STUDY ON BONDING AND CHEMICAL PROPERTIES OF COASTAL PLASTICS WASTE

HELMY BIN MUHAMAD KHAIRI

A report submitted in partial fulfillment of the

requirements for the award of the degree of

Bachelor of Chemical Engineering

Faculty of Chemical Engineering & Natural Resources

University Malaysia Pahang

JANUARY 2012

ABSTRACT

The study was conducted to characterize the chemical and bonding properties of coastal plastics waste. Growing of economic, human activity and industrial procedure are resulting in the increased of the plastics wastes. Plastics waste generates cause major challenge in waste handling because of the varying properties due to degradation. Furthermore, the harmful effect and toxical hazard of plastics is a real threat to the health and environment. In order to study the properties, two method of testing are used. The samples are sorted base on their four types of plastics. The type of plastics that were used in this study was PVC (Polyvinyl Chloride), PS (Polystyrene), PET (Polyethylene Terephthalate) and PP (Polypropylene). The samples of plastics that have been sorted then were shred using shredding machine. All the shredded samples were fed into the extrusion machine to get the long-shape of plastics which later pelletized using pelletizing machine. The testing methods involve in this study were TGA (Thermogravimetric) and FTIR (Fourier Transform Infrared Spectroscopy). The result obtained for FTIR analysis shows the different of bonding between coastal and virgin plastics. Other group of homologous series was found in the bonding of coastal plastics waste. The resulted data for TGA analysis show the higher value of thermal degradation for coastal plastics waste compared to virgin plastics. Sample of PVC, PS PET and PP was degrading at temperature of 357.77^{o}C, 384.25^{o}C, 397.97^{o}C and 362.61^{o}C which is much higher than the virgin plastics that degrade at temperature of 333^{o}C, 330^{o}C, 265^{o}C and 315^{o}C. It can be concluded that the coastal plastics waste differ from the virgin plastics in term of bonding and temperature resistant. It is due to the long exposure to the sun and presence of other minerals on coastal plastics waste. This study shows that the coastal plastics waste have an advantages and unique properties compared to the virgin plastics. This study will provide foundation for future research on desirable method to handle the coastal plastics waste. It will enable for greater research and their potential to be used in technologies of plastics recycling.

ABSTRAK

Kajian ini bertujuan untuk mengenalpasti ikatan dan kandungan kimia yang terdapat dalam bahan plastik terbuang yang terdapat di pantai. Peningkatan ekonomi, aktiviti dan perindustrian menyebabkan bahan plastik terbuang menjadi semakin banyak. Bahan plastik terbuang menjana cabaran utama dalam pengendalian buangan kerana sifat-sifat yang berbeza-beza disebabkan oleh degradasi. Tambahan pula, kesan yang berbahaya dan bahan toxic plastik adalah ancaman utama kepada kesihatan dan alam sekitar. Untuk menjalankan kajian ini, sampel plastik dikumpulkan dari pantai-pantai. Sampel dikutip dan diasingkan kepada empat bahagian mengikut jenis plastik. Jenis-jenis plastik yang dikaji adalah PVC (Polyvinyl Chloride), PS (Polystyrene), PET (Polyethylene Terephthalate) dan PP (Polypropylene). Setiap bahagian plastik tersebut dimasukkan ke dalam mesin penghancuran untuk mendapatkan saiz sampel yang lebih kecil. Seterusnya sampel dimasukkan ke dalam mesin extrude untuk mendapatkan rantaian sampel plastik sebelum dimasukkan ke dalam mesin pelletize. Dua jenis ujian dijalankan ke atas sampel-sampel tersebut iaitu FTIR (Fourier Transform Infrared Spectroscopy) dan TGA (Thermogravimetric). Hasil analisa FTIR menunjukkan perbezaan ikatan kimia antara plastik yang terdapat di pantai dan plastik biasa. Melalui analisa TGA, plastik yang terdapat di pantai menunjukkan perubahan peratusan jisim pada suhu yang lebih tinggi berbanding plastik biasa. Sampel PVC, PS PET dan PP mengalami perubahan peratusan jisim pada suhu 357.77^{o}C, 384.25^{o}C, 397.97^{o}C dan 362.61^{o}C manakala plastik biasa mengalami perubahan jisim pada suhu yang lebih rendah iaitu pada 333^{o}C, 330^{o}C, 265^{o}C and 315^{o}C. Kesimpulannnya, sampel plastik di pantai berbeza dengan plastik biasa dari segi ikatan kimia dan ketahanan pada suhu yang tinggi. Ini disebabkan oleh terdedahnya plastik di pantai kepada cahaya matahari untuk tempoh yang lama dan kehadiran mineral-mineral lain. Melalui kajian ini, kita dapat mengetahui kelebihan and keunikan bahan-bahan plastik yang terdapat di pantai jika dibandingkan dengan plastik biasa. Kajian ini akan menjadikan bahan-bahan plastik tersebut lebih bernilai melalui kajian-kajian yang lebih mendalam serta kegunaannya terhadap teknologi yang sedia ada.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, world are facing with the increasing of waste including food, paper and plastic waste. Growing of economic, human activity and industrial procedure are resulting in the increased of the wastes. In Asia and the other development country, waste consumption has rapidly increased due to the economic development. Plastics waste is the major consumption of waste compared to food and paper waste. Plastics waste can be found in the beach around the world. This plastics waste include plastic bottle, food container, drink cup, fish net and other thing that used plastics as their major component. All this plastics will cause a major challenge because it will give harmful effect. This plastics waste will not collected properly and placing it to disposed due to lacking of responsible by human. Plastic is found in 1860 then was widely used in the last 30 years ago. Plastics was widely used in applications of food, packaging, car manufacturing, agriculture and furniture product due to the property of light, durable, mouldable, hygienic and economic. Plastics consist of long chain molecules called polymers. Most plastics are non-biodegradable make it harmful to environment for hundreds of years. Plastic can be recycled due to its properties. Recycled processes are become popular over the world because it has advantages of energy saving and low cost. The technologies for converting plastics into resource have been grown rapidly. The technologies have been applied was a production of liquid fuel from plastics waste, plastics as a resources in blast furnace for steel industry and shredded waste plastics use as fuel in cement production. This study will give information about coastal plastics waste to be applied in industry. The new invented of study on the chemical properties of coastal plastics waste are being practiced to improved using of coastal plastics waste to become another valuable product.

