

Acylation/Cyclization of 1,6-Dienes with Ethers under Catalyst- and Base-Free Conditions

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(A) Typical experimental procedure for the acylation/cyclization

To a Schlenk tube were added 1,6-dienes **1** (0.2 mmol), ethers **2** (2.0 mL) and TBHP (anhydrous, 5 M in decane, 2.0 equiv). Then the tube was stirred at 120 °C sealed in air for the indicated time until complete consumption of starting material as monitored by TLC and/or GC-MS analysis. After the reaction was finished, the solution was concentrated under reduced pressure, and the mixture was purified by flash column chromatography over silica gel (hexane/ethyl acetate = 4:1) to afford the desired product **3**.

(B) Study of thermal degradation profiles of the crude mixture

To a Schlenk tube were added 1,6-diene **1a** (0.2 mmol), ethers **2a** (2.0 mL) and TBHP (anhydrous, 5 M in decane, 2.0 equiv). Then the tube was stirred at 120 °C sealed in air for 24 h. After the reaction was finished, the crude mixture was detected through thermal gravimetric analyzer (Figure 1). It was found that 1-ethoxy-1-hydroperoxyethane and TBHP has completely decomposed in the reaction system, which was further confirmed by the use of KI/HOAc solution.

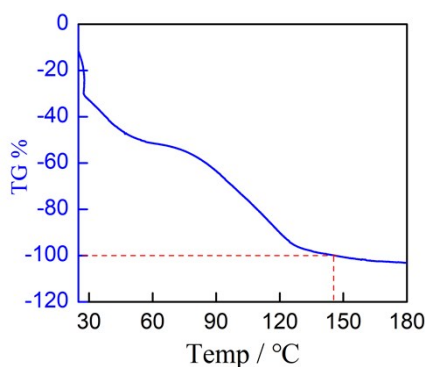
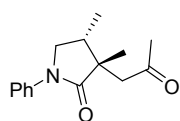


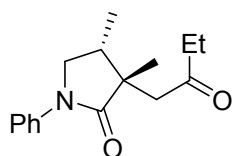
Figure 1. Thermal degradation profiles of the crude mixture

(C) Analytical data

3,4-Dimethyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one (3aa),

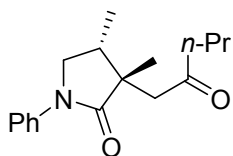


yellow oil (0.0387 g, 79% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.63 (d, J = 8.5 Hz, 2H), 7.37 (t, J = 8.0 Hz, 2H), 7.15 (t, J = 7.5 Hz, 1H), 3.96-3.92 (m, 1H), 3.47-3.44 (m, 1H), 2.86 (d, J = 18.0 Hz, 1H), 2.73 (d, J = 18.5 Hz, 1H), 2.51-2.47 (m, 1H), 2.16 (s, 3H), 1.30 (s, 3H), 1.02 (d, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.1, 177.4, 139.7, 128.8, 124.5, 120.1, 53.4, 47.1, 46.7, 36.0, 30.8, 23.5, 15.4; HRMS m/z (ESI) calcd for $\text{C}_{15}\text{H}_{20}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 246.1489, found 246.1491.



3,4-Dimethyl-3-(2-oxobutyl)-1-phenylpyrrolidin-2-one (3ab),

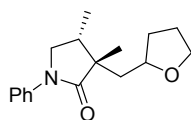
yellow solid (0.0368 g, 71% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.62 (d, J = 8.0 Hz, 2H), 7.37 (t, J = 8.0 Hz, 2H), 7.16-7.11 (m, 1H), 3.96-3.93 (m, 1H), 3.47-3.45 (m, 1H), 2.85 (d, J = 18.0 Hz, 1H), 2.70 (d, J = 18.0 Hz, 1H), 2.52-2.44 (m, 2H), 2.08-1.99 (m, 1H), 1.33 (s, 3H), 1.28 (d, J = 4.0 Hz, 3H), 1.02 (t, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 209.9, 177.4, 139.7, 128.8, 124.5, 120.1, 53.4, 47.1, 45.4, 36.7, 31.4, 23.6, 15.4, 7.8; HRMS m/z (ESI) calcd for $\text{C}_{16}\text{H}_{22}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 260.1645, found 260.1649.



3,4-Dimethyl-3-(2-oxopentyl)-1-phenylpyrrolidin-2-one (3ac),

yellow solid (0.0344 g, 63% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.62 (d, J = 8.0 Hz, 2H), 7.36 (t, J = 8.0 Hz, 2H), 7.14 (t, J = 7.5 Hz, 1H), 3.96-3.93 (m, 1H), 3.47-3.44 (m, 1H), 2.83 (d, J = 18.5 Hz, 1H), 2.69 (d, J = 18.0 Hz, 1H), 2.52-2.48 (m, 1H), 2.39 (t, J = 7.5 Hz, 2H), 1.61-1.56 (m, 2H), 1.29 (s, 3H),

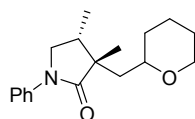
1.01 (d, $J = 7.0$ Hz, 3H), 0.90 (t, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 209.4, 177.4, 139.8, 128.8, 124.5, 120.1, 53.4, 47.1, 45.9, 45.5, 36.0, 23.5, 17.3, 15.5, 13.7; HRMS m/z (ESI) calcd for $\text{C}_{17}\text{H}_{24}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 274.1802, found 274.1800.



3,4-Dimethyl-1-phenyl-3-((tetrahydrofuran-2-

yl)methyl)pyrrolidin-2-one (4ae), yellow solid (0.0443 g, 81%

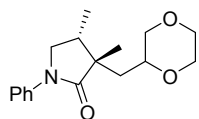
yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.64-7.62 (m, 2H), 7.36-7.33 (m, 2H), 7.11 (t, $J = 7.5$ Hz, 1H), 4.11-4.06 (m, 1H), 3.89-3.80 (m, 2H), 3.70-3.65 (m, 1H), 3.36 (t, $J = 9.0$ Hz, 1H), 2.62-2.58 (m, 1H), 2.06-2.00 (m, 1H), 1.93-1.88 (m, 2H), 1.84-1.80 (m, 1H), 1.77-1.73 (m, 1H), 1.53-1.49 (m, 1H), 1.11 (d, $J = 7.0$ Hz, 3H), 1.08 (s, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 178.8, 139.9, 128.7, 124.1, 119.7, 75.4, 67.5, 52.5, 47.0, 42.4, 33.9, 32.7, 25.4, 17.2, 13.2; HRMS m/z (ESI) calcd for $\text{C}_{17}\text{H}_{24}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 274.1802, found 274.1804.



3,4-Dimethyl-1-phenyl-3-((tetrahydro-2H-pyran-2-

yl)methyl)pyrrolidin-2-one (4af), yellow oil (0.0414 g, 72% yield,

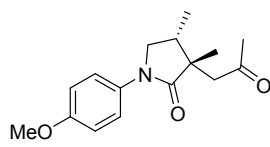
d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.63 (d, $J = 8.0$ Hz, 2H), 7.37 (t, $J = 7.5$ Hz, 2H), 7.14 (t, $J = 7.5$ Hz, 1H), 3.97-3.93 (m, 1H), 3.86-3.82 (m, 1H), 3.75-3.71 (m, 1H), 3.50-3.44 (m, 1H), 3.38-3.34 (m, 1H), 2.51-2.45 (m, 2H), 1.72-1.63 (m, 3H), 1.60-1.51 (m, 4H), 1.29 (s, 3H), 1.01 (d, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 177.4, 139.7, 128.8, 124.5, 120.0, 67.2, 62.4, 53.3, 47.1, 45.8, 35.9, 30.7, 25.5, 20.7, 19.7, 15.6; HRMS m/z (ESI) calcd for $\text{C}_{18}\text{H}_{26}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 288.1958, found 288.1954.

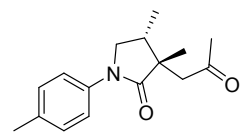


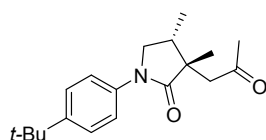
3-((1,4-Dioxan-2-yl)methyl)-3,4-dimethyl-1-phenylpyrrolidin-2-

one (4ag), yellow oil (0.0393 g, 68% yield, d.r. > 20:1); ^1H NMR (500

MHz, CDCl₃) δ : 7.63 (d, J = 9.5 Hz, 2H), 7.36 (t, J = 8.0 Hz, 2H), 7.13 (t, J = 7.5 Hz, 1H), 3.84-3.78 (m, 2H), 3.74-3.62 (m, 5H), 3.39-3.32 (m, 2H), 2.51-2.46 (m, 1H), 1.81-1.76 (m, 1H), 1.55-1.51 (m, 1H), 1.10 (d, J = 7.0 Hz, 3H), 1.07 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 178.6, 139.7, 128.8, 124.2, 119.7, 72.2, 71.5, 66.6, 66.3, 52.4, 46.3, 38.2, 34.3, 17.1, 13.1; HRMS m/z (ESI) calcd for C₁₇H₂₄NO₃ ([M+H]⁺) 290.1751, found 290.1755.

 **1-(4-Methoxyphenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3ba)**, yellow oil (0.0440 g, 80% yield, d.r. > 20:1); ¹H NMR (500 MHz, CDCl₃) δ : 7.52-7.50 (m, 2H), 6.91-6.90 (m, 2H), 3.91-3.88 (m, 1H), 3.80 (s, 3H), 3.42-3.39 (m, 1H), 2.84 (d, J = 18.5 Hz, 1H), 2.73 (d, J = 18.5 Hz, 1H), 2.49-2.45 (m, 1H), 2.16 (s, 3H), 1.29 (s, 3H), 1.02 (d, J = 7.0 Hz, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 207.1, 177.0, 156.7, 132.9, 122.0, 114.1, 55.5, 53.8, 46.8 (2), 36.2, 30.8, 23.5, 15.2; HRMS m/z (ESI) calcd for C₁₆H₂₂NO₃ ([M+H]⁺) 276.1594, found 276.1596.

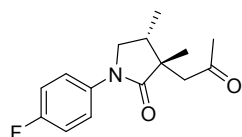
 **3,4-Dimethyl-3-(2-oxopropyl)-1-(p-tolyl)pyrrolidin-2-one (3ca)**, yellow solid (0.0409 g, 79% yield, d.r. > 20:1); ¹H NMR (500 MHz, CDCl₃) δ : 7.50 (d, J = 8.5 Hz, 2H), 7.17 (d, J = 8.5 Hz, 2H), 3.93-3.90 (m, 1H), 3.43-3.40 (m, 1H), 2.85 (d, J = 18.0 Hz, 1H), 2.72 (d, J = 18.0 Hz, 1H), 2.49-2.46 (m, 1H), 2.33 (s, 3H), 2.15 (s, 3H), 1.29 (s, 3H), 1.01 (d, J = 7.0 Hz, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 207.2, 177.1, 137.2, 134.2, 129.4, 120.2, 53.5, 47.0, 46.7, 36.0, 30.9, 23.3, 20.9, 15.4; HRMS m/z (ESI) calcd for C₁₆H₂₂NO₂ ([M+H]⁺) 260.1645, found 260.1647.



1-(4-(*tert*-Butyl)phenyl)-3,4-dimethyl-3-(2-

oxopropyl)pyrrolidin-2-one (3da), yellow oil (0.0470 g, 78%

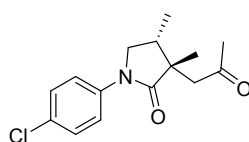
yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.56-7.54 (m, 2H), 7.40-7.38 (m, 2H), 3.96-3.92 (m, 1H), 3.45-3.42 (m, 1H), 2.87 (d, $J = 18.0$ Hz, 1H), 2.72 (d, $J = 18.0$ Hz, 1H), 2.51-2.47 (m, 1H), 2.16 (s, 3H), 1.31 (s, 9H), 1.29 (s, 3H), 1.01 (d, $J = 7.5$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.2, 177.2, 147.4, 137.1, 125.7, 119.7, 53.3, 47.0, 46.6, 35.9, 34.4, 31.3, 30.9, 23.2, 15.5; HRMS m/z (ESI) calcd for $\text{C}_{19}\text{H}_{28}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 302.2115, found 302.2117.



1-(4-Fluorophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-

2-one (3ea), yellow oil (0.0374 g, 71% yield, d.r. > 20:1); ^1H NMR

(500 MHz, CDCl_3) δ : 7.59-7.57 (m, 2H), 7.06 (t, $J = 8.5$ Hz, 2H), 3.92-3.88 (m, 1H), 3.45-3.42 (m, 1H), 2.84 (d, $J = 18.5$ Hz, 1H), 2.74 (d, $J = 18.5$ Hz, 1H), 2.49-2.45 (m, 1H), 2.16 (s, 3H), 1.29 (s, 3H), 1.02 (d, $J = 7.5$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.1, 177.4, 159.0 (d, $J_{\text{C-F}} = 242.5$ Hz), 135.7, 121.9 (d, $J_{\text{C-F}} = 8.0$ Hz), 115.5 (d, $J_{\text{C-F}} = 22.3$ Hz), 53.7, 47.0, 46.7, 35.9, 30.7, 23.9, 15.2; ^{19}F NMR (471 MHz, CDCl_3) δ : -117.8; HRMS m/z (ESI) calcd for $\text{C}_{15}\text{H}_{19}\text{FNO}_2$ ($[\text{M}+\text{H}]^+$) 264.1394, found 264.1392.



1-(4-Chlorophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-

2-one (3fa), yellow solid (0.0402 g, 72% yield, d.r. > 20:1); ^1H

NMR (500 MHz, CDCl_3) δ : 7.59-7.58 (m, 2H), 7.33-7.31 (m, 2H), 3.91-3.87 (m, 1H), 3.45-3.42 (m, 1H), 2.83 (d, $J = 18.0$ Hz, 1H), 2.73 (d, $J = 18.5$ Hz, 1H), 2.49-2.45 (m, 1H), 2.15 (s, 3H), 1.29 (s, 3H), 1.02 (d, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.0, 177.5, 138.3, 129.6, 128.8, 121.2, 53.3, 47.0, 46.9, 35.9,

30.7, 23.9, 15.2; HRMS m/z (ESI) calcd for $C_{15}H_{19}ClNO_2$ ($[M+H]^+$) 280.1099, found 280.1101.

