Supporting Information

Highly Efficient Esterification of Carboxylic Acids with O-H Nucleophiles through Acid/Iodide Cooperative Catalysis

Dongxu Zuo,[a,#] Xiong Xiao,[a,#], Xinyue Ma,[a] Peng Nie,[b] Long Liu,[a] and Tieqiao Chen[a,*]

[a]Key Laboratory of Ministry of Education for Advanced Materials in Tropical Island Resources, Hainan Provincial Key Laboratory of Fine Chemical, Hainan Provincial Fine Chemical Engineering Research Center, Hainan University, Haikou, 570228, China.
[b]Guizhou Institute for Food and Drug Control, 84 Shibei Road, Yunyan District, Guiyang City, Guizhou Province, 550000, China.

[*]E-mail: chentieqiao@hnu.edu.cn

Table of the contents

1. General Information 3

2. Optimization of Conditions for Reaction 4

3. Experimental Procedure 5

4. Gram-scale Reaction. 6

5. Measurement of Acyl Iodide by MALDI-TOF MS 7

6. Characterization of the products 8

7. References 23

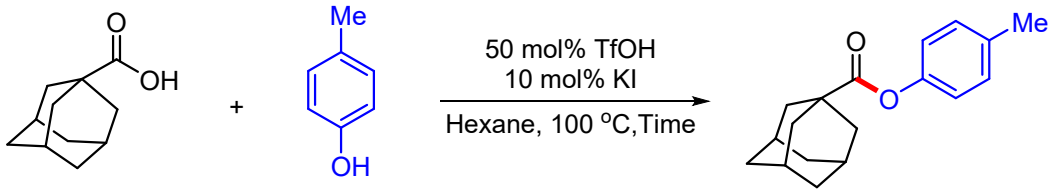
8. Copies of ^{1}H, ^{13}C and ^{19}F NMR Spectra of the Products 24

1. General Information

All experiments were carried out under nitrogen atmosphere using standard Schlenk techniques or in a dry glovebox. All heating (heating module) and stirring were conducted on the IKA (Model: RCT B S025). Solvents were dried over Na metal or CaH_2, and were distilled under nitrogen prior to use. All solvents and reagents were purchased from Tansoole, Meryer, Heowns, Energy Chemical, Alfa Aesar, and Aladdin. Column chromatography was performed using Silica Gel 60 (300-400 mesh). The reactions were monitored by GC and GC-MS, GC-MS data were recorded on GC-MS QP 2010 plus, and GC analysis was performed on GC 2014. The ^{1}H, ^{13}C and ^{19}F NMR spectra were recorded on a Bruker ADVANCE III spectrometer at 400 MHz, and 100 MHz respectively, and chemical shifts were reported in parts per million (ppm). The All solvents and reagents were purchased from Energy Chemical, Alfa Aesar, Heowns, Meryer and Aladdin.

2. Optimization of Conditions for Reaction

Competition experiments and time course experiments.[a]



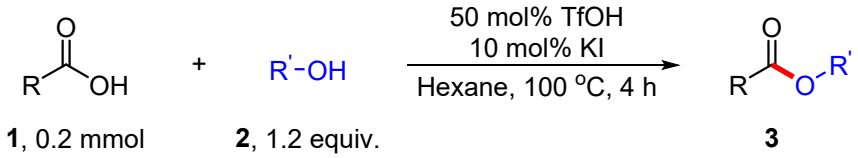
1a, 0.2 mmol **2a**, 1.2 equiv. **3a**

Entry	Time (h)	**3** Yield%[b]	**3** Yield%[b,c]
1	0.5	50	21
2	1.0	71	35
3	1.5	81	49
4	2.0	89	57
5	2.5	95	64
6	3.0	99	71
7	3.5	99	77
8	**4.0**	**99**	**71**

[a]Reaction conditions: **1a** (0.20 mmol), **2a** (0.24 mmol, 1.2 equiv), TfOH (0.10 mmol, 50 mol%), KI (0.02 mmol, 10 mol%), *n*-hexane (2 mL), 100 °C, N_2 atmosphere. [b]GC yield using tridecane as an internal standard. [c]No KI.

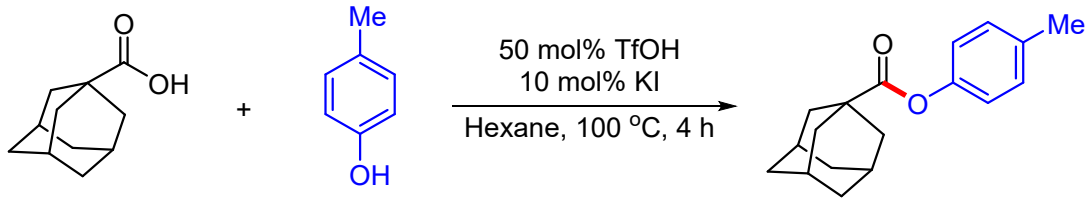
3. Experimental Procedure

General procedure for the esterification reaction:



An oven dried 25 mL Schlenk tube was charged with carboxylic acid **1** (0.20 mmol), phenol **2** (0.24 mmol, 1.2 equiv) and KI (0.02 mmol, 10 mol%). Subsequently, TfOH (0.10 mmol, 50 mol%) and *n*-hexane (2 mL) was added under N_2. The reaction mixture was allowed to react at 100 °C for 4 h. After completion of the reaction, the reaction mixture was then cooled down to room temperature, added by water (5 mL) and extracted with EtOAc (5 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under vacuo. Further purification by flash column chromatography on silica gel (eluting with petroleum ether/ethyl acetate= 50/1) provided the product **3**.

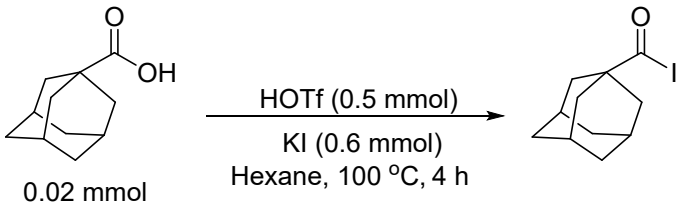
4. Gram-scale Reaction.



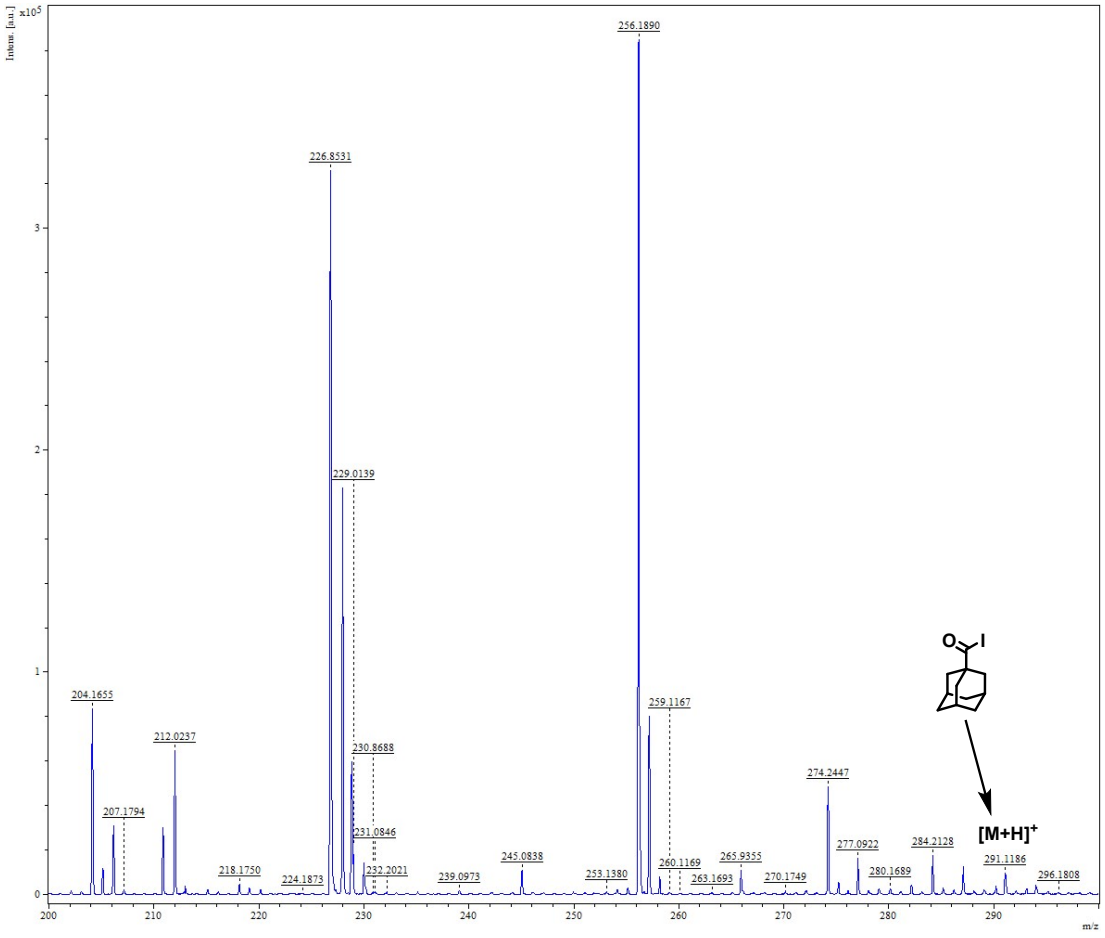
1a, 10 mmol **2a**, 1.2 equiv **3a**, 2.43 g yield 90%

An oven dried 250 mL Schlenk flask was charged with 1-adamantanecarboxylic acid **1a** (1.80 g, 10 mmol), *p*-cresol **2a** (1.30 g, 12 mmol) and KI (0.17 g, 1 mmol, 10 mol%). Subsequently, TfOH (0.75 g, 5 mmol, 50 mol%) and *n*-hexane (100 mL) was added under N_2. The reaction mixture was allowed to react at 100 °C for 4 h. After completion of the reaction, the reaction mixture was then cooled down to room temperature, added by water (30 mL) and extracted with EtOAc (30 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under vacuo. Further purification by flash column chromatography on silica gel (eluting with petroleum ether/ethyl acetate = 50/1) provided the product **3a** in 90% yield (2.43 g).

5. Measurement of Acyl Iodide by MALDI-TOF MS

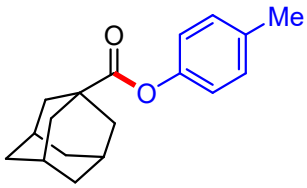


Experimental procedure: An oven dried 25 mL Schlenk tube was charged with carboxylic acid 1-adamantanecarboxylic acid **1a** (0.02 mmol), and KI (30 equiv). Subsequently, HOTf (25 equiv) and hexane (3 mL) was added under N_2, the reaction mixture was allowed to react at 100 °C for 4 h. After the completion of the reaction, the reaction mixture was cooled down to RT. Then, MeCN was added to dilute and dissolve the excess TfOH. The intermediate acyl iodide was determined by MALDI-TOF MS analysis using α-cyano-4-hydroxycinnamic acid (CHCA) as the matrix material.



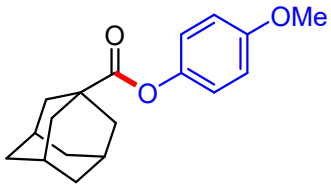
6. Characterization of the products

_p_-tolyl (3r,5r,7r)-adamantane-1-carboxylate (3a)



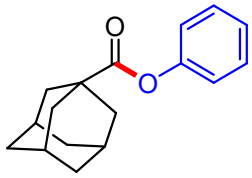
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3a** in 99% (53.4 mg) as a white solid, mp: 104-105 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.16 (d, J = 8.4 Hz, 2H), 6.93 (d, J = 8.0 Hz, 2H), 2.35 (s, 3H), 2.09-2.07 (m, 9H), 1.82-1.75 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.3, 148.8, 135.0, 129.8, 121.2, 40.9, 38.7, 36.4, 27.9, 20.8. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 271.1693; Found 271.1693.

4-methoxyphenyl (3r,5r,7r)-adamantane-1-carboxylate (3b)



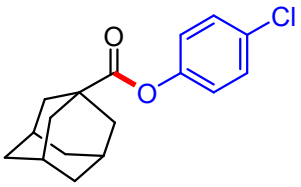
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound 3b in 90% (51.4 mg) as a white solid, mp: 64-65 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 6.95 (d, J = 8.8 Hz, 2H), 6.87 (d, J = 9.2 Hz, 2H), 3.79 (s, 3H), 2.08 (s, 3H), 2.05-2.04 (m, 9H), 1.80-1.73 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.5, 157.0, 144.5, 122.2, 114.4, 55.6, 40.9, 38.8, 36.4, 27.9. HRMS (APCI-TOF) m/z: [M + H]+ Calcd for $C_{18}H_{22}O_3$ 287.1642; Found 287.1641.

phenyl (3r,5r,7r)-adamantane-1-carboxylate (3c)



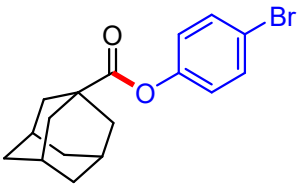
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound 3c in 88% (45.0 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.35 (dd, *J* = 7.2 Hz, 2H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.02 (d, *J* = 8.8 Hz, 2H), 2.07-2.04 (m, 9H), 1.79-1.92 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 176.2, 151.0, 129.3, 125.5, 121.5, 41.0, 38.7, 36.4, 27.9. HRMS (APCI-TOF) m/z: [M + H]+ Calcd for $C_{17}H_{20}O_2$ 257.1536; Found 257.1533.

4-chlorophenyl (3r,5r,7r)-adamantane-1-carboxylate (3d)



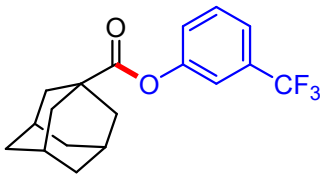
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound 3d in 83% (48.0 mg) as a white solid, mp: 79-80 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.32 (d, *J* = 8.8 Hz, 2H), 6.99 (d, *J* = 8.8 Hz, 2H), 2.08 (br, 3H), 2.04-2.03 (m, 6H), 1.80-1.73 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.9, 149.6, 130.8, 129.3, 122.9, 41.0, 38.7, 36.4, 27.8. HRMS (APCI-TOF) m/z: [M + H]+ Calcd for $C_{17}H_{19}ClO_2$ 291.1146; Found 291.1144.

4-bromophenyl (3r,5r,7r)-adamantane-1-carboxylate (3e)



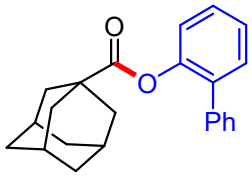
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3e** in 85% (56.5 mg) as a white solid, mp: 104-105 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 (d, *J* = 9.2 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 2.08 (br, 3H), 2.04-2.03 (m, 6H), 1.80-1.73 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.9, 150.1, 132.3, 123.4, 118.5, 41.0, 38.7, 36.4, 27.8. HRMS (APCI-TOF) m/z: [M + H]+ Calcd for $C_{17}H_{19}BrO_2$ 335.0641; Found 335.0640.

3-(trifluoromethyl)phenyl (3r,5r,7r)-adamantane-1-carboxylate (3f)



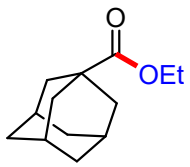
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3f** in 67% (43.1 mg) as a white solid, mp: 90-91 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.52-7.49 (m, 2H), 7.36 (s, 1H), 7.30-7.27 (m, 1H), 2.13-2.09 (m, 9H), 1.84-1.77 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.7, 151.2, 131.8 (q, $J_{C\text{-}F}$ = 32.7 Hz), 129.8, 125.2 (q, $J_{C\text{-}F}$ = 1.2 Hz), 123.6 (q, $J_{C\text{-}F}$ = 270.7 Hz), 122.3 (d, $J_{C\text{-}F}$ = 3.9 Hz), 118.9 (d, $J_{C\text{-}F}$ = 3.7 Hz), 41.1, 38.7, 36.4, 27.8. ^{19}F NMR (376 MHz, $CDCl_3$): δ -62.64. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{19}F_3O_2$ 325.1410; Found 325.1407.

[1,1'-biphenyl]-2-yl (3r,5r,7r)-adamantane-1-carboxylate (3g)



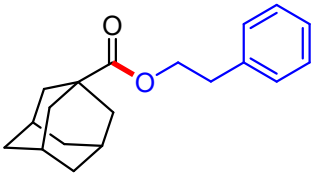
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3g** in 90% (59.5 mg) as a white soild, mp: 108-109 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.33 (m,, 7H), 7.30 (dd, J = 7.2, 1.2 Hz, 1H), 7.07 (dd, J = 8.0, 1.2 Hz, 1H), 1.99 (br, 3H), 1.81 (m 6H), 1.73-1.64 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.9, 148.1, 137.5, 135.2, 130.8, 129.2, 128.4, 128.0, 127.3, 125.9, 122.8, 40.8, 38.5, 36.4, 27.8. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{23}H_{24}O_2$ 333.1849; Found 333.1848.

ethyl (3r,5r,7r)-adamantane-1-carboxylate (3h)



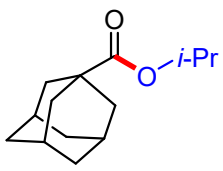
An oven dried 25 mL Schlenk tube was charged with carboxylic acid **1a** (0.20 mmol), ethanol **2h** (0.30 mmol, 1.5 equiv) and KI (0.02 mmol, 10 mol%). Subsequently, TfOH (0.10 mmol, 50 mol%) and *n*-hexane (2 mL) was added under N_2. The reaction mixture was allowed to react at 100 °C for 4 h. After completion of the reaction, the reaction mixture was then cooled down to room temperature, added by water (5 mL) and extracted with EtOAc (5 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under vacuo. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3h** in 80% (33.0 mg) as a yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.10 (q, *J* = 7.2 Hz, 2H), 2.00 (br, 3H), 1.87-1.86 (m, 6H), 1.73-1.66 (m, 6H), 1.22 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.7, 60.0, 40.5, 38.8, 36.5, 27.9, 14.2. This compound is known.[1]

phenethyl (3r,5r,7r)-adamantane-1-carboxylate (3i)



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3i** in 99% (56.0 mg) as a yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.30 (dd, *J* = 8.0 Hz, 2H), 7.24-7.21 (m, 3H), 4.26 (t, *J* = 7.2 Hz, 2H), 2.93 (t, *J* = 6.8 Hz, 2H), 2.00 (br, 3H), 1.85-1.84 (m, 6H), 1.74-1.66 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.6, 138.0, 129.0, 128.4, 126.4, 64.6, 40.6, 38.8, 36.5, 35.2, 27.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 285.1849; Found 285.1847.

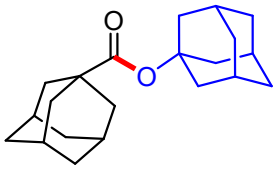
isopropyl (3r,5r,7r)-adamantane-1-carboxylate (3j)



An oven dried 25 mL Schlenk tube was charged with carboxylic acid **1a** (0.20 mmol), isopropyl alcohol **2i** (0.30 mmol, 1.5 equiv) and KI (0.02 mmol, 10 mol%). Subsequently, TfOH (0.10 mmol,

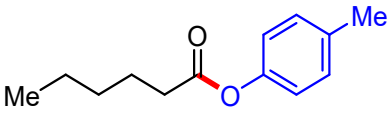
50 mol%) and *n*-hexane (2 mL) was added under N_2. The reaction mixture was allowed to react at 100 °C for 4 h. After completion of the reaction, the reaction mixture was then cooled down to room temperature, added by water (5 mL) and extracted with EtOAc (5 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated under vacuo. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3j** in 78% (34.4 mg) as a yellow liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.00-4.90 (m, 1H), 2.00 (br, 3H), 1.86-1.85 (m, 6H), 1.73-1.66 (m, 6H), 1.19 (d, J = 6.0 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.2, 66.8, 40.5, 38.7, 36.5, 28.0, 21.7. This compound is known.[2]

(3S,5S,7S)-adamantan-1-yl (3R,5R,7R)-adamantane-1-carboxylate (3k)



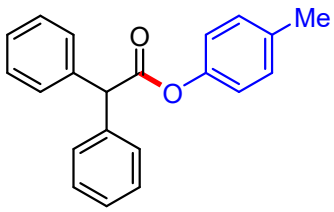
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 25/1) provided the title compound **3k** in 62% (38.5 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.15-1.99 (m, 8H), 1.83-1.60 (m, 14H), 1.42-1.26 (m, 8H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.0, 79.3, 41.3, 41.1, 38.9, 36.6, 36.3, 30.8, 28.1. This compound is known.[3]

***p*-tolyl hexanoate (3l)**



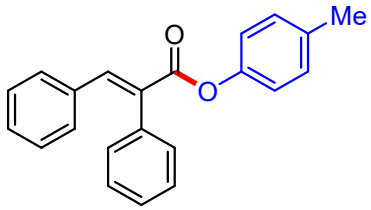
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3l** in 55% (22.4 mg) as a colourless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.16 (d, J = 8.0 Hz, 2H), 6.95 (d, J = 8.4 Hz, 2H), 2.53 (t, J = 7.2 Hz, 2H), 2.34 (s, 3H), 1.79-1.72 (m, 2H), 1.42-1.35 (m, 4H), 0.93 (t, J = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 172.5, 148.5, 135.3, 129.9, 121.2, 34.4, 31.3, 24.6, 22.3, 20.8, 13.9. This compound is known.[4]

***p*-tolyl 2,2-diphenylacetate (3m)**



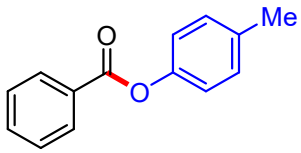
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3m** in 80% (48.1 mg) as a white solid, mp: 97-98 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.45-7.42 (m, 4H), 7.40-7.36 (m, 4H), 7.33-7.29 (m, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.96 (d, *J* = 8.4 Hz, 2H), 5.27 (s, 1H), 2.34 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 171.1, 148.5, 138.2, 135.5, 129.8, 128.7, 128.6, 127.4, 121.0, 57.0, 20.8. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 303.1380; Found 303.1379.

***p*-tolyl (*E*)-2,3-diphenylacrylate (3n)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3n** in 85% (53.1 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.06 (s, 1H), 7.43-7.40 (m, 3H), 7.37-7.35 (m, 2H), 7.28-7.19 (m, 5H), 7.13 (d, *J* = 7.2 Hz, 2H), 7.06 (d, *J* = 8.4 Hz, 2H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.5, 148.9, 141.8, 135.5, 135.3, 134.4, 132.0, 130.7, 129.8, 129.8, 129.3, 128.7, 128.2, 128.0, 121.2, 20.8. This compound is known.[5]

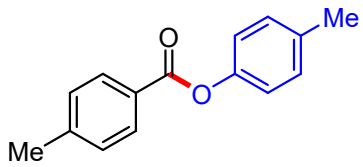
***p*-tolyl benzoate (3o)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the

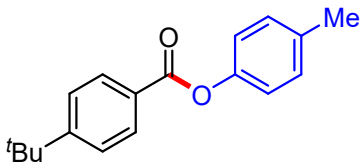
title compound **3o** in 85% (35.9 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.21 (d, *J* = 6.8 Hz, 2H), 7.64 (t, *J* = 7.2 Hz, 1H), 7.51 (dd, *J* = 8.0 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 8.4 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.4, 148.7, 135.5, 133.5, 130.1, 130.0, 129.7, 128.5, 121.4, 20.9. This compound is known.[6]

***p*-tolyl 4-methylbenzoate (3p)**



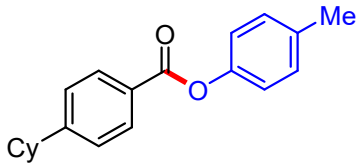
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3p** in 80% (35.9 mg) as a white solid, mp: 91-92 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.09 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.09 (d, *J* = 8.4 Hz, 2H), 2.45 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.4, 148.8, 144.3, 135.4, 130.2, 123.0, 129.2, 126.9, 121.4, 21.7, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{15}H_{14}O_2$ 227.1067; Found 227.1066.

***p*-tolyl 4-(tert-butyl)benzoate (3q)**



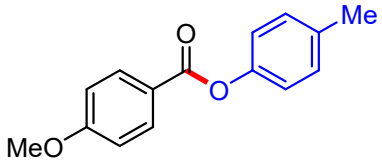
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3q** in 70% (37.2 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.13 (d, *J* = 8.8 Hz, 2H), 7.53 (d, *J* = 8.8 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 2.38 (s, 3H), 1.37 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.4, 157.3, 148.8, 135.4, 130.0, 129.9, 126.8, 125.5, 121.4, 35.2, 31.1, 20.9. This compound is known.[7]

***p*-tolyl 4-cyclohexylbenzoate (3r)**



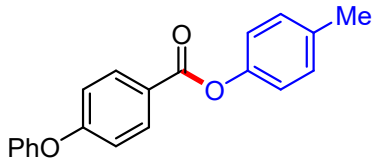
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3r** in 72% (42.0 mg) as a white solid, mp: 108-109 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.12 (d, *J* = 8.4 Hz, 2H), 7.34 (d, *J* = 8.4 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 2H), 7.07 (d, *J* = 8.4 Hz, 2H), 2.63-2.56 (m, 1H), 2.37 (s, 3H), 1.92-1.76 (m, 5H), 1.48-1.28 (m, 5H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.4, 154.2, 148.8, 135.4, 130.3, 130.0, 127.2, 127.0, 121.4, 44.8, 34.1, 26.7, 26.0, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 295.1693; Found 295.1691.

***p*-tolyl 4-methoxybenzoate (3s)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3s** in 81% (39.1 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.17 (d, *J* = 8.8 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 8.4 Hz, 2H), 6.99 (d, *J* = 8.8 Hz, 2H), 3.89 (s, 3H), 2.83 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.0, 163.7, 148.7, 135.2, 132.2, 129.9, 121.9, 121.4, 113.7, 55.4, 20.8. This compound is known.[7]

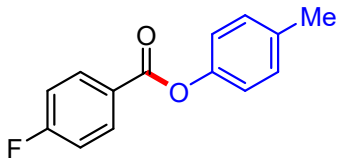
***p*-tolyl 4-phenoxybenzoate (3t)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3t** in 74% (44.5 mg) as a white solid, mp: 113-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.16 (d, *J* = 8.8 Hz, 2H), 7.41 (dd, *J* = 7.6 Hz, 2H), 7.23-7.20 (m, 3H), 7.11-7.03 (m, 6H), 2.37 (s,

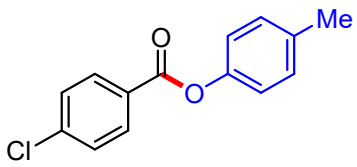
3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.9, 162.3, 155.5, 148.7, 135.4, 132.3, 130.1, 130.0, 124.6, 123.8, 121.4, 120.2, 117.3, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 305.1172; Found 305.1169.

***p*-tolyl 4-fluorobenzoate (3u)**



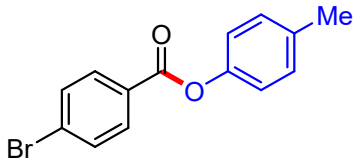
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3u** in 75% (34.4 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.21 (dd, J = 8.8, 5.6 Hz, 2H), 7.23-7.15 (m, 4H), 7.08 (d, J = 8.4 Hz, 2H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.0 (d, $J_{C\text{-}F}$ = 253.2 Hz), 164.4, 148.5, 135.6, 132.7 (d, $J_{C\text{-}F}$ = 9.4 Hz), 130.0, 125.8 (d, $J_{C\text{-}F}$ = 2.8 Hz), 121.2, 115.7 (d, $J_{C\text{-}F}$ = 21.9 Hz), 20.8. ^{19}F NMR (377 MHz, $CDCl_3$): δ -78.29. This compound is known.[7]

***p*-tolyl 4-chlorobenzoate (3v)**



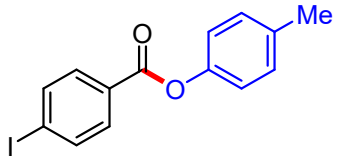
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3v** in 67% (32.5 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.13 (d, J = 8.8 Hz, 2H), 7.48 (d, J = 8.4 Hz, 2H), 7.23 (d, J = 8.4 Hz, 2H), 7.08 (d, J = 8.4 Hz, 2H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.5, 148.5, 140.0, 135.7, 131.5, 130.0, 128.9, 128.1, 121.2, 20.9. This compound is known.[7]

***p*-tolyl 4-bromobenzoate (3w)**



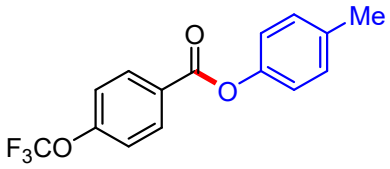
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3w** in 60% (34.4 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.06 (d, *J* = 8.4 Hz, 2H), 7.65 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.7, 148.5, 135.7, 131.9, 131.6, 130.0, 128.7, 128.6, 121.2, 20.9. This compound is known.[7]

***p*-tolyl 4-iodobenzoate (3x)**



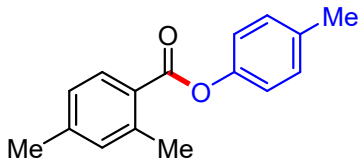
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3x** in 67% (44.9 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.91-7.86 (m, 4H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.9, 148.5, 137.9, 135.7, 131.5, 130.0, 129.2, 121.2, 101.4, 20.9. This compound is known.[8]

***p*-tolyl 4-(trifluoromethoxy)benzoate (3y).**



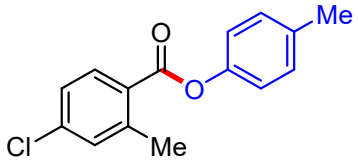
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3y** in 70% (41.2 mg) as a white solid, mp: 120-121 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.26 (d, *J* = 8.8 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.4 Hz, 2H), 7.10 (d, *J* = 8.4 Hz, 2H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.1, 153.0, 148.5, 135.7, 132.1, 130.0, 128.1, 121.2, 120.3, 120.3 (q, $J_{C\text{-}F}$ = 257.3 Hz), 20.8. ^{19}F NMR (376 MHz, $CDCl_3$): δ -57.37. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 297.0733; Found 297.0731.

***p*-tolyl 2,4-dimethylbenzoate (3z)**



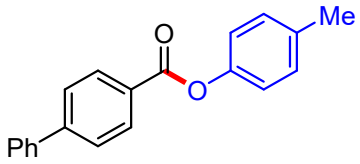
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3z** in 71% (33.9 mg) as a white solid, mp: 85-86 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.07 (d, *J* = 8.4 Hz, 1H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.13-7.12 (m, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 2.64 (s, 3H), 2.40 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.0, 148.7, 143.3, 141.4, 135.3, 132.7, 131.3, 129.9, 126.6, 125.7, 121.5, 21.9, 21.5, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{16}H_{16}O_2$ 241.1196; Found 241.1195.

