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Synthesis and Thermal Energy Storage Analysis of Copper Oxide Nano fluid for Heat Transfer Applications

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Abstract: In this paper we have discussed about the synthesis and thermal analysis of nanofluid as phase change material (PCM). Enhancement of thermal conductivity rate serves as a greatest challenge in the present scenario and to overcome this hindrance, nanofluid synthesis was made. Copper oxide nanoparticle was synthesised by double precipitation method and the nanofluid was prepared by two step method. Paraffin was selected as a base material in which the CuO-nanoparticle was dispersed. To check the thermal storage enhancement Differential scanning calorimetry (DSC) test was carried out. With the melting and solidification curve analysis we were able to infer that the latent thermal storage enhancement was increased drastically with the nanoparticle dispersed sample, than with the ordinary base material. The above nanofluid was subjected to laser flash analysis (LFA) to obtain the thermal conductivity enhancement rate. Thus, we can come up with a suggestion of using CuO nanofluid as an effective phase change material (PCM) for heating applications..

Keywords : Nanoparticles; Nanofluid; phase change material; Copper Oxide; paraffin.

I. INTRODUCTION

Phase Change Material (PCM) are those materials which changes its stage with slight change in temperature. They are broadly utilized in putting away inert warmth. They have numerous applications like warming, cooling, and so forth., They are commonly ordered into two kinds 1. Natural PCM's (Eg: paraffin, unsaturated fats) 2. Inorganic PCM's (Eg: metals, salt hydrates).Generally PCM's have low warm conductivity and warmth move rate (HTR). Warm conductivity and HTR of PCM's can be improved by different strategies like 1. Earthenware particles, 2. Metallic particles, 3. Carbon particles. Later new innovation is actualized to upgrade warm conductivity and HTR with the assistance of NANOTECHNOLOGY. Such another liquid is orchestrated by scattering nanoparticle into base liquids (PCM) called NANOFLUID. These nanoparticles have an increasingly surface to volume proportion which aides in the upgrade of warm conductivity and HTR. To the extent warm properties are concerned, the state of nanoparticles and grouping of the nanoparticle assume a huge job. Round and barrel shaped state of particles has increasingly surface zone which aides in putting away progressively idle warmth and improving HTR. The factor that influences warm conductivity is agglomeration of particles at the base. Surfactant and long time ultrasonication should be possible to keep away from sedimentation. Homogenous blend gives high warm attributes. As of late copper oxide (CuO) nanoparticles are ending up increasingly well known for its mechanical, warm, electrical properties and its application in different fields. There are numerous strategies to blend nanoparticles yet the technique which we select must be natural neighborly, easy to understand (safe) and savvy. Among the PCM's paraffin is viewed as truly outstanding for haeting application. In any case, its inconvenience is poor warm conductivity (0.22 W/mK). Paraffin has a dissolving purpose of 52-54°C density= 0.9 Kg/cm3 n=1.42 Cp=2.13K J/KgK atomic weight=353.77 g/mol. This paper talks about CuO nanoparticles with paraffin as base fluid is best reasonable for warming application. CuO nanoparticle is set up by twofold precipitation technique. Nanofluid is orchestrated by two stage strategy. The CuO nanoparticles is exposed to trademark examination like molecule size analyser (PSA) and transmission electron magnifying instrument (TEM). The CuO nanofluid is exposed to warm qualities examination like differential checking calorimetry (DSC) and LFA. The consequences of the above examination suggest that CuO/paraffin is the best for dormant warmth stockpiling during warming application.

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II. MATERIALS AND METHODS

Material

Copper acetate (Cu $(CH_3COO)_2$ H2O) and glacial acetic acid (CH_3COOH) were purchased from SRL, India. Sodium hydroxide (NaOH) pellets were purchased from Lobha Chemie. 2D water (two times deionised water) was used throughout the experiment. Paraffin is used as base fluid.

Characteristics Analysis Studies

Particle size analyser (PSA):

Particle size analyser is a device used to measure the average size of the particle at nano level. This machine was manufactured by Malvern Company, Germany. A very tiny amount of CuO nanoparticle is dispersed in DI water and dropped in ultrasonification for 15mins.

So that homogeneous mixture is obtained. The solution is partially filled in polystyrene cuvettes container and placed in the chamber. Laser beams are passed through the solution and average size of the particle was determined.

