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BIOPHYSICS PROPERTIES OF NHA – PMMA USED IN MEDICAL APPLICATIONS

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ABSTRACT

In this work we improving the mechanical properties for poly methyl methacrylate (PMMA) structure via reinforcement by Nano- Hydroxyapatite (NHA) with weighting ratios (1%, 2%, 3%, 4%, and 5%) by using mixing fluid to dispersing the ceramic powder (NHA) in PMMA matrix. Samples have been formed according to standard specifications for testing (surface hardness, impact strength, young modulus and compression resistance). The results show high improvements in these properties with increasing ratios for reinforce material compared with pure PMMA.

KEYWORDS: PMMA, NHA, poly (methyl methacrylate), mechanical properties.

Original Article

INTRODUCTION

At the current few years many studies have been focused on the hybrid nanocomposite organic – inorganic materials, there is a prospecting that the nanocomposite materials will supply a chief and development wherewithal of obtaining characteristics which could not be recognized within alone materials [1-3].

Composite materials with nanoscale domains show unique chemical and physical properties that are different from composites with micro-scale domains [4–6]. Organic – inorganic cross breeds, while organic polymers are scattered within inorganic phase by the side of nanometer or molecular stage, there is a huge investigate for the reason that exclusive characteristics could be resulted from nanometer length scales, like an altitude gas - barrier characteristic and brilliant solvent resistance, flame resistance and high lucidity. Optical lucidity is the most important properties of these cross bred sand it grow up as a reason of material dispersal within matrix in order of tens of nanometers, lowest than the wavelength of apparent and ultraviolet light. So that light doesn't diffusely waste [7].

Poly methyl methacrylate (PMMA) usually utilized as a cheap thermoplastic polymer at boundless applications. PMMA could be distributed like a hard, solid, but fragile material, with glass transference of temperature at 105°C. PMMA materials have better mechanical vigor, suitable chemical resistance, and very fine weather resistance. PMMA materials have appropriate processing characteristics, excellent thermoforming, and could be made to order with colors, flame extra delaying, UV absorptive additives, and scratch resistant coating [8, 9].

PMMA materials have been regularity utilized with different cultivates since that it is compatible with tissue of human being for the reason that its lucidity and bio-compatible, PMMA materials are important with optometry to replace the intraocular lens for cataract patients. PMMA is utilized to be like bone cement in orthopedic surgery. The modulus of flexibility is the same as natural bone and it give more normal feeling to patient as an opposite of metallic alternative. The reimbursement of using PMMA in human bodies is countered with the exothermal that occur at the same time as treatment by the acrylic. The heat that generated has a possibility of damages encirclement the tissue [10]. While PMMA materials are jointed with inorganic materials like SiO_2 and TiO_2 otherwise zirconium oxide (ZrO_2) within nanometer level, the resultant hybrid materials contain high strength and thermal firmness [11, 12].

Tooth enamel is the most mineralized tissue of human body. Its composition is 96 wt.% inorganic material and 4 wt.% organic material and water. In dentin, the inorganic material represents 70 wt.%. This inorganic material is mainly composed by a calcium phosphate related to the hexagonal hydroxyapatite, whose chemical formula is $Ca_{10}(PO_4)_6{\cdot}2(OH)$. Hydroxyapatite (HA) is the principle part of finish, which gives an appearance of splendid white and disposes of the diffuse reflectivity of light by shutting the little pores of the polish surface. Hydroxyapatite has for some time been among the most considered biomaterials in the medicinal field for the two its demonstrated biocompatibility and for being the fundamental constituent of the mineral piece of bone and teeth. Hydroxyapatite is likewise a critical wellspring of calcium and phosphate, imperative for the remineralization of demineralized polish zones. The inorganic part of all the mineralized tissues of the human body is, actually, comprised of a substantial commonness of calcium phosphate salts. Other inorganic materials, for example, calcium carbonates and sulfates are available in littler amounts as well; specifically hydroxyapatite speaks to 60– 70% and 90% in load of bone and veneer separately. The as of late created enthusiasm for nanotechnology in numerous fields is delivering fascinating and up and coming applications in dentistry for nano-hydroxyapatite, which presents precious stones going in size somewhere in the range of 50 and 1000 nm. The nano-hydroxyapatite has a solid capacity to bond with proteins, just as with parts of plaque and microscopic organisms, when contained in toothpastes. This capacity is because of the measure of nanoparticles, which impressively increment the surface zone to which proteins can tie. In addition, nano-hydroxyapatite likewise goes about as filler since it fixes little gaps and melancholies on finish surface, a capacity upgraded by the little size of the particles that form it.