***p*-tolyl 4-chloro-2-methylbenzoate (3aa)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3aa** in 65% (33.6 mg) as a white solid, mp: 95-96 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.44 (d, *J* = 8.0 Hz, 1H), 7.65-7.63 (m, 2H), 7.57 (d, *J* = 8.0 Hz, 2H), 7.42 (d, *J* = 8.4 Hz, 2H), 2.99 (s, 3H), 2.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.2, 148.4, 143.3, 138.7, 135.6, 132.6, 131.8, 130.0, 127.0, 126.1, 121.4, 21.8, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 261.0677; Found 261.0673.

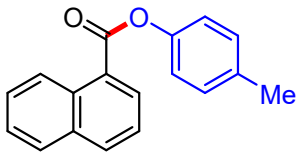
***p*-tolyl [1,1'-biphenyl]-4-carboxylate (3ab)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 50/1) provided the title compound **3ab** in 79% (45.0 mg) as a white solid, mp: 128-129 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.29 (d, *J* = 8.8 Hz, 2H), 7.75 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 7.2 Hz, 2H), 7.51 (dd, *J* =

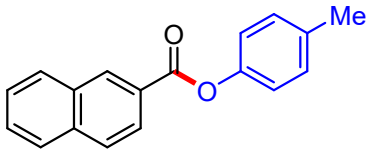
6.8 Hz, 2H), 7.44 (t, *J* = 7.2 Hz, 1H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.14 (d, *J* = 8.4 Hz, 2H), 2.41 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.2, 148.7, 146.2, 139.8, 135.5, 130.6, 130.0, 128.9, 128.3, 128.2, 127.3, 127.1, 121.3, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{16}O_2$ 289.1223; Found 289.1221.

***p*-tolyl 1-naphthoate (3ac)**



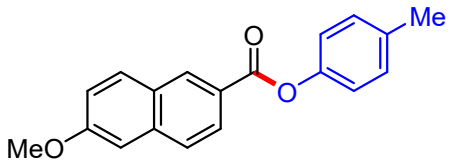
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ac** in 76% (39.7 mg) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.03 (d, *J* = 8.4 Hz, 1H), 8.46 (d, *J* = 7.2 Hz, 1H), 8.10 (d, *J* = 8.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.64 (dd, *J* = 7.2 Hz, 1H), 7.59-7.55 (m, 2H), 7.26 (d, *J* = 8.4 Hz, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 2.40 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.0, 148.7, 135.6, 134.2, 133.9, 131.7, 131.1, 130.0, 128.6, 128.1, 126.4, 126.0, 125.8, 124.5, 121.5, 20.9. This compound is known.[7]

***p*-tolyl 2-naphthoate (3ad)**



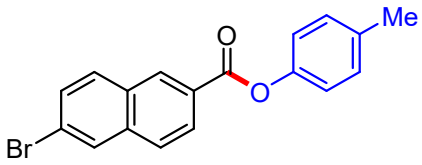
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ad** in 80% (41.5 mg) as a white solid. ^{1}H NMR (400 MHz, CDCl3): δ 8.79 (s, 1H), 8.20 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.00 (d, *J* = 8.0 Hz, 1H), 7.96-7.91 (m, 2H), 7.65-7.55 (m, 2H), 7.25 (d, *J* = 7.2 Hz, 2H), 7.15 (d, *J* = 8.4 Hz, 2H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.6, 148.8, 135.8, 135.5, 132.5, 131.8, 130.0, 129.5, 128.6, 128.3, 127.8, 126.9, 126.8, 125.5, 121.4, 20.9. This compound is known.[7]

***p*-tolyl 6-methoxy-2-naphthoate (3ae)**



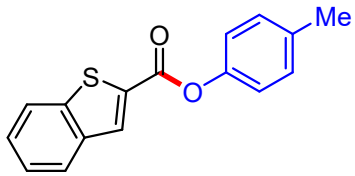
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ae** in 75% (43.1 mg) as a white solid, mp: 96-97 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.70 (s, 1H), 8.16 (dd, J = 8.4, 1.2 Hz, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.82 (d, J = 8.4 Hz, 1H), 7.25-7.19 (m, 4H), 7.13 (d, J = 8.4 Hz, 2H), 3.97 (s, 3H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.7, 159.8, 148.8, 137.5, 135.4, 131.6, 131.0, 130.0, 127.9, 127.0, 126.2, 124.6, 121.4, 119.8, 105.7, 55.4, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 293.1172; Found 293.1172.

***p*-tolyl 6-bromo-2-naphthoate (3af)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3af** in 65% (43.8 mg) as a white solid, mp: 101-102 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.21 (d, J = 8.8 Hz, 1H), 8.08 (s, 1H), 7.86-7.83 (m, 2H), 7.64 (d, J = 8.8 Hz, 1H), 7.24 (d, J = 8.0 Hz, 2H), 7.13 (d, J = 8.0 Hz, 2H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.2, 148.7, 136.6, 135.6, 131.7, 130.9, 130.9, 130.3, 130.0, 130.0, 127.4, 127.3, 126.6, 123.0, 121.3, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 341.0172; Found 341.0171.

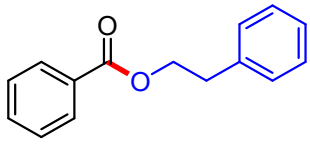
***p*-tolyl benzo[b]thiophene-2-carboxylate (3ag)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ag** in 60% (31.8 mg) as a white solid, mp: 76-77 °C. ^{1}H NMR (400 MHz,

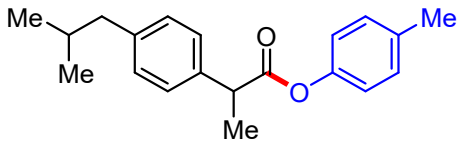
$CDCl_3$): δ 8.25 (s, 1H), 7.94-7.90 (m, 2H), 7.52-7.42 (m, 2H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.14 (d, *J* = 8.4 Hz, 2H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 161.4, 148.3, 142.6, 138.6, 135.8, 132.8, 131.8, 130.0, 127.2, 125.7, 125.0, 122.8, 121.2, 20.9. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 269.0631; Found 269.0630.

phenethyl benzoate(3ah)



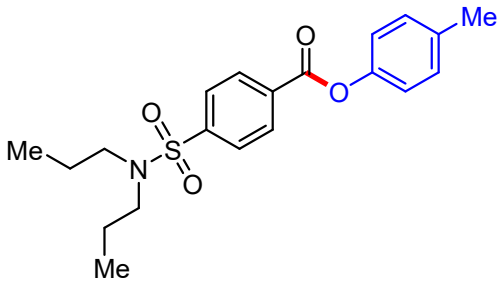
The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ah** in 90% (40.5 mg) as a colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.03 (d, *J* = 7.2 Hz, 2H), 7.56 (t, *J* = 7.6 Hz, 1H), 7.44 (dd, *J* = 8.0 Hz, 2H), 7.36-7.24 (m, 5H), 4.54 (t, *J* = 6.8 Hz, 2H), 3.09 (t, *J* = 6.8 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.5, 137.9, 132.9, 130.2, 129.5, 128.9, 128.5, 128.3, 126.6, 65.4, 35.2. This compound is known.[9]

***p*-tolyl 2-(4-isobutylphenyl)propanoate (3ai)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3ai** in 71% (41.7 mg) as a colourless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.30 (d, *J* = 8.0 Hz, 2H), 7.15-7.11 (m, 4H), 6.87 (d, *J* = 8.4 Hz, 2H), 3.92 (q, *J* = 7.2 Hz, 1H), 2.48 (d, *J* = 7.2 Hz, 2H), 2.32 (s, 3H), 1.92-1.82 (m, 1H), 1.60 (d, *J* = 7.2 Hz, 3H), 0.92 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 173.4, 148.6, 140.7, 137.3, 135.3, 129.8, 129.5, 127.2, 121.0, 45.2, 45.0, 30.2, 22.4, 20.8, 18.6. This compound is known.[10]

***p*-tolyl 4-(*N*,*N*-dipropylsulfamoyl)benzoate (3aj)**



The representative general procedure mentioned above was followed. Purification by preparative thin-layer chromatography (PTLC) on silica gel (petroleum ether/ethyl acetate = 100/1) provided the title compound **3aj** in 65% (48.6 mg) as a colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.31 (d, J = 8.4 Hz, 2H), 7.94 (d, J = 8.4 Hz, 2H), 7.24 (d, J = 8.4 Hz, 2H), 7.10 (d, J = 8.4 Hz, 2H), 3.13 (t, J = 7.6 Hz, 4H), 2.38 (s, 3H), 1.59-1.52 (m, 4H), 0.88 (t, J = 7.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.1, 148.4, 144.8, 136.0, 133.0, 130.8, 130.1, 127.1, 121.1, 49.9, 21.9, 20.9, 11.2. HRMS (APCI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{22}O_2$ 376.1577; Found 376.1577.

7. References

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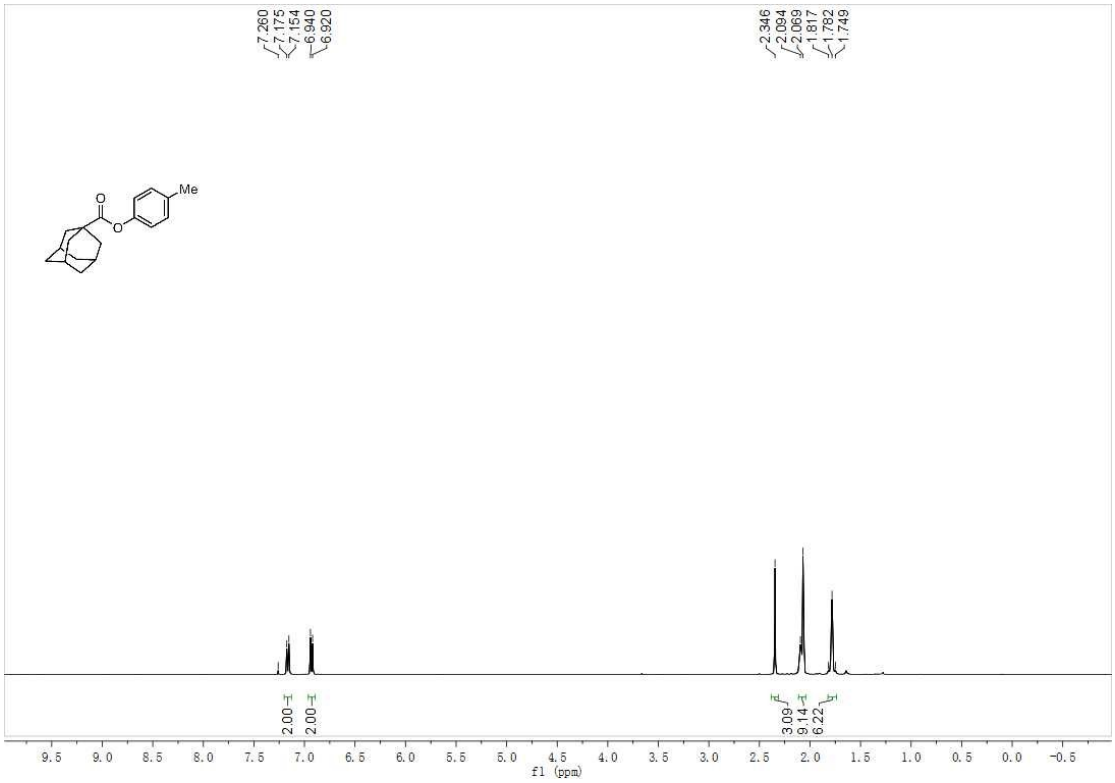
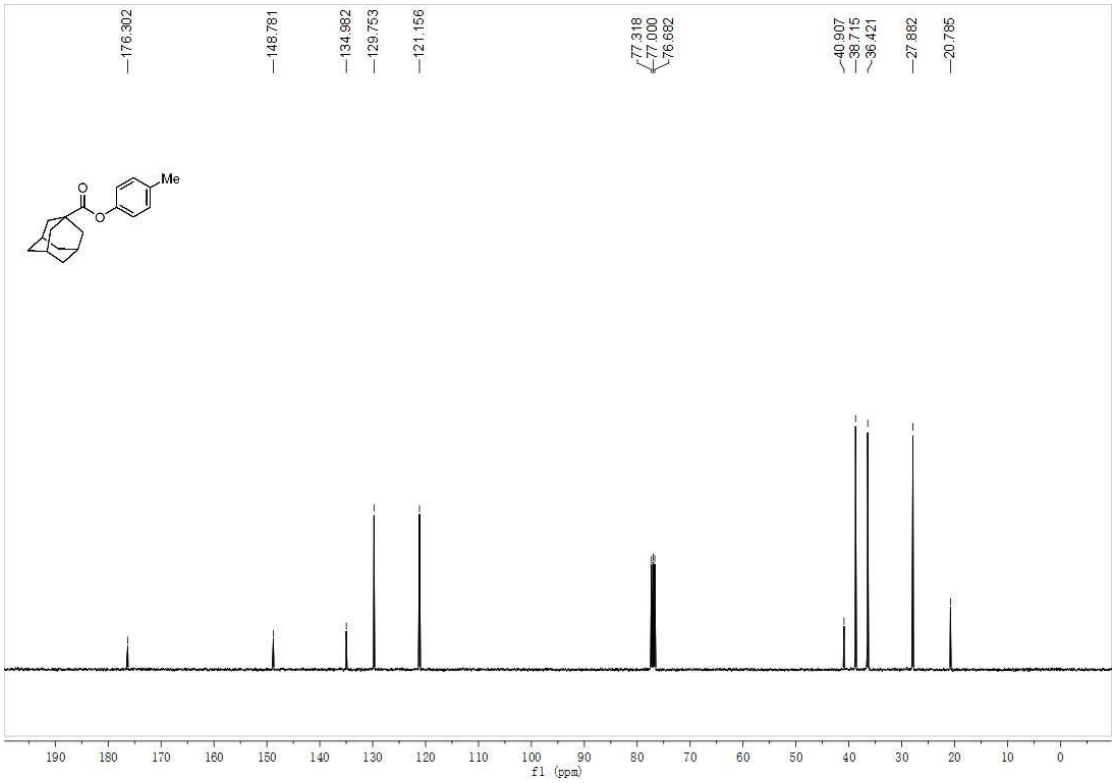
8. Copies of ^{1}H, ^{13}C and ^{19}F NMR Spectra of the Products

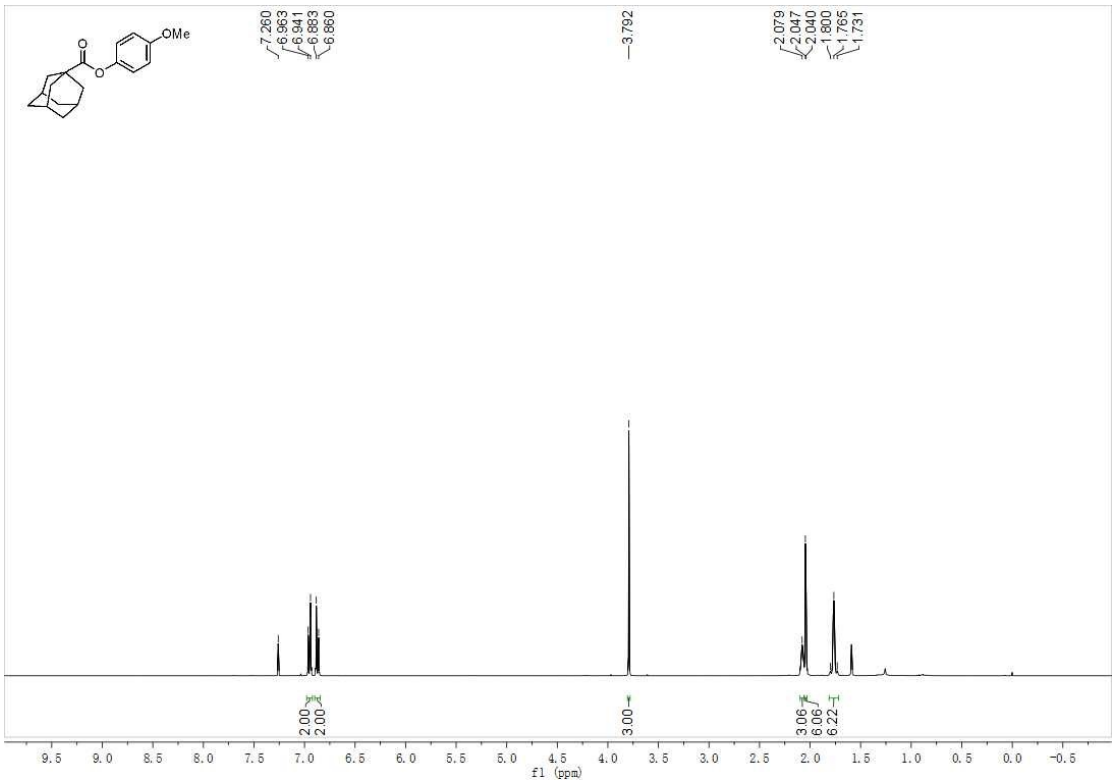
^{1}H NMR of compound **3a** (400 MHz, $CDCl_3$).



^{13}C NMR of compound **3a** (100 MHz, $CDCl_3$).

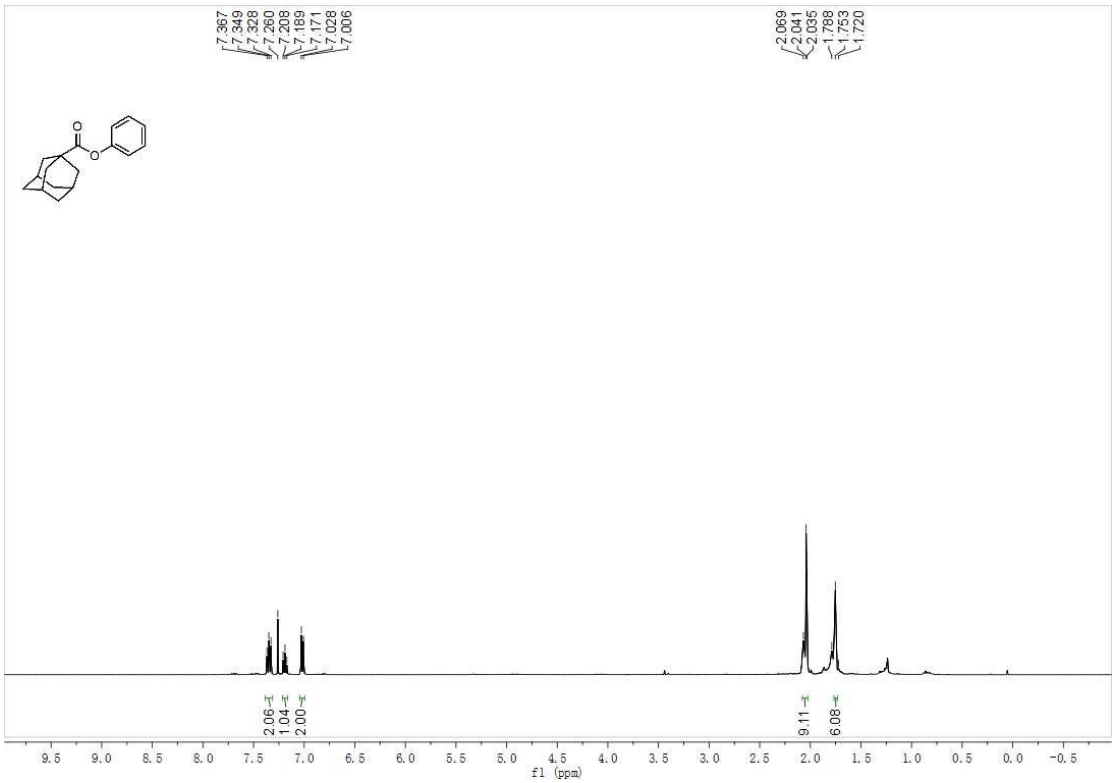


^{1}H NMR of compound **3b** (400 MHz, $CDCl_3$).

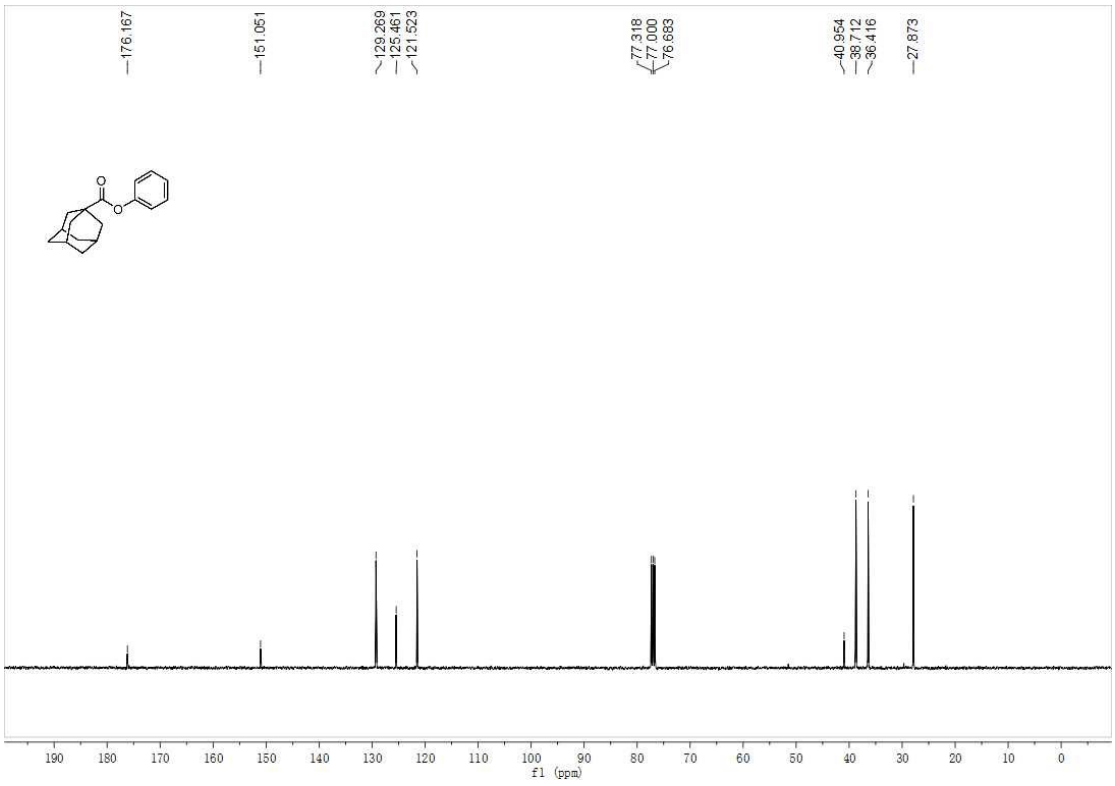


^{13}C NMR of compound **3b** (100 MHz, $CDCl_3$).

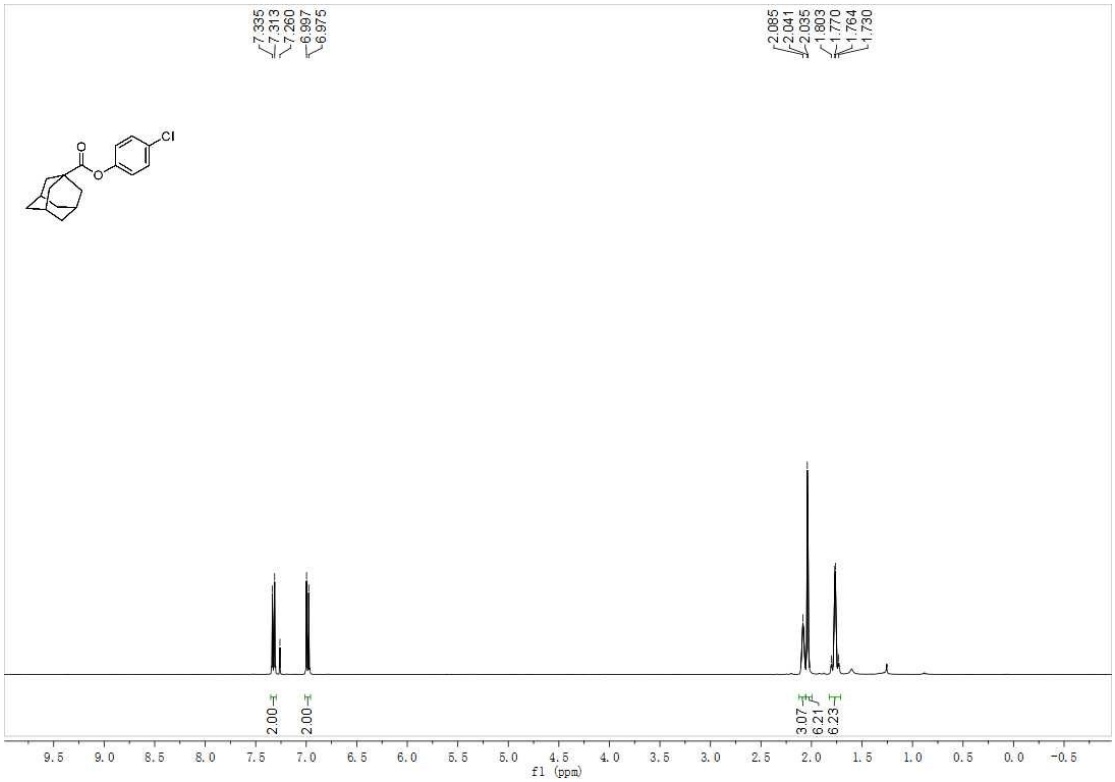
^{1}H NMR of compound **3c** (400 MHz, $CDCl_3$).



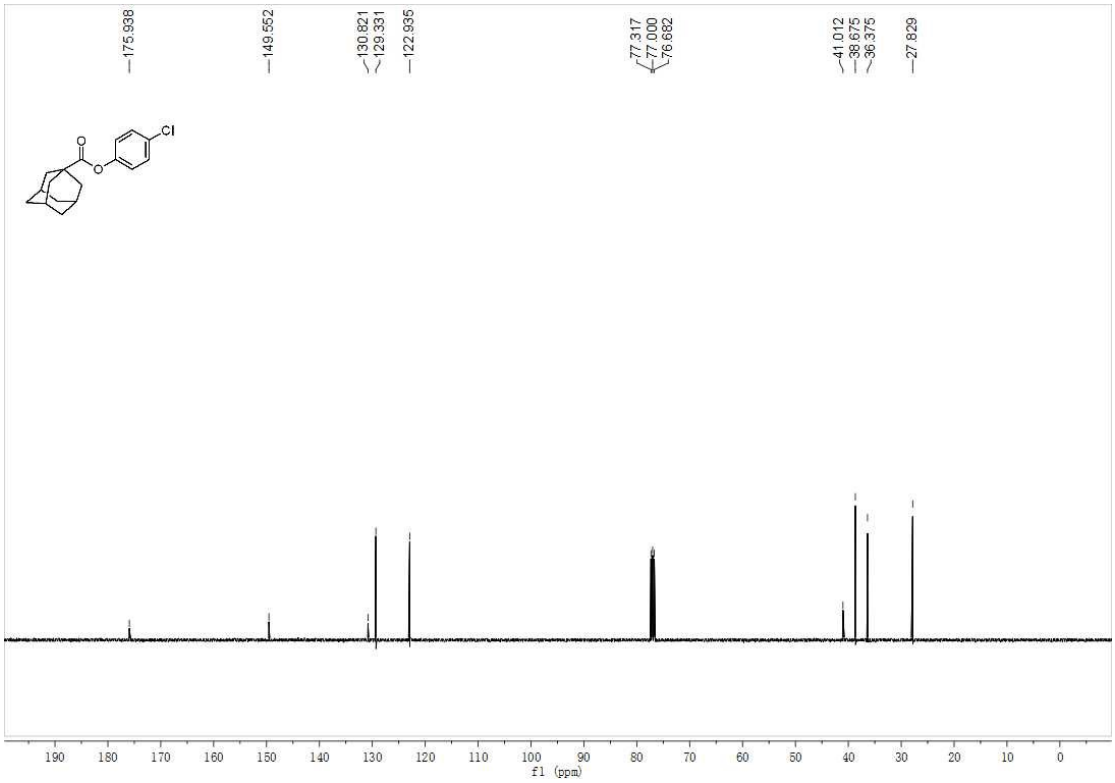
^{13}C NMR of compound **3c** (100 MHz, $CDCl_3$).



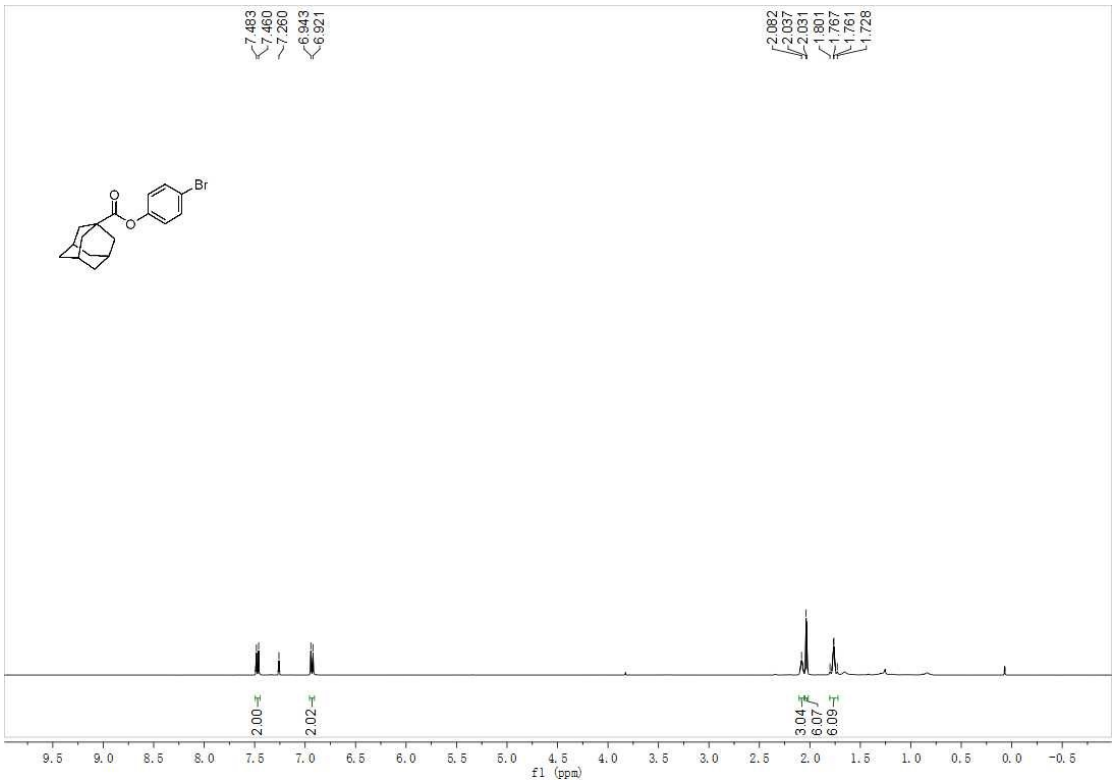
^{1}H NMR of compound **3d** (400 MHz, $CDCl_3$).



