THE STUDY OF OIL SPILLAGE CLEAN UP USING POLYMERS

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons) Petrochemical Engineering

Faculty of Engineering and Green Technology

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22nd September 2015

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree award at UTAR or other institutions.

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ABSTRACT

Oil spills have been a major concern for people around the world. It causes damage not only to the environment but also the health of human and the living of aquatic animals. Many oil spillage clean-up methods have been used to solve this problem. For example, the usage of booms and skimmers, chemical dispersant and natural break down of oil via biodegradation process. But all these lead to solid waste disposal problems. In recent years, researchers have focused on using polymers to absorb the oil in a spill. Having the properties of oleophilicity and hydrophobicity, polymers can be utilized to absorb oil at a high rate.

In this study, PMMA and PVC powders are used to test the oil sorption capacity. Fuel oil is used to resemble an oil spill phenomenon. Both these polymers are analysed using SEM (Scanning Electron Microscope) and FTIR (Fourier Transform Infrared Spectroscopy). The SEM analysis shows that polymer can absorb oil via the surface porosity into the capillary network. The FTIR analysis shows the functional groups that have been absorbed during the sorption process. Other than that, oil sorption capacity test is performed to understand the oleophilicity and hydrophobicity properties of polymers.

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LIST OF ABBREVIATIONS

PMMA	Poly (Methyl Methacrylate)
PVC	Poly Vinyl Chloride
SEM	Scanning Electron Microscope
FTIR	Fourier Transform Infrared Spectroscopy
KBr	Potassium Bromide
Wt	Total weight of oil and polymer (g)
Wp	Weight of polymer (g)
Wc	Weight of container (g)

CHAPTER 1

INTRODUCTION

1.1 Background of Study:

The Earth contains large reserves of oil and gas. Some of the oil and gas seeps through the cracks in which these reserves develop. This rarely causes any harm or damages to the nature. But there are times when human interference causes the same problem. In long run, this can harm the marine ecosystems of the world. (Conservation Institute, 2013)

In recent years, people over the world have considered seriously about oil spills. When there is an oil spill, it not only affects the environment but also to human being and aquatic animals.

Oil spill is a phenomenon where liquid petroleum is discharged into the surrounding by means of vehicles, pipeline or vessels. This can happen in large scales especially in large water bodies' area such as oceans. The cause of this is human negligence and leads to major form of pollutions. However, there are many sources of spills. Tankers on land can release crude oil. (Conserve-Energy-Future, 2013)

Waste oil from large scale industries or even well refined petroleum also can experience oil spills and their effects. Many considerations have to be analysed before carrying out the clean-up operations.

Oil spill can cause fatal damage to plants, animal and human life. The toxic substance in the oil can cause massive loss of species that live in the sea. Oil spill penetrates into the plumage and fur of birds, breaks down the insulating capabilities of feather which makes them heavier, disallow them to fly and kill them via poisoning or hypothermia.

Even though people and organizations around the world have taken much public attention towards oil spills, its occurrence have increased tremendously over the past few decades ever since the beginning of industrial revolution. (Conservation Institute, 2013)

There are many clean-up methods for oil spills such as the use of boom and skims. The boom works by slowing down the dispersion of oil. Generally, there are 3 different kinds of boom. Hard boom made from plastic, which is circular in shape and floats on top of water. It is weighted at the bottom. Sorbent boom is made of polymers which can absorb oil. Fire boom is very rarely used. (Conserve-Energy-Future, 2013)

In this research, polymers such as PMMA and PVC will be used to analyse the oil sorption capacity, surface morphology, absorption of polymers in water, and also the different functional groups affecting the sorption of oil.

1.2 Problem Statement:

Oil spills can be initiated by human interference, either a cause of mistake or being careless, equipment breaking down, natural disasters such as hurricanes, deliberate acts by terrorists, countries at war, vandals, or illegal dumpers.

Sometimes, oil sinks in freshwater, but this happens occasionally. Oil usually spreads out rapidly across the water surface to form a thin layer. This layer is called an oil slick.

When the oil continues to spread, the layer becomes thinner and thinner, finally becoming a very thin layer called a sheen, which resembles a rainbow. Depending on the circumstances, oil spills can be very harmful not only to marine birds and mammals but also aquatic animals.

To overcome the problems associated with oil spills in a cost effective way and prevent the problems that could probably arise from clean-up methods of oil spills, polymers have the capacity to absorb oil and it will be used in this research work for analysis.

The purpose of this study is to evaluate the oil sorption capacity of polymer so that polymers can be used as an alternative to conventional oil clean-up methods directly solving the solid waste disposal problems.

1.3 Project Objectives:

1) To evaluate and compare the oil sorption capacity of polymer used.
2) To evaluate the surface characteristics of polymer particles.
3) To study the oleophilicity and hydrophobicity of polymer. .

1.4 Project Outline:

Chapter 1:

- Introduction of oil spill, its causes and effects. Background of the study. Problem statement which leads to the objectives of this study.

Chapter 2:

- Literature review about the conventional oil spill clean-up methods. The recent development of using polymers to absorb oil in large water bodies.

Chapter 3:

- The project methodology including the preparation of oil and polymer samples, types of testing such as SEM and FTIR analysis.

Chapter 4:

- Results analysis via experimental approach. Discussion of the properties of polymers examined on the oil sorption capacity.

Chapter 5:

- Summary of this study and future recommendations to improve the experimental approach and analysis to get a better understanding on the properties of polymers in adsorbing oil.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

Oil spillage is a phenomenon where liquid petroleum hydrocarbons are accidentally released into the environment, usually during transportation of oil. The term oil spillage is generally referred to the release of oil in large bodies of water. But other than aquatic environment, oil sills can take place on land was well. The clean-up of oil spill especially in oceans where ship sinks or leakage occurs in pipeline can be a long term project. The longer the oil floats on water, the greater its impact to the environment.

Birds are one of the creatures impacted by oil spills. Oil can sink into and reduce the functionality of bird feathers. A bird's feathers provide insulation for extremely low temperatures. When their feathers are filled with oil, its insulation capability wouldn’t be effective. The oil also makes it difficult for birds to fly in the air. Therefore, they become more vulnerable to animals for prey. Birds tend to rub the feathers against their body sometimes in their beaks to clean themselves. (Conservation Institute, 2013)

Most birds affected by oil spills die when there are no proper protections. Many organizations work to save these animals. These animals face the same consequences when their fur is contaminated by oil. Engineers are called upon to come up with planned solutions in advance before the occurrence of a spill, or to customize systems based on a specific event.

Oil spillage can affect plants and animals via two ways, either from the oil or from clean-up operations. By understanding both these types of impacts, it will enable them to recover much more quickly.

Spilled oil can harm living things because its chemical constituents are poisonous. This can affect organisms both from internal exposure to oil through ingestion or inhalation and from external exposure through skin and eye irritation. Oil can also smother some small species of fish or invertebrates and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures. (Conserve-Energy-Future, 2013)

Since oil is less dense than water, the oil floats on water and the creatures most affected by oil are animals like sea otters and seabirds which are found on the sea surface or on shorelines. During most oil spills, seabirds are harmed and killed in greater numbers than other kinds of creatures. Other creatures, such as snails, clams, and terrestrial animals may suffer if the oil remains on the beach for a longer time.

It is important to understand the types of oil spill. The difference in oil type affects the environment in a variety of way. Animals and birds are affected differently by different types of oil. (Hernandez, 2015)

Generally, there are 2 types of oil, "light" and "heavy" oils. "Light" oil are volatile, meaning that under certain conditions, they tend to evaporate relatively quickly. If there is a spillage occur involving "light" oil, they will decompose in the air. Certain type of the "light" oil can ignite or explode. Others such as gasoline and diesel can be very toxic. They can kill animals or plants that they come in contact with them.

On the other hand, very "heavy" oils such as bunker oils, which are used to fuel ships, have a black appearance and may be sticky for a time until they weather sufficiently. But in a condition where they are not removed, even they can persist in the environment for months or even years. While these oils can be very persistent, they are generally significantly less acutely toxic than lighter oils. Instead, the short-term threat from heavy oils comes from their ability to smother organisms whereas over the long-term, some chronic health effects like tumors may result in some organisms. (Opet.com.tr, 2015)

Birds may die of hypothermia, a term used to describe the loss of its ability to keep them warm. The same consequences happen if sea otters become oiled. After days or weeks, some heavy oils will harden, becoming very similar to an asphalt road surface. In this case, heavy oils will be less harmful.

