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Study the effect of Juglans regia husk powder addition on the Tensile Strength Properties of High Density Polyethylene (HDPE)

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ABSTRACT : *The Mechanical properties of (High Density Polyethylene (HDPE)-M624): Juglans regia husk powder composite was assessed with respect to the effect of filler content Juglans regia varying from 5% to 50% by weight in the composite. Obvious improvement in the mechanical parameters was recorded when adding Juglans regia husk powder composite with 5% weight ratio. 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. Experimental difficulties appeared above 10% mixing ratio, and these difficulties were due to the separation in phase which makes the sample processing impossible. Experimental results showed that elastic behavior increased with increasing Juglans regia husk powder filler up to 5 % concentration.*

KEYWORDS : *HDPE, Juglans regia husk powder, Tensile Strength*

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I. INTRODUCTION

Polyethylene (PE) is one of four most popular thermoplastics in the world. PE is generally divided into high-density polyethylene (HDPE), low-density polyethylene (LDPE), and linear low-density polyethylene (LLDPE) [1]. HDPE is usually produced as bottles, containers, film or sheet, inject molding, pipe, conduit, and other products. Over 50% of HDPE products are manufactured with blow and injection molding [2]. HDPE is a highly flammable compound Finding a method to reduce the flammability of HDPE is of great scientific interest to researchers and industry because of the wide and varying uses of poly ethylene today[3]. High density polyethylene is an important commercial polymer and it is widely used for different engineering applications [4]. High density polyethylene (HDPE) is a commodity polymer broadly used for many industrial products. One of the most demanding applications of HDPE is the production of pipes and fittings for the transportation of water or gas under pressure [5].

Fillers are solids added to polymers to improve their properties and decrease the cost and have the opposite effect of plasticisers as decreasing the softer polymer, or known as organic or inorganic added to the polymer either for the purpose of increasing the volume of material plastic, which reduces the cost or may improve some mechanical properties [6-8].

The addition of fillers to polymers is a fast and cheap method to modify the properties of the base materials. For this reason, particulate filled polymers have been, and are, a subject of increasing interest in both industry and research. In this way, strength, stiffness, electrical and thermal conductivity, hardness and dimensional stability, among other properties, can be tailored to the required values [9].

In the present paper; the mechanical properties of (high density polyethylene: Juglans regia husk powder) have been investigated for different Juglans regia husk powder weight percentage (5%-50%). 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(25^{o}C). The results were analyzed based on (stress - strain) relationship and microscopic analysis used to interpret the physical behavior.

II. EXPERIMENTAL

2.1. Material basis:

A. HDPE (Scpilex M624) grade supplies from the state company for the petrochemical industry (SCPI) of (MI=5-7 GM/10min.) and (density = 0.961 GM/cc).

B. The Juglans regia husk powder as a filler which supplied from local market. The average Juglans regia husk powder particle size used in this work is (<212) µm. The chemical composition Juglans regia husk powder is shown in table1. [10]

Table (1) The Chemical Composition of rice husks fibers.

Chemical composition	Cellulose	Ash	Toluene Solubility	Lignin	Cutin	Chlorine	Nitrogen
wt.%	40- 60	0.9-1.5	0.5-1.0	20-30	0.8-1.59	0.10	0.10

2.2 Sample preparation

In this study, six weight percents of Juglans regia husk powder (5, 10, 15, 20, 25, and 50) % were used in the HDPE compounds. Juglans regia husk powder as a fine powder is mixed with 60g of high density polyethylene using Rheomix mixer 600 instruments attached to the Haake Rehochard meter with the following conditions; mixing time 15 min; mixing temperature 160^0C ; mixing velocity 32 RPM. The percent of Juglans regia husk powder in the filled high density polyethylene is shown in table 2. After that the final mold product is introduced in a laboratory compress under 5 tons at 175^0C 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 (1) for measuring the mechanical properties by using Instron instrument Zwick/Roel type [BT1-FR2.5 TN.D14] Figure (2) 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. [11-13]

Table (2) the wt% of the filler in polyethylene.

Filler (%)	HDPE (g)	Juglans regia husk powder
0	60	0
5	57	3
10	54	6
15	51	9
20	48	12
25	45	15
50	30	30

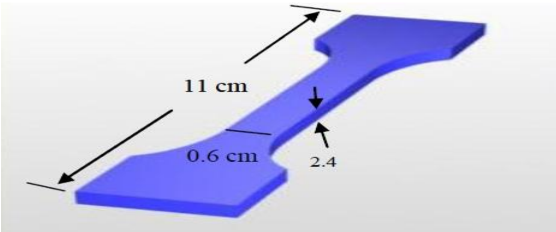

Figure .1. tensile specimen coupon dimensions centimeters

Fig.2. a photograph showing a mechanical measuring device (Tensile)

