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Book Review

HANDBOOK OF HETEROGENEOUS CATALYSIS

Second, Completely Revised and Enlarged Edition
Volume 5

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The fifth volume of the **Handbook of Heterogeneous Catalysis** is organized in two sections: *Environmental Catalysis* and *Inorganic Reactions*.

The information provided in the first chapter (***Environmental Catalysis***) of this volume remarkably reveals the increasing importance of applied environmental catalysis and moreover highlight the progress of modern society for minimizing the environmental impacts.

Although, the environmental catalysis is defined as the combined fields of heterogeneous, homogeneous and biocatalysis, this chapter is focused on the heterogeneous catalysis only. Catalysis in Environmental Protection reviews the fundamentals of the environmental catalysis by offering brief information on the history, potential and opportunities of this field, nicely illustrated by few carefully selected examples.

The future prospects of the catalysis for environmental protection including the conversion of renewable sources into chemicals, the switch from oil and gas to lignocellulose feedstocks are presented, as well. Due to the fact that the automotive exhaust is a major problem that closely went together with the industrialization of the Western world, the next sub-chapter deals with the Automotive Exhaust Treatment.

The first feature taken into account is the legislation which limits the gas emissions; brief overview of the origin of this legislation, followed by the actual state and future settlements are mentioned. The concepts and design of catalytic systems used for gasoline-engines as well as changes in engine design are properly described in this section.

The sub-chapter Flue Gases on Stationary Sources begins with an overview on the emissions coming from sources raging from private homes to small industries as well as waste incineration facilities to enormous coal-fired power plants. NO_x emissions are in detail discussed in the book covering their origins, in addition to the reducing/removal technologies.

This sub-chapter goes on with a discussion on other emissions such as sulfur, hydrogen sulfide, carbon monoxide, carbon dioxide, hydrocarbons, dioxins, as well as mercury oxidation and capture. Mutipollutant processes (such as the DESONOX processes or other combined processes) and new technologies for the selective reduction of NO_x, or the oxidative removal of a mixture of chlorinated ethenes and aromatic compounds in air, as well as the photocatalytic destruction of vinyl chloride close this sub-chapter. Catalytic Dehalogenation presents an overview of this subject, with emphasis placed on recent developments in this rapidly evolving field.

Some earlier, published reviews are listed, and the reader is referred to these for a discussion of the older literature. Solid Catalysts for the Oxidation of Volatile Organic Compounds introduces the significance of this topic and some applications of catalytic oxidation for VOC control. Actually, this sub-chapter treats the catalytic oxidation of low concentrations of VOCs in air.

The catalysts considered herein are supported noble metal (i.e. palladium, platinum) and metal oxides based on vanadium, cerium, copper, chromium etc. Summary introduction on the reactors design and process configurations developed for catalytic oxidation systems is also offered.

Catalytic Combustion provides a review of the status and of the perspectives of catalytic combustion for gas turbines. Initially, details on the basic concepts associated with the system requirements are presented, after which the design approaches based on lean and rich catalytic combustion are illustrated, together with reports of performances demonstrated in full-scale and field tests. Details of the most relevant characteristics of PdO-supported catalysts and of transition metal-substituted hexaaluminates that have been most extensively considered for lean combustion applications are outlined, along with those of the noble metal catalysts adopted in rich combustion systems. Finally, concise details are provided of the use of mathematical modeling as a tool for the design and analysis of catalytic combustors, and the perspectives for this technology outlined.

The sub-chapter Catalytic Routes to Hydro(chloro)fluorocarbons reviews some of the literature reported for the synthesis of chlorofluorocarbons alternatives. Due to the limited space available in this book, only few informative references summarizing the extensive and exciting types of heterogeneous catalysis are given.

The sub-chapter Heterogeneous Catalysis in the Troposphere is an synopsis on the experimental studies conducted on catalytic reactions with real atmospheric aerosols and model catalysts. It is suggested herein that thermal and photocatalytic reactions on solid and liquid aerosol particles can play an essential role in the global chemistry of the Earth's atmosphere.