Medium oils will last for some amount of time in the environment and have different degrees of toxicity. In a nutshell, the effects of any oil depend on where it is spilled, where it goes, and what animals and plants, or people, it affects.

2.2 Oil Spill Clean-up Methods:

1. **Usage of Booms and Skimmers:**

- Booms are long tubes used to contain the oil spills so that it does not spread out and affect other parts of water. Usually booms are installed 1.5 meter from the water surface. There are skirts which are fixed to the booms hanging inside the water. Other the other hand, skimmers functions as a collector to accumulate all the contaminated oil. These oils are transferred to a storage tanks via tubes and piping. The disadvantage of using booms and skimmers is that due to the flow of winds in oceans, its efficiency and effectiveness if reduced. (LawyerShop, 2015)

2. **The use of chemical dispersants.**

- Chemical dispersants are used to accelerate biodegradation processes. However, its usage can be toxic and affect aquatic animals. The chemicals from dispersants and also the oil which is broken down can be a great harm when it enters the food chain of organisms. (LawyerShop, 2015)

3. **The addition of biological agents**

- Without any addition of chemical or biological substances, the breaking down of oil can happen naturally. This process is called biodegradation. This cause of this process is bacteria and microorganisms. Fatty acids and carbon dioxide is produced from this process. These substances are less harmful compared to the contaminated oil. The addition of fertilizing nutrients can accelerate the rate of oil break down. (LawyerShop, 2015)

4. Natural Break down of oil

- Oil can disperse or decompose naturally if its possibility of harming the environment is low. Light oil can evaporate quickly under strong wind or high atmospheric temperature. (LawyerShop, 2015)

A major setback of using skimmers and booms is that it difficult to decompose. A new study utilizes plastic materials from polymers as a step toward to solve the oil spill problem. The absorption capacity of oil-SAP is 40 times its weight in oil. Adding on to that, it can be returned to a refinery for reprocessing of the collected oil into useful products like gasoline, diesel, and other hydrocarbon-based chemicals. (Materials360online.com, 2015)

The technology which has been used has not effectively clean up oil spills. Researches opted for a different approach while discovering 2 main advantages of polymers to absorb oil. Firstly, there is no pollution. Secondly, the materials used for clean-ups are inexpensive. (Hernandez, 2015)

Researchers have been able to use divinylbenzene to synthesize *x*-OS-DVB, a polyolefin terpolymer from the reaction between styrene, an aromatic and 1-octene, an aliphatic molecule. This copolymer works by absorbing almost 40 times its weight in oil via swelling. Besides that, the polymer does not absorb any water along the process. This corresponds to the polymer hydrophobicity properties. If a sorbent material absorbs water together with the oil, further processing such as heating is necessary to remove the water. Water absorption also causes the weight of polymer to increase. As a result, after absorbing the oil, the polymer does not float on water, it tends to sink underwater. This study has been published in Energy & Fuel (ACS publication).

The purpose of using monomers from aliphatic and aromatic to produce a polymer is to resemble the composition of oil. The effective bonding between polymer and oil can also be improved. Generally, polymer which have more amorphous region compared to crystalline region have higher absorption rate. The copolymer produced from styrene and 1-octene has this key characteristic. Polymers such as polypropylene having a higher crystalline region will not be able to absorb oil effectively. This is because the structure does not allow any diffusion between the polymer chains. The reaction between styrene and 1-octene improves the oil diffusion process because free volumes are formed between the polymer chains.

The copolymer is prevented from dissolving in oil because divinylbenzene crosslinks the aliphatic and aromatic molecules. The degree of crosslinks is indirectly proportional to the amount of oil being absorbed. By decreasing the crosslinks, oil absorption and swelling can be maximized. However, it is important to have a certain degree of crosslinks between polymer chains to have a better control on its solubility. This can be done by synthesizing polymers having high molecular weights. Ziegler-Natta catalyst is used to bind the monomer to form a long polymer chain. The resulting polymer has homogenous distribution with increased molecular weight. (Materials360online.com, 2015)

Researchers have done multiple tests to prove that oil-SAP is able to absorb 4 times the amount of oil absorbed by polymer like polypropylene sheets. This is because by using the sheets, absorbing process only occurs on the polymer surface. It does not enter the polymer matrix. The characteristic of oil-SAP such as high rate of absorption, high rate of oil recovery, and high oil sorption capacity makes it a suitable alternative in oil spill clean-ups compared to the conventional methods. (Opet.com.tr, 2015)

CHAPTER 3

PROJECT METHODOLOGY

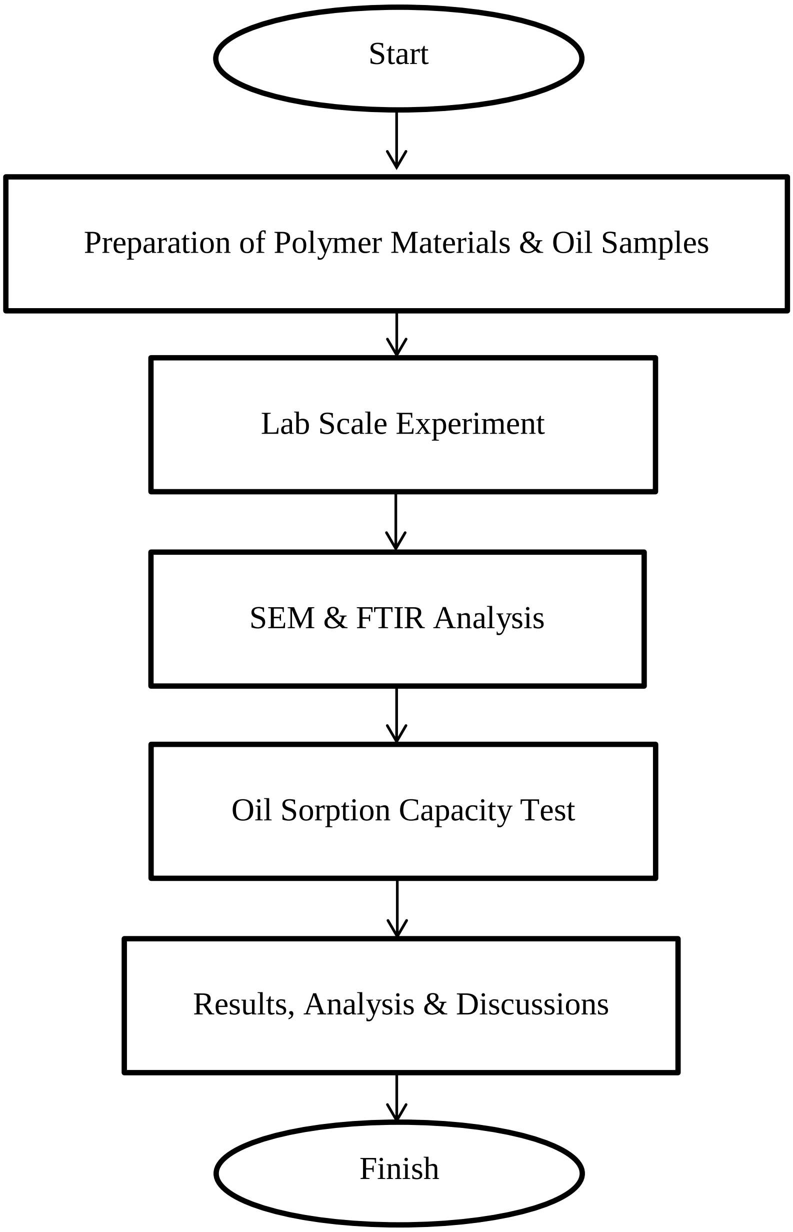

Figure 3.1 : Project Flowchart

3.1 Polymer Materials Preparations:

The polymers which are used in this research project are PMMA and PVC. These polymers are obtained in powder form to increase its efficiency in experimental approach because of its higher surface area compared to polymers in sheets or pellets form. Approximately 0.5600g of polymers was used for the SEM, FTIR and oil sorption capacity test respectively. The powders are made sure to be completely dried without any moisture in it. To ensure this, the polymers were put in the oven for 1 hour at 60 ^{o}C.

3.2 Preparation of Oil Samples:

Fuel oil (Gasoline 95) was collected from available local fuel station. Assuming that this fuel resembles the oil in a spillage, it has low boiling point which and be evaporated easily in ambient temperature or under sunlight. Therefore the oil is kept in a bottle and closed tightly. The table below shows the specifications of the fuel used.

