Direct proof of this formulation has been obtained by the synthesis of cytidine diphosphate choline (P^1-cytidine-5′-P^2-choline-pyrophosphate) from cytidine-5′-phosphate and phosphorycholine-1,2-C^{14} using N,N′-dicyclohexylcarbodiimide as condensing agent in the elegant procedure of Khorana.[6] The synthetic labeled cytidine diphosphate choline, isolated and purified by ion exchange chromatography, has been found to be converted to lecithin at rates far exceeding those observed with CTP + phosphorylcholine and in yields approaching one mole of lecithin for each mole of cytidine diphosphate chloline added. The nature of the lipide acceptor compound involved in reaction (2) is not known with certainty but is presumed to be an α,β-diglyceride.

These results are the first demonstration of cytidine-containing coenzymes in a specific role of major metabolic importance. Presumably compounds such as cytidine diphosphate ethanolamine may participate in cephalin synthesis. Further, reaction (2) involves a novel type of group transfer reaction in which the entire phosphorylcholine moiety is transferred, with the formation of a monophosphorus diester linkage. Reactions of this type may perhaps serve as models not only for synthesis of glycerophosphatides, but also of nucleic acids, where similar linkages are present.

[6] H. G. Khorana, THIS JOURNAL, **76**, 3517 (1954).

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RECEIVED NOVEMBER 26, 1954

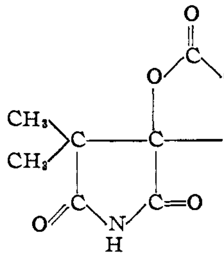
VITAMIN B_{12}. XXIV. DL-3,3-DIMETHYL-2,5-DIOXO-4-HYDROXYPYRROLIDINE-4-PROPIONIC ACID LACTONE AND DL-3,3-DIMETHYL-2,5-DIOXOPYRROLIDINE-4-PROPIONIC ACID, NEW DEGRADATION PRODUCTS

Sir:

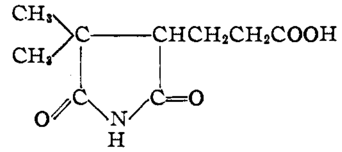
The oxidation of acid-hydrolyzed vitamin B_{12} with sodium chromate in acetic acid has given new pyrrole-like degradation products which have been identified by degradation and synthesis. These pyrrole-like products constitute the first detailed organic structural evidence concerning the heterocyclic nature of the red cobalt complex which remains after hydrolysis.

The chloroform-soluble portion of the oxidation reaction mixture was subjected to countercurrent distribution between chloroform and water. Material with a distribution coefficient near unity yielded a crystalline, weakly acidic substance (I) of m.p. 151–152°, of the composition $C_9H_{11}NO_4$. The compound showed infrared absorption bands at 3.02, 5.65, and 5.80 μ, in agreement with an imide structure containing a γ-lactone group. Hydrolysis converted the imide to a lactone dicarboxylic acid, m.p. 167–168°. The material from the chloroform–water distribution which was excessively soluble in the aqueous phase was redistributed between water and ether to yield a second imide (II), m.p. 143–144°, of the composition $C_9H_{13}NO_4$. Hydrolysis of the imide yielded a tricarboxylic acid, m.p. 152–153°.

Fusion of the imide (I) with potassium hydroxide gave succinic and isobutyric acids. When this imide was distilled with zinc dust, a basic product was obtained which gave a positive Ehrlich pyrrole test. Of two possible structures for the imide (I), DL-3,3-dimethyl-2,5-dioxo-4-hydroxypyrrolidine-4-propionic acid lactone was found to be correct by synthesis.



I

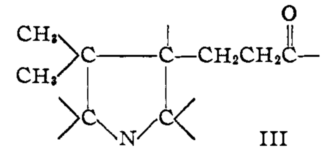


II

The sodium enolate of ethyl isobutyrate was treated with β-carbethoxypropionyl chloride. The resulting diethyl 2,2-dimethyl-3-oxo-adipate, on addition of hydrogen cyanide and hydrolysis of the cyanohydrin diethyl ester so produced, gave a compound identical with the lactone dicarboxylic acid. Pyrolysis of the ammonium salt of this synthetic lactone acid yielded the imide (I).

The composition and melting point of the tricarboxylic acid were found to correspond closely to those properties of 2-methyl-pentane-2,3,5-tricarboxylic acid.[1] A synthetic specimen of this acid was prepared[1] and found to be identical to that obtained by degradation. This synthetic acid on treatment with one mole of ammonia yielded, after pyrolysis, DL-3,3-dimethyl-2,5-dioxo-4-hydroxypyrrolidine-4-propionic acid, which was found to be identical to the imide (II).

The imide grouping of the degradation products I and II is most probably the result of the oxidation reaction. The imides are probably derived from a moiety or moieties in the vitamin B_{12} molecule having a pyrrolidine, pyrroline or pyrrolenine nucleus as represented by the partial structure III. Imides I and II are optically inactive. In view of the polyamide character of vitamin B_{12},[2] and our observation that the yield of acidic oxidation products is increased by prior hydrolysis, the presence of the free carboxyl group of partial structure III



III

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[1] Perkin and Thorpe, *J. Chem. Soc.*, **85**, 128 (1904).

