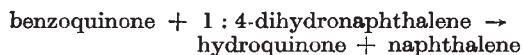


In addition to its theoretical interest, transfer-hydrogenation of the type described has considerable potentialities as a preparative method⁶ and represents a useful alternative to catalytic hydrogenation. Reduction is conveniently effected by heating the acceptor with *cyclohexene*, a palladium catalyst and (if desired) a solvent such as ether, tetrahydrofuran, dioxan, methanol, ethanol, *cyclohexene* or benzene under reflux for a few hours. No special apparatus is required and the products are readily isolated in high yields. In this way, for example, maleic acid can be converted quantitatively into succinic acid, stilbene into dibenzyl and nitrobenzene to aniline. Apart from its simplicity, this method is also valuable in virtue of the fact that with compounds containing several potential acceptor functions, transfer-hydrogenation is often more highly specific than ordinary catalytic hydrogenation. Thus, for example, *m*-dinitrobenzene can be converted in almost quantitative yield into *m*-nitroaniline (Table 3).

Uncatalysed Transfers

In the reactions so far discussed, the function of the metal catalyst is regarded as the dual one of 'activating' the transferable hydrogen (that is, reducing the energy⁷ required for the fission of the carbon-hydrogen bonds by some kind of metal-hydrogen bonding) and of exerting a favourable steric orienting influence on the donor-acceptor pair. In order to distinguish between factors associated with the catalytic mechanism and intrinsic structural influences, the study of hydrogen-transfer with acceptors sufficiently powerful to react under both catalytic and non-catalytic conditions is desirable. The quinones are a class of acceptors very suitable for this purpose.

The use of quinones as dehydrogenating agents for hydroaromatic and hydroheterocyclic compounds at high temperatures is well known⁷, although not widely practised. We find that non-catalysed transfer in such systems can occur under quite mild conditions. Thus the reaction:



proceeds quantitatively from left to right at 100°. The disappearance of quinone and appearance of hydroquinone can conveniently be followed by titration with titanous chloride and ceric sulphate, respectively, using suitable redox indicators such as methylene blue and diphenylamine sulphonic acid. When adequate precautions are taken to exclude side-reactions, hydrogen transfer is quantitative and exhibits straightforward second-order kinetics (first-order with respect to both donor and acceptor); furthermore, the rates of reaction of a number of related quinones show a linear relation to their oxidation-reduction potentials (Table 4). This significant result gives

Table 4. UNCATALYSED HYDROGEN-TRANSFER BETWEEN 1:4-DIHYDRONAPHTHALENE AND QUINONES IN PHENETOLE SOLUTION

Quinone	$10^4 k_2^{100}$ (gm.-mol./ lit./sec.)	E_{arr} (kcal./mol.)	E_0 (in volts)*
Benzoquinone	1.32	20.0	0.711
Toluquinone	0.428	20.5	0.656
Thymoquinone	0.087	20.5	0.589
1:4-Naphthoquinone	0.032	21.0	0.493

* In ethanol at 25° (Conant and Fieser, *J. Amer. Chem. Soc.*, **45**, 2208; 1923).

some grounds for confidence in the feasibility of a more general correlation, and the extension of the work to other classes of donors and acceptors is in hand.

- ¹ Wleland, *Ber.*, **45**, 484 (1912).
- ² Boeseken, *Rec. trav. Chim. Pays-Bas*, **37**, 255 (1918). Zelinsky and Pawlow, *Ber.*, **66**, 1420 (1933).
- ³ cf. Linstead *et al.*, *J. Chem. Soc.*, 1146 (1937); 1127, 1134, 1139 (1940).
- ⁴ cf. Akabori and Suzuki, *Proc. Imp. Acad. Japan*, **5**, 255 (1929). Kindler and Peschke, *Annalen*, **497**, 193 (1932). Kleiderer and Kornfeld, *J. Org. Chem.*, **13**, 455 (1948). Eschinazi and Bergmann, *J. Amer. Chem. Soc.*, **70**, 5651 (1950). Badcock and Pausacker, *J. Chem. Soc.*, 1373 (1951).
- ⁵ cf. Linstead *et al.*, *J. Amer. Chem. Soc.*, **64**, 1985 *et seq.* (1942).
- ⁶ British Patent Application 1097/51.
- ⁷ cf. Arnold *et al.*, *J. Amer. Chem. Soc.*, **61**, 1407 (1939); **62**, 983 (1940).