Table 1: Fuel Oil Specifications (Gasoline 95)

Characteristic	**Value**	**Unit**
Appearance	Clear & Bright	
Density (@15 ℃)	720-775	kg/m ^{3}
Vaporization percentage @100 ℃	46-71	% volume
Vaporization percentage @150 ℃	75	% volume
Final boiling point	210	℃
Oxidation stability	360	Minute

3.3 Experimental Approach:

The batch reactor set up was performed in the laboratory scale assisted by the lab officer. The batch reactor consists of 1 litre beaker with 200ml of water. Then, 50ml of fuel oil (Gasoline 95) is added without any purification to represent an oil spill scenario. A sample of PMMA with weighted amount is added to the system. The beaker is then taken outside of the laboratory and is placed in open environment under the sunlight. This is to resemble an oil spill phenomenon in large water bodies such as the ocean. The sample is kept for 2 hours to ensure proper sorption process.

After that, the sample is brought to the laboratory. A forceps and spatula is used to take the solid polymer after adsorption and placed in a test tube for SEM, FTIR and oil sorption capacity test. Following this, 4 samples were prepared and the procedures were repeated. Once all 5 samples are prepared, the procedures are again repeated using PVC powder instead of PMMA. Therefore, 10 samples are prepared for further analysis.

3.4 Scanning Electron Microscope (SEM) Analysis:

All 10 samples prepared are run tested for surface morphology and porous surface of polymers using the scanning electron microscope analysis. Polymer powders before and after the oil sorption were analysed using SEM to compare their microstructure change. Since the samples are moist with oil, it is kept in the oven for 2 hours at a temperature of 60 ^{o}C. To this to ensure that the samples are completely dry before analysis. SEM magnificent of 1000X, 5000X, 20 000X and 40 000X is set for all the samples.

3.5 FTIR Spectrum Analysis:

Minimal weighted quantity of PMMA powder is mixed with KBr Powder. It is then grinded for approximately 5-10 minutes. The powder is then placed in a die with a circular shape. The die with the powder is pressed to form a circular pellet. The transparency of sample is important to allow the infrared beams to pass through the sample for analysis. If the sample is opaque, the grinding process is repeated until a transparent pellet is obtained.

Opaque pellet becomes an obstacle for infrared beam to pass through and resulting in poor spectra. The pellet is then put in a clipper to begin analysis. The procedure is repeated for the different sorbent materials. The FTIR spectrum is obtained for PMMA powder before adsorption. This procedure is repeated using PVC powders. After the samples are dried in the oven, each samples after absorption was analysed suing the same procedure mentioned above. The comparison of peak intensity and amount of hydrocarbons absorbed are further discussed.

3.6 Equations and Parameters:

The amount of oil absorbed (g)

$= [W_t – W_p – W_c] / W_p$

Where,

W_t = Total weight of oil and polymer (g)

W_p = Weight of polymer (g)

W_c = Weight of container (g)

CHAPTER 4

RESULTS & DISCUSSION

4.1 SEM Analysis:

Scanning electron microscope (SEM) analysis was performed on both the samples before and after absorption. Microstructure images of samples are produced by scanning it with a focused beam of electrons. Signals are detected when these electrons interacts with the atoms in particles. The signal contains information on the surface topography and the samples composition. The specimens can be observed at high or low vacuum conditions.

The polymers samples of PMMA and PVC are made sure to be completely dry before running it through SEM analysis. To have a better study on the surface morphology, the analysis were performed at 1000X, 5000X, 20 000X and 40 000X magnifications. Figures below shows the images obtained for SEM:

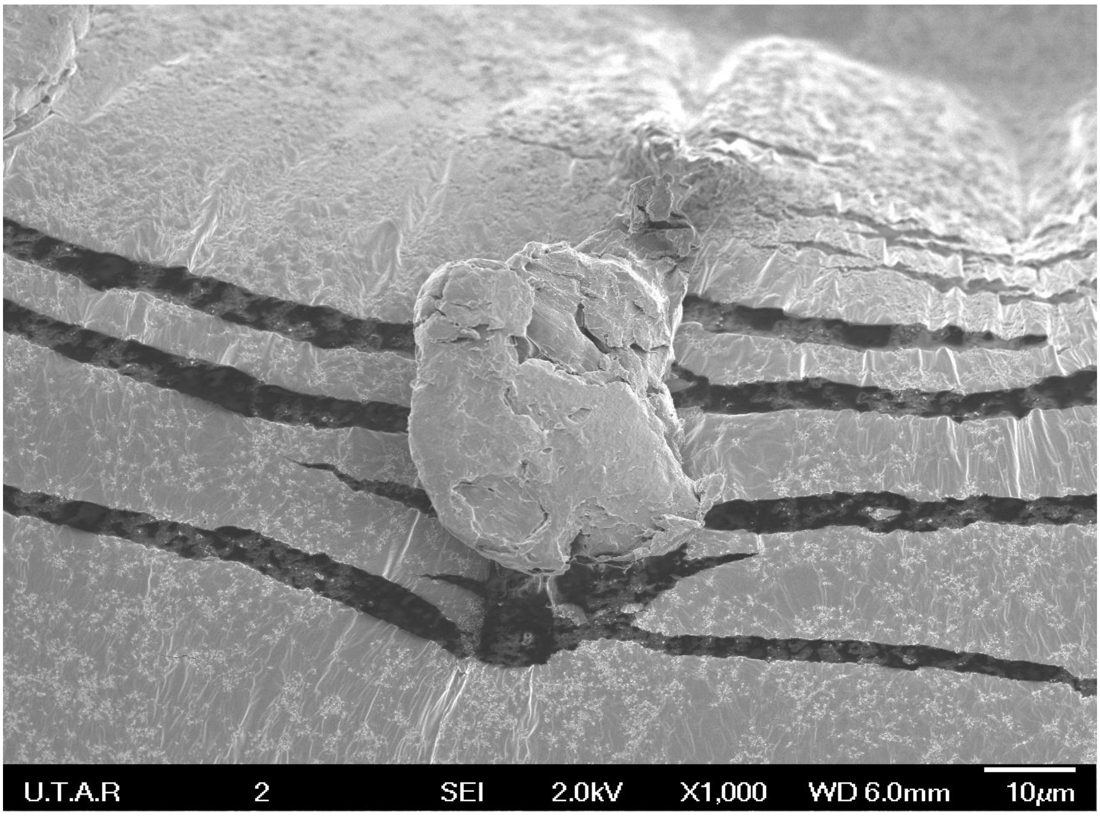

Figure 4.1 : SEM Image of PVC Before Adsorption at 1000X Magnification (T245)

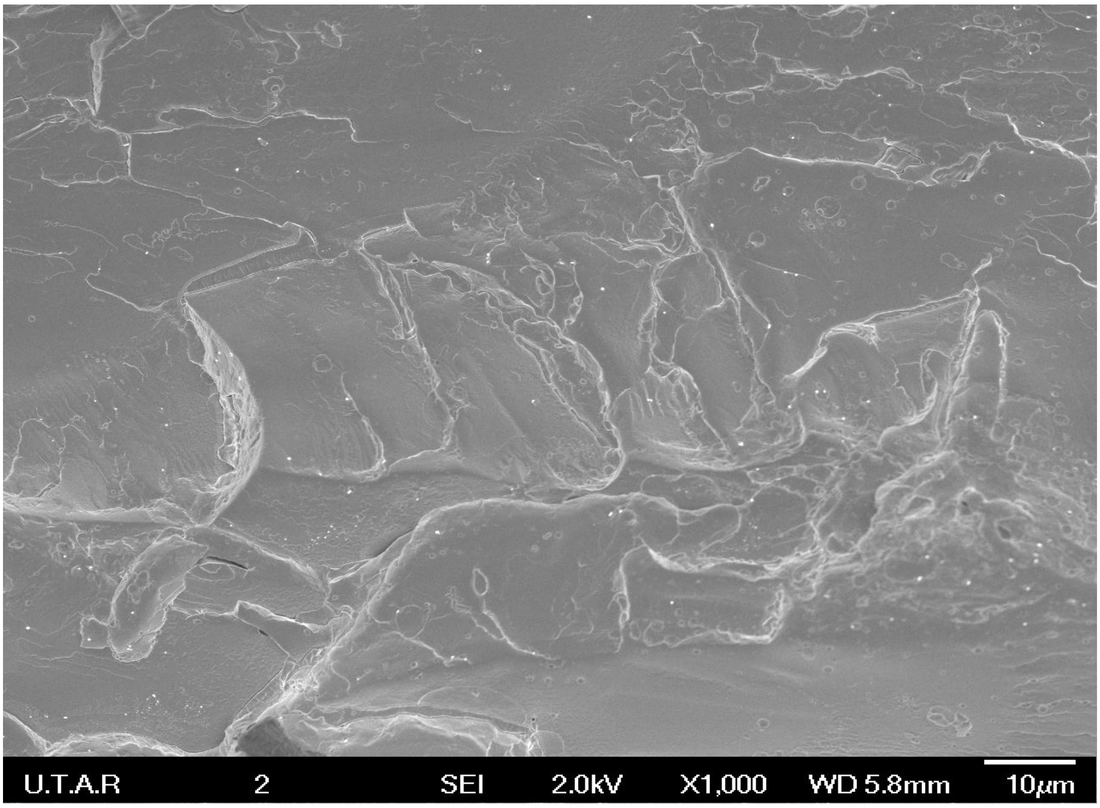

Figure 4.2 : SEM Image of PVC After Adsorption at 1000X Magnification (T246)

