Hitherto, the principal expenses of the Federal Council have been the annual subscriptions to the International Union, and the revenue has consisted mainly of grants from the Chemical Society and the Society of Chemical Industry. These grants cannot be increased, because both societies have already large calls upon their limited resources for other indispensable purposes; yet money is required to enable the Federal Council to develop its work on an adequate scale. At the meetings of the International Council in Brussels, Rome, and Lyons the foreign organisations corresponding to our Federal Council entertained the delegates to the Union. We shall have to return the compliment at next year's meeting in Cambridge. Further, whilst the prevailing financial stringency makes it impossible to carry out the large scheme outlined by the late Lord Moulton, it is at least necessary that we should make a beginning. We therefore ask for contributions to be devoted towards the scheme, and so convert into a useful form the sympathy of our chemical colleagues with the objects of the Federal Council.

In the present article we have touched on many questions—and therefore, perhaps, in too scanty detail—and have left unmentioned many others which are also of vital importance to the chemical organism. The nudity of our chemical compendia, the paucity of our efforts to cultivate the social side of chemistry, and so develop the excellent work of the Chemical Industry Club—these and many other matters call for attention; they call for a few chemists to lead and for many to collaborate, and above all they call for financial support.

With the above considerations in view the Federal Council has appointed a Benefaction Committee, with the request that they will collect funds. The Committee now consists of Sir William Pope, Dr. E. F. Armstrong, Mr. H. E. Coley, Mr. E. V. Evans, Mr. Emile Mond, Mr. W. J. U. Woolcock, and Dr. S. Miall; other names may be added at a later date. It is intended to issue a preliminary list of subscriptions, and when this has been completed to make a widespread appeal in a more or less public manner. It is requested that contributions be sent to Dr. S. Miall, Society of Chemical Industry, Central House, Finsbury Square, London, E.C.

W. J. POPE.
E. F. ARMSTRONG.
H. E. COLEY.
E. V. EVANS.
EMILE MOND.
W. J. U. WOOLCOCK.
STEPHEN MIALL.

The First List of Contributors to the Fund will be found on page 534 of this issue.

RECENT RESEARCH ON FORM-ALDEHYDE-RESINS

ALAN A. DRUMMOND

SINCE 1872, when Baeyer first observed that phenol reacts with formaldehyde to give a resinous condensation product, much work has been done with a view to making synthetic resins of this type commercial materials, and as a result, primarily of research by Dr. Baekeland, the technical world has come to realise the possibilities of phenolic condensation products for use in many industries. The object of the earlier workers was merely to produce substitutes for shellac, and it was not until recently that the peculiar properties of these resins, notably their resistance to heat, electricity and chemical action, were appreciated fully. Varnish manufacturers are still actively investigating the possible applications of synthetic resins, but the lack of uniformity in behaviour of different batches, made under supposedly identical conditions, has so far precluded extensive use in this industry.

During the past thirty years many data, more or less empirical, concerning synthetic resins have accumulated, mainly in the patent files. The number of patents taken out year by year in Great Britain since about 1897 up to the beginning of the war, shows clearly that interest in synthetic resins has been increasing steadily.

The graph indicates a general upward tendency in the number of patents, reaching a maximum soon after the publication of Baekeland's lecture in America on Bakelite and its

applications (*J. Ind. Eng. Chem.*, 1909, 149). Research in this subject was, naturally, retarded by the war, but it is now receiving renewed attention. The later patents relating to the subject still convey an impression of empiricism, but this may be due to the nature of the record, because systematic scientific method can rarely be deduced from a survey of patent specifications. The fact remains, however, that little or no fundamental work is being published on the exact course of the reaction involved in the production of phenol-formaldehyde resins. It is, perhaps, more along the lines of physico-chemical investigation that new knowledge will come. Up to the present, work has been concentrated mainly on the investigation of the chemical properties of the condensation product, on its behaviour towards various reagents, and on efforts to identify the individual constituents of the resins. As a result of this chemical study, attempts have been made to ascribe a definite constitution to the colloidal resin, but the results have been conflicting. Baekeland deduced an anhydride formula from the results of elementary analysis, starting with an assumption based on work done by Lederer (*J. prakt. Chem.*, 1894, **158**, 223), and Manasse (*Ber.*, 1894, **27**, 2409), who was the first to claim the synthesis of oxybenzyl alcohol by the condensation of phenol and formaldehyde in presence of basic catalysts. Raschig (*Zeit. angew. Chem.*, 1912, 1939) disputed Baekeland's conclusions, but without advancing very clear proof of his own deductions.

