

Supporting information

Vilsmeier Cyclization of α -Acetyl- α -aroyl Ketene-*N*, *S*-Acetals:

Direct and Efficient Synthesis of Halogenated Pyridin-2(1*H*)-ones

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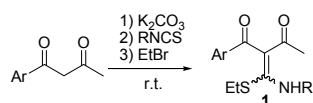
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1. General Considerations

All the manipulations of air-and/or moisture-sensitive compounds were carried out under a nitrogen atmosphere using standard Schlenk techniques. Reaction solvents were dried and distilled prior to use by the literature methods. ^1H and $^{13}\text{C}\{^1\text{H}\}$ NMR spectra were recorded on a Bruker DRX-600 spectrometer and all chemical shift values refer to δ TMS = 0.00 ppm or CDCl_3 (δ (^1H), 7.26 ppm; δ (^{13}C), 77.16 ppm). The HRMS analysis was achieved on Bruker microTof by using ESI method. All the melting points were uncorrected. Analytical TLC plates, Sigma-Aldrich silica gel 60F200 were viewed by UV light (254 nm). Chromatographic purifications were performed on SDZF silica gel 160.

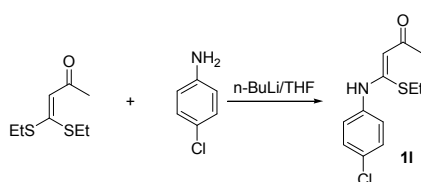
2. Experimental procedures

(1) Typical procedure for the preparation of α -acetyl- α -aroyl ketene-*N*, *S*-acetals **1a-k**



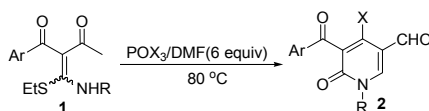
K_2CO_3 (5.0 mmol) was added to a stirred solution of 1-arylbutane-1, 3-dione (5.0 mmol) in DMF (10 mL), and the mixture was stirred for 1 h at room temperature. The isothiocyanate (5.0 mmol) was then added dropwise, and the mixture was stirred for 2 h at room temperature. The bromoethane (5.0 mmol) and K_2CO_3 (5.0 mmol) was added. The reaction was quenched with 100 mL of H_2O after the mixture was further stirred 4 h at room temperature. The resulting mixture was extracted with dichloromethane (3×30 mL), and the combined organic phase was washed with water, dried over anhydrous MgSO_4 , filtered, and evaporated in vacuo. The crude product was purified by silica gel chromatography (petroleum ether (30-60 $^\circ\text{C}$) /diethyl ether=30:1, v/v) to give α -acetyl- α -aroyl ketene-*N*, *S*-acetals **1a-k**.

(2) Typical procedure for the preparation of α -acetyl-*N*, *S*-acetals **1l**



To a stirred solution of 4-chlorobenzenamine (635 mg, 5 mmol) in dry THF (20 mL) was added *n*-BuLi (2.6 mL, 6 mmol) under nitrogen atmosphere over a period of 10 min at -78 °C. The reaction mixture was brought to room temperature and further stirred for 45 min. A solution of 4, 4-bis(ethylthio)but-3-en-2-one (900 mg, 5 mmol) in dry THF (10 mL) was added at 0 °C, and the reaction mixture was further stirred at room temperature for 2 h. It was refluxed for 18-20 h to complete the reaction, cooled, poured into saturated NH₄Cl solution (50 mL), and extracted with CHCl₃ (3×15 mL). The combined extracts were washed with water and brine, dried (Na₂SO₄), and evaporated to give crude product which was purified by silica gel chromatography (petroleum ether/ethyl acetate=6:1, v/v) to give **11** in 77% yield as a white solid.

(3) Typical Procedure for the Synthesis of 5-aryl-4-halo-3-formyl pyridin-2(1H)-ones **2**



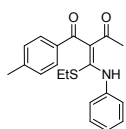
The Vilsmeier reagent was prepared by adding POX₃/DMF (1.5 mmol) into icecold dry DMF (1 mL) under stirring. The mixture was then stirred for 15 min at 0 °C. To the above Vilsmeier reagent was added **1** (0.25 mmol) as a solution in DMF (1 mL). The mixture was heated to 80 °C and stirred for 4.0 h. After cooling to room temperature, the resulting mixture was poured into saturated aqueous NaCl (100 mL), which was extracted with dichloromethane (3×30 mL). The combined organic phase was washed with water, dried over anhydrous MgSO₄, filtered, and evaporated in vacuo. The crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate=4:1, v/v) to give **2** as a white solid.

(4) X-ray crystallographic studies

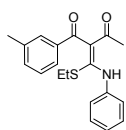
Single crystal X-ray diffraction data of compounds (*Z*)-**1a** were recorded on a Bruker SMART APEX II diffractometer with graphite-monochromated Mo K α radiation ($\lambda = 0.71073 \text{ \AA}$) at 293K. Cell parameters were obtained by global refinement of the positions of all collected reflections. Intensities were corrected for Lorentz and polarization effects and empirical absorption. The structures were solved by direct methods and refined by full-matrix least squares on *F*². All non-hydrogen

atoms were refined with anisotropic temperature parameters. All hydrogen atoms on carbon atoms were generated geometrically. Structure solution and refinement were performed by using the SHELXL-97 program. The X-ray crystallographic files, in CIF format, are available from the Cambridge Crystallographic Data Centre on quoting the deposition numbers CCDC 974611 for (*Z*)-**1a**. Copies of this information may be obtained free of charge from The Director, CCDC, 12 Union Road, Cambridge CB21EZ, UK (Fax: +44-1223-336033; e-mail: deposit@ccdc.cam.ac.uk or www: <http://www.ccdc.cam.ac.uk>).

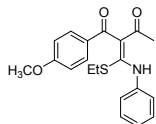
3 Analytical data



(Z)-2-(ethylthio(phenylamino)methylene)-1-*p*-tolylbutane-1, 3-dione ((Z)-1a): yield 85%. Yellowish crystalline solid. M.p.: 58-59 °C. ¹H NMR (600 MHz, CDCl₃) δ: 13.06 (s, 1H), 7.88 (d, *J* = 7.9 Hz, 2 H), 7.40 (d, *J* = 8.0 Hz, 2 H), 7.35 (t, 2 H), 7.27 (d, *J* = 7.9 Hz, 2 H), 7.21 (t, 1 H), 2.43 (s, 3 H), 2.21 (q, 2 H), 2.07 (s, 3 H), 0.88 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ: 195.9, 194.1, 158.6, 143.9, 138.9, 137.1, 129.5 (2C), 129.4 (2 C), 129.2 (2 C), 125.9, 124.3 (2 C), 116.3, 29.0, 28.0, 21.7, 14.0. HRMS Calcd for C₂₀H₂₁NO₂S: ([M+H]⁺) 340.1366; Found: 340.1366.

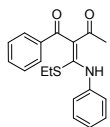


(Z)-2-(ethylthio(phenylamino)methylene)-1-*m*-tolylbutane-1, 3-dione ((Z)-1b): yield 86%. Yellowish liquid. ¹H NMR (600 MHz, CDCl₃) δ 13.07 (s, 1 H), 7.80 (s, 1 H), 7.76 (d, *J* = 7.4 Hz, 1 H), 7.40 (d, *J* = 8.1 Hz, 2 H), 7.37-7.33 (m, 4 H), 7.20 (t, 1 H), 2.42 (s, 3 H), 2.20 (q, 2 H), 2.08 (s, 3 H), 0.86 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 196.3, 194.2, 158.9, 139.8, 138.9, 138.5, 133.8, 129.7, 129.3 (2C), 128.5, 126.7, 126.0, 124.3 (2C), 116.4, 29.0, 28.1, 21.4, 14.0. HRMS Calcd for C₂₀H₂₁NO₂S: ([M+H]⁺) 340.1366; Found: 340.1380.



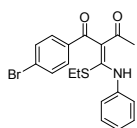
(Z)-2-(ethylthio(phenylamino)methylene)-1-(4-methoxyphenyl)butane-1, 3-dione

((Z)-1c): yield 84%. Yellowish crystalline solid. M.p.: 68-69 °C. ¹H NMR (600 MHz, CDCl₃) δ 13.03 (s, 1 H), 7.97 (d, *J* = 8.6 Hz, 2 H), 7.40 (d, *J* = 8.0 Hz, 2 H), 7.35 (t, 2 H), 7.20 (t, 1 H), 6.96 (d, *J* = 8.4 Hz, 2 H), 3.88 (s, 3 H), 2.23 (q, 2 H), 2.07 (s, 3 H), 0.90 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 195.0, 194.0, 163.7, 158.4, 139.1, 132.6, 131.8 (2 C), 129.3 (2 C), 126.0, 124.3 (2 C), 116.3, 114.0 (2 C), 55.6, 29.0, 28.0, 14.2. HRMS Calcd for C₂₀H₂₁NO₃S: ([M+H]⁺) 356.1315; Found: 356.1320.



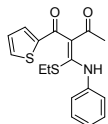
(Z)-2-(ethylthio(phenylamino)methylene)-1-phenylbutane-1, 3-dione ((Z)-1d):

yield 88%. Yellowish crystalline solid. M.p.: 66-67 °C. ¹H NMR (600 MHz, CDCl₃) δ 13.08 (s, 1 H), 7.97 (d, *J* = 7.3 Hz, 2 H), 7.55 (t, 1 H), 7.46 (t, 2 H), 7.39 (d, *J* = 7.8 Hz, 2 H), 7.34 (t, 2 H), 7.20 (t, 1 H), 2.20 (q, 2 H), 2.09 (s, 3 H), 0.84 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 196.1, 194.2, 159.1, 140.0, 139.0, 132.9, 129.3 (4 C), 128.7 (2 C), 126.1, 124.4 (2 C), 116.2, 29.1, 28.1, 14.0. HRMS Calcd for C₁₉H₁₉NO₂S: ([M+H]⁺) 326.1210; Found: 326.1214.

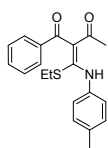


(Z)-1-(4-bromophenyl)-2-(ethylthio(phenylamino)methylene)butane-1, 3-dione

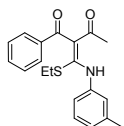
((Z)-1e): yield 90%. Yellowish crystalline solid. M.p.: 37-38 °C. ¹H NMR (600 MHz, CDCl₃) δ 13.11 (s, 1 H), 7.83 (d, *J* = 8.5 Hz, 2 H), 7.60 (d, *J* = 8.5 Hz, 2 H), 7.39-7.34 (m, 4 H), 7.21 (t, 1 H), 2.20 (q, 2 H), 2.09 (s, 3 H), 0.86 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 195.0, 194.0, 159.4, 138.8, 138.7, 132.0 (2 C), 130.8 (2 C), 129.3 (2 C), 128.0, 126.3, 124.4 (2 C), 115.6, 29.0, 28.2, 14.0. HRMS Calcd for C₁₉H₁₈BrNO₂S: ([M+H]⁺) 404.0315; Found: 404.0311.



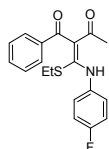
(Z)-2-(ethylthio(phenylamino)methylene)-1-(thiophen-2-yl)butane-1, 3-dione ((Z)-1f): yield 86%. Yellowish liquid. ^1H NMR (600 MHz, CDCl_3) δ 13.02 (s, 1 H), 7.68 (t, 2 H), 7.39 (d, $J = 7.5$ Hz, 2 H), 7.35 (t, 2 H), 7.21 (t, 1 H), 7.14 (t, 1 H), 2.50 (q, 2 H), 2.14 (s, 3 H), 0.92 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 193.5, 188.2, 158.8, 147.2, 138.7, 134.4, 133.4, 129.2 (2 C), 128.2, 126.1, 124.3 (2 C), 120.1, 28.7, 28.2, 14.0. HRMS Calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_2\text{S}_2$: ($[\text{M}+\text{H}]^+$) 332.0774; Found: 332.0793.



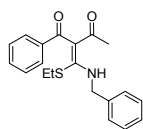
(Z)-2-((p-toluidino)(ethylthio)methylene)-1-phenylbutane-1, 3-dione ((Z)-1g): yield 83%. Yellowish crystalline solid. M.p.: 61-62 °C. ^1H NMR (600 MHz, CDCl_3) δ (Z)-1g: 13.09 (s, 1 H), 7.96 (d, $J = 7.6$ Hz, 2 H), 7.56 (t, 1 H), 7.47 (t, 2 H), 7.27 (d, $J = 7.4$ Hz, 2 H), 7.15 (d, $J = 7.9$ Hz, 2 H), 2.34 (s, 3 H), 2.20 (q, 2 H), 2.08 (s, 3 H), 0.84 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 196.3, 194.0, 159.6, 140.0, 136.2, 136.0, 132.9, 129.9 (2 C), 129.3 (2 C), 128.6 (2 C), 124.3 (2 C), 115.8, 29.0, 28.1, 21.1, 14.0. (HRMS Calcd for $\text{C}_{20}\text{H}_{21}\text{NO}_2\text{S}$: ($[\text{M}+\text{H}]^+$) 340.1366; Found: 340.1370.



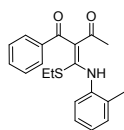
(Z)-2-((m-toluidino)(ethylthio)methylene)-1-phenylbutane-1, 3-dione ((Z)-1h): yield 85%. Yellowish liquid. ^1H NMR (600 MHz, CDCl_3) δ 13.07 (s, 1 H), 7.97 (d, $J = 7.4$ Hz, 2 H), 7.55 (t, 1 H), 7.46 (t, 2 H), 7.21 (t, 2 H), 7.19 (s, 1 H), 7.01 (d, $J = 7.5$ Hz, 1 H), 2.34 (s, 3 H), 2.22 (q, 2 H), 2.08 (s, 3 H), 0.85 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 196.2, 194.1, 159.3, 139.9, 139.3, 138.8, 132.9, 129.3 (2 C), 129.1, 128.6 (2 C), 126.9, 124.9, 121.3, 116.0, 29.0, 28.1, 21.4, 14.0. HRMS Calcd for $\text{C}_{20}\text{H}_{21}\text{NO}_2\text{S}$: ($[\text{M}+\text{H}]^+$) 340.1366; Found: 340.1385.



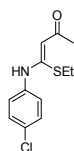
(Z)-2-(ethylthio(4-fluorophenylamino)methylene)-1-phenylbutane-1, 3-dione ((Z)-1i): yield 75%. Yellowish liquid. ^1H NMR (600 MHz, CDCl_3) δ 13.01 (s, 1 H), 7.96 (d, $J = 8.3$ Hz, 2 H), 7.56 (t, 1 H), 7.47 (t, 2 H), 7.36-7.34 (m, 2 H), 7.05 (t, 2 H), 2.20 (q, 2 H), 2.09 (s, 3 H), 0.85 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 196.1, 194.4, 161.6, 160.0, 159.2, 139.9, 133.1, 129.3 (2C), 128.7 (2 C), 126.4, 126.3, 116.4, 116.3, 116.1, 29.1, 28.2, 14.0. HRMS Calcd for $\text{C}_{19}\text{H}_{18}\text{FNO}_2\text{S}$: ($[\text{M}+\text{H}]^+$) 344.1115; Found: 344.1119.



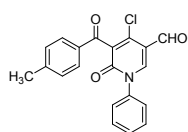
(Z)-2-((benzylamino)(ethylthio)methylene)-1-phenylbutane-1, 3-dione ((Z)-1j): yield 87%. Yellowish crystalline solid. M.p.: 61-62 °C. ^1H NMR (600 MHz, CDCl_3) δ 12.16 (s, 1 H), 7.90 (d, $J = 7.9$ Hz, 2 H), 7.54 (t, 1 H), 7.44 (t, 2 H), 7.37 (t, 2 H), 7.30 (d, $J = 7.2$ Hz, 3 H), 4.77 (d, $J = 5.8$ Hz, 2 H), 2.62 (q, 2 H), 2.09 (s, 3 H), 1.00 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 196.2, 193.8, 162.6, 140.3, 137.3, 132.5, 129.1 (2 C), 128.8 (2 C), 128.4 (2 C), 127.6, 126.9 (2 C), 114.35, 48.9, 30.4, 28.6, 14.2. HRMS Calcd for $\text{C}_{20}\text{H}_{21}\text{NO}_2\text{S}$: ($[\text{M}+\text{H}]^+$) 340.1366; Found: 340.1378.



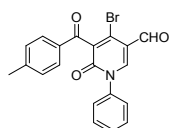
(Z)-2-((o-toluidino)(ethylthio)methylene)-1-phenylbutane-1, 3-dione ((Z)-1k): yield 87%. Yellowish liquid. ^1H NMR (600 MHz, CDCl_3) δ 13.08 (s, 1 H), 7.97 (d, $J = 7.4$ Hz, 2 H), 7.55 (t, 1 H), 7.46 (t, 3 H), 7.22 (d, $J = 7.3$ Hz, 1 H), 7.19-7.13 (m, 2 H), 2.37 (s, 3 H), 2.17 (q, 2 H), 2.11 (s, 3 H), 0.83 (t, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 196.2, 194.1, 160.7, 140.1, 137.6, 132.9, 132.8, 130.9, 129.3 (2 C), 128.6 (2 C), 126.6, 126.5, 125.5, 115.8, 28.9, 28.1, 18.2, 14.0. HRMS Calcd for $\text{C}_{20}\text{H}_{21}\text{NO}_2\text{S}$: ($[\text{M}+\text{H}]^+$) 340.1366; Found: 340.1382.



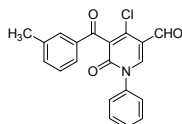
(Z)-4-(4-chlorophenylamino)-4-(ethylthio)but-3-en-2-one 1I: yield 76%. White crystalline solid, M.p.: 68-69 °C. ¹H NMR (600 MHz, CDCl₃) δ 12.93 (s, 1 H), 7.30 (d, *J* = 8.8 Hz, 2 H), 7.19 (d, *J* = 8.6 Hz, 2 H), 5.26 (s, 1 H), 2.84 (q, 2 H), 2.13 (s, 3 H), 1.32 (t, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 193.4, 164.5, 137.1, 131.7, 129.2 (2 C), 126.6 (2 C), 93.1, 29.4, 26.1, 13.4. HRMS Calcd for C₁₂H₁₄ClNOS: ([M+H]⁺) 256.0557; Found: 256.0553.



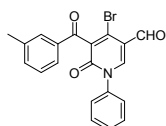
4-chloro-5-(4-methylbenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2a: yield 85%. White solid. M.p.: 160-161 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.14 (s, 1 H), 8.30 (s, 1 H), 7.85 (d, *J* = 8.2 Hz, 2 H), 7.53-7.48 (m, 3 H), 7.40 (d, *J* = 8.5 Hz, 2 H), 7.29 (d, *J* = 8.0 Hz, 2 H), 2.43 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 190.3, 185.6, 158.6, 145.8, 143.8, 143.2, 138.6, 133.1, 130.0, 129.9 (3 C), 129.8 (2 C), 129.7 (2 C), 126.3 (2 C), 114.5, 22.0. HRMS Calcd for C₂₀H₁₄ClNO₃: ([M+H]⁺) 352.0735; Found: 352.0739.



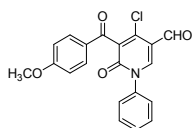
4-bromo-5-(4-methylbenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2b: yield 81%. White solid. M.p.: 173-174 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.10 (s, 1 H), 8.26 (s, 1 H), 7.85 (d, *J* = 8.2 Hz, 2 H), 7.53-7.48 (m, 3 H), 7.40 (d, *J* = 8.5 Hz, 2 H), 7.29 (d, *J* = 8.0 Hz, 2 H), 2.43 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 191.2, 187.5, 158.2, 145.7, 143.3 (2 C), 138.6, 133.0, 132.8, 132.6, 129.8 (2 C), 129.7 (2 C), 129.6 (2 C), 126.1 (2 C), 115.0, 22.0. HRMS Calcd for C₂₀H₁₄BrNO₃: ([M+H]⁺) 396.0230; Found: 396.0218.



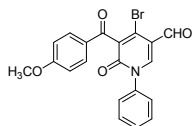
4-chloro-5-(3-methylbenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2c: yield 82%. Yellowish solid. M.p.: 171-172 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.18 (s, 1 H), 8.34 (s, 1H), 7.80 (s, 1 H), 7.55 (d, $J = 7.7$ Hz, 1 H), 7.57-7.52 (m, 3 H), 7.47 (d, $J = 7.4$ Hz, 1 H), 7.45-7.40 (m, 3 H), 2.45 (s, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 190.9, 185.5, 158.5, 143.7, 143.2, 139.0, 138.6, 135.5, 135.4, 129.9, 129.7 (4 C), 128.9, 126.8, 126.2 (2 C), 114.5, 21.4. HRMS Calcd for $\text{C}_{20}\text{H}_{14}\text{ClNO}_3$: $([\text{M}+\text{H}]^+)$ 352.0735; Found: 352.0730.



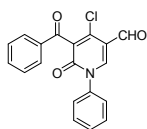
4-bromo-5-(3-methylbenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2d: yield 80%. Yellowish solid. M.p.: 163-164 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.11 (s, 1 H), 8.27 (s, 1H), 7.78 (s, 1 H), 7.74 (d, $J = 7.7$ Hz, 1 H), 7.53-7.49 (m, 3 H), 7.44 (d, $J = 7.5$ Hz, 1 H), 7.42-7.38 (m, 3 H), 2.42 (s, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 191.8, 187.5, 158.2, 143.4, 139.0, 138.6, 135.4, 135.0, 133.1, 132.8, 129.8, 129.7 (3 C), 129.0, 126.9, 126.1 (2 C), 115.1, 21.4. HRMS Calcd for $\text{C}_{20}\text{H}_{14}\text{BrNO}_3$: $([\text{M}+\text{H}]^+)$ 396.0230; Found: 396.0231.



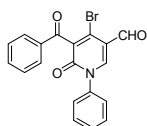
4-chloro-5-(4-methoxybenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2e: yield 85%. Yellowish solid. M.p.: 140-141 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.13 (s, 1 H), 8.29 (s, 1 H), 7.92 (d, $J = 8.8$ Hz, 2 H), 7.53-7.48 (m, 3 H), 7.39 (d, $J = 7.3$ Hz, 2 H), 6.96 (d, $J = 8.8$ Hz, 2 H), 3.87 (s, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 189.3, 185.8, 165.0, 158.8, 143.9, 143.3, 138.9, 132.2 (2 C), 130.3, 130.1, 130.0 (2 C), 128.8, 126.5 (2 C), 114.8, 114.7 (2 C), 56.0. HRMS Calcd for $\text{C}_{20}\text{H}_{14}\text{ClNO}_4$: $([\text{M}+\text{H}]^+)$ 368.0685; Found: 368.0680.



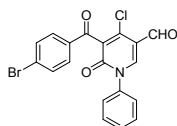
4-bromo-5-(4-methoxybenzoyl)-6-oxo-1-phenyl-1, 6-dihydropyridine-3-carbaldehyde 2f: yield 83%. Yellowish solid. M.p.: 96-97 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.10 (s, 1 H), 8.26 (s, 1 H), 7.92 (d, *J* = 8.8 Hz, 2 H), 7.53-7.48 (m, 3 H), 7.39 (d, *J* = 7.4 Hz, 2 H), 6.96 (d, *J* = 8.8 Hz, 2 H), 3.88 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 190.0, 187.5, 164.7, 158.2, 143.3, 138.6, 133.0, 132.8, 132.0 (2 C), 129.8, 129.7 (2 C), 128.1, 126.1 (2 C), 115.0, 114.8 (2 C), 55.6. HRMS Calcd for C₂₀H₁₄BrNO₄: ([M+H]⁺) 412.0180; Found: 412.0182.



