Supplementary Information

For

Metal-free Intermolecular C-O Cross-Coupling Reactions: Synthesis of *N*-hydroxyimide esters

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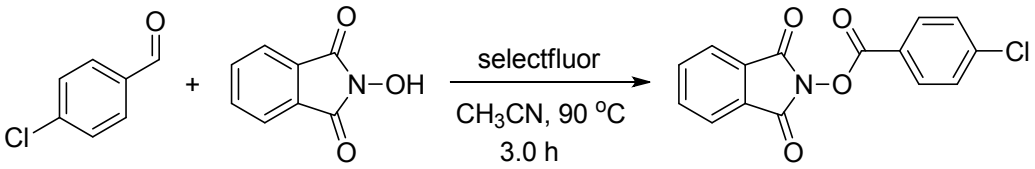
Ⅰ. General Considerations

All reagents were purchased from commercial sources and used without further treatment, unless otherwise indicated. All reactions were run under air with no precautions taken to exclude moisture. ^{1}H NMR and ^{13}C NMR spectra were recorded at 25 ºC on a Varian (400 MHz and 100 MHz). Melting points were obtained with a micro melting point XT4A Beijing Keyi electrooptic apparatus and are uncorrected. High resolution mass spectra were recorded on Bruck microtof. All reactions were monitored by TLC with Taizhou GF254 silica gel coated plates. Flash column chromatography was carried out using 200-300 mesh silica gel at increased pressure.

Ⅱ. General procedure for the preparation of 3

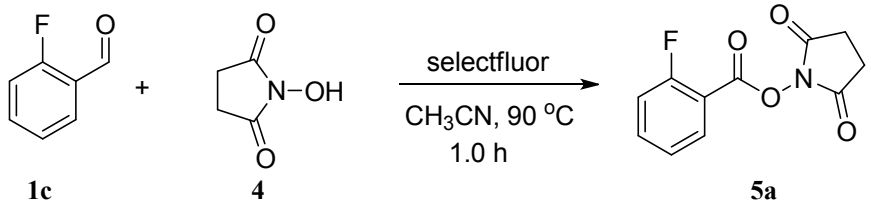
3a as an example



To a solution of the *N*-Hydroxyphthalimide (NHPI) **2** (58.7 mg, 0.36 mmol) in acetonitrile (3.0 ml) was added the 4-chlorobenzaldehyde **1a** (35 μL, 0.3 mmol) and selectfluor (127.5 mg, 0.36 mmol) in a sealed tube. The sealed tube was then tightly sealed with a screw cap and the reaction was stirred for the 3.0 h at 90 ºC. After the reaction finished, the reaction mixture was cooled to room temperature. The mixture was extracted with ethyl acetate (3 × 5.0 mL), the combined organic phases were dried over anhydrous Na_2SO_4 and the solvent was evaporated under vacuum. The residue was purified by column chromatography to give the corresponding products **3a** (82.3 mg, 91%).

Ⅲ. General procedure for the preparation of 5

3a as an example

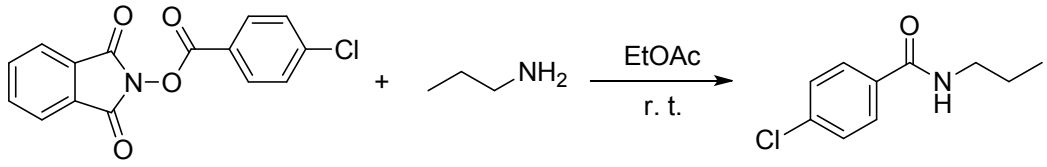


To a solution of the *N*-Hydroxysuccinimide **4** (NHSI, 41.4 mg, 0.36 mmol) in acetonitrile (3.0 ml) was added the 2-fluorobenzaldehyde **1c** (32 μL, 0.3 mmol) and selectfluor (127.5 mg, 0.36 mmol)

in a sealed tube. The sealed tube was then tightly sealed with a screw cap and the reaction was stirred for the 1.0 h at 90 ºC. After the reaction finished, the reaction mixture was cooled to room temperature. The mixture was extracted with ethyl acetate (3 × 5.0 mL), the combined organic phases were dried over anhydrous Na_2SO_4 and the solvent was evaporated under vacuum. The residue was purified by column chromatography to give the corresponding products **5a** (50.5 mg, 71%).

Ⅳ. General procedure for the preparation of 7

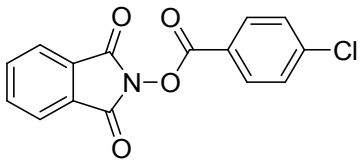
5a as an example



3a **6a** **7a**

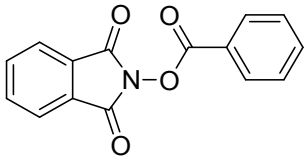
To a solution of **3a** (60.3 mg, 0.2 mmol) in EtOAc (2.0 mL) was added propan-1-amine **6a** (49.2 μL, 0.6 mmol), and the reaction mixture was stirred at room temperature. The progress of the reaction was monitored by TLC using ethyl acetate and petroleum ether as eluent. After completion, the crude mixture was concentrated and purified by column chromatography to afford the desired products **7a** (32.8 mg, 83%).

Ⅴ. Analytical data of Compounds 3, 5 and 7



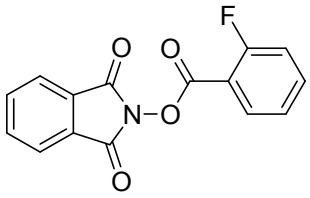
1,3-dioxoisoindolin-2-yl methyl terephthalate 3a[1]

White solid. mp: 182−183 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.52 (d, J = 8.8 Hz, 2H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.13 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 123.7, 124.0, 128.9, 129.3, 131.9, 134.8, 141.6, 161.9, 162.0. HRMS (ESI-TOF) Calcd for $C_{15}H_9ClNO_4$, $[M+H]^+$ *m/z* 302.0220; Found 302.0208.



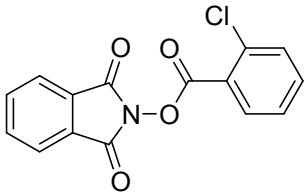
1,3-dioxoisoindolin-2-yl benzoate 3b[1]

White solid. mp: 98−101 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.54 (t, J = 7.6 Hz, 2H), 7.70 (t, J = 7.6 Hz, 2H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 8.19 (d, J = 7.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 124.0, 125.3, 128.8, 129.0, 130.6, 134.8, 134.8, 162.0, 162.8. HRMS (ESI-TOF) Calcd for $C_{15}H_{10}NO_5$, $[M+H]^+$ *m/z* 268.0610; Found 268.0615.



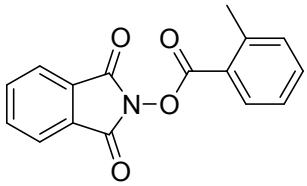
1,3-dioxoisoindolin-2-yl 2-fluorobenzoate 3c[2]

White solid. mp: 173−175 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.22-7.34 (m, 2H), 7.67-7.69 (m, 1H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.12-8.15 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 113.9, 114.0, 117.3, 117.5, 124.0, 124.4, 124.5, 129.0, 132.7, 134.8, 136.7, 136.8, 160.2, 160.3, 161.2, 161.8, 163.8. HRMS (ESI-TOF) Calcd for $C_{15}H_9FNO_4$, $[M+H]^+$ *m/z* 286.0516; Found 286.0531.



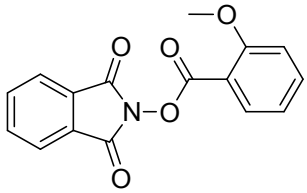
1,3-dioxoisoindolin-2-yl 2-chlorobenzoate 3d[1]

White solid. mp: 134−135 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.41-7.45 (m, 1H), 7.57 (d, J = 5.6Hz, 2H), 7.81-7.83 (m, 2H), 7.93 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.18 (d, J = 8.0Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 124.0, 124.8, 126.9, 129.0, 131.6, 132.4, 134.6, 134.8, 135.6, 161.2, 161.9. HRMS (ESI-TOF) Calcd for $C_{15}H_9ClNO_4$, $[M+H]^+$ *m/z* 302.0220; Found 302.0224.



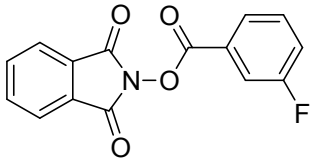
1,3-dioxoisoindolin-2-yl 2-methylbenzoate 3e

White solid. mp: 139−140 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.64 (s, 3H), 7.33-7.37 (m, 2H), 7.52-7.56 (m, 1H), 7.80-7.82 (m, 2H), 7.93 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.19-8.21 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.6, 124.0, 124.4, 126.1, 129.1, 131.4, 132.0, 133.9, 134.7, 142.1, 162.2, 163.1. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_4$, $[M+H]^+$ *m/z* 282.0766; Found 282.0761.



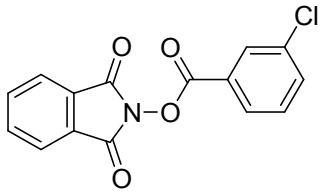
1,3-dioxoisoindolin-2-yl 2-methoxybenzoate 3f

White solid. mp: 159−160 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 3.93 (s, 3H), 7.03-7.07 (m, 2H), 7.59-7.63 (m, 1H), 7.79 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.91 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.11 (dd, J_1 = 1.6 Hz, J_2 = 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 56.1, 112.2, 114.2, 120.3, 123.9, 129.1, 132.7, 134.6, 135.9, 160.6, 161.3, 162.3. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_5$, $[M+H]^+$ *m/z* 298.0715; Found 298.0726.



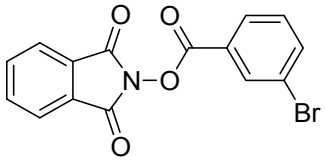
1,3-dioxoisoindolin-2-yl 3-fluorobenzoate 3g[2]

White solid. mp: 162−163 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.37-7.43 (m, 1H), 7.50-7.56 (m, 1H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.86 (d, J = 8.0 Hz, 1H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.99 (d, J = 7.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 117.3, 117.6, 122.0, 122.2, 124.0,126.4, 126.4, 127.2, 127.3, 128.9, 130.6, 130.7, 134.8, 161.2, 161.8, 163.7. HRMS (ESI-TOF) Calcd for $C_{15}H_9FNO_4$, $[M+H]^+$ *m/z* 286.0516; Found 286.0531.



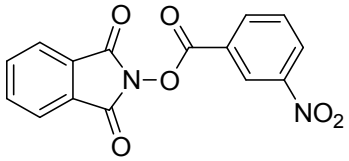
1,3-dioxoisoindolin-2-yl 3-chlorobenzoate 3h[1]

White solid. mp: 176−178 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.49 (t, J =8.0 Hz 1H), 7.67 (d, J = 8.0 Hz, 1H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 8.07 (d, J = 8.0 Hz, 1H) 8.15 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 124.0, 126.9, 128.7, 128.8, 130.2, 130.5, 134.9, 134.9, 135.1, 161.7, 161.8. HRMS (ESI-TOF) Calcd for $C_{15}H_9ClNO_4$, $[M+H]^+$ *m/z* 302.0220.; Found 302.0204.



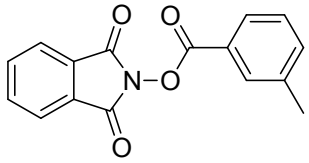
1,3-dioxoisoindolin-2-yl 3-bromobenzoate 3i[2]

White solid. mp: 209−210 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.42 (t, J =8.0 Hz 1H), 7.80-7.82 (m, 3H), 7.90-7.92 (m, 2H), 8.11 (d, J = 7.6 Hz, 1H), 8.30 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 122.8, 124.0, 127.1, 128.8, 129.1, 130.4, 133.3, 134.8, 137.8, 161.6, 161.8. HRMS (ESI-TOF) Calcd for $C_{15}H_9BrNO_4$, $[M+H]^+$ *m/z* 345.9715.; Found 345.9731.



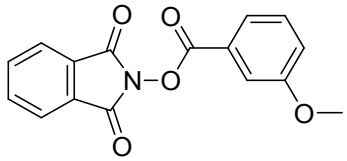
1,3-dioxoisoindolin-2-yl 3-nitrobenzoate 3j

White solid. mp: 214−215 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.79 (t, J =8.0 Hz 1H), 7.85 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.96 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 8.51-8.53 (m, 1H), 8.56-8.58 (m, 1H), 9.04-9.05 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 124.2, 125.6, 127.2, 128.9, 129.2, 130.3, 135.0, 136.0, 148.5, 161.1, 161.6. HRMS (ESI-TOF) Calcd for $C_{15}H_9N_2O_6$, $[M+H]^+$ *m/z* 313.0461.; Found 313.0444.



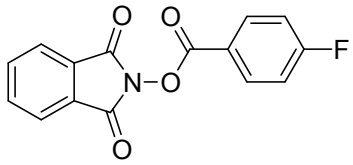
1,3-dioxoisoindolin-2-yl 3-methylbenzoate 3k

White solid. mp: 141−142 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.44 (s, 3H), 7.42 (t, J = 7.6 Hz, 1H), 7.50 (d, J = 7.6 Hz, 1H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.00 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.2, 124.0, 125.2, 127.8, 128.7, 129.1, 131.0, 134.7, 135.6, 138.8, 162.1, 162.9. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_4$, $[M+H]^+$ *m/z* 282.0766; Found 282.0771.



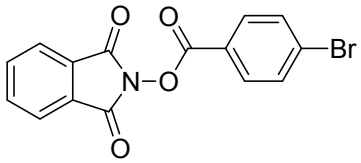
1,3-dioxoisoindolin-2-yl 3-methoxybenzoate 3l

White solid. mp: 132−134 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 3.87 (s, 3H), 7.21-7.24 (m, 1H), 7.43 (t, J = 8.0 Hz 1H),7.65-7.66 (m, 1H), 7.78-7.82 (m, 3H), 7.90-7.92 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 55.5, 114.7, 121.6, 123.0, 124.0, 126.3, 129.0, 129.9, 134.8, 159.7, 162.0, 162.7. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_5$, $[M+H]^+$ *m/z* 298.0715; Found 298.0721.



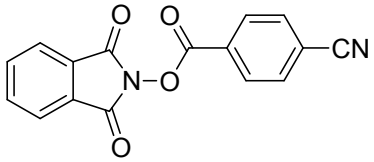
1,3-dioxoisoindolin-2-yl 4-fluorobenzoate 3m[2]

White solid. mp: 194−195 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.19-7.25 (m, 2H), 7.79-7.82 (m, 2H), 7.90-7.93 (m, 2H), 8.20-8.24 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 116.2, 116.4, 121.5, 124.0, 129.0, 133.4, 133.5, 134.8, 161.8, 162.0, 165.6, 168.1. HRMS (ESI-TOF) Calcd for $C_{15}H_9FNO_4$, $[M+H]^+$ *m/z* 286.0516; Found 286.0513.



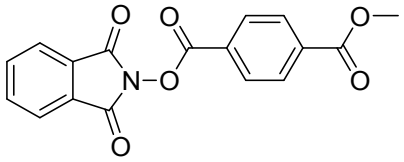
1,3-dioxoisoindolin-2-yl 4-bromobenzoate 3n[2]

White solid. mp: 190−192 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.68 (dd, J_1 = 1.6 Hz, J_2 = 6.8 Hz, 2H), 7.80-7.82 (m, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.04 (dd, J_1 = 2.0 Hz, J_2 = 6.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 124.0, 124.1, 128.9, 130.4, 131.9, 132.3, 134.8, 161.9, 162.0. HRMS (ESI-TOF) Calcd for $C_{15}H_9BrNO_4$, $[M+H]^+$ *m/z* 345.9715; Found 345.9725.



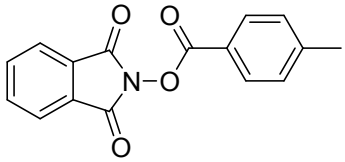
1,3-dioxoisoindolin-2-yl 4-cyanobenzoate 3o

White solid. mp: 219−221 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 7.82-7.86 (m, 4H), 7.94 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 8.30 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 117.4, 118.2, 124.2, 128.8, 129.2, 131.0, 132.6, 135.0, 161.5, 161.6. HRMS (ESI-TOF) Calcd for $C_{16}H_9N_2O_4$, $[M+H]^+$ *m/z* 293.0562; Found 293.0552.



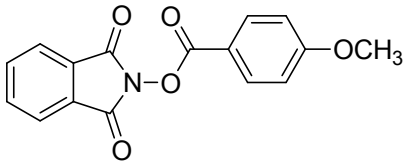
1,3-dioxoisoindolin-2-yl methyl terephthalate 3p

White solid. mp: 177−178 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 3.95 (s, 3H), 7.80 (d, J = 2.8 Hz, 2H), 7.89 (d, J = 2.8 Hz, 2H), 8.16 (d, J = 8.4 Hz, 2H), 8.23 (d, J = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 52.5, 124.0, 128.8, 128.9, 129.8, 130.5, 134.8, 135.5, 161.7, 162.1, 165.7. HRMS (ESI-TOF) Calcd for $C_{17}H_{12}NO_6$, $[M+H]^+$ *m/z* 326.0665; Found 326.0657.



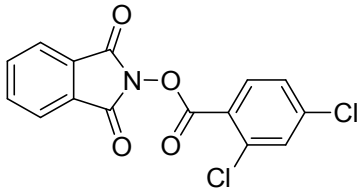
1,3-dioxoisoindolin-2-yl 4-methylbenzoate 3q[1]

White solid. mp: 167−168 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.47 (s, 3H), 7.33 (d, J = 8.0 Hz, 2H), 7.81 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 7.92-7.94 (m, 2H), 8.08 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.9, 122.5, 124.0, 129.1, 129.6, 130.7, 134.7, 146.0, 162.1, 162.8. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_4$, $[M+H]^+$ *m/z* 282.0766; Found 282.0772.



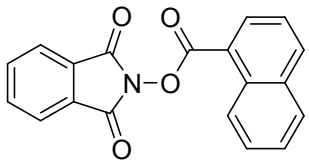
1,3-dioxoisoindolin-2-yl 4-methoxybenzoate 3r[1]

White solid. mp: 165−166 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 3.89 (s, 3H), 6.99 (d, J = 8.8 Hz, 2H), 7.79-7.81 (m, 2H), 7.90-7.91 (m, 2H), 8.14 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 55.6, 114.2, 117.2, 123.9, 129.0, 132.9, 134.7, 162.2, 162.4, 164.9. HRMS (ESI-TOF) Calcd for $C_{16}H_{12}NO_5$, $[M+H]^+$ *m/z* 298.0715; Found 298.0721.



1,3-dioxoisoindolin-2-yl 2,4-dichlorobenzoate 3s

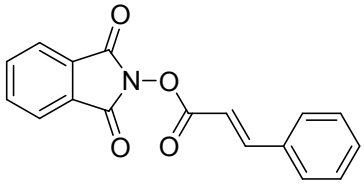
White solid. mp: 180−182 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ =7.42 (d, J = 8.4 Hz, 1H), 7.58 (s, 1H), 7.82 (d, J = 3.2 Hz, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 4.8 Hz, 2H), 8.13 (d, J = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 123.1, 124.1, 127.4, 128.9, 131.7, 133.4, 134.9, 136.8, 140.8, 160.4, 161.8. HRMS (ESI-TOF) Calcd for $C_{15}H_8Cl_2NO_4$, $[M+H]^+$ *m/z* 335.9830; Found 335.9835.



1,3-dioxoisoindolin-2-yl 1-naphthoate 3t[1]

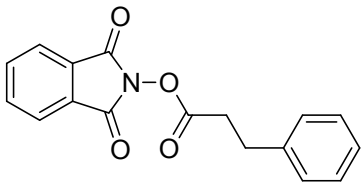
White solid. mp: 180−182 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ =7.57-7.62 (m, 2H), 7.64-7.69 (m,

1H), 7.81-7.83 (m, 2H), 7.92-7.96 (m, 3H), 8.16 (d, J = 8.0 Hz, 1H), 8.54 (dd, J_1 = 1.2 Hz, J_2 = 7.2 Hz, 1H),8.85 (d, J = 8.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 121.7, 124.0, 124.5, 125.3, 126.8, 128.7, 128.9, 129.1, 131.5, 131.9, 133.7, 134.8, 135.5 162.3 163.1. HRMS (ESI-TOF) Calcd for $C_{19}H_{12}NO_4$, $[M+H]^+$ *m/z* 318.0766; Found 318.0760.



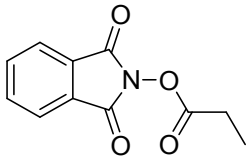
1,3-dioxoisoindolin-2-yl cinnamate 3u[2]

White solid. mp: 56−57 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 6.67 (d, J = 16.0Hz, 1H), 7.43-7.47 (m, 3H), 7.59-7.61 (m, 2H), 7.80-7.82 (m, 2H), 7.92 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H), 7.97(d, J = 16.0Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 111.8, 124.0, 128.7, 129.1, 129.1, 131.5, 133.6, 134.7, 150.0, 162.1, 163.0. HRMS (ESI-TOF) Calcd for $C_{17}H_{12}NO_4$, $[M+H]^+$ *m/z* 294.0766; Found 294.0754.



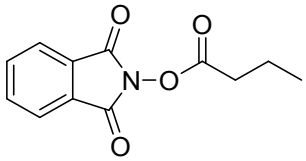
1,3-dioxoisoindolin-2-yl 3-phenylpropanoate 3v

White solid. mp: 66−67 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ =3.00-3.02 (m, 2H), 3.10-3.14 (m, 2H), 7.27-7.37 (m, 5H), 7.79-7.81 (m, 2H), 7.90 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 30.5, 32.7, 123.9, 126.7, 128.3, 128.7, 128.9, 134.7, 139.1, 161.8, 168.8. HRMS (ESI-TOF) Calcd for $C_{17}H_{14}NO_4$, $[M+H]^+$ *m/z* 296.0923; Found 296.0917.



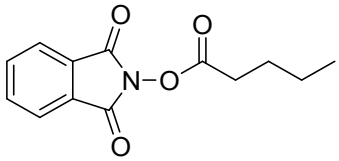
1,3-dioxoisoindolin-2-yl propionate 3w

White solid. mp: 86−88 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 1.31 (t, J = 7.6Hz, 3H), 2.71 (q, J = 7.6Hz, 2H), 7.79 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.89 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 8.7, 24.5, 123.9, 129.0, 134.7, 162.0, 170.3. HRMS (ESI-TOF) Calcd for $C_{11}H_{10}NO_4$, $[M+H]^+$ *m/z* 220.0610; Found 220.0608.



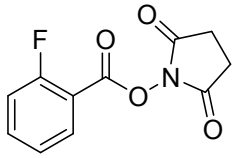
1,3-dioxoisoindolin-2-yl butyrate 3x

Colorless oil ^{1}H NMR (400 MHz; $CDCl_3$): δ = 1.08 (t, J = 7.2Hz, 3H), 1.78-1.88 (m, 2H), 2.65 (t, J = 7.2Hz, 2H), 7.79 (dd, J_1 = 3.2 Hz, J_2 = 5.6 Hz, 2H), 7.89 (dd, J_1 = 3.2 Hz, J_2 = 5.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.4, 18.3, 32.8, 123.9, 129.0, 134.7, 162.0, 169.5. HRMS (ESI-TOF) Calcd for $C_{12}H_{12}NO_4$, $[M+H]^+$ *m/z* 234.0766; Found 234.0761.



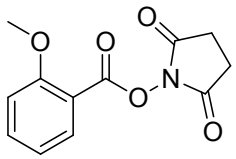
1,3-dioxoisoindolin-2-yl pentanoate 3y

White solid. mp: 55−56 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 0.97 (t, J = 7.2Hz, 3H), 1.45-1.50 (m, 2H), 1.73-1.81 (m, 2H), 2.67 (t, J = 7.2Hz, 2H), 7.77-7.92 (m, 2H), 7.87-7.89 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.6, 22.0, 26.7, 30.7, 123.9, 129.0, 134.7, 162.0, 169.6. HRMS (ESI-TOF) Calcd for $C_{13}H_{14}NO_4$, $[M+H]^+$ *m/z* 248.0923; Found 248.0919.



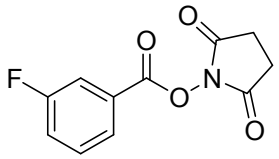
2,5-dioxopyrrolidin-1-yl 2-fluorobenzoate 5a

White solid. mp: 113−114 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.90 (s, 4H), 7.19-7.30 (m, 2H), 7.65-7.67 (m, 1H), 8.04-8.08 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.6, 113.6, 113.7, 117.2, 117.4, 124.4, 124.4, 132.5, 136.7, 136.8, 159.2, 159.3, 161.1, 163.7, 169.1. HRMS (ESI-TOF) Calcd for $C_{11}H_9FNO_4$, $[M+H]^+$ *m/z* 238.0516; Found 238.0508.



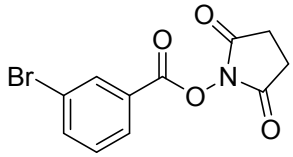
2,5-dioxopyrrolidin-1-yl 2-methoxybenzoate 5b

White solid. mp: 177−178 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.88 (s, 4H), 3.92 (s, 3H), 7.01-7.04 (m, 2H), 7.57-7.61 (m, 1H), 8.03-8.05 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.7, 56.1, 112.2, 114.1, 120.3, 132.7, 135.9, 160.3, 160.6, 169.4. HRMS (ESI-TOF) Calcd for $C_{12}H_{12}NO_5$, $[M+H]^+$ *m/z* 250.0715; Found 250.0721.



