

SYNTHESIS AND MICROSCOPIC STUDY OF POLY CARBONATE AND POLY METHYL METHACRYLATE BLENDS

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ABSTRACT

Natural polymeric materials such as shellac, amber and natural rubber have been used for centuries. A variety of other natural polymers also exist. Such as cellulose, which is the main constituent of wood and paper. The list of synthetic polymers includes synthetic rubber, Bakelite, neoprene, nylon, PVC, polystyrene, polyethylene, polypropylene, polyacrylonitrile, PVB, silicone, and many more. Because of the extraordinary range of properties of polymeric materials, they play an essential and ubiquitous role in everyday life. Their role ranges from familiar synthetic plastics and elastomers to natural biopolymers such as nucleic acids and proteins which are essential for life. Polycarbonate and poly methyl methacrylate are among the most technologically important polymers and this paper covers the importance of the blends of these two polymers.

Key words – Blends, Polycarbonate, Poly methyl methacrylate, THF, Thin films

1. Introduction

1.1 POLYMER

A **polymer** is a large molecule (macromolecule) composed of repeating structural units. These subunits are typically connected by covalent chemical bonds. Although the term *polymer* is sometimes taken to refer to plastics, it actually encompasses a large class of natural and synthetic materials with a wide variety of properties.

1.2 POLYCARBONATE

Polycarbonates, known by the trademarked names Lexan, Makrolon, MakrocLEAR and others, are a particular group of thermoplastic polymers. They are easily worked, moulded, and thermoformed. Because of these properties, polycarbonates find many applications. Polycarbonates do not have a unique plastic identification code. Polycarbonates received their name because they are polymers containing carbonate groups ($-\text{O}-(\text{C}=\text{O})-\text{O}-$). Most polycarbonates of commercial interest are derived from rigid monomers. A balance of useful features including temperature resistance, impact resistance and optical properties position polycarbonates between commodity plastics and engineering plastics.

1.2.2 Properties and processing

Polycarbonate derived from BPA is a very durable material. Although it has high impact-resistance, it has low scratch-resistance and so a hard coating is applied to polycarbonate eyewear lenses and polycarbonate exterior automotive components. The characteristics of polycarbonate are quite like those of polymethyl methacrylate (PMMA, acrylic), but polycarbonate is stronger, usable in a wider temperature range but more expensive. This polymer is highly transparent to visible light and has better light transmission characteristics than many kinds of glass. Polycarbonate has a glass transition temperature of about 150 °C (302 °F), so it softens gradually above this point and flows above about 300 °C (572 °F). Tools must be held at high temperatures, generally above 80 °C (176 °F) to make strain- and stress-free products. Low molecular mass grades are easier to mould than higher grades, but their strength is lower as a result. The toughest grades have the highest molecular mass, but are much more difficult to process.

1.2.3 Applications

Electronic components

Polycarbonate is mainly used for electronic applications that capitalize on its collective safety features. Being a good electrical insulator and having heat resistant and flame retardant properties, it is used in various products associated with electrical and telecommunications hardware. It also serves as dielectric in high stability capacitors.

Construction materials

The second largest consumer of polycarbonates is the construction industry, e.g. for domelights, flat or curved glazing, and sound walls.

Data storage

A major application of polycarbonate is the production of Compact Discs, DVDs, and Blu-ray Discs.

Automotive, Aircraft, and Security Components

In the automotive industry, injection moulded polycarbonate can produce very smooth surfaces that make it well suited for direct (without the need for a basecoat) metalised parts such as decorative bezels and optical reflectors. The cockpit canopy of the F-22 Raptor jet fighter is made from a piece of high optical quality polycarbonate, and is the largest piece of its type formed in the world.

Medical Applications

Some polycarbonate grades are used in medical applications and comply with both ISO 10993-1 and USP Class VI standards (occasionally referred to as PC-ISO). Class VI is the most stringent of the six USP ratings. These grades can be sterilized using steam at 120 °C, gamma radiation, or by the ethylene oxide (EtO) method.