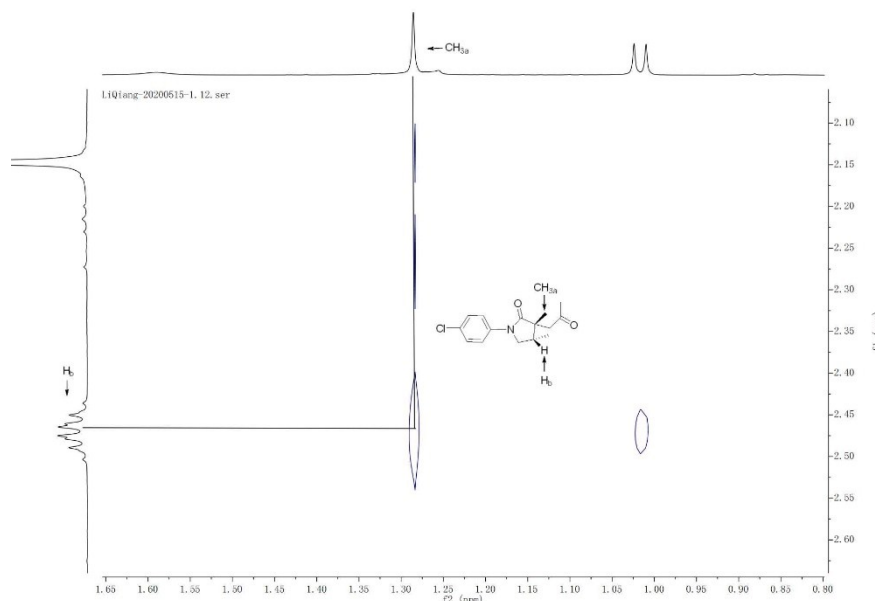
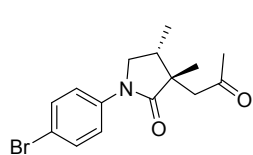


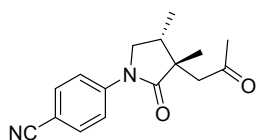
Figure 2. H-H Noesy: there is strong NOE between CH_{3a} and H_b



1-(4-Bromophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-

2-one (3ga), yellow solid (0.0452 g, 70% yield, d.r. > 20:1); 1H

NMR (500 MHz, $CDCl_3$) δ : 7.54 (d, $J = 9.0$ Hz, 2H), 7.47 (d, $J = 9.0$ Hz, 2H), 3.91-3.87 (m, 1H), 3.45-3.42 (m, 1H), 2.84 (d, $J = 18.5$ Hz, 1H), 2.74 (d, $J = 18.5$ Hz, 1H), 2.49-2.45 (m, 1H), 2.15 (s, 3H), 1.28 (s, 3H), 1.01 (d, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ : 206.9, 177.5, 138.8, 131.8, 121.5, 117.3, 53.2, 47.0, 46.9, 35.9, 30.7, 23.9, 15.1; HRMS m/z (ESI) calcd for $C_{15}H_{19}BrNO_2$ ($[M+H]^+$) 324.0594, found 324.0596.

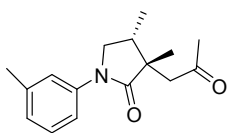


4-(3,4-Dimethyl-2-oxo-3-(2-oxopropyl)pyrrolidin-1-

yl)benzonitrile (3ha), yellow oil (0.0330 g, 61% yield, d.r. >

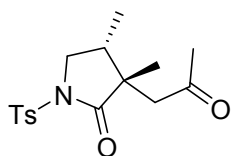
20:1); 1H NMR (500 MHz, $CDCl_3$) δ : 7.80 (d, $J = 9.0$ Hz, 2H), 7.65 (d, $J = 9.0$ Hz, 2H), 3.94-3.91 (m, 1H), 3.52-3.49 (m, 1H), 2.85 (d, $J = 18.5$ Hz,

1H), 2.77 (d, J = 18.5 Hz, 1H), 2.51-2.47 (m, 1H), 2.15 (s, 3H), 1.30 (s, 3H), 1.03 (d, J = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 206.7, 178.3, 143.5, 132.9, 119.5, 118.9, 107.2, 53.0, 47.3, 46.9, 35.7, 30.5, 24.4, 15.0; HRMS m/z (ESI) calcd for $\text{C}_{16}\text{H}_{19}\text{N}_2\text{O}_2$ ($[\text{M}+\text{H}]^+$) 271.1441, found 271.1439.



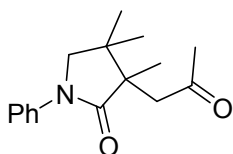
3,4-Dimethyl-3-(2-oxopropyl)-1-(*m*-tolyl)pyrrolidin-2-one (3ia),

yellow oil (0.0404 g, 78% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.42 (s, 1H), 7.32 (d, J = 8.0 Hz, 1H), 7.17 (d, J = 8.0 Hz, 1H), 6.90 (d, J = 7.5 Hz, 1H), 3.88-3.84 (m, 1H), 3.39-3.36 (m, 1H), 2.78 (d, J = 18.0 Hz, 1H), 2.65 (d, J = 18.0 Hz, 1H), 2.43-2.39 (m, 1H), 2.29 (s, 3H), 2.09 (s, 3H), 1.22 (s, 3H), 0.94 (d, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.2, 177.3, 139.6, 138.7, 128.7, 125.4, 120.9, 117.2, 53.5, 47.1, 46.7, 35.9, 30.9, 23.4, 21.6, 15.4; HRMS m/z (ESI) calcd for $\text{C}_{16}\text{H}_{22}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 260.1645, found 260.1643.



3,4-Dimethyl-3-(2-oxopropyl)-1-tosylpyrrolidin-2-one (3ja),

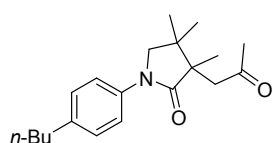
yellow oil (0.0355 g, 55% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.85 (d, J = 8.0 Hz, 2H), 7.26 (d, J = 8.0 Hz, 2H), 3.92-3.88 (m, 1H), 3.43-3.40 (m, 1H), 2.60 (d, J = 18.5 Hz, 1H), 2.49 (d, J = 18.5 Hz, 1H), 2.36 (s, 3H), 2.34-2.29 (m, 1H), 1.94 (s, 3H), 1.04 (s, 3H), 0.80 (d, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 206.0, 177.2, 145.1, 134.7, 129.6, 128.2, 51.7, 46.9, 46.6, 35.9, 30.3, 23.3, 21.7, 14.7; HRMS m/z (ESI) calcd for $\text{C}_{16}\text{H}_{22}\text{NO}_4\text{S}$ ($[\text{M}+\text{H}]^+$) 324.1264, found 324.1266.



3,4,4-Trimethyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one

(3ka), yellow oil (0.0420 g, 81% yield); ^1H NMR (500 MHz,

CDCl₃) δ : 7.61 (d, J = 8.0 Hz, 2H), 7.37 (t, J = 7.5 Hz, 2H), 7.15 (t, J = 7.5 Hz, 1H), 3.59 (d, J = 9.5 Hz, 1H), 3.41 (d, J = 9.5 Hz, 1H), 2.97 (d, J = 17.0 Hz, 1H), 2.61 (d, J = 17.0 Hz, 1H), 2.21 (s, 3H), 1.26 (s, 3H), 1.24 (s, 3H), 1.09 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 207.5, 177.5, 139.6, 128.9, 124.5, 119.8, 59.3, 50.6, 46.5, 38.4, 31.9, 24.9, 22.7, 18.0; HRMS m/z (ESI) calcd for C₁₆H₂₂NO₂ ([M+H]⁺) 260.1645, found 260.1649.



1-(4-Butylphenyl)-3,4,4-trimethyl-3-(2-oxopropyl)pyrrolidin-

2-one (3la), yellow oil (0.0523 g, 83% yield); ¹H NMR (500 MHz,

CDCl₃) δ : 7.50 (d, J = 8.5 Hz, 2H), 7.18 (d, J = 8.5 Hz, 2H), 3.57

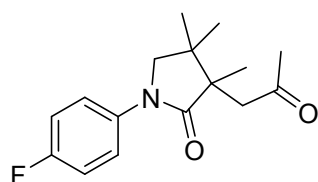
(d, J = 9.5 Hz, 1H), 3.38 (d, J = 9.5 Hz, 1H), 2.96 (d, J = 16.5 Hz, 1H), 2.62-2.57 (m,

3H), 2.21 (s, 3H), 1.59-1.56 (m, 2H), 1.37-1.32 (m, 2H), 1.25 (s, 3H), 1.23 (s, 3H), 1.08

(s, 3H), 0.90 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 207.6, 177.3, 139.3, 137.2, 128.8,

119.8, 59.4, 50.5, 46.5, 38.5, 35.0, 33.7, 31.9, 24.9, 22.7, 22.3, 18.0, 14.0; HRMS m/z

(ESI) calcd for C₂₀H₃₀NO₂ ([M+H]⁺) 316.2271, found 316.2273.



1-(4-Fluorophenyl)-3,4,4-trimethyl-3-(2-

oxopropyl)pyrrolidin-2-one (3ma), yellow oil (0.0432 g,

78% yield); ¹H NMR (500 MHz, CDCl₃) δ : 7.58-7.55 (m,

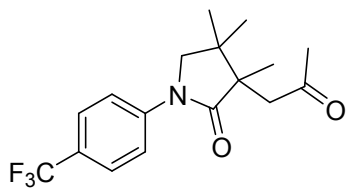
2H), 7.06 (t, J = 8.5 Hz, 2H), 3.56 (d, J = 9.5 Hz, 1H), 3.37 (d, J = 9.5 Hz, 1H), 2.96

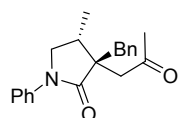
(d, J = 17.0 Hz, 1H), 2.62 (d, J = 17.0 Hz, 1H), 2.21 (s, 3H), 1.25 (s, 3H), 1.24 (s, 3H),

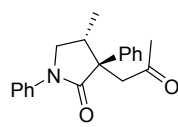
1.09 (s, 3H); ¹³C NMR (125 MHz, CDCl₃) δ : 207.4, 177.4, 159.0 (d, J_{C-F} = 242.8 Hz),

135.6, 121.5 (d, J_{C-F} = 7.8 Hz), 115.5 (d, J_{C-F} = 22.3 Hz), 59.6, 50.4, 46.5, 38.4, 31.8,

24.8, 22.8, 18.1; ^{19}F NMR (471 MHz, CDCl_3) δ : -117.7; HRMS m/z (ESI) calcd for $\text{C}_{16}\text{H}_{21}\text{FNO}_2$ ($[\text{M}+\text{H}]^+$) 278.1551, found 278.1555.

 **3,4,4-Trimethyl-3-(2-oxopropyl)-1-(4-(trifluoromethyl)phenyl)pyrrolidin-2-one (3na)**, yellow oil (0.0471 g, 72% yield); ^1H NMR (500 MHz, CDCl_3) δ : 7.77 (d, $J = 8.5$ Hz, 2H), 7.62 (d, $J = 9.0$ Hz, 2H), 3.60 (d, $J = 9.5$ Hz, 1H), 3.44 (d, $J = 9.0$ Hz, 1H), 2.96 (d, $J = 17.0$ Hz, 1H), 2.63 (d, $J = 17.0$ Hz, 1H), 2.21 (s, 3H), 1.27 (s, 3H), 1.25 (s, 3H), 1.10 (s, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.1, 178.1, 130.9, 128.8, 126.0 (q, $J_{\text{C-F}} = 2.8$ Hz), 124.0 (q, $J_{\text{C-F}} = 67.4$ Hz), 119.1, 59.1, 50.6, 46.5, 38.3, 31.7, 24.9, 22.8, 18.2; ^{19}F NMR (471 MHz, CDCl_3) δ : -62.1; HRMS m/z (ESI) calcd for $\text{C}_{17}\text{H}_{21}\text{F}_3\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 328.1519, found 328.1517.

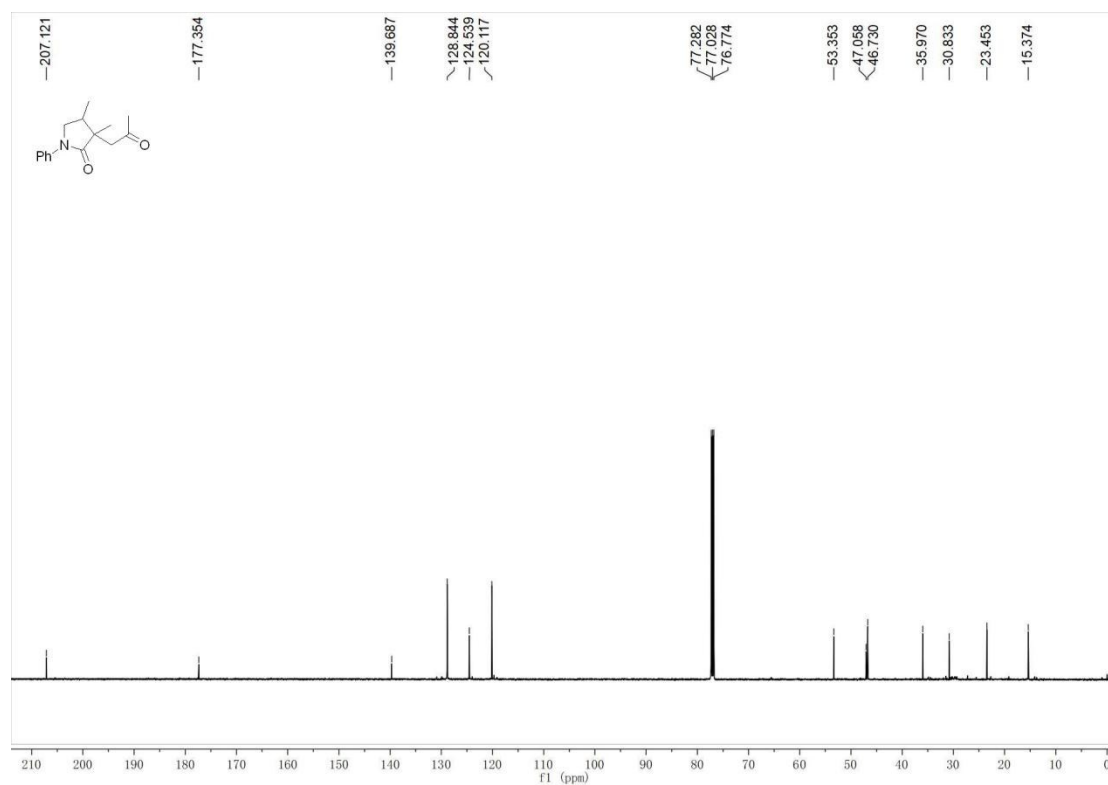
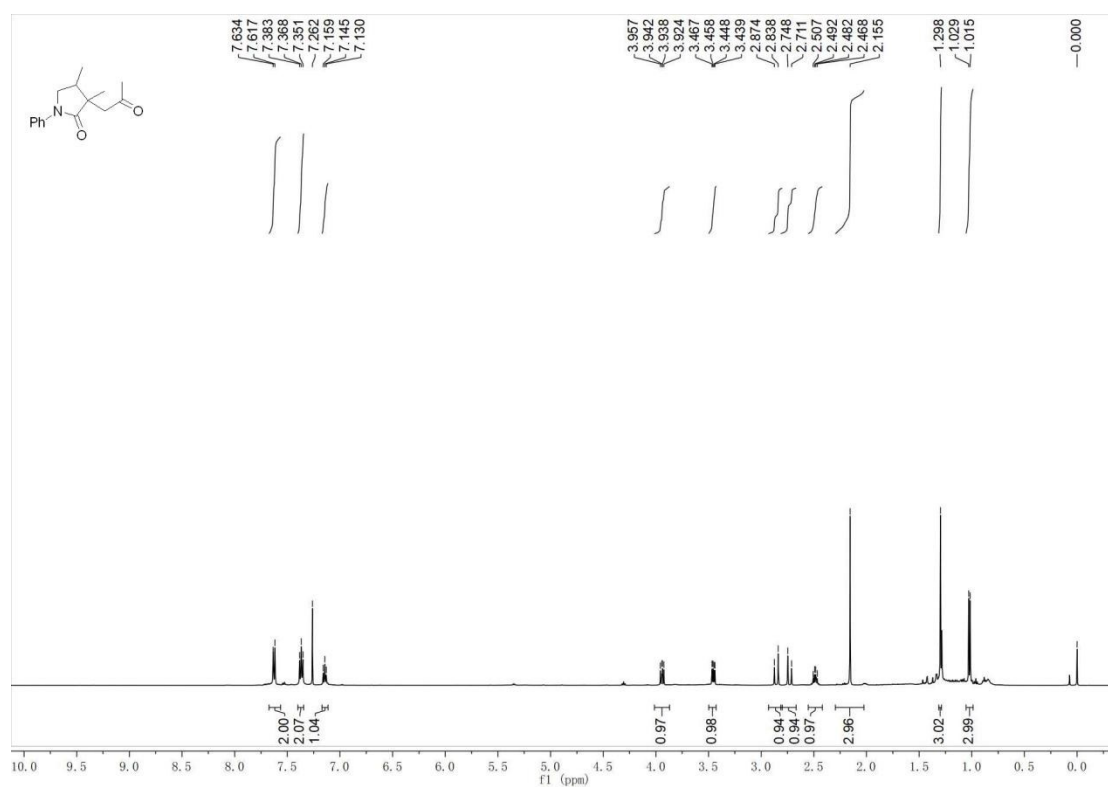
 **3-Benzyl-4-methyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one (3oa)**, colorless oil (0.0494 g, 77% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.47 (d, $J = 8.0$ Hz, 2H), 7.34 (t, $J = 8.0$ Hz, 2H), 7.24-7.22 (m, 3H), 7.20-7.18 (m, 2H), 7.14 (t, $J = 7.0$ Hz, 1H), 3.27-3.25 (m, 2H), 3.05 (d, $J = 13.5$ Hz, 1H), 2.96 (d, $J = 13.5$ Hz, 1H), 2.91-2.82 (m, 2H), 2.65-2.61 (m, 1H), 2.16 (s, 3H), 0.93 (d, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 207.2, 176.1, 139.3, 137.0, 130.4, 128.8, 128.3, 126.9, 124.7, 120.6, 53.7, 51.5, 47.0, 43.4, 32.1, 30.8, 15.7; HRMS m/z (ESI) calcd for $\text{C}_{21}\text{H}_{24}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 322.1802, found 322.1804.

