Asymmetric dihydroxylation of *trans*-stilbene with a new chiral ligand prepared using dihydrocinchonine and the C_2 symmetric chiral *trans*-9,10-dihydro-9,10-ethanoanthracene-11,12-dicarboxylic acid

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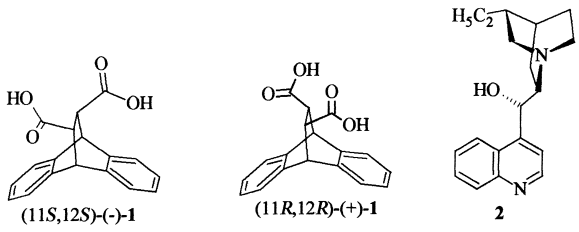
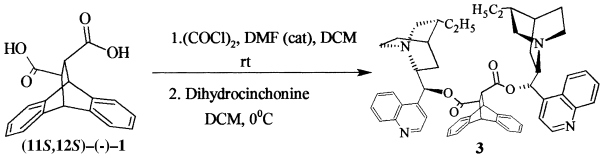
The role of linker chirality on the osmium catalysed asymmetric dihydroxylation of *trans*-stilbene has been examined using the ligand prepared from the C_2 symmetric chiral trans-9,10-dihydro-9,10-ethanoanthracene-11,12-dicarboxylic acid **1** and dihydrocinchonine (+)-**2**. Whereas the ligand prepared using (11*S*,12*S*)-(-)-1 as linker with dihydrocinchonine gave the diol in 85% ee in the asymmetric dihydroxylation of *trans*-stilbene, the diol was obtained in 52% ee using the ligand prepared from the (11R,12R)-(+)-**1**.

Keywords: Asymmetric dihydroxylation, *trans*-stilbene, chiral dicarboxylic acid and dihydrocinchonine.

Asymmetric dihydroxylation of olefins using OsO_4 in the presence of chiral ligands is a powerful technique for the preparation of chiral diols, an important class of compounds.[1] A large number of chiral ligands have been developed using achiral spacers and chiral cinchona alkaloid derivatives.[1,2] Recently, dicarboxylic acids have been introduced as spacers for the preparation of second generation ligands.[3] Very recently, we have developed a simple and convenient method of resolution of the C_2 symmetric chiral *trans*-9,10-dihydro-9,10-ethanoanthracene-11,12-dicarboxylic acid 1.[4] Sharpless and coworkers reported that the acetate ester of dihydrocinchonine or dihydrocinchonidine gives rise to optically active diols with enantiomeric purities substantially lower than those obtained using quinidine and quinine acetates in stoichiometric conditions.[5] Hence, we have examined the use of the chiral dicarboxylic acid as a spacer in the preparation of chiral ligands with dihydrocinchonine -(+)-**2**. The results are reported here.



The ligands **3** and **4** have been synthesised using (11*S*,12*S*)-(-)-1, (11*R*,12*R*)-(+)-**1**[4] and dihydrocinchonine-(+)-**2** through acid chloride preparation and esterification (Scheme 1 and Scheme 2).[6] A diastereomeric mixture **5** (mixture of **3** and **4**) was also prepared using (±)-**1** and dihydrocinchonine-(+)-**2** for comparison of the results.



Scheme 1

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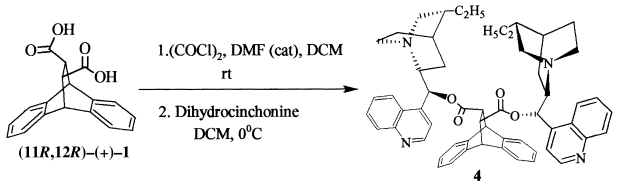
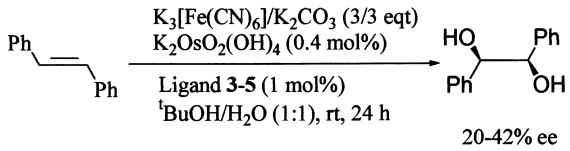


Scheme 2

Asymmetric dihydroxylation of *trans*-stilbene was carried out in the presence of 0.4 mol% of $K_2OsO_2(OH)_4$ and 1 mol% of ligands **3-5** in $^tBuOH/H_2O$ mixture and $K_3[Fe(CN)_6]/K_2CO_3$ at 25°C for 24 h (Scheme 3).[1] Under these conditions, the stilbene diol was obtained in 20–42%. The results are summarised in the Table 1.



