

Improving the behavior of unsaturated polyester against wear by reinforcing it with thermoplastic polymers

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Abstract

This work includes preparation of composite materials and hybrids of unsaturated polyesters (UP) by reinforcing it with poly methyl methacrylate (PMMA) and high density polyethylene particles (HDPE) or (PE). These composites and hybrids were prepared by a hand-layup method with specific per cents. Wear test was carried on prepared polymeric composites and hybrids and their behaviour were studied.

The study of wear was taken with respect to changing time with weight and its effect on density. The results show a remarkable behaviour in improving the behaviour of wear of unsaturated polyester after reinforcing by comparing this behaviour with plain unsaturated polyester sample. It was concluded that the wear of unsaturated polyester could be delay by reinforcing it with low cost materials like other polymers such as PMMA and HDPE.

Introduction

Wear is the progressive loss of material from surfaces as a result of contact with other surfaces. It can occur as a result of sliding or rolling contact between surfaces or from the movement of fluids containing particles over surfaces. Because wear is a surface effect, surface treatments and coatings play an important role in improving wear resistance. Lubrication can be considered to be a way of keeping the surface apart and so reducing wear[1].

Wear is a common, costly and gradual degradation process involving loss of material and damage to which object and machinery are generally subjected as a result of mechanical contact. Which is usually involving undesirable consequences. But Wear rarely involves sudden failure, hence it is frequently accepted that items wear out. Actually, wear rates can be varied by several orders of magnitude through choices in design and materials as well as through the conditions of use and maintenance. Lubrication to reduce wear is common strategy in tribology, the science and technology of interacting surfaces in relative motion [2].

Wear in polymers can be explained according if its thermoplastics or thermosets. Thermoplastics generally wear more readily than thermosets.

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Plastics wear primarily by adhesive and abrasive processes. There is usually little chemical enhancement of wear although the absorption of water by polymers such as nylon will strongly influence the wear rate. Plastics are also subjected to fretting wear but less often in bearing applications than metals [3].

The actual wear process of plastics is more complex than this. Repetitive sliding of a plastic on a metal counter face will produce a thin transferred film of plastic on the metal if the system is clean. With repeated passes, this film achieves equilibrium thickness and little further material is lost from the plastic. Where the system is greasy or contaminated there may be only poor adhesion of the plastic to the metal, thus producing high wear of plastic. Hence a poorly lubricated system may produce wear rates that are 100 or 1000 times larger than in a dry or clean system. Unfortunately wear measurements are subject to considerable uncertainty and scatter as a result of minor differences in test geometry, environment and other conditions [4].

V. Marusic and et.al. 2008. Studied the Abrasive wear resistance of glass fiber reinforced polyesters laminates. Tribological properties and damages of fiber reinforced polyester laminates have been examined; Correlation between tribological and mechanical properties was determined by analyzing test results [5].

Katia R. Reis and et.al. in the same year. They evaluate the wear resistance of poly methyl meth acrylate (PMMA) denture teeth based on their chemical composition when opposed by a ceramic antagonism. They conclude that the three types of PMMA denture teeth presented significantly different wear resistance against the abraded ceramic. The high-strength PMMA denture teeth were more wear-resistant than the conventional PMMA denture tooth [6].

Gaurav Pradhan & David John in 2009. Composites were fabricated using Epoxy and Polyester resin as polymer, chicken feather and coir dust as reinforcements. Composites without reinforcement and composite with 20% weight fraction reinforcements were made. They were then experimented in the erosion testing machine. Results showed a lesser erosion rate in coir dust reinforcement than in chicken feather. Also polyester matrix composites showed lesser erosion rate than epoxy matrix composites. [7].

R. Autay and et. al. in 2011 investigated the possible formulation of conductive polymer composite (CPC) from recycled poly(carbonate) (PC) and crushed rubber microparticles (CR) for tribological applications. Pin-on-disc tests carried out under water lubrication show that the wear rate increases with the increase in load and sliding velocity. Additionally wear experiments proved to be effective in evaluating the quality of PC/CR interface [8].

This work aimed to prepare composite materials and hybrids of unsaturated polyesters (UP) by reinforcing it with poly methyl methacrylate (PMMA) and

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high density polyethylene particles (HDPE) or (PE) and studying its behaviour when exposed to wear conditions.

