International Journal of Scientific Research in Science, Engineering and Technology (www.ijsrset.com)
© 2020 IJSRSET | Volume 7 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
DOI : https://doi.org/10.32628/IJSRSET207382

Synthesis and Characterization of Cu_2O Nanofluid

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ABSTRACT

This research paper objects is synthesis and characterization of Cu_2O nanofluid by using the chemical solution method. Characterization includes Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscope (SEM). The absorption peaks of FTIR spectrum can express the characterization of Cu_2O nanofluids. The SEM image graph can be expressed size d shape of the Cu_2O sample on the surfactant and pH of the mixture solution respectively. Cu_2O Nanofluids will be studied for their thermal conductivity and their electrical, magnetic and optical properties.

Keywords: Cu2O nanofluid, Chemical solution method, FTIR and SEM.

I. INTRODUCTION

Nanofluid is the heat transfer fluids containing nano-sized particles, fibres, or tubes that are stably suspended in a carrier liquid Since the concept of nanofluid was proposed researchers have been studying to it because of the thermal properties and the potential applications associated with heat transfer, mass transfer, wetting, and spreading. Cuprous-oxide (Cu_2O), being a versatile semiconductor with a narrow band gap of 2.17 eV and having the suitable energy level position. Cu_2O is a lower toxic and lesser cost materials, which makes it eco-friendly and suitable for large scale applications. There exist a range of Cu_2O Nano crystals with various morphologies including cubes, nanorods, nanospheres, pyramids, octahedrons and squares. In this work, Cu_2O nanorods were prepared by using chemical solution method to synthesize Cu_2O nanofluid: suspensions of cuprous-oxide (Cu_2O) nanoparticles in water. The structural, morphological and optical properties were experimentally studied in order to investigate the effect of reactant on the formation of Cu_2O nanofluid. The optical transmittance spectrum of Cu_2O nanofluid showed the optical window of Cu_2O nanofluid in the wavelength range of 400–700 nm. Morphology of Cu_2O nanofluid was examined.

II. BACKGROUND THEORY

Heat transfer fluids such as water, minerals oil and ethylene glycol play an important role in many industrial sectors including power generation, chemical production, air-conditioning, transportation and microelectronics. The performance of these conventional heat transfer fluids is often limited by their low thermal conductivities. According to industrial needs of process intensification and device miniaturization, development of high performance heat transfer fluids has been a subject of numerous investigations in the past few decades. Nanofluids, defined as suspended nanoparticles with the size of 1 to 100 nm inside fluids, have drawn vast attention due to recently claimed high performance in heat transfer in the literature. From heat transport point of view, various results with great disparities have been reported in recent years. For instance, it has been claimed that improving thermal transport properties of nanofluids would have several advantages and the most important one was summarized as below: Improvement of the efficiency of heat exchanging, reducing size of the system, and providing much greater safety margins, and reducing costs. It is important to note that synthesis and preparation phase of nanofluids would play major role, since better preparation results in better performance of nanofluids and improves thermal transport properties. Currently, most efforts are pushed to increase thermal conductivity while other thermal transport properties such as viscosity and heat capacity, have been paid less attention.

Metal colloidal nanoparticles with sizes comparable to their electron mean free path are becoming increasingly important in variety of scientific field due to their analytical, electrical and optical properties. The physical, chemical and photo physical properties of metals on the nanometres scale are highly influenced by the shape and size of the nanoparticle. Metal nanoparticles continue to be of great current interest in various forms like nanosphere, nanorods, nanowires etc. and are desirable for their optical, electronic, biological and chemical properties.

III. SAMPLE PREPARATION METHOD

Preparation of nanofluids is the first foot-step to the experimental studies of nanofluids. There are two primary methods to prepare nanofluids: the single-step preparation process and the two-step preparation process.

IV. RESULTS AND DISCUSSION

Synthesizing Cu_2O nanofluid by the CSM is based on following chemical reactions in solution:

$$CuSO_4 + 2NaOH = Cu(OH)_2 + Na_2SO_4; \quad (1)$$

$$Cu(OH)_2 \xrightarrow{\Delta} CuO + H_2O \quad (2)$$

$$4CuO + N_2H_4 = 2Cu_2O + N_2 + 2H_2O \quad (3)$$

The reaction between cupric-sulfate ($CuSO_4$) and sodium-hydrate (NaOH) yields cupric-hydroxide $Cu(OH)_2$ and sodium-sulfate (Na_2SO_4). Under heating by a constant-temperature (60° C) water bath with the magnetic stirring, $Cu(OH)_2$ is decomposed into cupric-oxide (CuO) and water (H_2O). The hydrazine-hydrate (N_2H_4) is then added as a reducer to reduce the cupric-oxide (CuO) into cuprous- oxide (Cu_2O). Nitrogen (N_2) and water (H_2O) are also produced at the same time.

