

This version of the ESI replaces the one published on 24.11.2023 as the previous version contained a mistake regarding the deuterated solvent that the mechanistic experiments were run into.

# **Organocatalytic Friedel-Crafts Arylation of Aldehydes with Indoles utilizing *N*-Heterocyclic Iod(az)olium Salts as the Halogen-Bonding Catalyst**

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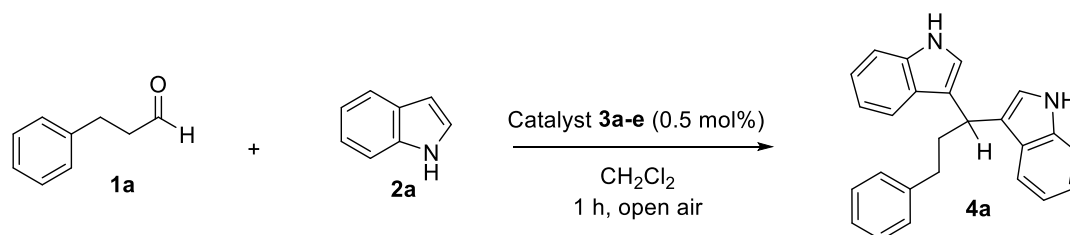
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## General Remarks

Chromatographic purification of products was accomplished using forced-flow chromatography on Merck<sup>®</sup> Kieselgel 60 70-230 mesh. Thin-layer chromatography (TLC) was performed on aluminum backed silica plates (0.2 mm, 60 F<sup>254</sup>). Visualization of the developed chromatogram was performed by fluorescence quenching using phosphomolybdic acid, anisaldehyde or potassium permanganate stains. Melting points were determined on a Buchi<sup>®</sup> 530 hot stage apparatus and are uncorrected. Mass spectra (ESI) were recorded on a Finningan<sup>®</sup> Surveyor MSQ LCMS spectrometer. HRMS spectra were recorded on a Bruker<sup>®</sup> Maxis Impact QTOF spectrometer. <sup>1</sup>H-NMR, <sup>19</sup>F-NMR and <sup>13</sup>C-NMR spectra were recorded on a Varian<sup>®</sup> Mercury (200 MHz, 188 MHz and 50 MHz, respectively) or on an Avance III HD Bruker 400 MHz (400 MHz, 376 MHz and 100 MHz, respectively) or on a Bruker Avance Neo 600 MHz (600 MHz and 150 MHz) and are internally referenced to residual solvent signals. Data for <sup>1</sup>H-NMR are reported as follows: chemical shift ( $\delta$  ppm), integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br s = broad signal), coupling constant and assignment. Data for <sup>19</sup>F-NMR are reported in terms of chemical shift ( $\delta$  ppm) and are internally referenced to trifluoroacetic acid (188 MHz) or fluoroform (376 MHz). Data for <sup>13</sup>C-NMR are reported in terms of chemical shift ( $\delta$  ppm). Mass spectra and conversions of the reactions were recorded on a Shimadzu<sup>®</sup> GCMS-QP2010 Plus Gas Chromatograph Mass Spectrometer utilizing a MEGA<sup>®</sup> column (MEGA-5, F.T.: 0.25  $\mu$ m, I.D.: 0.25 mm, L.: 30 m, T<sub>max</sub>: 350 °C, Column ID# 11475). Catalyst **3a-3e** were synthesized following literature procedures.<sup>1</sup>

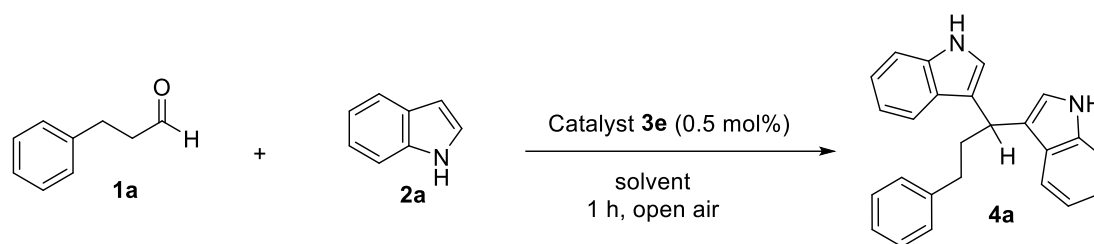
## Optimization of the Reaction Conditions for the Friedel-Crafts Arylation Between 3-Phenylpropanal (1a) and Indole (2a): Catalyst Screening



Entry	Catalyst	Yield <sup>[a]</sup> (%)
1	-	0
2	 3a	50
3	 3b	56
4	 3c	83
5	 3d	55
6	 3e	90

[a] Yield determined by <sup>1</sup>H-NMR using internal standard. The reaction was performed with 3-phenylpropanal (1a) (26 mg, 0.20 mmol), indole (2a) (52 mg, 0.44 mmol), catalyst 3a-e (0.5 mol%, 1.0 μmol) in CH<sub>2</sub>Cl<sub>2</sub> (0.5 mL) for 1 h.

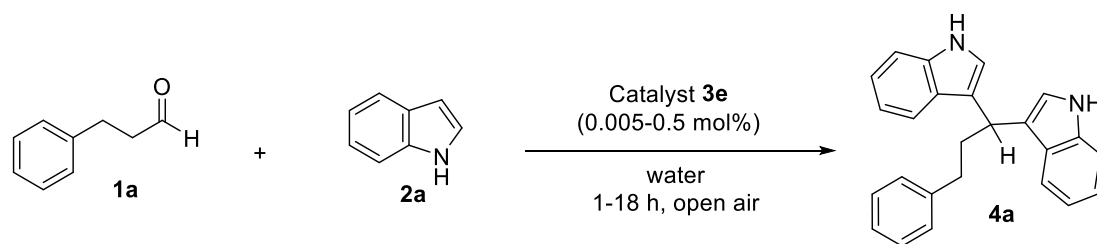
## Optimization of the Reaction Conditions for the Friedel-Crafts Arylation Between 3-Phenylpropanal (**1a**) and Indole (**2a**): Solvent Screening



Entry	Solvent	Yield <sup>[a]</sup> (%)
1	CH <sub>2</sub> Cl <sub>2</sub>	93
2	CHCl <sub>3</sub>	90
3	MeCN	93
4	EtOAc	89
5	DMSO	35
6	Toluene	96
7	Pet. Eth.	80
8	THF	50
9	H <sub>2</sub> O	97 (93)
10	Et <sub>2</sub> O	55
11	MeOH	53
12	Cyrene	-
13	2-Me-THF	76

[a] Yield determined by <sup>1</sup>H-NMR using internal standard, yield of **4a** after isolation by column chromatography in parenthesis. The reaction was performed with 3-phenyl-propanal (**1a**) (26 mg, 0.20 mmol), indole (**2a**) (52 mg, 0.44 mmol), catalyst **3e** (0.5 mol%, 1.0 μmol) in solvent (0.5 mL) for 1 h.

## Optimization of the Reaction Conditions for the Friedel-Crafts Arylation Between 3-Phenylpropanal (1a) and Indole (2a): Catalyst Loading

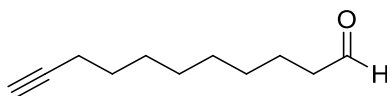


Entry	Catalyst loading (mol%)	Yield <sup>[a]</sup> (%)
1	0.005	60 <sup>[b]</sup>
2	0.01	87 (79) <sup>[b]</sup>
3	0.1	95 <sup>[b]</sup>
4	0.5	97 (93)

[a] Yield determined by <sup>1</sup>H-NMR using internal standard, yield of **4a** after isolation by column chromatography in parenthesis. The reaction was performed with 3-phenyl-propanal (**1a**) (26 mg, 0.20 mmol), indole (**2a**) (52 mg, 0.44 mmol), catalyst **3e** in water (0.5 mL) for 1 h. [b] Reaction time 18 h.

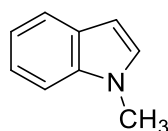
## Synthesis of Starting Materials

### 10-Undecynal (1h)<sup>2</sup>



To a flask containing 10-undecynol (504 mg, 3.00 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (3 mL), TEMPO (47 mg, 0.30 mmol) was added, followed by iodobenzene diacetate (1.06 g, 3.30 mmol). The reaction mixture was stirred at room temperature until TLC showed consumption of the alcohol and then diluted with CH<sub>2</sub>Cl<sub>2</sub> (12 mL). Saturated aqueous solution of Na<sub>2</sub>SO<sub>3</sub> (12 mL) was then added, the layers were separated and the aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 6 mL). The combined organic layers were washed with saturated aqueous NaHCO<sub>3</sub> (18 mL) and brine (18 mL), dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and concentrated in *vacuo*. The resulting oil was purified by flash chromatography (Pet. Ether/AcOEt 95:5); Colorless oil; 98% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 9.75 (1H, t, *J* = 1.4 Hz, CHO), 2.41 (2H, td, *J* = 7.3 and 1.4 Hz, COCH<sub>2</sub>), 2.16 (2H, td, *J* = 7.0 and 2.5 Hz, CH<sub>2</sub>), 1.93 (1H, t, *J* = 2.5 Hz, ≡CH), 1.58-1.65 (2H, m, CH<sub>2</sub>), 1.47-1.54 (2H, m, CH<sub>2</sub>), 1.24-1.39 (8H, m, 4 x CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 202.7, 84.5, 68.1, 43.8, 29.1, 29.0, 28.8, 28.5, 28.3, 21.9, 18.3; MS (ESI) *m/z* 189 [M+Na]<sup>+</sup>.

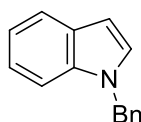
### 1-Methyl-1*H*-indole (2t)<sup>3</sup>



To a stirring solution of indole (352 mg, 3.00 mmol) in dry THF (6 mL) at 0 °C, NaH (180 mg, 60% dispersion in mineral oil, 4.50 mmol) was added under an argon atmosphere. The heterogenous reaction mixture was stirred at 0 °C for 15 min and at room temperature for 1 h. The reaction mixture was then cooled at 0 °C, iodomethane (0.2 ml, 4.00 mmol) was added and allowed to warm at room temperature. After 30 min, the reaction mixture was cooled at 0 °C, quenched with saturated aq. NH<sub>4</sub>Cl (5 mL) and extracted with diethyl ether (3 x 50 mL). The combined organic layers were

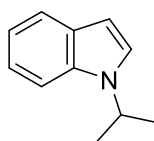
washed with brine (1 x 50 ml), dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and concentrated in *vacuo*. The resulting oil was purified by flash chromatography (Pet. Ether/AcOEt 10:1); Green oil; 83% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.68 (1H, d, *J* = 7.9 Hz, ArH), 7.38 (1H, d, *J* = 7.9 Hz, ArH), 7.28 (1H, t, *J* = 7.9 Hz, ArH), 7.16 (1H, t, *J* = 7.9 Hz, ArH), 7.10 (1H, d, *J* = 2.5 Hz, ArH), 6.54 (1H, d, *J* = 2.5 Hz, ArH), 3.84 (3H, s, NCH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.7, 128.7, 128.4, 121.4, 120.8, 119.2, 109.1, 100.9, 32.8; MS (ESI) *m/z* 154 [M+Na]<sup>+</sup>.

#### 1-Benzyl-1*H*-indole (2u)<sup>4</sup>



Same procedure as above using benzyl bromide; Yellow solid, mp 39-40 °C; 82% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.69 (1H, d, *J* = 7.8 Hz, ArH), 7.32-7.28 (4H, m, ArH), 7.17-7.11 (5H, m, ArH), 6.59 (1H, d, *J* = 2.3 Hz, ArH), 5.36 (2H, s, NCH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 137.5, 136.3, 128.7, 128.6, 128.2, 127.6, 126.8, 121.7, 121.0, 119.5, 109.7, 101.7, 50.1; MS (ESI) *m/z* 230 [M+Na]<sup>+</sup>.

#### 1-Isopropyl-1*H*-indole (2v)<sup>5</sup>

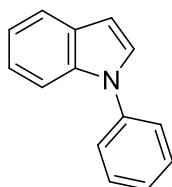


To a stirring solution of indole (352 mg, 3.00 mmol) in anhydrous DMF (6 mL) at 0 °C, NaH (180 mg, 60% dispersion in mineral oil, 6.00 mmol) was added under an argon atmosphere. The heterogenous reaction mixture was stirred at 0 °C for 30 min. Isopropyl iodide (0.7 ml, 7.50 mmol) was added, the reaction mixture warm at room temperature and allowed to stir for 12 h. Water (6 mL) was added and the reaction mixture was extracted with ethyl acetate (2 x 3 mL). The combined organic layers were washed using 1M aqueous HCl (3 x 3 mL) and water (2 x 3 mL), dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and concentrated in *vacuo*. The resulting oil was purified by flash chromatography (Pet. Ether/AcOEt 10:1); Yellow oil; 93% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.68 (1H, d, *J* = 7.8 Hz, ArH), 7.43 (1H, d, *J* = 7.8 Hz, ArH), 7.28-7.21



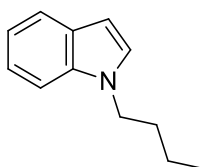
(2H, m, ArH), 7.14 (1H, t,  $J = 7.8$  Hz, ArH, ArH), 6.56 (1H, d,  $J = 2.5$  Hz, ArH), 4.78-4.68 (1H, m, NCH), 1.58 (6H, d,  $J = 6.7$  Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)  $\delta$ : 135.5, 128.6, 123.5, 121.1, 120.9, 119.2, 109.4, 101.1, 47.0, 22.8; MS (ESI)  $m/z$  182 [M+Na]<sup>+</sup>.

### 1-Phenyl-1H-indole (2w)<sup>4</sup>



In a Schlenk flask, iodobenzene (0.30 mL, 2.00 mmol), indole (352 mg, 3.00 mmol), Cu<sub>2</sub>O (30 mg, 0.20 mmol) and KOH (224 mg, 4.00 mmol) were added. After addition of dry DMSO (4 mL), the reaction mixture was stirred at 120 °C for 12 h under an argon atmosphere. The reaction mixture was diluted with EtOAc (10 mL) and washed with H<sub>2</sub>O (2 x 6 mL). The aqueous phase was extracted with EtOAc (2 x 6 mL) and the combined organic layers were washed with brine (1 x 20 mL), dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and the solvent was removed *in vacuo*. The resulting oil was purified by flash chromatography (Pet. Ether/AcOEt 20:1); Yellow oil; 60% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.73 (1H, d,  $J = 7.8$  Hz, ArH), 7.61 (1H, d,  $J = 8.1$  Hz, ArH), 7.58-7.54 (4H, m, ArH), 7.43-7.37 (2H, m, ArH), 7.30-7.18 (2H, m, ArH), 6.73 (1H, d,  $J = 3.2$  Hz, ArH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 139.8, 135.8, 129.6, 129.3, 127.9, 126.4, 124.4, 122.3, 121.1, 120.3, 110.5, 103.5; MS (ESI)  $m/z$  216 [M+Na]<sup>+</sup>.

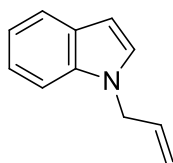
### 1-Butyl-1H-indole (2x)<sup>6</sup>



NaH (90 mg, 60% dispersion in mineral oil, 3.00 mmol) was added to indole (351 mg, 3.00 mmol) in dry DMSO (5 mL) under argon at room temperature and the reaction mixture was stirred for 2 h. Then, butyl iodide (772 mg, 4.20 mmol) was added and the reaction mixture was stirred for 4.5 h. When the reaction was judged complete by

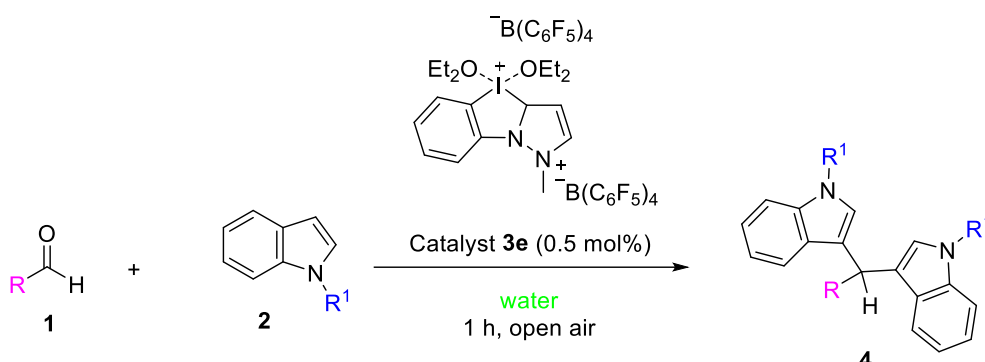
TLC, water (50 mL) was added and the crude reaction mixture was extracted with chloroform (3 x 50 mL). The combined organic layers were dried with anhydrous Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The resulting oil was purified by flash chromatography (Pet. Ether/AcOEt 20:1); Green oil; 51% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.66 (1H, d, *J* = 7.9 Hz, ArH), 7.38 (1H, d, *J* = 7.9 Hz, ArH), 7.23 (1H, t, *J* = 7.9 Hz, ArH), 7.15-7.09 (2H, m, ArH), 6.52 (1H, d, *J* = 2.8 Hz, ArH), 4.15 (2H, t, *J* = 7.1 Hz, NCH<sub>2</sub>), 1.90-1.81 (2H, m, CH<sub>2</sub>), 1.44-1.33 (2H, m, CH<sub>2</sub>), 0.97 (3H, t, *J* = 7.4 Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.0, 128.5, 127.8, 121.3, 120.9, 119.1, 109.4, 100.8, 46.1, 32.3, 20.2, 13.7; MS (ESI) *m/z* 196 [M+Na]<sup>+</sup>.

### 1-Allyl-1*H*-indole (2y)<sup>7</sup>



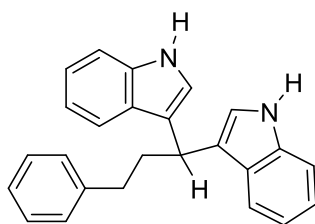
A 50 mL round-bottom flask equipped with a stir bar was charged with indole (234 mg, 2.00 mmol) and crushed potassium hydroxide (336 mg, 6.00 mmol). Then, DMSO (5 mL) was added to the flask and the solution was stirred at room temperature for 15 min. Next, allyl bromide (484 mg, 4.00 mmol) was added. The reaction mixture was further stirred at room temperature for 18 h. Then, the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> (15 mL) and washed with water (15 mL). The organic layer was dried with anhydrous Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated *in vacuo*. The resulting oil was purified by flash chromatography; Green oil; 96% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.67 (1H, d, *J* = 7.9 Hz, ArH), 7.36 (1H, d, *J* = 7.9 Hz, ArH), 7.24 (1H, t, *J* = 7.9 Hz, ArH), 7.15-7.10 (2H, m, ArH), 6.56 (1H, d, *J* = 2.5 Hz, ArH), 6.09-5.97 (1H, m, =CH), 5.26-5.19 (1H, m, =CHH), 5.17-5.08 (1H, m, =CHH), 4.77 (2H, d, *J* = 5.4 Hz, NCH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.1, 133.5, 128.7, 127.8, 121.5, 120.9, 119.4, 117.2, 109.5, 101.4, 48.8; MS (ESI) *m/z* 180 [M+Na]<sup>+</sup>.

## General Procedure for the Organocatalytic Reaction Between Aldehydes and Indoles

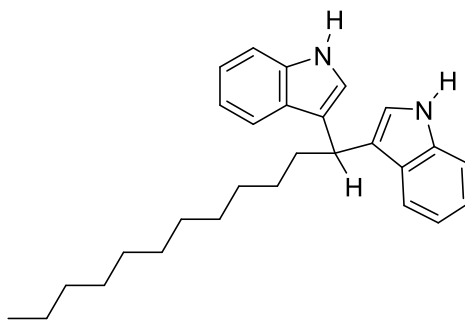


In a glass vial, containing catalyst **3e** (1.8 mg, 1.0  $\mu\text{mol}$ ) in  $\text{H}_2\text{O}$  (0.5 mL), aldehyde (0.20 mmol) and indole (0.44 mmol) were added consecutively. The reaction mixture was stirred for 1 h. After reaction completion, the reaction mixture was extracted with EtOAc (2 mL). The organic layer was dried over  $\text{Na}_2\text{SO}_4$  and concentrated *in vacuo*. The desired product was isolated after purification by column chromatography.

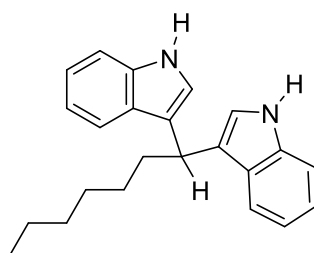
### 3,3'-(3-Phenylpropane-1,1-diyl)bis(1H-indole) (4a)<sup>8</sup>



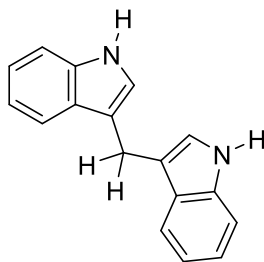
Brown solid; 93% yield; mp 156-158  $^{\circ}\text{C}$ ;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.88 (2H, br s, 2 x NH), 7.59 (2H, d,  $J = 8.1$  Hz, ArH), 7.36 (2H, d,  $J = 8.1$  Hz, ArH), 7.30 (2H, d,  $J = 8.1$  Hz, ArH), 7.26-7.16 (5H, m, ArH), 7.11-7.05 (2H, m, ArH), 7.03 (2H, s, ArH), 4.55 (1H, t,  $J = 8.0$  Hz, CH), 2.81-2.73 (2H, m,  $\text{CH}_2$ ), 2.65-2.55 (2H, m,  $\text{CH}_2$ );  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 142.6, 136.6, 128.5, 128.3, 127.1, 125.7, 121.8, 121.5, 120.1, 119.6, 119.1, 111.1, 37.4, 34.4, 33.5; MS (ESI)  $m/z$  373  $[\text{M}+\text{Na}]^+$ .

**3,3'-(Dodecane-1,1-diyl)bis(1*H*-indole) (4b)<sup>9</sup>**

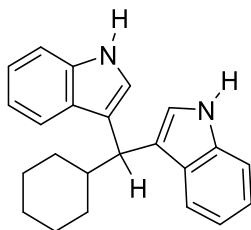
Brown oil; 60% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.88 (2H, br s, 2 x NH), 7.64 (2H, d, *J* = 7.5 Hz, ArH), 7.35 (2H, d, *J* = 7.5 Hz, ArH), 7.18 (2H, t, *J* = 7.5 Hz, ArH), 7.07 (2H, t, *J* = 7.5 Hz, ArH), 7.01 (2H, s, ArH), 4.51 (1H, t, *J* = 6.5 Hz, CH), 2.30-2.19 (2H, m, CH<sub>2</sub>), 1.36-1.20 (18H, m, 9 x CH<sub>2</sub>), 0.97-0.88 (3H, m, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.6, 127.2, 121.7, 121.3, 120.6, 119.7, 119.0, 111.0, 35.9, 34.0, 31.9, 29.8, 29.7, 29.6, 29.3, 28.3, 22.7, 14.1; MS (ESI) *m/z* 423 [M+Na]<sup>+</sup>.

**3,3'-(Heptane)bis(1*H*-indole) (4c)<sup>10</sup>**

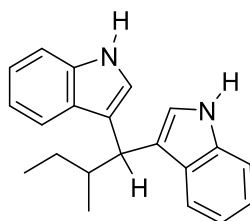
Brown oil; 84% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.83 (2H, br s, 2 x NH), 7.67 (2H, d, *J* = 7.9 Hz, ArH), 7.34 (2H, d, *J* = 7.9 Hz, ArH), 7.21 (2H, t, *J* = 7.9 Hz, ArH), 7.11 (2H, t, *J* = 7.9 Hz, ArH), 6.96 (2H, d, *J* = 2.0 Hz, ArH), 4.53 (1H, t, *J* = 7.3 Hz, CH), 2.33-2.21 (2H, m, CH<sub>2</sub>), 1.53-1.39 (4H, m, 2 x CH<sub>2</sub>), 1.38-1.25 (4H, m, 2 x CH<sub>2</sub>), 0.93 (3H, t, *J* = 6.7 Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.5, 127.2, 121.6, 121.4, 120.5, 119.6, 118.9, 111.0, 35.9, 34.0, 31.8, 29.4, 28.3, 22.7, 14.1; MS (ESI) *m/z* 353 [M+Na]<sup>+</sup>.

**Di-(1*H*-indol-3-yl)methane (4d)**<sup>11</sup>

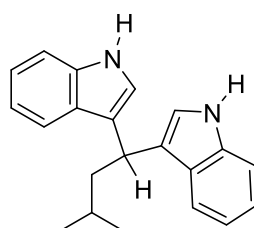
White solid; 50% yield; mp 160-162 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.89 (2H, br s, 2 x NH), 7.66 (2H, d, *J* = 7.5 Hz, ArH), 7.38 (2H, d, *J* = 7.5 Hz, ArH), 7.23 (2H, t, *J* = 7.5 Hz, ArH), 7.13 (2H, t, *J* = 7.5 Hz, ArH), 6.95 (2H, s, ArH), 4.28 (2H, s, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.4, 127.6, 122.2, 121.9, 119.2, 119.2, 115.7, 111.0, 21.2; MS (ESI) *m/z* 269 [M+Na]<sup>+</sup>.

**3,3'-((Cyclohexane)methylene)bis(1*H*-indole) (4e)**<sup>12</sup>

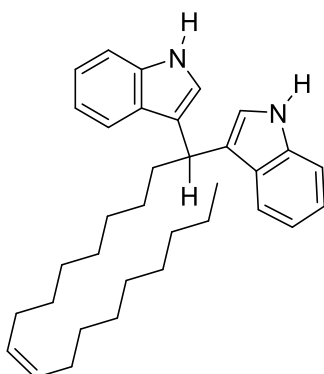
Brown solid; 74% yield; mp 158-160 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.90 (2H, br s, 2 x NH), 7.69 (2H, d, *J* = 7.8 Hz, ArH), 7.33 (2H, d, *J* = 7.8 Hz, ArH), 7.16 (2H, t, *J* = 7.8 Hz, ArH), 7.11 (2H, d, *J* = 7.8 Hz, ArH), 7.08 (2H, t, *J* = 7.8 Hz, ArH), 4.31 (1H, d, *J* = 8.7 Hz, CH), 2.34-2.22 (1H, m, CH), 1.87 (2H, d, *J* = 12.6 Hz, 2 x CHH), 1.76-1.62 (4H, m, 4 x CHH), 1.34-1.19 (4H, m, 4 x CHH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.3, 127.8, 121.6, 121.5, 119.7, 119.7, 119.0, 110.9, 42.9, 40.1, 32.4, 26.7, 26.7; MS (ESI) *m/z* 351 [M+Na]<sup>+</sup>.

