COMPARATIVE STUDY ON STABILITY OF NANOFLUID USING TWO DIFFERENT DISPERSING AGENTS

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This report is submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)

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DECLARATION

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"I hereby declare that the work in this report is my own except for summaries and quotations which have been acknowledge."

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Khas untuk keluarga tersayang, Khusus untuk ibunda

dan ayahnada tercinta

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ABSTRACT

Nanofluid have a big potential in term of heat transfer and become a need in industries and also for scientist around world . Apart from that nanofluid also can be used in variety of application such as cooling agent in automotive sector, heat transfer in electronic application and also used in cooling industries. Carbon Nanotube (CNT) is hard to disperse in base water and need a help from dispersing agent. So an experiment need to be run in order to produce the stable nanofluid based on uses of carbon nanotube and dispersing agents. The type of carbon nanotube used for this experiment is manufactured by Materials and Electrochemical Research Corporation (MER). This carbon nanotube is Multi-wall Carbon Nanotube (MWNT) and have large surface area and able to help during heat removing process. Regarding to this matter, two dispersing agent was introduced in order to help the CNT to disperse well in base water. Those two dispersing agent used in this experiment were Sodium Dodecyl Sulphate (SDS) and Polyvinylpyrrolidone (PVP). This surfactants help to reduce the water surface tension and increase the stability of nanofluid. The experiment started by weight percentage and ratio between the CNT and dispersing agent. Then the formation was homogenized, has been ultrasonic and checked the pH value. The stability result of nanofluids was determine after 100 hours kept in room temperature and being tested by using the stability test rig. The formation between MER and PVP give the best result in term of stability and also thermal conductivity. PVP is very good surfactant that help to increase the stability and thermal conductivity due to the efficient characteristic which are very soluble in water and produce less foam and bubble.

ABSTRAK

Bendalir -nano mempunyai potensi yang sangat besar dalam penukaran haba dan menjadi keperluan serta tarikan dari pelbagai industri dan juga saintis seluruh dunia. Selain daripada itu, bendalir-nano juga digunakan dalam pelbagai kegunaan seperti ejen penyejukan dalam sektor automotif, penukaran haba dalam aplikasi elektronik dan juga dalam industri penyejukan. Projek ini dijalankan adalah untuk menghasilkan bendalir nano yang stabil dengan menggunakan karbon nanotiub dan ejen penyebar. Jenis karbon nanotiub yang digunakan adalah MER. Karbon nanotiub in adalah jenis (MWNT) dan mempunyai permukaan yang luas dan mampu memberikan bantuan ketika proses pembuangan haba. Walaupun struktur karbon nanotiub adalah bagus tetapi ia tetap mempunyai satu masalah besar iaitu hydrofobik. Ini bermakna karbon nanotiub ini sukar untuk tehurai didalam air. Untuk menangani masalah ini dua ejen penyebar digunakan untuk membantu karbon nanotiub untuk terhurai di dalam air biasa. Dua ejen penyebar itu adalah (SDS) dan (PVP). Ejen penyebar ini akan megurangkan tekanan permukaan air dan menugkatkan kestabilan bendalir nano. Sebelum eksperimen dijalankan perbezaan dan nisbah diantara tiub karbon nano dan ejen penyebar perlu dikirakan dahulu. Keputusan kestabilan bendalir nano hanya dapat ditentukan selepas 100 jam di simpan pada suhu bilik dengan menggunakan rig ujian kestabilan. Gabungan antara MER dan PVP adalah yang terbaik dari segi kestabilan dan juga pengaliran haba. PVP mempunyai kriteria yang sangat bagus iaitu sangat mudah terlarut dalam air dan kurang menghasilkan buih.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Nanofluid is a material that consist of nanometer size particle which is able to disperse in base fluid such as water, ethylene glycol and engine oil. Nanofluid is used in important fields such as electronics, transportations, medicals, and Heating Ventilation and Air Conditioning (HVAC). Besides, nanofluid also known as a fluid that has properties of solid such as metal object that can transfer more heat or have a high thermal conductivity. Based on Xue. Q (2005) the thermal conductivity not only depends on volume fraction of a solid or liquid, but also depended on the particle size and interfacial properties. Nanofluid are also suspension of nanoparticles inside base fluid and there are many types of solid particles we used to prepare nanofluid . Nanofluid is the better choice compare to the solid even though solid is a good thermal conductivity but it cannot be used as a transfer heat equipment. It also have a large

surface area to volume ratio and thus have great potential in heat transfer. That the reason why nanofluid is widely used in industries now days.

1.1 Problem Statement

The main problem in this project is to determine which dispersing agent either SDS or PVP is better in term of stability and thermal conductivity. This experiment carry on to identify whether the nanoparticle is able to disperse in the water base or not. The nanoparticle used during this activity carry on is Carbon nanotube (CNT). In fact, the criterion of Carbon nanotube (CNT) is hydrophobic and in order to help CNT to disperse well in water, two dispersing agents are used. There are Sodium Dodecyl Sulphate (SDS) and Polyvinylpyrrolidone (PVP). Besides that, dispersing agent also help to increase the stabilize of nanofluid and enhance the thermal conductivity. Hence a further study about the water based carbon nanotube need to be done to see whether the nanofluid is better for cooling agent than the base water.

1.2 Objective

The main objective of this project is:

 To determine the stability of nanofluid based nanocarbon by using the dispersing agent which are Sodium Dodecyle Sulphate (SDS) and Polyvinylpyrrolidone (PVP).

1.3 Scope

1. To prepare the nanofluid by using carbon nanotube manufactured by Meterial Electrochemical Research (MER) with using the Sodium Dodecyle Sulphate (SDS) and Polyvinylpyrrolidone (PVP) as dispersing agent.

2. To identify the stability of nanofluid.

3. To find the suitable ratio of the amount of carbon nanotube and the amount of the dispersing agent to be mix with a certain amount of water.

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CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Nanotechnology is define as the technology used for design and fabrication material, devices and systems with control at nanometers dimensions. Nanotechnology is considered to be rather new technology but it has a lot of potentials that can be explore and the application. This technology is widely used in industries recently due to the benefit of nanoparticle structure. According to Kwak.K (2005), nanotechnology is the process of produce and use of materials with purposely engineered features close to the atomic or molecular scale. It means that the nanotechnology is dealing with small structure of atom which is they need some special device to be investigate and also invisible by the naked eyes. On the other hand, nanotechnology raises lots of the same concerns as virtually any new engineering, including concerns in regards to the toxicity and also environmental influence of nano components. Researchers tried to increase the thermal conductivity of base fluids by suspending solid nanoparticles in fluids since the

thermal conductivity of solid is typically better than liquids (Wang, et al, 2008). This technology is still fresh and new in industries field and got a lot of potentials to be explored. The continuously research need to keep in progress in order to achieve the main goal for development of nanotechnology and able conquer all industries around the world.

2.1 Nanofluid

2.1.1 Definition of Nanofluid

According to Singh A.K (2008), nanofluid are a suspension mixture of suspended nanoparticles in a base liquid is defined as a nanofluid. Nanofluid is refer to engineered colloids made of base fluids and nanoparticles (Cheng, 2009). Base fluids such as water, ethylene and engine oils are conventional fluids that been used as heat transfer fluids. According to Wang and Mujumdar (2006), nanofluid has a much larger relative surface area of nanoparticles compared to conventional heat transfer fluid. Nevertheless, it will not only increase the thermal conductivity but also the stability of the suspension. There are several examples of natural nanofluid which are blood, a complex biological nanofluid where different nanoparticles able to accomplish different functions. Apart from that, the function of the component actively respond to their local environment and also improve the abrasion relation of those properties when compare to the conventional solid or fluid mixture. Besides that nanofluids is a mixture of nanoparticles and fluid which are have enormous potential to improve the efficiency of heat transfer fluids, Hong and Tae-Keun (2000). When nanofluids are used as coolant in a liquid cooling process, the purely convective mode of heat transfer with the base fluid becomes a heat transfer problem with convection and conduction effects. In fact, mostly nano-element with high thermal conductivity can be dispersed in base fluids but only a few from that are suitable to be used for nanofluid purpose

2.1.2 Application of Nanofluids

There are several application of nanofluid due to the dynamic structure of nanoparticle which is now day be attractive by developer around the world. According to (Lixin, 2009), the replacement of cooling and heating water with nanofluid has the great potential to conserve one trillion Btu of energy where one Btu approximately to 1055.056 Joule.

