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# Electronic Supplementary Information

## Highly efficient visible-light-induced aerobic oxidative C–C, C–P coupling from C–H bonds catalyzed by gold(III)-complex

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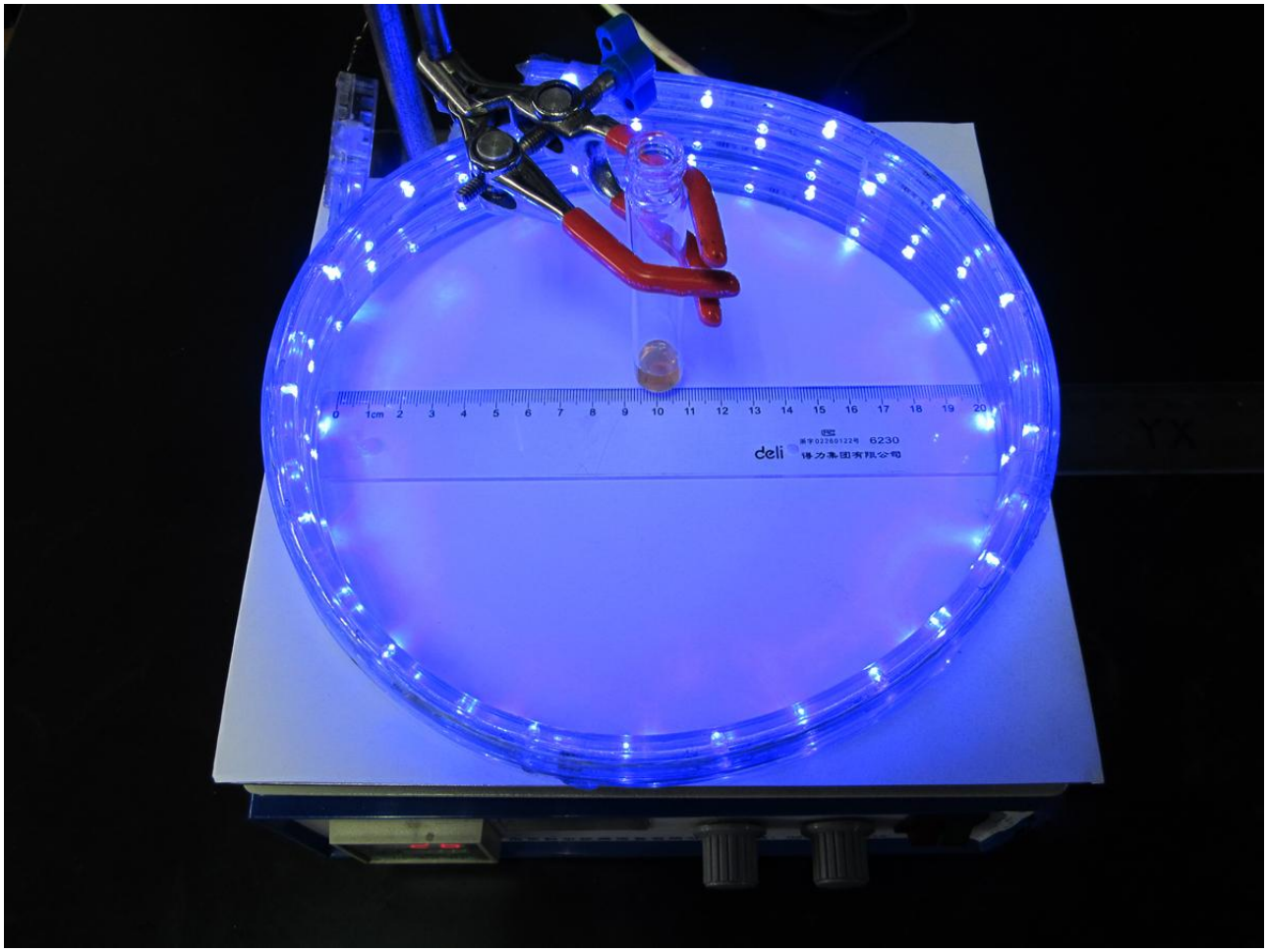
## General information

All reactions were carried out under air atmosphere unless otherwise noted. All reagents and solvents were obtained from commercial suppliers and used without further purification. The 1,2,3,4-tetrahydroisoquinoline derivatives were prepared according to reported procedures.[1] The $HAuCl_4$ $4H_2O$ was obtained from commercial supplier with 47.8% Au content. (Common metals such as Fe, Cu, Ni, Co < 0.1 ppm, measured on ICP-OES Optima 5300DV (Perkin-Elmer)). The gold complex **1a**,[2] **1b**,[3] **1c**[4] and **1d**[4] were obtained according to the process in literature. Reactions were monitored by TLC on silica gel plates (GF254). $^1$H NMR and $^{13}$C NMR spectra were recorded on 300 MHz spectrometer at room temperature. Chemical shifts (δ) are reported in ppm downfield from tetramethylsilane. Abbreviations for signal couplings are: s, singlet; d, doublet; t, triplet; m, multiplet. Electronic excitation and emission spectra were recorded on PerkinElmer LS 55 Fluorescence Spectrometer.

## Reaction apparatus

Visible-light-induced reactions were carried out irradiation by 5 W blue LEDs ($\lambda_{max}$ = 455 nm) strip surrounding the reaction tube.



**General procedure of the aerobic oxidative coupling reaction of amines and ketones**

To the mixture of *N*-Ar-1,2,3,4-tetrahydroisoquinoline **2** (0.1 mmol), gold-complex **1d** (5 mol%, 3.2 mg) and *L*-proline (10 mol%, 1.2 mg), the ketone **3** (0.5 mmol) and NMP (1.0 mL) were successively added into the tube. Then the reaction mixture was stirred at RT under air for 36 hours with blue LEDs 5 W. After the reaction finished, 20 mL of $H_2O$ was added into the mixture. The aqueous layer was separated and extracted with ethyl acetate (2 × 10 mL). The combined organic layer was dried with anhydrous $Na_2SO_4$, filtered, and concentrated under vacuum. After removing the solvents in vacuo, the residue was purified by flash column chromatography on silica gel or preparative TLC on GF254 to afford the desired coupling products **4a-r**.

**General procedure of the oxidative coupling reaction of amines with phosphine oxides and phosphites**

To the mixture of *N*-Ar-1,2,3,4-tetrahydroisoquinoline **2** (0.1 mmol), gold-complex **1d** (5 mol%, 3.2 mg), phosphine oxides or phosphites **11** (0.3 mmol) and $CH_3CN$ (1.0 mL) were successively added into the tube. Then the reaction mixture was stirred at RT under air for 24 hours with blue LEDs 5W. After the reaction finished, 20 mL of $H_2O$ was added into the mixture. The aqueous layer was separated and extracted with ethyl acetate (2 × 10 mL). The combined organic layer was dried with anhydrous $Na_2SO_4$, filtered, and concentrated under vacuum. After removing the solvents in vacuo, the residue was purified by flash column chromatography on silica gel or preparative TLC on GF254 to afford the desired coupling products **12a-i**.

**Electronic excitation and emission spectra of 1d, $O_2$ quenching effect, discussion.**

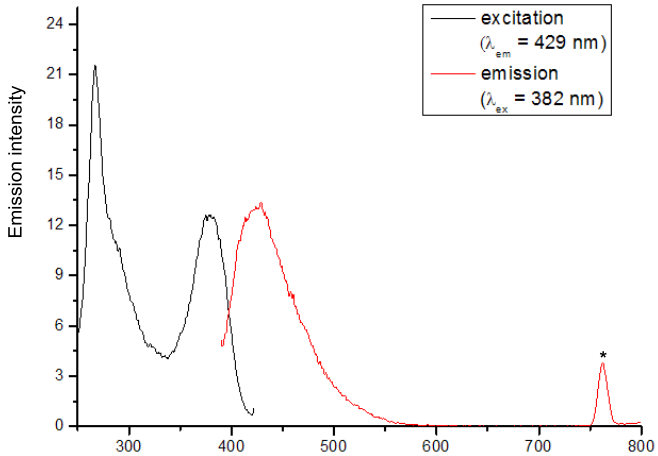



**Figure 1.** Electronic excitation and emission spectra of **1d** (concentration $1.0\times10^{-4}$ moldm$^{-3}$) in degassed $CH_2Cl_2$ at room temperature (after degassing with a stream of $N_2$ for 10 min, the excitation and emission spectra of the sample were collected). The asterisk indicates a second-order transmission of the 382 nm excitation.

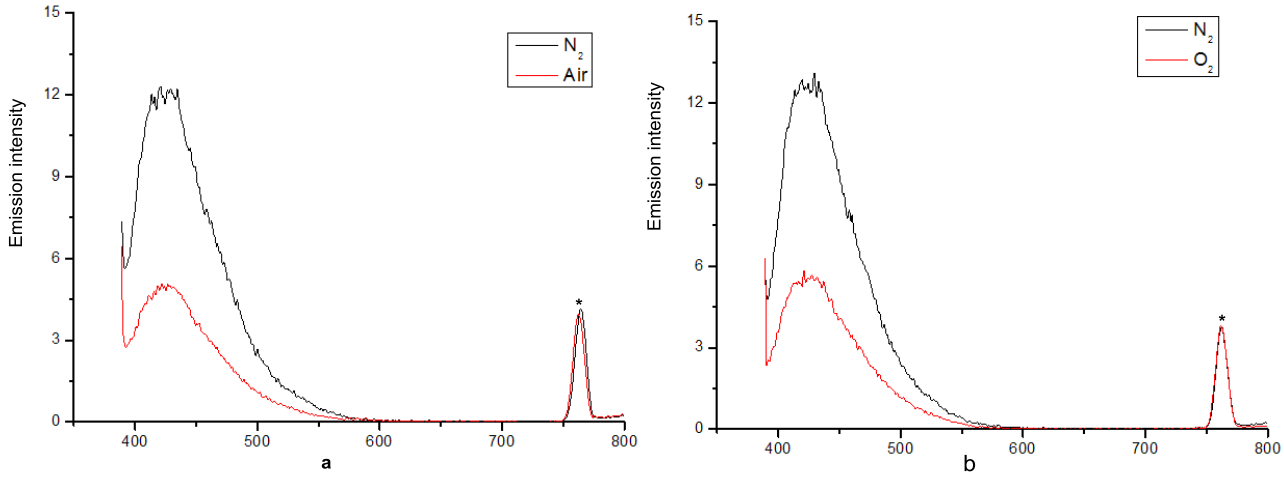
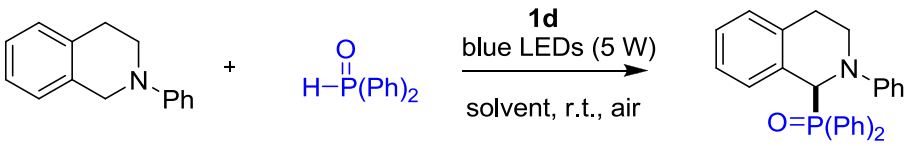



**Figure 2.** The $O_2$quenching effect on the emission intensity. Excitation wavelength: 382 nm, the asterisk indicates a second-order transmission of the 382 nm excitation. **Black**: emission spectra of **1d** (concentration $1.0\times10^{-4}$ moldm$^{-3}$) in $CH_2Cl_2$ at room temperature (after degassing with a stream of $N_2$ for 10 min, the emission spectrum of the sample was collected); **Red**: emission spectra of **1d** (concentration $1.0\times10^{-4}$ moldm$^{-3}$) in $CH_2Cl_2$ at room temperature (after exposure of the solution to air (or $O_2$) for 1 min, the emission spectrum of the sample was collected).

Importantly, significantly decrease in the emission intensity was detected upon exposure of solutions of **1d** to air (Figure 2). **1d** and light are required for efficient conversion to the oxidative C−C coupling product (Table 1, entry 11; Table 2, entry 8). We also detected iminium ion in the reaction of **2a** with **3a**. On the basis of results and literatures, singlet oxygen sensitized from the excited state of **1d** is suggested to be an active oxidant in this coupling reaction.[5] The iminium ions formed by the α-C−H bond of **2a** reacts with singlet oxygen. Subsequently, trapping of iminium ions with nucleophiles enamine (formed from the ketone and *L*-proline), resulted in the desired product **4a**.[6]

**Optimization for the coupling of amine with phosphine oxide** [a]




**2a** **11a** **12a**

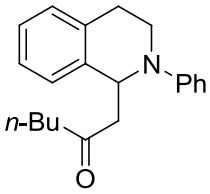
| Entry | **11a** | Solvent | Time[h] | Yield[%][b] |
|---|---|---|---|---|
| 1 | 0.5 mmol | NMP | 36 | 82 |
| 2 | 0.5 mmol | DMF | 36 | 72 |
| 3 | 0.5 mmol | MeOH | 36 | 32 |
| 4 | 0.5 mmol | $CH_2Cl_2$ | 36 | 45 |
| 5 | 0.5 mmol | MeCN | 36 | 88 |
| 6 | 0.3 mmol | MeCN | 36 | 87 |
| **7** | **0.3 mmol** | **MeCN** | **24** | **87** |

| | | | | |
|---|---|---|---|---|
| 8[c] | 0.3 mmol | MeCN | 24 | trace |
| 9[d] | 0.3 mmol | MeCN | 24 | trace |

[a] Reaction conditions: **2a** (0.1 mmol), catalyst **1d** (5 mol%), solvent (1.0 mL), 5 W blue LEDs ($\lambda_{max}$ = 455 nm), r.t., air. [b] Isolated yields. [c] Without **1d**. [d] The reaction was performed under an argon atmosphere (1.0 atm).

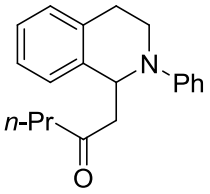
## Characterization data of compounds

1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4a**[7]



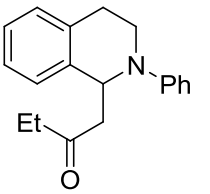

Yield 91%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.24 (m, 2 H), 7.16-7.11 (m, 4 H), 6.95-6.92 (m, 2 H), 6.78-6.74 (m, 1 H), 5.41 (t, *J* = 6.3 Hz, 1 H), 3.68-3.48 (m, 2 H), 3.11-2.99 (m, 2 H), 2.87-2.73 (m, 2 H), 2.37-2.18 (m, 2 H), 1.52-1.42 (m, 2 H), 1.28-1.18 (m, 2 H), 0.83 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.6, 148.8, 138.4, 134.4, 129.3, 128.6, 126.8, 126.7, 126.2, 118.0, 114.6, 54.9, 49.2, 43.8, 42.0, 27.3, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{21}H_{25}NNaO$ $[M+Na]^+$ 330.1828; found: 330.1827.

1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)pentan-2-one **4b**[6]



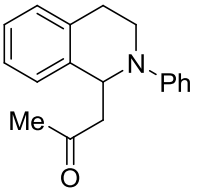

Yield 86%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.21 (m, 2 H), 7.16-7.11 (m, 4 H), 6.95-6.92 (m, 2 H), 6.79-6.74 (m, 1 H), 5.42 (t, *J* = 6.3 Hz, 1 H), 3.68-3.48 (m, 2 H), 3.11-2.99 (m, 2 H), 2.87-2.73 (m, 2 H), 2.36-2.16 (m, 2 H), 1.58-1.46 (m, 2 H), 0.83 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.4, 148.8, 138.4, 134.4, 129.3, 128.6, 126.8, 126.7, 126.2, 118.1, 114.6, 54.9, 49.2, 46.0, 42.0, 27.3, 16.9, 13.6 ppm. HRMS (ESI) m/z calcd for $C_{20}H_{23}NNaO$ $[M+Na]^+$ 316.1672; found: 316.1169.

1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)butan-2-one **4c**[6]



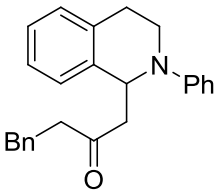

Yield 77%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.21 (m, 2 H), 7.16-7.11 (m, 4 H), 6.95-6.93 (m, 2 H), 6.79-6.74 (m, 1 H), 5.41 (t, *J* = 6.3 Hz, 1 H), 3.67-3.48 (m, 2 H), 3.11-2.99 (m, 2 H), 2.87-2.74 (m, 2 H), 2.40-2.20 (m, 2 H), 0.97 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.9, 148.8, 138.3, 134.4, 129.3, 128.6, 126.8, 126.7, 126.2, 118.1, 114.6, 55.1, 48.9, 41.9, 37.2, 27.2, 7.5 ppm. HRMS (ESI) m/z calcd for $C_{19}H_{21}NNaO$ $[M+Na]^+$ 302.1515; found: 302.1507.

1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)propan-2-one **4d**[7]



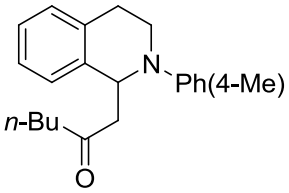

Yield 96%, white solid. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.22 (m, 2 H), 7.17-7.13 (m, 4 H), 6.95-6.92 (m, 2 H), 6.80-6.75 (m, 1 H), 5.40 (t, *J* = 6.3 Hz, 1 H), 3.68-3.48 (m, 2 H), 3.10-3.00 (m, 2 H), 2.86-2.78 (m, 2 H), 2.07 (s, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 207.2, 148.8, 138.2, 134.4, 129.3, 128.6, 126.8, 126.7, 126.2, 118.2, 114.7, 54.8, 50.1, 42.0, 31.1, 27.1 ppm. HRMS (ESI) m/z calcd for $C_{18}H_{19}NNaO$ $[M+Na]^+$ 288.1359; found: 288.1362.

