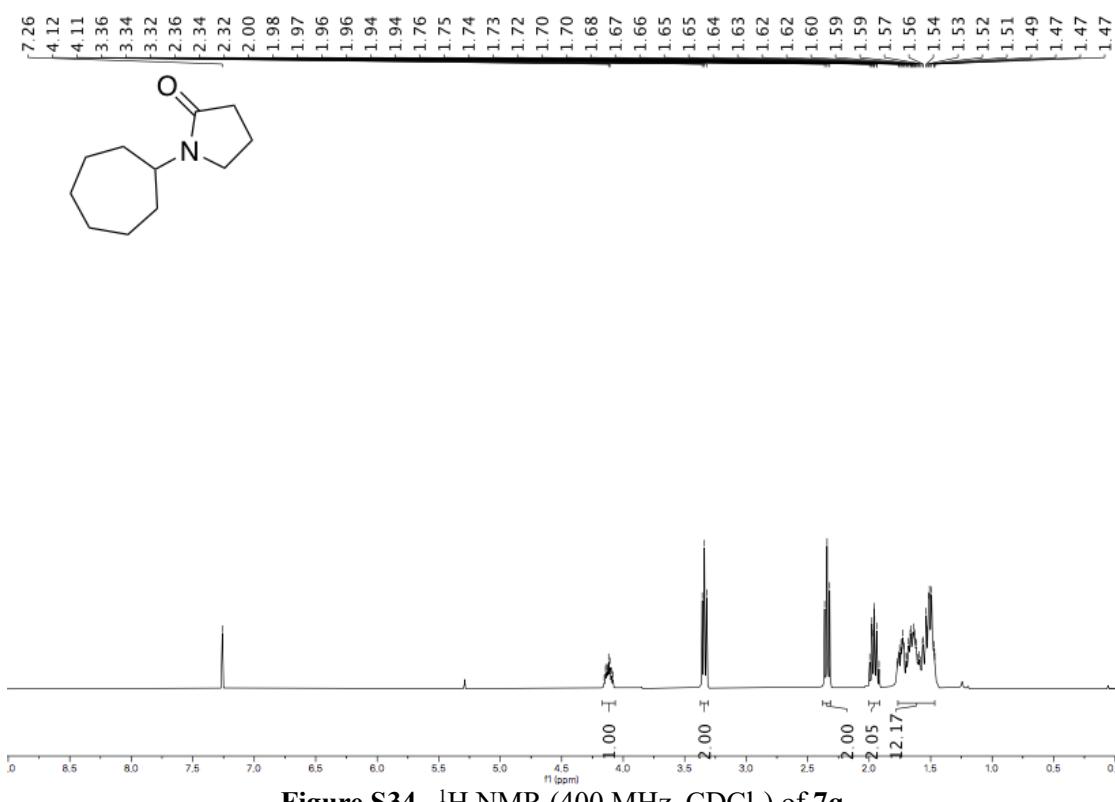
**Figure S31 -**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of **7o**



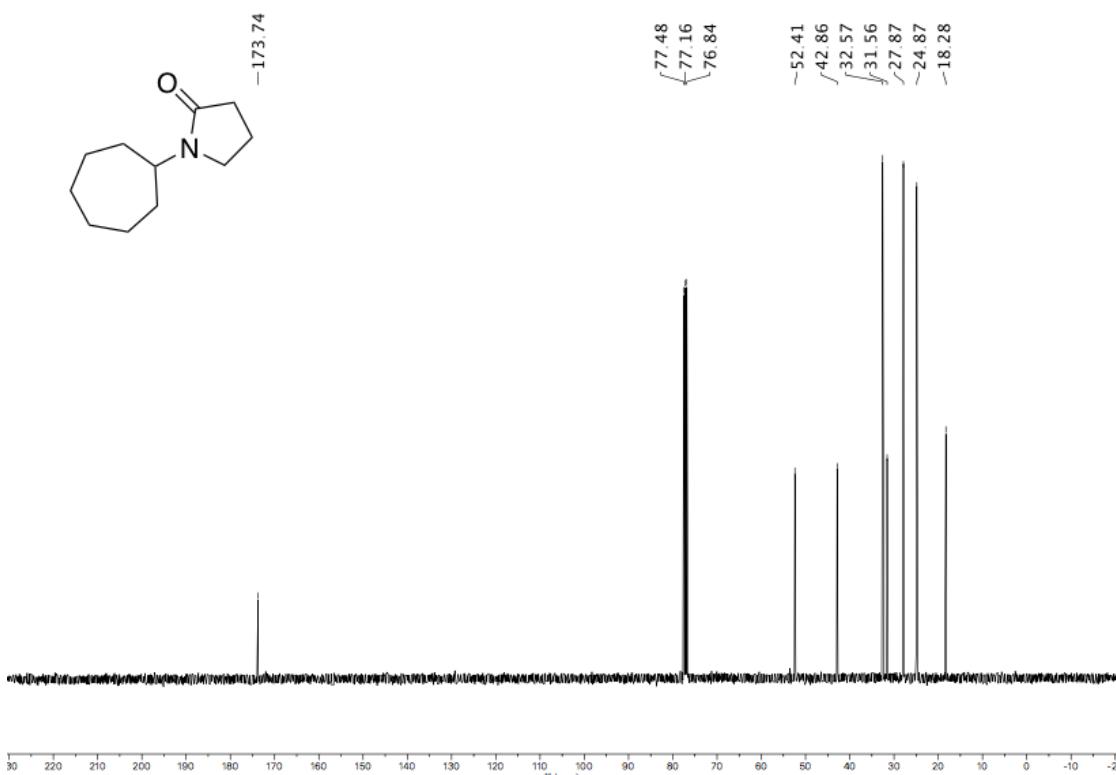
**Figure S32 -**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of **7p**



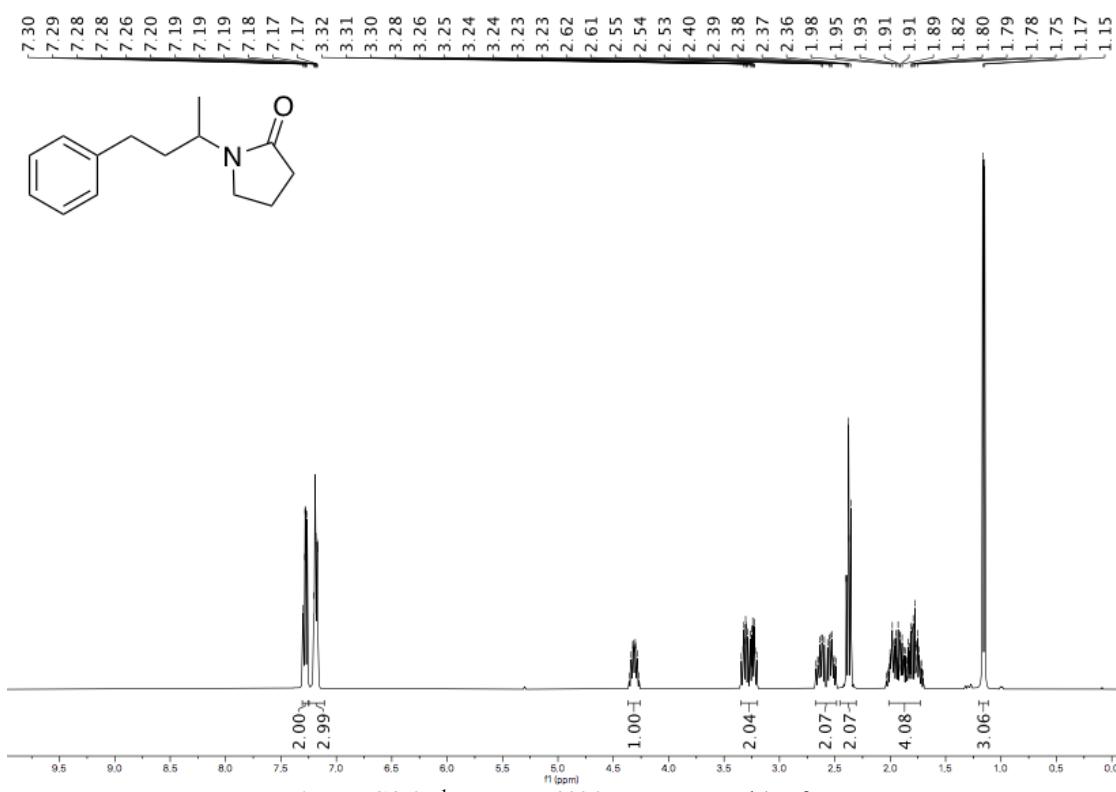
**Figure S33 -**  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of **7p**



