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Synthesis and Experimental Technique for the Study of Acoustic, Mechanical, Electrical and Optical Studies of Copper Nanofluid using a Novel One - Step Method

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Abstract: *A novel one-step method has been used in the synthesis of copper nanofluid. 0.01M copper acetate is reduced by glucose with the presence of Sodium lauryl sulphates. The measurements of Ultrasonic velocity, Compressibility, Density, Acoustic impedance, Inter molecular free path length, Bulk modulus, Rao's constant and Surface tension have been determined using nanofluid interferometer model NF-12X operated at 9 MHz frequency. Specific gravity bottle was utilized to measure the density of the nanofluids. The synthesized nanofluid is characterized by X-Ray diffraction (XRD), Scanning Electron microscopy (SEM) and optical studies. The Electrical conductivity was measured for different concentration using Digital conductivity meter model-RI 503.*

Key Words: Copper Nanofluid[1], Ultrasonic Parameters[2], XRD[3], SEM[4], FTIR[5], UV[6], Electrical Conductivity[7].

1. INTRODUCTION

The colloidal suspension of nanoparticles in the base fluid has turned now into the most advanced and dragging field in science due to the enhanced thermal conductivity than the traditional base fluids. Nanofluids can exhibit better heat transfer characters in the heat exchange systems and electronic cooling systems which is one of the natural advantages of nanofluids which the field of industry is starved for more than three centuries. nanofluids

Which are outcome of dispersing nano sized materials such as nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanobubbles or nano sheets in the base fluid like water, oil, acetone, heat transfer fluids, polymer solutions, bio-fluids and etc. These dispersing nanoparticles have dimension of 1-100 nm [1].The term nanofluid was coined by Choi [2]. Nano fluids have very diverse application in various technical fields which includes nano electronics, transportation, nuclear physics, nano solar collectors and biomedical science [3].

Fluids are categorized as metallic or nonmetallic. Nanofluid is also not an exception for this. But nanofluids are classified on the basis of behavior of colloidal particle in the base fluid [4]. There are two phases of nanofluid system one is liquid and another is solid. The stability of the fluid determines the life time of nanofluid. The method of preparation of these nanofluids generally follows in two methods: a) one-step method, b) two-step method. The dry nano sized powders is produced first either physical or chemical process at the second step of two step method the produced nano sized powders is made to dispersed into the base fluid with help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing and ball milling. In contrast to this in one-step method simultaneous making and dispersion in base fluid occurs at the same time [5].

Ultrasonic pulse velocity test in which the longitudinal ultrasonic waves has been used and it has become the most valuable tool for the study of various chemical and physical properties of the matter [6]. It is an important fact finding technique in the fields of fiber optics, optical metrology, astronomy, remote sensing and plasma physics. An ultrasonic interferometric sensor has used to measure suitable changes in the physical properties of fluids such as density, viscosity, surface tension, compressibility and bulk modulus. The shape of the particle will not have any effect on the ultrasound velocity for homogeneous dispersion [7]. Inter-molecule and Intra-Molecular interactions, structural and physio chemical behavior details can acquire at an exhaustive level by using ultrasonic, thermo-physical and thermodynamic properties of liquid mixtures. In this regard they possess a key role which no one can dispute. They also have a crucial role in verification of various liquid state theories which makes an attempt in an estimation of properties in liquid mixtures. To determine the precise values of velocity of sounds in liquids, Systematic study of Thermodynamic properties of solutions with a new type of multi-frequency ultrasonic interferometer is being done. Since they provide a way for studying physical forces acting amongst the molecules of different species they became one of the reasons for study of thermodynamic properties and thermo-physical of multi-component liquid mixtures [8].