Experimental work

Materials

-Matrix

1. Resin Unsaturated polyester (in a liquid state).
2. Accelerator Cobalt Naphthalate (in a liquid state).
3. Hardener Methyl ethyl Keton Peroxide (MEKP) (in a liquid state).

- Reinforcement

- a) PMMA polymer (poly methyl methacrylate) (in a solid state as small spheres).
- b) HDPE polymer (high density polyethylene) (in a solid state as small spheres).

Experimental Procedure

The basic processing procedure was started by preparing the materials, necessary to form composites and hybrids (resin, reinforcement, mold, mold release agent....etc.). The materials were weighed by a sensitive balance to weigh the proper quantities that is needed to produce the specimens.

A cylindrical metal mold of (1cm) in diameter which has a removable base to facilitate the demolding of the specimen after having sufficient rigidity beside a release agent is applied to the mold surface after it cleaned, were prepared.

Hand lay-up was chosen to form the specimens, unsaturated polyester was chosen to be the matrix is mixed with the accelerator (Cobalt Naphthalate) which will give it a pink colour after it was transparent, then the hardener (MEKP) is mixed with them. Each accelerator and hardener should add at specific percentages to keep the reaction under control because it's an exothermic reaction and to prevent any internal stresses or bubbles can occur. After the homogeneity is achieved in the polymer; the reinforcement is added (2, 4, 6 gm PMMA or PE or both on the hybrids) to the unsaturated polyester. Thoroughly mixing is recommended to achieve the best distribution in the formed composites or hybrids specimens.

The composites and hybrids that formed allowed curing at room temperature for 24 hours to reach complete hardening. After curing the specimens are demolded and weighed.

Wear test technique

First the specimens should cut in to proper length that fit the wear apparatus. The two surfaces of the specimen should be smooth and even without any appearing of resin peeling, defects, any impurities or strange substances that could prevent the direct contact with the apparatus.

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A proper load for the wear apparatus, position where the specimen put to test on the grinding paper, type of grinding paper its fineness where selected to carry the test. Steel grinding paper with medium fineness and the position of the specimen on the grinding paper were on the half distance between the exterior circle of the grinding paper and its centre as shown in figure (1).

When the test carried on, a direct contact of the specimen with the grinding paper (steel grinding paper) of the apparatus should be accomplished.

The test where carried at room temperature and the data of weight and length with time where recorded for all specimens (composites and hybrids).

Results and Discussion

Composite materials can behave differently in testing by wear according to reinforcing material, percent, and geometry of reinforcing, etc. beside roughness of surface, material that cause the wear, the load applied ...etc.

In this study the load and the type of grinding paper (stainless steel) were fixed and test carried on in different times.

Two factors were playing the major role in testing the unsaturated polyester; the first one is the time of exposure (i.e. time of applying the load on the specimen under test). The second factor is the type of reinforcing (if it's composite or hybrid).

A remarkable improvement was notice after reinforcing the unsaturated polyester (UP) with (PE) or with (PMMA) when subjected under load in the wear test.

It was noticed that, when unsaturated polyester specimen subjected to wear test it decreases in weight and length (wear can be measured in terms of themass, or volume, loss from a sliding or eroding contact [9]), more than when reinforced with PE or PMMA separately (i.e. composite not a hybrid) Because composite materials which is composed of two or more different kind of components gives rise to a new material with a combination of properties of both kind of components [5], i.e. the differences in properties in PE and PMMA made an improvement in the wear behavior of unsaturated polyester. Beside the reinforcing amounts effect the behavior of specimens to wear and this was shown in figures (2), (3) and(4) which when studying these figures will shows that as the reinforcing amount increase the behavior to wear improve.

Also it was notice that the PMMA as a reinforcing material almost stay in steady behavior as its amount increase. While the PE act differently as its amount increase but still resist the wear more efficiently than unsaturated polyester without reinforcing.

When comparing the behavior of PE with PMMA separately in each percent it was found that at low percents the PE is lower in wear than PMMA, but at higher percents the PMMA become better than PE; i.e. PMMA decrease in

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weight less than PE as shown in figures (5), (6) and (7). The reason of this behaviour is that PE and PMMA are thermoplastics but PE is semi-crystalline polymer, while PMMA is glassy polymer which is ductile-brittle and it's good against abrasion as long as it's under glass transition temperature [9, 10, 11].

