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Improvement of Mechanical and Water Absorbance Properties of Low-Density Polyethylene (LDPE) by using White Kaolin Powder (WK)

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ABSTRACT

In this research, the mechanical, thermal and water absorption properties of low-density polyethylene (LDPE) as matrix material. The white kaolin (WK) powder weight content in the consistent particle size (150 µm) and different weight ratios (5, 10, 20, and 30) wt.% and the chemical composition of WK were investigated by atomic absorption spectrum and x-ray diffraction. The mechanical tests such as tensile strength, modulus of elasticity, and elongation at break%, and test of water absorption were applied on the prepared samples. The obtained results showed that the addition 5-20% of white kaolin powder to LDPE led to increasing the tensile strength, modulus of elasticity, and a decrease of % elongation at break, Water absorption was reduced by increasing of white kaolin contents from 5-20%. However, the higher amount 30% of WK were increased.

1. Introduction

A composite consist of is a heterogeneous material that consists of mix two materials or more and is a mixed material that is insoluble in each other. In composites, one phase is mostly inorganic or natural fillers as dispersed phase in the matrix. Theses fillers have superior mechanical properties and chemical and enhance the performance of composites [1, 2]. Today, different inorganic and natural additives such as clay, glass fibers, and calcium carbonate are incorporating into thermoplastics compared with, organic fillers because they have abundant availability, low cost, and renewable nature [3, 4]. Now, the manufacture of composites is using in natural and inorganic fillers as reinforcing for thermoplastics polymer such high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET), they have attracted interest in terms of their low temperature [5,6]. Kaolin clay has several advantages of making composites with polymers such as high tensile strength, lower density, long fatigue life, high corrosion, high thermal stability, conduction, and insulation. The mineral kaolin clay is often applied as filler in polymers because it can create a smooth surface of polymers, decreases shrinkage during curing, increases thermal stability, and improves the action of resistance to chemical solvents. Kaolin also improves the flow properties of the polymers and uses as a rheological modifier [7-11].

2. Experimental Methods

2.1 Materials

Low-density polyethylene (LDPE) was provided from CABIC chemical company, KSA. White Kaolin clay powder was supplied from the Ceramic Factory in Ramadi, Iraq.

2.2 WK Treatment

The used kaolin clay powder was dried at a vacuum oven 70 °C for hours to remove the moisture and converted to a powder by passing to a molecular sieve to obtain particle size (150 µm) and then heated to 70 °C for 2 hours to ensure more homogeneous between the kaolin clay particles.

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2.3 Preparations of LDPE-WK Composites

LDPE powders were melted and blended in a shear mixer at a rate of 30 rpm and continued the mixing for 6-8 minutes to achieve the homogenous between the clay and polymer. The mixture was poured in metal plates, and a pressure of compress mixture started from 30 kg/cm^3 and then increased to 250 kg/cm^3 within 20 minutes. After 24 hours, the samples were removed from molds. The samples left for 24 hours to make more curing.

2.4 Analysis Methods

2.4.1 Tensile Tests

Tensile test samples were carried out by using Instron tensile machine model (Testometric, M500-50AT), UK. The crosshead speed was about 10 mm/min and according to ASTM-D638.

2.4.2 Water Absorption

The ASTM standard D750-95 was applied to test a water absorption. The samples were immersed in distilled water at room temperature. All of the samples after immersion were dried in an oven at 50 ^{0}C ±5 for 7 days and weighed. The water absorption was followed by weighing the samples at regular intervals. The following equation calculated the average reading of three samples,

$$\text{Water absorption \%} = \frac{WBI}{WAI} \times 100 \quad (1)$$

Where WBI and WAI represent Weight before and after immersion, respectively.

3. Results and Discussion

3.1 XRD and Atomic Absorbance Spectrum Analysis of WK

The white kaolin clay was analyzed by using atomic absorption spectrum instrument to test and identify the chemical elements as shown in Table 1 and tested by XRD instrument as shown in Fig. 1. According to atomic absorption spectrum, the silica and alumina have the higher ratios 40.24 and 38.95% respectively.