4-phenyl-1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)butan-2-one **4e**



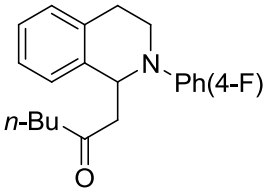

Yield 79%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.06 (m, 11 H), 7.16-7.11 (m, 4 H), 6.94-6.91 (m, 2 H), 6.80-6.75 (m, 1 H), 5.41 (t, *J* = 6.3 Hz, 1 H), 3.65-3.45 (m, 2 H), 3.08-2.98 (m, 2 H), 2.88-2.70 (m, 4 H), 2.63-2.51 (m, 2 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 208.4, 148.7, 140.8, 138.1, 134.4, 129.3, 128.6, 128.4, 128.2, 126.8, 126.7, 126.2, 126.0, 118.2, 114.7, 55.1, 49.4, 45.5, 41.9, 29.4, 27.2 ppm. HRMS (ESI) m/z calcd for $C_{25}H_{25}NNaO$ $[M+Na]^+$ 378.1828; found: 378.1839.

1-(2-p-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4f**



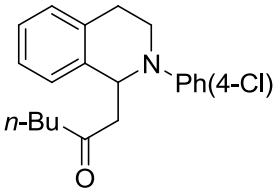

Yield 92%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.17-7.03 (m, 4 H), 7.06-7.03 (m, 2 H), 6.87-6.85 (m, 2 H), 5.37 (t, *J* = 6.3 Hz, 1 H), 3.65-3.43 (m, 2 H), 3.09-2.97 (m, 2 H), 2.81-2.70 (m, 2 H), 2.31-2.20 (m, 5 H), 1.51-1.41 (m, 2 H), 1.28-1.16 (m, 2 H), 0.84 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.7, 146.8, 138.4, 134.3, 129.8, 128.7, 127.7, 126.8, 126.6, 126.1, 115.4, 55.3, 49.0, 43.7, 42.1, 27.1, 25.5, 22.2, 20.3, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{26}NO$ $[M+H]^+$ 322.2165; found: 322.2161.

1-(2-(4-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4g**



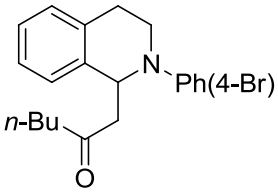

Yield 85%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.17-7.10 (m, 4 H), 6.94-6.86 (m, 4 H), 5.31 (t, *J* = 6.3 Hz, 1 H), 3.59-3.44 (m, 2 H), 3.07-2.97 (m, 2 H), 2.82-2.70 (m, 2 H), 2.36-2.22 (m, 2 H), 1.53-1.43 (m, 2 H), 1.29-1.17 (m, 2 H), 0.84 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.5, 156.4 (d, *J* = 236.9 Hz), 145.7, 138.1, 134.1, 128.8, 126.8, 126.7, 126.2, 116.9 (d, *J* = 7.4 Hz), 115.6 (d, *J* = 21.2 Hz) ppm. HRMS (ESI) m/z calcd for $C_{21}H_{24}FNNaO$ $[M+Na]^+$ 348.1734; found: 348.1736.

1-(2-(4-chlorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4h**



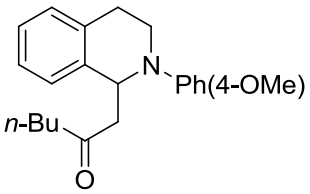

Yield 78%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.20-7.11 (m, 6 H), 6.88-6.84 (m, 2 H), 5.36 (t, *J* = 6.3 Hz, 1 H), 3.61-3.46 (m, 2 H), 3.09-2.97 (m, 2 H), 2.87-2.73 (m, 2 H), 2.36-2.21 (m, 2 H), 1.53-1.43 (m, 2 H), 1.29-1.19 (m, 2 H), 0.84 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.4, 147.4, 138.0, 134.1, 129.1, 128.6, 126.9, 126.8, 126.3, 115.7, 54.9, 49.1, 43.8, 42.1, 27.0, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{21}H_{24}ClNNaO$ $[M+Na]^+$ 364.1439; found: 364.1439.

1-(2-(4-bromophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4i**



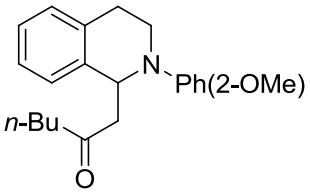

Yield 83%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.32-7.28 (m, 2 H), 7.17-7.11 (m, 4 H), 6.81-6.78 (m, 2 H), 5.36 (t, *J* = 6.3 Hz, 1 H), 3.59-3.49 (m, 2 H), 3.08-2.95 (m, 2 H), 2.87-2.73 (m, 2 H), 2.36-2.20 (m, 2 H), 1.52-1.42 (m, 2 H), 1.28-1.19 (m, 2 H), 0.84 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.4, 147.7, 137.9, 134.1, 131.9, 128.6, 126.9, 126.7, 126.3, 115.9, 109.8, 54.7, 49.1, 43.8, 42.0, 27.1, 25.5, 22.1, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{21}H_{24}BrNNaO$ $[M+Na]^+$ 408.0933; found: 408.0936.

1-(2-(4-methoxyphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4j**[7]



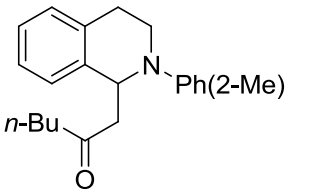

Yield 75%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.16-7.09 (m, 4 H), 6.92-6.88 (m, 2 H), 6.82-6.79 (m, 2 H), 5.28 (t, *J* = 6.3 Hz, 1 H), 3.74 (s, 3 H), 3.58-3.40 (m, 2 H), 3.07-2.95 (m, 2 H), 2.78-2.67 (m, 2 H), 2.33-2.21 (m, 2 H), 1.51-1.41 (m, 2 H), 1.28-1.16 (m, 2 H), 0.84 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.6, 153.1, 143.6, 138.4, 134.2, 128.8, 126.8, 126.5, 126.1, 118.1, 114.6, 56.0, 55.6, 48.9, 43.6, 42.7, 26.9, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{28}NO_2$ $[M+Na]^+$ 338.2115; found: 338.2125.

1-(2-(2-methoxyphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4k**



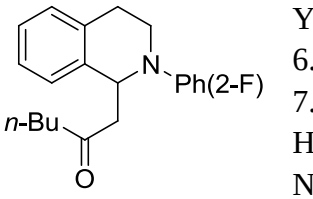

Yield 72%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.17-7.08 (m, 4 H), 7.00-6.95 (m, 1 H), 6.87-6.82 (m, 2 H), 5.35 (t, *J* = 6.0 Hz, 1 H), 3.85 (s, 3 H), 3.48-3.43 (m, 2 H), 3.00-2.93 (m, 2 H), 2.74-2.58 (m, 2 H), 2.23-2.19 (m, 2 H), 1.41-1.33 (m, 2 H), 1.26-1.15 (m, 2 H), 0.83 (t, *J* = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.6, 152.9, 139.7, 139.0, 134.2, 129.0, 126.9, 126.2, 126.0, 123.2, 121.3, 120.7, 111.6, 55.5, 55.4, 48.8, 43.2, 42.9, 27.5, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{28}NO_2$ $[M+Na]^+$ 338.2115; found: 338.2120.

1-(2-o-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4l**



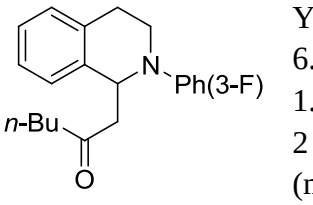

Yield 73%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.20-7.10 (m, 5 H), 7.05-6.93 (m, 2 H), 6.84-6.82 (m, 1 H), 5.01-4.96 (m, 1 H), 3.50-3.41 (m, 1 H), 3.21-3.14 (m, 1 H), 3.05-2.97 (m, 1 H), 2.90-2.79 (m, 1 H), 2.70-2.61 (m, 2 H), 2.30-2.25 (m, 5 H), 1.49-1.39 (m, 2 H), 1.22-1.17 (m, 2 H), 0.83 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.3, 149.7, 138.8, 135.0, 133.4, 131.1, 129.1, 126.6, 126.3, 126.2, 126.1, 123.5, 122.2, 56.8, 49.5, 43.9, 42.9, 29.7, 26.4, 25.5, 22.2, 18.0, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{26}NO$ $[M+H]^+$ 322.2165; found: 322.2168.

1-(2-(2-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4m**




Yield 68%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.19-7.01 (m, 4 H), 6.97-6.88 (m, 4 H), 5.18 (t, *J* = 6.3 Hz, 1 H), 3.56-3.51 (m, 2 H), 3.07 (dd, *J* = 7.2 Hz, 11.4 Hz, 1 H), 2.95-2.84 (m, 1 H), 2.76-2.65 (m, 2 H), 2.37-2.31 (m, 2 H), 1.51-1.41 (m, 2 H), 1.29-1.20 (m, 2 H), 0.85 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.2, 156.0 (d, *J* = 244.7 Hz), 138.1, 134.3, 129.1, 126.7, 126.5, 126.3, 124.2 (d, *J* = 3.4 Hz), 122.9 (d, *J* = 8.0 Hz), 122.0, 116.2 (d, *J* = 20.6 Hz) 56.0, 49.5, 43.4, 26.6, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{21}H_{24}FNNaO$ $[M+Na]^+$ 348.1734; found: 348.1729.

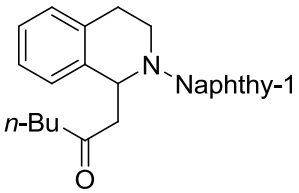
1-(2-(3-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4n**




Yield 80%, colorless oil. $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 7.20-7.13 (m, 5 H), 6.70 (dd, *J* = 8.4, 2.3 Hz, 1H), 6.60 (dt, *J* = 12.8, 2.4 Hz, 1H), 6.43 (td, *J* = 8.2, 1.8 Hz, 1H), 5.39 (dd, *J* = 7.2, 5.5 Hz, 1H), 3.61-3.50 (m, 2 H), 3.11-2.98 (m, 2 H), 2.91-2.75 (m, 2 H), 2.39-2.19 (m, 2 H), 1.53-1.43 (m, 2 H), 1.29-1.17 (m, 2 H), 0.84 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.2, 164.1 (d, *J* = 242.7 Hz), 150.3 (d, *J* = 10.3 Hz), 138.0, 134.2, 130.3 (d, *J* = 10.2 Hz), 128.5,

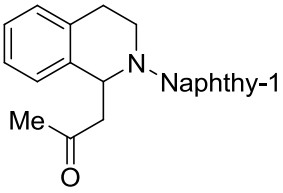
126.9, 126.8, 126.5, 109.4, 104.1 (d, $J$ = 21.6 Hz), 100.8 (d, $J$ = 25.8 Hz), 54.7, 49.2, 43.8, 42.2, 27.3, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{21}H_{24}FNNaO$ $[M+Na]^+$ 348.1734; found: 348.1736.

1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4o**



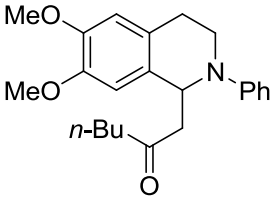

Yield 66%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 8.15-8.12 (m, 1 H), 7.82-7.79 (m, 1 H), 7.53 (d, $J$ = 8.4 Hz, 1 H), 7.47-7.44 (m, 2 H), 7.28-7.11 (m, 5 H), 6.92 (d, $J$ = 7.2 Hz, 1 H), 5.17 (t, $J$ = 6.3 Hz, 1 H), 3.72-3.63 (m, 1 H), 3.48-3.40 (m, 1 H), 3.14-3.06 (m, 1 H), 2.82-2.61 (m, 3 H), 2.30-2.24 (m, 2 H), 1.42-1.36 (m, 2 H), 1.28-1.08 (m, 2 H), 0.75 (t, $J$ = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.2, 147.7, 138.5, 134.8, 129.4, 129.3, 128.3, 126.6, 126.5, 126.2, 125.9, 125.4, 123.9, 123.8, 118.3, 58.0, 45.3, 42.6, 25.5, 22.2, 13.7 ppm. HRMS (ESI) m/z calcd for $C_{25}H_{27}NNaO$ $[M+Na]^+$ 380.1985; found: 380.1994.

1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)propan-2-one **4p**



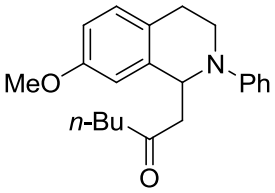

Yield 71%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 8.17-8.14 (m, 1 H), 7.84-7.80 (m, 1 H), 7.57-7.46 (m, 3 H), 7.29-7.12 (m, 5 H), 6.93 (d, $J$ = 7.2 Hz, 1 H), 5.17-5.12 (m, 1 H), 3.71-3.63 (m, 1 H), 3.48-3.42 (m, 1 H), 3.15-3.07 (m, 1 H), 2.89-2.59 (m, 3 H), 2.02 (s, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 207.0, 147.7, 138.2, 134.8, 129.4, 128.4, 126.6, 126.5, 126.3, 125.9, 125.7, 125.5, 124.0, 123.7, 118.3, 58.1, 45.1, 29.7 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{21}NNaO$ $[M+Na]^+$ 338.1515; found: 338.1528.

1-(6,7-dimethoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4q**




Yield 91%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.27-7.21 (m, 2 H), 6.95-6.92 (m, 2 H), 6.79-6.74 (m, 1 H), 6.67 (s, 1 H), 6.61 (s, 1 H), 5.33 (t, $J$ = 6.3 Hz, 1 H), 3.84 (s, 3 H), 3.82 (s, 3 H), 3.68-3.62 (m, 1 H), 3.53-3.48 (m, 1 H), 3.05-2.95 (m, 2 H), 2.81-2.69 (m, 2 H), 2.34-2.26 (m, 2 H), 1.53-1.43 (m, 2 H), 1.28-1. 20 (m, 2 H), 0.84 (t, $J$ = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 210.0, 148.9, 147.7, 147.3, 130.3, 129.2, 126.2, 118.2, 114.9, 111.2, 109.7, 55.9, 55.8, 54.6, 49.1, 43.9, 41.8, 26.7, 25.6, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{23}H_{29}NNaO_3$ $[M+Na]^+$ 390.2040; found: 390.2027.

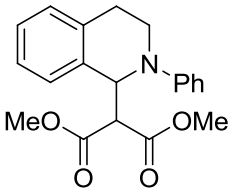
1-(7-methoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4r**




Yield 92%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.26-7.21 (m, 2 H), 7.03 (d, $J$ = 8.1 Hz, 1 H), 6.93 (d, $J$ = 8.1 Hz, 2 H), 6.78-6.69 (m, 3 H), 5.38 (t, $J$ = 6.3 Hz, 1 H), 3.75 (s, 3 H), 3.65-3.59 (m, 1 H), 3.54-3.45 (m, 1 H), 3.06-2.95 (m, 2 H), 2.82-2.71 (m, 2 H), 2.33-2.26 (m, 2 H), 1.53-1.43 (m, 2 H), 1.27-1. 19 (m, 2 H), 0.84 (t, $J$ = 7.5 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 209.6, 157.8, 148.9, 139.4, 129.5, 129.3, 126.3, 118.1, 114.7, 113.2, 111.4, 55.3, 55.0, 49.2, 43.7, 42.2, 26.3, 25.5, 22.2, 13.8 ppm. HRMS (ESI) m/z calcd for $C_{22}H_{27}NNaO_2$ $[M+Na]^+$

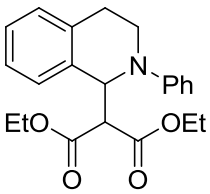
360.1934; found: 360.1939.

dimethyl 2-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)malonate **6a**[8]



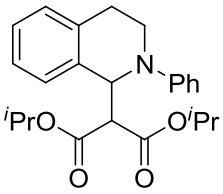
Yield 67%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.24-7.08 (m, 6 H), 7.00-6.97 (m, 2 H), 6.78-6.74 (m, 1 H), 5.70 (d, *J* = 9.6 Hz, 1 H), 3.95 (d, *J* = 9.6 Hz, 1 H), 3.70-3.61 (m, 5 H), 3.55 (s, 3 H), 3.13-3.02 (m, 1 H), 2.92-2.84 (m, 1 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 168.3, 167.4, 148.7, 135.6, 134.8, 129.1, 129.0, 127.6, 127.0, 126.0, 118.6, 115.2, 59.1, 58.2, 52.5, 42.2, 26.0 ppm.

diethyl 2-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)malonate **6b**[8]



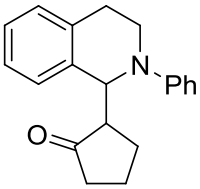
Yield 72%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.26-7.10 (m, 6 H), 6.99-6.97 (m, 2 H), 6.78-6.73 (m, 1 H), 5.72 (d, *J* = 9.3 Hz, 1 H), 4.17-3.95 (m, 4 H), 3.90 (d, *J* = 9.3 Hz, 1 H), 3.76-3.61 (m, 2 H), 3.55 (s, 3 H), 3.12-3.02 (m, 1 H), 2.92-2.83 (m, 1 H), 1.16 (t, *J* = 7.2 Hz, 3 H), 1.08 (t, *J* = 7.2 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 167.9, 167.1, 148.8, 135.9, 134.8, 129.0, 128.8, 127.5, 127.2, 126.0, 118.5, 115.1, 61.5, 59.5, 57.9, 42.3, 26.1, 13.9, 13.8 ppm.

diisopropyl 2-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)malonate **6c**[8]



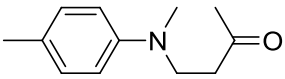
Yield 70%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.31-7.10 (m, 6 H), 6.98-6.95 (m, 2 H), 6.76-6.71 (m, 1 H), 5.71 (d, *J* = 8.7 Hz, 1 H), 5.1-4.97 (m, 2 H), 3.83 (d, *J* = 8.7 Hz, 1 H), 3.72-3.61 (m, 2 H), 3.11-3.00 (m, 1 H), 2.91-2.84 (m, 1 H), 1.20 (d, *J* = 6.3 Hz, 3 H), 1.11 (d, *J* = 6.3 Hz, 3 H), 1.10 (d, *J* = 6.3 Hz, 3 H), 1.02 (d, *J* = 6.3 Hz, 3 H) ppm; $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 167.5, 166.7, 148.9, 136.2, 134.8, 129.0, 128.8, 127.3, 127.2, 125.9, 118.3, 115.0, 69.1, 60.0, 57.5, 42.3, 26.1, 21.6, 21.5, 21.4, 21.2 ppm. HRMS (ESI) m/z calcd for $C_{24}H_{29}NNaO_4$ $[M+Na]^+$ 418.1989; found: 418.1991.