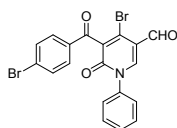
5-benzoyl-4-chloro-6-oxo-1-phenyl-1, 6-dihydropyridine-3-carbaldehyde 2g: yield 84%. Yellowish solid. M.p.: 138-139 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.14 (s, 1 H), 8.31 (s, 1 H), 7.95 (d, *J* = 7.5 Hz, 2 H), 7.63 (t, 1 H), 7.52-7.49 (m, 5 H), 7.39 (d, *J* = 7.3 Hz, 2 H). ¹³C NMR (150 MHz, CDCl₃) δ 190.7, 185.4, 158.5, 143.8, 143.3, 138.5, 135.4, 134.5, 129.9, 129.8 (2 C), 129.7, 129.4 (2 C), 129.1 (2 C), 126.2 (2 C), 114.5. HRMS Calcd for C₁₉H₁₂ClNO₃: ([M+H]⁺) 338.0579; Found: 338.0582.



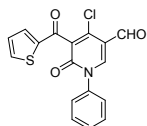
5-benzoyl-4-bromo-6-oxo-1-phenyl-1, 6-dihydropyridine-3-carbaldehyde 2h: yield 84%. Yellowish solid. M.p.: 148-149 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.10 (s, 1 H), 8.27 (s, 1 H), 7.96 (d, *J* = 7.4 Hz, 2 H), 7.63 (t, 1 H), 7.53-7.49 (m, 5 H), 7.39 (d, *J* = 7.4 Hz, 2 H). ¹³C NMR (150 MHz, CDCl₃) δ 191.6, 187.4, 158.2, 143.5, 138.5, 135.0, 134.5, 133.2, 132.6, 129.9, 129.7 (2 C), 129.5 (2 C), 129.1 (2 C), 126.1 (2 C), 115.0. HRMS Calcd for C₁₉H₁₂BrNO₃: ([M+H]⁺) 382.0074; Found: 382.0081.



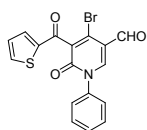
5-(4-bromobenzoyl)-4-chloro-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2i: yield 79%. Yellowish solid. M.p.: 106-107 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.13 (s, 1 H), 8.31 (s, 1 H), 7.80 (d, *J* = 8.5 Hz, 2 H), 7.64 (d, *J* = 8.5 Hz, 2 H), 7.53-7.49 (m, 3 H), 7.39 (d, *J* = 8.5 Hz, 2 H). ¹³C NMR (150 MHz, CDCl₃) δ 189.5, 185.0, 158.2, 143.8, 143.4, 138.2, 134.0, 132.2 (2 C), 130.6 (2 C), 129.8, 129.7 (2 C), 129.5, 128.8, 125.9 (2 C), 114.2. HRMS Calcd for C₁₉H₁₁BrClNO₃: ([M+H]⁺) 415.9684; Found: 415.9681.



4-bromo-5-(4-bromobenzoyl)-6-oxo-1-phenyl-1,6-dihydropyridine-3-carbaldehyde 2j: yield 77%. Yellowish solid. M.p.: 92-93 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.10 (s, 1 H), 8.28 (s, 1 H), 7.81 (d, *J* = 8.5 Hz, 2 H), 7.65 (d, *J* = 8.5 Hz, 2 H), 7.53-7.50 (m, 3 H), 7.39 (d, *J* = 8.3 Hz, 2 H). ¹³C NMR (150 MHz, CDCl₃) δ 190.7, 187.2, 158.2, 143.7, 138.6, 133.8, 133.5, 132.5 (2 C), 130.8 (2 C), 130.0, 129.9, 129.8 (2 C), 126.1 (2 C), 115.1. HRMS Calcd for C₁₉H₁₁Br₂NO₃: ([M+H]⁺) 459.9179; Found: 459.9185.

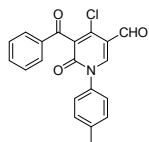


4-chloro-6-oxo-1-phenyl-5-(thiophene-2-carbonyl)-1,6-dihydropyridine-3-carbaldehyde 2k: yield 80%. White solid. M.p.: 115-117 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.15 (s, 1 H), 8.31 (s, 1 H), 7.78 (d, *J* = 4.9 Hz, 1 H), 7.69 (d, *J* = 3.8 Hz, 1 H), 7.54-7.50 (m, 3 H), 7.40 (d, *J* = 8.4 Hz, 2 H), 7.16 (d, *J* = 8.7 Hz, 1 H). ¹³C NMR (150 MHz, CDCl₃) δ 185.4, 182.3, 158.4, 144.0, 143.6, 142.5, 138.5, 136.1, 135.0, 129.9, 129.7 (2 C), 129.5, 128.6, 126.2 (2 C), 114.4. HRMS Calcd for C₁₇H₁₀ClNO₃S: ([M+H]⁺) 344.0143; Found: 344.0143.

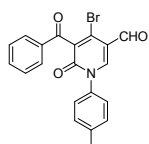


4-bromo-6-oxo-1-phenyl-5-(thiophene-2-carbonyl)-1,6-dihydropyridine-3-carbaldehyde 2l:

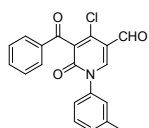
dehyde 2l: yield 79%. White solid. M.p.: 136-137 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.13 (s, 1 H), 8.30 (s, 1 H), 7.80 (d, *J* = 4.8 Hz, 1 H), 7.69 (d, *J* = 3.8 Hz, 1 H), 7.56-7.53 (m, 3 H), 7.44 (d, *J* = 8.3 Hz, 2 H), 7.18 (d, *J* = 8.7 Hz, 1 H). ¹³C NMR (150 MHz, CDCl₃) δ 187.4, 183.4, 158.1, 143.6, 142.1, 138.5, 136.1, 135.0, 133.5, 132.4, 129.9, 129.7 (2 C), 128.6, 126.1 (2 C), 115.0. HRMS Calcd for C₁₇H₁₀BrNO₃S: ([M+H]⁺) 387.9638; Found: 387.9640.



5-benzoyl-4-chloro-6-oxo-1-p-tolyl-1,6-dihydropyridine-3-carbaldehyde 2m: yield 85%. White solid. M.p.: 72-73 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.14 (s, 1 H), 8.30 (s, 1 H), 7.94 (d, *J* = 7.2 Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.30 (d, *J* = 8.4 Hz, 2 H), 7.27 (d, *J* = 8.4 Hz, 2 H), 2.41 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 190.7, 185.5, 158.6, 143.9, 143.2, 140.1, 136.0, 135.4, 134.5, 130.2 (2 C), 129.4 (2 C), 129.0 (2 C), 125.8 (2C), 114.3, 21.2. HRMS Calcd for C₂₀H₁₄ClNO₃: ([M+H]⁺) 352.0735; Found: 352.0736.

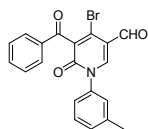


5-benzoyl-4-bromo-6-oxo-1-p-tolyl-1,6-dihydropyridine-3-carbaldehyde 2n: yield 81%. White solid. M.p.: 87-88 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.12 (s, 1 H), 8.29 (s, 1 H), 7.98 (d, *J* = 7.8 Hz, 2 H), 7.65 (t, 1 H), 7.52 (t, 2 H), 7.34-7.29 (m, 4 H), 2.44 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 191.6, 187.4, 158.2, 143.5, 140.1, 135.9, 134.9, 134.4, 133.0, 132.3, 130.2 (2 C), 129.4 (2 C), 129.0 (2 C), 125.7 (2C), 114.9, 21.7. HRMS Calcd for C₂₀H₁₄BrNO₃: ([M+H]⁺) 396.0230; Found: 396.0240.

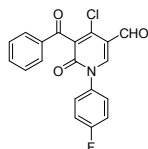


5-benzoyl-4-chloro-6-oxo-1-m-tolyl-1,6-dihydropyridine-3-carbaldehyde 2o: yield 82%. White solid. M.p.: 124-125 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.14 (s, 1 H), 8.30 (s, 1 H), 7.94 (d, *J* = 8.4 Hz, 2 H), 7.62 (t, 1 H), 7.50 (t, 2 H), 7.39 (t, 1 H), 7.28

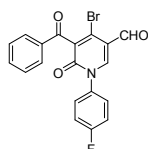
(d, $J = 7.7$ Hz, 1 H), 7.19 (t, 2 H), 2.41 (s, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 190.7, 185.5, 158.6, 143.9, 143.3, 140.0, 138.4, 135.4, 134.5, 130.6, 129.6, 129.5, 129.4 (2 C), 129.1 (2 C), 126.7, 123.1, 114.3, 21.3. HRMS Calcd for $\text{C}_{20}\text{H}_{14}\text{ClNO}_3$: ($[\text{M}+\text{H}]^+$) 352.0735; Found: 352.0737.



5-benzoyl-4-bromo-6-oxo-1-m-tolyl-1,6-dihydropyridine-3-carbaldehyde 2p: yield 83%. White solid. M.p.: 138-139 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.10 (s, 1 H), 8.26 (s, 1 H), 7.97 (d, $J = 8.1$ Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.40 (t, 1 H), 7.28 (d, $J = 7.6$ Hz, 1 H), 7.20 (t, 2 H), 2.41 (s, 3 H). ^{13}C NMR (150 MHz, CDCl_3) δ 191.6, 187.4, 158.3, 143.5, 140.0, 138.4, 135.0, 134.4, 133.1, 132.5, 130.6, 129.5, 129.4 (2 C), 129.0 (2 C), 126.2, 123.1, 114.9, 21.3. HRMS Calcd for $\text{C}_{20}\text{H}_{14}\text{BrNO}_3$: ($[\text{M}+\text{H}]^+$) 396.0230; Found: 396.0231.

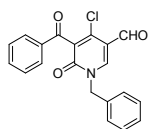


5-benzoyl-4-chloro-1-(4-fluorophenyl)-6-oxo-1,6-dihydropyridine-3-carbaldehyde 2q: yield 79%. White solid. M.p.: 148-149 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.14 (s, 1 H), 8.27 (s, 1 H), 7.94 (d, $J = 8.0$ Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.41-7.38 (m, 2 H), 7.20 (t, 2 H). ^{13}C NMR (150 MHz, CDCl_3) δ 190.5, 185.4, 163.8, 162.1, 158.5, 143.6, 143.4, 135.3, 134.6, 134.4, 129.4, 129.1 (2 C), 128.2 (2 C), 128.1, 116.9, 116.7, 114.6. HRMS Calcd for $\text{C}_{19}\text{H}_{11}\text{ClFNO}_3$: ($[\text{M}+\text{H}]^+$) 356.0485; Found: 356.0484.

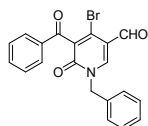


5-benzoyl-4-bromo-1-(4-fluorophenyl)-6-oxo-1,6-dihydropyridine-3-carbaldehyde 2r: yield 78%. White solid. M.p.: 128-129 °C. ^1H NMR (600 MHz, CDCl_3) δ 10.10 (s, 1 H), 8.23 (s, 1 H), 7.95 (d, $J = 8.0$ Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.42-7.38 (m, 2 H), 7.20 (t, 2 H). ^{13}C NMR (150 MHz, CDCl_3) δ 191.4, 187.3, 164.2, 161.2, 158.2, 143.2, 134.9, 134.5, 133.3, 132.8, 129.5 (2 C), 129.1 (2 C), 128.2, 128.1,

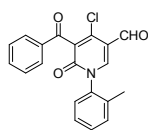
116.9, 116.7, 115.2. HRMS Cacl'd for $C_{19}H_{11}BrFNO_3$: $([M+H]^+)$ 399.9979; Found: 399.9981.



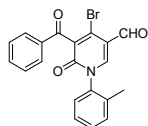
5-benzoyl-1-benzyl-4-chloro-6-oxo-1,6-dihydropyridine-3-carbaldehyde 2s: yield 85%. White solid. M.p.: 129-130 °C. 1H NMR (600 MHz, $CDCl_3$) δ 10.05 (s, 1 H), 8.23 (s, 1 H), 7.90 (d, $J = 8.0$ Hz, 2 H), 7.63 (t, 1 H), 7.49 (t, 2 H), 7.39-7.37 (m, 3 H), 7.36-7.34 (m, 2 H), 5.18 (s, 2 H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 190.7, 185.3, 159.0, 143.1, 143.0, 135.4, 134.5, 134.1, 129.4 (4 C), 129.2, 129.1 (2 C), 129.0, 128.9 (2 C), 114.5, 53.2. HRMS Cacl'd for $C_{20}H_{14}ClNO_3$: $([M+H]^+)$ 352.0735; Found: 352.0742.



5-benzoyl-1-benzyl-4-bromo-6-oxo-1,6-dihydropyridine-3-carbaldehyde 2t: yield 85%. White solid. M.p.: 137-138 °C. 1H NMR (600 MHz, $CDCl_3$) δ 10.00 (s, 1 H), 8.20 (s, 1 H), 7.90 (d, $J = 7.3$ Hz, 2 H), 7.63 (t, 1 H), 7.49 (t, 2 H), 7.39-7.35 (m, 5 H), 5.16 (s, 2 H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 191.7, 187.3, 158.7, 142.7, 135.0, 134.5, 134.1, 132.9, 131.8, 129.5 (2 C), 129.4 (2 C), 129.2, 129.1 (2 C), 128.8 (2 C), 115.1, 53.3. HRMS Cacl'd for $C_{20}H_{14}BrNO_3$: $([M+H]^+)$ 396.0230; Found: 396.0237.

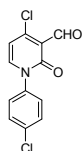


5-benzoyl-4-chloro-6-oxo-1-o-tolyl-1,6-dihydropyridine-3-carbaldehyde 2u: yield 77%. White solid. M.p.: 66-67 °C. 1H NMR (600 MHz, $CDCl_3$) δ 10.14 (s, 1 H), 8.19 (s, 1 H), 7.93 (d, $J = 8.3$ Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.39 (t, 1 H), 7.35 (d, $J = 7.5$ Hz, 2 H), 7.20 (d, $J = 7.9$ Hz, 1 H), 2.19 (s, 3 H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 190.5, 185.4, 158.2, 144.1, 143.5, 137.9, 135.5, 134.7, 134.5, 131.5, 130.3, 129.7, 129.3 (2 C), 129.1 (2 C), 127.6, 126.8, 114.4, 17.7. HRMS Cacl'd for $C_{20}H_{14}ClNO_3$: $([M+H]^+)$ 352.0735; Found: 352.0741.



5-benzoyl-4-bromo-6-oxo-1-(o-tolyl)-1,6-dihydropyridine-3-carbaldehyde 2v:

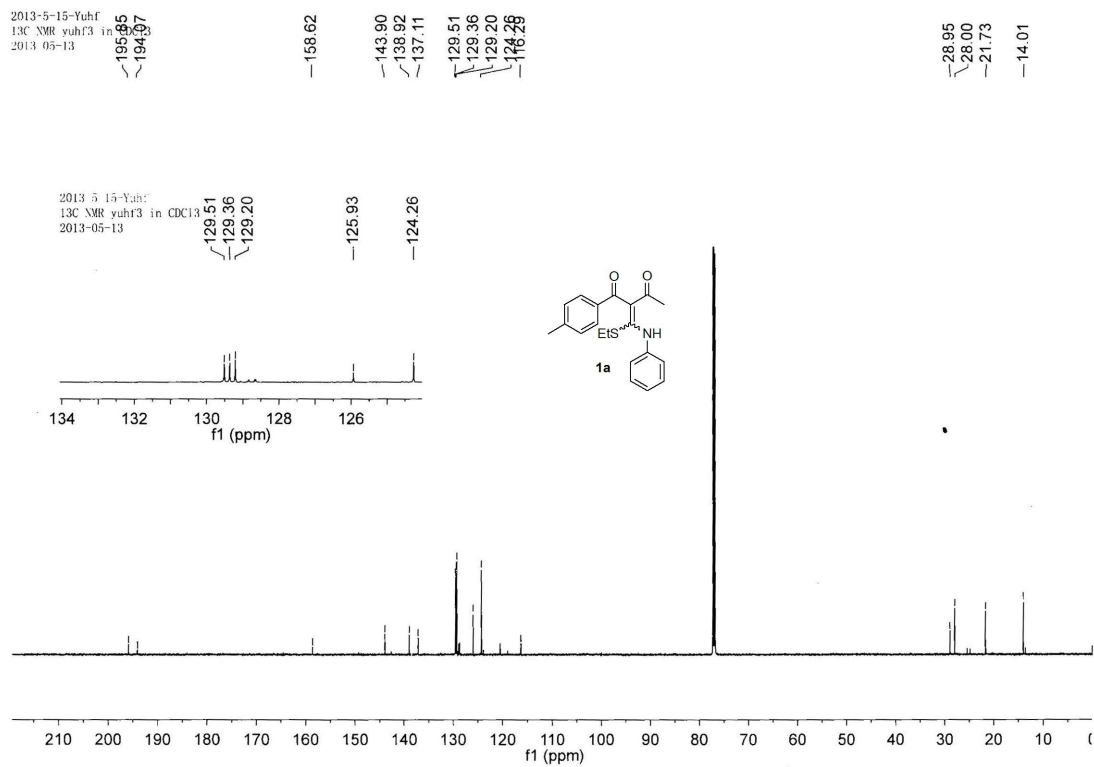
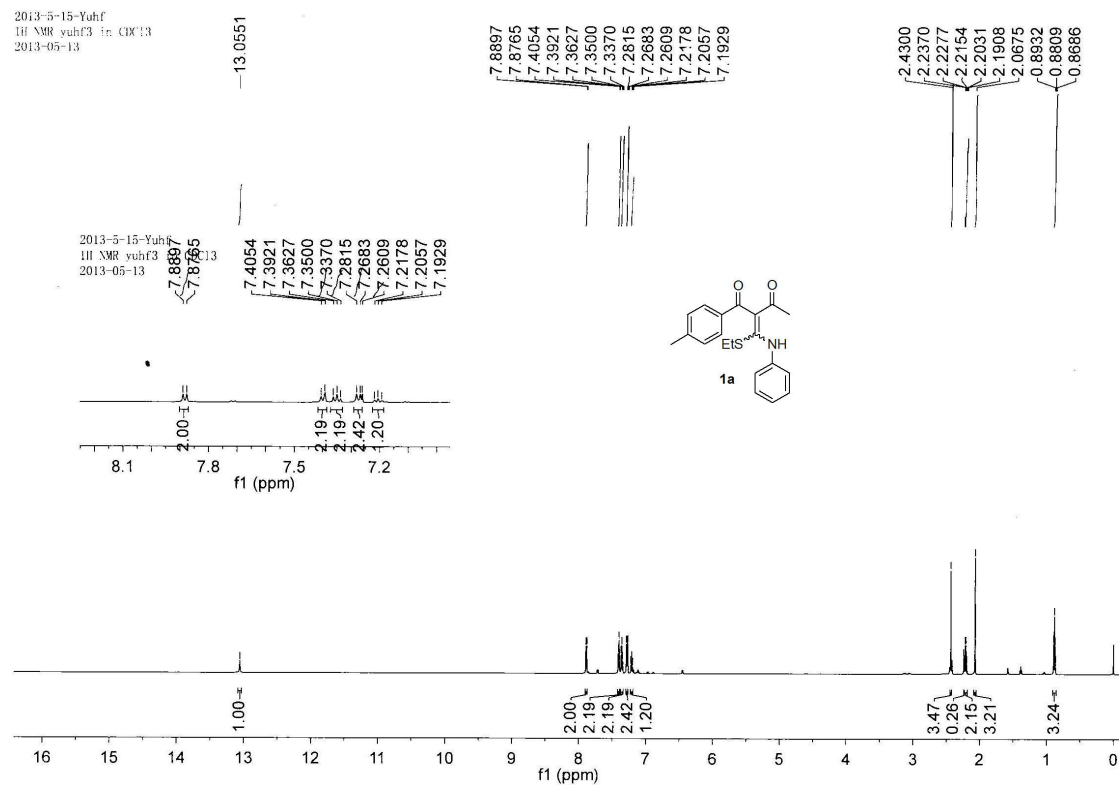
White solid. M.p.: 73-75 °C. ¹H NMR (600 MHz, CDCl₃) δ 10.10 (s, 1 H), 8.16 (s, 1 H), 7.93 (d, *J* = 8.3 Hz, 2 H), 7.63 (t, 1 H), 7.50 (t, 2 H), 7.39 (t, 1 H), 7.35 (d, *J* = 7.5 Hz, 2 H), 7.20 (d, *J* = 7.8 Hz, 1 H), 2.19 (s, 3 H). ¹³C NMR (150 MHz, CDCl₃) δ 191.5, 187.4, 158.8, 143.8, 137.9, 135.1, 134.7, 134.4, 133.3, 132.5, 131.5, 130.3, 129.4 (2 C), 129.1 (2 C), 127.6, 126.8, 115.0, 17.7. HRMS Calcd for C₂₀H₁₄BrNO₃: ([M+H]⁺) 396.0230; Found: 396.0235.



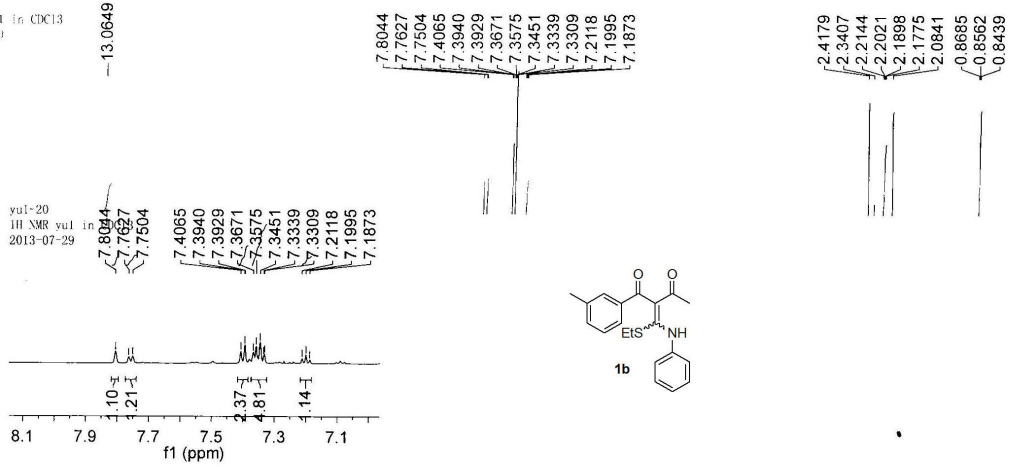
4-chloro-1-(4-chlorophenyl)-2-oxo-1,2-dihydropyridine-3-carbaldehyde 2w:

yellowish solid. M.p.: 166-167 °C. ¹H NMR (600 MHz, CDCl₃) δ: 10.27 (s, 1 H), 7.59 (d, *J* = 7.1 Hz, 1 H), 7.53 (d, *J* = 8.5 Hz, 2 H), 7.27 (d, *J* = 8.4 Hz, 2 H), 6.76 (d, *J* = 7.1 Hz, 1 H). ¹³C NMR (150 MHz, CDCl₃) δ 187.4, 181.9, 144.4, 141.9, 140.7, 136.3, 135.9, 130.2 (2 C), 128.1 (2 C), 115.2. HRMS Calcd for C₁₂H₇Cl₂NO₂: ([M+H]⁺) 267.9927; Found: 267.9928.

