International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 1 (2019) pp. 232-234

Development of Copper Oxide nanofluid for Engine Cooling System

Prakash.V, Jayant Pawar, Ashish kumar Patel, Amit Patwardhan, Rabinder Henry,

Pralhad P. Chhabria Research Center, Pune, India.

Abstract

Copper oxide nanofluids are prepared using two -step process is being reported. Nanoparticles were synthesized by chemothermal method with surfactant used as capping agent. Scanning electron microscopic image and X-Ray Diffraction result confirms the morphology and crystalline structure of the copper oxide nanoparticles. Well dispersed copper oxide nanofluids were obtained which would be further used in development of engine cooling system.

Keywords: Copper oxide, Nanoparticles, Nanofluids, Engine cooling system.

I. INTRODUCTION

Engine cooling system is the most vital part of the engine system which maintains the operating temperature of the engine by removing excess heat through the conductive and convective heat transfer process. As the complexity of engine system increases day by day the requirement of next-generation coolant liquid becoming the supreme mandate. Nanofluids are fluids that contain nanometer-scale material dispersed in the base fluid. There are numerous reports available in different types of nanomaterials like the metallic, metal oxide, nanocomposite, carbon nanofluids [1-5]. Still, there are many limitations which are not improved or standardized in nanofluids to make it as a consumer product. One of the major issues is the long-term stability of nanomaterial. Even though this has been reported theoretically that reducing the particle size and increasing the surface area of nanomaterial will solve the limitation[6]. Still, nanomaterials with greater stability are yet to be developed. Extremely few experimental research work are also available in well-stabilized nanofluids [7-9] however stabilization of those liquids at high temperature is not reported yet. This is due to the number of factors that has to be controlled to get the optimized liquid for commercial applications.

In this current work copper oxide (CuO) nanomaterials are synthesized using chemo-thermal process. And it is characterized by microscopic and XRD analysis to understand the CuO nanomaterial with respect to morphology and its crystalline structure. Further, the material is used to prepare two-phase copper oxide nanofluid for the engine cooling system. Experimental analysis of the stability of nanomaterials is also reported in different base fluids.

II. MATERIALS AND METHODS

Materials

Double distilled water was used in the experiment, Copper sulfate (CuSO4, purity=>98%) with >and, Sodium Hydroxide (NaOH) with >98 % purity and Sodium lauryl sulfate (SLS) purchased from Loba chemie- Mumbai and Merck chemicals India. All glassware and magnetic stirring beads were cleaned and sterilized prior to use it in the experiment.

Methods:

Copper sulfate and Sodium hydroxide were dissolved separately in Double distilled water (50 ml). The proportion of Copper sulfate and Sodium hydroxide is 1:1 ratio. 0.01 M of Sodium lauryl sulfate was completely dissolved in 5 ml of Double distilled water by continuous stirring at room temperature. The prepared greenish blue color copper solution and the magnetic bead were added into the conical flask and raised the bed temperature of a magnetic stirrer to 210 °C. After 15 min of stirring process, Firstly the prepared surfactant solution was added directly into copper sulfate solution. Finally, the prepared NaOH salt solution was added drop by drop into copper sulfate solution for 1hr. After an hour the solution was removed from stirrer bed to bring the prepared to room temperature. Once it reached room temperature the supernatant and precipitated copper hydroxide was clearly visible in the conical flask. This supernatant was removed and copper hydroxide was added into the centrifuge vial with more water to remove the residues available in the precipitate. Later the material was centrifuged at 7000 rpm to remove the sodium sulfate present in the water solution. Washing process was conducted for five times to remove maximum impurities in copper hydroxide powder. This powder was later dried and calcinated at 400 °C to produce copper oxide nanomaterials. The reaction process is given below.

$$CuSO_4 + NaOH + H_2O \rightarrow CuOH + NaSO_4$$

$$CuOH \rightarrow CuO$$

Charcterisation of Copper oxide nanomaterial:

Synthesized nanomaterials are further characterized with Scanning Electron Microscope to confirm the morphology of synthesized nanomaterials and X-Diffraction spectroscopy to confirm the crystalline structure of nanomaterials.

