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CONFERENCE REPORT

Studies on thermal, electrical and flame properties of surface modified cenosphere filled ABS composites

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Introduction

Growing industrial activities create a continual demand for improved materials that satisfy more stringent requirements, such as higher stiffness, electrical resistance, heat distortion temperature, and lower thermal expansion and cost. These requirements, which often involve a combination of many difficult-to-attain properties, can often be satisfied by utilizing a composite material, whose constituents act synergistically to solve the needs of the application.

A Cenosphere (CS) is a light weight, inert, hollow sphere made largely of silica and alumina and filled with air or inert gas., typically produced as a byproduct of coal combustion at thermal power plants. Cenospheres are hard and rigid, light, waterproof and insulative having density of about 0.4–0.8 g/cm^3 [1]. This makes them highly useful in a variety of products, notably fillers. The purpose of using CS as filler is not only for reducing the cost of valuable resin but also to ease out the environmental implications caused by CS [2, 3].

Acrylonitrile Butadiene Styrene (ABS) is a terpolymer having superior processability, high impact resistance, good dimensional stability, high strength, rigidity and good chemical resistance. These properties combining with excellent capabilities of ABS to be vacuum metalized and electroplated led it to the extensive use in engineering applications particularly in the field of automobiles.

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Table 1 Chemical composition of cenosphere

Chemical composition (wt%)	
SiO_2	55–61
Al_2O_3	26–30
Fe_2O_3	4–10
CaO	2–6
MgO	1–2
Na_2O,K_2O	0.45–0.55
CO_2 Gas	70 %
Nitrogen Gas	30 %

Experimental

Materials

ABS (ABSOLAC 100) material was used in this study. The material was manufactured by Styrolution ABS Limited and supplied by P.K. Polymers, Ahmedabad. CS having particle size 100–200 µm was supplied by Pearl Enterprise, Vadodara. The chemical composition of CS is shown in Table 1.

Silane treatment

The inorganic filler CS was surface treated with 3-Methacryloxypropyl Trimethoxy Silane (KBM-503) (2 % by weight of CS) before being added to ABS. The KBM-503 coupling agent was obtained from ShinEtsu Chemical Company Limited, Japan.

Composite and specimen preparation

Composites of ABS and CS (untreated and surface modified) were prepared using different compositions mentioned in the Table 2. The ABS was predried at 85 °C for

Table 2 Composition of ABS and cenosphere

Batch	Composition
ABSN	ABS + CS 0 wt%
ABS10CS	ABS + CS 10 wt%
ABS15CS	ABS + CS 15 wt%
ABS20CS	ABS + CS 20 wt%
ABS25CS	ABS + CS 25 wt%
ABS30CS	ABS + CS 30 wt%
ABS10CST	ABS + CS 10 wt% (Treated)
ABS15CST	ABS + CS 15 wt% (Treated)
ABS20CST	ABS + CS 20 wt% (Treated)
ABS25CST	ABS + CS 25 wt% (Treated)
ABS30CST	ABS + CS 30 wt% (Treated)

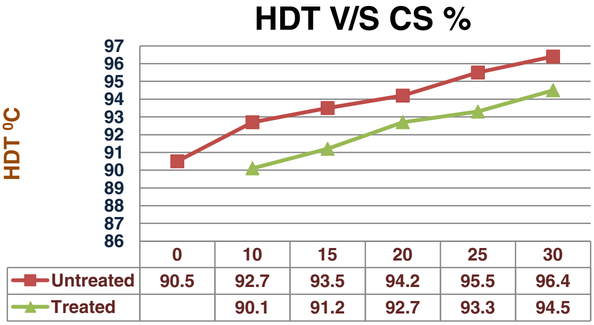


Fig. 1 Change in HDT with filler concentration

3 h and the ABS-CS mixture was melt blended using Co-rotating Twin Screw Extruder having L/D ratio 40:1 and temperature range of 220–230 °C. The specimens were prepared using Injection Molding machine at 230–255 °C [4, 5].

Characterization

HDT was measured by using HDT testing machine (CEASE, HDT junior) as per ASTM D 1525. DSC Q-200 (TA instruments) with refrigerated-cooling-system (RCS-90) and Nitrogen purge was used for DSC analysis. TGA Q-5000IR (TA instruments) was used for the TGA analysis. Rate of burning of samples was evaluated as per ASTM D 635 method using uniform sample thickness for the length of 100 mm. Dielectric breakdown voltage and dielectric strength of samples were tested as per ASTM D 149 short time method using dielectric test machine (CEAST) [6, 7].

