Asymmetric Synthesis Using Chirally Modified Borohydrides. Part 4.[1] Enantioselective Reduction of Ketones and Oxime Ethers with the Reagent prepared from Borane and Polymer-supported (*S*)-(−)-2-Amino-3-(*p*-hydroxyphenyl)-1,1-diphenylpropan-1-ol

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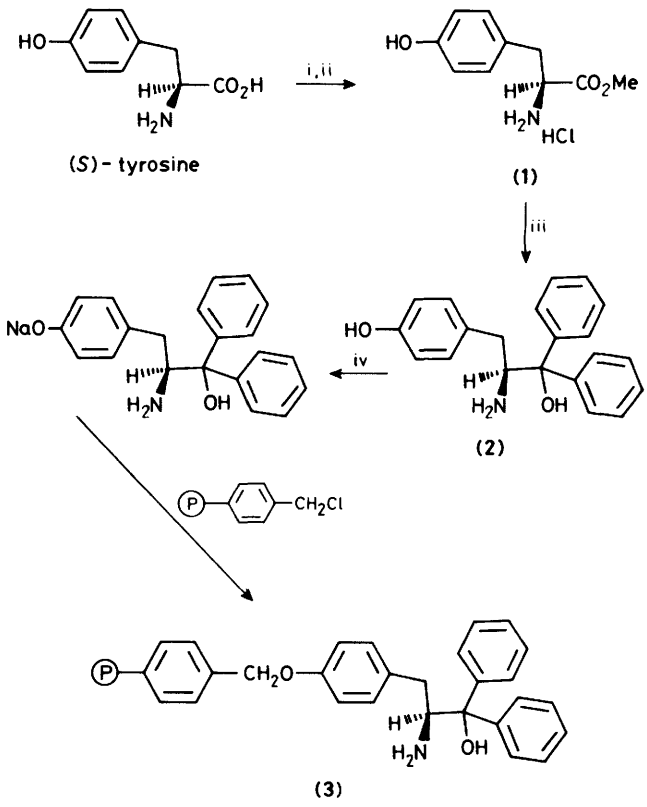
The polymer-supported chiral amino alcohol (**3**) has been prepared by the reaction of chloromethylated polystyrene resin and (*S*)-(−)-2-amino-3-(*p*-hydroxy)phenyl-1,1-diphenylpropan-1-ol (**2**); the chiral polymeric reagent has been prepared from (**3**) and borane. The asymmetric reductions of ketones and oxime ethers with the polymeric reagent have been shown to give optically active alcohols (up to 97% optical purity) and amines (up to 67% optical purity), respectively. The results are compared with those obtained with (*S*)-(−)-2-amino-1,1,3-triphenylpropan-1-ol (**4**) or (*S*)-(−)-2-amino-3-(*p*-benzyloxyphenyl)-1,1-diphenylpropan-1-ol (**5**) which are soluble model reagents.

We recently reported the asymmetric reduction of aromatic ketones with the polymer-supported chiral reducing agent prepared from polymer-bound (*S*)-pyrrolidin-2-ylmethanol [(*S*)-prolinol] and borane.[2] This polymer-supported chiral reagent has the following properties. (1) The reasonably high enantioselectivites obtained in the reduction of aromatic ketones were comparable with those obtained with a soluble reagent. (2) Almost quantitative yields of the corresponding secondary alcohols were obtained under mild conditions (at ambient temperature). (3) Polymer-bound (*S*)-prolinol was obtained easily with a high degree of functionalization, even for the macroporous resin which has a high degree of cross-linking (20%). (4) Easy separation of optically active product from polymeric chiral auxiliary was achieved by simple filtration. (5) Quantitative recovery and re-use of the polymeric reagent was possible with good reproducibility of the enantioselectivity.