2.1.2.1 Automotive application

In automotive application the nanofluid able to replace the existed material such as engine oils, automatic transmission fluids, coolants, lubricants, and other synthetic high-temperature due to the thermal conductivity of nanofluid is more better compare to these materials. Using nanofluid as coolants allows for smaller dimension and better positioning from the radiators. The usage of high-thermal conductive nanofluid inside radiators can cause a lowering of the frontal section of the radiator. The effective use of nanofluid furthermore contributed with a reduction regarding friction and also wear, lowering parasitic loss, operation regarding components for instance pumps and also compressors. So the nanofluid is really play their role as a coolant wisely and give a greater improvement of savings for the future plan.

2.1.2.2 Electronic application

Nanofluid is a new invention which is used for cooling of microchips in computers and other electronic appliances. The most important principal in developing smaller microchips is the rapid heat dissipation. So the nanofluid is really suitable to be used as liquid cooling in order to dissipated heat from microchip due to their high thermal conductivity. By using the nanofluid as a cooling agent, it can help to increase the life time of the electronic system. This new invention also able to make a greater improvement in electronic marketing.

2.1.2.3 Heat transfer application

Based on Routbort et al.(2008), noticed that employed nanofluid in industrial cooling that could result a great energy savings and resulting emissions reductions. The scientist around the world make an estimation that the replacement of nanofluid as cooling and heating water has potential to conserve in about 1 trillion Btu of energy. According to Thomas (2010) the system have used phase change materials as nanoparticles in nanofluid to ensure the simultaneously enhance the effective thermal conductivity and specific heat of the fluids. The main properties of nanofluid which make them is the good cooling agents are having good thermal conductivity and viscosity.

2.1.3 Stability of nanofluid

Nanofluid are new invention of engineering material consisting of nanometer-sized particles dispersed in base fluid. Based on the research , there are various properties of nanoparticles, such as multi-walled carbon nanotube (MWCNT), Single-Walled Carbon Nanotube (SWNT), fullerene, copper oxide, and silicon dioxide have been used to produce nanofluid. The production of nanofluid is about for enhancing thermal conductivity and lubricity. According to.Chen.L (2008), nanofluid technology becomes a new challenge for the heat transfer fluid because of these fluid is really good in thermal conductivity. The stability of nanofluid still need to be evaluate to ensure the nanofluid is in good condition. The nanofluid are considered to be stable when the nanoparticle size of supernatant particles remain constant. Sedimentation method of nanofluid in test tubes and then taken picture of the nanofluid mixture is also a usual method for observing the stability of nanofluid, Wei Yu and Xie. H (2011).

The suspension fraction of graphite nanoparticles should be calculated at a certain time in order to determine the stability result of nanofluid. For the sedimentation method, a long period for observation is the limitation that need to faced on. Therefore, other method has been created which is centrifugation method to evaluate the stability of nanofluid. Excellent stability of the nanofluid is due to the protective role of dispersing agent. The dispersing agent also help to retard the growth and agglomeration of nanoparticle by certain effect. The stability of nanofluid based nanocarbons are important because thermal conductivity enhancement depends on the volume fraction of the suspended particles, thermal conductivities of the particles and base fluids. The characteristics of the suspended particle and base fluids such as the particle morphology and the chemical structure of the particles is really effect the stability of the nanofluid, Kanagraj. S (2005).

2.2 Carbon Nanotube (CNT)

Carbon nanotubes (CNTs) are defined as the tubular structures that are typically of nanometer diameter and commonly micrometers in length, according to (Dresselhaus et. al 2004). Carbon-based materials such as diamond and in-plane graphite, display the highest measured thermal conductivity of any known material at moderate temperatures. Carbon nanotube are also good in mechanical and electrical properties and it has been proven by Lifei (Chen et al. 2008) in their journal. Carbon nanotubes also have high carrier mobility, ballistic transport and high compressible with high dielectrics. There tend to be many feasible symmetries or even geometries that may form on the cylindrical area in carbon nanotubes without having introducing any risk of strain. Based on Xue Q.Z. (2005), Carbon nanotubes (CNTs) have a very unique of structure and remarkable physical properties and already attracting much attention in the past few years. Apart from that, the well-known graphite carbon can build close and open cages based on the honeycomb atomic arrangement and pattern. Carbon nanotubes consist of rolled graphene sheets built from hybridized carbon atoms. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs).

2.2.1 Types of Carbon Nanotube

2.2.1.1 Single-Walled Carbon Nanotube (SWNT)
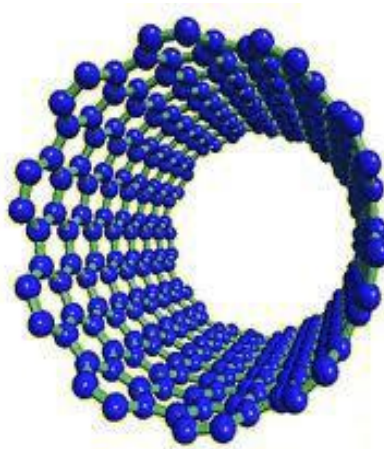
Figure 2.1 : Single-walled carbon nanotube
(source : Patel, 2008)

According to the Figure 2.1 single-walled carbon nanotube (SWNTs) actually introduced by Dr. Richard Smalley from Rice University Houston. According to the result from his experiment the SWNTs were imaged in high resolution mode (0.335 nm) using a Philips 420 transmission electron microscope (TEM). At atomic and molecular levels a digital images is captured in order to display the structure characteristics of the SWNTs. The structure of a SWNTs can be conceptualized by coating a one atom thick layer of graphite called graphene into a seamless cylinder. The close packing arrangement between the single-walled nanotubes structure is due to the van der Waals interaction. The packing can be seen as diamond lattice or hexagonal close packing.

The ability of single-walled carbon nanotubes which is its able to bend at any desired angle. Due to their remarkable properties the SWNTs is widely used for nano-electronic devices. There are several characteristics of nanotubes which are high carrier mobility, ballistic transport and high compatibility with high dielectrics. Now days

single-walled carbon nanotubes commonly used to replace the copper wire as the silicon chip. Carbon nanotube (CNTs) get more intention for future integrated circuit technology in the industries. This is because they have high current capability, excellent thermal and mechanical properties.

2.2.1.2 Multi-walled Carbon Nanotube (MWNT)
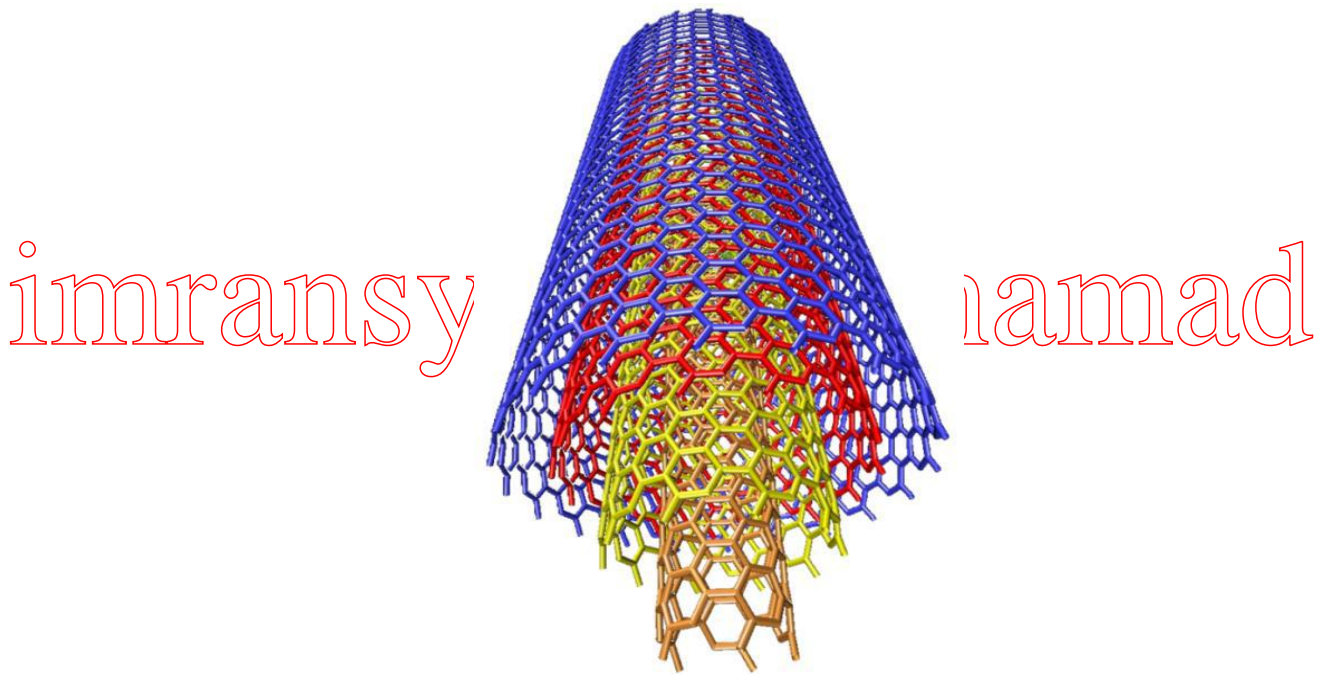
Figure 2.2 : Multi-walled Carbon Nanotube

