Study Compression and Impact Properties of PMMA Reinforced by Natural Fibers Used in Denture

Jawad K. Oleiwi
Department of Materials Engineering, University of Technology, Baghdad, Iraq.
jawadkad@yahoo.com

Sihama I. Salih
Department of Materials Engineering, University of Technology, Baghdad, Iraq.
sihama_salih@yahoo.com

Hwazen S. Fadhil
Department of Materials Engineering, University of Technology, Baghdad, Iraq.
Hawazen_s90@yahoo.com

Received on: 19/07/2017
Accepted on: 23/11/2017

Abstract- *The fracture in dentures prepared from acrylic resin occurs frequently during the accidental damage or service through heavy occlusal force [1]. Impact failures usually occur out of the mouth as a result of accidental dropping due to cleaning, coughing or sneezing or a sudden blow to the denture [2]. This paper is focused on the effect of natural fibers on the mechanical properties of PMMA by changing two parameters (content of fibers and length of fibers). Fibers were treated with alkaline solution to improve the interfacial adhesion. Composite specimens were prepared by using hand lay-up method. The results were showed that the increasing the weight fraction of both fibers lead to increase compression strength and decrease impact strength of composite specimens. While, increasing fiber length of both fibers lead to decrease compression strength and increase impact strength of the composite specimens. The largest value obtained for bamboo specimens at (2mm) fiber length and (9wt. %) and reach (530 MPa.). The main goal of this research is studying the impact and compression properties of PMMA reinforced by natural fibers (siwak and bamboo) by varying length and concentration of both kinds of fibers.*

Keywords- *Impact, compression, PMMA, natural fibers, impact properties, compression properties, denture.*

How to cite this article: J.K. Oleiwi, S.I. Salih and H.S. Fadhil, "Study Compression and Impact Properties of PMMA Reinforced by Natural Fibers Used in Denture," *Engineering and Technology Journal,* Vol. 36, Part A, No. 6, pp. 652-655, 2018.

1. Introduction

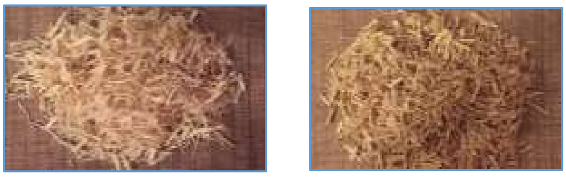
Increasing necessity for cost effective materials with relatively high strength to weight ratio, made researchers to study natural fibers. Today natural fibers are a popular choice for the applications in composite manufacturing. These natural fibers are plant based and are lignocelluloses in nature. They are composed from (lignin, pectin, cellulose, hemicelluloses and waxy substances). The natural fiber reinforced composites are comparably strong, lightweight and free from health hazards [3]. Despite the advantages of these fibers they weak adhesion between the fiber and matrix resin and weak resistance to moisture. Chemical treatment of fibers producing improvement in strength in addition to dimensional stability of polymer reinforced natural fiber due to reducing the hydrophilic behavior of the fibers by losing hydroxyl groups of fibers [4]. Inoue K. et.al, study some mechanical properties of PMMA was used for denture reinforced by glass fibers. The results were showed that the bending and impact properties for PMMA increased when the layers of fiber glass increased [5]. Koksal et al. estimate the influence of glass fibers in various contents (2.5, 3, 4 & 5%) on impact properties of PMMA. The results showed that the impact strength increase by increasing fraction of glass fiber and the highest value of impact strength found in weight fraction 5% [6]. Khalaf et al. have study the effect of strengthening acrylic resin reinforced with siwak micro powder on the some mechanical properties of. Results showed that strengthening acrylic resin by (7 %) siwak powder have a considerable reduce in impact, compressive and tensile strength [7]. Ravishankar et al. determine the impact properties of PMMA strengthened by polypropylene fibers by varying the weight fraction of fibers (2.5, 5 and 10 wt%). The result was showed that the polypropylene fiber improves the impact properties of acrylic base material and the higher value obtained at 10 wt. % of 12mm length of polypropylene fiber reinforced PMMA [8]. Salih et al. were developed the properties of PMMA by using two kinds of nano particles "nano-hydroxyapatite and micro-zirconia". In addition, two fibers (glass fiber and Kevlar fiber) added to PMMA. The results were showed that the magnitude of compression strength improved by adding particles. Results illustrated that the (PMMA-ZrO_2) composites have a larger magnitudes of the compression strength. In addition, the higher the magnitude of compression strength for the composite were found in (PMMA-ZrO_2-5% Glass Fiber) [9]. Salih et al. were improved properties of PMMA by adding different types of nano-

