

Supporting Information

Palladium-catalyzed Lewis acid-regulated cascade annulation of alkynes with unactivated alkenes to access diverse α -methylene - γ -lactones

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General methods

Melting points were measured using a melting point instrument and are uncorrected. ^1H and ^{13}C NMR spectra were recorded on a 400 MHz NMR spectrometer. The chemical shifts are referenced to signals at 7.24 and 77.0 ppm, respectively, and chloroform was used as a solvent with TMS as the internal standard. IR spectra were obtained with an infrared spectrometer on either potassium bromide pellets or liquid films between two potassium bromide pellets. GC-MS data were obtained using electron ionization. HRMS was carried out on a high-resolution mass spectrometer (LCMS-IT-TOF). TLC was performed using commercially available 100-400 mesh silica gel plates (GF₂₅₄). Unless otherwise noted, purchased chemicals were used without further purification.

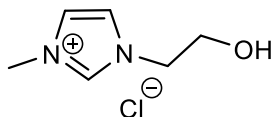
Typical procedure for the preparation of (*Z*)- α -methylene- γ -butyrolactone

A mixture of PdCl₂ (10 mol %), MgCl₂ (4 equiv) and CH₃CN (2 mL) was added to a tube equipped with a stir-bar. Then, alkynic acid (**1**, 0.2 mmol), and alkene (**2**, 0.3 mmol) were added to the tube under air and stirred at room temperature for 16 h. After the reaction was finished, the reaction was quenched by water and extracted with CH₂Cl₂ three times. The combined organic layers were dried over anhydrous Na₂SO₄ and evaporated under vacuum. The residue was purified by flash column chromatography on silica gel (hexanes/ethyl acetate: 20:1) to afford the desired products.

Typical procedure for the preparation of (*E*)- α -methylene- γ -butyrolactone

A mixture of PdCl₂ (10 mol %), AlCl₃ (6 equiv) and CH₃CN (2 mL) was added to a tube equipped with a stir-bar. Then, alkyne acid (**1**, 0.2 mmol), and alkene (**2**, 0.3 mmol) were added to the tube under air and stirred at 35 °C for 18 h. After the reaction was finished, the reaction was quenched by water and extracted with CH₂Cl₂ three times. The combined organic layers were dried over anhydrous Na₂SO₄ and evaporated under vacuum. The residue was purified by flash column chromatography on silica gel (hexanes/ethyl acetate: 20:1) to afford the desired products.

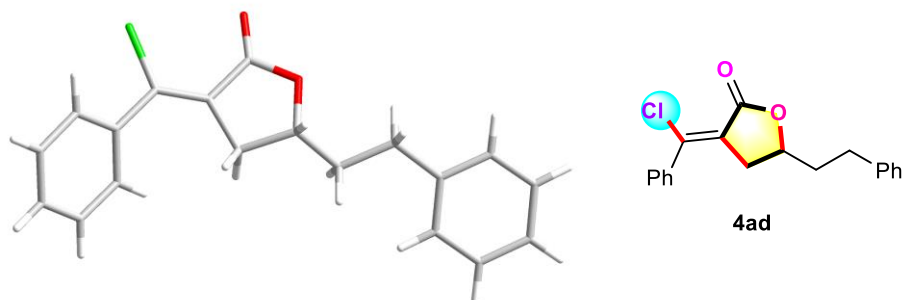
The structural formula of ionic liquid of [HOEMim]Cl



1-(2-Hydroxyethyl)-3-methylimidazolium Chloride

X-ray Crystallographic analysis for product 4ad

The CCDC number of the compound **4ad** is 2159530.

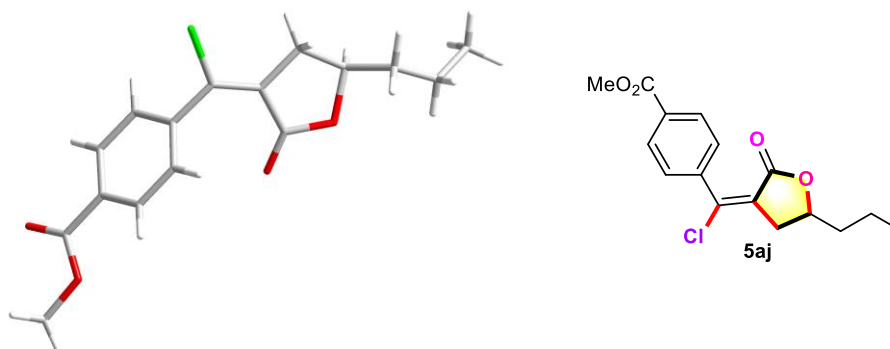


Crystal Data and Structure Refinement for Product **4ad**

Empirical formula	C ₁₉ H ₁₇ ClO ₂
Formula weight	312.77
Temperature	150(10) K
Wavelength	0.71073 Å
Crystal system	monoclinic
Space group	P2 ₁ /n
Unit cell dimensions	a = 20.2818(11) Å, α = 90.00°
	b = 7.3718(4) Å, β = 91.757(2)°
	c = 20.3050(13) Å, γ = 90.00°
Density (calculated)	1.369
Absorption coefficient	0.083
F(000)	1312
Crystal size	0.12 × 0.08 × 0.04
Theta range for data collection	4.014 to 52.786
Index ranges	-25 ≤ h ≤ 25, -9 ≤ k ≤ 8, -25 ≤ l ≤ 19
Reflections collected	21189
Independent reflections	6145
Completeness to theta = 29.55°	98.80%
Absorption correction	multi-scan
Refinement method	Full-matrix least-squares on F ²
Data/restraints/parameters	6145/0/398
Goodness-of-fit on F ²	1.055
Final R indices [I > 2σ(I)]	R1 = 0.0608, wR2 = 0.1219
R indices (all data)	R1 = 0.1110, wR2 = 0.1508

X-ray Crystallographic analysis for product **5aj**

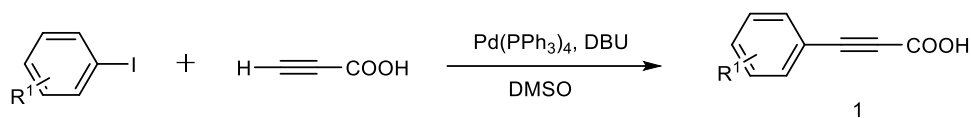
The CCDC number of the compound **5aj** is 2159532.



Crystal Data and Structure Refinement for Product **5aj**

Empirical formula	C ₁₆ H ₁₇ ClO ₄
Formula weight	308.74
Temperature	160(10) K
Wavelength	0.71073 Å
Crystal system	monoclinic
Space group	P2 ₁ /c
Unit cell dimensions	a = 5.6341(10) Å, α = 90.00°
	b = 30.099(5) Å, β = 96.992(6) °
	c = 9.1511(14) Å, γ = 90.00°
Density (calculated)	1.331
Absorption coefficient	0.083
F(000)	648
Crystal size	0.12 × 0.08 × 0.05
Theta range for data collection	4.684 to 52.208
Index ranges	-6 ≤ h ≤ 6, -36 ≤ k ≤ 37 -11 ≤ l ≤ 11
Reflections collected	17017
Independent reflections	3036
Completeness to theta = 29.55°	99.60%
Absorption correction	multi-scan
Refinement method	Full-matrix least-squares on F ²
Data/restraints/parameters	3036/0/210
Goodness-of-fit on F ²	1.043
Final R indices [I > 2σ(I)]	R1 = 0.0455, wR2 = 0.1003
R indices (all data)	R1 = 0.0702, wR2 = 0.1158

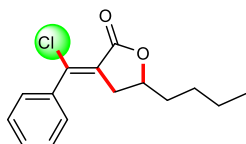
Procedure for the synthesis of 3-arylpropionic acids ^[1]



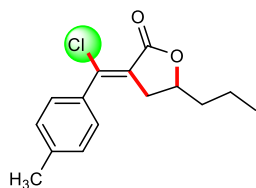
A 25-mL round bottom flask equipped with a magnetic stir bar was sequentially charged with aryl iodide (5.0 mmol), DBU (1.80 mL, 12 mmol), Pd(PPh₃)₄ (144.4 mg, 2.5 mol %) and DMSO (6 mL). A solution of propiolic acid (420 mg, 6.0 mmol) in DMSO (6 mL) was added into the flask. The mixture was stirred at room temperature for 12 h. After the reaction was complete, EtOAc (20 mL) was poured into the reaction mixture. The reaction mixture was extracted with saturated aqueous NaHCO₃ solution. The aqueous layer was separated, acidified to pH 2.0 by addition of cold HCl aqueous solution (1 N), and extracted with CH₂Cl₂. The combined organic layers were dried with anhydrous Na₂SO₄ and filtered, and the solvent was removed under reduced pressure. The resulting crude product was purified by column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 4:1, with 1% v/v HOAc) to afford 3-arylpropionic acids 1.

[1] Kyungho P, Thiruvengadam P, Ayoung P, Sunwoo L. *Tetrahedron Lett*, 2012, 53: 733-737.

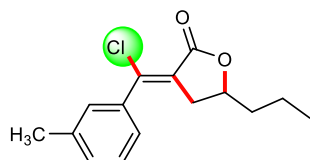
Characterization data for all products



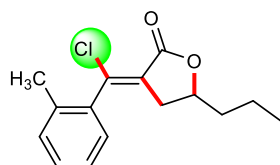
(Z)-5-Butyl-3-(chloro(phenyl)methylene)dihydrofuran-2(3H)-one (**3aa**): Yield: 83% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.56 - 7.47 (m, 2H), 7.49 - 7.41 (m, 3H), 4.55-4.30 (m, 1H), 3.12 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.72 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.82 - 1.64 (m, 1H), 1.62 - 1.51 (m, 1H), 1.52 - 1.32 (m, 2H), 0.94 (t, $J = 7.3$ Hz, 3H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 165.6, 162.2, 130.6, 130.5, 129.8, 129.4, 129.1, 129.0, 128.7, 128.5, 128.4, 128.2, 127.9, 127.0, 115.3 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2959, 2926, 2854, 1755, 1631, 1492, 1461; MS (EI) m/z 89, 115, 150, 179, 250; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{16}\text{ClO}_2$, $[\text{M} + \text{H}]^+$: 251.0834, found: 251.0833.



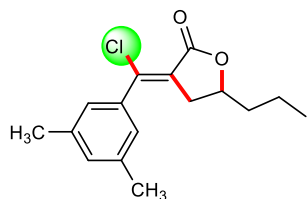
(Z)-3-(Chloro(*p*-tolyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ab**): Yield: 80% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.45 - 7.37 (m, 2H), 7.34 - 7.21 (m, 2H), 4.48 - 4.35 (m, 1H), 3.13 (dd, $J = 16.4, 7.2$ Hz, 1H), 2.73 (dd, $J = 16.4, 6.7$ Hz, 1H), 2.42 (s, 3H), 1.81 - 1.69 (m, 2H), 1.62 - 1.53 (m, 1H), 1.49 - 1.34 (m, 2H), 0.95 (t, $J = 7.2$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.7, 140.6, 139.7, 135.0, 129.2, 128.2, 122.3, 76.0, 38.0, 37.3, 21.4, 18.2, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2960, 2929, 2872, 1755, 1628, 1508, 1460; MS (EI) m/z 89, 115, 139, 164, 221, 264; HRMS-ESI (m/z): calcd for $\text{C}_{15}\text{H}_{18}\text{ClO}_2$, $[\text{M} + \text{H}]^+$: 265.0990, found: 265.0986.



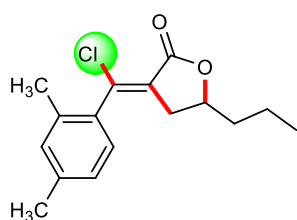
(*Z*)-3-(Chloro(*m*-tolyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ac**): Yield: 78% as a black oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.37 - 7.32 (m, 2H), 7.30 - 7.24 (m, 2H), 4.46 - 4.36 (m, 1H), 3.12 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.72 (dd, $J = 16.5, 6.7$ Hz, 1H), 2.42 (s, 3H), 1.81 - 1.68 (m, 1H), 1.61 - 1.55 (m, 1H), 1.51 - 1.39 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H). $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.6, 139.7, 138.5, 137.9, 130.9, 128.7, 128.4, 125.2, 122.8, 76.1, 38.0, 37.2, 21.4, 18.2, 13.9 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2958, 2925, 2855, 1755, 1630, 1460; MS (EI) m/z 89, 115, 139, 164, 221, 264; HRMS-ESI (m/z): calcd for $\text{C}_{15}\text{H}_{18}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 265.0990, found: 265.0986.



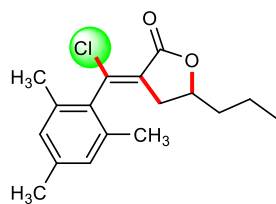
(*Z*)-3-(Chloro(*o*-tolyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ad**): Yield: 65% as a white solid; mp = 64.7-65.5 °C; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.50 - 7.41 (m, 5H), 4.49 - 4.38 (m, 1H), 3.11 (dd, $J = 16.5, 7.1$ Hz, 1H), 2.71 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.59 - 1.53 (m, 1H), 1.51 - 1.38 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.3, 138.1, 136.3, 136.2, 129.6, 128.9, 123.5, 76.0, 37.9, 37.2, 29.7, 18.2, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2958, 2922, 2851, 1752, 1629, 1590, 1488, 1462; MS (EI) m/z 81, 108, 115, 152, 183, 264; HRMS-ESI (m/z): calcd for $\text{C}_{15}\text{H}_{18}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 265.0990, found: 265.0986.



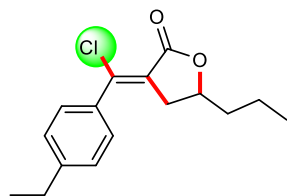
(Z)-3-(Chloro(3,5-dimethylphenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ae**): Yield: 76% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.08 (dd, $J = 10.1, 1.8$ Hz, 3H), 4.47 - 4.36 (m, 1H), 3.12 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.70 (dd, $J = 16.5, 6.7$ Hz, 1H), 2.37 (s, 6H), 1.78 - 1.66 (m, 1H), 1.62 - 1.55 (m, 1H), 1.53 - 1.37 (m, 2H), 0.95 (t, $J = 7.3$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.7, 139.8, 138.3, 137.9, 131.8, 125.8, 122.6, 76.1, 38.0, 37.2, 21.3, 18.2, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2961, 2872, 2736, 1748, 1631, 1600, 1463; MS (EI) m/z 77, 91, 115, 143, 178, 207, 278; HRMS-ESI (m/z): calcd for $\text{C}_{16}\text{H}_{20}\text{ClO}_2$ $[\text{M}+\text{H}]^+$: 279.1147, found 279.1144.



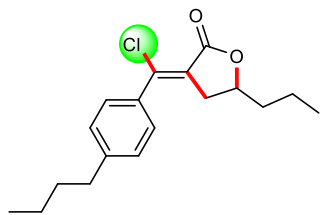
(Z)-3-(Chloro(2,4-dimethylphenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3af**): Yield: 63% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.12 - 7.01 (m, 3H), 4.57 (dd, $J = 7.5, 5.8$ Hz, 1H), 3.34 (dd, $J = 17.8, 7.9$ Hz, 1H), 2.84 (dd, $J = 17.8, 5.9$ Hz, 1H), 2.36 (s, 3H), 2.28 (s, 3H), 1.85 - 1.73 (m, 1H), 1.72 - 1.62 (m, 1H), 1.57 - 1.44 (m, 2H), 1.01 (t, $J = 7.3$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 165.9, 145.0, 139.7, 135.4, 133.0, 131.1, 128.30, 126.6, 76.0, 38.5, 35.9, 21.4, 19.2, 18.1, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2960, 2926, 2872, 1760, 1658, 1613, 1459; MS (EI) m/z 77, 91, 115, 128, 143, 208, 261, 278; HRMS-ESI (m/z): calcd for $\text{C}_{16}\text{H}_{20}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 279.1147, found 279.1143.



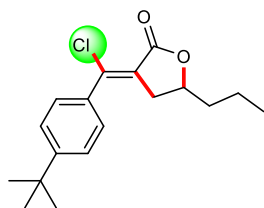
(Z)-3-(Chloro(mesityl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ag**): Yield: 62% as a yellow solid; mp = 73.0 - 73.6 °C; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 6.92 (s, 2H), 4.70 - 4.41 (m, 1H), 3.35 (dd, $J = 17.8, 8.0$ Hz, 1H), 2.86 (dd, $J = 17.8, 5.7$ Hz, 1H), 2.31 (s, 3H), 2.23 (s, 6H), 1.85 - 1.73 (m, 1H), 1.73 - 1.62 (m, 1H), 1.58 - 1.40 (m, 2H), 1.01 (t, $J = 7.3$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 165.7, 144.6, 139.1, 135.1, 135.1, 132.8, 128.5, 128.4, 126.4, 76.0, 38.6, 35.6, 21.27, 19.4, 19.4, 18.0, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2960, 2928, 2873, 1760, 1661, 1611, 1458; MS (EI) m/z 77, 91, 143, 157, 222, 257, 292; HRMS-ESI (m/z): calcd for $\text{C}_{17}\text{H}_{22}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 293.1303, found 293.1300.



(Z)-3-(Chloro(4-ethylphenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ah**): Yield: 83% as a black oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.44 (d, $J = 8.3$ Hz, 2H), 7.28 (d, $J = 8.1$ Hz, 2H), 4.49 - 4.34 (m, 1H), 3.14 (dd, $J = 16.4, 7.2$ Hz, 1H), 2.80 - 2.65 (m, 3H), 1.82 - 1.65 (m, 1H), 1.64 - 1.52 (m, 1H), 1.51 - 1.35 (m, 2H), 1.28 (t, $J = 7.6$ Hz, 3H), 0.95 (t, $J = 7.2$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.7, 146.8, 139.7, 135.2, 128.3, 128.0, 122.3, 76.0, 37.9, 37.3, 3.73, 18.2, 15.3, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2966, 2930, 2873, 1762, 1686, 1629, 1508, 1460; MS (EI) m/z 77, 115, 128, 143, 178, 235, 278; HRMS-ESI (m/z): calcd for $\text{C}_{16}\text{H}_{20}\text{ClO}_2$ $[\text{M}+\text{H}]^+$: 279.1147, found 279.1144.

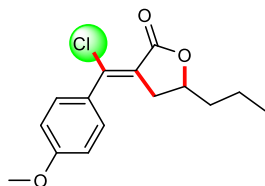


(*Z*)-3-((4-Butylphenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3ai**): Yield: 82% as a black oil; ^1H NMR (400 MHz, CDCl_3) δ 7.43 (d, $J = 8.1$ Hz, 2H), 7.25 (d, $J = 8.1$ Hz, 2H), 4.45 - 4.34 (m, 1H), 3.14 (dd, $J = 16.4, 7.2$ Hz, 1H), 2.74 (dd, $J = 16.5, 6.7$ Hz, 1H), 2.69 - 2.62 (m, 2H), 1.77 - 1.68 (m, 1H), 1.68 - 1.60 (m, 2H), 1.60 - 1.53 (m, 1H), 1.53 - 1.45 (m, 1H), 1.44 - 1.35 (m, 3H), 0.95 (t, $J = 7.3$ Hz, 6H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.8, 145.6, 139.7, 135.1, 128.5, 128.2, 122.3, 76.03, 38.0, 37.4, 35.5, 33.3, 22.4, 18.2, 13.9, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2959, 2931, 2870, 1758, 1628, 1508, 1462; MS (EI) m/z 91, 115, 128, 163, 206, 263, 306; HRMS-ESI (m/z): calcd for $\text{C}_{18}\text{H}_{24}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 307.1460, found 307.1457.

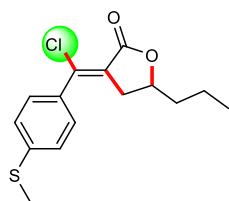


(*Z*)-3-((4-*tert*-Butylphenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3aj**): Yield: 79% as a white solid; mp = 179.0 - 179.8 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.46 (s, 4H), 4.50 - 4.35 (m, 1H), 3.17 (dd, $J = 16.4, 7.2$ Hz, 1H), 2.76 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.81 - 1.65 (m, 1H), 1.64 - 1.53 (m, 1H), 1.51 - 1.38 (m, 2H), 1.36 (s, 9H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 167.8, 153.7, 139.6, 134.9, 128.1, 125.5, 122.3, 76.0, 38.0, 37.4, 34.9, 31.2, 18.2, 13.8

ppm; $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 2962, 2931, 2871, 1757, 1628, 1508, 1463; MS (EI) m/z 91, 115, 141, 191, 291, 306; HRMS-ESI (m/z): calcd for $\text{C}_{18}\text{H}_{24}\text{ClO}_2$, $[\text{M}+\text{H}]^+$: 307.1460, found 307.1455.

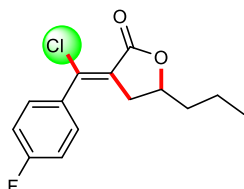


(Z)-3-(Chloro(4-methoxyphenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ak**): Yield: 68% as a white solid; mp = 74.1 - 74.5°C; ^1H NMR (400 MHz, CDCl_3) δ 7.53 - 7.45 (m, 2H), 7.03 - 6.91 (m, 2H), 4.45 - 4.32 (m, 1H), 3.88 (s, 3H), 3.15 (dd, $J = 16.3, 7.2$ Hz, 1H), 2.75 (dd, $J = 16.3, 6.7$ Hz, 1H), 1.78 - 1.69 (m, 1H), 1.61 - 1.54 (m, 1H), 1.53 - 1.36 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 167.9, 160.9, 139.5, 130.0, 121.5, 113.8, 76.0, 55.5, 38.0, 37.5, 29.7, 18.2, 13.8 ppm; $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 3482, 2958, 2925, 2853, 1753, 1628, 1604, 1509, 1462; MS (EI) m/z 77, 102, 145, 180, 237, 280; HRMS-ESI (m/z): calcd for $\text{C}_{15}\text{H}_{18}\text{ClO}_3$, $[\text{M}+\text{H}]^+$: 281.0939, found 281.0935.

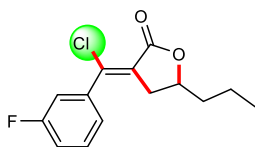


(Z)-3-(Chloro(4-(methylthio)phenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3al**) Yield: 81% as a yellow solid; mp = 87.9 - 88.3 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.44 (d, $J = 8.5$ Hz, 2H), 7.34 - 7.22 (m, 2H), 4.41 (q, $J = 7.0$ Hz, 1H), 3.14 (dd, $J = 16.4, 7.2$ Hz, 1H), 2.74 (dd, $J = 16.4, 6.7$ Hz, 1H), 2.54 (s, 3H), 1.81 - 1.68 (m, 1H), 1.62 - 1.53 (m, 1H), 1.53 - 1.37 (m, 2H), 0.95 (t, $J = 7.2$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.7, 142.2, 139.1, 133.9, 128.6, 125.4,

122.4, 76.0, 37.9, 37.4, 18.2, 15.1, 13.8 ppm; $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 2959, 2928, 2871, 1752, 1625, 1590, 1398; MS (EI) m/z 81, 115, 146, 161, 196, 253, 296; HRMS-ESI (m/z): calcd for $\text{C}_{15}\text{H}_{19}\text{ClO}_2\text{S}$, $[\text{M}+\text{H}]^+$: 297.0711, found 297.0710.

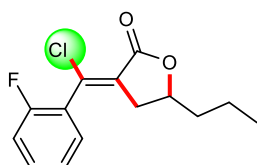


(*Z*)-3-(Chloro(4-fluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3am**): Yield: 79% as a yellow solid; mp = 49.3 - 49.6°C; ^1H NMR (400 MHz, CDCl_3) δ 7.56 - 7.47 (m, 2H), 7.14 (t, J = 8.5 Hz, 2H), 4.54 - 4.32 (m, 1H), 3.10 (dd, J = 16.5, 7.2 Hz, 1H), 2.71 (dd, J = 16.5, 6.7 Hz, 1H), 1.86 - 1.63 (m, 1H), 1.61 - 1.54 (m, 1H), 1.53 - 1.34 (m, 2H), 0.95 (t, J = 7.2 Hz, 3H) ^{13}C NMR (100 MHz, CDCl_3) δ 167.4, 163.4 (d, J = 252.1 Hz), 138.3, 133.9 (d, J = 3.5 Hz), 130.4 (d, J = 8.6 Hz), 123.2, 115.7 (d, J = 21.9 Hz), 76.0, 37.9, 37.2, 18.2, 13.7 ppm; $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 2962, 2934, 2874, 1756, 1632, 1600, 1506, 1462; MS (EI) m/z 89, 107, 133, 168, 225, 268; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{15}\text{ClFO}_2$ $[\text{M}+\text{H}]^+$: 269.0739, found: 269.0735

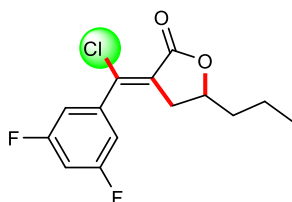


(*Z*)-3-(Chloro(3-fluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3an**): Yield: 78% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.44 (td, J = 8.0, 5.8 Hz, 1H), 7.28 (s, 1H), 7.25 - 7.21 (m, 1H), 7.21 - 7.11 (m, 1H), 4.53 - 4.36 (m, 1H), 3.13 (dd, J = 16.6, 7.2 Hz, 1H), 2.72 (dd, J = 16.6, 6.7 Hz, 1H), 1.79 - 1.70 (m, 1H), 1.57 - 1.51 (m, 1H), 1.50 - 1.37 (m, 2H), 0.97 (t, J = 7.3 Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.2, 161.2, 139.7, 130.3 (d, J = 8.4 Hz), 123.9 (d, J = 3.4

Hz), 117.2 (d, $J = 21.1$ Hz), 115.4 (d, $J = 23.1$ Hz), 76.1, 38.0, 37.1, 29.7, 18.2, 13.8 ppm;
 $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 2959, 2924, 2853, 1757, 1633, 1583, 1482, 1463; MS (EI) m/z 83, 107, 133, 168,
225, 268; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{15}\text{ClFO}_2$ $[\text{M}+\text{H}]^+$: 269.0739, found: 269.0735.

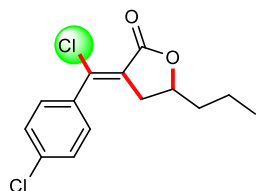


(*Z*)-3-(Chloro(2-fluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ao**): Yield: 78% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.56 - 7.37 (m, 2H), 7.35 - 7.19 (m, 1H), 7.15 (m, 1H), 4.61 - 4.32 (m, 1H), 2.91 (dd, $J = 16.9, 7.3$ Hz, 1H), 2.55 (dd, $J = 16.9, 6.6$ Hz, 1H), 1.93 - 1.64 (m, 1H), 1.59 - 1.52 (m, 1H), 1.52 - 1.36 (m, 2H), 0.94 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 166.9, 158.2 (d, $J = 251.8$ Hz), 132.7, 132.0 (d, $J = 8.5$ Hz), 130.1 (d, $J = 2.2$ Hz), 126.3, 125.7 (d, $J = 14.6$ Hz), 124.7 (d, $J = 3.7$ Hz), 116.3 (d, $J = 21.5$ Hz), 76.2, 38.0, 36.0, 36.0, 18.2, 13.7 ppm; $\nu_{\max}(\text{KBr})/\text{cm}^{-1}$ 2962, 2934, 2873, 1756, 1446, 1611, 1489, 1450; MS (EI) m/z 83, 107, 133, 168, 197, 225, 268; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{15}\text{ClFO}_2$ $[\text{M}+\text{H}]^+$: 269.0739, found: 269.0735.

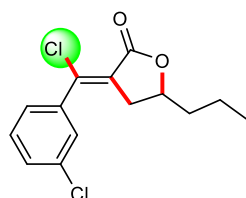


(*Z*)-3-(Chloro(3,5-difluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ap**): Yield: 79% as a yellow solid; mp = 82.8 - 83.3 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.10 - 7.01 (m, 2H), 6.96 - 6.85 (m, 1H), 4.54 - 4.30 (m, 1H), 3.13 (dd, $J = 16.7, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.7, 6.6$ Hz, 1H), 1.80 - 1.70

(m, 1H), 1.58 (ddd, $J = 19.0, 8.4, 4.8$ Hz, 1H), 1.53 - 1.36 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 166.9, 164.0 (d, $J = 12.8$ Hz), 161.5 (d, $J = 12.7$ Hz), 140.6 (t, $J = 9.7$ Hz), 136.3, 124.8, 111.6 (d, $J = 7.9$ Hz), 111.4 (d, $J = 7.9$ Hz), 105.7 (t, $J = 25.2$ Hz), 105.4, 76.1, 37.9, 37.0, 18.2, 13.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3092, 2965, 2931, 2880, 2861, 1757, 1640, 1592, 1434; MS (EI) m/z 75, 101, 125, 151, 186, 243, 286; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{14}\text{ClF}_2\text{O}_2$, $[\text{M}+\text{H}]^+$: 287.645, found 287.0641.

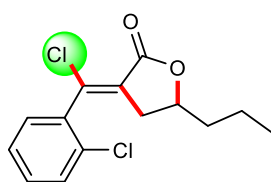


(*Z*)-3-(Chloro(4-chlorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3aq**): Yield: 80% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.49 - 7.42 (m, 4H), 4.53 - 4.36 (m, 1H), 3.11 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.78 - 1.71 (m, 1H), 1.59 - 1.53 (m, 1H), 1.50 - 1.38 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.3, 138.1, 136.3, 136.2, 129.6, 128.9, 123.5, 76.1, 37.9, 37.2, 29.7, 18.2, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2960, 2926, 2853, 1755, 1632, 1489, 1464; MS (EI) m/z 75, 114, 149, 183, 241, 284; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{15}\text{Cl}_2\text{O}_2$, $[\text{M}+\text{H}]^+$: 285.0444, found 285.0441.

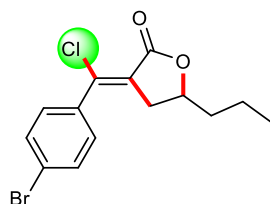


(*Z*)-3-(Chloro(3-chlorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ar**): Yield: 78% as a black oil; ^1H NMR (400 MHz, CDCl_3) δ 7.50 (s, 1H), 7.46 - 7.36 (m, 3H), 4.59 - 4.33 (m, 1H),

3.11 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.6, 6.6$ Hz, 1H), 1.78 - 1.69 (m, 1H), 1.59 - 1.52 (m, 1H), 1.51 - 1.36 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.2, 139.5, 137.6, 134.7, 130.3, 129.9, 128.2, 126.3, 124.1, 76.1, 38.0, 37.0, 29.7, 18.2, 13.8 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 2959, 2925, 2852, 1755, 1631, 1565, 1468; MS (EI) m/z 99, 114, 149, 184, 241, 284; HRMS-ESI (m/z): calcd for $\text{C}_{14}\text{H}_{15}\text{Cl}_2\text{O}_2$, $[\text{M}+\text{H}]^+$: 285.0444, found 285.0441.

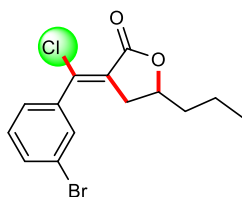


(*Z*)-3-(Chloro(2-chlorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3as**): Yield: 73% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.48 (q, $J = 3.4, 2.8$ Hz, 1H), 7.41 - 7.30 (m, 3H), 4.60 - 4.16 (m, 1H), 2.83 (ddd, $J = 54.6, 16.9, 7.3$ Hz, 1H), 2.42 (ddd, $J = 63.0, 17.0, 5.9$ Hz, 1H), 1.89 - 1.61 (m, 1H), 1.58 - 1.32 (m, 3H), 0.94 (t, $J = 7.1$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 166.9, 136.9, 136.0, 131.5, 131.0, 130.2, 129.3, 127.6, 125.9, 76.2, 38.1, 35.4, 18.1, 13.7 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 2962, 2934, 2837, 1759, 1654, 1469, 1433; MS (EI) m/z 75, 99, 114, 149, 184, 241, 284; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{Cl}_2\text{O}_2$, 285.0444, found 285.0440.

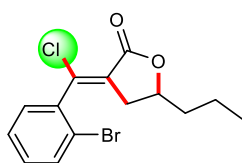


(*Z*)-3-((4-Bromophenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3at**): Yield: 78% as a yellow solid; mp = 81.2 - 81.6 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.64 - 7.55 (m, 2H), 7.44 - 7.33 (m, 2H), 4.49 - 4.39 (m, 1H), 3.10 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.70 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.78

- 1.69 (m, 1H), 1.61 - 1.53 (m, 1H), 1.53 - 1.38 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.3, 138.1, 136.8, 131.9, 129.7, 124.6, 123.6, 76.1, 38.0, 37.2, 29.7, 18.2, 13.8 ppm; IR (KBr) $_{\text{vmax}}/\text{cm}^{-1}$: 2958, 2924, 2853, 1752, 1631, 1485, 1460; MS (EI) m/z 97, 123, 164, 192, 220, 263, 328; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{BrClO}_2$, 328.9939, found, 328.9935.

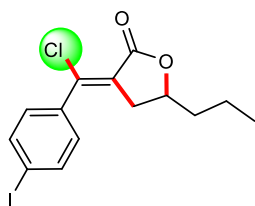


(*Z*)-3-((3-Bromophenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3au**): Yield: 76% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.65 (t, $J = 1.8$ Hz, 1H), 7.63 - 7.56 (m, 1H), 7.46 - 7.40 (m, 1H), 7.34 (t, $J = 7.9$ Hz, 1H), 4.52 - 4.36 (m, 1H), 3.11 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.6, 6.6$ Hz, 1H), 1.80 - 1.70 (m, 1H), 1.58 - 1.50 (m, 1H), 1.50 - 1.38 (m, 2H), 0.97 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 139.7, 137.5, 133.2, 131.2, 130.1, 126.7, 124.1, 122.6, 76.1, 38.0, 37.0, 29.7, 18.2, 13.8 ppm; IR (KBr) $_{\text{vmax}}/\text{cm}^{-1}$: 2959, 2923, 2852, 1756, 1633, 1559, 1467; MS (EI) m/z 88, 114, 150, 193, 230, 286, 328; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{BrClO}_2$, 328.9939, found, 328.9935.

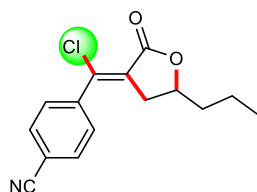


(*Z*)-3-((2-Bromophenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3av**): Yield: 75% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.67 (d, $J = 8.0$ Hz, 1H), 7.51 - 7.38 (m, 1H), 7.37 - 7.24 (m, 2H), 4.56 - 4.40 (m, 1H), 2.82 (dd, $J = 17.0, 7.5$ Hz, 1H), 2.41 (dd, $J = 17.0, 6.2$ Hz, 1H),

1.78 - 1.66 (m, 1H), 1.62 - 1.52 (m, 1H), 1.52 - 1.34 (m, 2H), 0.95 (t, $J = 6.8$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 166.9, 138.9, 137.5, 133.4, 131.0, 129.1, 128.2, 125.6, 120.8, 76.2, 38.1, 35.4, 18.2, 18.1, 13.8 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 2960, 2932, 2872, 1759, 1654, 1465, 1431; MS (EI) m/z 88, 115, 149, 193, 249; 287, 328; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{BrClO}_2$, 328.9939, found 328.9935.

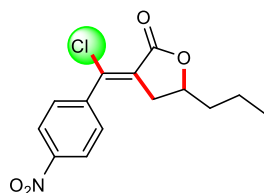


(*Z*)-3-(Chloro(4-iodophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3aw**): Yield: 83% as a yellow solid; mp = 85.3 - 85.8 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.82 - 7.74 (m, 2H), 7.24 (dd, $J = 8.5, 1.8$ Hz, 2H), 4.60 - 4.30 (m, 1H), 3.23 - 2.99 (m, 1H), 2.87 - 2.60 (m, 1H), 1.81 - 1.65 (m, 1H), 1.61 - 1.50 (m, 1H), 1.50 - 1.33 (m, 2H), 0.94 (q, $J = 7.1, 6.4$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.3, 138.2, 137.8, 137.3, 137.2, 129.8, 129.8, 123.6, 96.6, 76.1, 76.1, 37.9, 37.9, 37.1, 18.2, 13.8 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 2959, 2931, 2871, 1755, 1631, 1580, 1481, 1388; MS (EI) m/z 89, 115, 150, 178, 240; 275, 333, 376; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{ClIO}_2$, 376.9800, found 376.9793.

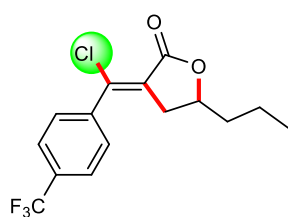


(*Z*)-4-(Chloro(2-oxo-5-propyldihydrofuran-3(2H)-ylidene)methyl)benzonitrile (**3ax**): Yield: 82% as a yellow solid; mp = 132.0 - 132.5 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.88 - 7.73 (m, 2H), 7.72

- 7.59 (m, 2H), 4.60 - 4.38 (m, 1H), 3.09 (dd, $J = 16.7, 7.1$ Hz, 1H), 2.70 (dd, $J = 16.7, 6.6$ Hz, 1H), 1.78 - 1.70 (m, 1H), 1.60 - 1.53 (m, 1H), 1.52 - 1.38 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 166.8, 142.0, 136.8, 132.5, 128.9, 125.2, 117.9, 113.9, 76.1, 37.9, 37.0, 29.7, 18.2, 13.7 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 2960, 2926, 2854, 2230, 1755, 1633, 1502, 1463; MS (EI) m/z 87, 113, 140, 175, 232; 275; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{15}\text{ClNO}_2$, 276.0786, found 276.0782.

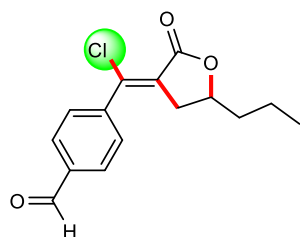


(*Z*)-3-(Chloro(4-nitrophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3ay**): Yield: 68% as a yellow solid; mp = 134.2 - 134.8°C; ^1H NMR (400 MHz, CDCl_3) δ 8.46 - 8.24 (m, 2H), 7.86 - 7.61 (m, 2H), 4.56 - 4.34 (m, 1H), 3.10 (dd, $J = 16.7, 7.1$ Hz, 1H), 2.72 (dd, $J = 16.7, 6.6$ Hz, 1H), 1.79 - 1.70 (m, 1H), 1.61 - 1.53 (m, 1H), 1.53 - 1.38 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 166.7, 148.3, 143.7, 136.4, 129.3, 125.5, 123.9, 76.2, 37.9, 37.0, 18.2, 13.7 ppm; IR (KBr) $_{\text{vmax/cm}^{-1}}$: 3080, 2957, 2924, 2854, 1752, 1635, 1599, 1462; MS (EI) m/z 88, 115, 150, 178, 195, 252; 295; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{ClNO}_4$, 296.0684, found 296.0681.

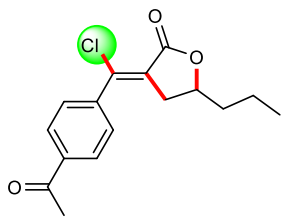


(*Z*)-3-(Chloro(4-(trifluoromethyl)phenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**3az**): Yield:

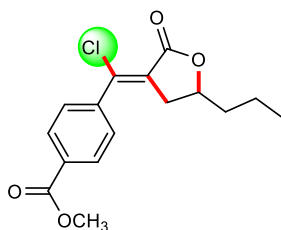
79% as a yellow solid; mp = 62.4 - 62.9°C; ¹H NMR (400 MHz, CDCl₃) δ 7.73 (d, *J* = 8.3 Hz, 2H), 7.63 (d, *J* = 8.2 Hz, 2H), 4.60 - 4.35 (m, 1H), 3.10 (dd, *J* = 16.6, 7.2 Hz, 1H), 2.71 (dd, *J* = 16.6, 6.6 Hz, 1H), 1.79 - 1.70 (m, 1H), 1.61 - 1.53 (m, 1H), 1.52 - 1.38 (m, 2H), 0.96 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.0, 141.2, 137.5, 132.1, 131.8, 128.6, 125.7, 125.7, 124.9, 124.6, 76.1, 37.9, 37.0, 18.2, 13.7 ppm; ν_{max}(KBr)/cm⁻¹ 2963, 2933, 2875, 1758, 1636, 1616, 1464; MS (EI) *m/z* 55, 133, 183, 218, 275; 318; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₅H₁₅ClF₃O₂, 319.0707, found 319.0703.



(Z)-4-(Chloro(2-oxo-5-propyldihydrofuran-3(2H)-ylidene)methyl)benzaldehyde (**3ba**): Yield: 81% as a yellow oil; ¹H NMR (400 MHz, CDCl₃) δ 10.09 (s, 1H), 7.98 (d, *J* = 8.3 Hz, 2H), 7.68 (d, *J* = 8.3 Hz, 2H), 4.63 - 4.24 (m, 1H), 3.11 (dd, *J* = 16.7, 7.1 Hz, 1H), 2.73 (dd, *J* = 16.7, 6.7 Hz, 1H), 1.79 - 1.70 (m, 1H), 1.63 - 1.54 (m, 1H), 1.54 - 1.39 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 191.2, 167.1, 143.2, 137.6, 137.0, 129.8, 128.9, 124.8, 76.2, 37.9, 37.1, 29.7, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3060, 2961, 2930, 2872, 1754, 1634, 1605, 1570, 1464; MS (EI) *m/z* 89, 115, 143, 178, 235; 278; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₅H₁₆ClO₃, 279.0783, found 279.0779.

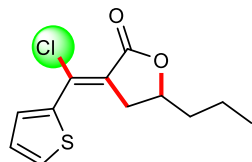


(Z)-3-((4-Acetylphenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**3bb**): Yield: 74% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.04 (d, $J = 8.3$ Hz, 2H), 7.61 (d, $J = 8.4$ Hz, 2H), 4.71 - 4.26 (m, 1H), 3.11 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.72 (dd, $J = 16.6, 6.6$ Hz, 1H), 2.66 (s, 3H), 1.79 - 1.69 (m, 1H), 1.61 - 1.53 (m, 1H), 1.52 - 1.38 (m, 2H), 1.06 - 0.91 (m, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 197.1, 167.1, 142.0, 138.0, 137.9, 128.5, 128.5, 124.4, 76.1, 37.9, 37.1, 29.7, 26.7, 18.2, 13.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3357, 3058, 2925, 2855, 1755, 1687, 1631, 1563, 1463; MS (EI) m/z 88, 114, 149, 177, 249, 277, 292; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{16}\text{H}_{18}\text{ClO}_3$, 293.0939, found 293.0934.

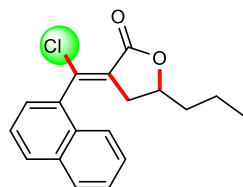


Methyl-(Z)-4-(chloro(2-oxo-5-propyldihydrofuran-3(2H)-ylidene)methyl)benzoate (**3bc**): Yield: 86% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 8.11 (d, $J = 7.1$ Hz, 2H), 7.58 (d, $J = 8.1$ Hz, 2H), 4.43 (p, $J = 6.7$ Hz, 1H), 4.04 - 3.88 (m, 3H), 3.10 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.6, 6.6$ Hz, 1H), 1.77 - 1.67 (m, 1H), 1.57 (tt, $J = 13.5, 5.5$ Hz, 1H), 1.53 - 1.35 (m, 2H), 0.95 (t, $J = 7.2$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.2, 166.1, 141.9, 138.0, 131.5, 129.8, 128.2, 124.3, 76.1, 52.5, 37.9, 37.1, 18.2, 13.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2959, 2874, 1758, 1634, 1609, 1568, 1436; MS (EI) m/z 89, 115, 149, 177, 208, 265; 308; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for

C₁₆H₁₈ClO₄, 309.0888, found 309.0882.

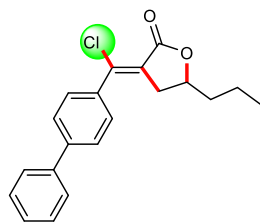


(Z)-3-(Chloro(thiophen-2-yl)methylene)-5-propyldihydrofuran-2(3H)-one (**3bd**): Yield: 71% as a yellow oil; ¹H NMR (400 MHz, CDCl₃) δ 7.62 (d, *J* = 4.9 Hz, 2H), 7.19 (dd, *J* = 4.9, 4.1 Hz, 1H), 4.63 - 4.46 (m, 1H), 3.41 (dd, *J* = 17.1, 7.7 Hz, 1H), 2.90 (dd, *J* = 17.1, 5.9 Hz, 1H), 1.81 - 1.73 (m, 1H), 1.69 - 1.63 (m, 1H), 1.59 - 1.42 (m, 2H), 0.99 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.9, 140.7, 132.9, 131.6, 130.7, 127.9, 119.1, 75.5, 38.4, 37.8, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3107, 2959, 2959, 2871, 1748, 1598, 1462; MS (EI) *m/z* 77, 121, 156, 185, 213, 256; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₂H₁₄ClO₂S, 257.0398, found 257.0393.

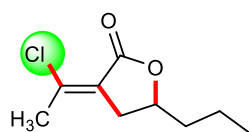


(Z)-3-(Chloro(naphthalen-1-yl)methylene)-5-propyldihydrofuran-2(3H)-one (**3be**): Yield: 77% as a yellow oil; ¹H NMR (400 MHz, CDCl₃) δ 7.99 - 7.96 (m, 1H), 7.94 - 7.87 (m, 3H), 7.63 - 7.54 (m, 3H), 4.49 - 4.36 (m, 1H), 3.18 (dd, *J* = 16.5, 7.2 Hz, 1H), 2.79 (dd, *J* = 16.5, 6.7 Hz, 1H), 1.80 - 1.70 (m, 1H), 1.62 - 1.52 (m, 1H), 1.52 - 1.35 (m, 2H), 0.95 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.6, 139.5, 135.1, 133.7, 132.5, 128.6, 128.5, 128.3, 127.8, 127.8, 127.1, 124.9, 123.3, 76.1, 38.0, 37.3, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3057, 2960, 2932, 2872, 1755, 1629, 1504, 1463; MS (EI) *m/z* 83, 165, 179, 200, 257, 300; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for

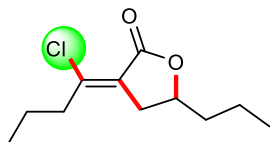
C₁₈H₁₈ClO₂, 301.0990, found 301.0986.



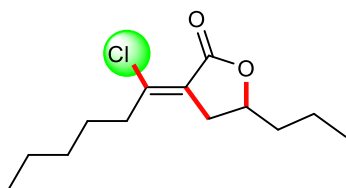
(Z)-3-([1,1'-Biphenyl]-4-ylchloromethylene)-5-propyldihydrofuran-2(3H)-one (**3bf**): Yield: 80% as a yellow solid; mp = 140.0 - 140.5 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.71 - 7.66 (m, 2H), 7.66 - 7.57 (m, 4H), 7.54 - 7.47 (m, 2H), 7.47 - 7.38 (m, 1H), 4.54 - 4.31 (m, 1H), 3.20 (dd, *J* = 16.5, 7.2 Hz, 1H), 2.80 (dd, *J* = 16.5, 6.7 Hz, 1H), 1.80 - 1.71 (m, 1H), 1.64 - 1.55 (m, 1H), 1.55 - 1.39 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.6, 143.1, 139.8, 139.2, 136.6, 129.0, 128.8, 128.1, 127.2, 122.9, 76.1, 38.0, 37.4, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 2957, 2927, 2870, 1739, 1617, 1485, 1463; MS (EI) *m/z* 95, 152, 165, 191, 226, 283, 326; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₂₀H₂₀ClO₂, 327.1147, found 327.1141.



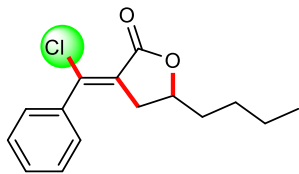
(Z)-3-(1-Chloroethylidene)-5-propyldihydrofuran-2(3H)-one (**3bg**): Yield: 92% as a yellow oil; ¹H NMR (400 MHz, CDCl₃) δ 4.50 - 4.41 (m, 1H), 3.18 - 3.01 (m, 1H), 2.68 - 2.49 (m, 1H), 2.26 (t, *J* = 1.7 Hz, 3H), 1.77 - 1.65 (m, 1H), 1.63 - 1.52 (m, 1H), 1.52 - 1.38 (m, 2H), 0.96 (d, *J* = 14.5 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.0, 139.5, 121.3, 75.5, 38.4, 34.8, 26.4, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 2961, 2933, 2873, 2859, 1757, 1655, 1436, 1379; MS (EI) *m/z* 67, 88, 93, 109, 137, 145, 188; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₉H₁₄ClO₂, 189.0677, found 189.0676.



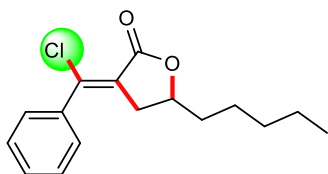
(Z)-3-(1-Chlorobutylidene)-5-propyldihydrofuran-2(3H)-one (**3bh**): Yield: 88% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 4.52 - 4.36 (m, 1H), 3.10 (dd, $J = 16.3, 7.8$ Hz, 1H), 2.60 (dd, $J = 16.3, 6.3$ Hz, 1H), 2.43 (t, $J = 7.3$ Hz, 2H), 1.84 - 1.65 (m, 4H), 1.63 - 1.54 (m, 1H), 1.52 - 1.44 (m, 1H), 1.15 - 0.65 (m, 6H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.1, 144.2, 121.2, 75.5, 40.9, 38.3, 34.8, 20.2, 18.2, 13.8, 13.3 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2962, 2873, 1758, 1645, 1457, 1348; MS (EI) m/z 81, 91, 109, 129, 145, 173, 216; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{11}\text{H}_{18}\text{ClO}_2$, 217.0990, found 217.0986.



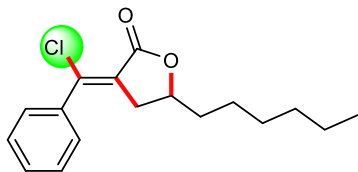
(Z)-3-(1-Chlorohexylidene)-5-propyldihydrofuran-2(3H)-one (**3bi**): Yield: 87% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 4.49 - 4.40 (m, 1H), 3.23 - 3.00 (m, 1H), 2.59 (dd, $J = 16.4, 6.3$ Hz, 1H), 2.44 (tt, $J = 7.5, 1.1$ Hz, 2H), 1.76 - 1.72 (m, 1H), 1.72 - 1.63 (m, 2H), 1.61 - 1.53 (m, 1H), 1.53 - 1.38 (m, 2H), 1.37 - 1.28 (m, 4H), 0.96 (t, $J = 7.3$ Hz, 3H), 0.91 (t, $J = 6.9$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.1, 144.5, 120.9, 75.5, 39.1, 38.3, 34.7, 30.9, 26.5, 22.4, 18.2, 13.9, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2959, 2931, 2869, 1758, 1648, 1462, 1151; MS (EI) m/z 80, 88, 117, 145, 153, 188, 244; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{13}\text{H}_{22}\text{ClO}_2$, 245.1303 found 245.1301.



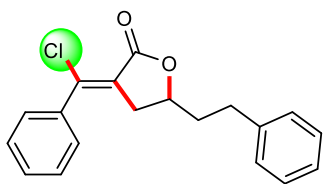
(Z)-5-Butyl-3-(chloro(phenyl)methylene)dihydrofuran-2(3H)-one (**4aa**): Yield: 78% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.54 - 7.49 (m, 2H), 7.48 - 7.41 (m, 3H), 4.47 - 4.30 (m, 1H), 3.12 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.73 (dd, $J = 16.6, 6.7$ Hz, 1H), 1.78 - 1.68 (m, 1H), 1.64 - 1.52 (m, 1H), 1.50 - 1.29 (m, 4H), 0.90 (t, $J = 7.0$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.6, 139.4, 137.8, 130.2, 128.6, 128.1, 123.1, 76.3, 37.2, 35.6, 27.0, 22.4, 13.9 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3060, 2958, 2930, 2859, 1757, 1631, 1491, 1465; MS (EI) m/z 89, 115, 150, 179, 207, 264; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{18}\text{ClO}_2$, 265.0990, found 265.0985.



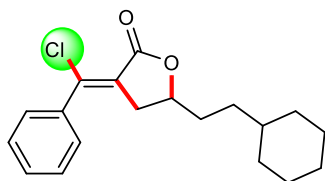
(Z)-3-(chloro(phenyl)methylene)-5-pentyldihydrofuran-2(3H)-one (**4ab**): Yield: 75% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.52 - 7.48 (m, 2H), 7.47 - 7.43 (m, 3H), 4.45 - 4.32 (m, 1H), 3.12 (dd, $J = 16.5, 7.1$ Hz, 1H), 2.72 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.78 - 1.69 (m, 1H), 1.64 - 1.52 (m, 1H), 1.42 - 1.23 (m, 6H), 0.89 (t, $J = 6.7$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.6, 139.4, 137.8, 130.2, 128.6, 128.2, 128.1, 123.1, 76.4, 37.2, 35.9, 31.4, 24.6, 22.5, 14.0 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3060, 2930, 2859, 1758, 1631, 1491, 1464; MS (EI) m/z 89, 115, 150, 179, 207, 278; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{16}\text{H}_{20}\text{ClO}_2$, 279.1147, found 279.1142.



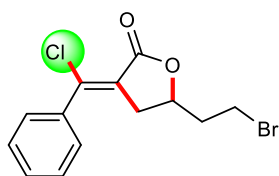
(Z)-3-(Chloro(phenyl)methylene)-5-hexyldihydrofuran-2(3H)-one (**4ac**): Yield: 72% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.53 - 7.48 (m, 2H), 7.48 - 7.43 (m, 3H), 4.44 - 4.35 (m, 1H), 3.12 (dd, $J = 16.5, 7.1$ Hz, 1H), 2.72 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.80 - 1.69 (m, 1H), 1.63 - 1.53 (m, 1H), 1.39 - 1.24 (m, 8H), 0.88 (t, $J = 6.4$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.6, 139.4, 137.9, 130.2, 128.6, 128.1, 123.1, 76.3, 37.2, 35.9, 31.6, 28.9, 24.8, 22.5, 14.0 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3060, 2929, 1857, 1759, 1631, 1491, 1464; MS (EI) m/z 95, 115, 150, 179, 207; 292; HRMS (ESI, m/z): $[\text{M}-\text{H}]^+$ Calcd. for $\text{C}_{17}\text{H}_{22}\text{ClO}_2$, 293.1303, found 293.1298.



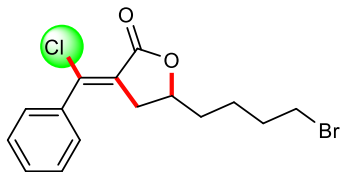
(Z)-3-(Chloro(phenyl)methylene)-5-phenethyldihydrofuran-2(3H)-one (**4ad**): Yield: 78% as a white solid; mp = 112.4 - 112.9 °C; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.53 - 7.48 (m, 2H), 7.48 - 7.42 (m, 3H), 7.34 - 7.27 (m, 2H), 7.25 - 7.12 (m, 3H), 4.45 - 4.31 (m, 1H), 3.11 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.93 - 2.79 (m, 1H), 2.79 - 2.69 (m, 2H), 2.12 - 2.01 (m, 1H), 1.98 - 1.84 (m, 1H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 167.5, 140.6, 139.7, 137.7, 130.3, 128.6, 128.5, 128.2, 126.3, 122.8, 75.3, 37.6, 37.1, 31.3 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3061, 3027, 2927, 2857, 1753, 1630, 1493, 1444; MS (EI) m/z 89, 115, 141, 179, 231, 276; 312; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{19}\text{H}_{18}\text{ClO}_2$, 313.0990, found 313.0984.



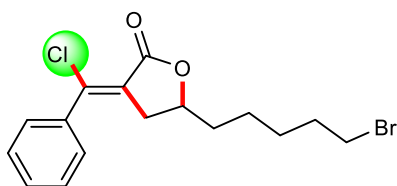
(Z)-3-(Chloro(phenyl)methylene)-5-(2-cyclohexylethyl)dihydrofuran-2(3H)-one (**4ae**): Yield: 81% as a black oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.56 - 7.49 (m, 2H), 7.48 - 7.42 (m, 3H), 4.58 - 4.46 (m, 1H), 3.13 (dd, $J = 16.4, 7.1$ Hz, 1H), 2.70 (dd, $J = 16.5, 6.8$ Hz, 1H), 1.82 - 1.60 (m, 8H), 1.45 - 1.33 (m, 1H), 1.31 - 1.06 (m, 4H), 1.04 - 0.82 (m, 2H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.6, 139.4, 137.9, 130.2, 128.6, 128.2, 123.0, 74.3, 43.9, 37.8, 33.9, 33.7, 32.8, 26.4, 26.1, 26.0; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3061, 2924, 2851, 1759, 1631, 1491, 1446; MS (EI) m/z 89, 115, 152, 179, 207, 276, 304; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{18}\text{H}_{22}\text{ClO}_2$, 305.1303, found 305.1297.



