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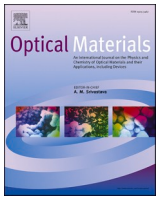

Research Article

Enhancement of optical and surface electronic properties in rGO-CuO nanocomposites for improved photocatalytic activities

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ABSTRACT

This study explains the systematic changes in surface electronic, linear, and nonlinear optical (NLO) characteristics of the rGO-CuO nanohybrid with different rGO concentrations for efficient photocatalytic properties. The interaction between rGO and CuO during the synthesis of the composite offers synergistic effects, resulting in the augmentation of its photocatalytic performance as compared to the individual components. Photogenerated charge carriers (e^- and h^+), their separation time, and the charge transfer mechanism play crucial roles in the enhancement of the photocatalytic activities of any materials. An increase in rGO concentration within the rGO-CuO samples led to enhanced nonlinearity measured through the z-scan technique, which in turn resulted in a longer photoinduced charge separation time and high defect density. Furthermore, the SKPM measurement confirms the rGO-controlled Fermi level modulation of rGO-CuO, which shows an efficient adjustment of the charge transfer between CuO and rGO. Under UV–Vis irradiation, the rGO-CuO nanocomposite demonstrated superior catalytic activity for the photoreduction of organic pollutants. The improvement in photocatalytic reduction of pollutants is primarily due to the material's reduced bandgap, the efficient charge separation, and the charge transfer mechanism. Overall, the combined effects highlight the nanocomposite's strong potential for applications in photoinduced catalytic reduction.

1. Introduction

The emergence of 2D materials with remarkable distinctive qualities has been revolutionized by the discovery of graphene, paving the way for the advancement of optical, electrical, and energy storage technologies of the next generation [1–5]. With their exceptional properties and versatile applications, they have garnered significant attention from researchers across various disciplines. Graphene oxide (GO), a derivative of graphene, is derived through oxidation and functionalization processes, which possess unique chemical and electronic properties that make it amenable to diverse applications [6–8]. Due to their unique properties and wide range of uses, graphene oxide and reduced graphene oxide (rGO) have drawn a lot of attention in the current generation to produce innovative materials with individualised characteristics and multi-functionality. The combination of rGO and metal oxide semiconductors in composite structures offers a synergistic platform that combines the exceptional properties of both materials [9–12].

Although nano-CuO exhibits excellent structural and functional characteristics, its practical use in large-scale photocatalytic applications remains limited. A major obstacle is the tendency of CuO nanoparticles to aggregate, which significantly impairs their catalytic performance. This clustering effect not only reduces the available surface area and diminishes light absorption but also facilitates the rapid recombination of photo-generated charge carriers, thereby lowering charge separation efficiency [13–15]. These combined effects lead to a notable decline in photocatalytic activity. Consequently, overcoming nanoparticle agglomeration and enhancing the overall efficiency of nano-CuO continues to be a critical area of focus in photocatalysis research. The incorporation of rGO in CuO composites modifies their morphological, structural, vibrational, linear, and nonlinear optical properties, including absorbance and photoluminescence properties [16–20]. Also, this incorporation of rGO into CuO matrices significantly improves the electrical conductivity, Synergistic Mechanical Strength, and Tunable Optical and Photocatalytic Properties of the composites. These properties are highly advantageous for applications in energy

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