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CONCENTRATION OF NANO FLUID/BASE FLUID SUSPENSION ENHANCE SURFACE CHARGE WITH PH STABILITY FOR LOW TO MEDIUM TEMPERATURE PHASE CHANGE MATERIALS

Bhushan Y. Patil [1], Dr. Nilesh P. Salunke [2], Dr. Vijay R. Diware [3], Vijay K. Suryavanshi [4], Pandit S. Patil [5]

[1] Research Scholar, Mechanical Engineering, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon, Maharashtra, India
[2] Professor, Mechanical Engineering, Shri Vile Parle Kelavani Mandal's Institute of Technology, Mumbai Agra Highway, Dhule, Maharashtra, India
[3] Associate Professor, Chemical Engineering, SSBTs College of Engineering & Technology, Post Box No. 94, Jalgaon, Maharashtra, India
[4] Assistant Professor, Applied Science Department, SES's R. C. Patel Institute of Technology, Shirpur, Maharashtra, India
[5] Assistant Professor, Mechanical Department, SES's R. C. Patel Institute of Technology, Shirpur, Maharashtra, India

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Corresponding Author

Bhushan Y. Patil,
bhushanpatilsai15@gmail.com

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ABSTRACT

Zeta potential and poly-dispersivity are used to characterize the samples that is obtained using absorption refrigeration system for low to medium temperature phase transition materials. Salicyclic acid, Benzanilide, Hydroquinone, Potassium thiocyanates, D-mannitol, Alunimium oxide, Iron oxide, and ZnO active concentration with base fluid, aspects including the influence of the PCMs property based on their phase transition mutual interaction are explored. In order to comprehend their behavior and improve their performance, functional materials synthesis and characterization depend heavily on the isoelectric point. Understanding the material surface charge role of the medium's pH stability to the many liquid-phase procedures involved in the synthesis of materials, since it conduct the processes like agglomeration, coagulation, peptization to form solid particles materials. Zeta potential measure, which commonly use concentration of volume fraction methods, electrophoretic migration techniques, are hence a valuable source of data.

Keywords: Zeta Potential, Poly-Dispersivity, PCMs- Phase Change Materials, SARS Solar Absorption Refrigeration System

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1. INTRODUCTION

The principle behind electrophoresis called as electrophoretic migration studies, is momentum of dispersed fluid particle state under effect of electric field produced by presence charged interface between particle surfaces with mass density of fluid electrophoretic mobility. Various electrophoretic procedures can be employed like solids, biomolecules, cells, colloids and fluids organic liquid, gel, aqueous liquid [1] Procedures for material characterization, particle deposition or separation that demand certain protocols and cells are distinguished. To better understand interact at solid-solid and solid-fluid interfaces amend the synthesis and performance of functional materials to provide information about surface charge while using electrophoretic migration measurement. For example by increasing active phase loading or enhancing its dispersion [2]. To characterize the reactivity of nanomaterial's and ultimately make them safe and sustainable by design, electrophoretic migration analysis is frequently performed [3, 96] Activity and selectivity are influenced by many factors like size, surface chemistry, morphology and texture, which highly depend interacting processes occurring during synthesis methods like concentration, temperature, type of support, pressure, pH, solvent, active phase precursors, is useful technique for heterogeneous catalysis [4]. The electrophoretic migration in catalysis has been neglected, because it is challenging to standardize operating techniques and circumstances, the results interpret properly from various laboratories and measuring apparatus. The surface charge of particles employed in heterogeneous catalysis basically oxidic nature compounds like metal hydroxides, silicates, oxides etc. Specifically examined in this article's overview to measure surface charges of particles using electrophoretic migration. The materials isoelectric point (IEP) employed as catalyst supports, active phases, additives as well as analysis of IEP final solid as function of composition and preparation method particularly important for design and fabrication of industrial catalysts. The purpose of this piece is to honour Professor F.J. Gil-Llambas, he was a pioneer in the application of this method to the characterization of catalysts based on transition metal oxides, which has proven to be very beneficial in processes like NOx removal (DeNOx) by selective catalytic reduction (SCR), hydro desulfurization (HDS), hydro des nitrogenation (HDN), and photo catalytic oxidation of volatile organic compounds (VOCs). Electro kinetic potential created in sliding plane between Stern and diffuse layers.[5] according to the ISO 13099 standard, which covers electroacoustic and electro kinetic procedures in Part 1 issued in 2012[6] Part 2: Optical Techniques, 2012[7]. Part 3, "acoustic techniques," published in 2014 [8]. In-progress Part 4 will discuss streaming present and possible approaches for porous medium of materials. Measuring zeta potential is frequently used by electrophoresis kinetic method, displacement of particles along direction suspended in aqueous ionic medium and analyzing speed, consider the potential difference in two electrodes immersed in suspension, alternately used techniques for specific applications, such as very concentrated slurries [9]. Gil-Llambas employed microscopes to determine the electrophoretic mobility of the materials mentioned in this paper up to the 1980s, but nowadays automated electrophoretic light scattering (ELS) is most widely used technique. [10] Often, using Henry's equation for an electrical field, the zeta potential (mV)[11] Effect of temperature, ionic strength, solids, and pH content must be taken into account for determine zeta potential values in order for them to indicative surface charge and ongoing systems behavior. Key elements influencing zeta potential in aqueous media is sample's pH and ion concentration must, however, also be taken into account. A larger double layer is visible in electrolyte solutions that are more diluted. Moreover, a rise in ionic strength may cause double-layer to collapse; such as zeta potential values insufficient to ascertain the solution's stability since a double-layer collapse causes the system to accumulate surface charge. This issue is avoided by zeta potential measurements with low or medium ionic strength. Because they rely on optical techniques like laser Doppler scattering, electrophoretic procedures demand highly diluted solutions (less than 0.01% solids) [12]. To estimate particle speed. Excessive dilution of concentrated samples can contaminate in liquid phase cause chemical, alterations at surface of the particles and solution, which could affect the electro kinetic behavior [13]. Steadily for the past but not least, it should be noted that while steps in the liquid phase or slurry used to make industrial catalysts frequently performed at ambient pressure temperature, representative measurements for other industrial processes like oil recovery, adsorption and flotation require different range of pressure and temperature conditions [14]. Studied how pressure and temperature affected zeta potential of the common quantity of minerals such calcite, quartz, and kaolinite. Zeta potential value decreased with temperature rate to each mineral, whereas the impact of pressure was discovered to be dependent on nature of minerals and pH of electrolytic solution [15].

