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Evaluation The Effect of Incorporation of Different Herbal Extract Powders (Either Neem or Aloe Vera) On Thermal Conductivity and Shear Bond Strength of Acrylic Soft Denture Liner Material

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Abstract

The main drawbacks of the soft liners were poor thermal conductivity and poor bonding between denture base and soft lining. The purpose of this study was to analysis the influence of incorporating either Neem or Aloe Vera on thermal conductivity and shear bond strength of heat cure acrylic soft liner. Sixty heat cure acrylic soft liner specimens were prepared and classified as two major groups based on tests that evaluated (thermal conductivity and shear bond strength), each major group sub classified for three groups based on incorporated material: The control group (10) specimens, (10) specimens with 10% by weight of Neem powder; (10) specimens with 10% by weight of Aloe Vera powder. Thermal conductivity specimens were fabrication with dimensions of (40 mm diameter × 2.5 mm thickness). Two acrylic block of shear bond strength specimens with dimensions (75mm × 25mm × 5 mm length, width, depth respectively) was fabrication. The reline material application on space between two acrylic blocks. The (Lee disc) equipment was used to assess thermal conductivity. With a crosshead speed of 0.5mm/min, a shear bond strength was measured. Data statically analyzed by One-way ANOVA and LSD tests. The results showed the Neem group had highest mean value of thermal conductivity and shear bond strength than aloe Vera and control groups at $p<0.01$. Either Neem or Aloe Vera increased thermal conductivity and shear bond strength of soft liner.

Introduction:

Soft polymers that could be adapted to the fitting or mucosal surface of hard dentures are called soft denture liners, soft denture liners serve a critical function in removable prosthodontics because of their capacity to provide a cushioning influence for maintaining the health of traumatized, swollen and damaged mucosa via absorption and fair redistribution of stresses over the whole area that covered by denture, thus eliminating the distortion of oral mucosa [(1)].

One of the major disadvantages of the heat acrylic soft liner was low thermal conductivity which was an important property of soft liner that effects on the acceptance of the patient to prosthesis. In addition, it has main impacts on health of underlying supporting tissues and salivary glands secretion especially parotid gland. In elder patients, high thermal conductivity of denture base material influence patient satisfaction, and better taste sensation, tissue preservation and reduce the feeling of denture as a foreign body so that several modifications have been done newly to overcome this problem and improve the thermal property[(2)]. The adhesive failure was one of the serious defects of the lining materials in clinical use and long-term bonding cannot be accomplished without avoiding leakage of fluids between the liner and denture base. This failure of bonding can also create a potential surface for microbial growth, and for the formation of plaque [(3)]. Soft liners have been used as carrier for antifungal drugs in treating denture stomatitis and in order to prevent infection by candida albicans [(4)]. Recently increased attention towards medicinal plants as new source of antifungal and antimicrobial agents, some herbal extracts addition to polymeric systems used as safe and effective therapeutic agents such as Neem, Aloe vera, tea and ginger plant extracts [(5)]. Neem (Azadirachta indica) was a source of medicinal tree from the Meliaceae family that was mostly cultivated in India. The Neem tree occurs throughout India, there are about 20 million trees in the country. The Neem leaves are used in the treatment of periodontitis. Oral odor, pain relief, tooth cleaning, as well as gingival bleeding, and plaque reduction are all uses for Neem twigs. Neem has antiviral, antifungal, antibacterial, antipyretic, anti-inflammatory, and antitumor properties [(6, 7)]. Aloe Vera was one of medicinal herbals extracted used in the therapeutic system by the Greeks as early as 400 B.C. and later by Arabian physicians. It was probably grown in all African countries, and it belongs to the Liliaceae family [(8, 9)]. Because it was analgesic, antibacterial, antiviral, antifungal, antioxidant immune modulating, antiseptic, anti-inflammatory properties, the aloe Vera (aloe barbadensis) powder was incorporated in polymeric systems [(10)]. This study is aimed to evaluate the influence of either Neem or Aloe Vera incorporated with soft lining material powder on thermal conductivity, and identify which material was the best appropriate material incorporated into heat cure acrylic soft liner material.

