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Research Article

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Study on the Effect of Titanium (IV) oxide as Coupling Agent on the Mechanical Properties of Magnesium hydroxide Filled HDPE/EVA Composites

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Abstract In the present work the effect of treatment of Titanate (IV) oxide as coupling agent on Magnesium hydroxide filled Ethylene Vinyl-Acetate Copolymer (EVA) and High Density Polyethylene (HDPE) as a matrix has been studied. Tensile properties and surface properties were compared and investigated by using a universal testing machine and Scanning Electron Microscopy (SEM) respectively. The Result Clearly showed that the treatment of Magnesium hydroxide imparts better reinforcing properties. Tensile strength, elongation at break, elastic modulus and hardness were improved by 19.05%, 200%, 66.67% and 1.0% respectively at (0.14) volume fraction.

Keywords Titanium (IV) oxide as Coupling Agent, Mechanical Properties of Magnesium hydroxide, Ethylene Vinyl-Acetate Copolymer (EVA) and High Density Polyethylene (HDPE).

Introduction

Magnesium hydroxide is inorganic filler which is used for development polymer–filler Matrix. In earlier work " Studies of effects of Mono-Alkoxy Pyrophophato Coupling Agent on the Mechanical properties of Magnesium Hydroxide Filled HDPE/EVA/$Mg(OH)_2$/Composites showed the improved mechanical properties of the composites [1-4].

In the present work Magnesium hydroxide was treated with titanium (IV) oxide as coupling agent (4% wt in powder form) for 100 gram (wt) of Magnesium hydroxide [5-8]. The treated filler (in various percentages) was incorporated in Ethylene Vinyl-Acetate Copolymer (EVA) and High Density Polyethylene (HDPE) using a melt compounding at 160^{o}C in ThermoHaake rheomixer with a rotation speed of 60 rpm, and the mixing time was 6 min for each sample . Finally the composites were moulded in to sheets form using compression moulding technique at 180 °C. Properties under consideration were tensile strength, elongations, hardness. Comparisons of magnitudes of property revealed that the treatment has a favorable effect on properties of composites.

Experimental Work

Materials

Ethylene vinyl-acetate copolymer (EVA, 8450#, VA=15%wt, MFR=1.5g/10min) was from Nippon, Japan, High-density polyethylene (HDPE, 5502#, MFR=0.35g/10min) was from Daelim, Korea. The filler magnesium hydroxide

($Mg(OH)_2$, average particle size=2μm) and Titanium (IV) oxide as coupling agent [(TiO_2) were obtained from Dalian Yatai Science and Technology New Material Co.Ltd. , China.

Physical parameters of Ethylene vinyl-acetate copolymer and High-density polyethylene, titanium (IV) oxide and Magnesium oxide are presented in tables 1, 2, 3 and 4 below respectively.

Table 1: General Characteristics of Ethylene vinyl-acetate copolymer

Trade Name	**NUC 8450, Nippon Unicar Co, Ltd**
Appearance	White
Mooney Viscosity (100^0C)	40
Specific Gravity (g/cm^3)	0.94
Melt Index (g/10 min)	0.1 to 0.20
Ash Content (%)	0.3

Table 2: General Characteristics of High Density Polyethylene

Trade Name	**HDPE, 5502 , Daelim, Korea**
Appearance	White
Specific Gravity (g/cm^3)	0.96
Melt Index (g/10 min)	0.05-0.8

Table 3: Physical characterization of Titanium (IV) Oxide (TiO_2)

Chemical Name	Titanium (IV)OXide
Typical Purity (%)	98
Physical Form	Powder
Color	White
Specific Gravity(g/cm^3)	4.26
Weight Loss After Drying (%)	$\leq$ 0.35
Heavy Mental (%)	$\leq$ 0.005
Average Particle Diameter (μm)	2
pH	6.5 – 8.0
Ash (%)	$\leq$ 0.0007
Soluble Substance in Water (%)	$\leq$ 0.1
Other Content (%)	$\leq$ 0.21

Table 4: Physical Properties of Magnesium hydroxide

Molecular formula	$Mg(OH)_2$
Molecular Weight	58.3
Purity	95%
Whiteness	90%
Colour	White
LOI	30
Average Particle Size (μm)	2
Specific Gravity (g/cm^3)	2.4
Moisture Content (%)	0.5
pH	7-8

Treatment of Magnesium hydroxide with Titanium (IV) Oxide (TiO_2)

As per the recommendations of the manufacturer of Titanium (IV)Oxide (TiO_2) as coupling agent, 4% (wt) powder of coupling agent was added into 100g Magnesium hydroxide .then dissolved in ethanol with magnetic stirring and then dried at room temperature and after that it was added to the composites.