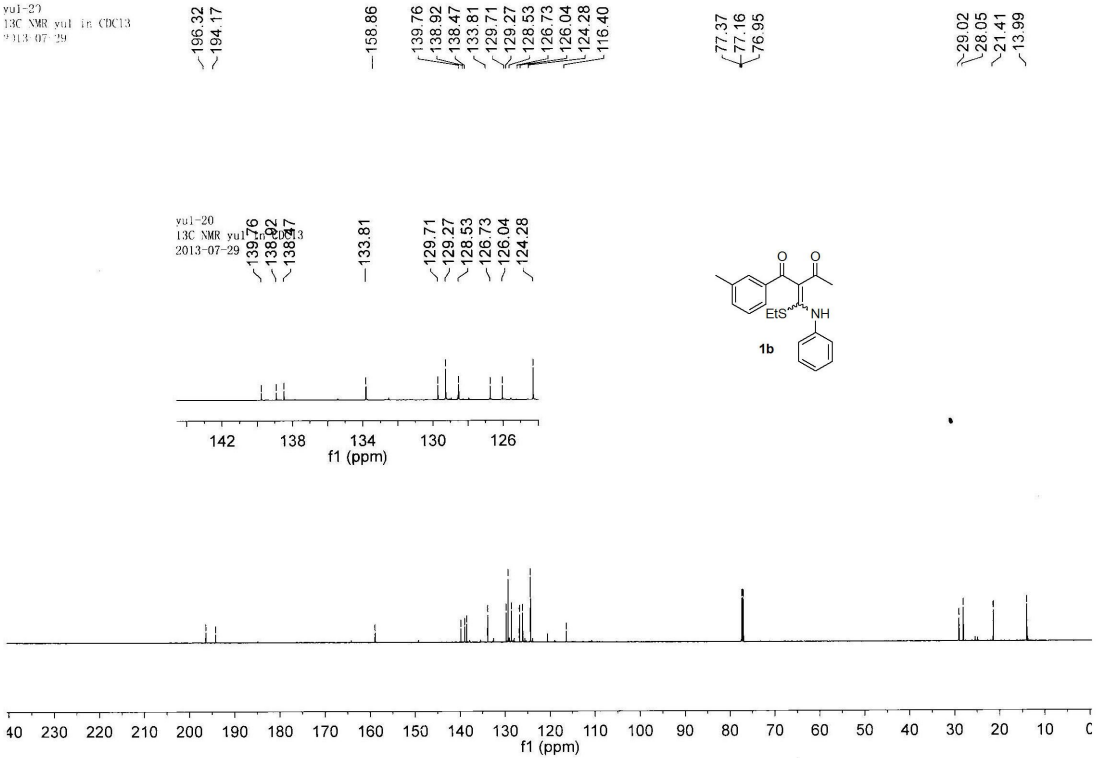
4. Copies of NMR spectra for new compounds



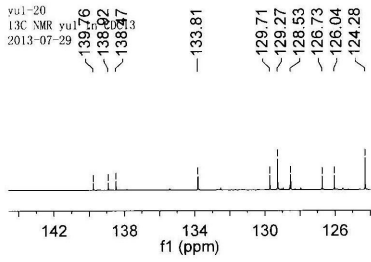
yu1-20
 1H NMR v.1 in CDCl3
 2013-07-29



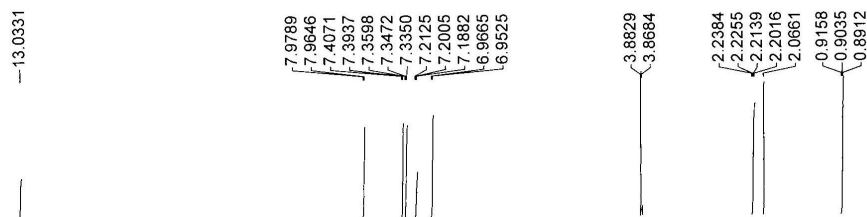
yu1-20
 13C NMR v.1 in CDCl3
 2013-07-29



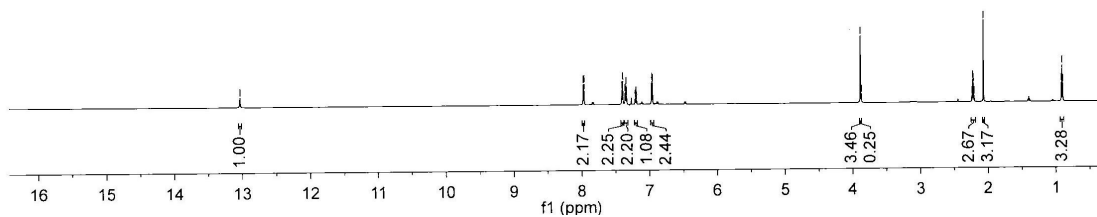
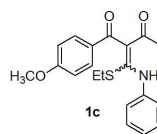
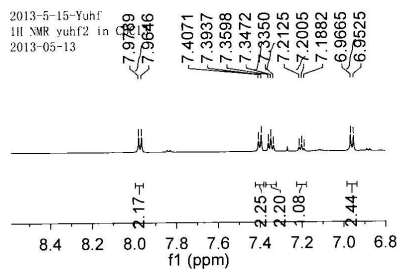
yu1-20
 13C NMR v.1 in CDCl3
 2013-07-29



2013-5-15-Yuhf
 1H NMR yuhf2 in CDCl3
 2013-05-13



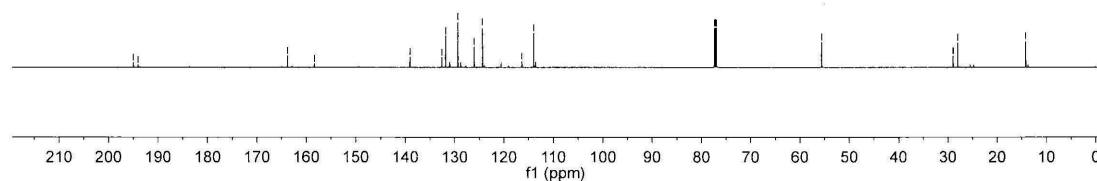
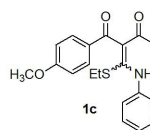
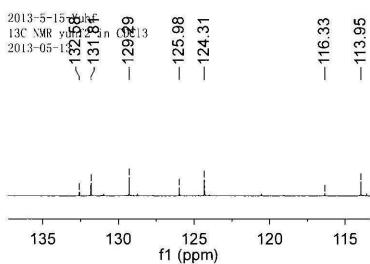
2013-5-15-Yuhf
 1H NMR yuhf2 in
 2013-05-13



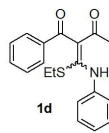
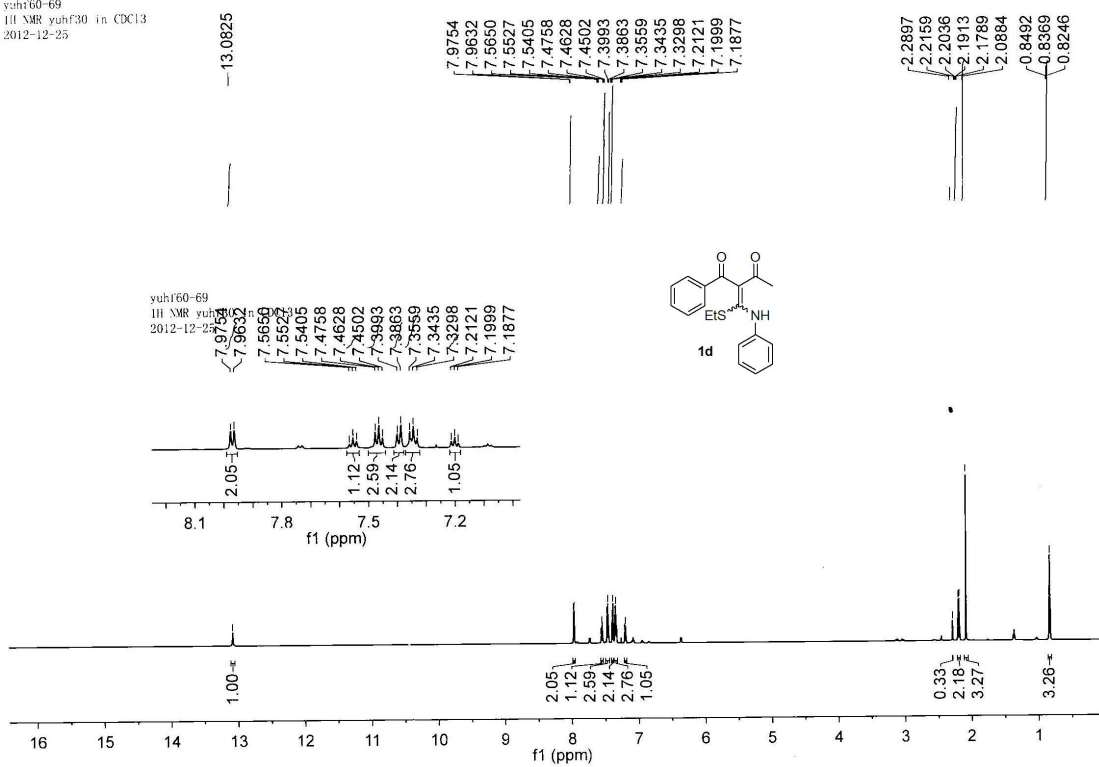
2013-5-15-Yuhf
 13C NMR yuhf2 in
 2013-05-13



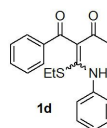
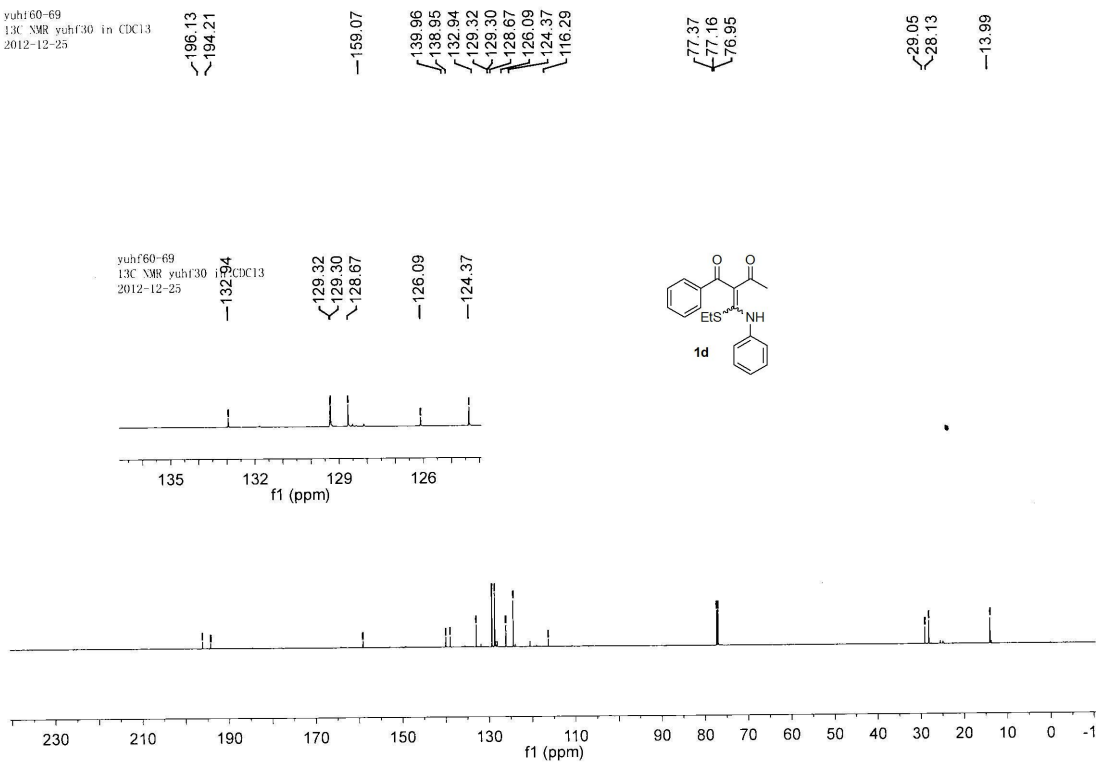
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 13C NMR yuhf2 in
 2013-05-13



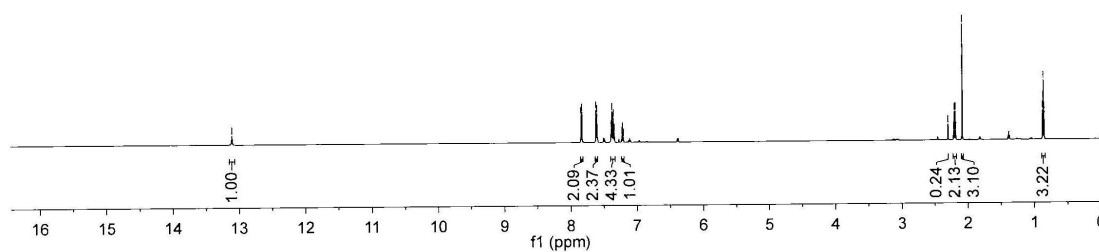
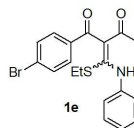
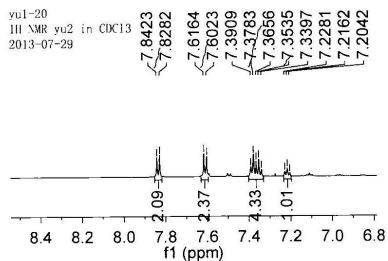
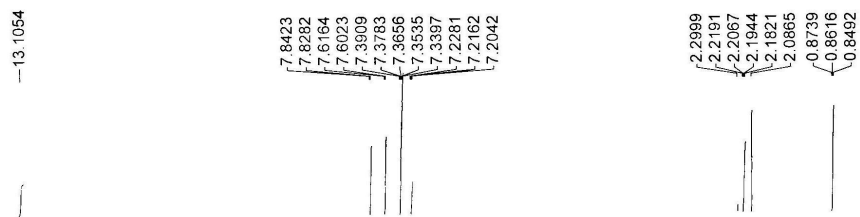
yuhf60-69
 1H NMR yuhf30 in CDCl3
 2012-12-25



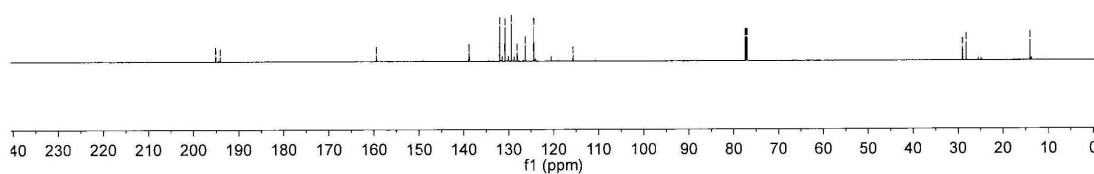
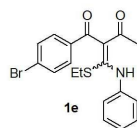
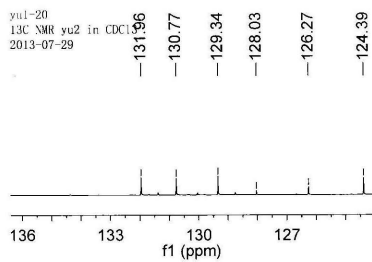
yuhf60-69
 13C NMR yuhf30 in CDCl3
 2012-12-25



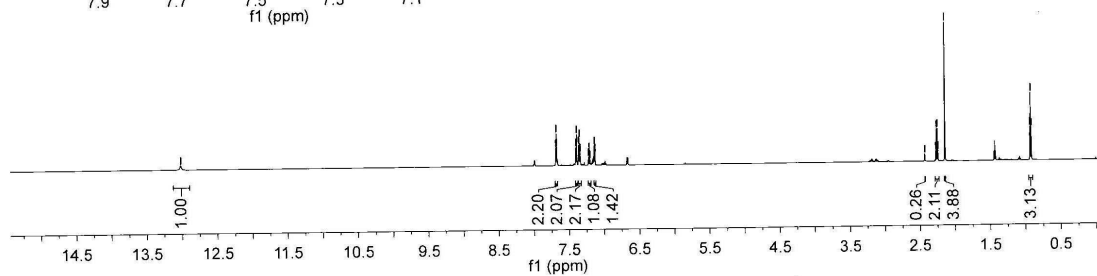
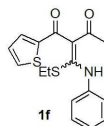
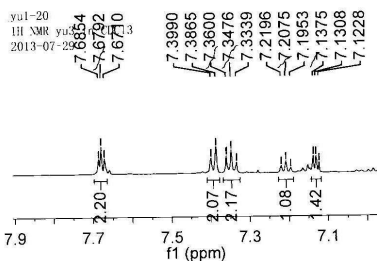
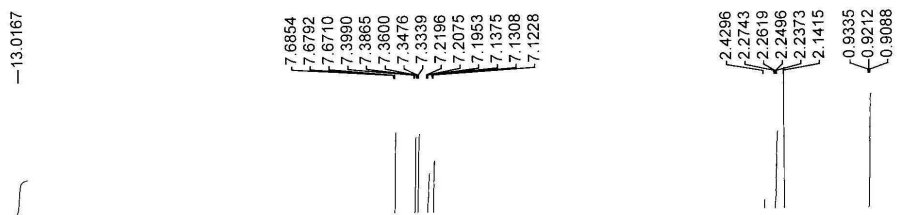
yu1-20
 1H NMR v.2 in CDCl3
 2013-07-29



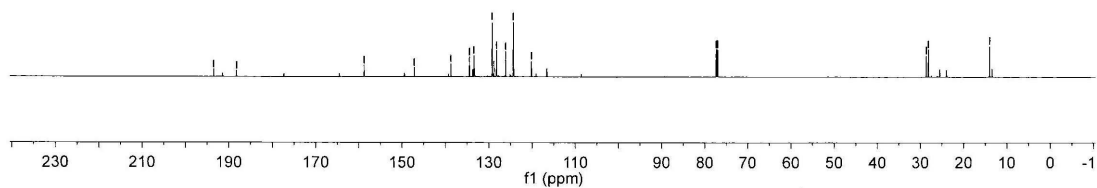
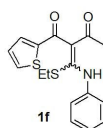
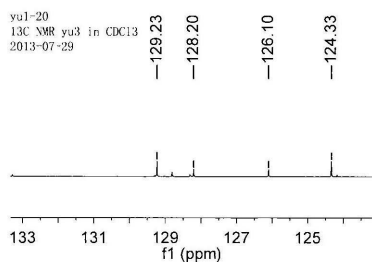
yu1-20
 13C NMR v.2 in CDCl3
 2013-07-29



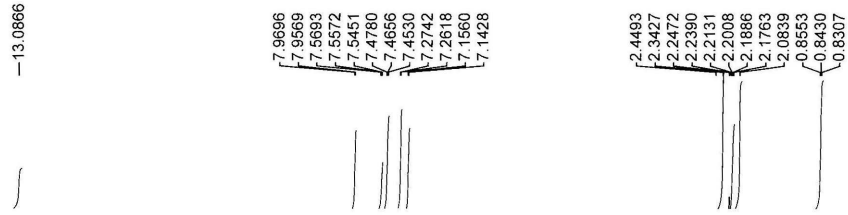
yu1-20
 1H NMR yu3 in CDCl3
 2013-07-29



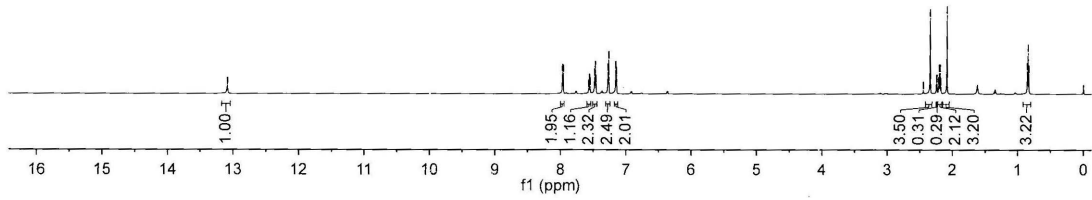
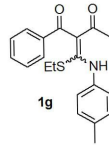
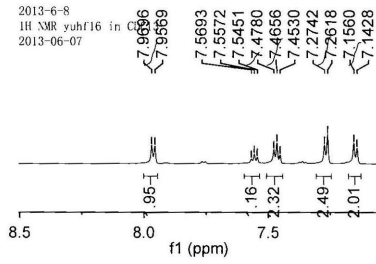
yu1-20
 13C NMR yu3 in CDCl3
 2013-07-29



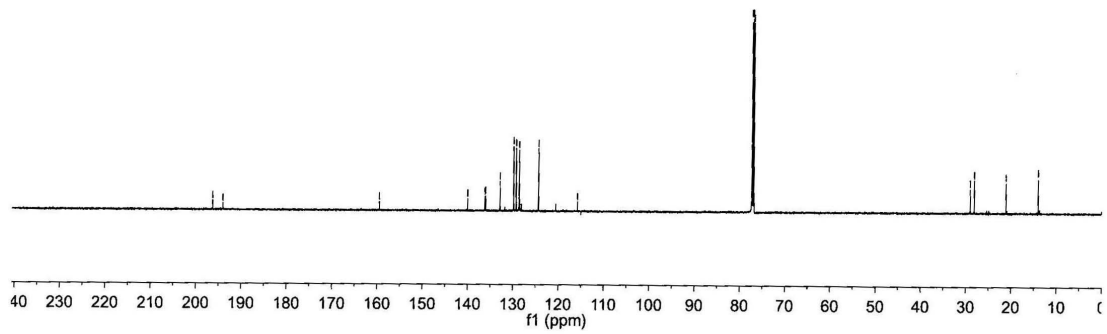
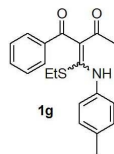
2013-6-8
 1H NMR yuhf16 in CDCl3
 2013-06-07



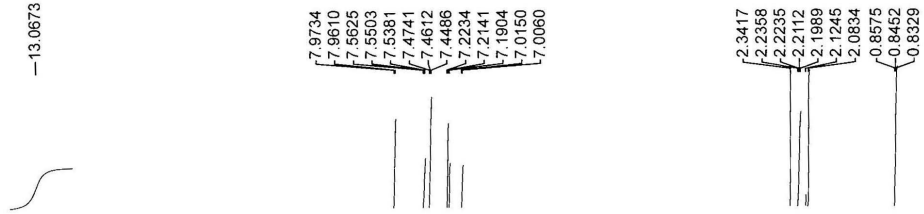
2013-6-8
 1H NMR yuhf16 in CDCl3
 2013-06-07



