J Nanostruct 14(4): 1308-1317, Autumn 2024

RESEARCH PAPER

Evaluation the addition Different PMMA/ZnO % Nanofillers on Shear Bond Strength of Acrylic Denture Teeth

Aymen Ameen ALwash

AL-Esraa University, Baghdad, Iraq

ARTICLE INFO

Article History:
Received 19 July 2024
Accepted 27 September 2024
Published 01 October 2024

Keywords:
ZnO Nanofiller
PMMA
Shear bond strength

ABSTRACT

The goal of the research was to find out the consequences on the shear bond strength of acrylic denture teeth by adding different PMMA/ZnO% (2%, 4% and 6%) reinforcing Nanofillers. Four groups were created from the 40 acrylic resin (PMMA) specimens.10 samples for each groups separated into the following: Group 1 was the control group, Group 2 contains 2% by weight of ZnO, Group 3 contains 4% by weight of ZnO and Group 4 contains 6% by weight of ZnO. The wax pattern sample had dimensions of 20 mm in length, 5 mm in diameter, the base of the cylinder specimen was 5 mm in thickness (the height) and 8 mm in diameter. These measurements were used to make acrylic cylinder forms. We analyzed the shear bond strengths of all samples. Presented in PMMA+ZnO 4% showed the maximum mean value of upper bound of shear bond strength which was equaled to (14.379), while in the PMMA+ZnO 6% recorded the minimum value of lower bound of shear bond strength (7.617). When their significant differences between the control group PMMA and the (PMMA+ZnO 4%), while when compared the control group PMMA and the (PMMA+ZnO 2%, 6%) there were non-significant differences.

How to cite this article
ALwash A. Evaluation the addition Different PMMA/ZnO % Nanofillers on Shear Bond Strength of Acrylic Denture Teeth. J Nanostruct, 2024; 14(4):1308-1317. DOI: 10.22052/JNS.2024.04.030

INTRODUCTION

Acrylic resin (PMMA) denture base materials had good esthetics and restoration of function [1]. Tissue compatibility, Color stability, dimensional stability, ease of fabrication and repair, capacity to imitate oral tissues, takes up and retains high polish and should not be porous, lack of taste, insoluble and low oral fluid sorption are all desirable characteristics [2-4]. It also has solid and lightweight material, as well as good impact strength [5]. Because (PMMA) is so widely used in prosthetic dentistry, despite all of its good features, the fracture between acrylic teeth and acrylic denture base resin occurs often in clinical practice [6,7]. Recent research claimed that Nano Oxide they can enhance the organic polymer's physical and optical properties, as well as provide resistance to cracking and aging caused by environmental stress [8]. The experiments assessed the effect of adding ZnO Nanoparticles in various concentrations on the acrylic resin denture base's and the acrylic teeth's shear bond strength. The biological characteristics of acrylic resins can be significantly improved by blending nanoscale zinc oxide (ZnO) with denture base resins. Additionally, nanomaterials offer a wider range of opportunities for identifying superior reinforcement materials [9,10]. The shear bond

* *Corresponding Author Email: masterdent9931@gmail.com*

strength of a material is known as its capability to resist forces it causes the material's interior construct to slide against itself, the shear strength dependent on cross-sectional area of a material [11].

MATERIALS AND METHOD

Specimens were prepared according to the ADA (Abu-Anseh, 2003 and Al-Huwaizi, 2005) [12,13]. For shear bond strength it was had cylindrical shape (5mm in diameter and 20 mm in length but overall