(source : C. Ross, 2008)

According to Figure 2.2 and Jonathan, (2008), Multi-wall Carbon Nanotube (MWNT) arrays regarding different thickness and length are already grown about silicon and also copper floors using substance vapor deposit. MWNTs are predicted to have higher thermal conductivity than any known material including diamond which is has high mechanical strength and can be grown as arrays of relatively high densities.

MWNTs have a current carrying capacity equal to that of the SWNTs but SWNTs have lover thermal conductivity than MWNTs. This is because MWNT have a simpler fabrication due to easier control of the growth process. Moreover, MWNTs are polymers of pure carbon and can be reacted and manipulated using the rich chemistry of carbon.

2.3 Dispersing Agent

Dispersing agent or surfactants are compounds that lower the surface tension of a liquid and also help carbon nanotube CNT to disperse easily in base water. According to Murshed. S.M (2008), the dispersing agent is defined as compounds having both polar and a polar groups, adsorb at the interface between immiscible bulk phases, such as oil and water, air and water or particles and solution, act to reduce the surface tension. So the surfactants is able help the Carbon nanotubes (CNTs) to disperse in base water due to consist of hydrophilic region of head and hydrophobic of tail. The adsorption of surfactants onto inorganic and organic surfaces usually depends on the chemical characteristics of particles, surfactant molecules and solvent, (Zhu. D et al. 2009). Different dispersing agents have different ability to disperse the carbon nanotube in base water also different strength to lower the surface tension of fluids. Dispersing agent not only help the nanofluid to become more stable in water but also help to reduce the coagulation of nanoparticle in nanofluid.

2.3.1 Polyvinylpyrrolidone (PVP)

As shown in Figure 2.3 Polyvinylpyrrolidone (PVP) is commonly called Polyvidone or Povidone which is a water-soluble polymer and it made from the monomer *N*-vinylpyrrolidone. PVP really has great flexibility and widely used in industries now day to improve strength and toughness. In paper manufacture PVP is used to increase strength and as a coating resin meanwhile in synthetic fiber industrial PVP is used to improve the dye receptivity. PVP is really soluble in cold water and it concentration is limited by viscosity. Hence this surfactant will assist the nanofluid to be more stable in base fluid. Small amounts of PVP effectively stabilize emulsion, dispersion, and suspensions. Even lyophobic collid, which exist without significant affinity for the medium can be protected by PVP, (Ashok K. Singh (2008)). PVP powder can be stored under room temperature and normal condition without undergoing decomposition or degradation.

However, since the powder is hygroscopic the safety precaution need to be taken to avoid any excessive moisture pickup. PVP is quite reactive and flammable, expose to extreme at elevated temperature should be avoided. There are several advantages of PVP in order to increase the stability of nanofluid which are good solubility in water, improve adhesion between to substance, and also non-toxic , odorless and chemically stable. On the other hand PVP is produce less foam during the homogenizing process compare with others dispersing agents.
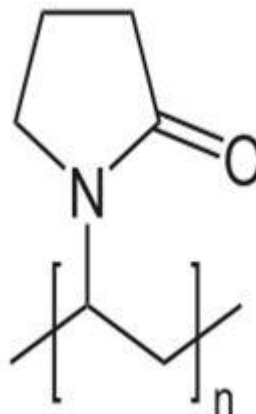
Figure 2.3 : Polyvinylpyrrolidone (PVP)

(source : wikipedia)

2.3.2 Sodium Dodecyl Sulphate (SDS)

As shown in Figure 2.4 Sodium Dodecyl Sulphate (SDS) is an organic compound and used in many cleaning and hygiene products. According to Baghalha (2011) it mention that the sodium dodecyl sulfate (SDS) are able to modify the hydrophobic surface of CNT and, hence stabilize its suspension in water. This surfactant consist of a 12-carbon tail attached to a sulfate group which is giving the material the amphiphilic properties required of detergent. SDS widely used in many cleaning application as detergent and highly effective surfactant in order require to remove any residues. Based on (Yujin Hwang et al. 2008) journals, among the various nanofluid preparation method, the addition of surfactants was known to be effective to homogeneously disperse nanoparticle in the base fluids. The surfactants resulted in the electrostatic repulsion between surfactant-coated nanoparticle, which significantly reduce the particle agglomeration due to van der Wall force attraction.
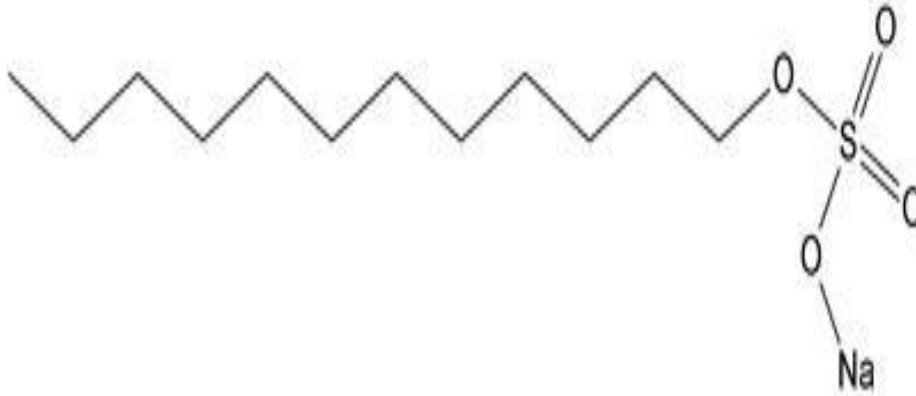
Figure 2.4 **:** Sodium Dodecyle Sulphate (SDS)

(Source : gbiosciences.com)

2.4 Synthesis of Nanofluid

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      Based on Savas Barber (2000) first prepared nanofluid by mixing nano particle with fluids. Due to the rapid development in the synthesis technique for nanofluids. Difference studies prepare nanofluids using different approaches, that why until now still do not has any standard preparation method for nanofluid. A usual problem faced in nanofluid manufacture is nanoparticle tendency to agglomerate into larger particle. It also limits the advantages of the high surface area of nanoparticles. In order to solve this problem the particle dispersion additives are often added to the base fluid with the nanoparticle.

2.4.1 Two Step Process

Two step process in which nanoparticles are first produced as a dry powder, typically by an inert gas. The resulting nanoparticle are then dispersed into a fluid. Torri S (2010). This procedure will produce a result in a large of nanoparticle agglomeration. Need to use two step in order to separate the nanoparticle.

2.4.2 Chemical Approach

Chemical approach is using the wet technology which is single-step approach. This method is process for growing nanostructure of variety metals such as semiconductor, non-metal and hybrid systems. There are several of advantages get from the chemical approach which are the surface function nanoparticle and nano rod metals or organic semiconductor, able to disperse in wide variety of media such as water and can be prepared wisely in order to produce monodispersed nanostructure. Moreover, nanofluids showed higher conductivity enhancement than the one made by using different method.

