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RESEARCH ARTICLE - MEDICAL TECHNIQUES

Influence of Silver-Zinc Zeolite Incorporation on Shear Bond Strength of Silicon Cold Cure Soft Liner

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Abstract

Back ground: Reduction of a durable bond to acrylic denture base is the main problem associated with soft liner materials.
Purpose: Evaluation of the influence of addition of Ag-Zn Zeolite on shear bond strength of silicon cold cure soft liner.
Approach: thirty specimens of silicon cold cure soft liner were constructed for shear bond- strength test and divided into three groups: Control groups: 10 specimens without incorporation of Ag-Zn Zeolite, Experimental group: 10 specimens with 0.5% by weight of Ag-Zn Zeolite Experimental Group: 10 specimens with 0.75 %by weight of Ag-Zn Zeolite Plastic pattern of acrylic block with dimensions (75 mm length x 25mm width x 5mm depth)was fabricated and evaluated by Instron testing machine.
Results: Least significant difference of (0.75%) of Ag-Zn zeolite group was significantly different compared with the experimental group of (0.5% and control group) at $p<0.05$.
Conclusion: The incorporation of 0.5%, 0.75% by weight into silicon cold cure soft liner had significant effect and causes improvement in shear bond strength.

Keywords: Silver; Zinc;Zeolite; Shear bond; silicon.

1. Introduction

The resorption of alveolar bone might cause poor adaptation of the prosthesis that causes discomfort for patients. However, by relining of denture this poor adaptation can be solved [1]. Relining is the step applied to resurface of a removable prosthesis with new substance, thus provide a precise adaptation to foundation area of the denture [2]. A denture may be relined at the chair side in the clinic or as laboratory steps. The chair side relining with soft liner is applied extensively in prosthetic treatment because of simplicity of this technique, and well fitness of prosthesis. Liner materials have a key role in new prosthodontics. They act as a rest for the mucosa through redistribution of stress transmitted to the bearing areas of edentulous ridge. The ideal characteristics of soft liner include, lack of odor and taste, resilience material, tear resistance, biocompatibility, adhesive bond strength , ease of adjustability, color stability, low adsorption in saliva , dimensional stability and ease of cleaning [3]. Silicon long term denture lining materials are available as one component material that cross linked at high temperatures [4]. The lack of adhesion of cold cure silicon soft liner to the denture base is one of the important serious problems. The failure of adhesion between the silicone denture lining materials and base of denture is very common and causes the deboned regions, functional failure of the prosthesis, and accumulation of calculus, plaque and bacterial growth [5]. The activity of bacteria is responsible to form the biofilm growth and degradation of polymeric material inside the human body. The biofilm is created on the surface of the material, it is difficult to remove it either by antibiotic treatment or washing [6]. There are multiple solutions to promote the antimicrobial characteristic of polymeric materials e.g. silver containing or antibiotics coatings [7]. The antimicrobial agent was added to materials as part of a current trend. Among the advantages of this procedure is the possibility of eluting the factors from the base of materials, thus stopping yeast, fungal and bacterial contamination. The Zeolites have been added to serve such objective. This study was designed to evaluate the influence of incorporation of Silver-Zinc Zeolite on shear strength of silicon cold cure soft liner.

2. Materials and Methods

2.1. Preparation of Ag-Zn Zeolite

Quantities are prepared for Zinc acetate (Zn), Silver acetate (Ag) and Zeolite 13X, (Fluka, Swiss) which were selected by molar mass for each compound. By using ion exchange method in water phase [8]. The ion exchange was obtained by connecting the amount from zeolite and amount of metals solution for interval of time range (2- 48) hours at stability temperature. highly deionized water (500 ml) was placed in a conical flask, then 25gm of Zn^{2+} acetate was added, Magnetic mixing capsule was used inside conical flask placed on magnetic stirring hot plate .After Zn^{2+} acetate was dissolved in highly deionized water , A 2.5 gm of Ag^{+} acetate was added ,the mixture of metals solution covered by aluminum foil to avoid light exposure, after that (50) gm. of rods Zeolite was added to the metals solution of ions (Zn^{2+}, Ag^{+}), that set it in thermostat horizontal shaker with 80 rpm at $25C^{O}$ for two hours. The vacuum filtration was used to filter the mixture, vacuum oven indicated to dry at 65 C^{O} overnight. The Planetary Ball Milling used for crushing Ag-Zn Zeolite into powder with average particle size (0.5-1µ) [9].

