EVALUATION OF SURFACE HARDNESS AND COLOR STABILITY OF MAXILLOFACIAL SILICONE ELASTOMER MODIFIED WITH ZNO NANOPARTICLES: THE EFFECT OF ARTIFICIAL AGING

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Abstract: Maxillofacial elastomers undergo significant changes in their structure and appearance during working life, mainly due to aging caused by exposure to extraoral conditions. Changes in color and surface, such as hardness, are often the main reasons for prosthesis replacement, as these are changes that are visually very noticeable, due to the specific facial location of the prosthesis. The aim of this study was to investigate the effects of incorporation of different weight percentages of ZnO nanoparticles into a commercial, colored maxillofacial silicone elastomer, on the surface hardness and color stability of silicone material subjected to artificial aging. The tested properties were selected because of their important clinical significance. **Keywords**: maxillofacial protesis, silicon elastomers, ZnO nanoparticles, surface hardness, color stability

INTRODUCTION

Maxillofacial prosthetics representing a science and art of anatomical, functional, and cosmetic reconstruction by means of artificial replacement of head and neck structures that are missing or defective. Silicone elastomers are the materials most commonly used to make these prosthetics . In maxillofacial area, this materials are exposed to various ekstraoral environmental factors, that can adversely affect the mechanical and physical properties of this material. Two major problems, associated with maxillofacial prostheses, used to rehabilitate patients with oralfacial defects are: 1) the degradation of static and dynamic physical properties of elastomers, and 2) discoloration of the prostheses in a service environment. Scientific studies have found satisfactory results by incorporating different kind of nanoparticles (NPs) into maxillofacial silicone elastomers, in terms of protecting such materials from degradation.

MATERIAL AND METHODS

Color evaluation were performed on 60 colored silicon specimens, divided into three groups: I - spaciements modified with 1% ZnO nanoparticles, II - speciement modified with 2% ZnO nanoparticles, III - control non modifed speciements. Outcomes were measured before and after accelerated aging for color changes as well as for surface hardness values.

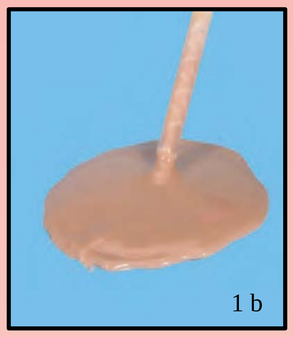


Figure 1a, 1b Mulisil Epithetic Country, Bredent, Germany-

Artificial aging

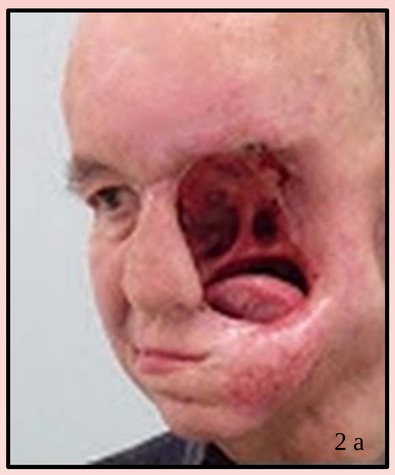
In order to simulate the effects of environmental conditions, samples of all examined groups were exposed to sunlight for 6 hours every day, during the period of maximum intensity of UVA and UVB rays - between 10 am and 4 pm, for a month. Measurement of color and surface hardness was performed after a period of 10 days, 20 days and 30 days.

Measurement of color change

The values of color changes of samples were performed initially and after each period of exposure of the samples to artificial aging (1, 20 and 30 days) by using Vita Easy Shade spectrophotometer, Germany, and the results were recorded in the CIELAB coordinate system. The color difference was calculated based on the following formula: [(ΔL *) 2 + (Δa *) 2 + (Δb *) 2] ½

Surface hardness measurement

The values of hardness were performed initially and after aging periods (1, 20 and 30 days), by using a digital durometer. The measurement was performed at 5 different points on the surface of the sample, and the mean value was recorded as the hardness of a particular sample.



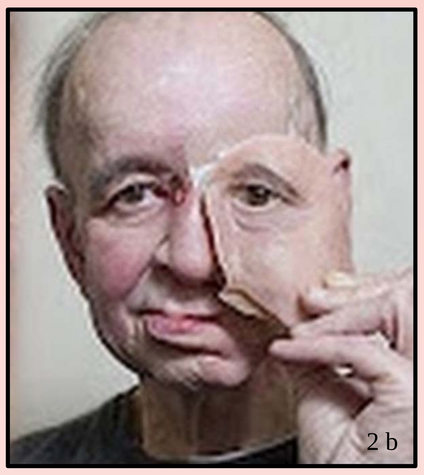


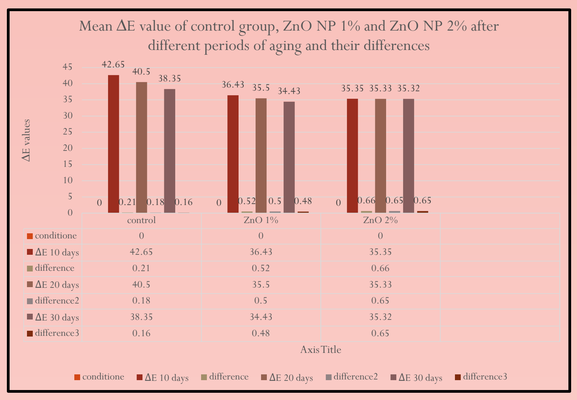
Figure 2a, 2b. – maxillofacial prosthesis (before and after)
https://www.inkedmag.com/the-list/medical-facial-prosthetics