2-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)cyclopentanone **8**[9]



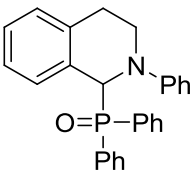
Yield 41%, yellow oil, dr = 3:1. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.38-6.67 (m, 9 H), [5.60 (d, *J* = 1.5 Hz), 5.25 (d, *J* = 3.6 Hz), 1 H], 3.79-3.45 (m, 2 H), 3.10-2.48 (m, 3 H), 2.36-1.53 (m, 6 H). HRMS (ESI) m/z calcd for $C_{20}H_{21}NNaO$ $[M+Na]^+$ 314.1515; found: 3314.1520.

4-(methyl(p-tolyl)amino)butan-2-one **10**[10]



Yield 32%, colorless oil. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.06 (d, *J* = 8.1 Hz, 2 H), 6.66 (d, *J* = 8.1 Hz, 2 H), 3.60 (t, *J* = 6.9 Hz, 2 H), 2.88 (s, 3 H), 2.70 (t, *J* = 6.9 Hz, 2 H), 2.26 (s, 3 H), 2.15 (s, 3 H). HRMS (ESI) m/z calcd for $C_{12}H_{17}NNaO$ $[M+Na]^+$ 214.1202; found: 214.1209.

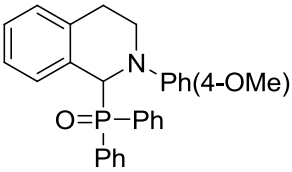
1-(diphenylphosphoryl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline **12a**[11]



Yield 87%, white solid, mp 200-203 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.88-7.79 (m, 2 H), 7.77-7.67 (m, 2 H), 7.58-7.51 (m, 1 H), 7.50-7.41 (m, 3 H), 7.38-7.30 (m, 2 H), 7.20-7.05 (m, 4 H), 6.93 (t, *J* = 7.2 Hz, 1 H), 6.86-6.74 (m, 3 H), 6.67 (d, *J* = 7.8 Hz, 1 H), 5.58 (d, *J* = 10.5 Hz, 1 H), 4.11-4.00 (m, 1 H), 3.64-3.53 (m, 1 H),

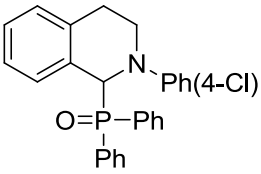
2.92-2.77 (m, 1 H), 2.75-2.63 (m, 1 H) ppm; MS (ESI) m/z calcd for $C_{27}H_{24}NNaOP$ $[M+Na]^+$ 432.15; found: 432.21.

1-(diphenylphosphoryl)-2-(4-methoxyphenyl)-1,2,3,4-tetrahydroisoquinoline **12b**[11]



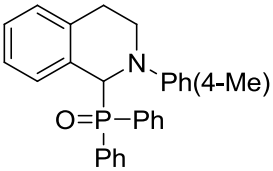

Yield 85%, white solid, mp 175-176 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.86-7.66 (m, 4 H), 7.60-7.31 (m, 6 H), 7.20-7.04 (m, 2 H), 7.00 -6.88 (m, 1 H), 6.81-6.58 (m, 5 H), 5.37 (d, *J* = 11.7 Hz, 1 H), 4.06 -3.92 (m, 1 H), 3.73 (s, 3 H), 3.47-3.35 (m, 1 H), 2.84-2.50 (m, 2 H) ppm; MS (ESI) m/z calcd for $C_{28}H_{26}NNaO_2P$ $[M+Na]^+$ 462.16; found: 462.06.

2-(4-chlorophenyl)-1-(diphenylphosphoryl)-1,2,3,4-tetrahydroisoquinoline **12c**[11]



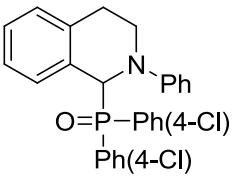

Yield 82%, white solid, mp 179-181 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.83-7.65 (m, 4 H), 7.60-7.52 (m, 1 H), 7.51-7.43 (m, 3 H), 7.40-7.31 (m, 2 H), 7.40-7.31 (m, 2 H), 7.20-7.13 (m, 1 H), 7.12-7.04 (m, 3 H), 6.98-6.91 (m, 1 H), 6.77-6.78 (m, 2 H), 6.65-6.58 (m, 1 H), 5.48 (d, *J* = 10.2 Hz, 1 H), 4.12-3.96 (m, 1 H), 3.57-3.45 (m, 1 H), 2.90-2.63 (m, 2 H) ppm; MS (ESI) m/z calcd for $C_{27}H_{23}ClNNaOP$ $[M+Na]^+$ 466.11; found: 466.19.

1-(diphenylphosphoryl)-2-p-tolyl-1,2,3,4-tetrahydroisoquinoline **12d**[11]



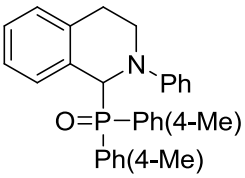

Yield 91%, white solid, mp 185-186 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.88-7.66 (m, 4 H), 7.60-7.31 (m, 6 H), 7.20-7.03 (m, 2 H), 7.02-6.88 (m, 3 H), 6.79-6.60 (m, 3 H), 5.48 (d, *J* = 11.4 Hz, 1 H), 4.10-3.94 (m, 1 H), 3.60-3.47 (m, 1 H), 2.88-2.72 (m, 1 H), 2.67-2.53 (m, 1 H), 2.23 (s, 3 H) ppm; MS (ESI) m/z calcd for $C_{28}H_{26}NNaOP$ $[M+Na]^+$ 446.16; found: 446.25.

1-(bis(4-chlorophenyl)phosphoryl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline **12e**[11]



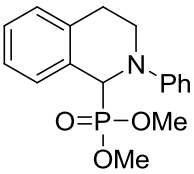

Yield 92%, white solid, mp 198-200 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.81-7.68 (m, 2 H), 7.66-7.54 (m, 2 H), 7.50-7.40 (m, 2 H), 7.37-7.30 (m, 2 H), 7.23-7.07 (m, 4 H), 7.06-6.96 (m, 1 H), 6.88-6.68 (m, 4 H), 5.54 (d, *J* = 10.8 Hz, 1 H), 4.06-3.88 (m, 1 H), 3.66-3.47 (m, 1 H), 2.92-2.56 (m, 2 H) ppm; MS (ESI) m/z calcd for $C_{27}H_{22}C_{l2}NNaOP$ $[M+Na]^+$ 500.07; found: 500.01.

1-(dip-tolylphosphoryl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline **12f**[11]




Yield 83%, white solid, mp 192-193 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.73-7.51 (m, 4 H), 7.26-7.03 (m, 8 H), 6.99-6.90 (m, 1 H), 6.87-6.60 (m, 4 H), 5.52 (d, *J* = 11.4 Hz), 4.07-3.93 (m, 1 H), 3.64-3.52 (m, 1 H), 2.92-2.76 (m, 1 H), 2.71-2.57 (m, 1 H), 2.41 (s, 3 H), 2.34 (s, 3 H) ppm; MS (ESI) m/z calcd for $C_{29}H_{28}NNaOP$ $[M+Na]^+$ 460.18; found: 460.12.

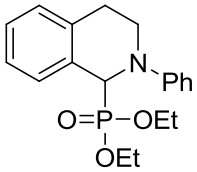
dimethyl 2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-ylphosphonate **12g**[12]




Yield 85%, white solid, mp 84-86 °C. $^1$H NMR (300 MHz, $CDCl_3$): δ = 7.40-7.34 (m, 1 H), 7.32-7.14 (m, 5 H), 7.02-6.95 (m, 2 H), 6.85-6.78 (m, 1 H), 5.21 (d, *J* = 20.1 Hz, 1 H), 4.08-3.97 (m, 1 H), 3.72-3.57 (m, 7 H), 3.15-2.92 (m, 2 H) ppm; MS

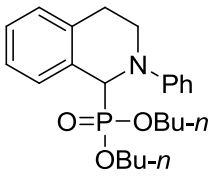
(ESI) m/z calcd for $C_{17}H_{20}NNaO_3P$ $[M+Na]^+$ 340.11; found: 340.15.

diethyl 2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-ylphosphonate **12h**[12]




Yield 88%, white solid, mp 61-63 $^oC$. $^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.42-7.34 (m, 1 H), 7.30-7.12 (m, 5 H), 7.02-6.95 (m, 2 H), 6.84-6.76 (m, 1 H), 5.19 (d, *J* = 19.8 Hz, 1 H), 4.16-3.82 (m, 5 H), 3.70-3.58 (m, 1 H), 3.15-2.93 (m, 2 H), 1.26 (t, *J* = 7.2 Hz, 3 H), 1.12 (t, *J* = 7.2 Hz, 3 H) ppm; MS (ESI) m/z calcd for $C_{19}H_{25}NO_3P$ $[M+H]^+$ 346.16; found: 346.12.

dibutyl 2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-ylphosphonate **12i**[12]




Yield 86%, colorless oil. $^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.42-7.34 (m, 1 H), 7.29-7.12 (m, 5 H), 7.01-6.94 (m, 2 H), 6.84-6.75 (m, 1 H), 5.21 (d, *J* = 19.8 Hz, 1 H), 4.09-3.75 (m, 5 H), 3.70-3.58 (m, 1 H), 3.18-2.93 (m, 2 H), 1.64-1.17 (m, 9 H), 0.89 (t, *J* = 7.5 Hz, 3 H), 0.83 (t, *J* = 7.5 Hz, 3 H) ppm; MS (ESI) m/z calcd for $C_{23}H_{32}NNaO_3P$ $[M+Na]^+$ 424.20; found: 424.31.

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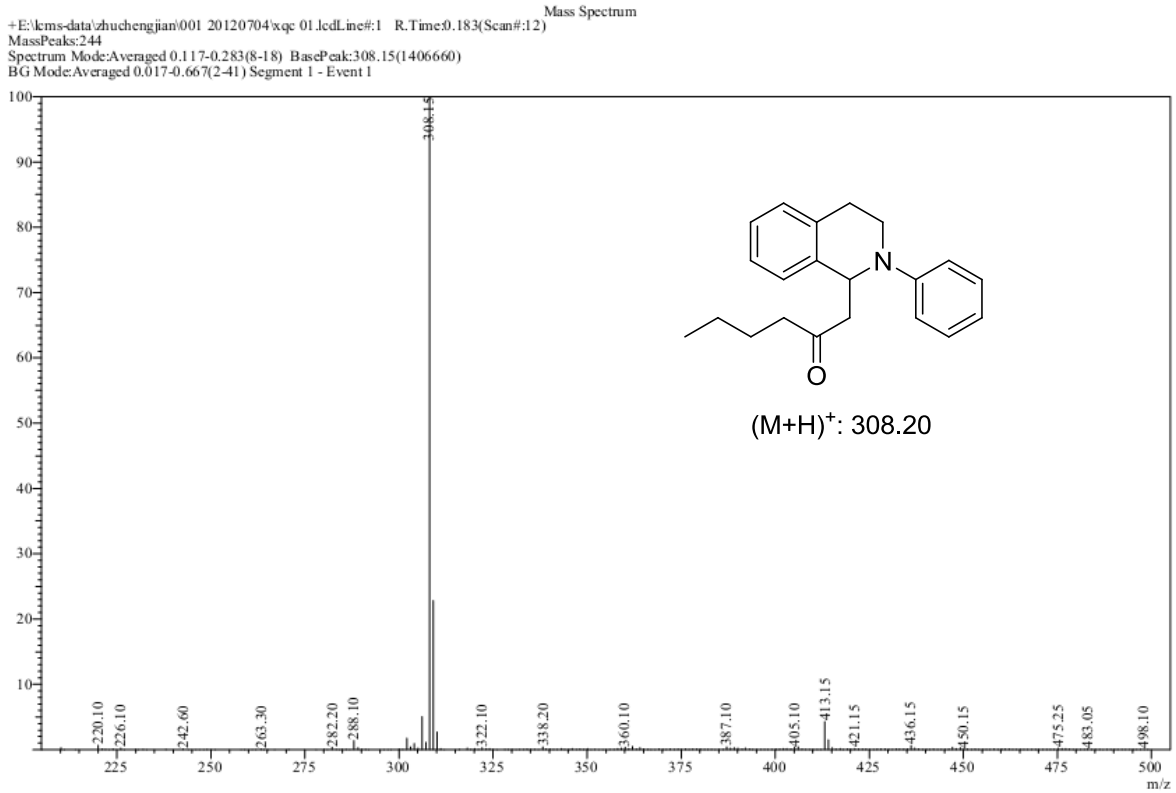
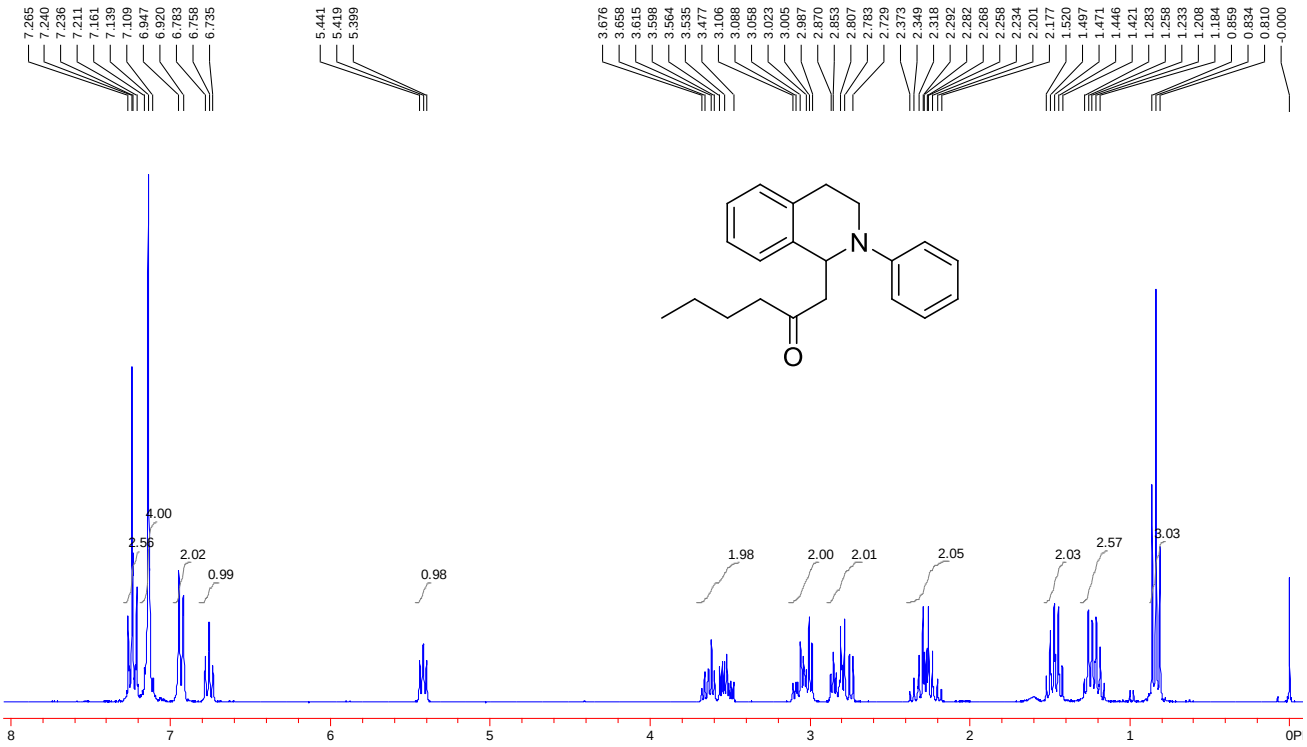
## Mass Spectrum of substance 4a