Materials and Methods:

Samples grouping

Sixty specimens of heat acrylic cure soft liner were prepared and classified into two major groups based on tests that evaluated (30 specimens for thermal conductivity and 30 specimens for shear bond strength), each major groups sub classified into three groups based on incorporated material as following:

Control group: 10 specimens without any incorporation.

Studied group: 10 specimens with incorporation 10% by weight of Neem powder.

Studied group: 10 specimens with incorporation 10% by weight of Aloe Vera powder.

Incorporation of either Neem or Aloe Vera powders into heat cures acrylic soft liner

The soft-liner specimens were attended according to manufacture instruction for mixing of heat acrylic soft lining material (P/L ratio: 1.2g of powder/1ml of liquid monomer). Either Neem powder (Davis finest company, India) or Aloe Vera powder (Mi nature company, India) with 10% by weight were incorporated into heat cures acrylic soft liner (Vertex). The weight of incorporation materials subtracted from the entire weight of soft liner powder to obtain the exact P/L ratio as follows:

1. Control group: 24g of powder, 20 ml of liquid.
2. Neem powder 10 % group: Neem powder (2.4 g), powder (21.6g), liquid (20 ml).
3. Aloe Vera powder 10 % group: Aloe vera powder (2.4 g), powder (21.6 g), liquid (20 ml).

Thermal conductivity test

Mold preparation

To preparation mold of thermal conductivity specimen usage plastic plate that cut into suitable shape using laser machine with the dimensions (40mm diameter × 2.5mm thickness), Fig. (1)[11, 12].

Specimen's preparation

After proportioning and mixing of either Neem or Aloe Vera powders with acrylic soft liner powder in the current research, all specimens were packed and cured according to manufacturer's instructions, then finished by using fine grit silicone polishing bur (China), and fine grit sand paper (China) with continual water cooling to counteract overheating and war-page, after that polishing was done as a conventional method. All specimens were stored in distilled water (Iraq) at 37°C for 48 hours [11].

Testing procedure

Testing procedure was done by using thermal conductivity apparatus (Lee disc), Fig. (2). Lee disc which consists of three copper discs (A, B and C) and it has a hole inside each disc to accept thermometers. The specimen was placed between copper disc A and B. Sixty watt electrical plate heater was sandwiched between discs (B and C). The power to the heater was switched on after tightening the clamp screw to hold all the discs together. The current (0.25 Ampere) and voltage (6 Volt) applied to the heater was monitored by using transformer, the temperature in disc (C, B) increase more than disc A after the heater switched on, because of the presence of specimen that act as an isolator. when temperature at disc C and B became equal and temperature of all parts of the apparatus had been stable to within $\pm$ 0.1°C for 30 minutes, the reading was recorded and thermal conductivity was calculated from the following equations [13, 14] :

$$e = \frac{I.V}{a_A T_A + as\frac{T_A + T_B}{2} + 2aH\frac{T_B + T_C}{2} + a_B T_B + a_C T_C} \quad (1)$$

e ***: Temperature loss per time in second***
I ***: The electric current via the heater (Ampere)***
V ***: The voltage within the heater (Volt)***
a_A, a_B, a_C ***: The surface area of disc A, B and C respectively in m^2***
as ***: The surface area of the specimen in m^2***
aH ***: The surface area of the heater in m^2***
T_A, T_B, T_C ***: The temperatures of discs A, B and C respectively in °C (degree centigrade).***
Can calculate the thermal conductivity after getting the value of (e) from the following equation:

$$K = \frac{ed}{2\pi r^2 (T_B - T_A)}\left[as\frac{T_A T_B}{2} + 2a_A T_A\right] \quad (2)$$

K ***: Thermal conductivity in w/m.°C***
d ***: The specimen thickness in m***
r ***: The specimen diameter in m***
T_A, T_B, T_C ***: The temperature in disc A, B and C measured in °C***
as ***: The surface area of specimen in m^2***
a_A ***: The surface area of disc A in m^2.***