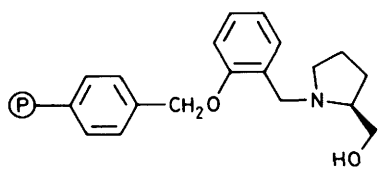
Our further investigations using the borane complexes with various optically active β-amino alcohols in solution showed that α,α-diphenyl-β-amino alcohols were an extremely effective chiral auxiliary for the induction of asymmetry.[3,4] Thus our attention was directed to the development of a method of anchoring the optically active α,α-diphenyl-β-amino alcohol to the polymer. The asymmetric polymeric reagent thus obtained may be expected to show an enzyme-like stereoselectivity based on the results from the solution systems.[3] Preparation of (**2**) was designed with this aim in mind. Compound (**2**) had a phenolic hydroxyl group to act as anchor to a chloromethylated polystyrene bead. In fact (**2**) was readily prepared from inexpensive and commercially available (*S*)-tyrosine by two steps (see Scheme 1). The anchoring reaction was carried out quantitatively. We now report the asymmetric reduction of prochiral aromatic ketones, α-halogenoketones, and oxime ethers with this new type of chiral polymeric reagent prepared from borane and compound (**3**). Related monomeric model chiral reagents (soluble reagents) from borane and compounds (**4**) or (**5**) were examined for comparison.



Scheme 1. *Reagents:* i, $SOCl_2$; ii, MeOH; iii, PhMgBr, THF; iv, NaH, *N*-methylpyrrolidone

Results and Discussion

Synthesis of (S)-(−)-2-*Amino*-3-(p-*hydroxy*)*phenyl*-1,1-*diphenylpropan*-1-*ol* (**3**).—The polymeric support chosen was a polystyrene (2% cross-linked with divinylbenzene) resin bead of the type used earlier that had been chloromethylated in the usual fashion.[5] We have already reported[2,6] the synthesis of a



(**6**)

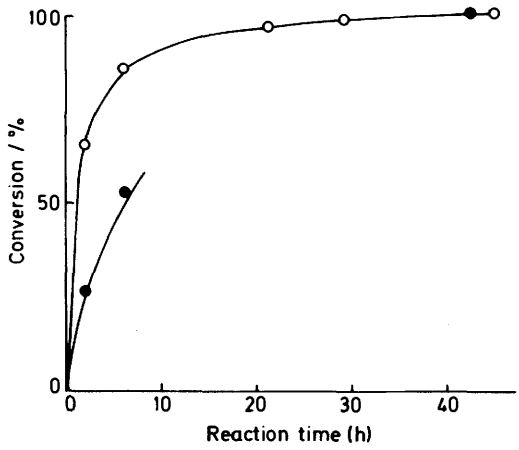
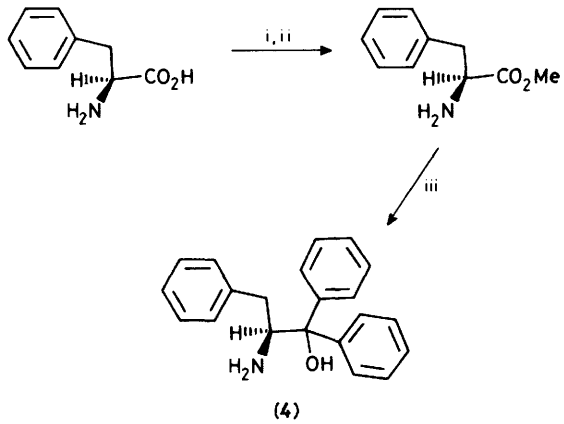


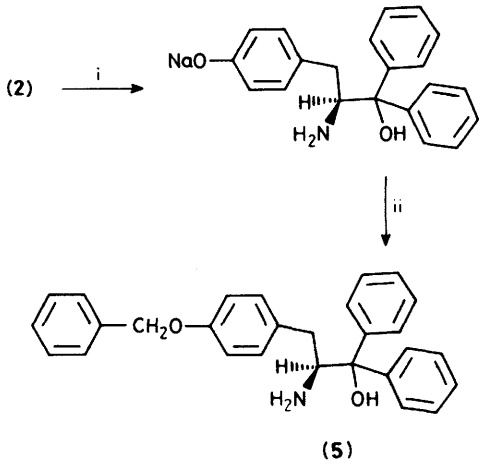
Figure 1. Reaction of cross-linked chloromethylated polystyrene resin and (**2**). ○: 2% cross-lined polystyrene, ●: 5% cross-linked polystyrene

