# Mechanical behaviour of Low Density Polyethylene / Shrimp Shells Composite.

**Abdullah A. Hussein[1], Abdulwahab A.Sultan[2] and Qusay A. Matoq[2]**
*[1]Department of Material Science, Polymer Research Center,University of Basrah,*
*[2] Basrah technical college.*
*[3] State Company for Petrochemical Industries*

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## ABSTRACT

In the present work, the mechanical behaviour of (LDPE-463) reinforced with Shrimp Shells (Metapenaeusaffinis) composite, as a function filler contact (5, 10, 15, 20, 25, wt %). Filler concentration has an obvious effect on improving several mechanical parameters. The parameters studied are young's modules, stress at break, and stress at yield which were increased with increasing filler concentration. Elongation as indirect results of stress at break was decreased with increasing filler concentration. It was found that the addition of Shrimp Shells to the LDPE leads to decreases impact strength. Results were analyzed in the frame of drawing model.

**Keywords:** Low Density Polyethylene**,** Shrimp Shells**,** Mechanical behaviour**.**

## Introduction:

Low density Polyethylene (LDPE) is a famous commercial polymers used in a many industrial applications. Electrically, it's known as insulating material. Its compatible properties such as good insulation together with excellent mechanical properties (high tensile strength) candidate their utilizing in different applications as active material replacing other materials [1]. The wide range temperature between its glass transition and melting point (-80,120$^{o}$C) displayed efficient characteristics to utilize the polymer as insulating cover for cables and wires [2].

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 [3].Polymer composites with special mechanical properties are widely used in various applications such as electrostatic discharge protection, electromagnetic shielding and field grading [4].

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 [5]. 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, antiblocking agent, slip agent, antistatic agents, stabilizers, color compounds and fillers [6].

Among biobased polymers, polysaccharides such as cellulose are adaptable materials that combine many valuable characteristics for technical applications. So recently, cellulosic plastics have gained importance in biocomposite formulations [7]. In addition, cellulose materials are used as reinforcement fibers because of their high mechanical and thermal performance [8].

Due to the favorable combination of easy processability and attractive mechanical properties, the use of polymer materials in structural applications has assumed large proportions over the last decades. To ensure proper operation under heavy duty conditions, these applications have to meet specific requirements regarding quality, safety, and mechanical performance (e.g. stiffness, strength and impact resistance). Mechanical performance is generally optimized by trial-and-error until the functional demands of the design are satisfied. This, however, implies by no means that the final result is fully optimized [9].

Using natural fillers to reinforce the composite materials offers the following benefits in comparison with mineral fillers strong and rigid, light weight, environmental friendly, economical, renewable and abundant resource. Many works have been devoted to use of other natural fillers in composites in the recent past and Shrimp shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. Composites of Shrimp shell filler can be used in the broad range of applications. Mechanical properties of the natural fiber composites depend on several factors such as the stress–strain behaviors of fiber and matrix phases, the phase volume fractions, the fiber concentration, the distribution and orientation of the fiber or fillers relative to one another.

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## Experimental:

### Materials:

Low density polyethylene (LDPE- 463) (MI=0.39 gm/10ml) and (density = 0.922 gm/cc) was obtained from the state company of petrochemical industries (SCPI), Basra, Iraq. Shrimp Shells particles were obtained from a local market.

### Sample preparation:

In this study, the concentrations of Shrimp Shells were used 5, 10, 15, 20, 25, wt% as a fine powder was mixed with LDPE using mixer 600 instrument attached to (Haaky Rheocard Torgue Rheometer) and carrer Hydraulic laboratory press instruments with following conditions. The mechanical tests instruments used for this purpose available in the state company of petrochemical industries (SCPI). The average Shrimp Shells particle size used in this work was (75) µm.

**Table (1): The operating conditions**.

| | |
|---|---|
| **Mixing temperature** | **160C$^o$** |
| **Mixing velocity** | **32 RPM** |
| **Mixing time** | **15 min.** |

The result product mold is introduced in laboratory compressor under 5 ton at 175 $^o$C for 3 min. The pressure then is rise gradually up to 15 ton and fixed the condition for 5 minute. The process was terminated by cooling the sample gradually to reach room temperature. Moisture of the laboratory is one of the most important parameter which must take into account in industries research [4].

