Sumer Journal for Pure Science (ISSN: 2790-7031)
SJPS 2024 (August), Vol. 3, No. 1, p.p.: 39-47

Enhancing the Mechanical and Physical Properties of PMMA Resin through Clove Particle Reinforcement

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Abstract

This research looks into adding natural bits from clove powder to make poly Methyl Methacrylate (PMMA) resin stronger. PMMA is a common material for dental prosthetics used every day. With great care the samples were made by hand in different amounts (8%, 6%, 4%, 2%and 0%) and with a particle size of 53 micrometers were prepared using the manual melding method. Mechanical properties such as tensile strength, bending strength and Physical properties such as thermal conductivity. The findings demonstrated an improvement in the results of the tensile values. The highest value was recorded at the volume fraction (4%), which reached 49 MPa), and the bending values also showed an improvement. The highest value was recorded at the volume fraction (4%), reaching 61 MPa), while the thermal conductivity value showed a decrease by increasing the volume fraction of powder, where the minimum value was recorded at the volume fraction (8%) reaching (0.044 W/m.℃). this study is good results can help in the area of biomaterials . It could start new improvements to make better dental stuff stronger and longer – lasting. Clove extracts was used to reinforce the polymethyl methacrylate (PMMA) resin used in denture bases. Samples with a granular size (53 micrometers) and volume fractions of Clove extracts was used to reinforce the polymethyl methacrylate (PMMA) resin used in denture bases. Samples with a granular size (53 micrometers) and volume fractions of

Keywords: Clove extracts, Mechanical properties, physical properties, Denture bases, Poly Methyl Methacrylate (PMMA) resin.

تعزيز الخواص الميكانيكية والفيزيائية لراتنج *(PMMA)* من خلال التدعيم بجزيئات القرنفل

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الخلاصة

تم استخدام مستخلصات القرنفل لتعزيز راتنج بولي مثيل ميثا اكليرك (PMMA) المستخدم في قواعد اطقم الاسنان وبكسور حجمية (0%,2%,4%,6%,8%) وبحجم حبيبي (53 مايكرو متر) باستخدام طريقة القولبة اليدوية . الخواص الميكانيكية مثل قوة الشد ,قوة الانحناء والخواص الفيزيائية كالتوصيلية الحرارية.اظهرت النتائج تحسنا في نتائج قيم الشد فقد سجلت اعلى قيمة عند الكسر الحجمي %(4) وقد بلغت (49MPa) وكذلك اظهرت قيم الانحناء تحسنا . فقد سجلت اعلى قيمة عند الكسر الحجمي %(4) اذ بلغت(61MPa) بينما بينت قيمة التوصيلية الحرارية انخفاضا مع زيادة الكسر الحجمي للدقائق حيث سجلت اقل قيمة عند الكسر الحجمي (8%) حيث بلغت (0.044W/m). يمكن ان تساعد النتائج الجيدة لهذه الدراسة في مجال المواد الحيوية . يمكن ان تعطي تحسينات جديدة لجعل الاسنان افضل واقوى واطول امد.

1. Introduction

As a result of the industrial and technological progress and development that the world is witnessing today in all fields, especially materials science, researchers sought to find alternatives to these materials with engineering specifications that are characterized by being good, cheap in price, and light in weight, so what is known as composite materials were produced [1]. Compound materials can be defined as materials resulting from the combination of two or more materials, resulting in new materials with new properties that cannot be obtained from the original materials individually [2]. These composite materials consist of a base material and a reinforcement material. The composite materials are often ceramic, polymeric, or mineral based, depending on the type of use, whether in industry or medical fields. [3,4] Nowadays, polymers play an important role in the field of denture bases. Teeth The most common material used to build dentures is polymethyl methacrylate [5]. Polymethyl methacrylate resin has several advantages, including its light weight, ease of repair, and reduced cost, in addition to being considered a non-toxic material [6-8]. Cloves are famous for their distinctive aromatic scent and have health benefits. The taste of cloves is described as sharp, pungent, and aromatic with a slight bitterness, and it is one of the most important Uses of clove powder: It contributes to the treatment of toothache because it contains the compound Eugenol, which is a natural anti-bacterial, anti-fungal, and pain-relieving compound [9].