Poly methyl methacrylate – Nano Hydroxyapatite (PMMA-NHA) is very important nanocomposites and was utilized to increase needed to the optical waveguides, ophthalmic lenses, anti-reflection coatings and viscose to optical materials [13]. Small particles with a diameter of 10 nm could be avoided Rayleigh spreading and would be integrated with polymer matrix at the same time as saving the optical transparency. There are a small number of reports of the synthesis of crystalline HA and the particle size average of 5nm [14, 15] besides of these reports, NHA dispersion has been colored, which enclosed their applications possibility. In recent times, since the enhancements with industrializing processes, it could be able to get non-aggregated HA nanocrystals of about (3 nm) within a hydrous solution [16]. This NHA aqueous solution was colorless and fitting to be used at the preparation of organic polymer nanocrystal and NHA hybrid materials.

Many researchers have focused on the use of nano-HA as a co-adjuvant material in oral surgery, especially regarding the improvement of the dental implant characteristics. In the work of Masahiro *et al.* of 2012 [17], they analyze a new compound with nano-polymorphic crystalline HA applied to microrough titanium surfaces through a combination of flame spray and calcination at a low temperature. It was then analyzed for the biological capacity to increase bone-implant integration.

The aim of the research is to develop nanocomposite materials from a bioceramic system and polymer, in which it compatible with the human body tissue to be used as compensatory materials to bones and teeth**.**

The first mechanical properties will be hardness; the unit and magnitude of the hardness are defined by Vickers hardness, which test method consists of indenting the test material with diamond indenter. The Vickers hardness is the quotient obtained by [18]:

$$HV = 1.854\ F/\ d^2 \ldots\ldots\ldots (1)$$

Where: F: load in (kgf), d: diagonal (mm), HV: Vickers hardness (MPa).

The compression strength is the most important mechanical property of restorative materials. The equation calculates by [19]:

$$\sigma_{comp} = P/A \ldots\ldots (2)$$

P: Pressure, A: Area.

The impact strength is ability of the material to resist the break of sudden impact, and it is an important property of the material especially dental materials. The impact strength was calculated using the following formula [20]:

$$I.S = E(J)/\ A \ldots\ldots.. (3)\ (KJ/m^2)$$

I.S: impact strength. E: Energy of fracture (KJ), A: Cross sectional (m^2).

MATERIALS AND METHODOLOGY

In this work soft powder of PMMA with granular size of (75µm) was used with the solvent chloroform; it has high transparency, volume density of (1.15 gm/cm^3) and refraction index 1.45, which is nearly similar to glass refracting. The NHA- powder (40 nm) with surface area of (50gm/m^2) (origin china) was used. The samples were obtained using the liquid mixing method and also the ultra-sound technique. The moldings were made of silicon according to the standard specifications. The laboratory tests of the samples prepared were carried out.

RESULTS AND DISCUSSIONS

In this work, we improved some of the mechanical properties of the poly methyl methacrylate (PMMA) as this structure lacks hardness and durability when used in practical applications. And it is extensively used in all fields, one of which is the medical applications as it is used in teeth and bones making and structuring together with the lenses of eyes; it is considered non-poisonous material which coincides with the human body. The hydroxyapatite nanocrystal was used in reinforcing PMMA matrix so as to improve its mechanical properties such as density, the surface hardness, compressibility solidity, Young modulus and impact strength as the Figures (1, 2, 3, 4 and 5) show the practical results of the tests of NHA – PMMA nanocomposites specimens.