2.3 Tensile Properties

The tensile properties were tested according to the ASTM Standard D-638: Standard Test Method for Tensile Properties of Plastics (2008) [14]. The amount of strength (σ), tensile strength and Young's modulus were calculated by the following equation [15,16]:

$$\sigma = F / A \qquad \textbf{.....(1)}$$

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

$$Tensile \quad strain\% = \frac{L - Lo}{Lo} \times 100 \qquad \textbf{.....(2)}$$

Where:
L: final length of sample, L0: original length of sample.
(Young's modulus) Y = stress/strain ......**(3)**

III. RESULTS AND DISCUSSION

Figure (3) and table (3) showed that the (stress - strain) curve of HDPE loaded with different percentages of Juglans regia husk powder were measured at a constant of loading rate at room temperature. Stress- strain curve has been dependent on the 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 [17]. 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. [18]

One of the most important engineering parameters 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 Juglans regia husk powder filler is shown in figure (4) Young's modulus varied between 373.633MPa to 593.773 MPa for Juglans regia husk powder ratio between 5 - 50% respectively. Young's modulus can refer 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 essentially depend upon the molecular behavior, include chemical composition and physical structure. The nonlinearity in the stress-strain curve neither 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. 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 [19]. The uncoiling mechanism is known as a relatively slow mechanism.

The result of the tensile strain at break of composites shown in Figure (5). 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 high 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 (5%) a (23.605%) then decreases with the increasing of filler ratio; at the percentage (10%) a (8.817%) which the a polymer has few flexibility and high a hardness there by acting Juglans regia husk powder to fill the spaces between the chains main polymer limited movement of the chains and thus less elongation and then decreased with the increasing of filler ratio; at the percentage (50%) a (1.954%). Polymeric chains that are not constrained by any free movement as a result of lack of homogeneity of the mixture, including the nature of the Juglans regia husk 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 Figure (6) and table (2) that the maximum tensile strength (σ_M) at 5% is 27.675 MPa so that amount of load tensile strength (σ_M) reversible when increasing the concentration of additive which works Juglans regia husk powder to reach 11.026 MPa at 50% the hardness increases when the polymer and thus the polymeric chains is constrained to decrease its flexibility.

Table .3. Parameters of mechanical properties

Filler content (wt.%)	**σ_M (MPa)**	**ε_M%**	**σ_B (MPa)**	**ε_B%**	**Young modulus (Mpa)**
0	33.554	6.751	10.818	163.387	497.022
5	27.675	7.407	5.510	23.605	373.633
10	25.624	6.862	23.641	8.817	373.418
15	24.295	5.553	23.321	6.114	437.511
20	22.670	4.463	22.353	4.599	507.954
25	22.599	4.786	21.93	4.195	471.353
50	11.062	1.863	10.249	1.954	593.773

Definition of Parameters Used in This Study
σM =tensile strength in MPa, εM =tensile strain , σB =tensile strees at break in MPa , εB =tensile strain at break , Y =Young's modulus in MPa.

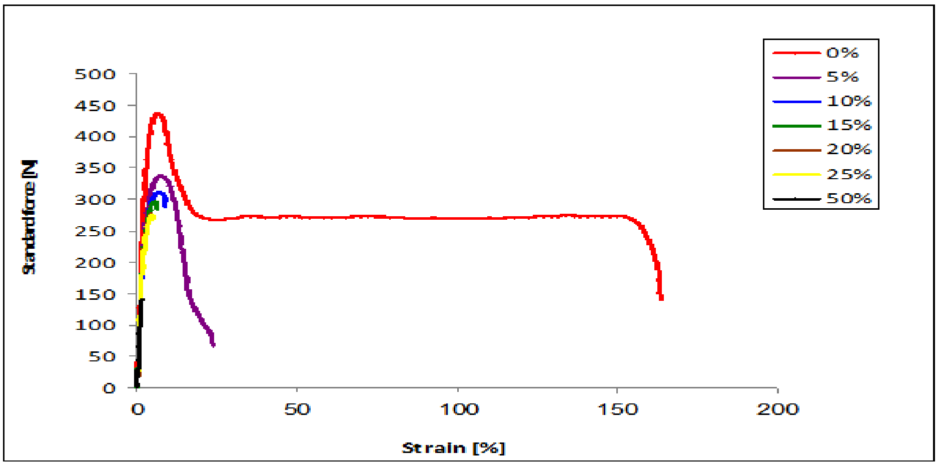

Figure. 3. The stress - strain curves of polymer composite with Juglans regia husk powder

