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STUDIES ON MORPHOLOGY, MECHANICAL AND OPTICAL PROPERTIES OF PP/HDPE/EVA/ PLA BLEND MODIFIED WITH AL_2O_3 PARTICLES FOR CAST FILM

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Abstract- In this present work, study of mechanical and optical properties of PP/HDPE/EVA/PLA (80/20/5/4) blend reinforced with nano alumina (Al_2O_3) particles is investigated. In the production process co-rotating twin screw extruder are utilized. Reinforced films are produced with 0.5, 1, 1.5 and 2 phr Al_2O_3 contents .The screw speed of the extruder is maintained at 150 rpm. After post extrusion, cast films are prepared. Mechanical performance analysis are done in order to examine the change in tensile strength, burst strength, tear strength and kinetic coefficient of friction of the polymeric films. Optical properties are performed for obtaining the data of haze and transmittance. The morphology is studied by Scanning Electron Microscopy (SEM). These results are related to the Al_2O_3 dispersion, to the type of the different composite formulations with PP/HDPE/EVA/PLA polymer matrix. It has been found that at 0.5 Phr loading of Al_2O_3 in PP/HDPE/EVA/PLA (80/20/5/4) blend has shown the highest burst and tear strength. On the other hand, the tensile strength shows decreasing order on Al_2O_3 loading 0.5 to 2 phr. Optical properties such as maximum value of transmittance and haze are also observed as loading of 0.5 Phr of Al_2O_3 in PP/HDPE/EVA/PLA (80/20/5/4) blend.

Keywords- *Nanocomposite; Mechanical properties; Optical properties; Film extrusion; Melt blending; nano alumina; morphological study.*

I. INTRODUCTION

Polymers filled with inorganic nano particles are very important sort of nanocomposites based on the use of a polymer matrix. They usually combine the advantages of polymer matrix such as low weight, easy formability with the unique characteristics of the inorganic nano particles. This kind of incorporation of the materials makes the nanocomposites to gain a series of properties such as optical, mechanical, electrical and magnetic. However, there are some disadvantages of nano particles like agglomeration followed by insufficient dispersion in the polymer matrix. This result generally leads poor optical and mechanical properties [1].

Alumina, one of the inorganic materials with high mechanical strength, is used as reinforcement material for polymers. Alumina (Al_2O_3) has received large interest because of its excellent dielectric properties, good thermal conductivity, high strength and resistance to strong acid and bases even at elevated temperature [2]. There is very limited available information on the mechanical and optical properties of Al_2O_3 modified PP composite.

Zelikman, E. et. al [3] studies the behavior of polypropylene nanocomposite containing alumina nanoparticles and improvement of mechanical properties of PP/alumina nanocomposites is found in some nanocomposites. In the previous work, we are investigated the effect of PLA on PP/HDPE/EVA blend. PP/ HDPE/EVA (80/20/5) ratio is fixed and PLA content is varied at different wt. composition of 4%, 8%, 12% and 16% by wt. and result is optimized at 4 wt% PLA loading into blend when compared with other compositions.

The main aim of this research is to investigate the effect of Al_2O_3 amount presence on mechanical properties such as tensile strength, tear strength, burst strength, coefficient of friction and optical properties such as haze and transmittance of PP/HDPE/EVA/PLA (80/20/5/4) blend.

II. EXPERIMENTAL SECTION

A. Materials

Polymer materials used in this study are polypropylene (Repol H030SG, Reliance) with melt flow index of 3.0 g/10 min, density of 0.900g/cm^3 and high density polyethylene (W50A009, GAIL) with melt flow index of 0.946, ethylene vinyl acetate (TAISOX 7350, Nippon Unicar) with melt flow index of 2.5 g/10 min, density of 0.930 g/cm^3, poly lactic acid (Revode 101,Hisun) with melt flow index of 2-10, density of 0.120 g/cm^3. Masterbatch of $CaCO_3$ is supplied by Jagdamba synthetic, India. Nano material is alumina (AL_2O_3) (PD scientific, Lucknow).