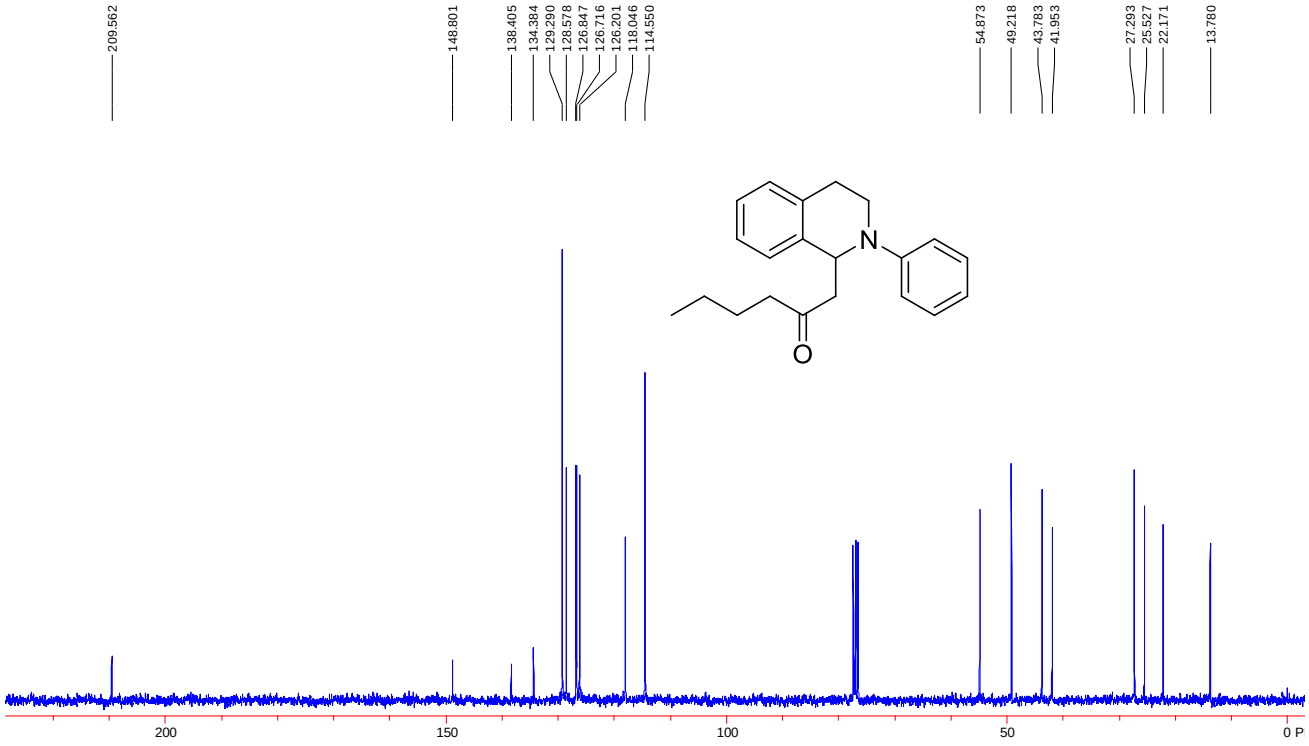


## $^{1}$H and $^{13}$C NMR spectra of 4a and new compounds

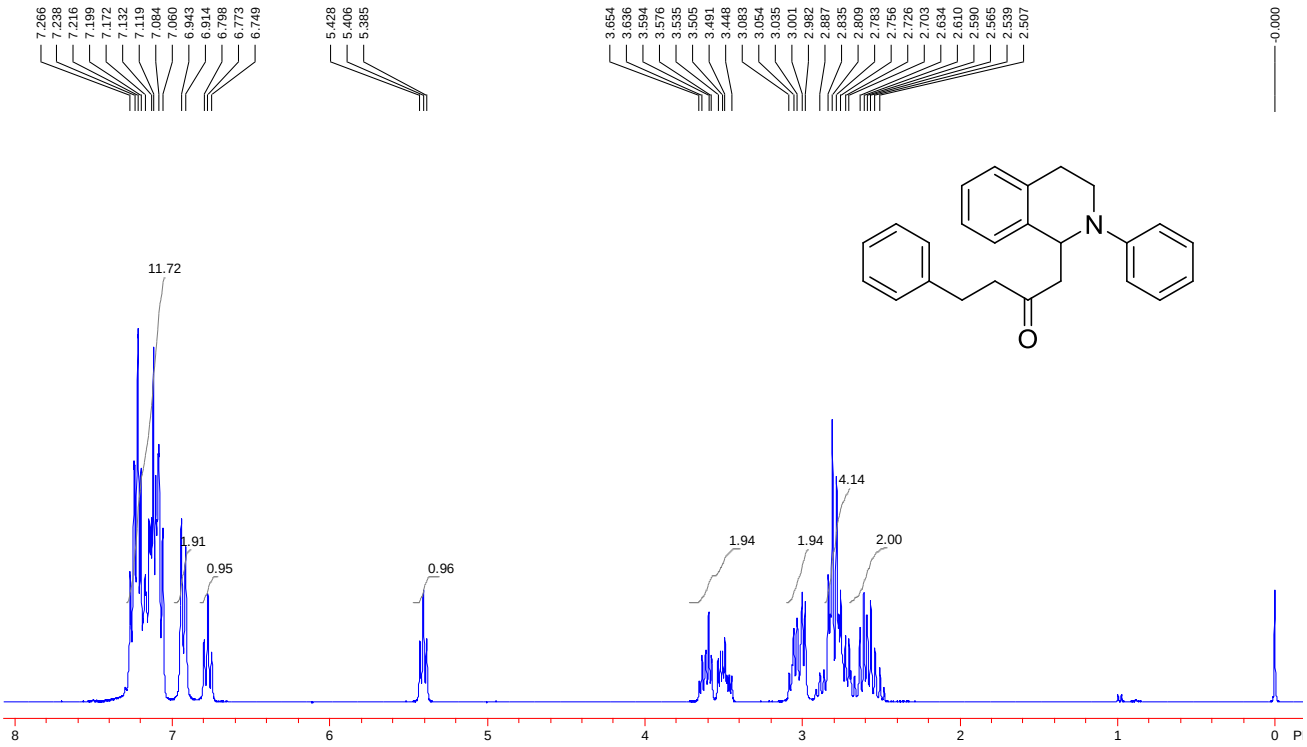
The $^{1}$H NMR of 1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4a**



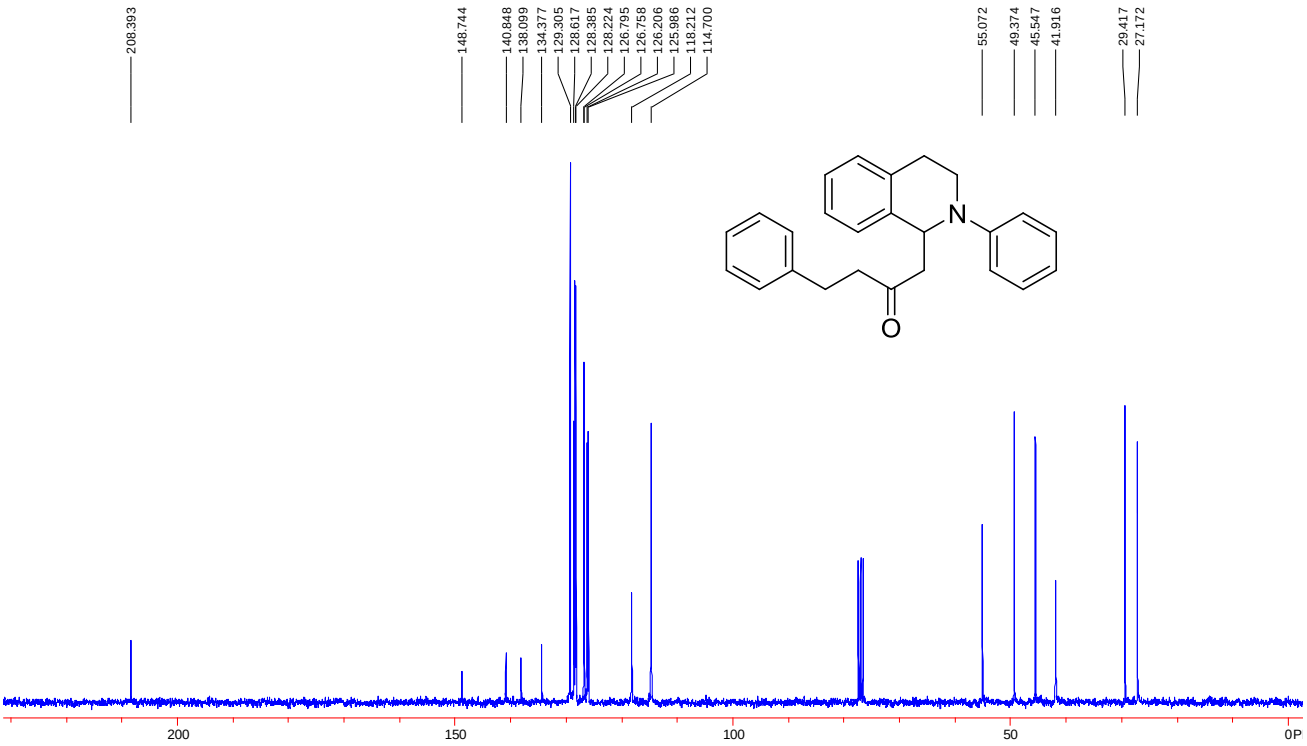

The $^{13}$C NMR of 1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4a**



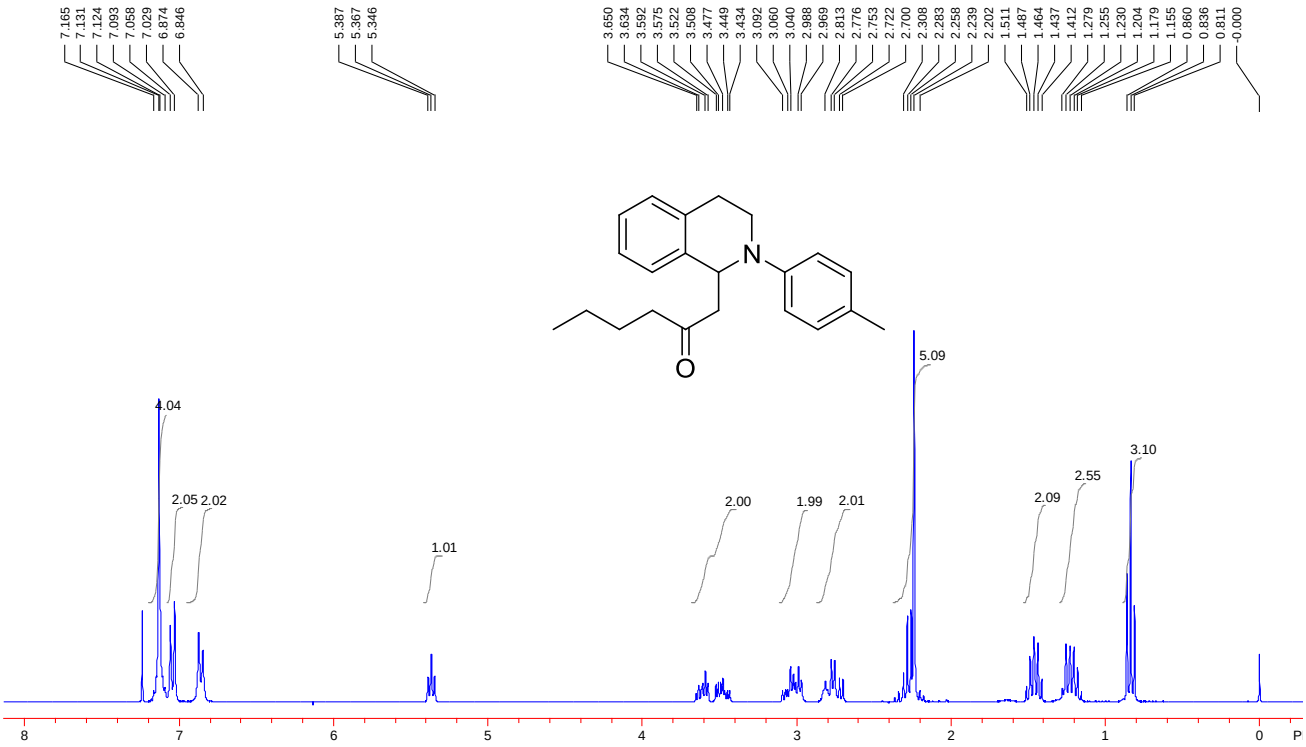
The $^{1}$H NMR of 4-phenyl-1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)butan-2-one **4e**



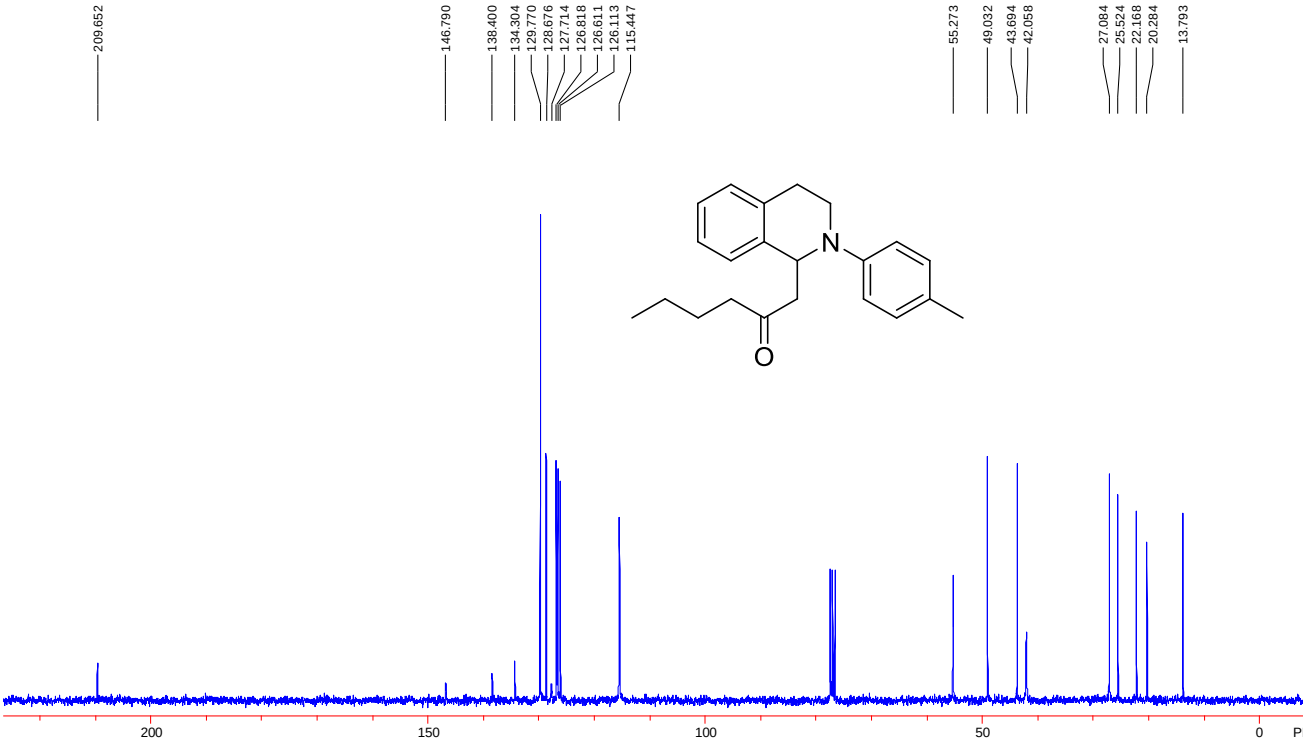

The $^{13}$C NMR of 4-phenyl-1-(2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)butan-2-one **4e**



