Supporting Information

Highly efficient and eco-friendly protocol to functionalized imidazoles via Ring-Opening of α-Nitro Epoxides

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General Information:

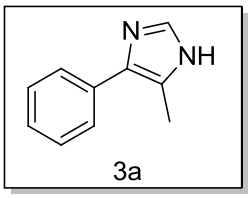
All solvents were purified according to standard methods prior to use. Melting points were recorded on a BÜCHI B-540 melting point apparatus. NMR spectra were recorded for ^{1}H NMR at 500 MHz and ^{13}C NMR at 125 MHz. For ^{1}H NMR, tetramethylsilane (TMS) served as internal standard (δ=0) and data are reported as follows: chemical shift, integration, multiplicity (s=singlet, d=doublet, t= triplet, q=quartet, m=multiplet), and coupling constant(s) in Hertz. For ^{13}C NMR, TMS (δ=0) or DMSO (δ=40.45) was used as internal standard and spectra were obtained with complete proton decoupling. IR spectra were recorded with a BRUKER VEC TOR 22 FT-IR spectrometer. LC-MS and HRMS data was obtained using Agilent Technologies 6224 TOF LC/MS. The starting materialα-nitro epoxideswere prepared according to literature methods. [1, 2] The starting material amines and amidine were commercially available.

General Procedure for the Synthesis of 3a-3u:

A mixture of amidines (0.15 mmol, 1.5 equiv) , base (0.2 mmol, 2.0 equiv) and 3 mL of solvent was stirred at 25 ℃ for 0.5h, nitroepoxide**1** (0.1 mmol, 1.0 equiv) was added, then the mixture was stirred at 25 ℃ for 8h.After the completeness of the reaction, the mixture was diluted with water and extracted three times with $CHCl_3$ (3 × 10 mL). The combined organic extracts were washed with brine, dried over Na_2SO_4, concentrated and purified by flash chromaraography (DCM/MeOH) on silica gel to afford 3a-3u.

Characterization Data of 3a-3u:

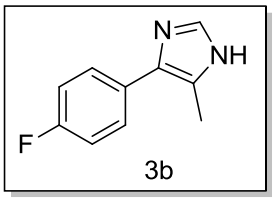
5-methyl-4-phenyl-1*H*-imidazole (3a)



3a

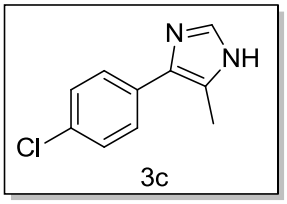
Yellow solid; m.p.186.6-188.5 ℃; ^{1}H NMR (500 MHz, DMSO) δ 12.08 (s, 1H), 7.61 (dd, J = 8.1, 0.9 Hz, 2H), 7.59 (s, 1H), 7.39 (dd, J = 10.7, 4.8 Hz, 2H), 7.23-7.19 (m, 1H), 2.37 (s, 3H).^{13}C NMR (125 MHz, DMSO) δ 134.2, 128.9, 126.3, 126.0, 12.5;IR (KBr) v: 3438, 3274, 3127, 3074, 3006, 2918, 2850, 2805, 2746, 2691, 2637, 2368, 1956, 1742, 1663, 1599, 1518, 1479, 1438, 1304, 1130, 1071, 951, 810, 767, 699 cm^{-1}; HRMS (ESI): m/z calcd.for $C_{10}H_{11}N_2$ $[M+H]^+$:159.0917, found: 159.0915.

4-(4-fluorophenyl)-5-methyl-1*H*-imidazole (3b)



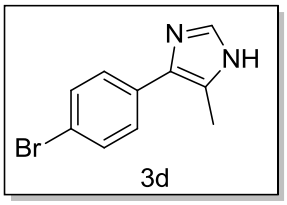
Yellow solid; m.p.156.8-158.6 ℃; ^{1}H NMR (500 MHz, DMSO) δ 12.11 (s, 1H), 7.65-7.62 (m, 2H), 7.59 (s, 1H), 7.24-7.19 (m, 2H), 2.36 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 161.9, 160.0, 134.2, 128.1, 115.7, 12.1; .HRMS (ESI): m/z calcd.for $C_{10}H_{10}FN_2$ $[M+H]^+$: 177.0828, found: 177.0827.

4-(4-chlorophenyl)-5-methyl-1*H*-imidazole (3c)



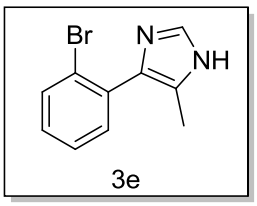
Yellow solid; m.p. 202.5-204.6 ℃; ^{1}H NMR (500 MHz, DMSO) δ 12.11 (s, 1H), 7.64 (d, J = 8.4 Hz, 2H), 7.60 (s, 1H), 7.43 (d, J = 8.4 Hz, 2H), 2.38 (s, 3H).^{13}C NMR (125 MHz, DMSO) δ 134.4, 130.4, 128.8, 127.8, 12.2; HRMS (ESI): m/z calcd.for $C_{10}H_{10}ClN_2$ $[M+H]^+$:193.0527, found: 193.0537.

4-(4-bromophenyl)-5-methyl-1*H*-imidazole (3d)



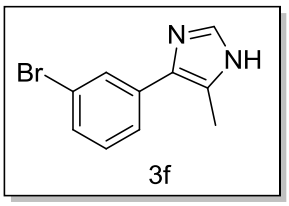
White solid; m.p. 215.1-216.2 ℃; ^{1}H NMR (500 MHz, MeOD) δ 7.63 (s, 1H), 7.57-7.56 (m, 2H), 7.51-7.49 (m, 2H), 2.41 (s, 3H). ^{13}C NMR (125 MHz, MeOD) δ 133.8, 132.9, 131.2, 128.1, 119.7, 10.3; HRMS (ESI): m/z calcd. for $C_{10}H_{10}BrN_2$ $[M+H]^+$:237.0022 found: 237.0018.

4-(2-bromophenyl)-5-methyl-1*H*-imidazole (3e)



Yellow viscous oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.43 (s, 1H), 7.64-7.62 (m, 1H), 7.52 (s, 1H), 7.34 -7.30 (m, 2H), 7.19 (ddd, J = 8.0, 6.6, 2.6 Hz, 1H), 2.18 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 134.0, 133.3, 133.1, 132.3, 131.7, 129.3, 127.9, 127.2, 124.0, 11.4; HRMS (ESI): m/z calcd.for $C_{10}H_{10}BrN_2$ $[M+H]^+$:237.0022 found: 237.0020.

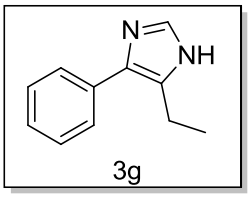
4-(3-bromophenyl)-5-methyl-1*H*-imidazole (3f)



3f

White solid; m.p. 189.2-191.5 ℃;^{1}H NMR (500 MHz, DMSO) δ 12.10 (s, 1H), 7.81 (s, 1H), 7.60 (s, 2H), 7.36 (dt, J = 15.5, 7.8 Hz, 2H), 2.39 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 134.5, 131.0, 128.5, 124.9, 122.4, 11.3; HRMS (ESI): m/z calcd. for $C_{10}H_{10}BrN_2$ $[M+H]^+$: 237.0022 found: 237.0022.

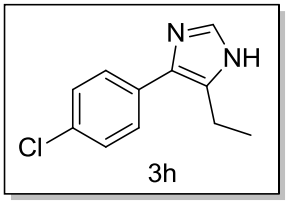
5-ethyl-4-phenyl-1*H*-imidazole (3g)



3g

White solid; m.p. 172.3-173.1℃; ^{1}H NMR (500 MHz, DMSO) δ 12.10 (s, 1H), 7.61 (s, 1H), 7.58 (dd, J = 8.1, 1.0 Hz, 2H), 7.39 (dd, J = 10.7, 4.9 Hz, 2H), 7.25-7.19 (m, 1H), 2.76 (q, J = 7.5 Hz, 2H), 1.22 (t, J = 7.5 Hz, 3H). ^{13}C NMR (125 MHz, DMSO) δ 135.1, 134.5, 128.9, 126.6, 126.2, 19.5, 14.6; IR (KBr) v: 3440, 3071, 3005, 2964, 2861, 2807, 2759, 2686, 2637, 1825,1638, 1600, 1518, 1478, 1320, 1262, 1131, 1068, 957, 912, 819, 770, 700 cm^{-1}; HRMS (ESI): m/z calcd. for $C_{11}H_{13}N_2$ $[M+H]^+$:173.1073, found: 173.1071.

4-(4-chlorophenyl)-5-ethyl-1*H*-imidazole (3h)

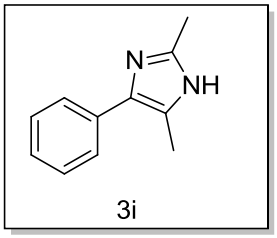


3h

Yellow solid; m.p. 178.2-179.6 ℃; ^{1}H NMR (500 MHz, DMSO) δ 7.64 (s, 1H), 7.60 (d, J = 8.5 Hz, 2H), 7.45-7.43 (m, 2H), 2.76 (q, J = 7.5 Hz, 2H), 1.21 (t, J = 7.5 Hz, 3H). ^{13}C NMR (125 MHz,

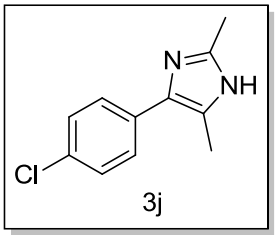
DMSO) δ 160.9, 134.7, 130.6, 128.9, 128.8, 128.6, 128.1, 19.3, 14.4; HRMS (ESI): m/z calcd. for $C_{11}H_{12}ClN_2$ $[M+H]^+$:207.0684, found: 207.0692.

2,5-dimethyl-4-phenyl-1*H*-imidazole (3i)



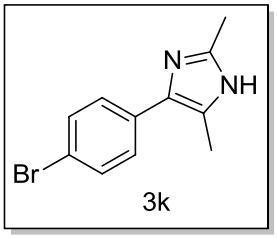
Yellow viscous oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 11.45 (s, 1H), 7.49 (d, J = 7.6 Hz, 2H), 7.34 (t, J = 7.6 Hz, 2H), 7.25 (t, J = 7.4 Hz, 1H), 2.35 (s, 3H), 2.34 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 142.9, 130.9, 130.1, 128.7, 127.3, 126.8, 125.2, 12.2, 11.1; IR (KBr) v: 3441, 3144, 2926, 2855, 1967, 1810, 1638, 1600, 1559, 1443, 1402, 1384, 1261, 1122, 1070, 955, 776, 765, 702 cm^{-1}; HRMS (ESI): m/z calcd. for $C_{11}H_{13}N_2$ $[M+H]^+$:173.1073, found: 173.1073.

4-(4-chlorophenyl)-2,5-dimethyl-1*H*-imidazole (3j)



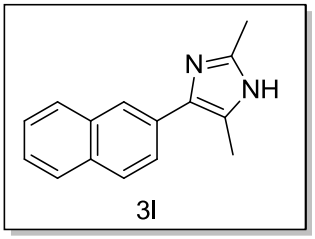
Yellow solid; m.p. 203.5-204.6 ℃; ^{1}H NMR (500 MHz, DMSO) δ 11.74 (s, 1H), 7.59 (d, J = 8.4 Hz, 2H), 7.40 (d, J = 8.5 Hz, 2H), 2.32 (s, 3H), 2.25 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 142.9, 131.7, 130.0, 128.7, 127.5, 14.2, 11.8; HRMS (ESI): m/z calcd. for $C_{11}H_{12}ClN_2$ $[M+H]^+$:207.0684, found: 207.0682.

4-(4-bromophenyl)-2,5-dimethyl-1*H*-imidazole (3k)



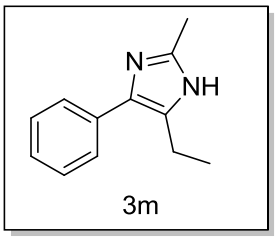
Yellow solid; m.p.202.2-203.8℃;^{1}H NMR (500 MHz, DMSO) δ 7.53 (s, 4H), 2.32 (s, 3H), 2.26 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 142.8, 131.7, 127.9, 118.5, 14.1, 12.3; HRMS (ESI): m/z calcd. for $C_{11}H_{12}BrN_2$ $[M+H]^+$:251.0178, found: 251.0180.

2,5-dimethyl-4-(naphthalen-2-yl)-1*H*-imidazole (3l)



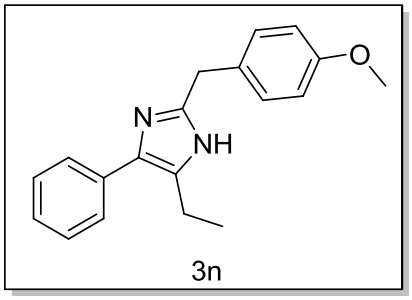
Yellow solid; m.p.236.3-238.6 ℃;^{1}H NMR (500 MHz, MeOD) δ 7.91 (ddd, J = 21.6, 10.5, 6.8 Hz, 3H), 7.55-7.45 (m, 4H), 2.45 (s, 3H), 2.12 (s, 3H).^{13}C NMR (125 MHz, MeOD) δ 143.2, 134.0, 132.2, 130.0, 129.5, 127.9, 127.8, 127.7, 127.4, 125.8, 125.6, 125.5, 124.9, 11.8, 9.74; HRMS (ESI): m/z calcd. for $C_{15}H_{15}N_2$ $[M+H]^+$:223.1230, found: 223.1225.

5-ethyl-2-methyl-4-phenyl-1*H*-imidazole (3m)



Yellow viscous oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.28 (s, 1H), 7.48 (d, J = 7.4 Hz, 2H), 7.35 (t, J = 7.6 Hz, 2H), 7.27 (t, J = 7.4 Hz, 1H), 2.75 (q, J = 7.6 Hz, 2H), 2.36 (s, 3H), 1.26 (t, J = 7.6 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 143.2, 131.4, 131.3, 129.9, 128.7, 127.3, 127.1, 18.7, 14.1, 12.5; HRMS (ESI): m/z calcd. for $C_{12}H_{15}N_2$ $[M+H]^+$: 187.1230, found: 187.1236.

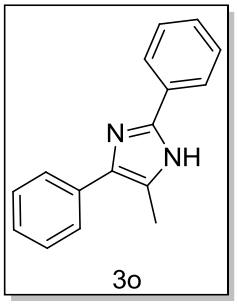
5-ethyl-2-(4-methoxybenzyl)-4-(naphthalen-2-yl)-1*H*-imidazole (3n)



Yellow viscous oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.78 (s, 1H), 7.47-7.45 (m, 2H), 7.33 (t, J = 7.6 Hz, 2H), 7.24 (dd, J = 12.8, 5.5 Hz, 1H), 7.15 (d, J = 8.5 Hz, 2H), 6.71 (d, J = 8.4 Hz, 2H), 4.01 (s, 2H), 3.69 (s, 3H), 2.70 (q, J = 7.5 Hz, 2H), 1.22 (t, J = 7.5 Hz, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 158.6, 146.1, 130.0,129.9, 129.5, 128.6, 128.4, 127.9, 127.1,127.0,114.1, 55.2, 32.6, 18.9, 14.1; IR

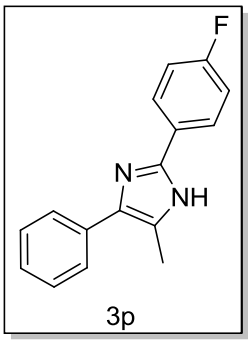
(KBr) *v*: 3436, 3144, 2963,2928, 2363, 1953, 1602, 1558, 1512, 1453, 1381, 1248, 1125, 1072, 1033, 823, 761, 699 cm^{-1}; HRMS (ESI): m/z calcd. for $C_{19}H_{21}N_2O$ $[M+H]^+$:293.1648, found: 293.1646.

5-methyl-2,4-diphenyl-1*H*-imidazole (3o)



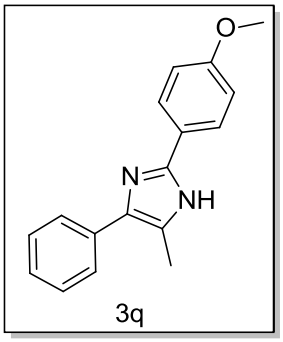
White solid; m.p. 180.2-182.5 ℃ (Lit.[3]180-184 ℃); ^1H NMR (500 MHz, DMSO) δ 12.42 (s, 1H), 8.00 (d, *J* = 7.5 Hz, 2H), 7.71 (d, *J* = 7.1 Hz, 2H), 7.51-7.39 (m, 4H), 7.38-7.30 (m, 1H), 7.25 (t, *J* = 7.3 Hz, 1H), 2.46 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 144.2, 131.1, 129.2, 128.9, 128.3, 126.6, 126.3, 125.1, 12.1;IR (KBr) *v*: 3441, 3075, 3030, 2960, 2772, 2691, 2634, 2588, 1934, 1880, 1643, 1496, 1460, 1408, 1326, 1280, 1159, 1128, 975,917, 768, 695 cm^{-1};HRMS (ESI): m/z calcd. for $C_{16}H_{15}N_2$ $[M+H]^+$:235.1230, found: 235.1235.

2-(4-fluorophenyl)-5-methyl-4-phenyl-1*H*-imidazole (4p)



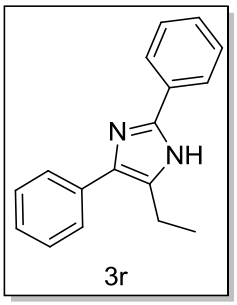
Yellow solid; m.p.78.6-81.2 ℃;^1H NMR (500 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 8.6, 5.3 Hz, 2H), 7.56 (d, *J* = 7.8 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.28 (d, *J* = 8.2 Hz, 1H), 6.98 (t, *J* = 8.4 Hz, 2H), 2.38 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 163.8, 161.8, 144.5, 132.9, 128.6, 127.2, 126.9, 126.7, 126.4, 115.8, 115.7, 12.2;HRMS (ESI): m/z calcd. for $C_{16}H_{14}FN_2$ $[M+H]^+$:253.1136, found: 253.1146.