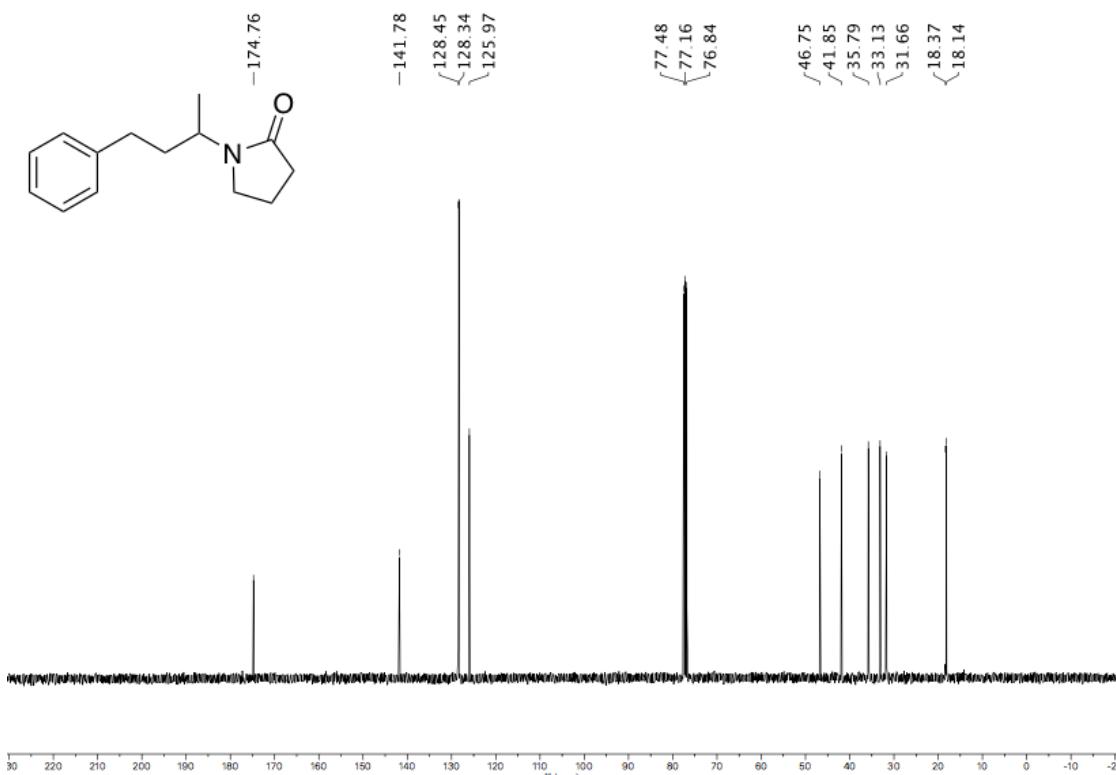
**Figure S34 -**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of **7q**



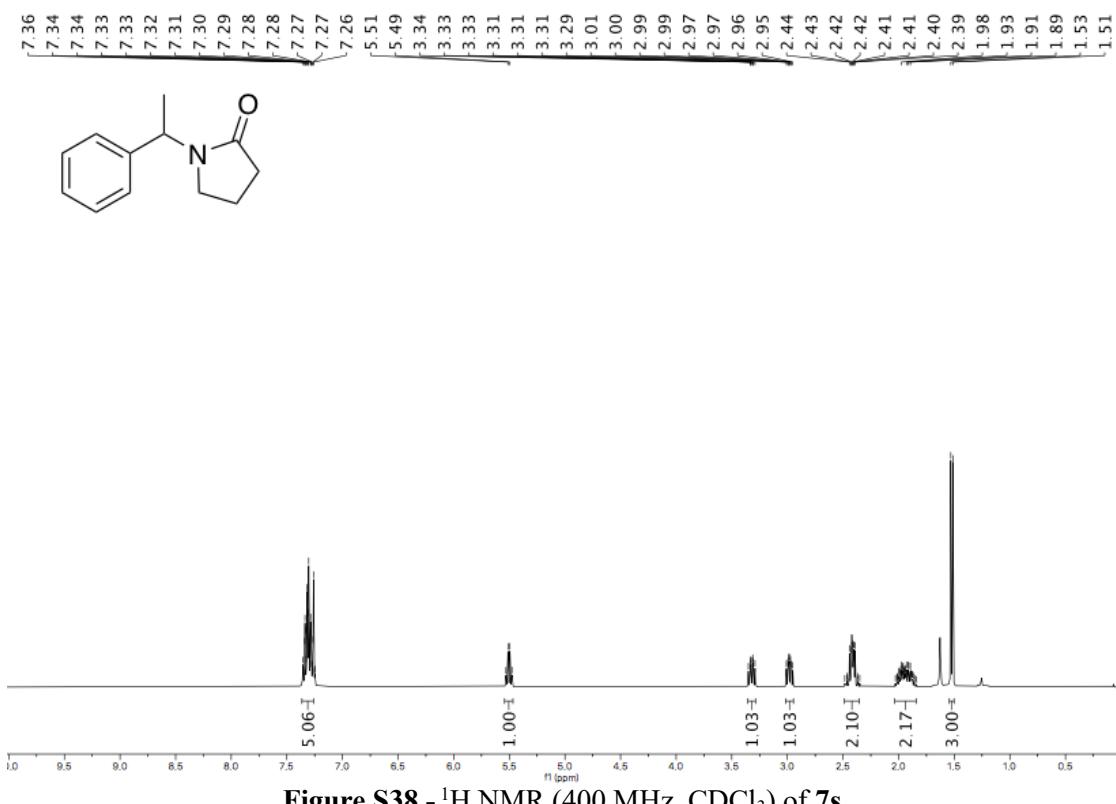
**Figure S35 -**  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of **7q**



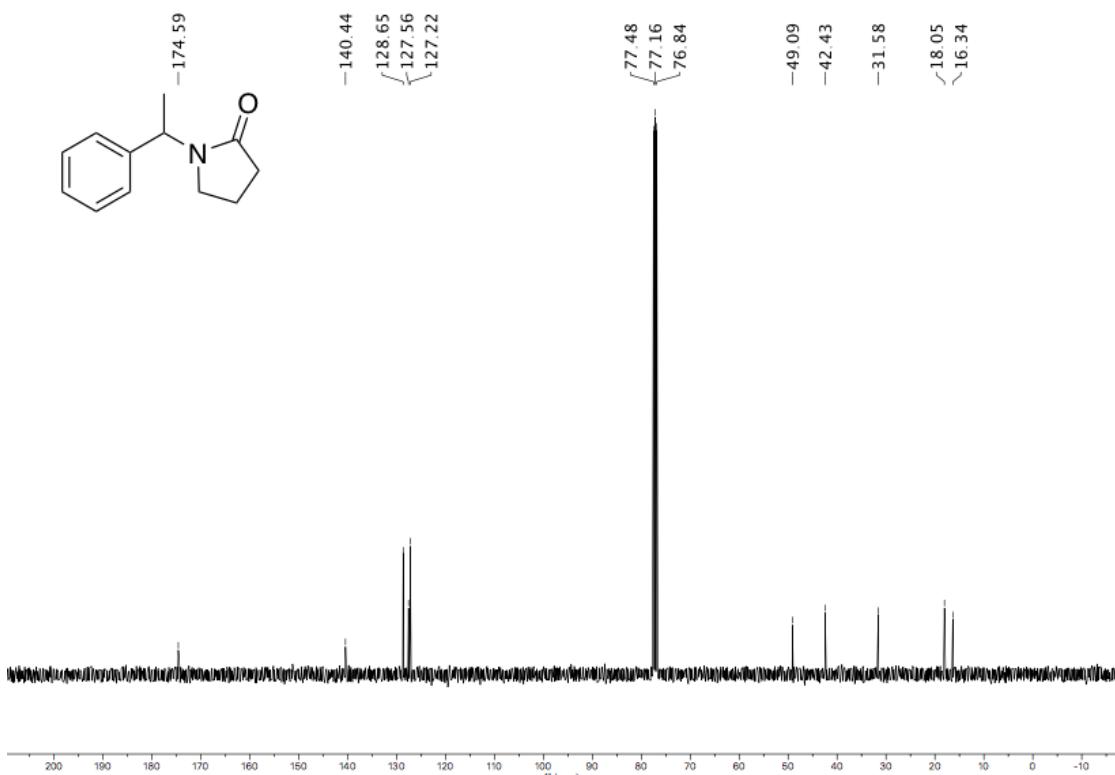
**Figure S36 -**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of **7r**



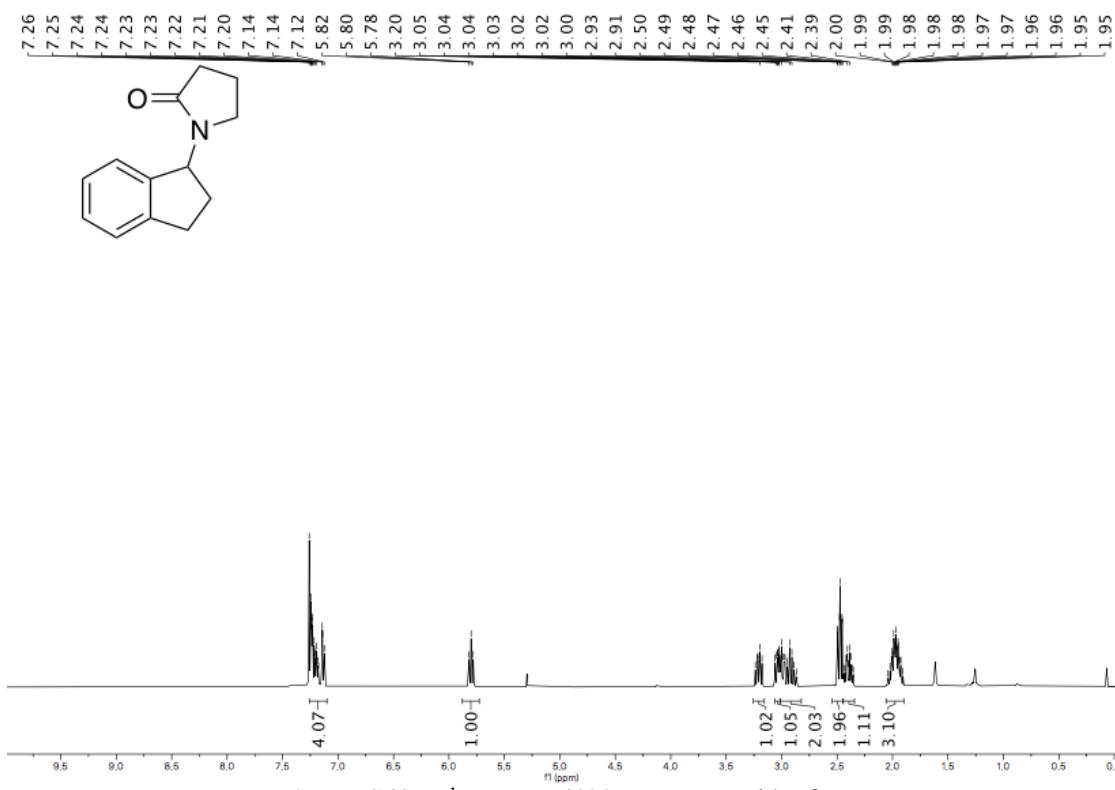
**Figure S37 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7r**