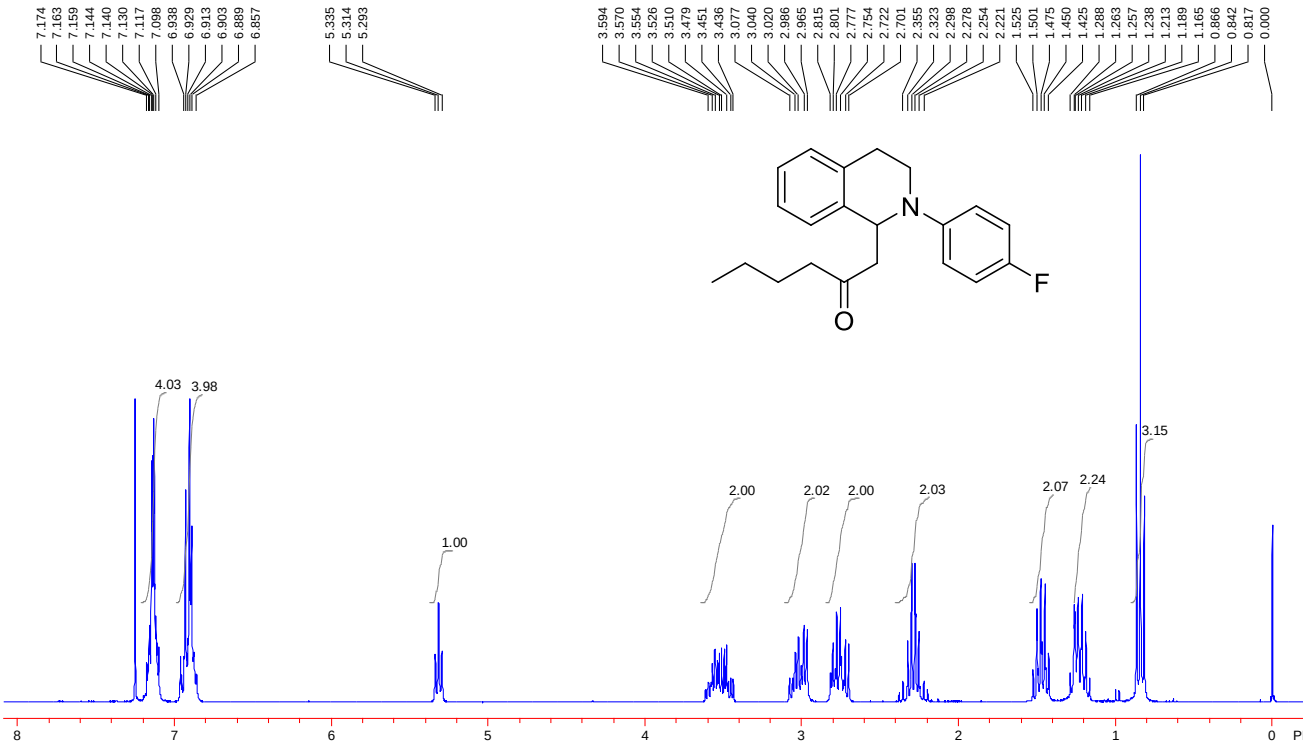
The $^{1}$H NMR of 1-(2-p-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4f**



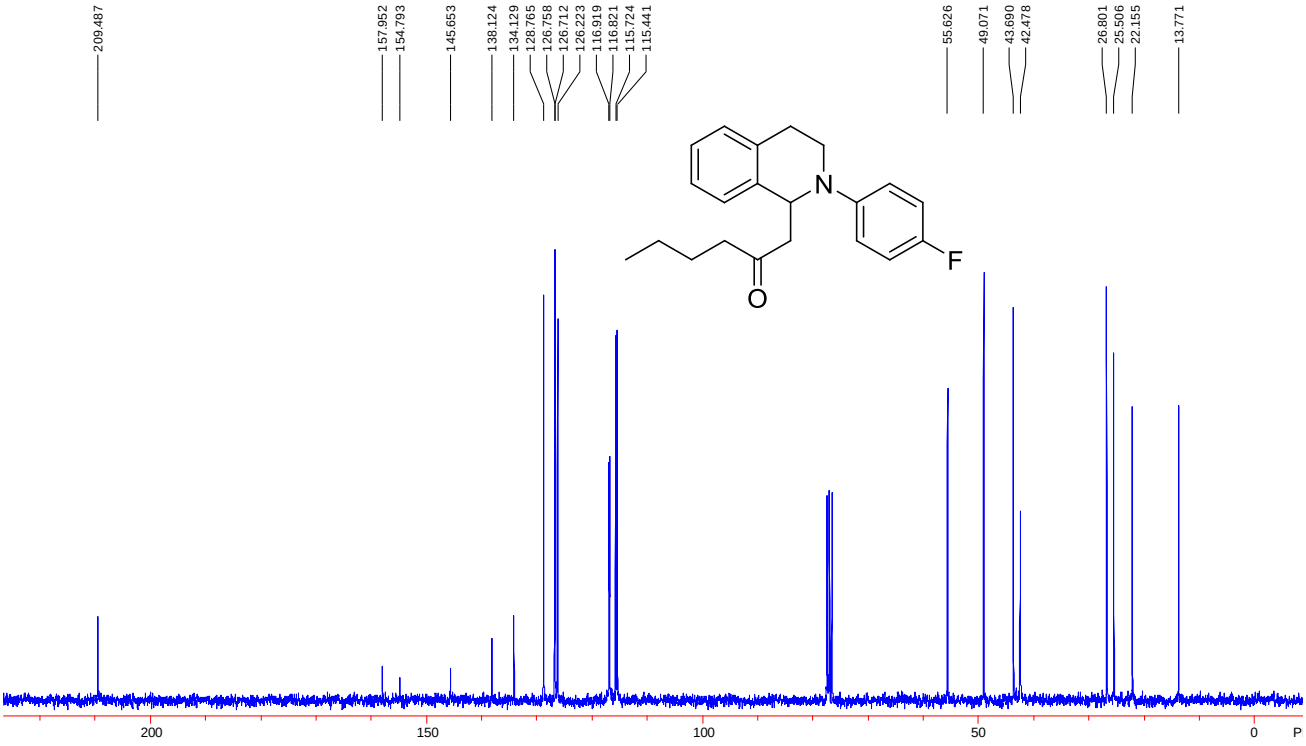

The $^{13}$C NMR of 1-(2-p-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4f**



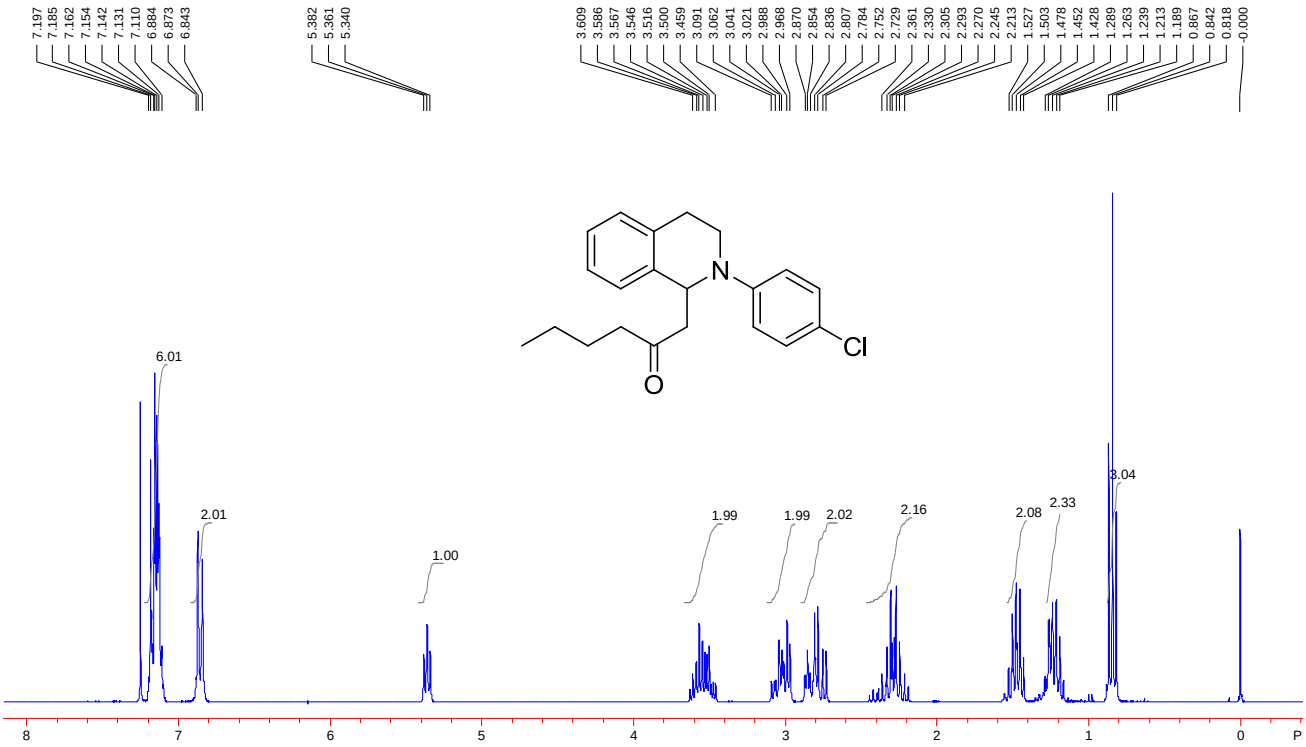
The $^{1}$H NMR of 1-(2-(4-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4g**



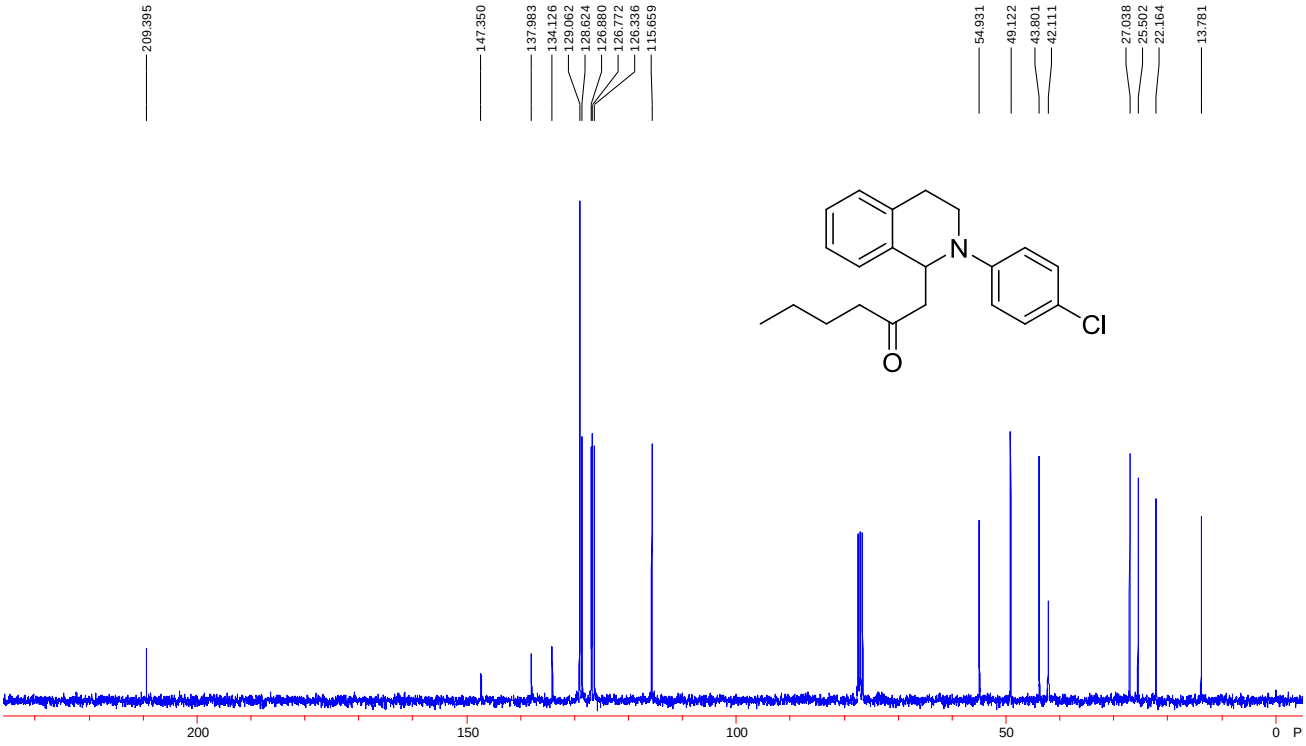

The $^{13}$C NMR of 1-(2-(4-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4g**



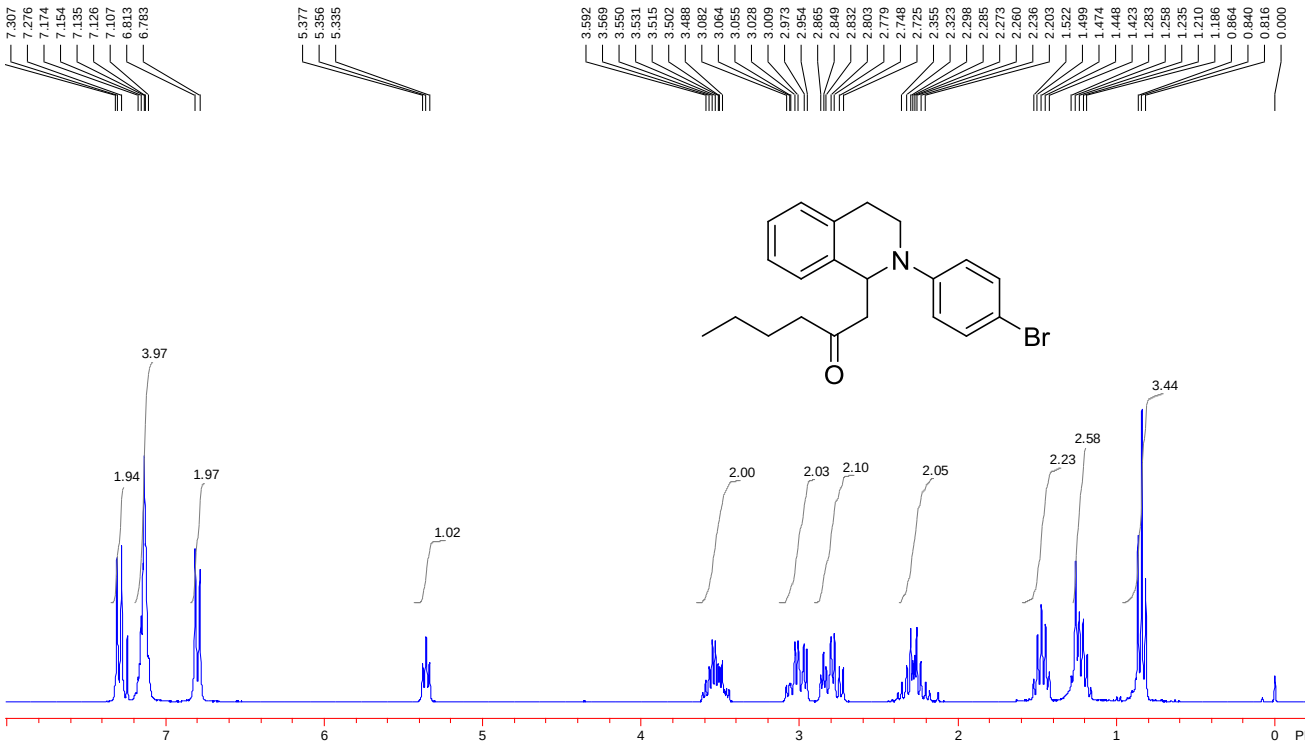
The $^{1}$H NMR of 1-(2-(4-chlorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4h**



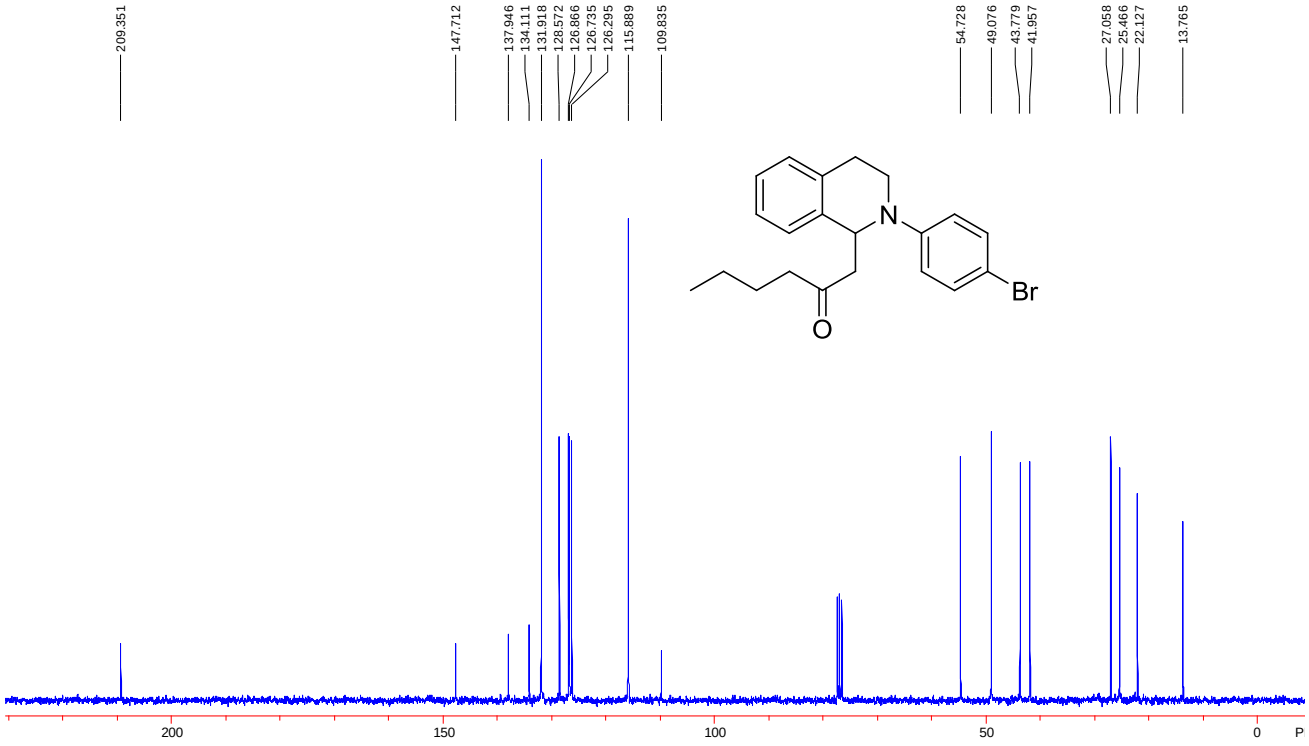

The $^{13}$C NMR of 1-(2-(4-chlorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4h**



