

# **CHEMISTRY**

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### Supporting Information

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**Rational Design of Sterically and Electrically Easily Tunable Chiral  
Bisimidazolines and Their Applications in Dual Lewis Acid/Brønsted  
Base Catalysis for Highly Enantioselective Nitroaldol (Henry)  
Reaction\*\***

Kuoyan Ma and Jingsong You\*

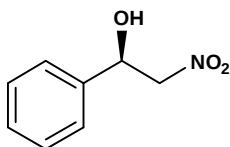
### ***Preparation of the racemic nitroaldols***<sup>[1]</sup>

A mixture of 1.0 mmol of aldehyde, 2.0 mmol of MeNO<sub>2</sub> and 3 drops of Et<sub>3</sub>N in 2.0 mmol of ethanol was stirred at room temperature for 10 h. Volatiles were removed in vacuo and the residue was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether to afford the racemic nitroaldol adduct.

### ***General procedure for the catalytic enantioselective Henry reaction***

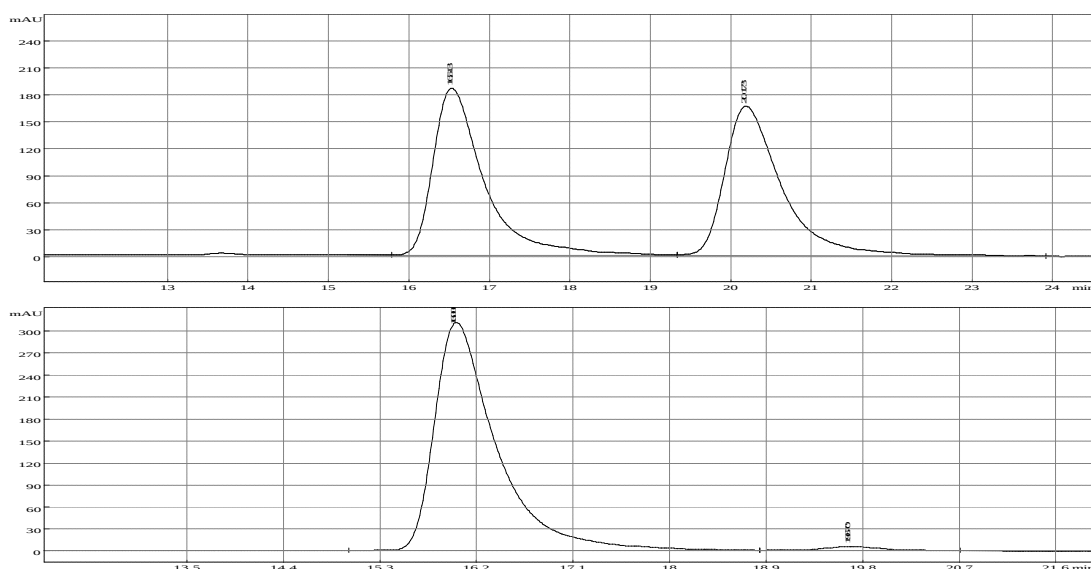
To a Schlenk tube equipped with a magnetic stirrer were added Cu(OTf)<sub>2</sub> (18.1 mg, 0.05mmol), ligand (S)-1 (0.0525 mmol) and ethanol (1.5 mL) under N<sub>2</sub> atmosphere at room temperature. After the mixture was allowed to stir for 2 h, aldehyde (0.5 mmol) was added, followed by the addition of dry freshly distilled nitromethane (0.26 mL, 5mmol) and triethylamine ( 7 µL, 0.05 mmol). The reaction mixture was stirred at the same temperature for 24 h. Volatiles were removed in vacuo, and the residue was purified by column chromatography on silica gel eluting with ethyl acetate/hexane to afford the nitroaldol adduct.

The yields of asymmetric Henry reactions reported are isolated yields and are the averages of two runs at least. Henry reaction products are known and their <sup>1</sup>H and <sup>13</sup>C NMR spectra agreed with those in the literature cited below.<sup>[2-3]</sup> Enantiomeric excess was determined by HPLC (LabTech 600 series) using Chiracel OD-H, OD, OJ, or AD-H column. The absolute configuration of nitroaldol adducts was assigned by comparison to literature compounds.<sup>[2-3]</sup>

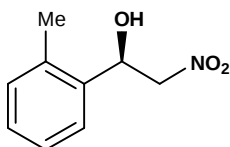


### (R)-2-Nitro-1-phenylethanol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 94% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.94 (br s, 1H; OH) , 4.39 (dd,  $J$  = 3.2, 9.4 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.43 (dd,  $J$  = 3.2, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 5.34 (2d,  $J$  = 3.1, 3.2 Hz, 1H;  $\text{CHOH}$ ), 7.18-7.38 ppm (m, 5H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 71.00, 81.22, 125.99 , 128.98, 129.04, 138.18 ppm; MS (EI,  $m/z$ ): 167 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 90: 10, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 19.67min (S), major enantiomer  $t_R$  = 16.00 min (R); 96% ee.<sup>[2]</sup>

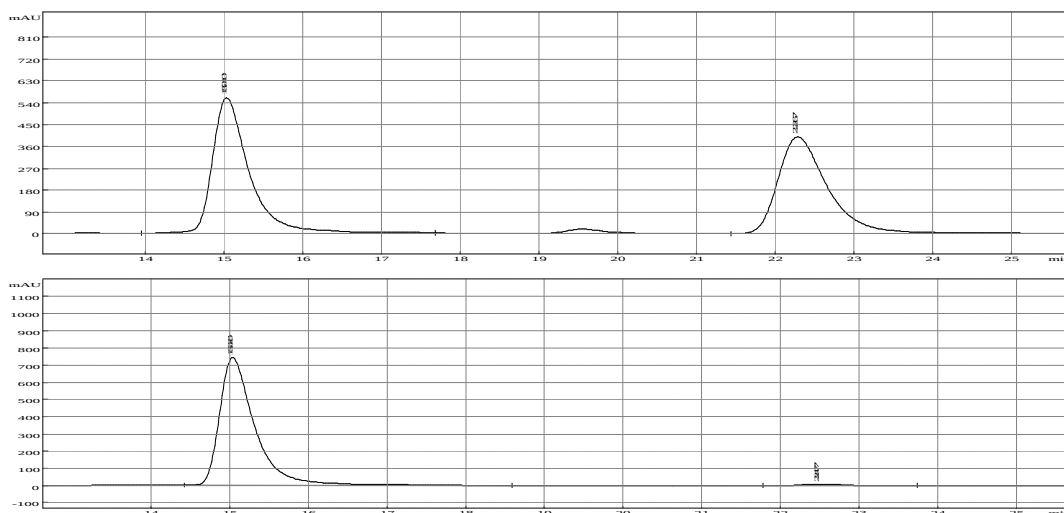


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 16.000 | 98.13    | 12560163 | 311560 |
| 2     | 19.670 | 1.868    | 239109   | 5826   |
| Total |        | 100      | 12799272 | 317386 |

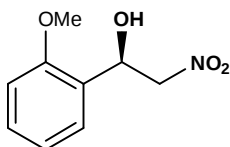


### (R)-2-Nitro-1-o-tolyethanol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 78% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.31 (s, 3H;  $\text{CH}_3$ ), 2.38 (br s, 1H; OH), 4.33 (dd,  $J$  = 2.8, 9.6 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.38 (dd,  $J$  = 2.7, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 5.58 (2d,  $J$  = 2.7, 2.7 Hz, 1H;  $\text{CHOH}$ ), 7.10- 7.21 (m, 3H; ArH), 7.43-7.46 ppm (m, 1H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 18.90, 67.97, 80.25, 125.64, 126.82, 128.74, 130.89, 134.47, 136.23 ppm; MS (EI,  $m/z$ ): 181 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 90:10, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 22.48min (S), major enantiomer  $t_R$  = 15.02 min (R); 97% ee.<sup>[2]</sup>

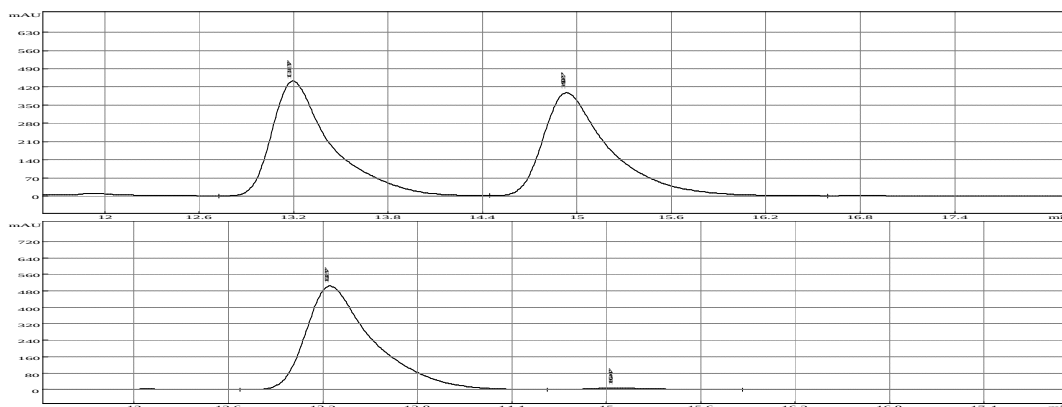


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 15.020 | 98.21    | 22936149 | 740470 |
| 2     | 22.477 | 1.788    | 417544   | 9456   |
| Total |        | 100      | 23353693 | 749926 |

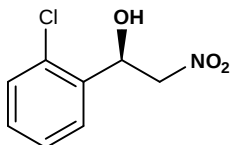


### (R)-1-(2-Methoxyphenyl)-2-nitroethanol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 65% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.97 (br s, 1H; OH) , 3.81 (s, 3H;  $\text{OCH}_3$ ), 4.46 (dd,  $J$  = 9.1, 3.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 4.50 (dd,  $J$  = 8.9, 3.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 5.53 (2d,  $J$  = 3.4, 3.4 Hz, 1H;  $\text{CHOH}$ ), 6.83 (d,  $J$  = 8.2 Hz, 1H; ArH), 6.91-6.96 (m, 1H; ArH), 7.23-7.29 (m, 1H; ArH), 7.38 ppm (2d,  $J$  = 1.5, 1.6 Hz, 1H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 55.42, 67.85, 79.86, 110.55, 121.20, 125.96, 127.23, 129.82, 156.02 ppm; MS (EI,  $m/z$ ): 197 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD column: *n*-hexane/isopropanol 90: 10, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 15.05 min (S), major enantiomer  $t_R$  = 13.24min (R); 96% ee.<sup>[2]</sup>

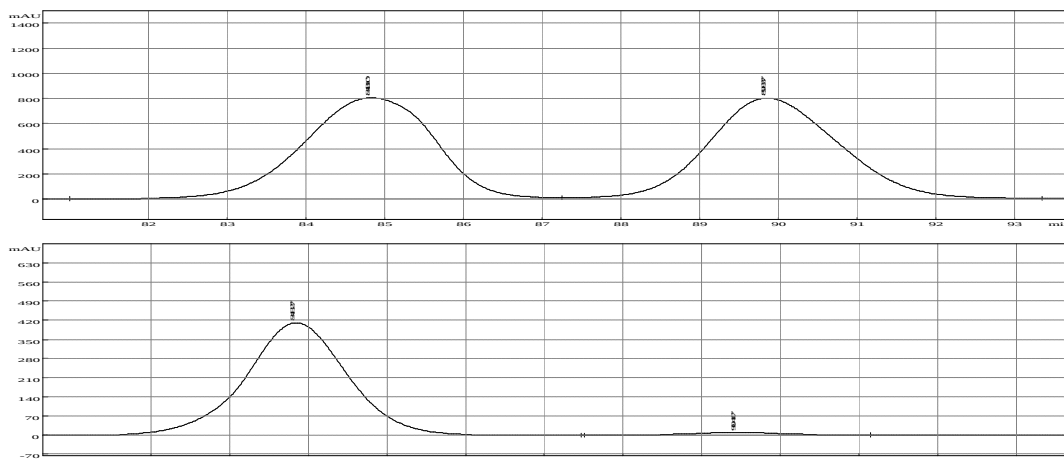


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 13.237 | 98.19    | 15050954 | 503004 |
| 2     | 15.047 | 1.811    | 277612   | 9089   |
| Total |        | 100      | 15328566 | 512093 |

