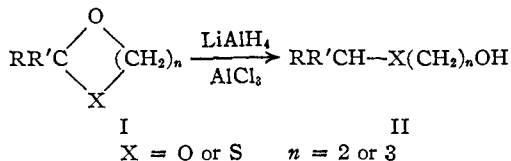


A NEW SYNTHESIS OF HYDROXYETHERS AND THIOETHERS

Sir:

In a previous communication¹ we described the reduction of acetals and ketals to ethers by means of lithium aluminum hydride-aluminum chloride. We now have extended this method to cyclic acetals and ketals and the corresponding hemithioacetals and hemithioketals. The cyclic oxygen derivatives (eq. X = O) are reduced to hydroxyethers. In the case of the sulfur derivatives (X =



S), the reductive cleavage involves largely, if not entirely, the carbon-oxygen bond, the carbon-sulfur-carbon bond being intact in the product. Thus this reduction constitutes a convenient method for synthesizing thioethers starting with aldehydes and ketones. The resulting thioethers contain a second functional group (hydroxyl) which is obviously capable of further chemical transformations.

Examples so far studied involve ethylene and trimethylene derivatives (eq., $n = 2$ or 3). Below are listed the aldehydes and ketones and the glycols or hydroxymercaptans from which the starting materials (I) were prepared and the yields in the reduction of I to the products II: cyclohexanone, ethylene glycol, 88%; cyclohexanone, trimethylene glycol, 89%; benzaldehyde, ethylene glycol, 89%; benzaldehyde, trimethylene glycol, 83%; cyclohexanone, mercaptoethanol, 91%; cyclohexanone, 3-mercapto-1-propanol, 91%; benzaldehyde, mercaptoethanol, 88%; benzaldehyde, 3-mercapto-1-propanol, 98%. All intermediates and products, where described in the literature, agreed in properties with those previously reported and, where new, had the correct carbon and hydrogen content. Moreover, the infrared spectra of all the reduction products were identical with those of authentic samples prepared (sometimes tediously) by the Williamson synthesis.

The method does not appear to be limited to hemithioketals of type I. For example, we have reduced 2-benzylthiotetrahydropyran, the addition product of dihydropyran and benzyl mercaptan, to 5-benzylthio-1-pentanol, $\text{HO(CH}_2\text{)}_5\text{SCH}_2\text{C}_6\text{H}_5$, in 58% yield.

The synthesis of 2-(cyclohexylthio)-ethanol is described as a typical example of the new method. In a 500-ml. three-necked flask equipped with a calcium chloride-protected reflux condenser, a sealed stirrer and a pressure-equalized addition funnel was placed 13.3 g. (0.1 mole) of aluminum chloride. The flask was cooled in an ice-bath for 0.5 hour and 100 ml. of sodium-dried ether was added slowly to dissolve the aluminum chloride, then 22.8 ml. (0.025 mole) of a 1.1M ethereal lithium aluminum hydride solution. After stirring for 0.5 hour, 7.9 g. (0.05 mole) of 1-oxa-4-

thiaspiro[4.5]decane² (cyclohexanone-mercaptoethanol hemithioacetal) dissolved in 100 ml. sodium-dried ether was added slowly to the cooled "mixed hydride" solution. Stirring was continued for 2 hours (temperature control at this stage is not essential). A total of 100 ml. of 10% sulfuric acid then was added to the cooled reaction mixture, dropwise at first. The layers were separated and the aqueous layer extracted with three 50-ml. portions of ether. The combined ether layers were dried, concentrated and the residue distilled to give 7.29 g. (91.1%) of 2-(cyclohexylthio)-ethanol, b.p. 84° (0.3 mm.), n_{D}^{25} 1.5128 (lit.³ b.p. 140° (18 mm.)) identical in infrared spectrum with a sample prepared from cyclohexyl mercaptan and ethylene oxide.

This research was supported by a grant from The Petroleum Research Fund administered by the American Chemical Society. Grateful acknowledgment is hereby made to the donors of this fund.

(2) C. Djerassi and M. Gorman, *THIS JOURNAL*, **75**, 3704 (1953).

(3) M. Mousseron, R. Jacquier, M. Mousseron-Canet and R. Zagdoun, *Bull. soc. chim. France*, 1042 (1952).