**3,3'-(2-Methylbutane)bis(1H-indole) (4f)<sup>13</sup>**

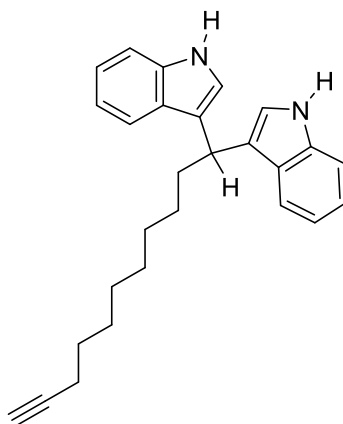
Brown oil; 79% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.84 (2H, br s, 2 x NH), 7.74-7.63 (2H, m, ArH), 7.30 (2H, t, *J* = 7.8 Hz, ArH), 7.18 (2H, t, *J* = 7.8 Hz, ArH), 7.14-7.09 (2H, m, ArH), 7.06 (2H, s, ArH), 4.44 (1H, d, *J* = 7.6 Hz, CH), 2.50-2.37 (1H, m, CH), 1.77-1.62 (1H, m, CHH), 1.30-1.15 (1H, m, CHH), 1.03 (3H, d, *J* = 6.5 Hz, CH<sub>3</sub>), 0.97 (3H, t, *J* = 7.3 Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.3, 136.2, 127.9, 127.7, 121.8, 121.6, 121.6, 119.6, 119.0, 111.0, 39.4, 39.4, 28.0, 17.8, 12.0; MS (ESI) *m/z* 325 [M+Na]<sup>+</sup>.

**3,3'-(3-Methylbutane-1,1-diyl)bis(1H-indole) (4g)<sup>13</sup>**

Brown oil; 98% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.80-7.65 (4H, m, 2 x NH and ArH), 7.33 (2H, d, *J* = 7.5 Hz, ArH), 7.24 (2H, t, *J* = 7.5 Hz, ArH), 7.15 (2H, t, *J* = 7.5 Hz, ArH), 6.93 (2H, s, ArH), 4.68 (1H, t, *J* = 7.2 Hz, CH), 2.18 (2H, t, *J* = 7.2 Hz, CH<sub>2</sub>), 1.80-1.68 (1H, m, CH), 1.08 (6H, d, *J* = 6.6 Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.5, 127.0, 121.7, 121.4, 120.4, 119.5, 119.0, 111.1, 45.2, 31.6, 25.9, 22.8; MS (ESI) *m/z* 325 [M+Na]<sup>+</sup>.

**3,3'-(Oleyl-2-methylene)bis(1*H*-indole) (4h)<sup>13</sup>**

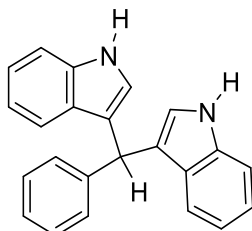
Brown oil; 80% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.84 (2H, br s, 2 x NH), 7.65 (2H, d, *J* = 7.8 Hz, ArH), 7.35 (2H, d, *J* = 7.8 Hz, ArH), 7.20 (2H, t, *J* = 7.8 Hz, ArH), 7.09 (2H, t, *J* = 7.8 Hz, ArH), 6.99 (2H, s, ArH), 5.47-5.37 (2H, m, 2 x CH=), 4.52 (1H, t, *J* = 7.2 Hz, CH), 2.31-2.22 (2H, m, CH<sub>2</sub>), 2.13-1.98 (4H, m, 2 x CH<sub>2</sub>), 1.46-1.24 (22H, m, 11 x CH<sub>2</sub>), 0.98-0.90 (3H, m, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.6, 129.9, 127.2, 121.7, 121.4, 120.5, 119.6, 118.9, 111.0, 35.8, 34.0, 31.9, 29.8, 29.5, 29.3, 29.3, 28.3, 27.2, 22.7, 14.1; MS (ESI) *m/z* 505 [M+Na]<sup>+</sup>.

**3,3'-(Undec-10-yne-1,1-diyl)bis(1*H*-indole) (4i)<sup>13</sup>**

Brown oil; 20% yield; Reaction time 1 h or 18 h; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.80 (2H, br s, 2 x NH), 7.67 (2H, d, *J* = 8.0 Hz, ArH), 7.34 (2H, d, *J* = 8.0 Hz, ArH), 7.24-7.18 (2H, m, ArH), 7.15-7.08 (2H, m, ArH), 6.96 (2H, d, *J* = 2.2 Hz, ArH), 4.53 (1H, t, *J* = 7.5 Hz, CH), 2.31-2.19 (4H, m, 2 x CH<sub>2</sub>), 2.01 (1H, t, *J* = 2.7 Hz, ≡CH), 1.61-1.52 (2H, m, CH<sub>2</sub>), 1.48-1.37 (6H, m, 3 x CH<sub>2</sub>), 1.37-1.29 (4H, m, 2 x CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.5, 127.1, 121.6, 121.4, 120.4, 119.6, 118.9, 111.0,

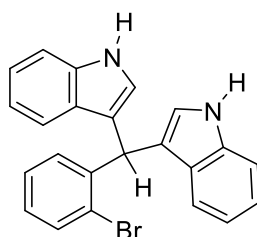
84.8, 68.1, 35.8, 33.9, 29.6, 29.4, 29.0, 28.7, 28.4, 28.2, 18.3; MS (ESI)  $m/z$  405  $[M+Na]^+$ .

**3,3'-(Phenylmethylene)bis(1*H*-indole) (4j)<sup>8</sup>**



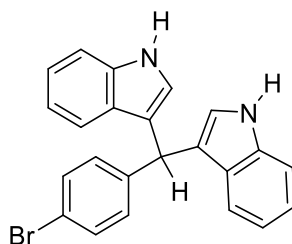
Red foam; 70% yield; mp 140-142 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.77 (2H, br s, 2 x NH), 7.45 (2H, d,  $J = 7.7$  Hz, ArH), 7.40 (2H, d,  $J = 7.7$  Hz, ArH), 7.38-7.31 (4H, m, ArH), 7.28 (1H, d,  $J = 7.7$  Hz, ArH), 7.23 (2H, t,  $J = 7.7$  Hz, ArH), 7.07 (2H, t,  $J = 7.7$  Hz, ArH), 6.62 (2H, d,  $J = 1.7$  Hz, ArH), 5.94 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 144.0, 136.6, 128.7, 128.2, 127.0, 126.1, 123.6, 121.9, 119.9, 119.6, 119.2, 111.0, 40.2; MS (ESI)  $m/z$  345  $[M+Na]^+$ .

**3,3'-((2-Bromophenyl)methylene)bis(1*H*-indole) (4k)<sup>14</sup>**

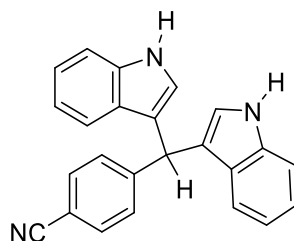


Pink foam; 96% yield; mp 76-78 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.83 (2H, br s, 2 x NH), 7.66 (1H, dd,  $J = 7.8$  and 1.4 Hz, ArH), 7.45 (2H, d,  $J = 7.9$  Hz, ArH), 7.37 (2H, d,  $J = 7.9$  Hz, ArH), 7.26 (1H, dd,  $J = 7.8$  and 1.9 Hz, ArH), 7.22 (2H, t,  $J = 7.9$  Hz, ArH), 7.17 (1H, td,  $J = 7.8$  and 1.4 Hz, ArH), 7.11 (1H, td,  $J = 7.8$  and 1.9 Hz, ArH), 7.07 (2H, t,  $J = 7.9$  Hz, ArH), 6.59 (2H, d,  $J = 2.2$  Hz, ArH), 6.35 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 143.0, 136.7, 132.8, 130.4, 127.8, 127.3, 127.0, 124.8, 123.8, 122.0, 119.9, 119.3, 118.4, 111.1, 39.5; MS (ESI)  $m/z$  425  $[M+Na]^+$ .

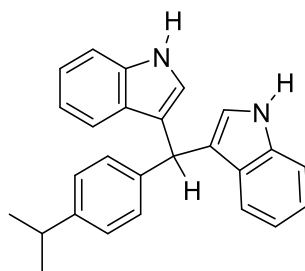


**3,3'-((4-Bromophenyl)methylene)bis(1H-indole) (4l)<sup>16</sup>**

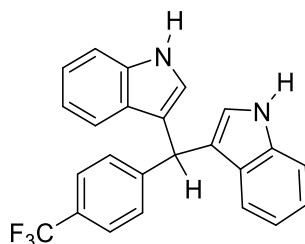
Red foam; 54% yield; mp 112-114 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.89 (2H, br s, 2 x NH), 7.46-7.39 (4H, m, ArH), 7.36 (2H, d, *J* = 7.6 Hz, ArH), 7.27-7.19 (4H, m, ArH), 7.07 (2H, t, *J* = 7.6 Hz, ArH), 6.60 (2H, s, ArH), 5.88 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 143.1, 136.6, 131.2, 130.4, 126.8, 123.6, 122.0, 119.8, 119.7, 119.3, 118.9, 111.1, 39.6; MS (ESI) *m/z* 425 [M+Na]<sup>+</sup>.

**3,3'-((4-Ethynylphenyl)methylene)bis(1H-indole) (4m)<sup>17</sup>**

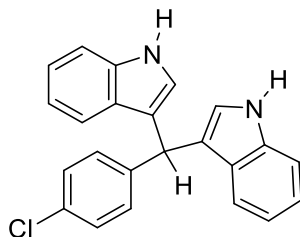
Red foam; 86% yield; mp 208-210 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 8.04 (2H, br s, 2 x NH), 7.57 (2H, d, *J* = 8.0 Hz, ArH), 7.47 (2H, d, *J* = 8.0 Hz, ArH), 7.40 (2H, d, *J* = 7.6 Hz, ArH), 7.36 (2H, d, *J* = 7.6 Hz, ArH), 7.23 (2H, t, *J* = 7.6 Hz, ArH), 7.06 (2H, t, *J* = 7.6 Hz, ArH), 6.66 (2H, d, *J* = 2.2 Hz, ArH), 5.96 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 149.8, 136.7, 132.1, 129.5, 126.7, 123.6, 122.2, 119.5, 119.2, 119.1, 118.1, 111.2, 109.9, 40.3; MS (ESI) *m/z* 370 [M+Na]<sup>+</sup>.

**3,3'-((4-Isopropylphenyl)methylene)bis(1H-indole) (4n)<sup>18</sup>**

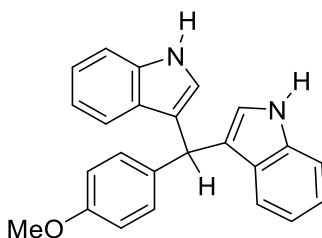
Orange oil; 53% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.80 (2H, br s, 2 x NH), 7.46 (2H, d, *J* = 8.3 Hz, ArH), 7.37-7.34 (2H, m, ArH), 7.31 (2H, d, *J* = 8.3 Hz, ArH), 7.24-7.16 (4H, m, ArH), 7.08-7.03 (2H, m, ArH), 6.65 (2H, dd, *J* = 2.4 and 0.8 Hz, ArH), 5.90 (1H, s, CH), 2.98-2.89 (1H, m, CH), 1.29 (6H, d, *J* = 6.8 Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 146.4, 141.2, 136.6, 128.5, 127.1, 126.2, 123.5, 121.8, 119.9, 119.9, 119.1, 111.0, 39.7, 33.6, 24.0; MS (ESI) *m/z* 387 [M+Na]<sup>+</sup>.

**3,3'-((4-(Trifluoromethyl)phenyl)methylene)bis(1H-indole) (4o)<sup>8</sup>**

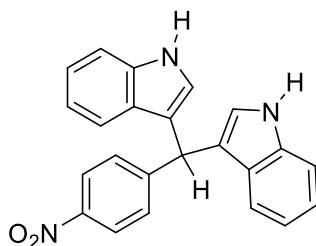
Brown foam; 77% yield; reaction time 18 h; mp 67-69 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.79 (2H, br s, 2 x NH), 7.60 (2H, d, *J* = 8.1 Hz, ArH), 7.51 (2H, d, *J* = 8.1 Hz, ArH), 7.46 (2H, d, *J* = 8.1 Hz, ArH), 7.38 (2H, d, *J* = 8.1 Hz, ArH), 7.31-7.25 (2H, m, ArH), 7.15-7.10 (2H, m, ArH), 6.61 (2H, dd, *J* = 2.4 and 0.8 Hz, ArH), 6.01 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 148.2, 136.7, 129.1, 128.5 (q, *J* = 32.0 Hz), 126.9, 125.3, 125.3 (q, *J* = 3.7 Hz), 124.5 (q, *J* = 272.0 Hz), 123.8, 122.3, 119.8, 119.5, 118.8, 111.3, 40.2; <sup>19</sup>F NMR: (376 MHz, CDCl<sub>3</sub>) δ: 62.1; MS (ESI) *m/z* 413 [M+Na]<sup>+</sup>.

**3,3'-((4-Chlorophenyl)methylene)bis(1*H*-indole) (4p)<sup>8</sup>**

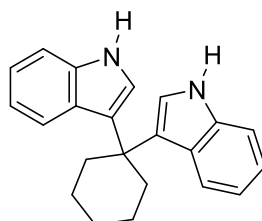
Orange foam; 80% yield; mp 77-79 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.70 (2H, br s, 2 x NH), 7.47 (2H, d, *J* = 8.0 Hz, ArH), 7.35 (2H, d, *J* = 8.0 Hz, ArH), 7.32 (4H, s, ArH), 7.30-7.26 (2H, m, ArH), 7.15-7.08 (2H, m, ArH), 6.56 (2H, dd, *J* = 2.4 and 0.8 Hz, ArH), 5.93 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.5, 136.5, 131.7, 130.0, 128.3, 126.8, 123.6, 122.0, 119.7, 119.3, 118.9, 111.1, 39.5; MS (ESI) *m/z* 379 [M+Na]<sup>+</sup>.

**3,3'-((4-Methoxyphenyl)methylene)bis(1*H*-indole) (4q)<sup>8</sup>**

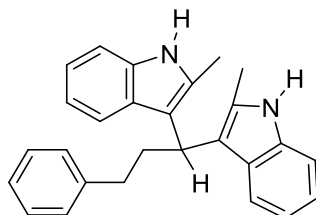
Orange solid; 75% yield; mp 188-190 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.89 (2H, br s, 2 x NH), 7.43 (2H, d, *J* = 7.9 Hz, ArH), 7.37 (2H, d, *J* = 7.9 Hz, ArH), 7.29-7.27 (2H, m, ArH), 7.20 (2H, t, *J* = 7.9 Hz, ArH), 7.04 (2H, t, *J* = 7.9 Hz, ArH), 6.85 (2H, d, *J* = 8.6 Hz, ArH), 6.66 (2H, d, *J* = 1.6 Hz, ArH), 5.87 (1H, s, CH), 3.81 (3H, s, OCH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 157.9, 136.7, 136.2, 129.6, 127.1, 123.5, 121.9, 120.0, 120.0, 119.2, 113.6, 111.0, 55.2, 39.3; MS (ESI) *m/z* 375 [M+Na]<sup>+</sup>.

**3,3'-((4-Nitrophenyl)methylene)bis(1H-indole) (4r)<sup>15</sup>**

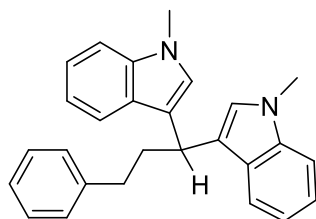
Pink solid; 88% yield; reaction time 18 h; mp 217-219 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 8.16 (2H, d, *J* = 8.6 Hz, ArH), 8.04 (2H, br s, 2 x NH), 7.53 (2H, d, *J* = 8.6 Hz, ArH), 7.41 (2H, d, *J* = 7.6 Hz, ArH), 7.36 (2H, d, *J* = 7.6 Hz, ArH), 7.23 (2H, t, *J* = 7.6 Hz, ArH), 7.05 (2H, t, *J* = 7.6 Hz, ArH), 6.71 (2H, d, *J* = 1.6 Hz, ArH), 6.02 (1H, s, CH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 151.9, 146.6, 136.7, 132.0, 129.5, 128.6, 126.7, 123.6, 122.3, 119.5, 118.1, 111.3, 40.2; MS (ESI) *m/z* 390 [M+Na]<sup>+</sup>.

**3,3'-((Cyclohexane-1,1-diyl)bis(1H-indole) (4s)<sup>19</sup>**

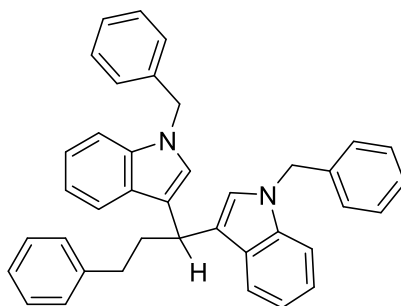
Brown foam; 96% yield; reaction time 18 h; mp 76-78 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.81 (2H, br s, 2 x NH), 7.65 (2H, d, *J* = 7.6 Hz, ArH), 7.32 (2H, d, *J* = 7.6 Hz, ArH), 7.15 (4H, t, *J* = 7.6 Hz, ArH), 7.05 (2H, s, ArH), 7.00 (2H, t, *J* = 7.6 Hz, ArH), 2.67-2.58 (4H, m, 4 x CHH), 1.78-1.62 (6H, m, 6 x CHH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 137.0, 126.2, 123.5, 122.1, 121.4, 121.1, 118.4, 111.1, 39.5, 36.8, 26.7, 22.9; MS (ESI) *m/z* 337 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(2-methyl-1H-indole) (4t)**<sup>20</sup>

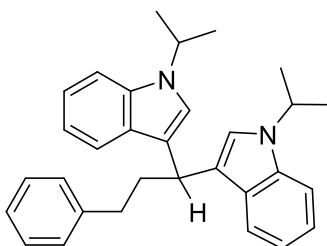
Brown solid; 75% yield; mp 188-190 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.69 (2H, d, *J* = 7.6 Hz, ArH), 7.63 (2H, br s, 2 x NH), 7.29 (2H, d, *J* = 7.6 Hz, ArH), 7.23 (3H, d, *J* = 7.6 Hz, ArH), 7.19 (2H, d, *J* = 7.6 Hz, ArH), 7.10 (2H, t, *J* = 7.6 Hz, ArH), 7.04 (2H, t, *J* = 7.6 Hz, ArH), 4.48 (1H, t, *J* = 7.4 Hz, CH), 2.85-2.71 (4H, m, 2 x CH<sub>2</sub>), 2.27 (6H, s, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.5, 135.1, 130.9, 128.5, 128.4, 128.2, 125.6, 120.4, 119.3, 119.0, 114.5, 110.1, 36.2, 34.9, 34.3, 12.6; MS (ESI) *m/z* 401 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-methyl-1H-indole) (4u)**<sup>21</sup>

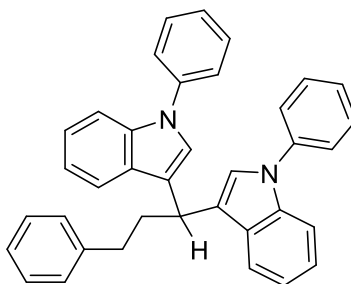
Brown oil; 76% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.61 (2H, d, *J* = 7.9 Hz, ArH), 7.31 (4H, d, *J* = 7.9 Hz, ArH), 7.27-7.19 (5H, m, ArH), 7.08 (2H, t, *J* = 7.5 Hz, ArH), 6.92 (2H, s, ArH), 4.54 (1H, t, *J* = 7.4 Hz, CH), 3.76 (6H, s, 2 x NCH<sub>3</sub>), 2.80-2.74 (2H, m, CH<sub>2</sub>), 2.62-2.54 (2H, m, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.7, 137.3, 128.5, 128.2, 127.5, 126.3, 125.6, 121.3, 119.7, 118.8, 118.5, 109.1, 37.9, 34.5, 33.3, 32.6; MS (ESI) *m/z* 401 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-benzyl-1H-indole) (4v)<sup>13</sup>**

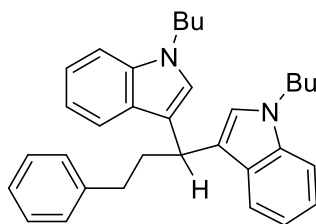
Brown oil; 94% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.76-7.67 (2H, m, ArH), 7.46-7.33 (10H, m, ArH), 7.31-7.23 (5H, m, ArH), 7.22-7.12 (8H, m, ArH), 5.36 (4H, s, 2 x NCH<sub>2</sub>), 4.67 (1H, d, *J* = 6.7 Hz, CH), 2.93-2.82 (2H, m, CH<sub>2</sub>), 2.78-2.66 (2H, m, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.6, 137.9, 137.0, 128.6, 128.5, 128.2, 127.4, 126.5, 125.8, 121.5, 119.9, 119.2, 118.7, 109.6, 49.7, 37.4, 34.4, 33.6; MS (ESI) *m/z* 553 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-isopropyl-1H-indole) (4w)**

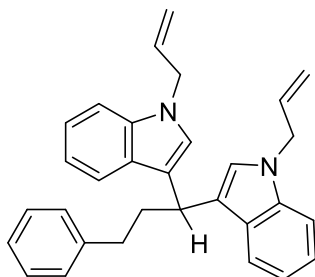
Brown oil; 80% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.61 (2H, d, *J* = 7.9 Hz, ArH), 7.40 (2H, d, *J* = 7.9 Hz, ArH), 7.34 (2H, t, *J* = 7.9 Hz, ArH), 7.26-7.20 (5H, m, ArH), 7.14 (2H, s, ArH), 7.07 (2H, t, *J* = 7.9 Hz, ArH), 4.75-4.65 (2H, m, 2 x NCH), 4.56 (1H, t, *J* = 7.3 Hz, CH), 2.80-2.71 (2H, m, CH<sub>2</sub>), 2.68-2.59 (2H, m, CH<sub>2</sub>), 1.56 (6H, d, *J* = 7.0 Hz, 2 x CH<sub>3</sub>), 1.54 (6H, d, *J* = 7.0 Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.8, 136.2, 128.6, 128.2, 127.6, 125.6, 121.1, 120.9, 119.7, 118.7, 118.3, 109.3, 46.8, 37.7, 34.5, 33.9, 22.8, 22.7; HRMS exact mass calculated for [M+Na]<sup>+</sup> (C<sub>31</sub>H<sub>34</sub>N<sub>2</sub>Na<sup>+</sup>) requires *m/z* 457.2614, found *m/z* 457.2622.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-phenyl-1H-indole) (4x)<sup>13</sup>**

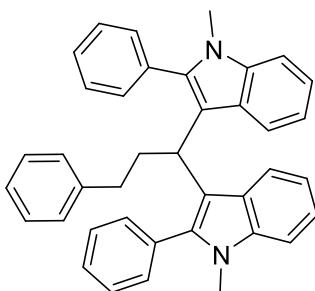
Brown oil; 99% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.97 (2H, d, *J* = 7.9 Hz, ArH), 7.85 (2H, d, *J* = 7.9 Hz, ArH), 7.72 (4H, d, *J* = 7.9 Hz, ArH), 7.67 (4H, t, *J* = 7.9 Hz, ArH), 7.57-7.54 (4H, m, ArH), 7.52-7.44 (7H, m, ArH), 7.40 (2H, t, *J* = 7.9 Hz, ArH), 4.94 (1H, t, *J* = 7.7 Hz, CH), 3.13 (2H, t, *J* = 7.7 Hz, CH<sub>2</sub>), 2.97 (2H, q, *J* = 7.7 Hz, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.3, 139.8, 136.4, 129.4, 128.6, 128.5, 128.3, 125.9, 125.7, 125.3, 124.1, 122.3, 120.8, 119.9, 119.8, 110.5, 37.5, 34.5, 33.3; MS (ESI) *m/z* 525 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-butyl-1H-indole) (4y)<sup>13</sup>**

Brown oil; 98% yield; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.84 (2H, d, *J* = 7.9 Hz, ArH), 7.53 (4H, t, *J* = 7.9 Hz, ArH), 7.48-7.38 (5H, m, ArH), 7.28 (2H, t, *J* = 7.9 Hz, ArH), 7.20 (2H, s, ArH), 4.78 (1H, t, *J* = 7.3 Hz, CH), 4.26 (4H, t, *J* = 7.1 Hz, 2 x NCH<sub>2</sub>), 3.05-2.95 (2H, m, CH<sub>2</sub>), 2.90-2.80 (2H, m, CH<sub>2</sub>), 2.07-1.94 (4H, m, 2 x CH<sub>2</sub>), 1.59-1.50 (4H, m, 2 x CH<sub>2</sub>), 1.17 (6H, t, *J* = 7.4 Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.8, 136.6, 128.5, 128.2, 127.6, 125.6, 125.4, 121.0, 119.9, 118.5, 118.3, 109.3, 45.9, 37.7, 34.5, 33.6, 32.3, 20.2, 13.7; MS (ESI) *m/z* 485 [M+Na]<sup>+</sup>.