Shear bond strength test

To evaluate shear bond strength of soft lining material to acrylic denture base, heat cure acrylic resin blocks (Spofa dental, Czech) with specified dimensions need to be made. Each shear bond strength test specimen consist of (2) heat cured acrylic blocks with dimensions of (75mm × 25mm × 5 mm length, width, depth respectively) with stopper of depth about 3mm, Fig. (3) [3,15]

Preparation of heat cure acrylic resin specimen:

The plastic pattern was invested primarily in additional silicone material (Zermack, Italy). After silicon setting, the silicon mold with plastic pattern together ware immersed in dental stone (Zermack, Italy) which was mixed according to manufacturer instructions (P/W ratio:

100gm/25ml). Packing of heat cure acrylic resin specimen was done depending on manufacturer's instructions (P/L ratio: 2.2gm of powder for each 1 ml of liquid monomer. Curing was done in a thermostatically controlled water bath (Spain) depended to manufacturer instructions (heating up to 70° C for 30 minutes and then increased to 100° C and kept for 30 minutes). Finishing was done to remove all flashes from acrylic specimen by using prosthetic hand piece (Marathon W&H; Korea) and acrylic bur, stone bur (China) followed by sand paper (China) for smoothing surface. Polishing was accomplished by using rag wheel and pumice (China) with lathe polishing machine (England), Fig. (4). All samples stored in distilled water in incubator (Germany) for 48 hours at 37°C [3,15].

Soft liner application:

Mold preparation:

Each specimen was involved of two acrylic blocks that put one over the other forming space between them with dimensions (25 mm ×25 mm ×3 mm length, width and depth respectively) for the soft liner application. In addition the handle thickness of acrylic block is 13mm, Fig. (5) [3,15].

Specimen preparation:

The silicon material (Addition type) was used to prepare mold for acrylic blocks. After setting, acrylic blocks with their silicon mold were immersed totally in freshly mixed dental stone which poured in custom fabricated metal flask. The space acrylic blocks between filled with wax (China), then flask was placed in water bath to eliminate all the wax, after that the mold was cleaned by soap and hot water. Proportioning and mixing of soft liner material was done. The soft liner material applied in the cavity prepared between the two acrylic blocks, the flask was locked under gradual pressure application to permit equal flow of the material throughout the mold cavity, curing procedure as well as finishing and polishing procedures were done as thermal conductivity test.

Testing procedure of shear bond strength

The specimens were stored in distilled water at 37 °C for 48 hours in an incubator before testing. The specimens were tested by using universal Instron testing machine (Instron 1195; England) with cross head speed (0.5mm/min), fig. (6).The value of shear bond strength for each specimen can be calculated by formula [16]:

$$\textit{Bond strength } (N/mm^2) = \frac{\text{Maximum load}}{\text{Cross sectional area}} = \frac{F}{A} \qquad \textbf{(3)}$$

F= force of failure (N)

A= Surface area of cross section (mm²).

Mode of failure

The nature of bond failure between acrylic soft liner and heat cure acrylic was examined after shear bond strength testing by using stereomicroscope (Italy) under 20x magnification for determining the type of failure either adhesive (if the failure occurred at the soft liner - denture base interface), cohesive (soft liner material ruptured within itself), or mixed (failure refers to both) [17].

Fourier transforms infrared spectroscopy (FTIR Bruker, Germany)

The FTIR used to determine any chemical reaction between either Neem or Aloe Vera powders with heat acrylic soft liner material. The control and studied specimens were tested by FTIR analysis to obtained FTIR spectra by scrapping a small amount of the specimens and placed on a specified plate inside the FTIR analyzer [18] .

Statistical Methods

The data of study analyzed by One-way ANOVA, levene test and least significant difference LSD used to determine which least two groups were not equal.

Results:

Thermal conductivity test

Statistical analysis indicated that the Neem 10% group has highest mean values (0.404±0.058), while control group had lowest mean values (0.334±0.053) and Aloe Vera 10% group was in between (0.380±0.041). With reference of testing equal variances (levene test) result showed non-significant difference at P>0.05 among studied groups, while one-way ANOVA result showed significant difference at P<0.05, Table (1). Least significant difference (LSD) test among studied groups for thermal conductivity test shows that the control group and Neem 10% group has recorded a statistically highly significant difference at P<0.01, and significant difference at P<0.05 with comparisons between the control and Aloe Vera 10%), while non-significant differences at P>0.05 between the Neem 10 % group and Aloe Vera10 % group, Table (2). All tested groups were graphically presented in Fig. (7).

