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"Graphene-Based Nanotechnologies for Energy and Environmental Applications"

Edited by Mohammad Jawaid (Universiti Putra Malaysia), Akil Ahmad (University of KwaZulu-Natal, South Africa) and David Lokhat (University of KwaZulu-Natal, South Africa), Micro and Nano Technologies Series, Elsevier, The Netherlands, 2019, 446 pages, ISBN: 9780128158111, £131.75, €159.16, US$170.00

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Introduction

The book titled "Graphene-Based Nanotechnologies for Energy and Environmental Applications", edited by Mohammad Jawaid, Akil Ahmad and David Lokhat, focuses on recent developments in graphene-based materials, composites and devices for a variety of applications in storage devices, supercapacitors, water treatment, ion-separation, photocatalysts and antimicrobial applications. It is part of the series Micro and Nano Technologies published by Elsevier. The first editor of the book, Mohammad Jawaid from the Universiti Putra Malaysia, has expertise in nanomaterials (particularly graphene materials) and their composites and has significant research output with a h-index of 53. The second editor, Akil Ahmad, currently a postdoctoral researcher at the University of KwaZulu-Natal, South Africa, has worked on nanomaterials synthesis and applications of nanomaterials in wastewater treatment. David Lokhat, the third editor of the book from the University of KwaZulu-Natal, has been working on reactor and extraction technologies.

The book is divided into three major parts: Introduction, Energy and Environment. Each category has many chapters written by diverse authors. A total of 59 authors from different affiliations contributed to the different chapters. Firstly, the introduction covers basic terminologies and definitions of nanotechnology, nanomaterials and provides specific literature background on graphene-based materials and their composites for energy and environmental applications. Ahmad *et al.* collected literature on graphene-based nanotechnologies, which covers the latest developments in graphene research around the world, and David Lokhat contributed towards energy and environmental applications leveraged by graphene derivatives along with publication statistics. Production methods, characterisation methods and properties of graphene and its applications in different areas are covered. The literature and data were collected and compiled from over 350 publications. Every chapter has a conclusion or concise summary with potential prospects for the future in each research or subject area.

Energy

Mamvura *et al*. (University of South Africa) have written a chapter on renewable energy systems using graphene derivatives. The chapter covers applications of graphene in battery-powered vehicles, fuel cells, solar cells and energy storage devices. Mohamed I. Fadlalla and Sundaram Ganesh Babu (University of Cape Town, South Africa) presented a chapter on graphene materials in photocatalytic water splitting for hydrogen production. Topics such as mono- or bi-semiconducting catalyst and

metal and non-metal doped graphene-based photocatalysts for water splitting applications are covered. Umar *et al.* (Universiti Sains Malaysia) included topics on metal decorated graphene nanocomposites for energy storage applications. Their chapter is mainly focused on metal-based composites, solar and fuel cells, supercapacitors and lithium-ion batteries and mechanisms of energy conversions are covered in detail. A chapter on graphene oxide (GO) for hydrogen storage applications was written by Azim *et al*. (University of KwaZulu-Natal). Composites of GO and reduced GO with metal oxides, carbon nanotubes and organic materials and relevant fabrication methods are well elaborated in this chapter. Professor Mohammad *et al*. (King Saud University, Saudi Arabia) have contributed a chapter towards graphene-derived nanocomposites as supercapacitors and electrochemical cells. This chapter includes the synthesis (**Figure 1**) and physical properties of graphene nanosheets, a section on biosensors and a short note on supercapacitors produced from graphene nanocomposites. Jean Mulopo and Jibril Abdulsalam (University of the Witwatersrand, South Africa) have provided a chapter on graphene-based energy storage applications (capacitors, batteries, fuel cells and solar cells) with an emphasis on electrical and thermal conductivity, specific surface area and specific heat properties.

Overall, this section of the book with six chapters covers a wide range of electronic devices incorporating graphene and its derivatives. In-depth analysis and data have been included from a significant number of publications and research works. Topics on graphene composite as air filters, gas sensors, volatile sensors, liquid sensors, radiation sensors and pollutant sensors are adequately discussed in these chapters.