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF NOTRE DAME
NOTRE DAME, INDIANA

ERNEST L. ELIEL

VICTOR G. BADDING

RECEIVED OCTOBER 5, 1959

ULTRAVIOLET LIGHT INDUCED TRANSFORMATION OF α -TROPOLONE¹

Sir:

Upon irradiation, colchicine (a methyl ether of a substituted α -tropolone)² and γ -tropolone methyl ether³ are transformed into valence tautomeric structures of the 3,2,0-bicycloheptadiene type. It has now been found that when α -tropolone is irradiated with ultraviolet light from a G. E. quartz mercury arc in aqueous solution, a 50% yield of a crude acid is obtained from which the pure 4-oxo-2-cyclopentene-1-acetic acid (I), m.p. 100.6–101.6°, $\epsilon_{\text{max}}^{218}$ 12,000, ν_{max} 1710 cm^{-1} ,⁴ can be obtained in 16% yield.

The spectral properties of I suggest the presence of either an unsubstituted cyclopentenone or an α,β -unsaturated acid chromophore. The former was shown to be present since I upon hydrogenation yielded a dihydro derivative (molecular distillation b.p. 100° (0.5 mm.), semicarbazone m.p. 203.0–203.4°) which in the infrared possessed bands at 1720 and 1740 cm^{-1} , characteristic of a carboxyl and a cyclopentanone group. The dihydro material upon Wolff-Kishner reduction yielded cyclopentaneacetic acid (*p*-bromophenacyl ester, m.p. 85.2–86.0°) which was identical with an authentic sample.

The carbonyl group of the dihydro derivative of the irradiation product was placed at C-3 on the cyclopentane nucleus by comparison with authentic samples of 2-oxo⁵ and 3-oxocyclopentane-1-acetic

(1) This work was supported in part by Grant No. A-709 (C6) B10, U. S. Public Health Service.

(2) E. J. Forbes, *J. Chem. Soc.*, 3864 (1955); P. D. Gardner, R. L. Brandon and G. R. Haynes, *THIS JOURNAL*, **79**, 6334 (1957).

(3) O. L. Chapman and D. J. Pasto, *ibid.*, **80**, 6685 (1958).

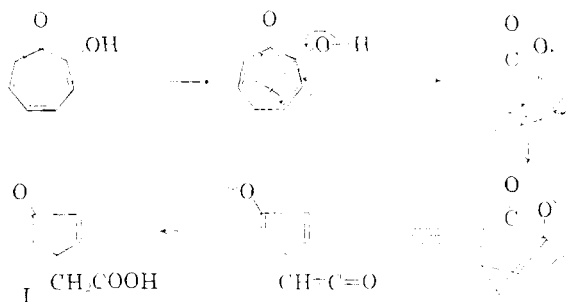
(4) The elemental analyses for all materials discussed are in agreement with theory.

(5) R. P. Linstead and E. M. Meade, *J. Chem. Soc.*, 940 (1934).

(1) E. L. Eliel and M. Rerick, *J. Org. Chem.*, **23**, 1088 (1958).

acids. The latter acid has been reported by Farmer⁶ (semicarbazone, m.p. 199°) but the material employed in the present study was prepared by Arndt-Eistert chain elongation of 3-oxocyclopentane-1-carboxylic acid.⁷ The infrared spectrum of the 2-oxo-derivative possessed bands at 1010 and 1118 cm.⁻¹ not shown by the 3-oxo-isomer and the spectrum of the dihydro irradiation material was identical with that of the 3-oxo-derivative. Furthermore, the semicarbazones of the dihydro material and the 3-oxo-isomer melt at 203.0–203.4° and show no depression upon admixture while the same derivative of the 2-oxo-isomer melts at 192.0–192.4° and upon admixture with either of the foregoing materials shows a m.p. depression. With the placement of the carbonyl group at C-3, in respect to the acetic acid side-chain, it follows that in the original irradiation product the only position for the olefinic linkage which gives rise to an unsubstituted cyclopentenone chromophore is between C-4 and C-5, thus forming structure I.

The formation of this material is viewed (shown below) as proceeding via an initial "photo" product of the 3,2,0-bicycloheptadiene type. In line with this postulate of a ketene intermediate, it is found that when α -tropolone is irradiated in ethanol, the ethyl ester of I is obtained.



(6) E. H. Farmer, *J. Chem. Soc.*, **123**, 3324 (1923).

(7) E. Hope, *ibid.*, 892 (1912); kindly supplied by Professor D. S. Noyce.

(8) National Science Foundation Predoctoral Fellow, 1959–1960.

(9) National Science Foundation Predoctoral Fellow, 1958–1959.