A similar behavior was noticed when studying the hybrid composites according to percents of components and length of time of exposure to wear load, which as the increasing in time cause increasing in wear i.e. increasing in losing weight as shown in figures (8),(9) and(10).

Figure (11) shows an improvement in wear behavior of UP after hybridization which means that hybrid composites weight decrease less than UP without reinforcing when subjected towards wear load.

When studying wear rate with density its found that the highest wear rate for the lowest percent in reinforcing material for both PE & PMMA because the most domenant is UP; and wear rates reduce with increasing volume percent of reinforcement [12] as showing in figure (12) and (13).

Conclusions

UP without reinforcing is the highest in wear and can be improved by reinforcing it with thermoplastic materials. When reinforced with PE its the highest in wear than PMMA. The hybridization also improve the the UP behavior against wear according to their percents. Time of expsure and percents of cmponents in composites or hybrid composites play a major role in studying wear.

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Figure (1) wear test device.

Figure (2) Effect of wear on weight at different time of PMMA and PE and plain up

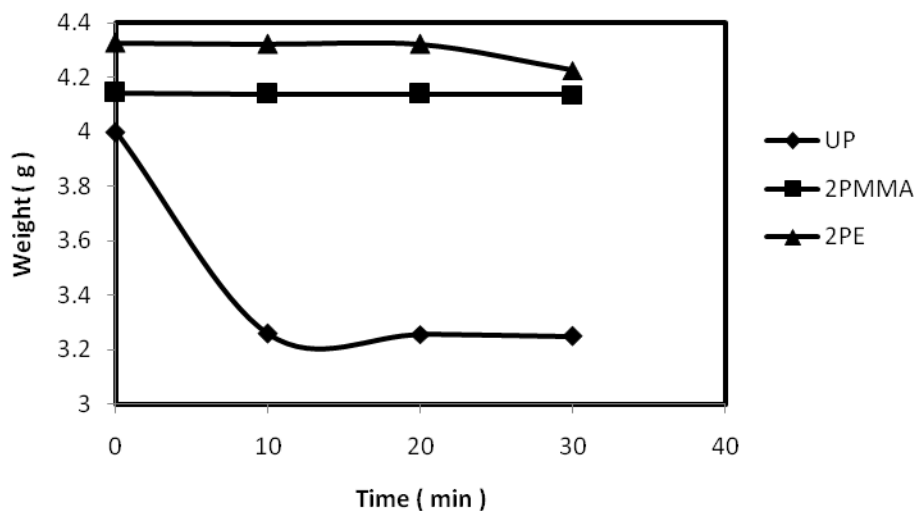


Figure (3) Effect of wear on weight at different time of PMMA and PE and plain up

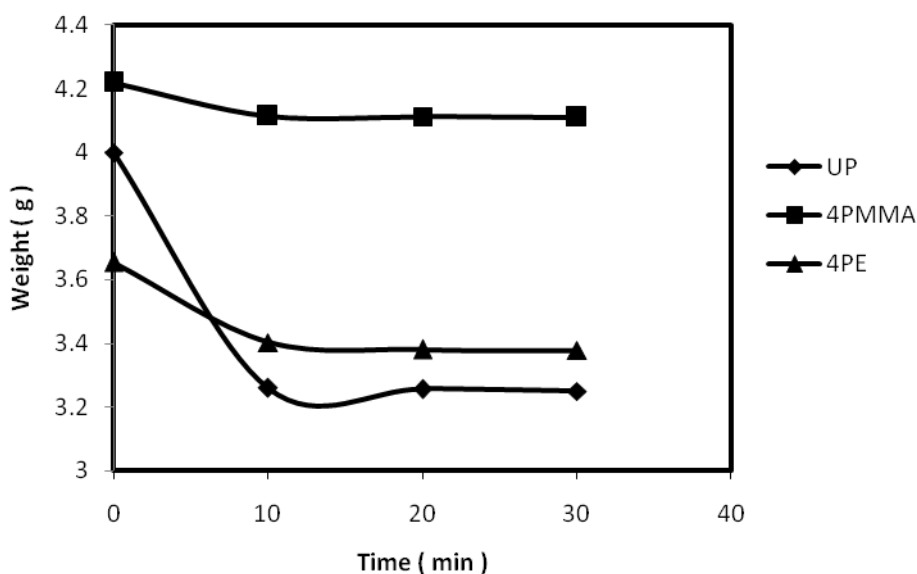


Figure (4) Effect of wear on weight at different time of PMMA and PE and plain up

