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# A New Chiral Bis(oxazolinylmethyl)amine Ligand for Ru-Catalyzed Asymmetric Transfer Hydrogenation of Ketones

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## Supporting Information

**Bis(acetimido methyl ether hydrochloride)amine Hydrochloride (2).** To a 125 mL filter flask was added iminodiacetonitrile (12.3 g, 0.1 mol), anhydrous methanol (6.4 g, 0.2 mol) and anhydrous ether (60 mL). The suspension was cooled to 0 °C. Anhydrous HCl gas (generated by adding conc. H<sub>2</sub>SO<sub>4</sub> dropwise to oven-dried NH<sub>4</sub>Cl) was bubbled into the above suspension while stirring. After about two hours, the bubbling was stopped and the reaction mixture was kept under HCl atmosphere at 0 °C overnight. The resulting white solid was filtered under nitrogen, washed with ether (3 x 20 mL), and evaporated to give product **2** as white hygroscopic powder (24.9 g, 76%).

**Bis[4-(R)-phenyloxazolin-2-yl-methyl]amine (1).** To a 50 mL Schlenk flask was added **2** (0.71 g, 2.66 mmol) and dichloromethane (10 mL). The white suspension was first cooled to 0 °C, and (R)-2-phenylglycinol (1.1 g, 7.98 mmol) was added in one portion. The reaction mixture was slowly warmed to rt and stirred overnight. The reaction mixture was poured into ice. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3 x 20 mL). The combined organic layer was dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The resulting brown oil was immediately chromatographed on a silica gel column (EtOAc : hexane = 6 : 1 with 3% triethyl amine), yielding **1** as a pale yellow oil (222 mg, 25%).  $[\alpha]_D^{20} = +46.5$  (*c* 3.35, toluene). <sup>1</sup>H-NMR (CDCl<sub>3</sub>) δ 7.22~7.34 (m, 10 H), 5.16~5.21 (m, 2 H), 4.62 (dd, *J* = 10.1, 8.4 Hz, 2 H), 4.09 (t, *J* = 8.4, 8.4 Hz, 2 H), 3.67 (d, *J* = 1.1 Hz, 4 H), 2.17 (s, 1 H). MS *m/z*: 335, 189, 175, 161, 120, 104, 91, 77, 42. HRMS calcd for C<sub>20</sub>H<sub>21</sub>N<sub>3</sub>O<sub>2</sub> (M<sup>+</sup>): 335.1634; found: 335.1635.

**Bis[4-(*R*)-phenyloxazolin-2-yl-methyl] methylamine.** The preparation was carried out as described for reaction of (*R*)-2-phenylglycinol with bis(2-cyanoethyl) methylamine in the presence of ZnCl<sub>2</sub> catalyst. (Jiang, Y.; Jiang, Q.; Zhu G.; Zhang, X. *Tetrahedron Lett.* **1997**, 38, 215). <sup>1</sup>H-NMR (CDCl<sub>3</sub>) δ 7.39~7.24 (m, 10 H), 5.28~5.19 (m, 2 H), 4.71-4.62 (m, 2 H), 4.14 (t, *J* = 8.4 Hz, 2 H), 3.64 (s, 4 H), 2.60 (s, 3 H). <sup>13</sup>C-NMR (CDCl<sub>3</sub>) δ 165.3, 142.0, 128.7, 127.5, 126.5, 74.6, 69.6, 53.2, 42.4.

**General Procedure for Asymmetric Transfer Hydrogenation.** In a glovebox, to a suspension of [Ru(PPh<sub>3</sub>)<sub>3</sub>Cl<sub>2</sub>] (10 mg, 0.01 mmol) in 2-propanol (5 mL) was added **1** (0.11 mL of 0.1 M solution in toluene, 0.011 mmol). The mixture was refluxed under N<sub>2</sub> at 82 °C for 2 h to give a green solution in the outside of drybox. The solvent was removed *in vacuo* and the greenish residue was washed with ether (10 mL) to remove any free PPh<sub>3</sub>. The residue was then redissolved in 2-propanol (5 mL), followed by addition of the ketone substrate (1 mmol) and NaOPr<sup>i</sup> (0.1 mL of 0.1 M solution in 2-propanol). The reaction was then carried out at 82 °C under nitrogen. The reaction mixture was eluted through a short silica gel plug eluting with ether to remove the catalyst. The enantiomeric excess and conversion were measured by capillary GC. The absolute configuration of products was determined by comparing the observed rotation with the reported value.

