PREPARATION AND CHARACTERIZATIONS OF ACRYLONITRILE BUTADIENE STYRENE (ABS) - CENOSPHERE COMPOSITES

[1] *JAYMIN R. DESAI* , [2] *S.C. SHIT,* [3] *M. D. SHAH AND* [4] *S. K. JAIN*

[1, 2, 3, 4] **Plastic Engineering Department, High Learning Centre,**
Central Institute of Plastic Engineering and Technology (CIPET),
Ahmedabad – 382445, Gujarat, INDIA.

jayminrdesai@yahoo.com, Subhasch.shit@yahoo.com, shh_mynk@yahoo.co.in, sandesh_cipet@hotmail.com

ABSTRACT : *Composites were developed with Acrylonitrile Butadiene Styrene (ABS) and varied filler concentration of Cenosphere (CS) (100-200 μm) from 0, 10, 15, 20, 25, and 30 wt% using co-rotating twin screw extruder and injection molded test specimens were prepared to study the effect of concentration of Cenosphere on the properties of Cenosphere filled ABS composites. The test result indicates improvement in flexural modulus, tensile modulus, flammability and thermal properties. Morphological properties of composites were evaluated by SEM analysis.*

KEYWORDS: Acrylonitrile Butadiene Styrene (ABS), Cenospheres (CS), Mechanical properties, Thermal properties, Morphological properties, Flammability.

1. Introduction

Enormous growth of automobile industry has encouraged the material developers to develop a wide range of property rich and cost effective filled composites. Cenospheres(CS) are hard and rigid, light weight, waterproof, 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. When pulverized coal is burned at power plants fly ash is produced. The fly ash comprises 50-90% of the solid products of combustion and usually contains 1-2 wt% of CS [1]. Cenospheres are one of the most useful fillers available to the plastic industry. The replacement of high priced and scarce resin is the most obvious advantage; but lower and controlled density, uniform shrinkage, increased tensile and flexural modulus, and mold fill-out are among other benefits. Unmatched properties of CS has expanded his growth in areas like plastics, ceramics, construction, automotive ,energy and thus help in decreasing environmental implications caused by the fly ash. Acrylonitrile Butadiene Styrene (ABS) is a versatile engineering terpolymer. superior properties like toughness and impact resistance, dimensional stability, good heat distortion resistance, abrassion resistance, good low -temperature properties and capability of being electroplated without great difficulty have exteded its use in particularly automobile interior and exterior parts as well as household appliances [2-6].

2. Experimental

2.1 Materials

The polymer used in this study was ABS (ABSOLAC 100) manufactured by Styrolution ABS limited and supplied by P.K. Polymers, Ahmedabad. The MFI of material is 8 gm/10 min with specific gravity 1.04 gm/cc. The fillers were supplied by Pearl Enterprise, Vadodara having particle size 100-200 µm. The chemical composition of CS is shown in Table 1.

Table 1 Chemical Composition of Cenosphere

Components	Weight %
SiO_2	55 - 61
Al_2O_3	26 - 30
Fe_2O_3	4 - 10
CaO	2 - 6
MgO	1 - 2
Na_2O_3 K_2O	0.45 - 0.55
CO_2 Gas	70%
Nitrogen Gas	30%

Table 2 Formulation of ABS-CS composites

Sr. No.	Sample	Composition
1	ABSN	ABS + CS 0 wt%
2	ABS10CS	ABS + CS 10 wt%
3	ABS15CS	ABS + CS 15 wt%
4	ABS20CS	ABS + CS 20 wt%
5	ABS25CS	ABS + CS 25 wt%
6	ABS30CS	ABS + CS 30 wt%

2.2 Composite and Specimen Preparation

ABS-CS composites were prepared using different composition which is mentioned in Table 2. The ABS is predried before compounding for 3 hrs at 85 °C to produce void free composites. The ABS-CS mixture was melt blended in Co-rotating Twin Screw Extruder having L/D ratio 40:1 using temperature range of 220 - 230 °C. Granules obtained were used for injection molding after predrying at 85 °C for the duration of 3-4 hrs. The process was carried in injection molding machine (Battenfeld 500) at 230-255 °C to produce standard test specimen for mechanical, thermal and electrical properties.

