Novel method to synthesize silver nanofluid for solar energy applications

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Abstract - ***Nanofluid is a new class of heat transfer fluid in the area of energy research and engineering. In the present work, silver/water nanofluid is synthesized and it is characterized. One step method was developed for the preparation of silver nanofluid without using any surfactant. Silver nitrate was used as precursor and sodium citrate as reducing agent. Investigation of sample was carried out to study the particle size, pH value, absorption spectra and zeta potential. Nanofluid with particle size 2nm to 6nm was achieved at 80°C temperature. Zeta potential was measured and has value of -38.5mV. Transmission electron micrograph showed the presence of uniform size of particles in the base fluid. The silver nanoparticles as prepared nanofluid found to have an uniform dispersion, narrow size distribution with good stability over ageing.***

Key Words: *Nanofluid1, Silver nanoparticles 2, Zeta potential 3, Heat transfer 4*

1. INTRODUCTION

Energy is essential for human life. Solar and wind energy are the most promising renewable sources of energy. Thermal energy storage is essential whenever there is a gap between demand and supply. Solar latent heat thermal storage utilizes phase change materials (PCM) due to its unique property of storing and releasing energy at constant temperature called phase change temperature along with high latent heat of fusion. The problem with the PCMs is that they have a low thermal conductivity [1, 2, 3]. Concept of nanofluids was proposed by Choi [4]. Nanofluid has been introduced to enhance the thermal conductivity of base fluid and PCM [5]. Wu et al., synthesized aluminum oxide nanofluid in water. It is reported the 10.5% enhancement in thermal conductivity of base fluid [6]. Liu et al, prepared TiO_2 nanoparticles and dispersed in saturated $BaCl_2$ aqueous solution with increased thermal conductivity considerably compared to the base material and with great increase in cold storage, rate of heat supply and heat supply capacity [7]. Out of the various methods for the preparation of nanoparticles, one step method is found to be simple. In one step method, nanoparticles are directly dispersed in base fluid and in case of two step method, nanoparticles are first produced then dispersed in base fluids. The disadvantage of two step method is that nanoparticles form clusters due to which proper dispersion is not possible. One step method produced better dispersion characteristics as compared to the two step method [8]. From last decade, thermal conductivity of nanofluids were investigated by many researchers and it is found that nanofluids have tremendous thermal conductivities as compared to base fluid [9,10,11,12,13,14,15,16,17,18,19,20]. Nanofluids have huge application in the field of electronics, imaging, Catalysis, chemical sensing, solar heating and solar cooling due to their unique optical, electrical, chemical, thermal, magnetic and mechanical properties [21].

S. Harikrishnan et al reported that thermal conductivity of phase change materials can be improved by dispersing the CuO nanoparticles in oleic acid as base fluid [23]. In his experiment CuO – Oleic acid nanofluid is prepared as new class of heat transfer fluid and suggested that it can be used as better PCM for cooling thermal energy storage application. Ozerinc et al reported that size, shape and concentration or volume fraction of nanoparticles effect the thermal conductivity of nanofluid [24]. He also reported that higher the concentration of nanoparticles in base fluid, higher is the thermal conductivity showing the linear behavior. But in some cases nonlinear behavior is observed due to the presence of surfactant, ultrasonication for long time and hydrophobic surface forces. Rao et al also reported various applications of nanofluids like friction reduction, solar absorption, energy storage, space and defence, magnetic sealing, antibacterial treatment, nano drug delivery and various biological applications [22].

2. EXPERIMENTAL

2.1 Materials

All reagents used in experiment are analytically grade and used without further purification. Silver Nitrate ($AgNO_3$, Merck) used as metal precursor to prepare the silver nanoparticles. Trisodium citrate ($C_6H_5O_7Na_3.2H_2O$, Merck) is used as reducing agent and distilled water as solvent.

2.2 Method of Preparation

Silver nanofluid is prepared by novel single step method with distilled water as the working fluid. In this method 0.02M solution of silver nitrate is prepared in distilled water. The reaction mixture was subjected to magnetic stirring for 20 minutes in a magnetic stirrer/ heater. 0.02 M solution of sodium citrate is prepared in distilled water and stirred at room temperature for 20min. After 20 min, sodium citrate solution was added slowly into silver nitrate solution. Magnetic stirring of final solution was continued till the color of solution turned to golden yellow. The solution was cooled at room temperature. Finally silver nanofluid is obtained without using any surfactant. The pH value of silver nanofluid was maintained in the range of 7 to 8.

3 CHARACTERIZATIONS

Silver nanofluid is characterized by using particle size analyzer, transmission electron microscope (TEM), UV-Vis spectroscopy and zeta potential analyzer.

3.1 Particle size analyzer

The particle size analyzer (Zetasizer ver. 6.20, Malvern) was used to measure the size distribution of nanoparticles. Zeta potential was also measured to analyze the stability of silver nanoparticles in nanofluid.