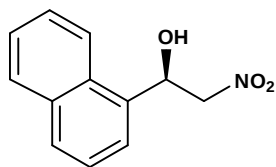


**(R)-1-(2-Chlorophenyl)-2-nitroethanol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 92% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.95 (br s, 1H; OH) , 4.35 (dd,  $J$  = 9.6, 2.3 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.39 (dd,  $J$  = 9.5, 2.4 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 5.76 (2d,  $J$  = 2.2, 2.2 Hz, 1H;  $\text{CHOH}$ ), 7.19-7.33 (m, 3H; ArH), 7.58 ppm (2d,  $J$  = 1.7, 2.0 Hz, 1H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 67.84, 79.31, 127.52, 127.61, 129.72, 129.94, 131.5, 135.50 ppm; MS (EI,  $m/z$ ): 201 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel AD-H column: *n*-hexane/isopropanol 98: 2, 0.3 mL/min, 215 nm; minor enantiomer  $t_R$  = 90.42 min (S), major enantiomer  $t_R$  = 84.83 min (R); 95% ee. <sup>[2]</sup>

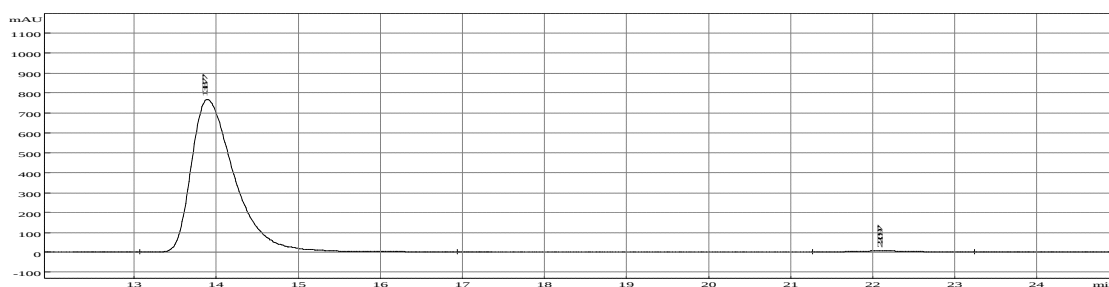
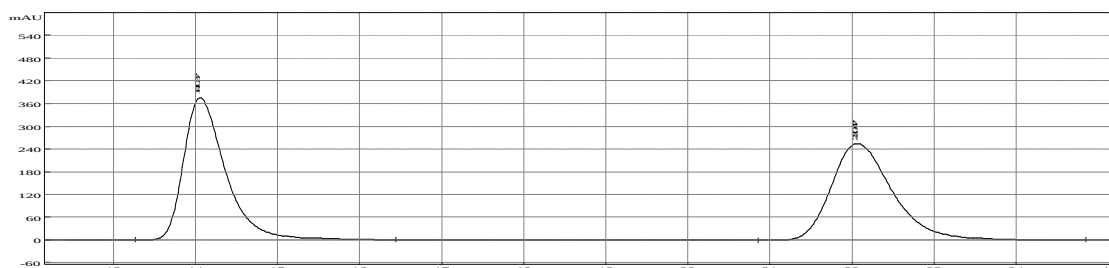


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 84.827 | 97.48    | 37982864 | 412910 |
| 2     | 90.417 | 2.522    | 982649   | 10298  |
| Total |        | 100      | 38965513 | 423208 |

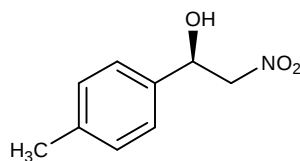


**(R)-1-(1-Naphthyl)-2-nitroethanol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give a pale yellow solid in 74% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.84 (br s, 1H; OH) , 4.61-4.73 (m, 2H;  $\text{CH}_2\text{NO}_2$ ), 6.25 (2d,  $J$  = 3.4,3.6 Hz, 1H; CHOH) , 7.50-7.63 (m, 3H; ArH), 7.76 (d,  $J$  = 7.2 Hz, 1H; ArH), 7.86-7.94 (m, 2H; ArH), 8.03 ppm (d,  $J$  = 8.3 Hz, 1H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 68.35, 80.81, 121.84,123.89, 125.52, 126.12, 127.10, 129.34, 129.44, 129.60, 133.56, 133.78 ppm; MS (EI,  $m/z$ ): 217 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 85: 15, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 22.10 min (S), major enantiomer  $t_R$  =13.88 min (R); 97% ee.<sup>[2]</sup>

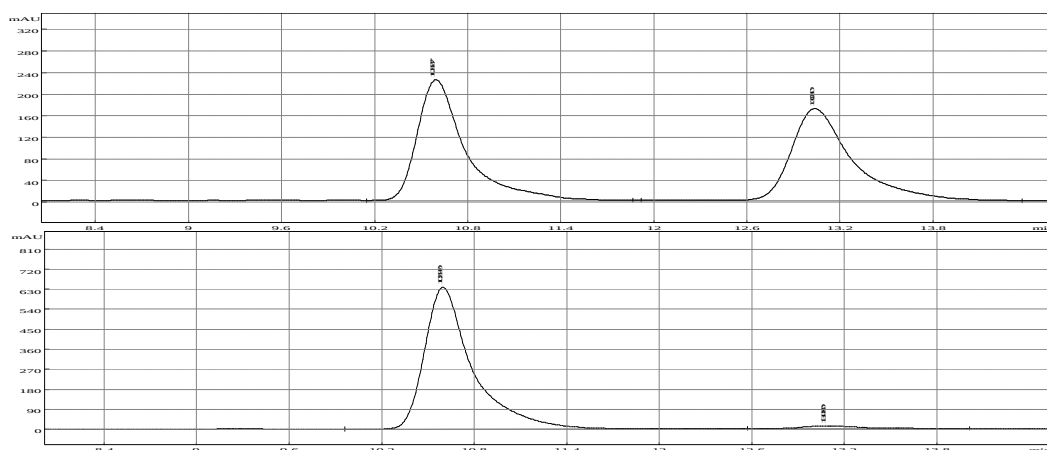


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 13.877 | 98.47    | 28318493 | 767779 |
| 2     | 22.097 | 1.524    | 438407   | 9286   |
| Total |        | 100      | 28756900 | 777065 |

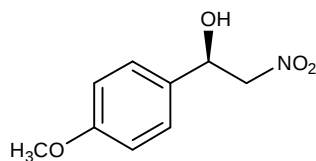


### (R)-2-Nitro-1-p-tolylethanol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 60% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.28 (s, 3H;  $\text{CH}_3$ ), 2.52 (br s, 1H; OH), 4.37 (dd,  $J$  = 3.2, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.42 (dd,  $J$  = 3.2, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 5.32 (2d,  $J$  = 3.1, 3.1 Hz, 1H;  $\text{CHOH}$ ), 7.09 ppm (2d,  $J$  = 8.1, 8.2 Hz, 4H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.15, 70.93, 81.28, 125.89, 129.70, 135.24, 138.93 ppm; MS (EI,  $m/z$ ): 181 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD column: *n*-hexane/isopropanol 85: 15, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 13.08 min (S), major enantiomer  $t_R$  = 10.59 min (R); 95% ee.<sup>[3]</sup>

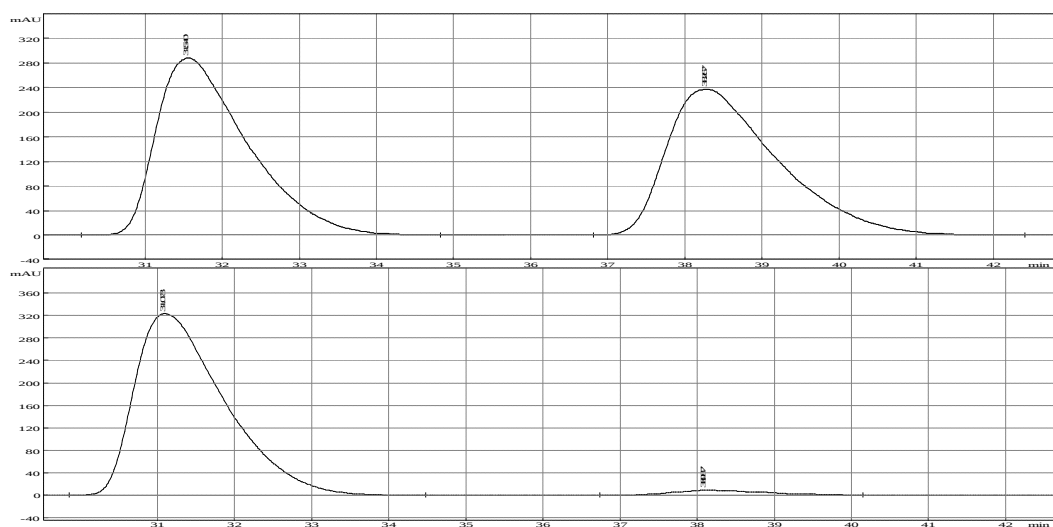


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 10.590 | 97.52    | 13798974 | 637898 |
| 2     | 13.080 | 2.473    | 349876   | 13459  |
| Total |        | 100      | 14148850 | 651357 |

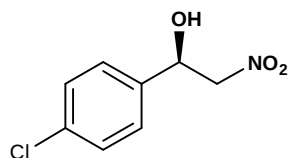


**(R)-1-(4-Methoxyphenyl)-2-nitroethanol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/3) to give colorless oil in 45% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.44 (br s, 1H; OH) , 3.74 (s, 3H;  $\text{CH}_3$ ), 4.37 (dd,  $J$  = 3.2, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 4.41 (dd,  $J$  = 3.2, 9.5 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 5.30 (2d,  $J$  = 3.2, 3.2 Hz, 1H;  $\text{CHOH}$ ) , 6.80-6.87 (m, 2H; ArH), 7.22 ppm (2d,  $J$  = 4.7, 4.7 Hz, 2H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 55.35, 70.67, 81.27, 114.42, 127.28, 130.28, 160.06 ppm; MS (EI,  $m/z$ ): 197 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OJ column: *n*-hexane/isopropanol 85: 15, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 38.09 min (S), major enantiomer  $t_R$  = 31.07 min (R); 94% ee. <sup>[3]</sup>

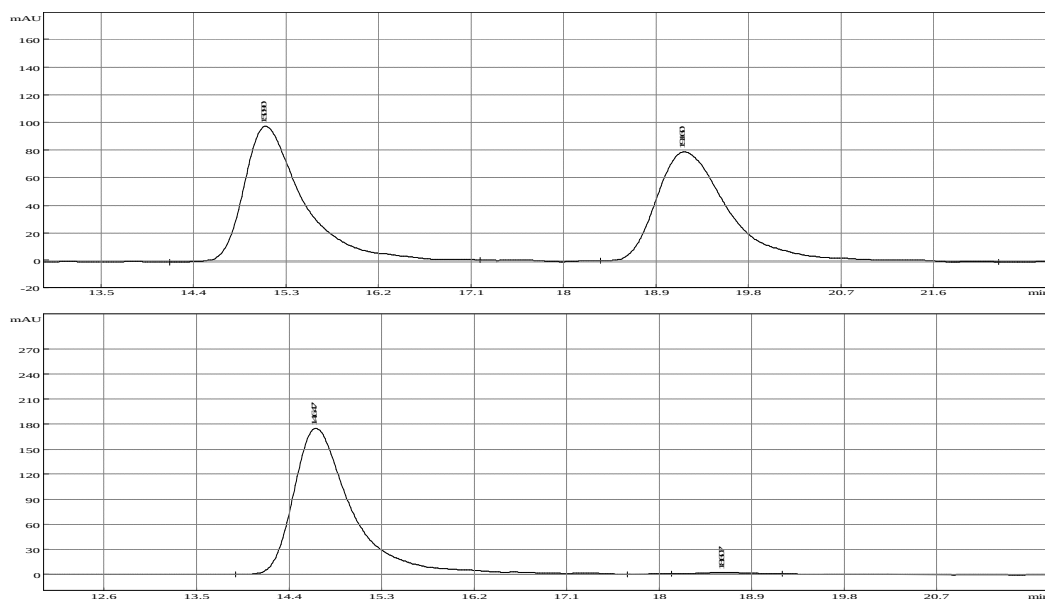


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 31.073 | 96.99    | 26166518 | 322798 |
| 2     | 38.087 | 3.011    | 812387   | 8906   |
| Total |        | 100      | 26978905 | 331704 |

