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Studying the Mechanical Properties of Denture Base Materials Fabricated from Polymer Composite Materials

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Abstract

In this research, the effect of adding two different types of reinforcing particles was investigated, which included: nano-zirconia (nano-ZrO_2) particles and micro-lignin particles that were added with different volume fractions of 0.5%, 1%, 1.5% and 2% on the mechanical properties of polymer composite materials. They were prepared in this research, as a complete prosthesis and partial denture base materials was prepared, by using cold cure poly methyl methacrylate (PMMA) resin matrix. The composite specimens in this research consist of two groups according to the types of reinforced particles, were prepared by using casting methods, type (Hand Lay-Up) method. The first group consists of PMMA resin reinforced by (nano-ZrO_2) particles, while the second group consists of PMMA resin reinforced by (micro-lignin) particles.

The mechanical tests performed in this research includedtensile test, compression test, impact test and hardness test. The results of this study showed that the values of tensile modulus of elasticity, compressive strength and hardness properties increased with increasing the volume fraction of these particles in PMMA composite materials. While, the values of tensile strength, elongation and impact strength properties decreased. Also, the addition of (nano-ZrO_2) particles showed greater effect than that of (micro-lignin) particles in some properties of PMMA composite materials for prosthesis denture base materials specimens, while they have lower effect for the other properties.

Keywords: *Compression Test, Lignin, Nano-ZrO_2, Hardness Test, Impact Test, Particles, PMMA, Tensile Test.*

1. Introduction

Many biomaterials are available in medicine and dentistry fields, which can be classified as metals, polymers, ceramics and composites materials, with all have advantages and drawbacks and they are developed to be used for bone and tooth problems. Polymers have low mechanical strength compared to bone and tooth. Metals have superior mechanical properties wear resistance and biocompatibility, but they are very corrosive. Ceramics are brittle and have low fracture toughness. All these properties of polymers, ceramics and metals are considered and combination to produce the composite materials. Although the polymer material using in dentistry fields, but polymer composites materials are available in a wide variety of compositions and properties, which make them suitable for several orthopedic and dentistry applications such as (dental implantation and denture base materials), because they have good properties such as good elastic modulus, high strength, low creep and high heat deflection as compared to polymer materials [1].

The composite materials have many important properties which make them suitable for many dentistry uses, therefore many researches done for bone, denture base and tooth substitute as composite materials composed of different particles and a polymer matrix [2].

Acrylic resins have been the most widely used and accepted among all denture base materials, and it was estimated that they represent (95%) of

the polymer materials in dentistry application as denture base materials, that usually consist of poly methyl methacrylate which is a thermoplastic polymer [3].

The first using of poly (methyl methacrylate) (PMMA) during the (1930), was used in dental prosthetics. In (1936) introduced (PMMA) as heat cure denture base material, when this material was molded to desired shape under heat and pressure, which became the major polymer to be used in last years as denture base material. The first using of (PMMA) as cold cure denture base material was in (1938). Furthermore, other thermoplastic polymers used as denture base materials from 1960 as alternative of (PMMA), but they have not been shown to produce denture of greater accuracy, better performance and have not been proved to be superior to (PMMA). A result the (PMMA) resin remains the materials of choice for denture base material [4].

Prosthetic dentistry is the replacement of missing teeth, which may have been lost for a variety of reasons, with either fixed or removable dentures, that using depending upon a many factors of these replacements. A partial denture are made to replace one or more of lost teeth and they have the advantage that support and retention can be derived from adjacent retained natural teeth and using design features such as occlusal rests and clasps. While, the complete denture replaces all the teeth in one dental arch, the objectives of these treatment they would be have good speech, good appearance, effective chewing and biting, comfort and the ability to engage in various social and interpersonal activities [3].

2. Aim of this Study

In this research, done several attempts to develop the poly methyl methacrylate (PMMA) that is used for upper or lower complete and partial denture base material with having desirable properties, by using the new type of cold cured PMMA resin to withstand against any denture fracture, and avoid or reduce the breakage of denture base material, by reinforcing PMMA with different type of particles (nano-zirconia and micro-lignin) with selected volume fractions, to product (nano to micro) composite materials for prosthetic dentures, and study the mechanical properties (tensile, compression, impact and hardness) of these materials.

3. Theoretical Part

3.1 Techniques of Polymerization Denture Base Materials

According to mode of chemical reaction to free radical generation, various methods were used for curing acrylic resin. They are classified as heat curing, cold (self) curing and light curing. The cold polymerizing denture base materials are chemically similar to the heat cured denture base, varying only in the manner in which polymerization method. The polymerization reaction is accelerated by chemical activation, rather than by heat, by added catalyst to the monomer, such as (dimethyl-para-toluidine). This catalyst leads to color stability property of chemically activated resins. Also the reducing agent adding to produce sufficient free radicals, which promote initiate the polymerization of the monomer in the denture base material at room temperature, therefore called cold curing [3].

