Improving Some Mechanical Properties of the System (PMMA-ZrO_2) Used in Medical Applications

Batool J. Obeid[1*], Fadhil K.Farhan[2], Elham J. Mohammed[3]
[1]Department of Mechanical Engineering, University of Hormozgan Qeshm campus, Qeshm, Iran; Email: Abothur7899@yahoo.com
[2] AL- KarkhUniversityof Science. College of Science.Department of Medical Physics
[3] University of Karbala. College of Science. Department of Physics

Abstract- In this work we improving some of mechanical properties for poly methyl methacrylate (PMMA) structure by reinforcement it with Zirconium dioxide Nano crystal (ZrO_2)with weighting ratios (1%,2%,3%,4%,5%)by using Mixing fluid to dispersing the ceramic powder in polymer. Samples have been formed according to standard specifications for testing (surface hardness , impact strength ,young moudulus and compression resistance).The results shows high improvement in this properties with increasing ratios for reinforce material compared with pure PMMA.
Keywords: PMMA, ZrO_2 , Poly(methyl methacrylate), Mechanical properties.

1. Introduction

At the current few years many studies have been focused on the hybrid nano-composite Organic – inorganic materials, there is a prospecting that the nano-composite materials will supply a chief and development wherewithal of obtaining characteristics which couldn't be recognized within alone materials [1-3].
Composite materials with nano-scale domains show unique chemical and physical properties that are different from composites with micro-scale domains.[4–6]. Organic–inorganic crossbreds, 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 crossbreds and 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 wasted.[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 a 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 a 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 body's are countered with the exothermal that occur at the same time as treatment by the acrylic. The heat that generated have a possibility of damages encirclement the tissue[10].while PMMA materials are joint with inorganic materials like SiO_2, TiO_2 otherwise zirconium oxide (ZrO_2) within nanometer level, the resultant hybrid materials contain high strength and thermal firmness [11,12].
Poly methyl methacrylate /zirconia (PMMA-ZrO_2) is very important nano-composites 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 ZrO_2 and the particle size average of 5nm.[14,15] besides of these reports, ZrO_2 dispersion has been coloured, which enclosed their applications possibility. in recent times, since the enhancements with industrializing processes, it could be able to get non aggregated ZrO_2 nanocrystals of about (3 nm) within an hydrous solution [16]. This ZrO_2aqueous sol was colorless and fitting to be used at the preparation of organic polymer nanocrystaland ZrO2 hybrid materials.

2. The Aim of the Research

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018

Develop a nano composite materials from a bioceramic system and polymer ,in which it compatible with the body tissue to be used as compensatory materials to bones and teeth**.**

3. Theoretical Part

1. Hardness test: The unit and magnitude of the hardness are defined by viekers hardness, which test method consists of indenting the test material with adiamoud indenter.
The viker hardness is the quotient obtaind by
$Hv = 1.854\ F/\ d^2$ ………(1)
Where:
F: load in (kgf)
d :diagonal (mm)
Hv: vikers hardness (MPa) [18]

2. Compression strength: The compression strength is the most important mechanical property of restorative materials.
The equation calculate by:
$\sigma_{comp} = P/A$ …….(2)[19]
P: Pressure.
A: Area.

3. Impact strength: It is ability of the material to resist the break of sudden impact , and it is an important property of the material specially dental materials.
The impact strength was calculated using the following formula;[20]
$I.S = E(J)/\ A$ ……..(3) (KJ/m^2)
I.S: impact strength .
E: Energy of fracture (KJ),A: Cross sectional (m^2).

4. Experimental and material used

In this work soft powder of PMMA with granular size of (75Mm) was used with the solvent chloroform; It has high transparency , volume, density of (1.15 gm/cm^3) and refraction index1.45 which is nearly similar to glass refracting , The Zirconium dioxide powder (40 nm) withsurface 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 matrices were made of silicon according to the standard specifications .The lab tests of the samples prepared were carried out.

