Supporting Information

Palladium installed copper-organic framework for C-C coupling reactions

Yu-Mei Wang[1], Mei-Xia Tao[1], Kai-Ming Mo[1], Xu Chen[1], Shu-Hua Zhong[1], Elena S Shubina[2], Guo-Hong Ning[1*] and Dan Li[1]

[1]College of Chemistry and Materials Science, Guangdong Provincial Key Laboratory of Supramolecular Coordination Chemistry, Jinan University, Guangzhou, Guangdong 510632, China

[2]A. N. Nesmeyanov Institute of Organoelement Compounds, Russian Academy of Sciences, Vavilov Str., 28, 119991 Moscow, Russia

E-mail: guohongning@jnu.edu.cn

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1. General Method

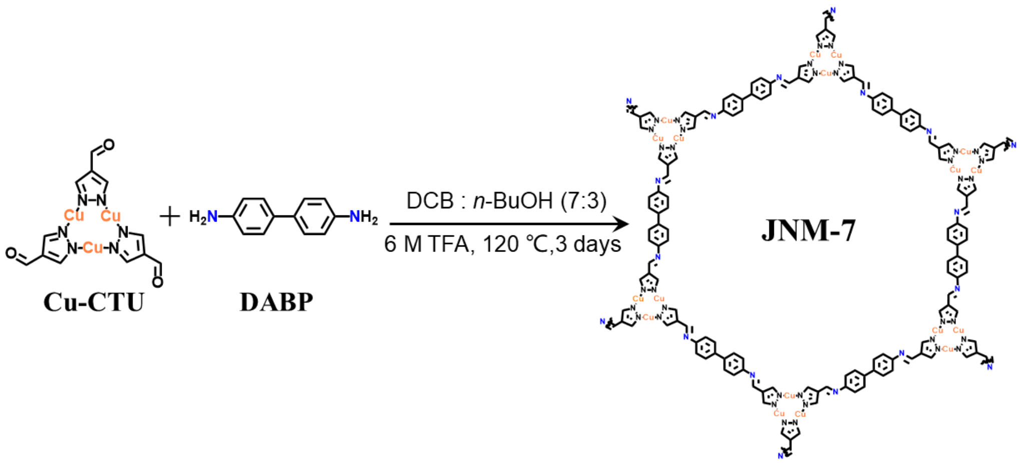
All chemicals and solvents were purchased and used without further purification. Powder X-ray diffraction (PXRD) data was collected at 40 kV, 30 mA using microcrystalline samples on a Rigaku Ultima IV diffractometer using Cu-Kα radiation (λ = 1.5418 Å). The measurement parameters include a scan speed of 0.5 °/min, a step size of 0.02°, and a scan range of 2θ from 1.5 ° to 30 °. Thermogravimetric analysis was performed on a Mettler-Toledo (TGA/DSC1) thermal analyzer. Measurement was made on approximately 5 mg of dried samples under a N_2 flow with a heating rate of 10 ℃/min from 40 ℃ to 800 ℃. The samples were outgassed at 100 ℃ for 8 h before the measurements. Surface areas were calculated from the adsorption data using Brunauer-Emmett-Teller (BET) methods. The pore size distribution curves were obtained from the adsorption branches using the density functional theory (DFT) method. The scanning electron microscopy (SEM) images and Energy Dispersive X-ray Spectroscopy (EDS) were obtained on a JEOLJSM7600F microscope, operating at an acceleration voltage of 5 kV and magnification is 2000. Fourier transform infrared (FT-IR) spectrum was measured using a Nicolet Avatar 360 FT-IR spectrophotometer. X-ray photoelectron (XPS) spectroscopy spectra were performed by a Thermo ESCALAB 250XI system. GC-MS analysis was carried out on an Agilent 7890B GC analyzer. X-ray photoelectron (XPS) spectroscopy spectra were performed by a Thermo ESCALAB 250XI system. Liquid ^{1}H and ^{13}C NMR spectra were recorded on a Bruker Biospin Avance (400 MHz) equipment using tetramethylsilane (TMS) as an internal standard. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublet, dt = doublet of triplet, m = multiplet, Flash column chromatography was performed using Merck silica gel 60 with commercially available solvents.

2. Synthesis of JNM-7 and JNM-7-Pd

2.1 Synthesis of Cu-CTU

Cu-CTU was synthesized according to the previously reported method.[1] A mixture of the ligand 1H-pyrazole-4-carbaldehyde (HL) (24.0 mg, 0.25 mmol), Cu_2O (14.3 mg, 0.1 mmol), 4 mL ethanol, and 0.1 mL pyridine was sealed in an 10 mL Pyrex tube, heated in an oven at 120 ℃ for 72 h. The light-yellow needle crystals of Cu-CTU formed were filtered and collected under a microscope manually. The yield of Cu-CTU: 23.7 mg (75.8%, based on Cu_2O). Chemical formula: $C_{12}H_9Cu_3N_6O_3$.

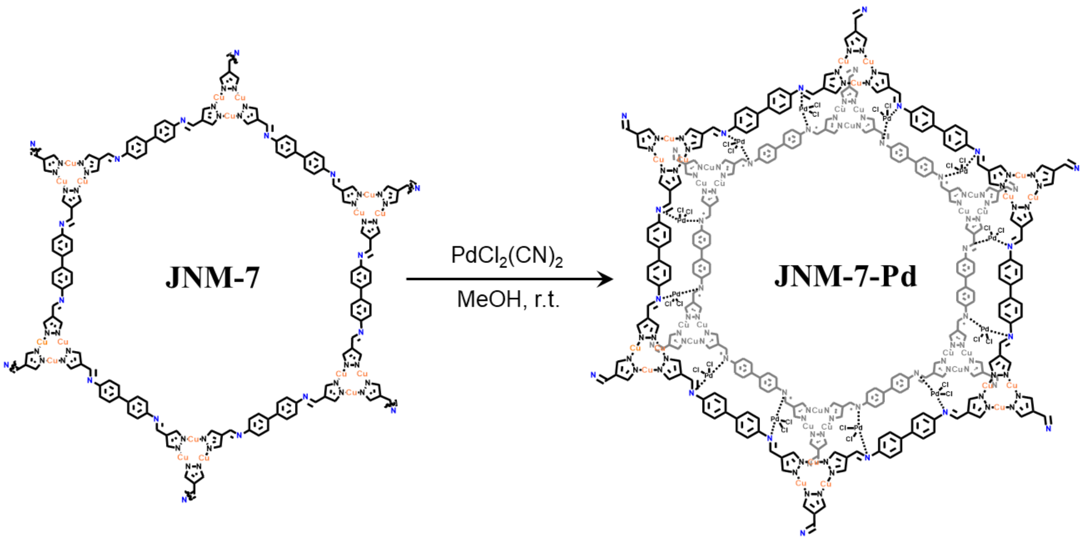
2.2 Synthesis of JNM-7



Scheme S1 Schematic diagram of the synthesis of **JNM-7**.

A 10 mL Schlenk tube was charged with Cu-CTU (23.7 mg, 0.05 mmol), *p*-4,4'-diaminobiphenyl (DABP) (13.8 mg, 0.075 mmol), 0.7 mL of 1,2-dichlorobenzene, 0.3 mL of 1-Butanol, and 0.1 mL of 6 M trifluoroacetic acid. Schlenk tube containing was flash-frozen at 77 K in a liquid nitrogen bath and degassed with three freeze-pump-thaw cycles. Upon warming to room temperature, tube was heated at 120 ℃ for 72 h. The brown solid from each tube was isolated by filtration, washed, and solvent exchanged with methanol. The resultant solids were dried under vacuum at 100 ℃ for 8 h to give **JNM-7** as brown powders. Yield: 21.5 mg (70.6% based on Cu).

2.3 Synthesis of JNM-7-Pd



Scheme S2 Schematic diagram of the synthesis of **JNM-7-Pd**.

JNM-7-Pd was synthesised using a solution impregnation method: 10 mg of $PdCl_2(CN)_2$ (0.04 mmol) was dissolved ultrasonically in 5 mL of methanol, then 40 mg of JNM-7 was added to the solution and the mixture was stirred for 12 h at room temperature. The solid was collected by filtration and washed three times with methanol, and then dried under vacuum at 100 °C for 10 h. The brown powder obtained was **JNM-7-Pd**.

3. Characterization of JNM-7 and JNM-7-Pd

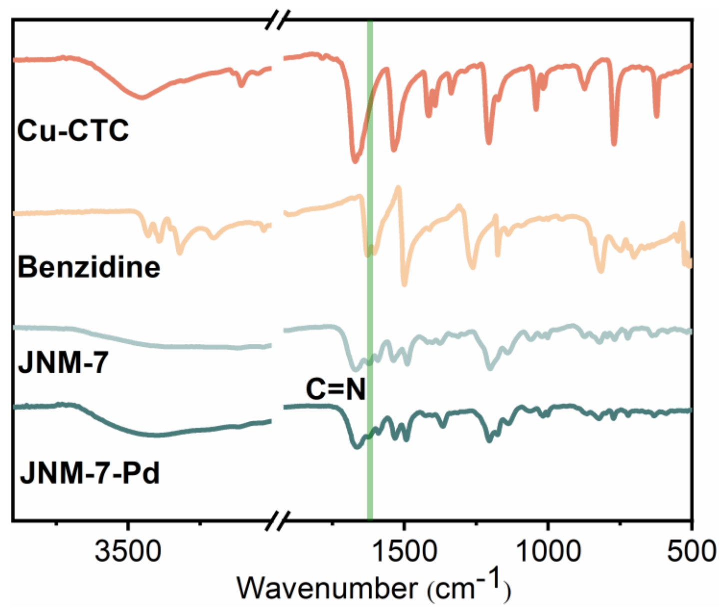


Figure S1 FTIR spectra of **JNM-7-Pd** and **JNM-7**.

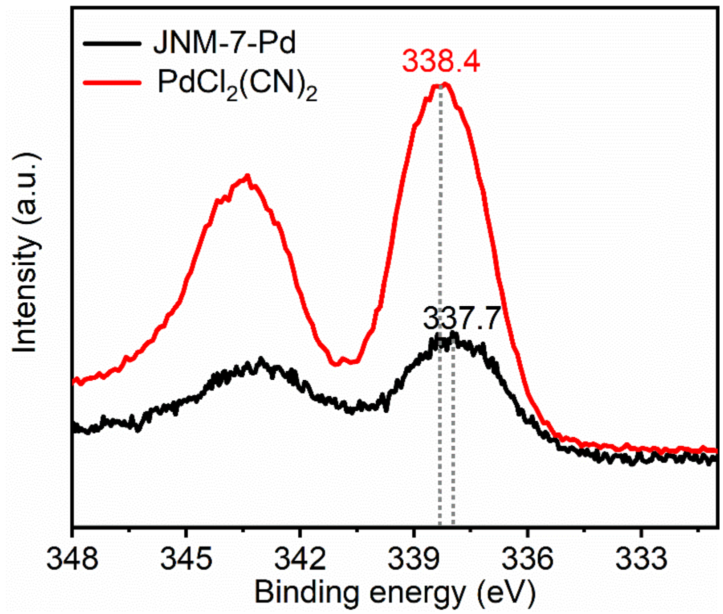


Figure S2 XPS spectra of free $PdCl_2(CN)_2$ (red) and **JNM-7-Pd**(black).

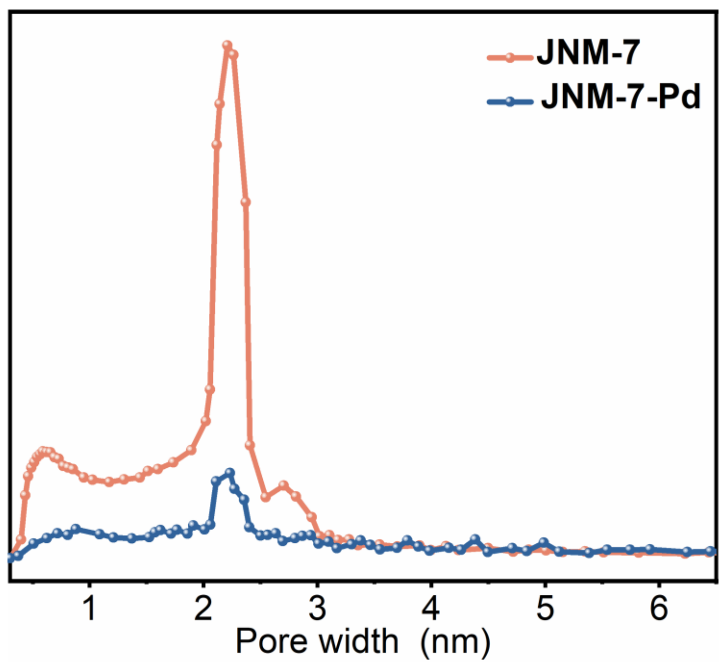


Figure S3 The pore size distribution of **JNM-7** and **JNM-7-Pd**.

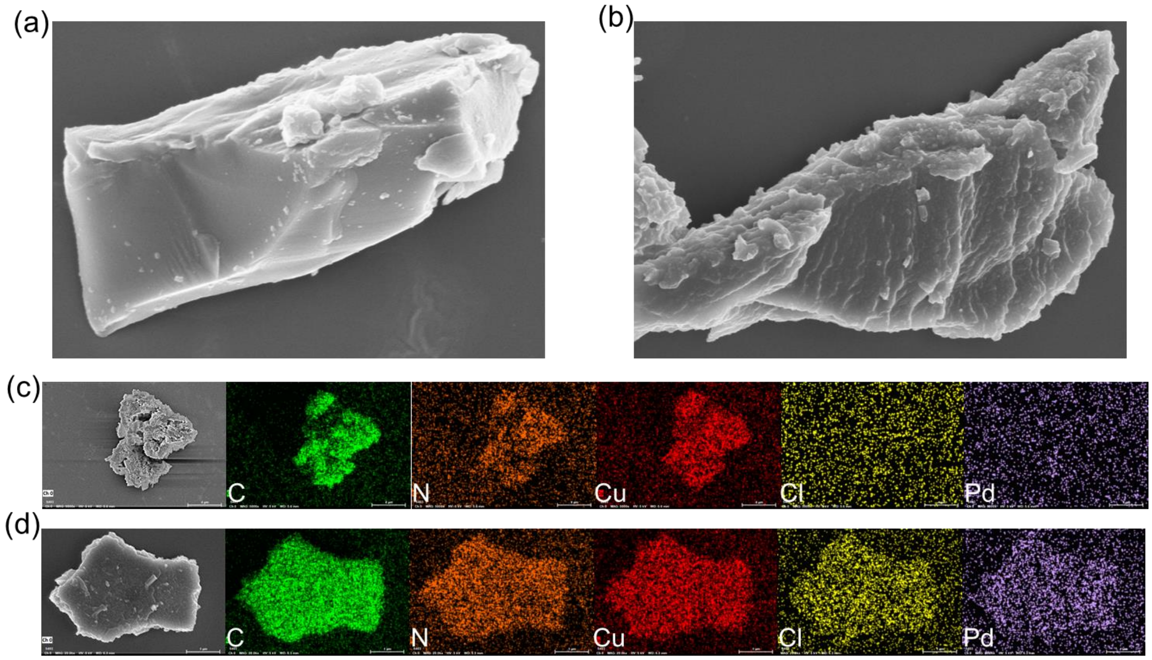


Figure S4 The SEM image of (a) **JNM-7** and (b) **JNM-7-Pd**. and EDS mapping of (c) **JNM-7** and (d) **JNM-7-Pd**

