SHORT PAPER

J. Chem. Research (S), 2003, 128-129

A novel asymmetric reduction of nitroolefin 2-nitro-1-phenyl-1-propene by using BINAP-ruthenium(II) complexes†

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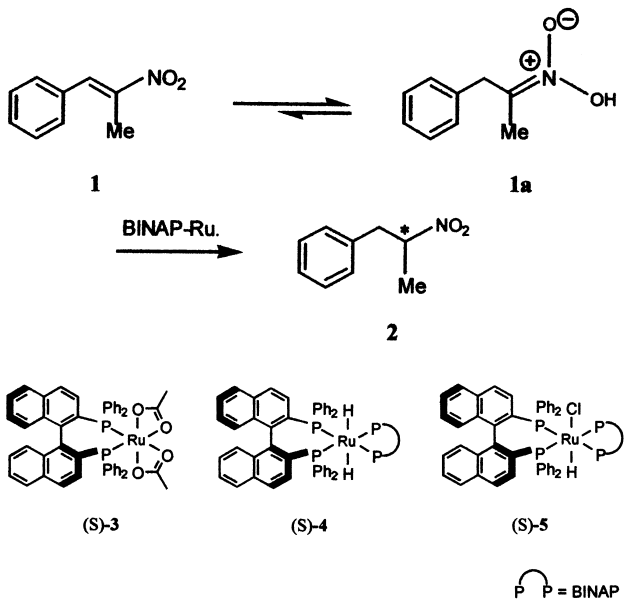
The ruthenium BINAP complex, [Ru(OAc)$_2${(S)-BINAP}], can catalyse the hydrogenation of 2-nitro-1-phenyl-1-propene (**1**) to give optically active 2-nitro-1-phenylpropane (**2**) in moderate enantiomeric excess.

Keywords: asymmetric reduction, nitroolefin, binap-Ru^{II} complex

Homogeneous enantioselective hydrogenation is an important method for the synthesis of optically active compounds, the emphasis having been on functionalised olefins or ketones.[1] Because organic nitro compounds can be easily converted to amines, the study of synthesis of chiral nitro compounds is regarded as a useful methodology to obtain chiral amines. In 1985, Sakai reported that chiral 1-phenyl-2-nitropropane could be synthesised by microorganisms from the substrate 2-nitro-1-phenyl-1-propene (**1**), but the enantiomeric excess by using this method was 27–43% ee at best.[2] Ruthenium complexes catalyse hydrogenation of various substrates including olefins, aldehydes, ketones and nitro compounds,[3] and BINAP–Ru^{II} complexes [BINAP = 2,2'-bis(diphenylphosphino)-1,1' -binaphthyl] can serve as excellent catalyst precursors for asymmetric hydrogenation.[4] We have investigated the asymmetric hydrogenation of 2-nitro-1-phenyl-1-propene using BINAP-Ru^{II} complexes. The catalysts were prepared *in situ* from [RuX$_2$(COD)] (X = Cl, COD = 1, 5-cyclooctadiene) and (S)-BINAP in dry methanol. The substrate **1** was prepared by refluxing benzaldehyde and nitroethane in the presence of ethylenediamine.



Scheme 1

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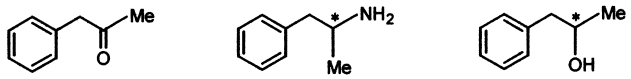
†This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*

Table 1 Asymmetric hydrogenation of **1** with (S)-**3**[a]

Solvent composition	Temperature /°C	Yield of **2** /%[b]	% ee[c]	Configuration
THF	90	7	4	R
CH_2Cl_2	90	30	10	R
Toluene	90	25	12	R
MeOH–C_6H_6 (5:1)	90	84	58	R
MeOH–C_6H_6 (5:1)	30	5	–	–

[a]Reaction condition: 24h, 90 kg/cm^2 of hydrogen in the presence of 3Å molecular sieves. Substrate concentration 0.12 M, 1 mol % of catalyst.
[b]Isolated yield.
[c]% ee was determinded by HPLC analysis using a Daicel Chiralcel OD column.