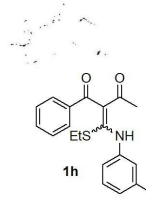
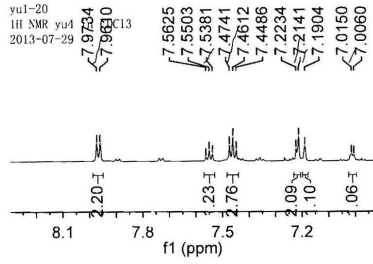
2013-6-8
 13C NMR yuhf16 in CDCl3
 2013-06-07



yu1-20
1H NMR yu4 in CDCl3
2013-07-29



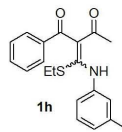
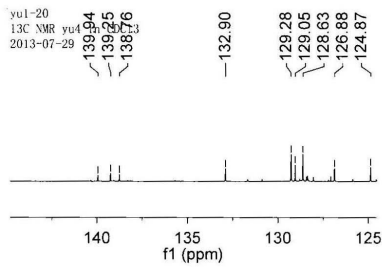
yu1-20
1H NMR yu4
2013-07-29



yu1-20
13C NMR yu4 in CDCl3
2013-07-29

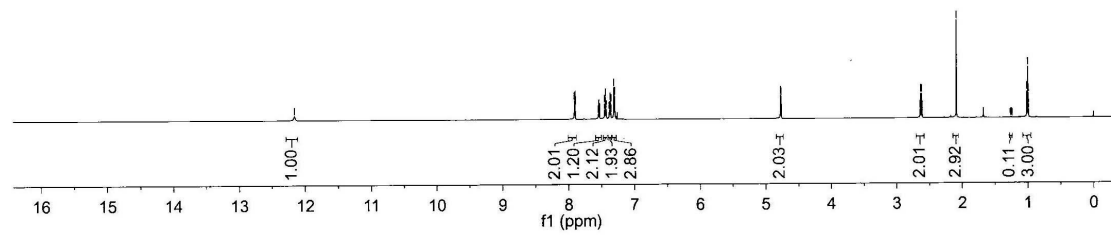
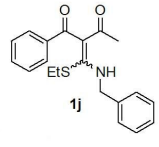
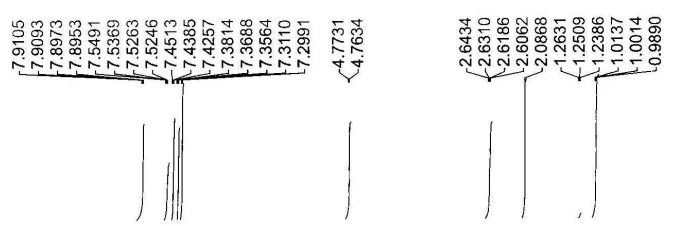
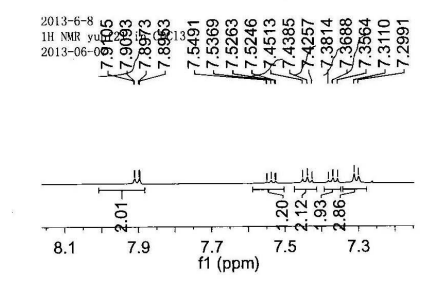


yu1-20
13C NMR yu4
2013-07-29

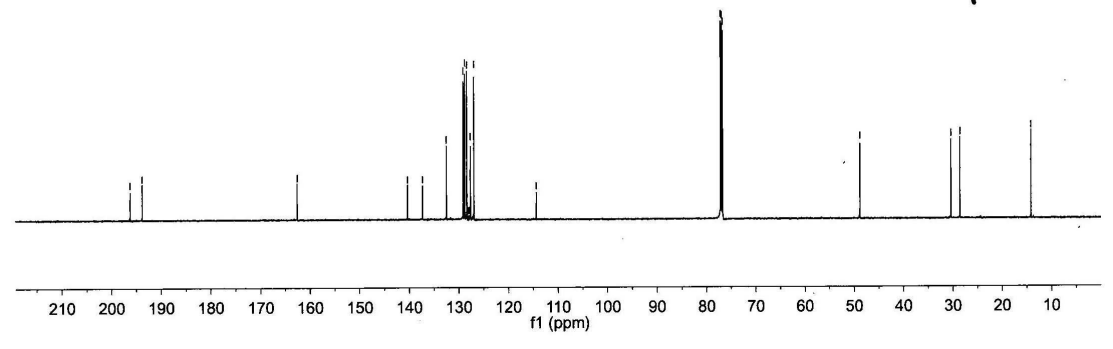
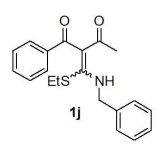
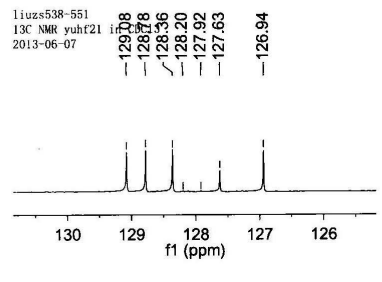


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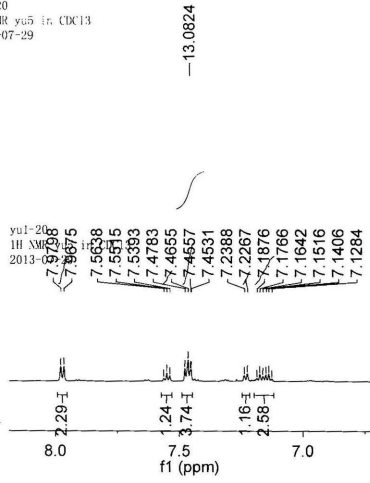
2013-6-8
 1H NMR yuhf21 f1 CUC13
 2013-06-07



liuzs538-551
 13C NMR yuhf21 f1
 2013-06-07

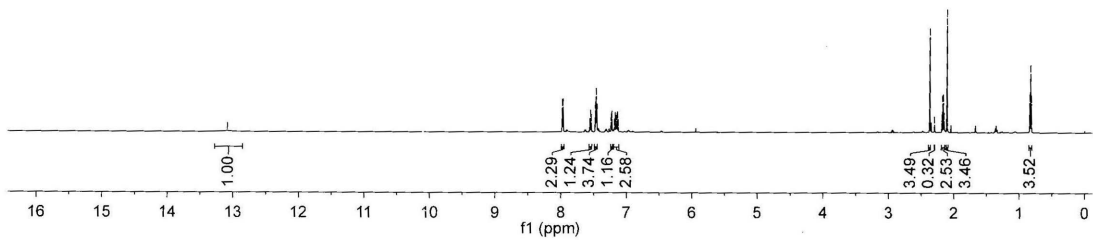
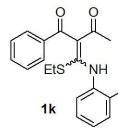


yu1-20
 1H NMR yu5 in CDCl3
 2013-07-29



7.9798
 7.9675
 7.5638
 7.5515
 7.5393
 7.4783
 7.4655
 7.4557
 7.4531
 7.2388
 7.2267
 7.1876
 7.1766
 7.1642
 7.1516
 7.1406
 7.1284

2.3707
 2.2988
 2.1864
 2.1740
 2.1617
 2.1494
 2.1079
 0.8395
 0.8272
 0.8148

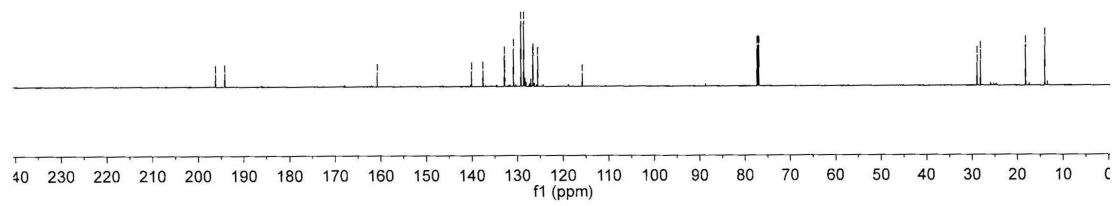
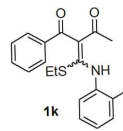
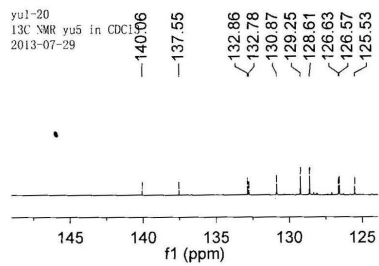


yu1-20
 13C NMR yu5 in CDCl3
 2013-07-29

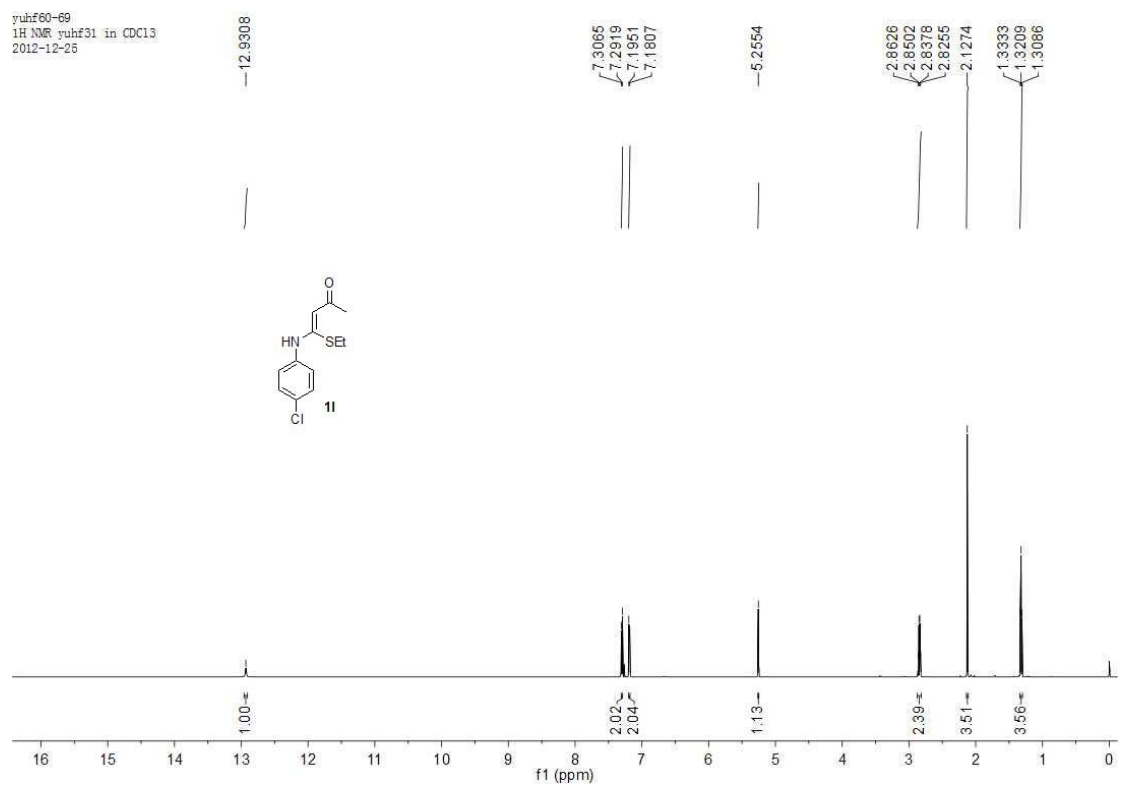
196.15
 194.13
 160.73
 137.55
 132.86
 132.78
 130.87
 129.25
 128.61
 126.63
 126.57
 125.53

77.37
 77.16
 76.95

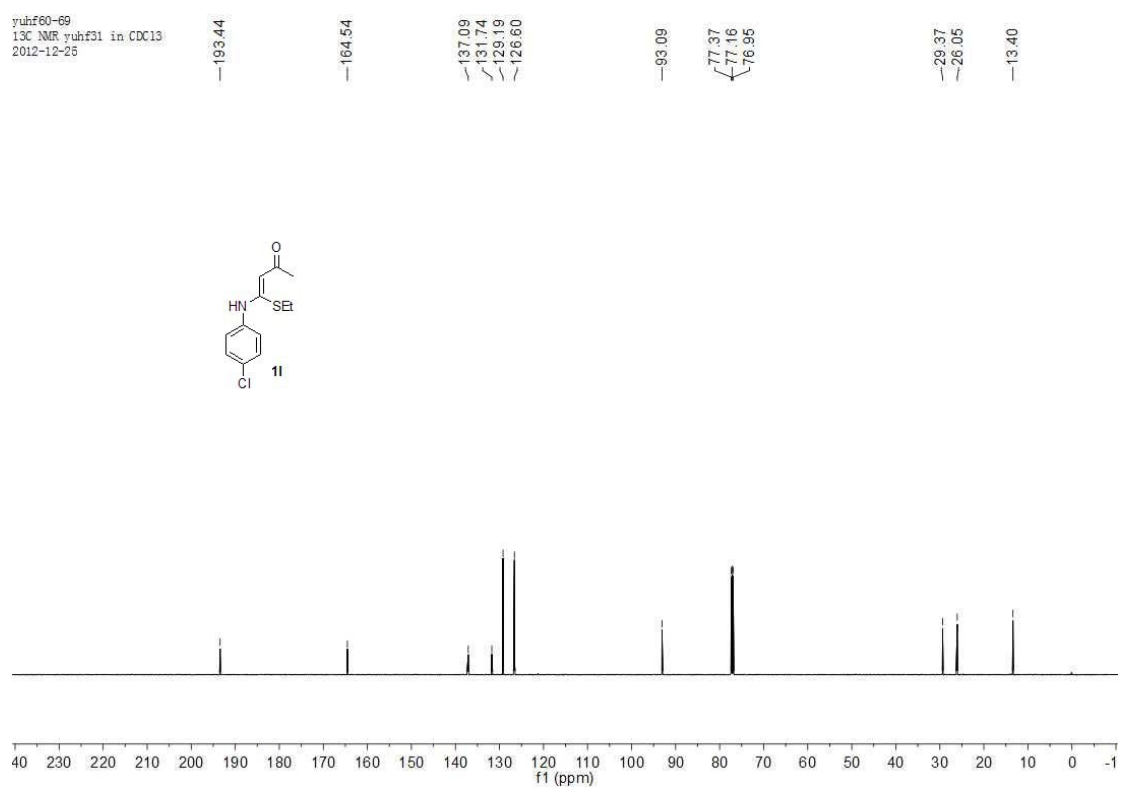
28.89
 28.14
 18.22
 14.01



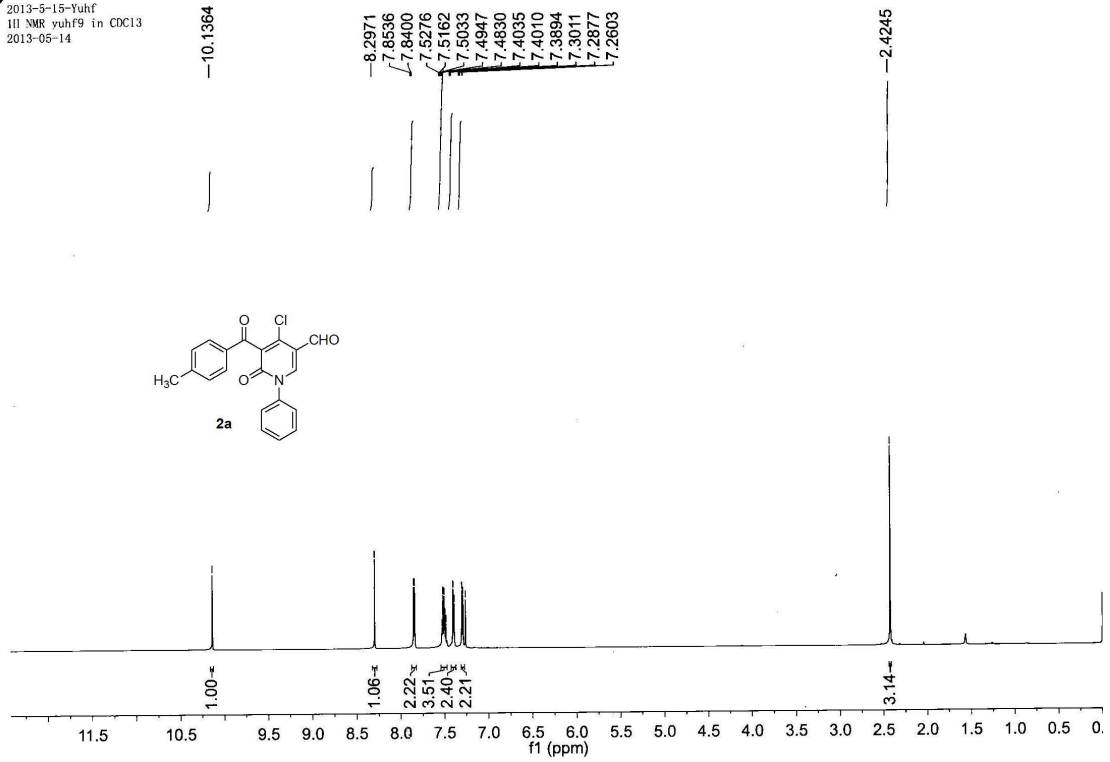
yuhf60-69
 1H NMR yuhf31 in CDCl3
 2012-12-26



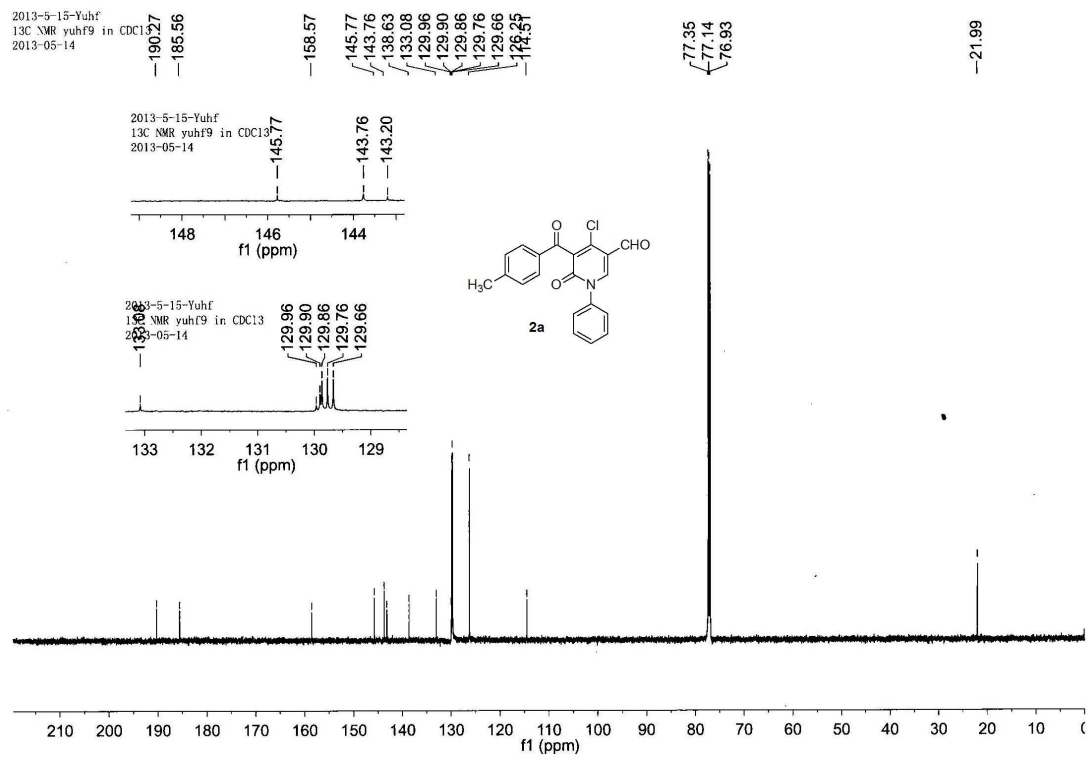
yuhf60-69
 13C NMR yuhf31 in CDCl3
 2012-12-26



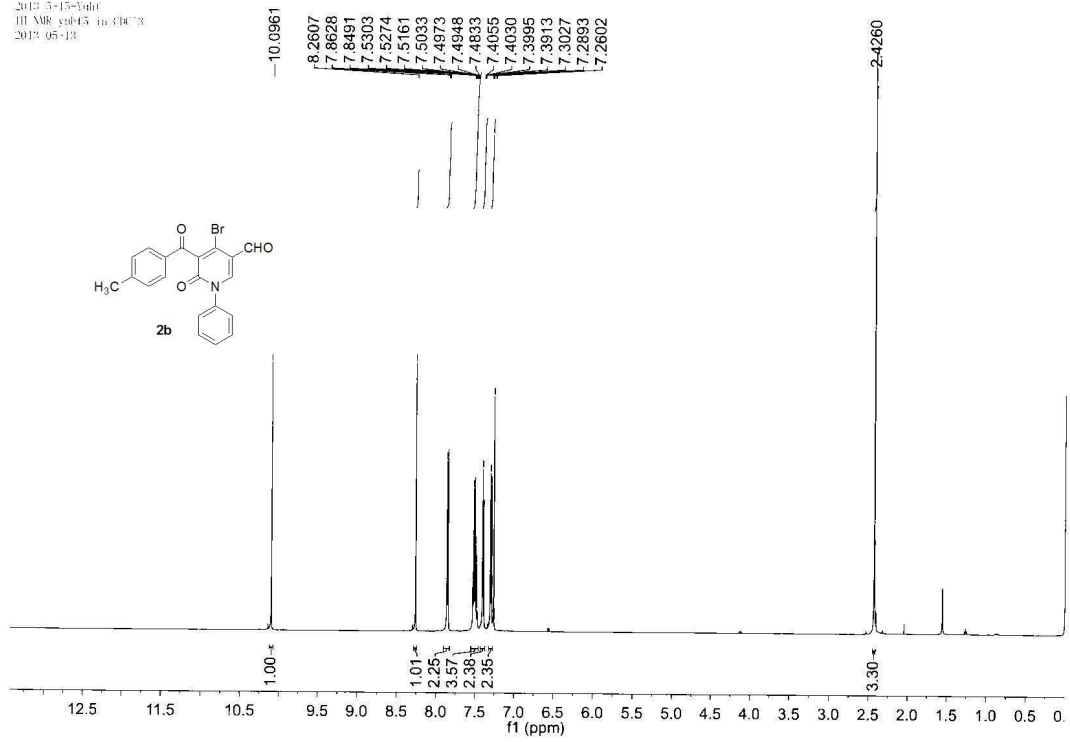
2013-5-15-Yuhf
 1H NMR yuhf9 in CDCl3
 2013-05-14



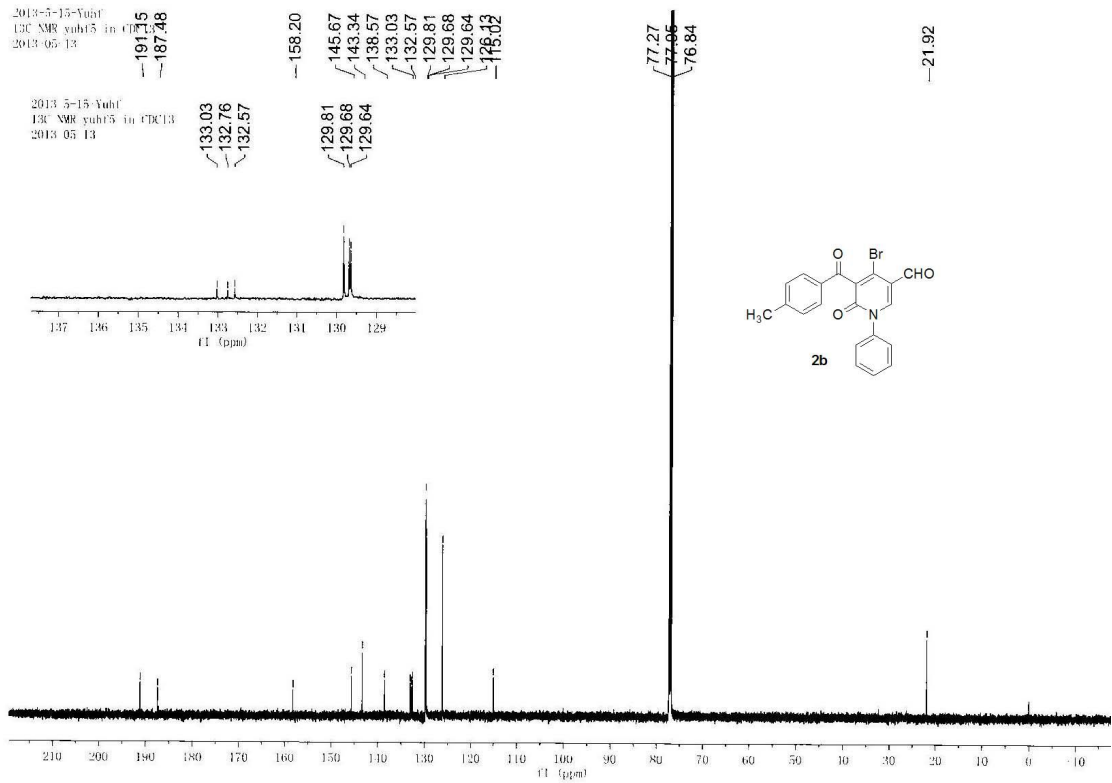
2013-5-15-Yuhf
 13C NMR yuhf9 in CDCl3
 2013-05-14



