The Use of Pomegranate Shell Residues to Reinforcement the PMMA Used in Dentures

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Abstract

Polymethyl methacrylate (PMMA) resin was used in this research with pomegranate peel particles in weight fractions ((0,5,10,15,20,25,30% as a reinforcement material with a granular size of 45µm)). The samples were subjected to mechanical tests to study some mechanical properties (hardness, tensile, compressive) at laboratory temperature (27°C).

The results of mechanical tests represented by (tensile, compressive) showed that the best value obtained for the tensile modulus is (68Mpa) at a mass fraction of 15%, and the best value for compressive strength (93 Mpa) at a mass fraction of 10%, while the hardness values reach the lowest value (70N/mm2 due to the increased reinforcement with pomegranate peels).

Key Words: PMMA, Pomegranate Shell, Tensile, Compression, Hardness.

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Introduction

Micro composites materials are one of the advanced materials classes that emerged at the end of the previous century and flourished in many industrial and life fields to solve all the problems we face [1] as composite materials have become one of the sources of attraction for investors and manufacturers. Therefore, its use has increased in various industries and technological applications, with its ideal characteristics, including strength, high rigidity, low costs, in addition to lightness in weight[2]. Given the requirements in all fields, the need has arisen to use composite materials with very high mechanical properties. Among the factors that affect the properties of the composite material are the size and shape of the reinforcement particles and how they are distributed in the substrate in a good way, in addition to the nature of the interconnection between the particles supported by the substrate, as well as the interface area [3]. Several polymers are used as a base material, including thermosetting (PMMA) resin. It is a synthetic acrylic resin, also called organic glass. It is widely used in the manufacture of dental dentures and is also used in composite materials such as memory disks. PMMA is characterized by durability, high transparency, corrosion resistance, good insulating properties, lightweight, resistance to many chemicals, and soluble in organic solvents. This resin has a double hardening specification. At the same time, it has high flexibility and bears great stress that prevents cracks from occurring during use. Pomegranate peels are agricultural residues available in large quantities and are natural and can show high hardness and hardness. It has encouraging advantages, including low cost, availability, biodegradability, broad flexibility, and acoustic insulation [3]. Low shrinkage during solidification can fill voids and bubbles formed during manufacturing.

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Equipment and Materials Used

Base Material

Polymethyl methacrylate (PMMA) resin with cold-type hardener was used as the base material. It is a light pink solid powder with a density of (1.19 g/cm³). It is converted to a liquid state by adding a hardener of methyl ethyl ketone peroxide, a transparent liquid with PMMA resin in a ratio of (1:2 g) to increase solidification speed.

Reinforcement Material

The reinforcement materials, pomegranate peels, were cleaned and placed under the sun's rays and then grinded well in a high-quality technical way to obtain minutes with a granular size of approximately (45 µm) in weight ratios (0,5,10,15,20,25,30%).

Sample Preparation

The method adopted for preparing the samples is the hand-lay-up molding method. According to international standards, aluminum molds were used, polished, and free from defects, with weight percentages (0,5,10,15,20,25,30%).

The (PMMA) was mixed with the pomegranate peels gradually and slowly to achieve complete homogeneity between (PMMA) and the pomegranate peels, and the mixing continued slowly so as not to create bubbles that affect the consistency process. The mixing is done in all directions to ensure the uniformity process for a period of (3 minutes) so that no lumps occur in the mixture prepared for pouring into the special molds. After ensuring the proportionality and the absence of lumps and obtaining a suitable viscosity, the mixture is poured into the mold regularly, and after the completion of the process of pouring the samples into the molds, it is left to solidify well for (15 minutes) at room temperature. Once frozen, it is placed in an electric oven at a temperature of (50°C) for a period of (1 h) in order to get rid of the internal stresses to obtain the best interlocking of the polymeric chains and the best stiffness. According to the weight ratios, the process is repeated with the same steps on all the overlapping samples.

Mechanical Tests

Tensile tests: Tensile samples were prepared according to the required standard dimensions and the approved American specifications (ASTMD 638-03) [5]. The tensioning device of the type LARYER Yaur Tasting Solutions was used. The device works to tighten the sample from the upper and lower side, and then a stress force (load) is applied to the sample until the collapse process (failure) occurs. By reading the graph, we get stress-strain curves. Figure (1) represents the standard dimension diagram for tensile testing according to the international specifications (ASTM), Figure (2) shows the tensile test samples, and Figure (3) represents the tensile testing device.

