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# Effect of silver nitrate on some mechanical properties of heat polymerizing acrylic resins

**Assiss. Prof. Dr. Sabiha Mahdi**
**Dr. Firas Abd K.**

## Abstract

**Aim**: The aimed study was to evaluate the influence of silver nitrate on surface hardness and tensile strength of acrylic resins.

**Materials and methods**: A total of 60 specimens were made from heat polymerizing resins. Two mechanical tests were utilized (surface hardness and tensile strength) and 4 experimental groups according to the concentration of silver nitrate used. The specimens without the use of silver nitrate were considered as control. For tensile strength, all specimens were subjected to force till fracture. For surface hardness, the specimens were tested via a durometer hardness tester. All specimens data were analyzed via ANOVA and Tukey tests.

**Results:** The addition of silver nitrate to acrylic resins reduced significantly the tensile strength. Statistically, highly significant differences were found among all groups ($P \leq 0.001$). Also, the difference between control and experimental groups was highly significant ($P \leq 0.001$). For surface hardness, the silver nitrate improved the surface hardness of acrylics. Highly significant differences were statistically observed between control and 900 ppm group ($P \leq 0.001$); and among all groups ($P \leq 0.001$)with exception that no significant differences between control and 150ppm; and between 150ppm and 900ppm groups($P > 0.05$).

**Conclusion**: The addition of silver nitrate to acrylics reduced significantly the tensile strength and improved slightly the surface hardness.

**Keywords: silver nitrate , tensile strength, surface hardness**

## Introduction

In dentistry, heat polymerizing acrylic resins are usually used as removable denture bases because of appropriate physical, mechanical and biological characteristics[1,2]. Patients with removable prostheses suffer from some infections that arise from the growth of microorganisms on the acrylic surface due to improper cleaning of oral cavities[3]. For example, elderly patients often face many challenges when cleaning their oral cavities. For those patients, there are several instructions given regarding the use of antimicrobial mouthwashes for proper cleaning. However, the poor psychological state for those patients might affect negatively the success of this process. For these reasons, the use of antimicrobial acrylic resins is necessary to prevent infection [4]. Silver nitrate is widely used in many applications in the field of medicine and dentistry. For instance, it is utilized to treat gonorrhea and eye diseases. This chemical compound is a poison, white in color, soluble in water, and can be prepared by the reaction between nitric acid and silver; followed by recrystallization to be purified[5]. In dentistry, Silver nitrate is used as antimicrobial substance, and has a significant impact against bacteria and fungal infections[6-8]. There were some published articles about the effects of antimicrobial silver nitrate on acrylic resin[9-12]. Farhood and Rafeeq [11] found that the use of silver nitrate has significantly enhanced the impact strength of cold polymerizing acrylic resin. Furthermore, Husseini and Hatoor [12]concluded that silver nitrate has a negative effect on heat polymerizing acrylic resin regarding the tensile strength. However, no published papers about the influence of silver nitrate on the surface hardness of acrylic resins. The current study was, hence, conducted to assess the effect of silver nitrate in different concentrations on tensile strength and surface hardness of heat polymerizing acrylic resin. The null hypothesis imposed that the addition of silver nitrate to pink heat polymerizing acrylics has no influence on their surface hardness and tensile strength.

## Materials &Methods

### Materials and Specimen groups

A total of sixty specimens were made from heat polymerizing acrylic resin(Ivoclar, Italy). According to the test utilized, there were 2 tests( tensile strength and hardness tests). In this study, experimental groups($AgNO_3$) with 2 concentrations at 150ppm and 900ppm were used. The control groups were fabricated. The dental stone (Zhermack, Italy) was utilized to form a mould for acrylic specimens.

### Acrylic specimens preparation

Acrylic specimens for hardness test in the current study were prepared depending on American Dental Association Specification Number 12 using a metal strip with dimensions of 65mm length X 10mm width X 2.5mm thickness [13]. For tensile strength test, acrylic specimens were made according to ISO specification Number 527 [14] using a metal strip with dimensions of 75mm length X 12mm width X 2.5 mm thickness as illustrated in the Figure 1(A and B). The procedure includes the lubrication of the two halves of a metal flask with a Vaseline to facilitate removal of acrylic samples from the mould. The dental stone and water with a ratio of 100 g/ 25 ml were mixed and placed into lower half of the flask at creamy state. The metal strips were gently positioned into mid with taking into mind half of their depth should be exposed to easily remove from stone mould(Figure 2). The stone surface and strips were lubricated with separating medium and left for 30 minutes to dry. The upper half was placed on its correct position and completely filled by the another stone mix and left to set for one hour. The two parts of the flask were then separated to remove the strips and then lubricated with separating medium. The acrylic powder was added to the monomer (22g/10 ml) depending on the manufacturer instructions. At dough state, the mixture was then packed into the mould. The upper and lower halves were then put in contact, ready to be pressed under hydraulic press for five minutes. The flask was then placed in water path machine to be cured according to the instructions prepared by manufacturers. The flask was then taken from the water bath and left to cool. Next, the flask was opened; acrylic specimens were taken carefully away from stone mould. The acrylic specimens were finished, polished and kept for seven days in water before testing [13] . This process was repeated to form 20 control specimens. The experimental specimens were made using the above process with exception that the 2 ml of silver nitrate nanoparticles were added to 8 ml of liquid monomer before mixing with 22 gram of acrylic powder.