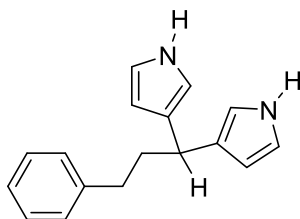
**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-allyl-1H-indole) (4z)<sup>13</sup>**

Brown oil; 97% yield; <sup>1</sup>H NMR (100 MHz, CDCl<sub>3</sub>) δ: 7.67 (2H, d, *J* = 8.0 Hz, ArH), 7.41-7.34 (4H, m, ArH), 7.32-7.23 (5H, m, ArH), 7.13 (2H, t, *J* = 8.0 Hz, ArH), 7.05 (2H, s, ArH), 6.13-6.00 (2H, m, 2 x =CH), 5.26 (2H, dd, *J* = 10.3 and 1.5 Hz, 2 x =CHH), 5.14 (2H, dd, *J* = 17.3 and 1.5 Hz, 2 x =CHH), 4.75 (4H, d, *J* = 6.1 Hz, 2 x NCH<sub>2</sub>), 4.62 (1H, t, *J* = 7.4 Hz, CH), 2.87-2.80 (2H, m, CH<sub>2</sub>), 2.72-2.63 (2H, m, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.7, 136.7, 133.8, 128.5, 128.2, 127.7, 125.6, 125.3, 121.3, 119.8, 118.6, 116.8, 109.5, 48.6, 37.7, 34.5, 33.5; MS (ESI) *m/z* 453 [M+Na]<sup>+</sup>.

**3,3'-(3-Phenylpropane-1,1-diyl)bis(1-methyl-2-phenyl-1H-indole) (4aa)**

Green solid; 78% yield; mp 130-132 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.69 (2H, d, *J* = 8.0 Hz, ArH), 7.44-7.35 (4H, m, ArH), 7.34-7.25 (7H, m, ArH), 7.24-7.17 (3H, m, ArH), 7.08 (2H, t, *J* = 7.5 Hz, ArH), 7.02-6.91 (5H, m, ArH), 4.56 (1H, t, *J* = 7.4 Hz, CH), 3.50 (6H, s, 2 x NCH<sub>3</sub>), 2.72-2.59 (4H, m, 2 x CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 142.4, 138.1, 136.9, 132.5, 130.9, 128.4, 128.0, 127.9, 127.6, 127.3, 125.2, 121.0, 120.8, 118.9, 115.8, 109.0, 36.7, 34.4, 34.2, 30.5; HRMS exact mass calculated for [M+Na]<sup>+</sup> (C<sub>31</sub>H<sub>34</sub>N<sub>2</sub>Na<sup>+</sup>) requires *m/z* 553.2614, found *m/z* 553.2614.

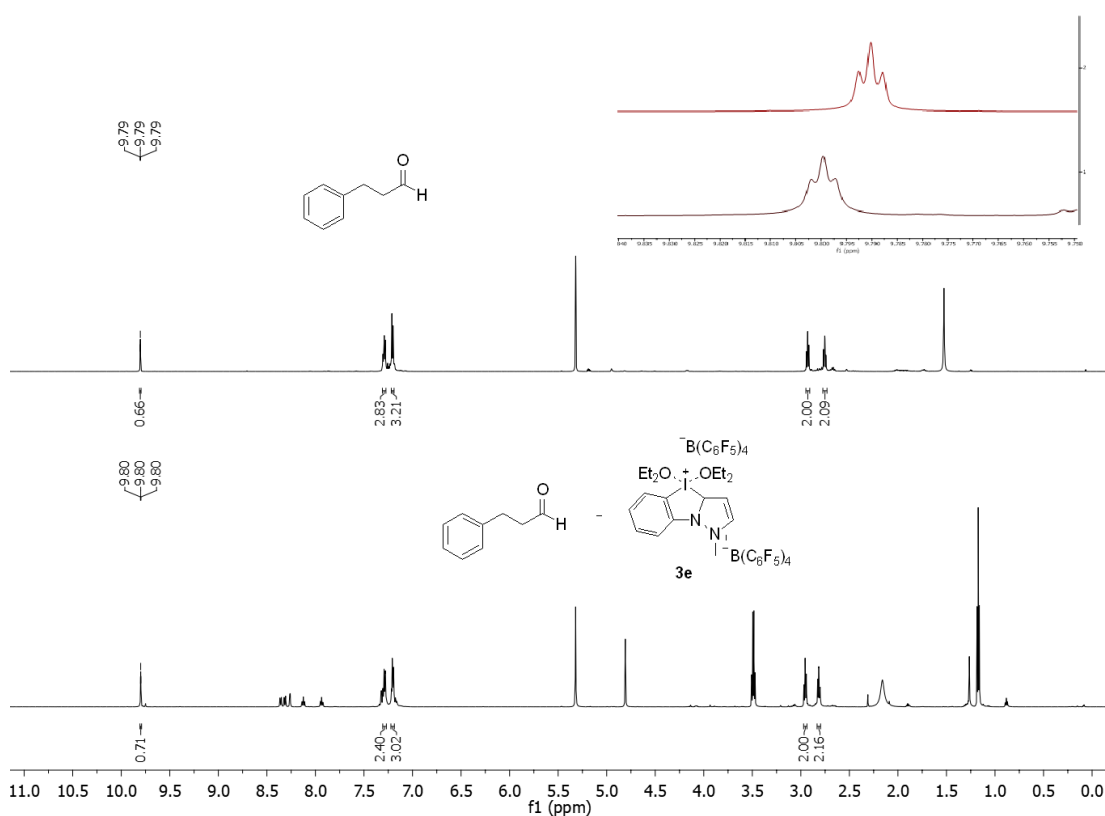


**3,3'-(3-Phenylpropane-1,1-diyl)bis(1H-pyrrole) (4ab)**

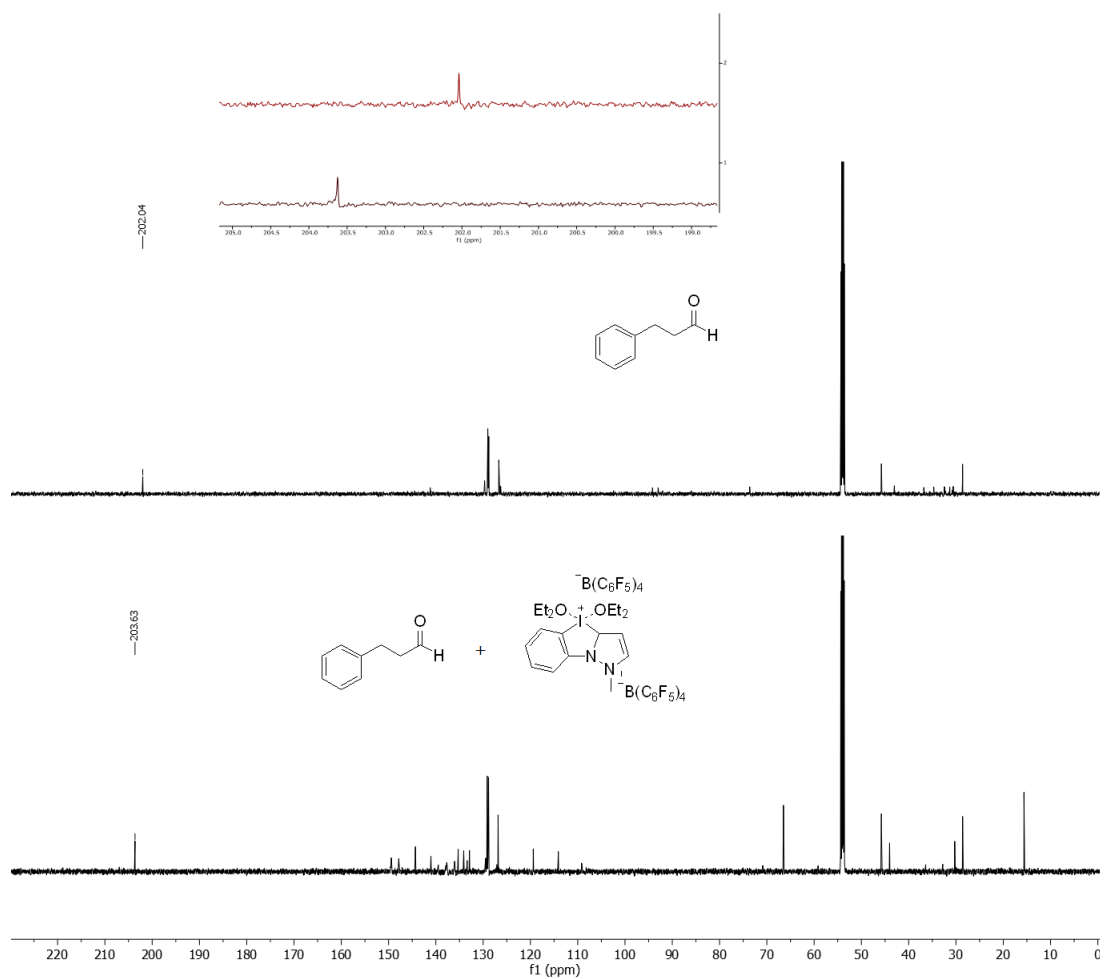
Brown oil; 60% yield;  $^1\text{H}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.38-7.06 (9H, m, ArH), 5.96 (2H, s, ArH), 3.90-3.78 (1H, m, CH), 2.68-2.55 (2H, m,  $\text{CH}_2$ ), 2.24-2.13 (2H, m,  $\text{CH}_2$ );  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 141.9, 132.7, 128.6, 128.5, 128.5, 128.3, 125.8, 117.7, 108.2, 105.5, 105.4, 105.2, 36.8, 35.2, 33.5; HRMS exact mass calculated for  $[\text{M}+\text{Na}]^+$  ( $\text{C}_{31}\text{H}_{34}\text{N}_2\text{Na}^+$ ) requires  $m/z$  273.1362, found  $m/z$  273.1366.

## NMR Mechanistic Studies

First, we investigated the halogen-bond (XB) between iodonium catalyst **3e** with 3-phenyl-propanal (**1a**) by  $^1\text{H}$ - and  $^{13}\text{C}$ -NMR (600 MHz and 150 MHz,  $\text{CD}_2\text{Cl}_2$ ). We observed a slight low-field proton and a significant carbon shift, which indicates the halogen bond between **3e** and **1a**.

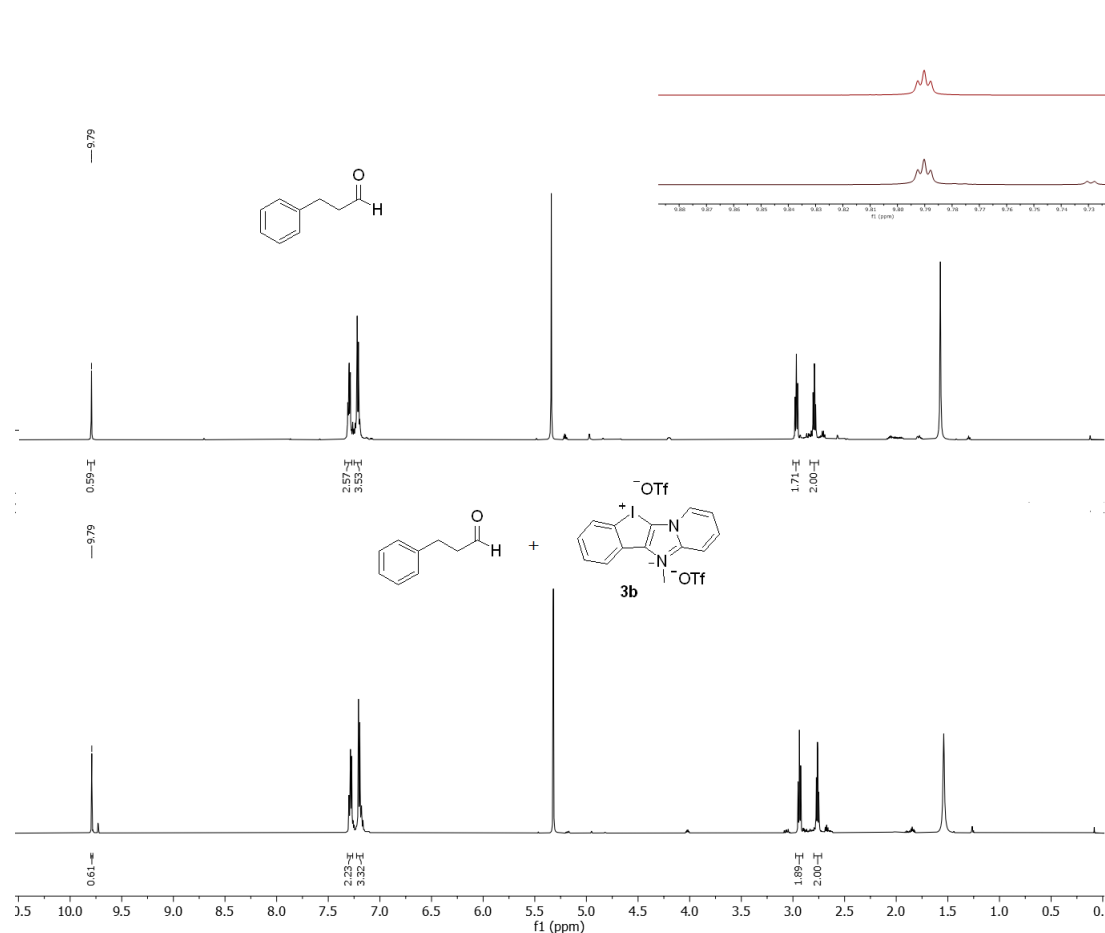


$^1\text{H}$ -NMR spectrum (600 MHz) of 3-phenyl-propanal (**1a**) and 3-phenylpropanal (**1a**) with catalyst **3e** in  $\text{CD}_2\text{Cl}_2$ .

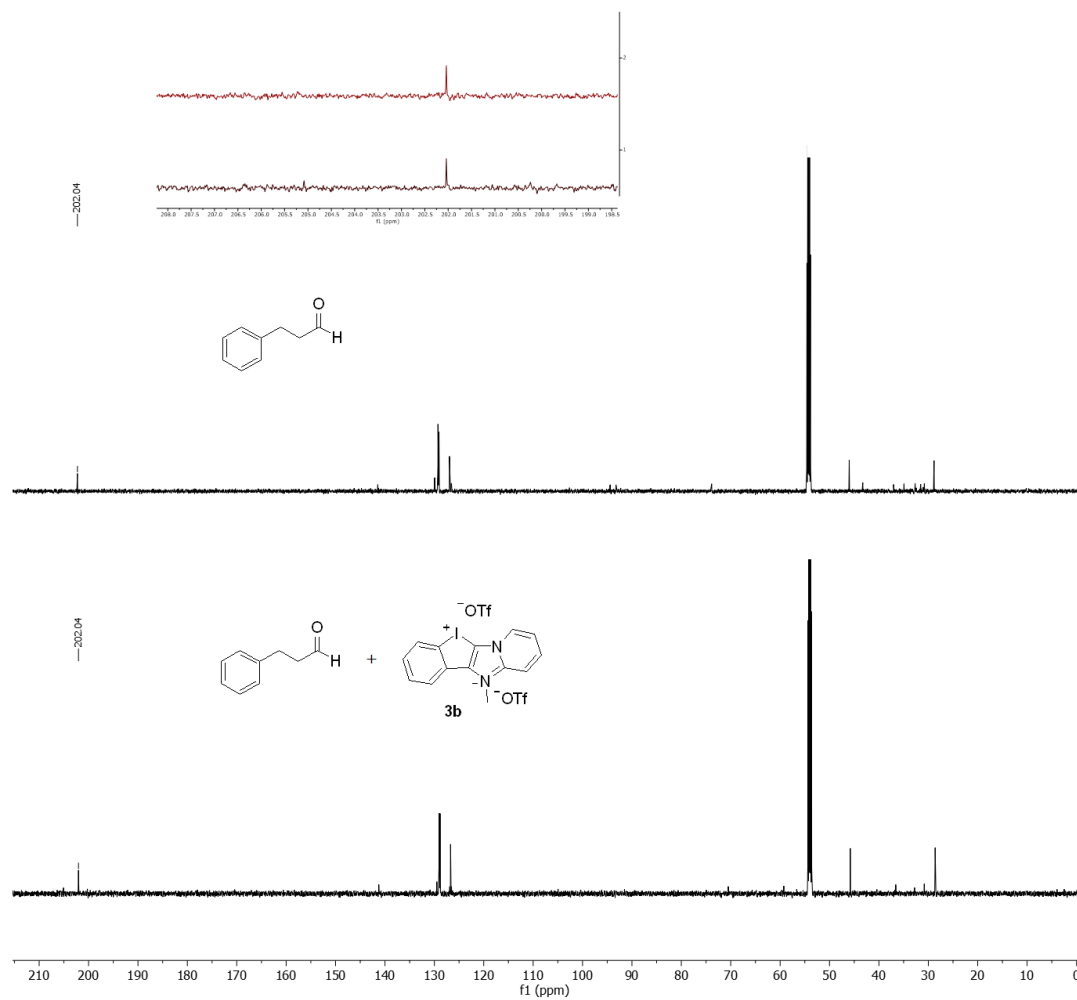


$^{13}\text{C}$ -NMR spectrum (150 MHz) of 3-phenylpropanal (**1a**) and 3-phenylpropanal (**1a**) with catalyst **3e** in  $\text{CD}_2\text{Cl}_2$ .

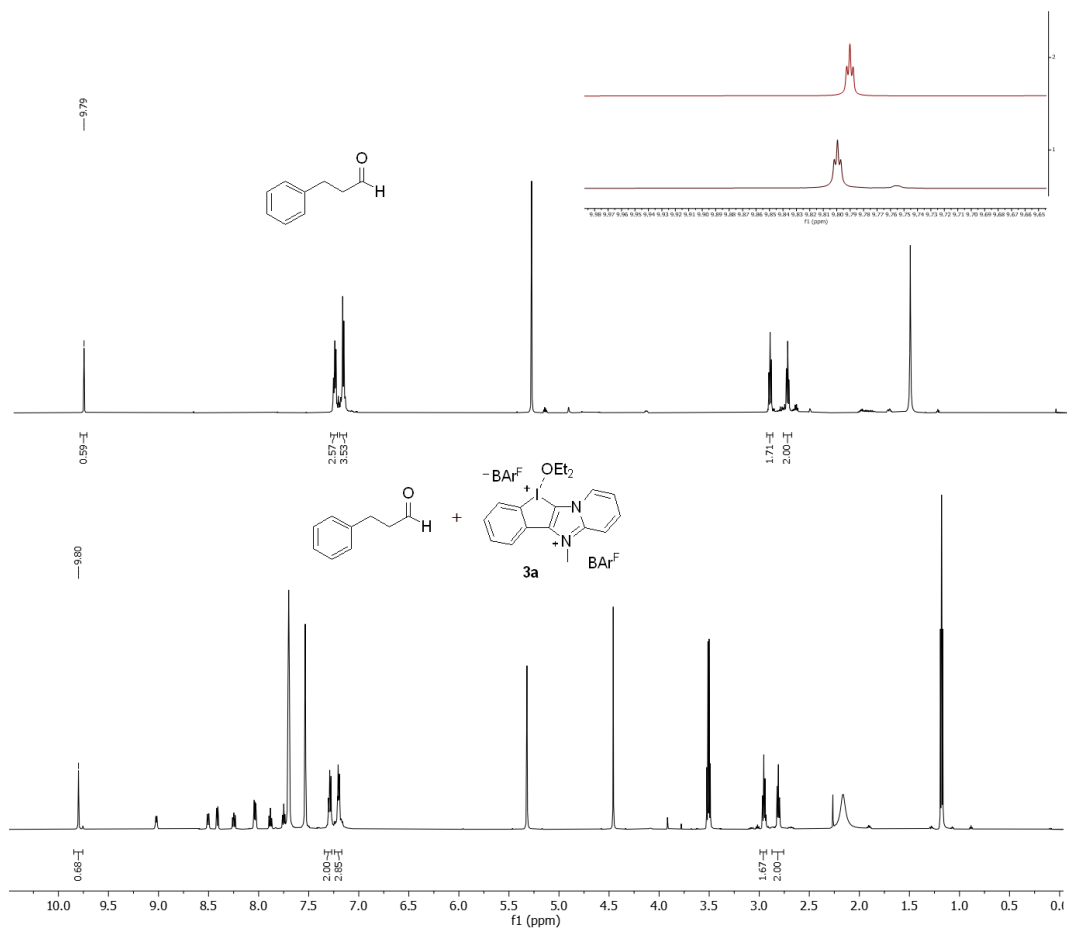
Also, we investigated the halogen-bond (XB) between iodonium catalysts **3b** or **3a** with 3-phenyl-propanal (**1a**) by  $^1\text{H}$ - and  $^{13}\text{C}$ -NMR (600 MHz and 150 MHz,  $\text{CD}_2\text{Cl}_2$ ). We observed similar low-field proton and carbon shifts, which indicates the halogen bond between **3a** and **1a**, but between **3b** and **1a**, we did not observe any significant change.



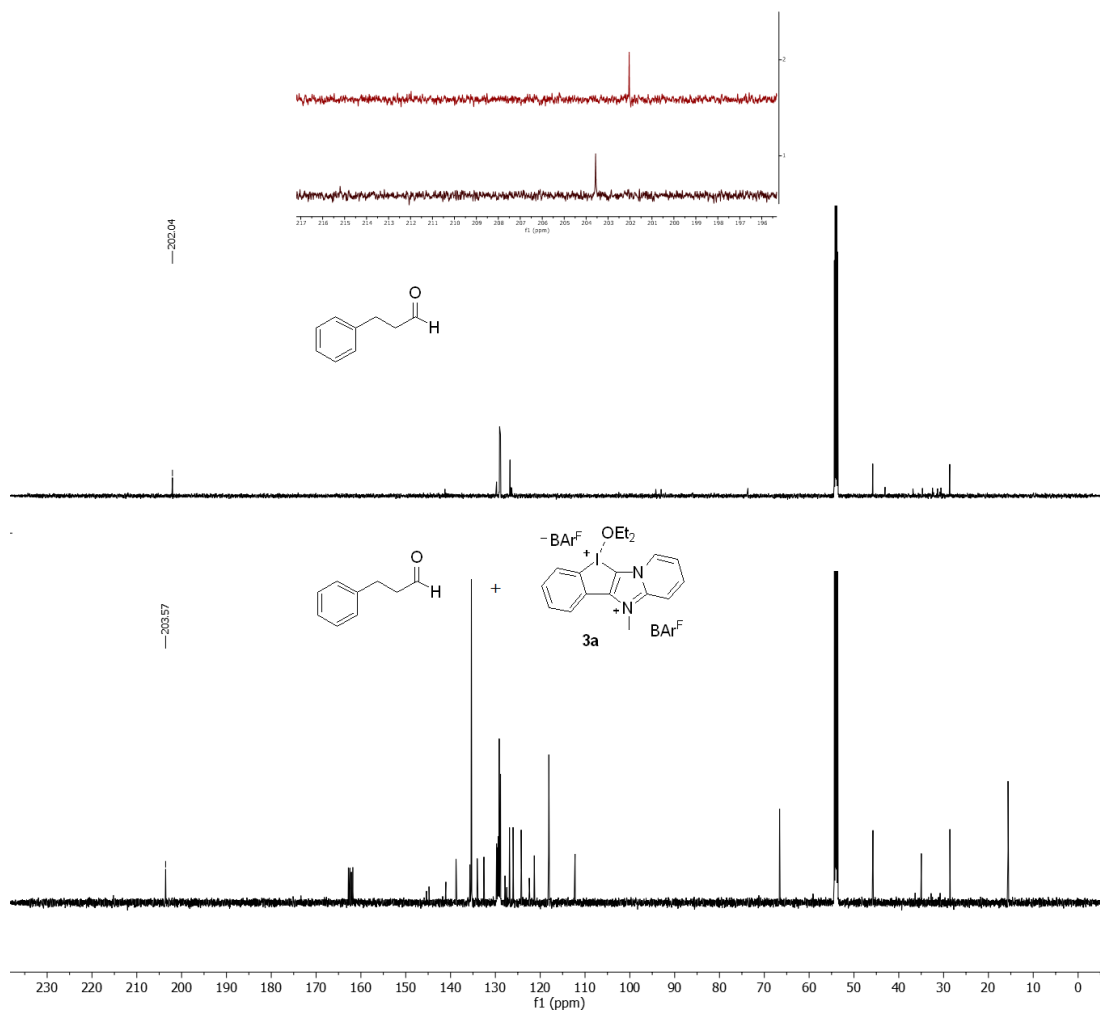
$^1\text{H}$ -NMR spectrum (600 MHz) of 3-phenyl-propanal and 3-phenylpropanal with catalyst **3b** in  $\text{CD}_2\text{Cl}_2$ .



$^{13}\text{C}$ -NMR spectrum (150 MHz) of 3-phenylpropanal and 3-phenylpropanal with catalyst **3b** in  $\text{CD}_2\text{Cl}_2$ .