1.2 PROBLEM STATEMENT

There are a lot of problem facing by country caused by the coastal plastics waste. It will affect the economy, environment, human and aquatic life. The increasing amount of coastal plastics waste will not be stopped as long as another method to handle it is found. Government has conducted many programs in order to gain awareness of environmental issue. The study of chemical properties of coastal plastics waste will give another method to handle the coastal plastics waste because it will make the waste material of coastal plastics become wealth towards the greater research about it. By study their properties, we will know the advantages of coastal plastics waste due to the long exposure to the sun or other sources that will make their properties become different compared to the common plastics.

1.3 OBJECTIVE

The main objective of this study is to make waste material of coastal plastics waste become wealth component by studying the chemical properties of coastal plastics waste. Regarding to the main objective, the related method were identified as followed:

i. To characterize bonding properties of the coastal plastics waste.
ii. To determine the thermal degradation of coastal plastics waste.
iii. To analyze the differences of bonding and chemical properties between coastal and virgin plastics.

1.4 SCOPE OF WORK

The study was conducted to investigate the chemical properties of coastal plastics waste. In order to know the properties, four method of testing are used. Sample of plastics are collected along the beach around Kuantan. All the plastics collected being cleaned to remove sand and dirt. Then the samples are sorted base on their 4 type of plastics. The type of plastics that were used in this study was Polyvinyl Chloride (PVC), Polystyrene (PS), Polyethylene Terephthalate (PET) and Polypropylene (PP). The samples of plastics that have been classed then were being shred using shredding machine. This is to reduce the size of larger sample of plastics like bottle or food container into smaller particles. Then all the samples are feed into the extrusion machine to get the long shape of plastics. The last step of preparing the sample is pelletized using pelletizing machine. Some of the testing method needs the samples in pellet shape. All tests were conducted at Faculty of Chemical Engineering and Natural Resources Laboratory, University Malaysia Pahang (UMP). The testing methods involve in this study were Fourier Transform Infrared Spectroscopy (FTIR) and Thermogravimetric (TGA). Figure 1.1 briefly describe the overall process flow of the experimental work.