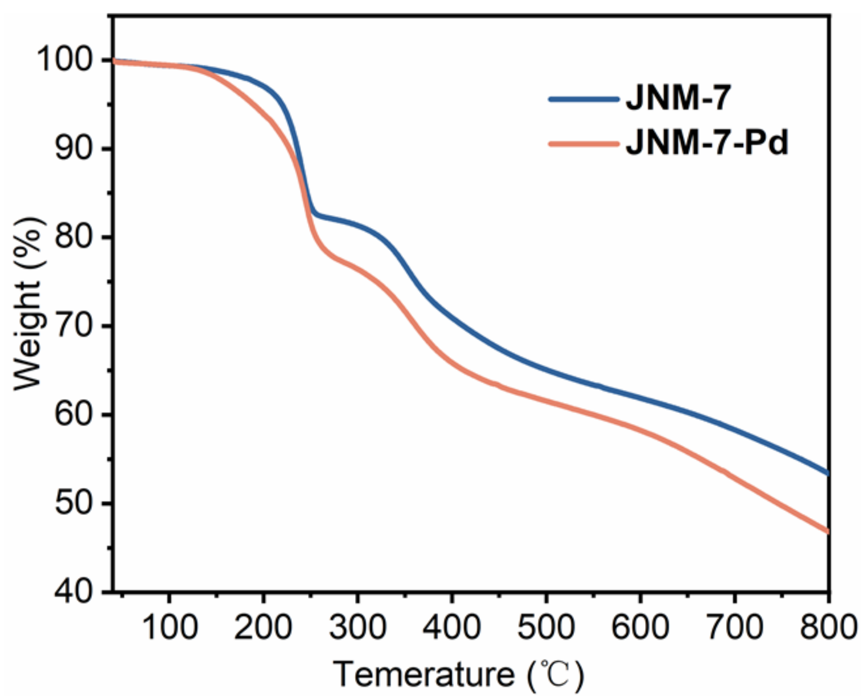
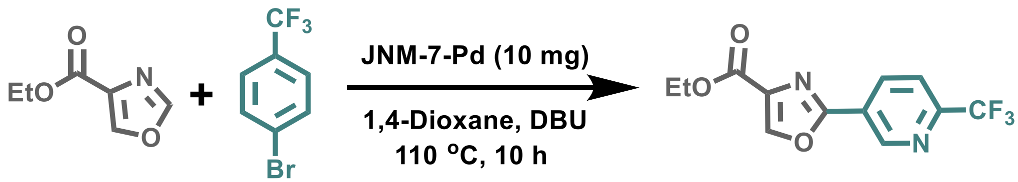


Figure S5 TGA curve of **JNM-7-Pd** and **JNM-7** under N_2 atmosphere.

4. The C-H arylation of indazole and aryl bromide



Scheme S3. General procedure for C-H arylation of indazole and aryl bromide

General procedures for C-H arylation of indazole and aryl bromide by JNM-7-Pd: 2-Trifluoromethyl-5-bromopyridine (0.7 mmol, 158 mg), Ethyl oxazole-4-carboxylate (0.77 mmol, 109 mg) **JNM-7-Pd** (10 mg) were weighed in a Schlenk tube and DBU (1.4 mmol, 209 µL) and 2 mL of 1,4 dioxane was added. The contained Schlenk tubes were snap-frozen in a liquid nitrogen bath at 77 K and degassed by three freeze-pump-thaw cycles. This was followed by a reaction at 110 °C for 10 hours. At the end of the reaction three extractions with water and ethyl acetate were performed. The organic layer was then concentrated under reduced pressure and the resulting crude reaction mixture was purified by silica gel column chromatography. The subsequent experimental process was same as the previous reaction.

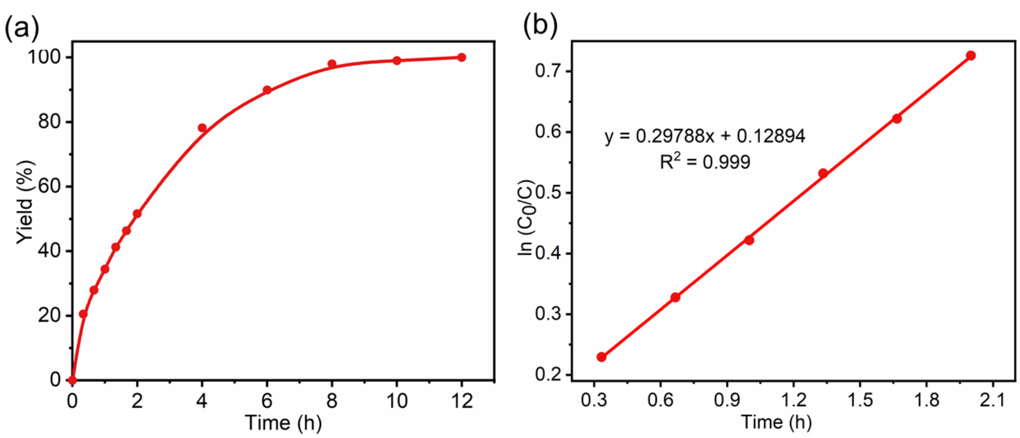
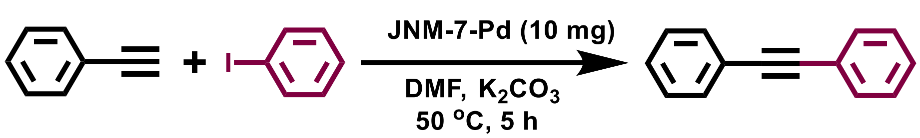


Figure S6 (a) Yields recorded at different reaction times. (b) Kinetic curve (ln(C_0/C) vs. t) of template reaction for C-H arylation reaction.

5. The Sonogashira cross-coupling reaction.



Scheme S4. General procedure for the Sonogashira cross-coupling reaction

General procedure for the Sonogashira cross-coupling reaction by JNM-7-Pd: Phenylacetylene (0.5 mmol, 55 μL), iodobenzene (0.6 mmol, 67 μL), K_2CO_3 (1.0 mmol, 138 mg), **JNM-7-Pd** (10 mg), and 2 mL of DMF were taken in a Schlenk vial. The contained Schlenk tubes were snap-frozen in a liquid nitrogen bath at 77 K and degassed by three freeze-pump-thaw cycles. The reaction was then carried out at 50 °C Celsius for 5 hours. At the end of the reaction three extractions with water and ethyl acetate were performed. The organic layer was then concentrated under reduced pressure and the crude reaction mixture obtained was purified by silica gel column chromatography. The same experimental procedure was used for the other substrates.

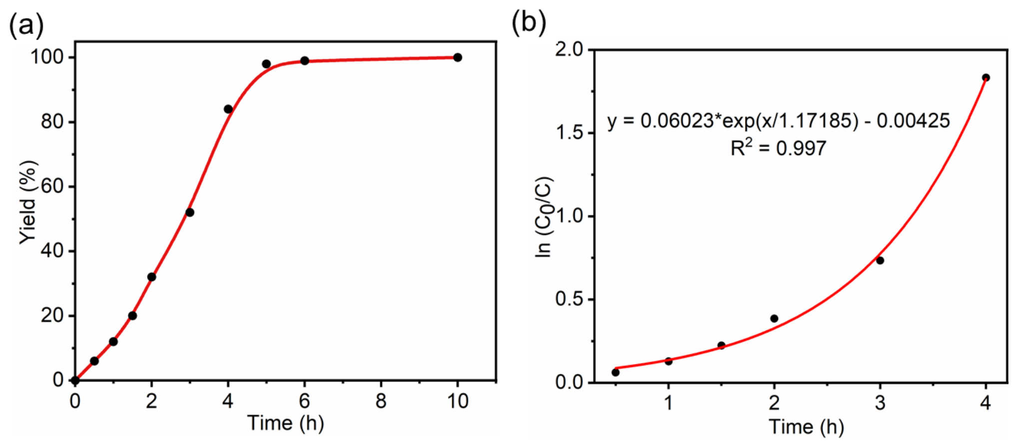


Figure S7 (a) Yields recorded at different reaction times. (b) Kinetic curve (ln(C_0/C) vs. t) of template reaction for the Sonogashira cross-coupling reaction.

6. Reusability of JNM-7-Pd

General method for recovery of JNM-7-Pd: At the end of the reaction, the solid was collected by centrifugation and washed with DMF, water, methanol and dichloromethane, respectively. Afterwards, the collected powder was dried in a centrally controlled drying oven at 100 °C for 5 hours.

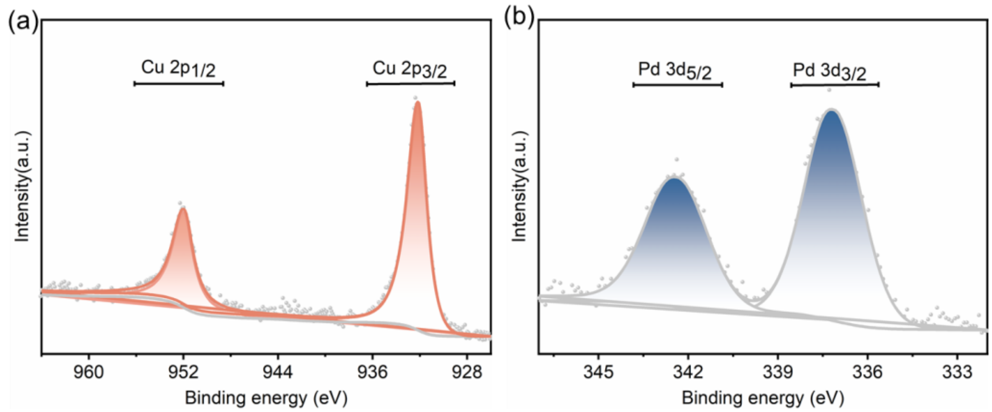


Figure S8 XPS spectra of Cu (a) and Pd (b) in **JNM-7-Pd** after three catalytic cycles for C-H arylation.

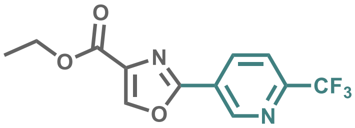
7. ICP analysis results

Table S1 ICP analysis results of various materials

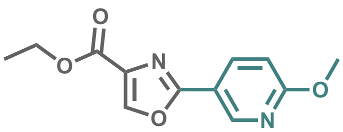
Material[a]	ICP analysis (ppm)		Mass ratio of Pd/Cu
	Cu	Pd	
Original **JNM-7-Pd**	44.834	16.723	0.373
JNM-7-Pd recovered from C-H arylation reaction	45.715	17.234	0.377
JNM-7-Pd recovered from Sonogashira coupling reaction	44.875	16.828	0.375
Solution of C-H arylation reaction[b]	8.293	0.025	--
Solution of Sonogashira coupling reaction[c]	0.427	0.007	--

a. The solid material was processed as follows: 4 mg of the solid was digested with aqua regia and then diluted to 25 mL with deionized water. b. 3 mL of the reaction solution was taken, the organic solvent was removed, and the residue was digested with aqua regia before being diluted to 25 mL with deionized water. c. 3 mL of the reaction solution was taken, the organic solvent was removed, and the residue was digested with aqua regia before being diluted to 50 mL with deionized water. It is noteworthy that the concentration of Pd ions in the reaction solution was too low, leading to significant experimental error. Therefore, the leaching rate of the catalyst was calculated based on the concentration of Cu ions.

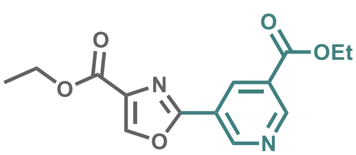
8. Characterization of compounds 3 and 6



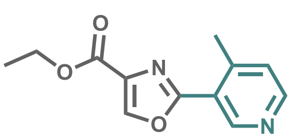
ethyl 2-(6-(trifluoromethyl)pyridin-3-yl)oxazole-4-carboxylate (3aa); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 9.42 (s, 1H), 8.59 (d, *J* = 8.3 Hz, 1H), 8.37 (s, 1H), 7.82 (d, *J* = 8.2 Hz, 1H), 4.48 – 4.42 (m, 2H), 1.42 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 160.89, 150.04, 149.69, 148.12, 144.86, 135.67, 135.46, 125.33, 120.75, 61.85, 14.44.



ethyl 2-(6-methoxypyridin-3-yl)oxazole-4-carboxylate (3ab); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.87 (s, 1H), 8.30 – 8.23 (m, 2H), 6.83 (d, *J* = 8.8 Hz, 1H), 4.47 – 4.37 (m, 2H), 3.99 (s, 3H) 1.40 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 166.10, 161.72, 161.19, 146.70, 143.95, 137.44, 135.02, 116.94, 111.75, 61.85, 54.46, 14.77.

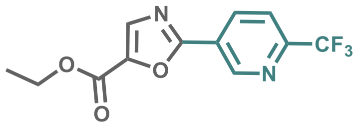


ethyl 2-(5-(ethoxycarbonyl)pyridin-3-yl)oxazole-4-carboxylate (3ac); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 9.43 (d, *J* = 83.5 Hz, 2H), 8.97 (s, 1H), 8.35 (s, 1H), 4.44 (dd, *J* = 7.2, 2.2 Hz, 4H), 1.42 (q, *J* = 7.3 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 164.43, 160.91, 159.40, 152.57, 151.09, 144.48, 134.98, 61.95, 61.66, 14.33, 14.31.

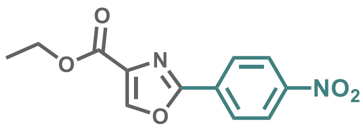


ethyl 2-(4-methylpyridin-3-yl)oxazole-4-carboxylate (3ad); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 9.12 (s, 1H), 8.51 (d, *J* = 5.1 Hz, 1H), 8.36 (s, 1H), 7.25 (d, *J* = 5.0 Hz, 1H), 4.37 (d, *J* = 7.1 Hz, 2H), 2.70 (s, 3H), 1.38 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR

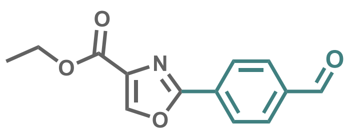
(101 MHz, $CDCl_3$, 298 K) δ [ppm] = 161.36, 160.84, 151.22, 149.96, 146.99, 144.26, 134.90, 126.55, 115.49, 61.55, 21.42, 14.42.



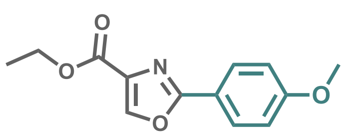
ethyl 2-(6-(trifluoromethyl)pyridin-3-yl)oxazole-5-carboxylate (3ba); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 9.46 (s, 1H), 8.58 (d, J = 8.4 Hz, 1H), 7.90 (s, 1H), 7.83 (d, J = 8.2 Hz, 1H), 4.44 (q, J = 7.1 Hz, 2H), 1.42 (t, J = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 160.45, 157.53, 148.58, 143.67, 135.83, 135.42, 125.27, 122.61, 120.75, 120.72, 62.09, 14.39.



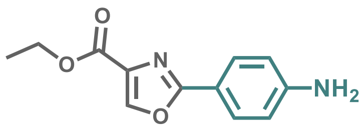
ethyl 2-(4-nitrophenyl)oxazole-4-carboxylate (3ae); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.37 – 8.24 (m, 5H), 4.43 (qd, J = 7.1, 1.6 Hz, 2H), 1.41 (td, J = 7.1, 1.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 160.85, 160.27, 149.21, 144.70, 135.43, 131.78, 127.74, 124.21, 61.63, 14.31.



