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RESEARCH ARTICLE

TENSILE STUDIES ON FLY ASH REINFORCED POLYSTYRENE COMPOSITES

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ABSTRACT

In this study the tensile strength, Young's modulus and extension at maximum load of different concentration of fly ash(FA) incorporated in polystyrene(PS) composites have been investigated. Fly ash incorporated PS composite films have been prepared with the solution casting method. It is found that, tensile strength increases upto 236.9% for 5wt% FA based composite in comparison to pure PS and Young's modulus increases upto 10.14% for 5wt% FA based composite in comparison to pure PS. The maximum extension in composite film is found 0.458 mm at the load of 117 N for 5wt% FA based composites.

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INTRODUCTION

Particle filled polymer composites have become attractive because of their wide range of applications and low cost. In general the mechanical properties of particulate filled polymer composites depend strongly on size, shape and distribution of filler particles in the polymer matrix (Shut, 1999). Fly ash is a by-product commonly produced by the combustion of coal in thermal power plants. The fly ash is separated from the hot fuel gases before it escapes into the atmosphere. The fly ash molecules are generally spherical in shape (Maiti and Lopez, 1992; Modern Plastics Encyclopedia Handbook, 1994; Harper, 1996; Berins, 1974; Neilsen, 1974). The mechanical properties of a polymer involve its behavior under stress. The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. Tensile strength is an important mechanical aspect widely measured for a material that is going to be stretched under tension. Tensile properties indicate how the material will react to force being applied in tension (Courtney, 1990).

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Mechanical properties are of relevance for all the applications of polymers in industry, optics, electronics, medicine etc.(Suwanprateeb, 2000; Zamfirova *et al.*, 2003). The improvement of mechanical properties demands a well understanding of the interdependence between molecular structure, morphology and processing methods on the one hand and ultimate mechanical properties on the other hand (Suwanprateeb, 1998).

Experimental

MATERIALS AND METHODS

For the preparation of the polymeric composite films ,the commercially available polymer Polystyrene obtained from-Research lab fine chemical industries Mumbai and fly ash in powder form obtained from thermal power plant, Singrouli (M.P.) used without further purification.

Preparation of specimen

Fly ash in different concentration was added to the polystyrene to yield the composite of required concentration and designated as pure polystyrene(PS), pure fly ash (FA), 3% FA & PS, 5% FA & PS and 8% FA & PS for 3,5 and 8 weight percentage concentration of fly ash respectively.

The solution casting method has been utilized to prepare the composite films of pure polystyrene(PS) and fly ash based composite films. 1,2 Dichloroethane has been taken as solvent. Fly ash and polystyrene were mixed in solvent 1,2 dichloroethane with the help of magnetic stirrer at 60 ^{0}C temperature for 6h. A known quantity of homogeneous solution poured in glass mould of size 5x5 cm^2 and kept in an electric oven at 70 ^{0}C temperature for 24h. Samples of 4x2 cm^2 size were cut from the pallets and kept in the air tight polyethylene bags .

Tensile studies

Experimentally the Tensile strength (stress and strain) and Young's modulus studies were carried out using Instron 3369(UTM) with extension rate 5mm/min. The final mechanical properties were evaluated with at least four different measurements, tests were at room temperature.

RESULTS AND DISCUSSION

Tensile Strength and Stress-Strain Behaviour of pure PS and FA based composites

The stress- strain behavior of pure PS and FA reinforced PS composites are shown in Figs. 1 (a-d) and stress-strain and modulus values are given in Table-1.

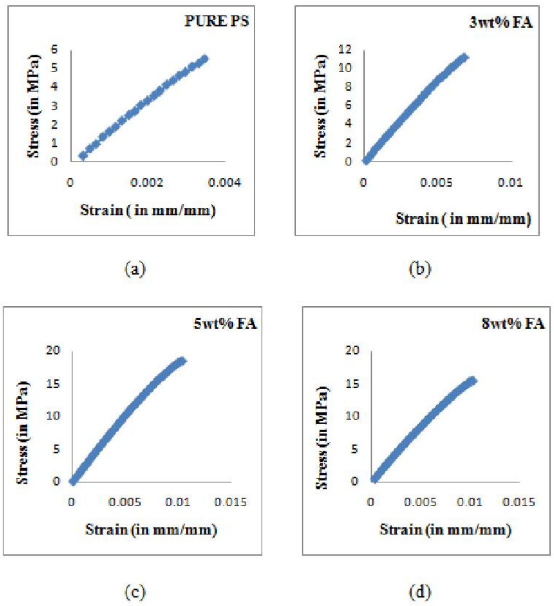

Fig.1 (a-d) Stress-strain curve of pure PS and FA reinforced PS composites

Table 1. Polystyrene – Fly-ash Composite sample description of tensile stress- strain with modulus of elasticity

