Int. J. Nano Dimens. 6 (3): 323-328, Summer 2015
ISSN: 2008-8868

Contents list available at **IJND**

International Journal of Nano Dimension

Journal homepage: ***www.IJND.ir***

Short Communication

A report on the latest trends in nanofluid research

A.L. Subramaniyan[1,*]
R. Ilangovan[2]

[1]Department of Physics, Thiagarajar College of Engineering, Madurai-625015, India.
[2]Department of Nanoscience and Nanotechnology, Alagappa University, Karaikudi-630003, Inida.

Received 22 September 2014
Received in revised form
17 November 2014
Accepted 21 November 2014

ABSTRACT

The term Nanofluids was first coined by Sir Stephen Choi in 1995 at Argonne National Laboratory ,U.S.A .Since the discovery, nanofluid have been explored as heat transfer fluids. Nanofluids increased the thermal conductivity of existing coolants (Water, Ethylene glycol) by a magnitude of hundred times which made them attractive for miniaturization of electronic devices .From 1995 till 2008 nanofluid research was focused on enhancing the thermal conductivity of the base fluid by various parameters like shape of nanoparticle, volume fraction of base fluid and material of base fluid and composition of nanoparticle. A lot of theoretical models have been evolved in an attempt to explain the basic mechanism of heat transfer in a nanofluid .Research has been with respect to viscosity, stability, thermal conductivity and convective heat transfer coefficients of nanofluids. From 2008 nanofluids have been investigated for their electrical properties and reported as electrical conductivity enhancers for base fluid. The latest trend in nanofluid is towards optical properties of nanofluid for direct absorption solar collectors.

Keywords: *Nanofluid; Thermal; Electrical; Magnetic; Optical.*

INTRODUCTION

Nanofluids are a tailored suspension of nanoparticles in a suitable base fluid. The idea of nanofluid was given by Stephen Choi in 1995 [1]. Nanofluids have superior thermal and electrical conductivity [2-4] in comparison to their base fluids. The key challenge in nanofluid technology is the stability of nanofluids as nanofluid properties vary with stability of nanofluid [5]. The underlying mechanism for nanofluid property is yet to be explained .At present deviations prevail between the theoretical and experimental values of thermal conductivity of nanofluid [6] and experimental values of thermal conductivity of same nanofluid investigated by different researchers across the globe. The enormous heat transfer capacity of nanofluid has motivated the researchers to explore the electrical properties [7].

* Corresponding author:
Alagappan Subramaniyan
Department of Physics,
Thiagarajar College of
Engineering, Madurai-625015,
India.
Tel +919487135464
Fax +91452 2483427
Email alsphy@tce.edu

There has been a continuous depletion of non-renewable energy resources and energy harvesting has been a crucial theme by science and technology departments universally. Recently nanofluids have been explored for their optical properties [8-11] and increased absorption of nanoparticles in a base fluid could aid the solar collector to increase its optical absorption spectrum. Thus optical properties of nanofluid have to be given greater emphasis by the scientific community to assist the depleting resources and increase the efficiency of renewable energy devices [12]. The nanofluids are also used to create nanofluid based optical filters [13].

EXPERIMENTAL

Experimental research with nanofluids consists of preparation and characterization of nanofluid which is followed by measurement of thermal conductivity, electrical conductivity and optical absorption in nanofluids to explore the thermal, electrical and optical properties respectively.

Nanofluids can be broadly classified as metallic and ceramic nanofluids depending on the solid phase of the nanofluid. Nanofluids can be prepared by single step or two step method. Single step involves direct synthesis of required nanoparticle in a suitable base fluid .Techniques include Vacuum evaporation onto running oil substrate (VEORS), Chemical vapor deposition. The process of synthesis may be suitable for metal nanofluids. The two step method is the most widely used procedure because of commercial availability of a variety of nanopowders like ZnO, TiO_2, CuO, Al_2O_3 and SiO_2. Advantages of two step synthesis include preparing nanofluid with any desired volume fraction of nanofluid and any combination of nanoparticle and base fluid. Nanofluid characterization is essential to ensure stability of nanofluid. The nanoparticles used can be characterized by XRD for average grain size, SEM for morphology, UV –Vis absorption for energy band gap or nanosized, FTIR for bond present in nanoparticle and TGA /DTA to identify the structural changes in the material. Nano fluids are characterized for their stability by zeta potential measurement and a potential above the range of +30mV to-30 mV ensures the stable nanofluid. The thermal conductivity of nanofluid can be determined by the hot wire transient method, steady state method or oscillator method.