Shear bond strength test

Table (3) showed that the control group has lowest mean value (0.444±0.084), while group of Neem 10% has highest mean values (0.560± 0.081) and Aloe Vera 10% group was in between (0.480±0.037). Levene test result showed no significant difference at P>0.05 among studied groups, while one-way ANOVA result showed highly significant difference at P<0.05. The results of (LSD) test showed that the Neem 10% group has recorded highly significant difference compared with control group at P<0.01, as well as non-significant difference at P>0.05 has recorded compared with Aloe Vera 10% group, while a statistically significant difference was accounted at P<0.05 between Aloe Vera 10%, and control groups, Table (4). All groups were present graphically in Fig. (8).

Mode of failure

The mode of failure of shear bond strength specimens was examined under stereomicroscope with (20x) magnification and categorized as either adhesive, cohesive or mixed failure, the stereomicroscope was appeared that all specimens of the control group had adhesive failure except one specimen which failed cohesively, Fig. (9) and all the specimens of Neem group had mixed failure, Fig. (10). While specimens of Aloe Vera group also had mixed failure except two specimens which failed cohesively, Fig. (11).

FTIR (Fourier transforms infrared) spectroscopy

All different functional groups present were studied via FTIR analysis. The characteristic bond in the acrylic soft liner (control group) were hydroxyl bond (O-H) represented by peak at 3000 cm^{-1}, alphabetic group (C-H) represented by peak at 2848-2958cm^{-1}, carbonyl bond (C=O) represented by peak at 1724cm^{-1}, carbonyl group (C-O) represented by peak at 1234 cm^{-1}, and stretching vibrate ester group (C-O-C) represented by peak at 1143-1174 cm^{-1}. FTIR spectrum results of soft liner with incorporation of Neem10% powder showed observed new peaks at 3437, 1635, 1518, 1348, 1116, and 1097 cm^{-1} this emphasize the existence of chemical bonding between the Neem powder and soft-liner material. While FTIR spectrum results of soft liner with incorporation of Aloe Vera 10% powder showed there was no change in absorption peaks this emphasize no chemical interaction between Aloe Vera powder and soft lining material, Fig. (12).

Discussion:

In this study an attempt was made to investigate the effect of incorporating either Neem or Aloe vera powders on thermal conductivity and shear bond strength of heat acrylic soft liner material. Thermal conductivity was the ability of material to transmit heat that important feature of dental prosthesis. It measured by determining the rate through which heat transmitted within material cross sectional area [19].

A highly significant increase in the rates of thermal conductivity with the incorporation of either Neem or Aloe Vera powders into heat acrylic soft liner material was occurred attributed to the overlapping of thermal conductive either Neem or Aloe Vera particles inside the polymer matrix to bridge the insulating effect of heat acrylic soft liner matrix. When the overlapping of thermal conductive particles will increase leads the particles to form pathway that permit to heat transition from one side of specimens to another side. The result of present study coincide with the result of [11]. As well as present (Si) element within structure of either Neem or Aloe Vera leads to creation of pathways between particles of soft liner for increased thermal conductivity property. This result agree with the result of Hasan WY, Ali MM [11].

Ideal bonding between soft denture liner and denture base material was necessary importance for the success of any denture [21].

As well as in this present study each group of Neem with (2-5μm) particle size and Aloe Vera (3-6μm) particle size a slightly higher significant bond strength than the control specimens. The improvement of shear bond strength may due to smallest size and irregular form of Neem and Aloe Vera particles compared to the large size and round beads of soft liner particle this aiding in micromechanical retention [15].

In addition the fairly uniform homogeneous blending particles of either Neem or Aloe Vera within the matrix of soft liner material which acting as filler, closing spaces between soft liner particles and increasing surface area for adhesion with denture base material [11].

