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Book review

Inositol Phosphates: by D. J. COSGROVE AND G. C. J. IRVING, Elsevier, Amsterdam, 1980, xii + 191 pages, \$46.25; Dfl. 95.00.

The widespread, natural occurrence of phosphoric esters of *myo*-inositol has been recognized for a long time, but the published information on these compounds is scattered throughout the literature of chemistry, biochemistry, soil science, and food technology. According to the preface, this monograph is the first attempt to bring together in one volume the present knowledge on all inositol phosphates since the standard work by T. Posternak (*The Cyclitols*, Herman, Paris, 1965). The authors are to be congratulated on the success of this immense task, including careful preparation of the text and formulas ready for photo-printing.

The book consists of three parts: Part I (Chemistry, Chapters 1–9, 276 references); Part II (Biochemistry, Chapters 10–13, 244 references), and Part III (Physiology, Chapters 14–16, 222 references).

After a brief, historical introduction, a chapter on chemistry discusses stereoisomerism, conformation, and nomenclature. In general, the authors follow the IUPAC nomenclature [*Eur. J. Biochem.*, 79 (1977) 1–15] and the Nomenclature of Inorganic and Organic Chemistry [*IUPAC Information Bull.*, 31 (1973) 30–35]; the prefixes di, tri, tetra, penta, and hexa are replaced by bis, tris, tetrakis, pentakis, and hexakis. The succeeding, detailed discussion of analytical methods of separation and purification of inositol phosphates includes paper chromatography, paper electrophoresis, t.l.c., and gel, gas–liquid, liquid, and ion-exchange chromatography.

The next chapter is devoted to the most widespread and most prominent member of the ester series, namely, *myo*-inositol hexakisphosphate, commonly known as "phytate" for the salts (*e.g.*, calcium/magnesium salt) and "phytic acid" for the free acid. The topics treated are: isolation, synthesis, and structure; also, salts, hydrolysis of salts, dissociation constants of the free acid, and complexes with metals, proteins, and lipids. It is interesting to know that only recently, by application of ^{31}P-n.m.r. spectroscopy, was it possible to determine all twelve dissociation constants (pK_a values) for *myo*-inositol hexakisphosphate, ranging from pK_a 1.1 (C-2) to 12.0 (C-1 or C-3); the book also compares the values obtained by other methods.

Certain constituents of the organic matter in soil, namely, *scyllo*-, *chiro*-, and *neo*-inositol hexakisphosphates, and the synthetic, *muco* isomer, are also surveyed. An additional topic in this segment includes a detailed study on the hydrolysis products from phytate, with emphasis on chemical reagents, and the preparation, characterization, stereochemistry, and chemistry of inositol pentakis-, tetrakis-, tris-, bis-, and mono-phosphates. This chapter may now be supplemented by recent, conformational studies of *myo*-inositol hexakisphosphate by ^{13}C- and ^{31}P-n.m.r. and Raman spectroscopy [L. R. Isbrandt and R. P. Oertel, *J. Am. Chem. Soc.*, 102 (1980) 3144–3148].

Part II is concerned with the phytases and their catalytic properties. Phytases are phosphomonoesterases capable of hydrolyzing *myo*-inositol hexakisphosphate, to yield inorganic orthophosphate and a series of lower phosphoric esters of *myo*-inositol and, ultimately, in some cases, free *myo*-inositol. The chapter describes sources of phytase in the seeds of higher plants (*e.g.*, barley, bean, corn, and pea), extraction and purification, assay, determination of molecular weight (*e.g.*, 1.6×10^5 for a mung-bean phytase), and catalytic properties. Also discussed are methods for the isolation of intermediates in the dephosphorylation of phytate by phytases, their chemical structure and stereochemistry, and the nature of the active centers of phytases. The authors next deal with the biosynthesis of inositol phosphates, reviewing the biosynthesis of *myo*-inositol by the cyclization of D-glucose, and emphasizing the importance of D-glucose 6-phosphate in the biosynthesis of the *myo*-inositol monophosphate intermediate. The biosynthesis of *myo*-inositol hexakisphosphate in plants may thus involve either *myo*-inositol + *myo*-inositol kinase, or D-glucose 6-phosphate + *myo*-inositol 1-phosphate synthase, to give the monophosphate intermediate, which is further catalyzed by phosphonoinositol kinase, to give, sequentially, bis-, tris-, tetrakis-, pentakis- and finally, hexakis-phosphate.

