

Electronic Supplementary Information

Direct C2-arylation of *N*-acyl pyrroles with aryl halides under palladium catalysis

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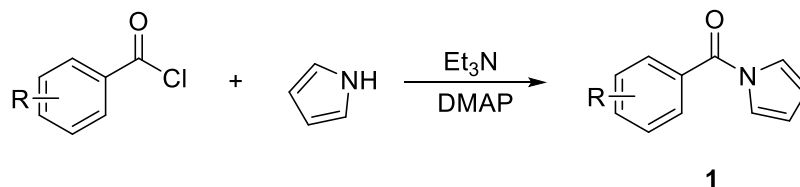
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2. General Information

All reactions were carried out under an atmosphere of air except noted. Dichloromethane and toluene were distilled prior to use under a nitrogen atmosphere. Silica gel (200–300 mesh) was used for flash chromatography. The *N*-acyl pyrroles were prepared according to the literature procedures.^[1] Formyl chloride, aryl iodides, aryl bromides, and other reagents were purchased from commercial sources and used directly. High-resolution mass spectra (HRMS) were recorded by using an Electrothermal LTQ-Orbitrap mass spectrometer. Melting points were measured by using a Gongyi X-5 microscopy digital melting point apparatus and are uncorrected. ¹H and ¹³C-NMR spectra were recorded with a Bruker Avance III 400 MHz NMR spectrometer with CDCl₃ as solvent. The chemical shifts are reported in ppm relative to CDCl₃ ($\delta = 7.26$) for ¹H NMR and relative to the central CDCl₃ resonance ($\delta = 77.0$) for ¹³C NMR. Coupling constants (*J*) are quoted in Hz. NMR data of known compounds is in agreement with literature values. Multiplicities are reported as follows: singlet (s), doublet (d), doublet of doublets (dd), triplet (t), quartet (q), and multiplet (m).

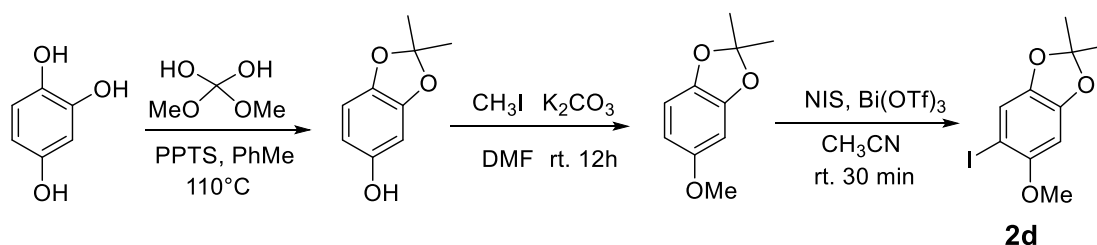
3. Experimental Procedures

3.1 General procedure for the synthesis of *N*-acyl pyrroles **1**:



Benzoyl chloride (10.0 mmol) was added dropwise to a stirred solution of pyrrole (0.85 g, 12.7 mmol), triethylamine (1.30 g, 12.8 mmol) and DMAP (122 mg, 1.0 mmol) in dry dichloromethane (15 mL) at 0 °C. The solution was allowed to warm to room temperature and stirred till the end of the reaction. The reaction mixture was then diluted with Et₂O, washed with 1 M HCl (15 mL), saturated aqueous NaHCO₃ (15 mL) and brine (15 mL), dried over Na₂SO₄ and filtered. The volatiles were removed in vacuo and the residue was subjected to flash column chromatography to give the *N*-acyl pyrroles.

3.2 Procedure for the synthesis of aryl iodide **2d**:

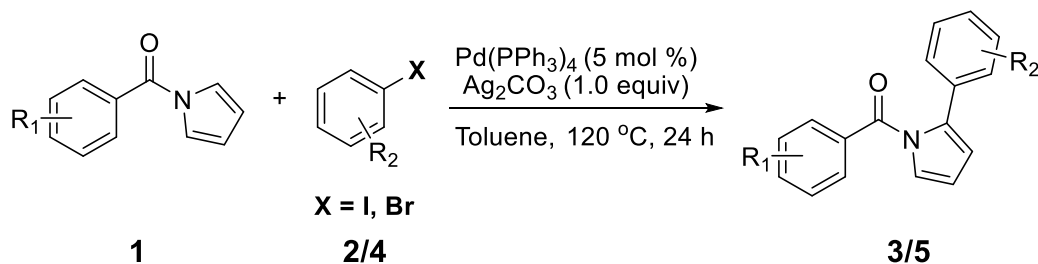


In a two-necked flask, equipped with a distillation apparatus in one neck and a stopcock in the other, were added benzene-1,2,4-triol (315 mg, 2.50 mmol), pyridinium *p*-toluenesulfonate (0.05 mg, 0.002 mmol), and anhydrous toluene (25 mL), and the mixture was stirred and heated to 110 °C. To the mixture was added 2,2-dimethoxypropane (0.45 mL, 3.65 mmol) portionwise. Then the mixture was continued to stir for 2 h. After cooling down, the solvent was removed under reduced pressure, and the residue was purified by flash chromatography to give 2,2-Dimethylbenzo[d][1,3]dioxol-5-ol as a colorless oil.^[2]

2,2-Dimethylbenzo[d][1,3]dioxol-5-ol (500 mg, 3.00 mmol) and potassium carbonate (621 mg, 4.50 mmol), and *N,N*-Dimethylformamide (5 mL) were added to a round-bottom flask, and the mixture was stirred at room temperature. To the mixture was added iodomethane (511 mg, 3.54 mmol) portionwise. Then the mixture was stirred till the end of the reaction. The reaction mixture was then diluted with H₂O (20 mL), extracted with EtOAc (3×20 mL), washed with brine (20 mL), dried over Na₂SO₄ and filtered. The volatiles were removed in vacuo and the residue was subjected to flash column chromatography to give 5-methoxy-2,2-dimethylbenzo[d][1,3]dioxole as a yellowish oil.

5-methoxy-2,2-dimethylbenzo[d][1,3]dioxole (350 mg, 1.54 mmol), *N*-iodosuccinimide (480 mg, 2.13 mmol), Bismuth trifluoromethylsulfonate (125 mg, 0.19 mmol), and acetonitrile (5 mL) were added to a round-bottom flask, and the mixture was stirred at room temperature for 30 min. The reaction mixture was then diluted with saturated Na₂S₂O₄ (20 mL), extracted with EtOAc (3×10 mL), washed with brine (20 mL), dried over Na₂SO₄ and filtered. The volatiles were removed in vacuo and the residue was subjected to flash column chromatography to give aryl iodide **2d** as a yellowish solid. ¹H NMR (400 MHz, CDCl₃) δ (ppm): 7.07 (s, 1H), 6.44 (s, 1H), 3.79 (s, 3H), 1.65 (s, 6H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm): 153.2, 148.7, 142.4, 119.1, 117.5, 95.1, 72.0, 57.3, 25.7. HRMS (ESI) *m/z*: Calcd for C₁₀H₁₁INaO₃ [M + Na]⁺: 328.9645, found 328.9650.

3.3 General Procedure for the Direct Oxidative Coupling between *N*-Acyl Pyrroles and aryl halides



A Schlenk reaction tube equipped with a magnetic stir bar was charged with Pd(PPh₃)₄ (0.05 equiv., 0.01 mmol), Ag₂CO₃ (1.0 equiv., 0.20 mmol), *N*-acyl pyrroles

1 (1.0 equiv., 0.20 mmol) and aryl halides 2 (1.5 equiv., 0.30 mmol) in toluene (2.0 mL). The tube was sealed under air and heated to 120 °C with stirring for 24 h. After cooling down, the solvent was removed under reduced pressure, and the residue was purified by flash chromatography (ethyl acetate/petroleum ether mixtures).

3.4 Previous Procedures and Results for the Direct Oxidative Coupling between *N*-Acyl Pyrroles and aryl halides

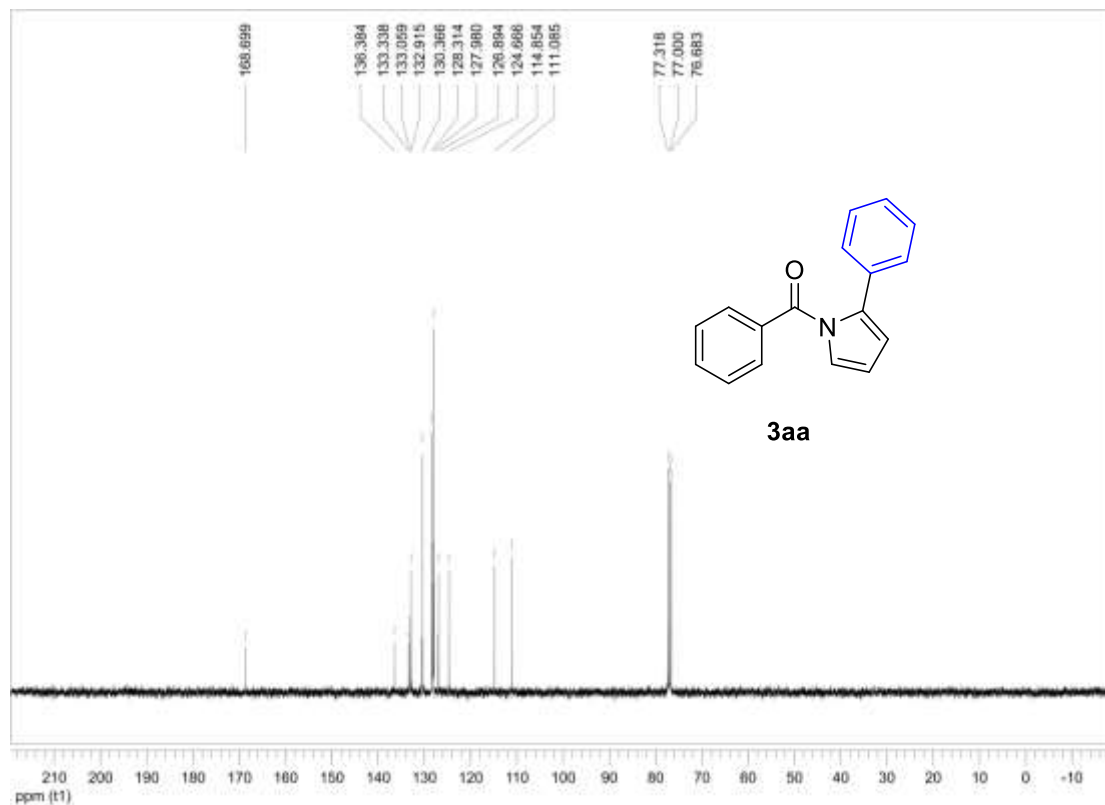
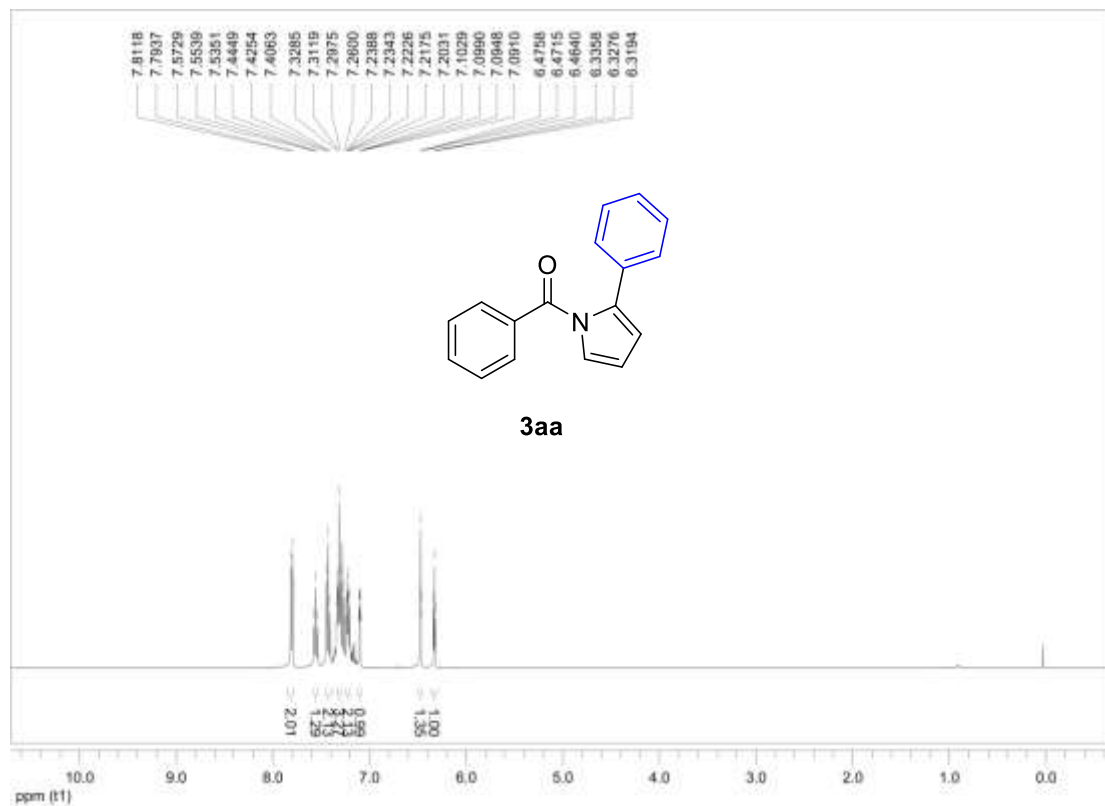
The previous reaction conditions from references¹⁻² were used for the transformation between *N*-Acyl Pyrroles and aryl halides, no desired C2-arylation product was obtained under these conditions.

References

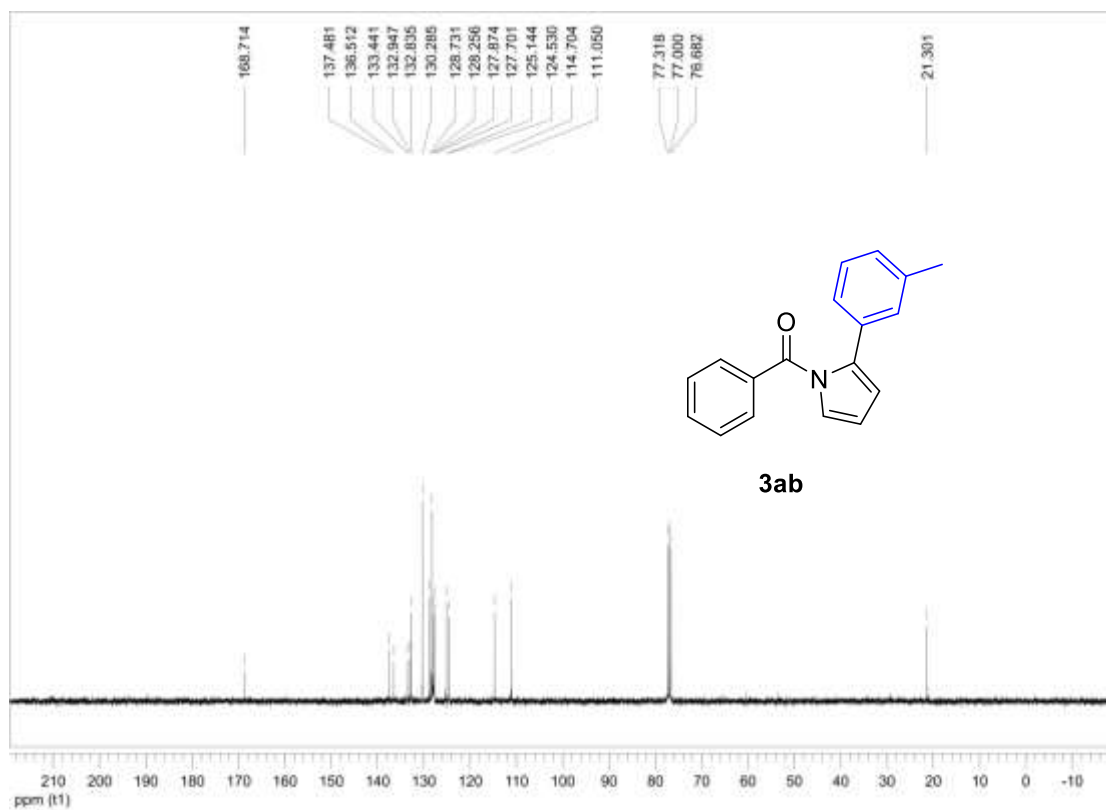
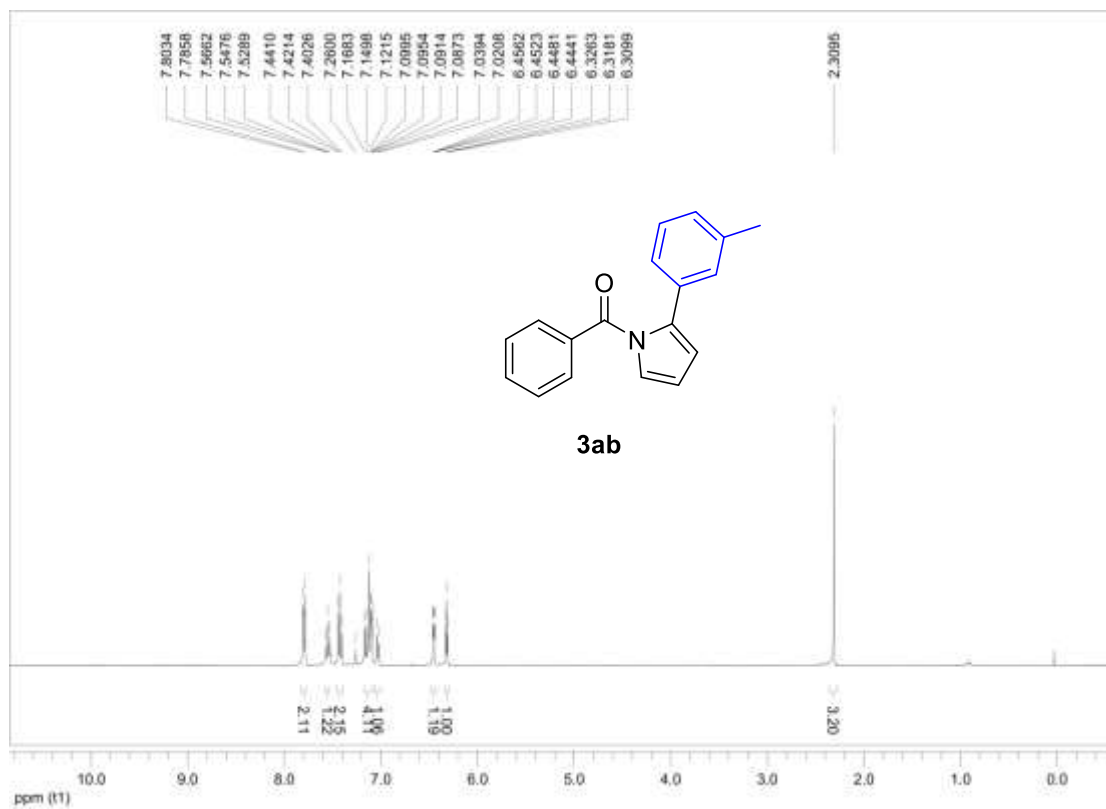
- [1] T. R. Bailey, *Tetrahedron Lett.* 1986, **27**, 4407–4410.
- [2] B. S. Cho, H. J. Bae, Y. K. Chung, *J. Org. Chem.* 2015, **80**, 5302–5307.

4. NMR Spectra for Products

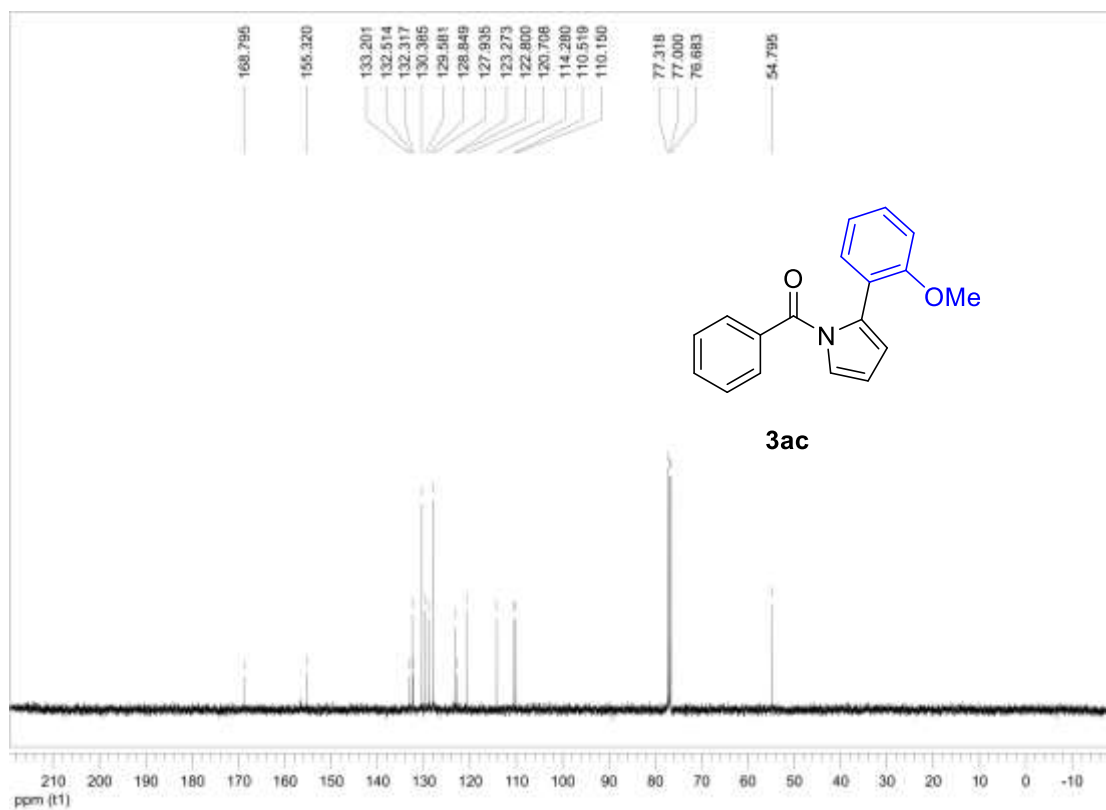
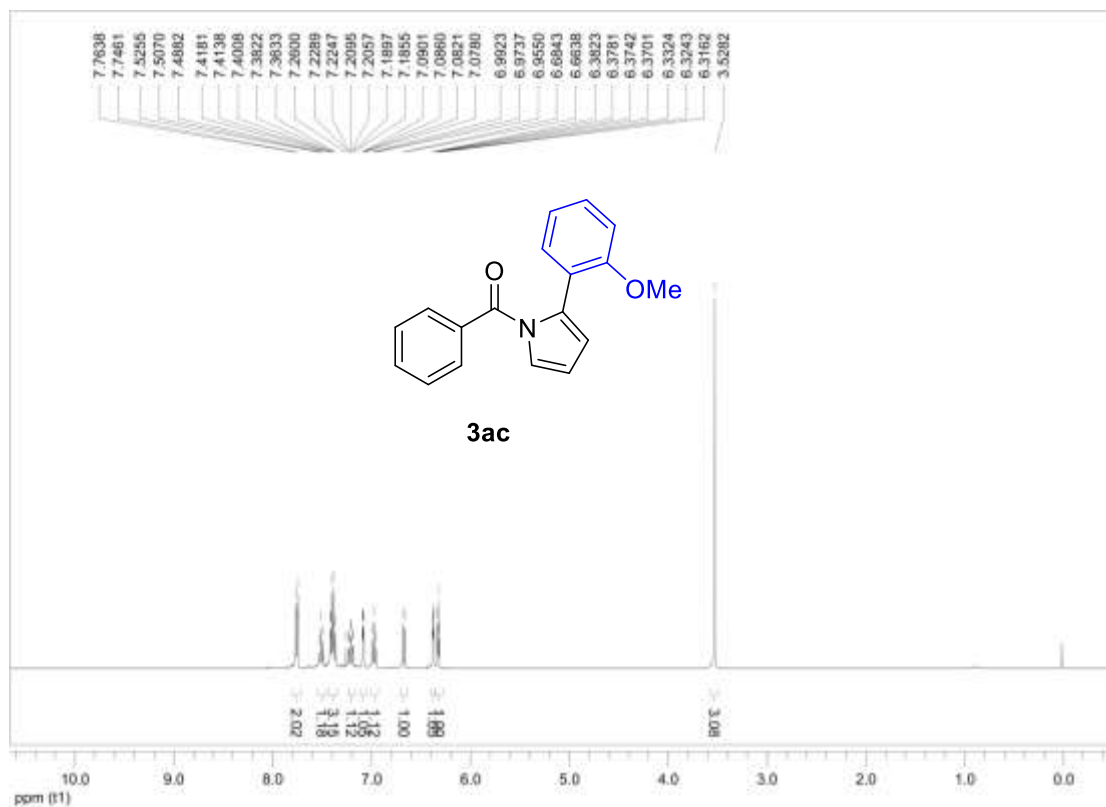
Phenyl(2-phenyl-1*H*-pyrrol-1-yl)methanone (**3aa**)



