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Effect of Water Absorption and Simulated Body Fluid on Surface Hardness of PMMA/PLA-$MgZnTiO_4$

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In this work, a mix of PMMA 50% and PLA 50%, and reinforced bioceramic triple (ZnO, MgO, TiO_2). For the purpose of testing for the absorption of the simulated solution of body fluids and water, After submerging it for one month and after calculating the surface hardness of the submerged and non-submerged. Laboratory results showed an improvement in the surface hardness of the submerged models in the body fluid, while the surface hardness of the submerged samples decreased in water, the results were interpreted based on the practical density before and after the immersion test.

Keywords: Body Fluid Solution, PLA, PMMA, Biochemistry Powder.

RESEARCH ARTICLE

1. INTRODUCTION

Clinical application of nanocomposite resins for restoration of posterior teeth requires some mechanical properties to avoid marginal degradation and fracture of restorations.[1] Many of the modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal, alloys, ceramics, and polymeric materials.[2] Poly methyl methacrylate (acrylic resin) has been the most extensively used material for the fabrication of dentures as it possess a combination of favorable characteristics such as easy laboratory manipulation, light weight, inexpensive fabrication, stability in the oral environment, lack of toxicity and appropriate aesthetic and color matching ability.[3] The development of composite or filled resin restorative materials since 1960 has resulted in higher mechanical properties, lower thermal coefficient of expansion, and lower dimensional change on setting and higher resistance to wear, thereby improving clinical performance.[4] Aesthetics are the main advantage of composites, since dentists can blend shades to create a color nearly identical to that of the actual tooth. Resin composite restorative materials have witnessed a tremendous development since their first application in dentistry in 1950. Due to their improved esthetic qualities, strength, and predictability, wears resistance, and reduced water sorption with respect to earlier versions, the use of composite restorations has become more and more popular in recent decades.[5] Biocompatible material is considered biocompatible if it does not produce harmful or toxic reactions in the tissues it contacts or adverse systemic reactions as a result of elements, ions, and/or compounds it releases. Biocompatibility, the materials used as implants are expected to be highly nontoxic and should not cause any inflammatory or allergic reactions in the human body. The success of the biomaterials is mainly dependent on the reaction of the human body to the implant, and this measures the biocompatibility of a material.[6] A brief summary of recent developments in the above-mentioned fields. Liu et al. in (2012), found that (trimethoxysilyl) propyl methacrylate (TMSPM) had a remarkable influence on the mechanical properties of the composites due to the improvement of interfacial adhesion between filler and matrix with better dispersion of the modificated particles in matrix. The surface modification of nano-SiO_2 with TMSPM reduces the particles' aggregation and improves the dispersion in organic solvent.[7] Alnamel in (2013), added silicon dioxide nanoparticles to PMMA and found that water sorption and solubility decreased as the percentages of silicon dioxide increased. Significant decrease in water sorption and solubility was obtained by the addition of 3% of surface TiO_2 anoparticles to heat polymerized acrylic resin.[8] Asar et al. in (2013), found that there was a significant increase in impact strength of heat polymerized acrylic resin after

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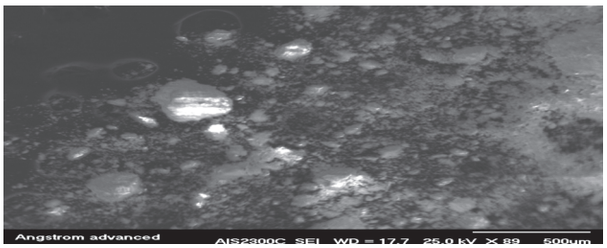

Fig. 1. SEM image of MZT.

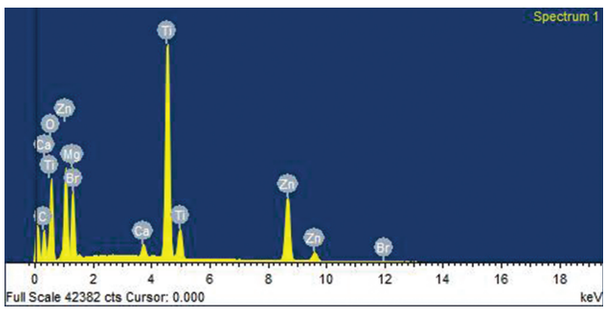

Fig. 2. EDX-spectrum analysis of MZT.

the addition of 1%Zr 1% TiO_2 surface modified micro particles.[9]

2. THEORETICAL PART

Water and Simulated body fluid (SBF) sorption of a material represents the amount of water adsorbed on the surface and absorbed into the body of the material during fabrication or while the restoration is in service, solubility represents the mass of soluble materials (residual monomer, plasticizing and initiating components) from the polymers [159]. Water sorption would lead to a variety of chemical and physical processes that may result in deleterious effects on the structure and function of dental polymers[10] Water molecules spread between the macromolecules of the material, forcing them apart thus affecting the dimensional instability,[11] furthermore subjecting the material to internal stresses that may result in crack formation and eventually, fractures of the denture[12] in addition it has detrimental effect on the color Stability.[13] Therefore, the water sorption is an critical problem that affects durability so many attempts were done to minimize water sorption of PMMA by incorporation of different types of fillers into resin matrix (nanocomposite). The value for the water sorption (W_{sp}), calculated for each specimen, expressed in microgram/ cubic millimeter, from the following equation ISO1567: 1999(E)

$$\text{Sorption } W_{sp}\ (\mu g/mm^3) = \frac{m_2 - m_1}{v}$$

$$\text{Sorption SBF } (\mu g/mm^3) = \frac{m_2 - m_1}{v}$$

m_2 = mass of the specimen in microgram after immersion. m_1 = mass of the specimen, in microgram before immersion. V = volume of the specimen, in cubic millimeter.

