Synthesis and characterization of copper and ferrous nanofluids by a one-step method

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Abstract - *This paper presents a one step method for the preparation of stable, non agglomerated copper nanofluids by reducing copper nitrate with sodium sulfite as reducing agent in ethylene glycol as base fluid by means of conventional heating using sodium lauryl sulphate (SLS) in the form of a surfactant. This method gives very large quantity of product in a very less time. The methods used for carrying out this characterization process of the nanofluids are X-ray diffraction (XRD) topography; Ultraviolet-visible analysis and Fourier transform infrared spectroscopy (FT-IR). Nano technology is a developing technology of this era. Here also describe examples of potential application and benefits of nanofluids and future research.*

Key Words: XRD topography, Fourier transforms infrared spectroscopy. Visible and ultraviolet spectrometers.

1. INTRODUCTION

This paper presents a procedure for preparing a nanofluids which is a suspension consisting of nanophase powders and a base liduid.By means of the procedure, some sample nanofluids are prepared. Nanofluids are a combination of particles between 1and 100 nanometers a surfactant and the base fluid. These nanofluids improve the heat transfer of the base fluids. The base fluid can be ethylene glycol, or propylene glycol, or an aliphatic hydrocarbon and water, oil, based heat transfer fluid[1][2]. Therefore fluids containing suspended solid particles are reasonably expected to have a higher thermal conductivity than pure fluids[3]. Nano fluids containing metallic or non-metallic particles and it's typically made of metals, oxides, carbides, or carbon nanotubes.

Nanofluids having suspensions of nanometer sized particle, this suspension of nano metric sized particles in fluid is called nano-fluid[4][5]. When the nanoparticles are properly dispersed, nanofluids can offer numerous benefits. For example 0.3 vol% copper nanoparticles dispersed in ethylene glycol is reported to increase its inherently poor thermal conductivity by 40%[6-9]

Hence the development of a new method for the preparation of copper nanofluids is inevitable [10-12]. With all these idea in mind, an attempt has been made in the present investigation to synthesize copper nanofluids by a one-step method using copper nitrate as a source for copper nanoparticles, ethylene glycol as base fluid and sodium sulfite as reducing agent by means of conventional heating.

In the one-step method, copper nanofluids of metallic copper dispersed in ethylene glycol are prepares using sodium sulfite as the reducing agent and conventional heating is carried out. The method is a unique one, where preparation of nanoparticles combined with the preparation of nanofluids and hence the process of drying, storage, transportation and redispersion of copper nanoparticles is avoided and ultimately it reduces the production cost as well.

2. EXPERIMENT

2.1 Preparation of copper nanofluids

All the regents used in our experiments were of analytical purity and were used without further purification. In this procedure 25ml ethylene glycol solution was takes in a 500 ml beaker. To this 15ml of (0.1M) copper nitrate, 50 ml of sodium lauryl sulphate (SLS) surfactant and 100 ml water was added. The reaction mixture was subjected to magnetic stirring for 15 min in a magnetic stirrer\heater. Then 30 ml of sodium sulfite was added and the magnetic stirring was continued for another 30 minute the colour of the mixture turned. Copper nanofluid was obtained after cooling the reaction mixture to room temperature. To hasten the reaction, few drops of dilute sulphuric acid were added and this can be neutralized by the addition of an equal amount of dilute ammonia.

2.2 Characterization

Characterization of the copper & ferrous nanofluid was done by X-ray diffraction topography, UV-visible analysis, and Fourier transforms infrared spectroscopy (FI-IR).

2.2.1 X-ray diffraction topography

Copper & ferrous nanofluid was diluted with absolute followed by centrifugation at 4000 rpm for 60 min. It was then washed with absolute ethanol and acetone. Further it was vacuum dried at 80^0 C for 2 h.