Preparation of Composites:

HDPE/EVA/$Mg(OH)_2/TiO_2$ composites were prepared via melt compounding at 160 ^oC in ThermoHaake rheomixer with a rotation speed of 60 rpm, and the mixing time is 6 min for each sample [5-13]. The mixed samples were transferred to a mold and preheated at 180 ^oC for 15 min, then was pressed at 20 MPa and then successively was cooled to room temperature while maintaining the pressure to obtain the composites sheets for further measurements. Before mixing, all the components were dried in vacuum oven at 80 ^oC for at least 12 hours.

Table 5: Compounding Recipe For HDPE/ EVA/$Mg(OH)_2/TiO_2$

Volume Fraction	EVA /HDPE (Wt – g)	Mg(OH)2 (Wt – g)	TiO_2 (Wt – g)
0.00	25/25 =50	0.0	0.0
0.04	22.5/22.5 =45	5	0.2
0.09	20/20 =40	10	0.4
0.14	17.5/17.5 =35	15	0.6
0.21	15/15 =30	20	0.8
0.28	12.5/12.5 =25	25	1.0
0.37	10/10 =20	30	1.2
0.48	7.5/7.5 =15	35	1.4
Filler (Treated & Untreated)		Variable (0.0 – 0.48 Volume Fraction)	
Curing Time		15 min	
Curing Temp.		180 ^oC	

Scanning Electron Microscopy (SEM)

The SEM micrographs of samples were observed by JEOL JSM-5510 scanning electron microscope. The samples were chosen after the tensile test. The content of HDPE/EVA/$Mg(OH)_2$ is 70%(-wt). The surface of the treated and untreated samples was coated with a thin layer of gold to avoid electrostatic charging during examination. Photographs of representative areas of the sample were taken at 5000X magnifications**.**

Measurement of Mechanical Properties

Mechanical properties such as tensile strength, elongation at break, elastic modulus were determined by subjecting dumbbell shaped specimens (in confirmation with ASTM D – 638) to a universal testing machine (Shenzhen Reger Instrument Co. Ltd, China). The sheets from which specimens were cut had been conditioned for 24 hours prior to subjecting to universal testing machine (100 kg load cell), at a crosshead speed of 50 mm/min. Hardness was measured by the machine – LX –A, produced by Liuzhong meterage factory, Shanghai China.

Results and Discussion

Treated Magnesium hydroxide composites showed improvement in mechanical properties and the mechanism of adhesion due to titanium (IV) oxide as coupling agent which was proposed for Magnesium hydroxide as a filler.

Tensile Strength

The dependence of the tensile strength on volume fraction of magnesium hydroxide is represented in Fig [1] . It is seen that on increasing the volume fraction of (both treated and untreated) magnesium hydroxide, the tensile strength increases up to a certain value and then it declines. The peak values of tensile strength of the composites correspond to 12.5 MPa and 10.5 MPa for treated and untreated Magnesium hydroxide composites respectively. It is noteworthy that the tensile strength of composites which is filled with treated Magnesium hydroxide at 0.14 volume fraction is 1.2 times higher than that of untreated Magnesium hydroxide composites.

Elongations at Break

The dependence of elongation at break with volume fraction of treated and untreated HDPE/EVA/$Mg(OH)_2/TiO_2$ composites is depicted in Fig [2]. The elongation of treated magnesium hydroxide at 0.14 volume fraction is about 200 times higher than that of untreated magnesium hydroxide.

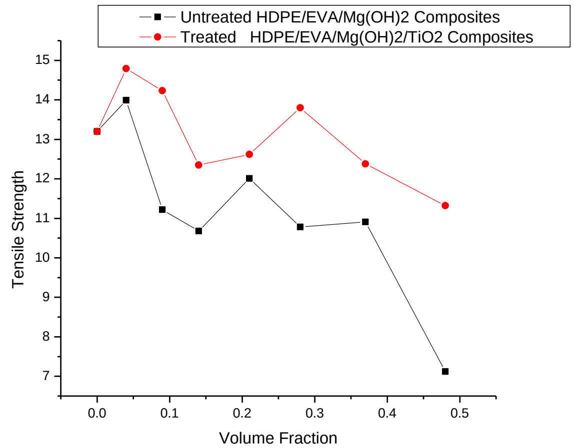

Figure 1: Tensile Strength of the Treated & Untreated HDPE/EVA/Mg(OH)$_2$/TiO$_2$ Composites