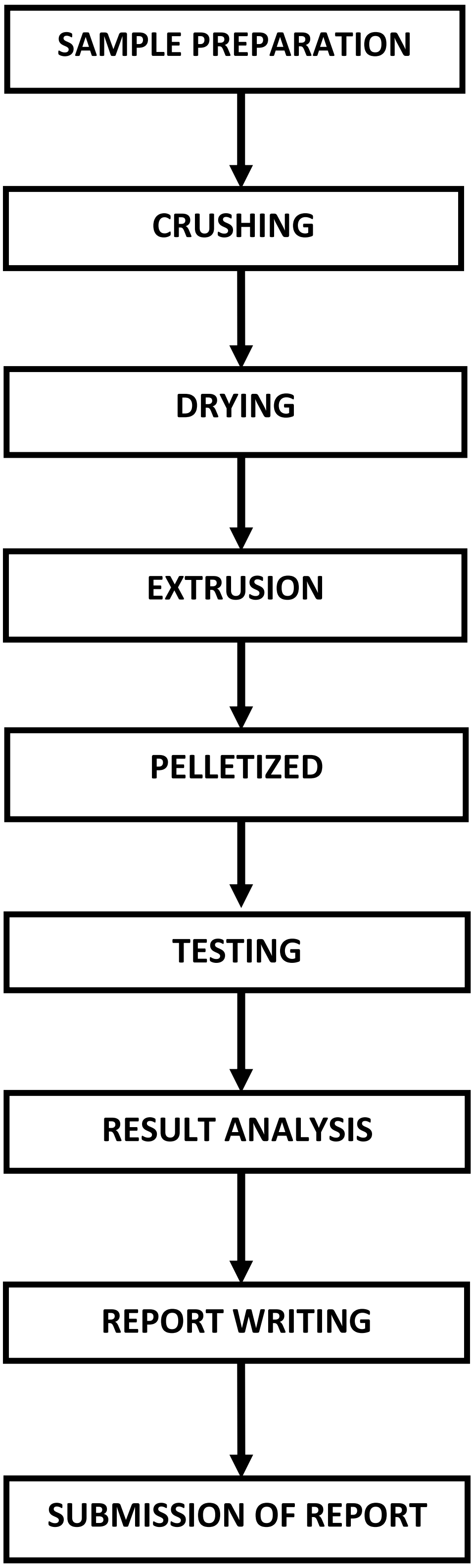


Figure 1.1: Flow Chart of Study

1.5 SIGNIFICANT OF STUDY

The research outcome is expected to provide alternative method of handling the waste material of coastal plastic waste. The chemical properties of coastal plastics waste obtained, will give sufficient information to be compared with common plastics. From this study, the application of waste material which very less practice in Malaysia might be explore further through utilization of coastal plastics waste as recommended for commercial product. In addition, the problem of environmental issue in beach can be reduced.

1.6 SUMMARY

Nowadays, coastal plastics wastes become the major problem to the entire world would have been dealing with issues for almost a century. Sources of the coastal plastic wastes will increase due to the rapidly used of plastic material in many application. This study will describe future the potential of coastal plastic wastes to be converting it to another valuable product.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

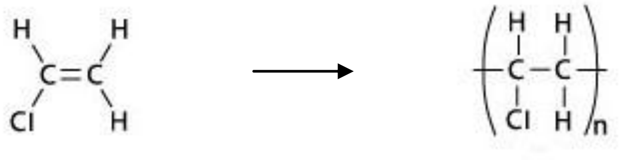
In this chapter, the coastal pollution, plastics properties and technology for plastics were reviewed from the other source of information like published material such as journals, articles, books and research papers. The sources of materials were found related to the environmental issue by coastal plastics and technology existing application of plastics waste done by the others.

2.2 HISTORICAL OF PLASTIC

Review from Malaysia Plastics Forum (MPF, 2007), history of plastics beginning with the words of Plasticus from Latin that means of capable of moulding and words of plastikos from Greek that means of “to mould” or “fit for moulding”. The first plastic was created by Alexander Parkes at 1862 in Great International Exibition in London.

2.3 TYPE OF PLASTICS

2.3.1 Polyvinyl Chloride (PVC)



Vinyl Chloride Monomer (VCM) Polyvinyl Chloride Polymer

Figure 2.1: Chemical structure of Polyvinyl Chloride

There are two methods for the production of vinyl chloride. First is by cracking ethylene dichloride in vapour phase and the second is by reacting acetylene with hydrogen chloride in the presence of a catalyst. Industrial polymerisation of vinyl chloride is carried out either in suspension or emulsion. Properties of PVC are tough, strong, with good resistance to chemicals, good low-temperature characteristics and flame-retardant properties. (James D. Idol et al., 2004) PVC is one of the economically and most widely used plastics globally. It is used for the large-scale production of cable insulations, equipments parts, pipes, laminated materials and in fibre manufacture. (V R Gowariker et al., 2008)

Table 2.1: Chemical properties of Polyvinyl Chloride

Chemical Properties:	Value:
Specific Gravity:	1.38
Thermal limit service temperature:	140 – 221 (^{o}F)
Melting Point:	360 - 390 (^{o}F)
Mold Temperature:	85 – 140 (^{o}F)
Density:	1.38 g/cm^3

Source: E. Alfredo Campo (2008)

2.3.2 Polystyrene (PS)

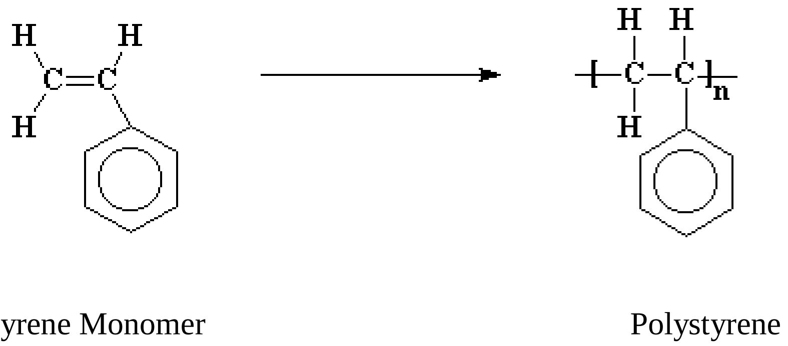


Figure 2.2: Chemical structure of Polystyrene

In 1839, polymerisation of styrene was observed then the commercial potential was realised nearly in 1930. Styrene is produced from ethylene and benzene. Ethylene was produced by passed into benzene in the presence of catalyst. Commercially available polystyrene is mostly of the atactic variety and is amorphous in nature. Polystyrene consists generally of linear molecules and is chemically inert. Polystyrene is widely used in industrial application of moulded containers, lids, jars, bottles, cabinets, toys, foamed plastics and many other household items. (V. R. Gowariker et al., 2008)