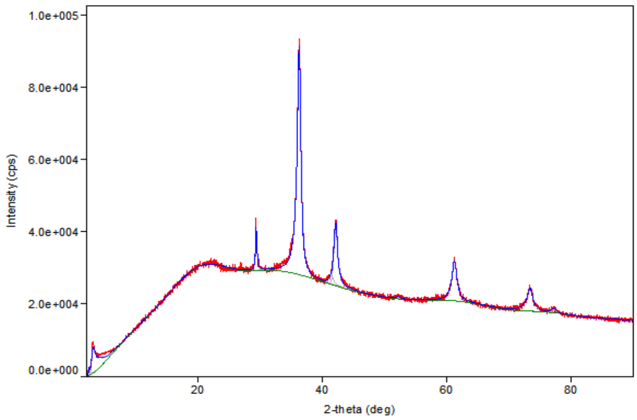

Fig-1: XRD pattern for 0.1conc. Copper nanofluids

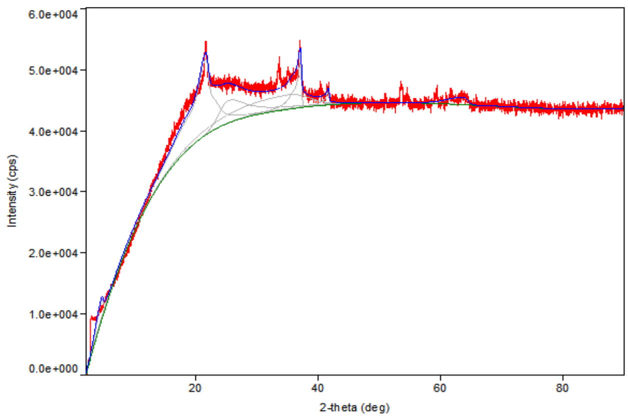

Fig-2: XRD pattern for 0.1conc. Ferrous nanofluids.

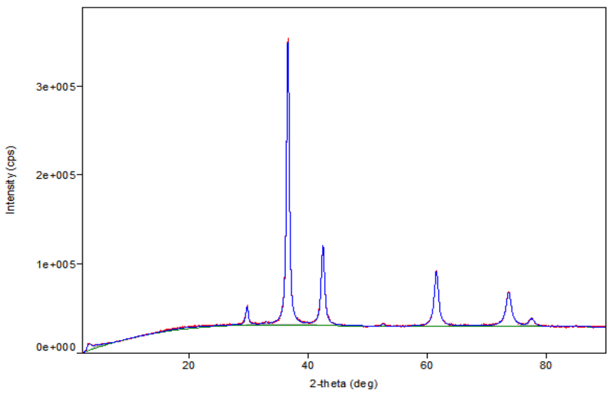

Fig-3: XRD pattern for 0.3conc. Copper nanofluid.

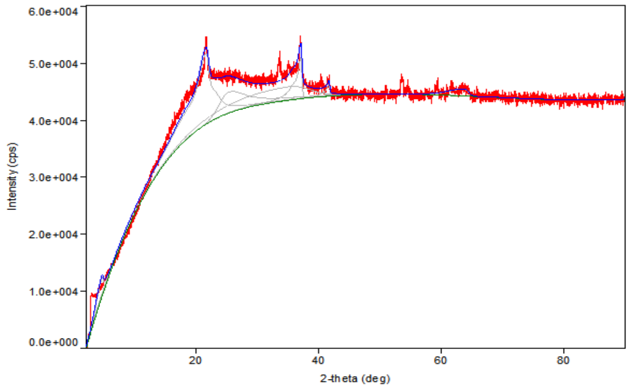

Fig-4: XRD pattern for 0.3conc. Ferrous nanofluid.