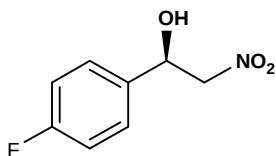


**(R)-1-(4-Chlorophenyl)-2-nitroethanol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 82% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.96 (br s, 1H; OH) , 4.46 (dd,  $J$  = 3.3, 9.2 Hz ,1H;  $\text{CH}_2\text{NO}_2$ ), 4.50 (dd,  $J$  = 3.3, 9.3 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 5.42 (2d,  $J$  = 3.3, 3.3 Hz, 1H;  $\text{CHOH}$ ), 7.33-7.40 ppm (m, 4H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 70.30, 81.00, 127.33, 129.23, 134.85, 136.59 ppm; MS (EI,  $m/z$ ): 201 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 90: 10, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 18.61 min (S), major enantiomer  $t_R$  =14.65 min (R); 98% ee. <sup>[2]</sup>

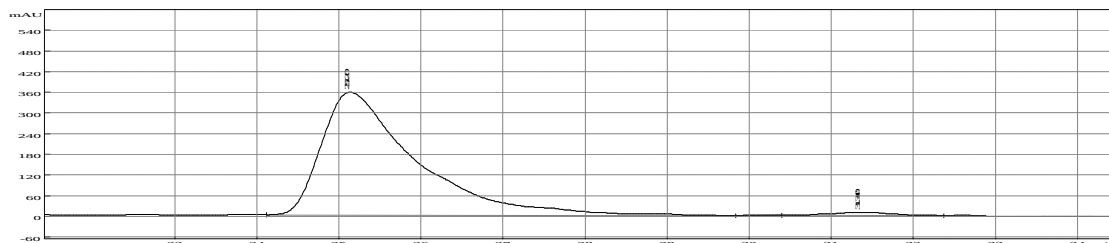
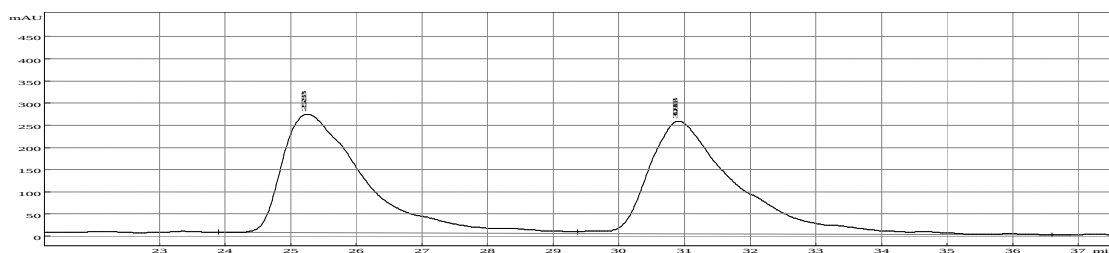


| Rank  | Time   | Quantity | Area    | Height |
|-------|--------|----------|---------|--------|
| 1     | 14.647 | 99.19    | 7010278 | 175255 |
| 2     | 18.607 | 0.8171   | 57752   | 2264   |
| Total |        | 100      | 7068030 | 177519 |

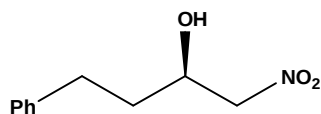


**(R)-1-(4-Fluorophenyl)-2-nitroethanol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 76% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.97 (br s, 1H; OH) , 4.45 (dd,  $J$  = 3.2, 9.3 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.50 (dd,  $J$  = 3.3, 9.4 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 5.43 (2d,  $J$  = 3.2, 3.2 Hz, 1H;  $\text{CHOH}$ ), 7.05-7.13 (m, 2H; ArH), 7.35-7.41 ppm (m, 2H; ArH);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 70.34, 81.14, 115.86, 116.14, 127.73, 127.85, 133.95, 134.00, 161.27, 164.55 ppm; MS (EI,  $m/z$ ): 185 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 95: 5, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 31.34 min (S), major enantiomer  $t_R$  = 25.12 min (R); 97% ee.<sup>[2]</sup>

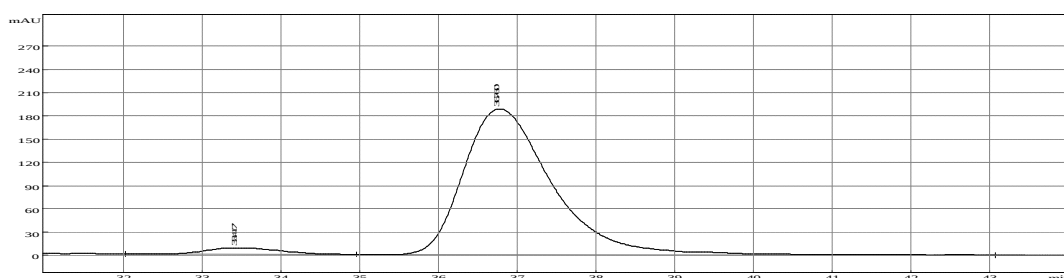
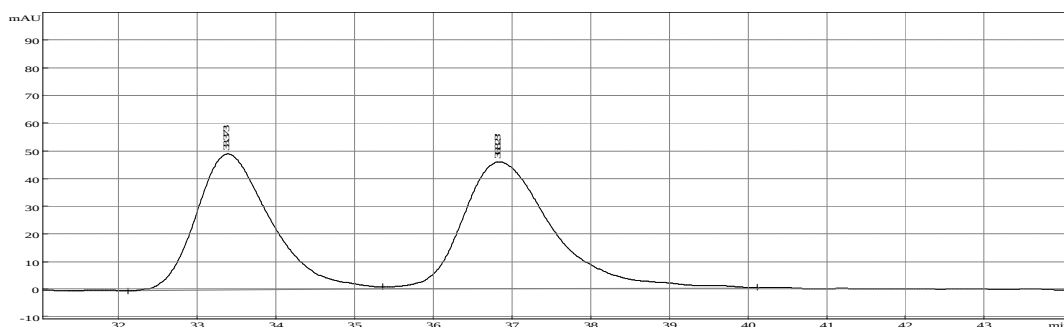


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 25.120 | 98.3     | 28228874 | 355758 |
| 2     | 31.340 | 1.701    | 488464   | 9458   |
| Total |        | 100      | 28717338 | 365216 |

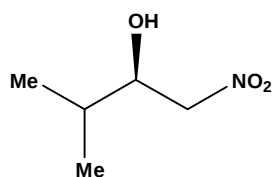


**(R)-1-Nitro-4-phenylbutan-2-ol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give a white solid in 95% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.70-1.81 (m, 2H;  $\text{CH}_2\text{CH}_2\text{Ph}$ ) , 2.50 (br s, 1H;  $\text{OH}$ ), 2.62-2.82 (m, 2H;  $\text{CH}_2\text{Ph}$ ) , 4.20-4.27 (m, 1H;  $\text{CHOH}$ ), 4.31 (d,  $J$  = 1.9 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ) , 4.33 (s, 1H;  $\text{CH}_2\text{NO}_2$ ), 7.11-7.18 (m, 3H;  $\text{ArH}$ ) , 7.21-7.26 ppm (m, 2H;  $\text{ArH}$ );  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 31.33, 35.14, 67.79, 80.57, 126.34, 128.42, 128.66, 140.62 ppm; MS (EI,  $m/z$ ): 195 [ $\text{M}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD-H column: *n*-hexane/isopropanol 92: 8, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 33.42 min (S), major enantiomer  $t_R$  = 36.76 min (R); 93% ee.<sup>[2]</sup>

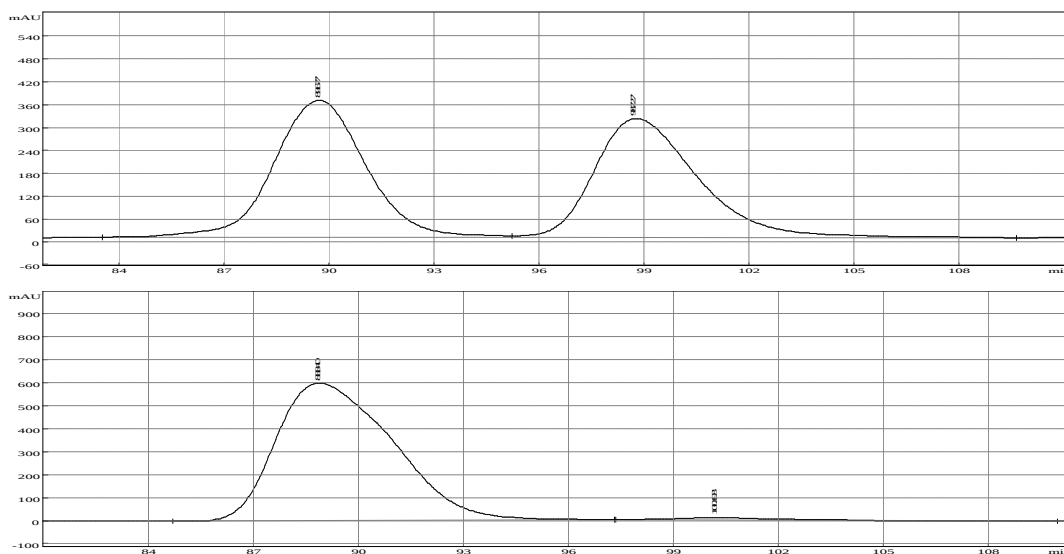


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 33.417 | 3.489    | 530594   | 8234   |
| 2     | 36.760 | 96.51    | 14677024 | 187700 |
| Total |        | 100      | 15207618 | 195934 |

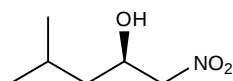


### (R)-3-Methyl-1-nitrobutan-2-ol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 91% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 0.97 (d,  $J$  = 4.4 Hz, 3 H;  $\text{CH}_3$ ) , 1.02 (d,  $J$  = 4.1 Hz, 3 H;  $\text{CH}_3$ ), 1.76-1.82 (m, 1H;  $\text{CH}(\text{CH}_3)_2$ ) , 2.52 (br s, 1H; OH), 4.06-4.12 (m, 1H;  $\text{CHOH}$ ) , 4.36 (dd,  $J$  = 8.8, 3.1 Hz, 1H;  $\text{CH}_2\text{NO}_2$ ), 4.40 ppm (dd,  $J$  = 8.7, 3.2 Hz, 1H;  $\text{CH}_2\text{NO}_2$ );  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 17.44, 18.42, 31.75, 73.38, 79.31 ppm; MS (EI,  $m/z$ ): 134 [ $\text{M}+\text{H}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel OD column: *n*-hexane/isopropanol 98:2, 0.2mL/min, 215 nm; minor enantiomer  $t_R$  = 100.19 min (S), major enantiomer  $t_R$  = 88.84 min (R); 96% ee.<sup>[2]</sup>