2,5-dioxopyrrolidin-1-yl 3-fluorobenzoate 5c

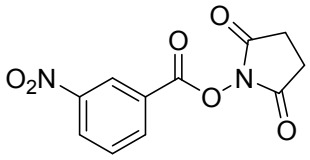
White solid. mp: 147−148 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.91 (s, 4H), 7.37-7.41 (m, 1H), 7.48-7.54 (m, 1H), 7.81-7.83 (m, 1H), 7.94 (d, J = 7.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.7, 117.3, 117.6, 122.0, 122.2, 126.4, 126.4, 127.1, 127.2, 130.6, 130.7, 160.9, 160.9, 161.3, 163.7, 169.0. HRMS (ESI-TOF) Calcd for $C_{11}H_9FNO_4$, $[M+H]^+$ *m/z* 238.0516; Found 238.0510.



2,5-dioxopyrrolidin-1-yl 3-bromobenzoate 5d[2]

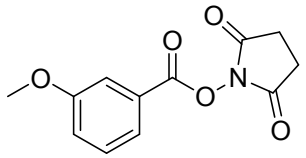
White solid. mp: 152−153 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.91 (s, 4H), 7.38-7.42 (m, 1H), 7.80-7.82 (m, 1H), 8.07 (d, J = 8.0 Hz, 1H), 8.27 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.7, 122.9, 127.1, 129.1, 130.4, 133.4, 137.9, 160.7, 168.9. HRMS (ESI-TOF) Calcd for $C_{11}H_9BrNO_4$,

[M+H]$^+$ *m/z* 297.9715; Found 297.9711.



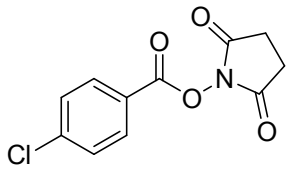
2,5-dioxopyrrolidin-1-yl 3-nitrobenzoate 5e

White solid. mp: 137−138 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.96 (s, 4H), 7.76-7.80 (m, 1H), 8.47 (d, J = 7.6 Hz, 1H), 8.56 (d, J = 8.0 Hz, 1H), 8.99 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.7, 125.5, 127.1, 129.2, 130.3, 135.9, 148.4, 160.1, 168.7. HRMS (ESI-TOF) Calcd for $C_{11}H_9N_2O_6$, [M+H]$^+$ *m/z* 265.0461; Found 265.0455.



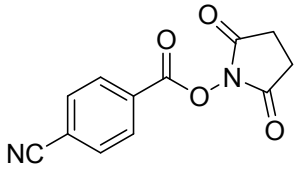
2,5-dioxopyrrolidin-1-yl 3-methoxybenzoate 5f

White solid. mp: 106−107 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.89 (s, 4H), 3.85 (s, 3H), 7.19-7.22 (m, 1H), 7.41 (t, J = 8.0 Hz, 1H), 7.60 (s, 1H), 7.73 (d, J = 7.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.6, 55.5, 114.6, 121.6, 123.0, 126.2, 129.9, 159.7, 161.8, 169.2. HRMS (ESI-TOF) Calcd for $C_{12}H_{12}NO_5$, [M+H]$^+$ *m/z* 250.0715; Found 250.0711.



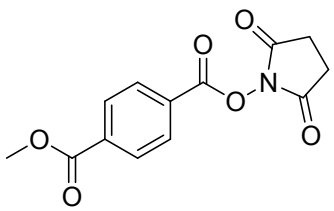
2,5-dioxopyrrolidin-1-yl 4-chlorobenzoate 5g

White solid. mp: 207−208 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.90 (s, 4H), 7.49 (d, J = 8.4 Hz, 2H), 8.06 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.6, 123.6, 129.3, 131.9, 141.7, 161.1, 169.1. HRMS (ESI-TOF) Calcd for $C_{11}H_9ClNO_4$, [M+H]$^+$ *m/z* 254.0220; Found 254.0225.



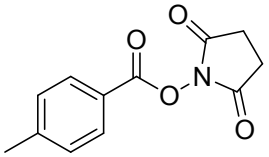
2,5-dioxopyrrolidin-1-yl 4-cyanobenzoate 5h

White solid. mp: 223−224 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.92 (s, 4H), 7.82 (d, J = 8.0 Hz, 2H), 8.23 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.6, 117.3, 118.3, 129.1, 131.0, 132.6, 160.5, 168.7. HRMS (ESI-TOF) Calcd for $C_{12}H_9N_2O_4$, [M+H]$^+$ *m/z* 245.0562; Found 245.0565.



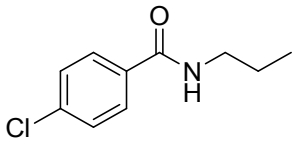
2,5-dioxopyrrolidin-1-yl methyl terephthalate 5i

White solid. mp: 170−171 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.92 (s, 4H), 3.97 (s, 3H), 8.16-8.22 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 25.7, 52.6, 128.9, 129.9, 130.5, 135.7, 161.2, 165.8, 168.9. HRMS (ESI-TOF) Calcd for $C_{13}H_{12}NO_6$, $[M+H]^+$ *m/z* 278.0665; Found 278.0661.



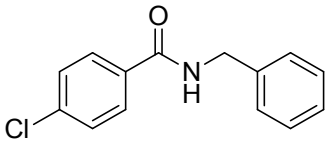
2,5-dioxopyrrolidin-1-yl 4-methylbenzoate 5j[2]

White solid. mp: 180−181 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.42 (s, 3H), 2.87 (s, 4H), 7.29 (d, *J* = 8.0 Hz, 2H), 8.00 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.8, 25.6, 122.2, 129.5, 130.5, 146.0, 161.8, 169.3. HRMS (ESI-TOF) Calcd for $C_{12}H_{12}NO_4$, $[M+H]^+$ *m/z* 234.0766; Found 234.0770.



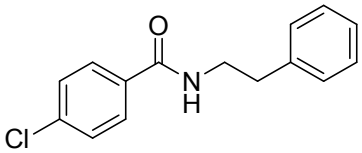
4-chloro-*N*-propylbenzamide 7a

White solid. mp: 98−101 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 0.96 (t, *J* = 7.2 Hz, 3H), 1.57-1.66 (m, 2H), 3.38 (q, *J* = 6.8 Hz, 2H), 6.38 (s, 1H), 7.36 (d, *J* = 8.4 Hz, 2H), 7.69 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.4, 22.8, 41.8, 128.3, 128.7, 133.2, 137.4, 166.5. HRMS (ESI-TOF) Calcd for $C_{10}H_{13}ClNO$, $[M+H]^+$ *m/z* 198.0686; Found 198.0682.



***N*-benzyl-4-chlorobenzamide 7b[2]**

White solid. mp: 161−164 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 4.60 (d, *J* = 5.6 Hz, 2H), 6.58 (s, 1H), 7.29-7.38 (m, 7H), 7.71 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 44.2, 127.7, 127.9, 128.4, 128.8, 132.7, 137.7, 137.9, 166.3. HRMS (ESI-TOF) Calcd for $C_{14}H_{13}ClNO$, $[M+H]^+$ *m/z* 246.0686; Found 246.0684.



4-chloro-*N*-phenethylbenzamide 7c[2]

White solid. mp: 129−130 ºC ^{1}H NMR (400 MHz; $CDCl_3$): δ = 2.92 (t, *J* = 6.8 Hz, 2H), 3.67-3.71 (m, 2H), 6.31 (s, 1H), 7.20-7.24 (m, 3H), 7.30-7.37 (m, 4H), 7.62 (d, *J* = 8.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 35.6, 41.2, 126.6, 128.2, 128.7, 128.7, 133.0, 137.6, 138.7, 166.4. HRMS (ESI-TOF) Calcd for $C_{15}H_{15}ClNO$, $[M+H]^+$ *m/z* 260.0842; Found 260.0839.

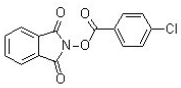
References

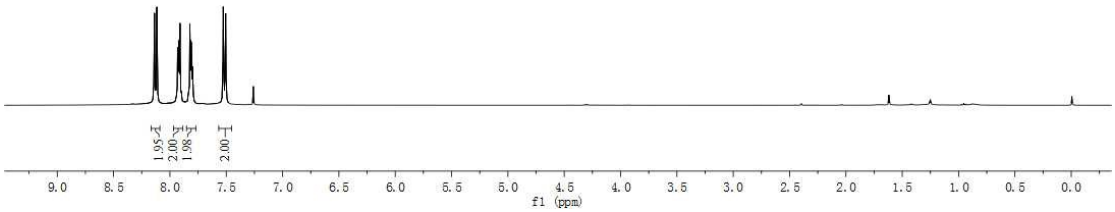
[1] B. Tan, N. Toda and C. F. Barbaras III, *Angew. Chem., Int. Ed.*, 2012, **51**, 12538.

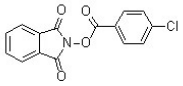
[2] M. Dinda, C. Bose, T. Ghosh and S. Maity, *RSC Adv.*, 2015, **5**, 44928.

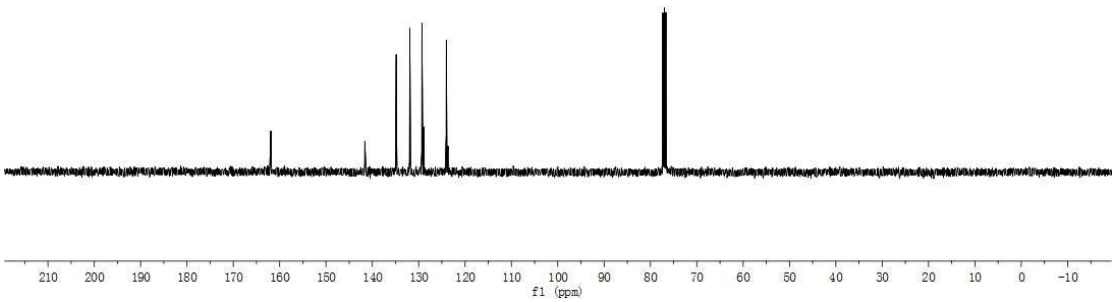
Ⅵ. ^{1}H and ^{13}C Spectra of Compounds 3, 5 and 7

Product 3a

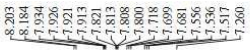


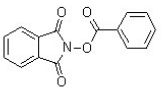


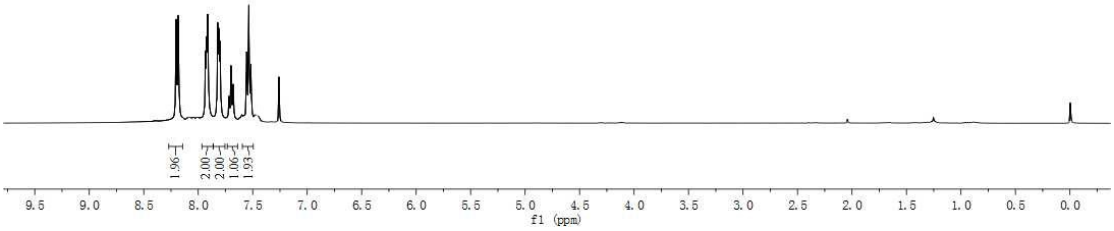




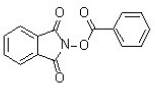
Product 3b

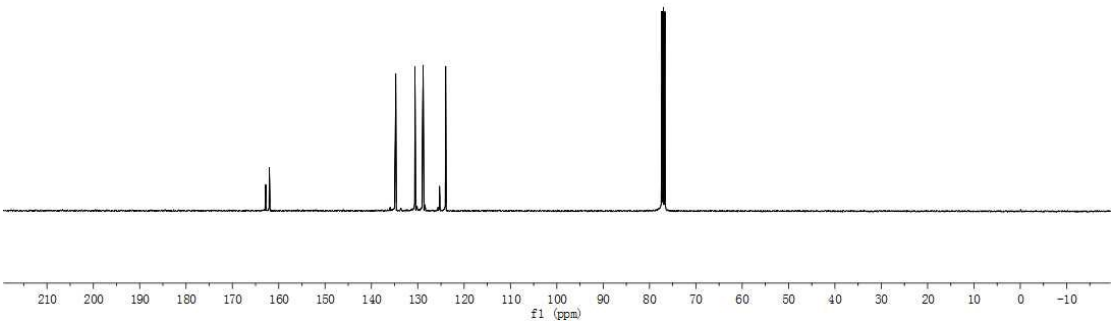

8.203
8.184
7.934
7.926
7.921
7.913
7.821
7.813
7.808
7.800
7.718
7.699
7.681
7.556
7.536
7.517
7.260




1.96
2.00
2.00
1.06
1.93
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)

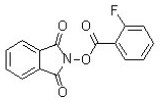

162.79
162.03
134.84
134.76
130.61
129.02
128.84
125.31
123.99
77.32
77.00
76.68

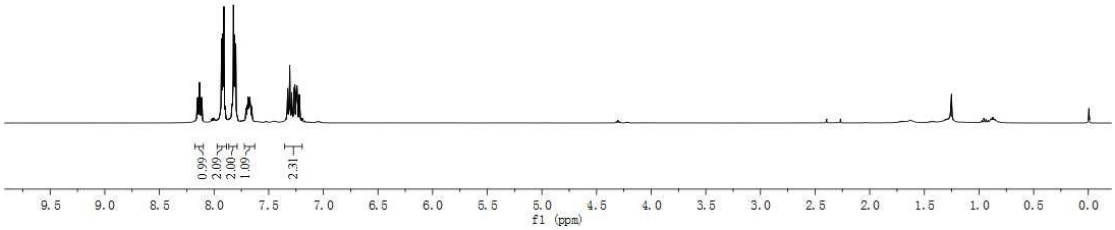


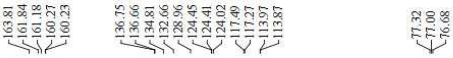

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

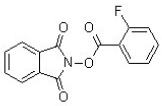
Product 3c

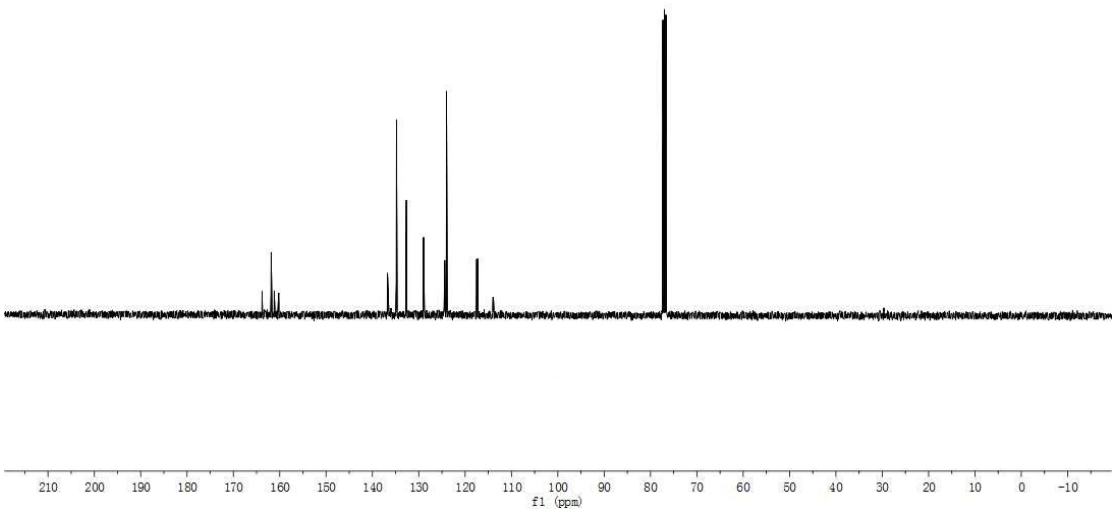

8.153
8.148
8.133
8.116
7.932
7.924
7.918
7.910
7.823
7.815
7.809
7.801
7.690
7.687
7.685
7.675
7.673
7.328
7.326
7.308
7.307
7.290
7.288
7.267
7.266
7.260
7.246
7.244
7.242
7.220


F
O
O
N
O
O


0.99
2.09
2.00
1.09
2.31
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)

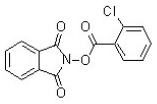

163.81
161.84
161.18
160.27
160.23
136.75
136.66
134.81
132.66
128.96
124.45
124.41
124.02
117.49
117.27
113.97
113.87
77.32
77.00
76.68

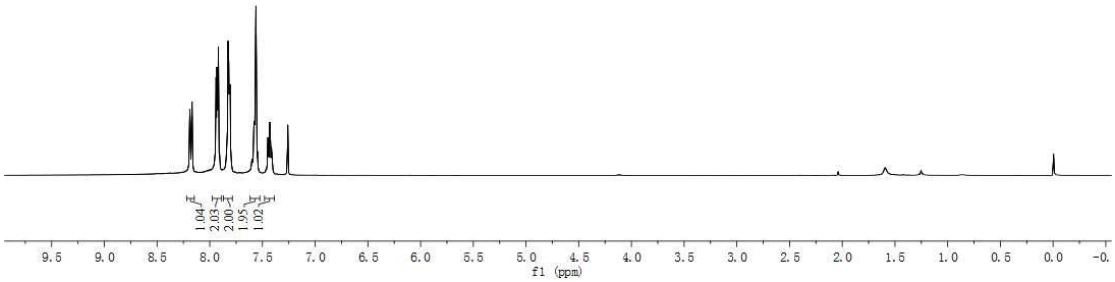

F
O
O
N
O
O


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)

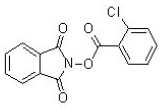
Product 3d

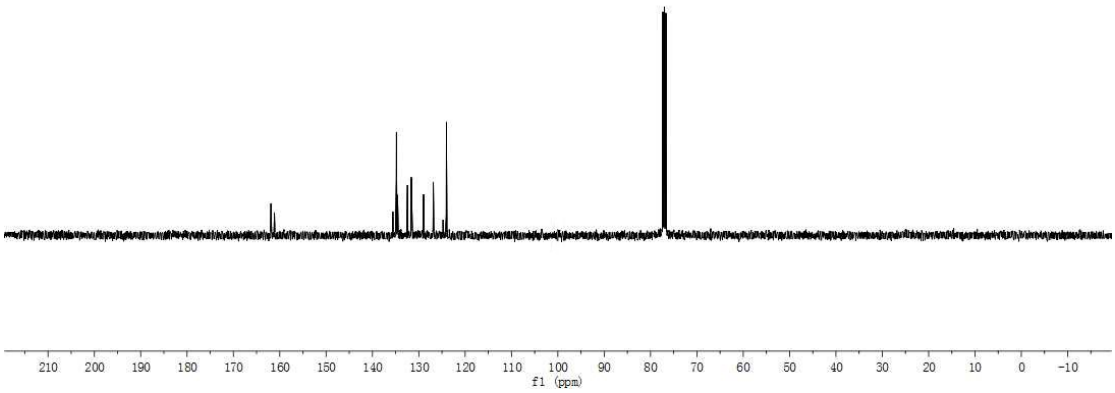

8.188
8.168
7.940
7.932
7.926
7.918
7.827
7.820
7.814
7.806
7.576
7.562
7.450
7.444
7.430
7.424
7.416
7.409
7.260


Cl
O
O
N
O
O


1.04
2.03
2.00
1.95
1.02
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)


161.89
161.15
135.61
134.82
134.58
132.43
131.62
128.99
126.86
124.75
124.04
77.32
77.00
76.68

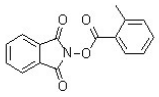

Cl
O
O
N
O
O

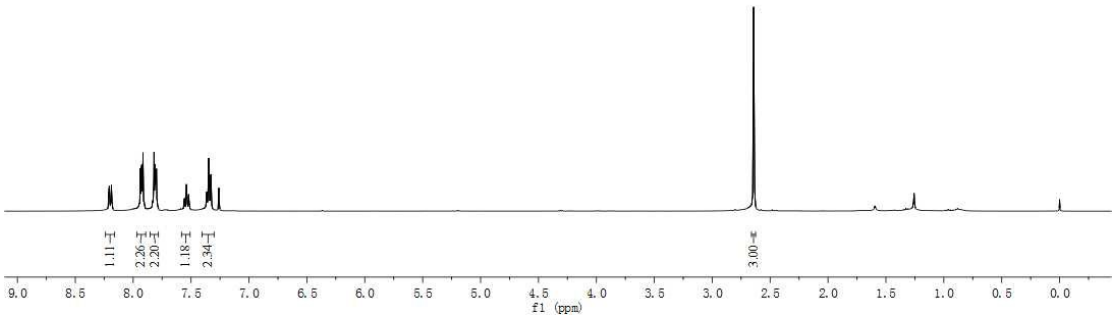

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

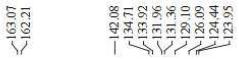
Product 3e

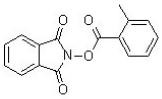

8.209
8.206
8.188
8.186
7.937
7.929
7.923
7.915
7.820
7.812
7.806
7.799
7.559
7.556
7.540
7.521
7.518
7.365
7.348
7.329
7.260

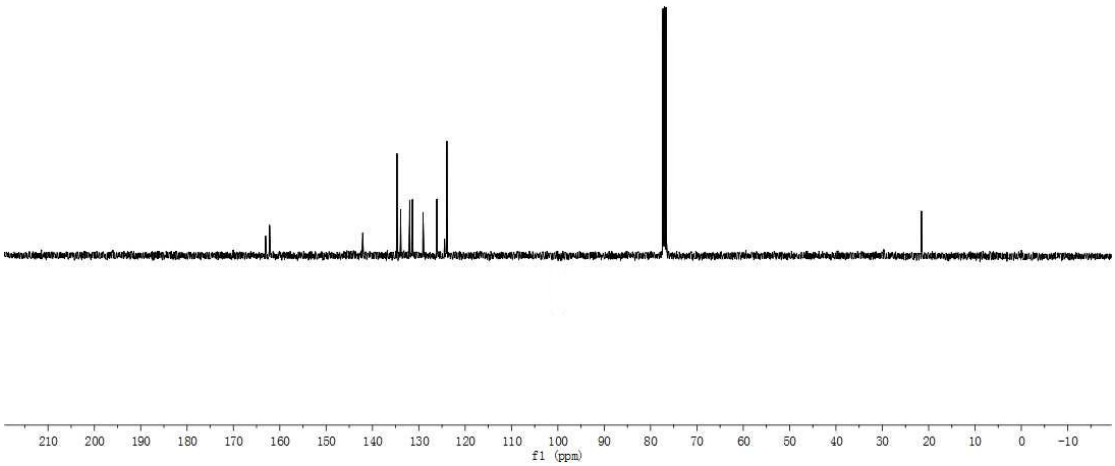
2.642



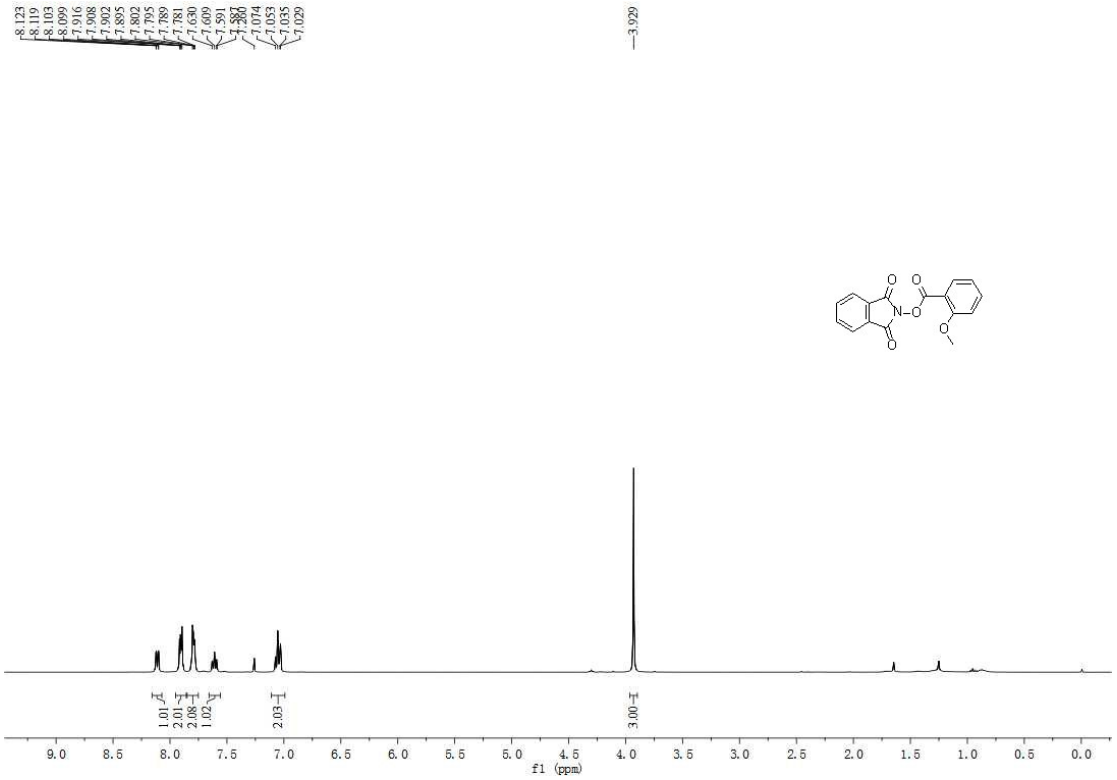

1.11
2.26
2.20
1.18
2.34
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

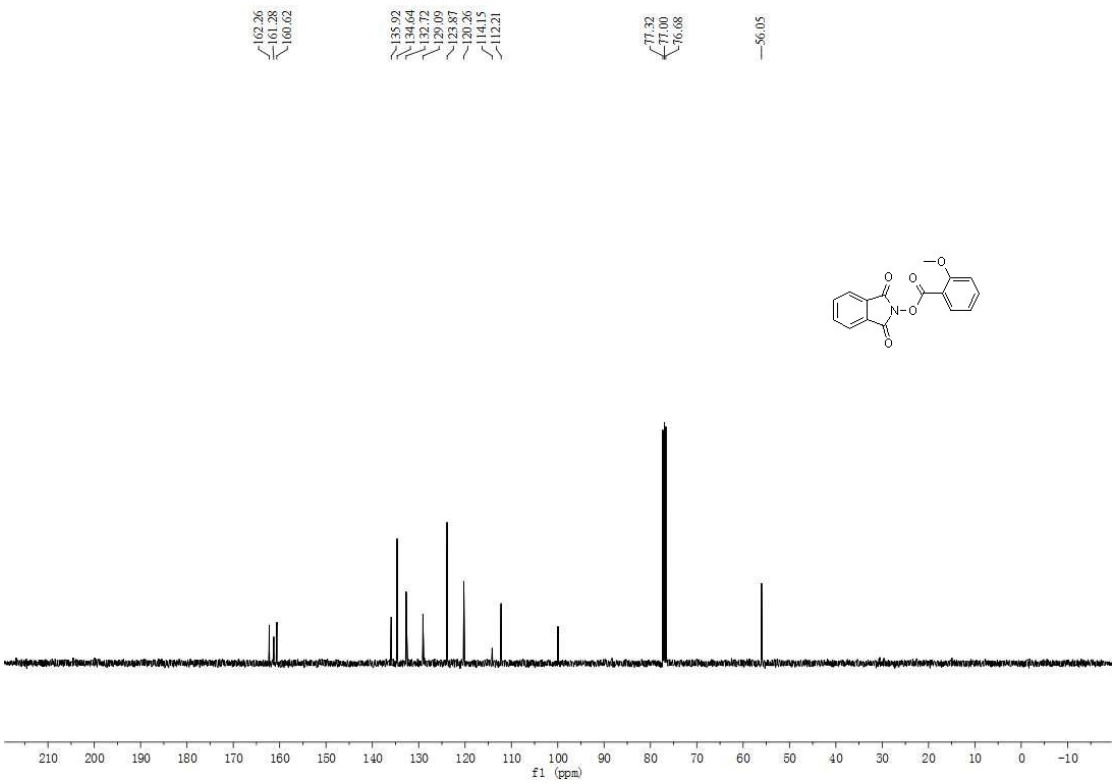

163.07
162.21
142.08
134.71
133.92
131.96
131.36
129.10
126.09
124.44
123.95
77.32
77.00
76.68
21.57




