Unlock the Secrets of Electrochemical Water Splitting with Emerging Materials

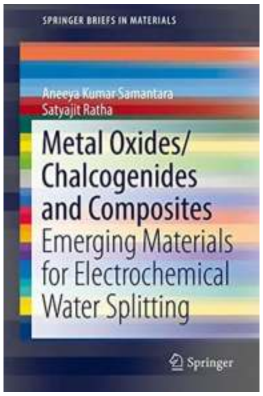
In recent years, the field of electrochemical water splitting has gained tremendous attention as a potential solution for sustainable energy production. This process involves the decomposition of water into hydrogen and oxygen gases using electricity. The key to efficient water splitting lies in finding innovative materials that can catalyze the electrochemical reactions while maintaining high performance and durability. In this article, we will delve into the fascinating world of emerging materials for electrochemical water splitting and explore their potential in shaping a greener future.

What is Electrochemical Water Splitting?

Electrochemical water splitting is the process of using an electrical current to break down water molecules into their elemental components - hydrogen and oxygen gases. This process offers a promising pathway for renewable hydrogen production and energy storage. It involves two half-reactions: the oxidation of water at the anode and the reduction of protons to hydrogen gas at the cathode.

Traditionally, water splitting has been achieved using expensive and rare materials, such as platinum, as catalysts. However, the high cost, limited availability, and low abundance of these materials have hindered their large-scale deployment. This has led researchers to explore alternative materials that are more abundant, cost-effective, and efficient.

Metal Oxides/Chalcogenides and Composites: Emerging Materials for Electrochemical Water



Splitting (SpringerBriefs in Materials)

by Aneeya Kumar Samantara (1st ed. 2019 Edition, Kindle Edition)

★★★★★ 5 out of 5

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The Role of Emerging Materials

The search for new materials for electrochemical water splitting has resulted in the discovery of various promising candidates. These emerging materials can be broadly categorized into three types:

1. Transition Metal-based Catalysts

Transition metals, such as nickel, cobalt, and iron, have emerged as highly efficient and cost-effective catalysts for water splitting. These materials possess the necessary properties to facilitate the electrochemical reactions with minimal energy loss. For example, nickel-based catalysts have shown remarkable efficiency and stability in the oxygen evolution reaction (OER), which occurs at the anode. Similarly, cobalt-based catalysts exhibit excellent performance in the hydrogen evolution reaction (HER), which takes place at the cathode. These transition metal-based catalysts offer a promising alternative to platinum and other expensive materials, making water splitting more economically viable.

2. Metal-Organic Frameworks (MOFs)

Metal-organic frameworks (MOFs) are a class of materials composed of metal ions or clusters coordinated with organic ligands. These porous structures offer a large surface area and tunable chemical properties, making them ideal candidates for catalytic applications. In recent years, researchers have demonstrated the potential of MOFs in electrochemical water splitting. For instance, MOFs containing metal centers like copper, cobalt, and nickel have shown remarkable activity in both the OER and HER. Additionally, the unique characteristics of MOFs, such as their high porosity and stability, make them promising materials for improved performance and long-term durability.

3. Two-dimensional (2D) Materials

Two-dimensional materials, including graphene and transition metal dichalcogenides (TMDs), have attracted significant interest for their unique electronic and catalytic properties. These materials possess a high surface-to-volume ratio, providing numerous active sites for catalytic reactions. Graphene-based catalysts have demonstrated exceptional performance in water splitting due to their superior electrical conductivity and stability. On the other hand, TMDs, such as molybdenum disulfide (MoS2) and tungsten diselenide (WSe2), exhibit excellent catalytic activity in both the OER and HER. The potential of 2D materials in water splitting lies in their tunable properties and ability to enhance the overall efficiency of the process.

The Future of Electrochemical Water Splitting

Research on emerging materials for electrochemical water splitting is still in its early stages, but the potential benefits are promising. These materials offer an opportunity to overcome the limitations of conventional catalysts, paving the way for large-scale and economically viable water splitting technologies. However, there are still challenges that need to be addressed, such as scalability, long-term stability, and integration with existing energy systems.

In , the search for innovative materials for electrochemical water splitting is a crucial step towards achieving sustainable and clean energy production. The emergence of transitions metal-based catalysts, metal-organic frameworks, and two-dimensional materials provides a glimpse into the future of water splitting technologies. As researchers continue to explore and develop these materials, we inch closer to unlocking the secrets of efficient and environmentally friendly energy production.