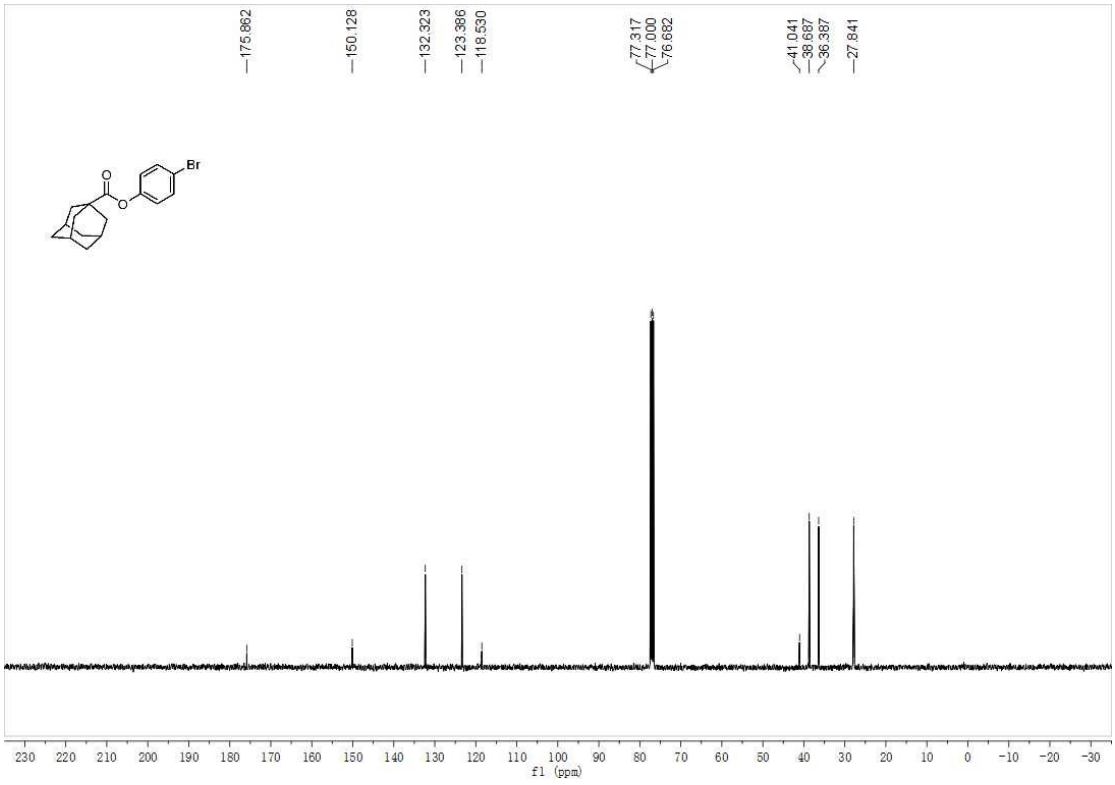
^{13}C NMR of compound **3d** (100 MHz, $CDCl_3$).



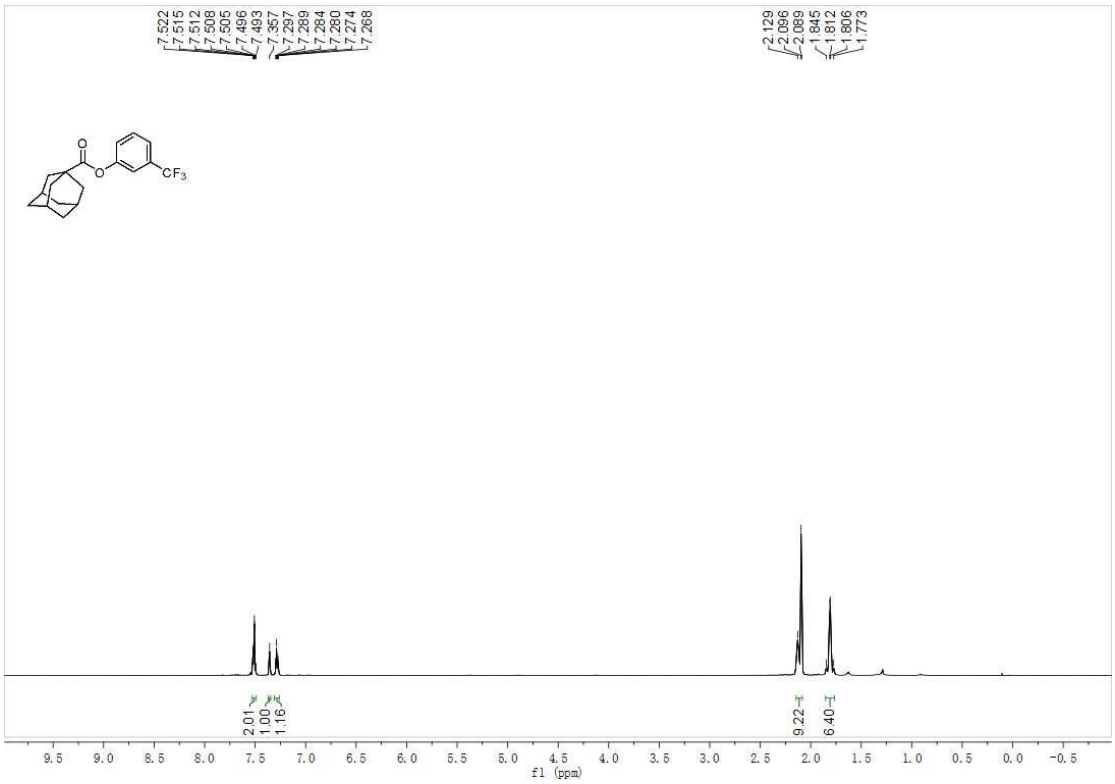
^{1}H NMR of compound **3e** (400 MHz, $CDCl_3$).



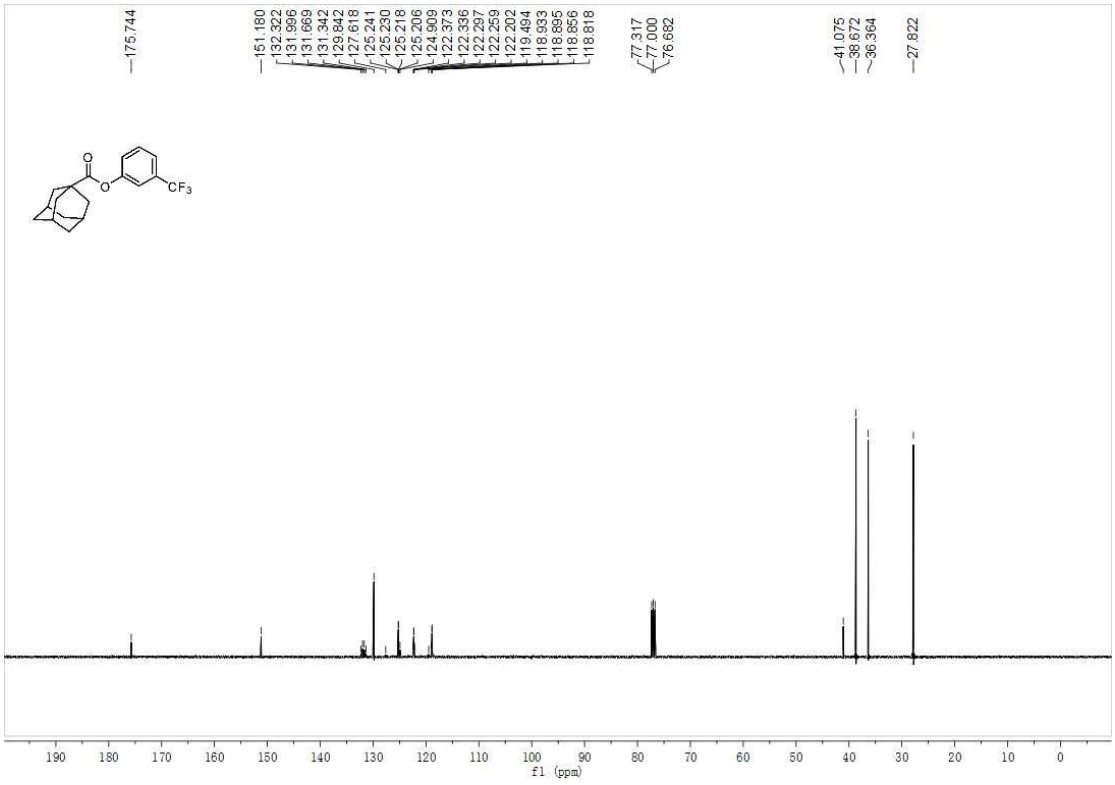
^{13}C NMR of compound **3e** (100 MHz, $CDCl_3$).



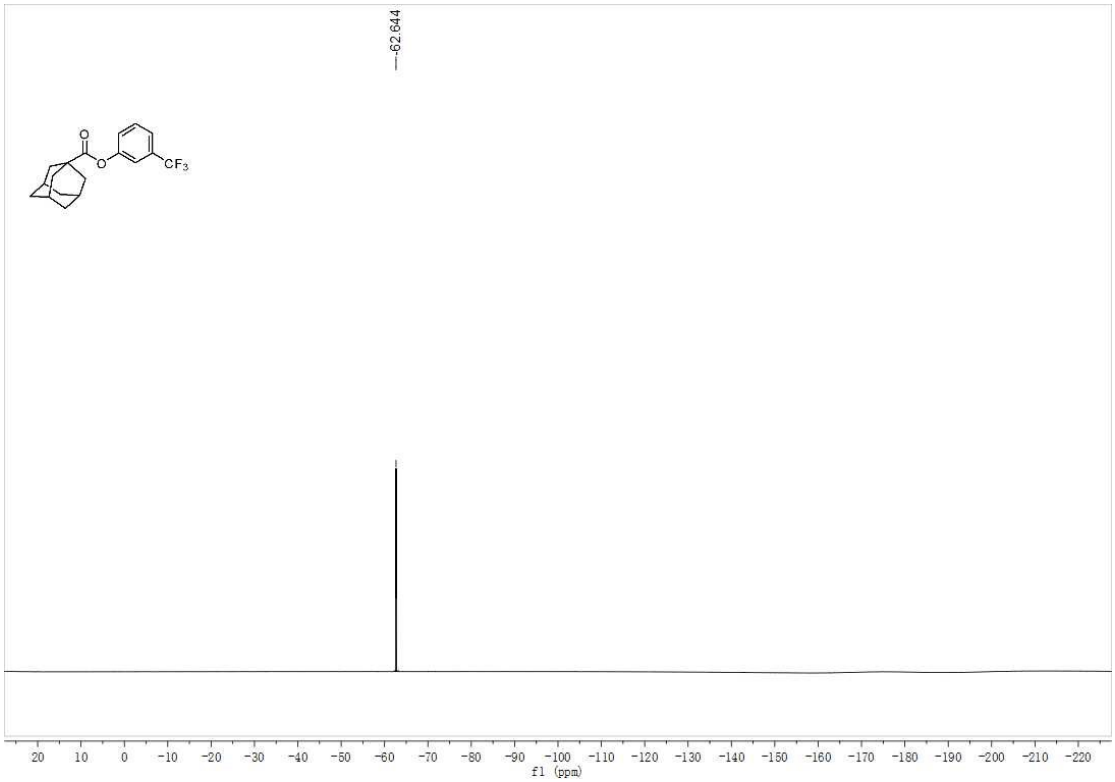
^{1}H NMR of compound **3f** (400 MHz, $CDCl_3$).



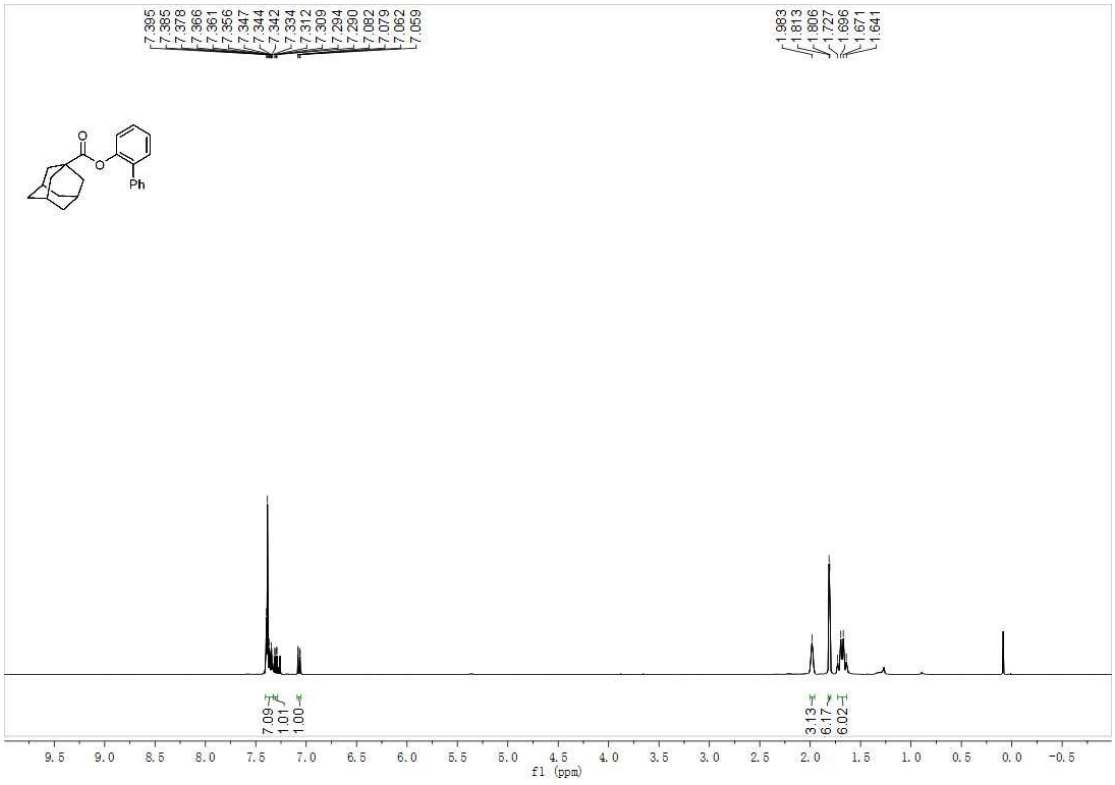
^{13}C NMR of compound **3f** (100 MHz, $CDCl_3$).



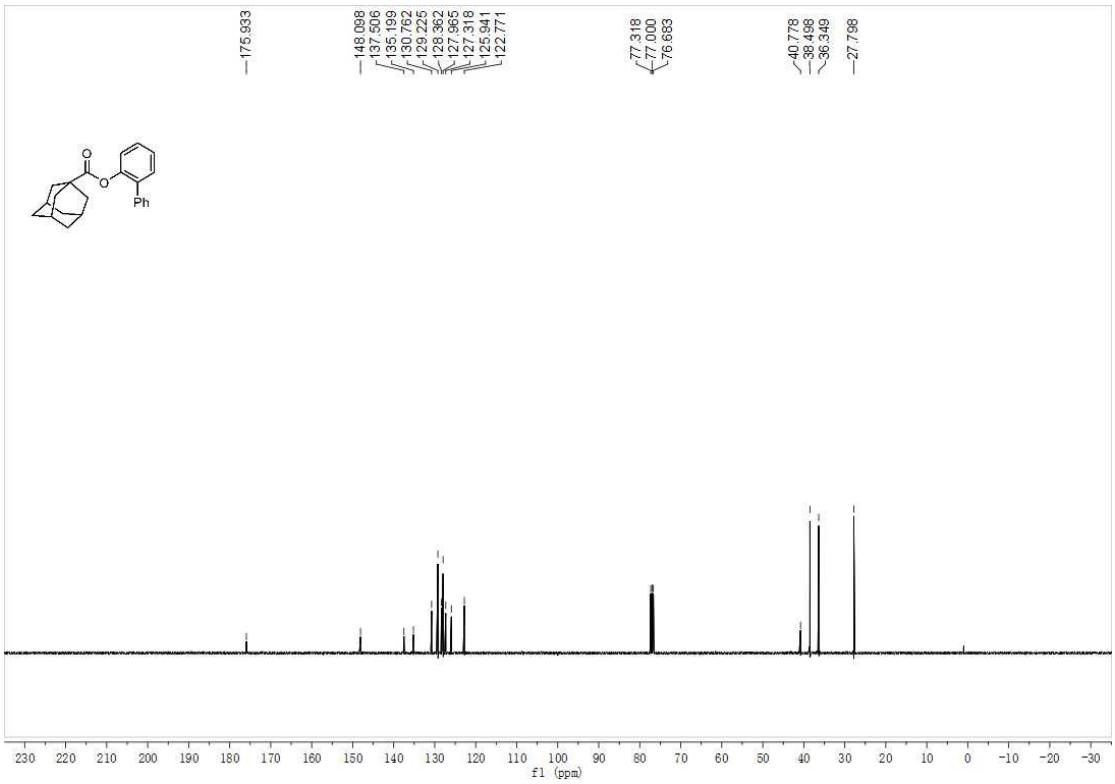
^{19}F NMR of compound **3f** (376 MHz, $CDCl_3$).



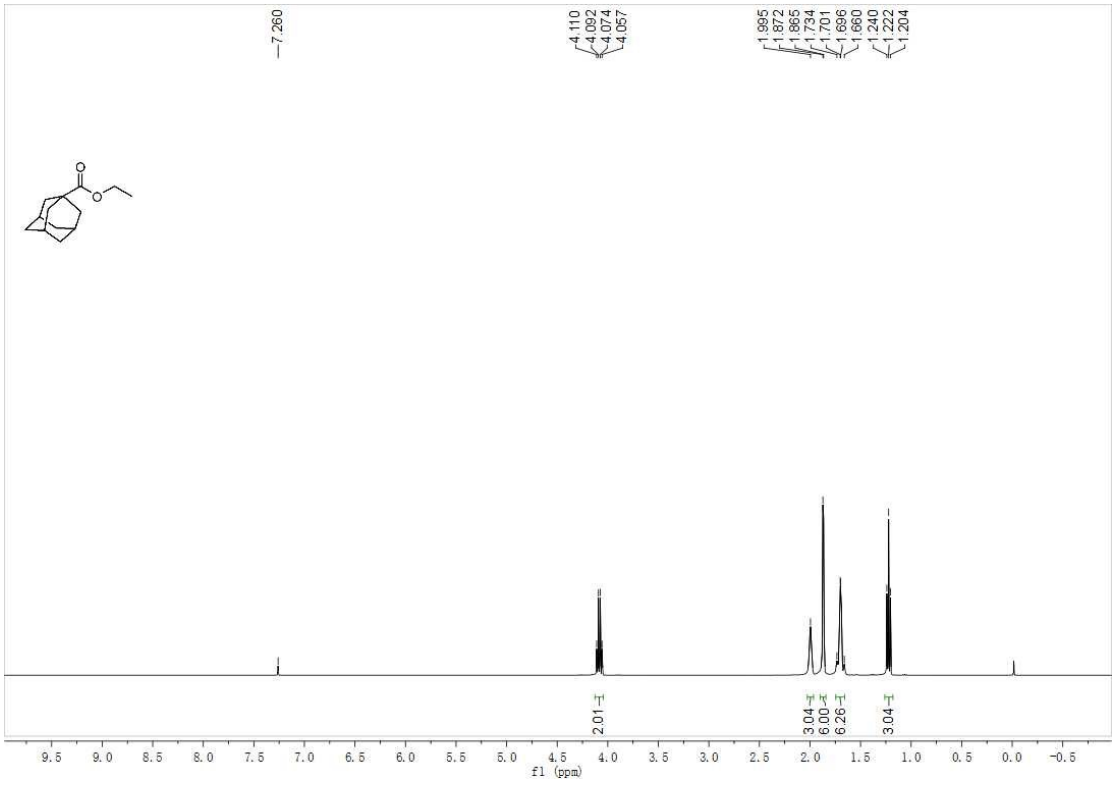
^{1}H NMR of compound **3g** (400 MHz, $CDCl_3$).



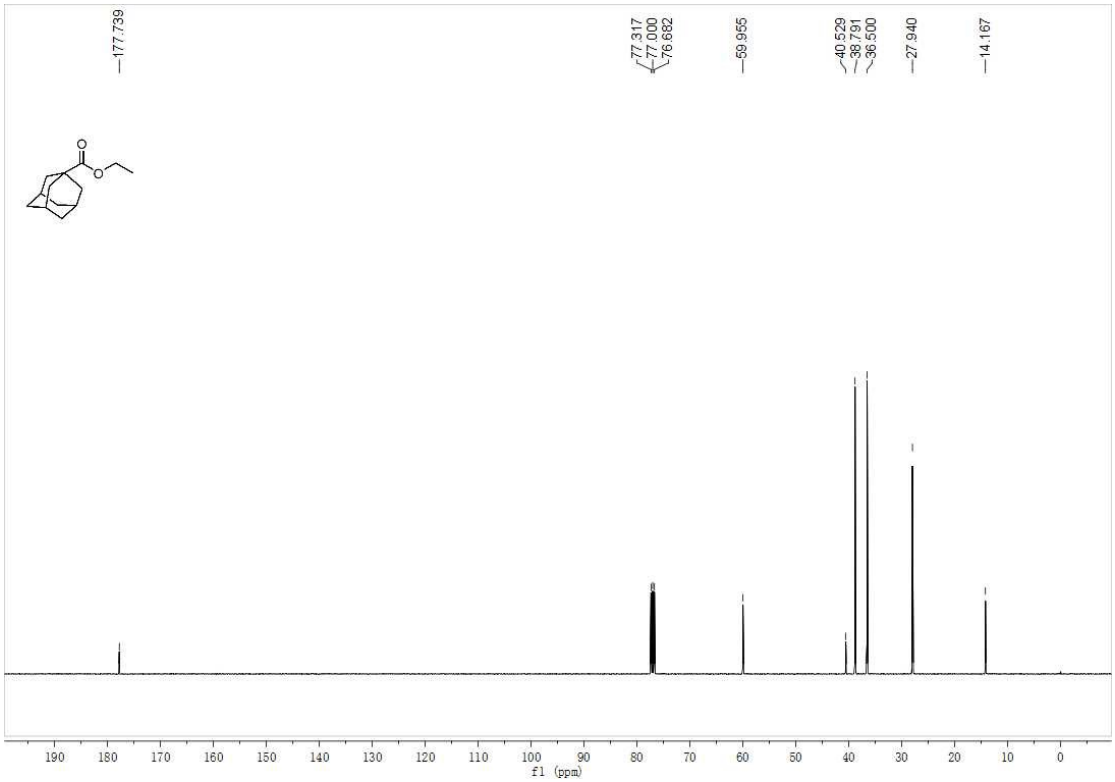
^{13}C NMR of compound **3g** (100 MHz, $CDCl_3$).



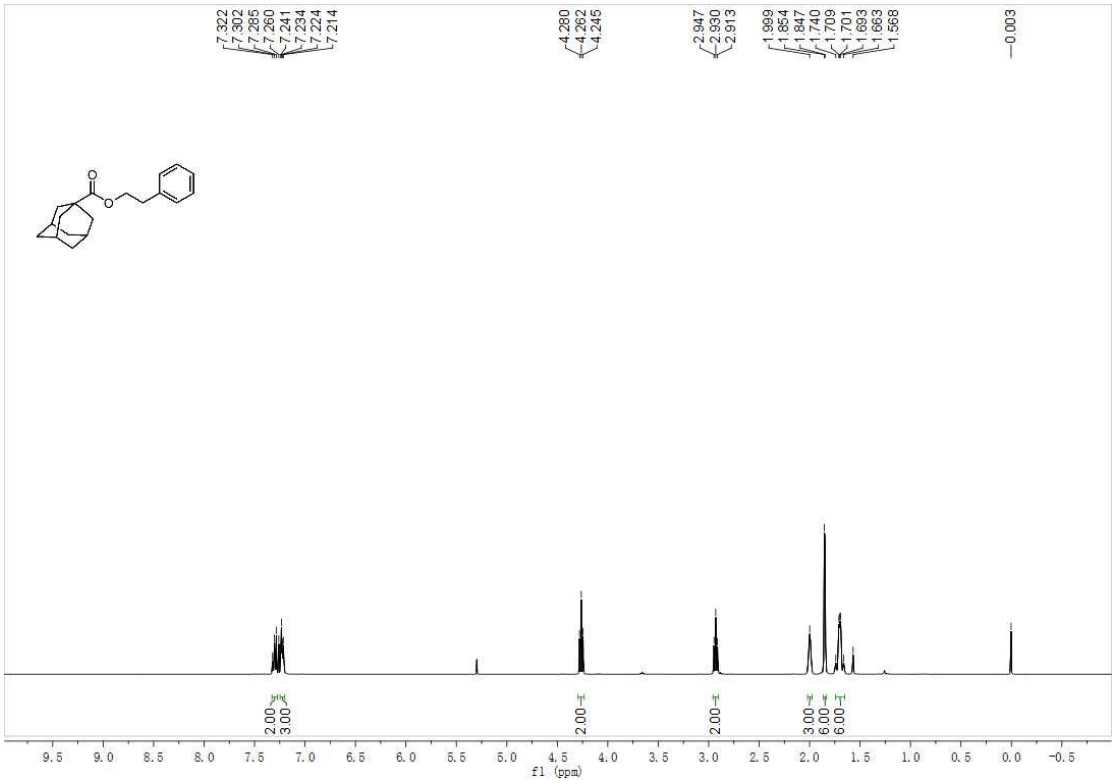
^{1}H NMR of compound **3h** (400 MHz, $CDCl_3$).



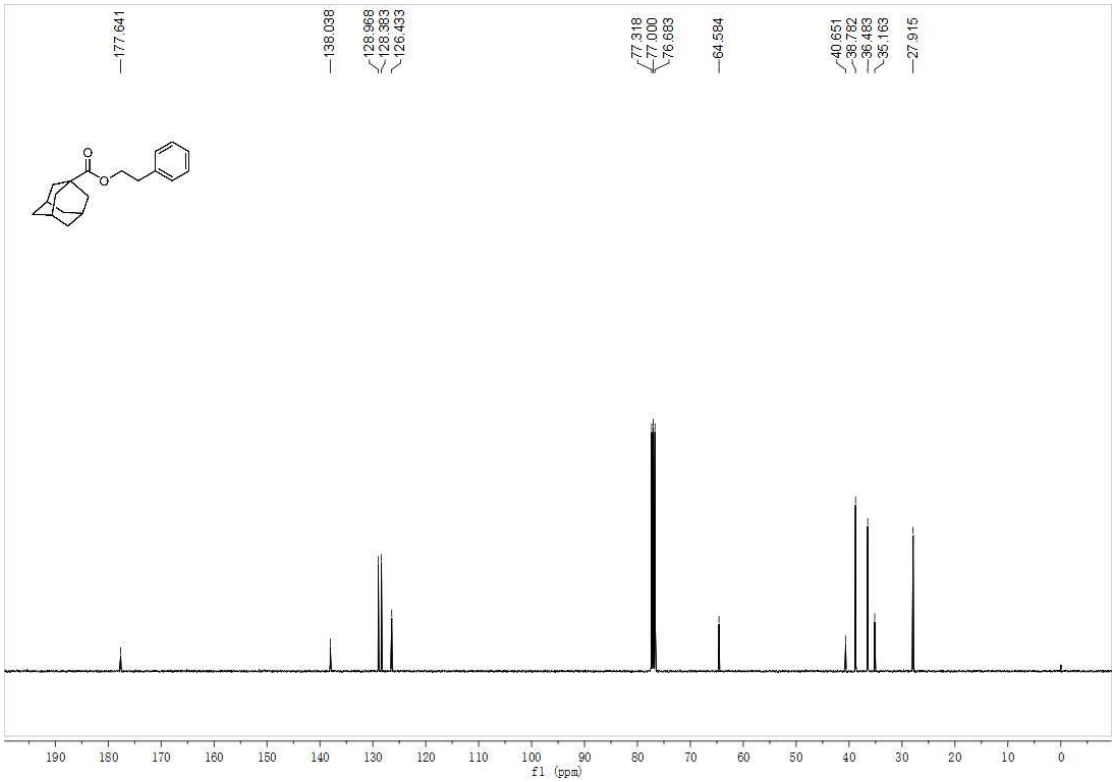
^{13}C NMR of compound **3h** (100 MHz, $CDCl_3$).



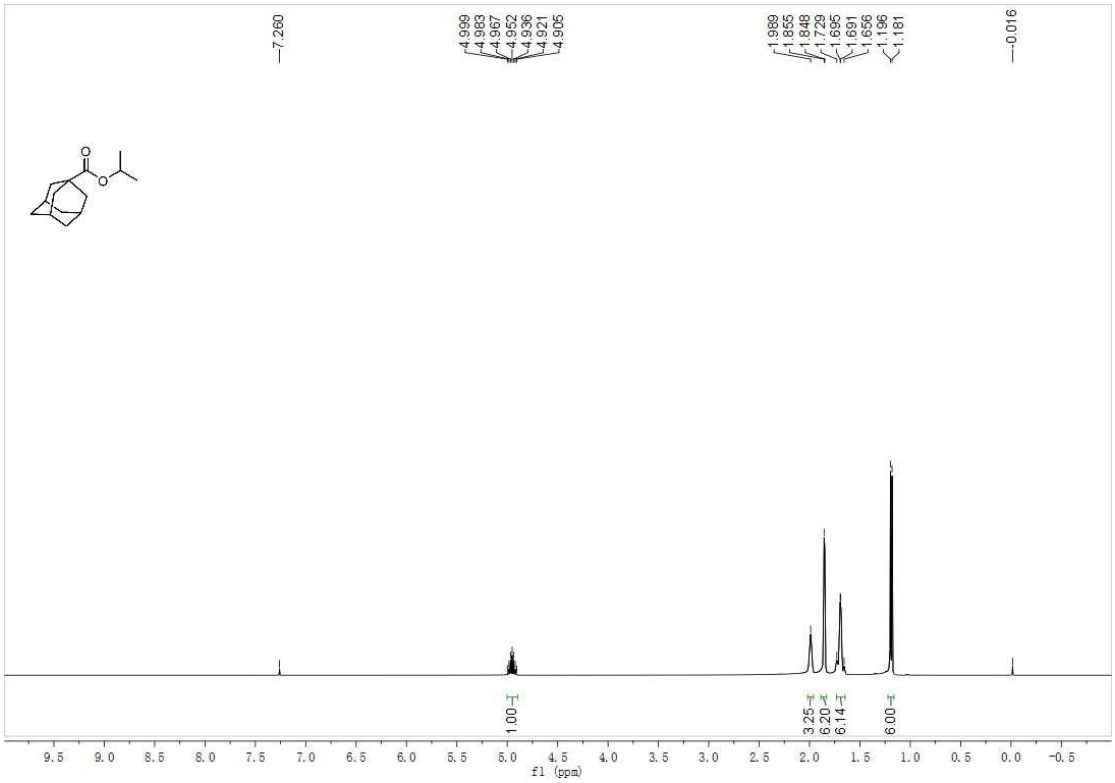
^{1}H NMR of compound **3i** (400 MHz, $CDCl_3$).