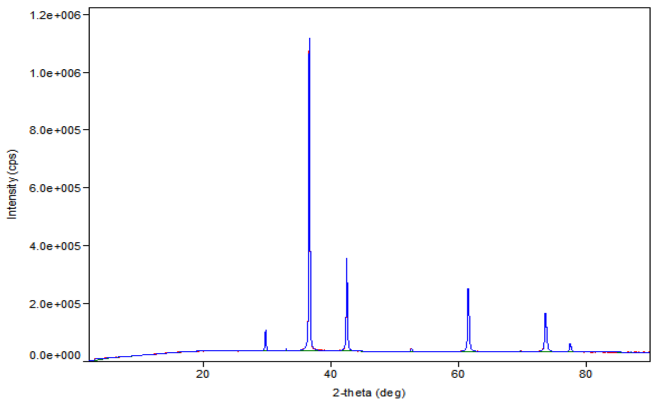

Fig-5: XRD pattern for 0.5conc. Copper nanofluid.

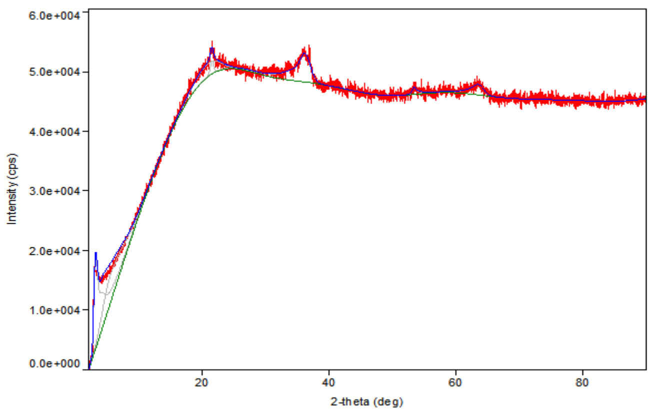

Fig-6: XRD pattern for 0.5conc. Ferrous nanofluid.

2.2.2 Fourier transforms infrared spectroscopy

A 510P FT-IR spectrometer was used to identify the ingredients of the reaction solution. The nanofluids were centrifuged at 16,000 rpm for 60 min and supernatant used for FT-IR analysis. Copper is an inorganic species, which shows characteristic. Absorption that can be identified qualitatively by UV-vis spectroscopy.

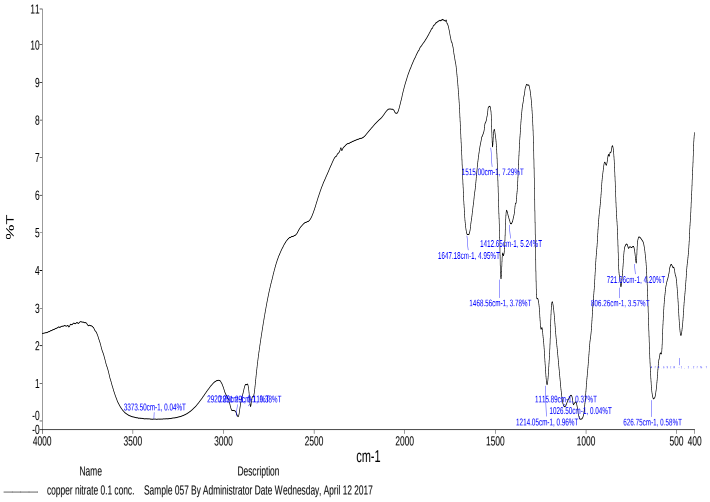

Fig-7: FT-IR spectrum of (0.1) copper nanofluid.

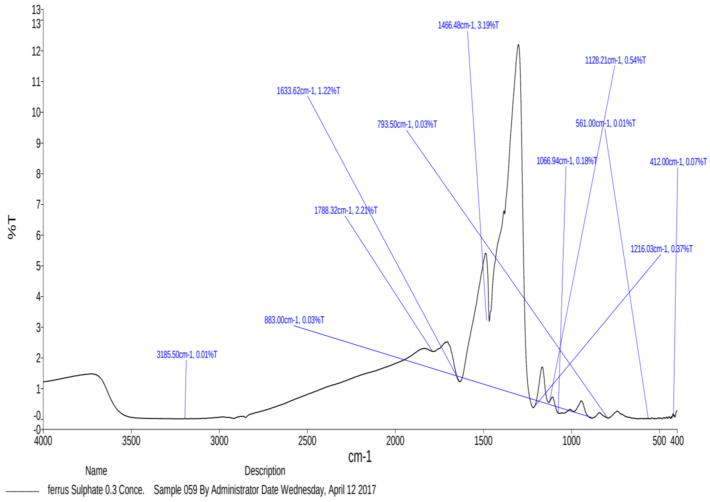

Fig-10: FT-IR spectrum of (0.5)copper nanofluid.