6 **7** **8**

In this work we report the asymmetric hydrogenation of nitroolefin 2-nitro-1-phenyl-1-propene, catalysed by using BINAP-Ru^{II} complexes in the presence of hydrogen (Scheme 1). The ruthenium complex catalyses the formation of nitronate anion (**1a**) which undergoes a hydrogenation and gives ultimately the saturated nitro compound.[5] The structure of intermediate **1a** was determined by the method of Meah and Massey.[6]

Hydrogenation of 2-nitro-1-phenyl-1-propene (**1**) was carried out by using (S)-**3** as catalyst at 90 °C under 90 kg/cm^2 of hydrogen in the presence of 3 Å molecular sieves for 24 h. MeOH–C_6H_6 (5:1) was the most suitable solvent for this asymmetric hydrogenation procedure, which could afford 2-nitro-1-phenylpropane (**2**) in 84% yield and 58% ee, while the use of THF and CH_2Cl_2 lowered either the yields or the enantiomeric excess. When dichloromethane was employed as solvent, phenylacetone (**6**) was also obtained in 66% yield and 2-nitro-1-phenylpropane (**2**) in 30% yield. Surprisingly, MeOH–C_6H_6 (5:1) afforded lower percent enantiomeric excess and lower yield at reduced temperature (Table 1).

Having optimised conditions for the asymmetric hydrogenation, (S)-**4** and (S)-**5** were employed to reduce 2-nitro-1-phenyl-1-propene (**1**) instead of (S)-**3**. Toluene is used as solvent in the hydrogenation at 125 °C and 160 °C. BINAP-Ru^{II} complexes (S)-**3**, (S)-**4** and (S)-**5** were used to hydrogenate 2-nitro-1-phenyl-1-propene (**1**) at 125 °C and 160 °C and the results were shown in Table 2.

Asymmetric hydrogenation of (**1**) was carried out at 90 °C by using (S)-**4** and (S)-**5** respectively. The product 2-nitro-1-phenylpropane **2** was obtained with low enantiomeric excess

Table 2 Asymmetric hydrogenation of (**1**) by using ruthenium complexes[a]

Entry	Solvent	Catalyst	Temperature	**2**		**7**		**8**
			°C	Yield %[b]	ee %[c]	Yield %[b]	ee %[c]	Yield %[b]
1	MeOH–C_6H_6 (5:1)	(S)-**4**	90	38	12			
2	MeOH–C_6H_6 (5:1)	(S)-**5**	90	35	10			
3	Toluene	(S)-**3**	125			55	10	43
4	Toluene	(S)-**4**	125			45	4	48
5	Toluene	(S)-**5**	160			51	4	45

[a]The reaction was performed in the autoclave under 90 kg/cm^2 hydrogen pressure in the presence of 3Å molecular sieves for 24 h using 1 mol % of ruthenium complex.
[b]Isolated yield.
[c]E.e. was determined by HPLC analysis by using a Chiralcel OD column.

and yield (Entry 1, 2). However when toluene was used as solvent and the reaction temperature was 125 °C and 160 °C, the hydrogenation afforded 45-55% of 1-phenyl-2-propylamine (**7**) though the enantiomeric purity was low (4–10% ee). Meanwhile 1-phenyl-2-propanol (**8**) was obtained as racemic mixture with yield of 43–48%.

In conclusion, we report here an efficient modification of a synthesis of a chiral nitro compound and a chiral amine. [$Ru(OAc)_2${(S)-BINAP}] and MeOH–C_6H_6 (5:1) are an efficient, novel system for synthesis of chiral 1-phenyl-2-nitropropane from 2-nitro-1-phenyl-1-propene, although the enantiomeric excess is low.