(*S*)-*N*-benzylprolinol-bound type polymer-support (**6**) carrying a benzyl phenyl ether linkage as a short spacer arm. We have now applied this anchoring method to the preparation of (**3**). The chiral amino alcohol containing a hydroxyphenyl group, (**2**), was prepared as shown in Scheme 1. The sodium phenoxide derivative of (**2**) was treated with the chloromethylated polystyrene bead to give the desired chiral amino alcohol bound polymer (**3**), as shown in Scheme 1. To ensure that the chloromethyl group of the bead would be completely etherified, an excess of (**2**) was used; this was readily removed after completion of the reaction by filtration and washing of the amino alcohol supported resin. Unchanged chiral amino alcohol (**2**) could be recovered from the filtrate without loss of optical purity, which supports the theory that no racemization accompanies the anchoring reaction. In the case of 2% cross-linked polystyrene beads (65.9% of the aromatic rings were chloromethylated) the percentage of anchoring achieved was 92% after 4 h at 45 °C. Above 90 °C, alkylation of the amino functionality might parallel the Williamson reaction. Asymmetric reduction using polymer obtained at such a high reaction temperature resulted in a lowering of the optical yield. The anchoring reaction (without side reaction) went to completion after 40 h at ambient temperature with slow stirring. Figure 1 shows the reaction rate of cross-linked (2% and 5%) chloromethylated polystyrene and (**2**). Although a highly cross-linked polymer (5% cross-linked) slowed down the introduction of (**2**), almost complete reaction could still be achieved over a longer reaction time. The weight increment of the polymer obtained agreed with that calculated from the degree of chloromethylation. The completeness of the reaction was conveniently checked by both the Beilstein test and by noting the disappearance of the characteristic i.r. absorption at 1 250 cm^{-1} attributed to chloromethyl groups. This was confirmed by the elemental analysis. Similarly, the structurally related monomeric chiral amino alcohols (**4**) and (**5**) were prepared from (*S*)-tyrosine and (*S*)-phenylalanine, respectively, according to Schemes 2 and 3.

Asymmetric Reduction of Prochiral Ketones with the Polymer-supported Chiral Amino Alcohol–Borane Complex.—As previously reported in the literature,[7] the optical yields of the secondary alcohols changed markedly with a change in the ratio of borane and chiral amino alcohol. Initially, therefore we examined the effect of this ratio on the optical yield. Asymmetric reduction of ketones was carried out in exactly the same manner as described previously for solution system, similar results being



Scheme 2. *Reagents:* i, $SOCl_2$; ii, MeOH; iii, PhMgBr, THF



Scheme 3. *Reagents:* i, NaH, *N*,*N*-dimethylformamide; ii, benzyl chloride

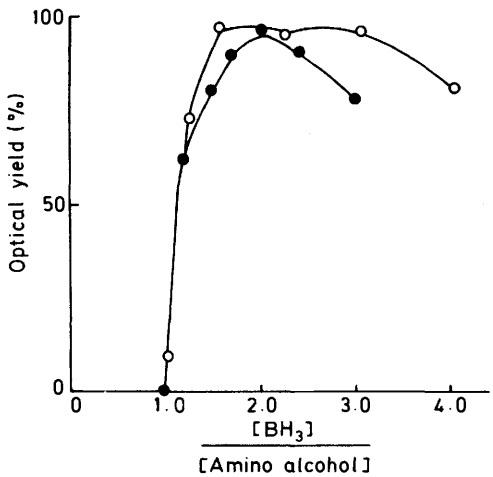


Figure 2. Effect of the ratio [BH_3]:[Amino alcohol] on the optical yield in the reduction of butyl phenyl ketone in THF at 30 °C ●: polymeric reagent (**3**)–borane, ○: monomeric reagent (**4**)–borane

obtained. Figure 2 shows that the maximum optical yield was obtained where the ratio of borane to amino alcohol was *ca.* 2:1. Excess of borane at a ratio higher than 3:1 of borane to the amino alcohol (**4**) gave rise to a low optical yield. Optical yields decreased considerably at ratios beyond 2:1 in the case of the

