Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 3 Vol 8 No 1 2023

Article

Evaluation of some Mechanical Properties of Room Temperature Maxillofacial Silicone after the addition of Nano Barium Titanate

Aseel F. Kumail, Thekra I. Hamad
Department, College of Dentistry/ University of Baghdad, Iraq.
*Correspondence: aseel.fatlawi1201a@codental.uobaghdad.edu.iq

Abstract
Background: Because facial prostheses are used to replace a missing piece of the face, they must be made of a material comparable to the soft tissues and skin in the surrounding area. Investigations have revealed that the maxillofacial silicone elastomer is often used for this purpose due to its biocompatibility, capacity to be easily colored by intrinsic or extrinsic coloration, and good elasticity. Aim of this study: The goal of this investigation was to evaluate the effect of the addition of Barium titanate (BaTiO3) Nanofillers in different percentages on some mechanical properties of VST-50 room-temperature vulcanized maxillofacial silicone.Methods: The Nano BaTiO3 was introduced to the VST-50 RTV maxillofacial silicone in percentages of 1% and 2% by weight, and the samples were tested for tensile strength (ISO 37: 2017), percentage of elongation (ISO 37: 2017), and tear strength (ISO 34-1: 2015). FE-SEM and EDS investigated the BaTiO3 Nanofillers dispersion in VST-50 silicone elastomer. Descriptive and inferential statistics were used to analyze the data. The changing significance was tested using a one-way ANOVA test. Results: FE-SEM imaging was used to determine the dispersion of the nanoparticles inside the silicone matrix, which exhibited a well-dispersed with some agglomeration as the filler fraction rose. The EDS test supports the incorporation of BaTiO3 nanoparticles in the polymer matrix. Compared to the control group, the 1% and 2 % groups showed substantial increases in tensile strength, percentage of elongation and non-significant difference between 1% and 2% groups, and 2% more increase in tear strength than 1% groups. Conclusion: Reinforcing VST-50 maxillofacial silicone with 1 % and 2% percentages of Nano BaTiO3 improved several of the room-temperature vulcanized silicone's mechanical qualities.

Keywords: Nano BaTiO3; percentage of elongation ; RTV maxillofacial silicone ; tear strength ; tensile strength.

Introduction

A congenital disability, trauma, or tumor surgery can all cause facial deformity. Surgical reconstruction may be impossible due to the size or location of the defect, as well as the patient's medical condition or personal preferences. Prosthetic rehabilitation is recommended in these situations: [1]

To improve the qualities of maxillofacial silicone, certain Nanofillers are added to the matrix, such as titanium silicate, which improves the mechanical properties of RTV maxillofacial silicone [2].

Because of its advantageous mechanical properties, nano barium titanate (NBT) as a family of ceramic materials has potential for biological applications [3]
The goal of this study was to evaluate the effect of different percentages (1%, 2%) of BaTiO3 Nanoparticles by weight on the tensile strength, elongation percentages, and tear strength of VST-50 RTV maxillofacial silicone [2].

Material and methods

Each leading group was subdivided into three subgroups: one for the tensile strength test, one for the percentage of elongation test, and one for the tear strength test; each leading group had 30 samples.
The materials used in this study are listed in Table 1.

Material	Manufacturer	Patch number
VST-50 RTV maxillofacial silicone elastomer	Factor II Inc., USA	F 15U138R06
Barium titanate nanoparticles 99.9% purity, 50-70 nm.	Sky Spring Nano-materils, Inc	1400GC

Table 1. The study materials.

