

**COMPATIBILITY STUDIES ON SOLUTION OF POLYSTYRENE /POLY
(METHYL METHACRYLATE) AND POLY (VINYL CHLORIDE) / POLY
(METHYL METHACRYLATE) BLENDS USING VISCOMETRY, FOURIER
TRANSFORMS INFRARED SPECTROSCOPY AND DENSITY METHODS**

BY

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ABSTRACT

Studies on solution of polystyrene /poly(methyl methacrylate) and poly(vinyl chloride) /poly(methyl methacrylate) were carried out to ascertain the compatibility of the polymer-polymer blends at temperature of 30⁰C using chloroform as solvent. Viscometric values of relative viscosity (η_{rel}) versus concentration of PS/PMMA were plotted, which gave S-shape indicating a heterogeneous mixture, whereas PVC/PMMA plot was observed to be homogenous mixtures indicating some level of linearity on different composition such as 0.4:1.6, 1.6:0.4, and 1.8:0.2 which may be used in polymer industry based on its area of applications. The experimental density of PS/PMMA blends were observed to be lower than the calculated values attributed to less chain packing in the blend solution as evidence of incompatibility, whereas PVC/PMMA showed an increase in experimental values than the calculated values which proved some level of compatibility. In addition, Fourier Transforms Infrared Spectroscopy method reveals that, PS/PMMA blend spectrum indicated no change in the position of either peak of aromatic ring of PS or lone pair peak of PMMA indicating incompatibility of the blend. Whereas there is existence of interaction between the carbonyl group (C=O) of PMMA and hydrogen atom of CHCl group of PVC in the entire composition indicating evidence of compatibility of the blend. Physiochemical analysis by use of FTIR method also reveals that poly (vinyl chloride)and Poly (methyl methacrylate) exhibited a positive molecular characteristics of apolymer blends. The viscometric and density methods have proved to be easy and reliable ways for determiningcompatibility of polymer blends in solution.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

The field of polymer science and technology has undergone the fastest development in polymer blends through research and development. Polymers are macromolecules with a wide range of applications depending on their properties (high strength, light weight, good flexibility, special electrical properties, and resistance to chemicals, amenability for quick and mass production and for fabrication into complex shapes in a wide variety of colors). An outstanding array of polymers that have the potential to be used in fibers, adhesives, coatings, gels, foams, films, thermoplastics and thermoset resins abound in nature (Yu and Lin, 2006). Today, the applicability of these polymers has been extended beyond the range that can be obtained from single polymers due to the emerging field of blending.

In the years ahead, polymers will continue to grow, and the growth from all indications will be not only from the development of new polymers, but also from the chemical and physical modifications of the existing ones. Besides, improved fabrication techniques will result in low-cost products.. Eventually, the challenges of recycling posed by environmental problems have led to further developments involving alloying and blending of plastics to produce a diversity of usable materials from what have hitherto been considered as wastes.

Blending of two or more polymers has become an important technique and is a well-established strategy for achieving and improving the cost performance ratio of polymeric products without the need to synthesize specialized polymer system (Janqueline and

Kroschwizi,1997).Polymer blends generate new materials with a combination of properties not found in the pure polymers and blending is often a faster and more effective way of achieving the required properties with reduced cost of an expensive engineering thermoplastic as a determinant factor in loading-bearing applications. Most of the earlier work in this field was based on observation and experience, which many blends produced were of academic rather than commercial interest (Cheremisinaff and Nicholas,1990).The main advantages of the blended systems are simplicity of preparation and ease of control of physical properties by compositional changes (Acosta and Morales, 1996, Rocco *et al*, 2001).

The concept of blending is about the use of good properties (favorable) of some polymers to correct the deficiencies (unfavorable properties) of other polymers. The process requires different knowledge and techniques than that used to develop new polymers as it requires, less input compared to synthesis of new product. The concept is all about the physical mixture of two or more structurally different homo or copolymers into a single continuous product(Janqueline and Kroschwizi, 1997)

Polymer blends are formed by the combination of two or more polymers with specific properties to produce a material with a compromise property. Thus, blending of polymers enables the production of new materials and composites with tailored properties for application in industries ranging from engineering to medicine. Apart from producing new materials with better properties for industrial applications, polymer blends have also proved to be economically and ecologically important (Vancouver, 1993). Polymer blends have become a very important subject for scientific investigation in recent years because of their growing commercial acceptance. The enhanced activities of polymer blends are of producing

advanced high performance polymeric materials and also the need for basic knowledge on their phase behavior. (Rhoet *al*, 1997, Oh and Kim, 1999)

Determination of compatibility in polymer blends is important because manifestation of their superior properties depends on compatibility of homo polymers at a molecular level. Blending of polymers is widely accepted in the industry for the production of a polymeric materials with specific applications through an inexpensive route which otherwise is not attainable with a single polymer. One of the important controlling parameter in this case is the degree of compatibility of the polymers blended. However, the degree of compatibility is very much dependent over the interaction between the polymeric phases of the polyblend (Hirotsu et al., 2000)

Compatibilization is the process of modification of interfacial properties in immiscible polymer blends. It results in the formation of polymer alloys and is accomplished by physical or chemical means. Blends have traditionally been produced from different thermoplastics and thermosets obtained from both non-renewable and renewable sources. However, in the last two decades, blends from polymers from renewable resources have attracted an increasing amount of attention due to environmental concerns and the problem of non-biodegradability of thermoplastics such as polystyrene, poly (methyl methacrylate), polyethylene, poly (vinylchloride), poly (vinyl acetate) etc., which are almost impossible to deal with in our everyday life. Some of the disadvantages of biodegradable polymers and blends obtained from renewable sources are their dominant hydrophilic character, fast degradation rate and, in some cases, unsatisfactory mechanical properties, particularly under wet environments (Yu et al., 2006). Also, overdependence on polymers from renewable

sources has greatly increased pressure on food sources as most renewable sources of polymers are sources of food and as a result food prices have increased and might continue to increase. (Rhoet *al.*, 1999)

In principle of this work, it is obvious to say that, the properties of synthetic polymers can be significantly improved by blending with natural polymers (Yu et al., 2006) The need, therefore for more compatibility research on improving the biodegradability and functional properties of traditional and versatile plastics like polystyrene, poly (vinyl chloride) and poly (methyl methacrylate) by blending them using viscometric, Fourier Transforms Infrared Spectroscopy and density method. These methods are quick and simple for compatibility studies in polymer blends because they require with no expensive equipment and yet offer a classification of the blends into compatible or incompatible(Rhoet *al.*, 1997, Oh and Kim, 1999).

Plates of polymer samples



I

II

III

I = Polystyrene (PS)

II = Poly (vinyl chloride)(PVC)

III = Poly (methyl-methacrylate)(PMMA)

1.2:1 Polystyrene (PS):

Polystyrene (PS) is a synthetic aromatic polymer made from the monomer styrene, a liquid petrochemical. It is a high molecular linear thermoplastic and is produced by free radical polymerization in bulk or suspension with peroxides or trace oxygen as initiators. It is an exothermic reaction(Fried, 2010).

Styrene polymers are non-polar, chemically inert, easy to fabricate and water resistant. These characteristics allow them to be used in many applications. Polystyrene has the following mechanical and electrical properties;

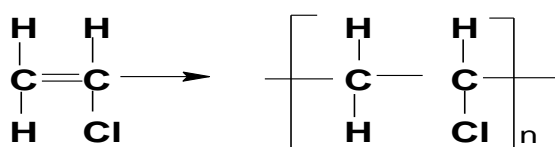
Density	1.062g/cm ³
Crystalline	2.61%
Glass transition temperature	100°C
Resistivity	10 ²⁰ – 10 ²² (Ω.M)
Tensile modulus	2600 – 4900 GPa (Fried J. 2010)

Pure polystyrene is brittle, hard, and hard enough that fairly high performance products can be made by giving it some of the stretched properties for the materials in case of poly-butadiene rubber. It is a very inexpensive resin per unit weight and it has rather poor barrier to oxygen and water vapour and has relatively low melting point. Polystyrene is chemically inert and resistant to acids and bases but dissolved by many organic solvents. Different types of styrenes are general high purpose (GHPS), high impact polystyrene (HIPS), low impact polystyrene (LIPS), and expandable polystyrene (EPS). Its area of applications are GHPS is used in production of cup, spoon, plates, packaging, transparent containers. HIPS are used in higher strength product like electrical appliances, refrigerator, engineering construction work, etc. EPS is used in light insulating materials, disposable plates, packaging materials, cutlery, meat trays, soup bowls, and fabricated work and LIPS is used in low impact strength product like food packaging Styrofoam and plastic containers (Fried J., 2010)

1.2:2 Poly(vinyl chloride)

PVC is one of the versatile manmade materials ever created and it is the third most widely produced plastic. The annual world production is estimated at about 31 million tons (Fried J. 2010). The widely used polymers are polyethylene, polypropylene before polyvinyl chloride. PVC is polymers of vinyl chloride and they are among the largest volume commodity thermoplastics. It is a white, brittle solid, but can be plasticized to make it more flexible, low cost, very durable, light weight, non-corrosive and has many unique features, in that it doesn't rot, it is weather resistant and retains its shape at room temperature. At a very high temperature, PVC can be reshaped which means it has great recycling possibilities.

Applications of plasticized PVC include wire coating, upholstery, floor coverings, film, tubing, ceiling, plumbing, weather boarding, stickers, car body stripes, tarpaulins, coats, jackets, shoes, bags apron, sport wears etc. Commercial PVC is a clear moderately tough, low crystallinity, ($T_g=87^{\circ}\text{C}$, $T_m=212^{\circ}\text{C}$) material with low to moderate molecular weight (25,000 to 150,000) g/mol^{-1}



Vinyl chloride Poly (vinyl chloride)

Polymerization of commercial-grade PVC is conducted by free-radical polymerization principally by suspension polymerization techniques, although emulsion polymerizations

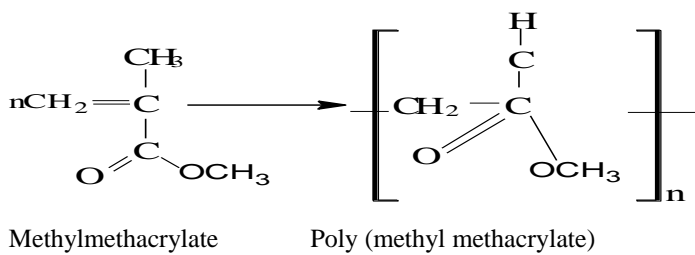
are commonly used and bulk polymerization. The toughness of PVC can be improved by blending with high impact resins such as methyl methacrylate-butadiene-styrene, acrylonitrile-butadiene-styrene etc. Some alternative stabilizers and additives are required for this application, so that they can have high weather and UV resistance, along with the brilliant white colour they are also known for extreme sports wear (such as skiing and diving suits). (Fried J. 2010)

1.2:3 Poly(methylmethacrylate)

Poly (methyl methacrylate) (PMMA) is one of the well-known brittle materials. In order to consider the chemical and mechanical properties of PMMA, numerous studies on the improvement methods have been extensively carried out in the many years. PMMA is among other commercially important vinyl polymers, but commercial grade PMMA is an amorphous polymer of moderate T_g (105°C) with high light transparency and good resistance to acid and environmental deterioration (Fried J., 2010). It is commercially polymerized by free radical initiator or anionic alloy at low temperature to give highly isotactic (Glass Transition Temperature, $(T_g) = 45^{\circ}\text{C}$,) and (Crystalline Melting Temperature, $(T_m)=160^{\circ}\text{C}$) or highly syndiotactic (Glass Transition Temperature, $(T_g)=115^{\circ}\text{C}$,) and (Crystalline Melting Temperature, $(T_m)=200^{\circ}\text{C}$) polymers.

PMMA is an economical alternative to polycarbonate (PC) when extreme strength is not necessary. Additionally, PMMA is not potentially harmful and subunits of it are found in polycarbonate. It is often preferred to others polymer because of its moderate properties, easy handling, processing, and low cost. The non-modified PMMA behaves in a brittle manner

when loaded, especially materials exerted with force, and is more prone to scratching than conventional inorganic glass. However, the modified PMMA achieves very high scratch and impact resistance. The most common method for promoting the toughness of PMMA is blending with the PVC. Conflicting data have been presented in literature concerning the compatibility of polyvinyl chloride (PVC) and poly (methyl methacrylate) (PMMA) (Schurer et al, 1975).



PMMA is commercially polymerized by free radical initiators such as peroxide and azo compounds in suspension or bulk polymerization. Bulk polymerization process is mainly used in the manufacture of sheets, rods, hard contact lenses etc. while suspension process is used in injection moulding products. It is sometimes called glass polymer because it is glassy in nature after processing.

Molecular formula	$(C_5O_2H_8)_n$
Molar mass(g/mol)	varies
Density	1.18 g/cm ³
Melting point	160 °C (320 °F)
Refractive index	587.6 nm. (Fried J., 2010)

PMMA has the following properties such as optical clarity (official glass), heat resistance, high impact strength, brittle, glassy, poor crash resistance, rarely attacked by mineral acid, amendable to some additives, polymer stabilizer, etc. PMMA swells and dissolves in many organic solvents, and it also has poor resistance to many other chemicals. Nevertheless, its environmental stability is superior to most other plastics such as polystyrene and polyethylene, and PMMA is therefore often the material of choice for outdoor applications and high light transmission (Robeson and Portofrei, 2007). Its area of applications are outdoor weathering, construction of aquarium, hand eye lens, orthopaedic surgery to fix implants and remodel lost bone, transparent glasses substitute etc. PMMA, in a purified form, CDs and DVCs, LCDs back lights, is used as the matrix in laser dye-doped solid-state gain media for solid state dye lasers. PMMA has also been used extensively as a hybrid rocket fuel. PMMA technology is utilized in roofing and waterproofing applications. By incorporating a polyester fleece sandwiched between two layers of catalyst-activated PMMA resin, a fully reinforced liquid membrane is created *in situ* (Ibrahim and Kadum, 2010).

1.2 Statement of Problem:

Majority of known polymeric materials are expensive, sometimes scarce, most of the polymer mixtures are immiscible, problem of determination of degree of compatibility, most solvents used in blending are toxic, and the toxic effect do not only affect living organism but also poison the earth.

1.3 Aims of the study

The aim of the study is to have a thorough understanding of the effect of molecular interaction and functional properties of polymer blends which helps in determining compatibility or incompatibility of PS/PMMA and PVC/PMMA using viscometric, Fourier transforms infrared spectroscopy and density methods.

1.4 Objectives of the study

The objectives of the study is to

- (i) Determine the compatibility in polymer blends (PS/PMMA and PVC/PMMA) of various compositions using viscometry, density and Fourier transforms infrared spectroscopy methods.
- (ii) Determine relative, specific, reduced and intrinsic viscosities of blend solutions using Oswald suspend level viscometer.
- (iii) To investigate the functional groups associated with the adsorption of the blends of polymers using FTIR.

1.5 Justification of the research

It is obvious to say that understanding the properties of polymer blends will increase its applicability and could create new materials for industrial use and exportation. It could also help in solving the environmental problems posed by the non-biodegradability of these widely-used thermoplastics and also contributing to the drive for the conversion of waste to wealth in the country ((Robeson and Portofrei, 2007). In addition, there are conflicting data in some literatures about polymer blends, there is need for more research on improving more polymer blends and justification of some these conflicting data.

1.6 Limitations of the study

Limitation of the study is to determine the compatibility of the polymer blends (PS/PMMA and PVC/PMMA) of various compositions using viscometric, Fourier transform infrared spectroscopy and density methods. Determine of relative, specific, reduced and intrinsic viscosities of blend solutions using Oswald suspend level viscometer was another important factor, which helps to investigate the functional groups associated with the adsorption of the polymer blends by the use of Fourier transform infrared spectroscopy. The results obtained supported most of the work in the literature of the polymer blends, although a use of chloroform as solvent is a new discovery of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

A polymer blend or alloy is a material which is similar to metal alloys and is formed by the mixing of at least two or more polymers together resulting in the creation of a new material with different physical properties. Blends offer a major alternative in solving emerging application requirements in engineering and other specialized fields. It demonstrates the ability to combine existing polymers into new properties, which offers the advantage of reduced research and development expenses compared to the development of new monomers and polymers to yield a similar property profile (Robeson and Portofrei 2007).

Most of the earlier work in this field based on observation and experience which many blends produced were of academic rather than commercial interest. Blending is an effective method for designing polymer materials with various properties. The advantage of blending is that properties of the existing polymer may be adjusted without the development of the new macromolecules. One of the important controlling parameters in this case is the degree of compatibility of the polymers blend. However, the degree of compatibility is very much dependent on the interaction between the polymeric phases of the polymer blend. Therefore, varying the interactive forces among the constituents of the system one can get the material of required mechanical properties (Mamza and Folaranmi, 1996).

A study on compatibility of polymer blends is necessary in order to obtain polymer blends of more desirable properties by mixing them together. The compatibility term describes the homogeneity of polymer mixtures at some temperatures with various solvents, thus it is very

important to examine the factors affecting the compatibility of polymer mixtures. Compatibility can be influenced by various factors such as intermolecular interaction, morphology, crystalline phase, and reduction of surface tension. Another way to promote or modify polymer–polymer compatibility is to incorporate hydrogen-bond interactions into blend components (Coleman and Painter, 1995).

There are several techniques for studying the compatibility of the polymer blends. The most useful techniques are viscometric measurements (Sun et al., 1999), thermal analysis (Song and Long, 1991), ultrasonic velocity (Singh and Paladhi, 1994), refractive index (Rajuluet al. 1999). NMR method (Crispim et al., 2000) and optical spectroscopy (Wu et al. 1999). Some of these techniques are complicated, costly and time consuming; hence it is desirable to identify simple, low cost and rapid techniques to study the compatibility of polymer blends. In considering this fact, Chee (1990) and (Sun et al., 1999), Wang and Fung (1992) have suggested a viscometric method for the study of polymer–polymer compatibility as simple, inexpensive, rapid technique and provide information about both polymer interactions and polymer solvent interaction in solution.

Viscometry is a simple and effective technique for monitoring the interactions in polymer blend's solutions. The viscosity is a very important physicochemical parameter in the study of compatibility of polymer blends and many studies have been done on measuring viscosity by using different techniques. The main viscosity measurement methods are capillary, rotational and vibratory viscometric methods. Capillary viscometric method was considered in this study because it is quick, cheap and simple for compatibility studies of polymer blends. In the capillary viscometer, the time needed to force the fluid to flow at a specified rate through a

special tube is measured. From viscometric measurements, relative, specific and reduced viscosities of pure polymers and their blends are obtained. It is an established fact that plots of absolute viscosity against concentration deviate from linearity according to the degree of compatibility of polymer blends (Kulshreshtha *et al.*, 1988; Williamson and Wright, 1965). Plots for compatible polymer blends tend to be linear whereas plots with an S-type indicating two phase formation in the case of incompatible systems. From the plots, it is evident that there are two phases with varying slopes. From the slopes obtained, it is easy to see that slope values are higher at lower concentrations but as the concentrations increase, slope values get reduced.

Intrinsic viscosity $[\eta]$ is a measure of the hydrodynamic volume occupied by a macromolecule, which is closely related to the size and conformation of the macromolecular chains in a particular solvent (Al-Assaf *et al.*, 2005; Higiro *et al.*, 2007). Intrinsic viscosity can be expressed in a number of ways but the fundamental models are those of Huggins and Kraemer (Huggins, 1942). Huggins approach to the determination of intrinsic viscosity is based on the measurements of specific viscosities at various concentrations (at the same shear rate), and extrapolation of the course of specific viscosity to infinite dilution. This is a linear regression.

Density is the measure of the relationship between the volume and the mass of a polymer blend and it is defined by divided mass by volume. Each type of polymer has a certain density (mass per unit volume). The density of a polymer blend is the sum of the mass fractional density of each type of polymer. Finding the mass of a substance is easily

accomplished using a balance, finding its volume requires measuring its physical dimensions. The water displacement method is an effective technique for finding the volume of a soluble or insoluble polymer blends and its subsequent density. In this study, density, viscosity and Fourier Transforms infrared measurement methods are suitable for estimation of polymer blends. The methods are presented in chapter three. These methods may be used for measurements of density and viscosity of liquids of high-pressure gases with a reliable result. It means that it is possible to measure density and viscosity of polymer melt simultaneously with a limited time and inexpensive method.