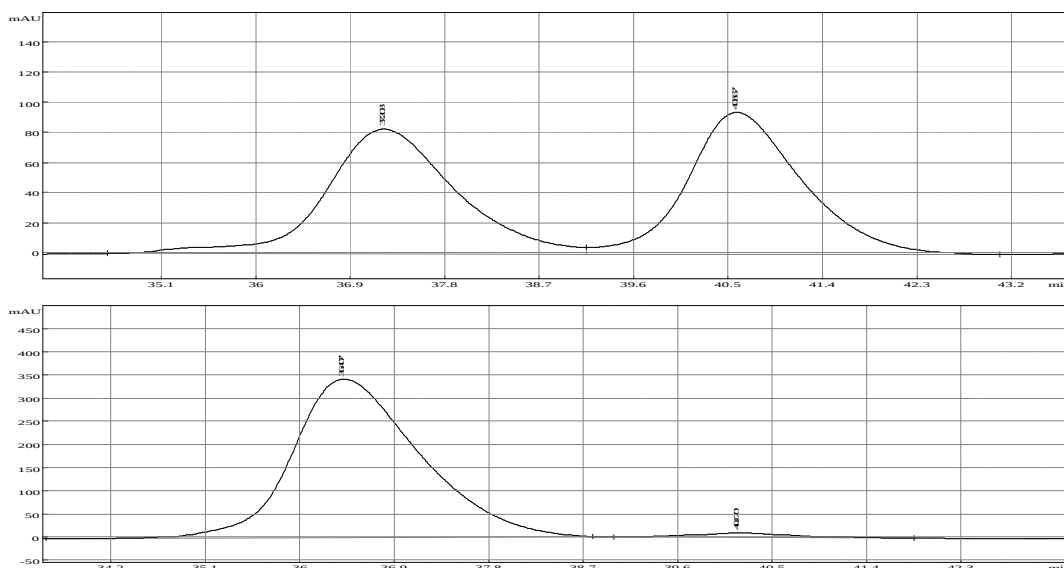


| Rank  | Time    | Quantity | Area      | Height |
|-------|---------|----------|-----------|--------|
| 1     | 88.840  | 98.08    | 138740109 | 597934 |
| 2     | 100.193 | 1.926    | 2724303   | 10802  |
| Total |         | 100      | 141464412 | 608736 |

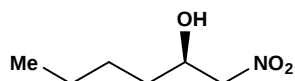


**(R)-4-Methyl-1-nitropentan-2-ol**

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/5) to give colorless oil in 88% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 0.87 (d,  $J$  = 4.4 Hz, 3 H;  $\text{CH}_3$ ), 0.89 (d,  $J$  = 4.4 Hz, 3 H;  $\text{CH}_3$ ), 1.11-1.21 (m, 1H;  $\text{CH}_2\text{CH}(\text{CH}_3)_2$ ), 1.39-1.48 (m, 1H;  $\text{CH}_2\text{CH}(\text{CH}_3)_2$ ), 1.72-1.81 (m, 1H;  $\text{CH}(\text{CH}_3)_2$ ), 2.54 (br s, 1H; OH), 4.28-4.37 ppm (m, 3H;  $\text{CH}_2\text{NO}_2$  and  $\text{CHOH}$ );  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.74, 23.11, 24.32, 42.58, 67.01, 81.02 ppm; MS (EI,  $m/z$ ): 148  $[\text{M}+\text{H}^+]$ ; enantiomeric excess was determined by HPLC with a Chiralcel OJ column: *n*-hexane/isopropanol 98: 2, 0.5 mL/min, 215 nm; minor enantiomer  $t_R$  = 40.17 min (S), major enantiomer  $t_R$  = 36.41 min (R); 96% ee.<sup>[2]</sup>

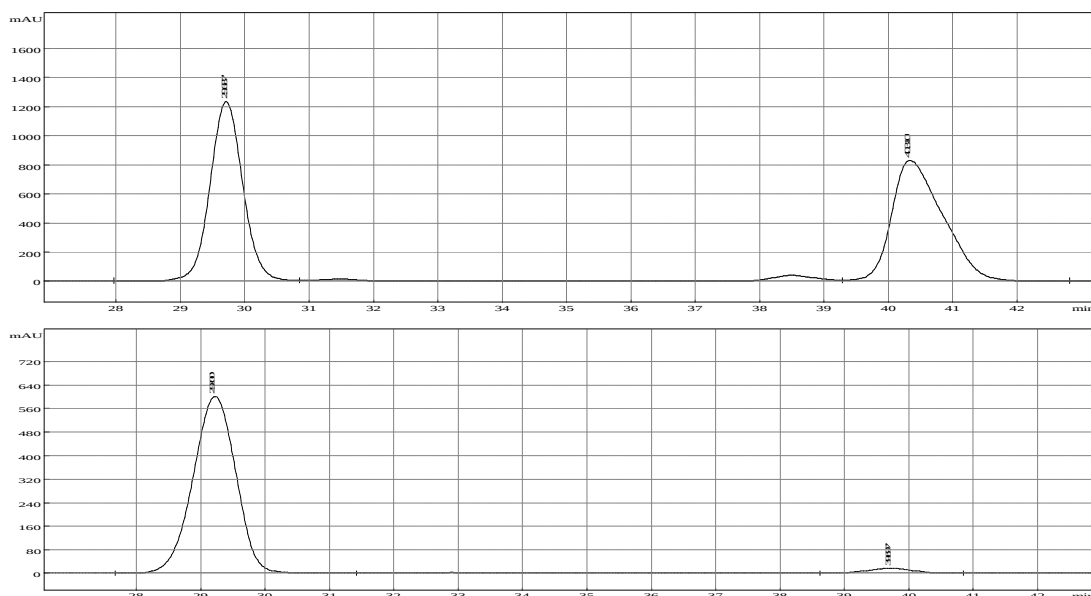


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 36.407 | 97.93    | 29044141 | 342701 |
| 2     | 40.170 | 2.064    | 612133   | 9336   |
| Total |        | 100      | 29656274 | 352037 |

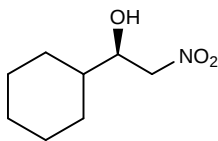


### (R)-1-Nitrohexan-2-ol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/7) to give colorless oil in 85% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 0.88 (t,  $J$  = 7.3 Hz, 3H;  $\text{CH}_3$ ), 1.30-1.56 (m, 6H;  $\text{CH}_3(\text{CH}_2)_3$ ), 2.62 (br s, 1H; OH), 4.25-4.46 ppm (m, 3H;  $\text{CH}_2\text{NO}_2$  and  $\text{CHOH}$ );  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 13.85, 22.39, 27.27, 33.44, 68.70, 80.69 ppm; MS (EI,  $m/z$ ): 148 [ $\text{M}+\text{H}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel AD-H column: *n*-hexane/isopropanol 98: 2, 0.8 mL/min, 215nm; minor enantiomer  $t_R$  = 39.70 min (S), major enantiomer  $t_R$  = 29.20 min (R); 94% ee.<sup>[2]</sup>

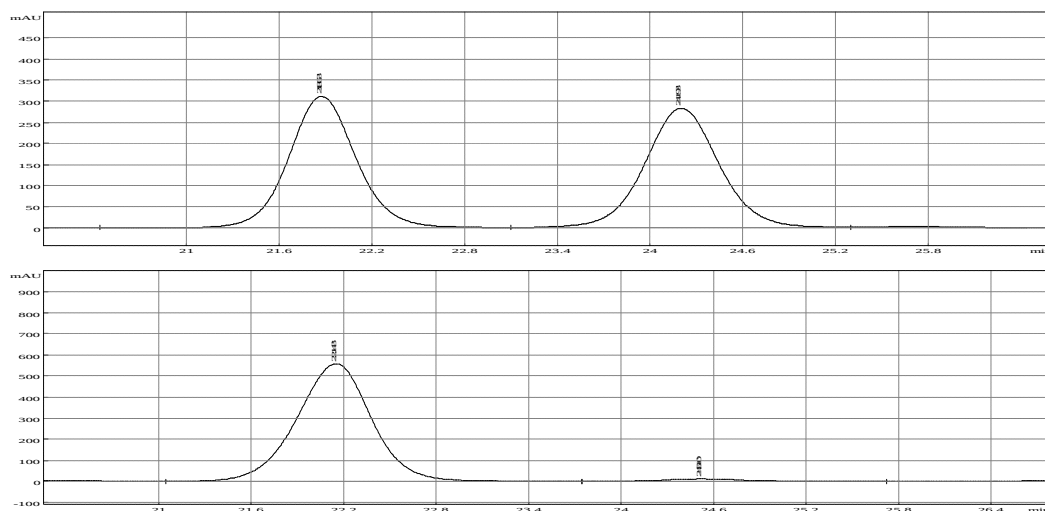


| Rank  | Time   | Quantity | Area     | Height |
|-------|--------|----------|----------|--------|
| 1     | 29.200 | 96.82    | 27791936 | 601022 |
| 2     | 39.697 | 3.179    | 912412   | 16799  |
| Total |        | 100      | 28704348 | 617821 |



### (R)-1-Cyclohexyl-2-nitroethanol

This compound was purified by column chromatography on silica gel eluting with ethyl acetate /petrol ether (1/7) to give colorless oil in 98 yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.02 -1.28 (m, 5H; cyclohexyl-**H**) , 1.41 -1.49 (m, 1H; cyclohexyl-**H**), 1.64 -1.70 (m, 2H; cyclohexyl-**H**), 1.75-1.84 (m, 3H; cyclohexyl-**H**), 2.35 (br s, 1H; **OH**) , 4.06-4.12 (m, 1H; **CHOH**), 4.38 (dd,  $J$  = 8.7, 3.2 Hz, 1H; **CH<sub>2</sub>NO<sub>2</sub>**), 4.42 ppm (dd,  $J$  = 8.7, 3.2 Hz, 1H; **CH<sub>2</sub>NO<sub>2</sub>**);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 25.76, 25.89, 26.09, 27.96, 28.83, 41.44, 72.84, 79.32 ppm; MS (EI,  $m/z$ ): 174 [ $\text{M}+\text{H}^+$ ]; enantiomeric excess was determined by HPLC with a Chiralcel AD-H column: *n*-hexane/isopropanol 97: 3, 0.8 mL/min, 215 nm; minor enantiomer  $t_R$  = 24.51 min (S), major enantiomer  $t_R$  = 22.14 min (R); 95% ee.<sup>[2]</sup>

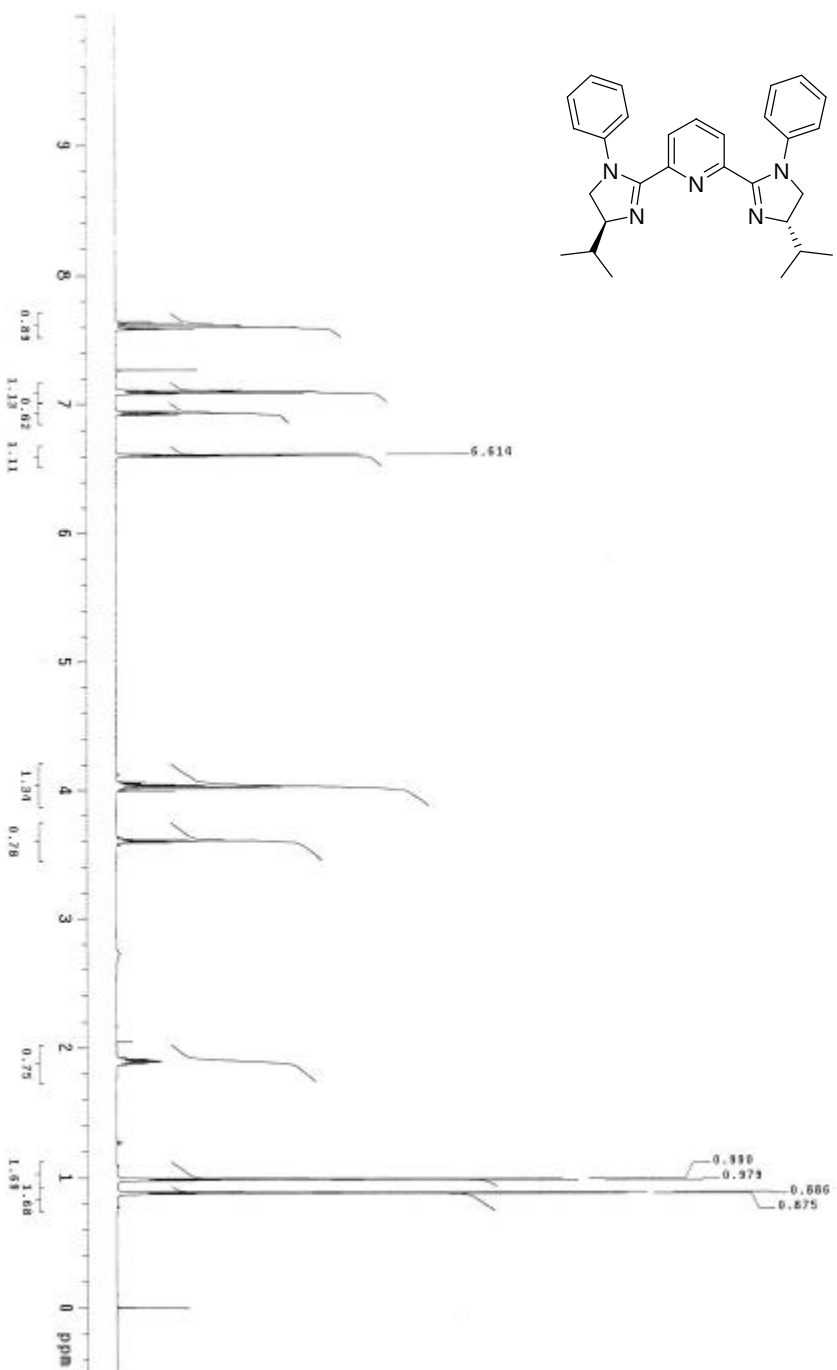
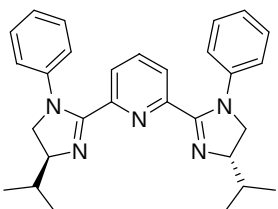