2.4.3 Laser Ablation

Laser Ablation one of the single-step approach that directly make and disperses nanoparticle in the base fluids. There are a lot of nanofluid have been prepared by laser ablation technique with ablate solid metal or semiconductor submerged in the base fluids. This method also useful for separate of nanofluid to study effect of particle size on the thermal conductivity.

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CHAPTER 3

METHODOLOGY

3.0 Experimental Procedure

There are several procedure to prepare the nanofluid:

a) The 40 ml of deionized water need to be weighted by using the analytical balance and need to keep in 40 ml bottle.

b) Then carbon nanotube (MER) and dispersing agent (SDS) or (PVP) also need to be weight according to the ratio get from the formulation.

c) Firstly need to put the dispersing agents into the deionized water and then shaking them.

d) After that put the carbon nanotube into the solution, the deionized water with dispersing agents and carbon nanotube need to homogenized by using homogenizer for one minute at 10000 rpm.

e) The next step is the solution need to be ultrasonic by using the ultrasonicator cleaning unit for 60 minute and temperature 25 ^{0}c at highest frequency.

f) After the ultrasonic is done pH value need to set approximately to nine and once again the solution need to be homogenize for another five minute at 10000 rpm.

g) Then used the stability testing rig to determine the stability after 100 hours.

h) As shown in the Figure 3.1 is flow chart of the nanofluid formation

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3.1 Flow Chart
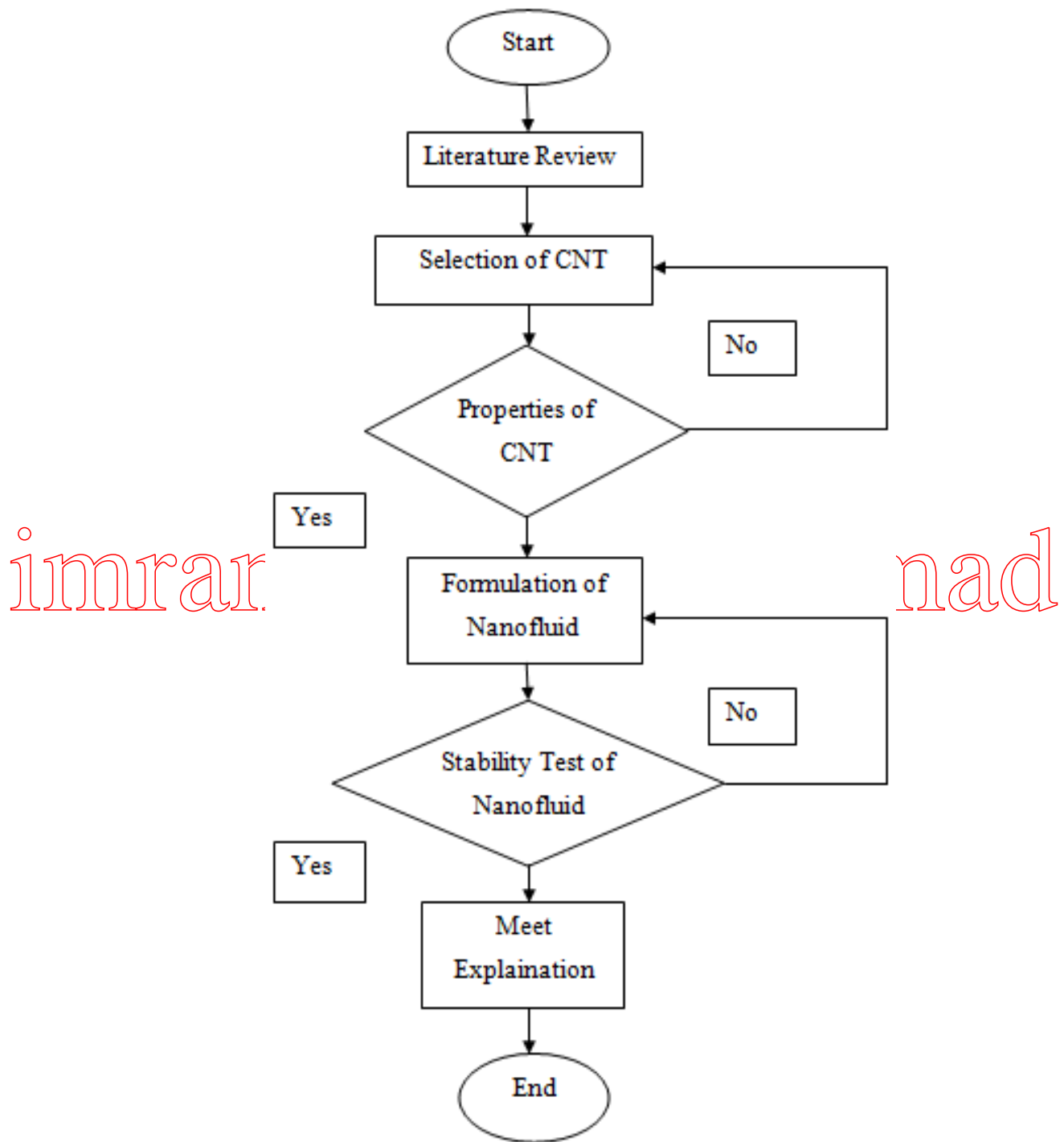
Figure 3.1: Flow chart preparation of nanofluid

3.2 Parameter use in experiment

There are several types of parameter used in order to find the stability of the nanofuids which are deionized water as base fluid, carbon nanotube as a raw material, dispersing agent as the catalyst and also the also ratio between carbon nanotube with dispersing agent.

3.2.1 Deionized water

The type of based fluids used in this experiment is deionized (DI) water. To produce deionized water, it may take some process in order to make it completely purify. however , the deionized water is commonly used in industry because it has good thermal conductivity compared to other base fluids.

3.2.2 Carbon Nanotube (CNT)

The CNT used for this project is carbon nanotube that manufactured by Materials and Electrochemical Research Corporation (MER) which is a Multi-wall Carbon Nanotube (MWNT). While the density used for CNT is 1.7 g/cm³, according to the Materials and Electrochemical Research Corporation (MER) catalog (2012).

3.2.3 Dispersing Agents

The surfactants used for this project are Sodium Dodecyl Sulphate (SDS) and Polyvinylpyrrolidone (PVP)**.** Need to determine which dispersing agent is more good in order to stabilize the nanofluids and assist the CNT to disperse in dionized water. Density used for SDS is about 1.01 g/cm³ meanwhile PVP is 1.3 g/cm³. J & K Scientific ltd and VWR Corporation (2007).

3.2.4 Ratio between CNT and Dispersing agents

According to the Table 3.1 it display the ratio between the CNT and dispersing agent. In order to get the accurate measurement the first step is need to make sure that the dispersing agent need to be measure 40% from the CNT. Then find the volume of CNT and surfactants to get the actual volume of deionized need to used.

Table 3.1 : Sample ratio between CNT and Dispersing agent

CNT(%)	Volume CNT	SDS (%)	Volume SDS	water (ml)
0.04	0.0235	0.0160	0.01584	39.96063
0.08	0.0471	0.0320	0.03168	39.92126

3.3 Apparatus

3.3.1 Mechanical Homogenizer

Based on the Figure 3.2 the homogenizer was manufactured by Lab Genius company and use for homogenized the surfactant, CNT into the distilled water. This unit can speed up until 27000 rpm. But during this experiment the best speed to stir the solution is 10000 rpm in one minute.
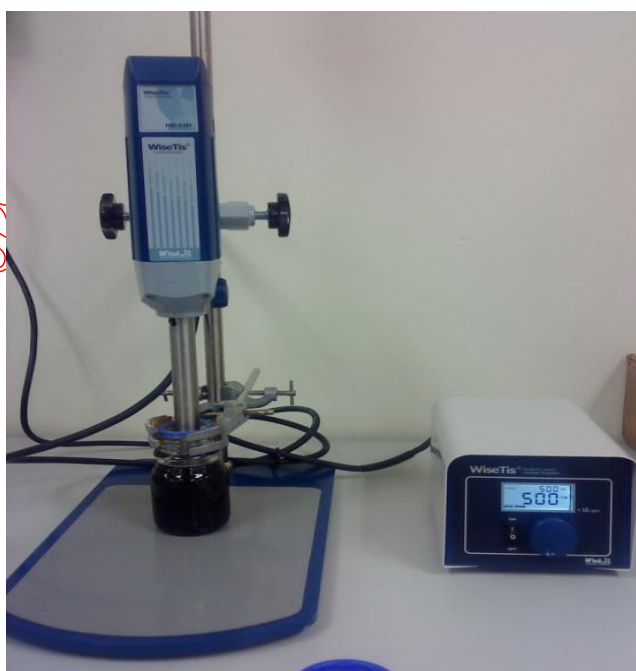
Figure 3.2 : Mechanical Homogenizer

3.3.2 Ultrasonic

Based on the Figure 3.3 the ultrasonic was manufactured by Elma Hans Schmidbauer GmbH & Co. KG a German company. By using the high ultrasonic power at perfect frequency and temperature it able to broken down the mixer particle and disperse the CNT.

