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"THE EFFECT OF FLY-ASH ON STRUCTURAL AND MORPHOLOGICAL PROPERTIES OF FLY-ASH "Based Polymer Composites"

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Abstract:

In this study the effect of fly-ash on surface morphology of different type of fly ash reinforced polystyrene composites have been investigated. FTIR spectra of pure polystyrene pure fly ash and fly ash based composites have been observed and analyzed. The shifting of parent peaks were observed in composite films.The shifting may come from the results of physical bonding between polystyrene and fly ash.SEM and AFM analysis is done to observe surface morphology and it confirms the presence of fly ash particles in polystyrene matrix. The AFM images confirm the presence of fly ash particle in Nano phase within PS matrix.

Keywords: FTIR, SEM, AFM, PS, FA.

1. Introduction

In resent time researchers are exploring the possible use of waste materials like fly ash in composites to produce good materials for wide range of application (Chauhan et al. 2010; SinglaManoj et al 2010). The flyash is produced as industrial by product from the combustion of coal in thermal power plant and properties of flyash depend primarily on the type of coal burned, the type of combustion of equipment used and the type of flyash collection mechanism (CelikOzlem et al. 2008). The major component of the flyash is silica and alumina and oxides of iron, calcium, magnesium along with elements like Ti, carbon, Mg. etc. (SinglaManoj et al. 2010). Fly ash can increase the strength and making these light weight composites very desirable forthe automotive , aircraft and aerospace industries (Abdullah et al. 2010). . Polymer composites are very important as they are widely used in large number of applications due to their light weight , easy of fabrication and variety of other properties (SinglaManoj et al. 2010; Chauhan et al. 2010). With increasing demands of high technology areas such as air frame, jet engines, space shuttlesand atomic energy field. The need for lightweight materials with high strength and stiffness has led to the development of flyash based composites In developing composites using most environmentally friendly wastes as reinforcing fillers and thermosetting polymers as matrixes. Recent investigations of polymer- based composite materials have opened new routes for polymer. Formulations and have allowed the manufactureof new product with optimal properties for special applications (Imoisiliet al.2012)

2. Experimental

2.1 Materials

For the preparation of the polymeric composite films ,the commercially available polymer Polystyrene obtained from-and fly ash in powder form has produced from thermal plant ,Singroli (M.P.) used without further purification.

2.2 Preparation of specimen

Fly ash in different concentration was added to the polystyrene to yield the composite of required concentration and labled as Pure polystyrene(PS),Pure fly ash (FA), 1% FA & 99% PS,3%FA & 97% PS and 8%FA & 92% PS. For 1, 3 and 8 weight percentageconcentration of fly ash respectively. The sol-gel method (Bajpai R et al. 2002; Ramrakhiani M et al. 2005; Patel Arunendra Kumar et al. 2011) 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 electric motor operating at 200 rpm in air atmosphere at 60^0C for 6 h. A known quantity of homogeneous solution poured in glass mould of size 5x5 cm^2 and kept in an electric oven at 70^0C temperature for 24h. Samples of 4x2 cm^2 size and 1mm thickness were cut from the pallets and kept in the air tight polyethylene bags .

2.3 FTIR Spectroscopy

The structural characterization of pure polystyrene, fly ash powder and their composites of various ratio were recorded with NICOLET 6700 (Thermo scientific) with resolution of 4 cm^{-1}

2.4 AFM study

In present investigation the surface topography was determined using SOLVER NEXT , NT-MDT, Moscow made in Russia atomic force microscopy and analysis was carried out using semi contact mode.

