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Investigation on Impact of Thermo Physical Properties of Graphene Water and Al2O3

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ABSTRACT

According to multiple scholarly and professional publications, introducing tiny fluids or operating waters with nanometer particulate size has significantly improved the thermal transmission characteristics of thermal exchange mechanisms. Prospective uses of tiny fluids in oil extraction and medication administration are drawing more interest. Reliability, along with effective productivity, is an obstacle, though. Stable enhancement and comprehension of tiny fluid dynamics are essential to ensure thermo physical qualities and exploit such enhanced fluids over time. This experimental work outlines upcoming exploration prospects to fill the divide between in-lab and production. It analyzes the state of the industry within tiny liquids studies, covering synthesis processes, stabilization assessment, and thermo physical features. Graphene water and Al2O3 are the two nanofluids considered in the experimental investigation. The outcomes of the research state that with an increase in temperature, the nanofluid density decreased, while all other properties, dynamic viscosity, specific heat capacity, and thermal conductivity values increased. Al2O3 has shown better performance in terms of dynamic viscosity, thermal conductivity, and specific heat capacity properties. XRD patterns are compared; an Al2O3 spike is high with 2θ = 30.1.

Keywords: Tiny fluid, nanometer, thermal transmission, thermal exchange mechanism, thermo physical properties, Graphene, Al2O3

1 INTRODUCTION

The thermal conductivity ratings of organic materials, metals materials, and oxides emphasize how drifting metals might boost thermal transmission capability [1]. Because of the extensive touch of contact and ease of mobility, nanofluids help heat transport devices escape blockages [2]. Energy plants, buildings, transportation, and corporate infrastructure all depend on them [3]. Because of its excellent viscosity, items handled using nanofluids experience choking consequences [4]. In 1995, Choi created a brand-new category of energy transmission liquids known as nanofluids, wherein suspended metallic atoms inside regular solutions are typically smaller than 100 nm [5]. This novel technique was utilized to scatter smaller nanoparticles in liquids after Max developed it more than 120 years earlier [6]. Al_2O_3 has shown better performance in terms of dynamic viscosity, thermal conductivity, and specific heat capacity properties. XRD patterns are compared; an Al2O3 spike is high with 2θ = 30.1. Maxwell et al. originally proposed the concept of scattering particles in streams over 120 years prior, and investigators at Argonne National Lab, Ahuja, and Liu et al. subsequently utilized it [7]. In contrast to liquids, the elevated thermal conductance of metallic above ambient temperature was essential to its functioning [8]. Metallic, nonmetallic, and visco-elastic nanoparticles combined inside a non-carcinogenic foundation liquid were all included in the 2000 definition of nanofluids by Xuan and Li [9-10]. They discovered that, depending on the particles' size, shape, and

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thermo-physical characteristics, introducing nanomaterials can raise efficient heat conductance by more than 20% [11].

The elements to consider when choosing nonmaterials to manufacture tiny liquids for thermal transmission [12]. According to Kang et al., applying nanoparticles covering a plenum surface improved its hydrophobicity, which decreased circulating energy and, therefore, boosted overall performance by about twenty-five per cent [13-14]. Ali et al. examined the impact of heat, low pH, and depth of film on the liquid-surface interaction of contact to validate the wet ability modifications by nano-coating [15-16]. Wider interaction degrees are typically developed by a liquid having pH levels of less than 7, but pH-neutral liquid exhibits the reverse effect [17]. Uses for tiny fluids include antimicrobial action, reducing decrease, sunblock goods, medications, and even magnetically closing [18]. In thermo devices such as radiators as thermally power preservation, the efficiency of temperature transmission is enhanced by tiny fluids, which are designed fluids that incorporate nanomaterials [19-20].

Thermal flux can be raised as much as 23.75% with mixed tiny fluids [20]. Effectiveness can be boosted by employing fields of magnets or refining the spacing of nanoparticles. However, higher resistive inefficiencies need to be resolved [21]. Heterogeneous combinations of essential fluids enhanced by having a nanoscale of a dimension of 100 nm are called tiny fluids, and they improve thermodynamic characteristics, including temperature transport capacities. Because of the substantial contact area-to-volume proportion, these dampers are appropriate towards commercial uses such as car systems and sunlight cells.[42-44] To improve thermal transmission in various economic operations, nanofluids-engineered concentrations of nanoscale in baseline fluids are employed.[45] These maximize resource consumption in cross-flow temperature exchange mechanisms, foodstuff interpreting, and temperature operation in refrigeration units[46]. Additionally, compounds enhance temperature control in CO_2 collection mechanisms, automobile heaters, and especially solar cells [47]. Table 1 shows the The majority frequently utilized in the formulations of nano fluids

Table 1. The majority frequently utilized in the formulations of tiny fluids.