Figure 3.3 : Ultrasonic

3.3.3 pH meter

Based on Figure 3.4 the pH meter is used to identify the required pH in order to check the stability of nanofluid after disperse in ultrasonic cleaner. In order to get the accurate pH value according to the suitable ratio between the carbon nanotube (MER) and dispersing agents (SDS) or (PVP).

Figure 3.4 : pH meter

3.3.4 Stability Test Rig

Based on Figure 3.5 the stability test rig function is to measure or identify the stability of nanofluid by using the combination of laser and test rig. It was measure after pH checking.

Figure 3.5 : Stability Testing Rig

3.4 Safety Precaution

There are some safety precaution need to follow in order to avoid any bad consequence. As known both SDS or PVP and CNT are in powder there are need to wearing the mask and the rubber glove either during carry on the experiment or not. This is because the powder can travel through the air and able to give an infection to our skin and eye. The inhalation of CNT may cause lung cancer or damage. If they spilled we need to handle carefully by using the sweeper or vacuum cleaner. Then need to spray with water at the place CNT spilled. Hands need to wash with soap or any detergents as long it able to kill any bacteria and keep our hand clean.

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CHAPTER 4

RESULT AND DISCUSSION

4.0 Result

Result is the final consequence of a sequence of actions. In term of this project, we gained results or outcome from our experiment and we will present it in tabular and graphical format. Discussion is one of the process to make a right decision. In discussion, all the result gain need to be make an analysis in order to find the exact decision. Good discussion will provide the good of evidence to show the result gain is same with the prediction.

4.1 Stability test

The stability test need to be done after all the sample are left for 100 hours. There are two types of stability test can be done which is through the visual test and by using the stability testing rig. For the first method we just need to determine the stability of the sample by using our naked eyes. If the color of the mixture is unchanged it mean the carbon nanotube disperse well in the dionized water. So the sample can be consider as stable sample . Besides if the solution turn to clear and the particle of the carbon nanotube become a sediment at the bottom of the testing tube that mean the sample is unstable and need to rejected. This unstable sample not included during the thermal conductivity test. Table 4.1 show the comparative result between the mixture of MER carbon nanotube with SDS and mixture of MER carbon nanotube with PVP.

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Synthesis of Carbon nanotube MER

Table 4.1 : Stability of nanofluid after 100 hours (MER and SDS)

sample	CNT(weight%)	PVP (weight%)	water (ml)	condition
NF001	0.10	0.0000	39.97647	unstable
NF002	0.10	0.0200	39.96855	unstable
NF003	0.10	0.0400	39.96063	unstable
NF004	0.10	0.0600	39.95271	unstable
NF005	0.10	0.0800	39.94479	unstable
NF006	0.10	0.1000	39.93687	unstable
NF007	0.20	0.0800	39.92126	stable
NF008	0.40	0.1600	39.84252	stable
NF009	0.50	0.2000	39.80315	stable
NF010	0.60	0.2400	39.76377	stable
NF011	0.80	0.3200	39.68503	stable
NF012	1.00	0.4000	39.60629	stable
NF013	1.20	0.4800	39.52755	stable
NF014	1.40	0.5600	39.44881	stable
NF015	1.50	0.6000	39.40944	stable
NF016	1.60	0.6400	39.37006	stable
NF017	1.80	0.7200	39.29132	stable
NF018	2.00	0.8000	39.21258	stable

Based on the Table 4.1 show the stability of nanofluid after 100 hours between the MER and SDS. There several parameter used in order to determine stability result of nanofluid. The first parameter used is density of CNT which is 1.7(g/cm^3). Secondly the density of SDS which is 1.01 (g/cm^3).Lastly, the volume of base water (dionized water) that has been used about 40 ml. The result show that the sample NF001, NF002,

NF003, NF004, NF005 and NF006 becoming unstable after been left for 100 hour at room temperature. For the rest sample is obviously stable and ready to be used for test the thermal conductivity. The number of sample is increase following the increment of the ratio between the CNT and PVP. Hence more increment of the ratio then the stability of the nanofluid is also increase. Refer to Appendix B, figure 5.1 show the condition of the stable sample and figure 5.2 show how stable sample is determine by using the stability test rig. On the other hand the figure 5.3 shown that the condition of unstable sample and figure 5.4 show that how the unstable sample is determine by stability test rig.

Table 4.2 : Stability of nanofluid after 100 hours (MER and PVP)

sample	CNT(weight%)	PVP (weight%)	water (ml)	condition
NF001	0.10	0.0000	39.9765	unstable
NF002	0.10	0.0200	39.9698	unstable
NF003	0.10	0.0400	39.9632	unstable
NF004	0.10	0.0600	39.9560	unstable
NF005	0.10	0.0800	39.9491	stable
NF006	0.10	0.1000	39.9432	stable
NF007	0.20	0.0800	39.9263	stable
NF008	0.40	0.1600	39.8526	stable
NF009	0.50	0.2000	39.8157	stable
NF010	0.60	0.2400	39.7788	stable
NF011	0.80	0.3200	39.7051	stable
NF012	1.00	0.4000	39.6314	stable
NF013	1.20	0.4800	39.5576	stable
NF014	1.40	0.5600	39.4839	stable
NF015	1.50	0.6000	39.4471	stable
NF016	1.60	0.6400	39.4102	stable
NF017	1.80	0.7200	39.3365	stable
NF018	2.00	0.8000	39.2627	stable

Based on the Table 4.2 show the stability of nanofluid after 100 hours between the MER and PVP. There several parameter used in order to determine stability result of nanofluid. The first parameter used is density of CNT which is 1.7(g/cm^3). Secondly the density of SDS which is 1.3 (g/cm^3).Lastly, the volume of base water (dionized water) that has been used about 40 ml. Hence the result show that the sample NF001, NF002, NF003 and NF004 becoming unstable after been leaved for 100 hour at room

temperature. For the rest sample is continuously stable and ready to be used for test the thermal conductivity. Same goes with the factor that influence the result for (MER VS SDS) as the number of sample is increase following the increment of the ratio between the CNT and PVP. If there are more increment of the ratio the stability of the nanofluid is also increase.

4.1.1 Thermal Conductivity

After all the stable samples are obtain we need to use an equipment which is KD2-Pro to determine the thermal conductivity of all those sample. This experiment need to use three different temperature for this test which is 6°C, 25°C and 45°C. The different temperature used is because we need to determine how does the thermal conductivity change according to the change of the temperature. Table 4.3 show the thermal conductivity of nanofluid according to the different temperature used.