FA Wt % Composite	Tensile Stress at Max. Load (MPa)	Tensile Strain at Max. Load (mm/mm)	Modulus (MPa)
Pure PS	5.50	0.0034	1617.64
3 wt % FA	11.19	0.0068	1645.58
5 wt % FA	18.53	0.0104	1781.73
8 wt % FA	15.38	0.0102	1507.84

The tensile strength of pure PS is shown in Fig1(a) the plot is linear, where stress is directly proportional to strain and this region is characterized as elastic region. This type of deformation can arise due to the bending or stretching of inter atomic bonds between atom of the polymer molecule. This type of deformation is almost instantaneous and recoverable as there is no permanent displacement of the molecules with respect to each other. In this region, the segmental motion of chain of the polymer plays a role for displacement. The elastic deformation occurs at a stress, which cause the chain to disentangle by overcoming the Vander Waals forces .The strain increases with the increase in stress and attains a maximum value .The stress at max. load for pure PS is 5.50 MPa and corresponding strain is 0.0034 mm/mm.

The effect of fly ash wt% on tensile strength of prepared composites are depicted in figs1 (b-d). It is clear that the specimen having 3wt% FA content is comparatively brittle and strong. On increasing the fly ash content in the composites, more stress is needed to break the sample. For specimen with 3wt% FA content , the value of maximum stress is 11.19 MPa and corresponding strain is 0.0068 mm/mm. The tensile strength increases with increase in FA content in the composite. This variation corresponds to the strengthened and brittle nature of prepared composite. For specimen with 5wt% FA content , the value of maximum stress is 18.53 MPa and corresponding strain is 0.0104 mm/mm. The specimen with 8wt% FA content, the value of maximum stress is 15.38 MPa and corresponding strain is 0.0102 mm/mm. The tensile strength increases continuously with increase in the content of fly ash from 0 to 8wt% is shown in Fig.2.

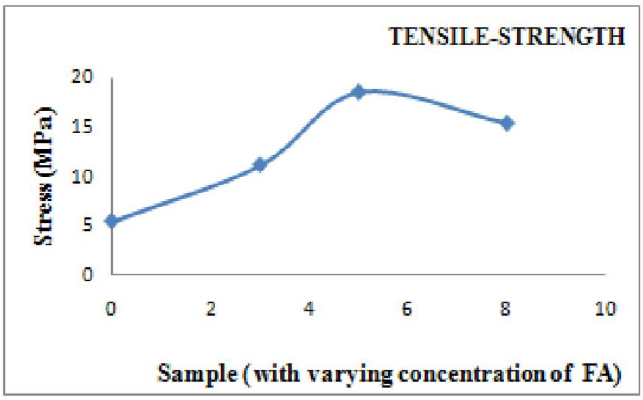

Fig. 2. Tensile strength of different wt% concentration of fly ash based composites

The tensile strength increase to 103.4% when FA concentration is 3wt% thereafter the tensile strength reaches its maximum value of 18.53 MPa when the content of fly ash is 5wt%. Here tensile strength increases to 236.9%, and for 8wt%, the tensile strength increase upto 179.6 % as compared to pure PS. When the concentration of FA is increasing, the morphology of composite appears to be quite compact , which may increase the strength of prepared polymer composites. Moreover, with higher FA content, i.e. 8wt% FA, the morphology of the composite appears somewhat heterogeneous, which decrease the strength of the composite. The size of FA particle is also affect the strength of composite. Workers (Bose Suryasarathi and Mahanwar, 2004; Anilkumar and Suresh Hebbar, 2013) have studied the tensile strength was high with smaller particle size of FA, because the smaller FA particles help in strengthing the matrix, acting as barriers to the dislocations when taking up the load applied.