Experimental

All ruthenium complexes were prepared according to literature procedures. The solvents were purified by short path distillation. Melting point was determined on a Micro capillary melting point apparatus and are uncorrected. ^{1}H NMR spectra were recorded on a Varian 500 MHz spectrometer. Flash chromatography was carried out with silica gel 60 N (spherical, neutral) from Merck. Enantiomeric excesses were determined by HPLC analysis using a Chiralcel OD column. All reactions were run in autoclave under hydrogen gas (90 kg/cm^2).

Procedure in reduction of 1-phenyl-2-nitropropene-1 (**1**): 2-nitro-1-phenyl-1-propene (500 mg, 3.06 mmol), [$Ru(OAc)_2${(S)-BINAP}] (26 mg, 0.0306 mmol) and MeOH-C_6H_6 (5:1) (25 ml) were added to a 100 ml autoclave, containing 1 g of 3 Å molecular sieves, with 90 kg/cm^2 hydrogen gas pressure under 90 °C stirring for 24 h. After removal of the solvent, the residue was purified by column chromatography on silica gel 60 N (neutral; hexane–ethyl acetate, 4 : 1, v/v) to give 2-nitro-1-phenyl propane (**2**) as a colourless oil (425 mg, 84 %). ^{1}H NMR ($CDCl_3$, 500 MHz) δ 1.54 (d, 3H, J = 6.7, CH_3), 2.99 (dd, 1H, J = 13.8 and 6.9, CH_2), 3.31 (dd, 1H, J = 13.8 and 7.3, CH_2), 4.76 (sex, 1H, J = *ca* 7.0, $CHNO_2$), 7.20 (m, 5H, C_6H_5). b.p.103–104 °C/4mm.

1-phenyl-2-propylamine (**4**): 2-nitro-1-phenyl-1-propene (**1**) and ruthenium complex (1 mol %) and solvent (25 ml) were added to a 100 ml autoclave, with 90 kg/cm^2 hydrogen pressure, under corresponding temperature stirring for 24 h. The reactor was cooled to room temperature and the solvent was evaporated, and then 1M HCl was added to the residue, the organic layer afforded 1-phenyl-2-propanol (**8**). The aqueous layer was neutralised with NH_4OH and extracted with ether, the organic layer was then dried by Na_2SO_4 and evaporated to give light brown 1-phenyl-2-propylamine (**7**) ^{1}H NMR ($CDCl_3$, 500 MHz) δ 1.12 (d, 3H, J = 6.9, CH_3), 2.50 (dd, 1H, J = 21.9 and 10.4, CH_2), 2.70 (dd, 1H, J = 20.2 and 4.6, CH_2), 3.16 (sex, 1H, J = *ca* 9.2, $CHNO_2$), 7.25 (m, 5H, C_6H_5). b.p. 102 °C/16mm.

1-phenyl-2-propanol (**8**): ^{1}H NMR ($CDCl_3$, 500 MHz) δ 1.25 (d, 3H, J = 14.8, CH_3), 1.56 (s, 1H, OH), 2.76 (m, 2H, CH_2), 4.02 (sex, 1H, J =ca 20.5, CHOH), 7.26 (m, 5H, C_6H_5). b.p. 125 °C/25mm.

We gratefully acknowledge Dr Abd EL-Wareth Sarhan for his advice, Mr Satoshi Murakami for his outstanding assistance with sample preparation and valuable analysis work.

Received 10 May 2002; accepted 18 September 2002
Paper 02/1385

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7 The preparation of starting material 1-phenyl-2-nitropropene-1 (**1**): A solution of benzaldehyde 6.4 g and ammonium acetate 1.0 g in nitroethane 20 ml was heated to reflux for 5 h. On cooling, after removal of the solvent, the residue was purified by column chromatography on silica gel 60 N (neutral; hexane-chloroform, 2 : 1, v/v), then recrystallised by hexane and gave **1** as a light yellow crystal 6.2 g (63 %), m.p. 71–73 °C. ^{1}H NMR ($CDCl_3$, 500 MHz) δ 2.46 (s, 3H, CH_3), 7.43 (m, 5H, C_6H_5), 8.10 (s, 1H, CH).