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STEREOCHEMISTRY OF SOME "MIXED HYDRIDE" REDUCTIONS OF 1-PHENYLCYCLOPENTENE OXIDE

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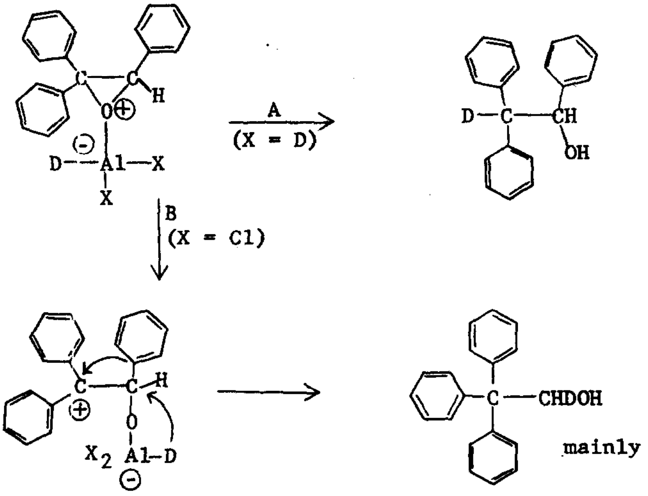
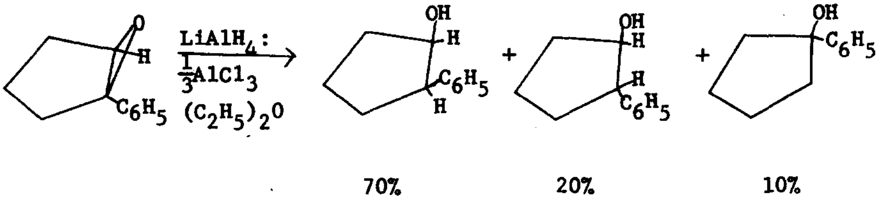
"Mixed hydride" reducing agents prepared from lithium aluminum hydride (LAH) and aluminum chloride in diethyl ether have been utilized by Eliel and coworkers (1-3) for the reduction of unsymmetrical epoxides, such as styrene oxide (1) and triphenylethylene oxide (2). Depending upon the ratios of LAH and aluminum chloride, different products were obtainable, as further elaborated by deuterium labeling. Ashby (4) has recently reported a thorough study of the mixed hydride reagents and concluded that the actual reducing species from $LiAlH_4:3AlCl_3$ and $LiAlH_4:\frac{1}{3}AlCl_3$ were $AlHCl_2$ and AlH_3, respectively. In addition, he proposed that these latter Lewis acids can initiate reduction of epoxides by attack on oxygen (4). The resulting complex could then collapse with intramolecular hydride transfer via a four-center transition state (A) or via a carbonium ion (B) when a stronger Lewis acid (and poorer hydride donor) was involved (e.g. $AlHCl_2$), in which case rearrangement could compete with reduction, as illustrated with triphenylethylene oxide and deuterium labeling.



The above scheme infers that reductive ring opening of unsymmetrical epoxides by LiAlH$_4$:$\frac{1}{3}$AlCl$_3$ proceeds at the most substituted carbon with overall *cis*-stereochemistry. However, Brown and Yoon^5 have recently shown that alane in *tetrahedrofuran*, and free of dissolved lithium salts, reduces styrene oxide mainly to 1-phenylethanol. Our present report deals with the steric course of ring opening by the "mixed hydride" reagent.

Some time ago (6) we had occasion to use LiAlD$_4$:$\frac{1}{3}$AlCl$_3$ for stereospecific deuteration via epoxide reduction and, as anticipated by the rationale below (6), found that the reaction proceeds mainly via <u>trans</u> stereochemistry, as illustrated below.



1-Phenylcyclopentene oxide (7), b.p. 123-125°/4mm, prepared by monoperphthalic acid epoxidation of 1-phenylcyclopentene (8), was reduced by excess $LiAlH_4:\frac{1}{3}AlCl_3$, using the procedure of Rerick and Eliel (2). Hydrolysis and work-up gave the three isomeric alcohols in the approximate ratios shown above. From alumina chromatography, a 60% yield of <u>cis</u>-2-phenylcyclopentanol (6), b.p. 113-115°/2mm, was obtained, which was shown to be free of 1-phenylcyclopentanol (8) and <u>trans</u>-2-phenylcyclopentanol (8) by v.p.c. (3 ft. "Tide" on Chromosorb P column).

Repetition of the above reduction of 1-phenylcyclopentene oxide (22 mmoles) with $LiAlD_4:\frac{1}{3}AlCl_3$ (42:14 mmole ratio) gave the above three alcohols, consisting of 80% <u>cis</u>-2-phenylcyclopentanol. The n.m.r. spectrum (in CCl_4 with internal TMS) of this deuterated product, obtained in 66% yield, showed $\gtrsim$ 0.8D at C_2 (by integration of the 2.75 p.p.m. benzylic proton signal) and $\lesssim$ 0.2D at C_1 (by integration of the 4.0 p.p.m. carbinol proton signal).

Thus it is clear that in the above reactions electrophilic catalysis by AlH_3 (or Li^+) causes epoxide opening predominantly at the more substituted carbon but that the hydride transfer is mainly intermolecular. Perhaps the intramolecular process depicted by Ashby (4) may be more dominant when alane is present in lower concentrations, thus slowing the competing bimolecular trans-opening of the alane-epoxide adduct. Solvent effects may also be important. These possibilities are presently being investigated.

Acknowledgement:

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