2.3 Characterization of Composites

Tensile strength and modulus were evaluated at laboratory conditions using Universal Testing Machine (INSTRON) as per ASTM D 638 method with a crosshead speed of 5 mm/min. Flexural strength and modulus were tested by AUTOGRAPH (AG-IS) according to ASTM procedure D 790. Impact strength was measured by impact tester (CEAST, Resil Impactor) at ambient condition according to ASTM D 256. Hardness values were measure by ASTM D 785 (R scale) with 1/2" ball indenter and 60 Kg load using hardness tester (SWARAJ ENGINEERING). HDT was measured by using HDT testing machine (CEASE, HDT junior) as per ASTM D 1525. DSC characterization (PERKIN ELMER, Diamond DSC) was carried out using heating rate 2 °C/min and nitrogen purging rate at 50 ml/min. Virgin ABS as well as ABS-CS composite samples were subjected to thermo gravimetric analysis using TGA (PERKIN ELMER, Pyris 1TGA) equipment and samples of 10 mg were heated from 50 to 800 °C at a heating rate of 10 °C/min in nitrogen atmosphere. Rate of burning of samples were 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 using dielectric test machine (CEAST). Scanning Electron Microscope (SEM) analysis was performed using JEOL (JSM-5610LV) for evaluating the fractured topography of the composites[5-8].

3. Results and Discussion

3.1 Mechanical Properties

Filler (CS) affects the tensile properties according to their packing characteristics and interfacial bonding. It was observed from figure 1(A) that the incorporation of CS in ABS matrix increases the tensile modulus due to effective stress transfer from matrix to the interface. However, tensile strength decreased with increased filler concentration reveals low interfacial bonding between matrix and filler. This is because the spaces between particles are filled with matrix. When a tensile load is applied, these matrix segments stretch and pull away from the particles, resulting in the very low strengths of highly filled composites. CS reduce the flexural strength in proportion to their relative packing volumes which was illustrated in figure 1(B). As the CS concentration increases the flexural strength decreases due to insufficient matrix available around CS particles. The flexural modulus increases with higher filler concentration due to increase in stiffness of the composites.

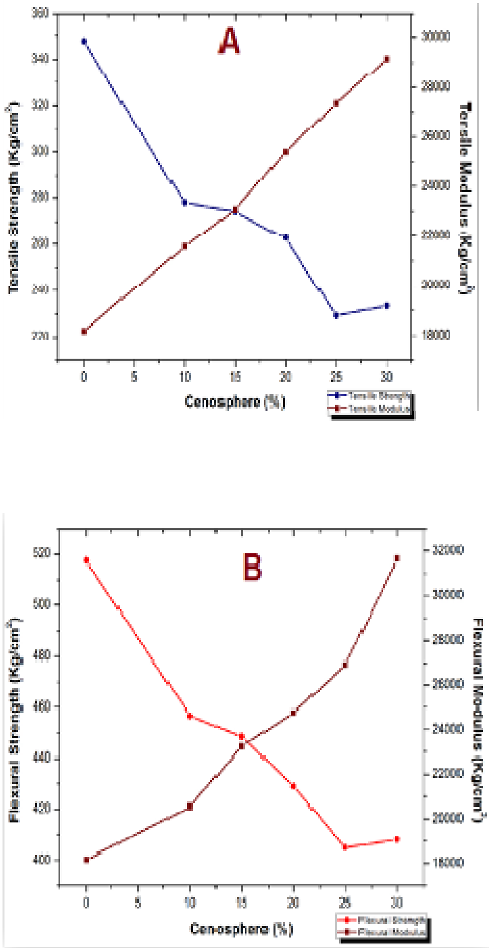


Fig.1 Effect of CS concentration on (A) Tensile Properties (B) Flexural Properties

