EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER PERFORMANCE BY USING NANO FLUID IN HEAT EXCHANGE

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Abstract

In many industrial processes, including power plants, chemical industries, manufacturing processes, automotives, and electronics, reducing the energy consumption of thermal energy systems is a difficult issue. One technique to decrease energy usage is to improve the performanceof heat exchange systems. There are numerous strategies available to speed up the systems' heat transmission. One effective method for accelerating the rate of heat transfer in systems is the use of nanofluids. Starting with Choi in 1995, other researchers contributed their theoretical and practical studies on the use of nanofluids for enhancing heat transfer using various nanoparticles of metal oxide, metal nanoparticles, graphene, and carbon nanotubes, among others. Whencompared to more conventional heat transfer fluids like water, oil, and ethylene glycol, they found that nanofluids had significantly improved thermal properties including thermal conductivity, viscosity, and heat transfer coefficient. The present investigation will focus on the synthesis and characterization of graphene and hybrid nanoparticles. The performance of heat transfer utilising five single nanofluids (Al_2O_3/EG, ZrO_2/EG, GO/EG, Gn/EG, CuO/EG) and three hybrid nanofluids (Ag_2ZrO_3/EG, Ag_2ZrO_3@GO/EG, and (Gn-CuO)/EG) was investigated using graphene and hybrid nanoparticleswith ethylene glycol as a base fluid. According to the available literature, the concentration of nanoparticles utilized in the creation of nanofluid is often greater than 1%. However, in this work,smaller volume concentrations will be considered in order to investigate their impact on the thermophysical properties (thermal conductivity, specific heat, viscosity, and so on) and heat transfer coefficient of nanofluids. The effect of surfactant on the enhancement of the nanofluid's thermal conductivity and stability will also be examined.

Keywords: *Heat transfer, insulation, conduction, heat transfer Coefficient, nano fluid, nano particles, thermal conductivity.*

INTRODUCTION

Thermal engineers are currently faced with a major challenge: by what method to enhance the thermal efficiency of heat transfer progressions. In this approach, device optimization is a typical practise that aims to increase performance by focusing on shrinking, size reduction, and, as a result, cost reduction. The goal of improving heat transfer is to save energy, which could inkling to a improved quality of life and the achievement of the goal of sustainable growth. Heat exchangers, evaporators, condensers, and sinks are examples of other heat transmission equipment. Both cooling and heating operations employ heat exchangers [1]. Heat exchangers are widely employedin air conditioning, power plants, space heating, cooling, chemical plants, oil refineries, petrochemical plants, natural gas extraction, wastewater treatment, and a variety of other heat transfer applications [2]. The primary issue is effective heating and cooling within storage fluid heat exchangers. To extract heat from the engine's cooling jacket, many automobiles employ a radiator heat exchanger system. The radiator is a component of the engine's cooling system. It's feasible that mixing nanoparticles into ordinary engine coolant will help radiator and heavy-duty engine cooling. The use of nanofluids can boost the rate of heat removal while also reducing the size of the cooling system, resulting in lower fuel consumption and cost savings.

Nanofluids

Ethylene glycol, water and engine oil are examples of conventional fluid with low thermal conductivity. From this point of view, there is a demand for the advancement of heat transfer fluid with high thermal conductivity than conventional fluids. Overflowing tests and hypothetical exams have been performed with Maxwell's critical thinking to achieve the goal of increased heat xn transfer attributes (1873). The micro particles floating in the fluid quickly settle on the wall edges, creating severe blockage.

The word nanofluid comes into play as a result of a list of microfluid's drawbacks. In typical liquids delivered by the expansion of molecule size below 100nm. Choi is the one who coined the term nanofluid (1995). Nanofluids offer good qualities such as a large surface to volume ratio, high thermal conductivity, a higher fundamental hotness transition, less obstructing, and a higher hotness move coefficient. Brownian movement of nanoparticles in the base fluid, requested layering of fluid atoms at the fluid molecule interface, ballistic nature of hotness transport in nanoparticles, and nanoparticle bunching are the fundamental components of hotness transport in nanofluids that have been clarified in the literature [22].