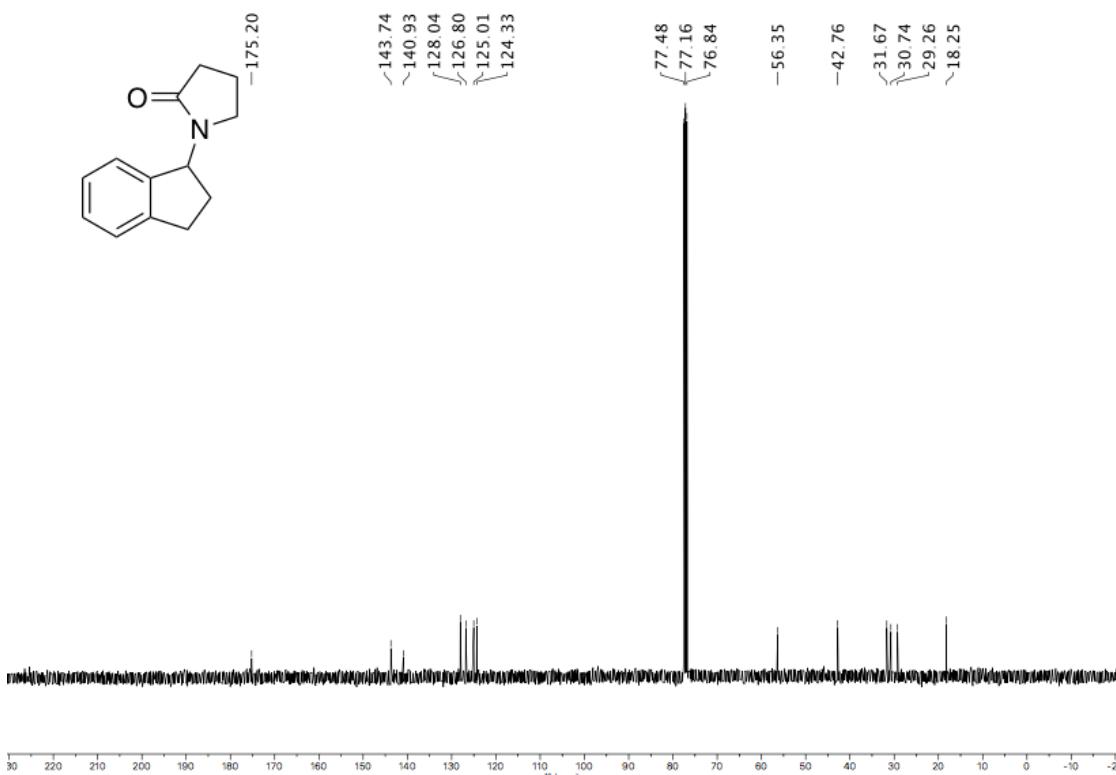
**Figure S38 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7s**



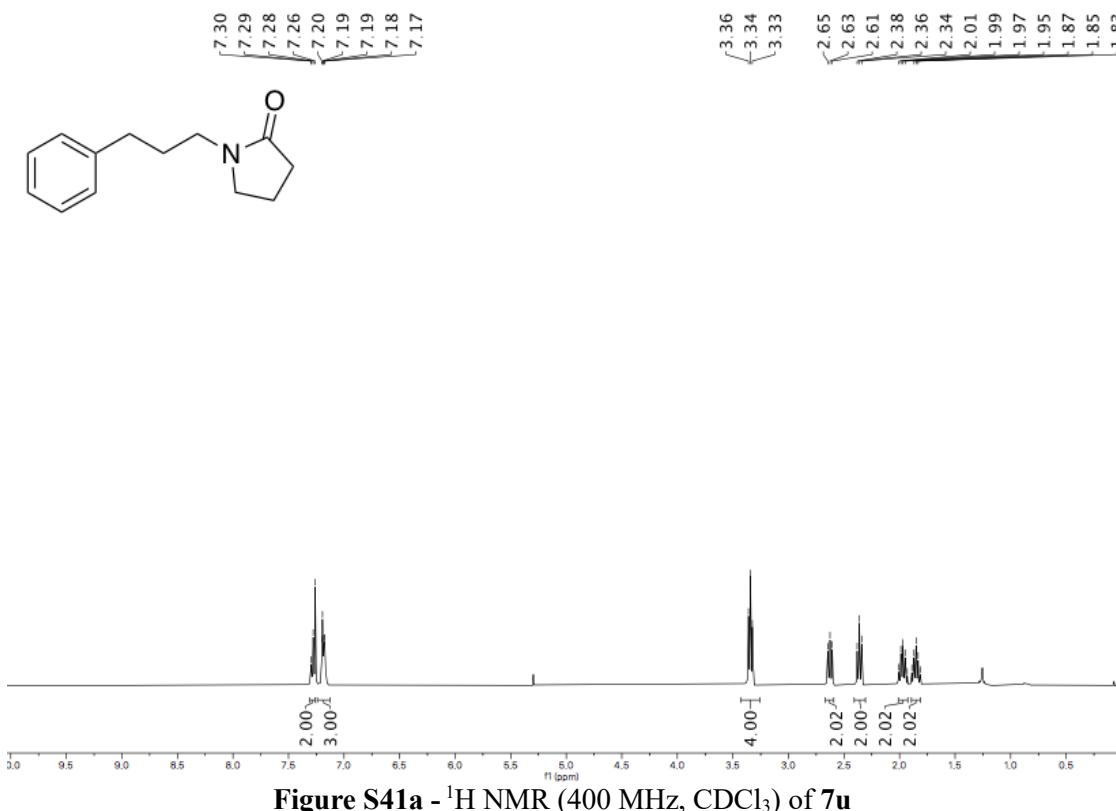
**Figure S39 -  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7s**



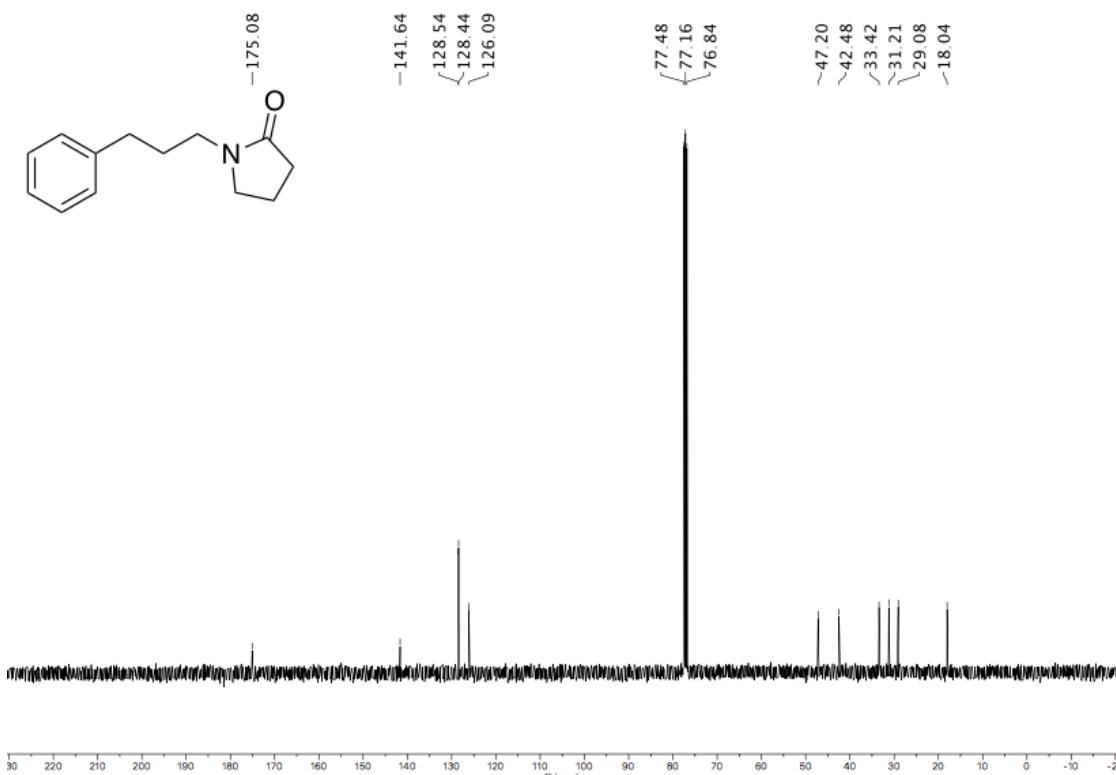
**Figure S40a -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7t**