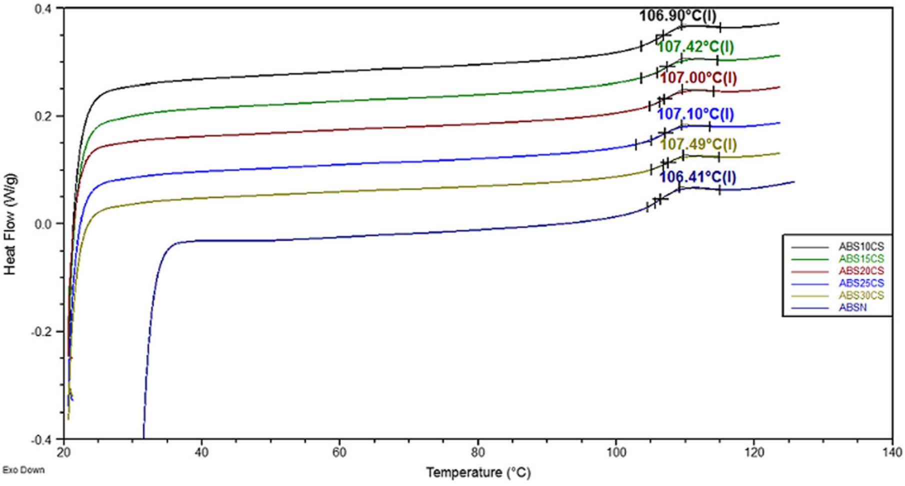


Fig. 2 DSC thermograms untreated compositions

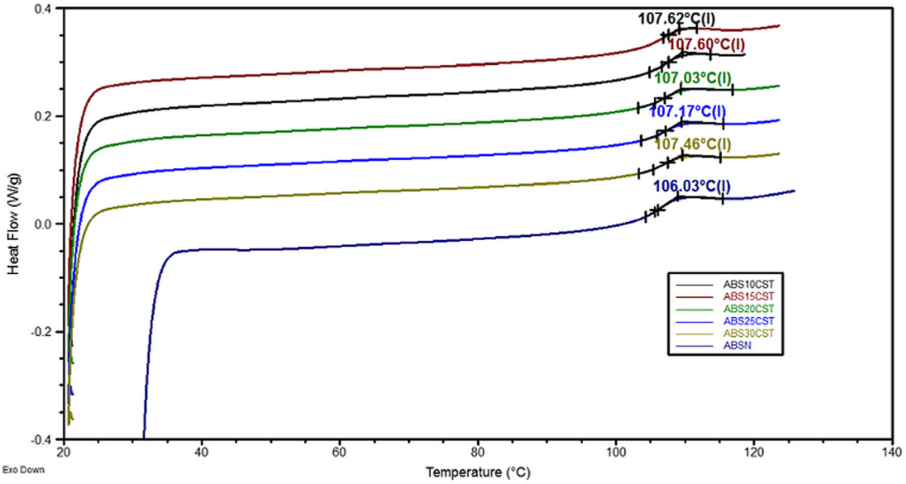


Fig. 3 DSC Thermograms of treated compositions

Results and discussions

Thermal properties

Heat deflection temperature (HDT) The data shown in Fig. 1 indicates increased distortion temperature with increase in filler content which supports chain stiffness due to filler addition. Both treated and untreated compositions showed similarity in the results. As the filler concentration increases the HDT increases. Very marginal change was observed in HDT in both the cases [8].