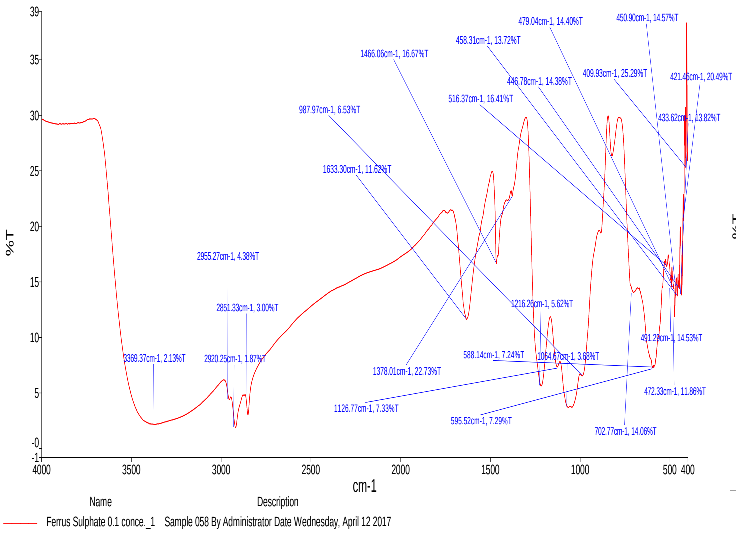

Fig-8: FT-IR spectrum of (0.1) ferrous nanofluid.

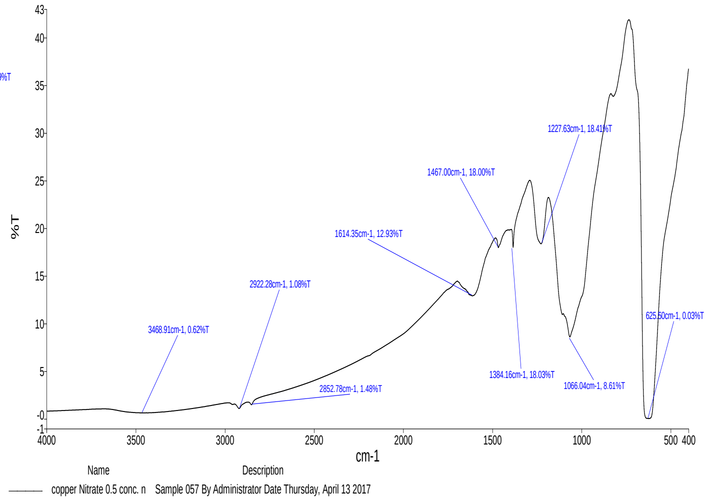

Fig-11: FT-IR spectrum of (0.3)ferrous nanofluid.

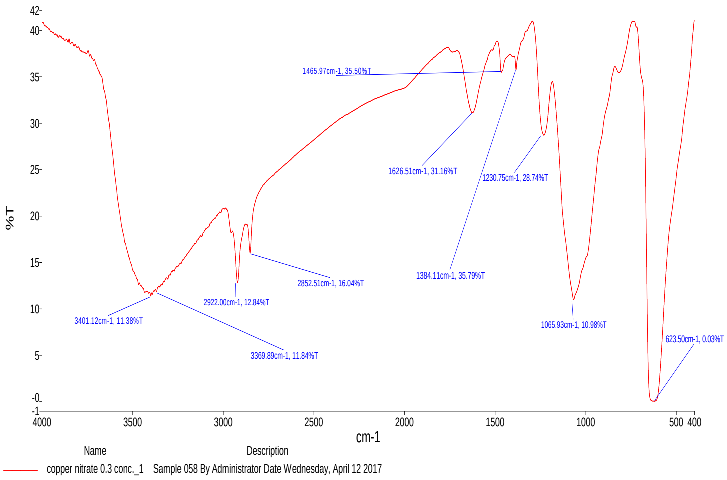

Fig-9: FT-IR spectrum of (0.3)copper nanofluid.