**GC Analytical Conditions.** Gas chromatograms were recorded on a HP 6890 with a Supelco β-DEX 120 chiral capillary column (30 m x 0.25 mm). The helium carrier gas flow rate was 1.0 mL/min. All of the retention time data were obtained at isothermal conditions. Racemic alcohols were obtained by NaBH<sub>4</sub> reduction of the corresponding ketones and used as the authentic samples for gas chromatography. **1-phenylethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, 118, 2521-2522). 120 °C, (*R*) isomer 12.95 min, (*S*) isomer 13.56 min; **1-phenyl-1-propanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, 118, 2521-2522). 125 °C, (*R*) isomer 18.32 min, (*S*) isomer 18.78 min; **1-phenyl-2-methyl-1-propanol** (Yamamoto et al. *Bull. Chem. Soc. Jpn.* **1974**, 47, 1555). 155 °C, (*R*) isomer 15.73 min, (*S*) isomer 16.04 min; **1-(2-methylphenyl)ethanol** (Nakamura, K.; Kawasaki, M.; Ohno, A. *Bull. Chem. Soc. Jpn.* **1996**, 69, 1079-1085). 150 °C, (*R*) isomer 7.02 min, (*S*) isomer 7.34 min; **1-(3-methylphenyl)ethanol** (Nakamura, K.; Kawasaki, M.; Ohno, A. *Bull. Chem. Soc. Jpn.* **1996**, 69, 1079-1085). 120 °C, (*R*) isomer 19.60 min, (*S*) isomer 20.53 min; **1-(4-methylphenyl)ethanol** (Nakamura, K.; Kawasaki, M.; Ohno, A. *Bull. Chem. Soc. Jpn.* **1996**, 69, 1079-1085). 130 °C, (*R*) isomer 11.67 min, (*S*) isomer 12.21 min; **1-(2-chlorophenyl)ethanol** (Nakamura, K.; Kawasaki, M.; Ohno, A. *Bull. Chem. Soc. Jpn.* **1996**, 69, 1079-1085). 160 °C, (*R*) isomer 7.50 min, (*S*)

isomer 7.97 min; **1-(3-chlorophenyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 140 °C, (*R*) isomer 16.40 min, (*S*) isomer 17.05 min; **1-(4-chlorophenyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 150 °C, (*R*) isomer 11.69 min, (*S*) isomer 12.16 min; **1-(2-methoxyphenyl)ethanol** (Bromley, L. A.; Davies, S. G.; Goodfellow, C. L. *Tetrahedron: Asymm.* **1991**, *2*, 139-156). 140 °C, (*S*) isomer 15.84 min, (*R*) isomer 16.48 min; **1-(3-methoxyphenyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 140 °C, (*R*) isomer 19.96 min, (*S*) isomer 20.59 min; **1-(4-methoxyphenyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 130 °C, (*R*) isomer 35.55 min, (*S*) isomer 37.15 min; **1-tetralol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 130 °C, (*S*) isomer 40.43 min, (*R*) isomer 41.33 min; **1-(1-naphthyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 160 °C, (*S*) isomer 42.29 min, (*R*) isomer 44.61 min; **1-(2-naphthyl)ethanol** (Noyori, R.; Ikariya, T.; Uematsu, N.; Hashiguchi, S.; Fujii, A. *J. Am. Chem. Soc.* **1996**, *118*, 2521-2522). 160 °C, (*R*) isomer 35.46 min, (*S*) isomer 36.02 min.