Tetrahedron Letters Vol. 21, pp 3443 - 3446
©Pergamon Press Ltd. 1980. Printed in Great Britain

0040-4039/80/0901-3443$02.00/0

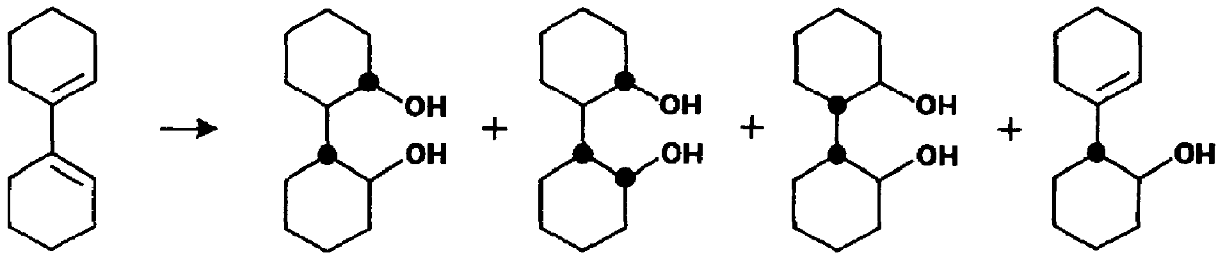
RELATIVE ASYMMETRIC INDUCTION IN THE HYDROBORATION OF BI-1-CYCLOHEXEN-1-YLS

Thomas W. Bell[1]
Department of Chemistry, University of California, Los Angeles 90024

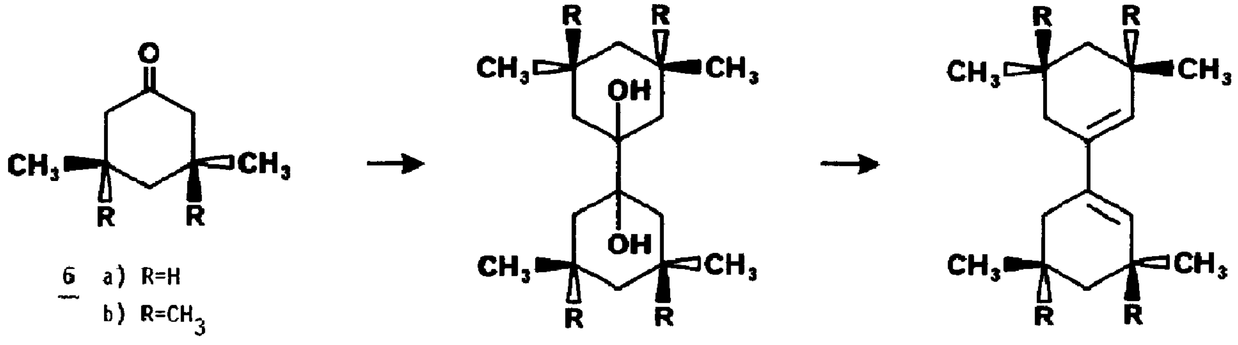
Abstract: Hydroboration-oxidation of the bi-1-cyclohexen-1-yls 1 and 8b gave single 1,4-diols, *d,l* 2 and *meso* 10b, respectively, whereas the chiral bi-1-cyclohexen-1-yl 8a, synthesized from (-)-*trans*-3,5-dimethylcyclohexanone, led to a mixture of two 1,4-diols (9a and 10a).

The ability of boranes to distinguish between diastereotopic faces of double bonds in rigid[2] and flexible[3] cyclic olefins has been amply demonstrated. In most cases this stereoselectivity is determined by the presence of adjacent or transannular substituents. This report describes examples of very high asymmetric induction in which the stereochemistry of borane addition is controlled by asymmetric centers which are external to a cyclohexene ring[4].

According to a previous report[5], the equimolar reaction of bi-1-cyclohexen-1-yl 1 with borane in tetrahydrofuran (BH_3-THF) at 0-20°C, followed by oxidation with alkaline hydrogen peroxide, led to a mixture of the *d,l*-diols 2 (58%) and 3 (3.4%), the *meso*-diol 4 (5.8%) and the monoaddition-oxidation product 5 (12%). We have found that the product selectivity of this reaction is greatly affected by stoichiometry and reaction temperature. Thus, reaction of BH_3-THF with 1 in 1.1:1 molar ratio at 0-20°C, followed by reflux (10 min.), then oxidation, gave a mixture of only 2 and 4 (3:1, respectively) in 89% yield. Similar results were obtained when thexylborane[2,6] and 1 were employed in 1:1 or 2:1 molar ratios. However, reaction of BH_3-THF with 1 in 2.1:1 molar ratio at -20 to 20°C, followed by oxidation, led to diol 2 (98%), accompanied only by a trace of diol 4.



