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Water Sorption and Solubility of Denture Base Resins- An Evaluation

KEYWORDS: Acrylic resins, denture base, plasticizer.

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ABSTRACT *Statement of problems: Water sorption and solubility are important properties of acrylic resins. Denture base acrylic resins have low solubility. This solubility results from the leaching out of un-reacted monomer and water soluble additives into the oral fluids. The solubility of denture base acrylic resins can cause oral soft tissue reactions. In addition, water absorbed into this material acts as a plasticizer and changes the mechanical properties such as hardness, transverse strength,fatigue limit as well as color and dimensional stability.*

Purpose:The aim of this study was to compare the water sorption and solubility of four different brands of heat cure denture base acrylic resins (Stellon, Acrylin-H, Trevalon and Trevalon-HI).

Materials and Methods: An experimental in vitro design was adapted. Four groups were prepared according to different brands of acrylic resin: Group A- Acrylin "H", Group B- Trevalon, Group C- DetreyStellon and Group D- Trevalon "HI". An eight circular discs specimen (diameter 50±0.01mm and thickness 0.5±0.01mm) that is two for each group were prepared. Discs were finished on the edge and equally from the both the molded surfaces to fabricate the discs of specific dimensions. The tests were conducted mainly in accordance with the American Dental Association Specification no. 12 / ISO: 1567-1981 (ISO: 6887-1986) for denture base acrylic resin. Intergroup differences were assessed using student "t" test.

Results: The heat-cured denture base material B (DetreyStellon) has the maximum mean value of water sorption while D (Trevalon "HI") showed minimum value of mean water sorption among different brands of acrylic resins. The water solubility was maximum for A (Acrylin "H") while minimum for D (Trevalon "HI"). Statistically, water sorption was highly significant in all the groups (P<0.001).

Conclusion: The heat-cured denture base material A (Acrylin "H") was the best of all and C (Trevalon) was worst among all materials used in this study.

Introduction

Loss of teeth is a matter of great concern to a majority of people and their replacement by artificial substitutes such as denture is vital to the continuance of normal life. Acrylic resins are widely used in dentistry. Prediction of the service life of acrylic resin material is difficult since many environmental factors affect durability.

One of the properties of acrylic resins is water sorption and release, which causes dimensional instability, thereby subjecting the material to internal stresses that may result in crack formation and eventually, fracture of the denture.[1,2] Because water interacts with the polymer chains, it may produce some effects such as reversible loosening or effective plasticization of the structure, salvation or reversible rupture of weak interchain bonds, and irreversible disruption of the polymer matrix. Therefore, the water sorption and solubility are the critical problems that affect the durability.[3] Takahashi *et al* [4] found that water molecules spread between the macromolecules of the material, forcing them apart. This behavior affects dimensional behavior and denture stability; therefore, water sorption and solubility of the denture base materials should be as low as possible. Many studies on the water sorption of denture resin have been conducted, and concluded that sorbed water would cause the decrease of mechanical properties.[2, 5–9]

Ideally, polymer network should be insoluble material with relatively high chemical and thermal stability. However, most of the monomers used in dental resin materials can absorb water and chemicals from the environment, and also release components into the surrounding environment. Both water sorption and solubility would lead to a variety of chemical and physical processes that may result in deleterious effects on the structure and function of dental polymers.[10] Denture base acrylic resins have low solubility, and the little that occurs is a result of the leaching out of traces of unreacted monomer and water-soluble additives into the oral fluids. However, these monomers sometimes produce a soft tissue reaction.[11] It is important to determine the residual monomer content and solubility of the tested materials as these properties influence the allergy

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susceptibility of these materials.[12–15] Due to the importance of these properties in the clinical and mechanical performance of an acrylic material, this study evaluated water sorption and solubility of different acrylic resins.

Materials and Methods

The experimental study was carried out in the department of Prosthodontics with the collaboration of Research Design and Standard Organization, Lucknow to evaluate water sorption and solubility of denture base resins.