Each subgroup was subdivided into three subgroups: one for the control group 0% (without Nano addition), one for the 1% by weight Nano BaTiO3 addition group, and another for 2% by weight Nano BaTiO3; each subgroup had 10 samples. Plastic molds were made with a CNC machine, and each mold has the same proportions for the base, frame, and cover sections.
The VST-50 room-temperature vulcanized maxillofacial silicone type used in this study is a two-part silicone with a 10:1 base-to-catalyst mixing ratio, according to the manufacturer's instructions. The control group's mixing began with adding the base to the electronic balance container. Then, the catalyst was added and started mixing by the vacuum mixer with a speed of 140±10 rpm and a vacuum of -0.095 MPa (28 inch Hg). For the reinforced groups, Nanopowder was put into the electronic balance container first, followed by the base, and then mixed without vacuum for 3 minutes, vacuum mixing for 7 minutes, catalyst addition, and vacuum mixing for the remaining 5 minutes, [4]
The silicone was ready to pour into the tensile strength test, percentage of elongation test, and tear strength test molds, after which the G-clamps were used to tighten the cover over the remaining mold sections. The mechanical properties of the RTV silicone were examined after 24 hours of complete vulcanization. The tensile strength is calculated using the following formula according to the ISO37:2017.
Tc =Fm/WT
Tc is the tensile strength of the material.
Fm denotes the maximal force required to rupture the specimen at its narrowest point (N).
W is the width and is measured in millimeters.
T is the thickness and is measured in millimeters (mm).
The elongation percentage was calculated using a formula according to ISO 37:2017.
E% = Lb-Lo /Lo X100
E% stands for elongation percentage.
Lb is the length at breakage and is measured in (mm).
The original length is Lo (mm).

The tear strength test was done by formula according to **ISO 34-1:2015** [5] a, samples with flat ends and a right angle at the middle.

Ts =f/d

The letter Ts stands for tear strength.

The maximal force is denoted by the letter f (N).

The thickness of the specimen is denoted by d (mm).

To examine the shape and size of BaTiO3 particles, a Field Emission Scanning Electron Microscope FE-SEM was used to scan barium titanate Nanopowder. The broken surfaces of the control and BaTiO3-containing specimens (1wt% BaTiO3 and 2wt% BaTiO3) were also scanned to assess BaTiO3 particle dispersion inside the silicone matrix. The specimens were made by cutting small pieces from silicone specimens and using a sputter coater apparatus to coat them with gold for 2 minutes.

The percentage of each component of barium titanate within the VST-50 silicone matrix can be determined using EDS. To reduce the overcharge effect on specimens during scanning, they were mounted on aluminum metal stubs and coated with gold.

Results

Using the one-way ANOVA test, the statistical findings of the tensile strength test revealed an increase in 1% and 2% groups, with P values less than 0.05. The percentage of elongation tests revealed a significant rise in 1% and 2% groups in a one-way ANOVA test, with a P value less than 0.05. (Table 2 and 3). Furthermore, using the one-way ANOVA test, the results of the tear strength test revealed a significant increase in the 1% and 2% groups, with P values less than 0.05 (Table 4).

Groups	Minimum	Maximum	Mean	±SD	F	P.valu e
0%	3.17	5.03	4.3830	0.53708	11.881	0.054
BaTiO3						
1%	4.71	5.64	5.2105	0.26339		
BaTiO3						
2%	4.41	6.37	5.4291	0.64109		
BaTiO3						

Table 2. Statistical test of Tensile strength (MPa).

Groups	Minimum	Maximum	Mean	±SD	F	P value
0%	461.09	654.05	555.7376	55.88744	12.523	0.012
BaTiO3						
1%	661.28	760.53	701.8376	34.68700		
BaTiO3						
2%	526.12	953.38	714.2028	119.51089		
BaTiO3						

Table 3. Statistical test of percentage of elongation (%).

Groups	Minimum	Maximum	Mean	±SD	F	P value

0%	18.60	21.77	19.7970	1.18644	34.425	0.757
$BaTiO_3$						
1%	20.49	24.60	22.7899	1.39547		
$BaTiO_3$						
2%	22.32	26.27	24.6027	1.33330		
$BaTiO_3$						

Table 4. Statistical test of the tear strength (N/mm).

The BaTiO3 Nano fillers were well dispersed throughout the maxillofacial silicone matrix, according to FE-SEM pictures(Figures 1&2&3).

