Ruthenium-catalyzed *meta*-C-H bond alkylation of aryl 2-pyridyl ketones

Gang Li,*[a] Chunqi Jia,[b†] Xiaofeng Cai,[a†] Lei zhong,[a] Lei Zou[a] and Xiuling Cui*[b]

[a]College of Chemistry and Chemical Engineering, Henan Province Key Laboratory of New Optoelectronic Functional Materials, Anyang Normal University, Anyang 455002, PR China.

[b]Engineering Research Center of Molecular Medicine of Ministry of Education, Key Laboratory of Fujian Molecular Medicine, Key Laboratory of Xiamen Marine and Gene Drugs, School of Biomedical Sciences, Huaqiao University, Xiamen 361021, PR China

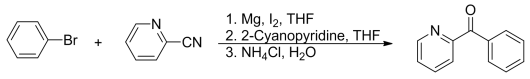
Supporting Information

1. General Information

All commercial reagents and solvents were used directly without additional purification. Column chromatography were performed on silica gel 200-300 mesh. ^{1}H NMR and ^{13}C NMR spectra were registered on a Bruker Ascend^{TM} 400 spectrometer (Germany). Chemical shifts were reported in units (ppm) referenced to 0.0 ppm of TMS in the ^{1}H spectrum and 77.0 ppm of $CDCl_3$ in the ^{13}C spectrum. All coupling constants were reported in Hertz (Hz). HRMS data were obtained on a Waters LCT Premierxe^{TM} (USA).

2. Experimental Section

2.1. Typical Procedure for the Synthesis of Phenyl(pyridin-2-yl)methanone.[1]



A solution of the aryl bromide derivatives (10.0 mmol, 1.0 equiv.) in 20 mL of THF was treated with magnesium (12.0 mmol, 1.2 equiv.) and 10 mg I_2 under N_2 atmosphere. After the formation of the Grignard reagent, the solution was cooled to room temperature, and added into the solution of 2-cyanopyridine (10 mmol, 1.0 equiv.) in THF (15 mL) at 0 °C dropwise. After the reaction was complete monitored by TLC, the reaction was quenched by addition of a solution of saturated NH_4Cl. The organic layer was separated and extracted twice with ethyl acetate. After evaporation, the residue was dissolved in Et_2O (80.0 mL), and 6 M HCl (10.0 mL) was added. After 30 min, the organic layer was separated. The aqueous layer was basified with saturated $NaHCO_3$, and then extracted three times with ethyl acetate. The combined organic layers were dried over Na_2SO_4 and evaporated in vacuo. The residue was purified by column chromatography with petroleum ether and ethyl acetate.

2.2. Typical experimental procedure of the *meta*-C_{Ar}-H bond alkylations of aryl 2-pyridyl ketones.

Aryl 2-pyridyl ketones (0.2 mmol), Alkyl bromide (0.6 mmol, 3.0 equiv.), [Ru(*p*-Cymene)Cl_2]$_2$, (0.01 mmol, 5 mol %), KOAc (0.6 mmol, 3.0 equiv), 1-AdCOOH (30 mmol %), dry toluene (1 mL) were charged into a pre-dried 30-mL pressure tube sealed with rubber plugs under N_2 atmosphere. The reaction mixture was stirred at 110 °C for 24 h. The reaction was cooled down to room temperature. The mixture was passed through a short pad of celite, washing with a mixture of EtOAc. The organic layer was concentrated under reduced pressure to give a crude oil, which was purified by column chromatography (ethyl acetate/petroleum as eluent) on silica gel to afford the desired products.

3. References

1. Beibei Liu, Ge Qu, Jun‐Kuan Li, Wenchao Fan, Jun-An Ma, Yan Xu, Yao Nie, Zhoutong Sun, Adv. Synth. Catal., 2019, 361, 3182.

4. Data and Spectra of ^{1}H NMR and ^{13}C NMR

Methyl 2-(3-picolinoylphenyl)propanoate (3a, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 3.8 Hz, 1H), 8.10-7.99 (m, 2H), 7.99-7.87 (m, 2H), 7.56 (d, *J* = 7.6 Hz, 1H), 7.53-7.37 (m, 2H), 3.82 (m, 1H), 3.66 (s, 3H), 1.54 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.69, 174.58, 154.98, 148.56, 140.61, 137.10, 136.59, 132.02, 130.08 (d), 128.41, 126.26, 124.65, 52.12, 45.30, 18.47. HRMS (ESI) Calcd. For $C_{16}H_{16}NO_3$: $[M+H]^+$, 270.1125, Found: m/z 270.1127.

Methyl 2-(2-methyl-5-picolinoylphenyl)propanoate (3b, slight yellow oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (d, *J* = 4.8 Hz, 1H), 8.00 (m, 2H), 7.91-7.80 (m, 2H), 7.48 (m, 1H), 7.31-7.22 (m, 1H), 4.01 (q, *J* = 7.1 Hz, 1H), 3.66 (s, 3H), 2.44 (s, 3H), 1.52 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.41, 174.73, 155.25, 148.48, 141.62, 139.12, 137.01, 134.58, 130.32, 129.88, 129.41, 126.09, 124.57, 52.09, 41.39, 19.90, 17.69. HRMS (ESI) Calcd. For $C_{17}H_{18}NO_3$: $[M+H]^+$, 284.1281, Found: m/z 284.1279.

Methyl 2-(4-picolinoyl-[1,1'-biphenyl]-2-yl)propanoate (3c, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81-8.70 (m, 1H), 8.11 (m, 2H), 8.00-7.89 (m, 2H), 7.56-7.36 (m, 7H), 3.97 (q, *J* = 7.1 Hz, 1H), 3.64 (s, 3H), 1.42 (d, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.40, 174.89, 155.00, 148.55, 146.26, 140.36, 138.78, 137.14, 135.75, 130.11, 129.81, 129.41, 129.05, 128.36, 127.66, 126.31, 124.69, 52.09, 41.19, 19.17. HRMS (ESI) Calcd. For $C_{22}H_{20}NO_3$: $[M+H]^+$, 346.1438, Found: m/z 346.1433.

Methyl 2-(2-chloro-5-picolinoylphenyl)propanoate (3d, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.77-8.66 (m, 1H), 8.15-8.04 (m, 2H), 7.93 (m, 2H), 7.51 (m, 2H), 4.26 (q, *J* = 7.2 Hz, 1H), 3.69 (d, *J* = 4.1 Hz, 3H), 1.56 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.34, 173.97, 154.57, 148.49, 138.79, 138.47, 137.23, 135.14, 131.25, 131.00, 129.45, 126.50, 124.72, 52.28, 42.24, 17.36. HRMS (ESI) Calcd. For $C_{16}H_{15}ClNO_3$: $[M+H]^+$, 304.0735, Found: m/z 304.0730.

Methyl 2-(2-fluoro-5-picolinoylphenyl)propanoate (3e, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 4.7 Hz, 1H), 8.13 (m, 1H), 8.09-8.02 (m, 2H), 7.92 (m, 1H), 7.56-7.48 (m, 1H), 7.15 (t, *J* = 9.1 Hz, 1H), 4.07 (q, *J* = 7.2 Hz, 1H), 3.69 (d, *J* = 4.8 Hz, 3H), 1.56 (d, *J* = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 191.95, 173.76, 164.65, 154.89, 148.43, 137.16, 132.81-132.33 (m), 128.01 (d, *J* = 15.5 Hz), 126.30, 124.68, 115.45, 115.22, 52.24, 38.63 (d, *J* = 2.1 Hz), 17.26. HRMS (ESI) Calcd. For $C_{16}H_{15}FNO_3$: $[M+H]^+$, 288.1030, Found: m/z 288.1032.

Methyl 2-(5-picolinoyl-2-(trifluoromethyl)phenyl)propanoate (3f, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 3.8 Hz, 1H), 8.10-7.99 (m, 2H), 7.99-7.87 (m, 2H), 7.56 (d, *J* = 7.6 Hz, 1H), 7.53-7.37 (m, 2H), 3.82 (M, 1H), 3.66 (s, 3H), 1.54 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.56, 173.97, 153.99, 148.64, 139.67, 137.29, 131.62, 131.31, 129.42, 126.82, 125.84, 125.78, 125.72, 125.67, 125.27, 124.75, 52.34, 40.91, 19.40. HRMS (ESI) Calcd. For $C_{17}H_{15}F_3NO_3$: $[M+H]^+$, 338.0999, Found: m/z 338.0994.