3.2 Common Causes of Dentures Fracture

One of the most serious complications with complete or partial prosthetic dentures is fracture, many studies on prosthetic denture were showed that the most common problem is fracture of dentures, in a survey reported on greater number of partial and complete dentures, show results about (63% to 68%) of dentures had broken within few years after fabrication in denture base materials [5].

There are several reasons for denture fracture, the denture fracture caused primarily by impact failure or by fatigue failure. In addition, wear and tear failures over time, by the temperature variations that found in hot and cold foods and drinks, as well as certain types of acidic foods and the moisture in your mouth can wear down a denture. Also many causes for the denture fraction, it was found such as: stress concentration (a large notch and thin denture), poorly fitting denture, lack of fitness denture, lack of balanced occlusion, porosity, bone loss can shrink the jaw. If your denture does not fit properly, it may move around in the mouth, and this lack of stability can cause stress and pressure points that lead to increased denture deformation which finally can cause crack or break denture, for these reasons trying to reinforce the PMMA matrix is to reduce these fracture problems [5].

3.3 Types of Fracture

The principle difference between the modes of fracture is the rate at which the stress is applied and relation to the ability of the polymer chain to distort at minimizes of stress concentration [6].

3.3.1 Impact Fracture

This type of fracture usually happens when patients are coughing which pushes the denture out of the mouth or accidental dropping of the denture over the hard floor or sink, also it may occur if the patient is involved in a violent accident. Figure (1) shows the images of impact fracture that occur in prosthetic denture [6].

Fig. 1. Show the Impact Fracture in the Prosthetic Dentures.

3.3.2 Fatigue Fracture

The fatigue failure occurs when the denture deforms repeatedly through the mastication process by small forces (occlusal forces) at this loading cycle that exceeds the mechanical capacity of denture base material. Figure (2) shows the images of fatigue fracture that occur in prosthetic denture [6].

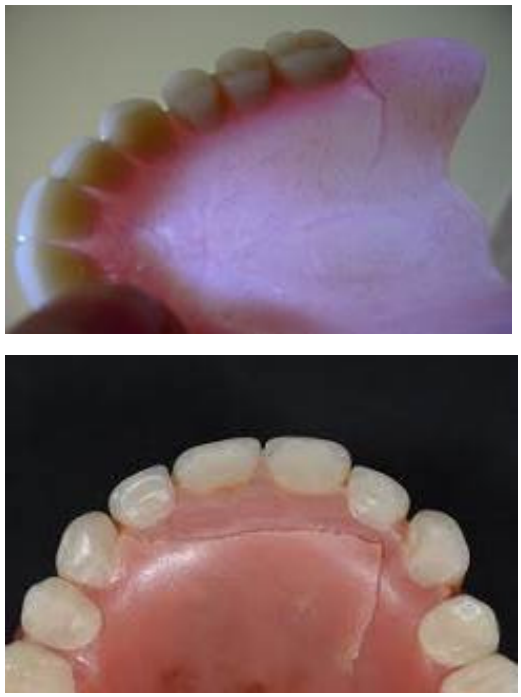


Fig. 2. Show the Fatigue Fracture in the Prosthetic Dentures.

4. Experimental Part

4.1 Poly (Methyl Methacrylate) (PMMA) Acrylic Resin

The matrix material that used in this research included cold curing poly methyl methacrylate (PMMA) as denture base materials, to preparation of test specimens for PMMA composite prosthetic dentures. PMMA is a linear thermoplastic polymer, the chains are thinner, smoother and slide past each other easily, finally material becomes softer, therefor can be fabrication and processed easily by (Hand lay-Up) methods. Cut surfaces of PMMA acrylics resin may be readily finished by polished by tipped tools.

This type of polymer materials distinguishes by many properties compared with other type of polymer such as: high strength, high modulus of elasticity, low elongation at break and good dimensional stability, but it has low impact strength and low fatigue strength. Also, PMMA resin is favored for its good physical properties such as the color which can like the human's internal skin with the pinkish color, low moisture, low water absorbing and high glass transition temperature [7]. Some mechanical and physical properties of (PMMA) resin that used in this study are shown in Table (1).

Table 1,
Some Mechanical and Physical Properties of PMMA Resin.

Tensile Strength (MPa)	Young's Modulus (GPa)	Impact Strength (kJ/m^2)	Flexural Strength (MPa)	Density (g/cm^3)
47 - 79	2.2 - 3.8	1.2 – 20	3 - 3.5	1.19

The cold cured was used to prepare the test specimens of the PMMA composite prosthetic dentures, consist of polymer powder and monomer liquid (methyl methacrylate, MMA). The standard proportion in mixing ratio is usually for cold cure acrylic resin of (15 g) polymer powder (PMMA) and (10 ml) monomer liquid (MMA) (1.5 g / 0.95g) by weight according to the manufacturer's instructions of manufacturer company. Where the mixture was mixed of liquid (MMA) in the clean and dry container (glass beaker), follow after that by slow addition of dry powder (PMMA) with or without particulate reinforces materials (nano-ZrO_2 or micro-lignin) to liquid (MMA), the mixture was stirred at room temperature continuously by using mechanical mixing (brabender mixer) at speed (20 r.p.m.) until reached to the dough stage, this mixer is shown in Figure (3), then poured with thin straight line in the center of opening mould with maximum time about (4.5 min) according to manufacture company. During mixture pouring in the glass mould, the mould must be vibrated from side to side to remove any gas bubbles from the specimens, and reminder of the mixture was poured into mould hole until the glass mould filling. This mixture was covered in closed container and left to stand on the bench top at room temperature for (8-13) min from beginning of mixing process as working time to increase the viscosity of mixture and surface of the pouring has become hard and matt.