The research aims to study the mechanical and physical properties of polymethyl methacrylate (PMMA) resin mixed with clove powder, which is used in denture bases.

(a)

(b)

Figure -1 (a) clove sticks, (b) cloves after the grinding process

2. Sample Preparation

The hand melding process was used to prepare the polymeric composites is one of the easiest and most common methods. Samples were cut and then ground and used in volume ratios of (8%, 6%, 4%, 2%, 0%) it is then progressively combined with PMMA to obtain Ensure complete homogeneity and avoid the formation of bubbles that form when mixed quickly. The mixing mechanism was carried out for a period of time (2 to 4 minutes) and to guarantee the homogeneity process in all directions. Then the material was poured into the prepared Molds and left for about 30 minutes. After freezing, and put it in the oven for one hour at 50 degrees

Celsius. after which the sample was left. In order to cool, this is called heat treatment. The aim is to eliminate the stresses generated during casting the sample, and the same steps are repeated for all samples according to their volumetric proportions.

3. Mechanical Tests

3.1 Tensile Test

According to the approved American dimensions, tensile test samples were prepared the tensile test was conducted for the prepared samples using a tension device of the type (LARYEE Your Tasting Solution), as shown in Figure (2), where the sample was fixed. In the place designated for it between the jaws for the sample path and ensuring that the sample does not move during the test procedure. When the device is turned on, the handles begin to tighten the sample from the upper and lower sides and by applying the tensile force on the sample through the graph on the computer screen (as the tension device is connected to a computer Electronic) for all samples, and through the device's graph we obtain the results in the form of a curve (stress – strain), from which the tensile strength can be calculated. Figure (3) shows the tensile samples before and after the test.