Fourier transforms infrared spectroscopy has proved to be an excellent tool to study the compatibility behavior PS/PMMA and PVC/PMMA blends. If the blend is compatible because of the specific interactions, the absorption spectrum of the blend will be the sum of the components, and then differences will be noted in the spectrum of the blend relative to the sum of those for the components. The Fourier transforms infrared spectroscopy investigation of a compatible blend will not only reveal the presence of such an interaction, but will provide information on which groups those polymer are involved. Fourier transforms infrared spectroscopy will remain a useful tool for identifying the functional groups present in a polymer molecule, which essentially are the same as those to be found in a simple aromatic/aliphatic molecule. Potential specific polymer incompatible blend interactions can be identified with FTIR spectroscopy, especially where semi-crystalline materials exhibit hydrogen bonding disruption.

Conflicting data have been presented in literature concerning the compatibility of poly vinyl chloride (PVC) and poly methyl methacrylate (PMMA). A large number of studies indicated that the tacticity of PMMA affected strongly the compatibility of PVC/PMMA blends (Chee, et al 1992). Most of the studies on polymer blends have shown that a plot of relative viscosity versus blend composition for compatible blends are linear and the higher value of intrinsic viscosities of a blend solution over a calculated value and percent composition is also evidence of positive interaction that can aid compatibility (Folaranmi and Kolawole, 1992).

Previous studies on the compatibility of PS/PMMA and PVC/PMMA are consistent with my results. For example, Raina et al. (2008) proposed that PS/PMMA blends are not compatible at 40°C in chloroform, whereas PVC/PMMA blends were compatible at the same temperature, solvent and they are close to that used in our studies of the compatibility of the polymer blends. Fourier transforms infrared spectroscopy method and density results also support the viscometric data.

On the other hand, Mamza and Folaranmi (1996) showed that Polystyrene and Polyvinyl acetate are completely incompatible. They investigated PS/PVAc in the whole composition range, using toluene methyl ethyl ketone and tetrahydrofuran as solvents and the results suggested incompatibility of PS/PVAc which depends on several factors and in particular, incompatibility increases as the annealing temperature is increased. Thus, the results reveal that molecular weight and temperature determines the extent of compatibility or incompatibility and in some cases not really the choices of solvent itself but also the type of polymer samples where by the effects of the solvents are feeble.

Mohammed and Raina (2008) studied the effect of polymer-polymer interactions on the compatibility of PVC/PMMA and PS/PMMA blends in a broad composition range using viscosity and FTIR techniques. From the viscometric data, the presence of attractive forces among different polymers was evaluated according to Sun et al. (1990), by the determination of parameter. Based on sign convention involved in the criterion, PS/PMMA system was found as incompatible while compatibility was observed in PVC/PMMA blend.

Mamza and Nwifo, (2008) carried out viscometric studies on blends of polystyrene (PS) and Polyvinyl acetate (PVAc), and reported compatibility domains along composition ranges. Also, the swelling behaviour of these blends in different solvents lead to incompatibility of the PS/PVAc polymer blends. Densities of melted polymer blends are based on two phase systems (crystalline and amorphous) and each phase may be characterized by a unique density.

Folaranmi and Kolawole (1992) carried out compatibility studies on solution of Polystyrene and Styrene-acrylonitrile copolymer blends at 25⁰C in methyl ethyl ketone (MEK) and chloroform at 2% total solid content by density and viscometric method. The experimental densities are higher in both solvents than the calculated densities. The plots of relative viscosity versus composition are linear for both solvents with small deviation from linearity above 80% styrene-acrylonitrile (SAN) in the blend solution in chloroform. Plot of intrinsic viscosity versus composition show higher observed values than calculated values which indicated that PS and SAN are compatible in certain compositions. The result is similar to

my studies using PVC/PMMA in chloroform with a closed temperature of 30⁰C confirming that in a blend solution polymer-polymer interactions dominate over polymer-solvent ones.

In general, a compatible blend of two polymers has properties somewhere between those of the two unblended polymers. On the course of these studies, three methods were considered to be simple, low cost and less time consuming for production of polymer blends. They are:

(a) By dissolving the polymers in a good solvent common to them, and if necessary, subsequently letting the solvent evaporate.

(b) In a mixer where the working temperature is high enough to melt or modify the polymeric components, without causing degradation of the same (Coelho, et al 2012)

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials and Equipment

Weighing balance (Digital), 25ml volumetric flasks, 250ml conical flask, 5ml graduated pipette, 25ml specific gravity bottle, Oswald capillary viscometer (model 1-7), Stirrer, Cotton wool, Fourier transform infrared spectrophotometer (Scimadzu FTIR-8400S), Oswald viscometer (type D), polystyrene (BDH England), poly (vinyl chloride)(BDH England), poly methyl methacrylate (BDH England) and chloroform (Analar BDH England), purchased from Romptech Scientific Supplies Company, Zaria.

3.2 Methods

3.2.1 Determination of solubility of the polymer samples in chloroform

The solubility was determined by measuring the already calculated two percentage of each polymer samples with addition of chloroform as solvent to make up 100ml as stock solution. Further dilution was done to obtain different concentrations shown in the below Tables 3.1 and 3.2.

3.2.2 Determination of density of the blend solutions

25ml of the blend solutions density were measured using a standard specific bottle volume of 25ml at 30⁰C with the help of digital analytical balance (Model xp-300, Denver instrument, USA) and the weight was recorded, expressed as percentage solubility of the polymer in the solvents according to the method by Carter and Sue (2005) and (Mamza and Folaranmi, 1996).

3.2.3 Determination of Fourier transforms infrared spectroscopy of the blend solutions

Fourier transforms infrared spectroscopy analysis of PS/PMMA and PVC/PMMA was carried out using Scimadzu FTIR-8400S Fourier transform infra-red spectrophotometer. The sample was prepared neatly and the analysis was carried out by scanning the sample through a wave number range of 400 to 4000cm⁻¹. FTIR analyses were performed and the different peaks present and the possible chemical interactions in the blends were examined (Mano et al, 2003).

3.2.4 Determination of the intrinsic viscosity of the polymer blends.

The stock solution of the PS/PMMA and PVC/PMMA was prepared by dispersing 2.0g of each polymer samples separately according to the two blends into 100ml of each solvent. 10ml of the prepared stock solution was transferred into Oswald capillary viscometer (model 1-17) with calibrated water bath using a thermometer with a precision of 0.01k, to equilibrate for 10 minutes at 30⁰C. 10ml of each stock solution was dispersed into the viscometer and allowed to flow below the lower mark on the bulb of the viscometer under the influence of

gravitational force. The time flow of the sample from the upper through the lower marks was noted and the flow time was recorded in seconds. Triplicate measurements were made and the average values reported. A serial dilution was carried out *in situ* to obtain other polymer concentrations of 0.02, 0.01, 0.006, 0.005, 0.004, 0.0034, 0.0028, 0.0026, 0.0022 and 0.002 g/dl, respectively.

CHAPTER FOUR

RESULTS

4.1 Viscometric study

Viscometric measurements data of relative, specific and reduced viscosities of the blends obtained are shown in Figure 4.1, 4.2, 4.3 and 4.6, 4.7, 4.8 respectively are plots of the different viscosities versus concentration in (g/dl) of PS/PMMA and PVC/PMMA polymer blends. Compatibility studies on blends of PS/PMMA and PVC/PMMA was prepared in different ratios by melt blending technique in chloroform using viscometric, Fourier transform infrared spectroscopy and density method showed that the PS/PMMA system was found as incompatible at 30°C where by neither linkage is interacting nor the aromatic ring is affected by blending these two polymers, because of these consequence of repulsive force between the two polymer deviated from linearity with a plot of S-shape. On the other hand, compatibility was observed in PVC/PMMA blend at the same temperature with higher value of intrinsic viscosities of a blend solution over a calculated value percent composition as evidence of specific interaction between the carbonyl groups of PMMA and the hydrogen atom of CHCl group of PVC in the entire composition range which showed some level of linearity from the plots. The most common method for promoting the toughness of PMMA is blending with the PVC.

The relative viscosity data is shown in Table 4.1 (PS/PMMA), and 4.2 (PVC/PMMA) and the plots are shown in Figure 4.1 and 4.2 respectively. The below equation was used to calculate the relative viscosity of the polymer blend:

$$\eta_{rel.} = t/t_0 \text{ ----- 3.1}$$

Where t = flow rate of solution blend

t₀ = flow rate of solvent (chloroform)

Viscometric data for specific viscosity of the polymer blends is shown in Tables 4.2 (PS/PMMA), 4.2. (PVC/PMMA) and Figures 4.5 is the plots of specific viscosity of blends respectively which is obtained from the equation:

$$\eta_{sp.} = [t-t_0] / t_0 \text{ -----3.2}$$

While reduced viscosity is shown in Figures 4.3, 4.7 of the blend are obtained from the equation:

$$\eta_{red} = \frac{\eta_{sp.} - 1}{C} \text{ ----- 3.3}$$

C

Where C = Concentration in g/dl

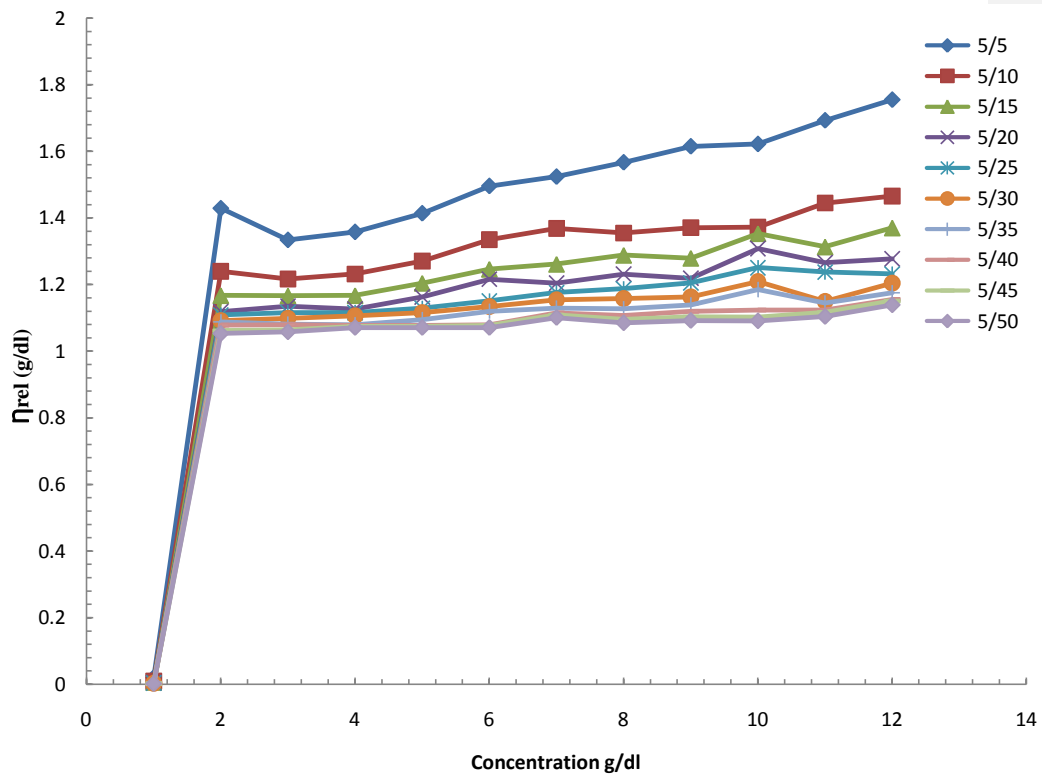


Figure 4.1: Plot of relative viscosity versus concentration of PS/PMMA polymer blend.

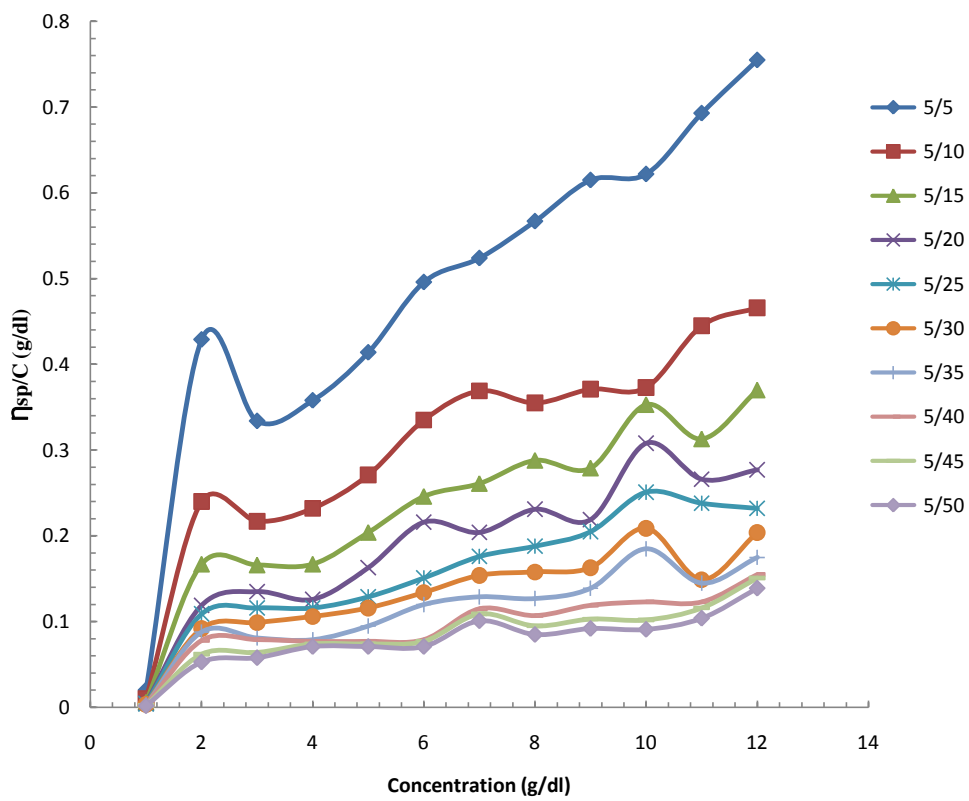


Figure 4.2: Plot of specific viscosity versus concentration of PS/PMMA blend.

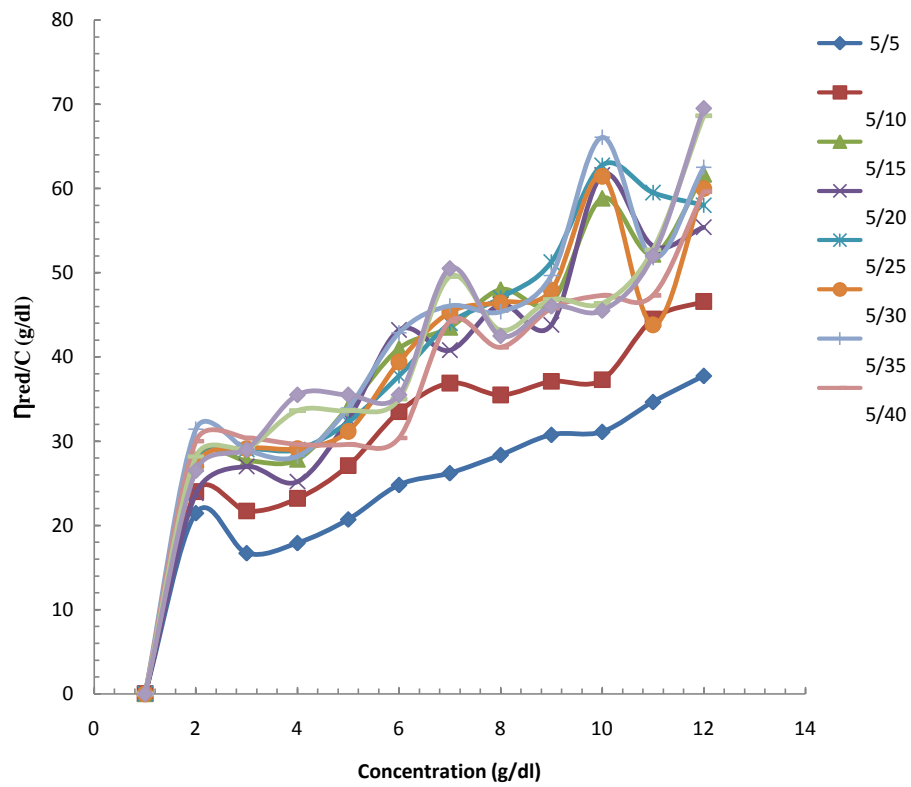


Figure 4.3: Plot of the reduced viscosity versus concentration of PS/PMMA polyblends.

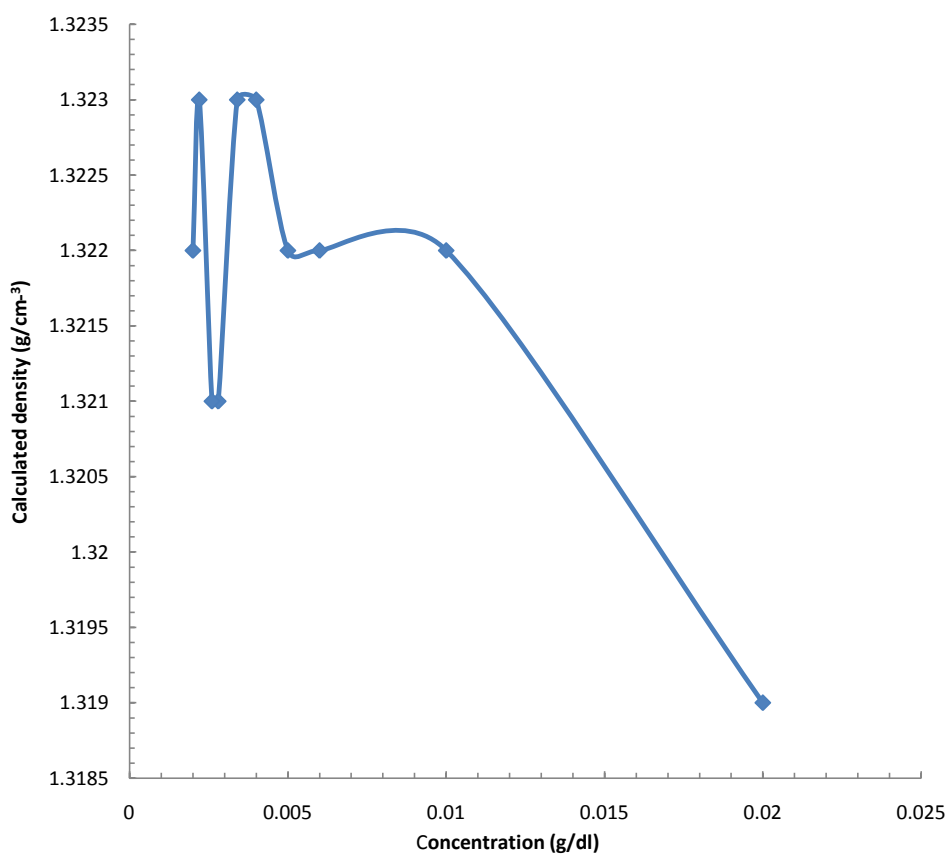
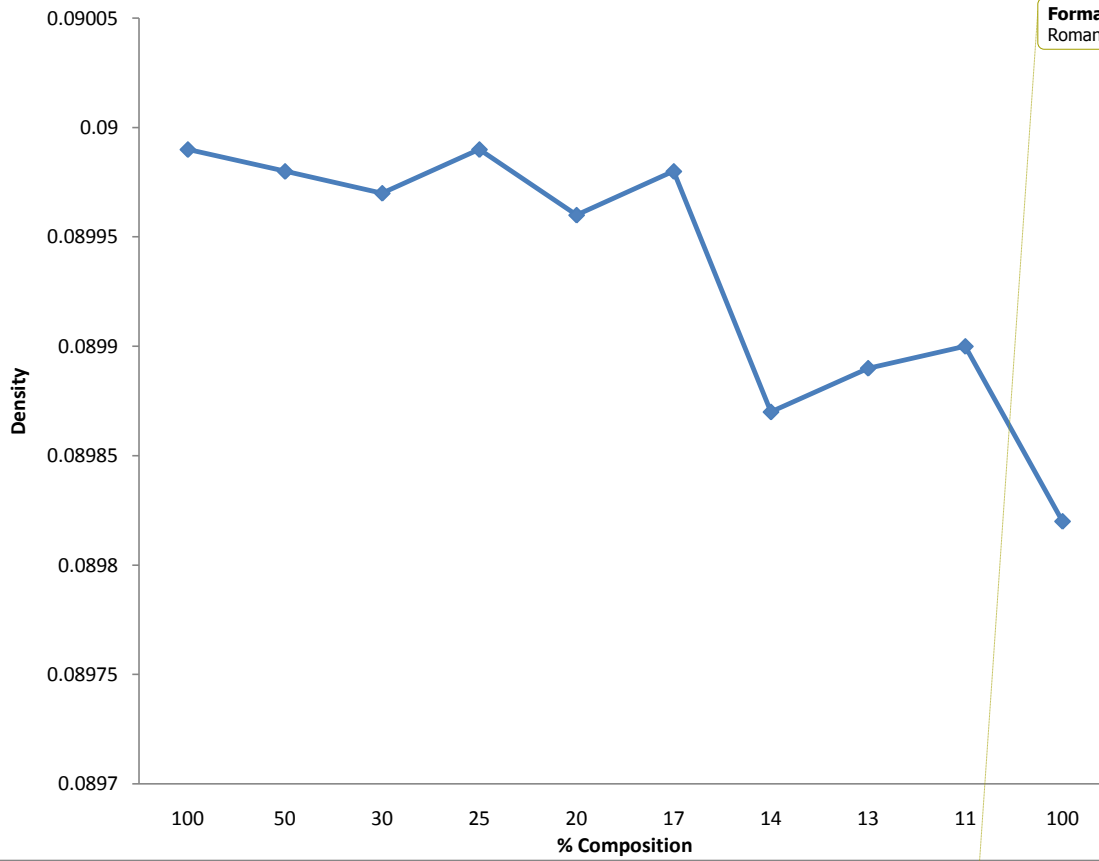


Figure 4.4: A plot of calculated density versus concentration of PS/PMMA polymer blend.



