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Evaluation Of Compressive Strength & Surface Roughness Of Type IV Gypsum Products By Adding Additives And Subjected To Air Drying And Microwave Drying

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Abstract

Introduction

Type IV Gypsum product is used in dentistry for making dies & study models for indirect for making dies & study models for indirect restorations. A die is a working replica of a single tooth. By adding additives to die stone, its mechanical properties can be altered. The current study was conducted to assess the effects of

adding additives and drying method on compressive strength & surface roughness. properties can be altered. The current study was conducted to assess the effects of adding additives and drying method on compressive strength & surface roughness.

Aim & Objective

The aim of this study is to evaluate the compressive strength & surface roughness of type IV gypsum products by adding additives and subjected to air drying and microwave drying.

Material and Methods

A total 240 samples out of which control group are 60. Compressive strength & Surface roughness were assessed by adding additives such as Glass fibers, Cured resin & Nylon fibers by 1% wt. then subjected to air drying and microwave drying. Compressive strength testing was done by using universal testing machine and surface roughness testing was done by using profilometer on all samples.

Results

The results indicates that the compressive strength and surface roughness are significantly affected by the kind of additive and no significant differences were observed between the two drying methods. ($P < 0.01\%$)

Conclusion

Cured resin have less surface roughness and Glass fibers have more compressive strength. Keywords: Type IV Gypsum, nylon fibers, air drying, microwave drying, compressive strength, surface roughness.

Introduction

Gypsum products are used in several areas in the field of dentistry. These materials must possess high mechanical properties (i.e. high compressive strength) in order to withstand the force when used to be clinically useful. For example, die stones are mainly used for crown and bridge restoration. Gypsum products are also used in casting gold alloys and soldering. Gypsum products can be used as mould materials for fabrication of removable appliance [1, 2, 3]. Gypsum products are based chemically on calcium sulfate hemihydrate and be unique in nature [4].

For this reason, these materials can be modified by using chemicals or any other materials to improve the physical and mechanical properties. The addition of chemicals reduces the amount of water required when mixing leading to enhance the mechanical properties [5]. The strength of gypsum products can be affected by several factors including the water / powder ratio, additives, mixing time, etc [6, 7, 8]. For example, a large amount of water relative to the powder leads to poor compressive strength. In addition, the additives such as gum arabic, ferric oxide, calcium oxide, and calcium carbonate have significantly enhanced the compressive strength of gypsum products [9, 10, 11, 12, 13, 14].

Moreover, the pulverized stone and cured resin, which were considered as waste materials, can be used again to enhance the mechanical properties of improved dental stone [15]. Dental models must be completely dry before using by the dental technician. This process often takes a longer time. As a result, several techniques have been used to speed up the drying time. The study was to evaluate the incorporation of some additives (i.e. Cured resin, Glass fibres, and Nylon fibers) and drying method (air dried and microwave dried) on compressive strength and surface roughness of type IV dental stone. The null hypothesis imposed that there are no significant differences among all groups.

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Methodology

In the present study the metal molds are used with 40mm in length × 20mm in breadth, maintaining the length - breadth ratio recommended by ANSI/ADA No. 25 (Figure 1). The metal molds are used to obtain dies made by polyvinylsiloxane in which the samples are made with type IV dental stone (Figure 2). The samples are formed by mixing the type IV dental stone with glass fibres, cured resin, nylon fibres by 1% wt. the prepared samples are dried at room temperature and in microwave oven at 400 watt for 5 min. after the samples are prepared. A total of 240 samples were prepared i.e., total of 120 samples were divided for each group which contains 15 samples (Glass fibers, Nylon fibers and Cured resin groups and Control group) for compressive strength measuring i.e. for air drying and microwave drying. The other 120 samples were prepared for surface roughness and were divided for each group.

Drying Method

For air drying technique, 120 samples were left in air for 24 hours before testing. For microwave drying, the other 120 samples were placed after thirty minutes from mixing and kept inside a microwave. In the present study, a low power of 400 Watts for 5 minutes was carried out as high power might generate more heat causing water loss, and subsequently drying of samples. Following that, all samples were ready for testing. These samples are the tested for Surface roughness by using Profilometer (Figure 3) and Compressive strength is tested by using Universal Testing Machine (Figure 4).

