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RESEARCH ARTICLE

EFFECT OF DIFFERENT CONCENTRATIONS OF TITANIUM DIOXIDE NANOPARTICLES ONTHE MECHANICAL PROPERTIES OFA MAXILLOFACIAL SILICONE ELASTOMER

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ABSTRACT

Introduction: Maxillofacial materials are used to replace missing facial parts which have been lost through disease or trauma. They are usually comprised of poly (dimethylsiloxane) (PDMS) elastomers.

Methods: The study was conducted using commercially available silicone elastomer used for the fabrication of maxillofacial prosthesis and UV shielding Titanium di-oxide nano- oxide particles. Various amounts of TiO_2 nano-oxide particles were added to the silicone elastomer: 0%, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%. A total of six experimental groups were created by combining silicone elastomer (Cosmesil M511) with Ti O_2nano- oxide particles. Statistical analysis was done using SPSS (Statistical Package for Social Sciences) software Version 20. One way analysis of variance (ANOVA) was used to test for any significant difference between the mean values of the materials tested. Post- test (Tukey post hoc) was used to determine whether the mean value of any particular material differed significantly from another specified material, while considering all the data.

Result: Mean (SD) change values of tensile strength for Control Group, 0.5% TiO_2, 1% TiO_2, 1.5% TiO_2, 2% TiO_2, 2.5% TiO_2, 3% TiO_2 was 3.7576 ±.06807, 3.8280± .09558, 4.0610± .06883,4.4210± .05078, 4.7865± .04694, 5.0245± .04264, 4.0984±.06753, 4.2824± .45293 respectively. The Change in Tear Strengthwas for Control group, TIO_21, TIO_{22}, TIO_{23}, TIO_{24}, TIO25, TIO26 was 3.5002 ± .05726, 4.2855 ± .07651, 4.6525± .07911, 5.6763 ± .11152, 6.0038 ± .08204, 6.2561 ± .09440, 5.0689 ± .10089respectively. Change in Tear Strengthwas for Control group, TIO_{21},TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 528.8000± 6.03324, 518.5000± 4.92725, 500.6000± 10.52193, 476.7000± 4.66786, 459.8000± 7.40570, 442.4000± 5.46097, 420.2000± 6.25033respectively The Change in Tear Strengthwas for Control group, TIO_21TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 34.8700 ± .40291, 35.8000± .64118, 37.0300± .75137, 38.1700± .35292, 40.0900± .43321, 41.5200± .44672, 41.6900± .28067 Respectively and these observed differences were statistically significant ($p<0.05$).

Conclusion: Within the limitations of this study, it was concluded that the use of tulle for the reinforcement of maxillofacial silicone elastomer provided the latter with improved mechanical properties, especially in terms of tear resistance. However, these results should be further supported with more clinical studies.

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INTRODUCTION

Maxillofacial materials are used to replace missing facial parts which have been lost through disease or trauma. They are usually comprised of poly (dimethylsiloxane) (PDMS) elastomers. Although widely used, these materials are far from ideal. The quality of thesematerials depends greatly on their two basic components, the PDMS chains and the silica fillers, and the interactions between these affects the overall strength and service life of the material.

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Important properties essential in a material used for the construction of maxillofacial prostheses are high tear strength, low hardness and a low enough viscosity to make manipulation of the uncured material manageable (Chalian *et al*., 1974; Conroy *et al*., 1979; Roberts *et al*., 1971 and Wolfaardt *et al*., 1985). The mechanical properties of a silicone elastomer are dependent on many factors. An important one of these is the molecular weight distribution which affects the mechanical properties of the elastomer. The blending of long and short chains of the same polymer gives a broader, bimodal molecular weight distribution, and a network prepared from such a blend is known as a bimodal network (Shah *et al*., 1996). The practical significance of such networks is to achieve elastomers possessing a combination of good mechanical properties such as tear strength, tensile behavior and resilience (Bhowmick *et al*., 1988; Mark, 1994 and Shah, 1990). The quality of these materials depends greatly on their two basic components, the PDMS chains and the silica fillers, and the interactions between these two components affects the overall strength and service life of the material. The following physical properties are essential in a material used for the construction of maxillofacial prostheses: (Chalian *et al*., 1974; Conroy *et al*., 1979; Roberts *et al*., 1971 and Wolfaardt, 1985), Clinically the most important physical property isthe tear strength of the material. The tearstrength of a PDMS maxillofacial material is extremely important particularly at the thin margins surrounding nasal and eye prostheses. This thin margin helps to mask the presence of a facial prosthesis to the surrounding facial tissue. The thin margins of the prosthesis is usually glued with medical adhesive to the patients face. When the facial prosthesis is removed, usually at night time or for cleaning, the thin margins are susceptible to tearing as the prosthesis is gently peeled away from the facial tissue. The facial prosthesis is then permanently damaged and hasto be replaced. Therefore it is important that a material with a high resistance to tearing is used to construct these prostheses. The tensile strength of the silicone elastomer gives an overall strength of the material and the resulting elongation gives an indication of the flexibility of the prosthesis. A prosthesis with a high elongation at break is desirable especially when peeling a nasal or eye prostheses from facial tissue. The hardness of the maxillofacial material is also a measure of flexibility and is important since it is desirable to have a material with similar hardness to the missing facial tissue.