Transmission electron microscope (TEM):

This microscope is manufactured by Philips Company, Japan. Transmission electron microscope (TEM) is a device in which a beam of electron is passed through the ultra thin specimen and image of the sample is obtained in the fluorescent screen. This technique is used in nanotechnology to measure the size of the particle and to get bright magnified image of the nanoparticles. A tiny amount of the sample is dispersed in water and dried for few minutes. Then it is placed in the sample chamber, and electron beam is passed through the specimen. Highly magnified image of the individual particle is reflected in the fluorescent screen. By adjusting the zoom (100nm level), particle image and size is obtained.

X-Ray diffraction analyser (XRD):

X-ray diffraction instrument manufactured by SII Germany, XRD is used to find the crystal structure and chemical compositions. Small amount of the sample is loaded in specimen plate and placed in X-ray chamber. High intensity X-rays are passed through the sample and made to scatter. By measuring the scattering intensity and scattering angle, the crystal structure and chemical composition were determined.

Thermal Characteristics Analysis Studies

Differential scanning calorimetry (DSC):

This instrument is manufactured by S II Company, Japan. DSC is used to measure melting point temperature, solidification point temperature and latent heat storage of the PCM mixture for different amount heat applied.

A tiny amount of mixture is filled in aluminium pan and placed in chamber. Nitrogen is used as cooling medium. Firstly, heat is applied and peak is obtained corresponding to melting point temperature of the mixture. Secondly, heating setup is replaced to cooling setup and peak is obtained corresponding to solidification point temperature.

III. RESULTS AND DISCUSSIONS

Characteristics Analysis of Nanoparticle

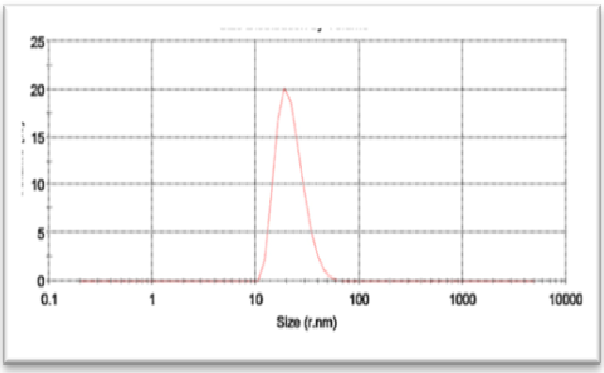

Figure 1: Particle size distributions.

Particle size analyser (PSA) refers that particles dispersed in DI water was in the size range of 1 to 100nm. It also indicates there is no sedimentation of particles at the bottom. The single peak in the graph shows that all the particles dispersed was nano sized and dispersion was homogeneous without any agglomeration. It is represented in graph Fig: 1

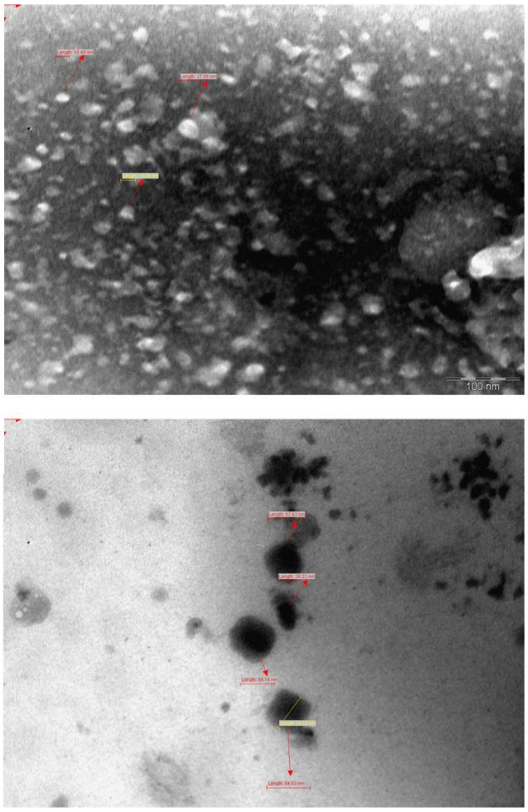

Figure 2: TEM images of CuO nanoparticles.

