CHEMISTRY LETTERS, pp. 645-648, 1976. Published by the Chemical Society of Japan

SYNTHESIS OF OPTICALLY ACTIVE METHYLOXIRANE FROM PROPYLENE CHLOROHYDRIN IN THE PRESENCE OF Co(SALEN) TYPE COMPLEX

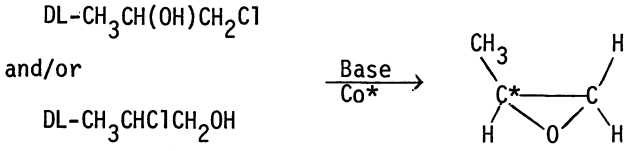
Michihiro ISHIMORI, Haruhiko AOI, Tsutomu TAKEICHI, and Teiji TSURUTA
Department of Synthetic Chemistry, Faculty of Engineering,
University of Tokyo, Bunkyo-ku, Tokyo 113

In the presence of optically active Co^{III} complex, methyloxirane was prepared from propylene chlorohydrin using a variety of bases. The highest optical purity of methyloxirane obtained was 27 %.

Optically active methyloxirane is usually prepared by the procedure explored by Levene and Walti,[1] which involves the microbiological reduction of hydroxyacetone to optically active propylene glycol by the reductase of yeast.

In a series of our studies using optically active Co(salen) type complexes, one-step synthesis of optically active methyloxirane from racemic propylene chlorohydrin was attempted. It has been reported that $Co^{II}(sal)_2$(R-CHXDA) complex, N,N'-bis(salicylaldehyde)-1(R),2(R)-1,2-trans-cyclohexanediiminatocobalt(II), is a low-spin square-planar complex having the λ-conformation of the central chelate ring.[2]

By use of a complex $[Co^{III}(sal)_2(R\text{-}CHXDA)]I$ as a chiral catalyst, prepared by the reaction of $Co^{II}(sal)_2$(R-CHXDA) with iodine,[3] synthesis of optically active methyloxirane was examined eliminating hydrogen chloride from racemic propylene chlorohydrin in combination with a variety of bases.



The results obtained with a commercial grade of propylene chlorohydrin having the ratio, 1-chloro-2-propanol/2-chloro-1-propanol≈7/3 (mol/mol), are summarized in Table 1. (S)(-)-Methyloxirane was preferentially formed with bases such as K_2CO_3, LiH, EtOLi, n-PrOLi, t-BuOLi, LiOH, and $Ba(OH)_2 \cdot 8H_2O$. The nature of bases used was shown to be one of the important factors for the selectivity in this asymmetric reaction. Among the bases examined, K_2CO_3 was found to be the most effective from the point of view of asymmetric selectivity. When the reactions were carried out with bases such as n-Bu_3N, $Mg(OH)_2$, MgO, and $ZnCO_3$ under similar conditions as in Table 1, no sign for formation of methyloxirane was detectable by vpc. The highly donating and polar solvent such as dimethyl sulfoxide[4] was found to be unfavorable for this asymmetric reaction, as demonstrated by

Table 1 Synthesis of Methyloxirane(MO) from Propylene Chlorohydrin(PCH)[a]

Base	Solvent	Time (day)	Conv.[c] (%)	MO/PCHcons[d] (%)	MO$[\alpha]_{589}^{20}$ [e] (°)
K_2CO_3	Dioxane	5	52	59	-1.44
	Dioxane/DMSO[b]	5	33	62	-0.69
LiH	Dioxane	6	36	82	-0.59
	Dioxane/DMSO[b]	3	44	86	-0.22
	DMSO	3	50	67	-0.09
MeOLi	Dioxane	4	34	83	0.00
EtOLi	Dioxane	4	43	82	-0.04
n-PrOLi	Dioxane	6	40	87	-0.04
t-BuOLi	Dioxane	4	26	82	-0.06
LiOH	Dioxane	4	40	41	-0.19
$Ba(OH)_2 \cdot 8H_2O$	Dioxane	6	36	69	-0.23

a) $[Co^{III}(sal)_2(R\text{-}CHXDA)]I$ 0.5 mmol, solvent 15 ml, PCH[1-chloro-2-propanol/2-chloro-1-propanol≈7/3 (mol/mol)] 60 mmol, base/PCH=1/2 (mol/mol); temp. 25°C. b) Dioxane/DMSO(dimethyl sulfoxide)=4 (v/v). c) PCH consumed/PCH initial x 100. d) MO produced (mol)/PCH consumed (mol) x 100. e) Specific rotation of MO formed, error ± 0.005°.