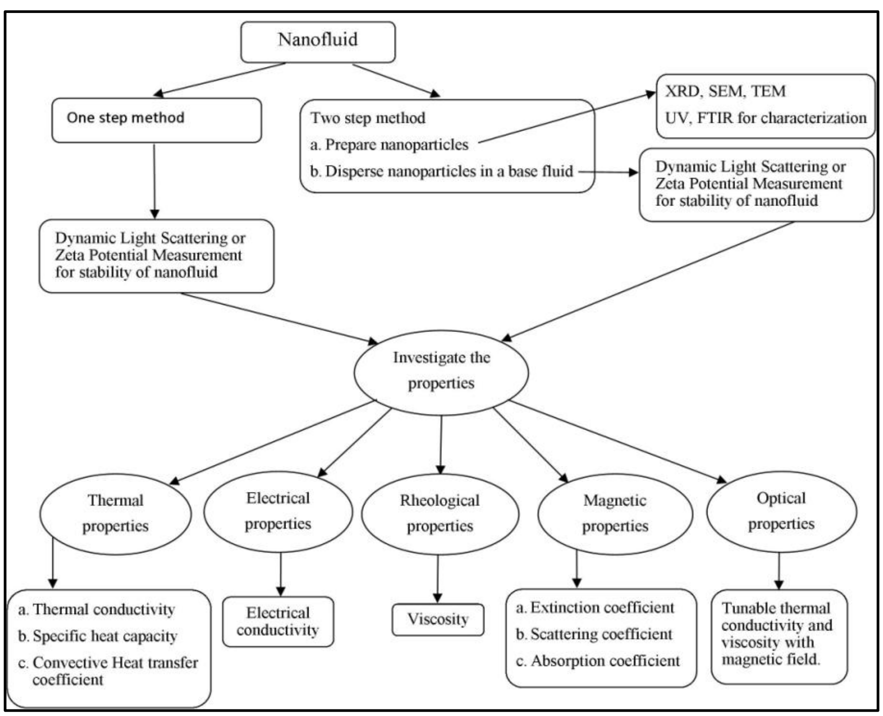

Fig. 1. Preparation, characterization and Investigated properties of nanofluid.

RESULTS AND DISCUSSION

Thermal properties of nanofluid

Thermal properties of nanofluid include thermal conductivity, specific heat capacity, thermal diffusivity, convective heat transfer coefficient and boiling heat transfer. A great deal of effort has been given to numerous theoretical models .The 100 year old Maxwell model predicts the thermal conductivity of nanofluid based on nanoparticle volume fraction irrespective of particle shape, size and interfacial layer thickness and the latest dynamic model includes all the above factors. All the models do not correlate to existing experimental results and deviations are yet to be satisfactorily explained. Practically the thermal conductivity is investigated by the hot wire transient method for the oxide and metallic nanofluids. Research has been done for TiO_2, Cu_2O, CuO, ZnO, Al_2O_3, MWCNT and SiO_2 nanoparticles with water, ethylene glycol,and propylene glycol .Metallic nanofluids show higher values of thermal conductivity than ceramic nanofluid. The enormous work and accompanying results have been reported by various reviews in nanofluids [6, 14].

Electrical Properties of nanofluid

Nanofluids also have high electrical conductivity as reported by the works of various researchers in Table 1. It can be summarized that electrical conductivity is yet to be explored to its full potential unlike the thermal properties. Electrical conductivity of nanofluid is one of the latest trends in nanofluid technology and research gap still prevails in explaining the underlying mechanism of electrical conduction and correlation with reported experimental and theoretical model.