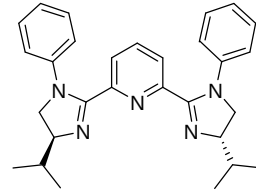
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| 2     | 24.510 | 2.287    | 444087   | 12595  |
| Total |        | 100      | 19420105 | 570523 |

## References:

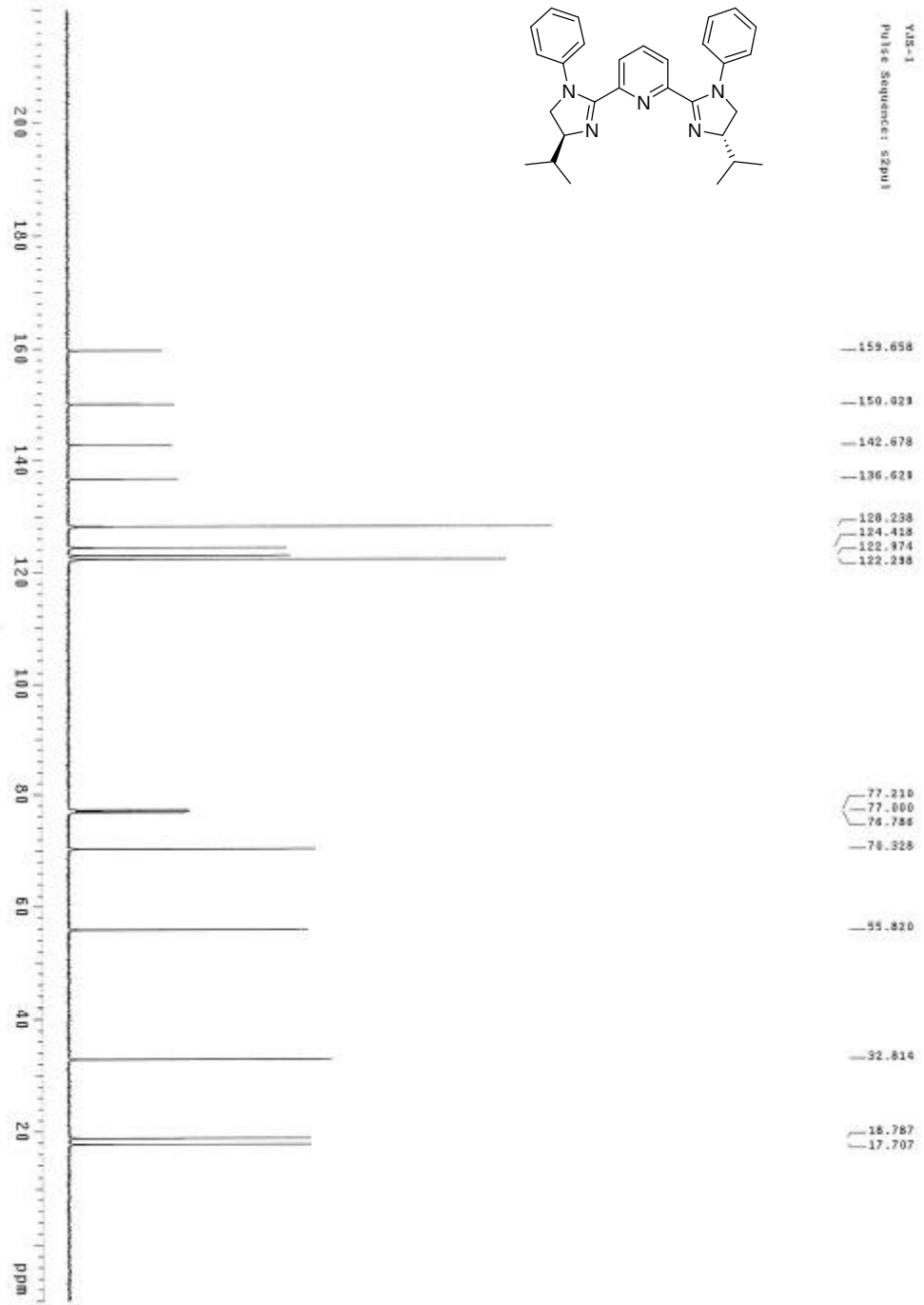
- [1] X. Beebe, N. E. Schore, M. J. Kurth. *J. Org. Chem.* **1995**, 60, 4196-4203.
- [2] D. A. Evans, D. Seidel, M. Rueping, H.W. Lam, J. T. Shaw, C. W. Downey. *J. Am. Chem. Soc.* **2003**, 125, 12692-12693.
- [3] B. M. Choudary, K. V. S. Ranganath, U. Pal, M. L. Kantam, B. Sreedhar. *J. Am. Chem. Soc.* **2005**, 127, 13167-13171.

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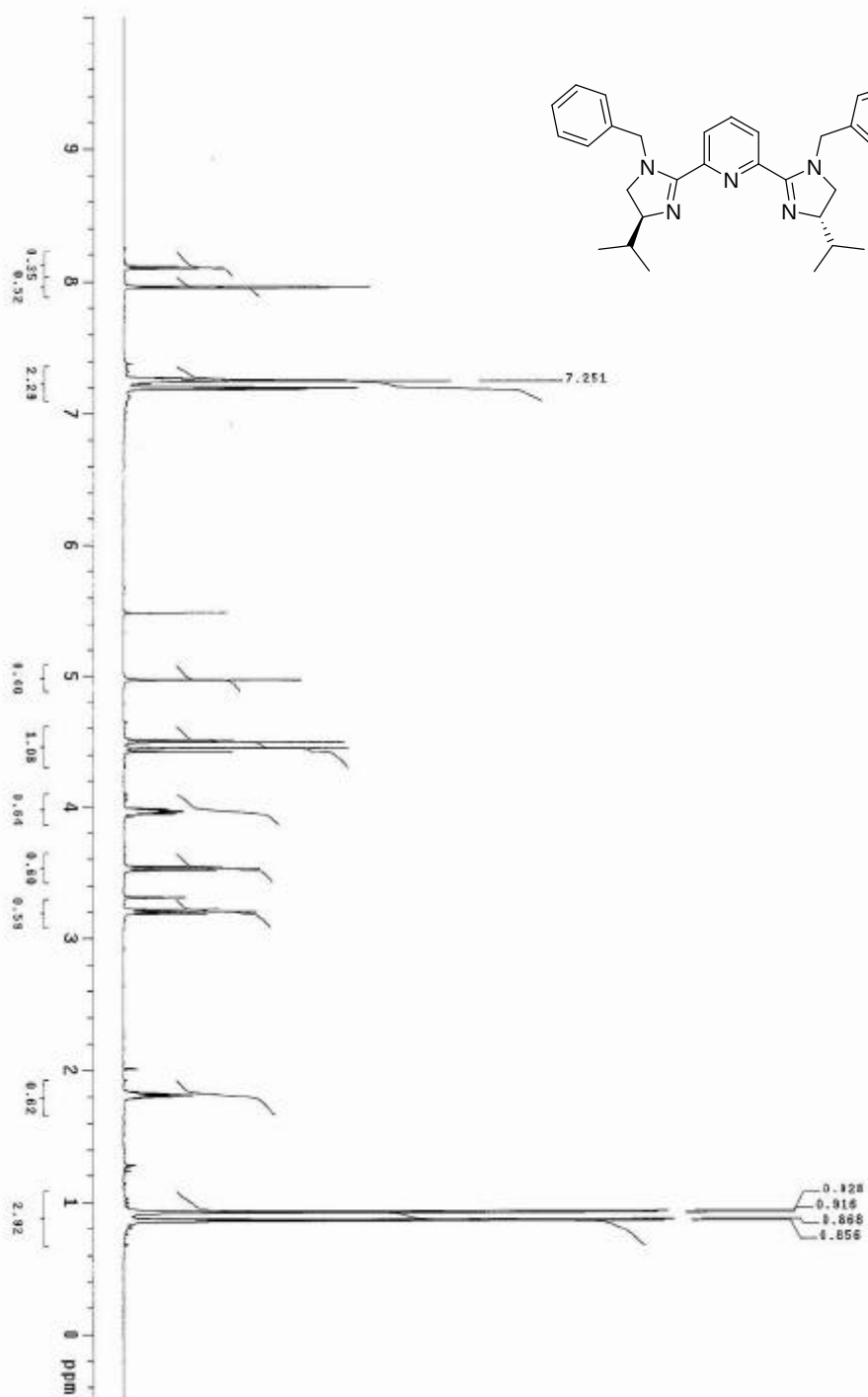
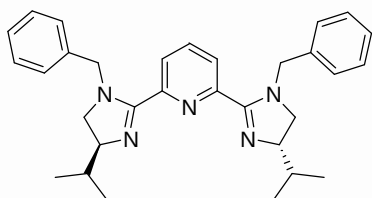




