CHEMISTRY LETTERS, pp. 797-798, 1990.

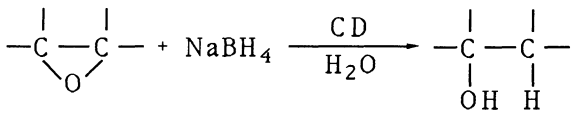
Selective Ring-opening Reaction of Epoxides with Sodium Borohydride in the Presence of Cyclodextrins in Aqueous Media

Ying HU, Mitsunari UNO, Akira HARADA,† and Shigetoshi TAKAHASHI*
The Institute of Scientific and Industrial Research,
Osaka University, Ibaraki, Osaka 567

In the presence of cyclodextrins, the ring-opening reaction of epoxides with $NaBH_4$ in aqueous media proceeded smoothly with high regio-selectivity, and kinetic resolution of racemic epoxides was observed.

Cyclodextrins(CDs), macrocyclic compounds consisting of α-1,4-linkaged D-glucopyranose, have attracted much attention because of the ability of forming inclusion complexes with a variety of organic compounds. We have been interested in a role of CDs as reaction vessels. When CDs are used as reaction vessels, we might expect that the environment surrounding the substrate will be changed greatly, especially in steric aspect. The steric control of reactions by CDs has been observed for the chlorination of anisole,[1] formylation of phenols,[2] reduction of ketones,[3] epoxidation of olefins,[4] and so on.

Previously we have reported the effect of CDs on the asymmetric epoxidation of olefins by using hydrogen peroxide.[4a] Here we wish to report the effects of CDs on the ring-opening reaction of epoxides by use of $NaBH_4$ in aqueous media.



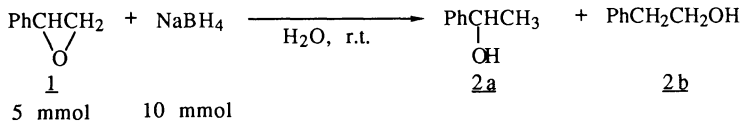
The ring-opening reaction of epoxides was carried out by stirring a mixture of epoxide, $NaBH_4$, and CD in water at room temperature. The results obtained for styrene oxide are shown in Table 1.

The effects of CDs on this reaction were found in three respects: Firstly, the ring-opening reaction of styrene oxide in aqueous media was remarkably accelerated, though $NaBH_4$ has been considered to be less effective for the ring-opening reaction of epoxides.[5] Secondly, the direction of ring-opening was changed, i.e. the product ratio of α-phenethyl alcohol 2a to β-isomer 2b was reversed as compared with that in the absence of CDs, and the main product of the reaction involving CDs was α-phenethyl alcohol. When the molar ratio between β-CD and styrene oxide was 2:1, α-phenethyl alcohol reached 94% selectivity.

† Present address: Department of Macromolecular Science, Faculty of Science, Osaka University, Toyonaka, Osaka 560.

Thirdly, kinetic resolution of racemic styrene oxide was observed. When β- or γ-CD was used, α-phenethyl alcohol was obtained with a majority of (S)-(-)-α-phenethyl alcohol, and recovered styrene oxide was rich in (S)-(-)-styrene oxide. Enantiomer excesses of produced α-phenethyl alcohol and recovered styrene oxide were 46 and 31%, respectively, when styrene oxide racemate and β-CD were used in the molar ratio of 1:2.

Table 1. Effects of CDs on the Ring-opening Reaction of Styrene Oxide



1 (5 mmol) 10 mmol 2a 2b

CD (mmol)	Time / h	Recovered 1		Product			
		Recovery / %	e.e.[a] / %	2a Yield/%	2a e.e.[a]/%	2b Yield/%	Selectivity of 2a /%
-	48	83	0	6	0	11	35
α-CD(1)[b]	48	45	0	31	0	23	57
β-CD(1)[b]	48	17	25(S)	66	15(S)	17	80
γ-CD(1)[b]	48	23	0	53	2(S)	24	68
β-CD(10)[c]	72	49	31(S)	48	46(S)	3	94

a) E.e. of styrene oxide and α-phenethyl alcohol were determined by HPLC (Chiracel OF) and specific rotatory power. b) H_2O, 2 mL. c) H_2O, 20 mL.

Besides styrene oxide, the ring-opening reaction of several epoxides was carried out successfully by the present method, and racemic 1,2-epoxyindane and 1,2-epoxy-3-phenylpropane were kinetically resolved to some extent during the reaction involving CD.

In comparison with the known processes[6] for the ring-opening reaction of epoxides using organic solvents and sensitive hydrides such as lithium aluminium hydride and diborane, the present method has the advantages of easy procedure, high regioselectivity, and high yield of ring-opening product, and provides a practical method applicable for organic synthesis. In addition, although the efficiency of kinetic resolution by CDs has not been satisfied yet, it has been suggested that CDs have fairly strong ability of recognizing asymmetric molecules.

References

1) R. Breslow and P. Campbell, *Bioorg. Chem.*, **1**, 140 (1971).
2) M. Komiyama and H. Hirai, *J. Am. Chem. Soc.*, **106**, 174 (1984).
3) H. Sakuraba, N. Inomata, and Y. Tanaka, *J. Org. Chem.*, **54**, 3482 (1989).
4) a) Y. Hu, A. Harada, and S. Takahashi, *Synth. Commun.*, **18**, 1607 (1988); b) S. Banfi, S. Colonna, and S. Julia, *ibid.*, **13**, 1049 (1983).
5) A. Ookawa, M. Kitamura, and K. Soai, *Heterocycles*, **27**, 213 (1988).
6) A. Hajos, *Complex Hydride*, Elsevier Scientific Publishing Co., Budapest, (1979); H. C. Brown and S. Krishnamurthy, *Tetrahedron*, **35**, 567 (1979).

(Received March 9, 1990)