1.1. ZETA POTENTIAL STABILITY OF NANO FLUIDS

Nanoparticles are likely to aggregate variety of factors van der Waals forces, Brownian motion, electrostatic force creating sedimentation that changes thermophysical and optical properties of nano fluids it may clog hydraulic components. The base fluid's dielectric constant, nano fluid's volume fraction, zeta potential value, pH value, size, shape and these variables significantly impacted on the stability of nanofluids. Potential difference between two charged nanoparticles is precisely proportional to the dielectric constant, acting as barrier to stop particle agglomeration brought on van der Waals forces [16]. As a result, base fluids with greater dielectric constants would provide nanoparticle dispersions that were more stable. Water is a better candidate for a base fluid since its dielectric constant 78.5 at 20^{0}C, higher than base fluid ethylene glycol and ethanol 24.6 at 20^{0}C [16, 17]. MWCNT plasma functional stability dispersed several base fluids was examined temperature and revealed that the Therminol VP-1 nanofluid had a significant degree of instability, whether water and ethylene glycol used based nano fluids had satisfactory stability for 8 months [18, 94]. Increasing absolute values of zeta potential indicate stronger electrostatic repulsion forces. The strength of electrostatic repulsion between nanoparticles measure zeta potential. When zeta potential is > 30 mV or < 30 mV, a nanoparticle dispersion is regarded as stable [16, 17, 19, 20, 21]. The pH of the nano fluids causes a drop zeta potential, which dependent on particle composition. In light of this, low pH solutions less than 6 [17, 20] demonstrate greater stability than medium pH dispersions.

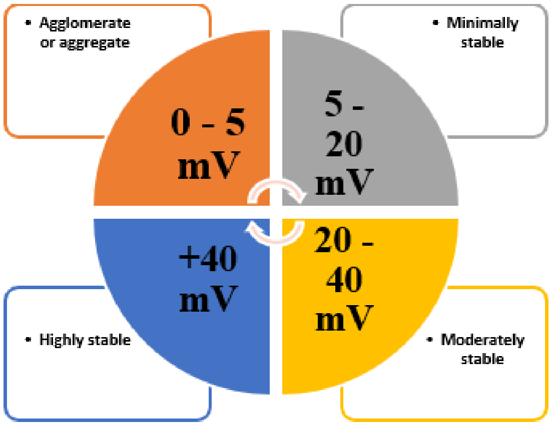


Fig. 1. PCM positive stability region of zeta potential (mV)

At larger particle sizes, the nano fluid's stability declines [16, 19, 22, 93] Yet, raising particle volume fraction results in stronger van der Waals attractive forces, which in turn causes more particle agglomeration [22]. This result was reached through a number of studies, and it advises future research into low volume fraction nano fluids. Finally, the stability of the dispersion is significantly impacted by the collector's operating circumstances. Number of collisions at elevated temperatures cause higher diffusion coefficients, which to facilitate particle aggregation [19]. Furthermore, it has been demonstrated that nano fluids with high temperatures have surfactant degradation that is more rapid, which affects the stability of the dispersion [19, 23]. It has been shown that in the turbulent flow regime, nanoparticle deposition is lower [24]. A significant influence in the stability of nano fluids is the method used to create them which can be either one-step or two-step method [19]. The one-step process particle size and shape can be precisely controlled, particle agglomeration is reduced, and as a result, extremely stable nano fluids are produced. Unfortunately, the one-step approach has high production costs and is only effective for small amounts of nano fluid. The two-steps method is a practical choice for large-scale production, although it has increased particle agglomeration, necessitating the use of stabilization techniques. Further details on preparation techniques and additional stabilizing methods can be obtained [16, 17].

1.2. IMPACT ON THE ENVIRONMENT AND TOXICITY

Nanoparticles can enter biological things due to their extremely small size, promoting cell, bacterial mutation and protein deterioration and negative changes impacting living things. According to toxicological tests, the toxicity level rises the size of the nanoparticles decreases [25, 26]. The chemical characteristics and the geometry also have an impact on a family of nanoparticles' level of toxicity [27, 28]. According to reports, tubular carbon black particles (SWCNTs) cause more lung toxicity than spherical carbon black particles [26]. These particles are more hazardous than quartz dust, which is notorious for leading to major respiratory ailments [29, 30]. According to in vitro testing, compared and graded the following frequently used metal nanoparticles: Zn-based materials are superior to Cu, Ag, Fe_3O_4, Al_2O_3, and TiO_2 in that order. It is quite challenging to assess toxicity level of nano fluids employed in DASC since so many different variables nano fluid, base fluid, particle size, particle shape, surfactants, thermal stability, volume fraction, composition, homogeneity, can affect it. Toxicity experimental studies of nano fluids required to determine toxicity limit, safe and secure future measures with nano-wastes management [31, 32, 33, 34]. Compared to conventional collectors, NDASC can reach higher efficiencies, which result in significant energy savings with reduction of CO_2 emissions [36]. While comparing a planar NDASC to a conventional FPC and a conventional water heater, it was determined that over a 15-year lifespan, a planar NDASC could save 740 kg and 23000 kg of CO_2 emissions, respectively. Using a typical FPC, it was demonstrated that using a CuO2 water-based nano fluid as HTF reduced CO_2 emissions by 175 kg compared to using water [37]. The energy savings associated with replacing half of conventional collectors now installed by NDASC were assessed, and it was determined that the related energy savings would amount to 857.5 million MJ per year. Unfortunately, NDASC produce nano-wastes at the end of their life cycles, whose handling needs to be improved and standardized [38]. Further information on strategies for separating and characterization of nano waste. The reader is able to recognize and estimate the precautions for handling nano-waste by viewing risk profiles for various nano materials [39].