1 2 3 4 5

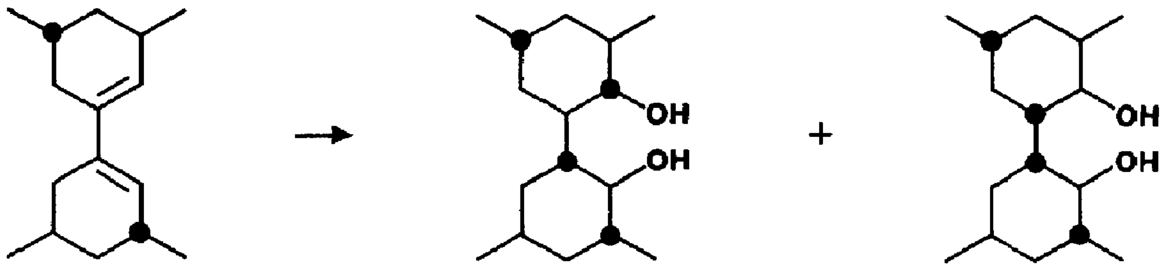


6 a) R=H

b) $R=CH_3$

7

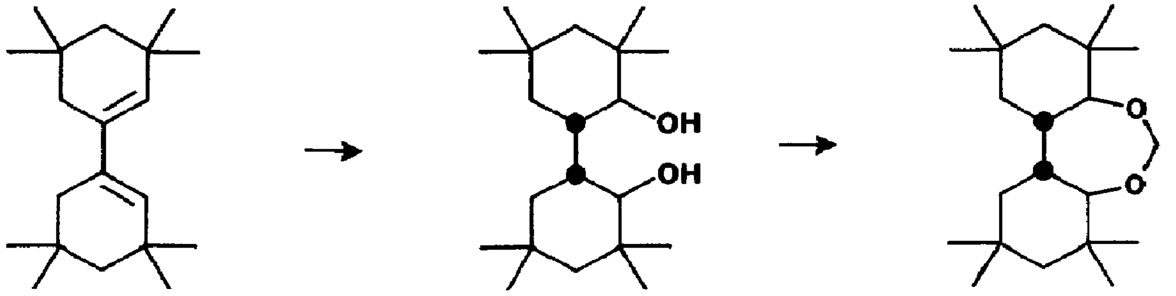
8



8a

9a

10a

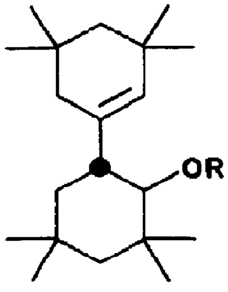


8b

10b

11

12



13

a) R=H

b) $R=CH_2Ph$

In order to examine the stereoselectivity of hydroboration of substituted bi-1-cyclohexen-1-yls, ketones 6a[7] and 6b[8] were converted to the pinacols 7a and 7b, respectively, using either magnesium amalgam-titanium tetrachloride in THF[9] or aluminum amalgam in dichloromethane[10]. Treatment of the pinacols with phosphorus oxychloride in pyridine[11,12] gave the symmetrical bi-1-cyclohexen-1-yls 8a and 8b. The reaction of BH_3-THF with (+)-8a (3:1 molar ratio) at -40 to 2°C, followed by oxidation, gave a mixture of diols which were separated by column chromatography on alumina. These products were identified on the basis of symmetry properties and ^{1}HNMR coupling constants as the symmetrical diol 9a (21%, m.p. 155.5-156.5°C, $[\alpha]_D^{25}$ + 34.4° (*c* 2.1, $CHCl_3$)) and the *pseudomeso* diol 10a (51%, m.p. 169.5-170.0°C, $[\alpha]_D^{25}$ -38.4° (*c* 2.0, $CHCl_3$)). Reaction of BH_3-THF with the octamethyldiene 8b (2.2:1 molar ratio) at -10 to 30°C, followed by prolonged oxidation, afforded a single product in 78% yield after recrystallization, m.p. 181.0-181.5°C. This product was identified as the *meso* diol 10b by reaction with N-bromosuccinimide in DMSO[13] to afford the methylene ketal 11 (96%), whose ^{1}HNMR spectrum (200 MHz, $CDCl_3$) exhibited an AB quartet centered at $\delta 4.99$ ($\Delta\nu = 0.57$ ppm, $J_{AB} = 5.62$ Hz). The distribution of product 1,4-diols 9a, 10a and 10b from dienes 8a and 8b could not be altered by changes in hydroboration conditions.

