# INVESTIGATION THE EFFECT OF NATURAL MATERIALS ON WEAR AND HARDNESS PROPERTIES OF POLYMERIC COMPOSITE MATERIALS

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**ABSTRACT :**

This research studied the properties of orange and pomegranate reinforced unsaturated polyester with different powder weight fraction *Wf*. The orange and pomegranate powders were added to unsaturated polyester at weight fraction (0,4 ,8 & 11 wt%) with grain size (53µm). The composite specimens were prepared by hand lay-up technique and cutting according to (ASTM) for wear test, hardness test to obtain of the composite specimens. The results show that the wear rate for all tested specimens increases with increase of time of applied load and the wear rate decreases with increasing weight fraction of particles. Also the best value of properties was obtained for composite materials reinforced with pomegranate peel at (=11wt%) than composite materials reinforced with orange peel at this value.

**Key word:- unsaturated polyester, wear properties, hardness properties, natural materials.**

# التقصي عن تأثير المواد الطبيعية على خواص البلى والصلادة للمواد المتراكبة البوليميرية

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**الخلاصة :-**

في هذا البحث تم دراسة خواص البلى والصلادة للبولي استر الغير مشبع المقوى بمسحوق البرتقال والرمان عند كسور وزنية مختلفة. تم أضافة كل من مسحوق البرتقال والرمان الى مادة الاساس البولي استر الغير مشبع بالكسور الوزنية التالية (0, 4, 8 &11 wt%) مع حجم حبيبي(53µm).حضرت العينات بطريقة يدوية وقطعت وفق المواصفات القياسية (ASTM) لفحصي البلى والصلادة.

النتائج اظهرت بإن معدل البلى لكل عينات الاختبار يزداد بزيادة وقت تسليط الحمل ويقل مع زيادة الكسر الوزني للمساحيق. أيضاً افضل قيم للخواص تم الحصول عليها للمواد المركبة المقواة بمسحوق الرمان حدثت عند كسر وزني (=11 wt%) افضل من مسحوق البرتقال عند هذه النسبة.

**الكلمات المرشدة :- البولي استر الغير مشبع ،خواص البلى ،خواص الصلادة، المواد الطبيعية.**

## INTRODUCTION :-

Composites are combinations of two or more than two materials in which one of the materials, is reinforcing phase (fibers, sheets or particles) and the other is matrix phase (polymer, metal or ceramic). Polymer matrix composites are mostly commercially produced composites in which resin is used as matrix with different reinforcing materials (Saxena, 2012). High performance FRP are also found in many diverse applications such as composite armouring design to resist the impact of explosions, wind mill blades, industrial shafts, and fuel cylinders for natural gas vehicles paper making rollers and even support beams of bridges (Verma, 2013). In the latest years industry is attempting to decrease the dependence on petroleum based fuels and products due to the increased environmental consciousness. This is leading to the need to investigate environmentally friendly, sustainable materials to replace existing ones. The tremendous increase of production and use of plastics in every sector of our life lead to huge plastic wastes. Disposal problems, as well as strong regulations and criteria for cleaner and safer environment, have directed great part of the scientific research toward ecocomposite materials. Among the different types of eco-composites those which contain natural fibers (NF) and natural polymers have a key role. Since few years polymeric biodegradable matrices have appeared as commercial products, however their high price represents the main restriction to wide usage. Currently the most viable way toward ecofriendly composites is the use of natural fibres as reinforcement. Natural fibers represent a traditional class of renewable materials which, nowadays, are experiencing a great revival (Cristaldi, 2010). **KUMAR, P. in (2012)** has illustrated mechanical and physical properties of composite materials made from orange peel reinforced epoxy resin were made using hand layup method. The results show that the maximum hardness, density, tensile, flexural and ILSS are getting for the material prepared with the 20 % reinforced orange peel epoxy composite (Kumar, 2012). **Aigbodion, V. S. & et al in (2012)** have investigated the thermal properties for high density polyethylene (HDPE) composite reinforced with 20 wt% orange peels ash particles (OPAp) was prepared by compression moulding. The results show that the HDPE/OPAp composite exhibited better thermal properties than that of HDPE with the introduction of 20wt% OPA particles and the fairly uniform distribution of the orange peels ash particles in the microstructure of HDPE/OPAp composites is the major factor responsible for the improvement in the thermal properties (Aigbodion, 2012). **Hashim, A. & et al in (2013)** have studied the optical properties of composite materials consisting of polyvinyl alcohol- polyacrylamide and pomegranate peel were prepared by using the casting method. The results show that the optical properties of polymer matrix are changed with the increase of the pomegranate peel concentrations (Hashim, 2013). **Aigbodion, V. S. and et al in (2013)** have investigated the mechanical properties and microstructural for composites consist of orange peels particles as a reinforcing material and high-density polyethylene (HDPE) as a noval matrix. The composites were produced by varying the orange peel particles (uncarbonized and carbonized) from (5-25 wt%). The results shown that there was a fairly uniform distribution of the orange peels particles in the microstructure of HDPE composites which is the major factor responsible for the improvement in the mechanical properties (Aigbodion, 2013). **Deshpande, S. & Rangaswamy, T. in (2014*)*** In this work, an investigation was carried out on E-glass fiber/jute fiber reinforced epoxy composites filled with varying concentrations of bone and coconut shell powder. The test results of these were compared with unfilled HFRP composites. From the results it was found that the mechanical