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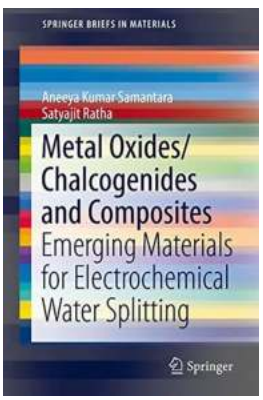


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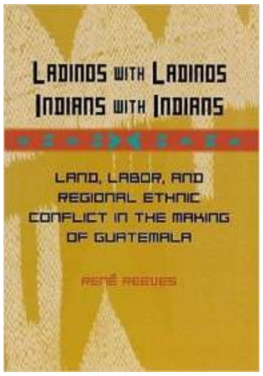
This book covers the recent development of metal oxides, hydroxides and their carbon composites for electrochemical oxidation of water in the production of hydrogen and oxygen as fuels. It includes a detailed discussion on synthesis methodologies for the metal oxides/hydroxides, structural/morphological characterizations, and the key parameters (Tafel plot, Turnover frequency, Faradic efficiency, overpotential, long cycle life etc.) needed to evaluate the electrocatalytic activity of the materials. Additionally, the mechanism behind the electro oxidation process is presented. Readers will find a comprehensive source on the close correlation between metal oxides, hydroxides, composites, and their properties and importance in the generation of hydrogen and oxygen from water.

The depletion of fossil fuels from the earth's crust, and related environmental issues such as climate change, demand that we search for alternative energy resources to achieve some form of sustainable future. In this regard, much scientific research has been devoted to technologies such as solar cells, wind turbines, fuel cells etc. Among them fuel cells attract much attention because of their versatility and efficiency. In fuel cells, different fuels such as hydrogen, CO2, alcohols, acids, methane, oxygen/air, etc. are used as the fuel, and catalysts are employed to produce a chemical reaction for generating electricity. Hence, it is very important to produce these fuels in an efficient, eco-friendly, and cost effective manner. The electrochemical splitting of water is an environmentally friendly process to produce hydrogen (the greener fuel used in fuel cells), but the efficiencies of these hydrogen evolution reactions (cathodic half reaction) are strongly dependent on the anodic half reaction (oxygen evolution reaction), i.e., the better the anodic half, the better will be the cathodic reaction. Further, this oxygen evolution reaction depends on the types of active electrocatalysts used. Though many more synthetic approaches have been explored and different electrocatalysts developed, oxide and hydroxide-based nanomaterials and composites (with graphene, carbon nanotubes etc.) show better performance.

This may be due to the availability of more catalytic surface area and electro active centers to carry out the catalysis process.



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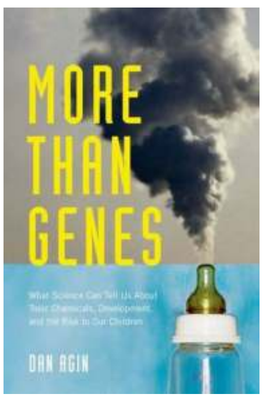

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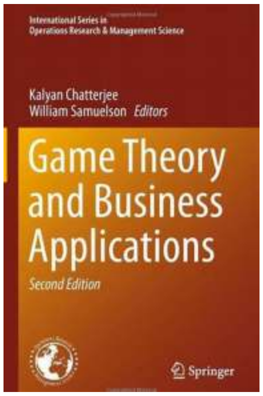

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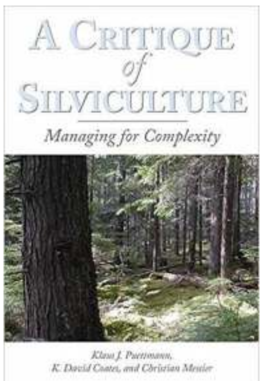

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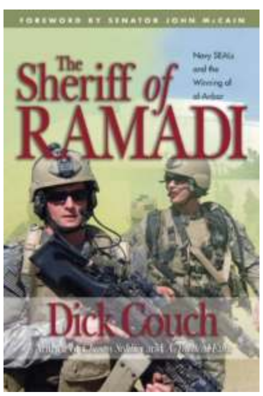

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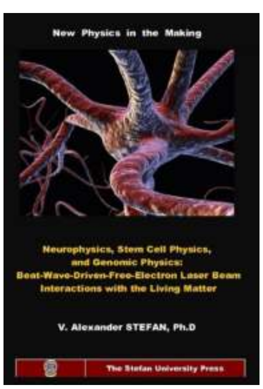

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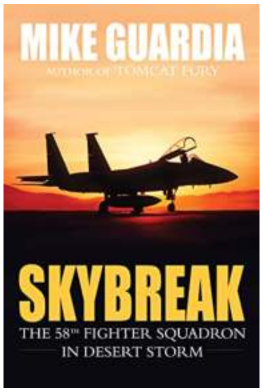

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