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)

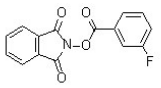
Product 3f

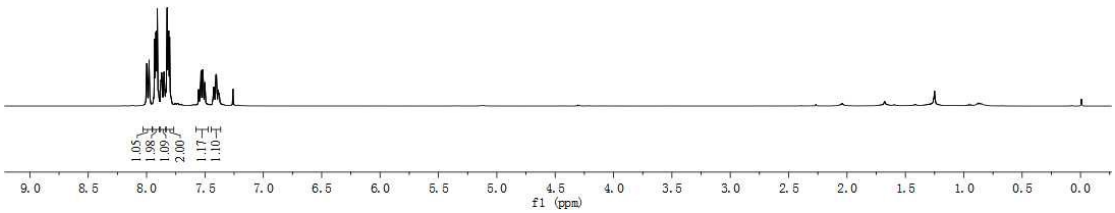

8.123
8.119
8.103
8.099
7.916
7.908
7.902
7.895
7.802
7.795
7.789
7.781
7.630
7.609
7.591
7.387
7.380
7.074
7.053
7.035
7.029
3.929
1.01
2.01
2.08
1.02
2.03
3.00
f1 (ppm)


162.26
161.28
160.62
135.92
134.64
132.72
129.09
123.87
120.26
114.15
112.21
77.32
77.00
76.68
56.05
f1 (ppm)

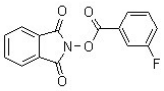
Product 3g

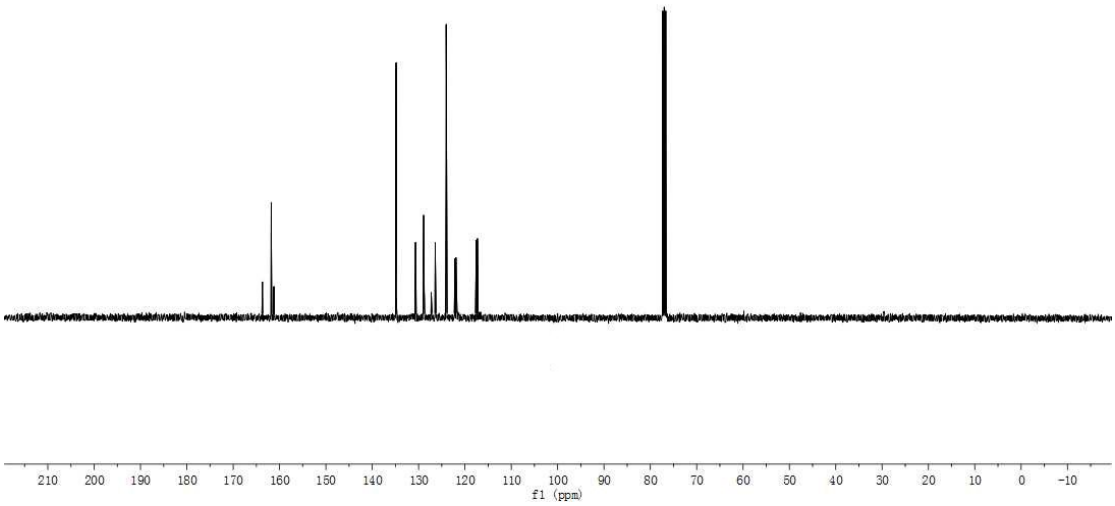

7.998
7.979
7.929
7.922
7.916
7.908
7.871
7.851
7.824
7.816
7.810
7.803
7.555
7.541
7.534
7.521
7.514
7.501
7.428
7.427
7.422
7.408
7.406
7.401
7.387
7.385
7.381
7.368
7.260




1.05
1.98
1.09
2.00
1.17
1.10
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)

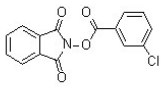

163.70
161.80
161.23
134.84
130.70
130.62
128.89
127.28
127.20
126.42
126.39
124.04
122.17
121.95
117.56
117.32
77.32
77.00
76.68

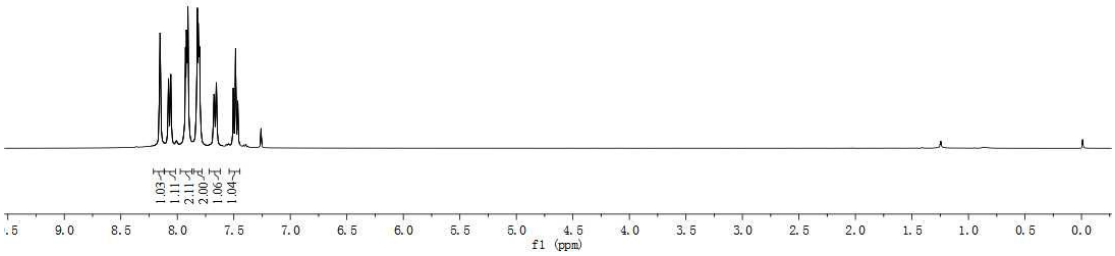



210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

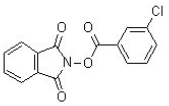
Product 3h

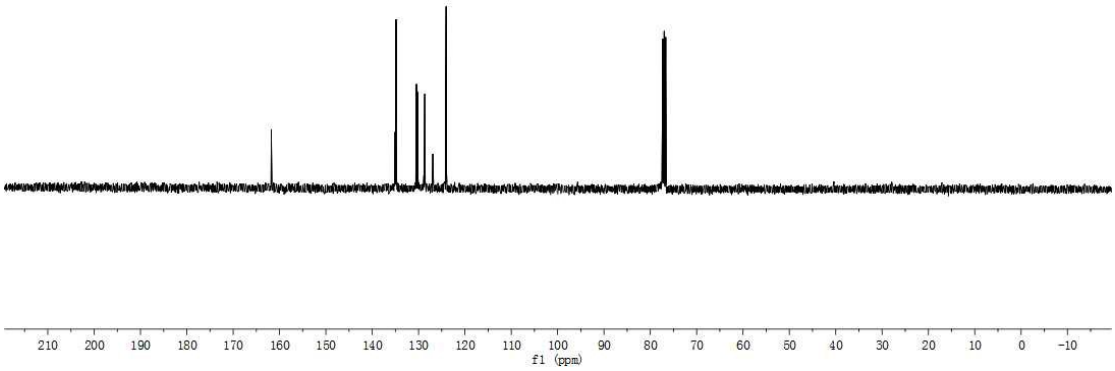

8.152
8.078
8.058
7.927
7.919
7.914
7.906
7.823
7.815
7.810
7.802
7.675
7.655
7.505
7.485
7.465
7.260


O
O
N
O
O
Cl

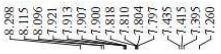

1.03
1.11
2.11
2.00
1.06
1.04
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

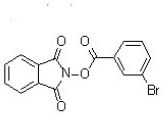

161.77
161.72
135.05
134.89
134.85
130.45
130.19
128.83
128.65
126.91
124.04
77.32
77.00
76.68

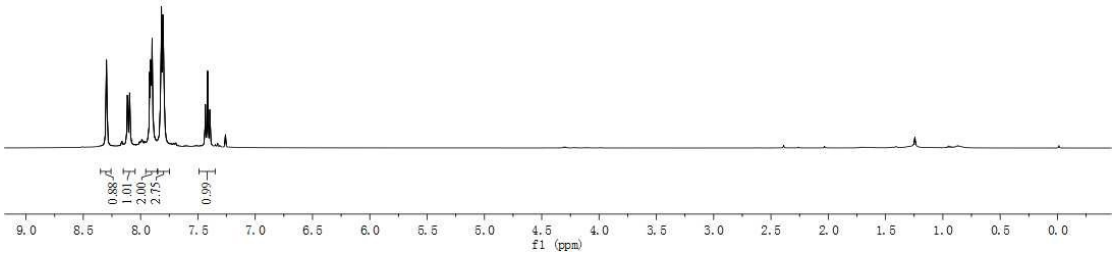

Cl
O
O
N
O
O


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)

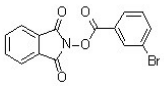
Product 3i

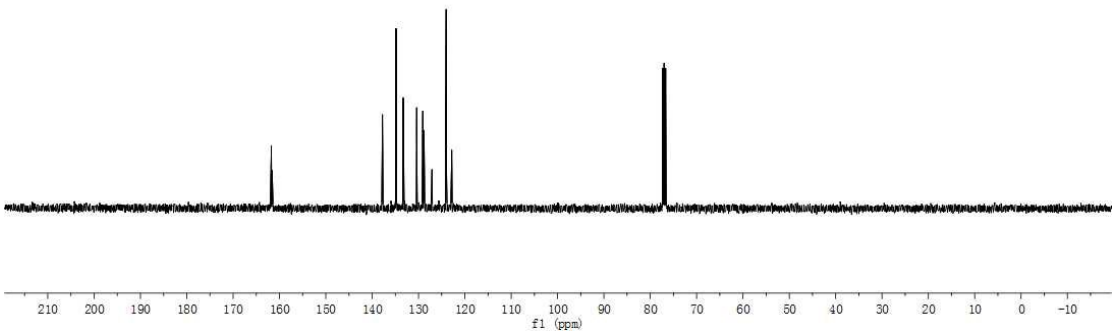

8.298
8.115
8.096
7.921
7.913
7.907
7.900
7.818
7.810
7.804
7.797
7.435
7.415
7.395
7.260


O
O
N
O
Br
O

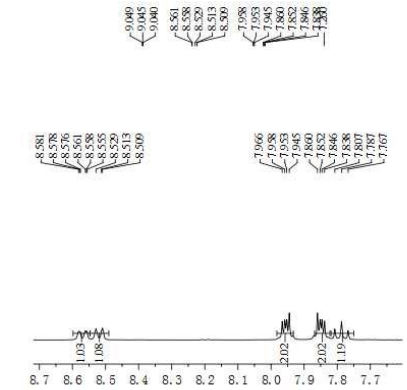

0.88
1.01
2.00
2.75
0.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

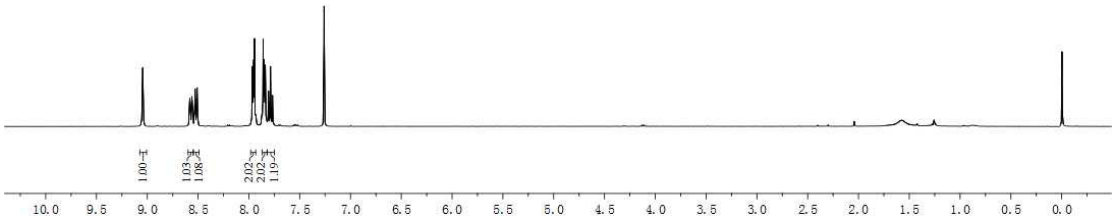

161.75
161.57
137.78
134.84
133.31
130.39
129.07
128.81
127.09
124.02
122.83
77.32
77.00
76.68

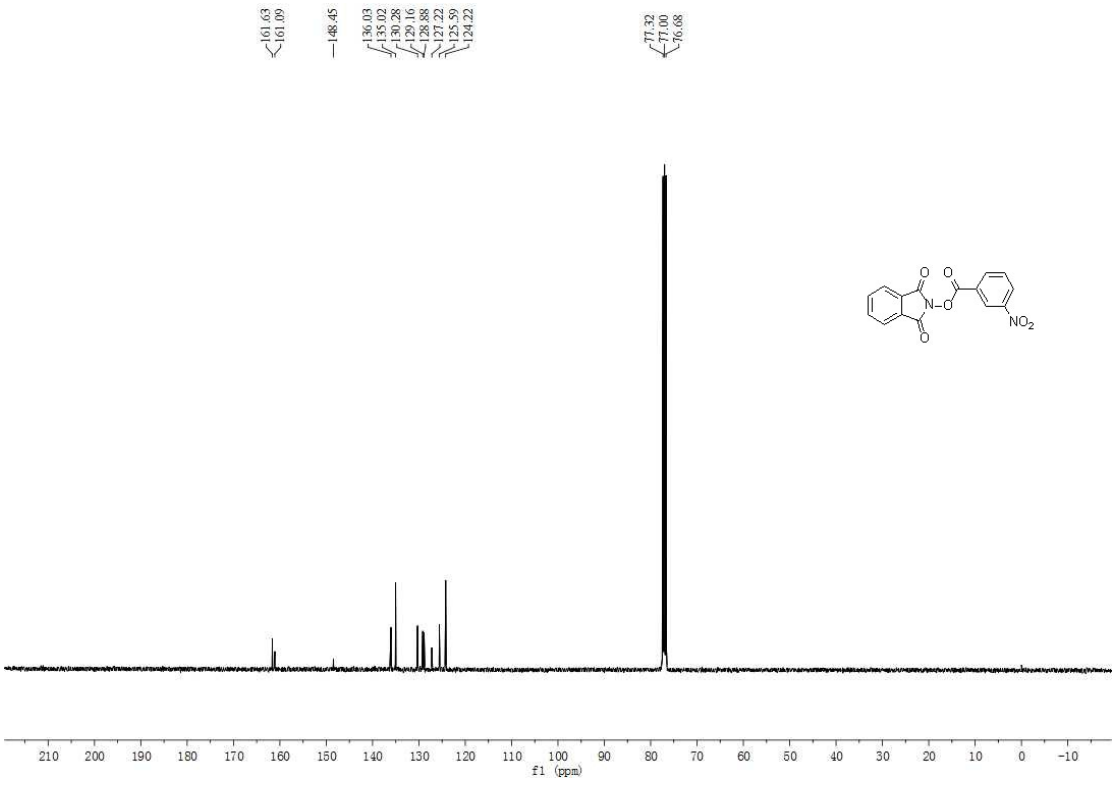

O
O
N
O
Br
O


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)

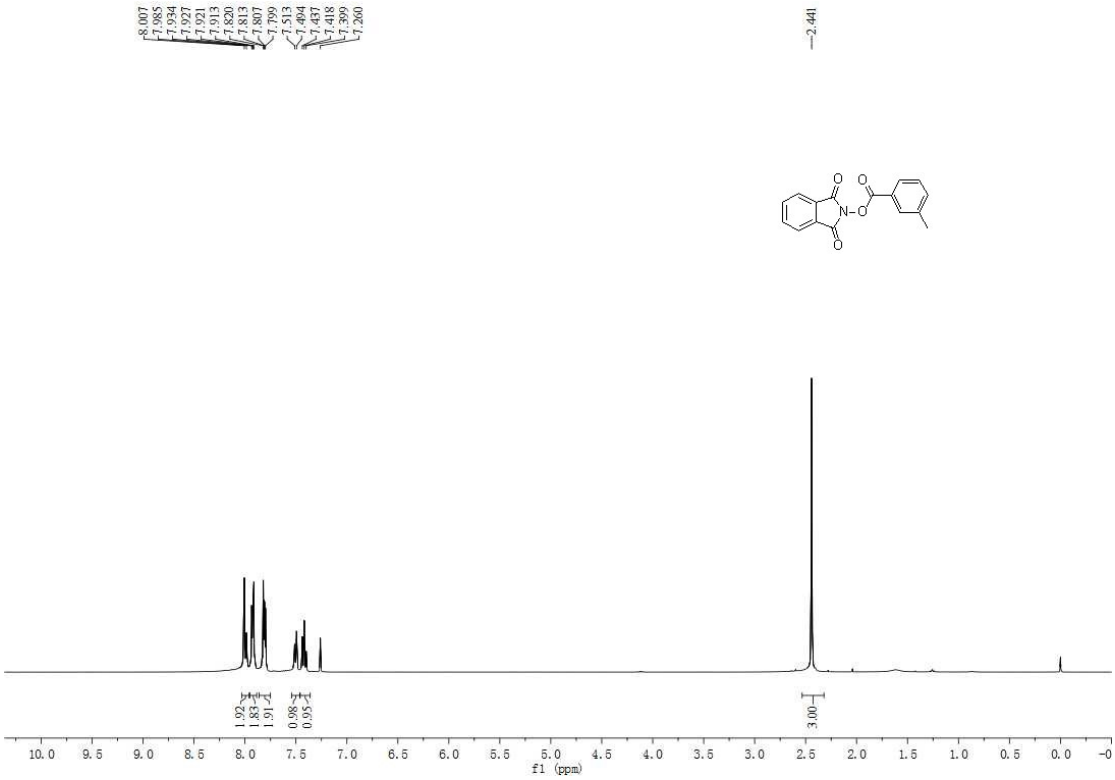
Product 3j

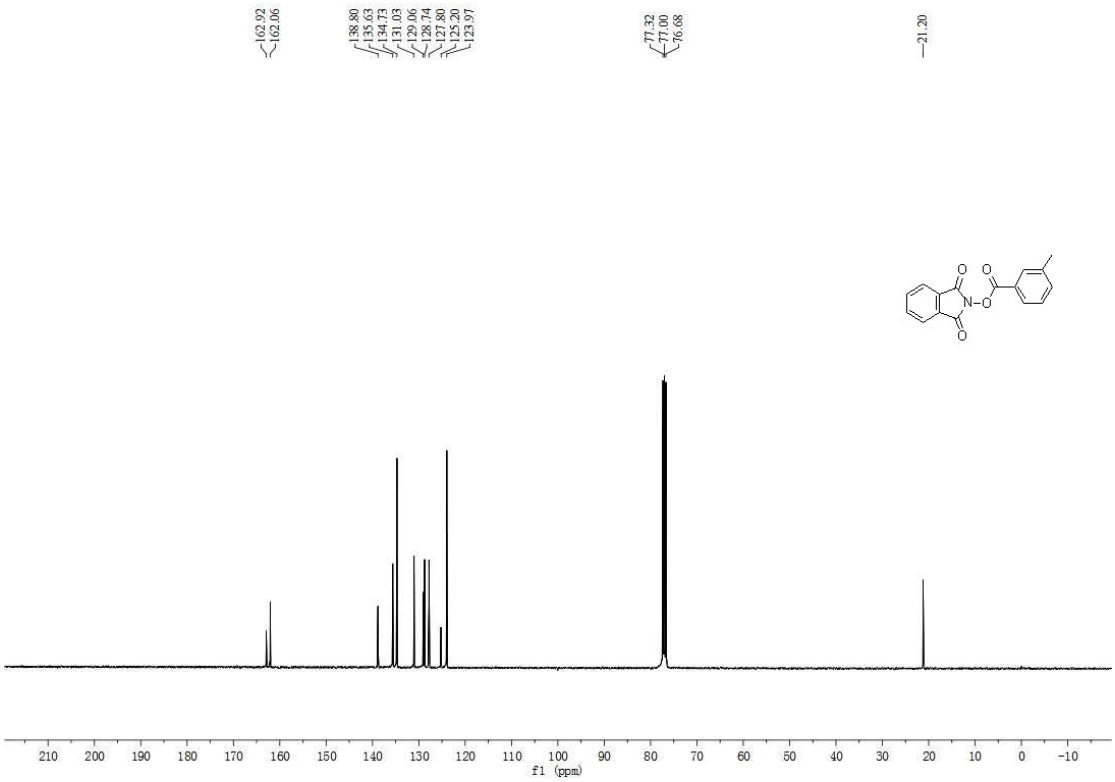






Product 3k

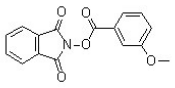

8.007
7.985
7.934
7.927
7.921
7.913
7.820
7.813
7.807
7.799
7.513
7.494
7.437
7.418
7.399
7.260
2.441
1.92
1.83
1.91
0.98
0.95
3.00
f1 (ppm)

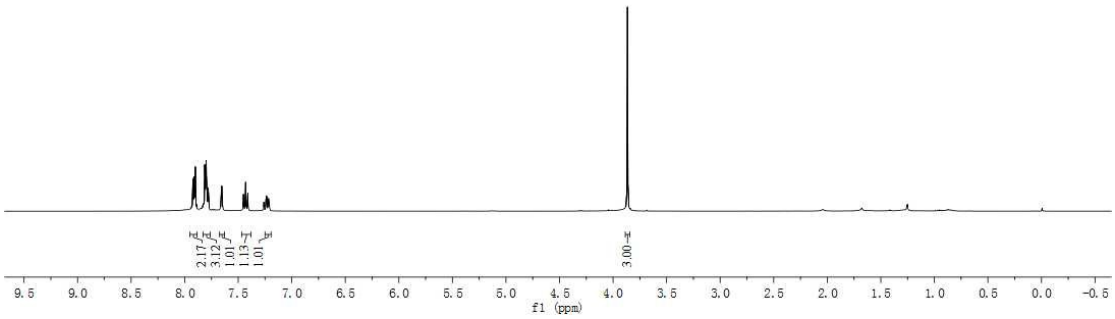

162.92
162.06
138.80
135.63
134.73
131.03
129.06
128.74
127.80
125.20
123.97
77.32
77.00
76.68
21.20
f1 (ppm)

Product 3l

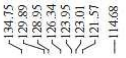

7.922
7.915
7.909
7.901
7.823
7.812
7.804
7.799
7.791
7.781
7.659
7.653
7.649
7.451
7.430
7.411
7.260
7.238
7.233
7.219
7.217
7.212

3.865



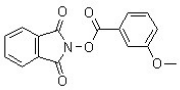

2.17
3.12
1.01
1.13
1.01
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

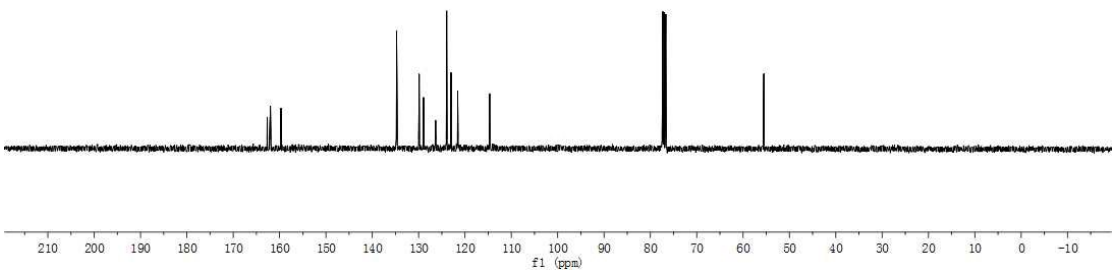

162.68
161.97
159.71


134.75
129.89
128.95
126.34
123.95
123.01
121.57
114.68


77.32
77.00
76.68

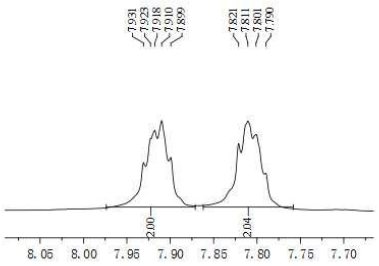

55.51

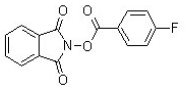


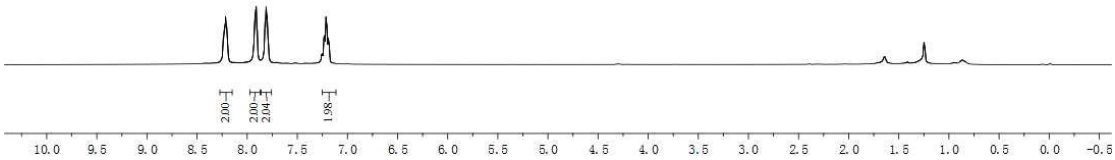

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

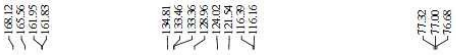
Product 3m

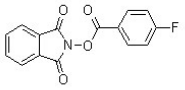

8.238
8.233
8.225
8.221
8.216
8.204
7.918
7.910
7.811
7.801
7.249
7.235
7.225
7.213
7.204
7.192

