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Electrical conductivity of CuO nanofluids

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ABSTRACT

An empirical electrical conductivity assessment of nanofluids comprising CuO nanoparticles water-based in different concentrations, particles size and various temperatures of nanofluids has been carried out in this paper. These experimentations have been done in deionized water with nanoparticles sizes such as 89, 95, 100 and 112 nm and concentrations of 0.12 g/l, 0.14 g/l, 0.16 g/l and 0.18 g/l so nanofluids obtain in temperatures such as 25°C, 35°C, 45°C and 50°C for investigation of their electrical conductivity. It is observed that, in water-based nanofluids, the electrical conductivity increases with increasing in both nanofluids temperatures and concentration respectively in the range 25–50°C and 0.12-0.18g/l. But in nanoparticles size rising in nanofluids we observe that electrical conductivity has a few increase when nanoparticles have 95nm diameters, so decrease for biggest nanoparticles such as 100 and 112nm. It seems that there is an optimum in electrical conductivity with resize of nanoparticles.

Keywords: *Nanoparticles; Electrical conductivity; CuO; Water-based nanofluid; Changes in Concentration and temperature*.

INTRODUCTION

Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing condensed nanomaterials. They are two-phase systems with one phase (solid phase) in another (liquid phase). Nanofluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields [1]. Electrical conductivity is an important property for technological applications of nanofluids that has not been widely studied. Conventional descriptions such as the Maxwell model do not account for surface charge effects that play an important role in electrical conductivity, particularly at higher nanoparticle volume fractions [2].

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Electrical conductivity of water shows its capability indicator in electrical current conductivity. The conductivity (or specific conductance) of an electrolyte solution is a measure of its ability to conduct electricity. The SI unit of conductivity is Siemens per meter (S/m). Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution [3]. Nanoparticles can improve electrical conductivity of liquids, for this reason it has been attempted to investigate in this research. Procurement of stable nanofluids is the first step and key topic of nanofluid research and applications. At present, some methods, such as dispersion method, direct evaporation condensation method (DECM), submerged-arc nanoparticles synthesis system (SANSS), laser ablation method, and wet chemical method, etc. have been applied to synthesize nanofluids [4-8]. Dispersion method is a two-step method [9-10], in which commercial nanoparticles are dispersed into base fluid under ultrasonic agitation or mechanical stirring. The advantage of this method is that it could prepare nanofluids in a large scale. However, nanoparticle aggregations are difficult to breakup under ultra-sonication or stirring. Thus, stability of nanofluids prepared with dispersion method is usually not ideal. DECM, SANSS, and laser ablation method are one-step physical methods [11-14], in which metal materials are vaporized by physical technology and cooled into liquids to obtain nanofluids. These physical methods provide excellent control on the particle size and can produce stable nanofluids. However, it is difficult to synthesize nanofluids in a large scale [15-17].

The electrical conductivity measurement instrument (EC meter)

The electrical conductivity of a solution of an electrolyte is measured by determining the resistance of the solution between two flat or cylindrical electrodes separated by a fixed distance [18]. An alternating voltage is used in order to avoid electrolysis. The resistance is measured by a conductivity meter. Typical frequencies used are in the range 1–3 kHz. The dependence on the frequency is usually small [19], but may become appreciable at very high frequencies, an effect known as the Debye–Falkenhagen effect. There are two types of cell, the classical type with flat or cylindrical electrodes and a second type based on induction. Schematic setup is shown in Figure 1.

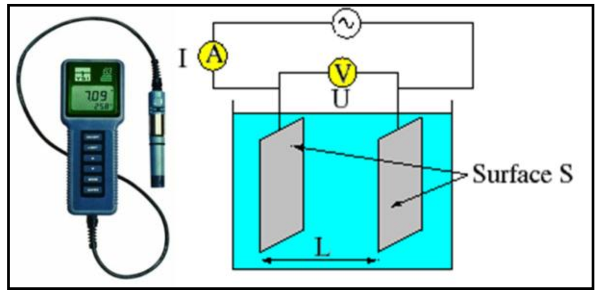

Fig. 1. electrical conductivity meter (EC meter)

EXPERIMENTAL

Experimental set up

Nanoparticles have been syntheses in deionized water by electric arc discharge. The used currents were 10, 20, 30, and 40A. Samples were separated from water by centrifuge and dried by non-direct heating. So analyses SEM and XRD supplied. These analyses (Figure 2) of the nanoparticles show that CuO nanoparticles shape are spherically and well dispersed and their diameters size were estimated as 89, 95, 100 and 112 nm.

