

## Book review

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*Catalysis. Progress in Research*, edited by F. Basolo and R.L. Burwell, Jr., Plenum Press, London, 1973, xvi + 193 pages, £5.50.

The related fields of heterogeneous catalysis, homogeneous catalysis and metalloenzyme catalysis have developed independently to a surprising extent. All three fields are concerned with certain problem areas which have enormous technological implications and bear directly on the need to husband our chemical and fuel resources more efficiently. These considerations set the scenario for an international, interdisciplinary conference to exchange ideas and this book is the published result.

Prior to the conference, twenty-five papers, either reprints or specially written reviews were circulated to outline the most important recent developments in the three areas. Ten of these papers, presumably the specially written reviews, constitute the bulk of this book.

The reviews on metalloenzyme catalysis are by C. Veeger (General Survey), J.E. Coleman (Catalysis by Metalloenzymes), S.J. Benkovic (Metal Ion Activated Enzymes) and G.A. Hamilton (Redox Reactions Catalysed by Metalloenzymes).

The heterogeneous catalysis reviews are by R.L. Burwell Jr. (General Survey), R.J. Kokes (The Nature of the Active Sites), C. Kemball (Selectivity and Poisoning), S.J. Teichner (Oxidation and Deoxidation) and W.K. Hall (Reaction Schemes and Coordinates). Homogeneous catalysis is represented by a single general review by J. Chatt and J. Halpern.

The proceedings of this conference went beyond an exchange of ideas however, and the last third of the book is devoted to summaries of group discussions of six topics of common interest: Kinetics and Mechanism, Hydrogenation and Dehydrogenation, Nitrogen Fixation, Oxygen Activation, Hydrocarbon Activation, and Heterogenizing Catalysts.

The reviews are excellent, clearly stated summaries. Care has been taken to avoid the special language which develops in a limited research area and can be largely incomprehensible to outsiders. The reviews can therefore be recommended to chemists who have no special knowledge of the subjects. A number of important subjects are not covered or discussed only briefly. Thus, there is no discussion of vitamin B<sub>12</sub> which is the only known case where organometallic chemistry is involved in an enzyme mechanism. Further, homogeneous catalysis is restricted to a single general review. If the remaining fifteen papers used as a basis for discussion were omitted because they were reprints, it is unfortunate that specific reference was not made to them. This omission is mitigated to some extent however by the inclusion of references in most of the reviews.

The group reports, although brief are important. They not only consider recent developments in technique and theory for their interdisciplinary relevance, but they also discuss current problems and how to solve them. They, therefore,

read something like proposals for future grants and will doubtless be useful for that purpose. Some very specific recommendations are made and persuasive cases argued for them. Some typical examples: (a) The study of metal cluster complexes as models for heterogeneous catalysis, (b) The study of hydrogen fixing bacteria to compare the responsible enzyme system with the well characterized homogeneous and heterogeneous systems, (c) A search for mutant enzymes with a high capacity for nitrogen fixation, (d) A search for soluble enzymes for hydrocarbon oxidation, and (e) A search for catalysts which will hydrogenate  $\text{CO}_2$  to useful products.

Research in both heterogeneous and enzyme catalysis is complicated by the difficulty of studying the reactive species. In the former case they can only be observed on catalyst surfaces. In the latter case, the molecules are so complex that just unravelling their structure is a major problem. Homogeneous catalysis by simple metal complexes is far more amenable to study and this has resulted in a better understanding of catalytic mechanisms in this field. This knowledge should be applicable to more complex systems. Presumably this expectation was partly responsible for the conference and thus this book. One therefore, looks for answers in this book to questions such as the following:

Many so called "model systems" have been examined in homogeneous catalysis for their relevance to heterogeneous and enzyme catalysis, to what extent have they been of value?

Is there something unique about catalysis at metal surfaces or is a metal-metal bond only a variant of metal-ligand bonds?

Is there something unique about the complex structures of metalloenzymes or could we get similar effects with low molecular-weight metal complexes having appropriate ligands and suitably placed cocatalyst centers? Questions of this type which cut across disciplines are difficult to answer. Qualifications are frequently needed to avoid being simplistic. However, many of the contributors have made a real effort to come up with answers and this is what gives the book much of its value. I hope I won't be accused of giving away the plot if I reveal that the expected relevance of homogeneous catalysis has been fulfilled to a greater extent in heterogeneous catalysis than in enzyme catalysis.

After reading the book I feel optimistic that homogeneous catalysis will find future relevance to enzyme catalysis. (See Coleman's review for some cautionary remarks, however.) The last report (Heterogenizing Catalysts) concerns the commercial application of homogeneous catalysts to heterogeneous catalysis. I look forward to the results of a future conference which could end with a report on the commercial application of homogeneous catalysts to enzyme catalysis entitled "Synthetic Enzymes".

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