Use of Glass Fibre Reinforced Epoxy in Artificial Teeth

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Abstract

Textile materials have found important non-traditional uses during the last decade. Medical textiles are one of the new emerging uses of technical textiles especially in denture. Glass, carbon, boron, and aramid fibres are being used to reinforce different types of matrix materials to gain some special properties for specific end use. In this work, multilayered glass fibre preform was used to reinforce epoxy resin and the produced composite was tested for some physical and mechanical properties. The results were then compared to those of the traditionally used materials in dentistry. The work had shown that the glass fibre reinforced epoxy polymer can be used in making artificial teeth in rather better properties compared to the now-a day used materials.

KEYWORDS: glass fibre, multi-layer composites, epoxy resin, hand-lay-up method, curing, artificial teeth, tensile and shear properties.

1. Introduction:

The field of medical textiles is becoming more important technology as a part of the general industrial textiles. Amongst different medical uses, textile materials are being widely used in the manufacturing of artificial teeth (John- Sakaguchi; 2005). The required properties of specific end use of textile composites can be acquired by structural modification since there is such a broad range of properties. The use of textile materials and their composites in implantation can be identified by structure, composition, surface behaviour, and degradability. A major concern with artificial implants is the reaction that a body will have towards the implant (Craig- Peton 2006).

Resin bonded glass fibre reinforced composite fixed dentures have been under development, but there is a lack of data regarding their usefulness (Vallittu- Sevelius 2000). Past research work suggested that the glass fibre reinforced resin may be an alternative for resin bonded fixed partial dentures (FDP) with a cost metal frame work (Izgi-Sakaguchi; 2011). Anusavicer *et al* (2007) determined the extent to which the mechanical and physical properties of the dental alloys and ceramics can predict the 5-year clinical performance of metal-ceramic and all-ceramic fixed dental prostheses (FDP)

Textile materials that are used in medical applications include fibres, yarns, fabrics, and their polymer reinforcements. Depending on each different application, their absorbency, tenacity, flexibility, softness, and at a time bio-stability are major concerns. Textile composites composite materials offer improved shear strength, damage tolerance, through-the-thickness properties, and structural integrity. Composites can be fabricated by many different methods. In this work, the hand-lay-up method was used to fabricate a multi-layered glass preform reinforced epoxy resin and the composite was tested for physical and mechanical properties. The results were then compared to the properties of

the traditional materials that are being used in making artificial teeth such as porcelain and acrylic.

2. Materials and testing methods:

Unidirectional aligned stitched glass filaments were cut into small pieces (20 cm×4 cm) and laminated to form a 1.32 mm thick laminate. A mixture of epoxy resin and methyl-ethylene ketone (in 4:1 ratio by weight) was applied thoroughly within the layers and on top of the whole laminate.

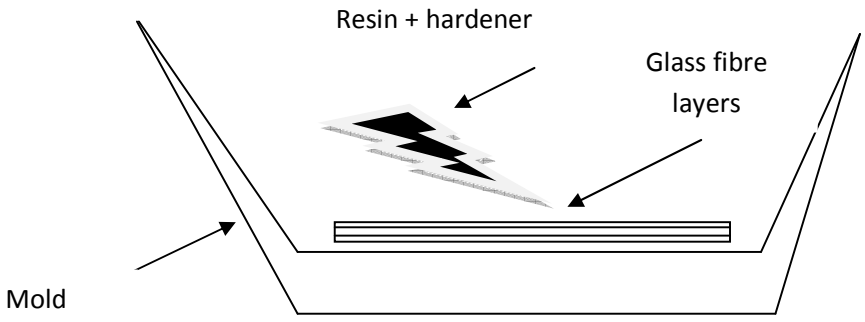

Figure 1: The hand lay-up method

The mixture was well distributed and squeezed to get rid of entrapped air. The hand lay-up method as shown in Figure 1 above was used to apply a pressure of 6 kg/cm^2 and the mold was kept for 24 hours at room temperature.
Curing and post-curing was done at 80^o C and 120 ^{o} C respectively for 2 hours each time. The basic data for the glass fibre filament used in this work is shown in Table I while Table II shows the data concerning the epoxy resin used.