Differential scanning calorimetry (DSC) The glass transition temperature (Tg) was evaluated using DSC technique. Figure 2 shows an overlay of DSC second-heat thermograms for ABS natural (unfilled) sample and ABS filled with Cenospheres

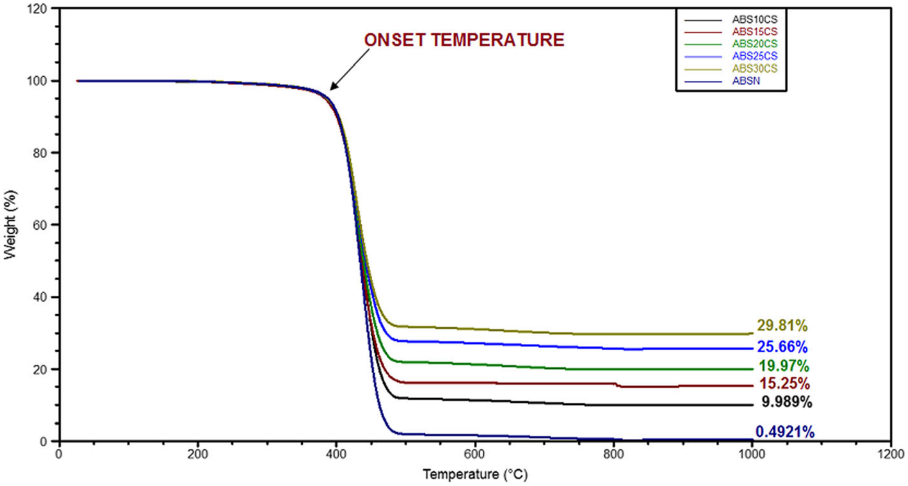


Fig. 4 TGA thermograms of untreated compositions

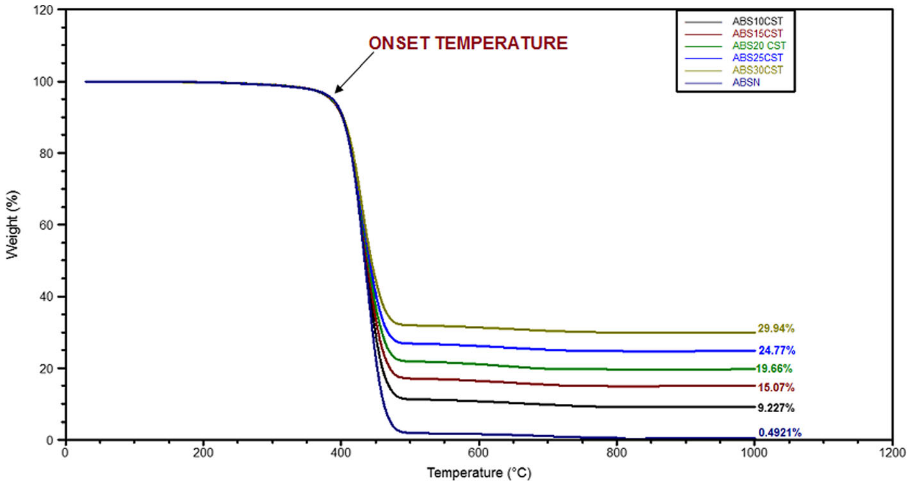


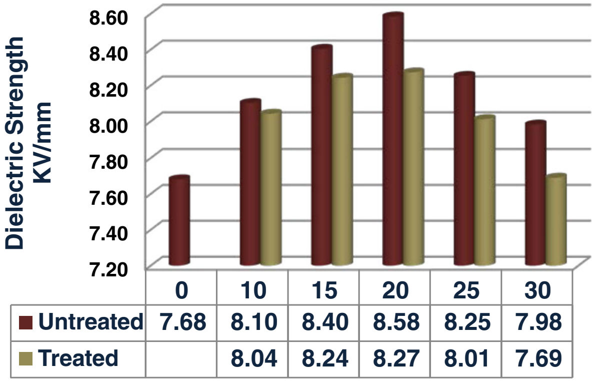
Fig. 5 TGA thermograms of treated compositions

(untreated) while Fig. 3 shows thermograms of ABS filled with Cenospheres (treated) at various concentrations.

Overall, all samples exhibited a glass-transition temperature around 107 °C which is an appropriate glasstransition temperature for ABS material and did not exhibit any thermal transition features like glasstransition during DSC run.

Thermo gravimetric analysis (TGA) TGA is an ideal technique to evaluate filler content in the final composite samples and analysis of decomposition temperature of ABS natural and ABS-CS composites.

Figures 4 and 5 shows overlay of untreated and treated compositions respectively which facilitates comparison of all the individual TGA profiles. In all samples, ABS starts to break down around 400 °C and pyrolyzed completely before 525 °C leaving inorganic material, Cenospheres, behind. It shows no significant change in decomposition temperature of ABS with rise in filler content i.e. thermal stability is not much affected by filler addition.