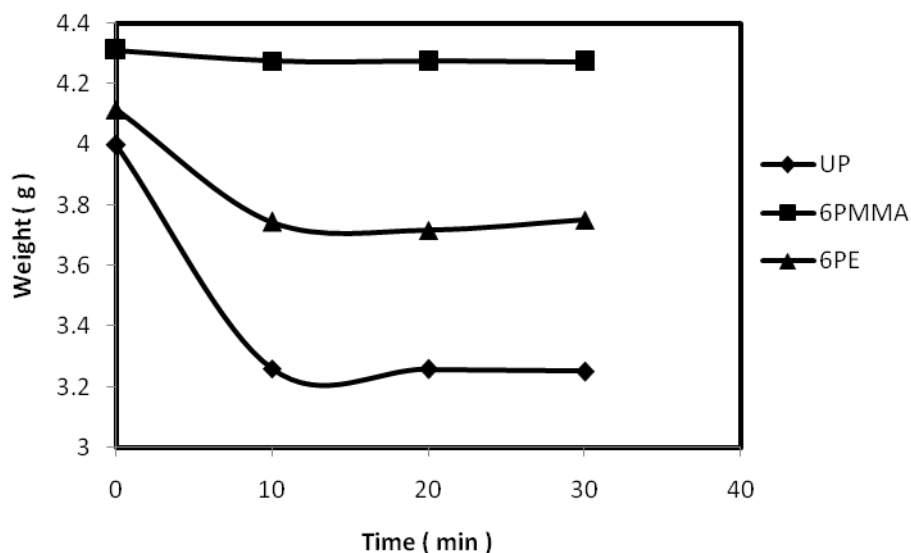


Figure (5) Effect of wear on weight at different time of PMMA and PE

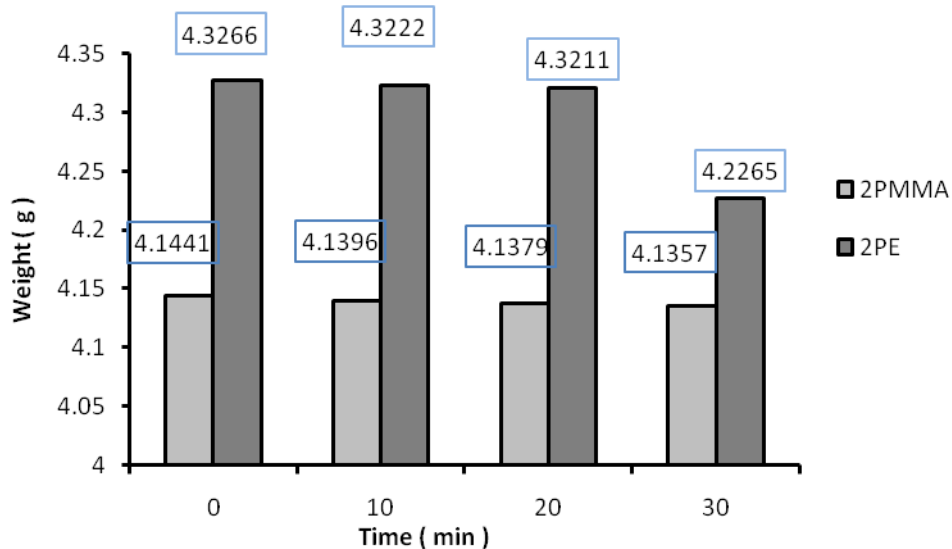


Figure (6) Effect of wear on weight at different time of PMMA and PE

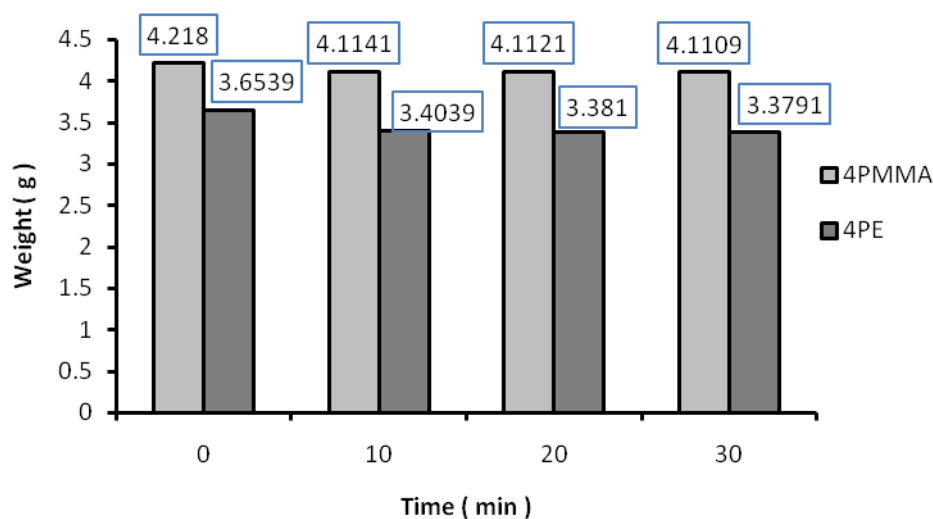
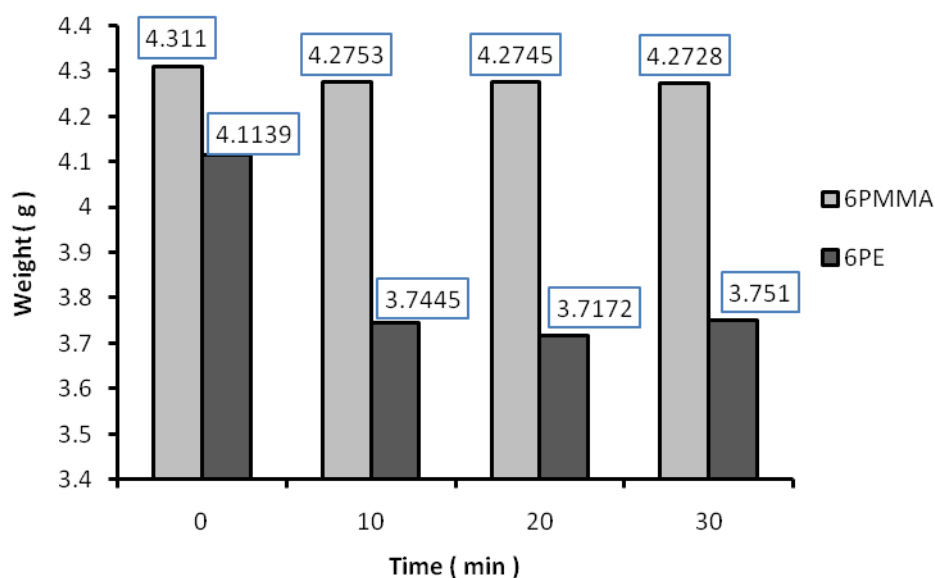
