

Journal Review

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All persons who are concerned in any way with the development of energy resources must, at times, have experienced a feeling of frustration at our inability to convert, or store, efficiently and economically, the abundant solar energy which falls on earth. Many naturally occurring processes have a photochemical basis and logical reasoning must give rise to the thought that the solution to the solar energy problem lies in photochemistry. The publication, in this special issue of the *Journal of Photochemistry*, of the six invited papers presented at the Second International Conference on the Photochemical Conversion and Storage of Solar Energy, held at Cambridge, England, in August, 1978, is therefore most welcome and opportune.

Because of its intermittent nature, variable intensity and, at least in some parts of the world, unpredictability, some form of energy storage is an essential adjunct to any solar energy system, and is becoming of increasing importance for the economic operation of other energy systems. The first paper in this special issue, *Energy Storage in Organic Photoisomers* by G. Jones, Sheau-Hwa Chiang and Phan Thanh Xuan of Boston University, U.S.A., is therefore of interest to many persons. The storage of energy as latent heat in chemical bonds is a fascinating concept; particularly attractive is the possibility of storage by this means for long periods; a capability which is lacking in many other storage systems. The paper outlines the general requirements which have to be met for the successful conversion and storage of solar energy by photochemical methods, briefly reviews recent work related to the development of organic photoreactions, and then goes on to consider photo-induced isomerization reactions in particular. Geometrical isomerizations are efficient, but energy differences are small, so valence isomerizations, which offer higher storage enthalpies (more than 10 kcal mol^{-1}) are preferred although they probably require a greater driving force. By circulation over a suitable catalyst the isomers revert to their original form with the release of the stored energy as heat.

Important factors in the successful large scale application of this method of energy storage are the availability of low cost storage materials and the number of energy storage and release cycles that can be obtained from them before some form of degradation occurs. The choice of inexpensive materials is not great, but the possibilities appear to be quite promising; information on cycle life is not yet available. The latter part of the paper deals with the selection of reactions, substrates, and mechanisms, and concludes with a consideration of possible methods of activation of chromophores to visible radiation.

Solar energy conversion is considered in two papers, *Photogalvanic Cells* by W. J. Albery and A. Foulds of Imperial College, London, U.K., and *The Physics and Chemistry of Solar Cells* by K. W. Böer of the College of Engineering, University of Delaware and SES Ltd., Newark, U.S.A.

The photogalvanic paper describes the theory of photogalvanic cells and from an analysis of the system deduces the vital characteristics of an ideal cell. The iron-ruthenium and iron-thionine cells are discussed with respect to these characteristics. The analysis suggests that power conversion efficiencies of around 20% are possible, but to-date, values of only about 1% have been obtained. Possible reasons for this low value appear to be the difficulty of developing the full voltage and the high value of the absorbance length; improvement of both these factors appears possible. The importance of mass transport, homogeneous and electrode kinetics, as well as photochemistry is emphasised. In the second paper a brief general introduction is given of the mechanism of photovoltaic cells, followed by a description of the difficulties of the physical theory of such cells, a description of their component parts, and of their operational properties. From consideration of the quantitative characteristics of each part, their additive effect, and the interplay between them, the theory of emitter-controlled, front wall cells is developed. In the development of this theory, the great importance of the chemistry of the interfaces between the various parts becomes apparent. The results of the theory are compared with experimental results for CdS-Cu₂S or Cd_z-Zn_{1-z}S-Cu₂S cells, and the application of the theory to the prediction of the performance of possible materials is given. The characteristics of possible materials are defined and an impressive list of candidate emitter materials is given. A number of material combinations appear to offer prospects for efficient solar cells but few of these have been examined. It would seem, therefore, that there is still hope that an inexpensive solar cell of useful efficiency may one day become a reality, but that silicon cells will probably continue to be the best available cell for some years to come.

In the paper *Light-induced Electron Transfer Reactions*, Norman Sutin of the Brookhaven National Laboratory, Upton, U.S.A., is concerned with photo-induced electron transfer reactions of metal complexes in solution, and uses the polypyridine-ruthenium complexes as an example with emphasis on the kinetic and mechanistic aspects. Redox quenching of activity converts the excited state into a powerful oxidant or reductant and so can lead to the generation of oxygen or hydrogen and possibly to the photo-induced decomposition of water. Obviously the choice of suitable quenchers is vital and back reactions must be suppressed. Possible ways of achieving this suppression are discussed. Theoretical models for electron transfer reactions are developed and the advantages of each model are discussed in terms of these two factors. The possibilities of developing working systems based on the most promising models are considered.

The principles of photoelectrochemical cells are described and the important factors for practical systems are detailed in the paper *Photoelectrochemistry and Heterogeneous Photocatalysis at Semiconductors* by Allen J.

Bard, The University of Texas at Austin, U.S.A. Cells are considered under the headings of photovoltaic, photoelectrosynthetic and photocatalytic types, and descriptions of each type are given. With the photovoltaic cells open circuit voltages of about 0.9 V have been obtained with efficiencies of up to 9%, no indication of cell size or weight is given. Photoelectrosynthetic cells are used to drive a cell reaction so that the radiant energy can be stored as a chemical fuel, e.g., hydrogen or oxygen. Efficiencies to-date are not very high for solar radiation and this type of cell appears to offer greater promise for driving other types of chemical reaction. Photocatalytic cells are used to overcome the energy of activation of a process and appear to offer promise in oxidation reactions and, perhaps, in the treatment of waste materials. The advantages of particulate systems in terms of lower costs and simplicity for photoelectrosynthetic and photocatalytic cells are cited, and some possible systems are described together with the practical applications of some of them. Finally, a model of photosynthesis is developed in comparison with the biological photosynthesis process for the oxidation of water and the reduction of CO_2 , and the requirements for the semiconductors and solutions for the photoelectrolysis of water are deduced.

The final paper, *Synthetic Molecular Organizes* by Hans Kuhn of the Max-Planck-Institut, Göttingen-Nikolausberg, F.R.G., although the least advanced practically, is probably the most fascinating. It suggests the possibility that molecular aggregates of specifically designed architecture (S.M. Os.), prepared by the assembly of monolayers of planned composition, operating as functional units, may be the means of developing large area solar energy conversion and storage devices. The basic design would be similar to the structure used naturally for the primary process of photosynthesis in plants. Ways of obtaining S.M.Os. are described and their possible applications are discussed in detail, together with supporting experimental evidence in some cases. Their use in systems of energy collection and trapping, charge separation, maintenance of charge separation and electron transfer, appear to be promising areas of application together with their use for examining tunnelling effects. Examples of their use for energy and electron transfer in photographic and photogalvanic processes are given.

This issue of the Journal should be read by all persons who believe that solar energy will make a significant contribution to future global energy requirements. I am looking forward to the papers to be presented at the next, 3rd, Conference to be held at the Solar Energy Research Institute, Golden, California, U.S.A., in August, 1980.

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