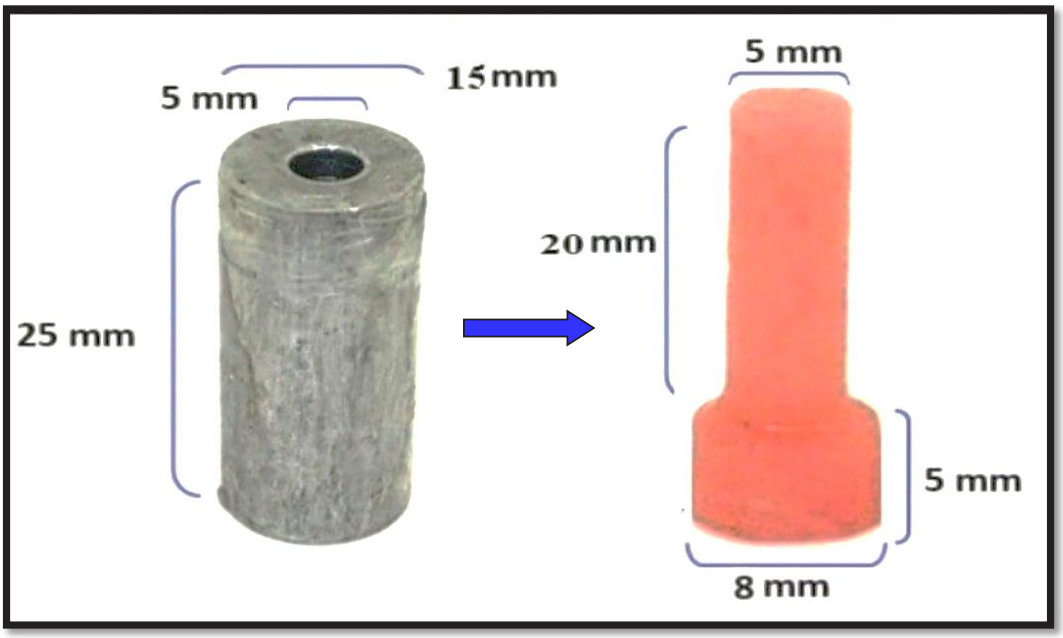

Fig. 1. The specimens shape for the wax pattern.

Fig. 2. The teeth were measured by used an electronic digital caliper

dimeter of mold 15 mm) consists of two ends. One end set on it the tooth and the other represent the base of the cylindrical specimen, which had an 8 mm diameter and a 5 mm thick (height) wall as shown in Fig. 1. 40 acrylic upper central incisors were used. They were had the same shape, size, and length of the teeth were measured by used an electronic digital caliper as shown in Fig. 2. Then were cut the cervical third of all the 40 teeth by used a laboratory engine [14]. Then the teeth are fixed on the wax pattern of the specimens at 45° degrees by used geometric Protractor [15]. By weight the addition of Nanofillers powder done in three groups, involves 2%, 4% and 6% to monomer, with sensitive balance high accuracy (±0.0000g) as in Fig. 3. By utilizing an ultrasonic homogenizer model 300 V/T (BIOLOGICS, INC.) type of mixing with (120W, 60KHz) for three minutes, the filler was well mixed with the monomer as shown in Fig. 4. To minimize the chance of particle aggregation and phase separation, the monomer solution containing Nanofillers was incorporated immediately with acrylic powder [16]. According to the instructions, the mixing ratio for acrylic resin was (2.5g: 1ml) P/L.

The specimens were grouped as following:

1. First group (group1): control group 10 samples (without any addition).
2. Second group (group2): addition 2% ZnO Nanoparticles 10 samples.
3. Third group (group3): addition 4% ZnO Nanoparticles 10 samples.
4. Fourth group (group4): addition 6% ZnO Nanoparticles 10 samples.

When the acrylic reached the dough stage, packing and curing were completed, and acrylic resin packaging was initiated. The resin is taken out of the container, rolled and put inside the molds. Finally, the flask was clamped under pressure (hydraulic press) until metal-to-metal contact was made, then left under pressure for five minutes at 20 bar. The flask was next transferred to the water bath, where it was cured for about an hour and a half at 74°C and it was heated to boiling for 30 minutes [17]. The acrylic specimens were then deflasking and taken out of the molds**.**

Every residual acrylic has been removed by a laboratory engine with an acrylic bur. To achieve a flawless finish a stone bur followed by a sandpaper in grain (120) with a constant refreshing effect. The

Fig. 3. Sensitive balance high

surface was polished skillfully using a bristle brush (vertex) and pumice, followed by polishing gel and a rouge wheel in a lathe polishing machine. After that, they were put in 25ML glass jars with aluminum closures that contained distilled water and were then 48 hours of incubation at 37 °C before being tested [16].