Compressive Strength Test

The Compressive strength test was carried out on all specimens using a Universal Testing Machine (Instron). The load was applied on each specimen with a constant speed of 0.5 mm/min until fracture. By the following formula: compressive strength = load (g) / surface area ($3.14cm^2$), the resultant values represented the compressive strength. (Gram / cm^2 = MPA).

Surface Roughness Test

A Stylus based Profilometer was used for testing the surface roughness of the samples. A diamond stylus is moved vertically in contact with a sample and then moved laterally across the sample for a specified distance and specified contact force. A Profilometer can measure small surface variations in vertical stylus displacement as a function of position. A typical Profilometer can measure small vertical features ranging in height from 10 nanometers to 1 millimeter. The height position of the diamond stylus generates an analog signal which is converted into a digital signal, stored, analyzed, and displayed. The radius of diamond stylus ranges from 20 nanometers to 50 micrometers, and the horizontal resolution is controlled by the scan speed and data signal sampling rate. The stylus tracking force can range from less than 1 to 50 milligrams.

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Results

	Group	Materials	Mean	SD	t-value	P-value
Compressive strength	Glass fibers	Air drying	85.21	4.48	0.56	0.58
		Microwave drying	84.27	4.76		
	Cured resin	Air drying	76.43	4.91	0.02	0.99
		Microwave drying	76.46	5.51		
	Nylon fibers	Air drying	61.77	4.78	0.04	0.97
		Microwave drying	61.86	7.00		
	Control	Air drying	68.39	2.68	0.37	0.72
		Microwave drying	68.76	2.85		

Table 1: Mean and Standard deviation for all study groups (Compressive strength)

	Group	Materials	Mean	SD	t-value	P-value
Surface roughness	Glass fibres	Airdrying	1.80	0.07	0.03	0.06
		Microwave drying	1.86	0.10		
	Cured resin	Airdrying	1.19	0.15	0.83	0.72
		Microwave drying	1.22	0.16		
	Nylon fibres	Airdrying	1.82	0.08	0.71	0.06
		Microwave drying	1.90	0.08		
	Control	Airdrying	1.10	0.12	0.23	0.29
		Microwave drying	1.14	0.09		

Table 2: Mean and Standard deviation for all study groups (Surface roughness)

	Groups	Air drying		Microwave drying	
		Mean	SD	Mean	SD
Compressive strength	Glass fibers	85.21	4.48	84.27	4.76
	Cured resin	76.43	4.91	76.46	5.51
	Nylon fibers	61.77	4.78	61.86	7.00
	Control	68.39	2.68	68.76	2.85
	P-value	**<0.01***		**<0.01***	

Table 3: Comparision between Compressive strength values of three groups of additives in type IV dental stone for air drying and microwave drying.