Methyl 2-(2-methoxy-5-picolinoylphenyl)propanoate (3g, colorless oil): ^{1}H NMR (400 MHz,

$CDCl_3$) δ 8.70 (d, *J* = 4.5 Hz, 1H), 8.05 (m, 2H), 7.98 (d, *J* = 7.8 Hz, 1H), 7.88 (m, 1H), 7.51-7.44 (m, 1H), 6.93 (d, *J* = 8.5 Hz, 1H), 4.05 (q, *J* = 7.2 Hz, 1H), 3.88 (d, *J* = 7.3 Hz, 3H), 3.65 (s, 3H), 1.49 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.24, 174.96, 160.79, 155.72, 148.32, 137.00, 132.78, 131.37, 129.46, 128.91, 125.84, 124.52, 109.78, 55.78, 51.93, 39.46, 16.97. HRMS (ESI) Calcd. For $C_{17}H_{18}NO_4$: $[M+H]^+$, 300.1230, Found: m/z 300.1231.

Ethyl 2-(2-methoxy-5-picolinoylphenyl)butanoate (3h, colorless oil): ^1H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, *J* = 4.7 Hz, 1H), 8.10-8.02 (m, 2H), 7.97 (d, *J* = 7.8 Hz, 1H), 7.87 (m, 1H), 7.53-7.40 (m, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 4.11 (q, *J* = 7.1 Hz, 2H), 3.95-3.81 (m, 4H), 2.08 (m, 1H), 1.88-1.71 (m, 1H), 1.18 (t, *J* = 7.1 Hz, 3H), 0.91 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.33, 173.85, 161.01, 155.70, 148.32, 137.02, 132.63, 131.78, 128.75, 128.05, 125.85, 124.53, 109.71, 60.50, 55.74, 46.22, 25.21, 14.19, 12.21. HRMS (ESI) Calcd. For $C_{19}H_{22}NO_4$: $[M+H]^+$, 328.1543, Found: m/z 328.1546.

Methyl 2-(2-methoxy-5-picolinoylphenyl)octanoate (3i, colorless oil): ^1H NMR (400 MHz, $CDCl_3$) δ 8.69 (d, *J* = 4.7 Hz, 1H), 8.09-8.01 (m, 2H), 7.98 (d, *J* = 7.8 Hz, 1H), 7.89 (m, 1H), 7.50-7.41 (m, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 3.99 (t, *J* = 7.5 Hz, 1H), 3.89 (s, 3H), 3.63 (s, 3H), 2.11-2.00 (m, 1H), 1.77 (m, 1H), 1.26 (m, 8H), 0.85 (t, *J* = 6.7 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 192.30, 174.49, 160.92, 155.65, 148.31, 137.04, 132.64, 131.77, 128.81, 128.08, 125.88, 124.56, 109.78, 55.82, 51.87, 44.21, 32.03, 31.61, 29.04, 27.49, 22.59, 14.06. HRMS (ESI) Calcd. For $C_{22}H_{28}NO_4$: $[M+H]^+$, 370.2013, Found: m/z 370.2010.

Methyl 2-(3-(4-methylpicolinoyl)phenyl)propanoate (3j, colorless oil): ^1H NMR (400 MHz, $CDCl_3$) δ 8.57 (d, *J* = 4.9 Hz, 1H), 8.04-7.83 (m, 3H), 7.55 (d, *J* = 7.8 Hz, 1H), 7.44 (t, *J* = 7.7 Hz, 1H), 7.31 (m, 1H), 3.82 (q, J = 7.2 Hz, 1H), 3.67 (s, 3H), 2.48 (s, 3H), 1.54 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 194.08, 174.60, 154.87, 148.43 (d, J = 10.2 Hz), 140.57, 136.76, 131.95, 130.06 (d), 128.37, 127.11, 125.43, 52.11, 45.31, 21.14, 18.46. HRMS (ESI) Calcd. For $C_{17}H_{18}NO_3$: $[M+H]^+$, 284.1281, Found: m/z 284.1285.

Methyl 2-(3-picolinoylnaphthalen-1-yl)propanoate (3k, slight yellow oil): ^1H NMR (400 MHz, $CDCl_3$) δ 8.78 (m, 1H), 8.57 (s, 1H), 8.19-8.09 (m, 3H), 8.02-7.93 (m, 2H), 7.70-7.64 (m, 1H), 7.59-7.52 (m, 2H), 4.54 (q, *J* = 7.1 Hz, 1H), 3.67 (s, 3H), 1.73 (d, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.46, 175.04, 148.57, 137.15, 133.56 (d, *J* = 13.1 Hz), 133.00 (d, *J* = 9.6 Hz), 130.98, 128.99, 126.26 (d), 124.79 (d), 123.21, 52.23, 41.75, 17.89. HRMS (ESI) Calcd. For $C_{20}H_{18}NO_3$: $[M+H]^+$, 320.1281, Found: m/z 320.1283.

Ethyl 2-(3-picolinoylphenyl)butanoate (3l, slight yellow oil): ^1H NMR (400 MHz, $CDCl_3$) δ 8.72 (d, *J* = 4.0 Hz, 1H), 8.09-7.97 (m, 2H), 7.97-7.85 (m, 2H), 7.58 (d, *J* = 7.3 Hz, 1H), 7.47 (m, 2H), 4.13 (m, 2H), 3.53 (t, *J* = 7.6 Hz, 1H), 2.13 (m, 1H), 1.90-1.77 (m, 1H), 1.22 (t, *J* = 7.0 Hz, 3H), 0.92 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.72, 173.64, 155.06, 148.54, 139.40, 137.06, 136.46, 132.43, 130.53, 130.10, 128.31, 126.19, 124.62, 60.76, 53.39, 26.80, 14.13, 12.14. HRMS (ESI) Calcd. For $C_{18}H_{20}NO_3$: $[M+H]^+$, 298.1438, Found: m/z 298.1434.

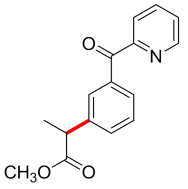
Methyl 2-(3-picolinoylphenyl)octanoate (3m, slight yellow oil): ^1H NMR (400 MHz, $CDCl_3$)

δ 8.71 (s, 1H), 8.06-7.97 (m, 2H), 7.96-7.82 (m, 2H), 7.56 (d, *J* = 7.0 Hz, 1H), 7.51-7.38 (m, 2H), 3.65 (s, 3H), 2.08 (s, 1H), 1.79 (s, 1H), 1.25 (s, 9H), 0.85 (d, *J* = 6.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.66, 174.21, 155.01, 148.53, 139.42, 137.06, 136.50, 132.40, 130.49, 130.14, 128.34, 126.21, 124.62, 51.97, 51.50, 33.48, 31.56, 28.97, 27.48, 22.54, 14.02. HRMS (ESI) Calcd. For $C_{21}H_{26}NO_3$: $[M+H]^+$, 340.1907, Found: m/z 340.1901.

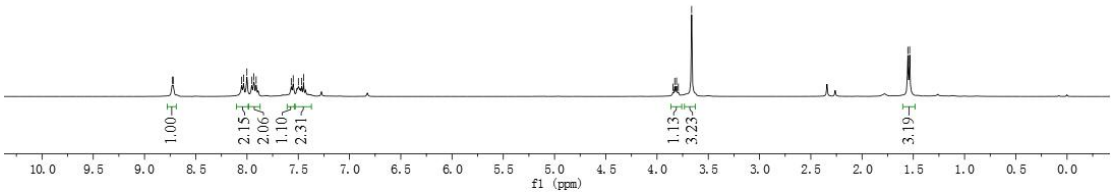
Ethyl 2-methyl-2-(3-picolinoylphenyl)propanoate (3n, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.79-8.68 (m, 1H), 8.06 (m, 2H), 7.91 (m, 2H), 7.59 (d, *J* = 7.9 Hz, 1H), 7.52-7.39 (m, 2H), 4.13 (q, *J* = 7.1 Hz, 2H), 1.62 (s, 6H), 1.19 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.84, 176.35, 155.11, 148.52, 145.01, 137.08, 136.26, 130.59, 129.70, 128.03 (d), 126.19, 124.64, 60.95, 46.55, 26.49, 14.02. HRMS (ESI) Calcd. For $C_{18}H_{20}NO_3$: $[M+H]^+$, 298.1438, Found: m/z 298.1434.

