Notification No: 543/2023
Dated of Award: 26-07-2023

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Topic of Research: **Synthesis, Characterization and Properties of Multifunctional Oxides Nanoparticles for Water Splitting Applications**

Findings

My thesis focuses on exploring the use of rare earth-based perovskite oxides as multifunctional catalysts for water splitting applications. Chapter 1 provides an introduction to the hydrogen economy and the different methods for hydrogen production, with a specific focus on rare earth-based perovskite oxides. The fabrication processes and characterization methods for these catalysts are thoroughly explained, and the thermodynamics of water splitting reactions are discussed. In Chapter 2, the fabrication and characterization of multiferroic terbium orthoferrite nanoparticles are described. These nanoparticles showed good photocatalytic, electrocatalytic, and photoelectrochemical activity for hydrogen production, attributed to their unique structural and optoelectronic properties. Chapter 3 explores the use of $GdFeO_3$ nanoparticles, which demonstrated notable hydrogen evolution without the need for a co-catalyst and also showed excellent oxygen evolution reaction (OER) performance with low overpotential. Chapter 4 investigates $GdCrO_3$ nanoassemblies, which exhibited remarkable hydrogen generation and improved OER specific activity as an electrocatalyst. In Chapter 5, the focus shifts to $DyCrO_3$ nanoparticles, which showed promising photocatalytic hydrogen generation and also served as efficient electrocatalysts for both HER and OER. Chapter 6 discusses the multifunctional properties of $TbCrO_3$ nanoparticles, including their capabilities in electrocatalytic seawater splitting and photocatalytic hydrogen evolution. These nanoparticles exhibited good OER activity and efficient hydrazine oxidation, making them suitable for seawater splitting applications. Finally, Chapter 7 explores the synthesis and multifunctional applications of $DyFeO_3$ nanoworms and $DyMnO_3$ nanoaggregates, which showed promising results in electrocatalytic water splitting and supercapacitor applications. Overall, this thesis delves into the development and characterization of rare earth-based perovskite oxide nanoparticles as effective catalysts for water splitting applications. The unique multiferroic and optoelectronic properties of these nanoparticles contribute to their enhanced catalytic performance in both photocatalysis and electrocatalysis. The research presented here offers valuable insights into the potential of these materials for building a sustainable hydrogen economy and highlights the importance of harnessing renewable energy sources for hydrogen production to address

environmental and energy challenges. By exploring these novel catalysts, this work contributes to bridging the gap between research and commercialization in the hydrogen economy field.