This study was carried out with the Objective to studyEffect of Different Concentrations of Titanium Dioxide Nanoparticles on The Mechanical Properties of A Maxillofacial Silicone Elastomer.

MATERIALS AND METHODS

The study was conducted using commercially available silicone elastomer used for the fabrication of maxillofacial prosthesis and UV shielding Titanium di-oxide nano- oxide particles. Various amounts of TiO_2nano-oxide particles were added to the silicone elastomer: 0%, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%. These concentrations are within range of 0% to 3% according to the manufacturer of nano- oxides (Technovent Co., UK). Silicone elastomer without nano- oxide particles served as control group. A total of six experimental groups were created by combining silicone elastomer (Cosmesil M511) with Ti O_2nano- oxide particles.

All the specimens created were evaluated for Tensile strength, Tear strength and percentage elongation using universal testing machine and Hardness was calculated with Shore A durometer Fabrication of specimens: The specimens were fabricated and polymerized as follow: A dumbbell and trouser shaped metal die was fabricated according to ASTM specifications. Gypsum mold was made using the die, and specimens were made from it by conventional flasking technique. A ratio of 10 gm (part A) of silicone elastomer to 1gm catalyst (part B) (10:1 =11gm totally) were prepared and mixed with various concentrations of Ti O_2nano- oxide particles by weight until a homogenous color is obtained. Then the mix is poured into the molds premade to the specific dimensions required by ASTM specifications. The molds closed, and polymerized in a dry heat oven at 100 degree Celsius for 1hr. (According to ASTM specifications, Five dumbbell shaped specimens of each combination were made for tensile strength and elongation and trouser shaped specimens were made for testing tear strength and hardness).

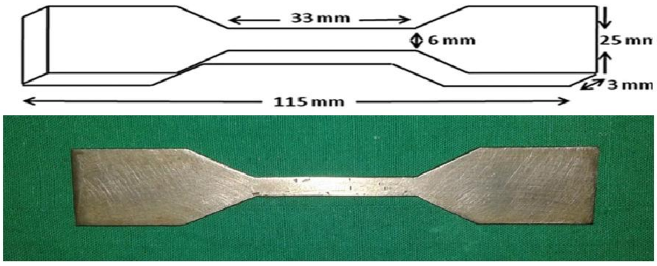

Figure 1. Dumbell shaped die according to ASTM specification

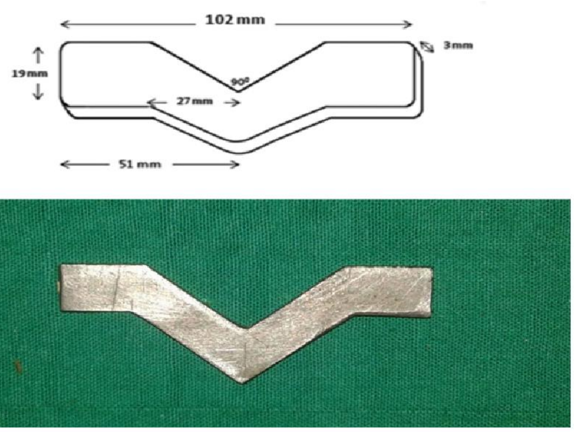

Figure 2. Trouser shaped die according to ASTM specification

Tensile strength: Dumbbell shaped specimens were made according to ASTM specifications for evaluating tensile strength.The thickness and width of each specimen was measured in different areas with digital vernier caliper and the average value was used in calculating the cross- sectional area of the specimens.Five specimens from each material were made and subjected to tensile strength. The testing was carried out on Tensile testing machine (DEBEL, Bangalore), fitted with 1000N load cell linked to an IBM compatible computer. The speed maintained in the machine was 20mm/min. The tensile strength was calculated automatically by the software using equation: Percentage Elongation: Stress (Nm-2) =Load / Initial cross sectional area It is measured from the start of separation to the point of fracture. Markings were made on specimens in its unstretched state, 25mm apart, equidistant from the center of the specimen, and perpendicular to its long axis. The distance between same markings is measured on specimen failure and percentage elongation calculated using following equation:

Percentage Strain (%) = (Extension / Original Length) X 100

Tear strength: Trouser shaped specimens were made for testing tear strength in the same manner as dumbbell shaped specimens were fabricated. The thickness of the specimen was measured in three different locations and the average was used in the calculations. Testing was carried out using Hounsfield testing machine (DEBEL, Bangalore), fitted with 1000N load cell. Specimens were tested at a constant crosshead speed of 20mm/min at a gauge length of 25mm. On failure of the specimen the computer software automatically calculated the tear resistance by using following equation: Ts= F/t

Where, Ts = Tear resistance (N/mm), F = Load at failure (N), t = Thickness of the specimen (mm).Hardness:For measuring hardness, two specimens were stacked on one another on a horizontal surface to obtain minimal of 6 mm thickness as required by ASTM D-2240. The Shore A durometer was held in a vertical position with the point of indenter atleast 0.5 inches from any specimen corner, then hardness was measured in three different locations and the average value was given as the hardness of that particular specimen.Statistical analysis was done using SPSS (Statistical Package for Social Sciences) software Version 20. One way analysis of variance (ANOVA) was used to test for any significant difference between the mean values of the materials tested. Post- test (Tukey post hoc) was used to determine whether the mean value of any particular material differed significantly from another specified material, while considering all the data.

RESULTS

The tensile strengths of nano-oxide elastomer groups in various concentrations are shown in Table 2.

Table 1. Ultimate Tensile Strength

	N	Mean	Std. Deviation	Std. Error
Control Group	10	3.7576	.06807	.02153
0.5% TiO2	10	3.8280	.09558	.03022
1% TiO2	10	4.0610	.06883	.02176
1.5% TiO2	10	4.4210	.05078	.01606
2% TiO2	10	4.7865	.04694	.01484
2.5% TiO2	10	5.0245	.04264	.01348
3% TiO2	10	4.0984	.06753	.02136
Total	70	4.2824	.45293	.05414

Table 2. Tear Strength

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
Control group	10	3.5002	.01811	.05726
TIO21	10	4.2855	.02420	.07651
TIO22	10	4.6525	.02502	.07911
TIO23	10	5.6763	.03526	.11152
TIO24	10	6.0038	.02594	.08204
TIO25	10	6.2561	.02985	.09440
TIO26	10	5.0689	.03190	.10089

Mean (SD) change values of tensile strength for Control Group, 0.5% TiO_2, 1% TiO_2, 1.5% TiO_2, 2% TiO_2, 2.5% TiO_2, 3% TiO_2 was 3.7576 ±.06807, 3.8280± .09558, 4.0610± .06883,4.4210± .05078, 4.7865± .04694, 5.0245± .04264, 4.0984±.06753, 4.2824± .45293. This observed difference was statistically significant ($p<0.005$).From the Above Table the Change in Tear Strengthwas for Control group, TIO21, TIO22, TIO23, TIO24, TIO25, TIO26 was 3.5002 ± .05726, 4.2855 ± .07651, 4.6525± .07911, 5.6763 ± .11152, 6.0038 ± .08204, 6.2561 ± .09440, 5.0689 ± .10089. Respectively, This observed difference was statistically significant ($p<0.05$).

From the below Table the Change in Tear Strengthwas for Control group, TIO_{21}, TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 528.8000±6.03324,518.5000±4.92725, 500.6000±10.52193, 476.7000±4.66786, 459.8000±7.40570, 442.4000±5.46097, 420.2000±6.25033 respectively and this observed difference is statistically significant ($p<0.05$)

Table 3. Percentage Elongation

	Statistic	Statistic	Std. Error	Statistic (SD)
Controlgroup	10	528.8000	1.90788	6.03324
TIO21	10	518.5000	1.55813	4.92725
TIO22	10	500.6000	3.32733	10.52193
TIO23	10	476.7000	1.47611	4.66786
TIO24	10	459.8000	2.34189	7.40570
TIO25	10	442.4000	1.72691	5.46097
TIO26	10	420.2000	1.97653	6.25033

Table 4. Shore A Hardness

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
Control group	10	34.8700	.12741	.40291
TIO21	10	35.8000	.20276	.64118
TIO22	10	37.0300	.23760	.75137
TIO23	10	38.1700	.11160	.35292
TIO24	10	40.0900	.13699	.43321
TIO25	10	41.5200	.14126	.44672
TIO26	10	41.6900	.08876	.28067

From the Above Table the Change in Tear Strengthwas for Control group, TIO_{21}, TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was34.8700±.40291, 35.8000±.64118, 37.0300±.75137, 38.1700±.35292, 40.0900±.43321, 41.5200±.44672, 41.6900± .28067 respectively and this observed difference is statistically significant ($p<0.05$).