Moreover the bonding surface area may also considered to be as an important factor, according to the specimens used in the present study, the bonding surface area (25mm × 25mm) was large and may help to enhance bonding these could explain the non-significant change in the bonding strength between Neem and Aloe Vera materials [17].

Conclusion:

In this current study, both Neem 10 % and Aloe Vera 10 % powders increased thermal conductivity and shear bond strength of heat acrylic soft liner material. Neem 10 % group showed highest thermal conductivity as well as highest shear bond strength with heat cured acrylic resin among all studied groups. Also, thermal conductivity and shear bond strength of heat acrylic soft liner material have been improved with both Neem 10 % and Aloe Vera 10 % powders.

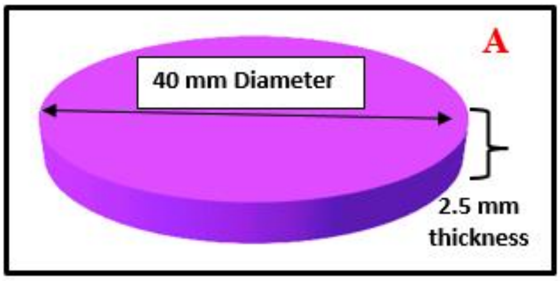

Fig. (1): (A) Dimensions of thermal conductivity specimen
(B) Plastic pattern of thermal conductivity specimen

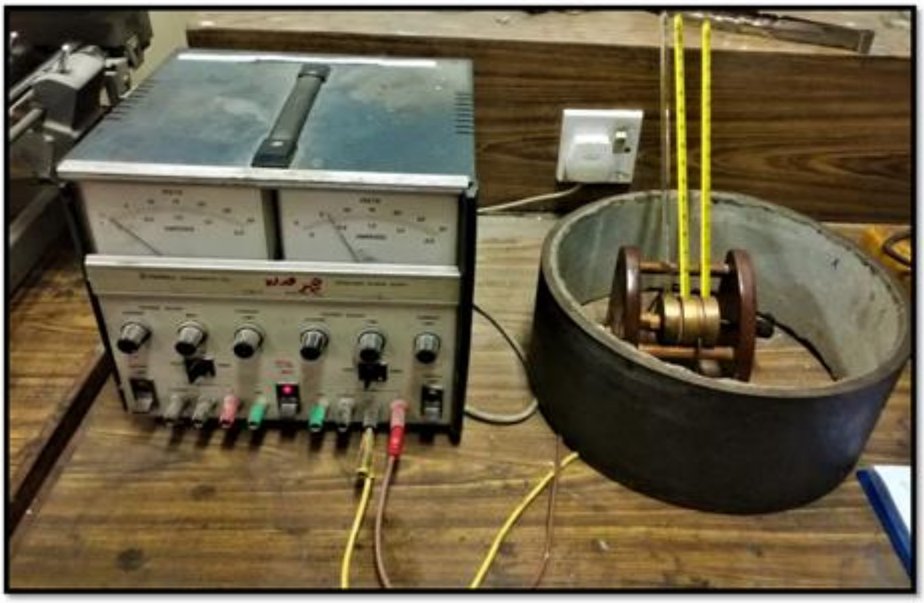

Fig. (2): Thermal conductivity apparatus (Lee disc)

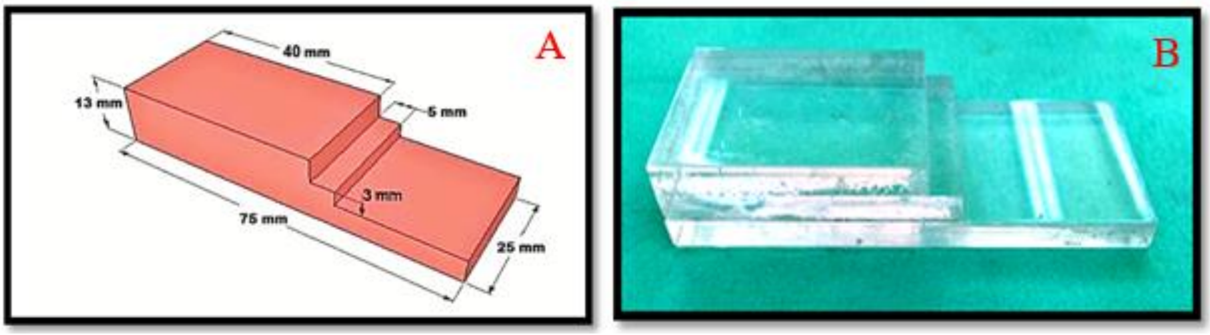

Fig. (3): (A) Dimensions of specimen shear bond strength, (B) Plastic pattern of specimen shear bond strength