Table 2 Synthesis of Methyloxirane from 1-Chloro-2-propanol and from 2-Chloro-1-propanol[a]

Substrate	Co^{III} [b]	Base	Time (day)	Conv.[c] (%)	MO/PCHcons[d] (%)	MO$[\alpha]_{589}^{20}$ [e] (°)	PCH$[\alpha]_{589}^{20}$ [f] (°)
1-chloro-2-propanol	A	K_2CO_3	6	20.2	38	-1.39	-0.08
	B	K_2CO_3	6	24.9	83	-2.57	-0.76
	B	LiH	6	44.4	55	-0.01	(-)0.00
2-chloro-1-propanol	A	K_2CO_3	5	4.4	67	-0.55	+0.13
	B	K_2CO_3	6	14.7	53	-4.08	+0.61
	B	LiH	5	28.5	61	-0.11	+0.15

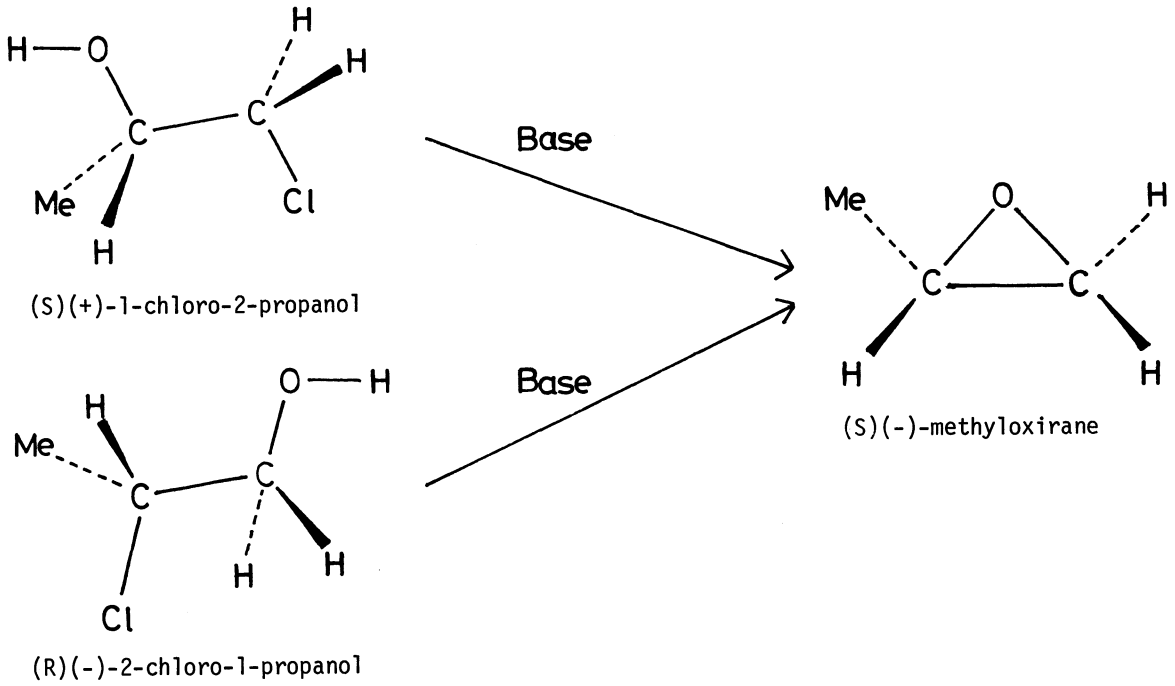
a) Co^{III} complex 0.5 mmol, dioxane 40 ml, PCH 120 mmol, base/PCH=1/2 (mol/mol); temp. 25°C. b) A: Prepared and purified in benzene according to Ref. 3. B: [Co^{III}]I (A) was further washed with 1-propanol. c), d), e) Descriptions as in Table 1. f) Specific rotation of unreacted PCH recovered (Obsd. in dioxane/m-xylene soln.).

the results with K_2CO_3 and with LiH.

