Stereoselective Oxidative Coupling and Asymmetric Hydride Reduction related to (−)-(*S*)-10,10′-Dihydroxy-9,9′-biphenanthryl

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Oxidative coupling of 9-phenanthrol (**1**) with a (−)-(*R*)-1,2-diphenylethylamine-copper(II) complex yielded (−)-(*S*)-10,10′-dihydroxy-9,9′-biphenanthryl (**2**) (98% optical purity); the chiral aluminium hydride reagent modified by (**2**) was found to exhibit enantioface selectivity towards a variety of prochiral carbonyl compounds.

While investigating novel asymmetric hydride reduction,[1] we found that 10,10′-dihydroxy-9,9′-biphenanthryl (**2**) is an excellent chiral modifier in asymmetric $LiAlH_4$ reduction. In this communication, we report a stereoselective oxidative coupling[2] of 9-phenanthrol (**1**) to provide the optically active (**2**), and an asymmetric hydride reduction utilizing (**2**) as the chiral modifier.

To a solution (−5 °C) of (−)-(*R*)-1,2-diphenylethylamine {$[\alpha]_D^{23}$ −50.8 °C (EtOH),[3] 99% optical purity} (60 mmol) and $Cu(NO_3)_2 \cdot 3H_2O$ (20 mmol) in methanol (60 ml), a solution of (**1**) (10 mmol) in methanol (20 ml) was added under a nitrogen atmosphere. After stirring at this temperature for 1 h, the reaction mixture was quenched with 2 M HCl and the product was extracted with diethyl ether. Silica gel chromatography provided 86% (−)-(*S*)-(**2**),† m.p. 234—236 °C, $[\alpha]_D^{23}$ −71 °C ($CHCl_3$).[4]‡

Following Noyori and co-workers' procedure,[1] a tetrahydrofuran solution of the modified hydride reagent (**4**) was

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† The (*S*)-configuration of (−)-(**2**) was determined by chemical correlation with (−)-(*S*)-2,2′-dihydroxy-3,3′-dimethyl-1,1′-binaphthyl (ref. 5). The optical purity of (−)-(**2**) was determined to be 98% by h.p.l.c. analysis with a column packed with poly-(triphenylmethyl methacrylate) (ref. 6).

‡ (−)-1,2-Diphenylethylamine was recovered (90% yield) without any noticeable loss in optical purity.

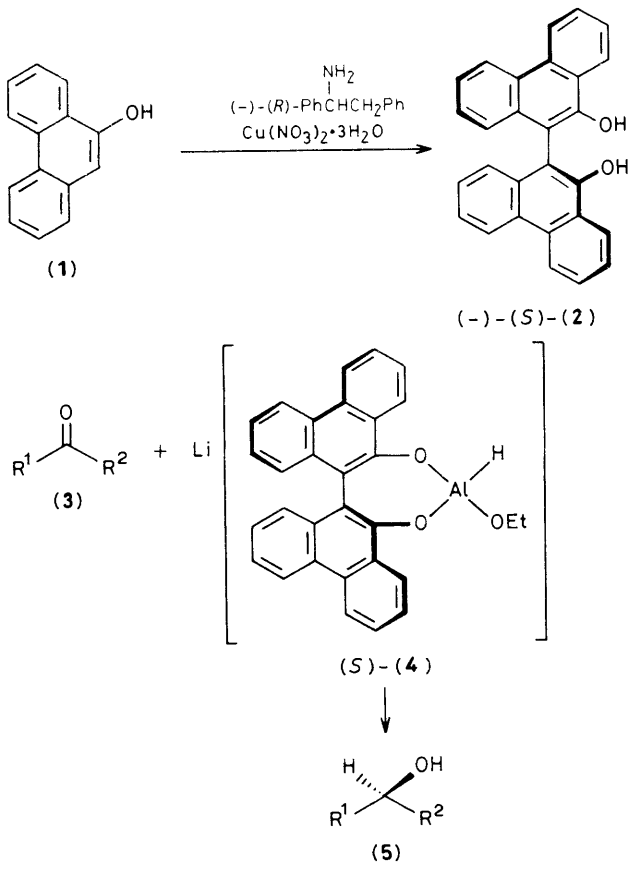

Table 1. Asymmetric hydride reduction of prochiral carbonyl compounds (**3**) with (*S*)-(**4**).[a]

Substrate (R^1COR^2)	Isolated yield/%	Alcohol (**5**) $[\alpha]_D^{25}$/° (*c*, solvent)	Alcohol (**5**) % Enantiomeric excess (configuration)
R^1 = Ph, R^2 = D[b]	74	+1.37 (6.25, C_5H_{10})	87 (*S*)[c]
R^1 = Ph, R^2 = Me	75	−41.8 (2.26, C_5H_{10})	97 (*S*)[d]
R^1 = Ph, R^2 = Et	78	−44.5 (2.54, $CHCl_3$)	98 (*S*)[e]
R^1 = Ph, R^2 = CH_2Ph	77	+54.8 (3.52, EtOH)	98 (*S*)[f]
R^1 = CH_2Ph, R^2 = Me	76	+13.8 (3.22, C_6H_6)	33 (*S*)[g]
R^1 = Bu^i, R^2 = Me	73	+4.31 (4.26, EtOH)	21 (*S*)[h]

[a] The reaction was carried out using (*S*)-(**4**) at −5 °C for 1 h. [b] 99% Deuteriated (ref. 7). [c] Based on $[\alpha]_D^{20}$ +1.58° (*c* 7.07, C_5H_{10}) (ref. 8). [d] Based on $[\alpha]_D^{21}$ −43.1° (C_5H_{10}) (ref. 7). [e] Based on $[\alpha]_D$ −45.45° (*c* 5.15, $CHCl_3$) (ref. 9). [f] Based on $[\alpha]_D^{18}$ +55.9° (*c* 1.40, EtOH) (ref. 10). [g] Based on $[\alpha]_D^{20}$ +41.8° (*c* 5.26, C_6H_6) (ref. 9). [h] Based on $[\alpha]_D^{20}$ +20.5° (EtOH) (ref. 9).

prepared *in situ* at room temperature from $LiAlH_4$, (−)-(*S*)-(**2**), and ethanol (1 : 1 : 1 mol ratio), and then cooled to −5 °C. The prochiral carbonyl compound (**3**) (1 equiv.) was added to this solution of (**4**) (3 equiv.) and stirred for 1 h at −5 °C. Routine work-up involving SiO_2 chromatography and distillation afforded the results summarized in Table 1.§ From these results it can be seen that (i) the chiral hydride reagent (**4**) exhibits good enantiomeric face selectivity towards the carbonyl compounds having a phenyl group directly linked to the carbonyl centre, (ii) the alcohol products (**5**) invariably have the (*S*)-configuration, and (iii) rather low selectivities were found with the aliphatic ketones.

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§ The chiral modifier (**2**) was recovered without any noticeable loss in yield and optical purity.