As shown in Fig. 5, the specimens were loaded to the point of brake, at which point a load of brake was recorded using the mode lwdw50 produced by Laryee. The shear bond strength was tested (ISO TR 11405) using a stainless steel chisel-shaped rod to apply the shearing force at 0.5 mm/min crosshead speed. The load cell depended on the force (F) in (N) at fracture and the adhesion surface area (S) in (mm^2), which were then converted to (Mpa) and had a setting of 100 kg. The following was the formula according to [15,18].

$$B.S = F / S$$

$B.S$ = Bond strength (N/mm^2) or (MPa),

F= Force at failure (N)

$S = (\pi / 4) \times D^2$; $\pi = 22/7$ or 3.14,

D (diameter) = 5mm, S = 19.64 mm^2.

After testing shear the PMMA with addition difference percentage of ZnO nano- practices, the site of the fractures was examined under SEM (Inspect S50) in the University of Technology Department of applied sciences as in Fig. 6. The Surfaces and morphology after addition nanoparticles to PMMA in different concentration were examined by ANOVA (LSD).

RESULTS AND DISCUSSION

The study descriptive statistics dependent variable of groups: Number, mean and S.D value of shear bond strength of groups as showed in Table 1, the maximum mean value was recorded by group3 (13.1069), while the minimum mean value was recorded by group4 (8.8890).

Fig. 4. Ultrasonic Homogenizer

Fig. 5. The specimens of shear at fracture

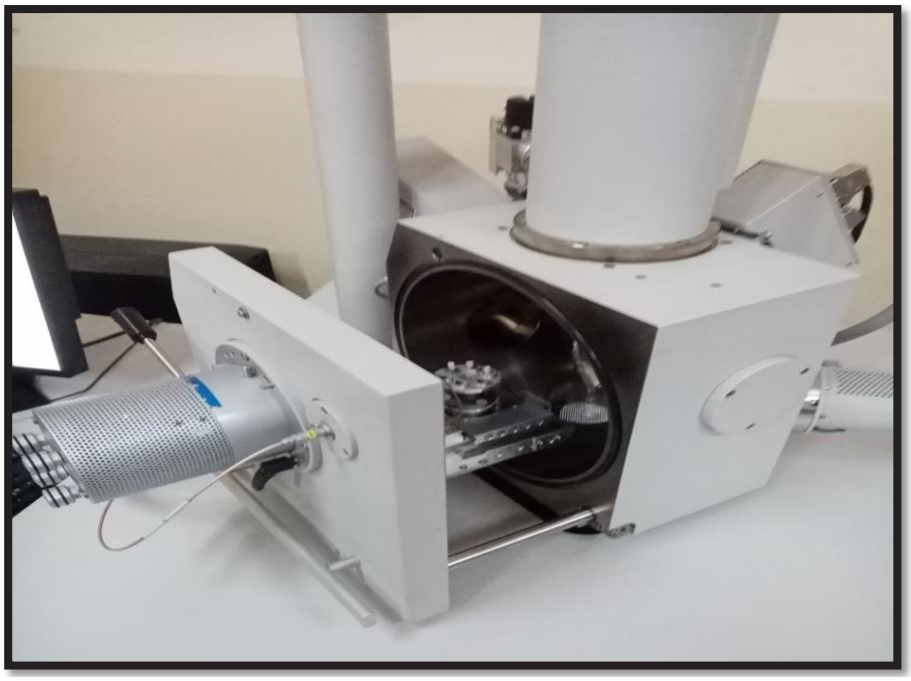

Fig. 6. The specimens inside the SEM

The descriptive of multiple comparisons of groups (control group PMMA, PMMA+ZnO 2%, 4% and 6%) concentrations were shown in Table 2 using the metrics Mean Different (I-J), Standard Error, P-Value, Sig., Lower Bound and Upper Bound. Significant differences were between the control group PMMA and the (PMMA+ZnO 4%), but not between the control group PMMA and the (PMMA+ZnO 2%, 6%). The shear bond strength test bar chart for the PMMA control group, PMMA+ZnO 2%, 4% and 6% is shown in Fig. 7.