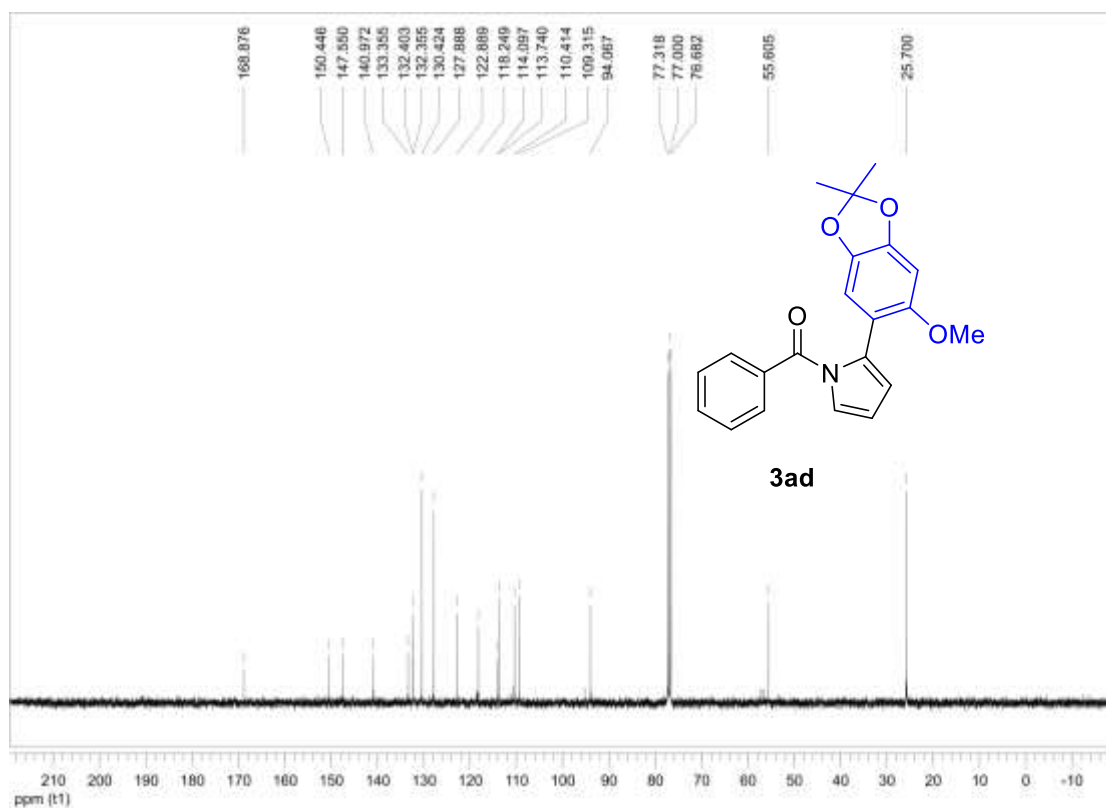
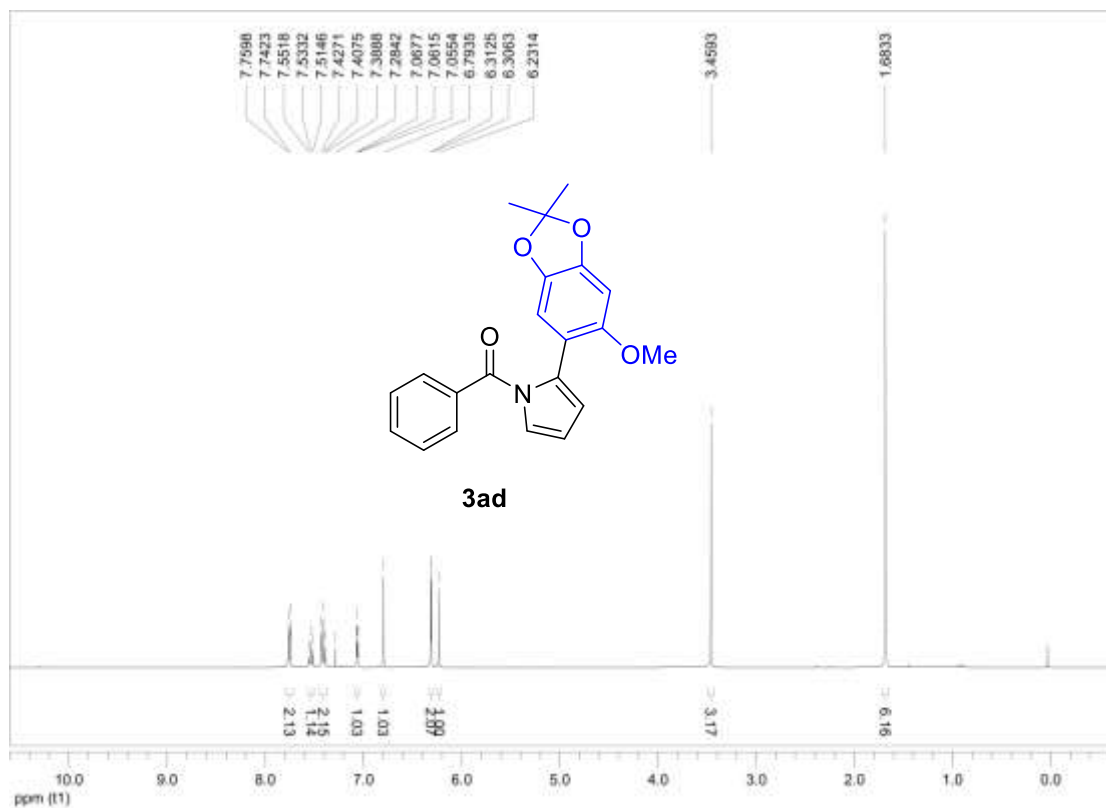
Phenyl(2-(*m*-tolyl)-1*H*-pyrrol-1-yl)methanone (3ab)



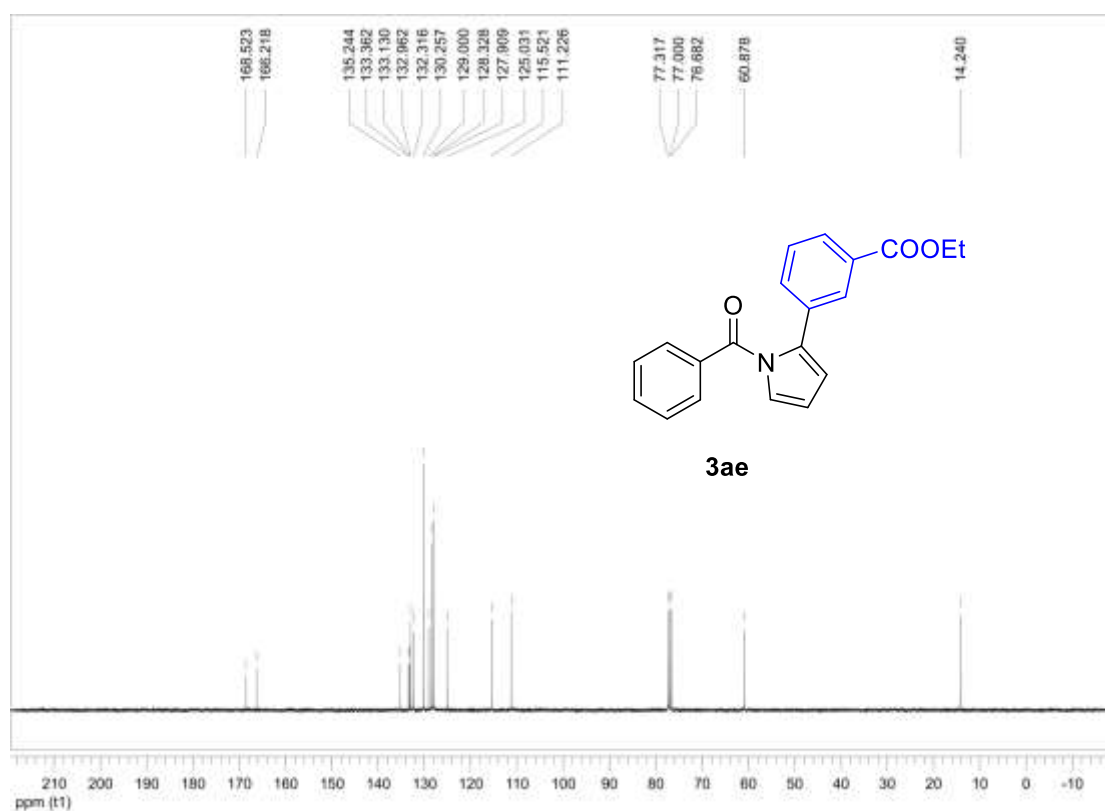
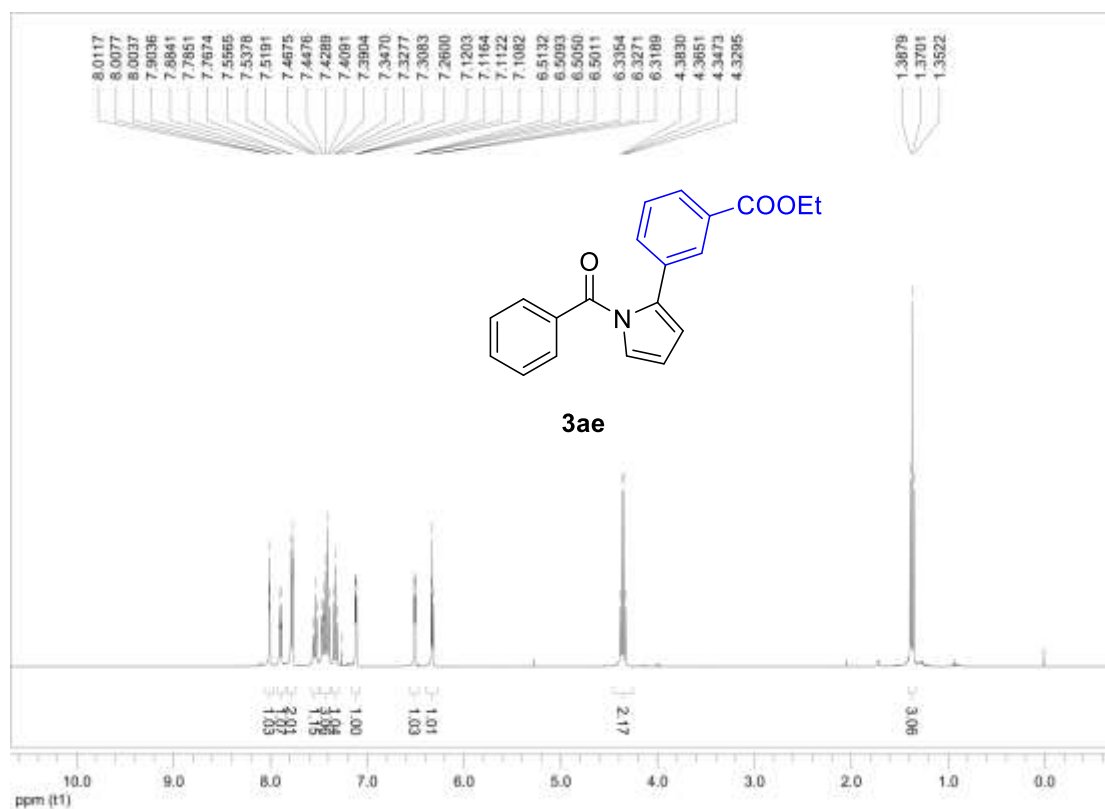
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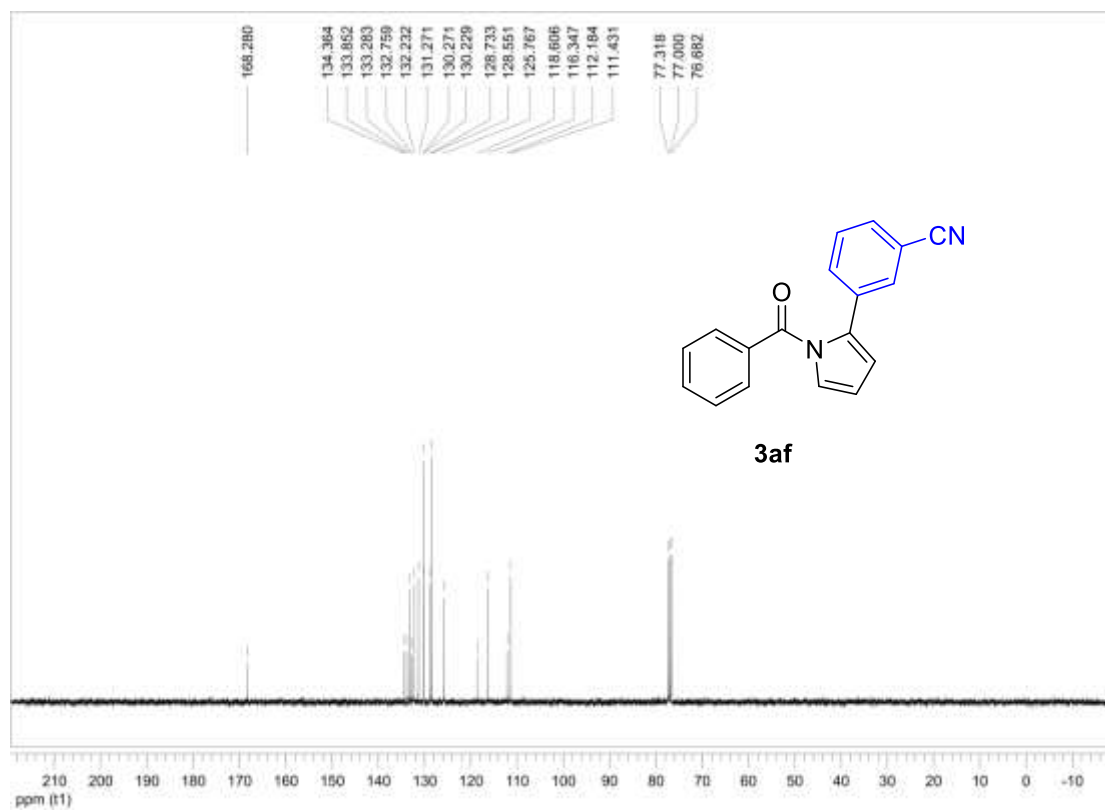
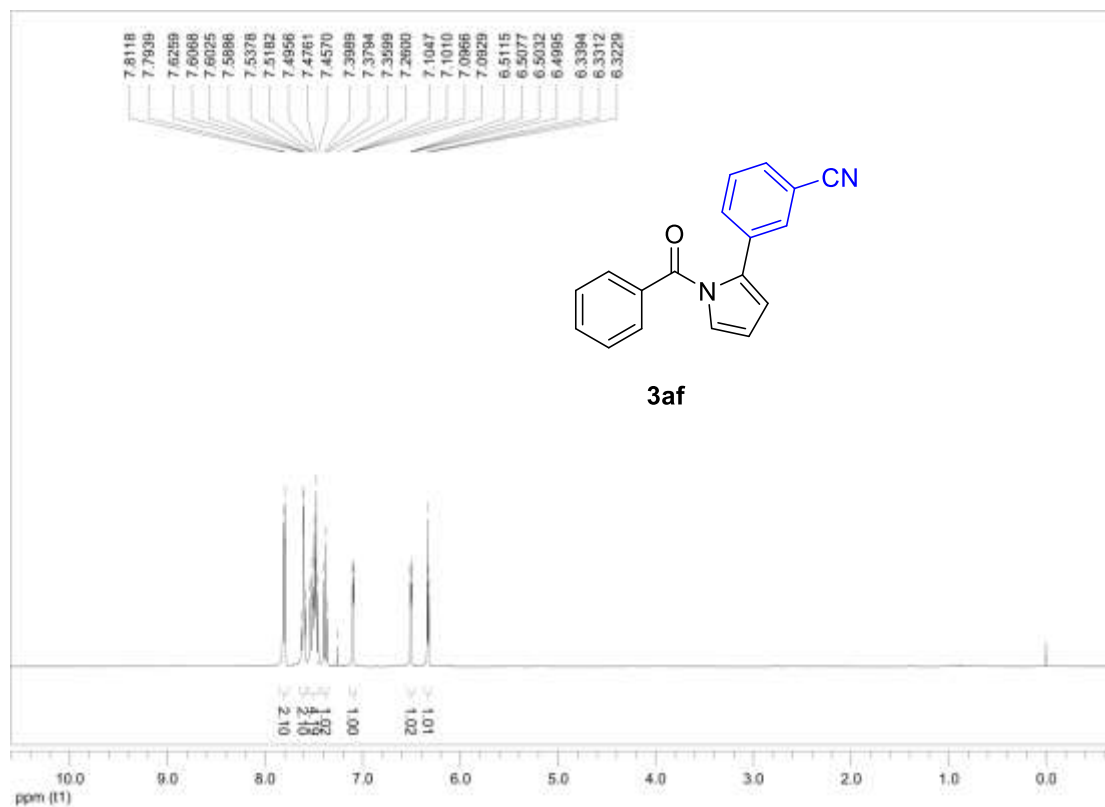
(2-(6-Methoxy-2,2-dimethylbenzo[d][1,3]dioxol-5-yl)-1H-pyrrol-1-yl)(phenyl)methanone (3ad)

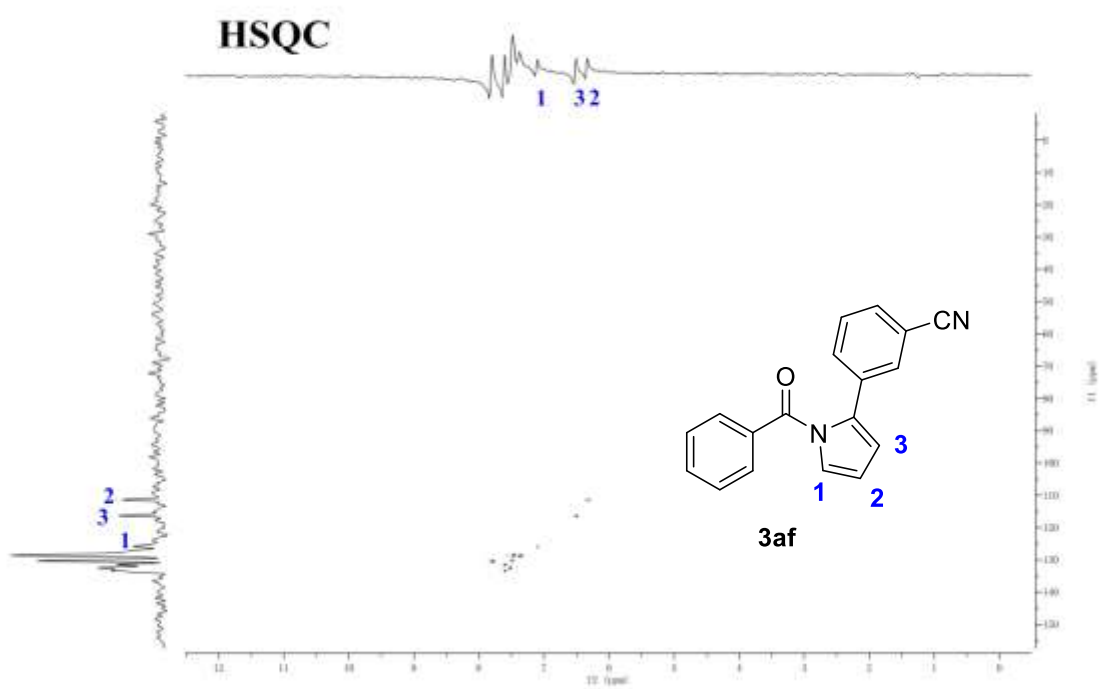
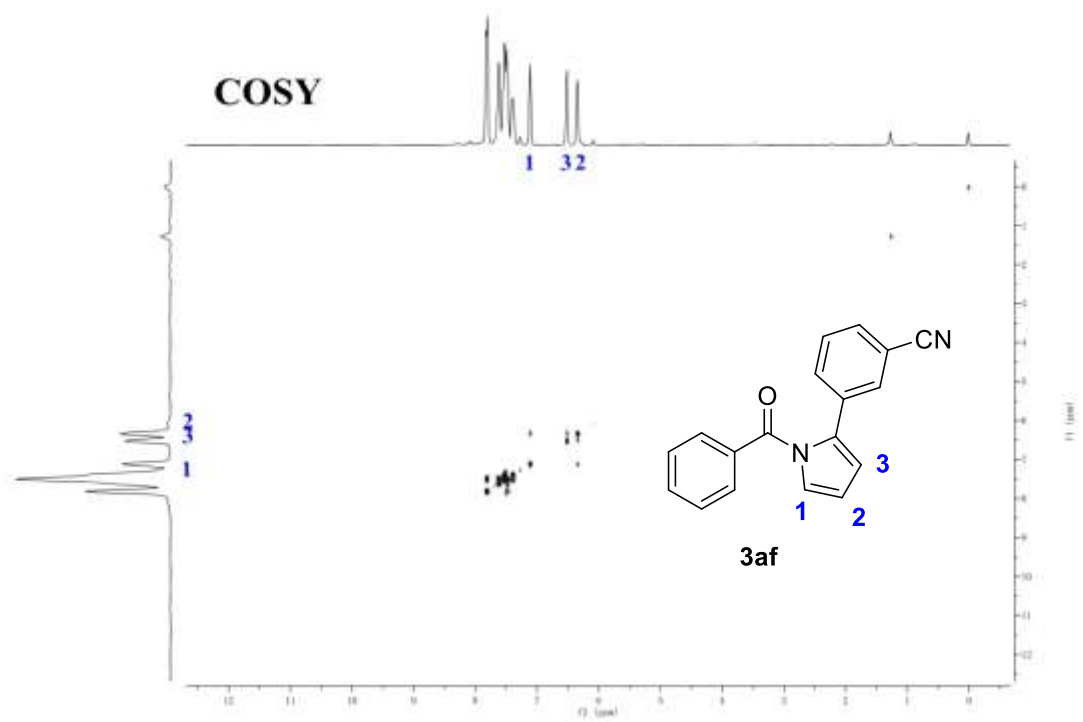


