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# Assessment of the Surface Roughness and Hardness of Acrylic Resin After Incorporation of Sodium Fluoride Salts (An *In-vitro Study*)

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## Abstract

The control of oral hygiene is of great importance, particularly in dental work, to prevent caries caused by bacteria. One method to inhibit bacterial growth is usually by using fluoridated dental materials. The objectives are to assess the effect of sodium fluoride powder (NaF) inclusion with different concentrations on the surface roughness and hardness of heat-cured acrylic resins. A total of forty disc-shaped samples with a diameter of (12±0.1) mm and a thickness of (2±0.1) mm have been fabricated from heat cure acrylic resin. They were grouped into four subgroups according to different concentrations of NaF with 10 specimens for each group. Sodium fluoride powder (NaF) was incorporated into the monomer in concentrations of 0% (control group), 1%, 3%, and 5%. Then mixing was done with polymer according to manufacturer instructions and the conventional flasking, and packing procedures were used. Finally, the specimens are subjected to hardness and surface roughness tests. The results of this study revealed that the lowest mean value surface roughness (Ra) was with the (5%) group of NaF (**7828**). While, for the surface hardness test, the group (5%) of Naf showed the highest mean value among their subgroups (**82.30**). According to the results of the current study, sodium fluoride powder (NaF) has a positive effect on both the surface roughness and hardness of acrylic resin.

**Keywords:** heat acrylic resin, sodium fluoride (NaF), hardness, roughness, deionized liquid.

## Introduction

Dental caries is known as the result of tooth surface dissolution caused by dental plaque which produces acid when exposed to sugars many times. (1). In addition to Periodontal diseases (gingivitis and periodontitis) which are inflammatory diseases of microbial origin. Dental biofilm that accumulates at and below the cervical line of the teeth is considered the highest risk factor for dental caries. Besides that, destructive and bad inflammatory immune response. (2). They are considered the most common diseases that affect humans worldwide if they are untreated (3). On the other hand, there is an increase in the prevalence of root caries associated with gingival recessions (4). The most likely affected teeth by carriers and periodontal diseases more than other teeth are the abutment teeth. The prevention of root caries in such teeth is critical because they are anchoring removable partial dentures and tend to be insufficiently cleaned (5). Fluoride application is the treatment of choice for prevention of caries development and gingivitis (6). It's used to prevent dental caries and may be used to increase bone density in osteoporosis. Also, it may render the enamel of teeth more resistant to acid, promote demineralization, or reduce microbial acid production (7). Different sources can convey fluoride to the oral cavity, such as fluoride dentifrices, fluoride mouth rinses, topical fluorides as well and fluoride-releasing restorative material, which are all effective in root caries prevention and recurrent caries suppression [7]. In the current study sodium fluoride (NaF) which is a white, odorless powder has been used. since it is the most increased fluoride compound release than other fluoride types followed by $CaF_2$ then amine fluorides. This can be associated with the compound's solubility, and its easily dissolving to free Na+ & F- ions [8,9].

Jasim BS & Ismail., 2014, Abdulsattar MH (2023) and Abdul-Latif Rashid A & Mousa Ouda L [10,11,12] used various sodium fluoride concentrations. They studied high fluoride concentrations e.g. 10% and 20%; however, the maximum NaF concentration was 20% since the dough stage did not reach 25% or more. Following two months of immersion in deionized water, the surface roughness and hardness increased; this can be attributed to fluoride's release, and this agreed with the finding of [7]

The wearing removable partial or complete dentures by geriatric patients has increased in proportion [13]. Thus, different concentrations (1%, 3%, and 5%) of sodium fluoride have been mixed with acrylic resin which is used in the fabrication of removable prostheses to assess the effects of these different concentrations on the surface's roughness and hardness of the acrylic resin.

## Material and method

### Samples preparation:

Forty-disc shapes of heat-cured samples of acrylic resins have been prepared by conventional methods. A silicon mold with a diameter of (12±0.1) mm and a thickness of 2(±0.1) mm [14] was used for the waxing of specimens that have been flasked Fig. (1, 2). Then, the metal flasks technique is used by coating them with a separating medium (cold mold seal). The lower half is filled with dental stone then the disc shape wax is fixed on it, after the stone sets, a separation medium is applied and left to dry. Following that, the upper half of the flask was filled with stone and vibrated to prevent air being entrapped. Then, wax elimination is accomplished according to instructions, and the two halves of flasks are opened and coated with the separation medium to be packed later.