Table 2.2: Chemical properties of Polystyrene

General Properties:	Value:
Specific Gravity:	1.05
Thermal limit service temperature:	158 – 122 (^{o}F)
Melting Point:	212 (^{o}F)
Mold Temperature:	50 – 175 (^{o}F)
Density:	1.4 g/cm^{3}

Source: E. Alfredo Campo (2008)

2.3.3 Polyethylene Terephthalate (PET)

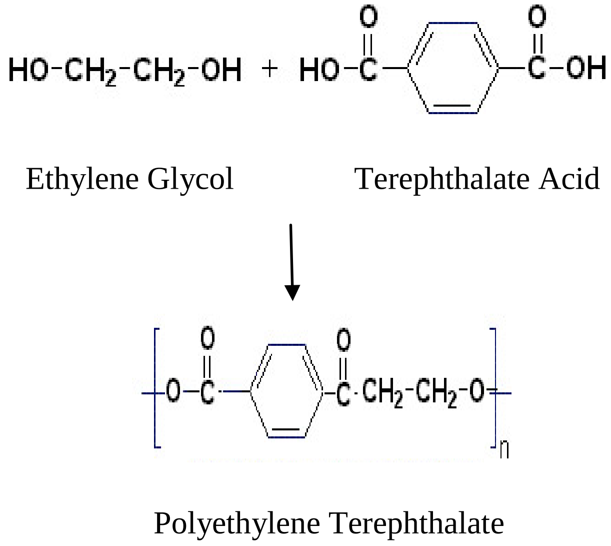


Figure 2.3: Chemical structure of Polyethylene Terephthalate.

Polyethylene terephthalate (PET) is determined by monomers ethylene glycol, a dialcohol and dimethyl terephthala. It was produced by the process of transeterification. (Prof Shakhashiri, 2011) PET have a properties of high strength, rigidity, chemical and abrasion resistance, impact resistance in oriented form, and a low coefficient of friction. (James D. Idol et al., 2004)

Table 2.3: Chemical properties of Polyethylene Terephthalate.

General Properties:	Value:
Specific Gravity:	1.67
Thermal limit service temperature:	392 (^{o}F)
Melting Point:	482 - 490 (^{o}F)
Mold Temperature:	150 – 250 (^{o}F)
Density:	1.38 g/cm^{3}

Source: E. Alfredo Campo (2008)

2.3.4 Polypropylene (PP)

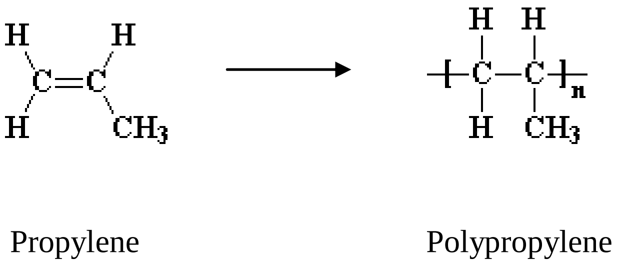


Figure 2.4: Chemical structure of polypropylene.

Polypropylene is produced by polymerisation techniques. Catalyst of Ziegler-Natta was used in production of polypropylene. The monomer, propylene is obtained as a byproduct from gasoline refineries. Properties of polypropylene is a low-density, hard, stiff, creep-resistant plastic with good resistance to chemicals, good wear resistance, low water absorption, and is relatively low cost. (James D. Idol et al., 2004) Polypropylene properties are resistant to many chemicals such as acids, alkalis and oils. But, it was less resistant to oxidation compared to polyethylene. It also stability towards heat and light is lesser than polyethylene. Polypropylene has excellent mechanical and dielectric properties and it is quite comparable to polyethylene with regard to moisture resistance. The applications of polypropylene are widely used in refrigerators, radios and TV's. It also used for producing package film, pipes, storage tanks, seat covers, monofilaments and ropes. (V R Gowariker et al., 2008)

Table 2.4: Chemical properties of Polypropylene.

General Properties:	Value:
Specific Gravity:	0.90
Thermal Limit service temperature:	212^{o}F
Melting Point:	329 - 338(^{o}F)
Mold Temperature:	85 – 175 (^{o}F)
Density:	0.905 g/cm^3

Source: E. Alfredo Campo (2008)

Table 2.5: Advantages and disadvantages of plastics.

Plastics	Advantages	Disadvantages
PVC	-Processed by all thermoplastics methods. -Wide range of flexibility. -Relatively low cost. -Not flammable. -Good Resistance to weathering. -Excellence resistance to water.	-Attacked severely by stronger solvent. -Limited thermal capability. -Higher density.
PS	-High gloss. -Processable by all thermoplastics method. -Low cost. -Good dimensional stability. -Good Rigidity.	-Flammable. -Poor solvent resistance. -Poor thermal stability.
PET	-Excellence resistance to water, salt solutions, weak acids and bases, gasoline and cleaning solutions. -Excellence electrical properties.	-Sensitive to alkaline oxidizing acids, hot water and strong bases. -Requires drying process before processing.
PP	-Low density polymer. -High melting point. -Good Chemical Resistance to hydrocarbons and alcohol. -Good fatigue resistance.	-Degraded by UV. -Flammable. -Difficult to bond. -Several metals accelerate oxidative degrading.