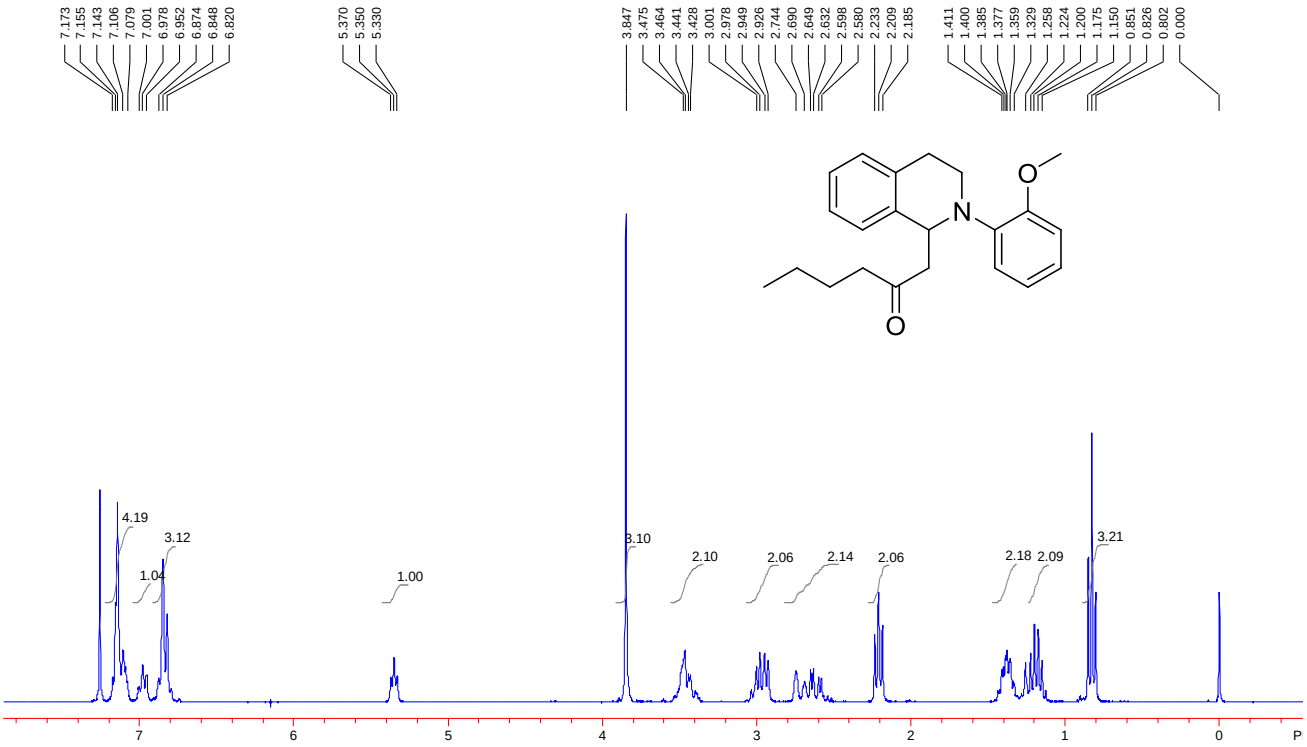
The $^{1}$H NMR of 1-(2-(4-bromophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4i**



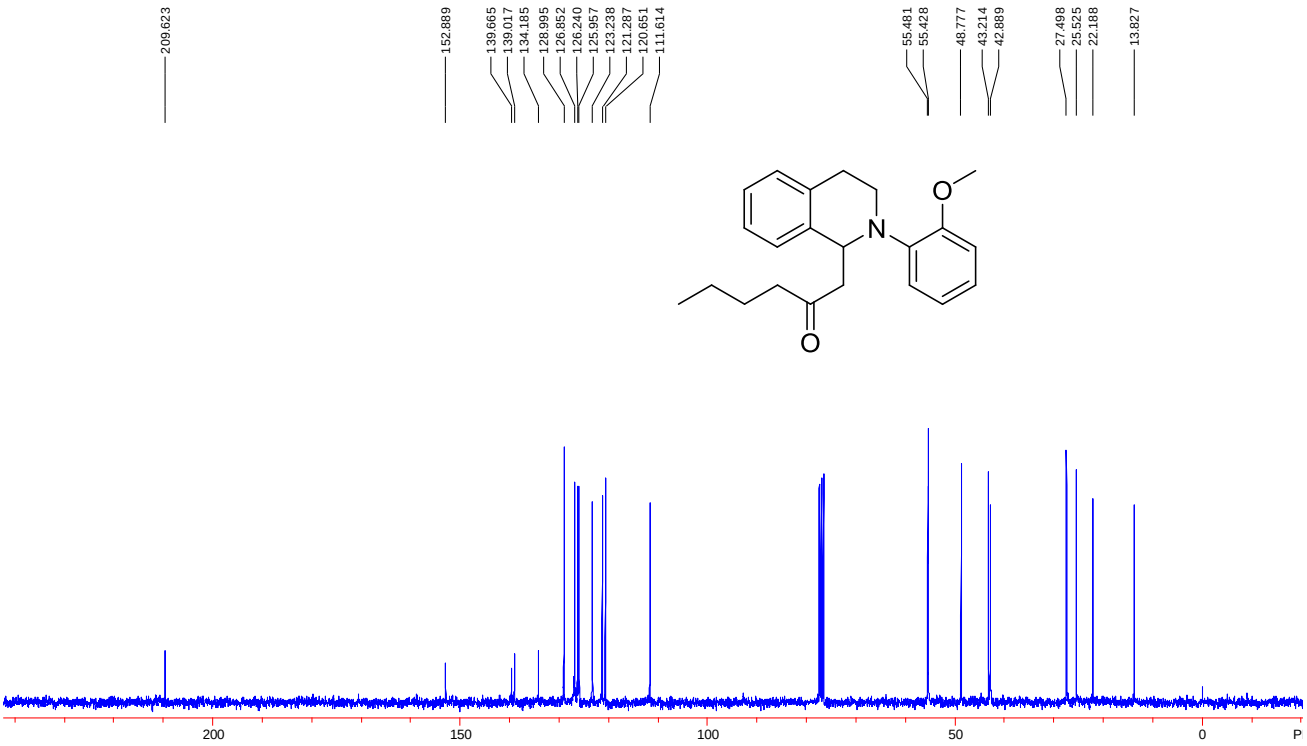

The $^{13}$C NMR of 1-(2-(4-bromophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4i**



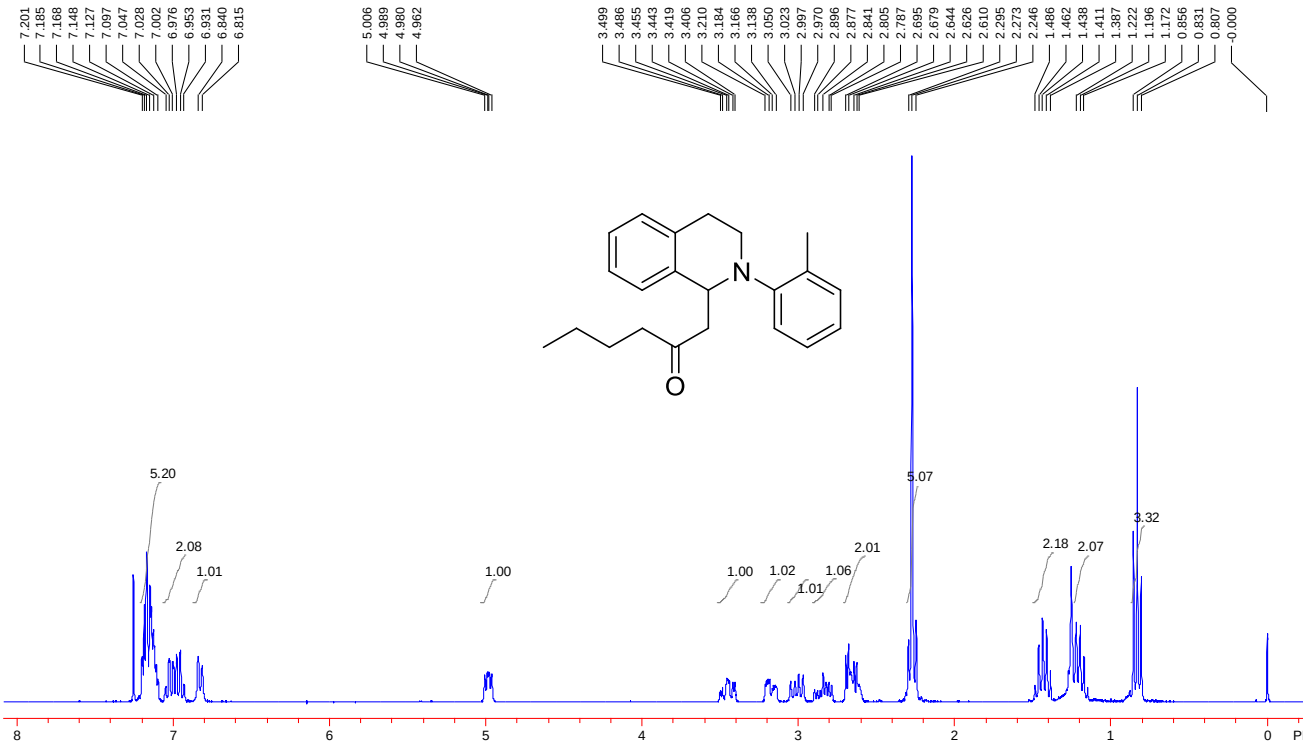
The $^{1}$H NMR of 1-(2-(2-methoxyphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4k**



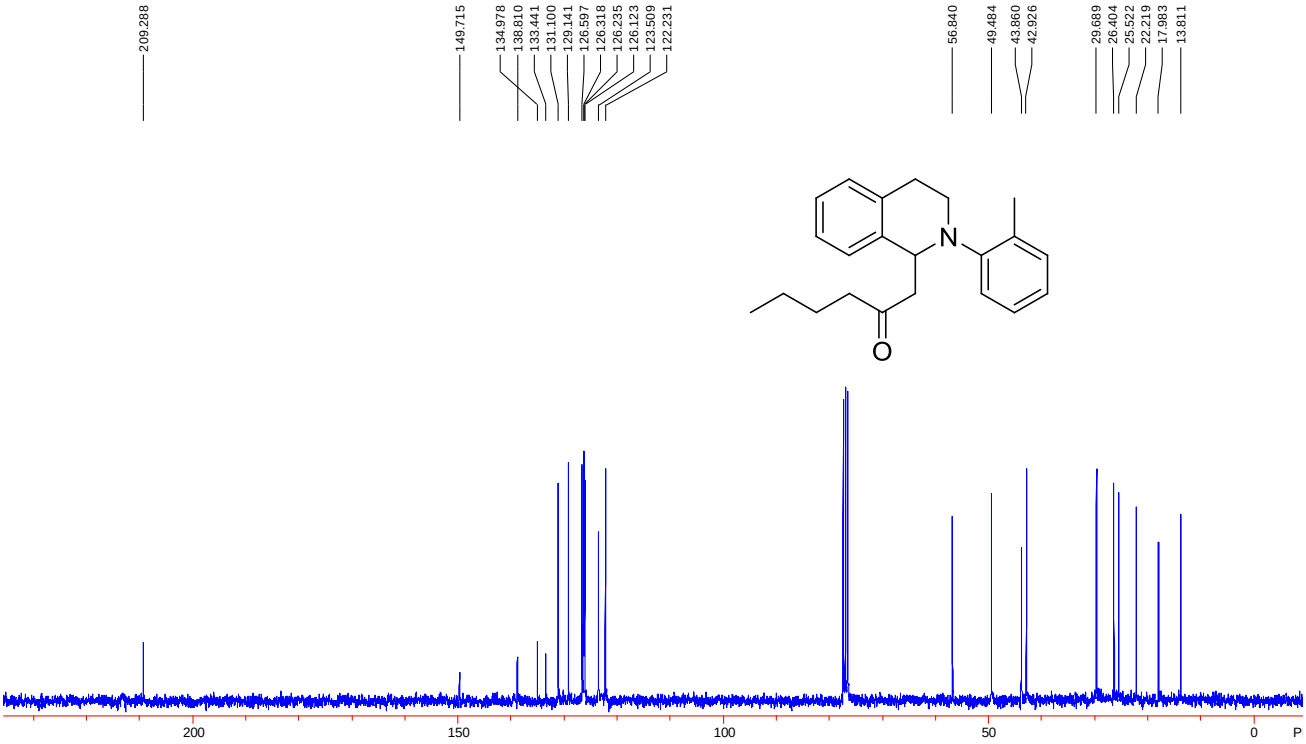

The $^{13}$C NMR of 1-(2-(2-methoxyphenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4k**



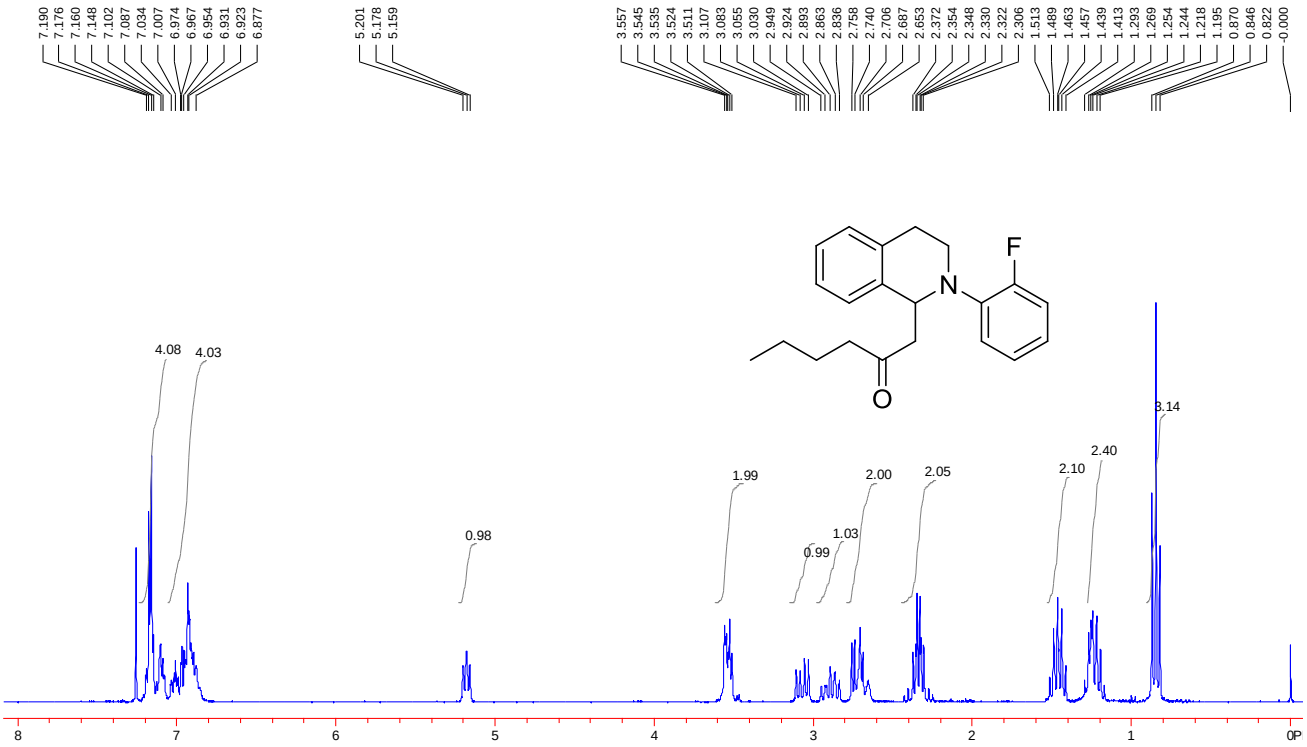
The $^{1}$H NMR of 1-(2-o-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4l**