Figure 1: silicon mold

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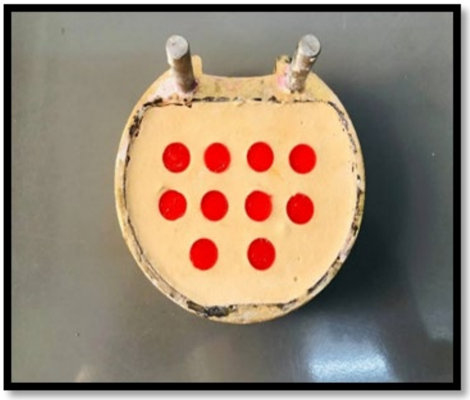

**Figure 2:** flasked specimens

**Mixing proportion of acrylic resins:**

The mixing ratio of acrylic resins was 2.5/1 by weight (P/L). The guidelines of the manufacturer were followed regarding mixing and manipulation. For the controls, 40ml of monomers was mixed with 100gm of powder. For 1% Naf, 1g of Naf powder was dissolved in 40 ml of monomers and mixed with 99gm of polymers. For 3% Naf, 3g of Naf powder was dissolved in 40ml of monomers and mixed with 97gm of polymer. For 5% Naf, 5g Naf powder was dissolved in 40ml of monomers and mixed with 95g polymer as shown in (Table. 1).

**Table 1:** Mixing ratio of acrylic resin

| NaF percentage | Amount of NaF | Amount of polymer | Amount of monomer |
|---|---|---|---|
| 0% | 0g | 100g | 40ml |
| 1% | 1g | 99g | 40ml |
| 3% | 3g | 97g | 40ml |
| 5% | 5g | 95g | 40ml |

**Packing and polymerization**

The glass stirrer has been used for mixing. The monomer with NaF suspension has been directly mixed with the acrylic powder, following the guidelines of the manufacturer to decrease particle aggregations and phase separations. Then, the mixture is left until the dough stage is reached. The packing stage was done after the resin reached the dough phase. The acrylic was removed from a glass container and packed in a flask which was coated with a separation medium and left to dry. Then, nylon sheets were used to aid in the separation of the two halves of the flask and remove or add another amount of resin. The flask's two halves are closed tightly and put at a hydraulic press. (85-90 bars for 1 minute). The pressure was applied at a slow rate on the flask and the flow of the dough was evenly done via the space of the flask. Then, the pressure is released and opened, then the excessive material is removed by using a sharp knife. Then, the closure for

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another time was done and a nylon sheet was removed. Finally, the flask's two halves were closed tightly and clamped to transfer to the water bath for curing. The water bath (rapid procedure) was used to polymerize specimens from heat-cured acrylic. The polymerization was performed via putting the clamped flask in a water bath and processing by heating the specimens at 74˚C for 1, 1/2 an hour, followed by increasing the temperature to the boiling point for 30 minutes in accordance with ADAS No.12 [15]. After the acrylic resin specimens were polymerized and cured, they were removed carefully from the stone molds. The conventional method was used to complete the acrylic resin specimens and to remove any excess flash of acrylic. The final specimens were immersed for 2 months in the daily changed deionized water.

**Testing methods**

Two months ago, all immersed specimens were subjected to a surface roughness test due to after this period deionizer liquid will increase the release of sodium fluoride salts [7]. using a profilometer device supplied with the diamond-made surface analyzer (sharp style). The profilometer records all the recesses and peaks that characterize the test surfaces by their scales. The acrylic samples were put on their stable stages and the position of the test areas was chosen then the analyzer passed in the correct direction along the surface of the samples as shown in Fig. 3 Then, they were subjected to a hardness test by using the duromter hardness devices, (shore D) scale type. The testing loads were applied equally to 50 N, and the specimens were located under the indenter area with a depressing time of measuring equal to 10 sec. The indicator of the digital shore-D device measures 0.8mm in diameter and tapers to a 1.6mm cylinder. After a firm pressing down of the indicator, the readings were recorded from the digital scales. Each scale results in a value between (0 and to100) hardness numbers, with higher a value indicating a harder material as shown in Fig.4.