To enhance the nanofluid stability and prevent the particle aggregation, some polyvinyl pyrrolidone (PVP; chemical surfactant) is added into $CuSO_4$ solution. In the process, the sodium-hydrate (NaOH) serves not only as a reagent, but also as a mean of adjusting the pH value of mixture for changing particle shape. In this synthesis of nanofluid by the CSM, the solution amount is 10 ml, 25ml, 35 ml and 3.5 ml for $CuSO_4$, PVP, NaOH and N_2H_4, respectively. The flow chart of the synthesis procedure is shown in Figure 1. The starting materials, mixture precursor solution, precipitated solution and heat-treatment at 60° C in water bath can be used.

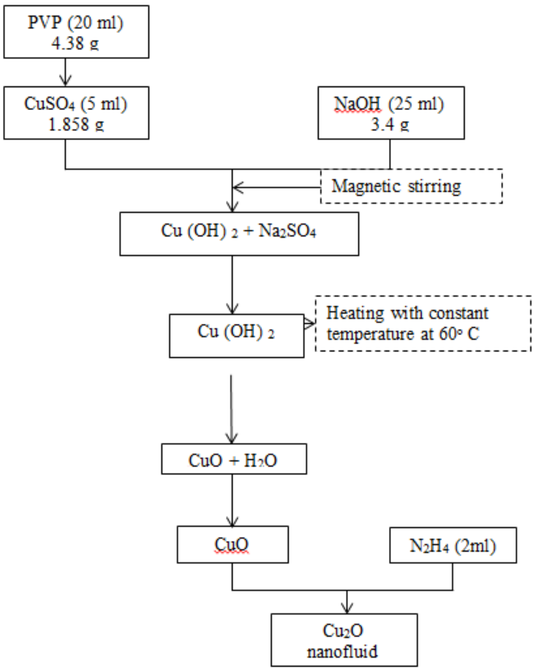

Figure1 Flow chats of the synthesis procedure.

A. **FTIR Spectroscopic Measurement**

Infrared spectroscopy is a chemical analytical technique which measures the infrared intensity versus wavelength (wave number) of light. Based upon the wave number, infrared light can be categorized as far infrared (4-400 cm^{-1}), mid infrared (400-4000 cm^{-1}) and near infrared (4000-14000 cm^{-1}). The infrared absorption spectra of the ferrites were measured using Fourier Transform Infrared Spectrometer. The structural analysis of Cu_2O nanofluid was done by using Fourier Transform Infrared Spectroscopy (FTIR). The FTIR spectrum of Cu_2O nanofluid is shown in Figure 2. The absorption peaks at each wavelength and their corresponding mode of vibrations are illustrated in Table 1. The Cu – O – Cu sharp band occurred around 619 cm^{-1}. Moreover, Cu– O stretching around 577 cm^{-1}, O – H stretching around 3462 cm^{-1} and Cu – OH vibrations around 900 cm^{-1} and 737 cm^{-1} , C – H stretching located around 2960 cm^{-1}, C = C stretching discovered around 1659 cm^{-1}, C – H bending occurred around 1456 cm^{-1} and 1319 cm^{-1}, C – O stretching located around 1290 cm^{-1}, 1163 cm^{-1} and 1018 cm^{-1}, S – O (stretching and bending) bands around 866 cm^{-1}, 849 cm^{-1}, 687 cm^{-1} and 644 cm^{-1} were also observed in the spectrum. Therefore these peaks are attributed to the formation of Cu_2O nanofluid. The literature values for each vibration are described for the reference.