1.3. PUMPING CAPACITY

The inclusion of nanoparticles causes base fluid's viscosity to increase, requiring more amount of pumping power and raising operational expenses [19]. It has been demonstrated that the insertion of nitrogen-doped graphene [40] and graphene nanoplatelets [41] in small amounts (less than 0.1 weight percent) has optimum impact on base fluid's viscosity. Examined was how the geometry of the MWCNT affected the nano fluid's viscosity, who established that particles with a high aspect ratio cause reduced viscosity growth [42]. Measured the relationship between viscosity and nanoparticle volume fraction and highlighted the considerable viscosity growth anticipated for high volume fractions. The projected viscosity increases, however, are low because the volume fraction range examined by these authors is greater than the normal particle concentration frequently linked with NDASC which is typically composed between 0.001 - 0.1 Vol % fluid viscosity and nanoparticle concentration solution relationship is positive nano fluids with lower particle volume fractions should have an advantage because they have more promising pore characteristics [43].

1.4. COMPONENTS' DETERIORATION AND RUST

The major obstacle of deterioration and rust brought on by the integration of nanoparticles must unavoidably be overcome. Stainless steel pipes were not harmed, in contrast to aluminium and copper pipes, which both exhibit considerable degradations, according to research on corrosion of metal to metal-oxide nanoparticles. Thus, stainless steel components are advised for the NDASC installation's hydraulic circuit [44, 45]. Authors have also looked into the impact of nanoparticle type, and they found that carbon-based nano fluids exhibit less corrosion than metal- or oxide-based nano fluids [46, 47, 48].

2. EXPERIMENTAL STUDIES OF NANO FLUIDS WITH BASE FLUID FOR MATERIALS THERMAL CONDUCTIVITY

Various studies enhance the thermal conductivity to analyze nano fluids depends different parameters like concentration of volume fraction, material, size, shape, nano fluid, base fluid material and ambient pressure temperature conditions. Parameters can be concluded concentration of volume fraction [52, 53, 54] Particle materials [52, 53, 54] Base fluid [55, 56, 57] Particle size [52, 58, 59, 60, 61, 62] Particle shape [63] Temperature [64, 65, 67, 68, 69] Clustering [69, 70, 71, 72] Conductive heat transfer of nano fluids [73, 74] Specific Heat [73, 74] Analysis of advanced convective heat transfer of nano fluids [75,76,77] Constant wall heat flux Boundary condition [75, 76, 77] Experiment in advanced convective heat transfer of nanofluids and base fluid [76, 77, 78]

Table 1 Empirical studies on thermal Conductivity

Empirical studies on thermal conductivity						
Literature	**Particle Size**	**Base Fluid**	**Particle volume Fraction (%)**	**Particle Size(nm)**	**Max Enhancement (%)**	**Findings**
Masuda et. al [79]	Al_2O_3	Water	1.30 to 4.30	13	32.4	31.85^{0}C
	SiO_3	Water	1.10 to 2.40	12	1.1	
	TiO_2	Water	3.10 to 4.30	27	10.8	86.85^{0}C
Lee et. al [58]	Al_2O_3	Water/EG	1.00 to 4.30/ 1.00 to 5.00	38.4	10/18	Room temperature
	CuO	Water/EG	1.00 to 3.41/ 1.00 to 4.00	23.6	12/23	
Wang et. al [80]	Al_2O_3	Water/EG	3.00 to 5.50/5.00 to 8.00	28	16/41	Room temperature
	Al_2O_3	EO/PO	2.25 to 7.40/5.00 to 7.10	28	30/20	
	CuO	Water/EG	4.50 to 9.70/6.20 to 14.80	23	34/54	
Eastman et. al [81]	Cu	EG	0.01 to 0.56	<10	41	Room temperature
Xie et. al [82]	Sic	Water/EG	078 to 4.18/0.89 to 3.50	26 sphere	17/13	Effect of particles shape
	Sic	Water/EG	1.00 to 4.00	26 sphere	17/13	Effect of particles shape
Xie et. al [83]	Al_2O_3	Water/EG	5.00	60.4	23/29	Room temperature
Das et. al [84]	Al_2O_3	Water	1.00 to 4.00	38.4	24	21^{0}C to 51^{0}C
	CuO	Water	1.00 to 4.00	28.6	36	
Murshed et. al [85]	TiO_2	Water	0.50 to 5.00	15 sphere	30	Room temperature
Hong et. al [71]	TiO_2	Water	0.50 to 5.00	10 × 40 rod	33	
	Fe	EG	0.10 to 0.55	10	18	Effect of clustering was investigated.
Li and Peterson [86]	Al_2O_3	Water	2.00 to 10.00	36	29	27.5^{0}C to 34.7^{0}C
	CuO	Water	2.00 to 6.00	29	51	28.9^{0}C to 33.4^{0}C
Chopkar et. al [61]	Al_2Cu	Water/EG	1.00 to 2.00	31/68/101	96/76/61	Effect of particles size was examined
	Ag_2A_1	Water/EG	1.00 to 2.00	33/80/120	106/93/75	
Beck et. al [87]	Al_2O_3	Water	1.86 to 4.00	8-282	20	Effect of particles size was examined
	Al_2O_3	EG	2.00 to 3.01	12-282	19	
Mintsa et. al [88]	Al_2O_3	Water	0 to 18	36/47	31/31	20^{0}C to 48^{0}C
	CuO	Water	0 to 16	29	24	
Turgut et. al [89]	TiO_2	Water	0.2 to 3.0	21	7.4	13^{0}C to 55^{0}C
Choi et. al [54]	MWCNT	PAO	0.04 to 1.02	25 × 50,000	57	Room temperature

Assael et. al[90]	DWCNT	Water	0.75 to 1.00	5 (Diameter)	8	Effect of sonication time was Examined
	MWCNT	Water	0.60	130 × 10,000	34	Room temperature
Liu et. al [91]	MWCNT	EG/EO	0.20 to 1.00/1.00 to 2.00	20 -50 (Diameter)	12/30	Room temperature
Ding et. al [92]	MWCNT	Water	0.05 to 0.49	40 nm (Diameter)	79	20^{0}C to 30^{0}C

EG: Ethylene glycol, EO: Engine oil, PO: Pump oil, TO: Transformer oil, PAO: polyalphaolefin MWCNT: Multi-Walled Carbon Nanotubes, DWCNT: Double-Walled Carbon Nanotubes

3. MATERIALS AND METHODS

Particle size and zeta-potential with particular focus on curved supports, measure zeta potential to coating of supports and control the synthesis is discussed in terms of material preparation. Prepared nano fluids used $C_7H_6O_3$ purity 99%, $C_{13}H_{11}NO$ purity 99%, $C_6H_6O_2$ purity 99%, KSCN purity 98.5%, $C_6H_{14}O_6$ purity 99%, Al_2O_3 purity 99%, and ZnO purity 99% was purchased from Sudarshan Scientific Laboratories, Nashik (Maharashtra, India) active concentration with base fluid, aspects including influence of concentration on qualities based on their mutual interaction was examined.

