Dispersion of Graphene Oxide in Ethylene Glycol and 2-Propanol

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1. Abstract

The dispersion of Grapene Oxide (GO) has been study in order to investigate the effect of time sonicating on the dispersion of GO in the ethylene glycol and 2-propanol. Besides, this experiment is also done to study the stability of the disperse GO in both solvents after a week. Poor stability of GO has become major problem during the dispersion of GO. In order to overcome this problem a study has been introduce which is dispersion of graphene oxide in solvents. In this study, the ethylene glycol and 2-propanol have been used as a solvent for the dispersion of GO. The focus of this research are on the dispersion behavior of GO when sonicate at different time (1 and 2 hour) and also on the stability of GO after been dispersed into both solvents after a week. The stability of GO in both solvents are studied by comparing with the stability of disperse GO in the water. Ethylene Glycol is a good solvent for dispersion of GO while the 2 -propanol is not suitable for the dispersion of GO by comparing to water.

2. Introduction

Nowadays, the Graphene Oxide (GO) are widely been used in the scientific and technological studies due to its strong mechanical strength [1, 2, 3], high electron mobility as well as high thermal conductivities [4]. According to the researchers, Graphene Oxide have wide application in biosensors, nano electronic devices, protein digestion, and catalysis [1, 5, 6]. The unique chemical structure of Graphene Oxide where it consists a lot of oxygen functional groups such as epoxide, hydroxyl, and carboxylic group [1-3, 6, 7] making the GO as a favorite for the support in enzyme immobilization [1-3]. Besides, having a lot of oxygen functional groups also making GO becomes strongly hydrophilic where it can easily be dispersed in the water [7].

Dispersion is a process by which agglomerated particles are separated from each other and a new interface between an inner surface of the liquid dispersion medium and the surface of the particles to be dispersed is generated [8]. For this case, it can be simplified as a process where the GO is dispersed in solvents. The dispersion of GO is study due to the problem during disperse GO in PBS. The dispersion of GO in PBS is not success since the solution start to agglomerate and settle after a short period of time. So after having the problem, the study of the stability of disperse GO in ethylene glycol and 2-propanol after a week is done.

Besides, the study about effect of time sonicating on the dispersion of GO in ethylene glycol and 2-propanol are also be done. The dispersion of GO can be done by using aqueous or any organic media [4-7]. Actually, dispersion is a complicated and less-understood process than most people believe. The dispersion of GO is considered success if the graphene oxide is dispersed at useful concentration and if graphene oxide remains dispersed over reasonable period of time [4]. To prepare a stable dispersion of GO, several studies have been developed which are dispersion of GO in solvent, using surfactants and also using colloidal suspension [5]. Other consideration that need to be taken to prepare a stable dispersion are, the solvent polarity, the surface tension and also the Hansen and Hilderbrand solubility parameter [5, 6].

3. Experiment section

3.1 Introduction

There are several methods available to be used for the dispersion of GO. However, for the research this time, the method used is dispersion of GO by using solvents [4, 5]. Two solvent have been chosen for the research this time which are ethylene glycol and 2-propanol.

3.2 Materials and Apparatus

For preparation of GO, the material used are Graphite powder Sodium Nitrate,$NaNO_3$, Potassium permanganate**,** Sulphuric acid**,** Hydrogen Peroxide **,** Deionized water**,** Ice bath and Hydrochloric acid while for dispersion of GO, the material used are 2- propanol, ethylene glycol, graphene oxide powder, and distilled water and the apparatus used are UV-Visible spectroscopy (UV-Vis spectra), ultrasonicate, glass cuvette (since we are using solvent cannot used the plastic cuvette for the safety purpose), bottles to place the disperse GO, electronic beam balance, measuring cylinder, beakers, stirrer, spatula, and micropipette.

