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Research Article

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Effect of Punica garantum peel powder on the tensile strength properties of Low Density Polyethylene

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Abstract The tensile strength of (LDPE-463): Punica garantum peel powder composite was assessed with respect to the effect of filler content shells powder Punica garantum varying from 1% to 10% by weight in the composite. Obvious improvement in the mechanical parameters was recorded best ratio 10% weight. The mechanical properties of loaded film have been evaluated through several parameters concerning the elastic deformation based on measuring the load – elongation characteristics. The behavior of the stress - strain curve was analyzed in terms of the cold drawing model. The elastic behavior decreased with increasing shells powder Punica garantum, while 1% is the best ratio that achieved best flam resistance.

Keywords tensile strength Properties, LDPE, Punica garantum

1. Introduction

Low-density polyethylene (LDPE) possesses good mechanical properties, good resistance to chemicals, and good process ability and has a wide range of applications, including the insulation of wire and cable. However, it has some disadvantages, such as a low melting temperature, low thermal stability and high flammability [1].

Low density polyethylene represents the majority of thermoplastics currently used as food packaging materials. Since the production and consumption of these polymers is incessantly increasing, the environmental impacts have become an important problem for considering the biopolymers [2].Polymer composites with special mechanical properties are widely used in various applications such as electrostatic discharge protection, electromagnetic shielding and field grading [3]. Mechanical properties of polymeric materials are important for nearly all applications in industry, technology, and the household. Particularly, stiffness, strength, and toughness are decisive properties in many uses. Mechanical properties depend strongly on chemical as well as on supermolecular structure of the polymeric material. While the chemical, molecular structure defines some basic properties such as rigidity, thermal softening, and melting behavior, the ultimate mechanical properties are fixed by the supermolecular structures or morphology. The same molecular structure can yield to many varied morphologies dependent on factors such as orientation due to fabrication, different cooling rates, changes in thermal history, and secondary crystallization [4]. Different parameters concerning this response have been measured and investigate such as young's modulus, tensile strength stress at a yield and break and elongation at yield and at break. The polymer characteristics can be controlled and altered by adding different additives such as antioxidants, anti blocking agent, slip agent, antistatic agents, stabilizers, color compounds and fillers [5].

Fillers are used along with various commodity as well as engineering polymers to improve the properties and reduce the cost. Incorporating inorganic mineral fillers into plastic resin improves various physical properties of the materials such as mechanical strength, modulus etc. In general the mechanical properties of particulate filled polymer composites depend strongly on size, shape and distribution of filler particles in the polymer matrix and extend of interfacial adhesion between filler and matrix [6, 7]. As fillers, mica, kaolin, calcium carbonate, and talc are the most often used to reduce both the production costs and to improve the properties of the thermoplastics, such as rigidity, strength, hardness, flexural modulus, dimensional stability, crystallinity, electrical and thermal conductivity. The fillers affect ultimate mechanical properties in two ways: (i) they act directly as harder particles with determined prop properties (shape, size, and modulus) and (ii) they affect crystallization processes in polymer matrix and ultimate super molecular structure of semi crystalline polymer [8 – 10].

The additives may not only alter mechanical properties, but also affect other properties such as dielectric, optical, thermal etc. Previous study [11] showed that adding carbon black to LDPE will increase its conductivity to reach the semi conducting limits. The additive affected mechanical parameters such as tensile strength and rigidity modulus. In the present investigation, mechanical properties of (LDPE: Punica garantum peel powder) have been investigated for different shells Punica garantum peel powder weight percentage (1%-10%). Parameters such as tensile strength(σ_M), tensile strain (ε_M) , tensile strees at break (σ_B) , tensile strain at break (ε_B), tensile strain at yield (ε_y) and Young's modulus(Y) have been measured at room temperature. The results were analyzed based on (stress - strain) relationship and microscopic analysis is used to interpret the physical behavior.

