Mechanical properties and water absorption of PVC cement doped with Oyster shell

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الخلاصة

تم في هذا البحث دراسة الخصائص الميكانيكية وامتصاصية الماء باستخدام عينات من بوليمر البولي فينيل كلورايد اللاصق والمضاف اليه مسحوق قشور المحار كحشوات مالئة وبنسب وزنيه (% 3, % 2, %1) وعند حجم دقائق للحشوات (µm 75~) . بينت النتائج العملية بان قشور المحار تعمل على تقليل الفراغات بين السلاسل البوليمرية ، مما يعكس إمكانية تحسين الخواص الميكانيكية للبوليمر مع المضاف عند هذه النسب ،كذلك تم اختبار امتصاصية الماء لهذه المتراكبات والتي نلاحظ تقليل الفراغات بين السلاسل البوليمرية والذي يمكن من خلاله استغلال المتراكبات المحضرة في التطبيقات الصناعية.

الكلمات المفتاحية :الخصائص الميكانيكية، البولي فينيل كلورايد اللاصق ، مسحوق قشور المحار.

Abstract

The mechanical behaviour of Polyvinyl chloride PVC cement/Oyster shell composites were studied. The range of added Oyster shell has the values (1, 2, and 3% wt with grain size <75µm) of PVC cement weight and, the best shells ratio was 3%. The properties (PVC cement/Oyster shell) composites were analyzed as a function of the shells concentrations. All prepared composites showed improved shells dispersion in the PVC cement matrix. All the composites displayed higher stress compared to pure PVC cement. Water absorption of the composites behaviors as function of months has also been Investigated.

Keywords: Mechanical properties, Polyvinyl chloride (PVC), Oyster shell**.**

1. Introduction

Polyvinyl chloride (PVC) is a famous commercial polymers used in a many industrial applications. It has high mechanical properties so it has been widely used due to its flexibility, durability, transparency, sterilization performance and low cost. It is properties candidate their utilizing in different applications as active material replacing other materials [1].

The mechanical properties of PVC where enhanced with producing blend and composite materials , Its mixing two material or more without perfect reaction together so that no new chemical material was formed but each component have separating state inside the composite materials [2, 3].

Studying mechanical properties for composite materials are very important and should be consider, this because it is determine behaviorism this materials under stress effect. As well as, studying material owned polymer substructure provided our research with important information to defining suitable composite material for applied purpose [4]. Reinforced composite materials with different types of class fibers, carbonic fibers and metals fibers have been widely used besides it have attracted the attention of many research, while the reinforced composite materials with grains did not have more interest[4, 5]. Fibers was used commercially to minimized the cost price of production, the other hand the grains was adding to improve the mechanical properties, such as, $CaCo_2$ (Calcite), Al_2O_3(Alumina) and SiC (Silicon carbide) was adding to improve mechanical properties such as hardness, rigidity and cohesion together with thermal properties improvement [5]. Composite materials with polymer substructure reinforced with material are widely used in various application such as cars industry, electric tools, and electronic industry [6,7]. Our aim in present research was studying effect adding Oyster shell grains with PVC cement by using different weight percentage on tensile stress in addition to humidity effect**.**

2. Experimental

2.1. Original material

Oyster shell particles are used as a reinforcement to enhance the mechanical properties of poly vinyl chloride. PVC cement (LICHIDE PVC cement 717-21 heavy duty-clear) was obtained from the SWAN TRADING (L.L.C) of density= 1.42 g/cc and Glass transition Temperature (Tg =75^{O}C). Oyster shell is obtained from the local market. The average Oyster shell particle size used in this work is (<75) μm. Oyster shell as a fine powder is mixed with PVC cement (as received) three concentrations of filler particles (1, 2, and 3wt%) at different weight fraction and then mixed at about 70^{0}C for 5 minutes. The initial curing was carried at room temperature for 24 hours, followed by post curing at 120^{o}C for 2 hours, and finally thermosetting sheets of PVC cement composite were made. The mechanical tests instruments used for this purpose available in the Department of Material Science, Polymer Research Center (PRC),University of Basrah.