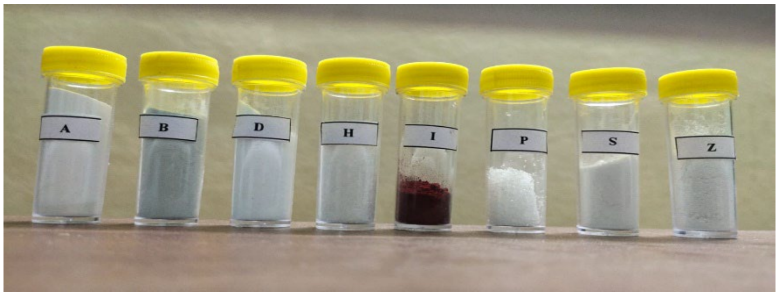


Fig. 2. Materials sample appearance with code

Table 2 Materials tested PCM in solar cooling [95].

Materials	Tested PCT (°C)		Tested PCE (kJ/kg)	
Phase	Melting	Solidification	Melting	Solidification
Salicylic acid	159.1 (m)	113.3 (s)	161.5 (m)	109.4 (s)
Benzanilide	163.6 (m)	136.1 (s)	138.9 (m)	129.4 (s)
D-mannitol	166.8 (m)	117 (s)	260.8 (m)	214.4 (s)
Hydroquinone	172.5 (m)	159.5 (s)	235.2 (m)	178.7 (s)
Potassium thiocyanate	176.6 (m)	156.9 (s)	114.4 (m)	112.5 (s)

(PCT = phase change temperature, PCE = phase change enthalpy, m = melting, s= solidification)

Using Nano Zetasizer (Zetasizer Ver. 8.02, Serial Number: MAL1051945, Malvern Instruments Ltd., United Kingdom)) fitted with a He-NE laser (633 nm), the mean particle size and poly dispersity index (PDI) of nanoparticles were determined. Using the aforementioned device, it was also possible to measure the electrical potential, or zeta-potential, at the nanoparticle's shear plane. Primary measurement, dispersions were diluted ten times with distilled water. Diffraction index for the aqueous phase was 1.33 at a temperature of 25 ± 1 ^{0}C.

The nano fluid and base fluid used for suspension in distilled water as well as ethylene glycol to comparatively tested base on particle volume fraction, particle size, particle shape for solid PCMs with suspended in solution. All the chemicals were chemically pure form. The PCMs studied base on thermal conductivity and transition of solid and liquid phase. The PCMs selected based on absorption refrigeration system solution was prepared by dissolving salicyclic acid, benzanilide, hydroquinone, potassium thiocyanates, D-mannitol, alunimium oxide, iron oxide, and zinc oxide taken chemically correct dispersant in distilled water and ethylene glycol with particle size to improve the surface charge. Dynamic viscosity and thermal conductivity of PCMs were explored in the energy storage system that was tested in various experimental studied. Zeta potential (mV), zeta deviation (mV), conductivity (mS/cm), Z-Average (d.nm), size distribution of PCMs, and PdI value were compared for PCMs at atmospheric pressure and temperature.

4. RESULTS AND DISCUSSION

Selected PCMs for low to medium temperature is used in absorption refrigeration system of physical, chemical and thermal stability to analyze isoelectric point and charged interface between the particle surfaces as recorded at different voltages to find particle speed and zeta potential. Remembering that the pH of the solution impacts how much charge is on the surface of nanoparticles is essential. In actuality, the isoelectric point certain pH is point at which surface charge is lowered to zero [97]

- Agglomerate or aggregate nature of particle surface charge range 0 - 5 mV
- Minimally stable particle surface charge range 5 - 20 mV
- Moderately stable particle surface charge range 20 - 40 mV
- Highly stable particle surface charge range 40+mV

As per results shown of concentration of nano fluid and base fluid dispersant with water obtained zeta Potential (mV) of PCMs applicable for absorption refrigeration system.

Sample A is recorded particle zeta potential and Z-Average (d.nm) values is -15 mV and 461.7 was minimally stable.

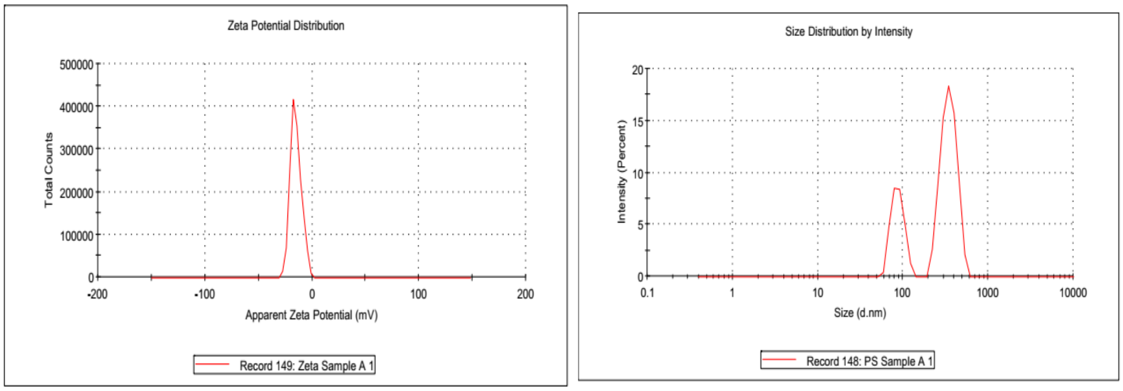

a)
b)

Fig. 2 Sample A dispersive with water zeta potential (a) and particle size distribution (b)

Sample B is recorded particle zeta potential and Z-Average (d.nm) values is -9.36 mV and 327.2 was minimally stable