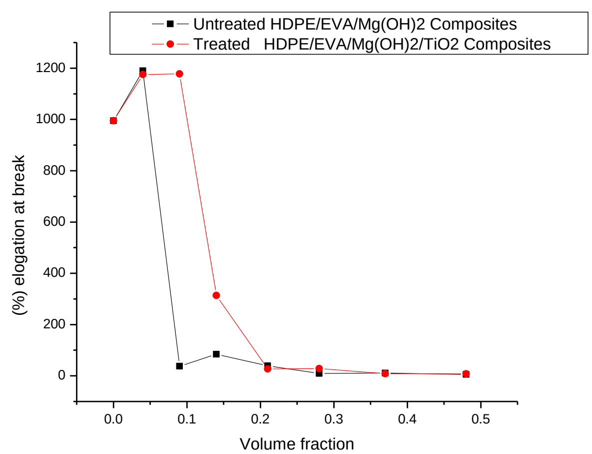

Figure 2: Elongation at break of the Treated & Untreated HDPE/EVA/Mg(OH)2/TiO$_2$ Composites

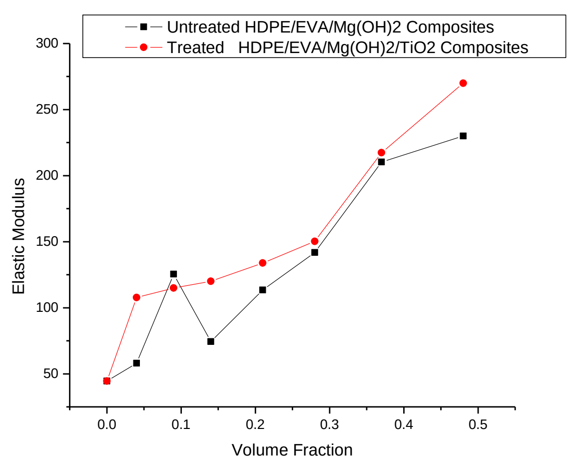

Figure 3: Elastic Modulus of the Treated & Untreated HDPE/EVA/Mg(OH)$_2$/TiO$_2$ Composites

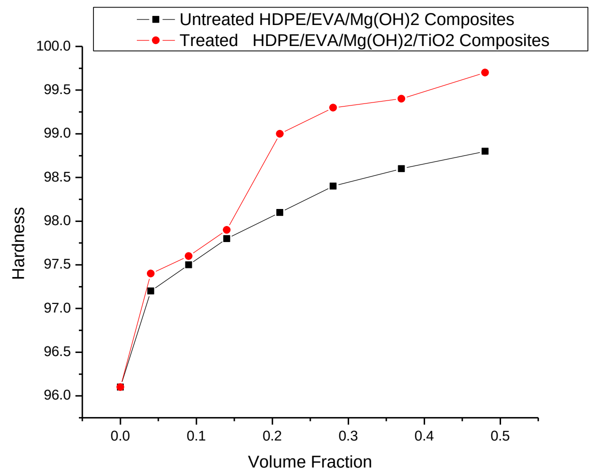

Figure 4: Hardness of the Treated & Untreated HDPE/EVA/Mg(OH)2/TiO_2 Composites

Elastics Modulus

Fig [3] shows the dependence of elastic modulus on concentration of treated and untreated filler in HDPE/EVA. It is seen that Elastic Modulus of both treated and untreated HDPE/EVA/$Mg(OH)_2$/TiO_2 composite has increased linearly on increasing the concentrations of fillers . The elastic modulus of treated magnesium hydroxide at 0.14 volume fraction is about 1.67 times higher than that of untreated magnesium hydroxide.

Hardness

Fig [4] shows the dependence of hardness on concentration of treated and untreated filler in HDPE/EVA. It is seen that, hardness of both treated and untreated $Mg(OH)_2$ –HDPE/EVA/TiO_2 composite has increased linearly by increasing concentrations of fillers, with a constant rate of increment for composites containing treated and untreated filler (separately) as evidenced by constant and identical slopes of the lines Fig [4]. The hardness of treated magnesium hydroxide at 0.14 volume fraction is about 1.0 times higher than that of untreated magnesium hydroxide.