Young's modulus of pure PS and FA based Composites

The effect of fly ash on stress modulus behavior of polymer composites are depicted in Fig.3 and Table-1. Young's modulus of the composite increases from 1617.64 MPa to 1781.73 MPa. The increase in young's modulus of polymer composites leads to the development of material having good elastic properties. However, decrease in modulus at higher concentration (8wt% FA) defines the decrease in elastic region of deformation, lesser flexibility and more brittleness of composite.

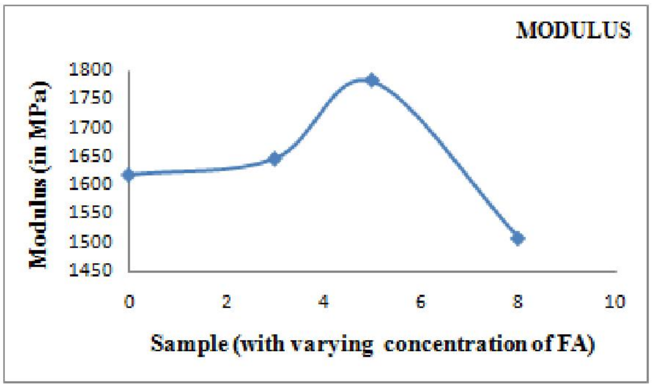

Fig. 3. Variation in Young's modulus with different Fly-ash (wt. %) concentration

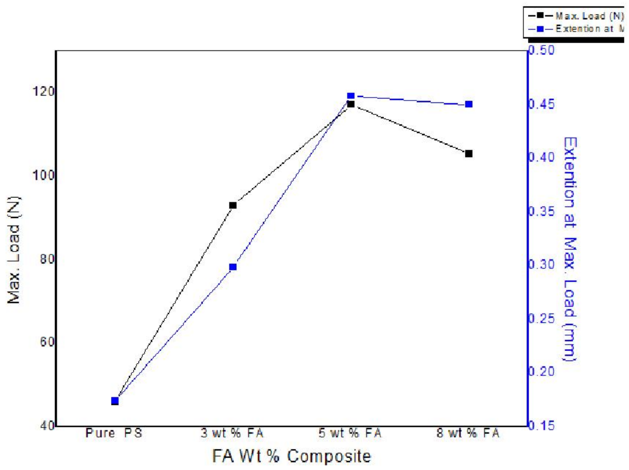

Fig. 4. Load and Elongation curves with respect to different wt% concentration of FA based polystyrene composites

Load-Extension behavior of pure PS and FA based Composites

The effect of fly ash on load- extension behavior of polymer composites are depicted in fig.4 and Table 2. Figure shows that extension is 0.174 mm at the load of 45.9 N for pure PS film. The extension with load increases for 3wt% FA reinforced PS composite. Here extension is 0.299 mm at 93.01 N load. The maximum extension is 0.458 mm at the load of 117.0 N for 5wt% FA based composite.

Extension decreases after 5wt% FA concentration. For 8wt% FA reinforced PS composite, the extension is 0.450 mm at load 105.2 N.

Table 2. For Polystyrene – Fly-ash Composite samples description of load and extension

FA Wt % Composite	Max. Load (N)	Extension at Max. Load (mm)
Pure PS	45.96	0.174
3 wt % FA	93.01	0.299
5 wt % FA	117.08	0.458
8 wt % FA	105.26	0.450

The feature of extension is related to crosslinking between composite contents (PS and FA). As the FA content increases in the composite which yields greater degree of brittleness in the composite. This phenomenon is due to change in crosslink density and morphology of the composite on increasing the FA content in the composite. Maximum elongation for specimen with 5wt% FA concentration can arise due to the segmental motion of uncross linked chains. On increasing the content of filler i.e. FA network becomes compact which increases its brittleness.

Conclusion

Tensile studies reveal that for developed fly ash reinforced polystyrene composite, as there is increase in concentration of fly ash the tensile strength increases. It suggests the presence of crosslink network and it imparts brittleness to the composite. The increase in young's modulus of polymer composites leads to the development of material having good elastic properties However , decrease in modulus at higher concentration (8wt% FA) defines the decrease in elastic region of deformation and composite become brittle. The increase in extension at maximum load of prepared composites suggests that increase in elastic region of deformation and also strain increases as the FA content increases leading to relatively strong and brittle nature of composite films. Thus incorporation of fly ash yields mechanically strong plastic and hardened polymer composites with improved utility.

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