Part III is devoted to the physiological role of phytate in plants and animals. The chapter covers factors leading to accumulation of phytate in the seeds at maturity, and its location in the aleurone layer, for example, in rice and wheat grains. Five physiological roles have been suggested for phytate in plants; these are as (*1*) a phosphorus reserve-store, (*2*) an energy store, (*3*) a competitor for ATP during its biosynthesis near maturity, (*4*) an immobilizer of multivalent cations needed for control of cellular processes, and (*5*) a regulator of the level of inorganic phosphates.

The physiology of animal phytate is discussed next. The existence of a large pool of 2,3-di-*O*-phosphonoglycerate (DPG) in the red cells of most mammals remained a mystery for many years, until it was discovered that this phosphoric ester can combine with human hemoglobin to lessen greatly its affinity for oxygen. A similar, physicochemical effect has been observed for phytic acid and the lower inositol phosphates. Owing to its very tight binding to deoxyhemoglobin, the hexakisphosphate is one of the most effective, chemical agents for decreasing the affinity of hemoglobin for oxygen. A recent, comparative study on inositol esters [R. E. Benesch, R. Edalji, and R. Benesch, *Biochemistry*, 16 (1977) 2594–2597] showed that *myo*-inositol hexakissulfate [A. J. Fatiadi, *Carbohydr. Res.*, 12 (1970) 293–296] is next to the hexakisphosphate in binding ability, and, consequently, in decreasing the affinity of hemoglobin for oxygen; this comparison is reflected by their binding constants (at pH 7.3, in 0.1M NaCl): DPG $10\mu\text{M}$, pentakisphosphate $1\mu\text{M}$, hexakissulfate $0.8\mu\text{M}$, and hexakisphosphate $0.06\mu\text{M}$. Thus, the tightness of binding of the four phosphate polyanions to deoxyhemoglobin (in a likely conformation) and, therefore, their magnitude as regards oxygen affinity, is directly related to the number of their negative charges (allosteric effect). Possible, medicinal importance of inositol esters in controlling the oxygen supply to animal red-cells, including human red-cells, would thus be anticipated. In addition, the chapter corrects an erroneous literature-report that the avian red-cell contains a high concentration of hexakisphosphate; the inositol ester identified is, however, actually the 1,3,4,5,6-pentakisphosphate. This chapter may now be supplemented by comprehensive studies on the physiology of *myo*-inositol hexakisphosphate (E. R. P. Zuiderweg, *On the Interaction of* myo-*Inositol Hexakisphosphate with Human Hemoglobin, a* ^{31}*P NMR and pH-stat Study*, Dissertation, University of Amsterdam, Holland, 1980, 1–116).

The next chapter examines the nutritional importance of phytate, *e.g.*, the availability and deficiency of calcium, copper, iron, magnesium, manganese, and phosphorus in commercial feeds for domestic animals, and in processed foods for humans. *myo*-Inositol hexakisphosphate may play a role in limiting the nutritional availability of essential, dietary minerals. Changes take place during the processing of food rich in phytate; such changes may affect the availability of phosphorus and associated cations. For a recent study on determination of the extent to which phytate, the major phosphorus-containing constituent of cereal grains, decreases the nutritional availability of dietary metal-ions (*e.g.*, of calcium, iron, and zinc) through complexation, see J. W. Edman, Jr., *J. Am. Oil Chem. Soc.*, 56 (1979) 736–740.

Dental and medical aspects of inositol phosphates are also of concern to the authors. Phytate lessens the solubility of the tooth enamel and of calcium phosphate; some labeled stannous salts of phytate have been used as hepatic-imaging agents, and as imaging agents for lymph nodes.

The book concludes with an Author Index and a detailed Subject Index; a Table of Contents is also provided at the beginning, so that any topics of interest may be readily located. The book is free from errors, except for two minor, typing errors (pp. v and 83).

In general, the monograph is scientifically sound and up-to-date, with references through 1977, and some for 1978. The book is written by specialists who are actively involved in the field, as evidenced by their own, numerous references (53) through Chapters 4–8, and 10–12.

The book covers all aspects of the chemistry, biochemistry, and physiology of inositol phosphates; the reviewer finds it to be useful and stimulating to researchers in the carbohydrate field, and it is also an important reference-source to all working in cell biochemistry, soil chemistry, and food technology. It is imperative that this book be on the shelves of all academic and pertinent, industrial libraries.

National Bureau of Standards
Washington, DC 20234

ALEXANDER J. FATIADI