IRAQI JOURNAL OF APPLIED PHYSICS
Vol. 22, No. 3, July-September 2026, pp. 350-357

Qasim S. Kareem [1*]
Nadhim A. Abdullah [2]
Hassan K. Ibrahim [3]
Khalid I. Ajeel [4]
Hussein F. Hussein [3]
Ibrahim K. Ibrahim [5]

Structural and Optical Characteristics of ZnO Nanoparticles-Doped Epoxy Resin Thin Films

In this study, pure epoxy resin (ER) was doped with zinc oxide nanoparticles (ZnONPs) at different weight fractions (0.01, 0.03, 0.05, 0.07 and 0.09 wt.%). The chemical cast deposition method was used to make six thin film samples (one pure and five doped). The structural and the linear optical properties of the prepared samples were investigated via X-ray diffraction (XRD) and UV-visible spectroscopy. The absorbance and reflectance have increased with increasing ZnONPs doping weight fraction, while transmittance has decreased and the energy bandgap have decreased from 3.42 to 2.79 eV. An increase in Urbach energy from 0.09 to 0.60 eV was observed with increasing doping weight fraction. Results presented herein revealed that the structural and optical properties of epoxy resin were improved by doping with ZnO nanoparticles.

Keywords: Epoxy resin; Zinc oxide; Thin films; Nanocomposites
Received: 26 May 2025; Revised: 16 November; Accepted: 23 November; Published: 1 July 2026

[1] Department of Physics, College of Education, University of Al-Qadisiyah, Diwaniyah, IRAQ
[2] Department of Materials Science, Polymer Research Centre, University of Basrah, Basrah, IRAQ
[3] Physics Department, College of Education for Pure Science, University of Basrah, Basrah, IRAQ
[4] Medical Instrumentation Techniques Engineering Department, Al-Kunooze University, Basrah, IRAQ
[5] Department of Chemistry and Polymer Technology, Polymer Research Center, University of Basrah, Basrah, IRAQ
* Corresponding author email: qasim.alshook@qu.edu.iq

1. Introduction

Epoxy resins are typically prepared by the interaction among bisphenol and 2-(Chloromethyl) oxirane [1]. Epoxy resins indicates to both the prepolymer and the resin or hardener method used to cure it. The development of highly oriented and transparent ZnO nanocomposites has been the subject of extensive research in recent years due to its many uses in technological devices, biosensors, and photo detectors [2-5]. They have exhibited markedly better physical properties, compared with the pure epoxy resin [2,3]. Recently, nanoparticles have got a lot of interest due to their outstanding features in various materials and their applications systems such as ZnO nanoparticles, which are n-type semiconductor with a fixed wurtzite structure and a wide band gap. Unlike many of its competitors, ZnO is inexpensive abundant, chemically stable and non-toxic [4,5]. In this study, the epoxy:ZnONPs nanocomposites were fabricated by mixing ZnO NPs with epoxy resin at different weight fractions of ZnO nanoparticles. The optical properties of these nanocomposites were studied as functions of the ZnO NPs doping weight ratio (0.01, 0.03, 0.05, 0.07, and 0.09 wt.%) at room temperature in UV-visible regions.

2. Experimental Work

An epoxy resin (Shape of product: 136-2A, and part number: 20209150) was mixed at a ratio of (3:1) to hardener was used in this work. Zinc oxide nanoparticles (ZnONPs) were provided by SkySpring nanomaterials Inc., USA, with 99.8% purity, 10-30nm size, product no. 8410DL, were used as doping material in this study. A three-steps solvent cleaning processes by ultrasonic bath technique were done on the glass substrates with dimensions of 75x25x1mm. They were acetone for 5 min., isopropyl alcohol for 5 min., deionized water for 5 min., followed by two hours drying at 80°C in an oven. The ER/ZnONPs mixtures were prepared by adding a specific amounts of ZnO NPs (0.001, 0.003, 0.005, 0.007 and 0.009 g), as shown in table (1), in a multistep process. Firstly, mechanical mixing of 10 g of epoxy resin with a definite quantity of ZnO NPs for two minutes, and secondly, the mixture was sonicated for 15 min in order to produce as high as much dispersion of ZnO NPs into epoxy matrix. However, the third step involved mixing epoxy with hardener at ratio of 3:1. Cast deposition method at room temperature was used to make the samples, then they were left at room temperature to dry for two days to ensure the best curing. The thickness of each sample was measured by digital micrometer, as shown in table (2).

The X-ray diffraction (XRD) was carried out using Philips PW 1700 X'Pert Pro diffractometer, anode of CuK X-ray source, anode current of 40 mA and operating voltage of 45 kV (Leiden, Netherlands), with 2θ varying between 10° and 80° in continuous style, with a step size of 0.02°, in 0.35 s per step for a count time.