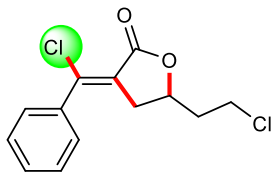
(Z)-5-(2-Bromoethyl)-3-(chloro(phenyl)methylene)dihydrofuran-2(3H)-one (**4af**): Yield: 82% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.53 - 7.48 (m, 2H), 7.48 - 7.43 (m, 3H), 4.70 - 4.60 (m, 1H), 3.58 - 3.47 (m, 2H), 3.22 (dd, $J = 16.6, 7.4$ Hz, 1H), 2.77 (dd, $J = 16.6, 6.6$ Hz, 1H), 2.31 - 2.20 (m, 1H), 2.15 - 2.05 (m, 1H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.0, 140.4, 137.6, 130.4, 128.7, 128.1, 122.1, 73.8, 38.8, 36.7, 28.3 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3059, 2928, 2853, 1755, 1630, 1577, 1490, 1442; MS (EI) m/z 89, 115, 150, 179, 207, 260, 314; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{13}\text{H}_{13}\text{BrClO}_2$, 314.97882, found 314.9776.



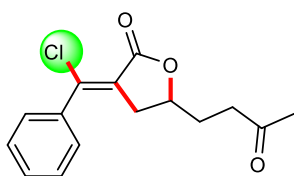
(Z)-5-(4-Bromobutyl)-3-(chloro(phenyl)methylene)dihydrofuran-2(3H)-one (**4ag**): Yield: 79% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.53 - 7.48 (m, 2H), 7.48 - 7.43 (m, 3H), 4.41 (qd, $J = 7.2, 4.8$ Hz, 1H), 3.41 (t, $J = 6.6$ Hz, 2H), 3.14 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.74 (dd, $J = 16.6, 6.7$ Hz, 1H), 1.90 (p, $J = 6.9$ Hz, 2H), 1.81 - 1.71 (m, 1H), 1.69 - 1.50 (m, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.4, 139.7, 137.8, 130.3, 128.6, 128.1, 122.7, 75.9, 37.1, 35.0, 33.3, 32.2, 23.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3059, 2938, 2864, 1750, 1631, 1577, 1491, 1440; MS (EI) m/z 89, 115, 150, 179, 207, 262, 342; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{17}\text{BrClO}_2$, 343.0095, found 343.0090.



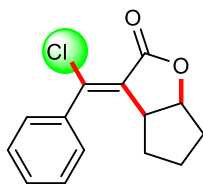
(Z)-5-(5-Bromopentyl)-3-(chloro(phenyl)methylene)dihydrofuran-2(3H)-one (**4ah**): Yield: 81% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.65 - 7.39 (m, 2H), 4.63 - 4.09 (m, 3H), 3.40 (t, $J = 6.7$ Hz, 1H), 3.13 (dd, $J = 16.6, 7.2$ Hz, 2H), 2.73 (dd, $J = 16.6, 6.7$ Hz, 1H), 1.93 - 1.82 (m, 1H), 1.81 - 1.68 (m, 2H), 1.68 - 1.56 (m, 1H), 1.56 - 1.36 (m, 4H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.5, 139.6, 137.8, 128.6, 128.1, 122.9, 76.1, 37.2, 35.7, 33.7, 32.5, 27.8, 24.2 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3059, 2935, 2860, 1748, 1631, 1577, 1491, 1441; MS (EI) m/z 89, 115, 150, 179, 207, 277, 356; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{16}\text{H}_{19}\text{BrClO}_2$, 357.0252, found 357.0246.



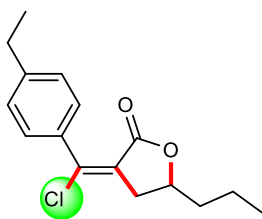
(Z)-3-(Chloro(phenyl)methylene)-5-(2-chloroethyl)dihydrofuran-2(3H)-one (**4ai**): Yield: 78% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.52 - 7.48 (m, 2H), 7.48 - 7.44 (m, 3H), 4.74 - 4.58 (m, 1H), 3.82 - 3.57 (m, 2H), 3.22 (dd, $J = 16.6, 7.3$ Hz, 1H), 2.78 (dd, $J = 16.6, 6.7$ Hz, 1H), 2.24 - 2.11 (m, 1H), 2.08 - 1.94 (m, 1H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 167.0, 140.4, 137.6, 130.4, 128.6, 128.1, 122.1, 72.9, 40.4, 38.7, 36.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3060, 2960, 2964, 2927, 1760, 1631, 1491; MS (EI) m/z 89, 115, 150, 207, 233, 269; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{13}\text{H}_{13}\text{Cl}_2\text{O}_2$, 270.0287, found 270.0284.



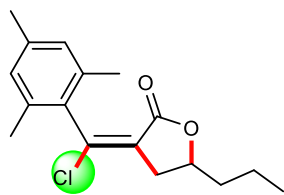
(Z)-3-(Chloro(phenyl)methylene)-5-(3-oxobutyl)dihydrofuran-2(3H)-one (**4aj**): Yield: 80% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.51 - 7.47 (m, 2H), 7.46 - 7.42 (m, 3H), 4.52 - 4.33 (m, 1H), 3.29 - 3.04 (m, 1H), 2.72 (dd, $J = 16.6, 6.4$ Hz, 1H), 2.66 (t, $J = 7.0$ Hz, 2H), 2.16 (d, $J = 1.9$ Hz, 3H), 2.03 - 1.92 (m, 1H), 1.86 - 1.75 (m, 1H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 207.3, 167.3, 139.9, 137.7, 130.3, 128.6, 128.1, 122.5, 75.2, 38.8, 37.1, 30.0, 29.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3061, 2925, 2853, 1754, 1709, 1631, 1491, 1441; MS (EI) m/z 89, 115, 155, 181, 217, 260, 278; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{16}\text{ClO}_3$, 279.0779, found 279.0778.



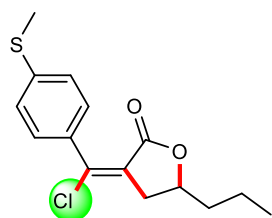
(*Z*)-3-(Chloro(phenyl)methylene)hexahydro-2H-cyclopenta[b]furan-2-one (**4ak**): Yield: 73% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.54 - 7.41 (m, 5H), 4.86 (dd, $J = 7.6, 3.3$ Hz, 1H), 3.61 - 3.42 (m, 1H), 2.15 - 2.01 (m, 1H), 1.83 - 1.59 (m, 5H); ^{13}C NMR (101 MHz, CDCl_3) δ 168.0, 140.5, 138.2, 129.9, 128.7, 128.7, 127.9, 82.0, 45.5, 34.0, 33.6, 23.5 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3067, 2962, 2869, 1754, 1628, 1459; MS (EI) m/z 89, 115, 155, 181, 217, 260, 248; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{14}\text{ClO}_2$, 249.0681, found 249.0672.



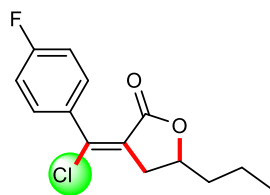
(*E*)-3-(Chloro(4-ethylphenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5aa**): Yield: 78% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.41 (d, $J = 8.3$ Hz, 2H), 7.21 (d, $J = 8.3$ Hz, 2H), 4.55 (tt, $J = 7.5, 5.8$ Hz, 1H), 3.31 (dd, $J = 17.9, 7.8$ Hz, 1H), 2.82 (dd, $J = 17.8, 6.1$ Hz, 1H), 2.68 (q, $J = 7.6$ Hz, 2H), 1.84 - 1.73 (m, 1H), 1.69 - 1.61 (m, 1H), 1.55 - 1.40 (m, 2H), 1.25 (t, $J = 7.6$ Hz, 3H), 0.98 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 166.2, 146.7, 145.9, 132.5, 129.2, 127.4, 123.6, 75.9, 38.5, 37.2, 28.8, 18.2, 15.1, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2963, 2931, 2872, 1756, 1639, 1507, 1459; MS (EI) m/z 77, 115, 143, 178, 235, 278; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{16}\text{H}_{20}\text{ClO}_2$, 279.1147, found 279.1145.



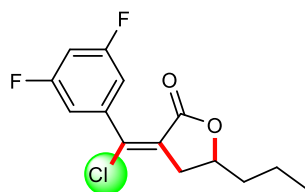
(*E*)-3-(Chloro(mesityl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ab**): Yield: 73% as a yellow solid; mp = 65.0 - 65.4 °C; ^1H NMR (400 MHz, CDCl_3) δ 6.91 (s, 2H), 4.71 - 4.49 (m, 1H), 3.35 (dd, $J = 17.8, 7.9$ Hz, 1H), 2.86 (dd, $J = 17.8, 5.7$ Hz, 1H), 2.31 (s, 2H), 2.23 (s, 6H), 1.84 - 1.73 (m, 1H), 1.73 - 1.64 (m, 1H), 1.56 - 1.43 (m, 2H), 1.01 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 165.7, 144.7, 139.1, 135.1, 135.1, 132.8, 128.5, 128.4, 126.4, 76.0, 38.6, 35.6, 29.7, 21.3, 19.4, 19.3, 18.0, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2925, 2863, 1760, 1661, 1610, 1453; MS (EI) m/z 77, 91, 143, 157, 222, 257, 292; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{17}\text{H}_{22}\text{ClO}_2$, 293.1303, found 293.1298.



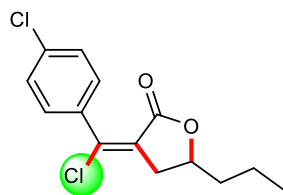
(*E*)-3-(Chloro(4-(methylthio)phenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ac**): Yield: 70% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.44 (d, $J = 8.5$ Hz, 2H), 7.24 (d, $J = 8.5$ Hz, 2H), 4.65 - 4.50 (m, 1H), 3.34 (dd, $J = 17.9, 7.8$ Hz, 1H), 2.84 (dd, $J = 17.9, 6.1$ Hz, 1H), 2.52 (s, 3H), 1.84 - 1.77 (m, 1H), 1.72 - 1.65 (m, 1H), 1.56 - 1.43 (m, 2H), 1.01 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 145.2, 142.0, 131.3, 129.7, 124.9, 123.7, 75.9, 38.5, 37.2, 29.7, 18.2, 15.1, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3356, 3206, 2921, 2852, 1750, 1636, 1589, 1461; MS (EI) m/z 80, 115, 146, 161, 196, 253, 296; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{18}\text{ClO}_2\text{S}$, 297.0711, found 297.0708.



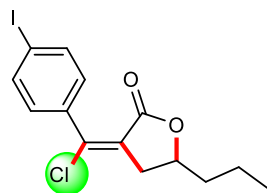
(*E*)-3-(Chloro(4-fluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ad**): Yield: 73% as a yellow solid; mp = 46.1 - 46.7°C; ¹H NMR (400 MHz, CDCl₃) δ 7.55 - 7.45 (m, 2H), 7.14 - 7.04 (m, 2H), 4.59 (tt, *J* = 7.5, 5.9 Hz, 1H), 3.34 (dd, *J* = 18.0, 7.8 Hz, 1H), 2.84 (dd, *J* = 18.0, 6.0 Hz, 1H), 1.87 - 1.73 (m, 1H), 1.74 - 1.62 (m, 1H), 1.61 - 1.41 (m, 2H), 1.01 (t, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.0, 163.6 (d, *J* = 251.0 Hz), 144.2, 131.4(d, *J* = 8.7 Hz), 131.2(d, *J* = 3.4 Hz), 124.5, 115.1 (d, *J* = 22.1 Hz), 76.0, 38.5, 37.0, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3490, 2959, 2931, 1753, 1642, 1504, 1460; MS (EI) *m/z* 83, 107, 133, 168, 197, 225, 268; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₄H₁₅ClFO₂, 269.0739, found 269.0736.



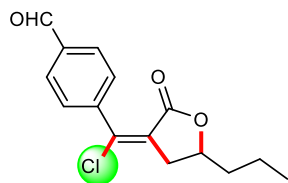
(*E*)-3-(Chloro(3,5-difluorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ae**): Yield: 64% as a yellow solid; mp = 98.4 - 98.9 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.05 - 6.97 (m, 2H), 6.92 - 6.84 (m, 1H), 4.61 (tt, *J* = 7.5, 5.9 Hz, 1H), 3.34 (dd, *J* = 18.2, 7.8 Hz, 1H), 2.84 (dd, *J* = 18.2, 6.0 Hz, 1H), 1.85 - 1.74 (m, 1H), 1.72 - 1.64 (m, 1H), 1.56 - 1.42 (m, 2H), 1.02 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.9, 164.0 (d, *J* = 12.8 Hz), 161.5 (d, *J* = 12.7 Hz), 140.6 (t, *J* = 9.7 Hz), 136.3, 124.8, 111.6 (d, *J* = 7.9 Hz), 111.4 (d, *J* = 7.9 Hz), 105.7 (t, *J* = 25.2 Hz), 105.4, 76.1, 37.9, 37.0, 18.2, 13.7 ppm; ν_{max}(KBr)/cm⁻¹ 2960, 2923, 1749, 1665, 1590, 1431; MS (EI) *m/z* 75, 151, 186, 214, 243, 286; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₄H₁₄ClFO₂, 287.0645, found 287.0642.



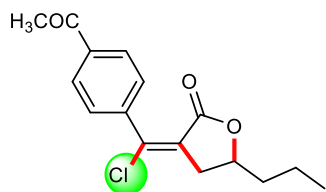
(*E*)-3-(Chloro(4-chlorophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5af**): Yield: 77% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.45 (d, $J = 2.2$ Hz, 3H), 7.28 (s, 1H), 4.47 - 4.37 (m, 1H), 3.10 (dd, $J = 16.5, 7.2$ Hz, 1H), 2.71 (dd, $J = 16.5, 6.7$ Hz, 1H), 1.81 - 1.69 (m, 1H), 1.57 - 1.53 (m, 1H), 1.51 - 1.39 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.25, 138.10, 136.29, 136.23, 129.54, 128.88, 123.52, 76.01, 37.94, 37.15, 29.71, 18.19, 13.73 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3395, 2925, 2860, 1755, 1633, 1485, 1459; MS (EI) m/z 75, 114, 149, 183, 241, 284; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{15}\text{Cl}_2\text{O}_2$, 285.0444, found 285.0439.



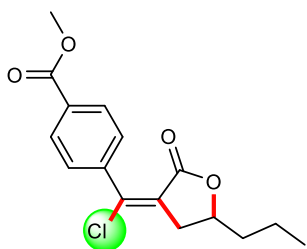
(*E*)-3-(chloro(4-iodophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ag**): Yield: 80% as a yellow solid; mp = 98.0 - 18.6 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.83 - 7.69 (m, 1H), 7.27 - 7.16 (m, 1H), 4.66 - 4.49 (m, 1H), 3.32 (dd, $J = 18.0, 7.8$ Hz, 1H), 2.82 (dd, $J = 18.1, 6.0$ Hz, 1H), 1.85 - 1.73 (m, 1H), 1.72 - 1.63 (m, 0H), 1.57 - 1.44 (m, 1H), 1.01 (t, $J = 7.3$ Hz, 2H); ^{13}C NMR (101 MHz, CDCl_3) δ 165.9, 144.1, 137.1, 134.6, 130.8, 124.9, 96.8, 76.1, 38.5, 37.0, 18.1, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 2959, 2865, 1755, 1643, 1581, 1472; MS (EI) m/z 89, 115, 150, 178, 240; 275, 333, 376; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{14}\text{ClIO}_2$, 376.9800, found 376.9794.



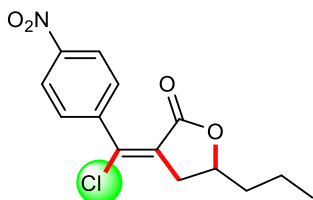
(*E*)-4-(Chloro(2-oxo-5-propyldihydrofuran-3(2H)-ylidene)methyl)benzaldehyde (**5ah**): Yield: 73% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 10.07 (s, 1H), 7.93 (d, $J = 8.1$ Hz, 2H), 7.65 (d, $J = 8.2$ Hz, 2H), 4.62 (tt, $J = 7.6, 5.8$ Hz, 1H), 3.37 (dd, $J = 18.2, 7.8$ Hz, 1H), 2.87 (dd, $J = 18.2, 6.0$ Hz, 1H), 1.85 - 1.78 (m, 1H), 1.73 - 1.67 (m, 1H), 1.56 - 1.45 (m, 2H), 1.02 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 191.2, 167.1, 143.2, 137.6, 137.0, 129.8, 128.9, 124.8, 76.2, 37.9, 37.1, 18.2, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3066, 2859, 1752, 1634, 1507, 1456; MS (EI) m/z 89, 115, 143, 178, 235; 278; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{15}\text{H}_{16}\text{ClO}_3$, 279.0783, found 279.0778.



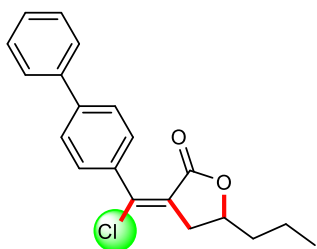
(*E*)-3-((4-Acetylphenyl)chloromethylene)-5-propyldihydrofuran-2(3H)-one (**5ai**): Yield: 70% as a yellow solid; mp = 99.7 - 101.1 °C; ^1H NMR (400 MHz, CDCl_3) δ 8.04 (d, $J = 8.4$ Hz, 2H), 7.61 (d, $J = 8.5$ Hz, 2H), 4.51 - 4.38 (m, 1H), 3.11 (dd, $J = 16.6, 7.2$ Hz, 1H), 2.75 - 2.70 (m, 1H), 2.66 (s, 3H), 1.80 - 1.72 (m, 1H), 1.58 - 1.53 (m, 1H), 1.51 - 1.39 (m, 2H), 0.96 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 197.1, 167.1, 142.0, 138.0, 138.0, 128.5, 128.5, 124.39, 76.1, 37.9, 37.1, 29.7, 26.7, 18.2, 13.7 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3343, 2923, 2858, 1755, 1722, 1686, 1458; MS (EI) m/z 88, 114, 149, 177, 249, 277, 292; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{16}\text{H}_{18}\text{ClO}_3$, 293.0939, found 293.0935.



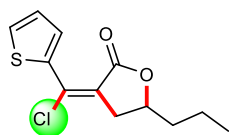
Methyl-(*E*)-4-(chloro(2-oxo-5-propyldihydrofuran-3(2H)-ylidene)methyl)benzoate (**5aj**): Yield: 72% as a yellow solid; mp = 103.0 - 103.6 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.12 - 8.04 (m, 2H), 7.62 - 7.52 (m, 2H), 4.61 (tt, *J* = 7.5, 5.9 Hz, 1H), 3.95 (s, 3H), 3.36 (dd, *J* = 18.1, 7.8 Hz, 1H), 2.86 (dd, *J* = 18.1, 6.0 Hz, 1H), 1.85 - 1.78 (m, 1H), 1.73 - 1.65 (m, 1H), 1.56 - 1.46 (m, 2H), 1.01 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.4, 165.8, 143.7, 139.5, 131.4, 129.2, 125.6, 76.1, 52.3, 38.5, 36.9, 29.7, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3357, 2957, 2923, 1755, 1722, 1460, 1433; MS (EI) *m/z* 88, 115, 149, 177, 208, 265, 308; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₆H₁₈ClO₄, 309.0888, found 309.0885.



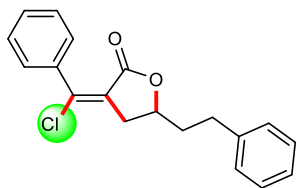
(*E*)-3-(Chloro(4-nitrophenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**5ak**): Yield: 64% as a yellow solid; mp = 129.0 - 129.5 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.38 - 8.28 (m, 2H), 7.76 - 7.66 (m, 2H), 4.55 - 4.38 (m, 1H), 3.10 (dd, *J* = 16.7, 7.2 Hz, 1H), 2.71 (dd, *J* = 16.7, 6.6 Hz, 1H), 1.82 - 1.69 (m, 1H), 1.53 - 1.48 (m, 1H), 1.48 - 1.39 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.7, 148.3, 143.7, 136.4, 129.3, 125.5, 123.9, 76.2, 37.9, 37.0, 18.2, 13.7 ppm; ν_{max}(KBr)/cm⁻¹ 3357, 2957, 2923, 1755, 1722, 1460, 1433; MS (EI) *m/z* 88, 115, 150, 178, 195, 252; 295; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₄H₁₅ClNO₄, 296.0684, found 296.0680.



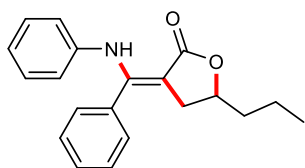
(*E*)-3-([1,1'-Biphenyl]-4-ylchloromethylene)-5-propyldihydrofuran-2(3H)-one (**5al**): Yield: 81% as a yellow solid; mp = 91.1 - 91.6 °C; ¹H NMR (400 MHz, CDCl₃) δ 7.67 - 7.56 (m, 6H), 7.51 - 7.44 (m, 2H), 7.42 - 7.35 (m, 1H), 4.61 (tt, *J* = 7.6, 5.8 Hz, 1H), 3.38 (dd, *J* = 18.0, 7.8 Hz, 1H), 2.88 (dd, *J* = 17.9, 6.1 Hz, 1H), 1.86 - 1.78 (m, 1H), 1.75 - 1.65 (m, 1H), 1.59 - 1.44 (m, 2H), 1.03 (t, *J* = 7.3 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.1, 145.3, 143.0, 140.3, 134.0, 129.8, 128.8, 127.8, 127.3, 126.6, 124.2, 76.0, 38.5, 37.2, 18.2 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3032, 2960, 2932, 1755, 1637, 1605, 1460; MS (EI) *m/z* 95, 152, 165, 191, 226, 283, 326; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₂₀H₂₀ClO₂, 327.1147, found 327.1143.



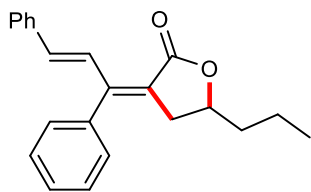
(*E*)-3-(Chloro(thiophen-2-yl)methylene)-5-propyldihydrofuran-2(3H)-one (**5am**): Yield: 74% as a yellow solid; mp = 49.7 - 50.3°C; ¹H NMR (400 MHz, CDCl₃) δ 7.95 - 7.90 (m, 1H), 7.53 (dd, *J* = 5.1, 1.1 Hz, 1H), 7.09 (dd, *J* = 5.1, 3.9 Hz, 1H), 4.58 (tt, *J* = 7.6, 5.8 Hz, 1H), 3.38 (dd, *J* = 18.2, 7.8 Hz, 1H), 2.89 (dd, *J* = 18.2, 6.1 Hz, 1H), 1.84 - 1.75 (m, 1H), 1.71 - 1.64 (m, 1H), 1.57 - 1.43 (m, 2H), 1.02 (d, *J* = 7.4 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 166.2, 138.1, 136.9, 132.9, 130.5, 127.2, 122.4, 76.0, 38.5, 38.4, 18.2, 13.8 ppm; ν_{max}(KBr)/cm⁻¹ 3007, 2958, 2925, 1744, 1596, 1460, 1416; MS (EI) *m/z* 97, 111, 121, 135, 165, 198, 221, 240, 256; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₂H₁₄ClO₂S, 257.0399, found 257.0396.



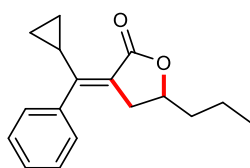
(*E*)-3-(Chloro(phenyl)methylene)-5-phenethyldihydrofuran-2(3H)-one (**5an**): Yield: 82% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.53 - 7.49 (m, 2H), 7.46 - 7.39 (m, 3H), 7.38 - 7.32 (m, 2H), 7.29 - 7.22 (m, 3H), 4.72 - 4.43 (m, 1H), 3.35 (dd, $J = 17.9, 7.8$ Hz, 1H), 3.05 - 2.68 (m, 3H), 2.28 - 2.09 (m, 1H), 2.08 - 1.97 (m, 1H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 165.9, 145.7, 140.6, 135.2, 130.3, 129.1, 128.6, 128.5, 127.9, 126.3, 124.0, 75.1, 38.2, 37.0, 31.3 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3026, 2924, 2855, 1754, 1644, 1492, 1446; MS (EI) m/z 89, 114, 141, 179, 231, 276, 312; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{19}\text{H}_{18}\text{ClO}_2$, 313.0990, found 313.0986.



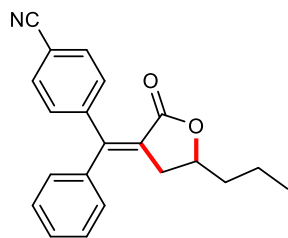
(*Z*)-3-(Phenyl(phenylamino)methylene)-5-propyldihydrofuran-2(3H)-one (**6**): Yield: 82% as a yellow oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 10.09 (s, 1H), 7.40 - 7.35 (m, 3H), 7.34 - 7.29 (m, 2H), 7.06 (t, $J = 7.8$ Hz, 2H), 6.89 (t, $J = 7.3$ Hz, 1H), 6.62 (d, $J = 8.0$ Hz, 2H), 4.50 (p, $J = 7.2$ Hz, 1H), 2.91 (dd, $J = 15.1, 8.2$ Hz, 1H), 2.47 (dd, $J = 15.1, 6.7$ Hz, 1H), 1.85 - 1.69 (m, 1H), 1.62 - 1.52 (m, 1H), 1.52 - 1.35 (m, 2H), 0.96 (t, $J = 7.2$ Hz, 3H); $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 173.8, 153.6, 140.2, 134.7, 129.2, 128.8, 128.6, 128.5, 122.8, 121.8, 93.7, 77.6, 38.5, 33.1, 18.3, 13.9 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3276, 3055, 2958, 2928, 1765, 1691, 1627, 1596, 1498; MS (EI) m/z 77, 115, 130, 180, 206, 237, 307; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{20}\text{H}_{22}\text{NO}_2$, 308.1645, found 308.1640.



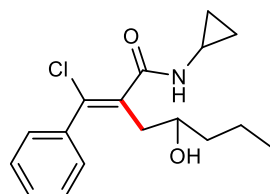
(*Z*)-3-((*E*)-1,3-Diphenylallylidene)-5-propyldihydrofuran-2(3H)-one (**7**): Yield: 87% as a yellow solid; mp = 145.3 - 146.0 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.76 (d, *J* = 16.1 Hz, 1H), 7.53 - 7.40 (m, 5H), 7.35 - 7.20 (m, 5H), 6.35 (d, *J* = 16.1 Hz, 1H), 4.46 (p, *J* = 7.1 Hz, 1H), 2.80 (dd, *J* = 17.8, 7.5 Hz, 1H), 2.41 (dd, *J* = 17.8, 6.4 Hz, 1H), 1.78 - 1.66 (m, 1H), 1.60 - 1.50 (m, 1H), 1.49 - 1.31 (m, 2H), 0.95 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 167.0, 150.6, 138.5, 138.4, 136.7, 128.8, 128.7, 128.7, 128.3, 128.1, 127.6, 125.6, 122.4, 76.8, 38.4, 35.9, 18.2, 13.9 ppm; ν_{max}(KBr)/cm⁻¹ 3057, 2959, 2929, 1735, 1612, 1447, 1351; MS (EI) *m/z* 91, 115, 141, 202, 217, 248, 318; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₂₂H₂₃O₂, 319.1693, found 319.1691.



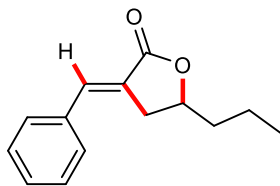
(*E*)-3-(Cyclopropyl(phenyl)methylene)-5-propyldihydrofuran-2(3H)-one (**8**): Yield: 87% as a yellow oil; ¹H NMR (400 MHz, CDCl₃) δ 7.42 - 7.30 (m, 3H), 6.99 (d, *J* = 6.9 Hz, 2H), 4.45 - 4.34 (m, 1H), 3.55 (tt, *J* = 8.3, 5.2 Hz, 1H), 2.58 (dd, *J* = 16.6, 7.7 Hz, 1H), 2.18 (dd, *J* = 16.6, 6.6 Hz, 1H), 1.69 (ddd, *J* = 17.8, 10.3, 6.3 Hz, 1H), 1.52 - 1.36 (m, 3H), 0.92 (t, *J* = 7.1 Hz, 3H), 0.87 - 0.81 (m, 2H), 0.43 (tdd, *J* = 12.1, 6.9, 2.0 Hz, 2H); ¹³C NMR (101 MHz, CDCl₃) δ 170.9, 158.0, 137.0, 128.4, 127.6, 127.5, 121.3, 76.6, 38.4, 35.5, 18.1, 13.8, 12.8, 6.1, 6.0 ppm; ν_{max}(KBr)/cm⁻¹ 3465, 3276, 2959, 2929, 1692, 1596, 1499; MS (EI) *m/z* 77, 91, 115, 155, 172, 186, 228, 256; HRMS (ESI, *m/z*): [M+H]⁺ Calcd. for C₁₇H₂₁O₂, 257.1536, found 257.1534.



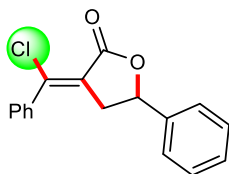
(Z)-4-((2-Oxo-5-propyldihydrofuran-3(2H)-ylidene)(phenyl)methyl)benzonitrile (**9**): Yield: 87% as a yellow solid; mp = 102.3 - 102.6 °C; ^1H NMR (400 MHz, CDCl_3) δ 7.65 (d, J = 8.4 Hz, 2H), 7.46 - 7.35 (m, 3H), 7.32 (d, J = 8.4 Hz, 2H), 7.23 - 7.12 (m, 2H), 4.58 - 4.45 (m, 1H), 3.19 (dd, J = 16.7, 7.0 Hz, 1H), 2.84 (dd, J = 16.7, 6.7 Hz, 1H), 1.83 - 1.74 (m, 1H), 1.69 - 1.58 (m, 1H), 1.56 - 1.41 (m, 2H), 0.98 (t, J = 7.3 Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 169.1, 149.4, 143.8, 139.8, 131.8, 130.2, 129.4, 129.0, 129.0, 128.7, 125.1, 118.8, 112.0, 76.8, 38.1, 36.9, 18.3, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3034, 3450, 2960, 2931, 2227, 1751, 1634, 1443; MS (EI) m/z 91, 115, 140, 217, 246, 274, 317; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{21}\text{H}_{20}\text{NO}_2$, 318.1489, found 318.1487.



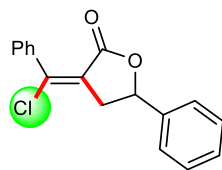
(Z)-2-(Chloro(phenyl)methylene)-N-cyclopropyl-4-hydroxyheptanamide (**10**): Yield: 87% as a yellow oil; ^1H NMR (400 MHz, DMSO) δ 8.26 (d, J = 4.3 Hz, 1H), 7.63 - 7.18 (m, 5H), 4.54 (s, 1H), 3.53 - 3.42 (m, 1H), 2.79 - 2.68 (m, 1H), 2.23 (d, J = 6.5 Hz, 2H), 1.38 - 1.25 (m, 2H), 1.21 - 1.09 (m, 3H), 0.79 (t, J = 6.9 Hz, 2H), 0.73 - 0.66 (m, 2H), 0.57 - 0.45 (m, 2H), ^{13}C NMR (101 MHz, DMSO) δ 169.1, 137.4, 135.8, 129.3, 128.9, 128.1, 68.1, 39.0, 22.8, 18.7, 14.3, 6.1, 6.0 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3409, 3270, 3060, 2959, 2928, 1744, 1623, 1544; MS (EI) m/z 89, 114, 141, 179, 231, 276, 307; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{17}\text{H}_{23}\text{ClNO}_2$, 308.1412, found 308.1410.



(*E*)-3-Benzylidene-5-propyldihydrofuran-2(3H)-one (**11**): Yield: 66% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.58 (d, $J = 5.8$ Hz, 1H), 7.54 - 7.33 (m, 5H), 4.65 (tt, $J = 7.7, 5.5$ Hz, 1H), 3.36 (ddd, $J = 17.4, 7.9, 2.8$ Hz, 1H), 2.85 (ddd, $J = 17.5, 5.6, 3.1$ Hz, 1H), 1.88 - 1.75 (m, 1H), 1.71 - 1.64 (m, 1H), 1.62 - 1.46 (m, 2H), 1.00 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (101 MHz, CDCl_3) δ 172.2, 136.4, 130.0, 129.8, 128.9, 128.8, 124.9, 77.5, 38.7, 33.7, 18.3, 13.8 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3059, 2958, 2927, 1748, 1654, 1454; MS (EI) m/z 89, 116, 129, 145, 173, 216; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{17}\text{O}_2$, 217.1223, found 217.1221.

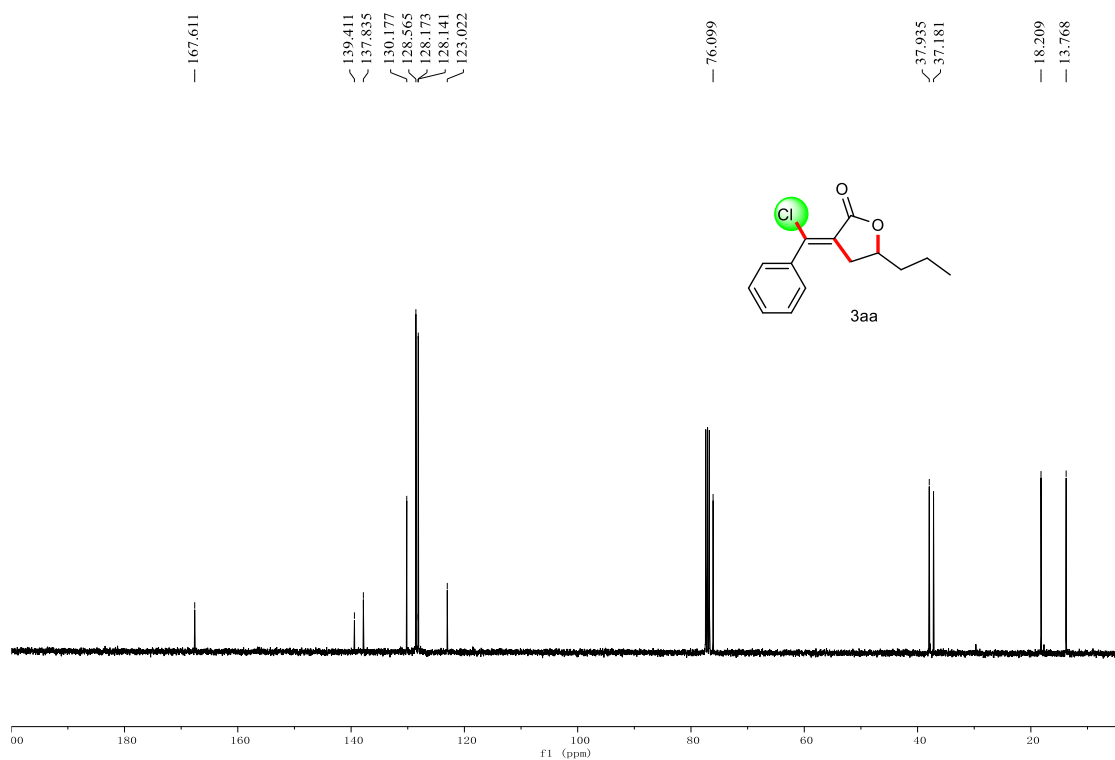
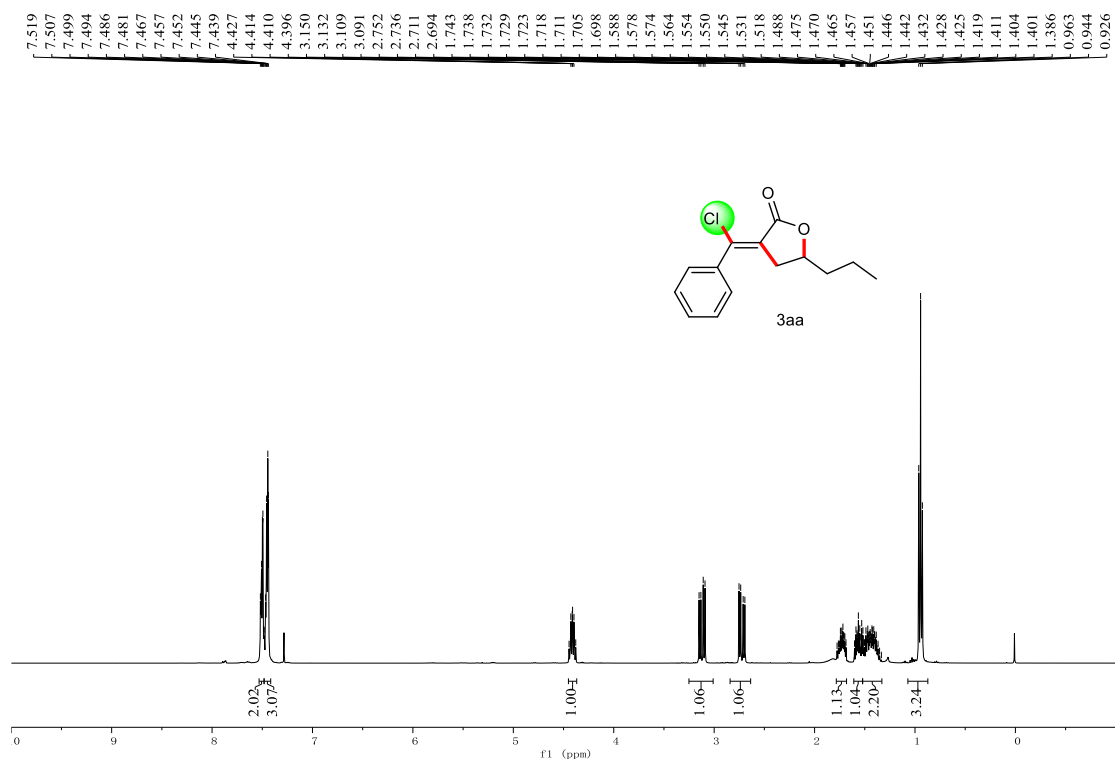


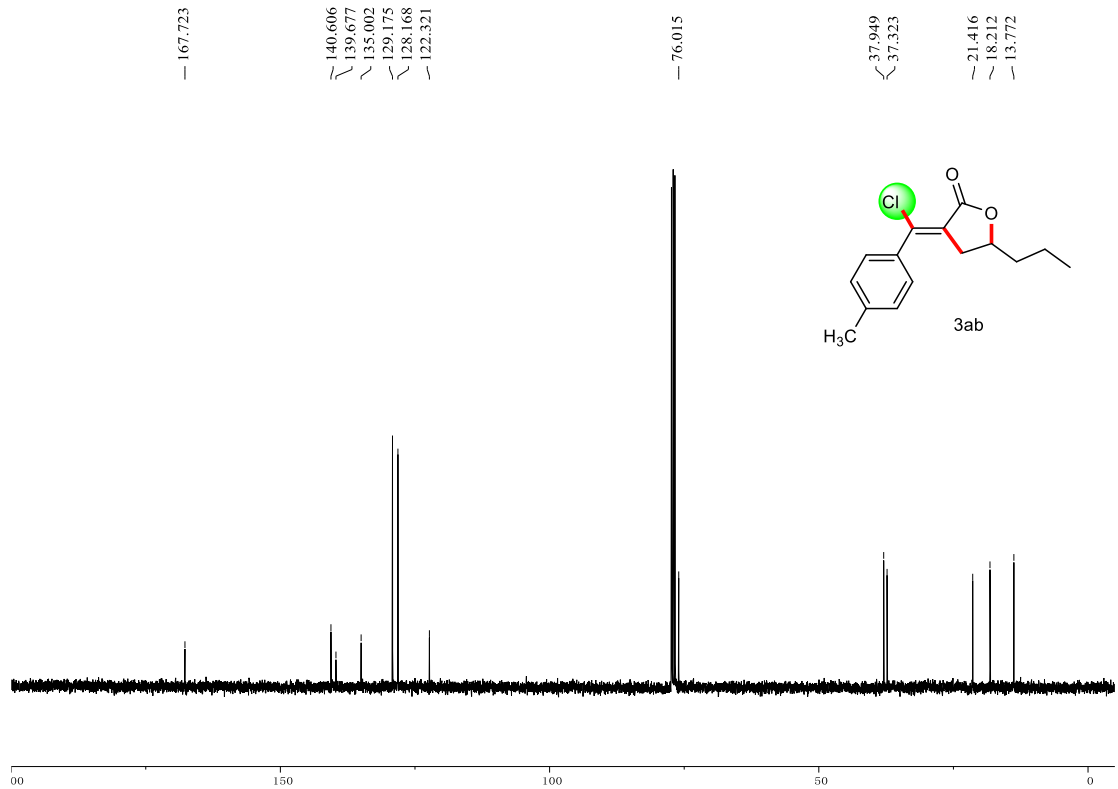
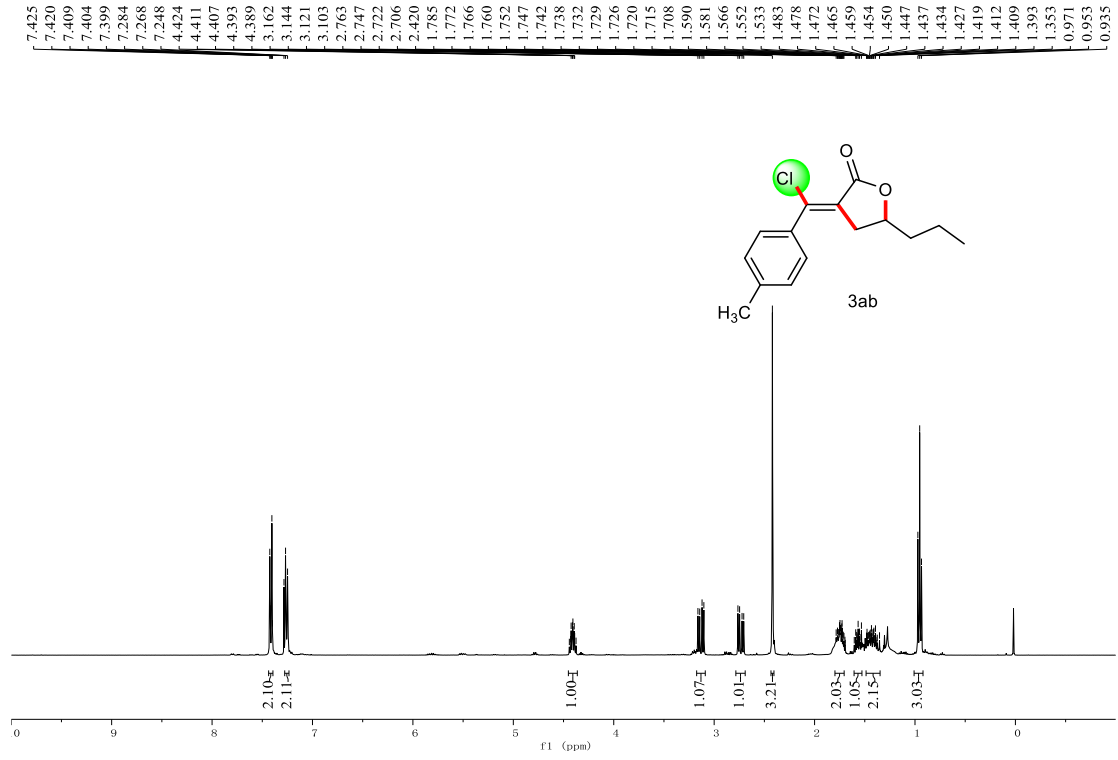
(*Z*)-3-(Chloro(phenyl)methylene)-5-phenyldihydrofuran-2(3H)-one (**12**): Yield: 90% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.54 - 7.49 (m, 2H), 7.47 - 7.42 (m, 3H), 7.43 - 7.29 (m, 5H), 5.41 (t, $J = 7.4$ Hz, 1H), 3.46 (dd, $J = 16.6, 7.4$ Hz, 1H), 3.07 (dd, $J = 16.6, 7.3$ Hz, 1H); ^{13}C NMR (101 MHz, CDCl_3) δ 167.4, 140.1, 139.3, 137.7, 130.4, 128.9, 128.7, 128.6, 128.2, 125.4, 122.5, 76.8, 40.0 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3061, 2925, 1962, 1644, 1493, 1446; MS (EI) m/z 89, 115, 127, 150, 178, 284; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{18}\text{O}_2$, 285.0677, found 285.0670.

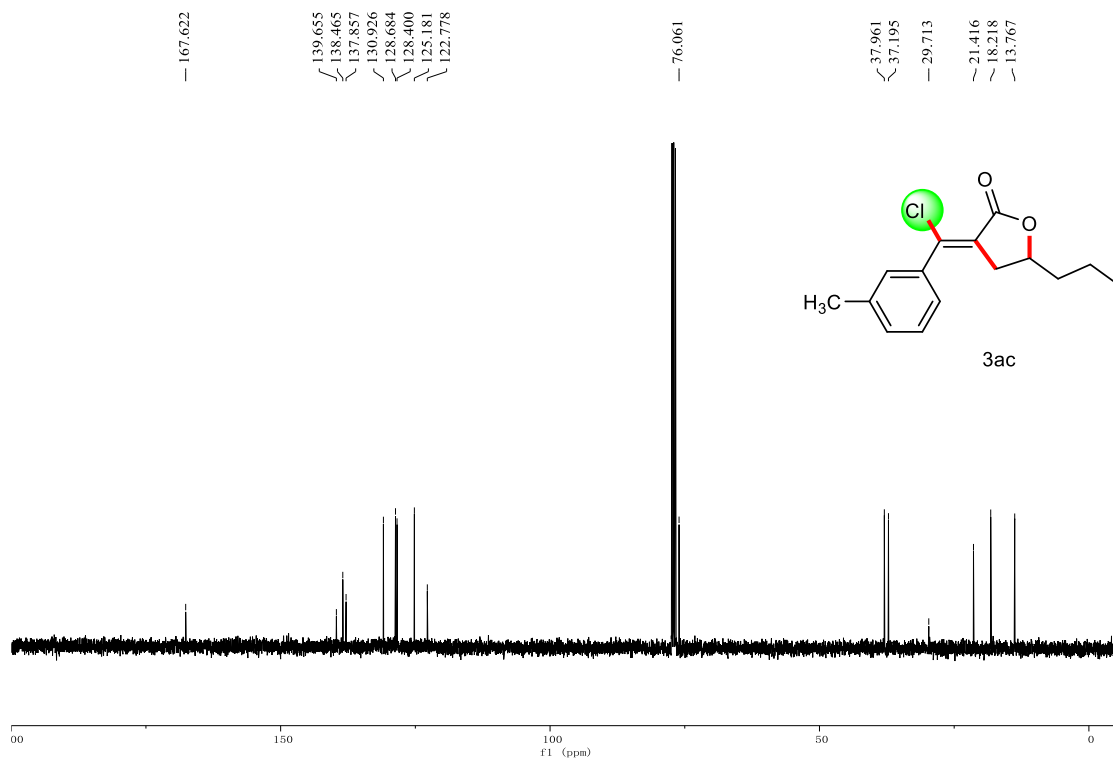
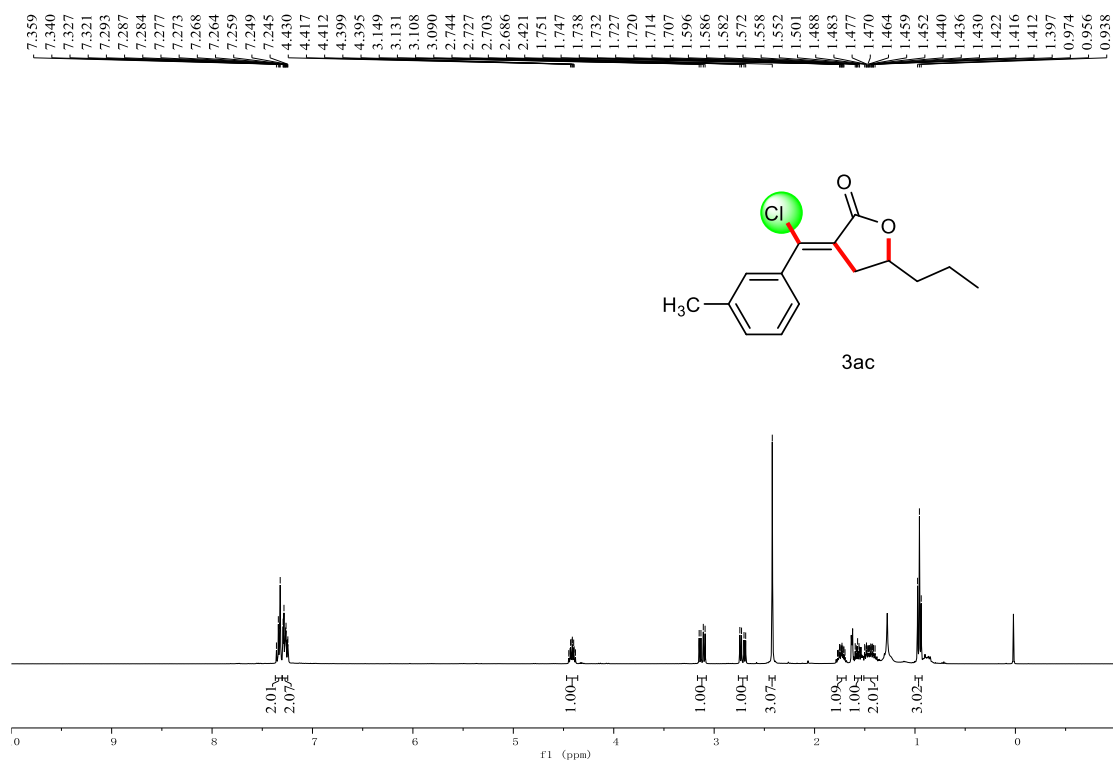


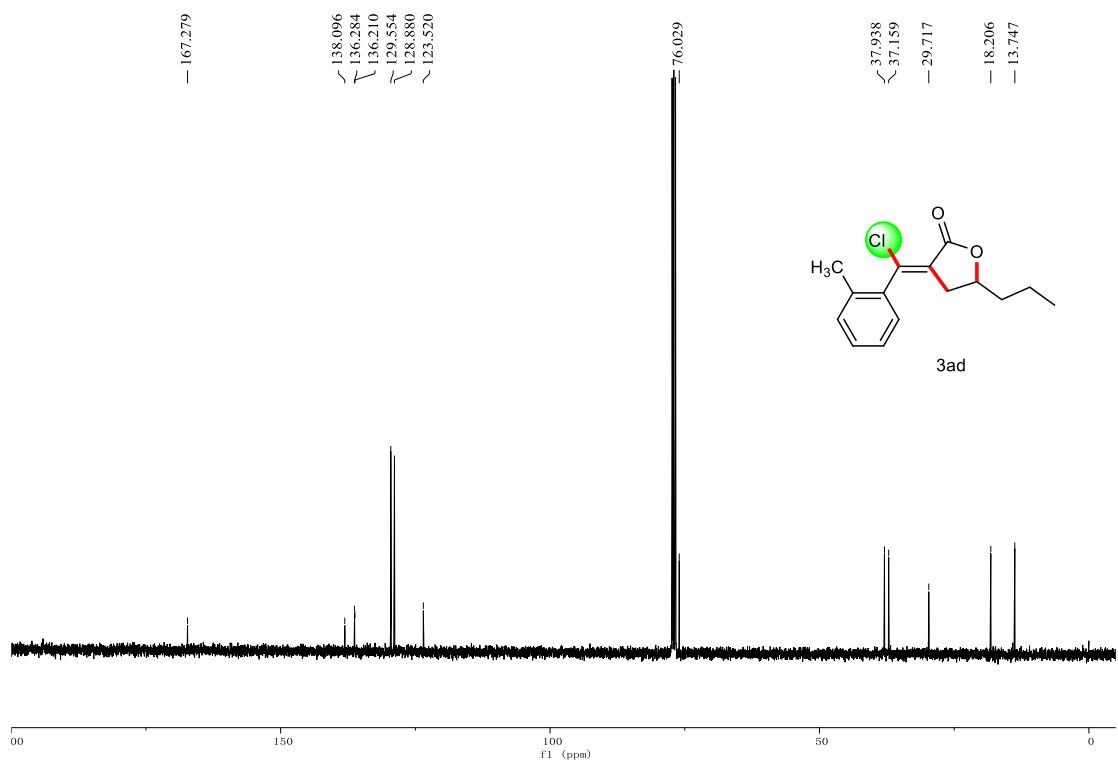
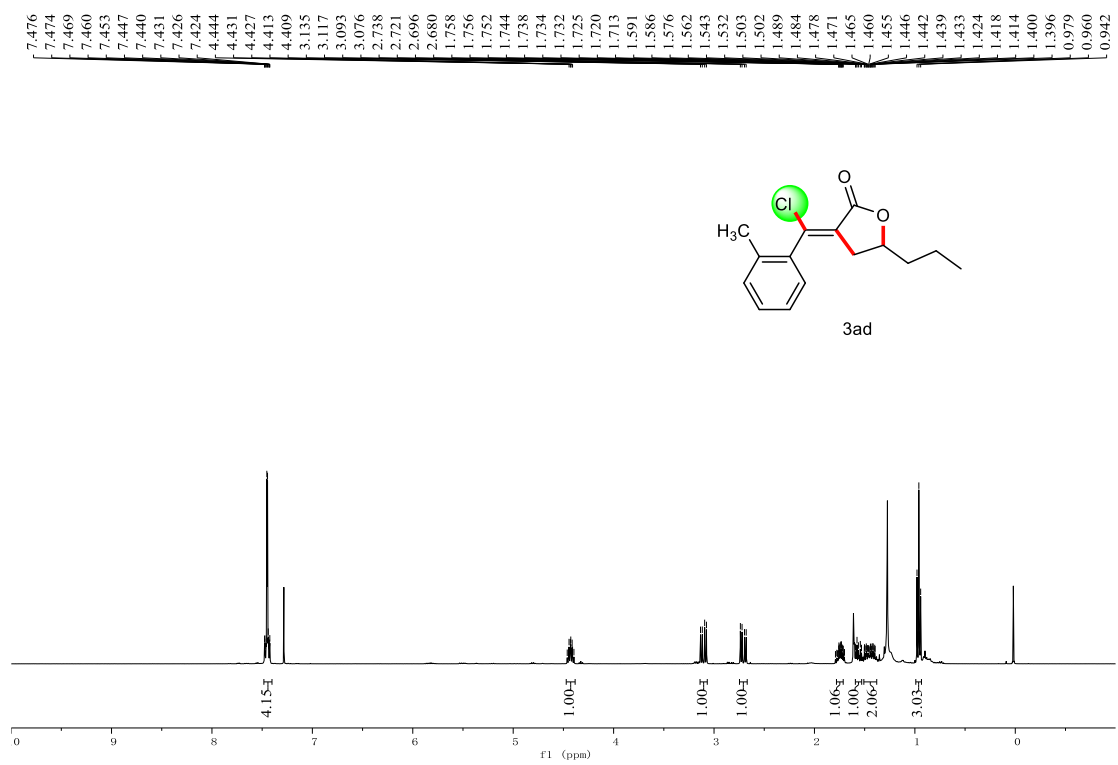
(*E*)-3-(Chloro(phenyl)methylene)-5-phenyldihydrofuran-2(3H)-one (**13**): Yield: 87% as a yellow oil; ^1H NMR (400 MHz, CDCl_3) δ 7.61 - 7.52 (m, 2H), 7.49 - 7.43 (m, 5H), 7.43 - 7.37 (m, 3H), 5.61 (dd, $J = 8.2, 6.4$ Hz, 1H), 3.71 (dd, $J = 17.9, 8.2$ Hz, 1H), 3.21 (dd, $J = 17.9, 6.4$ Hz, 1H); ^{13}C NMR (101 MHz, CDCl_3) δ 165.8, 146.0, 139.8, 135.1, 130.4, 129.2, 129.0, 128.7, 128.0, 125.5, 123.6, 76.7, 39.6 ppm; $\nu_{\text{max}}(\text{KBr})/\text{cm}^{-1}$ 3062, 2923, 1964, 1761, 1684, 1631, 1494; MS (EI) m/z 89, 115, 127, 150, 178, 284; HRMS (ESI, m/z): $[\text{M}+\text{H}]^+$ Calcd. for $\text{C}_{14}\text{H}_{18}\text{O}_2$, 285.0677, found 285.0673.

