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Synthesis, characterization of TiO_2 nano powder and water based nanofluids using two step method

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ABSTRACT

This paper summarizes some of our recent research work on the synthesis of nanofluids (dilute liquid suspensions of nanoparticles). In the present work, Tio_2 Nano particles have been synthesized by Sol-gel technique. The Prepared powders were characterized by using XRD, SEM. The Crystalline size of TiO_2 powder was found to ~6 nm for anatase at 400 ºC by controlling the acidity. TiO_2 water nanofluids with different volume concentrations from 1% to 2% were then prepared by dispersing the synthesized Nano particles in deionised water.

Key words: Nano Tio_2, Nano particles, SEM, XRD, Nano fluids.

INTRODUCTION

Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials **(**nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets**)** in base fluids. Common base fluids include water, organic liquids (e.g. ethylene, tri-ethylene-glycols, refrigerants, etc.), oils and lubricants, bio-fluids, polymeric solutions and other common liquids. Materials commonly used as nanoparticles include chemically stable metals (e.g. gold, copper), metal oxides (e.g., alumina, silica, zirconia, titania), oxide ceramics (e.g. Al_2O_3, CuO), metal carbides (e.g. SiC), carbon in various forms (e.g., diamond, graphite, carbon nanotubes, fullerene) and functionalized nanoparticles [1-5]. Nanofluids can be prepared by a one-step or a two-step method. In the two-step method in which nanoparticles or nanotubes are first produced as a dry powder [3] and then dispersed into a fluid in a second processing step [39-41]. In view of the synthetic methods developed for the preparation of nanostructure TiO_2, a wide variety of approaches including flame synthesis , ultrasonic irradiation, chemical vapor deposition, sol–gel Method. Among them, Compared to other methods, sol-gel route is regarded as a good method to synthesis ultra-fine metallic oxide and has been widely employed for preparing titanium dioxide (TiO_2) particles [42, 43]. TiO_2 water nanofluids with different volume concentrations from 1% to 2% were then prepared by dispersing the synthesized Nano particles in deionised water and particles size was found to be ~6nm [5,6]. Thermal conductivities of various solids and liquids are listed in table 1.

Table1: Thermal conductivity of various solids and liquids

	Material	**Thermal conductivity (W/mK)**
Carbon	Nanotubes Diamond Graphite Fullerenes film	1800-6600 2300 110-190 0.4
Metallic solids (pure)	Copper Aluminum	401 237
Nonmetallic solids	Silicon Alumina (Al_2O_3)	148 40
Metallic liquids	Sodium (644 K)	72.3
Nonmetallic liquids	Water Ethylene glycol (EG) Engine oil (EO)	0.613 0.253 0.145

MATERIALS AND METHODS

2. Experimental Study
2.1 Synthesis and preparation methods
The Preparation of nanofluids is the first key step in experimental studies with nanofluids.

2.1.1 Two step technique
Two-step method is the most widely used method for preparing nanofluids. Nanoparticles, nanofibers, nanotubes, and nanomaterials. In this method, first produced as dry powders by using chemical or physical methods [6-9]. We used sol gel technique for preparation of nano Tio_2 powders [8]. The obtained nanosized powder will be dispersed into a base fluid (Water) in the second processing step with the help of intensive magnetic force agitation.

2.1.2 Nano Tio_2 preparation by using sol gel technique
TiO_2 Nano-powders were prepared via sol–gel method using titanium tetraisopropoxide (TTIP, Merck), distilled water, ethyl alcohol (EtOH, Merck) as the starting materials. Titanium tetraisopropoxide was dropped slowly into the solution of water and ethyl alcohol while magnetic agitating continuously to get white slurry solution [36]. The obtained solutions were kept under slow-speed constant stirring on a magnetic stirrer for 40mins at room temperature [12]. Then the precipitated TiO_2 was filtered and dried at 50ºC for 1 h until it was turned into white block crystal. After ball milling the dried powders obtained were calcinated at 400ºC for 2 h to observe the phase changes accompanying the heat treatments [10-12].