Table 1 indicates that best results in electrical conductivity of nanofluid reported till date is ZnO in insulated oil and a 97, 300% increase in electrical conductivity are observed.

Optical Properties of nanofluid

The present drawback in direct absorption solar collectors is the poor absorption efficiency of working fluid. Addition of Nanoparticles in the base fluid can enhance the radiative properties of nanofluid thus increasing the efficiency. Todd. P. Otanicar [8] and coworkers have demonstrated 5% efficiency improvement with CNTs, graphite and silver nanoparticles. The absorption can further be increased by varying the shape of nanoparticles in the nanofluid. Christian Girginiov [9] and coworkers have proved the better results of photo thermal energy conversion of carbon black nanofluids in comparison to TiO_2, SiO_2, and ZrC. Himanshu Tyagi [10] and coworkers have demonstrated a 5-10% efficiency enhancement using nanofluid based concentrating parabolic solar collectors. M. Faizal and coworkers [11] have reported a payback period of 2.4 years and an average 170 Kg reduction in CO_2 emission by using nanofluid based solar collector instead of conventional collector. S. E Ghasemi has shown that the performance of nanofluids for solar absorption increases with increasing volume fraction by numerical analysis method.[12]The feasibility of nanofluid based optical filters has been reported by Robert Taylor [13] in which the design of nanofluids for long pass, short pass and band pass optical filters are presented [14-16].

Table 1. Previous Reports on electrical conductivity.

S.No	Nanoparticle	Base fluid	Vol%	% increase in conductivity	Investigator
1	ZnO	Insulated oil	0.75	97300%	L .P. Shen [2]
2	ZnO	Propylene Glycol	7	10000%	Steven Bryan white [3]
3	Al_2O_3	Water	3	15000%	S. Ganguly[4]
4	Al_2O_3	Water	1.44	3457.1%	Wong[7]

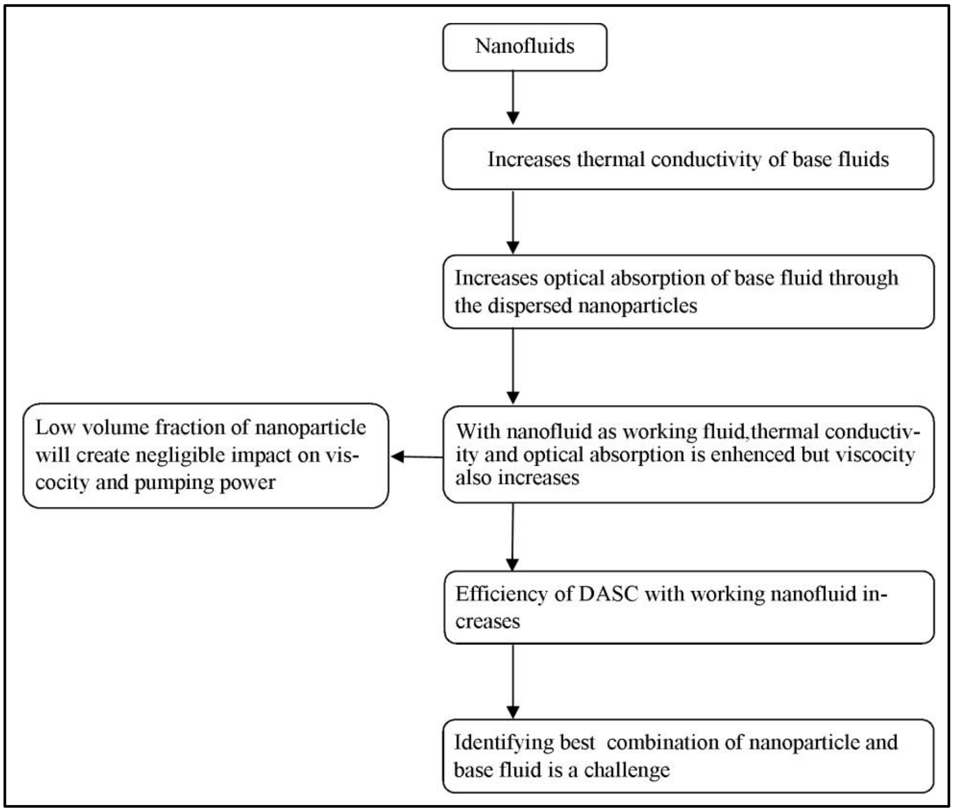

Fig. 2. Role of nanofluids to enhance efficiency of DASC.