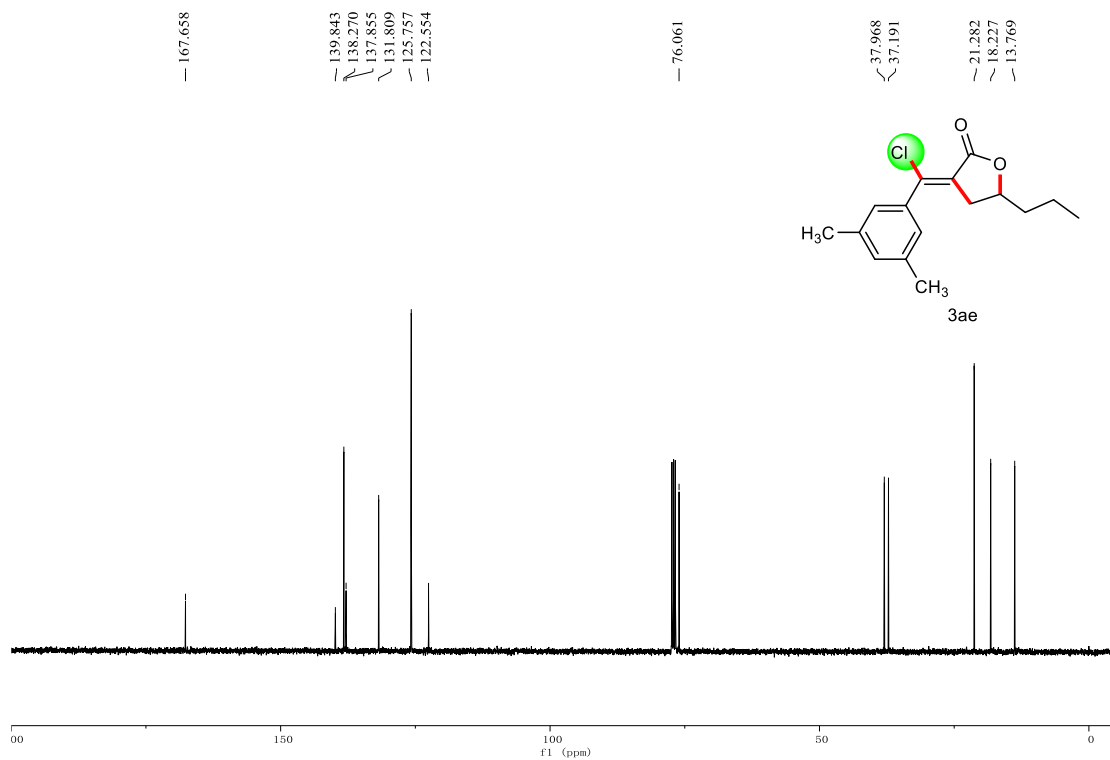
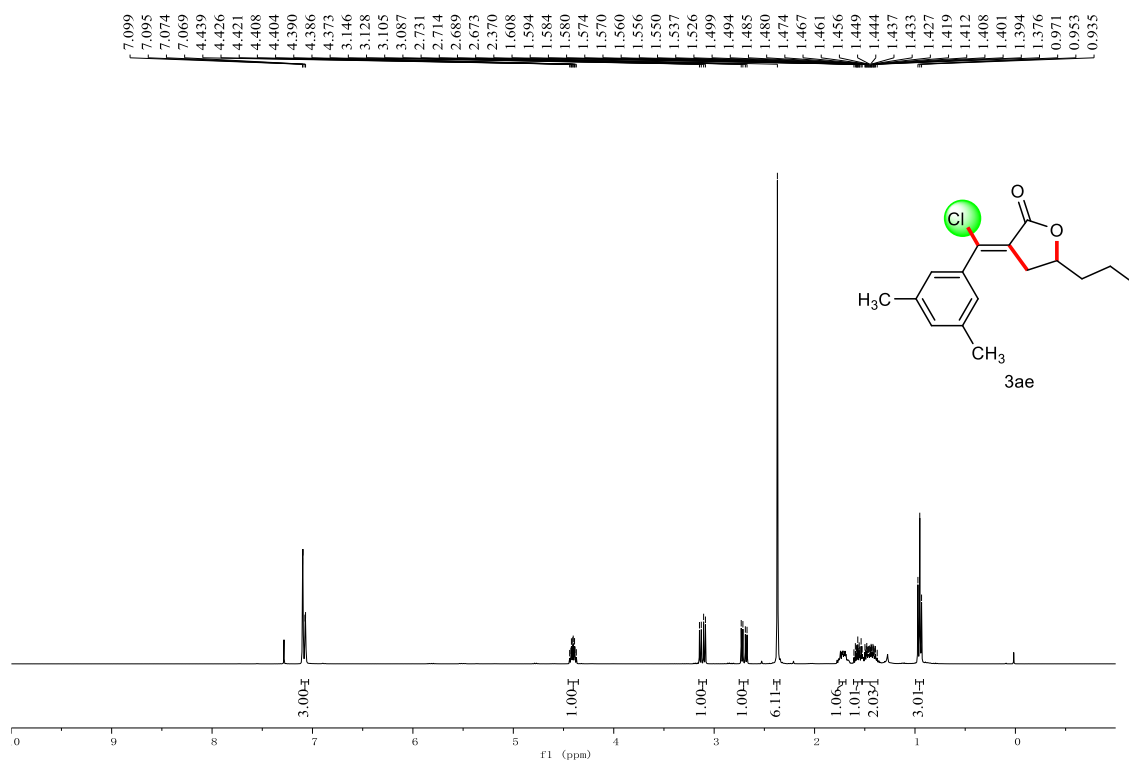
¹H and ¹³C NMR spectra of all compounds

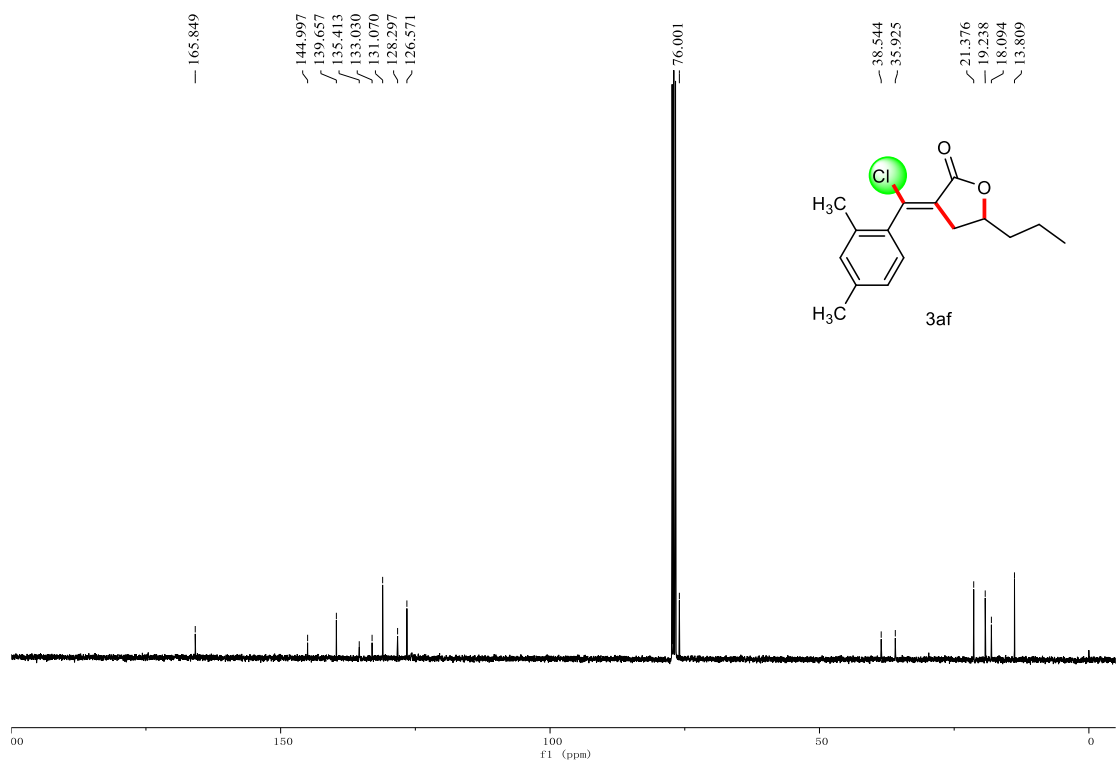
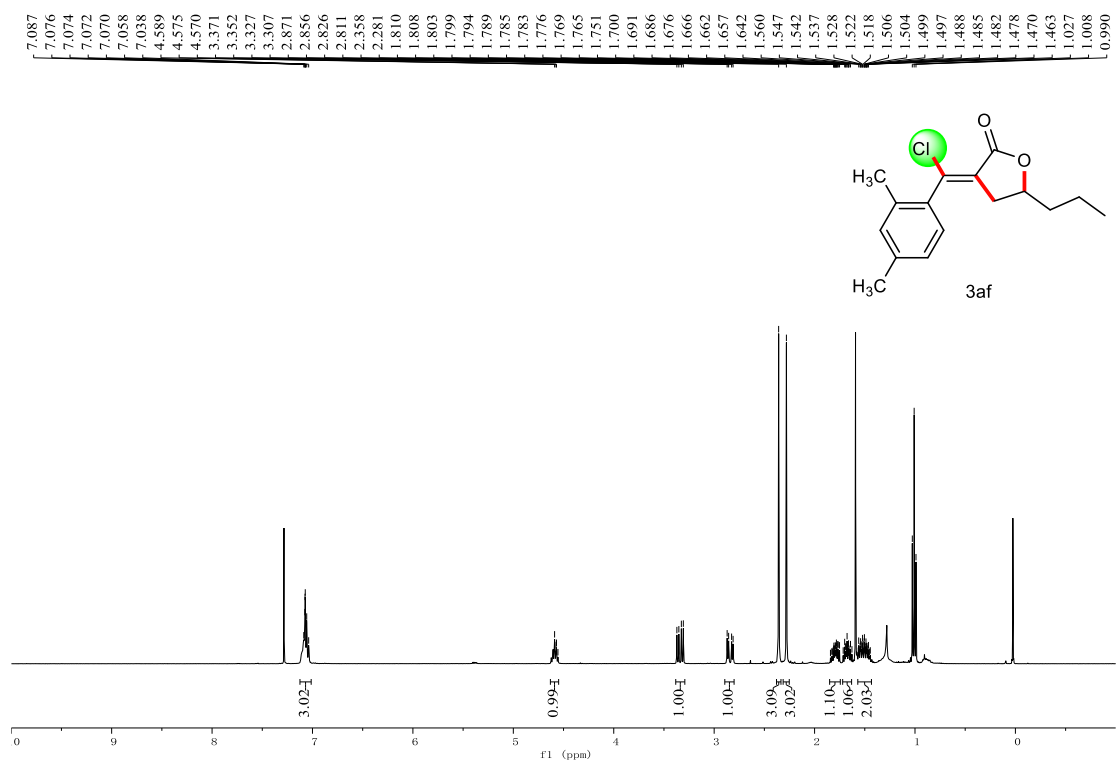


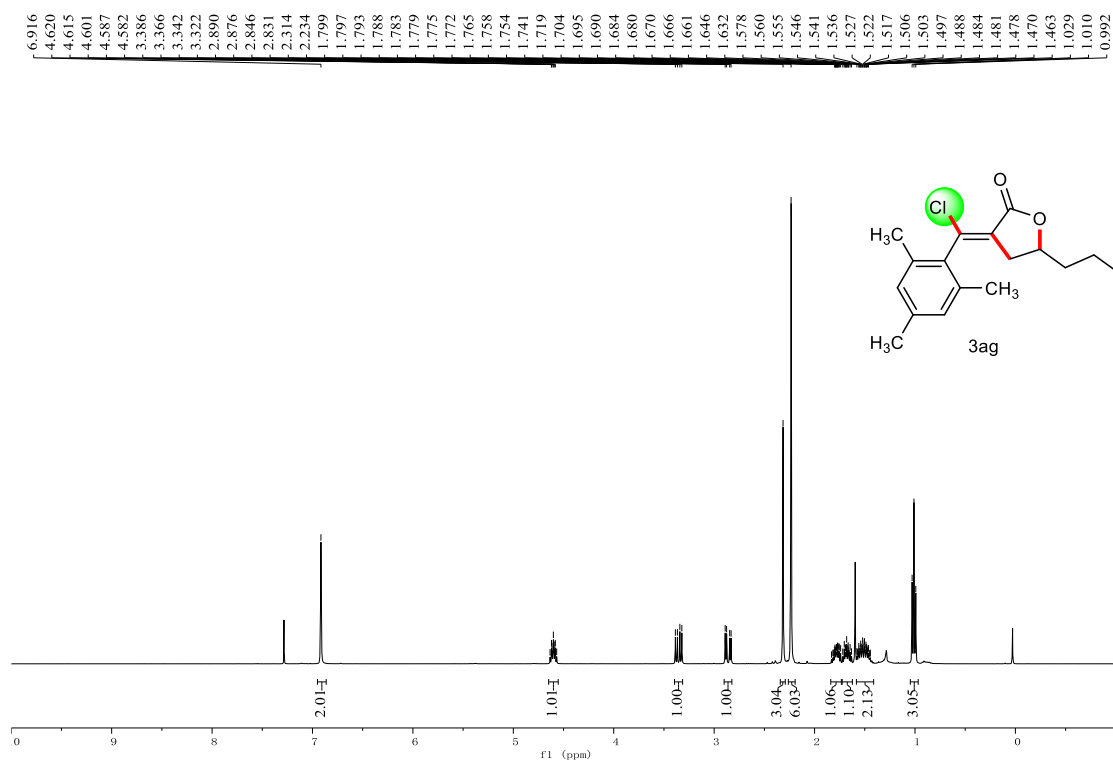










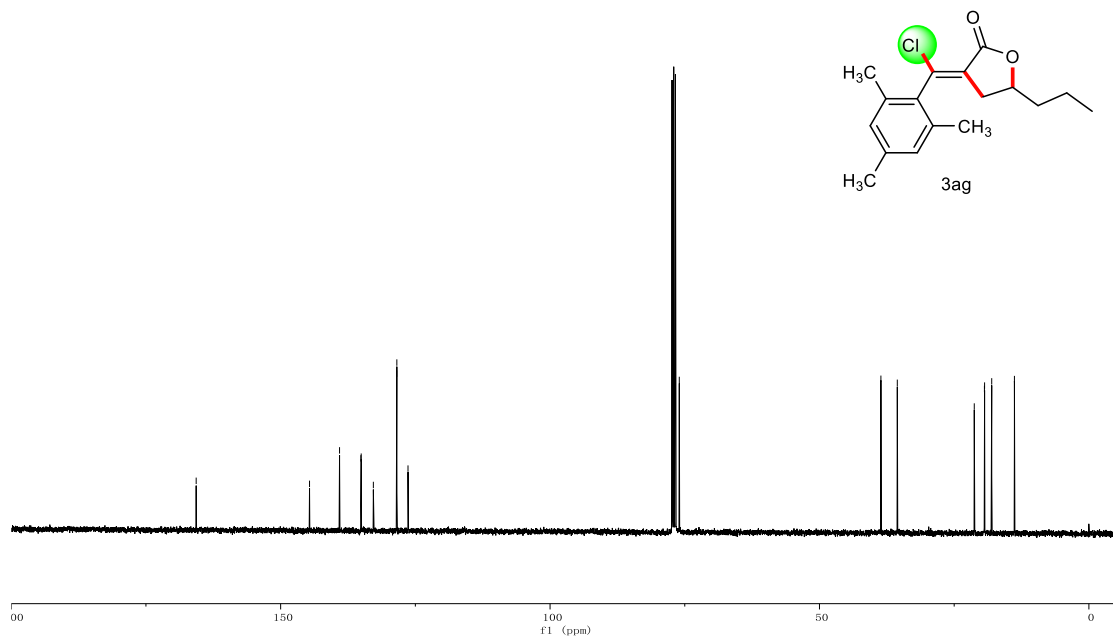


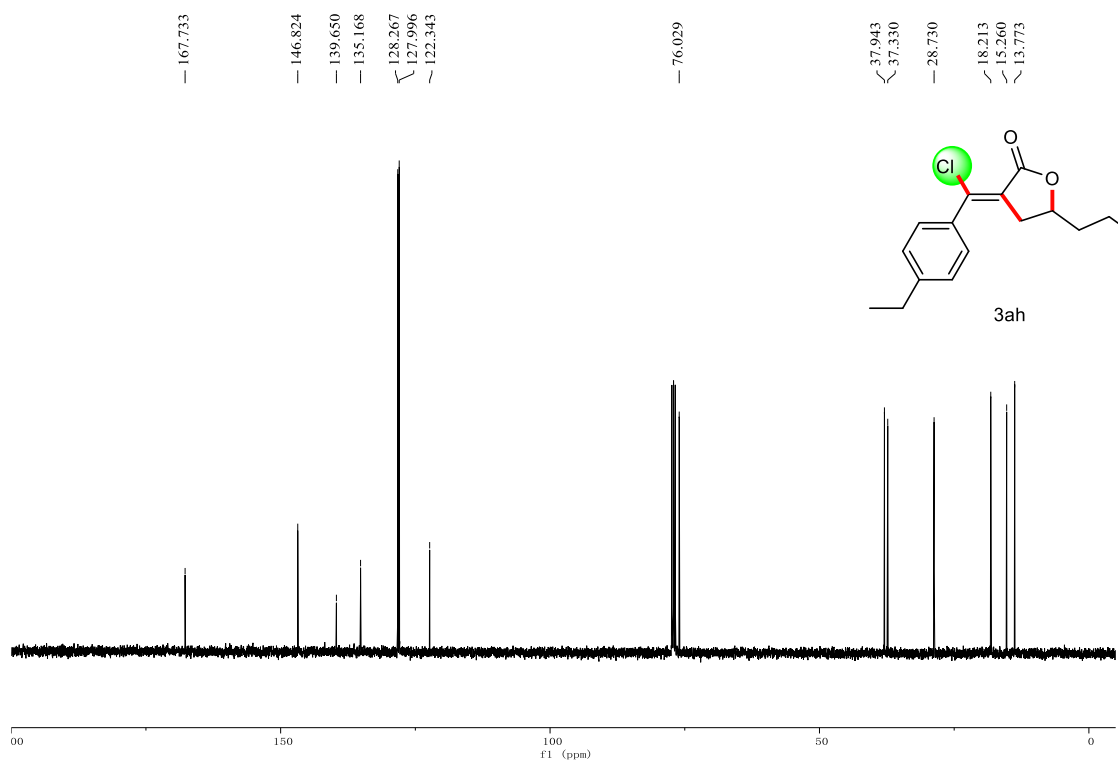
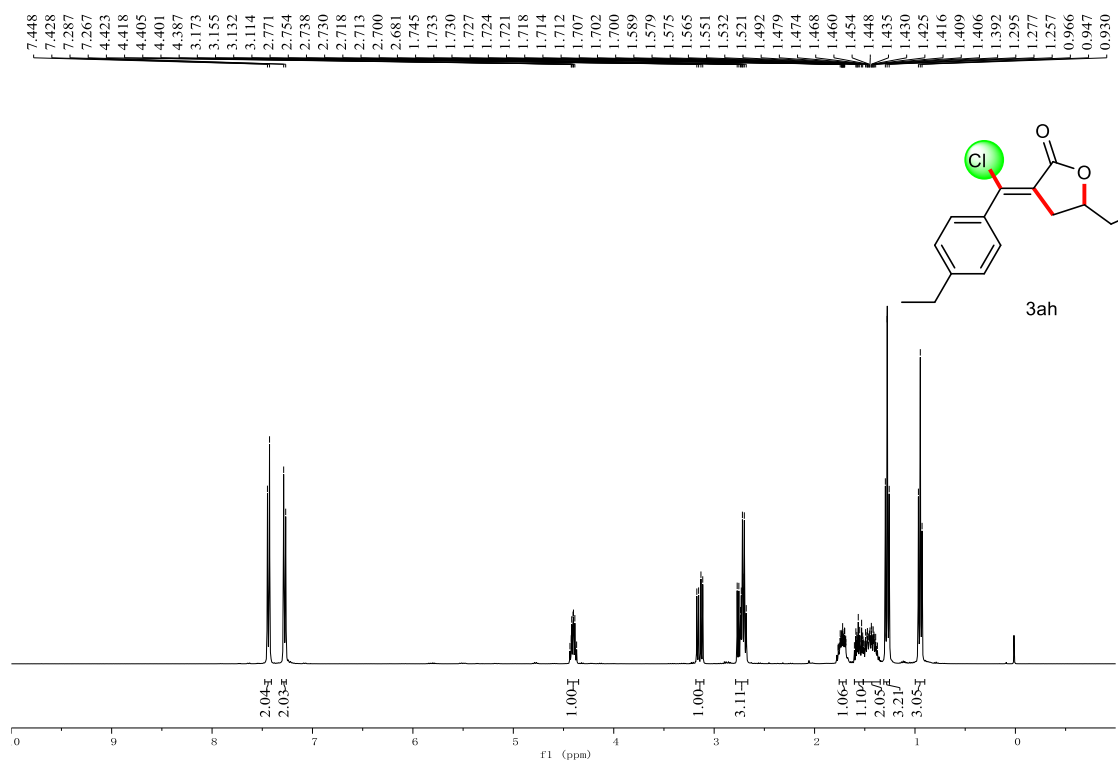
165.676

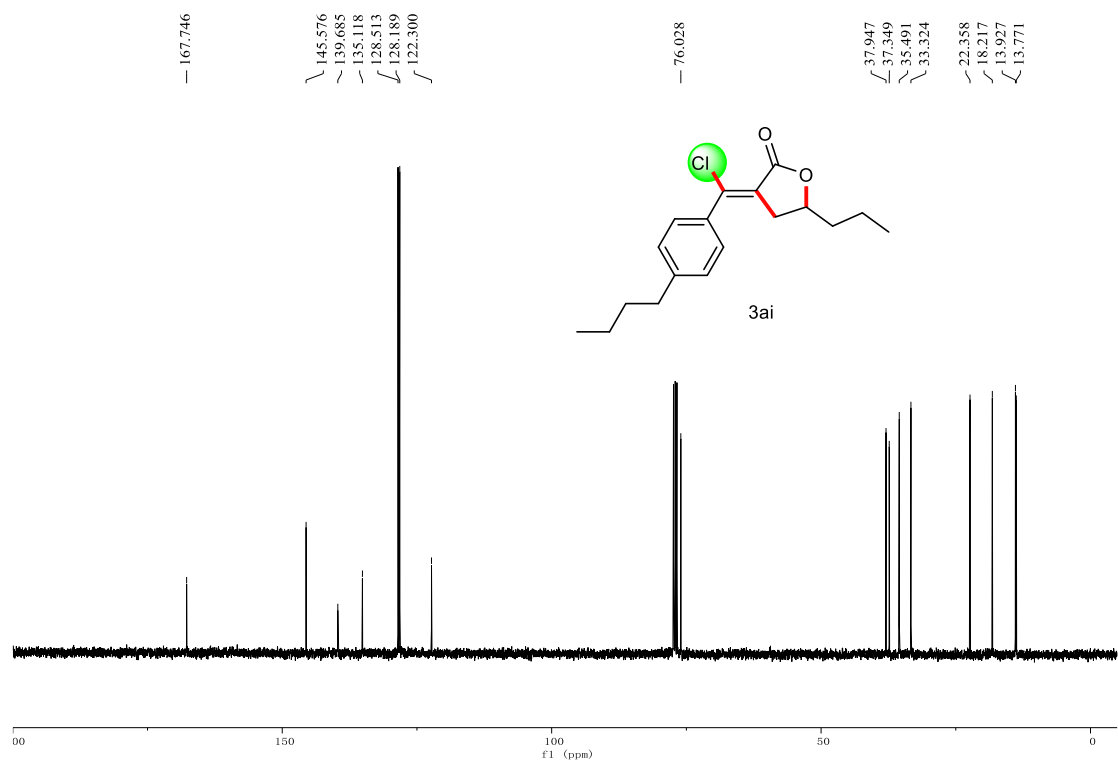
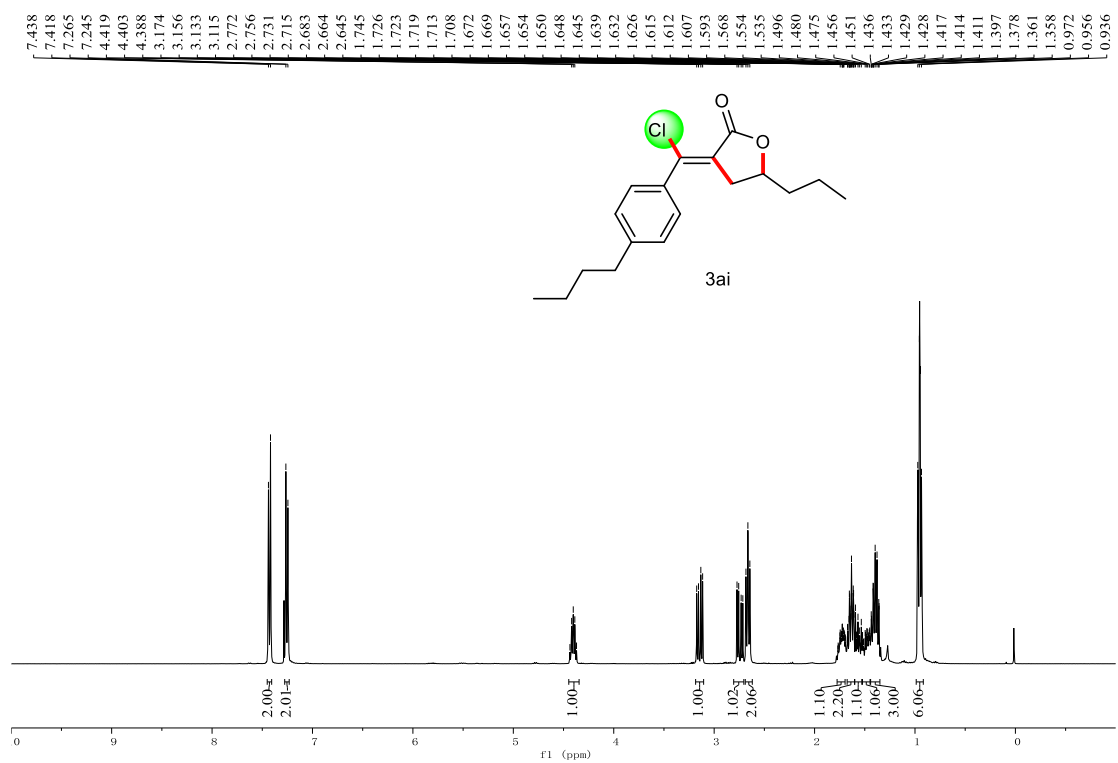
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128.459
128.434
126.363

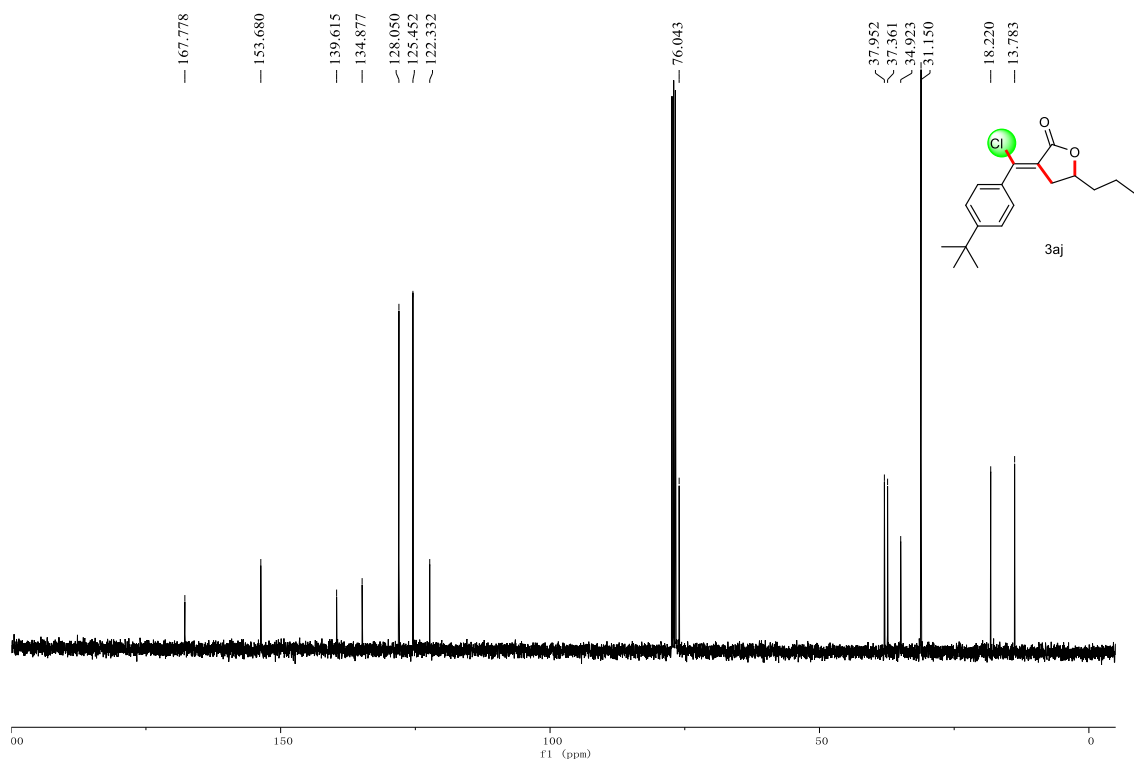
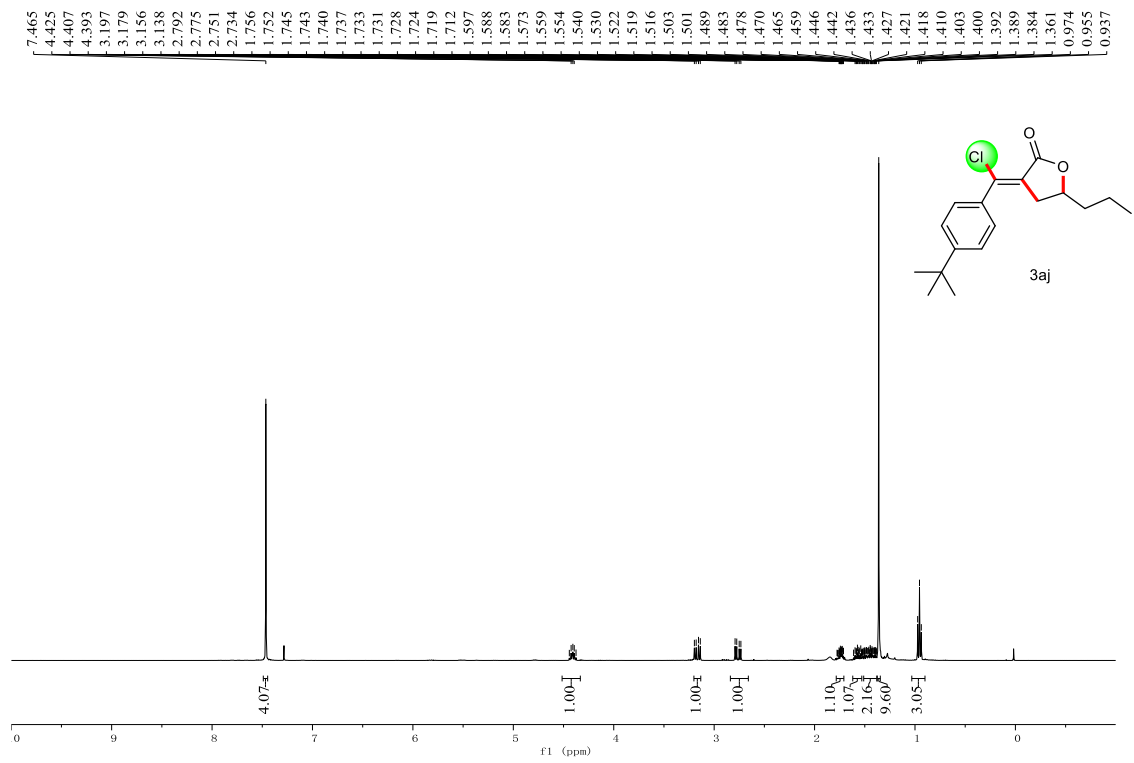
76.018

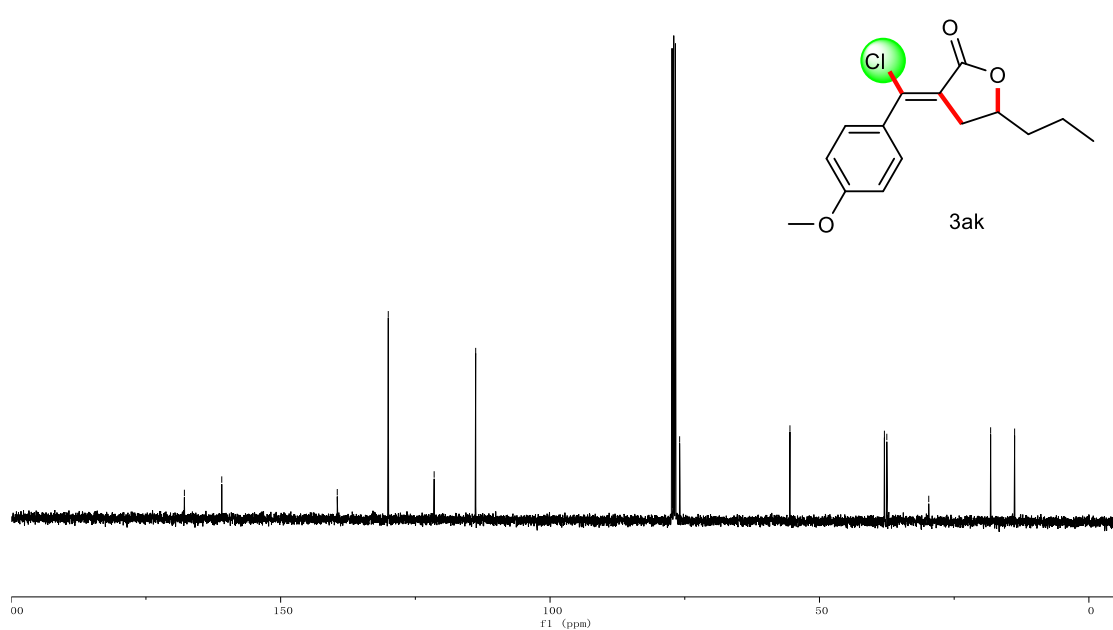
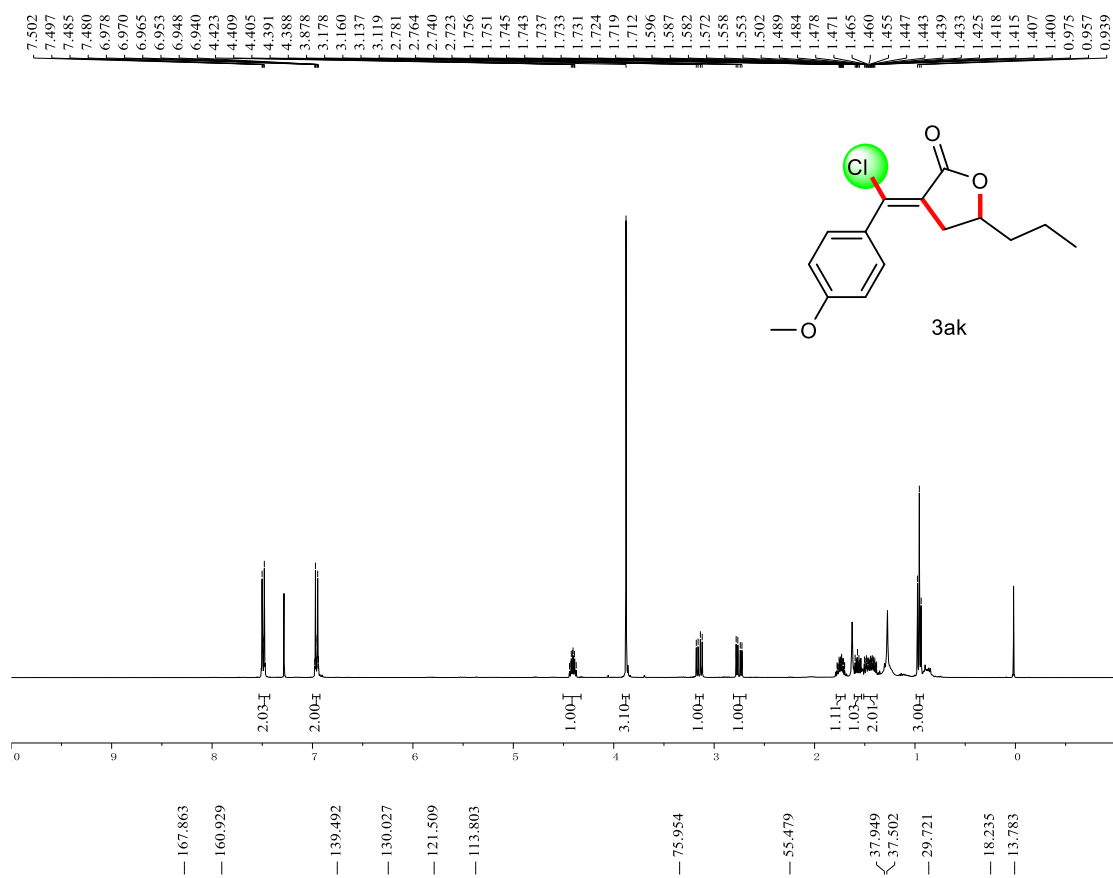
38.599
35.556
21.271
19.387
19.358
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13.820

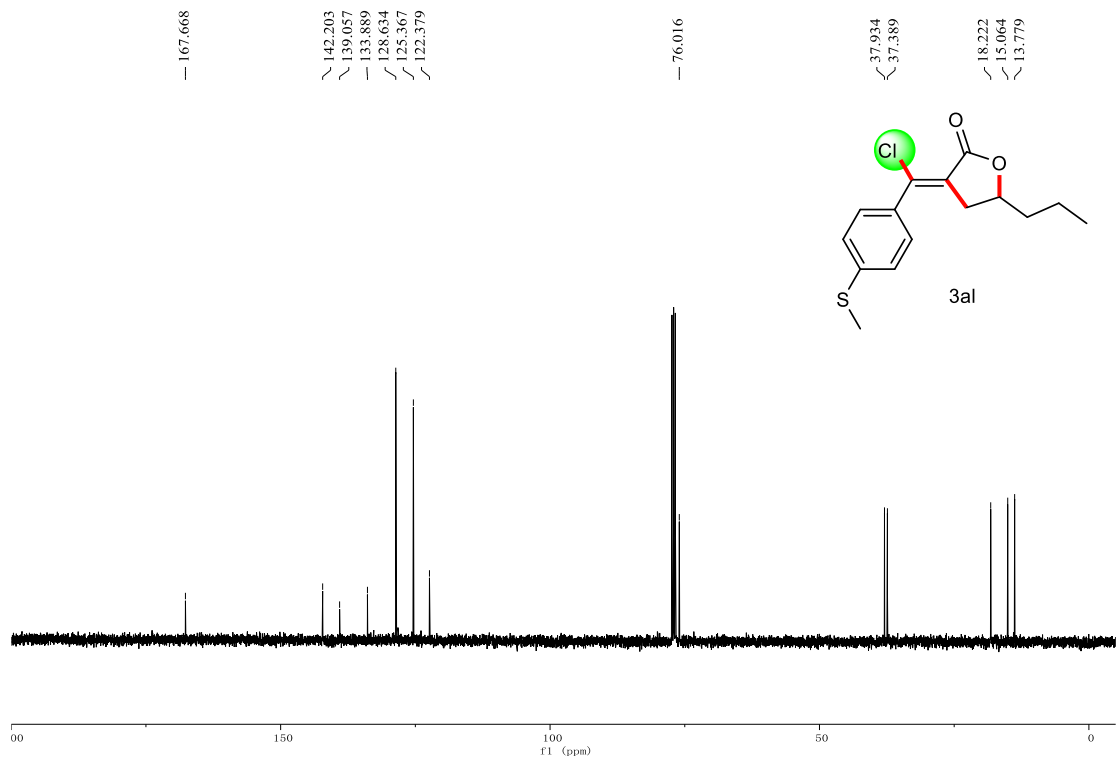
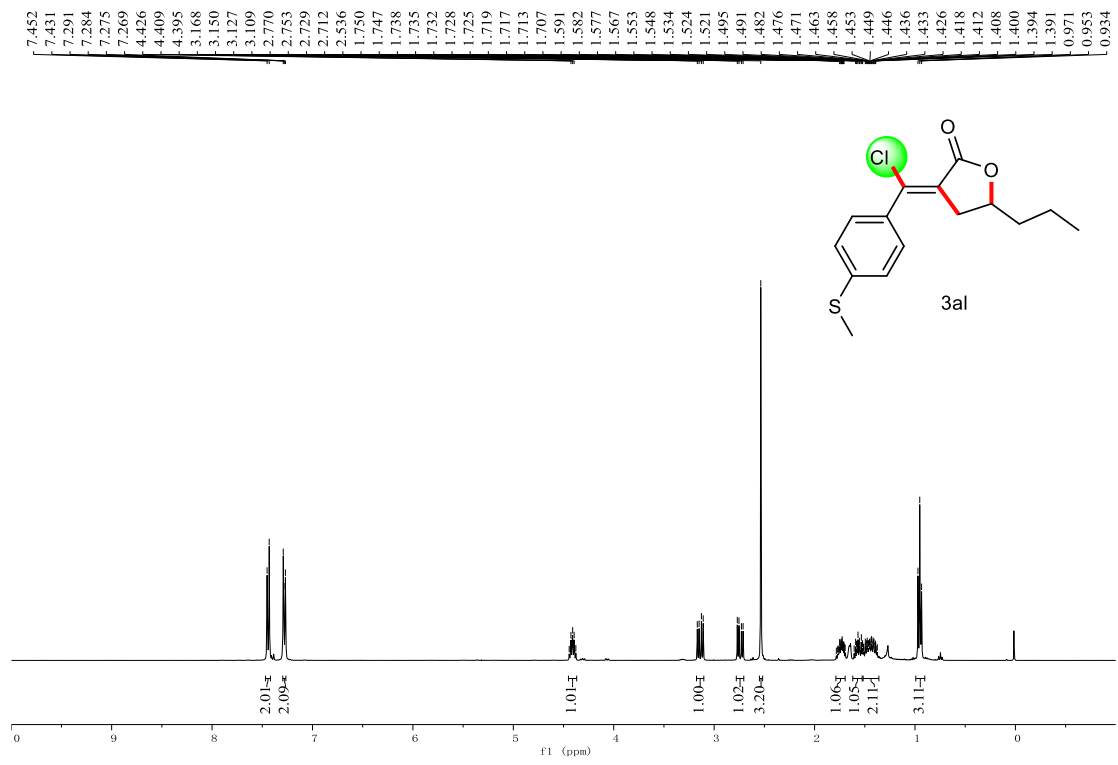


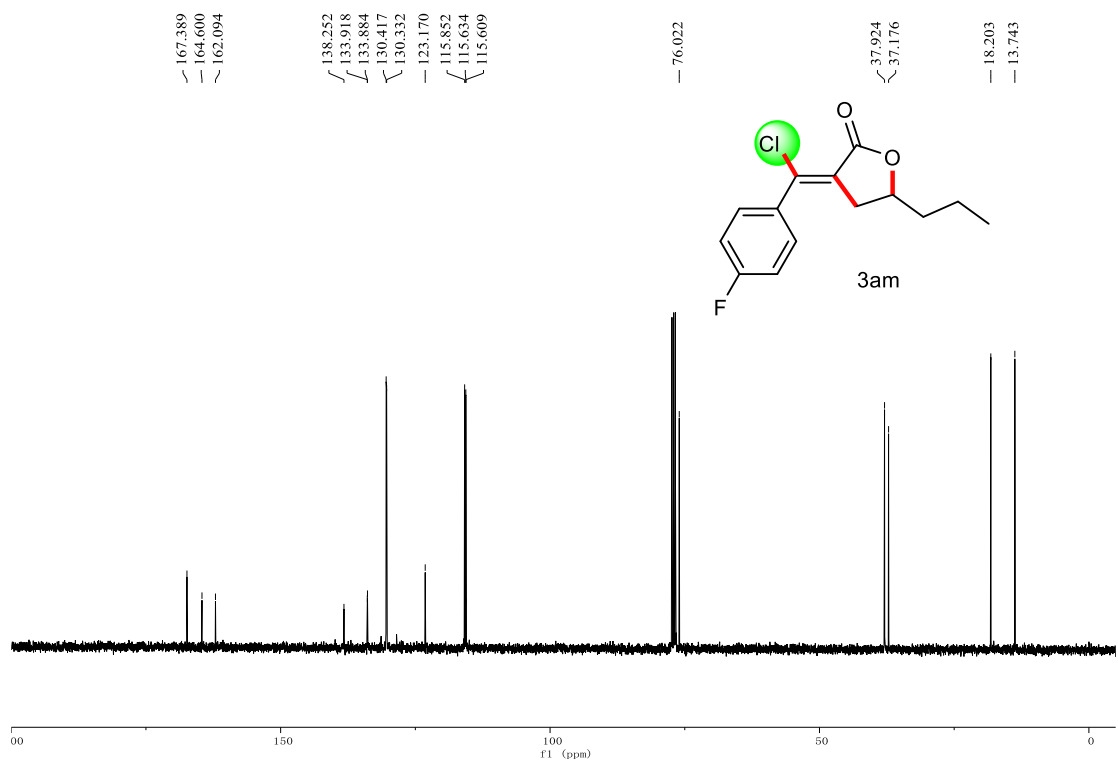
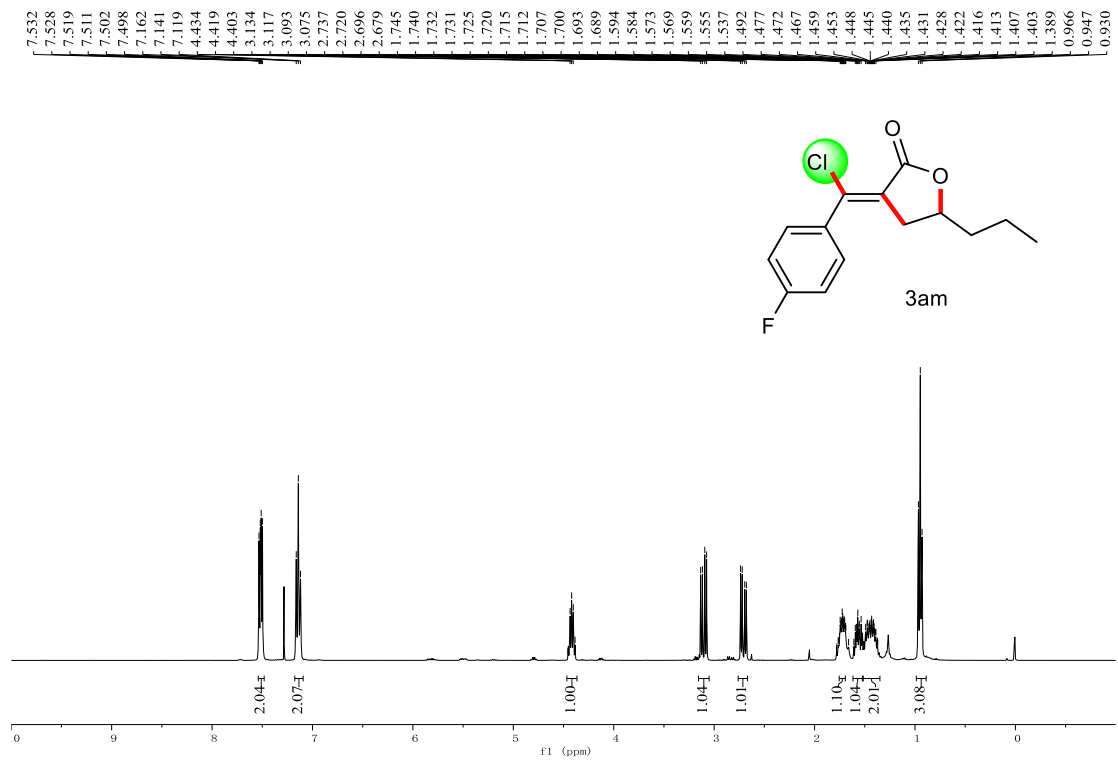


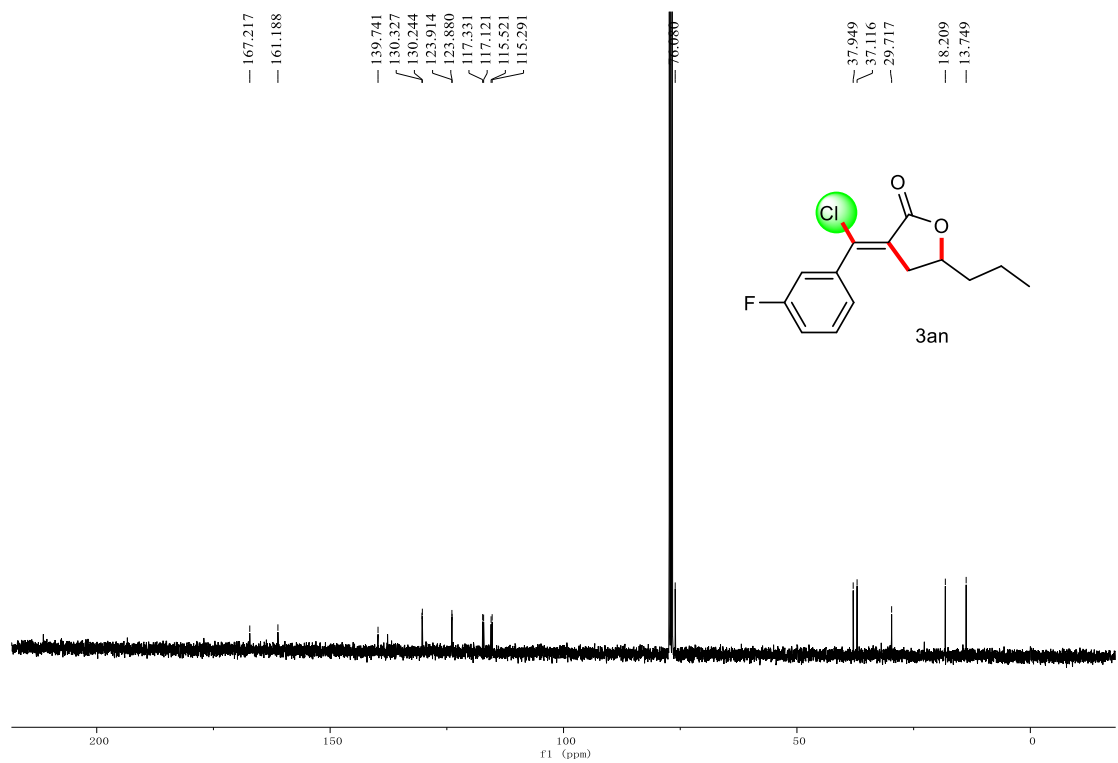
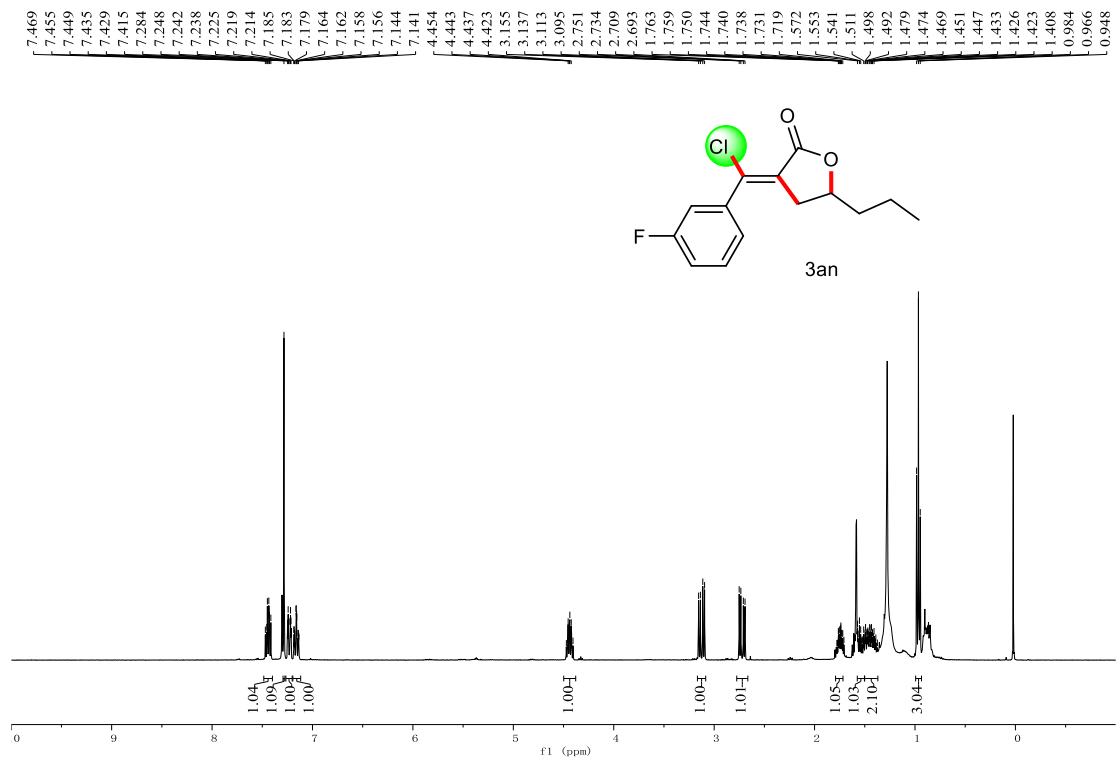


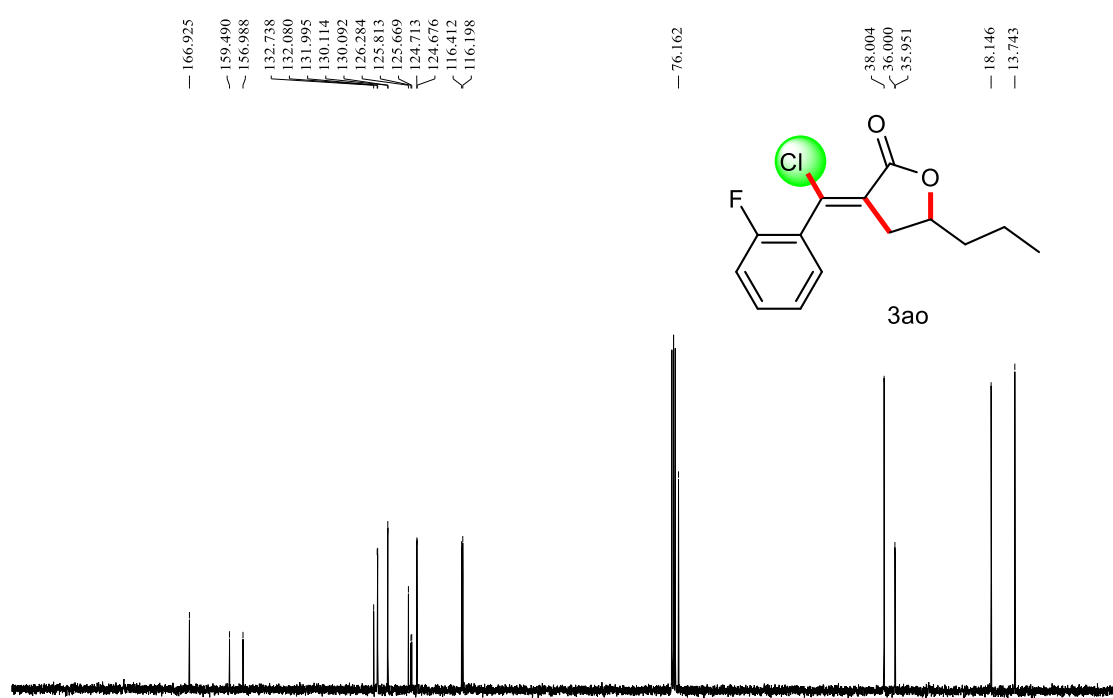
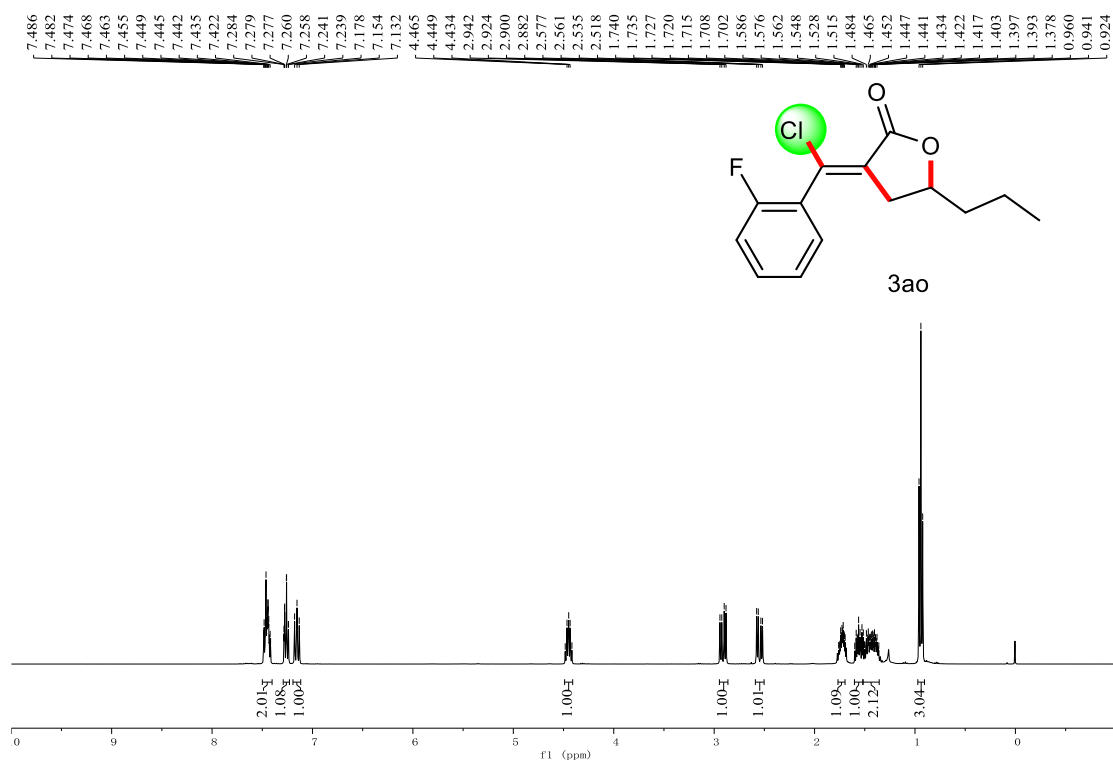