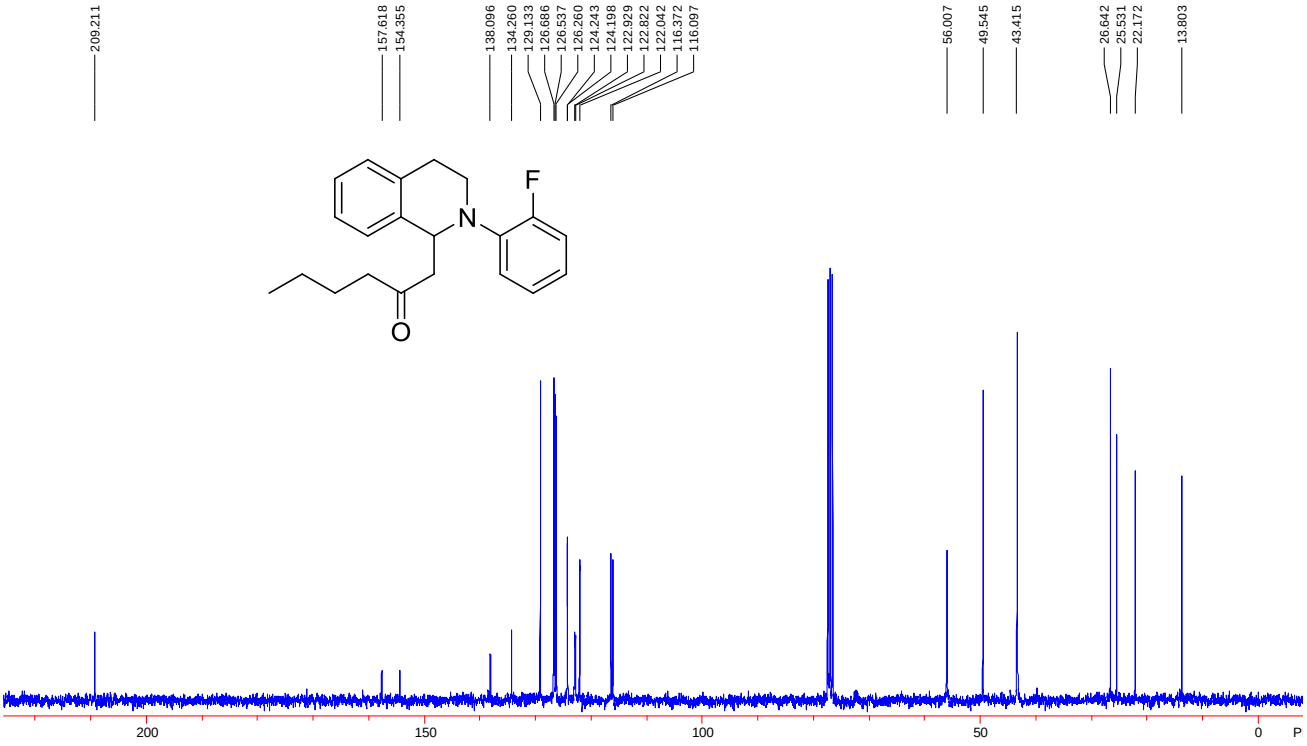

The $^{13}$C NMR of 1-(2-o-tolyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4l**



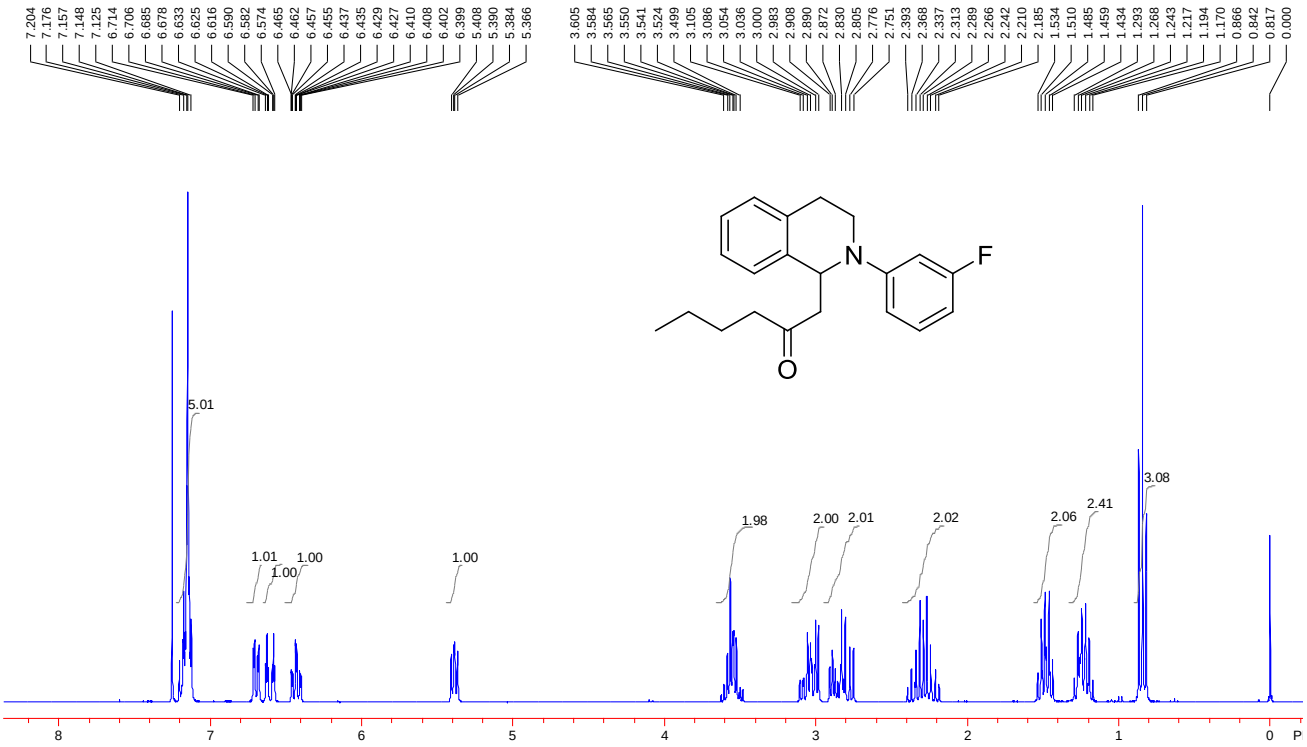
The $^{1}$H NMR of 1-(2-(2-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4m**



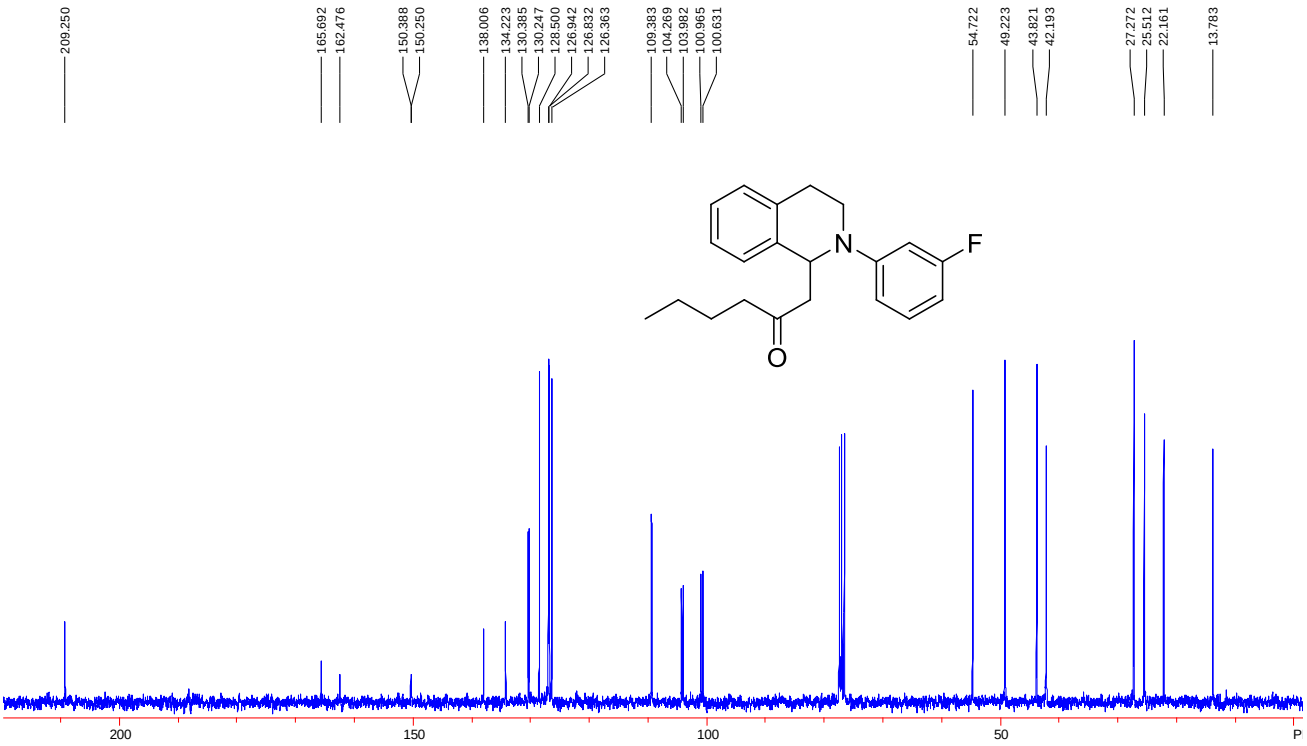

The $^{13}$C NMR of 1-(2-(2-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4m**



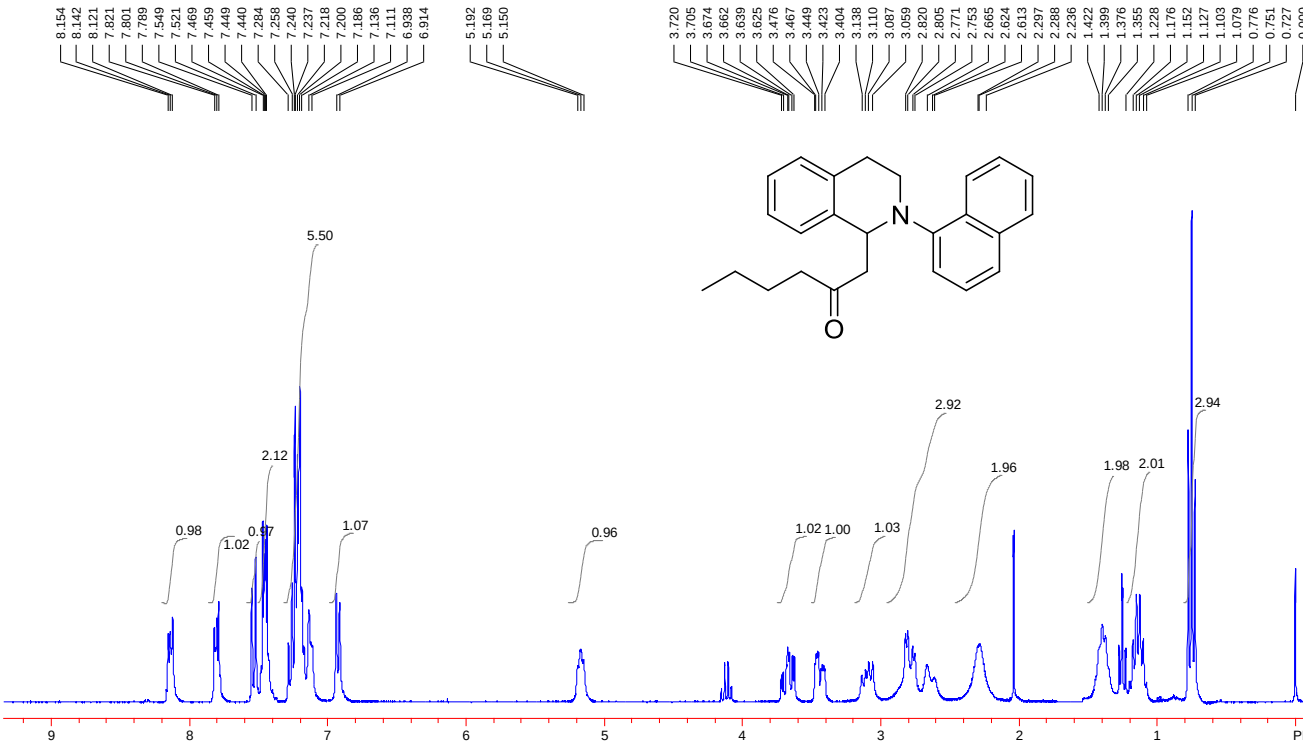
The $^{1}$H NMR of 1-(2-(3-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4n**



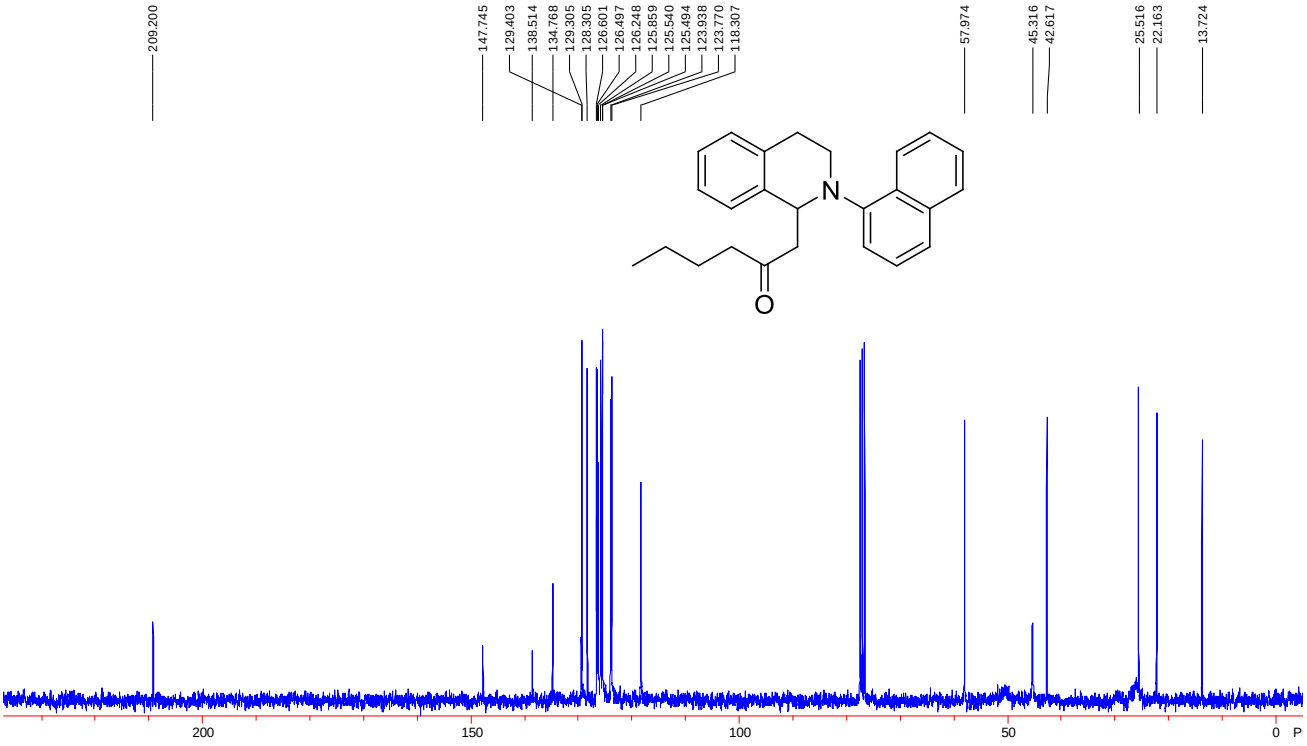

The $^{13}$C NMR of 1-(2-(3-fluorophenyl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4n**



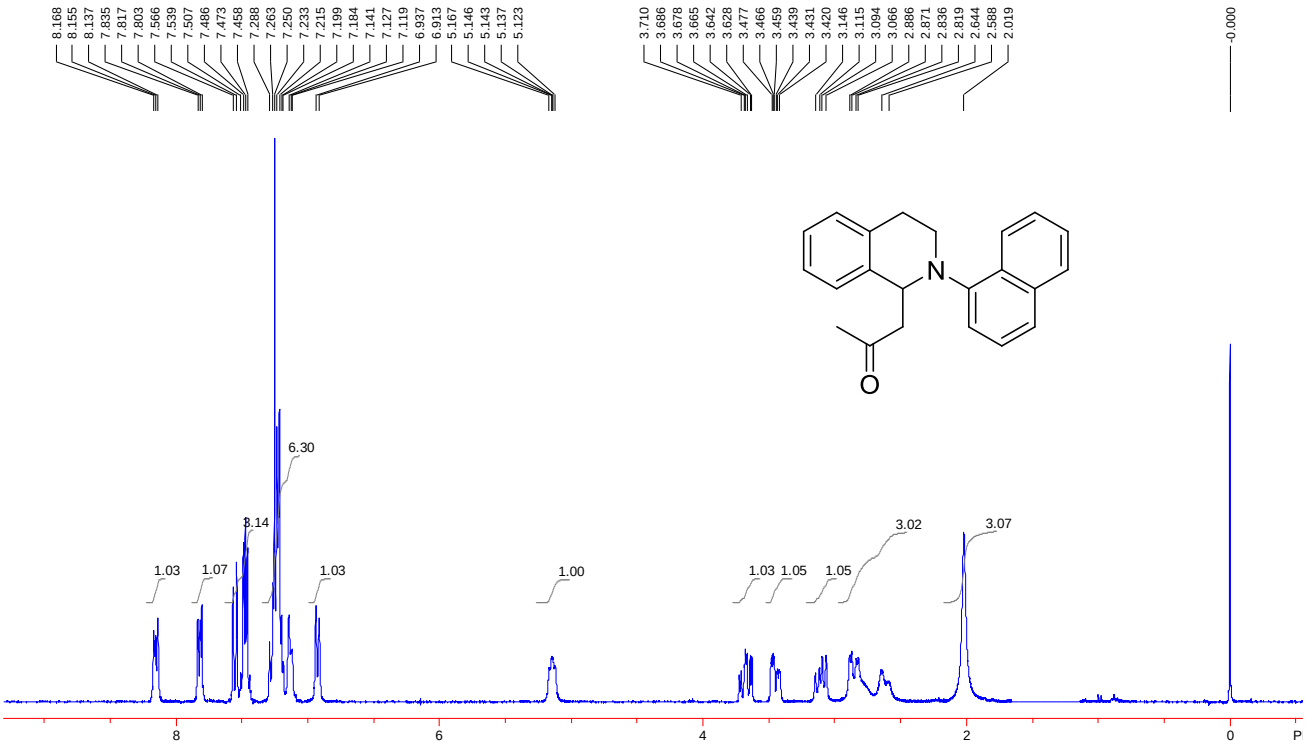
The $^{1}$H NMR of 1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4o**