II. RESULTS AND DISCUSSION

Synthesis of copper oxide nanomaterials:

Copper oxide was prepared using chemical energy and thermal energy as a source to initiate the nucleation process. Nucleation and crystal growth was started once the solution reached the pH between 8 and 9. Especially the reaction kinetics showed optical changes by changing the color from greenish blue color solution to opaque solution then into brown, dark brown and blackish brown color. The blackish brown color confirms the formation of copper hydroxide and oxide composition in the solution. This nucleation and growth take place even when the solution was placed at room temperature. This process is called Ostwald ripening and it will be completed when the Gibbs free energy of the solution (liquid system) reaches from negative to zero. To control this nucleation and growth process the surfactant was added. Which play the role of covering the nucleated copper oxide in particular size. This process controls the crystal growth of copper oxide to produce nanometer-scale copper oxide materials. Synthesized nanomaterials are further characterized by the Scanning Electron Microscope to confirm the morphology of synthesized nanomaterials and X-Diffraction spectroscopy to confirm the crystalline structure of nanomaterials.

Characterized results of copper oxide nanomaterials:

Scanning electron microscopic image given in fig 2 shows that the prepared materials are in nanometer scale and are cubic in structures. It also shows that particle formations are not uniform. The larger particles visible in the image are agglomerated nanoparticles. This will be dispersed well before e applying in nanofluid application to bring back the material in nanometer scale.

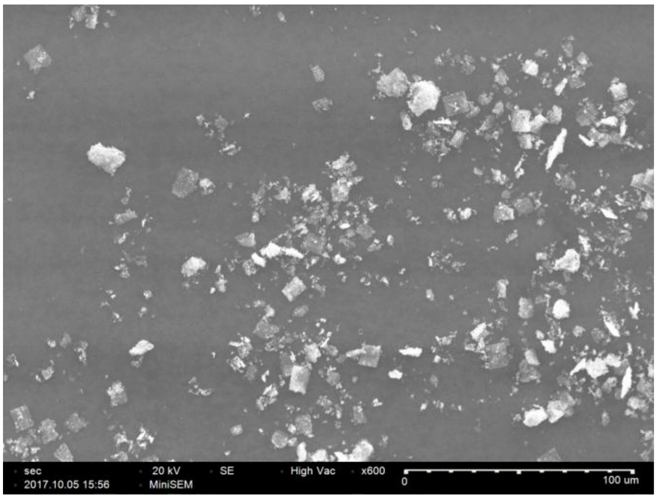

Fig. 2 Scanning electron microscopic image of synthesized copper oxide nanomaterials.

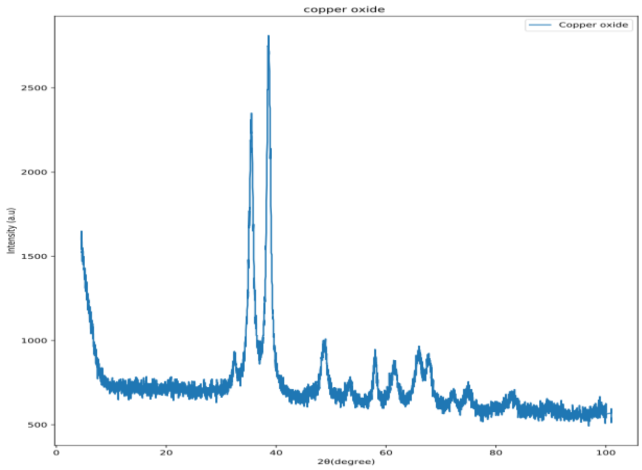

Fig. 3 X- Ray Diffraction graph of copper oxide nanomaterials.

In Fig. 3 the X-Ray diffraction peaks are similar with the earlier reports of synthesis of copper oxide nanostructured material for different application by Amrut.S.Lanje et al , Wenzhong Wang et al and CH. Ashok et al [10-12] This confirms that in the present work the synthesized copper nanoparticles also in monoclinic single crystalline phase.

Copper oxide nanofluids for engine cooling system:

Nanofluids were prepared by adding the synthesized nanomaterials into base fluids like ethylene glycol, ethylene glycol and water (1:1) and water given in Fig 4. 0.1 gm of synthesized copper oxide nanomaterials were dispersed into the solution using ultrasonic bath process. The image is given below shows the dispersed copper oxide nanoparticles in different base solution Fig 4. It is clearly observable that material is dispersed in different base fluids and shows good stability in ethylene glycol and water + ethylene glycol base fluids rather than water as base fluids after 24 hrs at room temperature.