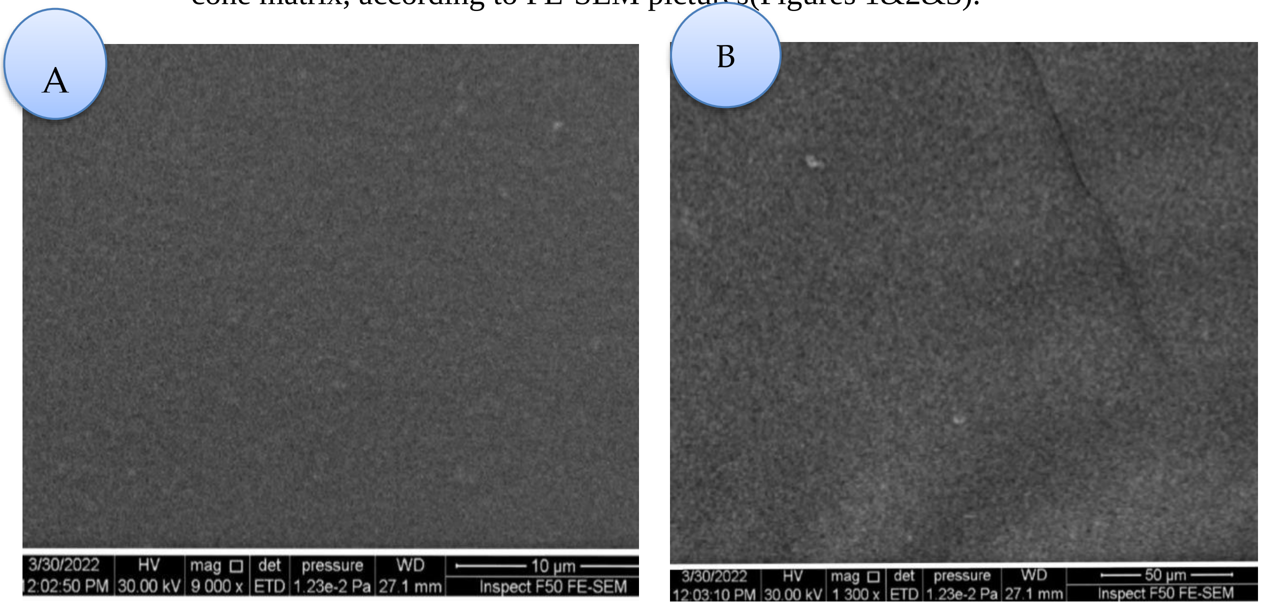


Figure 1. FE-SEM image of VST-50 maxillofacial silicone before adding BaTiO3 Nanofillers; A, 10µm magnification. B, 50 µm magnification.