Table 1. Asymmetric reduction of prochiral ketones with (**3**)–borane complex in THF at 30 °C. The yield of alcohol was 100% in each case.[a]

	Alcohol produced[b]	
Ketone	Optical yield (%)	Absolute configuration
MeCOPh	76[c] (87)	*R* (*R*)
EtCOPh	79[d] (79)	*R* (*R*)
PrCOPh	88[e] (82)	*R* (*R*)
BuCOPh	97[f] (93)	*R* (*R*)

[a] Based on relative g.l.c. peak areas of alcohol and ketone. [b] Values in parentheses were obtained from asymmetric reduction with (**4**)–borane complexes in THF at 30 °C. [c] In CH_2Cl_2 (U. Nagai, T. Shishido, R. Chiba, and H. Mitsuhashi, *Tetrahedron*, 1965, **21**, 1701). [d] In acetone (K. Kwart and D. P. Hoster, *J. Org. Chem.*, 1967, **32**, 1896). [e] In benzene (R. Noyori, I. Tomino, and Y. Tanimoto, *J. Am Chem. Soc.*, 1979, **101**, 3129). [f] Neat (A. Horeau, J. P. Guette, and R. Weiolmann, *Bull. Soc. Chim. Fr.*, 1966, 3513).

Table 2. Asymmetric reduction of α-halogeno ketones with the polymeric reagent prepared from borane and (**3**) in THF at 30 °C. The yield of halohydrin and styreneoxide was 100% each case.

	Halohydrin		Styrene oxide	
α-Halogeno ketone	Optical yield (%)	Absolute configuration	Optical yield (%)	Absolute configuration
$PhCOCH_2Cl$	84	*S*	85	*S*
$PhCOCH_2Br$	51	*S*	51	*S*

[a] In cyclohexane (L. C. J. van der Lean, J. B. N. Engberts, and T. J. deBoer, *Tetrahedron*, 1971, **27**, 4323). [b] In $CHCl_3$ (M. Imuta, K. Kawai, and H. Ziffer, *J. Org. Chem.*, 1980, **45**, 3352). [c] Neat (G. Berti, F. Bottari, P. L. Ferrarini, and B. Macchia, *J. Org. Chem.*, 1965, **30**, 4091).

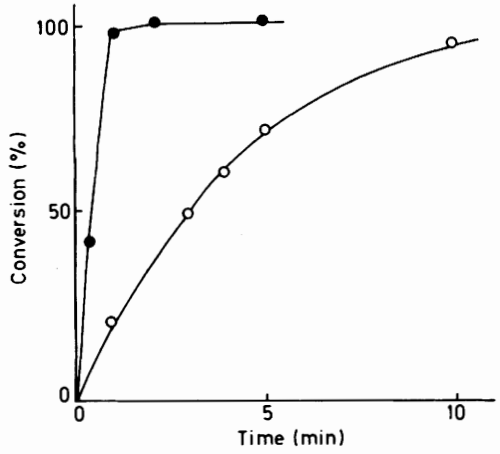


Figure 3. Time-conversion curves for the reduction of butyl phenyl ketone with BH_3: ○; and with (**3**)–BH_3 complex: ●