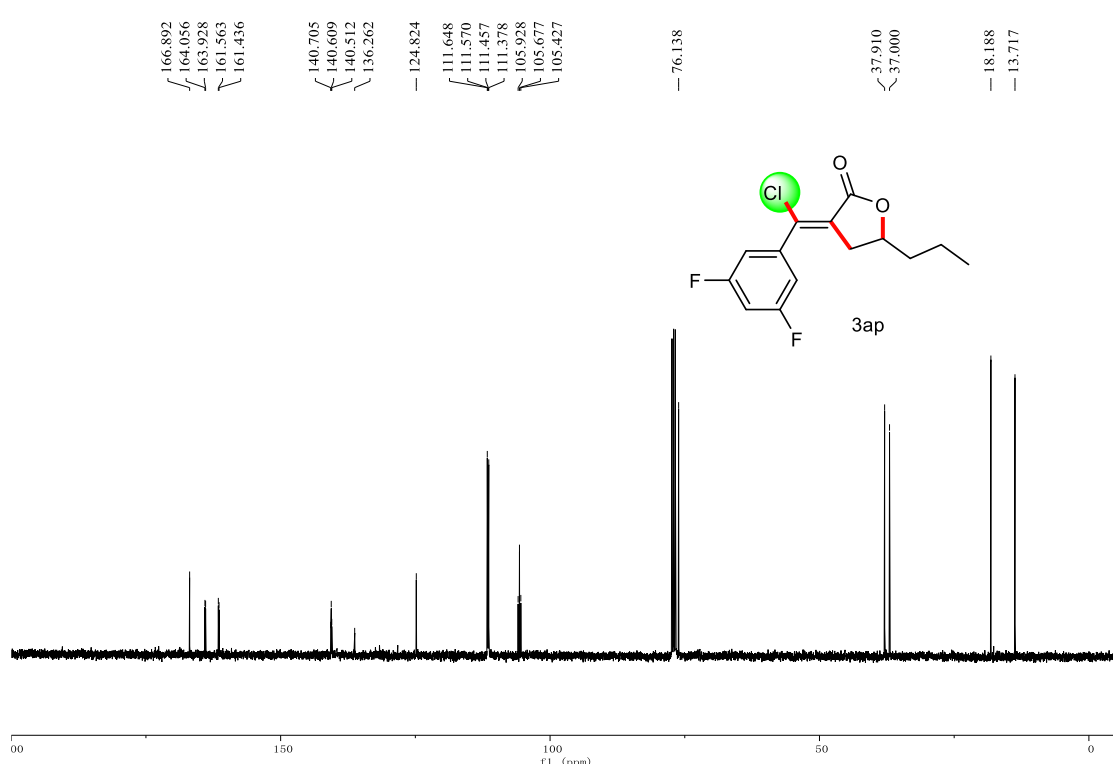
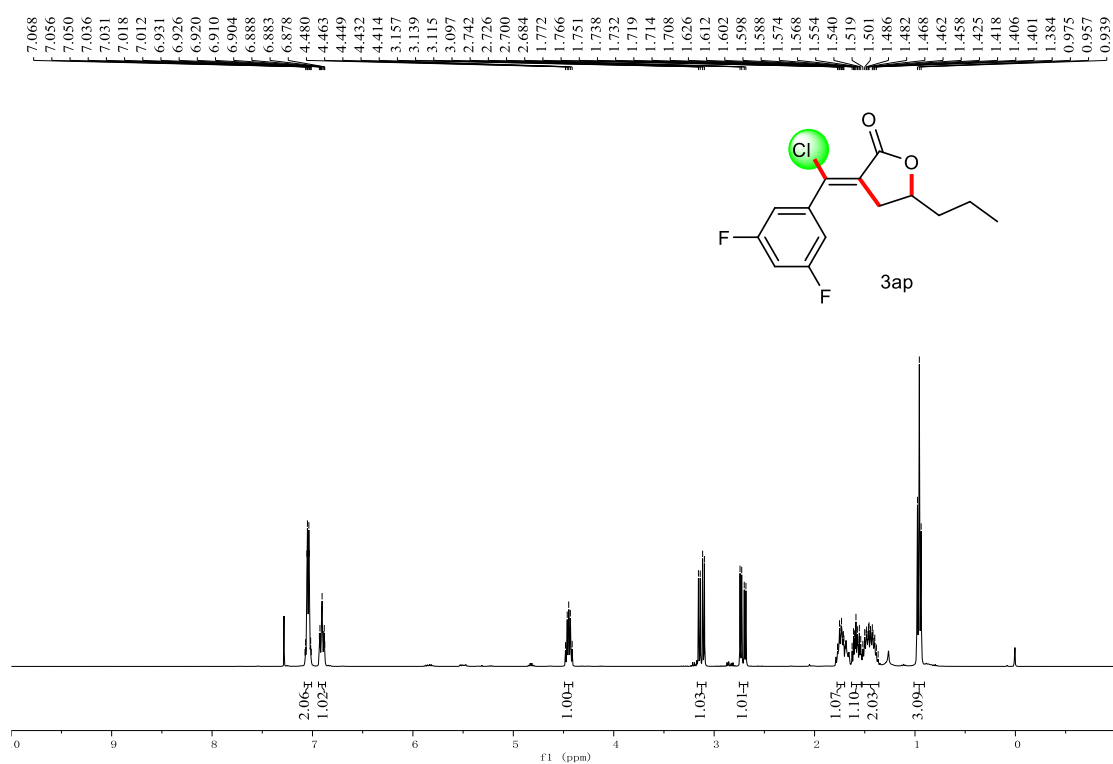


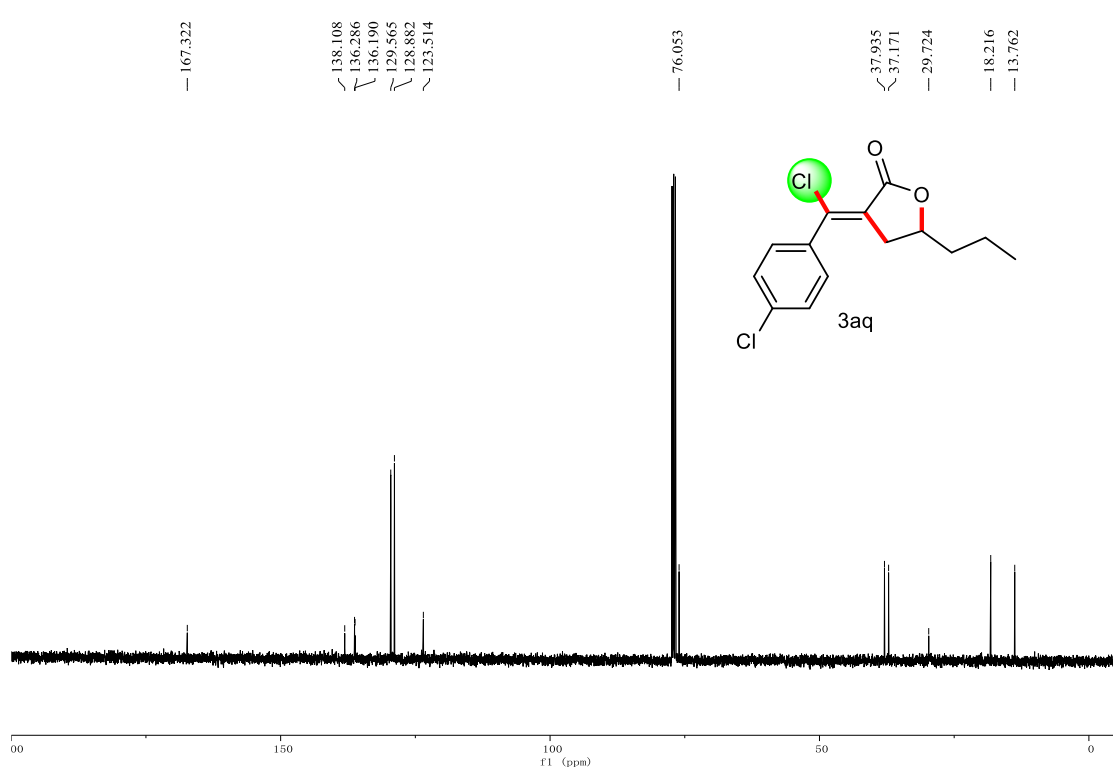
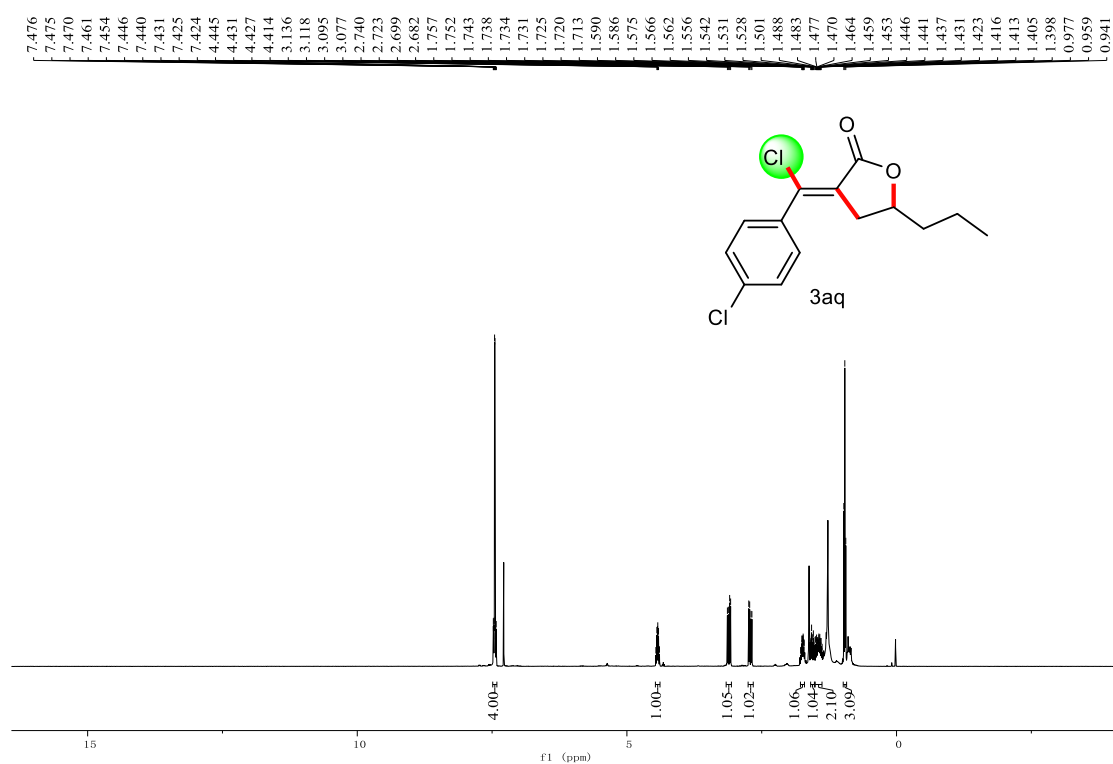


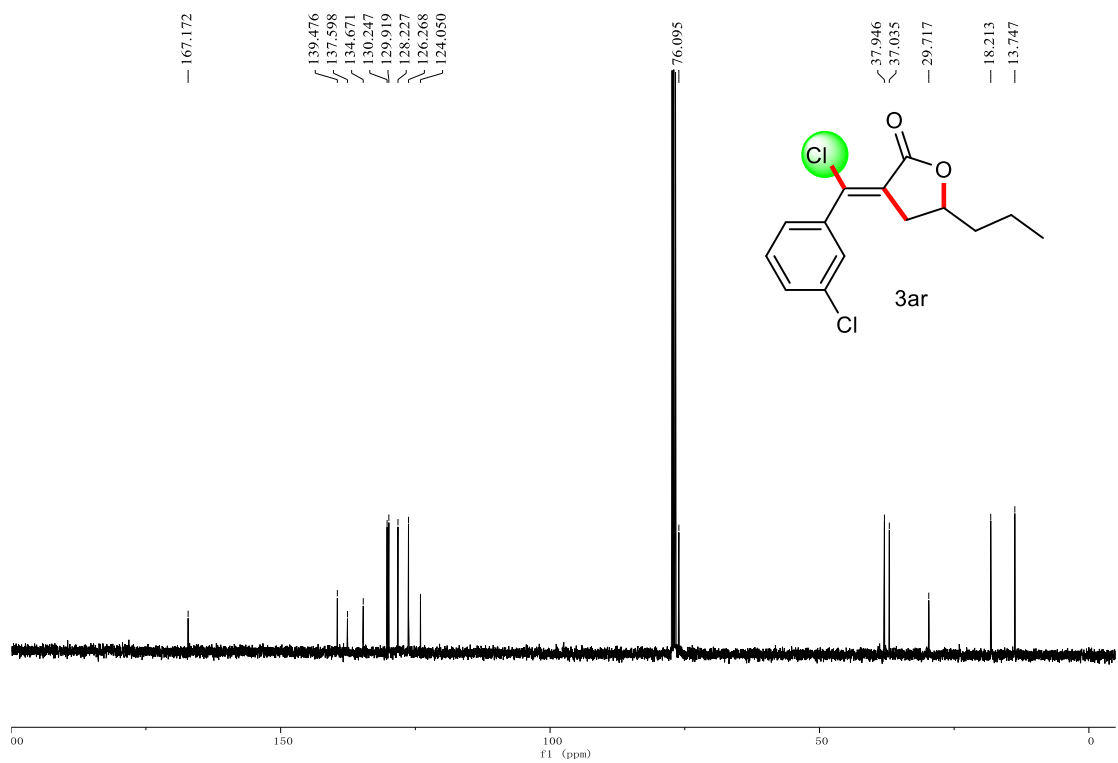
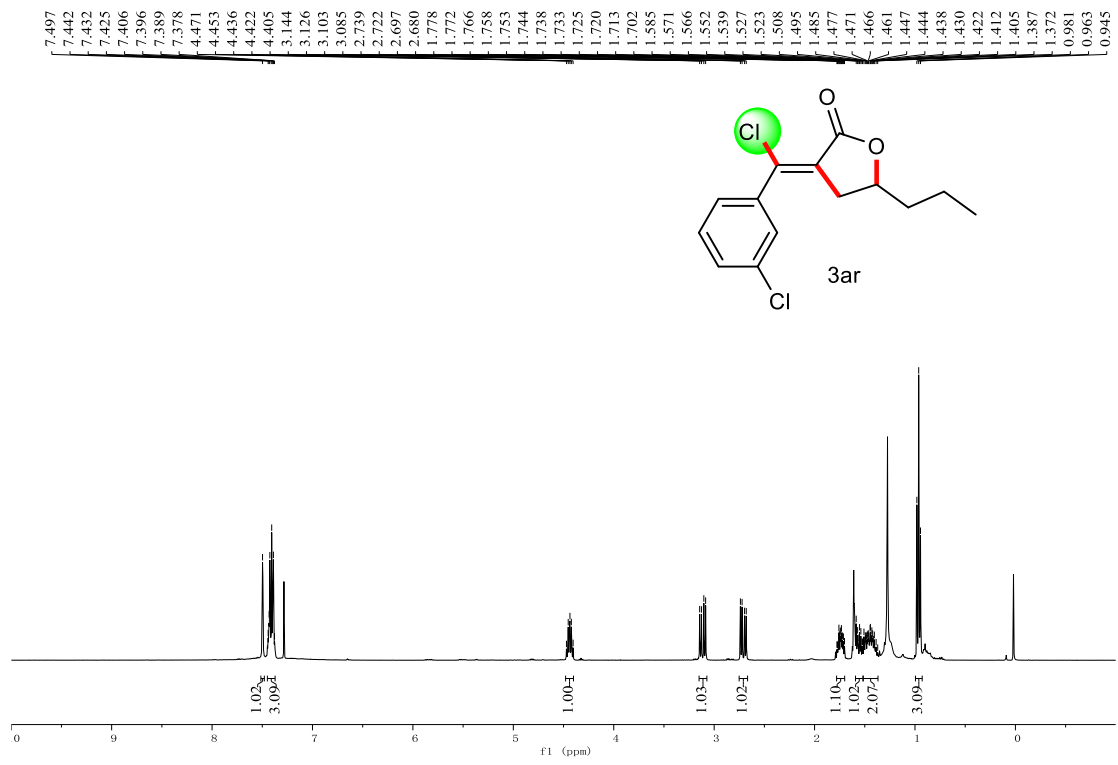


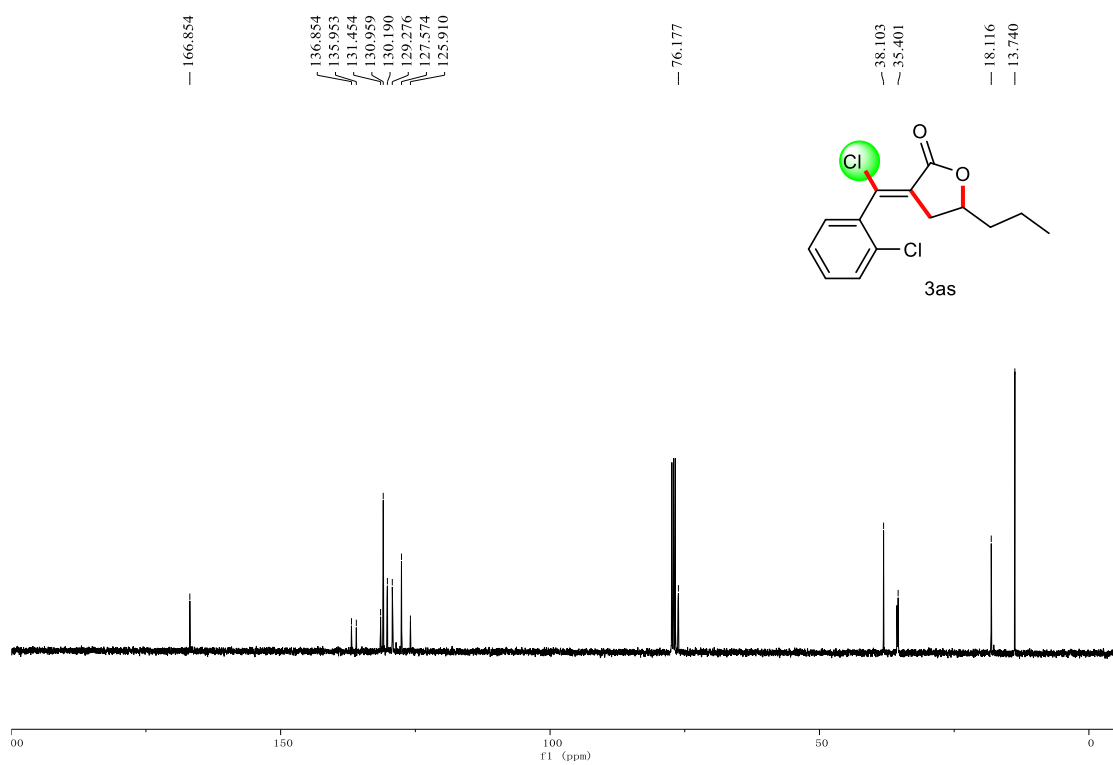
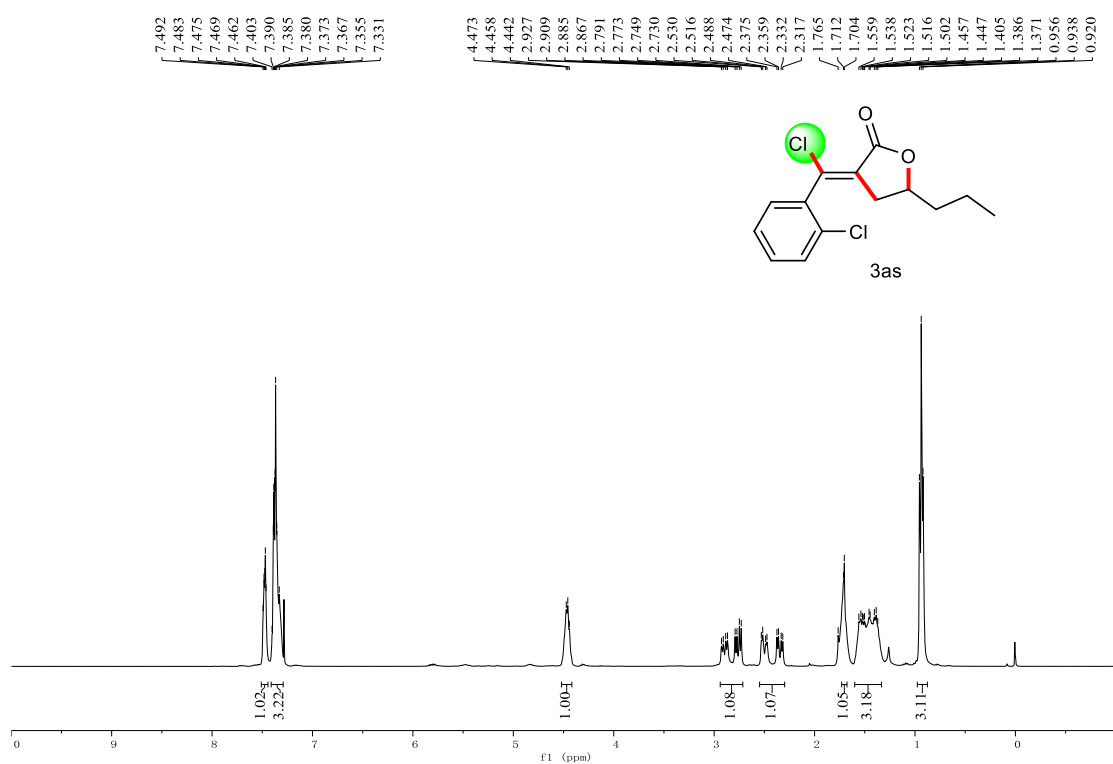


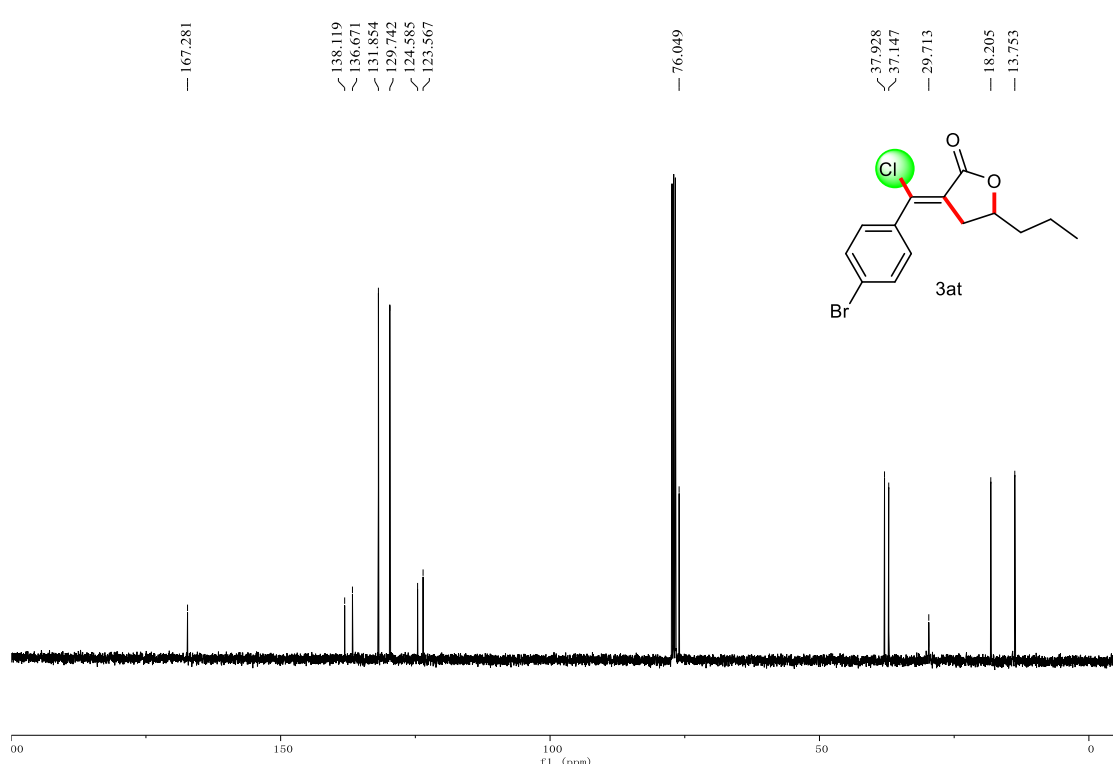
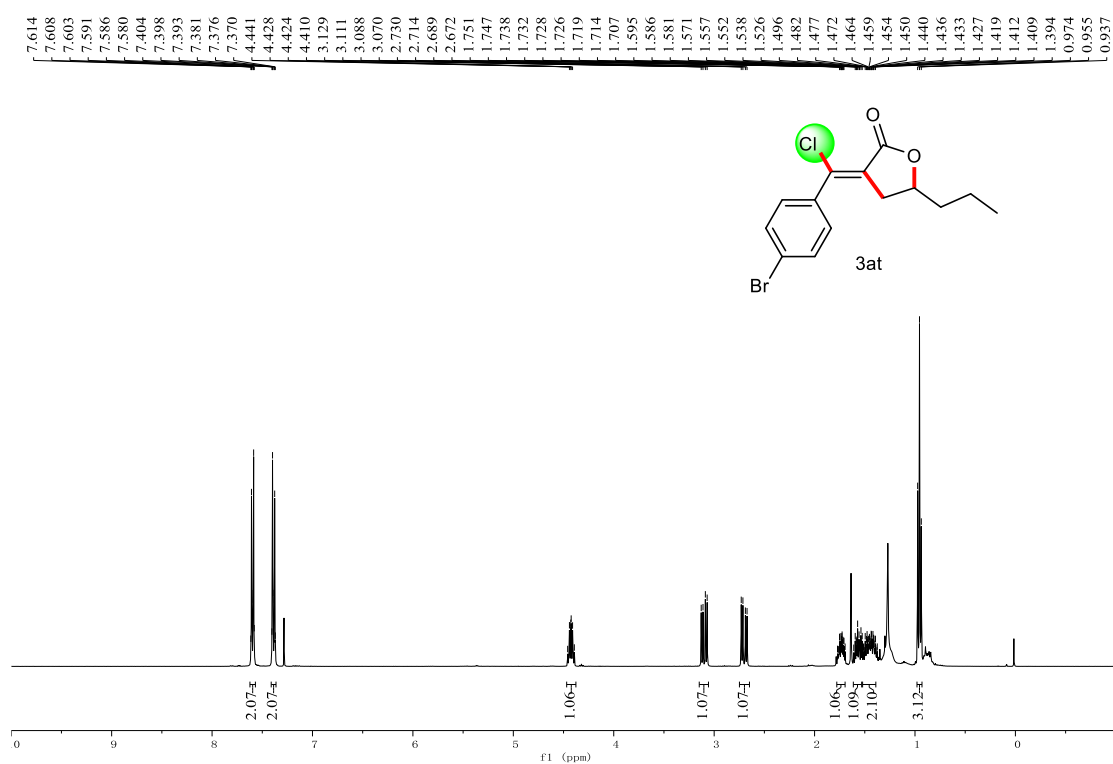


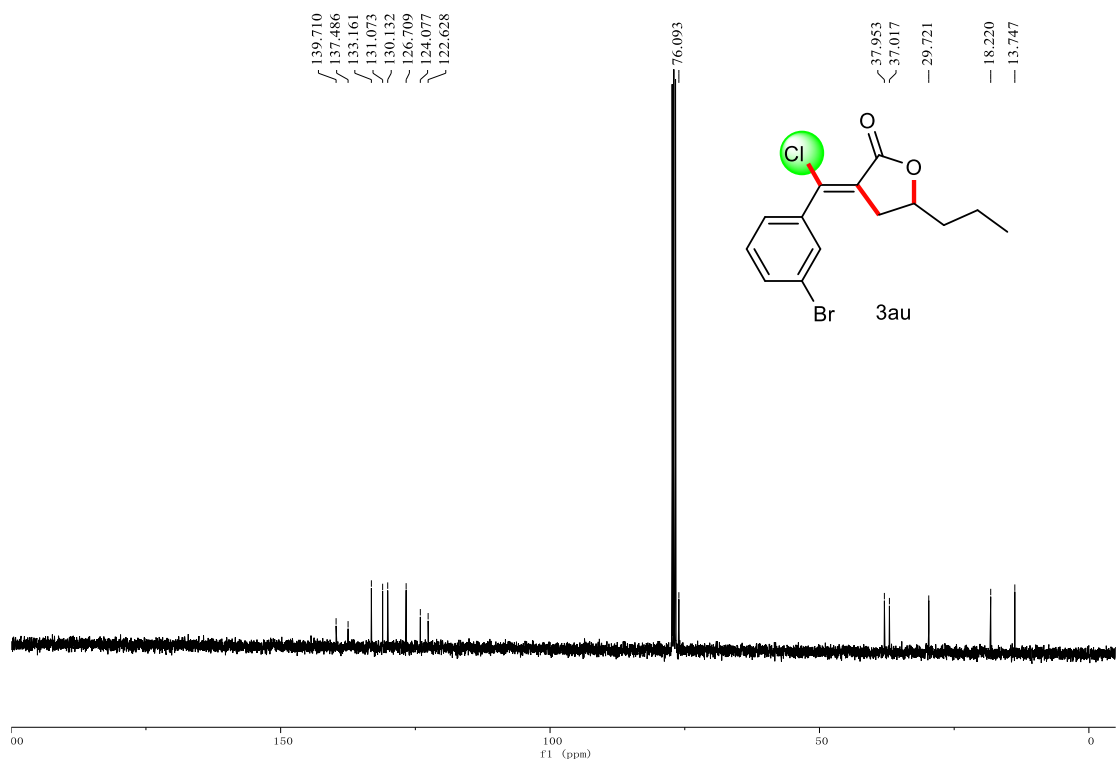
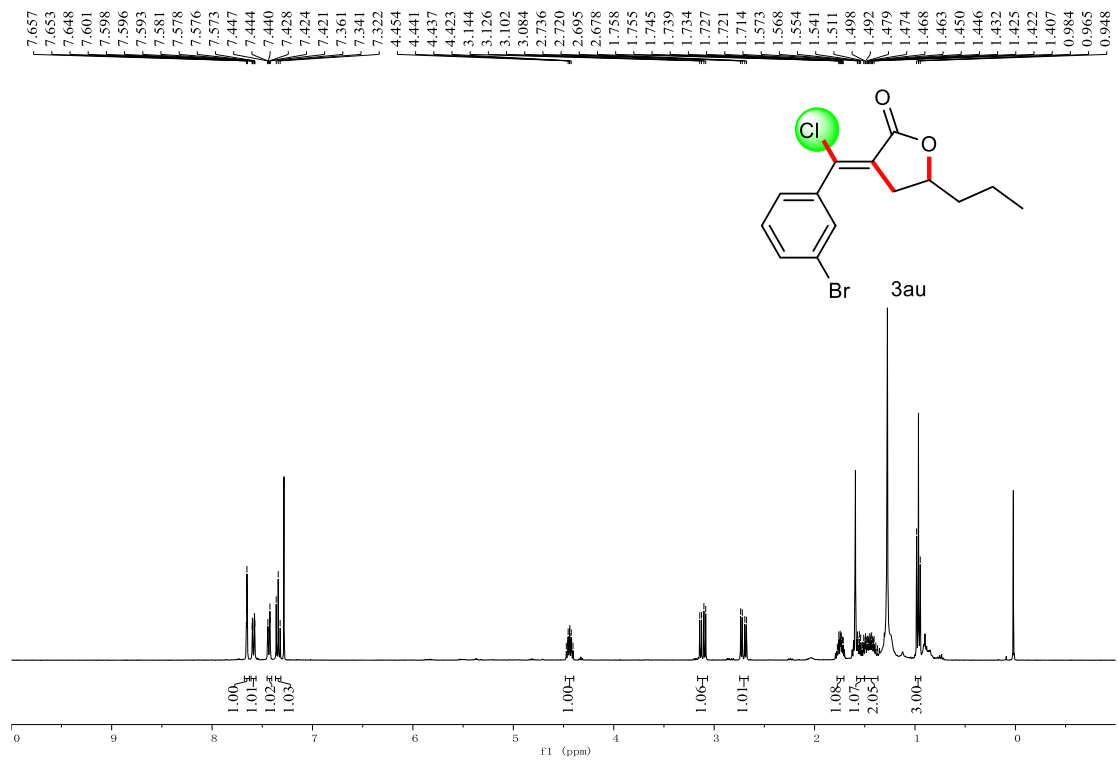


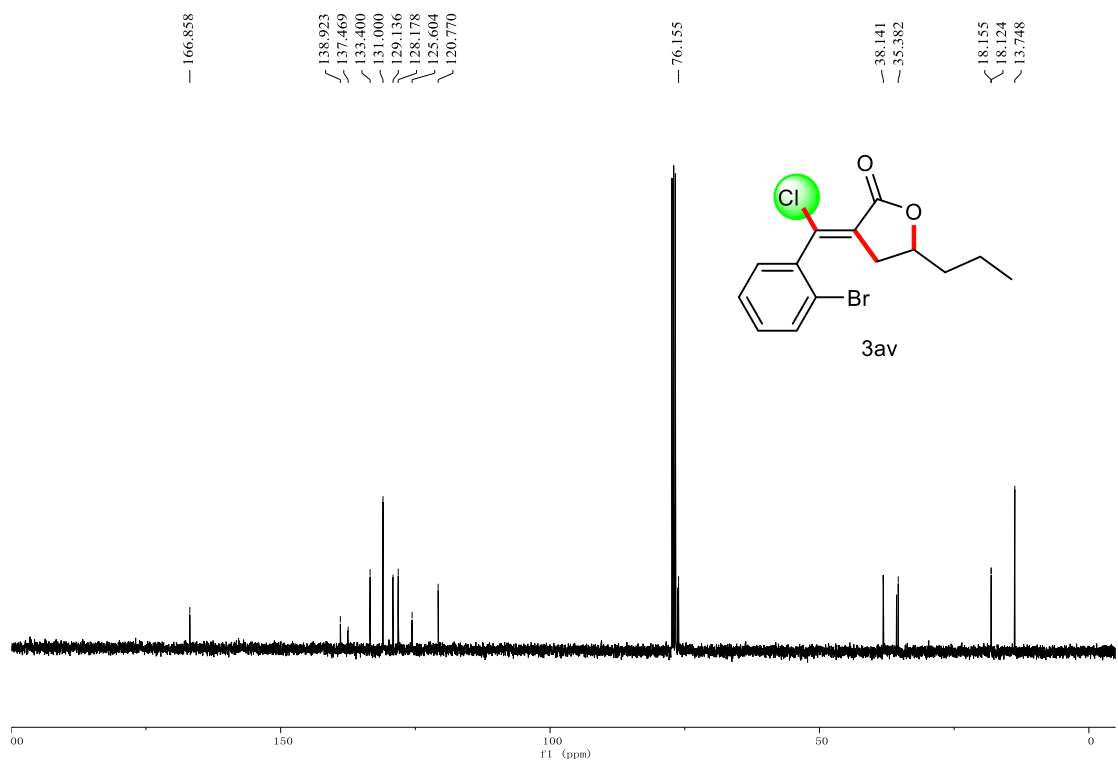
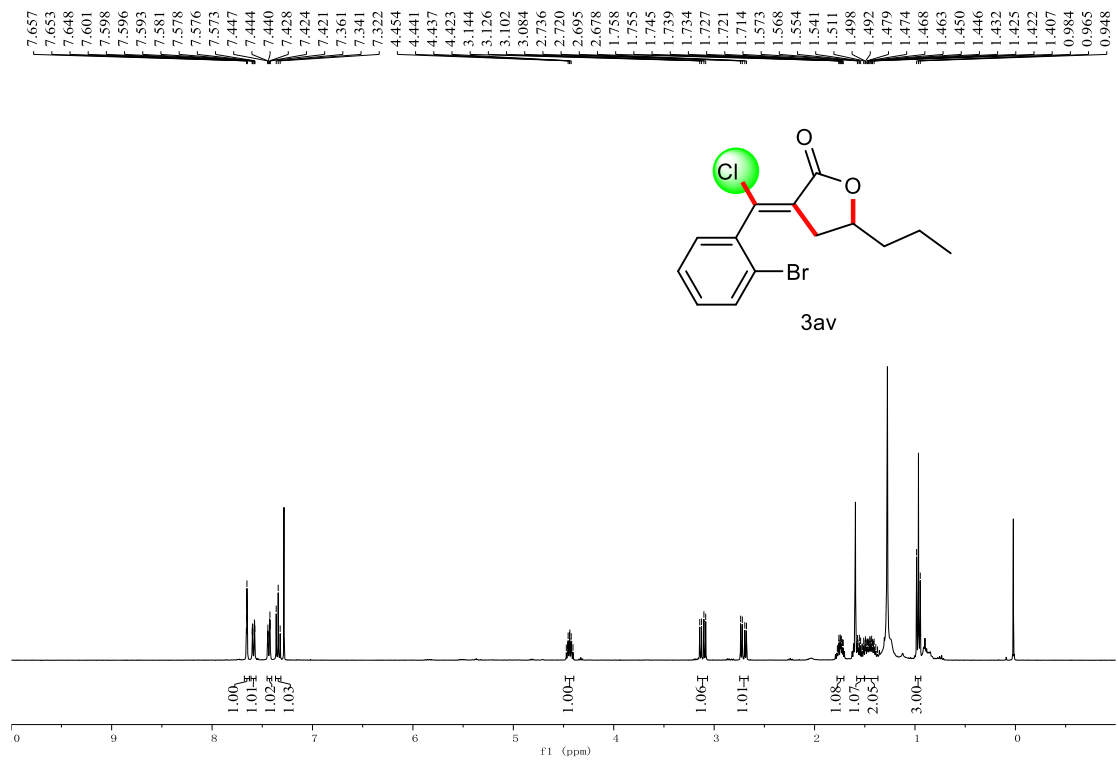


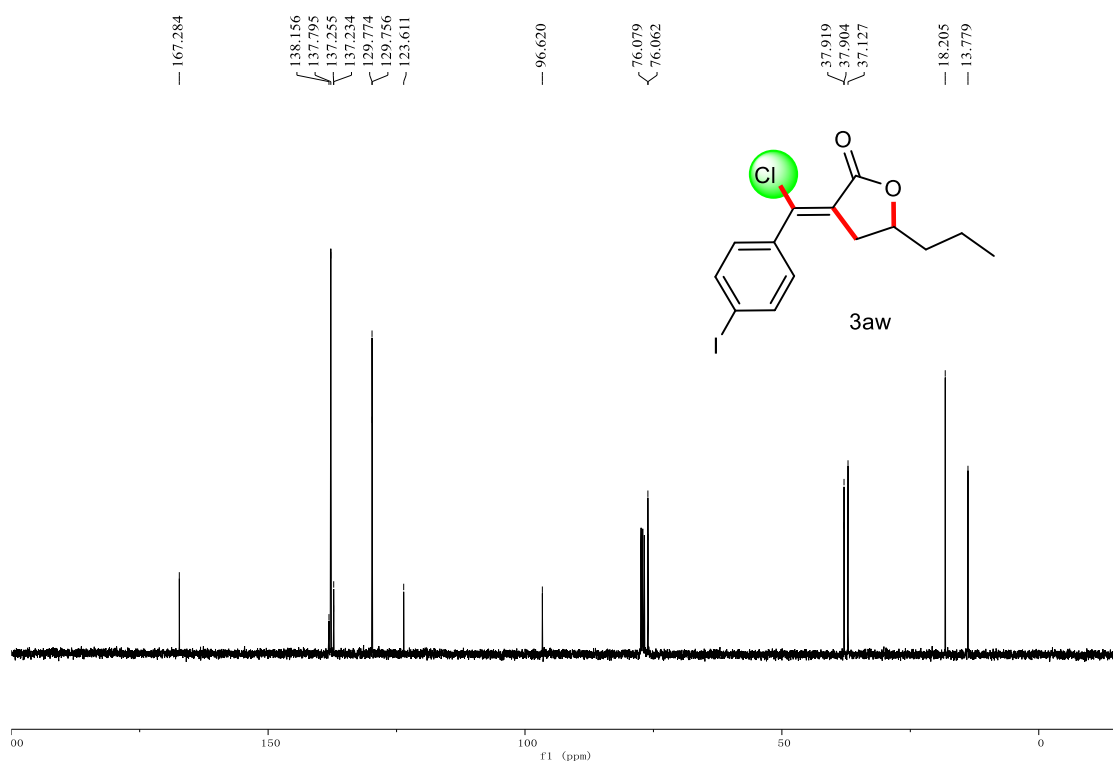
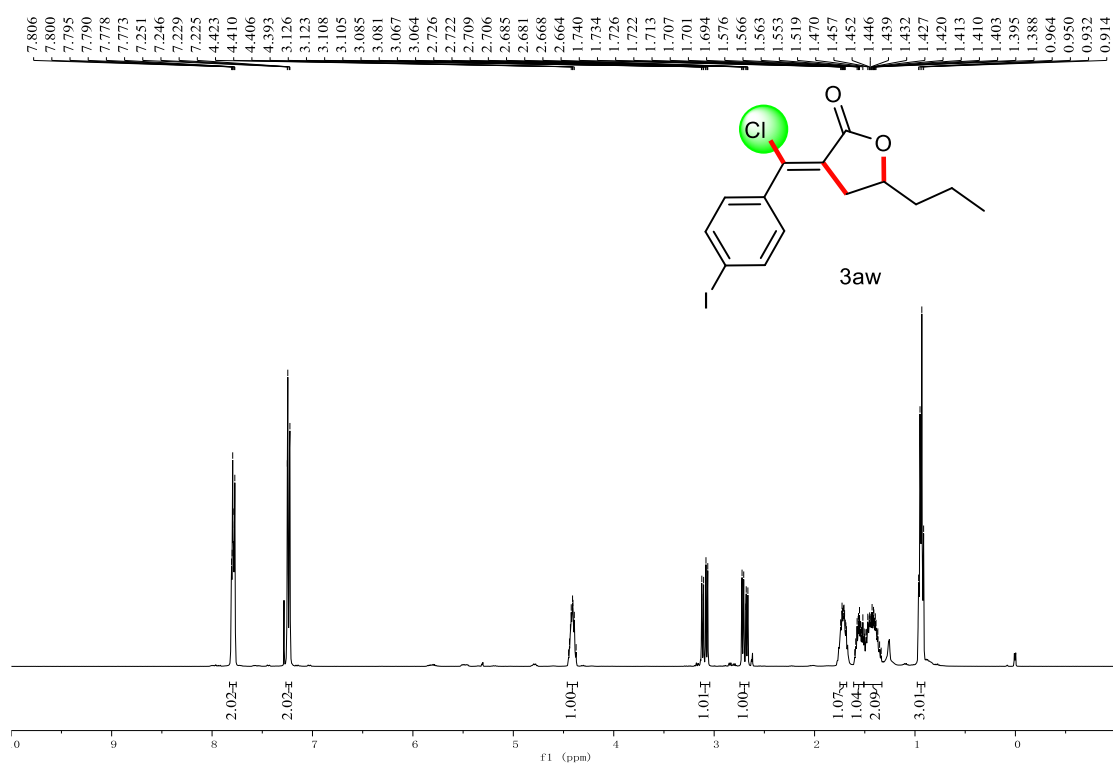


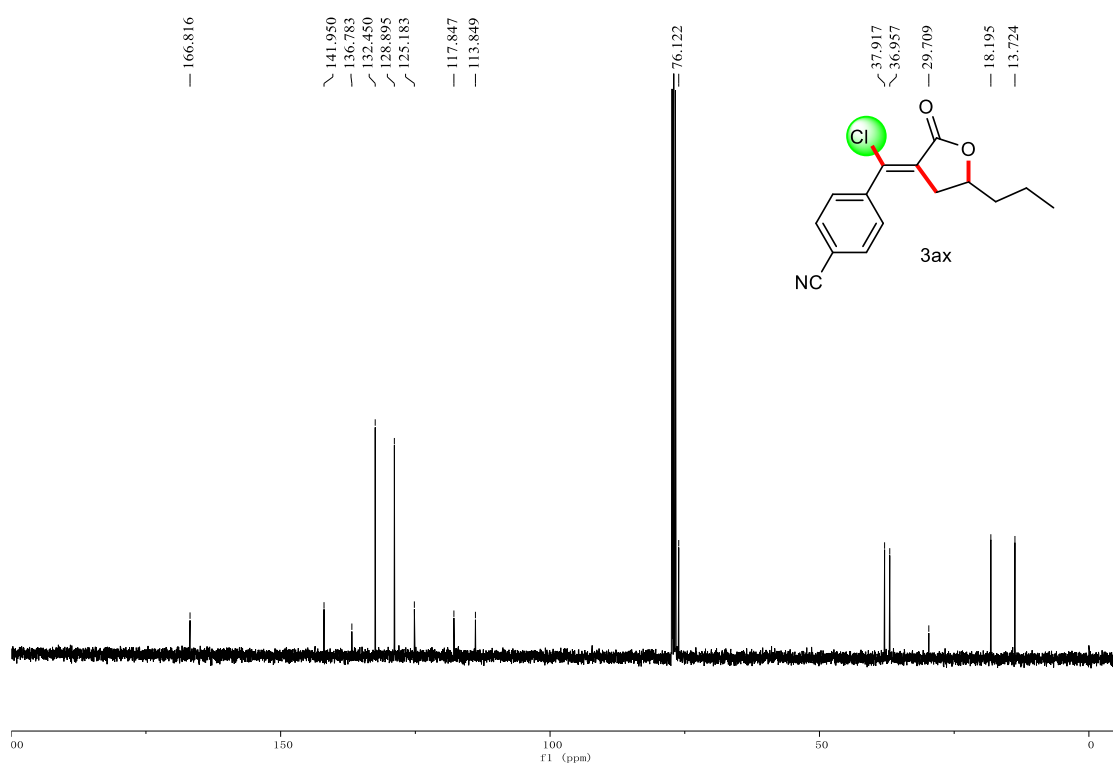
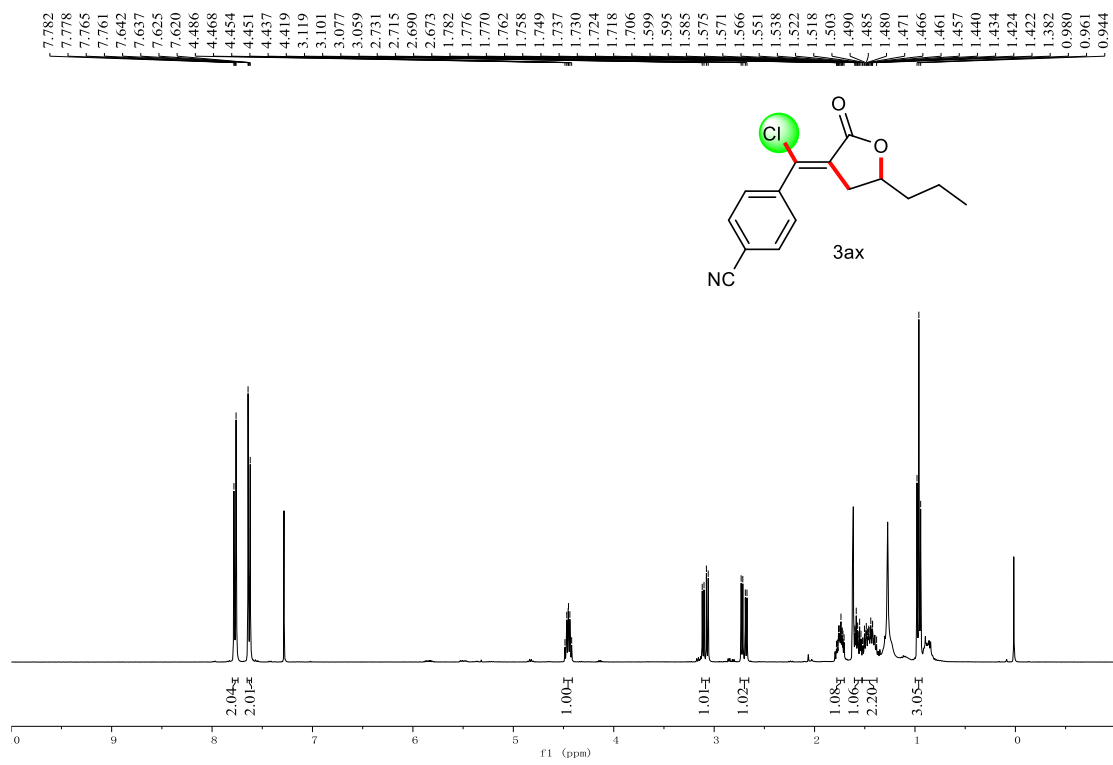


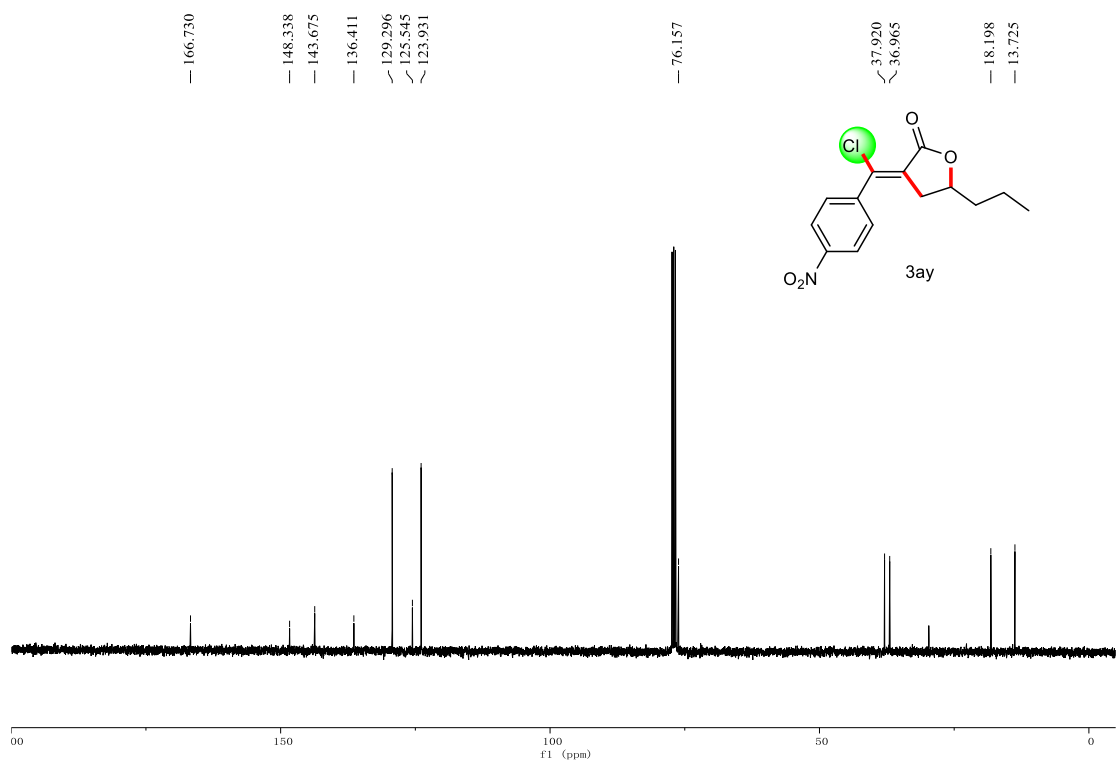
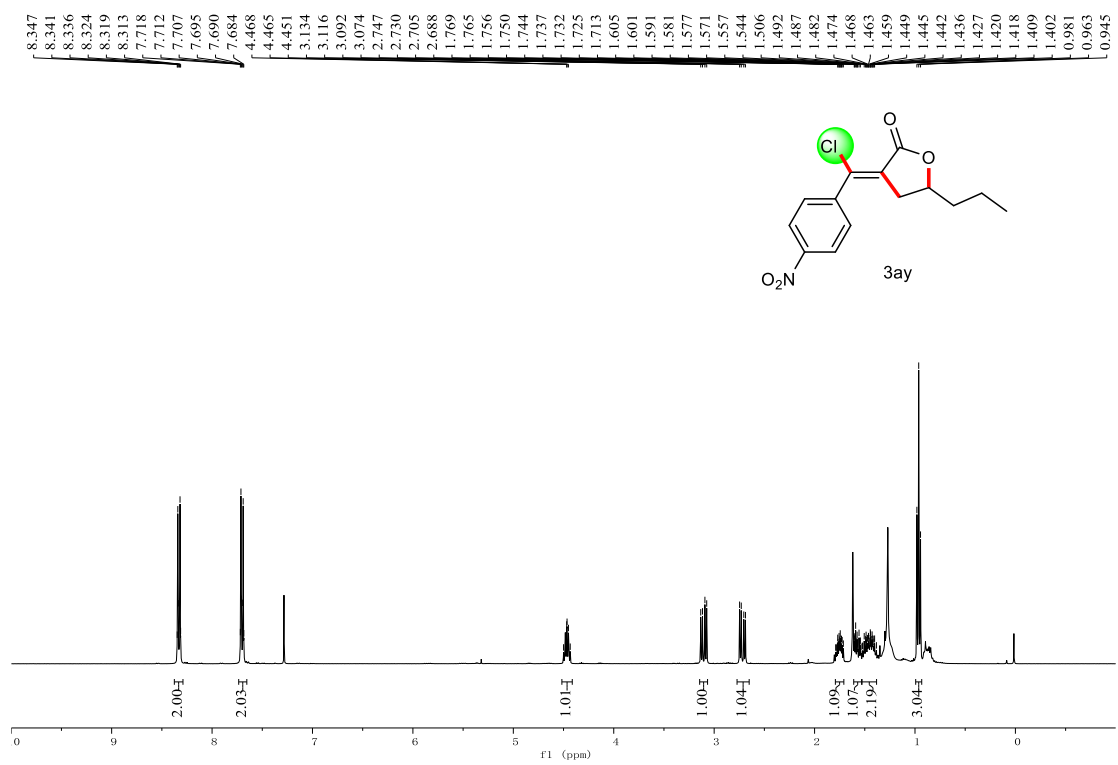