https://doi.org/10.30684/etj.36.6A.9
2412-0758/University of Technology-Iraq, Baghdad, Iraq

particles such as (fly ash, fly dust, Zirconia and aluminum) at various fractions (V%) of (1, 2 & 3 %) to PMMA. The results were showing that the flexural properties, impact strength and fracture toughness increased with increasing Content of particles and the highest values of obtaining for (PMMA:1% nono fly dust) and maximum values of fracture toughness obtained for (PMMA:3%nano fly dust) [10].

2. Materials and Methods

In this research bamboo and siwak fibers were used in three concentrations (3, 6 & 9 wt. %) and three different lengths (2, 6 & 12 mm) as reinforcing materials in PMMA resin, as shown in Figure (1, A, B).



(A): Bamboo fibers (B): Siwak Fibers

Figure 1: Materials that used in this research.

3. Alkali trTeatment

The fibers treated by 5% (weight/volume) alkaline solution (NaOH) at 25 °C for one day, keeping a (fiber/ liquor) proportion of 1:30 (w/v). The alkaline treated fiber wash sundry times with distilled water to eliminate the additional sodium hydroxide solution attaching to their surface. Later (PH) of solution balance to (7) by distilled water. Then the fibers dried at room temperature at five (days) and finally retained in a furnace at (50-60°C) until dry.

4. Preparation of Composites Specimens

According to needed percentage of (wt. %) (3, 6, 9%) of the strengthening material evaluating the quantity of strengthening material (siwak & bamboo fibers) with the electronic balance at precision (0.0001) digits based on the entire weight of the matrix material of PMMA essential for filler the stainless steel the cavities of the mould with the utilizing rule of mixture theory. One kind of treated fibers (Bamboo fibers or siwak fibers) and the liquid monomer (MMA) must be mixed together at room temperature homogeneously before adding powder to make composite specimens. Then powder added to the mixture and mixed orderly. The volumetric ratio of mixing the acrylic base resin is 3:1 (3 powder: 1 liquid monomer). The acrylic curing process is achieved by putting the sealed mould in the curing device (Ivomet) which exist in material engineering department as shown in Figure 2 at a temperature equivalent to about (55 ℃), and pressure equivalent to about (2.5 bar). The acrylic curing process is achieved by putting the sealed mould in the curing device (Ivomet) which exist in material engineering department as shown in Figure 2 at a temperature equivalent 55 °C, and pressure equivalent 2.5 bar. The sealed mould stayed in curing device (Ivomet) for about (30 min) to finish polymerization operation of acrylic samples and to enhance the physical properties. Then specimens removed from mould and after that the specimens heat treated at a temperature about (55°C) for 3 hours to eliminate remaining stresses because of demolding of the samples from the cavity of the mould.

Figure 2: Curing device

5. Compression Test

The compression test was carried out according to the international standard (ASTM D695) [11], at ambient temperature by using the universal tensile instrument. The compressive load was increased until the fracture of the sample occurs.

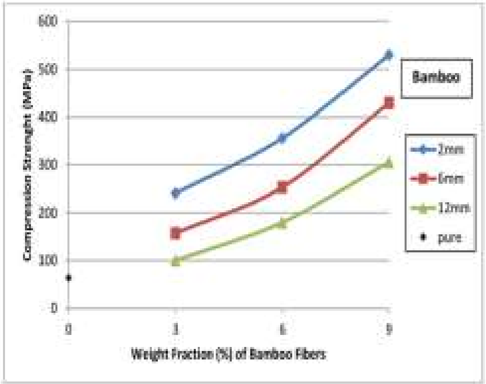
6. Impact Strength Test

The impact test is performed according to (ISO-180) by using Izod Impact test machine type is (XJU series pendulum Izod/Charpy impact testing machine) in the material engineering department labratory. In izod impact test the specimen clamped at one end and held vertically cantilevered beam and it has broken at impact energy of (5.5 J) of the pendulum and impact velocity (3.5 m/s) [12].