polymeric reagent. Based on the above results, asymmetric reductions were examined using the 2.2:1 reagent, unless otherwise stated. Results of the asymmetric reduction of several alkyl phenyl ketones with the monomeric reagent from (**4**) and borane are summarized in Table 1. All the optically active secondary alcohols produced were of *R* configuration. If no decrease in stereoselectivity is observed by performing asymmetric syntheses using an insoluble polymer-supported reagent, compared with the corresponding highly stereoselective monomeric soluble one, a number of advantages as mentioned above, accrue. In fact, the polymeric reagent prepared from (**3**) and borane realized the same degree of selectivity as the monomeric ones (see Table 1). This polymeric reagent from (**3**) and borane was also used to treat α-halogenoketones, which were reduced with high enantioselectivity to give the optically active halohydrins. Irrespective of their powerful reactivity towards carbonyl groups, the halogens remained intact during reduction. Although both α-chloro and α-bromo-acetophenones were reduced chemoselectively, sterically bulkier bromide lowered the enantioselectivity (Table 2). Treatment of the halohydrins with alkaline solution gave a synthetically useful chiral epoxide without racemization. In general, the rate of reaction with the insoluble polymeric reagent was slower than that with the soluble one, a result of the heterogeneous reaction. For example, asymmetric reduction of ketones with polymer-supported (*S*)-prolinol–borane complex required an appreciably longer reaction time (48—72 h was required to achieve 70—100% conversion). Interestingly, however, it was found that the reduction of ketones with the polymeric reagent from (**3**) and borane was an extremely fast reaction in spite of its insolubility. Figure 3 shows time-conversion curves for the reduction of butyl phenyl ketone with the polymeric reagent and with borane alone for comparison. The rate of reduction with polymeric reagent was faster than that with borane itself; complete reduction was achieved with the reagent within 30 min. No destruction of the polymer was observed after it had been used several times, only brief stirring being necessary for the quantitative reaction to occur. Easy product isolation was achieved by simple filtration. Both optical and chemical yields were reproducible as shown in Table 3. Consequently this polymeric reducing agent fulfils almost all the requirements for a good asymmetric synthesis although no simple explanation for this extraordinarily fast reaction can be offered at the present time.

Table 3. Recycling of (**3**)–borane complex in reduction of butyl ketone in THF at 30 °C. The yield of alcohol was 100% in each case.

	1-Phenylethan-1-ol	
Cycle	Optical yield (%)	Absolute configuration
1	78	*R*
2	97	*R*
3	92	*R*
4	92	*R*

Re-use of Polymeric Reagent.—One of the most useful features of the polymeric reagent was its ability to be recycled (see Table 3). The procedure of the asymmetric reduction using this polymeric reagent is as follows: preparation of the polymeric reagent by the reaction of polymer-supported chiral amino alcohol with borane, reduction of substrate, hydrolysis, separation, product isolation and purification, and regeneration of the polymer-supported chiral amino alcohol. During further studies on reductions using the polymeric reagent, an interesting fact was observed. After reduction of acetophenone with the reagent, careful filtration under a dry nitrogen stream without a hydrolytic process gave the THF solution as the filtrate; this was hydrolysed to yield the optically active secondary alcohol quantitatively. Thus the separation of the product by filtration can be performed before the hydrolysis process. Therefore without the process either of regeneration of the polymer-supported amino alcohol or preparation of the polymeric reagent, the chiral product can be isolated. Although no satisfactory proposals for the structure of the complex and the

reaction mechanism can be offered, the optically active alcohol was obtained from the filtrate in the following procedure. In the reduction of acetophenone, after separation of the product (76% e.e.), addition of 1 equiv. of borane to the polymer may regenerate the polymeric reagent. Added ketone was asymmetrically reduced again to give chiral alcohol (63% e.e.). If borane and substrate are supplied continuously, the chiral product can be obtained successively. This procedure is now under investigation.

Asymmetric Reduction of Oxime Ethers with the Chiral Polymeric Reagent.—We have extended the above investigations for ketones to the reduction of the isoelectronic imino group and thus obtained optically active amines. Compared with ketone reduction, few studies on the asymmetric reduction of ketone oximes have been reported. Asymmetric reduction of ketone oximes with lithium aluminium hydride–monosaccharide complex which has been shown to be an effective reducing agent for ketones was reported recently by Landor *et al.*[8] The highest optical yield (39% e.e.) so far found for acetophenone oxime was obtained with their improved reagent.[9] On the other hand, our reagent prepared from chiral amino alcohol and borane could reduce oximes or oxime ethers asymmetrically to give optically active primary amines having *S* configuration, which is the reverse of that obtained in ketone reduction. Because of the *anti*-configuration of oxime ethers, steric hindrance by the *O*-alkyl group *trans* to the large phenyl group may become a dominant factor in the stereoselectivity.

