



Thermal Properties of Acrylonitrile Butadiene Styrene Composites

G. S. Ananthapadmanabha*, Vikrant V. Deshpande

Department of Polymer Science & Engineering, Sri Jayachamarajendra College of Engineering, Mysore, Karnataka, India.

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ABSTRACT

The thermal properties of acrylonitrile butadiene styrene (ABS) composites with talc and calcium carbonate (CaCO_3) at 10%, 20%, 30%, and 40% loading were characterized using thermal methods like differential scanning calorimetry (DSC), thermogravimetric analysis (TGA) and heat deflection temperature (HDT). The study was carried out to investigate the effect of fillers with different shape on the properties like decomposition temperature, HDT of ABS. CaCO_3 particles are spherical and have an aspect ratio of 1, whereas talc is long, platy in nature and has a higher aspect ratio of typically about 20:1. Titanate coupling agent was added to improve the interfacial adhesion between the filler and the ABS matrix. Thermal properties showed no significant change with respect to the HDT, glass transition temperature by DSC as well as decomposition temperature by TGA methods.

Key words: Acrylonitrile Butadiene Styrene, composite, filler shape, thermal properties, coupling agent.

1. INTRODUCTION

Acrylonitrile butadiene styrene (ABS) is a two-phase polymer that consists of polybutadiene grafted with styrene, acrylonitrile, and styrene-acrylonitrile copolymer. The most important mechanical properties of ABS are impact resistance and toughness. ABS has moderate heat resistance and has useful characteristics within a temperature range from -20°C to 80°C . A variety of modifications can be made to improve heat resistance. In terms of price, as well as properties, ABS is positioned between the lower priced commodity plastics and highly priced engineering plastics. Thus, incorporation of fillers into ABS can provide an opportunity to compete with low-priced commodity plastics in terms of cost as well as highly priced engineering plastics in terms of performance. ABS finds applications in various fields such as appliance, automotive, business machines, packaging, pipes and fittings, and many other industrial applications with appliance and automotive being the dominant market for ABS polymer.

Fillers are usually added to lower the cost of the materials. They also lead to increase in stiffness, strength, hardness, and heat deflection temperature (HDT). It is also observed that mechanical properties tend to decrease less rapidly with increasing temperature. Various types of fillers, which are characterized by their shape and size, can have different effects on the polymer properties. Calcium carbonate (CaCO_3) being spherical in shape has an

aspect ratio of "1" whereas talc which is platy in shape has an aspect ratio of 20:1 will have a different effect on the properties. The bond strength between the polymer matrix and the filler is an important factor in determining the properties of the composites. Most of the mineral fillers are incompatible with the polymer matrix. The compatibility of the polymer and the fillers can be enhanced by using coupling agents. Coupling agents are bi-functional molecules, which bonds chemically with both, the polymer and the filler surface, improving the bond strength between the matrix and the filler.

Limited studies have been carried out on mineral fillers incorporated in ABS polymer. The studies that have been carried out are more concentrated on CaCO_3 filler. Other fillers that have found attention are fly ash, glass spheres, wollastonite, etc. [1,2]. Fillers such as talc and mica have also been incorporated in PC/ABS blends. Jiang *et al.* [3] investigated the properties of nano and micro CaCO_3 filled ABS composites. Tang *et al.* [4] studied the mechanical and thermal properties of ABS filled with CaCO_3 having different particle sizes as well as surface treatment. In the current investigation, thermal properties of ABS composites with talc and CaCO_3 were studied.

2. EXPERIMENTAL

ABS resin was procured from LG Chemicals. The ABS Grade used was HI 121H, Natural, which was

*Corresponding Authors:

E-mail: vikrantvd@gmail.com

E-mail: +91 9686694520

general purpose injection molding grade with melt flow index value of 25 g/10 min at 220°C/10 kg load as per ASTM D1238. Uncoated grades of talc and CaCO₃ with particle size of 5 μ was used for compounding with ABS. Titanate coupling agent was used for improving the adhesion between the polymer and the filler.

2.1. Compounding

ABS-talc and ABS-CaCO₃ composites were prepared by compounding in a Haake Rheomix OS –PTW16, twin screw extruder with an L/d ratio of 25. Talc and CaCO₃ were compounded individually with ABS at 10%, 20%, 30%, and 40% loading, 5% of coupling agent was added to all the batches. Processing in the Haake twin screw extruder was carried out at a temperatures range of 175-220°C. Torque was maintained at 60-70 Nm for all the batches. The extruded strands were pelletized and dried at 80°C for 3 h to remove the moisture. Test specimens were prepared by injection molding for further property evaluation and comparison studies. Test specimens were molded using Toshiba S-Tech100 injection molding machine for HDT tests as per ASTM standards.