 **4-Methyl-3-(2-oxopropyl)-1,3-diphenylpyrrolidin-2-one (3pa)**, yellow oil (0.0448 g, 73% yield, d.r. > 20:1); ^1H NMR (500 MHz, CDCl_3) δ : 7.60 (d, $J = 8.0$ Hz, 1H), 7.55 (d, $J = 7.5$ Hz, 2H), 7.37-7.30 (m, 5H), 7.24

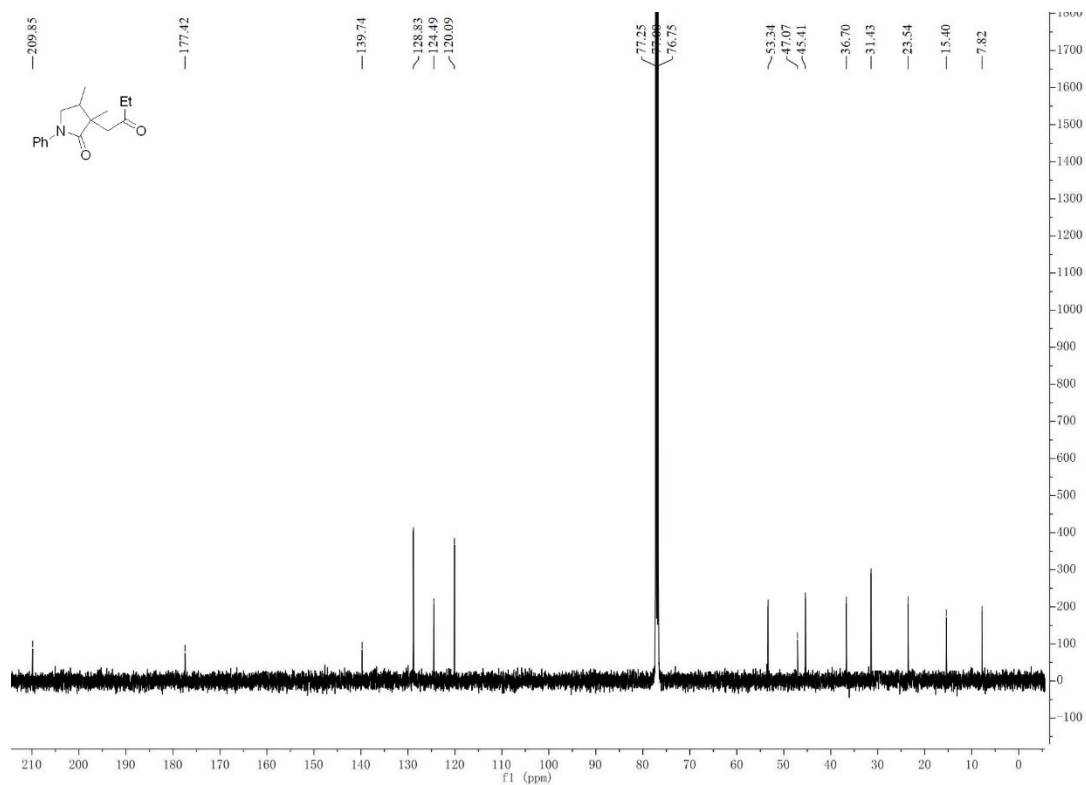
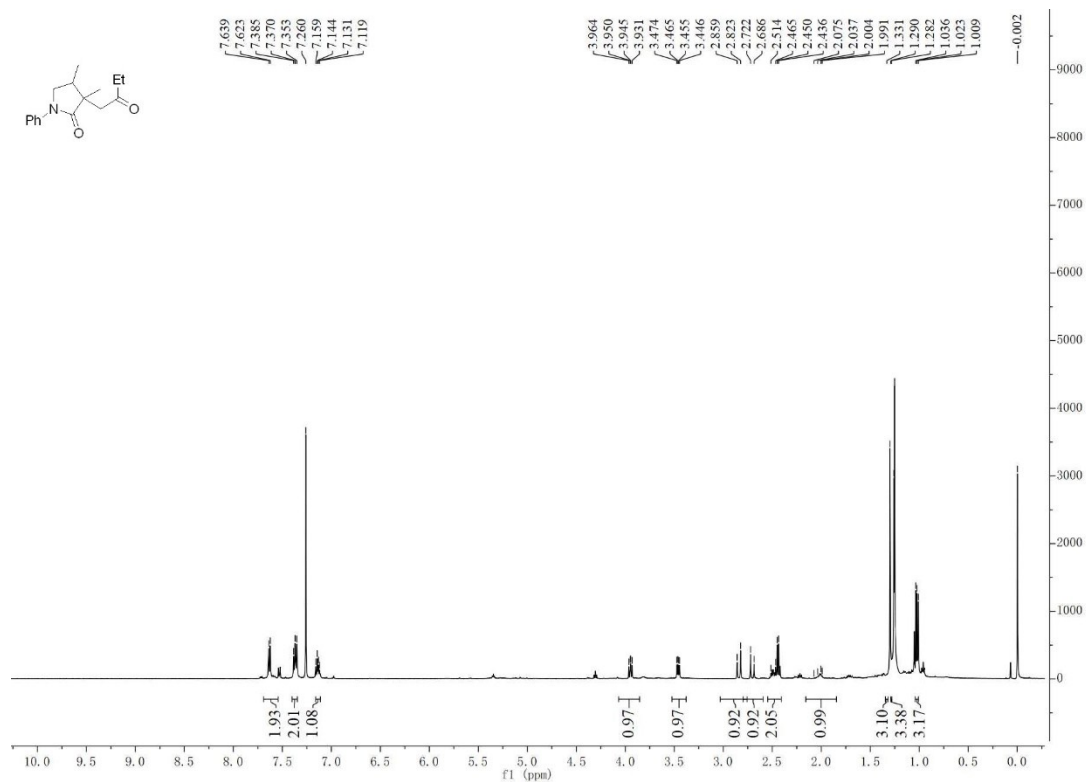
(t, $J = 7.5$ Hz, 1H), 7.14 (t, $J = 8.0$ Hz, 1H), 3.87-3.84 (m, 1H), 3.47-3.45 (m, 1H), 3.37 (d, $J = 18.0$ Hz, 1H), 3.29-3.27 (m, 1H), 3.04 (d, $J = 18.0$ Hz, 1H), 2.00 (s, 3H), 1.21 (d, $J = 7.0$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ : 206.7, 174.8, 140.7, 139.6, 128.8, 128.6, 127.2, 126.6, 124.6, 120.1, 55.2, 53.3, 47.5, 34.8, 31.2, 16.1; HRMS m/z (ESI) calcd for $\text{C}_{20}\text{H}_{22}\text{NO}_2$ ($[\text{M}+\text{H}]^+$) 308.1645, found 308.1647.

(D) Spectra

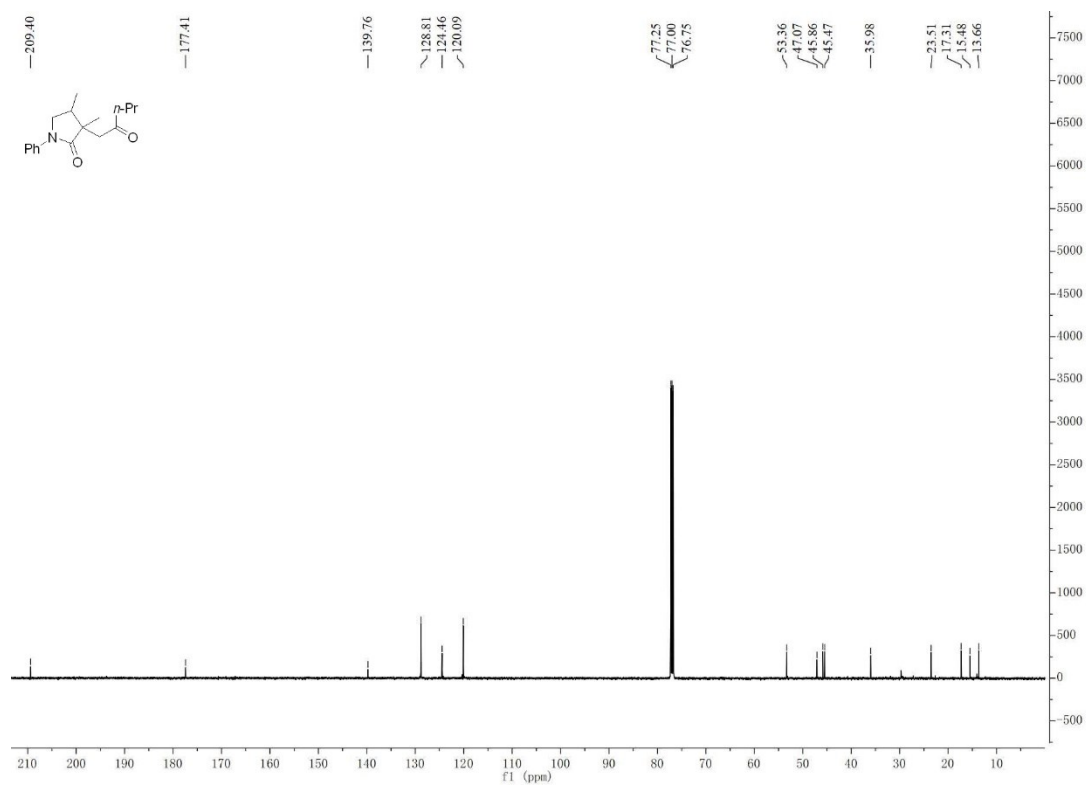
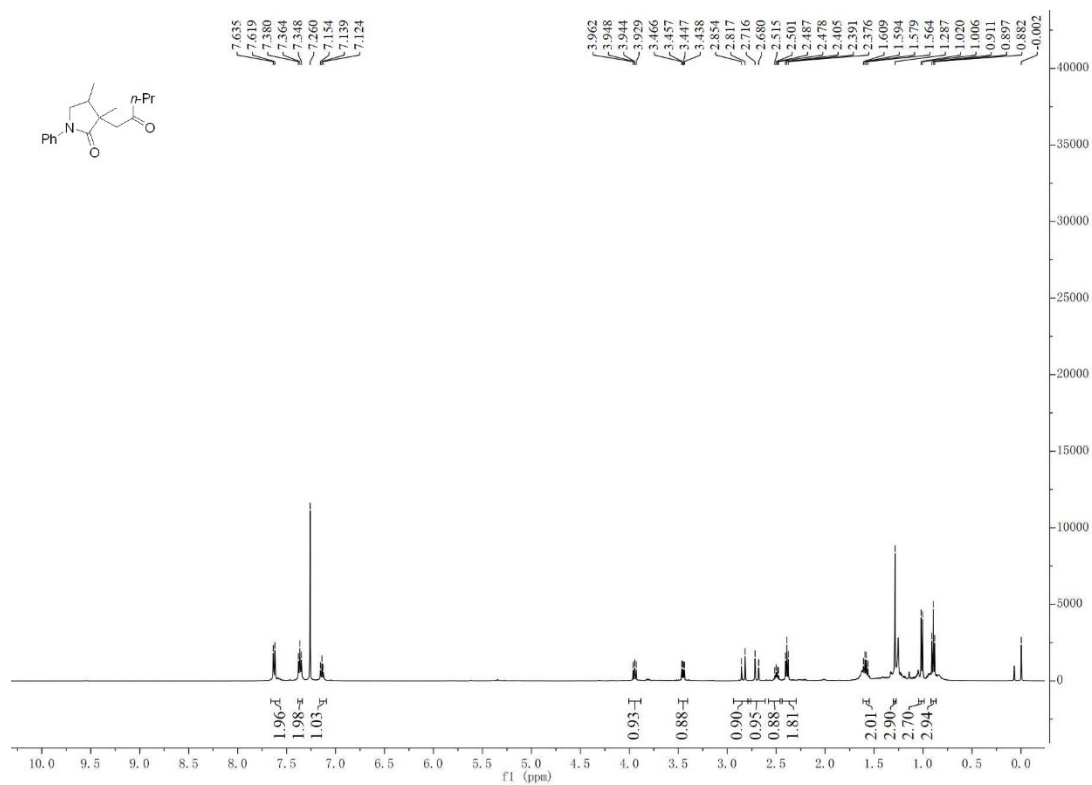
3,4-Dimethyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one (3aa)