5. Discussion

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 thelenses of eyes;it is considered non-poisonous material which coincides with the human body. The Zirconium dioxide Nano crystal was used in reinfocing PMMA so as to improve its mechanical properties such as the surface hardnessand compressibility solidity, Young moudulus and impact strength as the figures(1, 2, 3 and 4) show the practical results of the tests of (surface hardness, compressibility, Young moudulus, impact strength).
These properties were all improved when a reinforcement the strengthening material(n-ZrO_2) with forward increase in the percentages of the added material in comparison with the basic material PMMA. The reason behind the increase in thesurface hardness and in some of mechanical properties is that the reinforcing material has high surface hardness and surface area In addition to the high density, which 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 strengthand coefficient and this goes hand in hand with the source [21]

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018

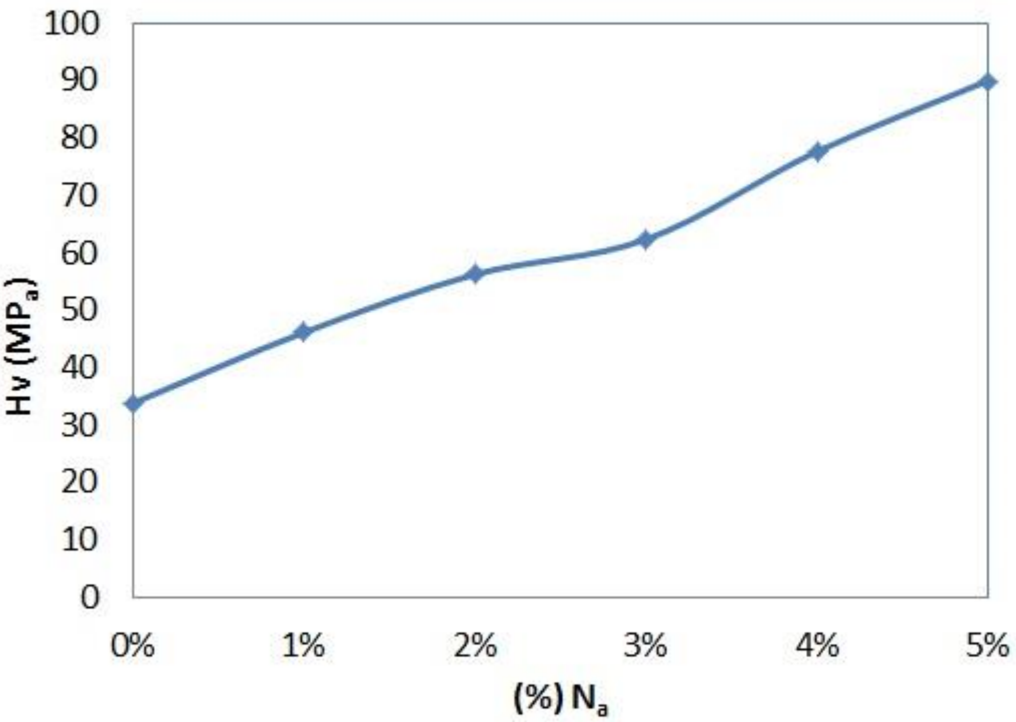

Fig. 1. The surface hardness value of nanocomposites (PMMA/ - $nZrO_2$)

