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Green Catalysts for Energy Transformation and Emission Control

Edited by Virender K. Sharma (Texas A&M University, College Station, Texas, USA), Sue-min Chang (National Chiao Tung University, Hsinchu, Taiwan), Ruey-an Doong and Chien-Hou Wu (National Tsing Hua University, Hsinchu, Taiwan), ACS Symposium Series, Volume 1184, American Chemical Society, Washington, DC, USA, 2014, ISBN 9780841230149, eISBN 9780841230156, £112.50, US$160.00

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Introduction

"Green Catalysts for Energy Transformation and Emission Control" is book 1184 in the ACS Symposium Series, which has been published since 1974 and is peer-reviewed, consisting of original research papers and review articles. The purpose of the series is to publish comprehensive books based on current scientific research presented at ACS sponsored symposia. The content of this particular volume was developed from the symposium of the same title, held at the 246th ACS national meeting in Indianapolis, Indiana, USA, in 2013 and sponsored by the ACS Division of Environmental Chemistry. It contains 12 chapters, covering a variety of topics within the subject area, including removal of environmental pollutants from gaseous and liquid phase systems. The research interests of the book's editors include environmental applications of iron species, use of nanoparticles for decontamination of wastewater, development of materials for photocatalysis and method development for trace analysis of environmental pollutants. The intended audience of this book is graduate students who are engaged in research in the fields of green chemistry, nanotechnology and environmental science.

Removal of Pollutants and Reduction of Greenhouse Gases

The first three chapters of the book cover quite varied topics: use of iron nanoparticles to remove organic pollutants in soil, biomass-derived coal-like fuel to reduce greenhouse gas emissions and synthesis of sensors to detect and remove environmental mercury contaminants. In the first chapter of the book, as well as reviewing the use of iron nanoparticles in remediation of soil contamination, including full-scale, real-life examples, J. Virkutyte (Hammontree and Associates Ltd, Ohio, USA) and R. S. Varma (US Environmental Protection Agency, Ohio, USA) provide a comprehensive introduction to the principles of green and sustainable remediation and the processes involved, which also acts as an introduction for the rest of the book.

The second chapter is less focused on removal of environmental pollutants than preventing them. G. K. Parshetti and R. Balasubramanian (National University of Singapore) describe how addition of hydrothermally carbonised oil-palm empty fruit bunch, the primary solid waste of palm oil processing, to coal at an optimum ratio can enhance the fuel's burning properties, so that less pollutants such as carbon monoxide and methane are produced. In Chapter 3, M. Lee *et al*. (Tunghai University, Taiwan) review current developments in the use of naphthalimide derivatives for chemical sensing of mercury, which is a highly toxic environmental pollutant. Such fluorochemosensors provide an improvement over typical detection methods since they are less

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costly, can be more selective and sensitive, and can provide results in terms of a visible colour change.

Photoactivated Materials

The next six chapters are all related to photoactivated materials. Chapters 4 to 7 discuss photocatalysis using a variety of materials for degradation of aqueous and gaseous compounds, using ultraviolet (UV) or visible light. Chapter 4 is concerned with the use of iron-containing silicate glasses as photocatalysts which can use visible wavelength light to decompose methylene blue dye. Y. Takahashi *et al*. (Tokyo Metropolitan University, Japan, and Kinki University, Japan) describe how catalysts were prepared using two different methods, and through Mossbauer spectroscopy and X-ray diffraction (XRD) it was determined that good catalytic activity could be attributed to the presence of α-Fe_2O_3.

In Chapter 5, acid yellow 17 is the target molecule for decomposition. C. Wu *et al*. (National Tsing Hua University, Taiwan, and Industrial Technology Research Institute, Taiwan) investigate the activity of soda lime glass-supported thin titania films of varying thickness, using UV light. It is concluded that there is an optimal film thickness, as a balance between the amount of titania providing active sites for catalysis, and the ability of the light to penetrate the catalyst material. Various methods of preparing the films are also reviewed. J. Chen *et al*. (Tunghai University, Taiwan) investigate in Chapter 6 how the morphology of anodic aluminium oxide (AAO) supported zinc oxide catalysts affects their activity for degradation of gaseous isopropyl alcohol under UV light. Plasma-enhanced chemical vapour deposition (PECVD) was utilised to deposit the zinc oxide at different weight loadings, which resulted in different morphologies; it was observed that a rod-like structure was the most active.