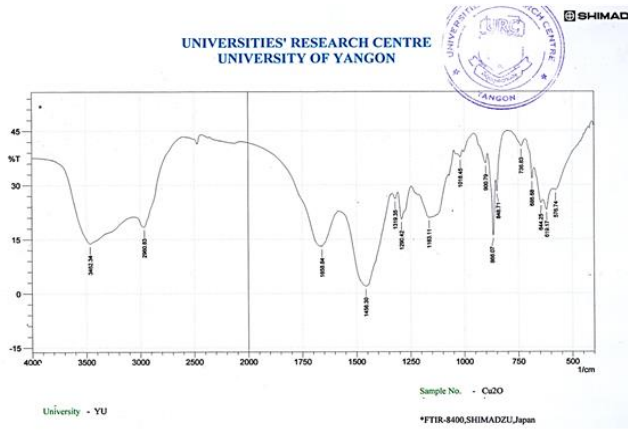

Figure 2 The FTIR spectrum of Cu_2O nanofluid

TABLE I
ASSIGNMENT OF THE BANDS IN THE FTIR SPECTRUM OF CU_2O NANOFLUID

Mode of Vibration	Wavenumber (cm^{-1}) For Cu_2O nanofluid	Wavenumber (cm^{-1}) Literature Value
Cu – O – Cu (the sharp band)	619	629 – 614
Cu – O stretching	577	590 – 530
O – H stretching	3462	3500 – 3200
Cu – OH vibrations	900, 737	987 – 735
C – H stretching	2960	2970 –2851
C = C stretching	1659	1665 – 1600
C – H bending	1456, 1319	1500 – 1350
C – O stretching	1290, 1163,1018	1200 –1080
S – O (stretching and bending)	866, 849, 687, 644	1100 – 600

B. **Morphology of Cu2O nanofluid SEM image**

Morphology of Cu_2O nanofluid was examined by scanning electron microscope (SEM). SEM images of Cu_2O nanofluid with different concentrations of 3.5 M is shown in Figure 3.

It was observed that Cu_2O nanofluid was composed of Cu_2O nanorods with average grain size around 1.37

μm in length and 0.18 μm in diameter for the sample with 2.45 M concentration and 1.64 μm in length and 0.23 μm in diameter for the sample with 0.086 M concentration. The obtained size of the particles is larger than nanoscale and it needs to control the concentration of the starting solution to form nanoparticles suspension in fluid. The size of the sample with higher concentration was slightly smaller than that with lower concentration. It may be due to the viscosity of the fluid which made the nanorods to cover each other in some parts. The formation of Cu_2O nanofluid in nanorods could provide better thermal and electrical conductivity.

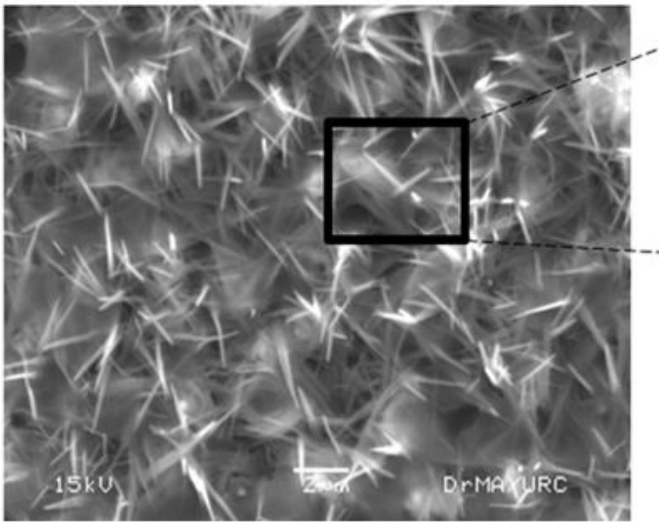

Figure 3 The SEM graph of Cu_2O nanofluid

V. CONCLUSION

The fluid exhabits Newtonian behaviour in the temperature range. This method can be proved to be simple, rapid, cost effective and highly useful for enhancing the thermal conductivity of the synthesized fluid. In this research, Cu_2O nanofluid can be synthesized by using the chemical solution method. FTIR spectrum of Cu_2O nanofluid with their corresponding mode of vibrations verified the formation of Cu_2O nanofluid in this synthesis. Moreover, morphology of Cu_2O nanofluid examined by SEM proved that Cu_2O nanofluid was composed of Cu_2O nanorods and it seems to provide better thermal and electrical conductivity. The optical transmittance spectrum of Cu_2O nanofluid occurred in the wavelength range of 400–700 nm showed the applicability of Cu_2O nanofluid as optical window material.

VI. ACKNOWLEDGMENT

I would like to express my sincere gratitude and special thanks to Rector, Dr. Ei Ei Hlaing University of Computer Studies (Taungoo) for her kind permission to carry out my research paper.

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Cite this article as :

San San Htwe, "Synthesis and Characterization of Cu2O Nanofluid ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 7 Issue 2, pp. 696-700, March-April 2020. Available at
doi : https://doi.org/10.32628/IJSRSET207382
Journal URL : http://ijsrset.com/IJSRSET207382