2. Experimental Procedure

2.1. Materials

Additive-free LDPE (SCILEN 22004), Trade Name Scpilex (463) and grade was supplied from the state company for petrochemical industry (SCPI) of (MI=0.39 gm/10ml) and (density = 0.922 gm/cc) [12]. The Punica garantum peel is obtained from local market Figure (1). The average Punica garantum peel particle size used in this work is (<212) µm. five concentrations of Punica garantum peel particles (1, 2.5, 3.5, 5 and 10 weight%) are used in the LDPE compounds.

Figure 1: ***Photograph of Punica garantum peel***

2.2. Sample preparation

In this study, five weight percents of Punica garantum peel powder (1, 2.5, 3.5, 5 and 10) % are used in the LDPE compounds. Punica garantum peel as a fine powder is mixed with LDPE using Rheomix mixer 600 instruments attached to the Haake Rehochard meter with the following conditions; mixing time 15 min; mixing temperature 160^{0}C ; mixing velocity 32 RPM. After that the final mold product is introduced in a laboratory compress under 5 tons at 175^{0}C for 3 minutes in a square frame where the pressure rises gradually up to 15 tons for a (6) minutes and after this period the sample sheet is cooled up to reach room temperature . This sheet of final product is used to prepare Samples dumbbell specimens are shown in Figure (2) for measuring the mechanical properties by using Instron instrument Zwick/Roel type [BT1-FR2.5 TN.D14] Figure (3) with the following conditions; chart speed (10) mm/min., crosshead speed 50 mm/min. The test specimen is positioned vertically in the grips of device then the grips are tightened evenly and firmly to prevent any slippage. The relationship between elongation and load is obtained directly from the instrument. [13-15]

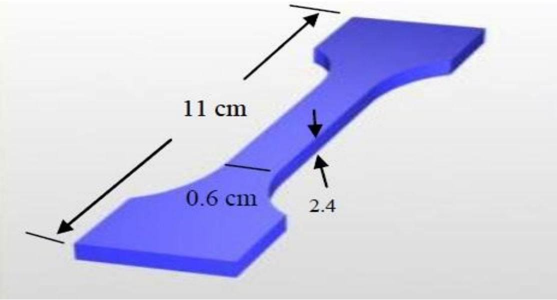

Figure 2: Shows the tensile specimen coupon dimensions centimeters

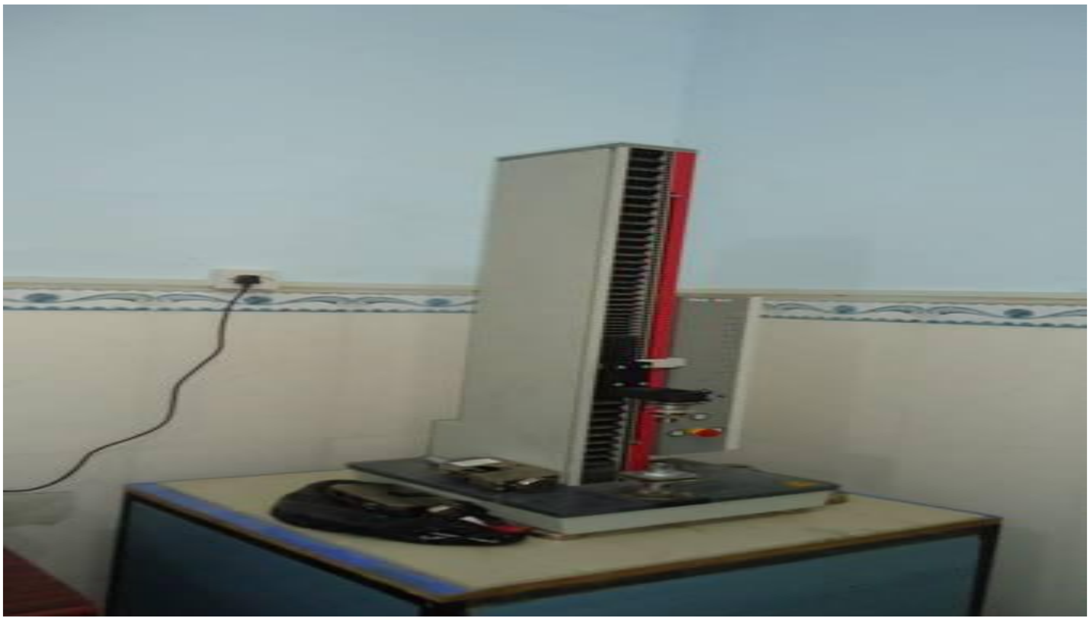

Figure 3: Tensile test of the specimens was carried out with a Zwick/Roel type [BT1-FR2.5 TN.D14]