Fig. 3. Mechanical Mixer (Brabender Mixer).

4.2 Particles Reinforcing Materials

Two types of particles were used in this study as reinforces materials with percentage of (0.5, 1, 1.5 and 2) Vol %, that added to the polymer powder (acrylic powder) include the following:

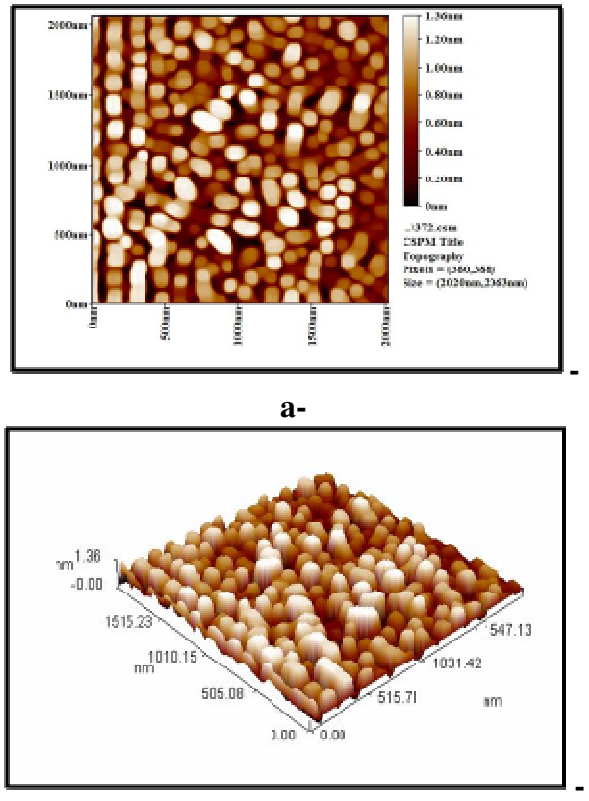
4.2.1 Micro-Lignin (Pumpkin) Particles.

There is a family of plants called the family of the Qur'aa and within this family squash, pumpkin and others. They have multiple shapes including spherical and linear. The pumpkin is generally multicolored, orange, yellow and green, which has been used in this study [8].

The pumpkin contains 95% water, the fruits of pumpkin are anti-oxidants, anti-infections, anti-bacteria, cancer and diabetes diseases because it contains of many basic nutrients needed the body to perform various functions, such as vitamin (A), anti-oxidation and metal materials (iron, magnesium, potassium, zinc, calcium and phosphorus). It also protects the mouth from the inside specifically of the various infections and slough that affect it, in addition activates gums and fights toothache. As well as to maintain the health of the skin and body, help to strengthen the immune system of the body and prevent the oxidation of cholesterol [8].

The particle size and particle size distribution of (micro-lignin) particles were carried out in Atomic Force microscopy (AFM) in Baghdad University Laboratories by using Scanning Probe

Microscopy (SPM). The result of particle size distribution of micro-lignin (pumpkin) particles structures in (2-D) and (3-D) as shown in Figure (4), and the average value of diameter was (136.05 nm).



a-

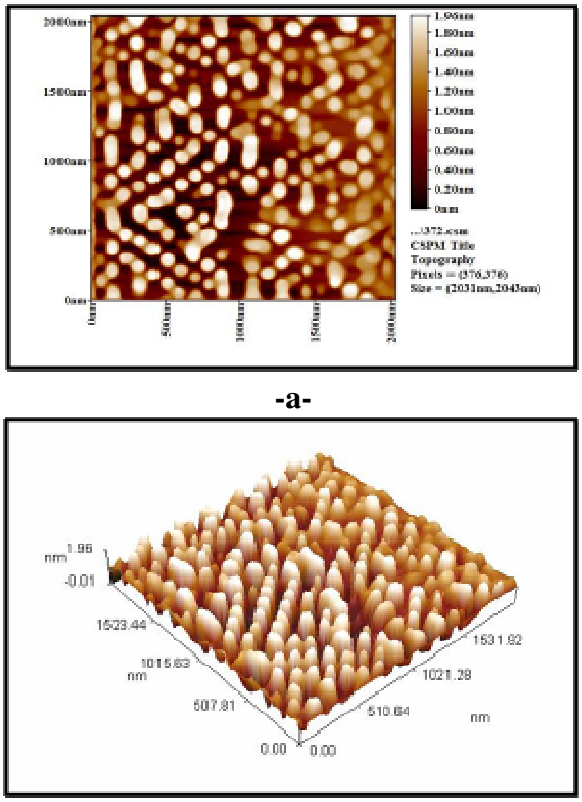
b-

Fig. 4. (a) Shows 2-Dimensions and (b) Shows 3-Dimensions of ((Micro-Lignin) Particles by AFM Test.