Al	Aluminium	EGO	EG Mix with Oils
Ag	Silver	GO	Graphene Oxide
CNT	Carbon Nanotubes	Mg	Magnesium
Cu	Copper	Si	Silicon
EG	Ethylene Glycol	Ti	Titanium
EG H_2O	Ethylene Glycol mix with water	Zn	Zinc

The contents, which include tiny particles, constitute tiny fluids are presented in Table 1. They are made of single-element nanomaterial and fall into two categories: single-material versus mixed tiny fluids [19]. First introduced by Choi in 1995, singular component tiny fluids were traditional tiny fluids generated by utilizing only one kind of particle for suspension formation [20-21]. Individuals function better because of their advantageous thermo physical characteristics [22]. First investigated by Jana et al. in 2007 to increase fluid heat conductance, blended tiny fluids are a sophisticated class of tiny fluids that blend many nanoscales in an initial solution [23]. The Cu/H_2O tiny liquid exhibited the best heat conductance, rising proportionally with particulate attention, according to an investigation research looked at Cu, CNTs, and Au nano in water [24]. Heat conductance was maintained by the prolonged settlement period in the CNT-Cu/H_2O tiny fluids [25].

Granular shipping, thermo-physical properties, and agglomeration tendencies are all impacted by production processes.[26] They have needed to be dispersed, resilient, and homogeneous. The two main producing processes are single-step and two-step [27]. The two-step procedure produces nanoparticles plus tiny fluids using mixers, magnetized knives, and ultrasonic showering [28]. The one-step method combines manufacturing and dispersal operations in one procedure for creating small particles [28]. A single-step straight evaporating strategy is a popular technique that freezes airborne particulates in the foundation solution [28]. Table 2 shows different types of nanoparticles used for preparation of nanofluids for various applications in heat exchangers.

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Table 2. The list of Ag-Cu.

Category of nanofluids	Examples
Alloy base	Ag-Cu, Cu-Zn and Fe-Ni
carbides of metals	B_4C, SiC and ZrC
Carbon-based components	Carbon nanotubes, Diamond and Graphite
one component	Ag, Cu and Fe
one component oxides	Al_2O_3, CuO, Cu_2O and TiO_2
oxides of several elements	$CuZnFe_4O_4$, $NiFe_2O_4$, and $ZnFe_2O_4$
Nitrides of metals	AlN, SiN and TiN

Akohet et al. devised the technique. Wagener et al. suggested an altered VEROS method in which researcher's synthesized fragments with Fe and Ag nanocrystals using high-temperature magnetron-based blasting [29]. Tran and Soong created Al_2O_3 tiny liquid by laser treatment; Zhu et al. produced Cu/EG tiny fluids by the chemical-based response; Eastman et al. created an altered VEROS procedure for Cu/EG tiny fluids and employed single-step techniques to reduce tiny particles aggregation [30-31]. Eastman et al. used this technique. Wang and Xu and Lee et al. to create their Al_2O_3 tiny fluids [32]. TiO_2/H_2O tiny fluids were synthesized using the same method by Murshedetal. Using the obtained Cu nanomaterials, Xuan and Li created transformers based on oils and aquatic tiny fluids [33].