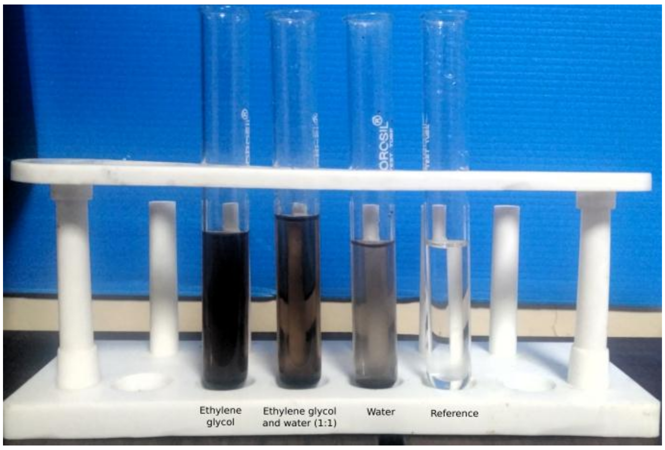

Fig. 4 Prepared Copper Oxide Nanofluids using different base fluids.

III. CONCLUSION

This simple chemical route to synthesis copper oxide nanomaterial using sodium lauryl sulfate as capping agent can give better result in controlling the morphology of nanomaterials. These changes are noticeable in characterization results, the copper oxide nanomaterials are in cubic structure and particles are agglomerated. XRD result confirms the formation of monoclinic crystalline structure of copper oxide. Synthesized nanomaterials are further dispersed in different base fluids and result shows that ethylene glycol base fluid shows good stability than water after 24 hrs at room temperature.

ACKNOWLEDGMENT

Authors sincerely thanks to Hope foundation and research center for the funding and support. We also thank all the team members who supported our work at Pralhad P Chhabria Research Center.

REFERENCES

[1] Peyghambarzadeh, S. M., Hashemabadi, S. H., Hoseini, S. M., & Jamnani, M. S. (2011). Experimental study of heat transfer enhancement using water/ethylene glycol based nanofluids as a new coolant for car radiators. *International Communications in Heat and Mass Transfer*, *38*(9), 1283-1290.

[2] Kulkarni, D. P., Vajjha, R. S., Das, D. K., & Oliva, D. (2008). Application of aluminum oxide nanofluids in diesel electric generator as jacket water coolant. *Applied Thermal Engineering*, *28*(14-15), 1774-1781.

[3] Peyghambarzadeh, S. M., Hashemabadi, S. H., Hoseini, S. M., & Jamnani, M. S. (2011). Experimental study of heat transfer enhancement using water/ethylene glycol based nanofluids as a new coolant for car radiators. *International Communications in Heat and Mass Transfer*, *38*(9), 1283-1290.

[4] Sahoo, R. R., & Sarkar, J. (2017). Heat transfer performance characteristics of hybrid nanofluids as coolant in louvered fin automotive radiator. *Heat and Mass Transfer*, *53*(6), 1923-1931.

[5] Soltanimehr, M., & Afrand, M. (2016). Thermal conductivity enhancement of COOH-functionalized MWCNTs/ethylene glycol–water nanofluid for application in heating and cooling systems. *Applied Thermal Engineering*, *105*, 716-723.

[6] Das, S. K., Choi, S. U., Yu, W., & Pradeep, T. (2007). *Nanofluids: science and technology*. John Wiley & Sons.

[7] Hwang, Y., Lee, J. K., Lee, J. K., Jeong, Y. M., Cheong, S. I., Ahn, Y. C., & Kim, S. H. (2008). Production and dispersion stability of nanoparticles in nanofluids. *Powder Technology*, *186*(2), 145-153.

[8] Witharana, S., Palabiyik, I., Musina, Z., & Ding, Y. (2013). Stability of glycol nanofluids—the theory and experiment. *Powder technology*, *239*, 72-77.

[9] Chiney, A., Ganvir, V., & Rai, B. (2014). Stable Nanofluids for Convective Heat Transfer Applications. *Journal of Heat Transfer*, *136*(2), 021704.

[10] Lanje, A. S., Sharma, S. J., Pode, R. B., & Ningthoujam, R. S. (2010). Synthesis and optical characterization of copper oxide nanoparticles. *Adv Appl Sci Res*, *1*(2), 36-40.

[11] Wang, W., Wang, L., Shi, H., & Liang, Y. (2012). A room temperature chemical route for large scale synthesis of sub-15 nm ultralong CuO nanowires with strong size effect and enhanced photocatalytic activity. *CrystEngComm*, *14*(18), 5914-5922.

[12] Ashok, C. H., Rao, K. V., & Chakra, C. S. (2014). Structural Analysis of CuO Nanomaterials Prepared by Novel Microwave Assisted Method. *Journal of Atoms and Molecules*, *4*(5), 803.