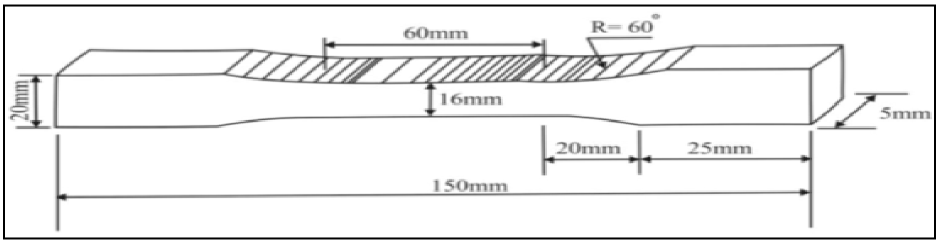

Figure 1. Scheme of tensile samples according to ASTM International Standards

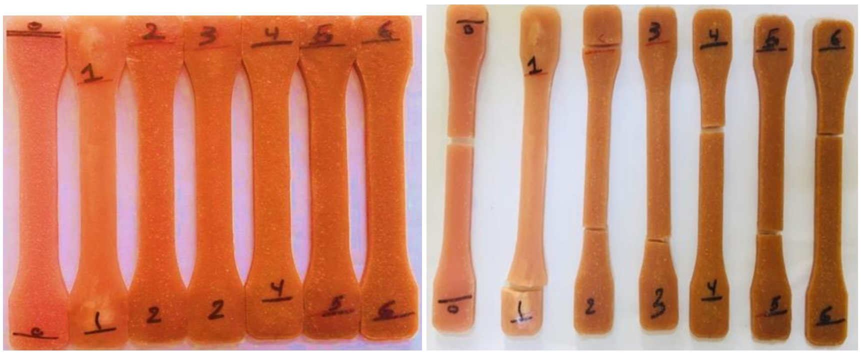

Figure 2. Tensile test samples before and after examination

Figure 3. Shows the tensile testing device

Compression tests: The compressibility test of the samples was carried out using the university testing device according to the international standard (ASTM D 695-02a) [6]. Figure (4) shows the compressibility test samples. The dimensions of the samples were 5 mm in length and width and 10 mm in height. This resistance is measured by the ratio of the applied load to the unit area of the cross-section exposed to the load [7]. Figure (5) represents the pressure test device for samples.

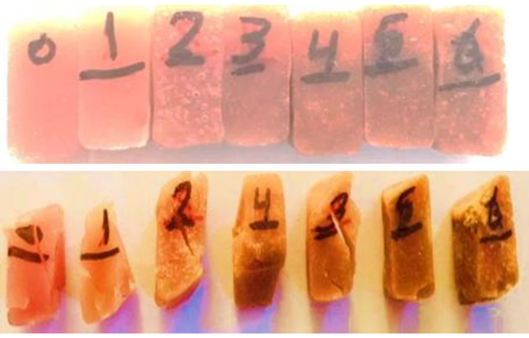

Figure 4. Compressive strength test samples before and after being tested

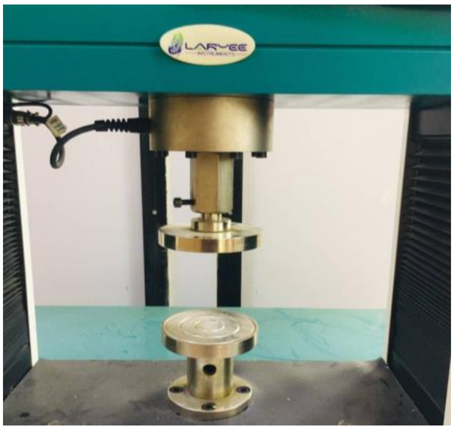

Figure 5. Shows the compression test device

Hardness

The concept of hardness is a measure of the deformation that occurs to the plastic, and the material suffers under the influence of external stress [8]. The hardness test was conducted using a surface hardness measuring device (Shore-D) according to the international standard (ASTMD2240) [9]. Using a point stitch tool and penetrating this tool into the material's surface under the influence of a particular load, the resistance is transmitted directly to the measuring meter to determine the hardness value to appear on the screen. We repeat the process five times. Figure (6) is a diagram to measure the dimensions of prayer. Figure (7) represents a hardness measuring device.