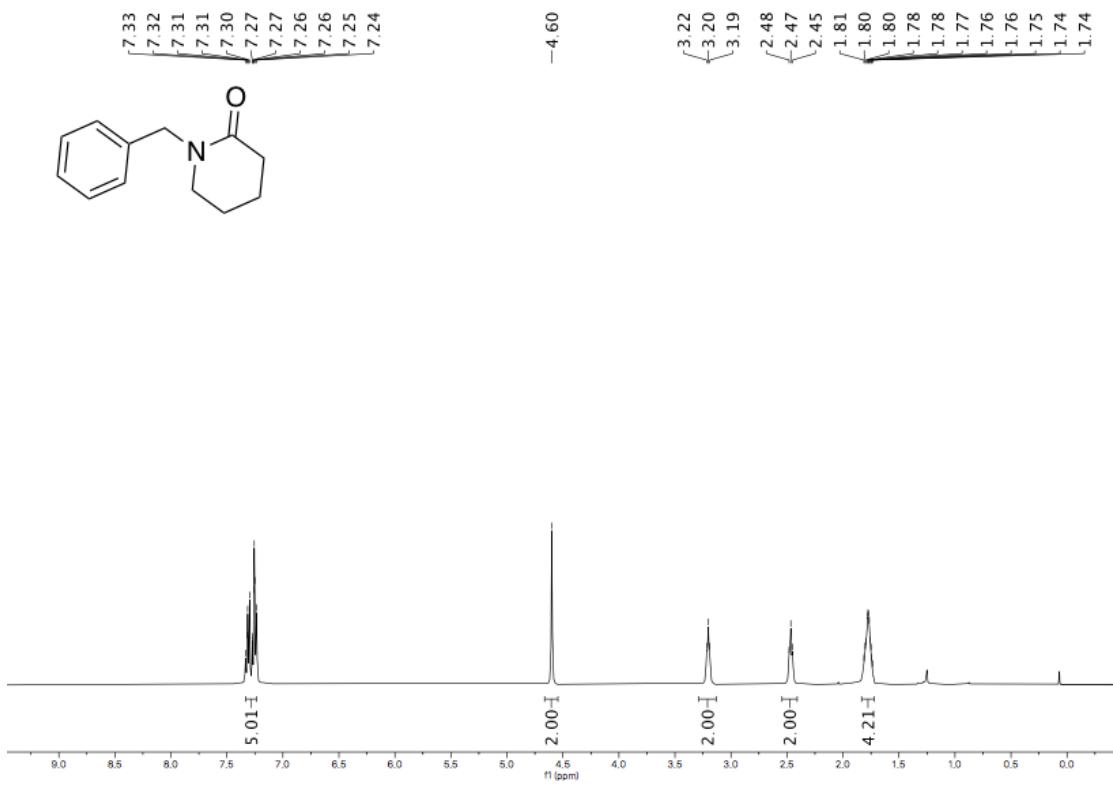
**Figure S40b -  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 7t**



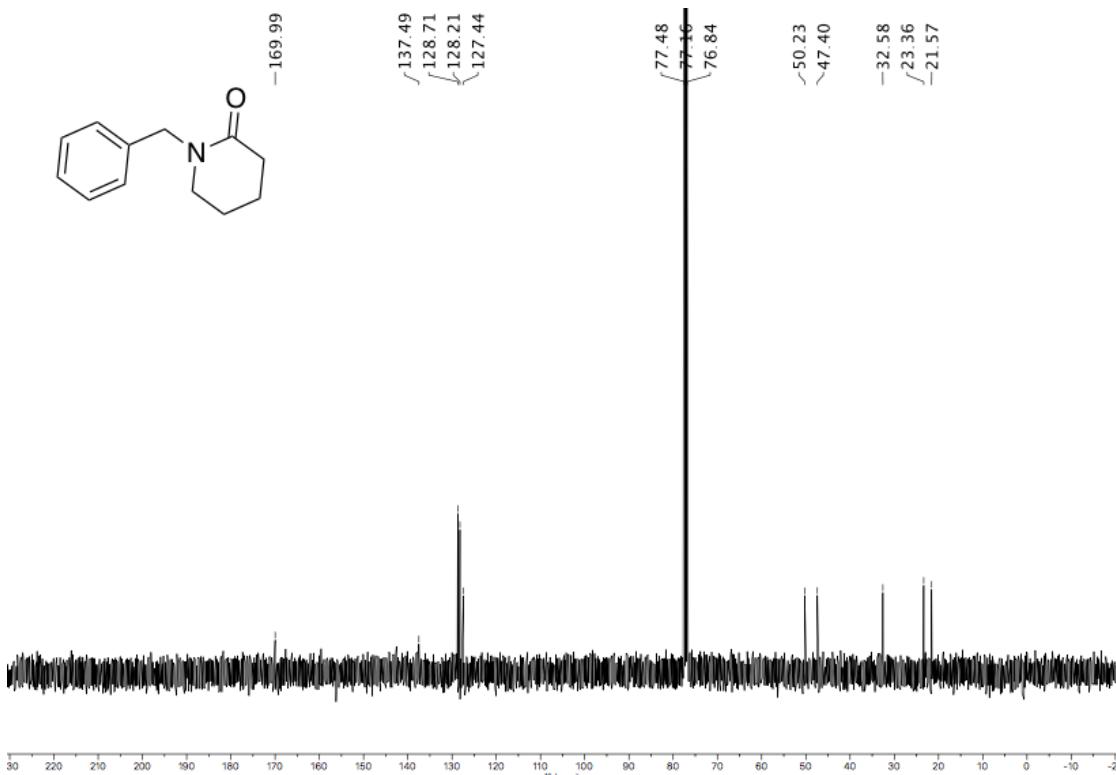
**Figure S41a -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 7u**



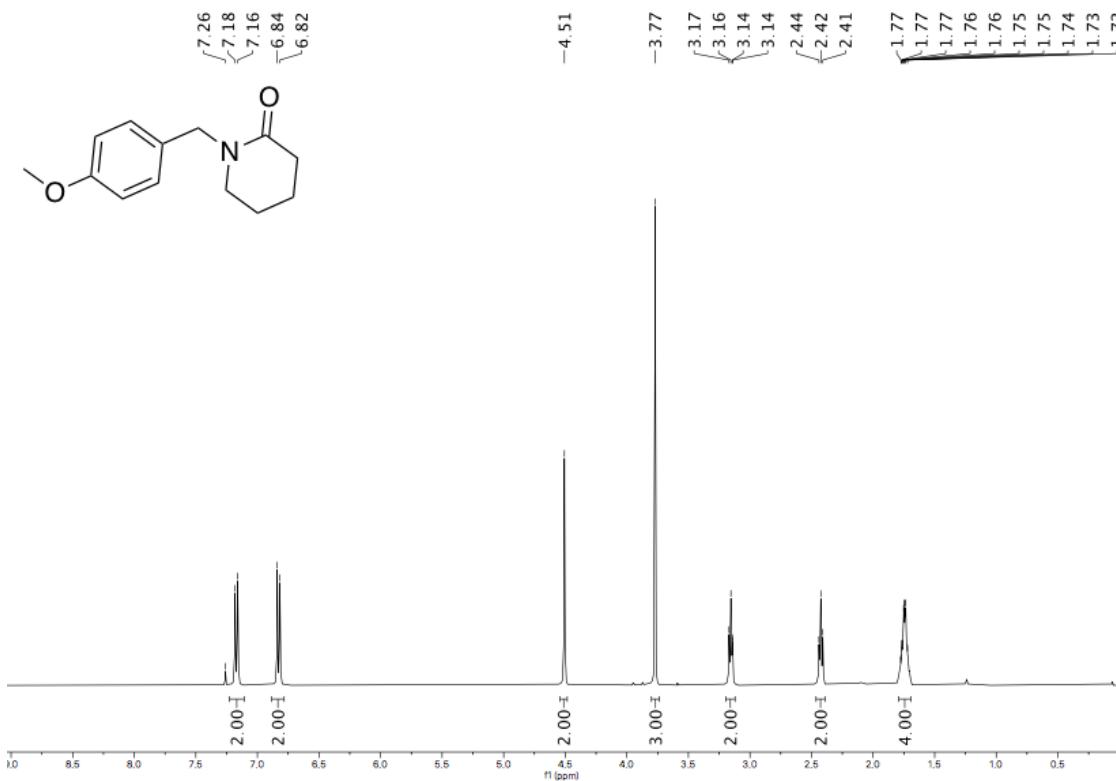
**Figure S41b -**  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of **7u**