**Figure 3:** D_ shore device

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**Figure 4:** profilometer device

## Results

### Surface roughness results

The lowest mean value of surface roughness (Ra) was in the 5% group, whereas the higher mean value of surface roughness was in the group 3%. On the other hand, a non-significant difference was found between the control and 1% groups. A one-way ANOVA test for the (Ra) group demonstrated highly significant differences between their subgroups. Finally, the LSD test revealed highly significant differences between most of the groups. While there is non-significant difference among control, 1% and 5% in addition between 1% and 3%. Table. 2, Fig.5

### Surface hardness results

The higher mean value for the surface hardness (IU) was respectively in their groups 5%, 3%, and 1% in comparison to a control group. One-way ANOVA and LSD tests represent there are high- significant differences among their groups in Tables. 3, Fig.6.

**Table 2:** Descriptive Statistics, ANOVA, and LSD of surface roughness among groups.

| Groups | Groups | Mean±SD | Max | Min | F- | Significant within the groups |
|---|---|---|---|---|---|---|
| Control | Group A | 1.7997±0.519 | 2.32 | 1.22 | **11.515** | **0.0001≤** |
| 1% | Group B | 1.9187± | 2.57 | 1.43 | | |
| 3% | Group C | 2.0773±0.555 | 2.71 | 1.44 | | |
| 5% | Group D | 0.7828±0.507 | 1.23 | 0.03 | | |
| Groups | | Mean Difference (I-J) | | | **P-value** | **Sig.** |
| Group A | B | -.11900 | | | .629 | (NS) |
| | C | -.27767 | | | .264 | (NS) |
| Group B | D | 1.01689* | | | .000 | (HS) |
| | C | -.15867 | | | .520 | (NS) |
| Group C | D | 1.13589* | | | .000 | (HS) |
| | D | -1.29456* | | | 000 | (HS) |

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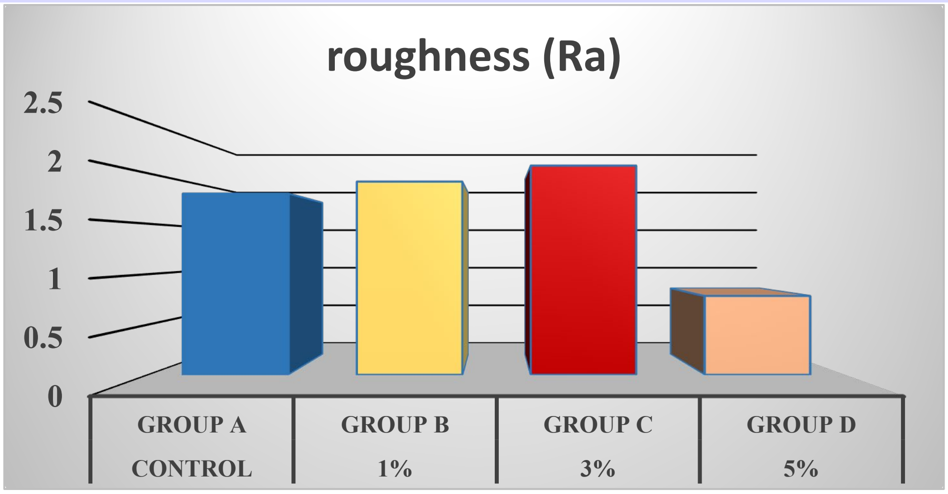


**Figure 5:** Bar chart of surface roughness (Ra) among the studied group

**Discussion**

The use of fluoridated dental material is the most effective manner for the prevention of dental caries [16]. It was demonstrated that fluorides containing dental acrylic resins are highly effective for suitable denture hygiene promotion, especially for old age people who require nursing care or have low abilities for performing normal daily living activities and children wearing acrylic appliances [17]. Fluorides which contain dental acrylic resin materials can improve acrylic resin properties [16].

Our study demonstrated that the addition of different concentration of NaF improve the hardness of acrylic resin and there is a highly significant difference between treated groups when compared with the control group as shown in Tables (4, 5, and 6), which may be attributed to the increasing of crystals per unit area due to the elevation in NaF concentration in acrylic resins because the crystals of NaF may be harder than acrylic polymers thus, more resistance will be provided to indenter penetrations with more hardness values will be acquired, and this result is consistent with [7,9].

Nevertheless, the results in the current study revealed a highly significant difference in roughness value for most groups which is considered an undesirable property, that may be due to interference of NaF in the polymerization process. This can occur by the polymer bead exposures which result in increased porosity and roughness [18]. The inclusions of fluorides in dental resins are inherently incompatibilities due to great differences in polarity between ionic fluorides and low-polarity dental resins. Such incompatibilities usually cause phase separations with the resin thus, fluorides are released within time [7,19]. while the 5% concentration group represents the lowest mean values of roughness this may be because of the reaction's exothermic heat that increases the resin dough's temperature higher than the monomer's boiling point tends to increase the porosity and decreases surface roughness this finding is consistent with [20]. The limitation of the current study was there are not many Iraqi studies were found to describe the inclusion of NaF powder into acrylic resin components.