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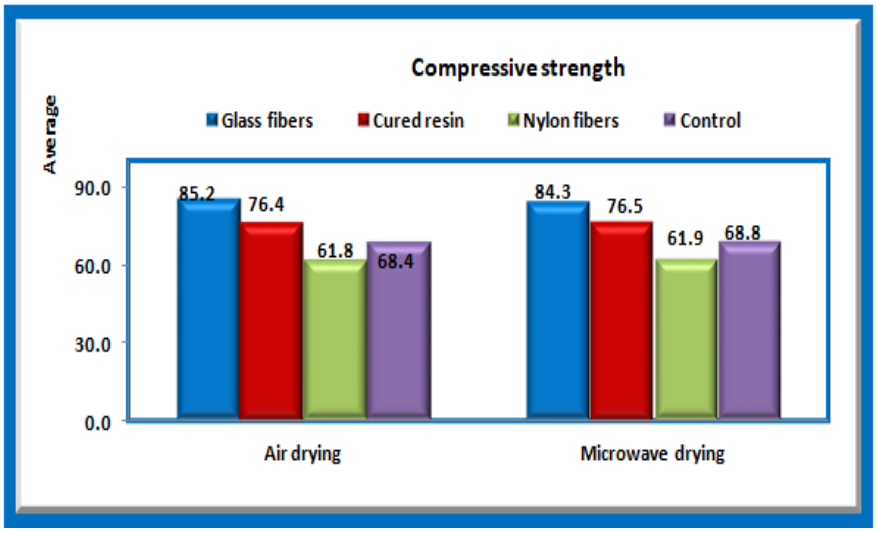
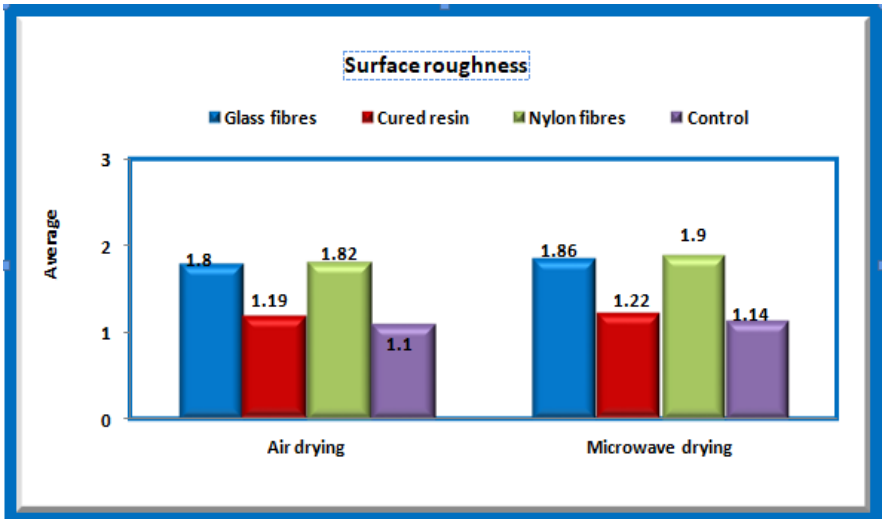
	Groups	Airdrying		Microwave drying	
		Mean	SD	Mean	SD
Surface roughness	Glass fibres	1.80	0.07	1.86	0.10
	Cured resin	1.19	0.15	1.22	0.16
	Nylon fibres	1.82	0.08	1.90	0.08
	Control	1.10	0.12	1.14	0.09
	P-value	<0.01*		<0.01*	

Table 4: Comparision between Surface roughness values of three groups of additives in type IV dental stone for air drying and microwave drying.



Graph 1: Comparision between Compressive strength values of three groups of additives in type IV dental stone for air drying and microwave drying.



Graph 2: Comparision between Surface roughness values of three groups ofadditives in type IV dental stone for air drying and microwave drying.

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After testing, the mean Compressive strength for the control group is about 68.4Mpa for air dried samples and 68.8mpa for microwave dried samples. The samples with Glass fibers, Cured resin, Nylon fibers have the mean Compressive strength of about 85.2Mpa, 76.4Mpa, 61.8Mpa respectively for air dried and 84.3Mpa, 76.5Mpa, 61.9Mpa respectively for microwave dried samples. The Compressive strength is increased for Glass fibres and Cured resin incorporated type IV dental stone (Table 1 & 3 and Graph 1).

After testing the mean Surface roughness for the control group is about 1.1Ra for air dried and 1.14Ra for microwave dried samples. The samples with Glass fibers, Cured resin, Nylon fibers have the mean surface roughness of about 1.8Ra, 1.19Ra, 1.82Ra respectively for air dried and 1.86Ra, 1.22Ra, 1.9Ra respectively for microwave dried samples. The Surface roughness is increased for all but for cured resin it is relatively low than others (Table 2 & 4 and Graph 2). The microwave oven drying is not negatively influenced the Compressive strength and Surface roughness of type IV dental stone.