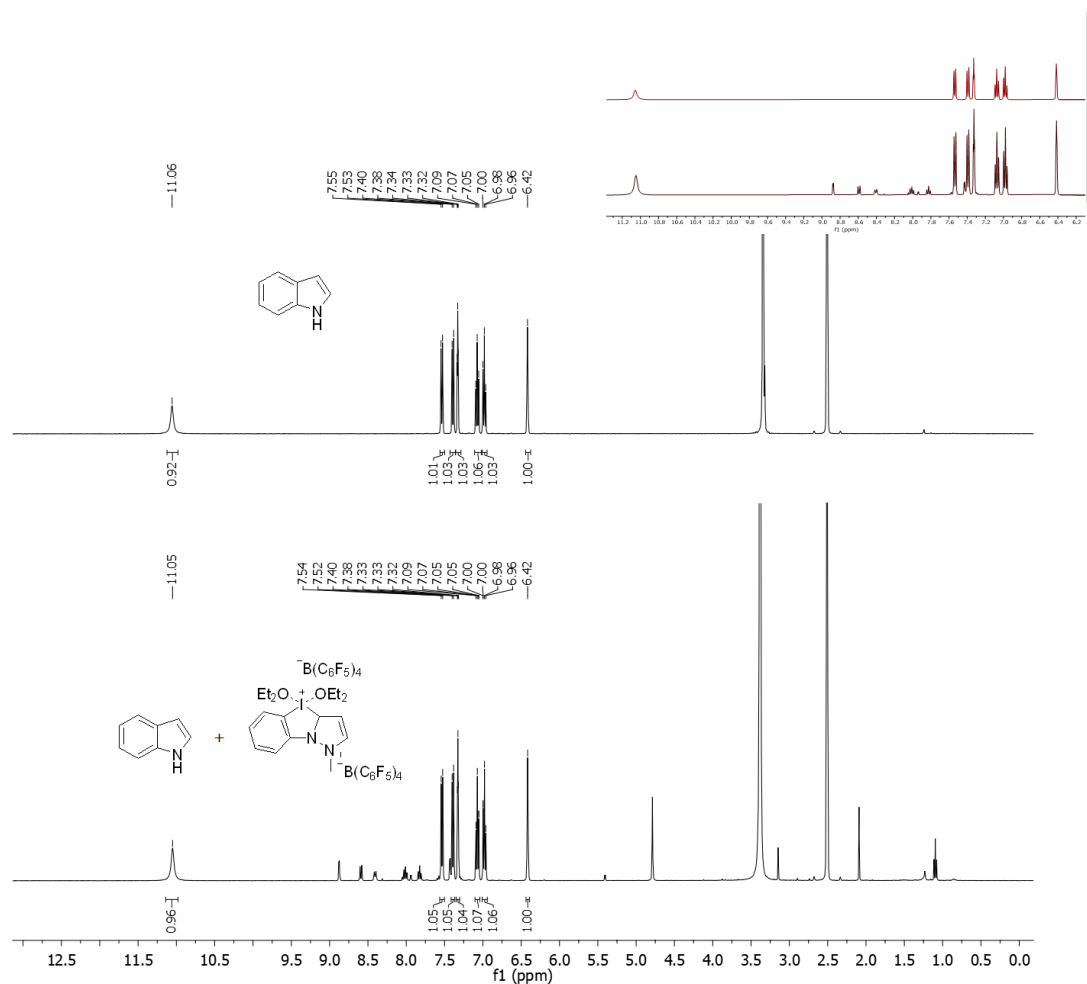


<sup>1</sup>H-NMR spectrum (600 MHz) of 3-phenylpropanal and 3-phenylpropanal with catalyst **3a** in CD<sub>2</sub>Cl<sub>2</sub>.



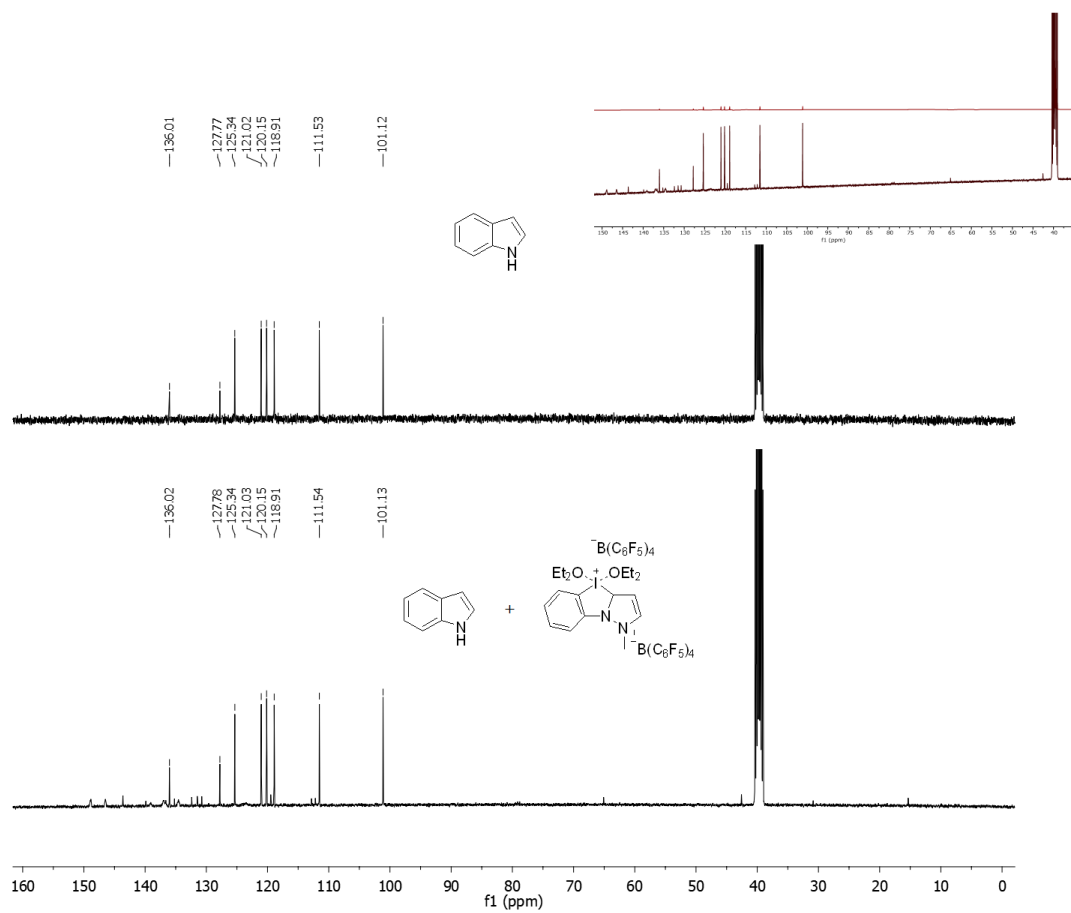
$^{13}\text{C}$ -NMR spectrum (150 MHz) of 3-phenylpropanal and 3-phenylpropanal with catalyst **3a** in  $\text{CD}_2\text{Cl}_2$ .

Next, we investigated the halogen-bond (XB) between iodonium catalyst **3e** with indole (**2a**) by  $^1\text{H}$ - and  $^{13}\text{C}$ -NMR (400 MHz and 100 MHz,  $\text{DMSO-}d_6$ ). We did not observe any significant change.



$^1\text{H}$ -NMR spectrum (400 MHz) of indole (**2a**) with catalyst **3e** in  $\text{DMSO-}d_6$ .





$^{13}\text{C}$ -NMR spectrum (100 MHz) of indole (**2a**) with catalyst **3e** in  $\text{DMSO-}d_6$ .

## Procedure for Gram Scale Reaction

In a round bottom flask, containing catalyst **3e** (2 mg, 1  $\mu$ mol), in H<sub>2</sub>O (25 mL), 3-phenyl-propanal (1.34 g, 10.00 mmol) and indole (2.58 g, 22.00 mmol) were added consecutively. The reaction mixture was stirred for 18 h. After reaction completion, the reaction mixture was extracted in EtOAc (50 mL). The organic layer was concentrated *in vacuo*. The desired product was isolated after purification by column chromatography, 2.74 g, 79% yield.

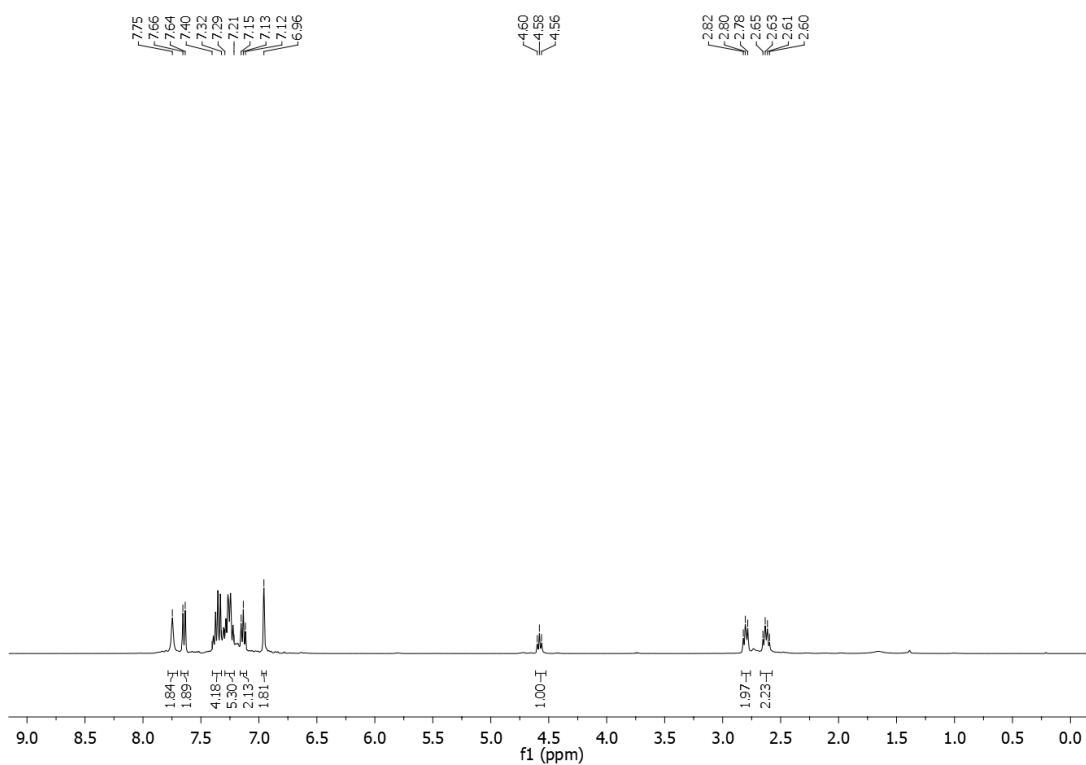
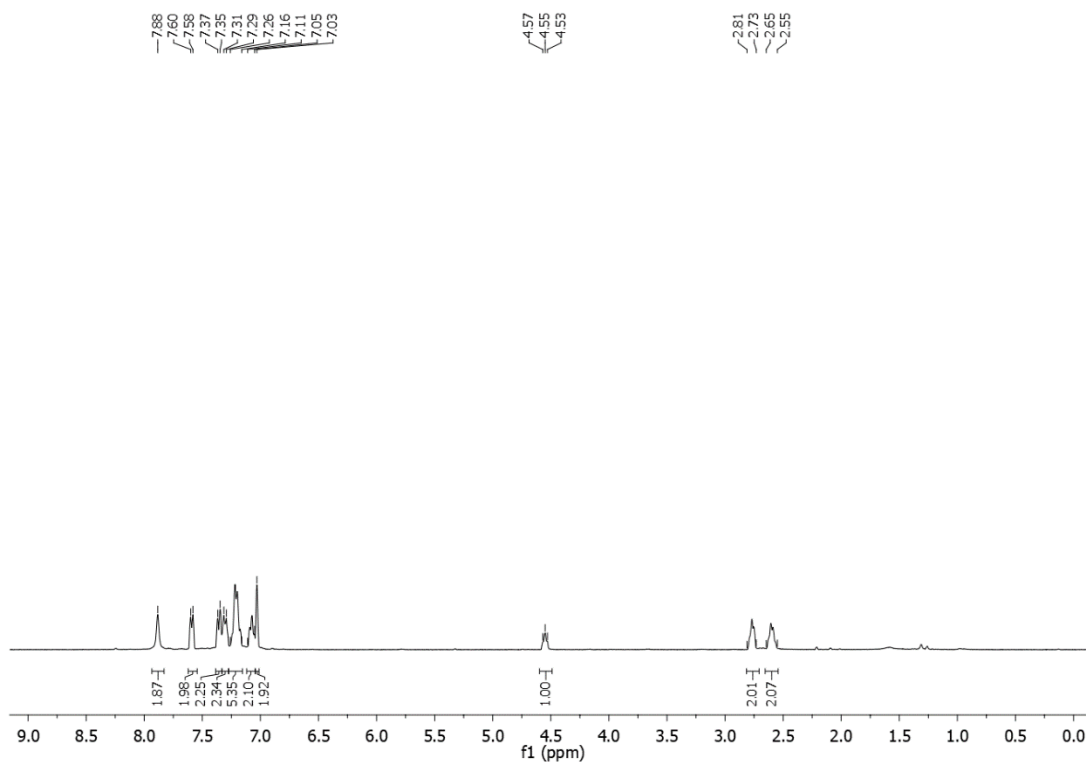
## Procedure for Green Metrics Reaction

In a glass vial, containing catalyst **3e** (0.4 mg, 0.2  $\mu$ mol) in H<sub>2</sub>O (0.5 mL), 3-phenyl-propanal (27 mg, 0.20 mmol) and indole (52 mg, 0.44 mmol) were added consecutively. The reaction mixture was stirred for 18 h. After reaction completion, the reaction mixture was extracted with EtOAc (2 mL). The organic layer was concentrated *in vacuo*. No further purification was required.

### E-factor calculation

After obtaining the desired product, without proceeding in purification by column chromatography, the E-factor was calculated.

$$\text{E factor} = [1804 (\text{EtOAc}) + 500 (\text{H}_2\text{O}) + 27 (3\text{-phenyl-propanal}) + 52 (\text{indole}) + 0.4 (\text{catalyst } \mathbf{3c}) - 68 (\text{product})] \text{ mg}/68 \text{ mg} = 34.1$$

**$^1\text{H}$  NMR spectrum (400MHz,  $\text{CDCl}_3$ ) of crude reaction mixture after extraction** **$^1\text{H}$  NMR spectrum (400 MHz,  $\text{CDCl}_3$ ) of isolated product after purification by column chromatography**

**Atom economy calculation**

$$\begin{aligned} \% \text{ Atom econ.} &= \frac{\text{Molar mass of Product}}{\text{Molar mass of All reactants}} \times 100\% = \frac{350 \text{ mg/mmol}}{(135 + 117 + 117) \text{ mg/mmol}} \\ &\times 100\% = 95\% \end{aligned}$$

**Atom efficiency**

For the formation of one molecule of product, only one molecule of water is lost.

**Carbon efficiency**

No carbon atom lost.

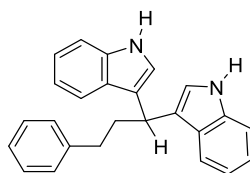
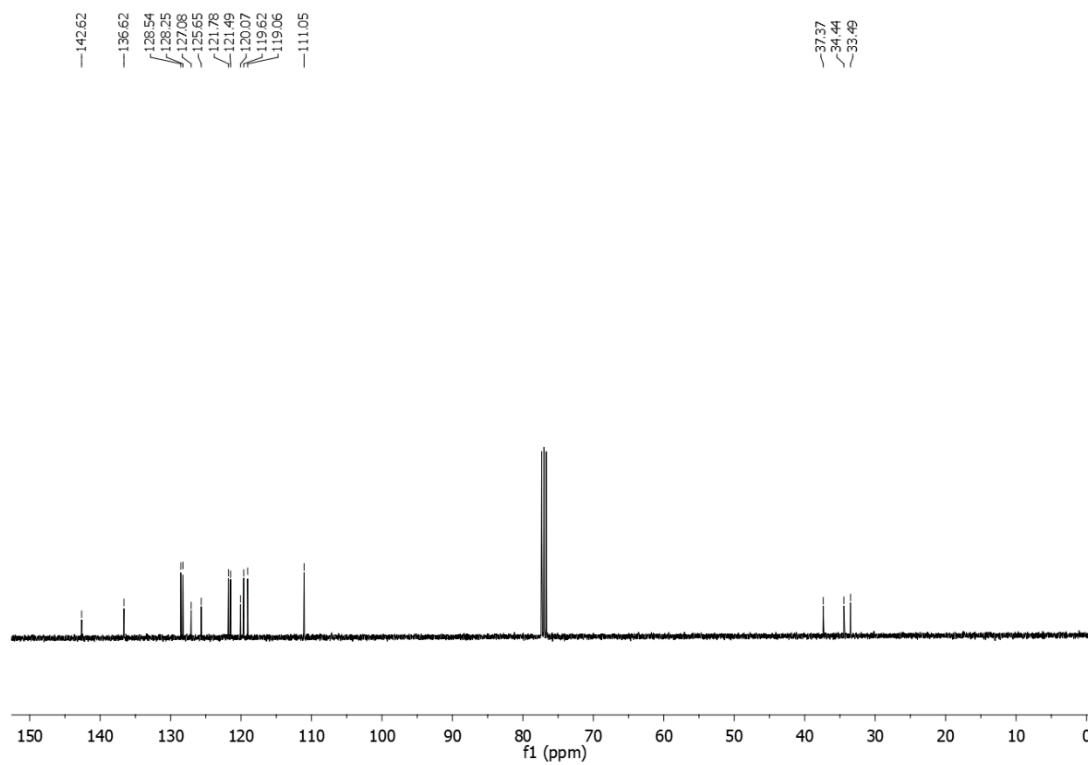
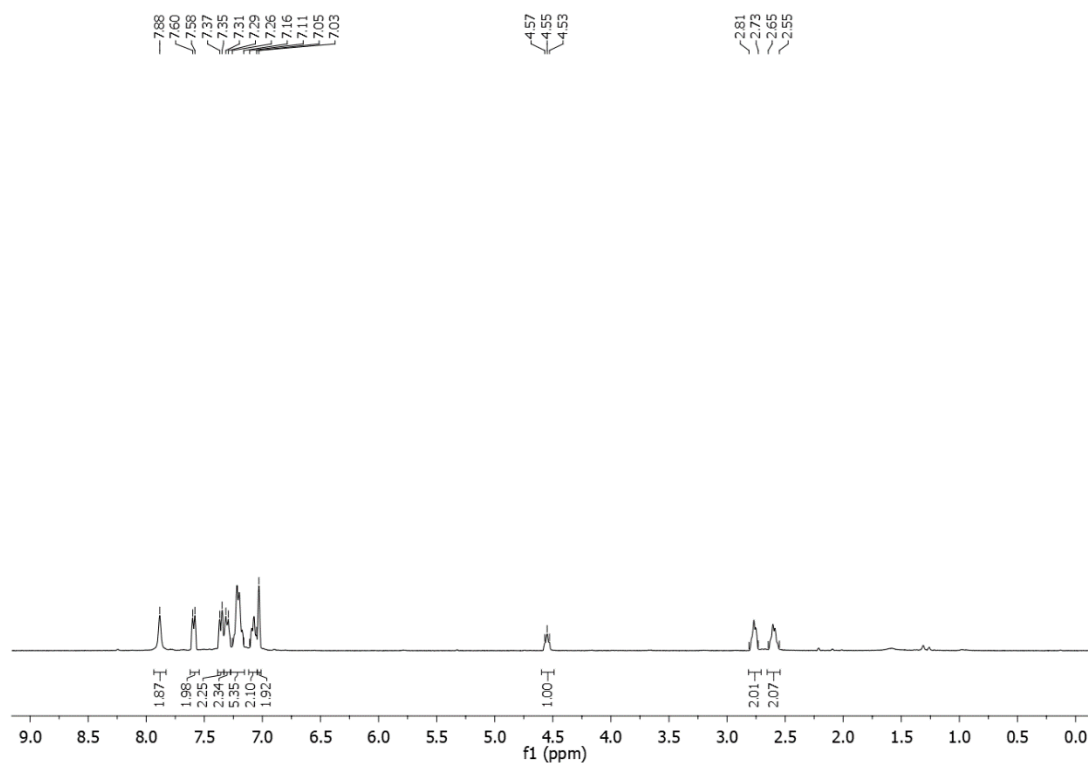
**Reaction mass efficiency**

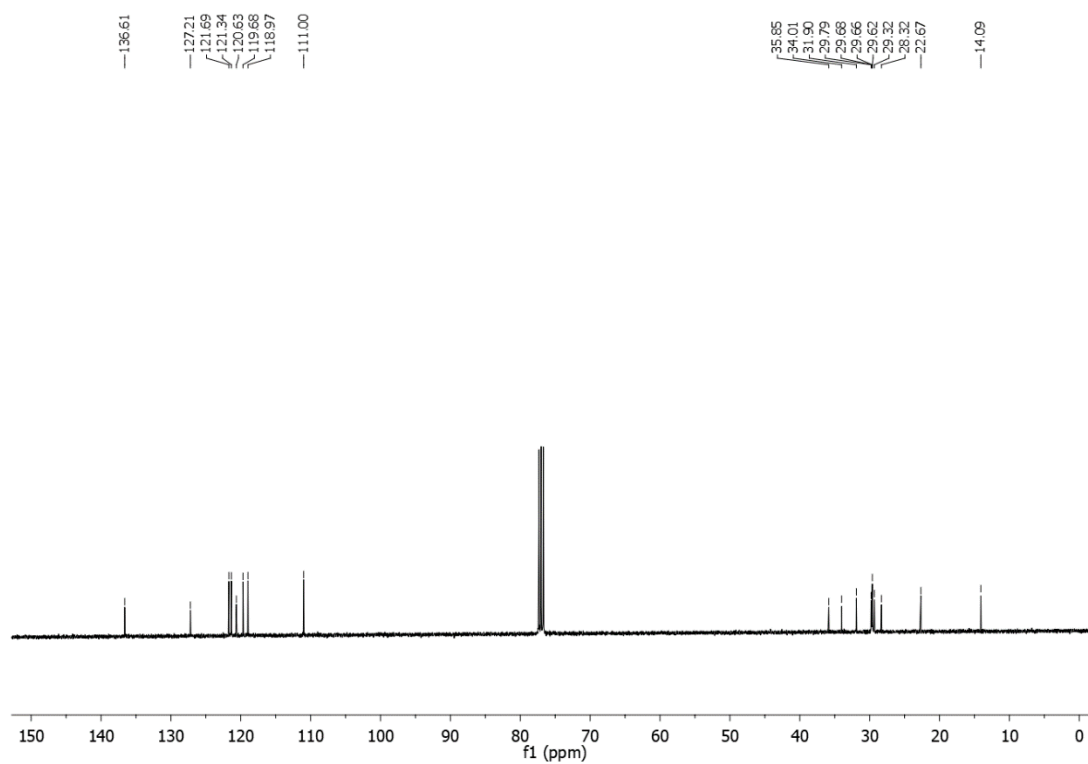
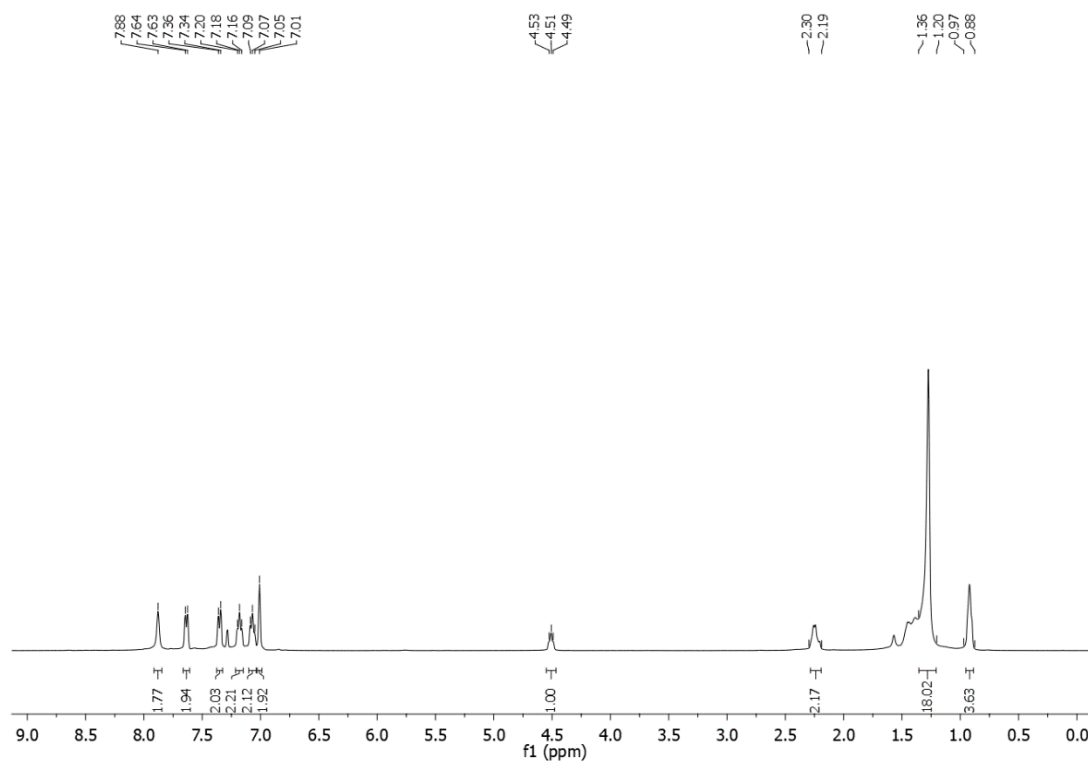
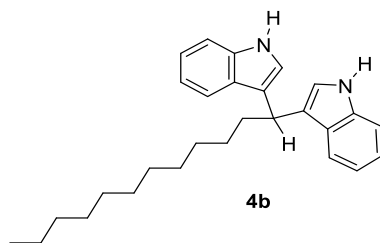
$$\frac{\text{Atom mass of desired product}}{\text{Mass of reactants}} \times 100\% = \frac{68 \text{ mg}}{27 \text{ mg} + 52 \text{ mg}} \times 100\% = 86\%$$