Methyl 2-methyl-2-(3-picolinoylphenyl)propanoate (3o, colorless oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (d, *J* = 4.7 Hz, 1H), 8.06 (m, 2H), 7.92 (m, 2H), 7.58 (d, *J* = 8.0 Hz, 1H), 7.53-7.39 (m, 2H), 3.66 (s, 3H), 1.63 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 193.84, 176.90, 155.05, 148.52, 144.80, 137.10, 136.31, 130.56, 129.77, 128.06 (d), 126.24, 124.67, 52.30, 46.58, 26.48. HRMS (ESI) Calcd. For $C_{17}H_{18}NO_3$: $[M+H]^+$, 284.1281, Found: m/z 284.1286.

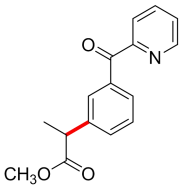

8.73
8.72
8.05
8.03
8.00
7.95
7.93
7.91
7.57
7.55
7.50
7.47
7.45
3.84
3.83
3.81
3.79
3.66
1.55
1.54


O
N
CH3O
O

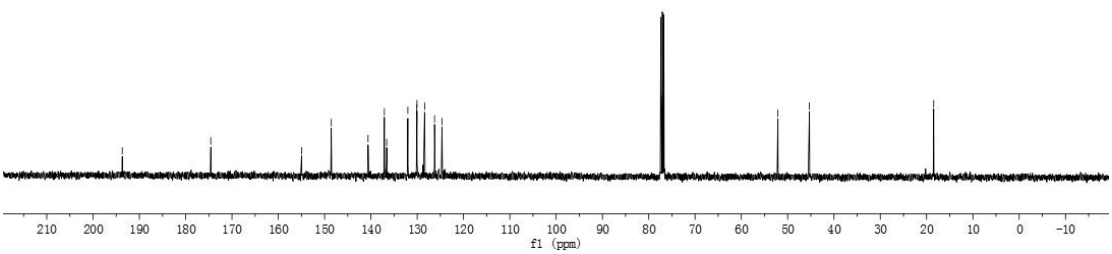
3a

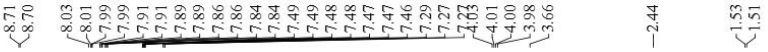

1.00
2.15
2.06
1.10
2.31
1.13
3.23
3.19
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

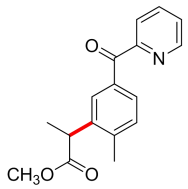

193.69
174.58
154.98
148.56
140.61
137.10
136.59
132.02
130.10
130.05
128.41
126.26
124.65
52.12
45.30
18.47


O
N
CH3O
O

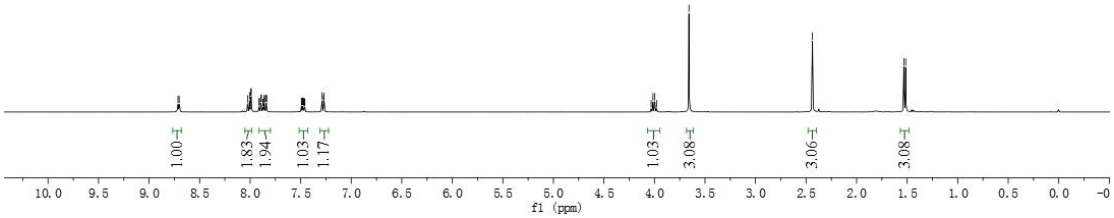
3a

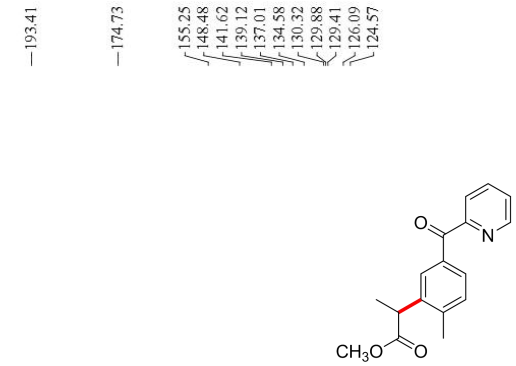

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.71
8.70
8.03
8.01
7.99
7.99
7.91
7.91
7.89
7.89
7.86
7.86
7.84
7.84
7.49
7.49
7.48
7.48
7.47
7.47
7.46
7.29
7.27
7.23
4.03
4.01
4.00
3.98
3.66
2.44
1.53
1.51


O
N
CH3O
O

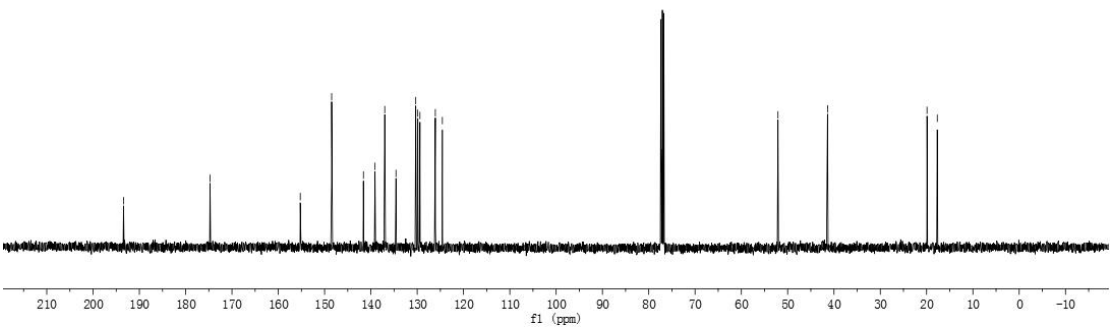
3b

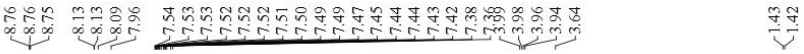

1.00
1.83
1.94
1.03
1.17
1.03
3.08
3.06
3.08
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0
f1 (ppm)

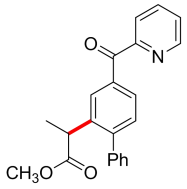

193.41
174.73
155.25
148.48
141.62
139.12
137.01
134.58
130.32
129.88
129.41
126.09
124.57
52.09
41.39
19.90
17.69

O
N
CH3O
O

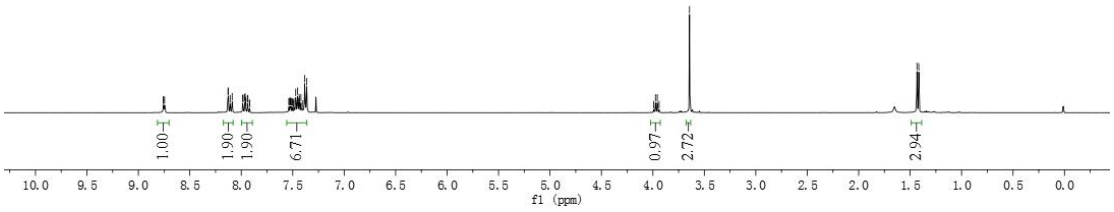
3b


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

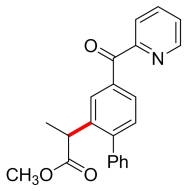

8.76
8.76
8.75
8.13
8.13
8.09
7.96
7.54
7.53
7.53
7.52
7.52
7.52
7.51
7.50
7.49
7.49
7.47
7.45
7.44
7.44
7.43
7.42
7.38
3.98
3.96
3.94
3.64
1.43
1.42


