Asymmetric Reduction of Ketones by Homogeneous Catalytic Hydrogenation

By P. BONVICINI, A. LEVI, G. MODENA, and G. SCORRANO*

(*Centro CNR Meccanismi di Reazioni Organiche, Istituto di Chimica Organica, Via Marzolo, 1–35100 Padova, Italy*)

Summary Catalytic asymmetric reduction of two simple ketones has been achieved by the use of a Rh^I complex with an optically active phosphine as ligand.

HOMOGENEOUS hydrogenation with chiral catalysts is attracting much interest, but it has been so far restricted to the reduction of the carbon–carbon double bond.[1]

We report our preliminary results on the first asymmetric homogeneous hydrogenation of simple ketones to optically active alcohols.

Following the report by Schrock and Osborn[2] that the cationic catalyst $[Rh(nbd)L_2]^+ClO_4^-$ (nbd = norborna-2,5-diene, L = PPh_2Me, $PPhMe_2$, or PMe_3) reduces ketones, we prepared, following the described procedure,[3] an optically-active catalyst by using as ligand *R*-benzylmethylphenylphosphine ($[\alpha]_D^{25}$ +84°, *c* 0·013 in toluene, lit.[4] $[\alpha]_D$ +81° in toluene).†

The reductions were carried out at room temperature under hydrogen (1 atmos), by adding the ketone (1 g) to the catalyst (0·02 g) in anhydrous ethanol (40 ml). The rates of reduction were not reproducible and often they decreased with the progress of the reaction. However, 20—40 mol of alcohol per mol of catalyst were always obtained within a

---

† All the polarimetric readings were made on a Perkin-Elmer 141 polarimeter with a 10 cm thermostatted cell.

reasonable length of time (24—80 h). No attempts have so far been made to optimize the reaction conditions.

We have tested our catalyst with phenyl methyl ketone and butan-2-one. The former gives 1-phenylethanol enriched in the *R*-(+) enantiomer ($[\alpha]_D^{25}$ + 3·4°, *c* 0·078 in EtOH; $[\alpha]_D^{23}$ + 4·5°, *c* 0·026 in CH_2Cl_2. For the *S* isomer lit.[5] $[\alpha]_D^{23}$ − 52·5°, *c* 2·27 in CH_2Cl_2) with an optical yield of 8·6%. The latter gives butan-2-ol with a low but significant optical activity, corresponding to an enrichment in the *R*-(−) isomer with an optical yield of 1·9% ($[\alpha]_D^{20}$ − 0·21°, $[\alpha]_{435\cdot9}^{20}$ − 0·55°, *c* 0·048 in EtOH. For the *S* isomer, lit.[6] $[\alpha]_D^{20}$ + 11·00°, $[\alpha]_{435\cdot9}^{20}$ + 29·17°, *c* 4·992 in EtOH).

Although the optical yields are not large, they compare well with those obtained in the reduction of carbon–carbon double bonds with Rh^I complexes containing similar chiral phosphines as ligands.[1b]

(*Received*, 31*st July* 1972; *Com.* 1343.)

---

[1] (a) R. S. Coffey in 'Aspects of Homogeneous Catalysis,' ed. R. Ugo, C. Manfredi, Milano, 1970; J. D. Morrison, R. E. Burnett, A. M. Aguiar, C. J. Morrow, and C. Phillips, *J. Amer. Chem. Soc.*, 1971, **93**, 1301; T. P. Dang and H. B. Kagan, *Chem. Comm.*, 1971, 481; P. Abley and F. J. McQuillin, *J. Chem. Soc.* (*C*), 1971, 844; W. S. Knowles, M. J. Sabacky, and B. D. Vineyard, *J. C. S. Chem. Comm.*, 1972, 10; (b) L. Horner, H. Siegel, and H. Buthe, *Angew. Chem. Internat. Edn.*, 1968, **7**, 942; W. S. Knowles and M. J. Sabacky, *Chem. Comm.*, 1968, 1445.

[2] R. R. Schrock and J. A. Osborn, *Chem. Comm.*, 1970, 567.

[3] R. R. Schrock and J. A. Osborn, *J. Amer. Chem. Soc.*, 1971, **93**, 2397.

[4] K. Naumann, G. Zon, and K. Mislow, *J. Amer. Chem. Soc.*, 1969, **91**, 7012.

[5] U. Nagai, T. Shishido, R. Chiba, and H. Mitsuhashi, *Tetrahedron*, 1965, **21**, 1701.

[6] J. Kenyon, H. Phillips, and V. P. Pittman, *J. Chem. Soc.*, 1935, 1072.