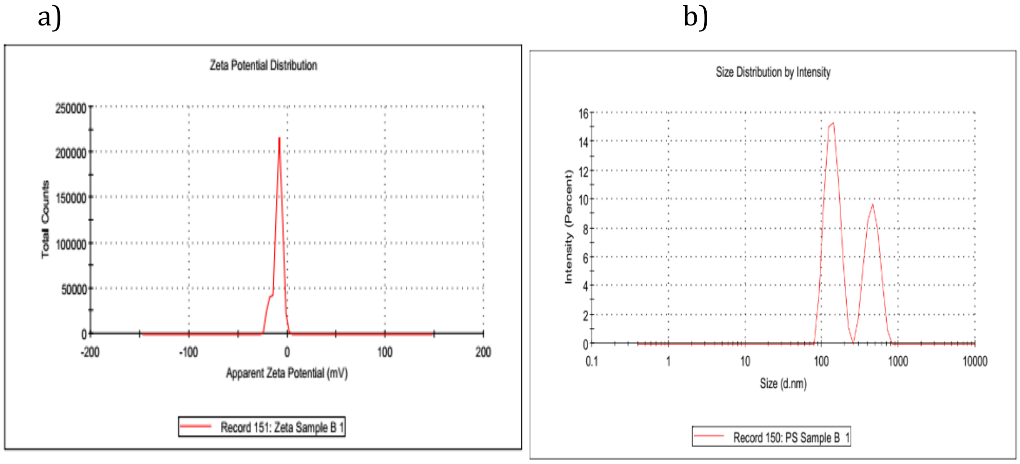


Fig. 3 Sample B dispersive with water zeta potential (a) and particle size distribution (b)

Sample D is recorded particle zeta potential and Z-Average (d.nm) values is -4.41 mV and 335.3 tend to agglomerate or aggregate

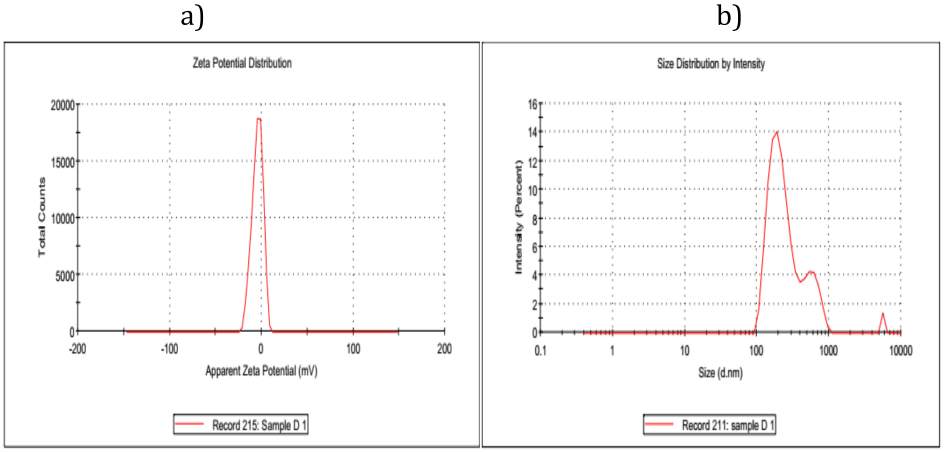


Fig. 4 Sample D dispersive with water zeta potential (a) and particle size distribution (b)

Sample H is recorded particle zeta potential and Z-Average (d.nm) values is -18.9 mV and 412 moderately stable.

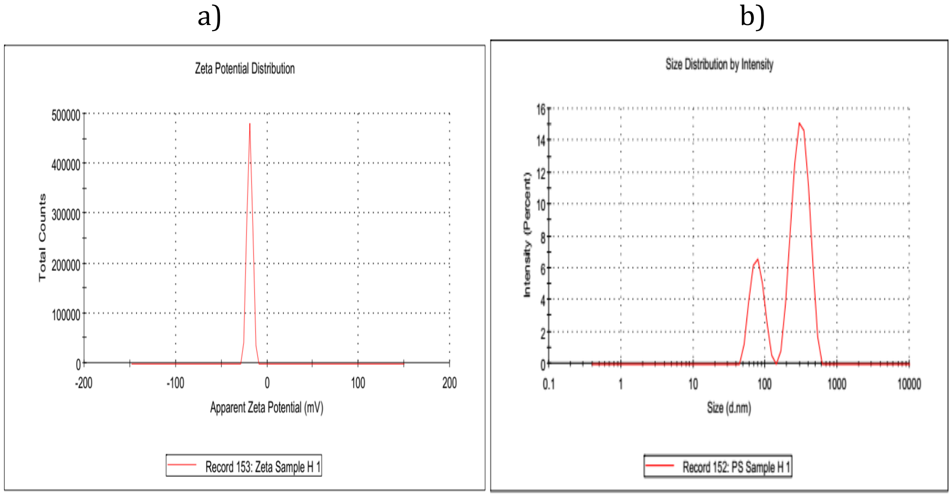


Fig. 5 Sample H dispersive with water zeta potential (a) and particle size distribution (b)

Sample I is recorded particle zeta potential and Z-Average (d.nm) values is -7.9 mV and 743.3 was minimally stable

a) b)

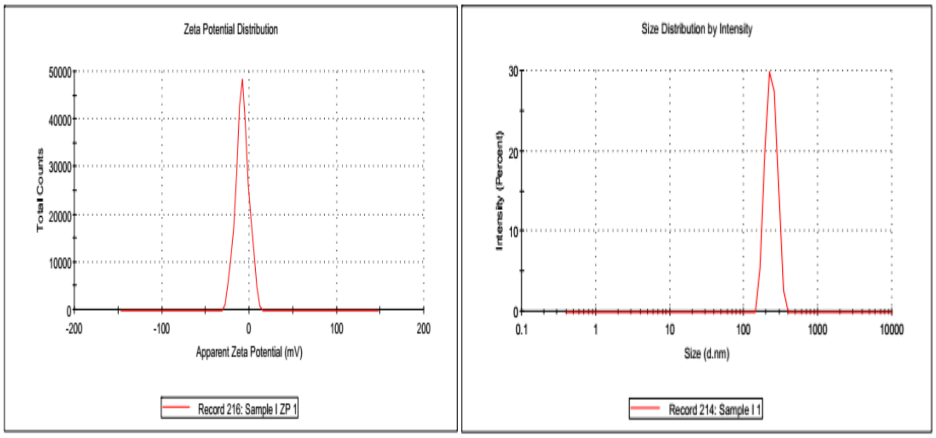


Fig. 6 Sample I dispersive with water zeta potential (a) and particle size distribution (b)