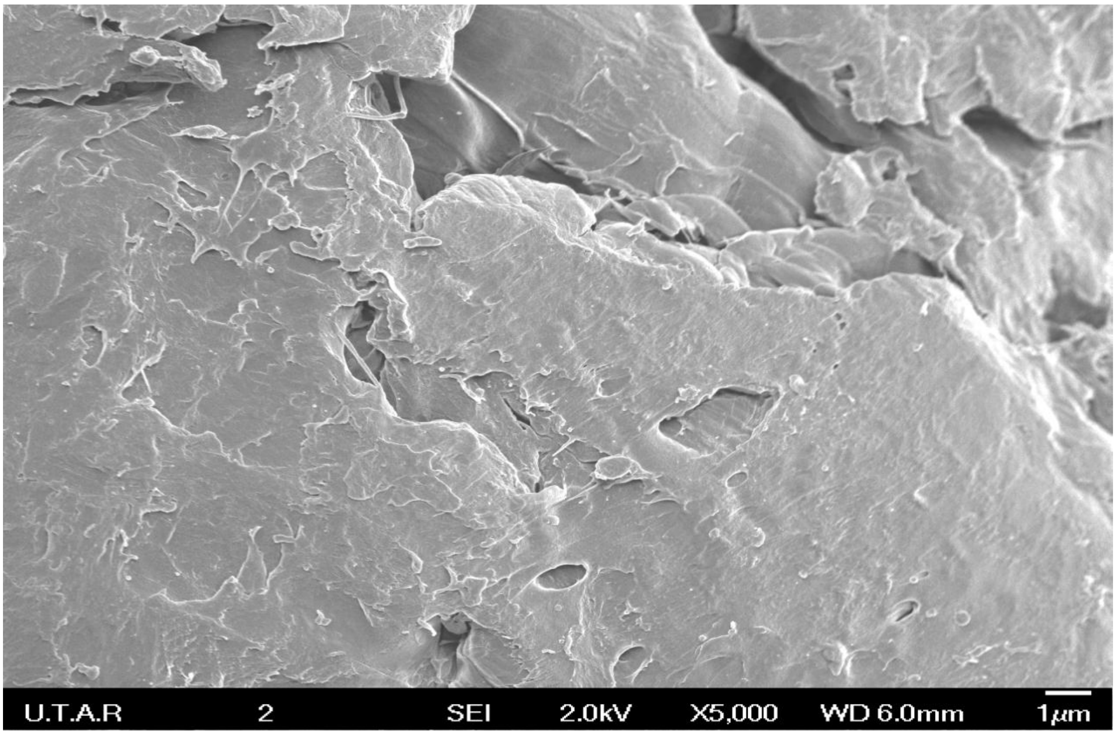

Figure 4.3 : SEM Image of PMMA Before Adsorption at 5000X Magnification (T246)

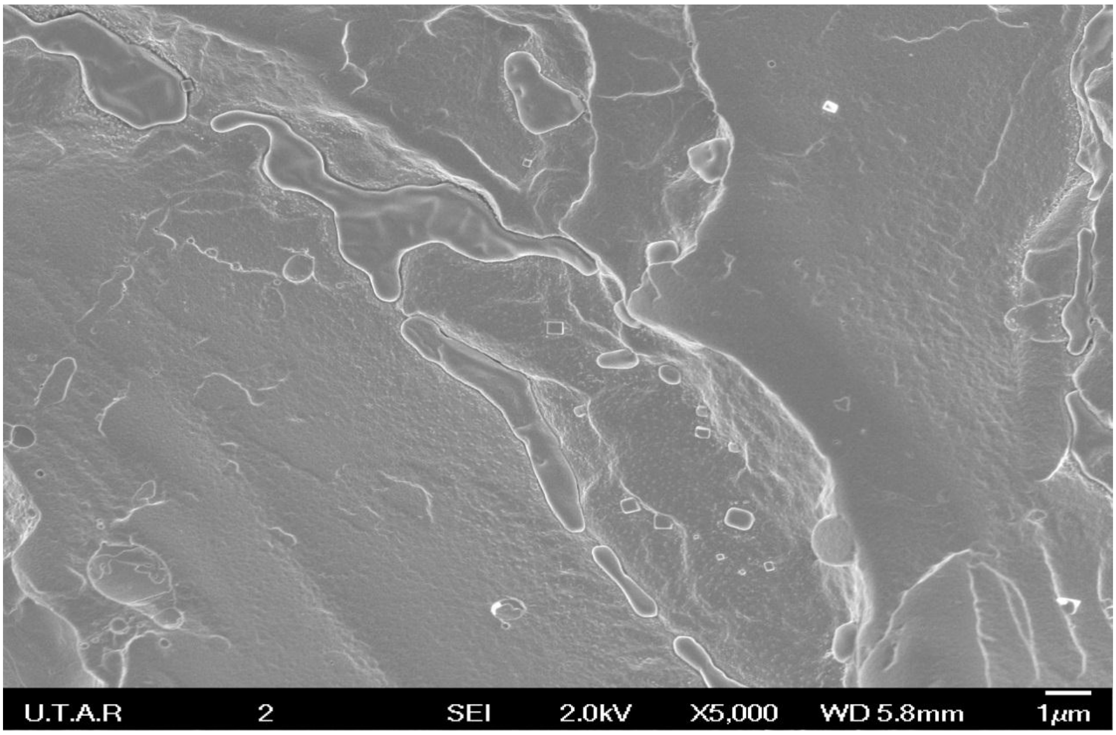

Figure 4.4 : SEM Image of PMMA After Adsorption at 5000X Magnification (T245)

Figure 4.1 shows the SEM micrographs of PVC powder before absorption. It can be seen that PVC powders exhibit groove structure characteristic before the absorption. Comparing the transparency or opacity of both analysed powders, PMMA powder shows more transparency compared to PVC powders. This explains that the microstructure of PMMA is less crystalline and contains higher percentage of amorphous region compared to PVC. The particle size of PMMA powder is smaller than that on PVC powder.

Figure 4.2 shows the SEM micrographs of PVC powder after absorption. It can be seen that deeper grooves are formed on the polymer surface. This indicates that the oil have been absorbed on the polymers causing swelling of the polymer particles. The oil adsorbed on the polymers could have forced the ongoing oil to be accumulated within the internal surfaces. (Saleem et al., 2015)

Figure 4.2 also shows some small protrusions attributed to captured oil spill droplets absorbed by scratches scattered on the PVC sheet surface. The surface of PVC is smoother after absorption indicating its large capability to soak up oil.

4.2 FTIR Analysis:

The Fourier Transform Infrared Spectroscopy *(*FTIR*)* analyses the different functional groups present in the particle of material. This technique is used to obtain and absorption, transmittance or emission of particles. The purpose of any absorption spectroscopy is to measure the efficiency of sample to absorb light at specific wavelengths. (Techniques, 2015)

A beam containing many frequencies of light is shined at once. The amount of beam that is absorbed by the sample is measured. The beam is then modified to obtain a different combination of frequencies. This arises a second data point. This process is repeated multiple times. (Techniques, 2015)

Typically, an ideal beam splitter transmits and reflects 50% of the incident radiation. Some materials or sample tested have limited range of optical transmittance. Therefore, several beam splitters are used interchangeably to cover a wide range of spectral. The splitters are usually made of KBr with a germanium-based coating that makes it semi-reflective. KBr absorbs strongly at wavelengths beyond 25µm ($400 cm^{-1}$). (Saleem et al., 2015)

Figure 4.5 and 4.6 shows the FTIR analysis of PMMA particles before and after oil adsorption respectively. Figure 4.7 and 4.8 shows the FTIR analysis of PVC particles before and after oil adsorption respectively.