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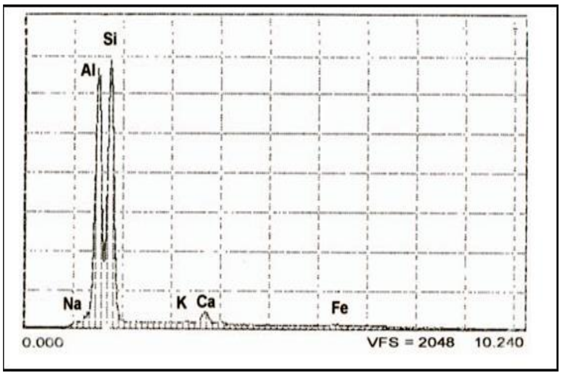

Fig. 1 XRD curve of White kaolin content (WK)

Table 1 The chemical analysis of WK by using atomic absorption spectrum

The Chemical Structures	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	BaO	Cao	K_2O	Li_2O	Na_2O
% of chemical composition	40.24	0.99	38.95	4.42	0.00	3.27	0.41	0.00	0.24

3.2 Water Absorbance

As shown in Fig. 2. The water absorption of LDPE-WK composites decreased continuously with increasing the WK amount of 5-20% when they immersed in distillation water for 7 days because they attributed great homogenous interaction between polymer and kaolin structures. However, the higher contents of white kaolin clay 30% in polymer composites increase water absorbance. The reason in that due to the difficulties of achieving a homogeneous dispersion in high filler content.

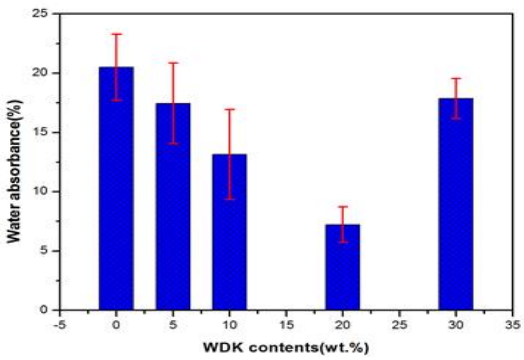

Fig. 2 Water absorbance of LDPE with different contents of WK fillers

3.3 Mechanical Tests

The tensile and modulus of elasticity of LDPE-WK composites were increased with the incorporation of WK contents of 5-20, but higher contents of WK 30% decreased the tensile and modulus. The tests of tensile properties can evaluate the effects of adding KW fillers in LDPE. It is evident from Fig. 3 and Table 2 that tensile strength increases with adding the amount of WK fillers (5-20%) to pure LDPE, compared with the higher content of Wk. 30%. The Table 2 shows that the significant content 20% WK increased to 37.51 MPa comparing with pure LDPE 15.8 MPa. The results of the modulus of elasticity as shown in Table 2 that appeared a significant increase 451.22, 579.39, 702.82 MPa with adding 5, 10, 20%Wk respectively while the higher amount of WK 30% didn't seem significant improvements. The results of elongation at break in Table 2 indicated that a higher value increases the elongation at break% 8.25 %, compared with 20%Wk 7.35%. The addition of different contents of WK didn't achieve progress changes in elongation at break %.

Table 2 Tensile stress-strain curves analysis of LDPE-WK composites

System%	Tensile strength (MPa)	Elastic of Modulus MPa	Elongation at break %
Pure LDPE	15.08	240.33	8.8
5 % WK	19.77	451.22	7.92
10 % WK	24.08	579.39	7.41
20 % WK	37.51	702.82	7.35
30 % WK	31.16	357.17	8.25

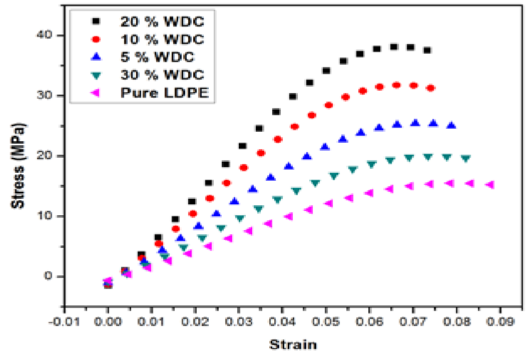

Fig. 3 Tensile stress -Strain curves of LDPE with different contents of WK fillers

4. Conclusion

The addition of WK fillers to LDPE has achieved improvements in the mechanical properties. The tensile strength, the modulus of LDPE/kaolin powder) composite slightly increased with the incorporation of the filler 5-20%. Elongation at break decreased slightly with increasing filler content. Water absorption of the composites was reduced with WK content of 5-20%.

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