The descriptive of dependent Variable (shear Bond Strength of groups) involved (Mean, Std. Error, Lower Bound and Upper Bound) of (group1, group2, group3 and group4) were seen in Table 3, the mean value of shear bond strength test were varied according to the concentration of a Nanofillers powder. In the group3 showed the maximum mean value of upper bound of shear bond strength which was equaled to (14.379), while in the group4 recorded the minimum value of lower bound of shear bond strength (7.617).

Results clearly showed the fracture site of PMMA under (SEM), after adding the different concentration of ZnO nanoparticles to the PMMA to assess the denture foundation and acrylic

Table 1. The descriptive Statistic for shear bond strength.

Descriptive Statistics Dependent Variable: Shear Bond Strength			
Groups	N	Mean	Std. Deviation
PMMA control	10	9.4621	2.69817
PMMA+ZnO 2%	10	9.7422	2.20261
PMMA+ZnO 4%	10	13.1069	1.72922
PMMA+ZnO 6%	10	8.8890	1.47162
Total	40		

Table 2. Multiple Comparisons shear PMMA to PMMA+ZnO.

multiple Comparisons							
Dependent Variable: Shear Bond Strength LSD							
(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P-Value	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
PMMA control group	PMMA+ZnO 2%	-.2801	.90029	.757	NS	-2.0792	1.5190
	PMMA+ZnO 4%	-3.6448*	.90029	.000	S	-5.4439	-1.8457
	PMMA+ZnO 6%	.5731*	.90029	.527	NS	-1.2260	2.3722

*The mean difference is significant at the P ≤ 0.05 level.

teeth's shear bond strength. Surface morphology of specimen and the distribution of nanoparticles can show by scanning electron microscopic in Figs. 8, 9 and10.

Results of this study showed the addition of PMMA+ZnO 2% and PMMA+ZnO 4% nanoparticles increased the mean value of shear bond strength compared with the controlled group as seen in Table 1. PMMA+ZnO 4% has the highest shear bond strength as shown in Fig. 7, but when increasing the percentage at 6% (PMMA+ZnO 6%) shear bond strength was decreased.

Shear bond strength an increase that occurred with the addition of ZnO 2% or ZnO 4%