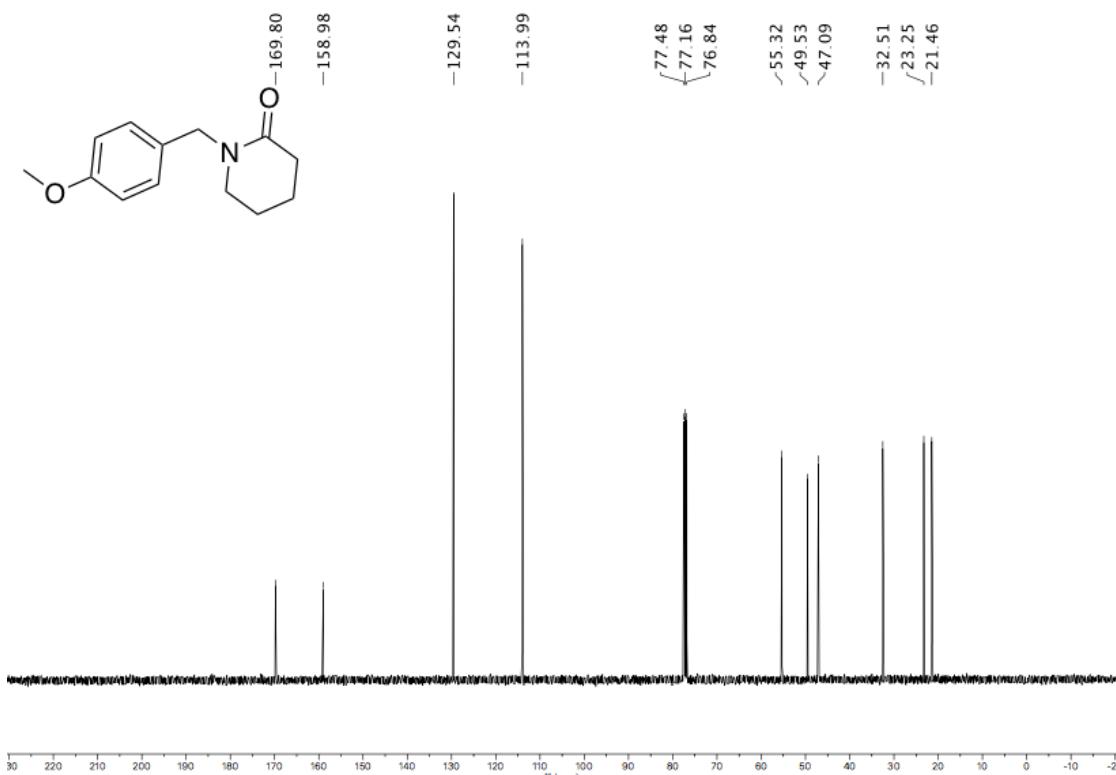
**Figure S42 -**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of **3a**



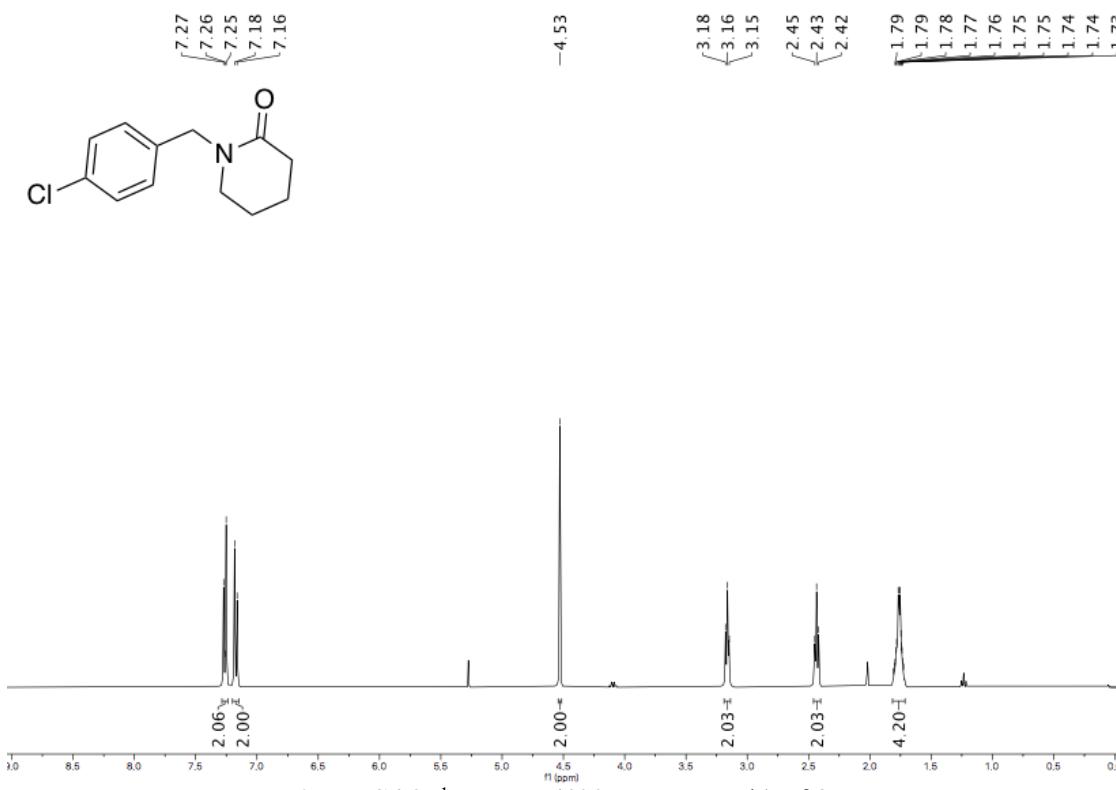
**Figure S43 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 3a**