### Characterization and measurements:

In order to measure the mechanical properties, samples with a respective shape (dumble) were prepared (20*20) cm2. with 2 mm thickness, by using instron instrument with following conditions; chard speed (10 cm/min), crosshead speed 20 cm/min. The prime consideration in determining the general utility of a polymer is its mechanical behavior, tensile properties, impact strength with 3 mm thickness, hardness and modulus of elasticity were carried out for examining the mechanical properties of the samples. The relationship between elongation and load value (force) is obtained directly from the instrument.

**Resulst and Discussions:**

The mechanical properties are connecting two interrelated objective, the macroscopic description of the particular behaviour and the explanation of this behaviour in molecular term [11]. The stress-strain curves of the samples were obtained directly from the load-elongation relationship. Tensile characteristics (tensile strength at yield & break, modulus of elasticity and tensile elongation) have been determined from the stress-strain curves.

Figure (1) illustrates the (stress - strain) curve of Low density polyethylene specimen composed with (5, 10, 15, 20, 25, wt%) Shrimp Shells measured at a constant rate loading at room temperature. The polymeric marital can be broadly classified in term of their relative brittleness, hardness, softness and toughness. The tensile (stress -strain) curve is a basis for such classification [12]. Low density polyethylene has a soft and tough behaviour, where this demeanor is characterized with low modulus and low yield stress. Stress strain curve describes the material characteristics and its less dependence on the arbitrary choice of specimen profile. Experimental data showed that adding Shrimp Shells does not change the above characteristics shown in figure (1) but change its properties and the stress at break was higher than stress at a yield about 14.5Mpa. According to the break down classification, the tensile (stress-strain) curve is averment the second behaviour of the fracture nominally cold drawing [12,13]. In this type three distinct regions can be distinguished from this curve; first is the linear region, second is the yield region, third is the elongation region up to the break.

The first region at Hook's Low obey is characterized with instantaneous and recoverable deformation associated which is with the bending and the stretching of the interatomic bonds among LDPE atoms. On the other hand, there is no permanent displacement of molecules relative to others. The first region can reflect the elastic limit region of the polymer, in which the uniform extension due to stress increased with a constant rate. The volume of the specimen remains constant during elastic deformation, so as the gauge length elongates, its cross-sectional area is progressively reduced. One of the most important engineering parameter which reflects the material resistance against deformation, and should be measured before designing polymer is the modulus of elasticity. It is a measure of the stiffness or rigidity of materials depending upon strength of interatomic bonds and compositions (can be calculated. From the slope of linear region). It can be estimated from the slope of the portion of the first region, which is found higher for a sample with a higher extension rate.

Figure (2) illustrates the relation between the modulus of elasticity versus different Shrimp Shells filler content. The modulus of elasticity varied between 160 to 185 for Shrimp Shells weight ratio between 5 to 25% respectively. It is clearly seen that the increase of wt.% Shrimp Shells filler leads to increase in the modulus of elasticity. That is due to the increase of linking force between the molecules of the matrix and thus become more elastic which leads consequently to a smaller deformation of sample, ultimate increase of modulus of elasticity [14,15]. This increment in the modulus of elasticity also can refer to an increase in the resistance of material to deformation. Proportional limit is referred to the highest stress that can be applied with Hook's low.

Figure (3) clearly shows the variation of stress at yield as a function of filler content. From this figure it is observed that there is a pronounced effect of the addition of filler at different weight percents ranging between (5-25) wt.% on the elongation at yield of the material, increasing filler content leads to an increase in the elongation at yield, this may be due to the fact that the perfect homogeneity of filler distribution is in the polymer matrix. On the other hand, the variation of stress at break versus Shrimp Shells filler content is shown in figure (4). It is clearly seen the stress at break usually increases with the addition of filler content. The increasing trend usually continues with increasing filler content, because the stress at break of polymer composite depends on the stress of filler and polymer [16], furthermore cracks can form either within or around the particles. Therefore, the voids and cracks do not transfer stress, making the material more compliable and thus upping the material elongation [17]. The stress at break is the final stage of segment variation. It is related to the transfer of the edge neck along the specimen which deforms the specimen volume in a large form [17].The elastic of ( LDPE : Shrimp Shells) in the region is not recoverable (permanent deformation) because an actual displacement of molecules are exist with respect each other.