O
N
Ph
CH3O
O

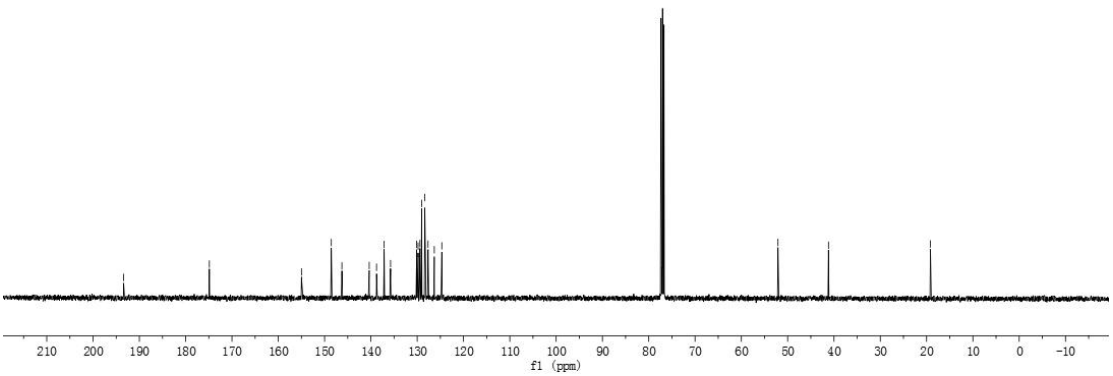
3c


1.00
1.90
1.90
6.71
0.97
2.72
2.94
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

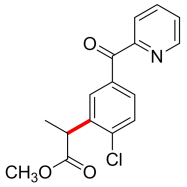

193.40
174.89
155.00
148.55
146.26
140.36
138.78
137.14
135.75
130.11
129.81
129.41
129.05
128.36
127.66
126.31
124.69
52.09
41.19
19.17


O
N
Ph
CH3O
O

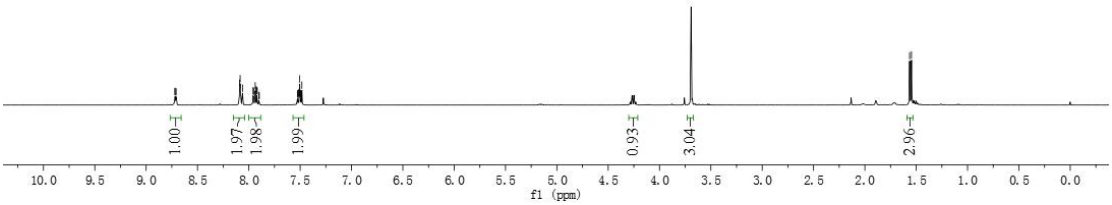
3c

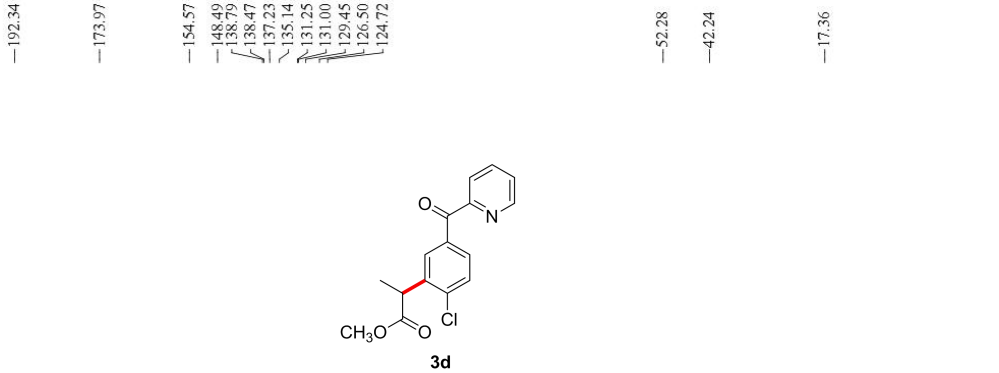

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.72
8.72
8.71
8.09
8.08
7.94
7.53
7.52
7.51
7.51
7.50
7.50
7.49
7.48
1.56
1.55


O
N
Cl
CH3O
O

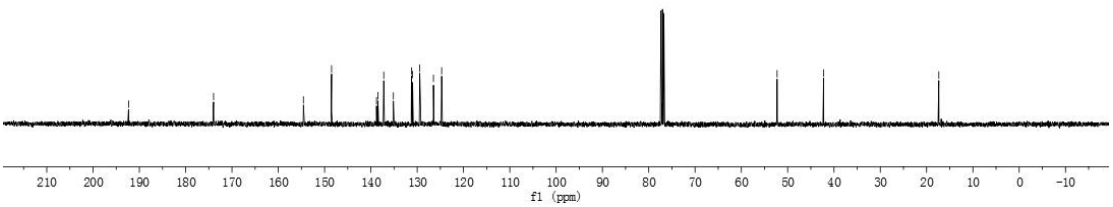
3d

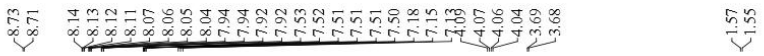

1.00
1.97
1.98
1.99
0.93
3.04
2.96
f1 (ppm)

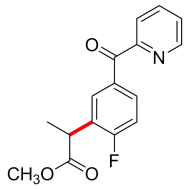

192.34
173.97
154.57
148.49
138.79
138.47
137.23
135.14
131.25
131.00
129.45
126.50
124.72
52.28
42.24
17.36

O
N
Cl
CH3O
O

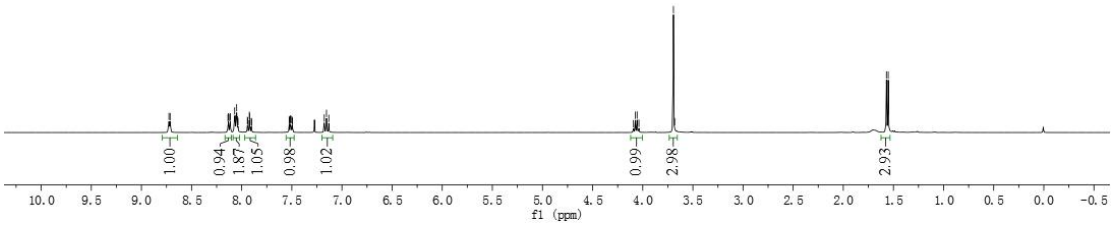
3d

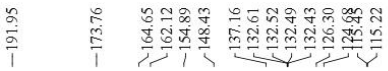

f1 (ppm)

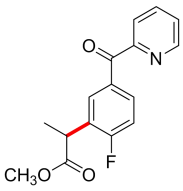

8.73
8.71
8.14
8.13
8.12
8.11
8.07
8.06
8.05
8.04
7.94
7.94
7.92
7.92
7.53
7.52
7.51
7.51
7.51
7.50
7.18
7.15
4.07
4.06
4.04
3.69
3.68
1.57
1.55


O
N
F
CH3O
O

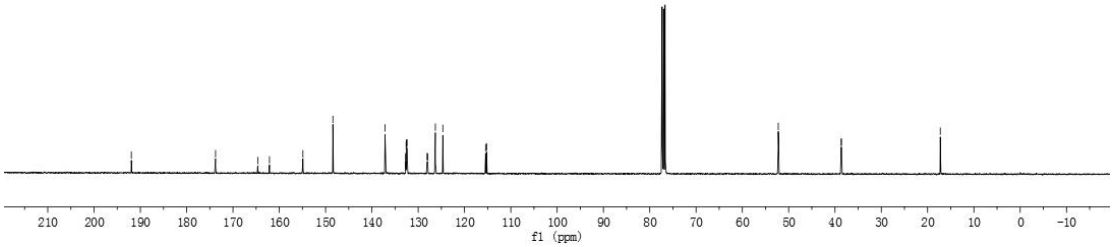
3e

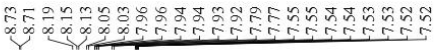

1.00
0.94
1.87
1.05
0.98
1.02
0.99
2.98
2.93
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

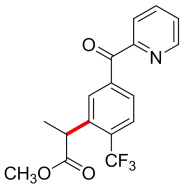

191.95
173.76
164.65
162.12
154.89
148.43
137.16
132.61
132.52
132.49
132.43
126.30
124.68
115.45
115.22
52.24
38.64
38.62
17.26