Electrical conductivity of nanofluids which is not widely studied so far but they possess the significant property for technological applications of nanofluids. The conductivity of an electrolyte solution is a measure of its material capacity to conduct electricity. Siemens per meter (S/m) is the SI unit of conductivity. These, conductivity measurements are used routinely in various environmental and industrial applications as a fast, inexpensive and reliable way to measure the ionic content which presents in a solution [9-12]. In the current days copper nanofluid was prepared by chemical one-step method. Copper nanoparticles attracted a greater interest among researchers due to their use as coolant and its inherent heat exchanging character [13]. Ultrasonic velocity, Density and various thermodynamic parameters are measured and the electrical conductivity have also been studied.

2. Experimental Procedure

2.1. Preparation of Copper Nanofluids

Copper nanofluids were prepared by chemical reduction of Copper acetate using glucose in the presence of Sodium lauryl sulfate (SLS) by one-step method. In this experimental procedure 30 ml of 0.01M aqueous solution of copper acetate was prepared by the addition of ammonium hydroxide till the color became deep blue. The mixture of solution was stirred with solution of SLS (30ml) in ethylene glycol (5ml). After 5 min 3g of glucose was added. Then the mixture was heated to 75^{0}C with stirring turns the color of the solution changed from golden yellow. At that the time sulphuric acid was added and stirred few minutes when the color changed to brown. Finally the solution was cooled at room temperature obtain a copper nanofluid.

The chemical reaction between copper and glucose is,

$2Cu_2+ + C_6H_{12}O_6 + 2H_2O \rightarrow Cu_2O + C_6H_{12}O_7 + 4H$

3. Result and Discussion

3.1. Ultrasonic Investigation

Ultrasonic investigation was accomplished using nanofluid interferometer (Model NF-12X). The ultrasonic velocity of copper nanofluid for frequency 9 MHz nanofluid interferometer is used in the assessment of several properties i.e. Intermolecular Free path Length, Compatibility, Rao's Constant Formalism, Surface tension Acoustic impedance and etc. Specific gravity bottle is utilized to execute density measurements. Density of Copper nanofluid under probing is found to be the value of 1531.52 kg/m^3. Digital conductivity meter, Modal: RI 503 is used to estimate the conductivity levels of the copper nanofluid.

3.2. Measurement of Ultrasonic Velocity

With the help of a variable path interferometer, ultrasonic velocity measurements have been made at 9 MHz of frequency. Specific thermostat is used to circularize water around the sample. Ultrasonic study of liquid and liquid mixtures has gained much importance in characterizing of thermodynamic and physio-chemical aspects of ternary liquid mixtures. Wavelength (λ) of the ultrasonic wave is determined by 2d/n m. The velocity of the fluid is calculated using the relation, (using the value of λ)

$$V = f.\lambda$$

Where f is the frequency of the generator. The ultrasonic velocity for 9 MHz frequency for nanofluid of copper is 2.0214 m/sec.

3.3. Measurement of Compressibility and Acoustic Impedance

The fractional decrease of volume per unit increase of pressure, when there is no heat inflows or out flows is called the adiabatic compressibility. These altering values are directly related to the compressibility of the medium. The compressibility of copper nanofluid is determined by the following formula:

$$K = \frac{1}{V^2\rho}\ m^2/\text{Newton}$$

Where ρ is density of nanofluid. The value of copper nanofluid compressibility is 1.5980 m^2/Newton [10-14].
The Acoustic impedance of copper nanofluid is calculated using the formula

$$Z = \rho\,.V\ (\text{kg}/m^2/\text{sec})$$

Where ρ is the density and V is the velocity of fluid. The Acoustic impedance of copper nanofluid is 3095.81 (kg/m^2/sec).

3.4. Measurement of Rao's Constant and Intermolecular Free Path Length (LF)

$$R = \frac{M}{\rho}.V^{1/3}\ (m^3/\text{mole})\ (m/s)^{1/3}$$

Where ρ = density, V = molar volume and
M= Molecular Weight. Measurement of Rao's constant of copper nanofluid is 0.1647 (m^3/mole) $(m/s)^{1/3}$. The Intermolecular Free Path Length (LF) is calculated from

$$L_f = K\ (\beta)^{1/3}(\text{Å})$$

Where β= adiabatic compressibility, K = temperature dependent Jacobson's Constant. The value of intermolecular free path length is 1.4000× 10^{-8}(Å).