Environmental Applications

The section of the book begins with a chapter on graphene-based sensors for the detection of volatile organic compounds (VOCs) written by Ansari *et al*. (Aligarh Muslim University, India). Graphene with metal additives as sensors and their functioning mechanisms have been well discussed in this chapter. Haseen *et al*. (Aligarh Muslim University) concentrated on the application of magnetite-GO composite for wastewater treatment. This chapter covers magnetite-GO for specific dispersive solid-phase extraction. Mohamma Laskar and Sana Siddiqui (Jazan University, Saudi Arabia) focused on GO-based filters for solid-phase extractions, including nascent GO, chelates adsorbed GO, functionalised GO with external molecules and specific GO nanocomposites. GO functionalised with magnetic molecules and their composites with polymer or metal matrices have been extensively studied. Reduced GO (rGO) derivatives for such applications are also included.

A chapter by Kumar *et al*. (King Abdulaziz University, Saudi Arabia) covers graphene-metal oxide composite photocatalyst for degrading water pollution. Structure and property (chemical and physical) relationships and the effect of graphene's bandgap on photocatalytic decomposition are interpreted. The mechanism of photocatalysis for relevant graphene materials and metal-GO and rGO composites are included. Hussain *et al*.

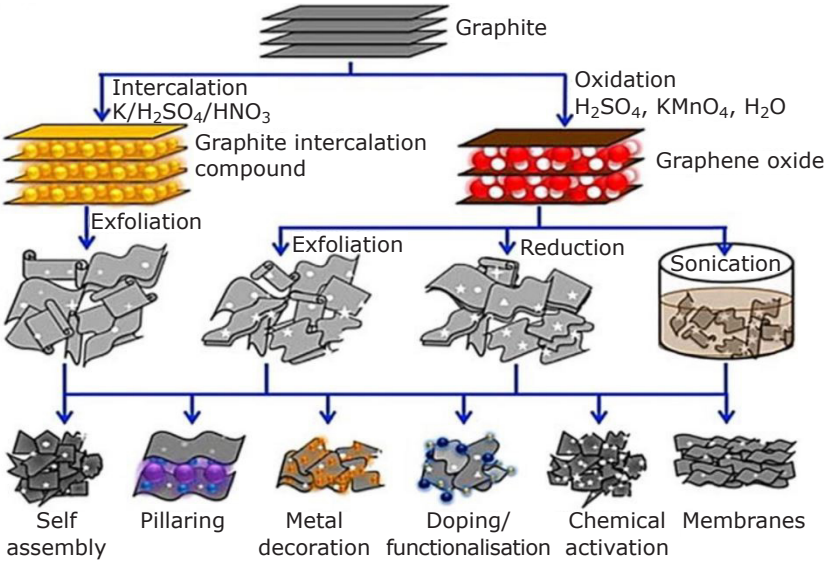


Fig. 1. Synthesis of graphene derivatives. Copyright (2019). Reprinted with permission from Elsevier

(Jubail Industrial College, Saudi Arabia) collated information on a new generation of GO for removal of polycyclic aromatic hydrocarbons from a wide range of literature and new results. The chapter covers several properties of graphene, such as mechanical, electrical and thermal properties and their influence on the interaction of polycyclic aromatic hydrocarbons as well as the role of GO as an adsorbent for such hydrocarbons. A chapter by Ng *et al*. (UCSI University, Malaysia) is dedicated to graphene-based membranes for separating hazardous contaminants in wastewater. This is probably the only chapter that gives importance to both polymer-based and metal-based graphene composites for the targeted application. Traditional thermoplastics (polystyrene, polyvinylidene fluoride, polyamide-imide, polyacrylonitrile and polyethersulfone) composites and conducting polymer (polyaniline)-based graphene composites are organised with their fabrication process and efficiency as a membrane in a descriptive manner.