Table 4. Asymmetric reduction of acetophenone oxime *O*-alkyl ether [Ph(Me)C=NOR] with (**3**)–borane complex in THF at 30 °C. The yield of amine was 100% in each case.

	1-Phenylethylamine[a]	
	Optical yield (%)	Absolute configuration
Me	18 (94)[d]	*S* (*S*)[d]
Et	25	*S*
CH_2Ph	17	*S*
CH_2Ph[b]	26	*S*
CH_2Ph[c]	6	*S*

[a] In methanol (W. Leithe, *Chem. Ber.*, 1931, **64**, 2827). [b] (**3**)–Borane complex was formed at 0 °C (see Experimental section). [c] The ratio of borane to (**3**) is 3:1. [d] Obtained from asymmetric reduction with (**5**)–borane complex in THF at 30 °C.

Table 5. Additive effect of Lewis Acid on the optical yield in the reduction of acetophenone oxime *O*-alkyl ether [Ph(Me)C=NOR] with (**3**)–borane complex in THF at 30 °C. The yield of amine was 100% in each case.

		1-Phenylethylamine	
R	Lewis Acid	Optical yield (%)	Absolute configuration
Me	BF_3·Et_2O	18	*S*
Me	$AlCl_3$	20	*S*
Me	$AlCl_3$[a]	67	*S*
Me	$ZnCl_2$[a]	50	*S*
Et	BF_3·Et_2O	33	*S*
Et	$AlCl_3$[a]	42	*S*
Et	$ZnCl_2$	22	*S*
CH_2Ph	BF_3·Et_2O	35	*S*
CH_2Ph	$AlCl_3$	31	*S*
CH_2Ph	$ZnCl_2$	44	*S*

[a] (**3**)–Borane complex was formed at 0 °C.

Monomeric model reagent prepared from (**5**) and borane showed a very high degree of enantioselectivity for the reduction of acetophenone oxime *O*-methyl ether to give (*S*)-1-phenylethylamine in 94% e.e. Other monomeric chiral amino alcohol–borane reagents were all effective for oxime ethers as previously reported.[1] The polymeric reagent prepared from (**3**) and borane could also reduce oxime ethers to the corresponding primary amines. Disappointingly, however, only low enantioselectivities were obtained (Table 4). Oxime ether was reduced slowly with 1 equiv. of borane in THF at 30 °C to the corresponding primary amine (60% conversion after 20 h). Quantitative conversion was achieved within a few hours by the use of 2 molar excess of borane to oxime ether. Unlike ketone reduction, the polymeric reagent reduced oxime ethers slower than the borane reagent. Complete reduction was achieved in *ca.* 24 h at 30 °C with the polymeric reagent. In the case of heterogeneous reaction by the polymeric reagent, faster reduction with unchanged free borane would be considerable. It was found that addition of a Lewis acid to the oxime ether before the reaction not only activated the substrate but also effected asymmetric induction in the reduction by the polymeric reagent. The effects of the addition of various Lewis acids are shown in Table 5. Furthermore, the reagent was also affected by the chiral complex formation temperature. When chiral complex was formed at 0 °C relatively high enantioselectivity was obtained. Asymmetric reduction of other prochiral compounds containing a C=N bond, such as imines, dihydroisoquinolines, and tetrahydropyridines is now under investigation.

Experimental

All reactions were carried out under nitrogen. THF was dried over sodium wire and distilled over lithium aluminium hydride ($LiAlH_4$) immediately before use. Acetophenone, ethyl phenyl ketone, propyl phenyl ketone, and butyl phenyl ketone were dried and distilled over calcium hydride. α-Chloroacetophenone and α-bromoacetophenone were recrystallized from carbon tetrachloride and methanol respectively. Acetophenone oxime *O*-alkyl ethers were prepared by the reaction of acetophenone oxime and alkyl halides.[10,11] $AlCl_3$ was dried *in vacuo* for 5 h at 80 °C prior to use. $ZnCl_2$ was purified by sublimation. Borane was prepared by the reaction of sodium borohydride with boron trifluoride–diethyl ether complex according to the procedure of Brown.[12] The purities of all reagents were checked by g.l.c. or by n.m.r. spectroscopy. All the materials described here were stored under nitrogen prior to use.