2.2 Characterization and measurements:

In order to measure the mechanical properties, samples with a respective shape (dumble) were prepared (12*12) cm^2 with 2 mm thickness, by using Zwick Rell instrument. The prime consideration in determining the general utility of a polymer is its mechanical behavior, tensile properties, 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.

Table (1) : The specification of PVC and Oyster shell powders

Oyster shell (%)	PVC (%)	No. sample
0	100	1
1	99	2
2	98	3
3	97	4

The Maximum tensile stress (engineering tensile stress) can be calculated according to the relation [8]:

$$\sigma_M = F / A \quad (N/mm^2) \qquad (1)$$

where F is the force (N), and A is the Area of sample section (m^2) .The engineering tensile(ϵ_B) and true (increment) tensile strain (ϵ_t) calculated by using equations [9, 10, 11].

$$\epsilon_B = \Delta L/L = (L-L_0)/L \qquad (2)$$

$$\epsilon_t = \delta L/L \qquad (3)$$

$$\epsilon_t = \int_{L0}^{L} \delta\epsilon = \int_{L0}^{L} \delta L/L = \ln (L/L_0) = \ln (1+ \epsilon_B) \qquad (4)$$

According to the equation (4) we can calculate Young's modulus by relation:

$$(\text{Young's modulus})\ Y = \text{stress} / \text{strain} \qquad (5)$$

2.3. Water Absorption Test

Water absorption test (ASTM D750-95) was done by total immersion of three samples in distilled water at room temperature. The water absorption was determined by weighing the samples at regular intervals (Weight gain). A Sartorius balance in the range (0.0001-200 gm) . The percentage of water absorption (M %), was calculated by [4, 12]:

$$W(\%) = [(W_2 - W_1)/W_1]*100\% \qquad (5)$$

where W1 and W2 are the dry and wet weights, respectively.

Measuring tensile toughness U_T can be considered as the area under the entire stress- strain curve which indicates the ability of the material to absorb energy or the total amount of work done per unit volume to fracture as shows in equation below [13]:

$$\text{Work per volume} = \int_0^{\varepsilon} E\ \varepsilon\ d\varepsilon = E\ \varepsilon_B{}^2/2 \qquad (6)$$

$$\text{Elastic energy} = E\ \varepsilon_B{}^2/2 \qquad (7)$$

3. Results 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 [14]. The standard force -strain curves of the samples were obtained directly from the load-elongation relationship. Tensile characteristics (standard force, tensile strength, engineering tensile and Young modulus) have been determined from the stress-strain curves.

Fig. (1) illustrates the (standard force - strain) curve of PVC cement specimen composed with (1, 2, and 3 wt%) Oyster Shells measured at a constant rate loading at room temperature. Experimental data showed that adding Oyster Shells does not change the above characteristics shown in Fig. (1) but change its properties and the standard force about 37.8 N at 3 wt% Oyster Shells .