3.3 Procedure of the experiment

3.3.1 Preparation of GO

Graphene Oxide is prepared by using modified Hummer's method. Graphene oxide is prepared by mixing 1g of graphite powder with 0.5 g of sodium nitrate in the 1000ml beaker. While stirring the mixture, 23ml of sulphuric acid is added into it. Continue stirred the mixture for about 1 hour. Then, gradually add 3g of $KMnO_4$ into the mixture. At this time, make sure that the temperature of the mixture is below 20^OC in order to prevent from overheating the mixture. Stir them for about 12 hour. After that, add 500ml of water into the same beaker while stir it vigorously. The dilute solution is formed. Finally, add 5ml of 30 % H_2O_2 into the solution to ensure the reaction of the solution with the $KMnO_4$ is complete. The mixture then washed with HCl and H_2O. After finish washing process, filter and drying is done to produce the graphene oxide. [2,3,9]. The sample is study by using Scanning Electron Microscopy (SEM).

3.3.2 Dispersion of GO

5 mg of graphene oxide is weighed by using electronic beam (make sure the bubble at the back of the beam is place in the circle given in order to get the correct reading). Measure 10 ml of ethylene glycol by using measuring cylinder. Pour the ethylene glycol into the beaker that contain the GO. Stir the mixture for about 15 min by using the stirrer at room temperature. After done stirring the mixture, pour the mixture into the bottle (make sure that the bottle is closed tightly in order to prevent the mixture from spilled during the sonicate process). Place the bottle into the ultrasonic to sonicate them (pour the water into the ultrasonic until ¾ full before switch on the instrument). Set the time sonicate for about 1 hour. After that, pipette 1 ml of the disperse GO into the glass cuvette then place them in the UV-Visible spectroscopy (make sure that the transparent part of the glass cuvette are at the east and west in order to get the correct reading) to get the absorbance value (set the wavelength at the range of 200nm to 1000nm) [6, 7, 8]. Store the disperse GO in the laboratory at room temperature for 1 week. After that, read the absorbance value of the disperse GO by using UV-Vis spectra at the same wavelength. In order to study the dispersion of GO, the picture are taken after done the stirring process, after done the sonicating process and also after been store for 1 week. The overall process above are repeated by using water and 2- propanol. After that, the same process are repeated again by using ethylene glycol, water and 2-propanol but this time the time sonicate is increase to 2 hours.

4. Result And Discussion

4.1 Result

The figure shows the result of the dispersion of GO, the graph of absorbance vs wavelength and image of GO by using SEM.