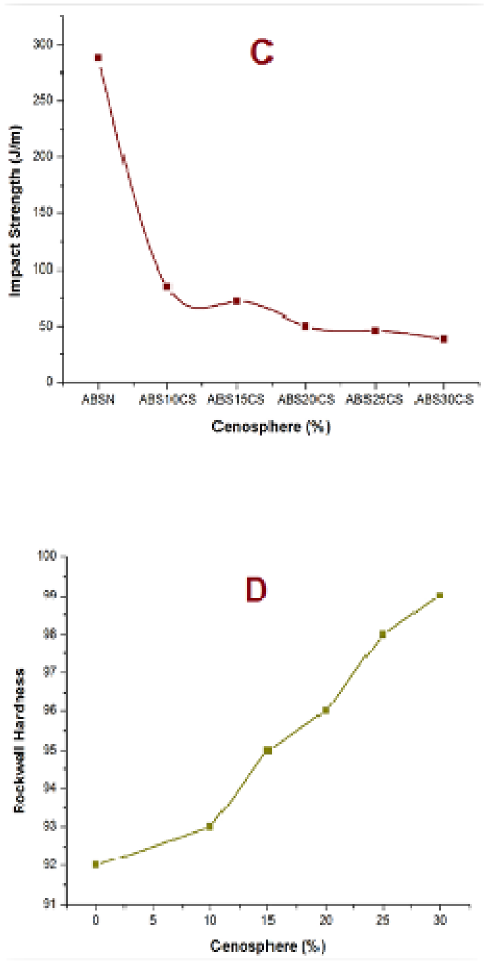


Fig.2 Effect of CS concentration on (C) Impact Strength (D) Rockwell Hardness

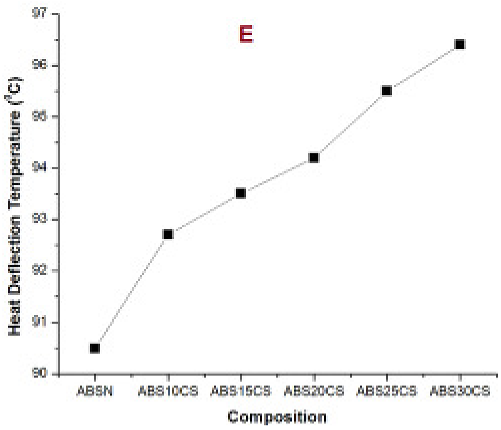
Impact strength of composites decreases sharply with increase in CS concentration which is shown in figure 2(C). An increase in CS concentration reduces the ability of ABS to absorb energy and thus reducing the toughness and leading to decreased impact strength. As CS concentration increases, the hardness of composite increases as shown in figure 2 (D).

3.2 Thermal Properties

The heat distortion temperature (HDT) shows qualitatively the same tendency as the tensile modulus in filled systems. The data shown in figure 3(E) indicates the increased distortion temperature with increase in filler content which supports chain stiffness due to filler addition. The glass transition temperature (Tg) was evaluated using DSC technique. Figure 3 (F) facilitate an overlay of all individual thermo grams.

Glass-transition-temperature (Tg) of the resin was evaluated using step-transition function, and an inflection point method. Overall, all samples exhibited glass-transition temperature around 105 ^{0}C which is an appropriate glass-transition temperature for ABS material. The increase in Tg values might be due to hindered chain movement with rise in filler concentration.

Thermo Gravimetric Analysis technically used to check % filler content left over after mass loss due to pyrolysis of ABS by heating to the temperature range of 50-800 ^{0}C and analysis of decomposition temperature of ABS natural and ABS filled with different filler concentration. It shows that no significant change in decomposition temperature of ABS with rise in filler content and thermal stability is not affected as shown in figure 4.