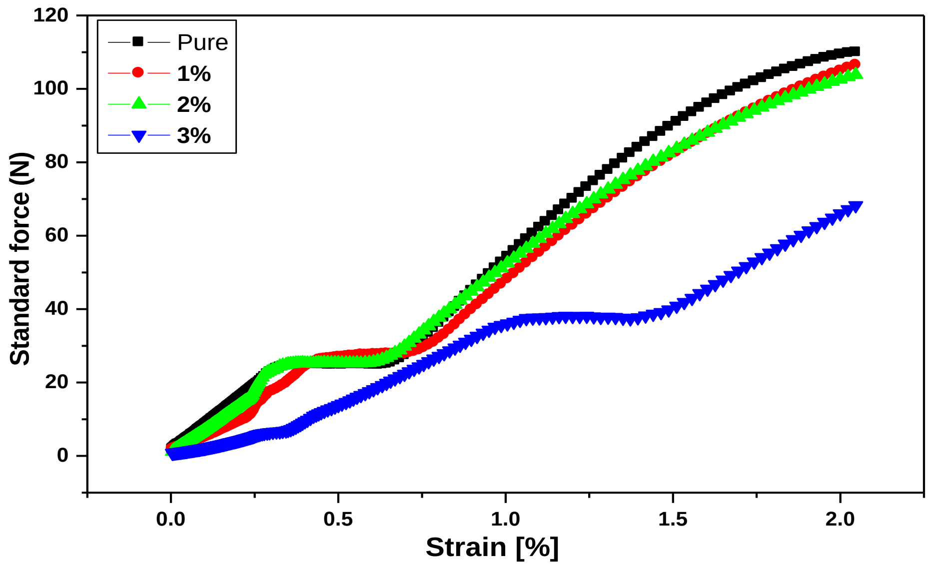

Fig. (1) standard force-Strain curve of (PVC cement/ Oyster shell) composites.

Fig. (2) shows the variation The engineering tensile (ϵ_B) and true (increment) tensile strain (ϵ_t) of PVC cement at different wt.% of Oyster Shells filler content, The results show that increasing the filler content of Oyster Shells leads to a increasing in (ϵ_B) and (ϵ_t). Therefore, the toughness of the polymer increasing and its ability to absorb and dissipate energy increasing, thus the polymer needs high impact energy to fracture [15].

Fig. (3) illustrates the relation between the maximum tensile stress versus different Oyster Shells filler content. The maximum tensile strength varied between 11.7Mpa to 15.3Mpa for Oyster Shells weight ratio between 1 to 3 wt% respectively.

It is clearly seen that the increase of wt.% Oyster Shells filler leads to increase in the maximum tensile stress. The increases in tensile strength are due to the rich adhesion of the filler-matrix and the agglomeration of filler particles. The strength of particulate filled polymer composites depends, to a great extent, on the interfacial adhesion between the matrix and the filler which will facilitate the transfer of a small section of stress to the filler particle during deformation [16].

Fig. (4) clearly shows the variation of the Young modulus as a function of filler content. From this Fig. it is observed that there is a pronounced effect of the addition of filler at different weight percents ranging between 1to3 wt.%, respectively. It is clearly seen that increasing of wt.% of Oyster Shells leads to a decrease in the Young modulus, because these Oyster Shells filler fill the spared space among the series polymer, so that the spared space is less for polymer element. The Young modulus and elastic the series polymer will be less from moving where increased the filler when increased the polymer and less elongation.

Fig. (5) illustrates the relation between the tensile toughness (U_T) versus different Oyster Shells filler content. This increment in toughness can be referred to increase the resistance of the material to deformation and its ability to resist crack propagation especially at 3% of filler content.