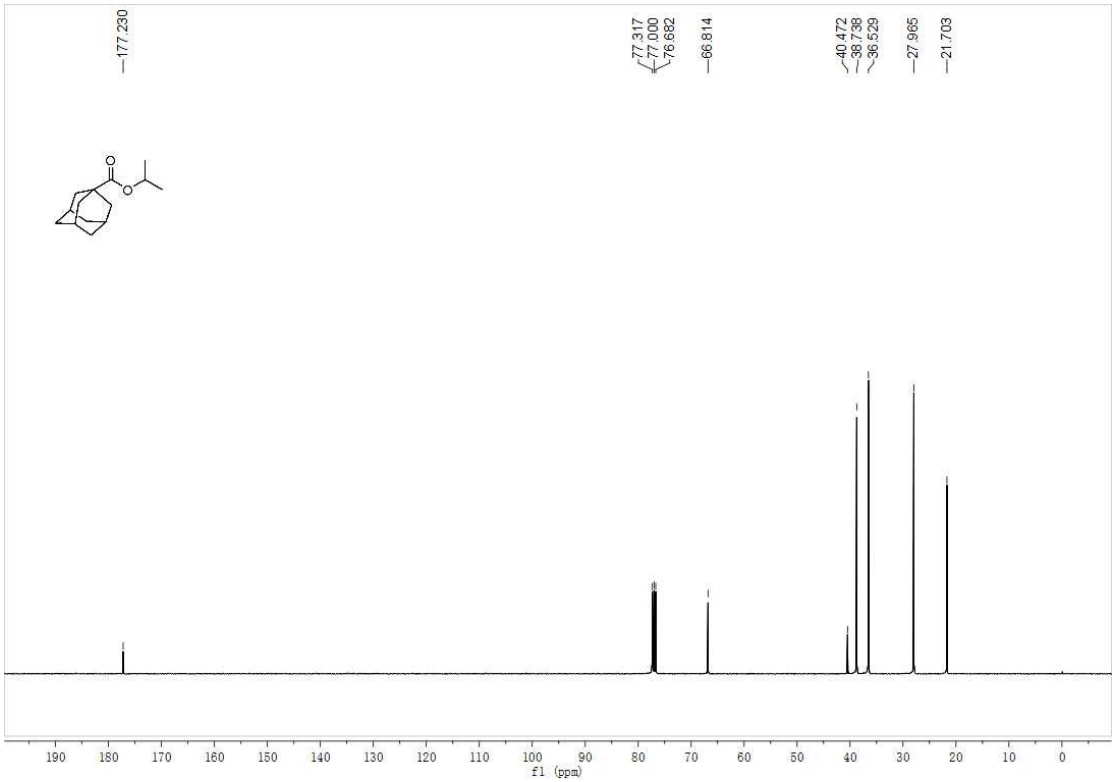
^{13}C NMR of compound **3i** (100 MHz, $CDCl_3$).



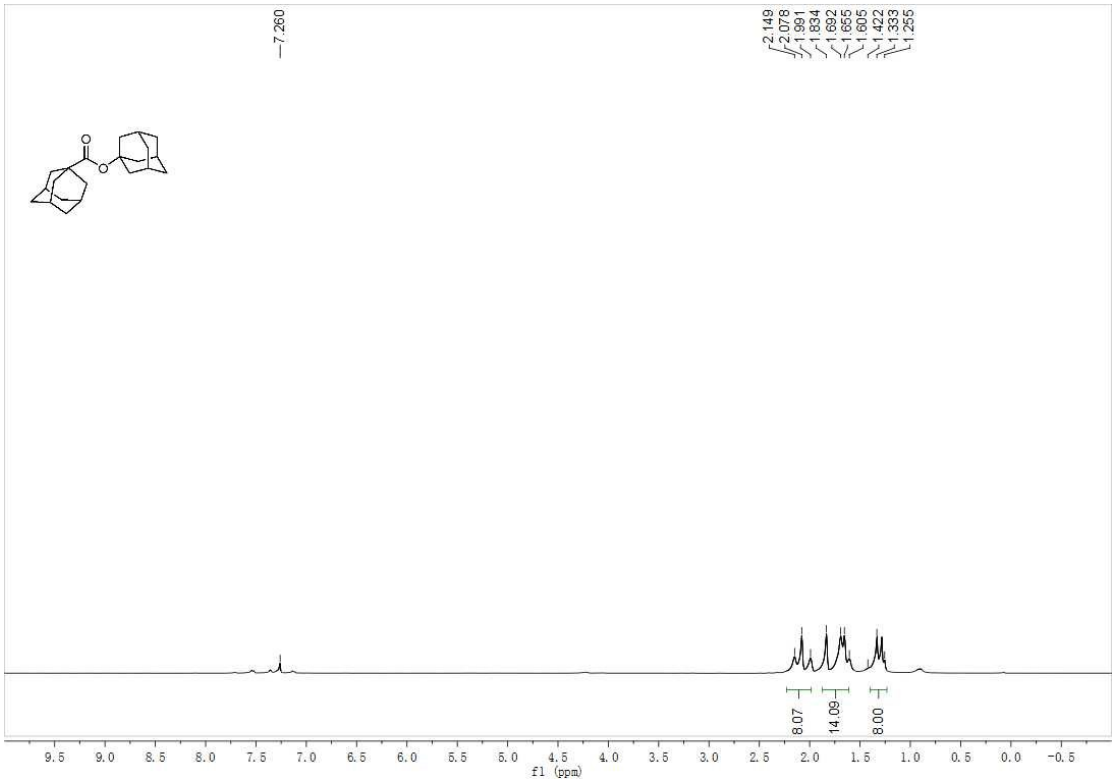
^{1}H NMR of compound **3j** (400 MHz, $CDCl_3$).



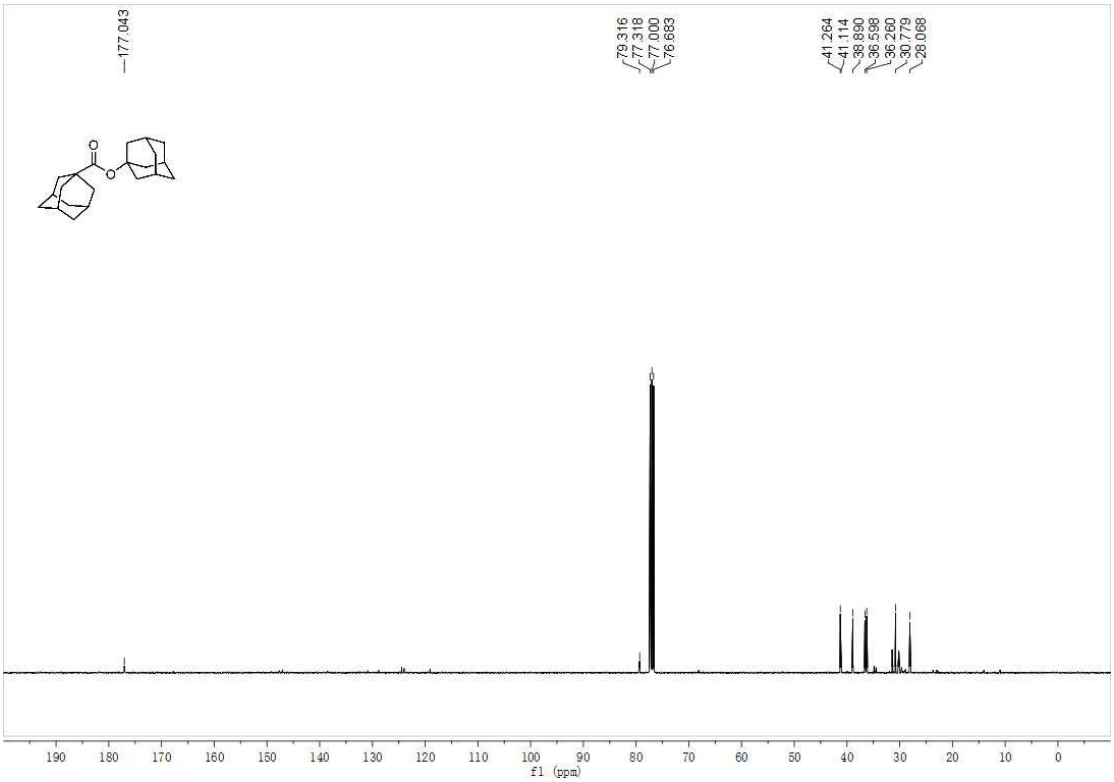
^{13}C NMR of compound **3j** (100 MHz, $CDCl_3$).



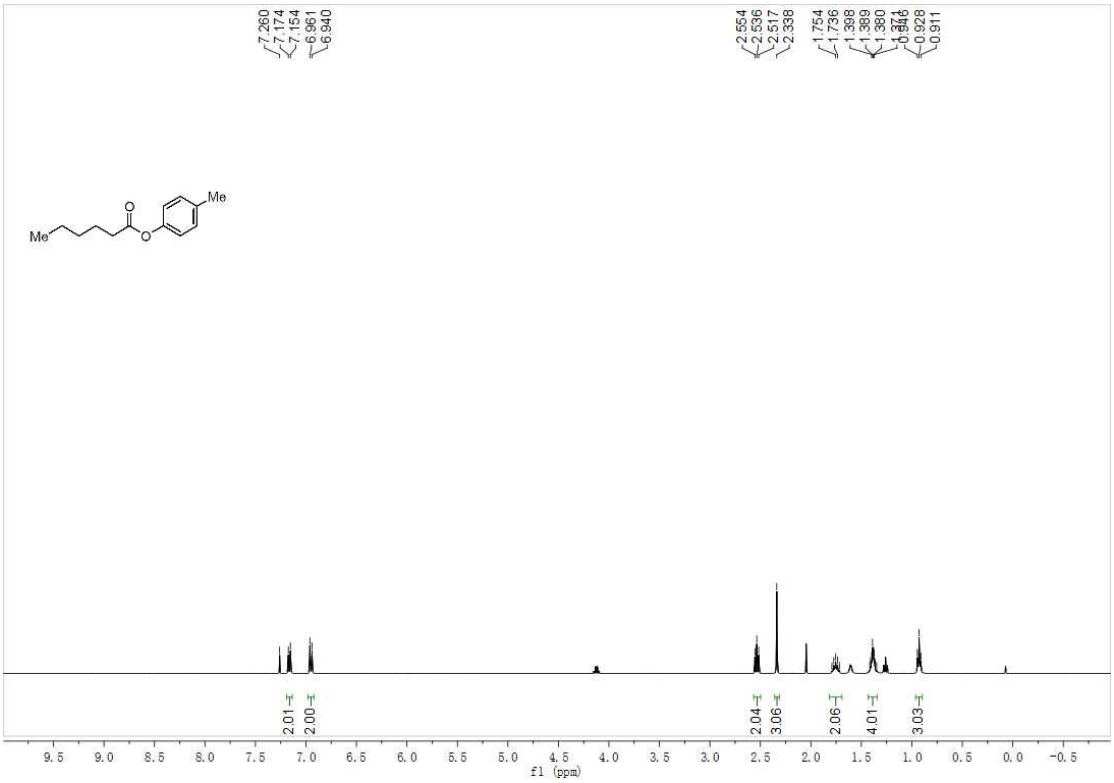
^{1}H NMR of compound **3k** (400 MHz, $CDCl_3$).



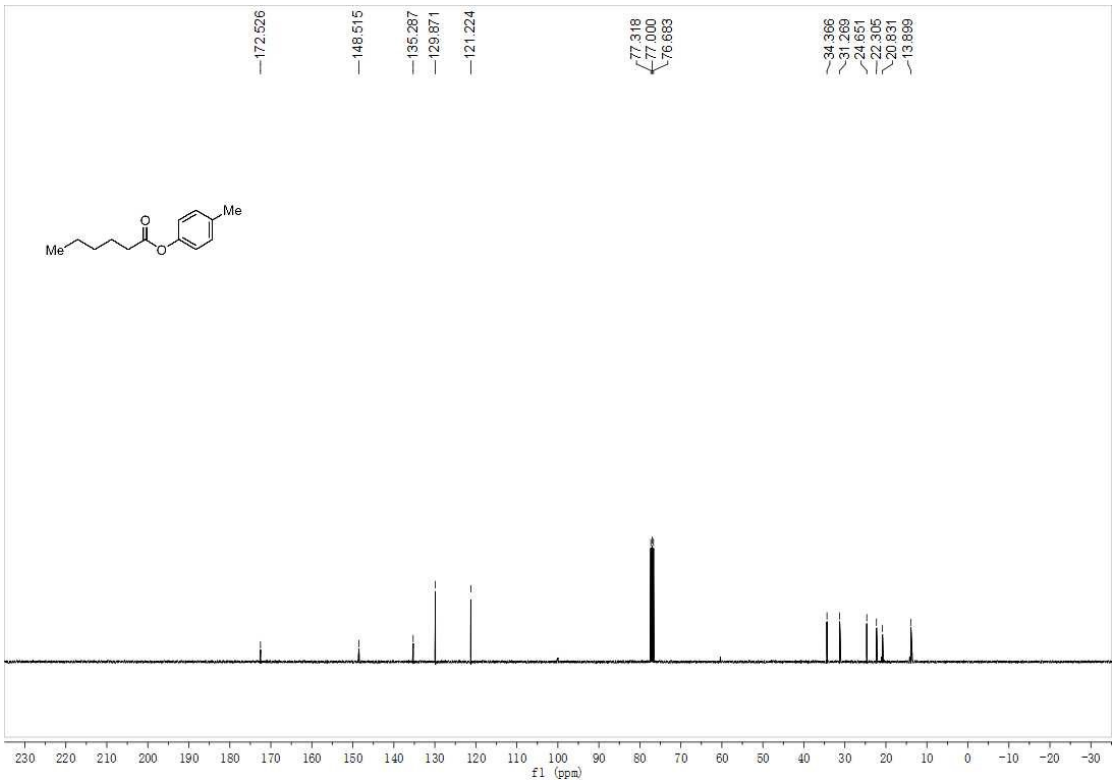
^{13}C NMR of compound **3k** (100 MHz, $CDCl_3$).



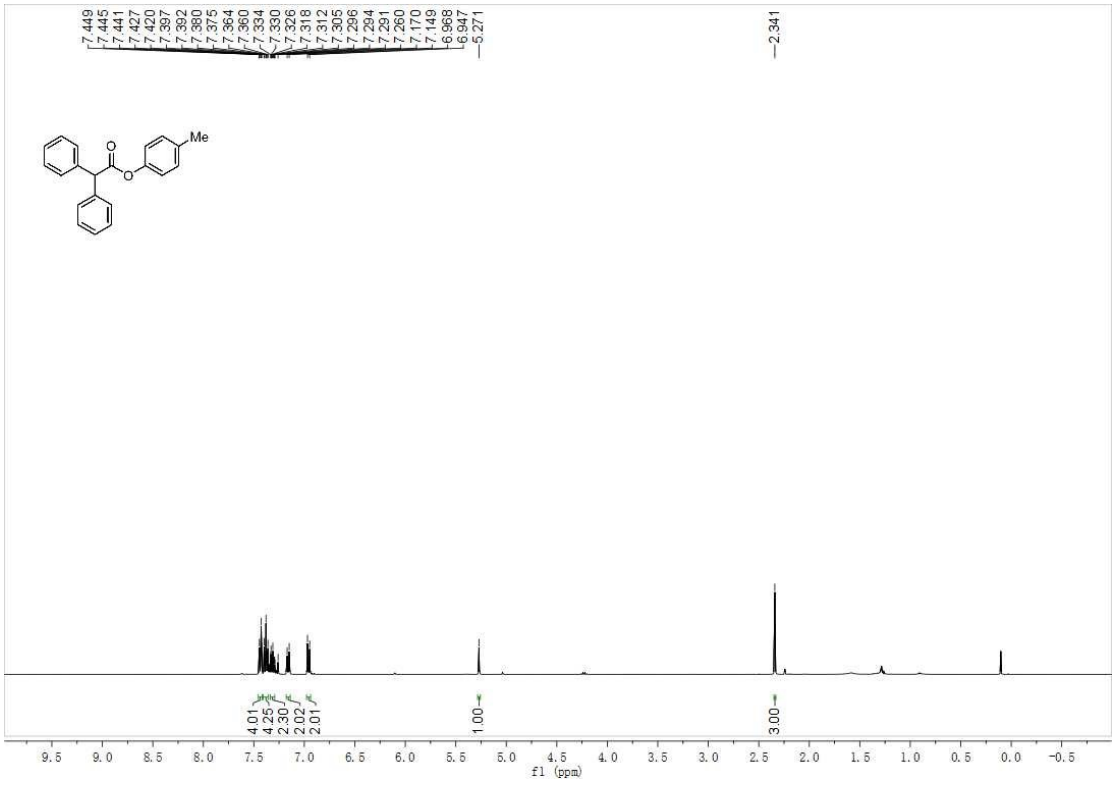
^{1}H NMR of compound **3l** (400 MHz, $CDCl_3$).



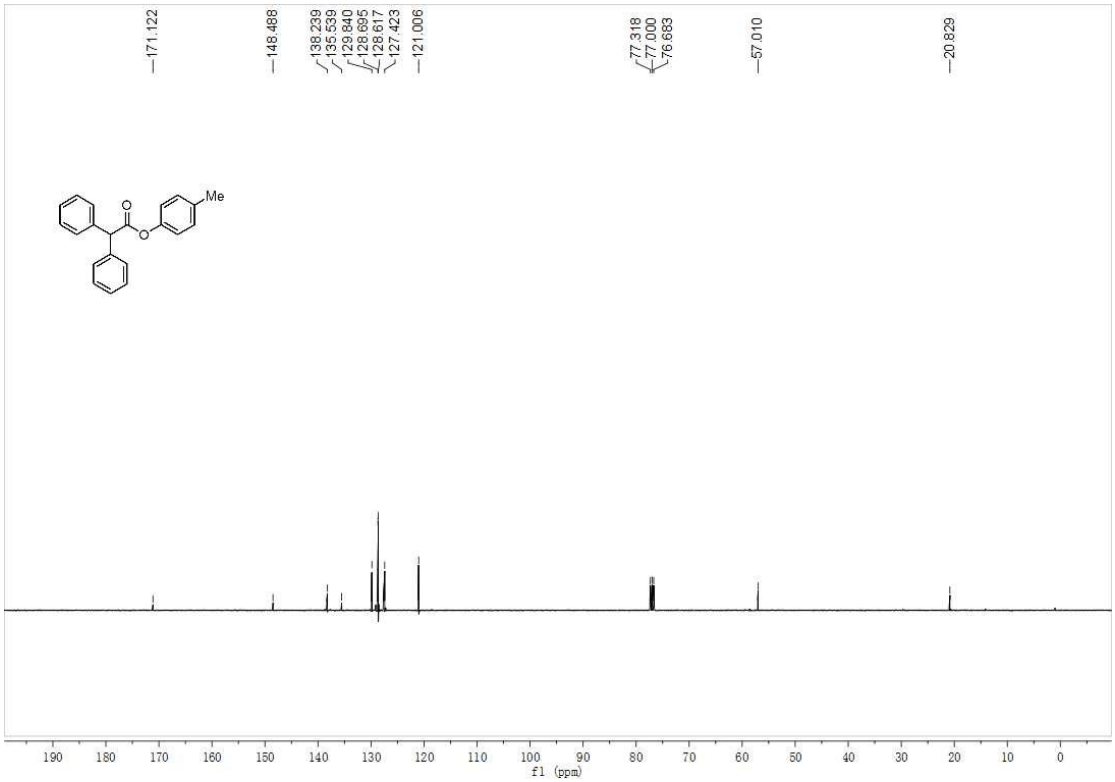
^{13}C NMR of compound **3l** (100 MHz, $CDCl_3$).



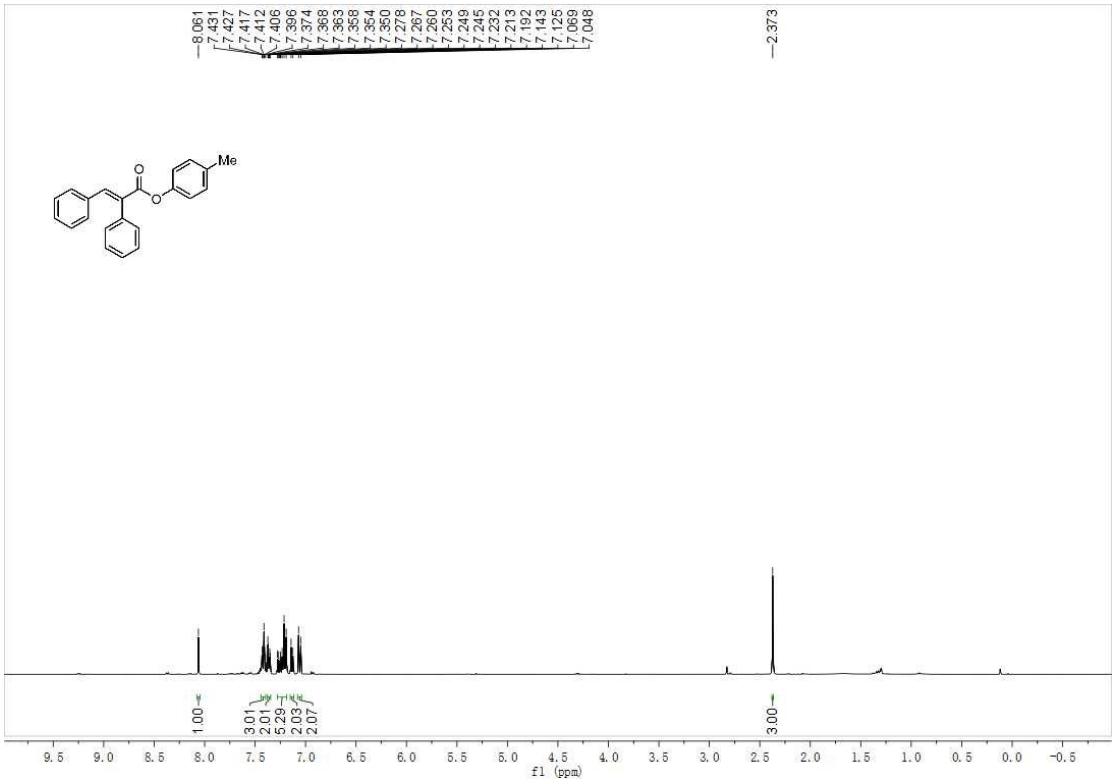
^{1}H NMR of compound **3m** (400 MHz, $CDCl_3$).



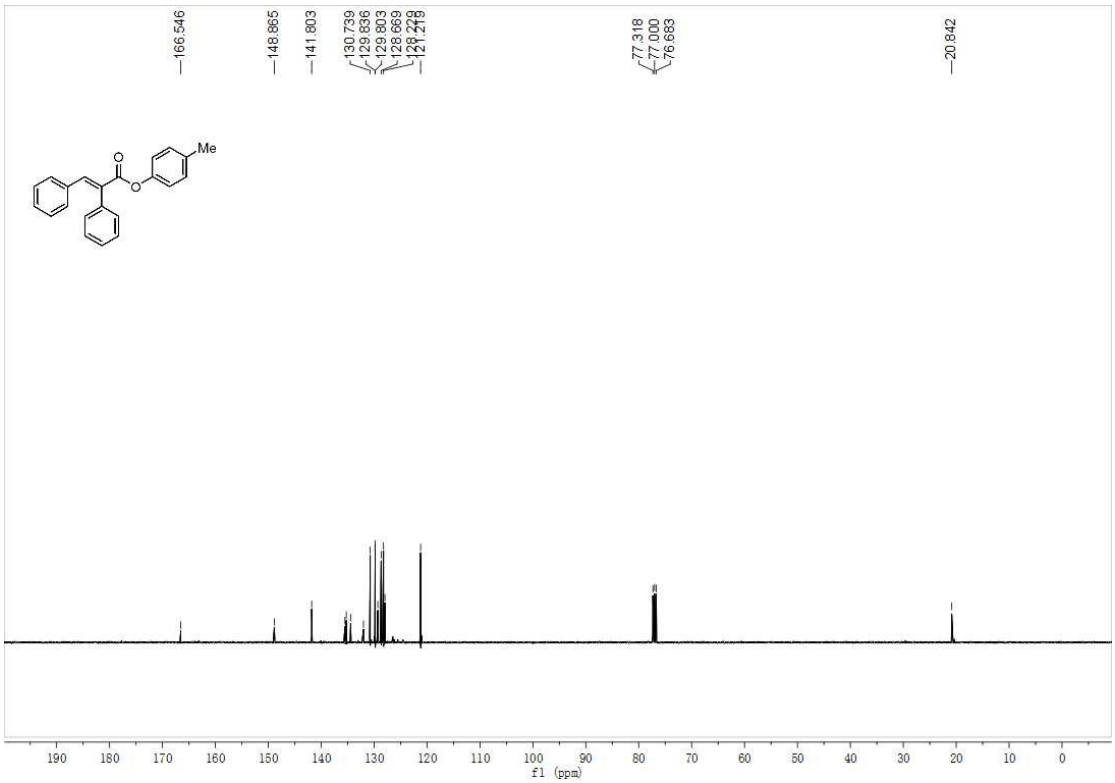
^{13}C NMR of compound **3m** (100 MHz, $CDCl_3$).



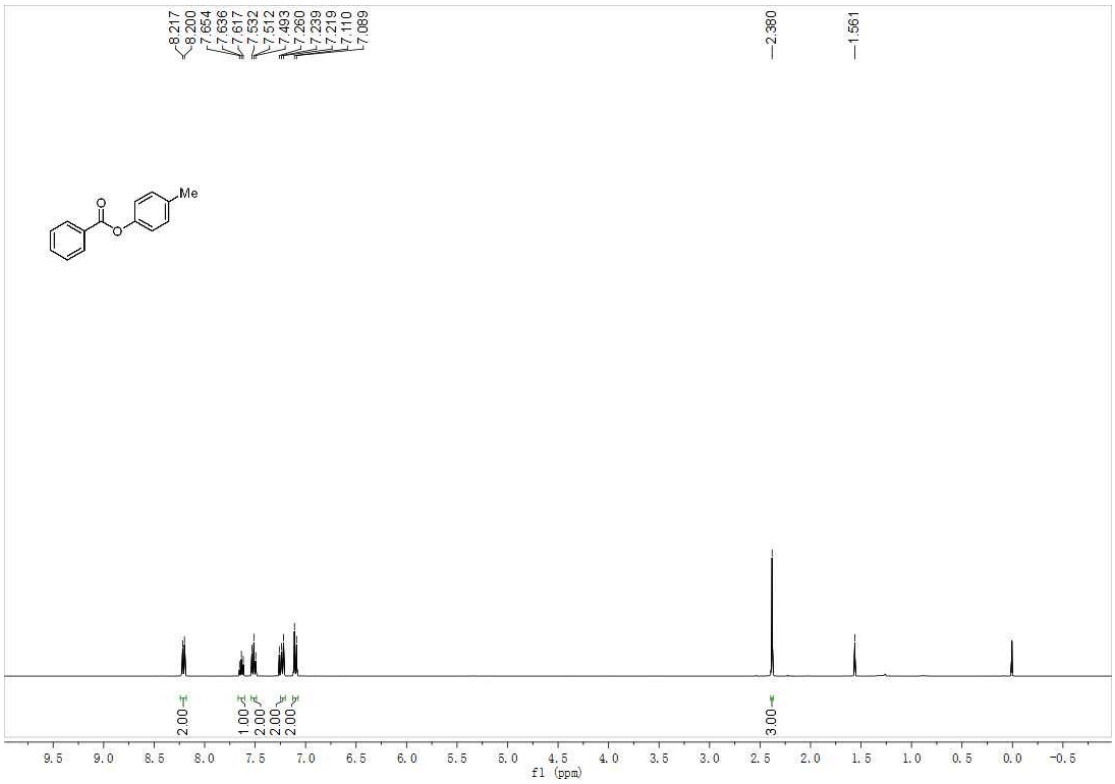
^{1}H NMR of compound **3n** (400 MHz, $CDCl_3$).



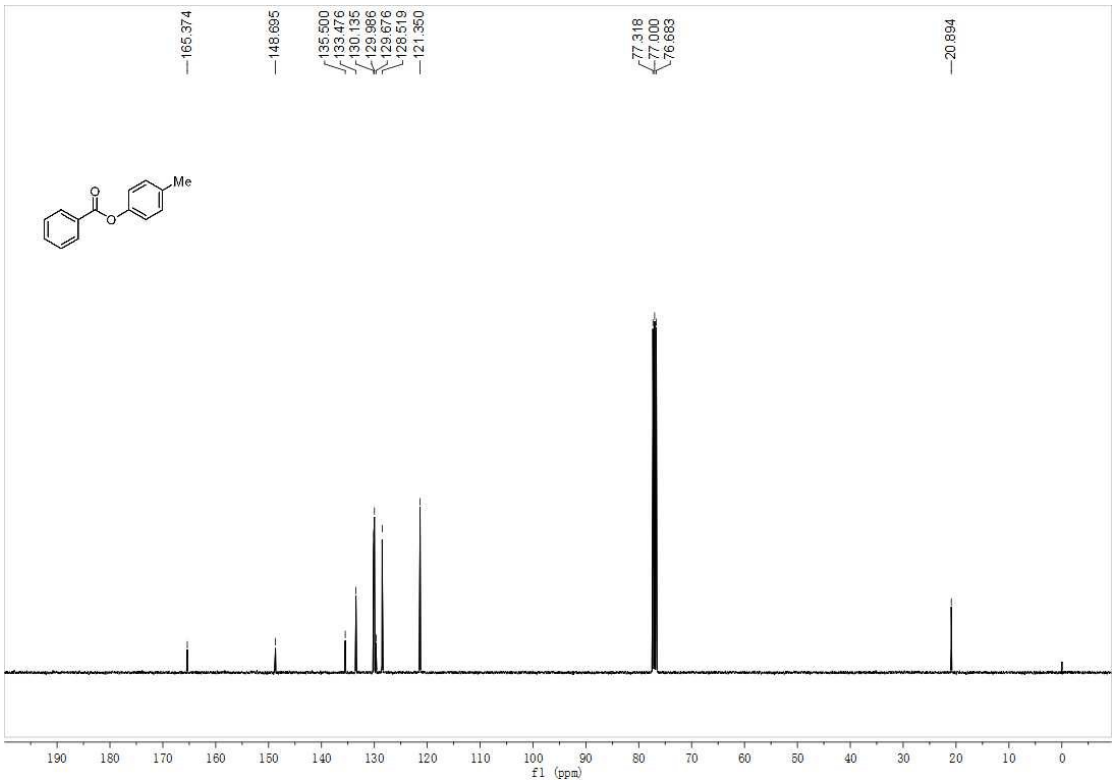
^{13}C NMR of compound **3n** (100 MHz, $CDCl_3$).



