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Examination of the structural, morphological, and self-cleaning characteristics of graphene oxide-based nanocomposite thin films

Rasha S. Yousif

Department of Petroleum Engineering, College of Engineering, University of Basrah, Basrah, Iraq

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ABSTRACT

In this study, graphene oxide (GO)-based nanocomposites containing zinc oxide (ZnO) and tin oxide (SnO_2) nanoparticles were fabricated and their structure, morphology, and self-cleaning properties were thoroughly examined. To the best of our knowledge, no effort has been made to prepare GO-ZnO and GO-SnO_2 nanocomposites and investigate their self-cleaning properties. In this regard, nanocomposites were initially synthesized by means of modified Hummer's method, followed by combining GO with ZnO and SnO_2 nanoparticles. In order to anchor prepared thin films onto glass substrates, spray pyrolysis technique was employed.

As evidenced by X-ray diffraction (XRD) spectroscopy, SnO_2 and ZnO nanostructures respectively have tetragonal rutile and wurtzite phases. Morphological investigations conducted by means of field emission scanning electron microscopy (FE-SEM) and atomic force microscopy (AFM) respectively revealed uniform distribution of nanoparticles and considerable variations in surface roughness, which corroborate the comprehensiveness of our study. The hydrophobicity and self-cleaning properties of our fabricated nanocomposites were scrutinized using contact angle test.

The findings obtained from contact angle measurements demonstrated that the GO-SnO_2 nanocomposites outperform other composites in terms of hydrophobicity. The great characteristics of our GO-based nanocomposites showed their potential for sophisticated coating applications, mainly for cleaning the surfaces.

Introduction

The unique features of graphene oxide (GO), consisting of structural, mechanical, and chemical properties, have made it a highly-used and versatile material in nanotechnology area. Some reasons for instance the large surface area of GO and the presence of a wide range of oxygen-containing functional groups, including carboxyl, epoxy, and hydroxyl, enable this material for tough and strong interactions with other materials. As a consequence, GO can be a useful candidate for synthesis of composite materials [1,2]. Fabrication of composites made up of GO along with metal oxides, including manganese dioxide (MnO_2) [3], zinc oxide (ZnO) [1], and tin oxide (SnO_2) [4,5], is one of the main developments in this area. This procedure can produce sophisticated composites, which demonstrate an enhanced mechanical strength, excellent photocatalytic properties, and significant self-cleaning abilities. Composites as hybrid materials show lots of potential for use in a wide range of industries, consisting of energy storage and conversion devices, different types of environmental remediation, and production of protective coatings [6,7].

In this direction, Al-Gaashani *et al.* [6] investigated the structural properties of GO and also the reasons behind the compatibility of the functional groups present in this material with metal oxides, which can bring about the uniform formation of composite and enhance distribution of nanoparticles within GO. The aforementioned features are required for cutting-edge uses [6]. High photocatalytic activities of GO-ZnO composites were also unveiled by Sharma *et al.* [7], which highlight their capability for energy-related and environmental areas. The optimization of properties of composites through the synergistic integration of GO with different metal oxides can enhance its usefulness for present-day technological advancements [1,3,8]. For instance, the biobased ternary nanocomposite of alkyd/β–MnO_2 nanorods@GO synthesized by Selim *et al.* exhibited a high hydrophobicity (141 degrees), excellent thermal stability, great chemical resistance against 3 N NaOH solution for 24 h, and great stability in a salt-fog environment for 500 h [9]. In addition, polydimethylsiloxane-polymethylmethacrylate (PDMS-PMMA) mixture incorporated with Ag–TiO_2@GO manifested an excellent hydrophobicity of 160°, a minimum surface free energy of 22.9 mN/m, and enhanced bulk mechanical properties, which make the

E-mail address: rasha.saad@uobasrah.edu.iq.

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