B. Nanocomposite film preparation

The compositions of the composites are given in Table 1. PP, HDPE, EVA and PLA are delivered in the form of pellets. Primarily PLA is dried in an air circulating oven at 80 °C for 2 hours prior to blending in order to remove moisture before processing. All ingredients are accurately weighed. The total composition thoroughly mix with inorganic nano material in poly begs. These row materials are loaded into a co-rotating twin screw extruder (BERSTORFF model ZE-25). The operation temperature during compounding for all composition is set as 160/170/180/190/200/ 210/220 ^{o}C. The screw speed is held at 150 rpm. The extrudate strands are pelletized and dried at 80º C for one hour. After the compounding, $CaCO_3$ is used as anti-fibrillation to prevent fibrillation of film and 1 wt% is incorporated in all compositions and finally fed into Haake Rheomix twin screw extruder (model-OS PTW16) temperature ranging from 100^0C to 260^0C along the barrel to the extruder and cast film test samples are obtained.

III. MECHANICAL PROPERTIES

A. Tensile properties

Tensile test of films according to ASTM D 882 standard is carried out with aid of Instron universal testing machine. The moving speed of crosshead is 500 mm/min for tensile strength measurement.

B. Tear strength

Tear strength test for films are performed according to ASTM D 1922 standard using the Elmendorf tear tester in both machine and transverse directions.

C. Burst strength

Burst strength test for films are carried out according to ASTM D 774 standard using burst strength tester.

D. Kinetic coefficient of Friction Kinetic coefficient of friction is determined according to ASTM D 1894 standard using coefficient of friction tester.

IV. OPTICAL PROPERTIES

A. Haze and Transmittance

Haze and value of transmittance are measured according to ASTM D 1003 using haze meter (model EEL 57 D). For each optical and mechanical analysis five specimens are tested and the average value is calculated.

V. SCANNING ELECTRON MICROSCOPY

Scanning electron microscopy (SEM) analysis is carried out with the help of FESEM, Carl Zeiss (model sigma). Prior to SEM analysis specimen gold coated with the help of gold sputtering unit to avoid the charging effect and enhance the emission of the secondary electrons.

VI. RESULTS AND DISCUSSION

A. Mechanical properties

a) Tensile strength. The Tensile strength of PP/HDPE/EVA/PLA blend with Al_2O_3 at different composition is shown in Figure 1. The nature of plot demonstrates a continuous decrease in tensile strength as the Al_2O_3 content in the matrix is increased. This decline nature in tensile strength might be because of lower interfacial adhesion between the hydrophilic filler and the hydrophobic polymer matrix which hinders proper load transfer between filler and matrix. The weak bonding between the hydrophilic filler and the hydrophobic matrix polymer obstructs stress propagation and causes the tensile strength to decrease as the filler loading increases in polymer matrix [4].

b) Tear strength. Figure 2, depicts the value of tear strength with respect to nano size alumina content. Maximum tear strength is achieved on 0.5 phr Al_2O_3 added into the PP/HDPE/EVA/PLA (80/20/5/4) blend in both machine and transverse directions due to incorporation of metallic content of alumina into polymer blend. Further loading of Al_2O_3 (1 phr to 2 phr), tear strength of nanocomposite is decreased in both directions due to poor dispersion of filler in polymer matrix.

c) Burst strength. Figure 3 shows the burst strength of PP/HDPE/EVA/PLA blend with respect to Al_2O_3 loading. Maximum burst strength (3.1 kg/cm^2) at 0.5 phr Al_2O_3 incorporated into the blend due to toughness of alumina. When the loading amount of overpasses 0.5 phr, the burst strength of nanocomposite does not rise and decrease in continuous manner (1 phr to 2 phr).

d) Kinetic coefficient of friction. PP/HDPE/EVA/PLA (80/20/5/4) blend has the lowest value of kinetic coefficient of friction (0.90). Figure 4 illustrated that the value of kinetic coefficient of friction is gradual increased on Al_2O_3 loading of 0.5 to 2 phr and the highest value of coefficient of friction (0.22) is achieved at 2 phr Al_2O_3.

B. Optical properties

a) Haze. Figure 5 depicts the haze properties of nanocomposites at various amount of Al_2O_3 content. The maximum property achieved (50.3 %) at 0.5 phr Al_2O_3 incorporated into the blend. It is evident that at further loading of alumina (1 phr to 2 phr) haze does not improve and follow a decline nature due to opaque nature of Al_2O_3.

b) Transmittance. Figure 6 demonstrates the value of transmittance of nanocomposites at various amount of Al_2O_3 content. The Composite has the highest value of transmittance (90.4%) at 0.5 phr Al_2O_3. The property trends show the decrement in the value of transmittance with increasing the Al_2O_3 content (1 phr to 2 phr) due to least transparency of Al_2O_3 with PLA.