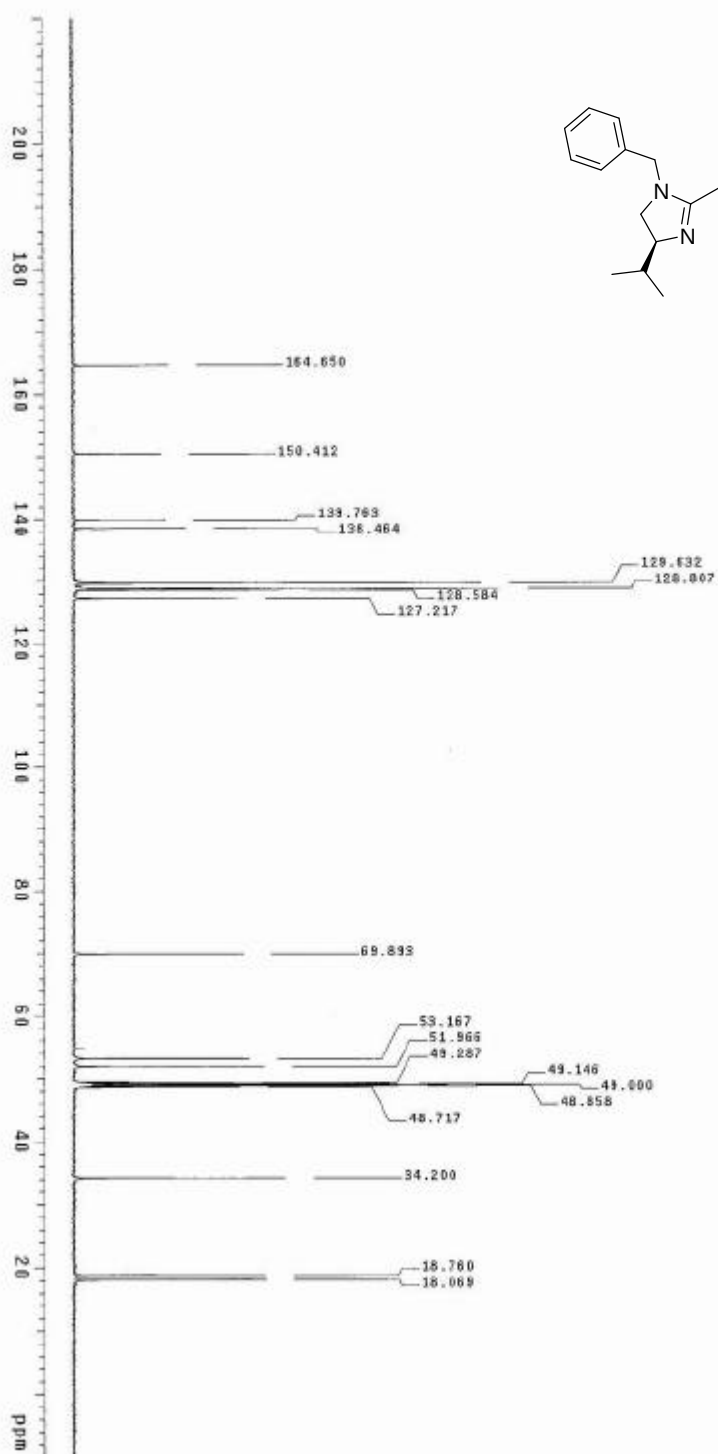
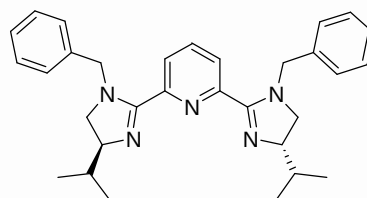
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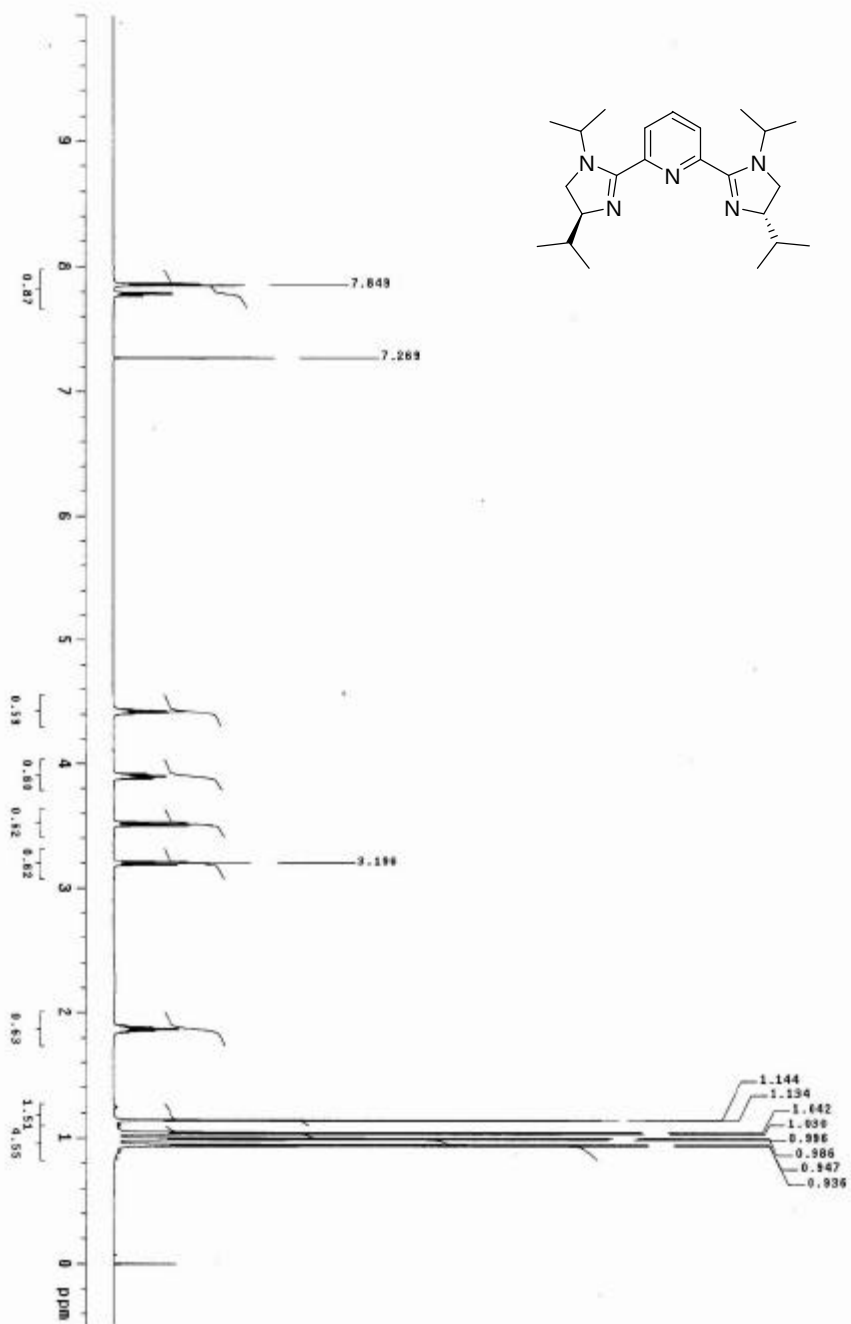
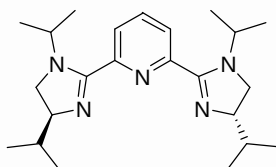
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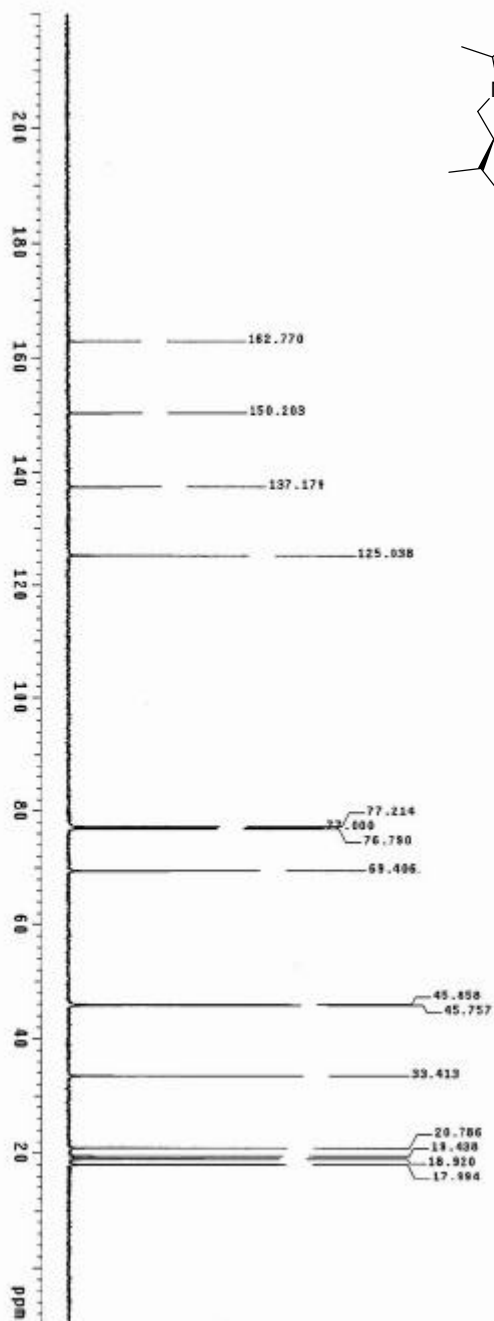
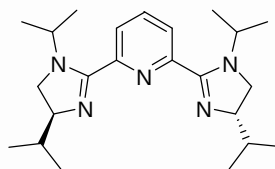
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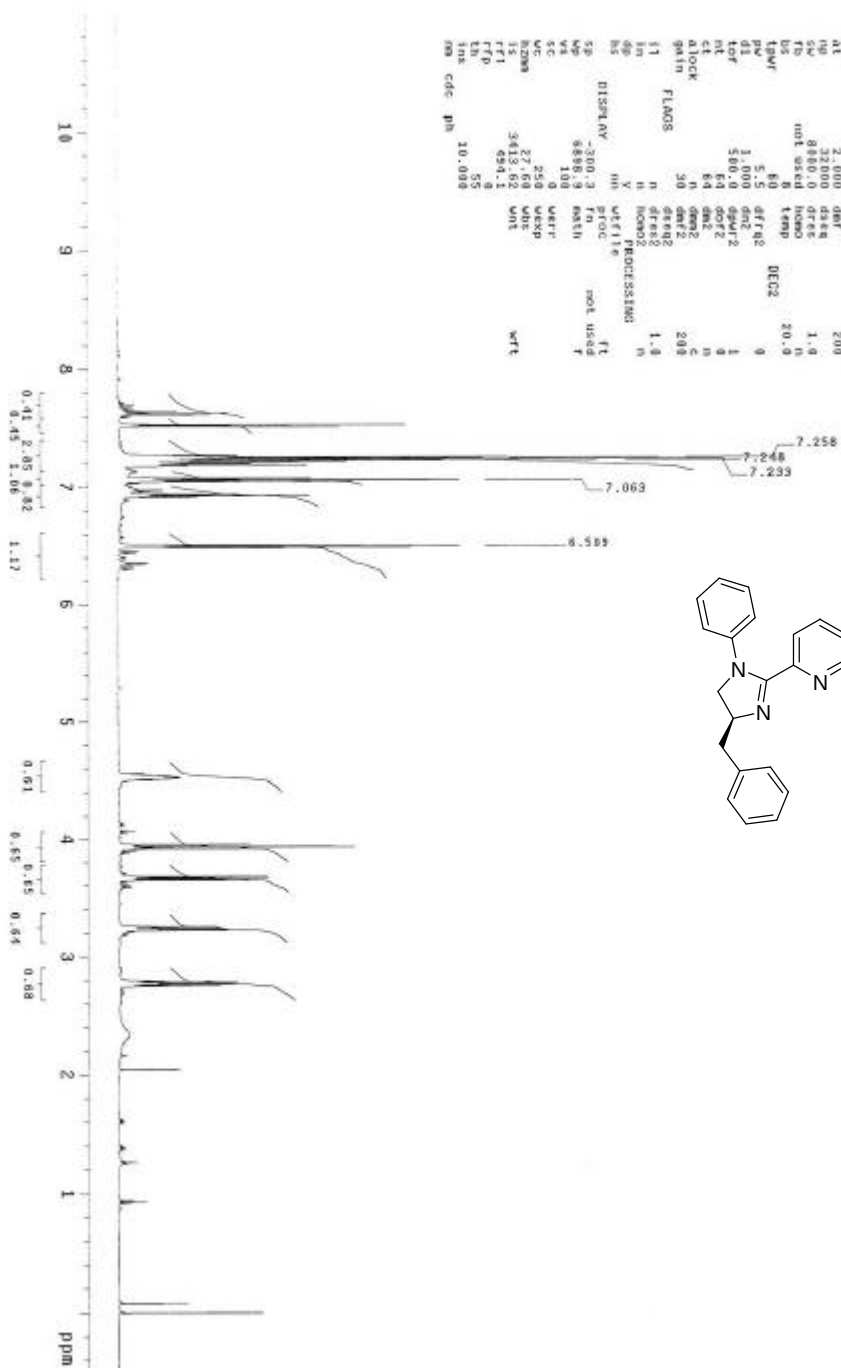
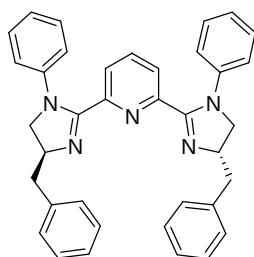


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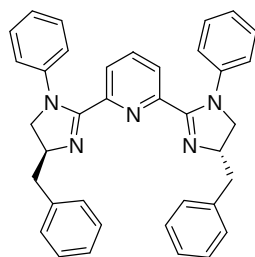
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[illegible]