Transmission electron microscope (TEM) analysis indicates that there is no cluster formation of particles. All the particles were individual and size ranges from 1 to 80nm. TEM results also indicate that all particles are in spherical shape. The bright TEM image is represented in Fig: 2

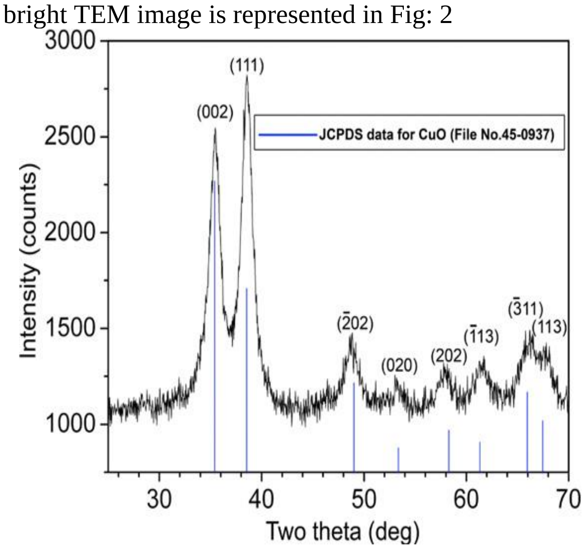

Figure 3: XRD pattern of CuO nanoparticles.

X-Ray diffraction results infer that samples are CuO crystals. It does not contain any form of impurities. The broadening of the peak indicates that the particles are in nano level. The XRD graph in shown in Fig.3.

Characteristics Analysis of Nanofluid

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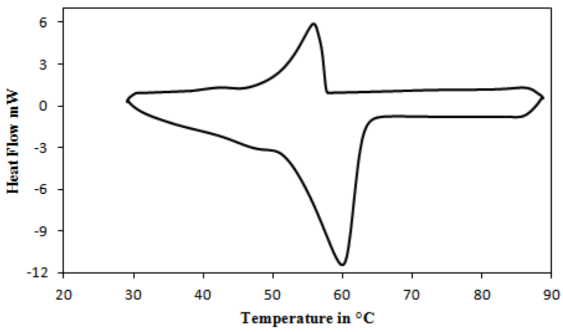

Figure 4: DSC measurements of CuO–paraffin nanofluids

Results obtained from DSC indicate that melting of the PCM starts from 48.4°C and ends at 62.8°C. Between the above mentioned temperature the phase change of paraffin from solid to liquid occurs. The latent heat stored during heating process is 99.4KJ/Kg. solidification of the PCM composite starts from 57.68°C and ends at 46.1°C. The latent heat stored during cooling process is 104 KJ/Kg. The left small peaks between 46.6°C and 48.9°C . The complete result is available in graph form in Fig:4

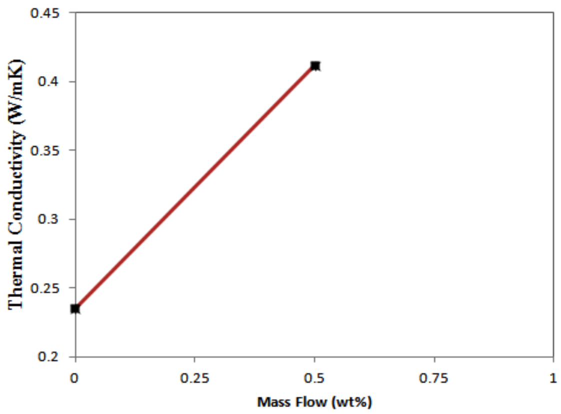

Figure 5: Thermal conductivity of the CuO–paraffin nanofluids

LFA 447 nanoflash analyser results are represented in Fig:5. This result indicates that thermal conductivity increases with increase in concentration of nanoparticles. For 50% (0.5gms) concentration the thermal conductivity was enhanced by 75.2%. Thermal conductivity of pure paraffin is 0.235 W/mK. After dispersion of nanoparticles in PCM, it has improved to 0.412 W/mK.

IV. APPLICATION

The major application of this CuO nanofluid is heating application. When it comes for heating application, renewable source of energy can be used to get effective and efficient heating and also it doesn't create any hazard to the environment. So, for solar based hating application we can use this pcm effectively. Solar water heater, for which this packed pcm can increase the efficiency of the system and helps storing more energy than normal, which is very useful for the present as well as the future.

V. CONCLUSION

The investigation of CuO-paraffin nanofluid as phase change material (pcm) for heating application was carried out successfully. The particle size analyser infers that cuo nanoparticles dispersed in paraffin was a homogeneous mixture which in turn enhances the thermal conductivity and HTR. The compound bond among paraffin and CuO is progressively steady that the nanoparticle does not settle down for a half year. The warm dependability test deduces that the scattering of CuO nanoparticles in paraffin could be viewed as a decent strategy to upgrade the warm conductivity of nanofluid which thus will help in expanding the warmth move rate, making it a superior stage change material (pcm).

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