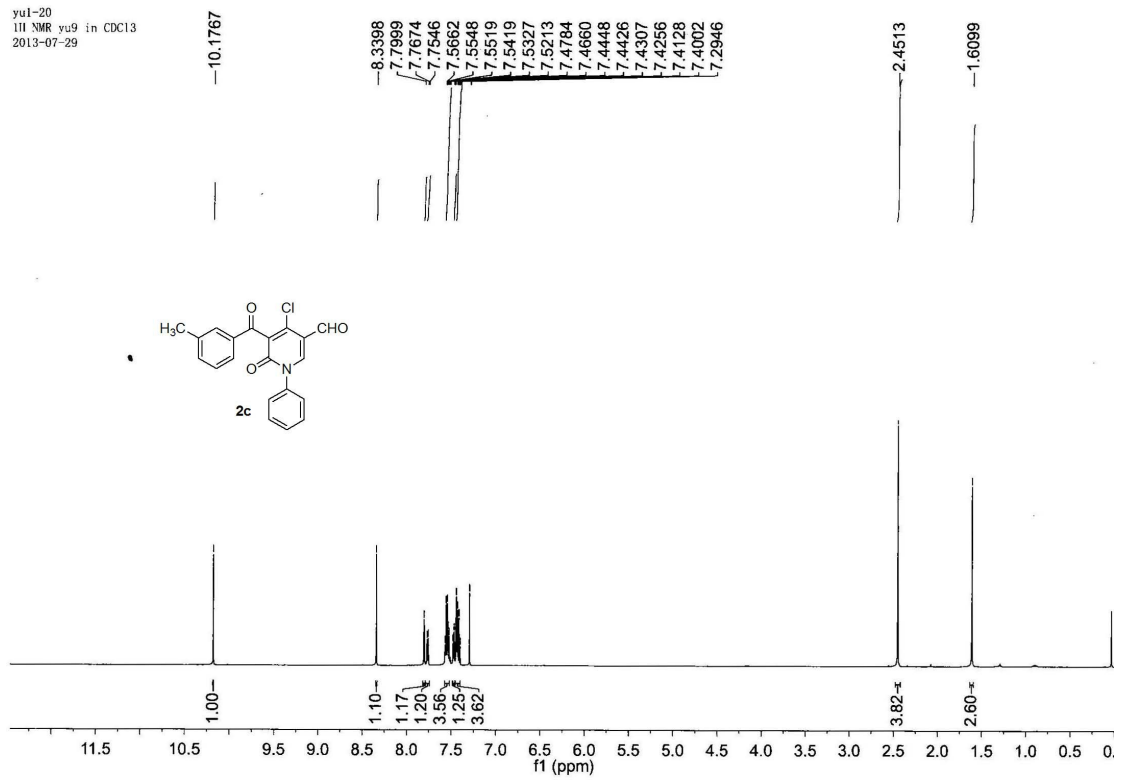
2013-5-15-Yuhf
 1H NMR sub15 in CDCl3
 2013-05-13



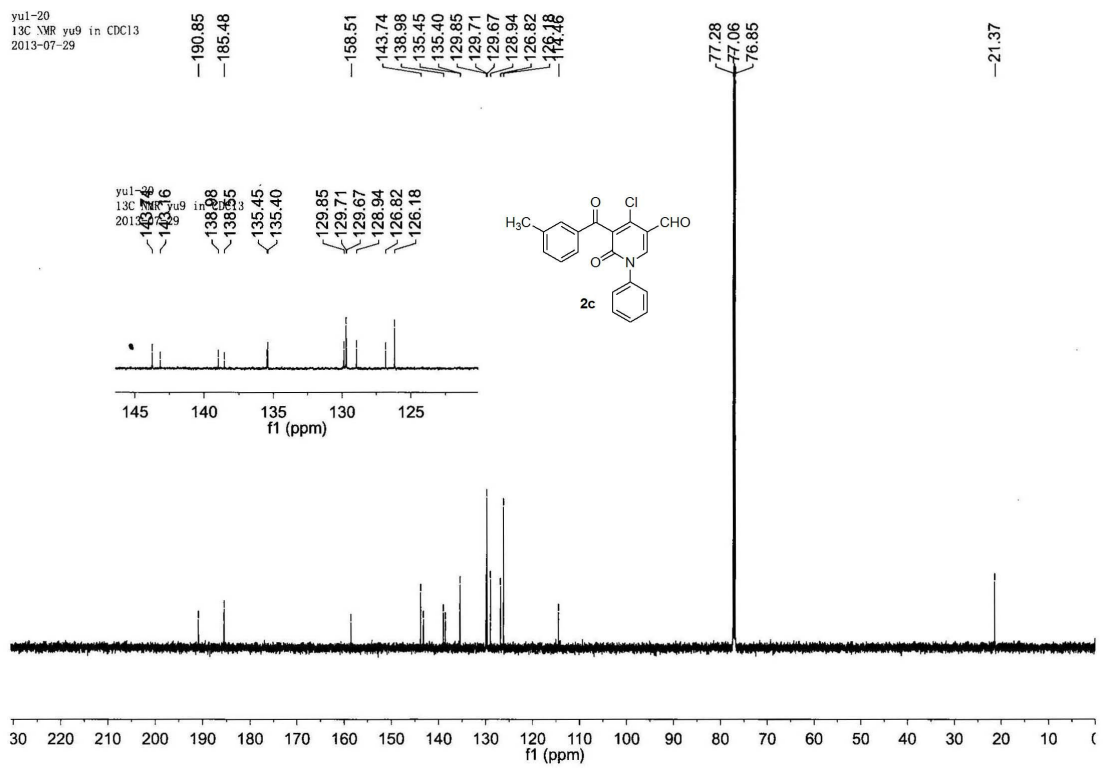
2013-5-15-Yuhf
 13C NMR sub15 in CDCl3
 2013-05-13



yu1-20
 1H NMR yu9 in CDCl3
 2013-07-29



yu1-20
 13C NMR yu9 in CDCl3
 2013-07-29

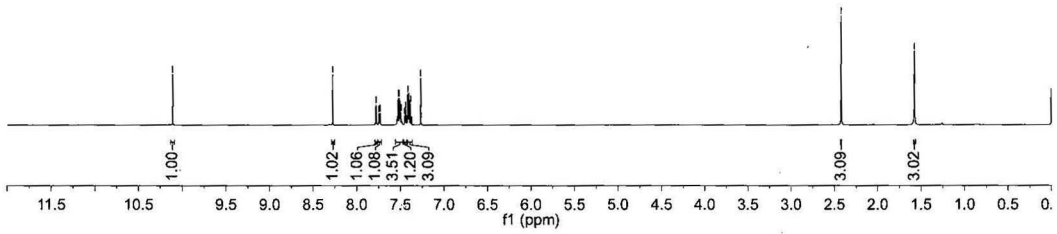
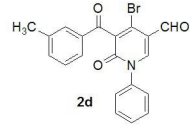
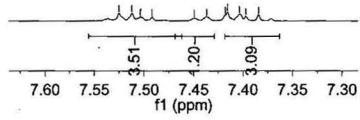


yu1-20
1H NMR yu10 in CDCl3
2013-07-29

10.1058
8.2741
7.7812
7.7463
7.7335
7.5250
7.5123
7.5035
7.4918
7.4494
7.4369
7.4181
7.4156
7.4038
7.3971
7.3843
7.2661

yu1-20
1H NMR yu10 in
2013-07-29

7.5250
7.5123
7.5035
7.4918
7.4494
7.4369
7.4181
7.4156
7.4038
7.3971
7.3843

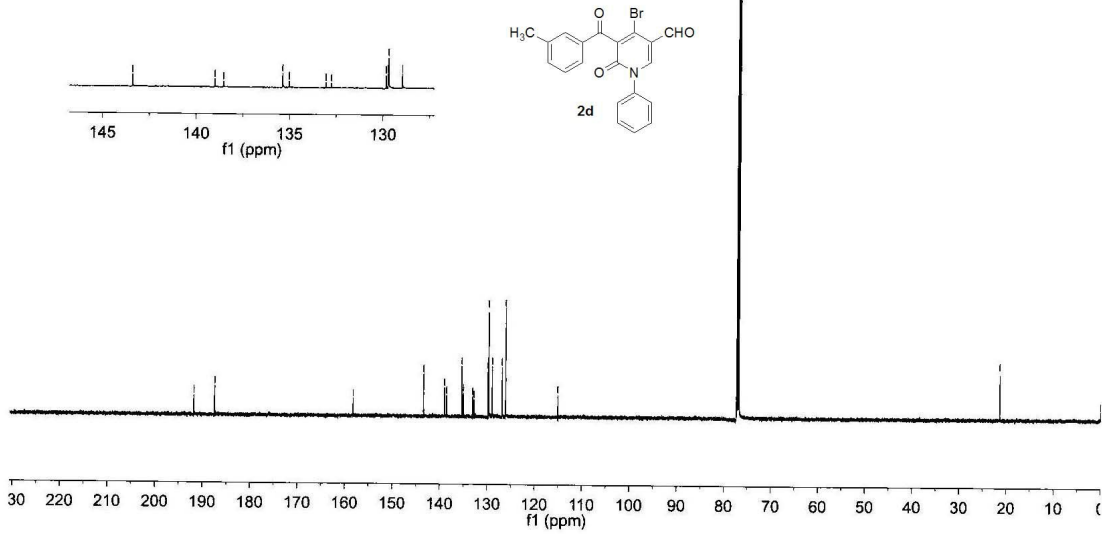
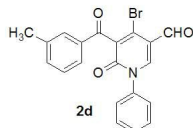


yu1-20
13C NMR yu10 in CDCl3
2013-07-29

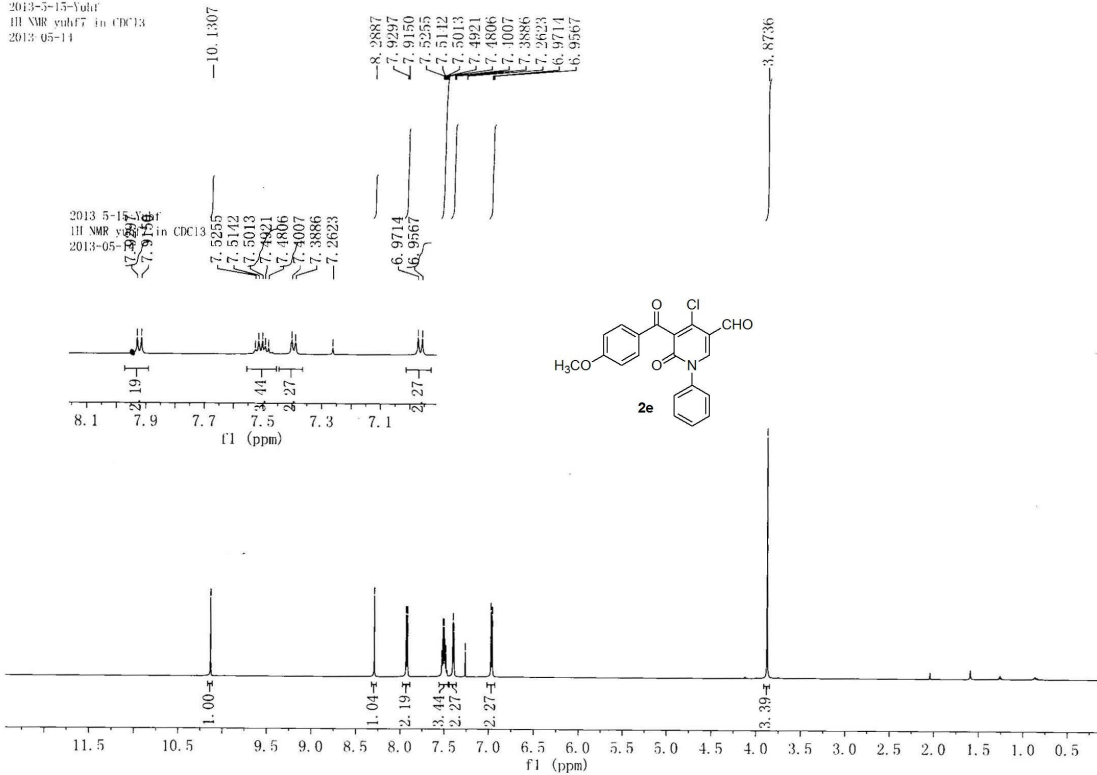
191.80
187.46
158.23
143.40
139.01
135.38
129.84
129.73
129.70
128.96
126.88
126.05
115.05

yu1-20
13C NMR yu10 in CDCl3
2013-07-29

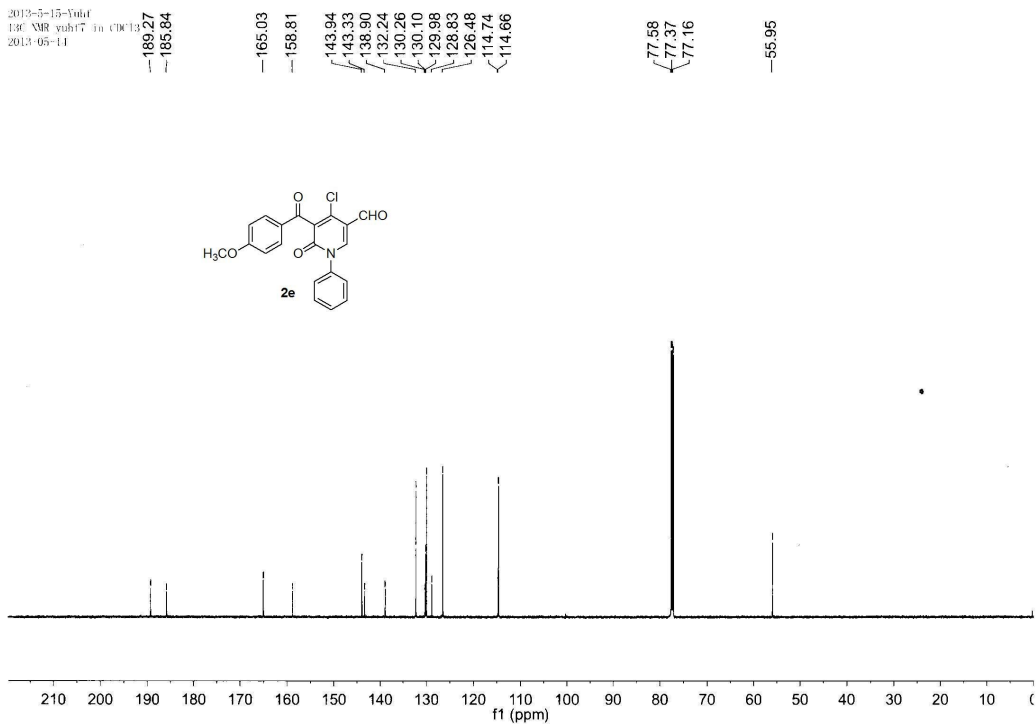
143.910
139.01
138.56
135.38
135.02
133.05
132.76
129.84
129.73
129.70
128.96



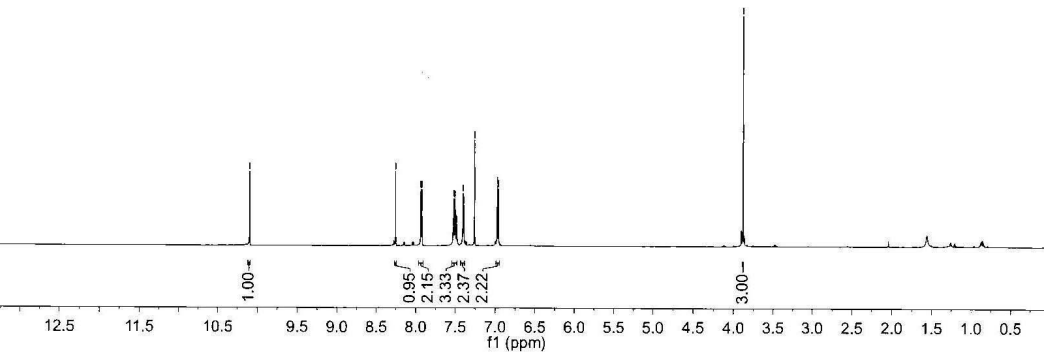
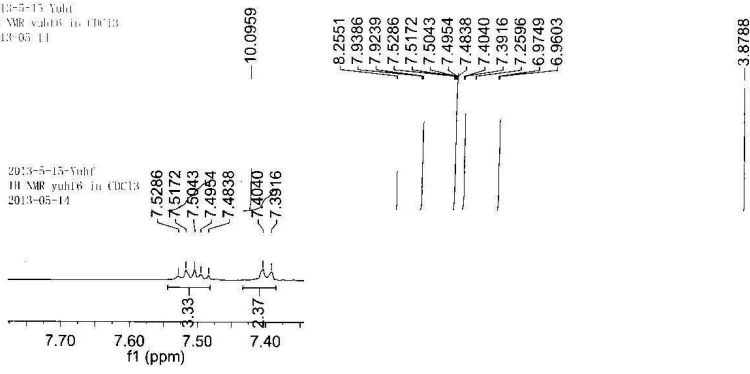
2013-5-15-Yuhf
 1H NMR sub17 in CDCl3
 2013-05-11



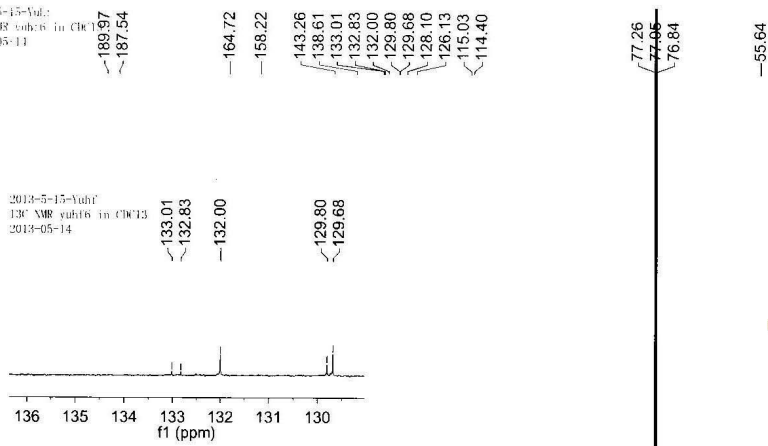
2013-5-15-Yuhf
 13C NMR sub17 in CDCl3
 2013-05-11



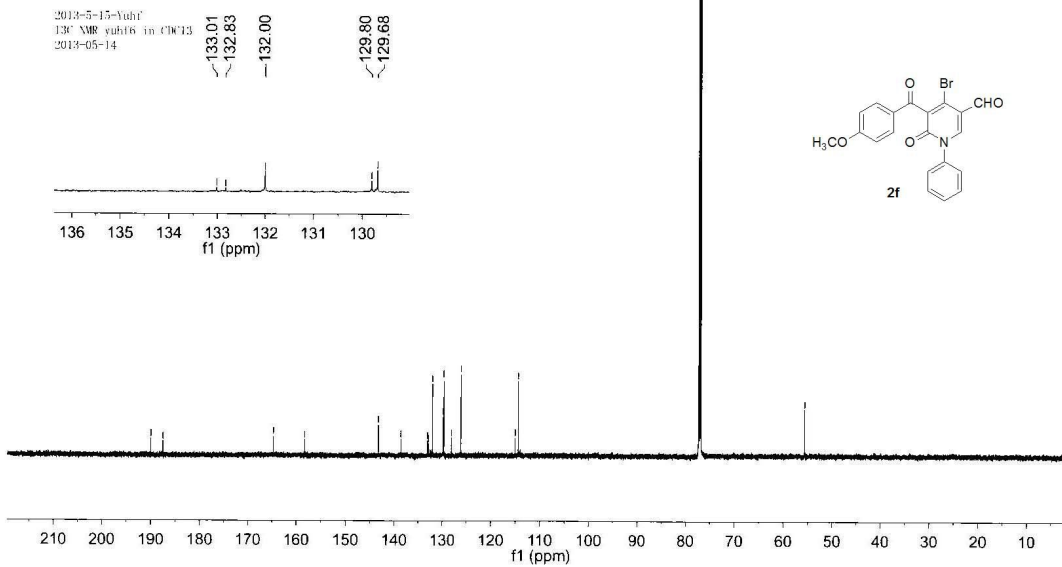
2013-5-15-Yuhf
 1H NMR yuhf16 in CDCl3
 2013-05-11



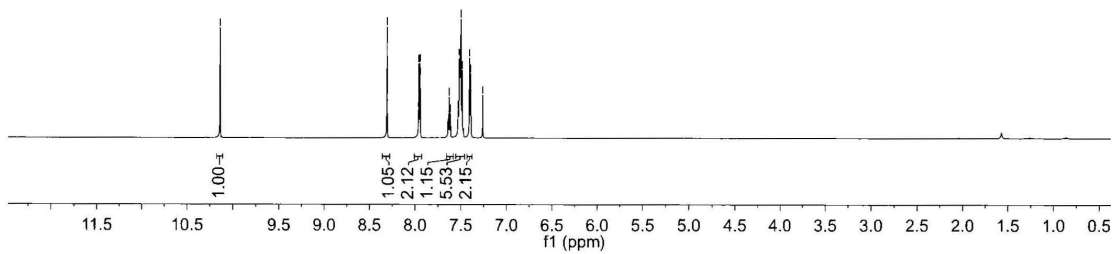
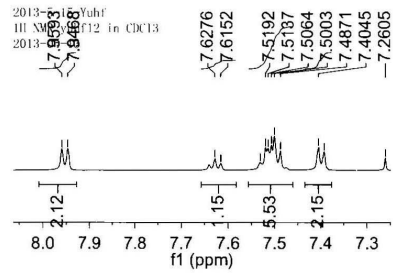
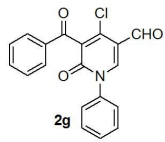
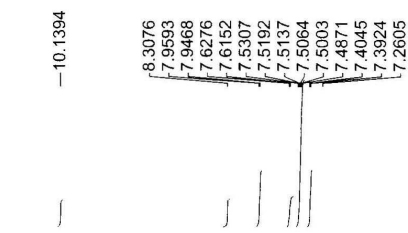
2013-5-15-Yuhf
 13C NMR yuhf16 in CDCl3
 2013-05-11



