ORIGINAL ARTICLE

Studying the Influence of Nano ZnO and Nano ZrO_2 Additives on Properties of PMMA Denture Base

SUROOR ABD ALWAHAB[1], JAAFAR M. MOOSA[2],.SADEER M. MAJEED[3]
[1]*B.Sc, Department of Applied Sciences, Materials Science branch, University of Technology, Baghdad, Iraq*
[2]*Asst. Professor Dr., College of Dentistry, Department of Basic Sciences, University of Baghdad, Baghdad, Iraq*
[3]*Dr, Department of Applied Sciences, Materials Science branch, University of Technology, Baghdad, Iraq*
Correspondence to +Dr. Jaafar M Moosa, E-mail: ekhlass838@gmail.com

ABSTRACT

Background: The Poly-Methyl methacrylate (PMMA) resin has been commonly used in the dental applications.
Aim: To prepare the the materials which are used for manufacturing a denture with the use of a composite material, as well as observing their characteristics.
Methods: There have been 2 additive types (Nano zirconium oxide and zinc oxide) with various percentages of the weight (1,2,3,4,5%) added into the PMMA resin for improving its characteristics.
Results: The mix has been experimentally selected for obtaining the optimal characteristics as well as avoiding the formation of the cracks. The PMMA and di- chloromethane ratio has been respectively (20%wt) and (80%wt) for the pure samples.
Conclusions: Results have shown that there has been a thermal conductivity increase, completion strength and a reduction in the roughness.
Keywords: PMMA, biomaterial Dental Materials, Prosthetic dentistry.

INTRODUCTION

Biomaterials are defined as natural or synthetic origin materials which are utilized as treatment supplement or replace any part of living tissue or to do function in close contact with living tissue. Therefore two important criteria that biomaterial must fulfill are biocompatibility and bio-functionality[1] The developments in artificial bone and tooth field seem to solve most of the hard tissue problems. On the other hand, artificial bone and tooth may cause an improvement in their properties[2].

Dental Materials, is a science dealing with materials which are utilized in dentistry, their chemical, physical, and mechanical characteristics, in addition to their manipulation as such characteristics are associated with the suitable utilization and selection by dentists. Studying the dental material provides dentists with the ability of understanding the behaviors of those materials, the suitable selection for appliance inpatient and the way of using them with gaining their optimal advantages[3]. The prosthetic dentistry can be defined as missing teeth replacement, which could have been lost for various reasons, with either removable or fixed dentures, which are utilized based on numerous factors of those replacements[4].

The denture base material is a biomaterial type which must have sufficient characteristics, performance, compatibility, as well as color and dimensional stability, besides the esthetic appeal and utilization in oral cavities the denture part resting on basis tissue and that the teeth are attached to. The acrylic prosthetic resin is used in various dental prostheses parts, which include the removable complete or partial dentures, transitional prostheses, and implant-supported prostheses. The PMMA was commonly used as a denture base material due to its desirable features[4].

PMMA is an often utilized inexpensive thermo-plastic polymer with boundless applications to the daily lives. The PMMA can be defined as the most commercially significant acrylic polymer which is distributed under numerous commercial names, such as Acrylate and Plexiglas. The high transparency results in making the PMMA a perfect substitute for the glass in which the weight or the impact is a serious issue. The PMMA has compatibility with the human tissues, which makes it a significant material for prosthetics and transplants, particularly in the ophthalmology area due to its transparent characteristics[5].

PMMA is known for its high Young's modulus, high mechanical strength, and low elongation at break. It doesn't shatter on rupture. It can be considered as one of the hardest thermo-plastics and has a high scratch-resistance as well. It shows low capacity for moisture and water-absorption, because of which the manufactured products have sufficient dimensional stability. Those two features are increased with the rising of the temperature[6]. Numerous research types were done to study denture base:

Chow, W. S., et al., (2013), have researched the impact of incorporating the particles of the hydroxyl-apatite (HA) on flexural characteristics of denture base. Results have shown that adding particles of (HA) increase the flexural modulus of PMMA denture base. In addition to that, the flexural strength and the flexural strain of the PMMA/HA composite materials have been reduced by adding particles of HA[7].