Continuous nanotechnology research helps to the development of novel fluids with higher heat transfer rates, which are referred to as nanofluids. Different base fluids and nanoparticles are shown in Figures 1 and 2. Nanofluids were created by dispersing nanometer-sized particles (1-100nm) in conventional fluids, resulting in nanofluids with higher thermal conductivity than normal fluids [4].

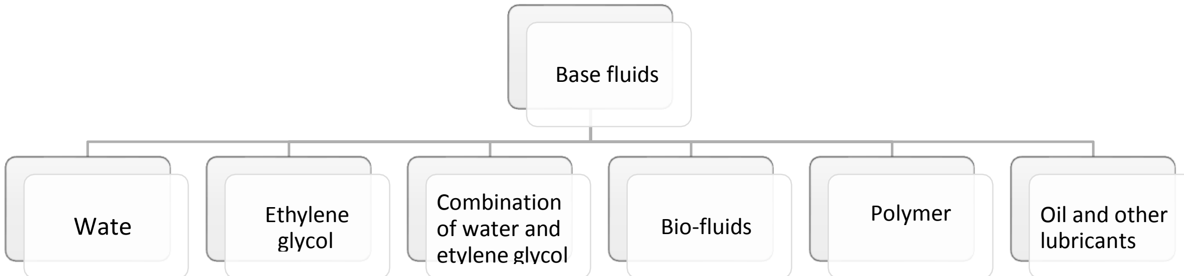

Figure 1.1 Different base fluids

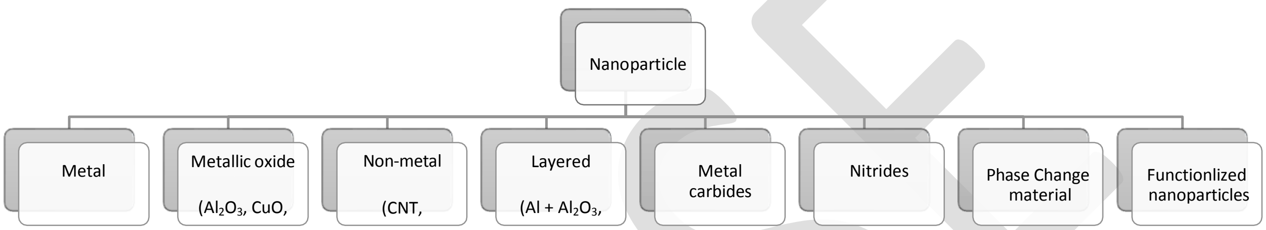

Figure 1.2 Different nanoparticles

Nanotechnology plays a major role in heat transfer optimization [14]. In the development of energy-proficient intensity move gear, the warm conductivity of intensity move liquids is basic. Heat move liquids like ethylene glycol, water, and oil, then again, are intrinsically unfortunate intensity move liquids. Because of the increasing global competition, there is a significant requisite

LITERATURE REVIEW

Heat exchangers are utilised in both cooling and heating processes [1]. Space heating, cooling, air conditioning, power plants, chemical plants, petrochemical plants, oil refineries, natural gas extraction, sewage treatment, and a variety of other thermal applications all employ heat exchangers. [2] The primary issue is the efficient heating and cooling of the heat exchangers. The basic example of a heat exchanger is seen in an internal combustion engine, where a circulating liquid known as engine coolant passes through radiator coils and is cooled by air. Following is a summary of the literature review on heat transfer and Nanofluid application (radiator).

Kulkarni et al. [24] investigated the use of Al_2O_3-water nanofluids as a coolant in diesel electric generators and discovered a drop in cogeneration efficiency. They discovered that when the volume concentration of particles increases, the specific heat of the nanofluid drops, affecting the engine's waste heat recovery.

The impact of nanofluid coolant in a truck engine was numerically simulated by Saripella et al. [25]. The basic liquid was a 50:50 mixture of water and ethylene glycol, with CuO particles addedat 2 percent and 4 percent to see how they affected the engine's temperature, pump speed, and energy. Numerical simulations have been performed on three parameters. Quantitative findings revealed increased engine horsepower of up to 5%, decreased coolant pump speed and power by up to 88 percent, and reduced radiator air side surface area by up to 5%, all of which resulted in lower aerodynamic drag and fuel consumption.