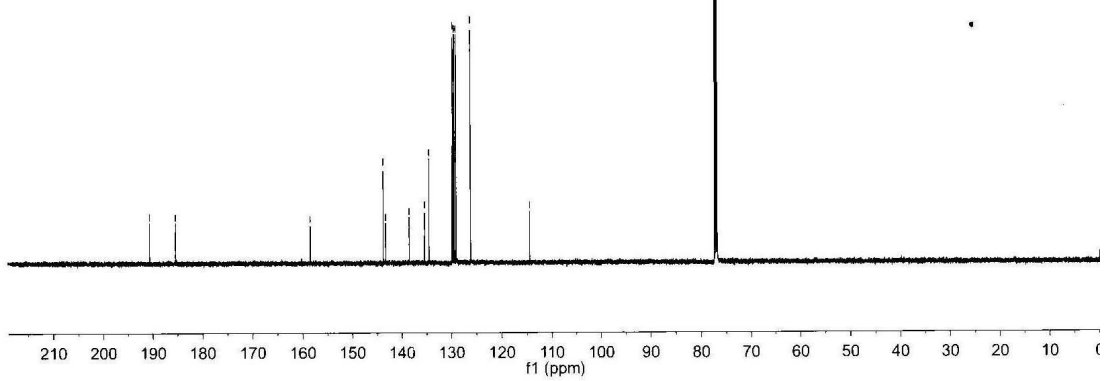
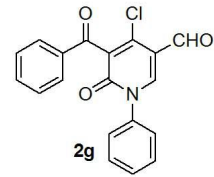
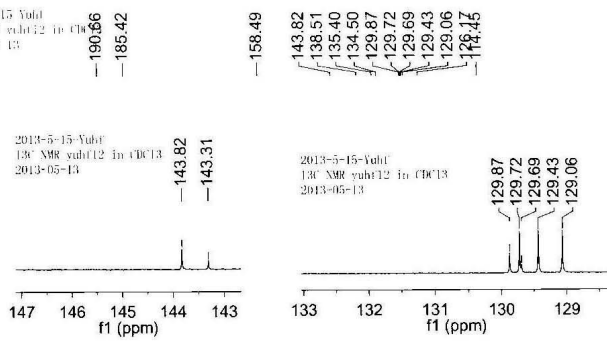
2013-5-15-Yuhf
 13C NMR yuhf16 in CDCl3
 2013-05-14



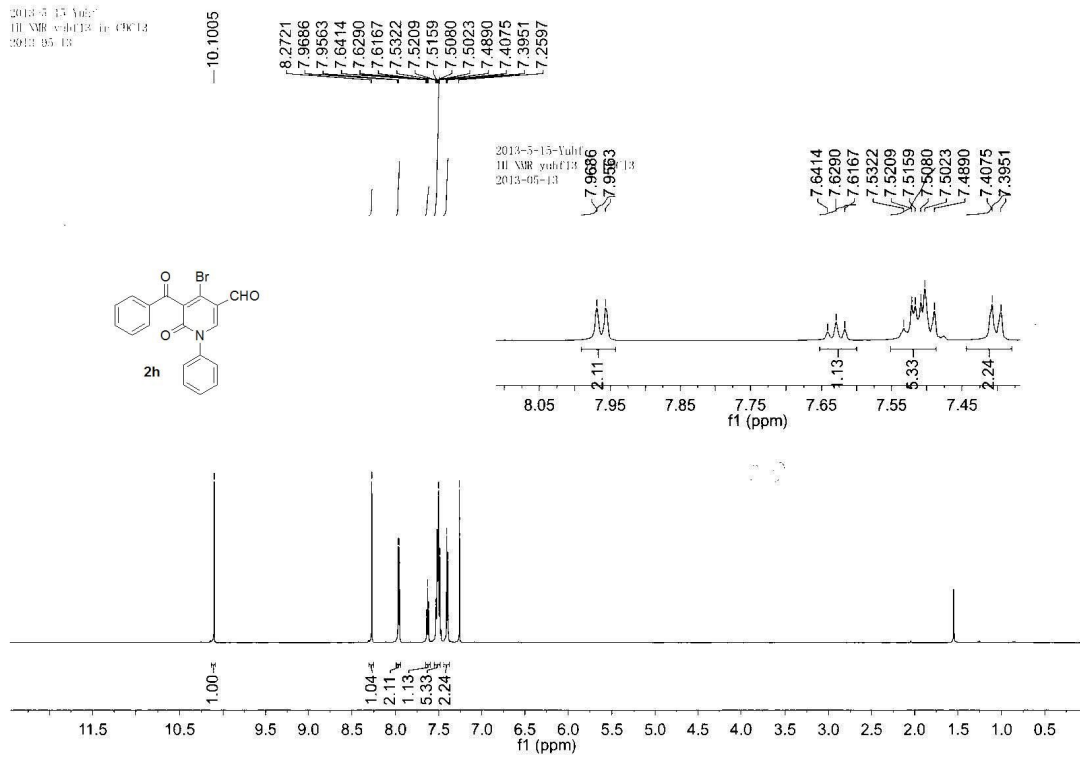
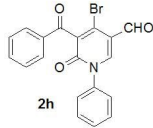
2013-5-15-Yuhf
 1H NMR yuhf12 in CDCl3
 2013-05-13



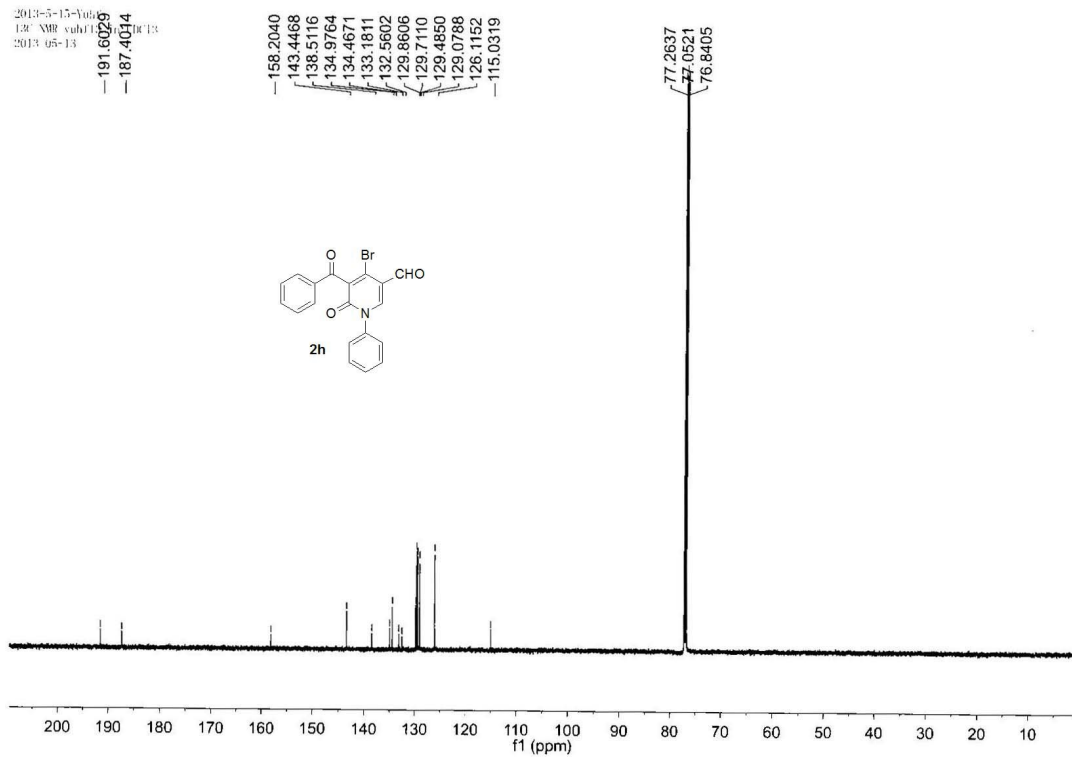
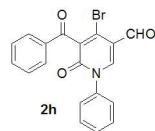
2013-5-15-Yuhf
 13C NMR yuhf12 in CDCl3
 2013-05-13



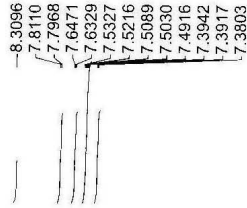
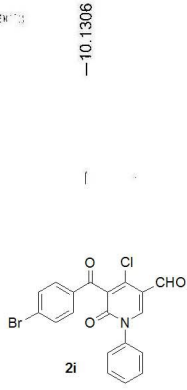
2013-5-15-Yuhf
1H NMR (400 MHz, CDCl₃)
2013-05-13



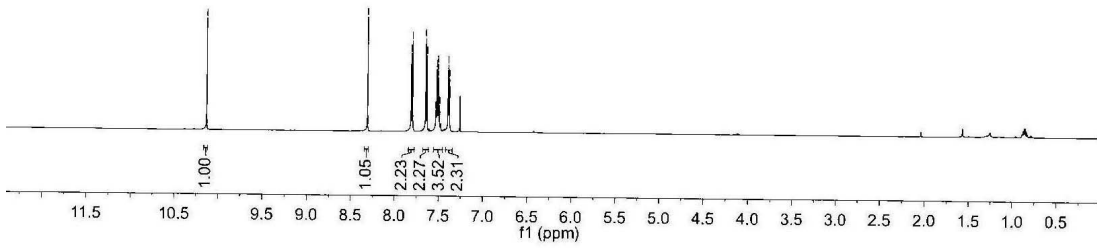
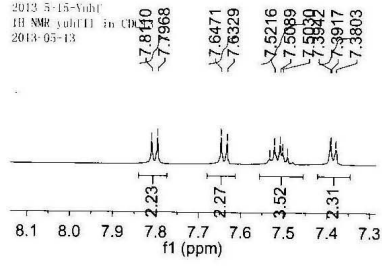
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13C NMR (100 MHz, CDCl₃)
2013-05-13



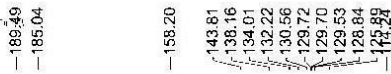
2013-5-15-Vol1
1H NMR (cdCl3) 36 (300°K)
2013-05-13



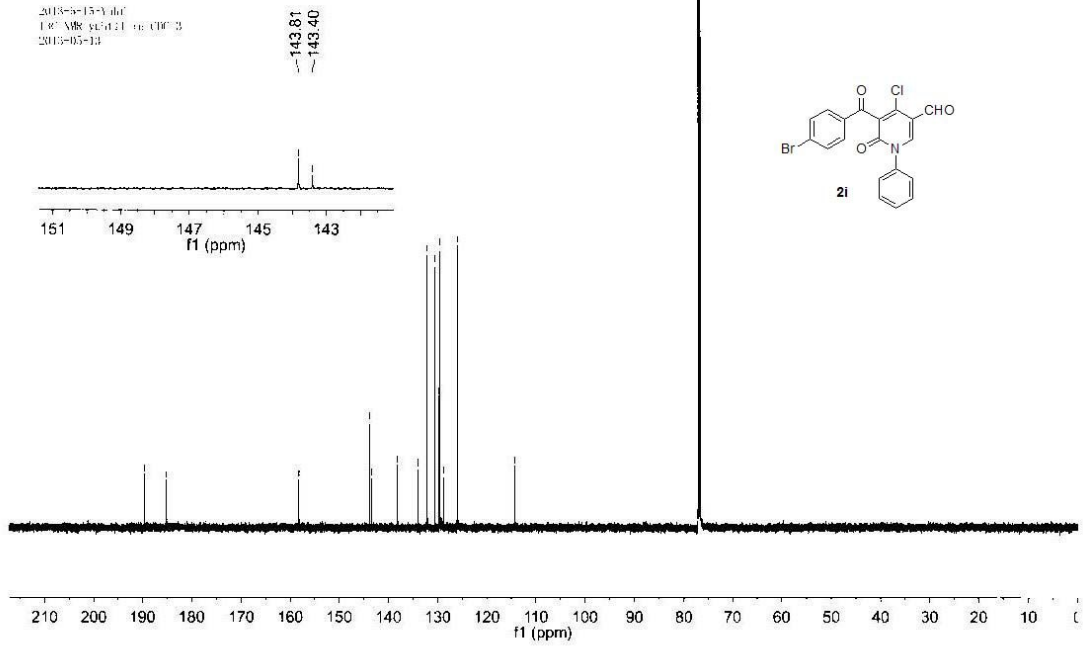
2013-5-15-Vol1
1H NMR (cdCl3) 36 (300°K)
2013-05-13



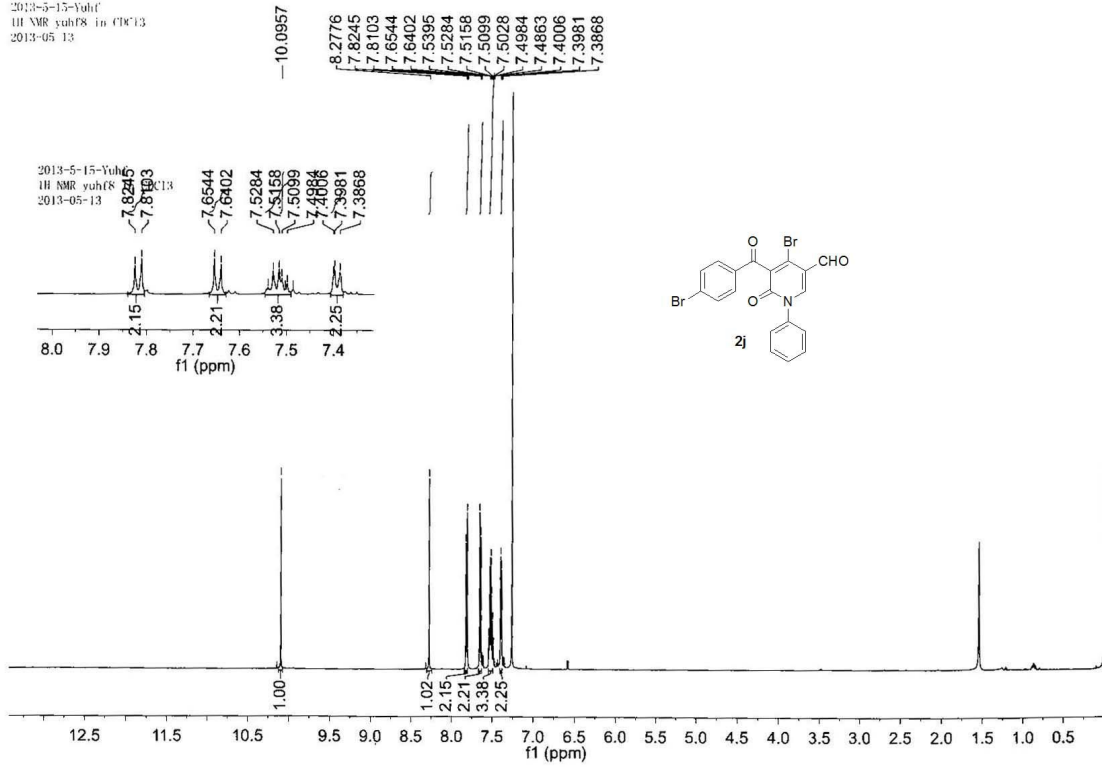
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13C NMR (cdCl3) 36 (300°K)
2013-05-13



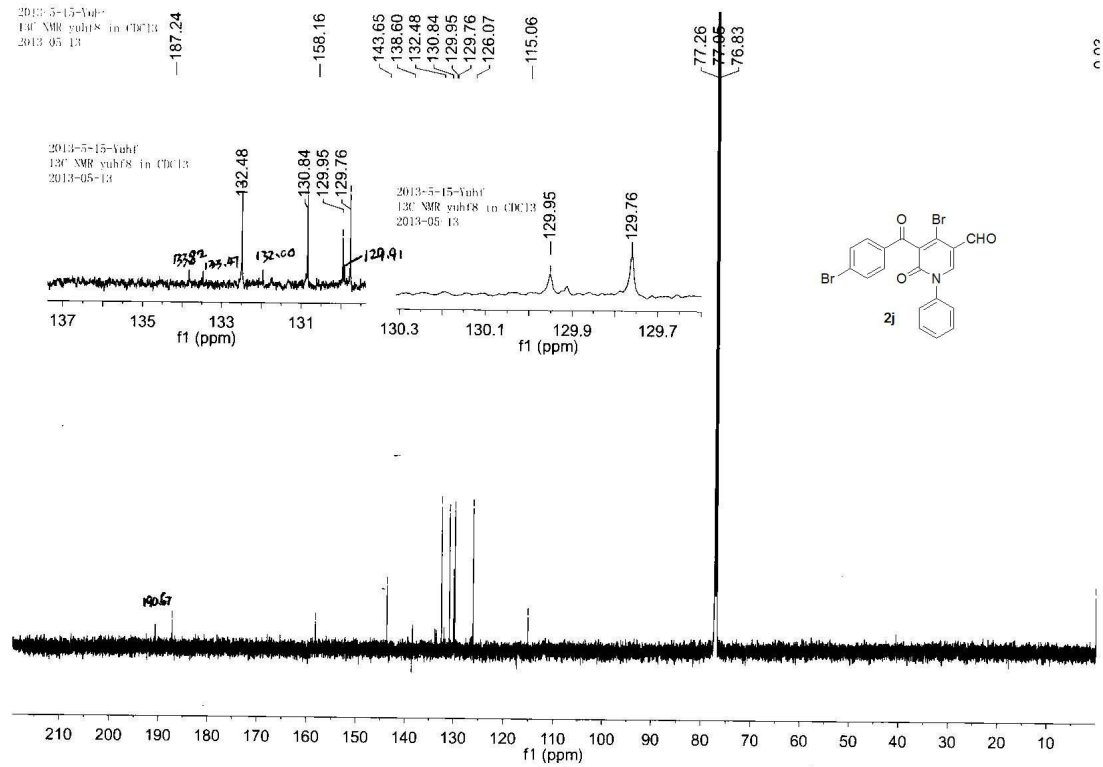
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13C NMR (cdCl3) 36 (300°K)
2013-05-13



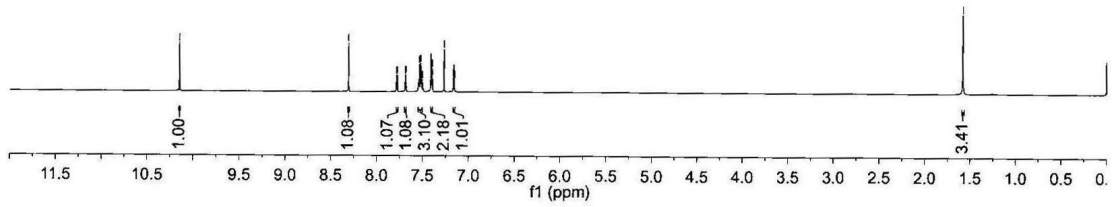
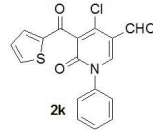
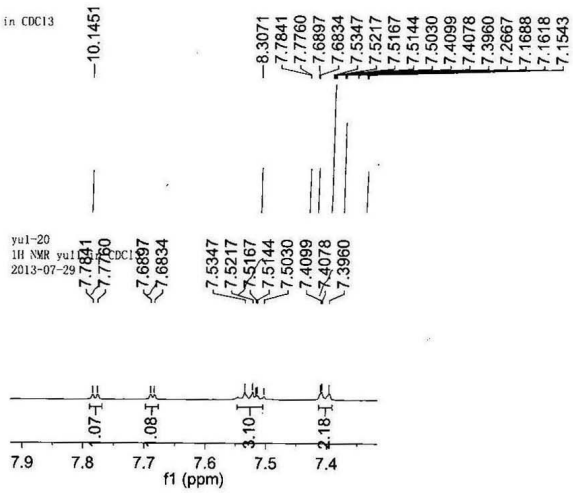
2013-5-15-Yuhf
 1H NMR yuhf8 in CDCl3
 2013-05-13



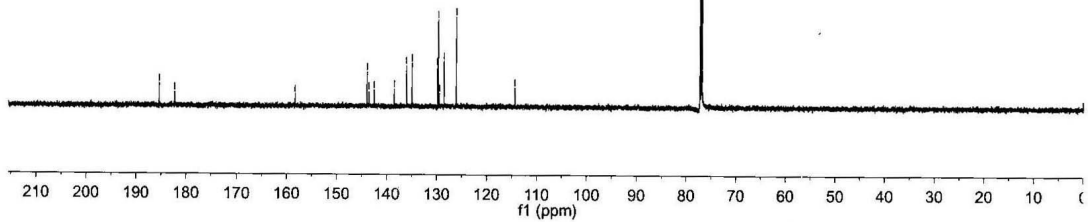
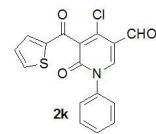
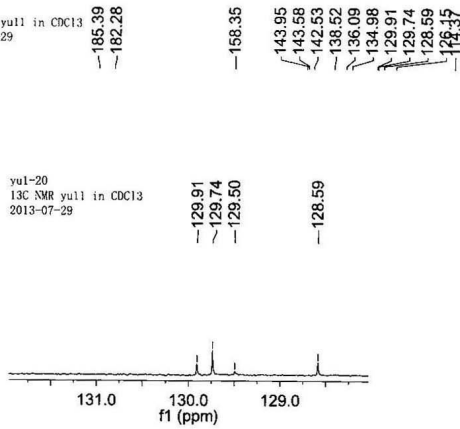
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 13C NMR yuhf8 in CDCl3
 2013-05-13



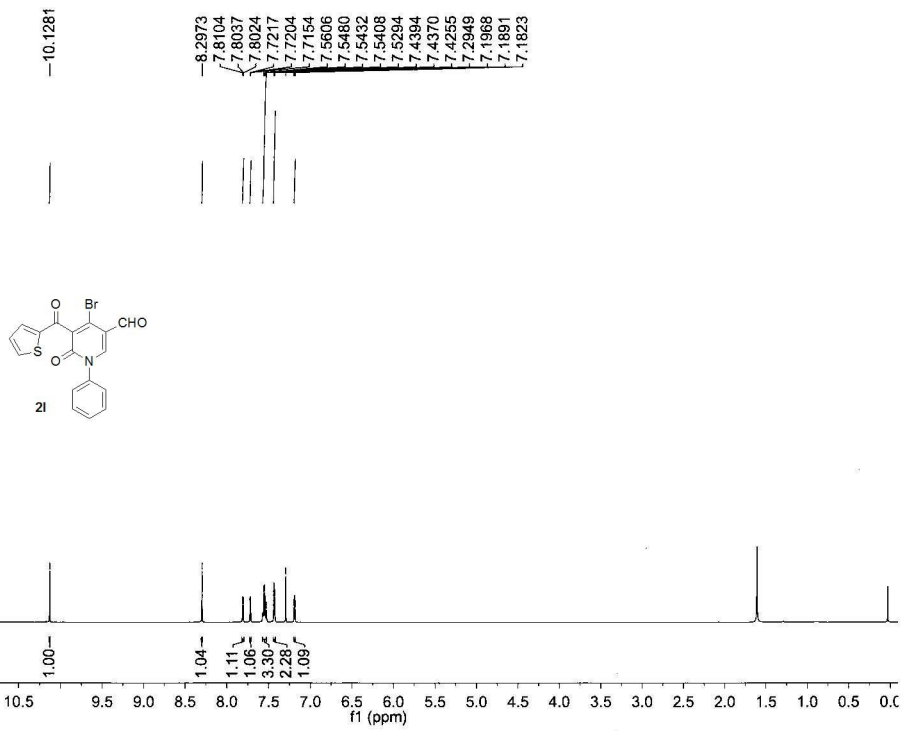
yul-20
 1H NMR yu11 in CDCl3
 2013-07-29



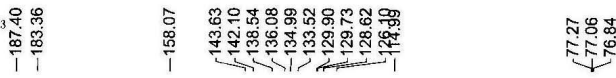
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 2013-07-29