## Mechanical tests

### Surface hardness test

A durometer hardness tester (Shore D, Italy)( Figure 3) was utilized for hardness test [15]. Three areas (left side, center and right side) on each specimen were tested for 10 seconds. The maximum and average readings were recorded.

### Tensile strength test

A universal testing machine (Tinius Olsen tensile machine /Germany) was used for tensile strength test( Figure 4). The load with a cross head speed of 0.5 mm/min was subjected on each acrylic specimen until fracture occurred( Figure 5) [16]. The load was recorded in Newton; and from the formula below, the tensile strength values were obtained:-Tensile strength ($N/mm^2$) = F (N) / A ($mm^2$) [17]. Where the letter (F) represents the maximum load at failure (Newton) while the letter (A) represent the cross sectional area, which measured in $mm^2$.

### Statistical analysis

All specimens data were statistically calculated by SPSS 20, providing values of mean, standard deviation, maximum and minimum load. The comparison was made among all groups by ANOVA ( one way of variance) and Tukey tests to show whether there were the significant results($P \leq 0.05$) or not ($P>0.05$).

## Results

The results of this study indicated that the surface hardness and tensile strength have significantly been influenced by the concentration of silver nitrate added to acrylic resin as follow:-

### 1.Hardness test

The current results showed that the use of silver nitrate in different concentrations has slightly affected the surface hardness of acrylic resins. All values of mean and standard deviation are demonstrated in Table 1. The results showed that the silver nitrate group (900 ppm) had the greatest value of mean surface hardness. In addition, the silver nitrate group with a concentration of 150 ppm increased slightly the surface hardness of acrylic resin in comparison to control group as illustrated in the Table 1 and Figure 6. Furthermore, highly significant differences among all groups($P \leq 0.001$) were observed as illustrated in Anova test(Table 2 ). Moreover, the Tukey multiple comparison test indicated that there were significant differences between 900 ppm silver nitrate and control groups where $P \leq 0.001$. On the other hand, no significant differences between 150 ppm silver nitrate and 900 ppm silver nitrate groups; and 150ppm silver nitrate and control were found($P>0.05$).

### 2.Tensile strength

The current results indicated that the addition of silver nitrate to heat cured acrylic resin in different concentrations has a significant effect on acrylic resin' tensile strength. All values of mean and standard deviation are shown below in Table 4**.** The results showed that the least value of mean tensile strength was with the experimental group (900ppm). Furthermore, the addition of 150ppm silver nitrate weakened significantly the tensile strength of acrylic resins as demonstrated in the Table 4 and Figure 7. In addition, highly significant differences were observed among all groups as presented in Table 5($P \leq 0.001$). Furthermore, there were highly significant differences between two groups where $P \leq 0.001$ as shown in the Tukey test (Table 6).

## Discussion

Heat polymerizing acrylic substances (polymethyl methacrylate) are the materials of choice in wide applications in dentistry because of their appropriate properties. Silver nitrate is commonly used as antimicrobial substances to avoid infections including the oral tissue and teeth in denture wearers[ 6]. Few published papers about the effects of adding the silver nitrate to acrylic resins on their mechanical properties were carried out in the literature[12]. The aimed study, therefore, was to assess the effect of silver nitrate ($AgNO_3$) in two different concentrations (150ppm and 900 ppm) on heat polymerizing acrylic denture base in terms of surface hardness and tensile strength. There were two experimental groups as well as control group for each test. For hardness test, the current study showed that the adding of silver nitrate to acrylic resin enhanced slightly the surface hardness when compared to control as demonstrated in Table 1. Though, no published papers about the effects of silver nitrate nanoparticles added to heat polymerizing acrylic resins on the surface hardness. Regarding tensile strength, the results of this study showed that the silver nitrate nanoparticles decreased significantly the tensile strength of acrylic specimens in comparison to control group as shown in Table 4. Such nanoparticles might act as plasticizers and residual compounds that diminishes the molecular binding of the monomer. The present results are in accordance with a study carried out by Al-Husayni and Hatoor [12] who concluded that the presence of residual compounds and plasticizers in acrylic denture base reduced significantly the tensile strength of acrylic specimens. Likewise, Kuroki et al [18] found that the addition of antimicrobial agents such as Zeomic, BacteKiller and Novaron has negatively decreased the tensile strength of acrylic resin. Besides, These results are similar to Nakanoda et al. [19] who reported the use of Silver-Zeolite had a negative influence on the tensile strength of acrylic resin. What is more , the present results are parallel to Wakasa et al.. [20] who indicated that the incorporation of Zeomic agent to acrylic resins decreased the tensile strength. From the current research, it is concluded that the addition of silver nitrate to heat cured acrylic resin in 150ppm and 900 ppm concentration significantly reduced its tensile strength; and improved somewhat the surface hardness. Further study will be required to assess the colour stability and other mechanical properties (i.e. Impact and flexural strength) of acrylic resins with different concentrations of silver nitrate.