Source: E. Alfredo Campo (2008)

2.4 PLASTICS APPLICATION

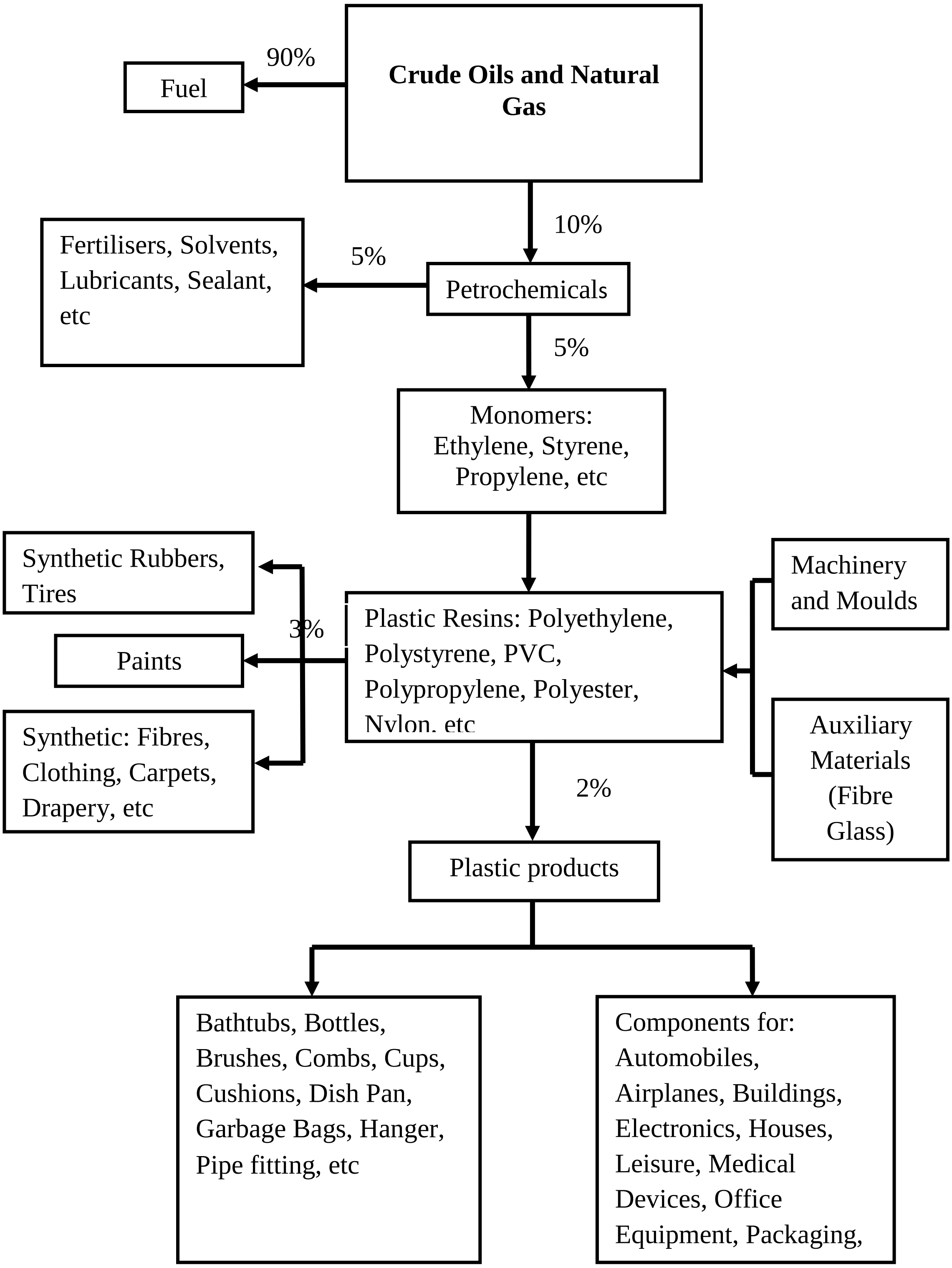


Figure 2.5: Application of plastic (Source: Malaysia Plastic Forum 2007)

2.5 PLASTIC WASTE

Plastic pollution is major problem facing by the development country like Malaysia. It is due to the increasing of plastic production, higher demand in industrial and lack of awareness among people. Plastic is very important in our life because it been use in many application in daily life. Started from the smaller size of plastics till the bigger one, it has their own role in any kind of situation.

2.5.1 Global

This situation will result in plastic pollution if it is not handled smartly. Based on the national academy of sciences 2007, it was estimated that about 6.4 million tons of plastics were dumping in world’s ocean each year.

