

Introduction: Heterogeneous Catalysis

Heterogeneous catalysis is crucial to chemical technology. Innumerable chemical reactions are facilitated by catalysts. Chemical bonds are broken and new chemical bonds are formed during the catalytic process. These events occur repeatedly, usually without a significant change of the catalyst. In the absence of the catalysts, this chemical transformation would either not occur or would take place with lower efficiencies or slower rates.

The study of heterogeneous catalysis dates back to the early 1800s. Faraday was one of the first scientists to examine the ability of platinum to facilitate oxidation reactions. Many other catalytic processes were subsequently developed that facilitated hydrogenation, dehydrogenation, isomerization, and polymerization reactions. These catalytic reactions all played a key role in the development of the industrial revolution.

The ability of catalysts to crack long-chain hydrocarbons to smaller chain hydrocarbons was critical for the emerging automobile industry. The catalytic processing of crude oil to fuels and other petrochemical products continued to impact society and lifestyles during the 1900s. As we approach the 21st century, we would have difficulty imagining our world without the fruits of heterogeneous catalysis. The needs for better catalysts will only increase as environmental and economic concerns motivate the development of more efficient catalysts.

This thematic issue of *Chemical Reviews* highlights many important topics in heterogeneous catalysis. These areas represent some of the many important subfields of heterogeneous catalysis. Other topics that are not included may have been recently reviewed elsewhere. In addition, other potential authors that were asked to write a review did not choose to contribute to this thematic issue at this time.

Generation of the catalyst is often critical for its subsequent performance. J. A. Schwarz, C. Contescu, and A. Contescu review this area in the article entitled "Methods for Preparation of Catalytic Materials". The supported metal catalyst plays a central role in heterogeneous catalysis. B. C. Gates overviews this area with his review "Supported Metal

Clusters: Synthesis, Structures, and Catalysis". Surface science has contributed to our understanding of supported metal catalysis by investigating chemical reactions on model single crystal surfaces. This area is described in the review "Model Studies in Catalysis Using Surface Science Probes" by D. W. Goodman.

Inorganic oxides and zeolites play an extremely important role in heterogeneous catalysis. The article entitled "Heterogeneous Base Catalysis" by H. Hattori provides a review of the development and current understanding of base-catalyzed reactions. Complementing this review, A. Corma provides an overview of acid-catalyzed reactions with the article "Inorganic Solid Acids and Their Use in Acid-Catalyzed Hydrocarbon Reactions". W. E. Farneth and R. J. Gorte describe the experimental methods that have been utilized to determine acidity in zeolites in the article "Methods for Characterizing Zeolite Acidity". The theoretical understanding of the zeolitic proton site and reactions catalyzed by these sites is reviewed in "Reactivity Theory of Zeolitic Brønsted Acidic Sites" by R. A. van Santen and G. J. Kramer.

Understanding the kinetics of heterogeneous catalysis is vital to establish product conversion rates and to identify the underlying mechanism of the catalytic reaction. The review on "Turnover Rates in Heterogeneous Catalysis" by M. Boudart explores the development of the important concept of turnover rates in heterogeneous catalysis. Recent modeling of the rates of catalytic processes have utilized Monte Carlo simulations. An overview of this approach is presented in "Modeling the Kinetics of Heterogeneous Catalysis" by H. C. Kang and W. H. Weinberg. Isotope studies have played an important role in establishing the kinetics and mechanism of chemical reactions. An overview of this area is presented by S. L. Shannon and J. G. Goodwin, Jr. in the review "Characterization of Catalytic Surfaces by Isotopic-Transient Kinetics during Steady-State Reaction". Oscillatory chemical reactions reveal the feedback between competing kinetic processes. Recent studies

of this phenomena on catalytic surfaces are reviewed in "Oscillatory Kinetics in Catalysis" by R. Imbihl and G. Ertl.

Environmental concerns will continue to influence catalysis and motivate the development of catalysts for environmental remediation. A. L. Linsebigler, G. Lu, and J. T. Yates, Jr., review a potentially important photocatalyst in "Photocatalysis on TiO₂ Surfaces: Principles, Mechanisms, and Selected Results". Reactions on supported metal catalysts often

involve migration of the adsorbed species from the metal to the oxide support or vice versa. This intriguing area is presented in the review "Spillover in Heterogeneous Catalysis" by W. C. Conner, Jr., and J. L. Falconer.

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