4.2.2 Nano-Zirconium Oxide (ZrO_2) Particles

Zirconium oxide (zirconia) is one of most important of bio-ceramics oxides, has shiny gray-white color and it is not available in nature as a pure oxide. The zirconia has important properties such as high fracture toughness, high tensile strength, high hardness, low modulus of elasticity, high flexural strength, high density, high thermal shock resistivity and thermal expansion similar to cast iron, high wear and corrosion resistance in acids and alkalis, also little chemical change during long term exposure to body fluid. Therefore, the zirconia using for many biomedical application, and introduced to solve the problem of alumina brittleness and the consequent potential failure of implants because it is exhibits the best mechanical properties, creating tougher prostheses [9].

The particle size and particle size distribution of (nano-ZrO_2) particles were carried out in Atomic Force microscopy (AFM) in Baghdad University Laboratories by using Scanning Probe Microscopy (SPM). The result of particle size distribution of (nano-ZrO_2) particles structures in (2-D) and (3-D) as shown in Figure (5), and the average value of diameter was (87.06 nm). Some mechanical and physical properties of (ZrO_2) that used in this study are shown in Table (2).



-a-

-b-

Fig. 5. (a) Shows 2-Dimensions and (b) Shows 3-Dimensions of (Nano-ZrO_2) Particles by AFM Test.

Table 2,
Some Mechanical and Physical Properties of (ZrO_2) Particles.

Tensile Strength (MPa)	Young's Modulus (GPa)	Compression Strength (MPa)	Flexural Strength (MPa)	Density (g/cm^3)
800-1500	205-210	2000	900-1200	5.7-6.1

4.3 Mechanical Tests

The mechanical tests were performed in this study to evaluate some mechanical properties of the PMMA composite materials for the prosthetic denture base include:

4.3.1 Tensile Test

The tensile test is performed according to (ASTM D638-03) by using tensile machine (universal testing machine), type (Instron) at a cross head speed (strain rate) of (5mm/min) and load was applied equal to (5 kN) until break the specimen occur. Figure (6) shows the standard specimen of tensile test. The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The elongation measurement is used to calculate the engineering strain. The tensile force is used to calculate the engineering stress by divided on normal cross-section area of the specimen. Final obtain the (stress–strain) curve [10].

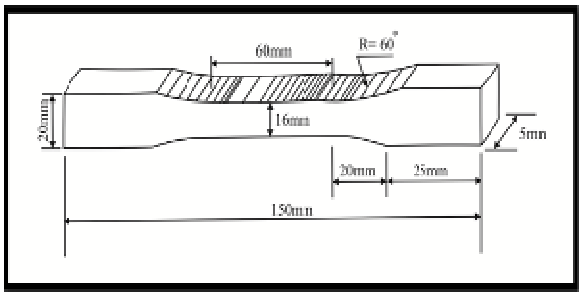


Fig. 6. Schematic Specimen for Standard Specimen of Tensile Test.

4.3.2 Compression Test

Compressive strength is the stress required to rupture a specimen i.e. (the amount of resistance to fracture under compression load). Compression failure in composite material depended up on the properties of matrix such as toughness, properties of reinforced such as volume fraction and interface. The compression test is performed according to (ASTM D695) by using the same tensile machine (universal testing machine), type (Instron) at across head (strain rate) of (5mm/min) and applied load was (25 kN) on the specimen's. Figure (7) shows the standard specimen of compression test. The compression tester similar to tensile tester, done by applying compressive load on the specimen's top and bottom at the same time until fracture of the specimen occur, five times were tested for each specimen and take the averaged for the final result of five specimens it was tested [11].

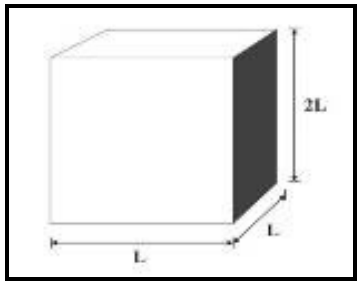


Fig. 7. Schematic Specimen for Standard Specimenof Compression Test.

4.3.3 Impact Test

An impact test is used to observe the behaviors of material will exhibit when it expose to shock loading that lead to deformation, then fracture of specimen. By determine the ability of the material to absorb energy during a collision. This energy may be used to determine the toughness, impact strength, fracture resistance, impact fracture resistance of the material. Izod impact that is used in this research is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. To perform this test the sample is placed into a holding in the device with the geometry according to (ISO-180) by using Izod Impact testing machine type is (XJU series pendulum Izod/Charpy impact testing machine), Figure (8) shows the standard specimen of impact test [12].