These properties were all improved when a reinforcement the strengthening material (NHA) with forward increase in the weight percentages of the added material in comparison with the basic material PMMA. The reason behind the increase in the surface hardness and in mechanical properties under study is that the reinforcing material has high surface hardness and surface area. In addition to the high density, this was resulted in an increase in the compaction process in the prepared samples with an obvious decrease in the gaps and the porosities obtained. This is clearly noticed in the practical results of the impact strength and coefficient and this goes hand in hand with the source [21]. Figures 6,7 shows the SEM and EDx images of a cross section nanocrystal (NHA).

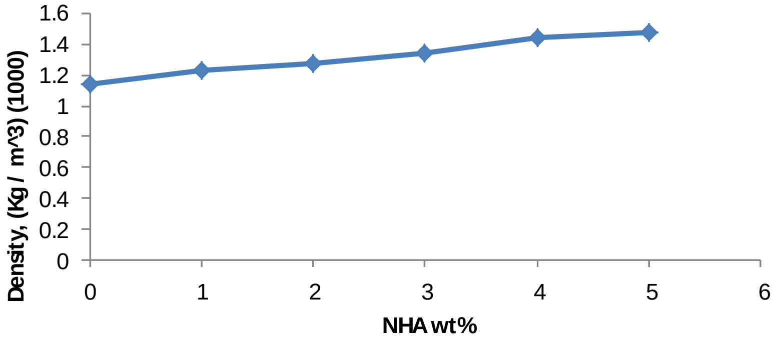


Fig. 1: Influnce of wt% of NHA on density of PMMA nanocomposites.

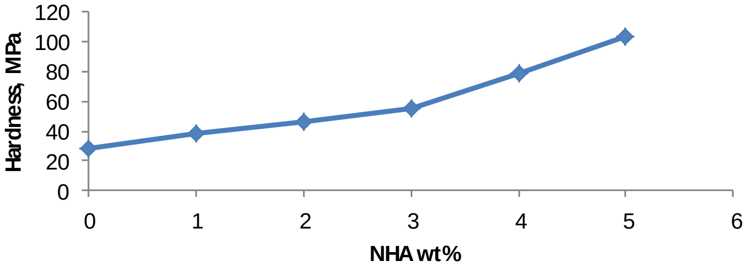


Fig. 2: Influnce of NHA wt% on hardenss of PMMA nanocomposites.

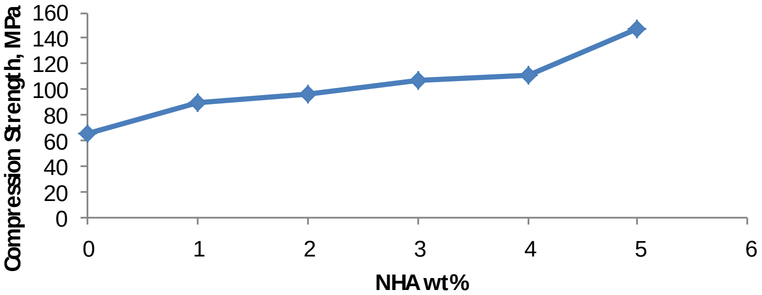


Fig. 3: Influnce of NHA wt% on compression strength of PMMA nanocomposites.

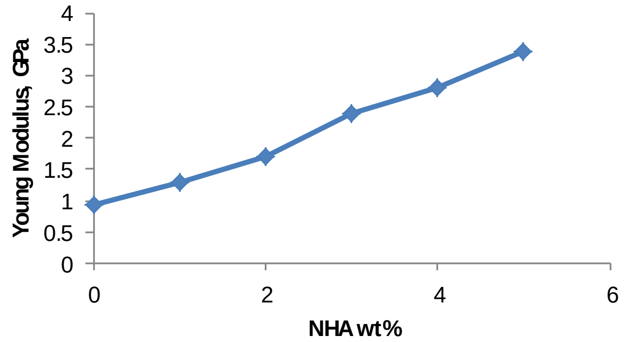


Fig. 4: Influnce of NHA wt% on Young modulus of PMMA nanocomposites.