2.2. Ag-Zn Zeolite characterization

Fourier transform Infrared spectroscopy (FTIR, Bruker, Germany): It is indicated to identify the functional groups of materials. The FTIR is applied to determine chemical properties and changes in the surface [10]. FTIR spectra of the untreated surface of cold cure silicon (Mollosil, Detax, Germany) and experimental specimens was gained by placing the surface to be analyzed on the diamond crystal. FTIR spectrum was taken by scrapping a small amount from the cold cure silicon specimens (control and experimental) and mixing with potassium bromide (KBr) salt, pressing as a disk by using a mini hand press (MHP-1 SHIMADZU), Potassium Bromide salt was used for aiding in transmission of IR rays through the specimens [11].

2.3. Samples grouping

Thirty specimens of cold cure silicon soft liner (Mollosil, Detax, Germany) were prepared for shear bond test and divided according to the incorporation of Ag-Zn zeolite as follows: -

1. Control Group: 10 specimens without incorporation of Ag-Zn Zeolite
2. Experimental Group (0.5%): 10 specimens with 0.5% by weight of Ag-Zn zeolite.
3. Experimental Group (0.75%):10 specimens with 0.75% by weight of Ag-Zn zeolite

Incorporation of Ag-Zn zeolite into cold cure silicon soft liner: The concentration of 0.5% and 0.75% by weight of Ag-Zn zeolite were depended in this study [12] and incorporated in cold cure silicon, therefore we should know the specific gravity of the silicone cold cure and convert the volume to weight according to the formula:

(Mass= density x volume)

The density of cold soft silicon liner is 1 g\ml. The volume of the sample Prepared for this study is 3ml. according to the equation the mass was calculated as follows:

Weight specimens of cold cure silicon $3 \times 1 = 3$ g

So the weight of powder: $3 \times 0.5/100 = 0.015$ g

The weight of powder: $3 \times 0.75\% = 0.022$g

2.4. Specimens design:

2.4.1. Proportioning and mixing a of heat cure acrylic resin

The plastic pattern of acrylic block was constructed with dimension of (75mm length × 25mm width× 5 mm depth). The handle thickness of acrylic block is [13mm]. Fig 1. According to instructions of manufacturer's, 2.2g of powder and 1ml of liquid monomer were mixed. [13]. Then, finishing of acrylic block was done by using the stone, acrylic burs followed by sand papers, polishing were done as conventional method. All samples were stored in distilled water at ($37C^{O}$) for two days [14]. One of the heat cure acrylic block was placed over the other block leaving space with dimensions (25mm length × 25mm width × 3mm depth), with stopper about 3mm depth which was filled with wax, After wax elimination , the space of stopper filled with cold cure silicon soft liner [15].

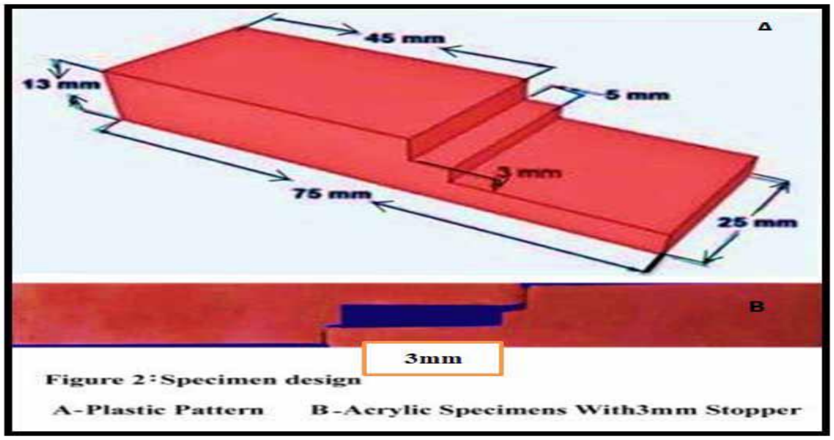

Fig.1. Speciemen for shear bond test

2.4.2. Mixing of cold cured silicone -based soft liner material

In control specimens equal quantity catalyst and base were mixed until obtaining a uniform mixture (30 seconds) then placed in the gap between the two acrylic blocks ,any excess material removed ,then specimens were placed under weight of 2 kg for stability and left till complete setting of silicon for (5min) [16] ,while in experimental specimens mixing of paste ,catalyst and Ag-Zn Zeolite according to table 1 the Ag-Zn zeolite was added to catalyst paste, manually mixed for 3 minutes by the same operator on the mixing paper pad [12] and complete the same steps with control specimens. After complete setting, the specimens was stored in distilled water in a container at 37 C^{O} for 24 hour [17].