Table 4.3: Thermal Conductivity for (MER and SDS)

Sample	Thermal Conductivity (W/m.K) for temperature		
	6°C	25°C	40°C
NF009	0.594	0.605	0.673
NF010	0.582	0.602	0.687
NF011	0.586	0.605	0.692
NF012	0.59	0.608	0.645
NF013	0.598	0.611	0.699
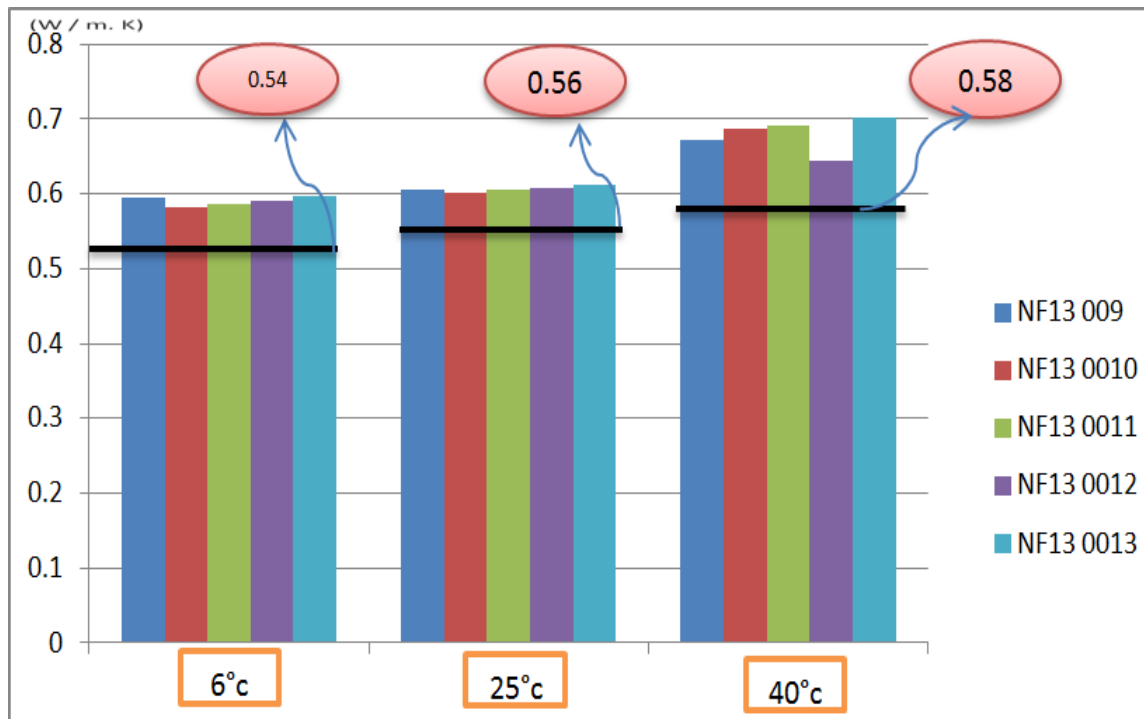
Figure 4.1: Thermal Conductivity Graph for (MER and SDS)

Based on Figure 4.1, the standard value for thermal conductivity is differ at each temperature. The thermal conductivity for deionized water at 6°C is 0.54 W/m.K, 25°C is 0.56 W/m.K and 40°C is 0.58 W/m.K According to the result the highest thermal conductivity at 6°C is sample NF013 with 0.598 W/m.K and followed by sample NF009 with 0.594 W/m.K .The lowest thermal conductivity at 6°C is sample NF010 with 0.582 W/m.K and second lowest is sample NF011 with only 0.586 W/m.K. At 25°C, the highest thermal conductivity is sample NF013 with reading is 0.611 W/mK and the lowest is sample NF010 with 0.602 W/m.K. While at the highest temperature testing 40°C, same goes with other temperature the sample NF013 once again shows tremendous result with the highest thermal conductivity with 0.699 W/m.K.

Table 4.4: Thermal Conductivity for (MER and PVP)

Sample	Thermal Conductivity for temperature		
	6°C	25°C	40°C
NF009	0.634	0.648	0.682
NF010	0.628	0.635	0.695
NF011	0.642	0.655	0.701
NF012	0.666	0.674	0.708
NF013	0.653	0.66	0.710
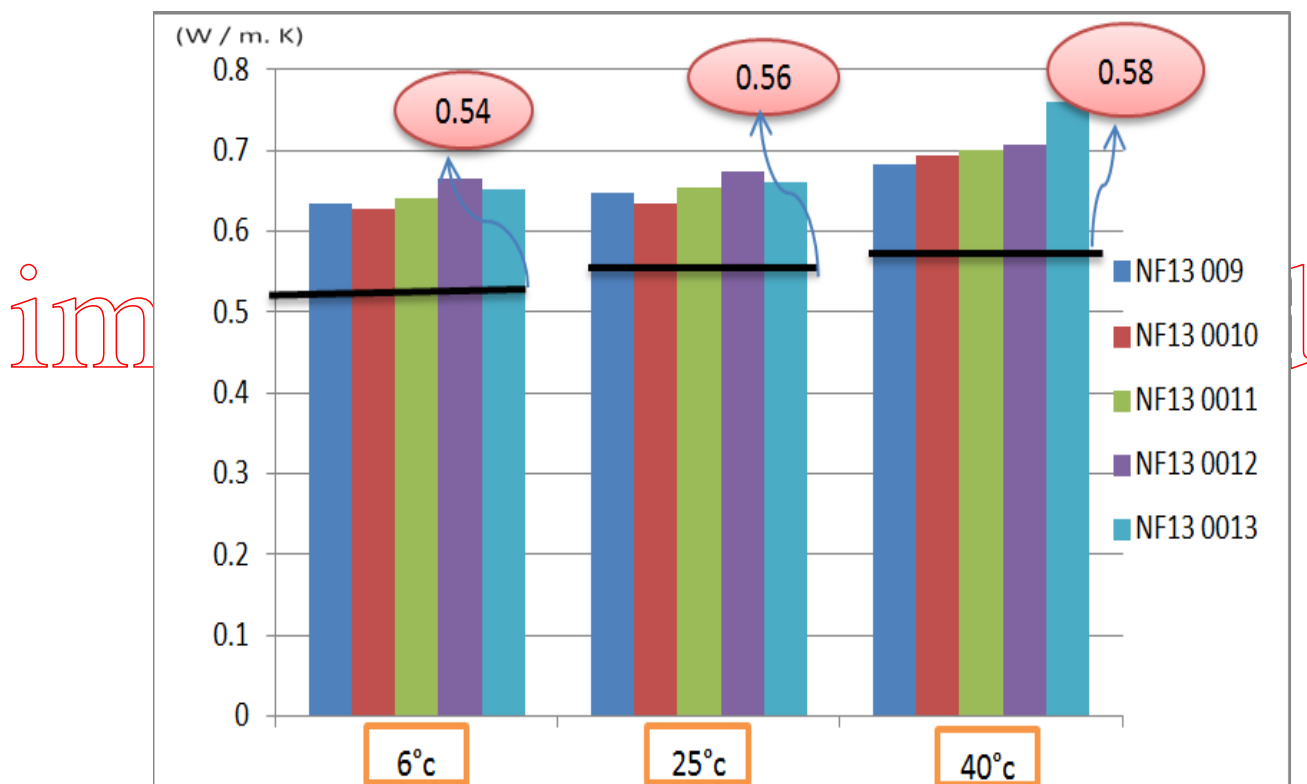
Figure 4.2 : Thermal Conductivity Graph for (MER VS PVP)

According to the Figure 4.2, highest thermal conductivity at 6°C is sample NF012 with 0.666 W/m.K and followed by sample NF013 with 0.653 W/m.K .The lowest thermal conductivity at 6°C is sample NF010 with 0.628 W/m.K. At 25°C, the

highest thermal conductivity is sample NF012 with reading is 0.674 W/m.K and the lowest is sample NF010 with 0.635 W/m.K. While at the highest temperature testing 40°C, there same different between the reading at temperature 6°C and 25°C where the sample NF013 has shows fabulous result with the highest thermal conductivity with 0.699 W/m.K compare with other sample.

4.1.2 Percentage of Enhancement of Thermal Conductivity

In order to get the percentage of enhancement of thermal conductivity, the thermal conductivity gain after carry on the experiment need to be compare to the actual thermal conductivity of deionized water according to appropriate temperature.

There is a formulation to get the accurate percentage of enhancement of thermal conductivity. The standard thermal conductivity for deionized water at 6°C is 0.54 W/m.K, 25°C is 0.56 W/m.K and 40°C is 0.58 W/m.K.

