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Development and characterization of Ethylene-Vinyl Acetate (EVA)/Fly ash composite

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Abstract—*In this paper Ethylene-Vinyl Acetate (EVA)/Fly ash have been prepared by melt mixing process in two roll mill. The morphological, thermal, electrical and mechanical properties of the EVA/Fly ash composites have been investigated using fouriertransform infrared spectroscopy (FTIR), vicatsoftening point tester (VSP), dielectric strength measuring equipment, universal testing machine (UTM), Shore Durometer hardness tester. The tensile strength of EVA/Fly ash at break increased by 17% at 20% weight of fly ash content. The density and hardness of composite have increased by 11% and 9% at 20% weight of fly ash respectively. The incorporation of fly ash into the EVA matrix resulted in an improvement in the VSP and tensile strengthat break of EVA/ fly ash composite. However, a decrease in the melt flow index was observed of the composite.*

1. INTRODUCTION

Fly ashes are mainly byproducts of the thermal power plants whichare produced from the combustion of carbon and fossil fuels andare comprised of primarily of SiO2 along with lower contents ofAl2O3, Fe2O3, Na2O, MgO, K2O, etc.Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or Filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. Over the last years, many researchers have conducted investigations with the possibility of utilizing fly ash which is justified by its chemical, physical and mechanical properties.It is urgent to consider how the vast quantity of harmful fly ash resources can be utilized.There are a large number of potential solutions to this problem.Fly ash produced from coal combustion was simply entrained in flue gases and dispersed into the atmosphere. This created environmental and health concerns that prompted laws that have reduced flyash emissions to less than 1% of ash produced. Worldwide, more than 65% of fly ash produced from coalpower stations is disposed of in landfills and ash ponds.Fly ash is an uncompact lightweight material with a lot of pores. It has a superior engineering capability in many aspects.In this paper Ethylene-Vinyl Acetate (EVA)/Fly ash have been prepared by melt mixing process in two roll mill.

Ethylene-vinyl Acetate (EVA), alsoknown as poly(ethylene-vinyl acetate) (PEVA). It is the copolymerof Ethylene and Vinyl Acetate.It is a polymer that approaches elastomeric materials in softnessand flexibility, yet can be processedlike other thermoplastics.

2. EXPERIMENTAL

2.1. Methods of preparation

Flyash was added to ethylene-vinyl acetate (EVA) in 10, 20,30,40 and 60% wt/wt ratios.Mixing was carried out in a conventional laboratory open tworoll mill (150 x 330 mm) at 110 – 115^{0}C. EVA was masticated and blended with fly ash. The compounded blends have been molded to obtain sheet (3.0 mm) thickness using an electrically heated hydraulic press at 150^{0}C for 10 min at a pressure of 180 Psi. The sheets were developed by compression molding from prepared composites by blending of EVA and fly ash. The specimens were cut from prepared sheets of different compositions according to respective ASTM standard. These samples were utilized for evaluating the thermal, mechanical and morphological performance of the composite.

Serial No.	Sample code	EVA (wt%)	Fly ash (wt%)
1.	A	100	0
2.	B	90	10
3.	C	80	20
4.	D	70	30
5.	E	60	40
6.	F	40	60

3. METHODS OF CHARACTERIZATION

The various characterization techniques used for the purpose of different types of study can be divided into following categories:-

3.1 Mechanical Properties: (a) Tensile Strength at break (b) Elongation at break (c) Hardness

3.2 Morphological Characterization: Fourier Transform Infrared Spectroscopy (FTIR).

3.3 Thermal Characterization: Thermo gravimetric analyzer (TGA).
3.4 Electrical Properties: Dielectric strength.

3.1. Mechanical Properties

The mechanical tests were performed on a universal testing machine (INSTRON, USA) with the maximum load capacity 100KN. Tensile tests were conducted according to ASTMD-638. For each composition, five measurements were taken and average values of strength and elongation were reported. Hardness was measured by Shore- D Durometer tester according to ASTM D 2240.