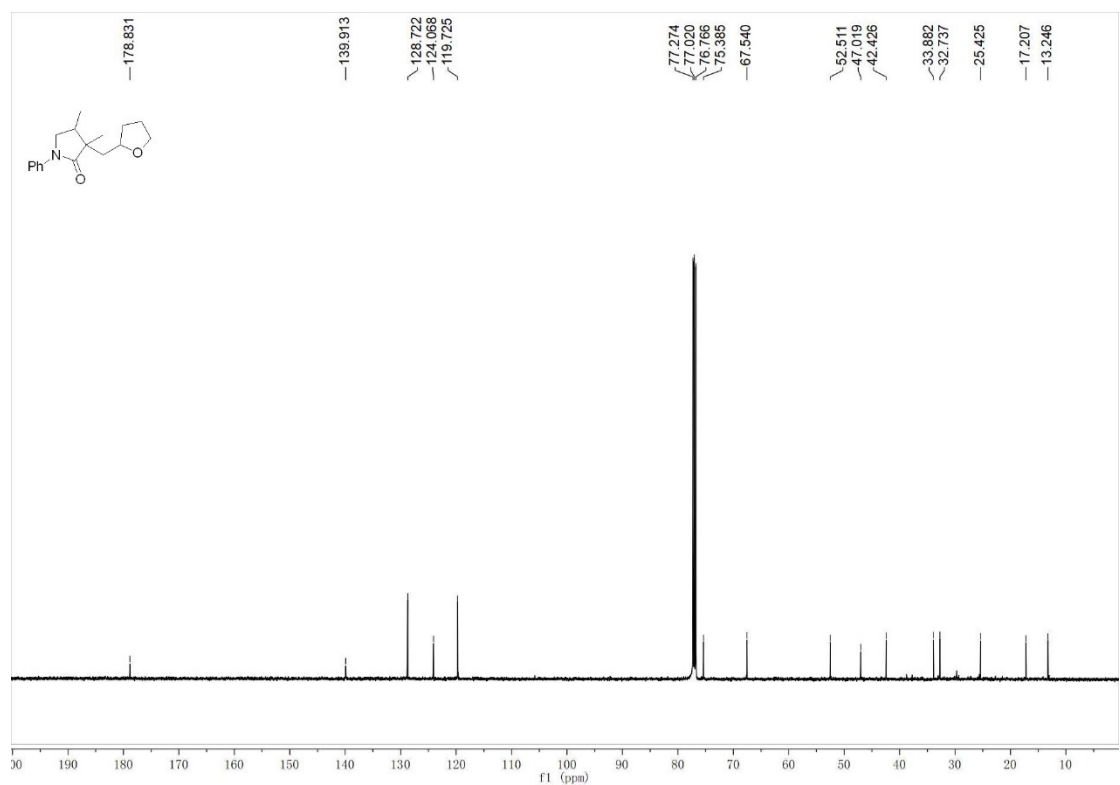
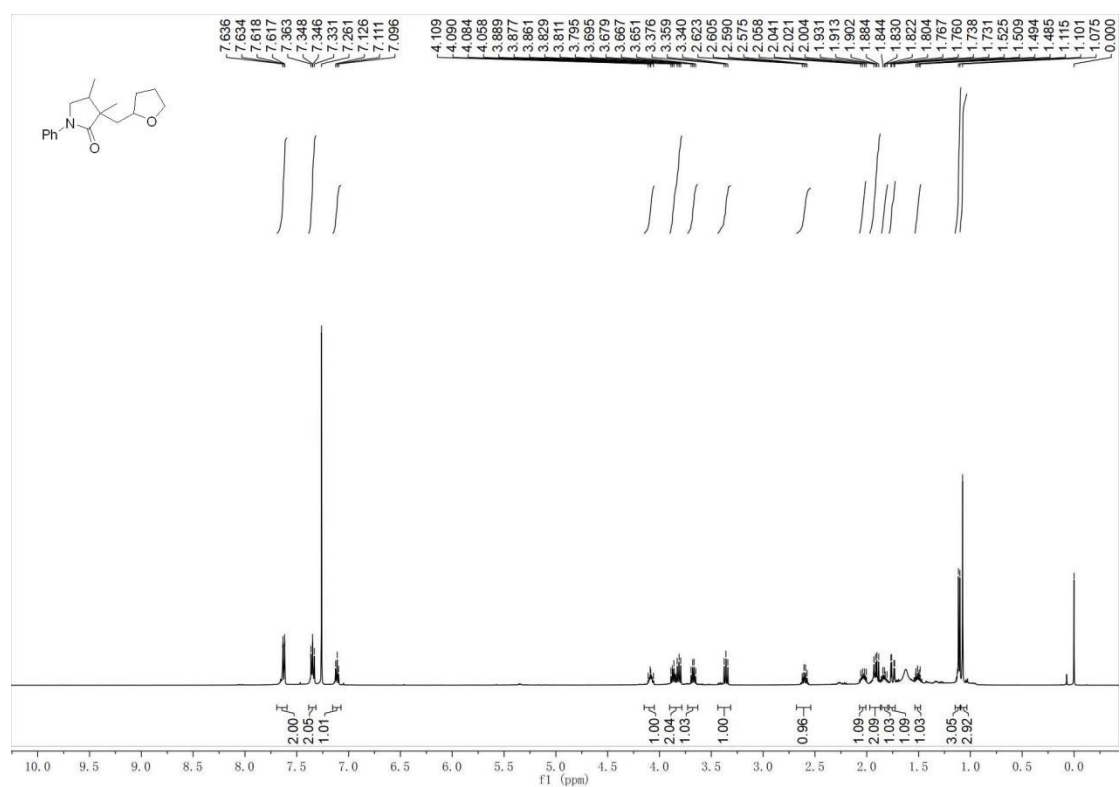
3,4-Dimethyl-3-(2-oxobutyl)-1-phenylpyrrolidin-2-one (3ab)



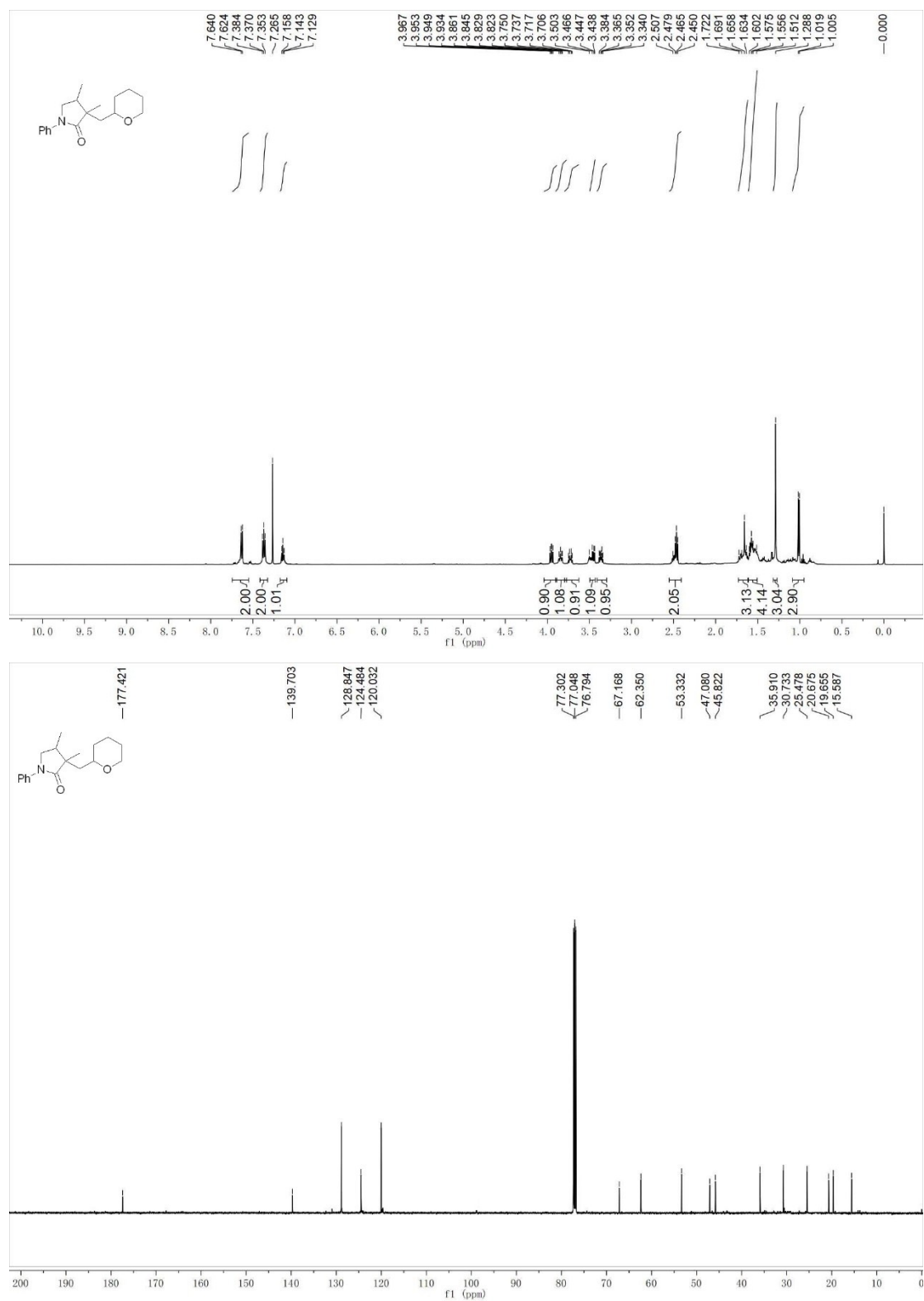
3,4-Dimethyl-3-(2-oxopentyl)-1-phenylpyrrolidin-2-one (3ac)



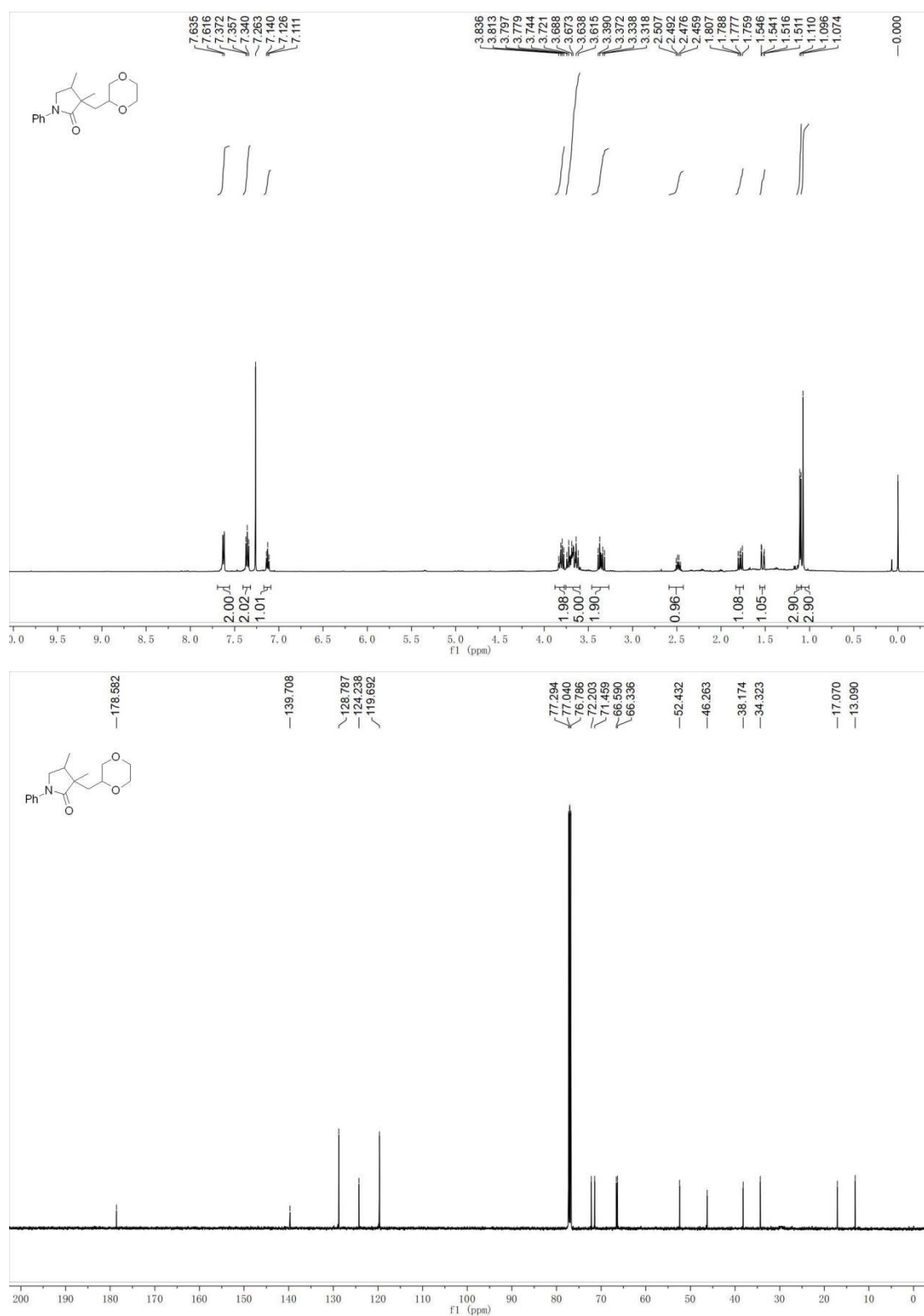
3,4-Dimethyl-1-phenyl-3-((tetrahydrofuran-2-yl)methyl)pyrrolidin-2-one (4ae)



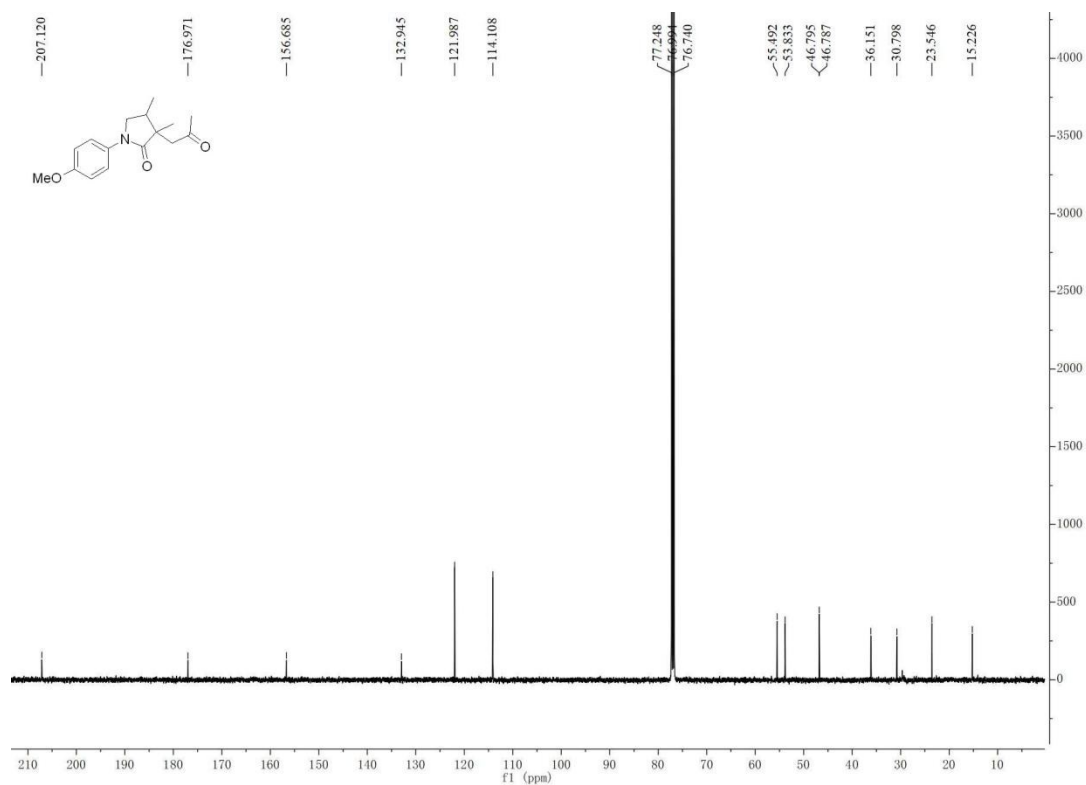
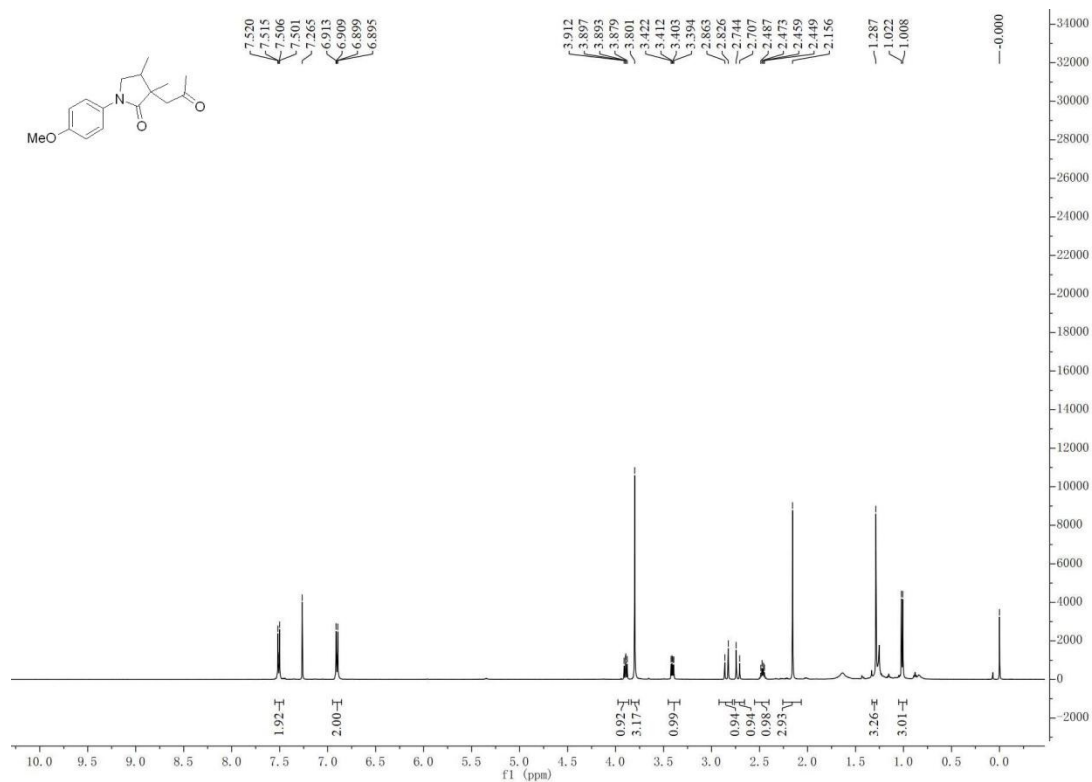
3,4-Dimethyl-1-phenyl-3-((tetrahydro-2H-pyran-2-yl)methyl)pyrrolidin-2-one (4af)