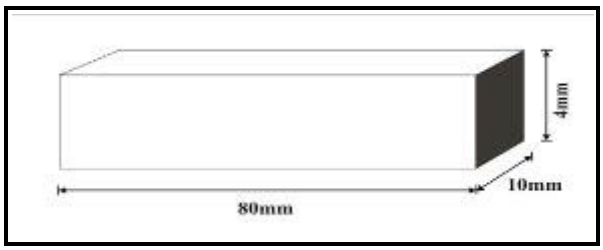


Fig. 8. Schematic Specimen for Standard Specimen of Impact Test.

In this type of impact test the specimen clamped at one end and held vertically cantilevered beam and it's broken by (5.5J) pendulum, at impact energy of (5.5J) and velocity (3.5 m/s). Then release the pendulum from a known height so that it collides with the impact specimen as sudden force, then record amount of energy that required to fracture this specimen, five times were tested for each specimen and take the averaged for the final result of five specimens it

was tested, the average impact energy of these specimens as shown in in Table (3) [12].

Table 3,
Impact Energy of PMMA Composite Reinforced by different Concentration of (Nano-ZrO_2 or Micro-Lignin) Particles.

Specimen Names	Average Impact Energy (J)
PMMA	26.6
PMMA + 0.5 % Nano-ZrO_2	22.9
PMMA + 1 % Nano-ZrO_2	19.5
PMMA + 1.5 % Nano-ZrO_2	13.31
PMMA + 2 % Nano-ZrO_2	11.56
PMMA + 0.5 % Micro-Lignin	25.9
PMMA + 1 % Micro-Lignin	23
PMMA + 1.5 % Micro-Lignin	21.64
PMMA + 2 % Micro-Lignin	17.44

4.3.4 Hardness Test

Hardness is the characteristic of a solid material expressing surface resistance to scratching, cutting, wear, indentation, penetration and workability from an applied force of sharp point and as indication of surface durability. Durometer hardness test is one of several methods that using to measures of the hardness in polymers and rubbers materials, there are several scales of durometer are used for materials with different properties. In this research the hardness test is performed by using dorumeter hardness device, type (Shore-D) scales according to (ASTM D2240), and standard specimen for hardness test as shown in Figure (9). The specimen place under the indenter area at load applied equal to (50 N) and depressing time of measuring equal to (15sec), each scale results in a value between (0 to 100) hardness numbers, with higher values indicating a harder material [13].

The surface of specimens must be smooth in zone test. Hardness value is very sensitive to the (specimen thickness, specimen diameter and distance from the edge more than 12 mm). Therefore, the minimum thickness of the specimen is (3 mm) with diameter more than (30mm). Each specimen was tested seven times at different position of each specimen at same time must be tested in the middle, not on the edge of the specimen, and average value was taken [13].

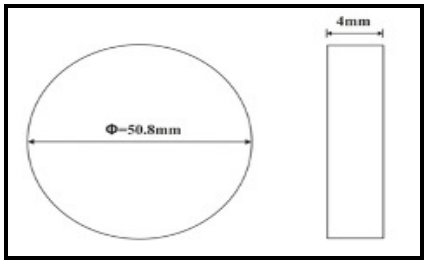


Fig. 9. Schematic Specimen for Standard Specimen of Hardness Test.

According to (ADA Specification No.12, 1999), all these tests specimens after complete finishing and polishing processes must be stored in distilled water at (37 ± 1) ℃ for (48 hr), in order to remove any residual monomer and release residual stress, also to ensure that the denture base materials remains in semi oral environment. Then, each test were carried out in air at room temperature (23 ± 2) ℃. Five specimens where used for most tests and final results represent the average for five specimens it was tested [14]. Figure (10) shows the solidified composite prosthetic dentures test specimens after remove from glass mould and before testing process.

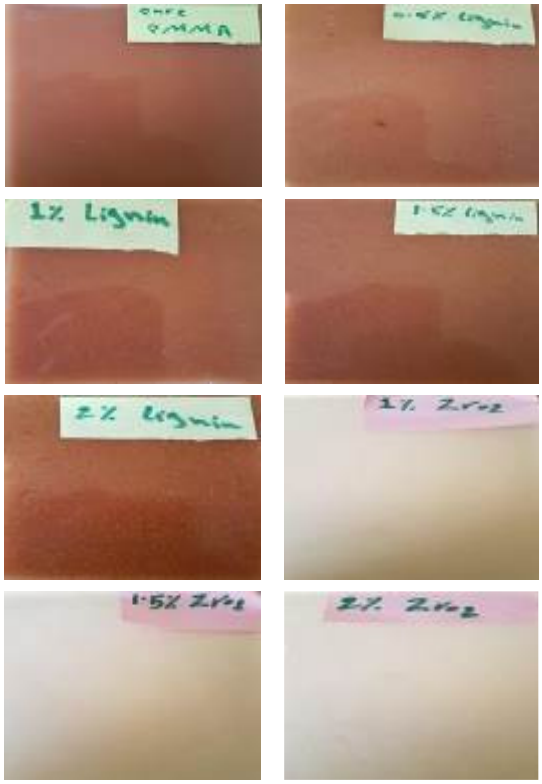


Fig. 10. Shows the Composites Prosthetic Dentures Specimens for Pure PMMA and PMMA Composite Reinforced by (Micro-Lignin or Nano-ZrO_2) Particles.