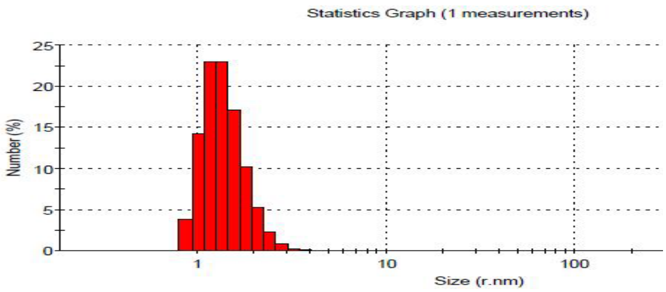

Fig – 1(a): Size distribution of particles in silver nanofluid

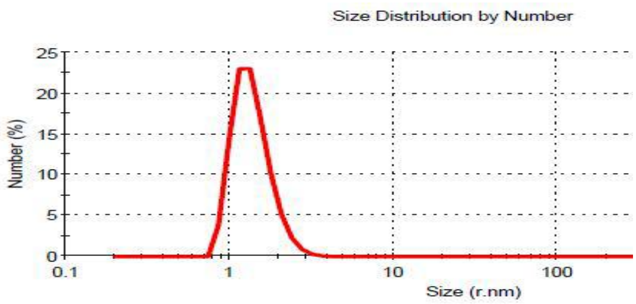

Fig – 1(b): Size distribution of particles in silver nanofluid

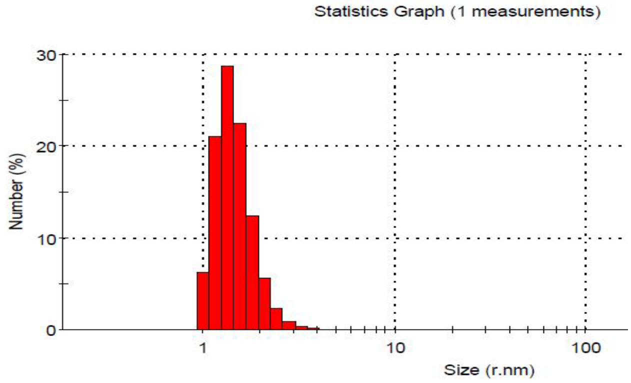

Fig – 1(c) Size distribution of particles in silver nanofluid after one week

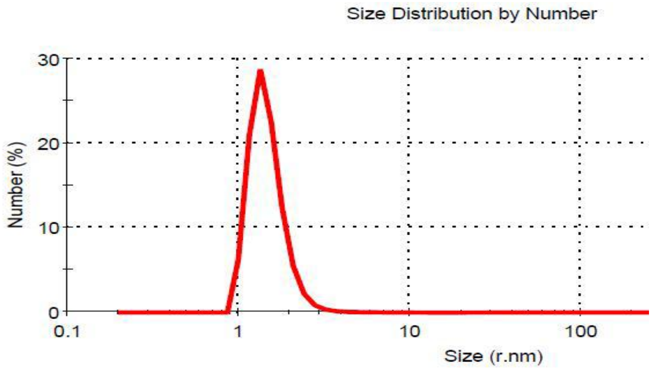

Fig – 1(d): Size distribution of particles in silver nanofluid after one week

3.2 UV- Vis spectroscopy

The absorption spectrum of synthesized silver nanofluid was observed by ultraviolet-visible spectrophotometer (UV 1700, Shimatzu). Fig. 2 shows the UV-Vis absorption spectra of silver nanofluid scanned in the wavelength range of 200 - 800 nm. It is observed that a single absorption peak at 446nm was observed which revealed the presence of silver nanoparticles.

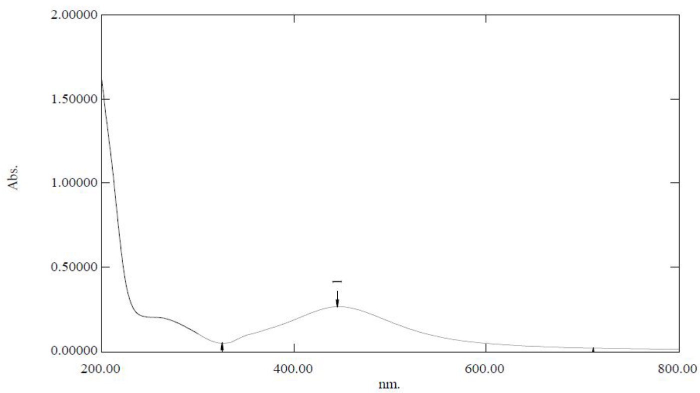

Fig – 2: Absorption spectra of silver nanoparticles.

