Influence of water absorption on fatigue behavior for chopped and woven-glass-fibers-reinforced PMMA denture

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Abstract

The influence of fiber orientation and water absorption on fatigue crack growth resistance for cold cure acrylic (PMMA) reinforced by chopped and woven -glass-fibers were investigated. A weight of 2 g for chopped fibers and the same weight for woven -glass-fibers (one layer) were used to prepare samples. Some of these samples would storage in dry condition; the others were immersed in water for 15 days. Fatigue test was carried out. The results shows that, for PMMA, the initial bending stress for dry specimen was 3.392 N/cm^2 and the number of cycles were 1364, the initial bending stress for wet samples was 4.20 N/cm^2, and the number of cycles was 2411. The samples would cut in two pieces because of the cracks would propagated fast during the test. Reinforcement PMMA with different kinds of glass fibers would increase the initial bending stresses for all specimens. The cracks would appear slowly during the test, and the specimens will not separate during the test except the samples which reinforced by Woven-Glass-Fibers.

Key words
water absorption, Fatigue, Denture

Article info
Received: Feb. 2011
Accepted: Oct. 2011
Published: Dec. 2011

تأثير امتصاصية الماء على خصائص الكلل للألياف الزجاجية نوع الحصيرة والعشوائي المسلحة بالبولي مثيل ميثا أكريليت

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الخلاصة:

تم دراسة تأثير اتجاهية الليف وامتصاصية الماء على ممانعة نمو الشق في فحص الكلل لعينات من الاكريليك البارد التقسية والمسلح بالالياف الزجاجية نوع الحصيرة والعشوائي . تم وزن ٢ غم من الالياف العشوائية والحصيرة (كطبقة واحدة) ، تم خزن هذه النماذج في الظروف الجافة ثم غمرت في الماء لمدة ١٥ يوم .

اظهرت النتائج ان متانة الانحناء الابتدائي للعينات الجافة كان بحدود ٣,٣٩٢ نيوتن / سم^2 وللعينات الرطبة بحدود ٤,٢ نيوتن / سم^2 و ان عدد الدورات بحدود ١٣٦٤ للعينات الجافة و٢٤١١ للعينات الرطبة ، كذلك لوحظ انكسار العينات بسبب انتشار الشقوق داخلها كما ان التسليح يزيد من متانة الانحناء الابتدائي لكل العينات حيث ان انتشار الشقوق يكون ببطئ بالنسبة للعينات المسلحة بنوع الحصيرة.

1-Introduction

PMMA has been the most popular material for construction of dentures since the 1930's because of its advantages including good aesthetics, accurate fit, stability in the oral environment, easy laboratory and clinical manipulation and inexpensive equipments. However, its fracture resistance is not satisfactory. According

to a survey 68% of dentures had broken within 3 years of their provision. Most of the fractures had occurred in the mouth whilst chewing and majority of dentures were made of acrylic resin while some had some form of strengtheners [1, 2].

Fiber-reinforced composites (FRC) have been tested as dental materials, and their use in dental applications is growing and includes their use in complete dentures, removable partial dentures, and fixed partial dentures.

These include fiber volume fraction, fiber adhesion to the resin matrix, and fiber orientation. Although a lot is known about the properties of FRC itself [3].

The interface between fibers and the acrylic resin matrix is considered to be an important factor in the reinforcement, and the microscopic surface structure may play a key role in the effectiveness of this reinforcement. Adequate adhesion of the fibers to the polymer matrix is one of the most important factors for strength.

The aim of this work was to study the effect of fiber orientation and content on the fatigue behavior of PMMA denture.

2-Experimental Part

2-1 samples preparation

1- A clean container was used to mix 5 g. of cold cure acrylic resin with 5 g. of methyl metha acrylate from (Marlic Medical Industries Co.) to prepare pure PMMA based denture.

2- One layer of woven – glass fiber was used to prepare samples of PMMA reinforced with glass fiber by using hand lay –up method.

3- The third group of samples were chopped glass fiber of g weight was used to prepare samples of PMMA reinforced with chopped glass fiber.

The samples were classified into two groups, the 1st group was immerced in water for 20 days, the data were recorded every day to evaluate the weight gain for the immersed samples, and the 2nd group was kept in dry condition at room temperature.

2-2 Fatigue test

Samples were tested with fatigue apparatus type (SCHENCK) with frequency equal to 15 Hz.

3-Results and Discussion

For un-reinforced PMMA , the initial bending stress for dry specimen was 3.392 N/cm^2 and the number of cycles were 1364 , the initial bending stress for wet samples was 4.20 N/cm^2 ,and the number of cycles were 2411 ,Table (1) , its mean that the water will enhance the fatigue properties of PMMA. The reinforced PMMA with glass fiber will increase the initial bending stress for all specimens, because water has polar dipole when these molecule were diffused into PMMA , the polar dipole will act as electrostatic force between polymer back bone chains, so that the polymers become more strength [6,7] .