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## References

1- Noort R V. Introduction to dental materials. 3rd edition. Elsevier Limited,2007.
2- Jasim BS, Ismail IJ. The effect of silanized alumina nano-fillers addition on some physical and mechanical properties of heat cured polymethyl methacrylate denture base material. Journal of Baghdad College of Dentistry.2014; 26(2):18-32.
3- Keng SB, Lim M. Denture plaque distribution and the effectiveness of a perborate –containing denture cleaners .Quintessence Int. 1996; 27: 341-345.
4- Fan C, Chu L, H Ralph Rawls, Norling BK, Cardenas H, Whang K. Development of antimicrobial resin –A pilot study. J Dental Mater. 2011; 27:322-8.
5- Wadhera A, Fung M. Systemic argyria associated with ingestion of colloidal silver. Dermatology on line J. 1995; 11:12.
6- Chen L, Chen X, Cuijpers V, Fan M, Frencken J.E. Optional use of silver nitrate and marginal leakage at the sealant enamel interface using micro-CT. Am J dent. 2009;22(5):269-72.
7- Kumar R, M¨unstedt H. Polyamide/silver antimicrobials:effectof crystallinity on the silver ion release".PolymInt. 2005; 54:1180-1186.
8- Irzh A, Perkas N, Gedanken A. Microwave assisted coating of PMMA beads by silver nanoparticles. Langmuir. 2007; 23: 9891-9897.
9- Casemiro LA, Gomes Martins CH, Panzeri FC, Pires -de –Souza, Panzeri H. Antimicrobial and Mechanical properties of acrylic resin with incorporated silverzinc zeolite –part one. Gerodontology. 2008; 25: 187-94.
10- Yu RY, Zhou Y.S, Feng HL. Silver ion release and particle distribution of denture base resin containing nanometer-sized silver –supported antimicrobial agent. Zhonghua Kou Qiang Yi Xue Za Zhi. 2008; 43:54-56.
11- Farhood I, Rafeeq A. Incorporation of Silver Nitrate on Transverse Strength and Impact Strength of Autopolymerizing Acrylic Resin. Karbala J. Med. 2014; 7(2):1992-1998.
12- Al-Husayni O, Hatoor N. Effect of silver nitrate incorporation into heat polymerized acrylic resin on some mechanical properties. Journal of Baghdad College of Dentistry.2014;26(4):78-85.
13- American Dental association / American material standers institute, specification No.12 for denture base polymer. Chicago council on dental matewrials and devices; 1999.
14- ISO specification Number 527 .International Organization for Standardization. Plastic Determination of tensile properties,1993.
15- American national standers institute/ American dental association specification No.57 for denture base polymers and devices. Chicago: council on dental material and devices, 2008.
16- Kareem A.E. The effect of fiber reinforcement on some properties of repaired acrylic resin with different joint shape prparation” M.Sc. thesis ,college of dentistry / University of Baghdad, 2005.
17- Craig RG, Powers JM. Restorative dental materials. 11th Edition. St.Louis :The C.V ,Mosby Co, Missouri.2002, Ch 7:p 195.
18- Kuroki K, Hayashi T, Sato K, Asai T, Okano M, Kominami Y, Takahashi Y, Kawai T. Effect of self cured acrylic resin added with an inorganic antibacterial agent on Streptococcus mutans. Dent Mater J. 2010; 29(3): 277–85.
19- Nakanoda S, Nikawa H, Hamada T, Yamamoto T, Nakamoto K .The material and antifungal properties of antibiotic zeolite incorporated acrylic resin. J Jpn Prosthodont Soc. 1995; 39: 919-26.
20- Wakasa K, Yosida Y, Nomura Y, Ikeda A, Nakatsuka A, Ogino S, Matsui H, Shirai K, Yoshioka M, Yamaki MA. Fundamental study on dental application of silver zeolite. J Hiroshima Univ Dent Soc. 1997; 29: 87-98.