1.3 POLY METHYL METHACRYLATE

Poly(methyl methacrylate) (PMMA) is a transparent thermoplastic, often used as a light or shatter-resistant alternative to glass. It is sometimes called **acrylic glass**. Chemically, it is the synthetic polymer of methyl methacrylate. The material was developed in 1928 in various laboratories, and was first brought to market in 1933 by Rohm and Haas Company, under the trademark **Plexiglas**. It has since been sold under many different names including Lucite and Perspex. It has a density of 1.17–1.20 g/cm³, which is less than half that of glass. It also has good impact strength, higher than both glass and polystyrene; however, PMMA's impact strength is still significantly lower than polycarbonate and some engineered polymers. PMMA ignites at 460 °C (860 °F) and burns, forming carbon dioxide, water, carbon monoxide and low molecular weight compounds, including formaldehyde.

PMMA is used in the lenses of exterior lights of automobiles.

- The spectator protection in ice hockey rinks is made from PMMA.
- It is used in motorcycle helmet visors.
- Historically, PMMA was an important improvement in the design of aircraft windows, making possible such iconic designs as the bombardier's transparent nose compartment in the Boeing B-17 Flying Fortress.
- Polycast acrylic sheet is the most widely used material in aircraft transparencies (windows). In applications where the aircraft is pressurized, stretched acrylic is used. Only in the most advanced modern fighter jets, such as the F-22 Raptor, has traditional acrylic been replaced by polycarbonate (Lexan).
- Police vehicles for riot control often have the regular glass replaced with acrylic to protect the occupants from thrown objects.
- Acrylic is an important material in the making of certain lighthouse lenses.

2. PC AND PMMA BLENDS

Good adhesion in polymer blends and composites is generally considered desirable, due to improvements in stiffness and modulus. However, if the adhesion is too strong, it can be detrimental to ductility. Many examples in the literature reveal the effect of adhesion on yielding of blends and composites. For example, in a study of polypropylene/ glass fiber composites, Sova¹ found that a composite with lower interfacial adhesion had a lower yield stress and higher ductility than a composite with better adhesion. With good adhesion between fiber and matrix, the glass fibers constrained yielding of the polypropylene, resulting in a higher yield stress. Fracture occurred shortly after the yield point. In another study of polypropylene/glass fiber composites, Kander and Siegmann used strain rate to vary the adhesion between fiber and matrix. They found that at slow deformation rates, lower adhesion resulted in more ductile behavior. At higher strain rates, better adhesion enabled the glass fibers to constrain yielding of the polypropylene and relatively brittle behavior was observed. Uncompatibilized blends failed by interfacial debonding and void growth. In this case, a model based on a modified cross-sectional area successfully described the yield stress. The effect of constraint from the well-adhered PS particles in compatibilized blends was well described with a modified yield strain approach. If the yielding behavior of the components is similar and the adhesion is sufficient to allow stress transfer between phases, both phases in a polymer blend can yield. For example, blends of polycarbonate (PC) and poly(acrylonitrile-butadiene- styrene) (ABS) are

compatible because of good interfacial adhesion of PC and poly(styreneco- acrylonitrile) (SAN). Santana et al. found the interfacial adhesion was sufficient to cause both PC and ABS to yield. The yield stress followed the rule of mixtures. Similarly, the yield stress of PC/poly(methylmethacrylate) (PMMA) blends obeyed the rule of mixtures because good adhesion ensured stress.

3. Experimental

3.1 Materials

PC – Poly Carbonate

PMMA – Poly Methyl Methacrylate

THF – Tetrahydrofuran(used as a solvent for casting the films)

3.2 Sample Preparation

PC and its blends with PMMA in different weight ratios were made by solution casting method. Tetrahydrofuran (THF) was used as solvent for all blends preparation. For making PC/PMMA blend, first of all an appropriate amount of PC and PMMA were dissolve into two separate breakers by using constant stirring at room temperature and also at constant temperature of about 50⁰ C in closed environment. PMMA solution was mixed in PC solution in a few steps followed by sonication for about 10-15 minutes.

After that, all the solution were casted in covered Petri dishes maintained at 50⁰ C for controlled evaporation for overnight. The films were cooled upto room temperature and then stored in sample boxes.