Gerrad Eddy and Jai Poinern [17] have investigated the photo thermal response of Carbon nanofluids for applications in DASC. Crabon nanospheres with a mean particle diameter of 210nm were produced by CVD. The nanofluid with a mass content of 0.04g, showed the largest enhancement of 8.1C. The thermal conductivity of carbon black nanofluids increases with increasing volume fraction and temperature and are recommended for solar energy absorption from the results of Hiatao Zhu [18].

It has been revealed that 95% of the incoming light can be absorbed in a nanofluid with thickness greater than or equal to 10 cm. Theoretical and Experimental results for optical properties of nanofluid matched well for Graphite and Aluminum nanofluids but had a deviation with respect to Copper, Silver and Gold nanofluids which was attributed due to Plasmon resonance by Robert A. Taylor [19]. Thus better models for metallic nanofluids are recommended and characterization of nanofluids from 50C to 500C is required to understand the working of liquid based solar collectors. Patrick Phelan have given a complete picture trends and opportunities in Direct-Absorption Solar Thermal Collectors [20].Solar absorption of TiO_2 water -nanofluids has been maximized by adding glass mixture of 0.3% for a 0.2wt% nanofluid [21].

CONCLUSIONS

Nanofluids have been investigated since 1995 and nearly two decades of research is completed. The first decade emphasized on the thermal properties like thermal conductivity, specific heat, boiling heat transfer, viscosity and stability. The second decade has seen the fascinating properties of electrical properties of nanofluid, magnetic ferro fluids and fluids for enhanced efficiency in solar absorption collectors. The thermal conductivity and viscosity of nanofluids could be tuned with the help of magnetic field [22]. Thus current trends have focused on nanofluids as energy harvesters.

Identifying stable nanofluids with high optical absorption capacity is the key issue in nanofluid based solar collectors. Nanofluids enhance solar energy absorption and be a solution to depletion energy crisis and simultaneously aid in novel optical filters. Investigations with Nanocomposite-Nanofluids are required to achieve still greater efficiencies for solar absorption.

ACKNOWLEDGEMENTS

The authors are thankful to encouragement given by Dr. V. Abhai Kumar, Principal, Thiagarajar College of Engineering Madurai for encouragement in the research work.