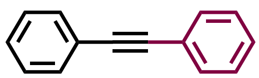
ethyl 2-(4-formylphenyl)oxazole-4-carboxylate (3af); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 10.08 (s, 1H), 8.33 (s, 1H), 8.29 (d, J = 8.3 Hz, 2H), 7.99 (d, J = 8.4 Hz, 2H), 4.44 (q, J = 7.1 Hz, 2H), 1.41 (t, J = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 191.39, 161.19, 161.04, 144.40, 137.79, 135.25, 131.37, 130.10, 127.43, 61.54, 14.33.



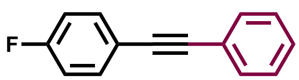
ethyl 2-(4-methoxyphenyl)oxazole-4-carboxylate (3ag); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.22 (s, 1H), 8.05 (d, J = 7.6 Hz, 2H), 6.97 (d, J = 7.8 Hz, 2H), 4.42 (q, J = 8.0, 7.6 Hz, 2H), 3.86 (s, 3H), 1.40 (t, J = 6.7 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 162.59, 161.97, 161.53, 143.20, 134.51, 128.67, 119.16, 114.24, 61.26, 55.43, 14.35.



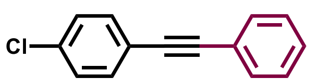
ethyl 2-(4-aminophenyl)oxazole-4-carboxylate (3ah); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.18 (s, 1H), 7.90 (d, J = 8.3 Hz, 2H), 6.71 (d, J = 8.3 Hz, 2H), 4.41 (q, J = 7.1 Hz, 2H), 3.99 (s, 2H), 1.40 (t, J = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 163.13, 161.70, 149.20, 142.79, 134.34, 128.62, 116.62, 114.58, 61.18, 14.36.



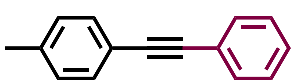
1,2-diphenylethyne (6aa); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.66 – 7.57 (m, 4H), 7.49 – 7.34 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 131.68, 128.42, 128.33, 123.35, 89.48.



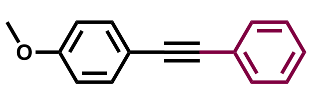
1-fluoro-4-(phenylethynyl)benzene (6ba); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.56 – 7.46 (m, 4H), 7.38 – 7.31 (m, 3H), 7.05 (t, J = 8.0 Hz, 2H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 133.66, 131.70, 128.52, 119.67, 115.90, 115.68, 92.85, 84.78.



1-chloro-4-(phenylethynyl)benzene (6ca); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.56 – 7.49 (m, 2H), 7.46 (d, J = 8.4 Hz, 2H), 7.41 – 7.28 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 134.39, 132.95, 131.74, 128.83, 128.63, 128.54, 123.07, 121.92, 90.45, 88.38.

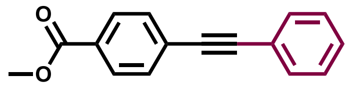


1-methyl-4-(phenylethynyl)benzene 6da); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.58 – 7.49 (m, 2H), 7.47 – 7.40 (m, 2H), 7.38 – 7.29 (m, 3H), 7.16 (d, J = 8.0 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 138.53, 131.69, 131.64, 129.26, 128.46, 128.22, 120.33, 89.69, 88.85, 21.65.

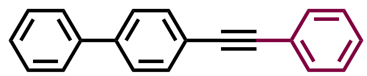


1-methoxy-4-(phenylethynyl)benzene (6ea); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.54 – 7.45 (m, 4H), 7.37 – 7.29 (m, 3H), 6.88 (d, J = 8.8 Hz, 2H), 3.83 (s, 3H).

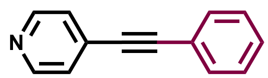
^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 159.76, 133.20, 131.59, 128.45, 128.08, 123.74, 115.53, 114.14, 89.50, 88.26, 55.45.



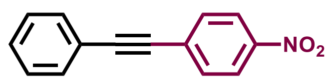
methyl 4-(phenylethynyl)benzoate (6fa); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.02 (d, *J* = 8.4 Hz, 1H), 7.59 (d, *J* = 8.4 Hz, 1H), 7.55 (dd, *J* = 6.6, 3.2 Hz, 1H), 7.40 – 7.34 (m, 2H), 3.93 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 166.60, 131.75, 131.52, 129.54, 129.48, 128.78, 128.45, 128.03, 122.72, 92.37, 88.64, 52.25.



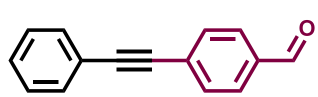
4-(phenylethynyl)-1,1'-biphenyl (6ga); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.62 (dd, *J* = 9.0, 1.5 Hz, 6H), 7.60 – 7.53 (m, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.40 – 7.34 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 140.99, 140.38, 132.06, 131.64, 128.89, 128.39, 128.30, 127.66, 127.05, 123.32, 122.20, 90.09, 89.32.



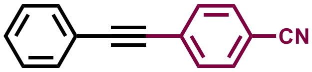
4-(phenylethynyl)pyridine (6ha); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.62 (d, *J* = 6.2 Hz, 2H), 7.58 (dd, *J* = 6.6, 3.2 Hz, 2H), 7.45 – 7.37 (m, 5H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 149.77, 131.89, 131.50, 129.23, 128.52, 125.56, 122.11, 93.99, 86.66.



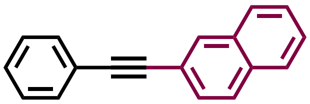
1-nitro-4-(phenylethynyl)benzene (6ab); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.22 (d, *J* = 8.8 Hz, 2H), 7.66 (d, *J* = 8.8 Hz, 2H), 7.56 (dd, *J* = 6.4, 3.3 Hz, 2H), 7.39 (dd, *J* = 5.2, 2.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 146.99, 132.29, 131.87, 130.29, 129.31, 128.56, 123.66, 122.12, 94.73, 87.57.



4-(phenylethynyl)benzaldehyde (6ac); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 10.00 (s, 1H), 7.85 (dd, *J* = 8.4, 3.4 Hz, 2H), 7.67 (dd, *J* = 8.2, 3.4 Hz, 2H), 7.56 (dt, *J* = 7.4, 3.8 Hz, 2H), 7.38 (q, *J* = 3.5 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 191.44, 135.43, 132.12, 131.83, 129.60, 129.01, 128.52, 122.52, 93.50, 88.59.

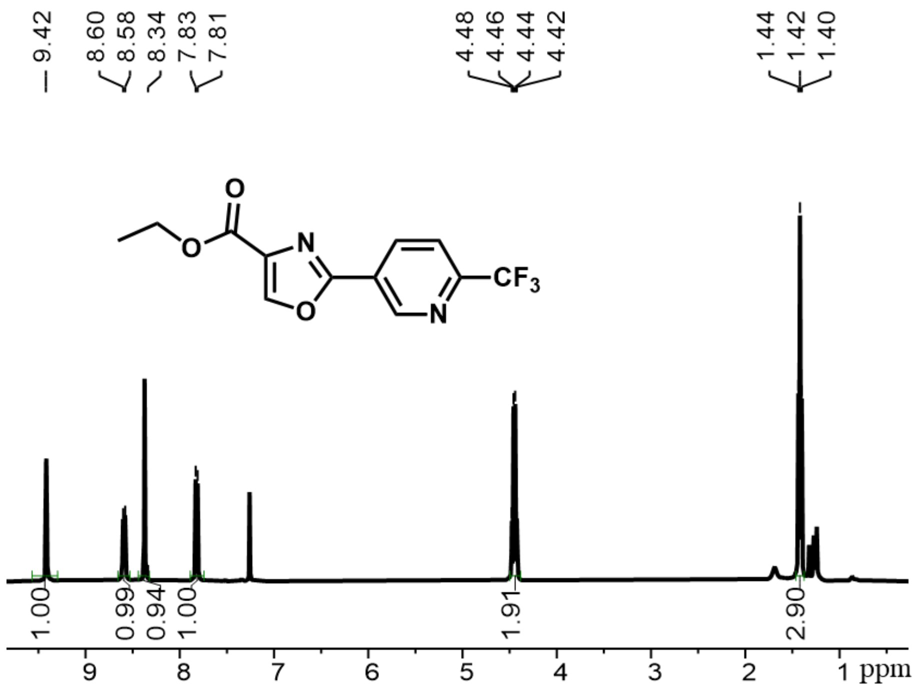


4-(phenylethynyl)benzonitrile (6ad); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 7.67 – 7.58 (m, 4H), 7.57 – 7.51 (m, 2H), 7.41 – 7.33 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 132.09, 132.07, 131.81, 129.15, 128.53, 128.27, 122.24, 118.55, 111.50, 93.80, 87.73.

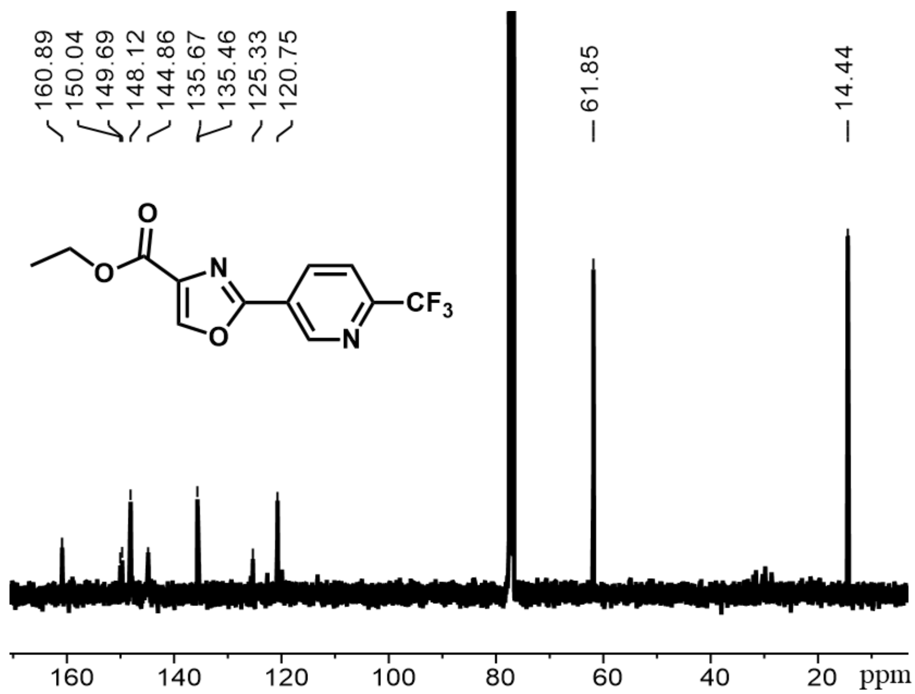


2-(phenylethynyl)naphthalene (6ae); ^{1}H NMR (400 MHz, $CDCl_3$, 298 K) δ [ppm] = 8.06 (d, *J* = 1.6 Hz, 1H), 7.82 (td, *J* = 5.3, 4.6, 2.4 Hz, 3H), 7.59 (dt, *J* = 6.9, 1.6 Hz, 3H), 7.54 – 7.47 (m, 2H), 7.42 – 7.34 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$, 298 K) δ [ppm] = 133.05, 132.82, 131.68, 131.45, 128.44, 128.40, 128.33, 128.02, 127.80, 126.68, 126.56, 123.31, 120.60, 89.80, 89.75.

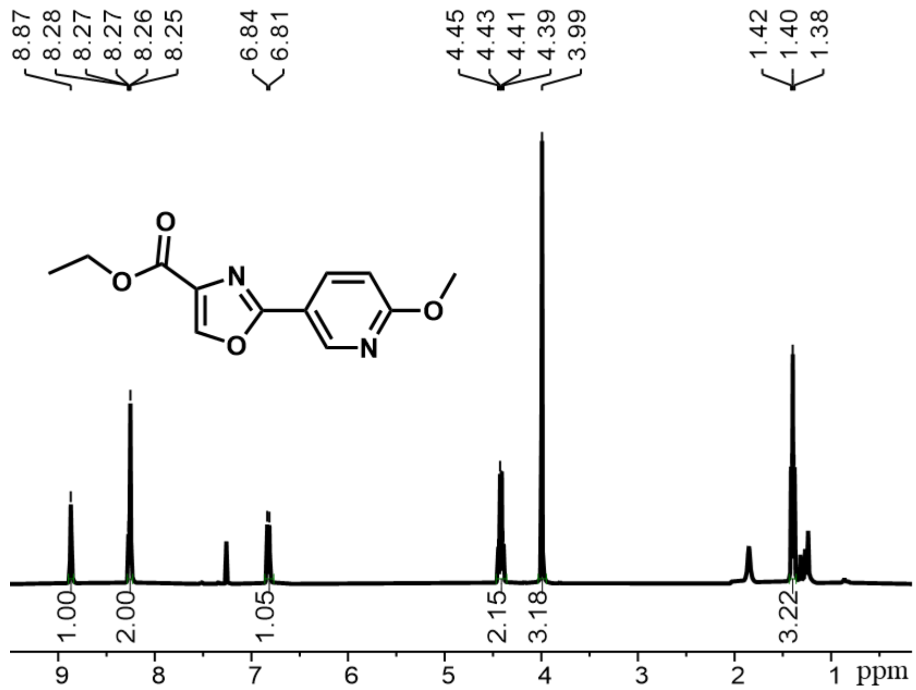
^{1}H NMR and ^{13}C NMR spectra of compounds 3 and 6



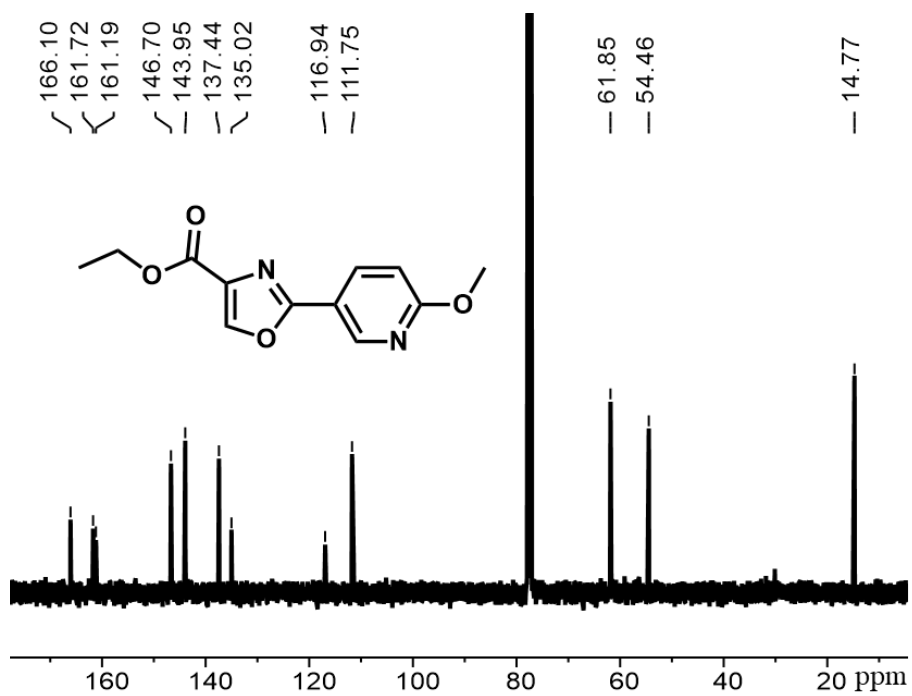
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3aa**.