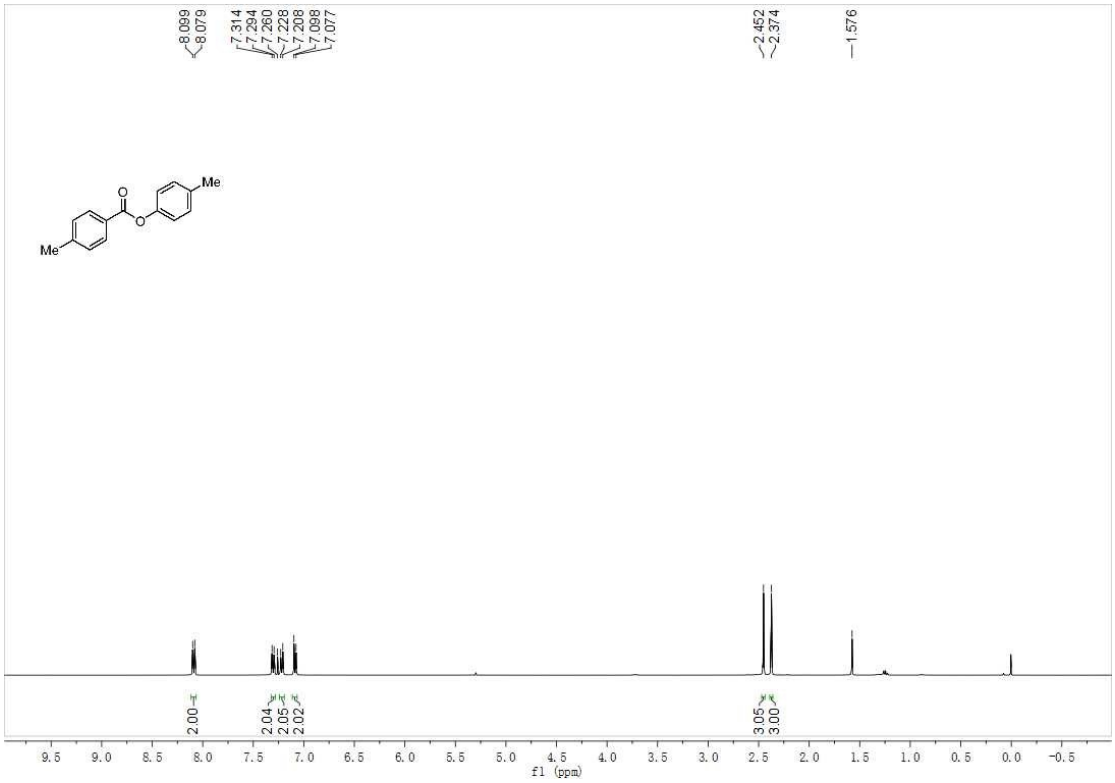
^{1}H NMR of compound **3o** (400 MHz, $CDCl_3$).



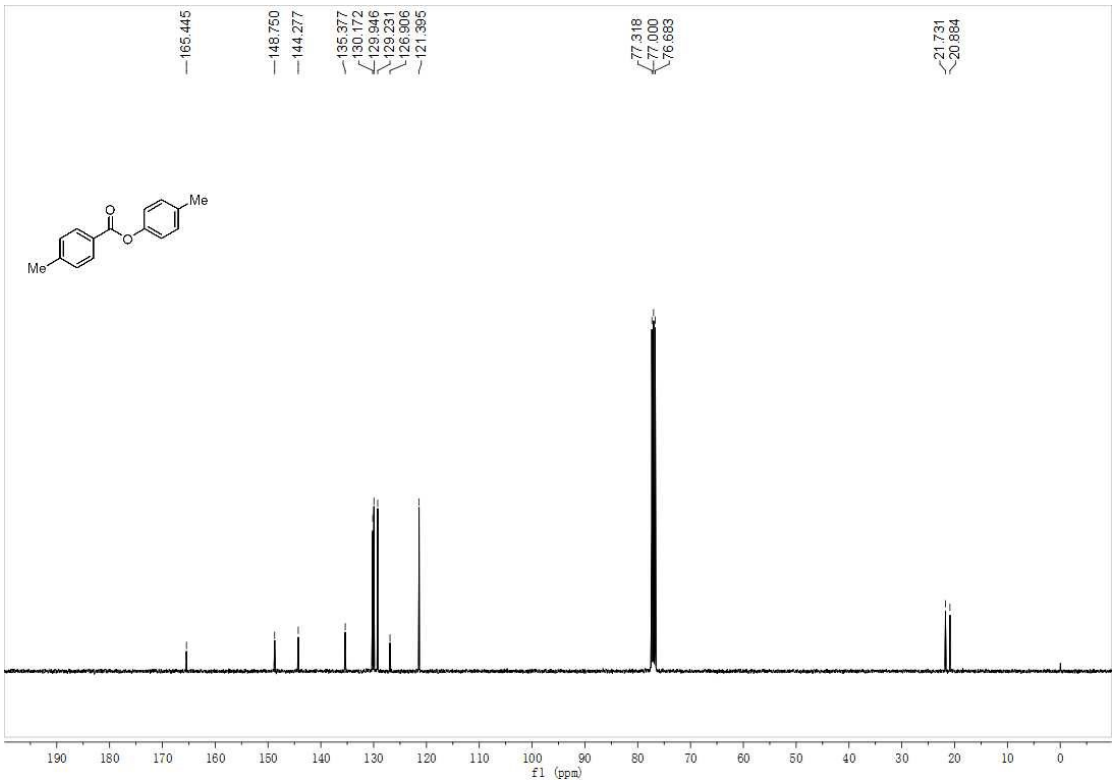
^{13}C NMR of compound **3o** (100 MHz, $CDCl_3$).



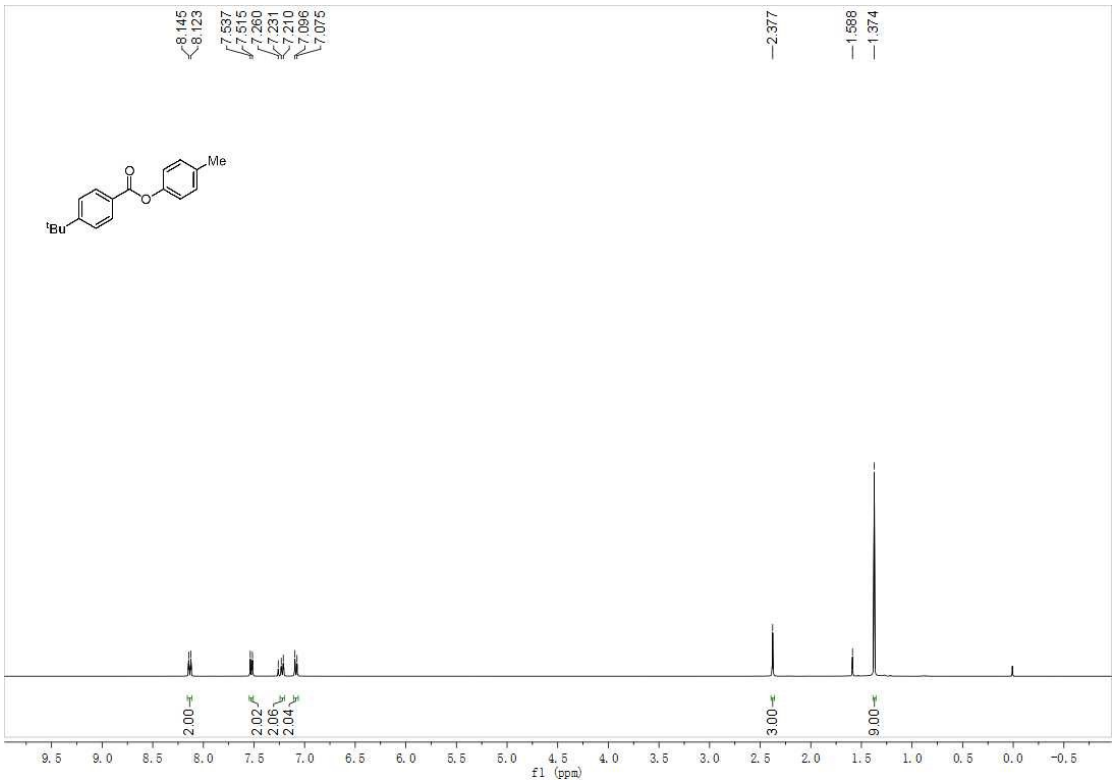
^{1}H NMR of compound **3p** (400 MHz, $CDCl_3$).



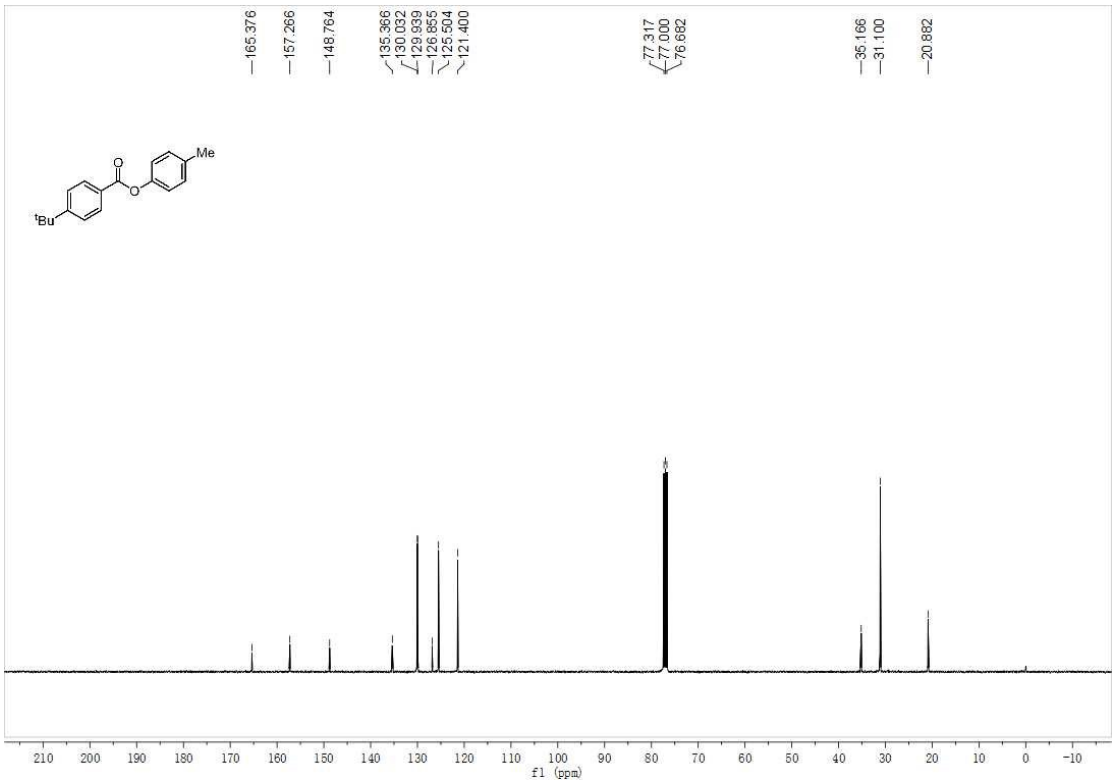
^{13}C NMR of compound **3p** (100 MHz, $CDCl_3$).



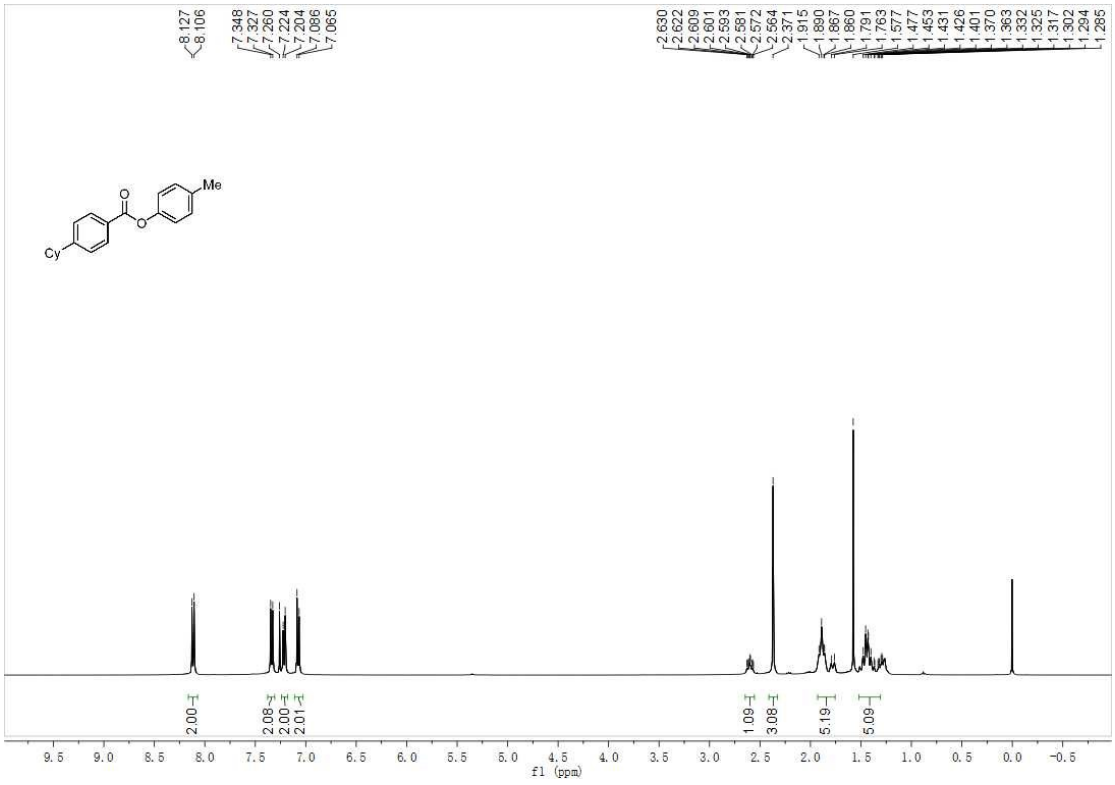
^{1}H NMR of compound **3q** (400 MHz, $CDCl_3$).



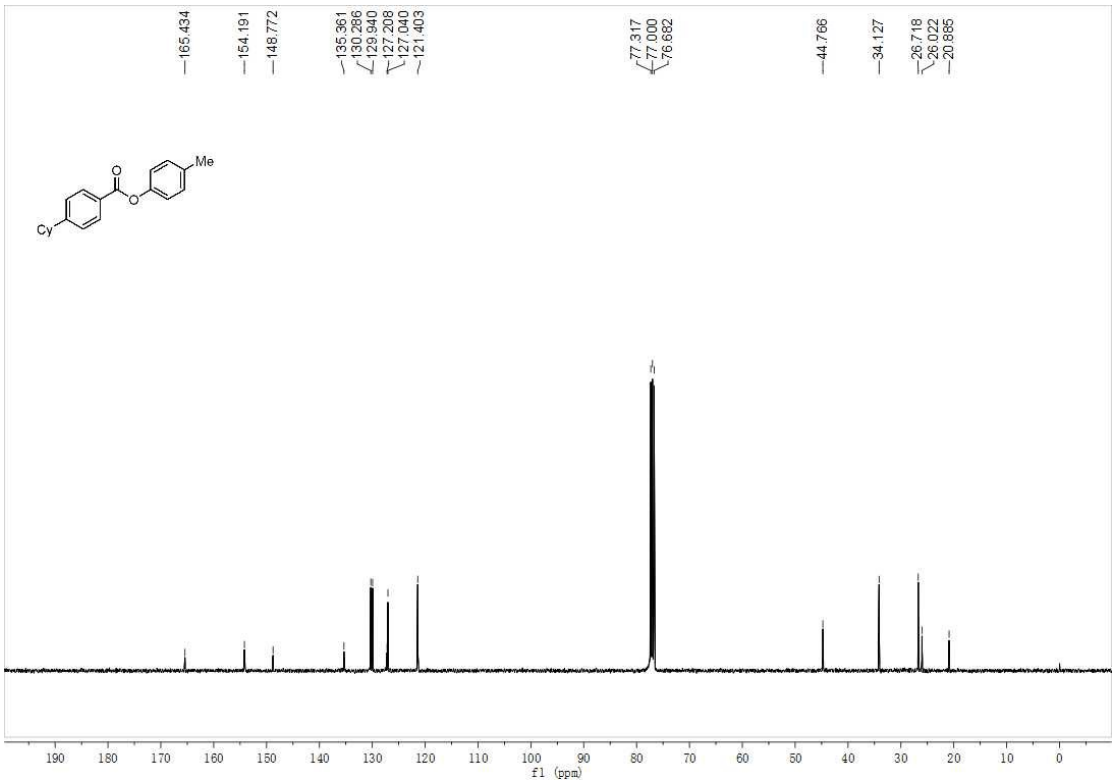
^{13}C NMR of compound **3q** (100 MHz, $CDCl_3$).



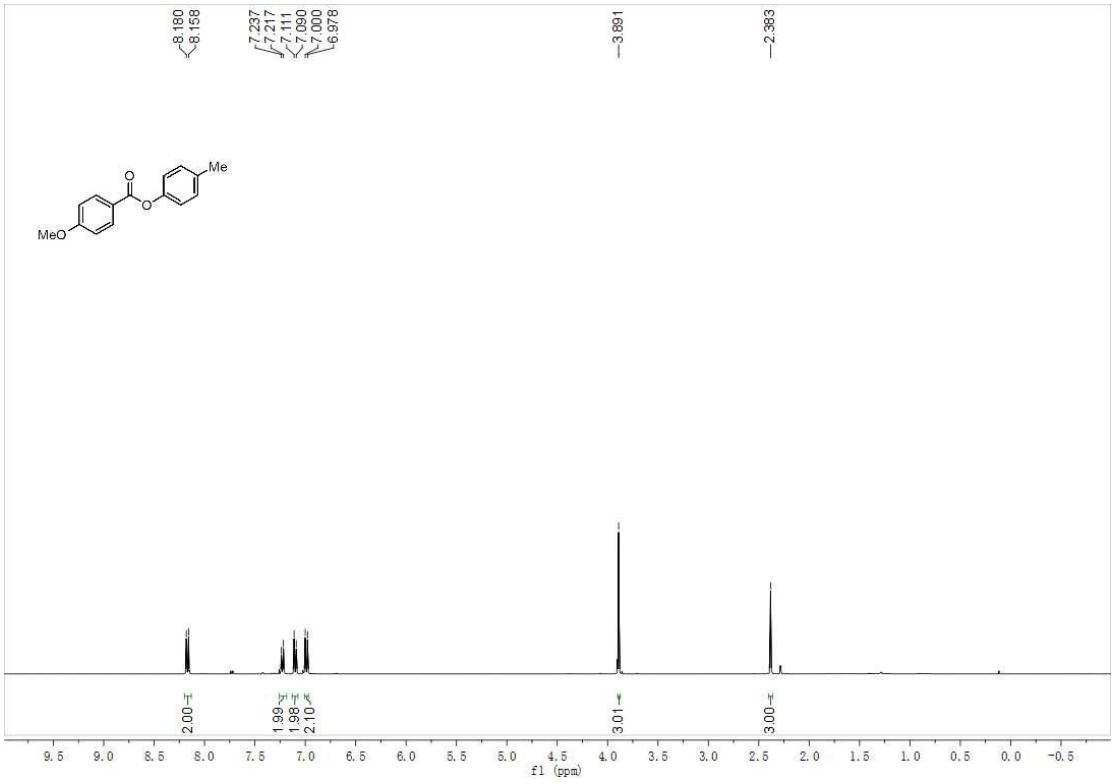
^{1}H NMR of compound **3r** (400 MHz, $CDCl_3$).



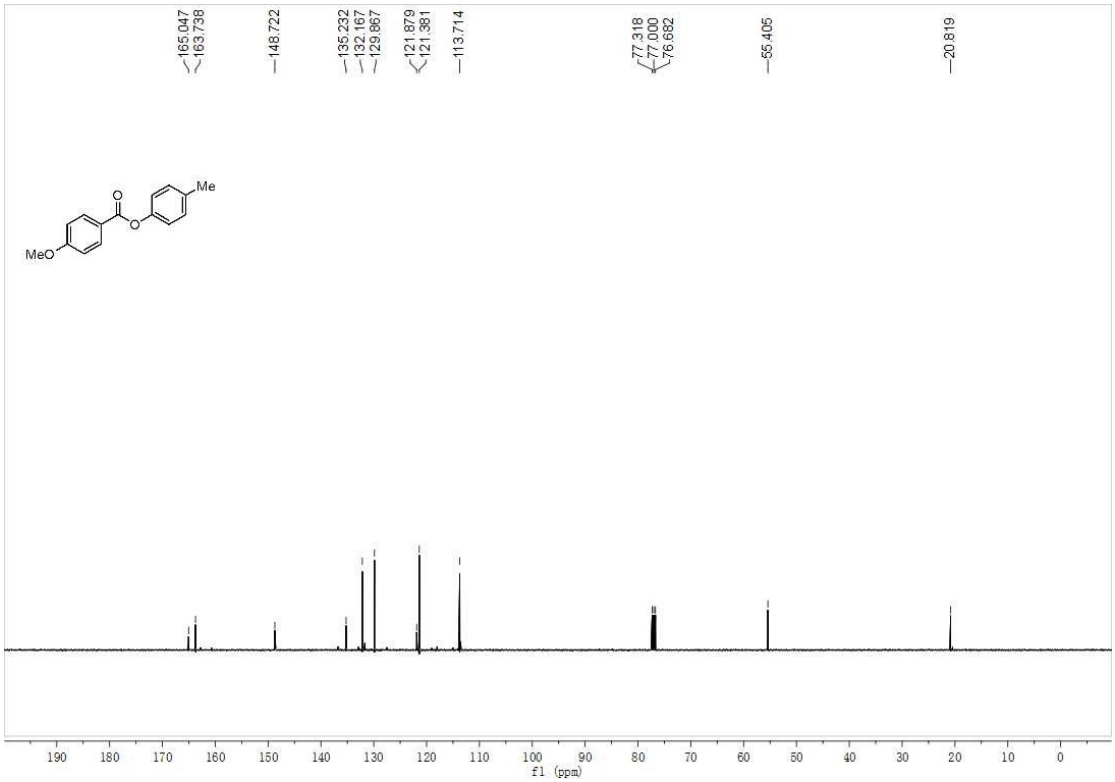
^{13}C NMR of compound **3r** (100 MHz, $CDCl_3$).



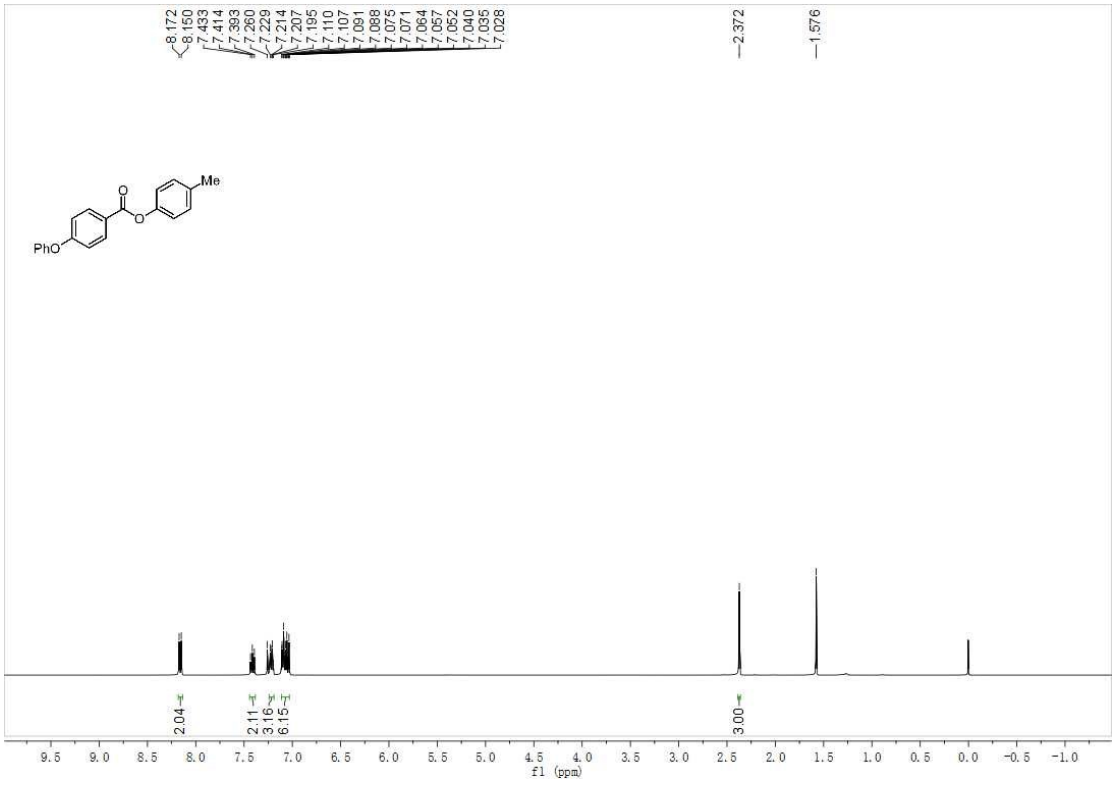
^{1}H NMR of compound **3s** (400 MHz, $CDCl_3$).



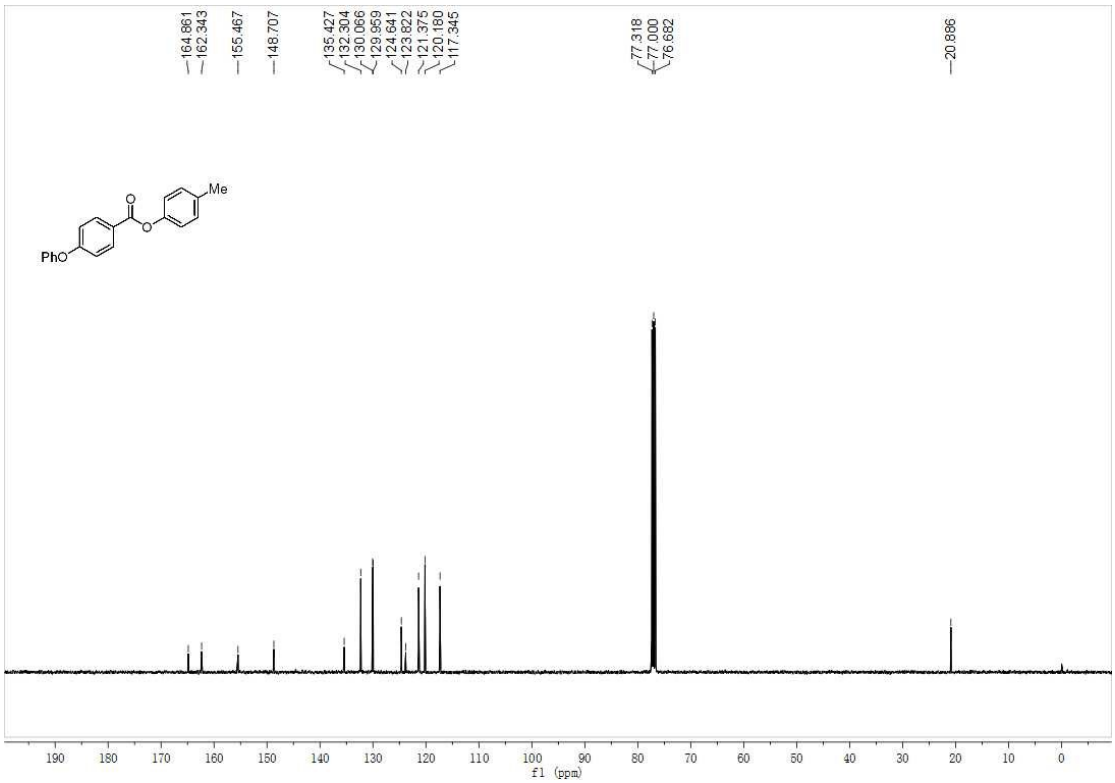
^{13}C NMR of compound **3s** (100 MHz, $CDCl_3$).