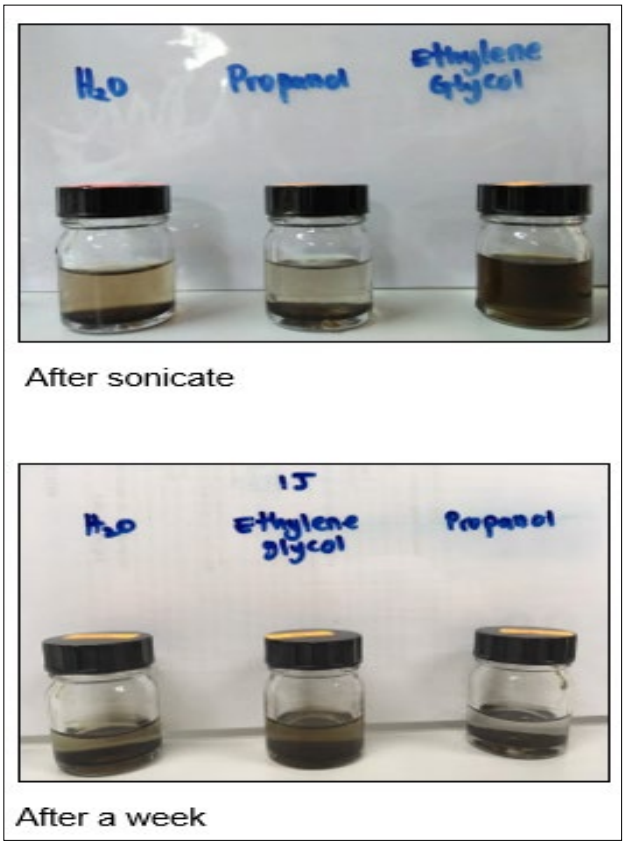

Figure 4.1: The dispersion of GO after sonicate for 1 hour and after a week

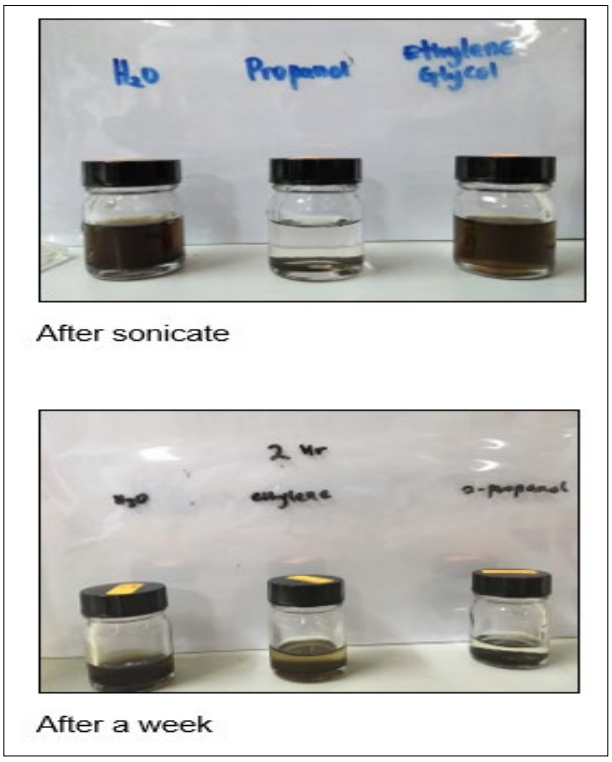

Figure 4.2: the dispersion of GO after sonicate for 2 hours and after a week

From the figure 4.1 and 4.2, it is clearly shows that the dispersion of GO in 2-propanol is not stable since the precipitate form can be clearly seen in the both condition which is in the 1 and 2 hours sonicating while for the ethylene glycol, the result is study by using the UV-Vis. However, in order to conform that the 2-propanol is not suitable for the dispersion of GO, the absorbance test is also done to it.

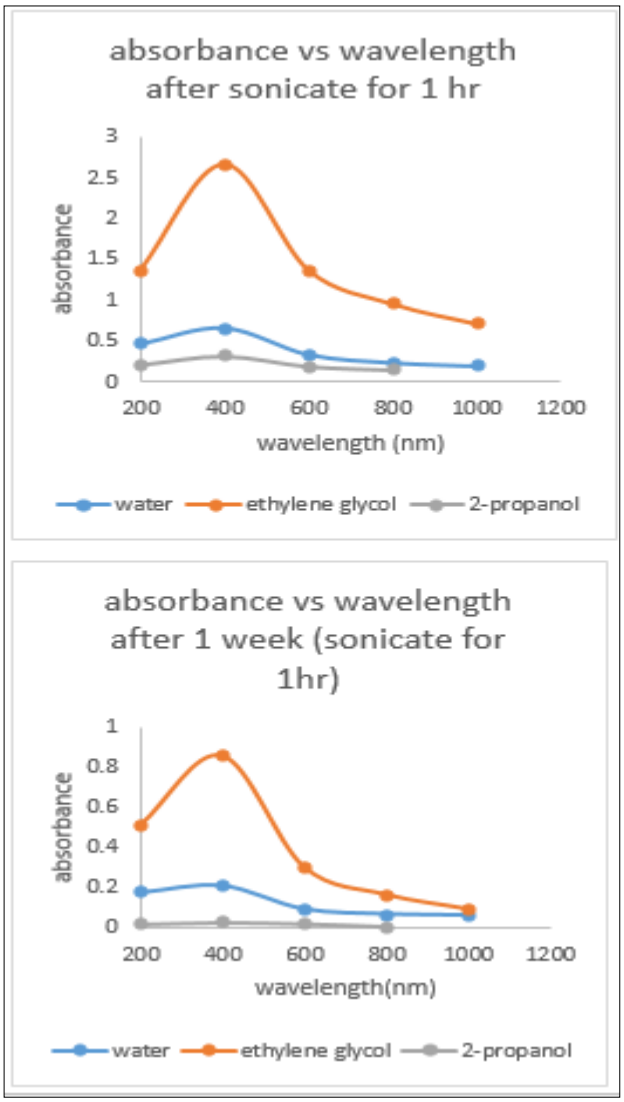

Figure 4.3: the absorbance value of GO in the 2-propanol and ethylene glycol at 1 hour time sonication and after a week

From the figure 4.3, the absorbance result shows that the dispersion of GO in 2-propanol is lower compared to water and ethylene glycol. The absorbance of 2-propanol after a week also shows that the dispersion of GO in 2-propanol is lower compared to others. So it is shows that 2-propanol is not stable for the dispersion of GO. According to previous study, the dispersion of GO in 2- propanol can only last for a few hours [5,6]. For the ethylene glycol, the absorbance value after sonicate is higher compared to water and 2-propanol. The result after a week still showing that the ethylene glycol is higher compared to others. In term of stability, the ethylene glycol after a week is quite stable since the amount of precipitate form is not too much as we can see in figure 4.1.