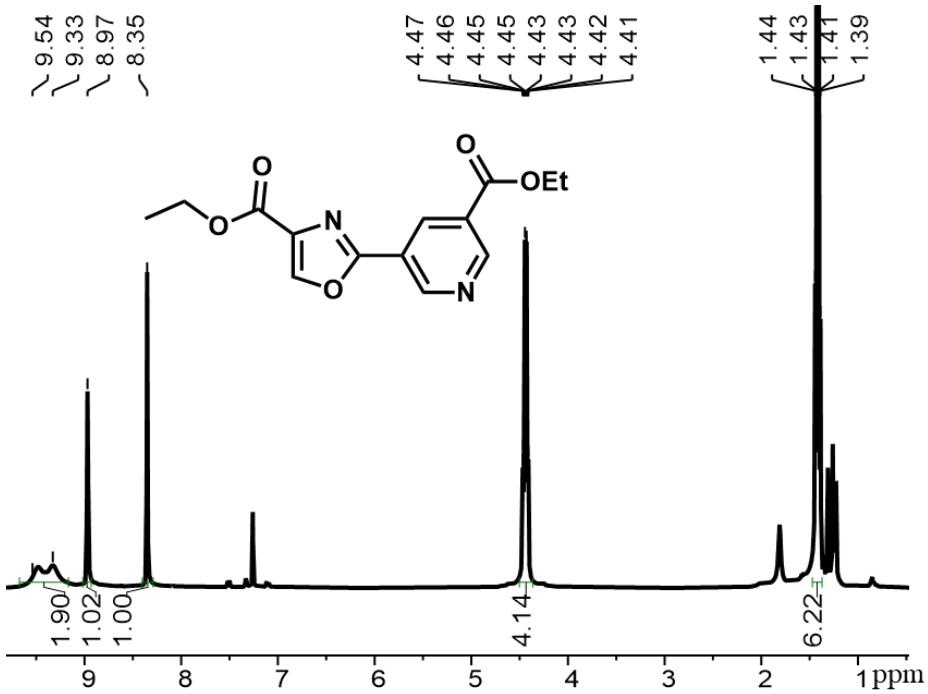
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3aa**.



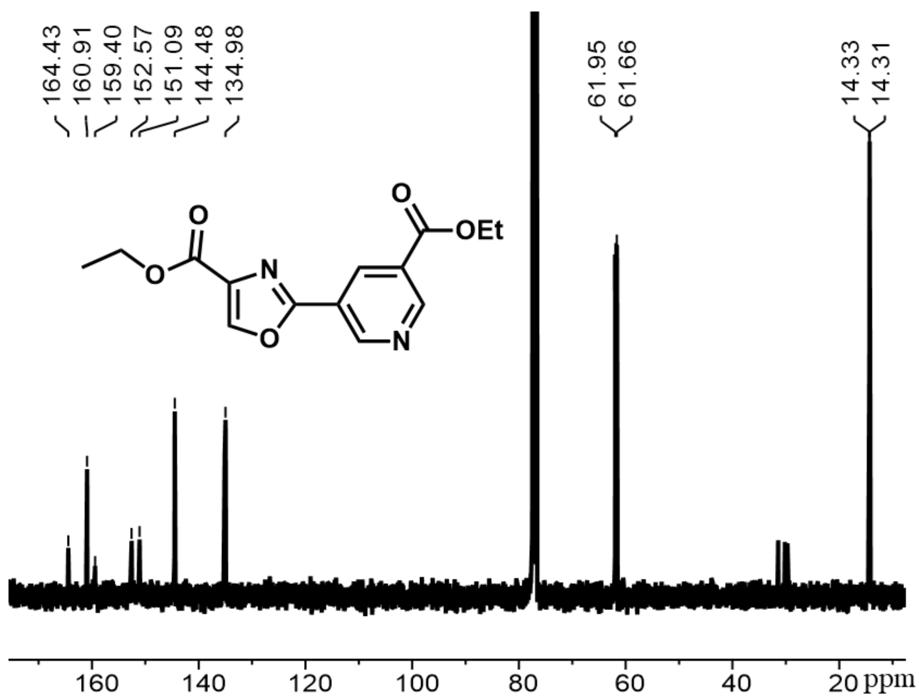
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ab**.



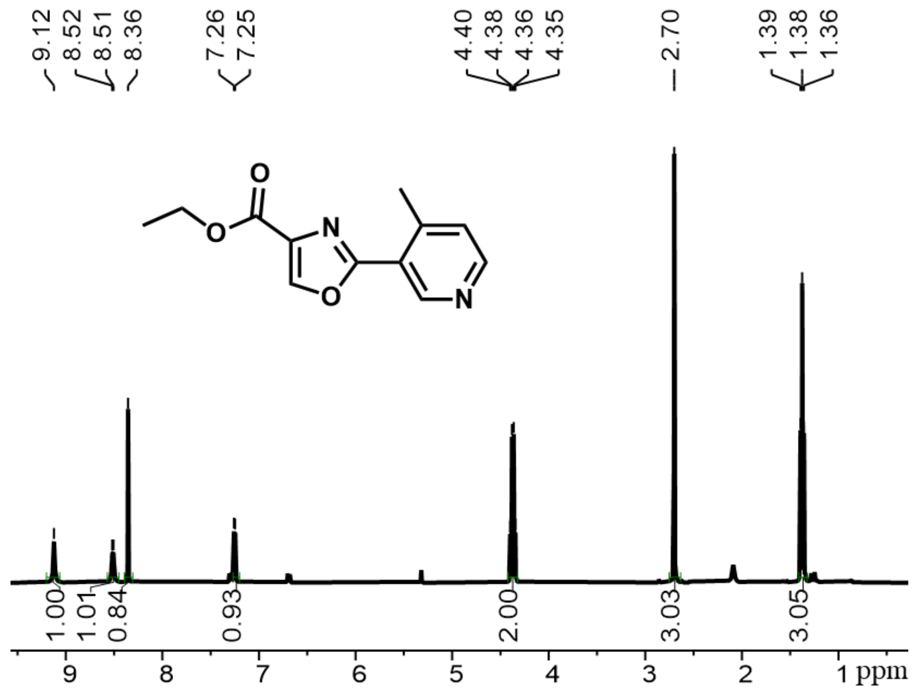
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ab**.



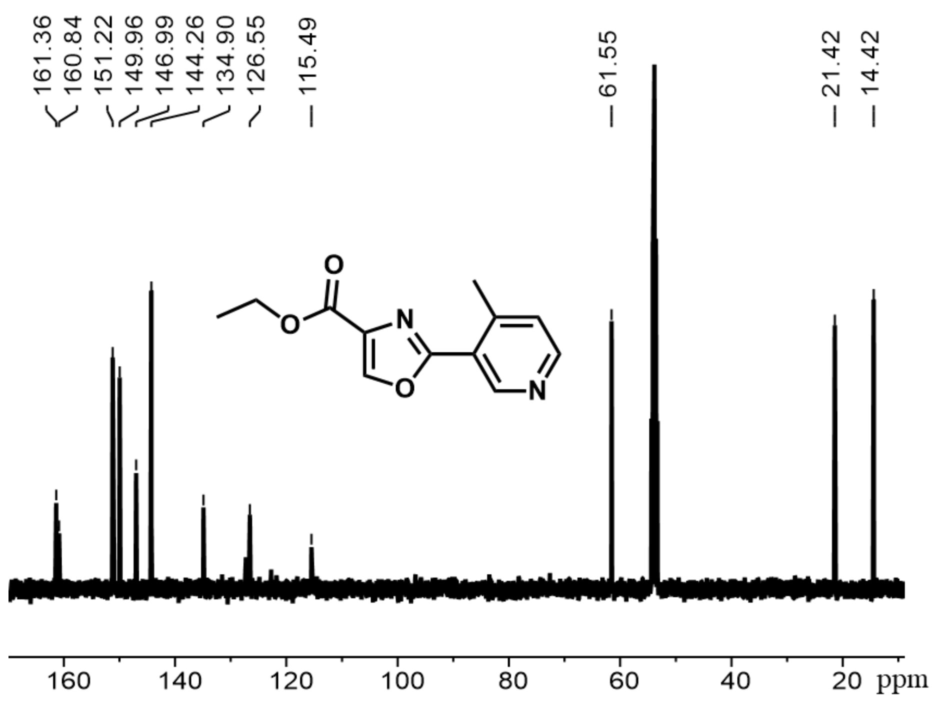
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ac**.



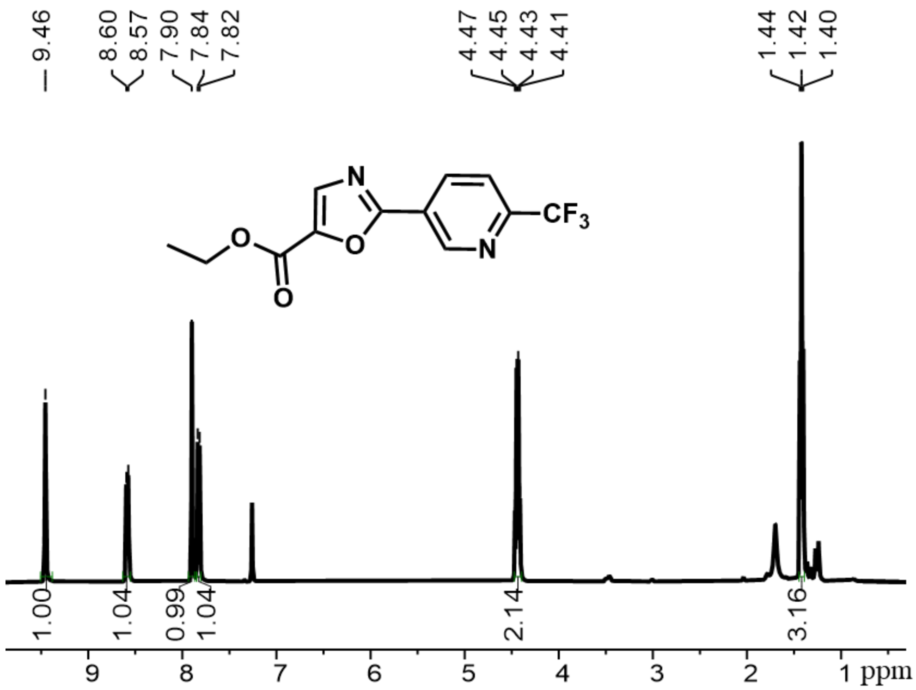
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ac**.



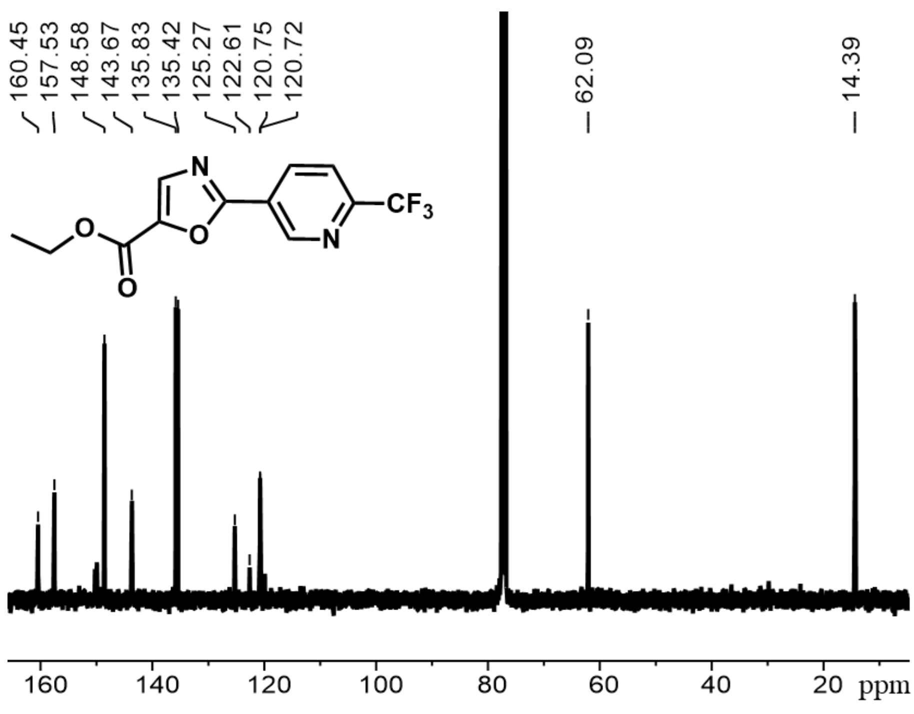
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ad**.



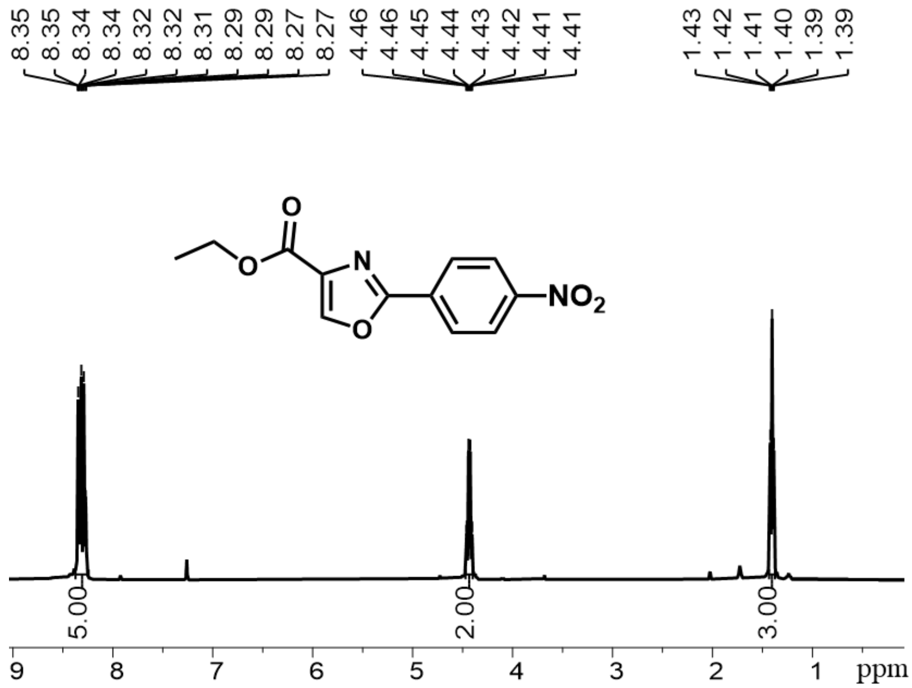
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ad**.