DEPARTMENT OF CHEMISTRY UNIVERSITY OF CALIFORNIA BERKELEY 4, CALIFORNIA

WILLIAM G. DAUBEN
KAY KOCH⁸
WILLIAM E. THIESSEN⁹

RECEIVED SEPTEMBER 8, 1959

PARTHENIN, A NEW GUAIANOLIDE

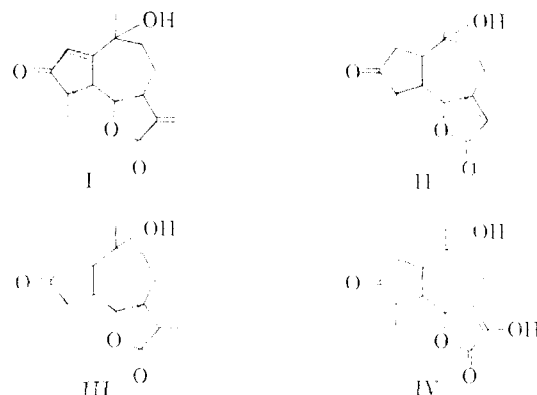
Sir:

The structure of parthenin,¹ the bitter principle of *Parthenium hysterophorus* L., may be represented as I.

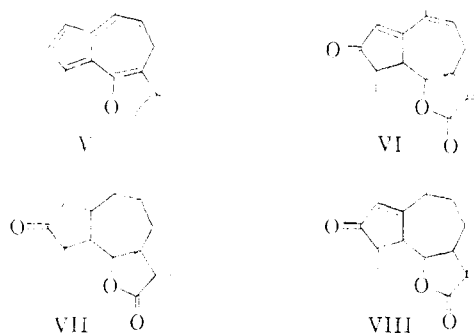
Parthenin, isolated in 0.14% yield, has the formula C₁₅H₁₈O₄, mol. wt. (Rast) 270, (C, 68.80; H, 7.13) m.p. 163–166°, [α]_D²⁵ + 7.02°, infrared bands (CHCl₃) at 3450 (–OH), 1755 and 1658 (α,β -unsaturated γ -lactone), 1718 and 1592 cm.⁻¹ (cyclopentenone), λ_{\max} (ethanol) 215 and 340 m μ (ϵ 15100 and 22). Catalytic hydrogenation gave dihydroparthenin (II, C, 68.24; H, 7.24), m.p. 142–144°, [α] + 16.6, infrared bands at 3450 (–OH), 1745 (combination of conjugated lactone

(1) H. V. Arny, *J. Pharm.*, 121 (1890); 169 (1897)

and cyclopentanone) and 1668 cm.⁻¹ (strong, conjugated C=C), λ_{\max} 220 and 261 m μ (ϵ 14000 and 70), and tetrahydroparthenin (III, C, 67.44; H, 8.26), m.p. 140–144°, [α] + 78.4, infrared bands at 3450 and (in acetonitrile) 1760 (γ -lactone) and 1742 cm.⁻¹ (cyclopentanone), λ_{\max} 277 m μ (ϵ 71).²



That the methylene group is conjugated with the lactone carbonyl is shown by the spectra, the preparation of a pyrazoline,³ a comparison of the C-methyl values of I and III and low temperature ozonolysis which resulted in formaldehyde and a compound C₁₄H₁₆O₄ (IV, C, 63.62; H, 5.88). Lithium aluminum hydride reduction of parthenin followed by dehydrogenation over palladium charcoal gave artemazulene (V). This determines the carbon skeleton and the point of attachment of the lactone ring.



The hydroxyl group is tertiary (resistance of I to chromic acid oxidation and acetylation). Its placement at C₁₀ of the guaianolide skeleton is dictated, *inter alia*, by the results of periodate titration of II and III (negative in neutral and alkaline solution) and dehydration of parthenin with formic acid which led to a dienone (VI, C, 74.08; H, 6.74), m.p. 125–126°, infrared bands at 1758, 1700, 1650 and 1550 cm.⁻¹, λ_{\max} 210 and 296 m μ (ϵ 14300 and 12500).

The cyclopentanone carbonyl is placed at C₂ as in helenalin,⁴ tenulin⁵ and baldulin.⁶ None of

(2) Cf. the hydrogenation of ambrosin L. Bernardi and G. Büchi, *Experientia*, **13**, 466 (1957); F. Šorm, M. Suchý and V. Herout, *Coll. Czechoslov. Chem. Commun.*, **24**, 1548 (1959).

(3) P. G. Deuel and T. A. Geissman, *THIS JOURNAL*, **79**, 3778 (1957).

(4) G. Büchi and D. Rosenthal, *ibid.*, **78**, 3860 (1956).

(5) D. H. R. Barton and P. de Mayo, *J. Chem. Soc.*, 142 (1956); C. Djerassi, J. Osiecki and W. Herz, *J. Org. Chem.*, **22**, 1361 (1957); W. Herz and R. B. Mitra, *THIS JOURNAL*, **80**, 4876 (1958).

(6) W. Herz, R. B. Mitra and P. Jayaraman, *ibid.*, **81**, 6061 (1959).