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2.5 SEM study

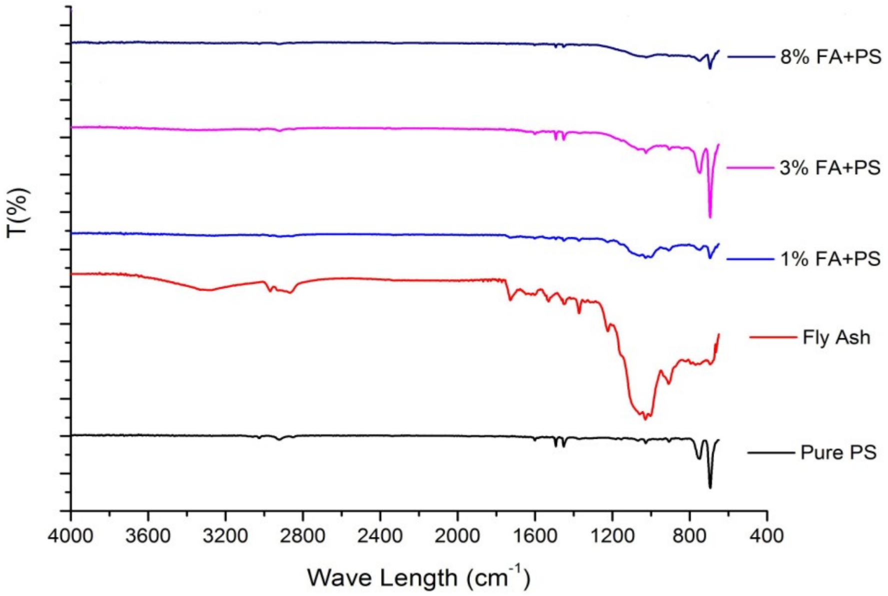
Experimentally the surface morphology was determined using JSM-6390A analytical scanning electron microscopy and analysis was carried out using supply voltage 110 volt 70 ampere and frequency 50/60 Hz.

3 Results and Discussion

3.1 FT- IR Spectroscopy

The FT-IR spectrum of pure polystyrene in (fig .1) indicates the details of functional groups present in the synthesized polystyrene. The absorption band indicating CH bands appear at approximately 1000 cm^{-1} for the in plane bends and about 675 cm^{-1} for the out of plane bend.(Sarkarmoinuddin et al.2013). Vinyl stretch at 910 and 1000 cm^{-1} and aeromatic ring stretch at 1496 cm^{-1} are present.The band at 1427 cm^{-1} attributed to Phenyl (Yongfeng Li et al.2011). The FT-IR spectra of fly ash shows the three characteristic bands centered around 1100, 1000 and 660 cm^{-1}. The strong and broad band at 1000 cm^{-1} is due to (Si-O-Si) asymmetric stretching vibrations and the other two bands at 1100 and 660 cm^{-1} are attributed to (Si-O) and (Al-O) vibrations respectively (CelikOzlem et al. 2008) .A band towards 1453 cm^{-1} has been assigned to the presence of sodium bicarbonates. Stretching and deformation modes of water were detected at 3500and 600 cm^{1}(FernandezJeinenez et al. 2005).FT-IR spectra of various concentrations of polystyrene–fly ash composites have been taken. For 1 weight percent concentration of fly ash the peaks appeared at 780 and 1024 cm^{-1} representing Al-O vibration and SiO_2 asymmetric stretching respectively. The shifting in the pecks of characteristic frequency of polystyrene with respect to the pure polystyrene is observed at frequencies: 1350 and 1380 cm^{-1} representing the presence of Phenyl band and aromatic ring stretch respectively .These shift also observedfor higher concentration.

Fig.1
FTIR



analysis of pure polystyrene(PS),Fly ash(FA) powder,1% FA and PS, 3%FA and PS, and 8%FA and PS

3.2 SEM

In SEM analysis it has been found that fly ash particles are spherical in shape of different size shown in fig. 2 (a). In fig.2(b) shows the SEM photo graph of pure PS. Scanning Electron Microscopy (SEM) have been used for the analysis of surface morphology of the material. The images of FA based polystyrene composite clearly shows the presence of particles of FA. It is also seen that a FA particle is fully covered by nanometer sized PS particles. For 1 wt% FA reinforced PS composite in fig.2(c) shows clearly a distinct image of smaller grains of FA..In fig.2(d) the image of 3 wt% FA reinforced PS composite , enhanced agglomeration and surface roughness caused by FA spherical particles. The filler and matrix were bonded metallurgically with interface layer between each other. In fig.2(e) fly ash particles are distributed in the matrix homogeneously with no signs of agglomerates or hole. As shown in all SEM images , there are no observable cracks or voids between the FA and the matrix, indicating that the FA particles have very good interfacial adhesion with the matrix. The use of FA in composites could be a means of beneficial way of utilization of FA .