Table I: Basic data for glass fibre filament

No.	property	value
1	Fibre diameter (µ)	9
2	Areal density (gm/m^2)	180
3	Density (gm/m^3)	2.54
4	Modulus (GPa)	72.4
5	Tensile elongation (%)	2.7

Table II: Basic data for epoxy resin

No.	property	value
1	Specific gravity	1.2
2	Tensile Modulus (GPa)	3.2
3	Tensile Strength (GPa)	85

The samples were then tested for their tensile strength, shear strength, and punch shear using the Universal Tensile Machine (UTM) {Hounsfield Tensometer).

2.1 Tensile strength test:

A necked-shape sample was prepared as shown in Figure 2 below. The tensile strength was determined by conducting the tension until the break point.

The following equation was used to calculate the tensile strength:

$$\sigma = F/A$$

σ is the tensile strength

F is the applied load

A is the cross-sectional area

But $A = b \times d$

where b is the width of the sample

and d is the thickness

The maximum loading capacity used in this test was 250 Kgs.

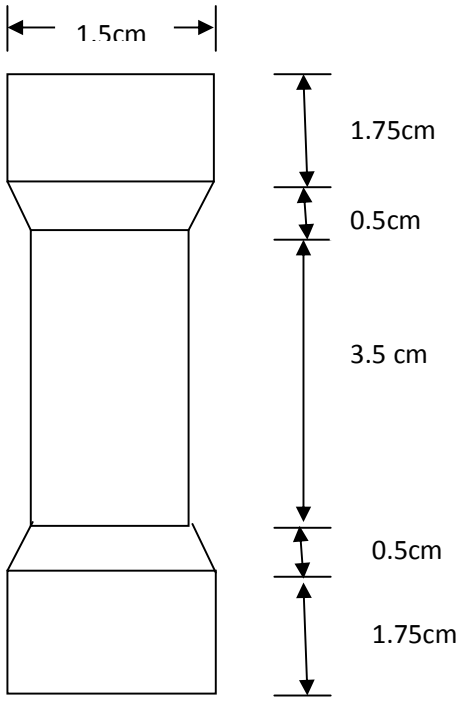

Figure 1: A necked-type specimen

2.2 Tensile shear and punch shear test:

The UTM was also used to test the specimen for the tensile and punch shear by measuring the transverse compression using the load beam with a maximum loading capacity of 500 Kgs.

3. Results and discussion:

The following table (Table No. 3) shows the average test results for different five samples for each test. In this table, properties for some other traditional materials used in artificial teeth, are also shown so that a comparison can be done easily.
The mainly used materials for replacement of degraded teeth are porcelain and acrylic. Other metallic materials are also being used but are expensive and their mechanical treatments are time consuming.

Table 3: Average test results for glass fibre epoxy composite

Property	Materials				
	Glass fibre epoxy composite	Gold alloy	Porcelain	Acrylic	Chromium-nickel cobalt
Tensile strength (MPa)	142	360	47	69	835
Shear strength (MPa)	39	-	-	62	-
Punch shear strength (MPa)	268	-	400	124	-
Elongation (%)	1.7	2	-	4.2	1.9

The moderate tensile strength was owned by the glass fibre reinforced epoxy. However, it has got better values compared to the mainly used materials, so it can be used in fabrication of artificial teeth. The low shear stress of the glass reinforced epoxy compared to acrylic and porcelain is due to in-plane delamination since the preform constitutes many layers. Nevertheless, this low shear stress has the advantage of preventing brittleness which causes edge fragmentation and breakage. This is mainly resulting from the low elongation owned by glass fibre the reinforced epoxy as shown in Table 3 above. Dealing with the punch shear stress and comparing it to the values in Table 3, the glass fibre reinforced epoxy has better punch stress than that of the acrylic which is soft and lower value than that of porcelain which is hard and brittle. From these results and in general, glass fibre reinforced epoxy with its reasonable results owned has better characteristics regarding the tensile strength than acrylic and porcelain. The alloys showed far better tensile strength values but they are not widely used because of their high expenses.

3. Conclusion:

This work had shown clearly that glass fibre reinforced epoxy resin composite materials can replace both porcelain and acrylic in artificial teeth fabrication. They are hard and tough enough to do so, as well, they are not susceptible to fragmentation and wear. They also resist cracking and edge fracture with time.

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