3.3 TEM analysis

TEM was used to investigate morphology and particle size of silver nanoparticles operated at 200kV. The sample was prepared by placing a drop of silver nanofluid on glass plate and it is dried. Fig. 3 shows TEM image of silver nanofluid taken for 50 × and 500 × magnification. It is found that particles in nanofluid are agglomerated. Transmission electron micrograph revealed that the average particle size of silver nanoparticles in nanofluid in the range of 2 to 25nm. Fig. 3(a) shows the diffraction pattern of silver nanoparticles.

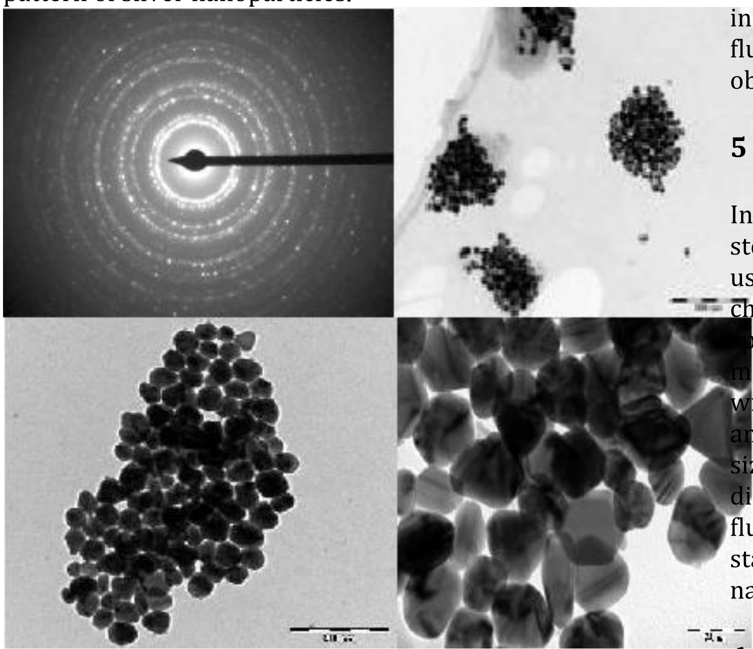

Fig – 3: (a) diffraction pattern, (b) 500nm, (c) 200nm, (d) 50nm: TEM images of silver Nanofluid

4 RESULTS AND DISCUSSION

The distribution of particles size of silver nanoparticles in water is shown in fig 1(a), (b). The distribution of size of silver nanofluid contains a sharp peak indicating the distribution of uniformly narrow sized silver nanoparticles in water. The results show that the particle size of Ag nanoparticles in base fluid are in the range of 2nm to 6nm, as shown in fig. 1(a), (b). The distribution of particle size of silver nanofluid was again recorded after one week, and it is shown in fig. 1(c),(d). The distribution of particle size after one week does not show any significant change in the base fluid, indicating good stability of nanoparticles in water. The viscosity of silver nanofluid was 0.8872 cP measured using particle size analyzer. The zeta potential of silver nanofluid was found -38.5mV, negative sign represents the repulsive forces present between the nanoparticles and high value indicates the good stability of silver nanofluid analogous to the zeta size analyzer.

UV-Vis absorption spectrum of silver nanoparticles is shown in fig 2. Generally, the typical absorption peak of silver nanoparticles was found at a wavelength corresponding to 460nm. In the fig. 2, the single absorption peak at 446nm was observed revealing the presence of silver nanoparticles. The peak shifting towards the shorter wavelength region was observed indicating the decrease in the size of nanoparticles.
The TEM images of silver nanofluid were analyzed after five weeks. The size of nanoparticles was varying from 2nm to 25nm as shown fig. 3. The small size of nanoparticles possess large surface to volume ratio which in turn would increase the thermal conductivity of base fluid. After five weeks, agglomeration of nanoparticles was observed and it is shown by TEM image (fig. 3)

5 CONCLUSIONS

In this work, silver nanofluid is prepared using novel one step method. Nanofluid was produced at 80°C without using surfactant. Samples of silver nanofluid are characterized by studying the particle size, absorption spectra, viscosity and zeta potential. It was found that this method produces least particle size, with a good stability without the use of surfactant during the experimentation and it is not reported in the literature earlier. The zeta sizer and TEM results indicate the uniform nar.row size distribution of suspended silver nanoparticles in the base fluid. Zeta potential measurement confirms the good stability of nanoparticles in the base fluid. The silver nanofluid is used for the heat transfer applications

6 FUTURE SCOPES

This new class of nanofluid can be used for the variety of applications. Investigations can be done in order to get desired size of nanoparticles by optimizing different concentrations of silver nitrate. As prepared nano fluid can be used for various heat transfer applications like solar cooling, solar heating and air conditioning devices. Silver has high thermal conductivity and as the size of nanoparticles is reduced in the base fluid, the thermal conductivity of base fluid increases. This property can be used in solar thermal energy storage systems, industrial heat exchangers based on heat transfer applications.

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BIOGRAPHIES

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