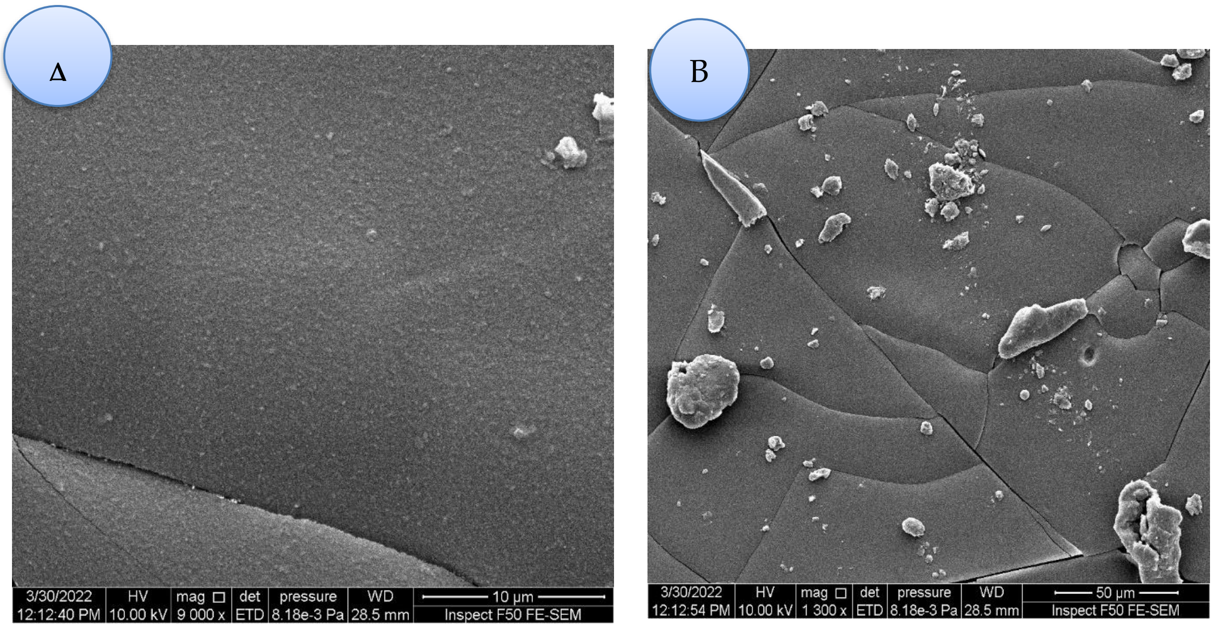


Figure 2. FE-SEM image of VST-50 maxillofacial silicone with 1% BaTiO3 Nanofillers; A, 10 µm magnification. B, 50 µm magnification.

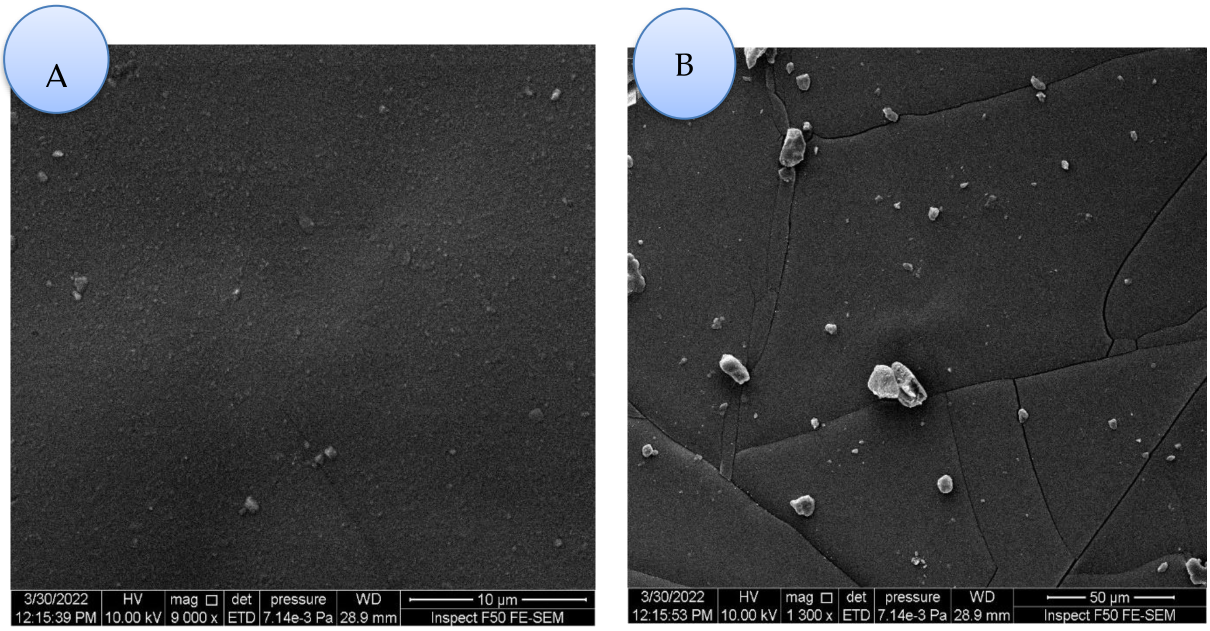
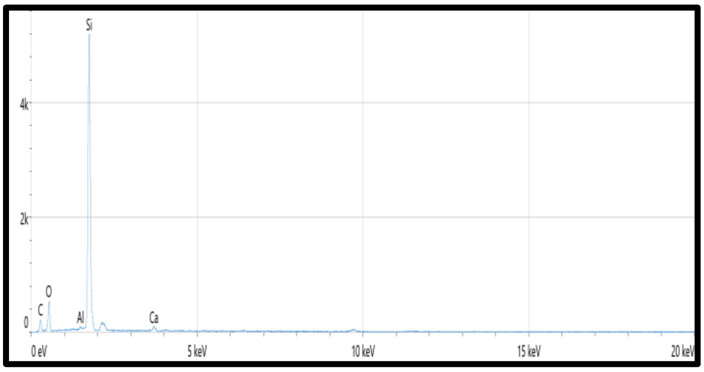


