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BOOK REVIEWS

Catalysts for Fuels from Syngas: New Directions for Research. By G. ALEX MILLS. IEA Coal Research, London, August 1988.

This book is a quite detailed report on the current state of science and technology of catalytic conversion of synthesis gas to liquid hydrocarbons and to oxygenated fuels. It identifies exploratory research results and new catalytic concepts of potential importance for improvements in indirect coal liquefaction. It is based on an evaluation of more than 300 recent research papers and concludes that there are three major opportunities to improve syngas conversion processes by means of new and improved catalysts which will provide higher selectivity to high-performance fuels, decreased plant investment costs, and improved thermal efficiency. The report includes recommendations for research for near term applications, research for the midterm, and research for the long range. The book is a valuable compilation and evaluation of research and development papers in the syngas conversion field. It contains a chapter of economic considerations which, however, is rather brief and does not allow conclusions as to the economic value of the individual process improvements. The author estimates that catalysts having improved capabilities for syngas conversion have the potential to improve the economics of synthetic fuels manufacture by 10 to 30%. This may be an optimistic estimate since the syngas conversion step contributes no more than one-third to the overall cost of a process based on coal and involving syngas production and purification as well as syngas conversion.

H. HEINEMANN

Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Applied Heterogeneous Catalysis. By J.-F. LE PAGE *et al.* [Transl. by Ethel B. Miller and Ryle L. Miller]. Editions Technip, Paris, 1987. 560 pp. Fr. F. 825.

A wealth of scientific and engineering experience has been contributed to the writing of "Applied Heterogeneous Catalysis" by a team of authors (J.-F. Le Page, J. Cosyns, P. Courty, E. Freund, J.-P. Franck, Y. Jacquin, B. Juguin, C. Marcilly, G. Martino, J. Miquel, R. Montarnal, A. Sugier, and H. van Landeghem) from the Institut Français du Pétrole. The book is a translation by Ethel B. Miller and Ryle L. Miller from the original French text published in 1978. It arose from the research of a group of scientists and engineers who determined and subsequently developed correlations enshrining the preparation and behaviour of catalysts used in the petrochemicals industry. Much of the information and all of the examples contained in the text are distilled from experimental data and operating experience of the Institut Français du Pétrole and Rhône-Poulenc who jointly formed the Procatalyse Company to develop appropriate catalysts suitable for commercial processes.

The full extent of the text comprises eight chapters totaling 508 pages including references but excluding the subject index, foreword, and preface. The first chapter deals with general matters and principles relating to heterogeneous catalysis. None of the principles are dealt with in any depth in this chapter but a useful introduction to what follows is given. Chapter 2 provides an introduction to the chemical kinetics of single and multistep reactions and indicates how a rate-limiting step may be identified. There is nothing contained in Chapter 2 which is not adequately discussed in other well-known texts.

Chapters 3, 4, and 5 on the other hand provide a good deal of original information concerning the selection, development, and preparation of catalysts used for petrochemical processing. They are nevertheless not unique because the principles of catalyst preparation were discussed at considerable length in the volumes of "Contact Catalysis" edited by Szabó and Kalló and published by Elsevier in 1976. Similarly much helpful material is incorporated in Chapters 6 and 7 which deal with the physical properties and physicochemical characteristics of catalysts. Many academic researchers would find the sections on morphological and mechanical properties helpful and instructive. Chapter 8 on the design of catalytic reactors is really a review of principles and practice which have been elaborated more explicitly elsewhere. Perhaps it is the more extensive and comprehensive Chapter 9 containing specific examples of catalyst and process development which is not only illuminating but also pertinent and specific. In this chapter alone a whole range of pragmatic design and operating experience is divulged which, collectively, is a useful reference source.

The claim that the book might be of interest to teachers (of chemistry and chemical engineering) is somewhat excessive for there is only a minimum of principles treated in any depth. However, the text

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does contrive, and somehow manage, to effect a balance between principles and practice and does include the important topic of catalyst preparation eschewed in most other texts. Both academic and industrial researchers will therefore find much to interest them between the covers of this book.

Due to the lapse in time between the original publication and its translation, no references later than 1980 are quoted and this is regrettable. However, Chapter 9 does describe unpublished useful and current process information.

W. J. THOMAS

School of Chemical Engineering
University of Bath
Bath BA2 7AY, United Kingdom

Catalysis in Coal Liquefaction: New Directions for Research. By FRANK J. DERBYSHIRE. IEA Coal Research, London, United Kingdom, 1988. 69 pp. $60.00 to member countries, $180.00 to nonmember countries.

IEA Coal Research issues report on various aspects of coal science and technology. The author chosen to write on catalysis in coal liquefaction faced a formidable task. There is a plethora of published papers on this subject and separating the wheat from the chaff is difficult. Fortunately, the author has written an excellent manuscript that is a must for any worker in, and around, the field of direct coal liquefaction. This could have been accomplished only by someone whose vast experience in this area lends confidence to his judgment.

The "direct" liquefaction of coal connotes the conversion of coal to liquids (with some gases) by a route that does not proceed by means of the intermediate production of synthesis gas. The latter is termed "indirect" liquefaction and is exemplified by the Fischer–Tropsch process. The direct catalytic liquefaction of coal is usually carried out at about 400°C and 13–20 MPa of H_2. Covalent bonds are broken under these conditions; it is generally assumed that the radicals formed are capped by hydrogen atoms from H_2 or from hydroaromatic polynuclear compounds in the solvent used to slurry the coal into the reactor.

Coals differ greatly in carbon, oxygen, and sulfur contents as well as in the amounts and kinds of inorganic materials. The fact that coals are solids greatly complicates processing. This volume, if studied carefully and the selected references read, will open the door a bit to the use of catalysts in direct coal liquefaction for those not familiar with the field. It has value as a guide for those not involved in this area of catalyst research; it furnishes a path through the foliage which precedes the dense woods that constitute direct coal liquefaction research. The way is not easy to follow and many workers in catalysis tend to avoid the subject.

Coal is a reactive macromolecular substance which may be "depolymerized" at comparatively low temperatures (100–250°C) with acid catalysts operating chiefly by ionic mechanisms. The catalyst should promote the cleavage of connecting linkages between clusters and also prevent retrogressive reactions of reactive intermediates. The difficulty lies in balancing the rather easily achieved depolymerization step with a high-temperature (400–450°C) hydrogenation (hydrogenolysis) step to produce quality distillate fuels while preventing the formation of high-molecular-weight substances. This is the heart of the problem in direct coal liquefaction and it is far from being solved. Evolutionary progress has been made; revolutionary solutions are called for. One apparent approach is to find factors which influence the introduction of catalysts to the coal in an active and highly dispersed form. Methods for quantifying the dispersion are needed. It is proposed that highly dispersed catalysts be used in a first stage, followed by a second upgrading step. Supported catalysts are generally used in this latter stage, but they are easily deactivated with high-boiling feeds. Perhaps research on catalyst–support interactions will be useful in this regard.

The author expresses surprise at how seldom optical and microscopic techniques have been used in the field of catalytic coal liquefaction. This is an area in which catalyst researchers can make significant contributions by introducing and modifying methods they commonly use. H_2S plays an important role in coal liquefaction although it is still unclear.

The bibliography is extensive but selective rather than comprehensive. This report could be of interest to catalyst researchers in general; workers in coal conversion would be well served to own this volume. However, the price of the report is a deterrent.

IRVING WENDER

Department of Chemical and Petroleum Engineering
University of Pittsburgh
Pittsburgh, Pennsylvania 15261