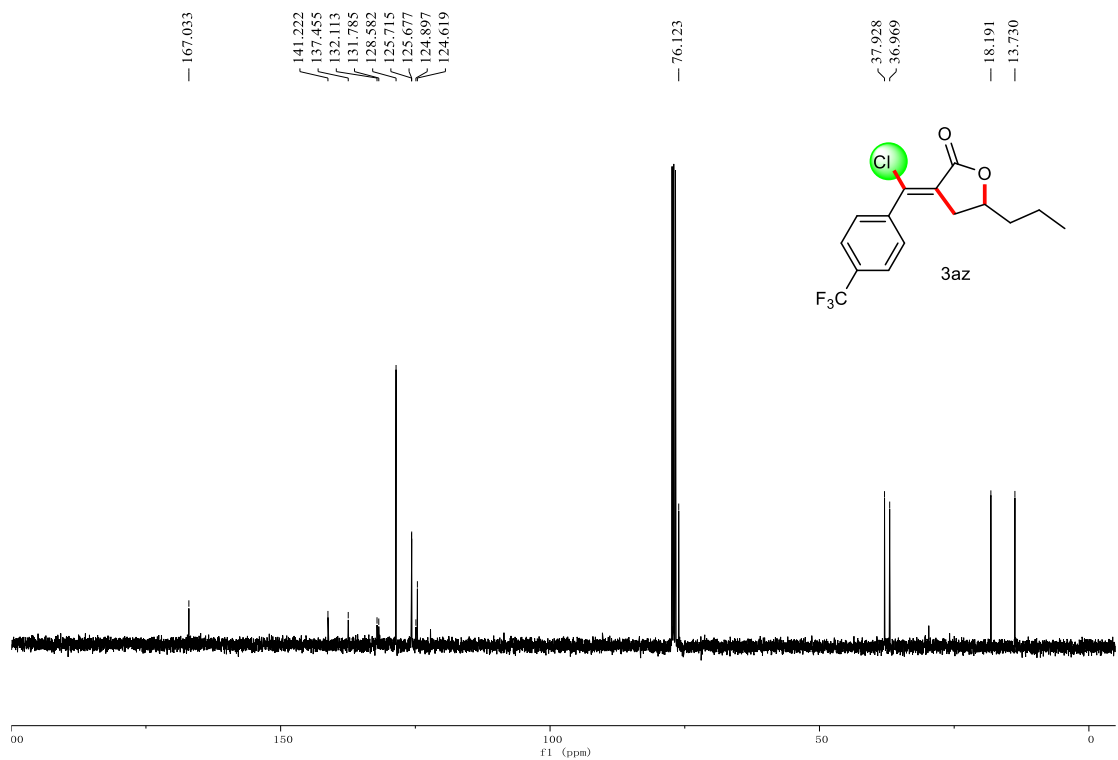
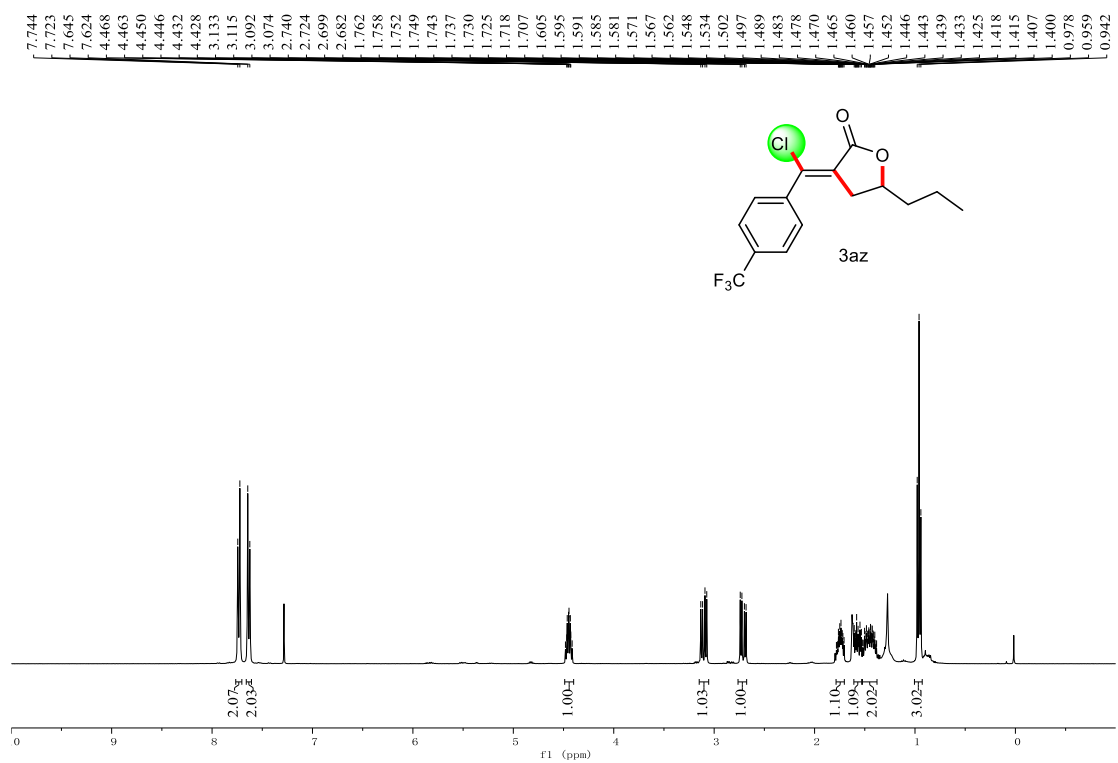


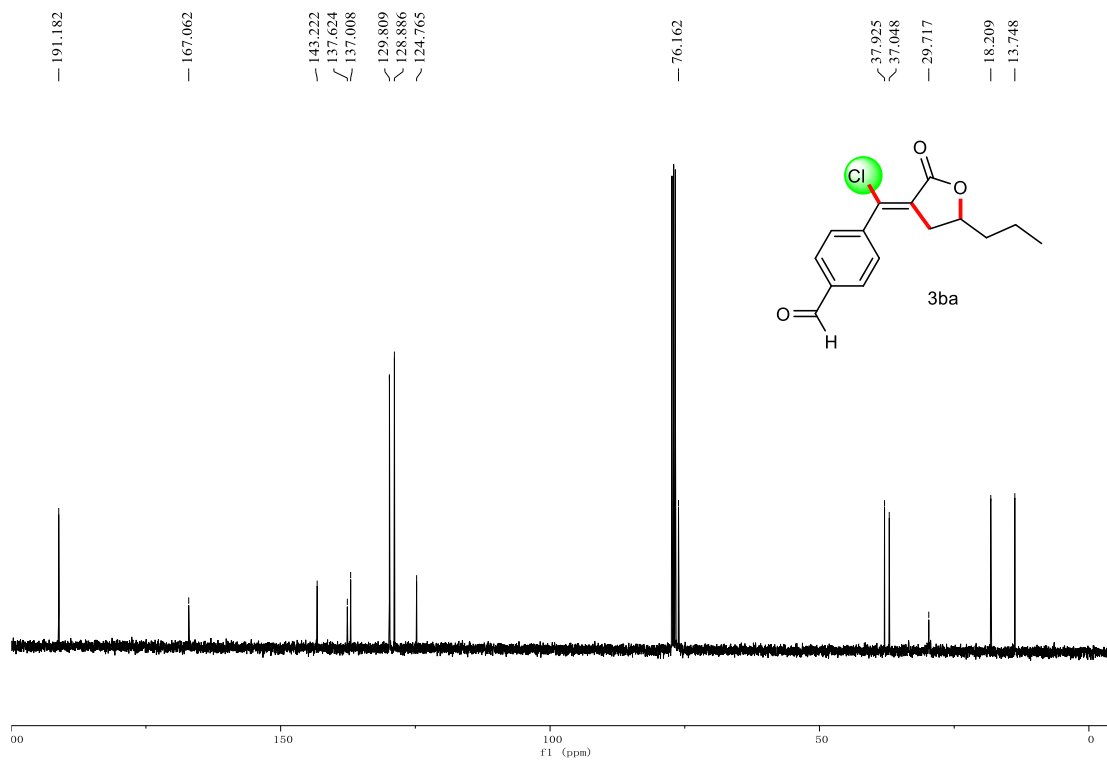
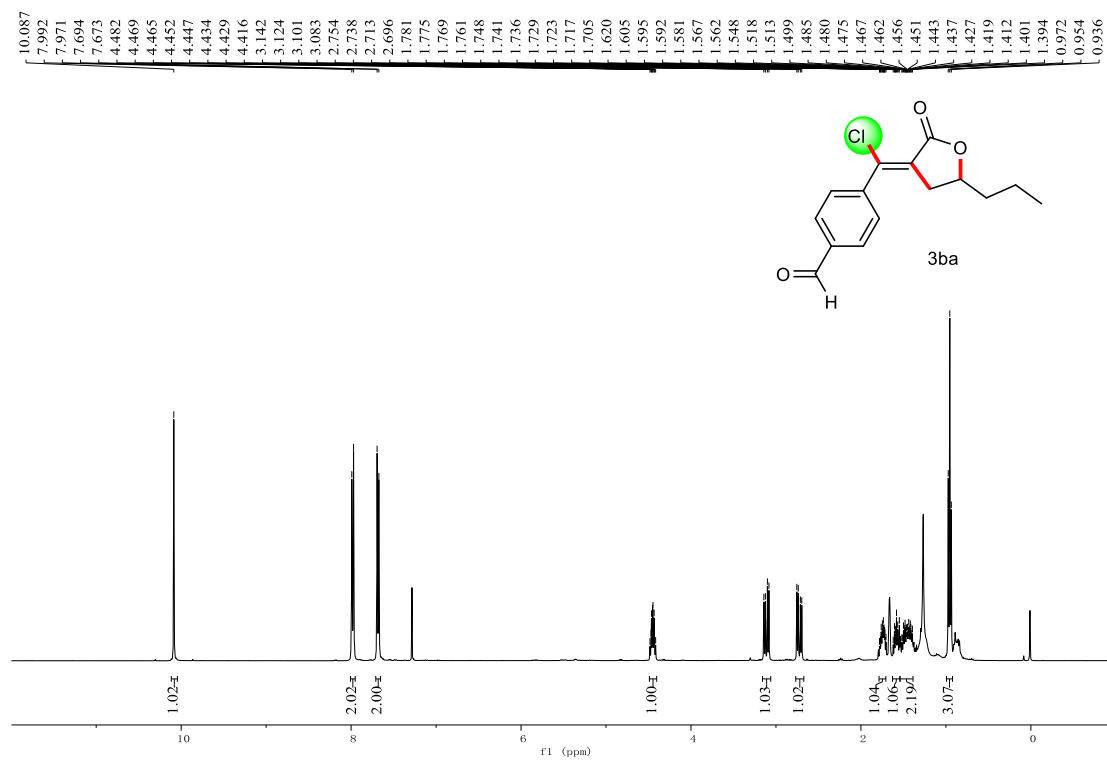


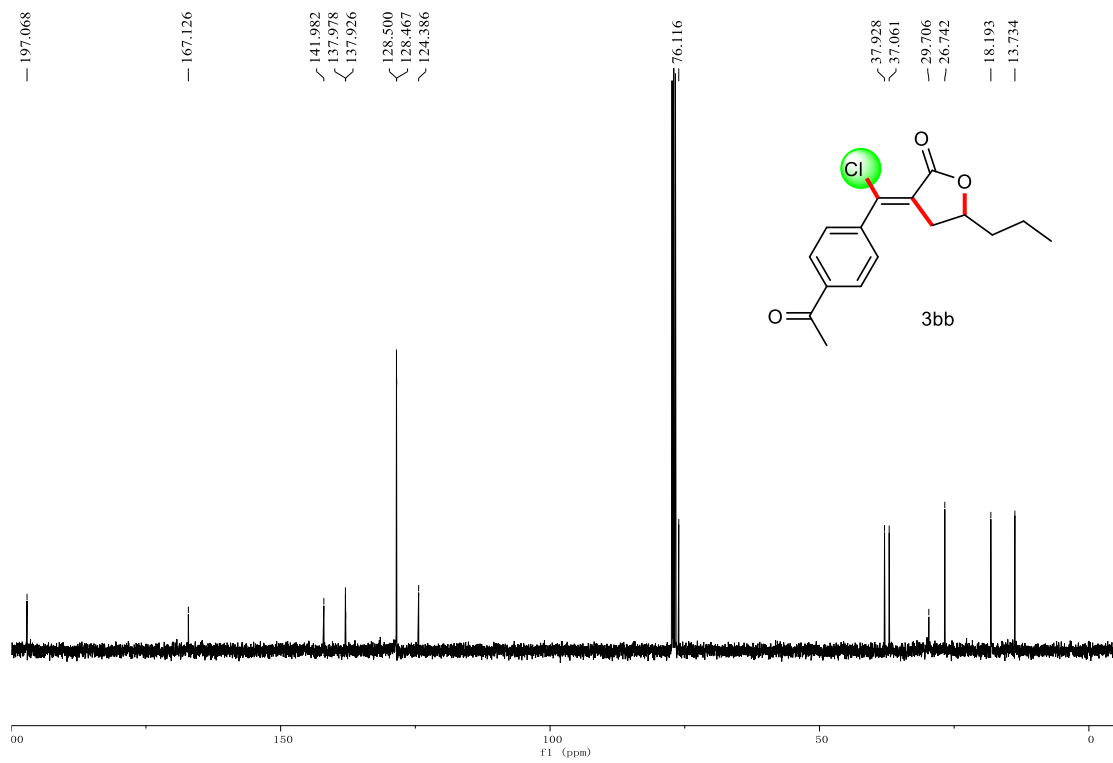
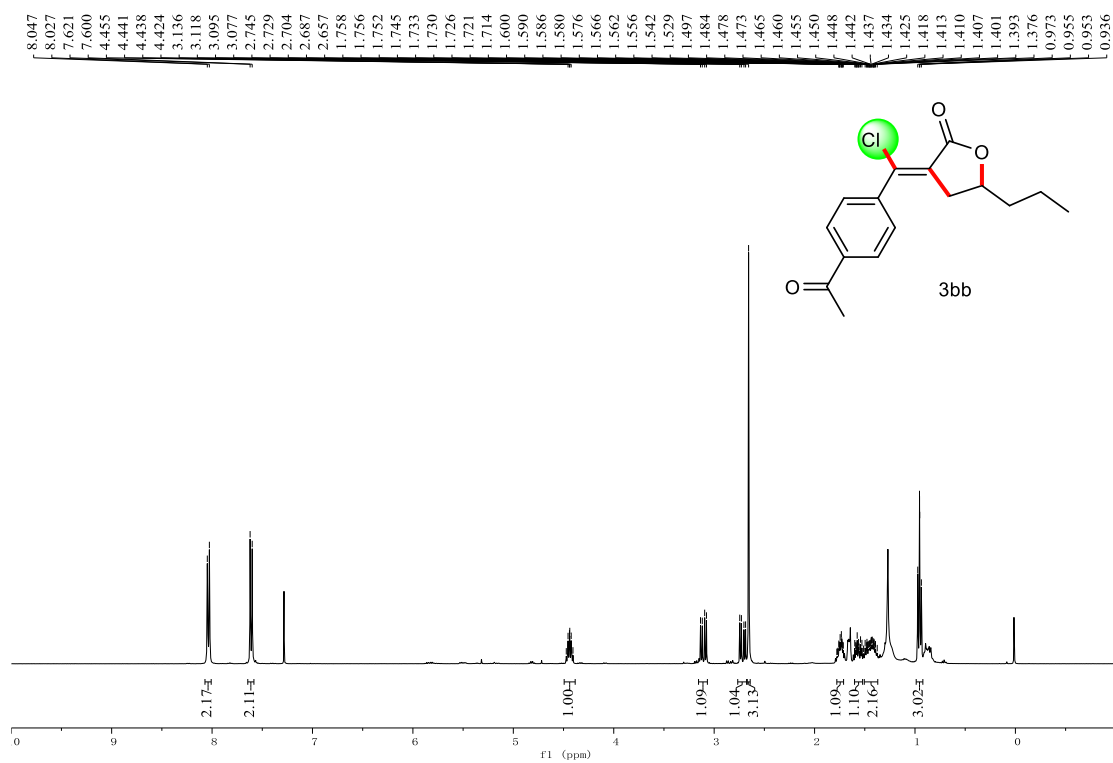


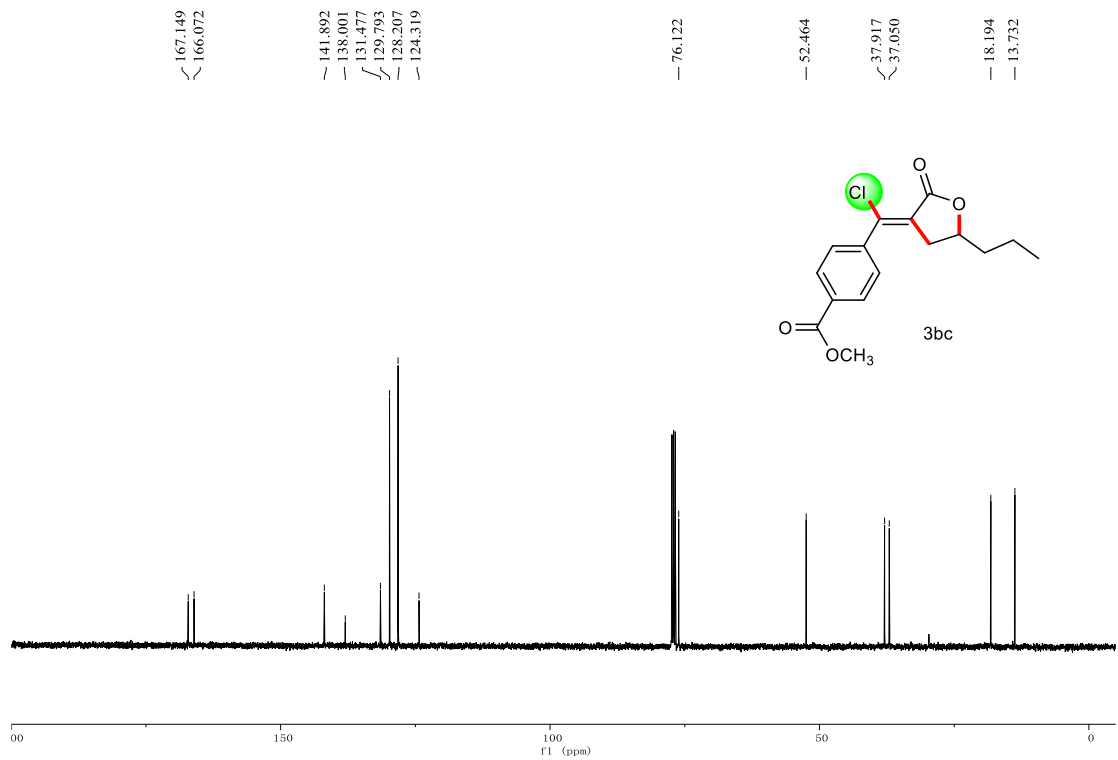
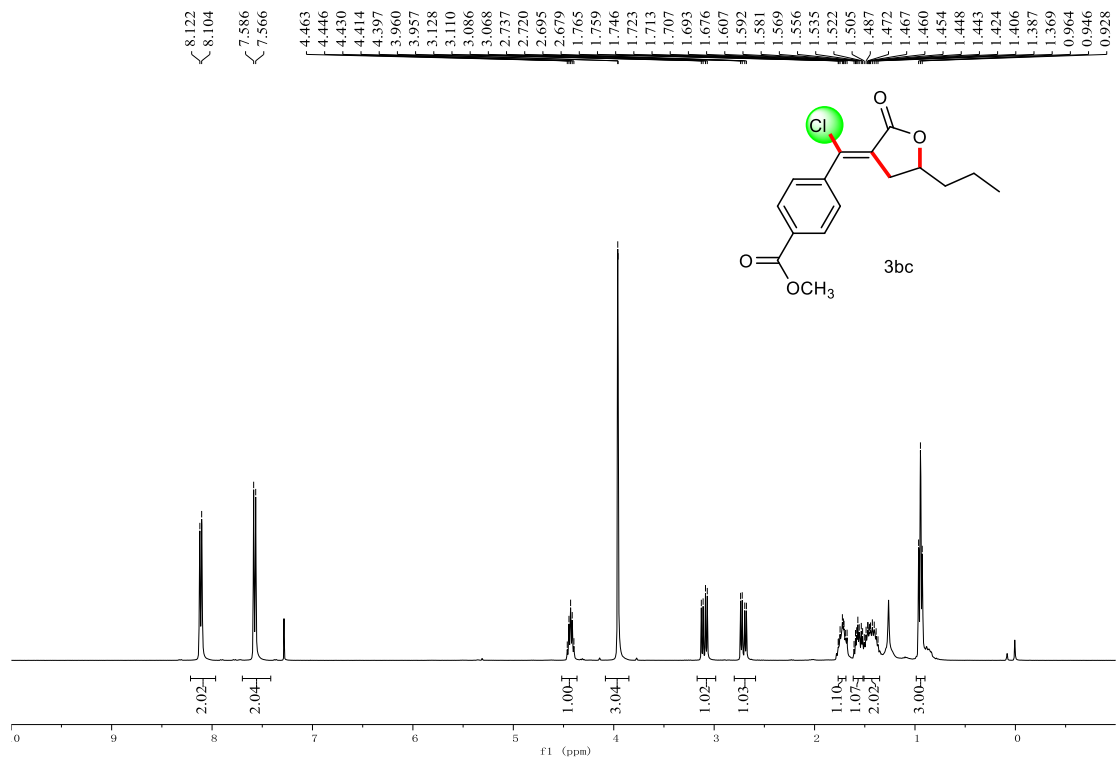


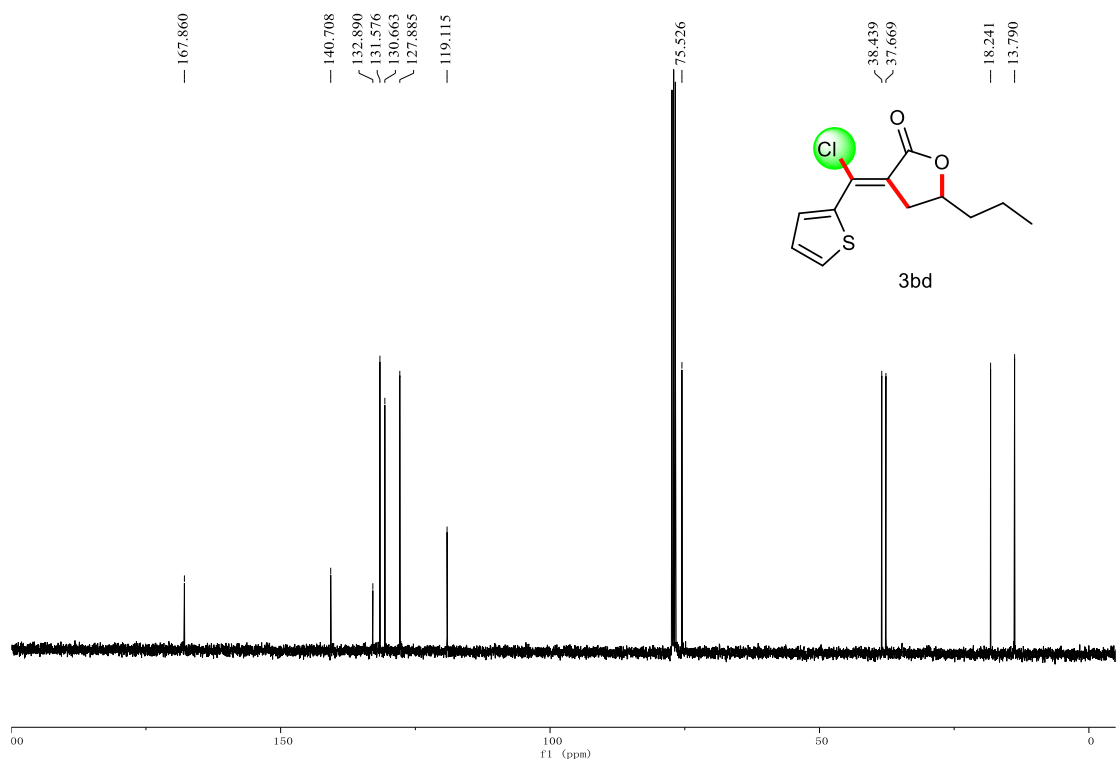
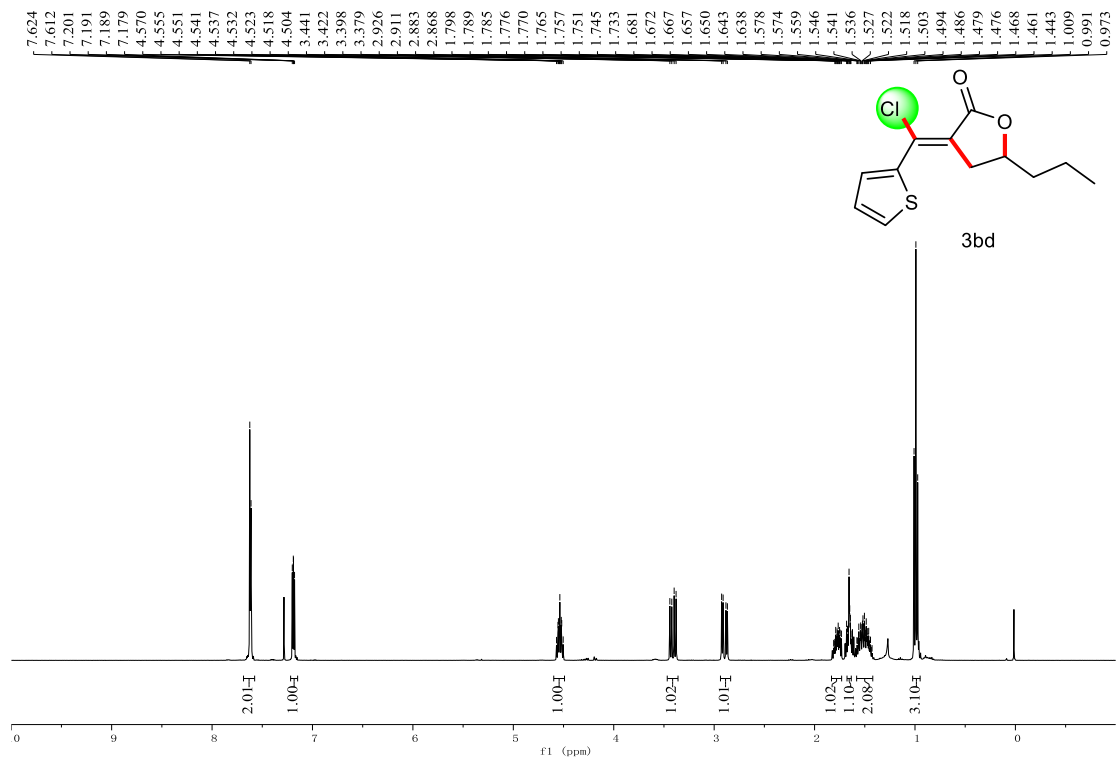


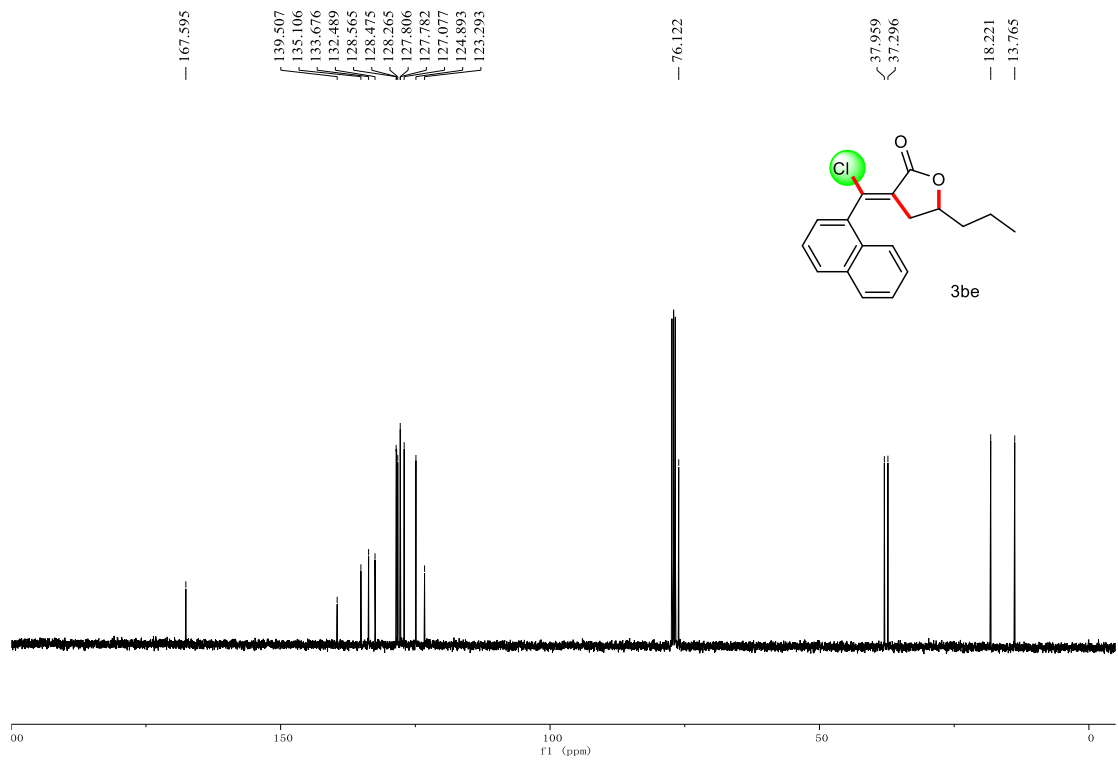
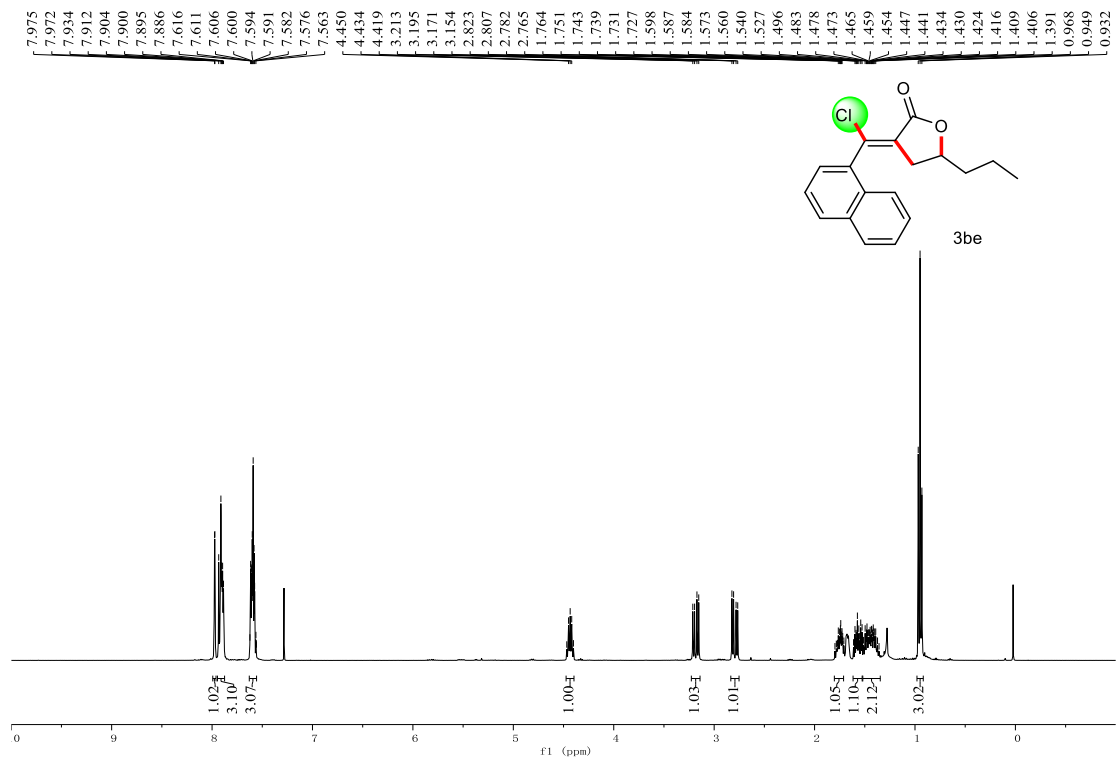


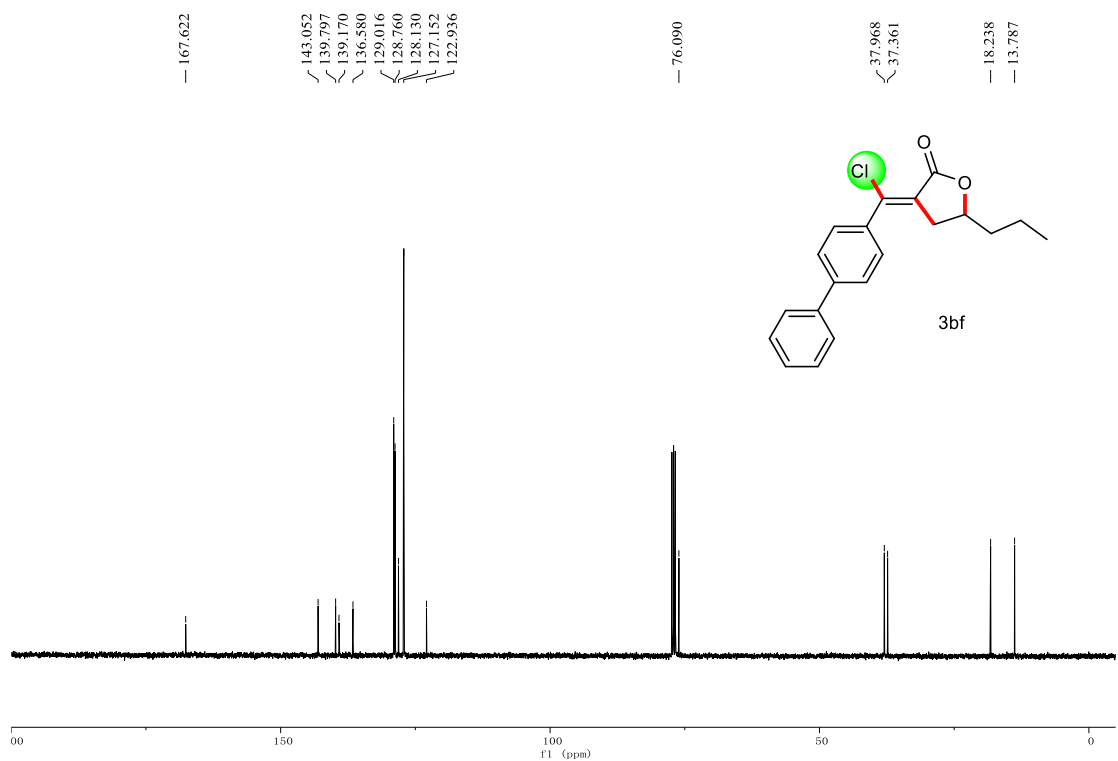
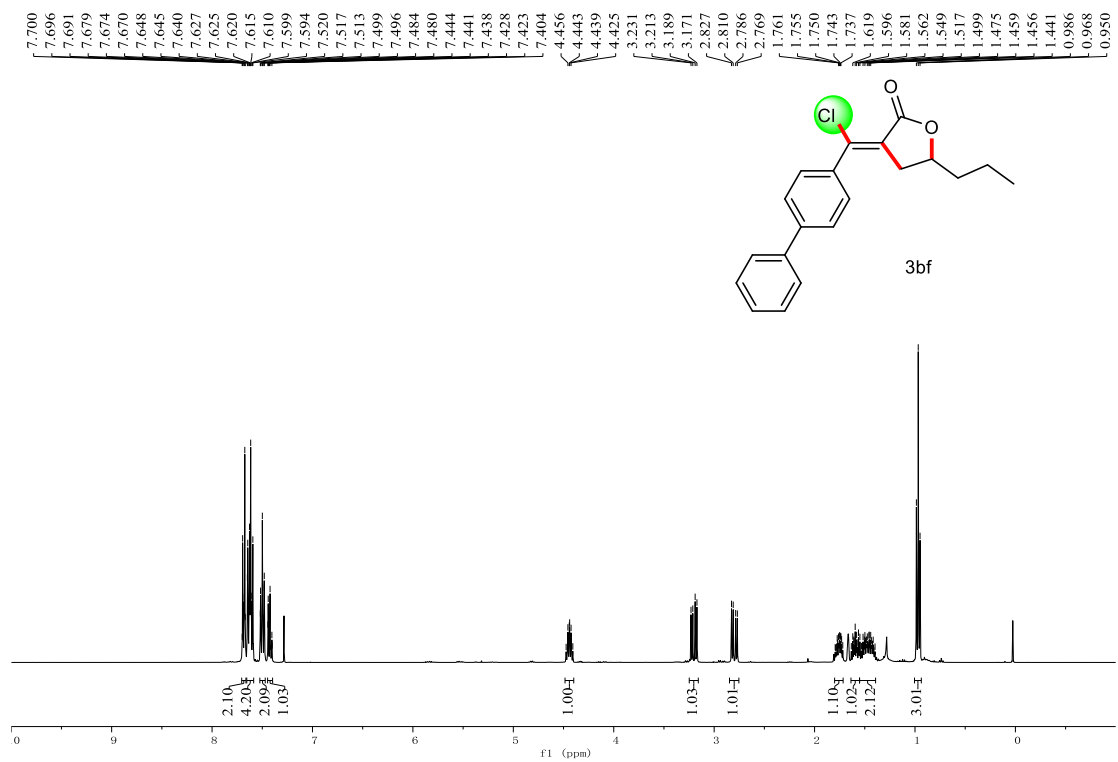




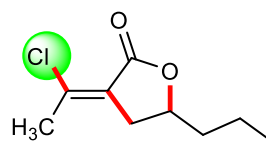




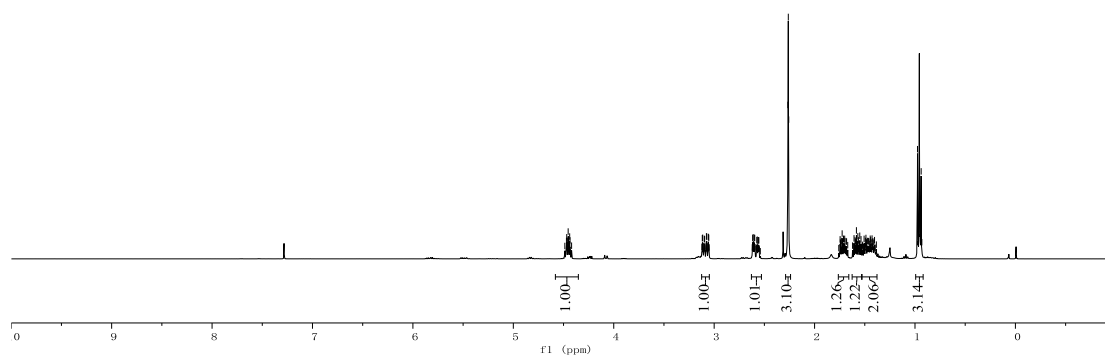




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3.073
3.058
3.054
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2.601
2.596
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3bg



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121.311

75.476

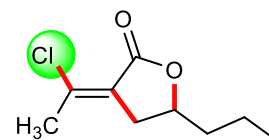
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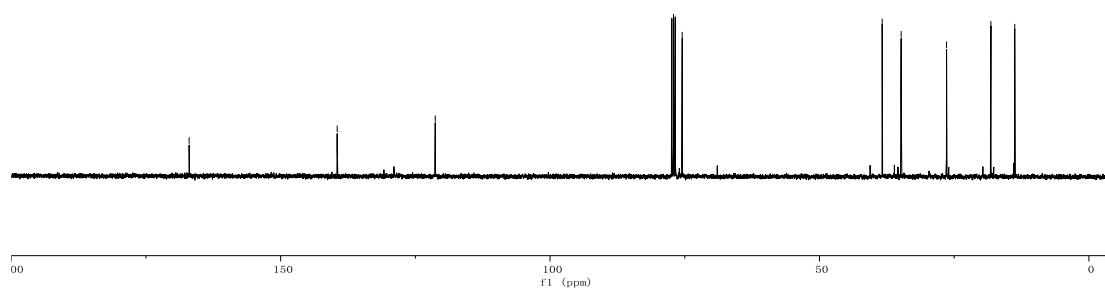
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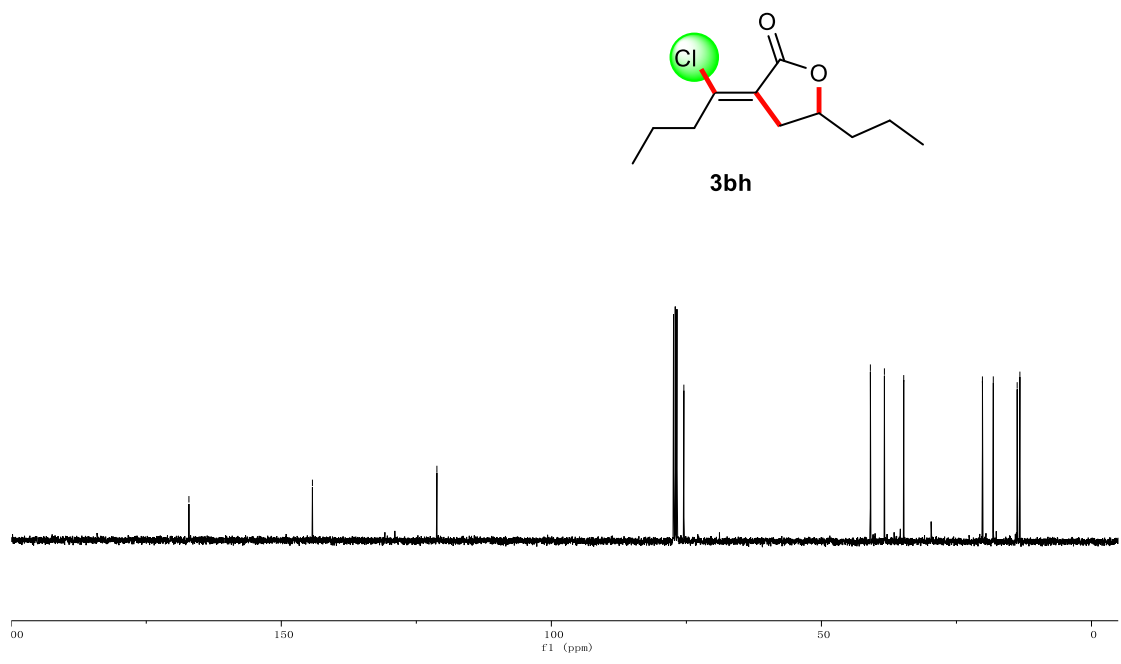
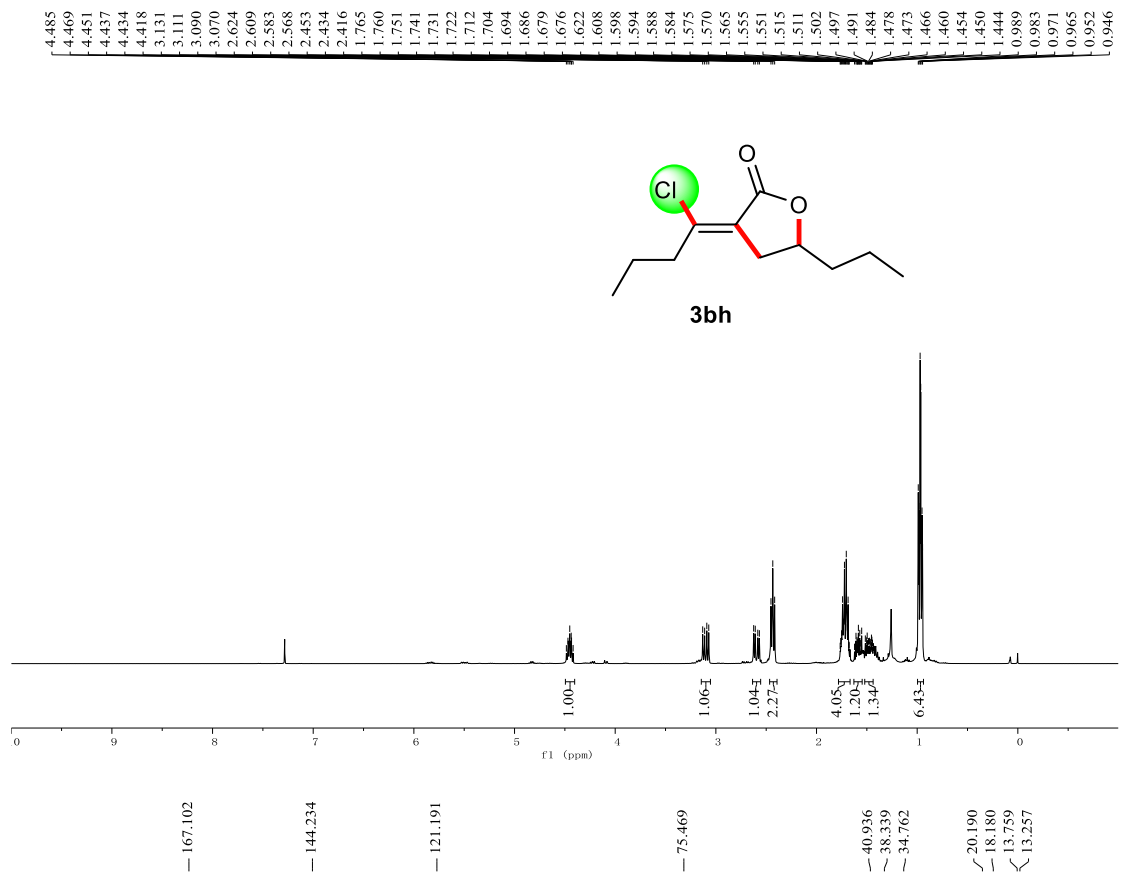
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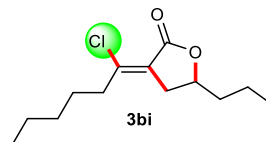
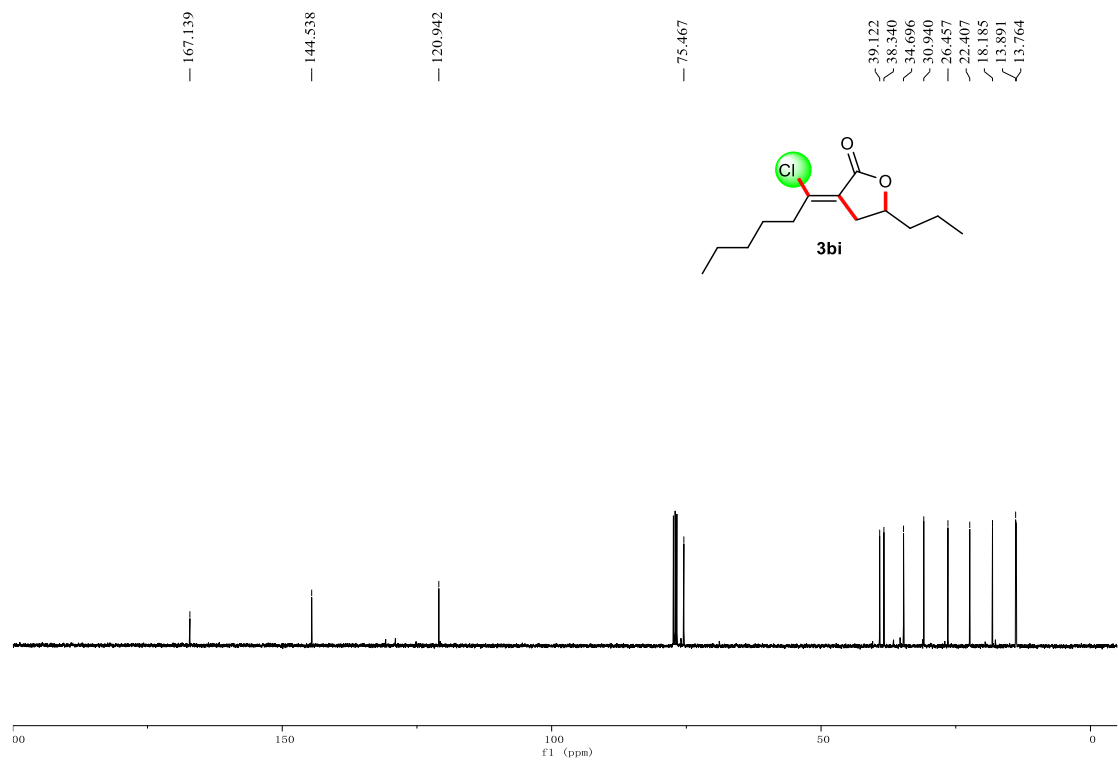
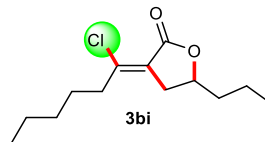
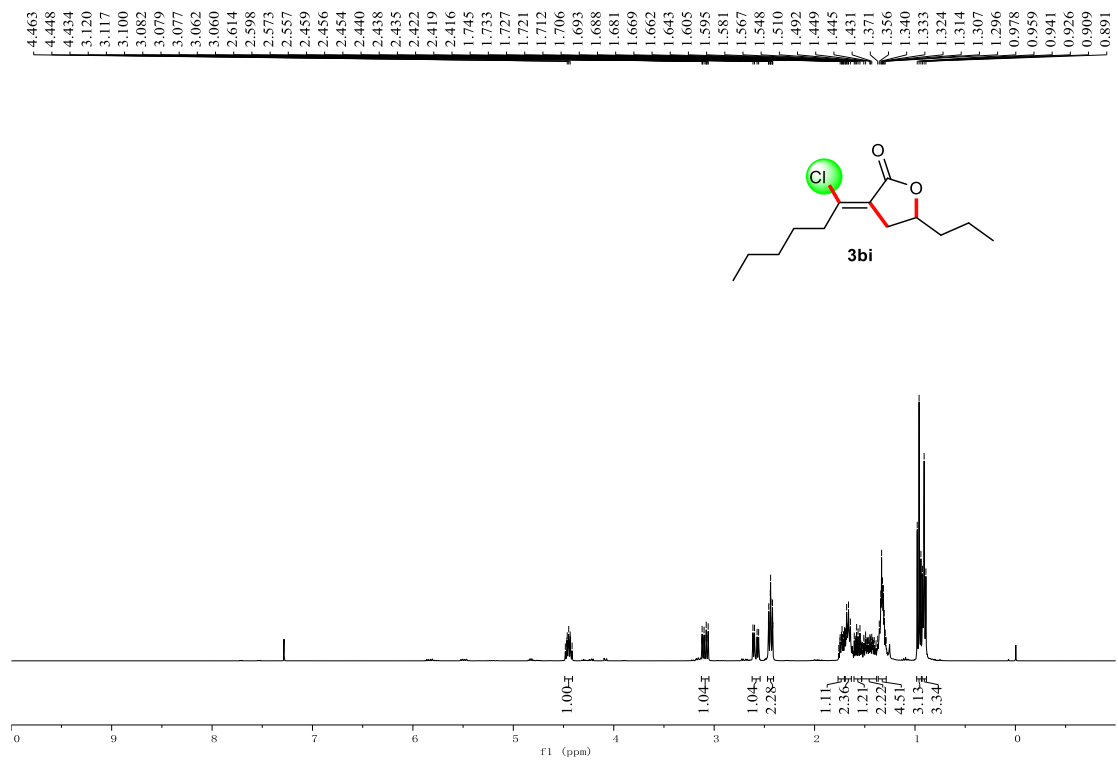
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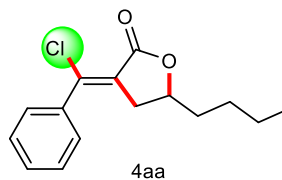
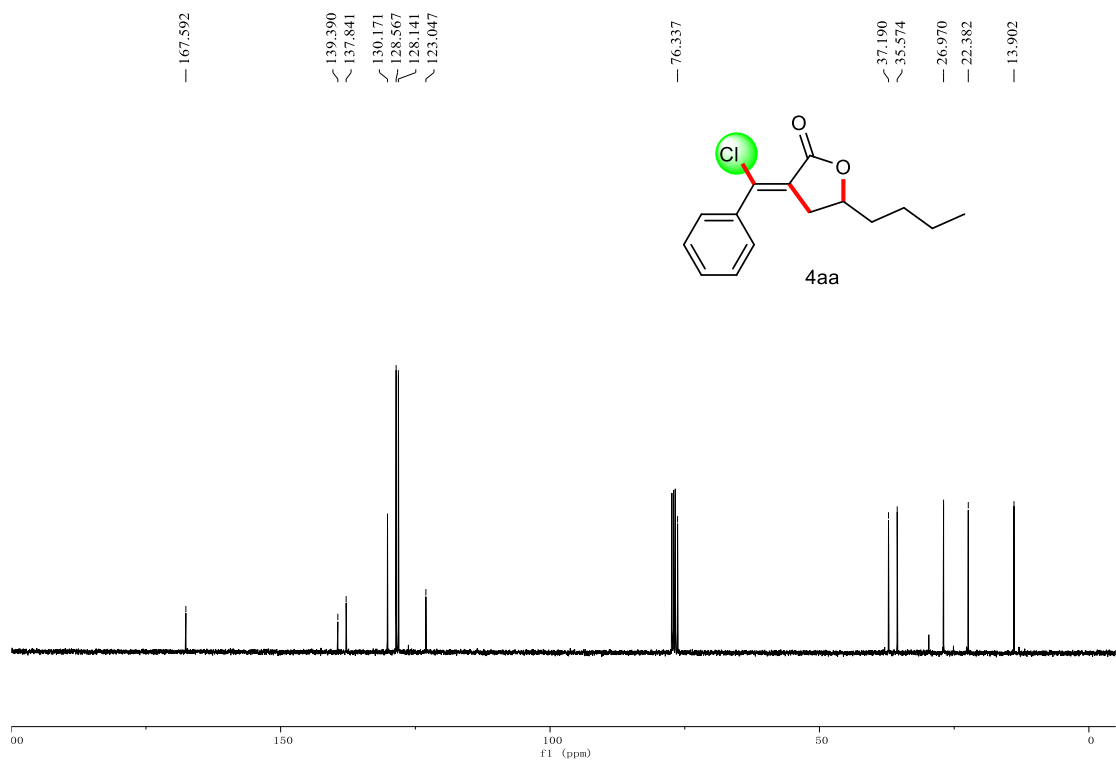
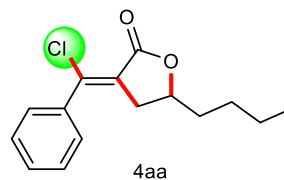
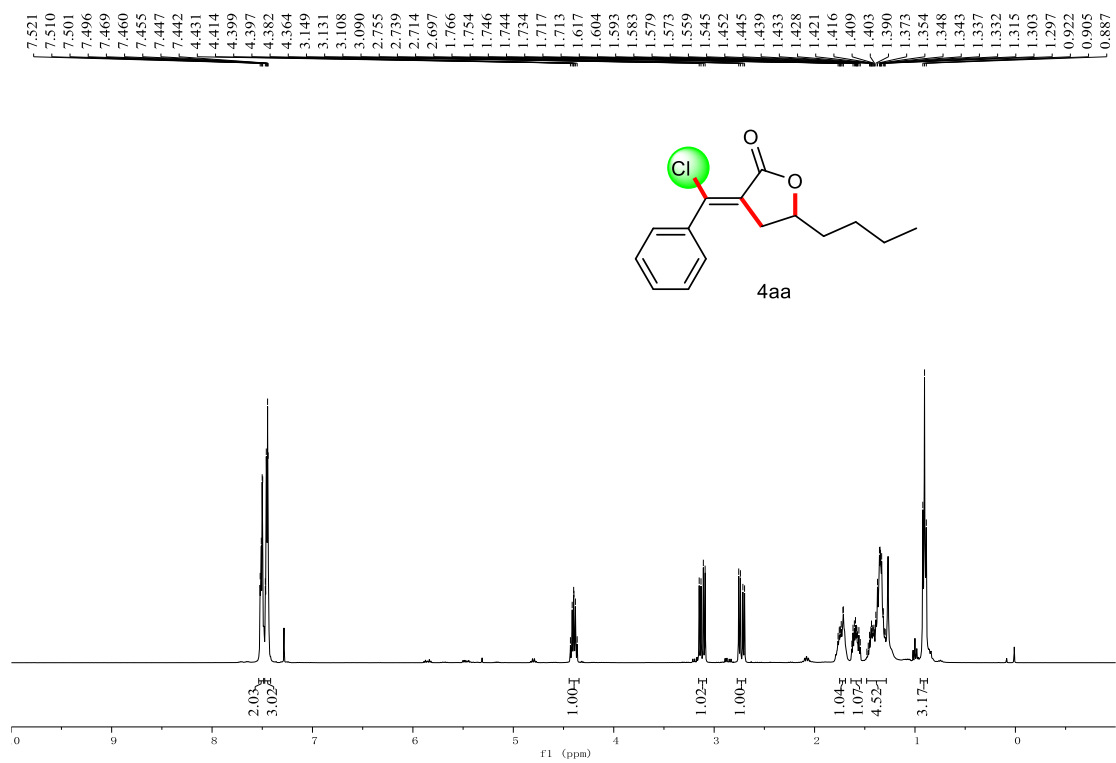
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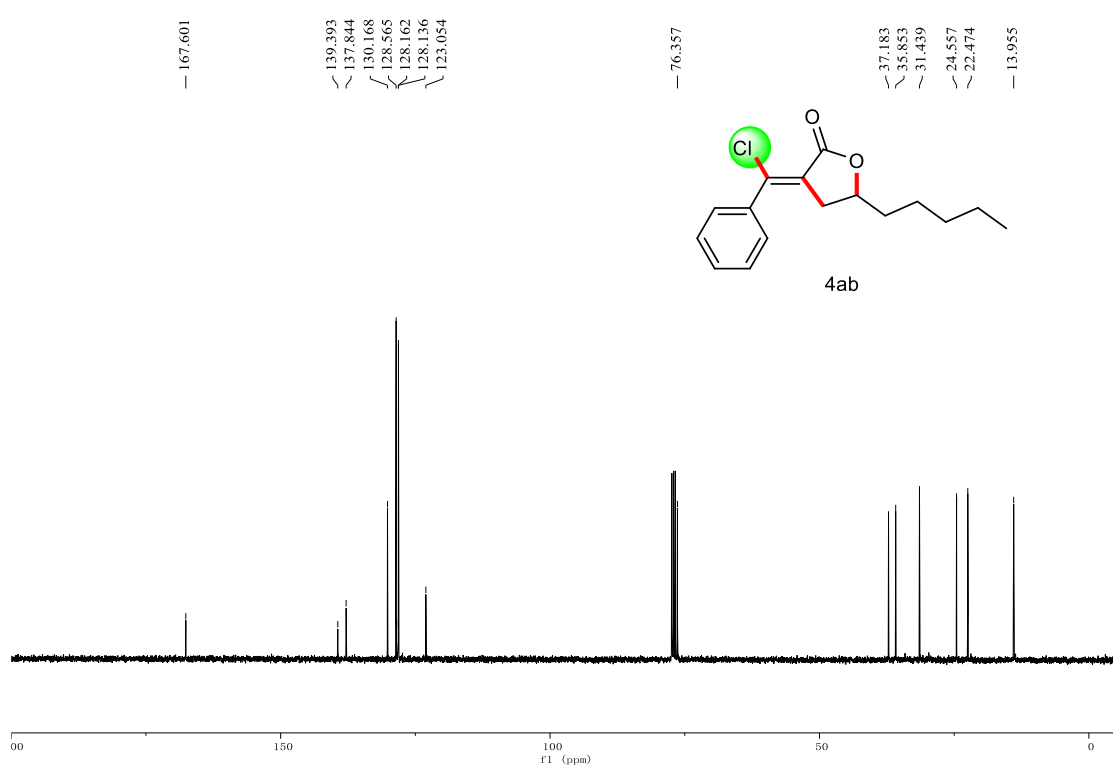
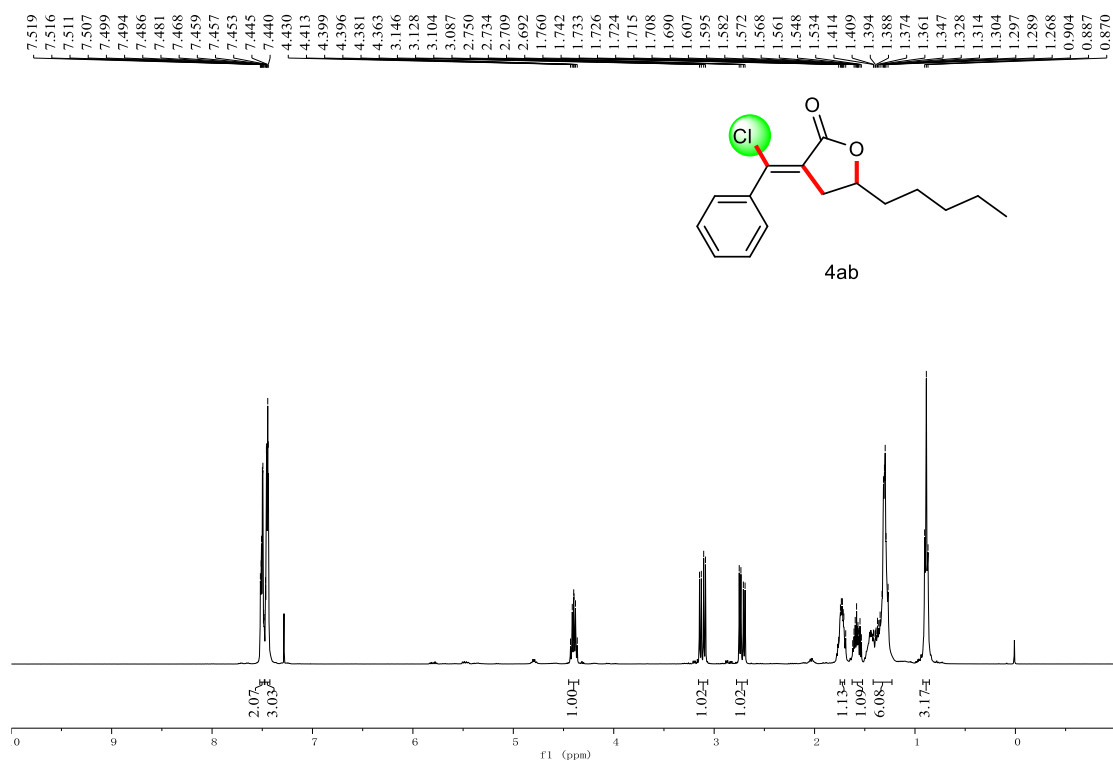