Recent work by Coster van Voorhout (*Chem. Weekblad*, 1920, **17**, 2) has supplied more definite information concerning the course of the reaction between phenol and formaldehyde. This worker has investigated the changes in viscosity that occur during condensation, and has successfully isolated chemical individuals from the reaction mixture. He has separated crystalline *o*- and *p*-oxybenzyl alcohols, when an alkaline catalyst was used, and he has shown the presence of dioxydiphenylmethane when the condensation was initiated by acids. His conclusion was that in all probability Baekelite consists of dioxydiphenylmethane (probably polymorphous) in colloidal solution, together with traces of phenol and formaldehyde.

It must appear from the foregoing that, valuable as a knowledge of the chemical constitution, based upon an investigation of the final condensation product, undoubtedly is, further practical advance can more readily be achieved by a synthetic study of the resin, *i.e.*, by investigating it before and during synthesis, rather than analytically after the synthesis has taken place. Such a study involves physical, as well as chemical examination: a study of the changes during condensation in such physical properties as viscosity and density. Coster van Voorhout's paper contains only a brief reference to viscosity

determinations; more data of this kind are wanted, and particularly by the manufacturer of formaldehyde-resins.

Air-drying varnishes or lacquers, containing formaldehyde-resins, are readily obtained; they yield films of good elasticity, which can be improved by the addition of such substances as celluloid, collodion, and cellulose acetate, but their durability in use is poor unless they have been stoved. A non-stoving varnish of acid-resisting properties would be of great service even in the chemical industry alone, particularly if it were also highly resistant to heat.

Another difficulty has been the restricted solubility of the finished resins; alcohol has proved to be the best solvent, even for the resins in their more soluble condition, *i.e.*, before the final reaction has been effected by stoving. Spirit as a solvent is not altogether desirable; for one reason, varnishes containing alcohol are liable to leave a track of trapped air-bubbles on the surface that is being covered, and these bubbles or pin-holes are not easily removed. Linseed oil, turpentine and similar oils are more useful varnish media. A process for obtaining oil-soluble synthetic resins has been protected (Albert and Berend, E.P. 15,875, 1914). Such so-called "albertole" resins, apparently contain, in addition to the formaldehyde-resins, at least 50 per cent. of natural rosin, and although the process claims to effect a specific reaction between the synthetic and the natural resins so that a durable oil-soluble varnish is obtained, it is difficult not to suspect the durability of a varnish film of such composition. A claim for the production of oil-soluble resins has also been made, whereby advantage is taken of the different reactivities of *m*- and *p*-cresol with formaldehyde; *p*-cresol, with an excess of formaldehyde and an acid catalyst, is stated to give a resin soluble in oils (Robinson-Bindley, Weller, and Duleken, E.P. 134,563, 1918). The biggest field of application for synthetic resin varnishes, as now made, is as insulators in the electrical industry, where they are used as stoving varnishes, particularly for coating insulating fabrics and tapes, and for impregnating coils.

Following the amalgamation of three of the foremost American manufacturers of insulating materials under the aegis of the General Baekelite Company (*cf. J.*, 1922, 320 R), the pooled resources of scientific and technical information should make possible very distinct advances in the methods of manufacture and application of formaldehyde-resins. In view of this strong competition, British manufacturers of electrical insulating material who are beginning to realise the specially advantageous properties of these resins, are likely to be seriously handicapped in their efforts to establish sound commercial processes, unless their methods have a firm scientific basis, founded on the results of systematic research.