## References

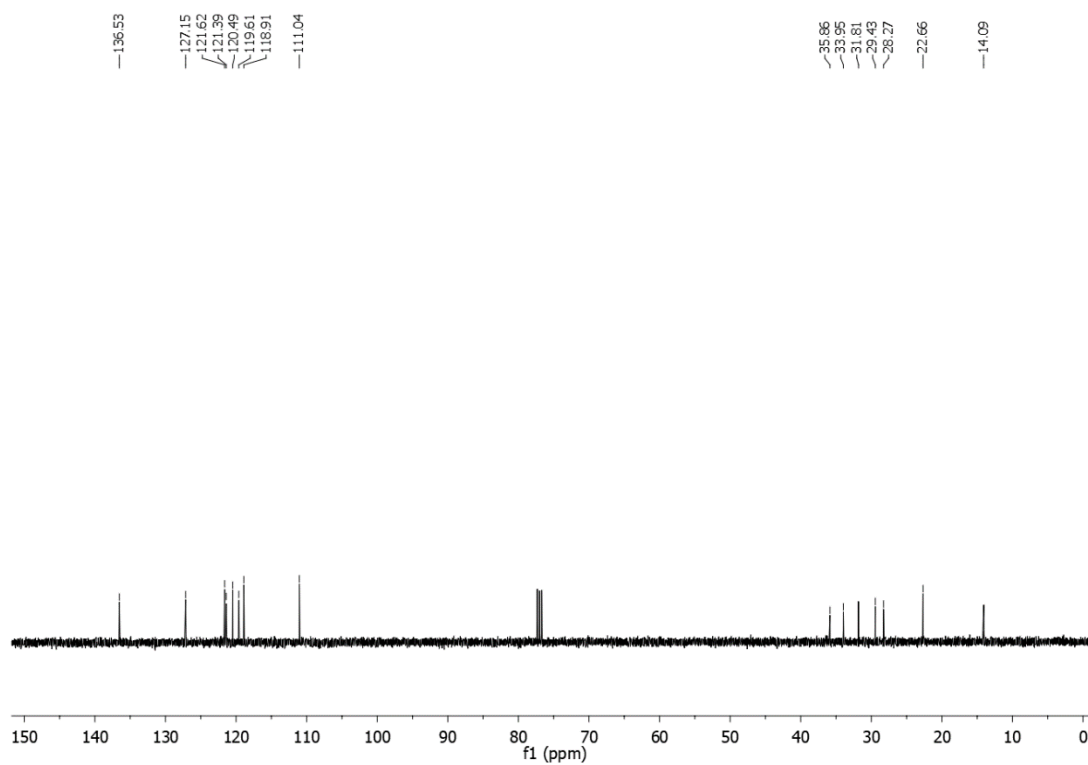
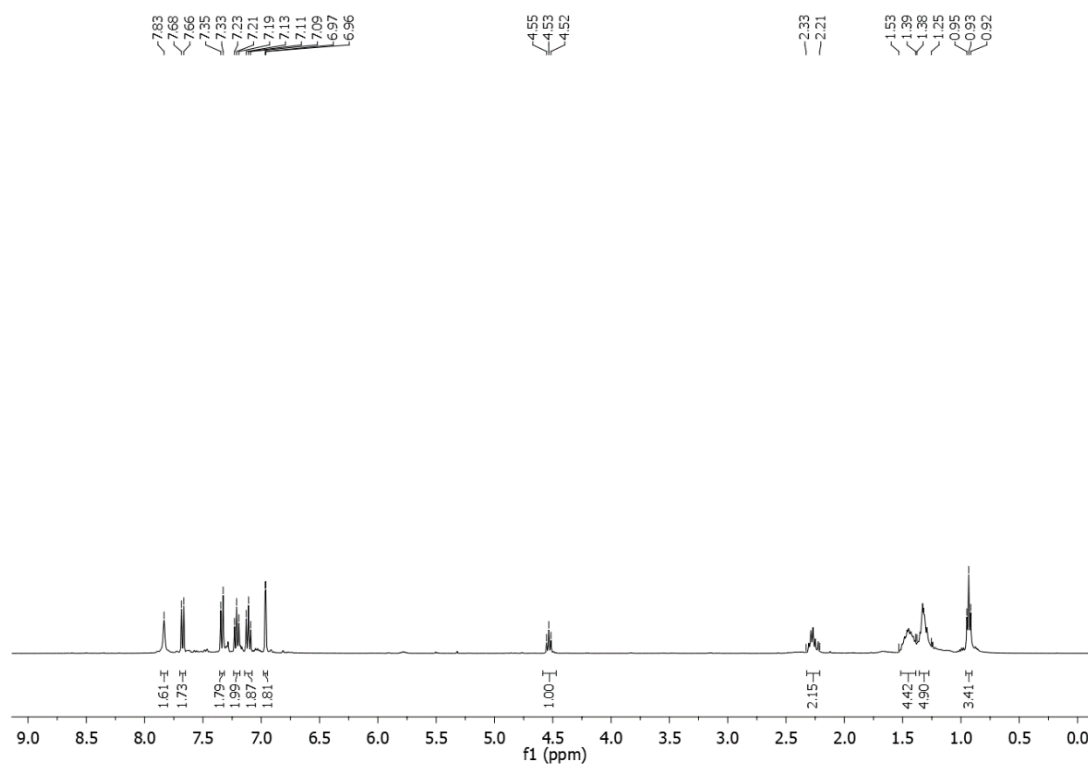
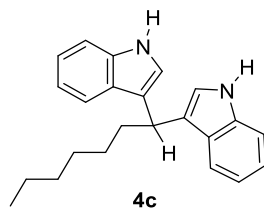
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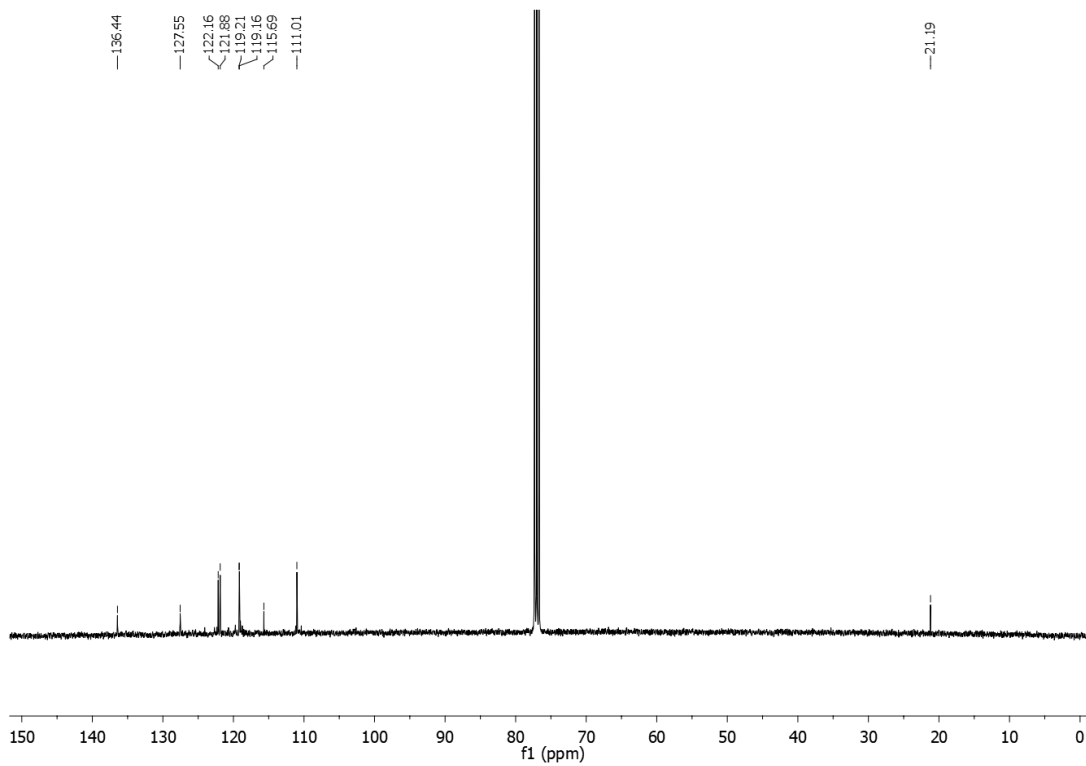
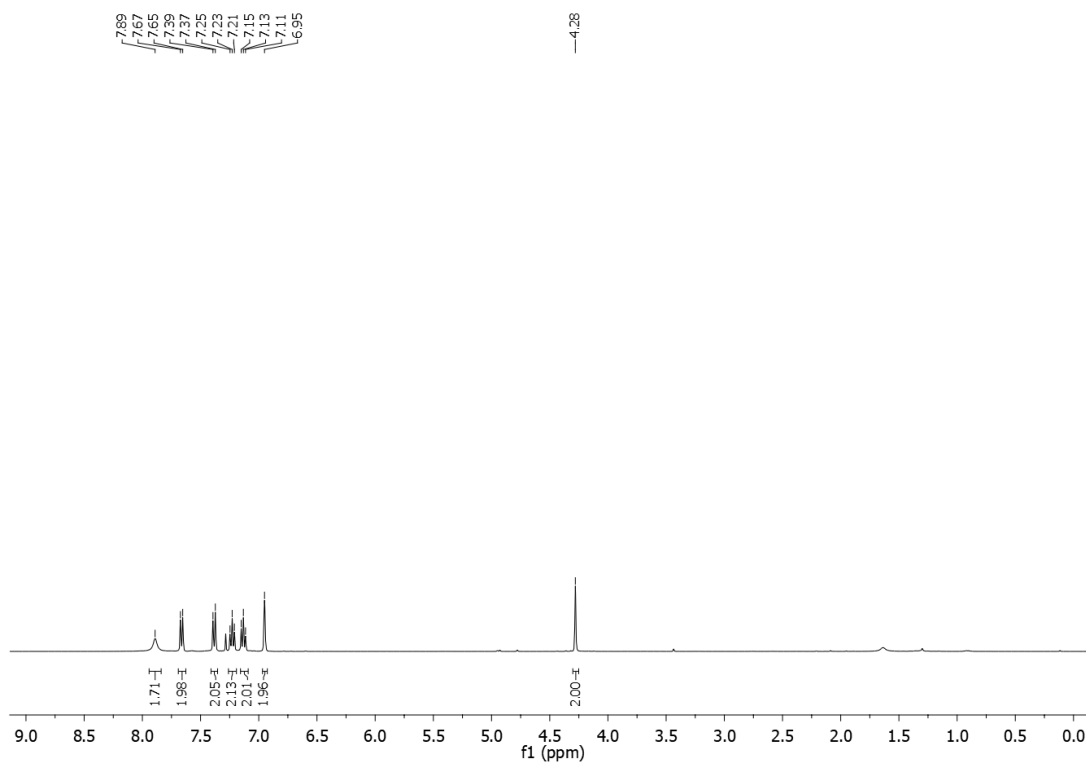
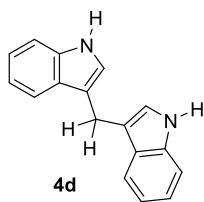
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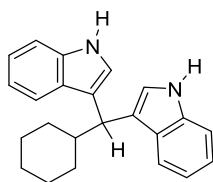
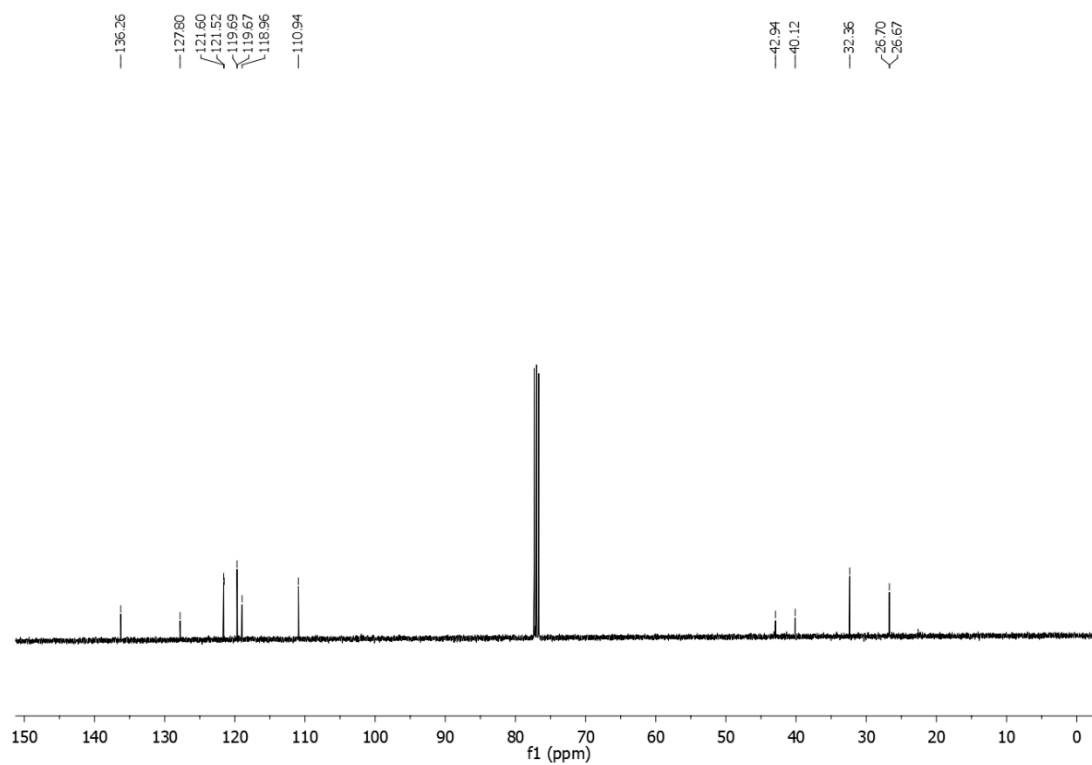
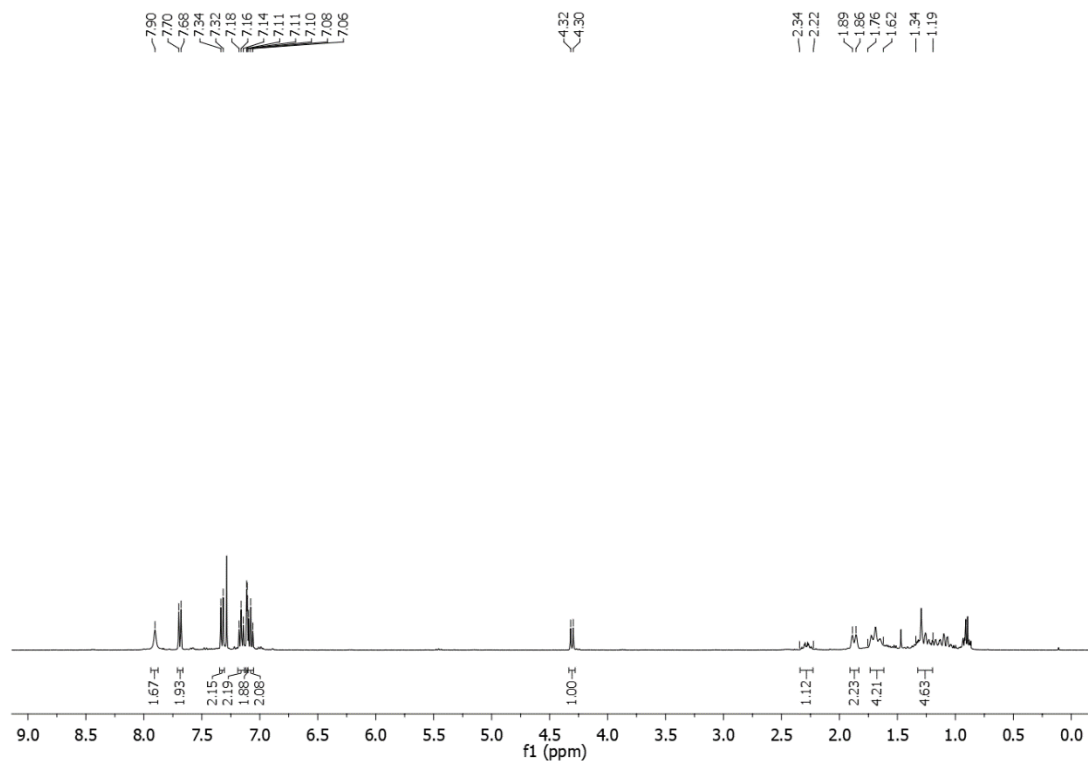
**4a**

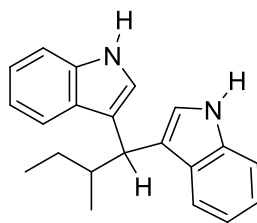
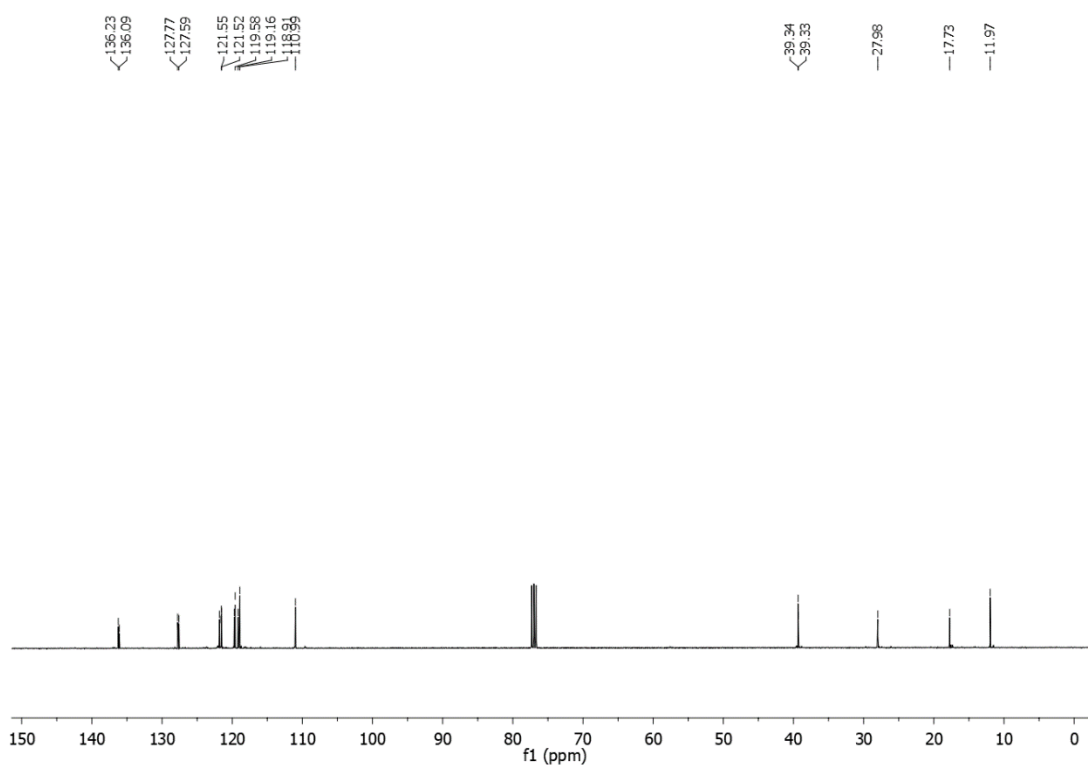
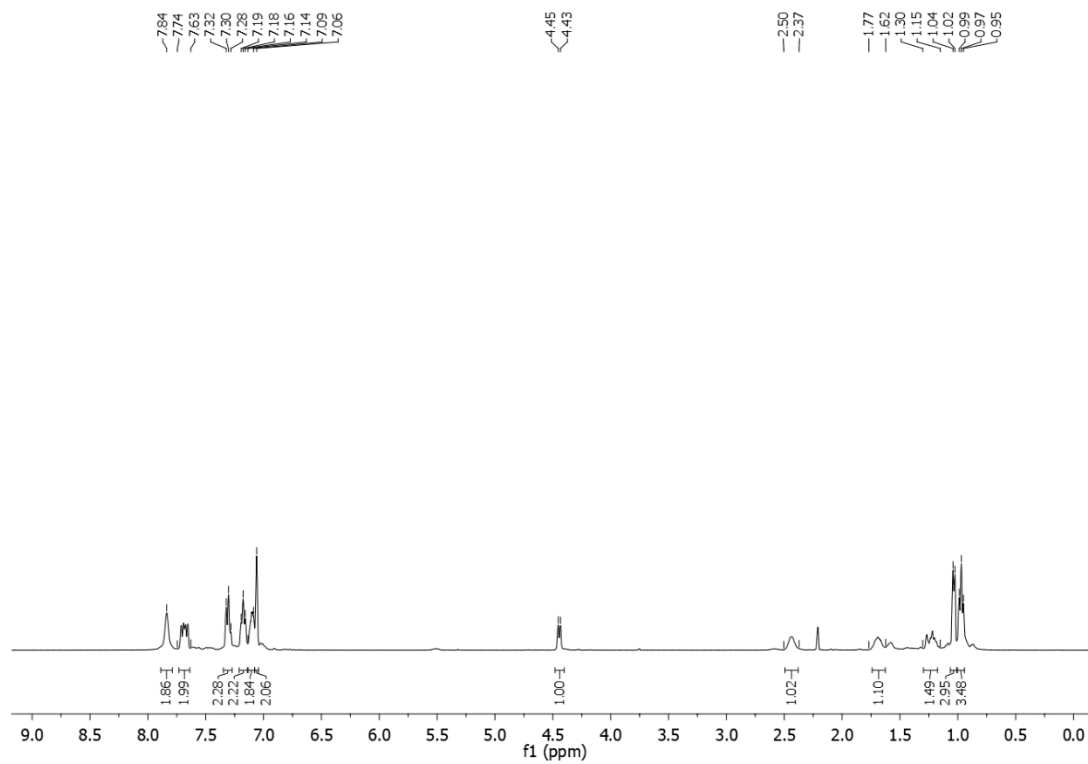


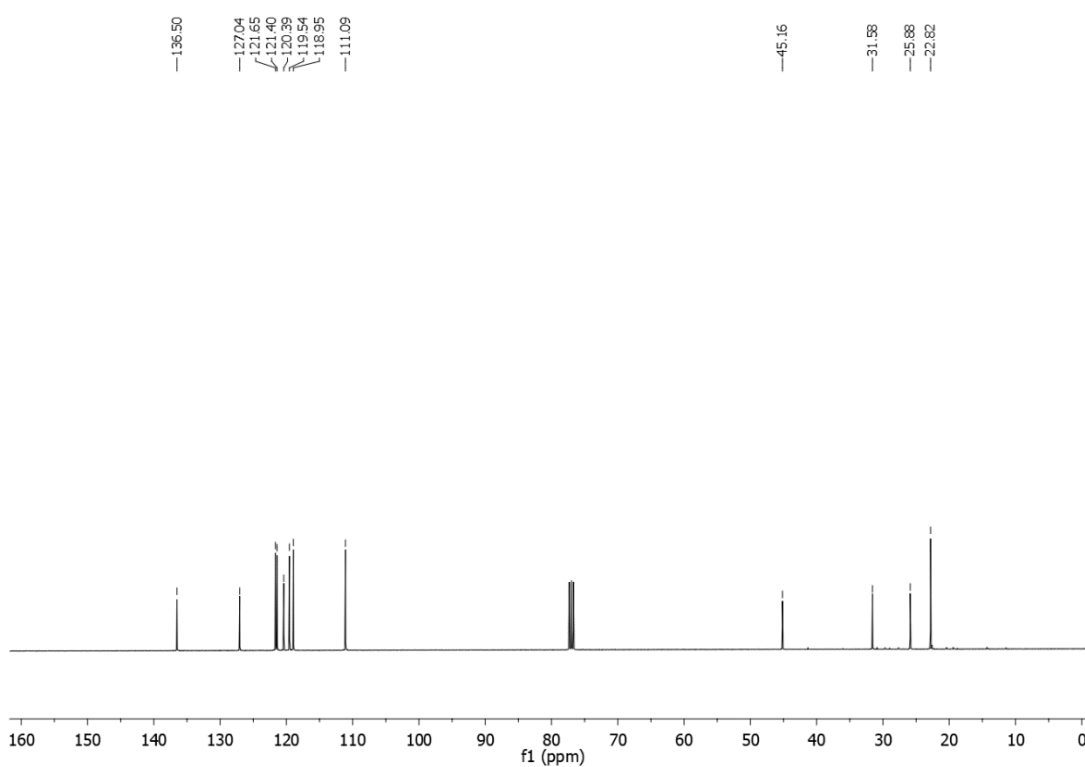
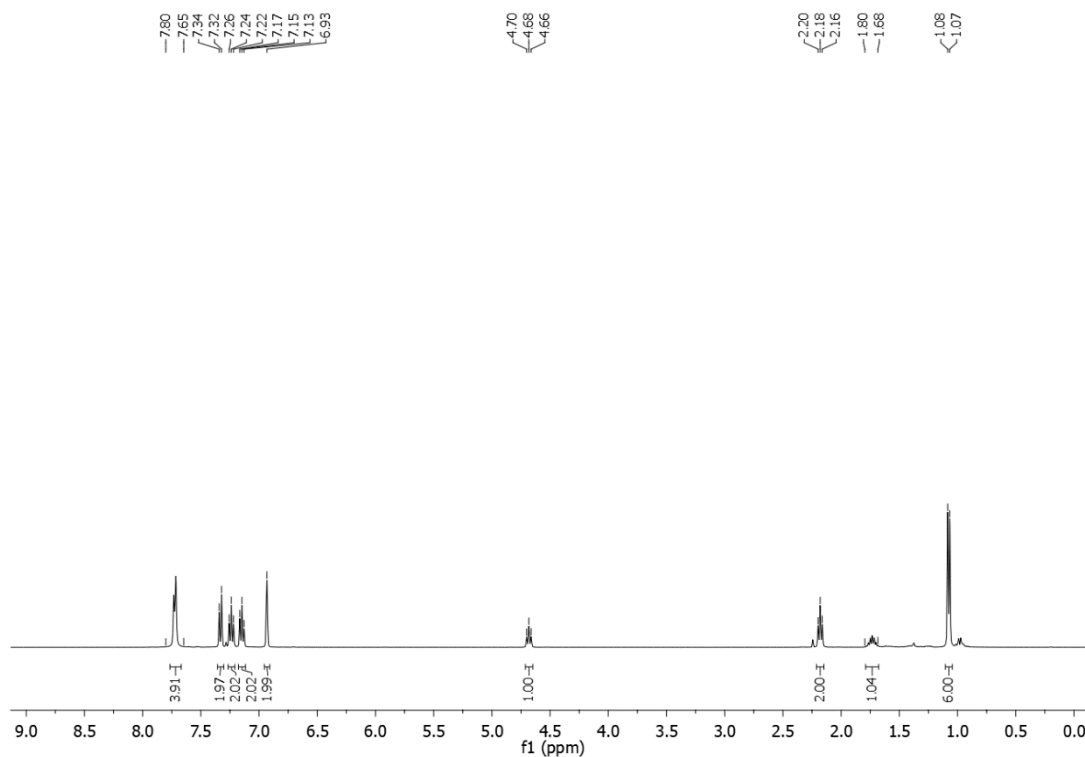
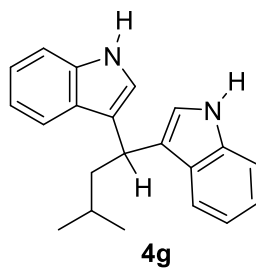