Table 2.6: Waste for major plastics.

Polymer	% discarded per year
Polyethylene (LDPE, HDPE)	65.5
Polystyrene (PS)	38.1
Polypropylene (PP)	27.5
Polyvinyl Chloride	17.9

Sources: Encyclopedia of Polymer Science and Engineering (2009)

2.5.2 Malaysia

Based on MPF 2007, In Malaysia, there are two major groups of plastic waste. First is household waste and second is industrial or factory waste. Industrial waste was classified in five major groups that are primary industrial waste, mixed consumer waste, agricultural waste, building and automotive waste and application waste.

Table 2.7: Classification of plastics waste in Malaysia

Waste	Source	Reuse Factor Application	Post-Use
Industrial	-Resin production of PS and PVC -primary processing from machinery equipment -scrap from moulding, thermoforming and processors	Medium to good quality and economically viable	Pipes and tubes
Mixed Consumer Waste	-houseware, appliances, toys, furniture, PVC sheets, diapers, packaging item.	-use more complex recycling machine. -non economical in terms of operation procedures	
Well-defined Industrial and Agricultural Waste	-drums from chemical industry -plastics container and synthetic fiber from textile industry -nets and boxes from farm areas	Important resource for recycling business	Processing of lower value-added products such as shoe soles, sandals, agriculture nursery and rubbish trash bags.
Long-life Building and Automotive Waste	-Water tanks (glass reinforced polyester resin) -PVC pipes and fitting -PVC wallpaper		

	-PS light diffuses
Short-Life Application Waste	-consumer packaging and disposable item such as shopping bags, food wrappers, PVC/EPS bottles and containers

Source: Malaysia Plastic Forum (MPF) 2007

2.6 COASTAL PLASTICS

According to the journal in marine pollution bulletin, plastics have become the global ocean wide problem. Due to its buoyancy, plastics particle is widely dispersed in the open ocean. However, physical forcing leads to accumulation in convergent zones resulting in regions of high concentrations near the centres of subtropical ocean (Pichel et al., 2007; IPRC, 2008; Law et al., 2010). Previous efforts have shown that plastic debris is prevalent along the coastline (Ribic et al., 2010) and immediately offshore of the eastern United States (Carpenter et al., 1972; Colton et al., 1974; Van Dolah et al., 1980), little is known about the distribution of plastic in the North Atlantic Ocean, especially east of the Gulf Stream. Moreover, there is even less information about physical properties of the debris such as individual size, shape, density, and elemental composition.

Researcher have analyzed the physical properties of 748 individual particles, a subset of more than 18,000 archived plastic samples collected in the western North Atlantic Ocean by Sea Education Association (SEA, Woods Hole, MA, USA) over the past 24 years. Plastic particles analyzed in this study were collected aboard the RV Westward and SSV Corwith Cramer on 11 cruises during the months of October and November between 1991–1995 and 2004–2007. Selected plastic particles were analyzed for size, mass, form, and material density. All samples were collected with a neuston tow, using a surface net-tow protocol that has been uniformly employed on SEA vessels for the past three decades. All plastic particles were visually identified, hand separated from plankton and tar, air-dried, stored in plastic bags and archived in darkness at room temperature. The selected archived samples were weighed on an analytical balance, and the longest edge of each particle was measured with a micrometer. By appearance, we noted the plastic form, including fragments or chips, sheets, industrial plastic pellets, fishing or marine line, polystyrene foam, and particles undefined by the latter forms.

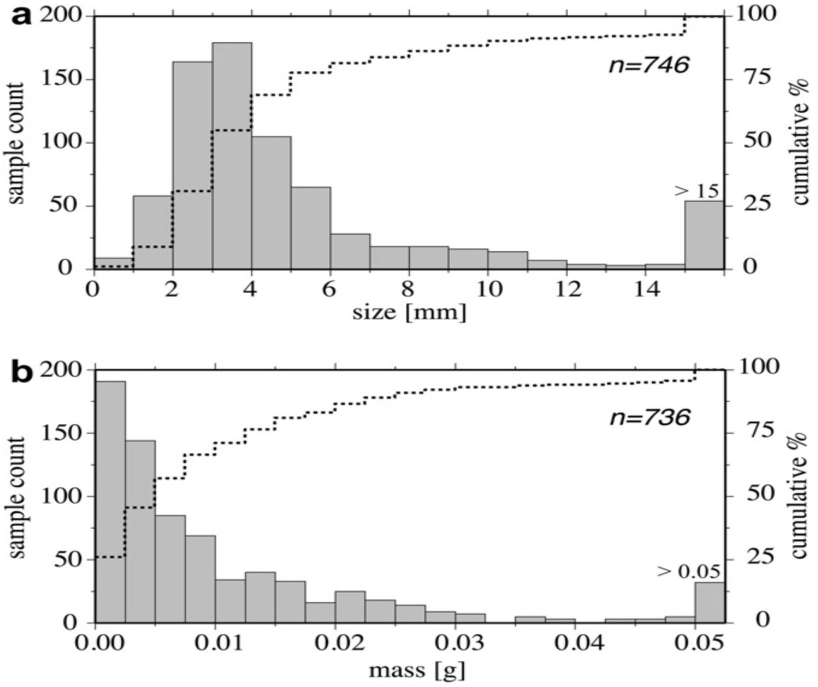


Figure 2.6: Plastic sample (a) size and (b) mass histograms. Dotted lines represent cumulative percentage. The vast majority of particles were less than 10 mm in size and had a mass less than 0.05 g.