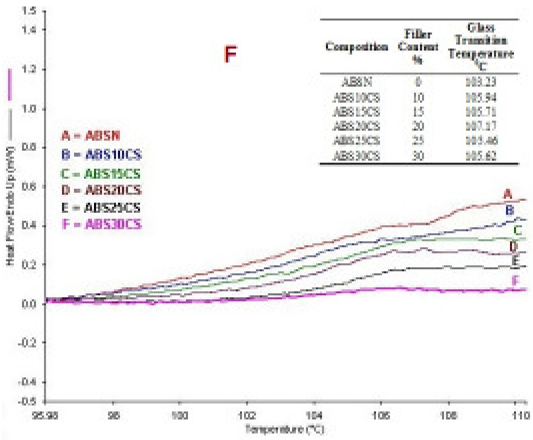


Fig.3 (E) HDT V/S CS Composition (F) DSC Analysis

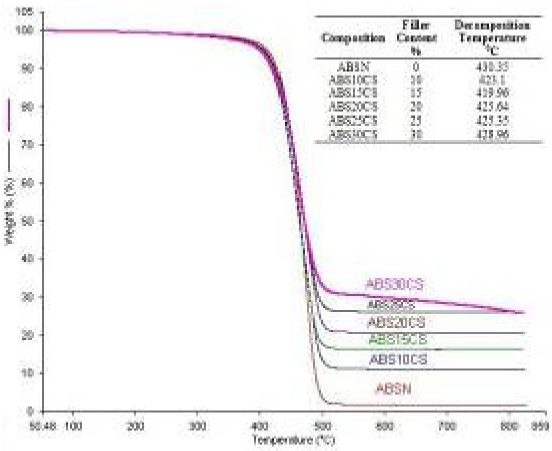


Fig.4 TGA Analysis

3.3 Rate of Burning

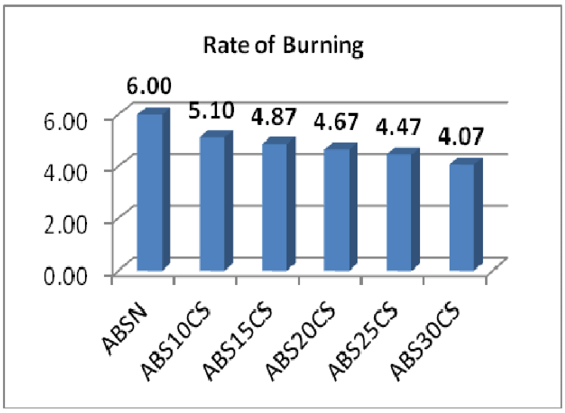


Fig.5 Effect of CS on Rate of Burning

The figure 5 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.

3.4 Electrical Properties

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

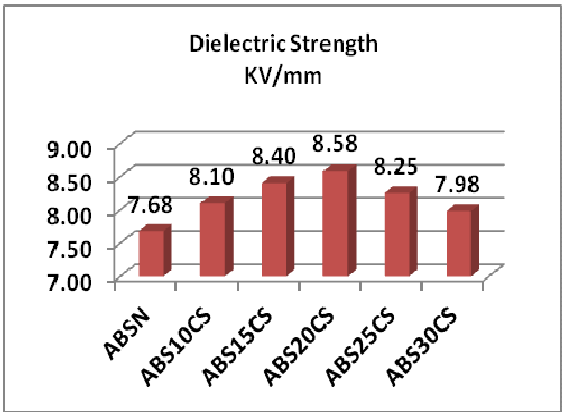


Fig.6 Effect of CS composition on Dielectric Strength

3.5 Phase Morphology

The SEM photomicrographs of impact fractured surfaces of ABS/CS composites of samples ABS10CS and ABS30CS are shown in figure 6 and 7 respectively.