5. Results and Discussion

5.1 Results and Discussion of Tensile Test for Modified Composites

The tensile strength values results that obtained from tensile test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (1), which show the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the tensile strength of PMMA composite. From this Chart can be noticed how the tensile strength values decreased with the increasing of the volume fraction of these particles in both groups of PMMA composite materials. This is due to the low strengthening and weak bond, and those particles cannot reduce the slipping of the PMMA chains [15 and 16].

It can also be noticed that the addition of micro-lignin particles has a noticeable effect on the tensile strength of PMMA composite specimens more than nano-ZrO_2 particles, therefore, tensile strength for (PMMA–micro-lignin) composite specimens is lower than values of tensile strength for (PMMA–nano-ZrO_2) composite specimens. Thus, the tensile strength value decreased from (51.7 MPa) for PMMA specimen (as referenced) to reach to the lower value of (22 MPa) for composite materials (PMMA–2% micro-lignin).

While the tensile modulus of elasticity values results that obtained from tensile test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (2), which show the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the tensile modulus of elasticity of PMMA composite.

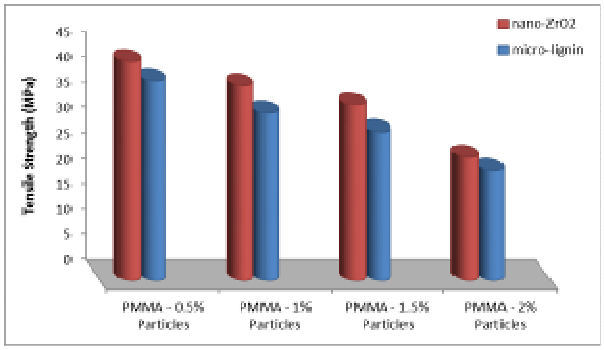


Chart 1. Shows Tensile Strength Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

From this Chart can be noticed how the tensile modulus of elasticity values increased with the increasing of the volume fraction of these particles in both groups of PMMA composite materials. This is due to the strengthening mechanism which meaning (those particles reduced the slippage of the PMMA chains by filling the spaces inside the PMMA matrix and created full interface, formation high bonding strength between particles and PMMA matrix). Furthermore, high modulus of elasticity of these particles as compared to PMMA resin [15 and 16].

It can also be noticed that the addition of micro-lignin particles has a noticeable effect on the tensile modulus of elasticity of PMMA composite specimens more than nano-ZrO_2 particles, therefore, the tensile modulus of elasticity for (PMMA–micro-lignin) composite specimens is higher than the values of tensile modulus of elasticity for (PMMA– nano-ZrO_2) composite specimens. Thus, the tensile modulus of elasticity value increased from (7.5 GPa) for PMMA specimen (as referenced) to reach to the higher value of (13.95 GPa) for composite materials (PMMA–2% micro-lignin).

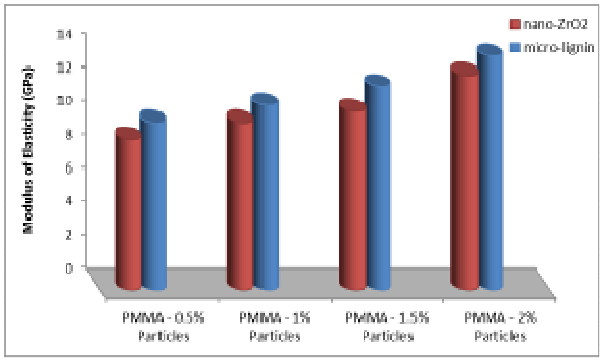


Chart 2. Shows Tensile Modulus of Elasticity Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

But the elongation percentage values results that obtained from tensile test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (3), which show the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the elongation percentage of PMMA composite. From this Chart can be noticed how the elongation percentage values decreased with the increasing of the volume fraction of these particles in both groups

of PMMA composite materials. This is due to the increasing in the particles number will be act as localized stress concentration regions, that lead to decreased the elongation percentage [15 and 16]. It can also be noticed that the addition of nano-ZrO_2 particles has a noticeable effect on the elongation percentage of PMMA composite specimens more than micro-lignin particles, therefore, elongation for (PMMA– nano-ZrO_2) composite specimens is lower than values of elongation percentage for (PMMA– micro-lignin) composite specimens. Thus, the elongation percentage value decreased from (6.3 %) for PMMA specimen (as referenced) to reach to the lower value of (1.9 %) for composite materials (PMMA–2% nano-ZrO_2).