REFERENCES

[1] Choi U. S, (1995), Enhancing Thermal Conductivity of Fluids with Nanoparticles, Developments and Applications of Non-Newtonian Flows, D.A. Siginer and H.P. Wang, eds, FED-Vol:231/MD-Vol. 66, *ASME, New York*, pp 99-105.
[2] Shen L., P., Wang H., Dong M., Ma Z. C, Wang H. B., (2012), Solvothermal synthesis and electrical conductivity model for the zinc oxide-insulated oil nanofluid. *Phys. Lett. A*, 376: 1053-1057.
[3] Bryan White S., Jau –Min Shih A., Patrick Pipe K., (2011), Investigation of electrical conductivity of Propylene Glycol based Zin Oxide Nanofluids. *Nanoscale Res. Lett.* 6: 346-349.
[4] Ganguly S., Sikdar S., Basu S., (2009), Experimental investigations of the effective electrical conductivity of aluminium. *Powder Technol.* 196: 326-330.
[5] Ghadimi A., Saidur R., Metselaar H. S. C., (2011), A review of nanofluid stability properties an characterization in stationary conditions. *Int. J. of Heat and Mass Trans.* 54: 4051-4068.
[6] Xiang-Qi-W., Arun S. M., (2007), Heat transfer characteristics of nanofluids: A review, *Int. J. Therm. Sci.* 46: 1-19.
[7] Wong K. F. V., Kurma T., (2008), Transport properties of Alumina nanofluids. *Nanotechnol.* 19: 345702
[8] Todd P O., Patrick E Ph., Ravi S P., Gary R., Robert A. T., (2010), Nanofluid based Direct Absorption Solar Collector. *J. Renewable and Sustainable Energy*. 2: 033102.
[9] Rumen K., Christian G., Petko S., (2013), Black Nanofluids for Solar Absorption on the basis of Hydrogen Peroxide treated Carbon Particles. *Adv. Nat. Sci. Theory Appl.* 2: 31-40.
[10] Vikrant Kh., Himanshu T., Patrick E. P., Todd P. O., Harjit S., R. A. T., (2013), Solar energy harvesting using nanofluid based concentrating solar collectors. *J. Nanotech. Engin. Medic.* 3: 031003.
[11] Faizal M., Saidur R., Mekhilef S., Alim M. A., (2013), Energy, Economic and environmental analysis of metal oxide nanofluid for flat plate solar collector. *Energy Conversion and Management*, 76: 162-168.
[12] Ghasemi S. E., Mehdizadeh Ahangar A. R., (2014), Numerical analysis of performance of solar parabolic trough collector with Cu-Water nanofluid. *Int. J. Nano Dimens.* 5: 233-240.
[13] Robert A. T., Todd P. O., Yasitha H., Fabienne B., Gary R., Evatt R., Hawkes X. J., Sylvian C., (2013), Feasibility of nanofluid based optical filters. *Applied Optics*.7: 1413-1422.
[14] Rashmi W., Khalid M., Song S., Saidur R., (2014), Preparation,Thermophysical properties and Heat Transfer Enhancement of nanofluids, *Mater. Res. Exp.* 1: 032001.
[15] Said Z., Saidur R., Rahim N. A., (2014), Optical properties of metal oxide based nanofluid. *Int. Comm. Heat and Mass Trans*. 59: 46-54.
[16] Kumar A., T., Ghosh P., Sarkar J., (2013), Solar water heating using nanofluids-A Comprehensive overview and Environmental Impact analysis. *Int. J. Emerging Technol. Adv. Engineer.* 3: 221-224.
[17] Eddy G., Poinern J., Brundavanam S., Shah M., Laava I., Fawcett D., (2012), Photothermal resonse of CVD synthesised

aqueous nanofluids for potential application in direct solar absorption collectors-A preliminary investigation. *Nanotech. Sci. Appl.* 5: 49-59.

[18] Han D., Meng Z., Wu D., Zhang C., Zhu H., (2011), Thermal properties of Carbon black aqueous nanofluids for solar absorption. *Nanoscale Res. Lett.* 6: 457-461.

[19] Robert A. T., Patrick E. Ph., Todd P. O., Ronald A., Ravi P., (2011), Nanofluid Optical Property Characterisation towards efficient direct absorption solar collectors. *Nanoscale Res. Lett.* 6: 225-229.

[20] Patrick Ph.,Todd P. O., Robert A. T., HimanshuT., (2013), Trends and opportunities in Direct-Absorption Solar Thermal Collectors. *J. Ther. Sci. Engin. Appl.* 5: 021003-1.

[21] Farhan L. R., Khudhair A. D., Ahmed H., (2014), Maximising of Solar Absorption bu TiO_2-water nanofluid with glass mixture. *Int. J. Res. Engin. Technol.* 2: 87-90.

[22] Shima P. D., Philip J., Raj B., (2009), Magnetically Controllable nanofluid with tunable thermal conductivity and viscosity. *Appl. Phys. Lett.* 95: 133112-18.

Cite this article as: A. Subramaniyan & R. Ilangovan: A report on the latest trends in nanofluid research. ***Int. J. Nano Dimens.*** 6 (3): 323-328, Summer 2015.