N.m.r. spectra were taken on a JEOL JNM-PMX60 (60 MHz) spectrometer. I.r. spectra were measured with a JASCO A-3 instrument for Nujol mulls. Melting points were determined on a Yanagimoto micro melting point apparatus. G.l.c. was performed on a Yanaco G180 instrument with a stainless-steel analytical column (3 m × 3 mm) packed with PEG 20M on Diasolid L. Optical rotations were taken on a JASCO DIP-140 digital polarimeter using a 1-cm or 10-cm thermostatted microcell.

(S)-(−)-2-*Amino*-3-(p-*hydroxyphenyl*)-1,1-*diphenylpropan*-1-*ol* (**2**).—(*S*)-Tyrosine methyl ester hydrochloride (23.2 g, 0.1 mol) was added portionwise, with ice–water bath cooling, to a THF solution of phenylmagnesium bromide [from bromobenzene (105 ml, 1.0 mol) and magnesium (25.5 g, 1.05 mol)], and the mixture was stirred at 0—10 °C for 5 h. The additive complex underwent slow decomposition when ice, 2M-HCl, and ammonia were added. When the decomposition was complete, the THF layer was separated, the aqueous layer was extracted with ethyl acetate (×4) and the combined extracts were dried ($MgSO_4$) and evaporated to afford (**2**) as a pale yellow solid. Recrystallization from ethanol–ethyl acetate–water (3:1:2 v/v)

gave colourless crystals (13.7 g, 43%), m.p. 215—217 °C, $[\alpha]_D^{25}$ −92.3° (*c* 0.377 in THF); δ($CDCl_3$) 7.67—6.50 (14 H, m), 4.00 (1 H, dd), and 2.40 (2 H, dd) (Found: C, 78.4; H, 6.8; N, 4.5. $C_{21}H_{21}NO_2$ requires C, 79.0; H, 6.6; N, 4.4%).

(S)-(−)-2-*Amino*-1,1,3-*triphenylpropan*-1-*ol* (**4**).[1]—This compound was prepared from (*S*)-phenylalanine methyl ester hydrochloride with an 8-fold excess of phenylmagnesium bromide in THF at 0—10 °C for 5 h. After work-up, (**4**) was obtained in 53% yield, m.p. 144—145 °C, $[\alpha]_D^{25}$ −88.50° (*c* 0.604 in $CHCl_3$).

(S)-(−)-2-*Amino*-3-(p-*benzyloxyphenyl*)-1,1-*diphenylpropan*-1-*ol* (**5**).[1]—(*S*)-(−)-2-Amino-3-(*p*-hydroxy)phenyl-1,1-diphenylpropan-1-ol (**2**) (5.0 g, 15.7 mmol) and dry *N*,*N*-dimethylformamide (50 ml) were placed in a 200 ml round-bottomed flask under nitrogen. Sodium hydride (0.38 g, 15.7 mmol) was added slowly with stirring. The resulting mixture was stirred at room temperature for 5 h under nitrogen. Water (20 ml) was added and *N*,*N*-dimethylformamide was evaporated. The aqueous layer was extracted with ethyl acetate (3 × 30 ml) and the extract was dried ($MgSO_4$) and evaporated to give a pale yellow solid. The crude product was recrystallized from ethanol to give white needles, (4.6 g, 71%), m.p. 136—137 °C, $[\alpha]_D^{25}$ −51.71° (*c* 1.534 in THF); δ($CDCl_3$) 7.60—6.53 (19 H, m), 4.84 (2 H, s), 3.93 (1 H, dd), 2.29 (2 H, d), and 1.00 (2 H, m) (Found: C, 82.4; H, 6.7; N, 3.5. $C_{28}H_{27}NO_2$ requires C, 82.1; H, 6.7; N, 3.4%).

