Edited by Vasile I. Parvulescu,
Monica Magureanu and Petr Lukes

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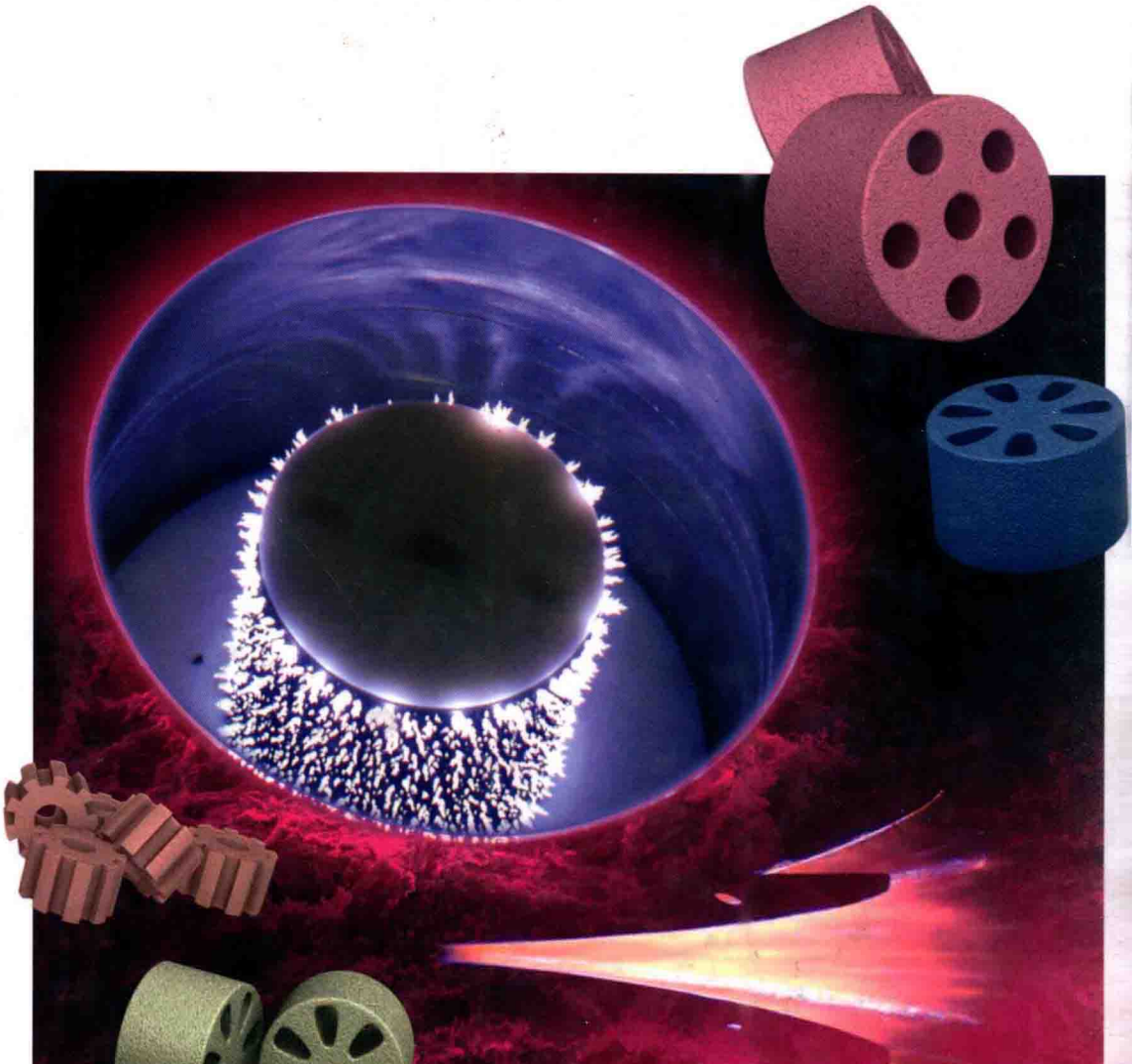
Plasma Chemistry and Catalysis in Gases and Liquids