3.2 Morphological Characterization

Fourier transform infra-red spectroscopy study was carried out using a Perkin Elmer Spectrum version 10.03.06 in a humidity free atmosphere at roomtemperature range 400-450^{0}C to investigate the possible interaction between ethylene-vinyl acetate (EVA) and fly ashcomposites.

3.3. Thermo gravimetric analysis (TGA)

In the present study, the pattern and thermal stability of the composites were determined by Pyres TGA-I (Perkin Elmer, USA) thermal analyzer. The weight loss of the samples was analyzed as a function of temperature through TGA. The quantity of the sample for each test was near about 4 mg and they were heated from 50^0 C to 650^{0}C at the controlled heating rate of 100^0 C/min under an inert atmosphere.

3.4 Electrical Properties

Dielectric strength determines the electrical strength of a material as an insulator. The test was conducted according to ASTMD-149-09. Each specimen thickness was kept as 3 mm and diameter 100*100 mm.

4. RESULTS AND DISCUSSION

The ethylene-vinyl acetate (EVA) and fly ash composites weretested for various properties.

4.1 Mechanical Properties

The results shows from Table 2, it is interesting to see that there is a significant improvement in the tensile properties of EVA/Fly ash composite. It has also been observed improvement in hardness and elongation.

Table 2: Mechanical properties of the EVA/Fly ash.

Sample code	Tensile strength at break (MPa)	Elongation at break	Hardness (Shore- D)
A	0.606	1182	43
B	0.624	1101	45
C	0.712	734	47
D	0.747	274.33	50
E	0.832	208.4	53
F	0.949	180.33	60

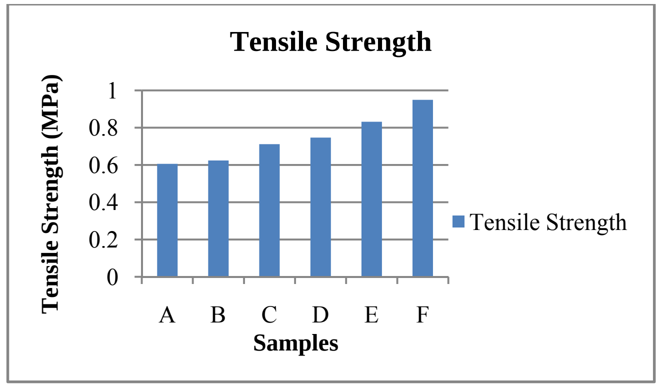

Fig. 1a: Variation in Tensile strength at breakof the composite samples.

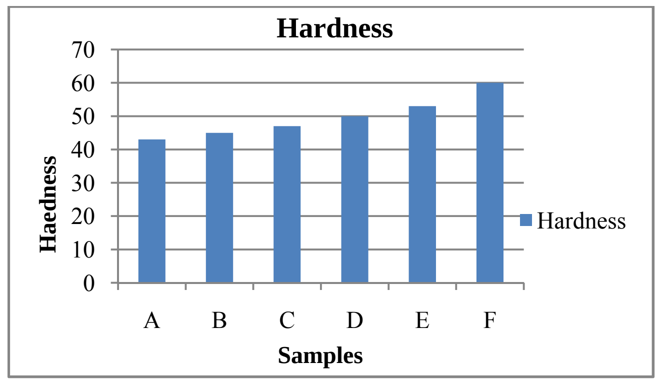

Fig. 1b: Variation in hardness of the composite samples.

4.2 Morphological Characterization

Fourier transform infra-red spectroscopy (FTIR) for various compositions of EVA/Fly ash are shown in Fig.1c.The major variatons are seen in the 60/40% wt. EVA/Fly ash sample.

