Intramolecular Delivery of a Water Equivalent in the Oxymercuration Reaction. Conversion of an Allylic Alcohol into a *cis*-Vicinal Diol

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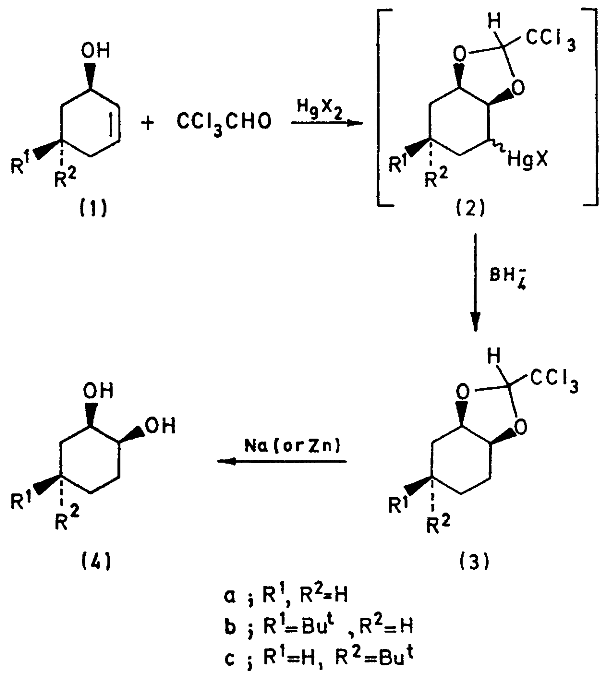
Summary A new directed synthesis of diols from unsaturated alcohols involving the oxymercuration-demercuration of hemiacetal intermediates is described.

Catalysis of a variety of hydrolytic reactions by the intervention of reversibly formed carbonyl addition intermediates is a well established process.[1] The utility of such intermediates as vehicles for achieving regio- and stereospecific synthetic reactions, however, has not been fully realized.[2] As part of a general programme exploring the synthetic value of such intermediates we have studied the intramolecular addition of the hemiacetal hydroxyl group to neighbouring double bonds. We report that in certain



Scheme

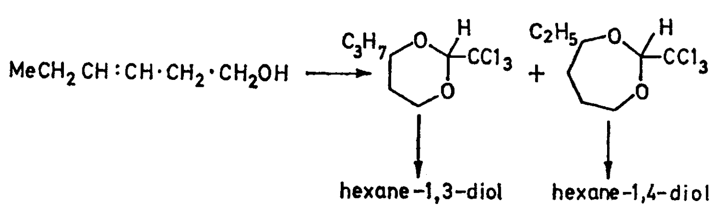
cases this process results in a highly regio-and stereospecific conversion of an allylic alcohol into a *cis*-1,2-diol.

This two-step approach is illustrated for cyclohex-2-en-1-ol derivatives in the Scheme. The cyclic chloral adducts are prepared by treatment of a mixture of the unsaturated alcohol (1 equiv.) and trichloroacetaldehyde (chloral) (2 equiv.) with mercuric trifluoroacetate[3] (1 equiv.) in dry THF at 25° for 24—60 hr, followed by *in situ* demercuration[4] with alkaline borohydride. By this procedure, (**3a**) (80%), b.p. 70—73° (0·1 mm), (**3b**) (92%), m.p. 91·5—92·5°, and the chloral acetal of 1-hydroxycyclohexanemethanol (90% from cyclohex-1-en-1-methanol), b.p. 95—96° (0·5 mm), have been prepared.† Although the trichloroacetal group is extremely stable to cleavage by acids,[5] it can be removed in essentially quantitative yield by (a) treatment under nitrogen with sodium dispersion (8 equiv.) in dry ether at 25° for 8—12 h, or (b) treatment with zinc dust (8 equiv.) in refluxing acetic acid for 12—24 h (the diacetate is usually isolated from this treatment).

The synthetic utility of this sequence is most evident for alcohols (**1a**) and (**1b**) which can be converted in overall yields of 79 and 88%, and > 99% isomeric purity, into the *cis*-1,2-diols (**4a**) and (**4b**) respectively. This is in marked contrast to the conventional oxymercuration–demercuration sequence which produces a mixture of all four possible diols in the case of (**1a**), and affords as the major product from both (**1a**)[6] and (**1b**)[7] the corresponding *trans*-1,3-diol. For the unsaturated cyclic alcohols investigated so far cyclization appears to be specific for the trichlorohemiacetals of equatorial allylic alcohols and fails completely with the axial allylic alcohol (**1c**) or the homoallylic alcohol, cyclohex-3-en-1-ol.

Little regiospecificity is observed when this two-step sequence is applied to acyclic unsaturated alcohols. For example *trans*-hex-2-en-1-ol is converted (79%) into a nearly equimolar mixture of 1,2- and 1,3-hexanediol. However, particularly striking is the large amount of hexane-1,4-diol which is ultimately produced from both *cis*- and *trans*-hex-3-en-1-ol (1,4/1,3 diol ratios = 0·82 and 2·1 respectively) and which apparently arises from kinetically controlled cyclization to form 7-membered as well as 6-membered ring cyclic adducts.‡ The apparent kinetic preference for cyclization of the *trans* isomer to form the 7-membered ring adduct is to our knowledge unprecedented.[8]

The success of this procedure with equatorial alcohols (**1a**) and (**1b**) undoubtedly derives from the fact that in aprotic solvents adduct formation between an olefin and mercuric trifluoroacetate is reversible.[3,9] Thus even if the kinetically preferred addition of a nucleophile occurs axially at C(3)[6,7] these adducts are formed reversibly and therefore, if thermodynamically favoured, intramolecular capture at C(2) can ultimately dominate. Consistent with this explanation is the observation that the n.m.r. spectrum of a mixture of (**1a**) (0·5M) and chloral (1·0M) shows a 45% decrease in the olefinic protons within one minute of the time the solution is made 0·5M in mercuric trifluoroacetate. However, adduct (**2a**) [characterized after reduction to



† All new compounds showed i.r. and n.m.r. spectra consistent with the indicated structures and correct combustion analysis. The chloral adducts are a mixture of epimers at the trichloromethyl-bearing carbon.

‡ Control experiments have established that the 7-membered cyclic acetal† is not formed during reductive demercuration by the reaction of hexane-1,4-diol and chloral (or chloral hydrate).

(**3a**)] builds up much more slowly reaching a maximum only after 60 h. Further investigations of the mechanism of this reaction are in progress.

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