Inadequate durability resulting from particle-liquid interactions makes selling tiny fluids difficult. Van der Waals pulls and twin electrically dual-repellent interactions are to blame [34]. For tiny fluids to maintain their thermo-physical characteristics and increase storage existence, stability is essential [35]. The electrically generated dual-layer repellent pressure must be greater than the Van der Waals pull to attain equilibrium [36]. The durability of tiny fluids varies between ±60mV and ±30mV, and their zeta potentials can be in two ways in nature. A zeta-size nanoinstrument that can be used for assessment [37]. The long-term stability of Au/water tiny fluids lacking dispersing agents was investigated by Kimetal and Wang et al., who found minus zeta values [38]. They also looked at the sustainability of Al_2O_3/H_2O and Cu/H_2 [38]. Tiny fluids were affected by pH as well as the content in sodium dodecyl benzene sulfonate [39]. The study measured the zeta value of aquatic tiny fluids using 0.05wt% nanomaterials [48]. At pH 8.0, findings indicated that the zeta potential readings for Al and Cu tiny fluids were less, but the dispersal of Cu/H_2O tiny fluid was higher [49]. Having the most excellent zeta interest value for Cu and Al tiny particles, the enhanced tiny fluid distribution. Having a minimal endurance period of 48 hrs for 20% bulk portion, Mondragon et al. discovered how raising the weight portion of silica nanomaterial lowers the zeta prospective in silicon water, these tiny fluids having varying pH levels [50-51]. Figure 1 summarises the aspects that affect nanofluid selection for any application.

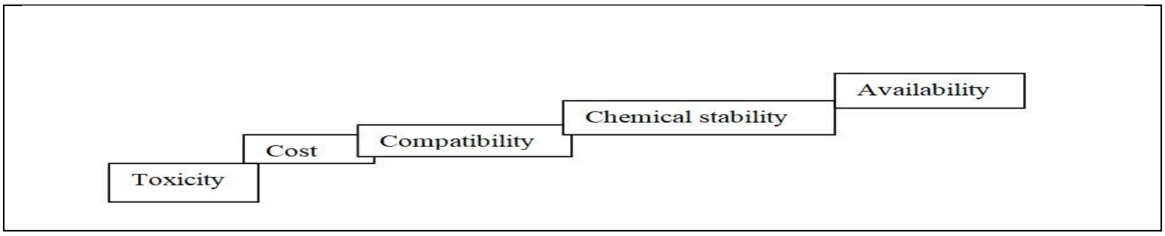

Figure 1. Summary on the factors that influence the selection of nanofluids.

2 MATERIALS AND METHODS

Since water is readily available and has strong thermo-physical qualities, it is utilized as the foundation fluid to prepare graphene and Al_2O_3 tiny fluids at values of 0.1%, 0.2%, 0.3%, and 0.5%. Aqua is the thermal transport carrier for every kind of heat exchanger in general [3]. An emulsifier has been added to the gel acacia. Varying

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proportions of graphene, as well as Al_2O_3 nanostructures, were chosen [12]. The needed amount of graphene plus Al_2O_3 particulates is combined using the foundation fluid after the requisite mass for a volumetric fraction is determined using the relation. $\varphi = \frac{\omega\rho_w}{\left(1-\frac{\omega}{100}\right)\rho_p+\frac{\omega}{100}\rho_w}$. [21]. An unequal mixture of strong nanomaterials in its foundation fluid was another significant issue during tiny fluids manufacturing; therefore, sonification utilizing cleansers plus an acoustic vibrating device is necessary to guarantee a consistent mix [30]. The mass of graphene and Al_2O_3 nanomaterials under several concentrations is measured using electronic measuring equipment [39]. Before acoustic sonification, a determined quantity of graphene and Al_2O_3 nanostructures is combined into the water and stirred manually by fingers [40].

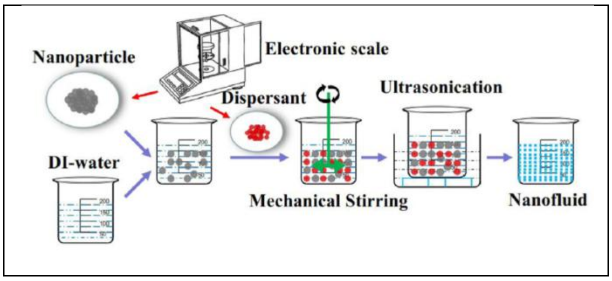


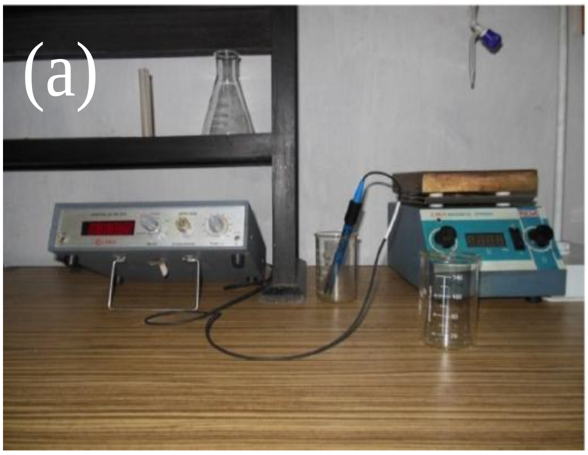
Figure 2. Flow sequence for preparation of Graphene and Al_2O_3.