O
N
F
CH3O
O

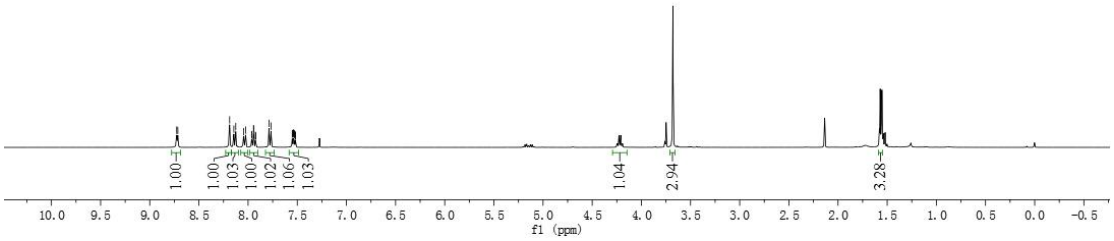
3e

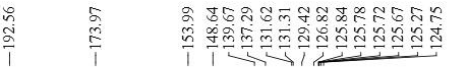

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

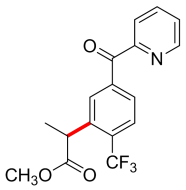

8.73
8.71
8.19
8.15
8.13
8.05
8.03
7.96
7.96
7.94
7.94
7.93
7.92
7.79
7.77
7.55
7.55
7.54
7.54
7.53
7.53
7.52
7.52


O
N
CH3O
O
CF3

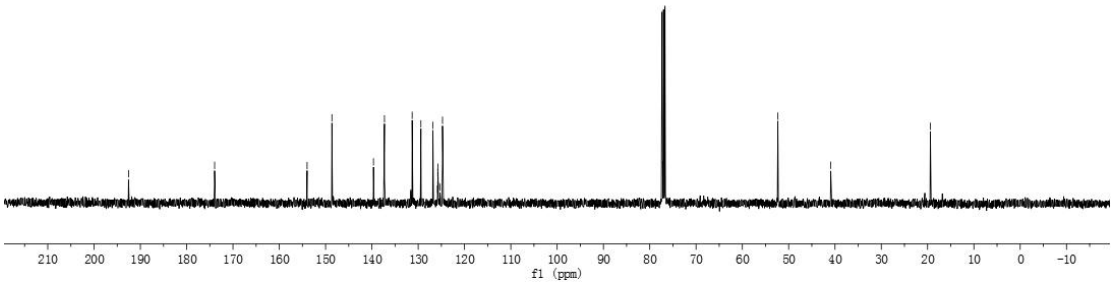
3f


1.00
1.00
1.03
1.00
1.02
1.06
1.03
1.04
2.94
3.28
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

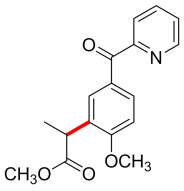

192.56
173.97
153.99
148.64
139.67
137.29
131.62
131.31
129.42
126.82
125.84
125.78
125.72
125.67
125.27
124.75
52.34
40.91
19.40


O
N
CH3O
O
CF3

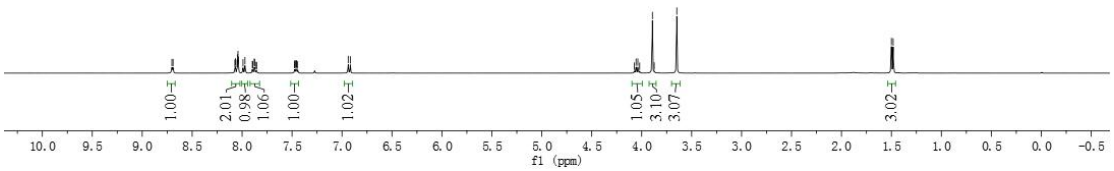
3f


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

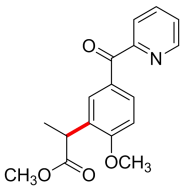

8.70
8.69
8.05
8.04
8.04
7.97
7.46
7.46
6.94
6.92
4.07
4.06
4.04
4.02
3.89
3.87
3.65
1.50
1.48


O
N
CH3O
O
OCH3

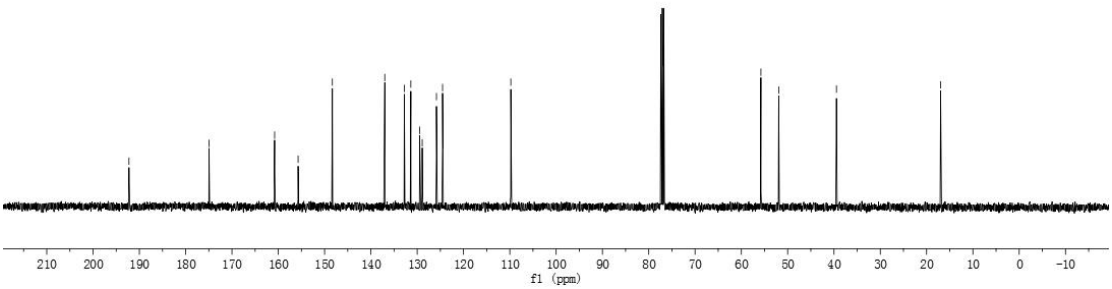
3g

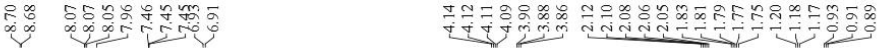

1.00
2.01
0.98
1.06
1.00
1.02
1.05
3.10
3.07
3.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

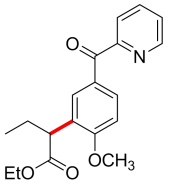

192.24
174.96
160.79
155.72
148.32
137.00
132.78
131.37
129.46
128.91
125.84
124.52
109.78
55.78
51.93
39.46
16.97


O
N
CH3O
O
OCH3

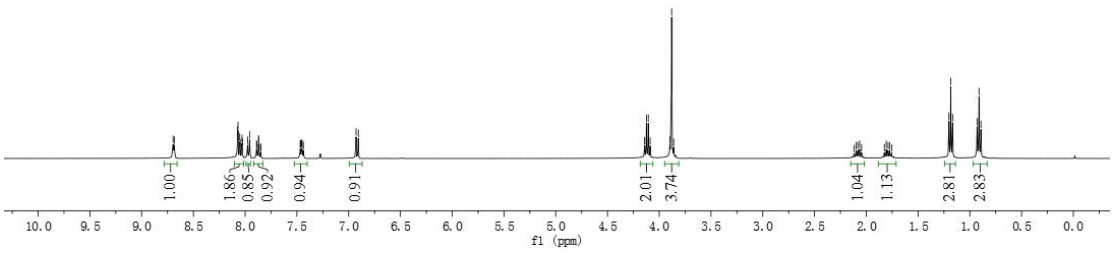
3g


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

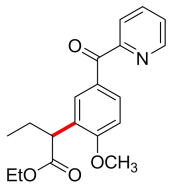

8.70
8.68
8.07
8.07
8.05
7.96
7.46
7.45
7.45
6.93
6.91
4.14
4.12
4.11
4.09
3.90
3.88
3.86
2.12
2.10
2.08
2.06
2.05
1.83
1.81
1.79
1.77
1.75
1.20
1.18
1.17
0.93
0.91
0.89


O
N
EtO
O
OCH3

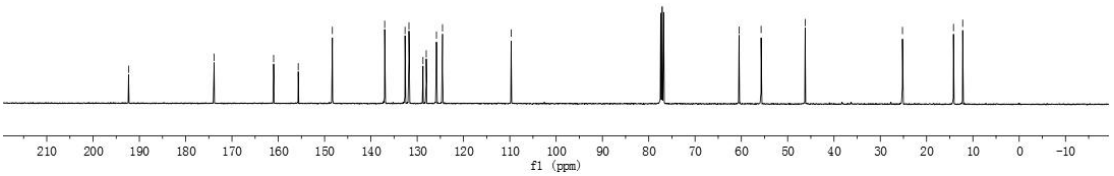
3h


1.00
1.86
0.85
0.92
0.94
0.91
2.01
3.74
1.04
1.13
2.81
2.83
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

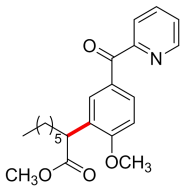

192.33
173.85
161.01
155.70
148.32
137.02
132.63
131.78
128.75
128.05
125.85
124.53
109.71
60.50
55.74
46.22
25.21
14.19
12.21