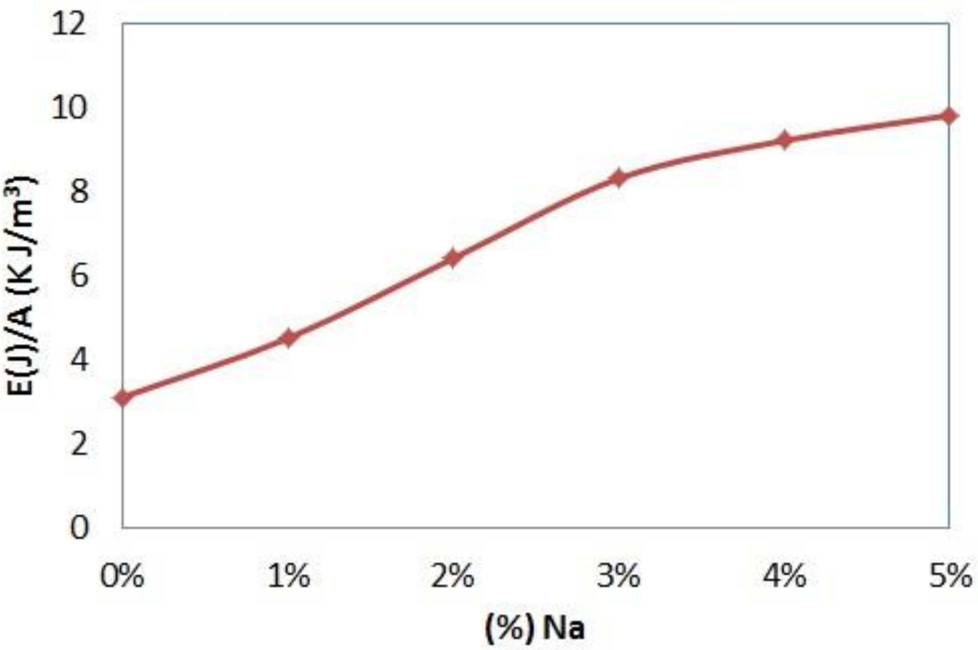

Fig. 2. The impact strength value of nanocomposites (PMMA/ - $nZrO_2$)

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018

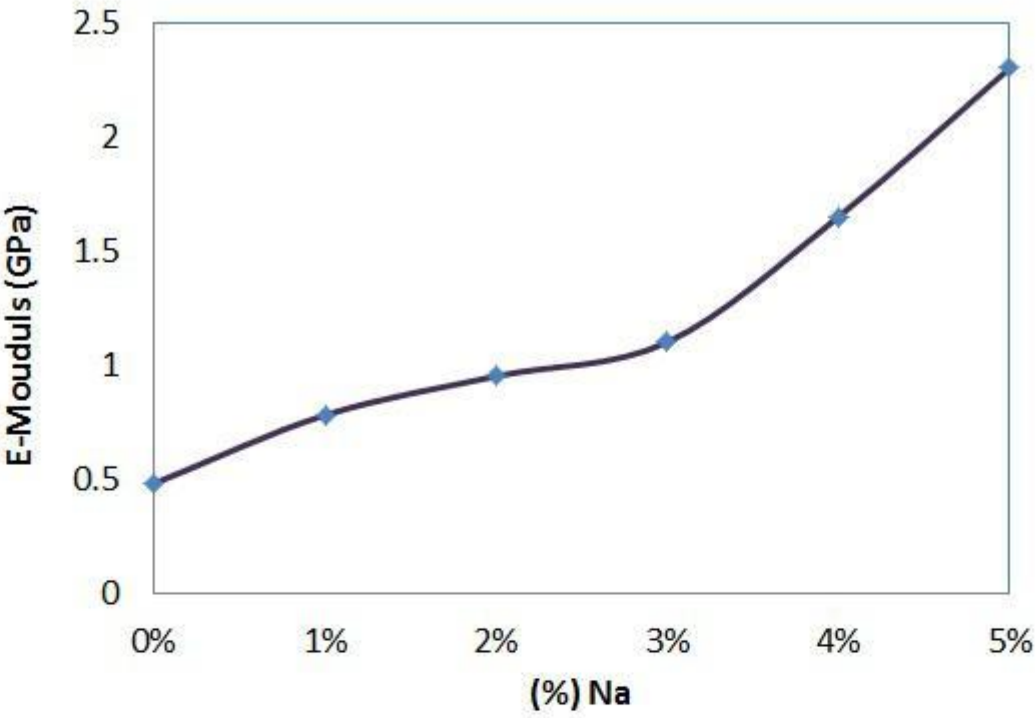

Fig. 3. The young moudulus value of nanocomposites (PMMA/ - $nZrO_2$)