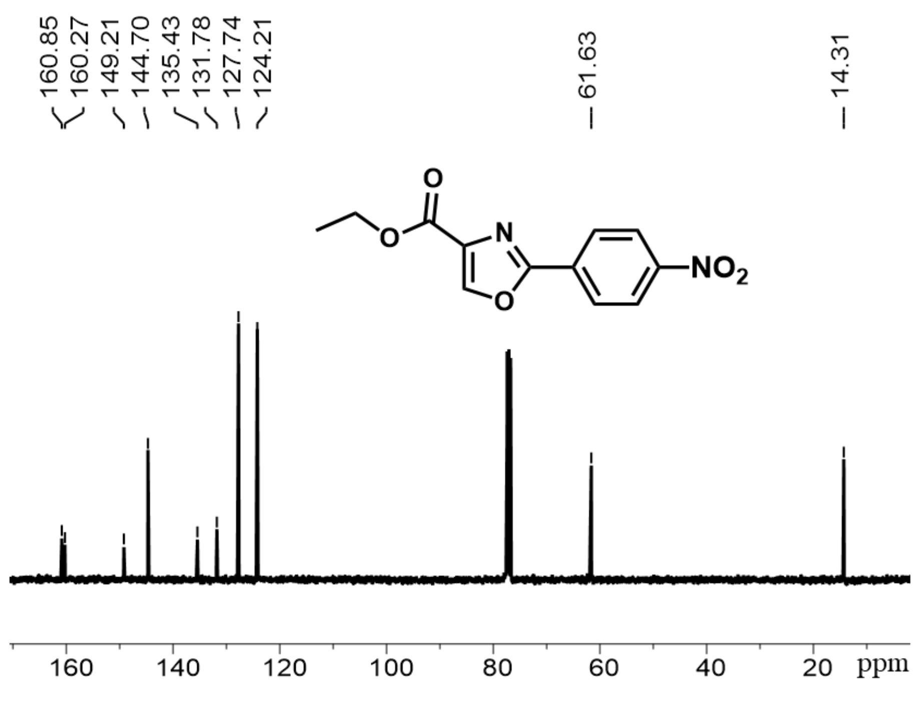
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ba**.



[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ba**.

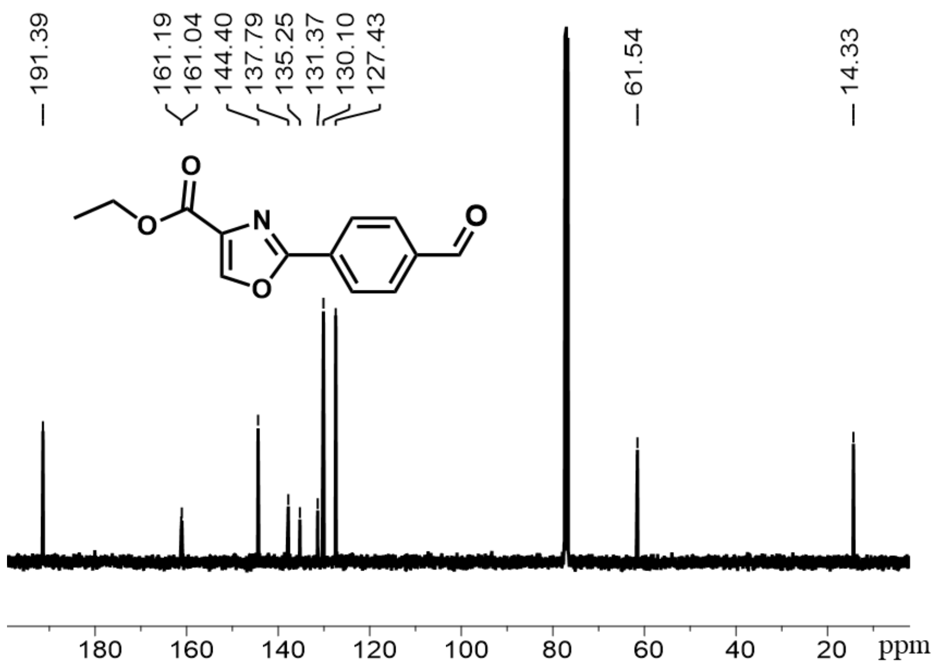


[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ae**.

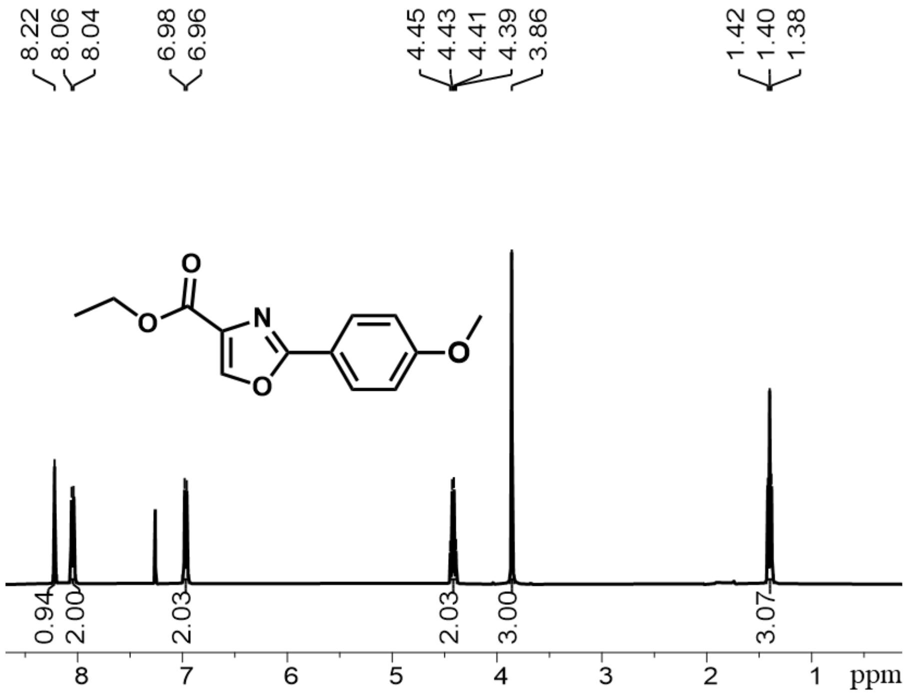


[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ae**.

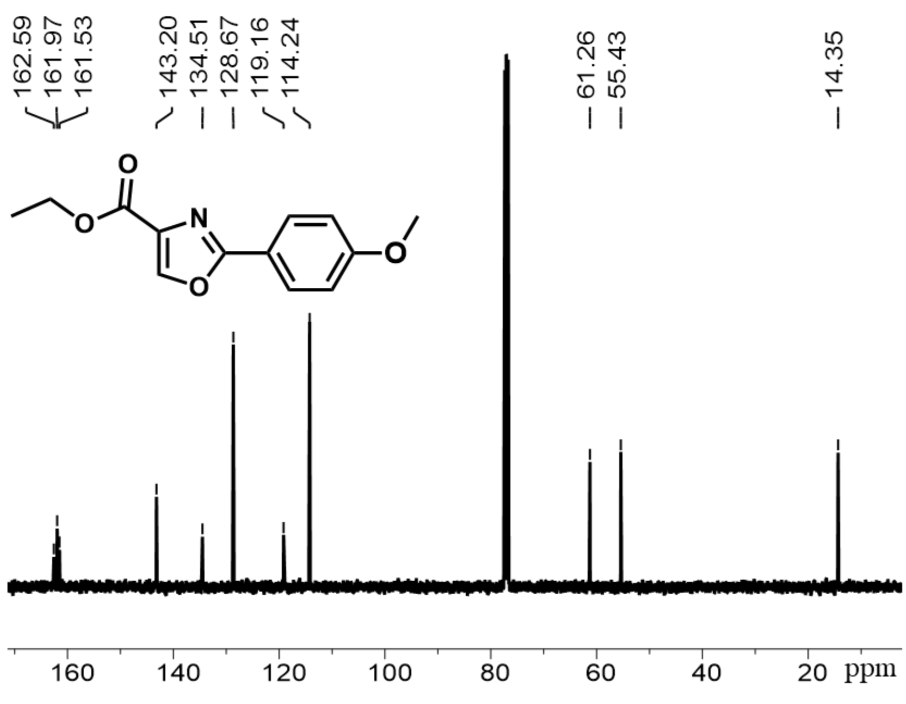
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3af**.



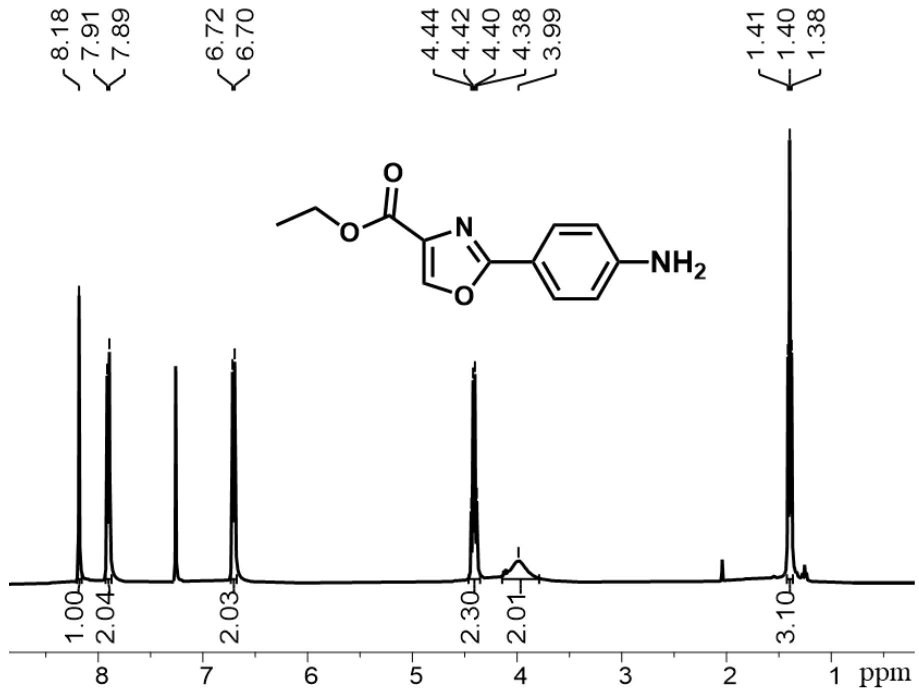
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3af**.



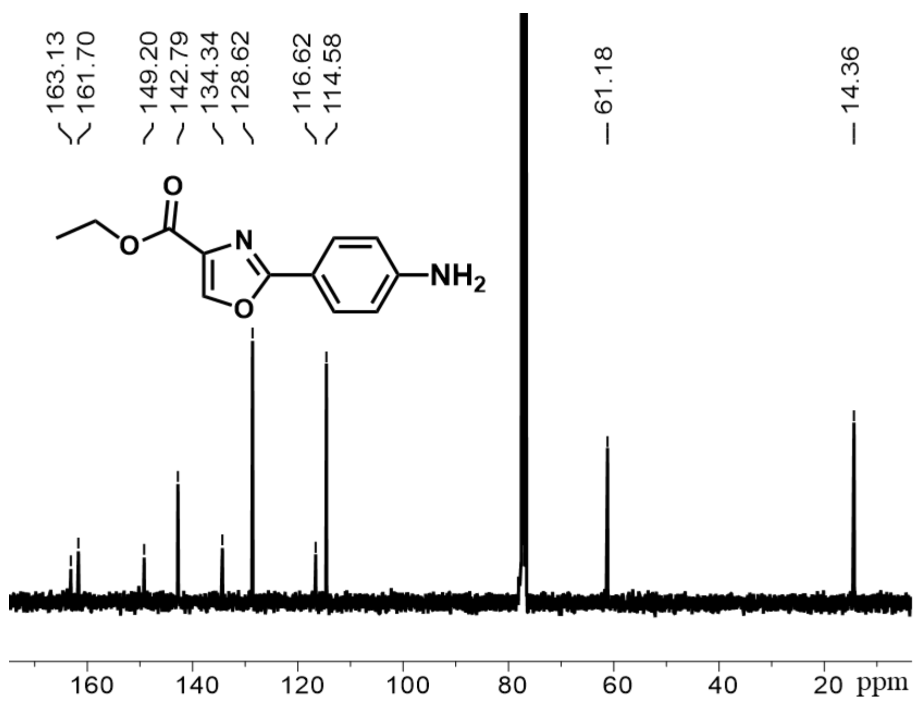
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ag**.



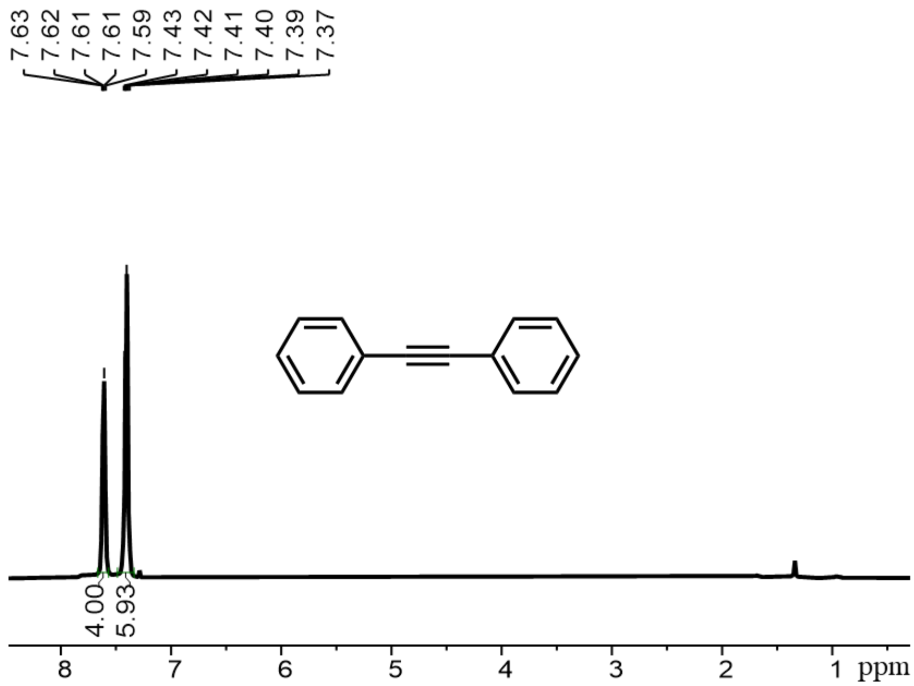
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ag**.



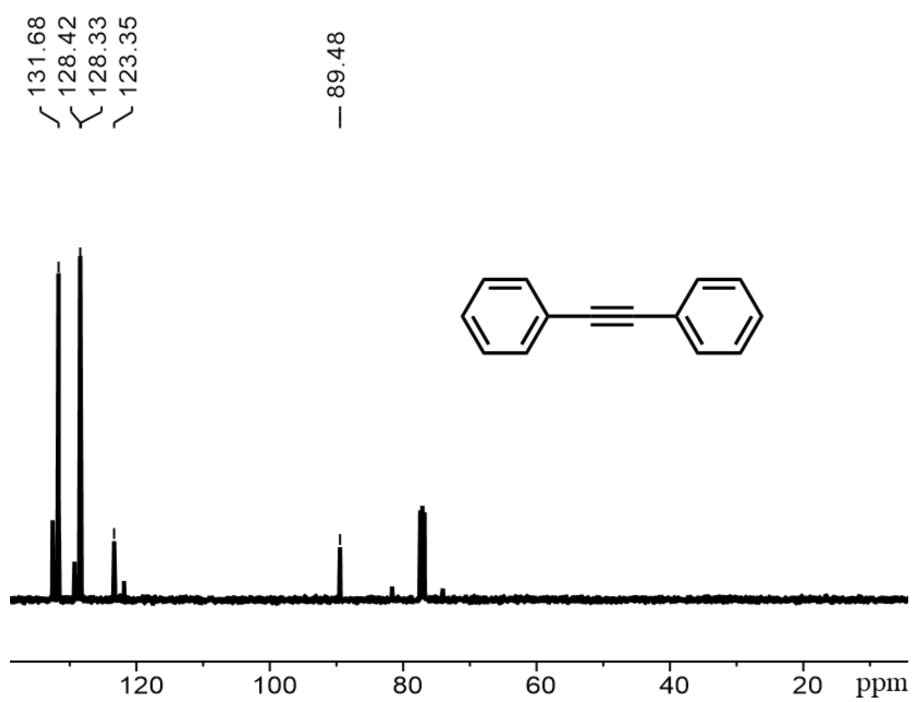
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **3ah**.