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**Table .3:** Descriptive Statistics, ANOVA, LSD of surface hardness among groups.

| Groups | Groups | Mean±SD | Max | Min | F- | Significant within the groups |
|---|---|---|---|---|---|---|
| Control | Group A | 63.4±2.503 | 67.0 | 61.0 | 183.161 | ≤0.0001 |
| 1% | Group B | 71.6±0.966 | 73.0 | 70.0 | | |
| 3% | Group C | 76.4±1.234 | 78.0 | 74.5 | | |
| 5% | Group D | 82.30±2.287 | 85.0 | 79.0 | | |
| Groups | | Mean Difference (I-J) | | | P-value | Sig. |
| Group A | B | -8.2000* | | | .000 | (HS) |
| | C | -13.0500* | | | .000 | (HS) |
| Group B | D | -18.9000* | | | .000 | (HS) |
| | C | -4.8500 | | | 000 | (HS) |
| Group C | D | .-10.7000 | | | 000 | (HS) |
| | D | -5.8500 | | | .000 | (HS) |

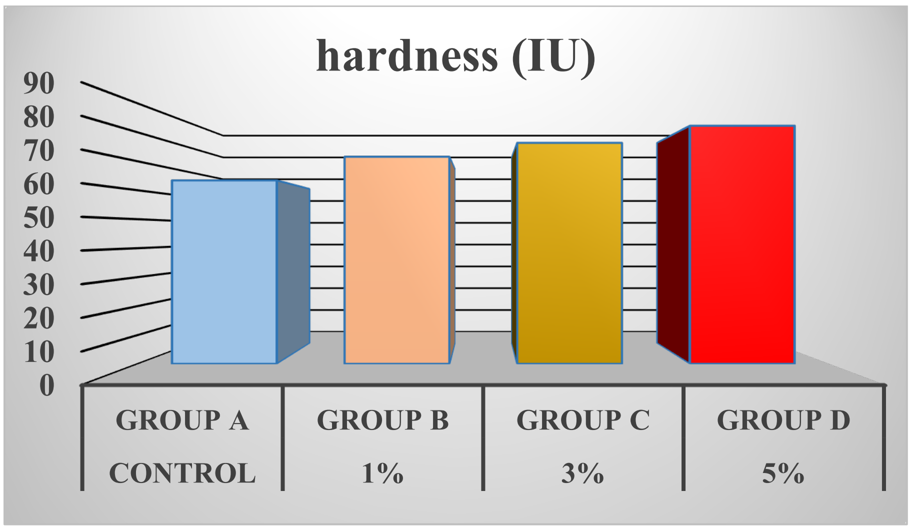


**Figure 6:** Bar Chart of surface hardness (IU) among the studied group.

## Conclusions

In the present study, sodium fluoride salts with concentrations of (1%, 3%, and 5%) represent one of the most effective ways for enhancing the mechanical and physical properties of acrylic resin denture bases. Since it increases their surface hardness and decreases their surface roughness.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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This research received no external funding.

## Data Availability Statement

Data are available from the authors upon reasonable request.

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## References

1. Fejerskov, O., Nyvad, B., & Kidd, E. (2015). Dental caries: what is it. In Dental Caries: The Disease and Its Clinical Management (pp. 7–10). Wiley Blackwell.

2. Chapple, I. L., Van Der Weijden, F., Doerfer, C., Herrera, D., Shapira, L., Polak, D., Madianos, P., Louropoulou, A., Machtei, E., & Donos, N. (2015). Primary prevention of periodontitis: managing gingivitis. Journal of Clinical Periodontology, 42(S16), S71–S76. https://doi.org/10.1111/jcpe.12366

3. Vos, T., Allen, C., Arora, M., Barber, R. M., Bhutta, Z. A., Brown, A., Carter, A., Casey, D. C., Charlson, F. J., Chen, A. Z., & others. (2016). Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet, 388(10053), 1545–1602.