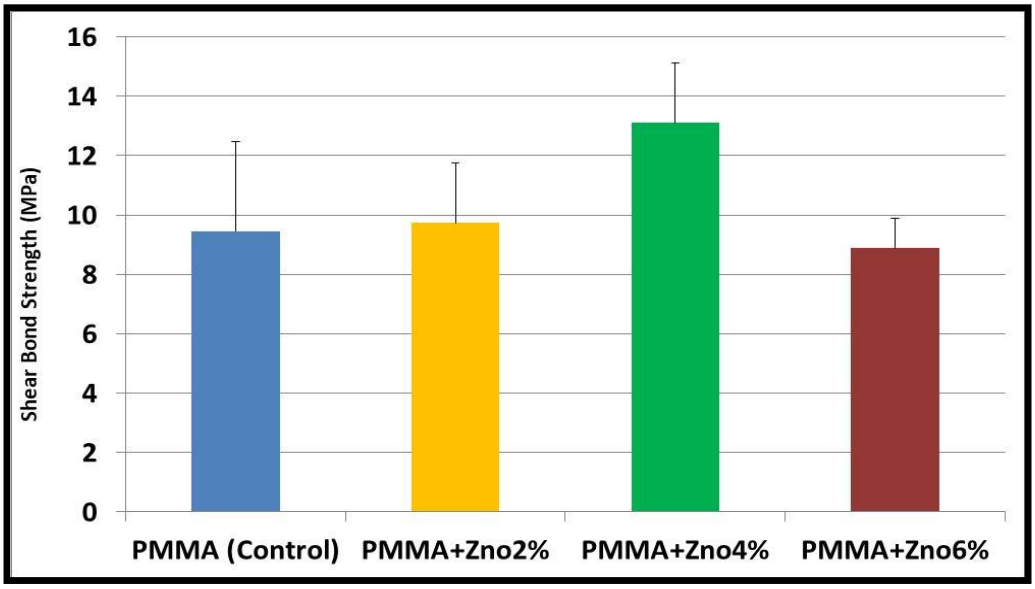

Fig. 7. The bar chart for shear bond strength(Mpa) for PMMA+ZnO

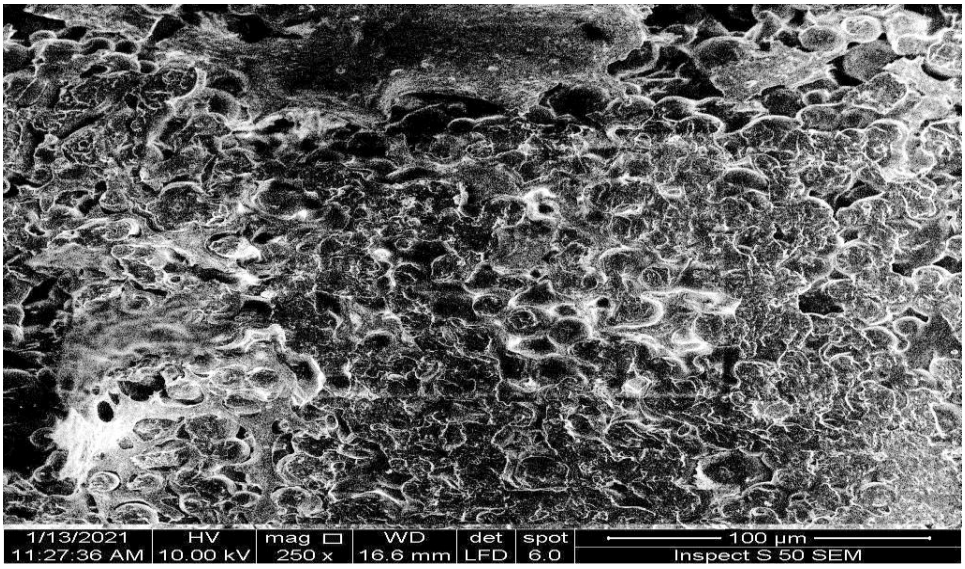

Fig. 8. SEM for PMMA control group (shear bond strength)

nanoparticles to PMMA this segmental motion of the macromolecular chains was limited as a result of the nanoparticles' ability to interconnect with the liner macromolecule chains, this made the resin harder and strong. This enhanced the surface form of the polymer and the construction, as shown in Fig. 9, led to increasing the shear bond strength explained by [18].

The present investigation revealed that the addition of (PMMA+ZnO 6%) decreased the shear bond strength, which may be because to the fact that all spaces between the PMMA chains were filled with ZnO nanoparticles caused separation in between these chains and due to weak force between these causing porous surface as shown in Fig. 10. led to a decrease in the shear bond strength, also because it stopped stress transformation this result agrees with [19] who were used organic montmorillonite to reinforce denture base nanocomposite. The final result is consistent with [20] when it was progressed and Future Perspective for reinforcing of denture base materials (Poly methyl methacrylate). To avoid negatively influencing the mechanical