Ali et al. [26] conducted experiments on a Toyota Yaris radiator's actual cooling system. They attempted to investigate the characteristics of forced convection thermal transfer using Al_2O_3 water nanofluid. They discovered that the heat transfer coefficient was at its best when the volume ratio was at 1%. By raising the volume portion, the radiator cooling scheme's efficiency would suffer.

Raja et al. [27] use Al_2O_3/water Nanofluid with different volume concentrations of 0.5, 1, 1.5, and 2 percent in a laminar flow in a shell and tube heat exchanger attached to a diesel motor under different load situations to investigate heat transfer, pressure drop, and NOx. Under no load conditions, a peak HTC improvement of 25% was achieved at 2 vol. percent at a peclet number of roughly 3000. The use of nano fluids reduced NOx emissions by 12.5 percent and 3-5 percent at full load and no load, respectively.Ettefaghi et al. [28] studied the thermal properties by adding MWCNTs with different concentration in engine oil. Thermal conductivity was discovered to be 13.2% at 0.5 wt%. Investigated that achieve higher stability with lower concentration.

Teng et al. [30] investigated the heat dissipation effectiveness of MWCNT Nanocoolant in a motorbike radiator. When compared to a mixture of water and ethylene glycol, the highest enhanced heat exchange ratio, pumping power, and efficiency factor were 12.8 percent, 4.9 percent, and 14.1 percent, respectively. Because the irregular flow density of NC improves the thermal resistance of the solid-liquid interface, efficiently limiting the contact zone between combinations of water-EG and MWCNTs, a nanocoolant with a larger concentration of MWCNT cannot obtain a better heat exchange ability.

Elias et al. [31] studied the specific heat, thermal conductivity, viscosity, and density of a radiator coolant based nanofluid containing Al_2O_3 nanoparticles at volume concentrations ranging from 0 to 1 with temperatures ranging from 10°C to 50°C. Al_2O_3 nanoparticles distributed in water and ethylene glycol-based coolant used in automotive radiators. Increasing the volume concentration of a nanofluid by 8.3% improves thermal conductivity but decreases specific heat.

METHODOLOGY

Heat exchanger frameworks definitely stand out lately since they have exhibited to have a ton of guarantee and are fundamentally expected to fulfill rising energy need. Further developed warming and cooling strategies, as well as original intensity move liquids with preferred heat move execution over those as of now accessible, are expected to lay out such a framework. The reconciliation of nanoparticles into heat move liquids to raise the warm conductivity of the following nanofluids has been cleared by past exploration. The objective of this study is to work on the thermophysical properties of intensity move liquids and their application in heat move by expanding the intensity transmission of nanofluids.

Finally, an experimental setup that includes a test rig with an automobile radiator was used to evaluate the effectiveness of heat transfer of the created nanofluids. The produced nanofluids with remarkable potential may be recommended for heating and cooling applications due to their greater thermal conductivity. The heat transfer coefficient was extensively investigated with various nanofluid volume concentrations. The nanoparticles were dispersed in base fluids (ethylene glycol) under laminar and turbulent flow regimes in a heat exchangers. The detailed methodology for attaining the proposed objectives is mentioned below in Figure 3.1 as a flow chart format. The purpose of this research is to see how different nanofluids perform in heat transmission. Objective has been comprise the following:

- To synthesize graphene and hybrid nanoparticles by using chemical reduction method
- To characterize graphene and hybrid nanoparticles by using XRD, SEM and TEM
- To investigate the effect of different volume concentration of nanoparticles on thermo-physical properties of nanofluids.
- To investigate and analyze the transfer of heat of coefficient with different volume concentration of nanofluids in heat exchanger.