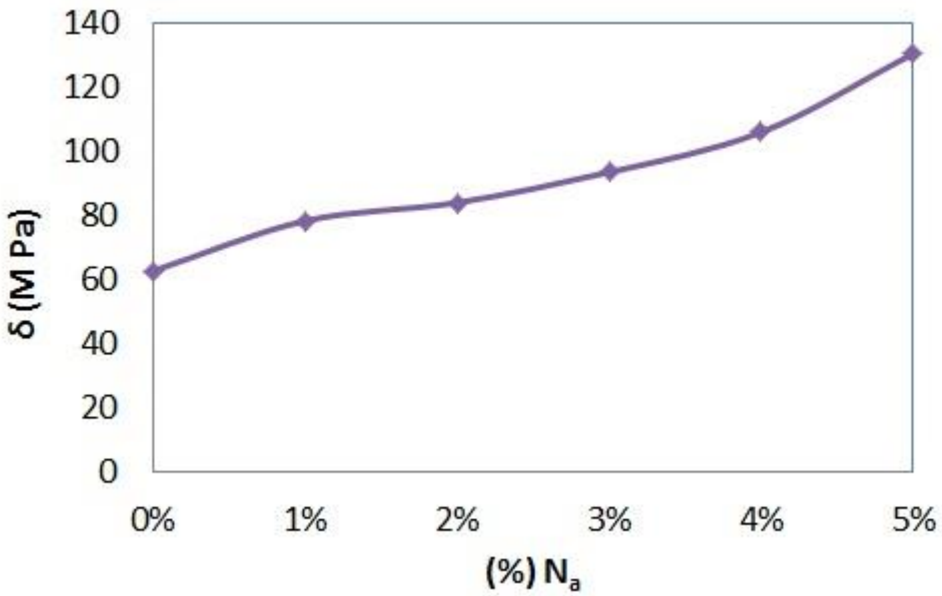

Fig. 4. The compressibility value of nanocomposites (PMMA/ - $nZrO_2$)

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018

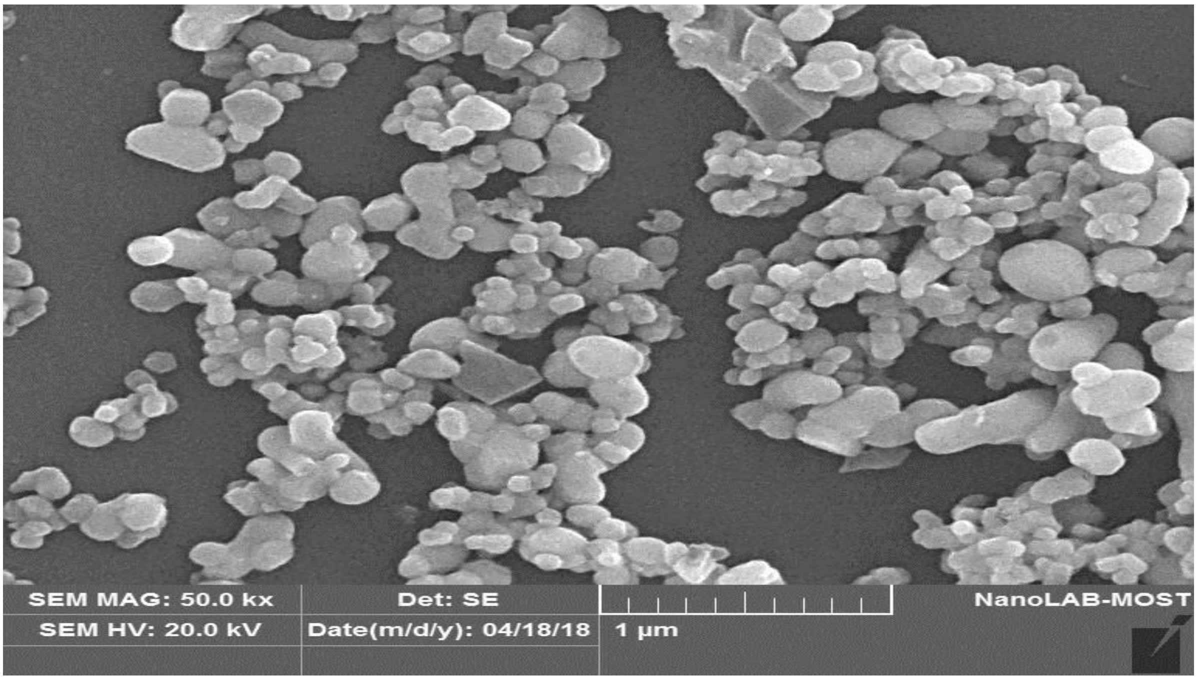

Fig. 5. SEM image of a cross section ofZirconium dioxide Nano crystal (ZrO_2)

6. Conclusions

The present research come out with the following conclusions:

1- When adding the (n-ZrO_2) powder with percentages less than 5%, this resulted in a constancy in the mechanical properties with successive increase in addition to a constancy in the dimensions of the prepared samples due to the fact that PMMA suffers shrinkage through time.