DISCUSSION

Fabrication of a maxillofacial prosthesis is a time consuming, labour-intensive, and costly procedure. However, two common causes lead to maxillofacial prostheses requiring frequent replacement Tensile Strength, Tear Strength, Percentage Elongation, Shore AHardnessnamely colour fade and physical properties' degradation of the materials used. On the other hand, in practical clinical settings, patients have an unrealistically high expectation of their prosthesis longevity).
Currently, the most widely used material for maxillofacial prostheses is silicone elastomer; but still, this material is far from ideal. When a maxillofacial prosthesis degrades, two aspects are affected: mass and colour. In published literature to date, most of the researches focus on degradation related with colour change, with little research on the mechanical features. Silicone elastomers have been used for over 50 years to fabricate facial prostheses for individuals with facial defects resulting from resection, trauma, or congenital anomalies (Kiat-amnuay, 2005). Prostheses made from silicone elastomers may improve the quality of life of patients. Although silicone elastomers that may extend the service life of prostheses are available, poor tear resistance and staining remain significant problems (Dootz, 1994). Currently, the most favorable materials can, at best, remain esthetic and serviceable for only 1 to 2 years (Yu, 1981). Lewis and Castleberry (Lewis, 1980), published a review of materials research and tabulated processing and performance characteristics of an ideal material with high values of tensile strength, toughness, and tear strength, but with low values of hardness. Most maxillofacial elastomers perform well initially; however, as time passes, deteriorationassociated with either degradation of mechanical properties or changes in appearance occurs (Goldberg, 1978).

Considering the psychological and social effects on patients of the failure of maxillofacial prostheses, it is necessary to improve the mechanical properties and color stability of elastomers used for maxillofacial prostheses. In the past few decades, most material research in this area has focused on optimizing prostheses performance by improving the physical and mechanical properties of prosthesis material so that it more closely resembles human skin and has longer service life (Dootz, 1994; Polyzois, 1995), In our study we have found thatMean (SD) change values of tensile strength for Control Group, 0.5% TiO_2, 1% TiO_2, 1.5% TiO_2, 2% TiO_2, 2.5% TiO_2, 3% TiO_2 was 3.7576 ±.06807, 3.8280± .09558, 4.0610± .06883,4.4210± .05078, 4.7865± .04694, 5.0245± .04264, 4.0984±.06753, 4.2824± .45293 respectively.The Change in Tear Strengthwas for Control group, TIO_{21}, TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 3.5002 ± .05726, 4.2855 ± .07651, 4.6525 ± .07911, 5.6763 ± .11152, 6.0038 ± .08204, 6.2561 ± .09440, 5.0689 ± .10089 respectively. Change in Tear Strengthwas for Control group, TIO_{21}, TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 528.8000± 6.03324, 518.5000± 4.92725, 500.6000± 10.52193, 476.7000± 4.66786, 459.8000± 7.40570, 442.4000± 5.46097, 420.2000± 6.25033 respectively The Change in Tear Strengthwas for Control group, TIO_{21},TIO_{22}, TIO_{23}, TIO_{24}, TIO_{25}, TIO_{26} was 34.8700 ± .40291, 35.8000± .64118, 37.0300± .75137, 38.1700± .35292, 40.0900± .43321, 41.5200± .44672, 41.6900± .28067 Respectively and these observed differences were statistically significant ($p<0.05$). Use of TiO_2nano-oxide particles for the reinforcement of maxillofacial silicone elastomer provided the latter with improved mechanical properties, especially in terms of tear resistance. The findings are in confirmation with Kathryn Bellamy (Kathryn Bellamy, 2003), and Ying Han *et al*. (2008).

Conclusion

Within the limitations of this study, it was concluded that the use of TiO_2 nano-oxide particlesfor the reinforcement of maxillofacial silicone elastomer provided the latter with improved mechanical properties, especially in terms of tear resistance. However, these results should be further supported with more clinical studies.