properties of the composites increased with the increase in filler content. Composites filled with 15% volume coconut shell powder exhibited maximum flexural strength, inter laminar shear strength (ILSS), tensile modulus and hardness. Maximum impact strength was achieved by addition of filler (15% Vol.) of bone powder (Deshpande, 2014). The aim of this research was to study the influence of weight fraction of natural powder on properties of unsaturated polyester reinforced by orange and pomegranate powder.

## THEORETICAL PART

Wear is one of the most commonly encountered industrial problems leading to the replacement of components and assemblies in engineering. In general there is great enthusiasm for wear resistant of the polymer, in order to obtain the optimal wear rate without compromising the beneficial properties of the matrix material (Zum-Gahr, 1985).

The following relation is used to investigate the wear rate which is (Dowson, 1978):-

$$W.R = \frac{\Delta W}{S.D} \quad (1)$$

Where:-

W.R:- Sliding wear rate is the weighted (gm/mm).

ΔW:- The change in weight during the experiment and calculated from following relationship:-

$\Delta W = W_1 - W_2$

Where:-

$W_1$:- Weight of sample before the test (gm).

$W_2$:- Weight of sample after the test (gm).

S.D: a sliding distance calculated from the following low:-

$S.D = S*t$ (2)

Where:-

S:- the speed of sliding (mm/min).

t:- time slip (min).

The hardness test is performed by using hardness (Shore D). For each specimen five hardness measurements were taken and the average hardness is calculated.

## EXPERIMENTAL WORK

Basically two main tasks were carried out to achieve the objectives of study. The first task was the preparation of composite material by combining the unsaturated polyester and oranag powder and pomegranate powder with different powder weight fraction (0, 4, 8 & 11 % $W_f$) and grain size (53μm). Then it was continued by performing the wear test and hardness test carried out to determine the characteristics of the studied composite. The usage of unsaturated polyester resin as a matrix was chosen because it is the standard economic resin commonly used, preferred material in industry and besides, it yields highly rigid

products with a low heat resistance property. The type of unsaturated polyester resin is provided from the Saudi Arabia Company in the form of transparent viscous liquid at room temperature. The resin was prepared by mixing unsaturated polyester with 2% hardener. The hardener type used is the Methyl Etheyl Keton Peroxide (MEKP).