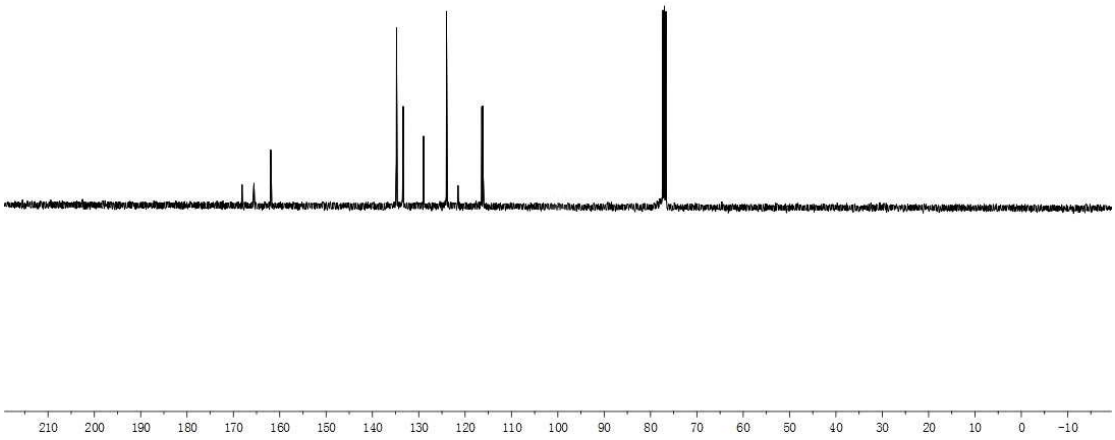

7.931
7.923
7.918
7.910
7.899
7.821
7.811
7.801
7.790
2.00
2.04
8.05
8.00
7.95
7.90
7.85
7.80
7.75
7.70




2.00
2.00
2.04
1.98
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

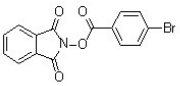

168.12
165.56
161.95
161.83
134.81
133.46
133.36
128.96
124.02
121.54
116.39
116.16
77.32
77.00
76.68

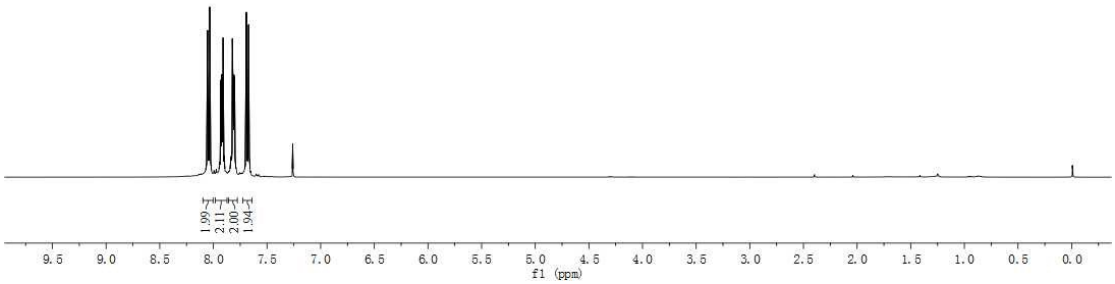



210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

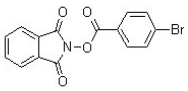
Product 3n

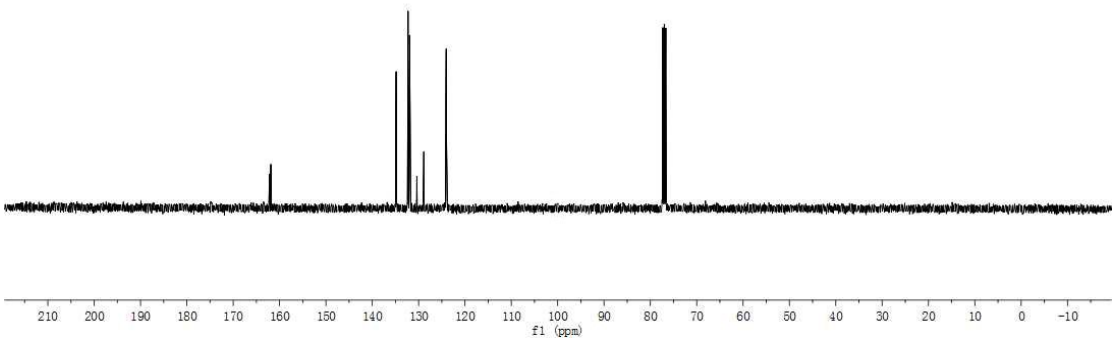

8.055
8.050
8.038
8.033
7.931
7.923
7.917
7.909
7.823
7.815
7.809
7.802
7.693
7.689
7.676
7.672
7.260


O
O
N
O
O
Br

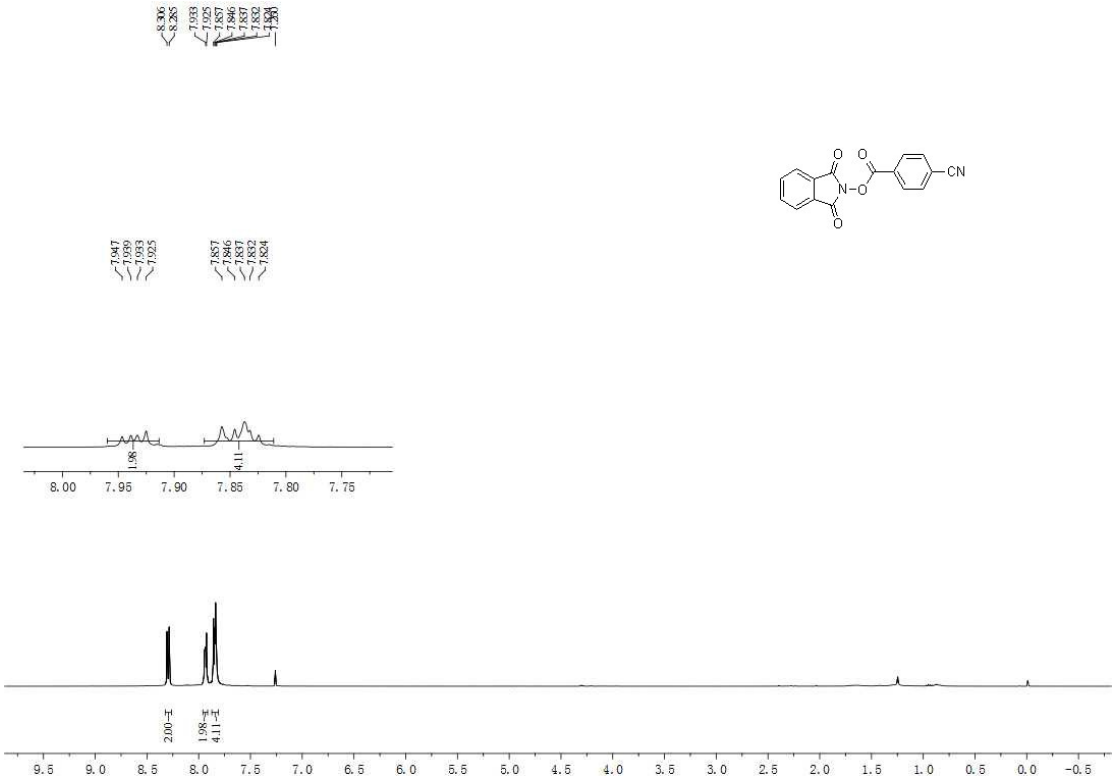

1.99
2.11
2.00
1.94
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

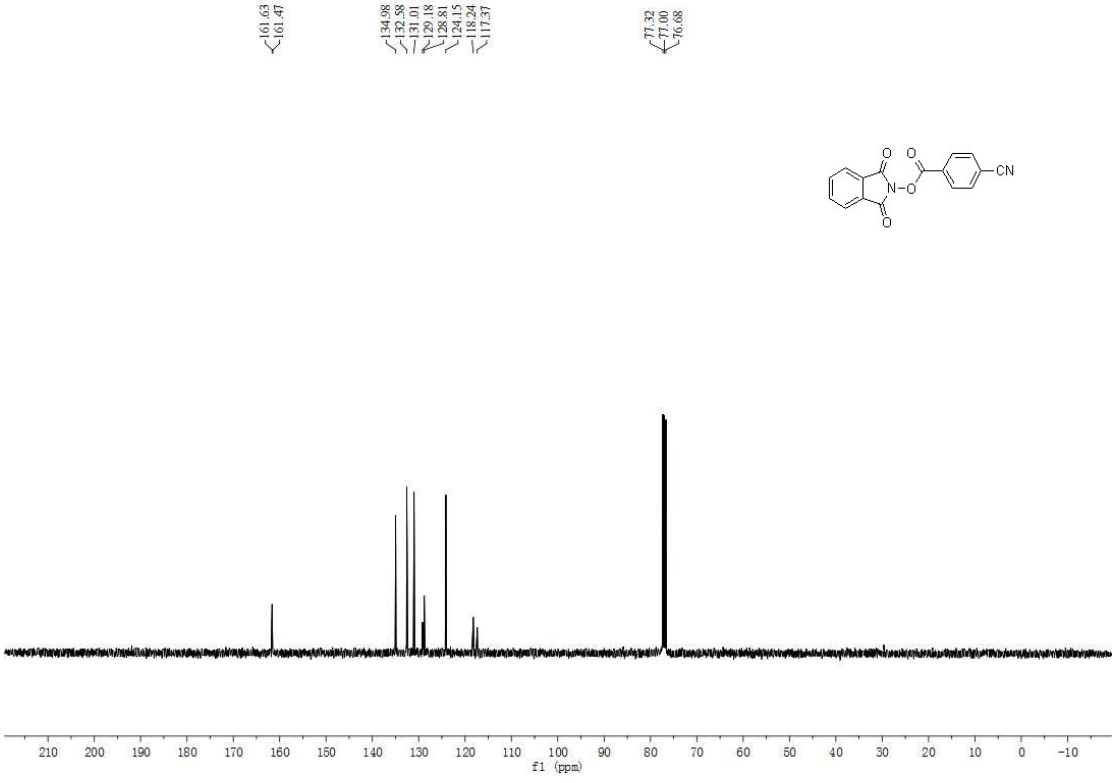

162.20
161.86
134.83
132.29
131.94
130.39
128.87
124.12
124.04
77.32
77.00
76.68


O
O
N
O
O
Br

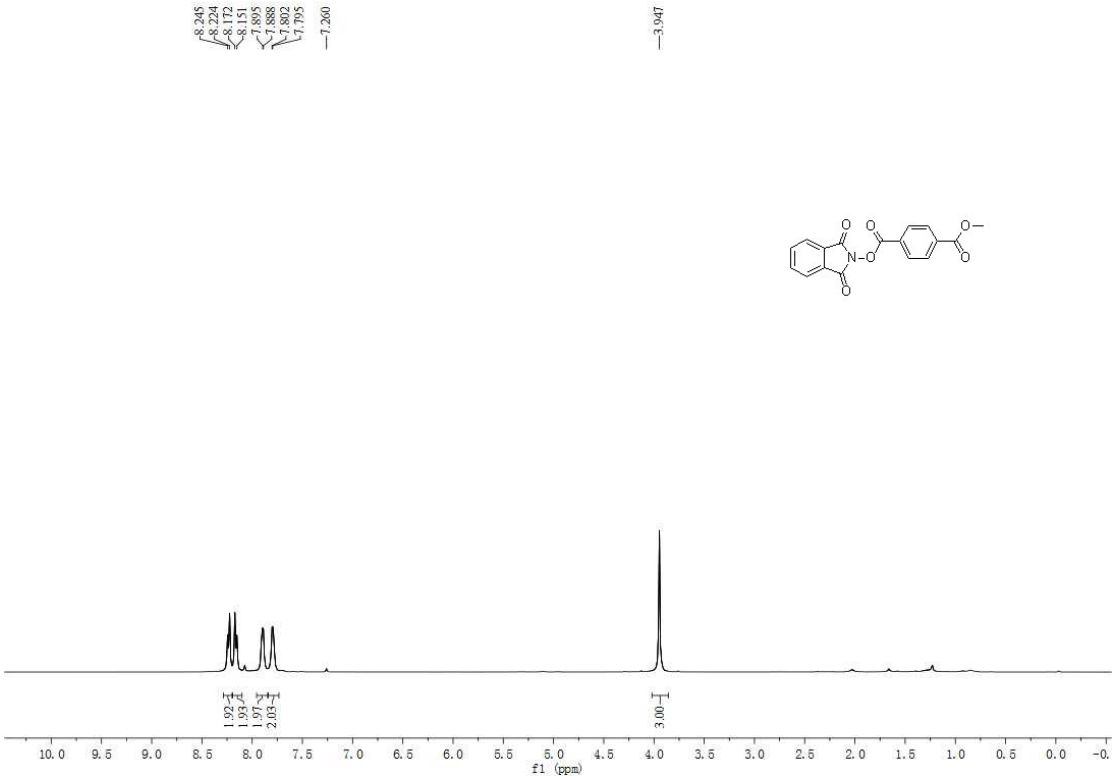

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

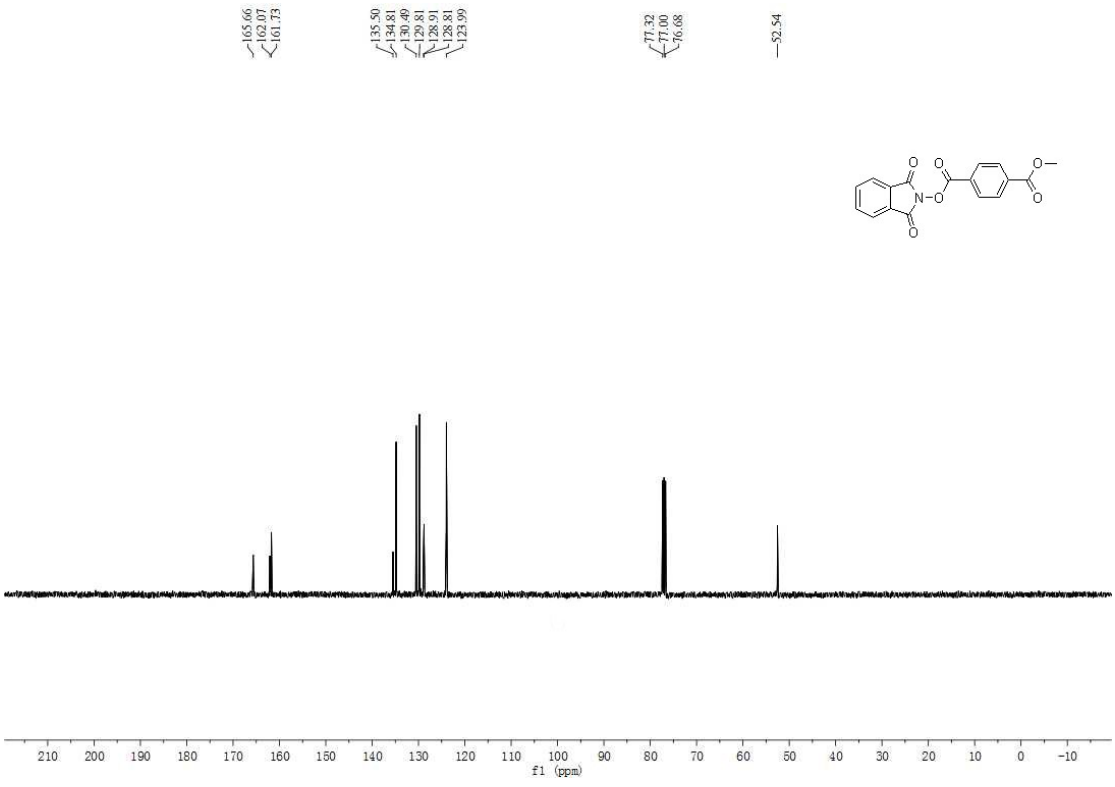
Product 3o



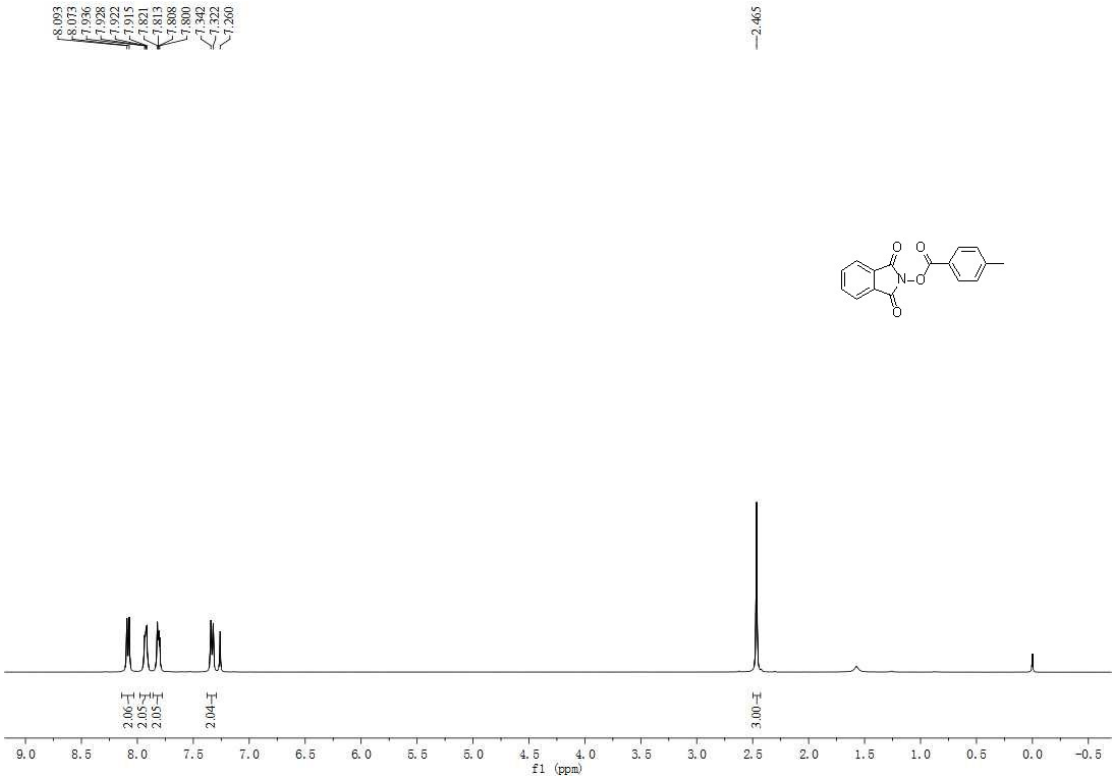


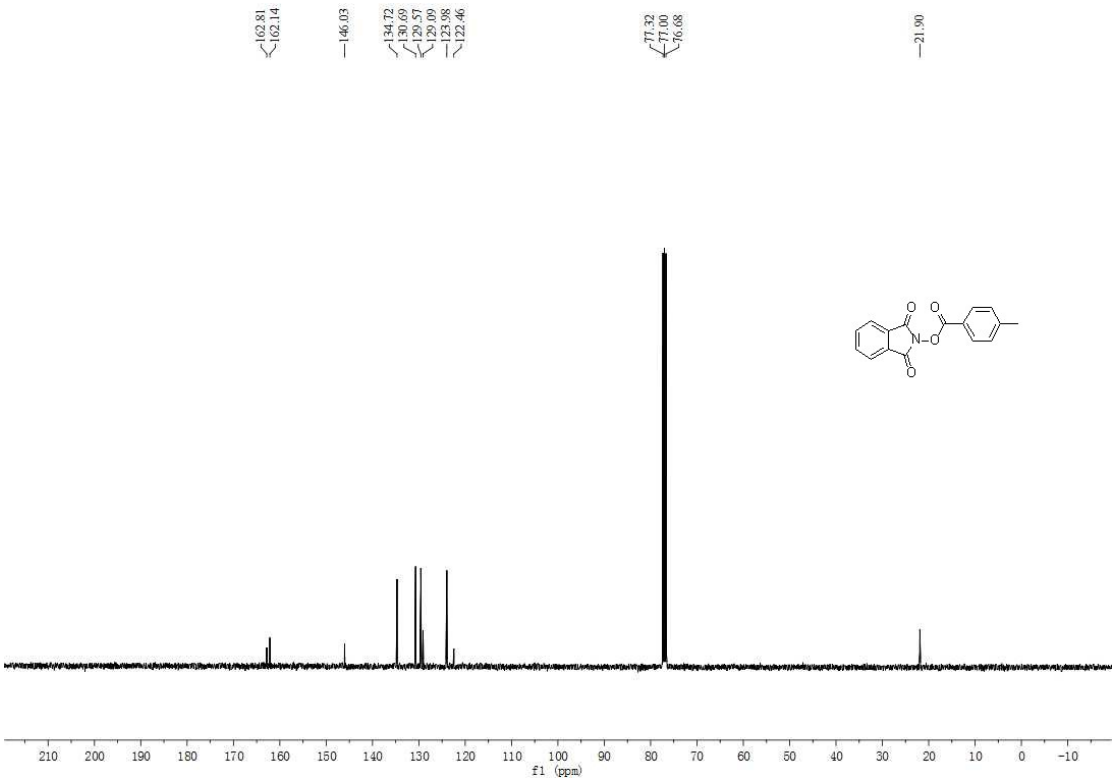
Product 3p


8.245
8.224
8.172
8.151
7.895
7.888
7.802
7.795
7.260
3.947
1.92
1.93
1.97
2.03
3.00
f1 (ppm)

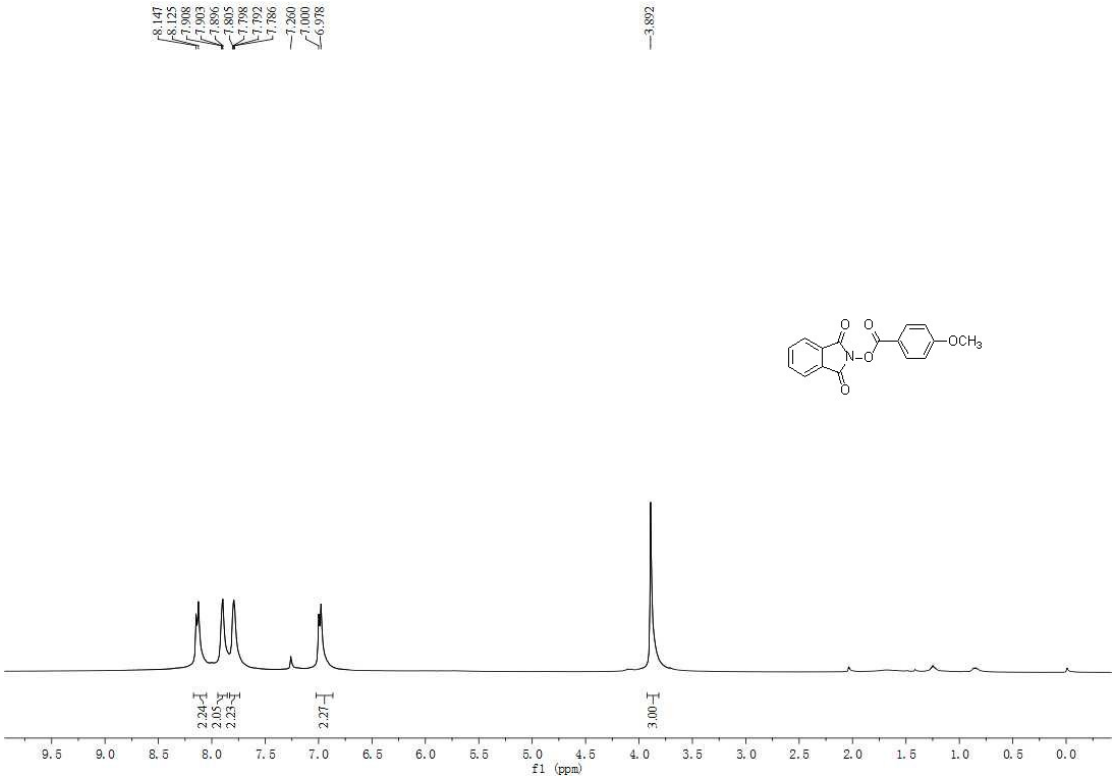

165.66
162.07
161.73
135.50
134.81
130.49
129.81
128.91
128.81
123.99
77.32
77.00
76.68
52.54
f1 (ppm)

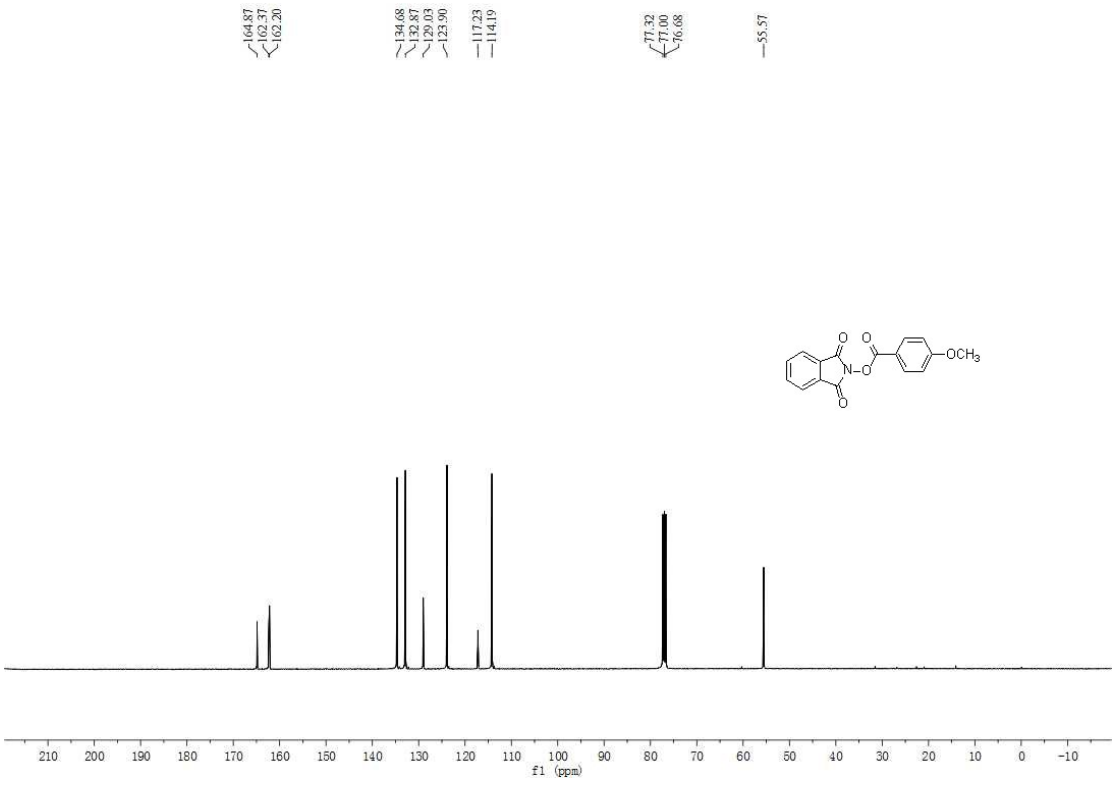
Product 3q


8.093
8.073
7.936
7.928
7.922
7.915
7.821
7.813
7.808
7.800
7.342
7.322
7.260
2.465
2.06
2.05
2.05
2.04
3.00
f1 (ppm)