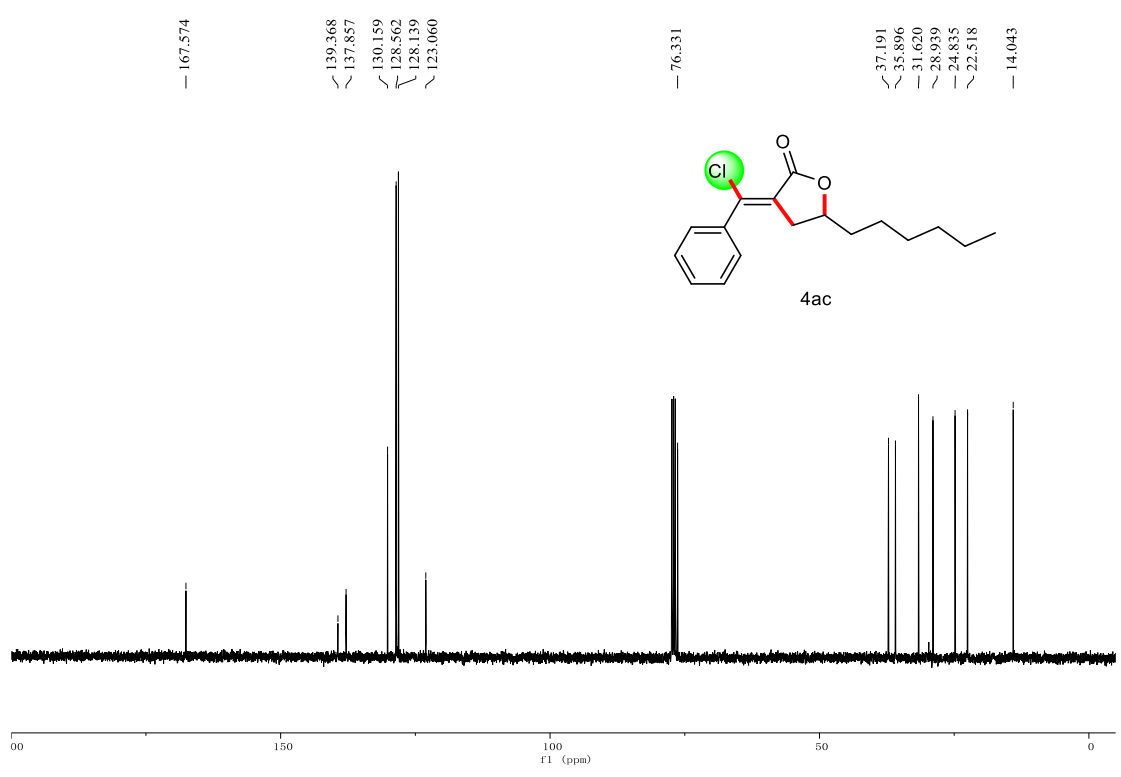
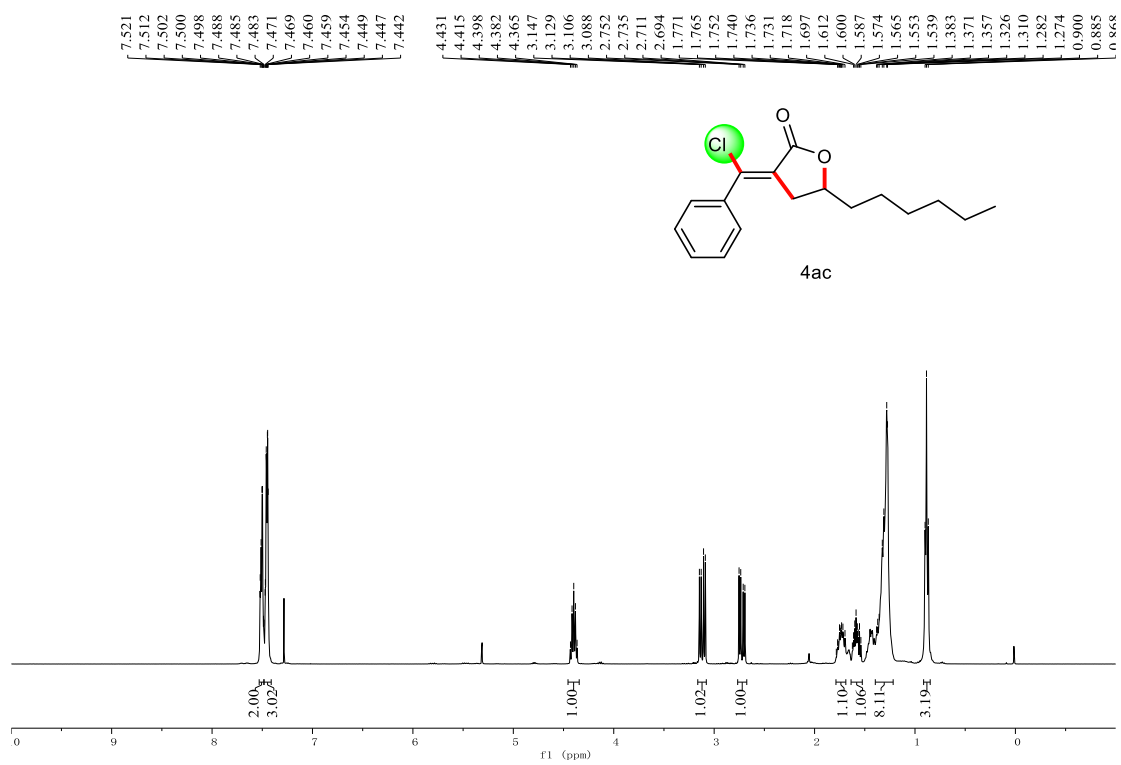


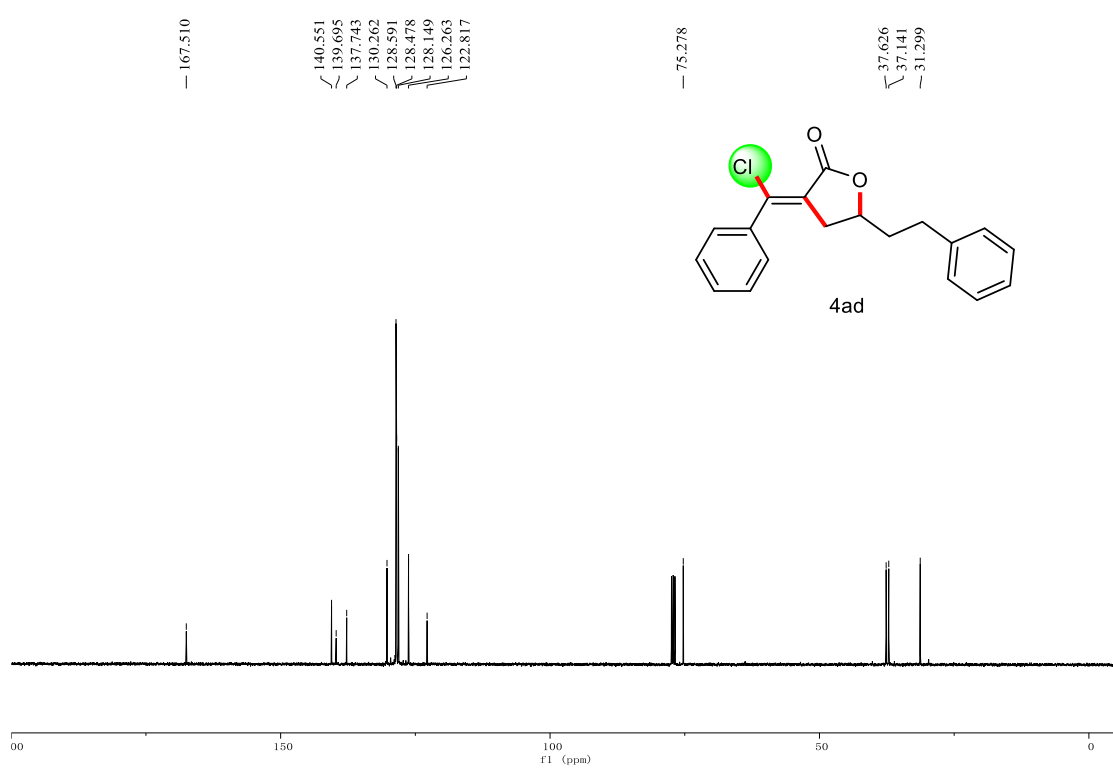
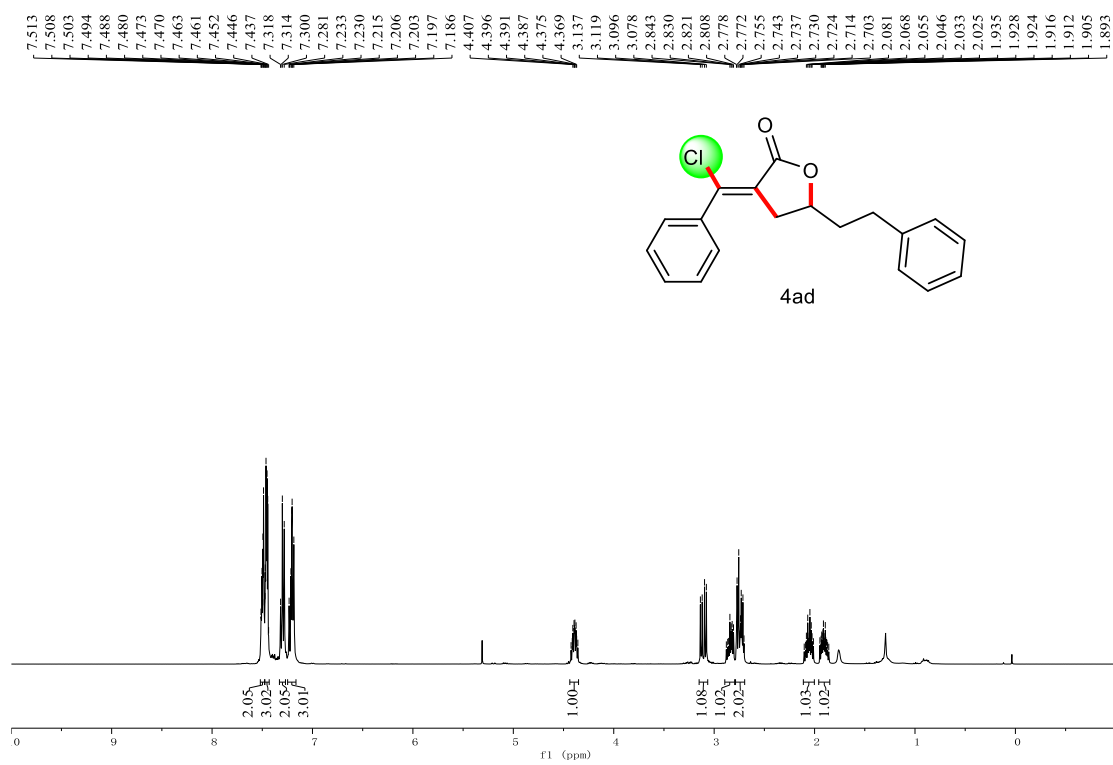


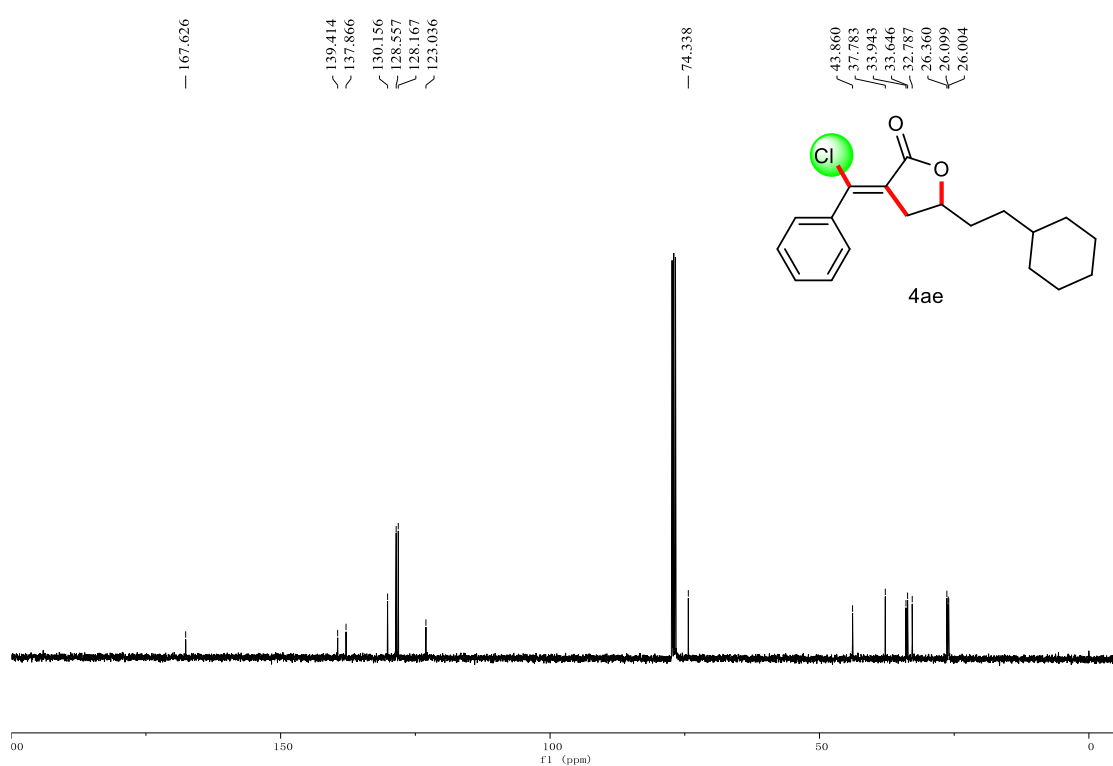
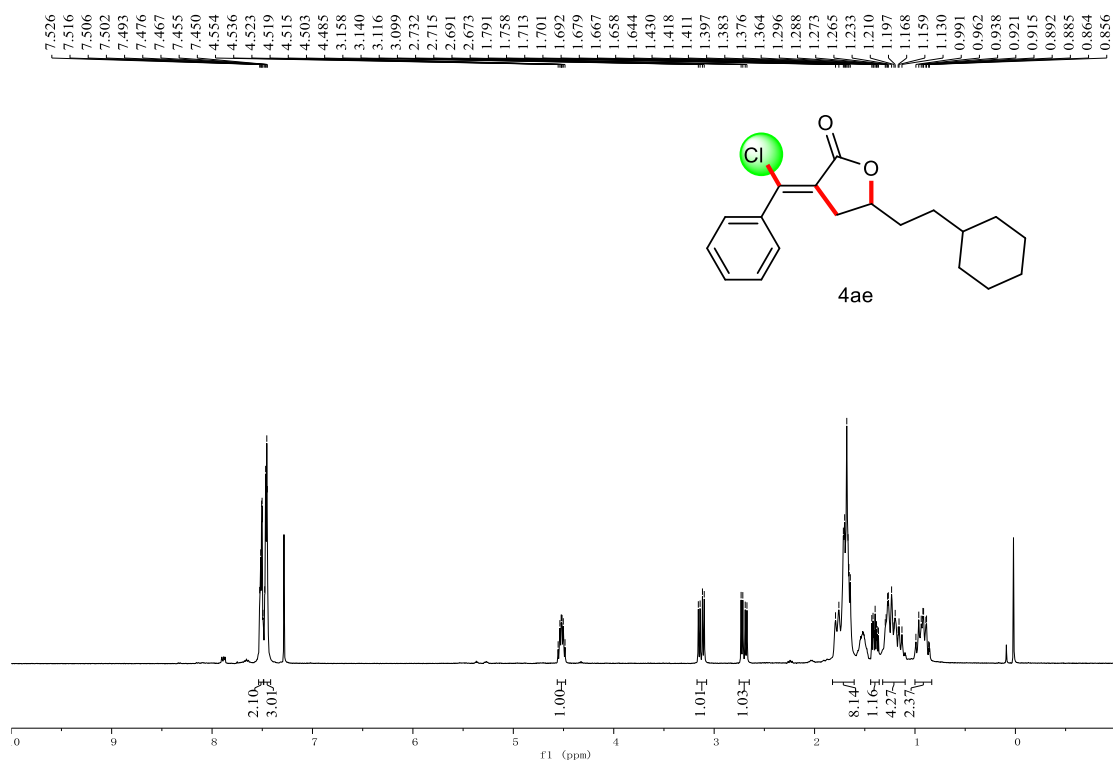
¹H and ¹³C NMR spectra of compounds 4

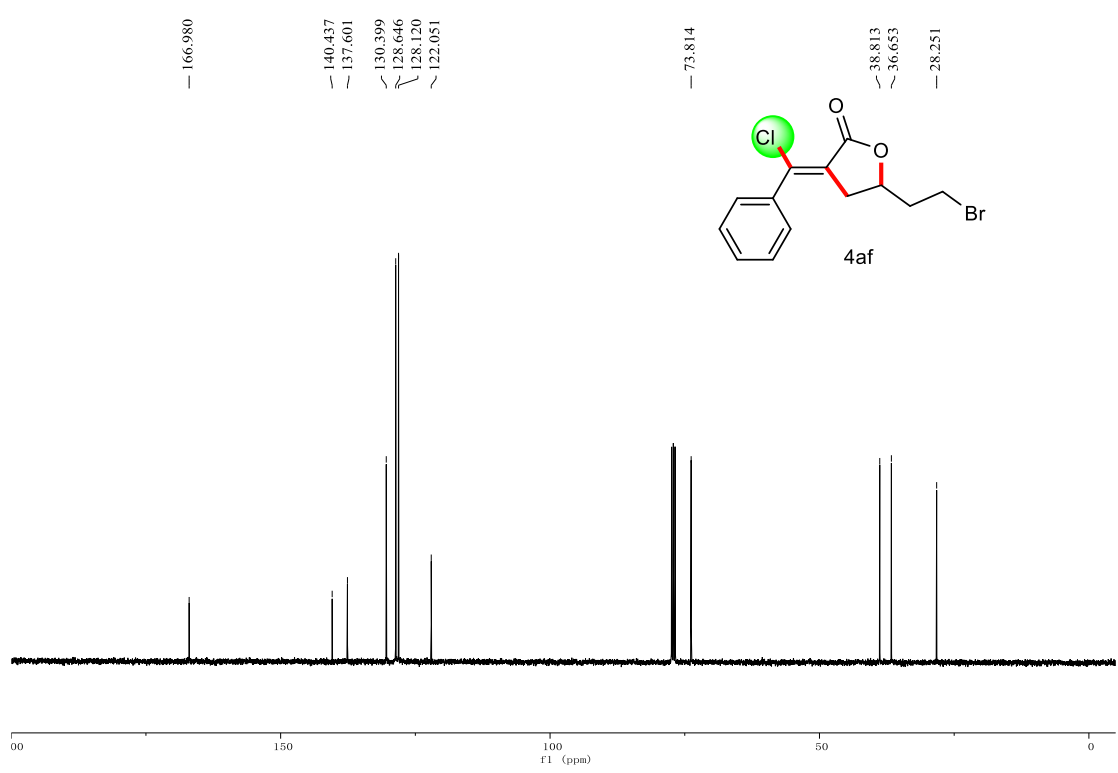
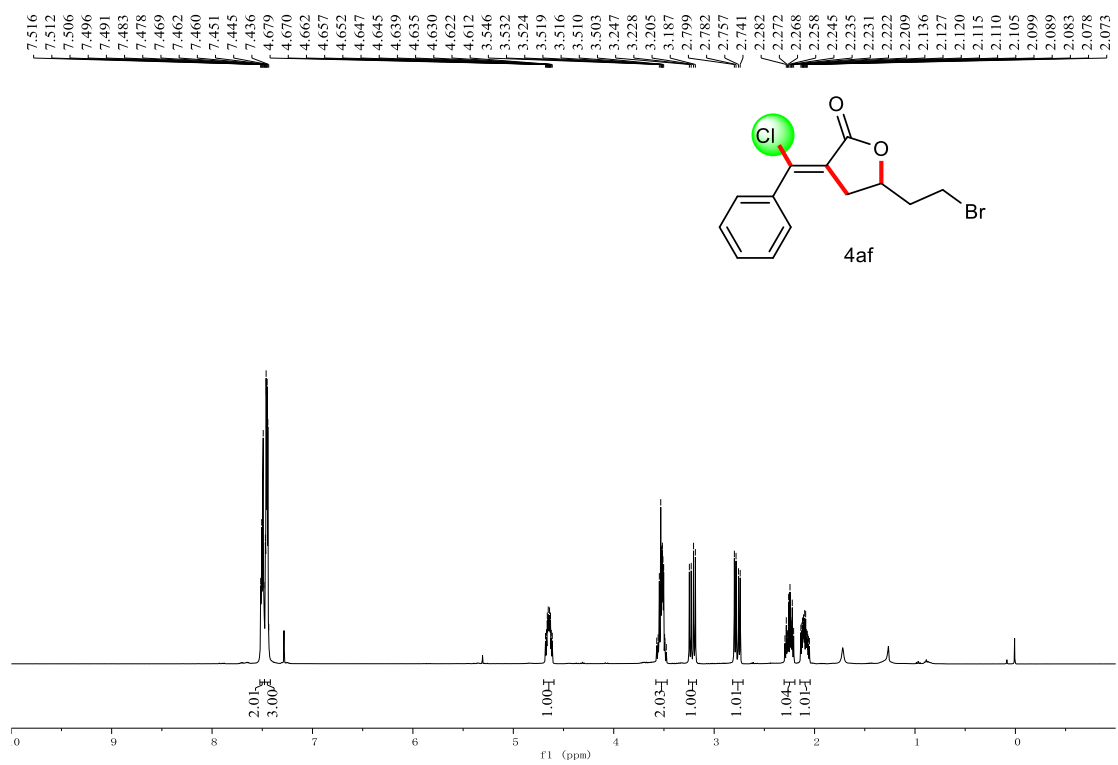


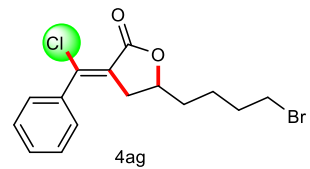
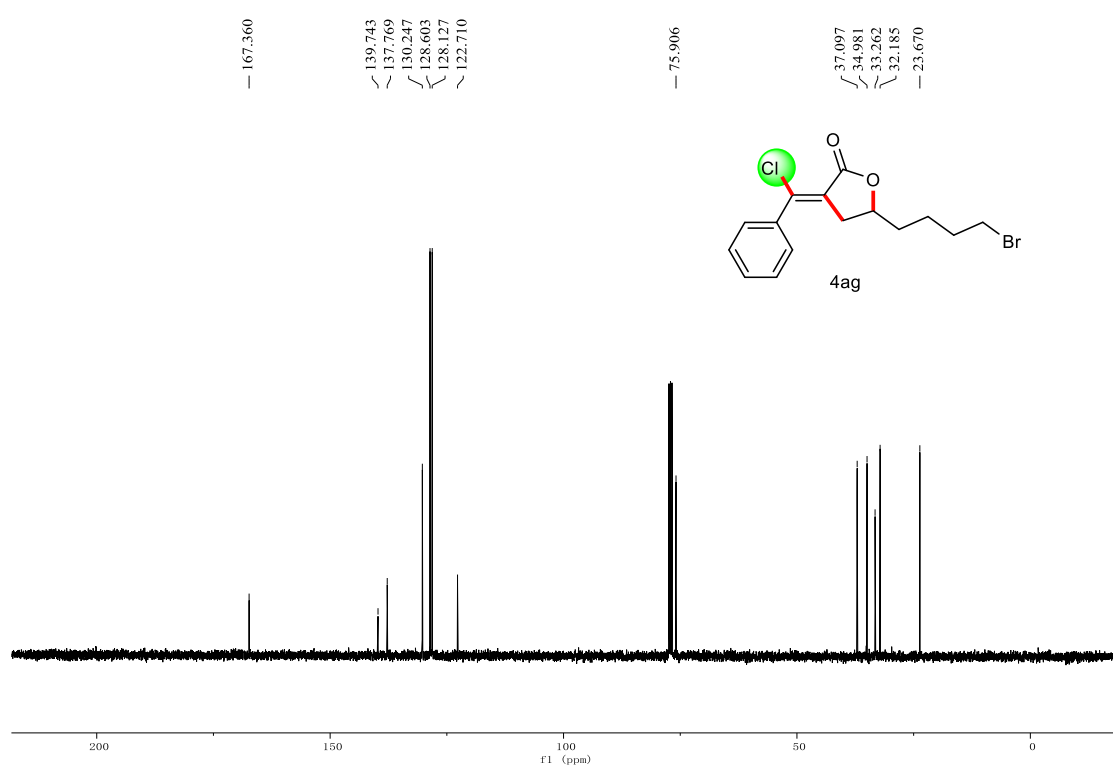
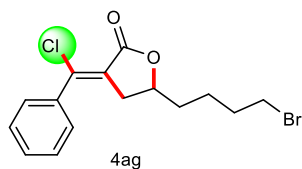
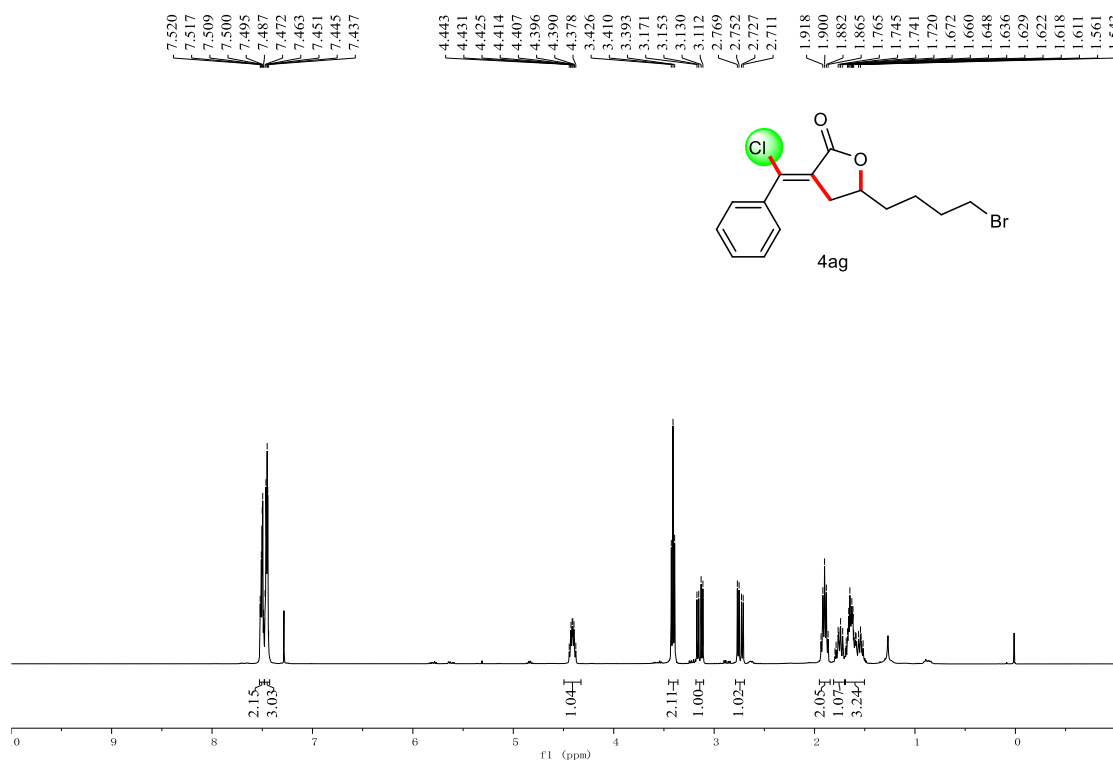


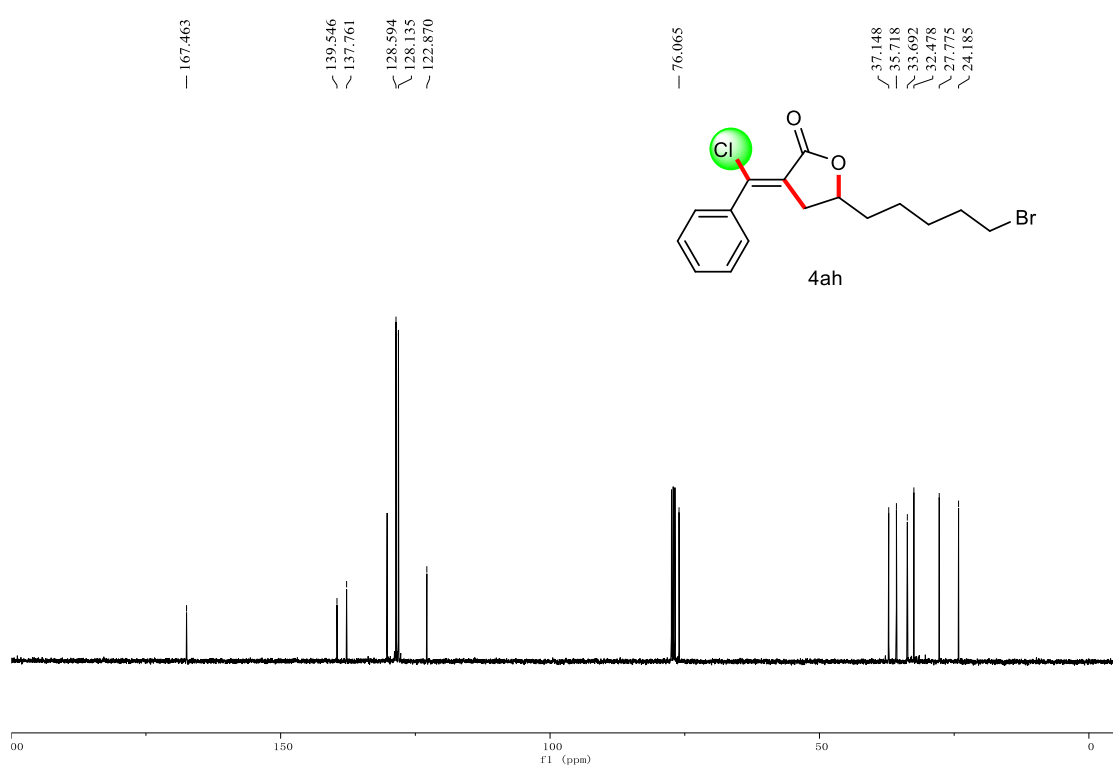
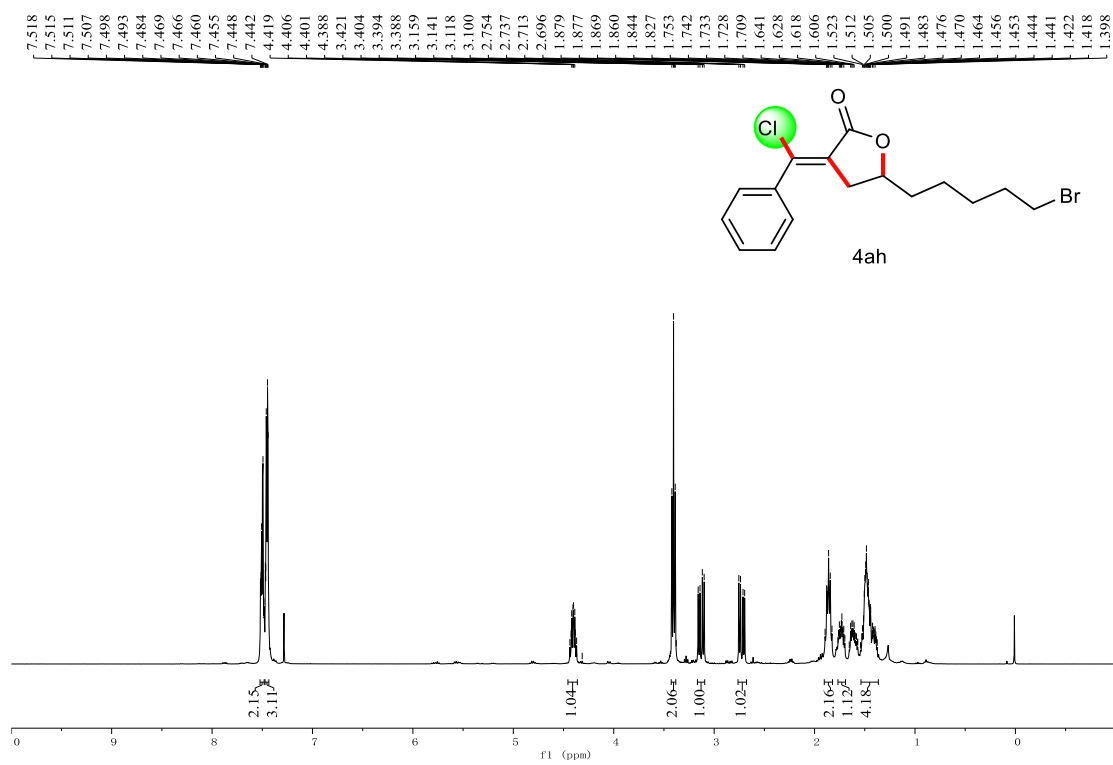


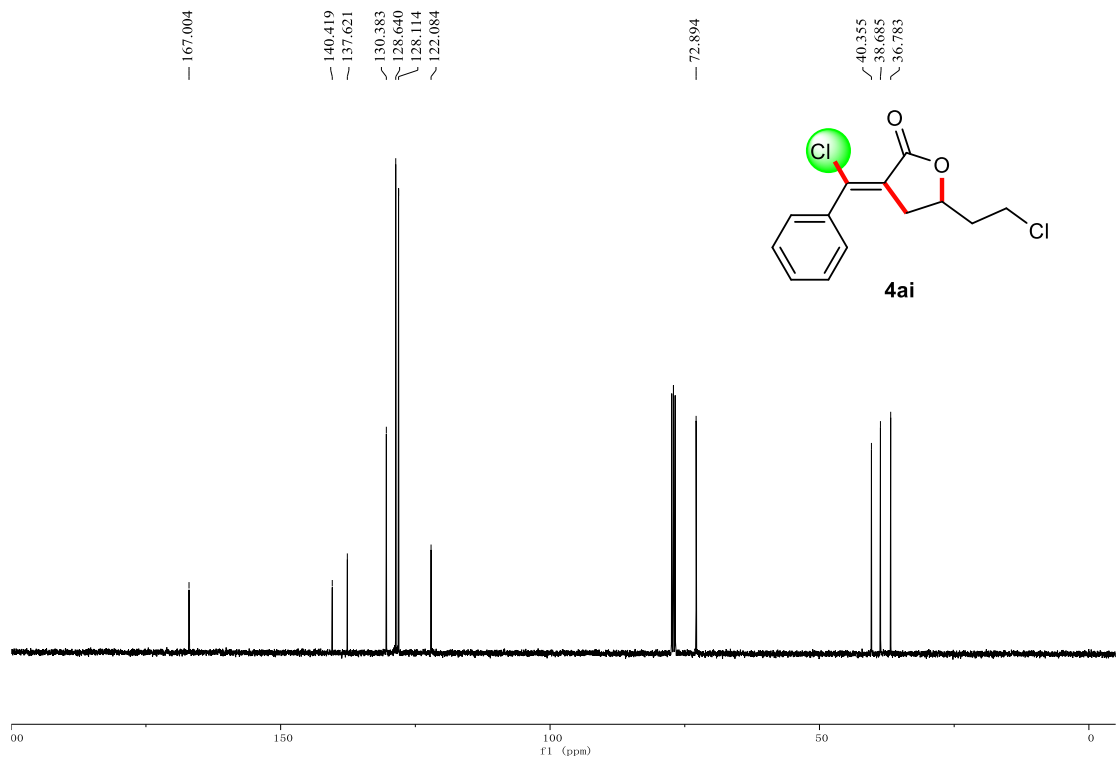
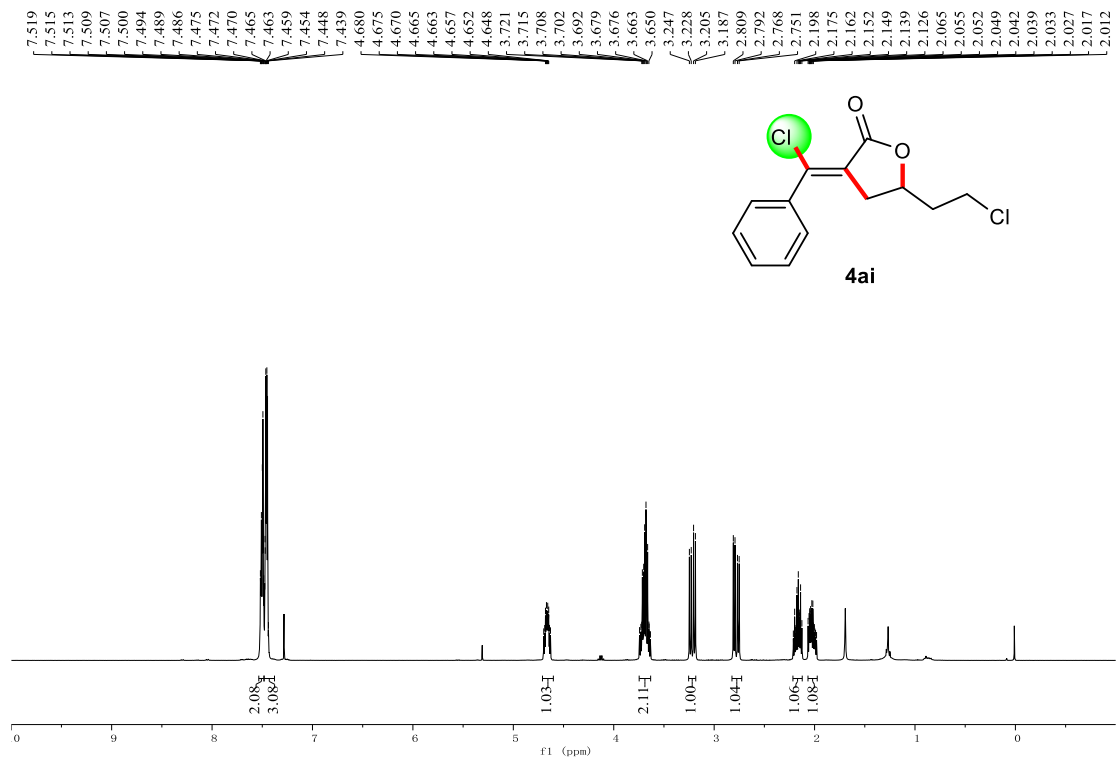


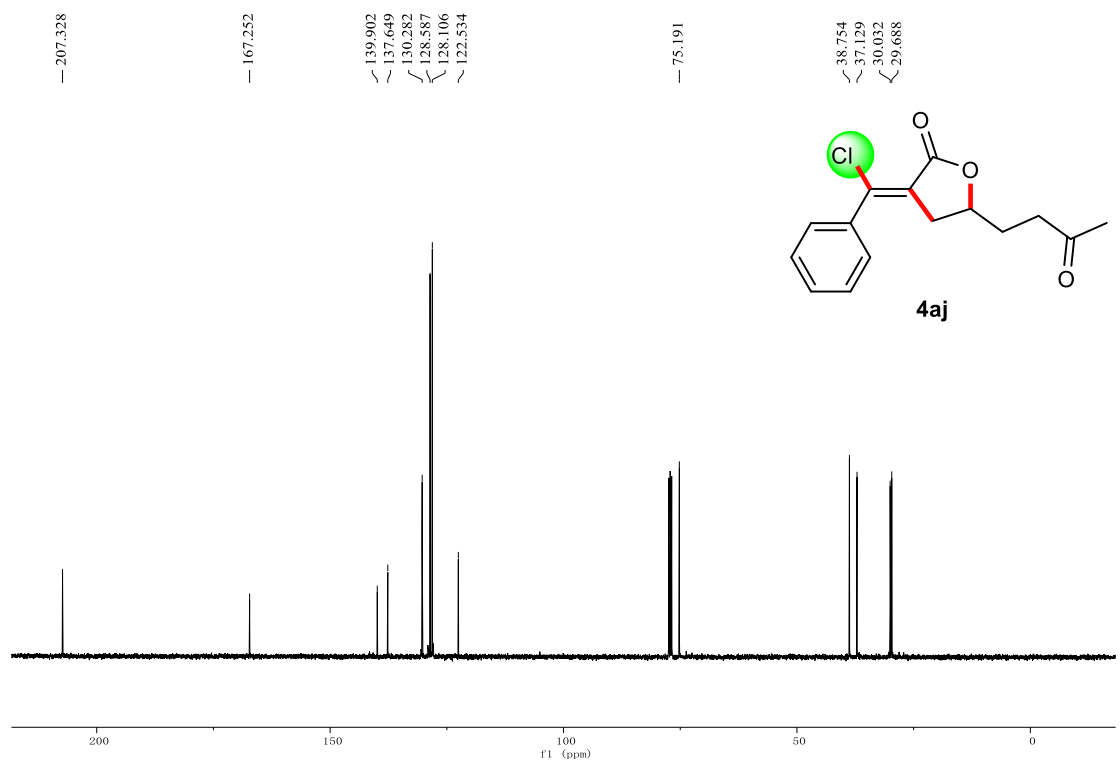
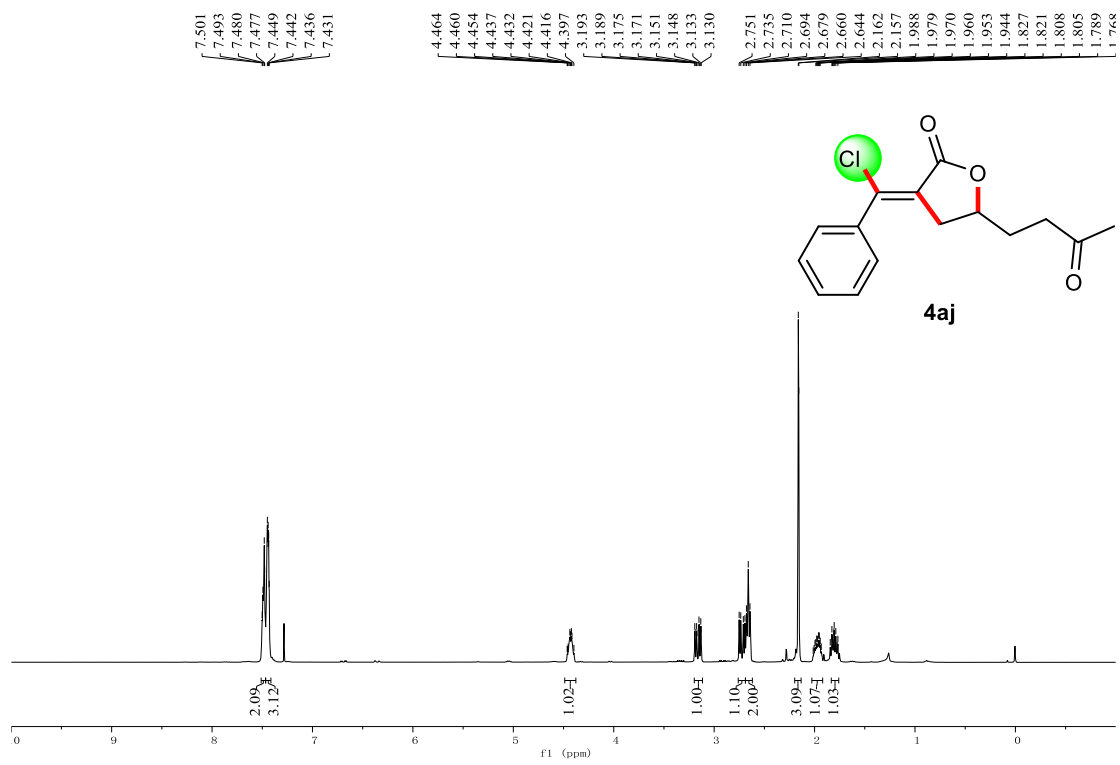


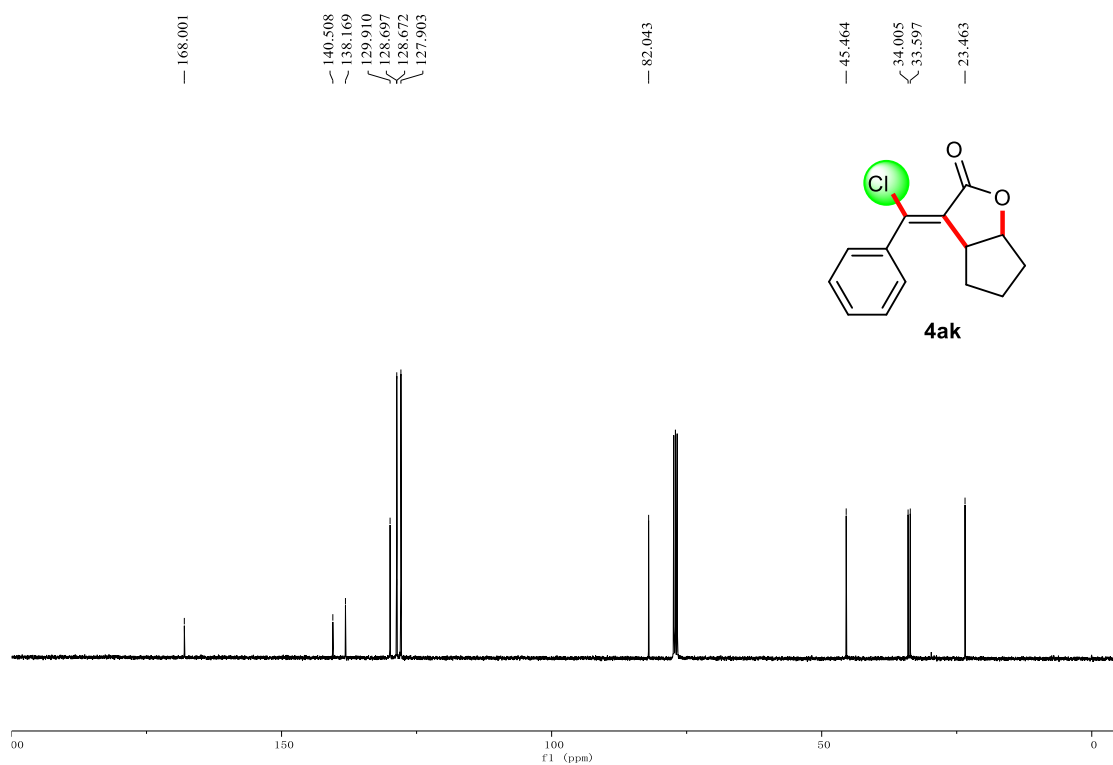
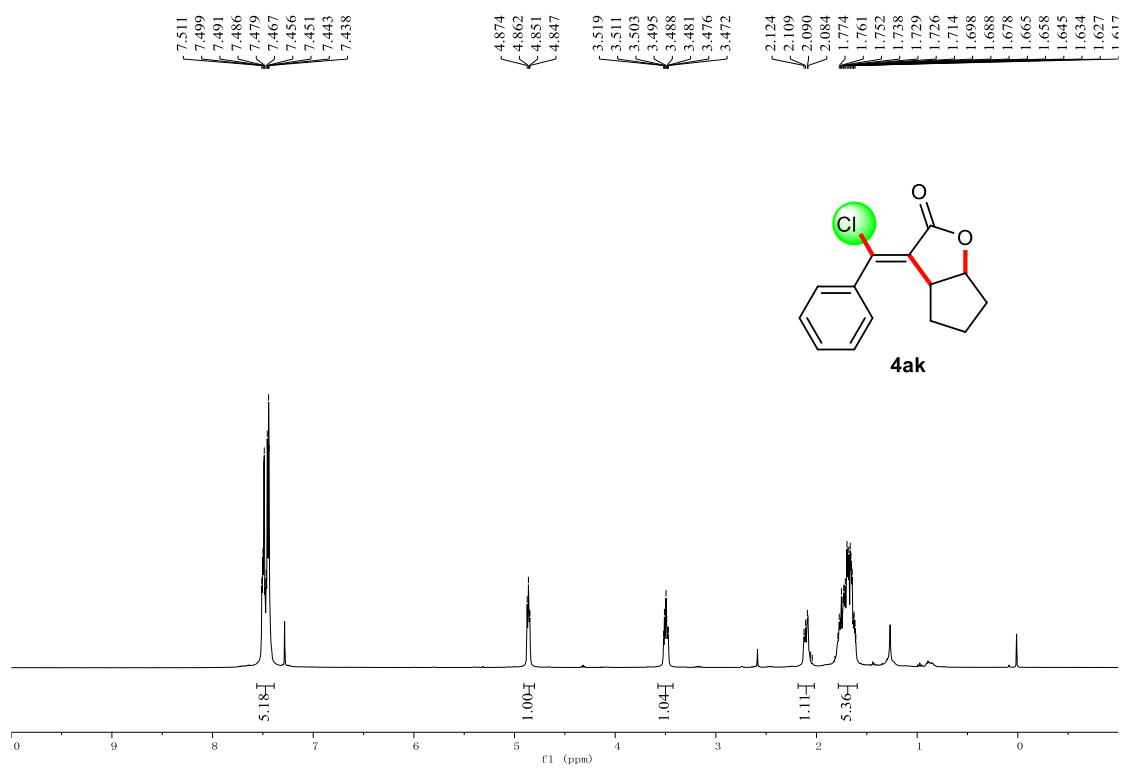