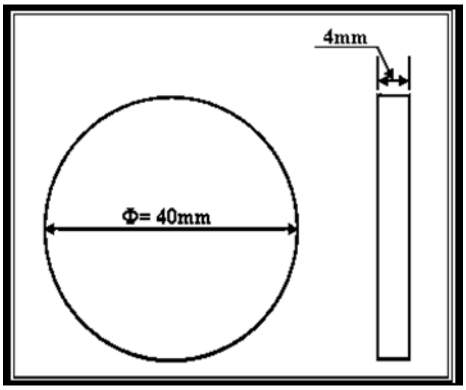

Figure 6. A diagram for measuring the dimensions of the hardness

Figure 7. The hardness measuring device

Results and Discussion

Tensile Test

Figure (8) shows the relationship between the tensile modulus of the composite materials and the quantity of the weight ratios of the particles prepared from the pomegranate peels. It was noted that the highest value of the tensile modulus when examining those samples that were prepared by

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weight ratios is (15%), reaching (68Mpa). This is due to the nature of the pomegranate peel particles and their association with the primary substance (PMMA). This made it more durable and cohesive, and the homogeneous distribution of the particles hindered the movement restriction of the polymeric chains. Moreover, this increases or decreases the tension and the critical role that the particles play by impeding the increase of slips occurring within the polymeric bonds. The decrease in the tensile value results from a decrease in the wetting property [10].

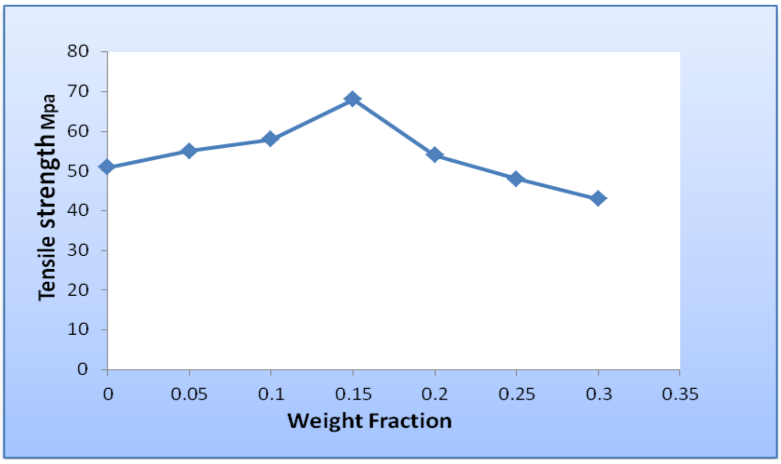

Figure 8. The relationship between tensile strength and mass fractions

Compressibility Test

This test aims to know the maximum stress that the samples prepared from polymeric materials and their compounds can withstand under the influence of vertical pressure applied to them. The test was conducted for all samples at laboratory temperature.

The results are shown in Figure (9) regarding the compressive strength values of the prepared samples showed a significant improvement in the compressive strength of all samples at the pomegranate peels. The best value obtained at (10%) by mass fraction reached (93).

The presence of the particles hinders the movement of the polymeric chains, leading to an increase in the material's resistance to the external stresses imposed on it [11]. This is due to the presence of those particles, as the load is distributed over the particles and is transmitted from the base material to those particles through the interface. Furthermore, those particles are the ones that bear the more significant part of the stress applied to the material, which raises the values of its compressive strength. Also, the binding efficiency between the base material and the particles works to raise the values of its resistance to compression. The compressive strength of the composite material increases with the increase in the percentage of added particles for the same reason mentioned.