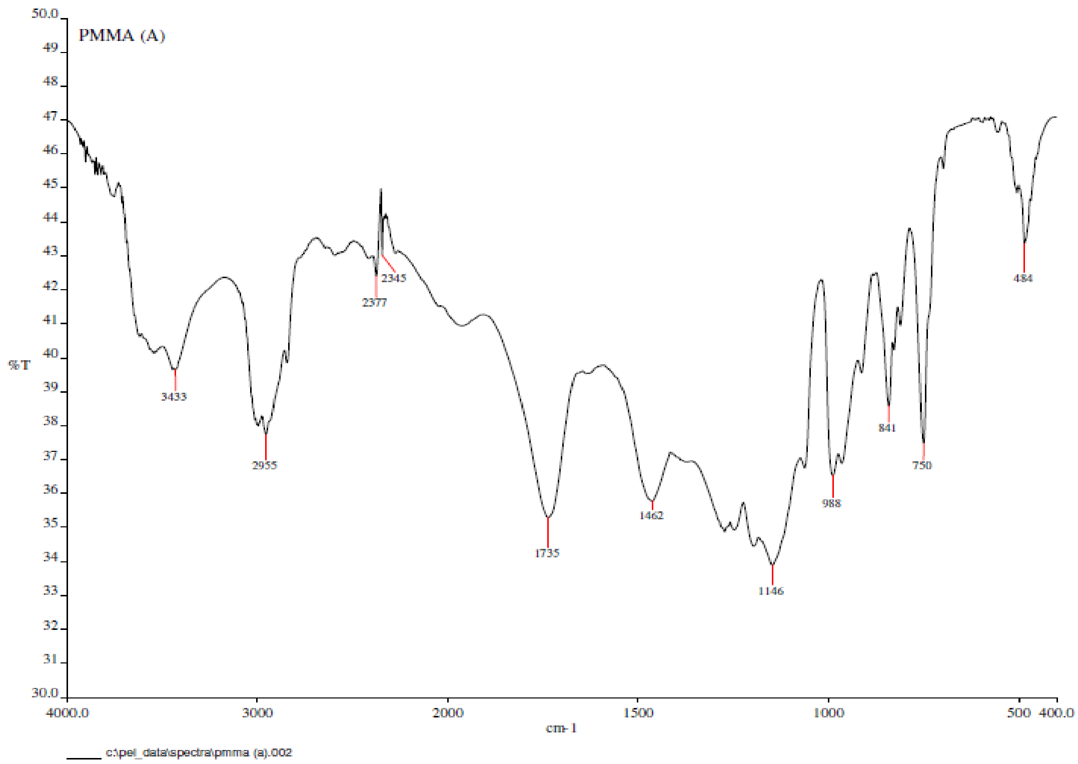

Figure 4.5: FTIR Analysis of PMMA Particles before Oil Adsorption

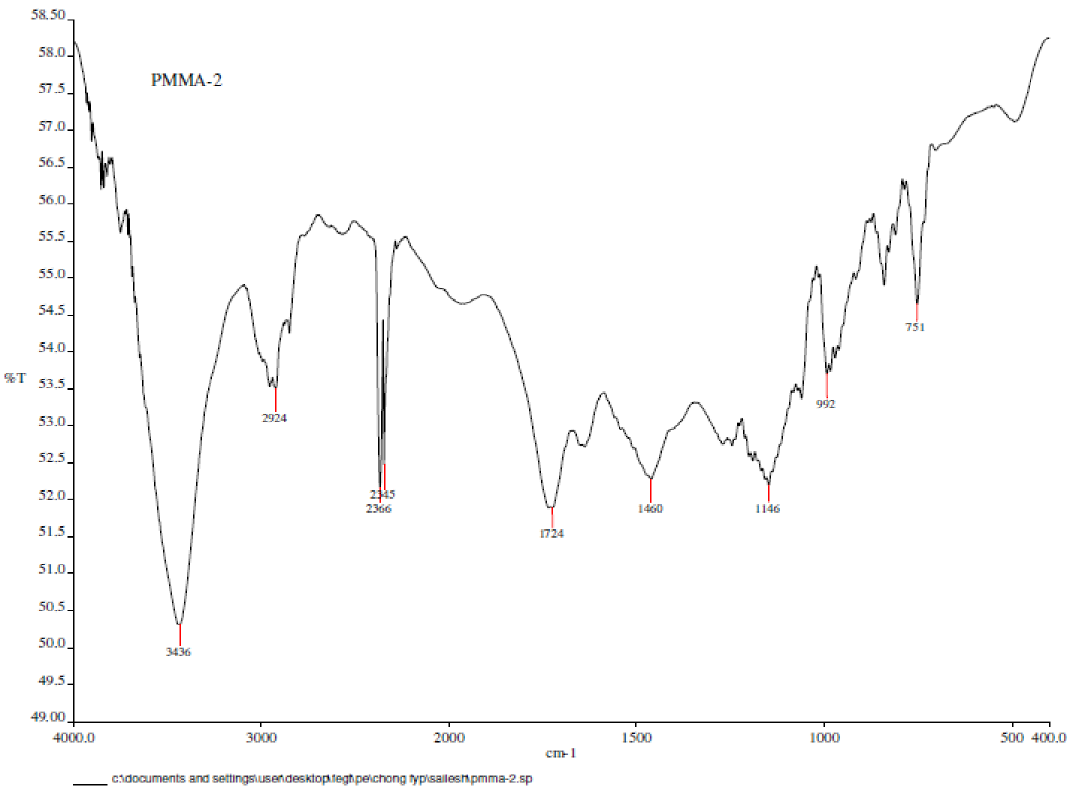

Figure 4.6 : FTIR Analysis of PMMA Particles After Oil Adsorption (Sample 2)

It can be seen that after the oil adsorption, the peaks are much steeper indicating the stretching of function groups present. At a frequency of 3436 cm-1, the bond present is N-H stretch with functional groups of primary, secondary amines and amides. At a frequency of 2345 cm-1, the bond present is C-H stretch with functional group of hydrocarbons. At a frequency of 2366 cm-1, the bond present is C-H=O stretch with functional group of aldehydes. These few peaks showed the largest intensity after the absorption. These values are obtained from the table of Infrared Absorption characteristic available in the appendix. This clearly shows that the polymers have absorbed amines, amides, hydrocarbons and aldehydes groups during the absorption process.