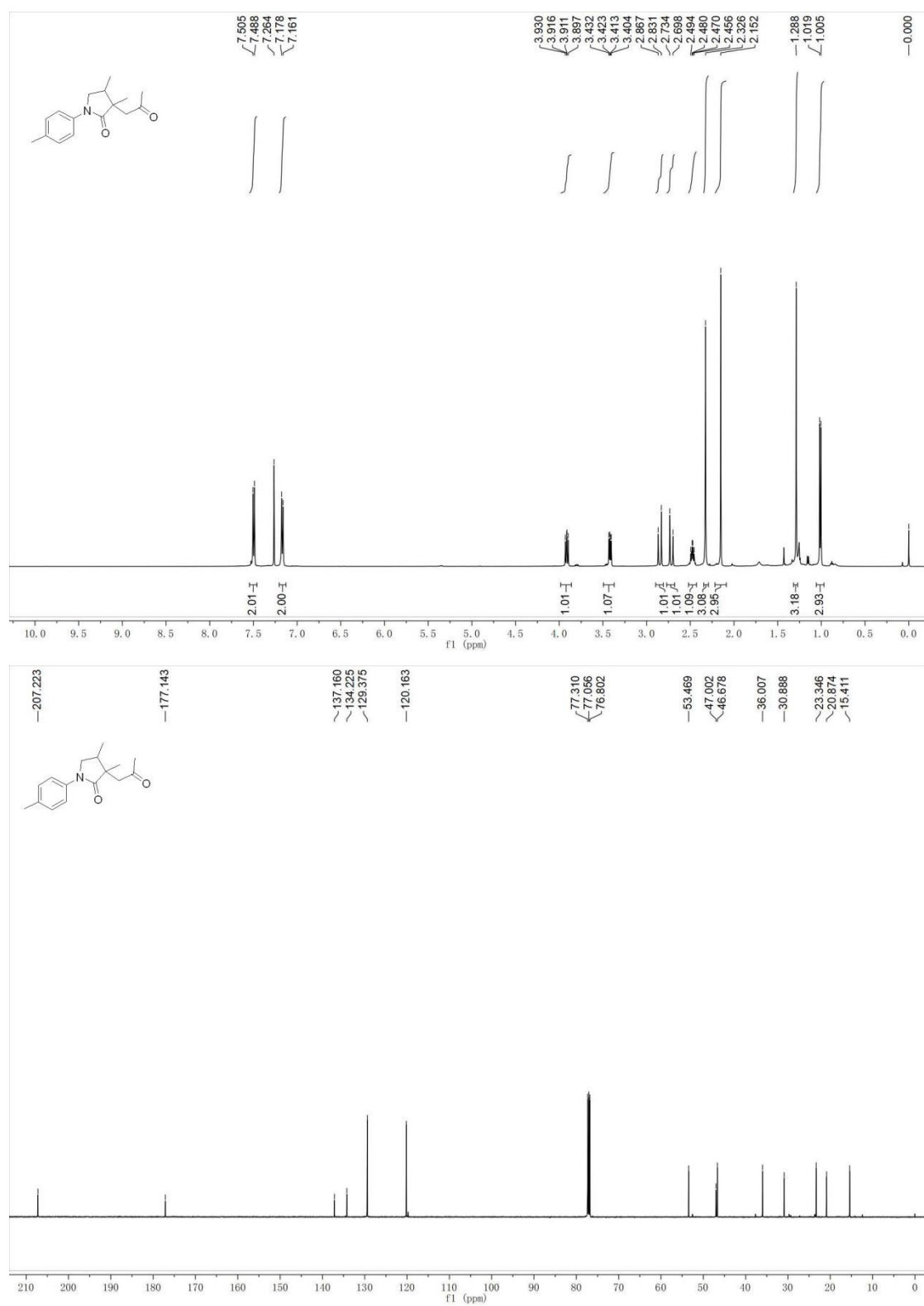
3-((1,4-Dioxan-2-yl)methyl)-3,4-dimethyl-1-phenylpyrrolidin-2-one (4ag)



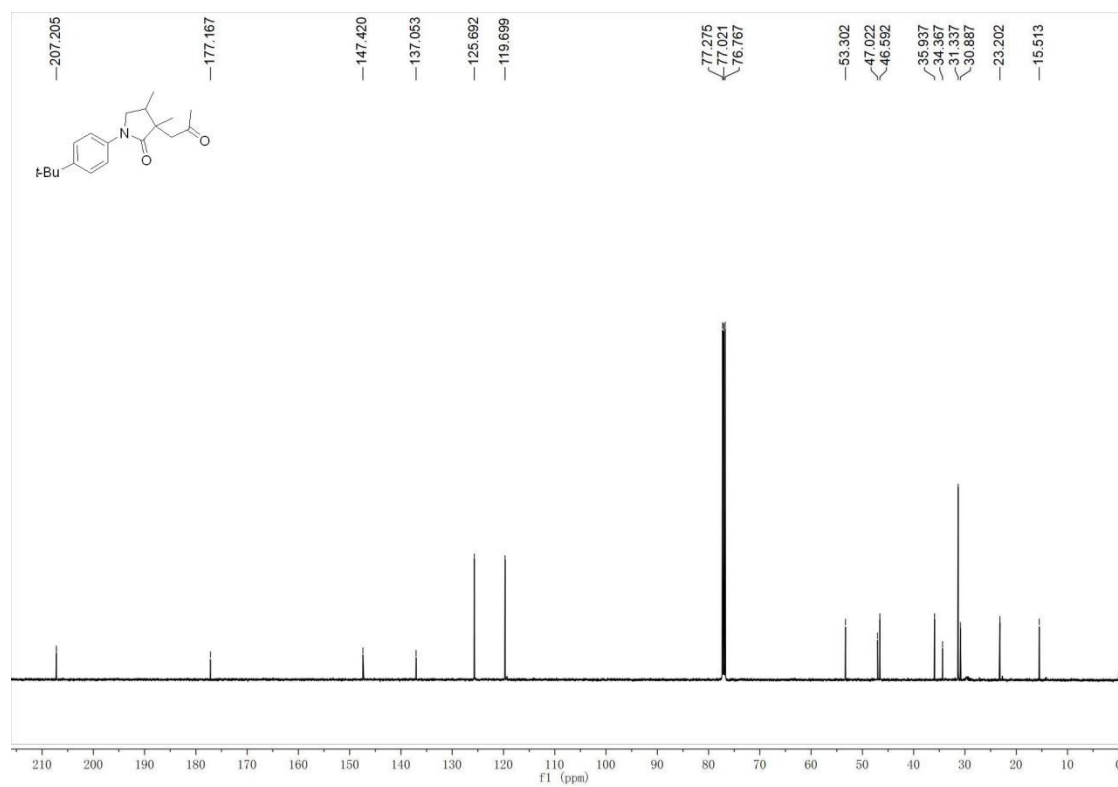
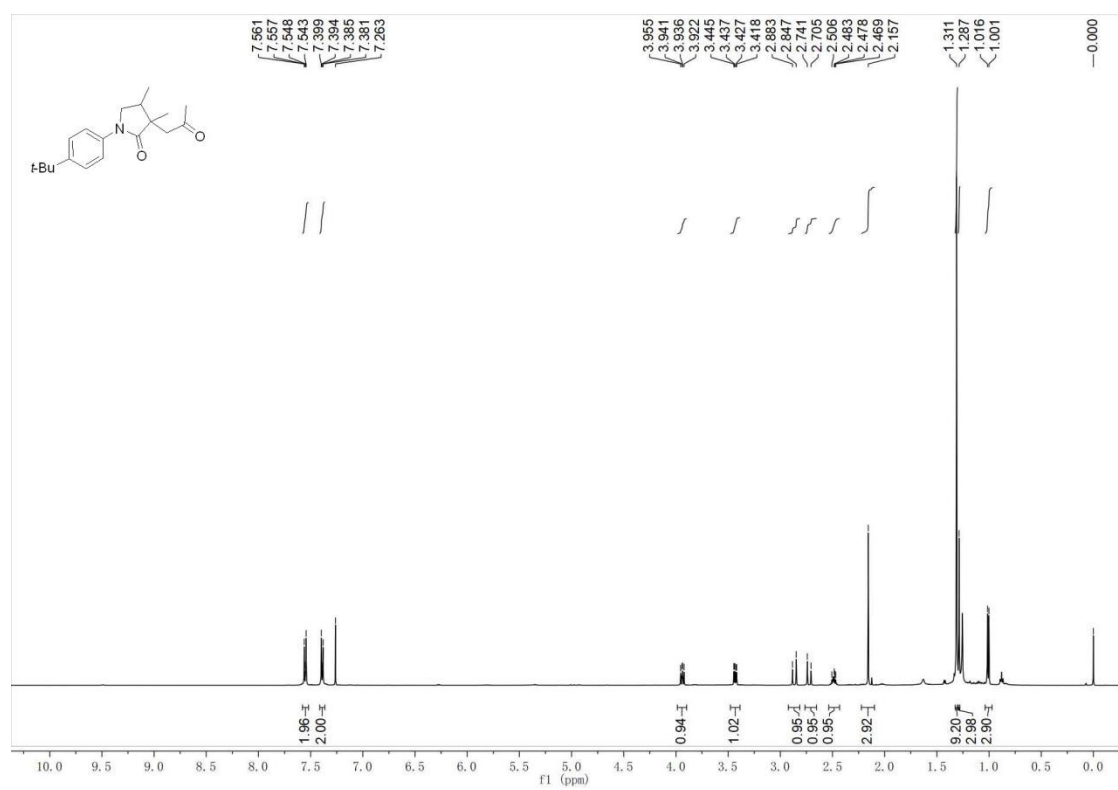
1-(4-Methoxyphenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3ba)



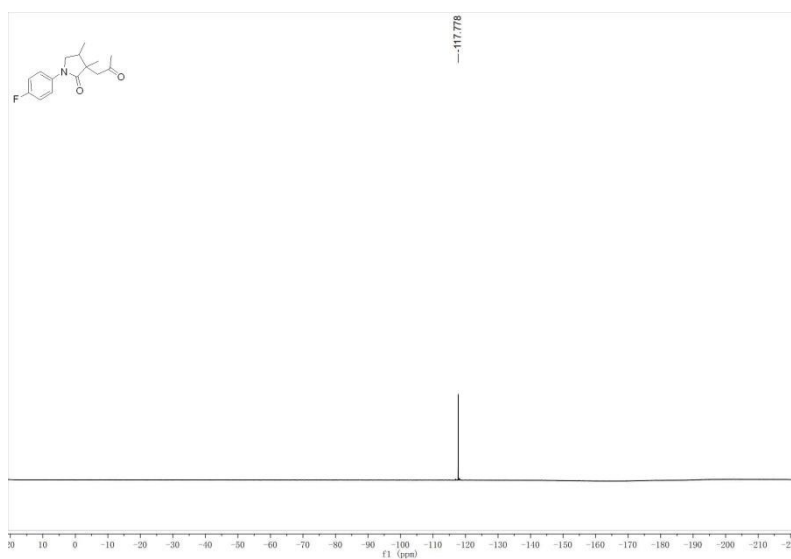
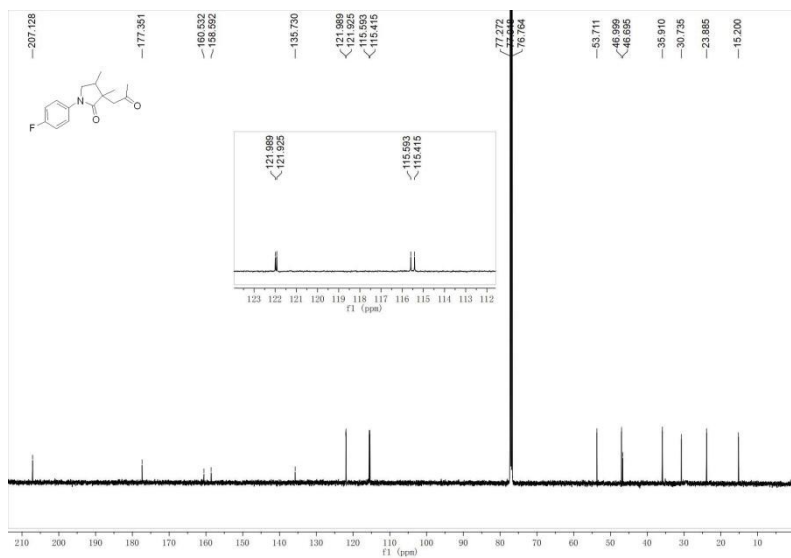
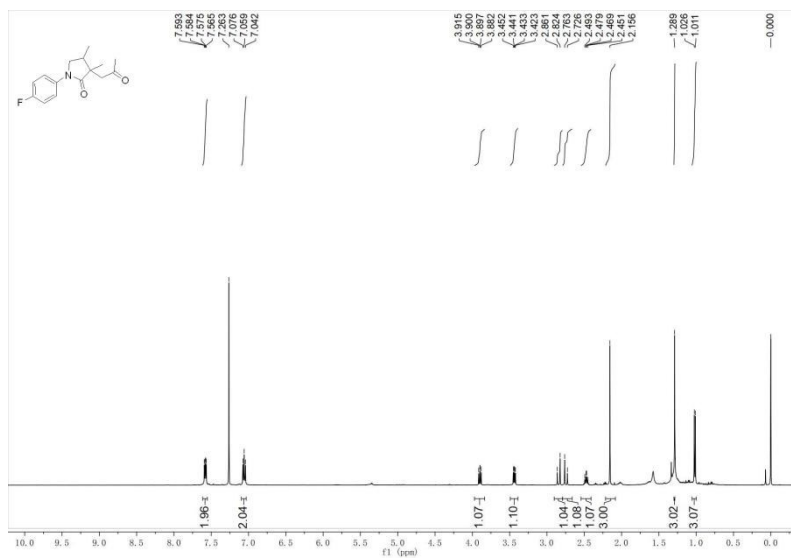
3,4-Dimethyl-3-(2-oxopropyl)-1-(*p*-tolyl)pyrrolidin-2-one (3ca)