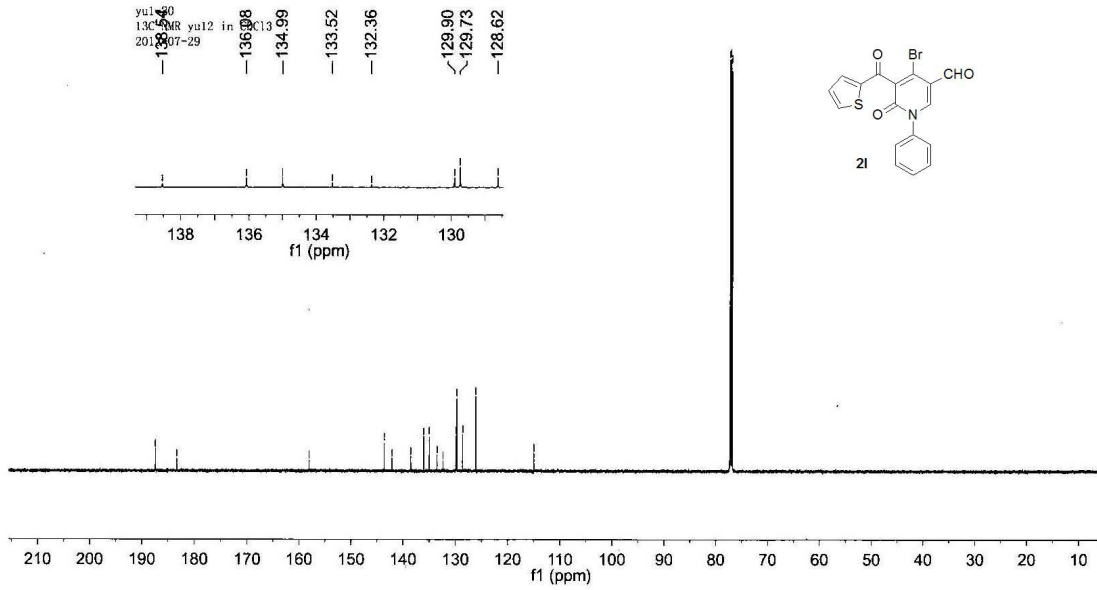
yul-20
 1H NMR yul12 in CDCl3
 2013-07-29



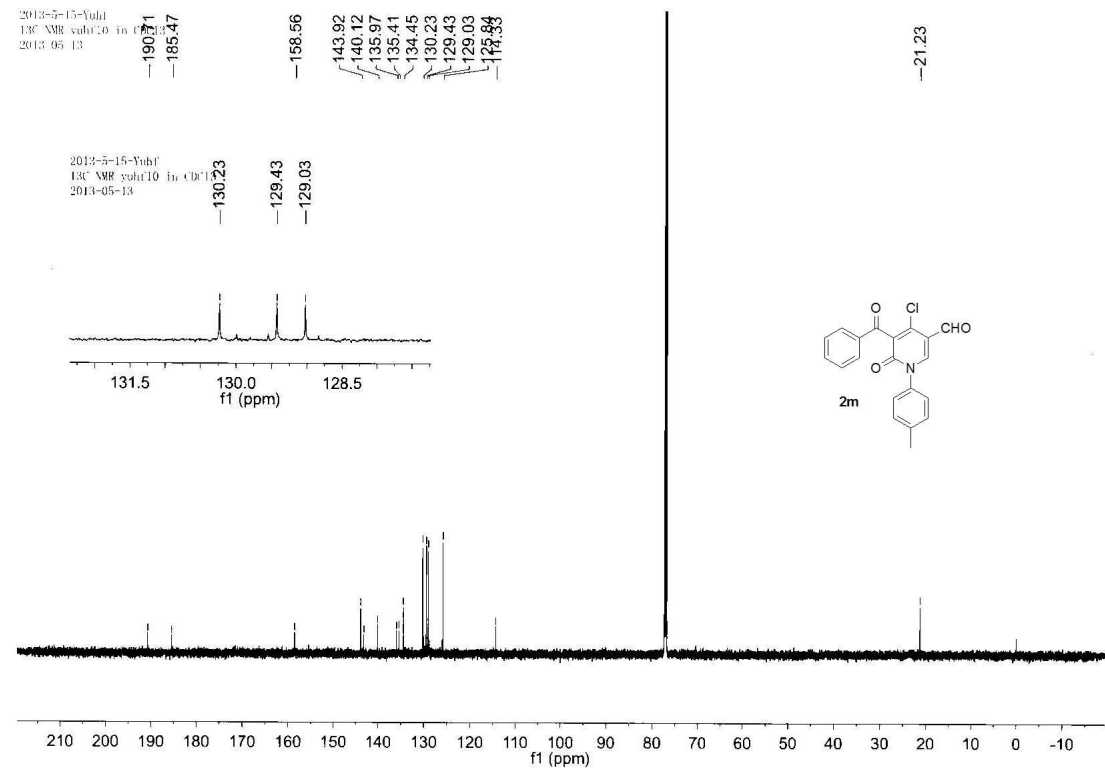
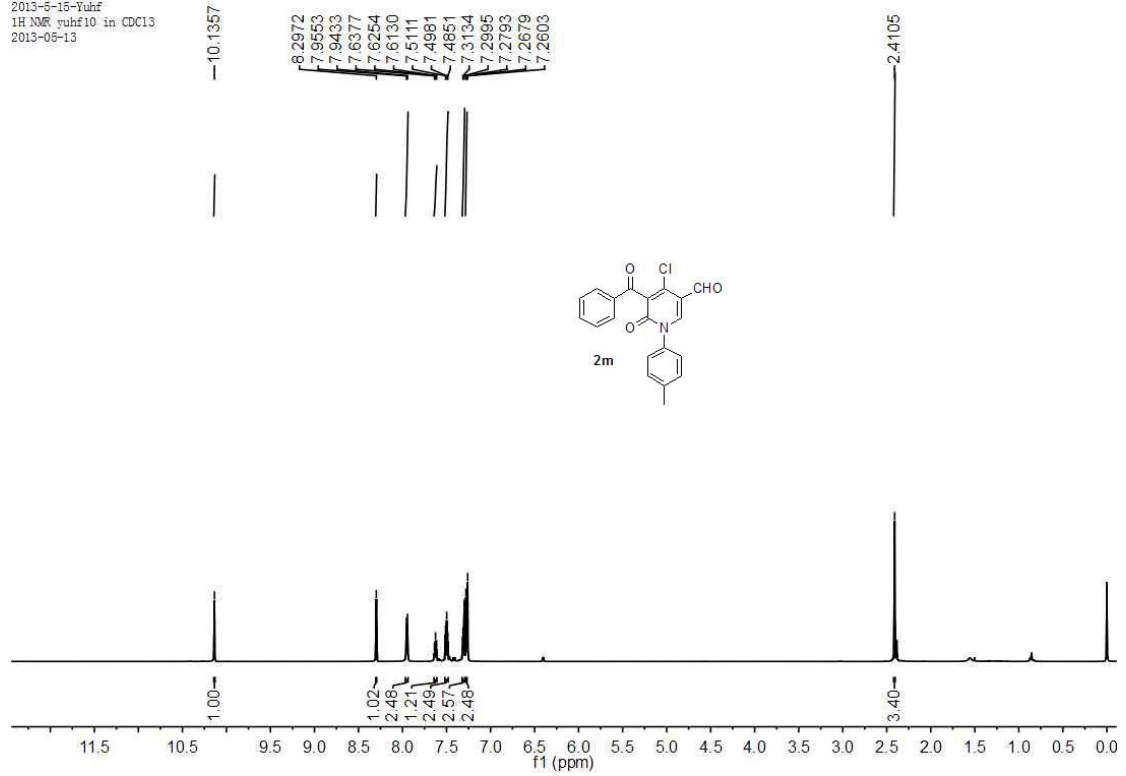
yul-20
 13C NMR yul12 in CDCl3
 2013-07-29



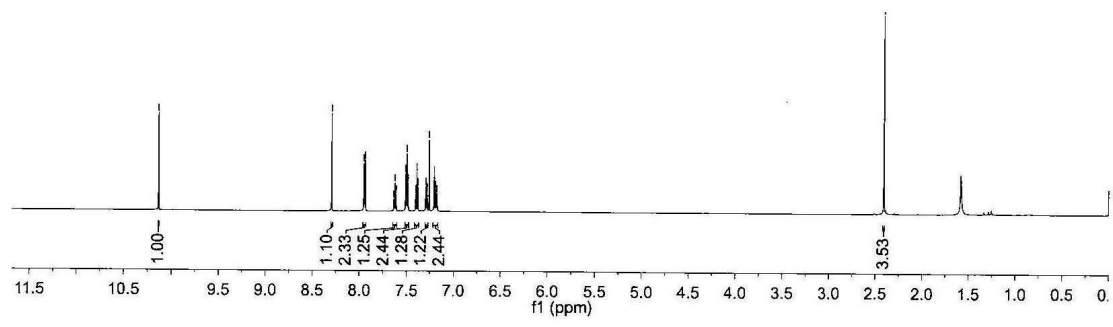
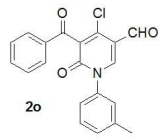
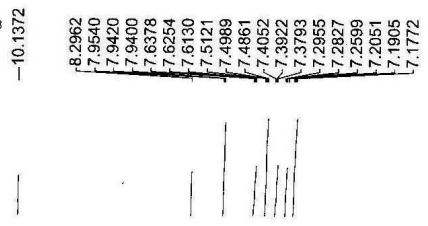
yul-20
 13C NMR yul12 in CDCl3
 2013-07-29



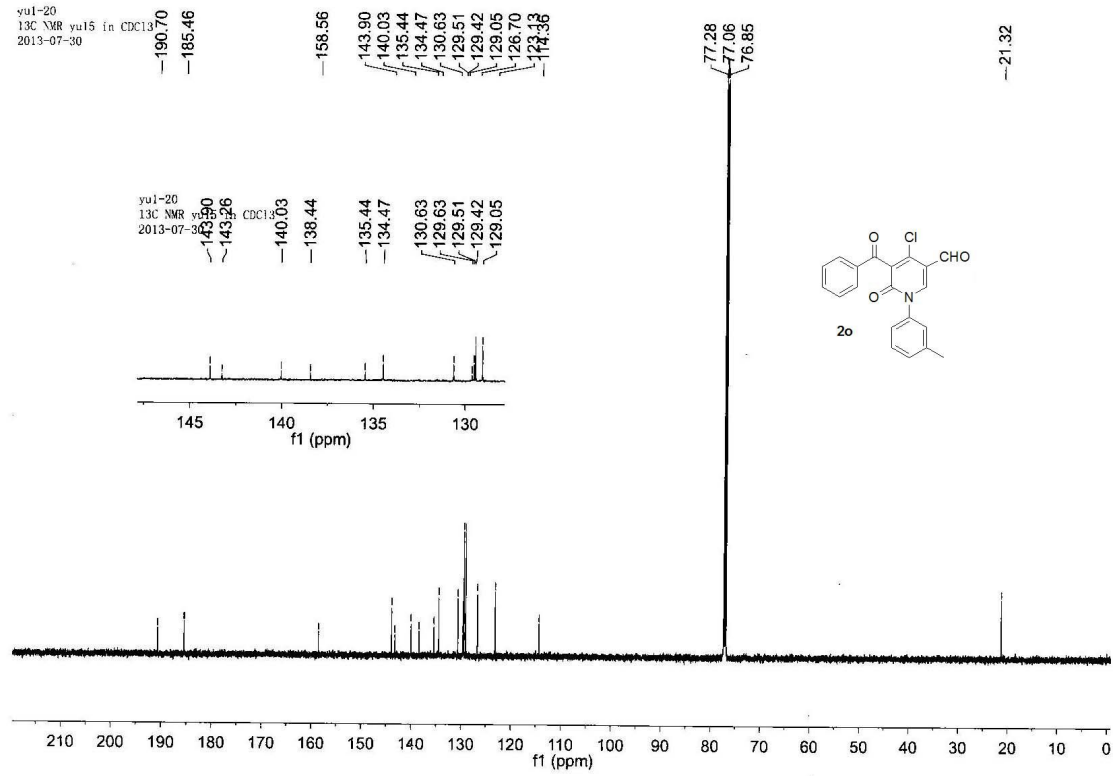
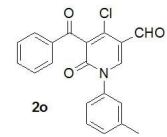
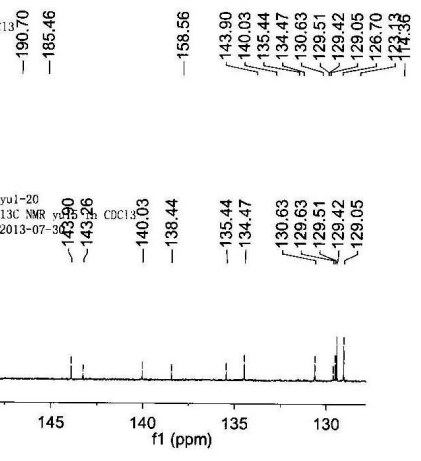
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 1H NMR yuhf10 in CDCl3
 2013-05-13



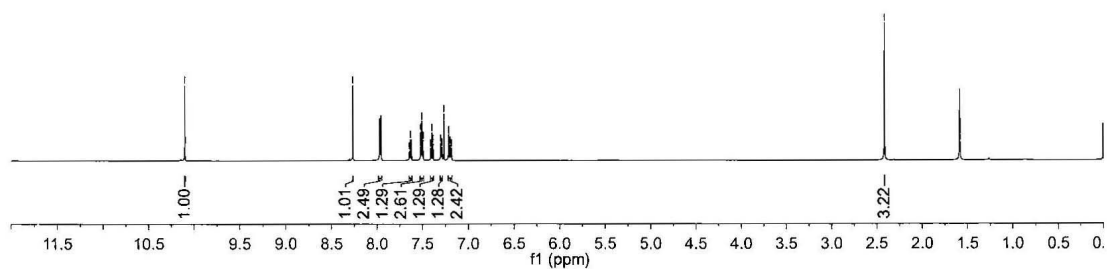
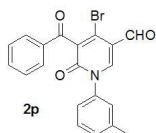
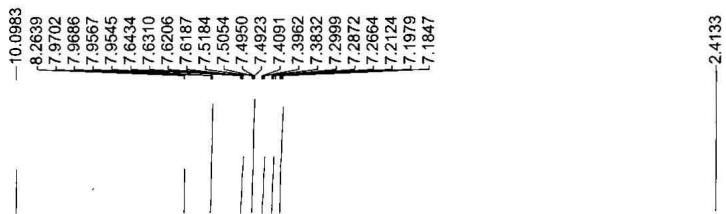
yul-20
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 2013-07-30



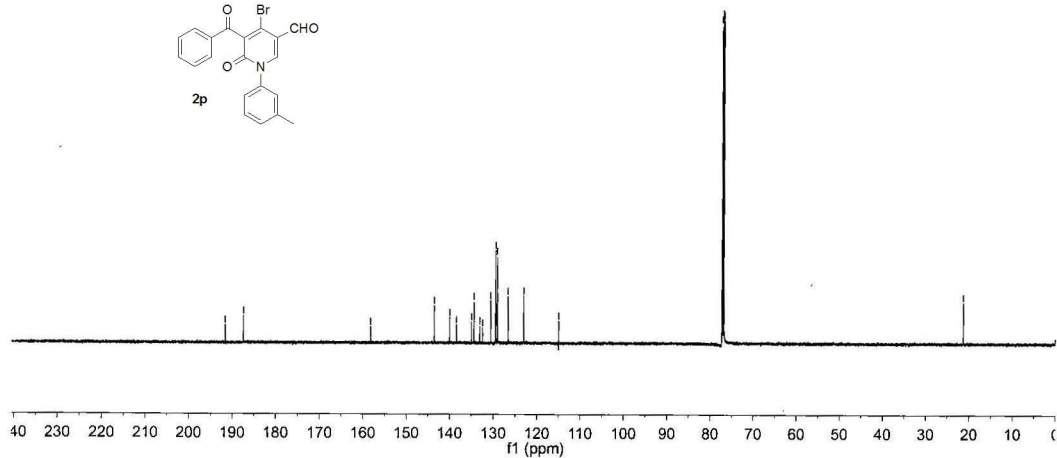
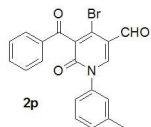
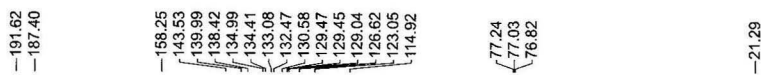
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 13C NMR yul15 in CDCl3
 2013-07-30



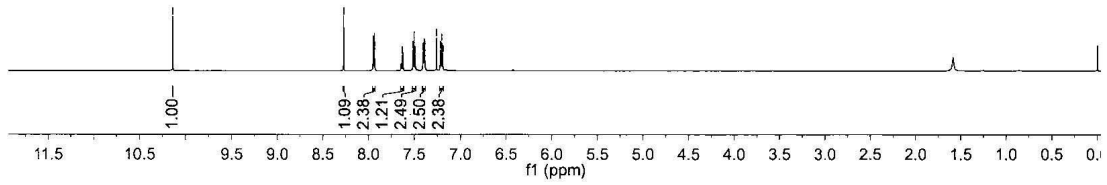
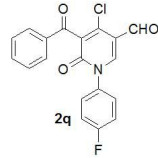
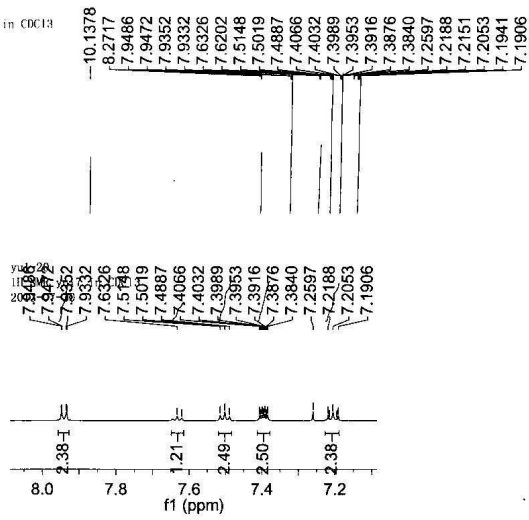
yu1-20
 1H NMR yu16 in CDCl3
 2013-07-30



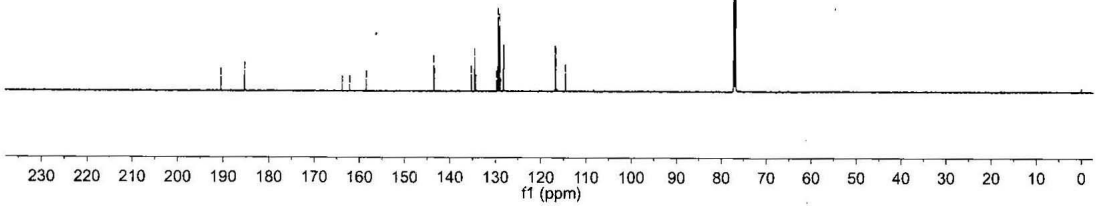
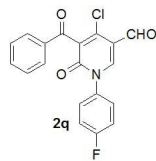
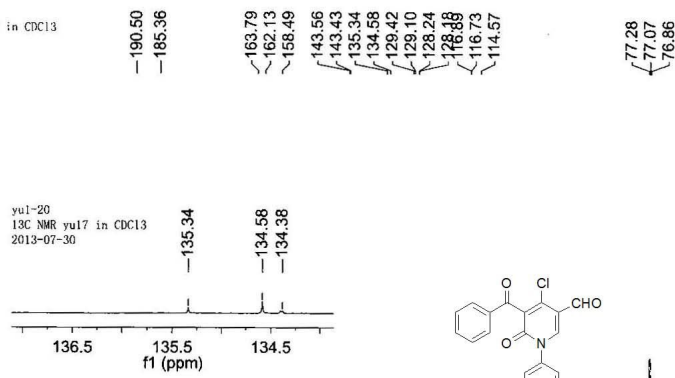
yu1-20
 13C NMR yu16 in CDCl3
 2013-07-30



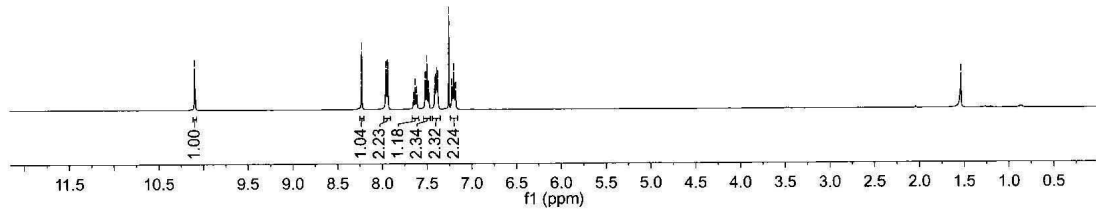
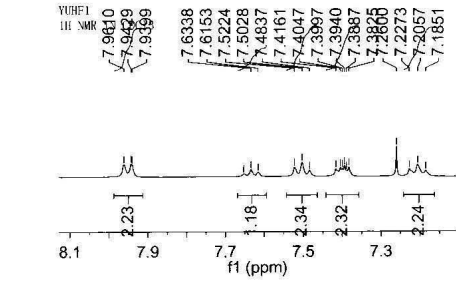
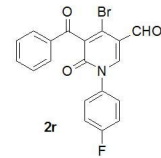
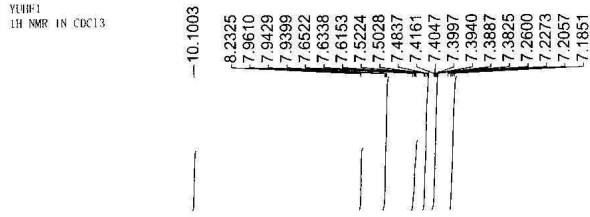
yul-20
 1H NMR yul17 in CDCl3
 2013-07-30



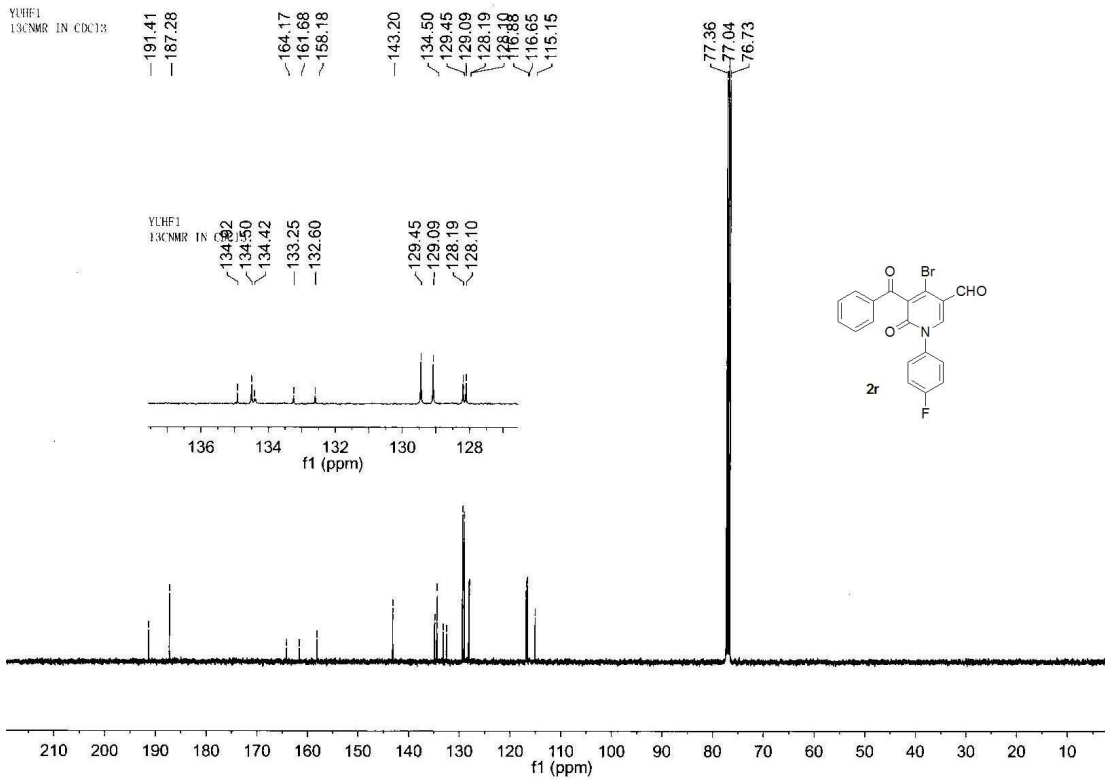
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 2013-07-30