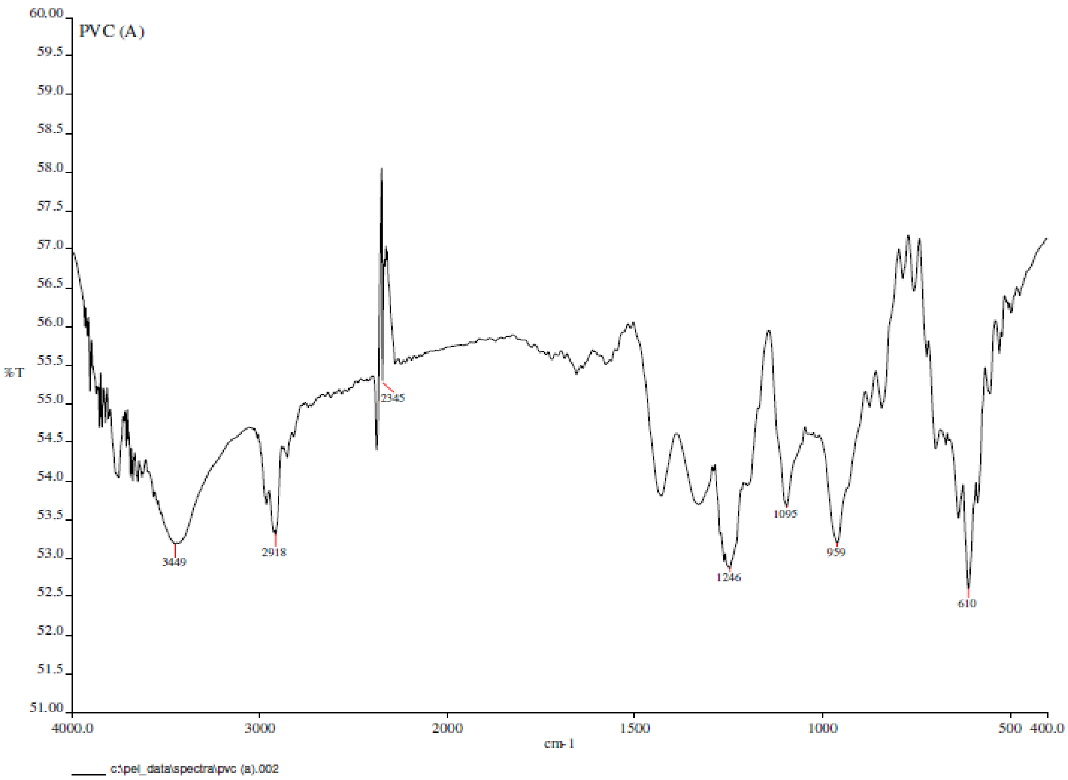

Figure 4.7 : FTIR Analysis of PVC Particles Before Oil Adsorption

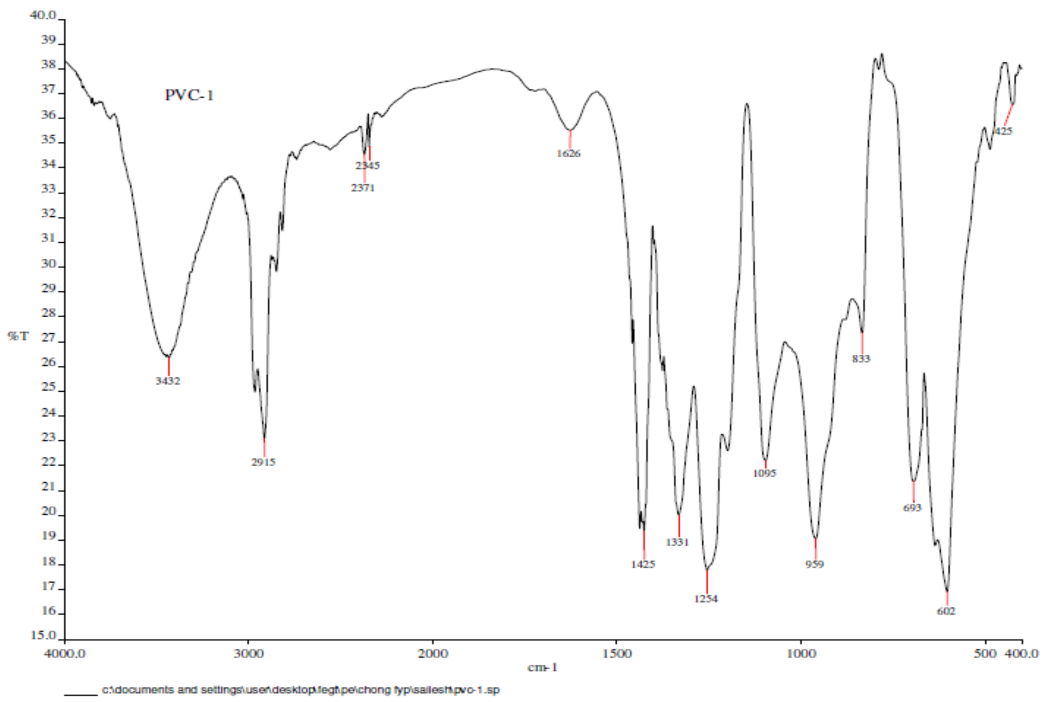

Figure 4.8 : FTIR Analysis of PVC Particles After Oil Adsorption (Sample 1)

Compared to the FTIR spectrum of PMMA particles, the spectrum for PVC particles shows larger intensity after the adsorption. At a frequency of 3434 cm-1, the bond present is N-H stretch with functional groups of primary, secondary amines and amides. At a frequency of 2915 cm-1, the bond present is C-H stretch with functional group of hydrocarbons. At a frequency of 1254 cm-1 1095 cm-1, the bond present is C-N stretch with functional group of aliphatic amines. At a frequency of 959 cm-1, the bond present is =C-H stretch with functional group of alkenes. At a frequency of 610 cm-1, the bond present is C-Br stretch with functional group of alkyl halides. These values are obtained from the table of Infrared Absorption characteristic available in the appendix. This clearly shows that the polymers have absorbed amines, amides, hydrocarbons, aldehydes, alkenes and alkyl halides functional groups during the absorption process.

4.3 Oil Sorption Capacity Test:

For the oil capacity test, approximately 0.5600g of PMMA and PVC powder were used in 200 ml of oil in a beaker. Table 2 shows 5 samples of PMMA powders before and after the oil sorption capacity test. Table 3 shows 5 samples of PVC powders before and after the oil sorption capacity test.

Table 2: PMMA Oil Sorption Capacity Test

	Sample	Before	After	Oil Absorbed
PMMA	1	0.5650	0.5960	0.031
	2	0.5600	0.5845	0.0245
	3	0.5500	0.5813	0.0313
	4	0.5649	0.5911	0.0262
	5	0.5600	0.5909	0.0309

Table 3: PVC Oil Sorption Capacity Test

	Sample	Before	After	Oil Absorbed
PVC	1	0.5600	0.5987	0.0387
	2	0.5630	0.5975	0.0345
	3	0.5690	0.6013	0.0323
	4	0.5678	0.5994	0.0316
	5	0.5680	0.6032	0.0352

From the oil capacity test using PMMA and PVC powders, the average oil adsorbed for PMMA was 0.02878g and for PVC was 0.03446g. Although the samples used for this research was minimal, the average oil adsorbed using both powder shows that PVC have higher capacity to adsorbed oil compared to PMMA. This was also proven in the FTIR analysis of both adsorptions where the intensity of peaks and the amount of functional group being adsorbed by PVS is higher compared to PMMA.

The oleophilicity and hydrophobicity of polymers are the 2 main properties in determining the oil sorption capacity. Other characteristics include high uptake capacity, buoyancy, retention over time and high rate of uptake of oil. (Yoneda, 2015)

Researchers have done study on the effect of different oil characteristic and the different type of sorbents affecting the sorption capacity. They concluded that different oil type and the weight to oil ratio of polymer used plays an important role in determining the oil sorption. Primarily, the pore size of particles and surface area of polymer are the key factors in oil sorption. Larger pore size increases the flowing rate of oil into the capillary network. (Yuan and Chung, 2012)

Oil which has high viscosity can absorb on the surface or polymer particle at a higher frequency. This is because they have a higher initial ratio. If the oil has high molecular weight, high viscosity and high specific gravity, it is able to pressure through the capillary network into the inferior of polymer particles. (Yuan and Chung, 2012)

The capillary penetration of oil into the small pores of particles is significantly affected by the viscosity of oil. This is proven from Darcy's law as well. When oil is more viscous, the pores may become obstructed decreasing the sorption capacity. Researchers analysed the effect of different materials and their microstructure on oil sorption and retention properties. (Yoneda, 2015)

Polymers such as PMMA exhibit superhydrophobicity and superoleophilicity. However, because oil-removing materials are easily fouled by high oil adhesion due to their oleophilic nature, the reusability of the polymers are limited by degraded separation or absorption capacity. (Yoneda, 2015)

In the case of water-removing materials, the wettability needs to be superhydrophilic; however, the polymer material needs to be superoleophobic underwater˙. The underwater superoleophobic interface with low affinity for oil drops prevents the polymer from oil fouling, which makes the oil and the polymer to be easily recycled. Polymers such as PMMA and PVC have both hydrophobicity and oleophilicity. (Yoneda, 2015)

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

The problems of oil spillage have become a very major concern for people around the world. This phenomenon affects not only the environment but also humans and aquatic animals. Many clean-up methods have been used for oil spills such as usage of booms and skimmers, chemical dispersants, additional of biological agents and lastly, the natural break down of oil. However, these methods lead to solid waste disposal problems.

A different approach have been focused on in recent years where polymers such as PMMA and PVC are used for oil spill clean-up because of its high sorption capacity, ease of disposal and reprocessing. Oil superabsorbent polymers have the capacity to absorb 40 times its weight to oil. The surface morphology of polymers after absorption was analysis using SEM. The surface becomes much smoother as a result from the oil being adsorbed on the pores of polymer particles. FTIR analysis was also performed showing the peak intensity and different types of functional groups being absorbed.

In order to improve the research results, differently types of polymers can be used to measure its oil sorption capacity. Polymer such as polypropylene, polystyrene and polyethylene might have a higher capacity to absorb oil because of its different functional groups and porosity. Other than that, nitrogen absorption analysis can be performed to have a better understanding on the surface morphology.

In this study, it is proven that the oleophilicity and hydrophobicity of polymers have high potential to absorb oil. Other than that, the surface characteristics such as porosity affect the oil sorption. The higher the porosity, the higher the oil intake via capillary actions. Thus, the objectives of this research have been verified successfully.

