Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Synthesis and Characterization of Silver-Copper Doped with Poly Ortho-toluidine Nanocomposites

Muhammad Nadeem*, Shanza Aqeel*

*Department of Basic Sciences, Faculty of Basic Sciences & Humanities, University of Engineering and Technology, Taxila, 47056, Pakistan

Email: badaninadeem@gmail.com , *shanzawah@gmail.com*

----------------------------------*************************----------------------------------

Abstract:

A novel and efficient strategy was established to synthesize Ag-Cu alloy doped with Poly Ortho-toluidine nanocomposites. The Ag-Cu alloy is synthesized by co-reduction method and doping is done by physical immobilization technique. Different analytical techniques were used to confirm the elemental and structural composition as well crystallite size and polymer coating. The mean crystallite size was found to be 33.77 nm by using Debye Scherrer's formula from XRD results. The polymer is well coated on silver copper alloy confirmed by SEM. Hence, the prepared nanocomposite might be a potential material for thermal conductivity enhancement.

Keywords: **Poly ortho-toluidine, Nanocomposite**

----------------------------------************************----------------------------------

I. INTRODUCTION

Highly efficient coolants are necessary in many applications such as transportation, power plants, electronic devices and solar panels. However, conventional fluids have become incompetent due to issues like low thermal conductivity. Therefore, nanofluids consist of solid nanometer (1-100nm) sized particles dispersed in base fluids like water; ethylene glycol and oil etc. were introduced. It was found that nanofluids are beneficial to augment the heat transfer capability [1].

Metals, metal-oxides and carbon nanotubes have immense thermal conductivity which makes them preferable but they lead to clogging in common base fluids and are less stable [2]. Among metals, Cu shows high thermal conductivity but low stability and reactivity. As a result, Cu based nanofluids have low shelf life. The stability of Cu based nanofluids can be enhanced by addition of materials like Ag, Au, Si and carbon nanotubes (SWCNT, DWCNT and MWCNT) etc [3]. S. Abbasi [4] prepared Ag-Cu based nanofluid and observed high thermal conductivity. Das and Ghosh [5] fabricated Ag-Cu based stable nanofluid and achieved very good heat transfer rate. Though, bimetallic nanofluids have good stability. However, stability can further be improved by addition of polymers like Polyvinyl chloride (PVC), Caster oil etc. Pot has high electrical and thermal conductivity along with very high dispersion stability which makes it a very good choice for doping metals to enhance their thermal and physical properties.

Hence, the purpose of this study is the synthesis and evaluation of Ag-Cu alloy doped with Poly Ortho-toluidine by considering nanoparticles shape, size and volume fraction which can be used for thermal conductivity.

II. METHODS AND MATERIALS

A. Chemicals

Copper Nitrate $Cu(NO_3)_2.3H_2O$, Sodium Poly-Acrylate, Sodium Borohydrate ($NaBH_4$), Silver Nitrate ($AgNO_3$), O-Toluidine, Sulfuric acid (H_2SO_4), De-ionized water and Ammonium per sulfate are purchased in Pakistan. All these chemicals were analytical grade and were used without additional purification.

B. Synthesis of Silver-Copper Nanoparticles

Silver Copper nano alloy were manufactured via. modified co-reduction method adjusting the molar ratio Ag:Cu as 3.6:1 at room temperature [6]. First, the solution of 0.6M Copper Nitrate and 0.6M Sodium Polyacrylate were prepared separately in 10ml deionized water. Then, both solutions were merged and stirred for one hour with the aim of control the size and morphology of nanoparticles. After that Solution of 1.668M Sodium Borohydrate prepared in 10ml deionized water was rapidly injected in above solution at constant stirring for 20minutes. Then, 2.16M Silver Nitrate dissolved in 10ml deionized water and stirr further for 30-40min at 350rpm and precipitates were washed out with ethanol via. centrifugation to remove residuals [6].

C. Orthotoluidine Coating

The fabricated Silver Copper nanoalloy was coated with Orthotoluidine through physical immobilization method. Orthotoluidine (1M) act as monomer was dissolved in deionized water followed by mixing the H_2SO_4 (1M) in above suspension solution and stir for 30 minutes. Then, another solution of AgCu (0.43M) is prepared by using acetone. Both solutions were mixed together and put on stirring for one hour. After one hour the polymerization reaction is performed by adding the oxidant ammonium per sulfate (0.5M) solution drop wise under vigorous stirring at room temperature. Later, the obtained dark green precipitates were washed out by centrifugation to remove impurities by using acetone. After three times of washing, the precipitates are put in oven at 40ºC for 20 hours to get resultant particles.

III. RESULT AND DISCUSSIONS

D. Phase Identification

Figure 1 represents the XRD spectrum of Ag-Cu-POT nanocomposites.