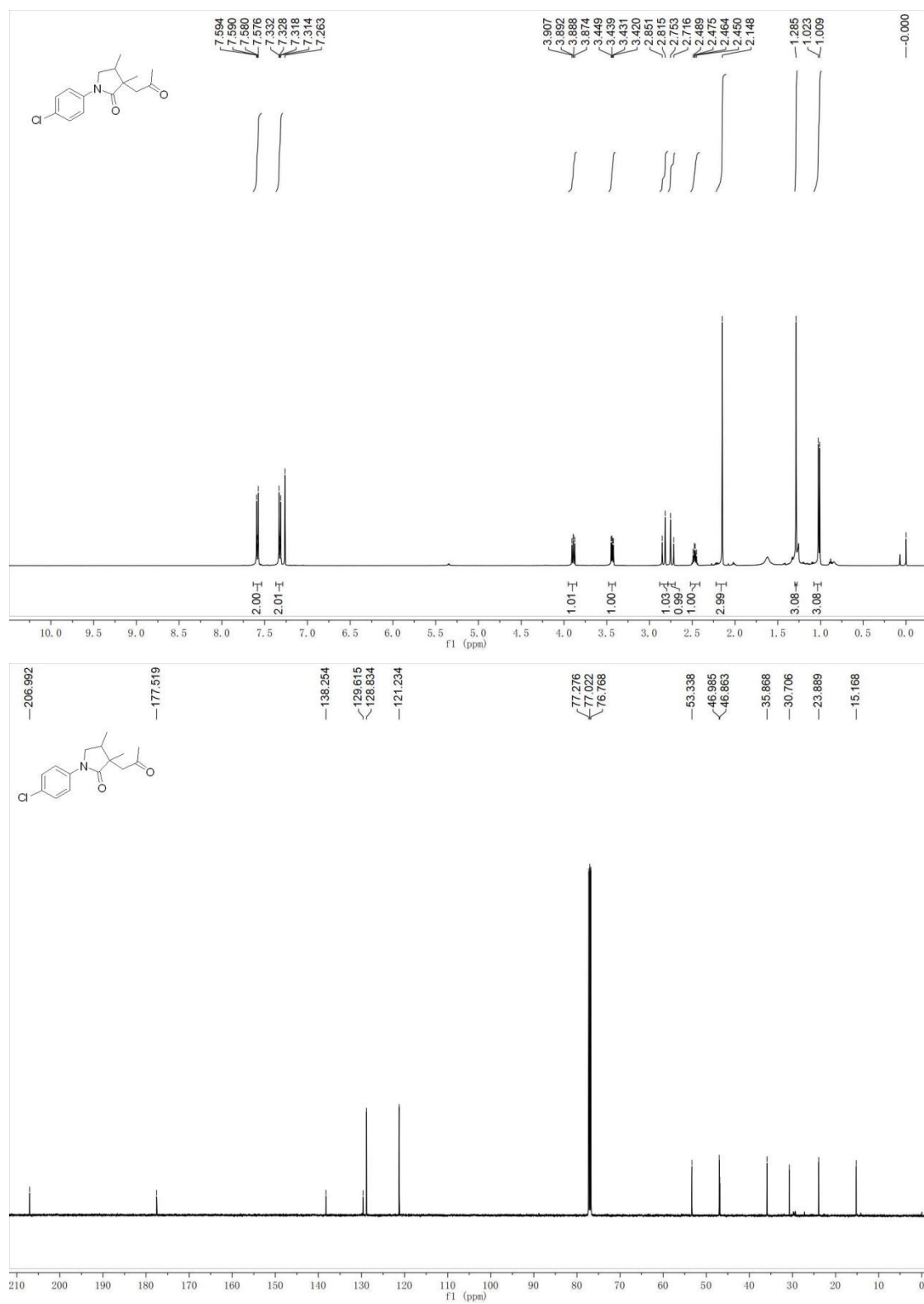
1-(4-(*tert*-Butyl)phenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3da)



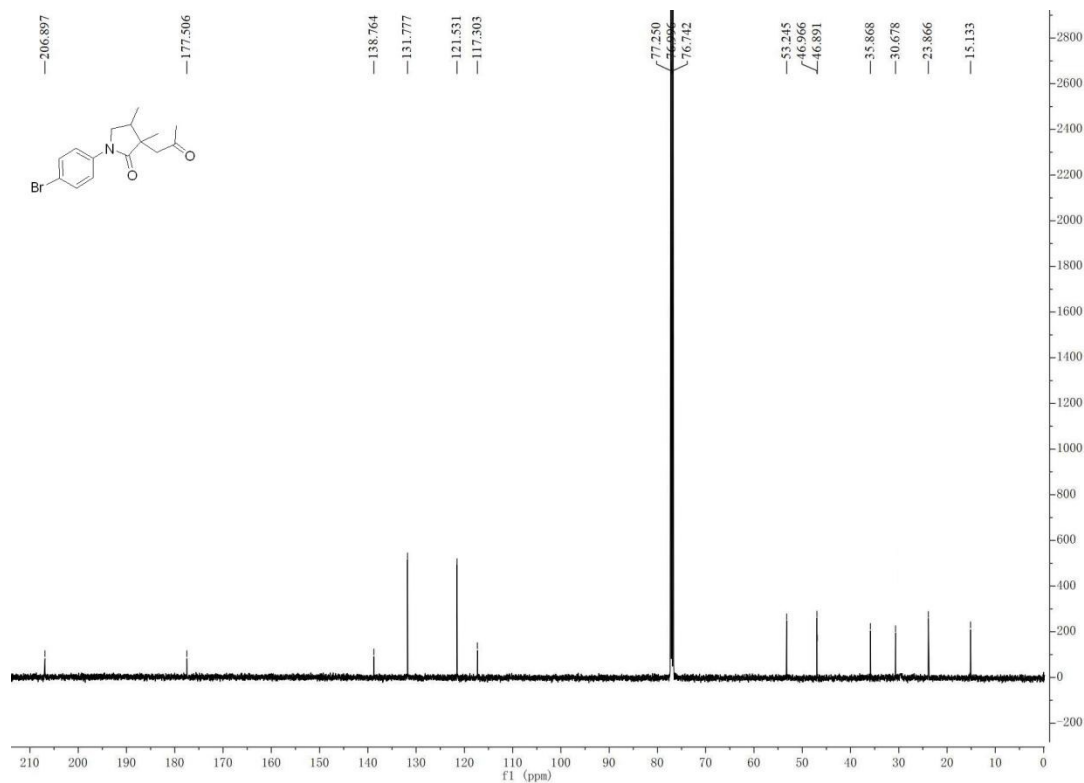
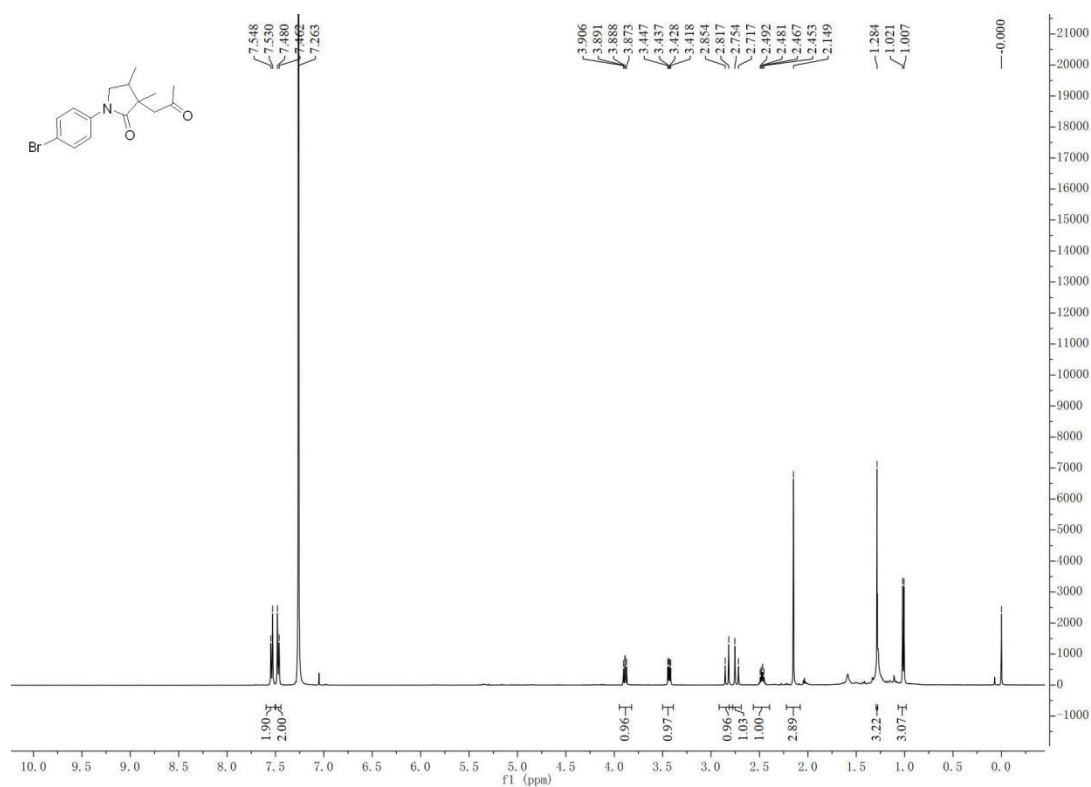
1-(4-Fluorophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3ea)



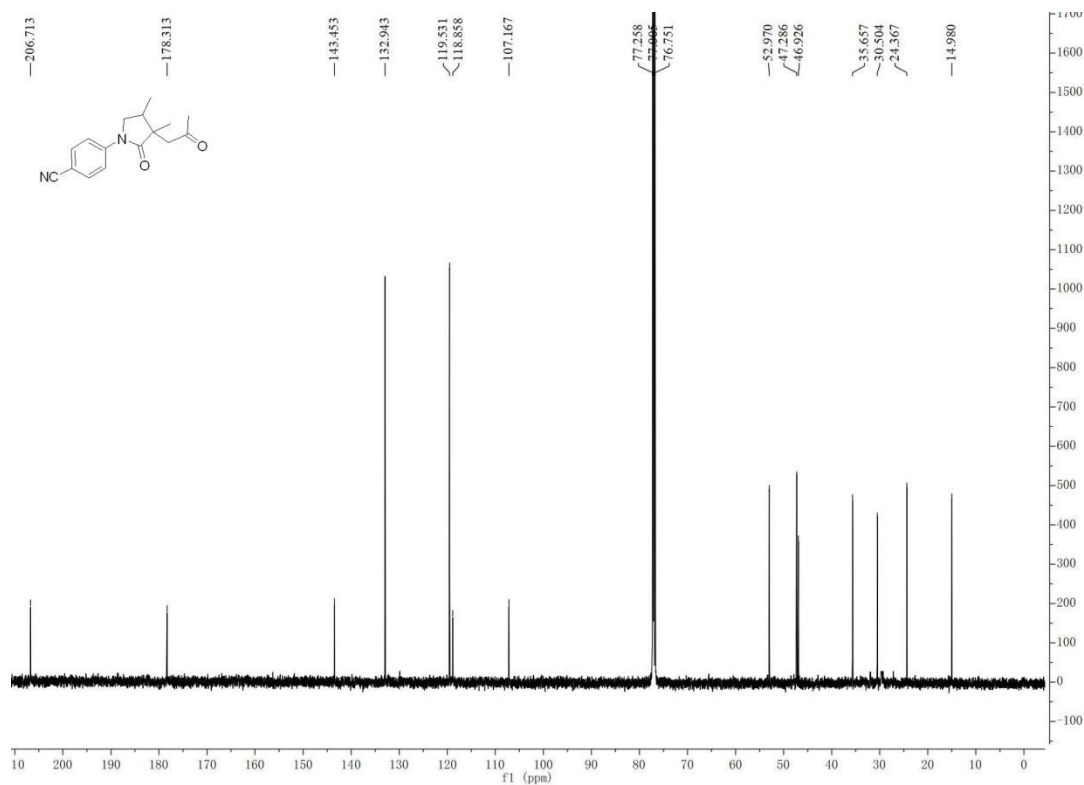
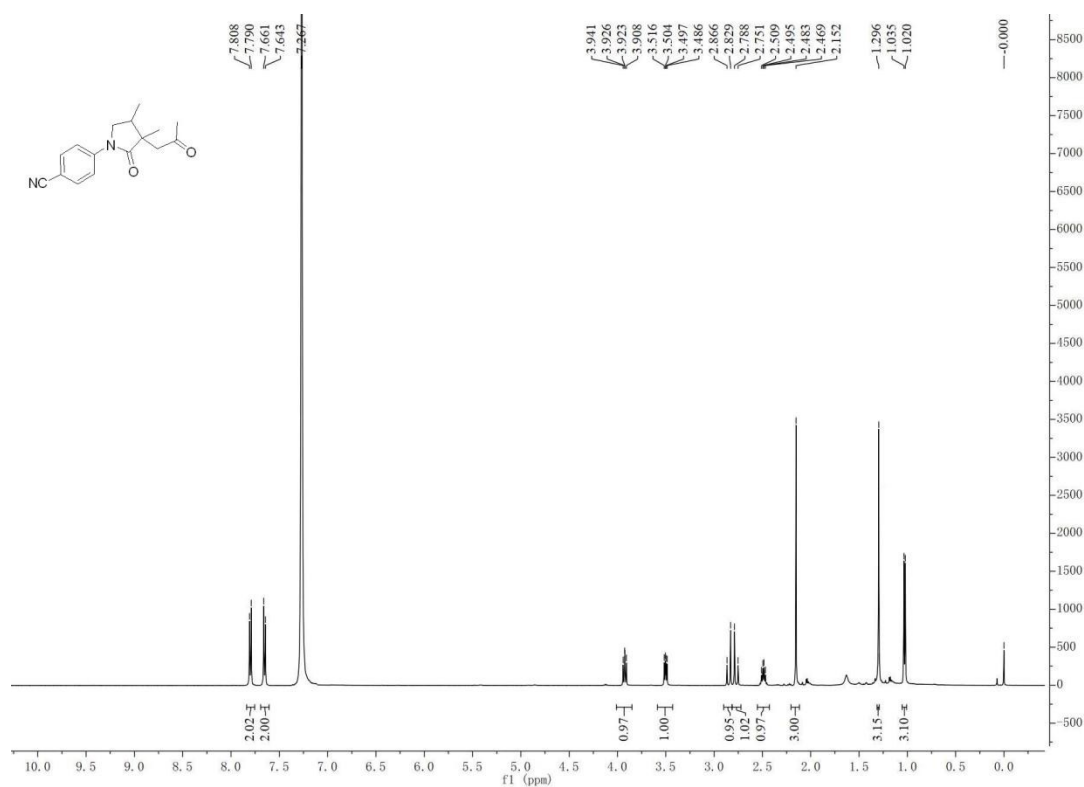
1-(4-Chlorophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3fa)