Table (1) Mean and standard deviation for the groups for surface hardness

| Groups | Mean ($g/mm^2$) | Standard Deviation | Manimum | Maximum |
|---|---|---|---|---|
| Control | 81.87 | 2.26 | 78.20 | 85.70 |
| Experimental 150ppm | 84.47 | 2.93 | 80.10 | 89.50 |
| Experimental 900ppm | 86.06 | 2.26 | 82.40 | 89.50 |

Table 2: Anova test for surface hardness($g/mm^2$)

ANOVA

| hardness | | | | | |
|---|---|---|---|---|---|
| | Sum of Squares | df | Mean Square | F | Sig. |
| Between Groups | 89.481 | 2 | 44.740 | 7.116 | .003 |
| Within Groups | 169.766 | 27 | 6.288 | | |
| Total | 259.247 | 29 | | | |

Highly significant ($P \leq 0.001$)

Table 3. Tukey multiple comparison test

| Groups | P value | Significance |
|---|---|---|
| Control<br>150ppm silver nitrate | 0.070 | N.S<br>($P>0.05$) |
| Control<br>900ppm silver nitrate | 0.002 | H.S<br>($P<0.001$) |
| 150ppm silver nitrate<br>900ppm silver nitrate | 0.346 | N.S<br>($P>0.05$) |

Highly significant ($P \leq 0.001$)

Table 5. ANOVA test for tensile strength test

ANOVA

| tensile | | | | | |
|---|---|---|---|---|---|
| | Sum of Squares | df | Mean Square | F | Sig. |
| Between Groups | 1957.894 | 2 | 978.947 | 57.950 | .000 |
| Within Groups | 456.113 | 27 | 16.893 | | |
| Total | 2414.007 | 29 | | | |

Highly significant ($P<0.001$)

Table 6. Tukey multiple comparison test

| Groups | P value | Significance |
|---|---|---|
| Control<br>150ppm silver nitrate | 0.000 | H.S<br>($P<0.001$) |
| Control<br>900ppm silver nitrate | 0.000 | H.S<br>($P<0.001$) |
| 150ppm silver nitrate<br>900ppm silver nitrate | 0.030 | H.S<br>($P<0.001$) |

Highly significant ($P<0.001$)


Figure 1. (A and B) .

Metal strips for hardness and tensile tests

Figure 2. Stone mould

Figure 3. Specimen under hardness tester


Figure 4. Tinius Olsen tensile machine

Figure 5. Specimen under tensile tester

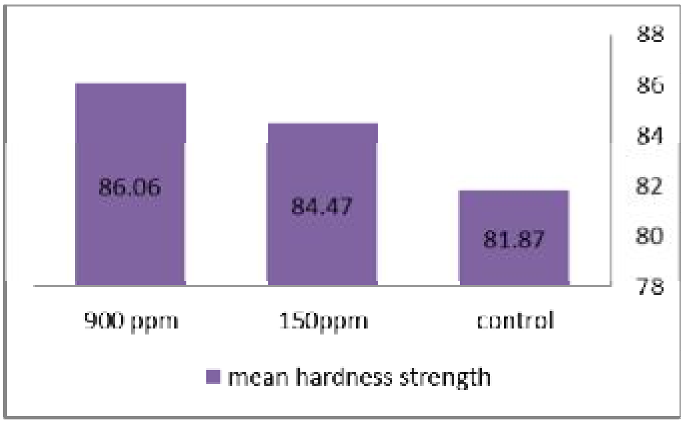


Figure 6. Bar chart of mean values for hardness test

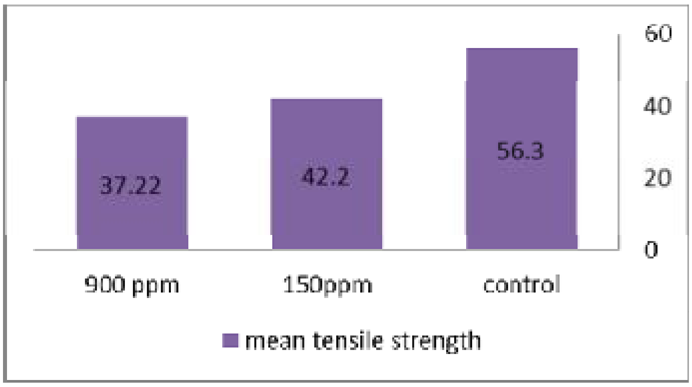


Figure 7. Bar chart of mean values for tensile strength test