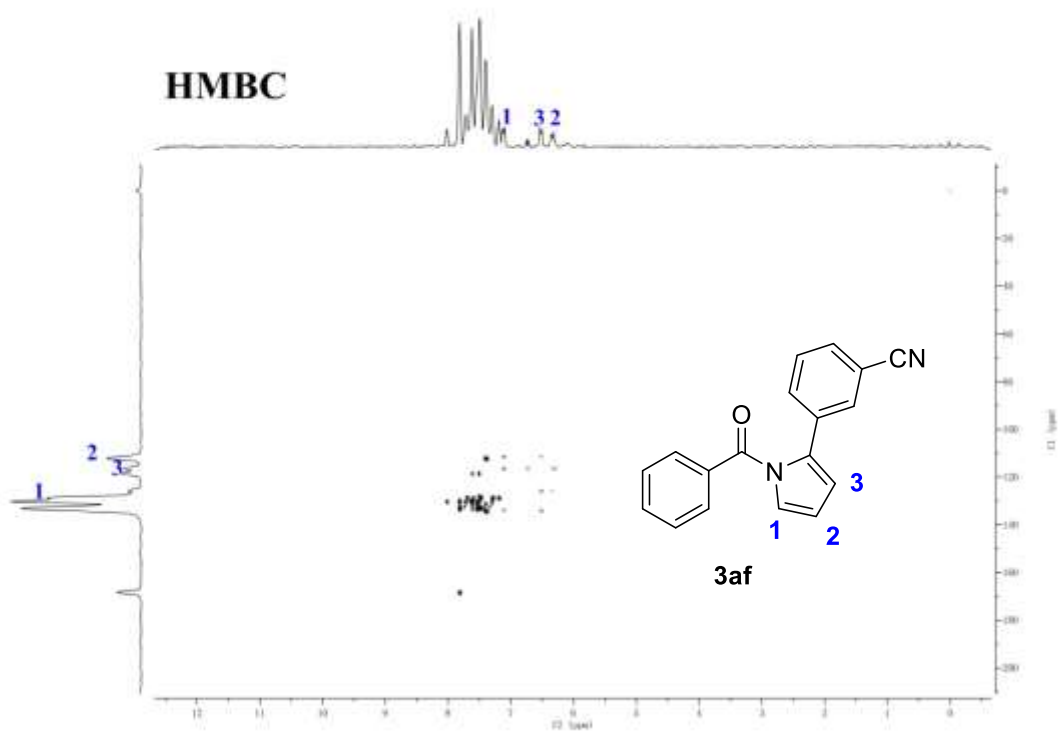
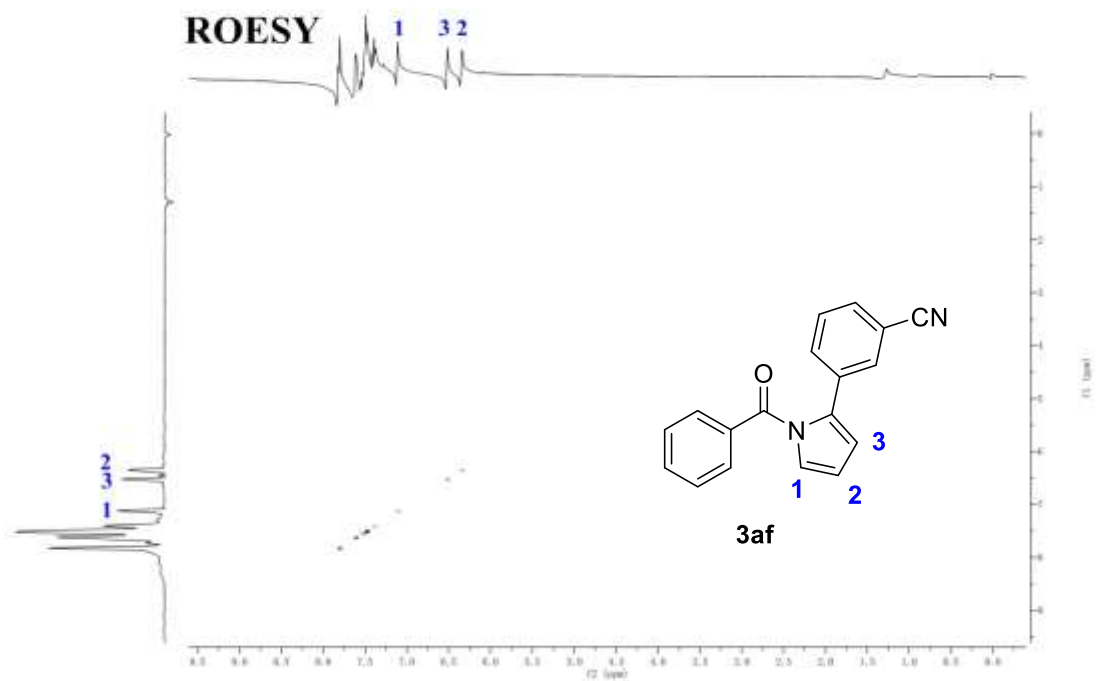
Ethyl 3-(1-benzoyl-1H-pyrrol-2-yl)benzoate (3ae)



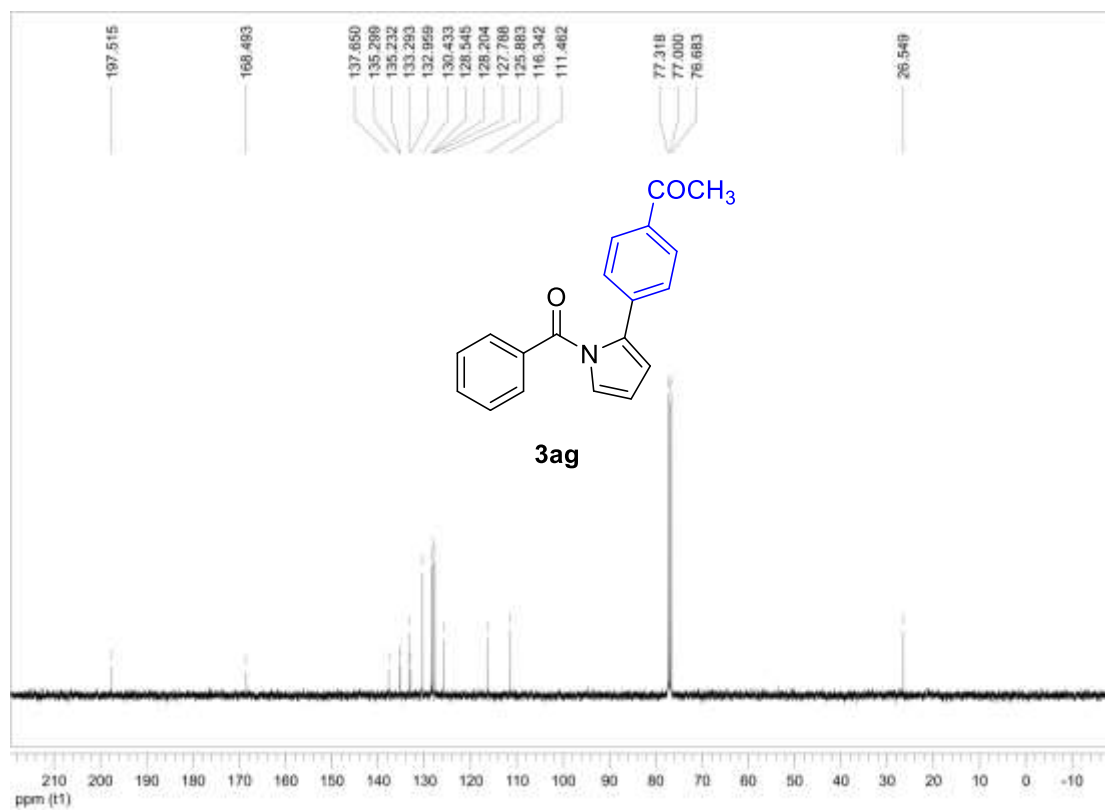
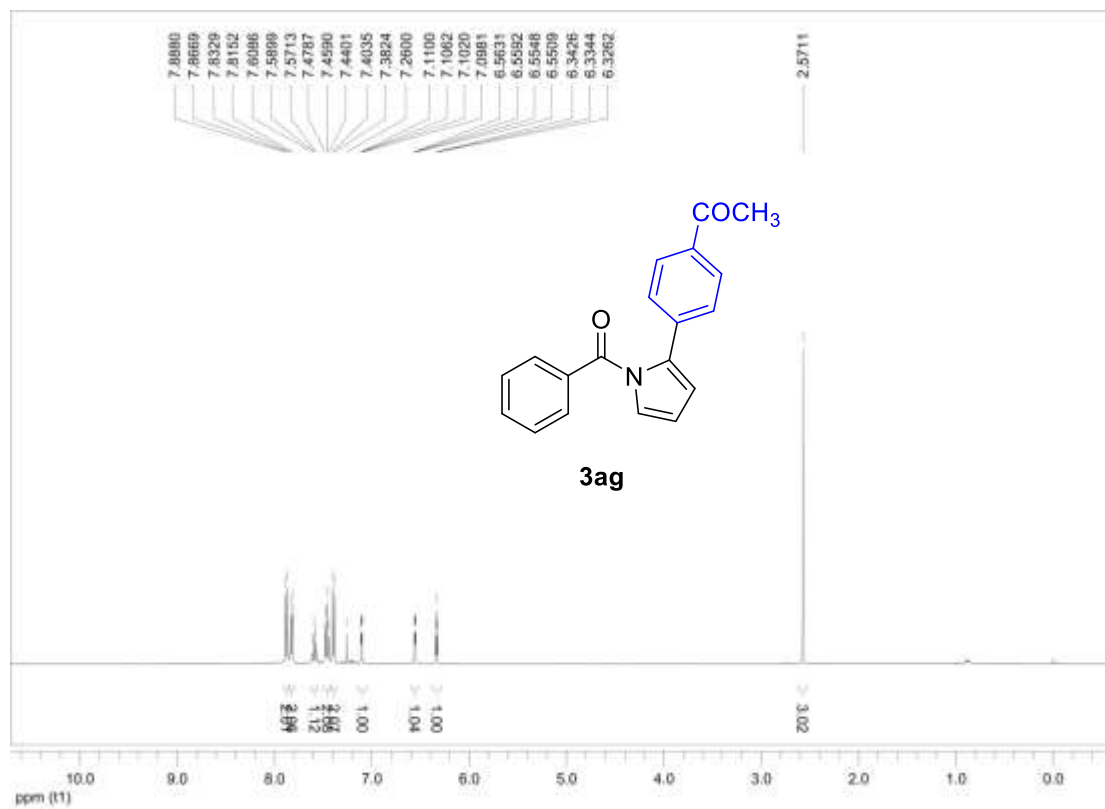
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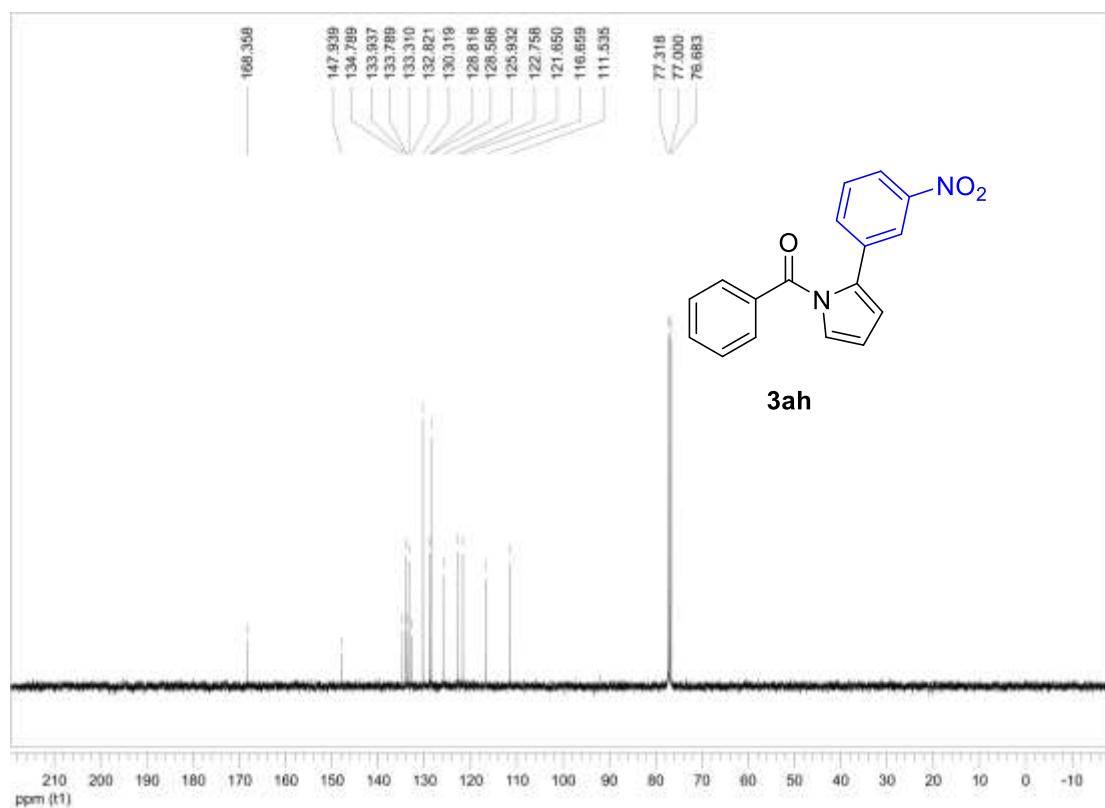
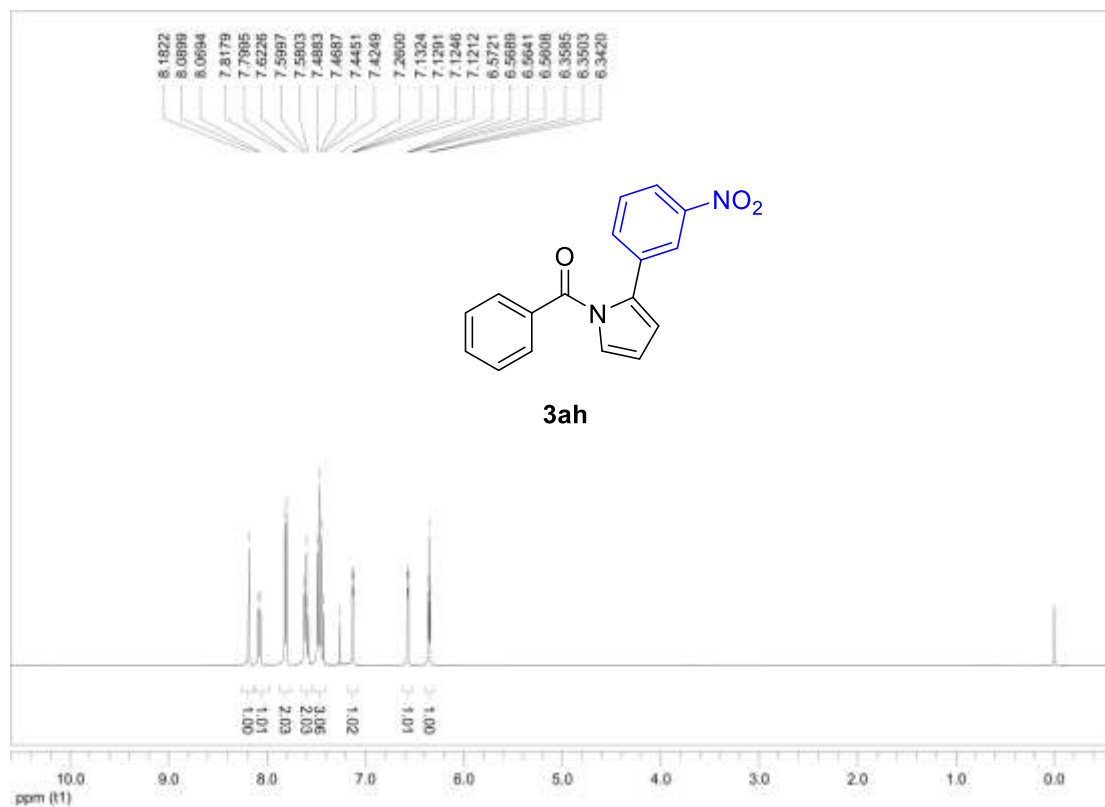




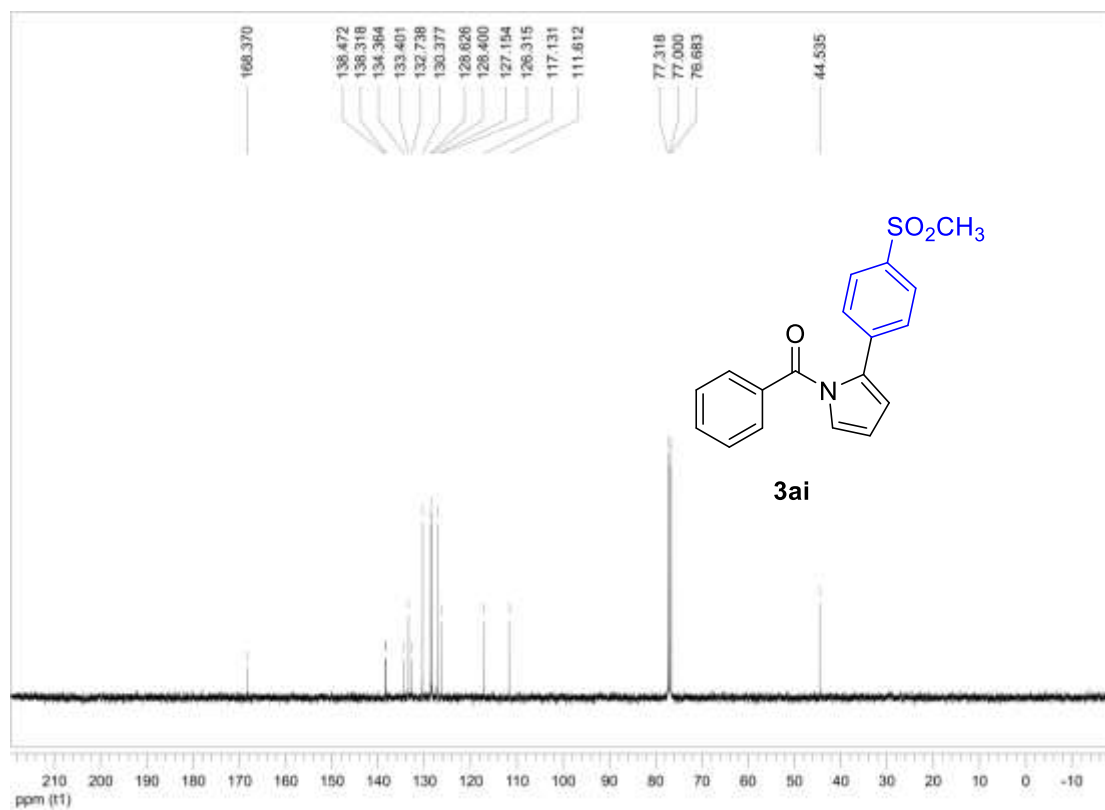
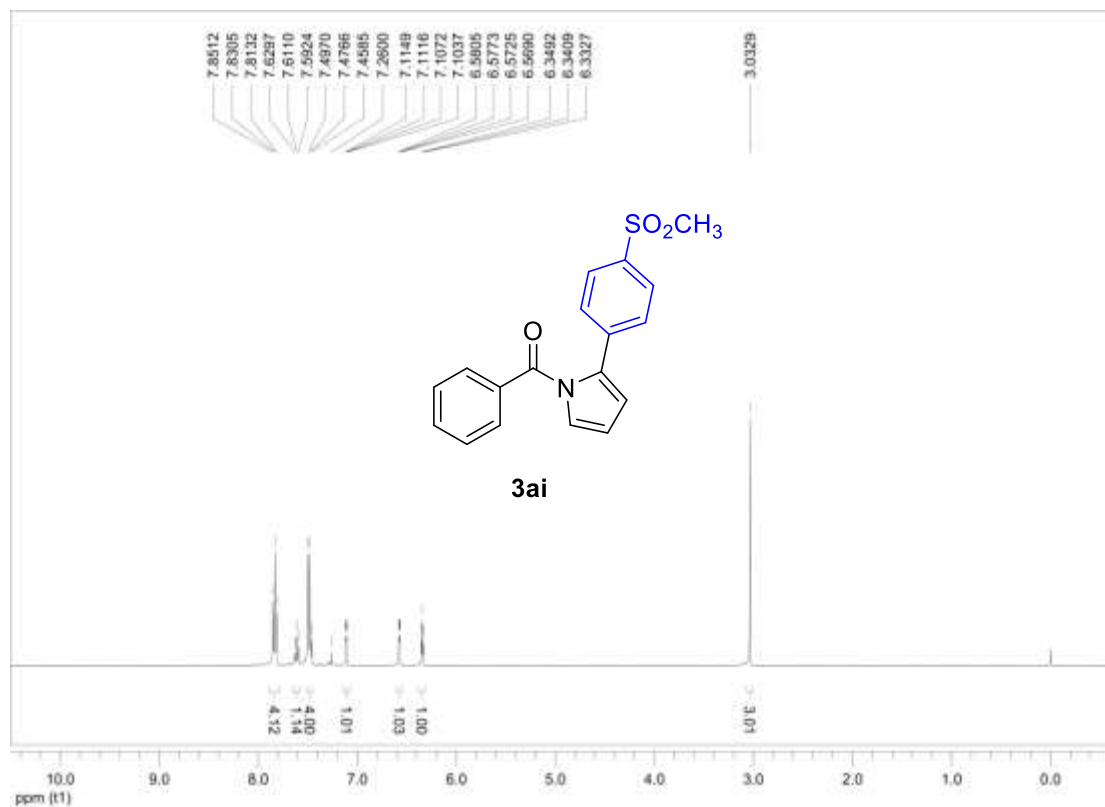
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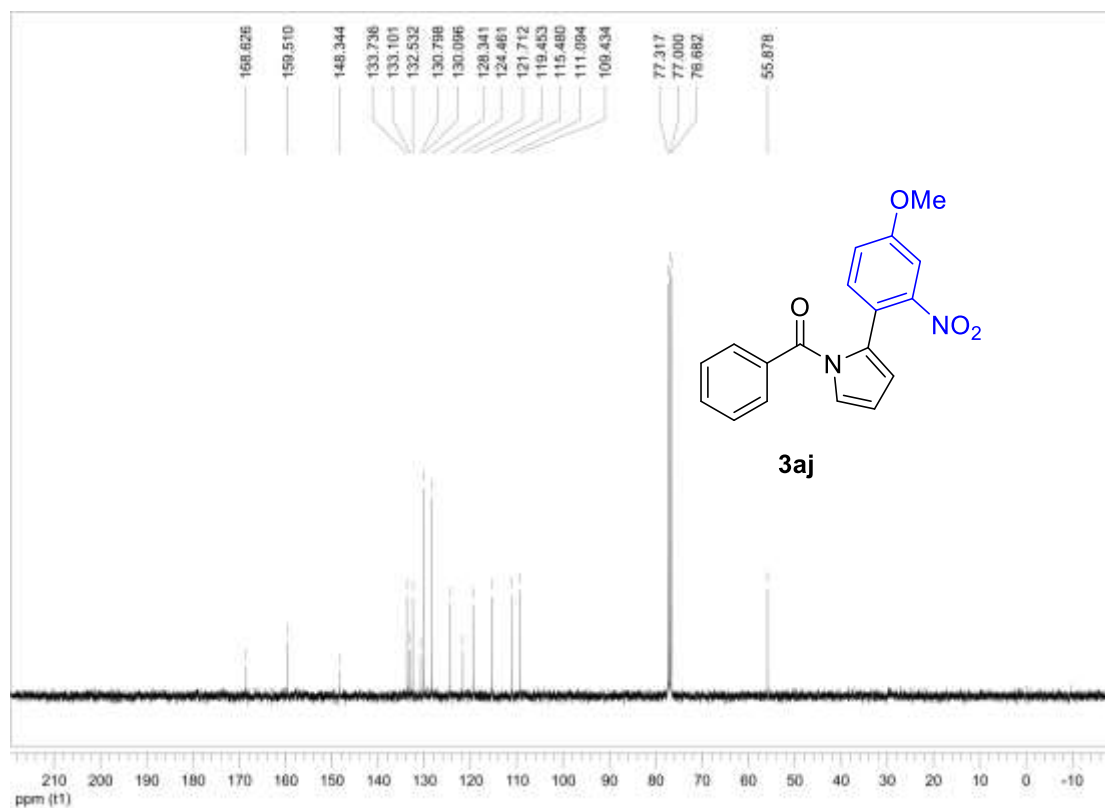
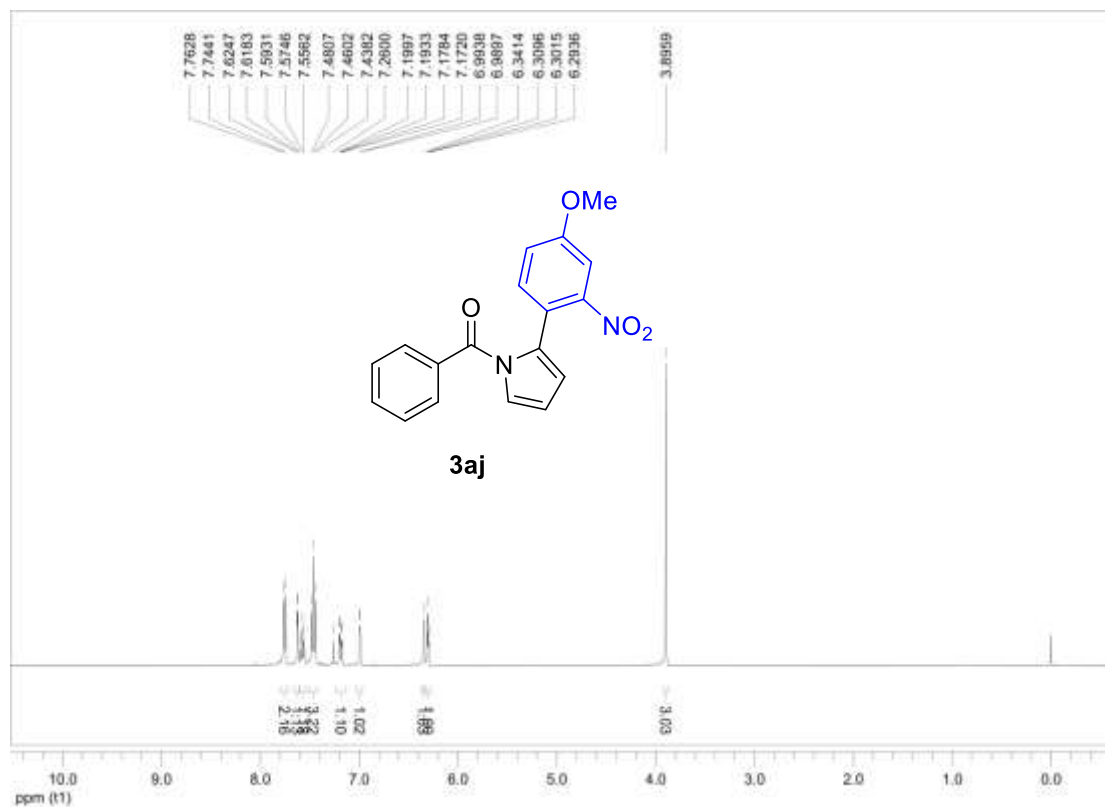
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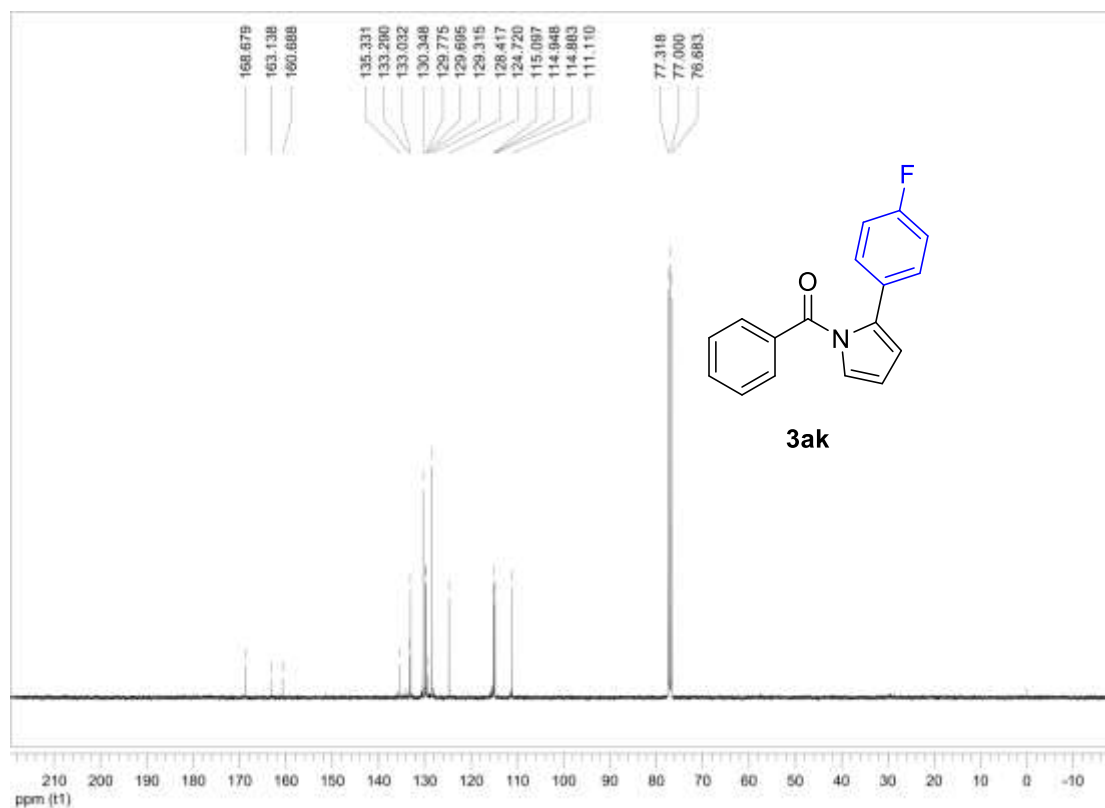
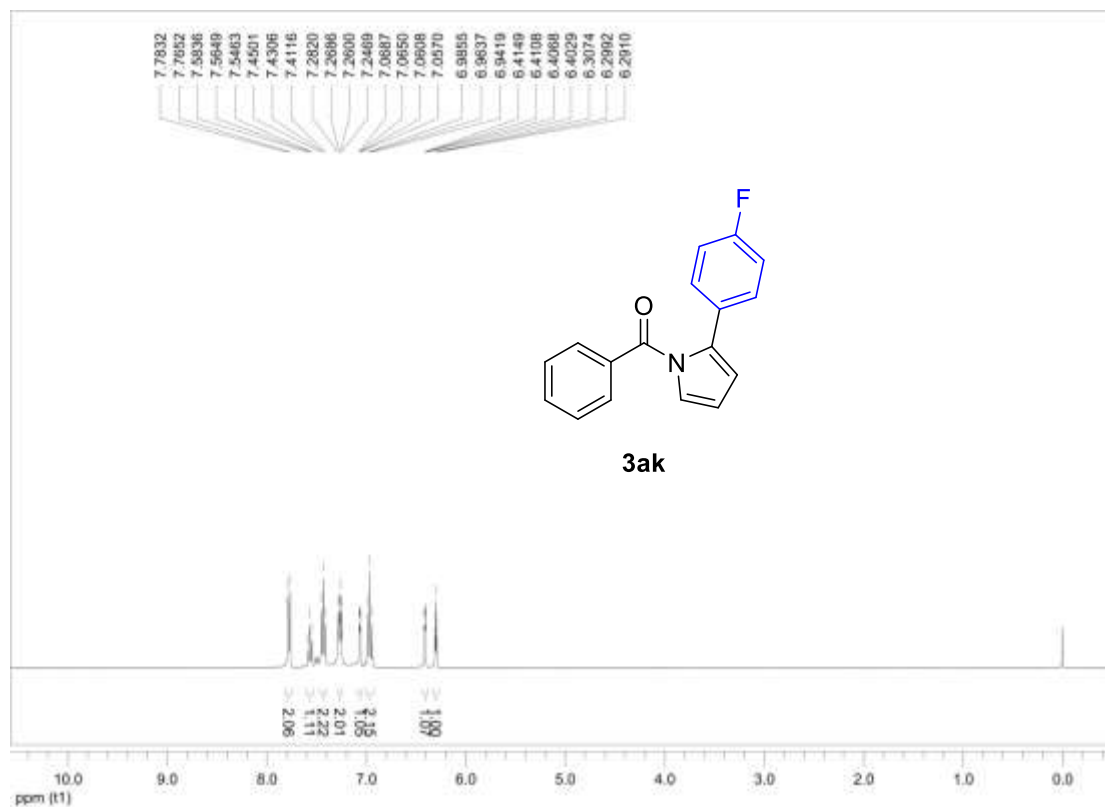
(2-(4-(Methylsulfonyl)phenyl)-1*H*-pyrrol-1-yl)(phenyl)methanone (3ai)