2-(4-methoxyphenyl)-5-methyl-4-phenyl-1*H*-imidazole (3q)



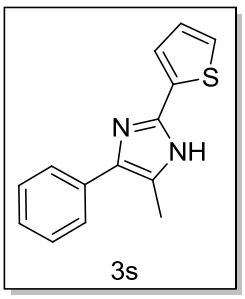
Yellow solid; m.p.72.1-73.6 ℃;^{1}H NMR (500 MHz, $CDCl_3$) δ 10.39 (s, 1H), 7.83 (d, J = 8.6 Hz, 2H), 7.56 (d, J = 7.5 Hz, 2H), 7.34 (t, J = 7.6 Hz, 2H), 7.23 (t, J = 7.3 Hz, 1H), 6.82 (d, J = 8.6 Hz, 2H), 3.77 (s, 3H), 2.34 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 159.7, 145.6, 133.3, 133.0, 128.5, 127.0, 126.9,126.4, 123.2, 114.1, 55.3, 12.1; HRMS (ESI): m/z calcd. for $C_{17}H_{17}N_2O$ $[M+H]^+$: 265.1335, found: 265.1335

5-ethyl-2,4-diphenyl-1*H*-imidazole (3r)



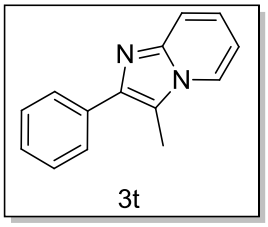
Light yellow solid; m.p. 188.1-189.2 ℃; ^{1}H NMR (500 MHz, DMSO) δ 12.34 (s, 1H), 7.99 (d, J = 5.4 Hz, 2H), 7.67 (s, 2H), 7.45 (dd, J = 16.7, 8.9 Hz, 4H), 7.33 (ddd, J = 44.7, 19.7, 18.6 Hz, 2H), 2.84-2.64 (m, 2H), 1.28 (t, J = 6.6 Hz, 3H). ^{13}C NMR (125 MHz, DMSO) δ 144.2, 136.3, 136.0, 131.1, 130.8, 129.1, 128.9, 128.3, 126.7, 126.3, 125.2, 18.9, 14.9; HRMS (ESI): m/z calcd .for $C_{10}H_{17}N_2$ $[M+H]^+$:249.1386, found: 249.1380.

5-methyl-4-phenyl-2-(thiophen-2-yl)-1*H*-imidazole (3s)



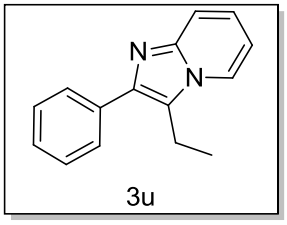
Light yellow solid; m.p. 211.6-213.7 ℃; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (d, J = 7.4 Hz, 2H), 7.44 (d, J = 3.1 Hz, 1H), 7.37 (t, J = 7.7 Hz, 2H), 7.27-7.22 (m, 2H), 6.99 (dd, J = 4.7, 3.9 Hz, 1H), 2.41 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 140.9, 133.5, 132.7, 128.6, 127.7, 126.9, 126.6, 125.5, 124.0, 12.4; HRMS (ESI): m/z calcd. for $C_{14}H_{13}N_2S$ $[M+H]^+$: 241.0794, found: 241.0795.

3-methyl-2-phenylimidazo[1,2-a]pyridine (3t)



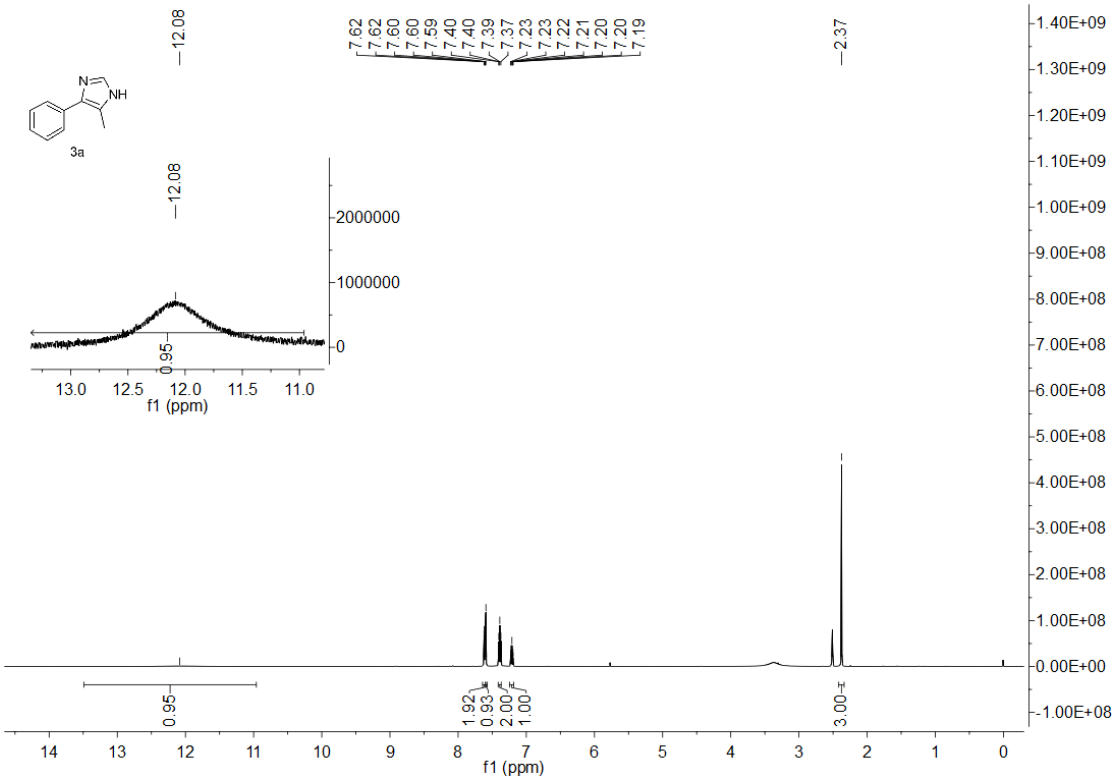
Yellow solid; m.p.157.2-158.3℃; ^{1}H NMR (500 MHz, DMSO) δ 8.26 (dt, J = 6.9, 1.1 Hz, 1H), 7.61-7.50 (m, 5H), 7.49-7.42 (m, 1H), 7.24 (ddd, J = 9.0, 6.7, 1.2 Hz, 1H), 6.86 (td, J = 6.8, 1.2 Hz, 1H), 2.37 (s, 3H). ^{13}C NMR (125 MHz, DMSO) δ 144.1, 140.8, 129.7, 129.5, 129.4, 128.4, 124.8, 123.9, 121.2, 116.9, 112.6, 14.4; HRMS (ESI): m/z calcd. for $C_{14}H_{13}N_2$ $[M+H]^+$: 209.1073, found: 209.1079.

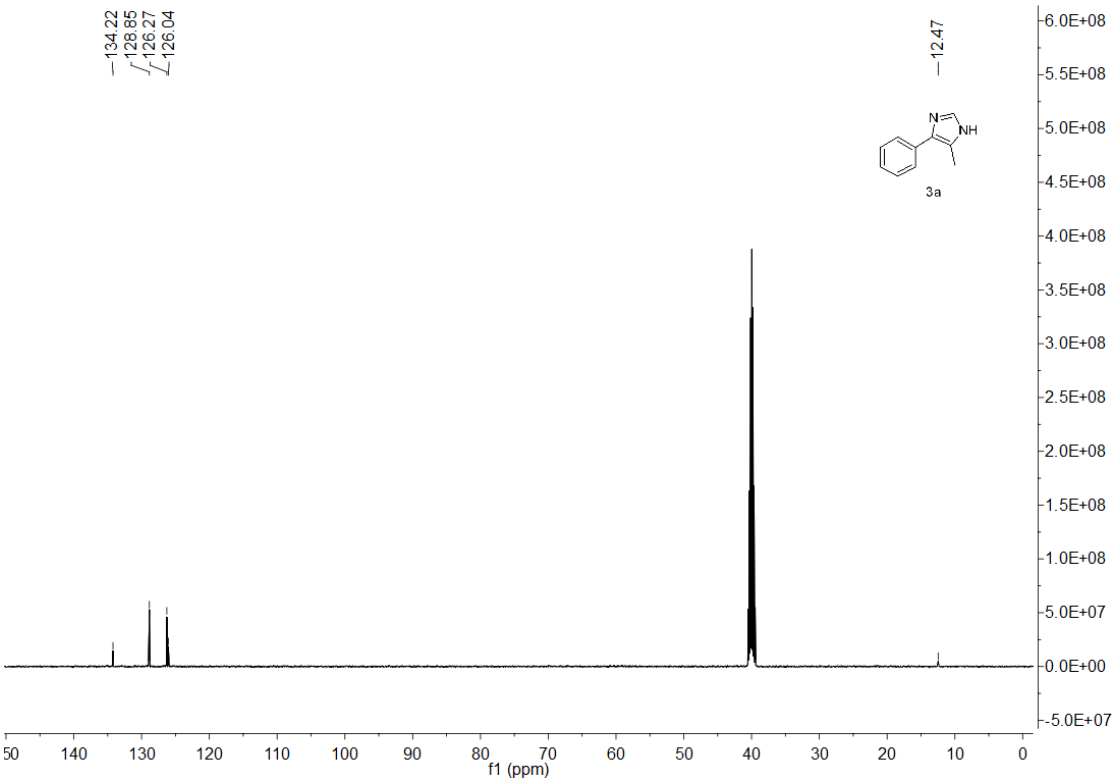
3-ethyl-2-phenylimidazo[1,2-a]pyridine (3u)

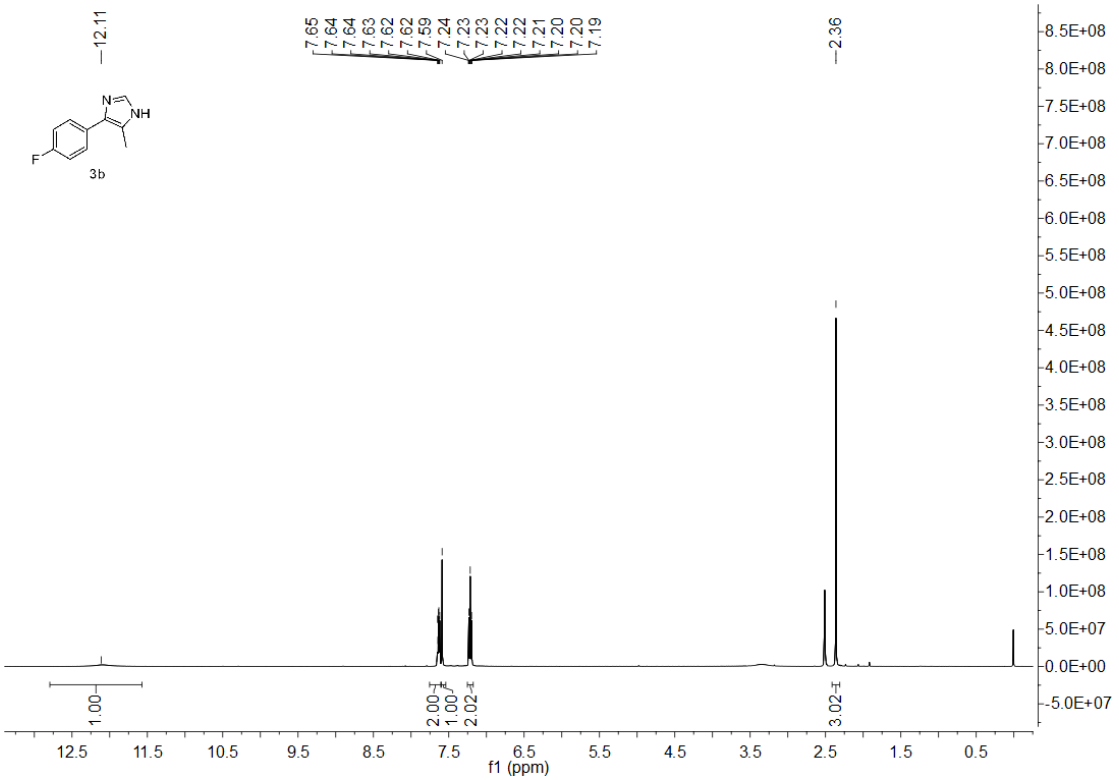


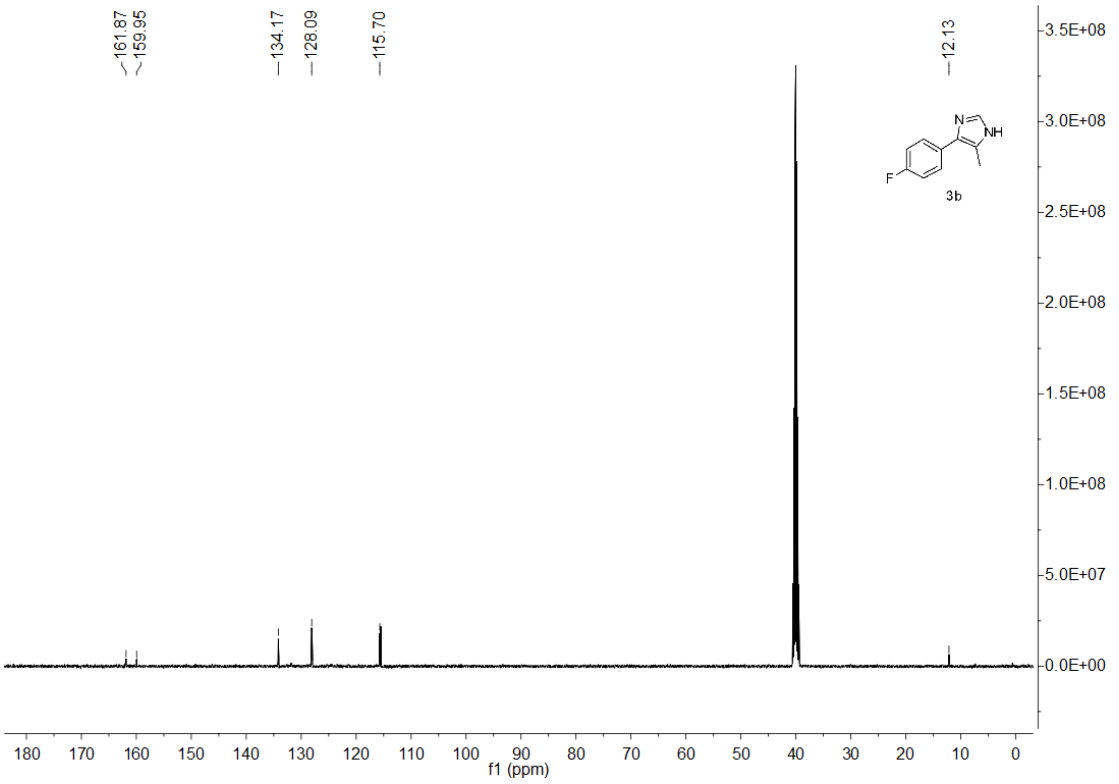
Yellow viscous oil;^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (d, J = 6.9 Hz, 1H), 7.59 (d, J = 9.0 Hz, 1H), 7.51 (dd, J = 10.5, 4.7 Hz, 2H), 7.42 (ddd, J = 9.0, 5.3, 1.2 Hz, 3H), 7.12 (ddd, J = 8.9, 6.7, 1.1 Hz, 1H), 6.68 (td, J = 6.8, 0.9 Hz, 1H), 2.81 (q, J = 7.6 Hz, 2H), 1.34 (t, J = 7.6 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 146.5, 144.6, 129.7, 129.5, 129.2, 128.2, 126.2, 124.0, 123.1, 117.1, 111.9, 21.1, 14.5; HRMS (ESI): m/z calcd.for $C_{15}H_{15}N_2$ $[M+H]^+$: 223.1230, found: 223.1236.