Mohamed, A. A., et al., (2014), have researched the impact of adding the zirconium oxide (ZrO_2) Nano-filler powder with various fractions of the weight. Results have shown that adding ZrO_2 Nano filler powder to heat-cured acrylic resins (PMMA) considerably increases the heat-polymerized acrylic resin's fracture toughness, hardness and flexural strengths[8].

Sama, A. A., et al., (2015), study the impact of adding titanium oxide Nano filler (TiO_2) on some of the physical and mechanical properties of the denture base

material. Results have shown that adding the TiO_2 Nano filler to the heat-cured acrylic denture based material will have a considerable effect on increasing the transverse strength and the impact strength, and a considerable increasing in Prosthetic dentistry hardness sand surface roughness of the surface. In addition to that, water sorption and decrease in comparison to control group (pure)[9].

Eman, M. R., et al., (2016), investigated the impact of adding Nanoparticles of ZrO_2 on fracture resistances of mandibular implant retain over denture base material and transmit stresses into implants. Results have shown that adding Nanoparticles of ZrO_2 considerably increase fracture resistance of the mandibular implant retain over denture base materials and reduce an issue of the redundant characteristic of the denture base materials[10].

MATERIALS AND METHODS

Experimental work:

Used materials

1. PMMA.
2. Methylene Chloride (CH_2Cl_2).
3. ZrO_2.
4. ZnO

Preparation of the Mould: The mold which has been utilized in the present research has been produced from the plastic is of a circular shape with a (2.50cm) height and a (4cm) diameter.

Proportioning and Mixing of PMMA: The mix has been selected in an experimental manner for obtaining the optimal characteristics, as well as for avoiding the formation of the cracks. The PMMA and di-chloromethane ratios have been respectively (20%) and (80%) for the pure samples. The Nano ZrO2 and ZnO ratios have been (0.02%, 0.04%, 0.06%, 0.08% and 1.0%) from PMMA ratio percentage.

Liquid di-chloromethane has been transferred into a clean and dry beaker, and after that, the particles of the PMMA have been added slowly into liquid. Magnetic stirrer has been utilized for homogenizing the mix. The beaker has to seal quite firmly for the sake of preventing formations of any bubbles and is put for 90min. in an electric stirrer to the point of homogenizing the solution. Then, the solution which has been homogenized is poured in the mold and left at a room temperature for 2 days in order to be cast. The mold has been lubricated earlier with the paraffin for preventing the adhesions and for the easy extraction of samples from mold.

Thermal Conductivity: The thermal conductivity (K) can be defined the inherent characteristic of a material that associates its capability of heat conducting. The coefficient of the thermal conductivity may be computed based on (Fourier Law).Thermal conductivity is dependent upon numerous factors, including (the crystallization degree, porosity, and molecular weights). Each one of the polymer materials has a decreased level of thermal conductivity falling in the range of (0.17W/m.K to 0.25W/m.K), which is why, the majority of polymers are used as insulation materials. This characteristic is a drawback of the PMMA in the case of being utilized as materials of the denture base; the denture bases' high thermal conductivity results in[11]:

1. Enhanced tissues.
2. Decreases the feeling of the dentures to foreign bodies.
3. A better taste appreciation.

Compression Test: The compression test (Brazilian) has been specified based on the ASTM (D- 664) through the use of the cylindrical samples. Those samples have been placed with the horizontal axis between the testing machine's platens. Diametrical strength has been computed based on the following equation:

$$Compression\ (\sigma) = \frac{2F}{\pi DL} \ldots\ldots\ldots (1)$$

(σ) represents the compression (MPa), (D) represents the specimen's diameter (mm), (F) represents the Maximal applied load (N), and (L) represents the specimen's length (mm).

Roughness: The product's roughness of the surface is of a high importance property and the requirements of the surface finish design for numerous reasons and considerations, including the Corrosion resistance, like the consideration of the cost, the electrical and the thermal contact resistance, notch sensitivity and fatigue. Successive processing like the coating appearance and painting, frictional, lubrication, and wear considerations.

RESULTS

Results of the tested are represented in figures 1, 2 and 3 by which the collected data from the tests were transferred into graphs. These graphs were discussed thoroughly in the discussion below.