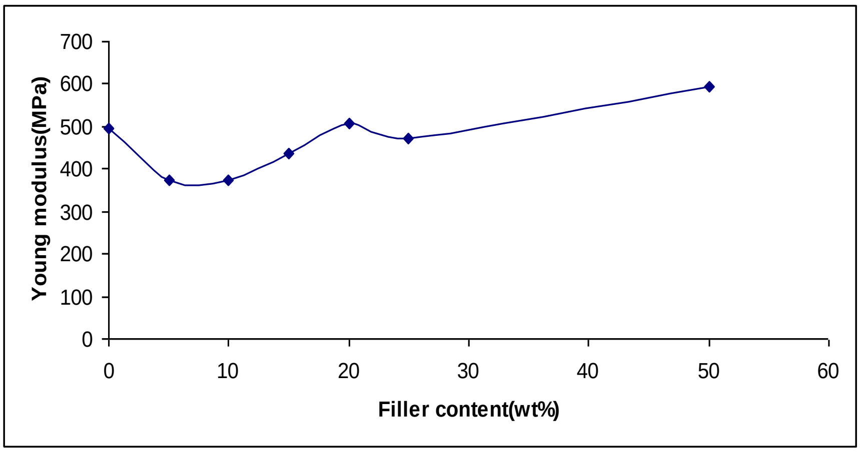

Figure.4. Variation between Young Modules and Filler content (wt.%).

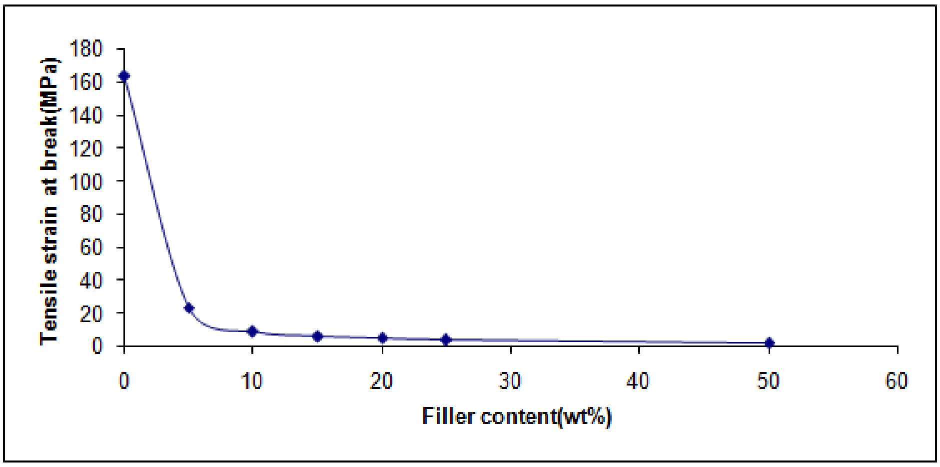

Figure.5. Variation between tensile strain at break and Filler content (wt.%).

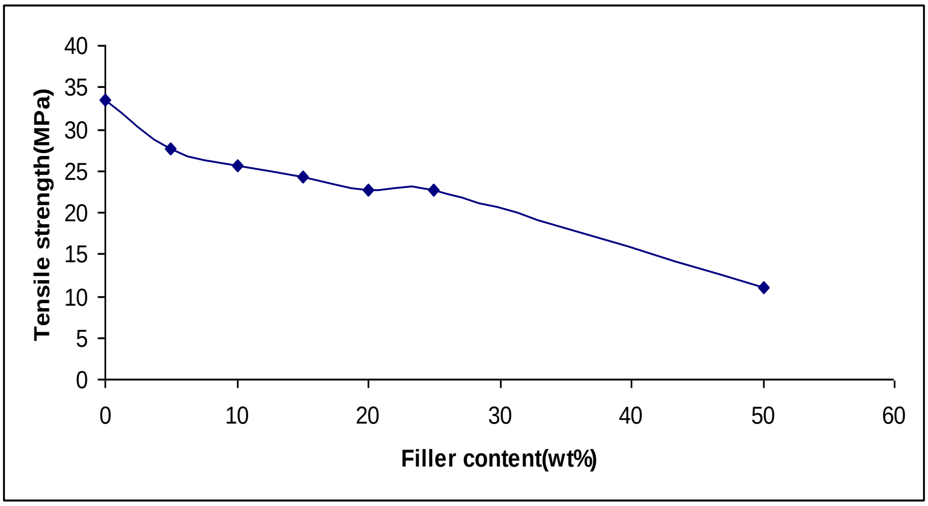

Figure.6. Variation between Tensile strength and Filler content (wt.%).

IV. CONCLUSION

Mechanical properties of high density polyethylene were changed by adding (Juglans regia husk powder) with different weight percentage. Polymer phase was decreased by stiffer material (Juglans regia husk powder). This interprets the weekend observed in mechanical properties above than 5% percentage. Accordingly, HDPE with 5% Juglans regia husk powder is recommended for industrial applications.

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