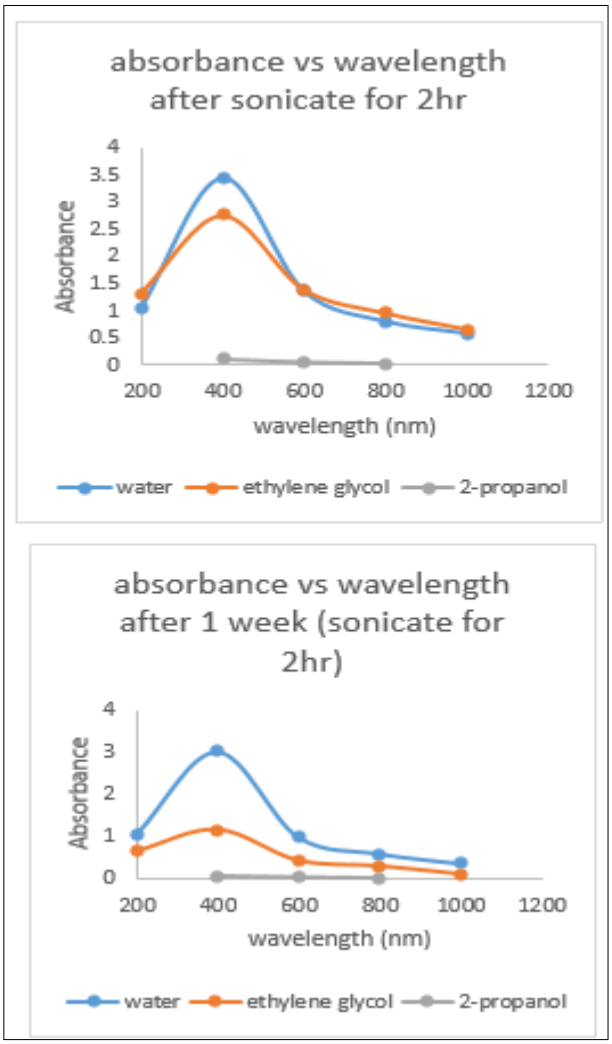

Figure 4.4: the absorbance value of GO in the 2-propanol and ethylene glycol at 2 hour time sonication and after a week

At the wavelength 200-250nm to 600-1000nm, the absorbance values of ethylene glycol is higher compared to water. This result is not the result that should be obtain. For the 2-propanol, the result obtain is quite similar with the result in figure 4.3 unless the absorbance value of 2-propanol at time 2-hour time sonication is decrease from the value at 1 hour time sonication. Here, it is obviously shows that 2-propanol is not suitable for dispersion of GO.

After a week, the absorbance values of ethylene glycol is lower compared to water. By comparing to the 1 hour time sonicating, the stability of the disperse GO at 2hours time sonicating is more stable since the absorbance values after a week in 2 hour time sonicate is higher compared to in 1 hour time sonicate.