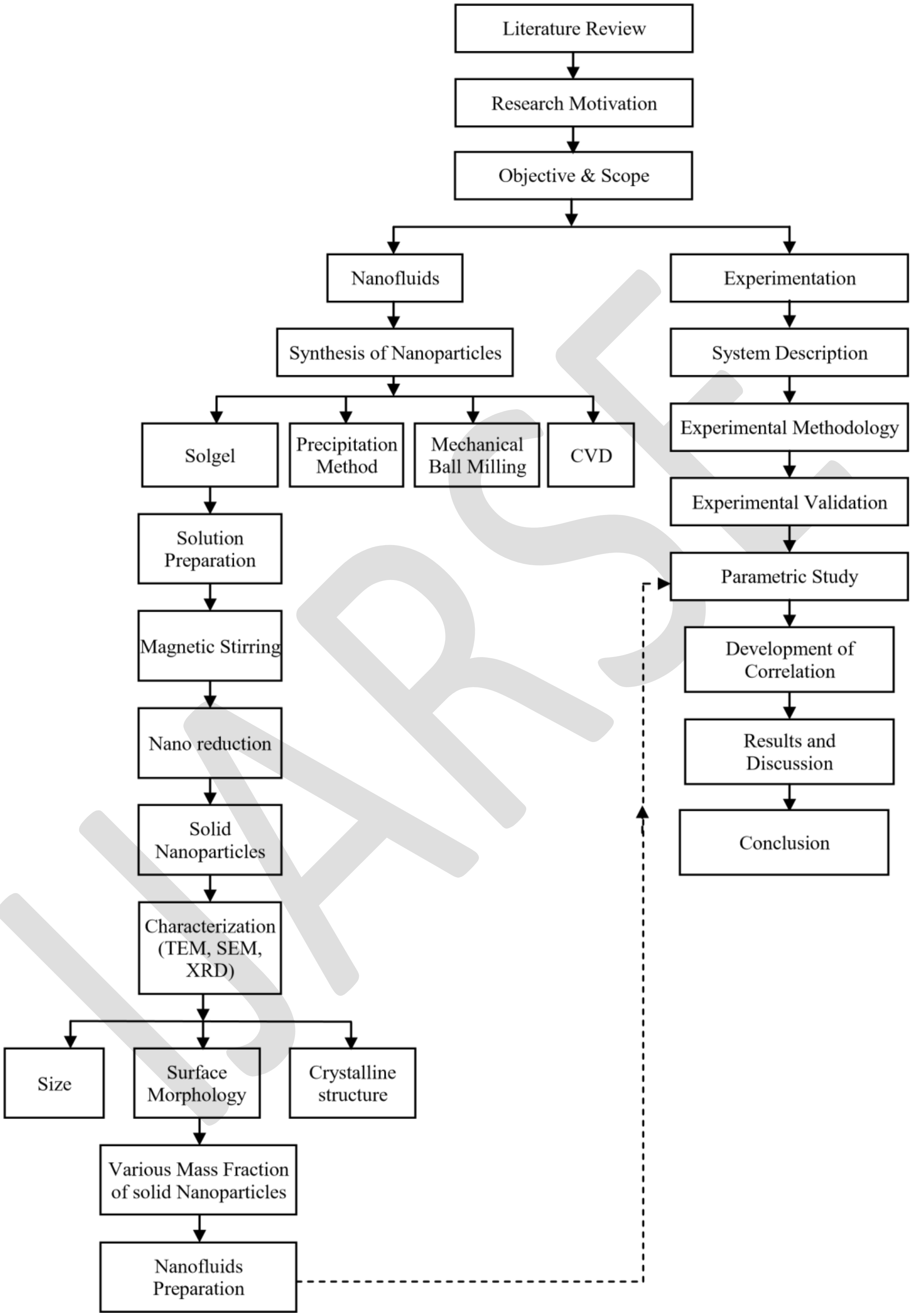

Figure 3.1 Flow chart representing the present research work methodology

RESULT & DISCUSSION

Graphene is a (2D) single-layer structure made up of covalently connected sp2-hybridized carbon atoms organised in a hexagonal honeycomb network. Andre Geim and Konstantin Novoselov found it in 2004. Graphene has a gigantic hypothetical explicit surface region (2630 m^2g^{-1}), solid characteristic versatility (200,000 $cm^2\ v^{-1}s^{-1}$), high Young's (equivalent to 1.0 TPa), and thermal conductivity (equivalent to 5000 $Wm^{-1}K^{-1}$), among other properties [1-4].