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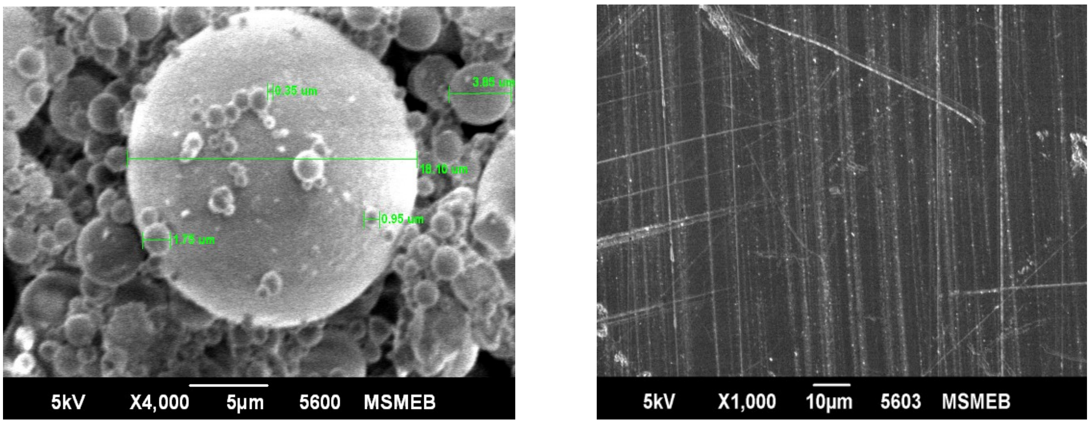
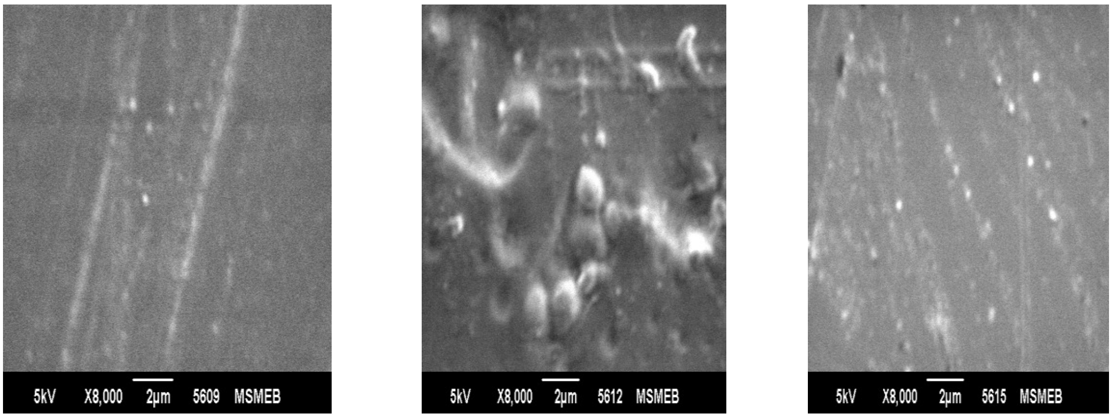