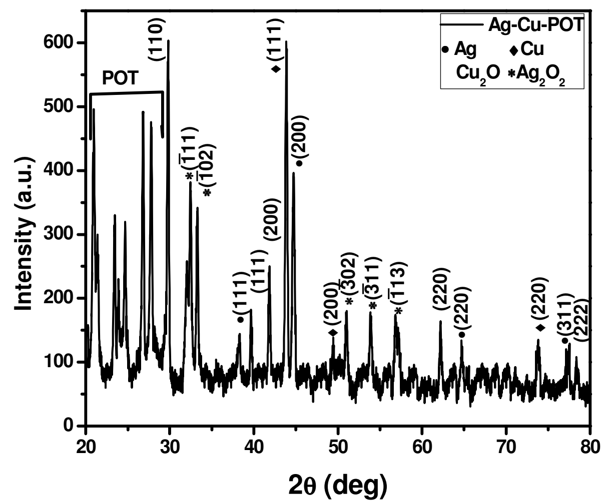

Figure 1: XRD spectrum of Ag-Cu-POT nanocomposites

The obtained XRD pattern showed seven broad peaks at different diffraction angle i.e., $2\theta=38.24^o$, 44.71^o, 64.70^o and 77.51^o belongs to FCC structure of metallic Ag with miller indices (111), (200), (220) and (311) respectively that were well matched with (JCPDS no.04-0783) and $2\theta=43.86^o$, 50.22^o, and 73.81^o revealed FCC crystal structure of metallic Cu with miller indices (111), (200) and (220) respectively that were consistent with (JCPDS no. 89-2838). The peaks of POT appeared at angle between 20^o-28^o. The crystallite size (D) of prepared sample was evaluated by using Debye Scherrer equation:

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

Where $\beta, \theta, \lambda,$ and D corresponds to full width at half maximum (FWHM), diffraction angle, wavelength and crystallite size and k represents the Scherrer constant which is (0.90) for spherical particles. The mean crystallite size was found to be 33.77 nm.

E. Compositional analysis

FTIR spectrum of Ag-Cu-POT nanocomposites given in Figure 2.

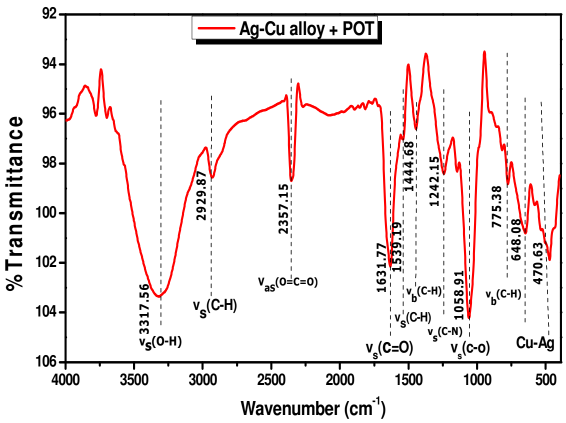

Figure 2: FTIR spectra of Ag-Cu-POT

A strong and broadband peak obtained at 3,250–3,450 cm^{-1} resembles to the stretching bond of O-H, representing the presence of hydroxyl groups and water molecules. The second weak bond was observed at 2929.87 cm^{-1} corresponding to alkenyl's C-H stretching bond vibration [7]. Another sharp and strong peak was observed at 2357.15 cm^{-1} belongs to carbon dioxide. This is due to the fact that carbon dioxide is present in the atmosphere around and absorbed by the material [8]. A medium but sharp peak at 1631.77 cm^{-1} can be indorsed to the C=O stretching band vibration. The reason is that carbon mono-oxide (CO) gas is usually adsorbed on the surface of the metal nanocomposites [9].

The stretching vibration bond of the metal-metal ion (Ag-Cu) band can be seen at 470.63 cm^{-1} [10]. No characteristic band can be attributed to Cu–O–C or Ag–O–C, which suggests that there is no strong interaction between Ag-Cu nanocomposites. The band at 1444.68 cm^{-1} and 775.38 cm^{-1} correspond to the bending of C-H vibration alkane methyl group. The peaks appeared at 1444.68 cm^{-1} , 1242.15 cm^{-1}, and 1058.91 cm $^{-1}$ correspond to C-H (alkane) bending, an amine group (C-N) stretching and C-O stretching respectively [11]. The other peaks bands are located at 648.08 cm^{-1} and 470.63 cm^{-1} which might be the indication of the presence of metal to metal bonding [12].

The presence of band at 470.63cm^{-1}displays not only the reduction of Cu and Ag ions by the hydroxyl group of POT, but also specifies POT as a capping agent.

F. Surface Morphology

SEM analysis was used to determine the surface morphology of the Ag-Cu-POT nanocomposites, which was depicted in Figure 3.