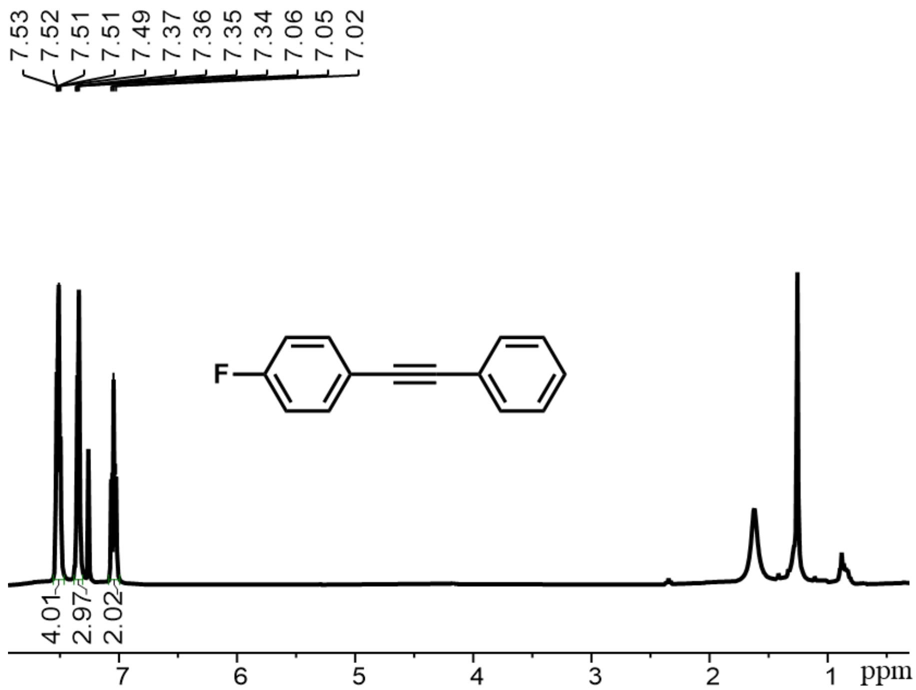
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **3ah**.



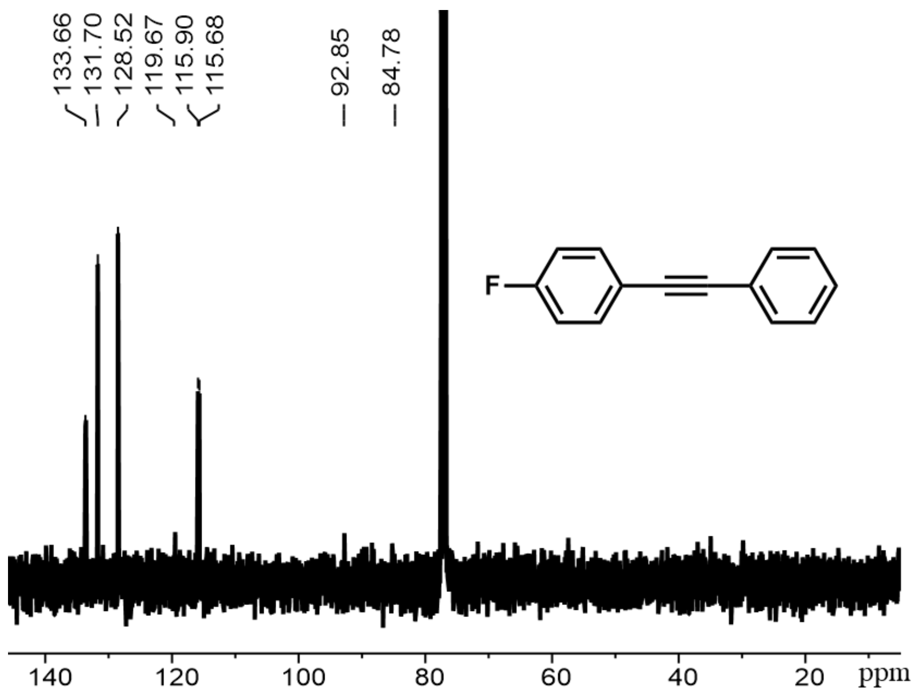
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6aa**.



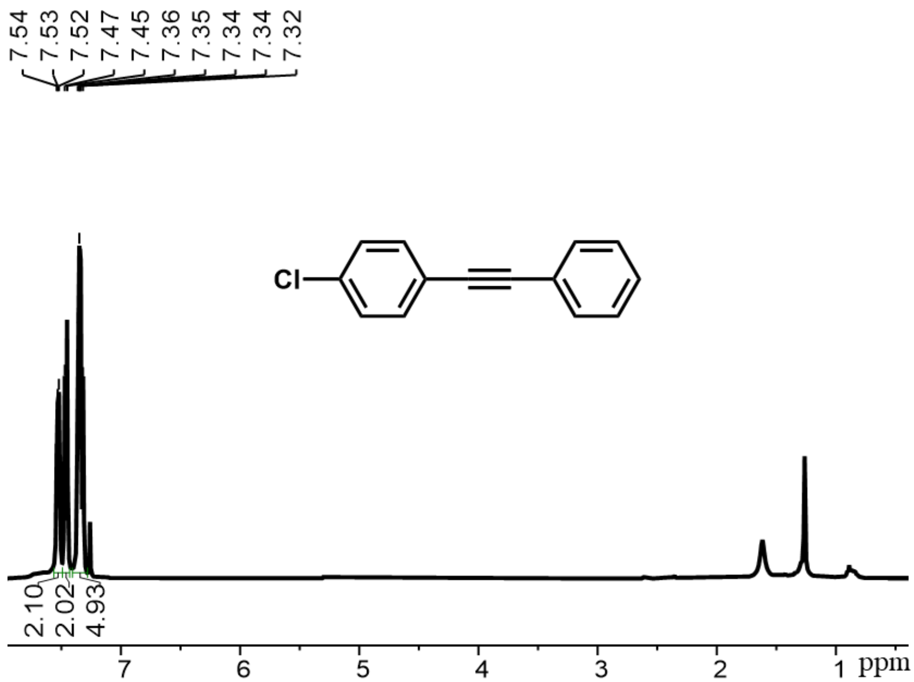
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6aa**.



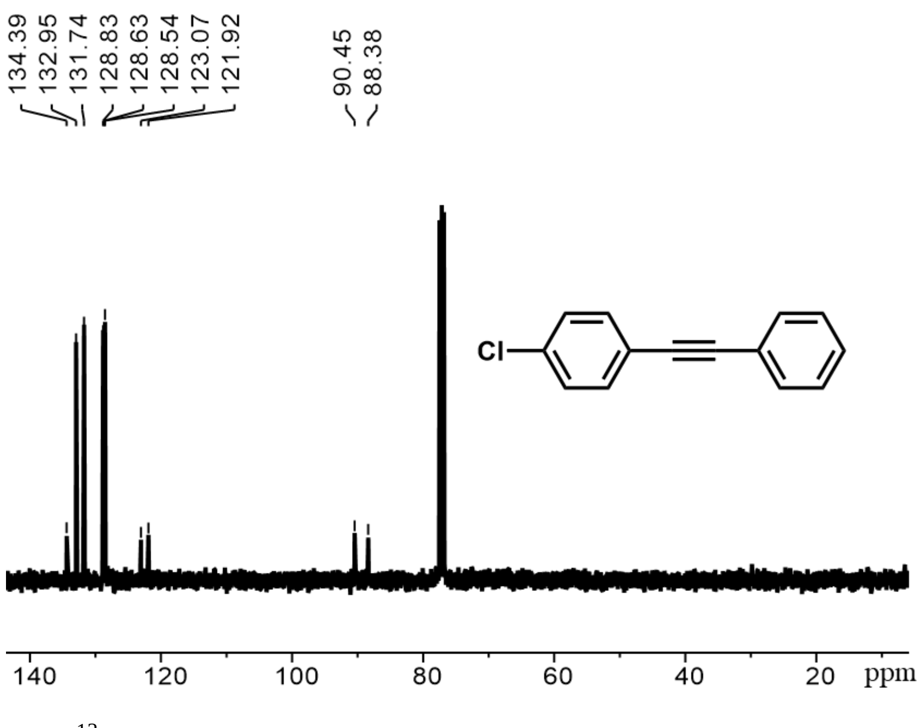
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ba**.



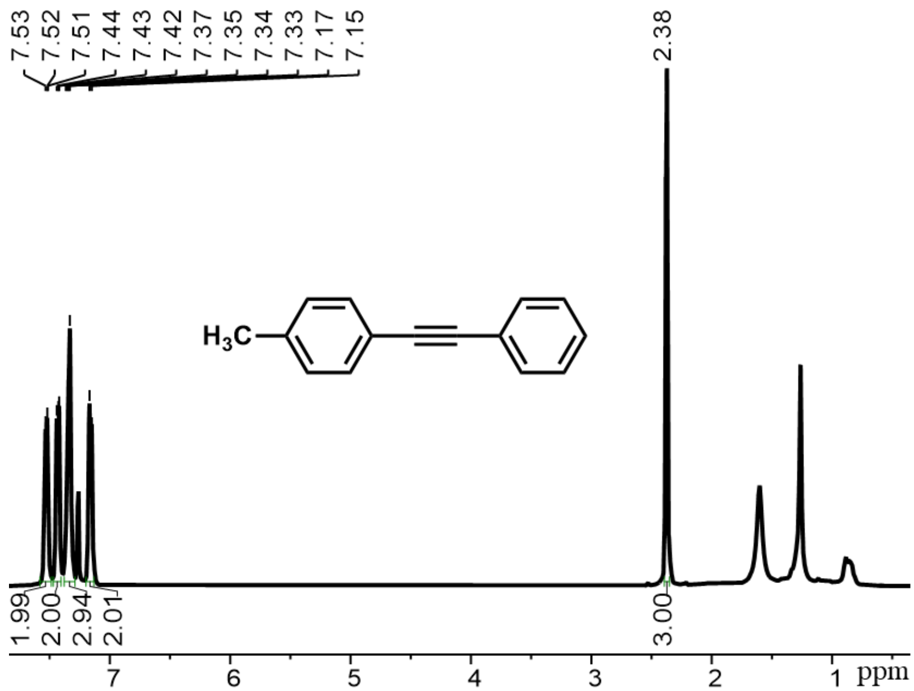
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ba**.



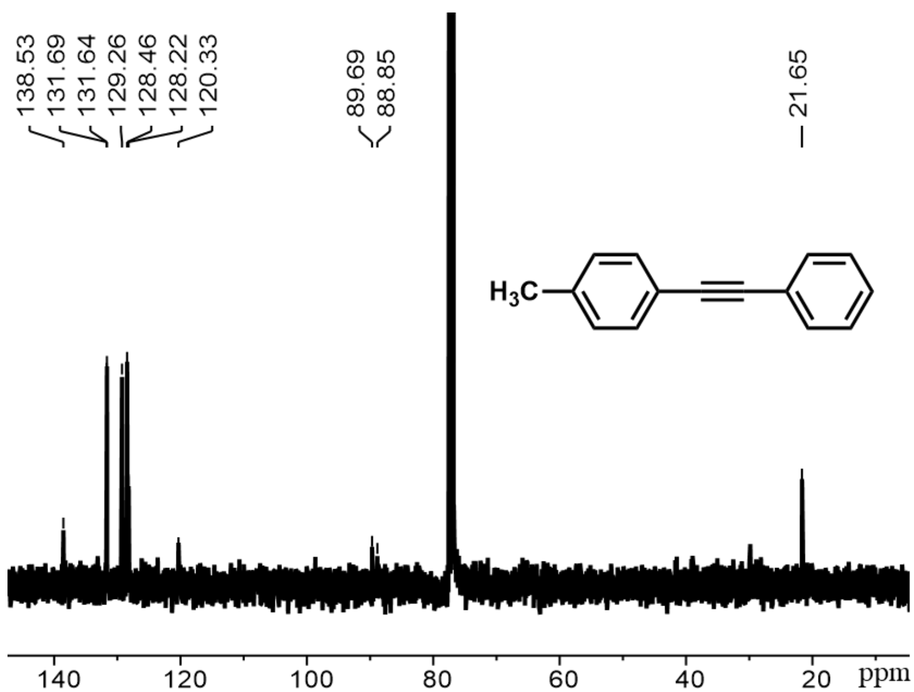
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ca**.



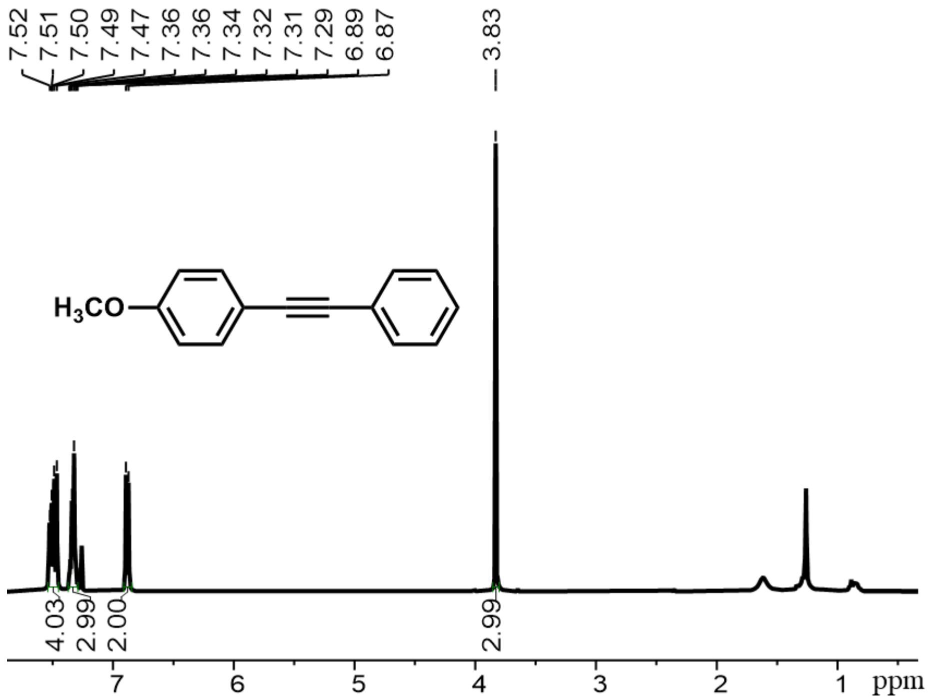
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ca**.



