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Enhancement of thermal conductivity and ultrasonic properties by incorporating CdS nanoparticles to PVA nanofluids

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Abstract: In the present work, semiconducting cadmium sulfide (CdS) nanoparticles have been synthesized by co-precipitation method. X-ray diffraction (XRD), UV–visible (UV/Vis) absorption spectroscopy, and high-resolution transmission electron microscopy (HRTEM) have been used for the characterization of the synthesized nanoparticles. Two-step technique has been used to formulate stable polyvinyl alcohol (PVA)-based CdS nanofluids at room temperature. Thermal conductivities of nanofluids at different temperatures have been measured using Hot Disc Thermal Constants Analyzer. Significant enhancement in thermal conductivity is noted at very low nanoparticle loading. Ultrasonic velocity and ultrasonic attenuation in the prepared nanofluids have been investigated using ultrasonic interferometer and Acoustic Particle Sizer (APS-100), respectively. APS-100 has been also used for the analysis of particle size distribution (PSD) of CdS nanoparticles in the prepared nanofluids. The PSD result of APS-100 is in good agreement with that of HRTEM. The characteristic behavior of CdS nanofluid is illustrated on the basis of its ultrasonic and thermal properties. The thermal conductivity enhancement increases with the temperature and reaches up to 61.6% for 1.0 wt% particle loadings at 80 °C. Our analysis shows that CdS nanofluids have potential application for effective heat transfer management in various cooling industries.

Keywords: CdS nanoparticles; nanofluids; thermal conductivity; ultrasonic attenuation spectroscopy; ultrasonic velocity.

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1 Introduction

Nanofluid is a simple and emerging product of nanotechnology. Nanofluids (NFs) are made by suspension of nanoparticles (NPs) in conventional base fluids such as water, oils, ethylene glycol, polyvinyl alcohol (PVA), etc. Since the pioneering work done by Choi in 1995, nanofluids have seen enormous growth in nanotechnology [1]. Nanofluids exhibit heat transfer properties superior to that of the conventional fluid due to the large surface to volume ratio of the suspended nanoparticles [2]. Nowadays, nanofluids have attracted great interest in the industrial field because of their broad applications such as heat exchangers, cooling of microchips, drug delivery, heat transfer augmentation in solar collectors, solar power generation, and enhanced oil recovery [3, 4].

There are many works reported in the literature about enhancement of thermal conductivity of NFs. In the last few years, many works have been done on the enhancement of thermal conductivity of the various NFs at different concentrations and temperatures by a number of researchers [5–8]. Masuda et al. [5] reported the effect of particle volume fraction in the enhancement of thermal conductivity in Al_2O_3, SiO_2, and TiO_2 nanoparticles–water-based NFs. At room temperature, they reported 32.4% thermal conductivity enhancement (TCE) for Al_2O_3/water nanofluid at 4.3 vol% concentration of NPs. This was the first experimental study regarding the thermal conductivity of NFs. Lee et al. [6] reported on the TCE of nanofluids by dispersing Al_2O_3 and CuO NPs in the matrix of water and ethylene glycol at room temperature. They observed 20% TCE for CuO/ethylene glycol nanofluid at 4.0 vol%. Wang et al. [7] reported a similar kind of study in water-based nanofluid by dispersion of Al_2O_3 and CuO NPs and reported a 40%