PLANNING AND BUDGETING OF INDUSTRIAL RESEARCH

THE report of the second Conference of Industrial Research Directors and Managers on the planning and financial control of industrial research, which was organized by the Industrial Research Committee of the Federation of British Industries, has now been published* and gives in full the introductory papers to each of the first four sessions and Dr. P. Dunsheath's final summing-up at the fifth. A selection of contributions to the various discussions is also included.

C. Paine, of Imperial Chemical Industries, Ltd., dealt with the planning and budgeting of research in a large organization and made some points of general interest, particularly in regard to long-range research, after emphasizing that the availability of good-quality leaders for further units of 6-10 men is one limiting factor on the rate at which a research organization and its budget can grow efficiently. The inception of long-term projects, arising as they do from new ideas or imaginative leaps by an individual mind, cannot be planned but only fostered. Having recruited the best quality of man available and assessed his experimental skill, imagination and technical judgment in the context of a shorter-term project, management can only exercise faith in that man and in its own judgment of him when he proposes a long-term topic for research. It is a function of management to seek constantly those factors of environment, stimulus and encouragement which assist a good man to function imaginatively at high level. A highly original exploratory project is not necessarily best served by using big battalions at the outset, and a research organization must always have reasonable opportunity and encouragement to pursue some of its own chance observations, however irrelevant these may appear in the early stages.

The long-term investigations which are sometimes referred to as 'background research', continued Mr. Paine, require a man of first-class intellectual capacity and imagination, but it is good practice to provide him with a research colleague with great experience and skill in the technology of related short-term problems. Apart from the selection of research projects, in which the essential questions are, first—What are the best topics and ideas to investigate?—and then—Can we afford to investigate all or only some of these?—there is the more difficult problem

* Report of the Second Conference of Industrial Research Directors and Managers: the Planning and Financial Control of Industrial Research. Organised by the F.B.I. Industrial Research Committee and held at Ashorne Hill, Leamington Spa, 10 to 12 November 1950. Pp. 88. (London: Federation of British Industries, 1951.) 3s.

of when to stop a project. Mr. Paine pointed out that this is a matter of the persistent sharpening of technical judgment and instinct by hard experience. Arbitrary intervention by management without the fullest attempt to understand and utilize the judgment of the research personnel involved almost invariably results in stopping the wrong project.

Other subjects of general interest raised in the discussions at the conference included the transfer and flexibility of staff, the origin of research problems and ideas, in which distinction was drawn between the two aspects, discovery and invention, and the costing and the evaluation of research. Some of the difficulties in, and objections to, costing research were discussed, and the importance was emphasized of making costing as simple as possible, accepting it as an approximate activity and putting it over intelligently to the research staff. There was general agreement that evaluation of research work is desirable; but the difficulties of expressing its value in financial terms are practically insuperable.

CONFERENCE ON DIELECTRICS

A CONFERENCE on dielectrics was held in Liverpool during July 23–25. The Conference was organized by the Department of Theoretical Physics of the University of Liverpool, in collaboration with the Department of Extra-Mural Studies of the University, the Institute of Physics and the Electrical Research Association.

Dielectrics is a subject which brings together people with very different backgrounds, including experimental and theoretical physicists, chemists and electrical engineers. Each group of subjects was therefore introduced by a fairly long review, summarizing the principal aspects or the recent advances connected with the subject for the benefit of those who are not working in that particular field. The reviews were followed by original contributions. These unfortunately had to be rather short because of the large number of papers presented.