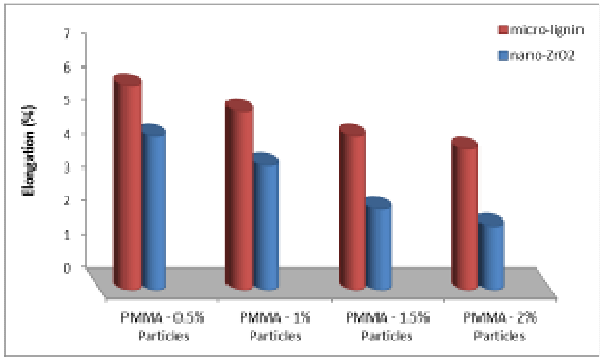


Chart 3. Shows Elongation Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

5.2 Results and Discussion of Compression Test for Modified Composites

The compressive strength values results that obtained from compression test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (4), which shows the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the compressive strength of PMMA composite. From this Chart it can be noticed how the compressive strength values increased with the increasing of the volume fraction of these particles in both groups of PMMA composite materials. This is due to the strengthening mechanisms which meaning the particles reduced the slippage of the PMMA chains by filling the spaces inside the PMMA matrix and it can also be related to the higher compressive strength of these particles as compared to PMMA resin [16 and 17].

It can also be noticed that the addition of nano-ZrO_2 particles has a noticeable effect on the compressive strength more than micro-lignin particles, therefore, compressive strength for (PMMA–nano-ZrO_2) composite specimens is higher than the values of compressive strength for (PMMA–micro-lignin) composite specimens. This is due to the improvement of the mechanical properties of ZrO_2 particles and the nature of ZrO_2 particles which has high compressive strength as shown in table (2). Thus, the compressive strength value increased from (176.5 MPa) for PMMA specimen (as referenced) to reach to the higher value of (360.3 MPa) for composite materials (PMMA–2% nano-ZrO_2).

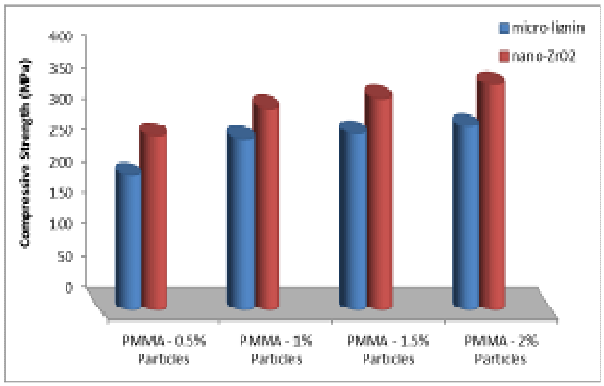


Chart 4. Shows Compressive Strength Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

5.3 Results and Discussion of Impact Test for Modified Composites

The impact strength values results that obtained from impact test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (5), which shows the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the impact strength of PMMA composite. From this Chart can be noticed how the impact strength values decreased with the increasing of the volume fraction of these particles in both groups of PMMA composite materials, because of any increasing in these particles numbers, it will be act as points for localized stress concentration regions from which the failure will begin. Furthermore, the natural of these particles is brittleness and weakness in the

ability of resistance to impact loads comparing with PMMA resin [16 and 18]. It can also be noticed that the addition of nano-ZrO_2 particles has a noticeable effect on the impact strength of PMMA composite more than micro-lignin particles, therefore, impact strength for (PMMA–nano-ZrO_2) composite specimens is lower than the values of compressive strength for (PMMA–micro-lignin) composite specimens. This is due to aggregated of (nano-ZrO_2) particles which have high surface energy. Thus, the impact strength value decreased from (6.65 kJ/m^2) for PMMA to reach to the lower value of (2.89 kJ/m^2) for composite materials (PMMA–2% nano-ZrO_2).

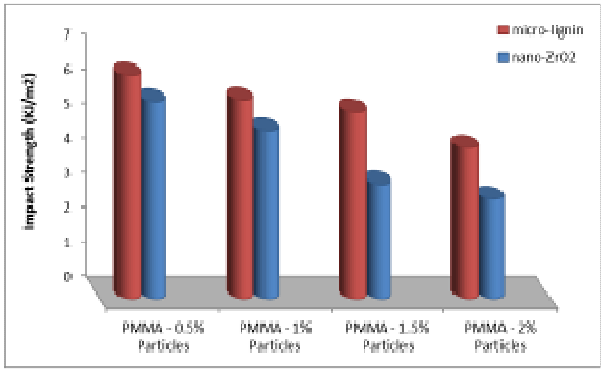


Chart 5. Shows Impact Strength Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

5.4 Results and Discussion of Hardness Test for Modified Composites

The hardness (shore-D) values results that obtained from hardness test that carried out on PMMA composite specimens for prosthetic denture base materials that prepared in this research are shown in the Chart (6), which shows the effect of adding both types of the particles which include (nano-ZrO_2 and micro-lignin) with different volume fractions on the hardness (shore-D) of PMMA composite.