Sample P is recorded particle zeta potential and Z-Average (d.nm) values is -9.74 mV and 278.2 was minimally stable. Zeta potential graph is disappeared for Sample P

Sample S is recorded particle zeta potential and Z-Average (d.nm) values is -2.07 mV and 333.2 tend to agglomerate or aggregate. Zeta potential graph is disappeared for Sample S

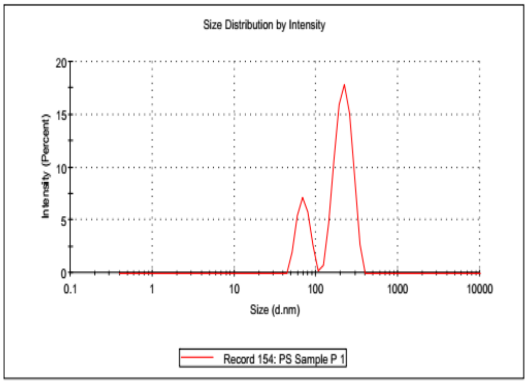


Fig. 7 Sample P dispersive with water particle size

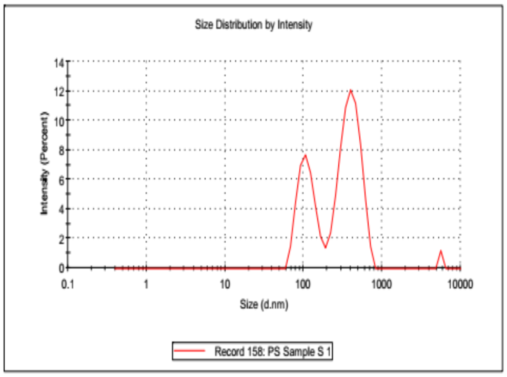


Fig. 8 Sample S dispersive with water particle size

Sample Z is recorded particle zeta potential and Z-Average (d.nm) values is -7.43 mV and 609.5 was minimally stable

a) b)

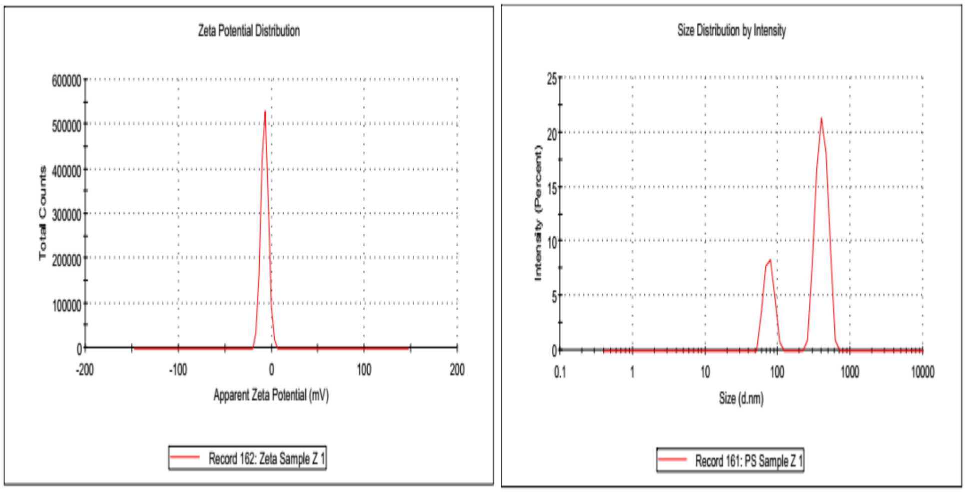
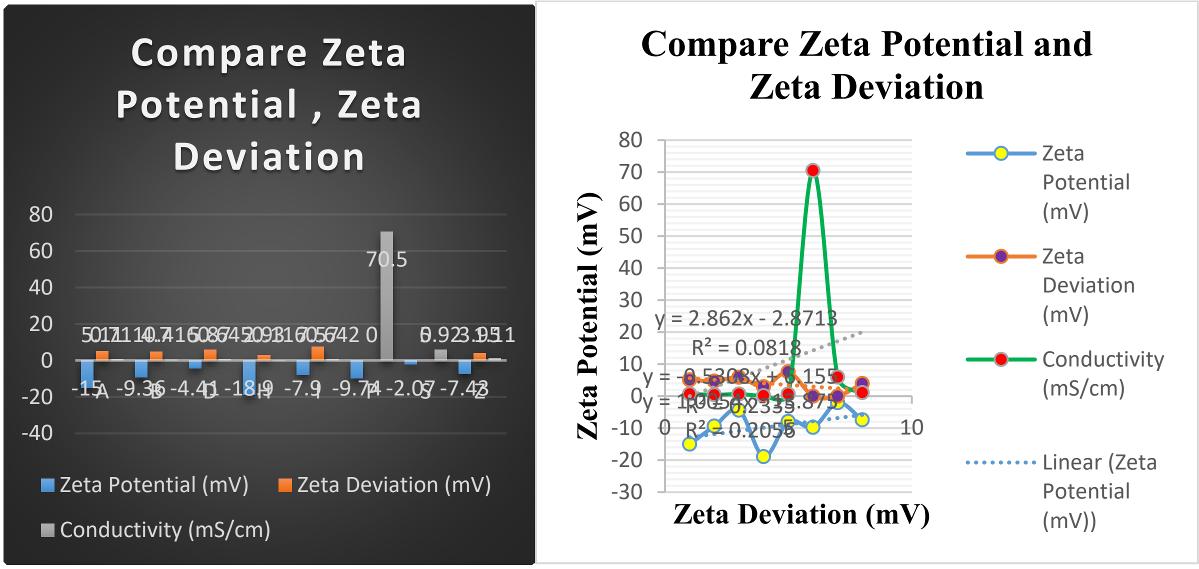


Fig. 9 Sample Z dispersive with water zeta potential (a) and particle size distribution (b)

Table 3 Concentration of Nano fluid and base fluid dispersant with water obtained zeta Potential (mV) of PCMs applicable for absorption refrigeration system.

Sample Code	Zeta Potential (mV)	Zeta Deviation (mV)	Conductivity (mS/cm)	Result quality
A	-15	5.11	0.711	Good
B	-9.36	4.7	0.416	Good
D	-4.41	5.87	0.645	Good
H	-18.9	2.93	0.116	Good
I	-7.9	7.57	0.642	Good
P	-9.74	0	70.5	Good
S	-2.07	0	5.92	Good
Z	-7.43	3.95	1.11	Good



a) b)

Fig. 10 compare zeta potential and zeta deviation (a) and linear performance of zeta potential and zeta deviation (b)

Table 4 Concentration of Nano fluid and base fluid dispersant with water obtained particle size distribution (d.nm) of PCMs applicable for absorption refrigeration system.