3.5. Measurement of Bulk Modulus and of Surface Tension

$$K = \frac{1}{\beta}\ N/m^2$$

The bulk modulus of copper nanofluid is calculated from the above formula. 6257.8 N/m^2 is the value of bulk modulus of copper nanofluid [14-17].

Surface Tension (S) is determined by the following formula:

$$V = \frac{S}{(6.3\times10^{-4}\ \rho)^{2/3}}$$

Value of surface tension is 3095.81

3.6. X-Ray Diffraction (XRD)

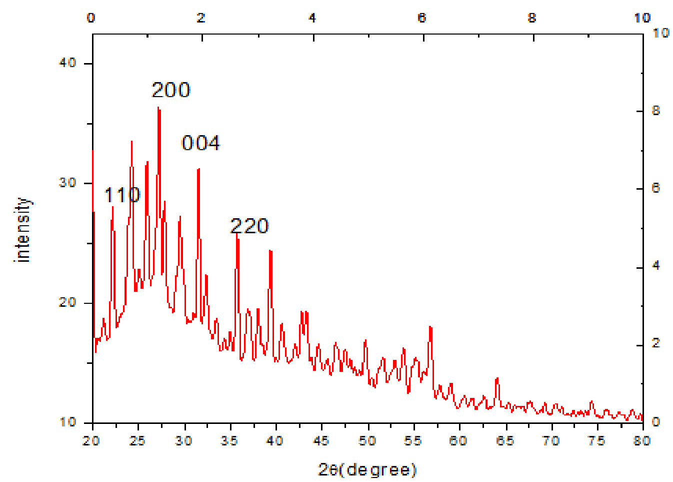

Fig-1: X-ray diffraction (XRD) of Copper nanofluid.

In X-ray diffraction experiment, the powder $Ba_{0.97}Ca_{0.03}SO_4$: Cu sample hkl value was calculated from XRD. All the XRD peaks of the compounds are orthorhombic structure, show in the fig 1. Hence, the lattice parameter is a=8.836Å, b=5.440Å, c=6.859Å. The peaks are corresponding to the 110, 004 and 220 planes respectively. The particle size was calculated using the Debye Scherer formula.

$$D = \frac{K\lambda}{\beta\cos\theta}$$

Where K is the Scherer constant λ is the wavelength of radiation, β stands for the full width at half maximum (FWHM) intensity of the diffraction peak for the particle size is to be calculated, θ denotes the diffraction angle of the concerned diffraction peak and D is refers to the thickness of the crystal. Based on this formula it is found that, the particle size is 44 nm,

3.7. Optical Properties:

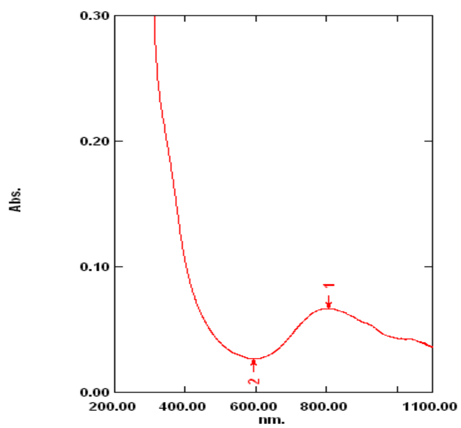

Fig- 2: UV – visible spectrum of copper Nanofluid

The absorption of UV radiation results from excitation of bonding electrons as a consequence, the wavelength of absorption peaks can be correlated with the type of the bonds in the species hence UV visible absorption spectroscopy is an proficient technique to observer the optical properties of quantum size particles. The absorption edge at 592 nm indicates the peak due to copper nanoparticles.