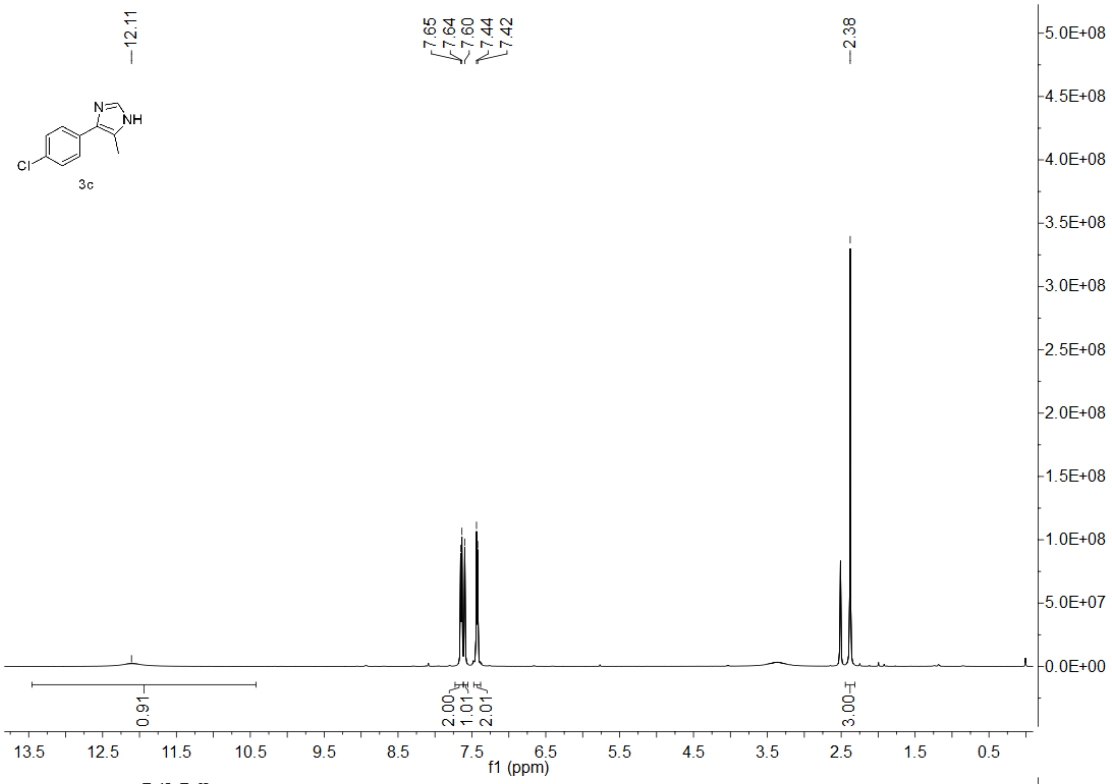
^{1}H NMR (500 MHz) and ^{13}C NMR (125 MHz) Spectra of 3a-3u:

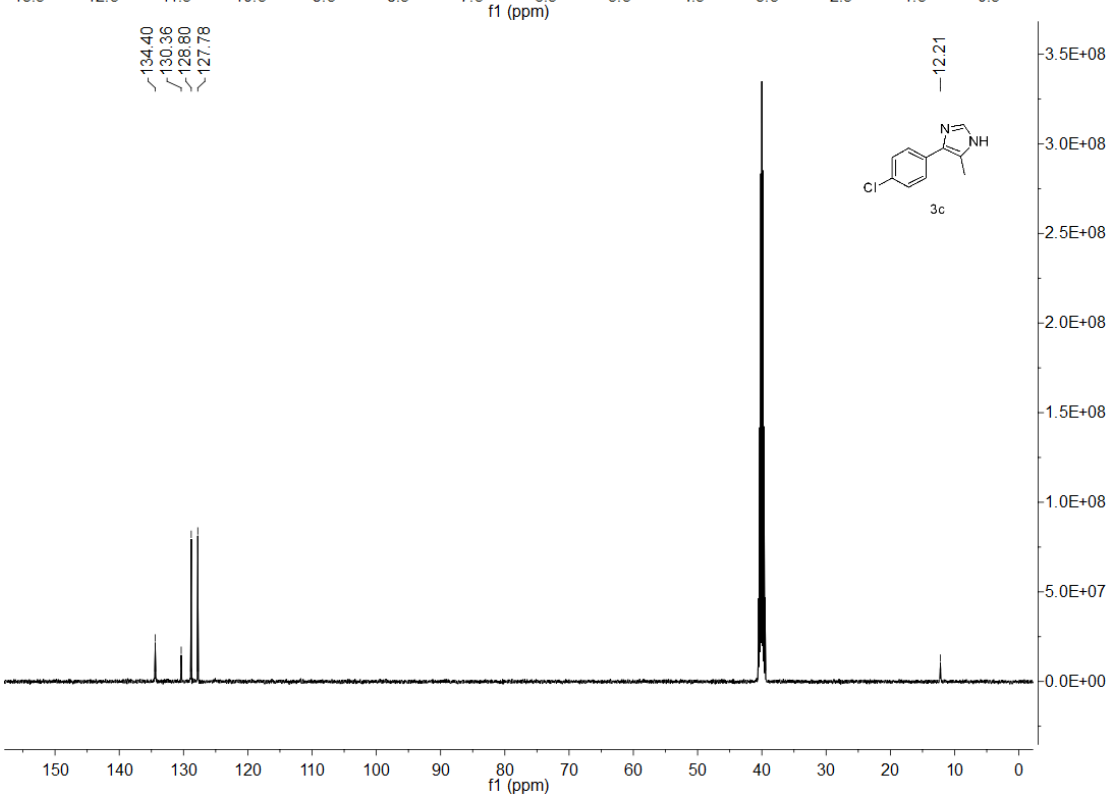


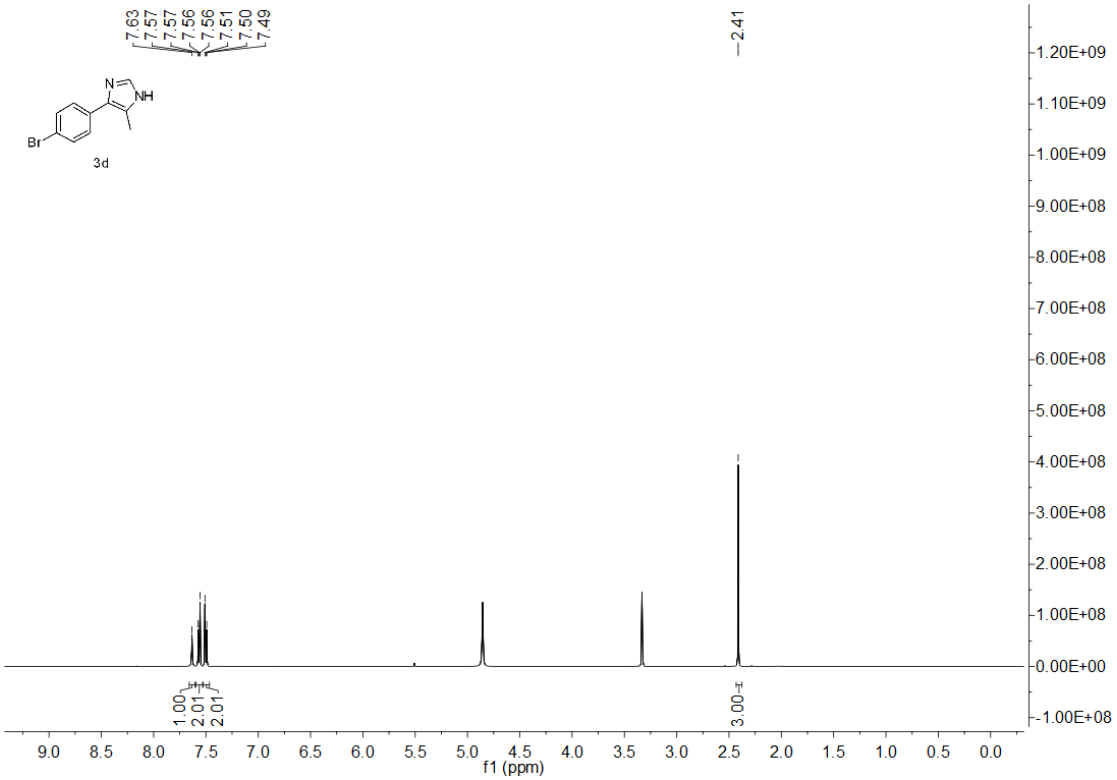


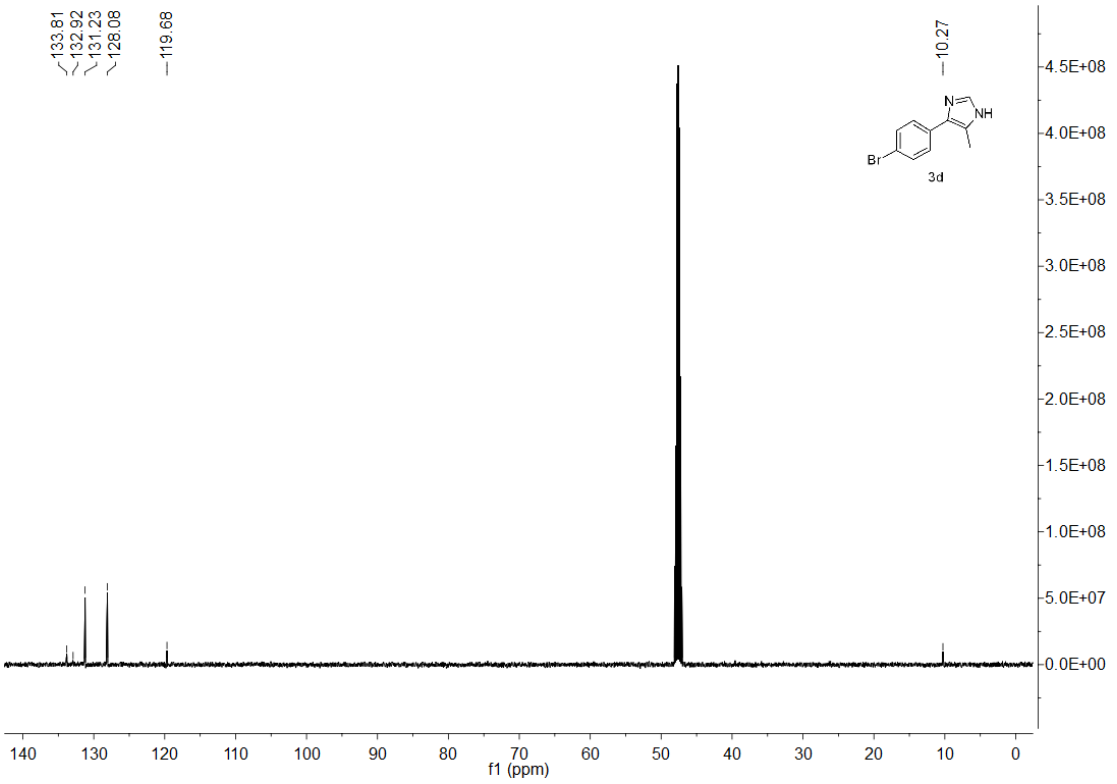

12.11
7.65
7.64
7.64
7.63
7.62
7.62
7.59
7.24
7.23
7.23
7.22
7.22
7.21
7.20
7.20
7.19
2.36
N
NH
F
3b
1.00
2.00
1.00
2.02
3.02
f1 (ppm)

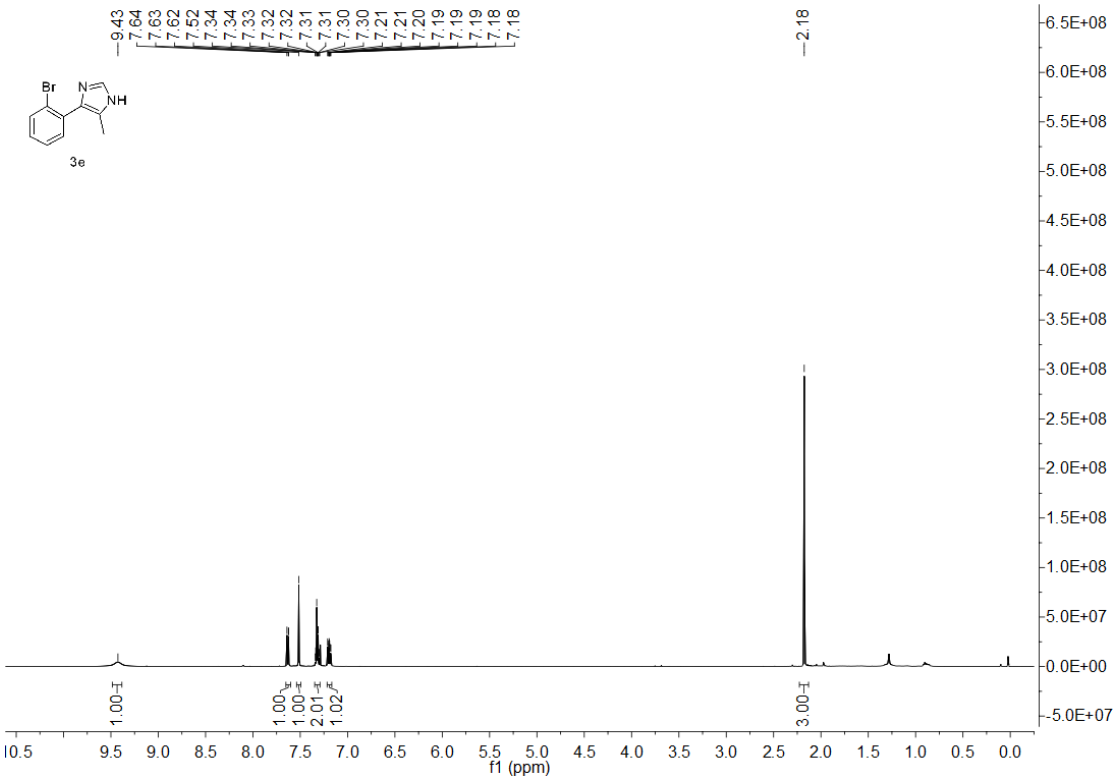

161.87
159.95
134.17
128.09
115.70
12.13
N
NH
F
3b
f1 (ppm)

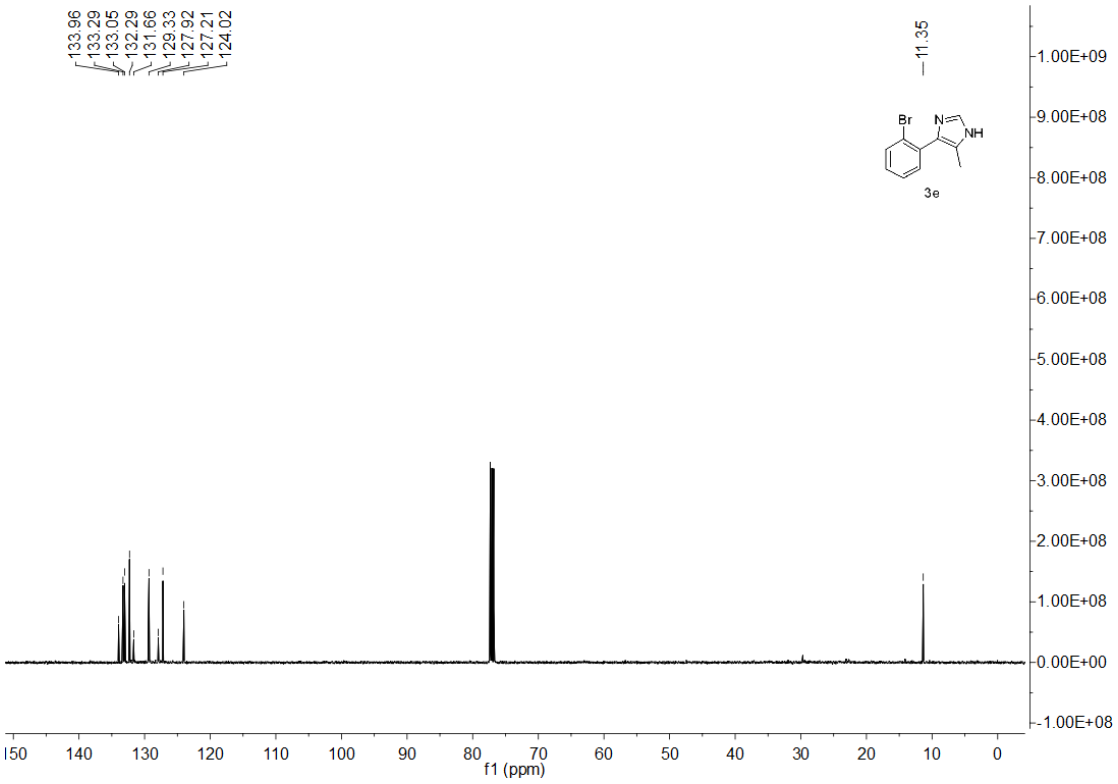

12.11
7.65
7.64
7.60
7.44
7.42
2.38
N
NH
Cl
3c
0.91
2.00
1.01
2.01
3.00
f1 (ppm)

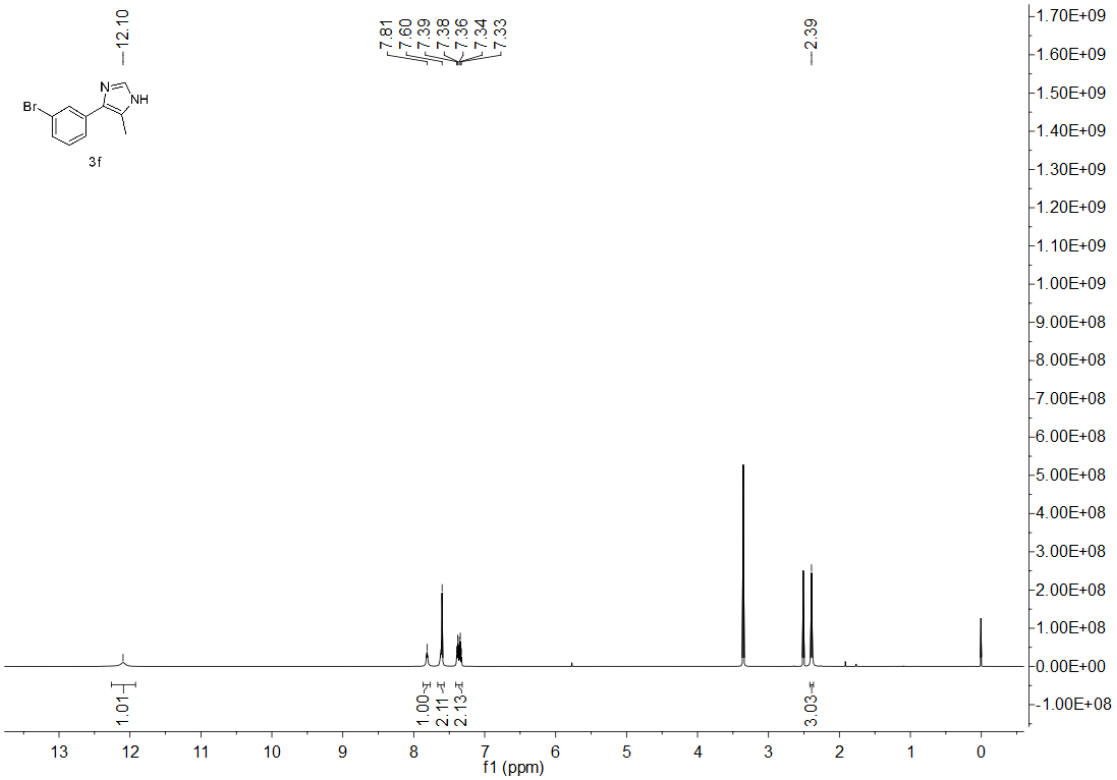

134.40
130.36
128.80
127.78
12.21
N
NH
Cl
3c
f1 (ppm)