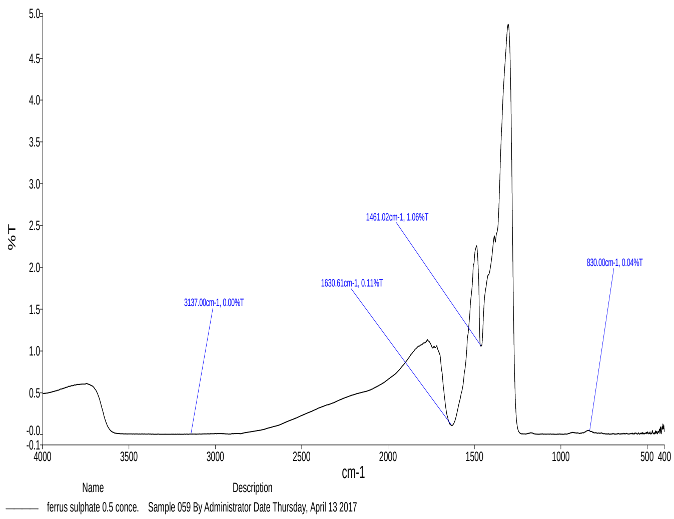

Fig-12: FT-IR spectrum of (0.5)ferrous nanofluid.

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2.2.3 UV-visible analysis

Visible and ultraviolet spectrometers or visible and ultraviolet spectrophotometry is routinely used in analytical chemistry for the quantitative determination of different analysis.

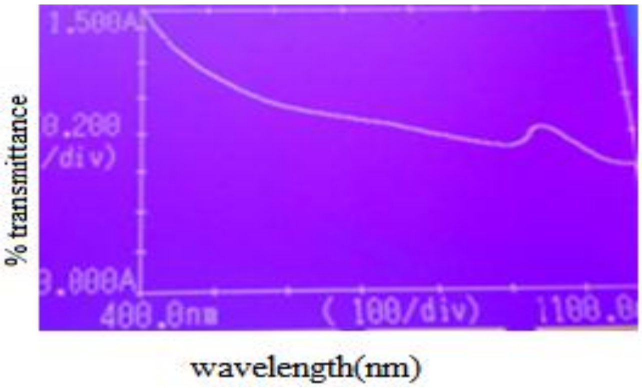

Fig-13: Analysis pattern of copper nanofluid by UV-vis method.

3. RESULTS AND DISCUSSION

A preparation method of nanofluids has been developed. With this method, several sampled nanofluids have been prepared by directly mixing nanophase powders and base fluids, which reveals the possibility of practical application of the nanofuid.

3.1 Data resulting from X-ray diffraction topography studies

The X-ray diffraction topography pattern of the copper nitrate sample is shown in Fig.1. Fig.3. and Fig.5.Diffraction peaks can be indexed to those of pure face centered cubic, corresponding to the number of peaks is 10 in Fig.1, corresponding to the 36.229, 93350,0,1.114. Similarly Fig.3 and 5 number of peaks 16 and 11 in here and its maximum peak 36.560,1114333.3,0200 in fig.3.and 36.567,353883.3,0.593 in fig.5.