3.8. FTIR

The functional groups present in the as-synthesized materials are identified by FTIR analysis. The IR spectra of Copper Nanoparticles are in the range of 4000 to 400 cm^{-1}.

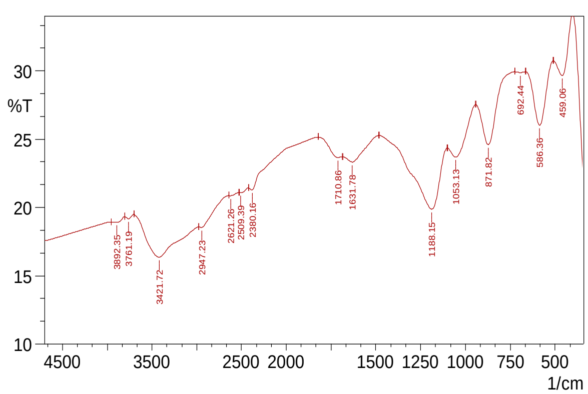

Fig-3: shows the FTIR spectra of copper nano fluid

3.9. Scanning Electron Microscopy (SEM)

When 30 Ml of 0.1 M copper acetate was reduced to copper and was simultaneously dispersed in the base fluid, in the presence of 0.01 M SLS solution.

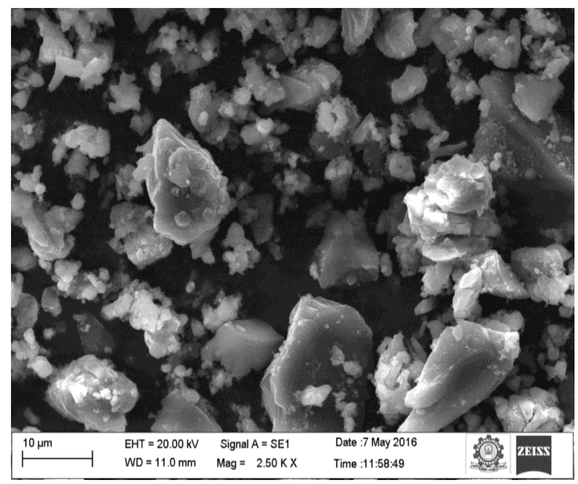

Fig - 4 :SEM image of copper nanofluid

3.10. Electrical Conductivity

The ability of charged particles (ions) which is in the suspension for carrying the charges (electrons) towards the respective electrodes when the field is subjected to electricity which is related to the electrical conductivity of a nanofluid present inside it. In nanofluids, the nanoparticles which is dispersed in a base fluid get charged because of the formation of Electrical Double Layer (EDL) around the particle surface of nano particles. These nano particles along with the Electrical Double Layer move towards oppositely charged electrode when a potentialis applied. The electrical conductivity of a nanofluid was determined by the electrophoretic mobility of charged particles.

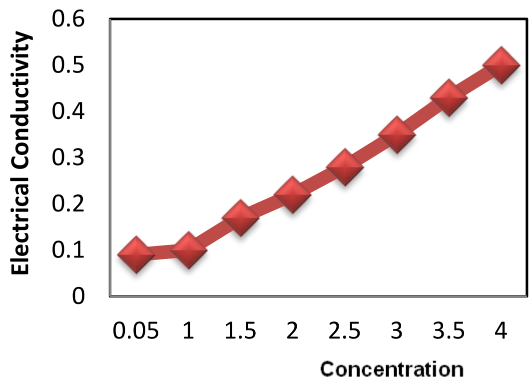

Chart - 1: The Electrical Conductivity of Copper Nanofluid

From the graph the electrical conductivity of copper is increase with the concentration.