Figure 1: The thermal conductivity of the Nano ZnO & ZrO_2 reinforced sample and the Pure PMMA sample

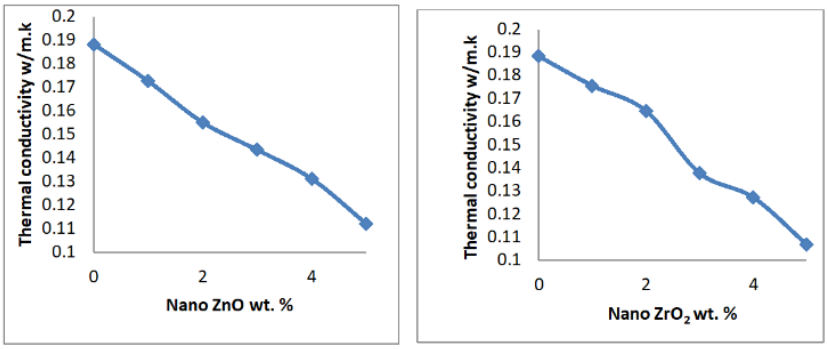


Figure 2: The compression strength for the Nano ZnO & ZrO_2 reinforced sample and pure PMMA sample

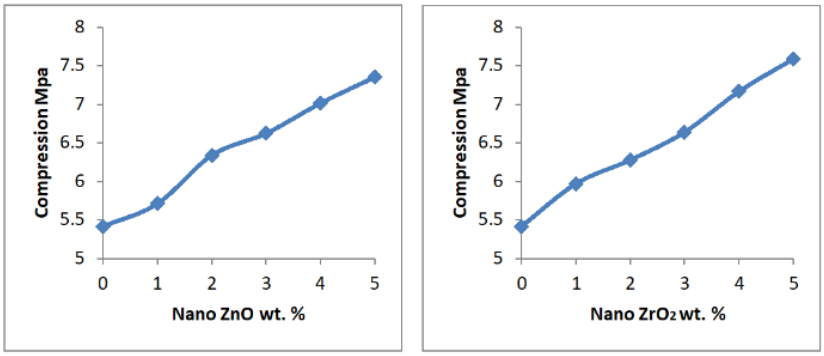
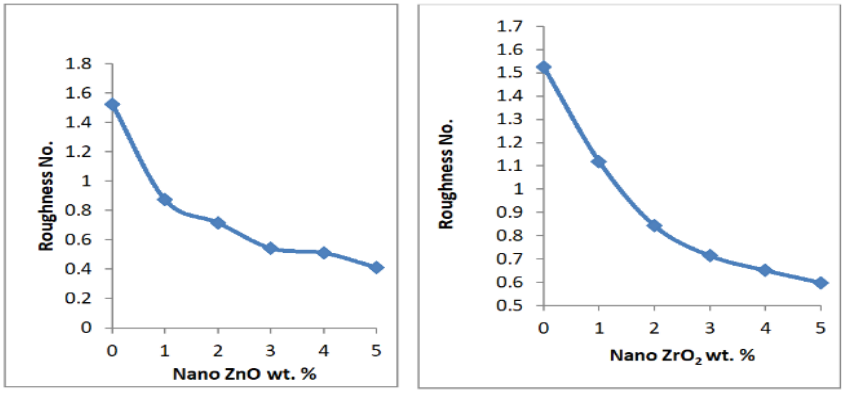


Figure 3: Roughness of the Nano ZnO and ZrO_2 reinforced sample and pure PMMA sample



DISCUSSION

Thermal conductivity Test: The thermal conductivity values for the pure PMMA, for each specimen which have been prepared in this study, have been shown in figure 1. The impact of adding different nano-particle types (ZnO & ZrO_2) have shown an increased values of the thermal conductivity due to ceramic nano-particles serving as physical centers of the cross-links between molecules of PMMA for phonon conduction, have insulating PMMA polymer with thermal conductivity[12].

Compression Test: The compression values for the pure PMMA, for each specimen which has been produced in this study, have been shown in figure 2. The impact of adding different nano-particle types (i.e., ZnO & ZrO_2) has shown an increased value of compression due to strong physical cross-links formation (supra-molecular) bonding covering (shielding) nano-particles, which, in turn, results in the prevention of the propagation of the cracks in the material of the PMMA, in addition to the fact that the sufficient bonding between nano-particles and the PMMA matrix results in changing the cracks' propagation[13, 14].