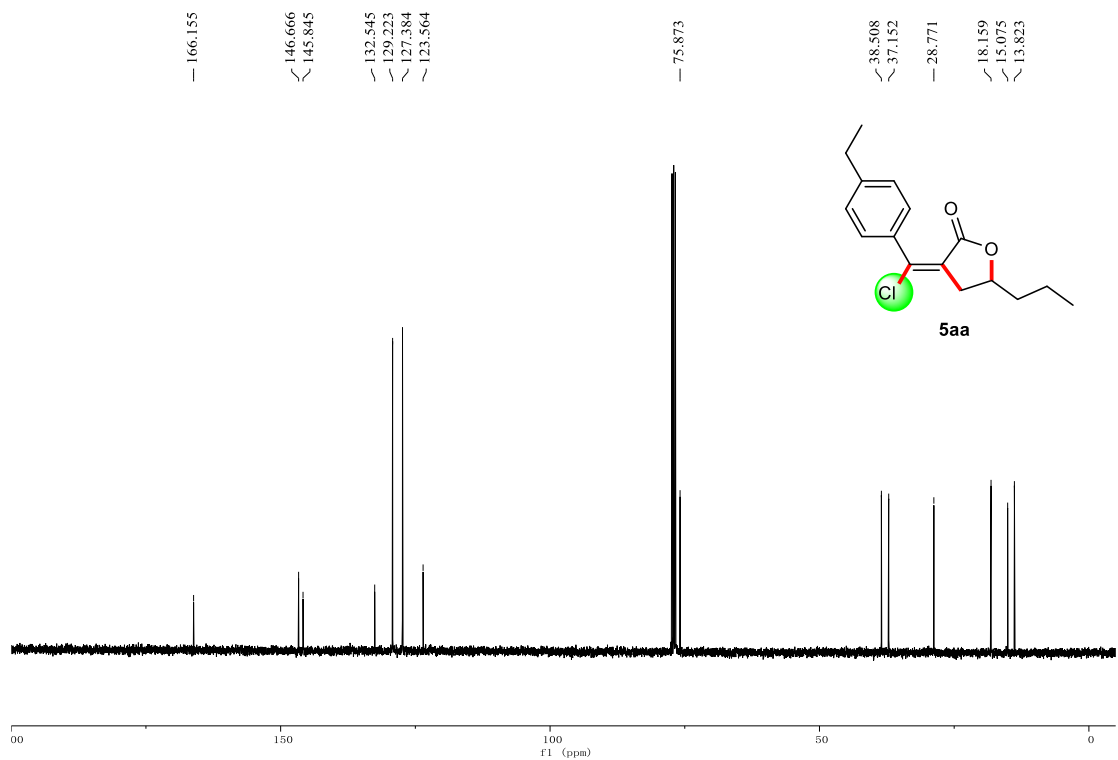
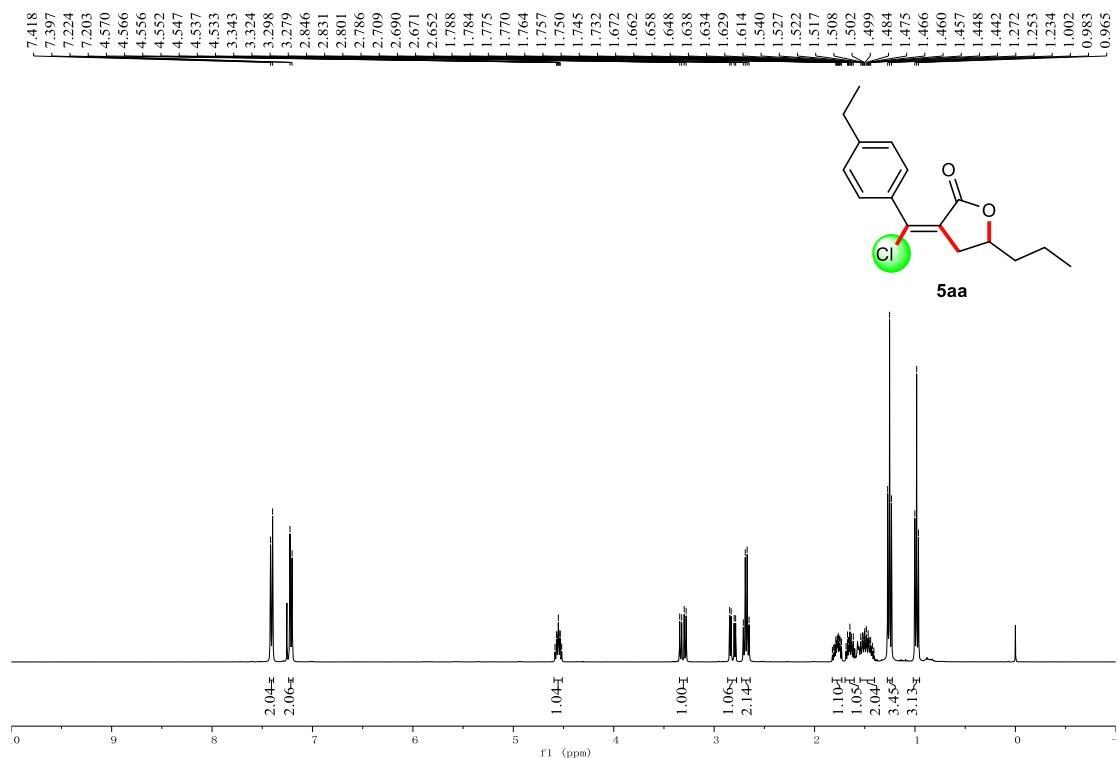


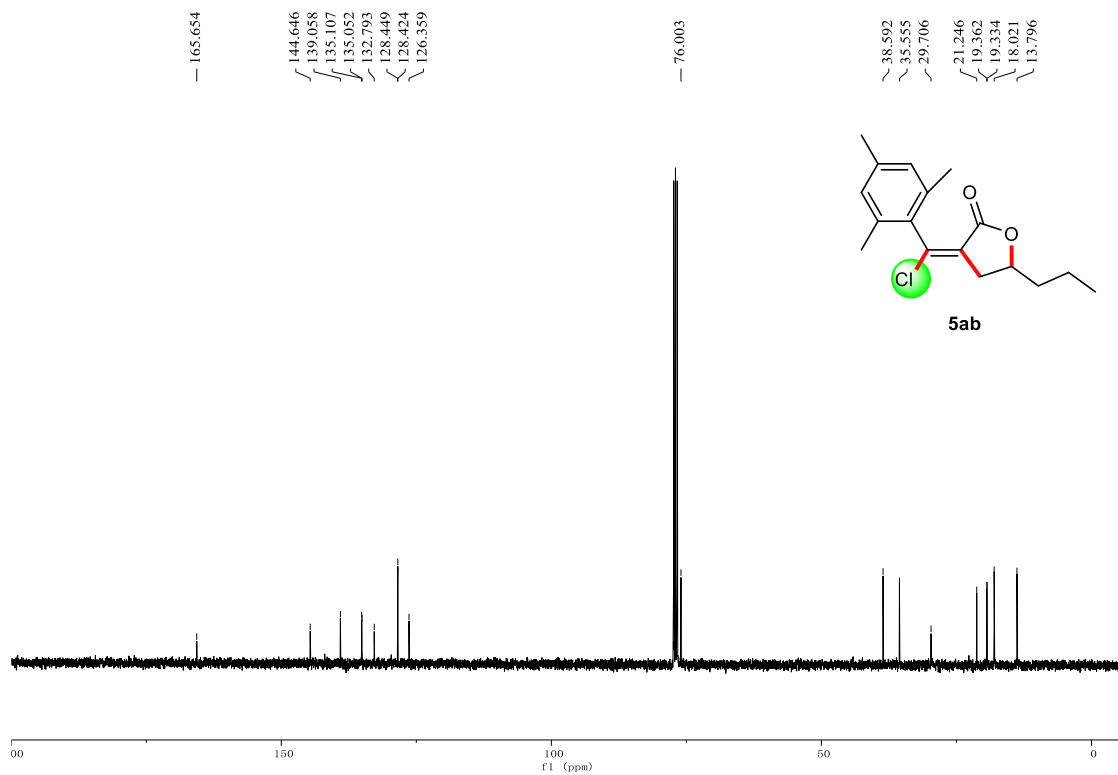
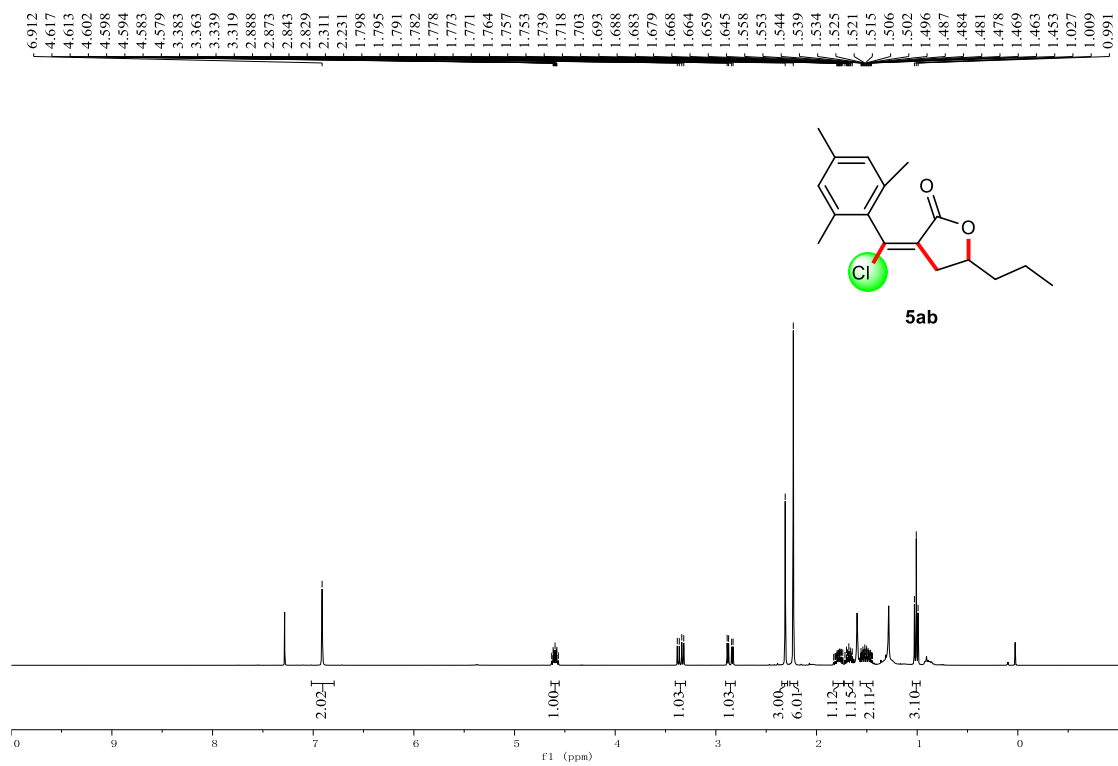


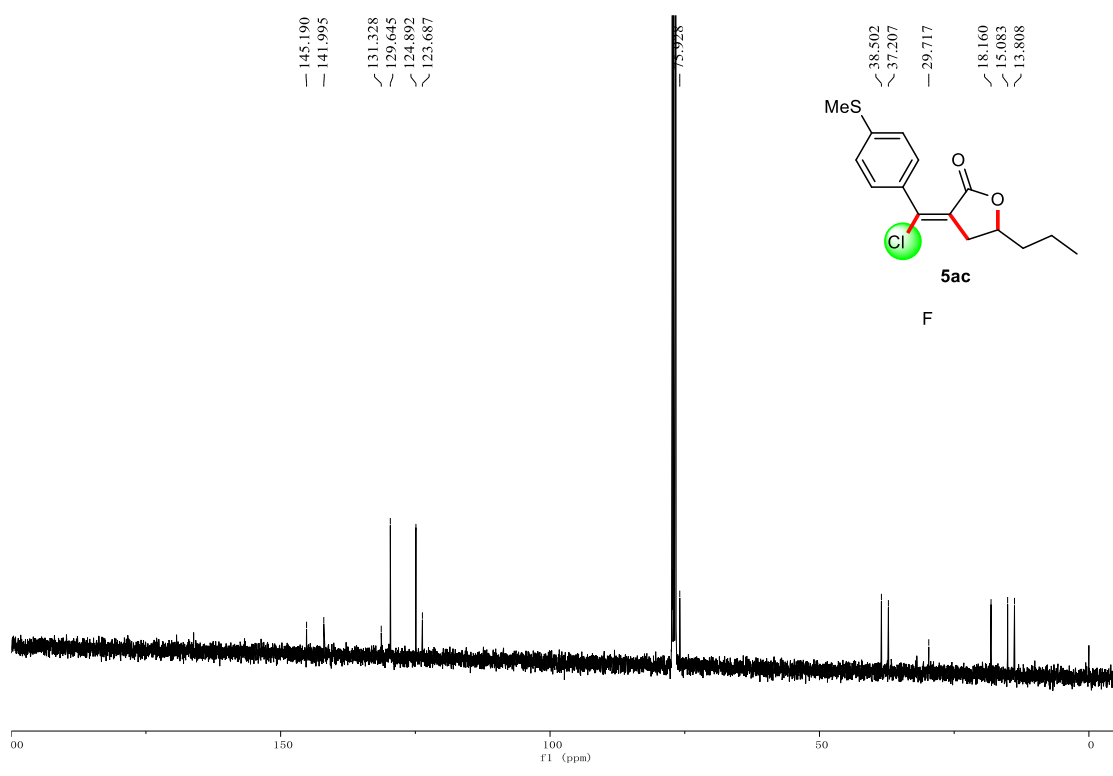
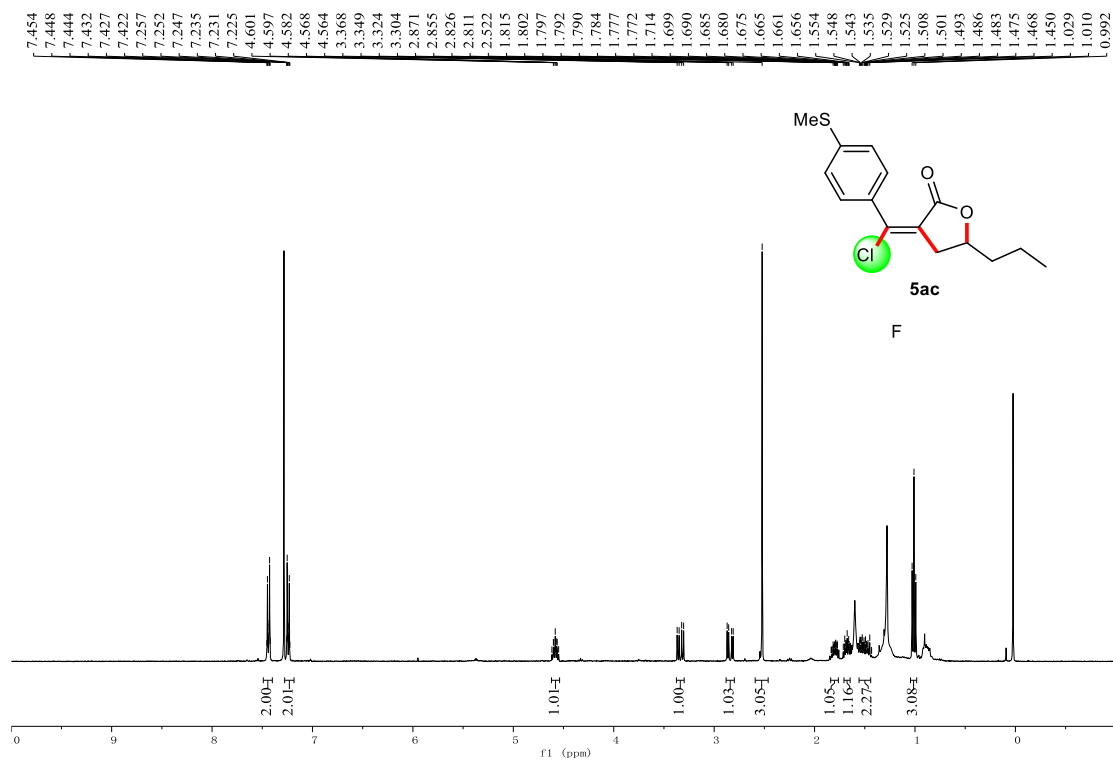


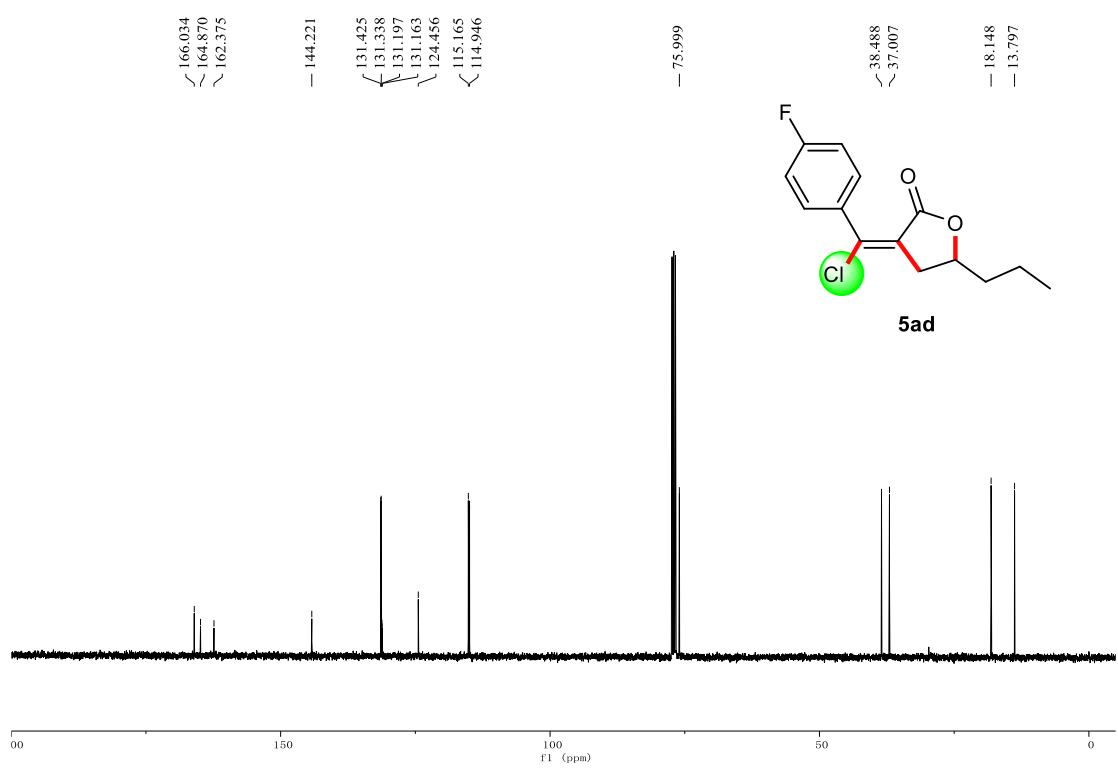
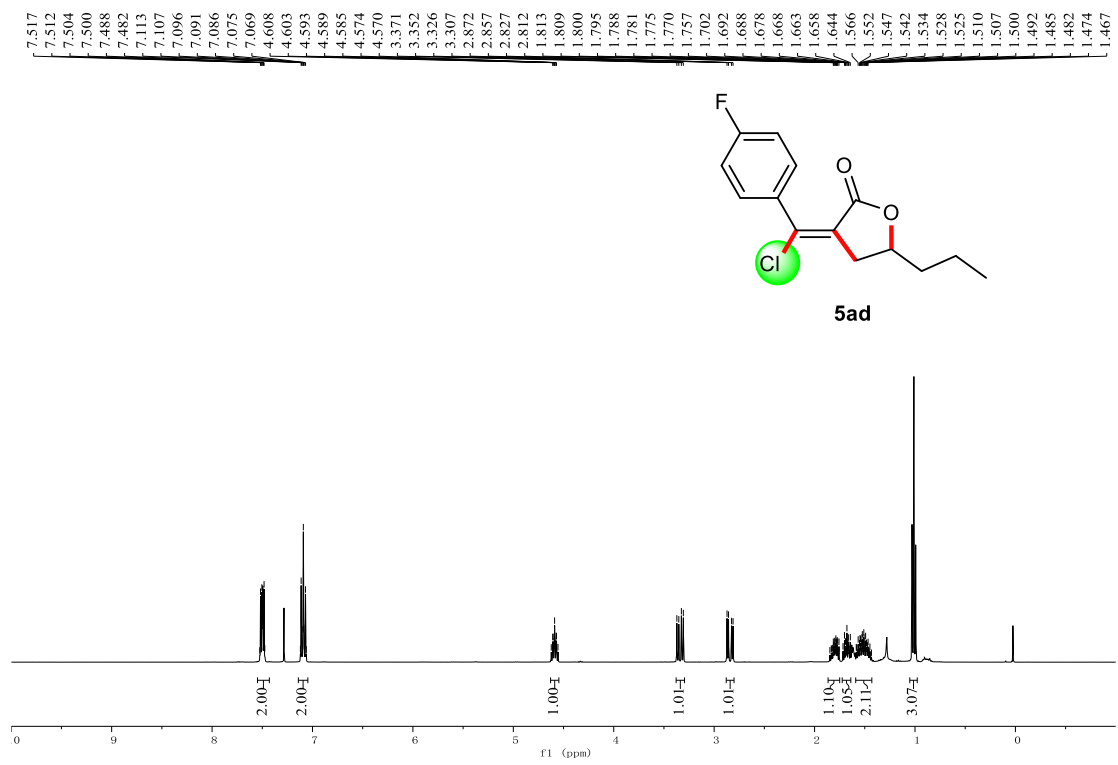


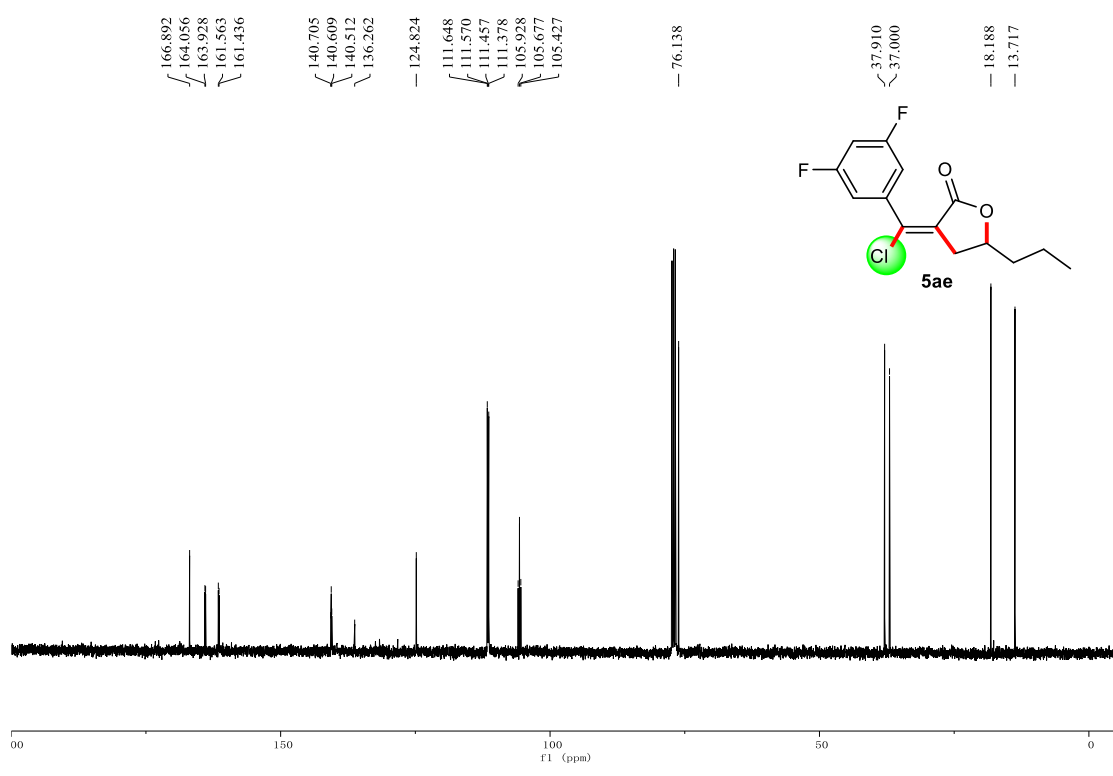
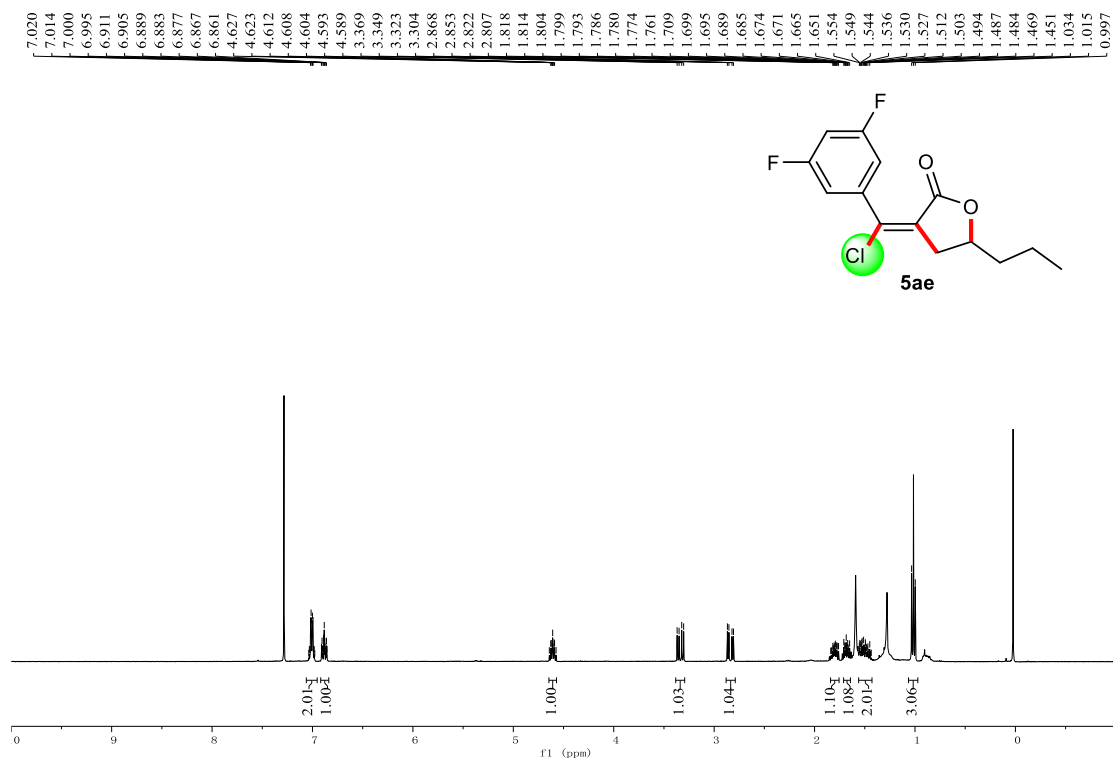
¹H and ¹³C NMR spectra of compounds 5

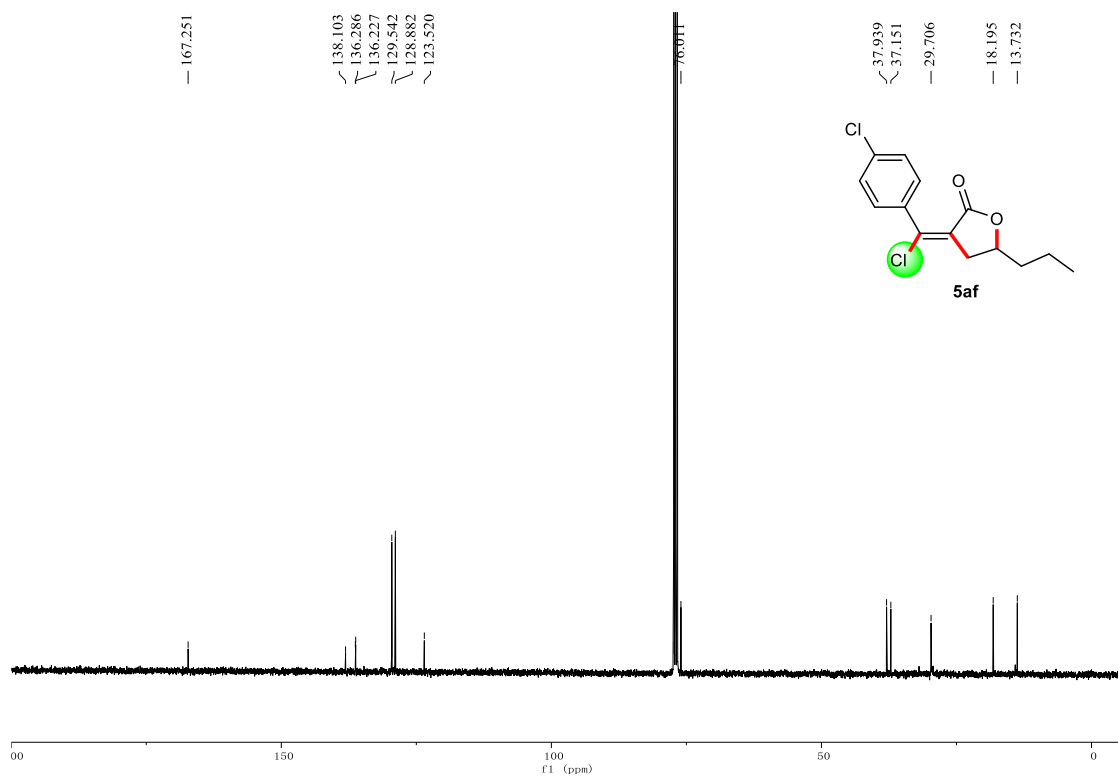
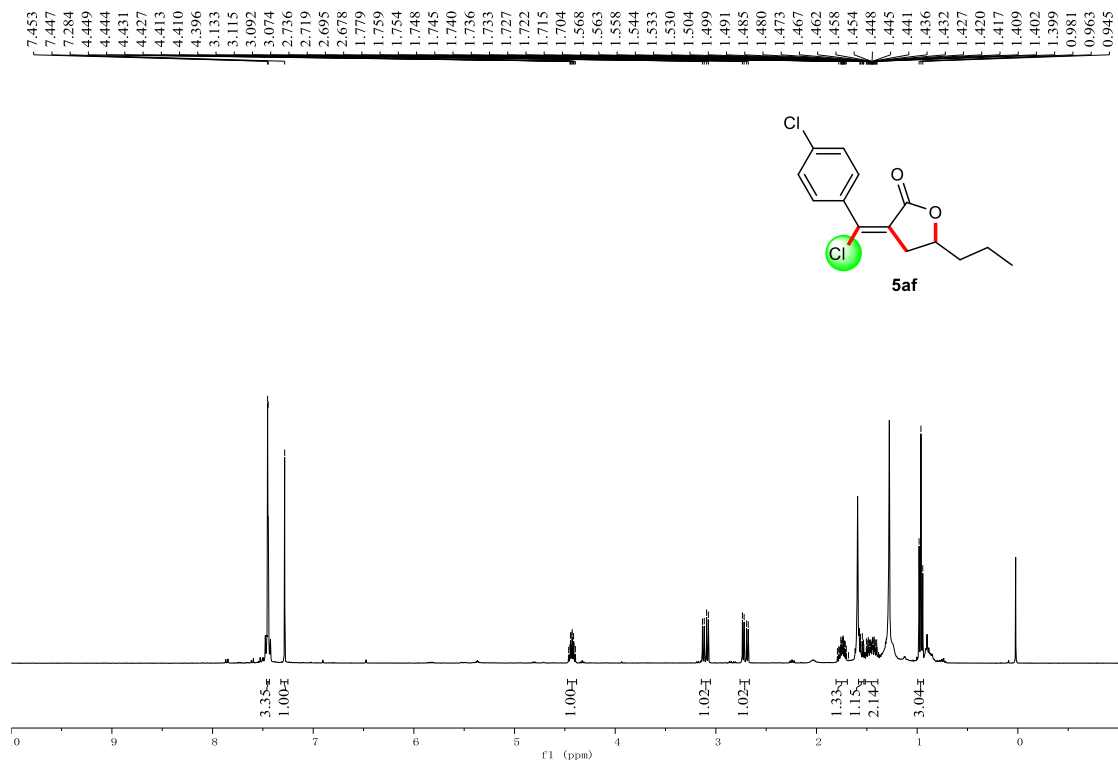


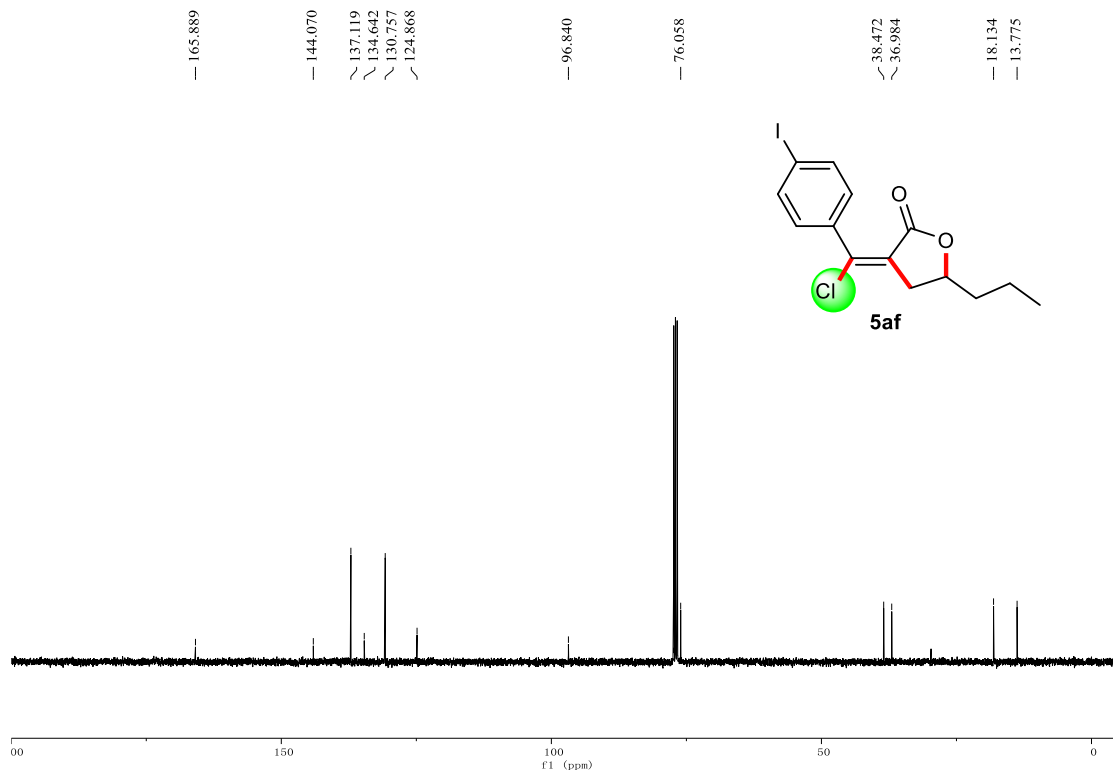
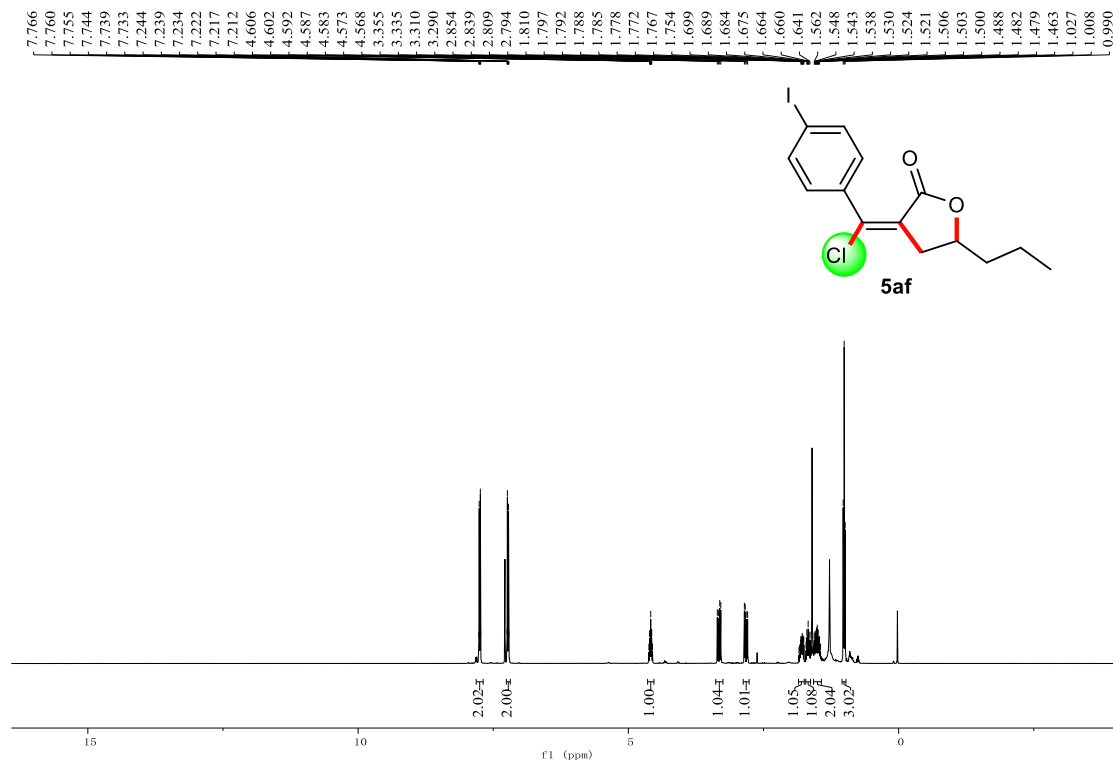


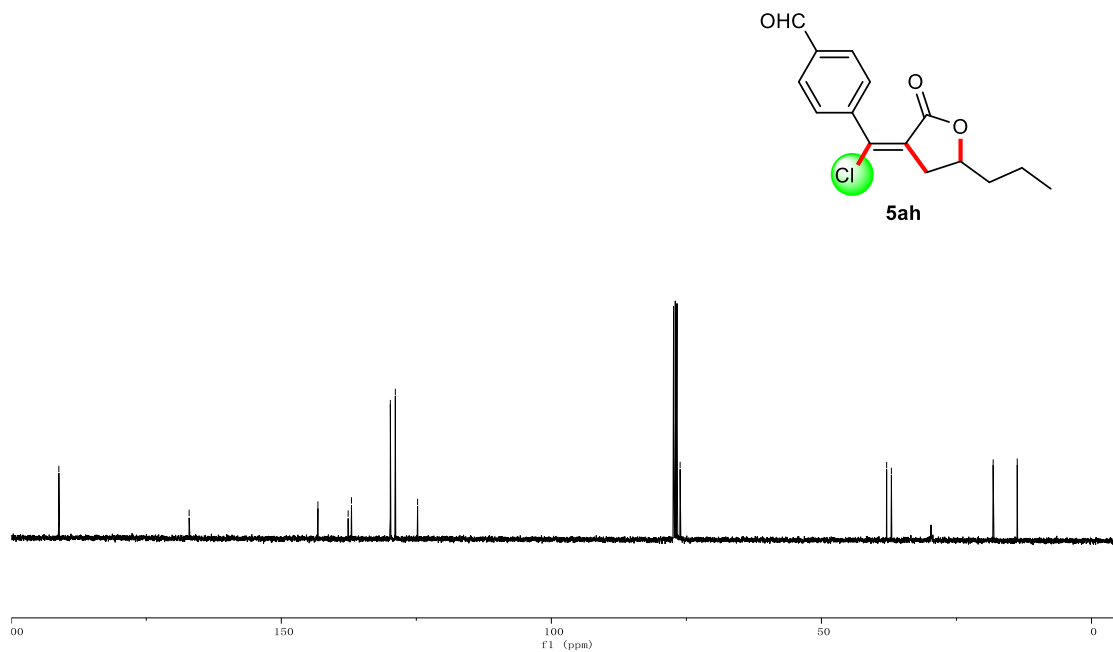
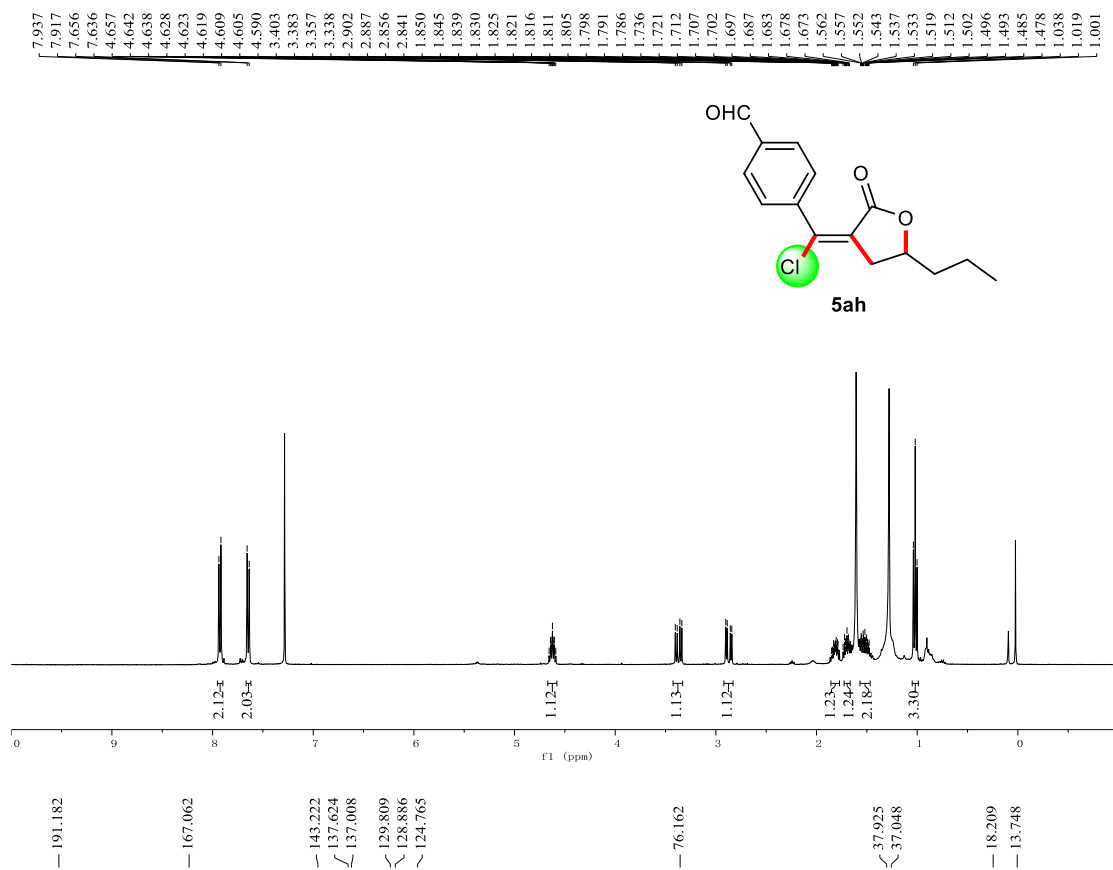


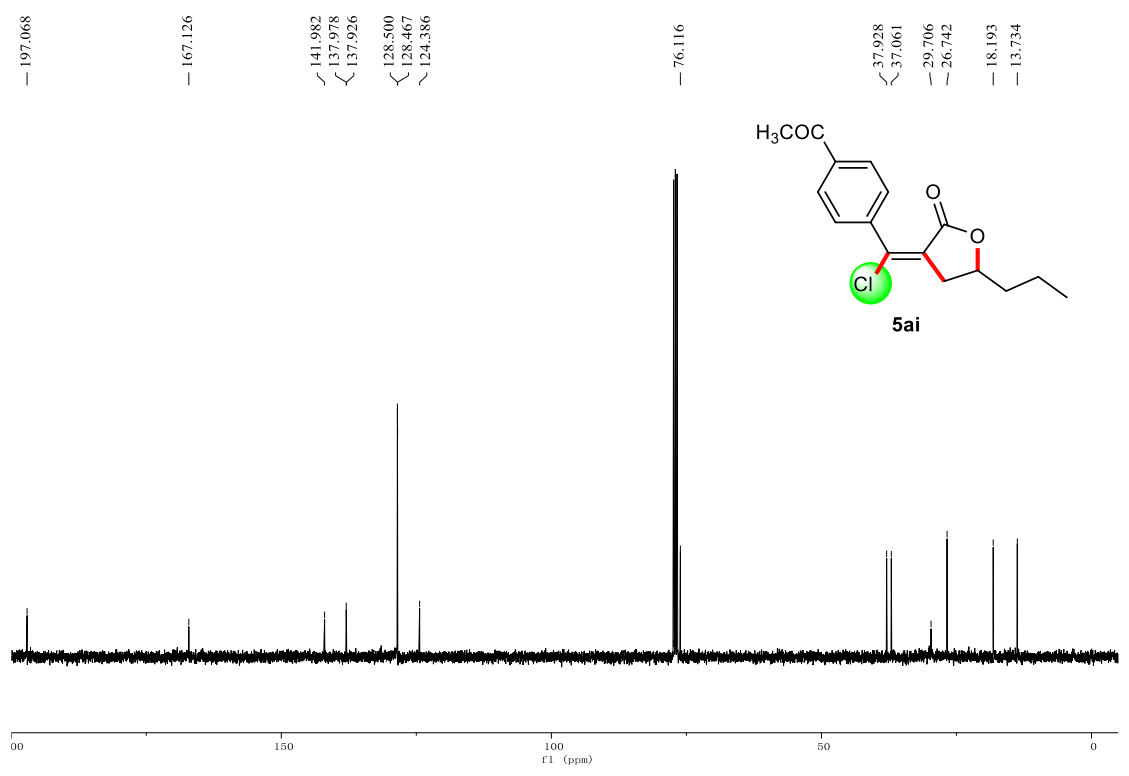
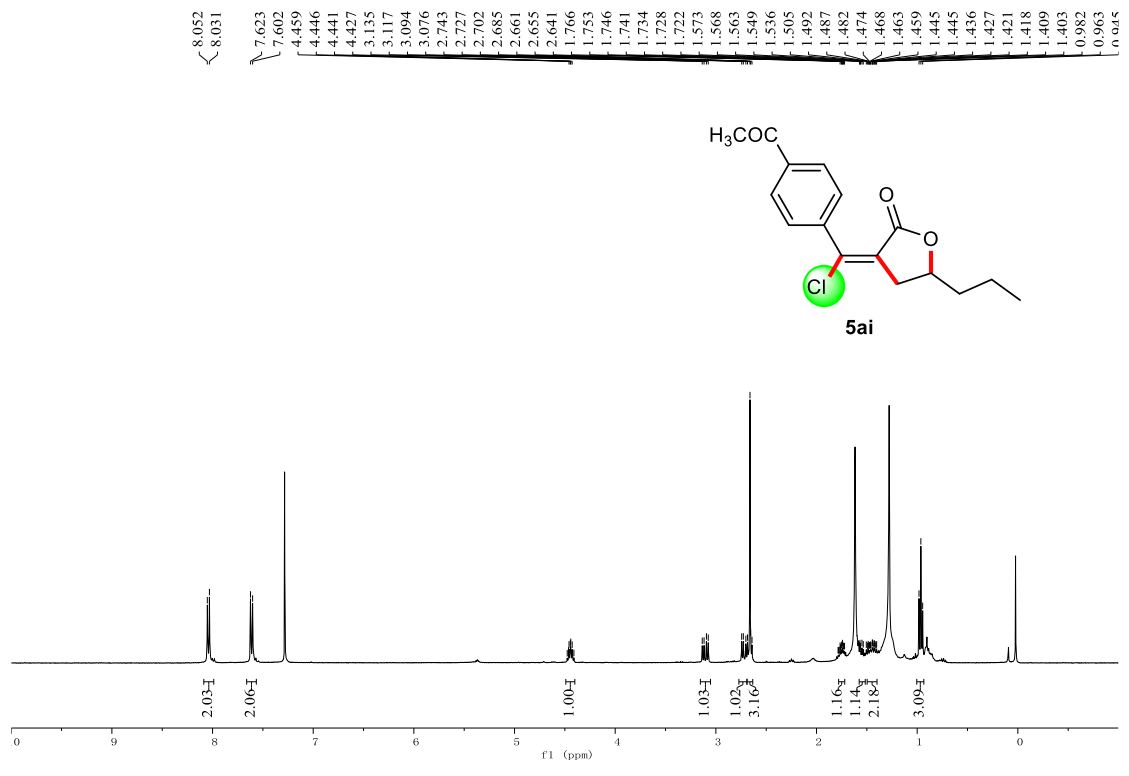


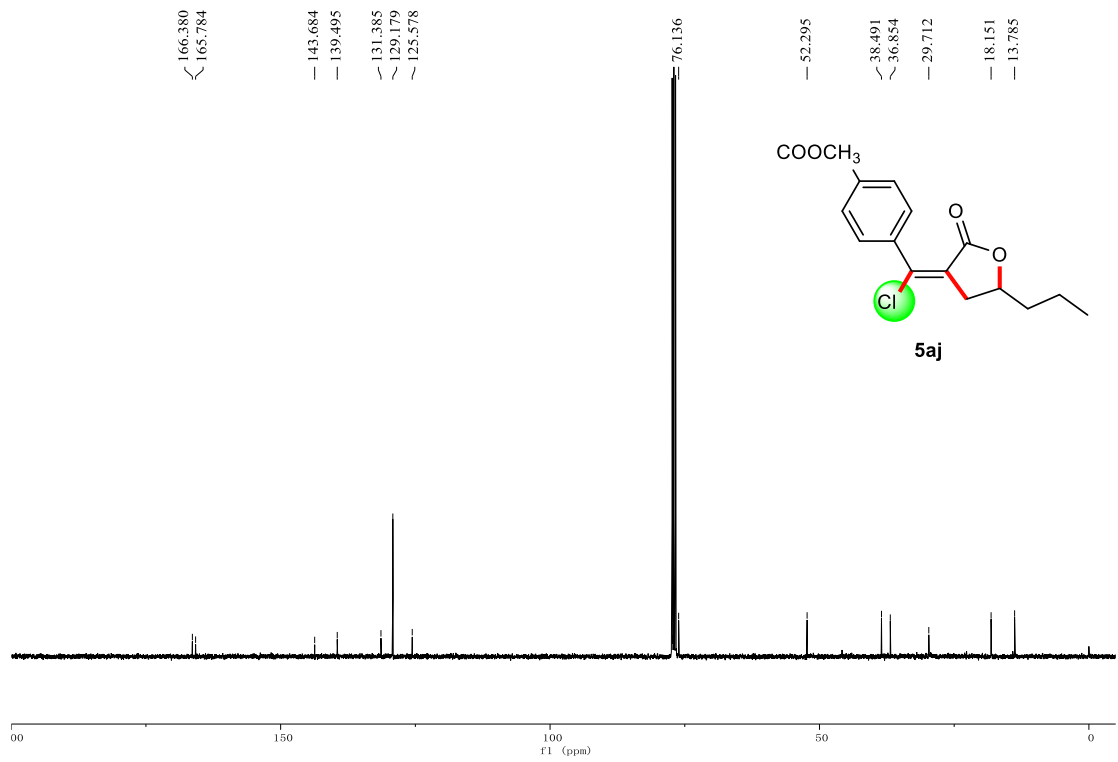
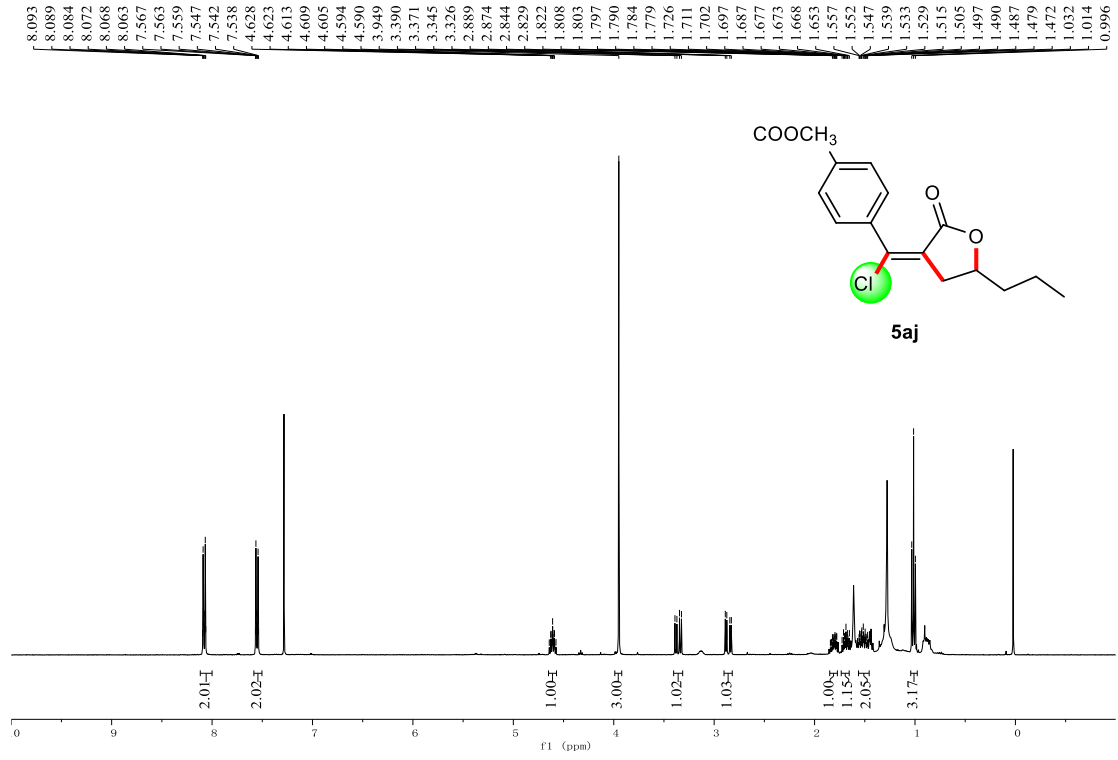


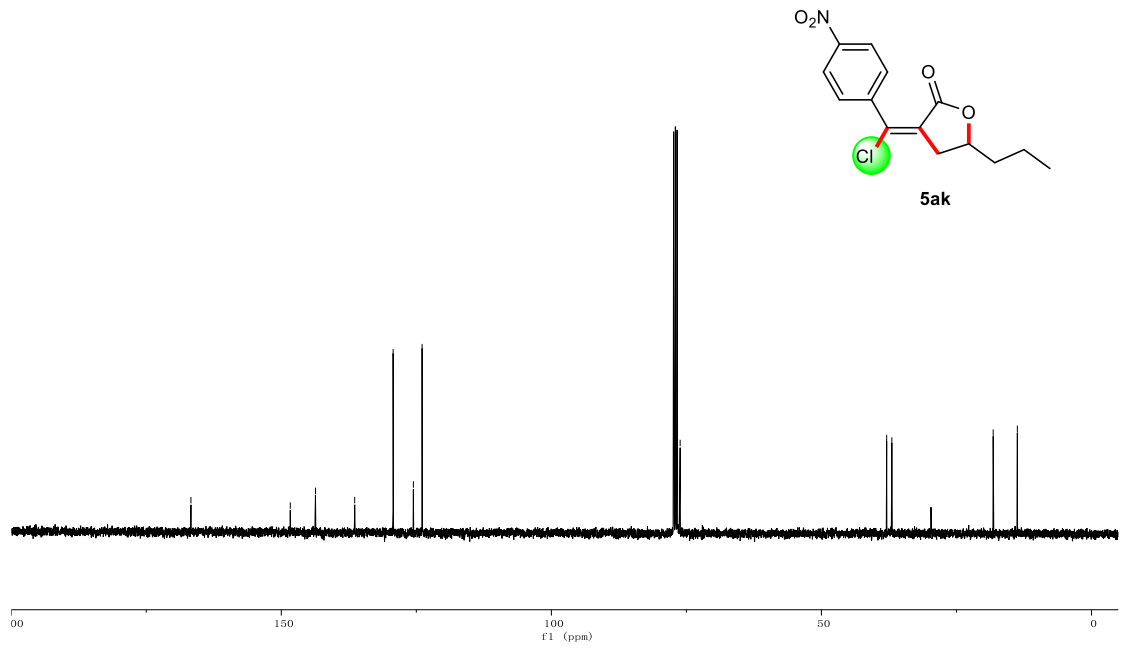
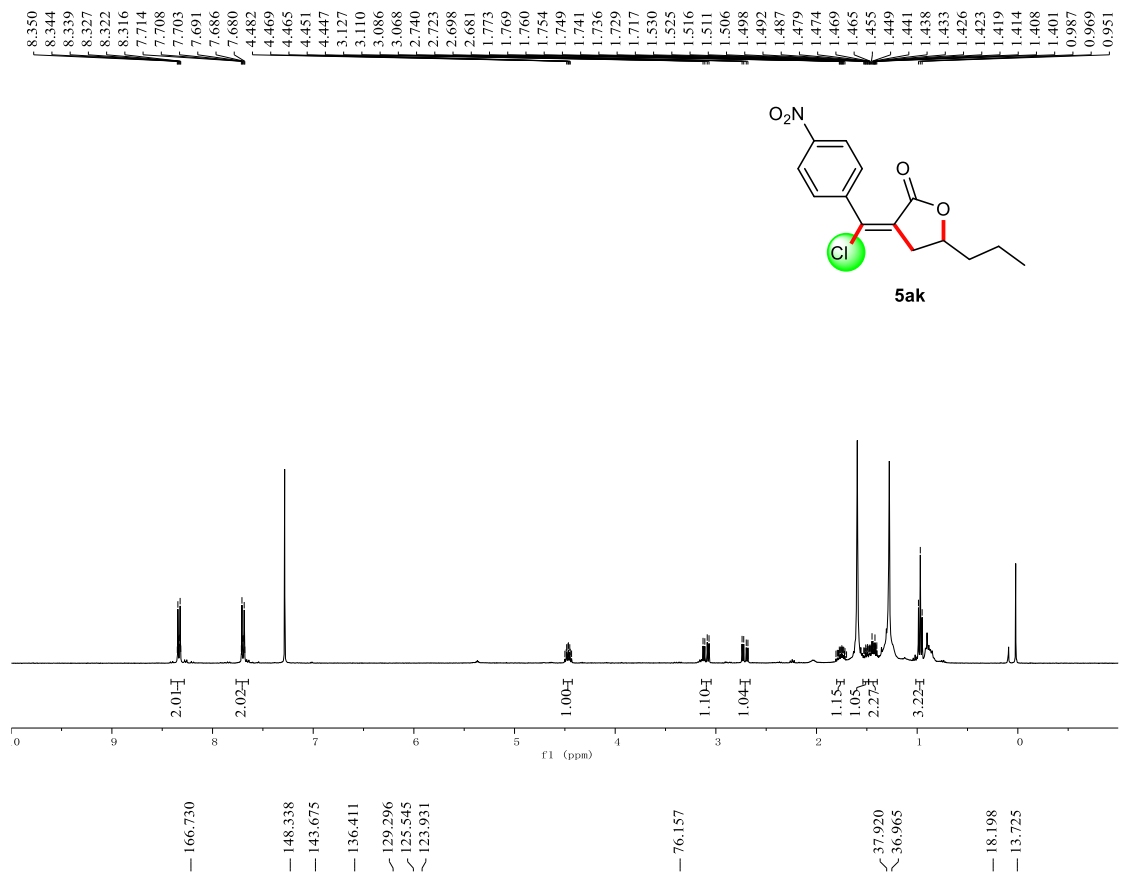