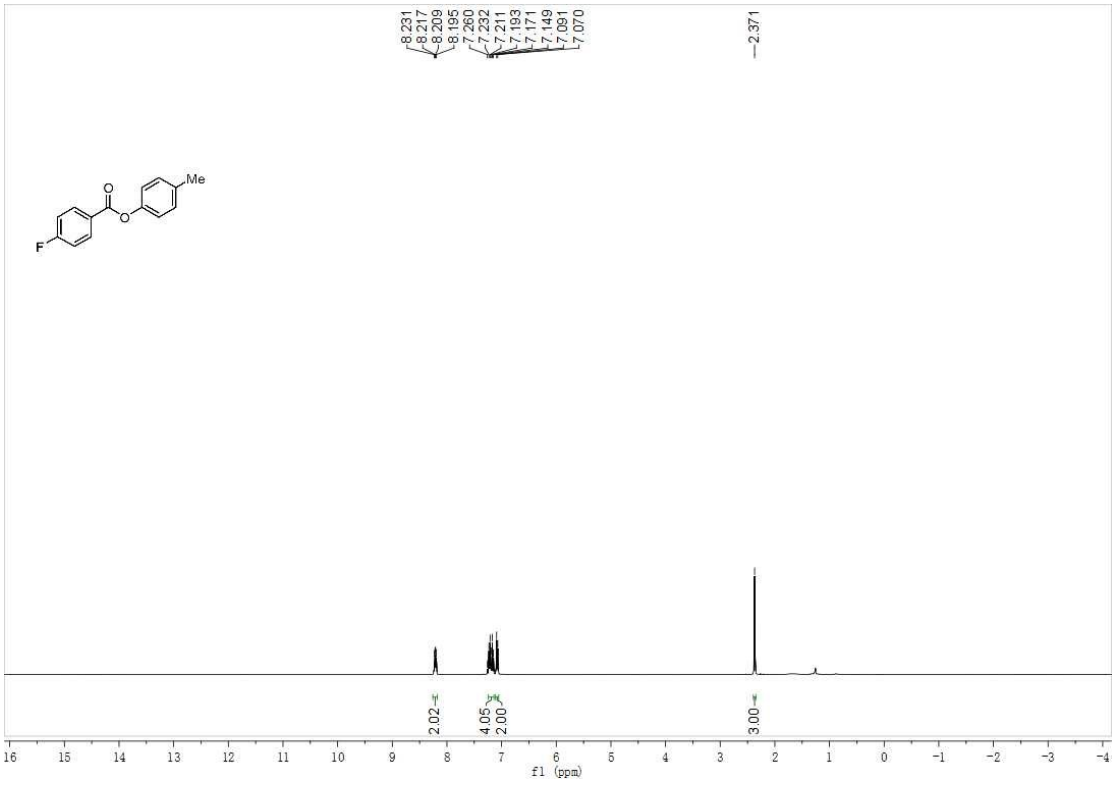
^{1}H NMR of compound **3t** (400 MHz, $CDCl_3$).



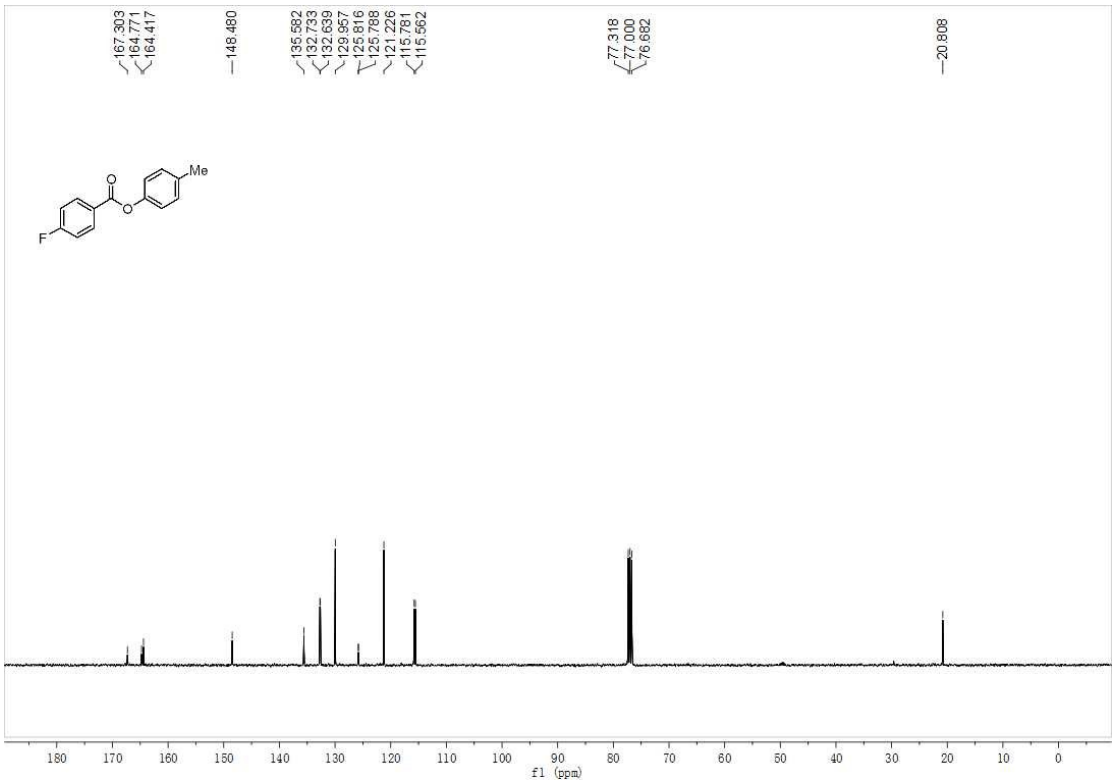
^{13}C NMR of compound **3t** (100 MHz, $CDCl_3$).



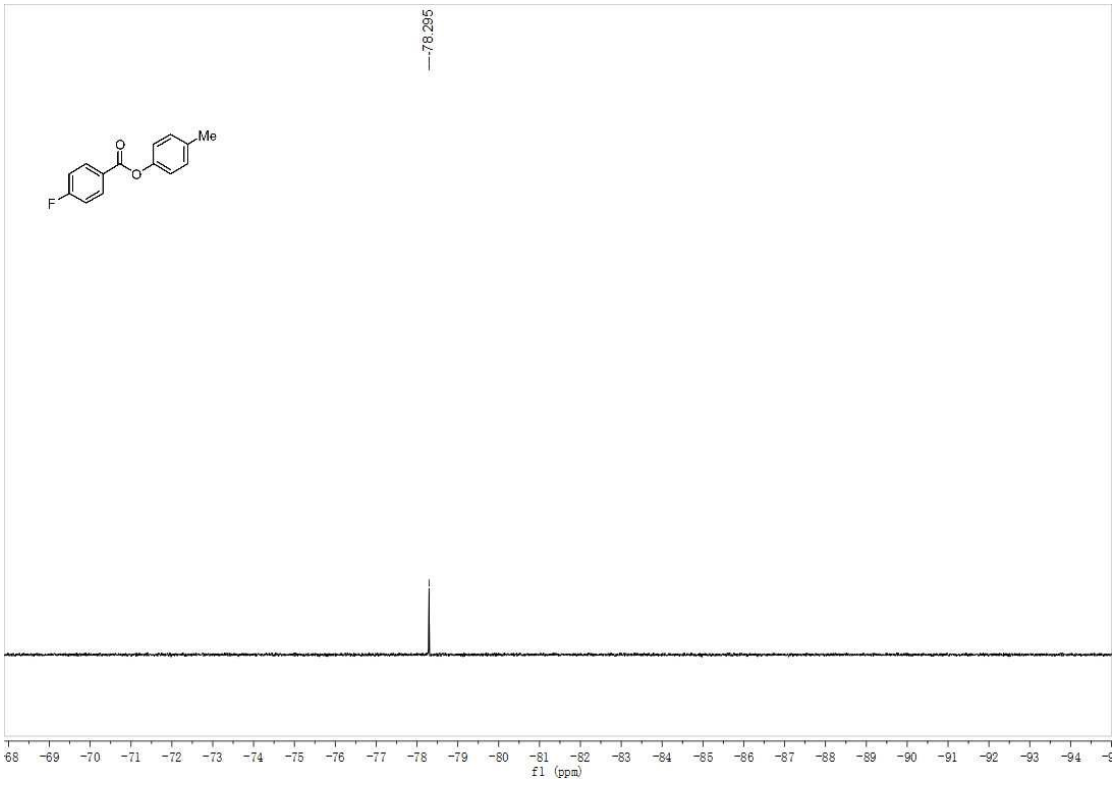
^{1}H NMR of compound **3u** (400 MHz, $CDCl_3$).



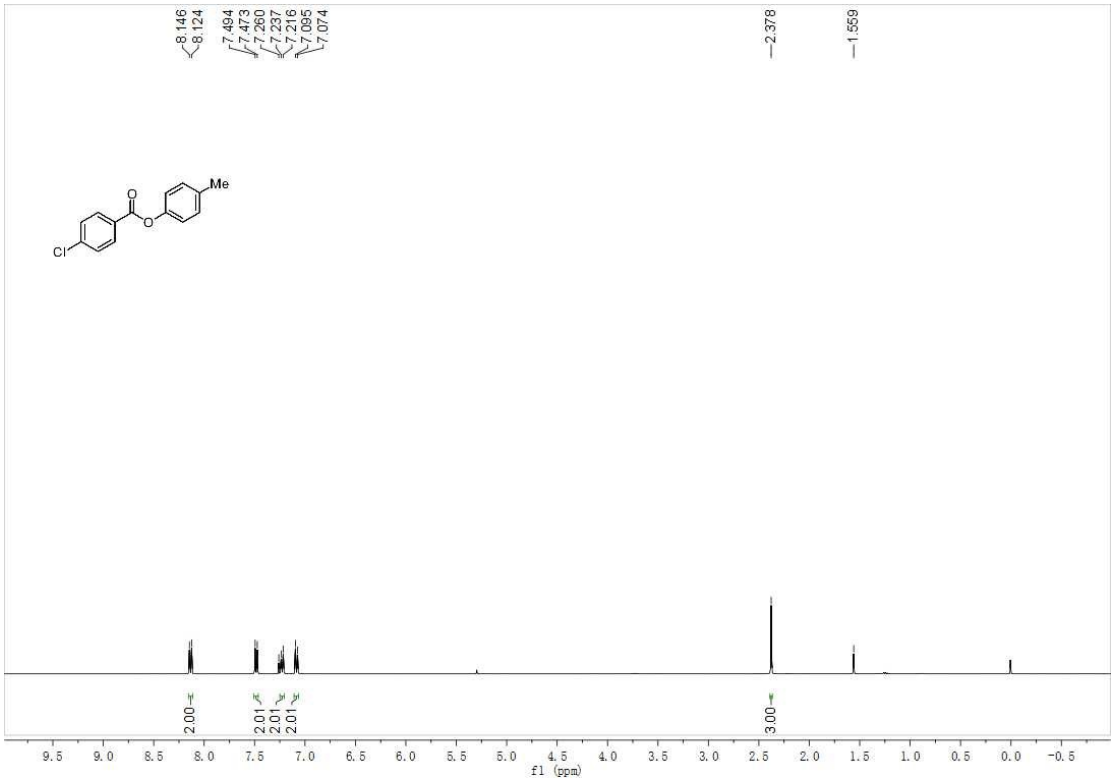
^{13}C NMR of compound **3u** (100 MHz, $CDCl_3$).



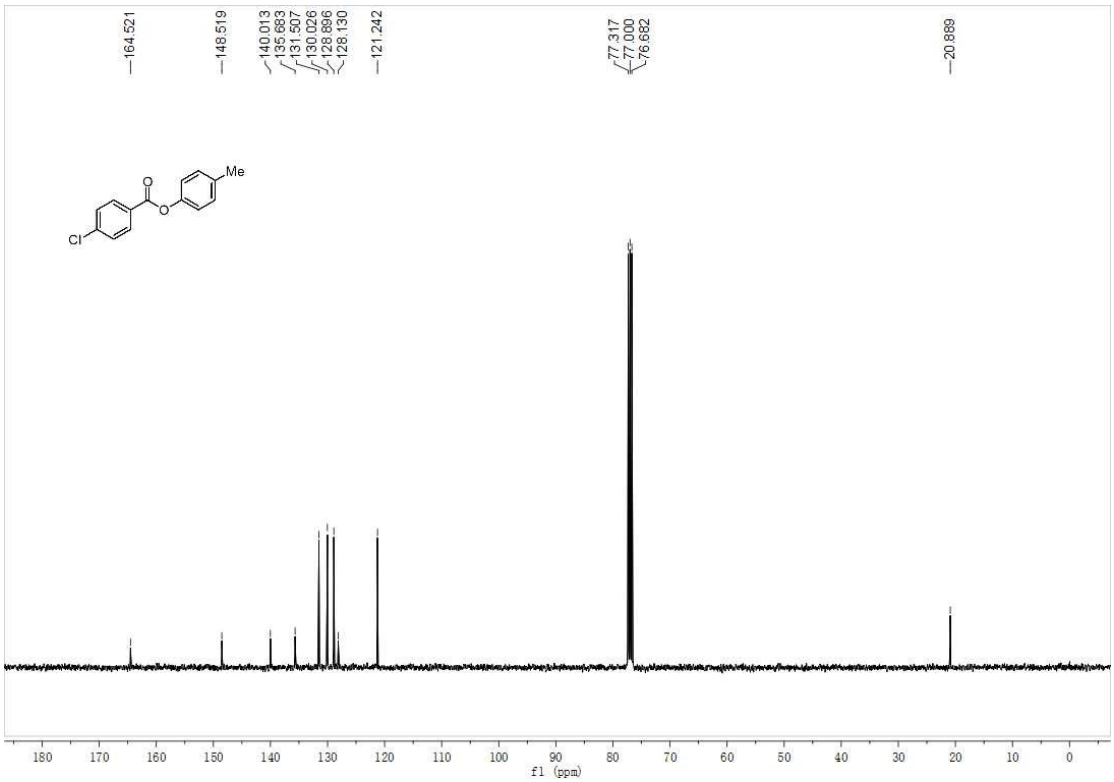
^{19}F NMR of compound **3u** (376 MHz, $CDCl_3$).



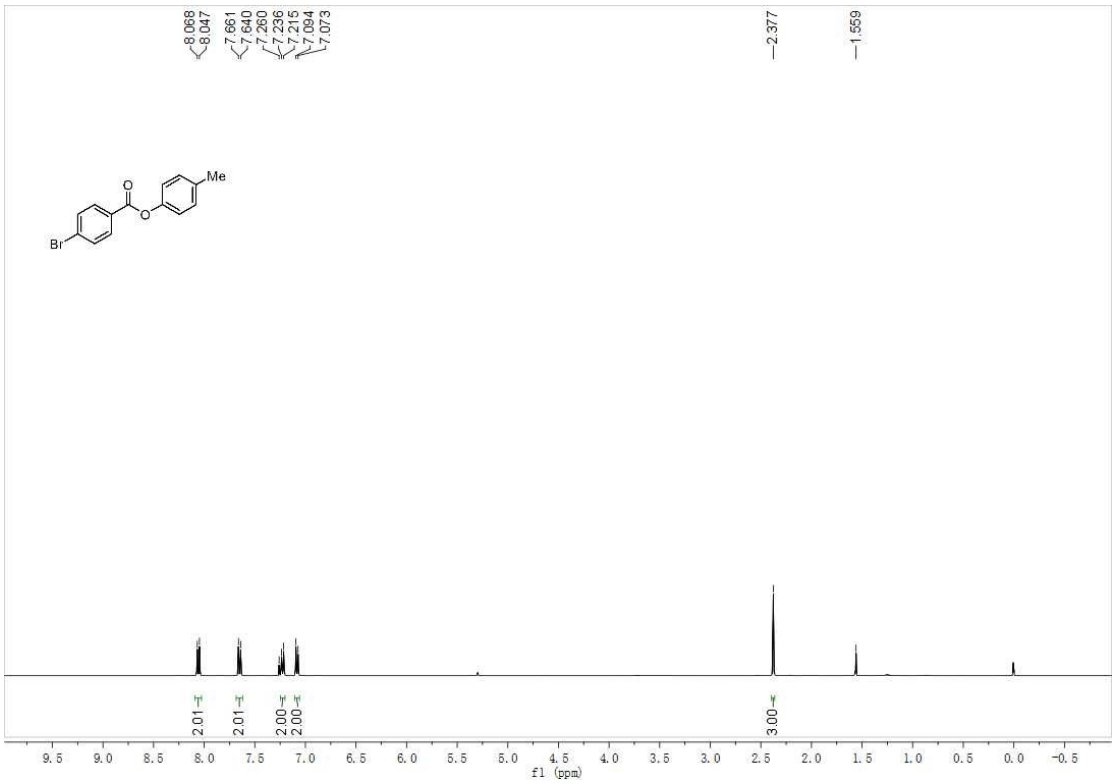
^{1}H NMR of compound **3v** (400 MHz, $CDCl_3$).



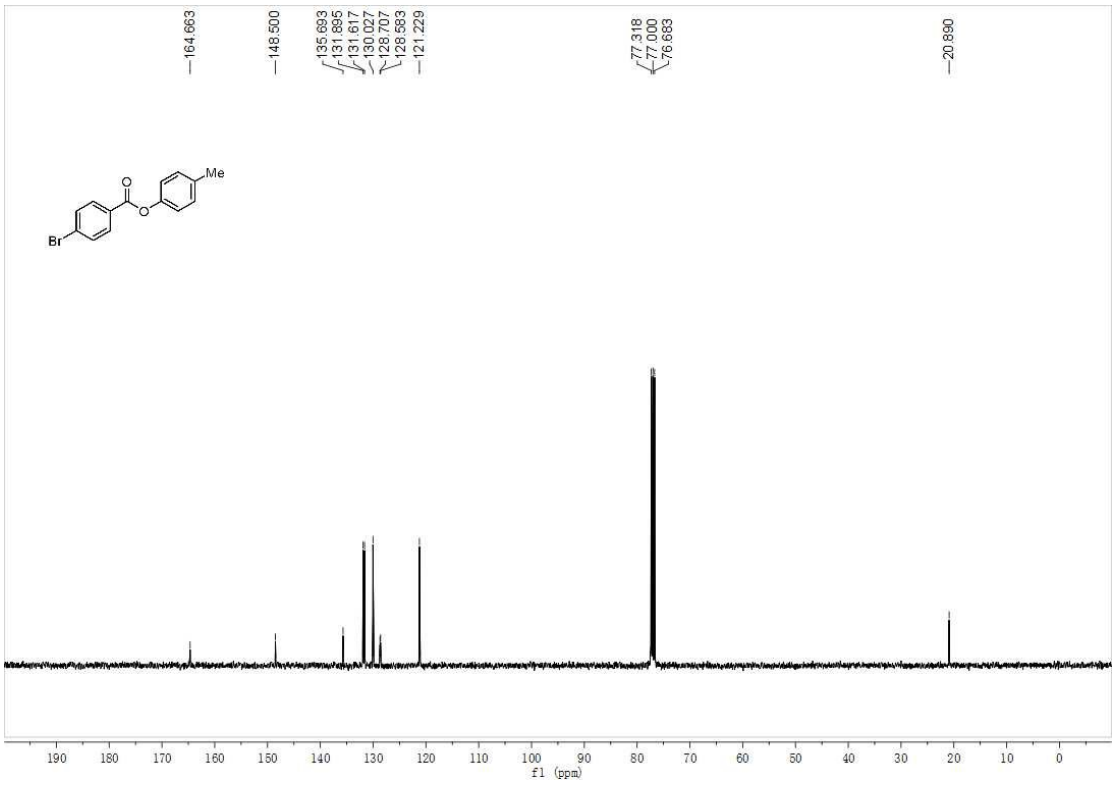
^{13}C NMR of compound **3v** (100 MHz, $CDCl_3$).



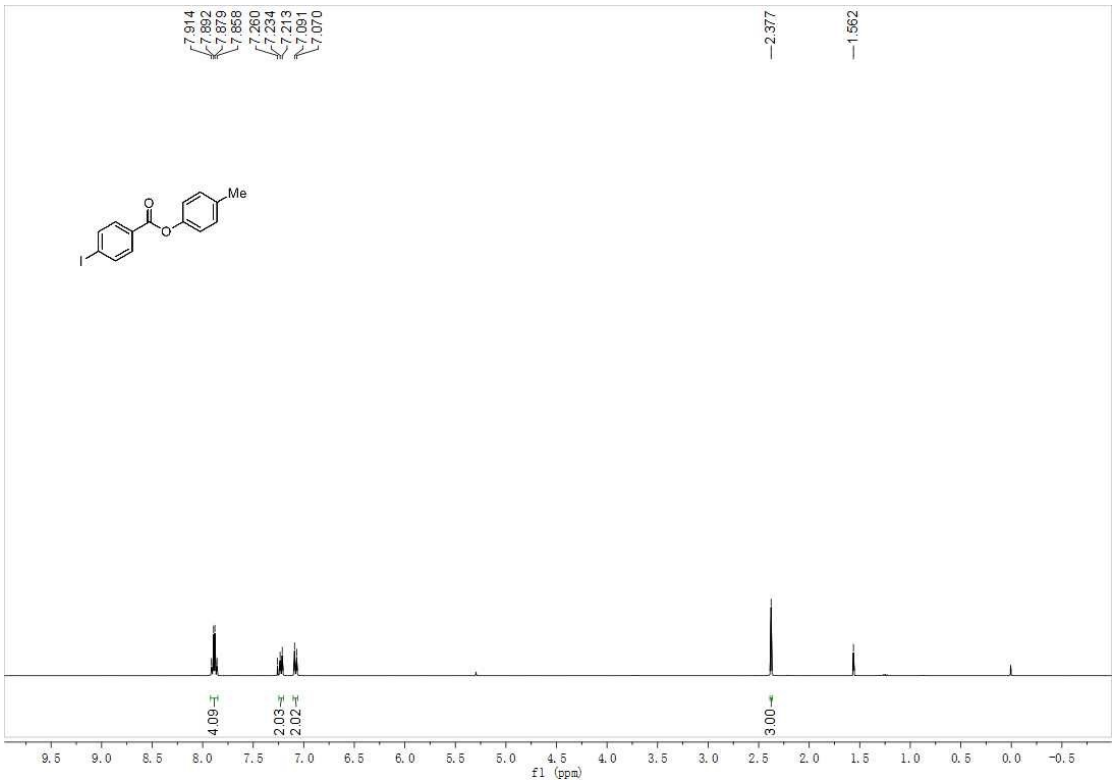
^{1}H NMR of compound **3w** (400 MHz, $CDCl_3$).



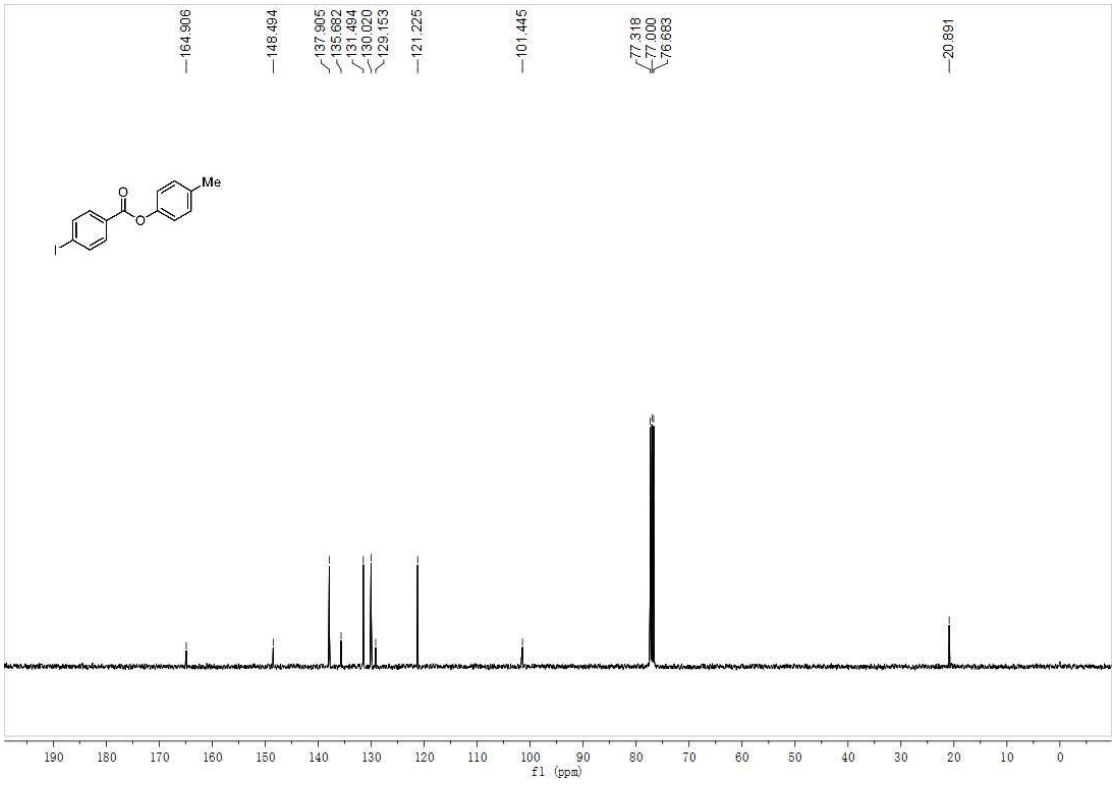
^{13}C NMR of compound **3w** (100 MHz, $CDCl_3$).



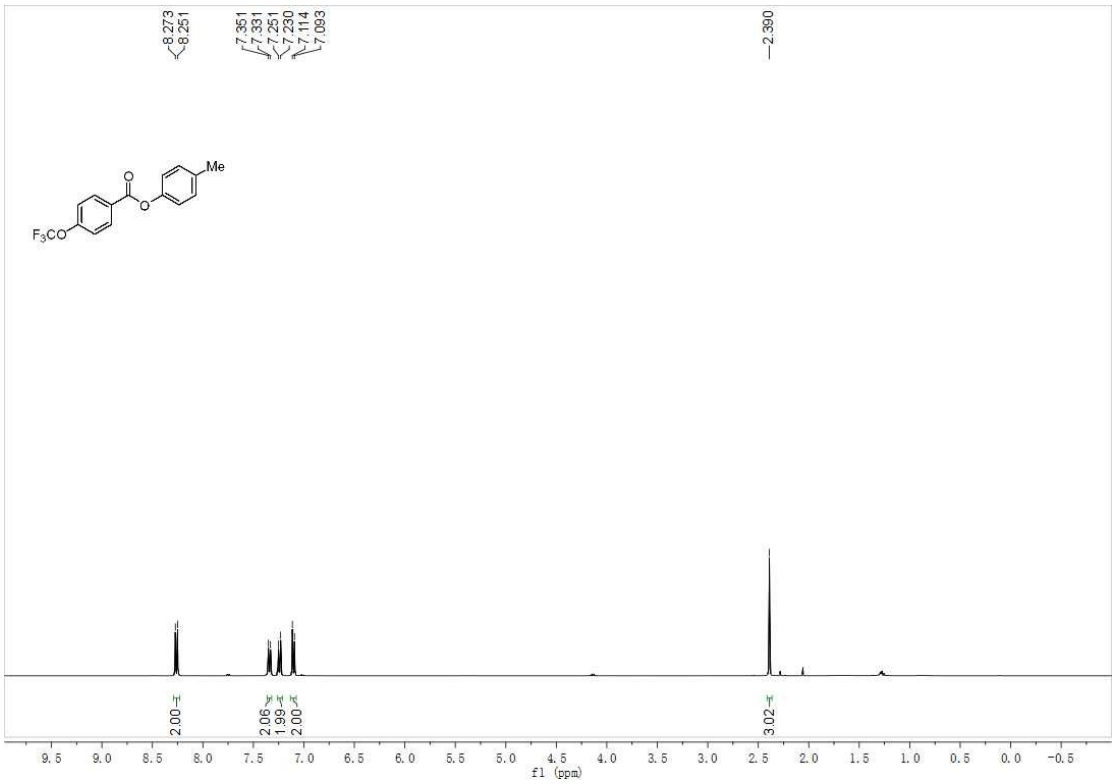
^{1}H NMR of compound **3x** (400 MHz, $CDCl_3$).



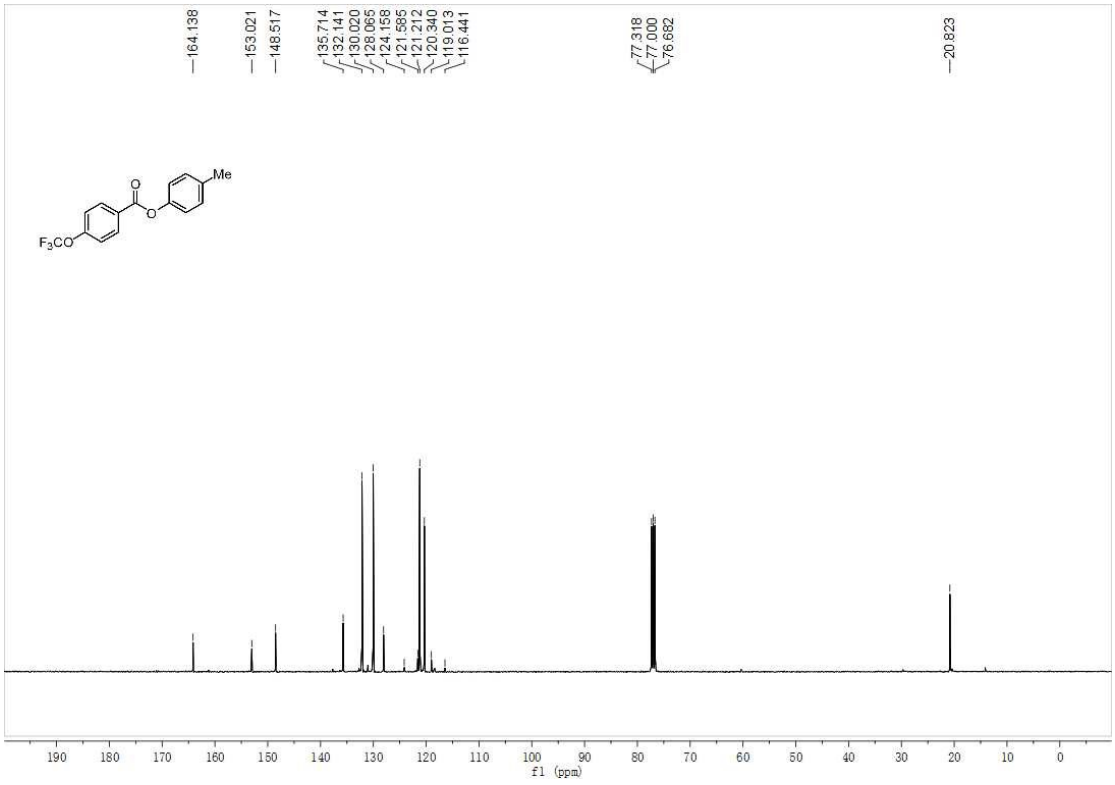
^{13}C NMR of compound **3x** (100 MHz, $CDCl_3$).