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Preface

Plasma-chemical and plasma-catalytic processes associated with low-temperature plasma generated by electrical discharges in gas, liquid, and gas–liquid environments have recently generated considerable interest. Nonthermal plasmas offer a unique way to initiate chemical reactions in the gas phase as well as in liquids, which have potential for practical utilization in different environmental, biological, or medical applications, and also in energy topics or molecular synthesis. Since plasma-chemical processes are rather nonselective, combination with catalysis can provide improved selectivity, by steering the reactions in the desired direction. Catalyst activation by plasma is different from that in case of conventional heating, and therefore the knowledge of plasma-catalyst interaction represents a key issue both from the fundamental point of view, for the understanding of reaction mechanisms involved in the plasma-catalytic process, and obviously, from the point of view of applications. Promising results have been obtained in environmental applications, where it was found that nonequilibrium plasma generated in electrical discharges at atmospheric pressure and room temperature can be successful in destroying a wide range of air pollutants. Serious attention is also directed to plasma-catalytic applications for hydrogen production, which plays a key role in fuel cell technology, as well as for the conversion of natural gas into syngas or into higher hydrocarbons, which can be used as fuel for transportation and raw material in chemical industry. In this direction, the control of catalyst properties by preparation or treatment techniques, as well as their modifications during plasma-catalytic reactions, catalyst stability, and regeneration processes, are important issues. Another vital issue for environmental research is water pollution. During the past 20 years, promising results have been obtained for the degradation of water pollutants and inactivation of various microorganisms using nonequilibrium plasma generated by electrical discharges in liquids and gas–liquid environments. These discharges have been shown to initiate various chemical and physical processes that have potential for practical utilization in different environmental, biological, or medical applications. For example, electrical discharges were successfully applied to degrade and inactivate a number of organic compounds and microorganisms in water. There are also first successful biomedical applications of discharge plasma in liquids.

This book provides an overview of the basic principles of plasma-chemical and plasma-catalytic processes generated by electrical discharges in gas, liquid, and gas–liquid environments, which is addressed by experts in the fields of plasma physics, plasma chemistry, and plasma catalysis. The book is divided into four major sections containing altogether nine chapters that cover the state of the art of this topic in both fundamental and applied aspects.

The first section contains two introductory chapters (Chapters 1 and 2). The first chapter provides an introduction to the fundamental aspects of nonthermal plasma generated by various types of electrical discharges operating in gas at atmospheric pressure and its properties. Chapter 2 focuses on the analysis of the intrinsic characteristics of the catalysts used in plasma-catalytic processes. The control of catalyst properties by preparation and treatment techniques and factors controlling the catalyst stability and regeneration processes represent other issues analyzed in this chapter. All these aspects are important criteria for the selection of appropriate catalysts for the desired applications.

The Chapters 3–5 give an extensive overview of the plasma-catalytic processes associated with low-temperature electrical discharge plasma in gases and their application for air pollution abatement. Chapter 3 is devoted to nitrogen oxides remediation ($deNO_x$) by plasma-assisted catalysis. Chapters 4 and 5 are dedicated to the decomposition of volatile organic compounds (VOCs) in air using plasma-catalytic systems. Results obtained in different plasma-catalytic systems are discussed, and the interactions between plasma and catalysts as well as the mechanisms responsible for NO_x and VOC remediation are addressed.

The Chapters 6–8 present the state-of-art fundamental and applied knowledge on plasma-chemical processes associated with nonequilibrium plasma generated by electrical discharges in liquids and gas–liquid environments. In these chapters, for the first time, a comprehensive overview of the elementary chemical and physical phenomena in low-temperature plasma in liquid and gas–liquid environments is provided, including fundamental mechanisms of plasma generation by electrical discharges in water and gas–liquid environments, chemistry and reaction kinetics of primary and secondary species generated by plasma in water and gas–liquid interfaces, mechanisms of interaction of plasma with chemical and biological content in water, plasma-catalytic processes in water and gas-liquid environments, and environmental and biomedical applications of plasma in water and gas–liquid environments.

Chapter 9 focuses on applications of nonthermal plasma and plasma-catalytic processes in energy conversion. An overview of the current state of hydrogen and syngas production, applications, and technical requirements is presented. Detailed discussions are provided with respect to steam reforming, partial oxidation, and carbon dioxide dry reforming, including coupling to higher hydrocarbons and plasma pyrolysis, as well as combined processes, highlighting the key issues to determine practical and economic viability.

This book is equally addressed to scientists and engineers with research interests in the fields of plasma, chemistry, catalysis, pollution abatement, synthesis of new

materials, or energy conversion techniques. It may also be a very good support for students and Ph.D. students performing research in one of these fields.

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