Understanding Heterogeneous Catalysis

ELECTRON MICROSCOPY IN HETEROGENEOUS CATALYSIS

BY P. L. GAI AND E. D. BOYES, Institute of Physics Publishing, Bristol, U.K., 2003, 233 pages, ISBN 0-7503-0809-5, £75, U.S.$110.00

Catalysis is a truly multidisciplinary subject covering aspects of surface science, materials science, physical/inorganic/organic chemistry, chemical engineering and computer modelling. Catalysts are found in many chemical processes, operating from room temperature to 1100°C (Andrussow process), at pressures from subatmospheric to hundreds of atmospheres, with a whole range of solvents, gas compositions and contact times.

"Electron Microscopy in Heterogeneous Catalysis" is an enjoyable account of the impact of electron microscopy on our understanding of heterogeneous catalysis. The book is the latest installment in the "Series in Microscopy in Materials Science". Microscopic techniques range from high resolution transmission electron microscopy (HRTEM), which under favourable conditions can image particles less than 1 nm in size, to nanoscale analytical techniques for the determination of elemental compositions of small catalyst particles. Equally important is environmental TEM with reaction cells in which catalysts can be dosed with gases and liquids, making the *in situ* study of working catalysts possible.

Of particular interest is Chapter 5 entitled 'Catalysis by supported small metal particles'. Here, an in-depth review of TEM studies in catalysis by supported metals is presented. Catalyst deactivation is examined in some detail, using Pt/Al_2O_3 and Pd/Al_2O_3 as two of the examples, with discussions on sintering mechanisms and effects. There is also a review of strong metal-support interaction (SMSI) effects when metal particles become covered by the support under reducing conditions at elevated temperatures. Here, TiO_2 as a support is examined in some detail.

Supported bimetallic or even multimetallic catalysts are also used in catalytic processes and the interaction between the components is generally complex. Pd-Cu/C is taken as one example and TEM shows that thermal treatments above 600°C give a f.c.c. continuous Pd-Cu alloy, while below 600°C ordered Cu_3Pd and CuPd phases are observed. Further complications arise as the morphology and composition of metal phases in the catalyst are often affected by the nature of the gas stream passing over it. For example, treatment of Cu-Ru/C with CO leads to sheet-like Cu particles and small Ru particles, while H_2 treatment gives large spherical Cu particles as well as small Ru particles. However, with $Pt-Rh/SiO_2$, TEM shows that under N_2 heat treatments only Pt-Rh alloy particles are formed, while in air rhodium oxide over-layers form around the metal particles. In both these cases the particles are polyhedral or spherical in shape; cubic and twinned particles are generated by high-temperature treatment in H_2.

Other chapters cover electron microscopy studies of oxide catalysts, studies of zeolite catalysts, and environmental catalysis and catalyst design – of significant interest to those in these fields.

Because of the broad nature of the subject Gai and Boyes have taken great care to introduce important materials science and chemistry concepts. In fact, the first 80 pages of the book are an introduction. Personally I found the chemistry aspect rather long and starting from too low a point with detail such as 'a material consisting of atoms of several elements is called a compound' spoiling the flow of the text. However, the authors have had a difficult task to introduce both chemistry to materials scientists and materials science to chemists and presumably both subjects to physicists and engineers. In spite of this the book is an interesting read and a welcome addition to the existing literature in catalysis science. It is aimed at those working in industry and academia and is suitable for undergraduate level and above.

P. J. COLLIER

Paul Collier is a Senior Research Scientist at the Johnson Matthey Technology Centre, Sonning Common, U.K. He is interested in all aspects of heterogeneous catalysis, especially gas phase catalysis.