4. Conclusion:

Through the one-step method, Copper nanofluid has been synthesized fruitfully. Copper acetate solution is slashed by glucose in the presence of SLS in the process of one-step method. Certain important physical parameters such as adiabatic compressibility, specific acoustic impedance, intermolecular free length, Rao's constant, bulk modulus etc. has been used to study the ultrasonic properties of the nanofluid and they are also evaluated by technologies like ultrasonic velocity, density. UV- Visible spectra, FTIR, XRD and SEM measurements which are also confirmed the formation of copper nanofluid which was produced earlier. The electrical conductivity also measured and they can be further used for the technological applications. The method which we studied so far is found to be trustworthy, simplistic in approach and cost efficacious.

REFERENCES

[1]. Abdul Quddoos, Aditya Anand, Gaurav Kumar Mishra, Purnima Nag *Nano fluids,* "Introduction, Preparation, Stability Analysis and Stability Enhancement Techniques", (2014), pp.31.

[2]. R Manimaran, K Palaniradja, N Alagumurthi, S Sendhilnathan, J Hussain, "Preparation and characterization of copper oxide nano fluid for heat transfer applications", (2014), pp.163.

[3]. Vimal Pandey, Giridhar Mishra, S K Verma, Meher Wan, R R Yadav, "Synthesis and Ultrasonic Investigations of CuO-PVA Nano fluid", (2012), pp.664.

[4]. Giridhar Mishra, Meher Wan, Vimal Pandey, Devraj Singh, R R Yadav, B, "Mishra Ultrasonic and Thermal Properties of Nano fluids Containing Copper Nanoparticles", (2013), pp.92.

[5]. Wei Yu, Huaqing Xie A, "Review on Nano fluids: Preparation, Stability Mechanisms, and Applications", (2012), pp.17.

[6]. Virendra Kumar, Kailash, "Characterization of Nano fluid of Copper", www.acoustics.asn.au/../p338.pdf.

[7]. B Pallavi Nalle, Asha Navpute, S P Jadhav, B R Shinde, S U Shinde, K M Jadhav, "Synthesis, Structural and Ultrasonic Characterization of CuO Nano fluid", (2015), pp.22.

[8]. Indu Saxena, R N Pathak, Vijay Kumar, Rikkam Devi, "Introduction of ultrasonic interferometer and experimental techniques for determination of ultrasonic velocity, density, viscosity and various thermodynamic parameters, (2015), pp.562.

[9]. Hanumantharao Konakanchi, Ravikanth Vajjha, Debasmita Misra, Debendra Das, "Electrical Conductivity Measurements of Nano fluids and Development of New Correlations, Journal of Nanoscience and Nanotechnology", (2011), pp.1.

[10]. K G KalpanaSarojini, Siva V Manoja, Pawan K Singha, T Pradeep, Sarit K Dasa, "Electrical conductivity of ceramic and metallic nano fluids, Colloids and Surfaces", (2013), pp.39.

[11]. H R Azimi, R Taheri ,"Electrical conductivity of CuO nano fluids", (2015), pp.77.

[12]. G Cynthia Jemima Swaranavalli, Belina Xavier, V Kannappan, "Synthesis and Characterization of Nanostructures Materials, (2010), pp.381.

[13]. Giridhar Mishra, Satyendra Kumar Verma, Devraj Singh, Pramod Kumar Yadawa, Raja Ram Yadav,"Synthesis and Ultrasonic Characterization of Cu/PVP Nanoparticles-Polymer Suspensions", (2011), pp.9.

[14]. George varughese, K T Usha, " *Variation of* Elastic Parameters of CdS:Ho Nano fluid-An Ultrasonic Study", (2014), pp.1525.

[15]. P S Nikam, Mehdi Hasan ,"Asian Journal of Chemistry",(1993), pp. 319.

[16]. Paladhi, R P Singh, " Acustica",(1990), pp. 90.

[17]. Shree Meenakshi, Pradeep E Jaya Sudhan, "Preparation and Characterization of Copper Oxide -Water Based Nanofluids by One Step Method for Heat Transfer Applications', (2015), pp.127.