was dried over sodium hydroxide and distilled under reduced pressure.

All of the fluoroisoquinolines and 1-hydroxyisoquinoline were prepared in this Laboratory[7] and were redistilled until the absorption spectra of successive distillates were identical.

Acknowledgment.—This work is part of a study of the preparation and properties of heterocyclic fluorine compounds being carried out in this laboratory, and was supported in part by the Office of Naval Research, Contract No. N8onr-69900.

(7) A. Roe and C. E. Teague, THIS JOURNAL, **73**, 687 (1951).

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C. RECEIVED JUNE 29, 1951

Sterols of Algae. III.[1] The Occurrence of Ergosterol in *Chlorella pyranoidosa*[2]

BY MARYLIN KLOSTY AND WERNER BERGMANN

It was reported in the first communication of this series,[3] that chondrillasterol is the principal sterol of the green alga, *Scenedesmus obliquus*. This sterol is of special interest because it is a $\Delta^{7,22}$-diene-3-ol and therefore potentially suitable for conversion into cortisone by methods now being investigated in several laboratories. The amount of chondrillasterol obtainable from *Scenedesmus*, however, appears too small to be of practical significance at this time. The studies on algae sterols have now been extended to other primitive algae of the class of *Chlorophyceae*, and in particular to those, whose commercial cultivation is contemplated by several organizations.

Through the courtesy of the Lederle Laboratories Division[4] the authors obtained several pounds of freeze-dried cells of a pure culture of the green alga, *Chlorella pyranoidosa*. Upon acetone extraction, the algae yielded 12.5% of lipoid material, of which 10% was unsaponifiable. The sterol content of the unsaponifiable fraction was approximately 20%, corresponding to 0.15–0.2% of the dry alga. A more efficient extraction was achieved when the cells were first triturated with warm glacial acetic acid and then exhaustively extracted with acetone. Cells so treated yielded a lipoid and sterol fraction corresponding, respectively, to 20 and 0.4%. The sterols were isolated from the unsaponifiable fraction either by precipitation with digitonine, by direct crystallization or better by way of their benzoates. The high negative rotation and the ultraviolet absorption spectra of the crude fractions indicated the presence of $\Delta^{5,7}$-sterols in excess of 75% of the mixture. Repeated recrystallizations of the benzoates eventually afforded ergosteryl benzoate, m.p. 169°; $[\alpha]^{25}D$ −72°. It was converted to ergosterol, m. p. 164°; $[\alpha]^{25}D$ −128°, and ergosteryl acetate, m.p. 176°; $[\alpha]^{25}D$ −88°.

Chlorella pyranoidosa appears to be the first organism other than fungi and lichens in which ergosterol has been shown to be the principal sterol.[5] As a minor component, 0.1–5%, ergosterol has been found in the sterol mixtures from cocksfoot,[6] cottonseed oil,[7] scopolia root oil[7] and wheat germ oil.[8] More substantial amounts of ergosterol have been found in the sterol mixtures from certain animals,[9] in particular invertebrates.[10]

Experimental

The following extraction procedure was found to be the most efficient. Fifty grams of freeze-dried cells of *Chlorella pyranoidosa*, which contained about 10% of moisture, was heated for one hour at 70° with 100 ml. of glacial acetic acid. The acid was then removed by freeze-drying, and the residue ground, and extracted in a Soxhlet apparatus with acetone for 24 hours. The extract was filtered to remove some amorphous, gray solid (1.5 g.), and the solvent was removed first by distillation and finally by freeze-drying. The extract thus obtained, 10 g., was saponified under nitrogen with 45 g. of a 20% solution of potassium hydroxide in 80% ethanol. After 24 hours 150 ml. of water was added, and the solution extracted seven times with 100-ml. portions of peroxide-free ether. The combined ether layers were washed with water and concentrated under nitrogen. After freeze-drying, the residue weighed 1.5 g. The sterol content of the residue, as determined by the digitonide method, was 13.4%, corresponding to 0.4% of the algae.

The unsaponifiable fraction obtained from several hundred grams of algae was dissolved in a minimum amount of boiling methanol. Upon cooling a waxy, crystalline material was obtained in a yield of 23%. It was dissolved in anhydrous pyridine and treated with an excess of benzoyl chloride for 24 hours at room temperature. The mixture was then poured into methanol, and the precipitate, m.p. 144–156°, recrystallized from ether–methanol; yield 11% of unsaponifiable fraction; m.p. 156–162°; $[\alpha]^{25}D$ −58. Several recrystallizations from dioxane–methanol and ethyl acetate afforded ergosteryl benzoate, m.p. 169°; $[\alpha]^{25}D$ −72° in chloroform. The ultraviolet absorption spectra indicated a purity in excess of 95%.

Anal. Calcd. for $C_{35}H_{44}O_2$: C, 84.00; H, 9.60. Found: C, 83.75; H, 9.93.