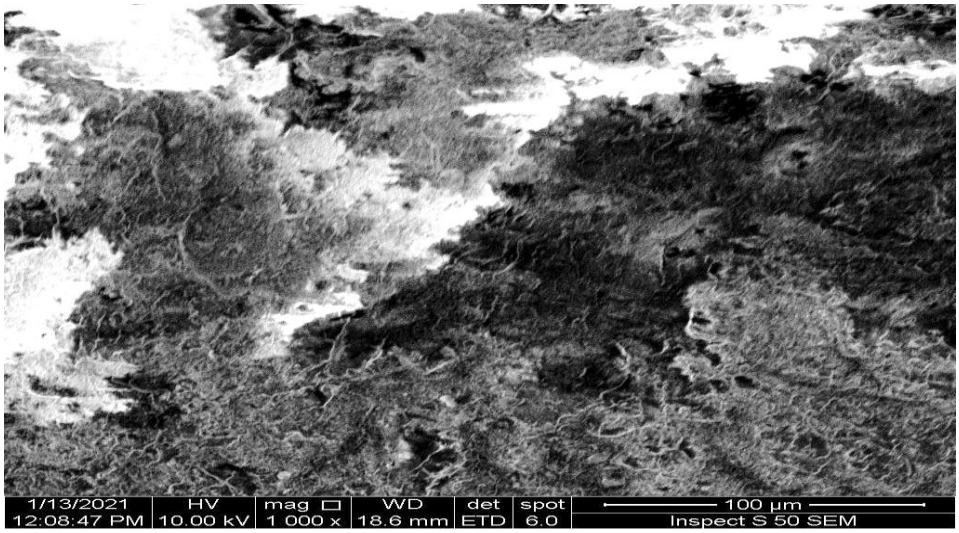

Fig. 9. SEM for PMMA+ZnO 4% (shear bond strength)

Table 3. Dependent Variable (Shear Bond Strength of groups)

Descriptive Statistics Dependent Variable: Shear Bond Strength					
Groups	N	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
PMMA control	10	9.4621	.637	8.190	10.734
PMMA+ZnO 2%	10	9.7422	.637	8.470	11.014
PMMA+ZnO 4%	10	13.1069	.637	11.835	14.379
PMMA+ZnO 6%	10	8.8890	.637	7.617	10.161

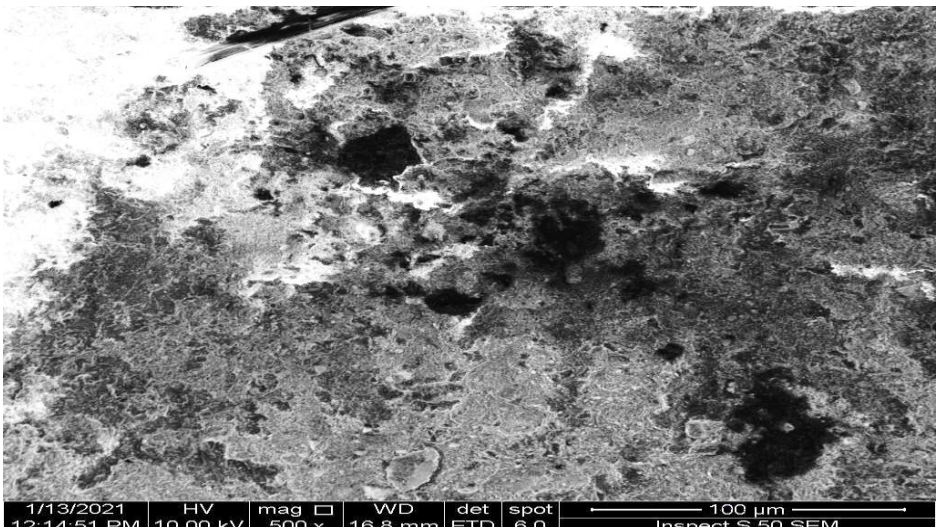

Fig. 10. SEM for PMMA+ZnO 6% (shear bond strength)

characteristics of the resin at increasing concentrations of additional fillers because of ZnO Nps' aggregation, it has been suggested that Nps must be evenly dispersed throughout the resin matrix.

CONCLUSION

1) The higher mean value was reported by group3 (13.1069), whereas the lower mean value was recorded by group4 (8.8890), giving group3 a superior performance than the control group.

2) The group3 showed the maximum mean value of upper bound of shear bond strength which was equaled to (14.379), while the group4 recorded the minimum value of lower bound of shear bond strength (7.617).

3) There was significant variation between group1 and group3, but not between group1 and (group2, group4).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCES