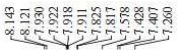

162.81
162.14
146.03
134.72
130.69
129.57
129.09
123.98
122.46
77.32
77.00
76.68
21.90
f1 (ppm)

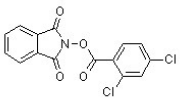
Product 3r

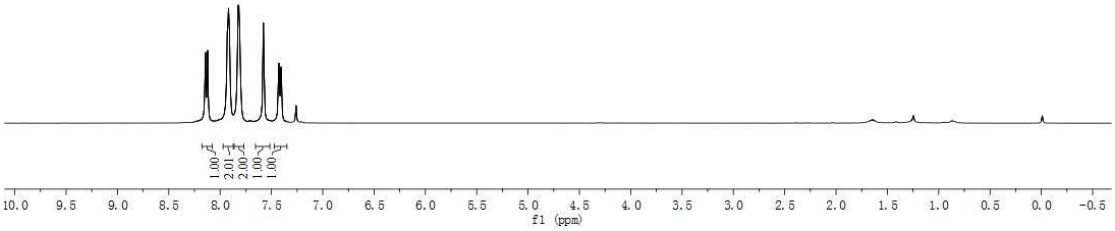

8.147
8.125
7.908
7.903
7.896
7.805
7.798
7.792
7.786
7.260
7.000
6.978
3.892
OCH3
2.24
2.05
2.23
2.27
3.00
f1 (ppm)


164.87
162.37
162.20
134.68
132.87
129.03
123.90
117.23
114.19
77.32
77.00
76.68
55.57
OCH3
f1 (ppm)

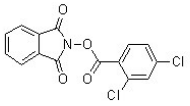
Product 3s

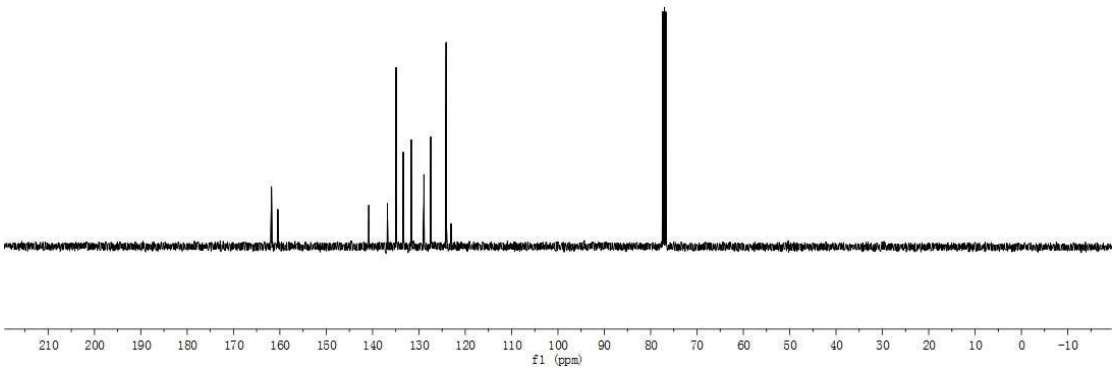

8.143
8.121
7.930
7.922
7.918
7.911
7.825
7.817
7.578
7.428
7.407
7.260


O
N
O
O
O
Cl
Cl

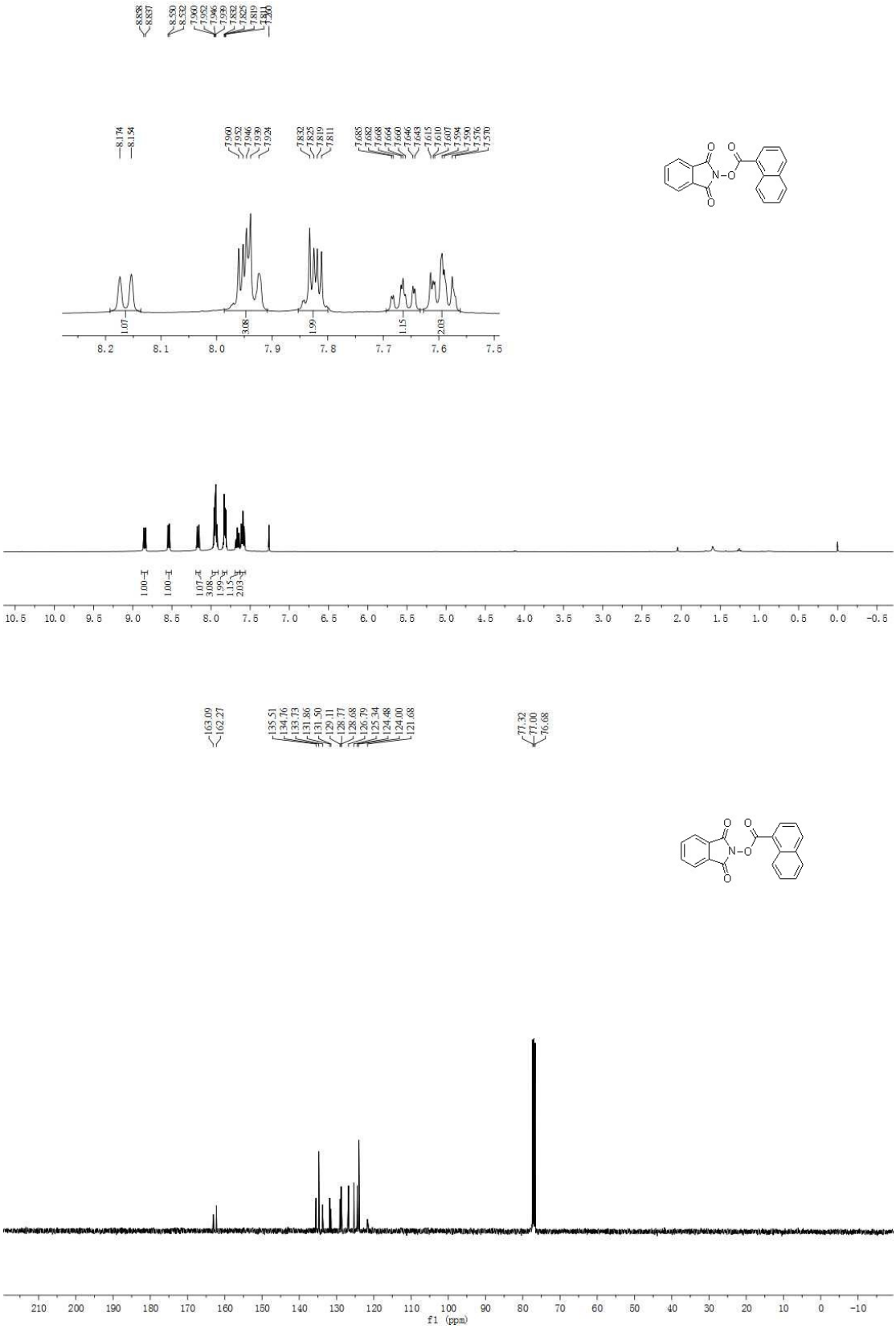

1.00
2.01
2.00
1.00
1.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


161.81
160.44
140.80
136.80
134.92
133.35
131.66
128.92
127.42
124.11
123.08
77.36
77.05
76.73


O
N
O
O
O
Cl
Cl

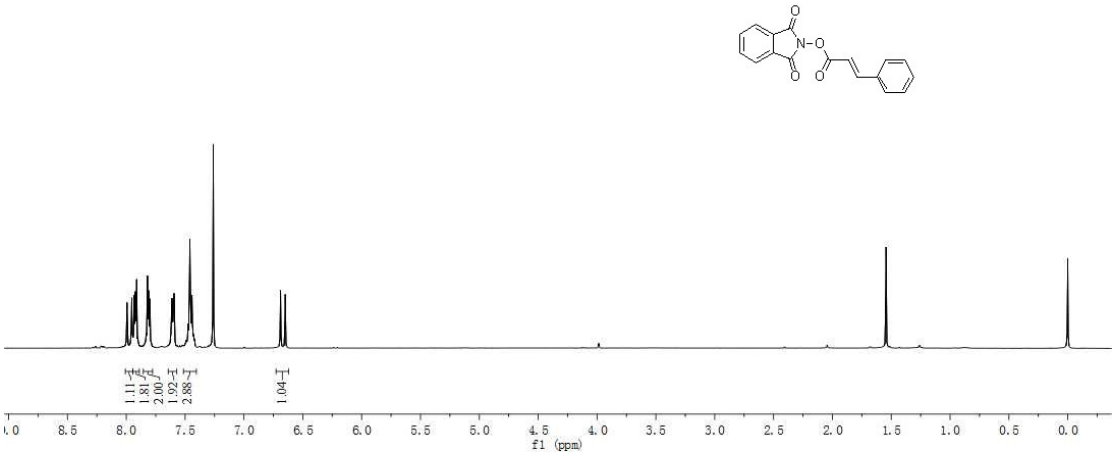

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

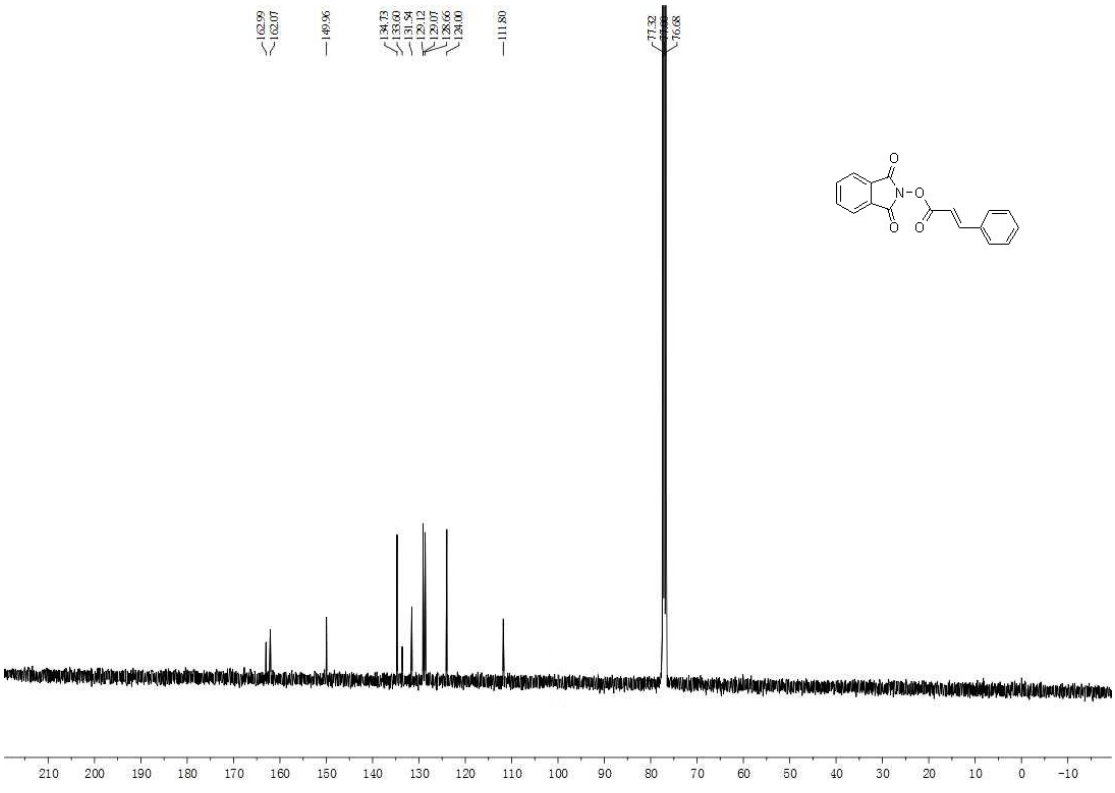
Product 3t



Product 3u


7.994
7.954
7.933
7.925
7.920
7.912
7.820
7.812
7.806
7.799
7.612
7.597
7.593
7.474
7.460
7.442
7.427
7.260
6.689
6.649

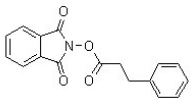

1.11
1.81
2.00
1.92
2.88
1.04
f1 (ppm)

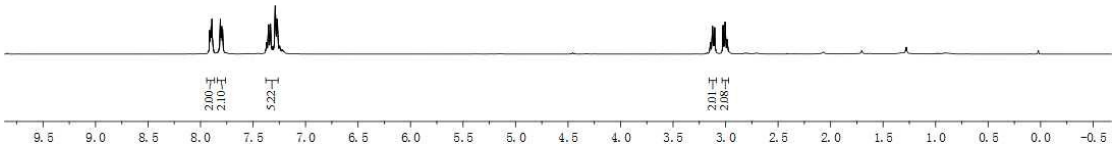

162.99
162.07
149.96
134.73
133.60
131.54
130.12
129.07
128.66
124.00
111.80
77.32
76.68

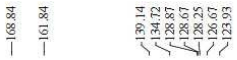
Product 3v

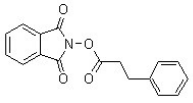

7.912
7.904
7.899
7.891
7.811
7.804
7.796
7.790
7.371
7.352
7.334
7.289
7.270

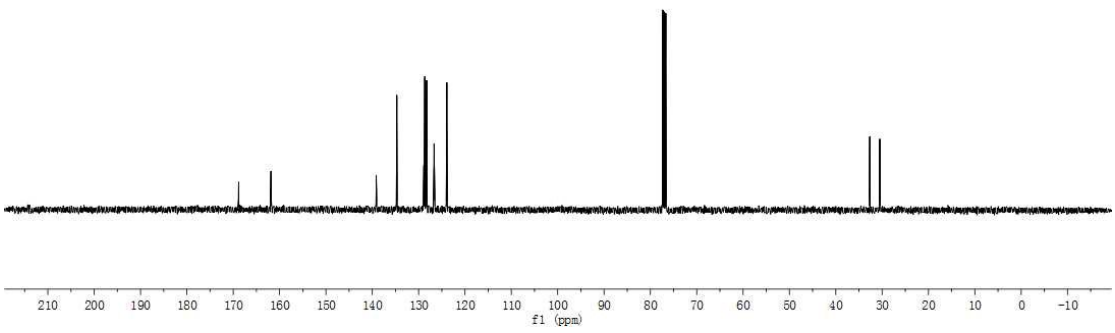

3.143
3.124
3.104
3.024
3.013
3.004
2.986
2.984



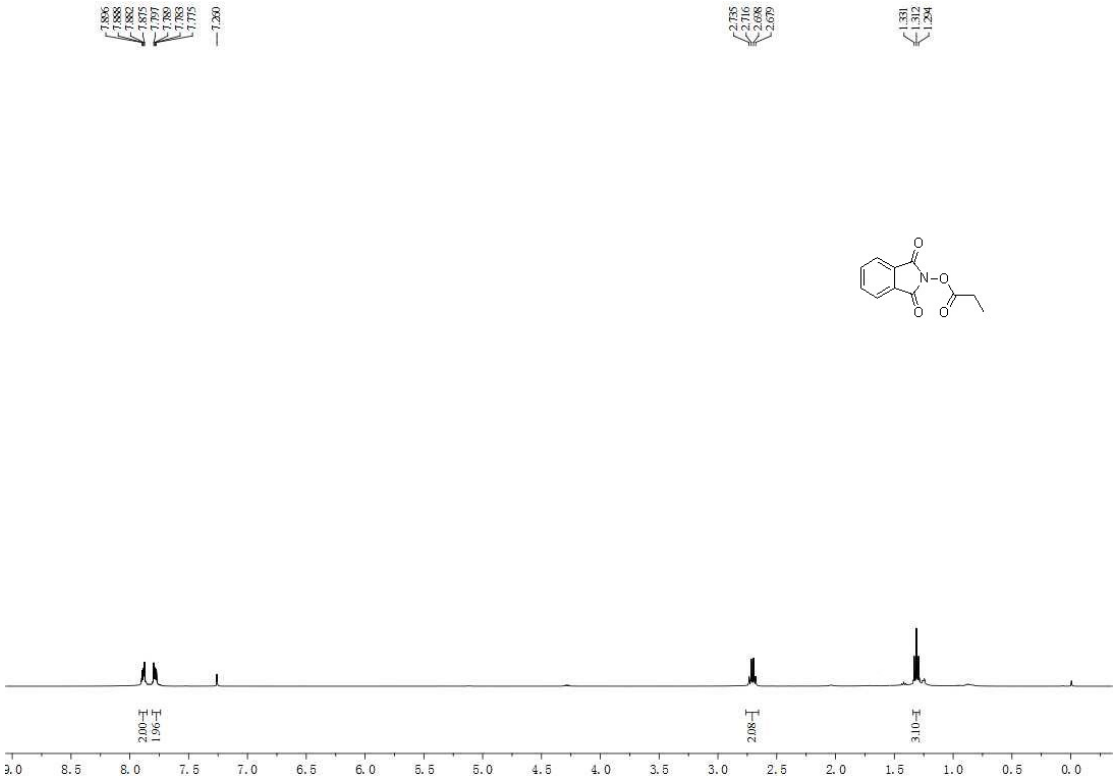

2.00
2.10
5.22
2.01
2.08
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5

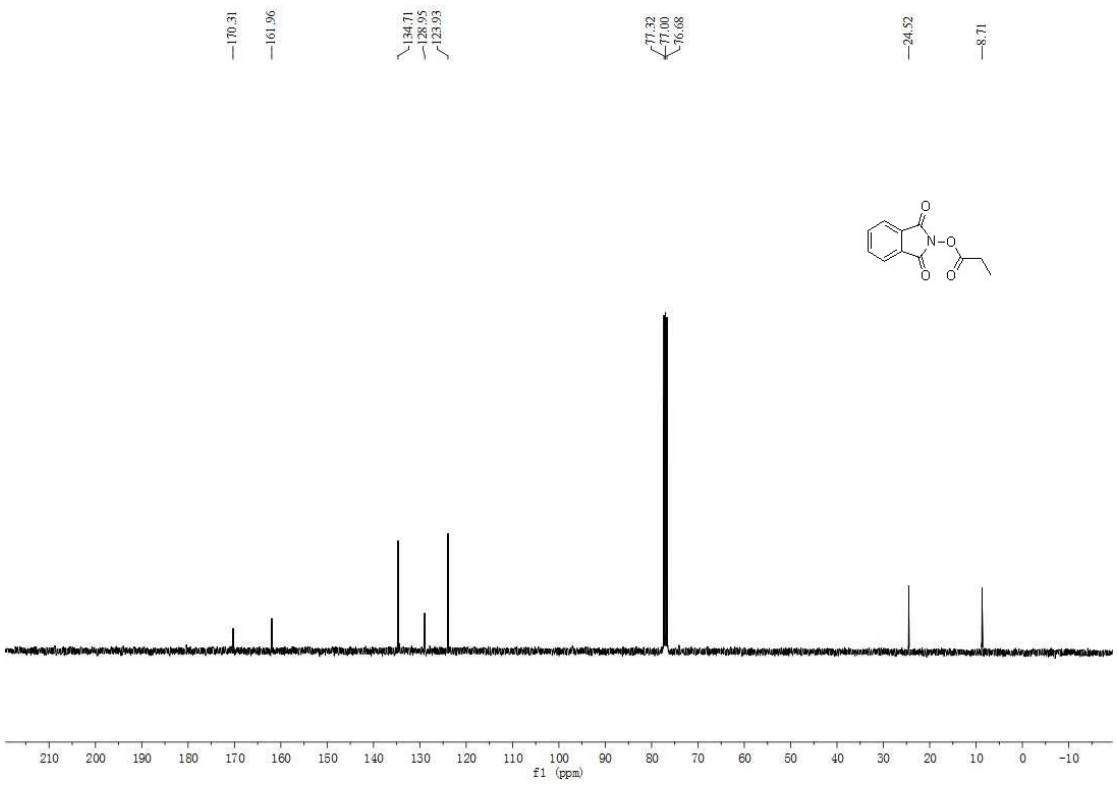

168.84
161.84
139.14
134.72
128.87
128.67
128.25
126.67
123.93
77.32
77.00
76.68
32.65
30.50




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)

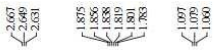
Product 3w

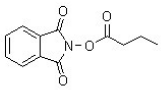

7.896
7.888
7.882
7.875
7.797
7.789
7.783
7.775
7.260
2.735
2.716
2.698
2.679
1.331
1.312
1.294
2.00
1.96
2.08
3.10

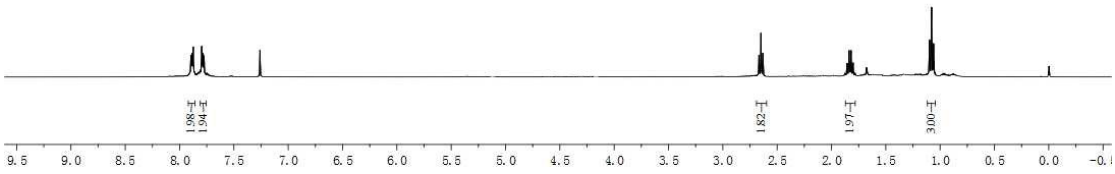

170.31
161.96
134.71
128.95
123.93
77.32
77.00
76.68
24.52
8.71
f1 (ppm)