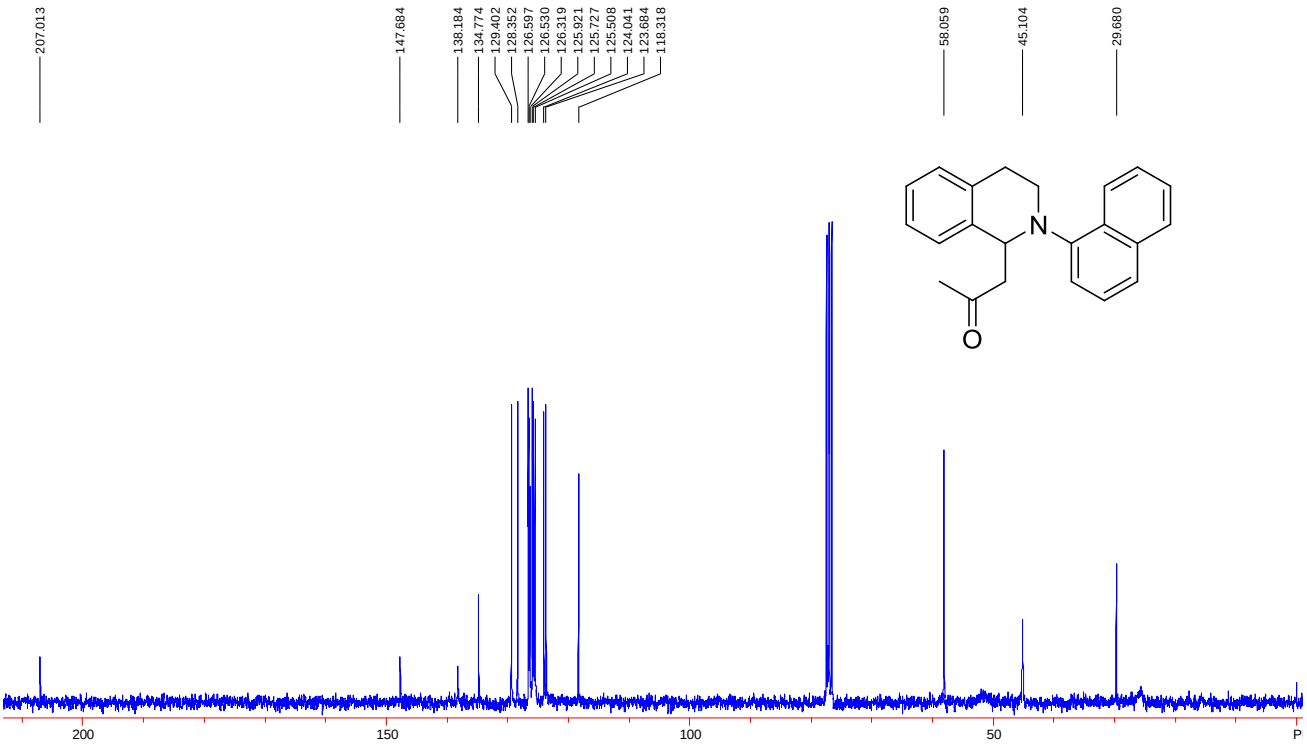

The $^{13}$C NMR of 1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4o**



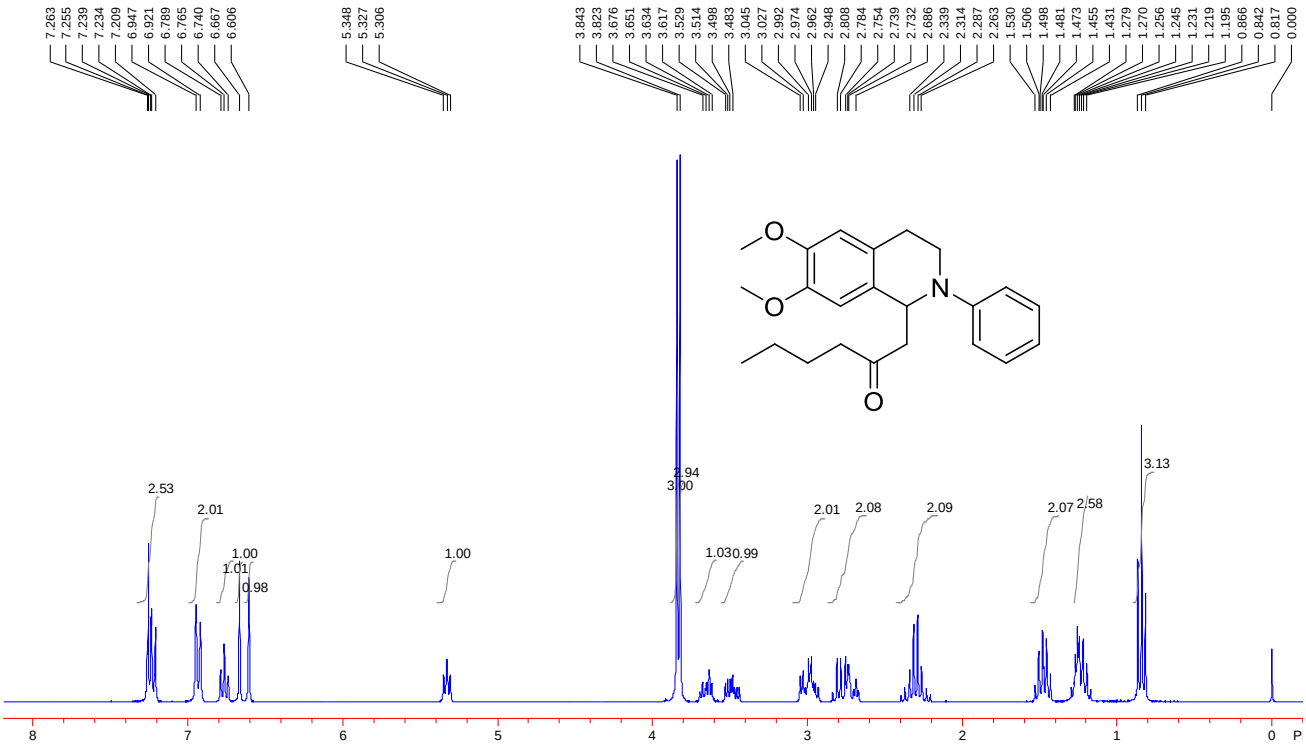
The $^{1}$H NMR of 1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)propan-2-one **4p**



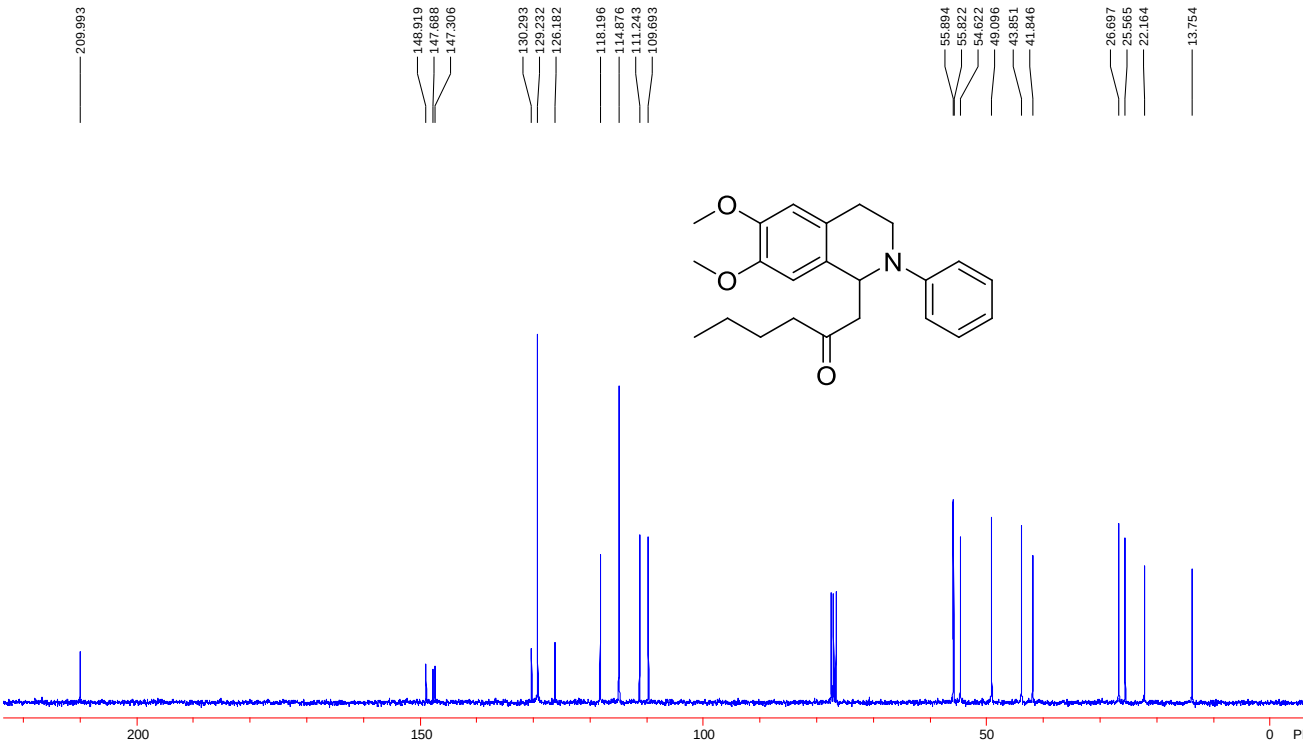

The $^{13}$C NMR of 1-(2-(naphthalen-1-yl)-1,2,3,4-tetrahydroisoquinolin-1-yl)propan-2-one **4p**



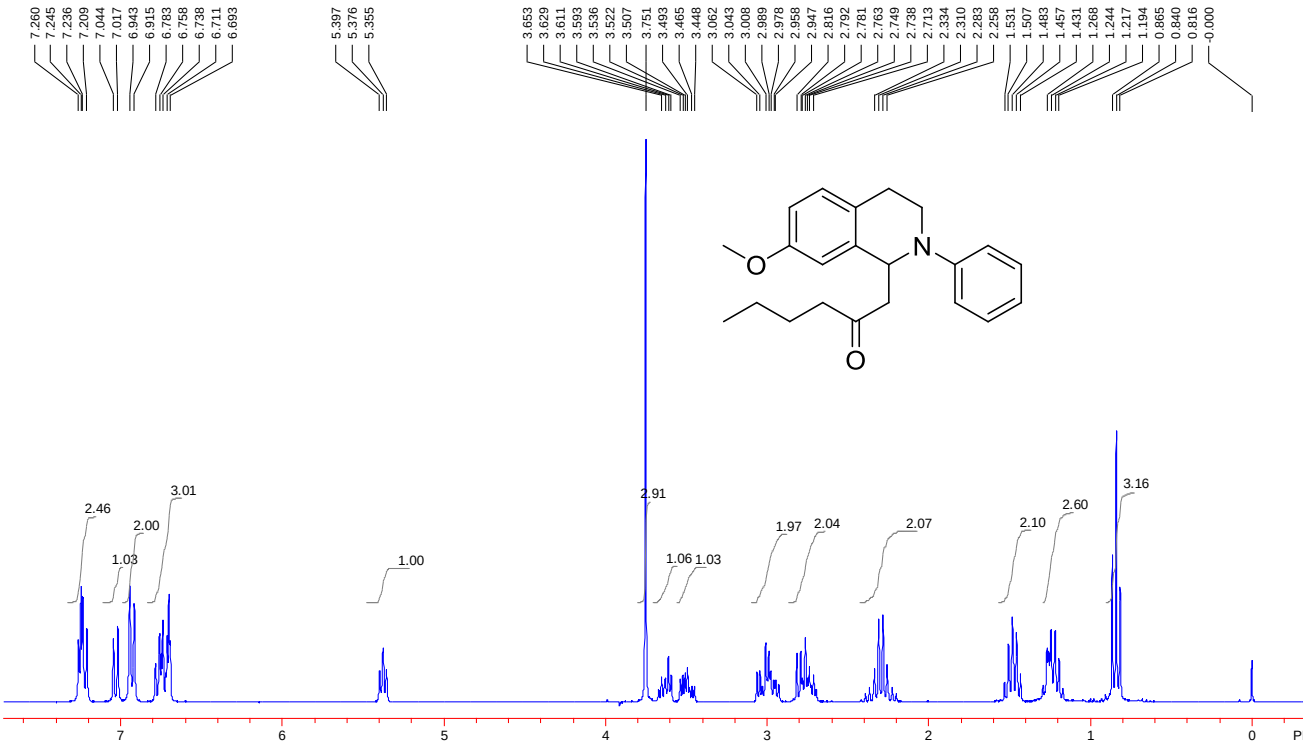
The $^{1}$H NMR of 1-(6,7-dimethoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4q**

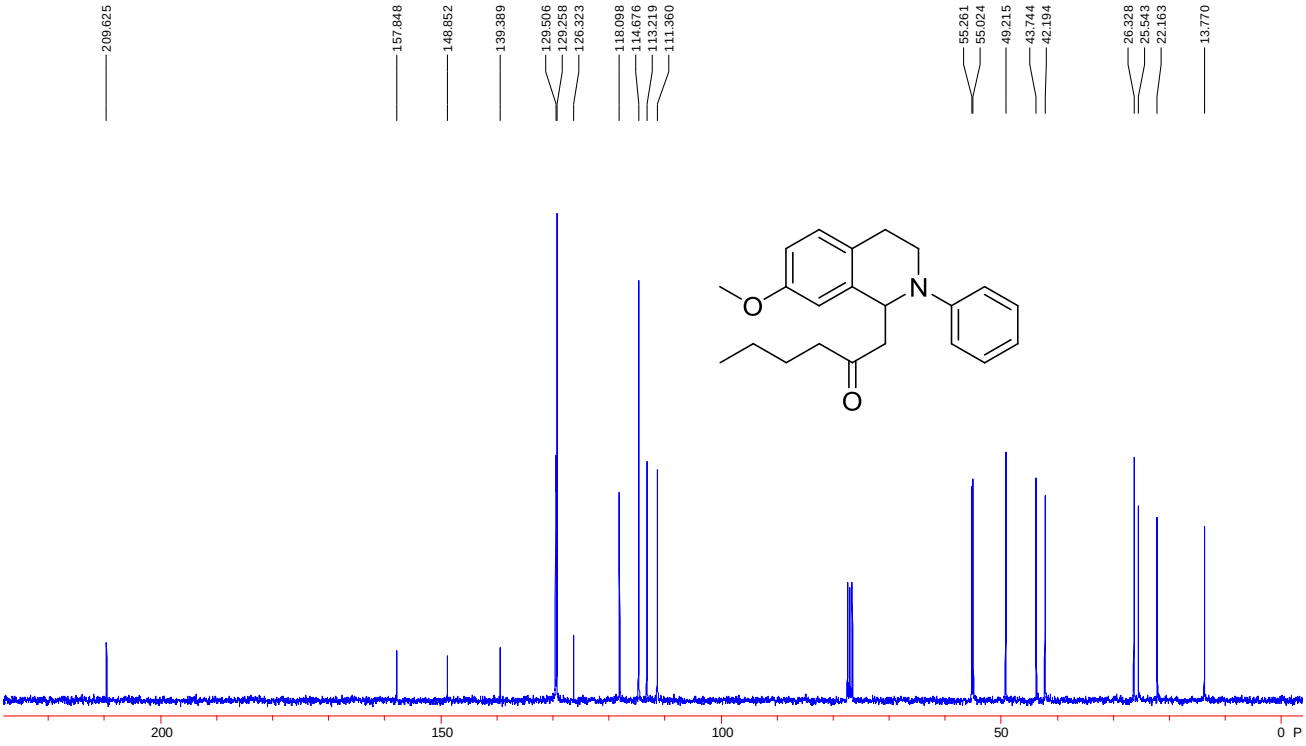



The $^{13}$C NMR of 1-(6,7-dimethoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4q**



The $^{1}$H NMR of 1-(7-methoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4r**




The $^{13}$C NMR of 1-(7-methoxy-2-phenyl-1,2,3,4-tetrahydroisoquinolin-1-yl)hexan-2-one **4r**