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Synthesis and characterization of samarium oxide (Sm_2O_3) nanoparticles for testing electrochemical sensing and photocatalytic applications

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ABSTRACT

Various solvent-mediated samarium oxide (Sm_2O_3) nanoparticles have been successfully synthesized using the microwave-assisted precipitation process. The structural, morphological, elemental, optical and electrochemical characteristics of the prepared Sm_2O_3 nanoparticles (SONPs) were examined using powder XRD, FTIR, SEM, EDX, TEM, UV, RTPL and CV analysis. The smaller particle size of cubic crystal-structured SONPs is examined in the range of ~5-15 nm. Optical absorbance spectra exhibited the wide band gap values of the synthesized SONPs. The prominent blue-green emission bands were detected in the RTPL emission spectra due to the presence of surface-related defects. The electrochemical behaviour of the SONPs was primarily examined using CV analysis. The photodegradation of the synthesized SONPs was examined using methylene blue (MB) dye, and a photodegradation efficiency value of 88.8% was obtained.

1. Introduction

In recent years, the rare-earth metal oxides have received much attention due to their unique optical and catalytic properties and are also attractive candidates for industrial waste water treatment [1–4]. Photocatalysis is one of the methods to clean the water from the waste water using organic dye with an illumination of suitable light source [5,6]. In particular, samarium oxide (Sm_2O_3), a p-type semiconductor nanoparticle, is widely used in an array of applications such as photocatalysts, semiconductor-based electronic devices, phosphors, luminescence devices, biochemical sensors, and medical diagnostics, making it one of the important rare earth oxide materials [3,4,7–9]. Sm_2O_3 has a larger band gap of 4.3 eV, which leads to better photocatalytic performance due to the slow recombination of electron-hole pairs when interaction with the light source [3,4,7,8]. In addition, it has large dielectric strength with good thermochemical stability, which makes it appropriate for use in electrical and biosensing devices [7,9]. Few researchers have attempted with Sm_2O_3-based composites through various chemical synthesis techniques for catalytic applications [10–15]. Moreover, Hamid Mohammad Shiri et al. [16], Mahmoud et al. [17], Ubale et al. [18], Longqing Ma et al. [19] and Enyi Hu et al. [20] studied the electrical and electrochemical properties for energy storage device and fuel cell applications. They reported the good ionic conductivity, which led Sm_2O_3 compounds being promising candidates in energy storage devices.

Various synthesis methods are generally adopted to synthesize the Sm_2O_3 nanoparticles (SONPs) such as organic and inorganic synthesis [2], precipitation, combustion and green [3,4], electrochemical [16], hydrothermal [17,18], wet chemical synthesis [19,20]. Among the synthesis processes, the microwave-assisted precipitation route offers several advantages over the other methods, such as low-temperature processing, low ageing time, chemical homogeneity, phase purity and high yielding powders etc. [8]. The microwave-assisted precipitation method performs effectively for forming smaller sized particles by directly heating the molecular starting materials with microwaves.

In order to create material qualities to utilize distinct and practical optical and photocatalytic capabilities as well as potential applications in a variety of sectors, the size of the particles and morphology are essential parameters. For instance, Mansoob Khan et al. [3] have investigated the nanostructured Sm_2O_3 for photocatalysis, sensors and biological applications. Hansong Xue et al. [21] have reported the optical behaviour of Sm_2O_3 spherical nanoparticles synthesized via the microwave-assisted hydrothermal method. Mehdi Rahimi-Nasrabadi et al. [22] have reported the photocatalytic activity of Sm_2O_3

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