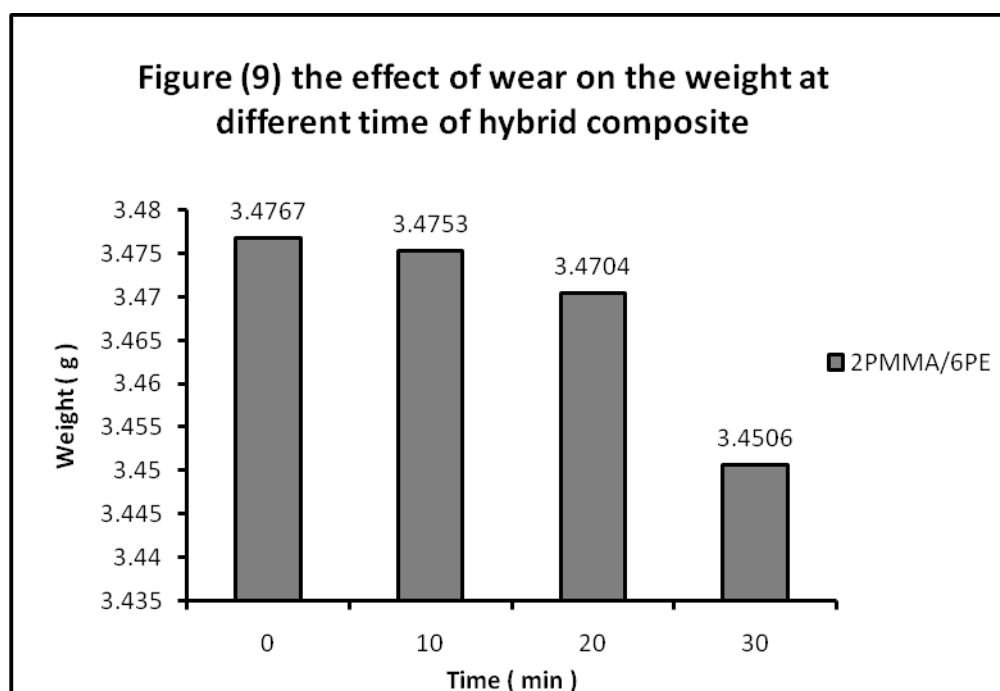
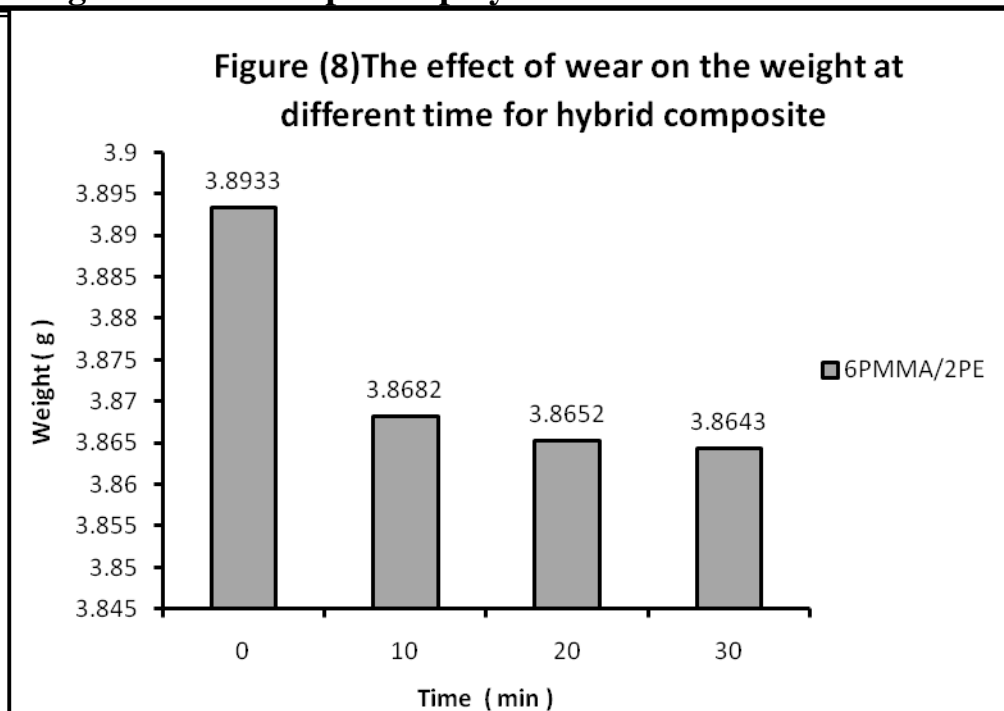
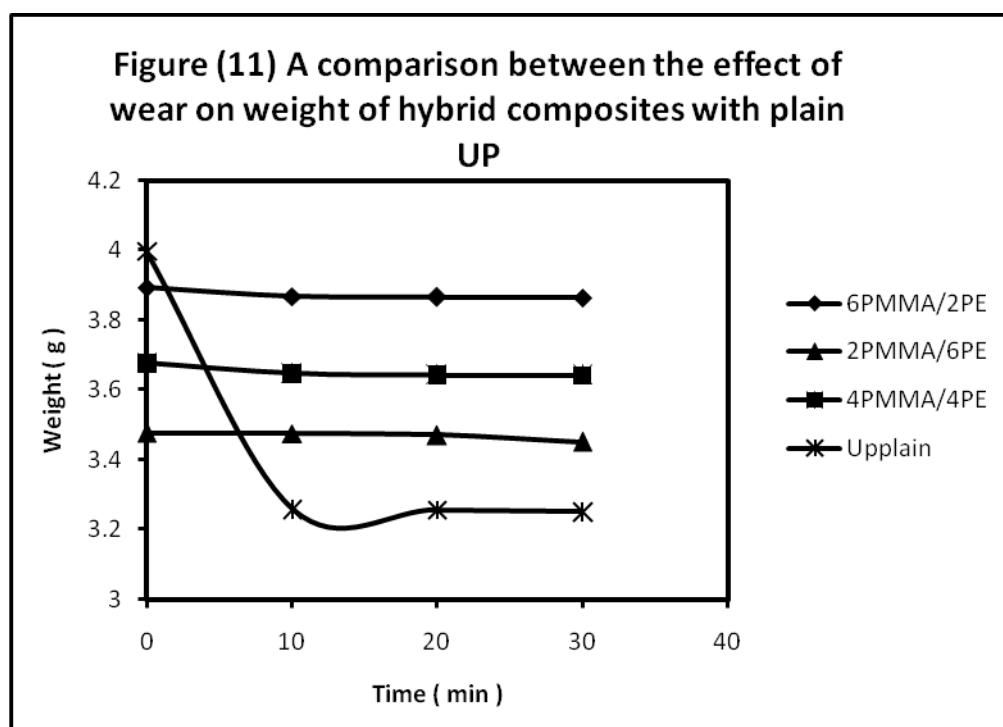
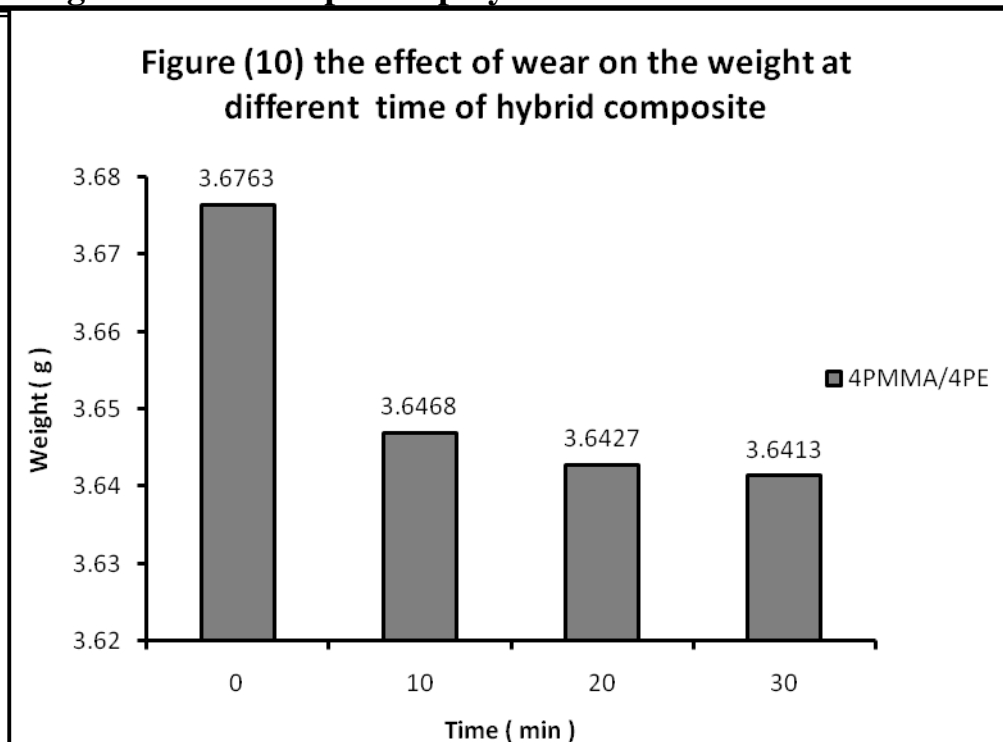
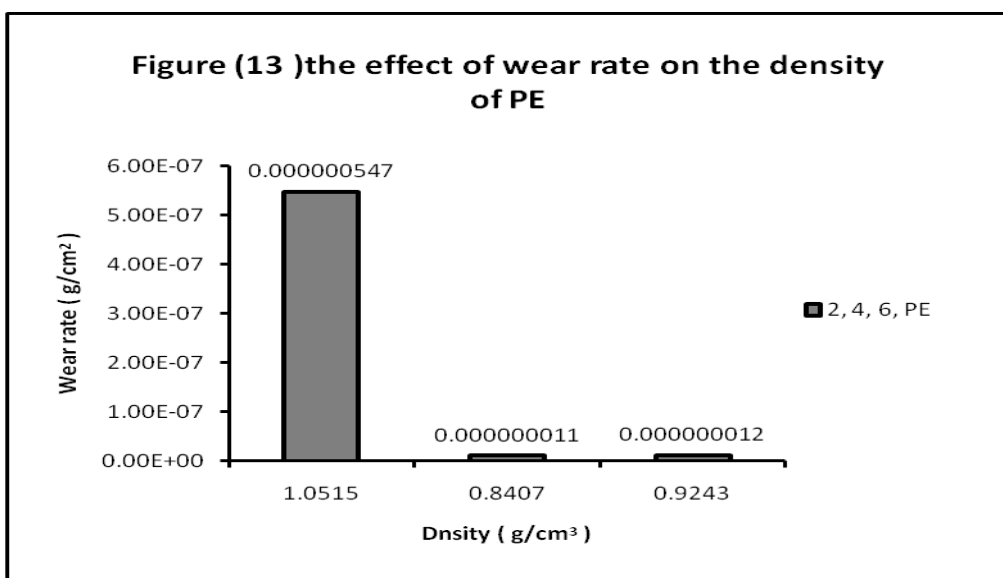
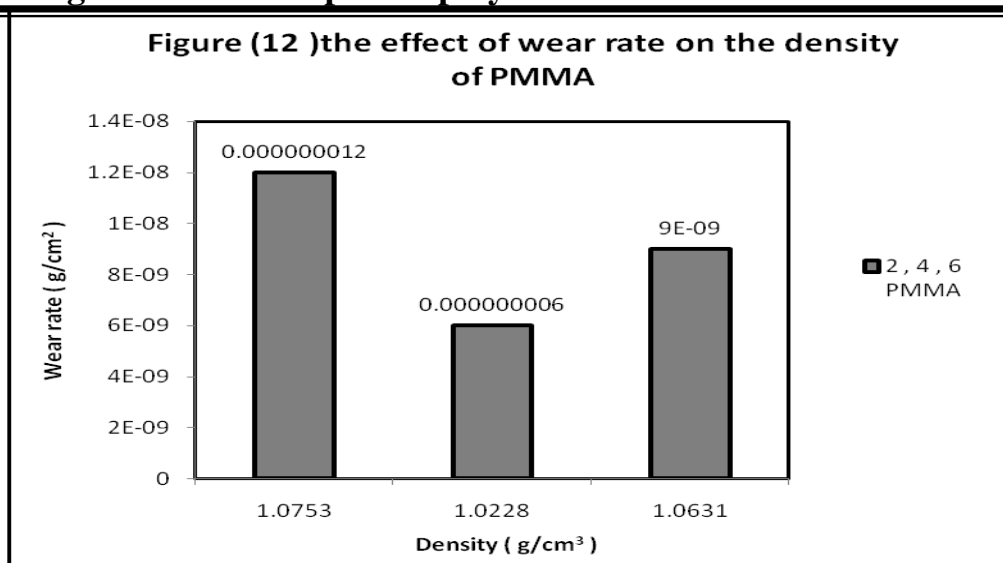


Figure (7) Effect of wear on weight at different time of PMMA and PE









تحسين سلوك البولي أستر غير المشبع للبلى بتدعيمه ببولييمرات مطاوعة حرارياً
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الخلاصة

تضمن هذا البحث تحضير مواد متراكبة واخرى هجينة من بوليمر البوليستر الغير مشبع وذلك بتدعيمه بحبيبات من مادة البولي ميثيل ميثا اكريلات (PMMA) و بوليمر البولي اثيلين عالي الكثافة (HDPE). وقد حضرت العينات بطريقة الصب اليدوي بنسب معينة.وقد درس فحص البلى على عينات المواد المتراكبة والهجينة البوليمرية حيث درس البلى للعينات وفقاً لتغير الزمن مع الوزن وتأثيره على تغيير قيم الكثافة.واظهرت النتائج تحسن في خواص البلى لعينات البولي استر الغير مشبع بعد التدعيم بمقارنتها بسلوك بوليمر البولي استر غير المشبع قبل

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التدعيم. وقد استنتج أنه يمكن تأخير زمن البلى للبولىستر غير المشبع وذلك بتدعيمه بمواد ذات كلفة واطئة مثل بوليمرات اخرى مثل PMMA و HDPE.