(a) **(b)**

Fig. 2 (a) and (b) SEM image of pure FA and pure PS



(c) **(d)** **(e)**

Fig. 2 (c) , (d) & (e) SEM image of 1,3 & 8 wt.% FA reinforced PS composite

3.3 AFM

It can be inferred from fig.3(a) & (b) of pure PS film that features like nano hills structure with 80 nm size are observed on pure PS film surface .The incorporation of FA in to the PS in different concentrations seems to development of nano domain globular structures within the PS matrix. The distinctive domains with reasonable size and shape of FA within the PS matrix are obtained for various compositions. 3D and 2D AFM image reveals the dispersion of well organized FA domains within the PS matrix fig.3 (c) & (d),(e) & (f) and (g) & (h). The density of the globular morphology in nano domain increases with increase in weight percent of fly ash in the polymer composite. The dimension of hills are order of 250 nm, 300 nm and 450 nm for 1 wt%, 3 wt% and 8 wt% concentration of FA in PS composite. Thus the distribution of these well organized FA nano-hill /domains within PS matrix may lead to enhancement of the micro-mechanical and crystallinity as

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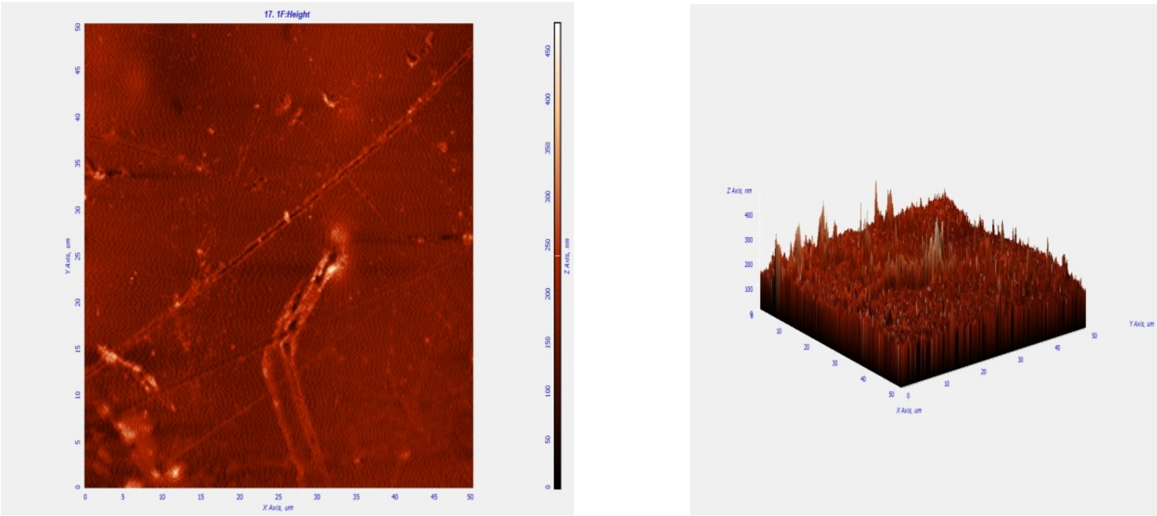
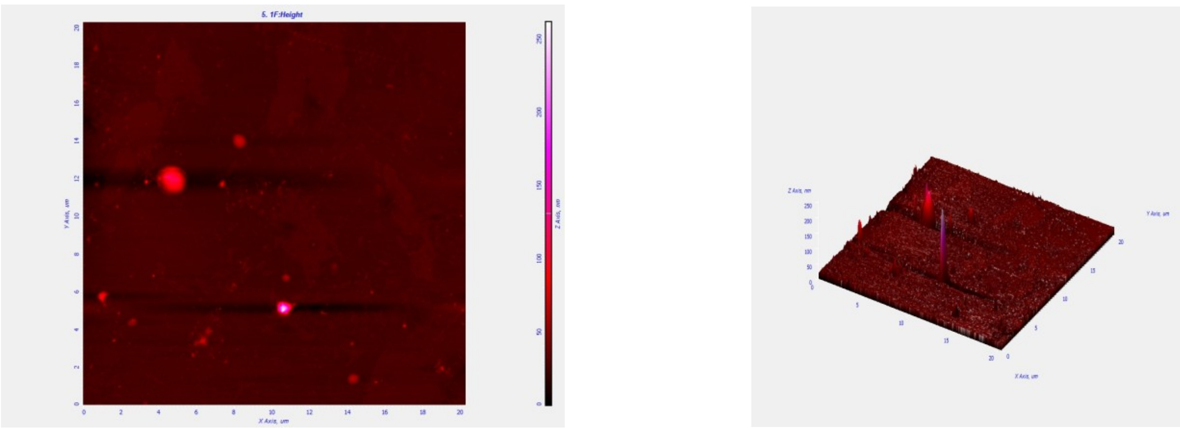
compared to the pure PS . As the content of FA within PS matrix increases, the number of nano domains are increasing and giving rough and stable surface to the developed nano composite films.