Figure 3. Macroscopic inspection images (a).Graphene water and (b). Al_2O_3 nanofluid.

Figure 4. Acoustic Vibrator image.

Figure 2 depicts graphene water and Al_2O_3 nanofluid fabrication. Figure 3 depicts graphene water with Al_2O_3 nanofluid. Acoustic vibration techniques alter the exterior characteristics of nanomaterials to create homogeneous solutions. That calls for using a machine, homogenizing, and acoustic treatment. On the other hand, this may result in deposition and agglomeration. Utilizing Arabian gum as a surfactant in chemical-based surface modifications may reinforce nanomaterials over fluid environments.

A pH tester has been employed to determine if the graphene tiny fluid becomes acidic. The temperature spectrum for newly synthesized graphene tiny fluid graphene was found to be 8.5<pH<10.5 and 6.5<pH<7 for Al_2O_3 water tiny fluid. Figure 4. shows the acoustic vibrator setup. Figure 5(a-b) shows the pH measurement setup.



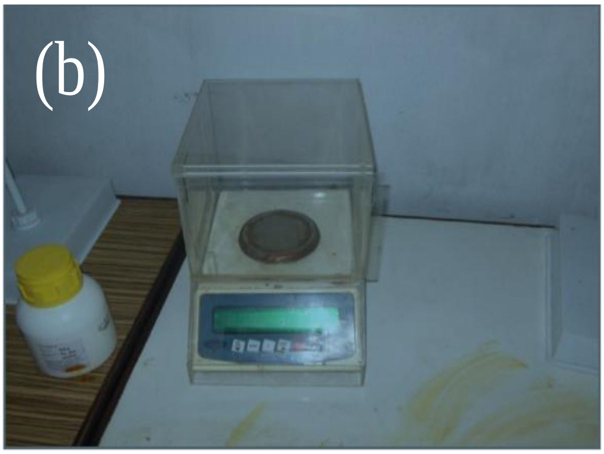


Figure 5. Measuring Devices are pH measurement and (b) Electronic Weighting Machine.

Applying 0.6% samples, the produced tiny fluids' sustainability is evaluated visually. After being kept inactive, the collected material is checked to verify the dispersion of nanomaterials. Pictures are snapped at multiple periods to see how tiny nanomaterials agglomerate and then settle. The graphene-water tiny fluid and Al_2O_3 were suitable operating fluids for feeding thermal transmission activities since they were steady for more than 60 days and showed minimal aggregation or settlement.

2.1 Description of Graphene & Al_2O_3

The work confirms the dimension with a form of the graphene-water tiny fluids by characterizing it using X-ray scattering characterization with SEM. According to studies, evidence supports the maker's standards regarding thermal transmission efficacy. Applying an X-ray diffract meter fitted with Cu Kα emission conformity, X-ray powder diffraction (XRD) research was performed to determine the crystallographic makeup of graphene. Six scattering spikes at 2θ, concerning 35.3°, 41.6°, 50.7°, 63.1°, 67.7°, and 74.5°, are indicated via respective indexes (220), (311), (400), (422), (511), and (440), each of which the contour's findings line up alongside typical forms of crystalline architecture. When those XRD patterns are compared, a graphene spike is seen around 2θ = 26.9. For Al_2O_3 six scattering spikes at 2θ, concerning 38.5° , 46.15°, 55.48°, 65.4°, 71.1° , 72.8°. When those XRD patterns are compared, an Al_2O_3 spike is seen around 2θ = 30.1. The nanomaterials were generally spherical in form and varied in diameter between 41 and 50 nm on aggregate. Figure 6 shows the X-ray Diffusions of Graphene and Al_2O_3.