C. Morphological studies of nanocompo -site.

SEM figure 7(a) and (b) shows the phase morphology of the PP/HDPE/EVA/PLA (80/20/5/4) blend and alumina modified PP/HDPE/EVA/PLA (80/20/5/4) blend. In the Figure 7a, SEM for PP/HDPE/EVA/PLA (80/20/5/4) blend indicates that the presence of PLA and EVA improves dispersion of HDPE into PP.

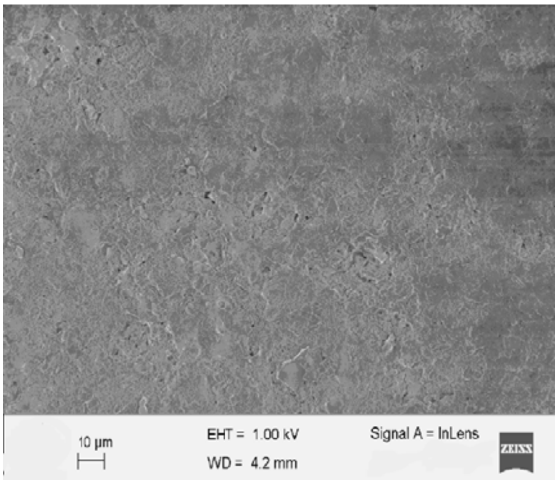

Figure 7a. SEM of PP/HDPE/EVA/PLA (80/20/5/4) blend.

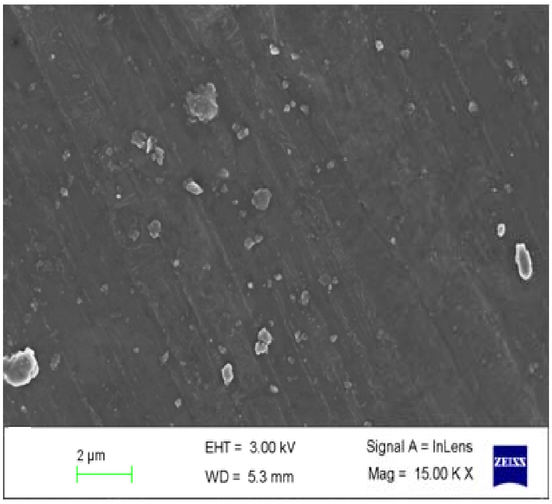

Figure 7b. SEM of Alumina modified PP/HDPE/EVA/PLA (80/20/5/4) blend.

The SEM of the Alumina modified PP/HDPE/EVA/PLA (80/20/5/4) blend demonstrates that the lower interfacial adhesion between the alumina and the PP/HDPE/EVA/PLA blend (Fig. 7b).

VII. CONCLUSION

The mechanical and optical properties are concluded at different formulations of PP/HDPE/EVA/PLA (80/20/5/4) blend with Al_2O_3 as following manner:
SEM micrographs gave a clue for lower dispersion of alumina at 0.5 phr loading in PP/HDPE/EVA/PLA (80/20/5/4) matrix. The tensile strength shows decreasing order with the addition of Al_2O_3 into blend. Burst and tear strength shows optimum properties at 0.5 phr Al_2O_3 incorporated into blend. PP/HDPE/EVA/PLA (80/20/5/4) blend has the minimum value of kinetic coefficient of friction. Modification of this blend with Al_2O_3 shows gradual increase in kinetic coefficient of friction. Haze and value of transmittance are found to be highest at 0.5 phr Al_2O_3 loading into the blend when compared with other compositions.

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Table 1. Formulation table of PP/HDPE/EVA/PLA with varying amount of Alumina content.

Formulations		PP (wt %)	HDPE (wt %)	EVA (Phr)	PLA (wt %)	Alumina (Phr)
PP/HDPE/EVA/PLA	(80/20/5/4)	80	20	5	4	-
PP/HDPE/EVA/PLA/Alumina	(80/20/5/4/0.5)	80	20	5	4	0.5
PP/HDPE/EVA/PLA/Alumina	(80/20/5/4/1.0)	80	20	5	4	1.0
PP/HDPE/EVA/PLA/Alumina	(80/20/5/4/1.5)	80	20	5	4	1.5
PP/HDPE/EVA/PLA/Alumina	(80/20/5/4/2.0)	80	20	5	4	2.0