[2] J. B. Armitage, J. R. Cannon, A. W. Johnson, S. F. J. Parker, E. S. Smith, W. H. Stafford and A. R. Todd, *ibid.*, 3849 (1953); H. Diehl and J. L. Ellingboe, *Iowa State College Journal of Science*, **27**, 421 (1953).

as an amide in the parent molecule is a distinct possibility.

Other investigators[3] have reported the isolation of oxalic, succinic, methyl succinic, and dimethyl malonic acids in addition to four unknown ones by the permanganate oxidation of acid-hydrolyzed vitamin B_{12}. Dimethyl malonic and succinic acids might be derived from moieties having structure III.

These imides I and II and their bearing upon the organic structure and coördination linkages of vitamin B_{12} are being studied further.

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RECEIVED NOVEMBER 16, 1954

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[3] H. Schmid, A. Ebnother and P. Karrer, *Helv. Chim. Acta*, **36**, 65 (1953).

BOOK REVIEWS

Elsevier's Encyclopaedia of Organic Chemistry. Vol. 12B, Part VII. Naphthalene: "Naphthoic Acids and Their Halogen Nitrogen and Hydroxyl Derivatives. Edited by D. F. RADT, Editor-in-Chief. Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Texas. 1953. xliii + 640 pp. 25.5 × 18 cm. $56.00 per single copy, $49.00 for series subscribers and $42.00 for set subscribers.

This latest volume of Elsevier covers the naphthoic acids and their derivatives, including the hydro derivatives. It is again a testament to the skill with which the technical details are handled: the arrangement, the method for citing references, use of formulas, and indexing. But perhaps the most useful feature is the careful editing of the literature. Thus the editors point out incomplete data such as solubility measurements at unspecified temperatures. Inconsistencies in the literature have been cleared up when possible by correspondence with the original investigator. Hence Elsevier is not only a guide to the literature, but frequently an invaluable source of additional information. Only occasionally is it evident that the editors are not writing in their native tongue. Thus yields are sometimes reported as "claimed," but the editors probably do not consider the figures less reliable than those reported without reservation. Again the statement that "In this volume the literature has been consulted up to and including 1944, the literature concerning the structure of compounds up to 1953" apparently means that the literature has been covered up to 1953 for those compounds that were known before 1945. This somewhat unorthodox approach is undoubtedly dictated by practical considerations and has the advantage that the common compounds are covered almost to the time of publication.

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The Sulphur Data Book. Compiled by the Technical Staff, Freeport Sulphur Company. Edited by WILLIAM N. TULLER, Superintendent of Laboratories, Louisiana Division, Port Sulphur, Louisiana. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y. 1954. vi + 143 pp. 16 × 23.5 cm. Price, $5.00.

"This book is a compilation of data of interest to the engineer and chemist using sulphur. The desire has been to offer working material, not a literature survey." The five sections deal respectively with the nature of sulfur, physical and chemical properties, reaction thermodynamics (in tabular form), solubility and analytical methods. Nineteen figures correlate the data in a clear and attractive fashion. In conclusion there are twelve pages of sulfuric acid conversion tables.

The somewhat limited objectives quoted above have admirably been attained. It should not be forgotten, however, that the volume on sulfur of Gmelins "Handbuch der anorganischen Chemie," in the completely rewritten eighth edition which appeared in the fall of 1953, is much more comprehensive and detailed and will be generally preferred as a reference work on the subject.

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Name Reactions in Organic Chemistry. By ALEXANDER R. SURREY, Sterling-Winthrop Research Institute, Rensselaer, New York. Academic Press Inc., 125 East 23rd Street, New York 10, N. Y. 1954. viii + 192 pp. 16 × 23.5 cm. Price $4.00.

This book consists of ninety-six short discussions of organic reactions which are usually designated by the names of the investigators who discovered or developed them. The general nature of each reaction is described and illustrated, often by examples selected from recent publications. Some additional information is then usually given, such as the experimental conditions, yields, mechanism, influence of substituents and recent applications. No attempt is made to supply experimental procedures. A short list of references (generally from three to seven) is given at the end of each discussion for the reader seeking an extensive and detailed treatment of the reaction. With the exception of the articles in which the reactions were originally described, the references are almost exclusively to more or less recent reviews, studies, and applications of the reactions published in the English language. Each discussion is preceded by a brief biographical sketch of the chemist after whom the reaction is named.

With a few exceptions, the reactions are considered in alphabetical sequence. The Stevens rearrangement is out of order, appearing between the McFayden-Stevens reduction reaction and the Mannich reaction. There are several instances where the author has included in the discussion of a name reaction a short description of another name reaction, because the reactions either are essentially similar or represent different methods for synthesizing the same type of compounds. Thus the Doebner reaction is included under the Knoevenagel reaction, and the Borsche carbazole synthesis under the Graebe-Ullmann synthesis. However, when each of two or more reactions, even though they are very closely related, deserves in the author's judgment at least a page of discussion, then each reaction is considered separately in alphabetical order, *e.g.*, the Claisen condensation and the Dieckmann reaction, the Leuckart and the Wallach reactions. In the reviewer's opinion, it would have been preferable to have organized the text on the basis of the nature of the reactions. An alphabetical listing of the names applied to them could then have appeared in the index. The use of a chemist's name to designate a reaction is primarily for convenience. What should receive the emphasis is not the association of a name with a reaction but the relation between reactions.

The author recognizes that his choice of reactions may perhaps be questioned. The reader will discover that well-known reactions have been omitted, such as the Schotten-Baumann reaction, Strecker's synthesis of α-amino acids,