

## Polymerization and Its Technical Applications.

[*Polymerization and Its Applications in the Fields of Rubber, Synthetic Resins and Petroleum.* By Robert E. Burk, Howard E. Thompson, Archie J. Weith and Ira Williams. (American Chemical Society, Monograph Series, Reinhold Publishing Corporation, 1937, pp. 312, Price \$ 7.50.)]

THE technical importance of natural synthetic products of high molecular weight has led in recent years to extensive research into every aspect of the processes of polymerization. While the name was originally more or less restricted to reactions in which high molecular substances were formed by a unit molecule capable of self-addition by means of primary valencies, the concept of polymerization has now been extended, for reasons elaborated by Carothers,<sup>1</sup> to any process of aggregation by condensation. Carothers defined polymerization as a chemical combination of a number of similar molecules to a single molecule, the essential feature of the phenomenon being the functional ability of the reagents or monomers to undergo indefinitely continuous condensation to form abnormally large molecules. In the book under review attention has been drawn to the desirability of retaining certain classifications within this very wide definition and of excluding from it the loose and impermanent types of chemical union such as association phenomena.

Polymerization has been regarded by the authors as one of those subjects which are intermediate between the theoretical fields in which the intrinsic interest of fundamental problems (the Raman effect, heavy water, etc.) lead to vigorous research and the industrial fields in which practical difficulties stimulate investigations of methods for their solution. It would perhaps be truer to say that polymerization is one of the chemical processes which are alike of profound interest to the academic chemist and of wide practical utility in numerous manufacturing operations; and the criticism that it has not received systematic encouragement at the hands of industrial concerns is not altogether justified. The extent to which organisations such as the I. G. Farbenindustrie have furthered and subsidized fundamental investigations with no immediate or obvious bearing in industry is remarkable. Two examples from the present book itself are the X-ray researches of Mark and Meyer of the I. G. Farbenindustrie on the structure of high polymers and the work of

Carothers of E. I. du Pont de Nemours and Co., on many theoretical aspects of addition and condensation polymerization.

Following reviews of the general features of polymerization, the relation between molecular structure and the rate of polymerization, catalysis and polymerization, the mechanism of polymerization reactions and the structure of polymers in respect of the liquid state, the book deals with the applications of polymerization processes in three important industries—rubber, synthetic resins and petroleum. The structural factors that may be said to predispose an organic compound to union with itself or with closely similar molecules have been enumerated as unsaturation, conjugation of unsaturated linkages, alkyl substitution, certain cyclic systems, halogen substitution, and the carboxyl group; each has been dealt with in detail with regard to examples of polymerizing substances, the products formed and the factors governing the phenomena. Since our knowledge of the part played by catalysts in polymerization is largely empirical, the chapter on catalysis consists of a tabular statement, running into 57 pages, of polymerizing substances and of reagents that catalyse each reaction, together with references to the relevant literature. The material thus collected and correlated should prove invaluable to the research worker in search of a suitable catalyst for a specific purpose. The precise rôle of catalysis in polymerization has remained obscure on account of the inherent complexities of the problem, but it has been noted that in two cases at least (the polymerization of ethylene, propylene and butylenes by phosphoric acid and the polymerization of diolefines by means of metallic sodium) the course of the reactions involved has been elucidated.

The treatment of the mechanism of polymerization from kinetic considerations has been limited by various difficulties—the sensitivity of polymerization reactions to catalysis, the multiplicity of the resultant products, the possibility (one should rather say the certainty) of the existence of chain reactions, and the mystery of the liquid state involved in many polymerizing systems. After a general review of our present

<sup>1</sup> *Chem. Rev.*, 1931, 8, 354; *Faraday Soc. Symposium on Polymerization*, 1935.

knowledge of each of these factors, the mechanism of polymerization has been discussed fully in the individual cases of the acetylenes, the olefines and the diolefines, the concluding part of the chapter, as well as chapter V being devoted to polymerization in liquid systems.

The chapters concerned with the part played by polymerization in the rubber, synthetic resin and petroleum industries are of uniform excellence. Every feature is clearly and adequately treated and the one defect of the earlier chapters—a tendency to sacrifice clarity for comprehensive cataloguing of published data is notably absent. While the study of the chemical structure of the technically valuable polymers is rendered a matter of the utmost complexity by reason of the high molecular weights and the nature of the substances as a mixture of closely related compounds rather than chemical individuals, the chemical and X-ray evidence has been extensively surveyed. Polymerization in the petroleum field is of necessity restricted to technical applications, such as the refining of petroleum products by selective polymerization, the use of inhibitors for the suppres-

sion of oxidation and consequent polymerization, the manufacture of artificial asphalt and the synthesis of motor fuels from gas.

To the general chemist who wishes to have an introduction to a new and rapidly developing branch of chemical technology, the usefulness of the book would be increased by an expansion of the chapter on the relation between molecular structure and polymerization, and more particularly by the inclusion of structural formulæ in at least a few of the more important of the numerous instances where the name of a compound does not lead to an immediate mental picture of its constitution. In discussing isoprene and its bearing on polymerization problems,<sup>2</sup> more pointed attention might have been drawn to the isoprene basis of the structure of many natural products. A very minor omission, which happens to be of interest to the reviewer, is the application of synthetic resins in the manufacture of anti-crease fabrics.

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<sup>2</sup> Cf. Whitby, *Trans. Inst. Rubber Industry*, 1929, 5, 185; 1930, 6, 40.

## ASTRONOMICAL NOTES.

**Planets during February 1938.**—Mercury will be a morning star during the month; on February 17 it will be in conjunction with Jupiter, the distance between the two planets at the time being  $1^{\circ} 23'$ . Mars will continue to be visible in the western sky in the early part of the night. Jupiter after passing conjunction with the Sun on January 29, becomes a morning star and can be seen, during the latter half of the month, as a bright object rising about three-quarters of an hour before sunrise. Saturn is situated in the same direction as Mars and on February 3, the two planetets will closely approach each other to an angular distance of about  $2^{\circ}$ . Uranus is in the constellation Aries and will be in conjunction with the Moon on February 7.

**The Minor Planet Eros.**—The physical nature of this well-known asteroid is discussed by F. Watson Jr. in *Harvard Circular*

419. From the short period light variations he deduces that the axis of rotation is pointing towards the direction indicated by the point on the celestial sphere whose co-ordinates are R.A.  $21^{\frac{1}{2}} 4^m$  Dec.  $51^{\circ}$  N. The rotation is found to be retrograde. The observations of Finsen and Van den Bos at Johannesburg in February 1931 appear to show that the asteroid is probably a long irregular solid about 35 kilometres long and 11 kilometres in diameter, and that the reflectivity is about 15 per cent. But the results of the work of Zessewitsch of the Leningrad Institute are not in agreement with these conclusions. His discussion seems to indicate that the direction of Eros' rotation does not remain constant, but is subject to considerable changes. The observations that will be made during the opposition of 1938 are likely to throw further light on the subject.