	0	10	15	20	25	30
■ Untreated	7.68	8.10	8.40	8.58	8.25	7.98
■ Treated		8.04	8.24	8.27	8.01	7.69

Fig. 6 Effect of CS concentration on dielectric strength

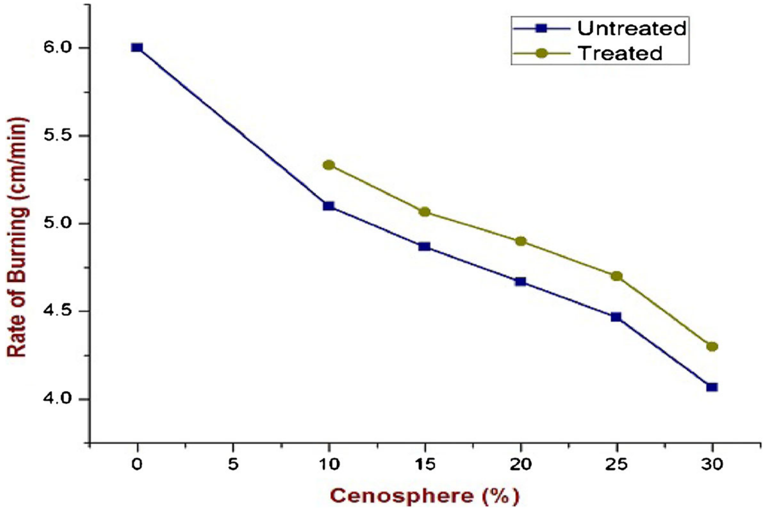


Fig. 7 Effect of CS concentration on rate of burning

Dielectric strength

Figure 6 indicates the dielectric strength improves with rise in filler content. The rise in dielectric strength observed up to 20 % loading and then it decreases. This may be due to leakage of current from un encapsulated interstitial filler particle at higher filler loading.

Both treated and untreated composite samples showed similar trends in dielectric properties. Untreated samples showed marginally higher values of dielectric strength than their treated counterparts.

Rate of burning

The data shown in Fig. 7 shows that the rate of burning decreases with increased concentration of cenosphere. It is due to the fact that the Cenospheres are not combustile and because there is a reduced amount of ABS, filled ABS usually burn less well than unfilled ABS.

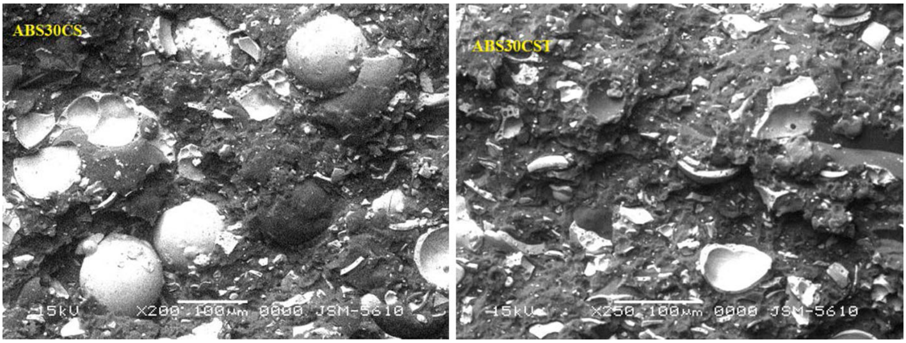


Fig. 8 SEM micrographs of ABS30CS and ABS30CST

Morphological properties

Figure 8 shows SEM micrographs of impact fractured surfaces of Untreated and Treated composites. Uniform distribution of the CS within ABS matrix is also confirmed by SEM micrographs. Good interfacial adhesion between matrix and filler is achieved with SCA which can be seen by the matrix covered surfaces of CS. Due to this there is increase in the properties of treated composites [9–12].

Conclusions

Following conclusions can be made:

The values obtained of glass transition temperature in DSC and the decomposition temperature in TGA clearly indicates that the thermal stability of the composite is not affected by the increase in CS concentration. In both treated and untreated compositions, the dielectric strength, HDT of the material increases and rate of burning decreases. Treatment of SCA improves interfacial adhesion ABS and CS.

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