The Effects of Nano Alumina On Mechanical Properties of Room Temperature Vulcanized Maxillofacial Silicone (Pilot Study)

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ABSTRACT

Background: Facial disfigurement can be the result of a congenital anomaly, trauma or tumor surgery, in many cases the prosthetic rehabilitation is indicated. Maxillofacial prosthetic materials should have desirable and ideal physical, aesthetic, and biological properties and those properties should be kept for long period of time in order to reach patient acceptance. Silicone elastomer are the most commonly used material for facial restoration because of its favorable properties mechanically and physically as the biocompatibility and good elasticity.

Aim of this study: This study aimed to evaluate the effect of addition of Aluminum oxide (Al_2O_3) Nano fillers in different concentrations on tear strength and hardness of VST 50F room temperature vulcanized maxillofacial silicone.

Methods: The Nano Al_2O_3 was added in a concentrations of 0.5%, 1%, 1.5% and 2% by weight to the VST 50F RTV maxillofacial silicone, the samples were tested for tear strength (ISO 34 -1) and shore A hardness (ISO 7619), the FTIR was used to analyze the interaction of the Nano Al_2O_3 with the silicone. The data were analyzed using descriptive and inferential statistics. One-way ANOVA test was used to test the changing significance.

Results: There was no interaction between the Nano-Al_2O_3 and the silicone in the FTIR. The results showed highly significant increase in tear strength and shore A hardness for the 1% and 1.5% concentration groups when Compared to control group.

Conclusion: The reinforcement of VST 50F maxillofacial silicone with 1% and 1.5% concentrations of Nano Al_2O_3 improved some of the mechanical properties of the room temperature vulcanized silicone.

Keywords: RTV maxillofacial silicone, Nano Al_2O_3, tear strength, shore A hardness. **(Received: 29/7/2019; Accepted: 1/9/2019)**

INTRODUCTION

The first part of the body that will contact the world is the face, the accepted appearance of the face is now became mandatory to be accepted in a job, appear in magazine or television and in marriage looking. Surgical reconstruction of the facial defects may not be possible owing to size or location of the defect, the patient's medical condition or personal desires may also preclude reconstructive surgery. In such cases, prosthetic rehabilitation is indicated [1].

Some Nano fillers are added to the matrix of maxillofacial silicone to improve its properties, as in the addition of titanium silicate which resulted in improvement of the mechanical properties of the RTV maxillofacial silicone [2]. The aluminum oxide (Al_2O_3) as a Nano-fillers characterized by its fair chemical inertness, its strength and stiffness among other ceramic oxides and by a preferable dielectric properties and refractoriness [3].

The aim of this study was to evaluate the effect of addition of different concentrations (0.5%,1%, 1.5% and 2%) by weight of Al_2O_3 Nano-fillers on tear strength and shore A hardness of VST 50F RTV maxillofacial silicone.

MATERIALS AND METHODS

The materials used in this study listed in (Table 1).

Table 1: The study materials

Material	Manufacturer	Patch number
VST 50F RTV maxillofacial silicone elastomer	Factor II Inc., USA	B 101918-1LB
Aluminum Oxide Nano fillers 99.5% purity, 40-60 nm.	US research nanomaterials inc., USA	1344-28-1

Two main groups were prepared, one for the tear strength test and the other for the hardness test, in each one of them a 25 samples were fabricated, each main group subdivided
into five subgroups which are the control group 0%(without Nano addition), 0.5%, 1%, 1.5% and

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2% by weight Nano Al_2O_3 addition groups, each of them had 5 samples. Plastic molds were fabricated using CNC machine, each mold consists of base, frame and cover parts in the same dimensions.

The maxillofacial silicone type used in this study was the VST 50F room temperature vulcanized one which is a two parts silicone, the mixing ratio of the base to the catalyst was 10:1 according to the manufacturer instructions, the mixing of the control group began with the addition of the base to the electronic balance container then the catalyst was added and started mixing by the vacuum mixer with a speed of 360 rpm and a vacuum was of (-10 bar), for the reinforced groups the Nano powder was added to the electronic balance container followed by addition of the base then starting mixing without vacuum for 3 minutes followed by mixing with a vacuum for 7 minutes followed by catalyst addition and mixing with vacuum for the remaining 5 minutes [4].