2.2. Characterization and Testing

Thermal properties for ABS composites were studied by differential scanning calorimeter (DSC), thermogravimetric analysis (TGA), and HDT. The studies were carried out as per ASTM standards. DSC was carried out as per ASTM D3418. The samples were scanned from room temperature to 250°C under an inert atmosphere at a rate of 10°C min⁻¹. TGA analysis was done as per ASTM E1131. The samples were heated from room temperature to 900°C in an inert atmosphere at a heating rate of 10°C min⁻¹. TGA analysis provides the data as a percentage of filler loading as well as decomposition temperature for the composites. HDT was carried out as per ASTM D 648.

HDT testing was done at a stress level of 1.8 MPa load. The properties of ABS/Talc and ABS/CaCO₃ composites were compared with virgin ABS that was run through the extruder, without any filler to have the same thermal history as that of the filled composites.

2.3. Thermal Properties

2.3.1. HDT

Figure 1 shows the effect of filler loading on the HDT of ABS resin. There was no significant change observed in the deflection temperature with slight rise

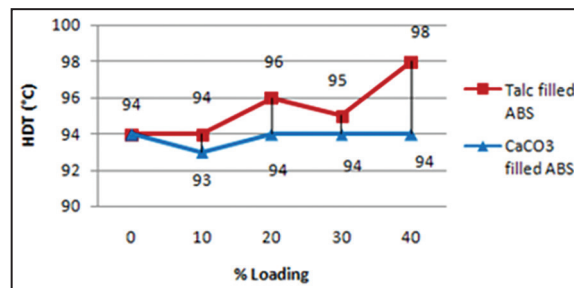


Figure 1: Heat deflection temperature of acrylonitrile butadiene styrene (ABS), calcium carbonate (CaCO₃) ABS/talc and ABS/CaCO₃.

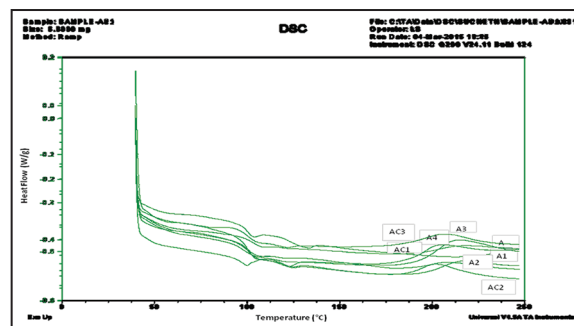


Figure 2: Differential scanning calorimetry thermograms of acrylonitrile butadiene styrene (ABS), calcium carbonate (CaCO₃) ABS/talc and ABS/CaCO₃.