From this Chart can be noticed how the hardness values increased with the increasing of the volume fraction of these particles in both groups of PMMA composite materials. This is due to the high hardness and brittleness of these particles as compared to PMMA resin alone, furthermore, related to the wettability and the bonding strength between the PMMA matrix and these particles, to make the harder surface by restricting the movement of the PMMA chains towards the stress that is applied on it [16 and 19].

It can also be noticed that the addition of micro-lignin particles has a noticeable effect on the hardness of PMMA composite specimens more than nano-ZrO_2 particles, therefore, hardness for (PMMA–micro-lignin) composite is higher than the values of hardness for (PMMA–nano-ZrO_2) composite specimens. Thus, the hardness value increased from (79) for PMMA specimen (as referenced) to reach higher value of (84.5) for composite materials (PMMA–2% micro-lignin).

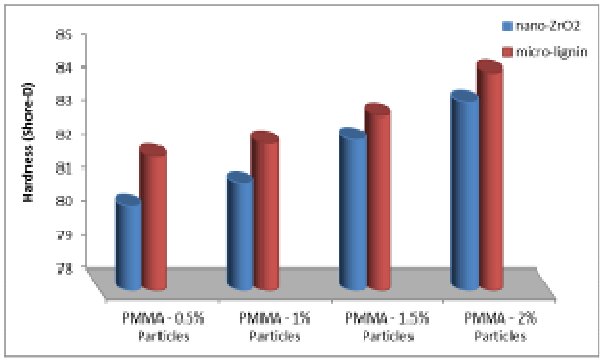


Chart 6. Shows Hardness Data of PMMA Composite Denture Base Materials as Function of (Nano-ZrO_2 or Micro-Lignin) Particles Content in Composite.

6. Conclusions

1. The (tensile modulus of elasticity, compressive strength and hardness) of PMMA composite prosthetic denture (PMMA–nano-ZrO_2), (PMMA–micro-lignin), were increased with the increasing of the volume fraction of (nano-ZrO_2 or micro-lignin) particles.
2. The (tensile strength, elongation percentage and impact strength) of PMMA composite prosthetic denture (PMMA–nano-ZrO2), (PMMA–micro-lignin), were decreased with the increasing of the volume fraction of (nano-ZrO2 or micro-lignin) particles.
3. The addition of (nano-ZrO2) powders has higher effect on the (elongation percentage, impact strength and compressive strength) properties of PMMA composite prosthetic denture base specimens more than the (micro-lignin) particles.
4. The addition of (micro-Lignin) powders has higher effect on the (tensile strength, tensile modulus of elasticity and hardness) properties of PMMA composite prosthetic denture base specimens more than the (nano-ZrO2) particles.

5. The maximum values for properties (tensile modulus of elasticity and hardness) were obtained in PMMA composites prosthetic denture (PMMA–micro-lignin).
6. The minimum values for properties (elongation and impact strength) were obtained in PMMA composite prosthetic denture (PMMA–nano-ZrO2).

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دراسة الخصائص الميكانيكية لمادة قاعدة طقم الأسنان مصنعة من مواد متراكبة بوليمرية

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الخلاصة

في هذا البحث تم التقصي عن تاثير اضافة نوعين مختلفين من دقائق التقوية تضمنت دقائق الزركونيا النانوية ودقائق اللكنين المايكروية والتي تمت اضافتهما بكسور حجمية مختلفة هي (٠,٥ %، ١ %، ١,٥ %، و ٢ %)، على بعض الخواص الميكانيكية للمواد المتراكبة البوليمرية المحضرة في هذا البحث بوصفها مادة لقاعدة طقم الاسنان الأصطناعية الكاملة او الجزئية، وذلك باستخدام راتنج البولي مثيل ميثا اكريليت المعالج ذاتياً بوصفها مادة أساساً. وقد تم تحضير عينات المواد المتراكبة باستخدام طرائق السباكة، وقد استخدمت طريقة (الصب اليدوي) على شكل مجموعتين هما : المجموعة الاولى تضم راتنج البولي مثيل ميثا اكريليت مقواة بدقائق الزركونيا النانوية، وا الثانية تضم راتنج البولي مثيل ميثا اكريليت مقواة بدقائق اللكنين المايكروية وتضمنت الاختبارات الميكانيكية التي تم اجرائها في هذا البحث فحوصات الشد و الانضغاط، الصدمة، والصلادة. وقد أظهرت نتائج هذه الدراسة بان قيم خواص (معامل مرونة الشد، مقاومة الانضغاط والصلادة) ازدادت مع زيادة الكسر الحجمي لهذه دقائق في المواد المتراكبة البوليمرية. بينما قلت قيم خواص (مقاومة الشد و الاستطالة ومقاومة الصدمة). كذلك ان دقائق الزركونيا النانوية تمتلك تاثيراً اكبر من دقائق اللكنين المايكروية على بعض خواص المواد المتراكبة البوليمرية لعينات مادة قاعدة طقم الاسنان الأصطناعية بينما تمتلك تاثيراً اقل على الخواص الاخرى لهذه المادة.