7. Compression Test Results

Compression test for composite specimens with bamboo and siwak reinforcing fibers are shown in Figure 3and 4 respectively. It can be noticed from the Figures 3 and 4 that the compression strength of specimens enhances by increasing the weight fraction of two fibers types in this study, the reach maximum at weigh fraction equal to (9%), the increase in compression strength is due to ability of fibers to strength the matrix and improvement in mechanical bonding between fibers and matrix (PMMA) that providing better compressive strength by increasing fibers [13]. The values of compression strength of pure PMMA specimens about (64.4 MPa) whiles the higher magnitude of compression strength of composite sample reinforced by bamboo and siwak fibers found at 9 wt. % and fiber length (2mm) reach (530 MPa & 310 MPa) respectively.

Figure 3: Compression strength of composite



specimens reinforced with bamboo fibers.

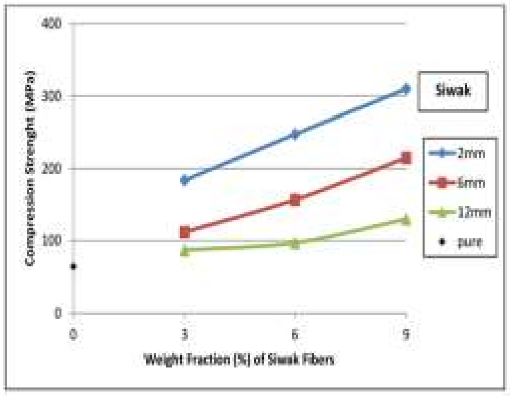


Figure 4: Compression strength of composite specimens reinforced with siwak fibers.

8. Impact Strength Test Results

Impact strength is the absorb energy by composite materials through a cross vassal area for composite samples. The impact test is various from other mechanical tests because it is so fast. Where the sample is subjected to the fast stress leading to changes in the behavior of composite material. The Figures 5 and 6 shown relationship between the impact strength and weight fraction of the fiber reinforcement bamboo and siwak respectively, which added to the acrylic resin matrix.

Impact strength of the composite specimen is controlled by two elements: first, the capability of the reinforcing material to stop crack propagation by absorbing energy and the second one, poor bonding between reinforcing fiber and matrix, which cause micro-spaces and result in crack propagation [14]. Figures 5 and 6 illustrated the impact strength for pure acrylic (PMMA) is reached to (8.75 kJ/m2), and more than specimen reinforced with fibers. Impact strength reduces with increasing weight fraction of fibers, because of stress concentration areas in the polymer matrix which caused by clustered fibers and voids by an increasing percentage of fibers and reduction in bonding between fiber and acrylic resin (PMMA) [15]. Also can be observed from figures 5 and 6 the samples with fiber length (12mm) have higher values impact strength than samples with a lower length. Bamboo specimen has higher value than siwak specimen because greater force was required to propagate a crack through the interface during impact. The lower values of impact strength for composite sample reinforced with bamboo & siwak fibers were found at (9 wt. %) and (2mm) fiber length and equal to (3 & 2.5 KJ/m^2), respectively.