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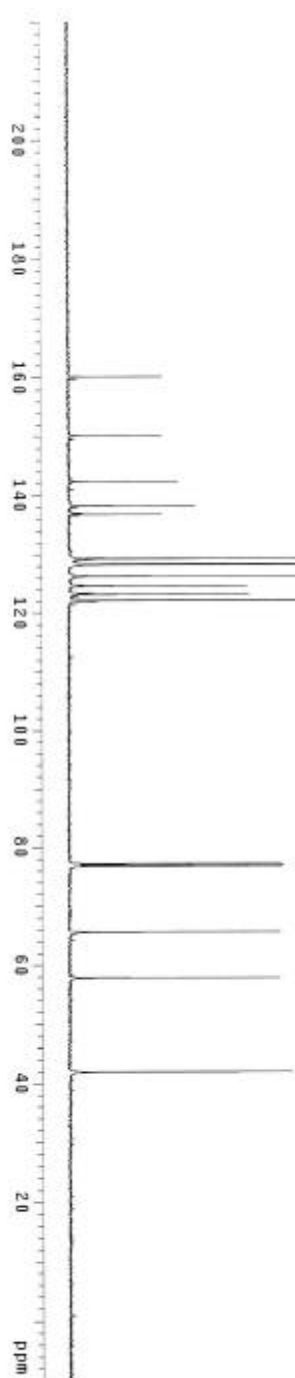
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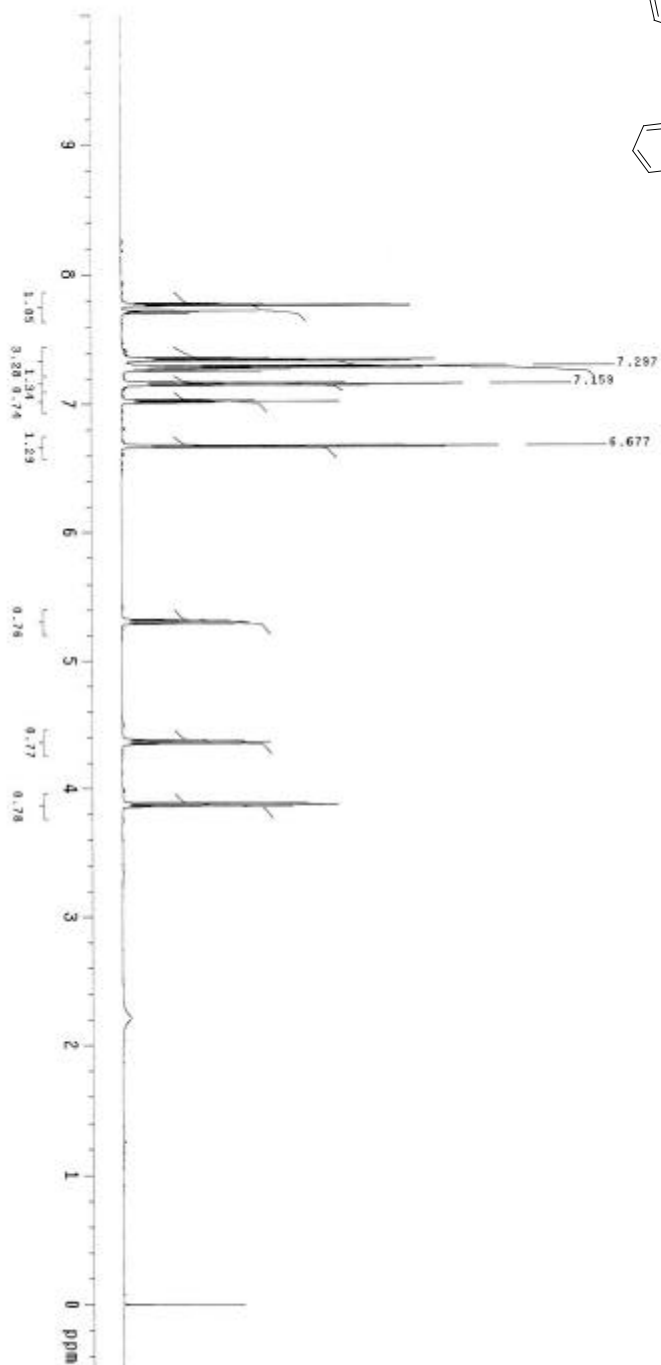
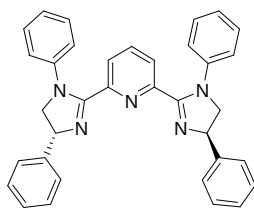
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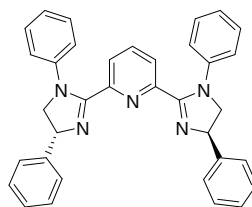


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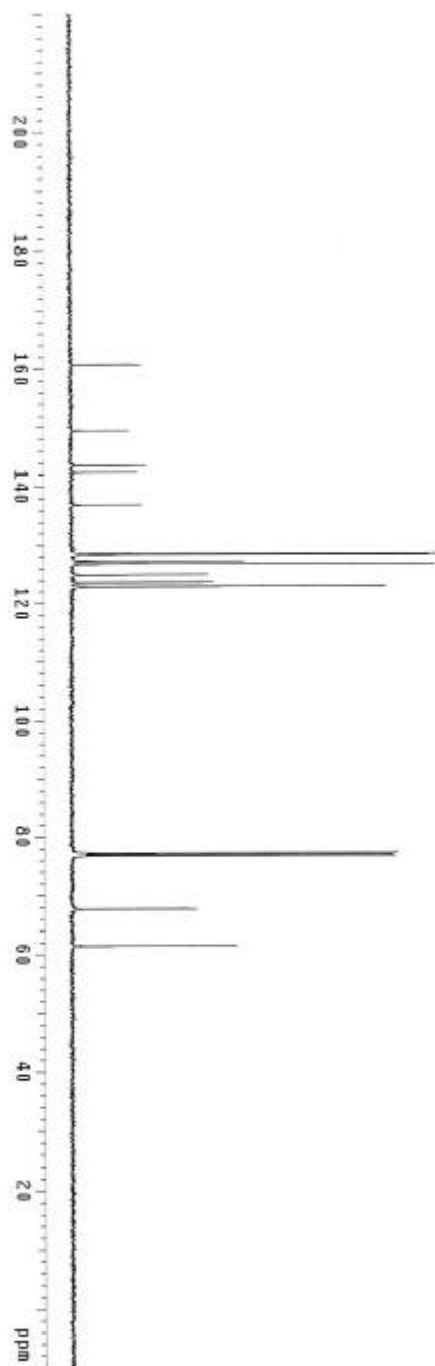


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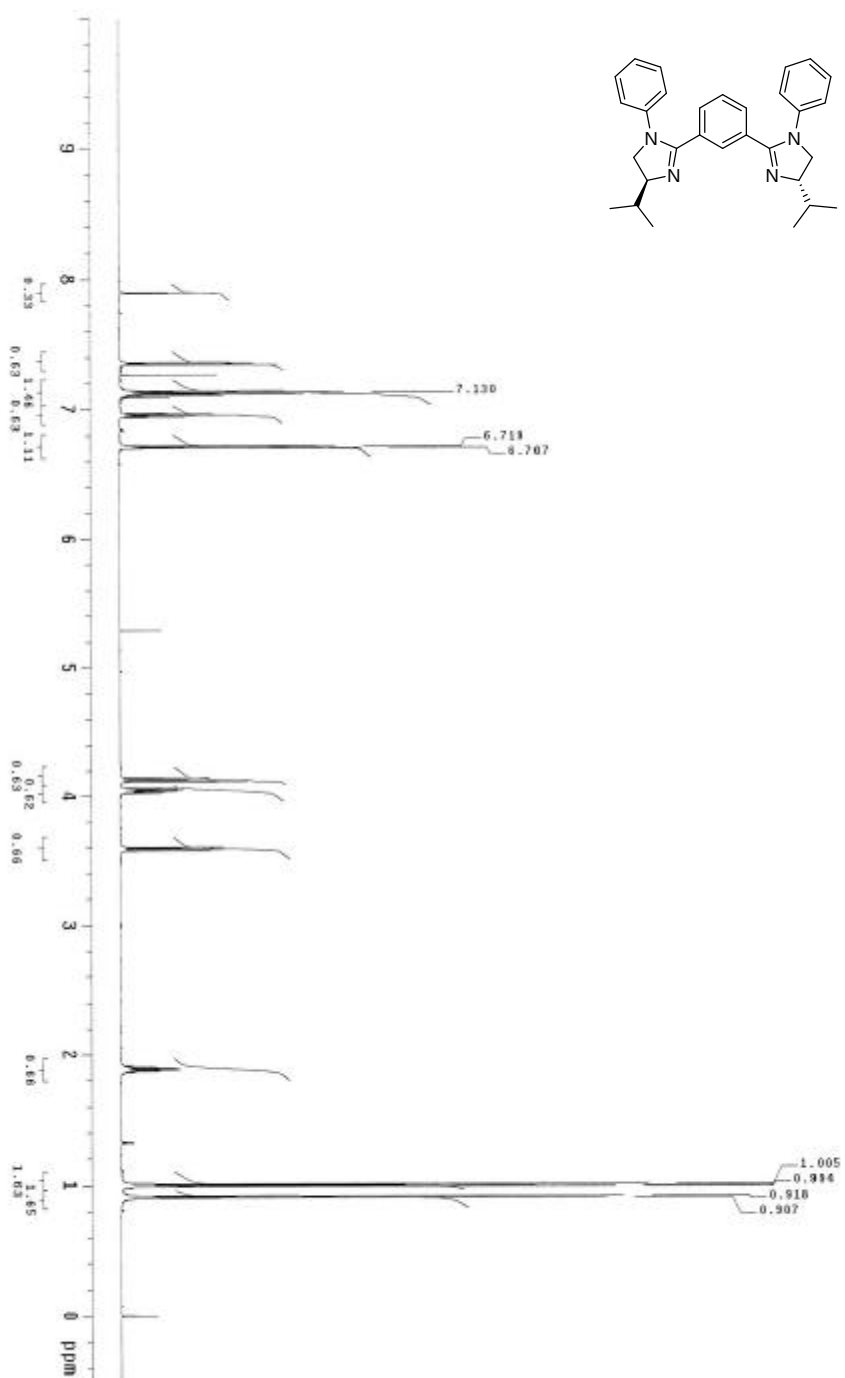
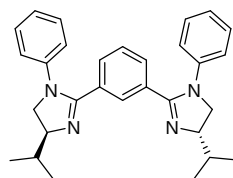
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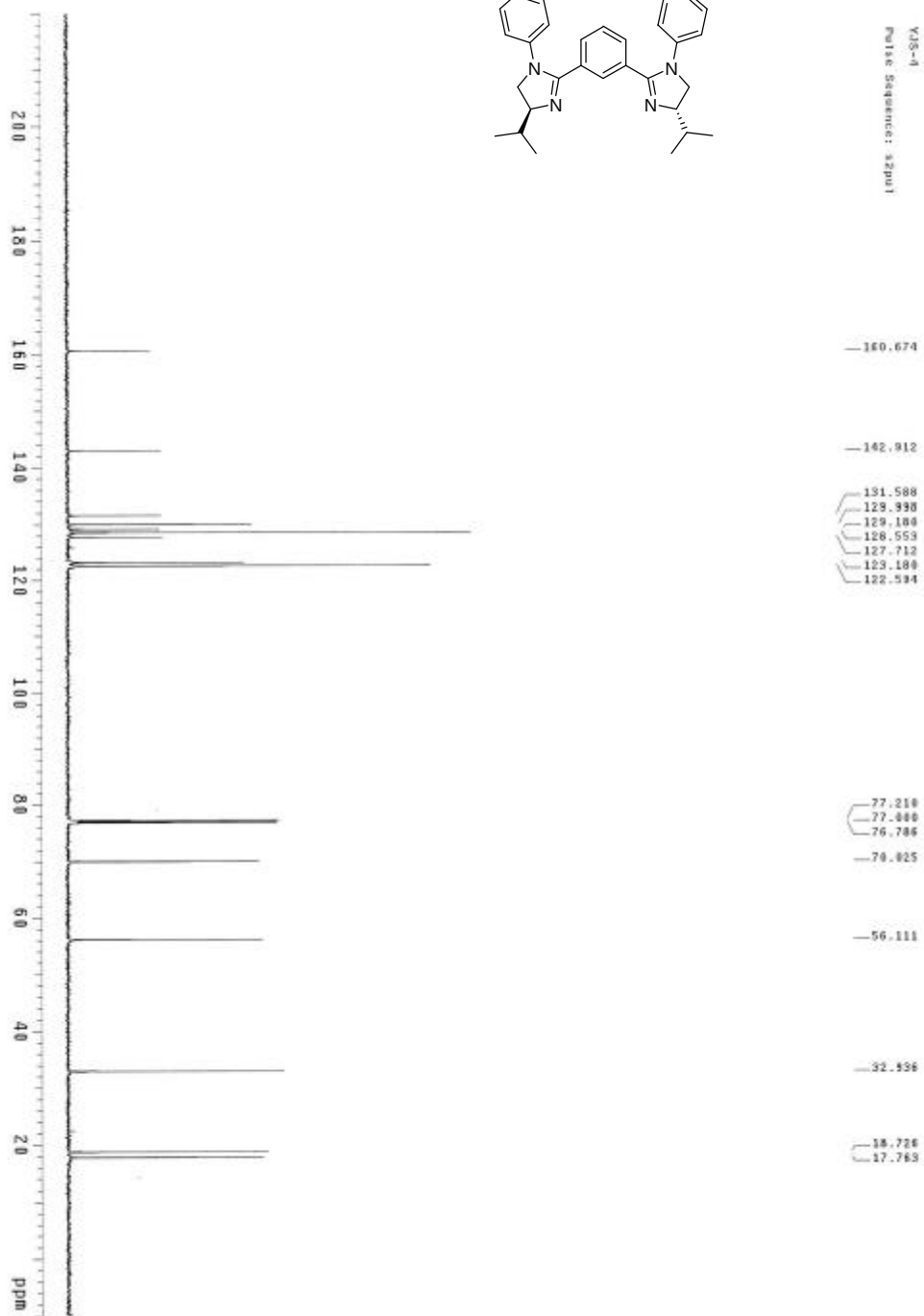
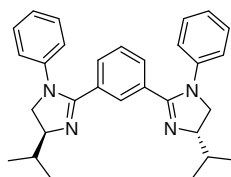