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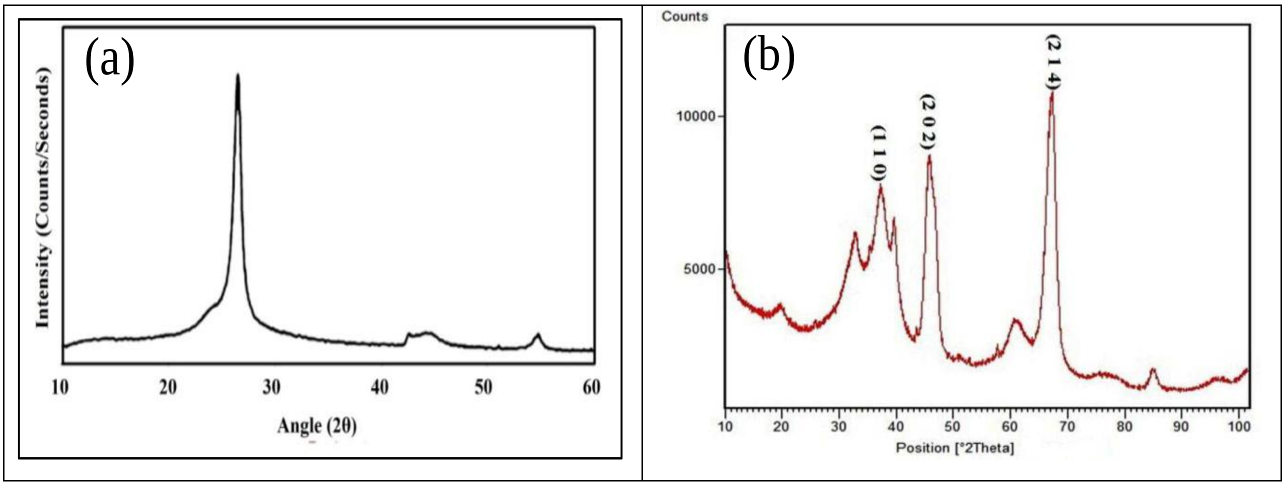

Figure 6. XRD spectrum of (a) Graphene and (b) Al_2O_3 powders.

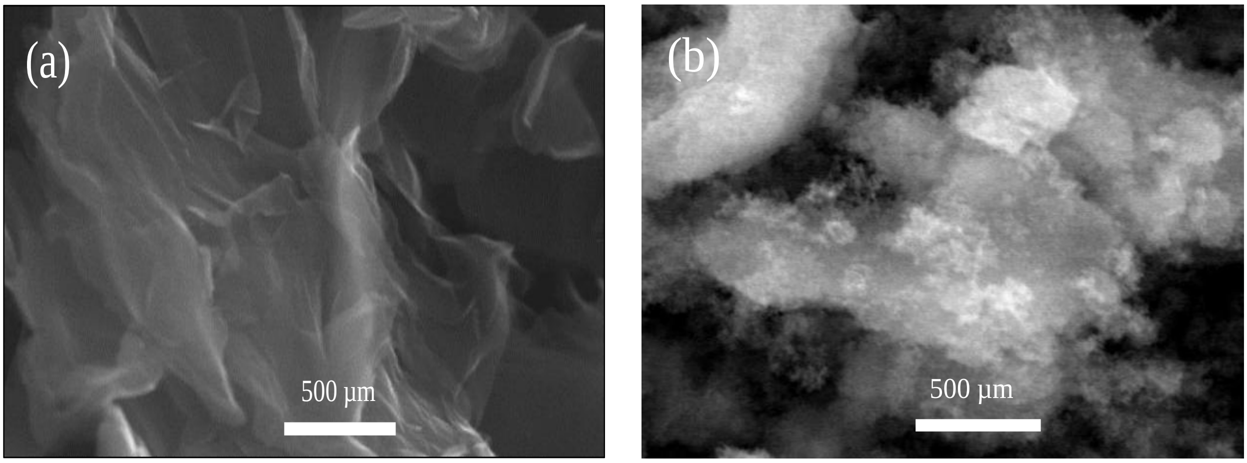

Figure 7. SEM images of (a) Graphene and, (b) Al_2O_3 powders.

In order to investigate the shape and phase distribution of graphene, a scanning electron microscope image of the GnP., is presented in Figure 7(a). Graphene sheets have a huge surface area that can be identified. Additionally, it is evident that the graphene structure is nanoscale in at least one dimension, which is highly important. Figure 7(b) displays the dry nanoparticles' SEM picture. The Al_2O_3 nanopowders' morphology is shown in these SEM pictures. The nanoparticles' characteristic shape is spherical, and their average size ranged between 41 and 50 nm.