Percentage of enhancement

$$= \frac{\text{experimental thermal conductivity}}{\text{standard thermal conductivity}} \textbf{ X 100\% - (100\%).................Equation 4.1}$$

Table 4.5 : Percentage of enhancement of thermal conductivity for PVP

Sample	Percentage of enhancement of Thermal Conductivity W/m.K for temperature		
	6°C	25°C	40°C
NF009	17.4%	15.7%	17.5%
NF010	16.2%	12.1%	19.8%
NF011	18.1%	16.9%	20.8%
NF012	20.2%	20.3%	22.1%
NF013	20.3%	17.8%	22.4%

Based on the table 4.5 it show that the pattern of increment of thermal conductivity at three different temperature is quite systematically. The percentage of enhancement of the thermal conductivity is increase due to the increasing of temperature. At temperature 6°C the highest percentage enhancement of thermal conductivity is sample NF013 with 20.3% and the lowest is sample NF010 with 16.2%. Besides that at temperature 25°C the highest percentage enhancement of thermal conductivity is sample NF012 with 20.3% and the lowest is still the same which is sample NF010 with 12.1%. At temperature 40°C the highest percentage enhancement of thermal conductivity is sample NF013 with 22.4% and the lowest is sample NF009 with 17.5%. Sample NF013 at temperature 40°C has the best enhancement of thermal conductivity compare to other sample at each temperature.

4.2 Discussion

In this test, need to determine which dispersing agent is more better in order to help the carbon nanotube to disperse well in the water. There are two dispersing agent used which is Sodium Dodecyl Sulphate (SDS) and Polyvinylpyrrolidone (PVP). All sample need to undergo all the process such as homogenizing, ultrasonic and also pH level testing. After that all the sample will be test by using the stability testing rig and also by visual test. All the result had been recorded as shown in Table 4.1 and Table 4.2

4.2.1 Stability

According to the stability table a conclusion can be made which is the dispersion of carbon nanotube MER and PVP as dispersing agent is better then formation between MER and SDS. Obviously show that there are only four sample of MER and PVP have been rejected meanwhile there are six sample of MER and SDS have been rejected. There are several characteristic of PVP that help to increase the stability of nanofluid. Firstly the most efficient characteristic of PVP is very good solubility in water. Secondly this dispersing agent able to help improve adhesion between two substance which is deionized water and the carbon nanotube CNT. Apart from that, also has been proven by the researcher that this surfactant is non-toxic, odorless and chemically stable. While this experiment, only used a small amount of PVP will effectively stabilize the dispersion and suspension process. The most important characteristic of PVP that made it more better that SDS is it produce less foam and bubble during the circulation process in any of application. Formation of foam and bubble will lead to the cavitations which produce the bad consequent such as wear , tear and rust.

4.2.2 Thermal conductivity

Refer to the thermal conductivity graph for Figure 4.1 (MER and SDS) and Figure 4.2 (MER and PVP) a conclusion can be made which is the thermal conductivity of the nanofluid is increase according to the increment of the temperature used. Temperature 40°C have the higher thermal conductivity compare to other temperature. This happen because, hence the heat is applied to the matter that has mass the particle will vibrate. Same with this case, the particle of nanotube will move faster and more particle will collide toward each other at 40°C compare with other temperature. On the other hand, the increment of the CNT also one of the most vital factor that effect the thermal conductivity to rising up. The particle nanotube is very efficient in thermal conductivity due to their unique structure. The carbon nanotube has large surface area and will easily exposed to the heat. So when the weight percentage of CNT and dispersing agent increase the thermal conductivity also increase. High increment of the thermal conductivity will give the high percentage of enhancement of thermal conductivity that will giving a lot of benefit. This nanofluid is more efficient than water and should replace it in a cooling system and be the important cooling agent.

4.2.3 Comparison of carbon nanotube (CNT)MER and Nanoamor

Table 4.6 : Stability of nanofluid (Nanoamor and SDS) and (Nanoamor and PVP)

sample	Condition for SDS	Condition for PVP
NF001	stable	stable
NF002	stable	stable
NF003	stable	stable
NF004	stable	stable
NF005	stable	stable
NF006	stable	stable
NF007	stable	stable
NF008	stable	stable
NF009	stable	stable
NF010	stable	stable
NF011	stable	stable
NF012	stable	stable
NF013	stable	stable
NF014	stable	stable
NF015	stable	stable
NF016	stable	stable
NF017	stable	stable
NF018	stable	stable

According to the result display in Table 4.6, it shown that all the sample from NF001 to NF018 is stable even after 100 hours. It obviously display that the CNT nanoamor is more better that CNT of MER. The reasons that this particular type of carbon nanotube is so capable of producing a very impressive result of stability is because it has an OH functional group which made it more easy to be interact with the water molecule around. Apart from that the CNT of nanoamor only require less amount

of dispersing agent to produce a stable nanofluid compare to the other carbon nanotube that does not has OH functional group. Then this CNT also need less adhesion force from dispersing agent to create a special bonding with the water structure. Hence the stability of the nanofluid not only influence by the present of good dispersing agent but also due to the good of carbon nanotube.

4.2.4 Comparison of carbon nanotube (CNT) MER and Pyrograf

Table 4.7: Stability of nanofluid (Pyrograf and SDS) and (Pyrograf and PVP)

sample	Condition for SDS	Condition for PVP
NF001	unstable	stable
NF002	unstable	stable
NF003	unstable	stable
NF004	stable	stable
NF005	stable	stable
NF006	stable	stable
NF007	stable	stable
NF008	stable	stable
NF009	stable	stable
NF010	stable	stable
NF011	stable	stable
NF012	stable	stable
NF013	stable	stable
NF014	stable	stable
NF015	stable	stable
NF016	stable	stable
NF017	stable	stable
NF018	stable	stable

Based on the Table 4.7 only sample NF001, NF002 and NF003 for formation between Pyrograf and SDS have been rejected and all the rest sample is perfectly stable. Type of carbon nanotube also effect the stability and thermal conductivity of nanofluid. So the result will slightly difference between the different uses of CNT. The pyrograf is has been proven better then MER due to the type of structure they made up. MER consist of multi-walled nanotube (MWNT) but the pyrograf consist of carbon fiber. The

advantage of pyrograf is the length of the tube and it have surplus value compared to MER. The length of tube may affect the stability and thermal conductivity of each nanofluid in term of dispersion and absorption. The longer the tube the higher of increasing the stability and thermal conductivity will produced. In fact the longer of the carbon nanotube the large surface area of it. So in term of dispersion the CNT will able to disperse well the based water without any problem. For absorption process the CNT will expose more to the heat because the large surface are they have.

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CHAPTER 5

CONCLUSION

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5.0 Conclusion

As a conclusion the nanofluid is really important in the heat transfer process due to the excellent thermal conductivity. CNTs and dispersing agents also play their vital role in order to ensure the nanofluid is stable. The large surface area of CNT will increase enhancement of thermal conductivity and stability of nanofluid. Excellent stability of nanofliud is due to the protective role of dispersing agent. Hence there are really a good relation between the CNT and dispersing agent in order to produce the stable nanofluid. The objective is successfully achieved in order to determine the stability of nanofluid by using the SDS and PVP as dispersing agent. So it proven that the PVP is more better that SDS in term of stability and also in term of thermal conductivity. This is because PVP has efficient characteristic such as good solubility in water and effectively stabilize the dispersion and suspension process.