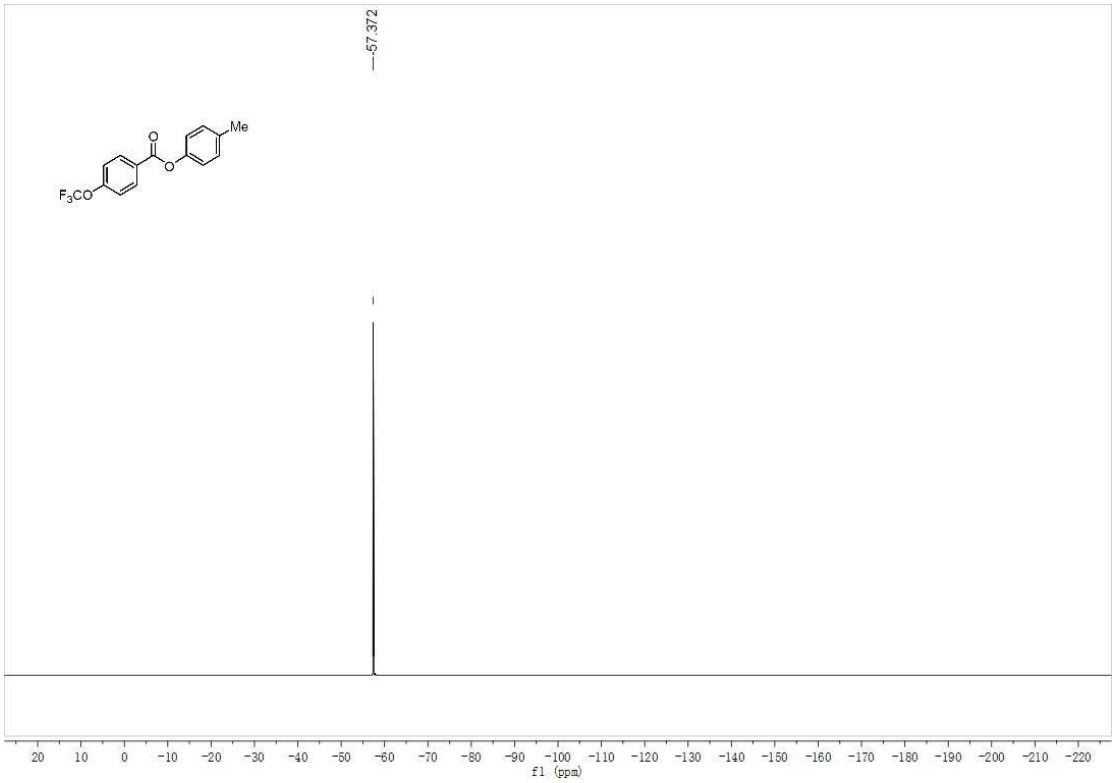
^{1}H NMR of compound **3y** (400 MHz, $CDCl_3$).



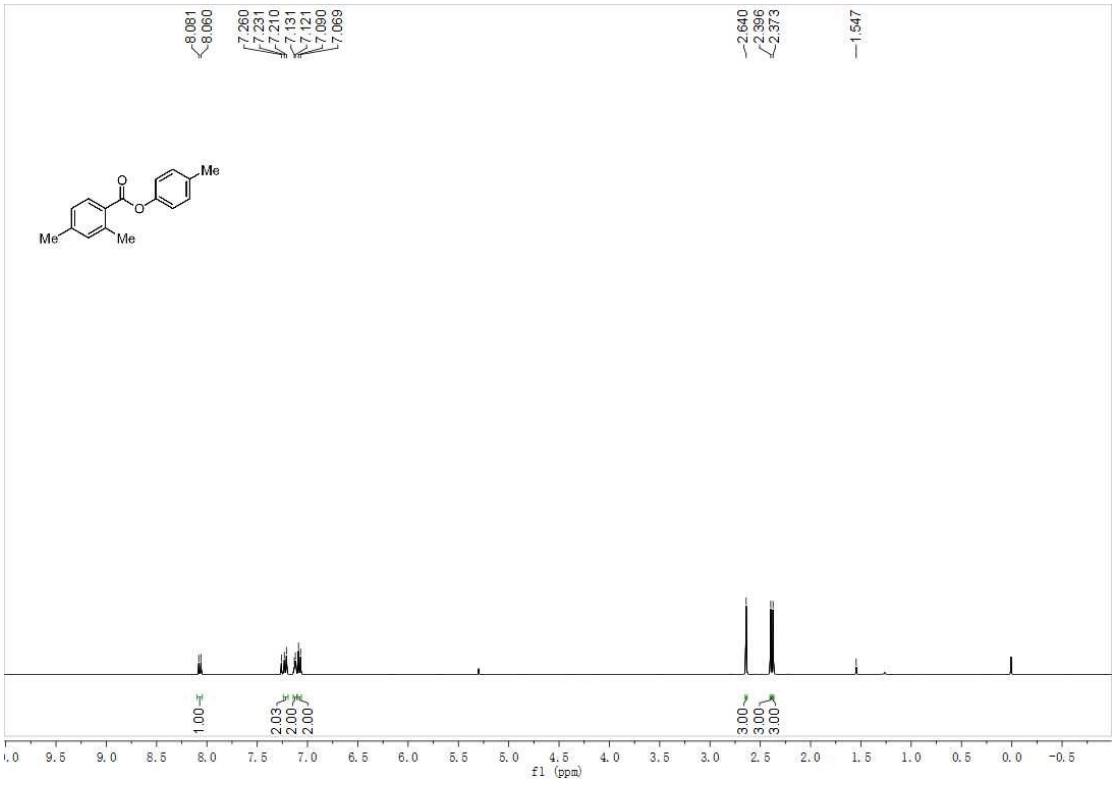
^{13}C NMR of compound **3y** (100 MHz, $CDCl_3$).



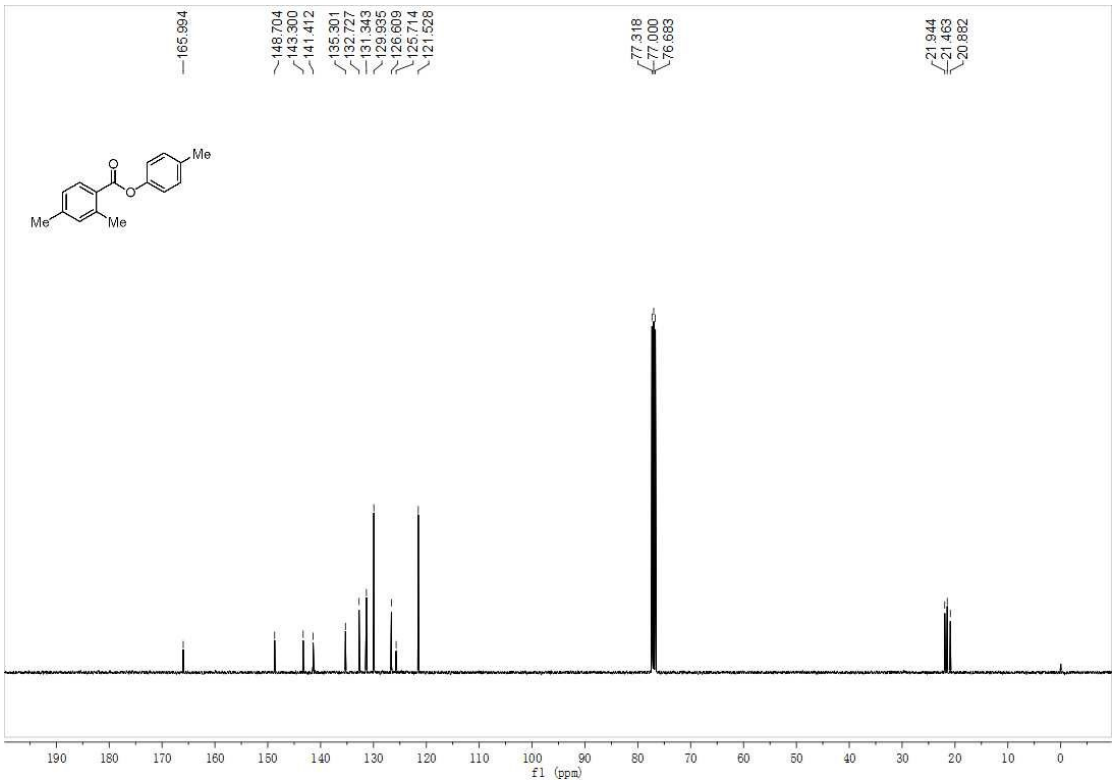
^{19}F NMR of compound **3y** (376 MHz, $CDCl_3$).



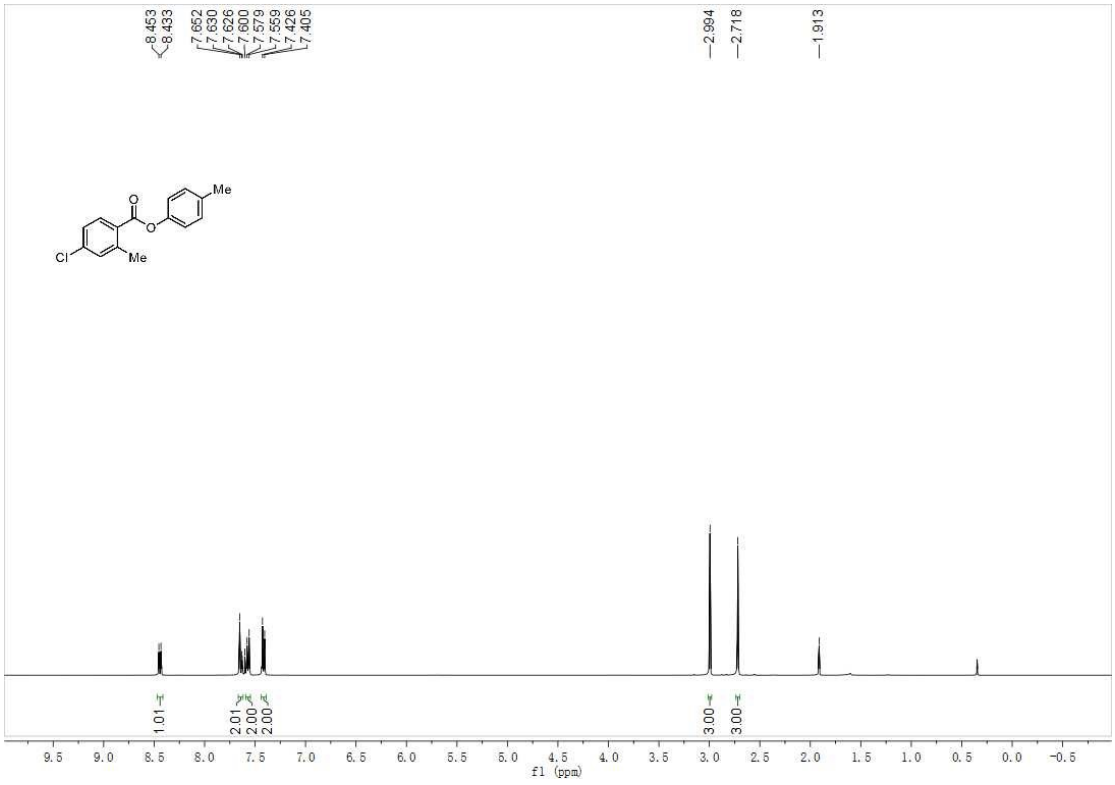
^{1}H NMR of compound **3z** (400 MHz, $CDCl_3$).



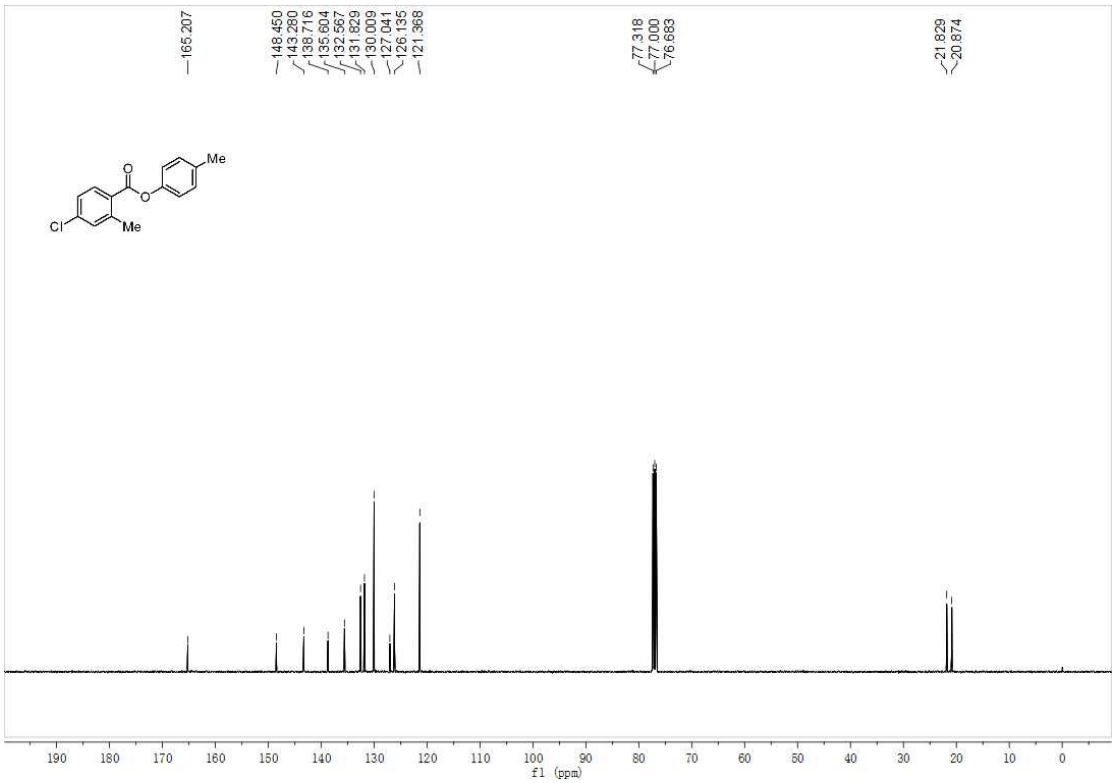
^{13}C NMR of compound **3z** (100 MHz, $CDCl_3$).



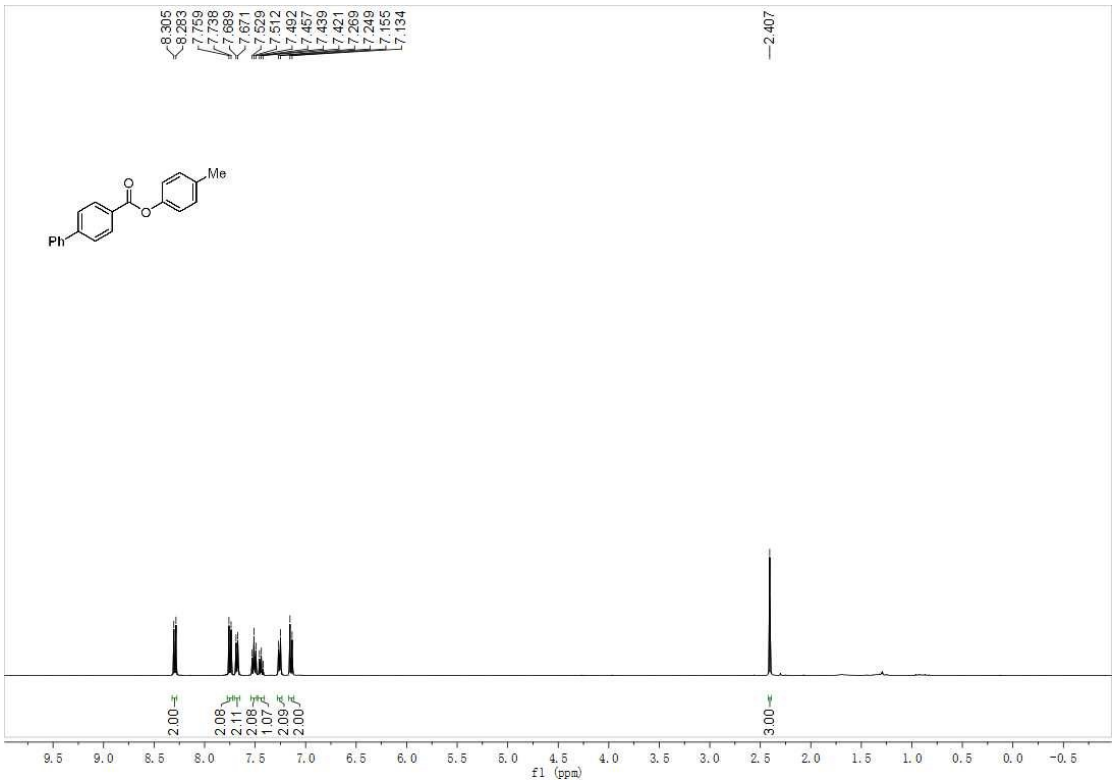
^{1}H NMR of compound **3aa** (400 MHz, $CDCl_3$).



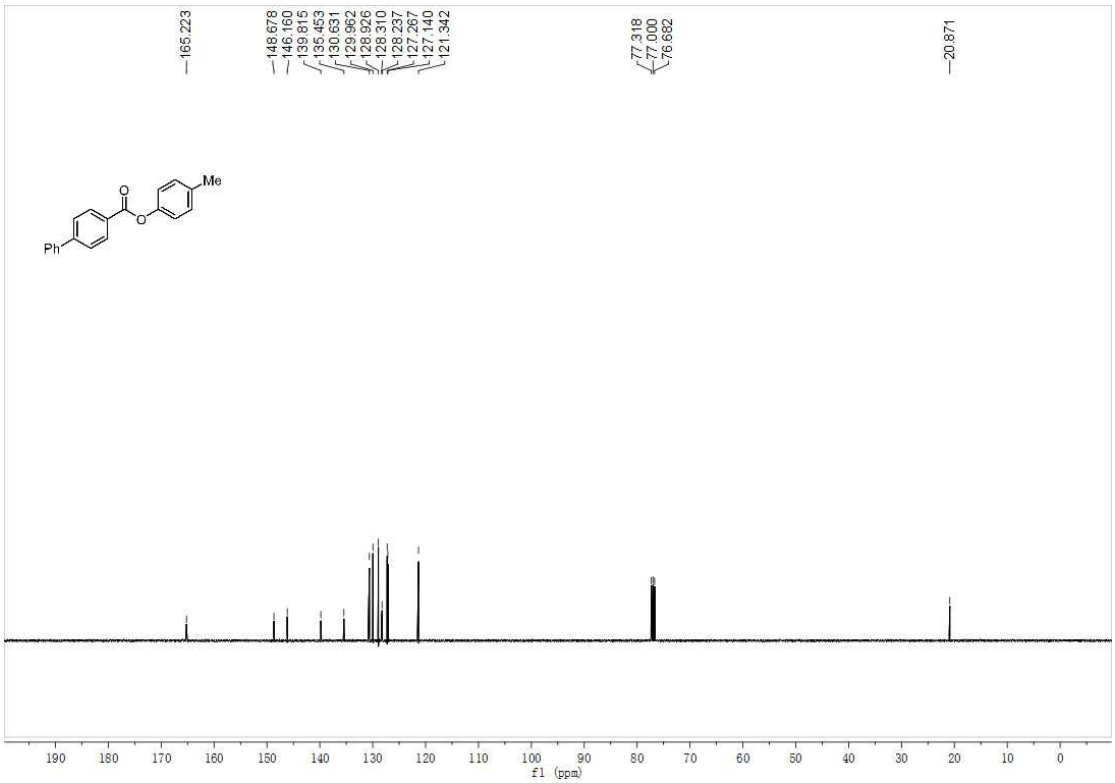
^{13}C NMR of compound **3aa** (100 MHz, $CDCl_3$).



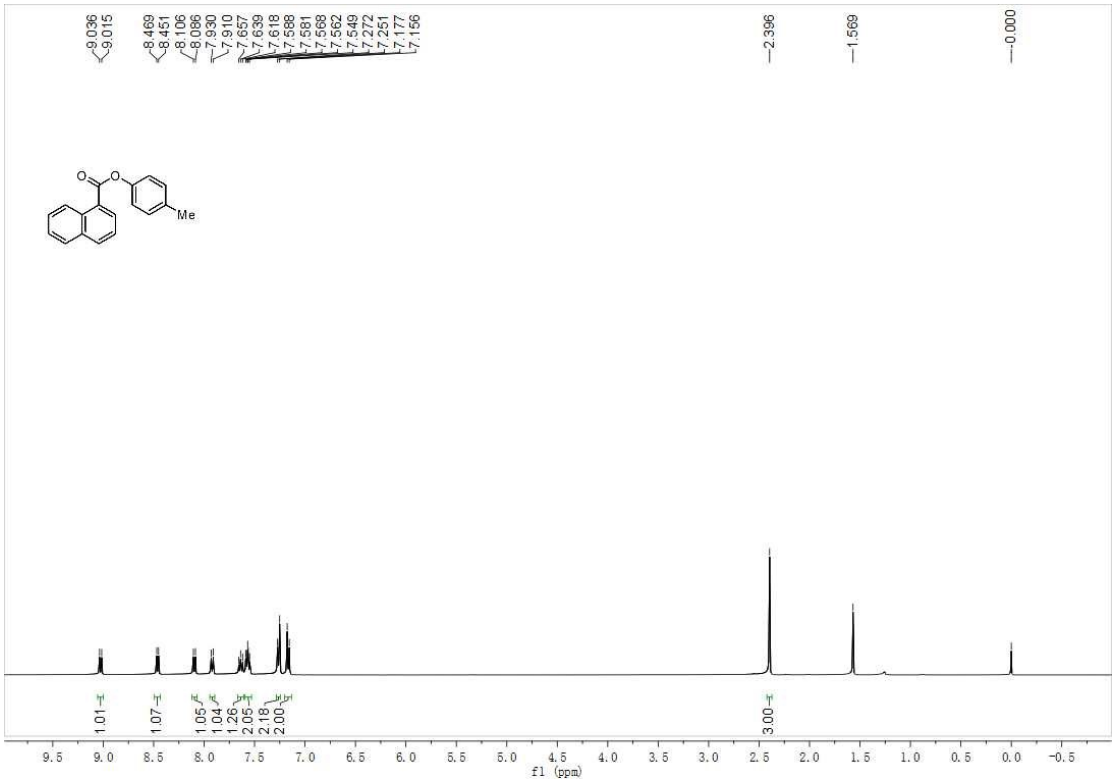
^{1}H NMR of compound **3ab** (400 MHz, $CDCl_3$).



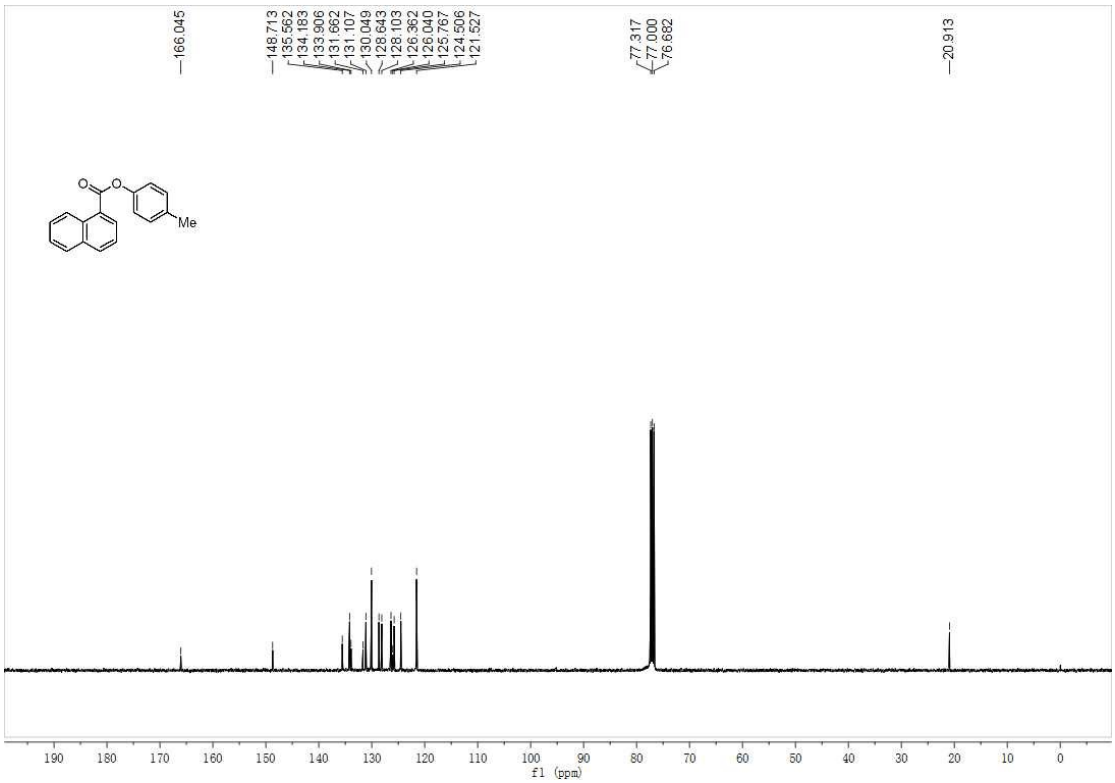
^{13}C NMR of compound **3ab** (100 MHz, $CDCl_3$).



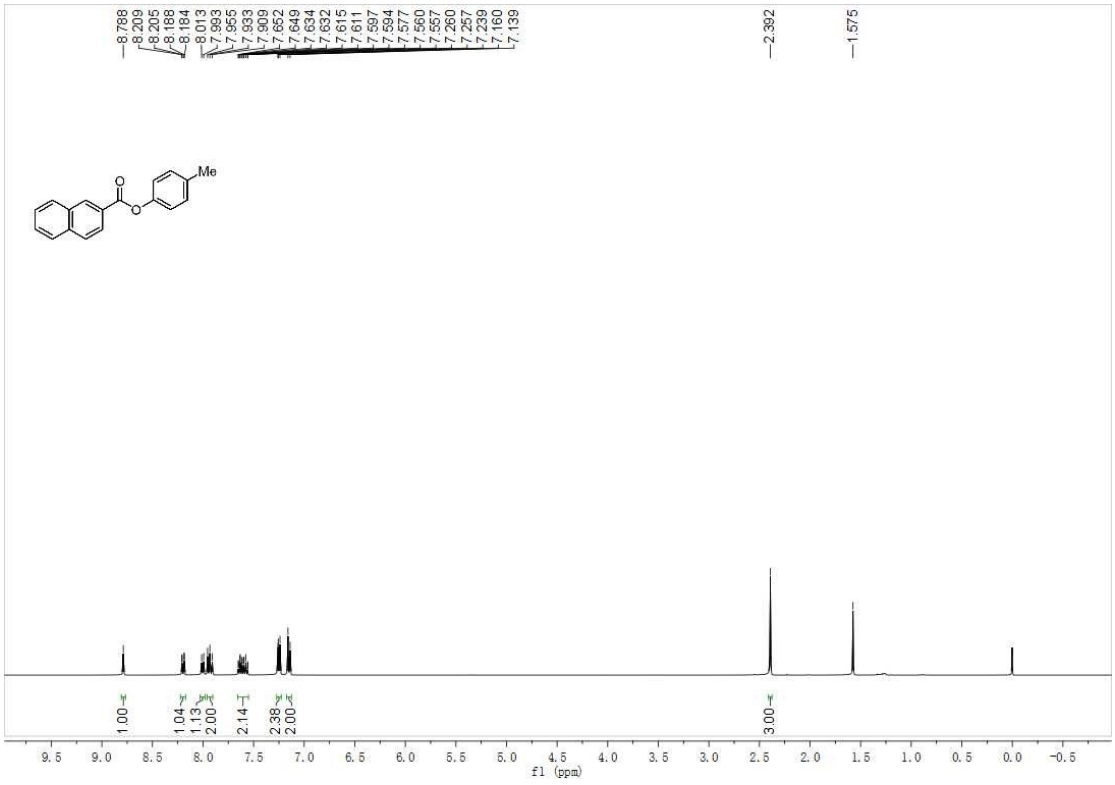
^{1}H NMR of compound **3ac** (400 MHz, $CDCl_3$).



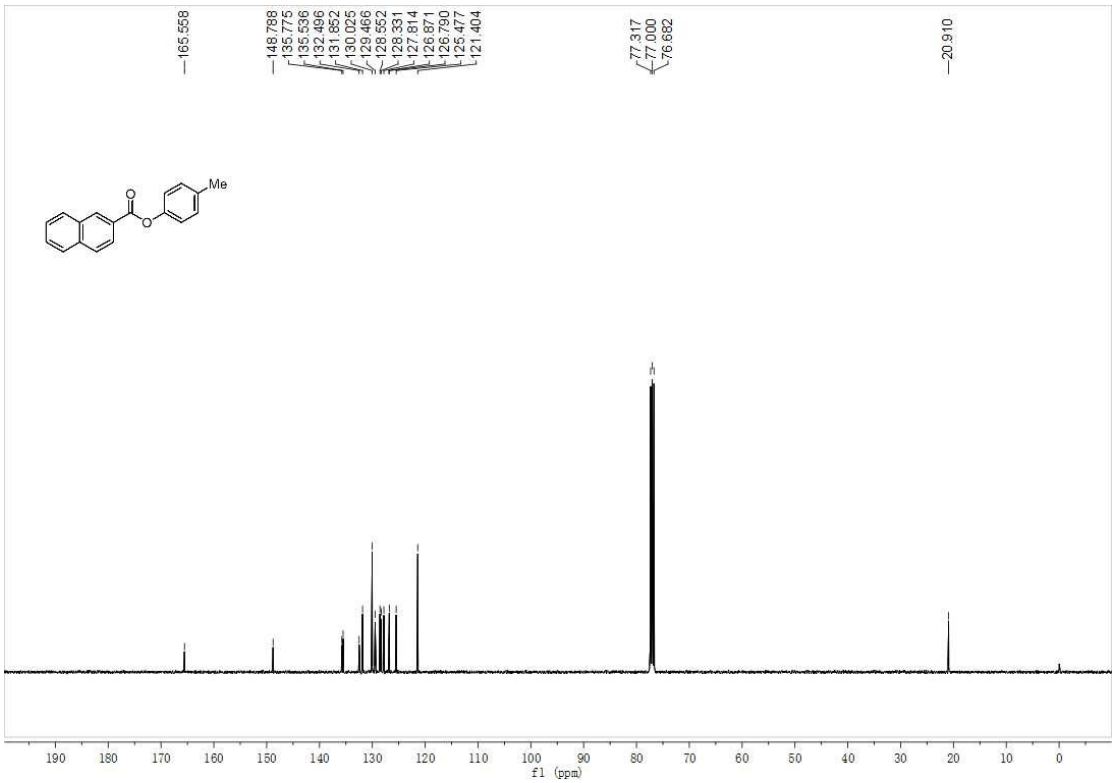
^{13}C NMR of compound **3ac** (100 MHz, $CDCl_3$).