Figure -2 Tensile testing device

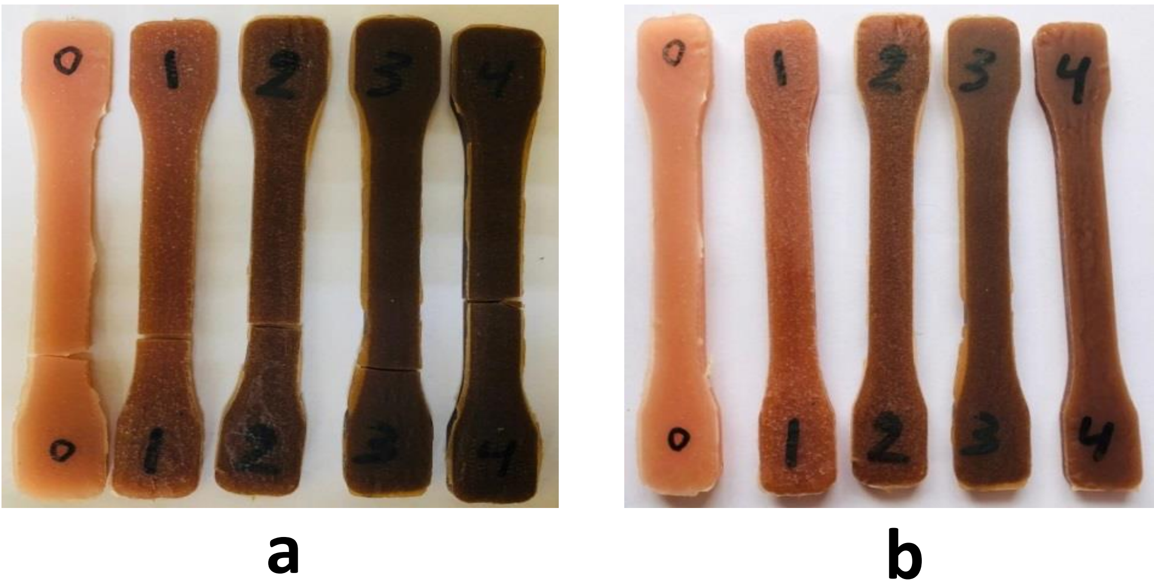

Figure -3 Tensile test samples (a) before and (b) after testing

3.2 Bending Test

The (LYREE Your Tasting Solution) device shown in Figure (4) was used to conduct the Tree Point Bending Test, where the sample is installed on two fulcrums and then a load is gradually applied so that the load is concentrated in the middle of the sample and the sample begins by bending and through the graph, we obtain the values of bending resistance. The bending samples were prepared with standard dimensions (4.8 x 10 x 100 mm^3) according to the international standard specifications (ASTM D-790). Figure (5) shows the bending samples before and after the test.

Figure -4 Bending testing device

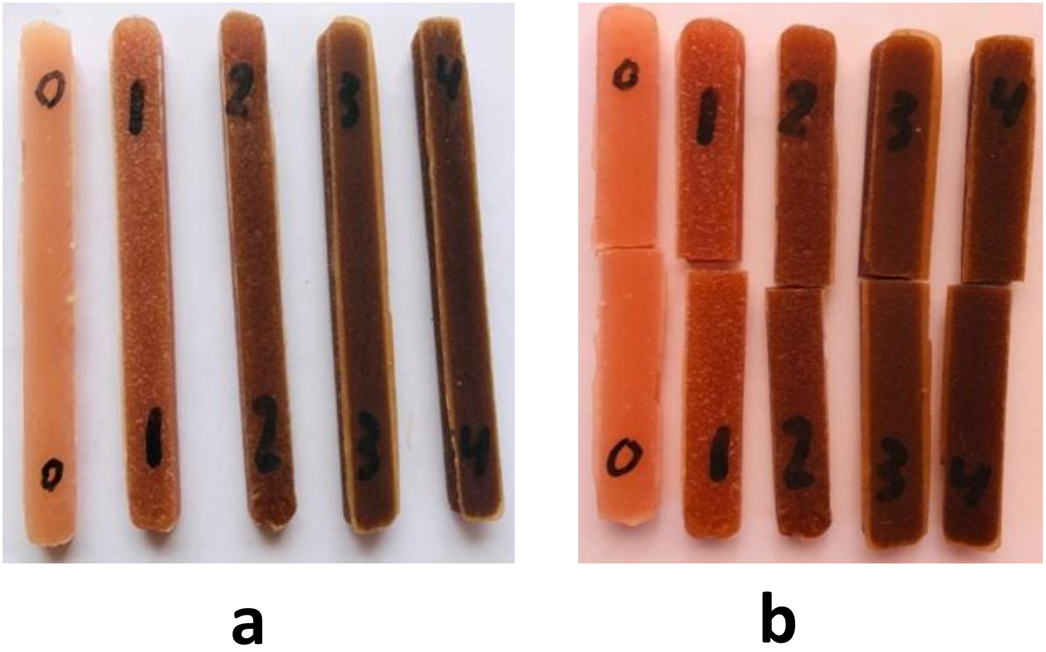

Figure -5 Bending test samples (a) before and (b) after testing

4. Physical Tests

Thermal conductivity: Using Lee's Disk device, shown in Figure (6), samples were examined for thermal conductivity. This device consists of an electric heater, as well as three copper disks, where heat is transferred from the heater to the next disk and then reaches the disk. Finally, passing through the test sample and through the three heaters inside the copper discs, the temperature of the three discs is calculated (Ta ,Tb ,Tc) The thermal conductivity can be calculated by knowing the radius (r) (mm)) and the thickness of the disc (ds) (mm) and the potential difference, which is equal to(6 volt) and the current equals(0.25 Ampere). The shape (7) test samples.