Because of graphene's exceptional electrical, thermal, optical, and mechanical properties, numerous engineering applications investigations have been documented. In comparison to other nanoparticles, graphene nanoparticles have the following advantages [5, 6, and 7]:

- Higher thermal conductivity
- Require less power to pump and save energy
- Easy to synthesis and stable
- Corrosion, clogging and degradation minimized
- Reduced need of fluid for heat transfer
- Larger area to volume ratio increased heat transfer capability

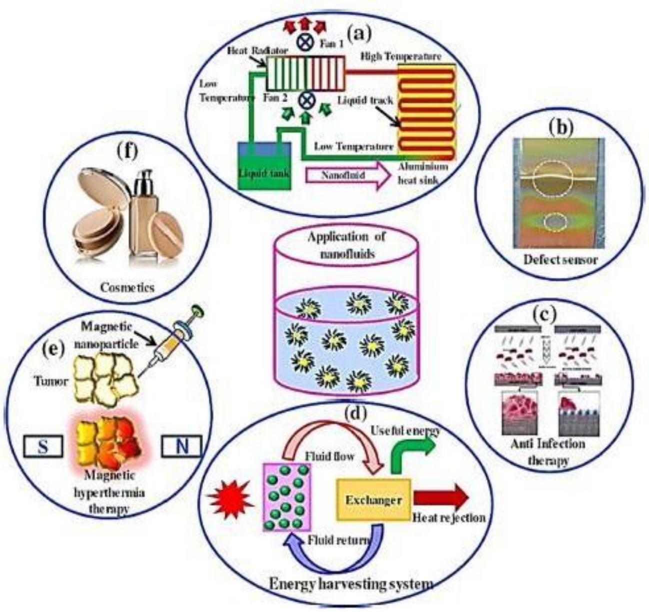

Figure 4.1 some common engineering applications of graphene nanofluids, [8 and 9]

Graphene Oxide (GO) Nanoparticles

When quantum phenomena are involved, nanomaterials exhibit different size-dependent physical, chemical, and mechanical properties in the range of 1-100 nm. As a result, characterization of nanomaterials provides us with a better understanding of the material for its correct application. When describing NPs, size and shape are two of the most important factors to consider. We may likewise appraise surface science and measure size dispersions, level of total, surface burden, andsurface region. Various properties and potential uses of NPs might be affected by size circulation and normal ligands present on the outside of the particles. In addition, as a first stage after nanoparticle blend, the valuable gem construction of the NPs and their substance arrangement creation are assessed.