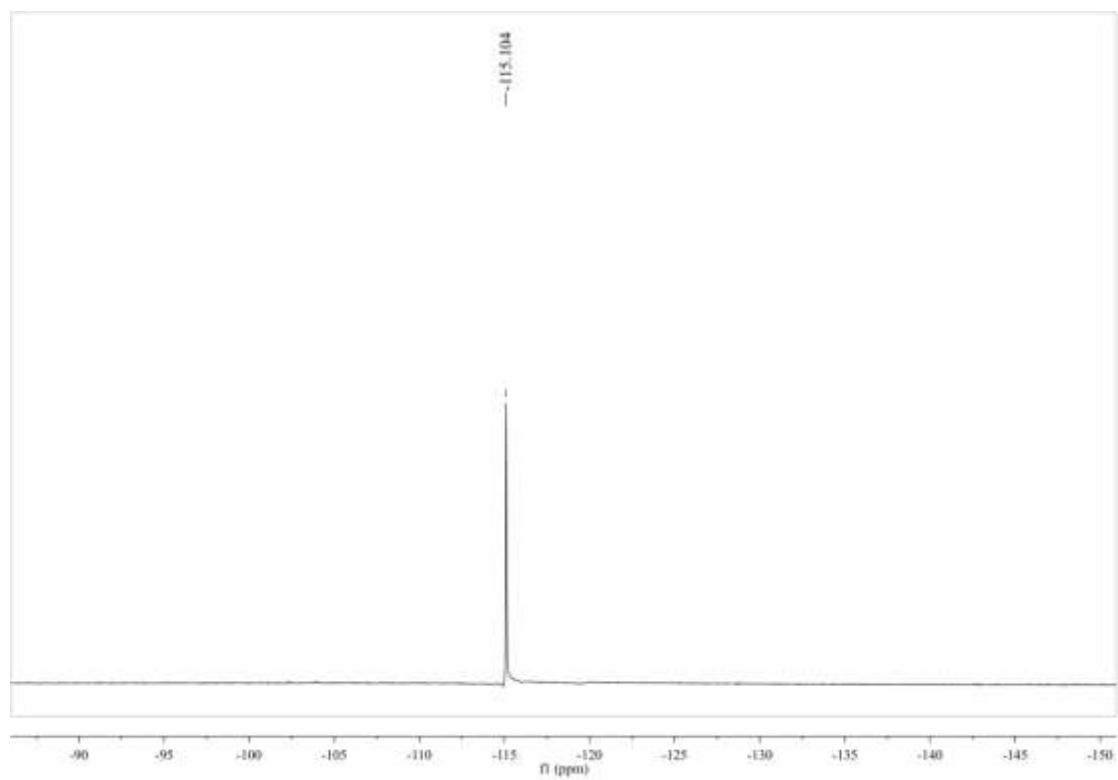


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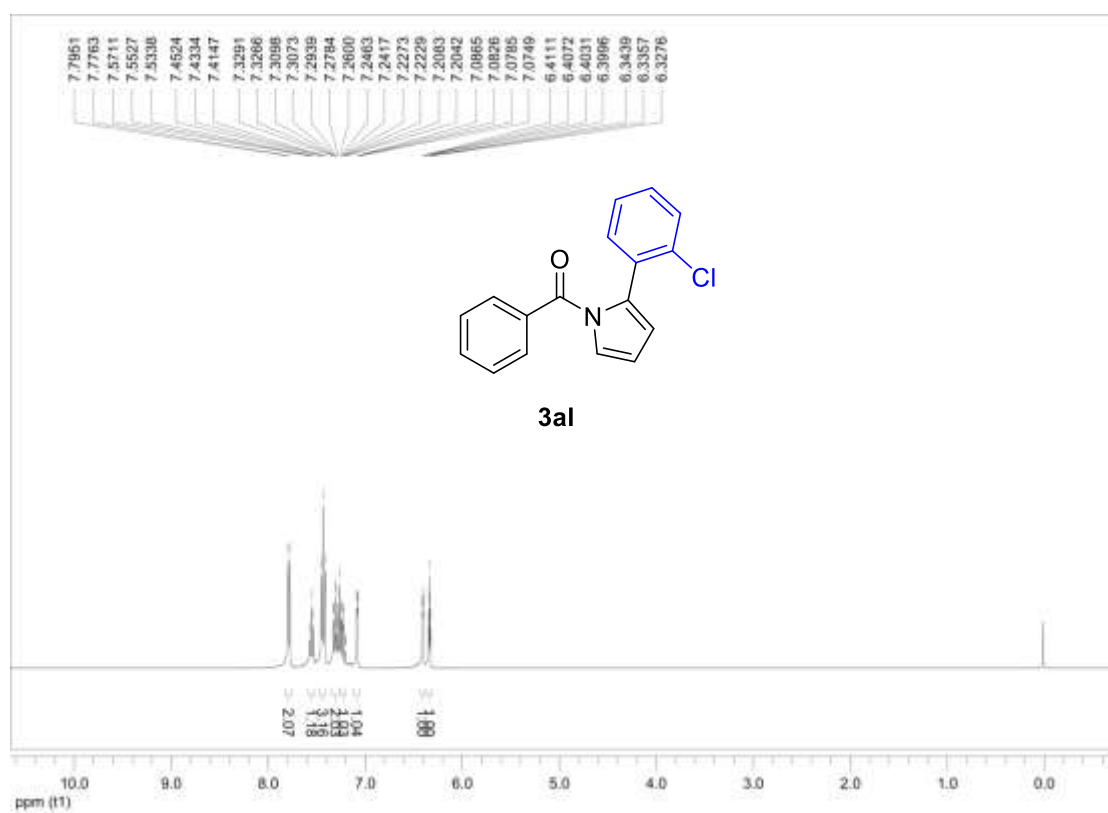


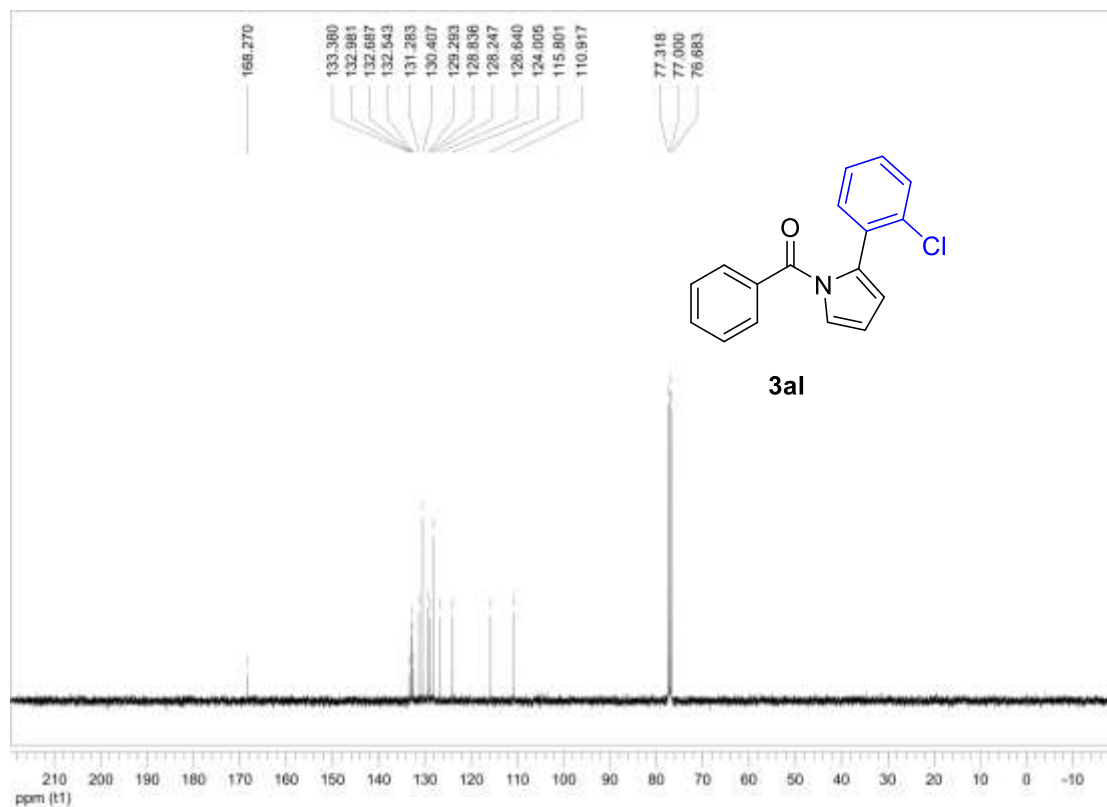
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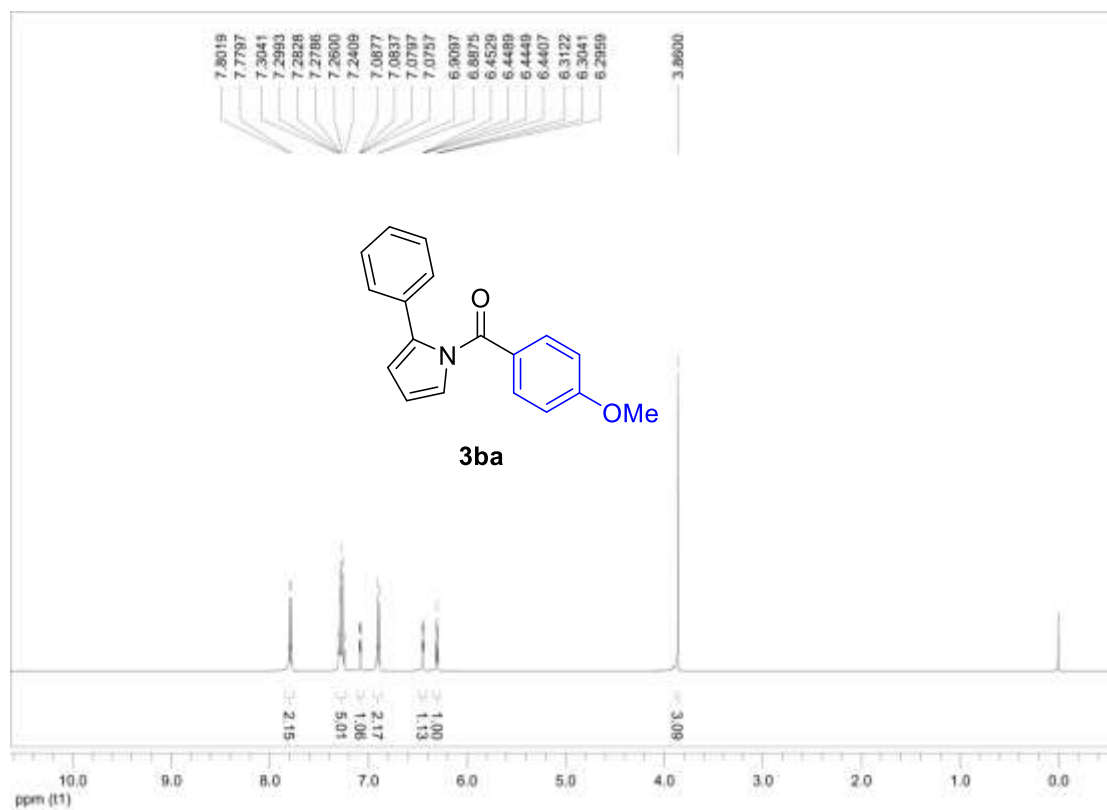


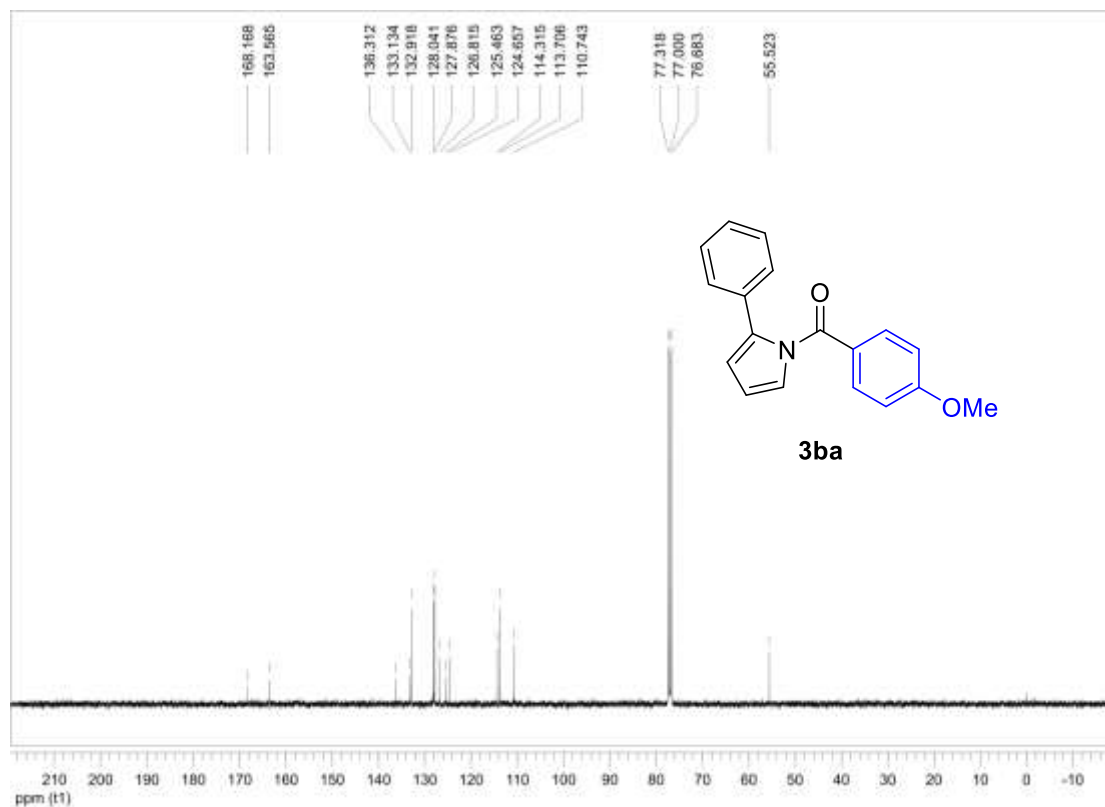
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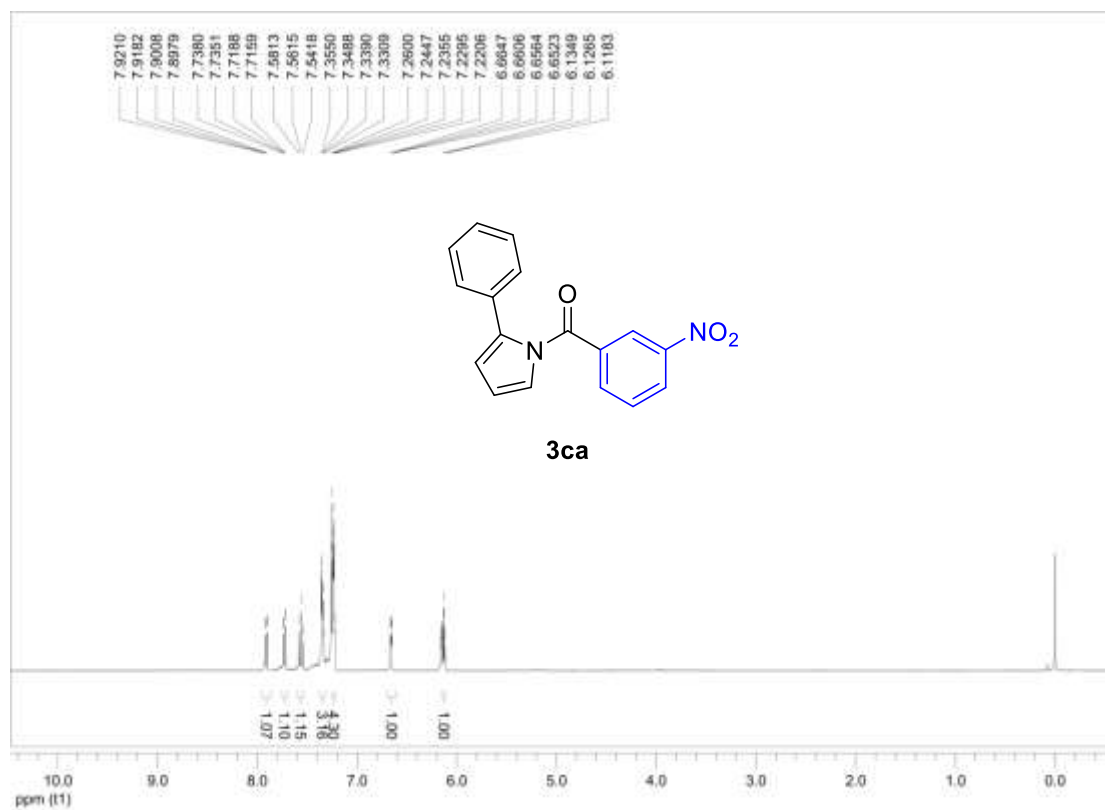