Product 3x

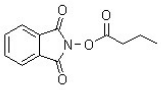

7.896
7.888
7.883
7.875
7.796
7.788
7.782
7.774
7.260

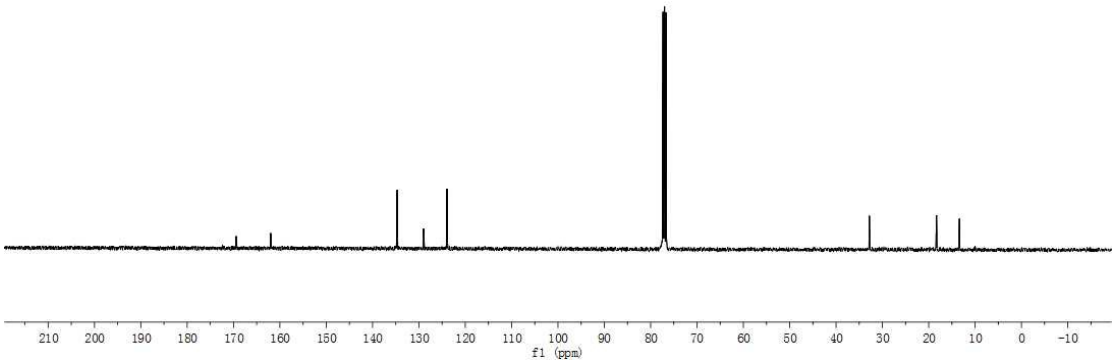

2.667
2.649
2.631
1.875
1.856
1.838
1.819
1.801
1.783
1.097
1.079
1.060



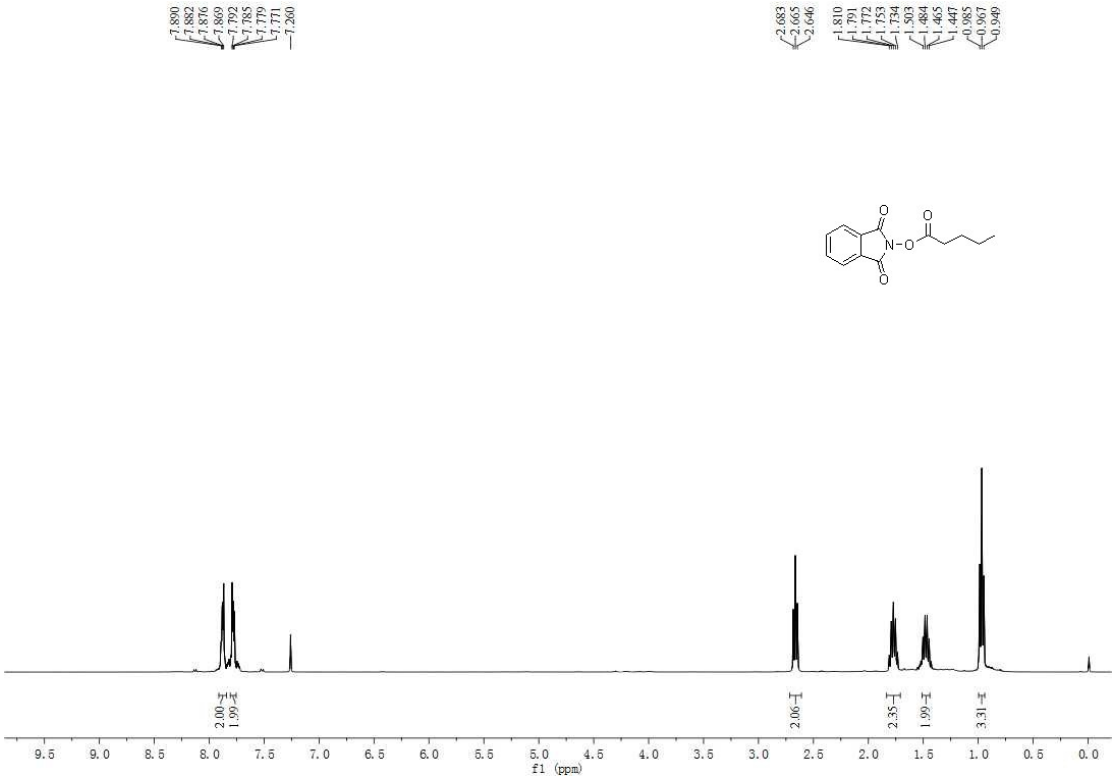

1.98
1.94
1.82
1.97
3.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

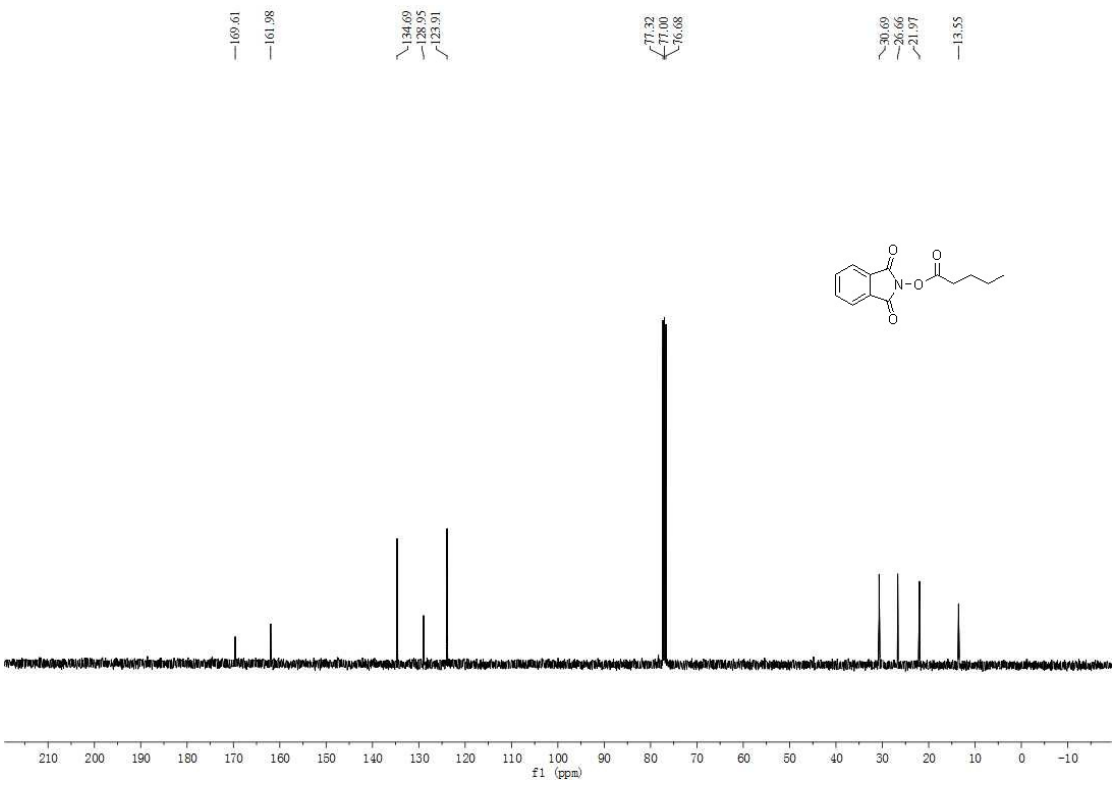

169.45
161.99
134.69
128.99
123.92
77.32
77.00
76.68
32.81
18.32
13.37



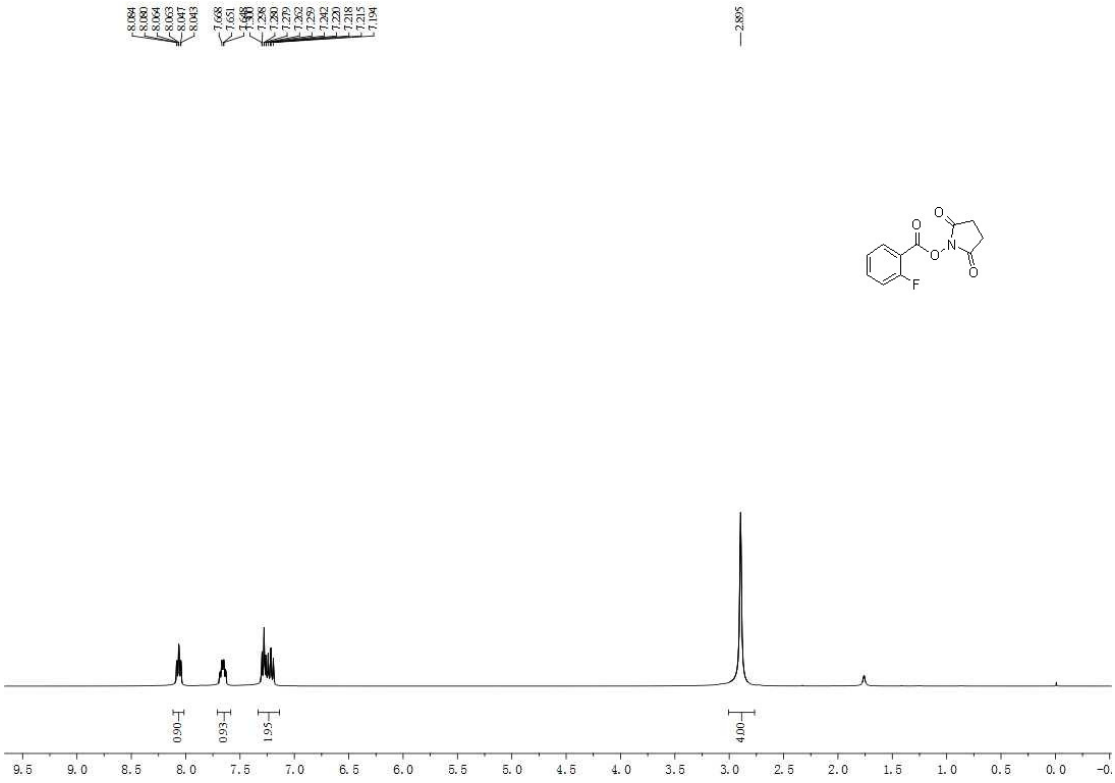

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

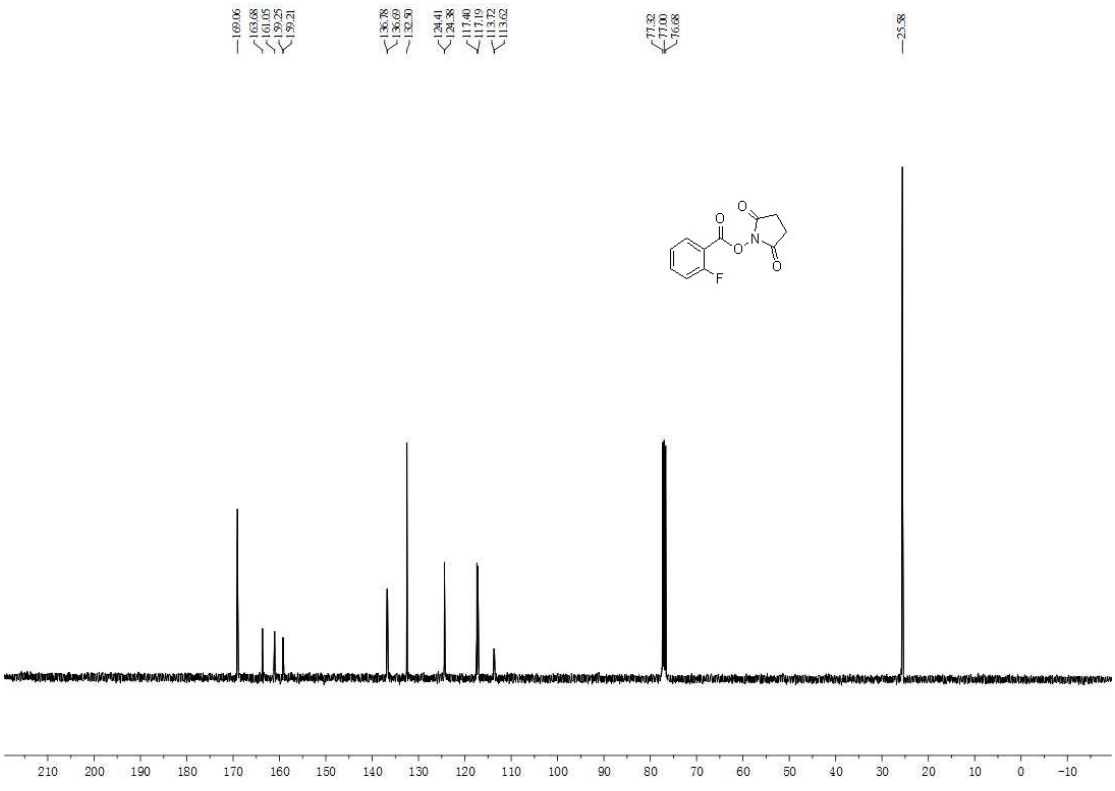
Product 3y


7.890
7.882
7.876
7.869
7.792
7.785
7.779
7.771
7.260
2.683
2.665
2.646
1.810
1.791
1.772
1.753
1.734
1.503
1.484
1.465
1.447
0.985
0.967
0.949
2.00
1.99
2.06
2.35
1.99
3.31
f1 (ppm)

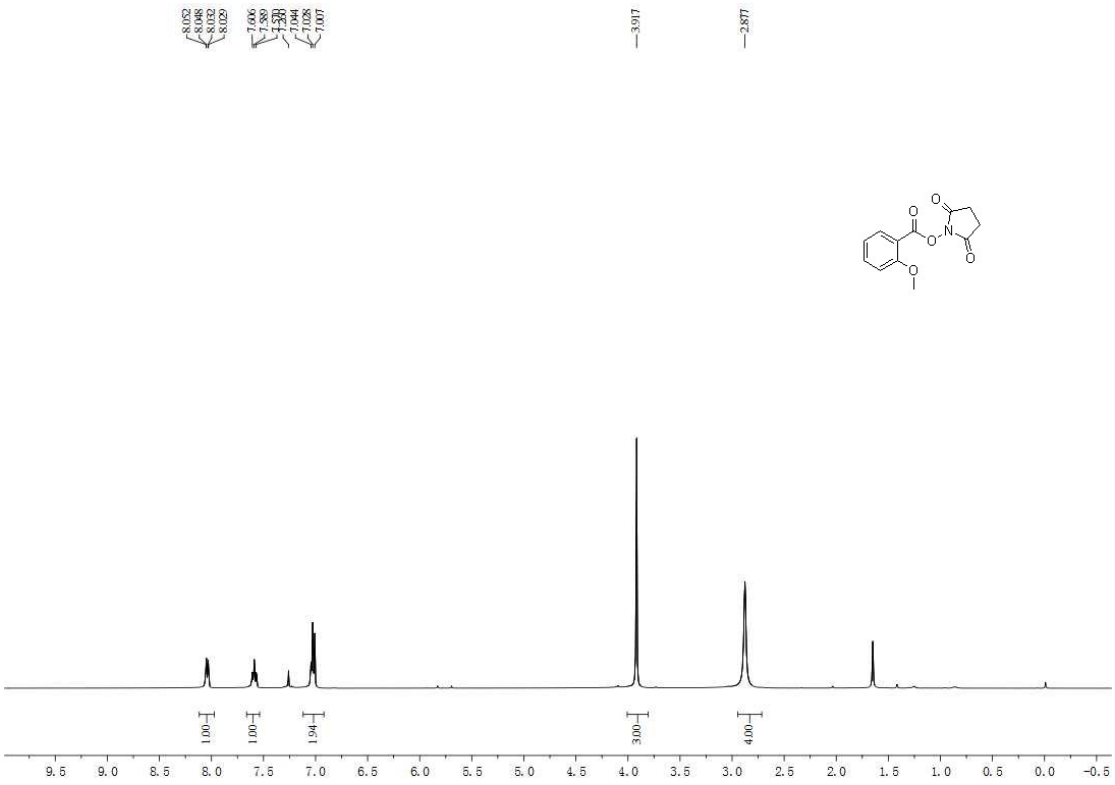

169.61
161.98
134.69
128.95
123.91
77.32
77.00
76.68
30.69
26.66
21.97
13.55
f1 (ppm)

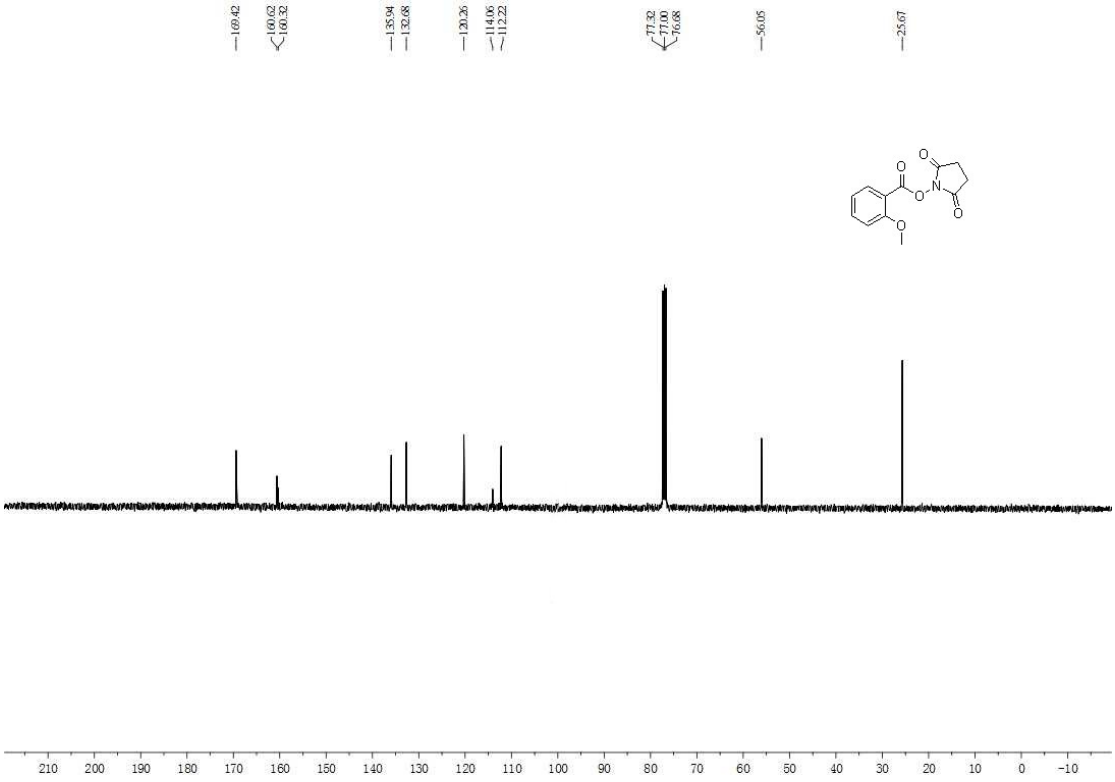
Product 5a


8.084
8.080
8.064
8.063
8.047
8.043
7.668
7.651
7.208
7.280
7.279
7.262
7.259
7.252
7.250
7.218
7.215
7.194
2.895
O
O
N
O
O
F
0.90
0.93
1.95
4.00
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

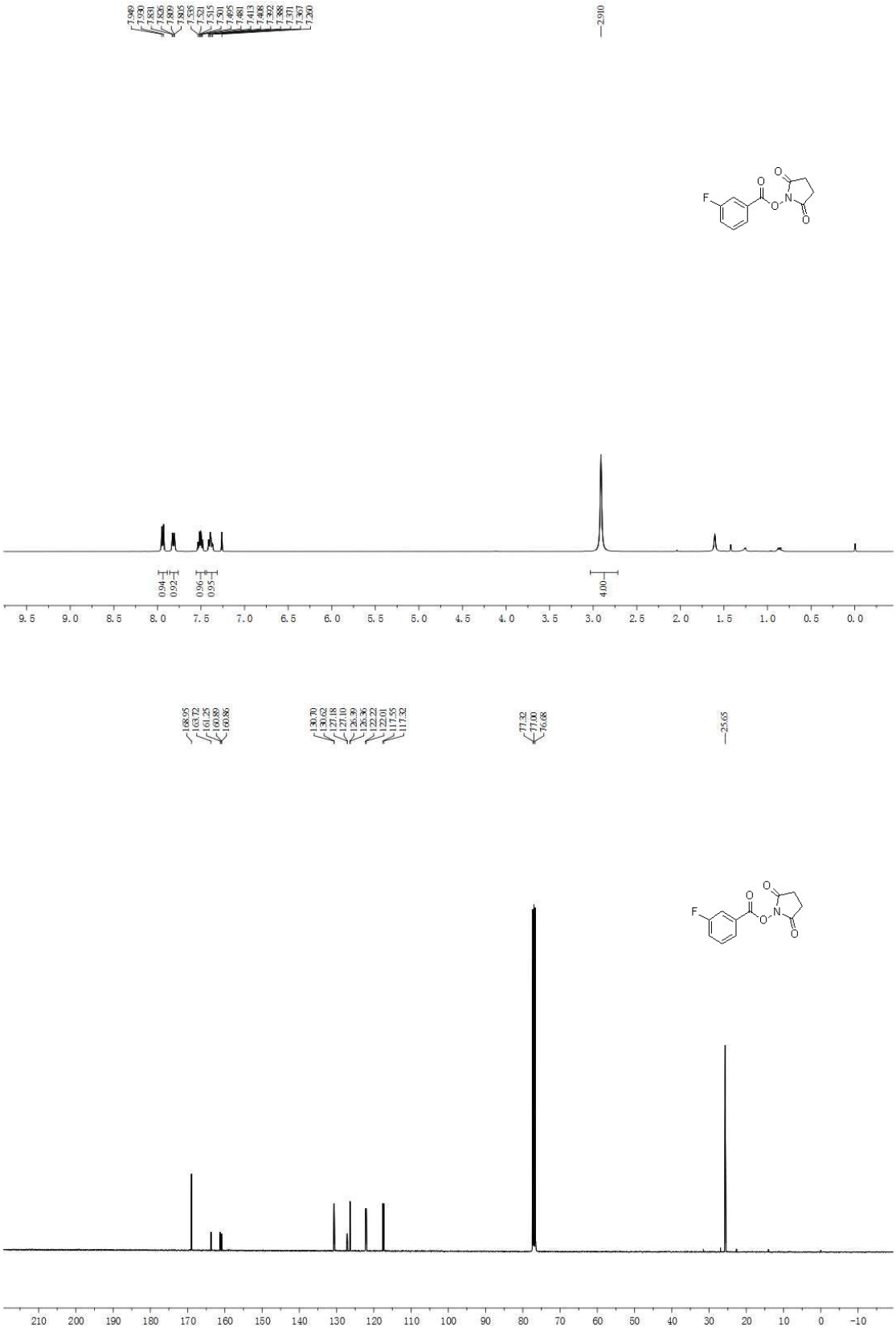

169.06
163.68
161.05
159.25
159.21
136.78
136.69
132.90
124.41
124.38
117.40
117.19
113.72
113.62
77.32
77.00
76.68
25.58
O
O
N
O
O
F
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

Product 5b

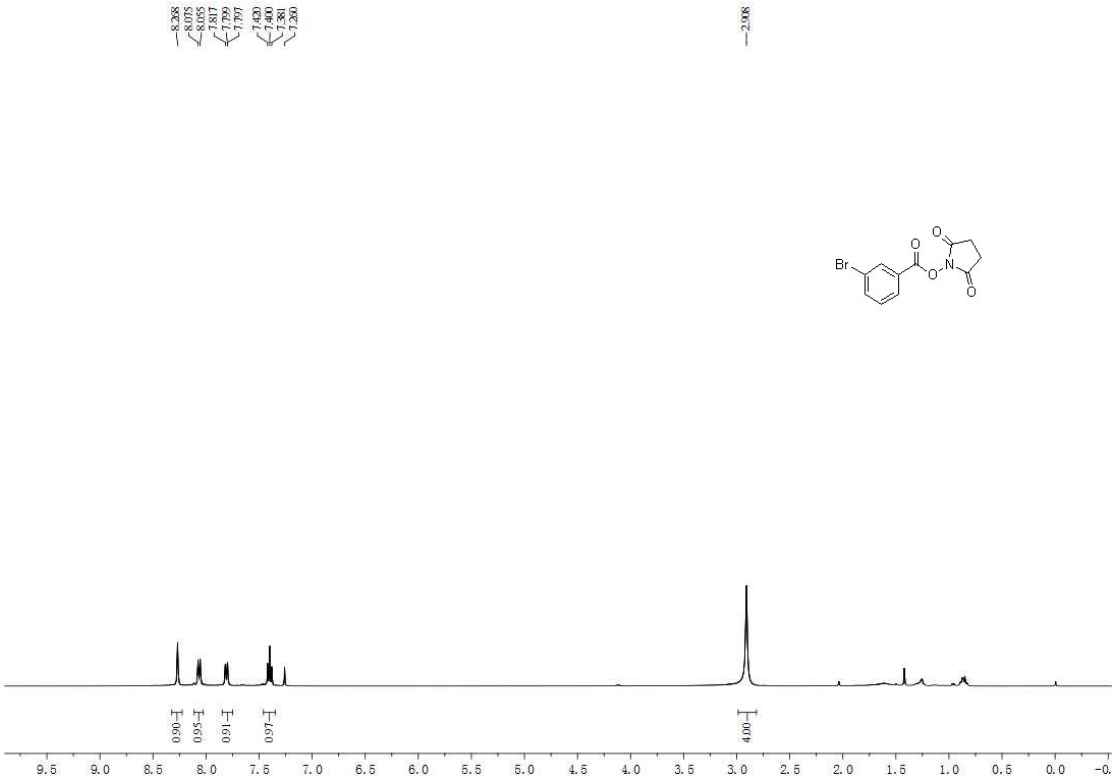

8.052
8.048
8.032
8.029
7.606
7.589
7.520
7.504
7.104
7.028
7.007
3.917
2.877
1.00
1.00
1.94
3.00
4.00

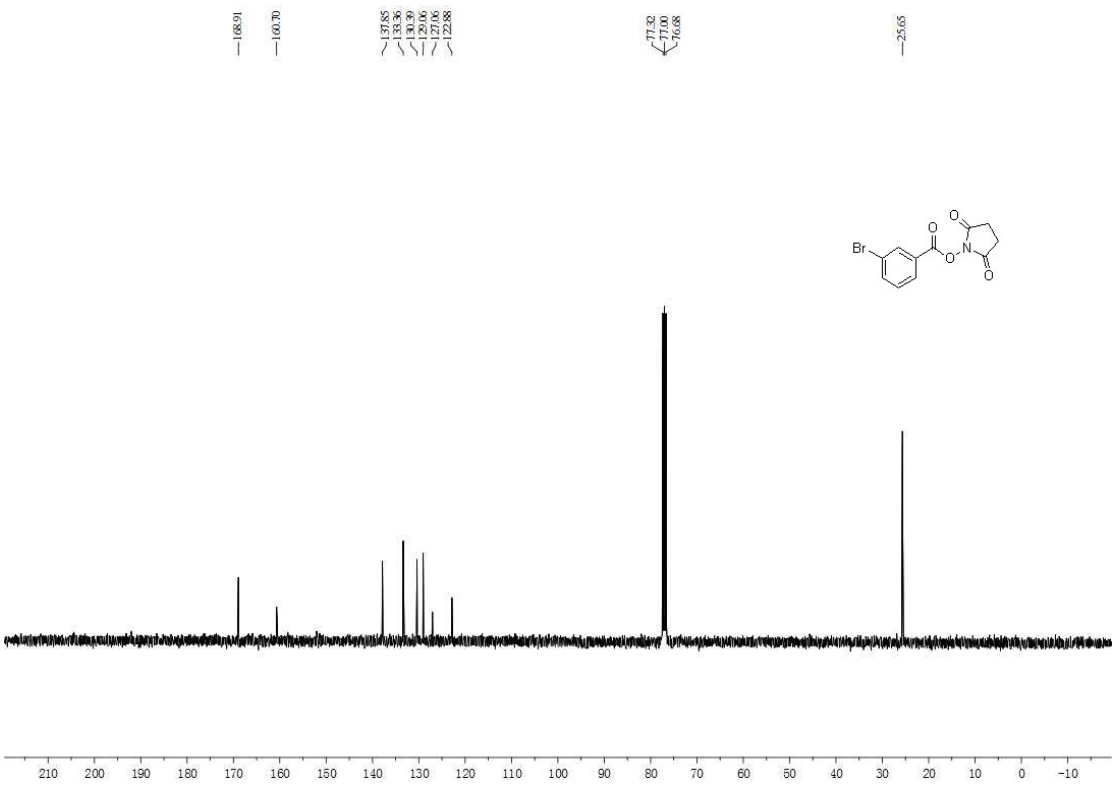

169.42
160.62
160.32
135.94
132.68
120.26
114.06
112.22
77.32
77.00
76.68
56.05
25.67