The silicone became ready to be poured in the molds of tear strength test and hardness test, followed by tighten the cover with the remaining molds parts by the G-clamps. After 24 hours of complete vulcanization of the RTV silicone the mechanical properties were tested. The tear strength calculated using the following formula according to the **ASTM D624 (2012)** [5]:

$$\boldsymbol{Tear\ strength} = \frac{\mathbf{F\ (Maximum\ force\ at\ breakage(KN))}}{\boldsymbol{D\ (thickness\ of\ the\ sample(m))}}$$

A samples with flat ends and a right angle at the middle. While the hardness test was done by a digital shore A hardness durometer device according to **ASTM D2240-05** [6], a samples with a length of 25 mm and a width of 25 mm and a thickness of 6 mm were fabricated.

RESULTS

The statistical results of tear strength test showed a highly significant increase in 1% and 1.5% groups by doing the one way ANOVA test and found that the P values < 0.05. The results of shore A hardness tests showed an increasing in all reinforcement groups except in 0.5% group when compared to the 0% group by doing the one way ANOVA test and found that the P value < 0.05 (Table 2 and 3).

Table 2: Statistical test of Tear strength (N/mm)

Groups	Minimum	Maximum	Mean	±SD	F	P value
0% Al_2O_3	25.5	25.7	25.6	0.22	116.63	.001
0.5% Al_2O_3	25	25.2	25.1	0.31		
1% Al_2O_3	26	26.6	26.2	0.26		
1.5% Al_2O_3	27.9	28.4	28.2	0.22		
2% Al_2O_3	26.4	26.8	26.6	0.14		

Table 3: Statistical test of the Shore A hardness (IU)

Groups	Minimum	Maximum	Mean	±SD	F	P value
0% Al_2O_3	27.3	27.9	27.4	0.4	500.7	0.000
0.5% Al_2O_3	26.5	26.9	26.7	0.23		
1% Al_2O_3	27.5	27.7	27.6	0.3		
1.5% Al_2O_3	28	28.5	28.3	0.3		
2% Al_2O_3	34.5	34.9	34.6	0.3		

There was no any interaction between the Al_2O_3 Nano fillers and the VST 50F maxillofacial silicone in the FTIR analysis (Figures 1&2).

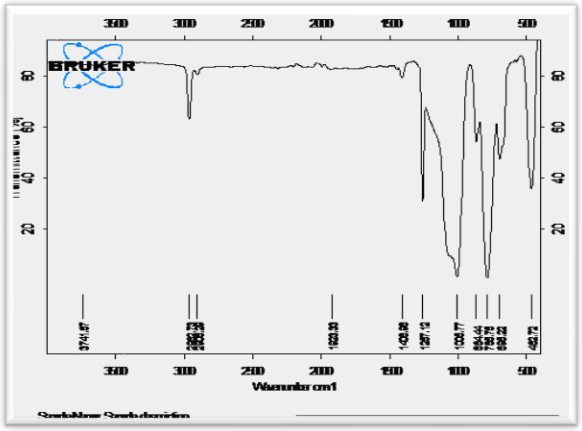

Figure 1: the FTIR of the VST 50F maxillofacial silicone before addition of Al_2O_3 Nano fillers

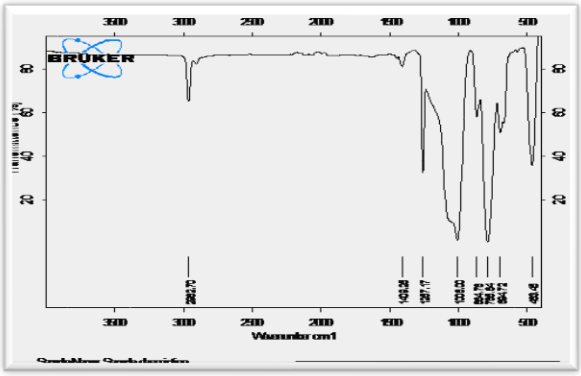

Figure 2: the FTIR of the VST 50F maxillofacial silicone after addition of Al_2O_3 Nano fillers