Roughness Test: Roughness values for pure PMMAs, for each specimen which has been prepared in this study, have been shown in figure 3. The impact of adding different nano-particle types (ZnO & ZrO_2). It may be seen that surface roughness values have decreased with the increase in the volume fraction of every particle type for each group. Which is associated with the test of surface roughness is related to an external surface instead of the composite specimens' inner surface. In addition to that, the amount of the particles which will be involved in the composite specimens' surface increased with an increase in those particles' volume fraction in the composite of the PMMA[15].

CONCLUSION

The impact of adding ZnO and ZnO_2 nanoparticles has shown effect on the PMMA denture base as the following

1. Increase thermal conductivity.
2. Increase compression value.
3. Decrease the surface roughness with the increase in the volume fraction.

REFERENCES

1. Ramakrishna S, Mayer J, Winter-mantel E, Leong KW, "Biomedical Applications of Polymer-Composite Materials: A Review", Composit Sci Technol. 2001; 61: 1189- 1224. DOI: 10.1016/S0266- 3538(00)00241-4.
2. Hench LL, "Biomaterials: A forecast for the Future", Biomaterials. 2002; 19: 1429-1423.
3. Anusavice KJ. "Phillips' Science of Dental Materials", 10TH Ed., WB. Saunders Co. Philadelphia, PP. (237-271), (1996).
4. Qahtan AH. " Study the Effect of Nano-Al2O3 and Fiber Glass on Mechanical and Physical Properties of PMMA Composites for Prosthetic Denture", Engin Technol J. 2018; 36: Part A, No. 7. DOI: 10.30684/etj.36.7A.3.
5. Campo EA. The Complete Part Design Handbook, Hanser, 2006.

6. Harper CA. Handbook of Plastic Processes, John Wiley & Sons, 2005. DOI:10.1002/0471786586.
7. Shyang CW. Tay, H. K., Azlan, A. and Mohd I. Z. A.,"Flexural Properties of Hydroxyapatite Reinforced Poly (methylmethacrylate) Composites". J Reinforced Plastics and Composites 2008; 27(9):945-952. DOI: https://doi.org/10.21271/ZJPAS.31.s3.15
8. Mohamed AA, Mohamed IE. "Effect of Zirconium Oxide Nano Fillers Addition on the Flexural Strength, Fracture Toughness and Hardness of Heat-Polymerized Acrylic Resin", World J Nano Sci Engin. 2014; 4(2): 50-57. DOI: 10.2147/IJN.S152571.
9. Sama AA, Shatha SA. "The Effect of the Addition of Silanized Nano Titania Fillers on Some Physical and Mechanical Properties of Heat Cured Acrylic Denture Base Materials", J. Bagh. Coll. Dentistry. 2015; 27(1): 86-91.
10. Eman MR, Amani RA, Asmaa NE. "Effect of Nano-Zirconia Reinforcement on Stresses and Fracture Resistance of Lower Implant Retained Over Denture", Res. J Pharmac Biolog Chem Sci. 2016; 7(3): 897-903. DOI: 10.1055/s-0039-1688533
11. Philips RM. Skinners Science of Dental Materials, 8Thed.W.B.Saunders, company. Philadelphia, New York, USA, (1982}.
12. Vishal M, Kananbala S. " Evaluation of Morphological Effect on Thermal and Mechanical Performance of PS/PMMA/CdS Nanocomposite Systems ", Adv Nanoparticles. 2013; 2(3): 205-216. DOI: 10.4236/anp.2013.23029
13. Majid S, Nabi MK, Abbas R., " An Experimental Investigation of HA/AL2O3 Nano Particles on Mechanical Properties of Restoration Materials ", Engin Solid Mechan. 2014; 2(3): 173-182.
14. Suryasarathi B, Mahanwar PA. "Effect of Fly Ash on the Mechanical, Thermal, Dielectric, Rheological and Morphological Properties of Filled Nylon 6". J Minerals & Materials Charact Engin. 2014; 3(2): 65-72.
15. Al-Momen MM. "Effect of Reinforcement on Strength and Radio-opacity of Acrylic Denture Base Materials". M. Sc. Thesis., College of Dentistry, University of Baghdad, Iraq, (2000).