2.2 Nanofluids preparation using Tio_2 nanoparticles
The TiO_2 Nano particles have an average size of 6 nm used for investigation in the present experimental work. The photographic view of the nanoparticles as seen by the naked eyes is shown in the Figure 2.1 [12, 13]. The distribution of TiO_2 nanoparticles at Nano scale can be observed under a Scanning Electron Microscope (SEM). The SEM images of TiO_2 nanoparticles as shown in the figure 3.2 [35-37]. Preparation of nanofluids is an important stage and nanofluids are prepared in a systematic and careful manner [13-16]. A stable nanofluid with uniform particle dispersion is required and the same is used for measuring the thermo physical properties of nanofluids [17].

Figure 2.1: Photographic view of Tio_2 nanoparticles

In this method a small amount of suitable surfactant, generally one tenth of mass of nanoparticles, is added to the base fluid and stirred continuously for few hours. Nanofluids prepared using surfactants will give a stable suspension with uniform particle dispersion in the host liquid [18, 19]. The nanoparticles remain in suspension state for a long time without settling down at the bottom of the container [30].

After estimate the amount of nanoparticles required for preparation of TiO_2 Nanofluids for a given volume concentration [20]. Nanoparticles are mixed in the base fluid of water [31-33]. In the present investigation, neither surfactants nor acid are added in the TiO_2 nanofluids, because with the addition of surfactants the thermo physical properties of nanofluids are affected [20-22].

Addition of acid may damage the tube material because corrosion takes place after a few days with the prolonged usage of such nanofluids in practical applications [22]. All the test samples of TiO_2 nanofluids used subsequently for estimation of their properties were subjected to magnetic stirring process followed by ultrasonic vibration for about 2 hours [23-25]. The photographic view of TiO_2 nanofluids sonication process using a Ultrasonic Cleaner is shown in the figure 2.2

Figure 2.2: Ultrasonic Cleaner apparatus for sonication process of TiO_2 Nanofluids

The TiO_2 nanofluids samples thus prepared are kept for observation and no particle settlement was observed at the bottom of the flask containing TiO_2 nanofluids even after 3 hours .[24-28] The photographic view of TiO_2 nanofluids suspension prepared after magnetic stirring and sonication process is as shown in Figure 2.3