**Figure S44 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 3b**



**Figure S45 -**  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of **3b**



**Figure S46 -**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of **3c**

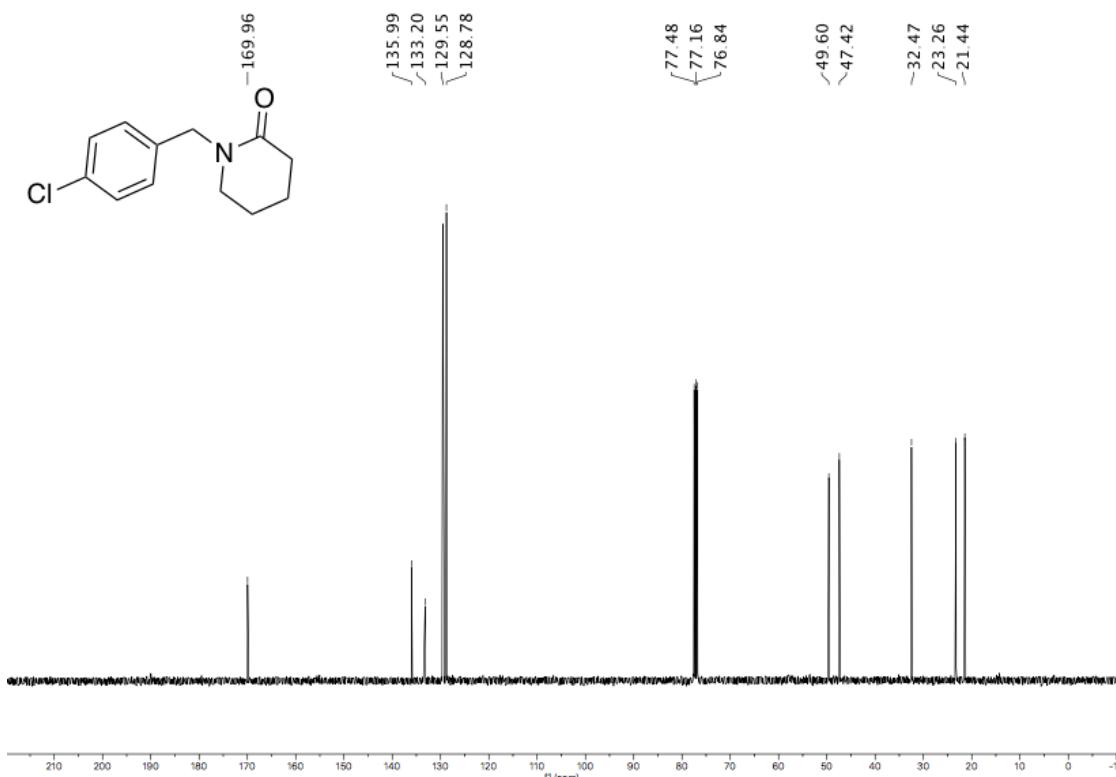


Figure S47 - <sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of **3c**

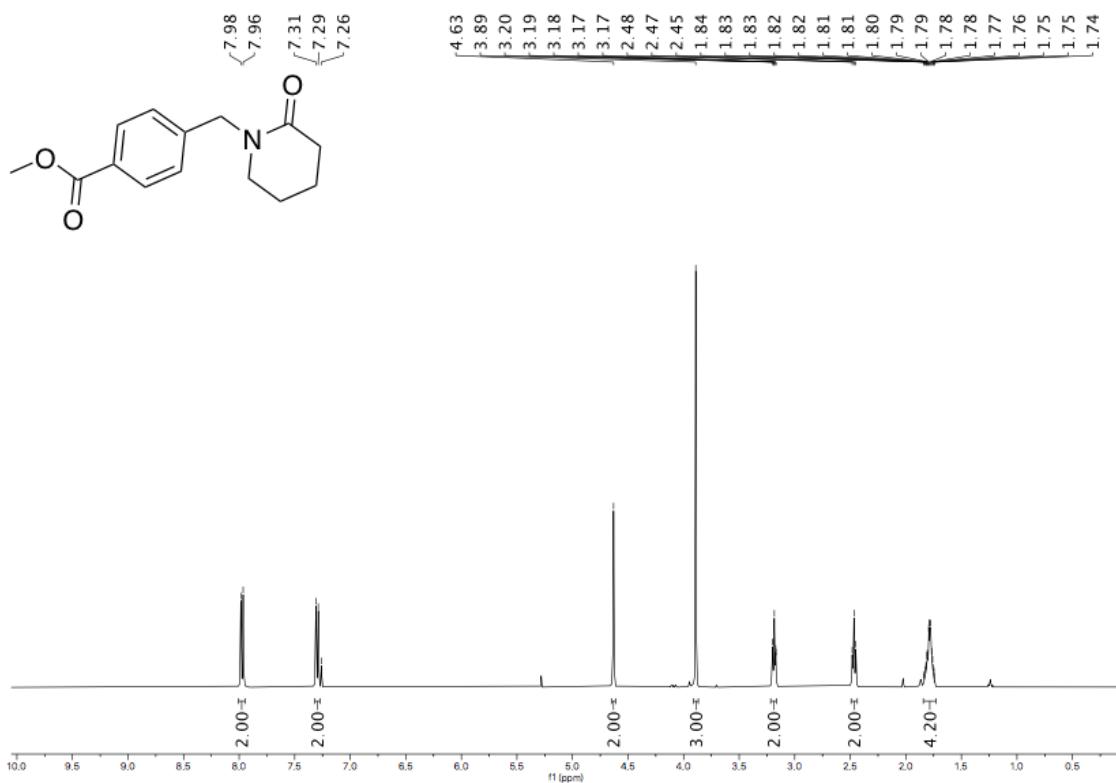
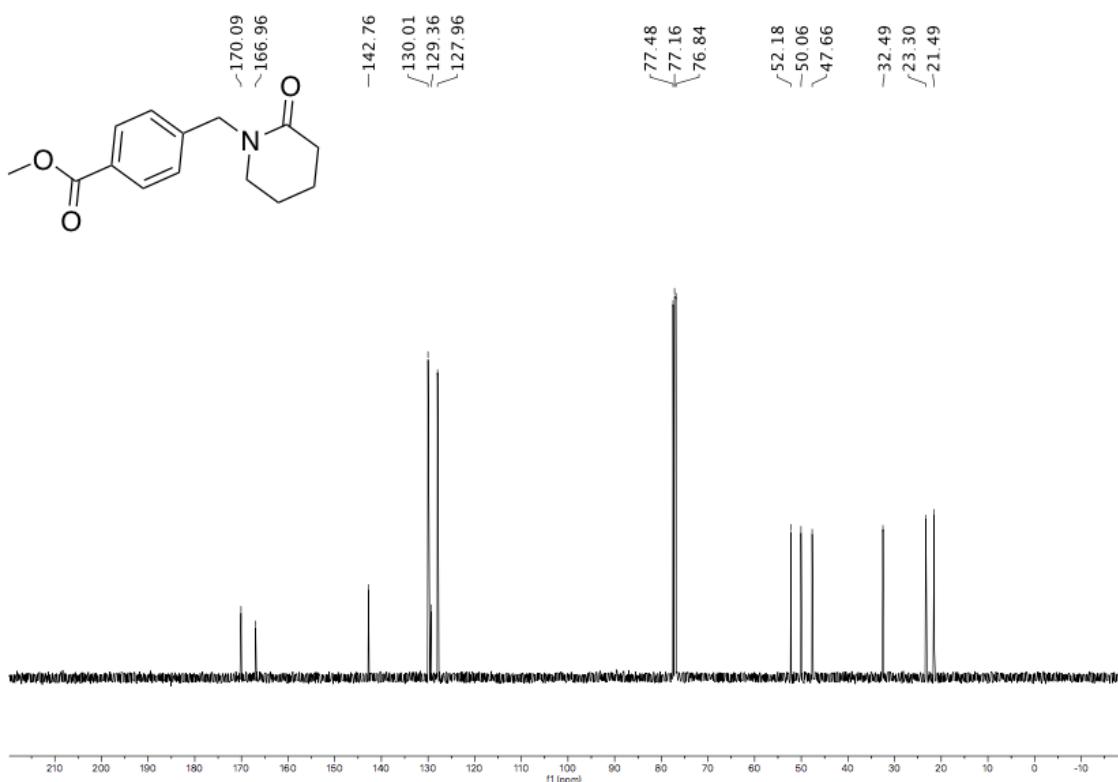
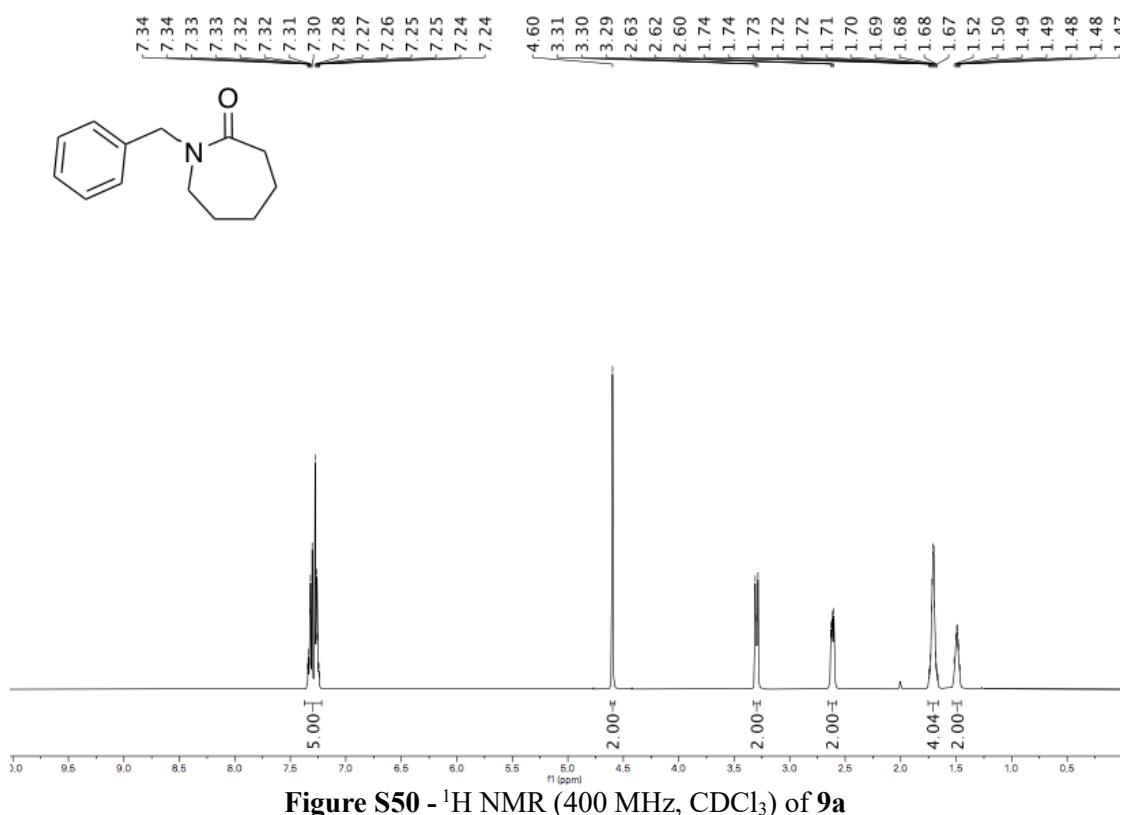


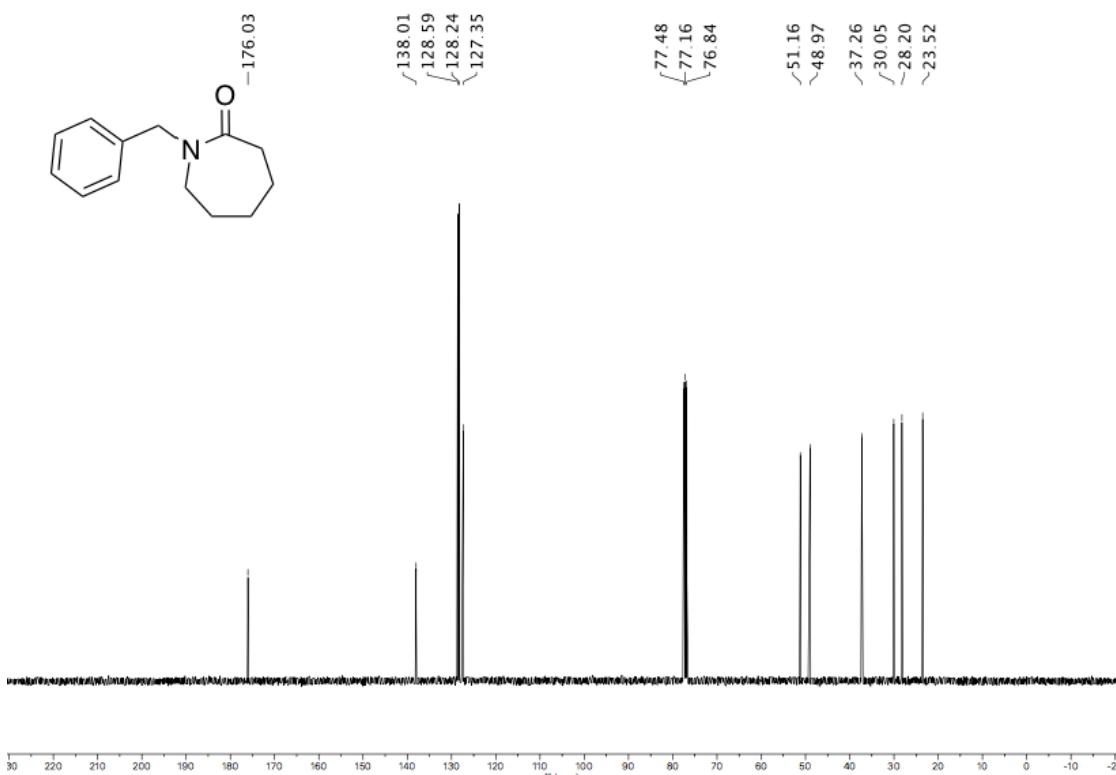
Figure S48 - <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of **3d**