O
N
EtO
O
OCH3

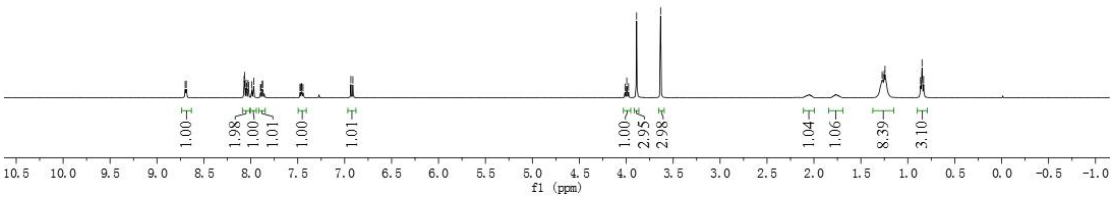
3h


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

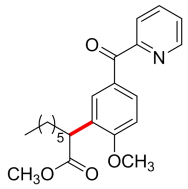

8.70
8.69
8.07
8.07
8.05
8.03
7.97
7.88
6.93
6.91
4.01
3.99
3.98
3.89
3.63
1.27
1.26
1.25
1.24
0.86
0.85
0.83


O
N
5
CH3O
O
OCH3

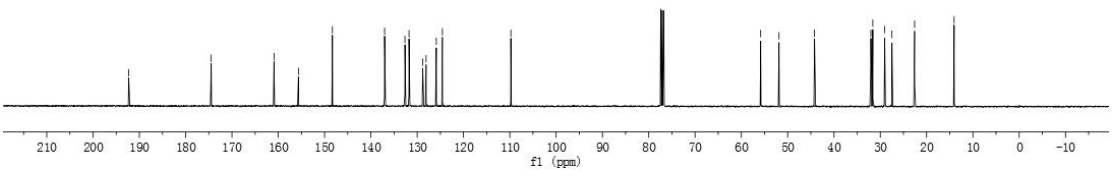
3i

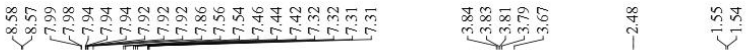

1.00
1.98
1.00
1.01
1.00
1.01
1.00
2.95
2.98
1.04
1.06
8.39
3.10
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

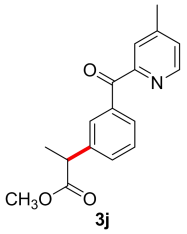

192.30
174.49
160.92
155.65
148.31
137.04
132.64
131.77
128.81
128.08
125.88
124.56
109.78
55.82
51.87
44.21
32.03
31.61
29.04
27.49
22.59
14.06


O
N
5
CH3O
O
OCH3

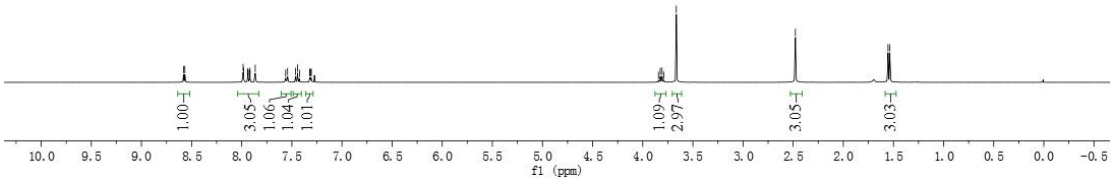
3i

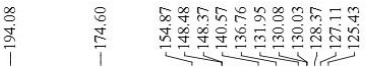

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

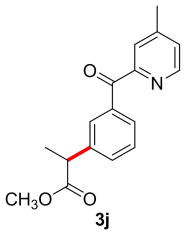

8.58
8.57
7.99
7.98
7.94
7.94
7.94
7.92
7.92
7.92
7.86
7.56
7.54
7.46
7.44
7.42
7.32
7.32
7.31
7.31
3.84
3.83
3.81
3.79
3.67
2.48
1.55
1.54


O
N
CH3O
O

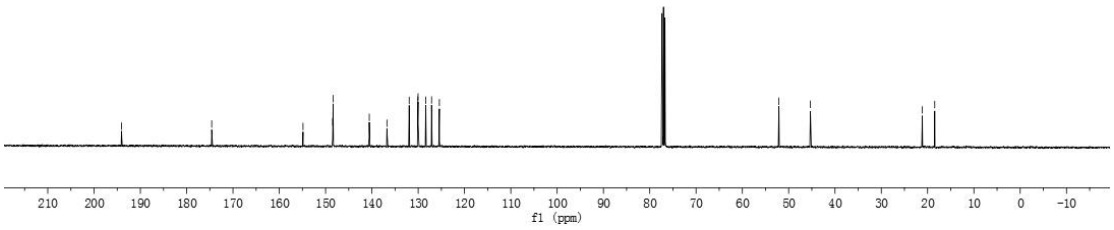
3j


1.00
3.05
1.06
1.04
1.01
1.09
2.97
3.05
3.03
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

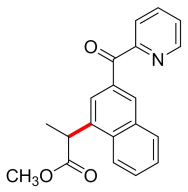

194.08
174.60
154.87
148.48
148.37
140.57
136.76
131.95
130.08
130.03
128.37
127.11
125.43
52.11
45.31
21.14
18.46


O
N
CH3O
O

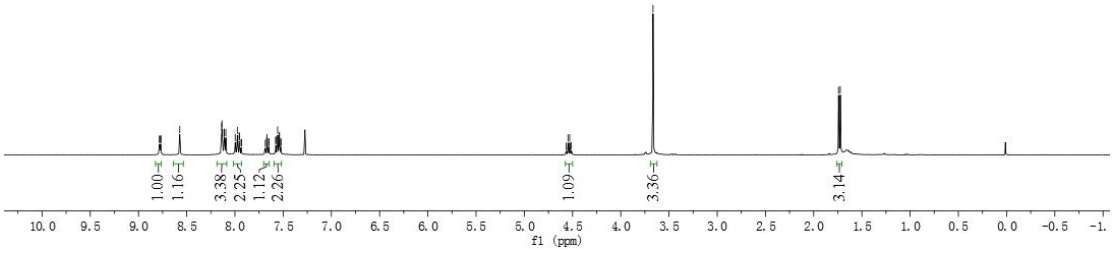
3j

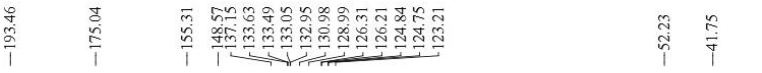

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

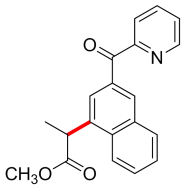

8.78
8.78
8.77
8.77
8.57
8.14
8.13
8.11
8.11
8.09
8.00
7.98
7.97
7.96
7.95
7.67
7.58
7.58
7.56
7.54
7.54
7.54
4.57
4.55
4.53
4.51
3.67
1.74
1.72


O
N
CH3O
O

3k

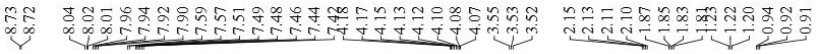

1.00
1.16
3.38
2.25
1.12
2.26
1.09
3.36
3.14
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)

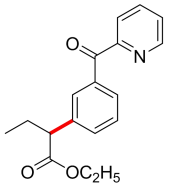

193.46
175.04
155.31
148.57
137.15
133.63
133.49
133.05
132.95
130.98
128.99
126.31
126.21
124.84
124.75
123.21
52.23
41.75
17.89


O
N
CH3O
O

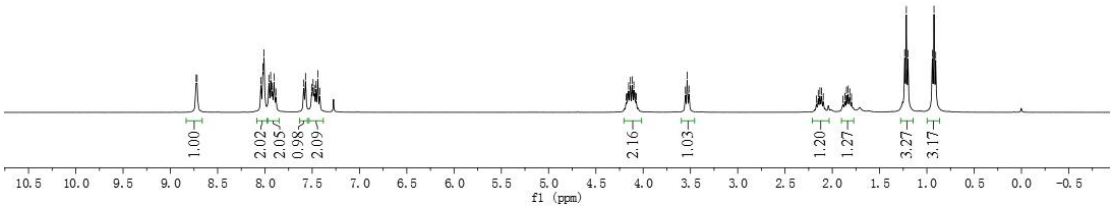
3k

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

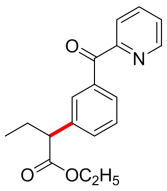

8.73
8.72
8.04
8.02
8.01
7.96
7.94
7.92
7.90
7.59
7.57
7.51
7.49
7.48
7.46
7.44
4.17
4.15
4.13
4.12
4.10
4.08
4.07
3.55
3.53
3.52
2.15
2.13
2.11
2.10
1.87
1.85
1.83
1.22
1.20
0.94
0.92
0.91