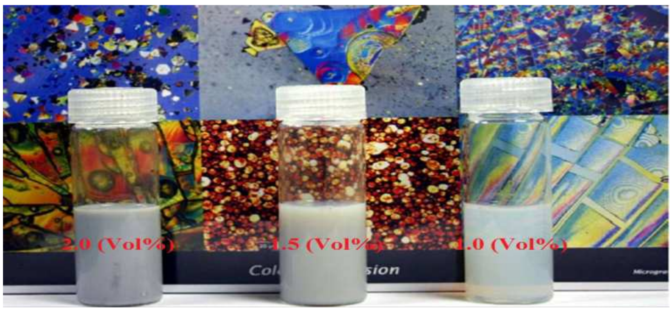


Figure 2.3: The photographic view of Tio2 nanofluids suspension

RESULTS AND DISCUSSION

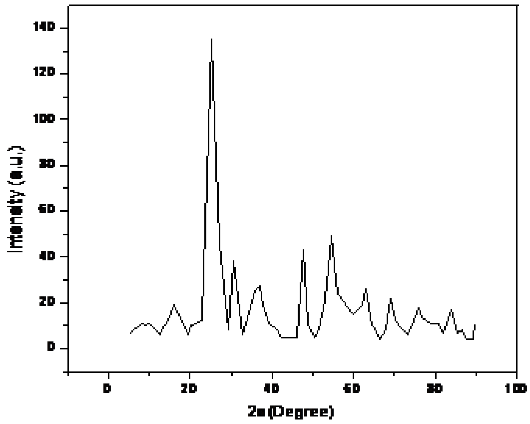


Figure 3.1: XRD Patterns of Titania particles calcinated at 400^0c

3.1 Calcination temperature

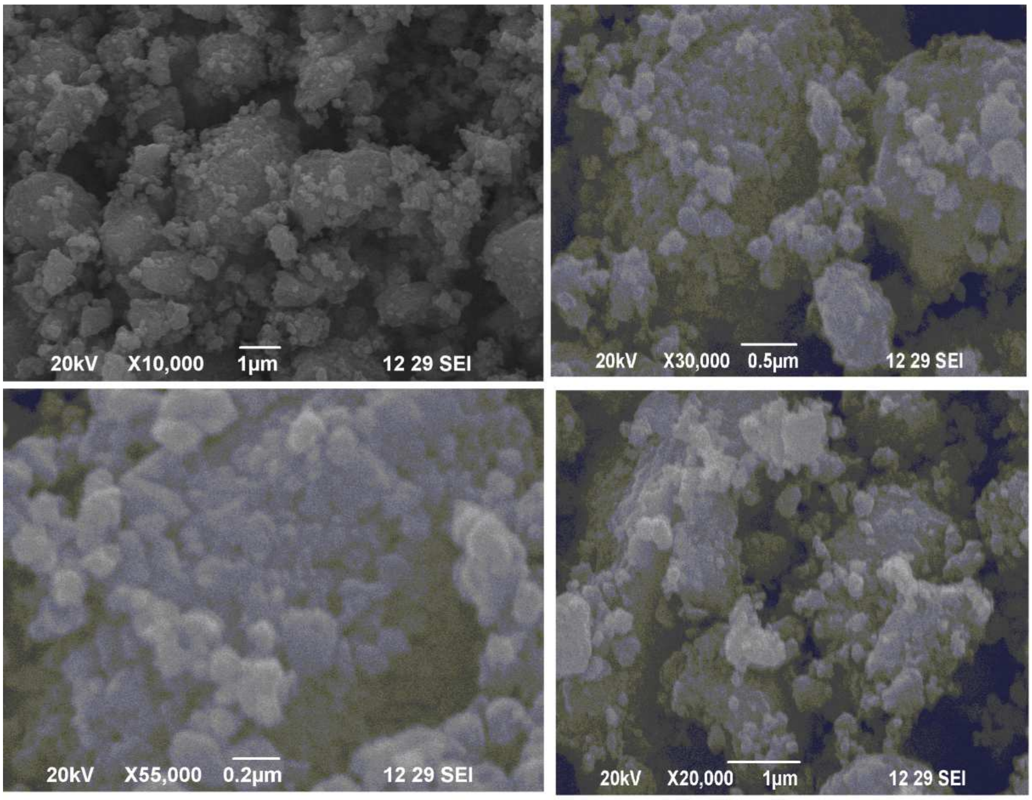
Powder X-ray diffraction (XRD) as shown in figure 3.1and it was used for identification of crystalline phases and estimation of the crystallite size. The X-ray diffraction (XRD) patterns were performed on a Seimens/ D5000 X-ray diffractometer. From the line broadening of corresponding X-ray diffraction peaks and using the Scherrer formula the crystallite size, L has been estimated.

$$L = K\lambda / (\beta \cos \theta)$$

where λ is the wavelength of the X-ray radiation (Cu Kα = 0.15406 nm), K is a constant taken as 0.89, β is the line width at half maximum height, and θ is the diffracting angle. The surface morphology of the calcinated powders at 400ºC was observed on scanning electron microscopy (SEM).

3.2 SEM Morphology

The morphology of calcinated titania powders at 400ºC observed by SEM is shown in Fig. 3.2. The size of titania particles was about 6 nm and non hard-grained aggregates that are constituted of sharp faceted nanoscaled crystals were formed [28-30].



3.2 SEM Morphology of calcinated titania powder at 400^{0}c

CONCLUSION

Nanofluids, i.e., well-dispersed metallic nanoparticles at low volume fractions in liquids, enhance the mixture's thermal conductivity over the base-fluid values. Thus, they are potentially useful for advanced cooling of micro-systems. In summary, Nano- TiO_2 powders have been prepared by sol-gel method and found to be 6nm. The future scope in the nanofluids research cycle are to concentrated on heat transfer enhancements and determine its physical mechanisms, taking into consideration such items as the optimum particle size and shape, particle volume concentration, fluid additive, particle coating, and base fluid. TiO_2 water nanofluids with different volume concentrations from 1% to 2% were then prepared by dispersing the synthesized Nano particles in deionised water.

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