In order to elucidate the features of this asymmetric reaction, pure DL-1-chloro-2-propanol and DL-2-chloro-1-propanol were each prepared by reducing chloroacetone and α-chloropropionic acid with $LiAlH_4$.[5] The reactions with 1-chloro-2-propanol and with 2-chloro-1-propanol as substrates are shown in Table 2. L(-)-methyloxirane was formed both from DL-1-chloro-2-propanol and from DL-2-chloro-1-propanol. The highest optical activity obtained in Table 2 is -4.08°, its optical purity being 27 % based on the optical rotation of pure R(+)-methyloxirane,[6] $[\alpha]_{589}^{20}$ + 15°.

On the other hand, the unchanged 1-chloro-2-propanol recovered showed (-) optical rotaion, while the unchanged 2-chloro-1-propanol gave (+) optical rotation. This may indicate that (S)(L)(+)-1-chloro-2-propanol is converted to (S)(L)(-)-methyloxirane where no asymmetric center is involved and that (R)(D)(-)-2-chloro-1-propanol to (S)(L)(-)-methyloxirane[7] with inversion of configuration at the asymmetric carbon atom. It has been established, as for stereochemistry of the oxirane formation from halohydrin, that cyclization takes place by back side attack of the alcoholate anion formed initially by the action of a base, at the carbon atom bearing the leaving halogen atom.[8] However, it is not clear whether this S_N2 mechanism holds completely in the above cobalt catalyzed asymmetric reactions, although the reaction seems to proceed by the inversion mechanism; the poor material balance, methyloxirane formed/propylene chlorohydrin consumed (mol/mol %) in Table 2, makes it difficult to discuss this problem more strictly.

A study of the mechanism involving the interaction of propylene chlorohydrin with the optically active cobalt complex is now in progress.



REFERENCES and NOTE

1. P.A. Levene and A. Walti, J. Biol. Chem., 68, 415 (1926).
2. a) H. Aoi, M. Ishimori, S. Yoshikawa, and T. Tsuruta, J. Organometal. Chem., 85, 241 (1975); b) H. Aoi, M. Ishimori, and T. Tsuruta, Bull. Chem. Soc. Japan, 48, 1897 (1975).
3. C. Floriani, M. Puppies, and F. Calderazzo, J. Organometal. Chem., 12, 209 (1968).
4. e.g., E.M. Arnett, "Progress in Physical Organic Chemistry", Vol. 1 , p.223, ed. by S.G. Cohen, A. Streitwieser, and R.W. Taft, John Wiley and Sons Inc., New York, 1963.
5. C.A. Stewart and C.A. VanderWerf, J. Amer. Chem. Soc., 76, 1259 (1951).
6. a) C.C. Price and M. Osgan, J. Amer. Chem. Soc., 78, 4787 (1956); cf. b) B. Franzus and N. Shieh, J. Org. Chem., 31, 4286 (1966).
7. The absolute configurations are based on the result that the ethyl ester of (R)(D)(-)-lactic acid is reduced to (R)(D)(-)-propylene glycol; a) P.A. Levene and H.L. Haller, J. Biol. Chem., 67, 329 (1926); b) E. Baer and H.O.L. Fischer, J. Amer. Chem. Soc., 70, 609 (1948) c) Ref. 6 b).
8. a) J.D. Bartlett, J. Amer. Chem. Soc., 57, 224 (1935); b) S. Winstein and H.J. Lucas, ibid., 1576 (1939).

(Received April 15, 1976)