The benzoate was refluxed for one hour with a 3% solution of potassium hydroxide in ethanol in an atmosphere of nitrogen. The solution was then diluted with water, and the precipitated ergosterol was recrystallized several times from acetone and ethyl acetate, m.p. 162°; $[\alpha]^{25}D$ −128° (chloroform). Acetylation by reflux with acetic anhydride afforded ergosteryl acetate, m.p. 176°; $[\alpha]^{25}D$ −92° (chloroform). None of the products gave depressions of melting points when mixed with authentic material.

(1) Paper II, THIS JOURNAL, **73**, 2395 (1951).

(2) This investigation was supported by a research grant from the National Institute of Health, Public Health Service.

(3) W. Bergmann and R. J. Feeney, *J. Org. Chem.*, **15**, 812 (1950).

(4) American Cyanamid Co., Pearl River, New York.

(5) The statement made in Elsevier's "Encyclopaedia of Organic Chemistry," Vol. **14**, 69 (1940), that ergosterol is present in the brown alga, *Fucus crispus*, is in error. It is based on a brief note by Gérard (*Compt. rend.*, **126**, 909 (1898)) which states that the sterol of *Fucus* gives color reactions reminiscent of those shown by sterols from cryptogams. Since then it has been shown that fucosterol is the principal sterol of this alga.

(6) A. Pollard, *Biochem. J.*, **30**, 382 (1936).

(7) A. Windaus and F. Bock, *Z. physiol. Chem.*, **250**, 258 (1937).

(8) A. Windaus and F. Bock, *ibid.*, **256**, 47 (1938).

(9) A. Windaus and O. Stange, *ibid.*, **244**, 218 (1936)

(10) F. Bock and F. Wetter, *ibid.*, **256**, 33 (1938).

STERLING CHEMISTRY LABORATORY
YALE UNIVERSITY
NEW HAVEN, CONNECTICUT RECEIVED NOVEMBER 29, 1951

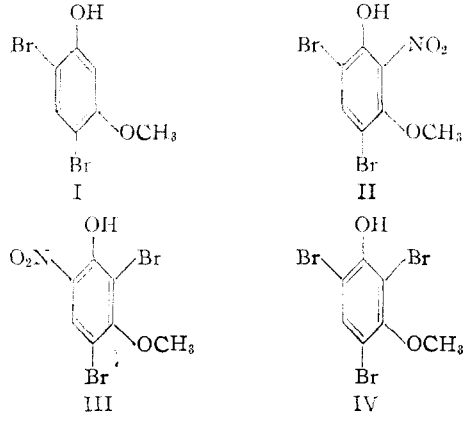
[FROM THE CHEMICAL LABORATORY OF THE ACADEMY OF COMMERCE IN VIENNA]

Bromination of Resorcinol Monomethyl Ether and Debromination of Tribromoresorcinol Monomethyl Ether

BY MORITZ KOHN

The bromination of resorcinol monomethyl ether with two molecules of bromine yields a crys-

talline dibromo product which must be 1-hydroxy-3-methoxy-4,6-dibromobenzene (I), since its methylation yields 4,6-dibromoresorcinol dimethyl ether.[1] The nitration of I yields a nitrodibromoresorcinol monomethyl ether, which according to the method of preparation should be 1-hydroxy-2-nitro-3-methoxy-4,6-dibromobenzene (II). The m.p. of this substance is, however, very close to the melting point of the isomeric 1-hydroxy-3-methoxy-2,4-dibromo-6-nitrobenzene (III) reported by Kohn and Loeff.[2,3] The nitration of purest 2,4,6-tribromoresorcinol monomethyl ether (IV) produces an identical substance. Therefore in the nitration of I a migration of the bromine atom from



position 6 into position 2 takes place. A similar rearrangement was observed by Hodgson and Dyson[4] who found that the nitration of the 3-monobenzoate of 4,6-dibromoresorcinol leads to the 2,4-dibromo-6-nitroresorcinolmonobenzoate.

Reduction of tribromoresorcinol monomethyl ether (IV) with zinc dust and acetic acid removes the bromine atom between the OH– and the OCH_3– group forming I. Thus the reduction of IV proceeds in the same way as the reduction of 2,4,6-tribromoresorcinol, whereby 4,6-dibromoresorcinol[5] is formed.

Experimental

4,6-Dibromoresorcinol Monomethyl Ether (I).—Resorcinol monomethyl ether (19.5 g.) is dissolved in 60 cc. of chloroform, the mixture cooled in an ice-bath and a cooled solution of 16 cc. of bromine in 60 cc. of chloroform is slowly added through a dropping funnel with continuous stirring. After 6 hours the chloroform is evaporated on a steam-bath. The residue is triturated with low boiling petroleum ether and the solid is collected (31 g.). After removal of the petroleum ether by evaporation an oily residue is obtained (about 10 g.). This oil yields by bromination in glacial acetic acid tribromoresorcinol monomethyl ether (IV) (10 g., m.p. 105° after recrystallization).