REFERENCES

Bhowmick, A.K., Stephens, H.L. 1988. Editors. Handbook of elastomers; new developments and technology, Plastic Engineering Series.New York: Marcel Dekker.

Chalian, V.A., Philips, R.W. 1974. Materials in maxillofacial prosthetics. *J Biomed Mater Res Symp*, 5:349–63.

Chalian, V.A., Philips, R.W. 1974.Materials in maxillofacial prosthetics. *Journal of Biomedical Materials Research Symposium,* 5:349—63.

Conroy, B., Haylock, C., Hulterstrom, A.K., Pratt, G., Winter R.W. 1979. Report of a four year research and development programmeinvolving the Institute of Maxillofacial Technology and the University of Wales Institute of Science and Technology aimed at the production of a new facial prosthetic system. *Proc Inst Maxillofac Technol*., p. 218–45.

Conroy, B., Haylock, C., Hulterstrom, A.K., Pratt, G., Winter, R.W. 1979. Report of a four year research and development programmeinvolving the Institute of Maxillofacial Technology and the University of Wales Institute of Science and Technology aimed at the production of a new facial prosthetic system. *Proceedings Institute of Maxillofacial Technology,* 218—45.

Dootz, E.R. 1994. Koran A 3rd, Craig RG. Physical properties of three maxillofacial materialsas a function of accelerated aging.*J ProsthetDent.,*71:379-83.

Goldberg, A.J., Craig, R.G., Filisko, F.E. 1978. Polyurethane elastomers as maxillofacial prosthetic materials*. J Dent Res.,* 57:563-9.

Kathryn Bellamy, G. Limbert, Mark G. Watersa, J. Middleton. 2003. An elastomeric material for facial prostheses: synthesis, Experimental and numerical testing aspects. Biomaterials 24, 5061–5066.

Kiat-amnuay, S., Johnston, D.A., Powers, J.M, Jacob, RF. 2005. Color stability of dry earth pigmented maxillofacial silicone A-2186 subjected to microwave energy exposure. *J Prosthodont.*, 14:91-6.

Lewis, D.H., Castleberry, D.J. 1980. An assessment of recent advances in external maxillofacialmaterials.*J Prosthet Dent.,* ;43:426-32.

Mark, J.E. 1994. Elastomeric networks with a bimodal chain-length distribution. *Accounts Chem Res*., 27:271–8.

Polyzois GL. 1995. Evaluation of a new silicone elastomer for maxillofacial prostheses.*J Prosthodont*, 4:38-41.

Polyzois, G.L., Winter, R.W., Stafford, G.D. 1991. Boundary lubrication and maxillofacial prosthetic polydimethyls iloxanes. *Biomaterials.,*12:79—82.

Roberts, A.C. 1971. Silicones for facial prostheses.*Dent Practitioner,* 21:267–84.

Roberts, A.C. 1971. Silicones for facial prostheses. *Dental Practitioner*, 21:267—84.

Shah, G.B. 1990. Aspects of the polycondensation of hydrofunctionalpolydimethylsiloxanes.hDthesis, University of Wales College of Medicine, UK.

Shah, G.B., Winter, R.W. 1996. Effect of bimodality on tear properties of silicone networks. *Macromol Chem Phys.,* 197:2201–8.

Veres, E.M., Wolfaardt, J.F., Becker, P.J. 1990. An evaluation of the surface characteristics of a facial prosthetic elastomer. Part I: Review of the literature on the surface characteristics ofdental materials with maxillofacial prosthetic application. *Journal of Prosthetic Dentistry*, 63:193—7.

Veres, E.M., Wolfaardt, J.F., Becker, P.J. 1990. An evaluation of the surface characteristics of a facial prosthetic elastomer. Part II: the surface texture. *Journal of Prosthetic Dentistry*, 63:325—31.

Veres, E.M., Wolfaardt, J.F., Becker, P.J. 1990. An evaluation of the surface characteristics of a facial prosthetic elastomer. Part III: wettability and hardness. *Journal of Prosthetic Dentistry,* 63:466—71

Waters MGJ, Jagger RG, Winter RW. 1996. Effect of surface modified fillers on the water-absorption of a (RTV) silicone denture soft lining material. *Journal of Dentistry* 24:297—300.

Waters, M.G.J, Jagger, R.G., Polyzois, G.L. 1999. Wettability of silicone rubber maxillofacial prosthetic materials. *Journal of Prosthetic Dentistry,* 81:439—43.

Wolfaardt JF, Chandler HD, Smith BA. 1985. Mechanical properties of a new facial prosthetic material. *J Prosthet Dentist*, 53: 228–34.

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