RESULTS

Results showed that the presence of nanoparticles influenced the properties of the assessed groups. Modification of facial silicon by ZnO nanoparticles increased hardness values. The highest values of surface hardness were observed for the groups with addition of 2 % ZnO NP, group without NP showed the lowest values of surface hardness. ZnO NP modified specimens showed minimal or no color change, representing significant color stability after being subjected to outdoor weathering.
Most of the results of color change in all examined groups are above 3.3 DE units, which indicates that the color change after the period of artificial aging can be visually noticeable. According to the results of the paired t-test, there is a statistically significant difference between the hardness of the samples of all three examined groups before and after exposure to artificial aging ($p < 0.001$).

Effect of ZnO nanoparticles concentration

Comparing the results of color change in the examined groups after 10 days of artificial aging, it was shown that group II with 2% ZnONPs shows the lowest value of color change. After 20 and 30 days of aging, group II with 2% ZnONPs shows the least color change. Comparing the hardness of the tested samples, it was shown that group II with 2% ZnONPs shows the highest hardness value. After 20 and 30 days of aging, group II with 2% ZnO still shows the highest hardness value, followed by group I with 1% ZnONPs and the control group.



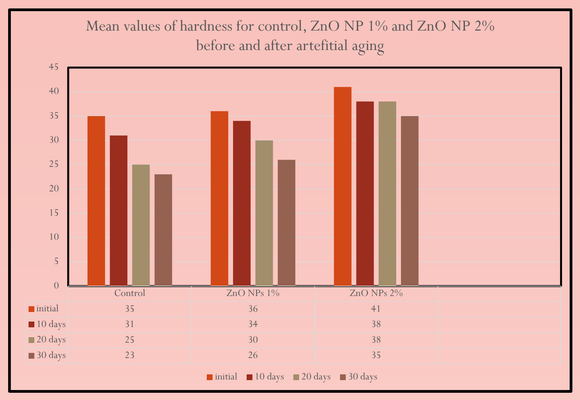


Figure 3a. – Mean values of color alteration for control, ZnO NP 1% and ZnO NP 2% group after artefitial aging
Figure 3b. – Mean values of hardness for control, ZnO NP 1% and ZnO NP 2% group before and after artefitial aging

CONCLUSION

Based on the findings of this in vitro study, the modification of maxillofacial silicon elastomer material by addition of ZnO nanoparticles can be recommended.

REFERENCES

[1] Rena L.J. Cruz, Maureen T. Toss, Sean K. Powell, Maria A. Woodruff. Advancements in Soft-Tissue Prosthetics Part B: The Chemistry of Imitating Life. Front Bioeng Biotechnol. 2020; 8: 147.
[2] Cifter ED, Ozdemir-Karatas M, Cinarli A, Sancakli E, Balik A, Evlioglu G BMC. In vitro study of effects of aging and processing conditions on colour change in maxillofacial silicone elastomers. Oral Health. 2019 Jun 19;19(1):122.
[3] Nithin Kumar S, Ramesh C. Effect of nanoparticles on color stability and mechanical and biological properties of maxillofacial silicone elastomer: A systematic review.2020;20:3:244-254.
[4] Sonnahalli NK, Chowdhary R. Effect of nanoparticles on color stability and mechanical and biological properties of maxillofacial silicone elastomer: A systematic review. J Indian Prosthodont Soc 2020;20:244-54.
[5] Akash RN, Guttal SS. Effect of incorporation of nano-oxides on color stability of maxillofacial silicone elastomer subjected to outdoor weathering. J Prosthodont 2015;24:569-75.
[6] Bangera BS, Guttal SS. Evaluation of varying concentrations of nano-oxides as ultraviolet protective agents when incorporated in maxillofacial silicones: An in vitro study J Prosthet Dent 2014;112:1567-1572
[7] Kalaignan P, Mohan J.S. Impact of Maxillofacial Prostheses on Oral Health Related Quality of Life (OHRQoL). Biomed Pharmacol J 2018;11(2).
[8] Eltayyar N.H, Alshimy A.M, Abushelib M.N. Evaluation of intrinsic color stability of facial silicone elastomer reinforced with different nanoparticles. Alexandria Dental Journal. (2016) 41:50-54 50.