The results of the study indicated that the Compressive strength was significantly affected by the kind of additive utilized & there was a significant increase in the values of mean Compressive strength for Cured resin, Glass fiber specimens compared with control group and decrease in the Nylon fibers when compared with the control group. The Surface roughness was significantly low for specimens with Cured resin than the specimens with Glass fibers and Nylon fibers. For drying method, the independent T test confirmed statistically no significant differences were observed between the two drying methods ($P>0.01$).

Discussion

Various studies have been conducted on Gypsum products to enhance their mechanical properties. The incorporation of various additives (i.e. gum arabic, calcium oxide, etc) could decrease the amount of water when mixing leading to improve the mechanical properties of Gypsum products [16, 17]. In the current study Glass fibers, Cured resin, Nylon fibers have been used to indicate whether there is an improvement in the mechanical properties of Gypsum products or not. According to the literature, the use of Glass fibers has a great influence on mechanical properties of Gypsum products [18]. In the current study, it was found that the use of Glass fibers has a significant effect on Compressive strength of Gypsum products than the other additives and the use of Cured resin has a less significant effect on Surface roughness than other additives (Table 1, 2, 3 & 4 and Graph 1 & 2). These results agrees with a study conducted by Vijayaraghavan et.al, [15] which confirmed that there is a significant improvement in the Compressive strength of all specimens after using Cured resin and Glass fibers. The Cured resin has the ability to reduce the brittleness and improve the scratches during the sculpting process. The use of cured resin at 1% by weight in this study as a greater concentration would reduce the setting time of hemihydrates [19]. On the other hand, that the use of Glass fibers gives a more dense arrangement of crystals leading to increased hardness and compressive strength [20].The use of Nylon fibers will create higher porosity or cavity between the matrixes which causes Compressive strength to decrease [21]. The Glass fibers and Nylon fibers are in a linear form and the Cured resin in a spherical form which shows less Surface roughness in Cured resin and more Surface roughness in the Glass Glass fibers and Nylon fibers.

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Regardless of the type of additive used, the current results are consistent with the study carried out by Hatem et.al, [9] which revealed that the use of calcium oxide and gum arabic enhanced reasonably the compressive strength of dental stone. Besides, the results of the study showed no significant difference between the two drying methods. The microwave specimens almost had the highest values. These findings are in accordance with Vijayaraghavan et.al, [15] which indicated no significant differences were observed between the methods of drying. The null hypothesis was refused since significant differences were observed among allgroups.

Conclusion

The following conclusions were drawn based on the results obtained in the in vitro study were:

1. The Glass fibers incorporated type IV Gypsum products have a more Compressive strength and the Cured resin incorporated type IV Gypsum products have less Surface roughness.

2. Drying the specimens in the microwave for 5 minutes can fasten the drying time and permit early manipulation of models

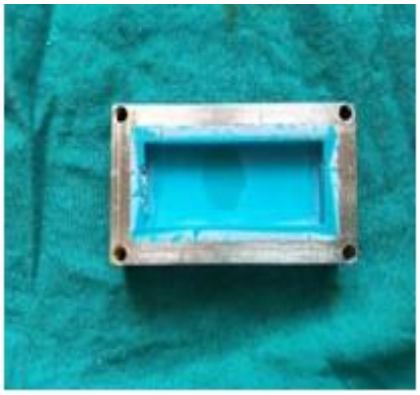

Figure 1: 40*20mm Mold acc. to ANSI / ADA No. 25

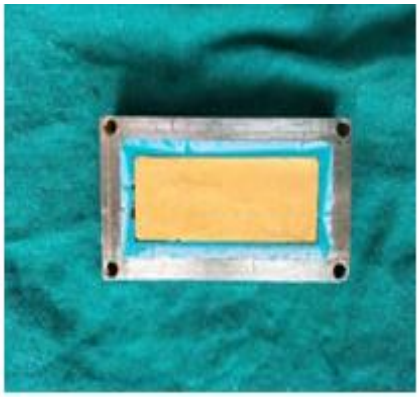

Figure 2: 40*20mm Moldwith type IV dental stone

Figure 3: Measuring surface roughness by using Profilometer

Figure 4: Measuring compressive strengthby using Universal Testing Machine

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