Product 5c

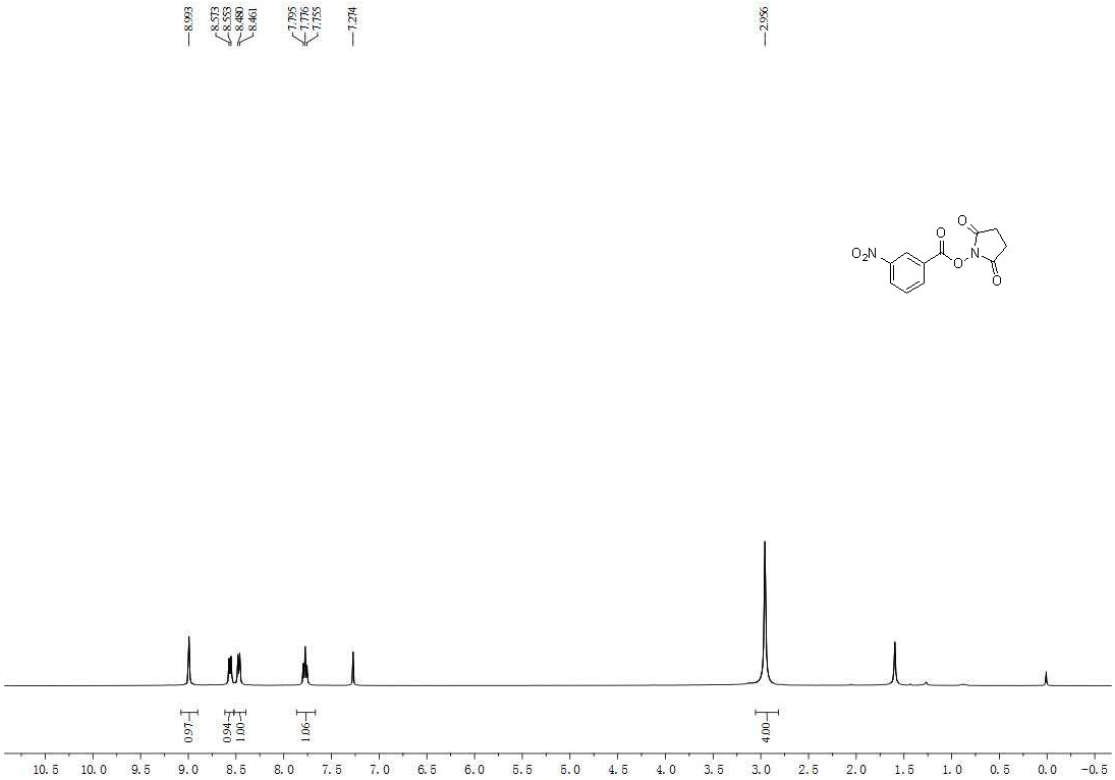

7.949
7.930
7.831
7.826
7.809
7.805
7.535
7.521
7.515
7.501
7.495
7.481
7.413
7.408
7.392
7.388
7.371
7.367
7.260
2.910
F
O
O
N
O
O
0.94
0.92
0.96
0.95
4.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
168.95
163.72
161.25
160.89
160.86
130.70
130.62
127.18
127.10
126.39
126.36
122.22
122.01
117.55
117.32
77.32
77.00
76.68
25.65
F
O
O
N
O
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

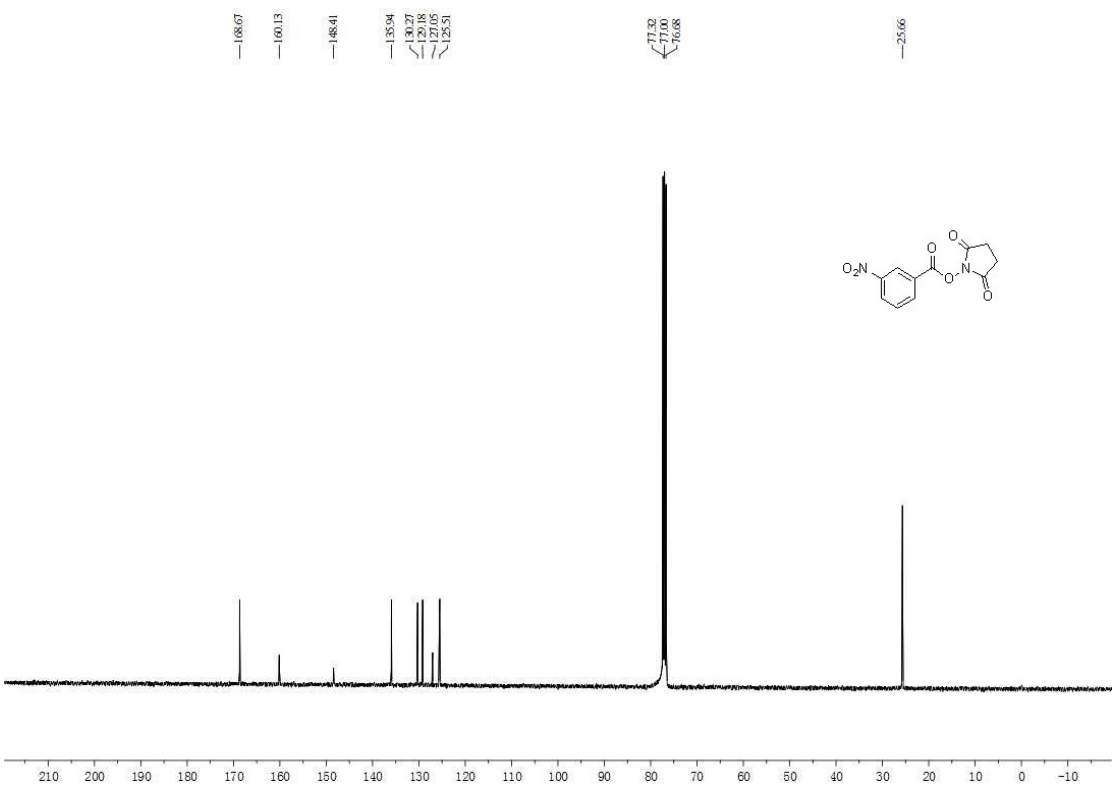
Product 5d


8.208
8.075
8.055
7.817
7.799
7.797
7.420
7.400
7.381
7.200
2.908
Br
O
N
0.90
0.95
0.91
0.97
4.00
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

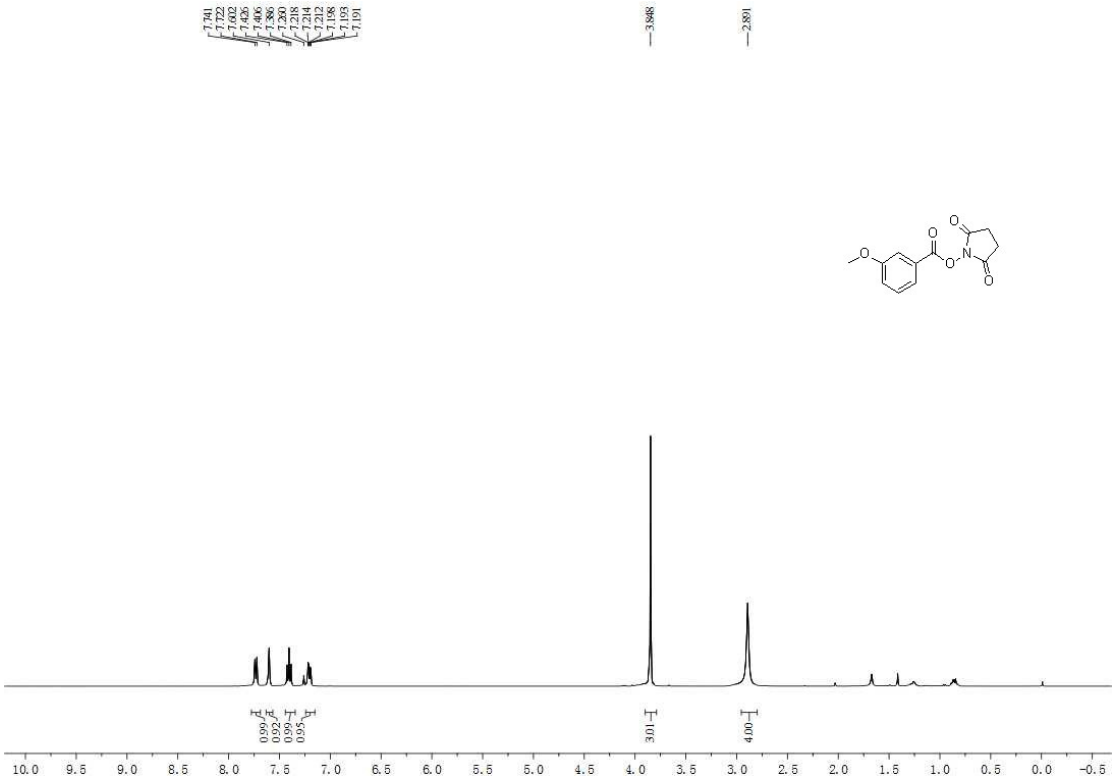

168.91
160.70
137.85
133.36
130.39
129.06
127.16
122.88
77.32
77.00
76.68
25.65
Br
O
N
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

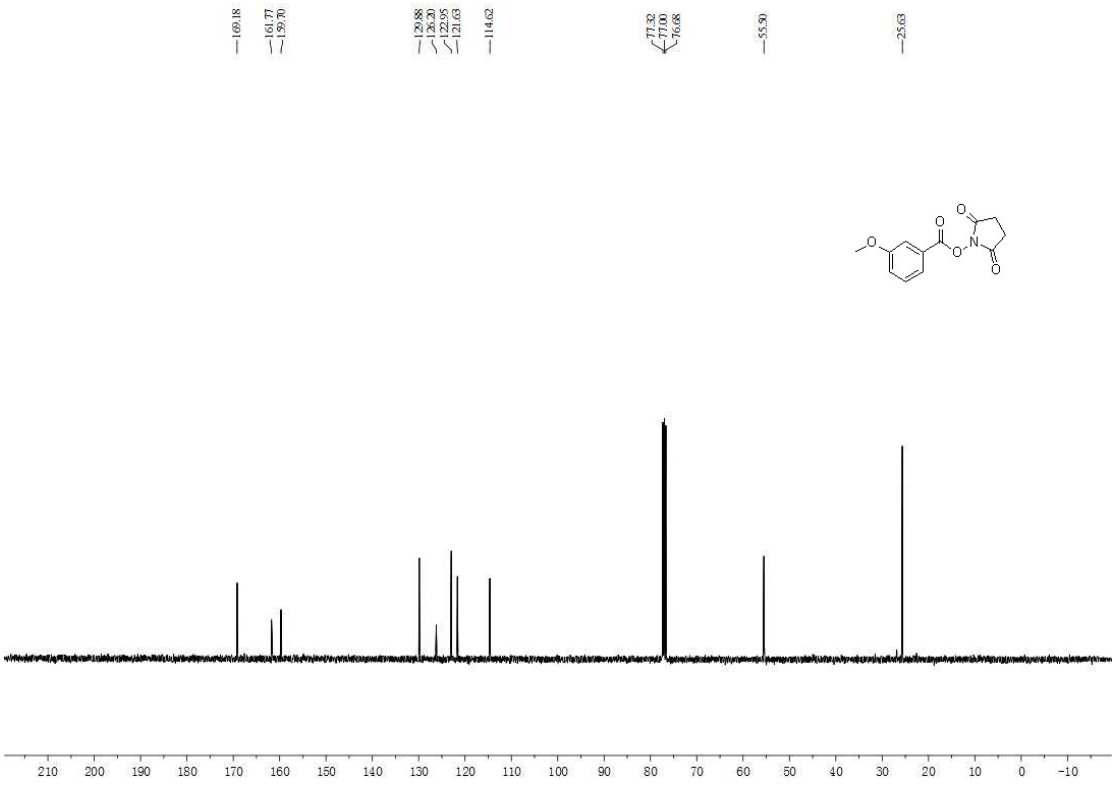
Product 5e


8.993
8.573
8.553
8.480
8.461
7.795
7.776
7.735
7.274
2.956
0.97
0.94
1.00
1.06
4.00

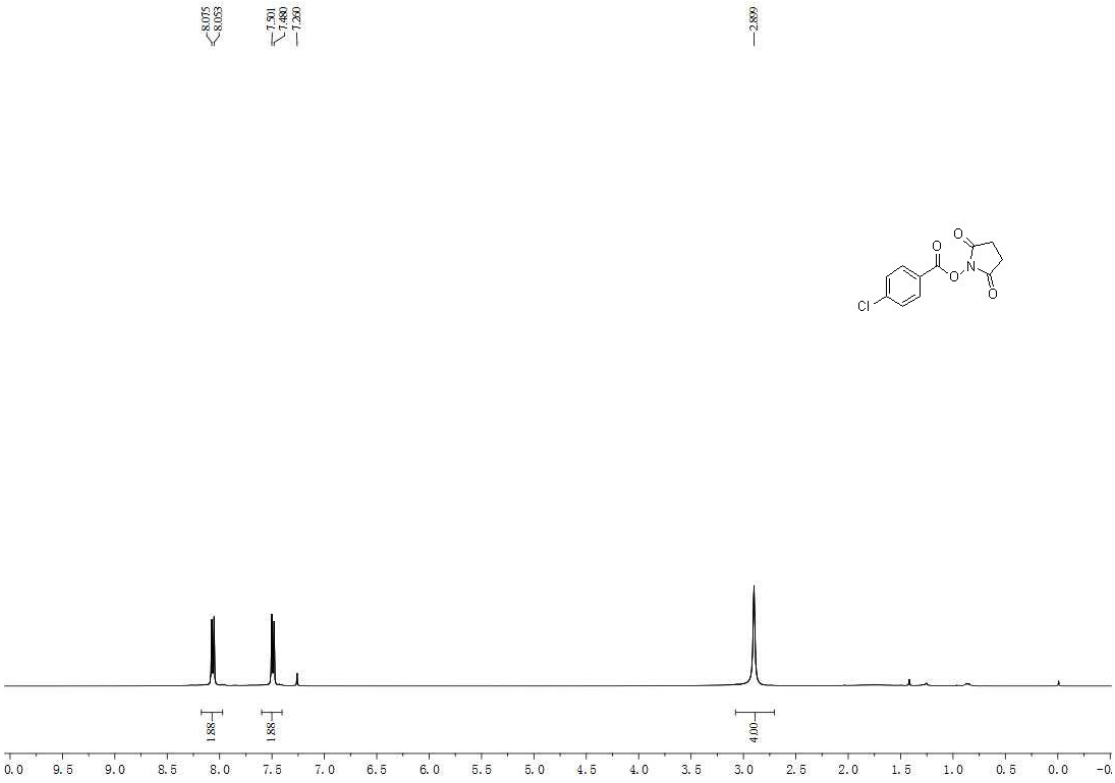

168.67
160.13
148.41
135.94
130.27
129.38
127.05
125.51
77.32
77.00
76.68
25.66

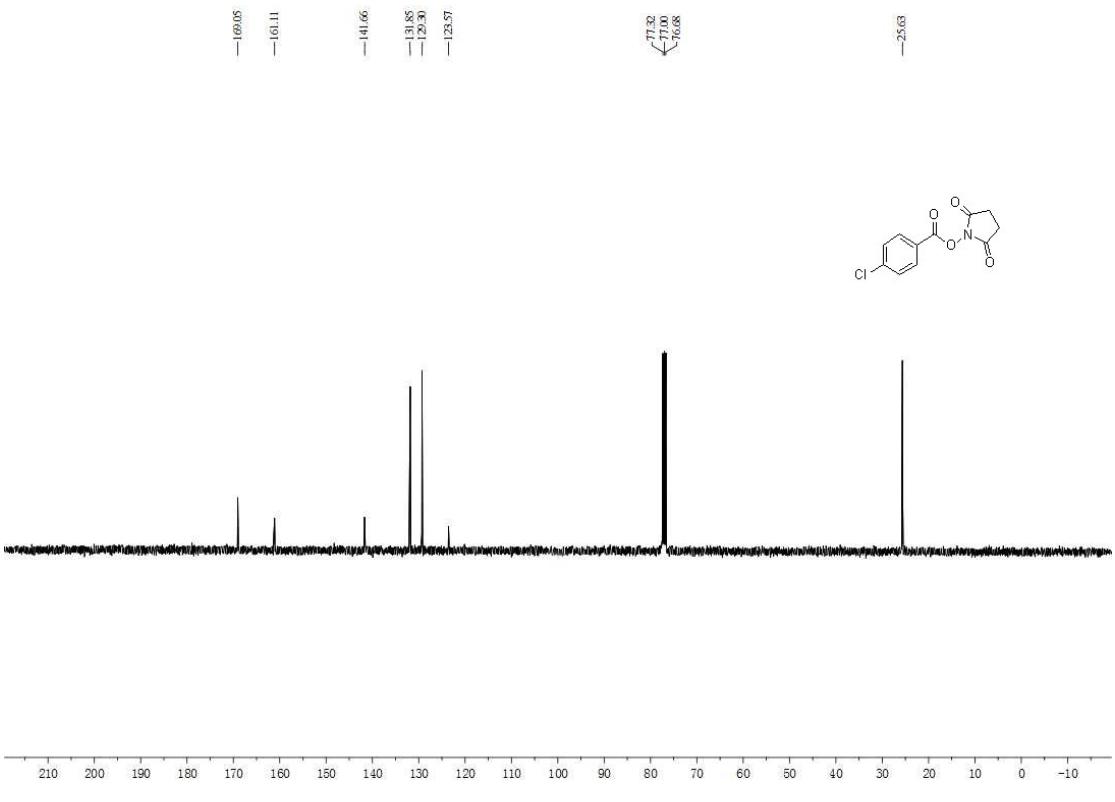
Product 5f


7.741
7.722
7.602
7.425
7.406
7.386
7.220
7.216
7.214
7.212
7.198
7.193
7.191
3.848
2.891
0.99
0.92
0.99
0.95
3.01
4.00
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

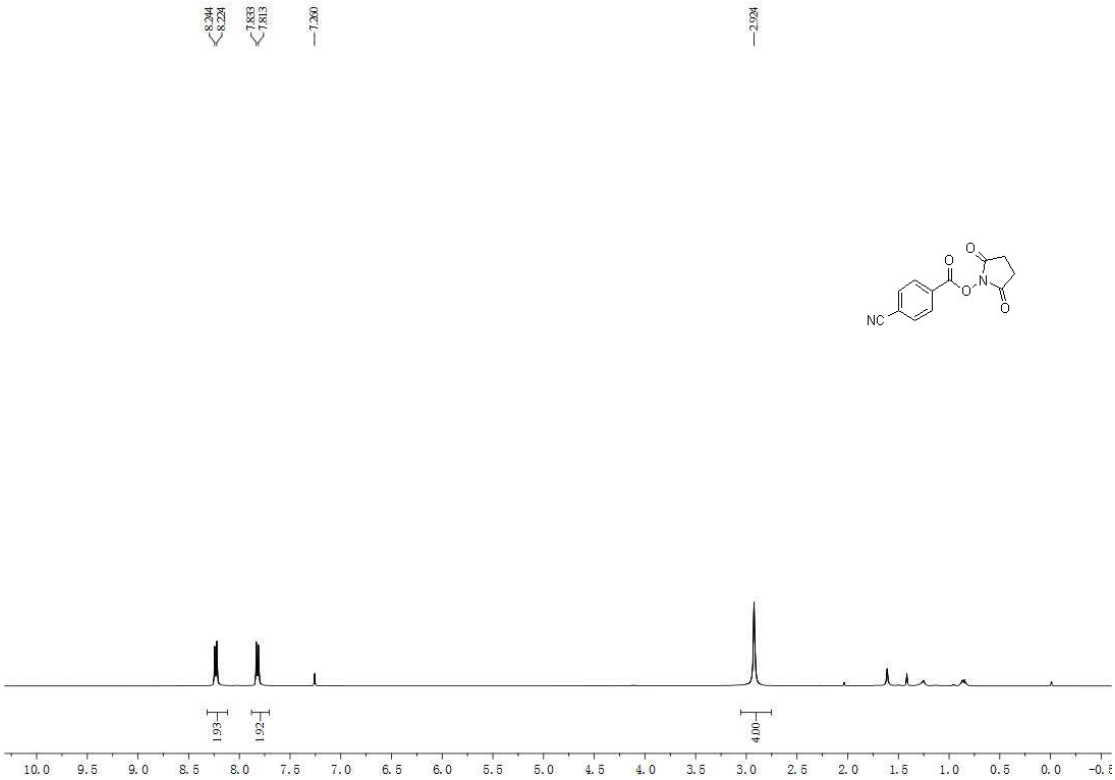

169.18
161.77
159.70
129.88
126.20
122.95
121.63
114.62
77.32
77.00
76.68
55.50
25.63
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

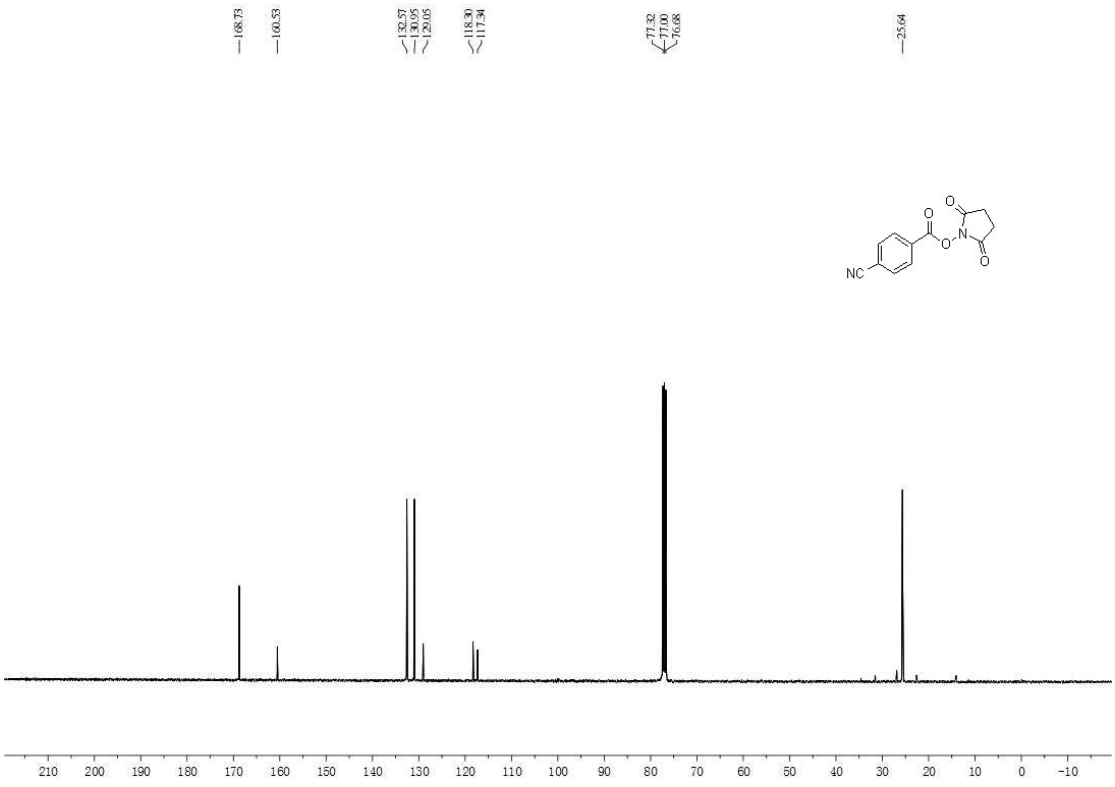
Product 5g


8.075
8.053
7.501
7.480
7.200
2.899
Cl
1.88
1.88
4.00

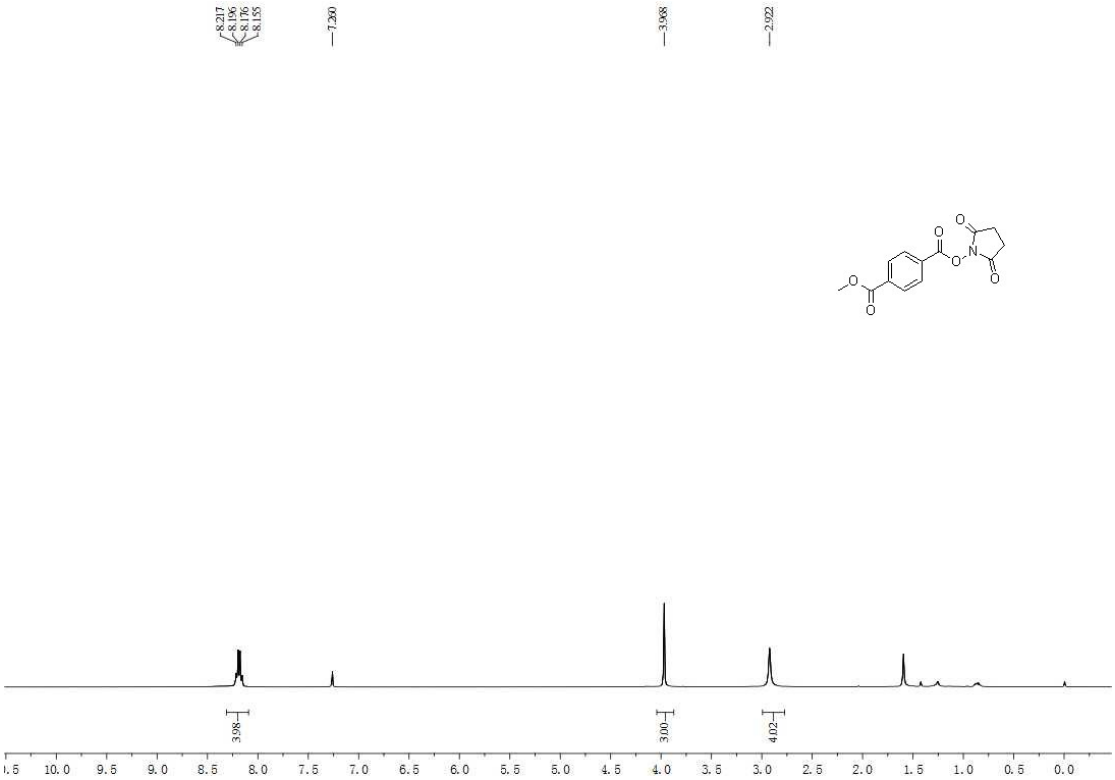

169.05
161.11
141.66
131.85
129.30
123.57
77.32
77.00
76.68
25.63
Cl

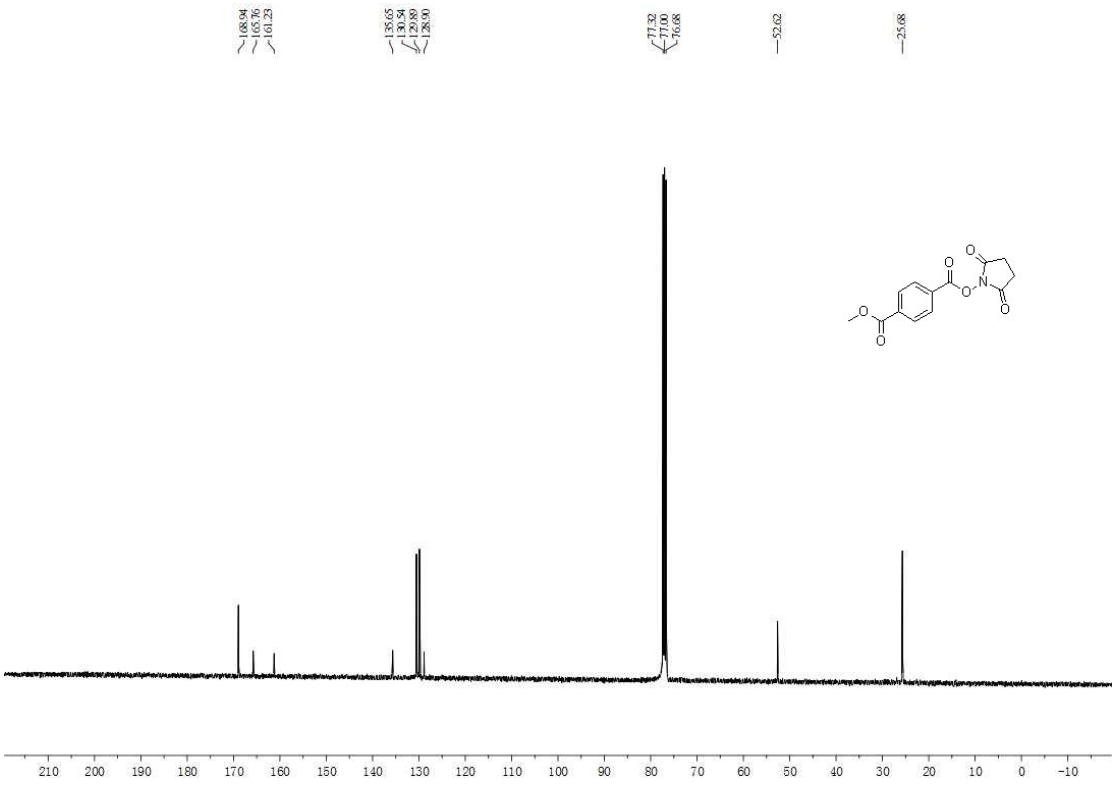
Product 5h


8.244
8.224
7.833
7.813
7.260
2.924
NC
1.93
1.92
4.00
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