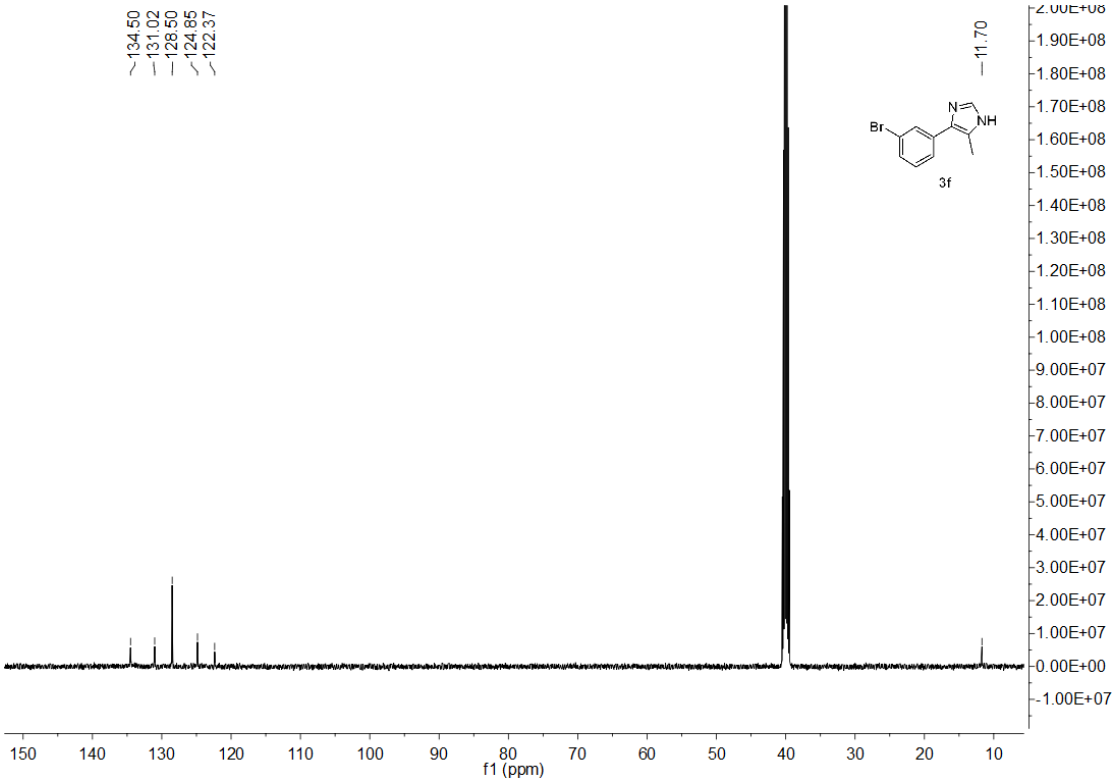

7.63
7.57
7.57
7.56
7.56
7.51
7.50
7.49
2.41
N
NH
Br
3d
1.00
2.01
2.01
3.00
f1 (ppm)

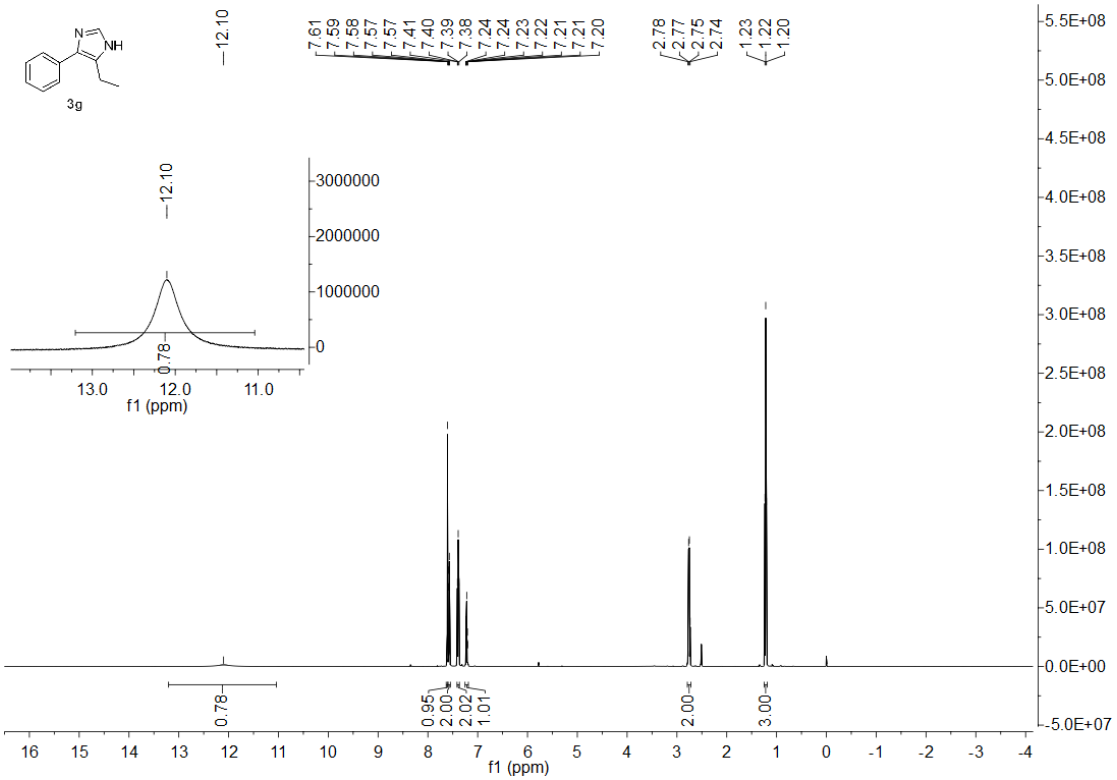

133.81
132.92
131.23
128.08
119.68
10.27
N
NH
Br
3d
f1 (ppm)

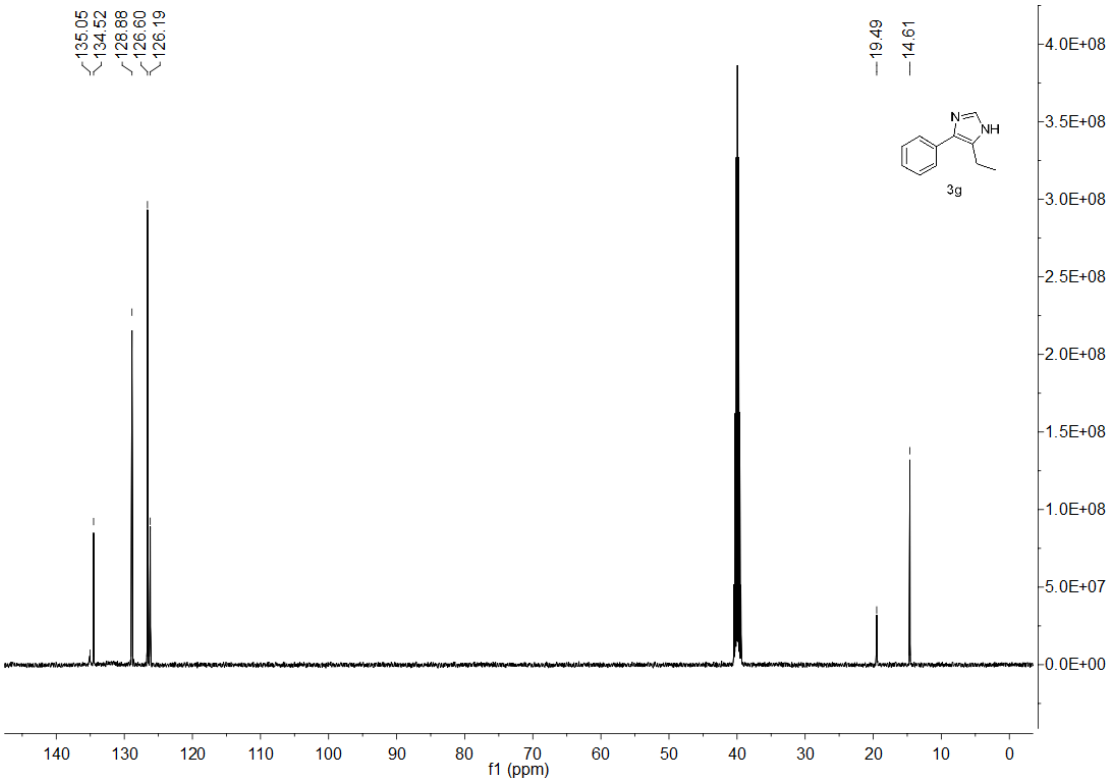

9.43
7.64
7.63
7.62
7.52
7.34
7.34
7.33
7.32
7.32
7.31
7.31
7.30
7.30
7.21
7.21
7.20
7.19
7.19
7.19
7.18
7.18
2.18
Br
N
NH
3e
1.00
1.00
1.00
2.01
1.02
3.00
f1 (ppm)

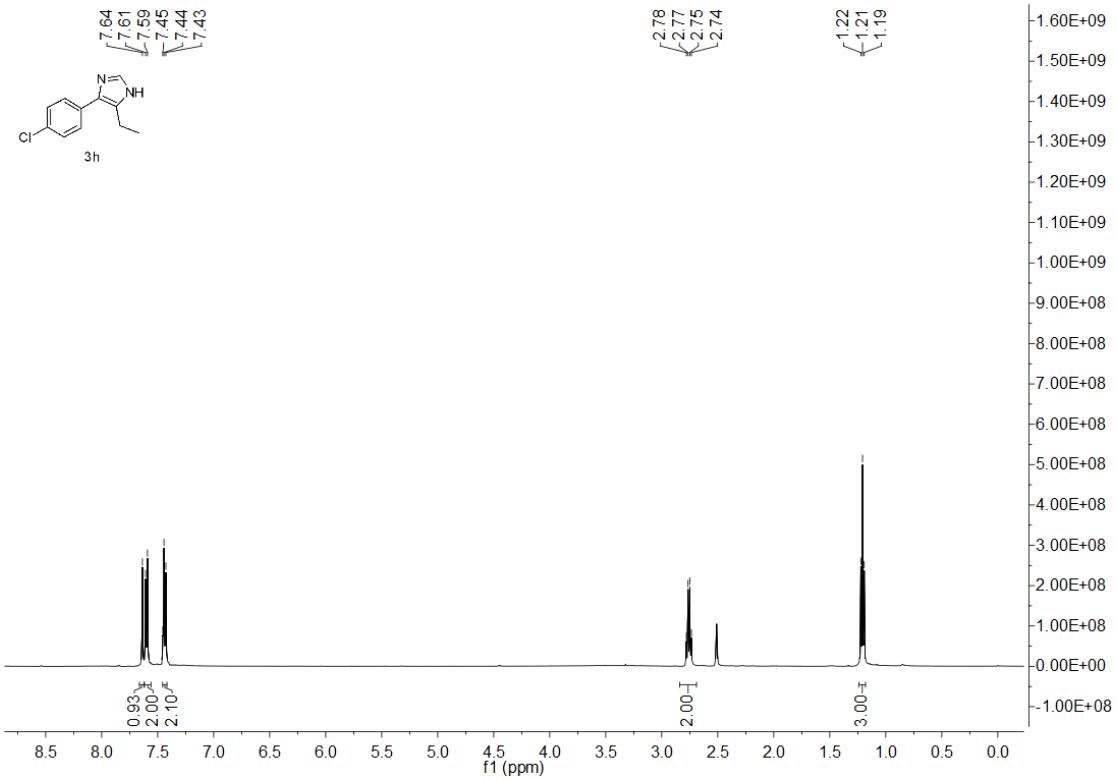

133.96
133.29
133.05
132.29
131.66
129.33
127.92
127.21
124.02
11.35
Br
N
NH
3e
f1 (ppm)

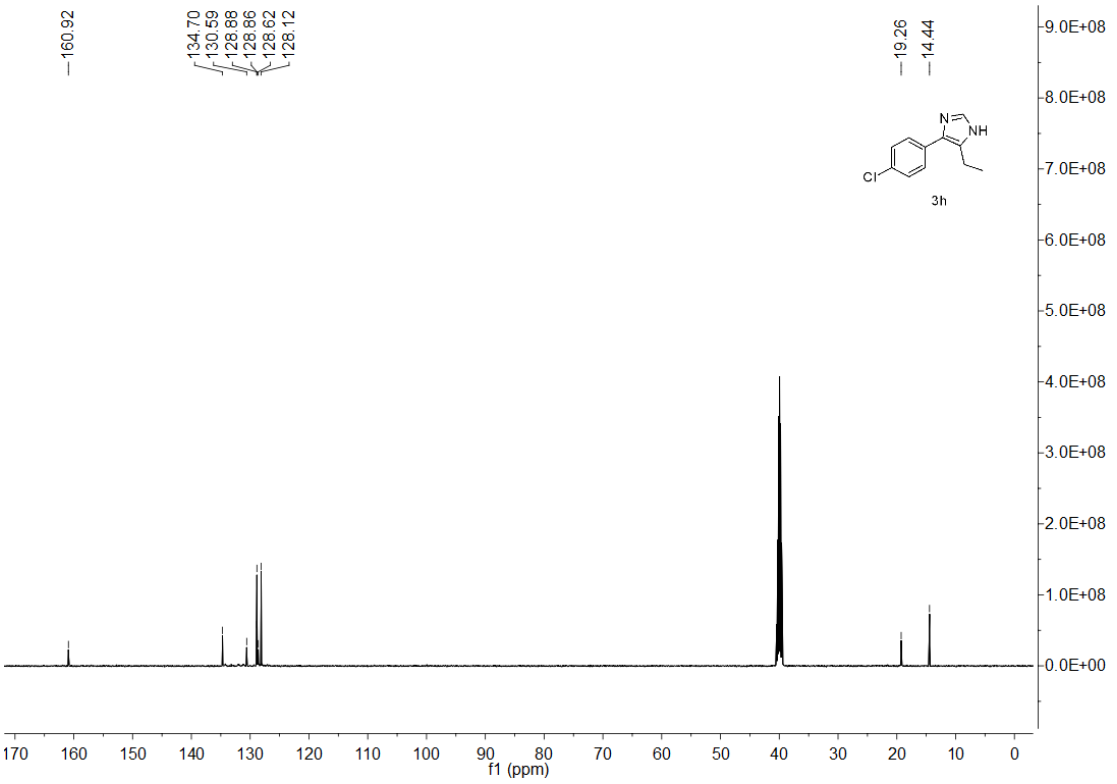

12.10
7.81
7.60
7.39
7.38
7.36
7.34
7.33
2.39
Br
N
NH
3f
1.01
1.00
2.11
2.13
3.03
f1 (ppm)


134.50
131.02
128.50
124.85
122.37
11.70
Br
N
NH
3f
f1 (ppm)


3g
12.10
7.61
7.59
7.58
7.57
7.57
7.41
7.40
7.39
7.38
7.24
7.24
7.23
7.22
7.21
7.21
7.20
2.78
2.77
2.75
2.74
1.23
1.22
1.20
0.78
0.95
2.00
2.02
1.01
2.00
3.00
f1 (ppm)


135.05
134.52
128.88
126.60
126.19
19.49
14.61
3g
f1 (ppm)


7.64
7.61
7.59
7.45
7.44
7.43
2.78
2.77
2.75
2.74
1.22
1.21
1.19
N
NH
Cl
3h
0.93
2.00
2.10
2.00
3.00
f1 (ppm)