Source: Marine Pollution Bulletin (2010)

To make comparison of the density of pelagic plastic samples to plastic debris, they analyzed 410 plastic pieces collected from an enclosed beach on Washburn Island, Massachusetts. Beach samples were collected weekly along a 70-m^2 transect at low tide over a 2-month period in the summer of 2009. The densities of beach plastics ranged from 0.752 to 1.39 g ml^{-1}, which, in contrast to pelagic plastic samples, more closely match the densities of common consumer plastics.

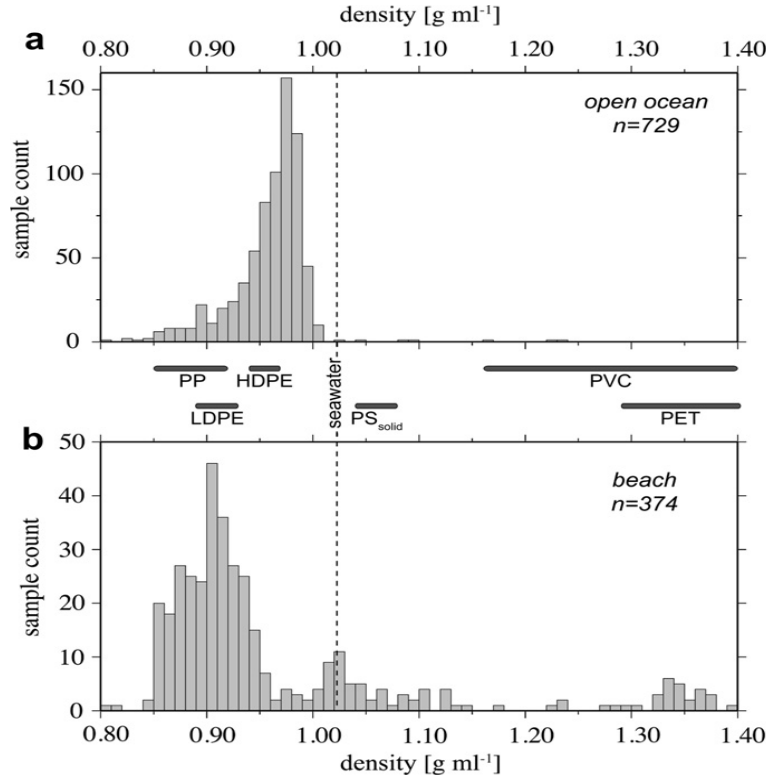


Figure 2.7: Plastic density histograms of (a) open ocean and (b) beach samples. Horizontal bars indicate known densities of major consumer plastics. Dashed line represents measured mean western North Atlantic surface seawater density. Note that only six pelagic samples have densities greater. Than seawater, and that beach plastic values are consistent with the densities of common consumer plastic.

Source: Marine Pollution Bulletin (2010)

The high degree of overlap between the densities of beach plastic and virgin polymers, suggests that plastic resin types 1–6 are found along coastlines (consistent with Ribic et al., 2010) and that particle densities remain largely unchanged in this environment. In contrast, processes acting at sea seem to change the density of plastic particles.

2.7 PLASTICS POLLUTION

Plastic pollution gives a negative effect to human and aquatic life. It was affected about 267 aquatic species worldwide including of sea turtle, sea bird and mammal species. The most of the species were affected through ingestion, starvation, suffocation and digestion. (Laist et al., 2009) plastics particle is affected of 100, 000 aquatic animal annually. (Lim Kok Boon, 2007) Prof Dr Gan Seng Neon (2007) said that waterways of rivers, streams, ponds and oceans are polluting with hundred thousand tons of discarded plastics. He said that the most affected way of discarded plastics is aquatic life like birds and sea turtles are mistaken of plastics pellet for food.

Based on the survey made by U.S. Department of Commerce (1999), land based sources of plastics is the most contributor to marine pollution. It comes from littering, municipal landfills, transportation of garbage, industrial facilities, beach visitors and trash collection from public venues.