**Figure S49 -**<sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of **3d**



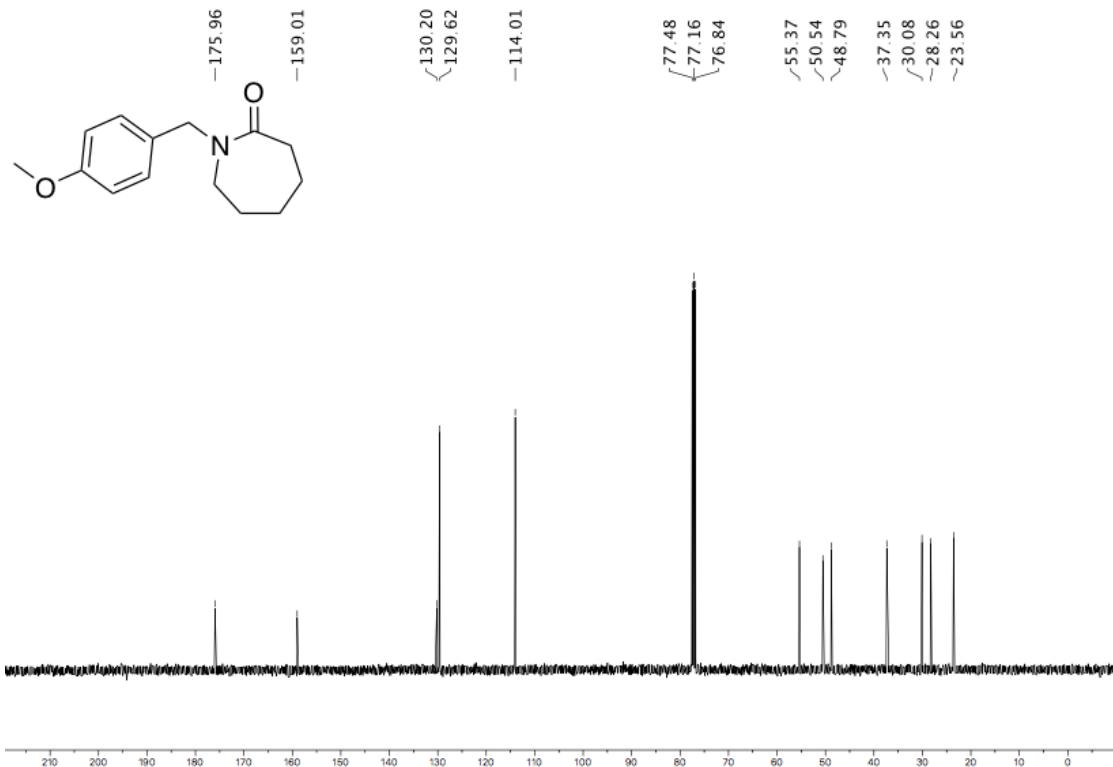
**Figure S50 -**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of **9a**



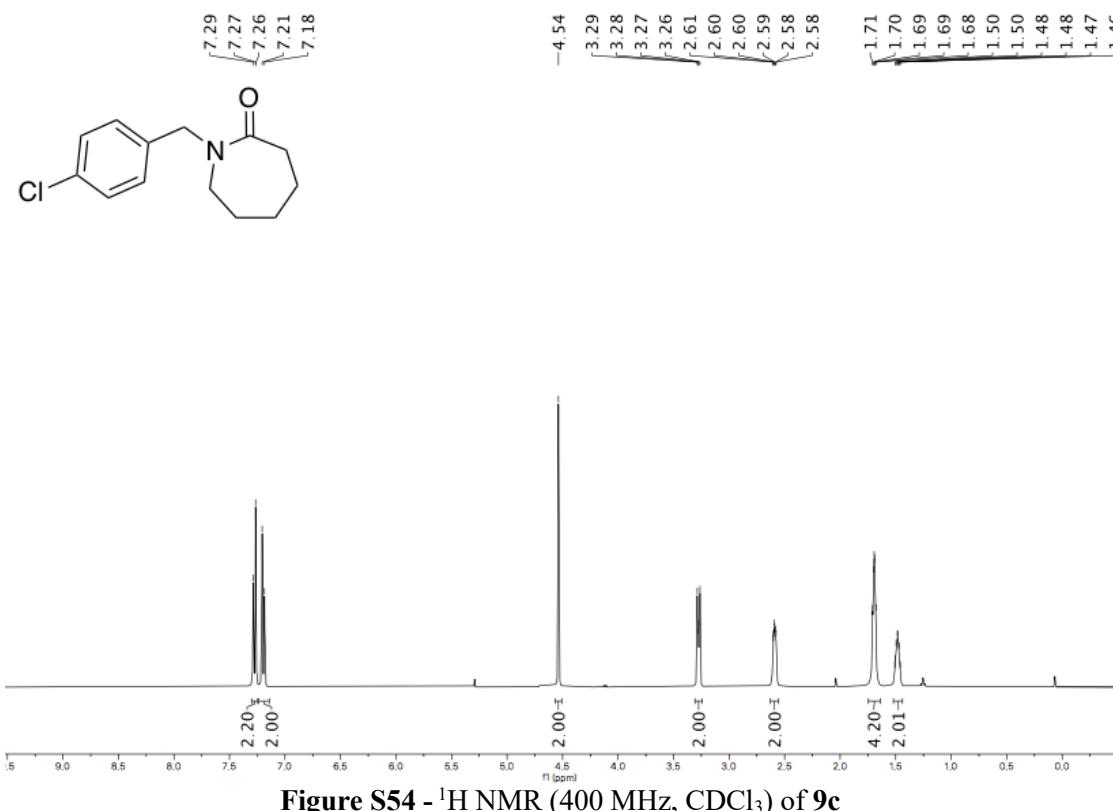
**Figure S51 -  $^{13}\text{C}\{^1\text{H}\}$  NMR (101 MHz,  $\text{CDCl}_3$ ) of 9a**



**Figure S52 -  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) of 9b**



**Figure S53 -  $^{13}\text{C}\{\text{H}\}$  NMR (101 MHz, CDCl<sub>3</sub>) of **9b****



**Figure S54 -  $^1\text{H}$  NMR (400 MHz, CDCl<sub>3</sub>) of **9c****

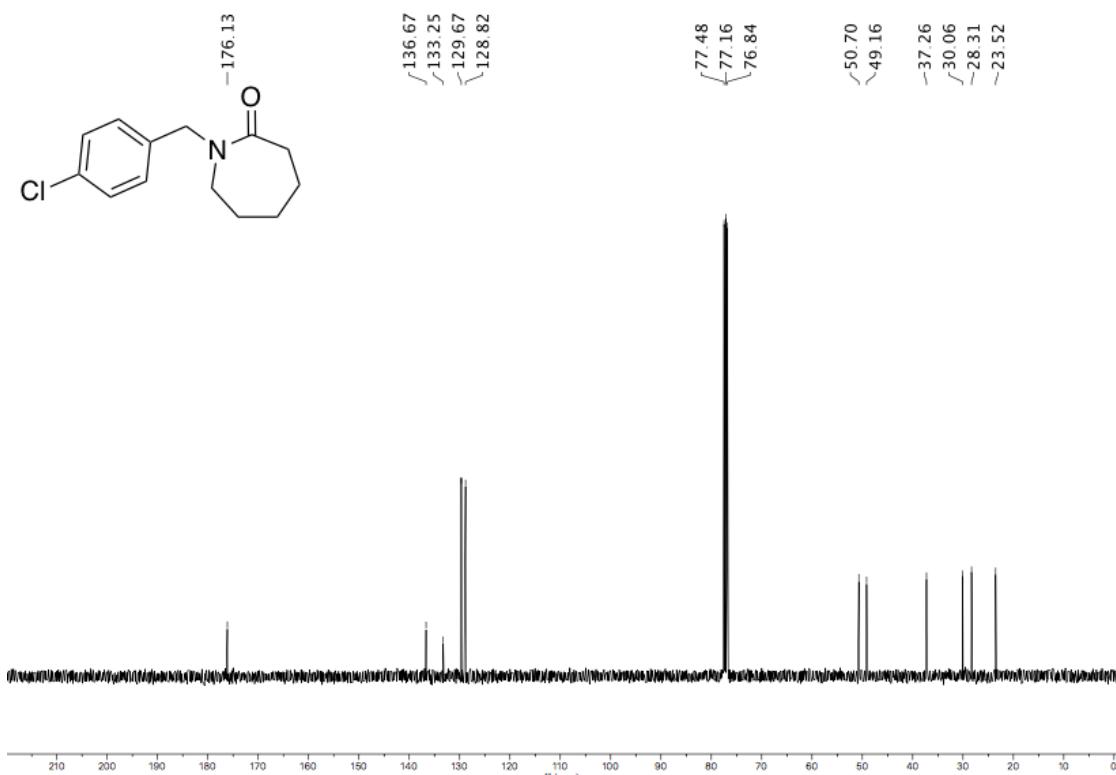


Figure S55 - <sup>13</sup>C{<sup>1</sup>H} NMR (101 MHz, CDCl<sub>3</sub>) of **9c**