160.92
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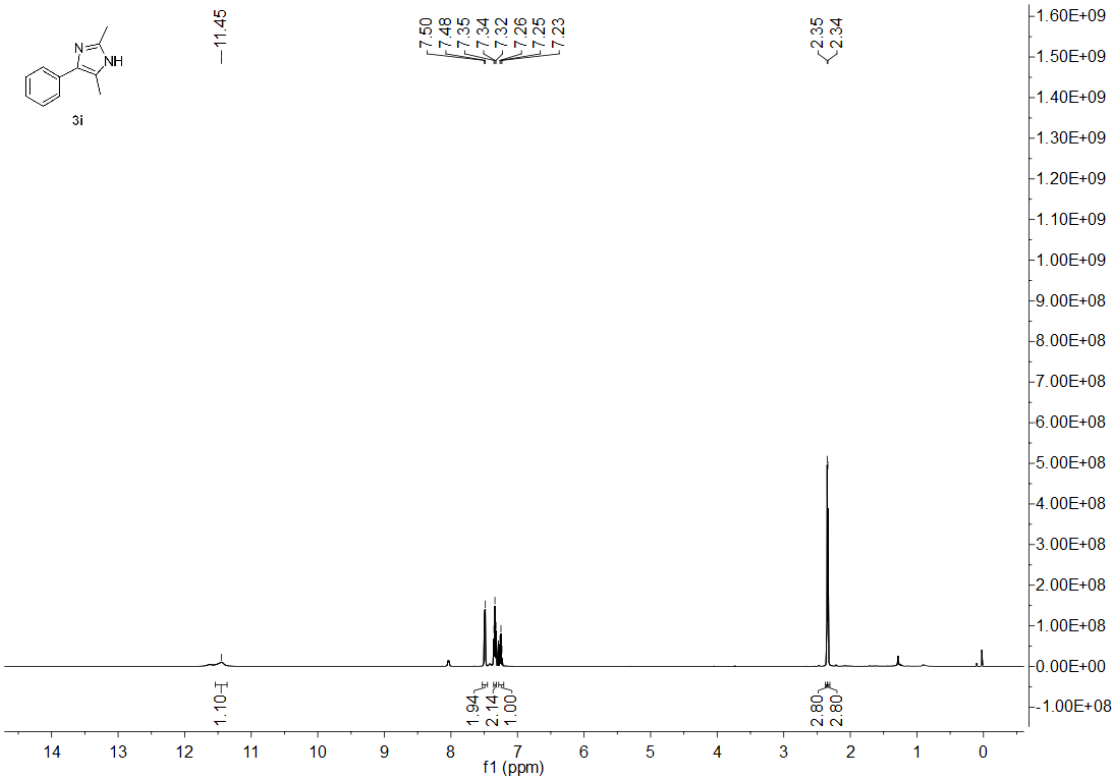
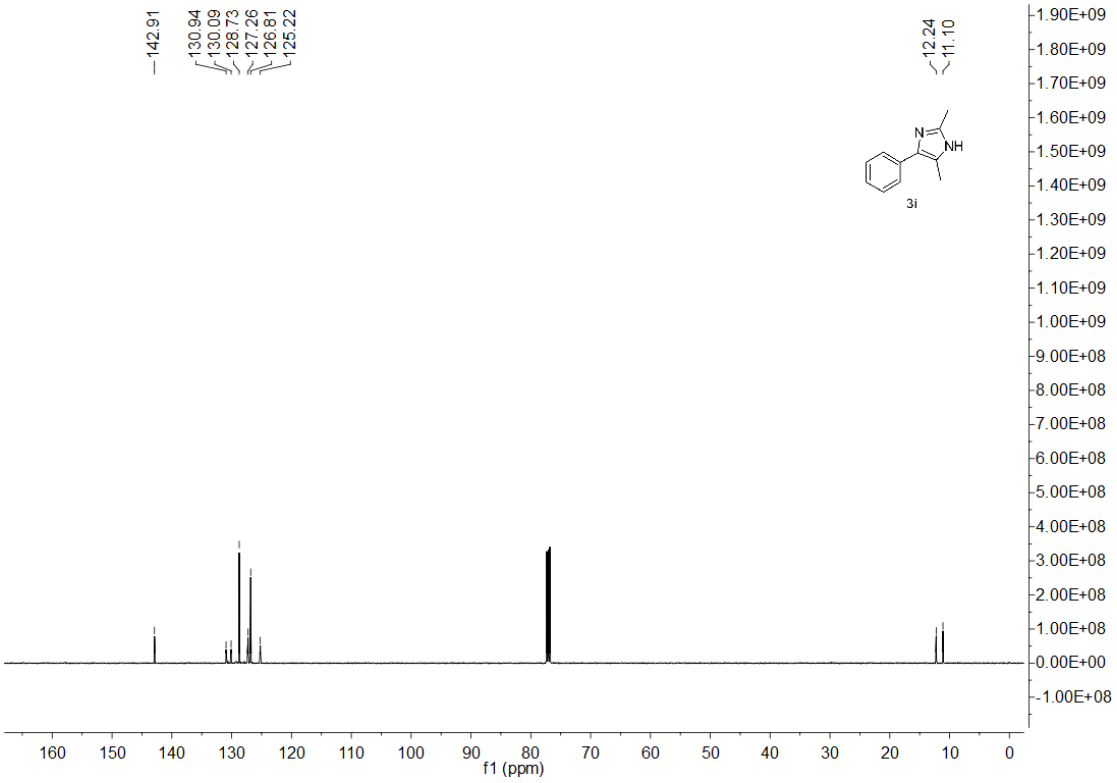
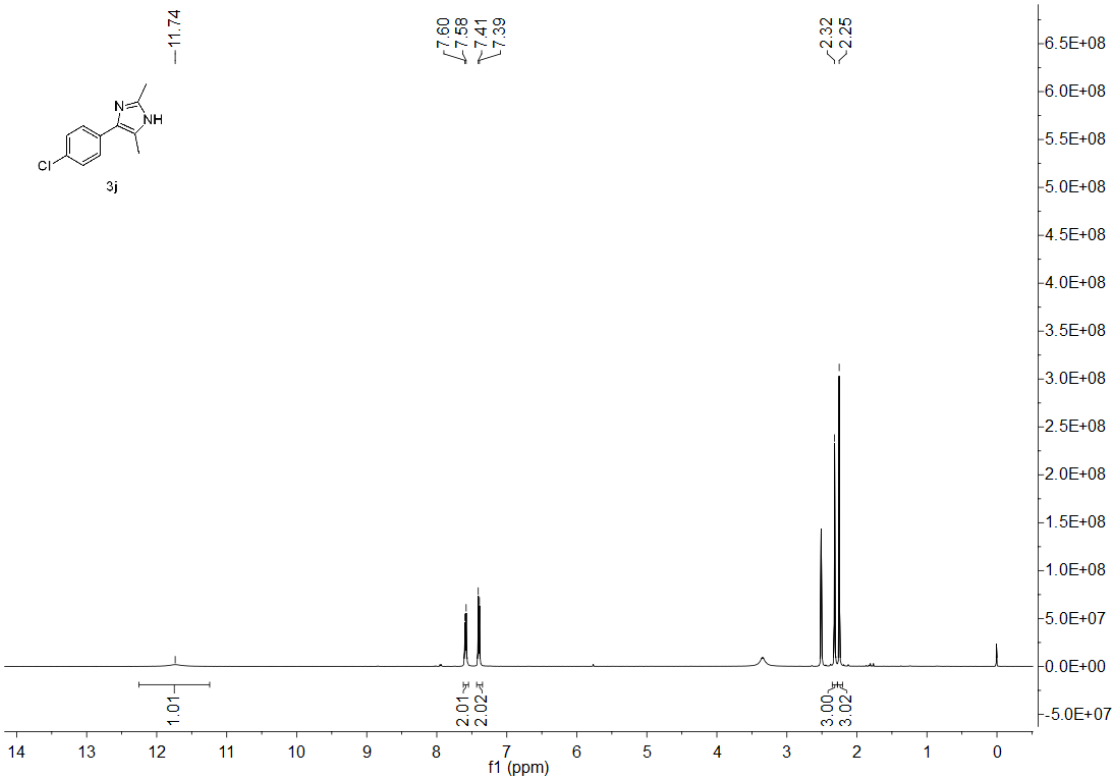
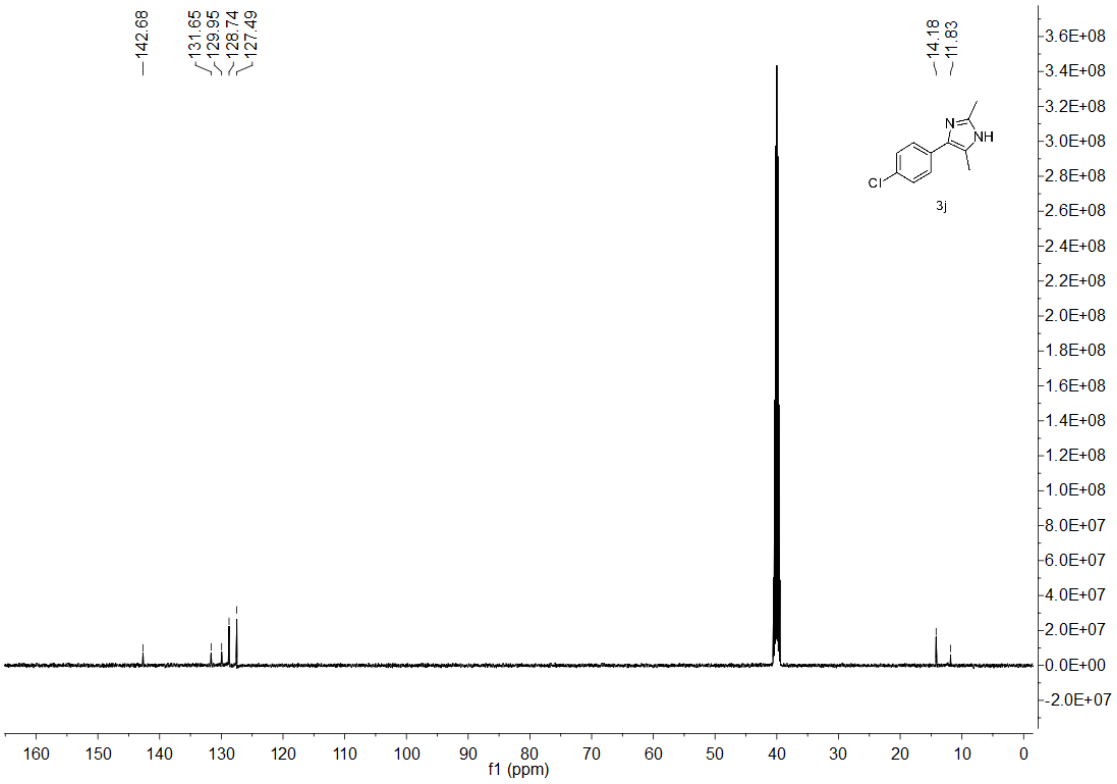
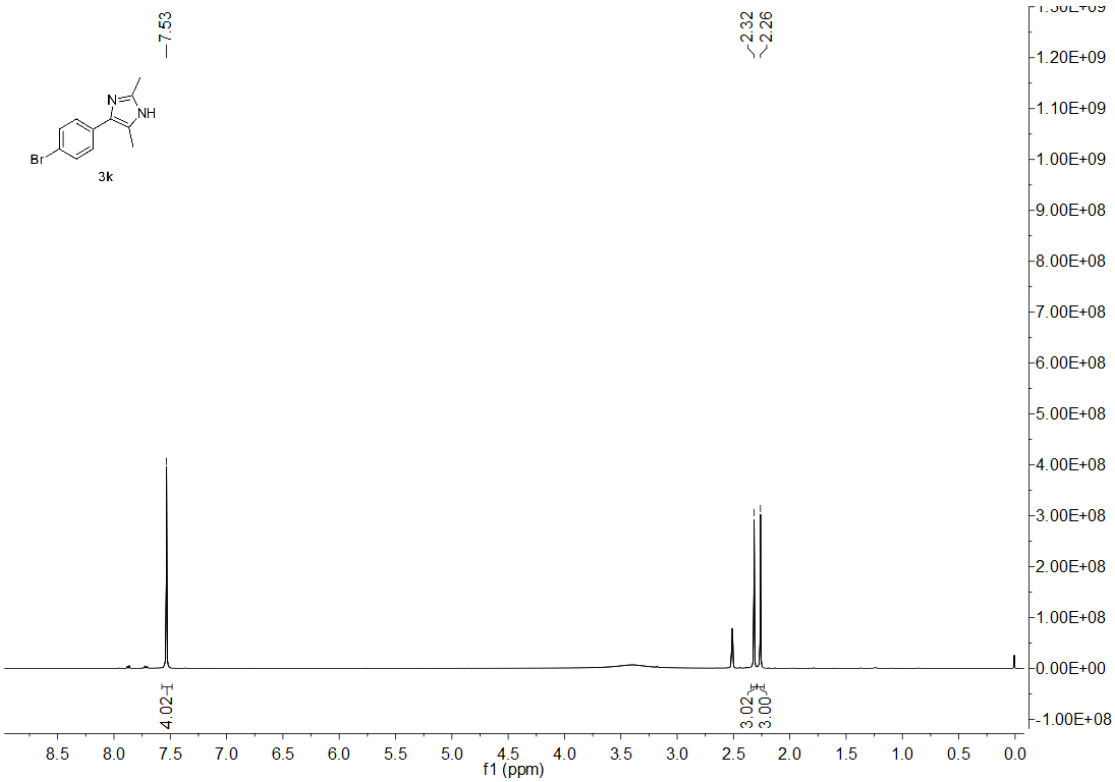
130.59
128.88
128.86
128.62
128.12
19.26
14.44
N
NH
Cl
3h
f1 (ppm)

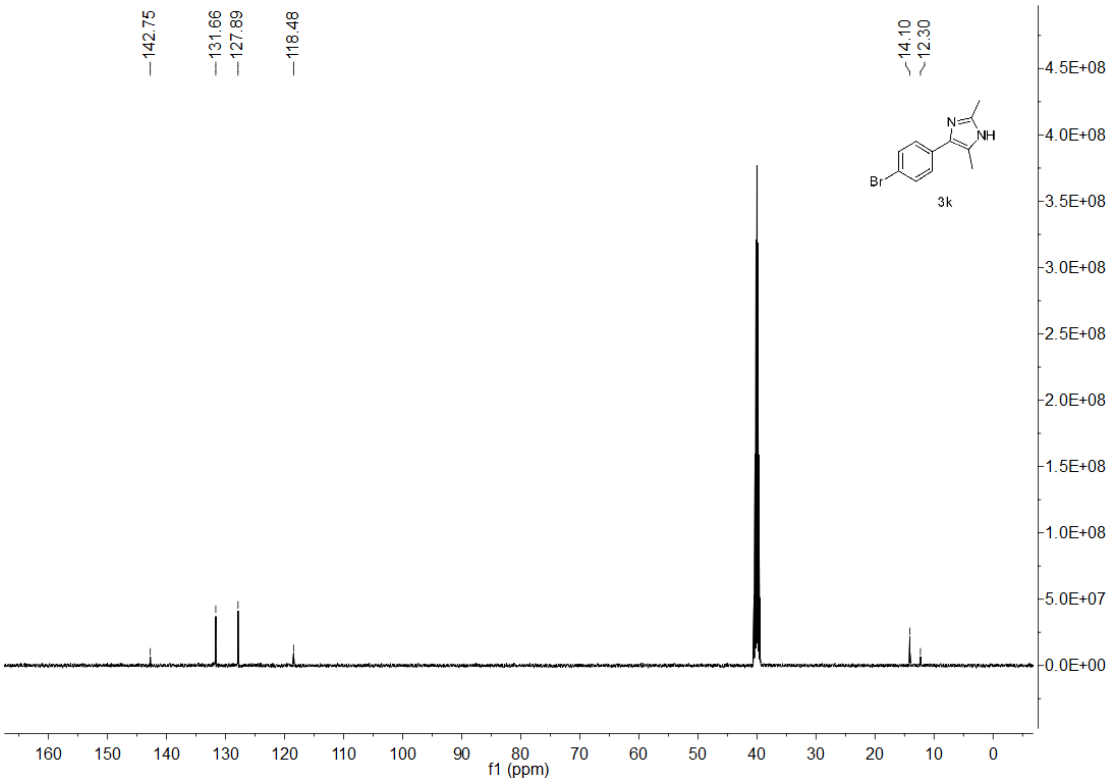

11.45
7.50
7.48
7.35
7.34
7.32
7.26
7.25
7.23
2.35
2.34
3i
1.10
1.94
2.14
1.00
2.80
2.80
f1 (ppm)


142.91
130.94
130.09
128.73
127.26
126.81
125.22
12.24
11.10
3i
f1 (ppm)


11.74
7.60
7.58
7.41
7.39
2.32
2.25
N
NH
Cl
3j
1.01
2.01
2.02
3.00
3.02
f1 (ppm)


142.68
131.65
129.95
128.74
127.49
14.18
11.83
N
NH
Cl
3j
f1 (ppm)


7.53
2.32
2.26
N
NH
Br
3k
4.02
3.02
3.00
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)
1.20E+09
1.10E+09
1.00E+09
9.00E+08
8.00E+08
7.00E+08
6.00E+08
5.00E+08
4.00E+08
3.00E+08
2.00E+08
1.00E+08
0.00E+00
-1.00E+08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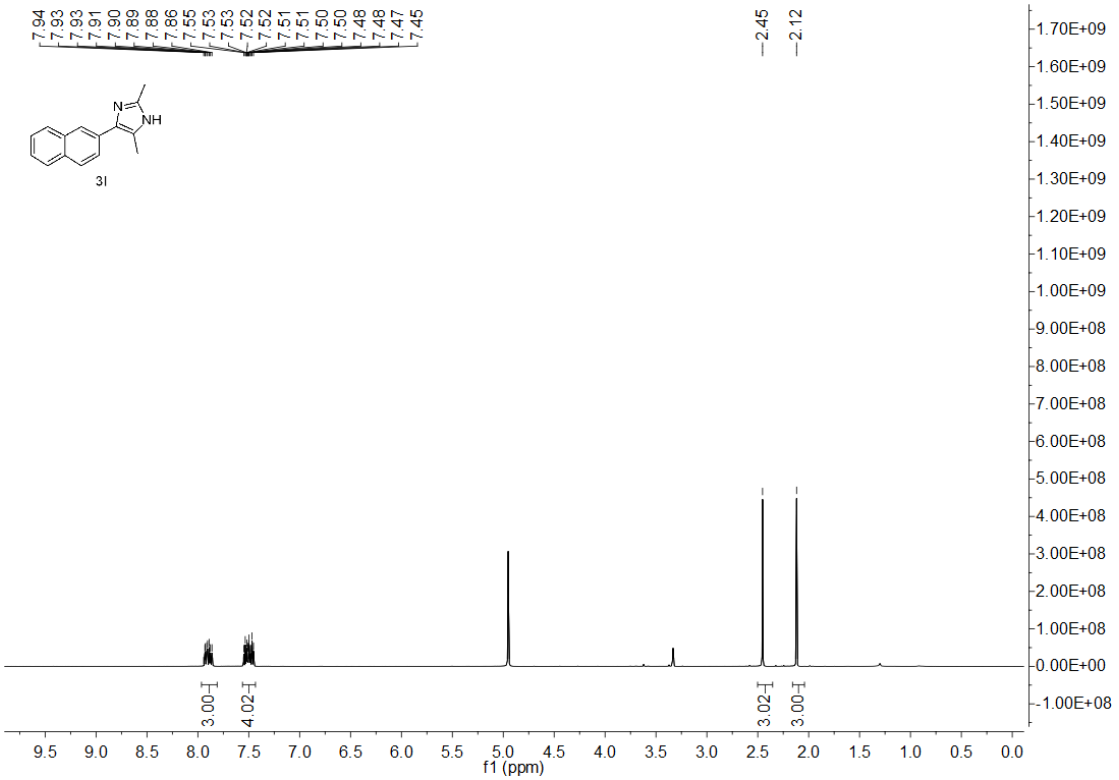
131.66
127.89
118.48
14.10
12.30
N
NH
Br
3k
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00