The meetings were held in one of the residential halls of the University situated outside the city in pleasant surroundings, and all the meals were also served in the same building. The sittings were fairly short with long intervals for coffee, lunch and tea, which all helped to give plenty of opportunity for private discussions, which was one of the principal aims of the conference.

About a hundred and sixty people attended the meetings, a third of whom came from overseas. The distinguished visitors from abroad included E. Bauer (Paris), C. J. F. Böttcher (Leyden), R. H. Cole (Brown University), R. M. Fuoss (Yale University), M. Magat (Paris), J. C. Slater (Massachusetts Institute of Technology) and C. P. Smyth (Princeton).

The field which showed the greatest advance since the conference on the same subject held in Bristol in 1946 was that of the ferro-electrics. While the reasons for ferro-electricity were obscure in 1946, the main principles are now well understood.

A considerable amount of work was presented on the phase transitions of solid hydrogen halides, but the state of affairs is very complicated and a complete explanation of the connexion between the dielectric and structural changes of these materials at the transitions is still outstanding. Important results

have been obtained on the electrical breakdown of liquids, and significant advances were also presented in many other fields.

The most controversial subject turned out to be the breakdown of solids.

The first day started with a short introduction to the Conference by H. Fröhlich. This was followed by a review by J. C. Slater of the theory of ferro-electricity and permanent polarization. Prof. Slater presented his subject in a remarkably clear way, so that even those who had known nothing about it previously grasped the principles of ferro-electricity. A. F. Devonshire explained that the electric and elastic constants of the non-cubic phases of barium titanate can be calculated from the constants of the cubic phase; but in order to use these results for the calculation of the constants of a ceramic, which is polycrystalline, one would have to average over crystallographic directions and it is not known how the averaging process is to be carried out. D. M. Finlayson reported measurements on potassium dihydrogen phosphate which showed that both the 'free' and the 'clamped' dielectric constants become independent of temperature at about 60° K., whereas current theories suggest that this should occur at about 100° K. The discrepancy indicates that down to 60° K. small fields can induce a movement of the domain walls.

K. Huang presented two phenomenological equations and suggested that these make the treatment of the interaction of an ionic crystal with an electric field easier than previous methods. He showed how these equations can be applied to various problems, in particular to the transverse optical vibrations in the crystal. Two papers, by A. Schallamach and by C. G. Garton, discussed the distribution of relaxation times in amorphous materials. L. Hartshorn reviewed methods used for the measurement of dielectric constants with high accuracy and discussed the practical limitations. He explained why the accuracy is highest in the centimetre region. This review was followed by many very short communications concerning experimental methods.

The second day started with C. P. Smyth's excellent review on the connexion between chemical structure and dielectric properties. Prof. Smyth also mentioned some recent results concerning long-chain alcohols in long-chain organic solvents. For alcohols of moderate chain-length the relaxation time is independent of the viscosity of the solvent, which shows that the forces governing molecular rotation are not connected with the flow viscosity. But for alcohols with very long chains, the relaxation time is not independent of the flow viscosity of the solvent. J. Lamb presented measurements on solid pentamethyl-chlor-benzene and similar materials, which exhibit excellent Debye curves with scarcely any spread of relaxation times. These materials are so like the ideal theoretical model in behaviour because their molecules are very rigid and have very nearly circular cross-sections. R. H. Cole showed absorption curves of glycerine derivatives. He showed, with the aid of Cole-Cole plots, that a number of these compounds possess two distinct relaxation mechanisms. He also mentioned measurements on solid hydrogen bromide and said that by annealing it between the electrodes one gets rid of hysteresis effects and at the lowest transition the dielectric constant then reaches values of about 200. D. H. Whiffen said that a number of non-polar liquids exhibit a very small dielectric absorption in the