By recrystallization of 10 g. of the crude dibromoether from petroleum ether 6 g. of the pure substance is obtained; colorless prisms, m.p. 73–75°.

Anal. Calcd. for $C_7H_6O_2Br_2$: Br, 56.73. Found: Br, 56.65.

The substance is very difficultly soluble in boiling water, more easily when diluted with alcohol or methanol. Its methylation yields 4,6-dibromoresorcinol dimethyl ether,[1] m.p. 141–143°.

1-Hydroxy-3-methoxy-2,4-dibromo-6-nitrobenzene (III).—One and nine-tenths grams of I is dissolved in 15 cc. of glacial acetic acid and to this cooled solution a cooled mixture of 1.5 cc. of nitric acid in 10 cc. of glacial acetic acid is added. The liquid is kept in an ice-bath until the color turns light brown-yellow and is afterwards poured on 500 g. of ice. The solution is stirred until the oily precipitation solidifies. The crude product is collected, converted with potassium hydroxide into its red potassium salt, which is collected (1.4 g.) and then decomposed by diluted sulfuric acid. The yellow nitro product is recrystallized from alcohol; prisms, m.p. 123–126°.

Anal. Calcd. for $C_7H_5O_4NBr_2$: N, 4.29. Found: N, 4.03.

The m.p. of a sample prepared according to Kohn and Loeff[2] was 125–127°, its mixed m.p. with III prepared from I gives no depression.

Debromination of the tribromoresorcinol monomethyl ether (IV) is accomplished by dissolving 5 g. of IV in 10 cc. of glacial acetic acid and 10 cc. of water and boiling with 5 g. of zinc dust for 12 minutes. The mixture is cooled, filtered and the filtrate precipitated by the addition of ice-water (3 g.). The crude product is recrystallized from petroleum ether and washed with benzine, m.p. 72–74°. The m.p. of a mixture of this substance and the product of the bromination of resorcinol monomethyl ether is not depressed. The methylation of this substance yields 4,6-dibromoresorcinol dimethyl ether, m.p. 141–143°.[1]

536 WEST 113 ST.
NEW YORK 25, N. Y.

RECEIVED JULY 6, 1951

(1) M. Kohn and G. Loeff, *Monatsh.*, **45**, 590 (1924).
(2) M. Kohn and G. Loeff, *ibid.*, **45**, 594 (1924).
(3) L. Raiford and J. H. Scott, *J. Org. Chem.*, **2**, 213 (1937).
(4) H. Hodgson and R. C. Dyson *J. Chem. Soc.*, 946 (1935).
(5) M. Kohn and L. Steiner, *J. Org. Chem.*, **12**, 30 (1947).

Ultrasonic Velocity in Some Alkyl Aryl Ketones

BY R. T. LAGEMANN,[1] B. F. LANDRUM,[2] C. T. LESTER, O. MILNER AND E. G. MCLEROY

The results to be described represent further efforts to find what relationships exist between molecular structure and the velocity of ultrasonic waves in liquids. Previous work has been reviewed by several writers,[3–5] including a recent paper by two of the present authors.[6]

The fifteen alkyl aryl ketones investigated are listed in Table I. An examination of Table I shows that increase in molecular weight is accompanied by a decrease in ultrasonic velocity within the limits of this series. When increase in molecular weight is accompanied by chain branching a considerably greater drop in velocity is noted. A similar effect of chain branching has been noted in isomeric alcohols.[7] When the molecular sound velocity[8] of these ketones are computed, the most highly branched ketones also show the lowest values within any group of isomers.

Experimental[9]

Preparation of Ketones.—The acetophenones, propiophenones and isobutyrophenones were prepared by a standard procedure.[10] The pivalophenones were prepared by the procedure of Marvel and co-workers.[11] All the ketones were twice distilled through an efficient column. Constant boil-

(1) Physics Dept., Vanderbilt University, Nashville, Tennessee.
(2) Taken in part from the Ph.D. Thesis of B. F. Landrum, Emory University, 1951.
(3) S. Parthasarathy, *Current Science*, **6**, 322 (1938).
(4) L. Bergman, "Der Ultraschall," S. Hirzel, Zurich, 1949.
(5) P. Vigoureux, "Ultrasonics," John Wiley and Sons, Inc., New York, N. Y., 1951.
(6) R. T. Lagemann, R. Gwin, C. T. Lester, J. R. Profitt, Jr., and E. C. Suratt, THIS JOURNAL, **73**, 3212 (1951).
(7) A. Weissler, *ibid.*, **70**, 1634 (1948).
(8) M. R. Rao, *J. Chem. Phys.*, **9**, 692 (1941).
(9) All m.ps. and b.ps. reported are uncorrected.
(10) A. H. Blatt, "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 3.
(11) J. H. Ford, C. D. Thompson and C. S. Marvel, THIS JOURNAL, **57**, 2619 (1935).