3 Results & Discussions

3.1 Density

Physical features of thermoregulation of Graphene & Al_2O_3 focus mainly on calculating thermo-physical characteristics and seek to ascertain the tiny fluid's efficacy metrics, including the density, specified heat, heat conductance, as well as viscosity. Figure 8(a) represents the density (Kg/m3) variations of graphene water and Al_2O_3 with respect to absolute temperature (K). Nanofluid density usually depends on the friction factor, Reynolds number, Nusselt number, and pressure loss. Researchers quantify the phase-change medium density in volume or weight percent. Nanofluid density rises with the concentration of the nanoparticle at the constant temperature. Experimental studies on the density of Al_2O_3 nanofluids and graphene water have revealed that when the temperatures of these materials rise, their densities decrease.

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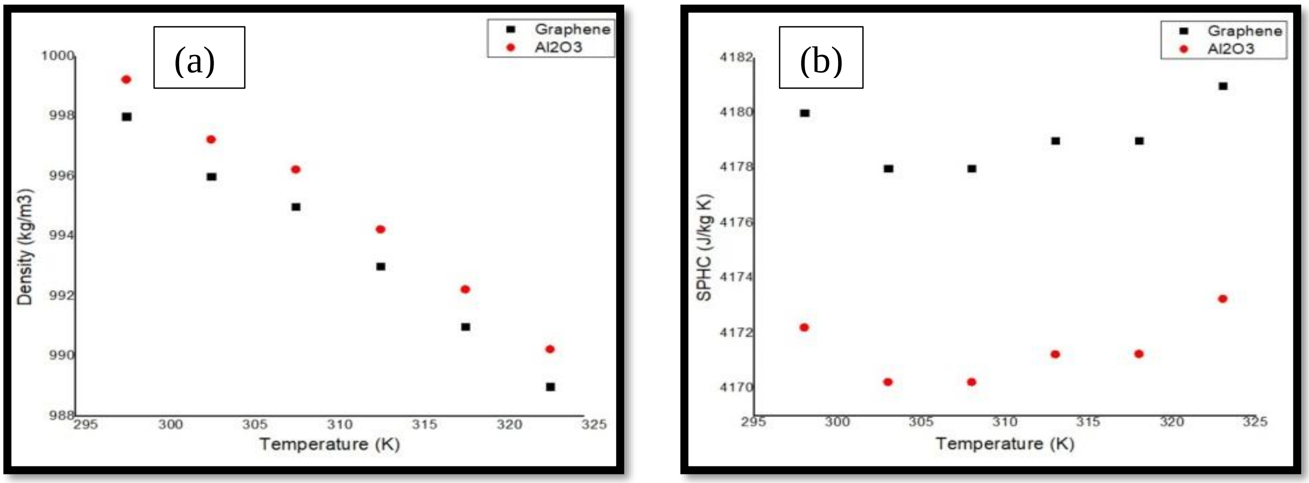

Figure 8(a-b). Graph represents (a). Density variations, and (b).Specific heat capacity variations.

Specific heat capacity

Figure 8(b) represents the specific heat capacity (J/kg-K) variations of graphene water and Al_2O_3 concerning absolute temperature (K). The amount of heat energy transmitted from one unit mass or substance by one degree of temperature to alter the system temperature is known as the specific heat. Two models of the particular heat determine nanofluid-specific heat. Model I uses the nanoparticles' volume content that Pak and Cho showed by looking at the mixture of liquid and particles. Xuan and Roetzel proposed Model II, which centres on the idea that the nanoparticles and the fluid around them are in thermal equilibrium. The nanofluids' specific heat capacity increases when the nanoparticle concentration increases. Graphene water and Al_2O_3 nanofluids have been studied experimentally, and it has been found that as the temperatures of the fluids rise, so does their specific heat capacity.

3.2 Thermal conductivity

Figure 9(a) represents the thermal conductivity (kW/mK) variations of graphene water and Al_2O_3 with respect to absolute temperature (K). When studying the phenomenon of the convection heat transfer, the suspension fluid thermal conductivity is crucial. The thermal conductivity of composite solution is obviously increased by the appearance of nanoparticles in many base materials, including methanol, glycerol, organic and inorganic compounds, gear oil, engine oil, water, ethylene as well as propylene glycol. Brownian motion as well as liquid layering at the liquid-particle interface are the two main causes of the increase in thermal conductivity of nanofluids. Brownian motion causes nanoparticles to travel through liquid and sometimes collide, allowing direct solid–solid heat transport, which boosts nanofluid thermal conductivity. Experimental studies on the thermal conductivity of Al_2O_3 nanofluids and graphene water have revealed that as the temperatures of these materials rise, so does their thermal conductivity.