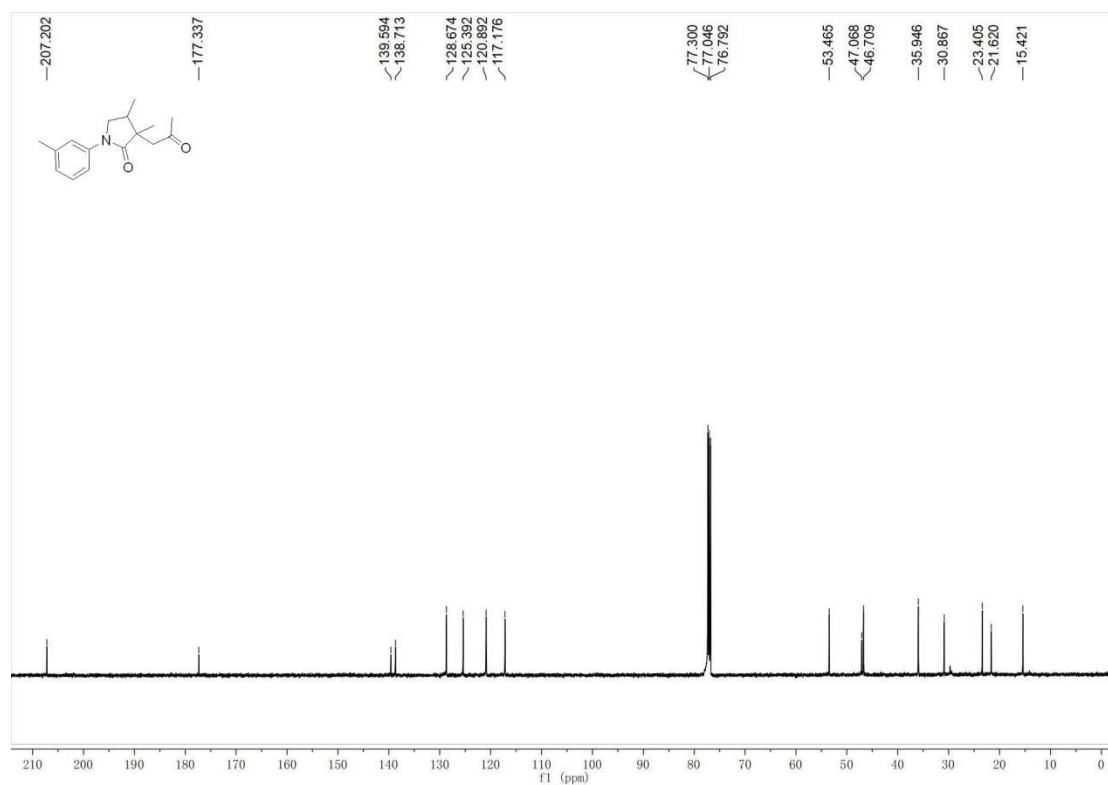
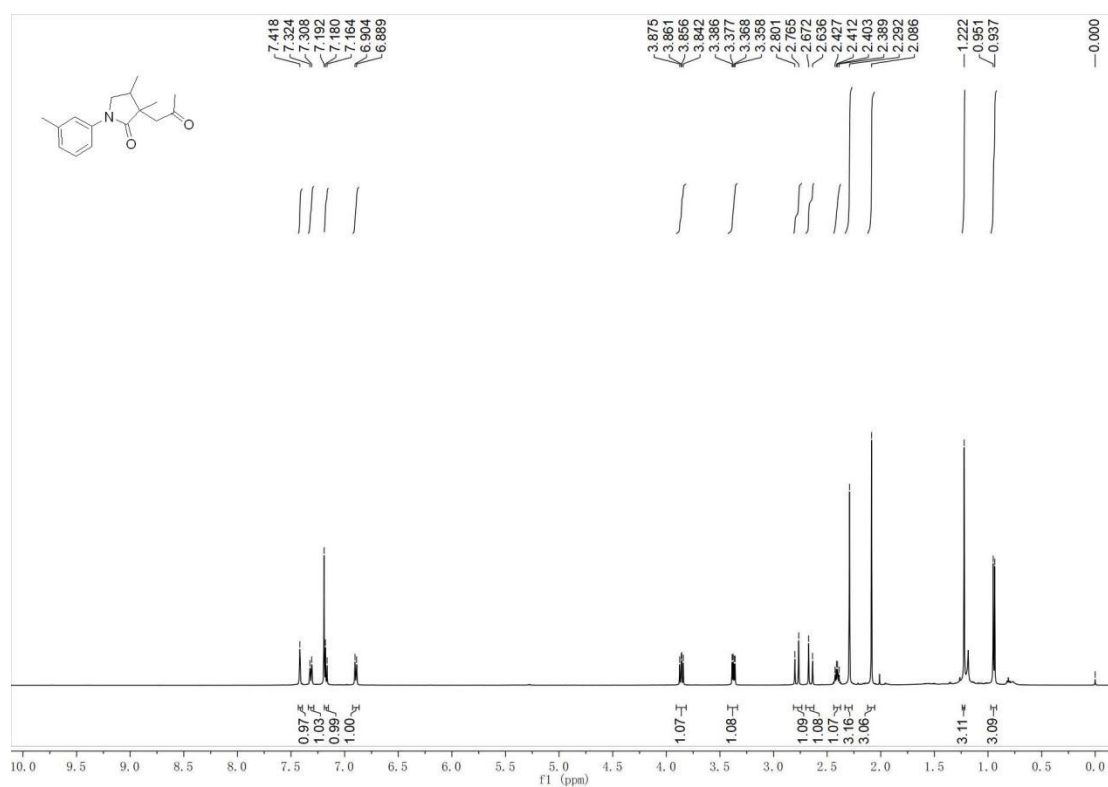
1-(4-Bromophenyl)-3,4-dimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3ga)



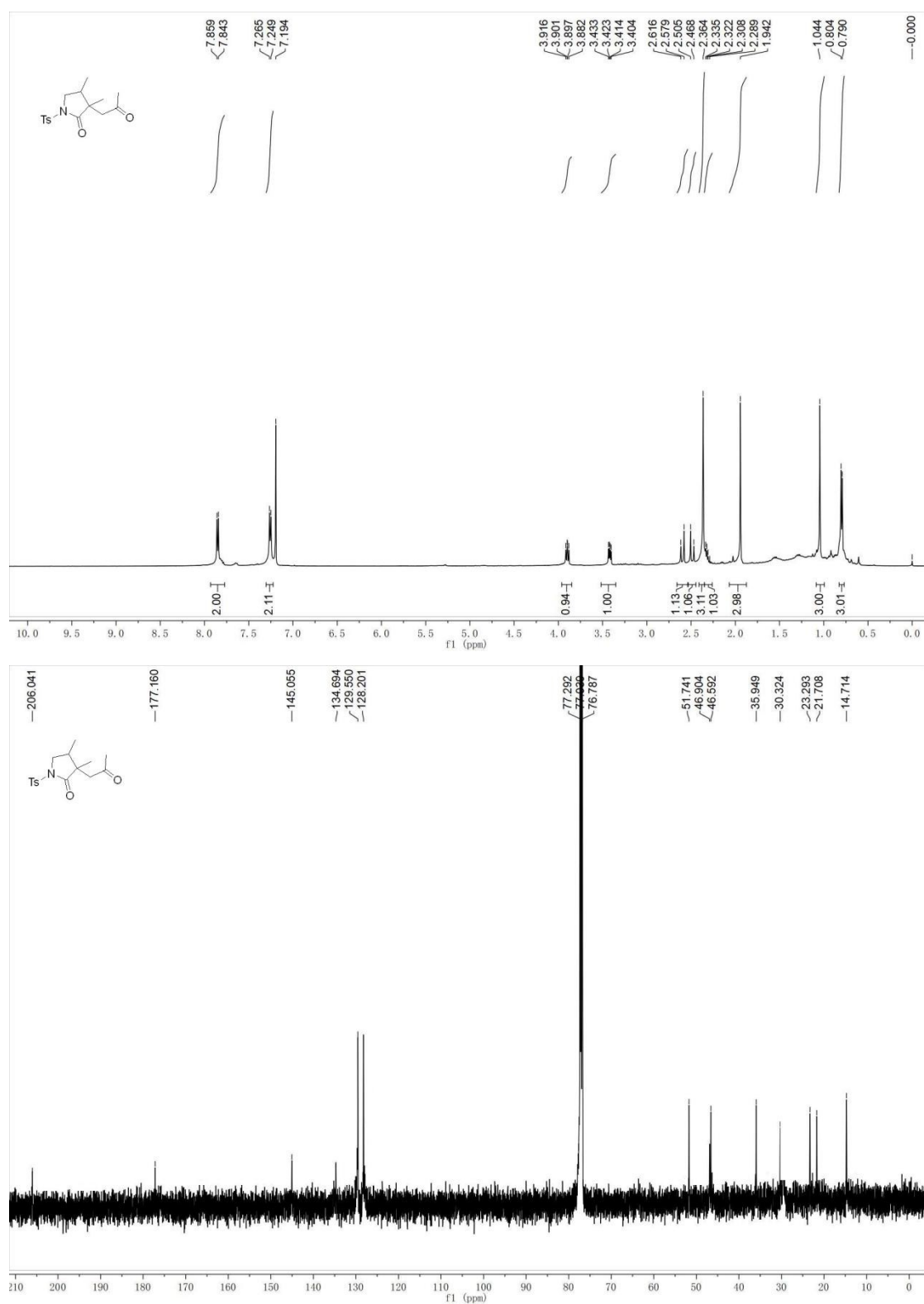
4-(3,4-Dimethyl-2-oxo-3-(2-oxopropyl)pyrrolidin-1-yl)benzonitrile (3ha)



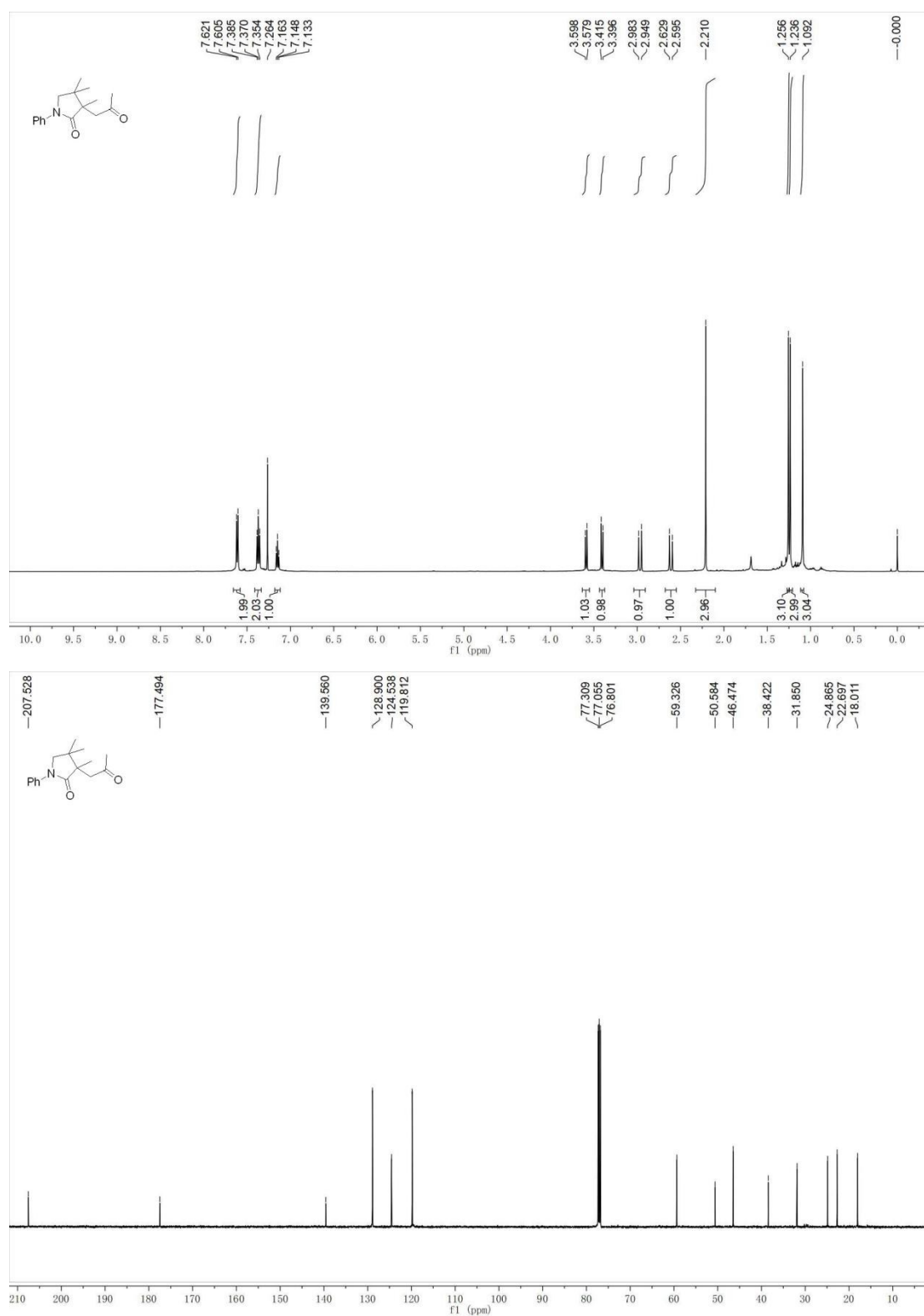
3,4-Dimethyl-3-(2-oxopropyl)-1-(*m*-tolyl)pyrrolidin-2-one (3ia)