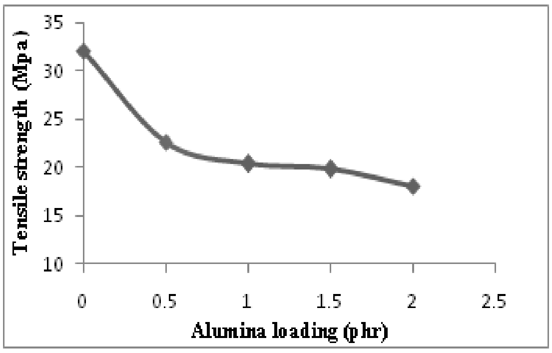

Figure 1. Tensile strength of nanocomposite with different loading of Alumina.

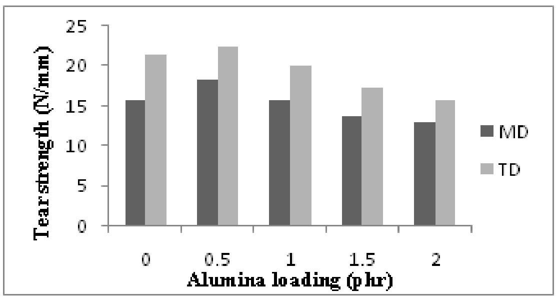

Figure 2. Tear strength of nanocomposite with different loading of Alumina.

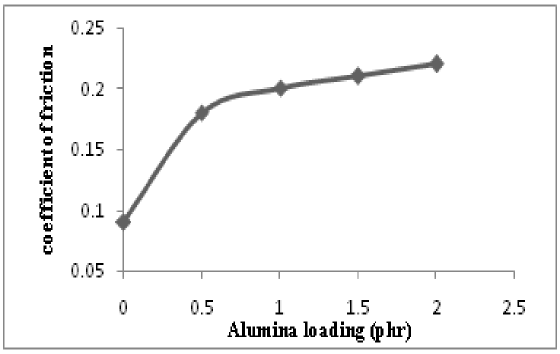

Figure 3. Kinetic Coefficient friction of nanocomposite with different loading of Alumina.

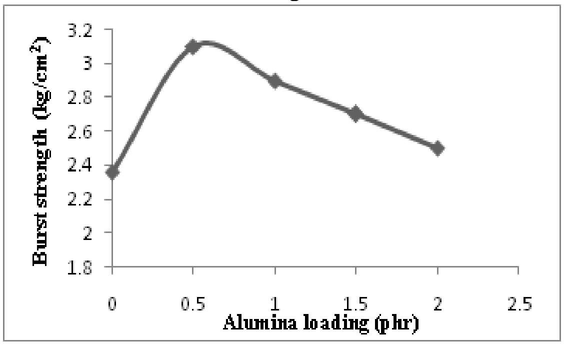

Figure 4. Burst strength of nanocomposite film with different loading of Alumina.

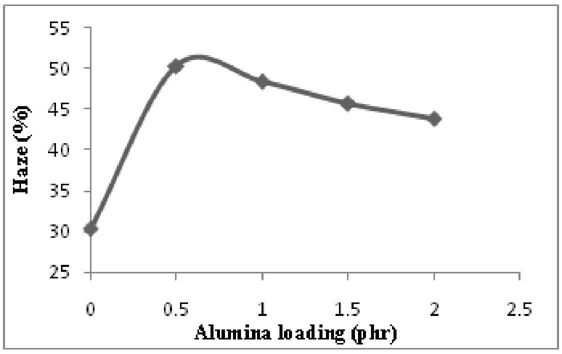

Figure 5. Haze of nanocomposite film with different loading of Alumina.

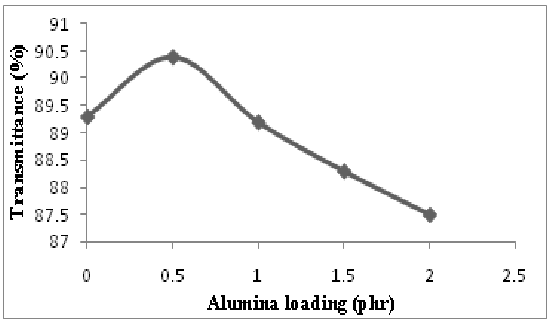

Figure 6. Transmittance of nanocomposite film with different loading of Alumina.

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