Figure -6 Thermal conductivity testing device

Figure -7 Thermal conductivity test samples

5. Results and Discussion

5.1 Tensile testing findings

A tensile test was conducted for samples prepared from polymethyl methacrylate (PMMA) resin reinforced with clove fines. It was found that the tensile strength values increased with increasing volume fraction of fines and that the highest value was obtained at the volume fraction (4%). It reached (49 MPa), as shown in Figure (8). We conclude that the grain size has an effect on the tensile strength values and the reason for this is that the reinforcement materials that are larger in size when they stick together create gaps between them that are difficult for the base material to enter, which leads to the weakness of the overlay material. As for the reinforcement materials that are smaller in size, when they stick together, no interspaces are generated between them, which gives better cohesion, and this agrees with the researcher [10]

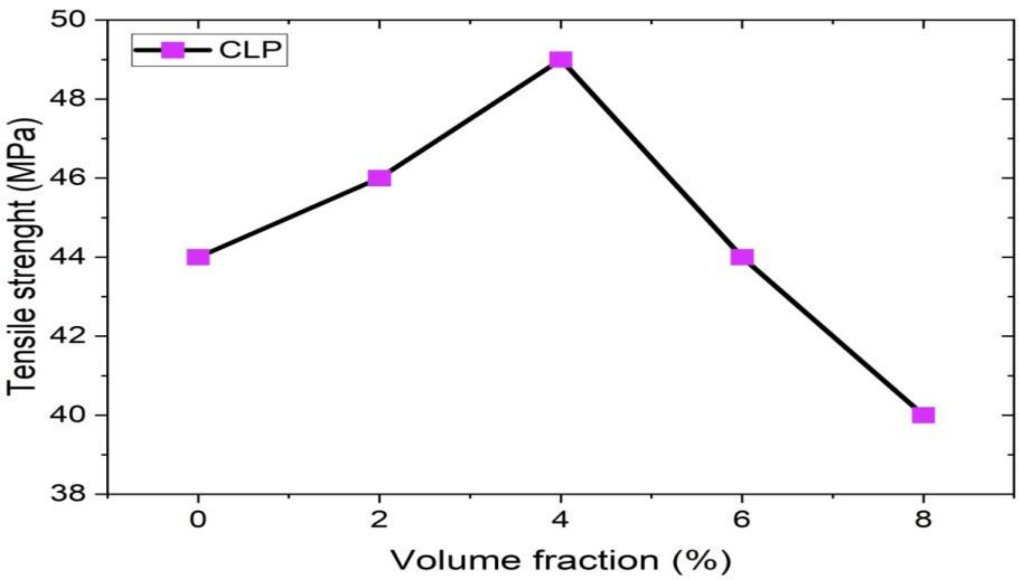

Figure -8 The relationship between tensile strength values and volume fraction

5.2 Bending testing results

Figure (9) shows the results of the bending resistance test begin to increase when reinforced with clove minutes, as the highest value was recorded at the volume fraction (4%), reaching 61 MPa). The reason for this is that the minutes bear the bulk of the stresses that are imposed. On the sample, as the clove powder has a great ability to wet the resin when it is in the liquid state, and thus the force of interlocking between the resin and the particles is great [11].