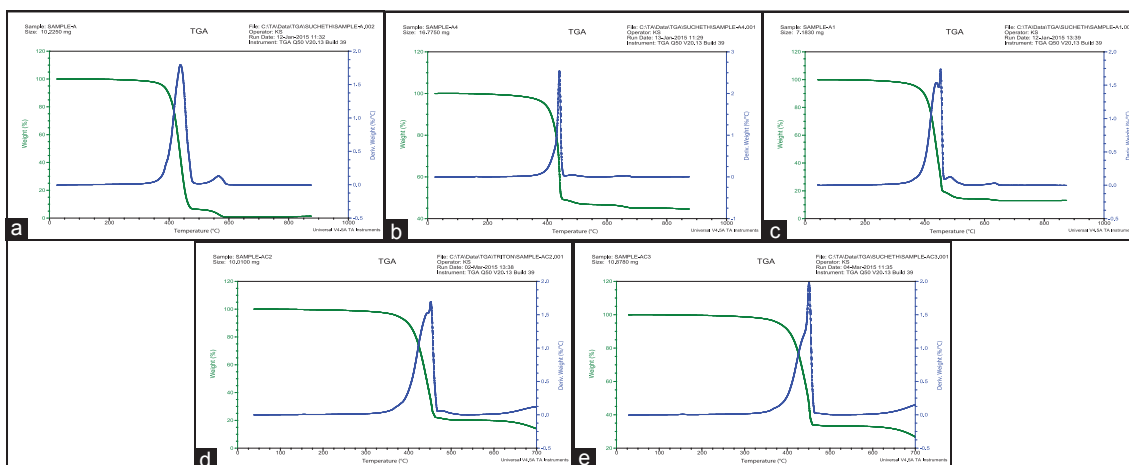


Figure 3: Thermogravimetric analysis thermograms of acrylonitrile butadiene styrene (ABS), calcium carbonate (CaCO₃) ABS/talc and ABS/CaCO₃ (a) virgin, (b) 20% talc, (c) 40% talc (d) 20% CaCO₃, (e) 40% CaCO₃.

Table 1: Characteristics of the fillers.

Fillers	Supplier	Density	Particle size (d50)	Treatment
Talc	Golcha	2.7	5.2	Un-coated
CaCO ₃	Omya	2.71	5.1	Un-coated

in case of talc filled ABS. There was no reduction seen in the thermal property. HDT is carried out in flexural mode, and although it is known that fillers improve the stiffness of the polymer, there was no significant increase in the deflection temperature. It may be due to the reason that ABS is an amorphous polymer, and the polymer phase is soft and deforms on the application of heat, which is not the case with semi-crystalline polymers, which tend to be harder and denser than amorphous polymers. The addition of fillers to amorphous polymer gives HDT value, which is close to its T_g , whereas fillers in semi-crystalline polymers will give the HDT value which is close to its T_m . Thus, fillers will play an important role in raising the HDT of semi-crystalline polymers than in the case of amorphous polymers (Table 1).

2.3.2. DSC

ABS/talc and ABS/CaCO₃ composites in Figure 2 were characterized using DSC. The sample was heated at 10°C min⁻¹ in an inert atmosphere. As glass transition temperature (T_g) or melting temperature (T_m) is the characteristic of the polymer, addition of the filler will not increase the T_g or T_m value, it may only increase the service temperature of the composite as the rigid particles will restrict the mobility of the polymer chains. Thus, there was no change observed in the glass transition value of the ABS resin. Virgin ABS showed a T_g of 102°C; whereas as filled ABS composites showed the T_g value around 100°C.

2.4. TGA

TGA analysis provides the filler content and the decomposition temperature for the polymer composites.

CaCO₃ filled composites show a different behavior in TGA as compared to talc filled composites (Figure 3). Two step decompositions are seen in CaCO₃ composites. The first step shows the decomposition of ABS resin whereas the second step shows the decomposition of CaCO₃ to CaO and CO₂. This is seen in temperature range of 650-750°C. In the case of talc composites, only ABS matrix decomposes as talc is thermally stable up to 1200°C. Apart from this,

there was no significant change in the decomposition temperatures for the composites as against the unfilled resin.

3. CONCLUSION

Two fillers with different shapes were compounded with ABS to investigate if there is any effect on the thermal properties of ABS resin. The composites were characterized to see if there was any change in the decomposition temperature, service temperature as well as T_g . It was observed that the T_g being the characteristic of the polymer, it will not change by the addition of any type of filler. Usually, spherical (isotropic) fillers will give least improvement in HDT whereas isotropic fillers like talc, mica are better, but there was no significant increase in the HDT values for both ABS/talc and ABS/CaCO₃ composites. This can be attributed to the soft nature of the polymer phase, which deforms on the application of heat, as ABS is an amorphous polymer. Similarly, there was no change observed in the decomposition temperatures for both the composites. Thus, fillers may be less effective with amorphous polymers as compared along with semi-crystalline polymers when it comes to thermal properties. Although there was no increase observed in the properties of the composites, there was no deterioration of any of the property by addition of the fillers to ABS. Further investigation needs to be done to determine the effect on mechanical, physical, and rheological properties.

4. REFERENCES

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***Bibliographical Sketch**



Vikrant V. Deshpande completed his Bachelor's degree in Polymer Engineering from Pune University in the year 2004. He is currently doing Master in Science & Engineering by Research from VTU, Belgaum/ SJCE Mysuru. He has an industrial experience of 9 years in various areas like R&D, application & business development, polymer processing and testing. He is currently working with one of the leading FMCG Company, in the area of material development. His area of experience covers speciality polymers, polymer compounding, injection molding and certification of polymer materials for electrical and electronic applications. His field of interest includes polymer materials, processing and application development.