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APPENDICES

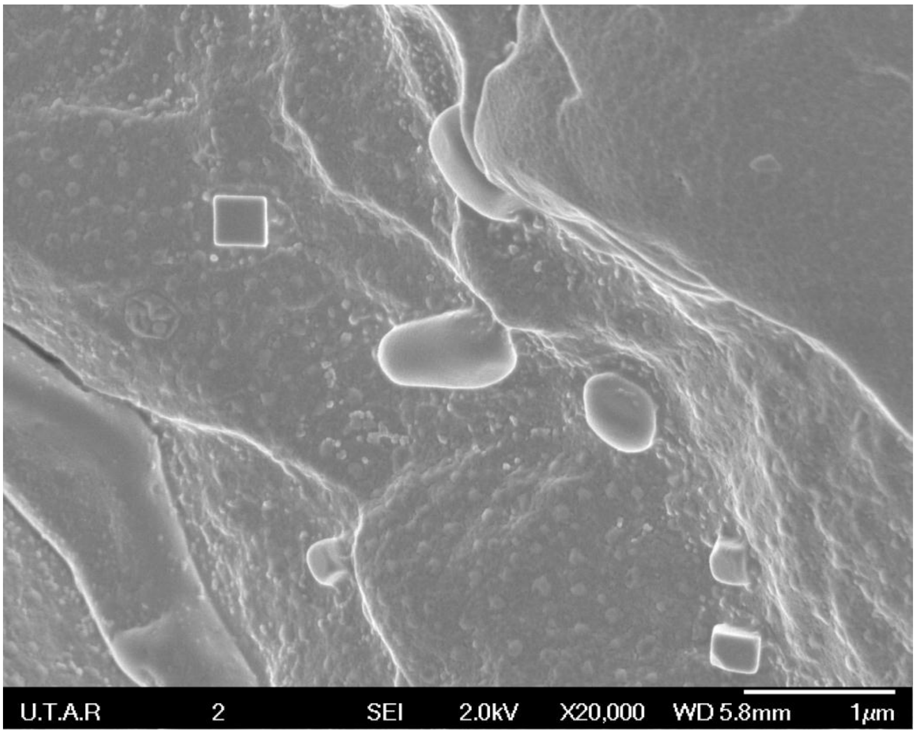

Figure 4.9: SEM Image of PVC Before Adsorption at 20 000X Magnification

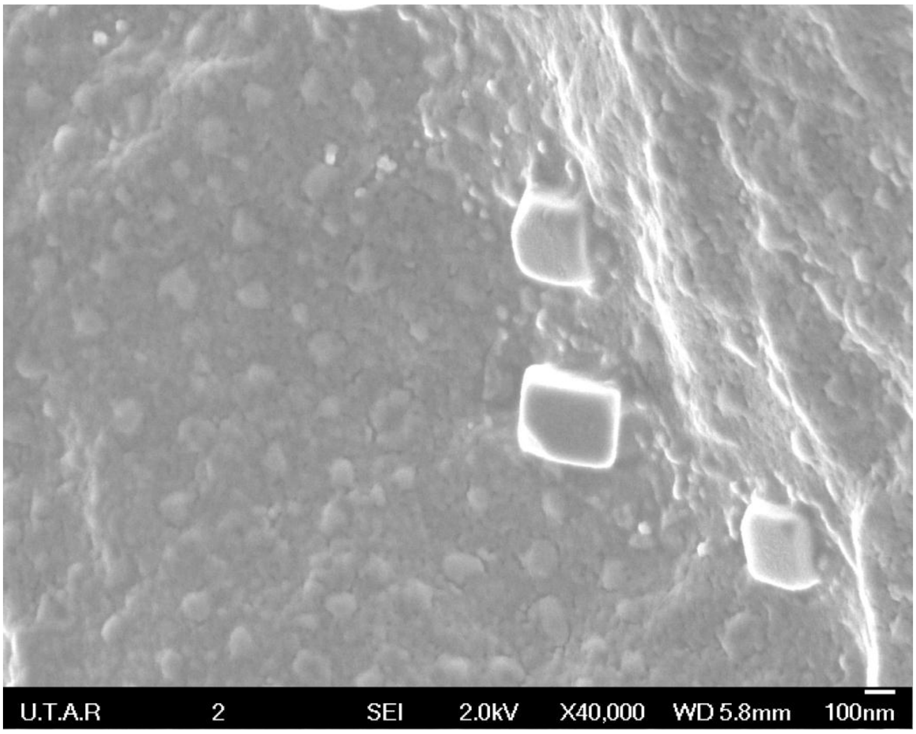

Figure 4.10: SEM Image of PVC Before Adsorption at 40 000X Magnification

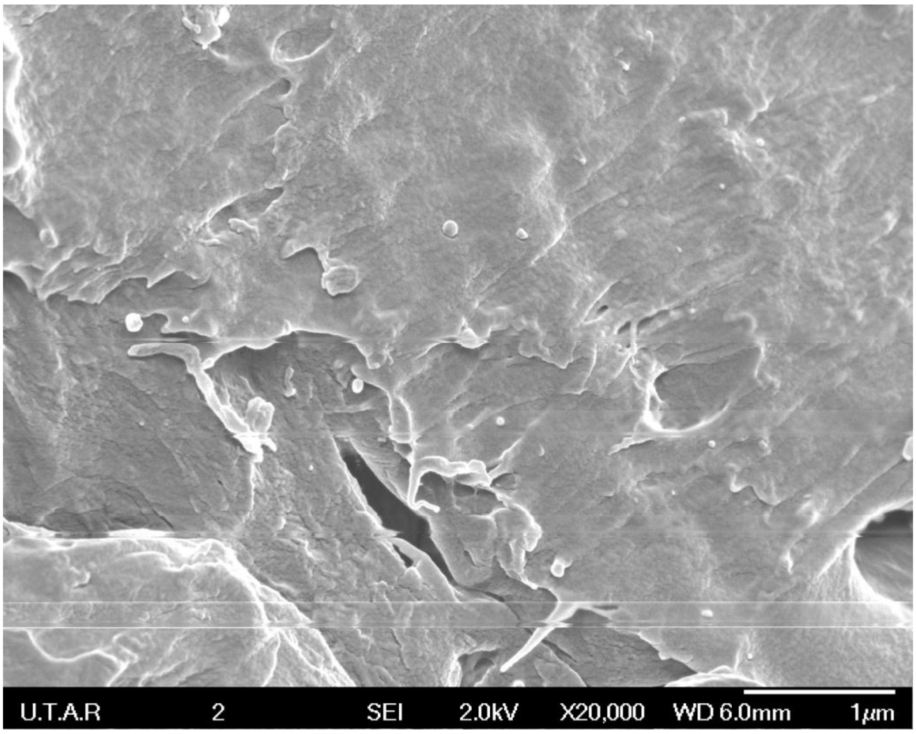

Figure 4.11: SEM Image of PMMA After Adsorption at 20 000X Magnification

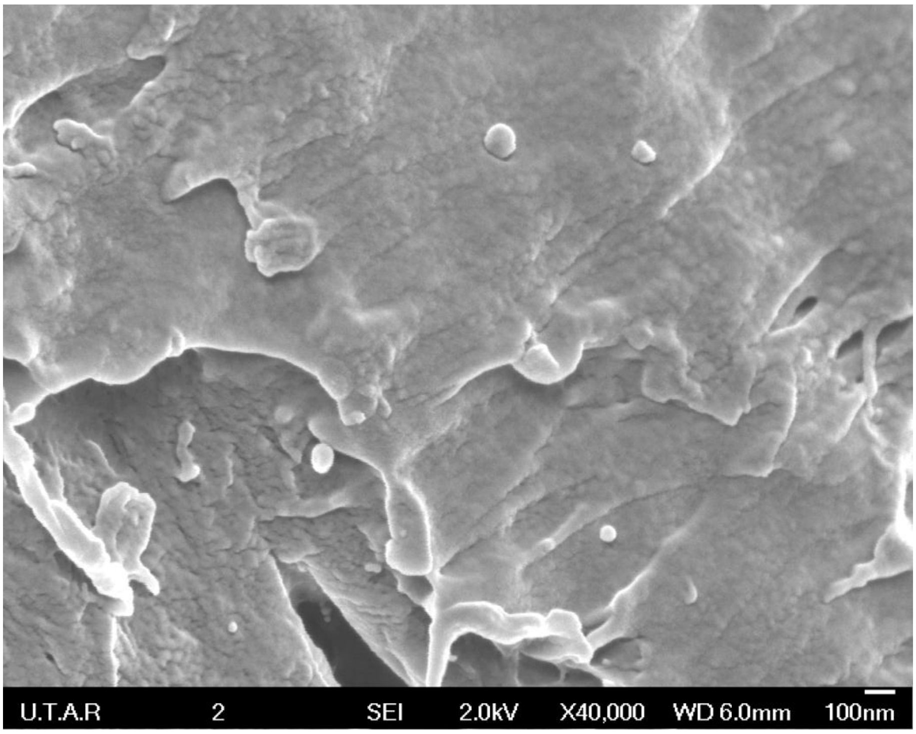