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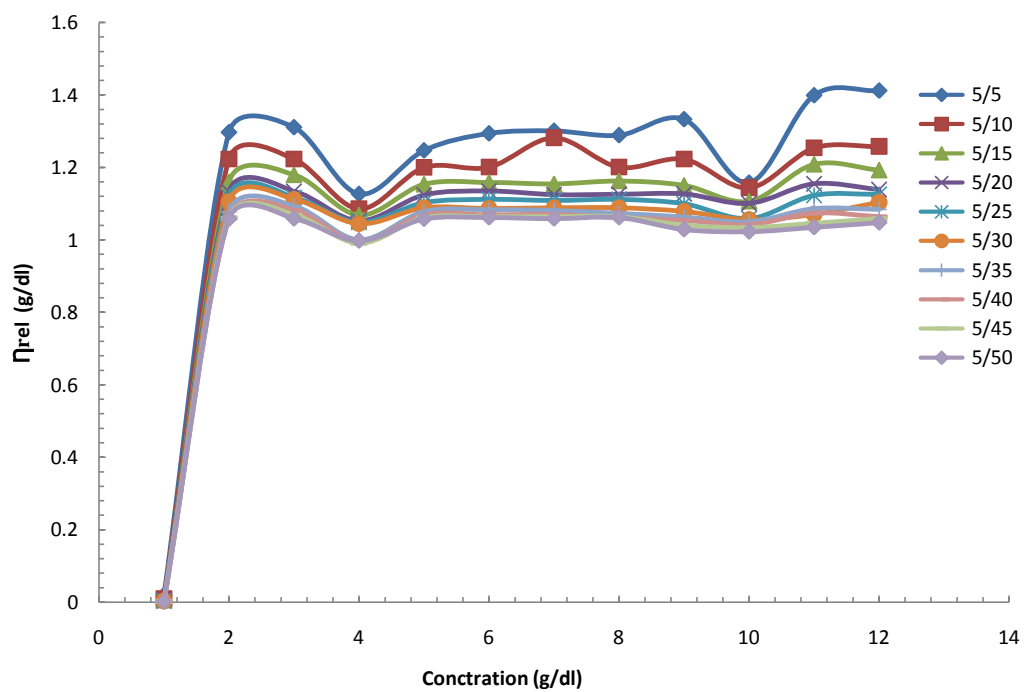


Figure 4.5: Plot of relative viscosity versus concentration of PVC/PMMA polymer blends,

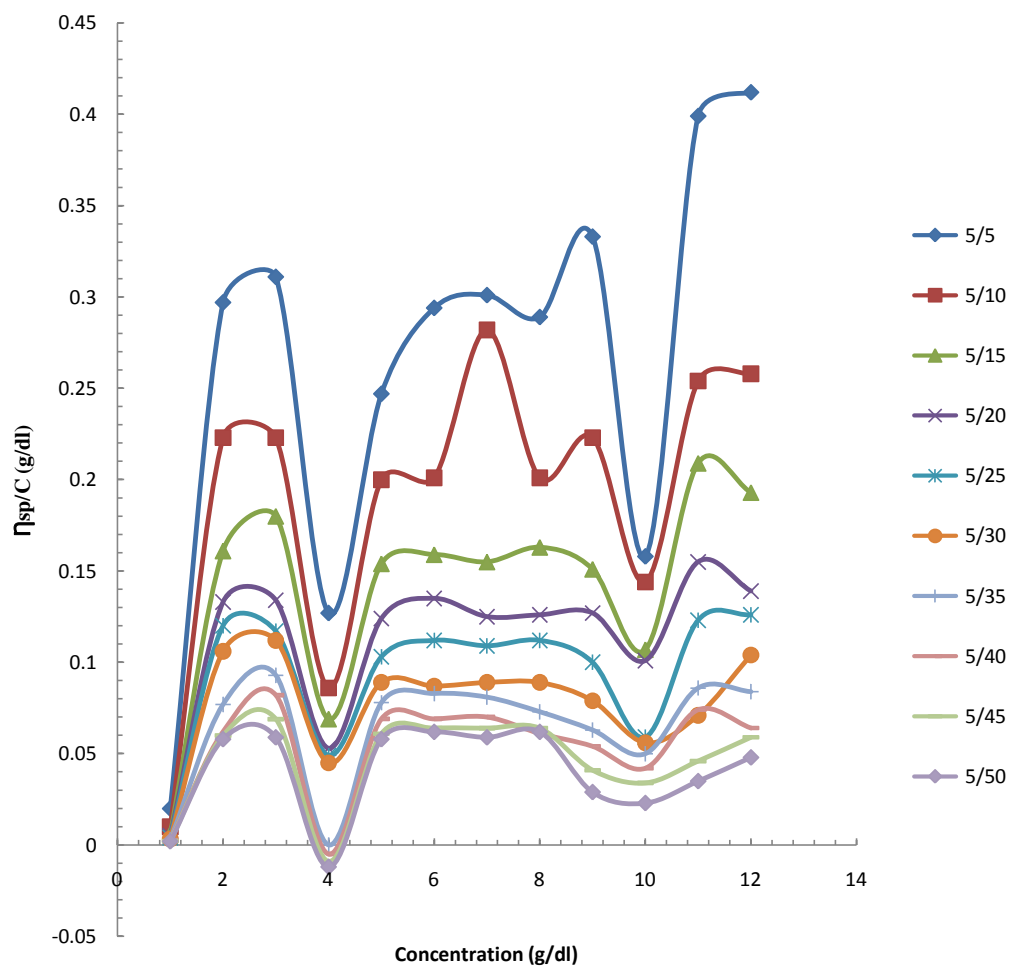


Figure 4.6: Plot of specific viscosity versus concentration of PVC/PMMA polyblends.

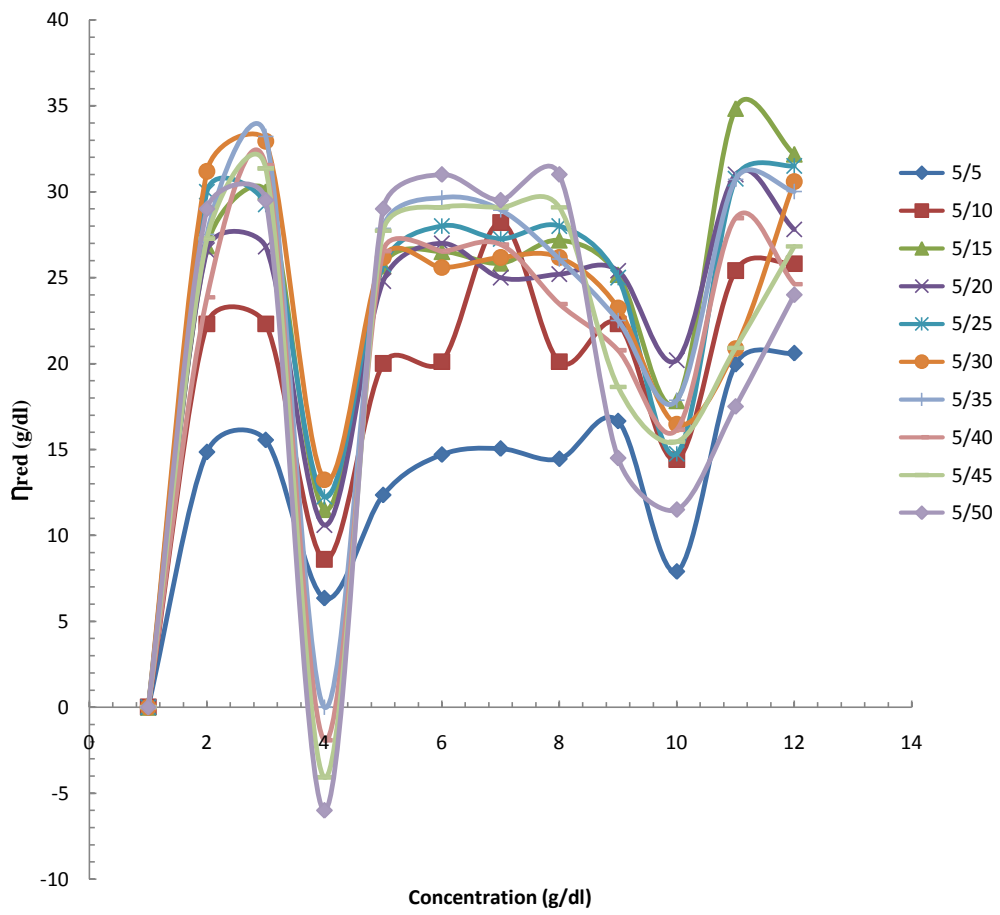


Figure 4.7: Plot of the reduced viscosity versus concentration of PVC/PMMA polyblend.

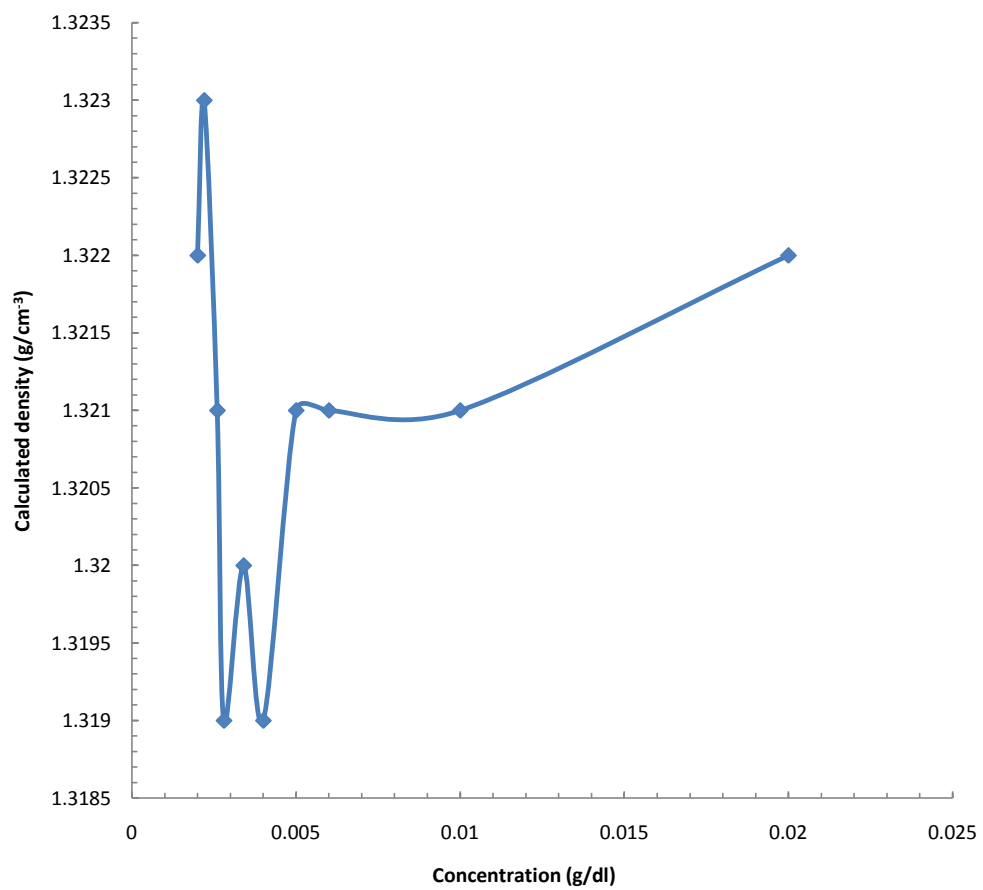


Figure 4.8: Plot of calculated density versus concentration of PVC/PMMA polymer blend.

CHAPTER FIVE

5.0 DISCUSSION

The value of relative viscosity versus concentration in g/dl of the PS/PMMA was plotted and reduced viscosity is obtained in Figure 4.3. Plot of reduced viscosity versus concentration of PS/PMMA reveals an S-shape indicating multiple phases and the extent of its deviation from linearity reveals the degree of incompatibility of the two polymers at the temperature of 30°C with the use of chloroform as solvent. This may be attributed to the mutual repulsion of molecules in solutions which leads to a decrease of dynamic volume of the polymer (Roovers and Kranse, 1980).

Also intrinsic viscosities data of (PS/PMMA) appeared in Tables 4.4 and data of density shown in Table 4.9. Both showed lower values than the expected values from calculations. A plot of density versus percent composition of the blend (PS/PMMA) in Figure 4.5 showed overlapping on most compositions like 0.4:1.6, 1.6:0.4 and 1.8:0.2 of PS/PMMA blends respectively, which can both be attributed to the possible presence of incompatibility of the polymer blend at the used temperature and solvent (chloroform).

From Figure 4.6, it is evident that the plots of relative viscosity versus concentration (PVC/PMMA) are linear in certain compositions in the solvent (chloroform), at a temperature of 30°C indicating evidence of compatibility of the polymer blend when compared to the plot in Figure 4.1 (PS/PMMA) which showed an S-shape.

Tables 4.4 indicated the values of the intrinsic viscosity (PS/PMMA), slopes ('b') and intercepts ($[\eta]$) obtained from plots of reduced viscosity against the concentrations of

the polymer blends in chloroform which showed some irregularities attributed to incompatibility. This result is comparable to that of earlier reports of Mohammad and Raina (2008).

Tables 4.5 and Figure 4.10 present a comparison of the experimental and calculated densities of the polymer blends (PS/PMMA). The observed values are lower than that calculated assuming volume additive of the constituents. According to Shur and Randy (1981), decrease in weight is due to molecular interaction and compatibility of the polymers. Table 4.10 and Figure 4.5 of density shows increase of weight which is an evidence of linearity of blend (PVC/PMMA). It had already been established that variations are linear for compatible blends and non-linear for incompatible blends (Chee, 1990).

Figure A2 in the appendix with 00:2.0 PS/PMMA composition shows absorption band at 3437.26 cm^{-1} indicating stretches of O-H is attributed to the presence of carboxylic acid. Ar C-H stretches at 3053.42 cm^{-1} indicated aromatic compound. While the absorption band at 2349.38 indicated no band information. Figure A4 with 0.2:1.8 composition of PS/PMMA showed in the appendix indicated no band information at 3641.73 cm^{-1} and 2332.02 cm^{-1} . The spectrum of 3431.48 displayed a weak stretch of N-H at 3431.48 cm^{-1} indicated amides, =C-H stretches at 3049.56 cm^{-1} characterized alkenes (Gilani *et al.*, 2011). A broad O-H stretches at 2613.63 due to (-COOH) functional groups indicated the presence of carboxylic acids (Vinod and Sashidhar, 2010). Figure A6 with 0.4:1.6 composition of PS/PMMA indicated N-H stretch due to amides observed at 3429.55 cm^{-1} , =C-H stretches were found at 3055.35 cm^{-1} showing the presence of alkenes, where a strong C-H bending stretches due to alkanes and alkyls presence.

Figure 6.4.7 with 0.6:1.4 composition of PS/PMMA shows carboxylic acid exhibited typical features at absorption band [at 3435.34cm⁻¹](#) with a strong broad [peak O-H stretches](#). The presence of aromatic compound as functional group [stretches](#)Ar C-H at 3051.49 cm⁻¹, whereas no band information was found at 2355.16cm⁻¹. Figure 6.4.9 with 0.8:1.2 composition of PS/PMMA shows absorption bands at 3657.16 and 2353.23cm⁻¹ show no band information, O-H stretches at 3437.36cm⁻¹ and 2621.35cm⁻¹ with a strong broad peak indicated the presence of [O-H](#) stretch vibrations (Cunha *et al.*, 2007). [Another peak was](#)Ar C-H [stretches at 3055.35cm⁻¹](#) indicated aromatic compounds. Figure 6.4.11 with 1.1:1.0 compositions PS/PMMA shows broad O-H peak stretches at 3417.98cm⁻¹ indicated the presence of carboxylic acid and C-H stretches strongly at 2935.76 cm⁻¹ indicated alkanes and alkyl. For composition 1.8:0.2 PS/PMMA in Figure 6.4.19, the absorption band at 3406.40 showed a strong stretches of O-H indicated carboxylic acid, a weak =C-H stretches at 3041.84 due to presence of alkenes, and at 2926.11cm⁻¹ strong C-H stretches indicated alkanes and alkyl. FTIR spectrum for 1.6:0.4 PS/PMMA of Figure 6.4.17 with 1.6:0.4 compositions shows the absorption bands at 3423.76 and 2621.35cm⁻¹ indicated a strong stretches of O-H indicated carboxylic acid. Ar C-H stretches at 3055.35cm⁻¹ indicated aromatic compound. [At 2621.35cm⁻¹, C-H is strongly stretches at 2914.54 as indication of alkanes and alkyls, but no band information found at 234](#)C-H strongly stretches at 2922.25 [Composition 1.4-0.6 of PS/PMMA shown](#)indicated alkanes and alkyl. Peaks 2347.45 and 2065.83 showed no band information.

Figure 6.4.23 with 0.0:2.0 composition of PVC/PMMA in appendix shows the absorption band at 667.39 cm⁻¹ indicates C-Br bond stretching to that of the alkyl halides. The IR

frequency band at 1030.02 cm^{-1} is due to C-N stretching vibration mode corresponding to the absorption band at 1163.11 cm^{-1} is the C-H wagging mode of vibration of the $-(\text{CH}_2\text{H})$ bond. N-O asymmetric vibrational mode yielded 1489.1 cm^{-1} absorption band. This spectrum is comparable to that of earlier reported by Subban and Arof (2004), asymmetric vibrational mode of PVC are obtained at 1164 cm^{-1} (C-H of CHCl). The vibrational frequency of 1718 cm^{-1} is as a result of C=O stretching characteristic of α, β -unsaturated ester. O-H bond stretching of the free hydroxyl group resulted in 3057.15 cm^{-1} band. Peak at 3057.27 cm^{-1} can be attributed to C-H stretching vibrational mode of the alkane. Figure 6.4.25 with 0.2:1.8 composition of PVC/PMMA shows IR spectrum absorption band at 673.18 cm^{-1} due to $-\text{C}=\text{C}-\text{H}$ bending vibration characteristic of alkynes. C-H stretching resulted in the peak at 1035.81 cm^{-1} , N-O asymmetric stretching resulted in the peak at 1506.46 cm^{-1} , C-C stretch characteristic of in-ring aromatics gave rise to the peak at 1477.52 cm^{-1} , whereas, $=\text{C}-\text{H}$ stretching resulted in absorption at both 3036.06 and 3090.07 , that of O-H stretch resulted in the peak at 3466.2 cm^{-1} . Figure 6.4.27 with composition 0.4:1.6 shows IR spectrum absorption bands at 1647.26 cm^{-1} and 3090.07 cm^{-1} due to $-\text{C}=\text{C}-$ and $=\text{C}-\text{H}$ stretching, respectively. Asymmetric stretching mode was observed at 1506.46 cm^{-1} due to N-O group whereas bending mode of vibration was observed at 673.18 cm^{-1} due to $-\text{C}=\text{C}-\text{H}$. Other stretching mode of vibration was observed at 3036.06 , 1730.2 , 11477.52 cm^{-1} peaks due to C-H, C=O, and C-C, respectively. Figure 6.4.29 with 0.6:1.4 composition of PVC/PMMA shows two $=\text{C}-\text{H}$ stretching mode of vibration characteristic of alkenes resulting in absorption bands at 3036.06 and 3090.07 cm^{-1} . Asymmetric stretching mode of vibration gave rise to peaks at absorption band 1506.46 cm^{-1} due to N-H 1^0 amines whereas bending modes of vibration

results in absorption band peaked at 1649.19 cm^{-1} . Two normal stretching mode of vibration gave rise to absorption bands at 673.18 and 1734.06 cm^{-1} due to C-Br C=O functional groups respectively.