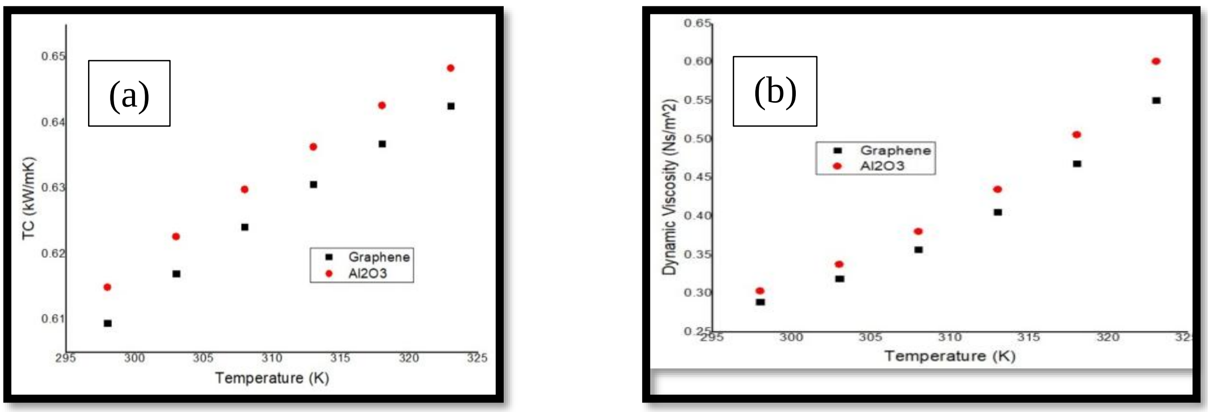

Figure 9 (a-b). Graph represents the (a). Thermal conductivity and, (b). Dynamic Viscosity

3.3 Dynamic Viscosity

Figure 9(b) represents the dynamic viscosity (Ns/m²) variations of graphene water and Al_2O_3 concerning absolute temperature (K). The pressure drop and pumping power are highly dependent on the dynamic viscosity of the nanofluids, which is a critical parameter in the heat transfer performance of the medium. The nanofluids' effective viscosity is based on the base fluid viscosity and the amount of nanoparticles suspended in the fluid. Similarly, particle size and the type of nanoparticles also affect the viscosity. However, temperature is the main factor significantly affecting nanofluids' viscosity. Typically, nanofluid viscosity is measured with a rotating Rheometer, piston-type rotating Rheometer, and capillary viscometers. The dynamic viscosity of graphene water and Al2O3 nanofluids increases as the temperature of the fluids increases, as indicated by experimental investigations on their thermal conductivity.

4 Conclusions

The appropriate nanoparticles, graphene and Al_2O_3, were selected to prepare nanofluids. Water was used as a base fluid for the preparation of graphene and Al_2O_3. Gum Arabic was used as a surfactant. The morphology and structure of graphene and Al_2O_3 have been examined via a scanning electron microscope (SEM) and X-ray diffraction analysis (XRD) at varying concentrations. Visual observation is implemented to evaluate the generated nanofluid's stability. The thermal conductivity, density,

- Viscosity and specific heat are the thermo physical properties characterized at different temperatures and compared with each other. It is observed that as the temperature increases, the density of graphene water and Al_2O_3 decreases.
- The comparison of graphene water's density with Al_2O_3 graphene water has shown the lowest value of 989 Kg/m3 with a corresponding temperature of 323 K.
- Dynamic viscosity, specific heat capacity, thermal conductivity, and temperature increase as temperature rises.
- The comparison of the specific heat capacity of graphene water's value with Al_2O_3 graphene water's has shown the highest value of 4181 J/kg K, with a corresponding temperature of 323 K.
- Al_2O_3 has shown the highest thermal conductivity and dynamic viscosity values as 0.6484 k W/mK and 0.6015 Ns/m^2 with a corresponding temperature of 323 K.

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