(a) (b)

Fig 3 (a) and (b) Pure PS 2D & 3D AFM Topography



(c) (d)

Fig 3 (c) and (d) 1% FA composite 2D and 3D AFM Topography

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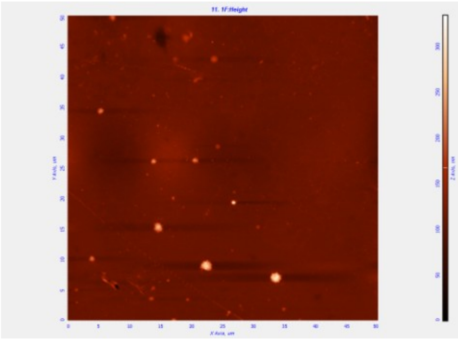
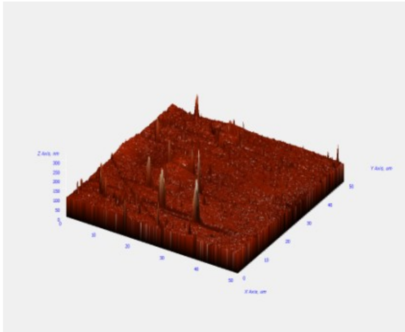
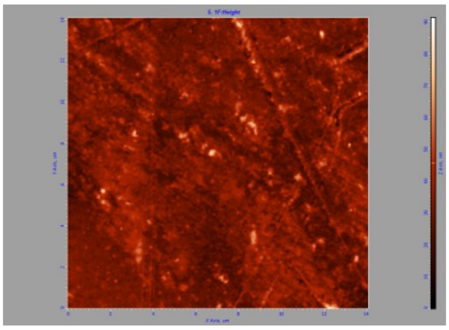
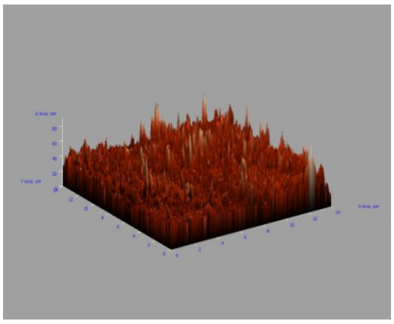




(e) (f)

Fig 3 (e) and (f) 3% FA composite 2D & 3D AFM Topography





(g) (h)

Fig 3 (g) and (h) 8% FA composite 2D & 3D AFM Topography

Conclusion

The outcome of the studies undertaken for the structural and morphological behaviour of fly ash reinforced polystyrene composite can be formed.

(1) The FT-IR studies of pure polystyrene, fly ash and fly ash reinforced polystyrene composite confirms the formation of new peaks and shifting of existing peaks which occurs in the prepared composites thus there is a better linkage of flyash molecules with polystyrene molecules confirming the development of stable composites.

(2) The SEM studies of fly ash particles are distributed in the matrix homogeneously with no signs of agglomerates or hole. As shown in all SEM images , there are no observable cracks or voids between the FA and the matrix, indicating that the FA particles have very good interfacial adhesion with the matrix. The use of FA in composites could be a means of beneficial way of utilization of FA , which is considered as an environmental pollutant.

(3) The AFM studies confirms the distribution of well organized FA nano-hill /domains within PS matrix may lead to enhancement of the micro-mechanical and crystallinity as compared to the pure PS . As the content of surface to the developed nano composite films. All these studies confirms that the addition of fly ash within the polystyrene causes the enhancement in crystallinity and morphology yielding better microchemical properties.

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