Table 1. Amount of base and catalyst paste of silver-zinc zeolite

Type soft liner materials	Incorporation of Ag Zn zeolite concentration	Amount of incorporation of Ag Zn Zeolite	Quntityof base(gm)	Quantity of catalyst(gm)
cold cure Silicon	0%	0	1.5 g	1.5 g
	0.5%	0.015 g	1.5 g	1.5g
	0.75%	0.022g	1.5 g	1.5g

2.5 Testing procedure

The Instron testing device with a suitable grips was used for testing specimens. All specimens subjected at load cell capacity of (100Kg) and speed equal to 0.5mm/min until fracture occurred. The maximum load demand for the failure was recorded. The shear bond strength value for all specimens were measured according to formula [18].

Bond- strength (N/mm^2) = (maximum load / cross section area) = F /A

3. Results

3.1. Fourier transfer infrared spectroscopy (FTIR)

The FTIR spectrum of control cold cure silicon group (CCS) revealed the characteristic band which are SI-SI represented by the peak at 601-661 cm-1 ,SI-C represent by the peak at 700-786,SI-O-SI represented by the peak 1009-1258,CH3 peak at 1412-1538,at range from 3000-2500 for SI-OH and H-O-H at peak 2962.59 as in Fig 2 A. After incorporation of Ag-Zn zeolite as shown in (Fig 2-B) both spectra for cold cure silicon (control and experiment) are quite similar except for SI-O-SI and CH3 which has stretching for experimental specimens of cold cure silicon soft liner.

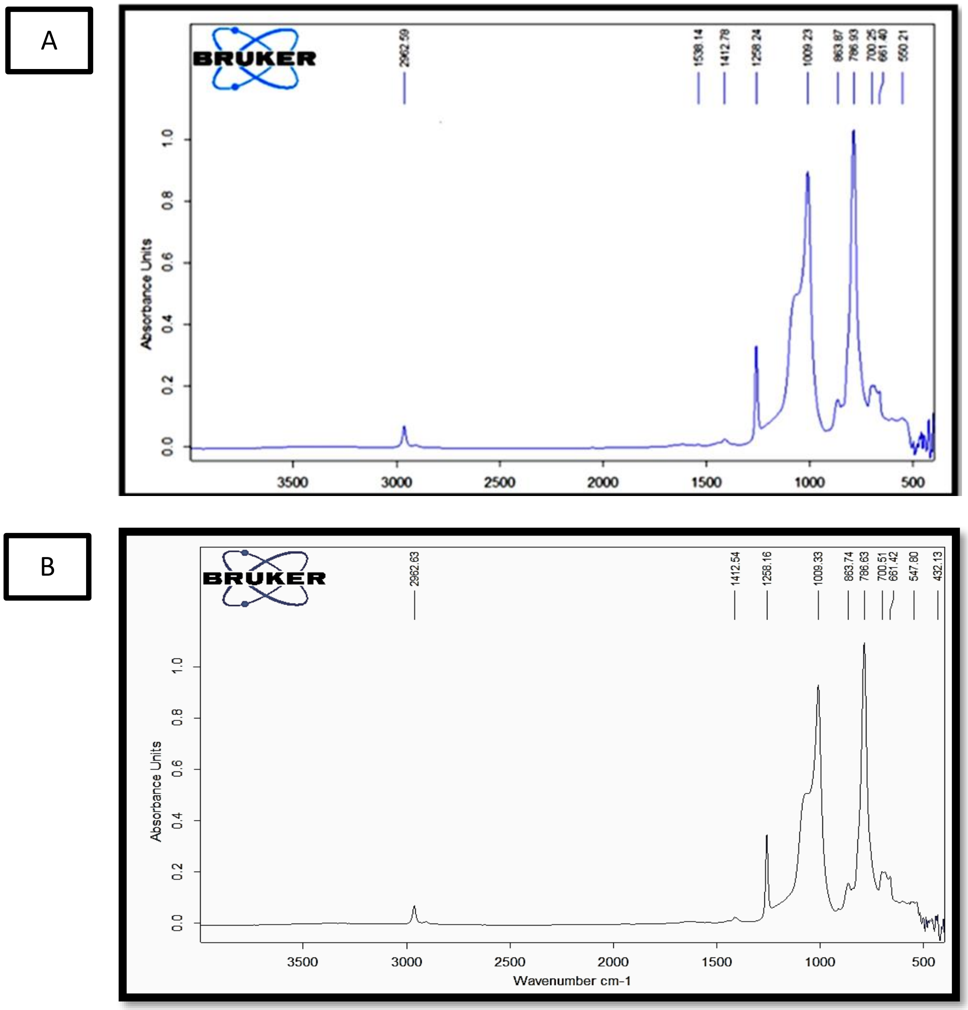

Fig. 2. FTIR: A- control specimens of silicon cold cure, B- FTIR of silicon cold cure after incorporation of Ag-Zn Zeolite