The increasing in cycles for dry PMMA according to lubricated process , i.e., the water molecules will locate between the chains of PMMA, so that when the specimens was tested under different cycles bending stress, the molecules for polymer will have more freedom for movement , beside , water will softening the PMMA .The reinforced PMMA with chopped and woven glass fiber will increase the initial bending stresses for all reinforced specimens , Table (2).The maximum value for initial bending stress was observed at 2g of chopped glass fiber, this mean that , chopped fibers will distributed randomly in all of areas for these specimens , so that , the fibers will increase the strength of PMMA .The increasing in the number of cycles also observed for the reinforced PMMA because fibers will restricted the propagation of cracks , which were initiated at the end of fibers.

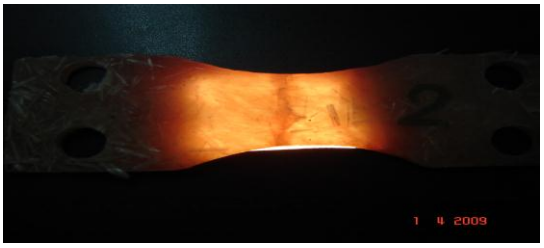
For PMMA reinforced with woven fibers, the initial bending stress and the number of cycles will decrease, because,in woven glass fibers reinforced with PMMA , the woven fiber will located at the middle of specimen, Fig(1),

so that two separated regions will occur (i.e. upper region and lower region).The woven fiber will prevent the PMMA from penetrating between up and down regions, so that , interface laminate will be form and reduce the adhesion forces, Table (3).

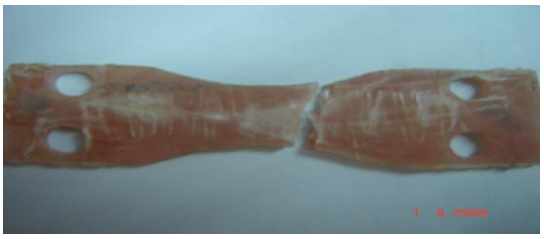
The photographic pictures for dry and wet PMMA , shows that the specimen will cut into two pieces , as shown in Fig(1) , while for PMMA reinforced with chopped glass fiber , the picture shows that there are cracks propagated in the middle of samples and no separation for these specimen will occur ,Fig(2,3).For dry PMMA reinforced with one layer of woven roving glass fiber ,the sample will not be separated and only cracks will be seen, Fig(4), in wet sample of PMMA reinforced with one layer of woven roving glass fiber , the specimen will cut into two pieces , because the water will diffuse in the interface between fiber and matrix, so that debonding process will occurred, Fig(5).

Fig(1): Photographic pictures for pure PMMA

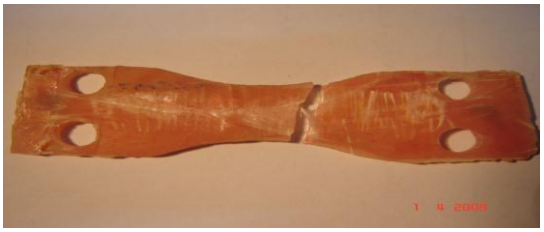
Fig(2): Photographic pictures for wet PMMA reinforced with chopped glass fiber



Fig(3): Photographic pictures for dry PMMA reinforced with chopped glass fiber



Fig(4): Photographic pictures for wet PMMA reinforced with woven glass fiber



Fig(5): Photographic pictures for dry PMMA reinforced with woven glass fiber

Table (1): The initial bending stress and Number of Cycles for Pure PMMA

Pure PMMA	Initial bending stress (N/cm^2)	No. of cycles
Dry samples	3.392	1364
immersed in water	4.206	2411

Table (2): The initial bending stress and Number of Cycles for PMMA reinforced with 2g of chopped glass fiber

a-Dry samples

bending stress (N/cm^2)	No. of cycles
61.9	0
40.476	1472
19.047	3378

b- Immersed in water

bending stress (N/cm^2)	No. of cycles
20.238	0
14.285	3102
11.904	3855
8.333	7125

Table (3):The initial bending stress and Number of Cycles for PMMA reinforced with one layer of woven glass fiber

a-Dry samples

bending stress (N/cm^2)	No. of cycles
16.66	0
13.09	6
11.904	78
5.952	747
4.761	990

b- Immersed in water

bending stress (N/cm^2)	No. of cycles
13.09	0
11.904	39
7.142	180
4.761	3118
2.38	3866

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