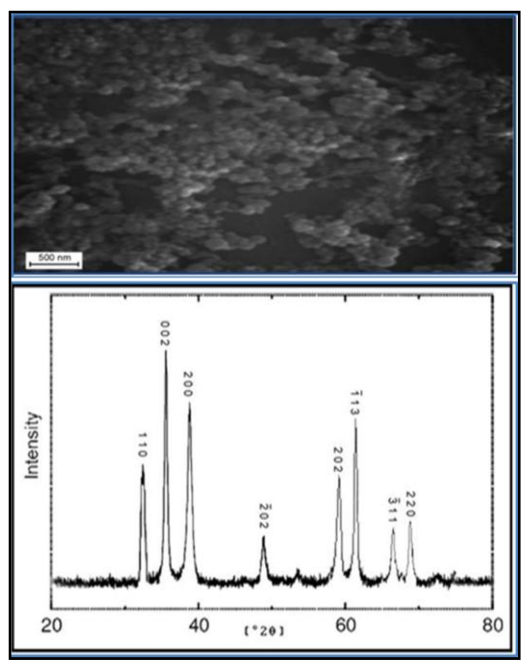

Fig. 2. Scanning electron microscope (SEM) images and X Ray Diffraction (XRD) of CuO nanoparticles.

RESULTS AND DISCUSSION

Preparation and electrical measurement with change in concentration and diameter of nanofluids

The electrical conductivity of de-ionized water was measured as 0.055µs/cm. CuO nanoparticles with various diameters added to water so dispersed by ultrasonic waves for investigation of changes in the electrical conductivity of pure water. Different concentrations of this suspension such as 0.12 g/l, 0.14 g/l, 0.16 g/l and 0.18 g/l provided so their electrical conductivity were evaluated in 25°C by ECmeter. These results are given in Table 1.

Table 1. Result of CuO nanofluids electrical conductivity with various concentrations and diameters

	0.12 g/lit	0.14 g/lit	0.16 g/lit	0.18 g/lit
89nm	0.083	0.089	0.091	0.097
95nm	0.097	0.101	0.106	0.108
100nm	0.065	0.066	0.069	0.073
112nm	0.061	0.062	0.066	0.07

According to this table the diagrams shows in Figure 3 would be imaginable.

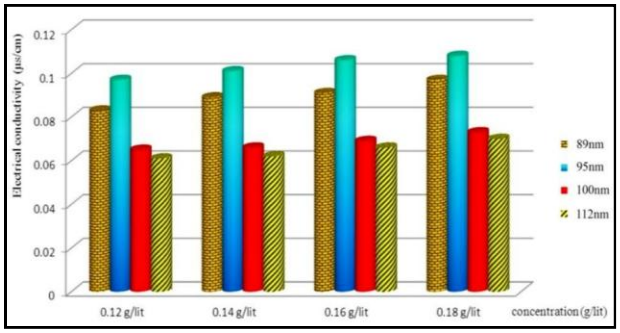

Fig. 3. Effect of nanoparticles size on the electrical conductivity of CuO based–water nanofluids with different concentrations

According to Figure 3 looks nanoparticles size has an optimum in 95 nm and these particles make maximum conductivity. Figure 3 shows that if nanofluids concentration increased then the electrical conductivity has been growth. This growth is liner in all of samples and nanofluids with concentration of 0.18 g/l and Nanoparticles with a diameter of 95 nm have maximum conductivity.

Effect of temperature on nanofluids electrical conductivity

The suspension with concentration of 0.18 g/lit has been test for investigation of change temperature effects on electrical conductivity of CuO nanofluids. Results are given in Table 2 and Figure 4. The dispersed Nanoparticles deposited in temperatures above 50°C because of nanoparticles growthing.

Table 2. Result of temperature effect

	89nm	95nm	100nm	112nm
25 °c	0.097	0.108	0.073	0.07
35 °c	0.105	0.111	0.079	0.072
45 °c	0.115	0.116	0.082	0.075
50 °c	0.119	0.118	0.09	0.081

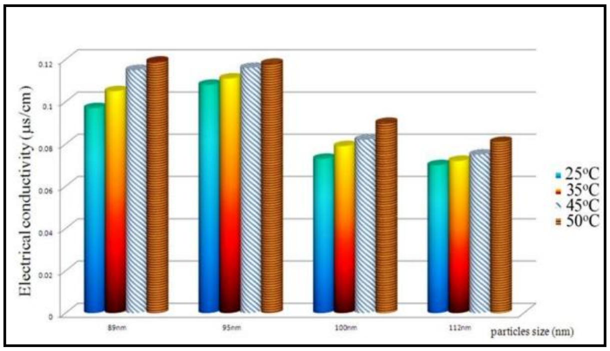

Fig. 4. Effect of temperature on the electrical conductivity of CuO–water nanofluids (0.18 g/lit)

Figure 4 shows that, temperature rising lead to an increasing in nanofluids particles with various sizes that can because of CuO as a semiconductor. Increase in temperature cause electrons that exist in valence electrons going to conductivity layer and participate in conductance or conductivity.

CONCLUSIONS

In this paper nanoparticles size, nanofluids concentration and temperatures change effects have been assessment. It shows that there is an almost linear increase in electrical conductivity of water-based nanofluids with particle concentration. But in nanoparticles size rising in nanofluids we observe that electrical conductivity has a few increase when nanoparticles have 95nm diameters so decrease for biggest nanoparticles such as 100 and 112nm. It seems that there is an optimum in electrical conductivity with resize of nanoparticles. The effect of temperature on the electrical conductivity of CuO–water nanofluids has been studied and we derive if the nanofluids temperature rises, then we are witnessing an increase in electrical conductivity. So, increasing in concentration and temperature leads to electrical conductivity increment and changes in particles size has an optimum.

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