2.3. Tensile Properties

The tensile properties were tested according to the ASTM Standard D-638: Standard Test Method for Tensile Properties of Plastics [16]. The dimensions of the dumbbell-shaped specimens. The amount of strength (σ), tensile strength and *Young's modulus* were calculated by the following equation [17, 18]:

$$\sigma = F / A \tag{1}$$

Where F = force (N) , and A =sample section area (mm^2).

$$Tensile \quad strain\% = \frac{L - Lo}{Lo} \times 100 \tag{2}$$

Where:

L: final length of sample, L0: original length of sample.

(Young's modulus) Y = stress/strain (3)

3. Results and Discussion

Figure (4) and table (1) show the (stress - strain) curve of LDPE loaded with Punica garantum peel powder percentage measured at a constant rate loading at room temperature. Stress- strain curve has been dependent in description instead of load-elongation curve because it describes the material characteristics and is less dependent on the arbitrary choice of specimen profile. It's well known that polyethylene belongs to where this behavior has characterized with low modulus and low yield stress. According to the break down classification, the stress-strain curve is exemplifying the second behavior of the fracture nominally cold drawing. In this type three regions can be distinguished; first is the linear region, second is the yield region, third is the elongation region up to the break. In the first region, (linear region), where the deformation was not very large, Hook's Low is obeyed which characterized the instantaneous and recoverable deformation associated with the bending and stretching the inter atomic bonds between the polymer atoms. One of the most important engineering parameter which reflects the material resistance against deformation, and should be measured before designing polymer is Young's modulus. Young's modulus can be estimated from the slope of the portion of the first region , which is found a higher for a sample with a higher extension rate. The variation of Young's modulus against Punica garantum peel powder filler is shown in Figure (4) Young's modulus varied between 104.9 to 192.04 for Punica garantum peel powder ratio between 1 - 10% respectively. This increment in Young's modulus can referred to increase the resistance of material to deformation. The volume of the specimen remains constant during elastic deformation, so as the gauge length elongates, its cross-sectional area is progressively reduced. Mechanical properties are essentially depend upon the molecular behavior, includes chemical composition and physical structure. The nonlinearity in the stress-strain curve neither be caused by increasing free volume or filler contents nor to be connected to the viscous flow. It can be related to the shear component of the applied stress [17]. In the region confined between the proportionality limit and the yield point the deformation in this region is not stantanuosely recoverable, but it’s ultimately and can be characterized like straightening out of a coil portion of the molecular chains [18]. The uncoiling mechanism is known as a relatively slow mechanism.

The result of the tensile strain at break of Punica garantum peel powder particle: low density polyethylene composite is shown in Figure (6). The tensile strain at break (ε_B) decreases gradually, it appears as a shoulder. Maximum tensile may be explained due to the perfect homogeneity of filler distribution in the polymer matrix. studied the mechanical properties of low density polyethylene, tensile strain (ε_B) show the relation between the percentage of elongation with the concentration of additive, the elongation of the polymer begins at the percentage (0%) of the polymer pure it (418.85%) and then decreases when the percentage (10%) a (24.2%) which is a polymer few flexibility and has a hardness high there by acting Punica garantum peel powder to fill the spaces between the chains main polymer limited movement of the chains and thus less elongation . Polymeric chains that are not constrained by any be free movement as a result of lack of homogeneity of the mixture, including the nature of the Punica garantum peel powder characterized by rigidity, which in turn increase the stiffness of the polymer and reduce elongation increased concentration of additive and worked to increase the density of the polymer.

It is clear from the Figure (7) and table (1) that maximum tensile strength (σ_M) at 10% is 16.9 MPa so that amount of load tensile strength (σ_M) reversible when decreasing the concentration of additive which works Punica garantum peel powder to reach 12.8MPa at 1% the hardness increases when the polymer and thus the polymeric chains is constrained to decrease its flexibility.

