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The international debate on Novel Nanofluid based on Water-Loaded Delafossite CuAlO2 Nanowires: Structural and thermal properties

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Presentation: Ultra High - performance cooling has emerged as crucial requirement of many industries including microelectronic devices, engine cooling systems, nuclear power system, chemical reactors, refrigeration systems and etc. Recent experimental results show the potential of the thermal behavior for the suspended nanometallic in conventional fluids; nanofluid. In this study, one - dimensional delafossite CuAlO2 nanowires will be synthesized via easy microwave hydrothermal approach. A novel type of nanofluid consisting of CuAlO2 nanowires suspended in distilled water at various volume fractions of (0.0, 0.2, 0.4 and 0.6 wt%) will be fabricated using an easily scalable sonication approach. The structure and microstructure of as synthesized CuAlO2 will be examined in terms of X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDS), transmission electron microscopy (TEM) and field emission scanning electron microscopy (FESEM). Furthermore, the thermal conductivity and specific heat capacity of water based nanofluid will be measured at different volume fractions and temperatures. With all of these data, the delafosite CuAlO2 nanowires loaded water base nanofluid can be a promising composite to fabricate new type nanofluid for industrial applications.

Nanofluid is considered as an important material to enhance the thermal performance of any thermomechanical system. Nanofluids are colloidal suspensions of solid nanomaterials (sizes range from 1 to 100 nm) in base fluid. Recent studies reveal that nanofluids have excellent thermal properties, thermal diffusivity, thermal conductivity, viscosity, specific heat capacity, and heat transfer coefficients. However, liquids consisting of particles manifest many issues in terms of particle deposition, blockage of flow paths, corrosion of pipelines, and low pressure. Recent advances in material technology allow the synthesis of innovative heat transfer fluids with enhanced transport and thermal properties by suspending nanoparticles in base fluids. Generally, nanofluids possess some remarkable properties, such as less clogging problem, reduced heat transfer system size, higher thermal conductivity, better stability, and lower pressure. In recent years, different scientific endeavors have been carried out in the quest of new nanofluid composites with improved parameters. Nanofluids can be synthesized by either one- or two-step methods. In the one-step technique, nanoparticles and nanofluids are prepared together; hence, this route can reduce the aggregation of nanoparticles during drying, storage, transport, and dispersion of nanoparticles. Therefore, it is impractical to implement the one-step technique on a wide manufacturing scale. In contrast, in the two-step approach, nanoparticles and nanofluids are prepared separately. Although the area of application can be expanded by this method, the nanoparticle agglomeration, and clustering profoundly affect the strengths of nanofluids. Hence, finding the stability of nanofluids is a great challenge in the two-step technique. Cuprous aluminate delafossite (CuAlO2) nanostructured has been synthesized for some time using chemical or physical routes. Among all the techniques which have been employed to fabricate CuAlO2 nanostructured, the water-based nanofluid loaded one-dimensional delafossite CuAlO2 nanowire has not yet been explored deeply. The main purpose of this research was to fabricate novel nanofluid consisted of water-loaded CuAlO2 nanowires. The microstructures of the as-synthesized CuAlO2 nanowires were examined. Finally, the thermal properties of fabricated nanofluids were investigated in detail.

Experimental Segment

Preparation of Delafossite $CuAlO_2$ Nanowire

All reagents (Sigma-Aldrich, St. Louis, Missouri, US) of this study were of analytical grades and used without further purification. One-dimensional delafossite $CuAlO_2$ nanowires were synthesized directly by reacting copper acetate ($Cu(CH_3COO)_2$), aluminum acetate ($Al(OH)(C_2H_3O_2)_2$), and urea (NH_2CONH_2) under microwave hydrothermal method. The solutions were prepared by dissolving equimolar 0.7 mole of copper acetate and aluminum nitrate ($Al(NO_3)_3$) in isopropanol (C_3H_8O), and simultaneously, a solution of 2.5 g urea and 25 mL isopropanol was added dropwise into the aqueous solution. The as-obtained solution was stirred in a magnetic stirrer at room temperature for 60 min to yield a homogenous solution. The solution was then placed in an autoclave (100 mL Teflon-lined). The autoclave was placed in a household microwave oven and heated at 300°C for 10 min at 1200 watts. The temperature of the microwave oven was controlled with a fiber-optic temperature sensor (Model 1000, Probe LIC-2, 100574, Luxtron Corp., Mountain View, CA). All microwave treatments were operated at 3.5 GHz frequency. After the reaction, the autoclave was cooled down to room temperature. The final product, after being collected, was rinsed with deionized (DI) water followed by ethanol to avoid any agglomeration. Finally, the obtained product was oven-dried at 60°C for 24 h, and the final brownish white powder was collected for further characterization and physical tests.

Fabrication of Water-Loaded $CuAlO_2$ Nanowires-Based Nanofluid

$CuAlO_2$ nanowires with different weight percentages (0, 0.2, 0.4, and 0.6 wt%) were first dispersed in DI water to prepare a nanofluid mixture. pH of each mixture was measured and if necessary was adjusted to 4.0 ± 0.2 by adding hydrochloric acid. The mixtures were then irradiated using ultrasound (Sonics and Materials, Inc., Fibra Cell Fx 750) for 30 min to break the accumulated particles to obtain higher homogeneity. pH of the mixtures was maintained below the isoelectric point of $CuAlO_2$ nanoparticles (7–9 for alumina) to ensure positive surface charges on nanoparticles. It can be posited that surface charges on nanoparticles resulted from the reaction of hydroxyl groups (−OH) with H^+ of water.

Biography

Haya Alhummiany is currently Assistant Professor of Physics at King Abdulaziz University. Her primary research focuses on nanoscale materials and organic Solar Cell fabrication and characterization of the nanophotonic devices. She holds a Ph.D. degree (2013) from the University of Nottingham, UK and a MSc degree (2005) from King Abdulaziz University, SA. In 2017, she joined MIT Ibn Khaldun Fellowship for Saudi Arabian Women at MIT's Department of Materials Science and Engineering. Prior to joining MIT, she was a Deputy Director, Centre of Nanotechnology at KAU.

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