Scheme 3

Indeed, it was observed that the linker chirality does have an effect on the enantioselectivity of the stilbene diol produced. For example, when the ligand **5** derived from (±)-**1** and dihydrocinchonine-(+)-**2** was used, the stilbene diol was obtained in 31% ee. The use of diester **4** prepared from (11R,12R)-(+)-**1** and dihydrocinchonine-(+)-**2** gave the stilbene diol only in 20% ee. On the other hand, the diester **3** derived from (11S,12S)-(-)-**1** and dihydrocinchonine-(+)-**2** gave the stilbene diol in 42% ee.

When the concentration of $K_2OsO_2(OH)_4$ and ligand **3** were increased respectively to 1.2 mol% and 3 mol% the enantiomeric excess of stilbene diol formed was increased to 61%. Further increase in concentration of $K_2OsO_2(OH)_4$ and ligands had no effect on the ee of diol formed. When the reaction was carried out using 1.2 mol% of $K_2OsO_2(OH)_4$ and **3** mol% of ligand **3** at 0 °C for 12 h, the ee of stilbene diol obtained from *trans*-stilbene was increased to 85% (Table 1, entry no. 6). Under the same conditions, the ligand **4** gave stilbene diol in 52% ee. Though there is no change in configuration of the diol formed (Table 1), the level of stereoselection is affected by the change in chirality of the linker. Previously, Sharpless and coworkers reported that the acetate ester of dihydrocinchonine or dihydrocinchonidine gives rise to optically active

Table 1 Asymmetric dihydroxylation of *trans*-stilbene[a] using ligands **3-5**

No.	$K_2OsO_2(OH)_4$ /mol %	Ligand /mol %	Conditions[b] /h, °C	Diol-**6**% ee[c]	Yield[d] /%
1	0.4	**5,** 1	24, 25 °C	(1R,2R),31	81
2	0.4	**4,** 1	24, 25 °C	(1R,2R),20	80
3	0.4	**3,** 1	24, 25 °C	(1R,2R),42	72
4	1.2	**3,** 3	24, 25 °C	(1R,2R),61	89
5	2.0	**3,** 5	24, 25 °C	(1R,2R),59	89
6	1.2	**3,** 3	12, 0 °C	(1R,2R),85	79
7	1.2	**4,** 3	12, 0 °C	(1R,2R),52	59

[a]In all experiments *trans*-stilbene (1 mmol) was used. [b] ^{t}BuOH (15 ml) /H_2O (15 ml) were used as a solvent in all entries. [c]ee = enantiomeric excess, (Based on[7] $[\alpha]_D^{25}$ = (+) 92 (C 1.2, EtOH) for (1R,2R)-(+)-diphenyl-1,2-ethane-1,2-diol and $[\alpha]_D^{25}$ = (-) 92 (C 1.2, EtOH) (1S,2S)-(-)-diphenyl-1,2-ethane-1,2-diol). [d]Yields are of isolated and purified products.

diols with enantiomeric purities substantially lower under stoichiometric conditions. However, these authors have not reported the %ee of the product. We have observed that using catalytic amounts (3 mol%) of 9-*O*-acetyldihydrocinchonidine along with 1.2 mol% $K_2OsO_2(OH)_4$, the stilbene diol was obtained in 76% ee. However, using 5 mole% of 9-O-acetyldihydrocinchonidine along with 2 mol% of $K_2OsO_2(OH)_4$, the stilbene diol was obtained in 84% ee.

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Techniques used: IR, ^{1}H, ^{13}C NMR, mass spectral and elemental analysis.

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Tables: 1

Schemes: 3

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