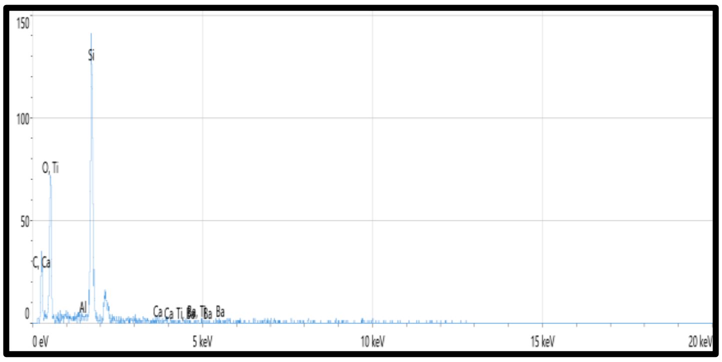
Figure 3. FE-SEM image of VST-50 maxillofacial silicone with 2% BaTiO3 Nanofillers; A, 10 µm magnification. B, 50 µm magnification.

The percentage of each component of barium titanate within the VST-50 silicone matrix was determined using EDS imaging (Figure 4&5&6).



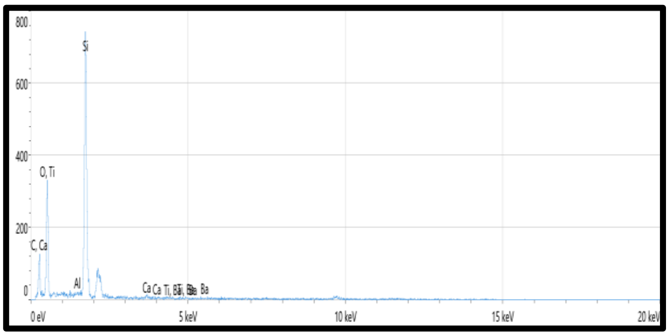
Weight % Error	Weight %	Atomic % Error	Atomic %	Element
0.7	23.0	1.1	34.8	C
0.7	31.8	0.8	36.2	O
0.0	0.2	0.0	0.2	Al
0.2	43.9	0.2	28.4	Si
0.1	1.0	0.0	0.5	Ca

Figure 4. EDS for VST-50 maxillofacial silicone before the addition of BaTiO3 Nanofillers.



Weight % Error	Weight %	Atomic % Error	Atomic %	Element
1.8	23.5	2.6	34.8	C
1.9	36.3	2.1	40.4	O
---	0.0	---	0.0	Al
1.1	38.4	0.7	24.3	Si
0.4	0.5	0.2	0.2	Ca
0.1	0.1	0.1	0.1	Ti
1.1	1.1	0.1	0.1	Ba

Figure 5. EDS for VST-50 maxillofacial silicone with 1% BaTiO3 Nanofillers.



Weight % Error	Weight %	Atomic % Error	Atomic %	Element
1.1	21.7	1.7	33.3	C
0.9	32.1	1.0	37.0	O
0.1	0.2	0.1	0.1	Al
0.5	44.3	0.3	29.0	Si
0.2	1.1	0.1	0.5	Ca
0.2	0.2	0.1	0.1	Ti
0.4	0.4	0.1	0.1	Ba

Figure 6. EDS for VST-50 maxillofacial silicone with 2% BaTiO3 Nanofillers.

Discussion

Because many earlier research demonstrated that adding fillers on a Nanoscale improved the mechanical qualities of maxillofacial silicone, Barium titanate Nano fillers were chosen to be added because they offered several advantages over other Nano filler kinds [3]

Tensile strength tests revealed that adding (2wt% BaTiO3) followed by (1wt% BaTiO3) increased tensile strength compared to the control group. As shown, the increase in tensile strength can be attributed to the physical interaction of BaTiO3 nanoparticles with the silicone matrix, which increases the strength of the polymer chains[6]

The cross-linking mechanism, density, and nature of the interaction between fillers and polymer matrix all influence the tensile strength of VST-50 silicone[7]

The results showed an increase in elongation percentage after adding 1% and 2% BaTiO3 nanoparticles.