7.94
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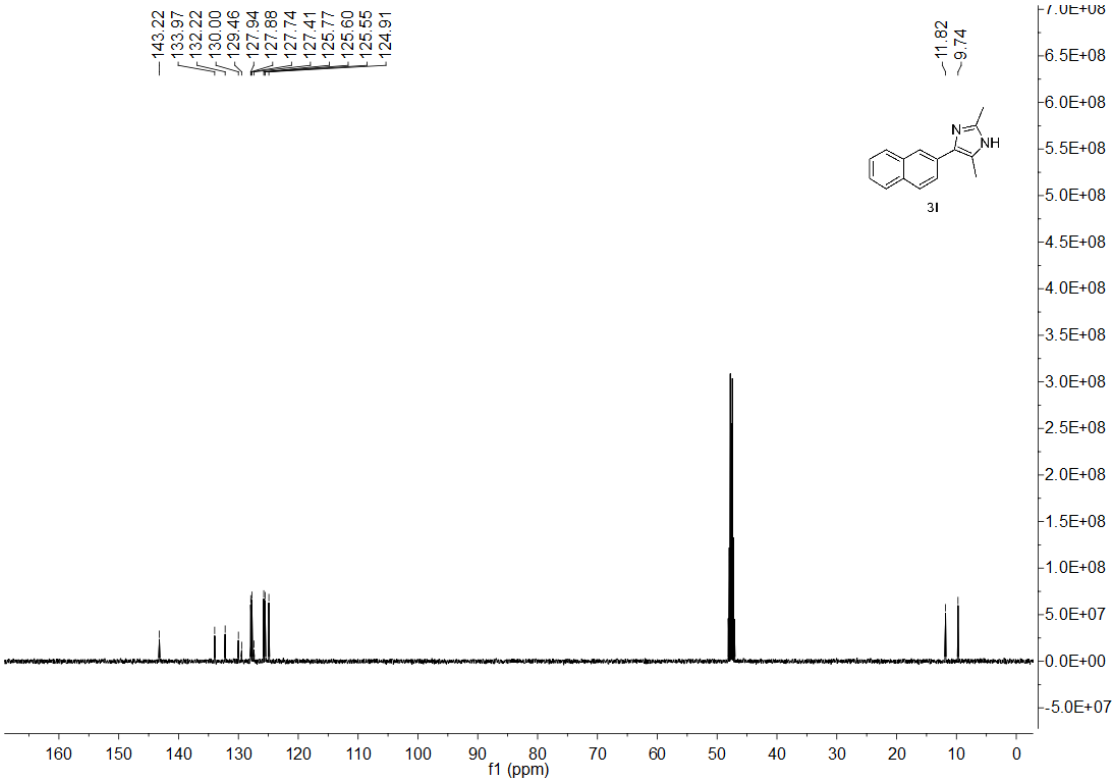
7.91
7.90
7.89
7.88
7.86
7.55
7.53
7.53
7.52
7.52
7.51
7.51
7.50
7.50
7.48
7.48
7.47
7.45
2.45
2.12
N
NH
3l
3.00
4.02
3.02
3.00
f1 (ppm)


143.22
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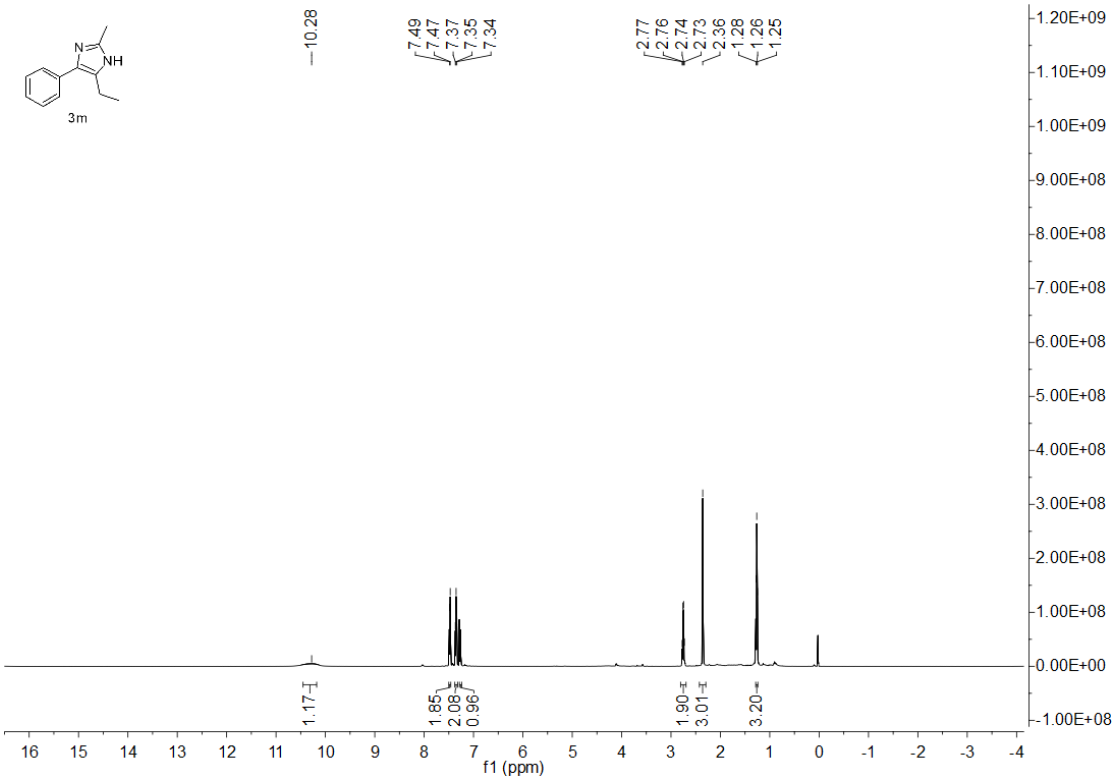
130.00
129.46
127.94
127.88
127.74
127.41
125.77
125.60
125.55
124.91
11.82
9.74
N
NH
3l
f1 (ppm)


3m
10.28
7.49
7.47
7.37
7.35
7.34
2.77
2.76
2.74
2.73
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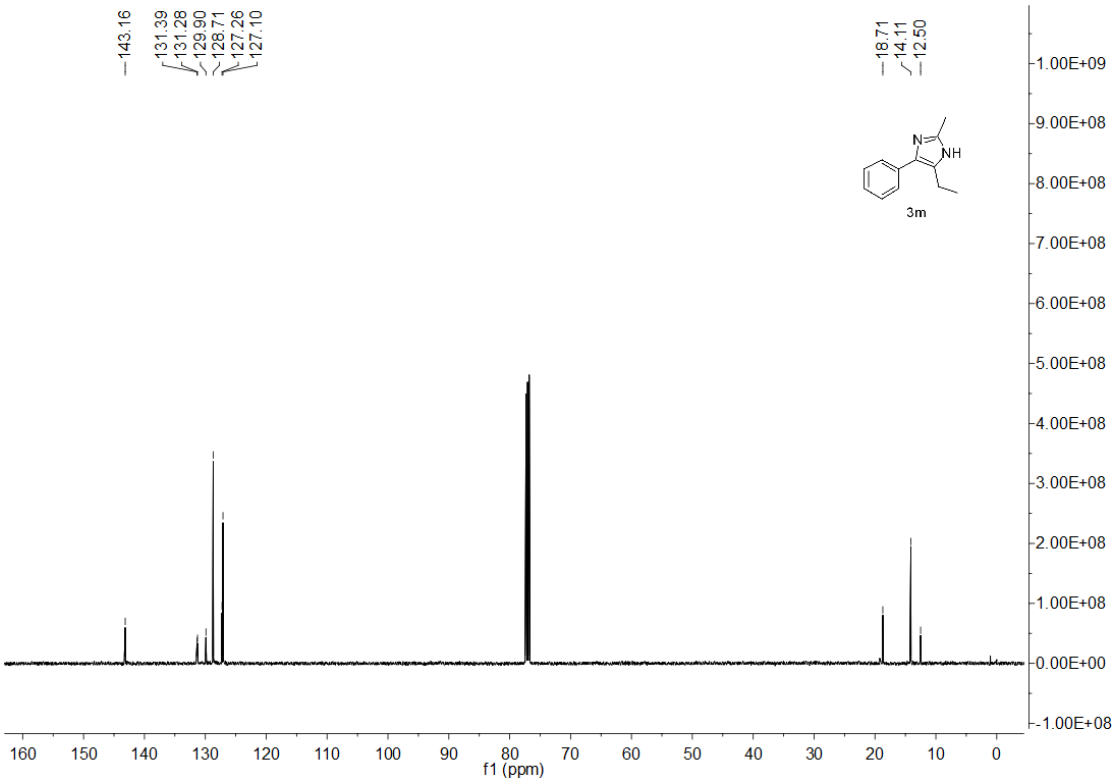
1.28
1.26
1.25
1.17
1.85
2.08
0.96
1.90
3.01
3.20
f1 (ppm)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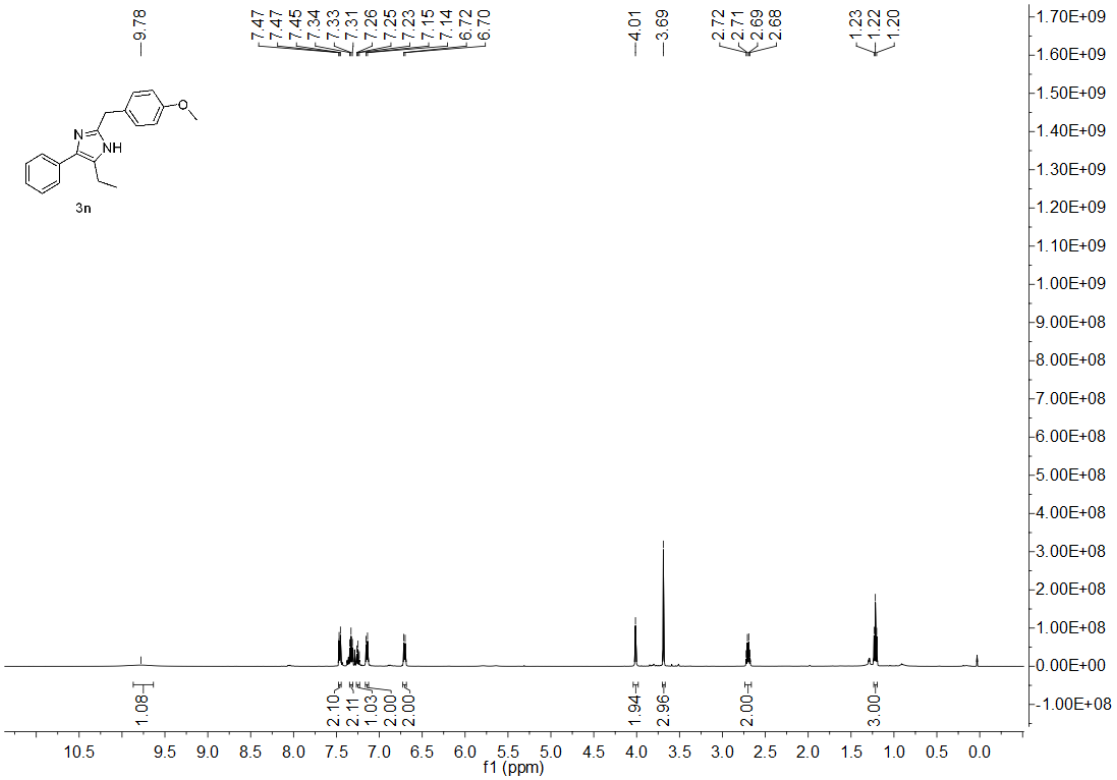
128.71
127.26
127.10
18.71
14.11
12.50
3m
f1 (ppm)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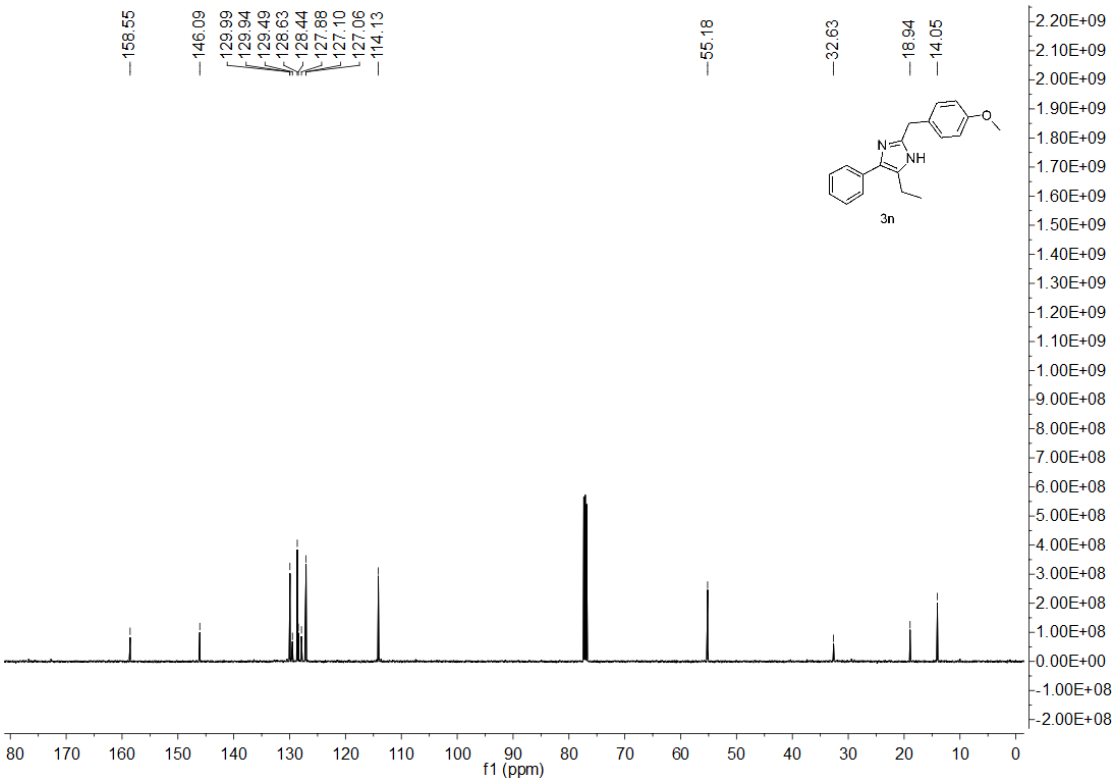
7.34
7.33
7.31
7.26
7.25
7.23
7.15
7.14
6.72
6.70
4.01
3.69
2.72
2.71
2.69
2.68
1.23
1.22
1.20
3n
1.08
2.10
2.11
1.03
2.00
2.00
1.94
2.96
2.00
3.00
f1 (ppm)


158.55
146.09
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129.94
129.49
128.63
128.44
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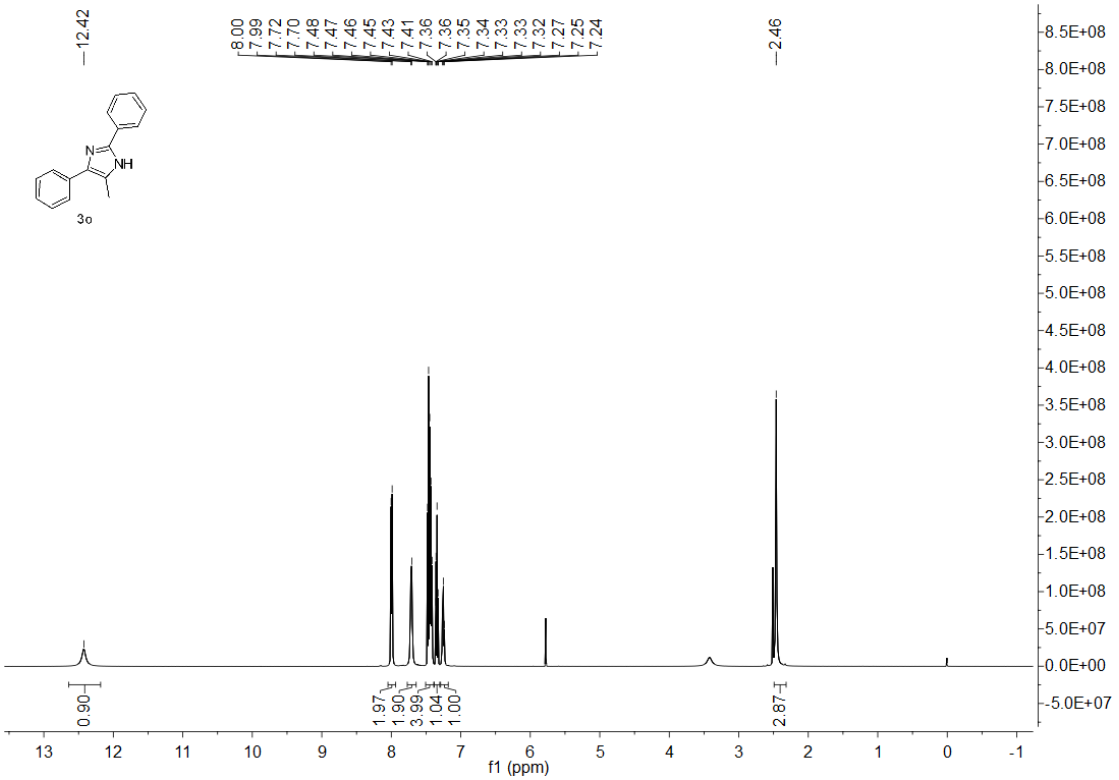
127.10
127.06
114.13
55.18
32.63
18.94
14.05
3n
f1 (ppm)


12.42
8.00
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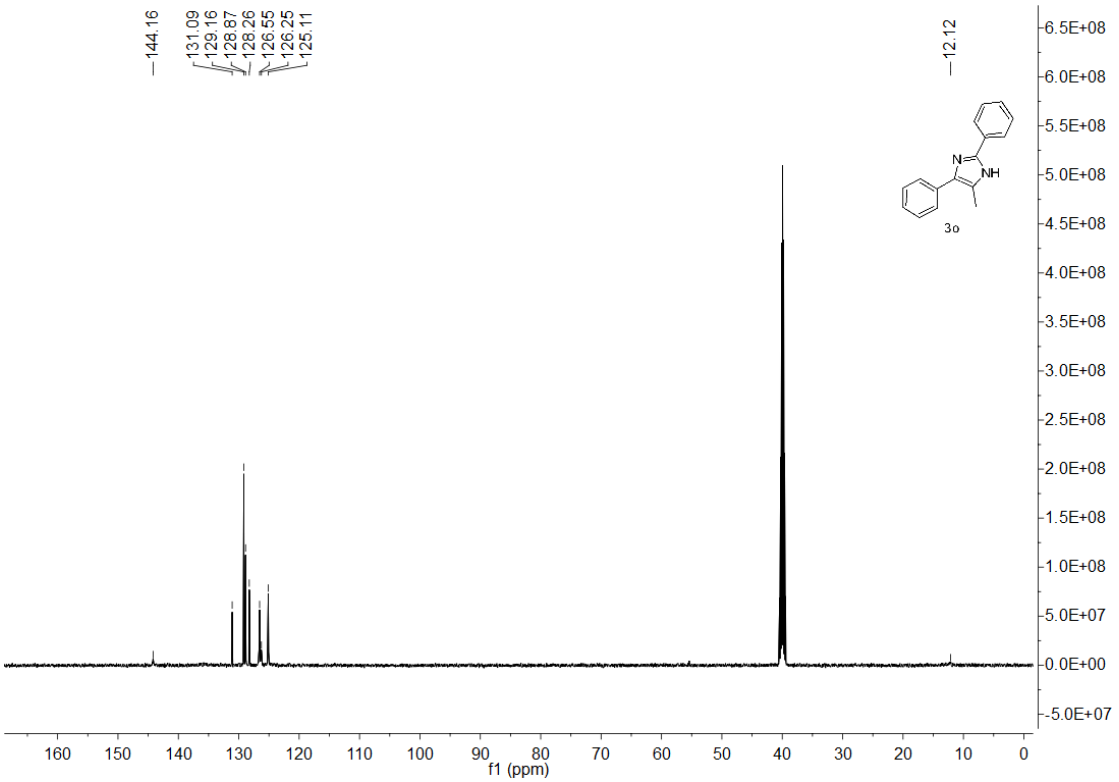
7.72
7.70
7.48
7.47
7.46
7.45
7.43
7.41
7.36
7.36
7.35
7.34
7.33
7.33
7.32
7.27
7.25
7.24
2.46
N
NH
3o
0.90
1.97
1.90
3.99
1.04
1.00
2.87
f1 (ppm)