Figure 6.4.31 with composition 0.8:1.2 shows -C=C- mode appeared at 673.18 cm^{-1} . Characteristic C-C stretching (in-ring) aromatic band was at 1734.06 cm^{-1} . C-N stretching vibration characteristic of the aliphatic amines gave rise to absorption band at 1035.81 cm^{-1} . Two band peaks of C=O stretching vibration characteristic of α, β -unsaturated aldehydes and ketones and saturated aliphatic were observed at 1683.91 and 1734.06 cm^{-1} respectively. C-H stretching vibration band characteristic of aromatics was observed at 3036.06 cm^{-1} . Figure 6.4.33 with composition 1.0:1.0 of PVC/PMMA shows a strong C-Br stretching at 673.18 cm^{-1} , =C-H stretching vibration at 3036.06 and 3070.78 cm^{-1} . Asymmetric stretching due to N-O was observed at 1506.46 cm^{-1} . C=O vibration resulted into band peaks at 1734.06 cm^{-1} , C-C stretch was observed 1477.52 cm^{-1} and C-N stretch gave peak at 1035.81 cm^{-1} . Figure 6.4.35 with 1.2:0.8 composition shows C-Br stretches was observed at 671.25 cm^{-1} , N-H wag gave rise to absorption at 858.35 cm^{-1} . =C-H bending vibration gave a frequency band at 3057.27 and 958.65 cm^{-1} . Stretching vibration characteristic of C-N gave peak frequencies of 1031.95 and 1170.83 cm^{-1} . In-ring stretching vibration characteristic of C-C aromatics was observed at 1487.17 cm^{-1} . C=O stretch of that of α, β -unsaturated esters was observed at 1718.63 cm^{-1} . C-H stretch vibration was observed at 2931.9 cm^{-1} . A medium stretching vibration yielded frequency band at 3352.39 cm^{-1} due to $1^0, 2^0$ amine and amides. Figure 6.4.37 with 1.4:0.6 compositions of PVC/PMMA shows the characteristic of C-Br stretching and was observed at 673.18 cm^{-1} . Absorption bands at 3036.06 and 3090.07 cm^{-1} was due to

stretching mode of vibration of =C-H bonds of alkenes group. C-N bond stretching due to aliphatic amines peaked at 1035.81 cm^{-1} whereas N-H bond bending was due to 1° amines at band frequency of 1649.19 cm^{-1} . Asymmetric N-O bond vibration of nitro compounds was observed at 1506.46 cm^{-1} .

The observed frequency band at 1479.45 cm^{-1} was due to C-C bond stretching of in-ring aromatics. Figure 6.4.39 with composition 1.6:0.4 shows C-O bond stretching at 1035.81 cm^{-1} probably due to alcohols, carboxylic acids, esters and ethers was observed whereas C=O stretching vibration mode gave rise to a peak at 1683.91 and 1734.06 cm^{-1} . These absorption bands are due to α , β -unsaturated aldehydes, ketones and aldehyde and unsaturated aliphatic respectively. Absorption bands at 3443.05 and 3348.54 cm^{-1} are typical of O-H stretching mode of alcohols and phenols. The absorption band at 1477.52 and 1533.46 cm^{-1} is due to asymmetric stretching of nitro compounds. The presence of bond stretching at 3443.05 cm^{-1} is due to =C-H bond of alkene group. The characteristic C-Br stretch due to alkyl halides was observed at 673.18 cm^{-1} . Figure 6.4.41 with composition 1.8:0.2 shows the characteristic absorption band at 673.18 cm^{-1} C-Br stretch due to alkyl halides was observed. C=O stretching vibration mode gave rise to a peak at 1683.91 and 1734.06 cm^{-1} . These absorption bands are due to α , β -unsaturated aldehydes, ketones and aldehyde and unsaturated aliphatic respectively. The absorption band at 3036.06 cm^{-1} of O-H stretch mode of vibration is due to carboxylic acid. The broad band occurring at 3036.06 cm^{-1} is due to the presence of hydroxyl group (i.e. OH stretch), the characteristic in-ring C-C stretching of the aromatics was observed at 1477.52 cm^{-1} . C-N bond stretching resulted in the peak at 1035.81 cm^{-1} . Asymmetric stretching of N-O resulted in the 1506.46 cm^{-1} . Figure 6.4.43 with 2.0:00

compositions of PVC/PMMA shows N-H bond stretching and bending occurred at 3350.46 and 1622.19 cm^{-1} respectively. The characteristic C-C bond stretching of the in-ring aromatics was observed at 1473.66 cm^{-1} . The IR band at 1683.91 cm^{-1} attributed to C=O stretching vibration of α , β -unsaturated aldehydes, ketones was observed. Absorption band at 3037.99 cm^{-1} was due =C-H bond stretching characteristic of alkenes. The C-Br bond stretching gave rise to 673.18 cm^{-1} . The peak at 3441.12 cm^{-1} was due to O-H stretch. C-N stretching vibration gave absorption band at 1035.81 cm^{-1} .

Examining the absorption bands for each of the blend ratio, it can be seen that there is a shift in the position of the peaks at the C=O bond in PMMA. That is, for pure PMMA, C=O bond stretching is 1730.21 cm^{-1} which is shifted to 1683.91 cm^{-1} in blend ratio of 1.6:0.4, 0.8:1.2, 1.8:0.2 and 2.0:0.0 and also 1718.63 cm^{-1} , in the blend ratio of 1.2:0.8. It therefore means that there is a level of interaction between PVC and PMMA at the C-Cl and C=O groups in the blend ratios specified above. Earlier reports by Saikia and Kumar (2005), pointed out that the Krigbaum seems to be well applicable in describing the compatibility of PS/PMMA and PVC/PMMA polymer blend systems. The viscometric, density and FTIR techniques pointed out the existence of interaction between the carbonyl groups of PMMA and the hydrogen atom of CHCl group of PVC in the entire compositions of PVC and PMMA in both solution and solid state and such levels of interaction do not exist in PS/PMMA blend. But peaks of PS/PMMA indicated no linkage in the interaction nor are the aromatic rings affected by blending these two polymers. This result is comparable to that of earlier reports of Mohammad and Raina (2008).

6.0 CONCLUSION

- (i) Compatibility of polymer blends basically depends in principles on the method used and the temperature of blending. Studies on compatibility of polymer blends solution using viscometric, FTIR and density methods reveal degree of compatibility and the good level of compatibility between PVC and PMMA blend.
- (ii) PS/PMMA blend shows no degree of compatibility and it revealed that plots of relative viscosity are almost an S-shape. This is an indication that the polymers are incompatible in the studied solvent (chloroform) at temperature of 30°C. This may be attributed to the mutual repulsion of molecules in solutions which lead to decrease of dynamic volume of the polymer.
- (iii) There is now a clear understanding of predicted better grade polymers from blend studied in this research where by detecting the concentration of maximum molecular interaction of the functional groups of the polymer blend a cheaper.
- (iv) The FTIR spectrum recorded on PS/PMMA blend didnot indicate the existence of any interaction between the components. There is no change in the position of eitherpeak of aromatic ring of PMMA or the either lone pair. But there is existence of interaction between the carbonyl groups of PMMA and the hydrogen atom of CHClgroup of PVC in the entire composition.
- (v) During the course of my study, the three methods reveal that compatibility of PS//PMMA and PVC/PMMA using chloroform as solvent at 30°C depends on the

molecular weight of the blend and temperature. Used of chloroform as a solvent produces a quick solubility in PVC/PMMA but not in PS/PMMA at 30⁰C when compare to other solvent used in some literature.

- (vi) The three testing compatibility methods reveal that maximum interaction of PMMA/PVC blend can be obtained at 40:60, 60:40 and 80:20 (%) composition at 30⁰C with chloroform as solvent, which are the concentration at which the polymers can be mixed to obtain a good results, but other concentration could be good based on it area of applications.

6.1RECOMMENDATION

Although there are conflicting data in some literatures on polymer blends, there is need for more research on improving more polymer blends, justification of some these conflicting data in the literatures, study some of the functional properties of traditional and versatile polymers by use of different solvents and temperature when blending. Viscometric, FTIR and density methods are quick and simple for compatibility studies in polymer blends because they require inexpensive equipment and yet offer a classification of the blends into compatible or incompatible.

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LIST OF APPENDICES

Table 3.1: Composition ratio of PS/PMMA blends (g/dl).

SAMPLES	PS	PMMA
A1	0	100
A2	10	90
A3	20	80
A4	30	70
A5	40	60
A6	50	50
A7	60	40
A8	70	30
A9	80	20
A10	90	10
A11	100	0

Table 3.2: Composition ratio of PVC/PMMA blends (g/dl).

Conc. g/cm ³	SAMPLES												
	PVC							PMMA					
	B1	A1	A2	A3	A4 ⁰	A5	A6	A7	100	A8	A9	A10	A11
	Conc.(dl)	00;2.0	0.2;1.8	0.4;1.6	0.6;1.4	0.8;1.2	1.0;1.0	1.2;0.8	1.4;0.6	1.6;0.4	1.8;0.2	2.0;0.0	
	B2				10				90				
	B3				20				80				
	B4				30				70				
	B5				40				60				
	B6				50				50				
	B7				60				40				
	B8				70				30				
	B9				80				20				
	B10				90				10				
	B11				100				0				

Table 4.1: Relative Viscosity of PS/PMMA

5/5	0.02	1.429	1.334	1.358	1.414	1.496	1.524	1.567	1.615	1.622	1.693	1.755
5/10	0.01	1.24	1.217	1.232	1.271	1.335	1.369	1.355	1.371	1.373	1.445	1.466
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
5/15	Conc (g/dl)	0.02	0.2	1.8	0.4	1.6	0.6	1.4	0.8	1.2	1.0	1.3
		0.67	0.166	0.16	0.167	0.14	0.26	0.11	0.188	0.6	0.4	0.2
		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5/20	0.005	1.119	1.135	1.126	1.163	1.216	1.204	1.231	1.219	1.308	1.266	1.277
5/25	0.004	1.109	1.116	1.116	1.129	1.151	1.176	1.188	1.205	1.251	1.238	1.232
5/30	0.0034	1.092	1.099	1.106	1.116	1.134	1.154	1.158	1.163	1.209	1.149	1.204
5/35	0.0028	1.088	1.081	1.079	1.095	1.12	1.129	1.127	1.139	1.185	1.145	1.175
5/40	0.0026	1.078	1.079	1.077	1.077	1.079	1.115	1.107	1.119	1.123	1.123	1.155
5/45	0.0022	1.062	1.064	1.074	1.074	1.077	1.109	1.095	1.103	1.102	1.116	1.151
5/50	0.002	1.053	1.058	1.071	1.071	1.071	1.101	1.085	1.092	1.091	1.104	1.139

Table 4.2: Specific Viscosity of PS/PMMA

0.02	0.429	0.334	0.358	0.414	0.496	0.524	0.567	0.615	0.622	0.693	0.755
0.01	0.24	0.217	0.232	0.271	0.335	0.369	0.355	0.371	0.373	0.445	0.466
0.006	0.167	0.166	0.167	0.204	0.246	0.261	0.288	0.279	0.353	0.313	0.37
0.005	0.119	0.135	0.126	0.163	0.216	0.204	0.231	0.219	0.308	0.266	0.277
0.004	0.109	0.116	0.116	0.129	0.151	0.176	0.188	0.205	0.251	0.238	0.232
0.0034	0.092	0.099	0.106	0.116	0.134	0.154	0.158	0.163	0.209	0.149	0.204
0.0028	0.088	0.081	0.079	0.095	0.12	0.129	0.127	0.139	0.185	0.145	0.175
0.0026	0.078	0.079	0.077	0.077	0.079	0.115	0.107	0.119	0.123	0.123	0.155
0.0022	0.062	0.064	0.074	0.074	0.077	0.109	0.095	0.103	0.102	0.116	0.151
0.002	0.053	0.058	0.071	0.071	0.071	0.101	0.085	0.092	0.091	0.104	0.139

Table 4.3: Reduced Viscosity of PS/PMMA

Conc. g/dl	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
	00;2.0	0.2;1.8	0.4;1.6	0.6;1.4	0.8;1.2	1.0;1.0	1.2;0.8	1.4;0.6	1.6;0;4	1.8;0.2	2.0;0.0
0.02	21.45	16.70	17.90	20.70	24.80	26.20	28.35	30.75	31.10	34.65	37.75
0.01	24.00	21.70	23.20	27.10	33.50	36.90	35.5	37.10	37.30	44.50	46.60
0.006	27.83	27.67	27.83	34.00	41.00	43.50	48.00	46.50	58.83	52.17	61.67
0.005	23.80	27.00	25.20	32.60	43.20	40.80	46.20	43.80	61.6	53.20	55.40
0.004	27.25	29.00	29.00	32.25	37.75	44.00	47.00	51.25	62.75	59.50	58.00
0.0034	27.06	29.12	29.12	31.18	39.41	45.29	46.47	47.94	61.47	43.82	60.00
0.0028	31.43	28.93	28.21	33.93	42.86	46.07	45.36	49.64	66.07	51.79	62.50
00.0026	30.00	30.38	29.62	29.62	30.38	44.23	41.15	45.77	47.31	47.31	59.62
0.0022	28.18	29.09	33.64	33.64	35.00	49.55	43.18	46.82	46.36	52.73	68.64
0.002	26.500	29.00	35.5	35.5	35.50	50.50	42.50	46.00	45.50	52.0	69.50

Table 4.4: Huggins parameter, intrinsic viscosity for PS/PMMA

Conc. (g/cm)	Conc. (g/dl)	b	$[\eta]$ (Intrinsic)	R^2
5/5	0.02	0.0241	20.62	0.9929
5/10	0.01	0.0468	15.19	0.964
5/15	0.006	0.0457	16.356	0.9772
5/20	0.005	0.0488	19.409	0.9605
5/25	0.004	0.0542	23.851	0.9376
5/30	0.0034	0.074	24.173	0.9569
5/35	0.0028	0.0663	26.521	0.9525
5/40	0.0026	0.0644	28.641	0.9765
5/45	0.0022	0.1016	30.606	0.8925
5/50	0.002	0.0918	33.135	0.9624

Table 4.5: Density of PS/PMMA blend

Conc.(g/dl)	Conc.(100g/cm ⁻³)	Observed	Calculated	Observed (%)
0.02	5/5	0.08987	1.319	89.87
0.01	5/10	0.09003	1.322	90.03
0.006	5/15	0.08999	1.322	89.99
0.005	5/20	0.09007	1.322	90.07
0.004	5/25	0.08999	1.323	89.99
0.0034	5/30	0.08997	1.323	89.97
0.0028	5/35	0.08996	1.321	89.96
0.0026	5/40	0.09004	1.321	90.04
0.0022	5/45	0.08999	1.323	89.99
0.002	5/50	0.09003	1.322	90.03

$$\text{Calculated density} = \frac{X_3 - X_1}{X_2 - X_1}$$

rWhere X1 = Weight of empty bottle

X2 = Weight of empty + distilled water

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Conc. Conc.(g/dl)	00;2.0	0.2;1.8	0.4;1.6	0.6;1.4	0.8;1.2	1.0;1.0	1.2;08	1.4;0.6	1.6;0;4	1.8;0.2	2.0;00

X3 = Weight of empty + solvent

5/5	0.02	1.297	1.311	1.127	1.247	1.294	1.301	1.289	1.333	1.158	1.399	1.412
5/10	0.01	1.223	1.223	1.086	1.2	1.201	1.282	1.201	1.223	1.144	1.254	1.258
5/15	0.006	1.161	1.18	1.069	1.154	1.159	1.155	1.163	1.151	1.107	1.209	1.193
5/20	0.005	1.133	1.134	1.053	1.124	1.135	1.125	1.126	1.127	1.101	1.155	1.139
5/25	0.004	1.120	1.117	1.049	1.103	1.112	1.109	1.112	1.100	1.059	1.123	1.126
5/30	0.0034	1.106	1.112	1.045	1.089	1.087	1.089	1.089	1.079	1.056	1.071	1.104
5/35	0.0028	1.077	1.093	1.000	1.078	1.083	1.081	1.073	1.063	1.05	1.086	1.084
5/40	0.0026	1.062	1.082	0.995	1.069	1.069	1.07	1.061	1.054	1.042	1.074	1.064
5/45	0.0022	1.060	1.069	0.991	1.061	1.064	1.064	1.064	1.041	1.034	1.046	1.059
5/50	0.002	1.058	1.059	0.998	1.058	1.062	1.059	1.062	1.029	1.023	1.035	1.048

Table 4.6: Relative Viscosity of PVC/PMMA

Table 4.7: Specific Viscosity of PVC/PMMA

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Conc.(g/dl)	00;2.0	0.2;1.8	0.4;1.6	0.6;1.4	0.8;1.2	1.0;1.0	1.2;0.8	1.4;0.6	1.6;0;4	1.8;0.2	2.0;0.0
0.02	0.297	0.311	0.127	0.247	0.294	0.301	0.289	0.333	0.158	0.399	0.412
0.01	0.223	0.223	0.086	0.2	0.201	0.282	0.201	0.223	0.144	0.254	0.258
0.006	0.161	0.18	0.069	0.154	0.159	0.155	0.163	0.151	0.107	0.209	0.193
0.005	0.133	0.134	0.053	0.124	0.135	0.125	0.126	0.127	0.101	0.155	0.139
0.004	0.12	0.117	0.049	0.103	0.112	0.109	0.112	0.1	0.059	0.123	0.126
0.0034	0.106	0.112	0.045	0.089	0.087	0.089	0.089	0.079	0.056	0.071	0.104
0.0028	0.077	0.093	0.00	0.078	0.083	0.081	0.073	0.063	0.05	0.086	0.084
0.0026	0.062	0.082	-0.005	0.069	0.069	0.07	0.061	0.054	0.042	0.074	0.064
0.0022	0.06	0.069	-0.009	0.061	0.064	0.064	0.064	0.041	0.034	0.046	0.059
0.002	0.058	0.059	-0.012	0.058	0.062	0.059	0.062	0.029	0.023	0.035	0.048

Table 4.8: Reduced Viscosity of PVC/PMMA

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Conc. (g/dl)	0.2;2.0	0.2;1.8	0.4;1.6	0.6;1.4	0.8;1.2	1.0;1.0	1.2;0.8	1.4;0.6	1.6;0.4	1.8;0.2	2.0;0.0
Conc. (g/cm ³)				b			<i>Intrinsic</i> []		<i>R</i> ²		
0.02	14.85	15.55	6.35	12.35	14.70	15.05	14.45	16.65	7.90	19.95	20.60
0.01	22.30	22.30	8.60	20.00	20.10	28.20	20.10	22.30	14.40	25.4	25.80
0.006	26.83	30.00	11.50	25.67	26.50	25.83	27.17	25.17	17.83	34.83	32.17
0.005	26.60	26.80	10.60	24.80	27.00	25.00	25.20	25.40	20.20	31.00	27.80
0.004	30.00	29.25	12.25	25.75	28.00	27.25	28.00	25.00	14.75	30.75	31.50
0.0034	31.18	32.94	13.24	26.18	25.59	26.18	26.18	23.24	16.47	20.88	30.59
0.0028	27.50	33.21	0.00	27.86	29.64	28.93	26.07	22.50	17.86	30.71	30.00
0.0026	23.85	31.54	-1.920	26.54	26.53	26.92	23.46	20.77	16.15	28.46	24.62
0.0022	27.27	31.36	-4.09	27.73	29.09	29.09	29.09	18.64	15.45	20.91	26.82
0.002	29.00	29.50	-6.00	29.00	31.00	29.50	31.00	14.50	11.5	17.5	24.00