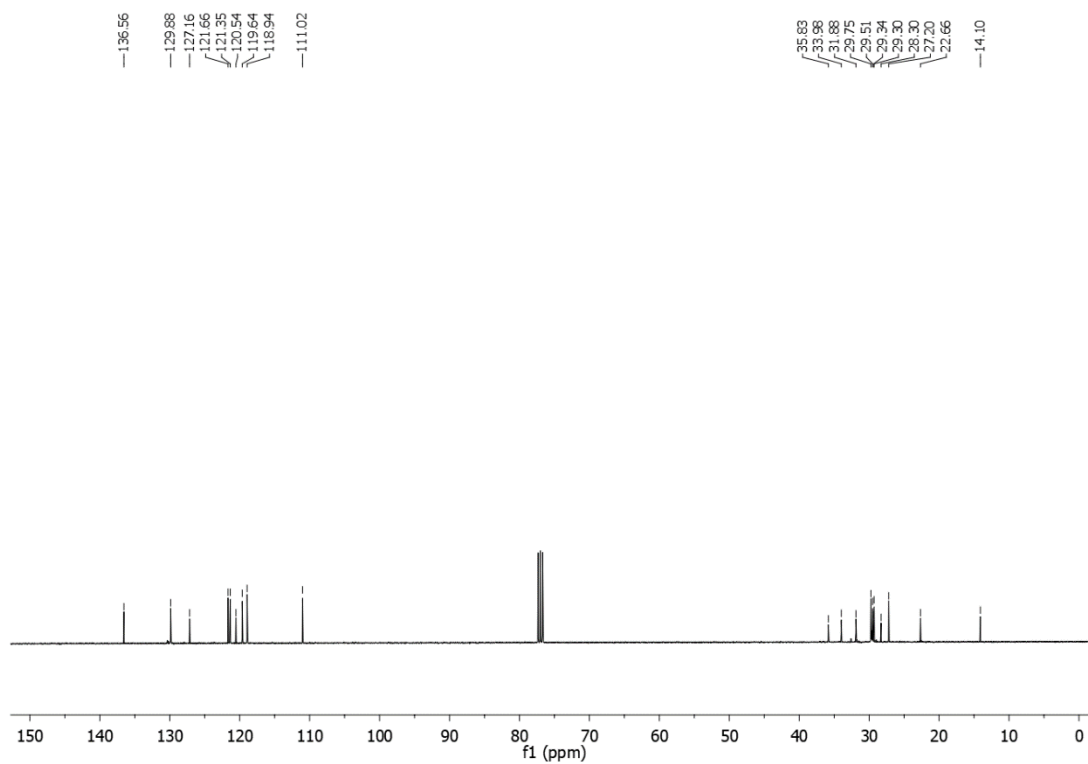
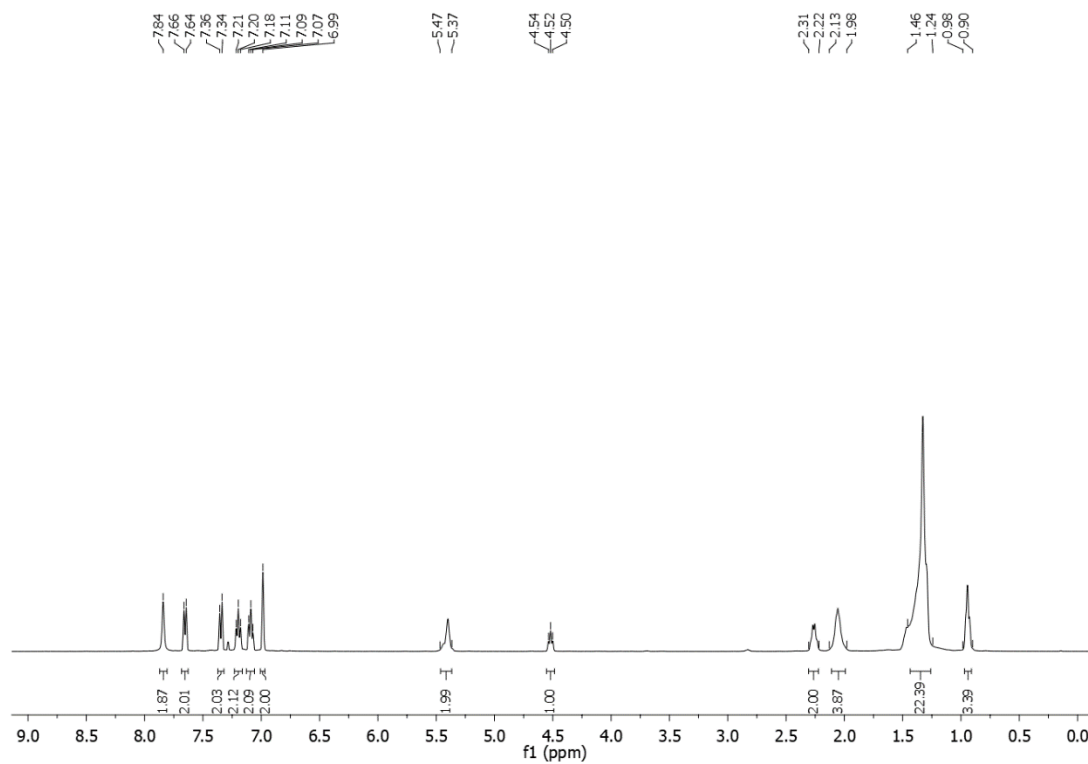
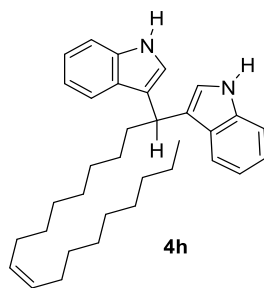




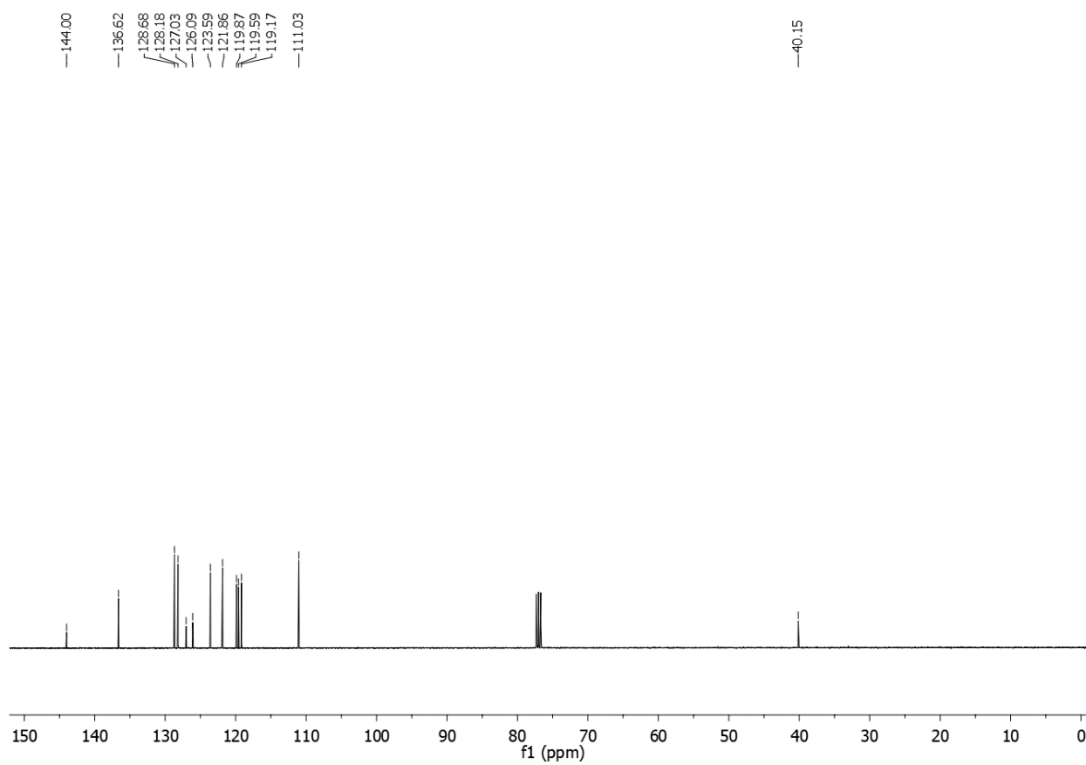
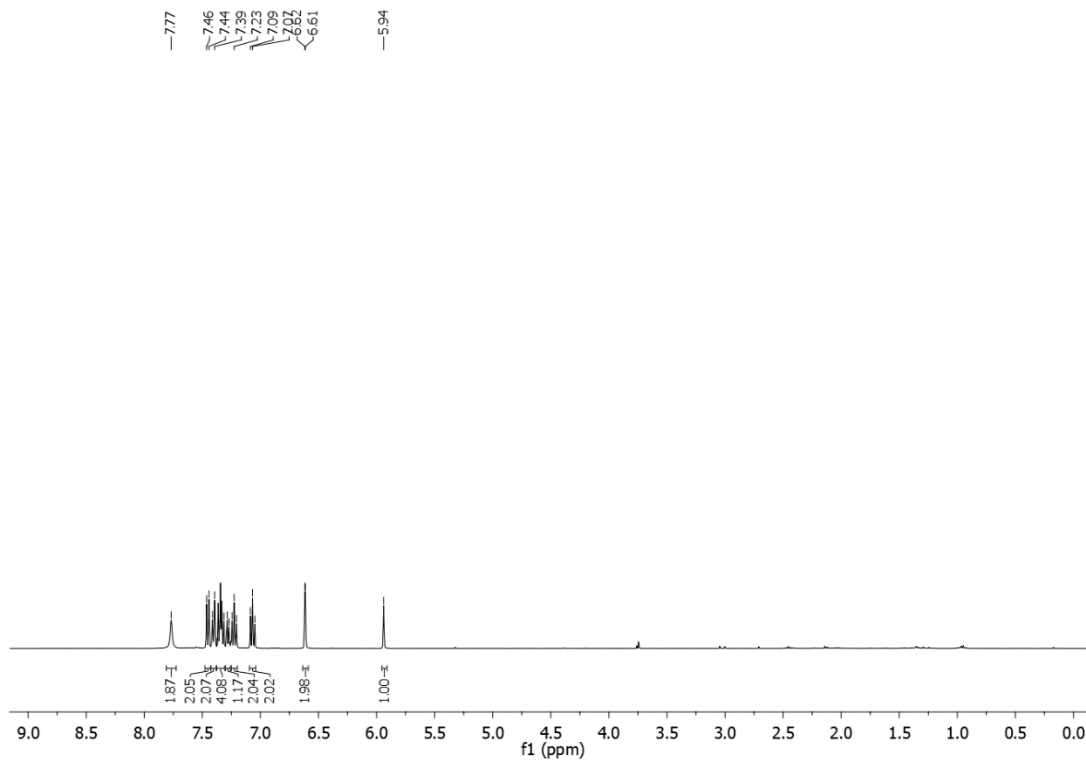
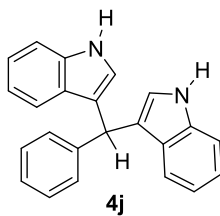
**4e**

**4f**

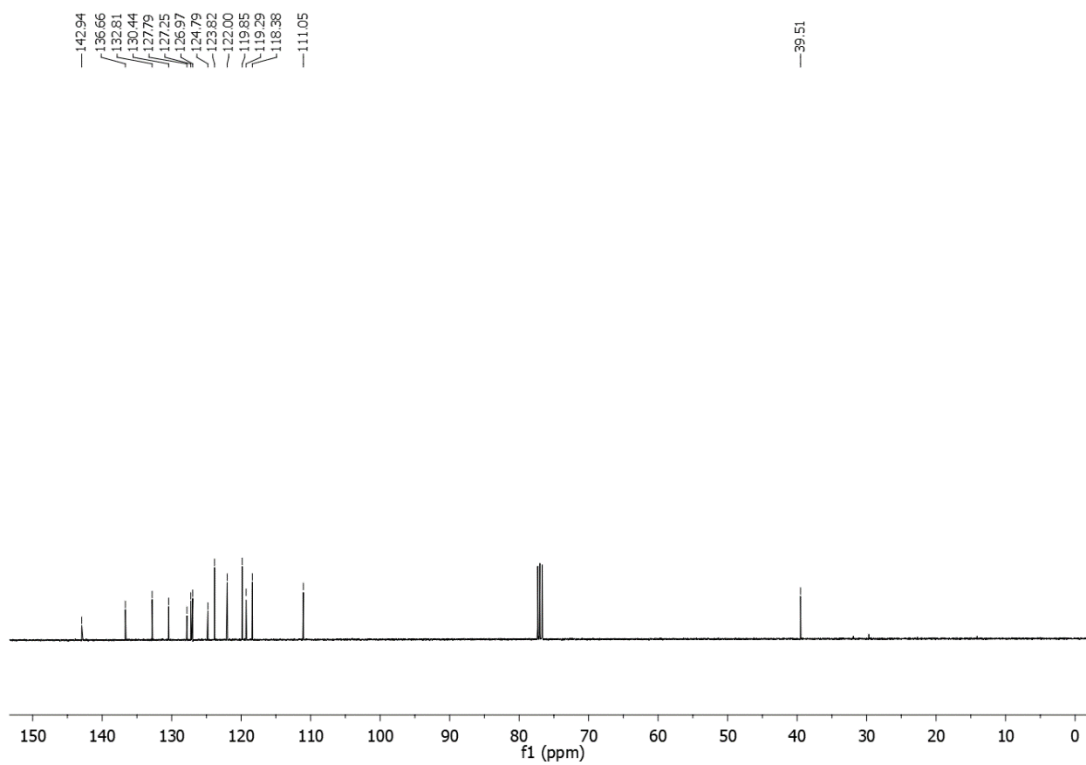
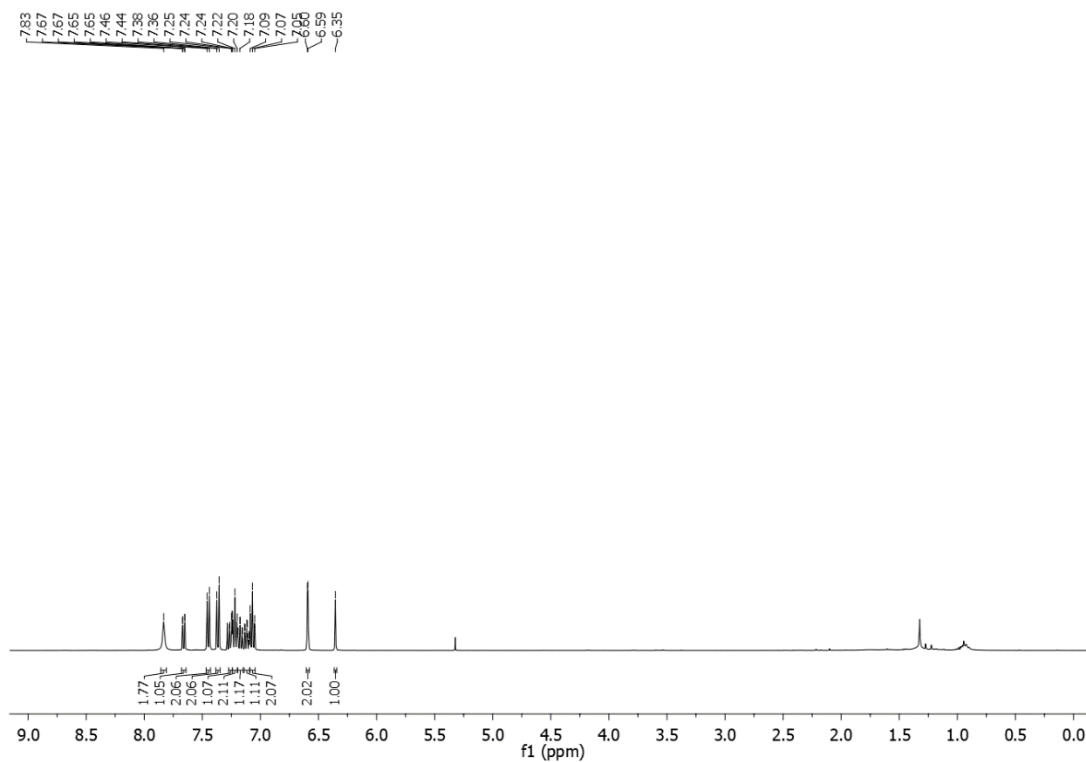
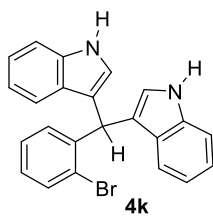


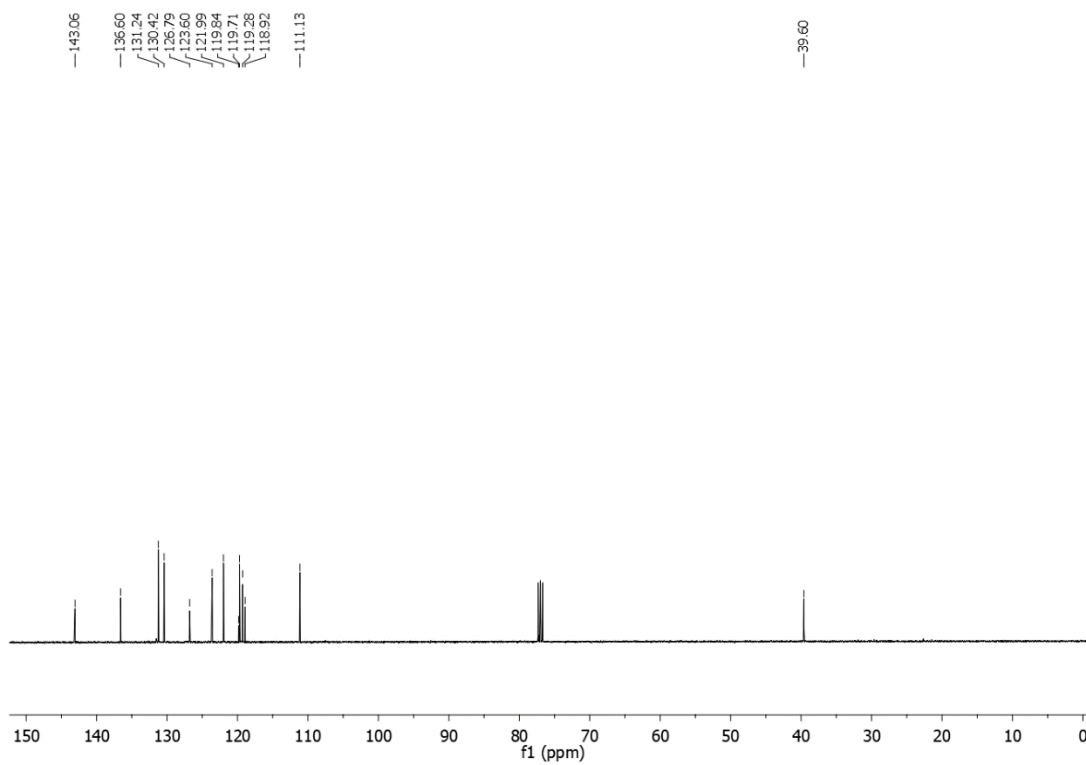
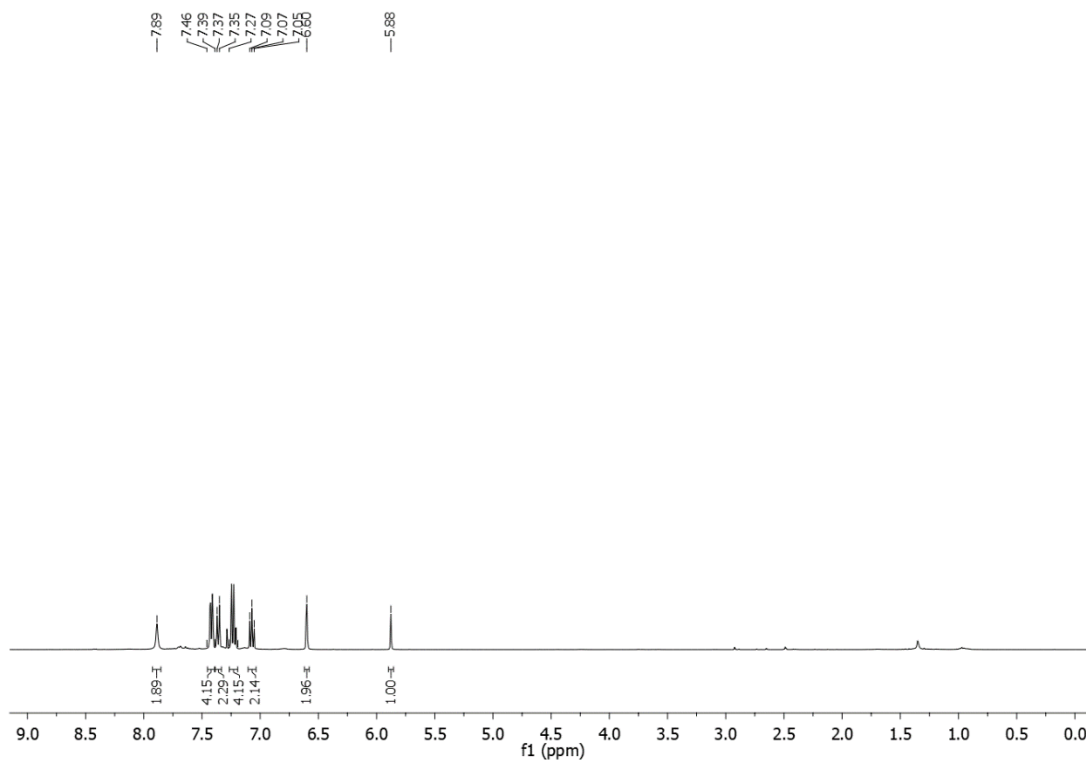
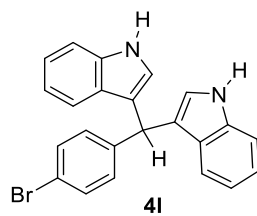


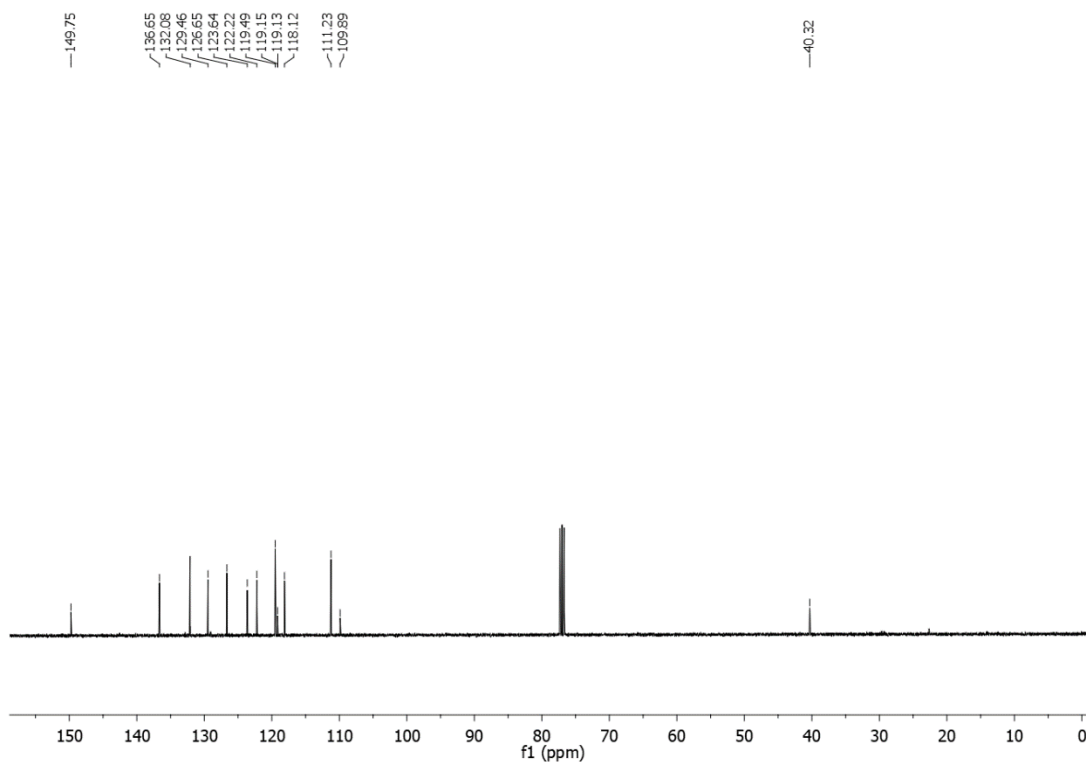
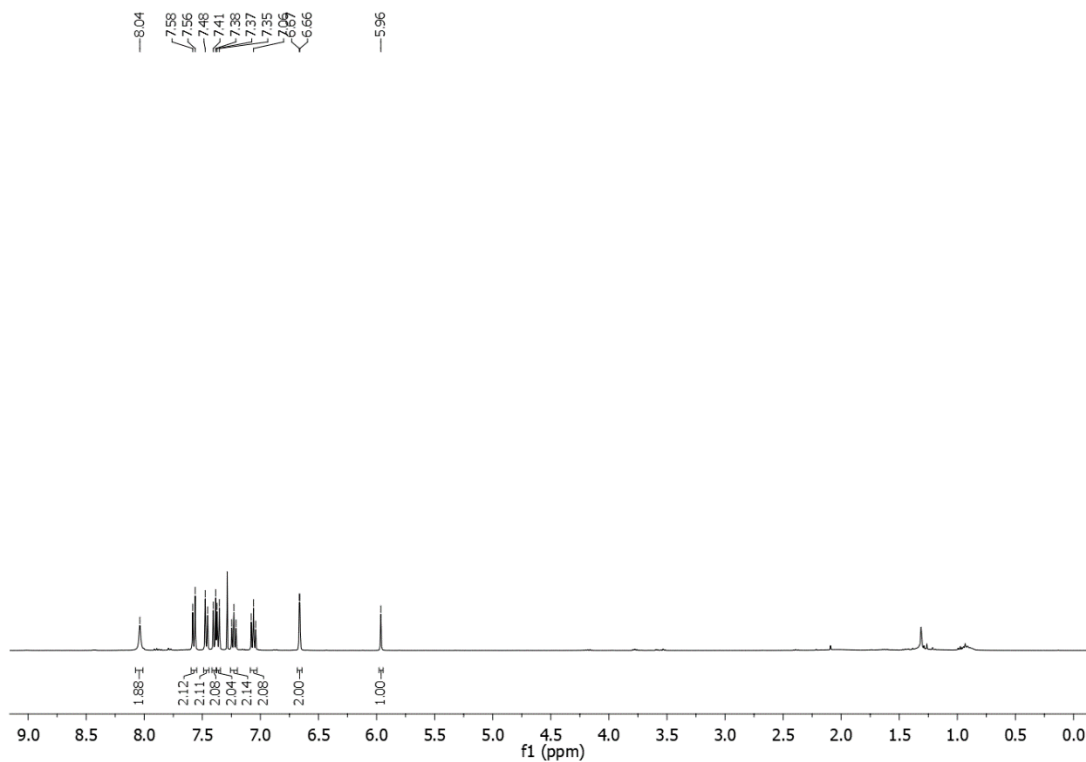
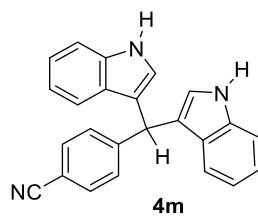