O
N
O
OC2H5

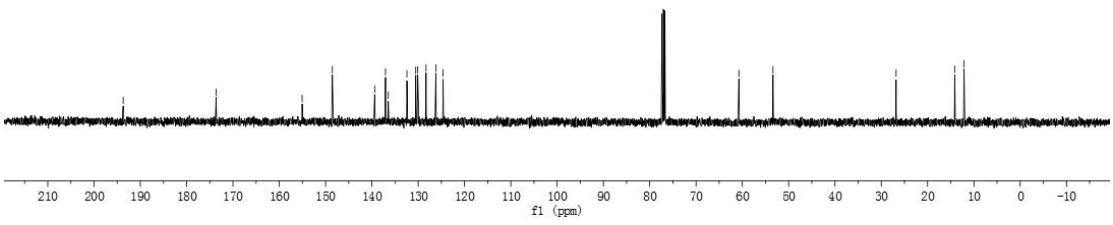
3l


1.00
2.02
2.05
0.98
2.09
2.16
1.03
1.20
1.27
3.27
3.17
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

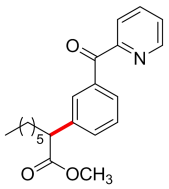

193.72
173.64
155.06
148.54
139.40
137.06
136.46
132.43
130.53
130.10
128.31
126.19
124.62
60.76
53.39
26.80
14.13
12.14


O
N
O
OC2H5

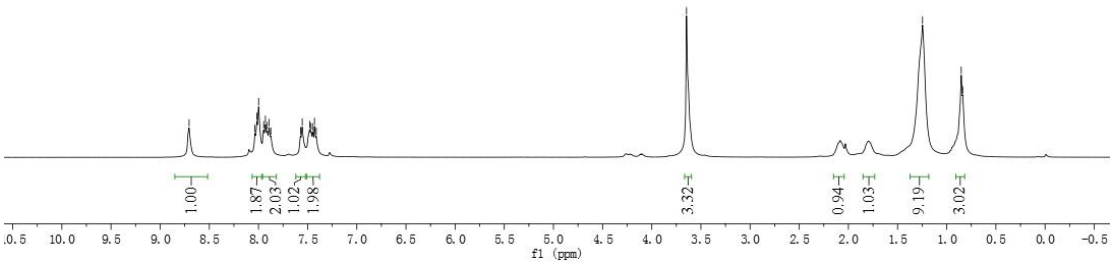
3l

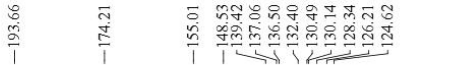

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

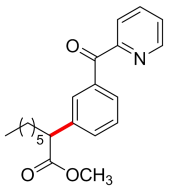

8.71
8.04
8.02
8.00
7.95
7.93
7.91
7.89
7.87
7.57
7.56
7.48
7.47
7.45
7.43
7.41
3.65
1.25
0.85
0.84


O
N
5
O
OCH3

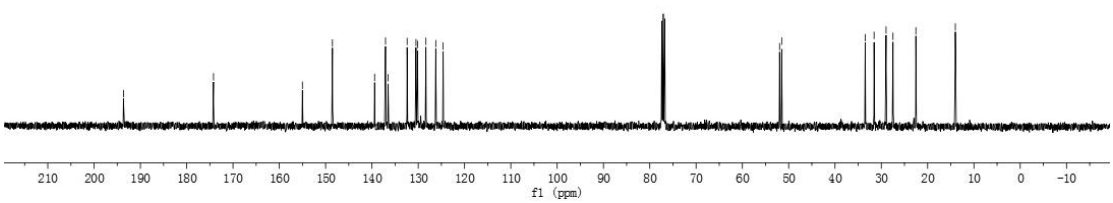
3m


1.00
1.87
2.03
1.02
1.98
3.32
0.94
1.03
9.19
3.02
f1 (ppm)

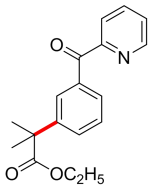

193.66
174.21
155.01
148.53
139.42
137.06
136.50
132.40
130.49
130.14
128.34
126.21
124.62
51.97
51.50
33.48
31.56
28.97
27.48
22.54
14.02


O
N
5
O
OCH3

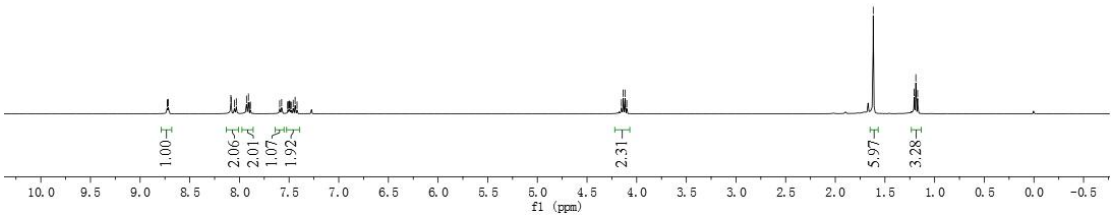
3m


f1 (ppm)

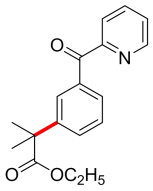

8.73
8.73
8.72
8.09
8.08
8.05
8.03
7.93
7.91
7.89
7.59
7.58
7.51
7.51
7.50
7.50
7.50
7.49
7.48
7.48
7.46
7.44
4.15
4.14
4.12
4.10
1.62
1.21
1.19
1.19
1.17


O
N
O
OC2H5

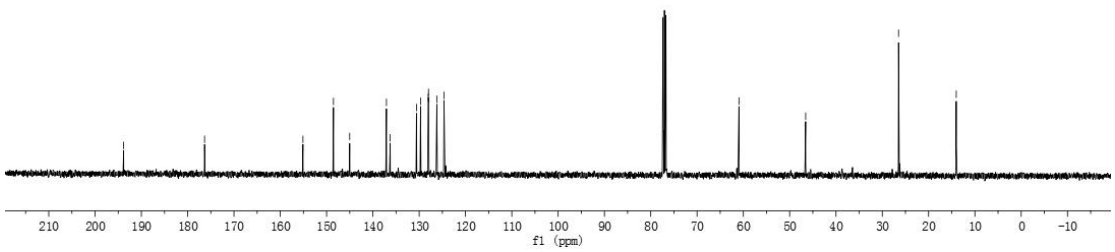
3n

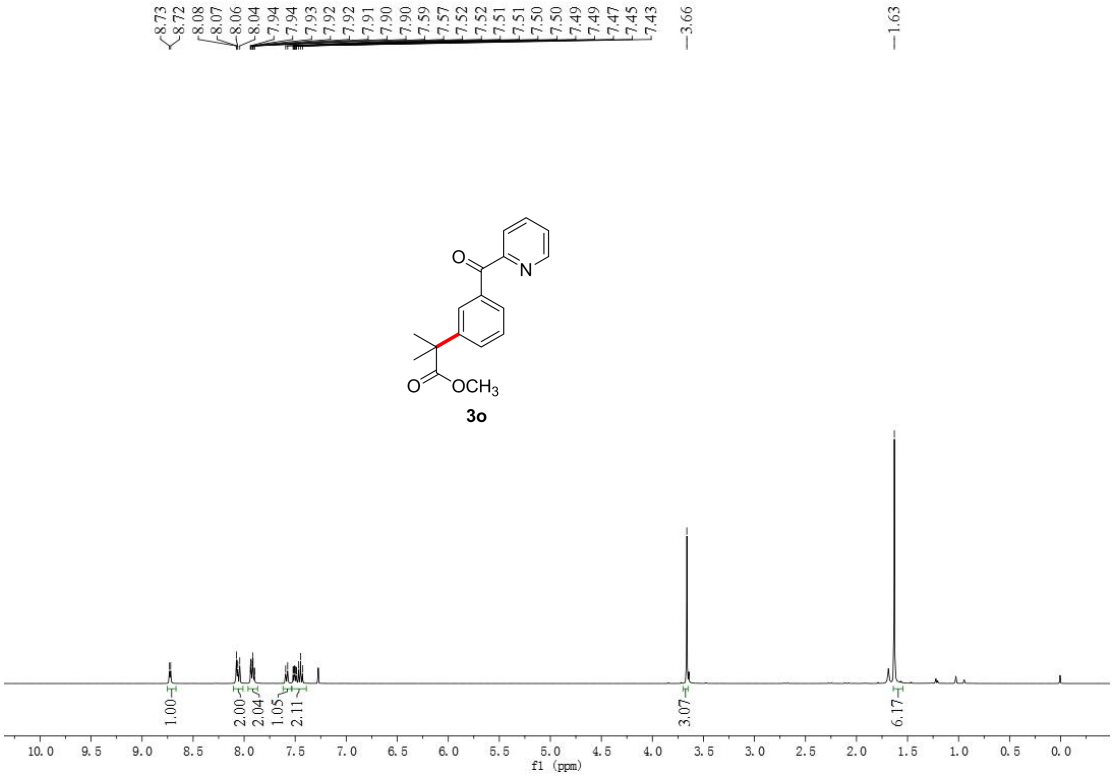

1.00
2.06
2.01
1.07
1.92
2.31
5.97
3.28
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