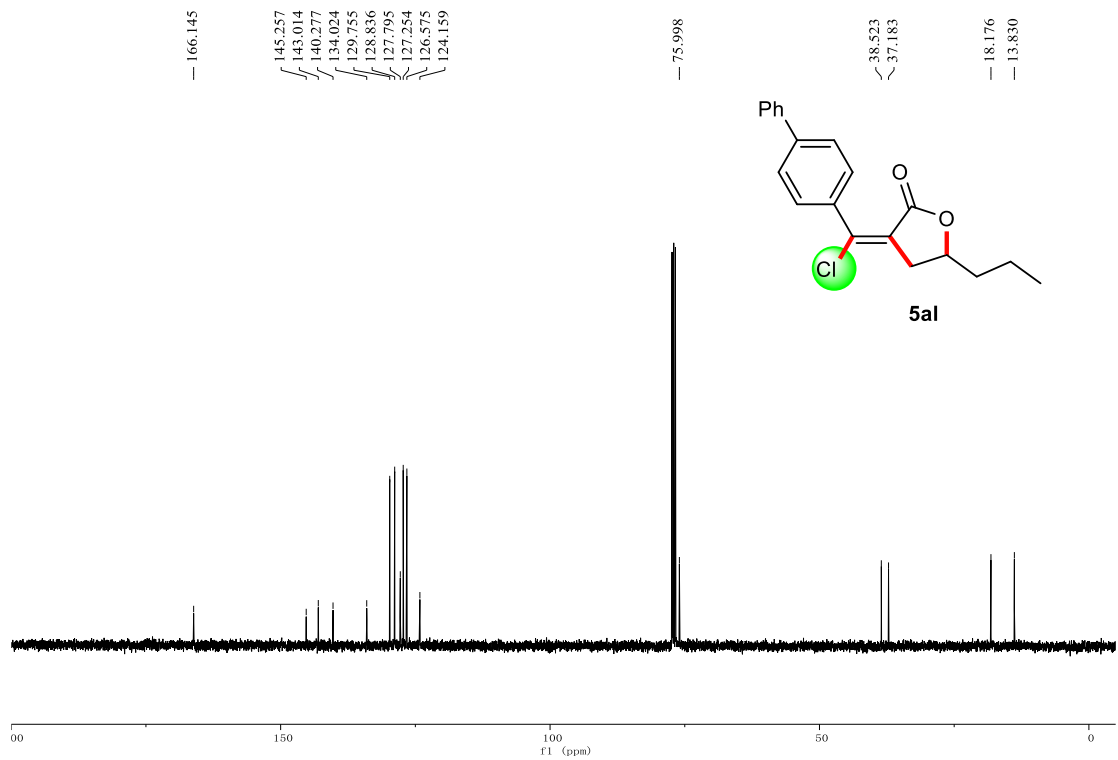
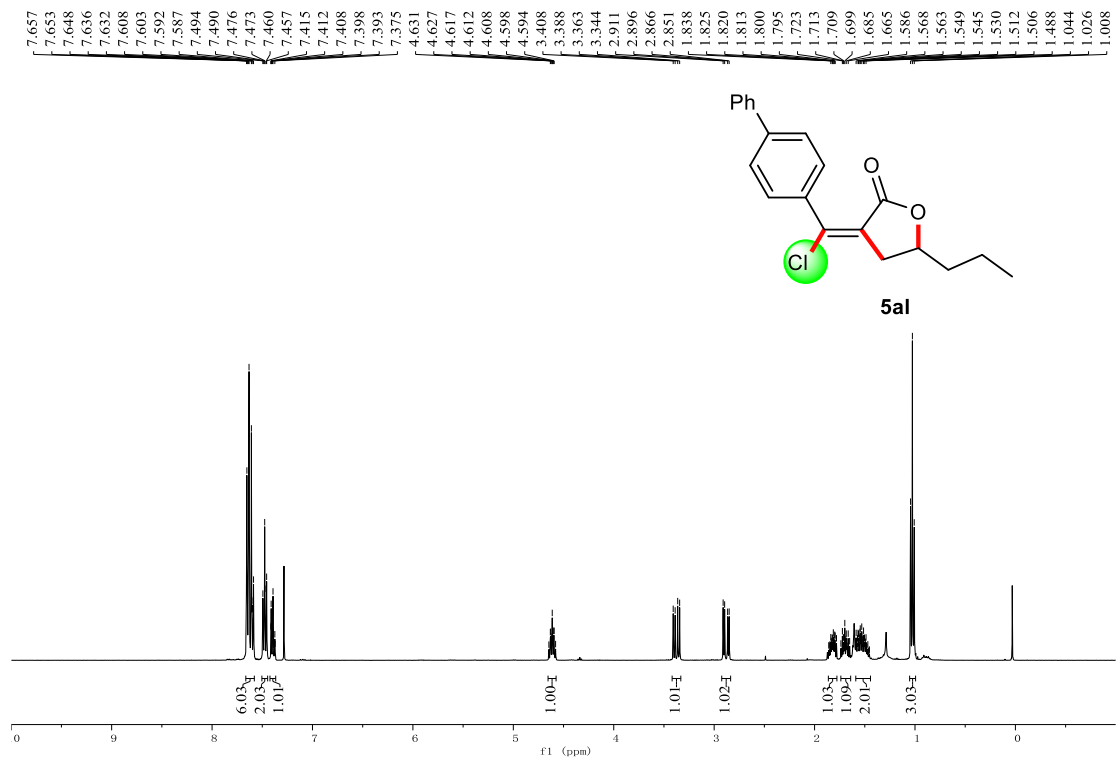


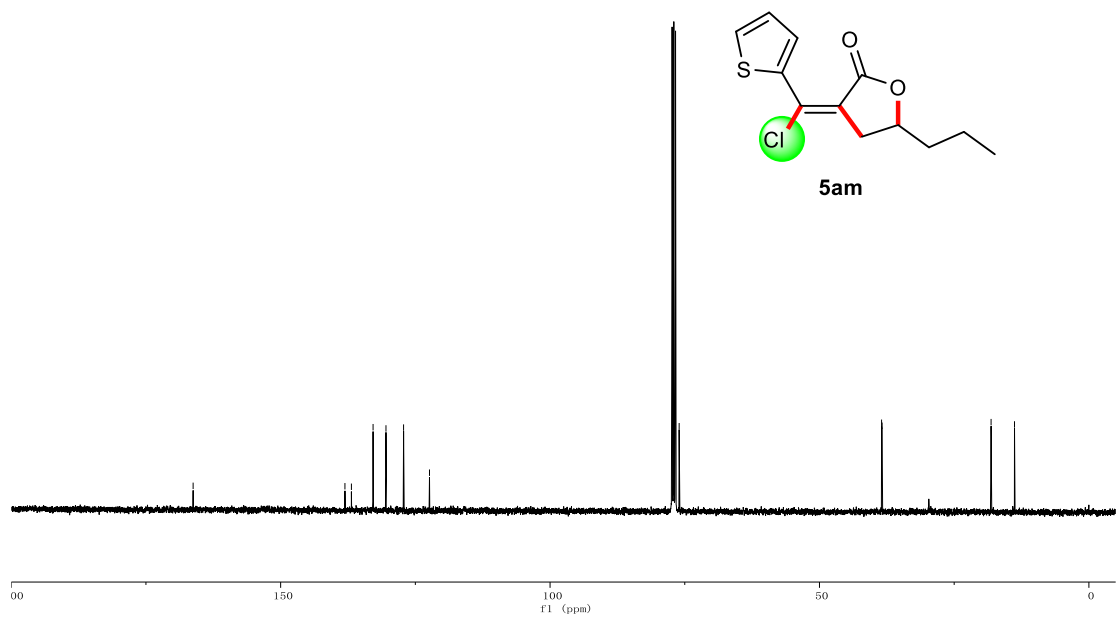
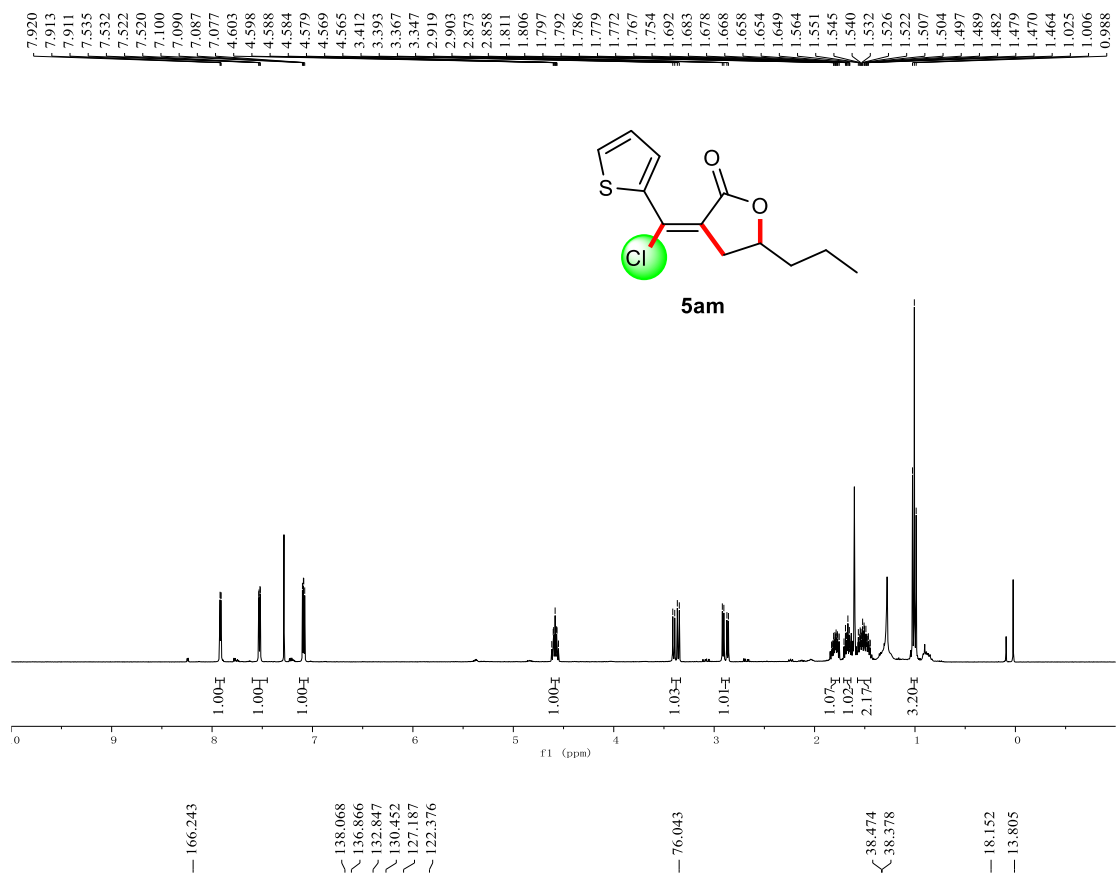


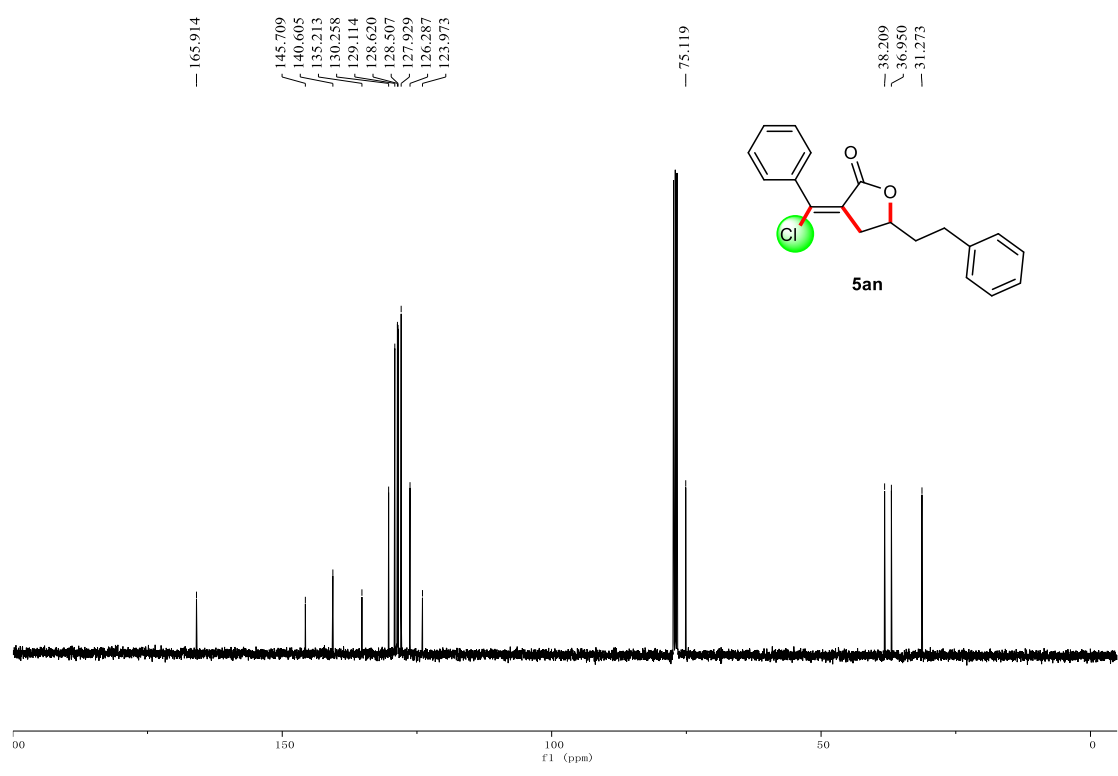
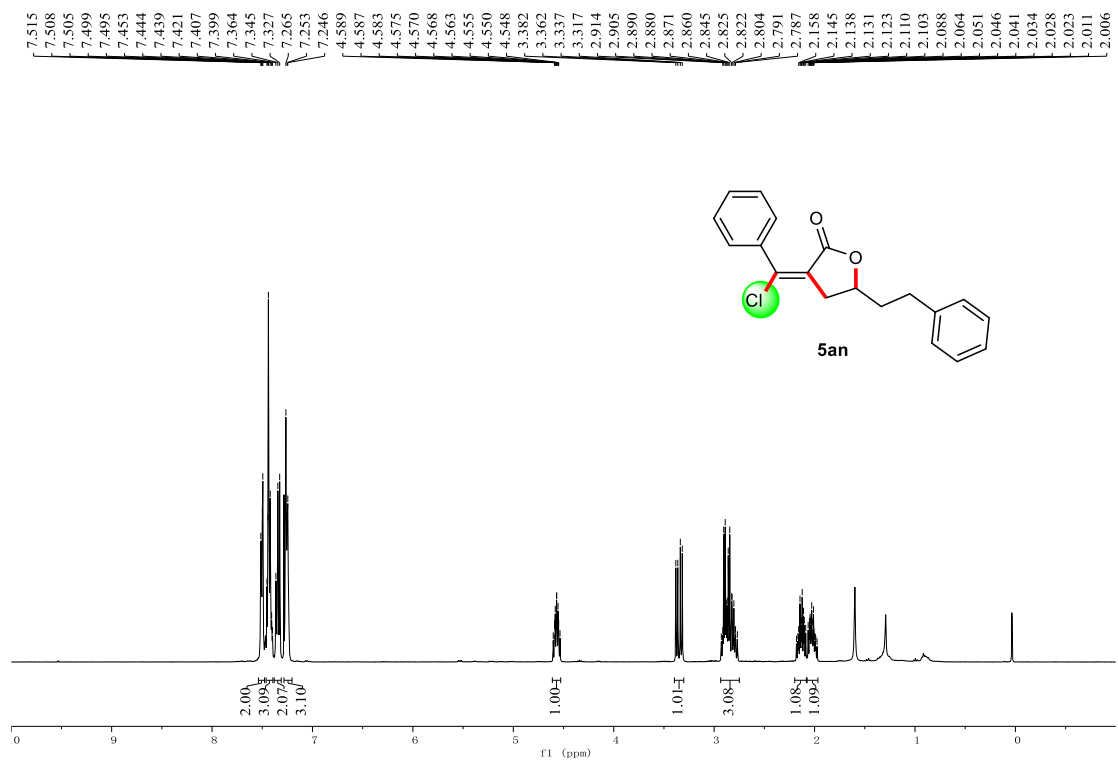




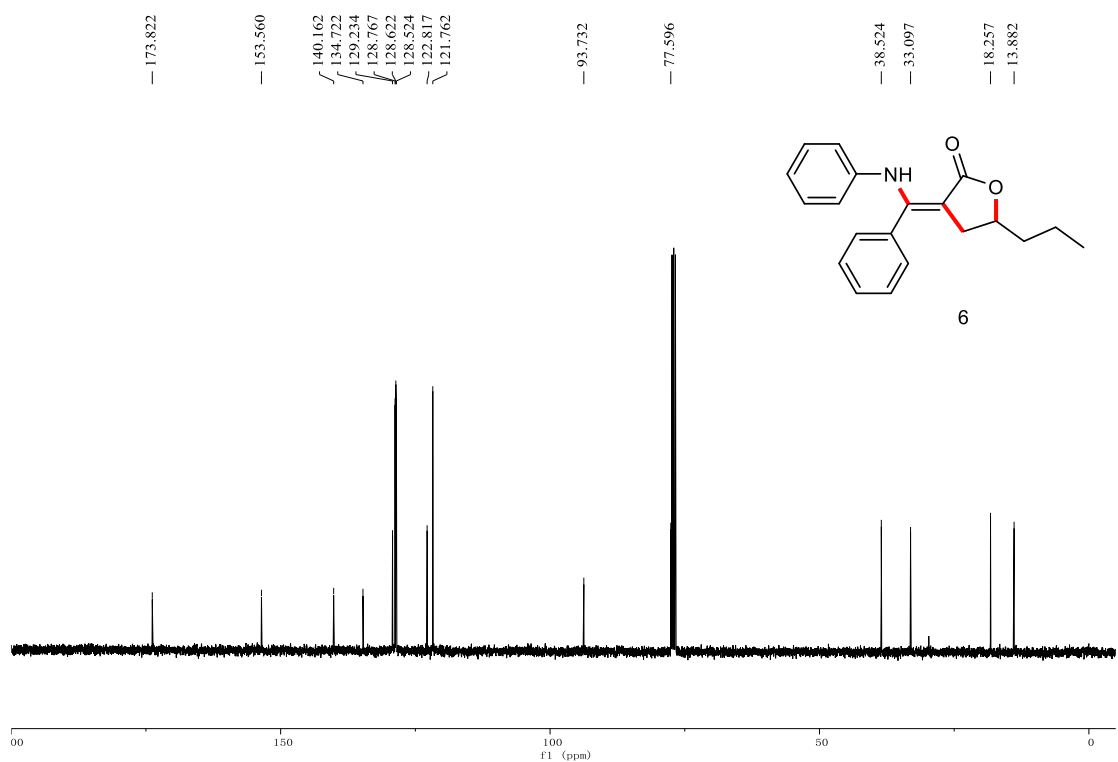
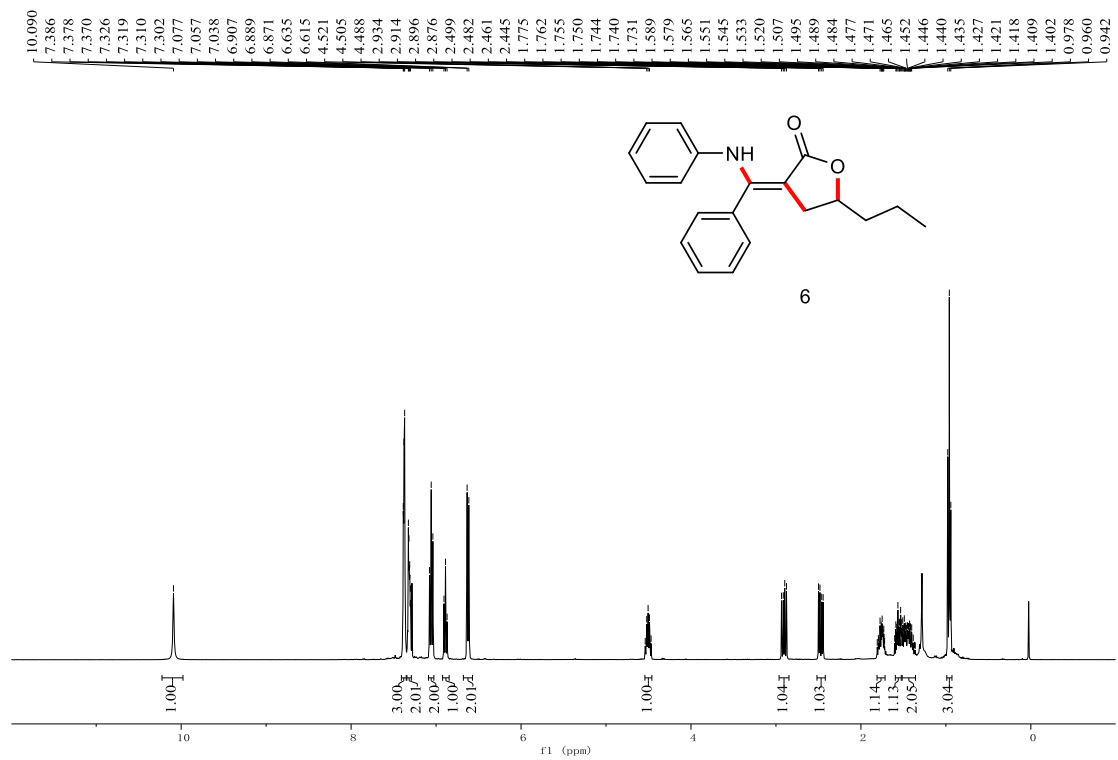




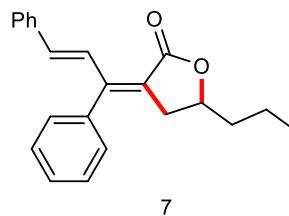
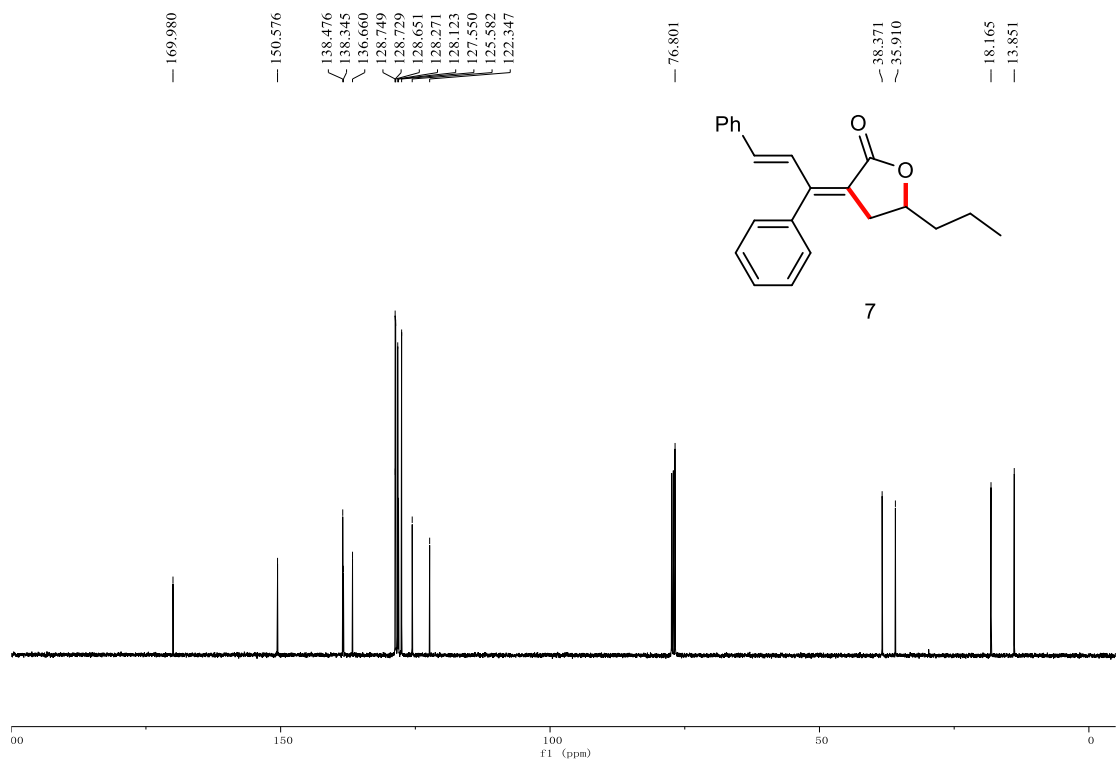
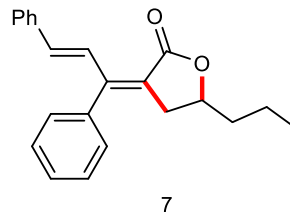
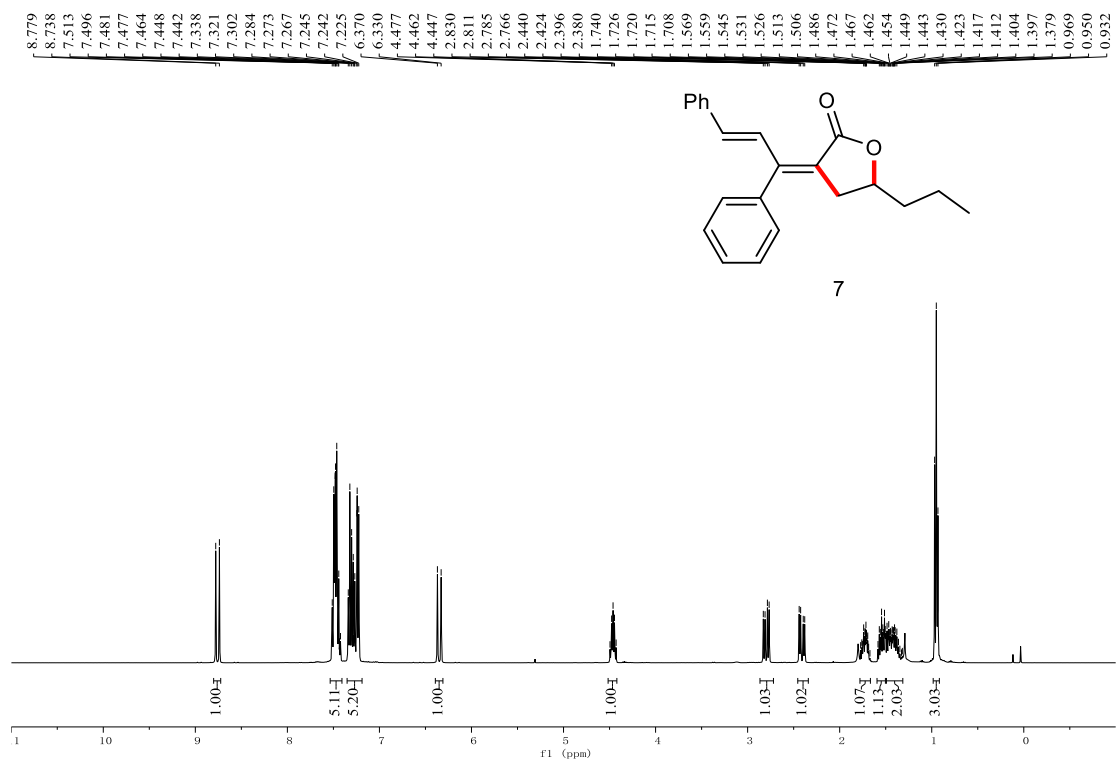




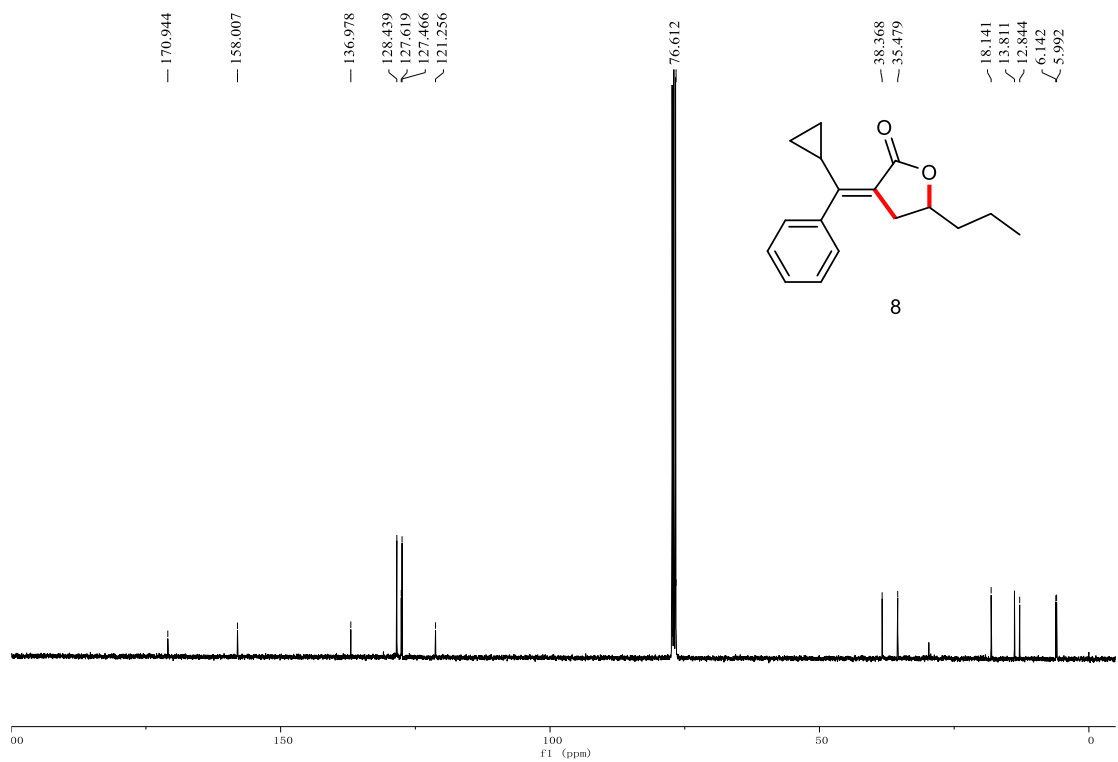
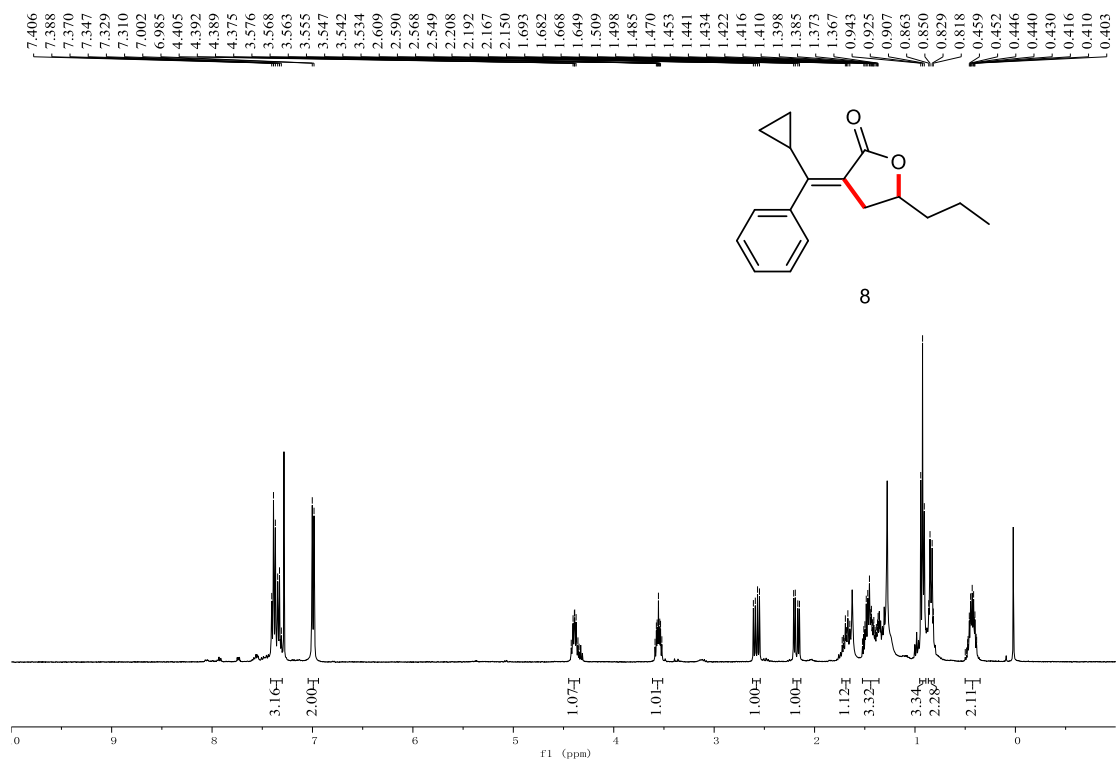
^1H and ^{13}C NMR spectra of compounds 6



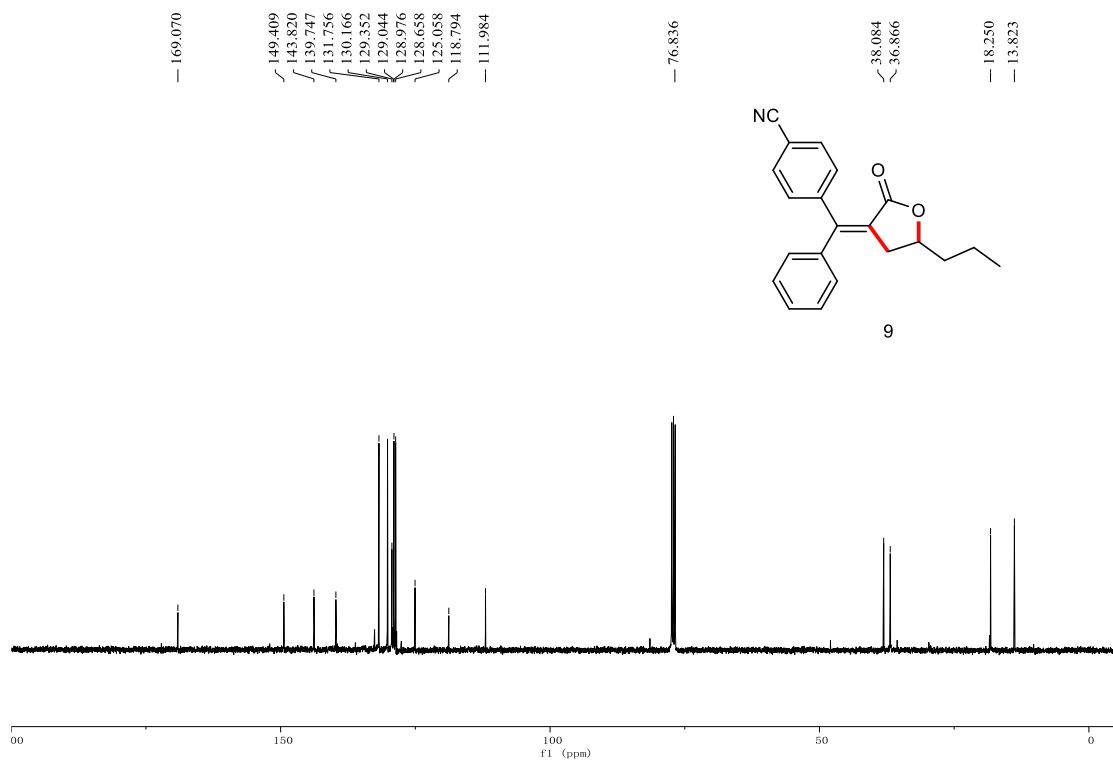
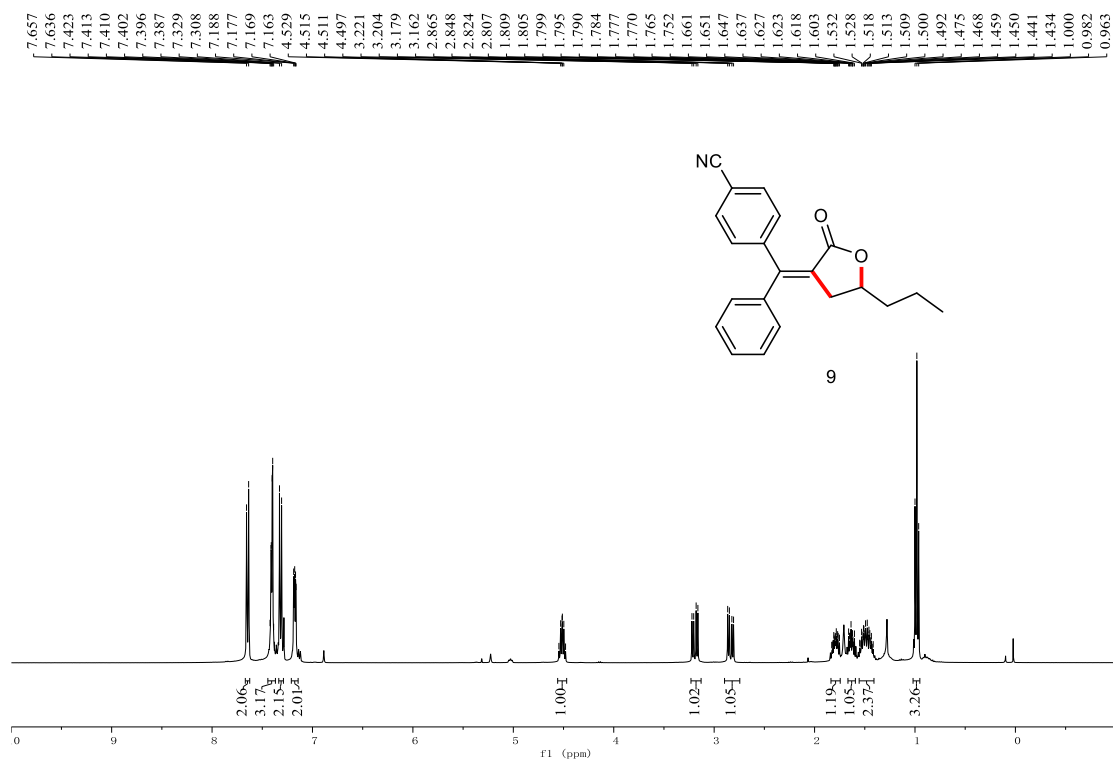
¹H and ¹³C NMR spectra of compounds 7



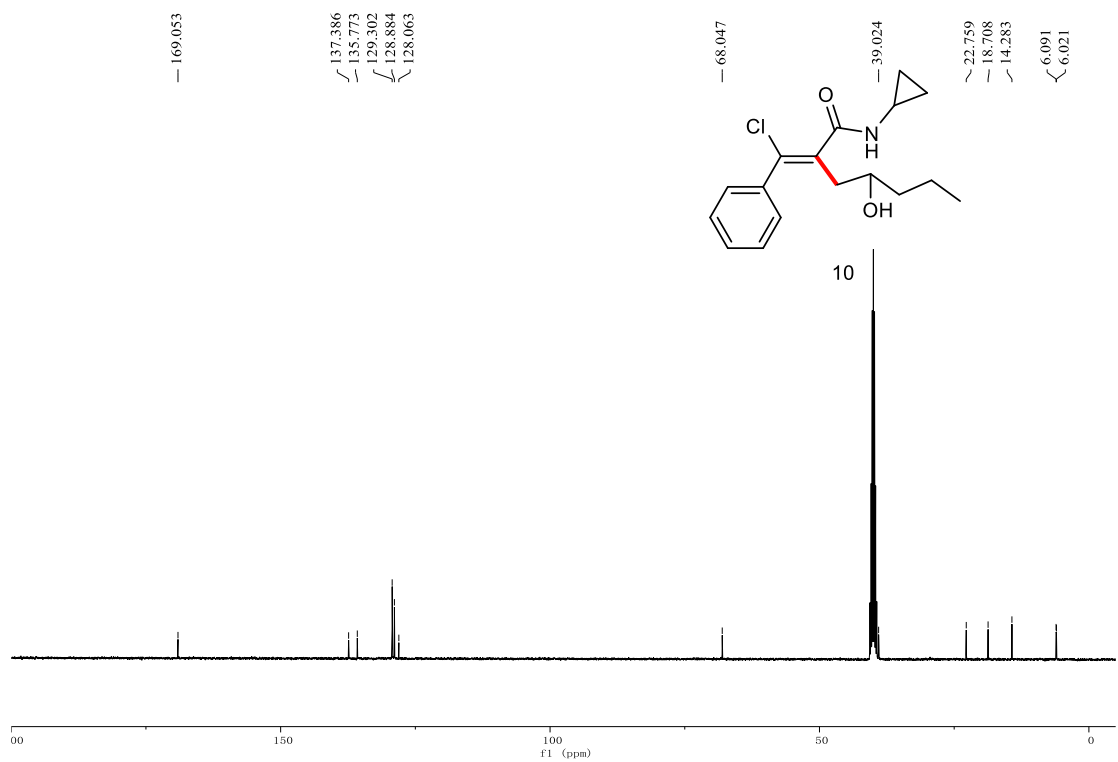
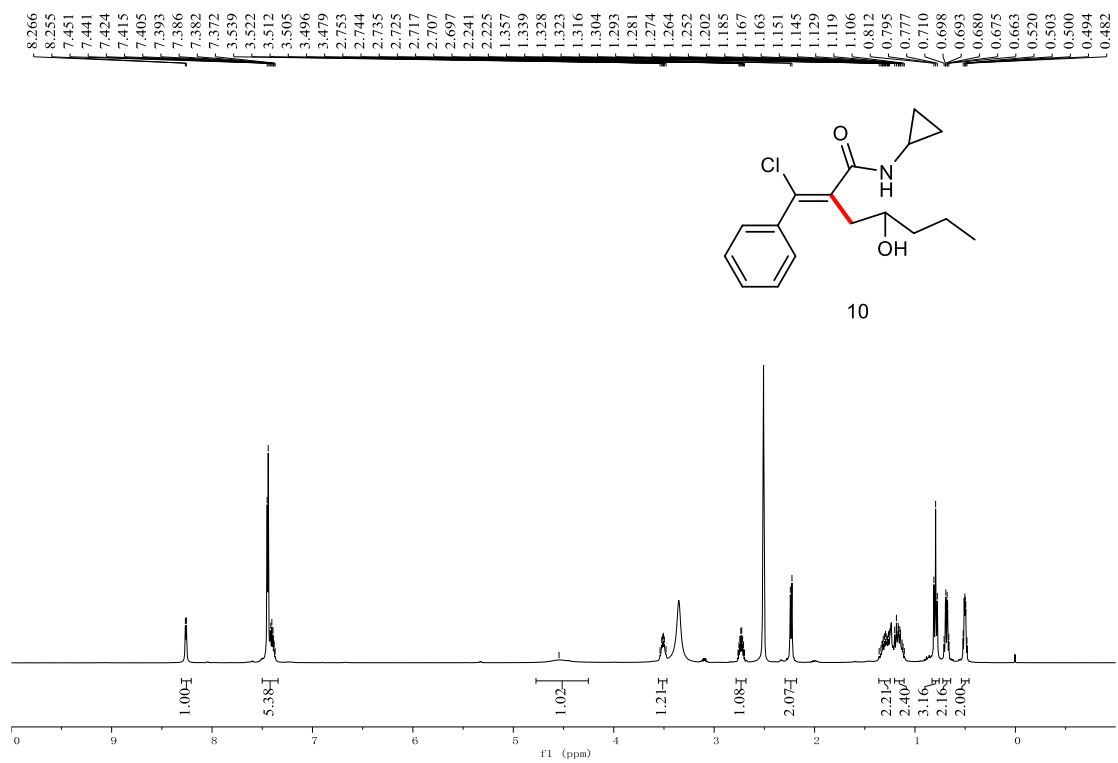
¹H and ¹³C NMR spectra of compounds 8



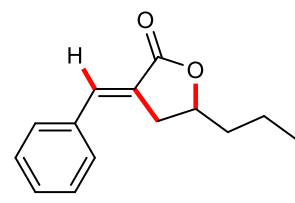
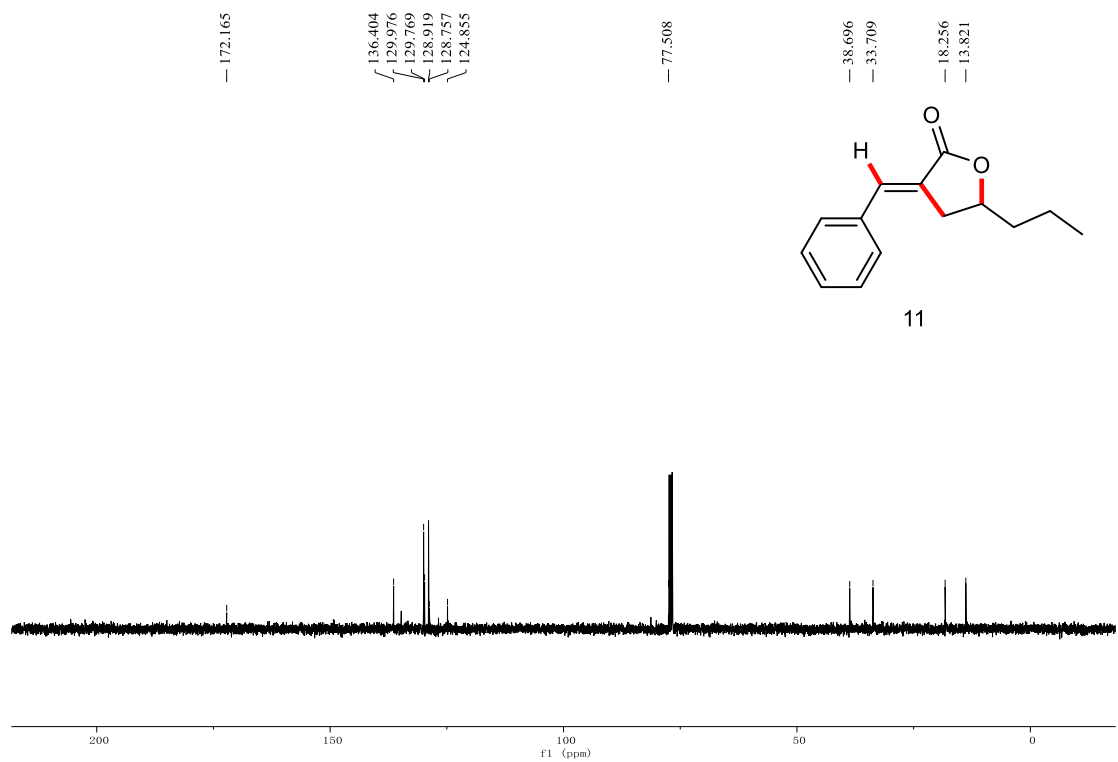
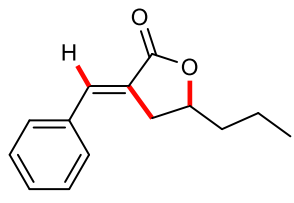
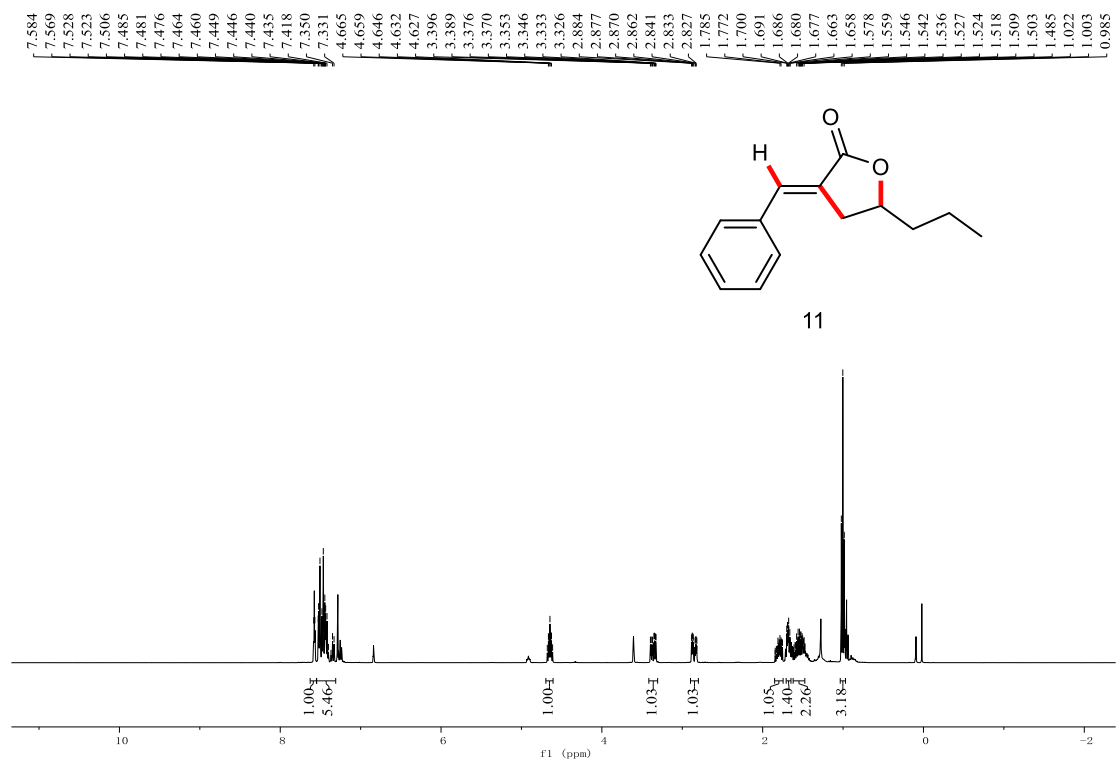
¹H and ¹³C NMR spectra of compounds 9



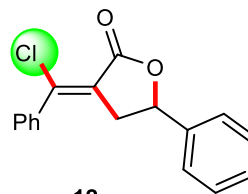
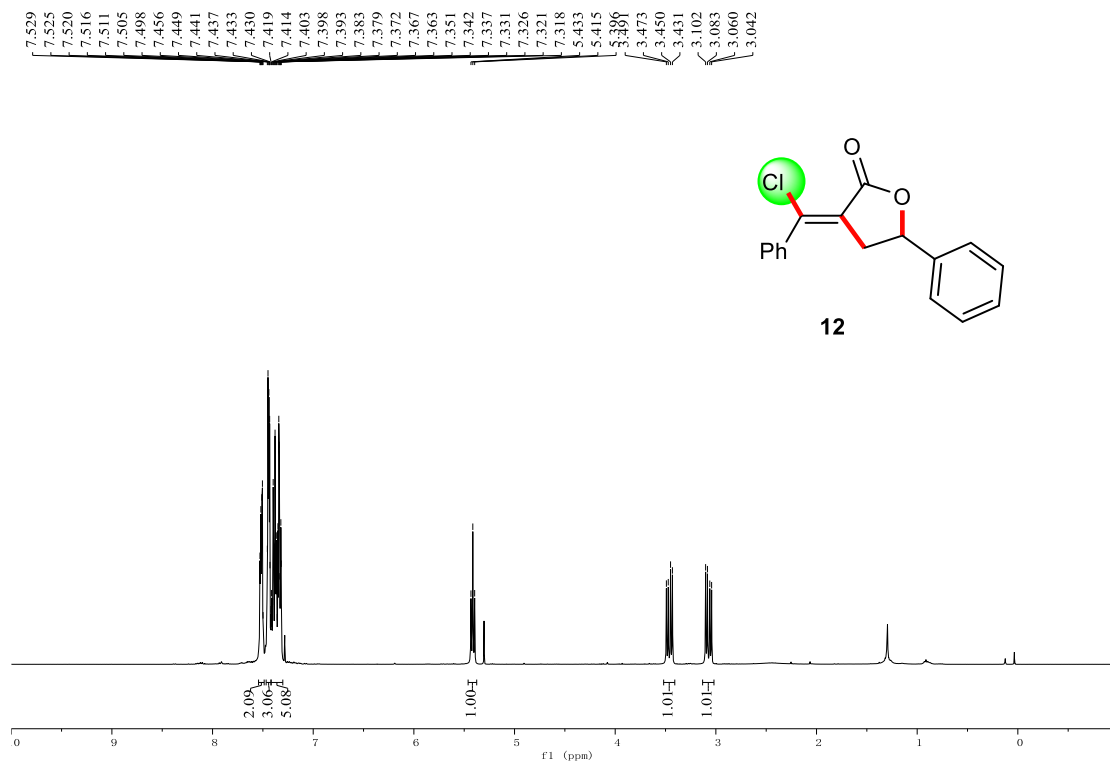
¹H and ¹³C NMR spectra of compounds 10



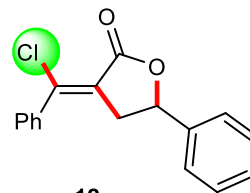
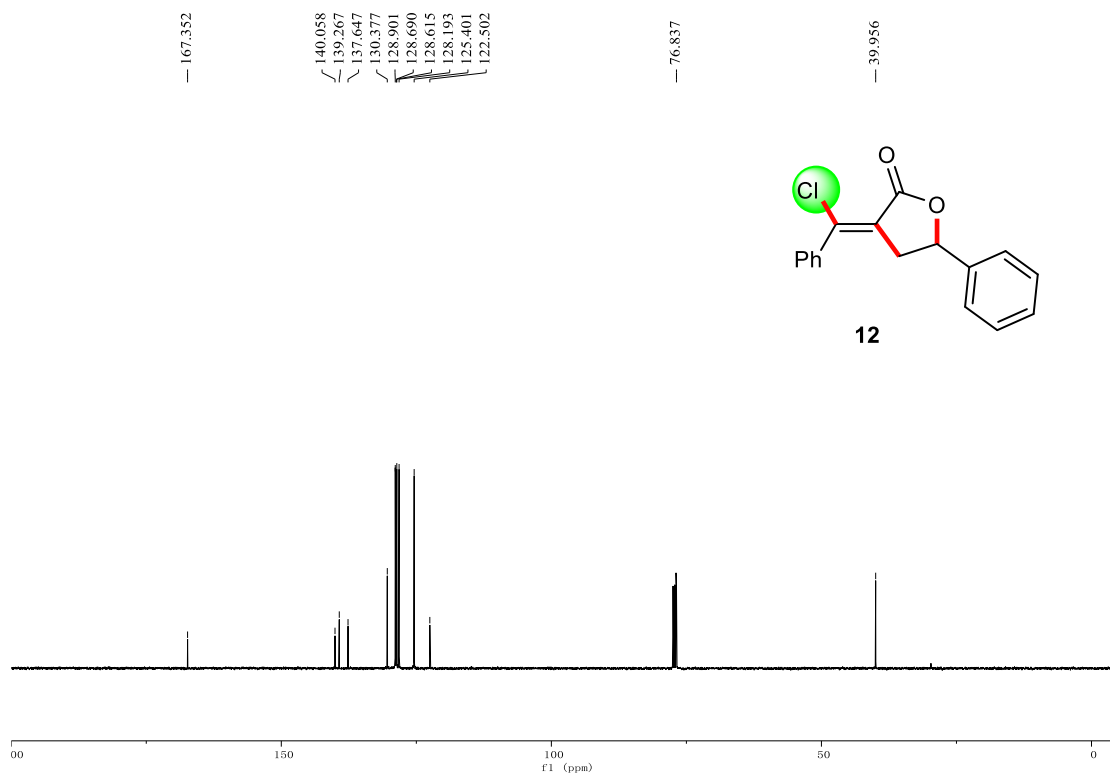
^1H and ^{13}C NMR spectra of compounds 11



¹H and ¹³C NMR spectra of compounds 12



12



12

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