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APPENDIX A

Sample Calculation

1. Sample calculation for volume of water for 40 ml :-

    Density of CNT (g/cm^3) : 1.7   CNT %   : 0.04

    Density of SDS (g/cm^3) : 1.01   PVP % : 0.008

    $$Volume \ = \frac{Weight\ percentage}{Density}$$

    volume of CNT = 0.04/1.7 = 0.0235 m^3

    volume of SDS = 0.008/1.01 = 0.00792 m^3

2. Sample Calculation for Percentage Enhancement of Thermal Conductivity

    Thermal conductivity of water at 6°C = 0.54W/m.K

    Thermal Conductivity of nanofluid at 6°C = 0.594W/m.K

    $$\frac{0.594}{0.54}X100\% = 110\%$$

    $$110\% - 100\% = 10\%$$

APPENDIX B
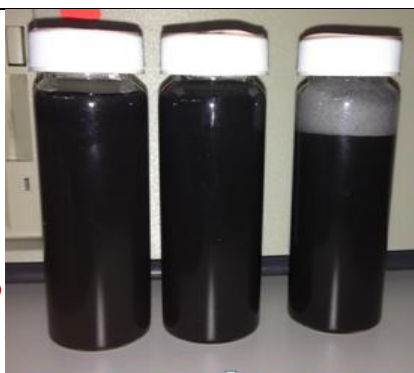
Figure 5.1 Stable sample

Figure 5.2 Show how stable sample is determine
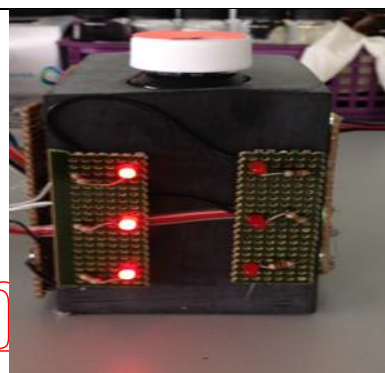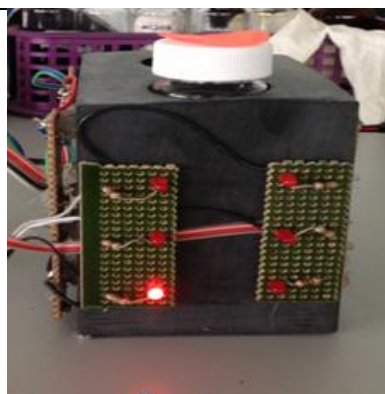

Figure 5.3 Unstable sample

Figure 5.4 Show the sample is unstable

Figure 5.5 Weighing the CNT

Figure 5.6 Adjustable temperature of water bath

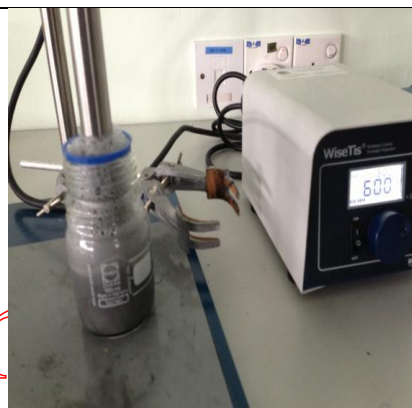Figure 5.7 Comparison between CNT MER and Pyrograf

Figure 5.8 SDS produce foam during homogenizing

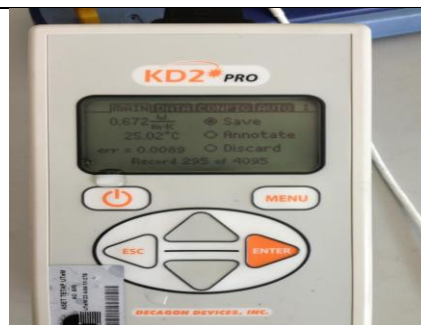Figure 5.9 Use parafilm to cover the surfactant from split

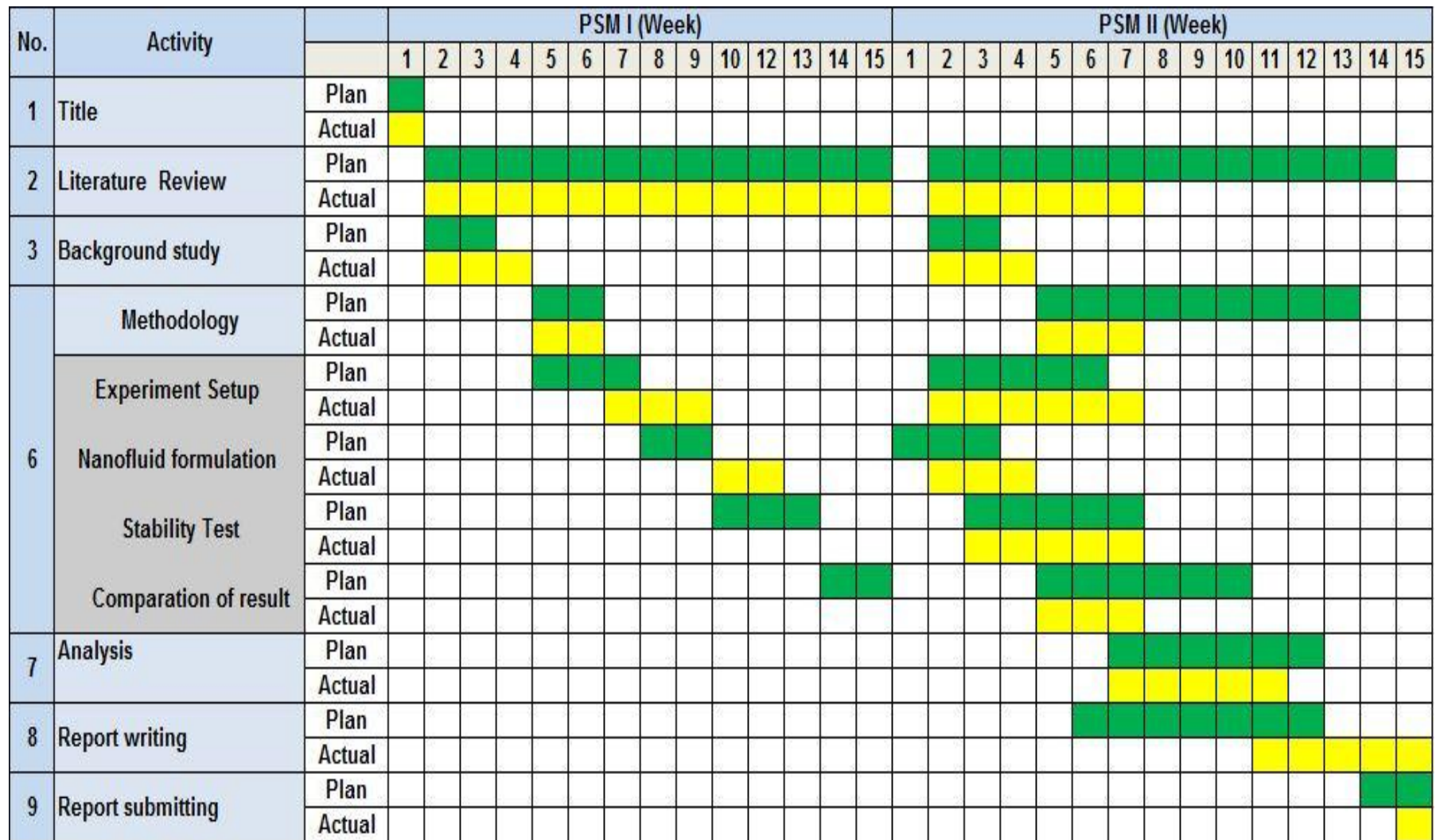Figure 5.10 KD2 Pro use to take thermal conductivity reading

No.	Activity		PSM I (Week)														PSM II (Week)													
			1	2	3	4	5	6	7	8	9	10	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Title	Plan	G																												
		Actual	Y																												
2	Literature Review	Plan		G	G	G	G	G	G	G	G	G	G	G	G	G		G	G	G	G	G	G	G	G	G	G	G	G	G	
		Actual		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y								
3	Background study	Plan		G	G													G	G												
		Actual		Y	Y	Y												Y	Y	Y											
	Methodology	Plan					G	G													G	G	G	G	G	G	G	G	G		
		Actual					Y	Y													Y	Y	Y								
6	Experiment Setup	Plan					G	G	G									G	G	G	G	G								
		Actual							Y	Y	Y							Y	Y	Y	Y	Y								
	Nanofluid formulation	Plan							G	G								G	G	G										
		Actual										Y	Y					Y	Y	Y										
	Stability Test	Plan								G	G	G							G	G	G	G								
		Actual																Y	Y	Y	Y	Y								
	Comparation of result	Plan													G	G			G	G	G	G	G							
		Actual																Y	Y	Y										
7	Analysis	Plan																			G	G	G	G	G	G				
		Actual																			Y	Y	Y	Y	Y	Y				
8	Report writing	Plan																				G	G	G	G	G	G			
		Actual																										Y	Y	Y	Y	Y
9	Report submitting	Plan																													G	G
		Actual																														Y

Figure 5.11 Gantt Chart fot PSM 1 and PSM 2

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