Probing the Rubber Toughening of a Novel Aromatic Polyamide Thermoplastic

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Abstract---As the use of aromatic polyamide (APA) thermoplastic in structural and technical applications increased, the fracture toughness of this polymer became a decisive factor in material selection. Therefore, much attention was required to develop effective toughening methods for these polymers. One strategy which has been successful in toughening APA polymers was rubber toughening that involved the addition of elastomeric inclusions into a polymer matrix. In this project, a novel APA was fabricated by the condensation of diamines and diacid chloride under anhydrous conditions in a solvent. Then these APA chains were end-capped with amine groups. Later, the amine functionalized APA was blended with anhydride grafted rubber copolymer. Ultimately, toughened and strengthened APA-based blends of varying rubber content were obtained. Finally, the thermal, mechanical and morphological properties of the blends were evaluated using TGA, UTM, FESEM and FTIR techniques

Keywords--- blends; thermal properties; morphology; mechanical properties

I. INTRODUCTION

This project concerns with a resolving solution to a big issue of the use of aromatic polyamide in structural application. As the use of Aromatic Polyamide is increasing due to its increasing applications such as gears, lightly loaded slider pads, hammer heads, pneumatic brake liners, industrial pneumatic and hydraulic hose applications, sports items, electrical and electronics devices, and other engineering fields [11], its lower toughness is of a big concern for the researchers. Many researchers have adopted different techniques to get the job done. One of the most emerging and promising technique is the rubber toughening of the polymer. In this technique, the elastomer in the form of rubber is added as a modifier in the matrix polymer i.e. Aramid. This elastomer, in the form of inclusions, disperses into the matrix. On load application, it crazes and tries to absorb the load. As a result, more force is required to shatter the matrix polymer. In other words, the polymer is toughened. This is what we call as rubber toughening which is the main objective of this project.

Plastics obtained by blending different types of polymers have an enhanced mechanical profile [1–3]. The binary blends of styrene/butadiene block copolymers with polystyrene (PS) have specific industrial importance [4, 5]. Feng et al. [6–8] studied the effect of star and tri-block copolymer architecture on miscibility and mechanical properties of styrene/butadiene block copolymer/PS blends. Furthermore, the micromechanical behavior of blends of styrene/butadiene block copolymer with PS was discussed by Argon and coworkers [9] and Aggarwal [10]. Their reports show that block copolymer modified PS have better mechanical properties than the one modified by conventional rubber [10].

In this study, high molecular weight aromatic polyamide chains (APA) were synthesized from aromatic diamine and aromatic diacid chloride via solution polymerization under anhydrous conditions. Amine functionality was introduced to APA producing amino functional Aramid which served as a reactive compatibilizer, being reactive with the rubber. It was then blended with different proportions (0 to 100 wt. %) of rubber in order to enhance the toughness of the APA thermoplastic. After blending the blend samples were subjected to thermal, mechanical and morphological analyses.

II. MATERIALS AND METHODS

A. *Materials*

- Aromatic diamine
- Aromatic diacid chloride
- Rubber
- Solvent

B. *Synthesis of Aramid Matrix and blend preparation*

High molecular weight aromatic polyamide chains (APA) were synthesized from aromatic diamine and aromatic diacid chloride via solution polymerization under anhydrous conditions. Amine functionality was introduced to APA producing amino functional Aramid which served as a reactive compatibilizer, being reactive with the rubber.

It was then blended with different proportions (0 to 100 wt. %) of rubber in order to enhance the toughness of the APA thermoplastic.

III. RESULTS AND DISCUSSIONS

A. *TGA*

The temperature T_{10} profile of the samples shows the trend of change in the thermal stability (Note that the term S3 means Aramid content by weight %). The blends have an improved thermal stability as compared to the APA matrix as shown in the graphical profile at 10% degradation (*Fig.1*).

B. *Mechanical*

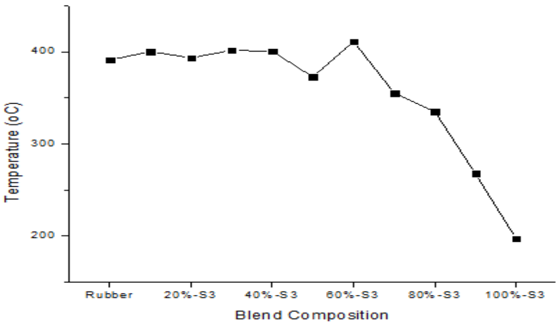

Fig. 1. *Thermo gravimetric Analysis of blends*

The toughness of the blends has an increasing trend with the addition of rubber (Note that the term S3 means Aramid content by weight %). Similar toughness values have been observed when 20%, 30% and 80% rubber is added. But since the basic application of the APA is towards stiffness and with a sample having 80% rubber, there will be less stiffness and more bending, so the samples having 20% and 30% rubber are of more importance as been observed by the mechanical profile (Fig.2).

C. FESEM

We can clearly observe a very good distribution of phases and a good miscibility among the components. A very good compatibility among the two phases that is the APA and the rubber is also observed in *Fig.3* which clearly depicts the reason for the increase in the mechanical and the thermal profile of the APA matrix because of the addition of the rubber.

D. FTIR

The FTIR spectroscopic analysis has shown that the desirable linkages are formed between rubber and APA.

IV. CONCLUSIONS

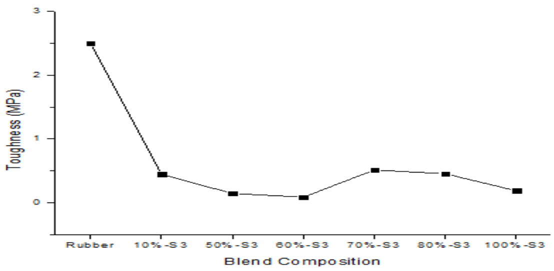

Fig. 2. *Toughness Profile of blends*

The strategy adopted for the toughening of the aramid is the rubber toughening of the Aramid matrix. The study reflects the following attributes:

– There is a significant increase in the mechanical properties of the blends because of strong bonding between aramid and rubber.
– The stable morphology of the blends has played a significant role in the improved profile of mechanical properties
– The strong bonding between the anhydride group (rubber) and the amine group (Aramid) has resulted in a better thermal profile and thus the blends are thermally more stable.

On the basis of the morphological, thermal, and mechanical

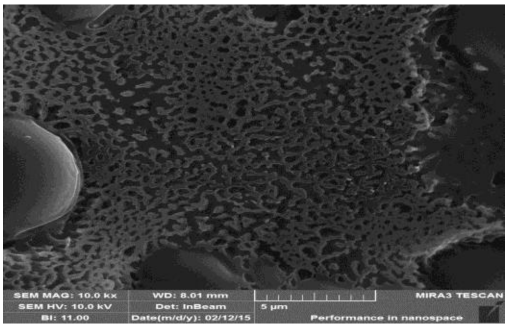

Fig. 3. *FESEM Image of blend*

properties it can be stated that blends of rubber with APA exhibit better synergy, as reflected by improved mechanical properties and thermal analysis.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

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