Investigation on stability of TiO$_2$-SiO$_2$ nanofluids with ratio (70:30) in W/EG mixture (60:40)

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Abstract. Nowadays, thermal energy is essential to the protection of the renewable technology ecosystem in the world. Most researchers study nanofluid related to increased demand for thermal energy, which includes the heating and cooling process. The goal of this analysis was therefore to determine the stability of TiO$_2$-SiO$_2$ nanofluids (70:30) suspended in W/EG (60:40). This study will help researchers gain insight into the impact of nanoparticle stability on hybrid nanofluids, which will enable researchers to add nanoparticles to solar collector. TiO$_2$-SiO$_2$ nanofluids with ratio 70:30 was prepared using a one-step process at a volume concentration of 0.3, 0.5, 0.7, and 1.0%. Two of nanoparticles are used, namely TiO$_2$ and SiO$_2$, and distributed in the base W/EG mixture (60:40). The stability investigation of hybrid nanofluids in this research is performed by UV-Vis, visual sedimentation. The findings from this investigation is stability analysis of hybrid nanofluids by UV-Vis process, which is stable up to 10 days after preparation with 2-hour sonication time. For concentration ratio of 1.0% of the volume concentration of hybrid nanofluids. The optimal absorbance value is 2.3 after 24 hours, which is the ideal consistency of the fluid. Concentrations of 0.3, 0.5 and 0.7% begin to decrease after 24 h and continue to decrease until 10 days (240 h).

Keywords: nanofluids, renewable energy, thermal, particles

1. Introduction

Nowadays, thermal energy is essential to the protection of the renewable technology ecosystem in the world. Most researchers study nanofluid related to increased demand for thermal energy, which includes the heating and cooling process. This investigation shows that it relates to the equipment industry, such as cooling equipment, lubrication, solar collector, heat exchanger and automotive cooling systems [1-7].

The nanofluid preparation method is important in order to minimize the agglomeration of nanoparticles and thus improve stability. The most popular technique used in the processing of nanofluids is one-step and two-step processes [8-10]. The one-step approach is the mechanism of synthesizing and dispersing nanoparticles simultaneously in a base liquid. However, this approach is not feasible for the industry, and refers only to low vapor pressure liquids. Another nanofluid preparation process known as the two-step method. There are two processes in this system, namely (i) the synthesis
of nanoparticles in powder form (ii) the distribution of nanoparticles in the base liquid to form a stable and homogeneous solution [11].

Nanofluid stability and size of nanoclusters impact thermal conductivity parameters [12]. Nanofluid stability is known as the resistance of nanoparticles to aggregation. Factors such as Van der Waals attractions induce aggregation, which results in the creation of nanoclusters in nanofluids [13], [14]. The structure of nanoclusters depends on the scale of the nanofluid particles. The stability of nanofluid is very important for its application; a small analysis has been performed to estimate the stability of the suspension. UV – Vis spectrophotometric tests have been used to quantitatively describe the colloidal stability of the dispersion [15]. It can be extended to all baseline fluids, while zeta potential analysis restricts the viscosity of baseline fluid [16], [17].

The mixture of two or more separate nanoparticles in the liquid base, according to [18], is intended for hybrid nanofluids. Higher thermal conductivity and lower viscosity than microfluidics are the benefits of using nanofluid in heat transfer applications. A variety of research and analyses has been released on hybrid nanofluids for possible investigations [19], [20]. Their papers contribute to the planning, performance and implementation of hybrid nanofluid. The presence of strong particles results in curious features of the basic thermo-physical properties of nanofluids. A variety of researchers have studied thermal conductivity, viscosity, density and stability in recent years [10], [15], [16], [21].

The goal of this analysis was therefore to determine the stability of TiO$_2$-SiO$_2$ nanofluids (70:30) suspended in W/EG (60:40). This study will help researchers gain insight into the impact of nanoparticle stability on hybrid nanofluids, which will enable researchers to add nanoparticles to solar collector.