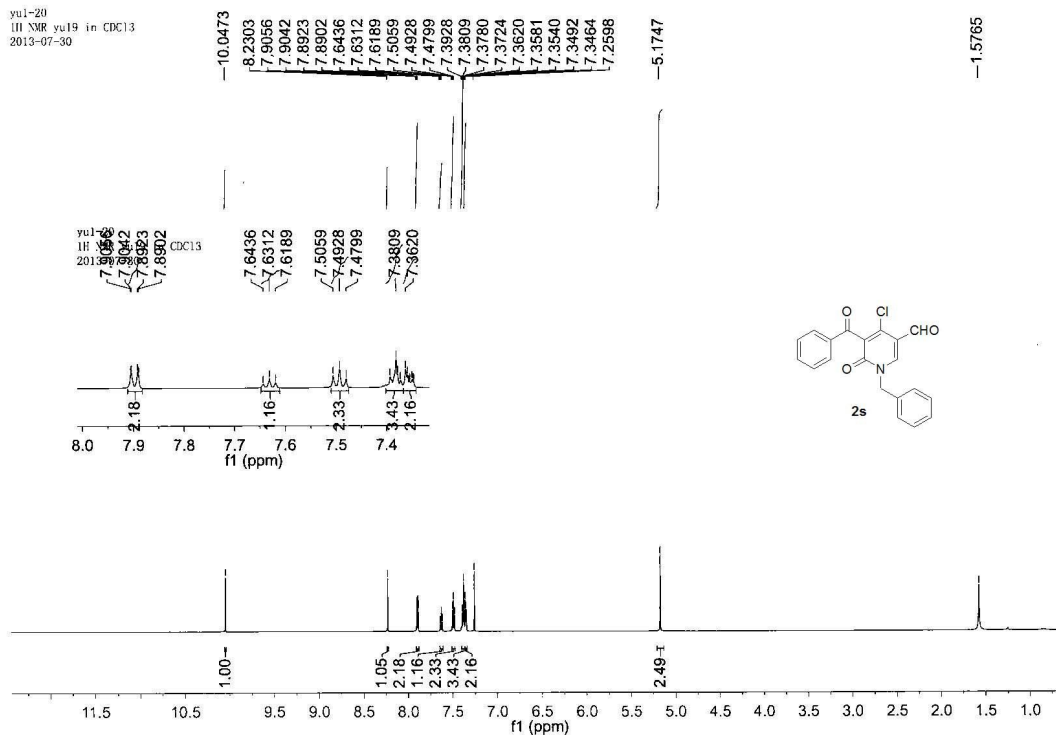
YUHF1
1H NMR IN CDCl3



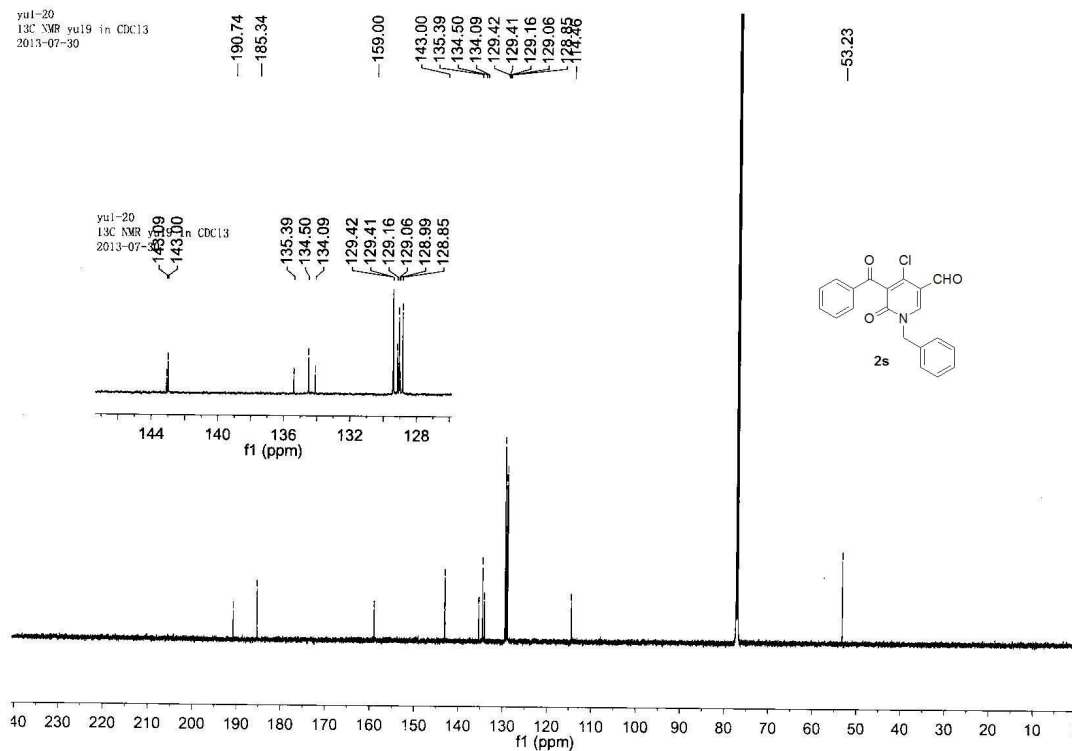
YUHF1
13C NMR IN CDCl3



yul-20
 1H NMR yu19 in CDCl3
 2013-07-30



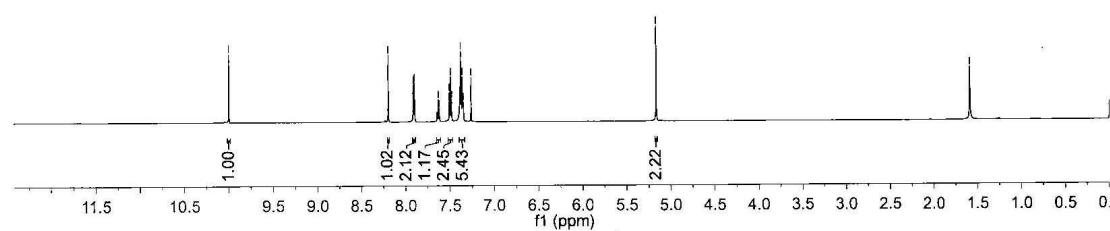
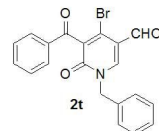
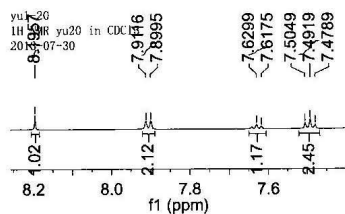
yul-20
 13C NMR yu19 in CDCl3
 2013-07-30



yu1-20
1H NMR yu20 in CDCl3
2013-07-30

9.9971
8.1957
7.9116
7.8995
7.6299
7.6175
7.5049
7.4919
7.4819
7.4789
7.3885
7.3768
7.3684
7.3602
7.3563
7.3475
7.2597
5.1633
1.5865

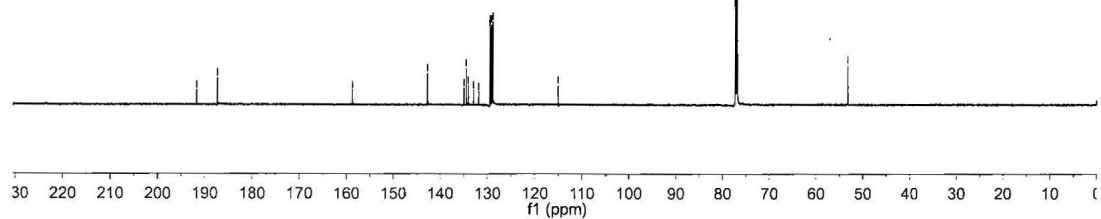
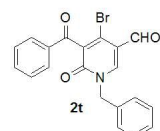
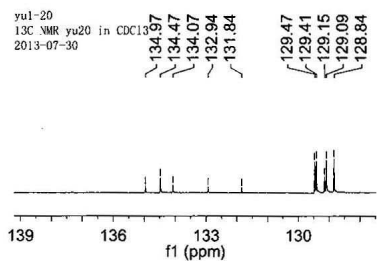
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1H NMR yu20 in CDCl3
2013-07-30



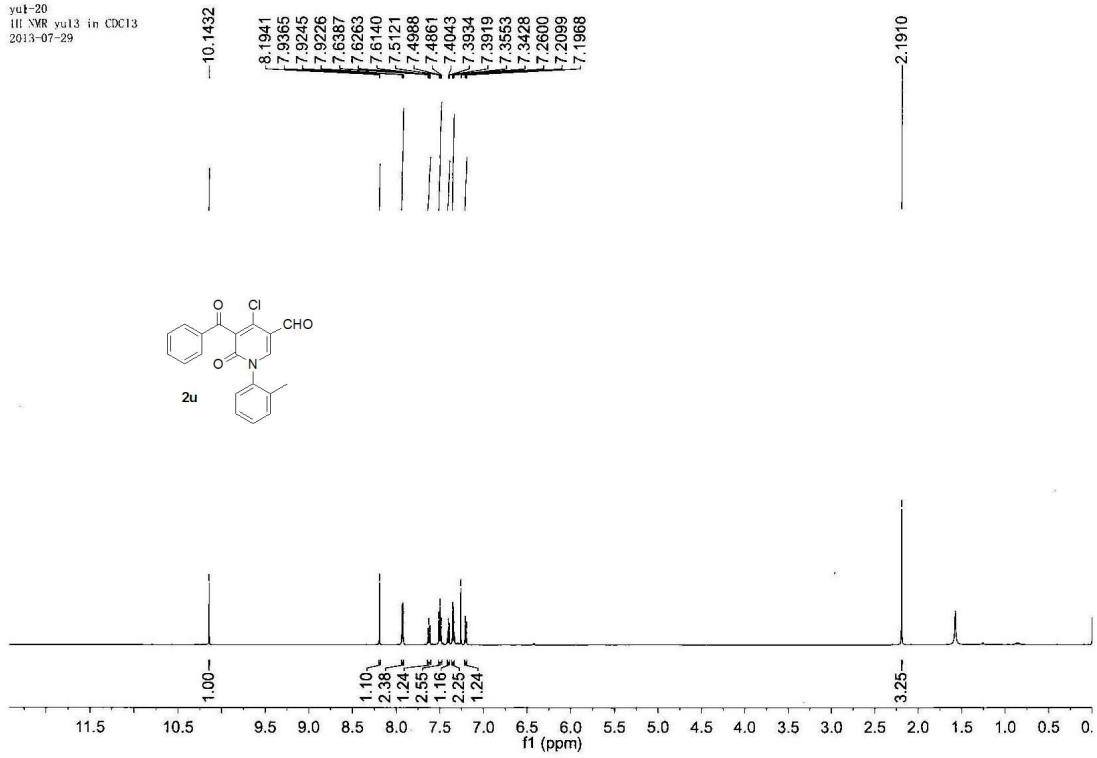
yu1-20
13C NMR yu20 in CDCl3
2013-07-30

191.69
187.33
158.74
142.74
134.97
134.47
134.07
132.94
129.47
129.41
129.15
129.09
128.84
128.07
128.07
77.27
77.06
76.85
53.26

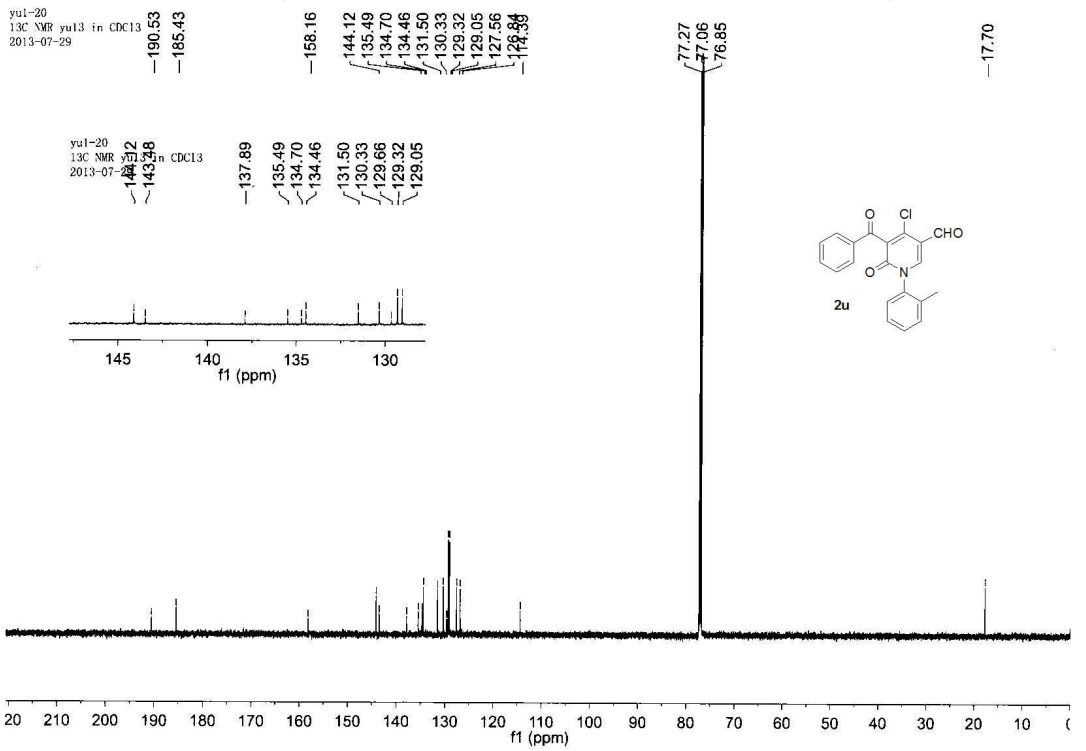
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13C NMR yu20 in CDCl3
2013-07-30



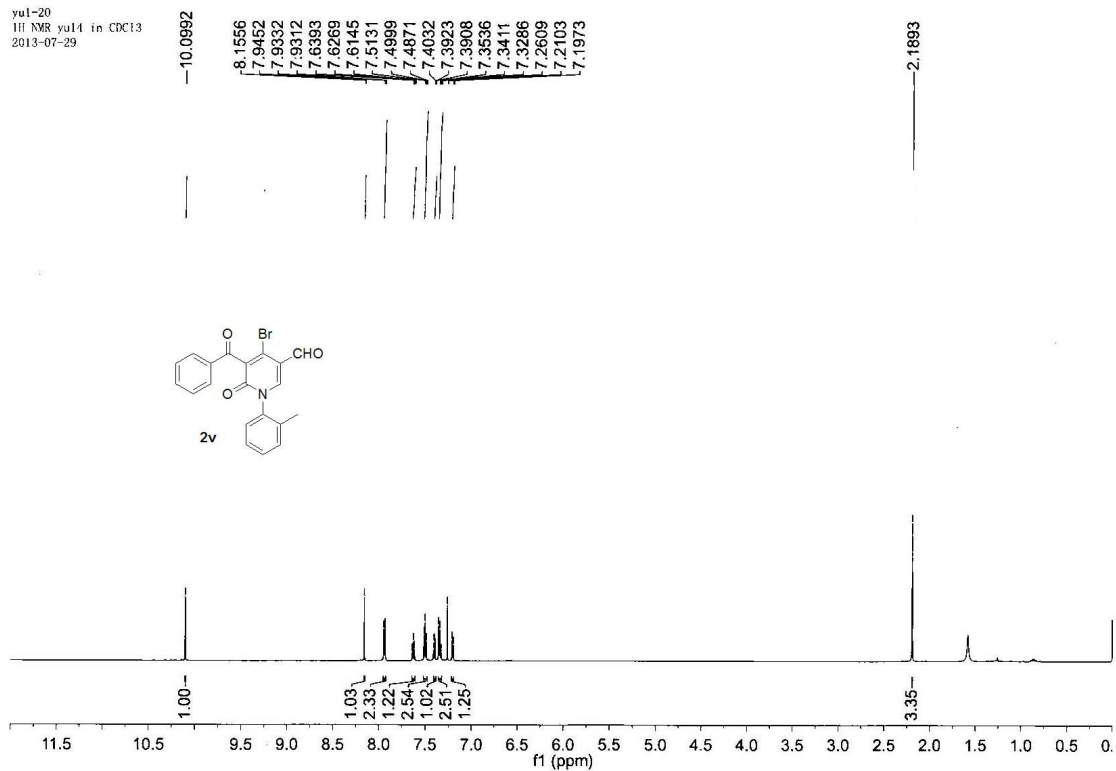
yu1-20
 1H NMR yu13 in CDCl3
 2013-07-29



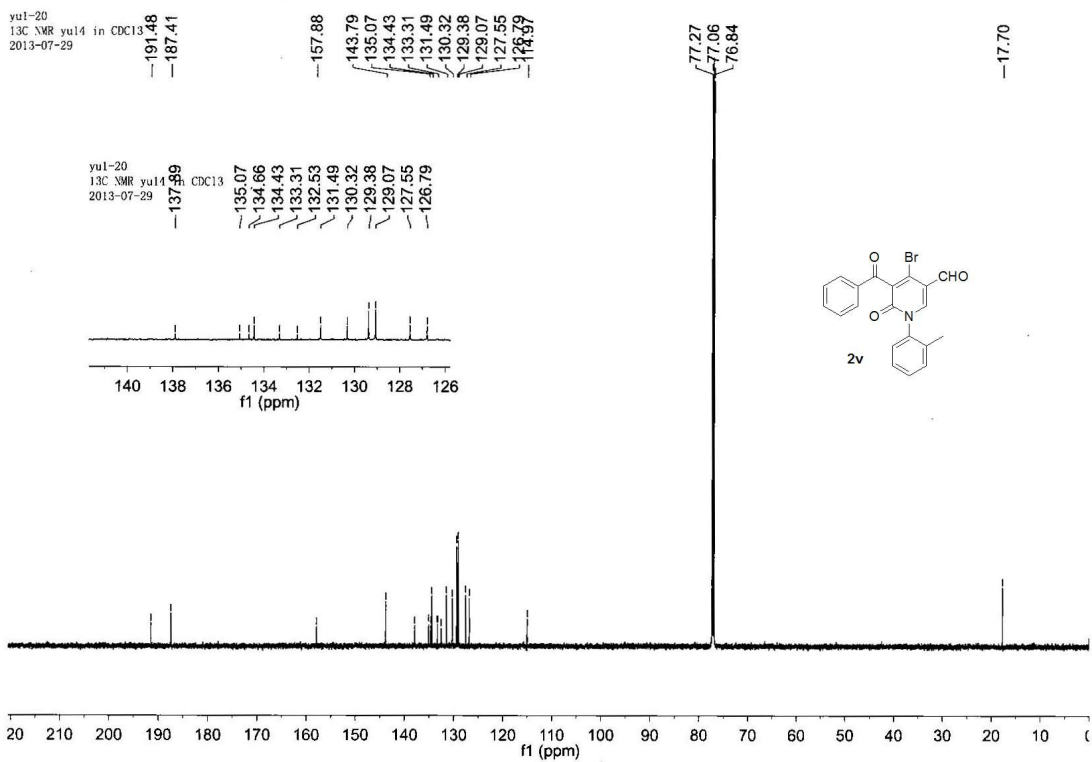
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 13C NMR yu13 in CDCl3
 2013-07-29



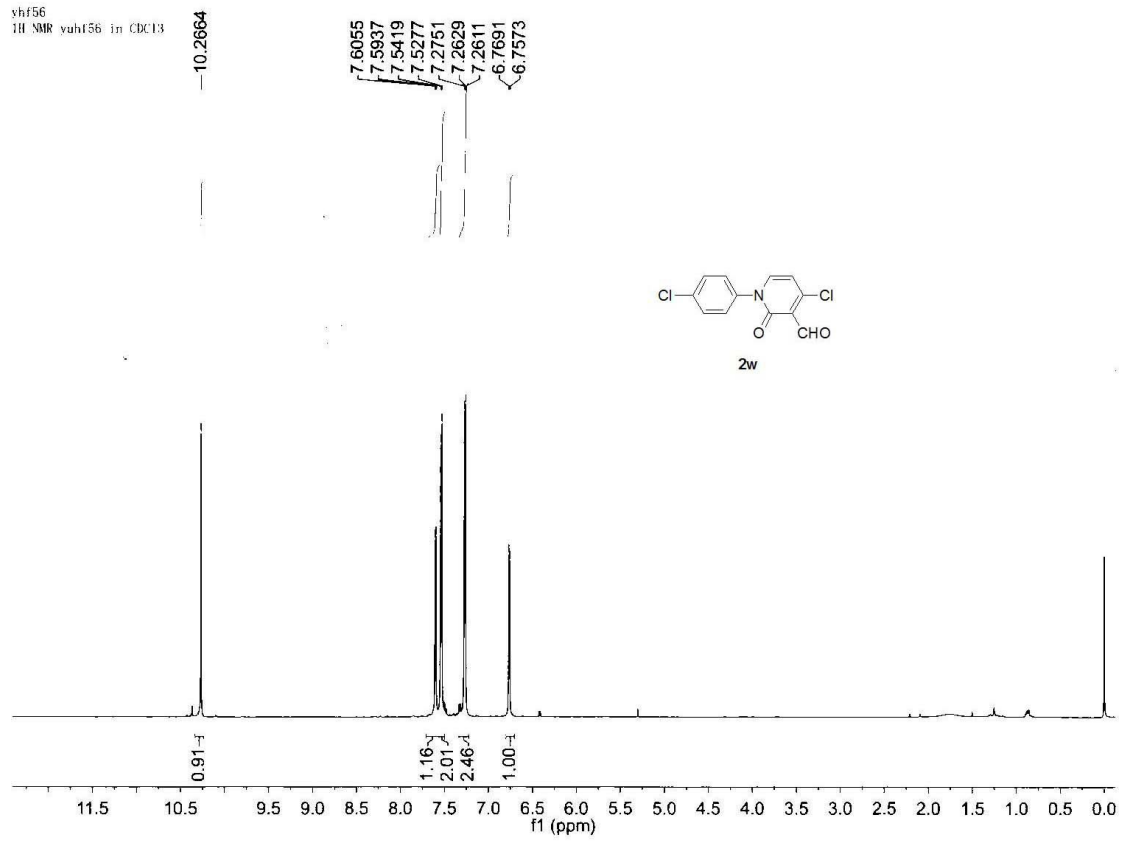
yu1-20
 1H NMR yu14 in CDCl3
 2013-07-29



yu1-20
 13C NMR yu14 in CDCl3
 2013-07-29



yhf56
1H NMR yhf56 in CDCl3



yhf56
13C NMR yhf56 in CDCl3

