

Sporopollenin: edited by J. BROOKS, P. R. GRANT, M. D. MUIR, P. VAN GIJZEL and G. SHAW, Academic Press, London and New York, 1971, 718 pp. £8.00, \$23.00.

BIOPOLYMERS of irregular structure have offered the chemists unusually difficult problems. Such polymers which for various reasons have remained insufficiently studied are the 'cutins' of plant epidermis and the 'sporopollenins' of certain spores and pollen. Like the 'suberins' of cork, all cutins about whose chemistry there are any publications are hydrolyzed by alkali. The sporopollenins, however, are non-hydrolysable. Like several other polymers they are resistant to acetolysis and this fact has been used almost as a criterion on sporopollenins ever since 1933, when acetolysis was first introduced as an analytical technique for pollens. This criterion may be useful in researches on spores and pollen but should be used with great caution on amorphous fossil products and, particularly, meteorites. The outstanding property of the sporopollenins is their remarkable anaerobic durability. It is firmly established that sporopollenins are highly unsaturated. Nevertheless, pollen and spore membranes can, under favourable conditions, remain morphologically virtually unchanged during several hundred million years.

Sporopollenins are produced in Nature in very large quantities. During its lifetime a single spruce may produce some 50 kg of pollen (10 kg of sporopollenin). There are many spruces and were it not for the aerobic instability of the sporopollenins we would be drowned in dunes of pollen. Many geological deposits such as peat, coals and even sedimentary rocks can contain considerable amounts of spore and pollen membranes in various states of preservation. Palynology, the science of pollen and spores, is therefore, a subject of great interest not only to botanists and chemists but also to geologists, pedologists and geochemists.

The present volume is the result of a symposium held in London in 1970. It encompasses twenty-five papers written by active workers in the field. Only a few of the papers deal with the chemistry of sporopollenins. In the introductory paper J. Heslop-Harrison gives a broad account of the botanical aspects of the sporopollenins. He discusses the morphogenesis of the pollen membranes and the adaptive role of the intriguing and taxonomically important sculpturing of the outer layer of many pollen membranes, the 'sexines'. Apparently they arose as the result of a co-evolution of plants and insects but evidently fortuitous factors played an important role. Many challenging questions are raised and the desirability of exact chemical studies on the structure of sporopollenins and cutins from widely separated taxa is emphasized. Now that pollen from many plants is commercially available in almost unlimited quantities this can and should be done, not least because of the potential technical value of sporopollenin-like materials as substitutes for biologically resistant products as, e.g. polythene.

The pollen membranes, 'exines', are not homogeneous structures. The innermost layers, the 'intine', is largely composed of cellulose. Then follow layers of 'nexine' and finally the 'sexine'. Several beautifully illustrated papers deal with the formation of these layers by deposition of sporopollenin, a product which is evidently produced by the gradual polymerization of hypothetical monomers. Apart from cytochemical reactions of rather doubtful value, many modern physical methods have been used to follow these events, e.g. fluorescence and electron microscopy. The possible analogy between sporopollenin formation and emulsion polymerizations, which is pointed out by G. Shaw, is intriguing. The sexine, apparently, is more resistant than the nexine layers which often differ as regards stainability, fluorescence, etc. If this is due to different sporopollenins, to varying degrees of

cross-linking or to trapped 'impurities' is difficult to say. The diminishing osmium stainability during sexine maturation may well be due to progressive saturation caused by condensation reactions. The detailed architecture of the walls has been studied with the aid of scanning electron microscopy and using microtomic sections or ultrasonically produced fragments. There are several papers dealing with the changes which the membrane substances seem to undergo during the course of time, e.g. aromatizations, degradation by microorganisms or reactions caused by elevated temperatures.

In view of its fundamental importance for pollen analysis, A. J. Havinga's investigation of the durability of pollen in various types of soil is welcome. Some pollens are fairly easily destroyed. Other papers deal with the isolation of 'exinites' from coals by mechanical powdering and subsequent flotation as well as with the investigation of their constituents, e.g. by gas chromatography. For comparative purposes some results obtained from recent pollen are recorded. A more comprehensive survey of what is known about the pollen constituents of low molecular weight would not have been out of place. G. Shaw describes his and his collaborators' important chemical studies on pollen and spore membranes which incidentally supersedes the publication of our own independent investigations. Like the pioneer in this field, F. Zetzsche, they (and we) found that ozonization is the best method for obtaining reasonable yields of definable degradation products from sporopollenins. Unfortunately it is not possible to draw any definite conclusions as regards the structure of these polymers from the results. Actually our knowledge has not advanced very much from the point reached by Zetzsche. He tentatively suggested that the sporopollenins might be of terpenoid origin. Shaw vigorously advocates his postulate that sporopollenins are derived from carotenoids which is not very far from Zetzsche's view. In our speculations we have been inclined to believe that poly-unsaturated long chain hydrocarbons and/or alcohols might serve as monomers. Cutins and sporopollenins would then be biosynthetically related. Feeding tissue cultures or suitable microorganisms with labelled potential precursors might shed some light on the origin of sporopollenins.

A work covering so many disparate aspects of sporopollenins is bound to cause difficulties to readers of different specialization. The chemist will certainly find the pollen morphological terminology truly bewildering, particularly when not uniformly used. He will surely appreciate P. Echlin's pedagogically clear paper on the production of sporopollenin from the 'tapetum'. Botanists will probably be irritated by the frequent misspelling of Latin names of plants in some contributions, but all will certainly be grateful to F. P. Jonkers for the excellent and well balanced summary which concludes this informative but far too spaciouly produced book.

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