When the fine particle filler interacts with the matrix, the elongation at the break of the filling system can rise, according to a previous study [8,9]

Tear strength also increased due to the delicate scattering of BaTiO3 Nanoparticles, and physical interaction with the matrix of the VST-50 silicone can explain this increase in tear strength, which may lead to an increase inthe density of the silicone and the resistance to tear [10,11]

The dispersion of nanoparticles inside the silicone matrix was studied by FE-SEM imaging, which revealed a well-dispersed with some agglomeration as the filler percentage increased. The EDS test confirms the presence of $BaTiO_3$ nanoparticles in the polymer matrix [12,13].

Conclusions

Adding 1% and 2 % Nano $BaTiO_3$ to VST-50 RTV maxillofacial silicone improved the tensile strength, elongation percentage, and tear strength.

Conflict Of Interest

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

References

1. Maller, US , Karthik K, Maller SV. .Maxillofacial prosthetic materials—past and present trends. JIA.2020;1(2):25-30.
2. Alsmael MA, Ali MM. The Effect of Nano Titanium Silicate Addition on Some Properties of Maxillofacial Silicone Material". *Journal Of Research In Medical And Dental Science*.**2018**;*6(5)*:127-132.
3. Yu J, Chu J. Nanocrystalline Barium Titanate. California, USA: American Scientific Publishers.2004: pp.389-416.
4. Tukmachi M, Moudhaffer M. Effect of nano silicon dioxide addition on some properties of heat vulcanized maxillofacial silicone elastomer. JPBS. 2017;12(3-4):37-43.
5. ASTM D624-00.Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers. ASTM International, West Conshohocken, PA, USA. 2012
6. Rajkumar K, Ranjan P, Thavamani P, Jeyanthi P, Jeyanthi P . Dispersion studies of nano-silica in nbr based polymer nanocomposite " *Rasayan Journal of chemistry*. **2013**;*6(2)*: pp. 122-133.
7. Aziz T, Waters M., Jagger R. (2003a). Analysis of the properties of silicone rubber maxillofacial prosthetic materials. *Journal of Dentistry*,**2003**;*31(1):* pp. 67-74.
8. Kong SM, Mariatti M, Busfield JJC. Effect of types of fillers and filler loading on the properties of silicone rubber composite. *J. Reinforced Plastics and Composite*.**2011**;*30*: 1087-96.
9. Harper CA. Handbook of plastics, elastomers, and composites. New York: McGraw-Hill. 2002 Jun.
10. Abdukareem, A. A. and Hamad, T. I. The Effect of Aluminum Oxide Nanoparticles on Some Mechanical Properties of Room Temperature Vulcanized Maxillofacial Silicone After Artificial Aging. *Journal of Baghdad College of Dentistry*. **2019**.
11. Abdulhamed, A. N., and Mohammed. M. Evaluation of thermal conductivity of alumina-reinforced heat cure acrylic resin and some other properties. *Journal of Baghdad College of Dentistry*, **2010**, *22(3)*, pp. 1-7.
12. Yehya, W. A. Seasonal Monumental Insects Accompanying Euphrates Poplar Leaves. Journal of Life Science and Applied Research 2020, 1, 45-53.
13. Othman Ghazi Najeeb Alani , Yassen Taha Abdul-Rahaman and Thafer Thabit Mohammed. Effect Of Vêo® Premium and Vitamin C Supplementation on Lipid Profile Before and During Pregnancy in Some Local Iraqi Ewes During Heat Stress. Iraqi Journal of Science.2021, Vol. 62, No. 7, pp: 2122-2130.

Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023
Citation: Kumail, A.F.; Hamad, T.I. Evaluation of some Mechanical Properties of Room Temperature Maxillofacial Silicone after addition of Nano Barium Titanate. Revis Bionatura 2023;8 (3) 35. http://dx.doi.org/10.21931/RB/CSS/2023.08.03.35