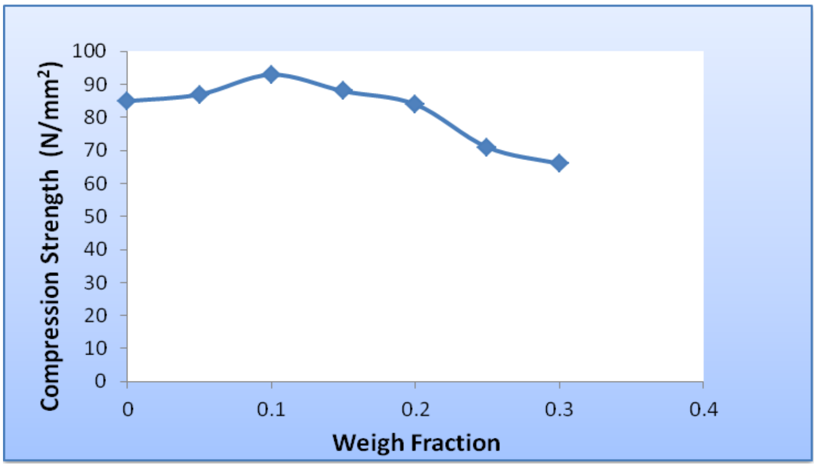

Figure 9. The relationship between compressive strength and mass fractures

Hardness Test

The hardness test enables us to know the extent of the cohesion and strength of the mass of the material. Therefore, this test was conducted to measure the surface hardness of the samples prepared from the polymeric materials and their compounds from the particles and the different reinforcement ratios. We notice from Figure (10) that the hardness values of the samples fortified with pomegranate peel particles begin to decrease with the increase in the weight fraction of the pomegranate peel particles. This is due to the low hardness of these particles. This is due to the presence of those cemented particles that are characterized by their low hardness [12]. The reason is that the high-density pomegranate peel particles led to filling (dam) and reducing the gaps and voids formed during the molding process. This leads to an increase in entanglement and agglutination, which reduces the movement of molecules and chains and thus increases the resistance of the surface of the material to stitches and deformation [13].

When the particles are small, they easily penetrate the substrate and into the pores and interfacial spaces that are likely to form during the sample preparation process. This increases the contact area between the composite material components, increases the bonding between its components in an integrated manner, and gives more positive values when testing the hardness. The plasticity that may occur in the material due to an external influence, and therefore the addition of particles leads to a decrease in the hardness values when the weight fractions of the pomegranate peel particles increase [14]. This can be considered a measure of deformation.

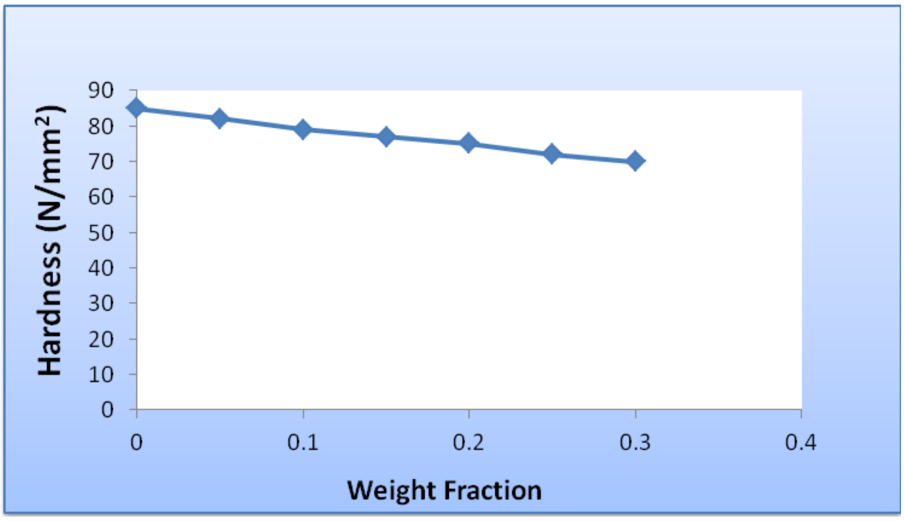

Figure 10. The relationship between hardness and mass fractions

Conclusions

Through the results obtained, it was found when using quantities of pomegranate peel particles with polymethyl methacrylate (PMMA) resin, an improvement in the mechanical properties (tensile, compressive). The higher the weight ratios of the pomegranate peel particles and the decrease in the mechanical properties (hardness), the higher the weight percentages of the pomegranate peel particles.

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