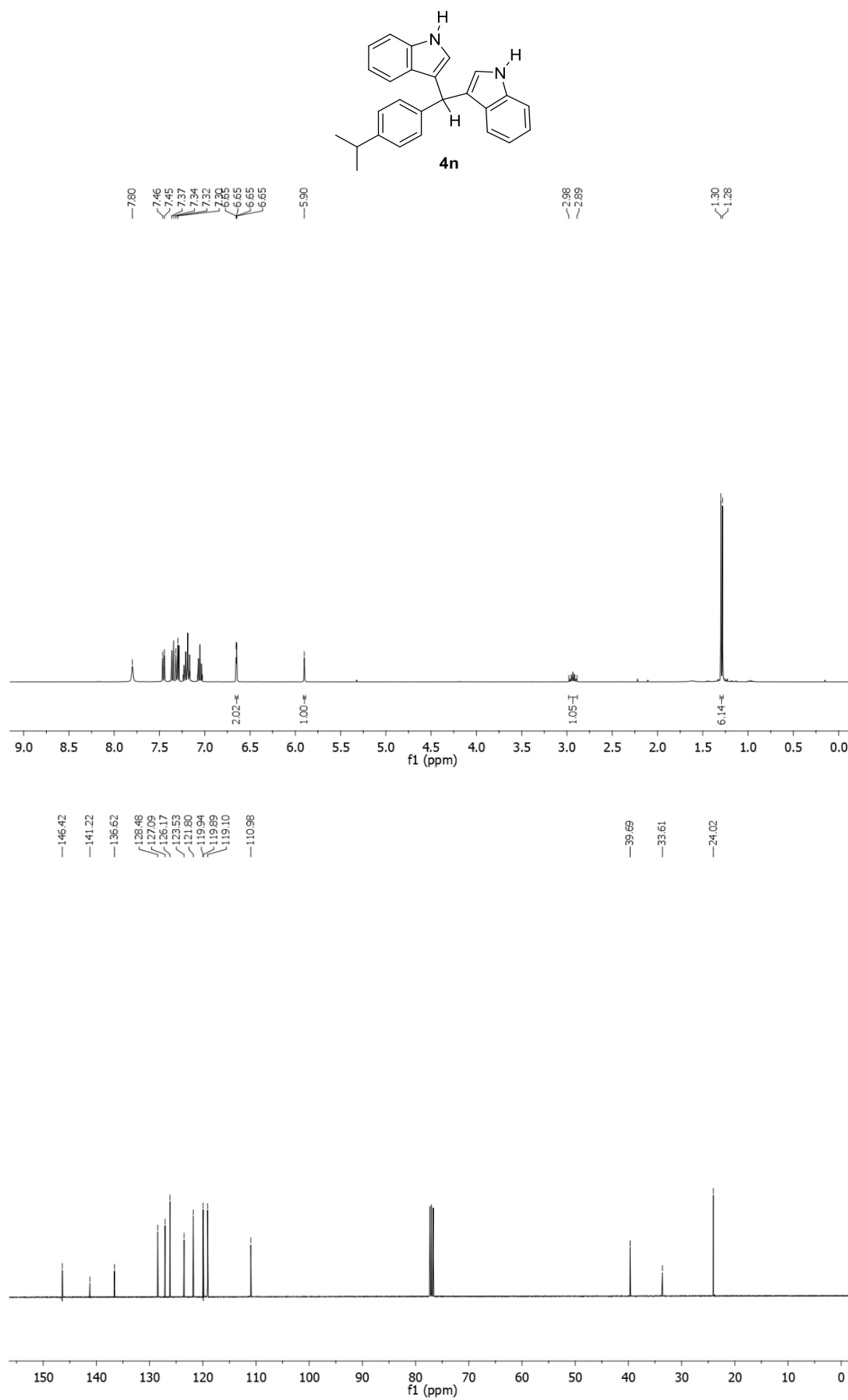


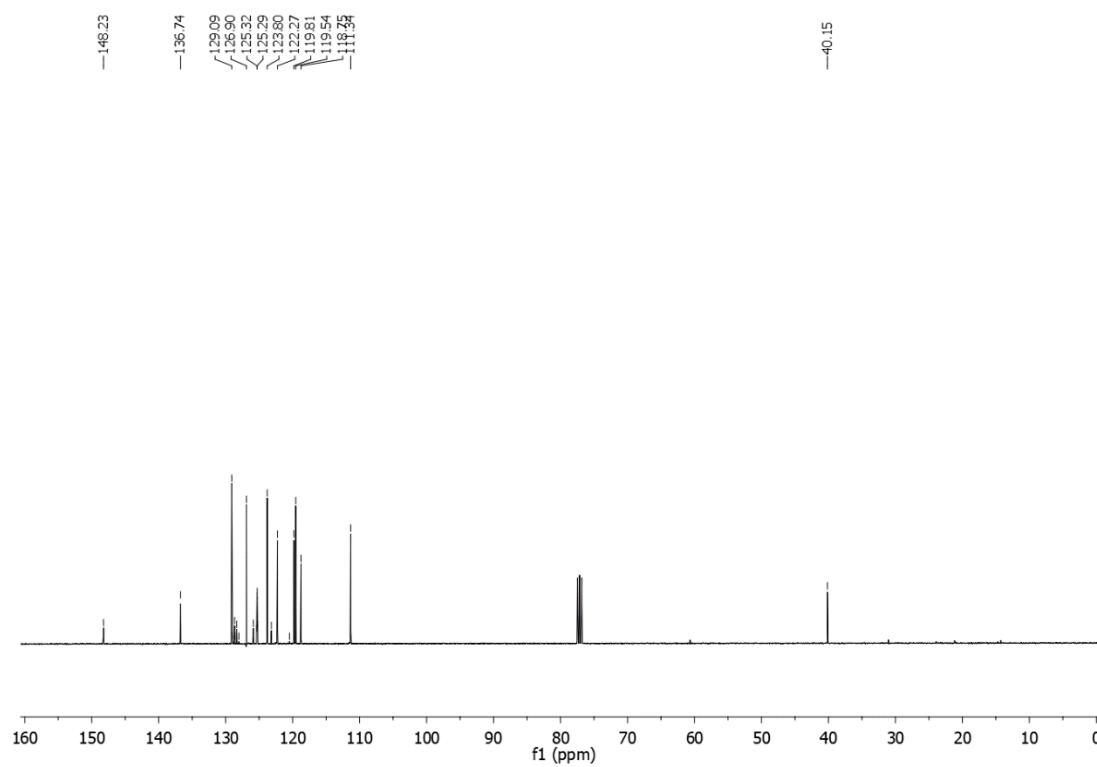
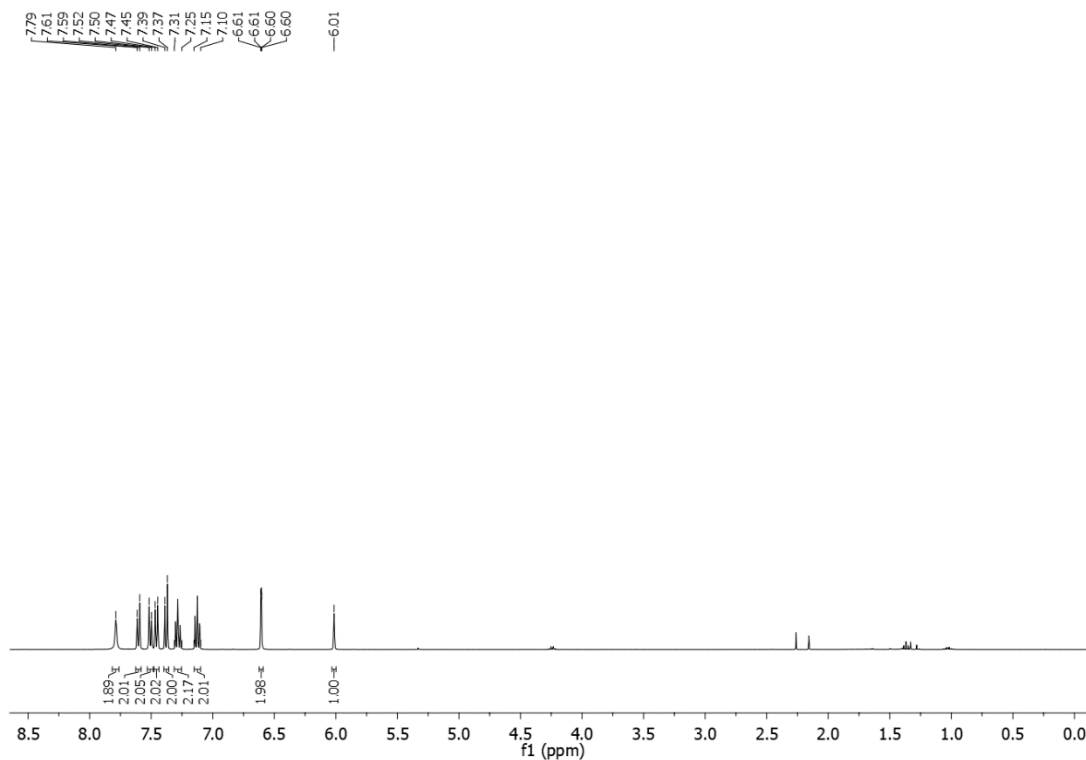
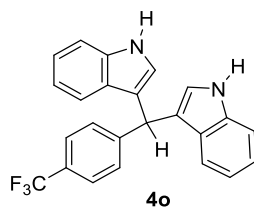


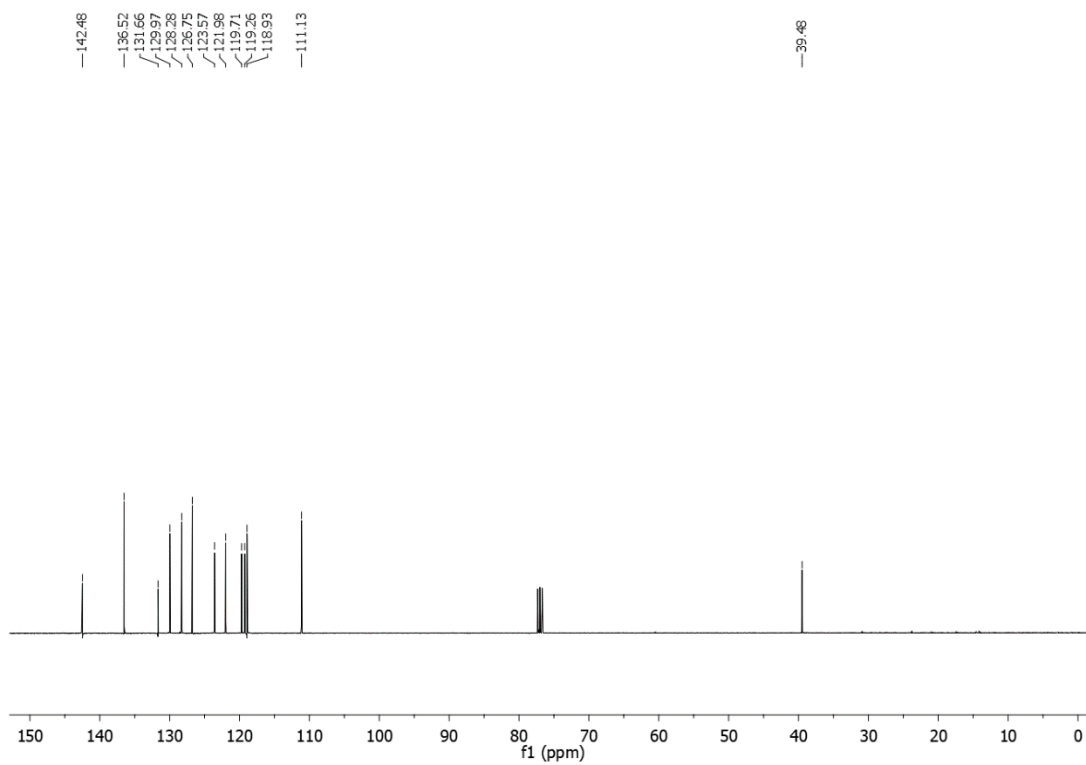
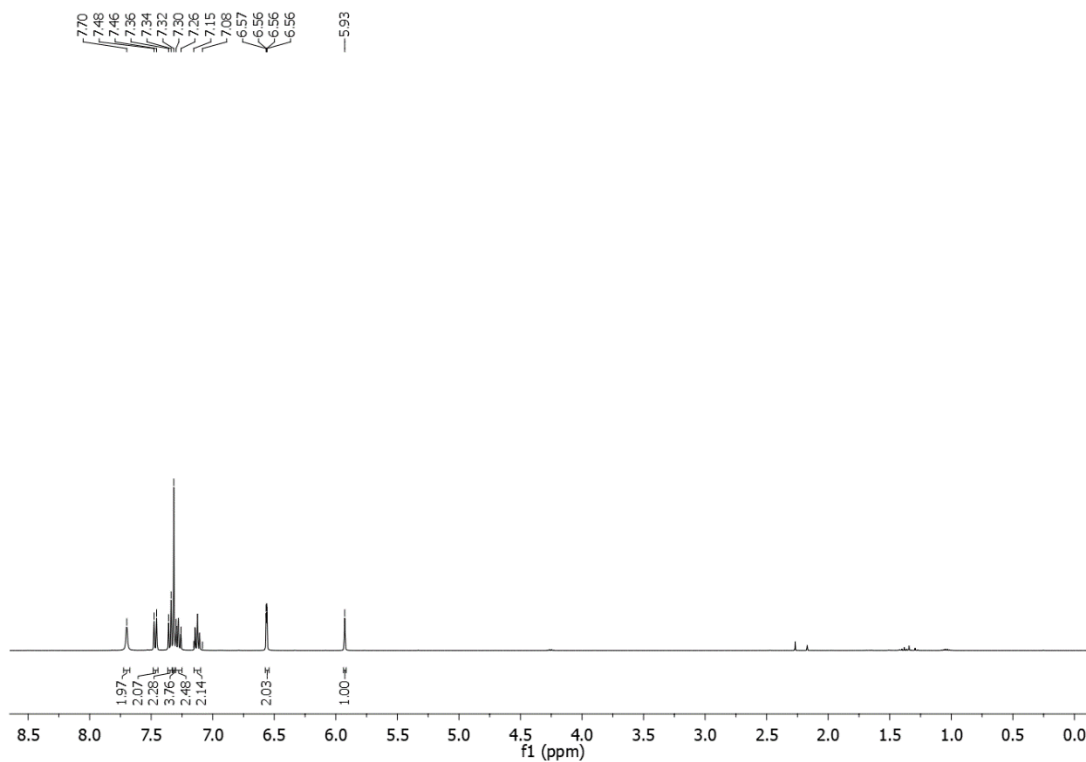
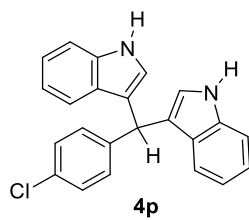


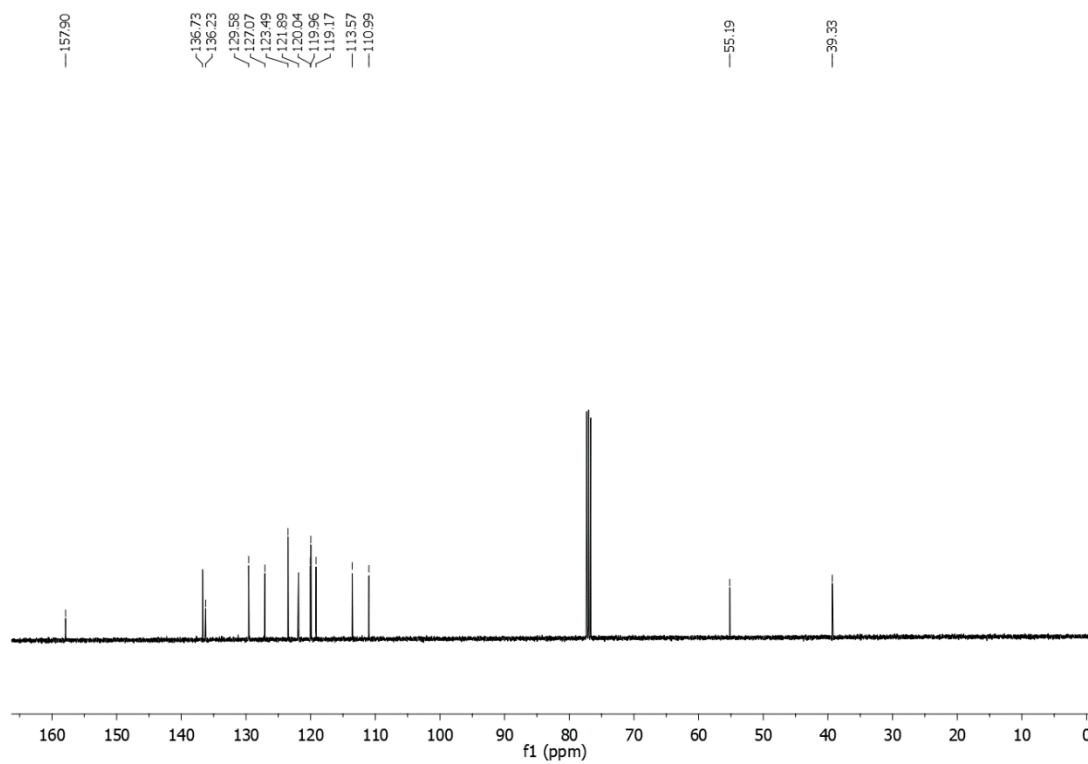
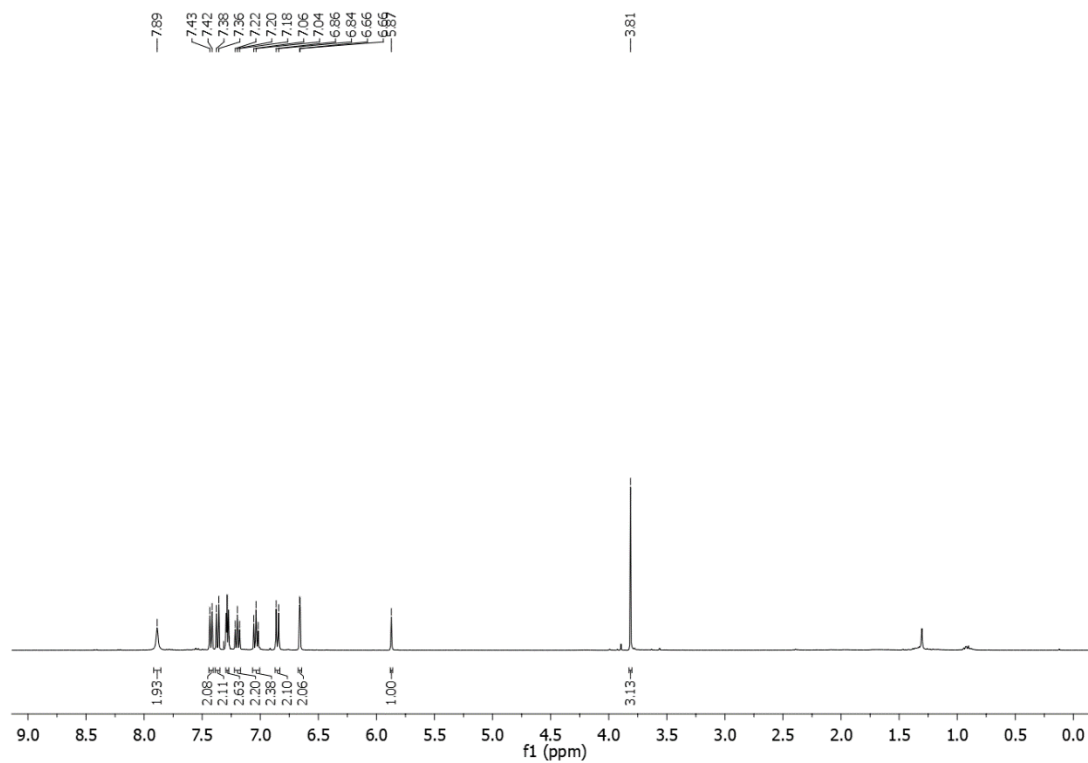
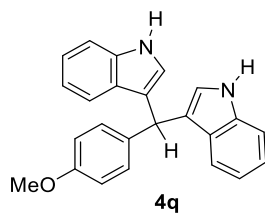


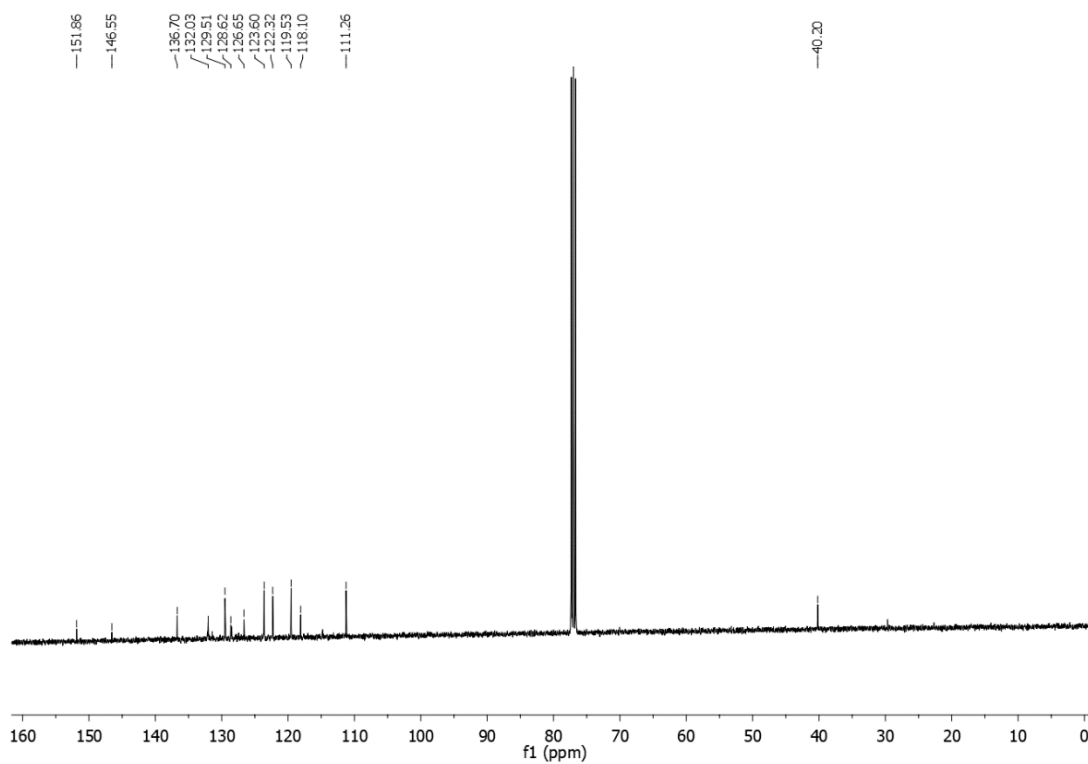
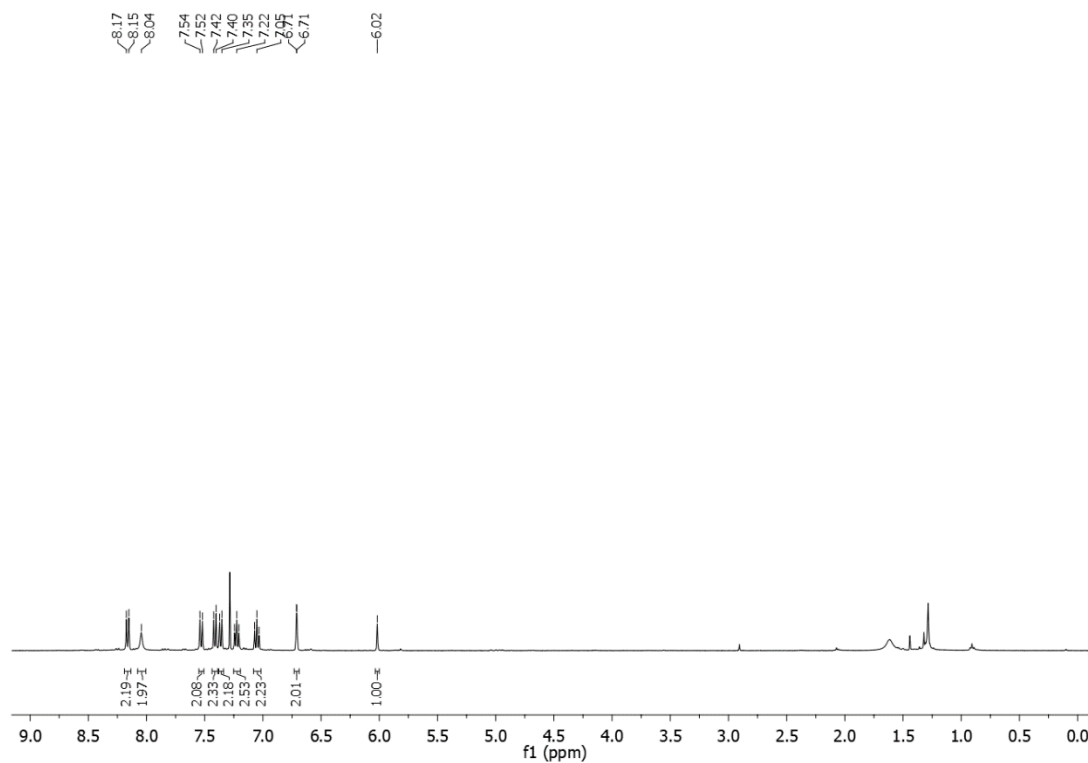
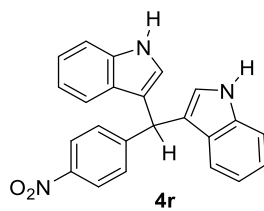