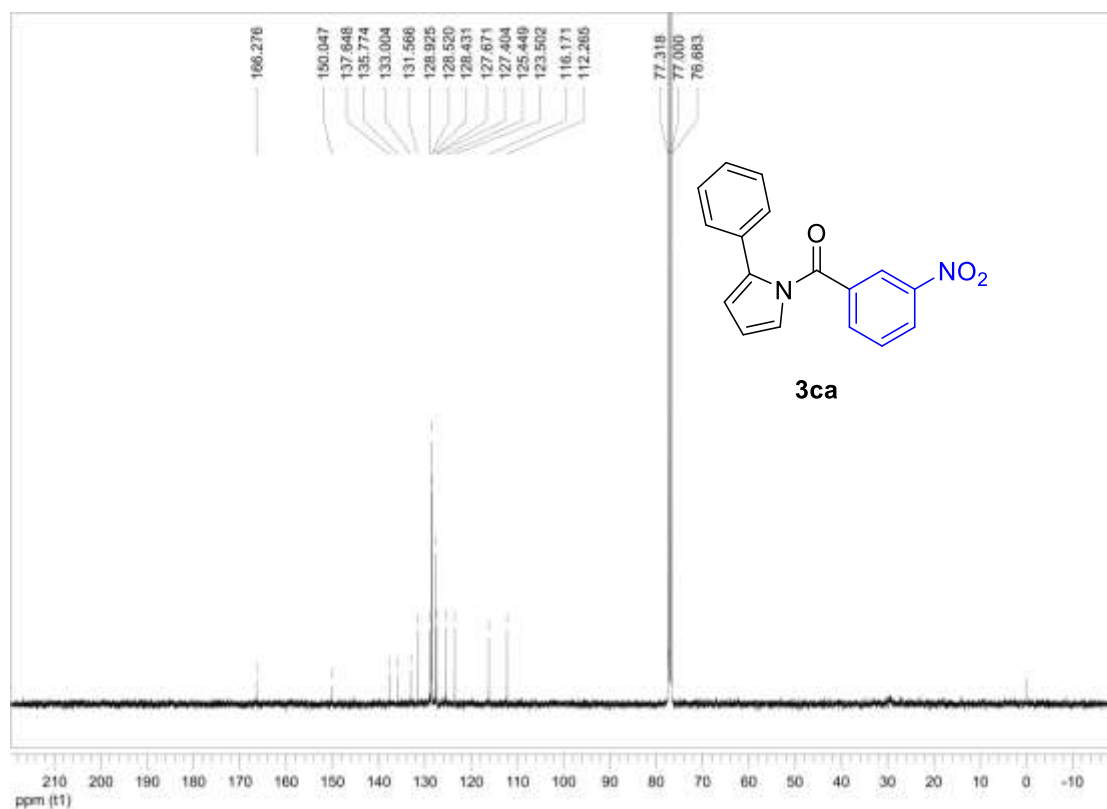
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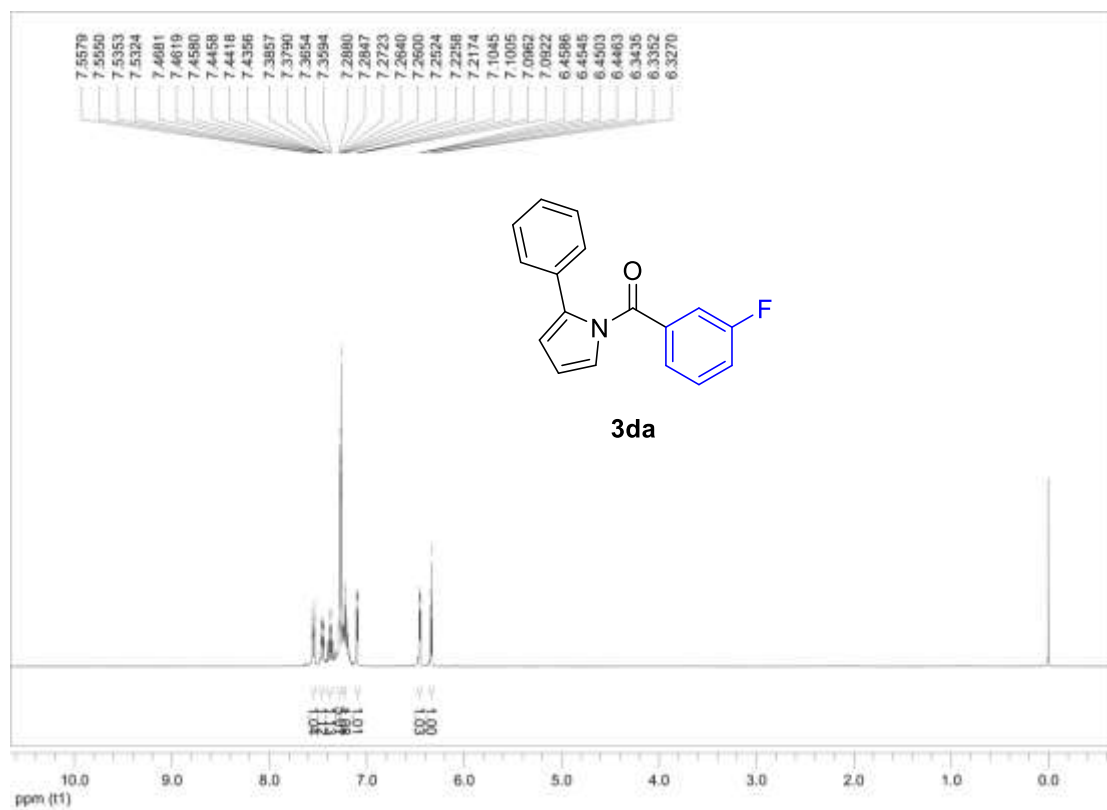


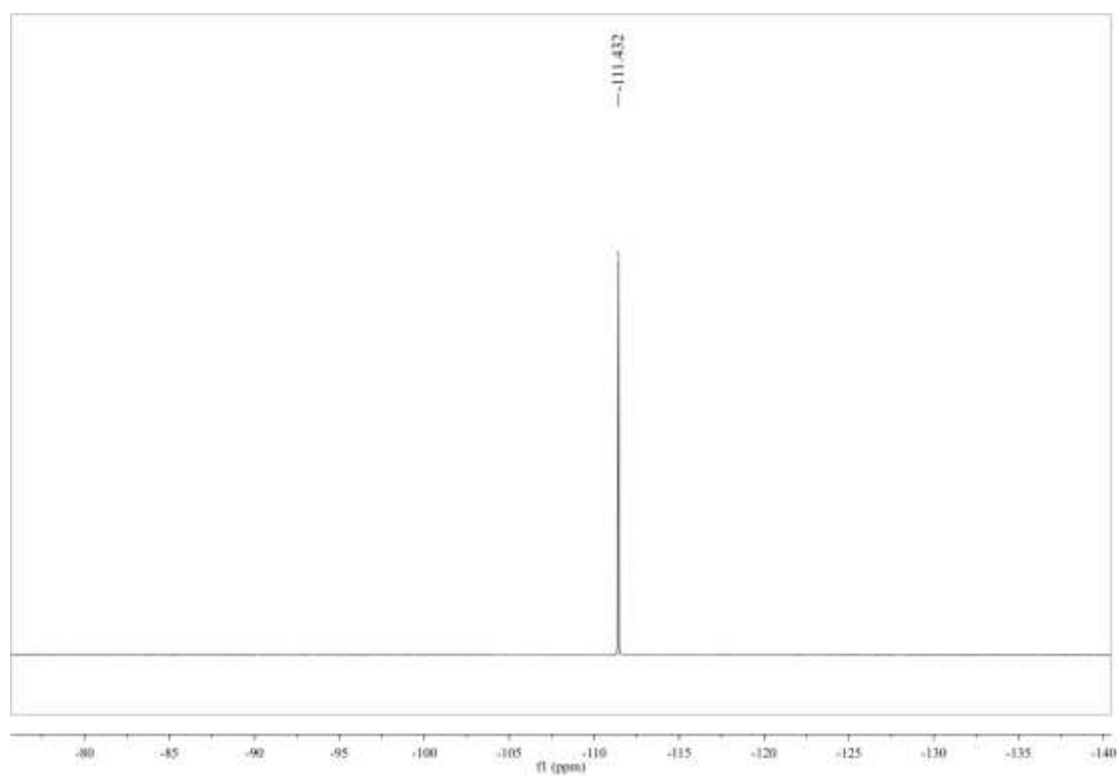
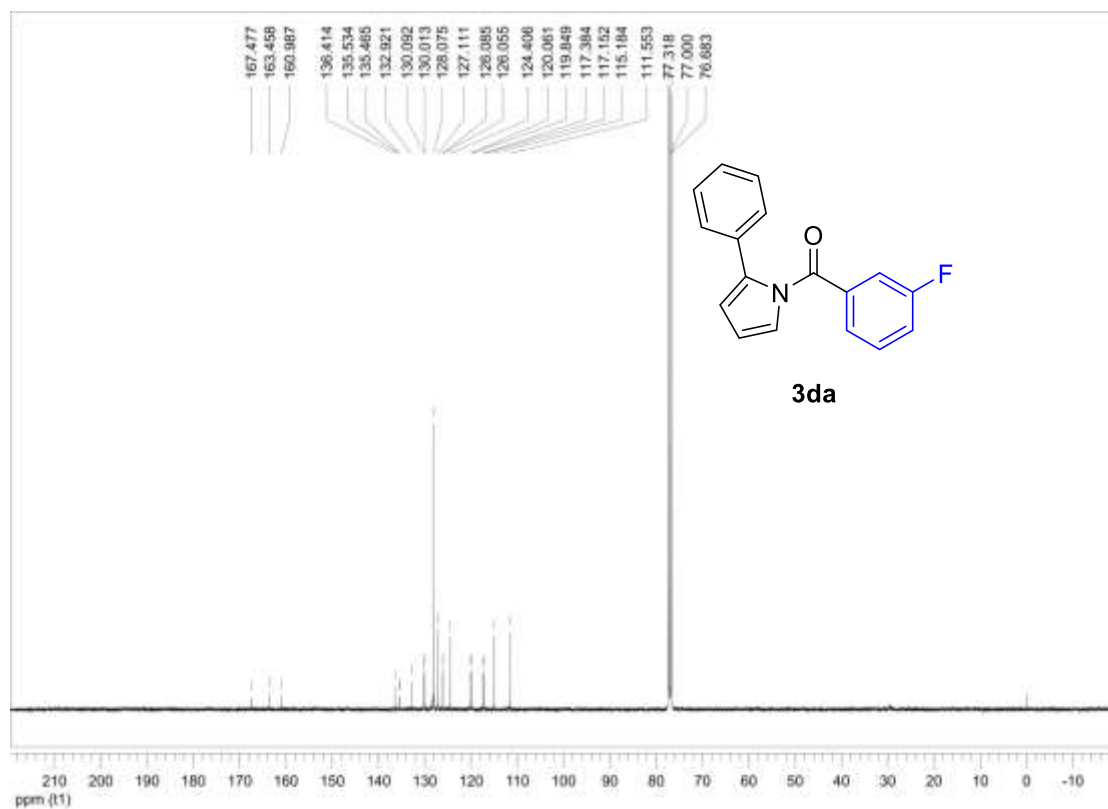
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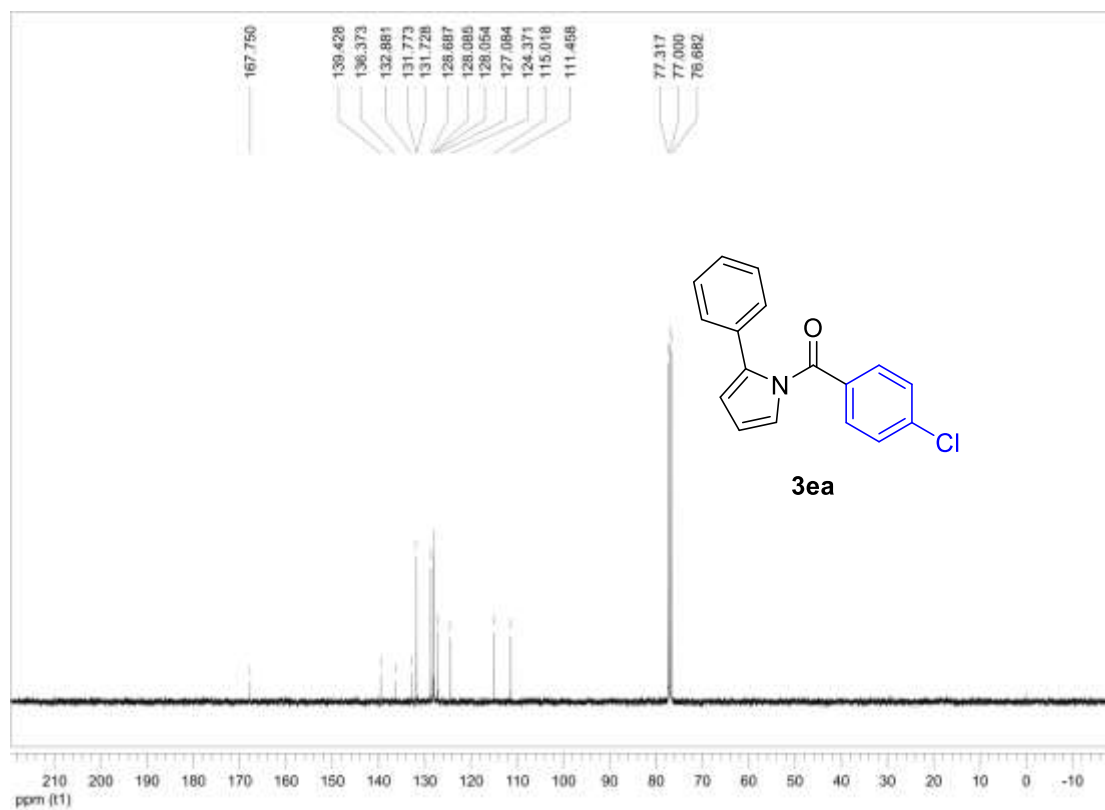
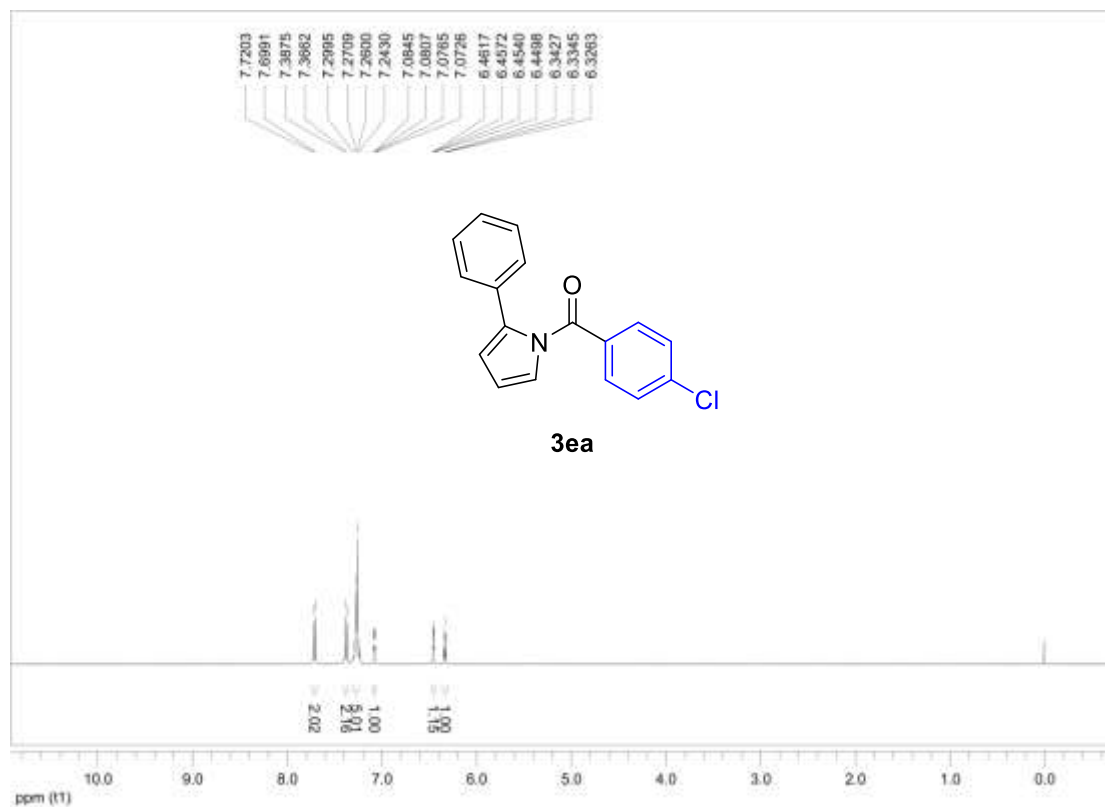


(3-Fluorophenyl)(2-phenyl-1H-pyrrol-1-yl)methanone (3da)

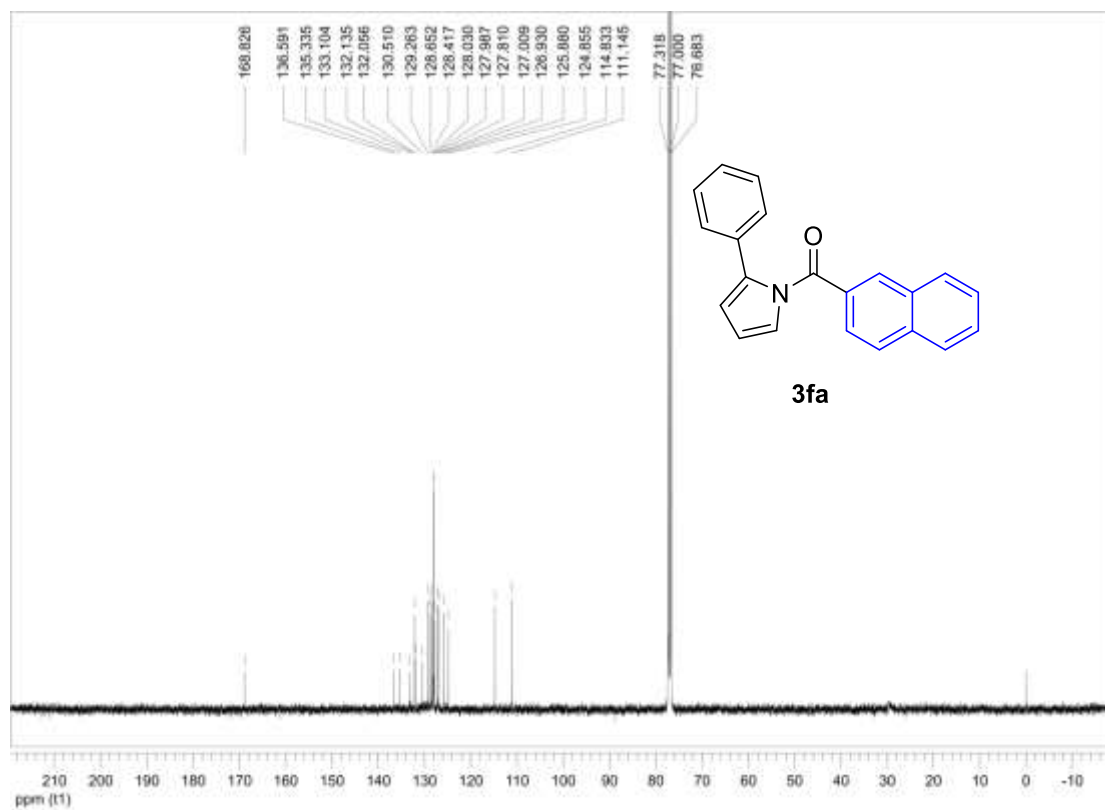
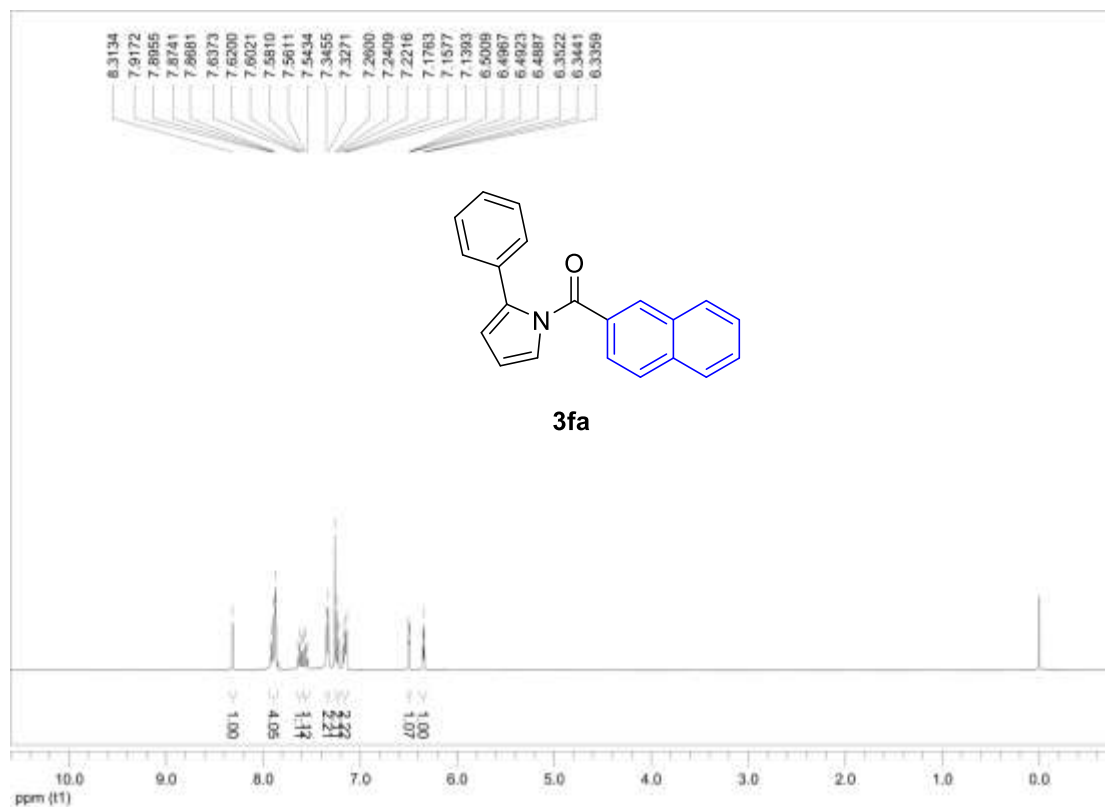