3.2. Statistical analysis

Shear bond strength:
A-As shown in table 2 the lowest mean value in control cold cure silicon (0.416±0.088). While the highest mean value is related to (Ag -Zn Zeolite 0.75 %) group (0.0484 ±0.048).
Result of the Leven test and One-Way ANOVA was non-significant difference at P>0.05 among studied groups.

B- The Least Significant Difference – LSD as in table 3) revealed that (Ag -Zn Zeolite of 0.75%) group was accounted significant- difference to that of control group at P<0.05, the (Ag -Zn Zeolite 0.5 %) group was accounted no significant difference to that of control group at p>0.05, while the comparison between (Ag-Zn 0.5 % and Ag -Zn Zeolite 0.75 %) was non-significant difference at P>0.05.

Table 2. Descriptive statistic and Testing Homogeneity of Variances (levene test) and ANOVA test of bond strength

Groups	NO	Mean	Std.d	Std.E	Min	Maxi	Leven	ANOVA
Control	10	0.416	0.088	0.028	0.352	0.585	2.801	2.427
Ag -Zn Zeolite 0.5 %	10	0.451	0.065	0.020	0.329	0.572		
Ag -Zn Zeolite 0.75 %	10	0.484	0.048	0.015	0.416	0.560	NS	NS

Table 3. LSD test among groups shear bond strength of cold cure silicon

Group	Group	Mean Diff. (I-J)	Sig.	C.S. (*)
control cold cure silicon	Ag -Zn Zeolite 0.5 %	-0.0342	0.276	NS
	Ag -Zn Zeolite 0.75 %	-0.0678	0.036	S
Ag -Zn Zeolite 0.5%	Ag -Zn Zeolite 0.75 %	-0.0336	0.285	NS

4. Discussion

Antimicrobial Zeolites are used as filler with dental materials to prevent contamination by yeast, bacteria and fungi also to estimate some mechanical and physical properties [19]. $Zn^{+2}$and Ag^{+} are used as a cation in the denture base material due to possessing strong antimicrobial activity. In this study, the result of (FTIR) for control and experimental specimens are quite similar except for SI-O-SI and CH_3 which has stretching vibrated band with experimental specimens due to the distribution and interaction between cold cure silicon and Ag-Zn Zeolite, this result could reveal that some properties of shear bond -strength of silicon cold cure was improved[8].
Evaluating the bond strength between base material and soft denture lining that subject to forces in clinical situation which is represented more closely by tear and shear forces [20]. The most common reason of failure in resilient lining material is separation of soft lining from base of denture [21]. Lack of adhesion creates an environment favorable to microorganisms. For silicon liner, the use of solvent seems to improve the adhesion to poly (MMA), So it favors to penetrate and create mechanical blockage [22].
The result showed a significant difference of experimental group(0.75%) of Ag-Zn zeolite compared with experimental group (0.5% and control group) as in tables (2 and 3) .The ability of high flow of soft liner used in this study is one of the important factor that get better bond strength, which allow the material to adjust easily to the bonding surface and supply well contact. Moreover, the dimension of specimens (25mm x25 mm) is considered large and may aid in the improvement of bonding strength. The zeolite was filling the spaces between soft liner that act as filler and lead to increase the surface area of lining material with denture base. The particle size (0.5-1um) of Ag-Zn leads to lock all voids and pores that appear in silicon cold cure and obvious in FTIR result. The result supported by FTIR showed the band of SI-O-SI and CH_3 has stretching for cold cure silicon with Ag-Zn zeolite due to the interaction and distribution between silicon cold cure and the Ag Zn zeolite [23].

5. Conclusion

1. Fourier Transform infrared spectrophotometer (FTIR) was a necessary way to appear the interaction between Ag-Zn zeolite and silicon cold cure.
2. The incorporation of 0.5% and 0.75% by weight in silicon cold cure had significant effect on shear bond strength and water sorption.

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