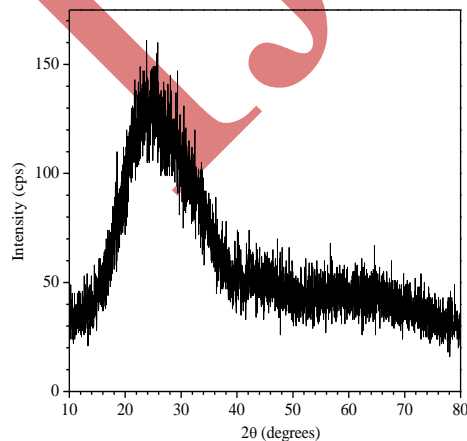
In the proposed work we have synthesized PC and PMMA Blends for various compositions as mentioned below:

- PC (5%) + PMMA (95%)
- PC (20%) + PMMA (80%)
- PC (90%) + PMMA (10%)

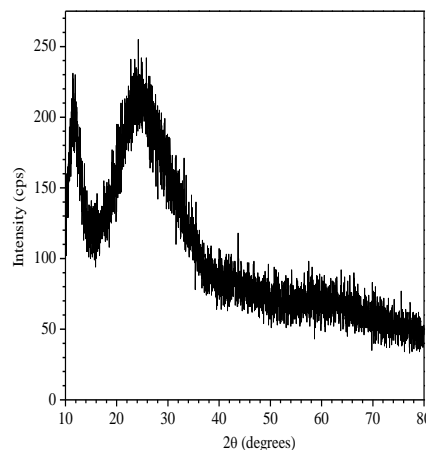
All these compositions have been made to investigate the miscibility of PMMA into PC. This current effort is well investigated from the point of view of commercial applications as the demand of PC in the world is increasing tremendously. We have made this attempt at our laboratory and present few results for future research.

4. Results

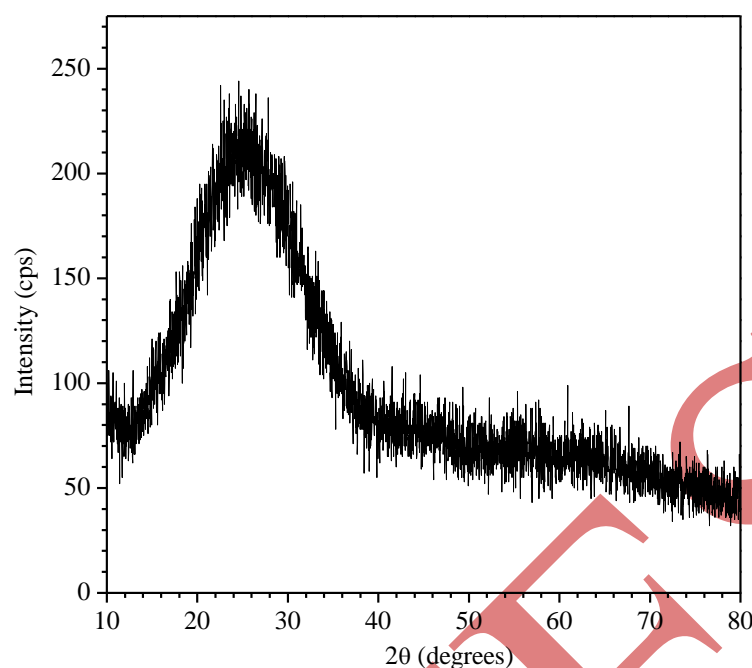
X-RAY Diffraction



(XRD Pattern of 95%PMMA and 5% PC)



XRD patterns of (80 % PMMA and 20% PC)



(XRD Pattern of 90% PC and 10% PMMA)