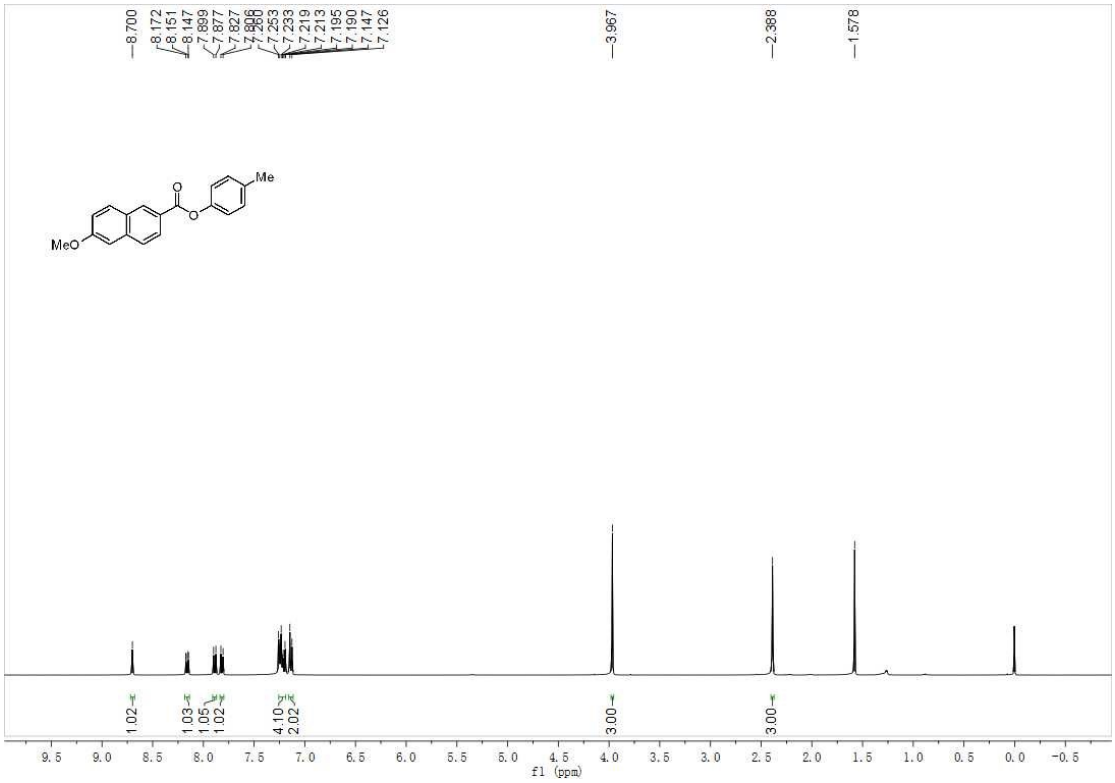
^{1}H NMR of compound **3ad** (400 MHz, $CDCl_3$).



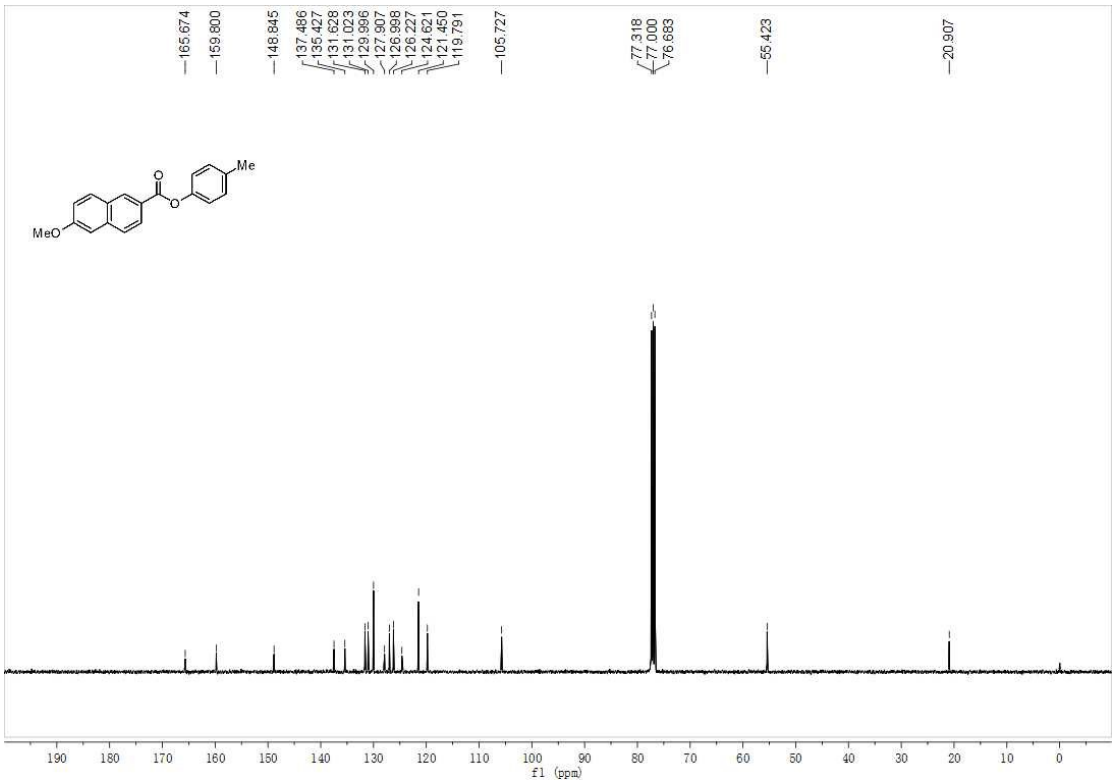
^{13}C NMR of compound **3ad** (100 MHz, $CDCl_3$).



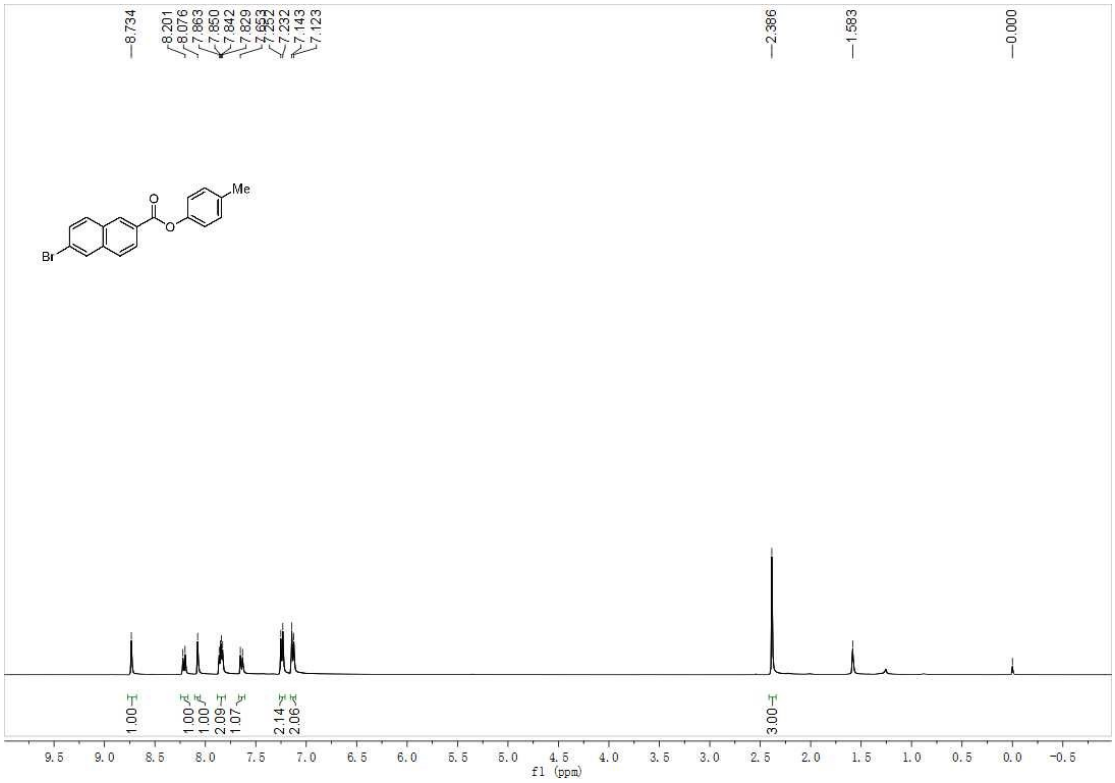
^{1}H NMR of compound **3ae** (400 MHz, $CDCl_3$).



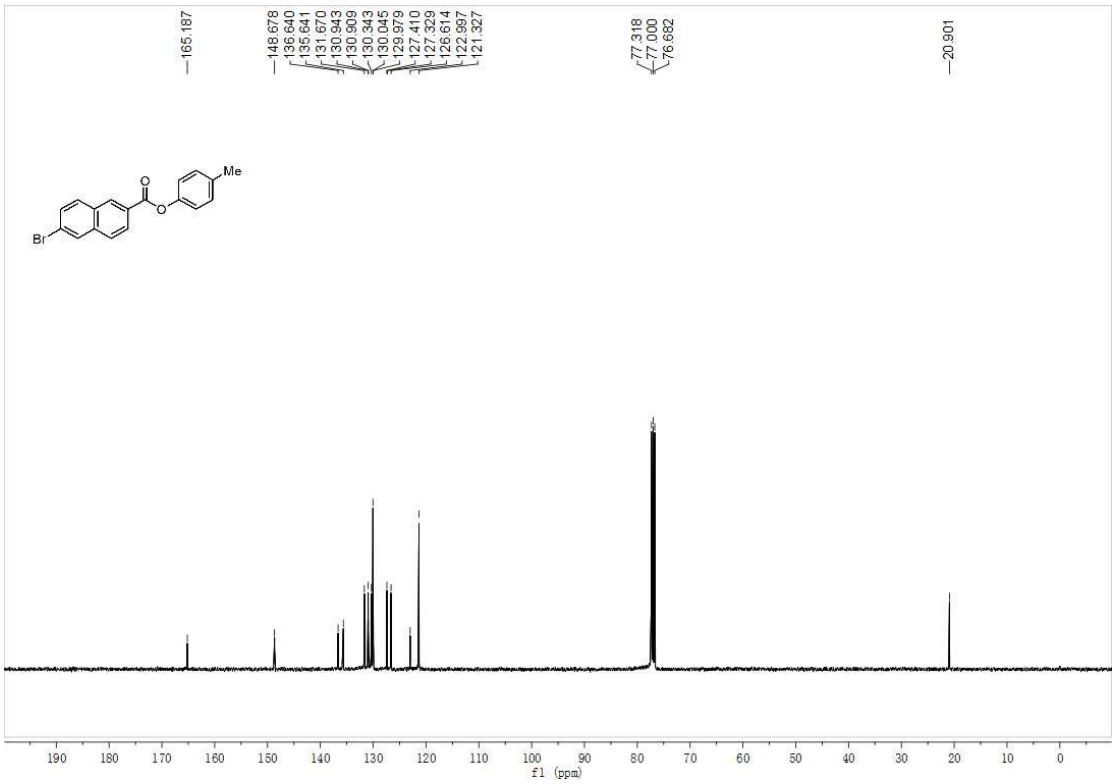
^{13}C NMR of compound **3ae** (100 MHz, $CDCl_3$).



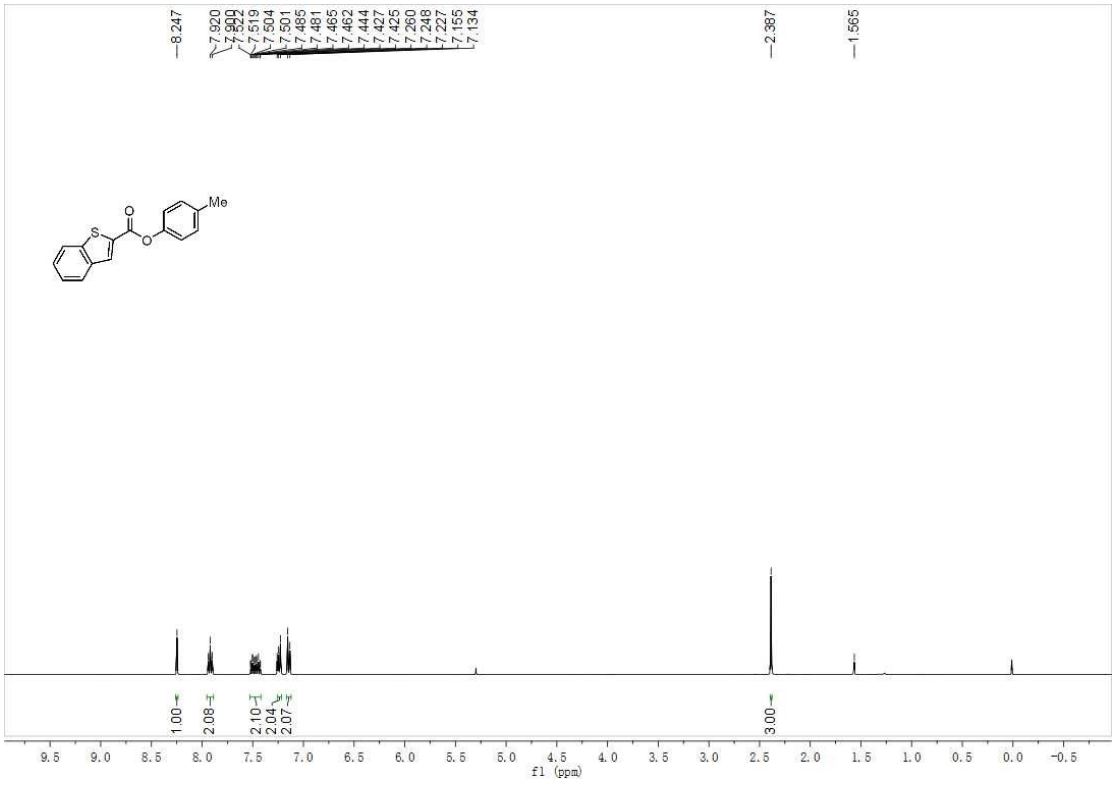
^{1}H NMR of compound **3af** (400 MHz, $CDCl_3$).



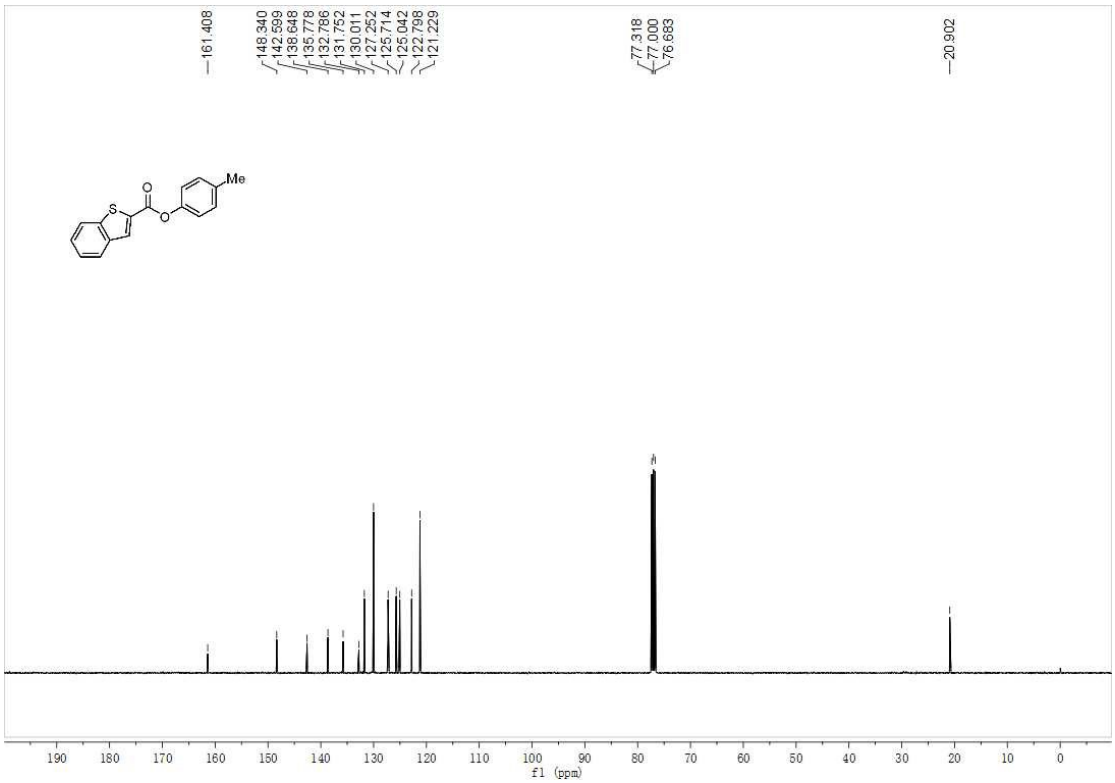
^{13}C NMR of compound **3af** (100 MHz, $CDCl_3$).



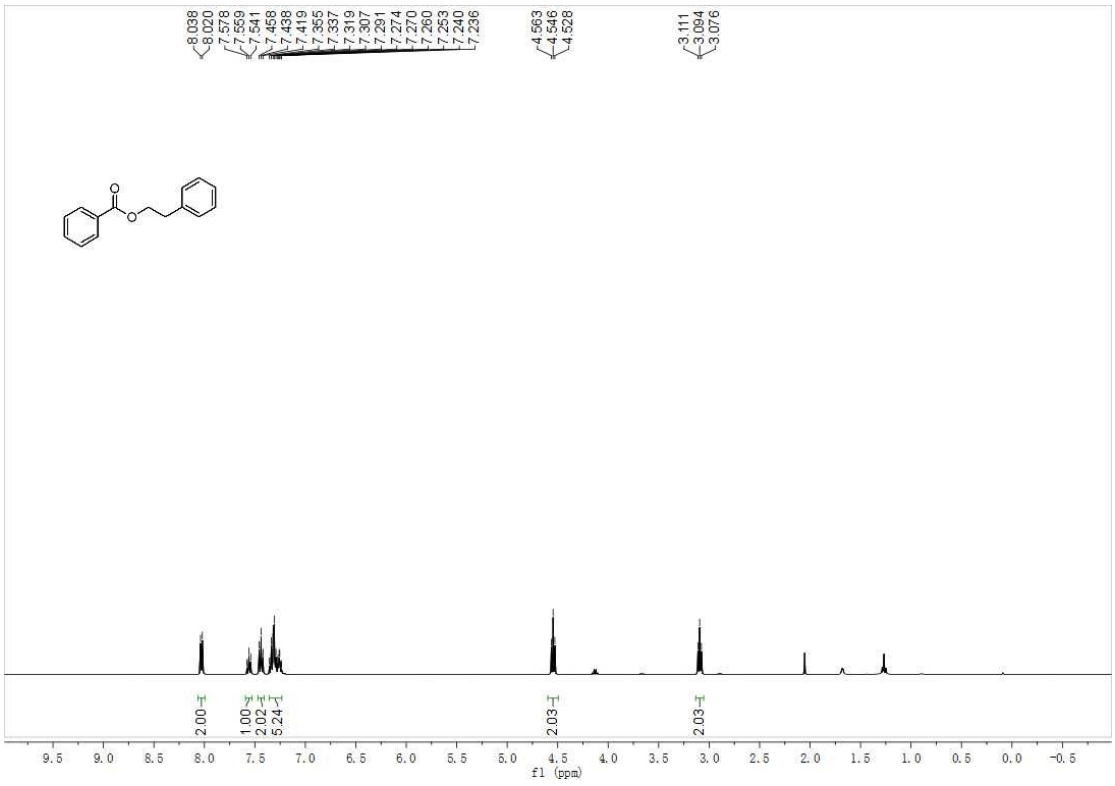
^{1}H NMR of compound **3ag** (400 MHz, $CDCl_3$).



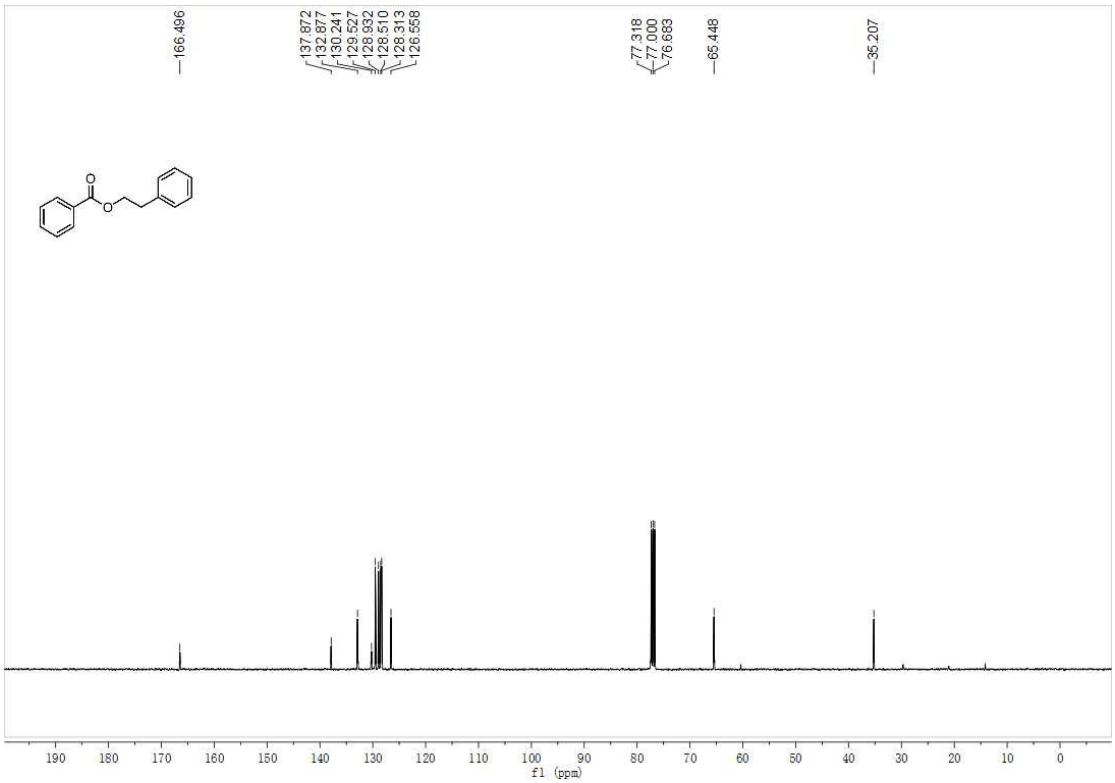
^{13}C NMR of compound **3ag** (100 MHz, $CDCl_3$).



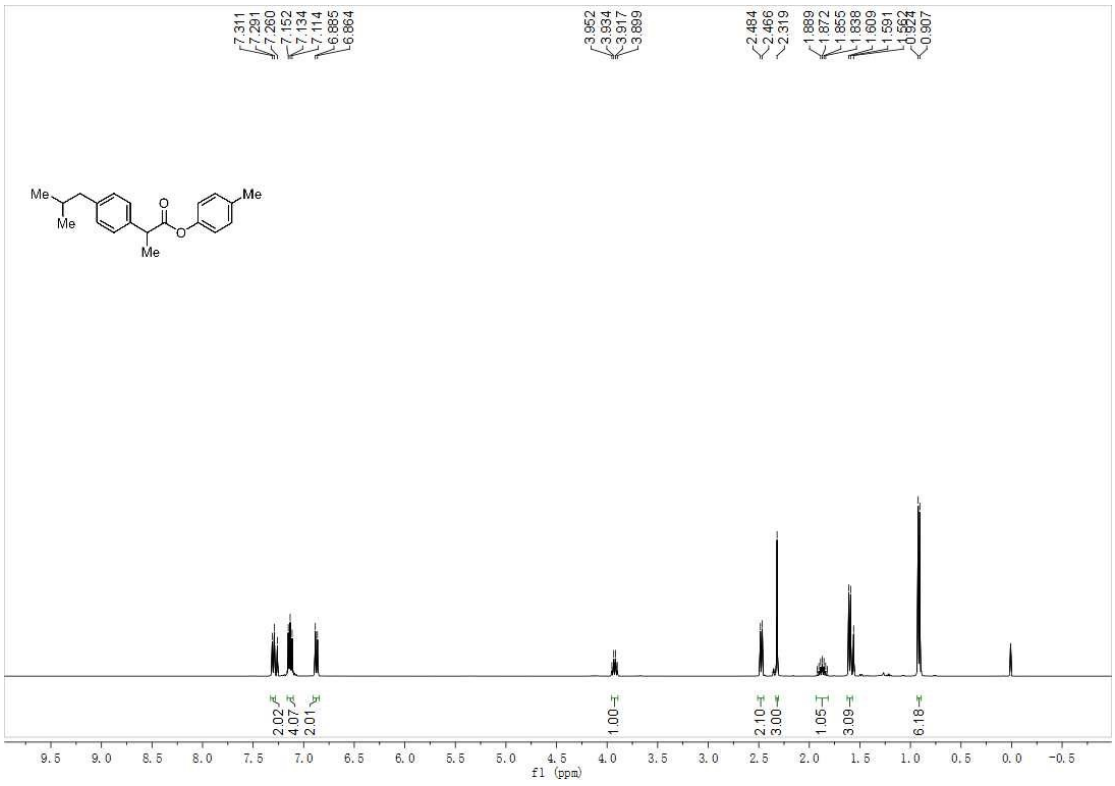
^{1}H NMR of compound **3ah** (400 MHz, $CDCl_3$).



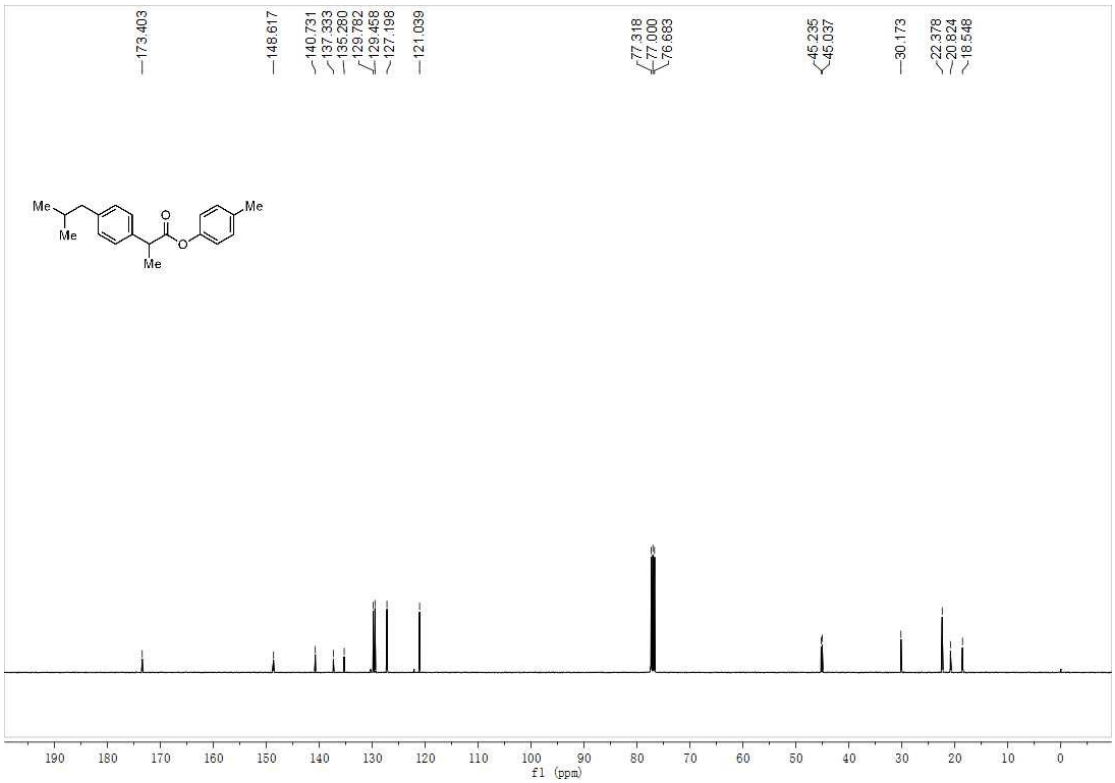
^{13}C NMR of compound **3ah** (100 MHz, $CDCl_3$).



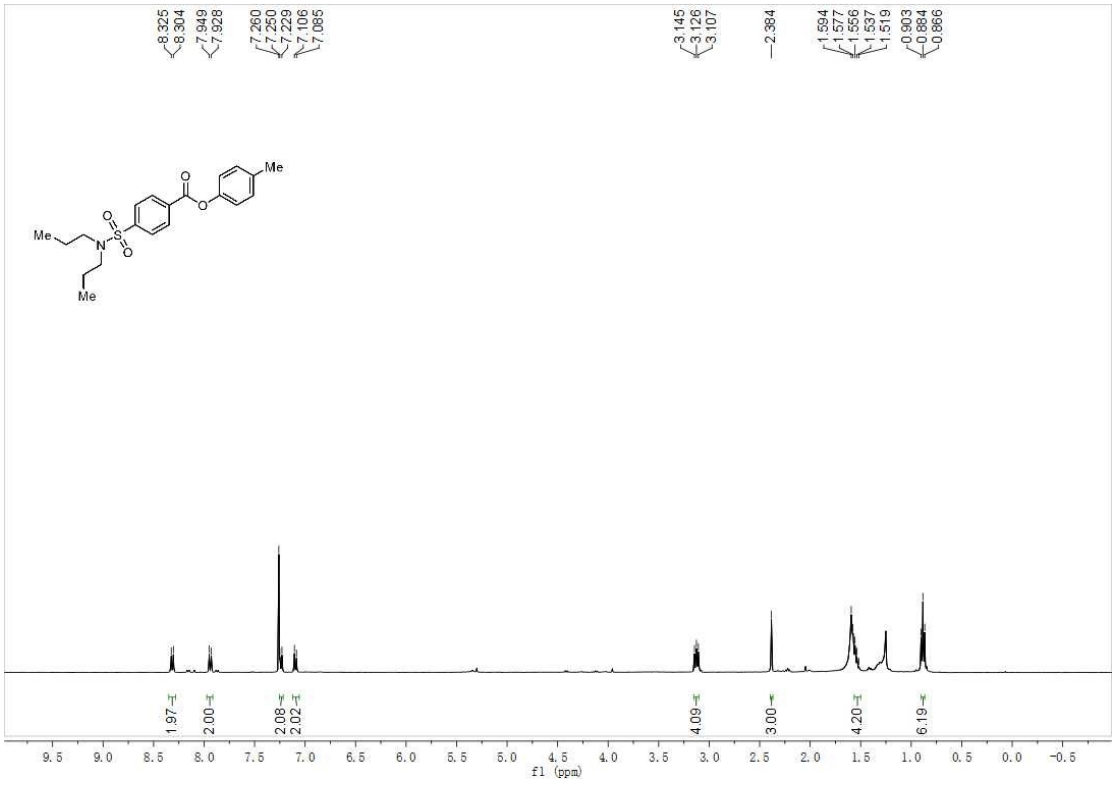
^{1}H NMR of compound **3ai** (400 MHz, $CDCl_3$).



^{13}C NMR of compound **3ai** (100 MHz, $CDCl_3$).



^{1}H NMR of compound **3aj** (400 MHz, $CDCl_3$).



^{13}C NMR of compound **3aj** (100 MHz, $CDCl_3$).