3. EXPERIMENTAL DETAILS

In this work, the polymer mixture was synthesized by mixing 50% of PMMA and 50% of PLA using the mixture method to obtain a homogeneous mixture of materials. The ceramic powder of zinc oxides, magnesium and titanium nanotubes was prepared with 1:1:1 ratio using the effective mechanical mix. The ceramic ball mill was used with a rotational speed of 350 rpm and the tubular furnace was used for thermal reaction at 1300 °C. For a three-dimensional system, as shown in Figure 1, it represents an image of the scanning electron microscope and Figure 2, which represents the energy dispersion spectrometer of the reaction compounds. The models were formed for the purpose of examining the surface hardness in the form of three groups. The water absorption and the solution were similar to the body fluids after the immersion of the models in the second and third groups in the water and in the solution for 30 days.

4. RESULTS AND DISCUSSION

The results of the test for the prepared samples were significantly improved by increasing the weight ratio of the prepared bioceramic powder. The samples were prepared in three groups. The first group was submerged in a solution similar to the body fluid. The second group was submerged in water. The third group was left immersion and the surface hardness was calculated using a Vickers hardness device. The samples were immersed in the first and second group for 30 days away from sunlight. Table I shows the percentage values of the absorption of a solution similar to the body fluid and the values of surface hardness before and after immersion. Figure 3 shows the relationship between surface hardness before and after immersion with the percentage of absorption. The increase

Table I. Experimental SBF absorption values.

Sample code	Weight before test (M1) (mg)	Weight after test (M2) (mg)	Volume of sample cm^3	Absorption M2–M1/Vmg/cm^3	Surface hardiness MPa before	Surface hardiness MPa after
PMMA/PLA	1.78	1.87	1.65	0.05	21.8	32.1
3%MZT	1.83	1.87		0.024	40.1	47.3
5%MZT	1.96	1.99		0.018	52.3	58.8
7%MZT	1.92	1.93		0.006	83.4	91.4
10%MZT	1.94	1.94		0	98.3	104.3

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Table II. Experimental water absorption values.

Sample code	Weight before test (M1) (mg)	Weight after test (M2) (mg)	Volume of sample cm^3	Absorption M2–M1/Vmg/cm^3	Surface hardiness MPa before	Surface hardiness MPa after
PMMA/PLA	1.78	1.89	1.73	0.062	21.8	19.6
3%MZT	1.83	1.85	1.79	0.0111	40.1	33.9
5%MZT	1.96	1.98	1.81	0.011	52.3	46.7
7%MZT	1.92	1.95	1.87	0.016	83.4	67.9
10%MZT	1.94	1.96	1.93	0.010	98.3	76.4

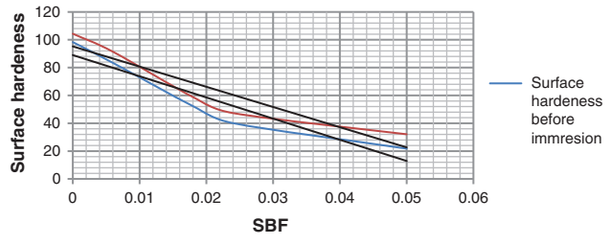

Fig. 3. Experimental values of surface hardiness with absorption (SBF), blue curve before immersion, red curve after immersion.

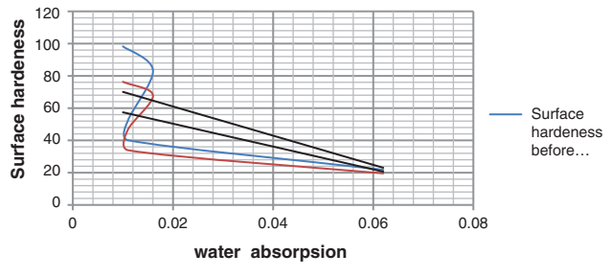

Fig. 4. Experimental values of surface hardiness with absorption (water), blue curve before immersion, red curve after immersion.

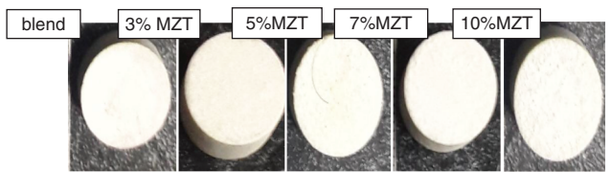

Fig. 5. Images of nanocomposites after immersion in SBF.

in the percentage of the material in the ceramic powder has significantly improved the surface hardness of the submerged samples. In the solution similar to the body fluid and the reason is due to the stability of volume and increase the mass of samples increase sequential percentage of ceramic powder, resulting in an increase in the volumetric density of all samples and close all the pores on the surface of the solution and solution Yen layer of it. While the second group samples submerged in water, the surface hardness decreased significantly due to the large size of the samples and the decrease in the volumetric density due to the opening of the pores in the surface of the models. Figure 4 shows the relationship between the surface hardness before and after immersion in water with the percentage of absorption. Figure 5 shows images of the light microscopy of the layer of the white precipitate of the body-like solution in the first group samples. The prepared mixtures supported by the triple ceramic powder are considered to be compensatory substances for bones and teeth and their brutality

5. CONCLUSIONS

We can conclude from the current research that:

1. Through practical results, we can deduce that the prepared composites have increased their density when immersed in the solution similar to the body fluid.
2. Prepared composites submerged in water decreased their density resulting in a clear reduction in surface hardness.
3. Prepared composites can be compensatory substances for bones and teeth to be compatible with body tissues through the adhesion of the solution similar to the body fluid on the surface of the samples, especially models that have a high proportion of ceramic powder.

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