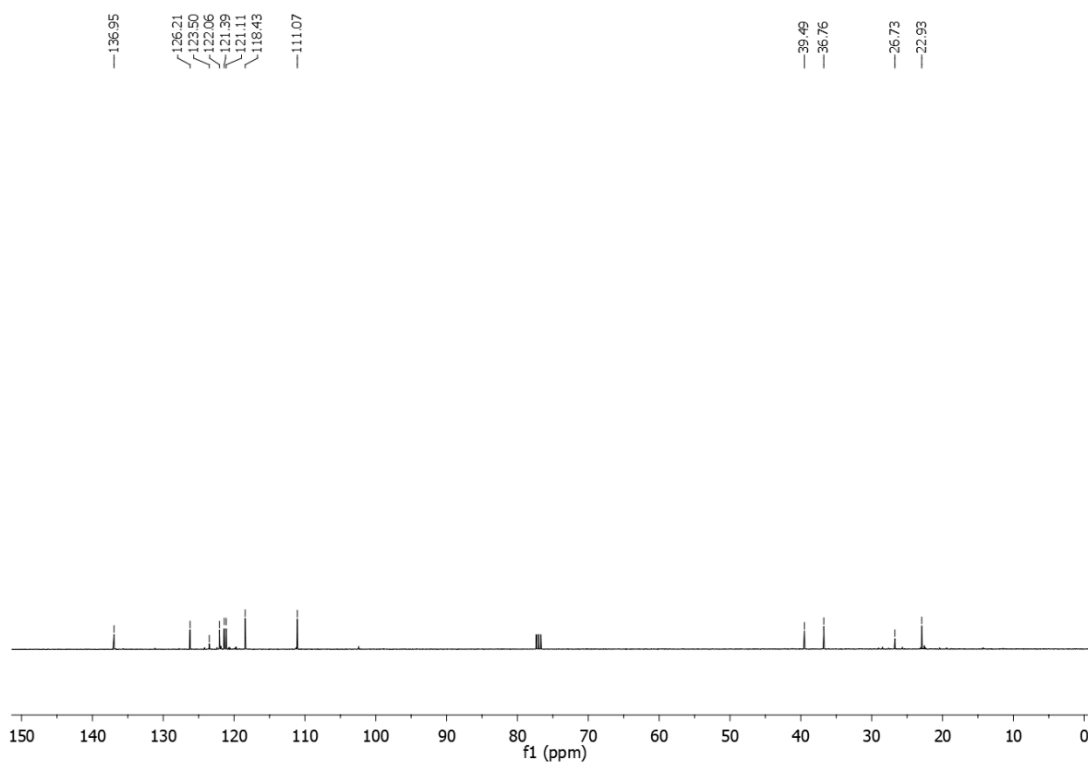
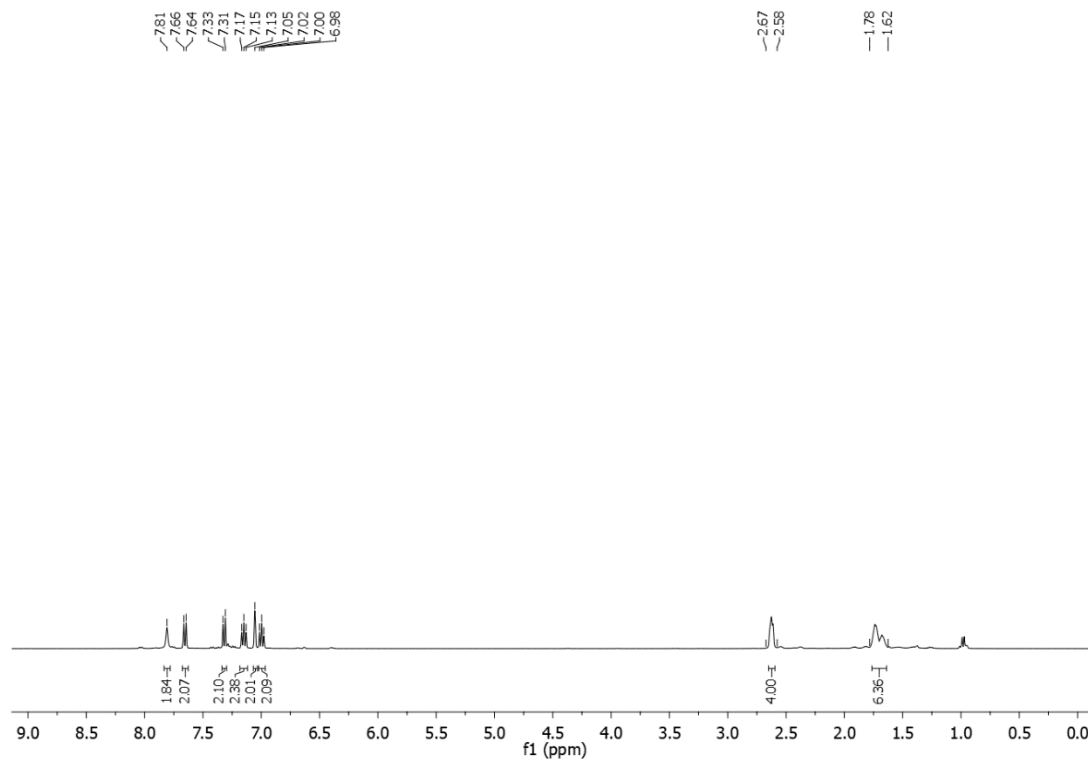
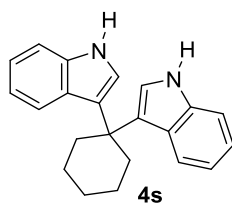




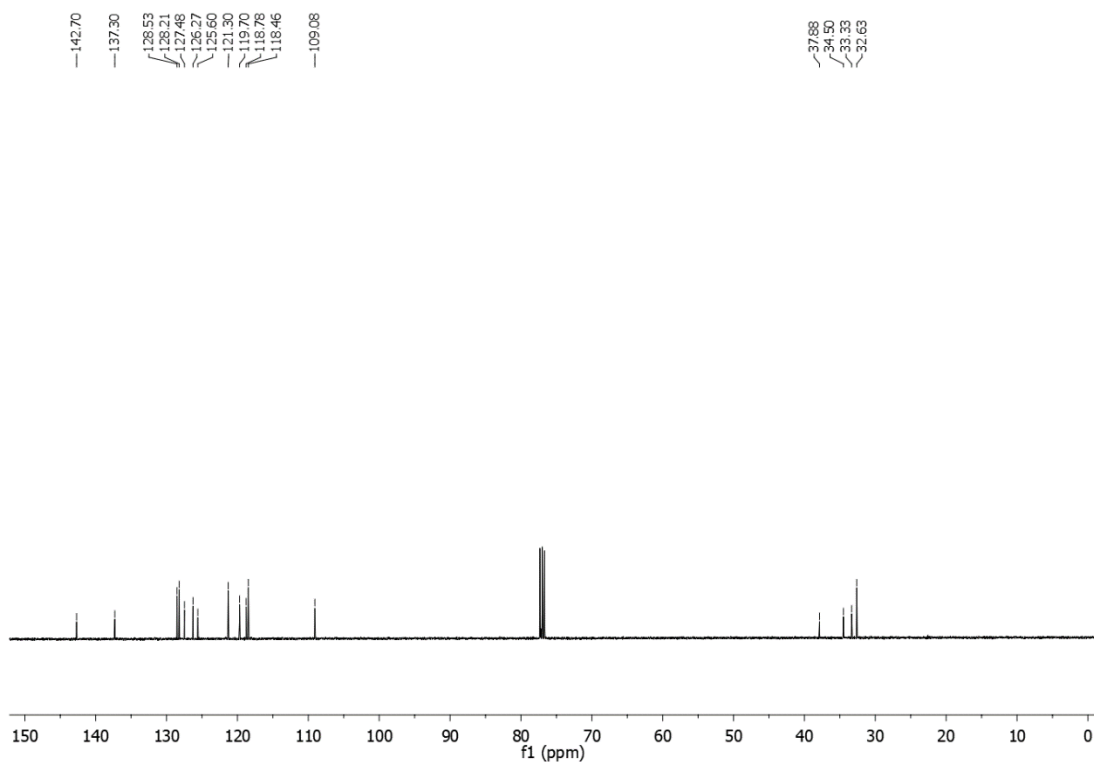
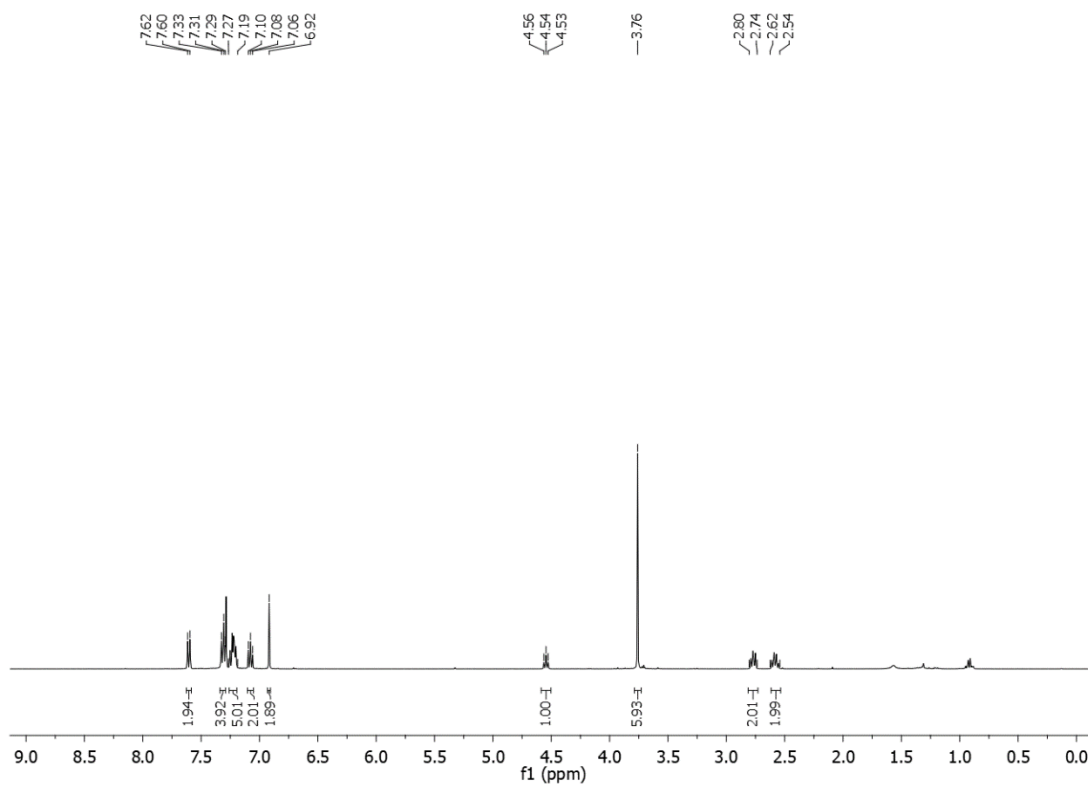
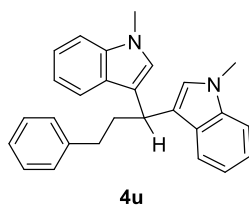


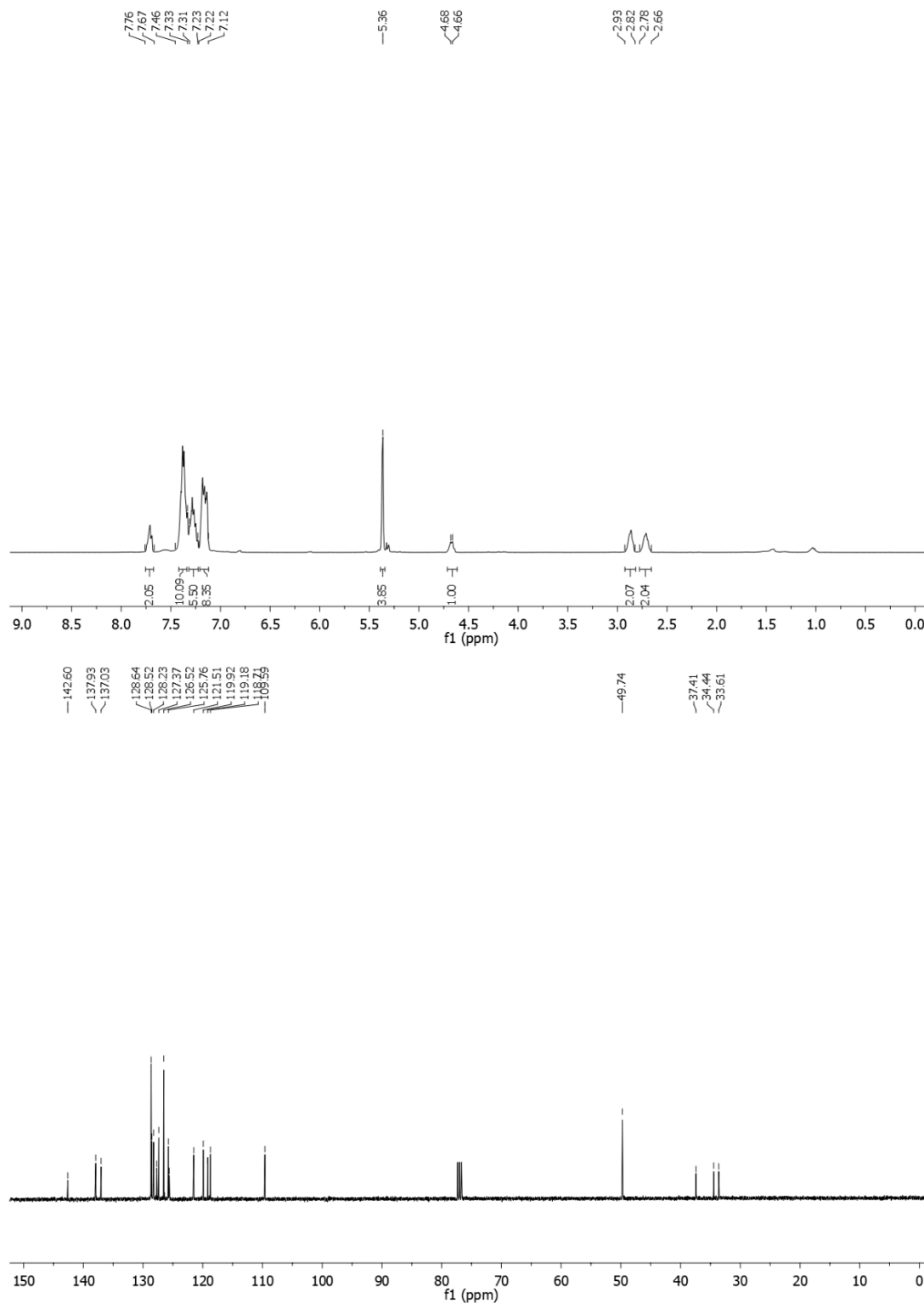
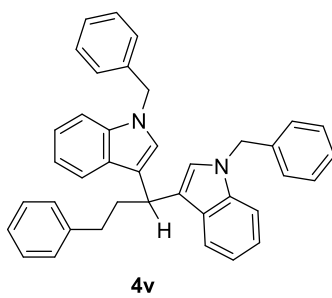


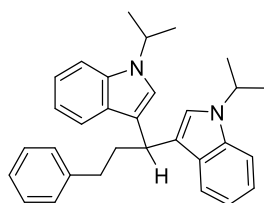
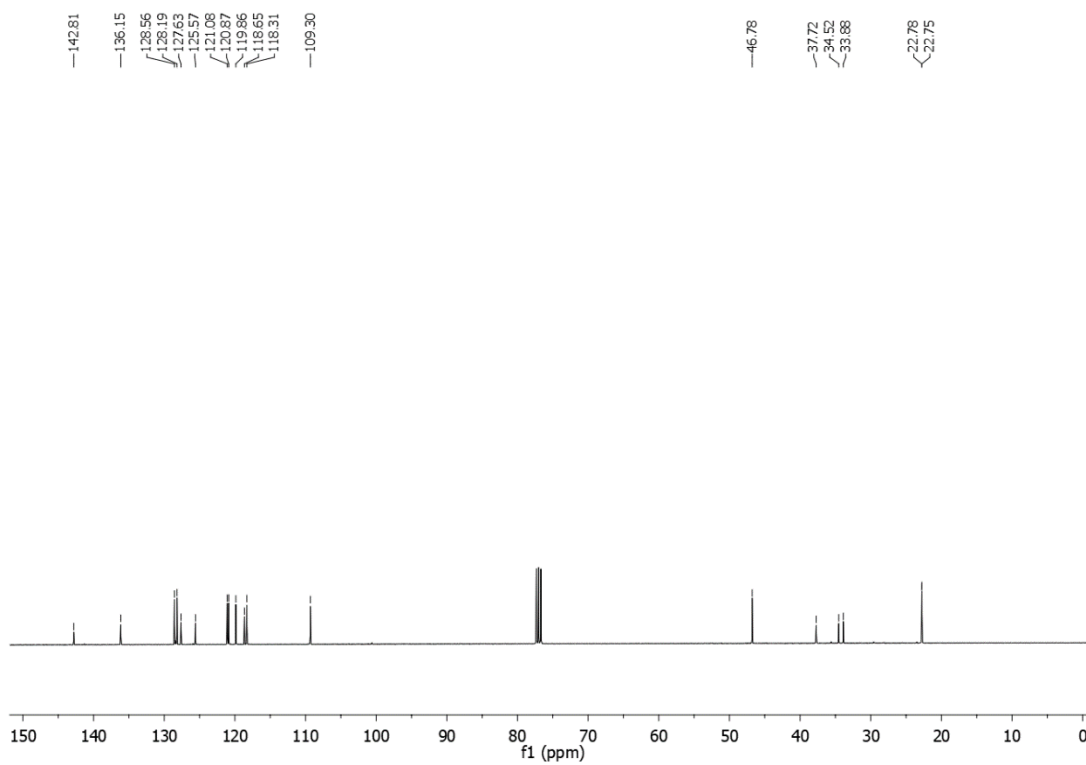
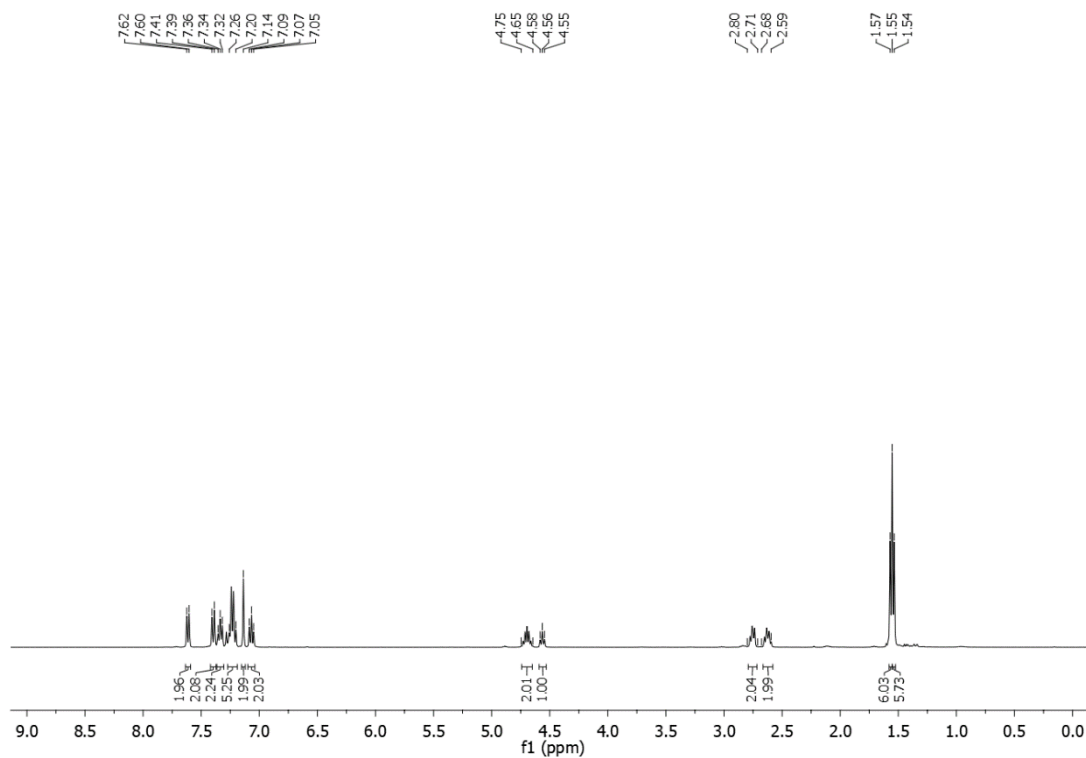


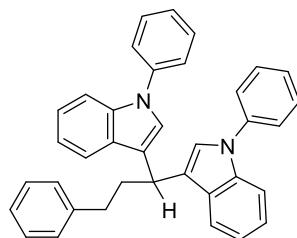
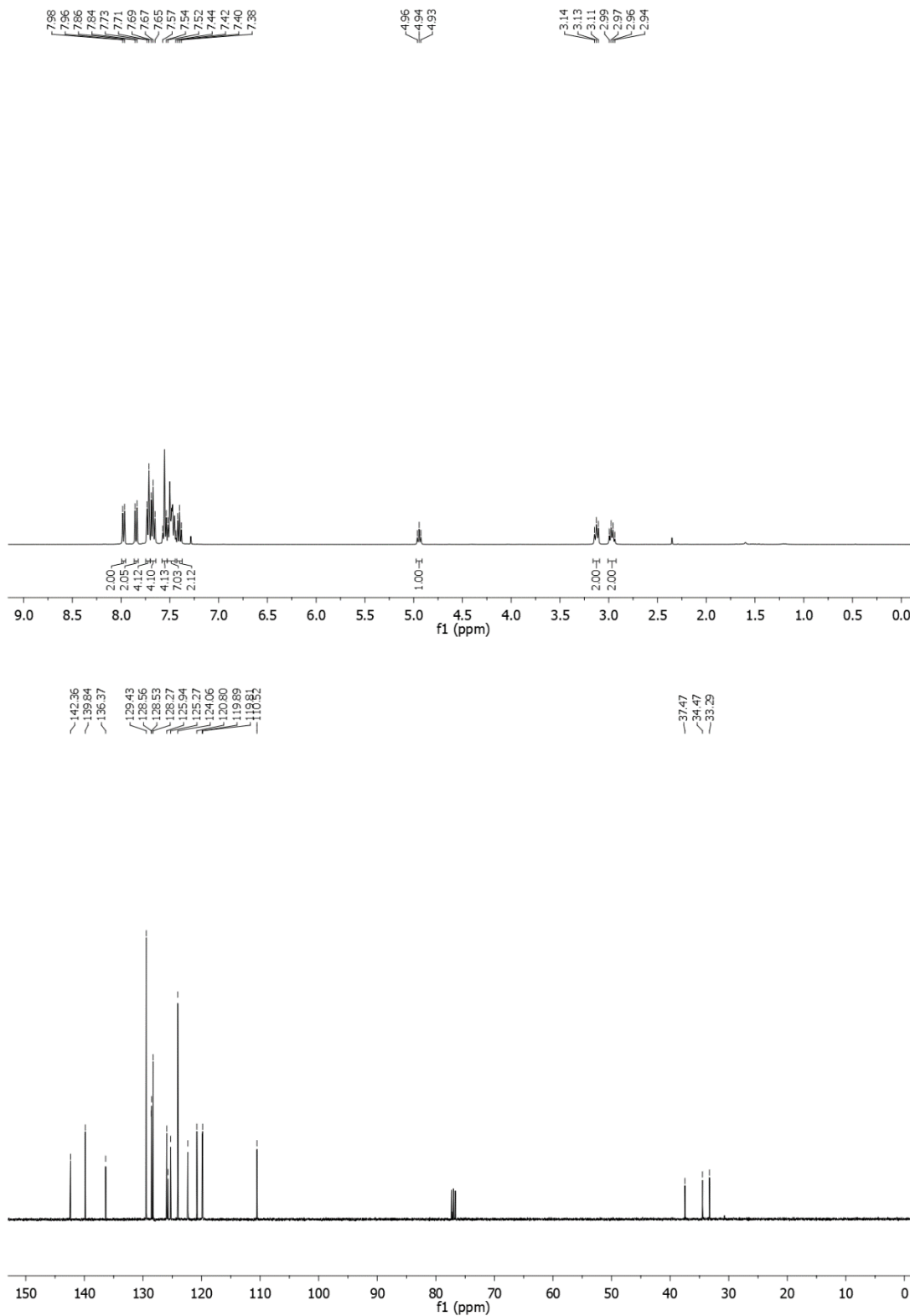


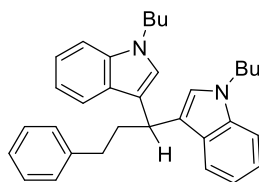






**4w**

**4x**

**4y**