Figure (5) shows the variation of Elongation as a function of filler content. Elongation varied between Shrimp Shells weight ratio between 5 to 25% respectively. From this figure, it is clearly seen that increasing of wt.% of Shrimp Shells leads to a decrease in the %elongation at break, because these Shrimp Shells filler fill the spared space among the series polymer, so that the spared space is less for polymer element. The Elongation and elastic the series polymer will be less from moving where increased the filler when increased the polymer and less Elongation.

Figure (6) shows the variation of the impact strength of LDPE at different wt.% of Shrimp Shells, The results show that increasing the filler content of Shrimp Shells leads to a decrease in the impact strength. Therefore, the toughness of the polymer decreases and its ability to absorb and dissipate energy decrease, thus the polymer needs low impact energy to fracture [17, 18].

**Conclusion:**

It was shown in this study that the mechanical behaviour for low density polyethylene was improved by adding Shrimp Shells with different filler content. It was found that modulus of elasticity has increases with increasing filler content. The increase in tensile at the yield and break may be related to the increase in the material homogeneity. Polymer phase was diluted by stiffer material (Shrimp Shells). This interpreted the weak end observed in mechanical properties above 10% percentage. Accordingly, LDPE with 10% Shrimp Shells is recommended for industrial applications.

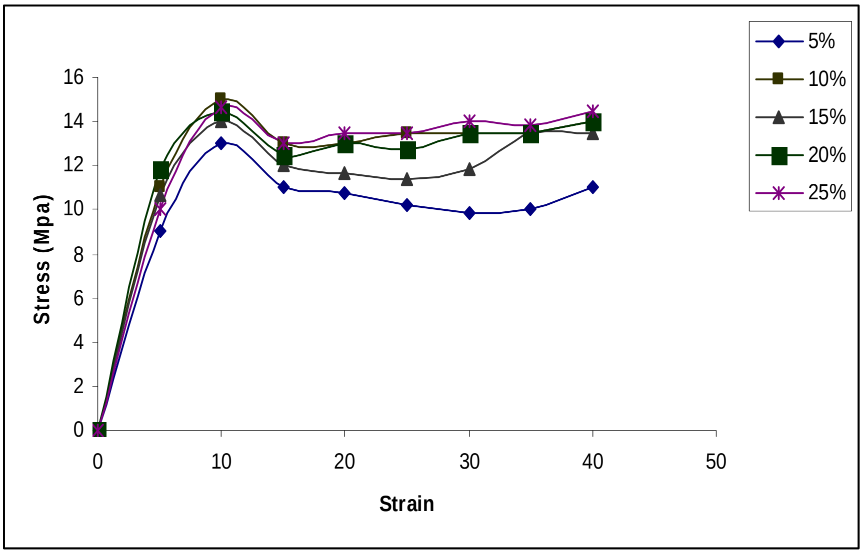


**Figure (1) Stress-Strain curve for samples.**

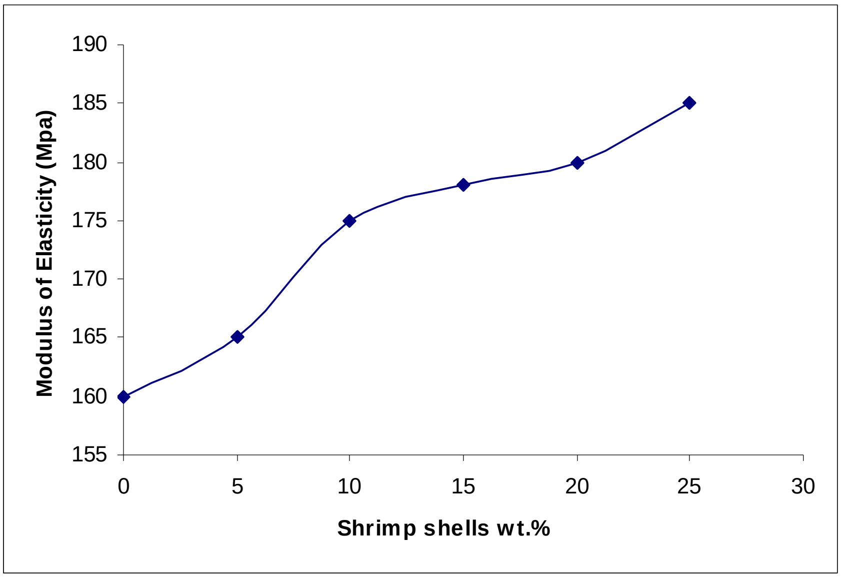


**Figure (2) Modules of elasticity LDPE as a function of Shrimp Shells content (Wt.%).**

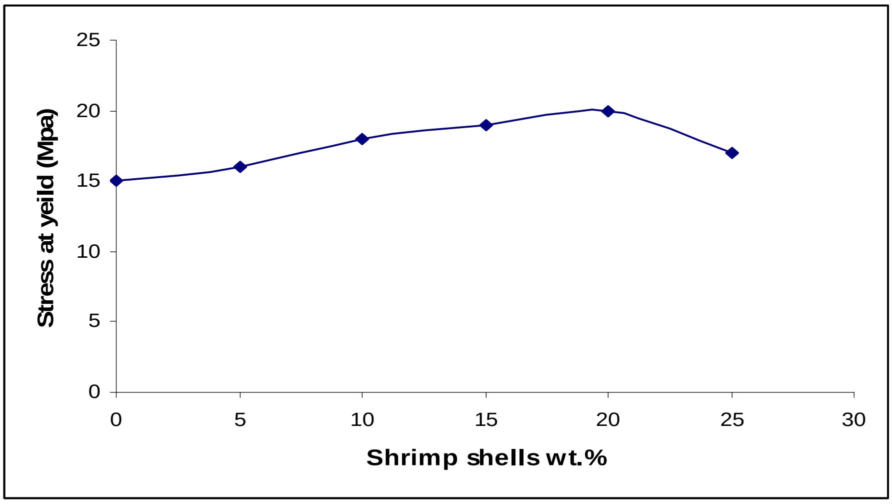


**Figure (3) Stress at at yield of LDPE as a function of Shrimp Shells content (Wt.%).**

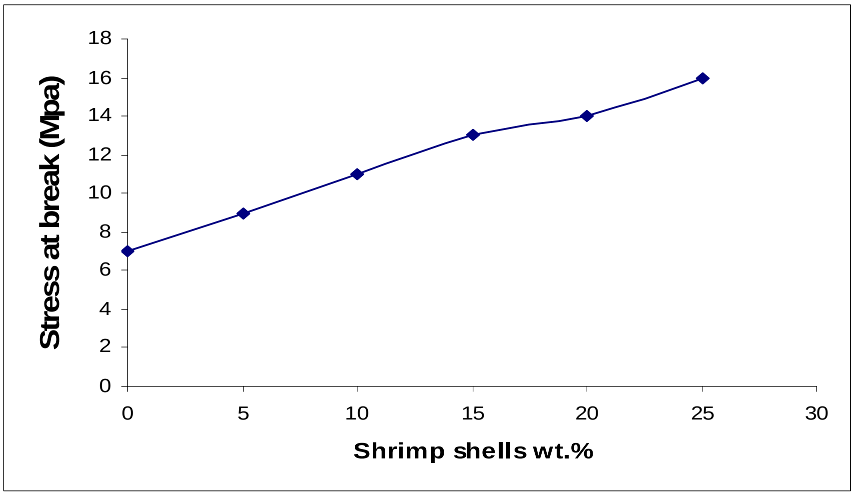


**Figure (4) Stress at break of LDPE as a function of Shrimp Shells content (Wt.%).**

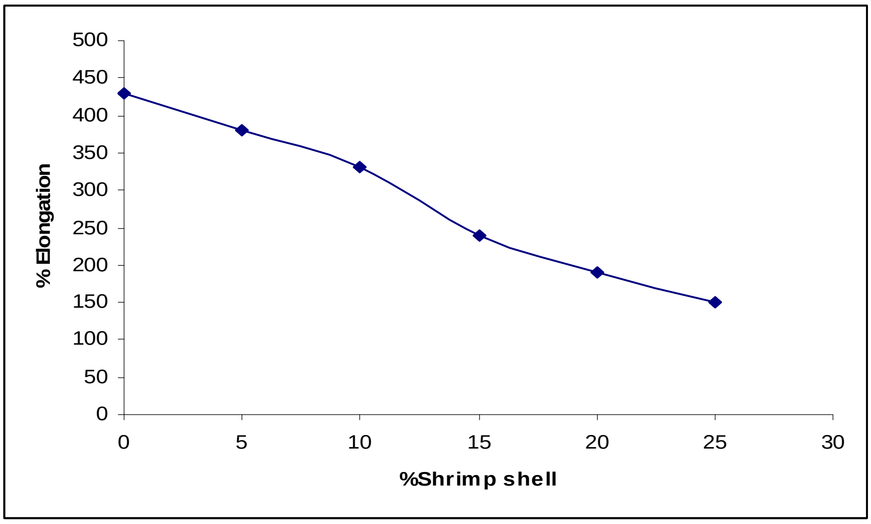


