Heterogeneous Catalysis of Mixed Oxides
Perovskite and Heteropoly Catalysts

Volume 176

Makoto Misono
Professor Emeritus of the University of Tokyo
Department of Applied Chemistry
Graduate School of Engineering
Hongo, Tokyo, Japan
### Contents

1. **Basis of Heterogeneous Catalysis**  
1.1 Catalyst and Catalysis  
   1.1.1 Rate and Equilibrium of Chemical Reaction and Role of Catalyst  
   1.1.2 Three Essential Functions of Catalyst  
   1.1.3 Essence of Catalytic Functions Based on Reaction Mechanism  
   1.1.4 A Short History of Industrial Catalysts  
   1.1.5 Classification of Catalysts  
   1.1.6 Practical Applications of Catalysts  
   1.1.7 Components and Shape of Industrial Catalysts  
1.2 Rate of Catalytic Reaction and Reaction Mechanism  
   1.2.1 Reaction Rate  
   1.2.2 Adsorption on Solid Surface; Rate and Isotherm  
   1.2.3 Rate Equation of Catalytic Reaction  
   1.2.4 Reactor Type and Rate Expression  
   1.2.5 Elucidation of Reaction Mechanism  
   1.2.6 Mass and Heat Transfer  
   1.2.7 Deactivation of Catalyst  
   1.2.8 Comparison of Heterogeneous, Homogeneous and Biocatalysis  
1.3 Catalyst Design  
1.4 Preparation and Characterization of Catalysts  
References  

2. **Chemistry and Catalysis of Mixed Oxides**  
2.1 Chemistry of Binary Oxides  
   2.1.1 Structure of Binary Oxides (or Single Metal Oxides)  
   2.1.2 Lattice Defects and Nonstoichiometry (Berthollide Compounds)  
   2.1.3 Surface Structure of Single Metal Oxides  
   2.1.4 Chemical Properties of Single Metal Oxides  
   2.1.5 Catalysis of Single Metal Oxides  
2.2 Chemistry of Mixed Oxides  
   2.2.1 Structure of Mixed Oxides  
   2.2.2 Valence and Defects in Mixed Oxides  
   2.2.3 Acidity and Basicity  

References
4.2 Chemistry of Heteropoly Compounds in Solution
4.2.1 Formation and Stability of Heteropolyanions
4.2.2 Acidic Properties in Solution
4.2.3 Redox Properties in Solution
4.3 Structure of Heteropoly Compounds in the Solid State
4.3.1 Hierarchical Structure of Solid Heteropoly Compounds
4.3.2 Primary Structures
4.3.3 Secondary Structures
4.3.4 Tertiary Structure; Particle Size, Surface Area, and Pore Structure
4.3.5 Stability
4.4 Chemical Properties of Heteropoly Compounds in the Solid State
4.4.1 Pseudoliquid Behavior
4.4.2 Acidic Properties
4.4.3 Reduction and Oxidation (Redox) Properties
4.5 Catalysis of Heteropoly Compounds
4.5.1 Three Types of Catalysis in the Solid State
4.5.2 Acid Catalysis
4.5.3 Oxidation Catalysis
4.5.4 Bifunctional Catalysis
4.6 Supported Heteropoly Catalysts
4.6.1 Necessity of Supported Heteropoly Catalysts
4.6.2 Heteropoly Compounds Supported on SiO₂
4.6.3 Industrial Production of Ethyl Acetate from Ethylene and Acetic Acid

References

5. Mixed Oxides as Catalyst Supports

5.1 Roles of Catalyst Supports
5.1.1 Improvement of the Catalytically Active Component Itself
5.1.2 Improvement of the Catalyst as a Whole
5.2 Perovskites as Catalyst Supports
5.2.1 Perovskites Supports
5.2.2 Perovskite Supports for Automotive Catalysts
5.3 Ceria–Zirconia and Related Mixed Oxides
5.3.1 Storage Effect for Oxygen and Nitrogen Oxide
5.3.2 Mixed Oxide Supports for Noble Metals of Automotive Catalysts
5.4 Heteropolyacids (Polyoxometalates) as Catalyst Supports
5.5 Zeolites as Catalyst Support
5.5.1 Dispersion of Metal Ions by Ion Exchange
5.5.2 Pd Supported on ZSM-5 for NO—CH₄—O₂ Reaction

References

Index