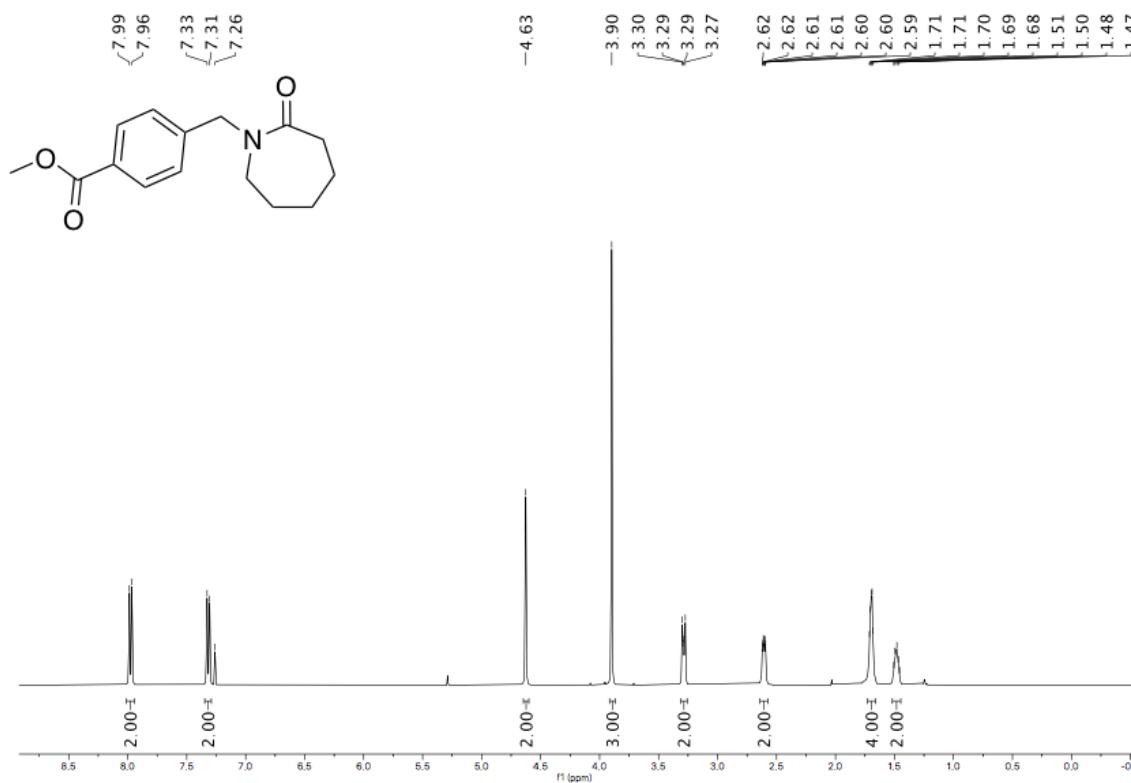
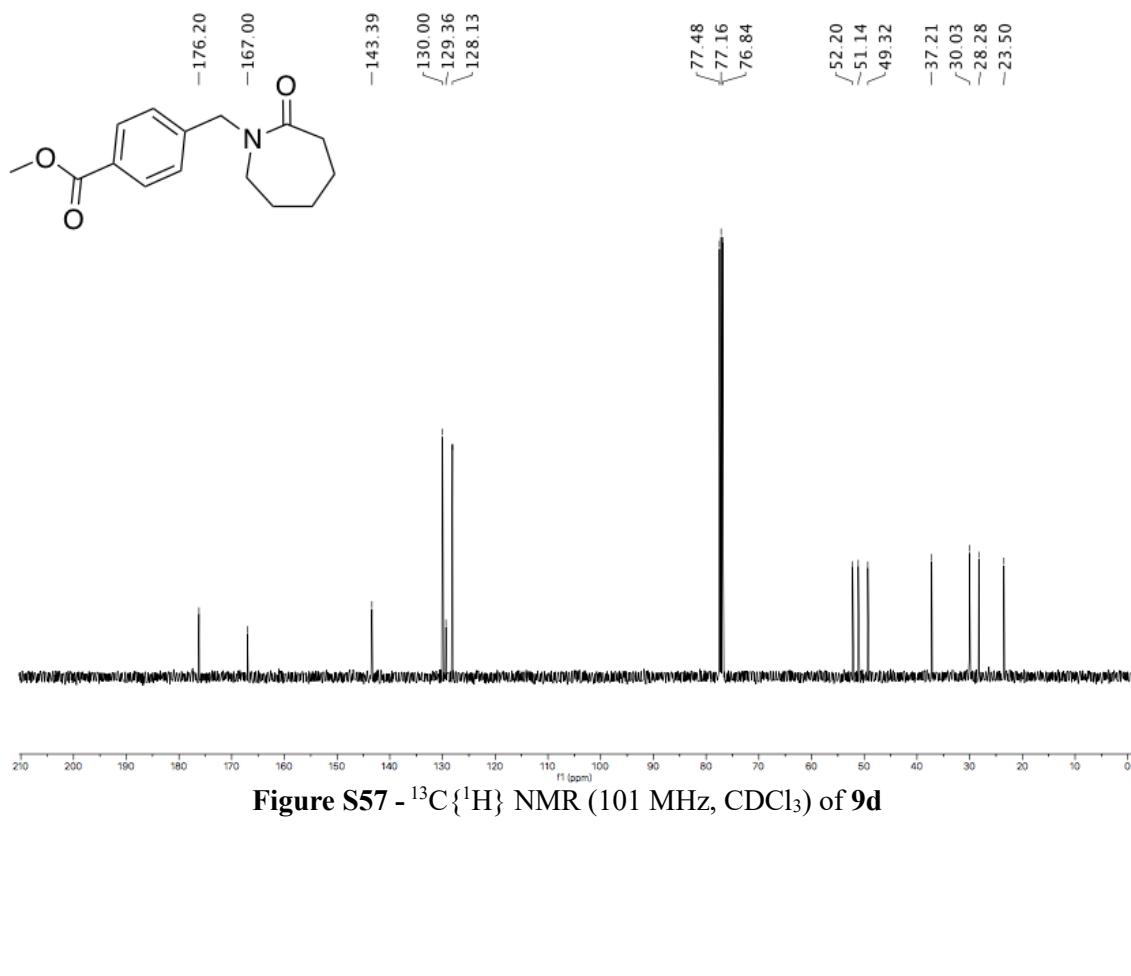


Figure S56 - <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) of **9d**



## 5- References

1. J. Mun, M. B. Smith, *Synth. Commun.* **2007**, *37*, 813–819.
2. K. Kim, S. H. Hong, *J. Org. Chem.* **2015**, *80*, 4152–4156.
3. Y. T. Oh, K. Senda, T. Hata, H. Urabe, *Tetrahedron Lett.* **2011**, *52*, 2458–2461.
4. A. K. Mahalingam, Y. Wan, A. M. Murugaiah, C. Wallinder, X. Wu, B. Plouffe, M. Botros, F. Nyberg, N. Gallo-Payet, M. Alterman, *Bioorg. Med. Chem.* **2010**, *18*, 4570–4590.
5. G. Wuitschik, M. Rogers-Evans, A. Buckl, M. Bernasconi, M. Märki, T. Godel, H. Fischer, B. Wagner, I. Parrilla, F. Schuler, J. Schneider, A. Alker, W. B. Schweizer, K. Müller, E. M. Carreira, *Angew. Chem. Int. Ed.* **2008**, *47*, 4512 –4515.
6. J. Watanabe, Y. Kagoshima, E. Tokumaru, K. Murata, T. Baba, M. Kitagawa, A. Kurimoto, M. Numata, M. Shiroishi, T. Shinozaki, Patent, WO2020116662 A1 2020-06-11.
7. Y. Urade, K. Shigeno, Y. Tanaka, J. Kuze, M. Tsuchikawa, T. Hosoya, Patent JP2007051121 A 2007-03-01.
8. S. Ward, P. Beswick, L. Pennicott, T. Reuillon, I. Chuckowree, C. Villalonga-Barber, R. A. Porter, Patent WO2019166822 A1 2019-09-06.
9. Y. Yang, M. Shi, *J. Org. Chem.* **2005**, *70*, 8645–8648.
10. S. Wang, J.-X. Zhang, T.-Y. Zhang, H. Meng, B.-H. Chen, W. Shu, Che. *Nature Commun.* **2021**, *12*, 2771.
11. S. Sugiyama, K. Morishita, M. Chiba, K. Ishii, *Heterocycles* **2006**, *70*, 599–607.
12. K. M. Orrling, X. Wu, F. Russo, M. Larhed, *J. Org. Chem.* **2008**, *73*, 8627–8630.
13. B. Fanté, Y. Soro, S. Siaka, J. Marrot, J. Coustard, *Synth. Commun.* **2014**, *44*, 2377–2385
14. A. Nova, D. Balcells, N. D. Schley, G. E. Dobereiner, R. H. Crabtree, O. Eisenstein, *Organometallics* **2010**, *29*, 6548–6558.
15. M. Seto, K. Aikawa, N. Miyamoto, Y. Aramaki, N. Kanzaki, K. Takashima, Y. Kuze, Y. Iizawa, M. Baba, M. Shiraishi, *J. Med. Chem.* **2006**, *49*, 2037–2048.
16. Y. Sunada, H. Kawakami, T. Imaoka, Y. Motoyama, H. Nagashima *Angew. Chem. Int. Ed.* **2009**, *48*, 9511 –9514.
17. M. Plaza, C. Jandl, T. Bach, *Angew. Chem. Int. Ed.* **2020**, *59*, 12785–12788.