2- From the results obtained, we conclude that the nano composites 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.

3- 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.

References

[1] Novak, B. M. Hybrid nanocomposite materials—between inorganic glasses and organicpolymers. Adv. Mater. 5, 422–433 (1993).

[2] Schubert, U., Husing, N. & Lorenz, A. Hybrid inorganic-organic materials by sol-gelprocessing of organofunctional metal alkoxides. Chem. Mater. 7, 2010–2027 (1995).

[3] Wen, J. & Wilkes, G.L. Organic/inorganic hybrid network materials by the sol-gelapproach. Chem. Mater. 8, 1667–1681 (1996).

[4] Schmid, G., Maihack, V., Lantermann, F. &Peschel, S. Ligand-stabilized metal clustersand colloids: properties and applications. J. Chem. Soc. Dalton Trans. 589–595 (1996).

[5] Beecroft, L. L. &Ober, C. K. Nanocomposite materials for optical applications. Chem.Mater. 9, 1302–1317 (1997).

[6] Mucic, R. C., Storhoff, J. J., Mirkin, C. A. &Letsinger, R. L. DNA-directed synthesis ofbinary nanoparticle network materials. J. Am. Chem. Soc. 120, 12674–12675 (1998).

[7] Bohren, C. F. & Huffman, D. R. Absorption and Scattering of Light by Small Particles(Wiley: New York, 1983).

[8] Stickler, M.; Rhein, ibid.

[9] Kine, B.B; Novak, R.W., "Acrylic and Methacrylic Ester Polymers" in Encyclopedia ofPolymer Science and Engineering, Wiley: New York, 1985, 262.

[10] Strong, Plastics Materials and Processing, Prentice Hall, 2000

[11] Huang, Z. H. &Oiu, K. Y. Preparation and thermal property of poly(methyl methacrylate)silicate hybrid materials by the in-situ sol-gel process. Polym. Bull. 35, 607–613(1995).

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018

[12]
[13] Wang, H. T., Xu, P., Zhong, W., Shen, L. & Du, Q. Transparent poly(methyl methacrylate)/silica/zirconia nanocomposites with excellent thermal stabilities. Polym. Degrad.Stabil. 87, 319–327 (2005).
[14] Hu Y., Zhou S., Wu L.: Surface mechanical propertiesof transparent poly(methyl methacrylate)/zirconiananocomposites prepared by in situ bulk polymerization.Polymer, 50, 3609–3616 (2009).
[15] He, W., Guo, Z. G. &Pu, Y. K. Polymer coating on the surface of zirconia nanoparticlesby inductively coupled plasma polymerization. Appl. Phys. Lett. 85, 896–898(2004).
[16] Joo, J., Yu, T., Kim, Y. W., Park, H. M., Wu, F. X., Zhang, J. Z. &Hyeon, T. Multigramscale synthesis and characterization of monodisperse tetragonal zirconia nanocrystals.J. Am. Chem. Soc. 125, 6553–6557 (2003).
[17] Kinoshita, T. Method for Producing Metal Oxide Nanoparticle, JP Patent 2006-016236(2006).
[18] Otsuka, T. &Chujo, Y. Preparation and characterization of poly(vinylpyrrolidone)/zirconium oxide hybrids by using inorganic nanocrystals. Polym. J. 40, 1157–1163
[19] (2008).
[20] PoskusL.T,placido E," Influence of placement techniques on vikershardeness of class11 composite vesin; Dent Mater.V. 20,PP.726-732;(2004).
[21] Craig R. and power J.M; " Restorative dentd materials " 12th Mosby Inc. Ch.4:pp. 53-65; (2006).
[22] Williams.J.W; "Fracture Mechanical of polymers" Elis Horwoodlimited, London (1984).
[23] D.R.Paul and L.M.Robeson,"Polymer nanotechnology : nanocomposites", Polymer , vol.49,no.15,pp.3187-3204, 2008.

*Corresponding Author: *Batool J. Obeid*
Article History: Received: June 15, 2018, Revised: August 15, 2018, Accepted: Sep 15, 2018