It is seen that the *direction* of interannular asymmetric induction in the bi-1-cyclohexen-1-yl system is reversed by the presence of methyl groups in the 3,3',5 and 5' positions. If it is assumed that hydroboration stereochemistry is determined by the ground state olefin conformation[3a] and that this conformation of the bi-1-cyclohexen-1-yl·BH_3 monoadduct is best represented as 12[14], then diol 2 results from the attack of a second BH_3 molecule on the cyclohexene face *opposite* the BH_2 group of 12. Alternately, the major products of dienes 8a and 8b would result from monoadduct conformations corresponding to 12 by cyclization[15] or by direction of the second BH_3 molecule to the double bond face which is nearest to the BH_2 group. Cyclization appears unlikely, since monohydroboration products, such as 13a, can be isolated in good yields if these dienes are treated with equimolar BH_3-THF under conditions which give complete reaction with excess BH_3-THF. Furthermore, hydroboration-oxidation of 13a or hydroboration-oxidation-hydrogenolysis of 13b also yielded exclusively the *meso* diol 10b, in agreement with the directive effects of alcohol and ether substituents in hydroboration[16].

The synthesis and complexation properties of crown ethers derived from diols 2, 4, 9a, 10a and 10b will be reported shortly[17].

Acknowledgments. This work was supported by a grant from the National Science Foundation, GP 33533X. Professor D. J. Cram is warmly thanked for helpful discussions and encouragement in this research.

References and Notes

1. Current address: Cornell University, Department of Chemistry, Baker Laboratory, Ithaca, New York 14853 USA.
2. H. C. Brown, "Organic Syntheses via Boranes," John Wiley & Sons, New York, 1975, and references therein.
3. *Inter alia*, a) F. Fringuelli, V. Mancini and A. Taticchi, *Annali di Chimica* (Rome), **64**, 775 (1974); M. H. Gordon and M.J.T. Robinson, *Tetrahedron Lett.*, 3867 (1975); b) L. Brener and H. C. Brown, *J. Org. Chem.*, **42**, 2702 (1977); c) Y. Senda, S. Kamiyama and S. Imaizumi, *Tetrahedron*, **33**, 2933 (1977).
4. An additional example is apparently provided by *cyclic* hydroboration of 1-(2'-methylenecyclohexyl)-cyclohexene: A. Pelter, M. G. Hutchings and K. Smith, *J. Chem. Soc., Chem. Commun.*, 1048 (1971); A. Pelter, K. Smith, M. G. Hutchings and K. Rowe, *J. Chem. Soc., Perkin I*, 129 (1975).
5. F. Plénat, F. Pietrasanta, M. R. Darvich and H. Christol, *Bull. Soc. Chim. Fr.*, 2071 (1976).
6. H. C. Brown and C. D. Pfaffenberger, *J. Am. Chem. Soc.*, **89**, 5475 (1967).
7. N. L. Allinger and C. K. Riew, *J. Org. Chem.*, **40**, 1316 (1975).
8. M. S. Kharasch and P. O. Tawney, *J. Am. Chem. Soc.*, **63**, 2308 (1941); C. W. Jefford, R. McCreadie, P. Muller and J. Pfyffer, *J. Chem. Ed.*, **50**, 181 (1973).
9. E. J. Corey, R. L. Danheiser and S. Chandrasekaran, *J. Org. Chem.*, **41**, 260 (1976).
10. A.A.P. Schreibmann, *Tetrahedron Lett.*, 4271 (1970).
11. A. Butenandt and J. Schmidt-Thomé, *Ber.*, **71**, 1487 (1938); *idem*, *ibid.*, **72**, 182 (1939).
12. D. S. Greidinger and D. Ginsburg, *J. Org. Chem.*, **22**, 1406 (1957).
13. S. Hanessian, G.Y.-Chung, P. Lavallee and A.G. Pernet, *J. Am. Chem. Soc.*, **94**, 8929 (1972); S. Hanessian, P. Lavallee and A. G. Pernet, *Carbohydrate Research*, **26**, 258 (1973).
14. In this representation, the best planes of the six-membered rings are roughly perpendicular to one another, as suggested by examination of Corey-Pauling-Koltun molecular models.
15. For a review on cyclic hydroboration, see: H. C. Brown and E. Negishi, *Tetrahedron*, **33**, 2331 (1977).
16. *Inter alia*, H. C. Brown and M. K. Unni, *J. Am. Chem. Soc.*, **90**, 2902 (1968).
17. Microanalytical and spectral data were consistent with the proposed structures of all new compounds.

(Received in USA 1 May 1980)