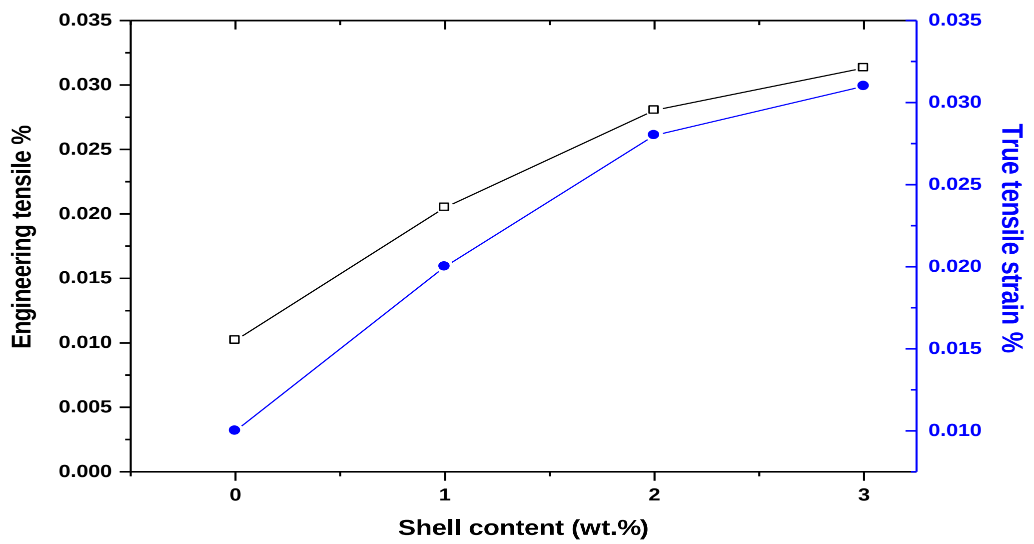

Fig. (2) Effect of filler content on the engineering tensile (ϵ_B) and true (increment) tensile strain (ϵ_t) of (PVC cement/ Oyster shell) composites.

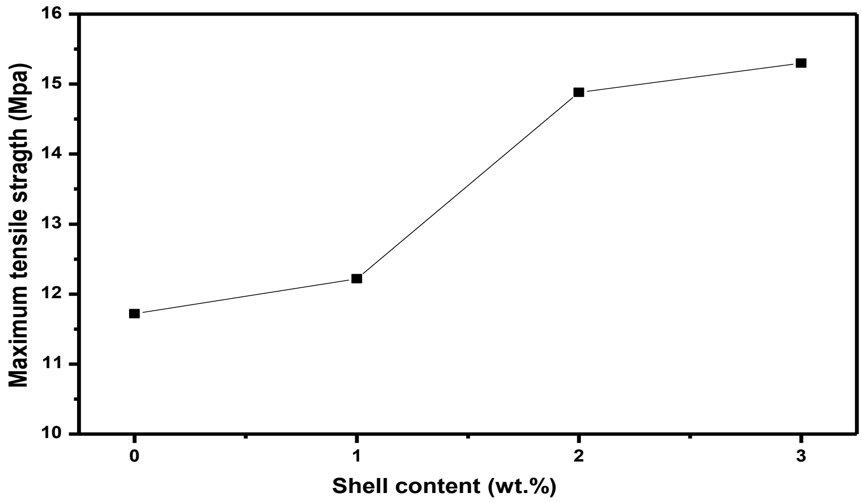

Fig. (3) Effect of filler content on the maximum tensile stress curve of (PVC cement/ Oyster shell) composites.

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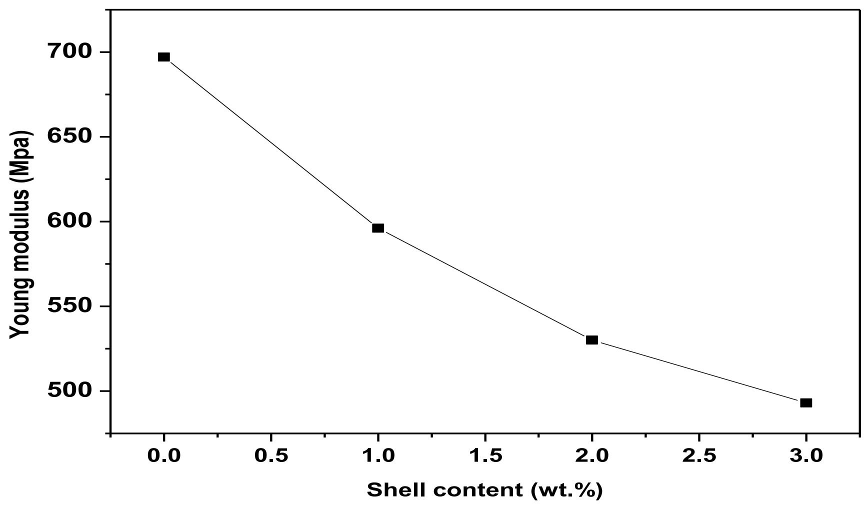

Fig. (4) Effect of filler content on the Young modulus of (PVC cement/ Oyster shell) composites.