144.16
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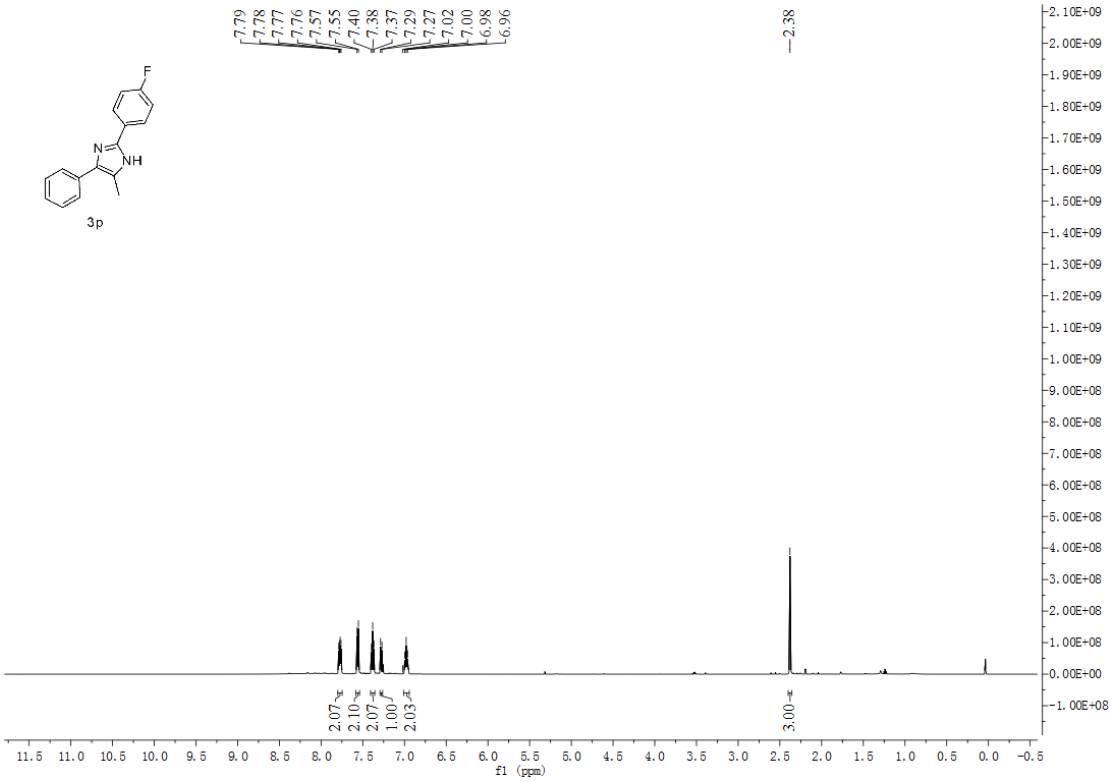
128.87
128.26
126.55
126.25
125.11
12.12
N
NH
3o
f1 (ppm)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7.76
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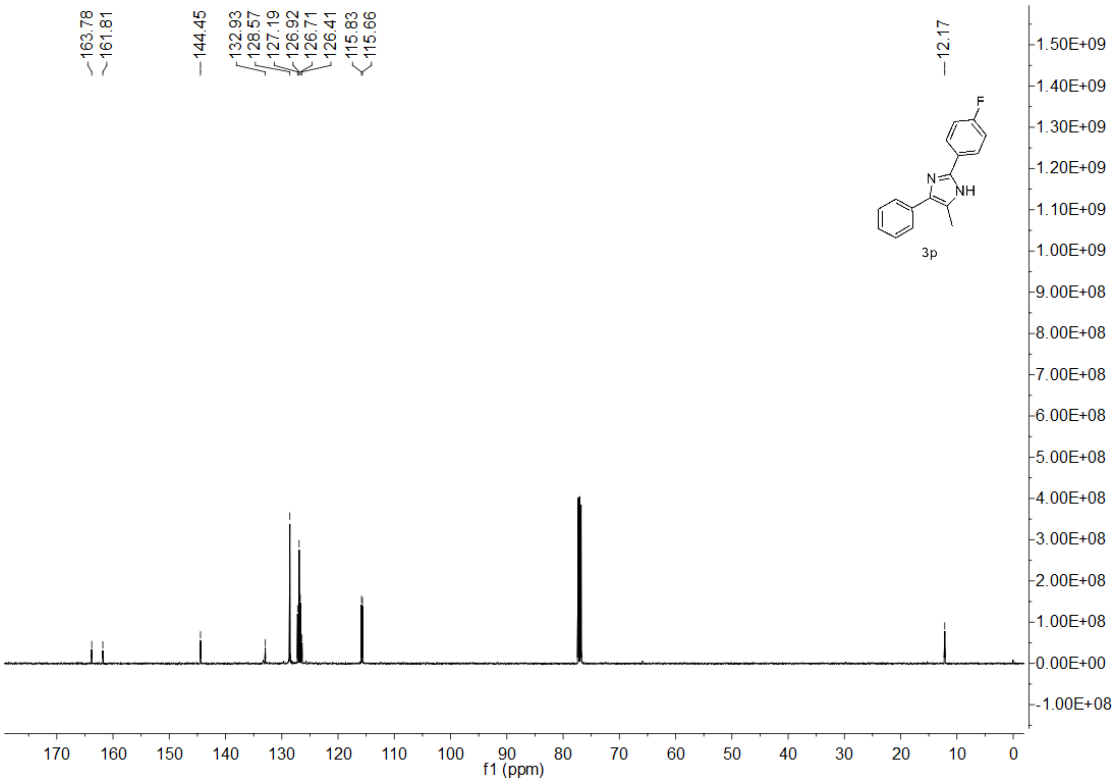
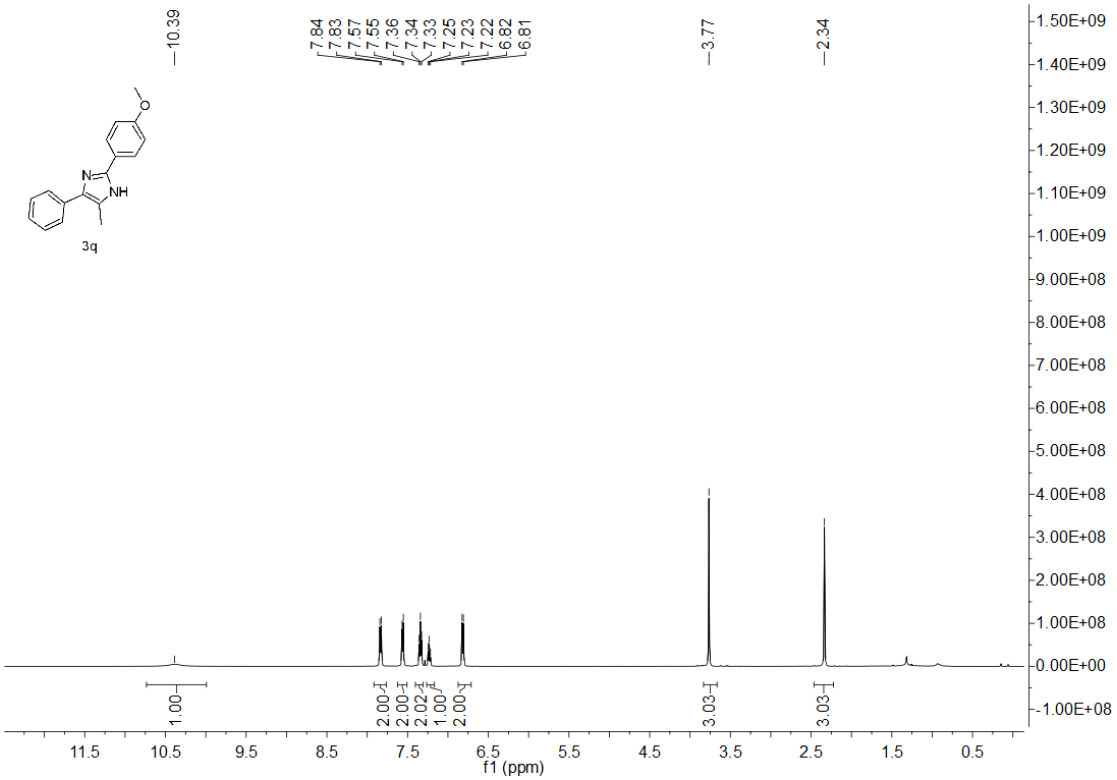
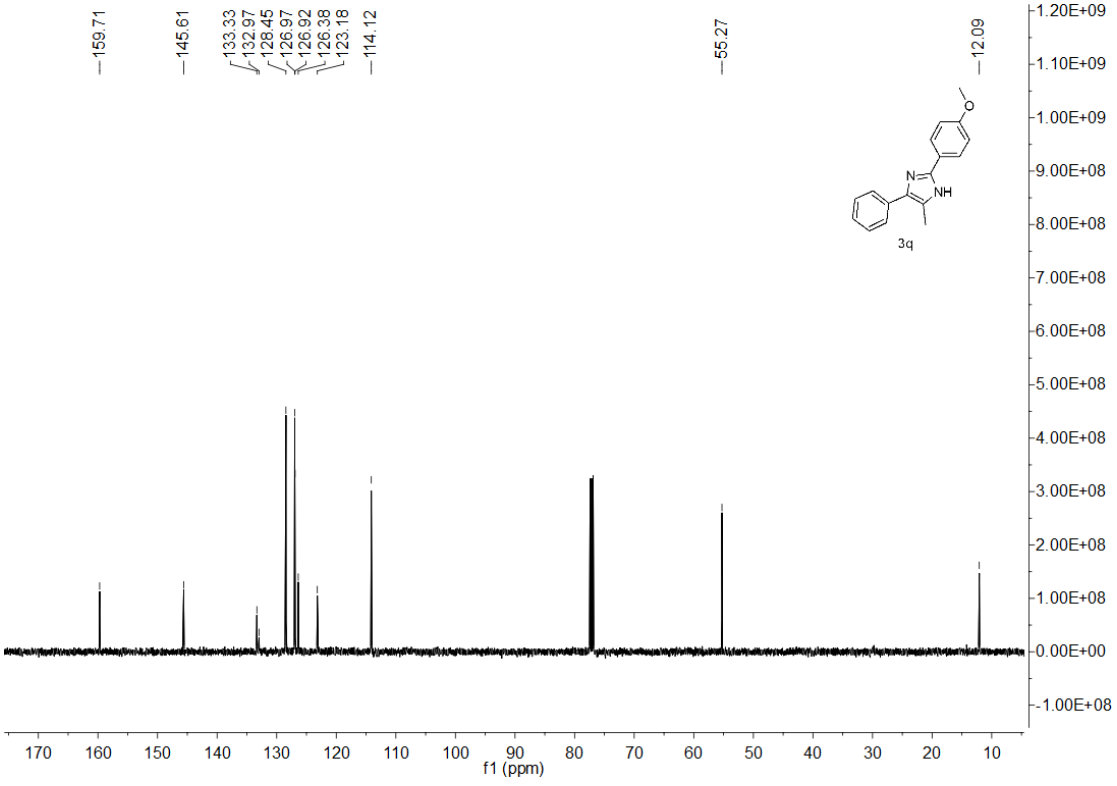
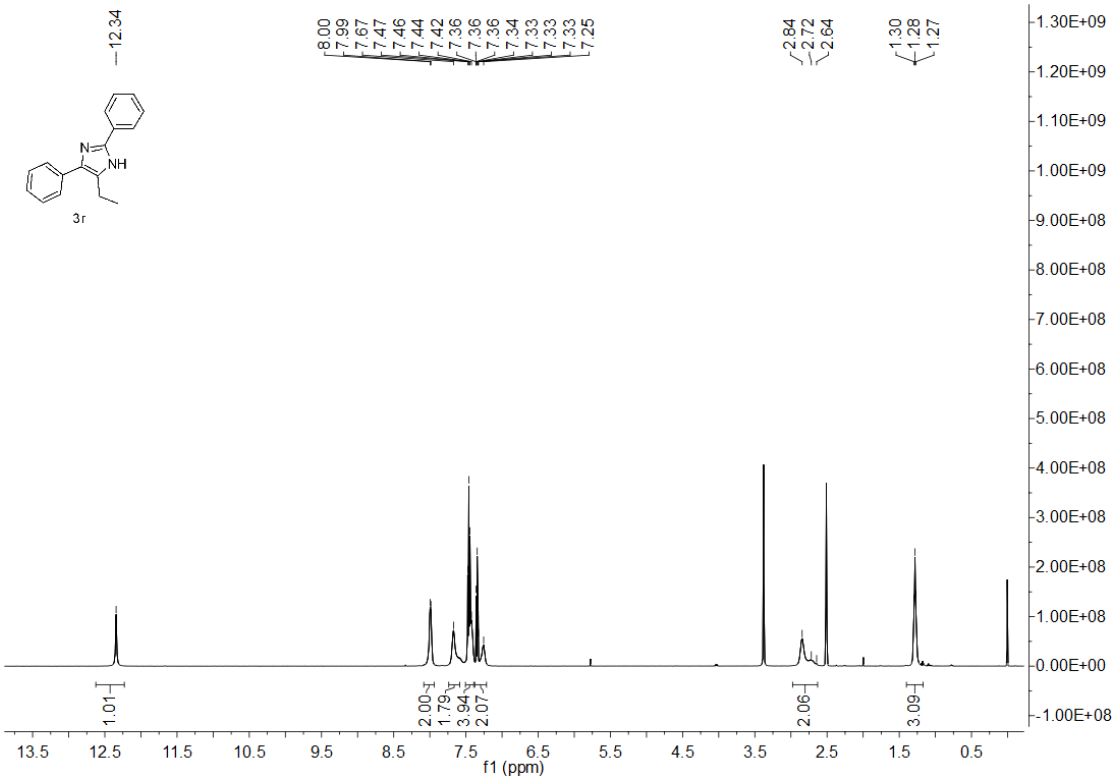
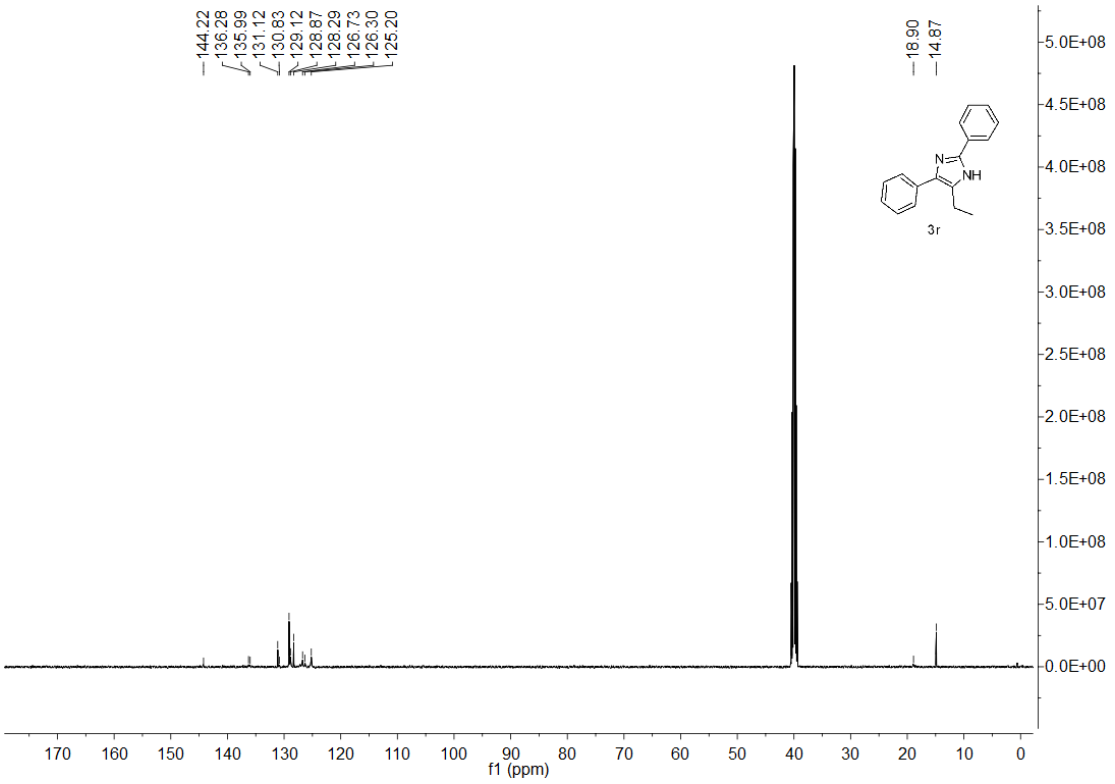
7.55
7.40
7.38
7.37
7.29
7.27
7.02
7.00
6.98
6.96
2.38
F
N
NH
3p
2.07
2.10
2.07
1.00
2.03
3.00
f1 (ppm)