## PREPARATION OF COMPOSITES

The composite specimens were fabricated by using hand lay-up technique. Composites having different powder content were prepared by varying the type, weight fraction. In the first process of preparing the composite specimens preparation process is to set the percentage of powder content in the composite. The amount of resin needed for each category of composite was calculated after that. Then the resin was mixed uniformly with hardener, the mixture was poured carefully into the moulds and left in the mould for 24 hours. After the composites were fully dried, they were separated off from the moulds, and then put the specimens in oven at (55 ºC) for (1 hrs) (Flex, 2012). Specimens are prepared after the composites are ready. for hardness test the specimens cut according to (ASTM D-2242) standard. Samples have been cut into a diameter of (40mm) and a thickness of (5mm) (Annual Book of ASTM Standard, 1988). The rotating Pin -on- Disc wear testing machine done within a conditioned laboratory environment. The weighing method was used to determine the mass loss of the test specimens before and after the test. The sample was fixed in holder and was abraded under load (0.5 Kg) and a sliding speed (2 m/sec.) with different time (2, 4& 6 min). The dimension of the specimen was 9.5 mm diameter and 20 mm length based on the standard wear tests described in ASTM standard D5963-97a (ASTM International, 2001).

## RESULTS AND DISCUSSIONS :-

### 1- Wear test result

Figures (1and2) show the relationship between wear rate and weight fraction of particles for composite specimens. It was observed from these results the wear rate for all tested specimens increases with increase of time of applied load. This is due to the deeper grooving and more material removal from the sample with increasing load. The neat unsaturated polyester shows the highest wear rate because abrasive particles penetrate deeper into the softer matrix forming a series of tracks. Also from these figures can be seen the wear rate decreases with increasing weight fraction of particles. This behavior may be due to when the addition of particles into the matrix increase the average hardness of the composites and also increases particles-matrix adhesion which reduces the material removal.

### 2- HARDNESS TEST RESULTS

Figure (3) shows the relationship between hardness value and weight percentage of particles for composite specimens. From this figure it was noticed that the increased weight fraction of particles leads to enhancement of the hardness value for all composite samples. This is due to the presence of particles that are stronger and stiffer than matrix material .

## CONCLUSIONS :-

The main conclusions of this search are:-

1- The wear rate of composite materials increased with increased time applied load and decreased with increased weight fraction of particles for two type of reinforcement.

2- The hardness value of composite materials increased with increased weight fraction of particles higher value of hardness obtained at (=11 wt%)

for two type of reinforcement.

3- The best value of properties was obtained for composite materials reinforced with pomegranate peel powder than composite materials reinforced with orange peel powder.

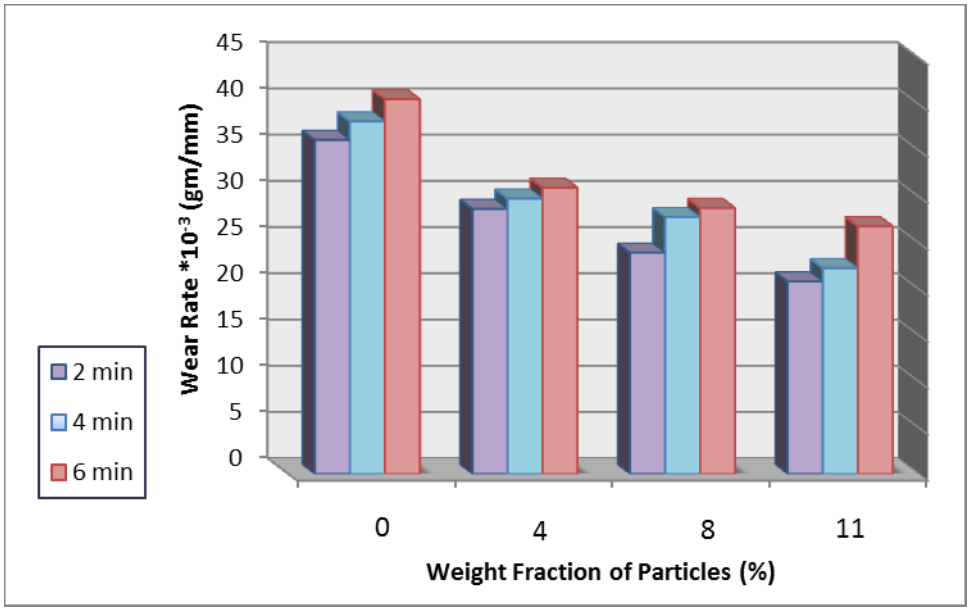


Fig. (1): Shows the relationship between wear rate & weight fraction of particles for composite materials reinforced with orange peel powder.