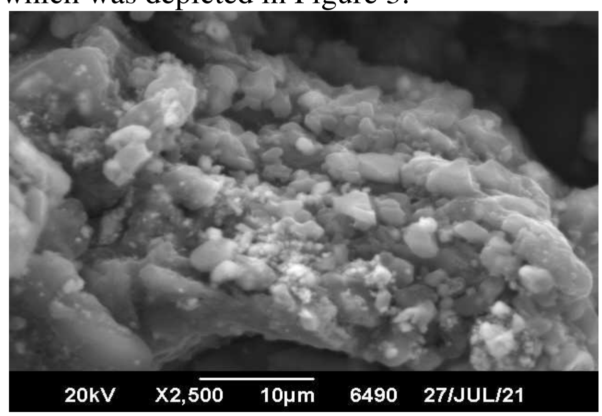

Figure 3: SEM image of Ag-Cu-POT at 10µm

This result showed the spherical agglomeration which indicates that the Ag-Cu nanoparticles are surrounded by polymer chains (POT). In other words, due to the physical immobilization, the polymer gets coated onto the surface of the Ag-Cu nanoparticles, resulting in improved performance [13]. SEM images demonstrated both crystalline and amorphous structure of prepared Ag-Cu-POT sample.

IV. Conclusions

Silver Copper alloy doped with Poly Ortho-Toluidine nanocomposites were successfully synthesized via simple and efficient method which is co-reduction and physical immobilization. XRD results revealed the crystal structure and average crystallite size of 33.77 nm of prepared sample. SEM results showed both crystalline and amorphous structure of resultant nanocomposites. Hence, the prepared nanocomposite can be used to prepare suitable nanofluid for enhancing the thermal conductivity in automobiles

ACKNOWLEDGMENT

The authors would like to thank University of Engineering and Technology, Taxila for their support in the present work.

REFERENCES

[1] A. Gakare, A. Sharma, and G. Saxena, "Review on Recent Automotive Experimental Applications of Nano Coolants," *Journal of Nanoscience Nanoengineering and Applications,* vol. 9, pp. 1-10, 2019.

[2] E. M. C. Contreras, G. A. Oliveira, and E. P. Bandarra Filho, "Experimental analysis of the thermohydraulic performance of graphene and silver nanofluids in automotive cooling systems," *International Journal of Heat and Mass Transfer,* vol. 132, pp. 375-387, 2019.

[3] W. Yu, D. M. France, S. U. Choi, and J. L. Routbort, "Review and assessment of nanofluid technology for transportation and other applications," 2007.

[4] S. Abbasi, "The thermal conductivity modeling of nanofluids involving modified Cu nanorods by Ag nanoparticles," *Heat and Mass Transfer,* vol. 55, pp. 891-897, 2019.

[5] S. Das and M. Ghosh, "An experimental investigation on thermal conductivity and stability of aqueous and nonaqueous nanofluids containing Ag–Cu alloy nanoparticles," *Materials Research Express,* vol. 6, p. 115027, 2019.

[6] P. N. Njoki, A. E. Rhoades, and J. I. Barnes, "Microwave-Assisted synthesis of Anisotropic copper–silver nanoparticles," *Materials Chemistry and Physics,* vol. 241, p. 122348, 2020.

[7] D. F. Katowah, M. A. Hussein, M. Alam, T. Sobahi, M. Gabal, A. M. Asiri, and M. M. Rahman, "Poly (pyrrole-co-o-toluidine) wrapped CoFe 2 O 4/R (GO–OXSWCNTs) ternary composite material for Ga 3+ sensing ability," *RSC advances,* vol. 9, pp. 33052-33070, 2019.

[8] Y. A. Arfat, J. Ahmed, and H. Jacob, "Preparation and characterization of agar-based nanocomposite films reinforced with bimetallic (Ag-Cu) alloy nanoparticles," *Carbohydrate Polymers,* vol. 155, pp. 382-390, 2017.

[9] C. A. Poteet, K. M. Pontoppidan, S. T. Megeath, D. M. Watson, K. Isokoski, J. E. Bjorkman, P. D. Sheehan, and H. Linnartz, "Anomalous CO2 Ice toward HOPS-68: A Tracer of Protostellar Feedback," *The Astrophysical Journal,* vol. 766, p. 117, 2013.

[10] A. A. Salam, R. Singaravelan, P. Vasanthi, and S. B. Alwar, "Electrochemical fabrication of Ag–Cu nano alloy and its characterization: an investigation," *Journal of Nanostructure in Chemistry,* vol. 5, pp. 383-392, 2015.

[11] G. Mohamed Saeed, S. Radiman, S. S. Gasaymeh, H. Lim, and N. M. Huang, "Mild hydrothermal synthesis of Ni–Cu nanoparticles," *Journal of Nanomaterials,* vol. 2010, 2010.

[12] M. J. Yee, N. Mubarak, M. Khalid, E. Abdullah, and P. Jagadish, "Synthesis of polyvinyl alcohol (PVA) infiltrated MWCNTs buckypaper for strain sensing application," *Scientific reports,* vol. 8, pp. 1-16, 2018.

[13] J. Ahmed, K. V. Ramanujachary, S. E. Lofland, A. Furiato, G. Gupta, S. Shivaprasad, and A. K. Ganguli, "Bimetallic Cu–Ni nanoparticles of varying composition (CuNi3, CuNi, Cu3Ni)," *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* vol. 331, pp. 206-212, 2008.