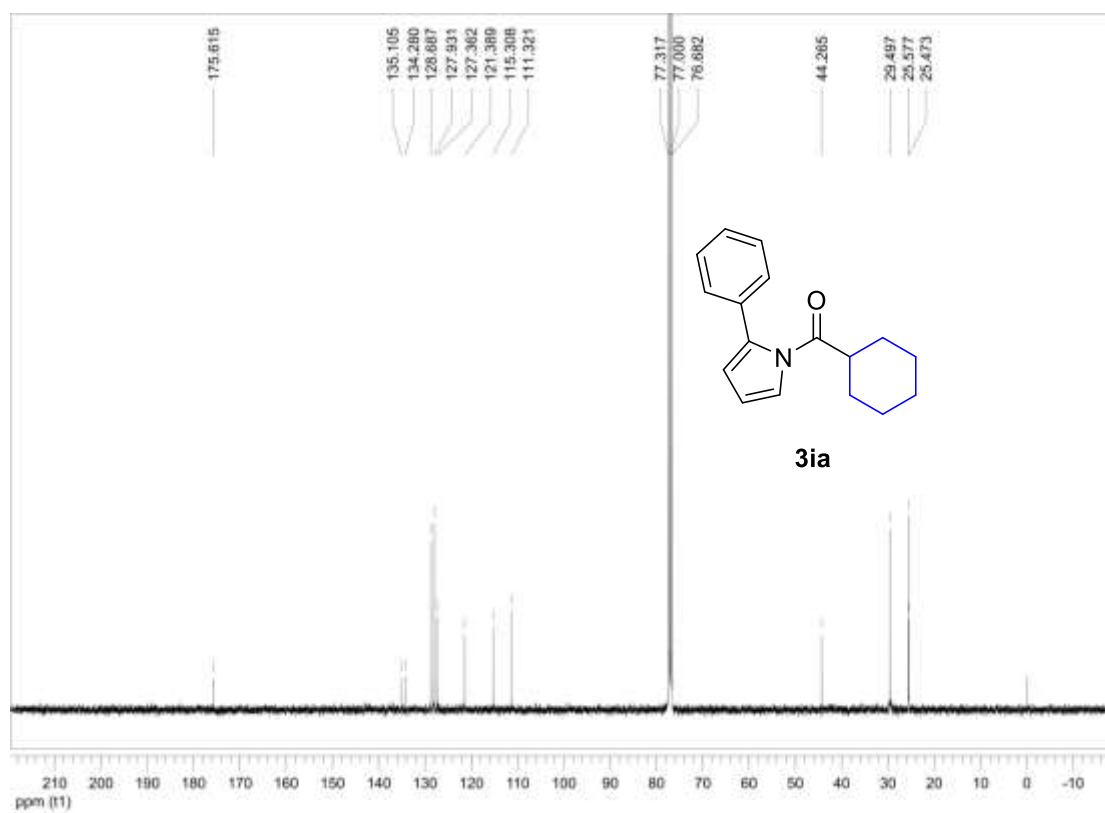
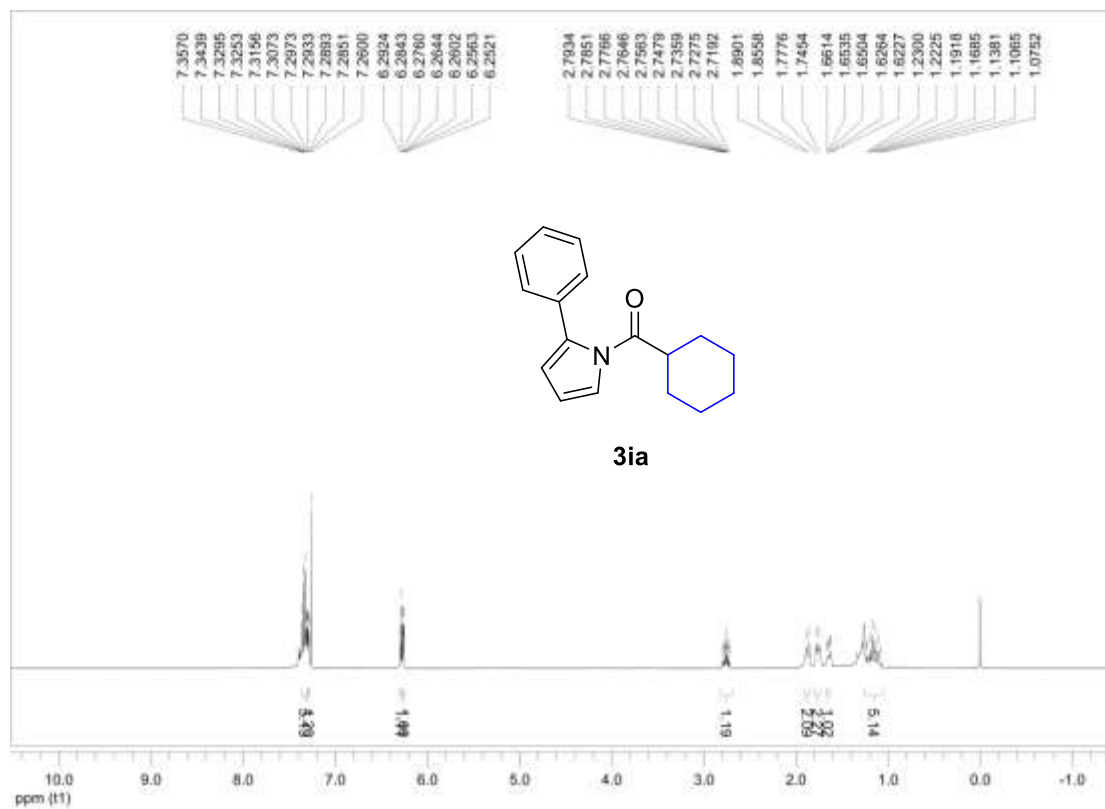
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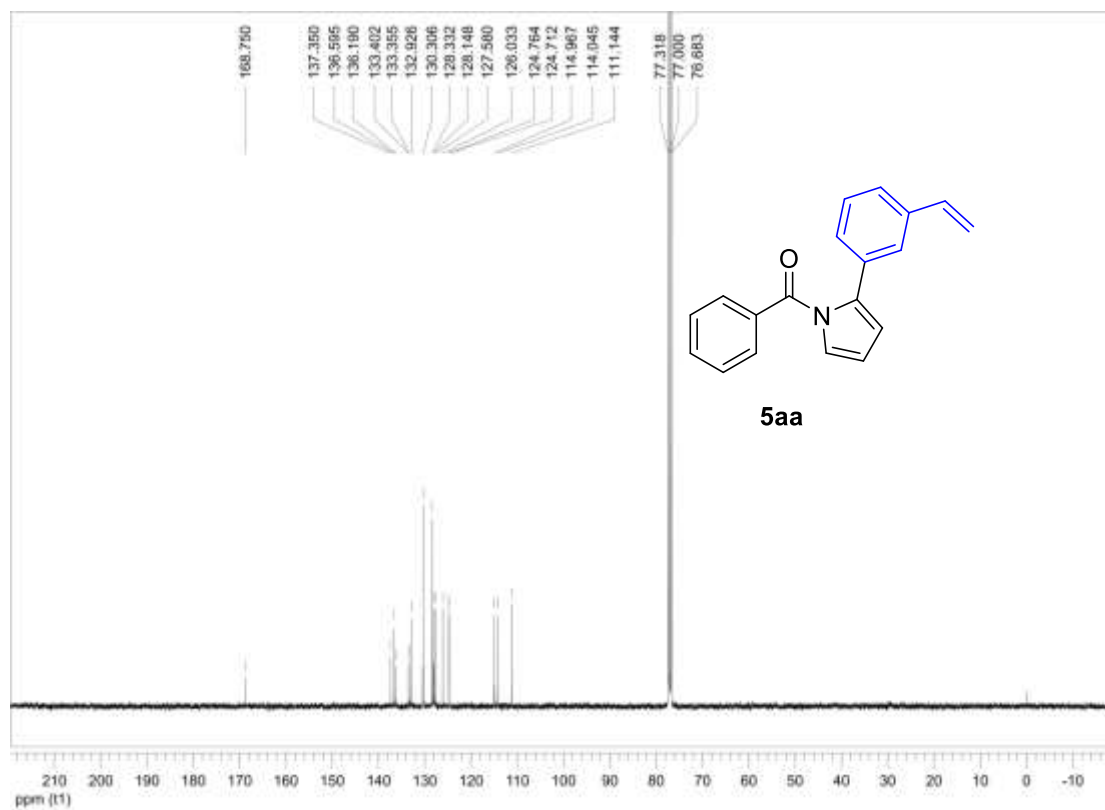
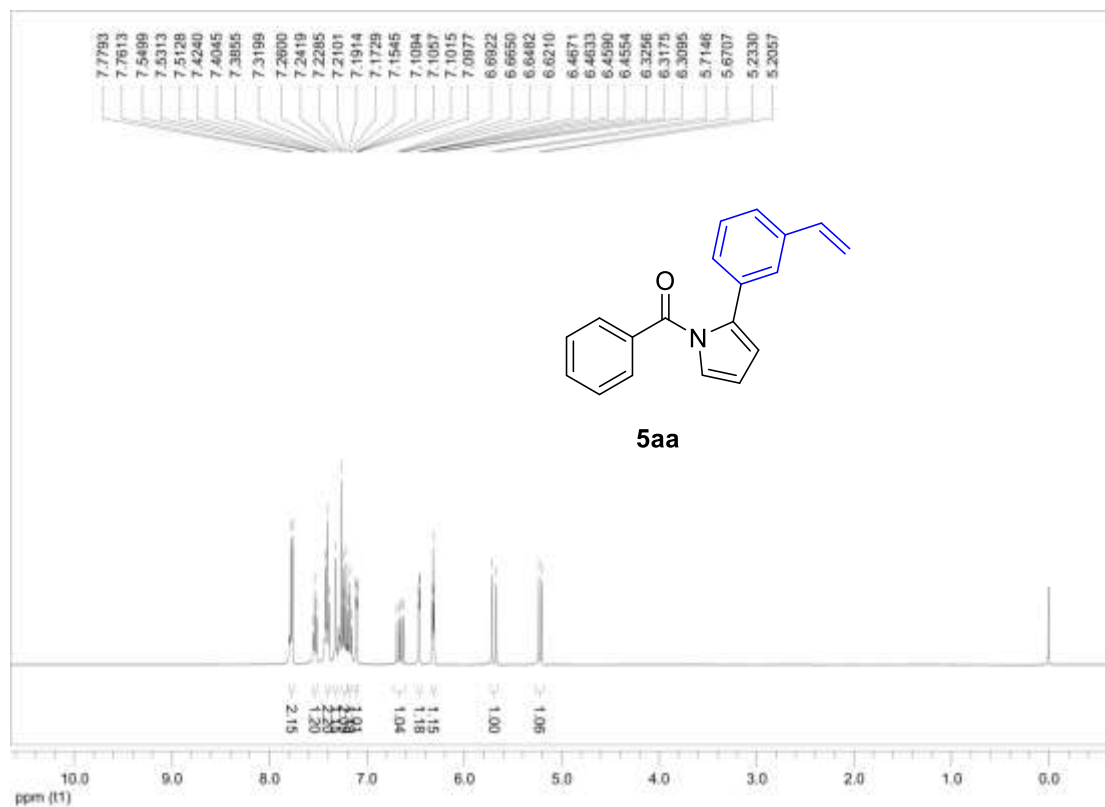
Naphthalen-2-yl(2-phenyl-1H-pyrrol-1-yl)methanone (3fa)



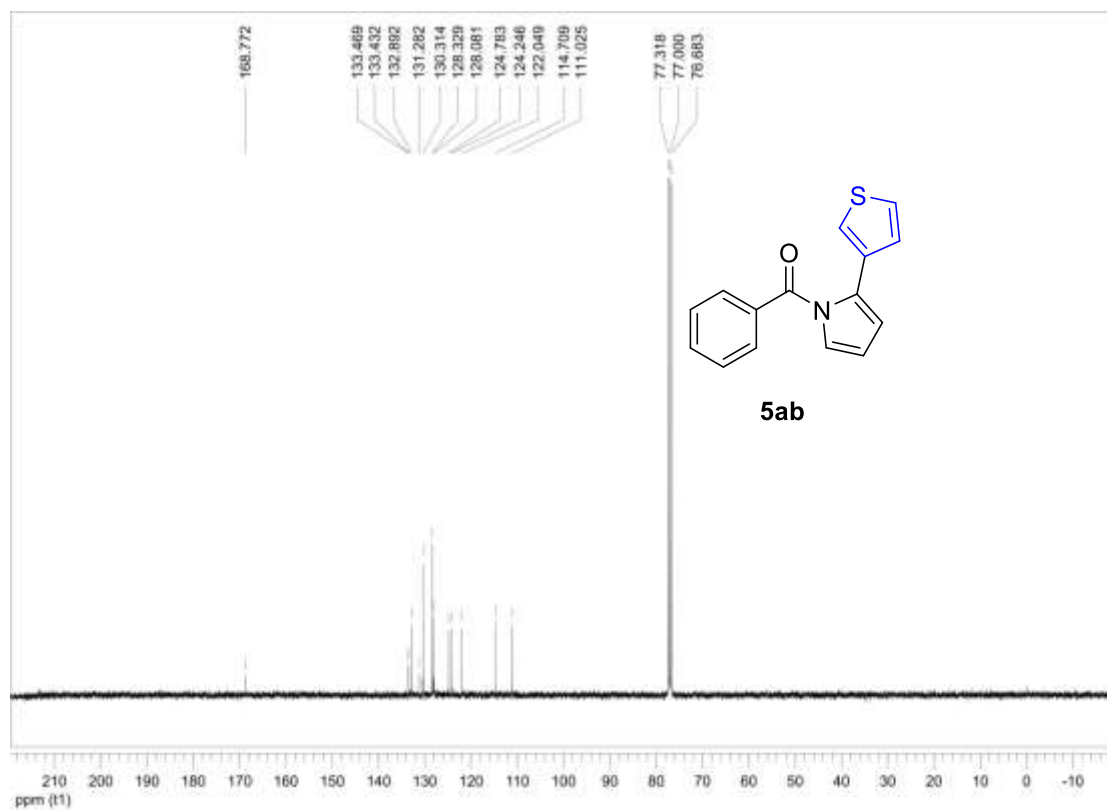
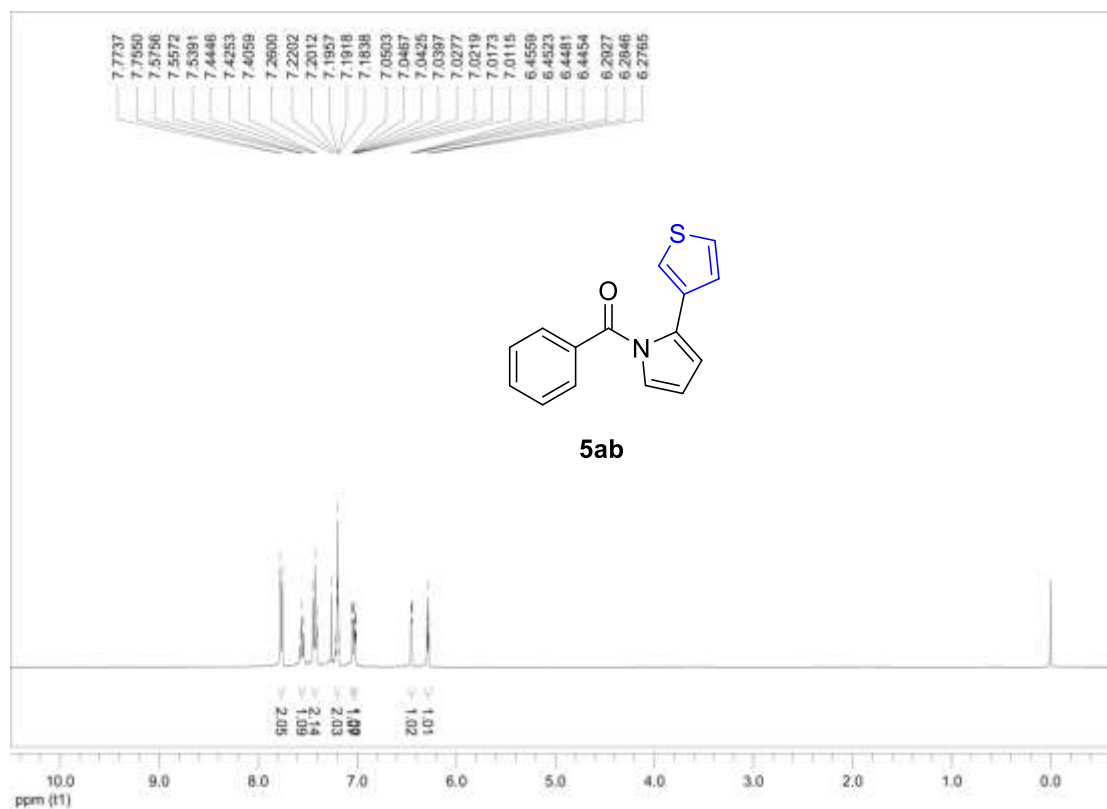
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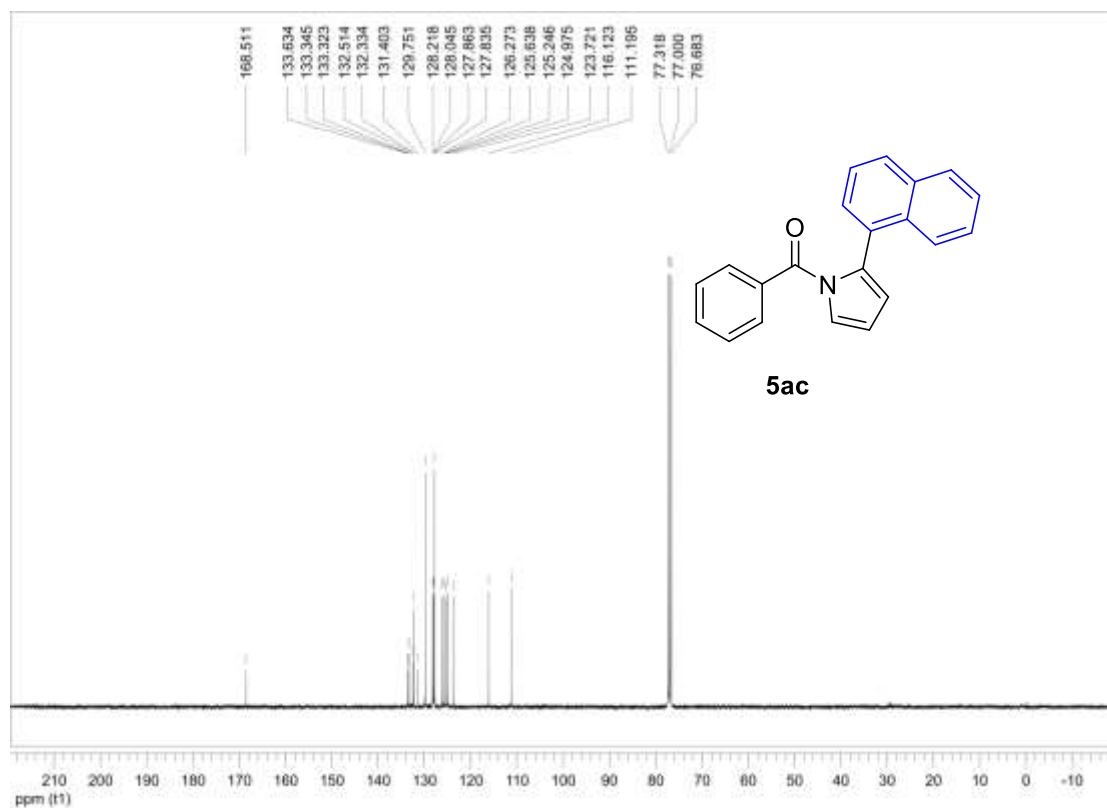
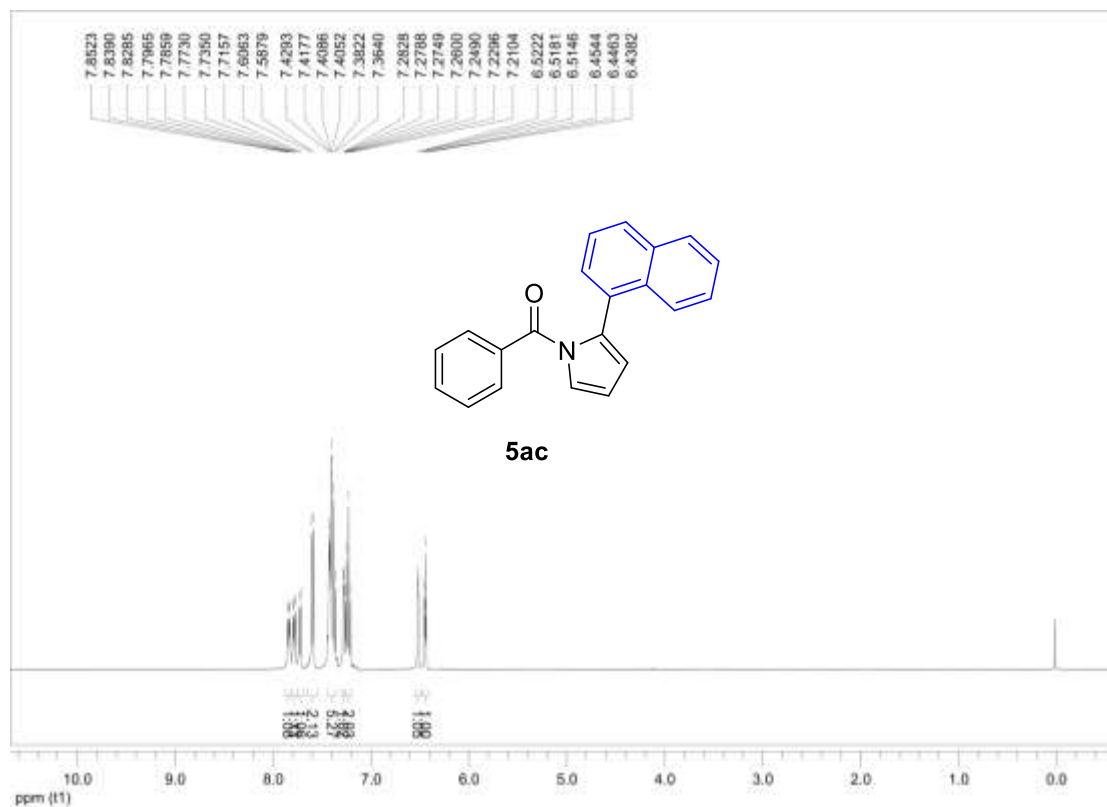
Phenyl(2-(3-vinylphenyl)-1H-pyrrol-1-yl)methanone (5aa)