Similarly in ferrous sulfate the X-ray diffraction topography pattern of the sample is shown in Fig.2, 4 and 6 respectively. It can be seen from XRD analysis, that the pattern corresponding to the ferrous sulfate nanofluids solution resembles the pattern of copper nitrate. The diffraction peak corresponding to the Fig.2 and 4 is same 46.477,54850.0 and in Fig.6 25.387,55141.7

3.2 Result of FT-IR spectra

The FT-IR spectra for the analytical copper nanofluids solution and for ferrous sulfate nanofluids solution are shown in Fig 7,9,11 and Fig.8, 10, 12 respectively. Fig.7(0.1) Conc. Number of peaks is 14 and maximum peak area/height 1515(cm^{-1})/7.29(%T) ,Fig.9.(0.3)Conc. Number of peaks is 10 and maximum peak area/height 1465.97(cm^{-1})/35.50(%T), Fig.11.(0.5)Conc. Number of peaks 9 and maximum peak area/height 1227.63(cm^{-1})/18.41(%T) for copper nanofluid solution and Fig.8(0.1)Conc. Number of peaks is 25 and maximum peak area/height 409.93(cm^{-1})/25.97(%T) ,Fig.10(0.3)Conc. Number of peaks is 11 and maximum peak area/height 1466.48(cm^{-1})/3.19(%T) and Fig.12(0.5)Conc. Number of peaks is 4 and maximum peak area/height 1461.02(cm^{-1})/1.06(%T) for ferrous nanofluid solution. It can be seen from the FT-IR analysis, that the spectrum corresponding to the copper nanofluids solution resembles the spectrum of ferrous nanofluids solution.

3.3 UV-visible analysis

The result of UV-visible analysis shown in Fig.13. The peak at 972.0 λ (nm) in the visible region shows the existence of copper. Furthermore, the shape of the absorption 0.828 band illustences uneven distribution above and below the peak maximum.

3. CONCLUSIONS

A one step method was developed for preparing copper nanofluids by reducing copper nitrate using sodium sulfite as reducing agent and ethylene glycol as base fluid by means of conventional heating. This one-step method for preparing copper nanofluids is advantageous over other more conventional methods due to the following reasons.

- It is an in situ, one-step method.
- Non-agglomerated and stably suspended copper nanofluids are obtained.
- Copper & ferrous nanofluids can be synthesized in a short time.
- This method is economical.
- The synthesized copper nanofluid has superior thermal conductivity properties when compared with conventional engine coolant fluids.

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REFERENCES

[1] Taylor, R.A.; et al. "Small particles, big impacts: A review of the diverse applications of nanofluids". Journal of Applied Physics. **113** (1): 011301-011301-19. Doi:10.1063/1.4754271.

[2] Buongiorno, J. (March 2006). "Convective Transport in Nanofluids". Journal of Heat Transfer. American Society

of Mechanical Engineers. **128** (3): 240. Doi:10.1115/1.2150834. Retrieved 27 March 2010.

[3] U.S.Choi,development and application of Non-Newtonian Fluid,in D.A.Siginer, H.P. Wang(Eds,),FED,Vol 231,ASME, New York,1995,P.99.

[4] A.S Ahuja,J. Appl. Phys, 46(1975)3408

[5] A.S.Ahuja, Int, J.,Heat Mass Transfer 25(1982)725

[6] J.A. Eastman,U.S. Choi,S.Li, W. Yunand,L.J. Thompson, Appl. Phys, Lett. 78(2001)718,

[7] Y.Xuan,Q.Li,Int,J.Heat Fluid Flow 21(2000)58

[8] X.Xang,X.Xu, U.S.Choi,J.Thermophys. Heat Transfer 13(1999)434.

[9] S.Lee,U.S.Choi,S.Li,J.A.Eastman,J.Heat Transfer 121(1995)280.

[10] Eastman at el., Appl. Phys. Lett. 78 (6) (2001) 718-720.

[11] Das, Saritk; Stephen U.S.Choi, Wenhua Yu, and T.Pradeep(2007). Nanofluid Science & Technology.

[12] P.Keblinski, J.A.Eastman, and D.G.Cahill. Nanofluids for thermal transport. Mater.today, 8:36-44, 2005.