Table 4.9: Huggins parameter, intrinsic viscosity for PVC/PMMA

5/5	0.02	-752.57	30.303	0.783
5/10	0.01	-936.97	33.679	0.8911
5/15	0.006	398.96	27.391	0.0904
5/20	0.005	-881.91	29.703	0.9753
5/25	0.004	-839.25	30.683	0.9001
5/30	0.0034	-668.93	30.076	0.7794
5/35	0.0028	-798.82	29.905	0.8209
5/40	0.0026	-152.9	22.305	0.0508
5/45	0.0022	-401.28	17.578	0.4058
5/50	0.002	-211.55	27.266	0.0391

Table 4.10: Specific gravity of PVC/PMMA blend

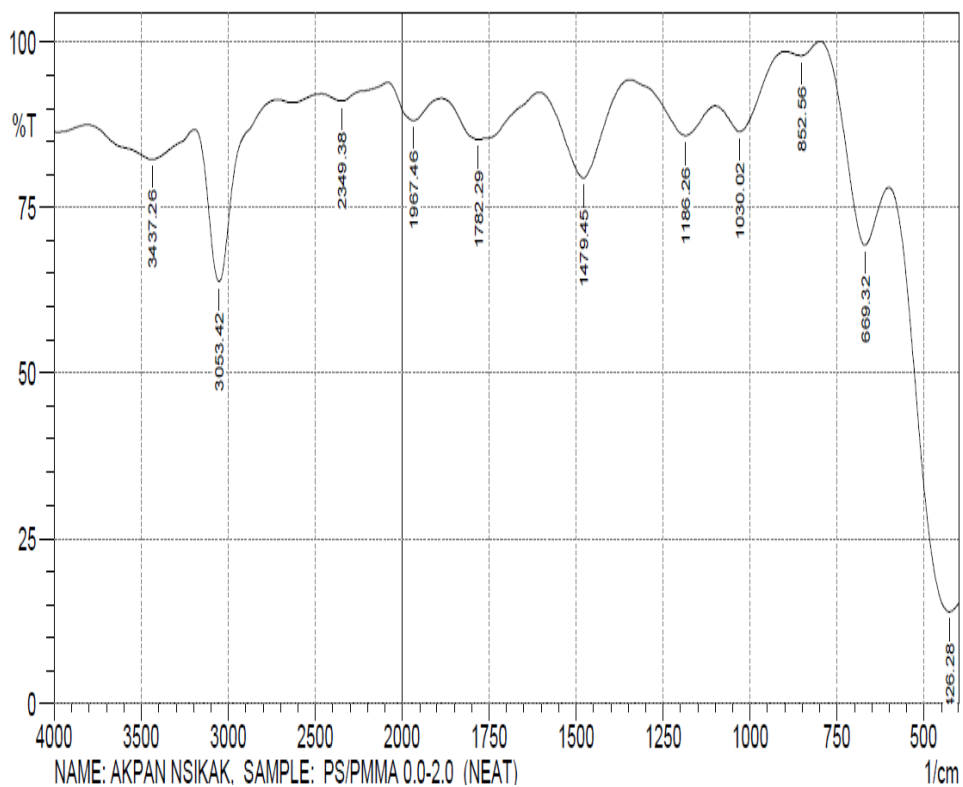
Conc. (g/dl)	Conc. (g/100cm ³)	Observed	Calculated	Observed (%)
0.02	5/5	0.08999	1.322	89.99
0.01	5/10	0.08998	1.321	89.98
0.006	5/15	0.08997	1.321	89.97
0.005	5/20	0.08999	1.321	89.99
0.004	5/25	0.08996	1.319	89.96
0.0034	5/30	0.08998	1.320	89.98
0.0028	5/35	0.08996	1.319	89.96
0.0026	5/40	0.08989	1.321	89.89
0.0022	5/45	0.08990	1.323	89.90
0.002	5/50	0.08982	1.322	89.82

A1: FTIR data spectrum of 0.0:2.0 (PS/PMMA)

Peak	Intensity	Area	Assignment
426.28	13.949	99.327	C-I Stretch alkyl, halides
669.32	69.278	17.726	C-H bend, alkenes
852.56	97.947	0.6	C- C l stretch alkyl halides
1030.02	8643	7.892	C-F Stretch alkyl halides
1186.26	85.851	11.486	C-O stretch alcohols
1479.45	79.409	15.819	ring C=C Stretch aromatic compound
1782.29	85.31	15.068	C=O Stretch esters
1967.46	88.115	8.341	
2349.38	91.106	13.302	
3053.42	63.782	44.013	Ar C-H Stretch aromatic compound
3437.26	82.246	45.331	O-H stretch Carboxylic acids,

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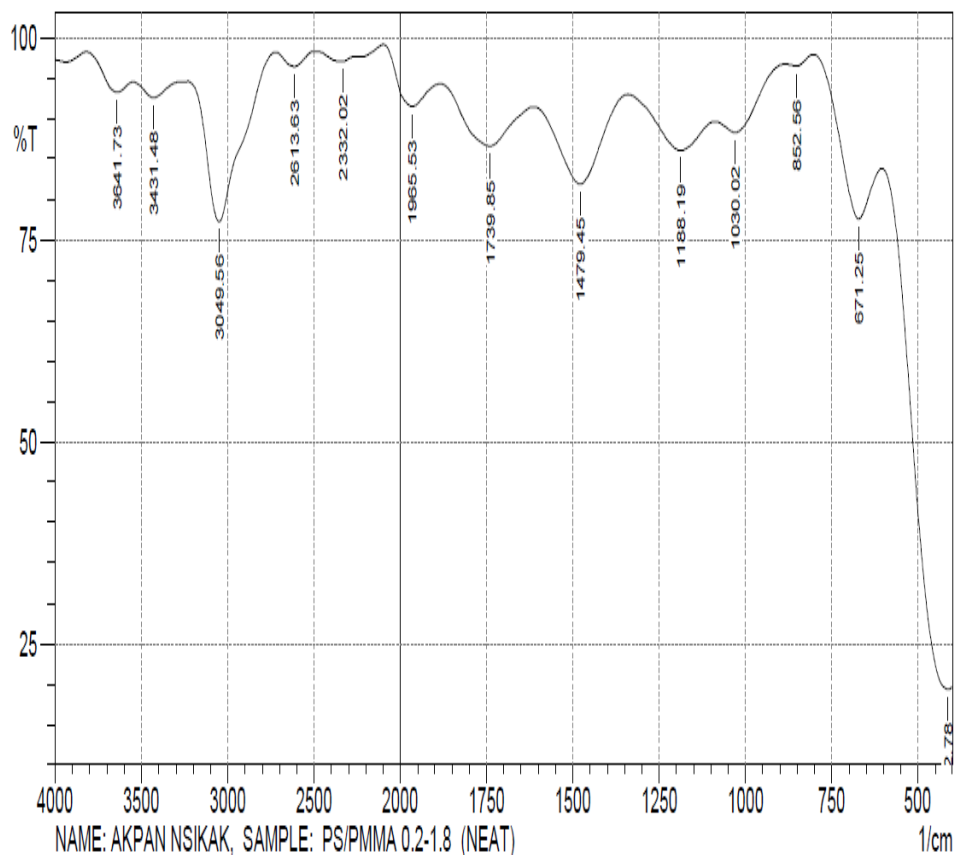
A2: FTIR spectrum graph of 0.0:2.0 (PS/PMMA)

A3: FTIR data spectrum of 0.2:1.8(PS/PMMA)

Peak	Intensity	Area	Assignment
412.78	19.379	80.401	C-I Stretch alkyl halides
671.25	77.59	13.015	C-H bend alkenes
852.56	96.505	1.097	
1030.02	88.297	7.652	C-F stretch alkyl halide
1188.19	86.06	12.884	C=O stretch alcohols
1479.45	81.868	16.082	ring C=C stretch aromatic compounds
1739.85	86.856	12.84	C=O Stretch ester
1965.53	91.527	5.112	
2332.02	97.123	2.55	
2613.63	96.459	2.636	O-H Stretch carboxylic acid
3049.56	77.283	27.783	C-H stretch alkenes
3431.48	92.582	7.626	N-H stretch, amides
3641.73	33.25	5.876	

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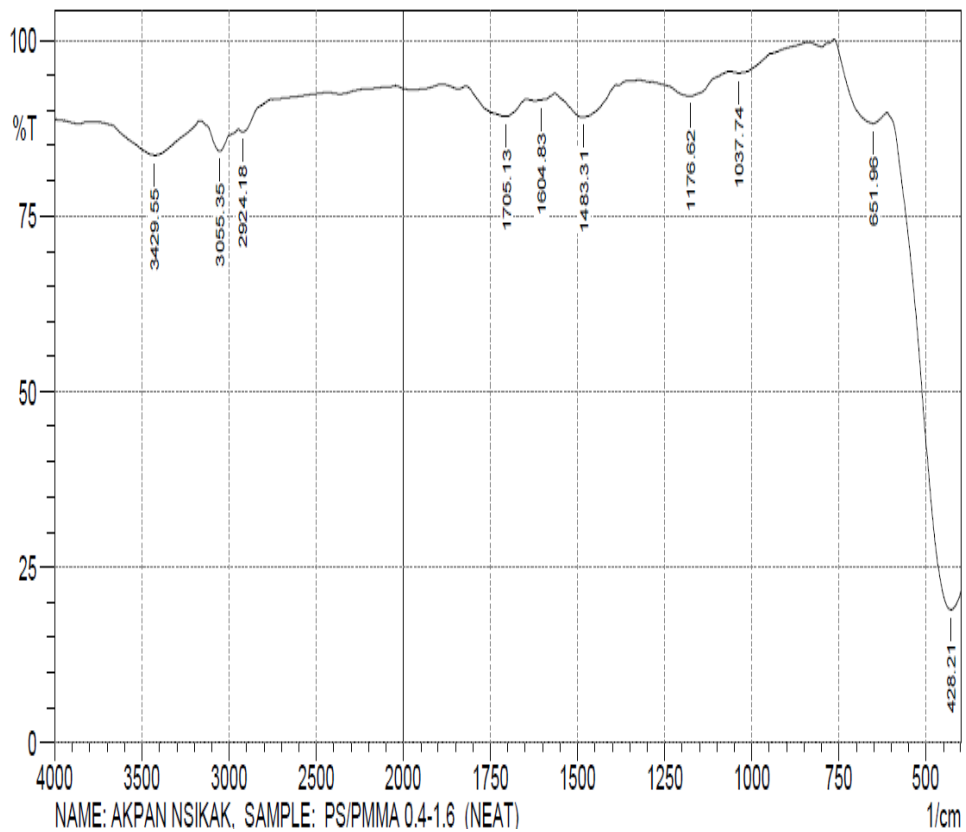
A4: FTIR spectrum graph of 0.2:1.8 (PS/PMMA)

Table A5: FTIR data spectrum of 0.4:1.6 (PS/PMMA)

Peak	Intensity	Area	Assignment
428.21	18.976	79.909	C-I Stretch alkyl halides
651.96	88.192	5.998	C-H bend alkynes Stretch
1037.74	85.341	2.504	C-O Stretch alcohol
1176.62	92.026	6.465	
1483.31	89.057	7.435	
1604.83	91.505	0.369	N-H bend amines
1705.13	89.176	2.75	C=O Stretch aldehydes
2924.18	86.936	9.217	C-H Stretch alkanes and alkyls
3055.35	84.208	13.713	=C-H Stretch alkenes
2429.55	83.646	35.365	N-H Stretch amides

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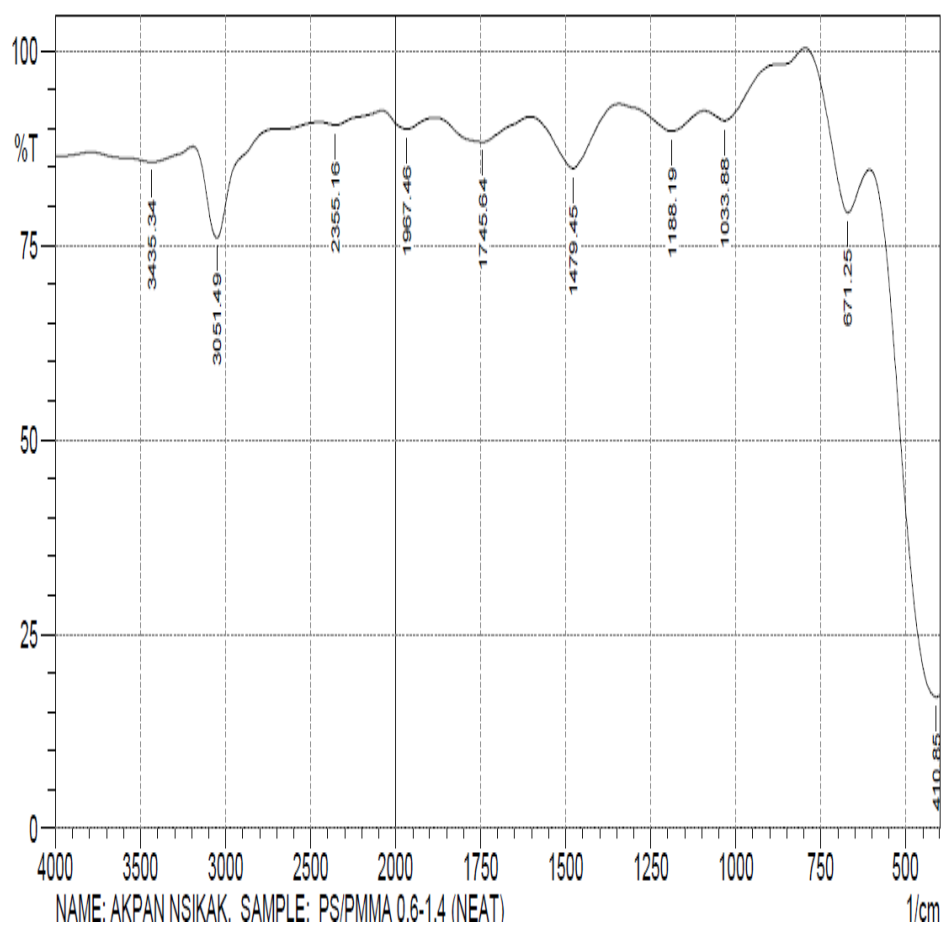
A6: FTIR spectrum graph of 0.4:1.6 (PS/PMMA)

Table A7: FTIR spectrum data of 0.6:1.4 (PS/PMMA)

Peak	Intensity	Area	Assignment
410.35	16.968	83.912	C-I Stretch alkyl halides
671.25	79.171	10.766	C-H bend alkenes
1033.88	91.011	6.087	C-F Stretch alkyl halides
1188.19	89.63	8.828	C-O stretch alcohols
1479.45	84.872	13.183	Ring C=C aromatic compounds stretch
1745.64	88.262	13.12	C=O Stretch ketones
1967.46	89.911	8.042	
2355.16	90.452	14.794	
3051.49	75.937	35.2207	Ar. C-H Stretch aromatic compound
3435.34	85.631	38.382	O-H Stretch carboxylic acid

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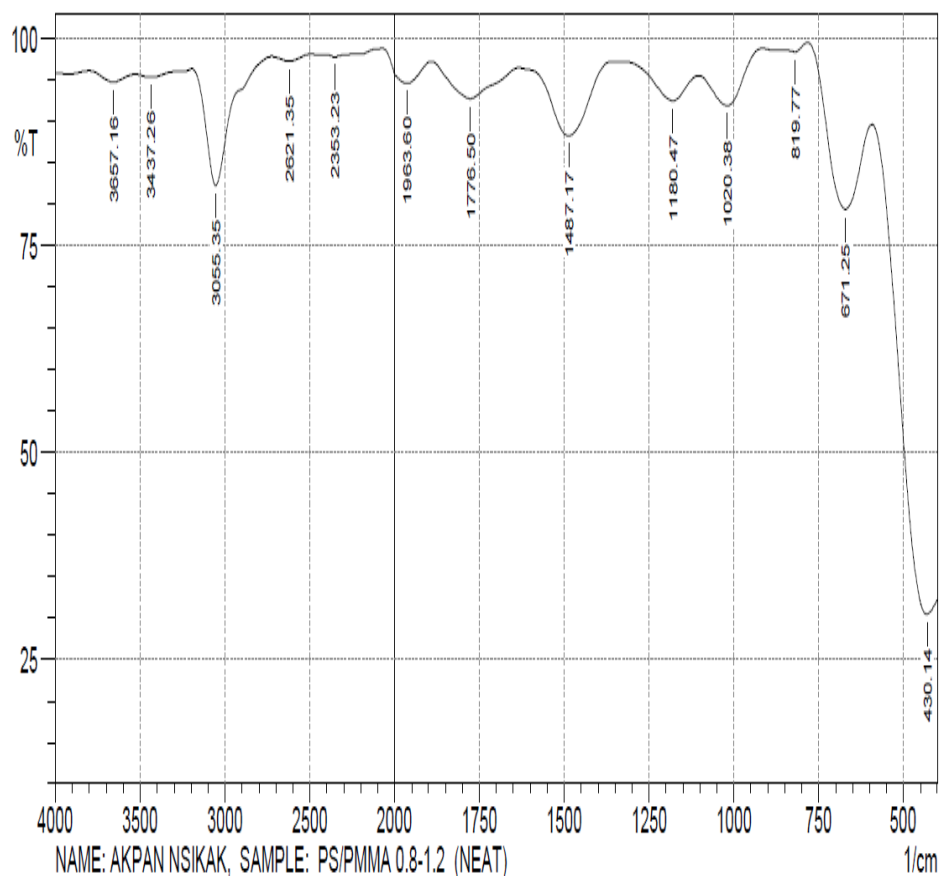
A8: FTIR spectrum graph of 0.6:1.4 (PS/PMMA)

Table A9: FTIR data spectrum of 0.8:1.2 (PS/PMMA)

Peak	Intensity	Area	Assignment
430.14	30.512	58.207	C-I Stretch alkyl halides
671.25	79.392	11.577	C-H bend alkenes
819.77	98.365	0.509	C-H bend aromatic compounds
1020.38	91.861	4.46	C-F Stretch alkyl halides
1180.47	92.45	5.106	C-O stretch alcohols
1487.17	88.228	8.468	Ring C=C stretch aromatic compounds
1776.5	82.705	6.177	C=O Stretch esters
1963.6	94.52	2.883	
2353.23	97.774	1.662	
2621.35	97.238	2.445	O-HStretch carboxylic acid
3055.35	82,228	16.866	Ar C-H Stretch aromatic compound
3437.26	85.272	5.214	O-H Stretch carboxylic acid