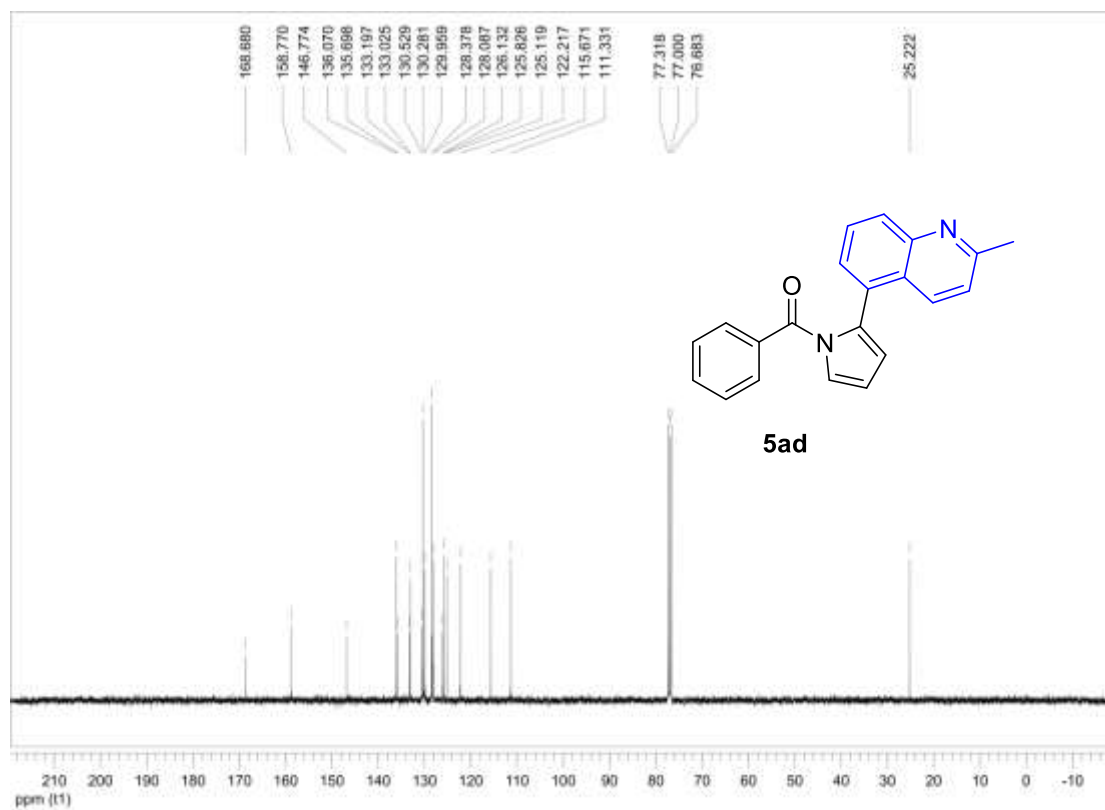
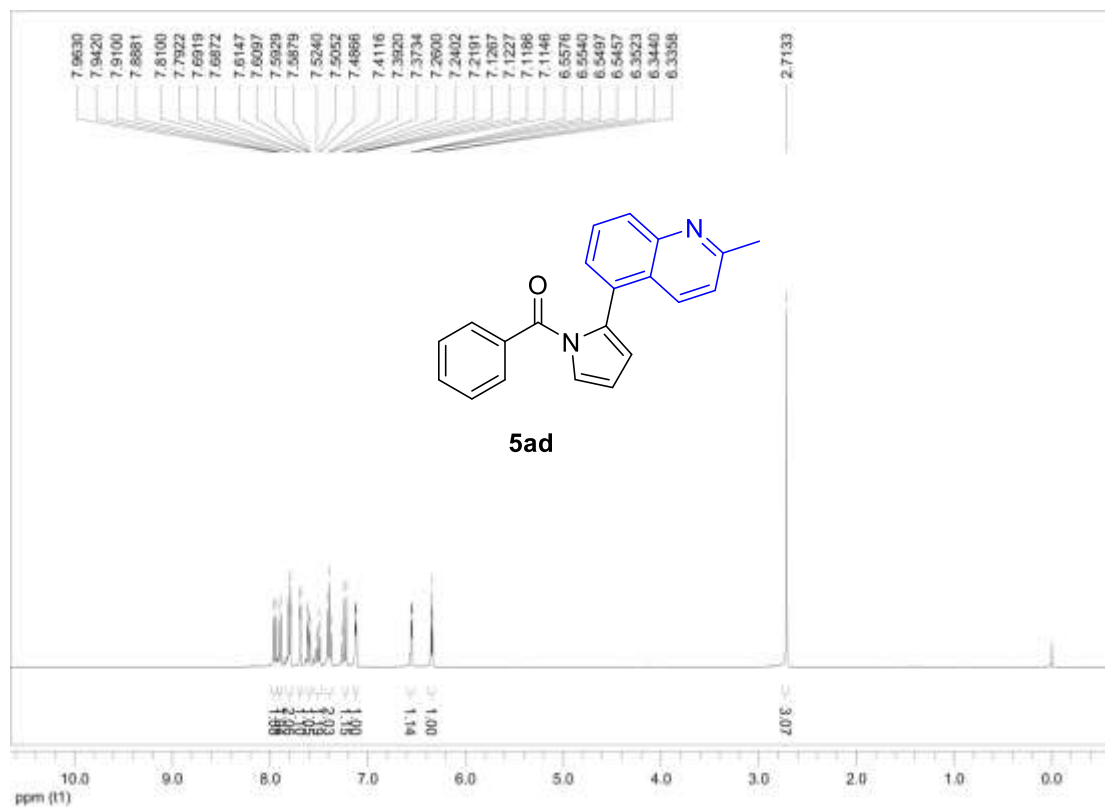
Phenyl(2-(thiophen-3-yl)-1H-pyrrol-1-yl)methanone (5ab)



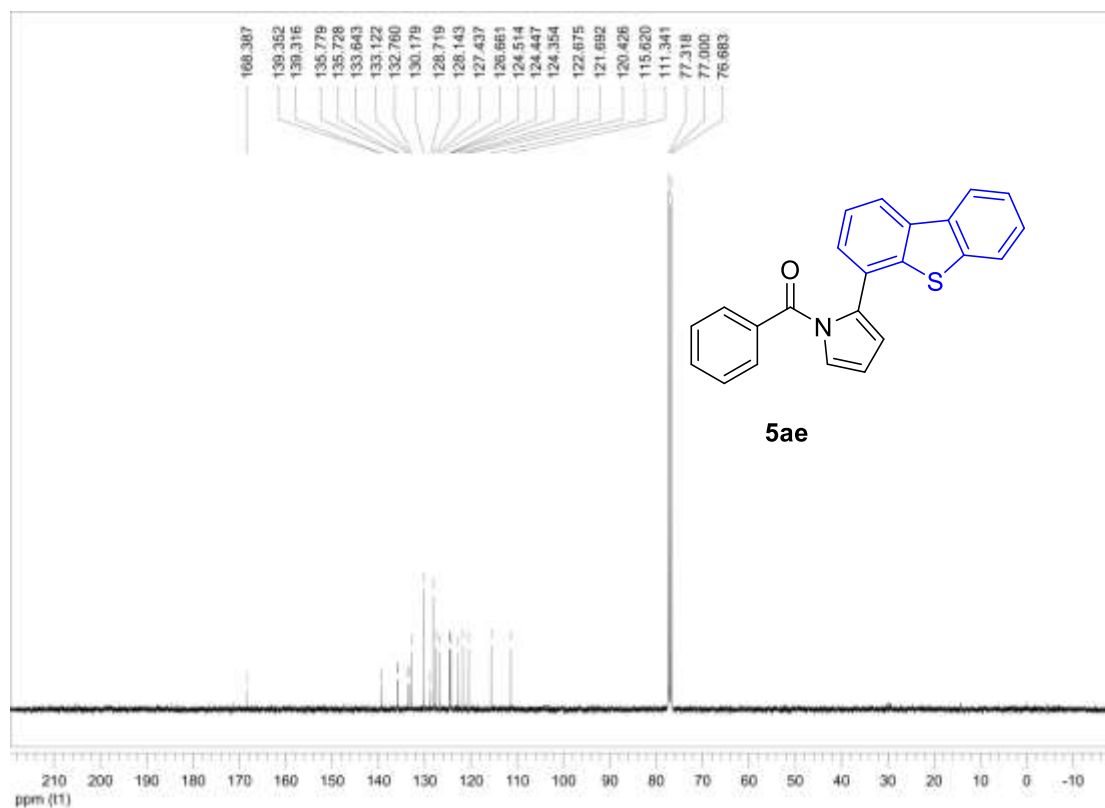
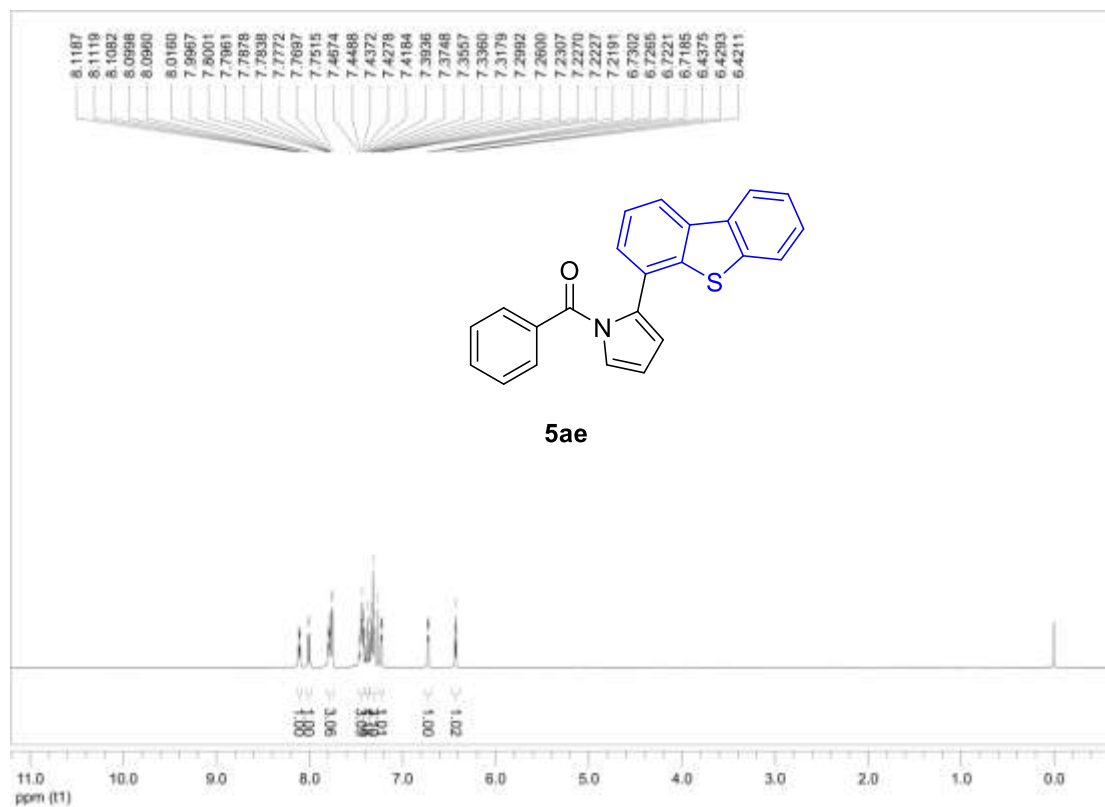
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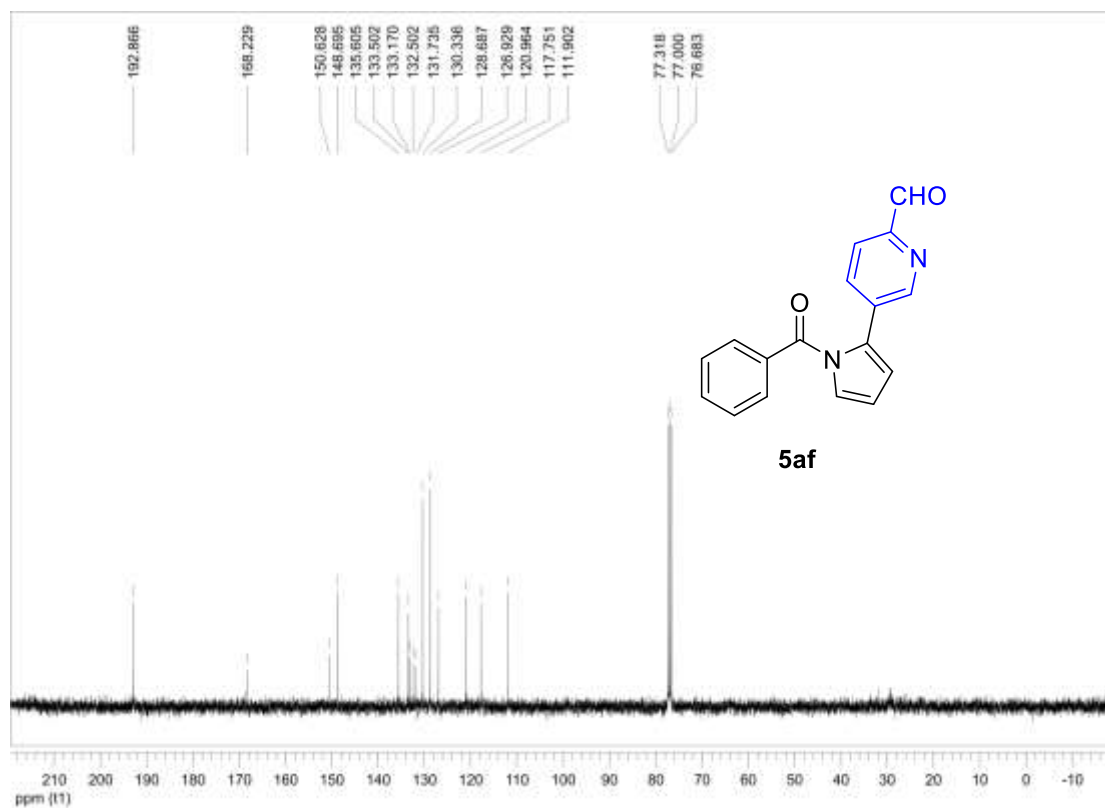
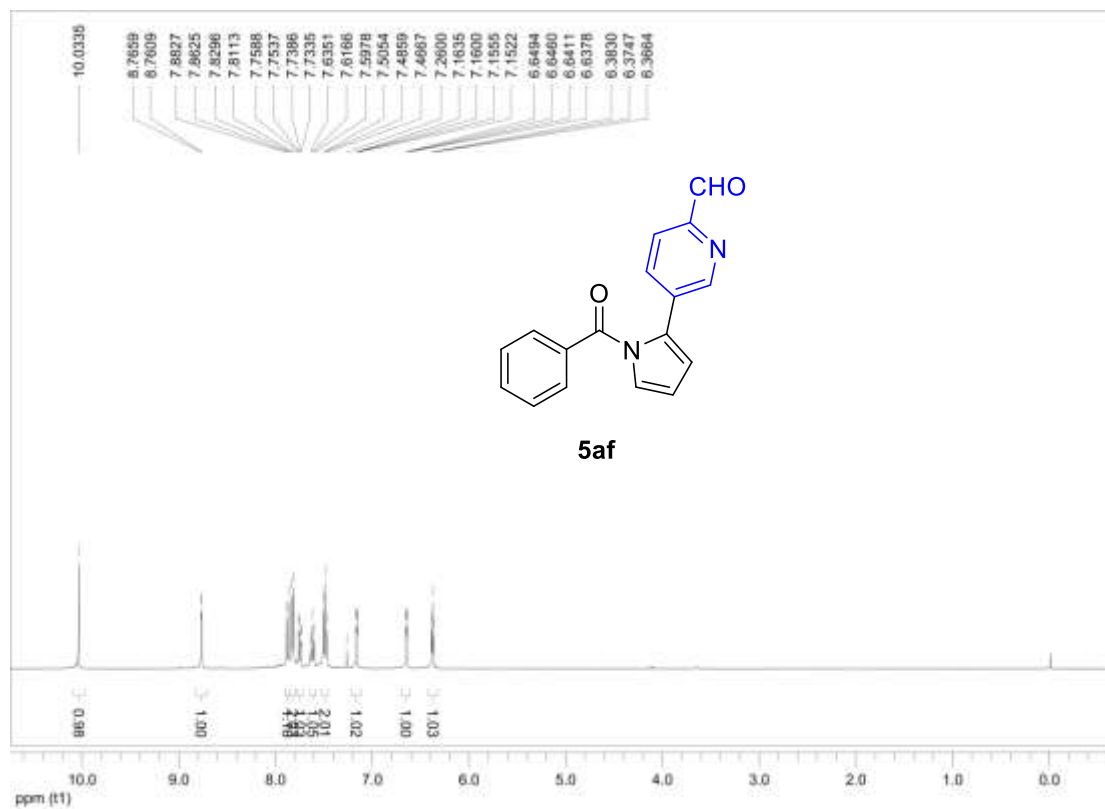
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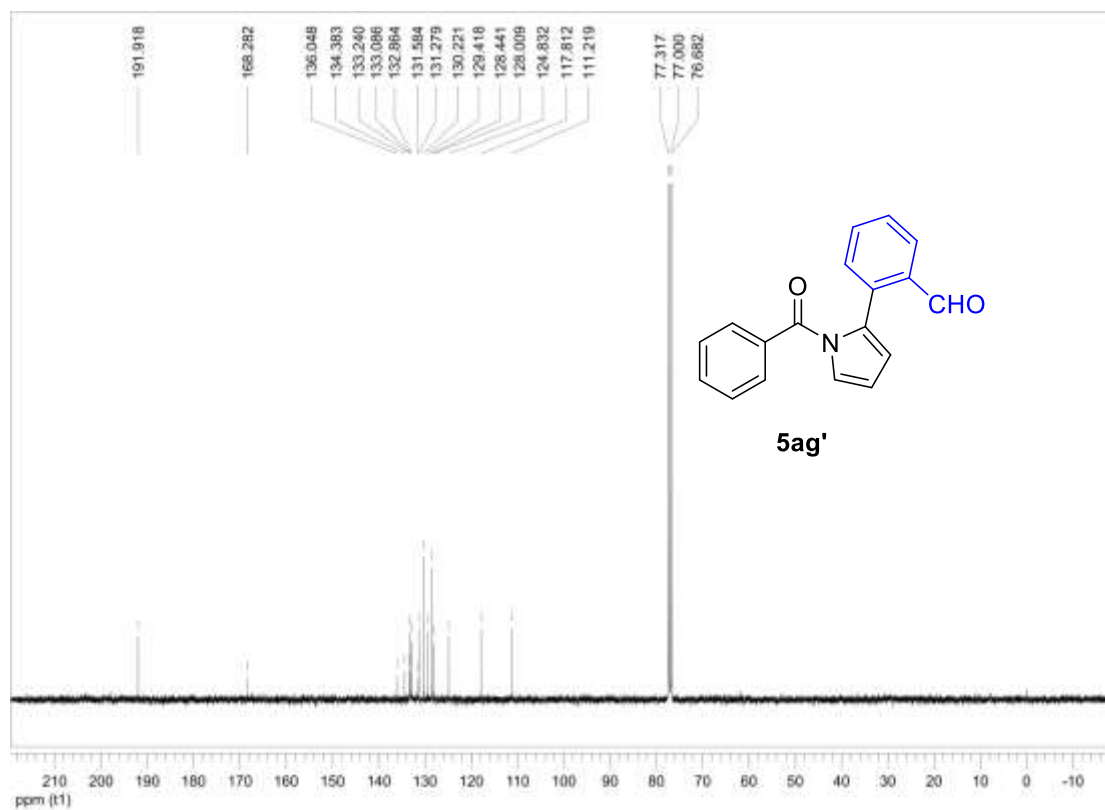
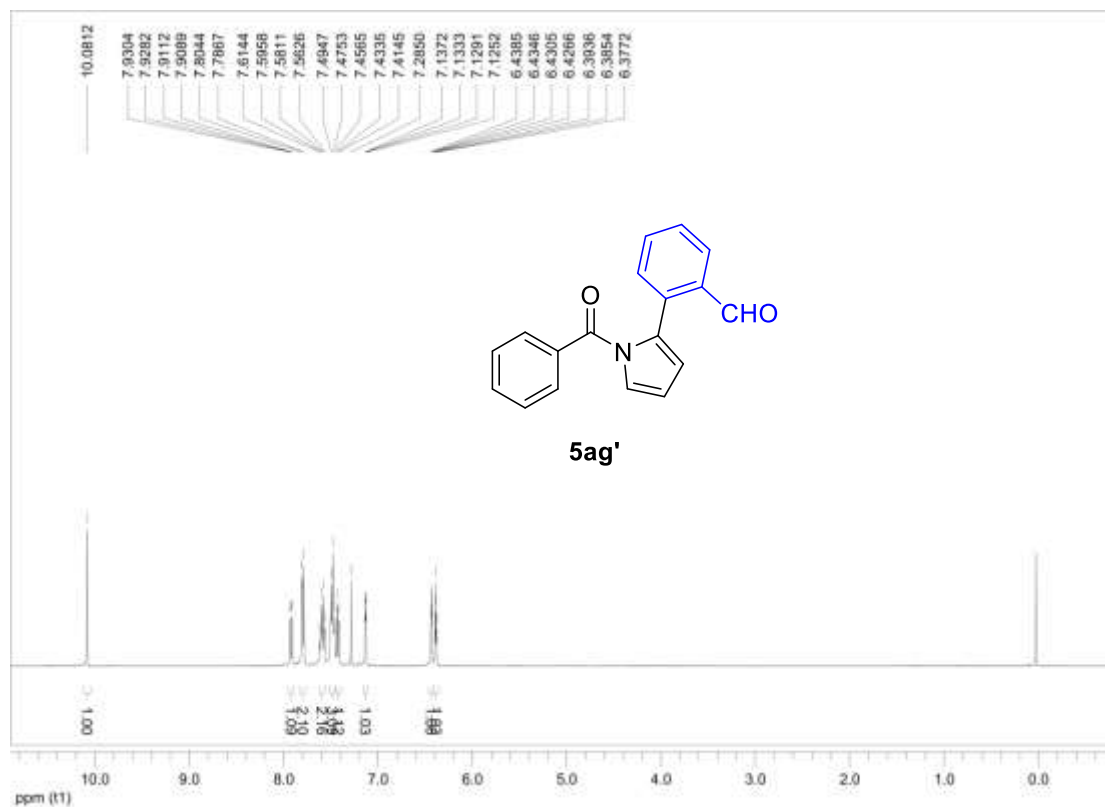
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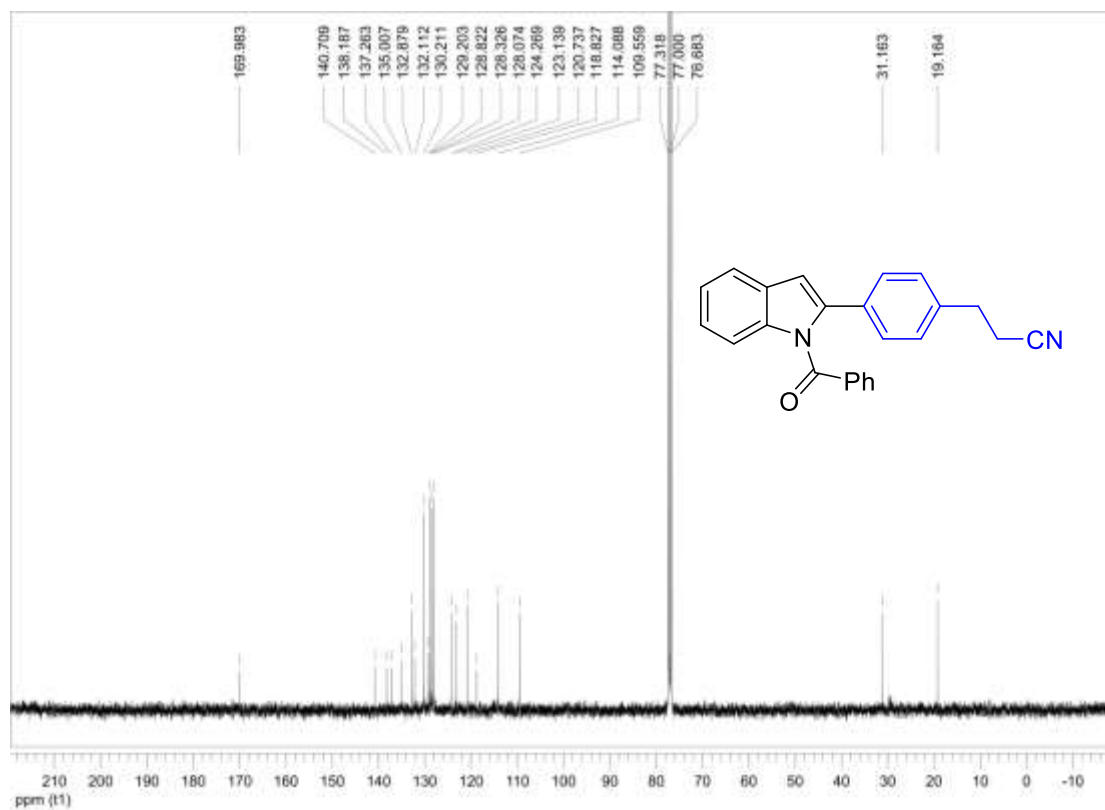
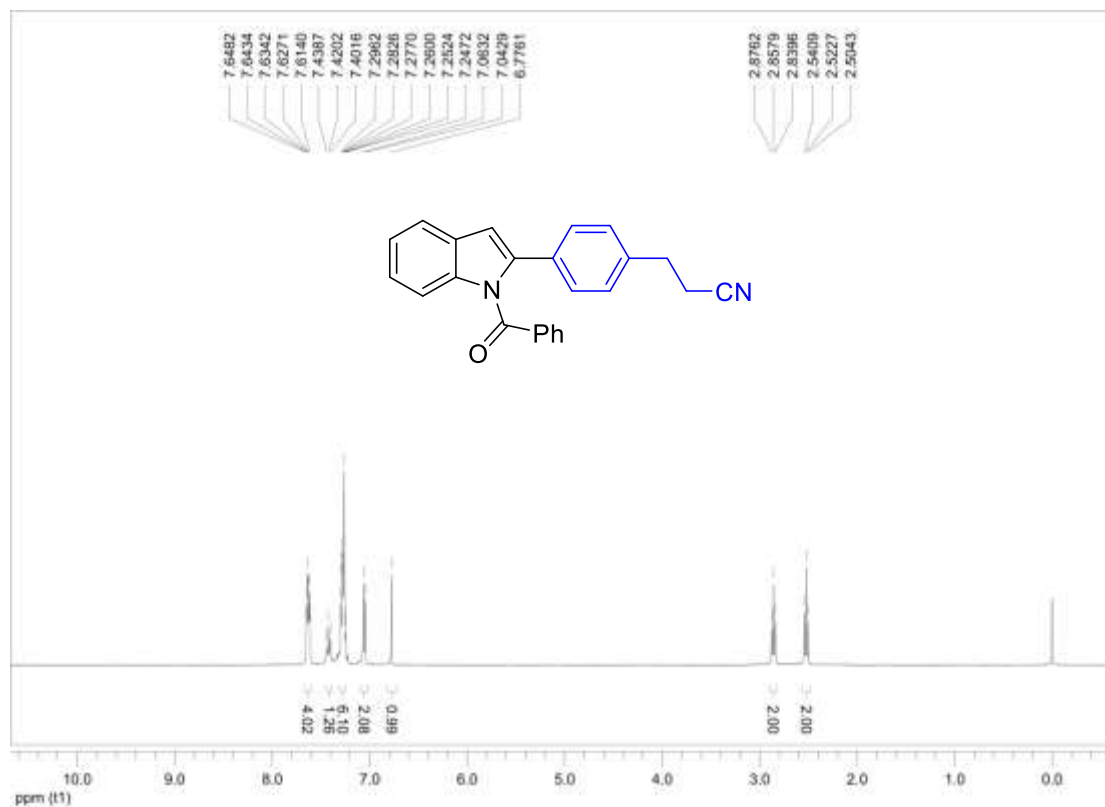
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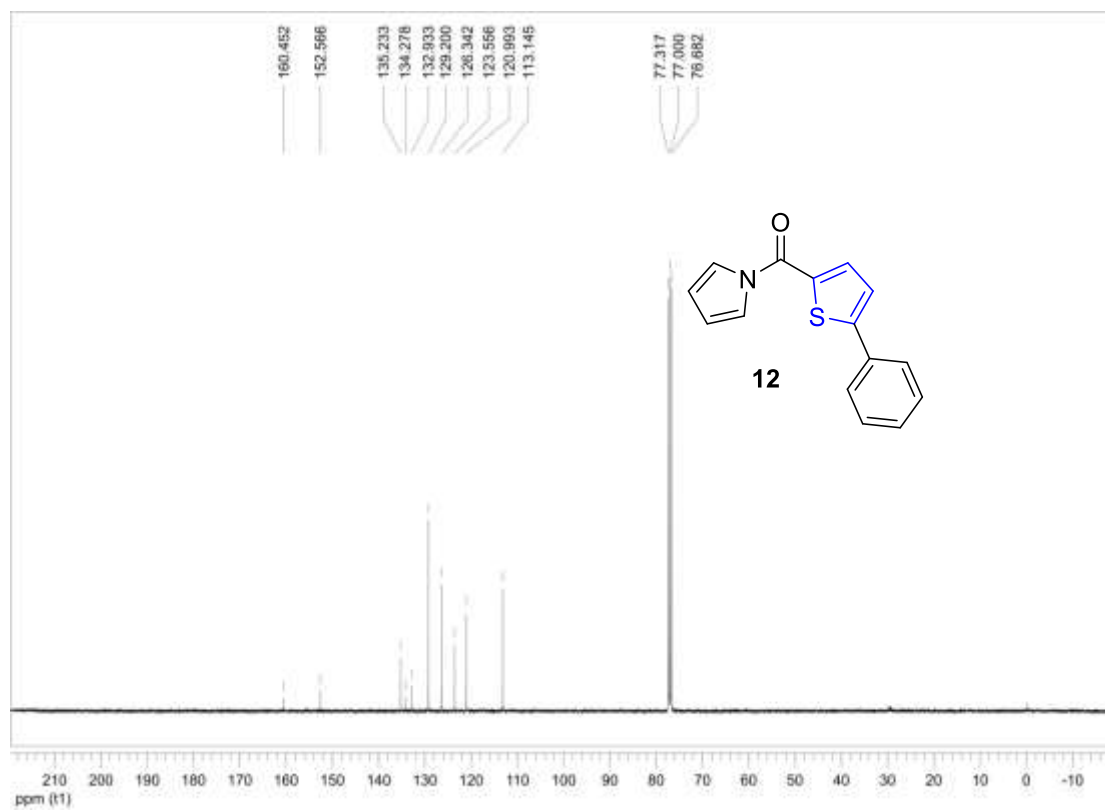
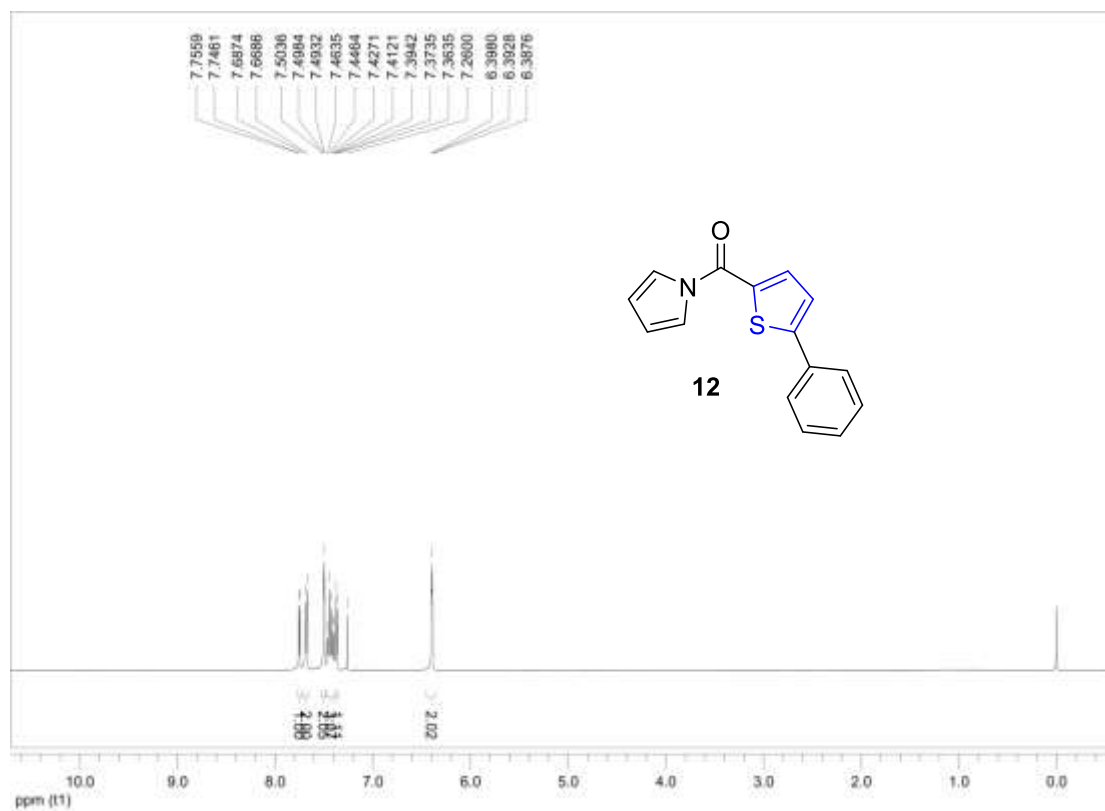
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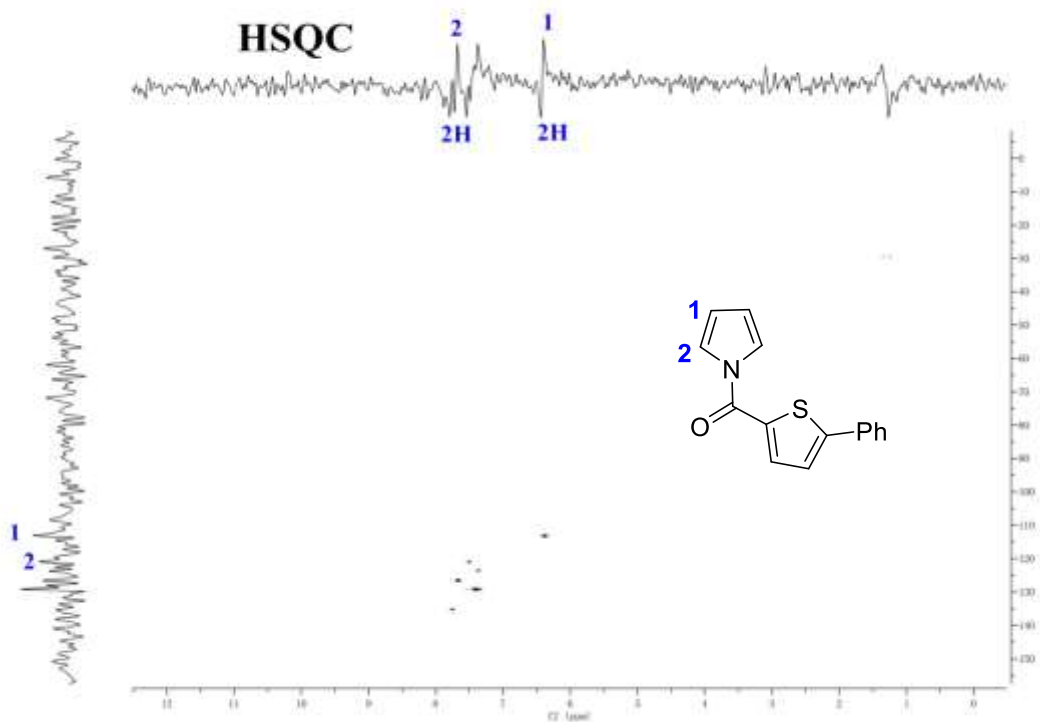
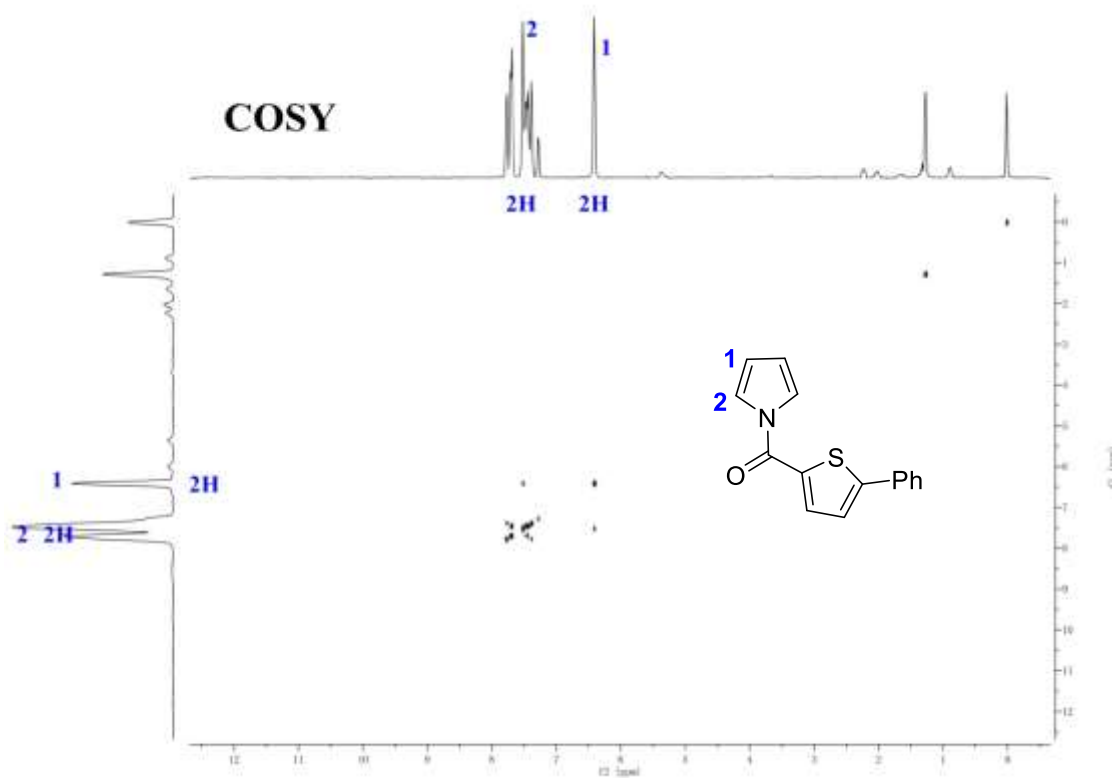