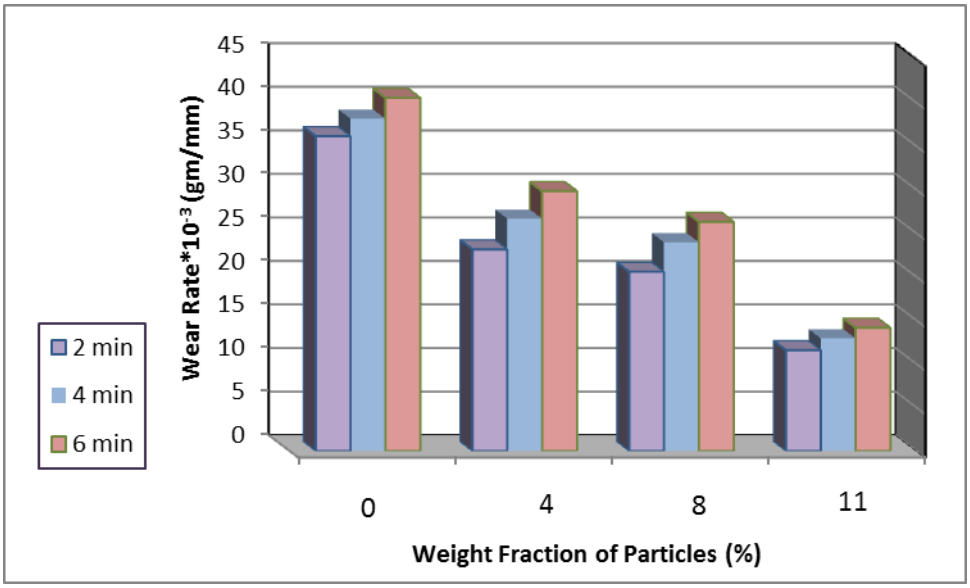


Fig. (2): Shows the relationship between wear rate & weight fraction of particles for composite materials reinforced with pomegranate peel powder.

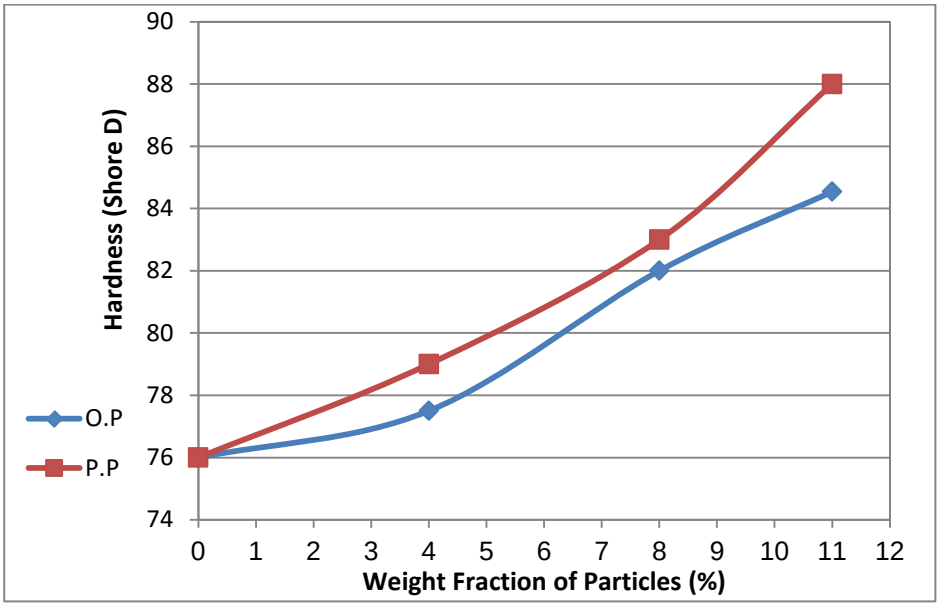


Fig. (3): Shows the relationship between hardness value & weight fraction of particles for composite materials.

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