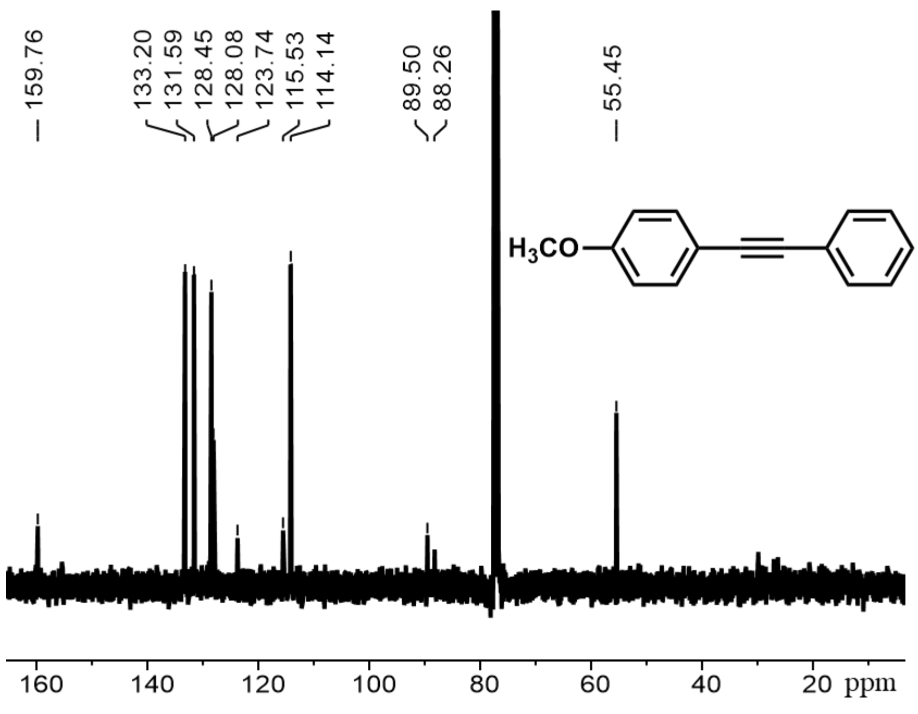
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6da**.



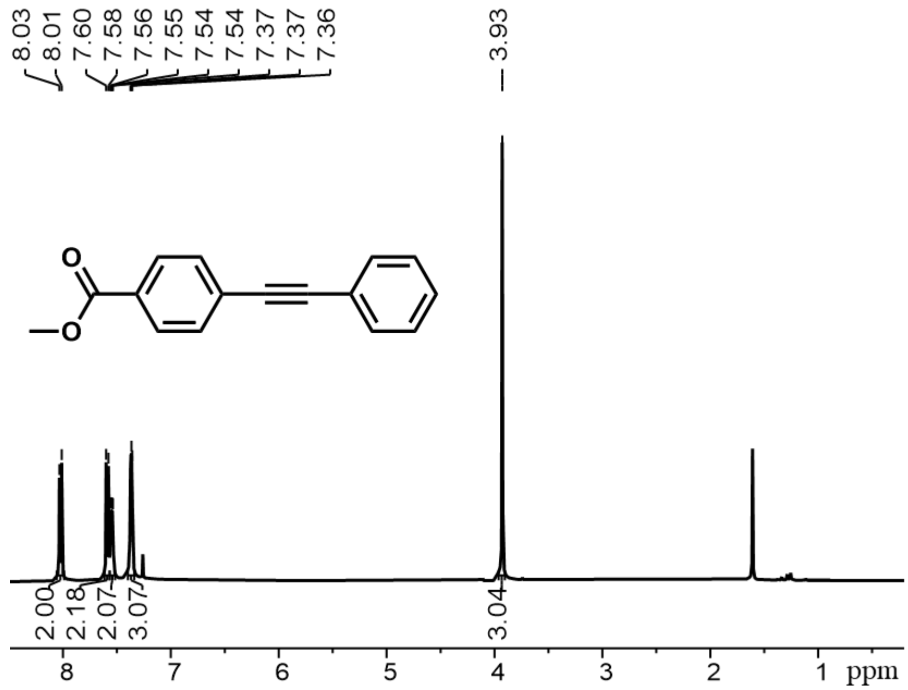
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6da**.



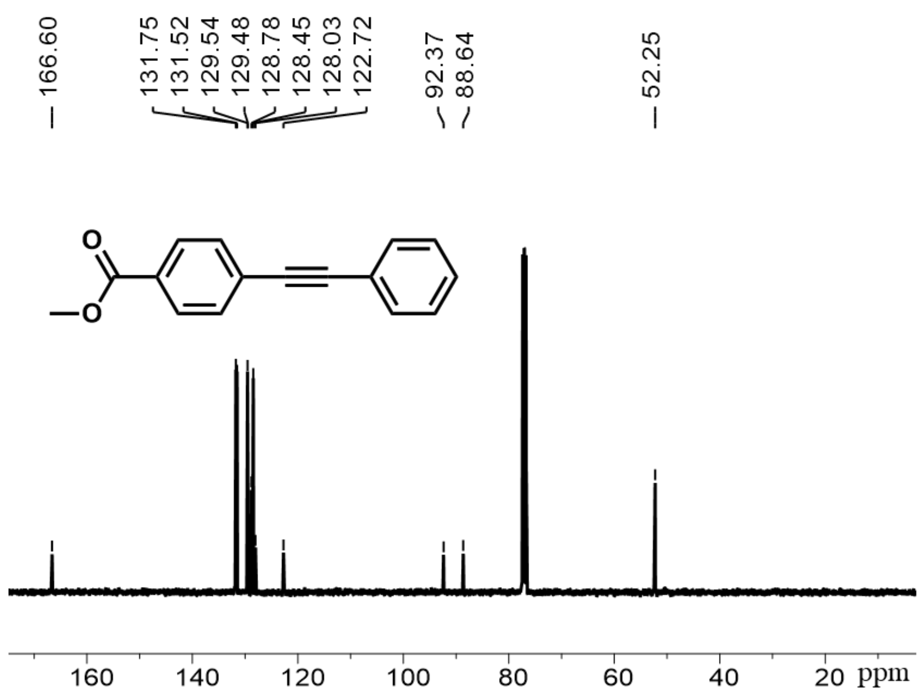
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ea**.



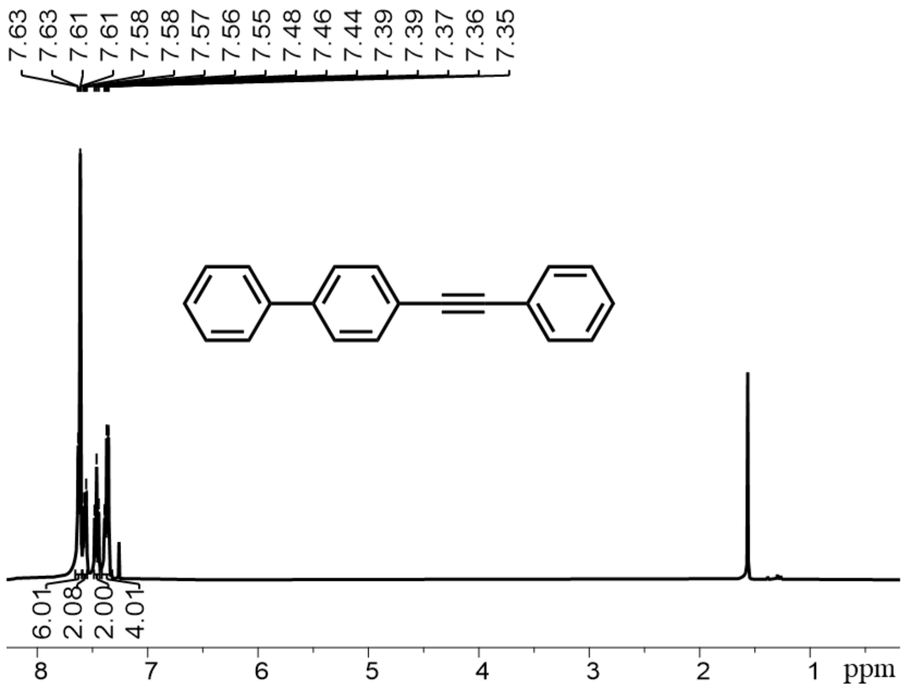
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ea**.



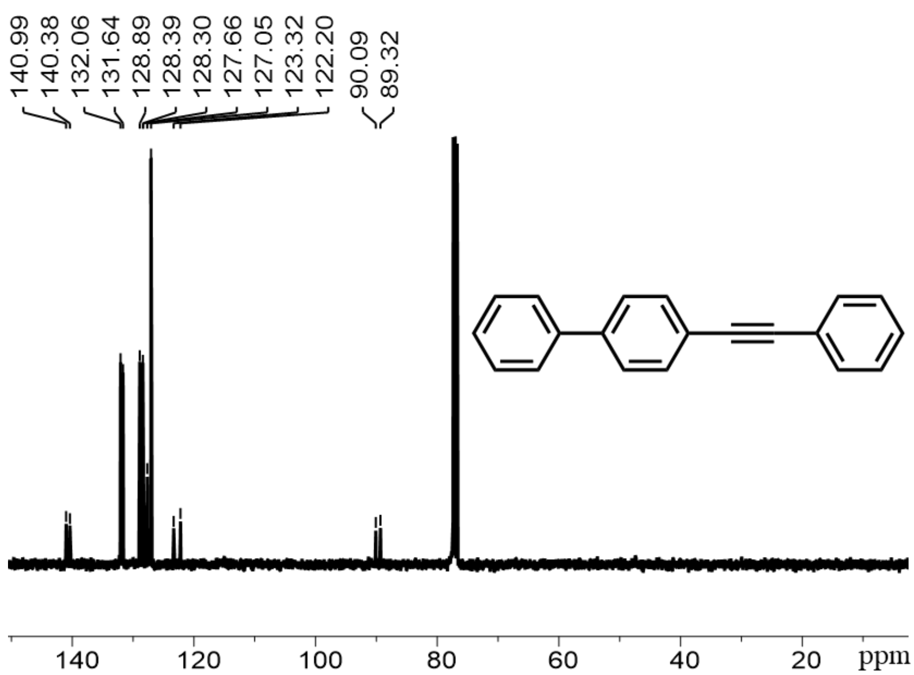
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6fa**.



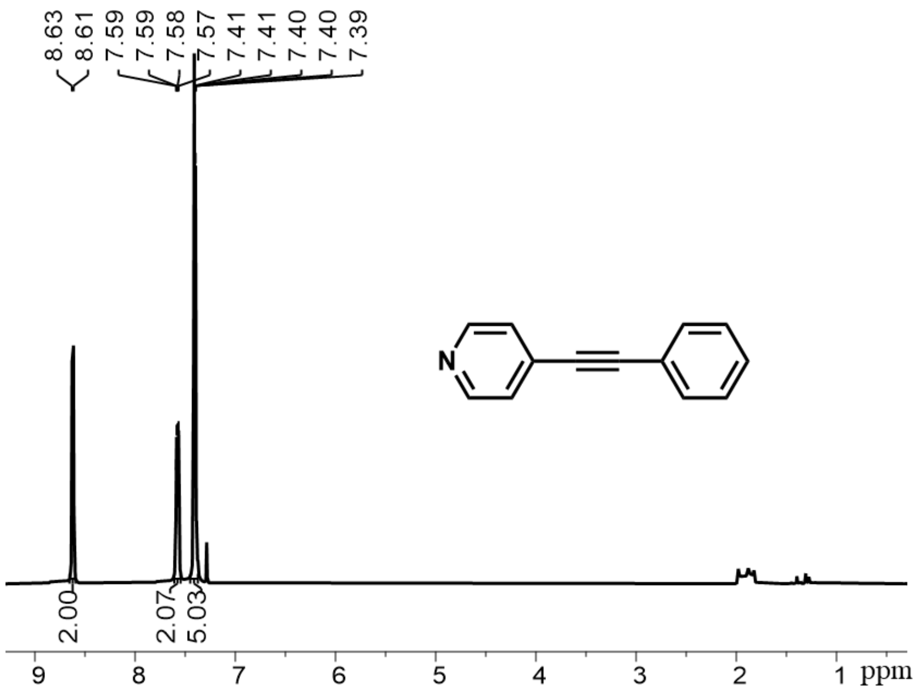
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6fa**.



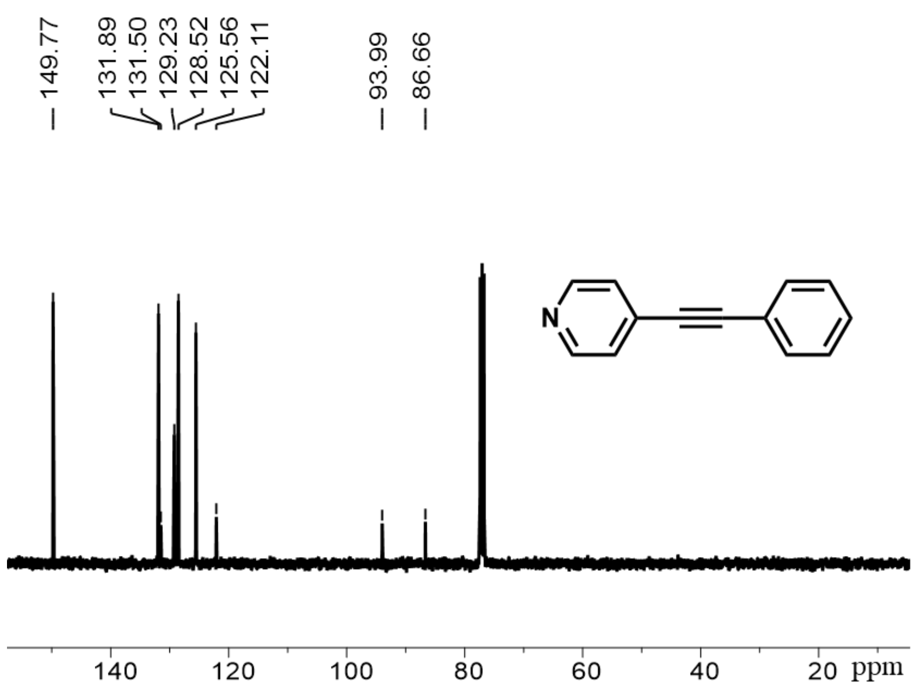
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ga**.



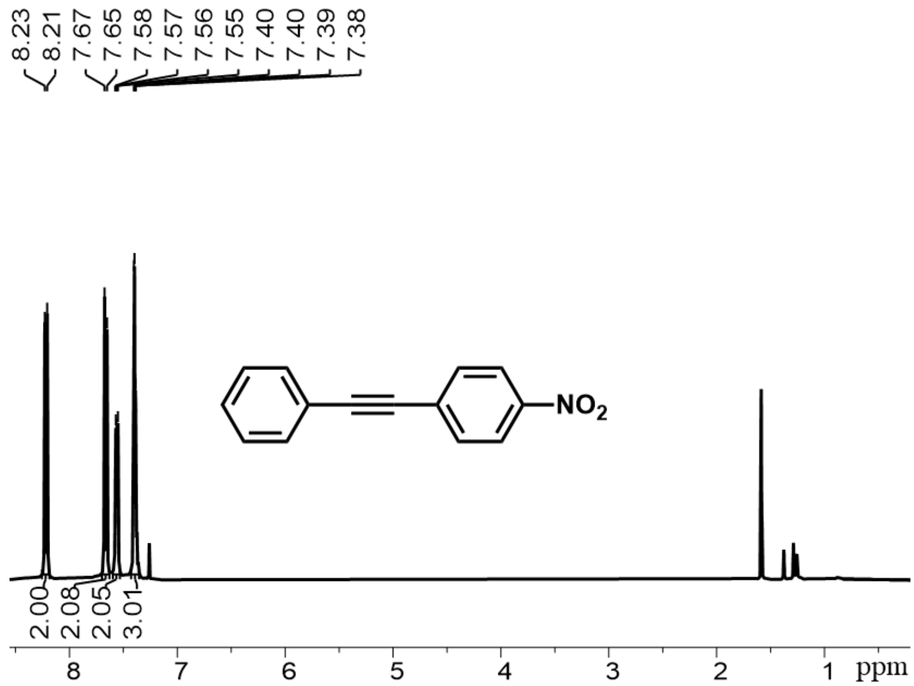
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ga**.