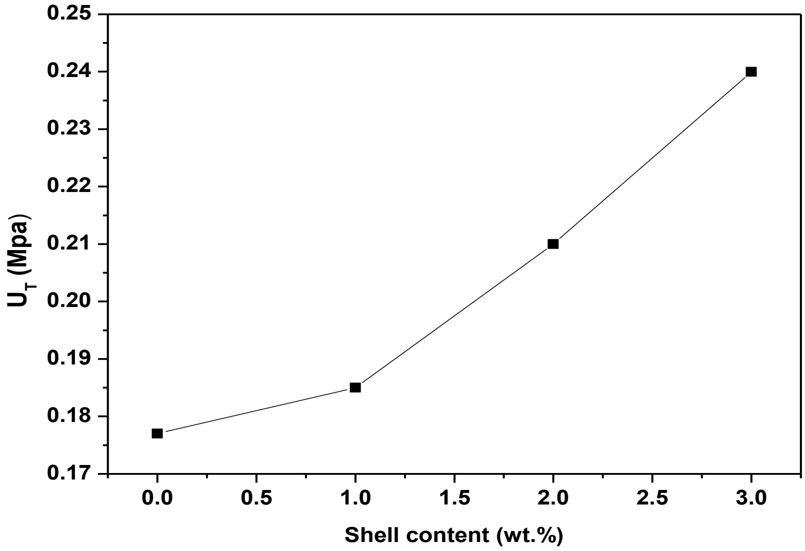

Fig. (5) Effect of filler content on the tensile toughness of (PVC cement/ Oyster shell) composites.

Fig. (6) show the variation of ratio of water absorption versus exposure time (month) for (PVC cement/ Oyster Shells) composite with different fillers content. It can be seen from the Fig. that, the composites with higher filler content show less water absorption. This is due to the higher contents of filler content in the composites that can absorb less water. As the filler content increases, the formation of percolation increases due to the facilities of achieving a homogeneous dispersion of filler at high filler content. The percolation of the filler in composites decreases the water absorption of the composites [17].

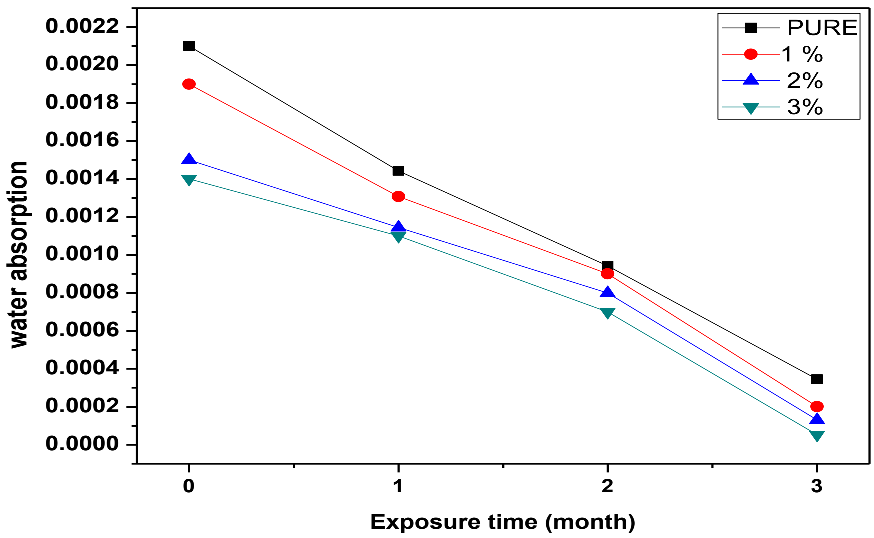

Fig. (6) Effect of exposure time on the humidity of (PVC cement/ Oyster shell) composites.

4. Conclusion:

It was shown in this study that the mechanical properties for PVC cement was improved by adding Oyster Shells with different filler content. It was found that the engineering tensile and true (increment) tensile strain has increases with increasing filler content. The increase in maximum tensile stress may be related to the increase in the material homogeneity. Polymer phase was diluted by stiffer material (Oyster Shells). This interpreted the weak end observed in mechanical properties above 3% percentage. Accordingly, PVC cement with 3% Oyster Shells is recommended for industrial applications.

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