Table 1: Parameters of mechanical properties

Filler content (wt.%)	**σ_M (MPa)**	**ε_M%**	**σ_B (MPa)**	**ε_B%**	**Young modulus (MPa)**
0	15.15	414.25	14.00	418.85	3.65
1	12.8	12.2	8.15	147.6	104.9
2.5	13.21	10.7	7.90	46.7	123.45
3.5	11.6	10.7	3.31	22.5	108.41
5	13.8	10.2	3.23	29.2	135.29
10	16.9	8.8	3.28	24.2	192.04

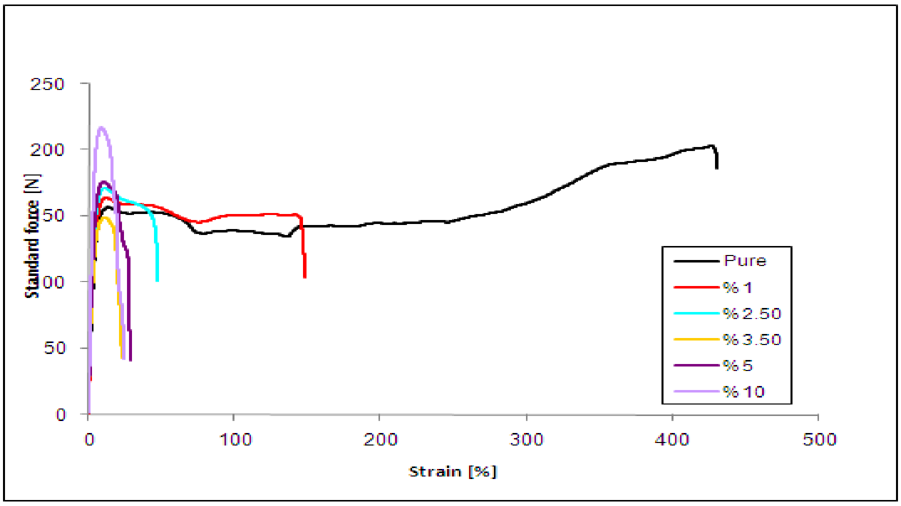

Figure 4: The stress - strain curves of polymer composite with Punica garantum peel powder

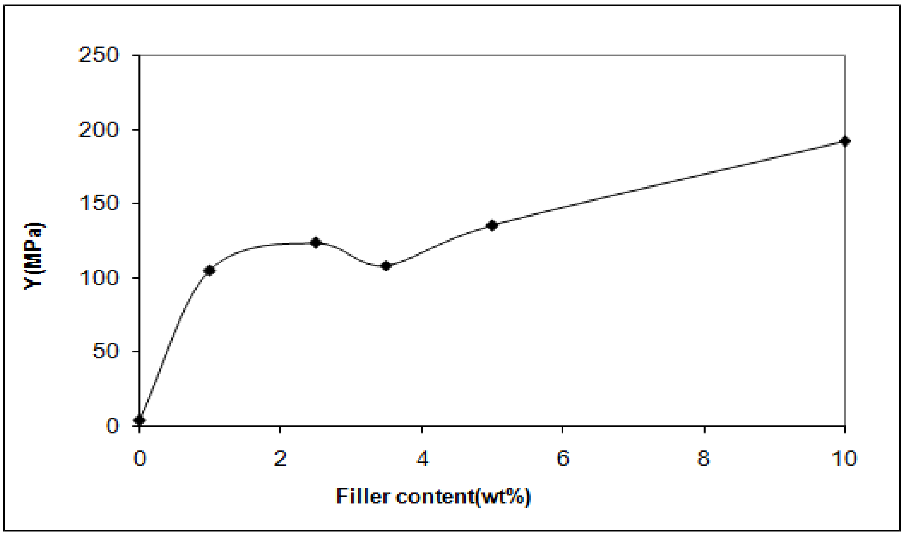

Figure 5: Variation between Young Modules and Filler content (wt.%)