Sample Code	Z-Average (d.nm)	PdI	Intercept	Result quality
A	461.7	0.741	0.92	Refer to quality report
B	327.2	0.573	0.755	
D	335.3	5.75	0.796	
H	412	0.675	0.611	
I	743.3	0.656	0.688	
P	278.2	0.576	0.877	
S	333.2	0.598	0.792	
Z	609.5	0.808	0.75	

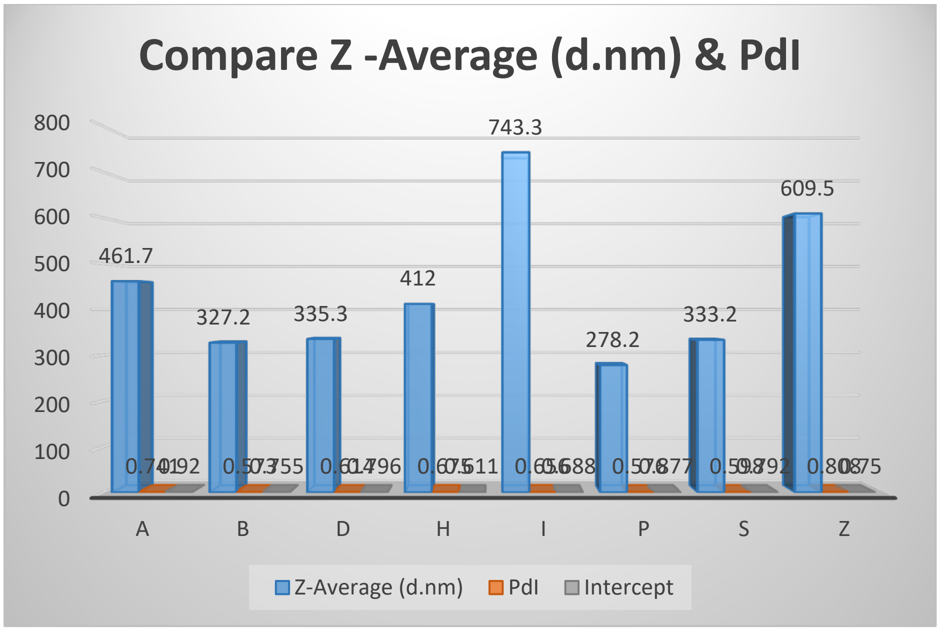
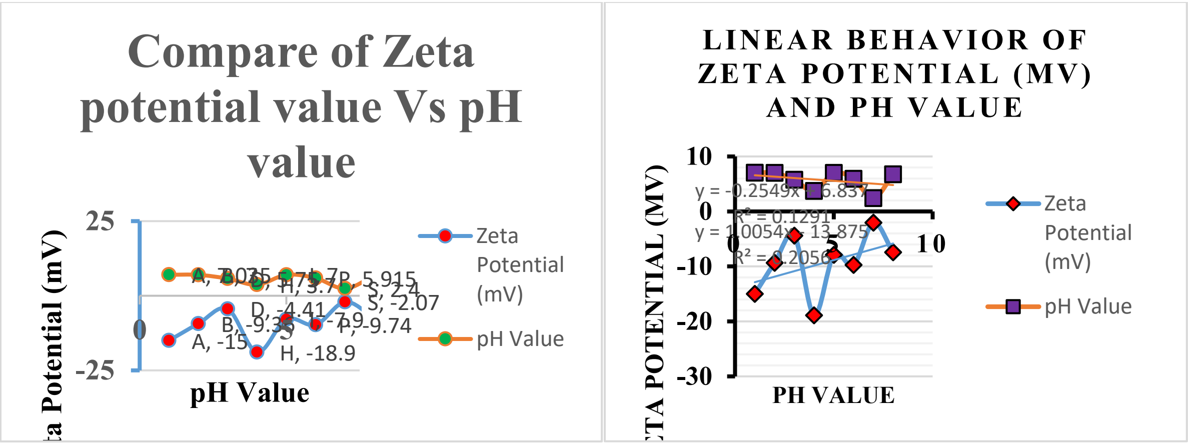


Fig. 11 compare Z-Average (d.nm) and PdI (a)

Table 5 obtained zeta Potential (mV) with pH stability for PCMs applicable for absorption refrigeration system.

Sample Code	Zeta Potential (mV)	pH Value
A	-15	7.035
B	-9.36	7
D	-4.41	5.75
H	-18.9	3.7
I	-7.9	7
P	-9.74	5.915
S	-2.07	2.4
Z	-7.43	6.72


a)

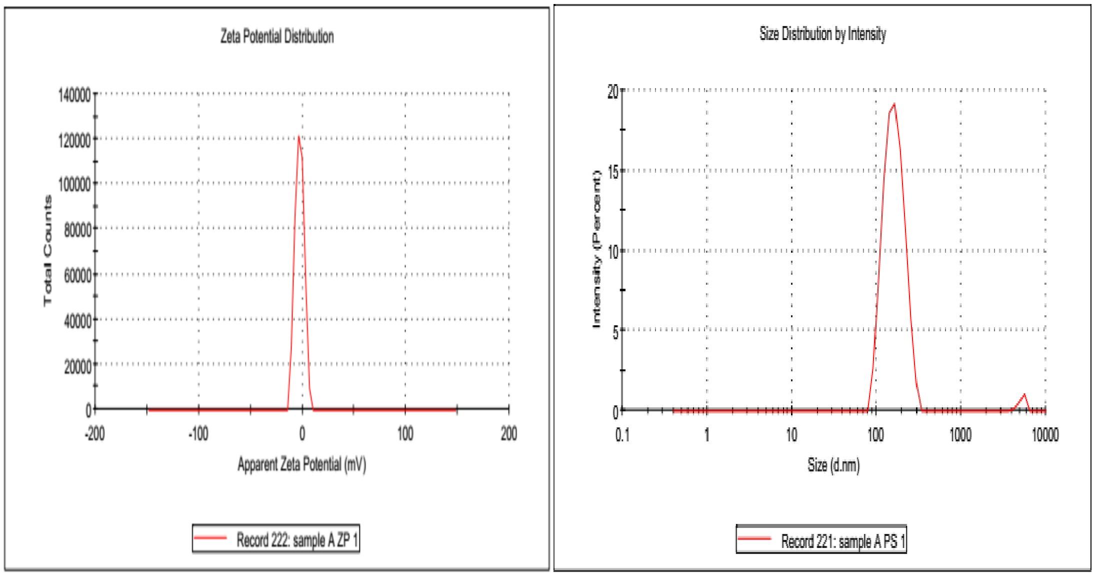
b)