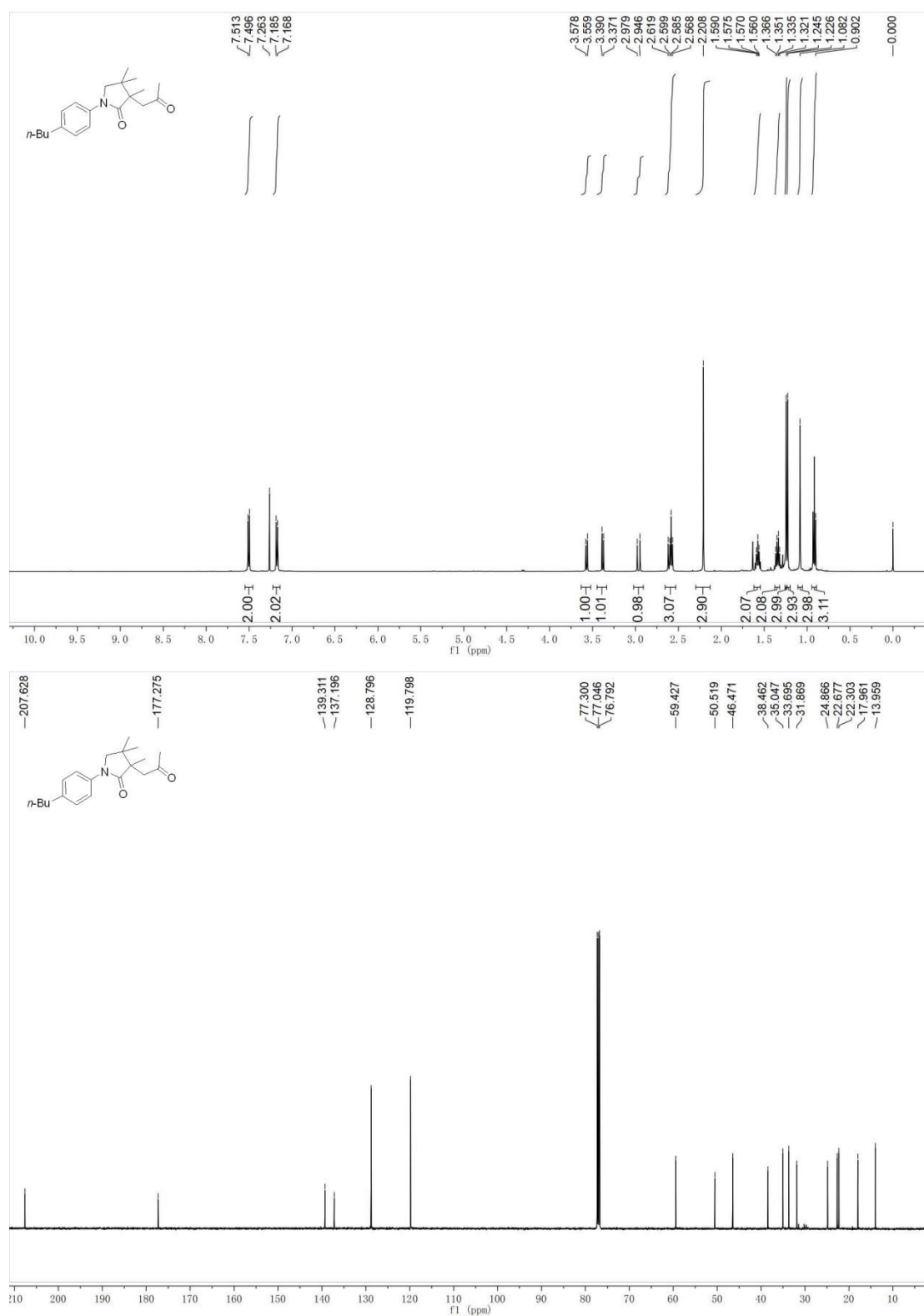
3,4-Dimethyl-3-(2-oxopropyl)-1-tosylpyrrolidin-2-one (3ja)



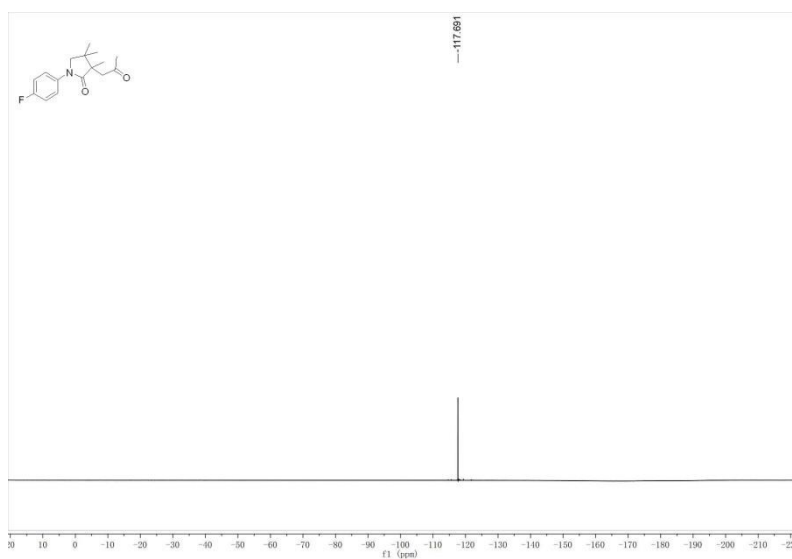
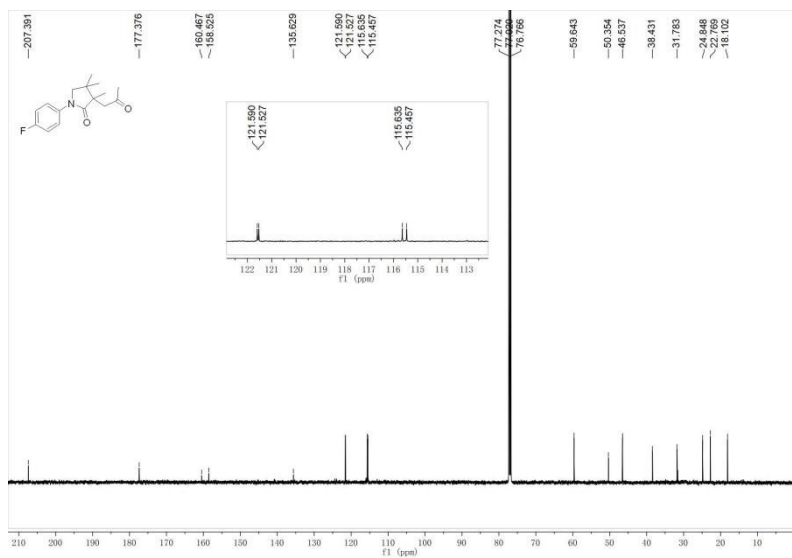
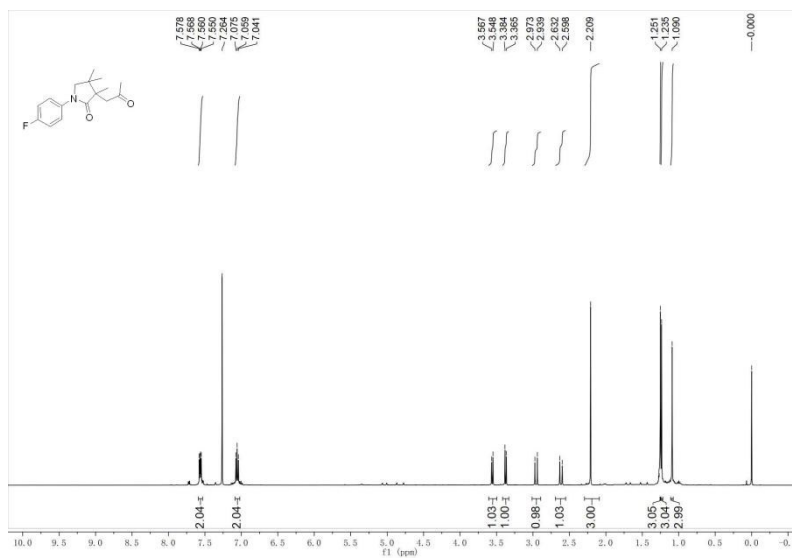
3,4,4-Trimethyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one (3ka)



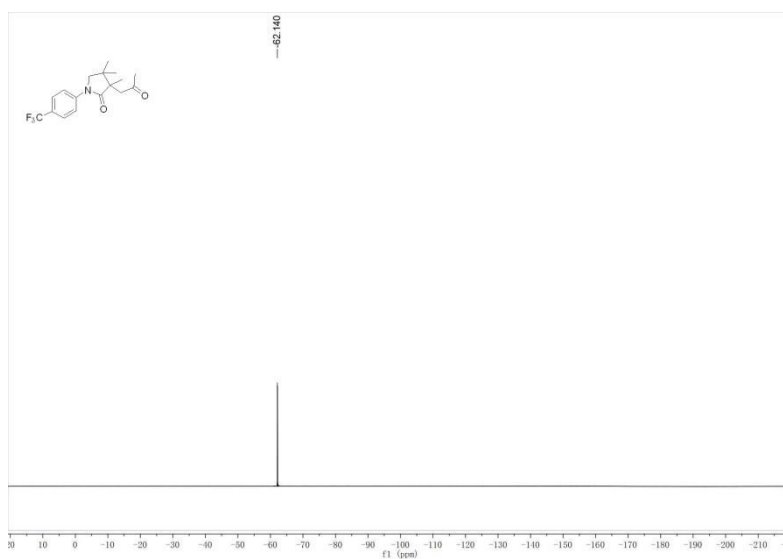
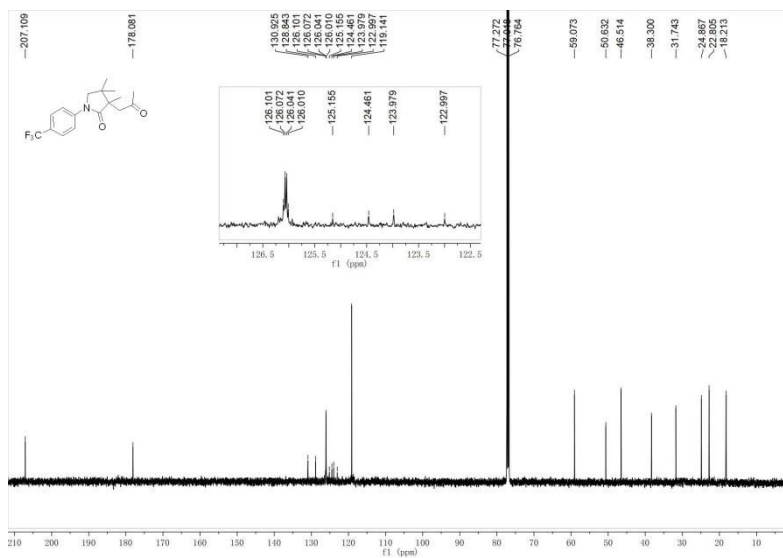
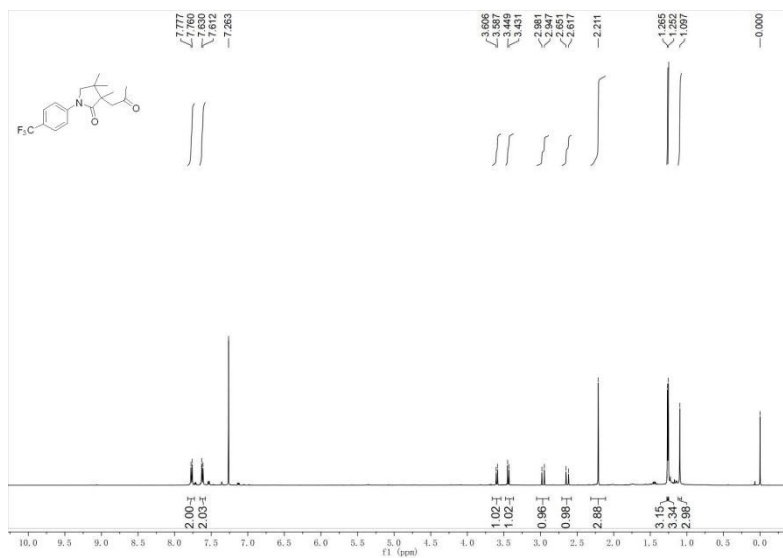
1-(4-Butylphenyl)-3,4,4-trimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3la)



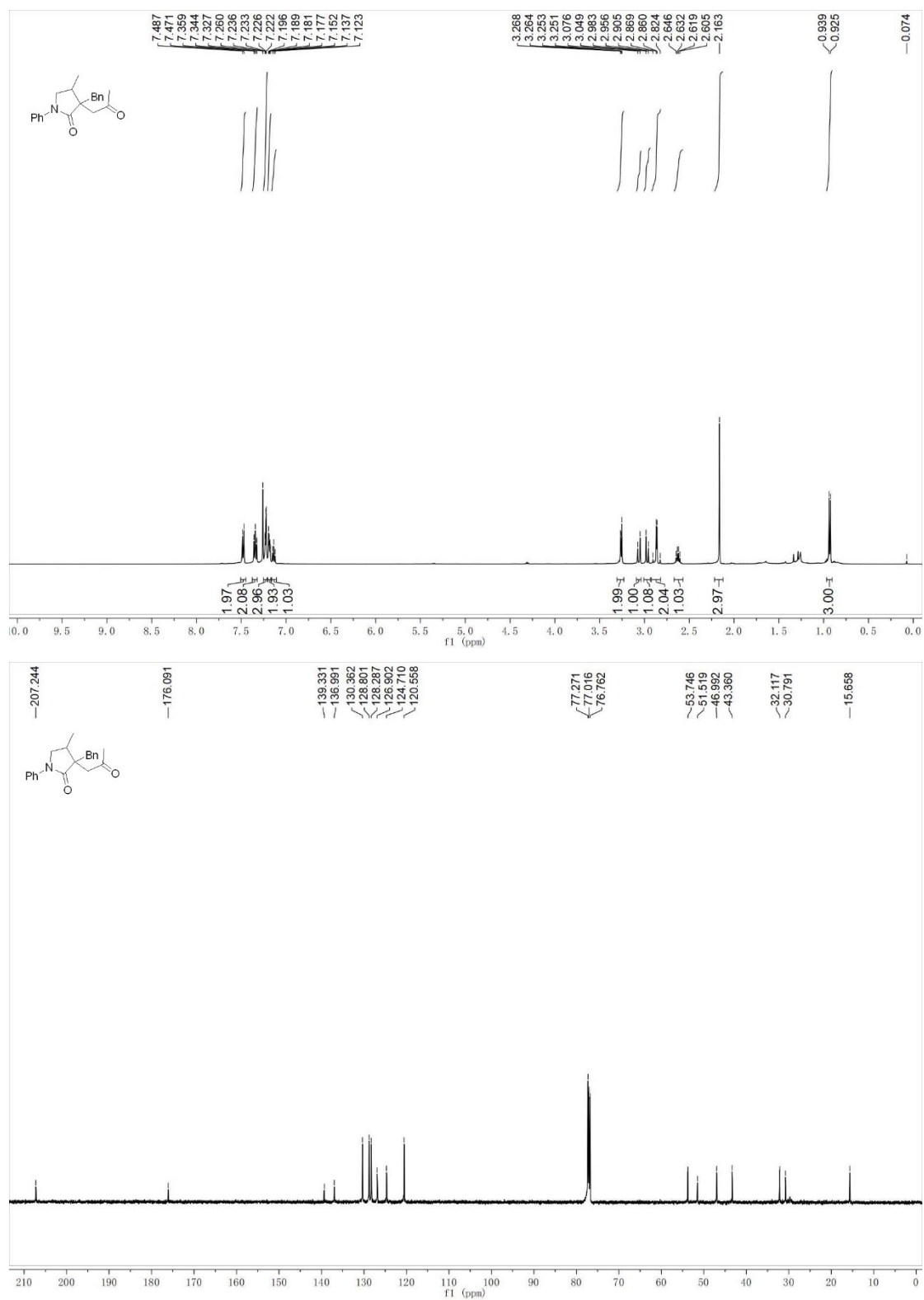
1-(4-Fluorophenyl)-3,4,4-trimethyl-3-(2-oxopropyl)pyrrolidin-2-one (3ma)



3,4,4-Trimethyl-3-(2-oxopropyl)-1-(4-(trifluoromethyl)phenyl)pyrrolidin-2-one (3na)



3-Benzyl-4-methyl-3-(2-oxopropyl)-1-phenylpyrrolidin-2-one (30a)



4-Methyl-3-(2-oxopropyl)-1,3-diphenylpyrrolidin-2-one (3pa)