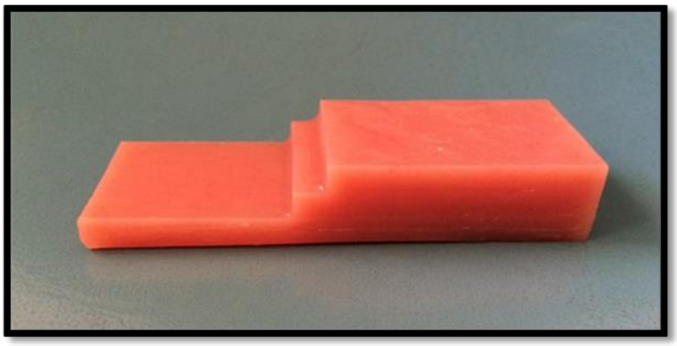

Fig. (4): Acrylic block for soft liner application

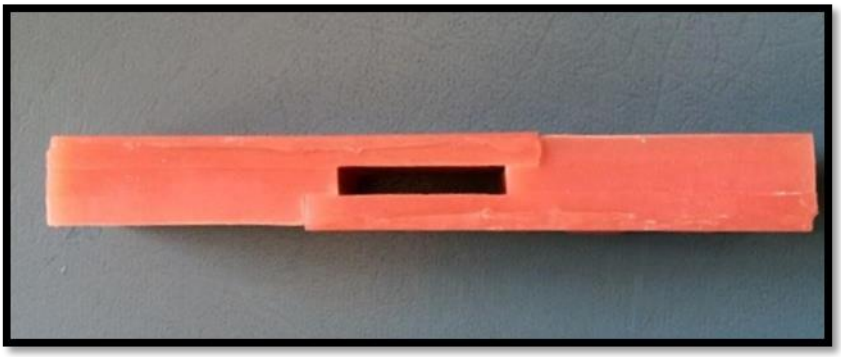

Fig. (5): Acrylic mold ready for soft liner application

Fig. (6): Instron testing machine during test the shear bond strength specimen

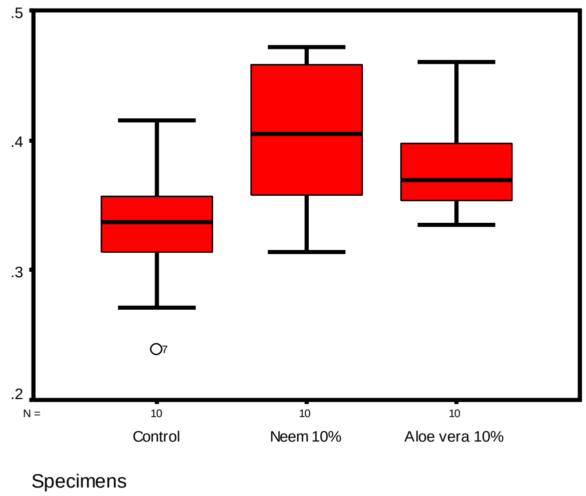

Fig. (7): Stem-Leaf Plots for all thermal conductivity studied groups

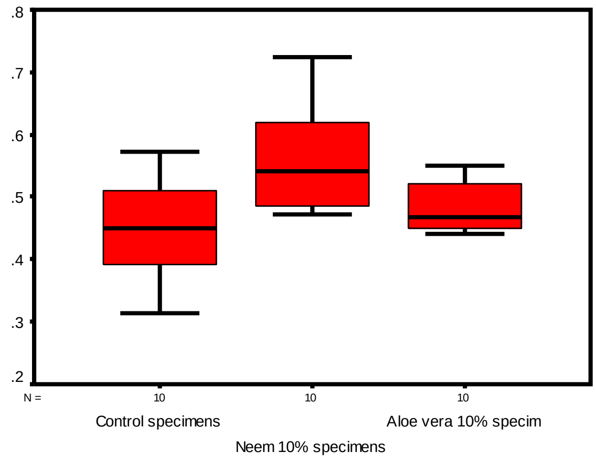