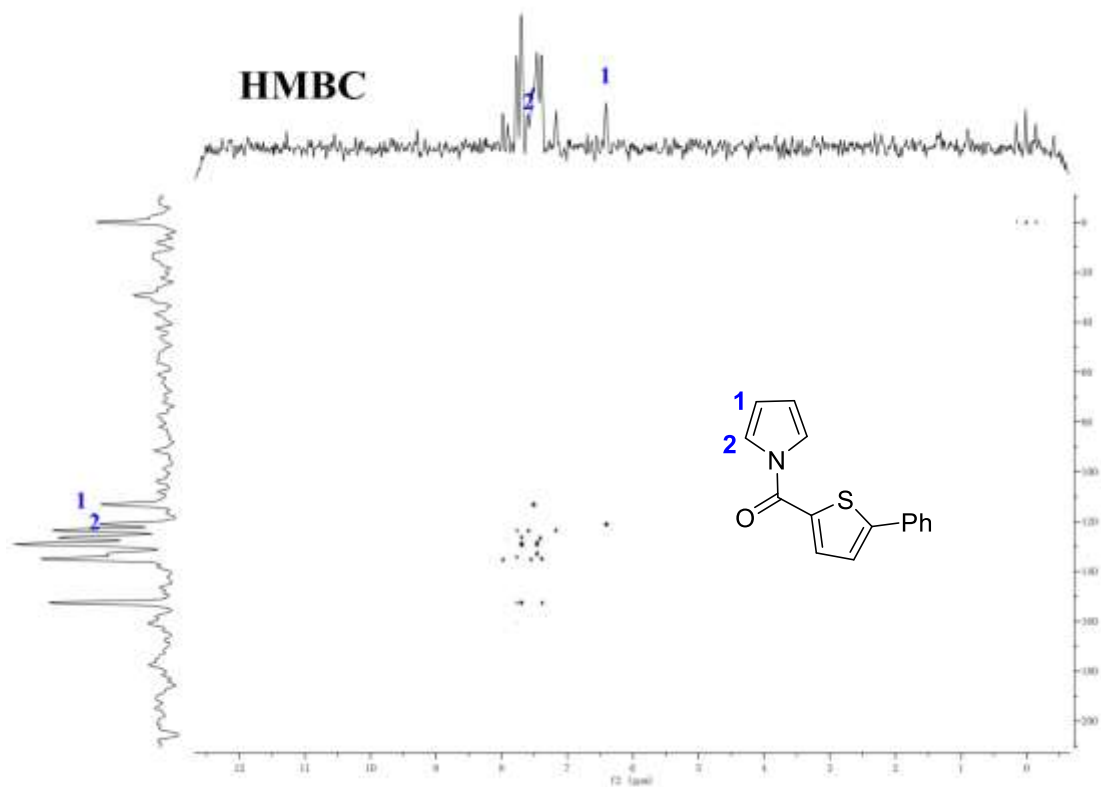
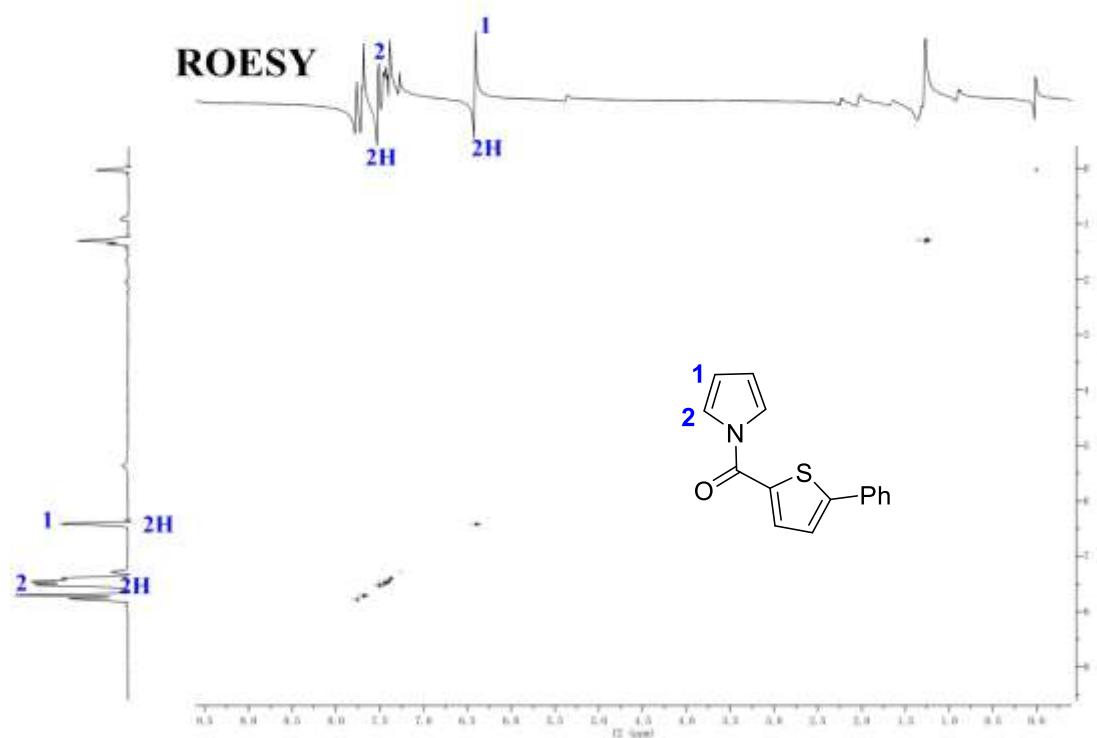
3-(4-(1-benzoyl-1H-indol-2-yl)phenyl)propanenitrile (11)



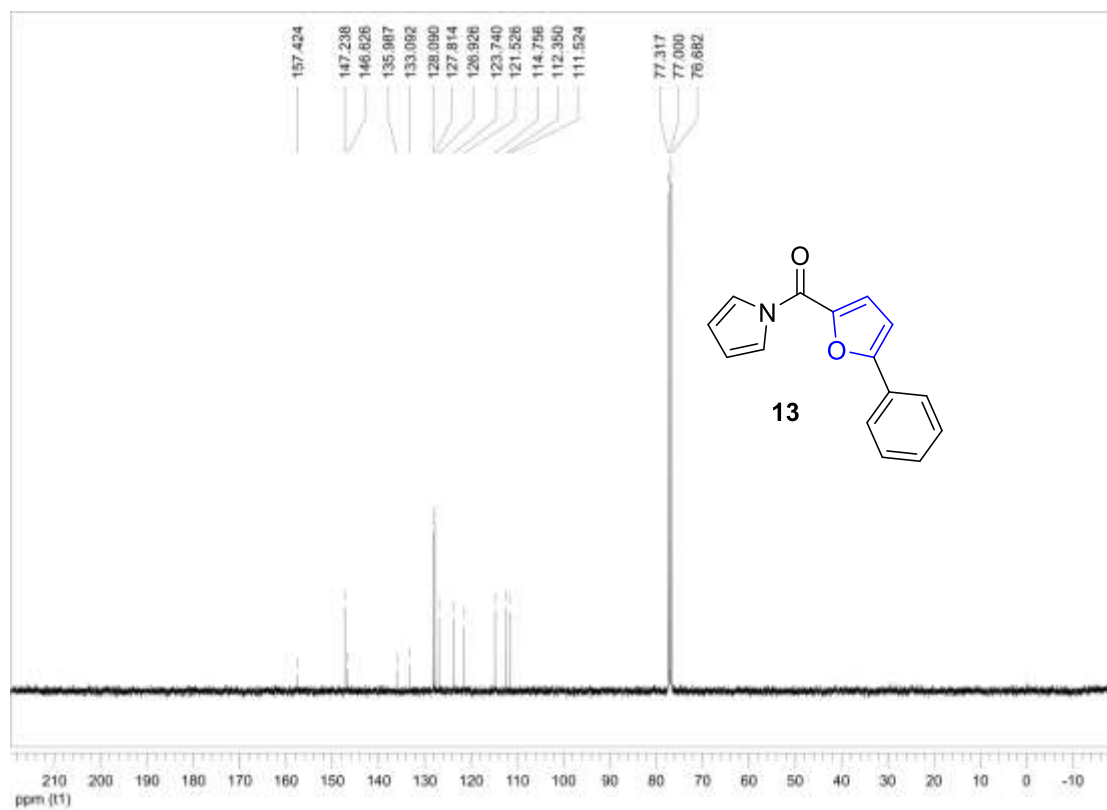
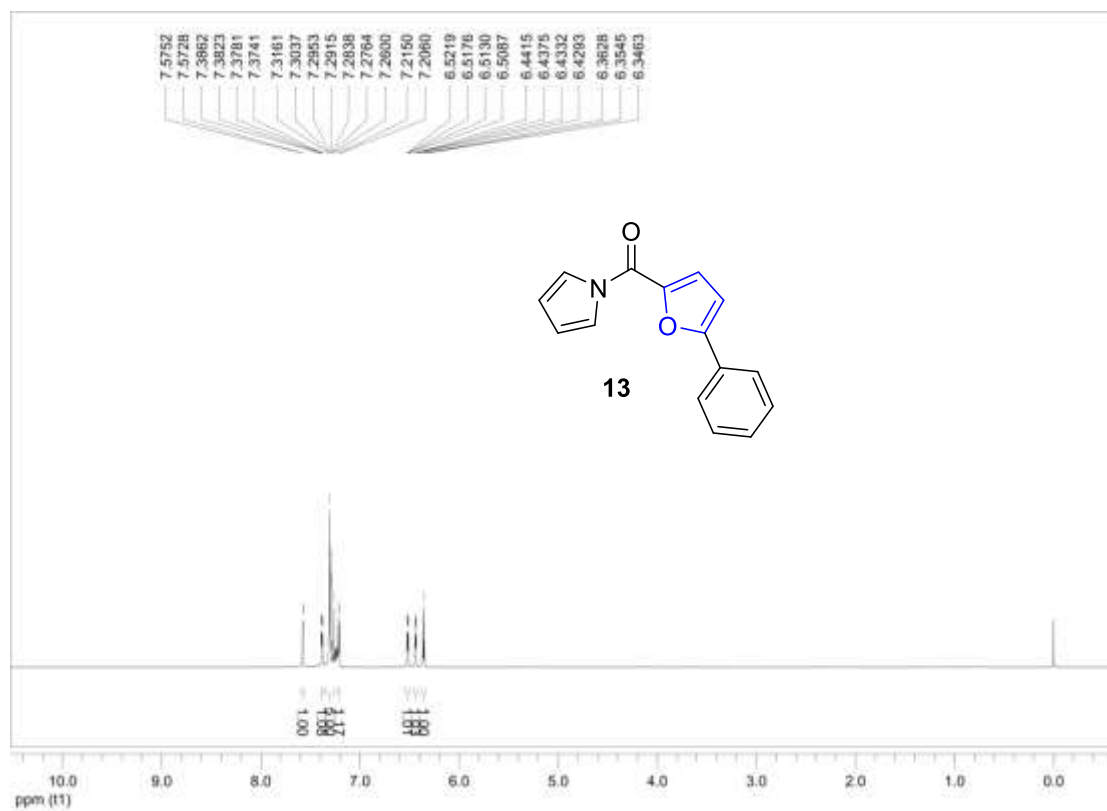
(5-phenylthiophen-2-yl)(1H-pyrrol-1-yl)methanone (12)







(5-phenylfuran-2-yl)(1H-pyrrol-1-yl)methanone (13)



1-Benzyl-2-phenyl-1H-pyrrole (15)