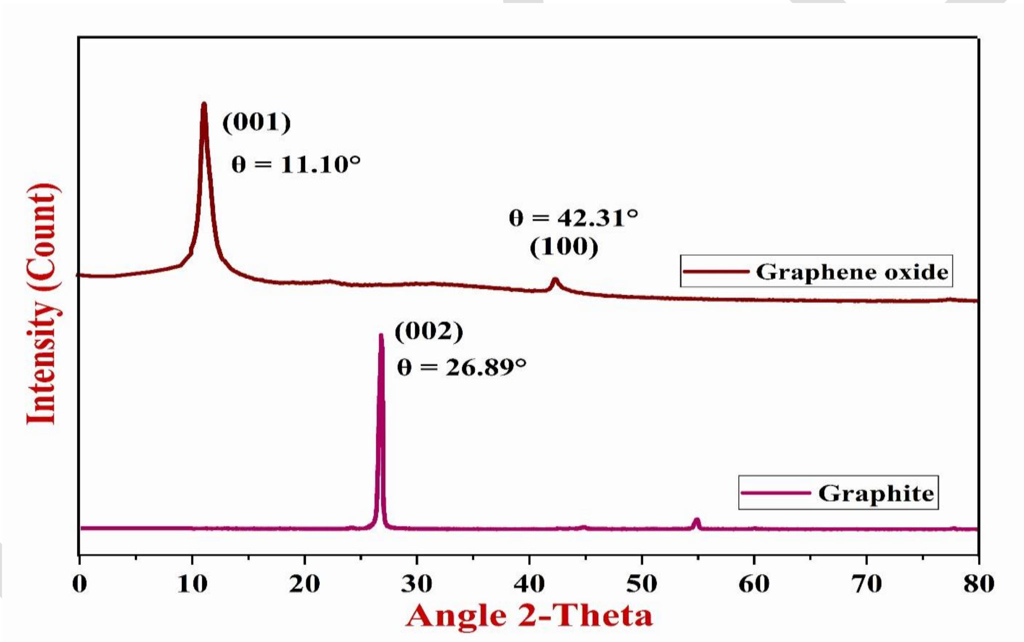

Figure 4.2 XRD pattern of the graphite and graphene oxide

X-ray diffraction was used to examine the structural morphology of the synthesised GO, which was also linked to the GO and Graphite diffraction patterns as shown. Nanoparticles, while the sharp trademark diffraction pinnacle of GO was found at 2θ, 11.43°, and 42.00°, individually, which relates to the (001) and (100) planes of GO. The bending peaks in this dataset were strikingly similar to those in the normal JCPDS file. To affirm the immaculateness of the orchestrated GO, the examination diffraction example of unadulterated graphite was additionally displayed in Figure4.2.

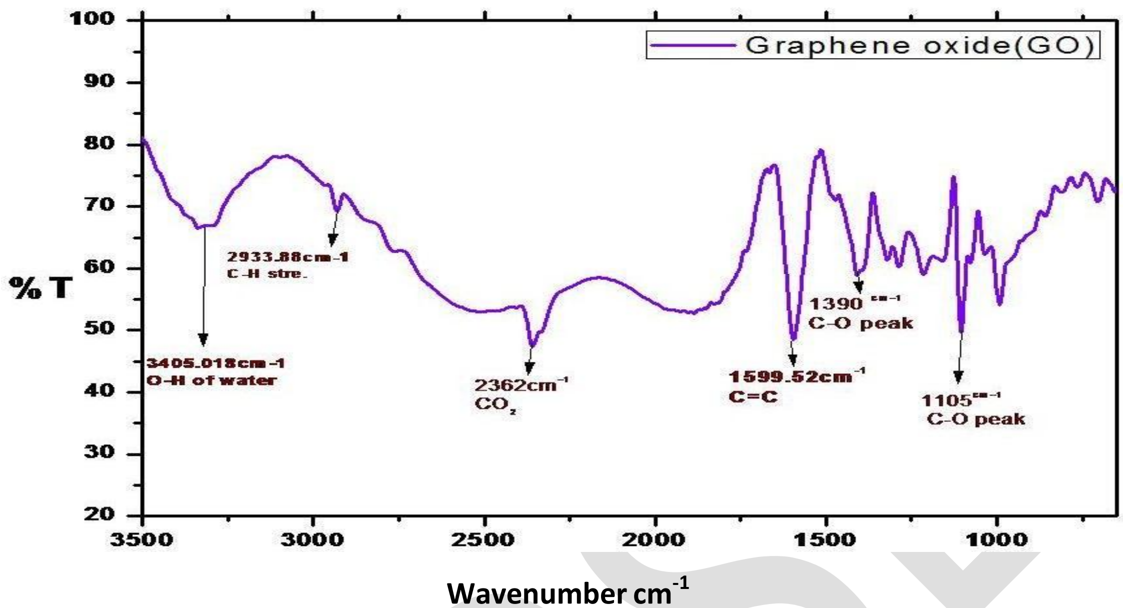

Figure 4.3 FTIR pattern of the graphene oxide

CONCLUSION

In this work, the use of single (Gn, CuO, GO, Al_2O_3 and ZrO_2) and hybrid (Gn-CuO, Ag_2ZrO_3 and Ag_2O@GO) nanofluid was synthesized successfully and characterized by XRD, SEM, and TEM techniques. The experimental study on thermophysical properties and heat transfer performance o of nanofluids in heat exchanger (automobile radiator) is carried out. The measured thermophysical properties have been compared with some well-known existing correlations. The thermophysical properties such as thermal conductivity, viscosity, density and specific heat of the nanofluids were analysed before conducting heat transfer characteristics study. With varying volume concentration and temperature, nanofluids were made using ultrasonication and a magnetic stirrer. Thermal conductivity enhancements were studied in relation to nanoparticle volume concentration and temperature. Nanofluid prepared by using five different volume concentration (0.02, 0.04, 0.06, 0.08 and 0.1 vol. %) and temperature ranging from 30 to 50 degree Celsius.

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