Chemistry in the Environment

Advanced Materials for Emerging Water Pollutant Removal

Edited by Pei Sean Goh, Devagi Kanakaraju, Anwar Iqbal and Ahmad Fauzi Ismail

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Advanced Materials for Emerging Water Pollutant Removal

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Preface

Water scarcity is an increasing issue on every continent. Along with climate change, the global issue is escalated by urbanization, population growth, and pollution. According to the World Bank report, 80% of wastewater enters water bodies without being adequately treated. The release of vast amounts of industrial and domestic wastewater results in the pollution of the water environment and ecosystem. Proper treatment of these wastewaters allows their reutilization for many purposes and applications including industrial processes and irrigation. Advanced materials are known to be promising tools to alleviate the impacts of these issues. In the last decade, tremendous efforts have been made to progress in the field of synthesis and application of advanced materials especially for use in environmental remediation. Advanced materials including nanomaterials and biomaterials can be used to remove pollutants from water and air. A wide range of advanced materials can be prepared through affordable, energy-efficient approaches. They can also be easily retrofitted in existing wastewater or air filtration systems.

This edited book, *Advanced Materials for Emerging Water Pollutant Removal*, explores the potential of advanced materials to deal with the various kinds of pollutants found in water bodies. This book aims to bring together the ideas and innovations of researchers working in the field, and provides a detailed overview of the development of various functional advanced materials for the removal of emerging pollutants. This edited book comprises eight chapters that focus on the synthesis, characterization, and modification of nanomaterials as well as their applications and evaluation of their performance. The engineering of materials through innovative synthesis and modification approaches allows the fine-tuning and optimization of materials in terms of their functionality and efficiency. With the ever-growing threats of

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conventional and emerging pollutants in our water, the advancements made over the past decade could serve as a catalyst in revolutionizing efforts in environmental remediation.

We extend our heartfelt gratitude to all the contributors for their expertise and dedication in completing the chapters. Their insights are substantial in shaping the contents of this edited book. We would also like to thank the publisher for their support throughout the preparation and production processes. Lastly, by harnessing the advantages of a broad range of advanced materials, we aim to not only address the alarming pollution and water scarcity issues, but also contribute to the Sustainable Development Goals particularly Sustainable Development Goal 6: Clean Water and Sanitation. It is hoped that this edited book will provide inspiration and guidelines to propel the research community towards a cleaner and more sustainable future.

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CHAPTER 3

Membranes for the Removal of Endocrine Disrupting Compounds from Aqueous Environments

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3.1 Introduction

Endocrine-disrupting chemicals or compounds (EDC) are varied arrays of compounds that can disrupt the typical operation of the endocrine system, which controls the production and regulation of hormones in the body.[1] These compounds have the ability to imitate, obstruct, or disrupt the function of natural hormones, resulting in various negative impacts on human health and the environment.[2] EDCs encompass a range of chemical categories, including pharmaceuticals, pesticides, substances utilized in the plastics sector and consumer goods, industrial waste items, contaminants, and

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certain naturally occurring plant components.[3] EDCs encompass both natural molecules like phytoestrogens and manufactured chemicals such as pesticides, plastics, and medications.

The common technique employed to eliminate chemical pollutants from drinking water treatment systems is not highly efficient. Research has shown that flocculation or coagulation processes are able to remove less than 40% of EDC.[4] UV irradiation, ozonation, and membrane treatment are advanced methods that can enhance water purification by eliminating EDCs.[5] Compared to other advanced technologies that may discharge treatment by-products into the water, membranes are highly effective at reducing the concentration of EDCs.[6] Membrane techniques such as microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO) are commonly used in water treatment facilities.[7]

3.2 Toxicity of EDC

3.2.1 Source and Groups of EDCs

EDCs, according to the description by the US Environmental Protection Agency can be categorized as a substance that is not produced by an organism with the ability to manipulate the hormone metabolism.[8] The mechanism by which EDCs disrupt hormones starts by them mimicking the hormone structure that allows them to bind the receptor. The binding of EDCs to the receptor blocks the actual hormone thus leading to instability especially to the organisms endocrine, immune, and nervous systems.[9] The disruption in the vital function could cause several diseases mainly cancer, diabetes, and infertility.[10] As well as diseases, EDCs may contribute to genetic changes by modifying the DNA through acetylation and methylation which could still occur even at low concentrations.[11] A verbatim description by the World Health Organization (WHO) regarding endocrine disrupting compounds is: "group of exogenous compounds that interfere with endocrine system functioning and has adverse health effects on organ-ism and its subpopulation/progeny".[12]

Another name for EDCs is endocrine modulator and environmental hormone which can be categorized as either natural or synthetic depending on the synthesis pathways. Some of the synthetic endocrine modulators are bisphenol A, polychlorinated biphenyls, and triclosan while the natural source is phytoestrogen which can be found in soy milk. Meanwhile, the EDCs that are responsible for interfering with estrogen hormone are xenoestrogen which can be sourced from bisphenol A and soy milk. Both EDCs are known to mimic the estrogen hormone which allow it to bind to the hormone receptor that control the reproductive system. The binding of EDCs to the receptor in the case of xenoestrogen will induce irregular development, DNA modification, and the alteration of the placenta.[13] In the US, based on population sampling from urine analysis, it is approximated that 92% of