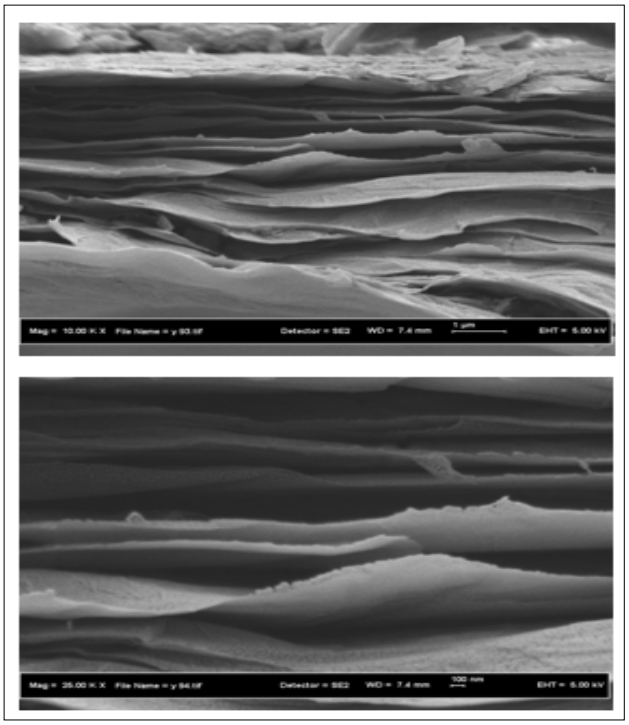

Figure 4.5: Shows the structure of GO by using SEM

4.2 Discussion

table 4.1: the solubility values [6]

solvents	GO solubillity ($\mu g/ml$)
water	6.6
2-propanol	1.82
Ethylene glycol	5.5

By referring to the solubility of the ethylene glycol,2-propanol and water in table above, the data clearly shows that the dispersion of GO in water should be higher than the dispersion of GO in ethylene glycol and 2-propanol [5, 6, 10, 11]. However, for the 1 hour time sonicating, the result is opposite to this data where at 1 hour time sonication, the result obtain, ethylene glycol is better in disperse the GO compared to water. This result is also not same with the previous study [5, 6] where from previous study the absorbance of GO in water is higher compared to ethylene glycol at 1 hour time sonication. The dispersion of GO into the solvents usually achieved by using sonication. The sonication will create the shear stress as well as cavitation in the solvent [4]. The stress and cavitation will effect to break the GO. The dispersion process is claim to linked by the sonication time and also power of sonication [4]. That why at 1 hour time sonicating, the absorbance value of ethylene glycol is higher compared to water because the stress produce by the sonication process in the dispersion of GO in water is not enough to break the bond in the water [4]. As a prove, from the figure 4.1, the amount of precipitate after the sonication process in water is still a lot. This shows that the GO is not fully disperse in the water. As we increase the time sonicating for 2 hours, the absorbance values of water is higher than ethylene glycol. While for the ethylene glycol, as the time sonication increase to 2 hours, the absorbance values of it just having a slight increase since the dispersion process is almost done in it.

As for the 2 -propanol, the absorbance values at 1 hour time sonication is low since the solubility of GO in 2-propanol is low. In order to study the effect of time sonication on 2 -propanol, the time sonication is increase to 2 hour but the absorbance values become lower. This happen because for the certain solvent that has low boiling point like 2 -propanol, increasing the time sonicating will only reduce the graphene size and will cause defects where it can damage the GO properties [4]. That why at 2 hour time sonication the absorbance values of 2 -propanol is lower compared to in 1 hour time sonication.

At 2 hour time sonication, at the wavelength of 200-250 nm and at 600-1000 nm, the bond at these wavelength for ethylene glycol is C-C bond while the bond at these wavelength for the water is C-O. So for C-O bond it is obvious that more energy is needed to break the C-O bond compared to C-C, so that why at these wavelength the absorbance value of ethylene glycol is higher compared to water [10]. The absorbance of ethylene glycol after a week is lower than water because the C-O bond is more stable than the C-C bond. So that why the absorbance value after a week at 2 hour time sonication of ethylene glycol is lower compared to water [5]. However, in term of stability, both water and ethylene glycol can be consider as stable since after a week the absorbance values for both solvent is still high. This result is also supported by the previous studies [4,- 6, 11]

5. Conclusion

As a conclusion, the dispersion of GO is highly depend on the solubility of the solvent as well as time of sonication. The higher the solubility of GO in the solvent, the higher the absorbance value recorded. Besides, the higher the time sonication,the bigger the absorbance values unless for the case of 2-propanol because increasing the time sonication for 2-propanol will only damage the GO properties [4] resulting in smaller values of absorbance. So from these research, it is clearly shows that ethylene glycol is a good solvent for the dispersion of GO by comparing with water. The 2-propanol is highly not recommended to be use in dispersion of GO.

6. Acknowledgements

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7. References

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