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# Advanced Nanomaterials and Nanocomposites for Sustainable Electrochemical Energy Conversion and Storage

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## Extended Abstract

With rapidly escalating environmental concerns and the accelerated depletion of fossil fuel resources, there is an urgent demand for the development of advanced technologies for sustainable energy production. Nanostructured materials with high surface areas have attracted significant interest owing to their unique physicochemical properties and their wide-ranging applications in electrocatalysis, photocatalysis, energy conversion, and energy storage. In recent years, our research team has designed and systematically investigated a diverse range of functional nanomaterials. In this talk, we present the design and synthesis of advanced cobalt-, palladium-, ruthenium-, and graphene-based nanomaterials and nanocomposites. These materials were comprehensively characterized using a suite of surface and structural techniques, including Raman spectroscopy, Fourier transform infrared spectroscopy, X-ray diffraction (XRD), high-energy XRD, scanning electron microscopy, transmission electron microscopy, energy-dispersive X-ray spectroscopy, X-ray photoelectron spectroscopy, and X-ray absorption spectroscopy, alongside detailed electrochemical studies. The electrochemical properties of these nanomaterials and nanocomposites, as well as their promising applications in hydrogen production and storage and carbon dioxide reduction, are highlighted. Particular emphasis is placed on the critical roles of nanostructured surfaces in enabling advanced electrochemical processes. Finally, the implications of these findings for the development of next-generation electrochemical technologies for clean and sustainable energy applications will be discussed.