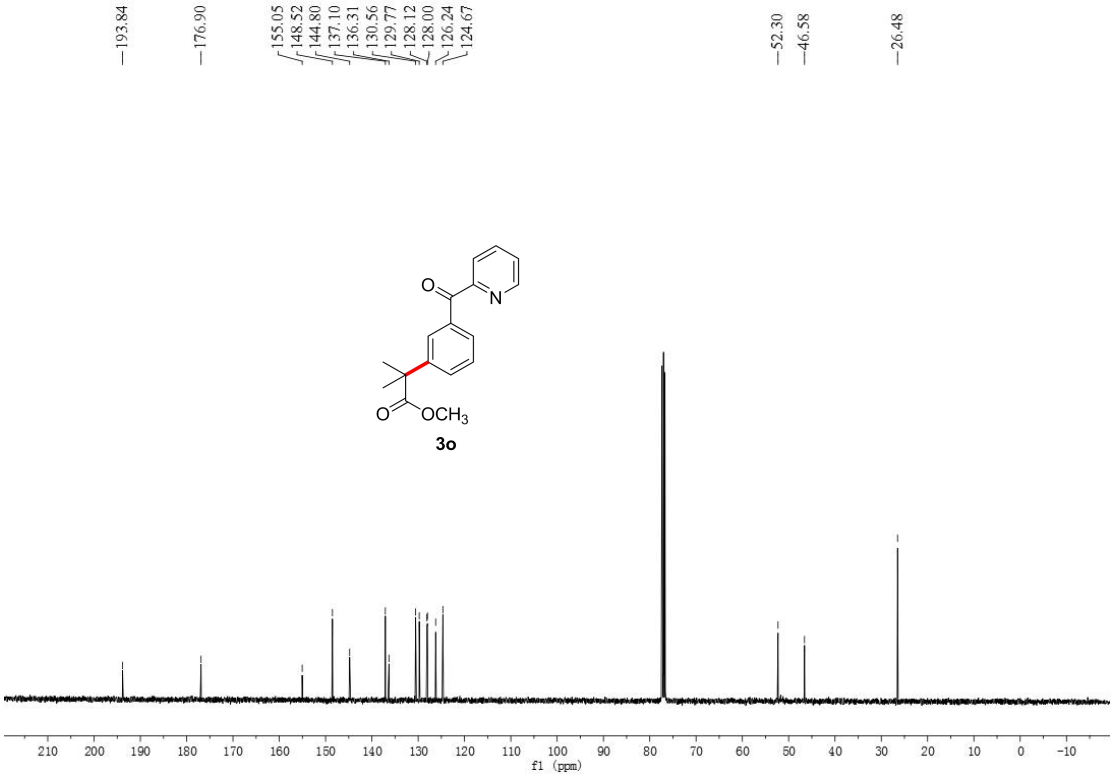

193.84
176.35
155.11
148.52
145.01
137.08
136.26
130.59
129.70
128.06
128.00
126.19
124.64
60.95
46.55
26.49
14.02

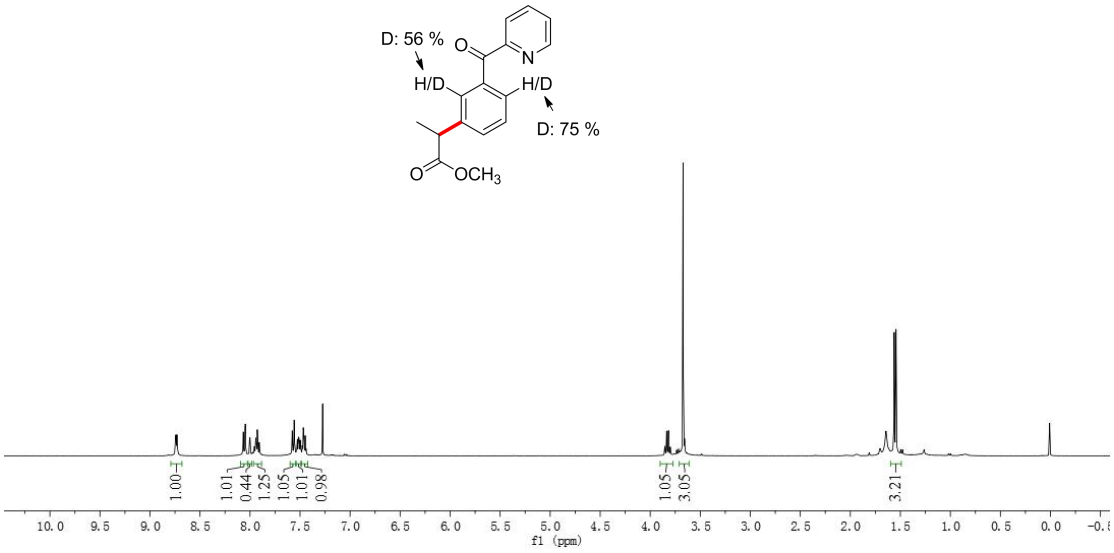

O
N
O
OC2H5

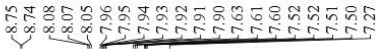
3n

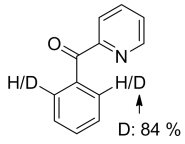

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

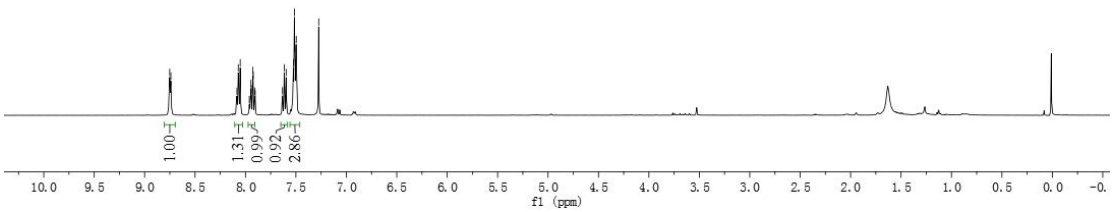

8.73
8.72
8.08
8.07
8.06
8.04
7.94
7.94
7.93
7.92
7.92
7.91
7.90
7.90
7.59
7.57
7.52
7.52
7.51
7.51
7.50
7.50
7.49
7.49
7.47
7.45
7.43
3.66
1.63
O
N
O
OCH3
3o
1.00
2.00
2.04
1.05
2.11
3.07
6.17
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


193.84
176.90
155.05
148.52
144.80
137.10
136.31
130.56
129.77
128.12
128.00
126.24
124.67
52.30
46.58
26.48
O
N
O
OCH3
3o
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


D: 56 %
O
N
H/D
H/D
D: 75 %
O
OCH3
1.00
1.01
0.44
1.25
1.05
1.01
0.98
1.05
3.05
3.21
f1 (ppm)


8.75
8.74
8.08
8.07
8.05
7.96
7.95
7.94
7.93
7.92
7.91
7.90
7.63
7.61
7.60
7.52
7.52
7.51
7.50
7.27


O
N
H/D
H/D
D: 84 %


1.00
1.31
0.99
0.92
2.86
f1 (ppm)