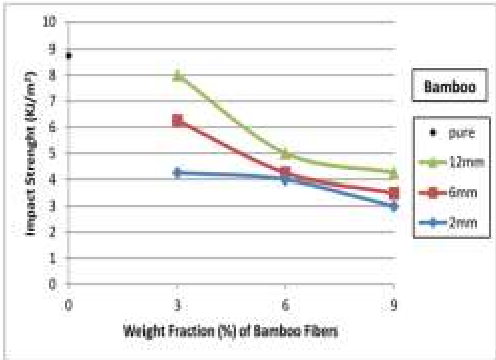


Figure 5: Impact strength of specimens reinforced with bamboo fibers

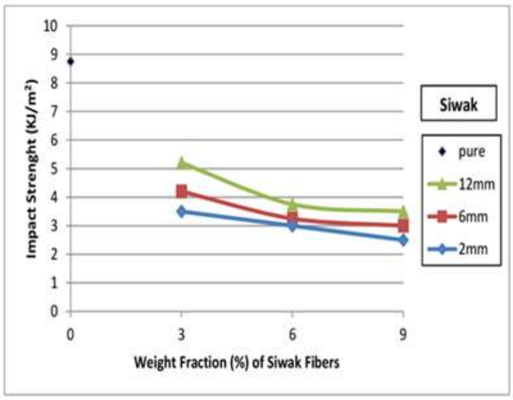


Figure 6: Impact strength of specimen reinforced with siwak fibers

9. Conclusions

1. The higher value of impact strength was for pure PMMA sample.
2. The impact strength reduce by increasing the (wt. %) of both fibers while, Compression strength increase by increasing the (wt. %) of both fibers.
3. Specimen pure poly methyl methacrylate has compressive strength lower than specimens reinforced with miswak or bamboo fiber.
4. The optimum value of compression strength found for bamboo specimens at (2mm) fiber length and (9wt.%) and equal to (530 MPa.).

References

[1] S.B. Al-Zahrani, "Causes of denture fracture: A survey," Saudi Dental Journal, Vol.18, No.3, 2006.

[2] S. A. Naji, "A clinical Study of Complete and Partial Denture Fracture at Four Hospitals in Iraq," MDJ, Vol.9, No.2, 2012.

[3] Jha. Kanishka, Y.K. Tyagi, and H.O. Maurya, "study on the mechanical properties of PMMA composite using ridge gourd fiber," Journal of Engineering and Applied Sciences, Asian Research Publishing Network (ARPN), Vol.11, No.18, 2016.

[4] L. Mohammed, M.N. Ansari, G. Pua, M. Jawaid, M.S. Islam, "A review on natural fiber reinforced polymer composite and its applications," International Journal of Polymer Science, (2015).

(http://dx.doi.org/10.1155/2015/2439

[5] T. Kanie, K. Fujii, H. Arikawa, K. Inoue, "Flexural properties and impact strength of denture base polymer reinforced with woven glass fibers," Dental Materials, official publication of the academy of dental materials, Vol.16, No.2, PP.(150-158), 2000.

[6] I. Dikbas, O. Furnuz, F. Unalan & T. Koksal, "Impact strength of denture polymethyl methacrylate reinforced with different forms of E-glass fibers," Acta Odontologica Scandinavica, Vol.71, 727-732, 2013.

[7] H.A. Rahman, "Effect of Siwak on Certain Mechanical Properties of Acrylic Resin", Journal of Oral and Dental Research, Vol. 1, No. 1, 40-45, 2013.

[8] M. Mathew, K. Shenoy, K. S. Ravishankar," Impact strength of poly propylene fiber reinforced PMMA", International Journal of Scientific & Engineering Research, Vol.5, No.9, (2014).

[9] S.I. Salih, J.K. Oleiwi and Q.A. Hamad., "Investigation of Fatigue and Compression Strength for the PMMA Reinforce d by Different System for Denture Applications," International Journal of Biomedical Materials Research, Vol. 3, No. 1, 5- 13, 2015.

[10] S.I. Salih, J.K. Oleiwi and A.M. Talea, "Flexural and impact properties of PMMA nano composites and PMMA hybirds nano composites used in dental applications," The Iraqi Journal for Mechanical and Material Engineering, Vol. 17, No. 1, 2017.

[11] Annual Book of ASTM Standard, "Standard Test Method for Compressive Properties of Rigid Plastics," D 695-02a., Vol. (08.01), PP. (1-8), 2002.

[12] Annual Book of ISO Standard, "Standard Test Method for Unnotched Izod Impact Testing of Plastics," ISO-180, PP. (1-2), 2006.

[13] P.K Mallick., "Fiber-Reinforced Composite: Materials, Manufacturing, and Design," International Standard Book, 3rd edition, 2007.

[14] M. Sumaila, I. Amber, and M. Bawa, "Effects of fiber length on the physical and mechanical properties of random oriented, nonwoven short banana (Musa Balbisiana) fibre/epoxy composite," Asian Journal of Natural & Applied Sciences, Vol. 2, No.1, 39-49, 2013.

[15] O. Karacaer, T.N. Polat, A. Tezvergil, L.V. Lassila, P.K. Vallittu, "The effect of length and concentration of glass fibers on the mechanical properties of an injection- and a compression- molded denture base polymer," Journal of Prosthetic Dentistry, Vol. 90, 385-93, 2003.