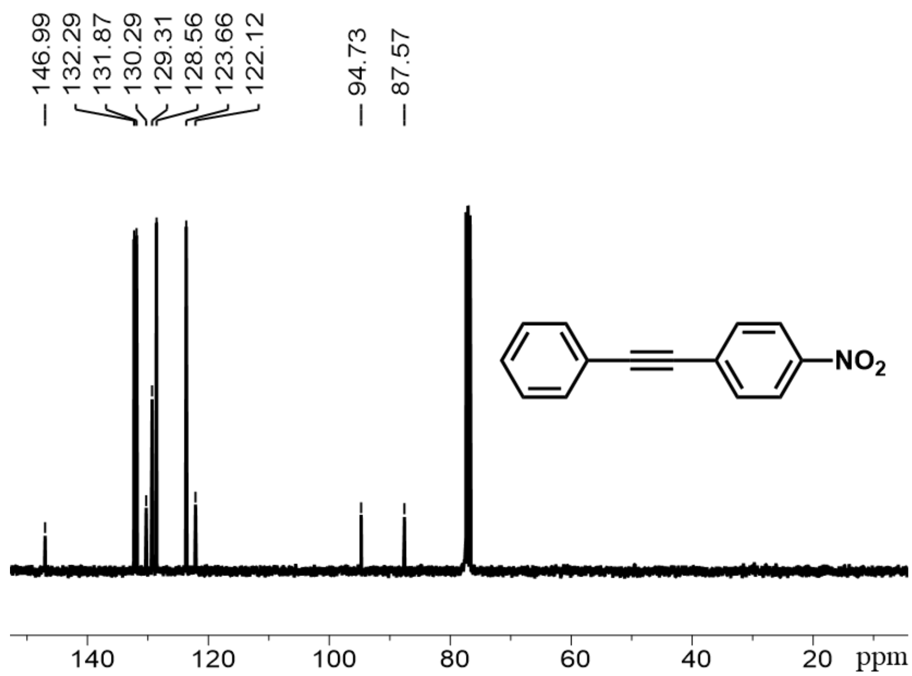
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ha**.



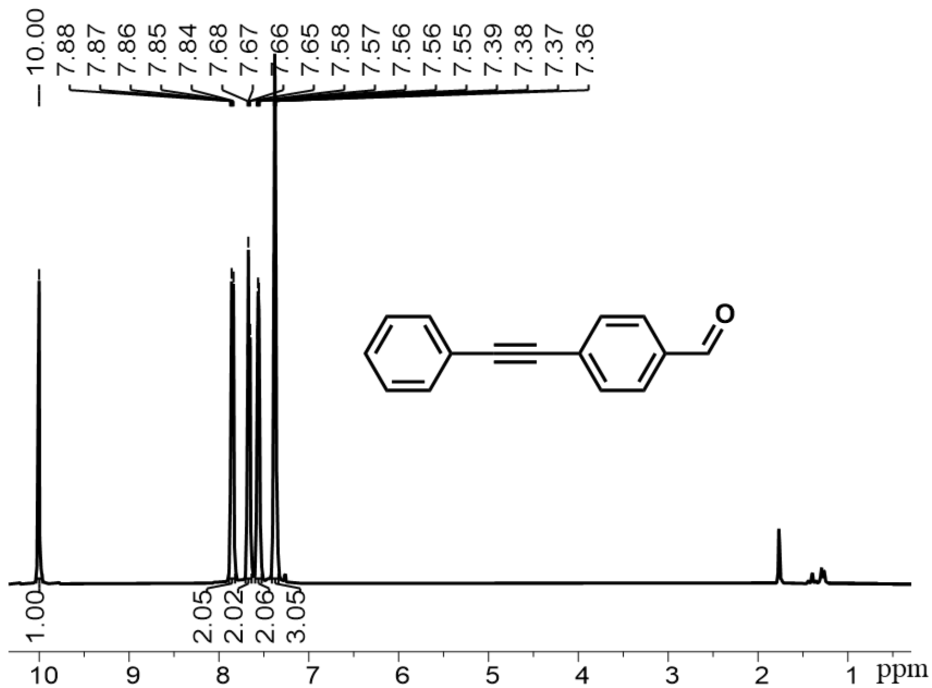
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ha**.



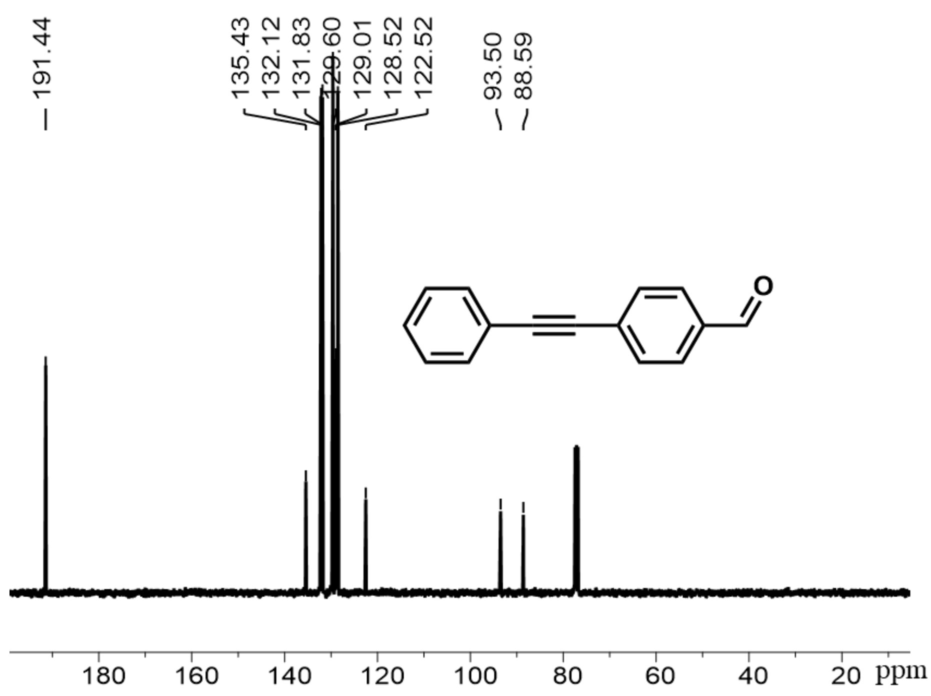
[1]H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ab**.



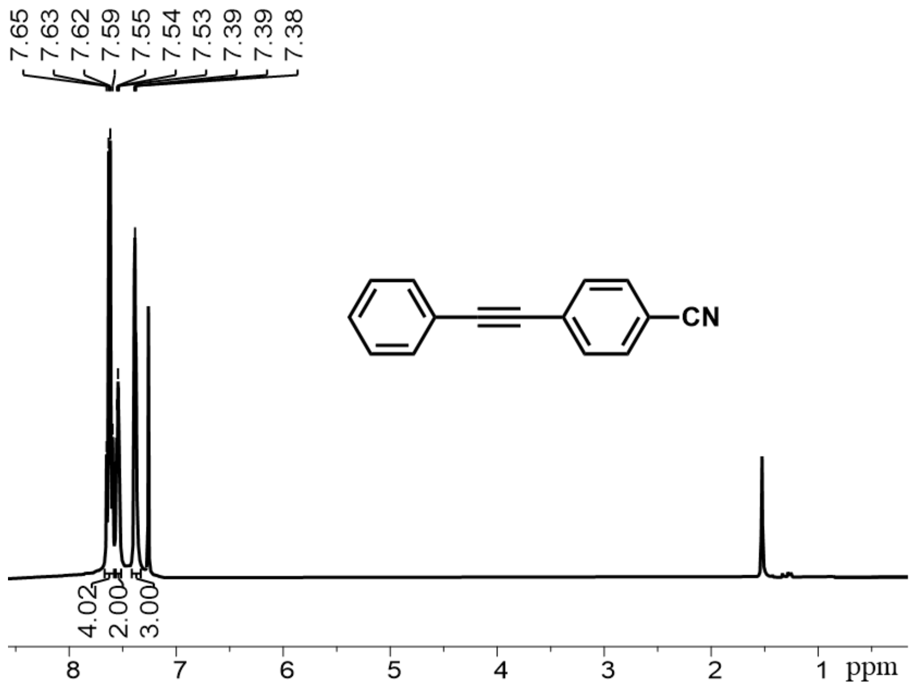
[13]C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ab**.



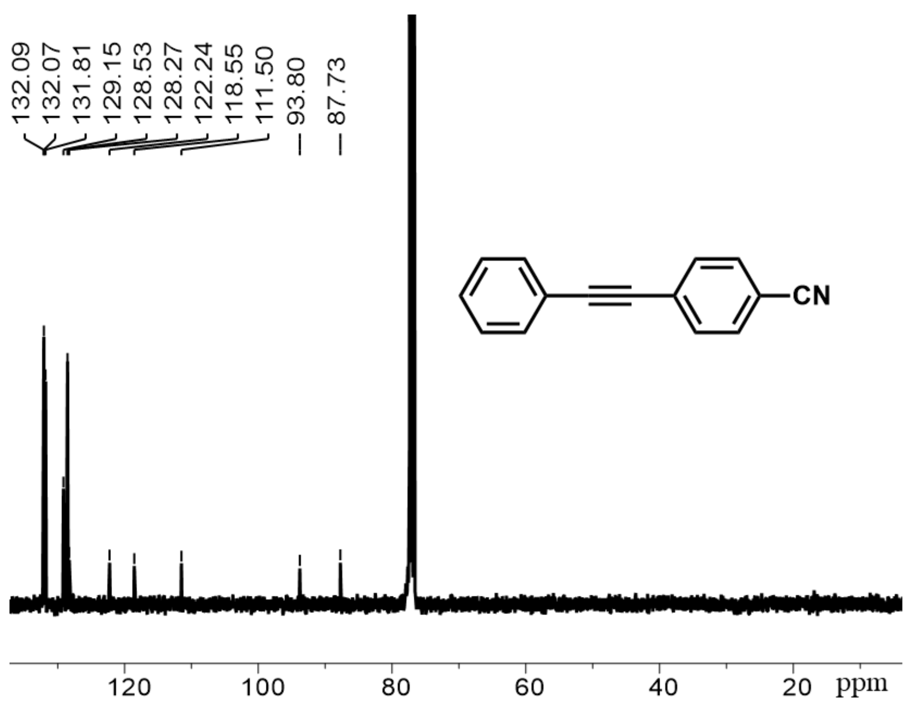
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ac**.



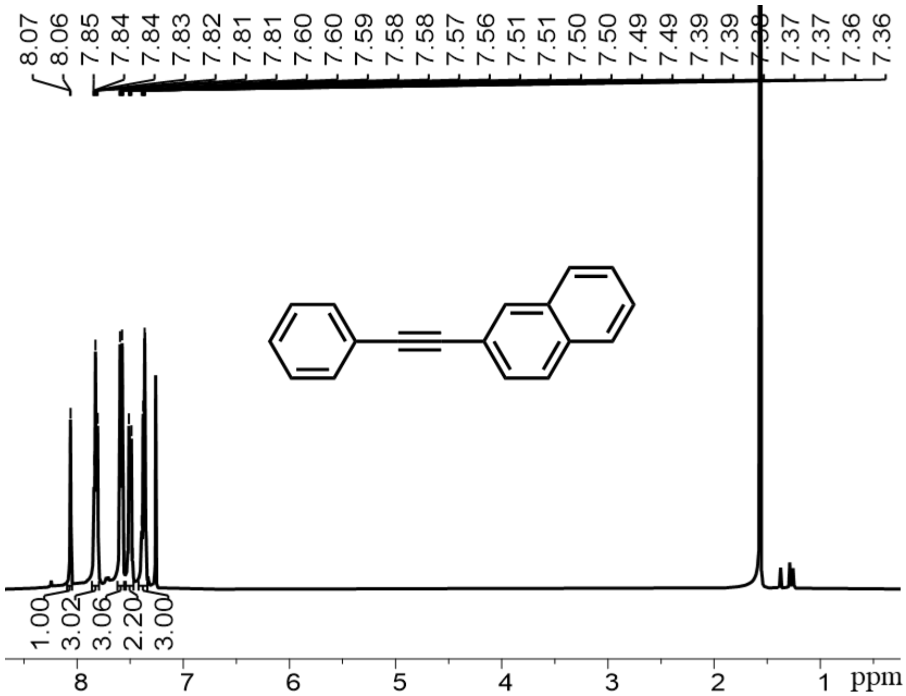
^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ac**.



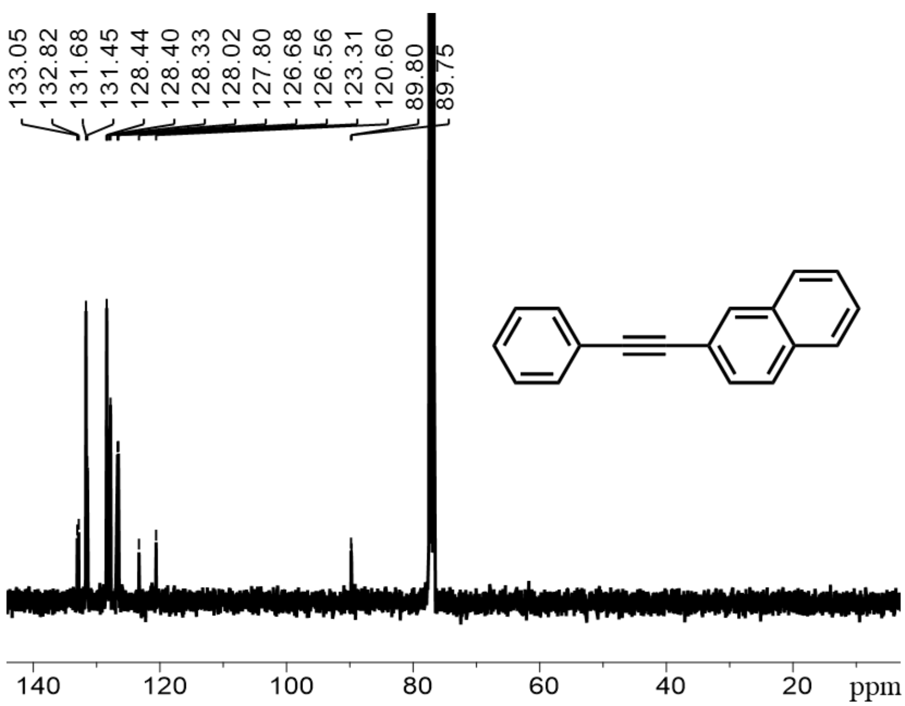
^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ad**



^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ad**.



^{1}H NMR spectrum (400 MHz, $CDCl_3$, 298 K) of compound **6ae**.



^{13}C NMR spectrum (101 MHz, $CDCl_3$, 298 K) of compound **6ae**.