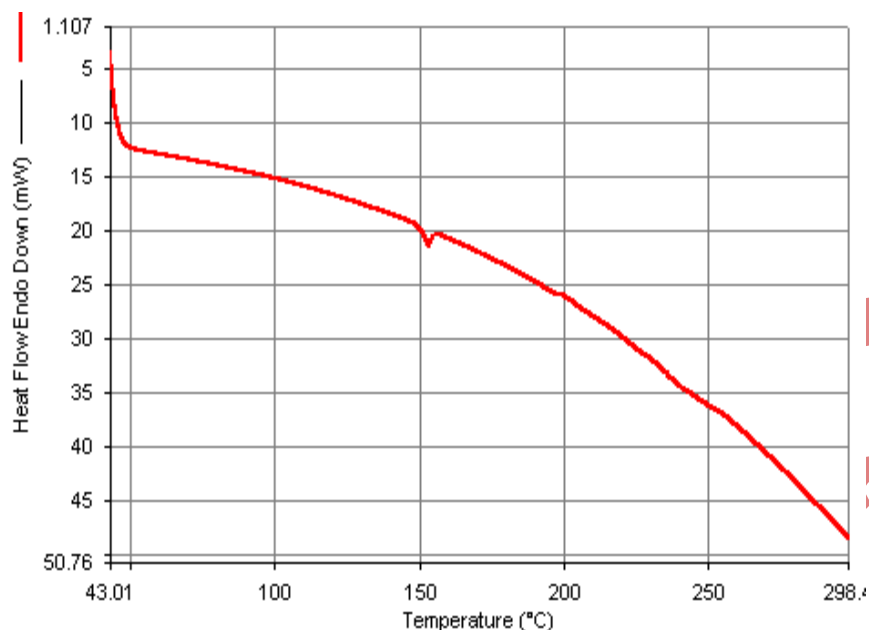
XRD is a useful tool for examining the crystalline phase of PC and PMMA in the blend samples. XRD patterns were recorded using 18k rotating anode based Rigaku powder diffractometer fitted with curved crystal monochromator in the diffracted beam. Samples of PC/PMMA blends were crushed into fine powder using an agate mortar pestle. Films of pure PC and PMMA blends were placed on glass plates and heated to a temperature of 150 degree c to 200 degree c till their softening. These softened samples were then pressed with glass plates to a uniform thickness. These samples were allowed to cool to room temperature and films were removed from glass plates. Figures present the XRD patterns of the PC/PMMA ends. It can be seen from the above XRD pattern that the structure of PC and PMMA blends for various compositions are amorphous in nature. It can also be seen from the XRD patterns that there is no miscibility PC and PMMA in the blend prepared at the laboratory. This result is in accordance with the earlier report made by workers in this field that the blends of PC and PMMA can never be miscible. This is the reason that researchers are working to find out methods to obtain miscible blends of PC and PMMA for technological applications.

When the PMMA content was either reduced or increased, there is still not miscibility in the blend as depicted from the XRD patterns. It is reported that the PMMA XRD patterns indicates that the PMMA crystals were mostly in the α phase. As the PMMA content was increased to >20 wt.%, the blends (20 wt.% and 30 wt.%) showed a new peak as evident from the XRD diffraction data.

Diffraction Scanning Calorimetry

The figure below shows the DSC melting thermograms for the PC/PMMA blends with various PMMA contents. An endothermic peak corresponding to the melting of PC was observed. The melting temperature decreased slightly with increasing PMMA content. The enthalpy of melting decreased. The crystallinity of the blends was obtained by dividing the melting enthalpy by 104.5 J/g. This change was induced mostly by the dilution effect of the introduced PMMA. The α and β phases of PC crystals were reported to have different melting temperatures and sometimes exhibit multiple peaks

on the DSC curves. Normally, the melting point of pure α phase PVDF is approximately 170 °C. The β phase PC has a slightly lower melting temperature. Therefore, the decrease in melting temperature might be due to the different phases of PC in the PC/ PMMA blends.



DSC of PC and PMMA Blends

Atomic Force Microscopy

The AFM picture of PC and PMMA blends for composition PC 20% and PMMA 80% has been depicted in Fig.. It can be seen from the photograph that the upper surface of the blend is translucent in nature and the internal microstructure is not possible to analyse. The AFM photograph also reveals that there is peeling of particles of blends which are of nano meter size. It can be investigated that the miscibility can not be achieved for blends prepared by a simple solvent casting route. It is also imperative that ample amount of work is required to obtain miscible and transparent blend of PMMA and PC which may be useful for commercial applications.



AFM Image of PC and PMMA Blends

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