1. Revised American Dental Association Specification No. 12 for denture base polymers. The Journal of the American Dental Association. 1975;90(2):451-458.
2. Clinical Transesophageal Echocardiography. Howard C. Dittrich Mosby Yearbook, St. Louis (1992) Mosby Yearbook, St. Louis (1992) 179 pages, illustrated, $95.00 ISBN: 0-8016-1211-X. Clin Cardiol. 1993;16(4):365-365.
3. Dolney D. Basic Radiological Physics, 2nd Edition. KuppusamyThayalan, Author. Jaypee Brothers Medical Publishers Pvt Ltd, New Delhi, India, 2017. Paperback 480 pp. Price: $31.15. ISBN: 978-9352700486. Medical Physics. 2020;47(10):5402-5402.
4. Chadwick RG, McCabe JF, Walls AWG, Storer R. The effect of storage media upon the surface microhardness and abrasion resistance of three composites. Dent Mater. 1990;6(2):123-128.
5. Dow's 2009 performance buoyed by successful Rohm and Haas integration. Additives for Polymers. 2010;2010(4):10.
6. Mohamed R, P. K N, Shenoy D, Sesha Reddy P, R. Jain A, Varma ACU. A Comparitive Study on the Tensile Bond Strength of Conventional Denture Base Resin to Cross Linked Acrylic Tooth Using two Different Curing Cycles: An Invitro Study. Biomedical and Pharmacology Journal. 2017;10(1):447-454.
7. Schoonover IC, Fischer TE, Serio AF, Sweeney WT. Bonding of Plastic Teeth to Heat-Cured Denture Base Resins. The Journal of the American Dental Association. 1952;44(3):285-287.
8. Liu G, Li Y-f, Yan F-y, Zhao Z-x, Zhou L-c, Xue Q-j. Effect of Nanoscale SiO_2 and TiO_2 as the Fillers on the Mechanical Properties and Aging Behavior of Linear Low-Density Polyethylene/Low-Density Polyethylene Blends. Journal of Polymers and the Environment. 2005;13(4):339-348.
9. Vikram S, Chander NG. Effect of zinc oxide nanoparticles on the flexural strength of polymethylmethacrylate denture base resin. European oral research. 2020;54(1):31-35.
10. Figure 10: The plausible mechanism of formation of zinc oxide nanoparticles (ZnO-NPs) from neem aqueous leaf extract. PeerJ.
11. Shear strength of soils. Advanced Soil Mechanics: CRC Press; 2013. p. 423-528.
12. Alkinani GA. Evaluation of Shear Bond Strength between Thermosens as Relining Material and Different Denture Base Materials. Journal of Baghdad College of Dentistry. 2014;26(4):28-31.
13. Aljudy HJ. Effect of Plasma Treatment of Acrylic Denture Teeth and Thermocycling on the Bonding Strength to Heat Cured Acrylic Denture Base Material. Journal of Baghdad

College of Dentistry. 2013;25(Speacial Issue 1):6-11.
14. Yaseen IN. Effect of Different Surface Treatments on The Tensile Bond Strength Between Acrylic Resin Teeth and Denture Base Material. Iraqi Dent J. 2016;38(3):142.
15. Safi IN, Hussein ANA, Aljudy HJ. Effect of Surface Treatments and Thermocycling on Shear Bond Strength of Various Artificial Teeth with Different Denture Base Materials. Journal of Baghdad College of Dentistry. 2013;25(1):5-13.
16. Alnamel HA, Mudhaffer M. The Effect of Silicon Di Oxide Nano - Fillers Reinforcement on Some Properties of Heat Cure Polymethyl Methacrylate Denture Base Material. Journal of Baghdad College of Dentistry. 2014;26(1):32-36.
17. Tyrrell J. 3511 [JAMES TYRRELL] to LOCKE, [c. 17 April 1704] (3477, 3575). The Clarendon Edition of the Works of John Locke: The Correspondence of John Locke: In Eight Volumes, Vol. 8: Letters Nos. 3287–3648: Oxford University Press; 1989. p. 270-270.
18. Katsikis N, Zahradnik F, Helmschrott A, Münstedt H, Vital A. Thermal stability of poly(methyl methacrylate)/silica nano- and microcomposites as investigated by dynamic-mechanical experiments. Polymer Degradation and Stability. 2007;92(11):1966-1976.
19. Li ZA, Liu L, Xiao Q. Using organic montormollontrite to reinforce the structure and flexural property of denture base nanocomposites. J Appl Polym Sci. 2009;112(6):3548-3553.
20. Franklin P, Wood D, Bubb N. Reinforcement of poly(methyl methacrylate) denture base with glass flake. Dent Mater. 2005;21(4):365-370.