Polymer-supported (S)-(−)-2-*Amino*-3-(p-*hydroxyphenyl*)-1,1-*diphenylpropan*-1-*ol* (**3**).—Dry *N*-methylpyrrolidine was added with stirring to compound (**2**) (16 g, 50 mmol) and the resulting mixture was stirred until the evolution of hydrogen ceased. Chloromethylated polymer resin (2% cross-linking, 5.06 g, 20 mmol Cl) was added and the resulting mixture was stirred at room temperature for 45 h under nitrogen. The polymer was filtered off, washed successively with water, methanol, THF, THF–water, THF, and methanol, and dried *in vacuo* at 50 °C to yield (**3**) (10.7 g) (Found: C, 84.6; H, 7.0; Cl, 0.0; N, 2.6. Calc. for C, 84.50; H, 6.91; Cl, 0.00; N, 2.61).

Asymmetric Reduction of Ketones with the Polymeric Reagent Prepared from (**3**) *and Borane*.—Polymeric reagent was prepared by treatment of compound (**3**) (5.36 g, 10 mmol) with an excess of borane (22 mmol) in THF at −78 °C; the mixture was then warmed to 30 °C and stored overnight, at 30 °C. To this suspension was added a solution of propyl phenyl ketone (1.19 g, 8 mmol) in THF (5 ml) with stirring, and the resulting mixture was thermostatted at 30 ± 0.5 °C for 30 min. After hydrolysis with 2M-HCl, the polymer (**3**) was filtered off by suction, and was recovered almost quantitatively as its HCl salt. The filtrate was extracted with ethyl acetate (3 × 10 ml) and the combined extracts were washed with saturated aqueous NaCl (2 × 10 ml), dried ($MgSO_4$), and evaporated to give a colourless oil. The conversion was checked by g.l.c. (100%). The crude product was then distilled by bulb-to-bulb distillation to give 1-phenylbutan-1-ol (1.08 g, 90% of isolated material); it was characterized by i.r. and n.m.r. spectroscopy and was shown to be homogeneous by t.l.c. and g.l.c. analyses.

The optical rotation for the benzene solution was $[\alpha]_D^{25}$ +39.80° (*c* 1.57 in benzene). The optical yield, 88%, was calculated by the observed optical rotation and the known maximum rotation of 1-phenylbutan-1-ol, $[\alpha]^{26}{}_{D_{max.}}$ −45.2° (*c* 4.81 in benzene).[13]

Asymmetric Reduction of Ketone Oxime Ethers with the Polymeric Reagent Prepared from (**3**) *and Borane*.—Polymeric reagent was prepared by treatment of compound (**3**) (5.36 g, 10 mmol) with an excess of borane (20 mmol) in THF at 0 °C and the mixture was stirred at 0 °C for 6 h. To this suspension was added a solution of acetophenone oxime *O*-benzyl ether (1.8 g, 8 mmol) in THF (5 ml) with stirring, and the resulting mixture was thermostatted at 30 ± 0.5 °C for 24 h. After hydrolysis with 2M-HCl, the polymer (**3**) was filtered off by suction, and recovered almost quantitatively as its HCl salt. The resulting acidic solution was shaken with ether, cooled, basified with ammonium hydroxide, and extracted with ether (3 × 10 ml). The combined extracts were dried ($MgSO_4$) and evaporated to give a colourless oil which was subjected to bulb-to-bulb distillation to give 1-phenylethylamine (0.82 g, 85% isolated material); it was characterized by i.r. and n.m.r. spectroscopy and shown to be homogeneous by t.l.c. and g.l.c. analysis. The optical rotation for the methanol solution was $[\alpha]_D^{25}$ −7.43° (*c* 2.33 in methanol). The optical yield, 26%, was calculated by the observed optical rotation and the known maximum rotation of 1-phenylethylamine, $[\alpha]^{20}{}_{D_{max.}}$ −29° (in methanol).[14]

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