Figure 4.12: SEM Image of PMMA After Adsorption at 40 000X Magnification

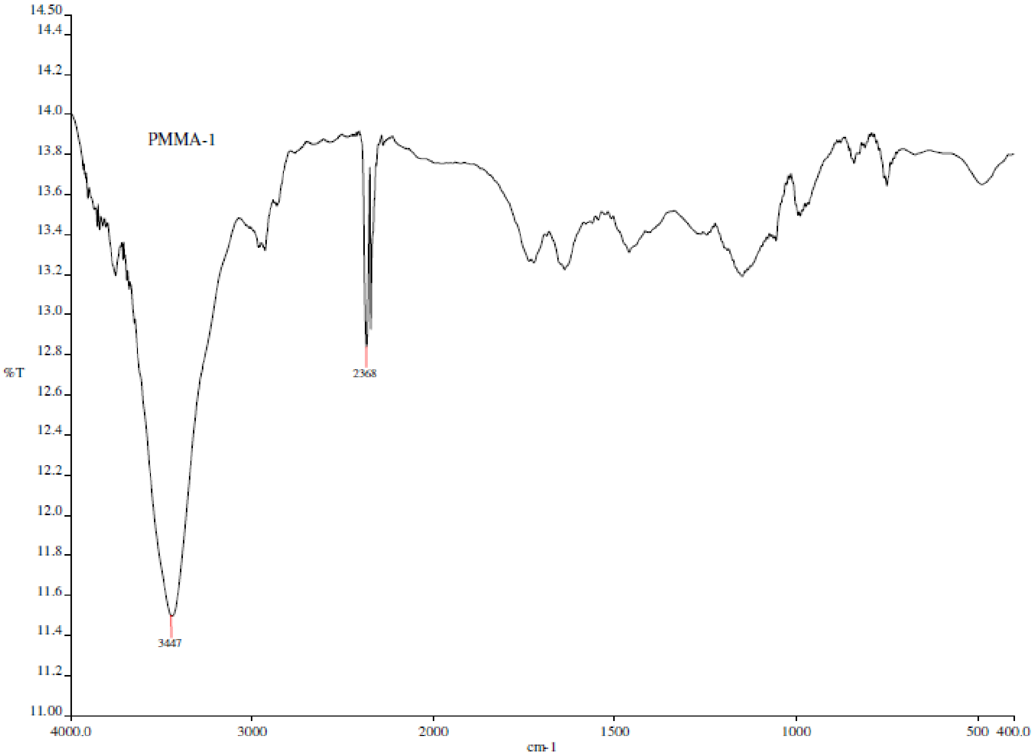

Figure 4.12: FTIR Analysis of PMMA Particles After Oil Adsorption (Sample 1)

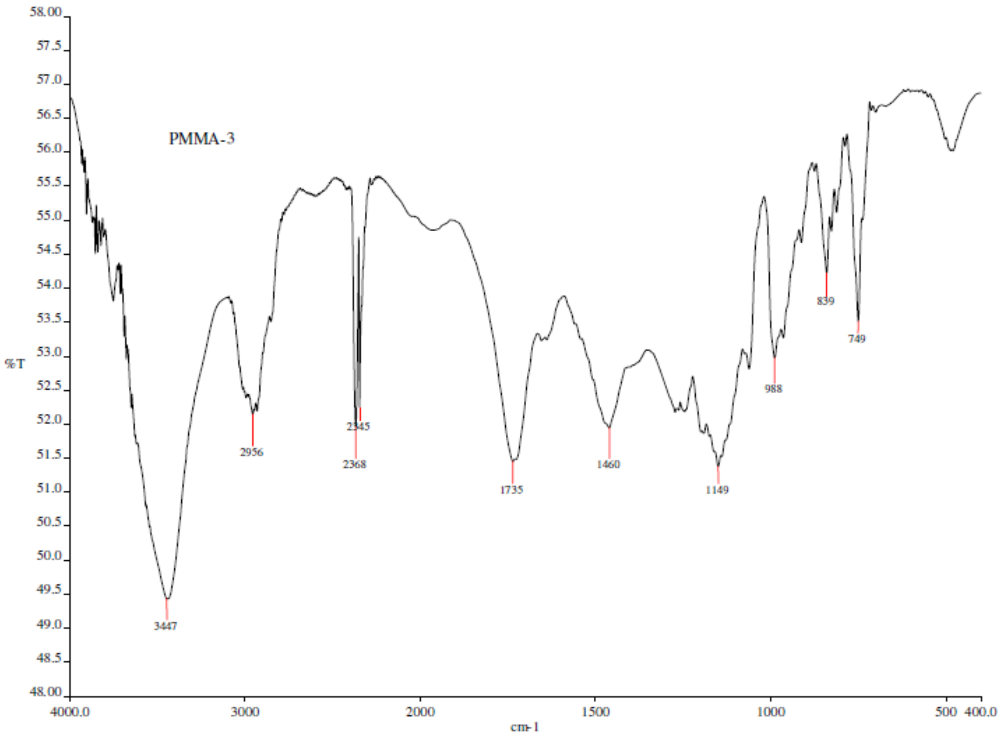

Figure 4.13: FTIR Analysis of PMMA Particles After Oil Adsorption (Sample 3)

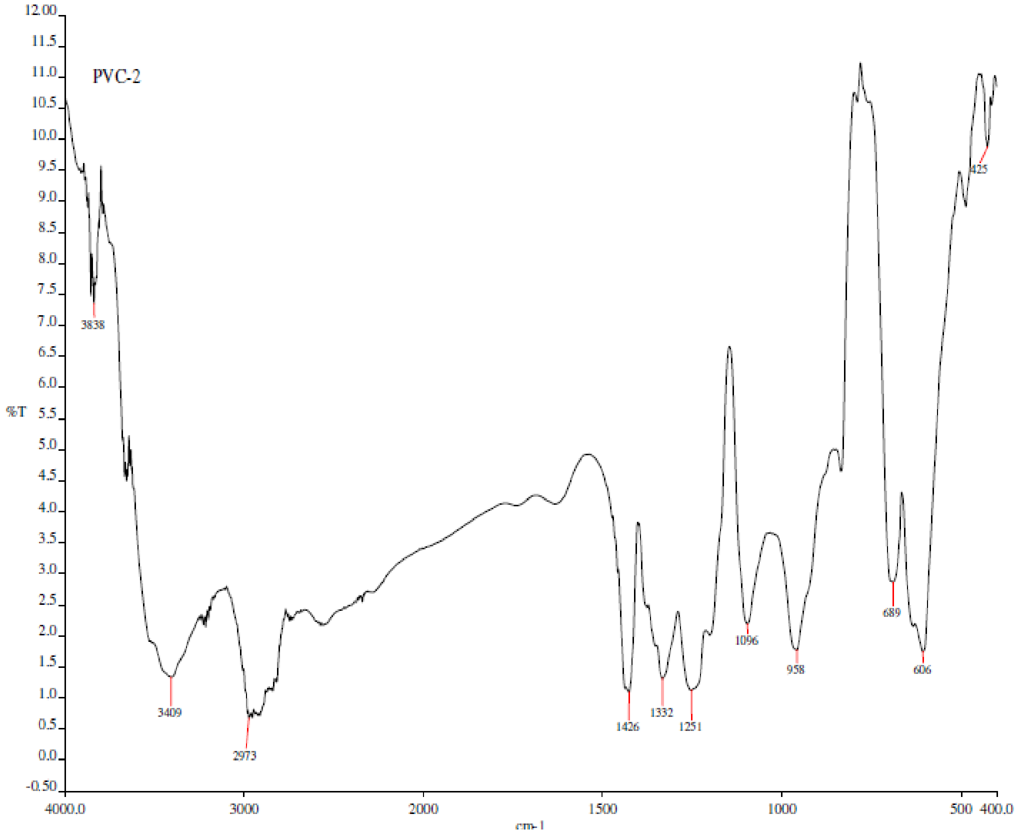

Figure 4.14: FTIR Analysis of PVC Particles After Oil Adsorption (Sample 2)