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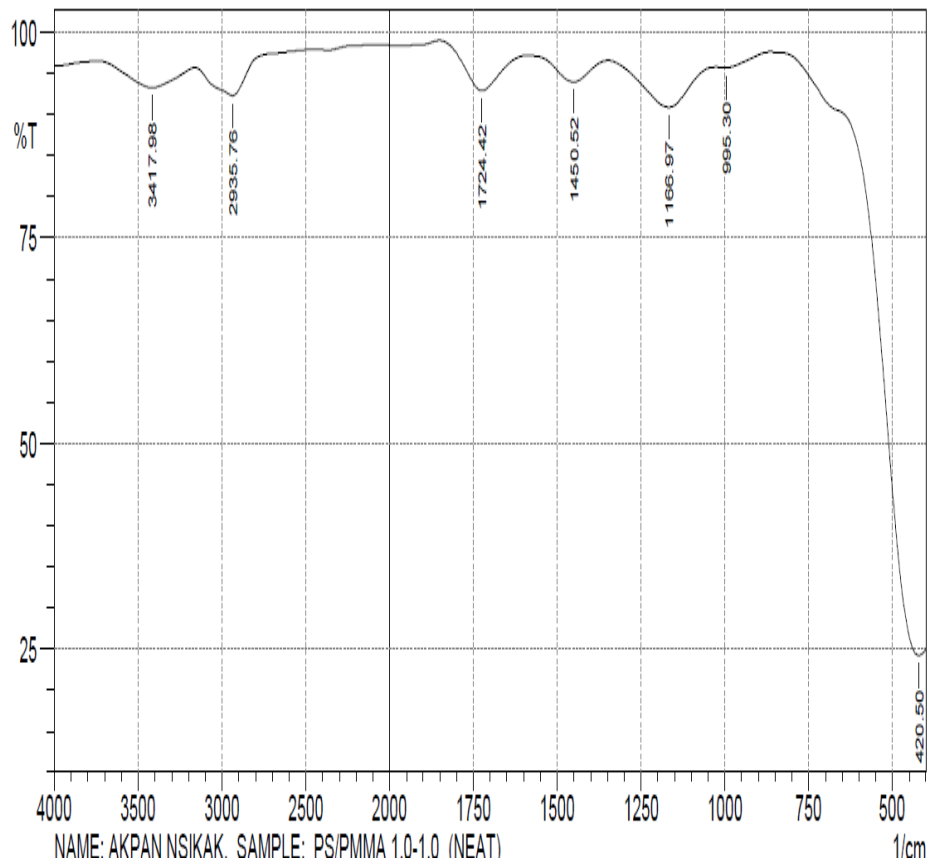
A10: FTIR spectrum graph of 0.8:1.2 (PS/PMMA)

Table A11: FTIR data spectrum of 1.0:1.0 (PS/PMMA)

Peak	Intensity	Area	Assignment
420.5	24.224	80.375	C-I Stretch alkyl halides
995.3	95.719	2.507	
1166.97	90.895	9.017	C-O Stretch alcohol
1450.52	93.962	4.622	Ring C=C Stretch Aromatic compound
17124.42	92.892	4.882	C=O stretch ester
2935.76	92.279	13.429	C-H Stretch alkanes and alkyls
3417.98	93.269	13.671	O-H Stretch carboxylic acid

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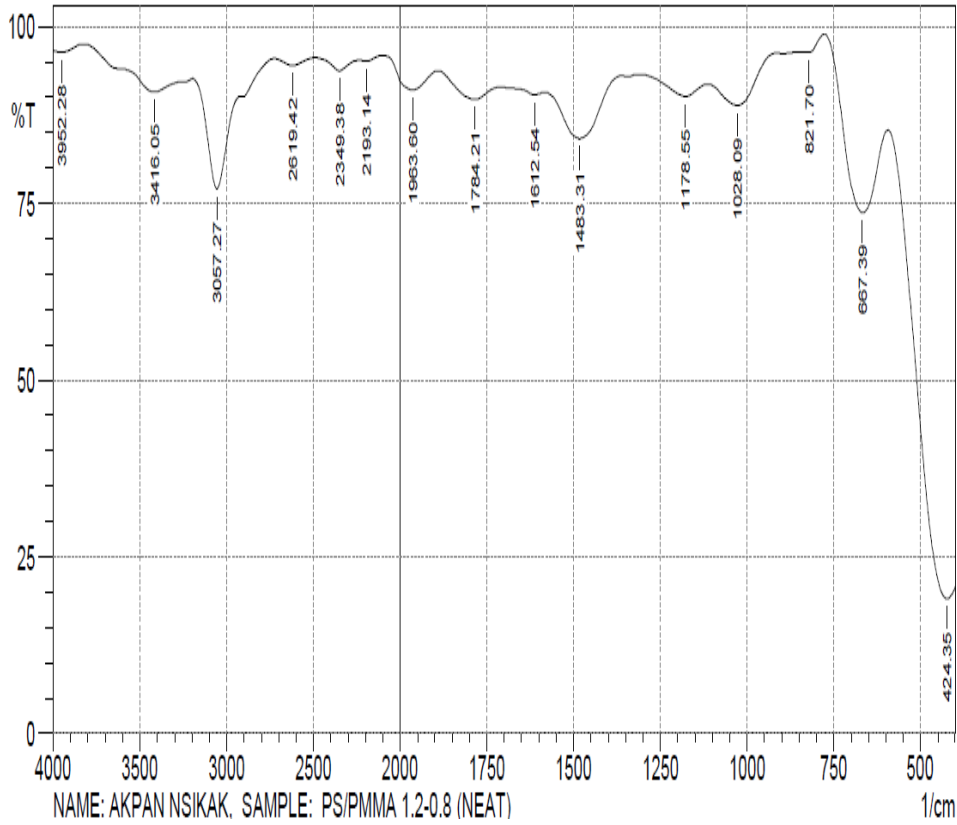
A12: FTIR spectrum graph of 1.0:1.0 (PS/PMMA)

A13: FTIR data spectrum of 1.2:0.8(PS/PMMA)

Peak	Intensity	Area	Assignment
451.36	16.9403	80.6602	C-I Stretch alkyl halides
680.89	92.5304	1.8704	=C-H bend alkenes
758.05	98.0789	0.3174	C-Clalkyl halides
1141.9	93.4127	6.9998	C-O Stretch alcohol
1450.52	92.3723	1.7457	Ring C=C stretch aromatic compound
1600.97	92,8574	1.2641	N-H bend amides
1730.21	93.0018	2.2183	C=O Stretch esters
1809.23	95.2304	0.7153	C=O Symmetric anhydrides
2926.11	89.5061	4.2297	C-H Stretch alkanes and alkyls
3041.84	90.8726	3.0614	=C-H Stretch alkenes
3406.4	89.7038	11.1239	O-H Stretch Carboxylic acids

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A14: FTIR spectrum graph of 1.2:0.8 (PS/PMMA)

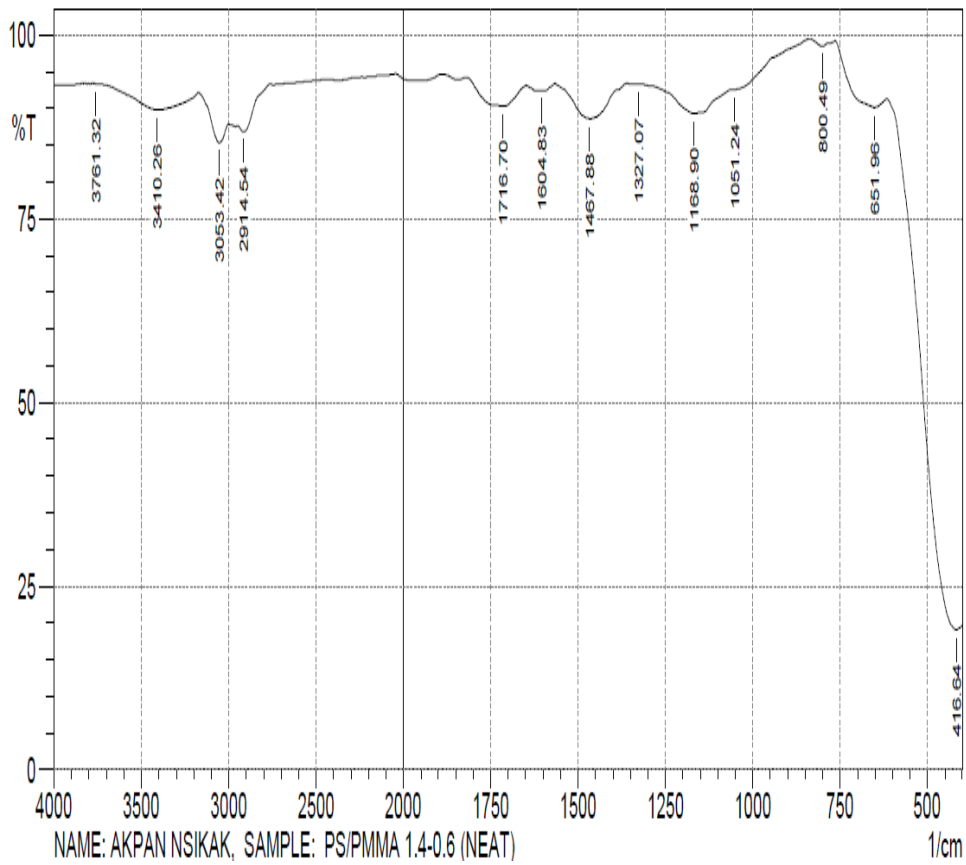
Table A15: FTIR data spectrum of 1.4:0.6 (PS/PMMA)

Peak	Intensity	Area	Assignment
426.28	18.087	79.787	C-I Stretch alkyl halides
671.25	62.489	21.459	=C-H bend alkenes
806.27	97.378	0.819	C-Cl Stretch alkyl halides
1024.24	85.157	7.773	C-F stretch alkyl halides
1176.62	89.456	6.395	
1373.36	94.406	1.722	-CH(CH ₃) ₂ bend
1491.02	77.626	13.016	Ring C=C Stretch Aromatic compound
1587.47	91004	1.795	
1697.41	91,876	2.353	
1786.14	88.251	6.566	
1963.6	90.752	4.437	
2065.83	98.359	0.279	C-H stretch

			alkanes
2347.455	96.203	1.732	O-H stretch,
2621.35	96.597	1.643	free h
2922.25	88.715	6.414	O-H Stretch
3055.35	63.88	25.071	C-H Stretch
3423.76	88.741	16.128	alkane
			Ar C-H Stretch
			aromatic
			O- H Stretch
			carboxylic acid

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A16: FTIR spectrum data of 1.4:1.6 (PS/PMMA)

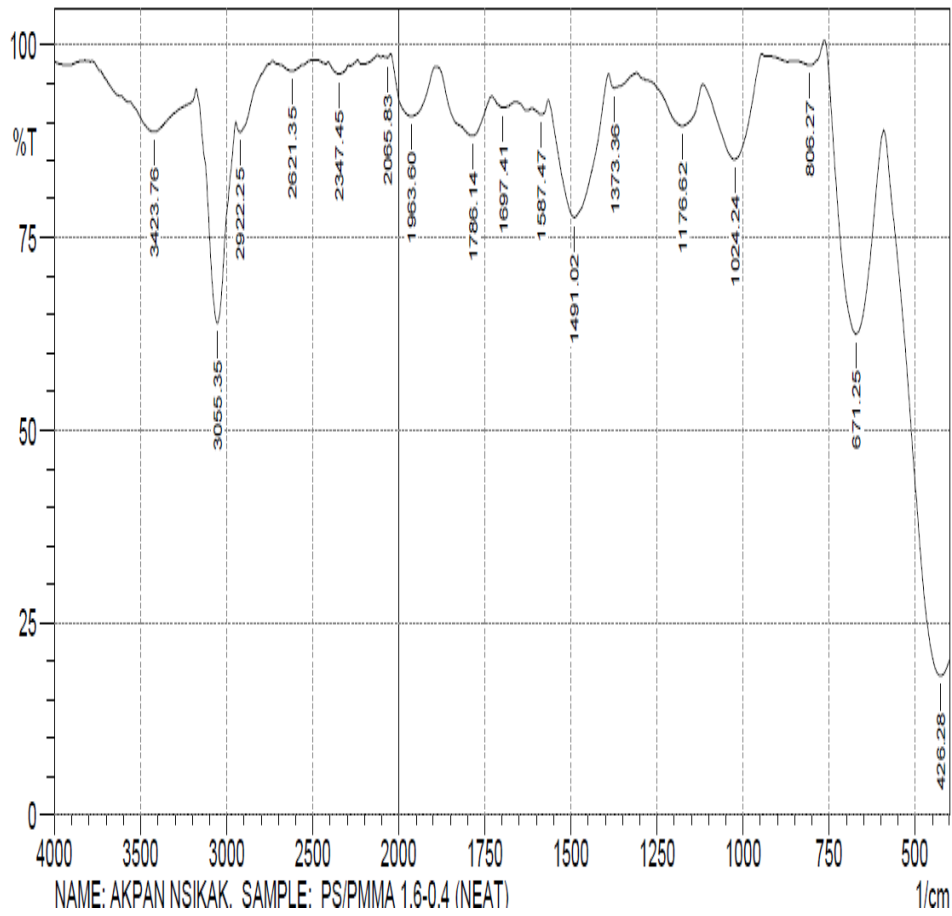
A17: FTIR spectrum data of 1.6:0.4 (PS/PMMA)

Peak	Intensity	Area	Assignment
426.28	18.087	79.787	C-I Stretch alkyl halides
671.25	62.489	21.459	=C-H bend alkenes
806.27	97.378	0.819	C-Cl Stretch alkyl halides
1024.24	85.157	7.773	C-F stretch alkyl halides
1176.62	89.456	6.395	
1373.36	94.406	1.722	-CH(CH ₃) ₂ bend
1491.02	77.626	13.016	Ring C=C Stretch Aromatic compound
1587.47	91004	1.795	
1697.41	91,876	2.353	
1786.14	88.251	6.566	
1963.6	90.752	4.437	
2065.83	98.359	0.279	C-H stretch alkanes

2347.455	96.203	1.732	O-H stretch, free h
2621.35	96.597	1.643	O-H Stretch
2922.25	88.715	6.414	C-H Stretch alkane
3055.35	63.88	25.071	Ar C-H Stretch aromatic
3423.76	88.741	16.128	O- H Stretch carboxylic acid

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR - 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



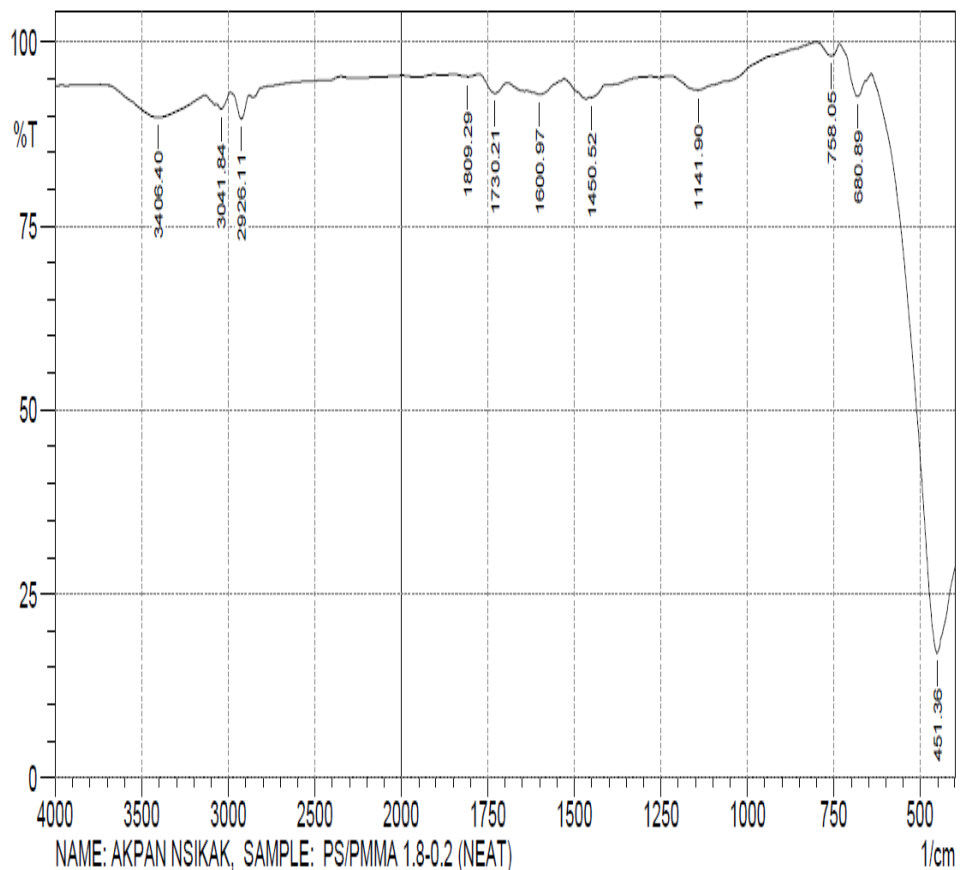
A18: FTIR spectrum graph of 1.6:0.4 (PS/PMMA)

A19: FTIR data spectrum of 1.8:0.2 (PS/PMMA)

Peak	Intensity	Area	Assignment
416.64	19.119	78.682	C-I Stretch alkyl halides
651.96	90.149	5.126	C-H bend alkynes
800.49	98.427	0.256	C-Cl stretch alkyl halides
1051.24	92.606	3.707	C-O stretch alcohol
1168.9	89.323	10.486	C-O stretch alcohol
1327.07	93.361	0.173	C-F Stretch alkyl halides
1467.88	88.584	7.668	C-H bend alkanes and alkyls
1604.83	92.367	0.265	N-H bend amines
1716.7	90.297	3.11	C=O Stretch ketones
2914.54	86.857	8.627	C-H Stretch alkanes
3053.42	85.311	9.394	Ar C-H aromatic compound
3410.26	99.829	6.257	O-H stretch, carboxylic acid

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



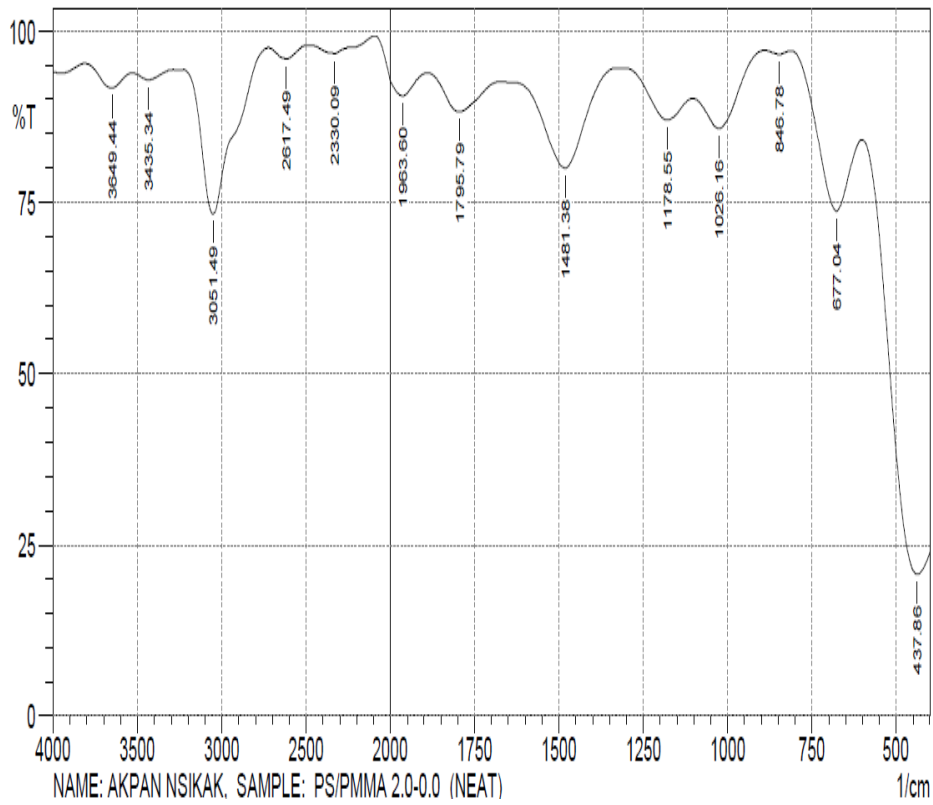
A20: FTIR spectrum graph of 1.8:0.2 (PS/PMMA)

A21: FTIR data spectrum of 2.0-0.0 (PS/PMMA)

Peak	Intensity	Area	Assignment
437.86	20.6698	81.0103	C-I Stretch alkyl halides
677.04	73.74	16.3624	=C-H bend alkenes
846.78	96.6323	1.0728	C-C I Stretch alkyl halides
1026.16	85.7979	9.1694	C-F stretch alkyl halides
11788.55	87.0575	9.6947	C-O stretch alcohol
1481.38	79.9923	17.3287	ring C=C stretch aromatic compound
1795.79	88.1939	9.0608	C=O symmetric anhydrides
1963.6	90.5753	5.2118	
2330.09	96.766	2.7263	
2617.49	95.9837	3.3891	O-H Stretch carboxylic acid
3051.49	73.3048	31.7008	Ar C-H Stretch aromatic compound
3435.34	92.8968	6.9675	O-H Stretch
3649.44	91.711	8.5096	carboxylic

