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A NOVEL CYCLOPROPANOL FORMATION

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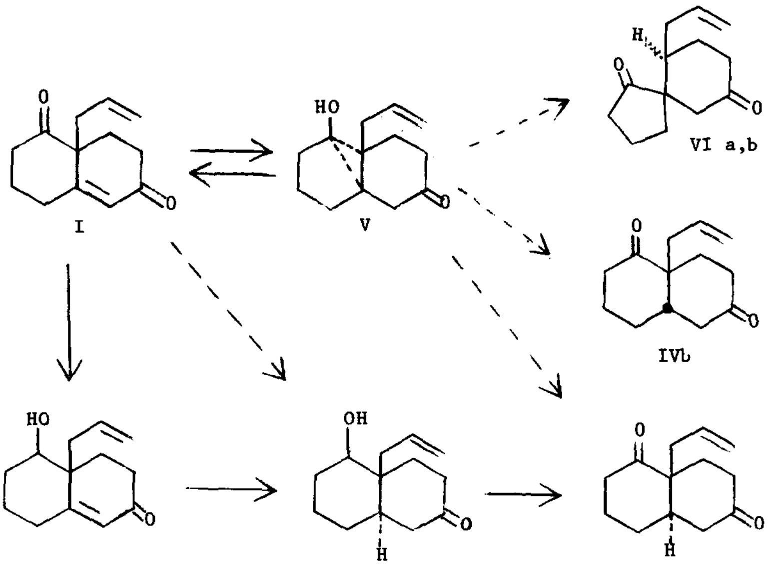
Reduction of unsaturated functions by alkali metal in liquid ammonia solutions is a widely used synthetic method,[1,2] and the large body of data regarding these reactions is in substantial agreement with currently accepted mechanistic rationalizations.[3] In this communication we report an unexpected transformation of the enedione I which represents a new diversion in enone reductions.

Allylation of dihydroresorcinol followed by Michael addition of methyl vinyl ketone yielded a monocyclic triketone which was cyclized to I, mp 61.5-62.5, by the action of pyrrolidine. The structure of I was supported by its analysis, infrared spectrum (ν_{max} 1705, 1670, 1640, 1615, 980, 925 cm^{-1}), ultraviolet absorption ($\lambda_{max}^{C_2H_5OH}$ 248 mμ, log ε 4.06) and nmr spectrum (1H multiplet τ 4.18, 3H multiplet ca τ 4.8, 12H multiplet τ 7.1-8.0).



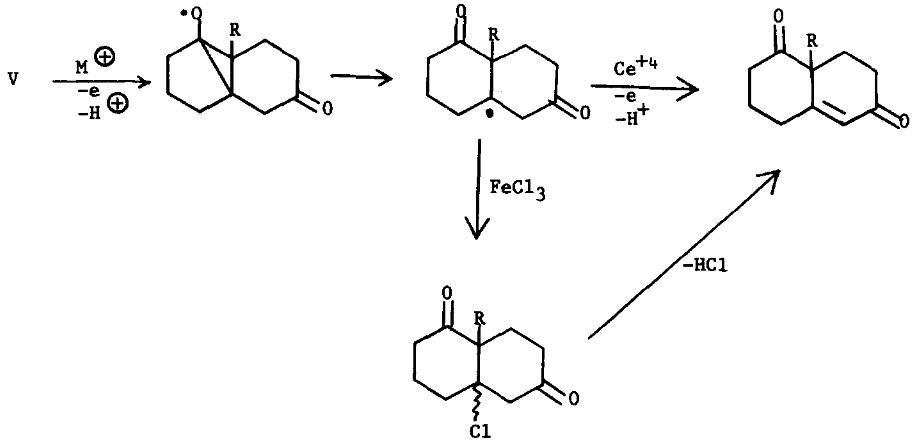
Reduction of I by a solution of lithium in ammonia and ether yielded a ketol, mp 86-87°, believed at first to be II. Attempts to prepare a benzyl ether or ethylenedioxy ketal derivative from this ketol were, however, frustrated by its facile conversion to unknown dicarbonyl compounds. Authentic II was then prepared by a two step sequence: treatment of I with $NaBH_4$ gave the unsaturated ketol III which was reduced to II by the action of lithium in ammonia - THF. Although II proved to be a liquid and did not yield crystalline derivatives, its purity and identity were established by TLC and absorption spectroscopy (C=O: ν_{max} 1700 cm^{-1}; $\gt$CHOH: ν 3450 cm^{-1}, 2H multiplet ca. τ 6.80 changing to a 1H multiplet at τ 6.75 upon washing with D_2O; $-CH=CH_2$: ν_{max} 1615, 980 and 910 cm^{-1}, 3H multiplet τ 4.85-5.12).