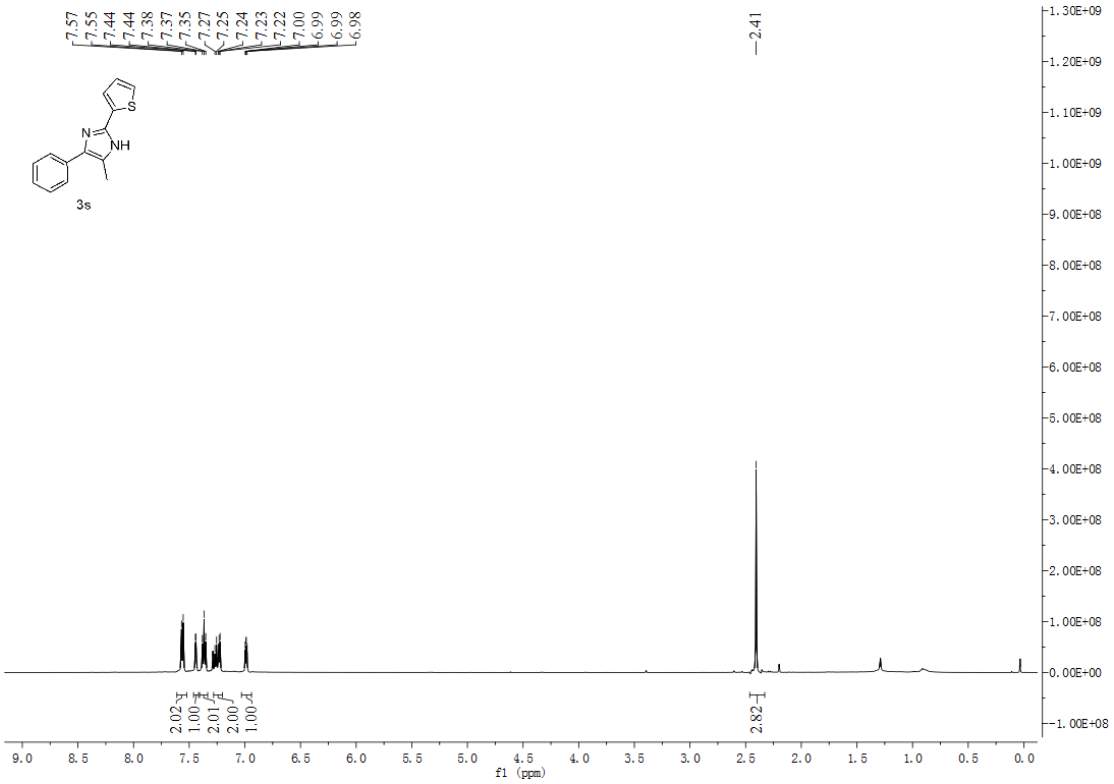

163.78
161.81
144.45
132.93
128.57
127.19
126.92
126.71
126.41
115.83
115.66
12.17
F
N
NH
3p
f1 (ppm)

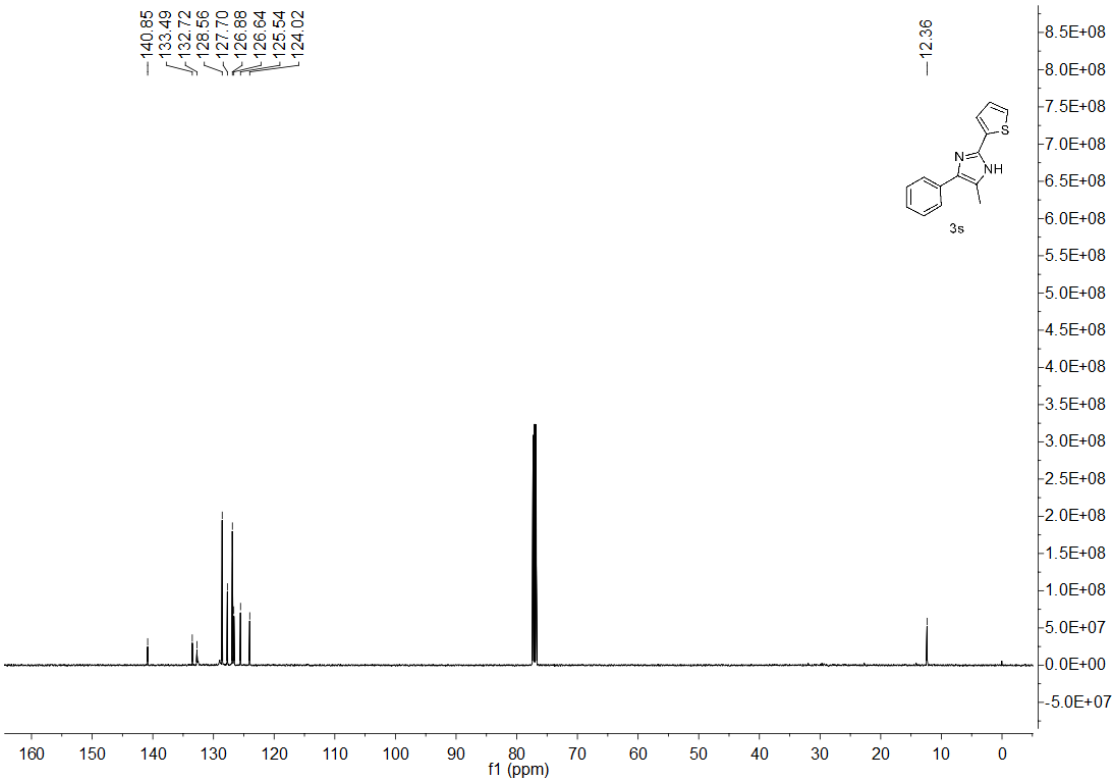

10.39
7.84
7.83
7.57
7.55
7.36
7.34
7.33
7.25
7.23
7.22
6.82
6.81
3.77
2.34
3q
1.00
2.00
2.00
2.02
1.00
2.00
3.03
3.03
f1 (ppm)

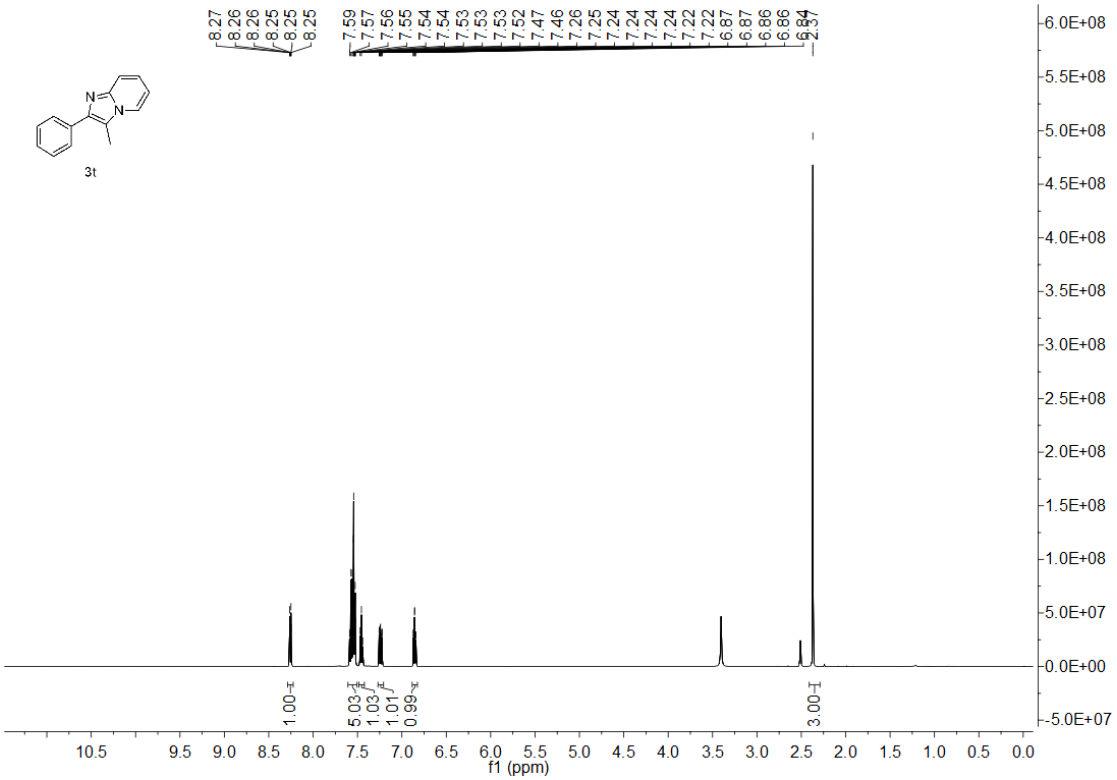

159.71
145.61
133.33
132.97
128.45
126.97
126.92
126.38
123.18
114.12
55.27
12.09
3q
f1 (ppm)

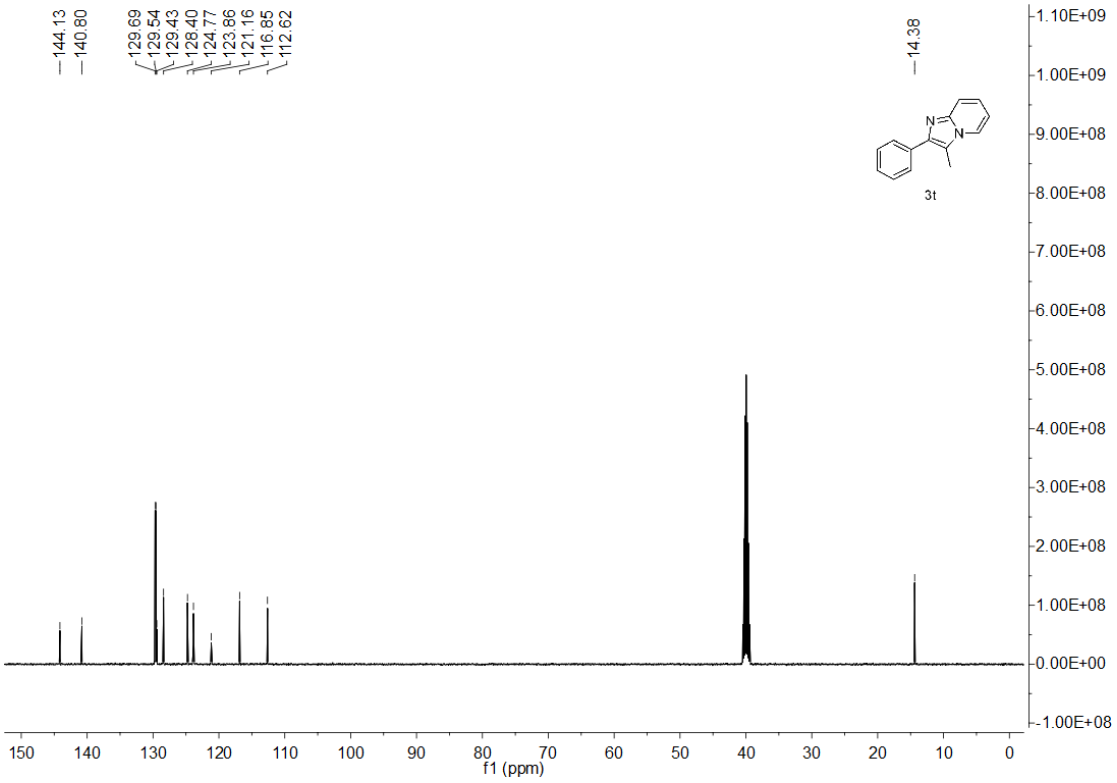

12.34
8.00
7.99
7.67
7.47
7.46
7.44
7.42
7.36
7.36
7.36
7.34
7.33
7.33
7.33
7.25
2.84
2.72
2.64
1.30
1.28
1.27
3r
1.01
2.00
1.79
3.94
2.07
2.06
3.09
f1 (ppm)

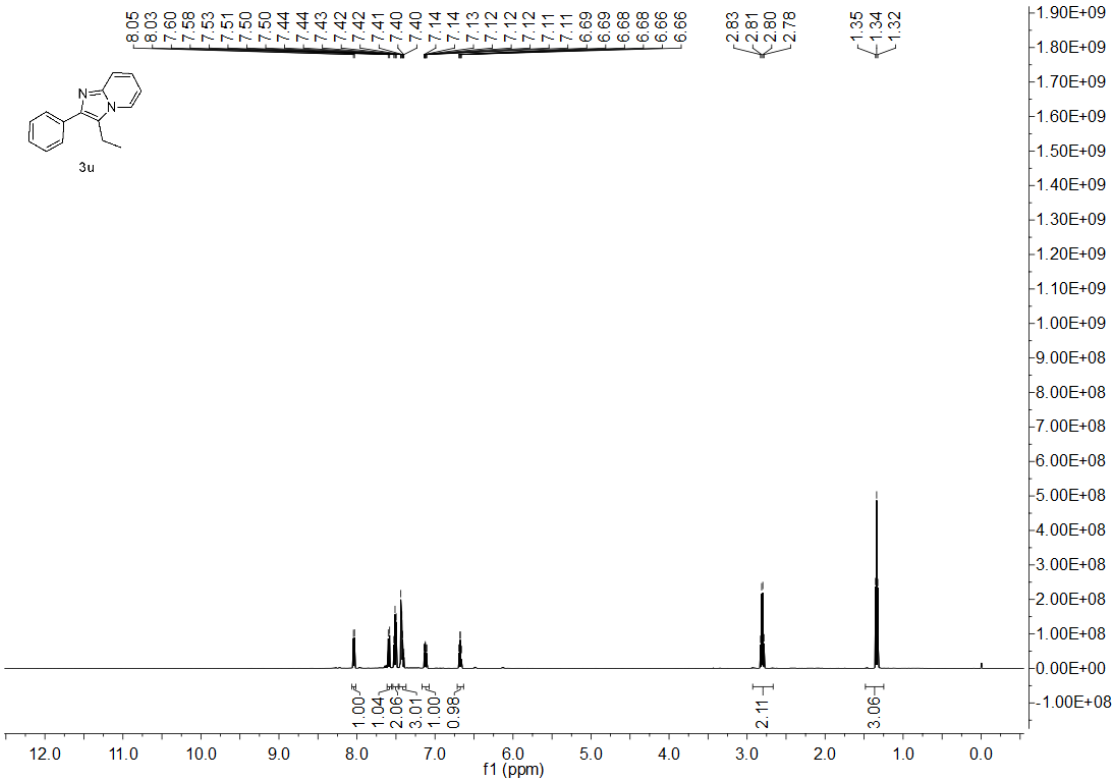

144.22
136.28
135.99
131.12
130.83
129.12
128.87
128.29
126.73
126.30
125.20
18.90
14.87
3r
f1 (ppm)

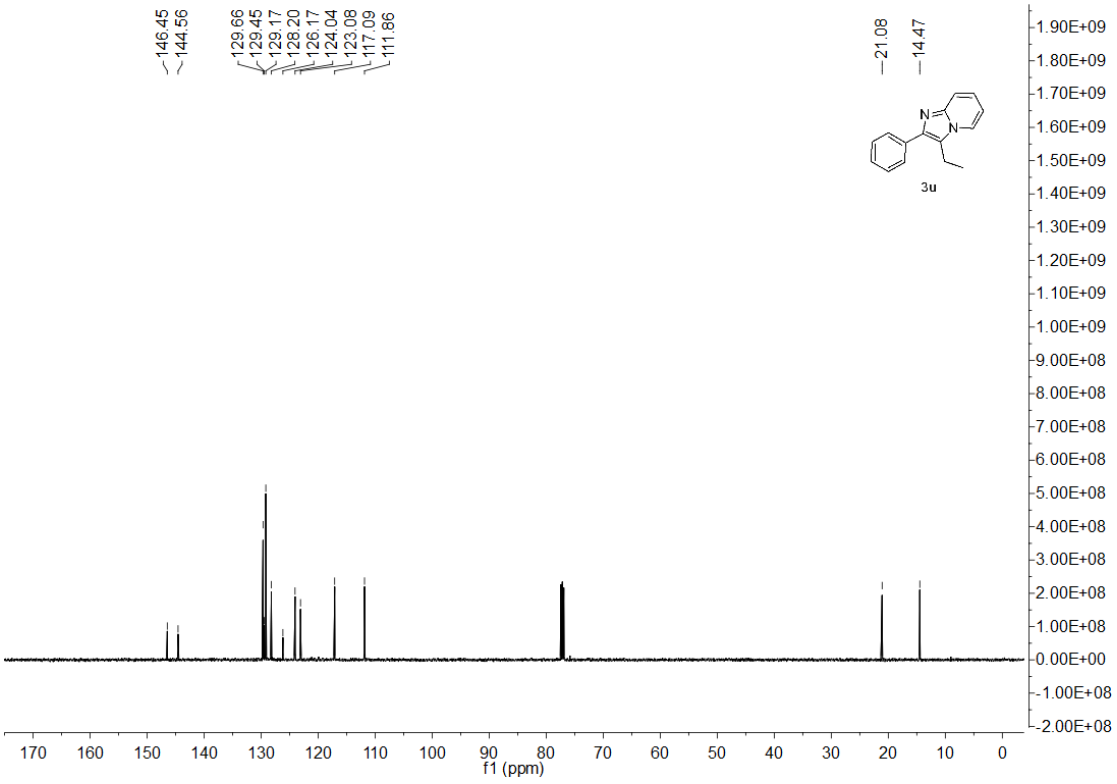

7.57
7.55
7.44
7.44
7.38
7.37
7.35
7.27
7.25
7.24
7.23
7.22
7.00
6.99
6.99
6.98
2.41
3s
2.02
1.00
2.01
2.00
1.00
2.82
f1 (ppm)


140.85
133.49
132.72
128.56
127.70
126.88
126.64
125.54
124.02
12.36
3s
f1 (ppm)


8.27
8.26
8.26
8.25
8.25
8.25
7.59
7.57
7.56
7.55
7.54
7.54
7.53
7.53
7.53
7.52
7.47
7.46
7.26
7.25
7.24
7.24
7.24
7.24
7.22
7.22
6.87
6.87
6.86
6.86
2.37
3t
1.00
5.03
1.03
1.01
0.99
3.00
f1 (ppm)


144.13
140.80
129.69
129.54
129.43
128.40
124.77
123.86
121.16
116.85
112.62
14.38
3t
f1 (ppm)





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2. A. Vidal-Albalat, S. Rodr ́guez and F. V. Gonz ́alez, *Org Lett.*, 2014, **16**, 1752.

3. S. Mitra, A. K. Bagdi, A. Majee and A. Hajra, *Tetrahedron Lett.*, 2013, **54**, 4982.