Fig. (8): Stem-Leaf Plots for all shear bond strength studied groups

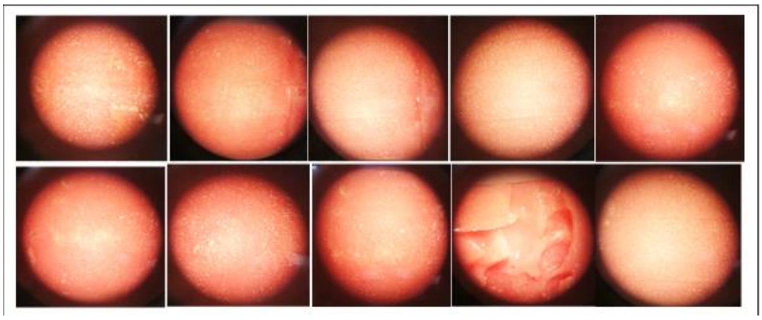

Fig. (9): Mode of failure of specimens shear bond strength (control group)

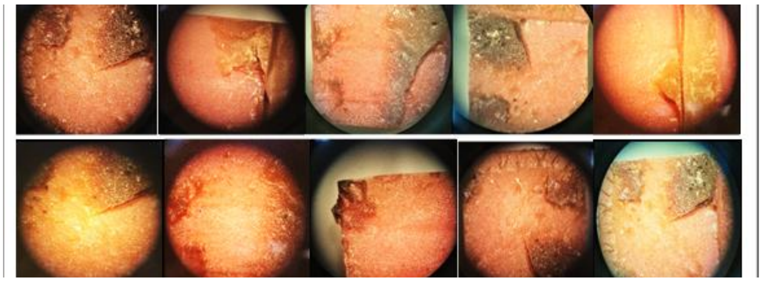

Fig. (10): Mode of failure of specimens shear bond strength (Neem 10 % wt.)

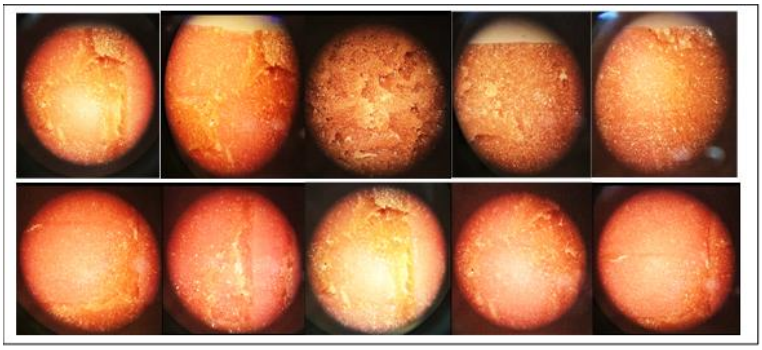

Fig. (11): Mode of failure of specimens shear bond strength (Aloe vera 10 % wt.)