2. Materials and Method

2.1. Material

The preparation of hybrid nanofluids involved three distinct forms of single nanofluids, namely TiO$_2$ and SiO$_2$ blended together and distributed in the base Water/EG mixture. Both single nanofluids were collected from US Research Nanomaterials, Inc. The corresponding nanoparticle sizes for TiO$_2$ and SiO$_2$ are 50 and 2 nm with a purity of 99% and 99.99% respectively, with weight concentrations of 40 and 25 wt. %. The properties of each nanoparticle are shown in Table 1. The base fluid used in this analysis was a mixture of water and EG at a ratio of 60:40 (vol.%). The properties of ethylene glycol are shown in Table 2. Nanoparticle scale characterization of the hybrid nanofluid by field electron microscope (FESEM) scanning technique. The definition of FESEM for nanoparticles shown in Figure 1 (a) and Figure 1 (b).

| Properties                  | TiO$_2$ | SiO$_2$ |
|-----------------------------|---------|---------|
| Molecular mass, g mol$^{-1}$| 79.86   | 60.08   |
| Average particle diameter, nm | 50      | 30      |
| Density, kg m$^{-3}$        | 4230    | 2220    |
| Thermal conductivity, W m$^{-1}$ K$^{-1}$ | 8.4    | 1.4     |
| Specific heat, J kg$^{-1}$ K$^{-1}$ | 692    | 745     |

| Properties                  | EG      |
|-----------------------------|---------|
| Vapour pressure, mmHg at 20 °C | 0.08    |
| Boiling point, °C            | 195–198 |
| Melting point, °C            | -13     |
| Density, g ml$^{-1}$ at 25 °C | 1.113   |
2.2. Preparation of TiO\textsubscript{2}-SiO\textsubscript{2} nanofluids with ratio (70:30)

The one-step process is used for the preparation of TiO\textsubscript{2}-SiO\textsubscript{2} nanofluids with ratio 70:30. TiO\textsubscript{2}-SiO\textsubscript{2} nanofluids were prepared by mixing together all two single nanofluids (TiO\textsubscript{2} and SiO\textsubscript{2}) and undergoing a mixing and sonication phase. Initially, the preparation of nanofluids began with the measurement of the necessary volume by concentration. In this analysis, hybrid nanofluids were prepared at a concentration of 0.3, 0.5, 0.7 and 1.0%. Nanofluids were first prepared at the maximum concentration, 1.0%, and then reduced to the lowest concentration. TiO\textsubscript{2} and SiO\textsubscript{2} single nanofluids were supplied in a water suspension with a weight concentration of 40, 25% for TiO\textsubscript{2} and SiO\textsubscript{2} respectively. Eq. (1) \[9\] is used to translate the concentration of weight to the concentration of volume. The dilution from a higher concentration of volume to a lower concentration of volume used the Eq. (2) \[10\] by introducing the essential fluid (\(\Delta V\)).

\[
\phi = \frac{\omega \rho_w}{100 \rho_w + (1 - \frac{\omega}{100}) \rho_p}
\]

\[
\Delta V = (V_2 - V_1) = V_1 \left(\frac{\phi_1}{\phi_2} - 1 \right)
\]

All single nanofluids were mixed together at a volume ratio of 70:30 to form TiO\textsubscript{2}-SiO\textsubscript{2} nanofluids. Complete volumes of 100 mL have been prepared for each concentration of hybrid nanofluid. The blended solution of the two single TiO\textsubscript{2} and SiO\textsubscript{2} nanofluids was mixed together using a magnetic stirrer for 120 minutes. The solution was then subjected to a sonication phase using an ultrasonic bath to improve stability.

2.3. Stability of TiO\textsubscript{2}-SiO\textsubscript{2} nanofluids with ratio (70:30)

The stability investigation of TiO2-SiO2 nanofluids with ratio (70:30) in this research is performed by visual inspection, calculation of UV-Vis spectrophotometer and zeta potential. Sedimentation by visual examination was done for up to 60 days. Nanofluid shall be called stable when the concentration is steady. Previously, name \[23\] have used the same process for visual sedimentation of \[18\], prepared nanofluids. The UV-Vis was done for 10 days (250 h) based on the length of the sonication. Following the analysis by \[10\] the wavelength of the UV-Vis spectrophotometer is set at 900 nm. UV-Vis measures...
3. Results and Discussion