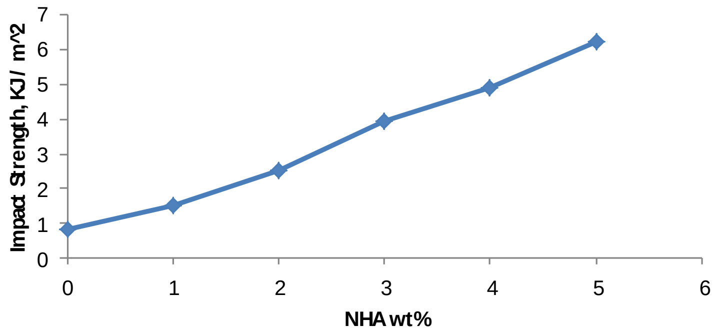


Fig. 5: Influnce of NHA wt% on impact strength of PMMA nanocomposites.

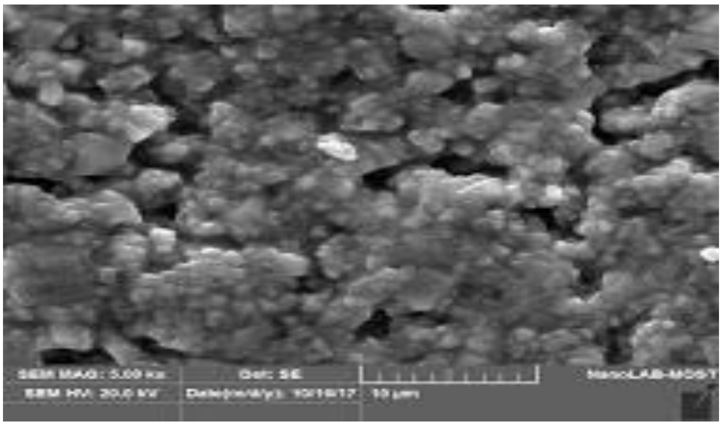
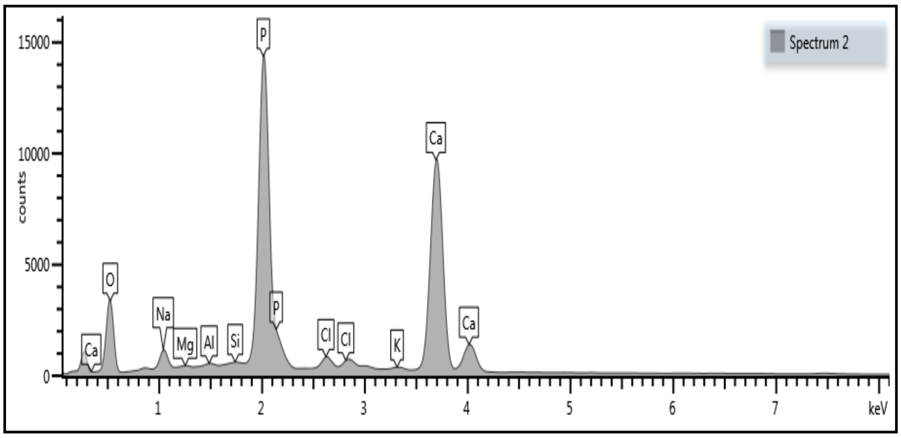


Fig. 6: SEM image of a cross section nanocrystal (NHA).



Element	Wt%	Wt% Sigma
O	41.67	0.28
Na	2.65	0.07
Mg	0.15	0.04
Al	0.24	0.03
Si	0.23	0.03
P	23.77	0.15
Cl	1.47	0.04
K	0.38	0.03
Ca	29.45	0.17
Total:	100.00	

Fig. 7: EDx image with element table of a cross section nanocrystal (NHA).

CONCLUSIONS

The present research comes out with the following conclusions: when adding the (NHA) powder with percentages less than 5%, this resulted in constancy in the mechanical properties with successive increase in addition to constancy in the dimensions of the prepared samples due to the fact that PMMA suffers shrinkage through time. From the results obtained, we conclude that the nanocomposites prepared are suitable for being compensatory materials for bones and teeth as they are biologically conform to human body in addition to the fact that the aesthetic value of the samples prepared and their resemblance to the teeth and the bones of human beings. To improvement in the impact strength and surface hardness, from the practical results obtained may lead to consider such materials and composites as materials to be used in the applications of the sanitary applications resisting breakage. In addition nano-HA paste is a potent stimulator of cell proliferation, which probably contributes to the fundamental process of periodontal tissue regeneration.

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