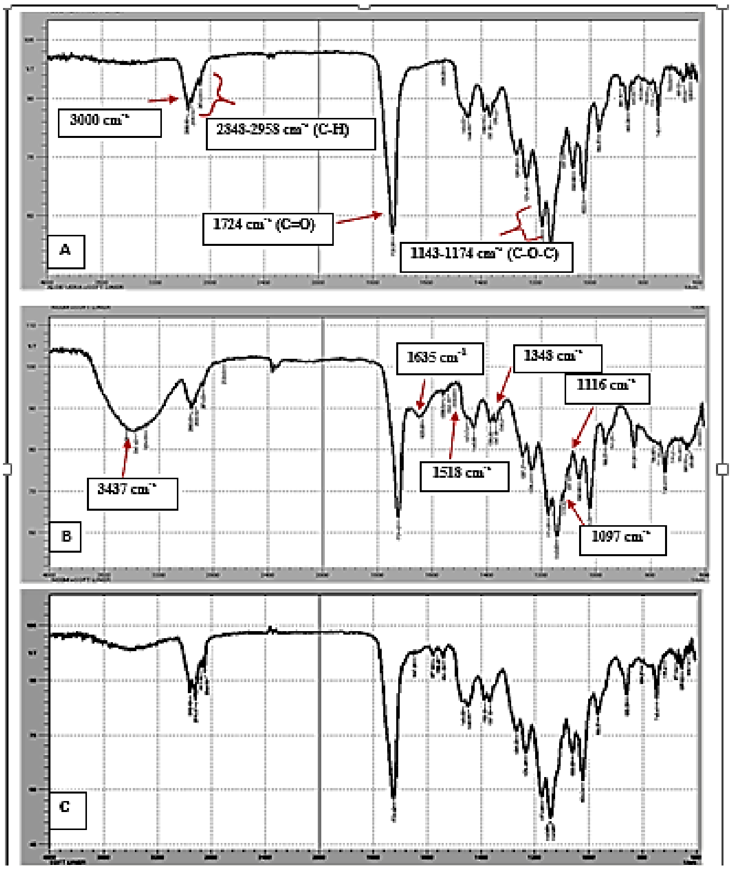

Fig. (12): FTIR analyzer (A) soft liner specimen (control) (B) specimen after incorporation of 10% of Neem (C) specimen after incorporation of 10% of Aloe

Table (1): Descriptive statistics with Levene and one-way ANOVA test for all thermal conductivity studied groups

Test	Groups	No.	Mean	Std. D.	Min.	Max.	Levene Test	ANOVA Test
Thermal conductivity (w/m.c.)	Control	10	0.334	0.053	0.239	0.416	p= 0.940 (NS)	p= 0.015 (S)
	Soft liner with10% wt. Neem powder	10	0.404	0.058	0.314	0.472		
	Soft liner with10% wt. Aloe Vera powder	10	0.380	0.041	0.335	0.460		

NS: Non Sig. at p>0.05 ; S: Sig. at p<0.05

Table (2): (LSD) test of thermal conductivity test among studied groups

(I) Group	(J) Group	Mean Diff. (I-J)	Sig. P-value	C.S. (*)
Control group	Soft liner with 10% wt. Neem powder	0.070-	0.005	HS
	Soft liner with 10% wt.Aloe vera powder	0.056-	0.042	S
Soft liner with 10% wt. Neem powder	Soft liner with 10% wt. Aloe vera powder	0.024	0.304	NS

HS: Highly Sig. at p<0.01; S: Sig. at p<0.05 ; NS: Non Sig. at p>0.05

Table (3): Descriptive statistics Levene and One-way ANOVA test concerning shear bond strength test for all group

Test	Groups	No.	Mean	Std. D.	Min.	Max.	Levene Test	One-way ANOVA Test
Shear bond strength	Control	10	0.444	0.084	0.314	0.573	p=0.064 (NS)	p=0.003 (HS)
	Soft liner with10% wt. Neem powder	10	0.560	0.081	0.472	0.724		
	Soft liner with10% wt. Aloe Vera powder	10	0.480	0.037	0.441	0.549		

HS: Highly Sig. at p<0.01; NS: Non Sig. at p>0.05

Table (4): (LSD) test among studied groups for shear bond strength test

(I) Group	(J) Group	Mean Diff. (I-J)	Sig. P-value	C. S. (*)
Control group	Soft liner with10% wt. Neem powder	- 0.116	0.001	HS
	Soft liner with10% wt. Aloe Vera powder	0.08	0.016	S
Soft liner with10% wt. Neem powder	Soft liner with10% wt. Aloe Vera powder	- 0.036	0. 264	NS

HS: Highly Sig. at p<0.01; S: Sig. at p<0.05 ; NS: Non Sig. at p>0.05

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