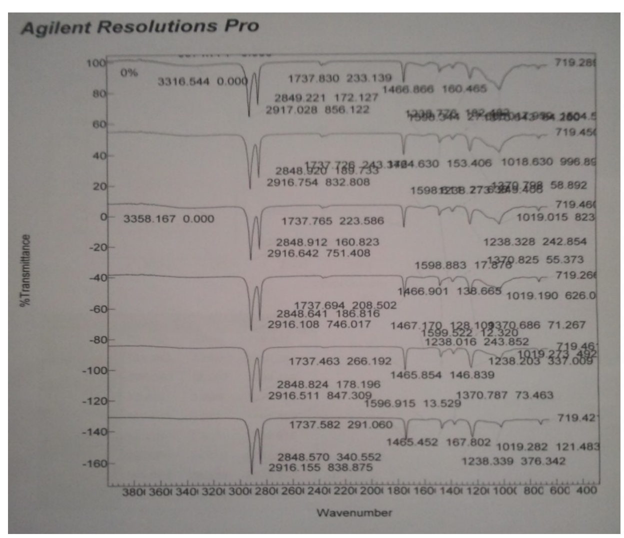

Fig. 1c: FTIR curve of EVA/Fly ash composite at different wt% of Fly ash

4.3 Thermal Characterization

Thermo gravimetric analyzer (TGA) of EVA/Fly ash composite of different samples has been done and the %wt loss with respect to temperature is shown in fig.1d.The minimum %wt loss is observed in the 60/40% EVA/Fly ash sample.

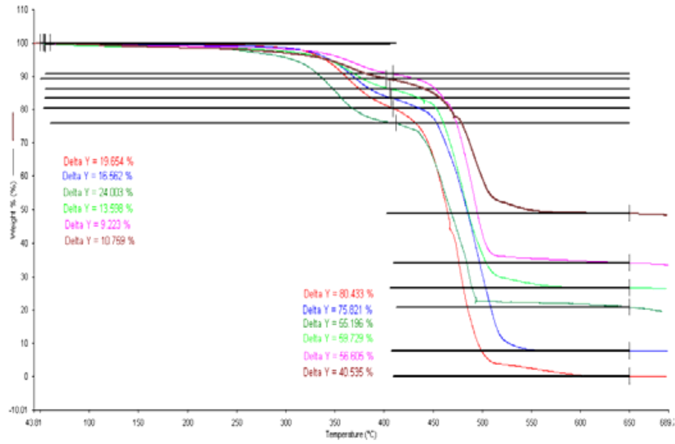

Fig. 1d: TGA curve of EVA/Fly ash composite at different wt% of Fly ash

4.4 Electrical Properties

Dielectric strength test result shown in fig. 1c. Highest Dielectric strength 9.7 KV/mm observed in 60/40% EVA/Fly ash..

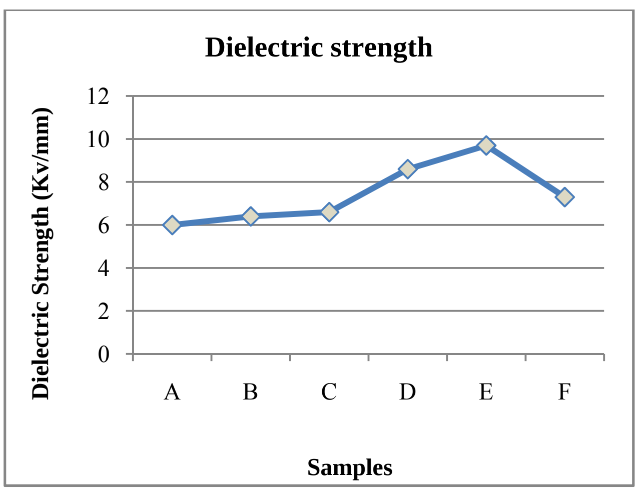

Fig. 1b: Variation in dielectric strength of the composite samples.

5. CONCLUSIONS

In this paper, the influence of EVA and fly ash experimentally investigated.Mechanical properties such as tensile strength at break and hardness increase as the fly ash content are increased and reach to the maximum (at 60% wt. of fly ash). This showed a remarkable enhancement when compared to virgin Ethylene-Vinyl Acetate (EVA).TGA studies reveal that thermal stability increases appreciably with the incorporation of higher content of Fly ashinto the EVA/Fly ash composite.The maximum enhancementin dielectric strength was observed in 40/60 wt%. EVA/Fly ash sample.

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