DISCUSSION

Many previous studies results showed that the addition of fillers in a Nano scale improved the mechanical properties of the maxillofacial silicone, so the Aluminum oxide Nano fillers were chosen to be added because it had many preferable properties when compared to other Nano filler types [3].

The results showed an increase in tear strength after reinforcement except for the 0.5% and 2% reinforcement groups, that may be due to the ability of the Nanoparticles to be trapped within the silicone matrix and in some polymer chains and then a 3D mesh formation would result in a physical interaction which my lead to increase the density of the silicone and the resistance to tear[7]. For the decrease in tear strength in the 0.5% this may be due to the very small amounts of fillers which act as impurities that would affect the polymerization process of the silicone without formation a 3D mesh [8], while for the decrease in tear strength in the 2% group this may be caused by beginning of fillers to agglomerate in the silicone matrix with the increasing in concentration of added fillers which may results in restriction of flow and movement of the polymer matrix when the stretching forces increased [9]

shore A hardness also increased for the reinforced samples which may be due to The filler adherence to each other when increasing the filler concentrations made it fill the inter-aggregate areas within the silicone matrix so it will resist the indentation loads [10]. For the reduction in the 0.5% group may be due to the small amounts of the Nano fillers added which would be as an impurities and interact with the polymerization process of the silicone [8].

CONCLUSIONS

The reinforcement of VST 50F RTV maxillofacial silicone with 1% and 1.5% Nano Al_2O_3 improved some of the mechanical properties of silicone with the best improvement occur after 1% and 1.5% Nano Al_2O_3 reinforcement.

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الخلاصة.

مقدمة: تعويضات الوجه والفكين يجب ان تكون مصنوعة من مواد ذات خصائص متوافقة مع الجلد والانسجة الرخوة حول الجزء المفقود، توجد عدة مواد لعمل تعويضات الوجه ولكن اكثرها استعمالا في وقتنا الحالي هي مادة السيليكون المطاط الخاص ولكن وجد ان خصائص مادة السيليكون الخام غير كافيه لاستعماله في تعويضات الوجه لذلك ركزة كثير من البحوث في الآونة الأخيرة على اضافه حبيبات الاكاسيد النانوية الى السيليكون بهدف تحسين خصائصه الميكانيكية والفيزيائية.

اهداف البحث: الغرض من هذا البحث هو دراسة تأثيرات إضافة حبيبات اكاسيد الألمنيوم النانوية على بعض الخصائص الميكانيكية لسيليكون تعويضات الوجه والفكين.تم إضافة اكاسيد الالمنيوم النانوية بتراكيز مختلفه (0.5%, 1% ,1.5%, 2%).

طريقة العمل: تم اتباع تعليمات المصنّع في طريقة خلط المادة السيليكون ونسبها وتم تحضير مجموعتين رئيسيتين من العينات المجموعة الأولى لفحص قوة التمزق، والمجموعه الثانيه لفحص الصلابة كما وتم إجراء فحص FTIR لتقييم الارتباط الكيميائي لحبيبات اكاسيد الالمنيوم النانوية مع السيليكون.

النتائج: أظهرت نتائج الاختبارات زيادة عالية احصائيا بقوة التمزق والصلابة وكانت اعلى النتائج هي لمجموعتي التركيزين المضافين 1% و 1,5% من الحبيبات النانوية مقارنة بالمجموعات الأخرى والمجموعة الضابطة.

الاستنتاجات: نستنتج بان إضافة حبيبات اكاسيد الالمنيوم النانوية إلى مادة السيليكون المطاط عزز بعض الخواص الميكانيكية لهذه المادة.