Fig. 12 compare zeta potential and pH value (a) and linear performance of zeta potential and pH value (b)

As per elemental analysis of nano fluid and base fluid dispersant with water obtained sample A and sample H is zeta potential and Z-Average (d.nm) values particles are moderately stable at pH value. Sample A was recorded particle zeta potential and Z-Average (d.nm) values is -15 mV and 461.7 was minimally stable. Sample A purity is 99% with range of 6.5-7.5 pH stability was good similarly another sample H is recorded particle zeta potential and Z-Average (d.nm) values is -18.9 mV and 412 moderately stable. Sample H purity is 99% with 3.7 pH stability was good.

Selected sample A and sample H obtained good results of zeta potential value and Particle size -15 mV to -20 mV as a base fluid dispersant with water is minimally and moderately stable.

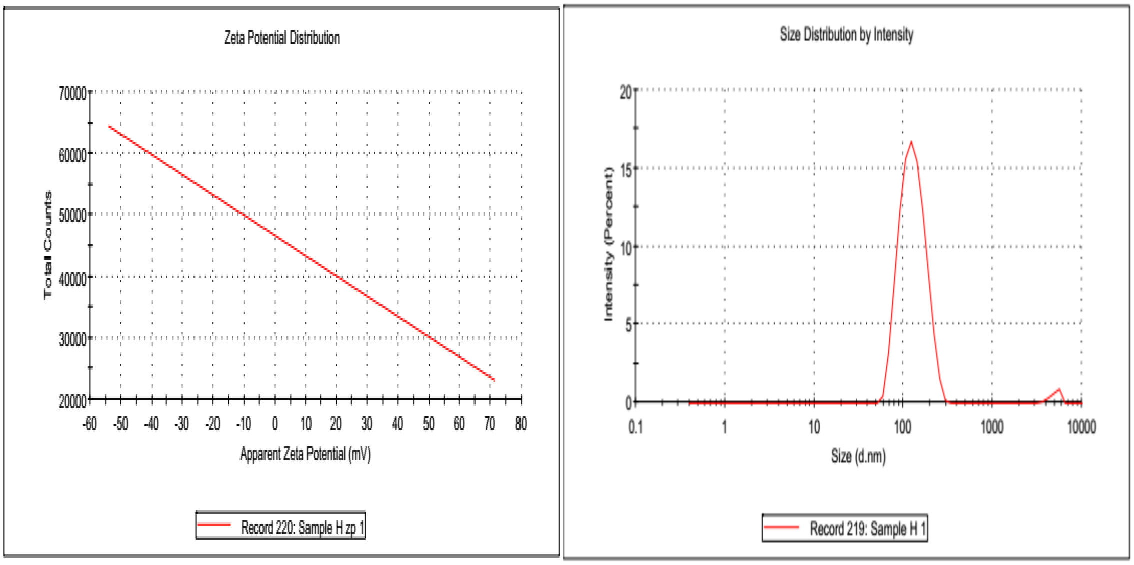
Sample A is recorded particle zeta potential and Z-Average (d.nm) values is -2.62 mV and 141.7 tend to agglomerate or aggregate


a)

b)

Fig.13 Sample A dispersive with water zeta potential (a) and particle size distribution (b)

Sample H is recorded particle zeta potential and Z-Average (d.nm) values is -20.8 mV and 246 moderately stable.


a)

b)

Fig.14 Sample H dispersive with water zeta potential (a) and particle size distribution (b)

Table 6 Concentration of Nano fluid and base fluid Zeta Potential (mV) obtained dispersant with ethylene glycol of PCMs applicable for absorption refrigeration system.

Sample Code	Zeta Potential (mV)	Zeta Deviation (mV)	Conductivity (mS/cm)	Result quality
A	-2.62	4.21	0.609	Good
H	-20.8 (-487)	246	0.651	Good

Table 7 Concentration of Nano fluid and base fluid dispersant with water obtained particle size distribution (d.nm) of PCMs applicable for absorption refrigeration system.

Sample Code	Z-Average (d.nm)	PdI	Intercept	Result quality
A	141.7	0.330	0.525	Refer to quality report
H	116.4	0.251	0.498	

Comparatively tested elemental analysis of nano fluid and base fluid dispersant with ethylene glycol obtained Sample A was recorded particle zeta potential and Z-Average (d.nm) values is -2.62 mV and 141.7 tend to agglomerate or aggregate. Sample A purity is 99% with range of 6.5-7.5 pH stability was good similarly another sample H is recorded particle zeta potential and Z-Average (d.nm) values is -20.8 mV and 246 moderately stable. Sample H purity is 99% with 3.7 pH stability was good.

5. CONCLUSION

Surface charge potentially work with zeta potential measuring range performed by electrophoresis are highly significant values during phase change materials in development stages. PCM materials possibility obtained results to increase energy storage stability with highest thermal conductivity nanoparticles suspended in base fluid. As results to comparison with the literature data, which obtained PCMs tested studies shown thermal conductivity of concentration of nano fluids depends on mass density, volume fraction, material phases, size, shape, quantity of base fluid material and ambient pressure temperature conditions. Nano materials and base fluid concentration highly change the thermal conductivity, zeta potential values, pH and PDI for hydroquinone, aluminum oxide, which moderately stable it possible to use energy storing stability into PCMs for useful to thermal storage to supply energy to absorption refrigeration system to increase surfactant concentration in base fluid's to raises thermal conductivity and increasing convective heat transfer coefficient. Solid form of nanoparticles with proper shape of PCM with typical length scales of 1-100 nm. In nano fluids, spherical particles are most frequently used. Nanoparticles in the forms of rods, tubes, and discs are also employed.

CONFLICT OF INTERESTS

None.

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