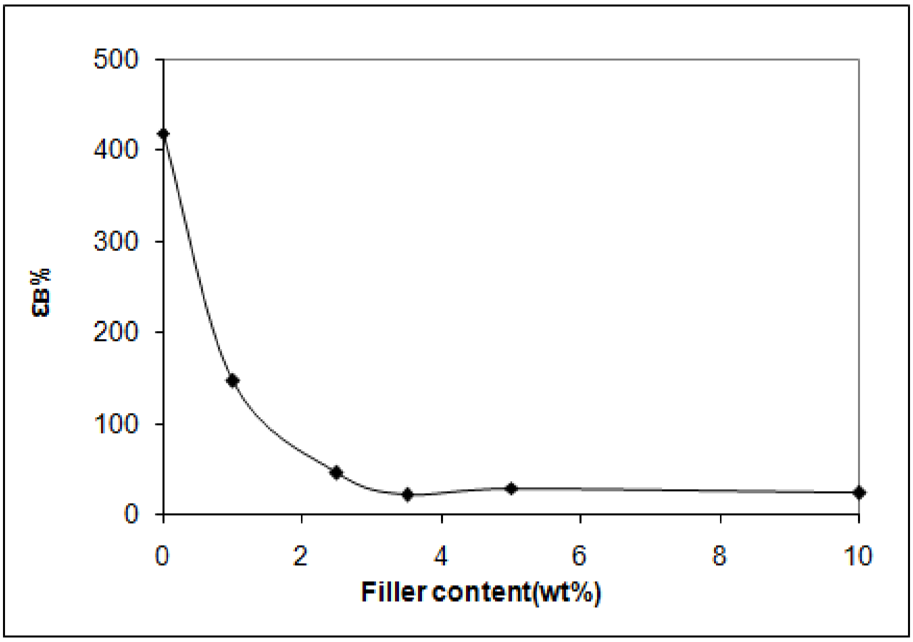

Figure 6: Variation between tensile strain at break and Filler content (wt.%)

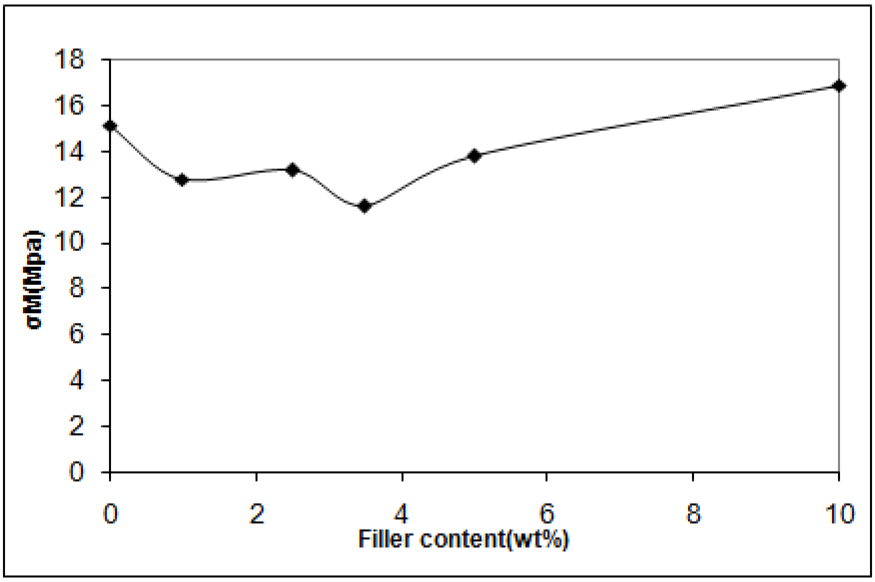

Figure 7: Variation between Tensile strength and Filler content (wt. %)

Conclusion

It was shown in this study that the mechanical behavior for low density polyethylene was improved by adding Punica garantum peel powder with different filler content. It was found that modulus of elasticity has increases with increasing filler content. Polymer phase was diluted by stiffer material (Punica garantum peel powder). This interpreted the weak end observed in mechanical properties less 10% percentage. Accordingly, LDPE with 10% Punica garantum peel powder is recommended for industrial applications.

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