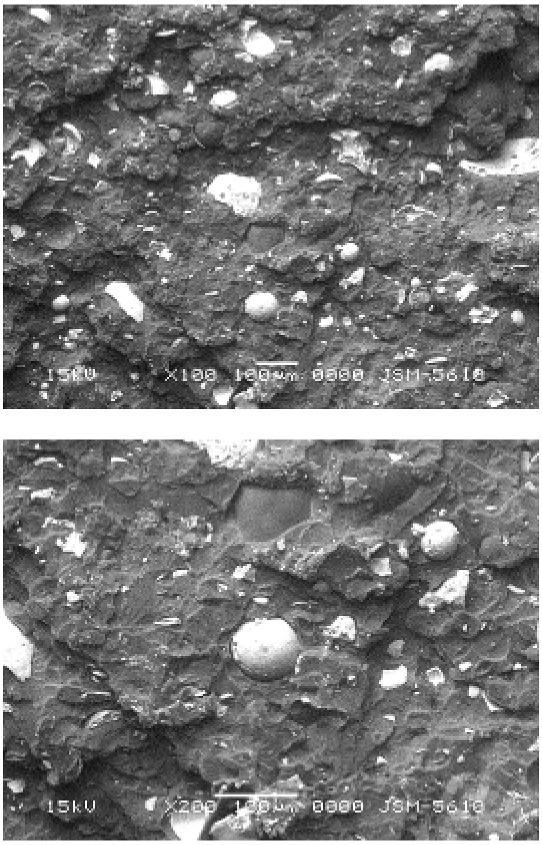


Fig.7 SEM micrographs of ABS10CS

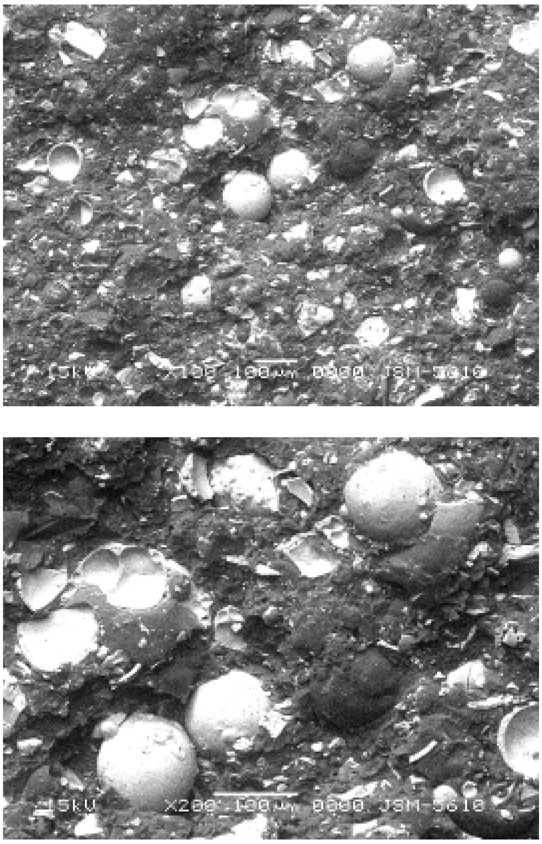


Fig.8 SEM micrographs of ABS30CS

Figure 7 and 8 confirms the spherical shape and size (100-200 µm) of the cenosphere and the broken surfaces indicates that the CS are hollow spheres. Photomicrographs clearly indicate that the particles of CS are uniformly and distinctively located in ABS matrix which resembles with the result of left over filler % obtained by TGA. Some pits are observed on the fractured surfaces of composites supports the poor interfacial bonding of filler and matrix. Figure 8 indicates at higher filler concentration, the filler particles were separate but were not encapsulated fully by matrix material which may lead to weakness in tensile strength and flexural strength.

4. Conclusions

Some characteristics features observed from this paper:

With increase in the CS loading the tensile and flexural modulus, hardness and heat distortion temperature increases due to increase in the stiffness of composite. Weak interfacial bonding of CS and ABS matrix decreases the tensile and flexural strength. With increase in CS concentration the dielectric strength increases and rate of burning decreases. The addition of CS does not affect the thermal stability of composites.

5. Acknowledgement

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5. References

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