4. Al-Hasnawi, K. I., & Al-Obaidi, W. A. (2014). Effect of Nd-YAG laser-irradiation on fluoride uptake by tooth enamel surface (In vitro). Journal of Baghdad College of Dentistry, 26(2), 154–158. https://doi.org/10.12816/0015182

5. Ali, A. (2014). Evaluation of the effect of sodium fluoride addition on some mechanical properties of heat cure acrylic denture base materials. Journal of Baghdad College of Dentistry, 26(2), 9–13. https://doi.org/10.12816/0015248

6. Figuero, E., Nóbrega, D. F., García-Gargallo, M., Tenuta, L. M., Herrera, D., & Carvalho, J. C. (2017). Mechanical and chemical plaque control in the simultaneous management of gingivitis and caries: a systematic review. Journal of Clinical Periodontology, 44(S18), S116–S134. https://doi.org/10.1111/jcpe.12674

7. Rashid, A. A. (2014). Effect of sodium fluoride on the properties of acrylic resin denture base material subjected to long-term water immersion. Journal of Baghdad College of Dentistry, 26(2), 14–21. https://doi.org/10.12816/0015249

8. Al-Jorani, L. E., Al-Azzawi, S. I., & Yaseen, I. N. (2015). Comparing &Evaluating the Effect of Air-Powder Polishing System on the Hot Cure Acrylic Denture Base Material Cured by Different Methods. Al Mustansiriyah Journal of Pharmaceutical Sciences, 15(2), 1–12. https://doi.org/10.32947/ajps.v15i2.165

9. Hussain, W. A., & Hashim, F. S. (2017). Effect of additives on impact strength of denture base resin. Iraqi Journal of Science, 860–867.

10. Jasim, B. S., & Ismail, I. J. (2014). 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, 26(2), 18–23. https://doi.org/10.12816/0015190

DOI: 10.32828/mdj.v19i2.891

11. Abdulsattar, M. H. (2023). Assessment of The Mechanical and Color Changes Properties of Denture Base Material After Reinforcement with Nanoparticles Material. Tikrit Journal for Dental Sciences, 11(1), 8–15. https://doi.org/10.25130/tjds.11.1.2

12. Rashid, A. A.-L. (2011). Effect of The Elevated Temperature on the Tensile Strength of Cold Cured Acrylic Denture Base in Comparison to Heat Cure Acrylic. Mustansiria Dental Journal, 7(1), 126–133.

13. Sabir, D. B., & Omer, Z. Q. (2019). Evaluation of Fluoride release from orthodontic acrylic resin by using two different polymerizations techniques: An InVitro Study. Erbil Dental Journal (EDJ), 2(2), 149–156. https://doi.org/10.15218/EDJ.2019.04

14. Srithongsuk, S., Anuwongnukroh, N., Dechkunakorn, S., Srikhirin, T., & Tua-ngam, P. (2012). Investigation of fluoride release from orthodontic acrylic plate. Advanced Materials Research, 378–379, 681–687. https://doi.org/10.4028/www.scientific.net/AMR.378-379.681

15. Hachim, T. M., Abdullah, Z. S., & Alausi, Y. T. (2013). Evaluation of the effect of addition of polyester fiber on some mechanical properties of heat cure acrylic resin. Journal of Baghdad College of Dentistry, 25(3), 23–29. https://doi.org/10.12816/0015096

16. Wong, M., Clarkson, J., Glenny, A.-M., Lo, E., Marinho, V., Tsang, B., Walsh, T., & Worthington, H. (2011). Cochrane reviews on the benefits/risks of fluoride toothpastes. Journal of Dental Research, 90(5), 573–579. https://doi.org/10.1177/0022034510393346

17. Alla, R., Raghavendra, K., Vyas, R., & Konakanchi, A. (2015). Conventional and contemporary polymers for the fabrication of denture prosthesis: part I-overview, composition and properties. International Journal of Applied Dental Sciences, 1(4), 82–89.

18. Prapansilp, W., Rirattanapong, P., Surarit, R., & Vongsavan, K. (2017). Fluoride release from different powder liquid ratios of Fuji VII. Mahidol Dental Journal, 37(2), 217–222.

19. Zahroon, S. F. J. (2014). Development of a novel acrylic resin as a fissure sealant [Doctoral dissertation, University of Newcastle upon Tyne].

20. Rashid, A. A.-L. (2015). Influence of different concentrations of fluoride on the porosity of acrylic resin denture base materials. Iraqi Dental Journal, 37(2), 56–61. https://doi.org/10.26477/idj.v37i2.44