Hossain *et al*. (Universiti Sains Malaysia) focused on antimicrobial activity of graphene-based materials. The antimicrobial mechanism of major graphene derivatives (GO, rGO and graphene) are discussed along with the performances of their composites with hydrogel and polymer dispersions. The effect of toxicity of graphene materials on antimicrobial activity adds to the value of this chapter. Graphene-metal oxide hybrid composites for treating textile dyes are discussed in a chapter by Shahadat *et al*. (Indian Institute of Technology, Delhi). This short chapter attempts to add to the knowledge of graphene-metal synthesis for removal of industrial dyes and provides details of the effects of functional groups (hydroxyl, carboxyl and oxygen) present in the composite systems on their performance. Reddy (Universiti Teknologi PETRONAS, Malaysia) and co-authors emphasised graphene nanomaterials for removal of pharmaceutical compounds in drinking water. The impacts of surface functional groups, sorption kinetics, pH and temperature on absorption stability of graphene-based materials and nanocomposites are discussed in detail. Research data on polymer-based, ceramics-based and metal-based composites are also covered in this chapter. Two chapters, by Yadav *et al*. (Shree Velagapudi Ramakrishna Memorial College, India) and Abbas *et al*. (Universiti Sains Malaysia), focus on the application of graphene composites in air quality and wastewater treatment. **Figure 2** depicts different applications in which graphene nanocomposites can be utilised.

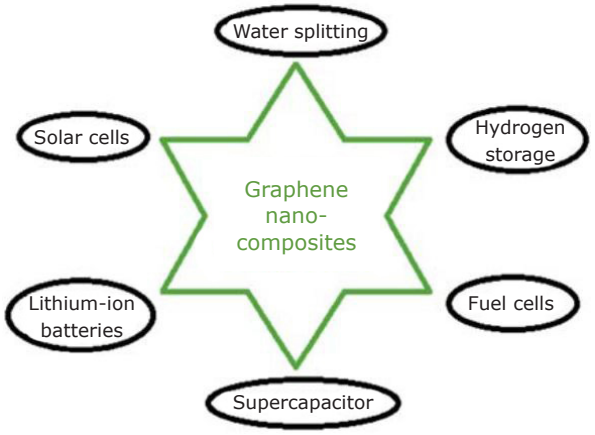
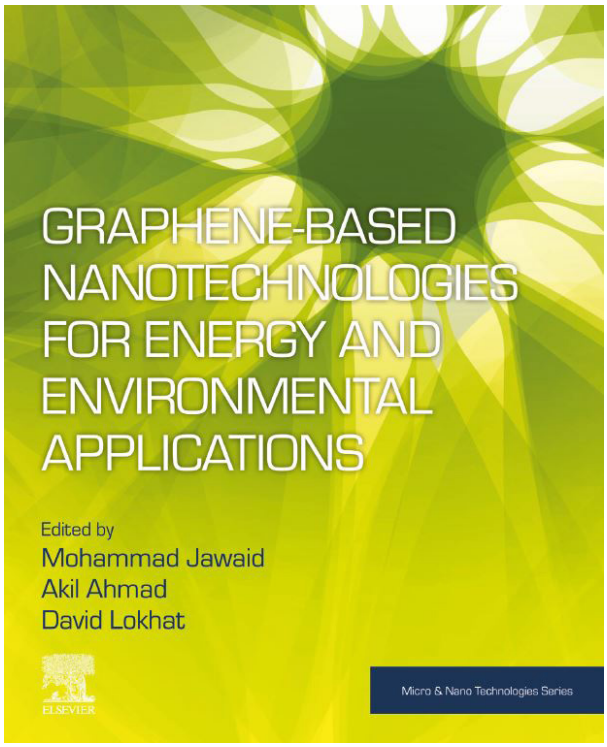


Fig. 2. Applications of graphene nanocomposites. Copyright (2019). Reprinted with permission from Elsevier

Conclusions

Each chapter provides solid knowledge in its prescribed subject matter, and they read and flow well. However, looking collectively, there are several duplications and repetitions found in the book, especially the synthesis of graphene and applications such as storage devices and water treatment. These chapters are written using different language, and the knowledge is not very diverse. Another major flaw of the book is that it has missed out on the latest developments in graphene-based polymer composites and their multifunctional applications in energy and environment, which is a significant subject area that is expected to be covered in a book like this. There is only one chapter (Chapter 15) that covers sufficient polymer-graphene composites in the removal of hazardous contaminants from wastewater. Other application areas related to energy and environment are completely neglected. Furthermore, while most chapters have excellent illustrative figures, a few chapters do not have a single figure. It is always better and more attractive to have figures to effectively convey scientific concepts and processes. The summary in each chapter is concise, and future prospects are given appropriately. The front cover, preface, table of contents, index and back cover are suitable and sufficient.

Summing up, this book provides useful knowledge predominantly in graphene-based materials for storage cells, sensory and wastewater treatment applications.



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The Reviewer

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