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



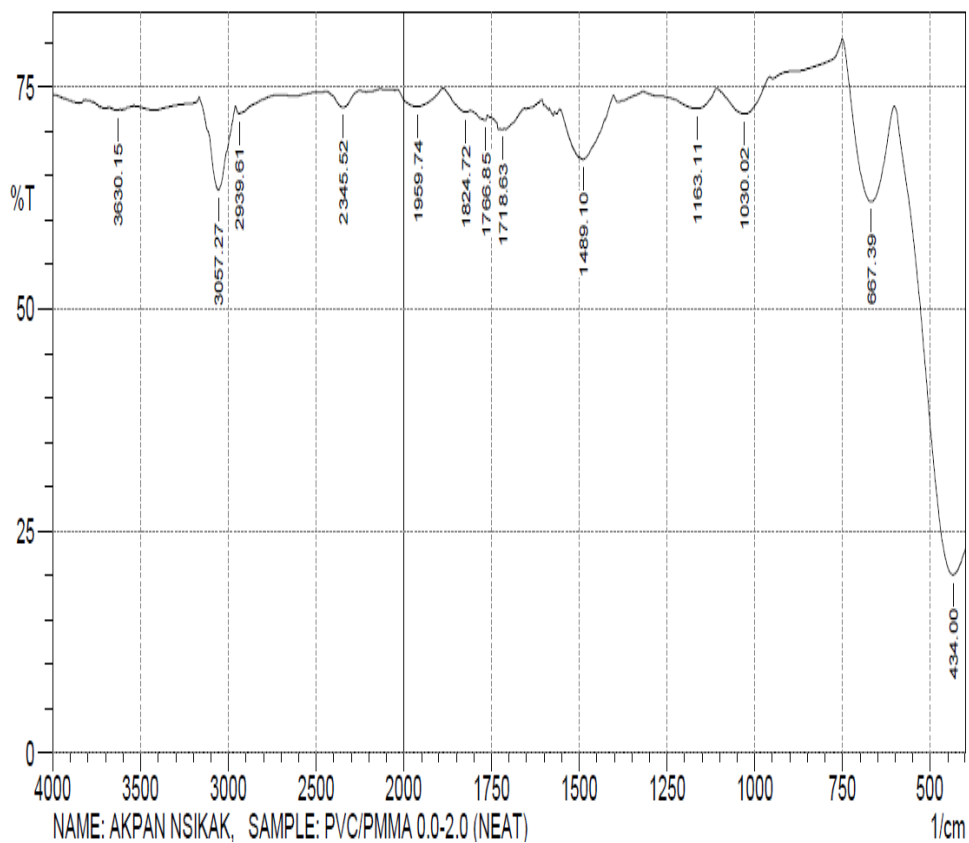
A22: FTIR spectrum graph of 2.0:0.0 (PS/PMMA)

B23: FTIR data spectrum of 0.0:2.0 (PVC/PMMA)

Peak	Intensity	Area	Assignment
434	20.006	88.584	
667.39	62.04	25.004	C-Br Stretch alkyl halides
1030.02	71.927	20.263	C-N Stretch aliphatic amines
1163.11	72.582	21.62	C-H wag $-(CH_2X)$ alkyl halides
1489.1	66.806	20.97	N-O asymmetric stretch nitro compound
1718.63	70.169	1.778	C=O stretch α,β -unsaturated ester
1766.85			
1824.72			
1959.74			
2345.52			
2939.61			
3057.27	63.373	34.506	C-H stretch alkanes
3630.15	72.345	2.977	O-H stretch, free hydroxyl

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



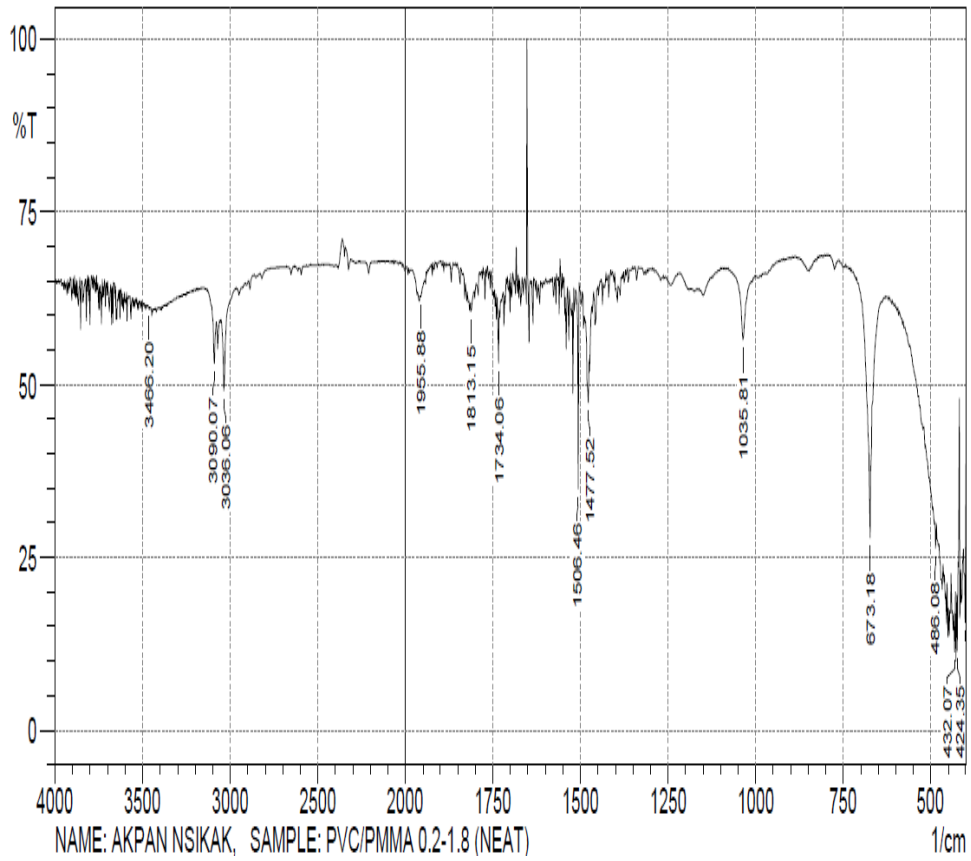
B24: FTIR spectrum graph of 00:2.0 (PVC/PMMA)

B25: FTIR data spectrum of 0.2:1.8 (PVC/PMMA)

Peak	Intensity	Area	Assignment
401.21			
424.35			
432.07			
486.08			
673.18	27.839	21.623	-C=C-H bend alkynes
1035.81	56.545	11.223	C-H stretch aliphatic amines
1477.52	47.397	4.241	C-C stretch (in-ring) aromatics
1506.46	34.939	2.475	N-O asymmetric stretch nitro compounds
1734.06	53.065	1.374	C=O stretch aldehydes, saturated aliphatic
1813.15			
1955.88			
3036.06	49.187	19.365	O-H stretch carboxylic acids
3090.07	53.112	9.727	=C-H stretch alkenes
3466.2	61.131	1.641	O-H stretch, H-bonded alcohols, phenols

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



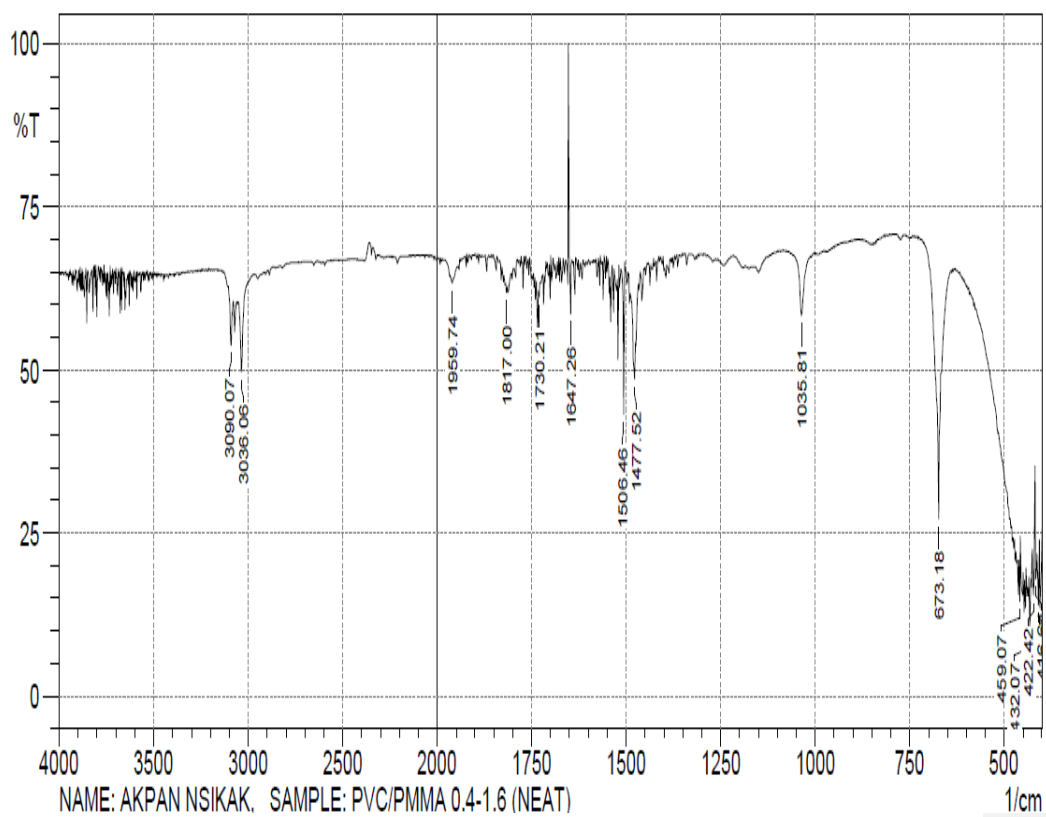
B26: FTIR spectrum graph of 02:1.8.0 (PVC/PMMA)

B27: FTIR spectrum data of 0.4:1.6 (PVC/PMMA)

Peak	Intensity	Area	Assignment
405.06			
408.92			
416.64			
422.42			
432.07			
673.18	27.232	21.584	-C=C-H bend
1477.52	48.636	10.383	C-C stretch (in-ring) aromatics
1506.46	43.114	5.665	N-O asymmetric stretch nitro compounds
1647.26	58.536	2.214	-C=C- stretch alkenes
1730.21	61.116	1.651	C=O stretch aldehydes, saturated aliphatic
1817			
1959.74			
3036.06	49.641	16.567	C-H stretch aromatics
3090.07	53.826	9.344	=C-H stretch alkenes

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



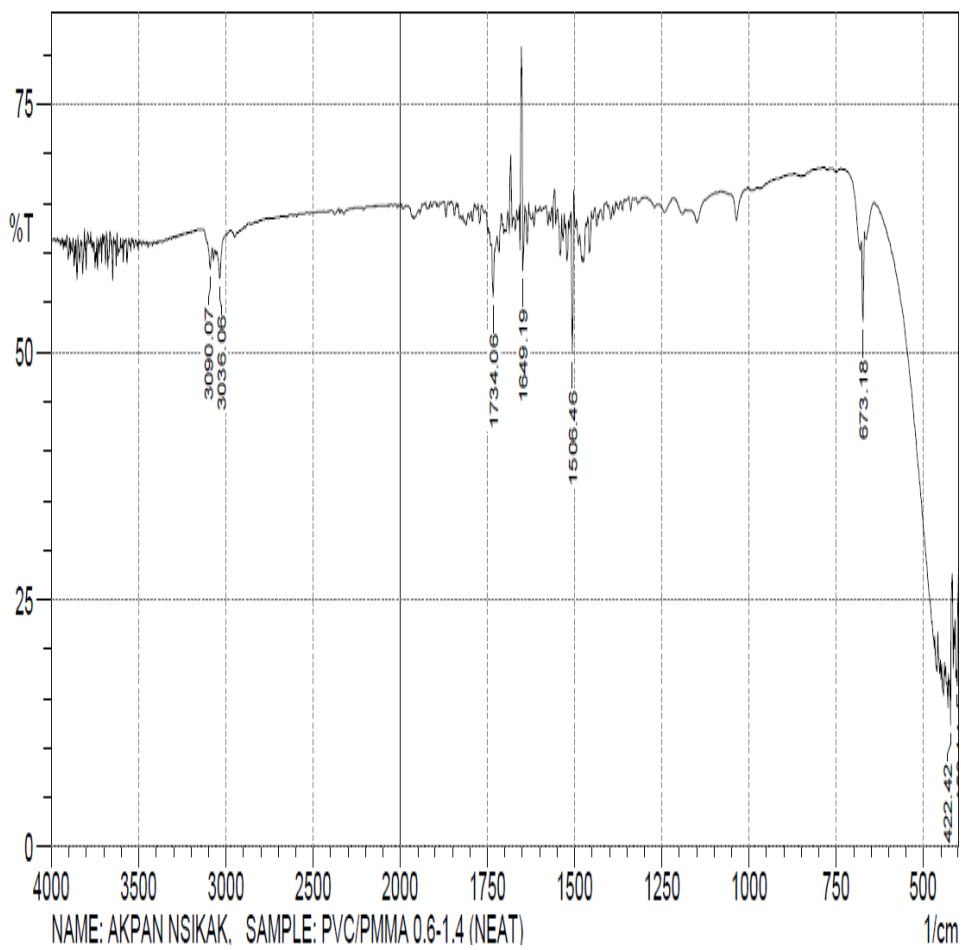
B28: FTIR spectrum graph of 0.4:1.6 (PVC/PMMA)

B29: FTIR data spectrum of 0.6:1.4 (PVC/PMMA)

Peak	Intensity	Area	Assignment
403.14			
422.42			
673.18	53.046	1.92	C-Br stretch
1506.46	49.839	1.975	N-O asymmetric stretch nitro compounds
1649.19	58.135	1.78	N-H bend 1 ^o amines
1734.06	55.554	2.272	C=O stretch aldehydes, saturated aliphatic
3036.06	57.445	9.918	=C-H stretch alkenes
3090.07	58.375	6.464	=C-H stretch alkenes

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



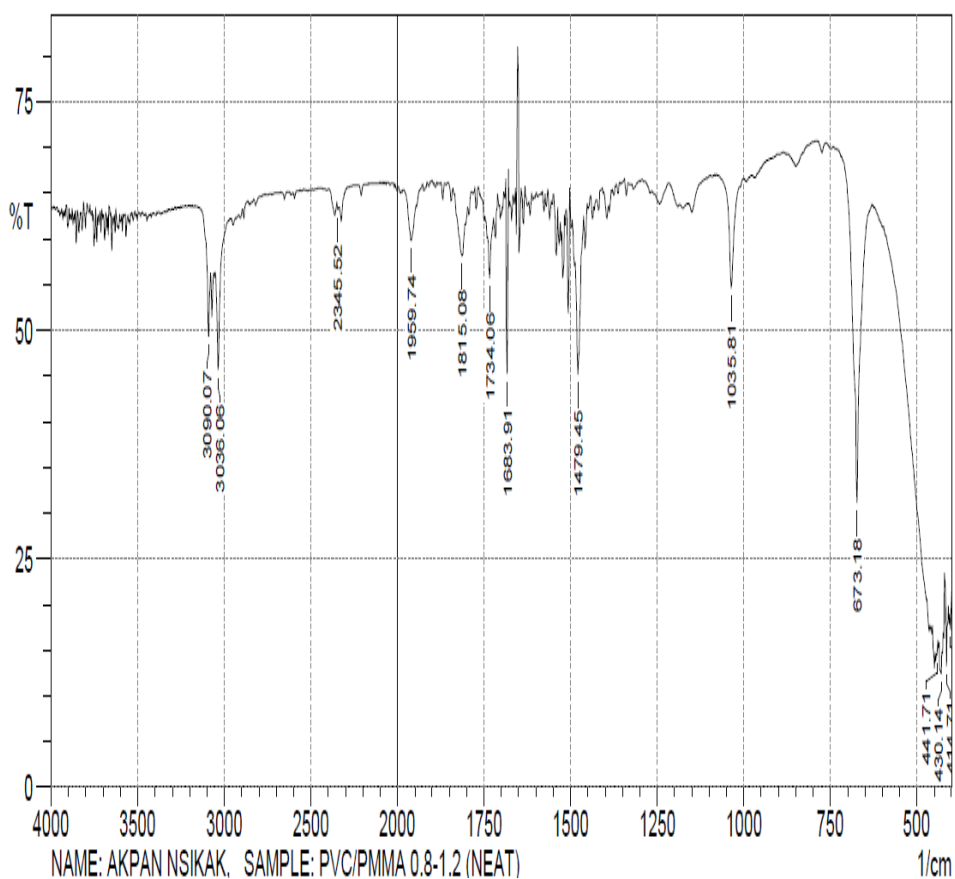
B30: FTIR spectrum graph of 0.6:1.4 (PVC/PMMA)

B31: FTIR data spectrum of 0.8:1.2 (PVC/PMMA)

Peak	Intensity	Area	Assignment
403.14	17.215	6.974	
414.71	13.291	5.921	
430.14	12.379	12.616	
441.71	14.395	6.424	
673.18	31.1	25.923	-C=C-H alkyne
1035.81	54.569	15.062	C-N stretch aliphatic amines
1479.45	45.151	8.208	C-C stretch (in-ring) aromatics
1683.91	45.283	2.131	C=O stretch α,β -unsaturated aldehydes, ketones
1734.06	55.676	3.959	C=O stretch aldehydes, saturated aliphatic
1815.08	58.178	6.312	
1959.74	59.852	7.815	
2345.52	63.243	2.286	
3036.06	45.621	21.03	C-H stretch aromatics
3090.07	49.317	15.495	

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



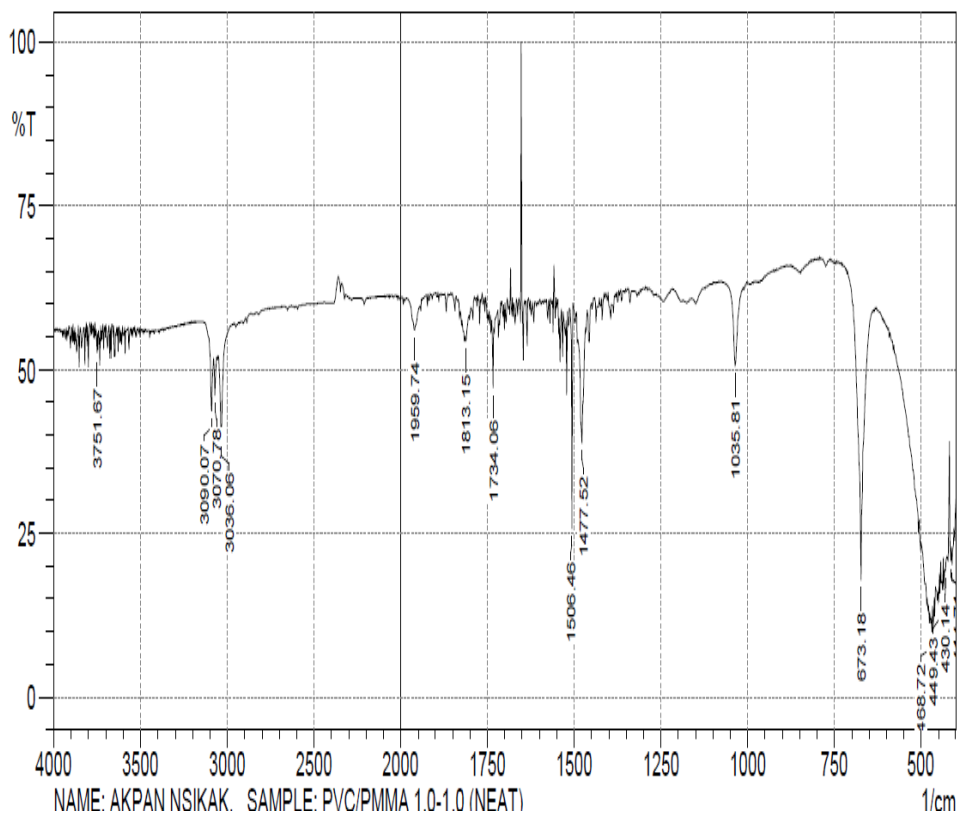
B32 FTIR spectrum graph of (0.8:1.2) PVC/PMMA