SEM of Composites

The SEM photomicrographs of filler magnesium hydroxide and Titanium (IV) oxide are shown in plates 1 & 2. It is clear from these photographs that untreated magnesium hydroxide and Titanium (IV) oxide show tendency to form agglomerates. SEM of HDPE/EVA/$Mg(OH)_2$ /TiO_2 Composites are shown in plates 3-6. Untreated composite fracture shows non -adhesive appearance and formation of agglomerates while treated composites show a very uniform distribution, regular and adhesive appearance indicating further enhancement in polymer–filler attachment.

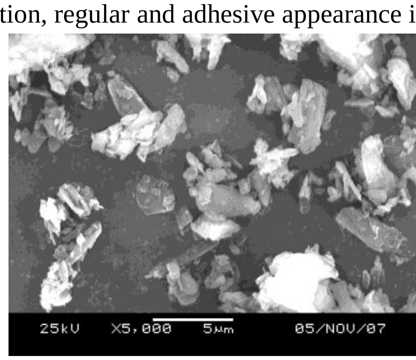

Plate 1: SEM of $Mg(OH)_2$ Powder (5μm)

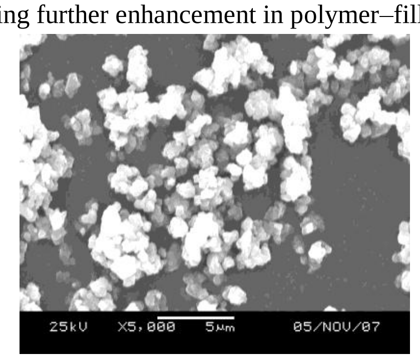

Plate 2: SEM of TiO_2 Powder (5μm)

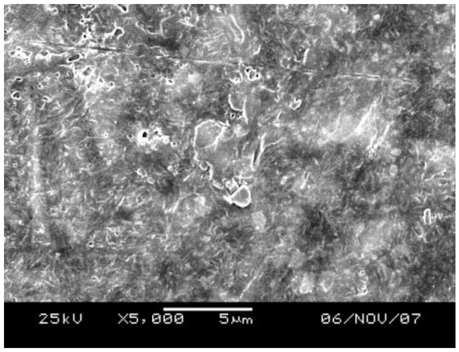

Plate 3: HDPE/$Mg(OH)_2$

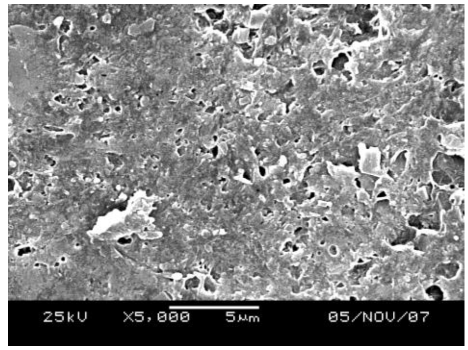

Plate 4: EVA/$Mg(OH)_2$

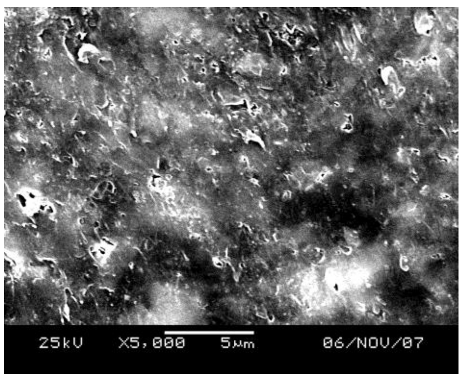

Plate 5: HDPE/EVA/$Mg(OH)_2$ Composites

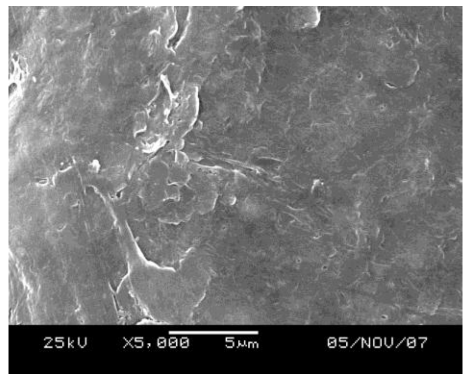

Plate 6: HDPE/EVA/$Mg(OH)_2$/TiO_2 Composites

Conclusions

The treatment of Magnesium hydroxide with Titanium (IV) oxide has affected magnitudes of (%) elongation at break, tensile strength elastic modulus and Hardness. The filler treatment has proved to be beneficial by enhancing polymer–filler adhesion as evidenced by SEM study. Considering the cost of the filler and the improvement in properties, the treatment is advisable.

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