3.1. Visualization effect of TiO$_2$-SiO$_2$ nanofluids

Stability by Hwang et al, 2007 is one of the variables that can influence the efficiency of nanofluids. Decreasing thermal conductivity of nanofluid is the solution and blocking of microchannels formed by the aggregation of nanoparticles. Consequently, the properties that affect nanofluid are also stable. It is one of the big problems that can alter the essence of nanofluid by either studying influences that influence the distribution of nanofluid stability or nanofluid stability that are specifically related to its electro-kinetic properties. The balance of the Al$_2$O$_3$-Cu nanofluids hybrid was studied at various volume levels [24] and occurred when the delay in freezing triggered their possible lack of heat transfer. The stability of the assessment and prosecution should also not be overlooked. As heat transfer is applied, the thermal properties of the hybrid nanofluid thermal, if it can be decreased, then good stability can alter and deliver efficient results.

![Figure 2](image)

(a) First day  
(b) After 60 days

Figure 2. Sedimentation observation of TiO$_2$-SiO$_2$ nanofluids samples for (a) first day; (b) after 60 days

Figure 2 (a) presented that nanofluids prepared using a one-step process do not exhibit deposition, and this proves that the nanofluid is in a good shape. On the basis of this visual analysis, many researchers are doing the same thing (Ramadhan, et al, 2020) and are studying their stability assessments at various temperatures. The nanofluid stability of TiO$_2$-SiO$_2$ is determined by absorption as seen in Figure 2 (b). The sample was left at the return temperature for 60 days. The ideal absorption ratio would be one (100 percent) which reflects excellent stability during the deposition phase. The nearer rate is one with a rise in deposition period to assess the balance of the sample.

In order to determine the consistency of the concentration of the TiO$_2$-SiO$_2$ nanofluid hybrid volume, distributed in W: EG with a mixing ratio of 60:40, simple indoor deposition monitoring. The parameters taken into account during the sedimentation process are based on the percentage of velocity progress in time. A quicker phase happens when the setting is higher than seen in Figure 3.
3.2. Stability of TiO$_2$-SiO$_2$ nanofluids using UV-Vis spectrophotometer

The same study of nanofluid stability using the UV-Vis spectrophotometer was previously suggested and studied by researchers [25]. The absorbance of nanofluids is linearly increasing with the increase of volume concentration. This trend is in agreement with the Beer-Lambert Law, which is the value of the absorbance is equivalent to concentration [4, 9]. TiO$_2$-SiO$_2$ Nanofluid of absorption and sedimentation time was commonly observed for 240 hours for a different wavelength of 850 nm as seen in Figure 4.

![Figure 3. Illustration of the nanofluid sample on the sedimentation process](image)

![Figure 4. Absorbance of TiO$_2$-SiO$_2$ nanofluids with sedimentation time for different concentration](image)

Figure 4 indicates a concentration ratio of 1.0% of the volume concentration of hybrid nanofluids. The optimal absorbance value is 2.3 after 24 hours, which is the ideal consistency of the fluid. Concentrations of 0.3, 0.5 and 0.7% begin to decrease after 24 h and continue to decrease until 10 days (240 h). Thus, it can be inferred that nanofluid has a greater capacity for agglomeration and accelerated
deposition at lower concentrations. In terms of diffusion, there is also a high concentration of more suspended nanoparticles.

4. Conclusions
In this study, TiO$_2$-SiO$_2$ nanofluids for ratio (70:30) preparation can be successfully prepared using a one-step process. Stability analysis of hybrid nanofluids by UV-Vis process, which is stable up to 10 days after preparation with 2-hour sonication time. For concentration ratio of 1.0% of the volume concentration of hybrid nanofluids. The optimal absorbance value is 2.3 after 24 hours, which is the ideal consistency of the fluid. Concentrations of 0.3, 0.5 and 0.7% begin to decrease after 24 h and continue to decrease until 10 days (240 h).

Acknowledgements
The facilities of a laboratory to the authors by the Advanced Automotive Liquid Laboratory, Faculty of Mechanical Engineering, Universiti Malaysia Pahang is gratefully acknowledged.

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