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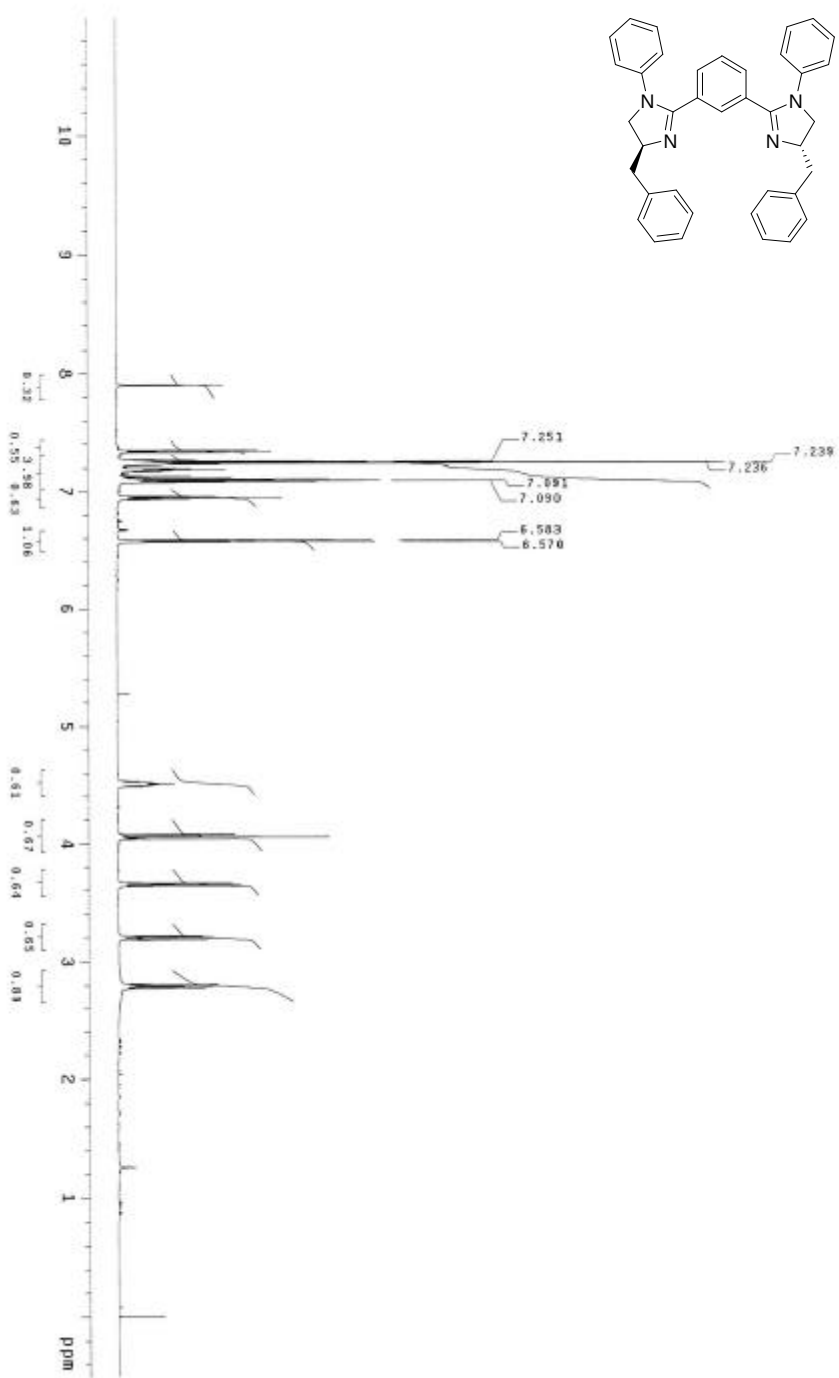
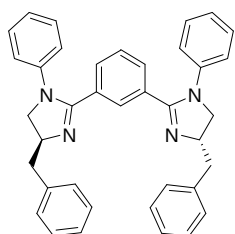
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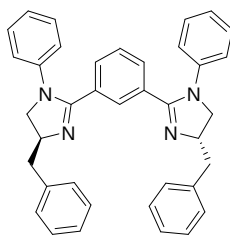
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YJ5-6

Pulse Sequence:  $\alpha 2\text{pu}$ 

VJS-8  
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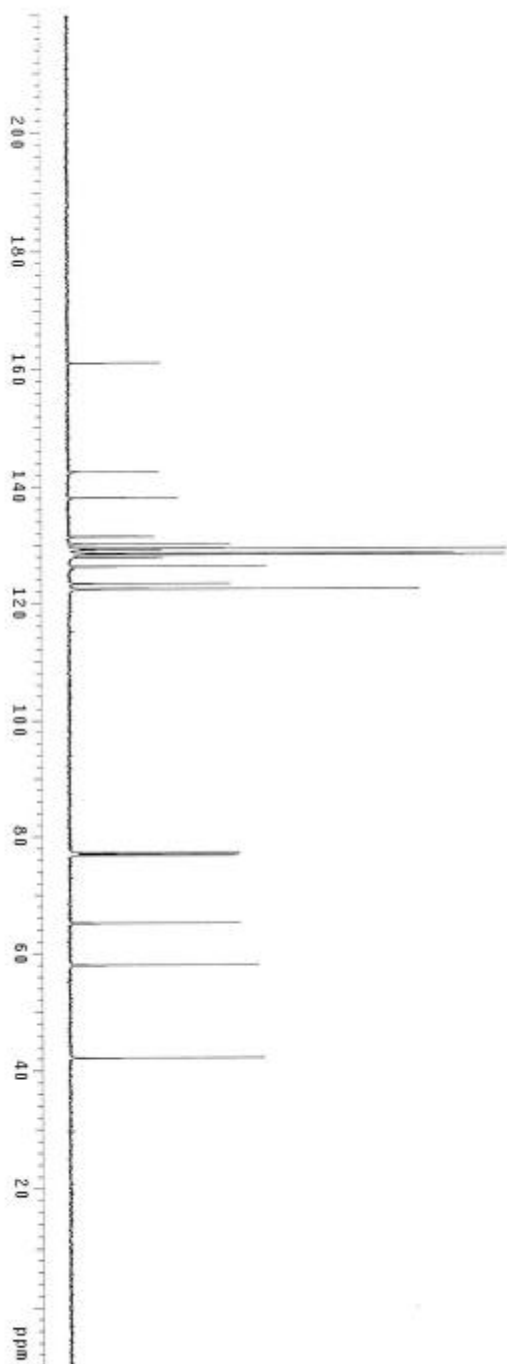
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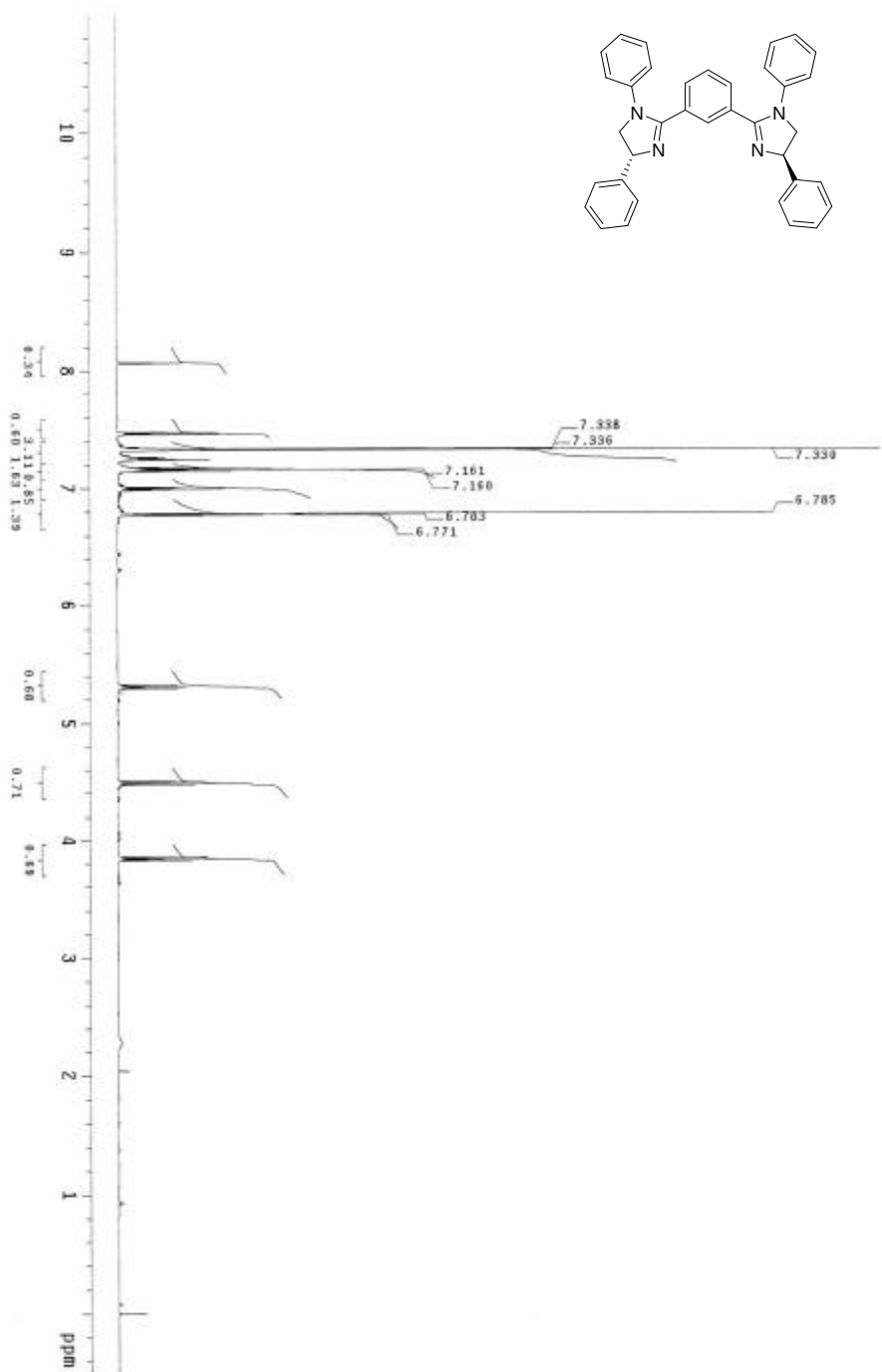
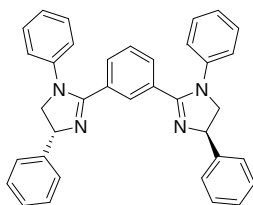
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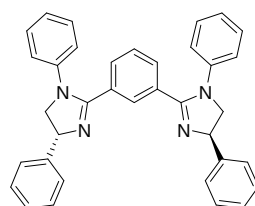
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