Since the ketol (mp 87°) obtained from the reduction of I was clearly not II, we extended our investigation and now report evidence supporting the novel cyclopropanol structure V for this compound. A $C_{13}H_{18}O_2$ composition for V is indicated by analysis, and the relative abundance of the isotope peaks related to the molecular ion (m/e = 206) in the mass spectrum. Absorptions at 3590, 1705, 1640, 985 and 920 cm^{-1} in the infrared require the presence of a saturated unstrained ketone function, a hydroxyl group and a vinyl group. The latter two functions are also characterized by a broad one proton singlet at τ 5.85 (rapidly washed out by D_2O) and a complex three proton multiplet at τ 4.0-5.2 in the nmr. The remaining part of the nmr spectrum is crowded into the τ 7.6-8.2 region and does not lend itself to facile interpretation. It is significant that no absorption (other than OH) occurs from τ 5.8-6.9 where one expects to find $H-\overset{|}{\underset{|}{C}}-O-$.

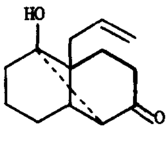
The three membered ring of cyclopropanols is known to be cleaved by the action of acids or bases,[4] and from these reports the stereoisomeric pairs of diketones IVa,b and VIa,b were anticipated as possible products from V. Since authentic IVa, mp 78-79°, ν_{max} 1705 cm^{-1}, could be prepared by $CrO_3\cdot$ pyridine oxidation of II, we hoped to effect a correlation with V in this manner. However, the products of acid and base treatment of V proved to be isomeric diketones, the infrared spectra of which (ν_{max} 1740 and 1710 cm^{-1}) suggest membership in the spiro[4.5]decane system (VIa,b). Although this kind of transformation is readily accomodated by the cyclopropanol structure (V), it does not accomplish the desired correlation with a known compound.

In contrast to other 3°-alcohols, cyclopropanols are easily oxidized by certain metal cations (eg Fe^{III} and Ce^{IV}).[5] This reaction has been successfully applied to V (eq. 1). Aqueous ferric chloride converts V to an unstable chloro derivative (ν_{max} 1705 cm^{-1}) which loses hydrogen chloride on warming to give I in 70% yield. Although V readily reduces aqueous ceric sulfate suspensions, the reaction with ethereal ceric nitrate is cleaner and also leads to I.

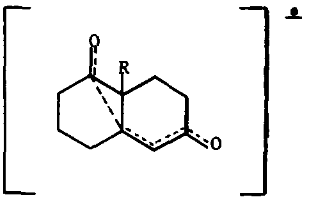
(1)



The evidence presented above confirms structure V for the reduction product from I. The isomeric cyclobutanol structure (VII) cannot reasonably account for the formation of five-membered ring ketones on acid or base treatment of this compound. Oxidation of VII to I is also unlikely.



VII



VIII

The reaction described in this communication appears to be another example[6] of intramolecular electrophilic attack at the β-carbon atom of an enone radical anion (or dianion); although, a discrete homoallylic radical anion intermediate (VIII) cannot be ruled out.

Conflicting reports concerning the reduction of 1,6-dioxo-8a-methyl-1,2,3,4,6,7,8,8a-octahydronaphthalene have been made,[7,8] but in our hands this compound has yielded an equivalent cyclopropanol species.

References

(1) H. O. House, "Modern Synthetic Reactions", W. A. Benjamin Inc., New York, 1965.

(2) H. Smith, "Organic Reactions in Liquid Ammonia, Chemistry in Non-aqueous Ionizing Solvents", Vol. 1, part 2, Wiley, New York, 1963.

(3) G. Stork and S. D. Darling, *J. Am. Chem. Soc.*, **86**, 1761 (1964).

(4) C. H. DePuy, *Acct. Chem. Res.*, **1**, 33 (1968).

(5) S. E. Schaafsma, H. Steinberg and Th. J. DeBoer, *Rec. Trav. Chim.*, **85**, 73 (1966).

(6) G. Stork, P. Rosen, N. Goldman, R. V. Coombs and J. Tsuji, *J. Am. Chem. Soc.*, **87**, 275 (1965).

(7) V. Prelog and D. Zäch, *Helv. Chim. Acta*, **42**, 1862 (1959).

(8) C. Boyce and J. Whitehurst, *J. Chem. Soc.*, 2680 (1960).

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