Chapter 7, by one of the editors S.-m. Chang (National Chiao-Tung University, Taiwan), is a review of the effects of bulk and surface doping of titania on photocatalytic activity. The review focuses more on the catalytic materials themselves and the various mechanisms by which doping affects their activity rather than any particular reaction, although decolouration of acid naphthol red solution is one that is mentioned. It is concluded that surface doping of titania is more beneficial than bulk doping.

Chapters 8 and 9 extend photoactivation to electrochemistry, discussing the use of titania and platinum-doped titania as a photocathode for hydrogen evolution from water splitting, and silver doped bismuth iodide as a photoanode in a photo fuel cell for simultaneous electricity generation and degradation of organic wastewater pollutants respectively. In Chapter 8, H. Liao and R.-a. Doong (National Tsing Hua University, Taiwan) report the investigation and optimisation of the parameters in the preparation of titania nanotubes, and how the addition of platinum significantly increases the photoconversion efficiency. In Chapter 9, C. He *et al*. (Sun Yat-sen University, China; South China Normal University, China and Guangdong Provincial Key Laboratory of Environmental Pollution Control and Remediation Technology, China) synthesise and characterise bismuth iodide and silver-bismuth iodide electrodes and test their activity using bisphenol A solutions as simulated wastewater. It was concluded that the addition of silver enhanced both the efficiency of electricity generation and degradation of pollutants in the photo fuel cell under visible light.

Environmental Decontamination

The final three chapters of the book are each concerned with iron species and their use in environmental decontamination, since iron is an earth-abundant element. Chapter 10 briefly reviews the use of iron-enriched mineral oxides for water decontamination before describing two studies carried out by the authors: Y. Li and W. Yan (Texas Tech University, USA), to investigate the importance of the amount of iron present. In Chapter 11, Y. Wanatabe *et al*. (Tokyo Metropolitan University, Japan, and Kinki University, Japan) used a variety of characterisation techniques to analyse the effect of trichloroethylene and methylene blue decomposition on the local structure of mixtures of metallic iron and iron oxides, and demonstrated that the activity of the mixtures was enhanced when nanoparticles were used. In Chapter 12, V. K. Sharma (Texas A&M University, USA) *et al*. discuss the use of ferrate(VI) for the treatment of odorous gases, such as organosulfur compounds. The iron is reduced by the reaction, through transfer of oxygen from the ferrate species, resulting in iron(II) or iron(III) products, however, it is stated that iron(VI) could be generated *in situ* electrochemically.

Conclusions

Overall, the chapters in this book cover a range of topics relating to mitigation of environmental

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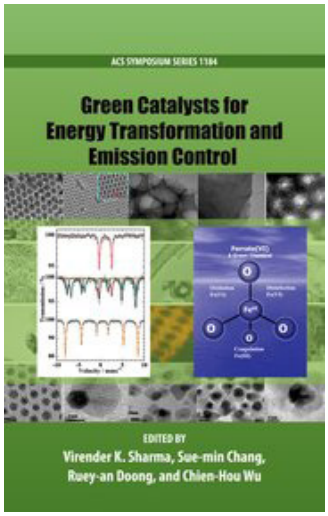
pollutants and are accessible to readers with an interest in this broad area, due to introductions which explain each topic area well, although some prior knowledge of catalysis or the analytical techniques used may be an advantage in terms of understanding the data presented. The title of the book is slightly misleading, however, as not all chapters are about catalysts. A substantial portion of the book is concerned with photo-activated materials, particularly photocatalysts for treatment of wastewater, and so it may be of most interest to readers involved in this area of research. These chapters also provide sufficient description of the sometimes complex mechanisms involved that those unfamiliar with the concept should be able to understand their content.



"Green Catalysts for Energy Transformation and Emission Control"

The Reviewer

Dr Catherine Davies is a Post Doctoral Research Associate at the Cardiff Catalysis Institute. Her current research interests are in heterogeneous catalysis for automotive applications, focusing on catalysed oxidation of particulate matter.

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