**Figure (5) The variation of Elongation of LDPE as function of Shrimp Shells Content (Wt.%).**

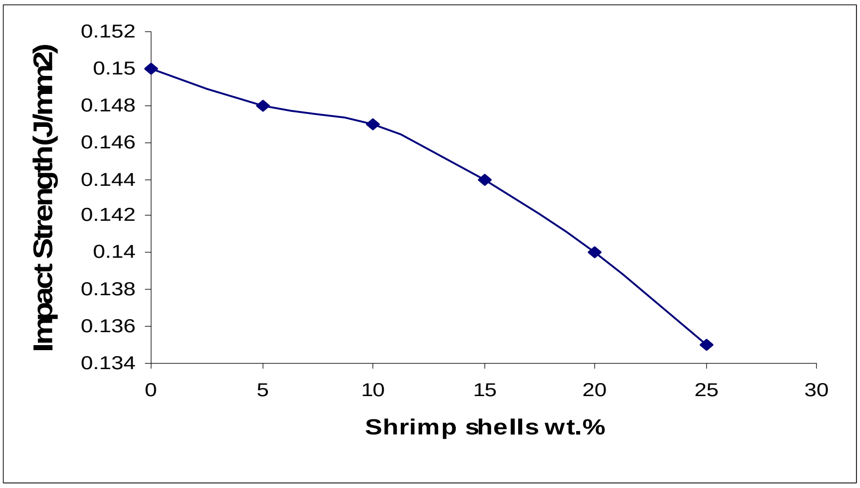


**Figure (6) Impact strength of LDPE as a function of Shrimp Shells content (Wt.%).**

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## دراسة السلوك الميكانيكي لمتراكب البولي اثيلين واطئ الكثافة/ قشور الروبيان .

**الخلاصة:**

تم تحضير مزيج من بولي اثلين واطئ الكثافة (463) و قشورالروبيان نوع (ميتابنايص أ فانيص) غير المرغــوب ، حيث لا يمتلك أي قيمة غذائية ممكن أن يستفاد منها وبنسب وزنية تتراوح (5, 10, 15, 20, 25, wt%) كدالــه للمــالئ المضاف ، وتمت دراسة السلوك الميكانيكي لهذا الخليط. أظهرت النتائج العملية بان إضافة المالئ يعمــل علـــى تحـــسين الخواص الميكانيكية وذلك بزيادة قوة الإجهاد ومعامل يونك و الإجهاد عند الوهن والإجهاد عند القطع. كما وجد أن مقــدار الاستطالة يقل مع زيادة تركيز المضاف. أما بالنسبة إلى فحص الصدم فقد وجد إنه يقل بزيادة نسبة المالئ . لذلك فان البولي اثلين الواطئ الكثافة وبد ون إضافة قد أعطى أعلى قيمة للصدم. تم تحليل البيانات العملية بالاعتماد على موديل السحب.