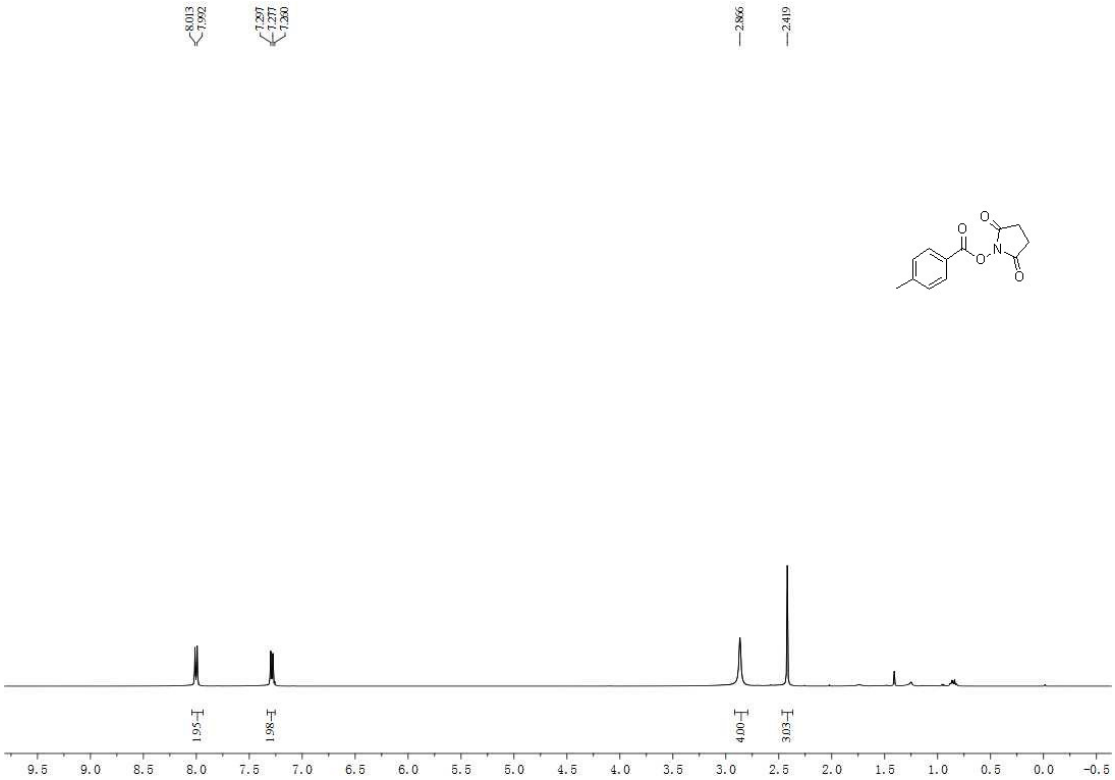

168.73
160.53
132.57
130.95
129.05
118.30
117.34
77.32
77.00
76.68
25.64
NC
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

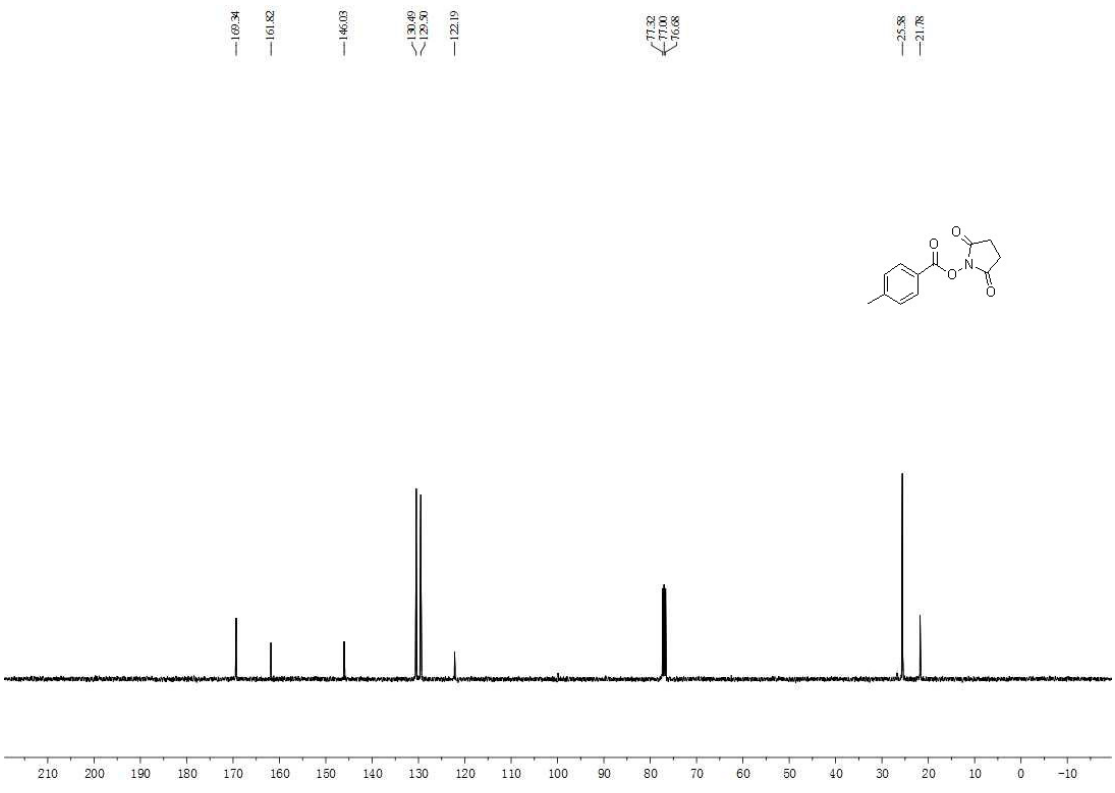
Product 5i


8.217
8.196
8.176
8.155
7.260
3.968
2.922
3.98
3.00
4.02

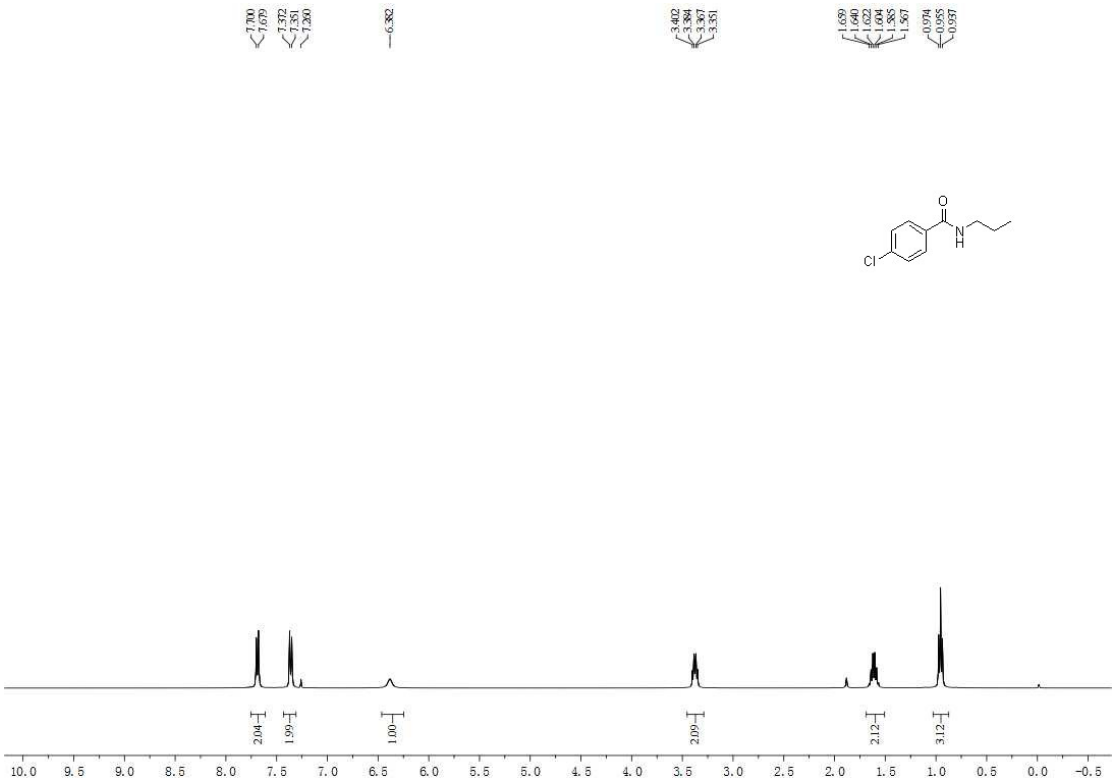

168.94
165.76
161.23
135.65
130.54
129.89
128.90
77.32
77.00
76.68
52.62
25.68

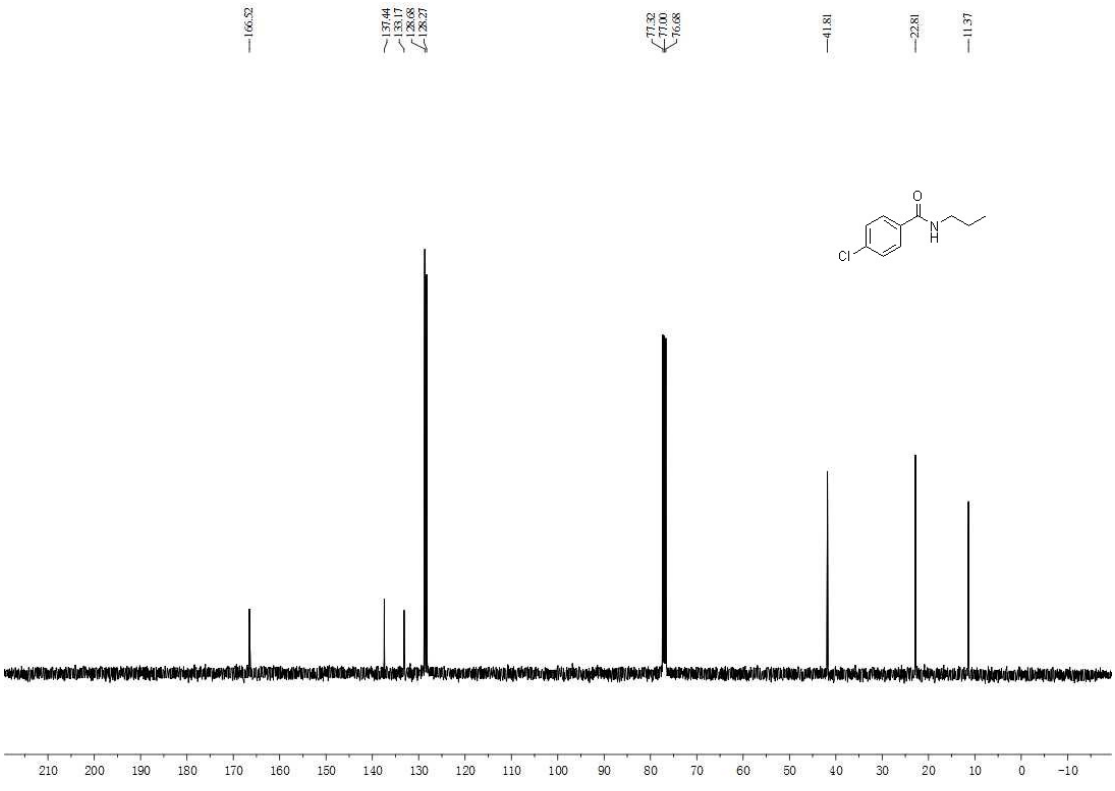
Product 5j


8.013
7.992
7.297
7.277
7.260
2.866
2.419
1.95
1.98
4.00
3.03
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

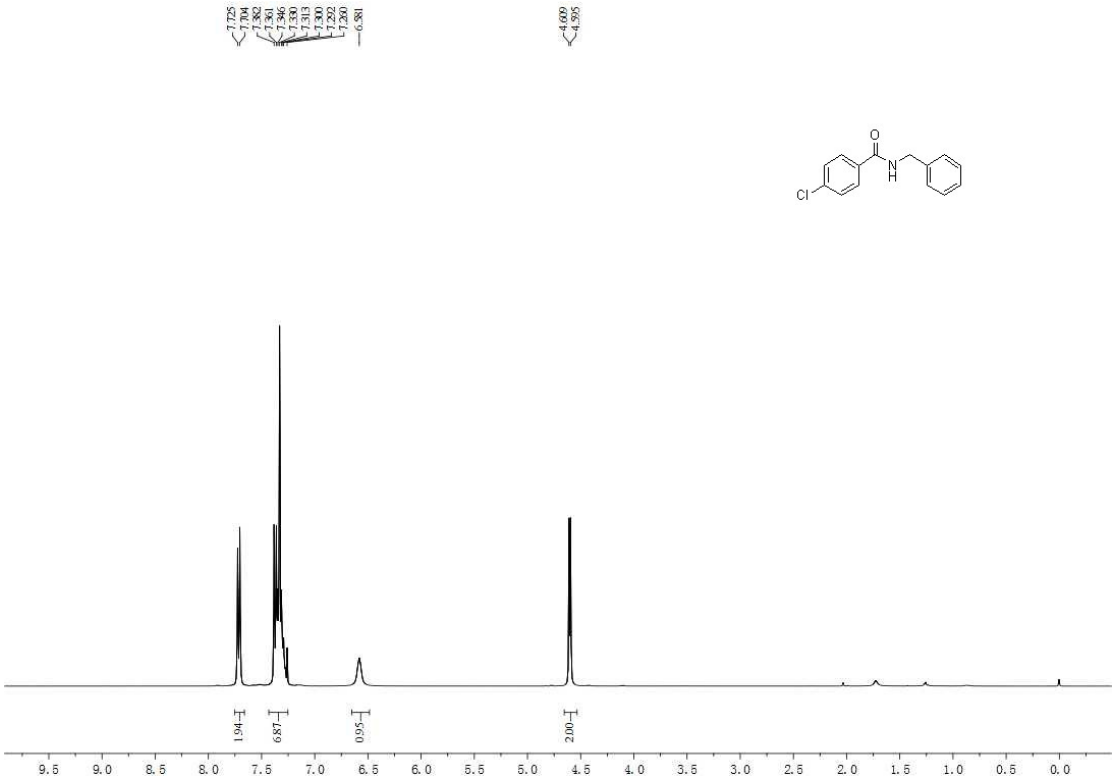

169.34
161.82
146.03
130.49
129.50
122.19
77.32
77.00
76.68
25.58
21.78
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

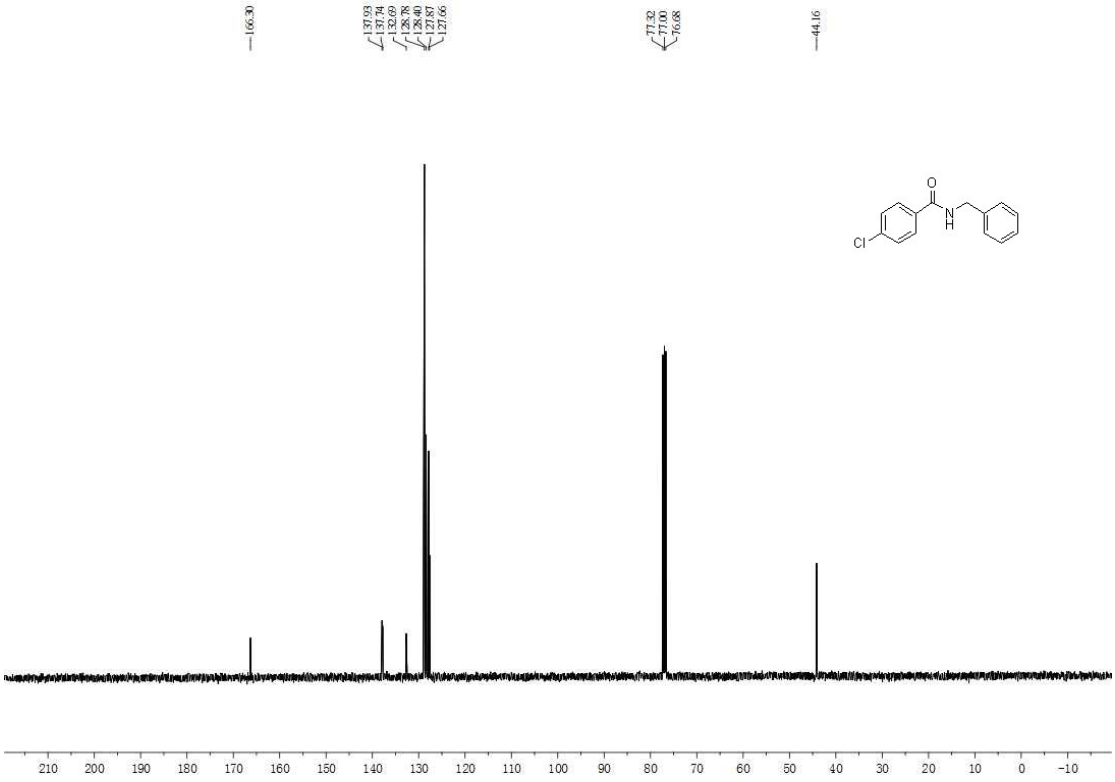
Product 7a


7.700
7.679
7.372
7.351
7.200
6.382
3.402
3.384
3.367
3.351
1.650
1.640
1.622
1.604
1.585
1.567
0.974
0.955
0.937
O
N
H
Cl
2.04
1.99
1.00
2.09
2.12
3.12
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

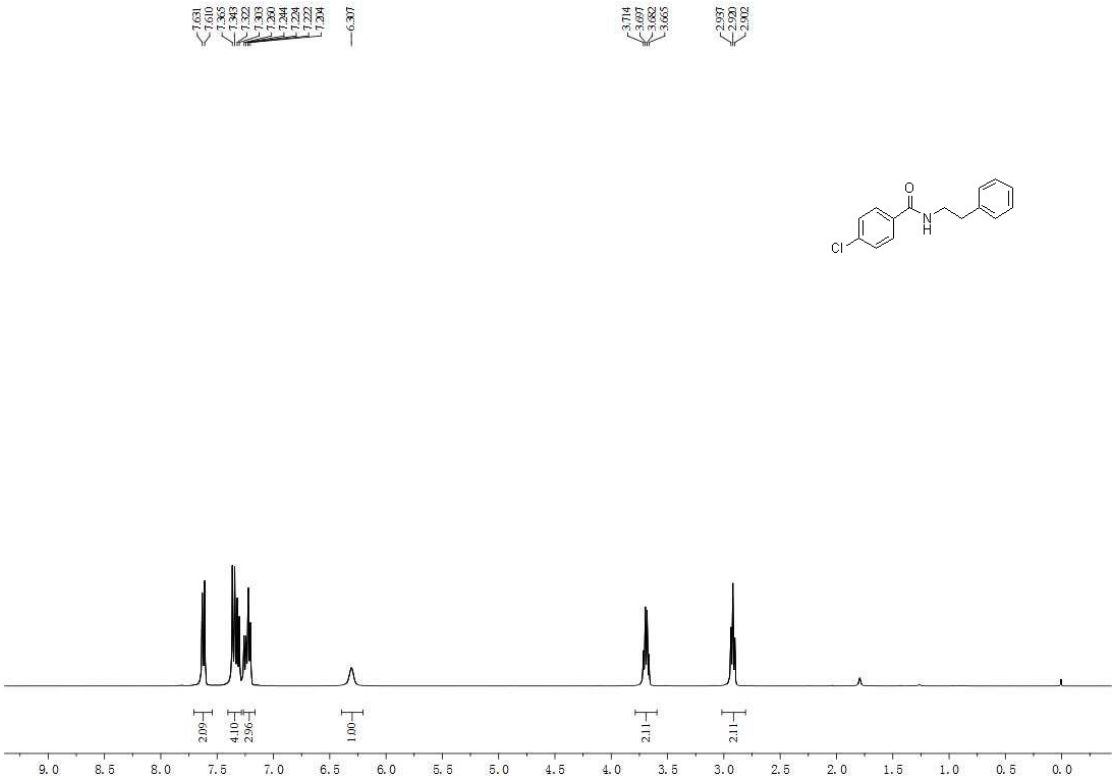

166.52
137.44
133.17
128.68
128.27
77.32
77.00
76.68
41.81
22.81
11.37
O
N
H
Cl
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

Product 7b


7.725
7.704
7.382
7.361
7.346
7.339
7.313
7.300
7.292
7.260
6.581
4.609
4.595
O
N
H
Cl
1.94
6.87
0.95
2.00
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


166.30
137.93
137.74
132.69
128.78
128.40
127.87
127.66
77.32
77.00
76.68
44.16
O
N
H
Cl
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

Product 7c


7.631
7.610
7.365
7.343
7.322
7.303
7.290
7.284
7.224
7.222
7.204
6.307
3.714
3.697
3.682
3.665
2.937
2.920
2.902
O
N
H
Cl
2.09
4.10
2.96
1.00
2.11
2.11
9.0
8.5
8.0
7.5
7.0
6.5
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3.5
3.0
2.5
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1.5
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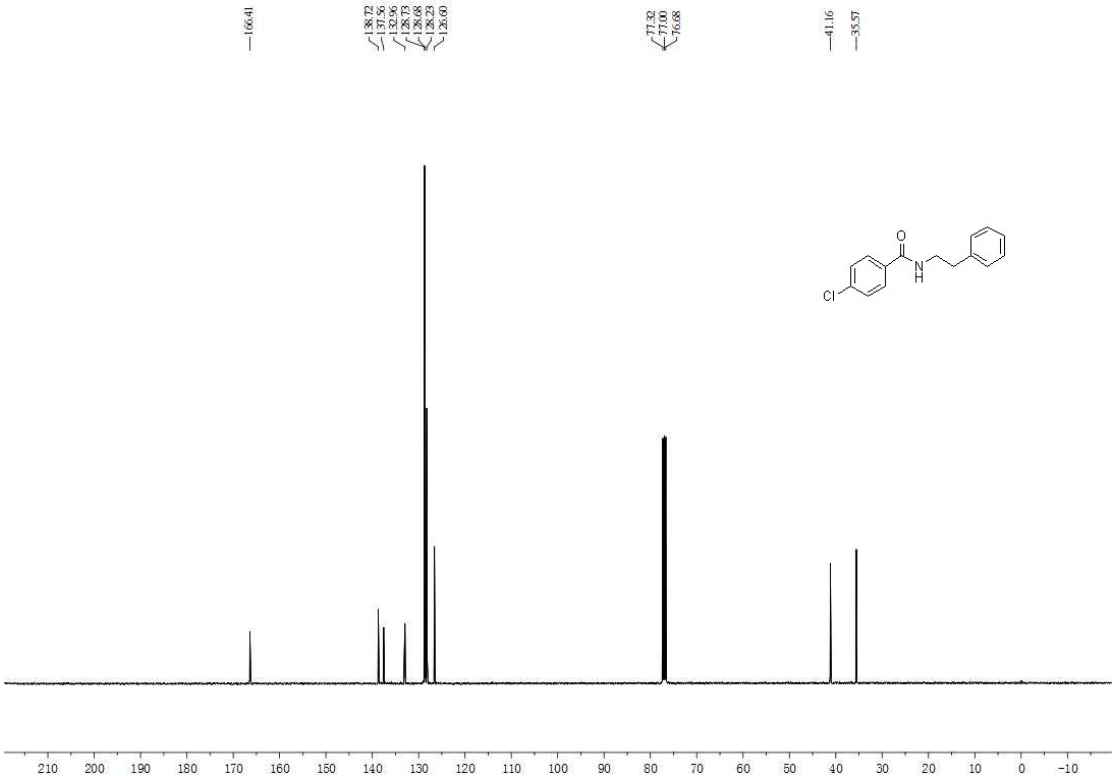
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138.72
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129.56
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128.23
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41.16
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210
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