The next sub-chapter, Conversion of Biomass on Solid Catalysts, deals with the various applications of heterogeneous catalysis for converting biomass either to biobased chemicals and polymers or to heating and transportation fuels. However, it is stressed that enzymatic catalysis and homogeneous catalysis play important roles in biomass conversion; indeed, fermentation and hydrolysis are often the first steps employed in biomass processing. Therefore, in many instances, efficient processes combining biotechnologies and heterogeneous catalysis must be developed. Catalysis in Water Remediation is a sub-chapter dedicated to oxidative and reductive catalytic processes as useful tools to treat wastewaters. The oxidative processes such as wet air oxidation (i.e. conventional, supercritical and catalytic water air oxidations), Fenton processes (both conventional and photo-assisted Fenton processes) as well as photocatalysis are very well documented providing practical information on the catalytic systems and processes conditions. Unlike oxidations, reductive processes of hydrodeclorination and hydrodenitration have low history, their technical and commercial relevance is still considerably inferior and they are regarded more as alternative processes for water remediation.

Consequently, the literature is not as rich in information as their counterparts, i.e. oxidative processes. This is the reason why this book provides more details about these two reductive pathways.

Second chapter (***Inorganic Reactions***) brings attention to the important reactions such as ammonia synthesis, ammonia oxidation, hydrocyanic acid production etc that are known as important processes in the industrial chemistry.

The sub-chapter Ammonia synthesis provides an overview of the ammonia synthesis reaction, not only in terms of mechanism at atomic level, but also with regards to the material science of the catalytic system. Some basic consideration including the reaction pathway, the know-how in choosing the proper catalyst along to the reaction efficiency, thermodynamics features and real research needs open this sub-chapter. Comprehensive information concerning the generation and structure of the "ammonia iron" (iron metal with a particular texture), as better catalyst than "normal iron", can be found in the book. Special attention is given to single crystal approach in the iron system which allows developing a reaction mechanism based on the observation of elementary steps. Because ruthenium-based systems stand out among the group of non-iron catalysts with application in ammonia synthesis, the present book offers a relevant literature on this topic. Finally, the sub-chapter contains a full description of the mechanism of ammonia synthesis including basic kinetics and microkinetic models.

In the sub-chapter Ammonia oxidation the reader can find introductory features concerning the process for producing nitric acid from ammonia as well as its history and the chemistry of the process. This sub-chapter reviews some of the literature reported for catalysts used in this process, especially, platinum based catalysts has been received special attention keeping in mind that they still hold the supremacy in ammonia oxidation. During last years important progress has been made to gain more insight into the reaction mechanism of the Hydrocyanic Acid Production. Consequently, this sub-chapter offer few historical dates on this topic followed by recent research investigations into the catalysis, process and reactor engineering of hydrocyanic acid production. Hydrogen Sulfide to Sulfur (Claus Process) is an overview on the Claus process, the most significant gas desulfurizing process, covering few key dates in the history of this process, its chemistry, proper catalysts as well as the reactor design.

The sub-chapter Oxidation of Sulfur Dioxide looks inside of the most important industrial application of the sulfuric acid production. Thermodynamic consideration, reaction mechanism and kinetics, besides of the process engineering are well documented herein giving to the reader opportunity to acquire practical information on this topic. As it is indicated by the title, the sub-chapter Müller-Rochow Synthesis: The Direct Process to Methylchlorosilanes deals with the copper-catalyzed reaction of silicon with organic chlorides by which organochlorosilanes are formed.

The authors review in this the current level of knowledge and understanding on the formation of methylchlorsilanes by direct synthesis. The influencing parameters, their complex interaction and the strong impact of reactor design and reactor conditions along with the importance of the copper catalyst are highlighted.

The sub-chapter Catalytic Decomposition of Energetic Compounds: Gas Generators and Propulsion presents a survey of the catalytic decomposition of energetic compounds, mainly for propulsion applications, from past to future.

The sub-chapter is focused on the different catalytic ignition systems that have been developed and the associate monopropellants and bipropellants that have been proposed: hydrogen peroxide, hydrazine, ionic liquids, nitrous oxide, perspective and future propellants. The most pertinent data and references have been selected to provide a limited overview of this research and application fields. Within this chapter the most pertinent American Institute of Aeronautics and Astronautics papers dealing with catalytic propulsion have been included.

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