B33: FTIR spectrumdata of (1.0:1.0) PVC/PMMA

Peak	Intensity	Area	Assignment
410.85			
414.71			
430.14			
449.43			
468.72			
673.18	17.889	26.969	C-Br stretch alkyl halides
1035.81	50.497	13.761	C-N strength aliphatic amines
1477.52	38.819	7.708	C-C stretch (in-ring) aromatics
1506.46	25.63	2.976	N-O asymmetric stretch nitro compounds
1734.06	47.26	1.592	C=O stretch aldehydes, saturated aliphatic
1813.15			
1959.74			
3036.06	39.291	24.54	=C-H stretch alkenes
3070.78	45.965	4.759	=C-H stretch alkenes
3090.07			
3751.67			

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



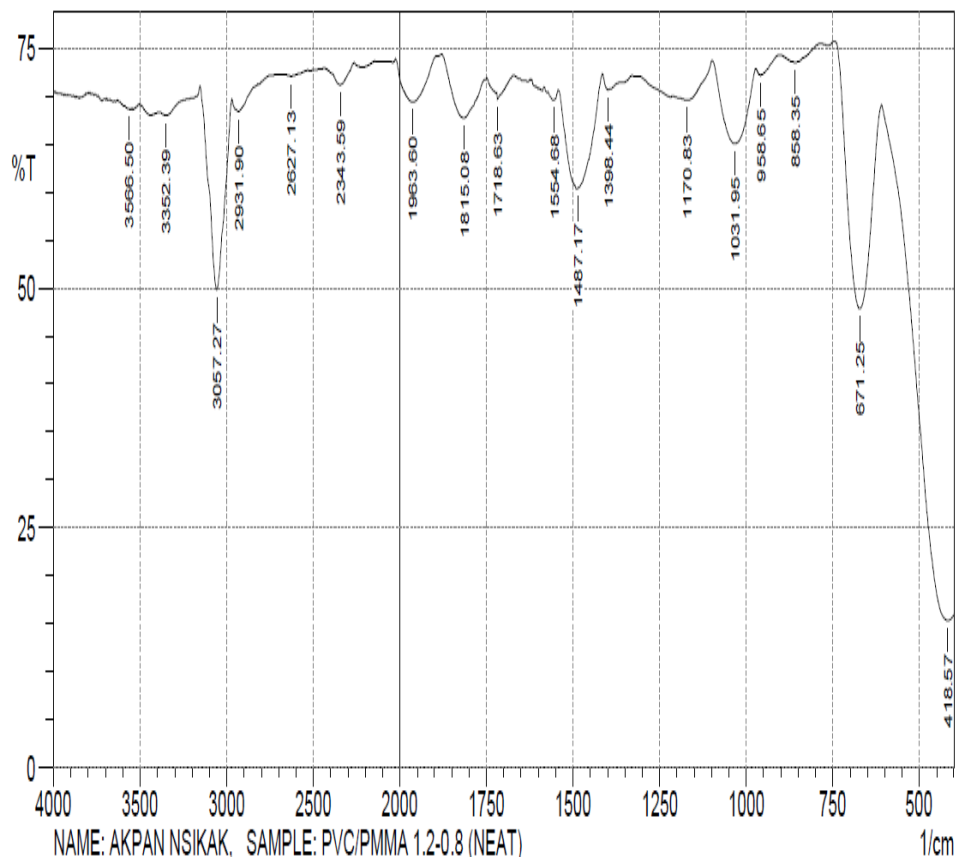
B34: FTIR spectrum graph of 1.0:1.0 (PVC/PMMA)

B35: FTIR data spectrum of 1.2:0.8 (PVC/PMMA)

Peak	Intensity	Area	Assignment
418.57			
671.25	47.852	31.464	C-Br stretch alkyl halides
858.35	73.556	15.221	N-H wag 1 ⁰ ,2 ⁰ amines
958.65	72.181	9.447	=C-H bend alkenes
1031.95	65.044	20.865	C-N stretch aliphatic amines
1170.83	69.578	17.183	C-N stretch aliphatic amines
1398.44			
1487.17	60.342	24.134	C-C stretch (in-ring) aromatics
1554.68			
1718.63	69.734	6.925	C=O stretch α,β -unsaturated esters
1815.08			
1963.6			
2343.59			
2627.13			
2931.9	68.433	23.371	C-H stretch alkanes
3057.27	49.883	41.096	=C-H stretch alkenes
3352.39	68.005	37.708	N-H stretch 1 ⁰ ,2 ⁰ amine, amides
3566.5			

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



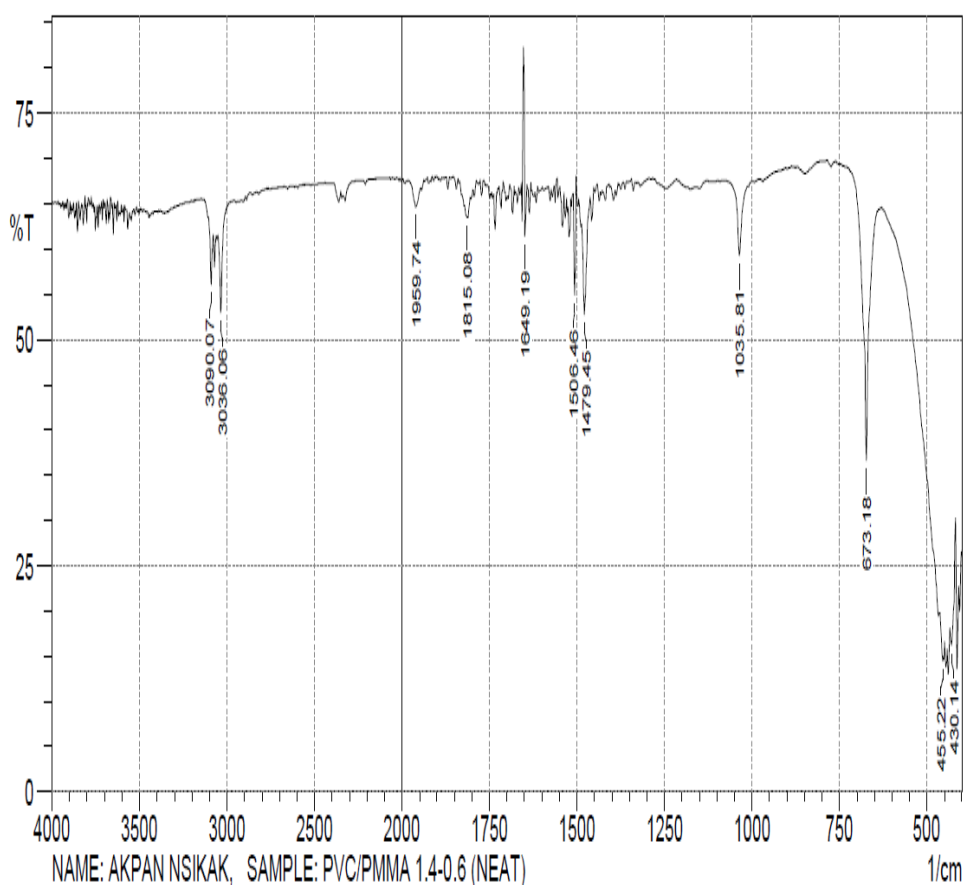
B36: FTIR spectrum graph of 1.2:0.8 (PVC/PMMA)

B37: FTIR data spectrum of 1.4:0.6 (PVC/PMMA)

Peak	Intensity	Area	Assignment
430.14			
455.22			
673.18	36.587	24.783	C-Br stretch alkyl halides
1035.81	59.224	14.421	C-N stretch aliphatic amines
1479.45	52.752	5.666	C-C stretch (in-ring) aromatics
1506.46	54.876	1.747	N-O asymmetric stretch nitro compounds
1649.19	61.394	1.61	N-H bend 1 ⁰ amines
1815.08			
1959.74			
3036.06	52.97	14.358	=C-H stretch alkenes
3090.07	56.092	10.786	=C-H stretch alkenes

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR-8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



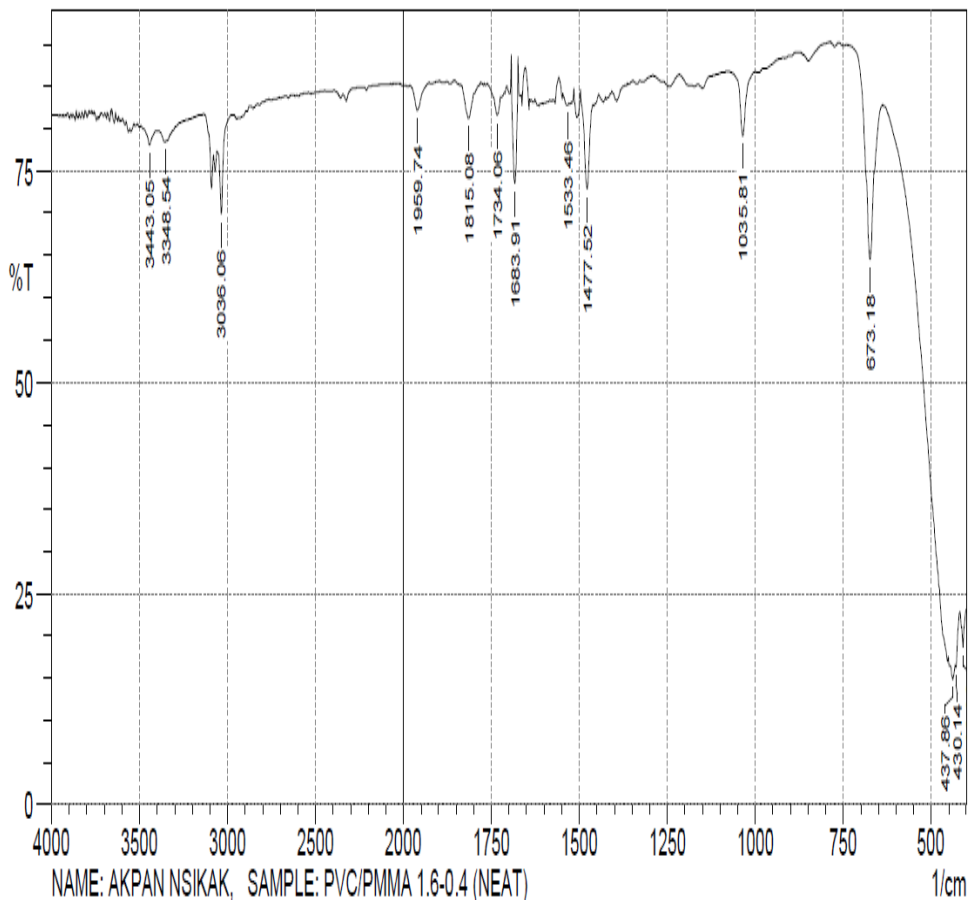
B38: FTIR spectrum graph of 00:2.0 (PVC/PMMA)

B39: FTIR data spectrum of 0.0:2.0 (PVC/PMMA)

Peak	Intensity	Area	Assignment
408.92			
430.14			
437.86			
673.18	64.587	6.687	C-Br stretch alkyl halides
1035.81	79.225	5.509	C-O stretch alcohols, carboxylic acids, esters, ethers
1477.52	72.838	3.632	N-O asymmetric stretch nitro compounds
1533.46	82.8	0.472	N-O asymmetric stretch nitro compounds
1683.91	73.522	2.9025	C=O stretch α,β -unsaturated aldehydes, ketones
1734.06	81.685	1.614	C=O stretch aldehyde, unsaturated aliphatic
1815.08			
1959.74			
3036.06	69.924	8.932	=C-H stretch alkenes
3348.54	78.555	9.402	O-H stretch, H-bond alcohols, phenols
3443.05	78.098	6.674	O-H stretch, H-bond alcohols, phenols

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR - 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



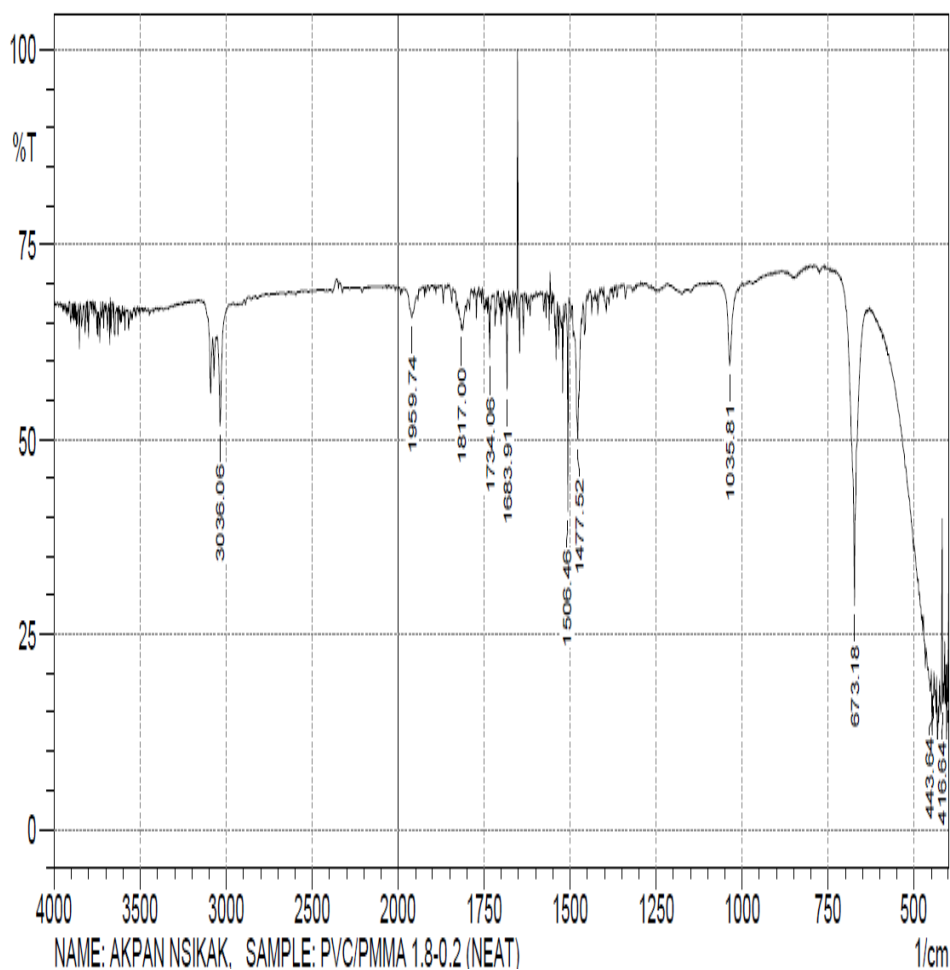
B40: FTIR spectrum graph of 1.6:0.4 (PVC/PMMA)

B41: FTIR data spectrum of 1.8:0.2 (PVC/PMMA)

Peak	Intensity	Area	Assignment
401.21			
416.64			
443.64			
673.18	28.614	20.023	C-Br stretch alkyl halides
1035.81	59.524	8.240	C-N stretch aliphatic amines
1477.52	50.02	3.308	C-C stretch (in-ring) aromatics
1506.46	40.86	2.138	N-Oasymmetric stretch nitro compounds
1683.91	56.329	1.146	C=O stretch α ,unsaturated halides, ketones
1734.06	60.402	1.092	C=O stretch aldehydes, saturated aliphatic
1817			
1959.74			
3036.06	51.77	14.17	O-H stretch carboxylic acid

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



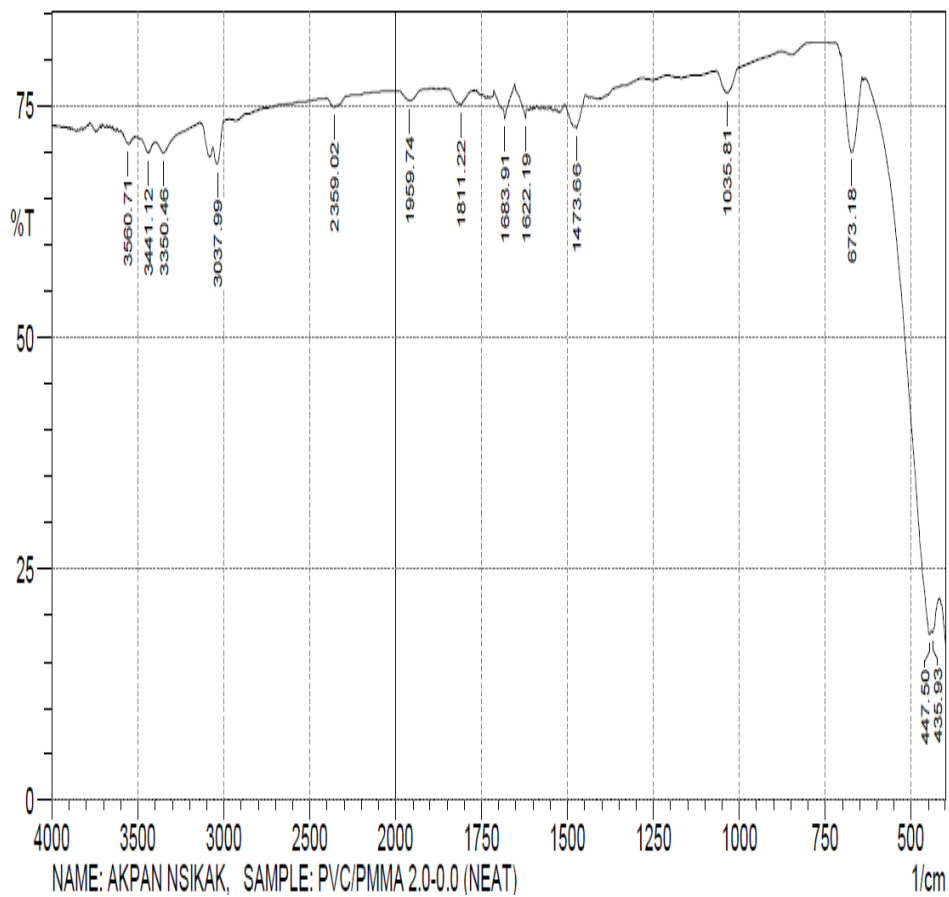
B42: FTIR spectrum graph of 1.8:0.2 (PVC/PMMA)

B43: FTIR data spectrum of 2.0:0.0 (PVC/PMMA)

Peak	Intensity	Area	Assignment
435.93			
447.5			
673.18	69.951	8.13	C-Br stretch alkyl halides
1035.81	76.408	19.185	C-N stretch aliphatic amines
1473.66	72.569	4.003	C-C stretch (in-ring) aromatics
1622.19	73.617	4.059	N-H bend 1 ⁰ amines
1683.91	73.554	7.556	C=O stretch α,β -unsaturated aldehydes, ketones
1811.22			
1959.74			
2359.02			
3037.99	68.75	13.845	=C-H stretch alkenes
3441.12	69.939	15.64	O-H stretch, H-bonded alcohols, phenols

FTIR ANALYSIS RESULT NARICT,ZARIA

FTIR- 8400S FOURIER TRANSFORM
INFRARED SPECTROPHOTOMETER



B44: FTIR spectrum graph of 2.0:0.0 (PVC/PMMA)

LIST OF ABBREVIATIONS:

PS – Polystyrene

PVC – Poly (vinyl chloride)

PMMA – Poly (methyl methacrylate)

FTIR – Fourier Transforms Infrared Resonance

GHPS – General High Purpose Styrene

HIPS – High Impact Polystyrene

GPPS – General Purpose Polystyrene

CD – Compact Disc

LCD – Liquid crystal display

MEK – Methyl Ethyl Ketone

PVCA – Poly Vinyl Acetate

SAN – Acrylonitrile

DSC – Digital Still Camera

PC – Personal Computer

THF – Tetrahydrofuran

FDA – Drug Administration Agency

SYMBOLS:

$[\eta]$ = intrinsic viscosity

η_{rel} = relative viscosity

η_{sp} = specific viscosity

C = concentration

K' = Huggin's coefficient

K'' = Kraemer's coefficient

x = Mark-Houwink exponent

t = flow rate of the solution blend

t_0 = flow rate of the solvent (chloroform)

LIST OF PLATES:

I – Polystyrene

II – Poly (vinyl chloride)

III – Poly (methyl methacrelate)