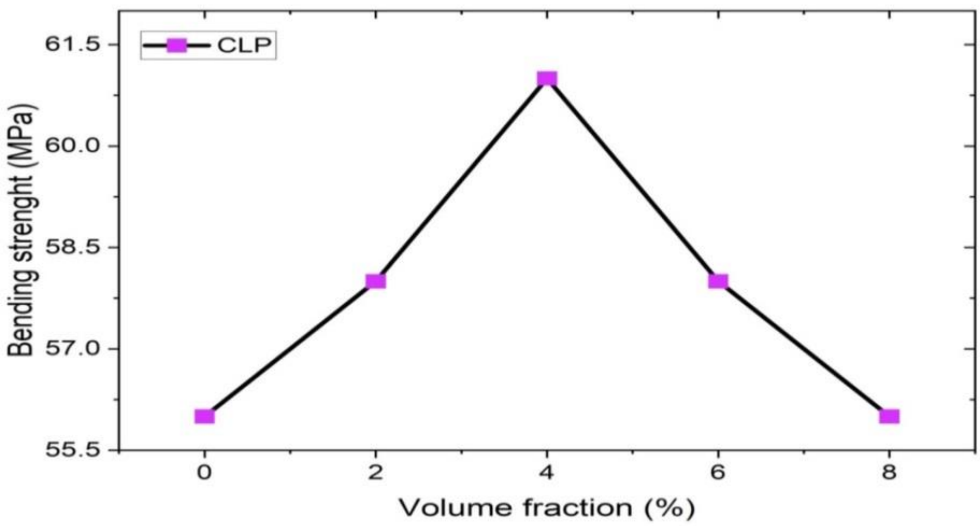

Figure -9 The relationship between bending values strength and volume fraction

5.3 Thermal conductivity testing results

It was shown in Figure (10) when the polymethyl methacrylate resin was reinforced with clove powder that the thermal conductivity values began to decrease with increasing volume fraction. The lowest value of thermal conductivity was recorded at the volume fraction (8%), which reached (0.044). W/m.℃) The reason for this is due to the insulating nature of the particles that have been added to the resin, as they generate air voids inside it, which works to insulate heat, as the transmission of elastic waves (phonons) is through the vibratory movement of atoms through the base material and by the covalent bond. The phonons will suffer from an obstruction in their movement when they reach the particles due to the difference in the structure of the composition between the two media (the base material and the support material), and all of this causes a decrease in the thermal conductivity values, and this agrees with the researcher [12].

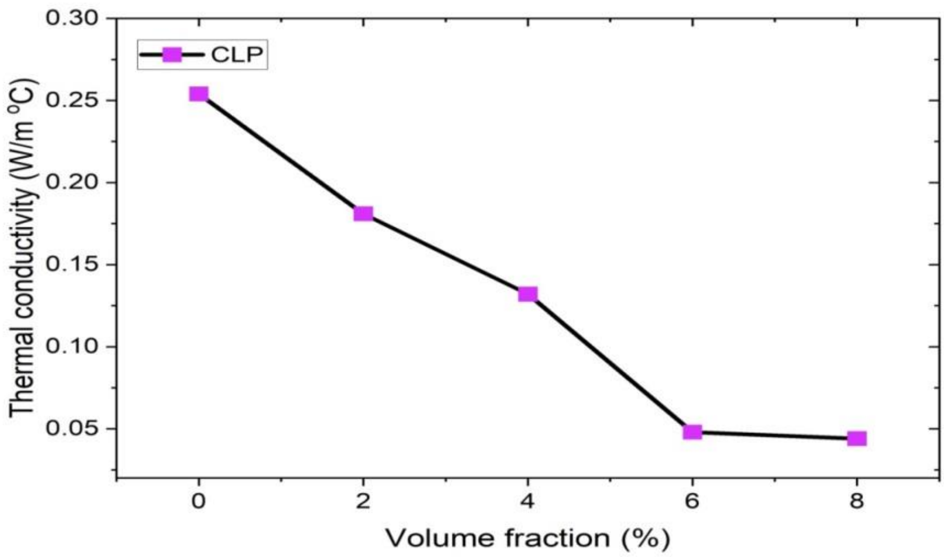

Figure -10 The relationship between volume fraction and thermal conductivity values

6. Conclusions

The results showed an improvement in the values of tensile strength and flexural resistance when using polymethyl methacrylate (PMMA) resin reinforced with clove particles with increasing volume fractions, while we found a decrease in thermal conductivity values with increasing volume fraction. This effect is evidence of the intense strength of clove particles within the PMMA matrix, which makes for a very strong argument towards the prospect that such composite materials may be found useful in many situations. The consideration of clove microstructure on mechanical performance is crucial. In fact, the investigation of whether the buildup of clove particles causes the alteration of microstructure that led to the improved resistance of the material to the penetration and the scratches deserves more attention. This work is not just to emphasize the possible yields that could be accomplished by blending clove dusts but also to let the researchers have more extensive deliberation about the complexity of the interactions that are involved with the base polymer matrix. These achievements are essential for maturing the knowledge on the polymer composites and they provide a basis for discovering new innovative strategies that will be applicable in a wide range of engineering and biomedical fields.

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