Based on Marine Environmental Research, pollution of the marine environment by plastics debris is well recorded. In a review of the plastics materials effect on the marine environment, Derraik (2002) says that plastics are the most of marine pollutant. The sources of plastics are fishing gear (nylon nets and lines), garbage dumping at sea and plastics littering. This pollutant treat to marine due effected by various species of seabirds, marine mammals and sea turtles. Little of people known about the causes, quantity and effect of plastics particles in oceanic pelagic ecosystems. Microscopic plastics material is widespread in the oceans and has accumulated in the pelagic zone and habitats. Another source of plastics waste are plastics resin pellets and granules used for the manufacture of plastics product (Gregory, 1978; Shiber, 1987; Redford et al., 1997; McDermid and McMullen, 2004). Studies (Wong et al., 1974; Shaw, 1977;

Shaw and Mapes, 1979; Day and Shaw, 1987; Day et al., 1990) in 1970 and 1980 showed that plastics particle was spread in the surfaced waters of the North Pacific Ocean. Small plastics particle are found in plankton. The distribution of floating plastics in the ocean is related to surface circulation and winds. (Shaw and Mapes, 1979; Wilber, 1987; Day et al., 1990). Moore (2001) said that high concentrations of small plastics particles in surface plankton sample collected at eleven sites. Moore (2002) and Lattin(2004) recorded that relatively high concentration of plastics particles in surface plankton samples collected at several sites off the southern California coast, in the san Gabriel River Basin and Santa Monica Bay off Los Angeles.

Based on article written by Dr Pola Singh-*director-general of Maritime Institute of Malaysia* in star online (19 July 2010), he said that our ecosystem and marine resources face great danger. Reefs suffer from dynamite fishing, overfishing, and harmful effects of coastal development, sedimentation, and coral bleaching. The growing human population, pollution and unchecked coastal developments add to this misfortune. Improper disposal of industrial, agricultural and domestic wastes leads to pollution. Adding to these are rising temperatures and sea levels. Damages can be minimized and in certain cases reversed if the public is aware of the multiple roles of the seas in helping to manage resources in an ecologically sustainable manner. The natural environment is dynamic and ever changing but the impact of human influence on marine environment can be managed. It is therefore crucial for us to modify our behaviours and attitudes towards the seas and protect the fragile marine environment and ecosystems. Studies showed most plastics dumped end up in the oceans, adversely affecting nearly 200 different species of sea life. Bags find their way into the sea via drains and sewage pipes. Fish and turtles die from ingesting the bags, mistaking them for food.

2.8 TESTING TECHNIQUES

2.8.1 Introduction

Polymer testing and characterization consist of several analytical techniques that evaluate the physical and chemical structures of polymers and their additives. The testing techniques are very important in several industrial in order to make improvement by research and development of new findings.

2.8.2 FTIR spectroscopy

The history of FTIR begins in the 1950. It was introduced at the end of 1960s. The first infrared spectrophotometer needs a highly cost. In the mid of 1980s, some improvement have been made and resulted in the more competitive price and many advantages of the analyzed techniques. Another improvements make are reduction in time, improvement in the energy consumed and more sensitivity. (M. C. Garry et al., 2005)

Infrared spectroscopy is widely used by organic and inorganic chemists. This techniques is the measurement of different IR frequency by a sample. It was finding the chemical functional groups in the sample. Different functional groups absorb characteristics frequencies of IR radiation. IR spectrometers can detect wide range of samples type such as gases, liquids and solids. It becomes the popular techniques for compound identification. (C. P. Sherman Hsu, 2000)

The theory of Fourier Transform Infrared Spectroscopy (FTIR) based on the functionality on the principle that almost all molecules absorbs infrared light. Only the monatomic (He, Ne, Ar, etc) and homopolar diatomic (H2, N2, O2, etc) molecules do not absorb infrared light. (Jorge. E. Perez and Richard T. Meyer, 2000)

Fourier Transform Infrared Spectroscopy (FTIR) also known as infrared spectroscopy is the most important technique used to identify polymeric materials. FTIR analyzed based on the interaction between matter and electromagnetic radiation of wavelength in the infrared region. The infrared electromagnetic radiation produces vibration and rotation changes in the molecule distinctive of the analyzed the chemical structure in substance. The advantages of this techniques is very fast, easy qualitative and quantitative analysis and relatively low instrumentation cost. (Alberto Naranjo et al., 2008)

Nowadays, a wide range of FTIR analysis are available with the selection of the proper techniques depends on various criteria of sample type, information sought, sample size, destructive and non-destructive analysis, time and cost.

2.8.3 FTIR Spectrophotometer

Based on the figure, the FTIR consists of the following components of IR source, beam splitter, sample compartment, detector and signal process units.

The source is the component of the FTIR spectrophotometer that produces wide spectra of IR radiation to interact with sample. The IR source is a refractory material heated at a high temperature. The IR radiation emitted by the source is the function of the source. (Alberto Naranjo et al., 2008)

The common radiation source for the IR spectrometer is an inert solid heated electrically to 1000 to 1800 °C. Three popular types of sources are Nernst glower (constructed of rare-earth oxides), Globar (constructed of silicon carbide), and Nichrome coil. They all produce continuous radiations, but with different radiation energy profiles. (C. P. Sherman Hsu, 2000)

The beam splitter is a moving semitransparent mirror where the interference occur and all the wavelength of the IR radiation is encoded in an interferogram by using a Fourier Transform. A laser signal is used for the internal calibration of the interferometer, leading to a precision of around 0.01cm^{-1}.The most important beam