The following standard materials were used for this study:

1. Denture base resins: four brands of denture base resins were included in the study. (Table1)
2. Dental stone plaster, Kalstone (Kalabhai Karson Pvt. Ltd., Mumbai, India)
3. Cold Mould Seal (Stellon, Dental Products of India Ltd., Wallace street, Mumbai-1, India)
4. White Petroleum Jelly (Ponds India Ltd., Madras, India)
5. Cellophane sheet

Methods for detection of water sorption and solubility test of different acrylic resins were divided into three parts-

(A) Preparation of specimens:

A stainless steel circular die disc (diameter 50±0.01mm, (M.A. engineering work, Lucknow) was mounted with stone plaster (Kalabhai Karson Pvt. Ltd., Mumbai, India) in the Hanau flask (Hanau Eng. Co. Buffalo, N.Y., U.S.A.) (Fig. 1). The stone plaster in the shallow half of the flask was poured against a glass plate to obtain smooth surface. Dewaxing was done. Separating media (Cold mould seal, Dental product of India, Ltd. Wallace Street, Mumbai-1, India) was applied followed by packing with heat-cured resins and then processed in acrylizer (Hustman, Bath, England) and sample were recovered (Fig. 2). After processing, the discs were finished on the edges and equally from both molded surfaces to fabricate with specific dimensions (diameter 50±0.01mm thickness 0.5±0.01mm). Two specimen discs of each brand of denture base resin were taken for the test. The test was conducted mainly in accordance with the A.D.A. Specification no. 1567-1981(ISO: 6887-1986) for denture base polymer. The room temperature of laboratory was varied from 29-34 °C during the entire procedure of experiments.

(B) Test procedure for water sorption:

For each experiment two discs were taken and conditioned at a temperature of 37±2°C for 24 hours in a dessicator (Purnima Globaltech (India) 798-799, housing board colony, Ambala cantt,_India) containing thoroughly dried silica gel for dehydration of the specimen. Thereafter, the discs were transferred to another dessicator for additional one hour. The discs were then removed and weighed to the nearest of 0.02 mg. The whole of dehydration cycle was repeated until a constant weight was attained, that is, until the weight loss of each disc was not more than 0.5 mg in any of the 24 hrs period. The discs were then immersed in distilled water at a temperature of 37±1°C for 7 days. The discs were then removed with a tweezers, wiped off with a clean dry towel until made free from visible moisture, waved in air for 15 seconds and then finally weighed one minute after removing from the water. Measurements of specimens were taken with help of sensitive digital caliper (Yamayo Classic, Japan, minimum measuring capacity 0.01mm). The diameter and mean of 5 thickness measurements, 1 at the center and 4 at equidistance positions around the circumference were measured which were used for calculating the surface area of the specimen discs. The averages of the determined values for the two discs were recorded to the nearest 0.01 microgram/cubic millimeter. For each material the experiment was repeated twice and final water sorption value was calculated in microgram/cubic millimeter.

(C) Test procedure for water solubility:

After completion of water sorption test, the same discs were reconditioned in the dessicator for 24 hrs and followed by additional one hour in a separate dessicator (figure 3). The discs were then removed and weighed to the nearest of 0.2 mg. The dehydration cycle was repeated until a constant weight was attained, that was until the weight loss of each disc was not more than 0.5 mg in any of 24 hrs period. The discs were finally weighed and the reading was noted. For each material, the experiment was repeated twice and the average value of water solubility was calculated in µg/cmm.

Statistical analysis:

(A) Water sorption test:

(i) Water sorption (mg/cmm) = M2-M1 / V
Where M 1 = Conditioned mass, in milligram of the disc, M2 = mass, in milligrams of the disc after immersion, V = Surface area of the disc in cubic millimeters

(ii) Surface area (in cmm) $V = \pi d \times h$
Where d = diameter of the disc in mm, h = height in mm

(B) Solubility test:

Solubility (mg/cmm) = M1-M3 / V Where M1= Conditioned mass, in milligram of the disc, M3 = Reconditioned mass in mg of the disc, V = Surface area of the disc in cubic millimeters

The values have been shown as mean ± SD/SE and intergroup comparisons have been made using student "t"-test. The confidence level of the study was kept at 95% and a "P" value less than 0.05 indicated statistically significance difference.

Observations:

The present study comprised of four brands of commercially available heat cured denture base resins. A total number of eight specimens were prepared that is two for each group, for water sorption and solubility test. Statistical analysis was done with the help of SPSS software.

Table 2 showed the mean analysis of water sorption of four denture base resin materials with SD and SE values. The mean value of water sorption was minimum with D (Trevalon "HI") and maximum with B (Detrey Stellon). Table 3 showed the comparison of water sorption among the materials. This table depicts that the "t" value for water sorption was highly significant statically in all the groups ($p<0.001$). Table 4 showed the mean analysis of water solubility of various materials with SD and SE values. The mean value of water solubility was maximum with A (Acrylin "H") and minimum with D (Trevalon "HI"). Table 5 showed the comparison of water solubility among the materials with "t" and "p" values. This table depicted that the "t" value for water sorption was highly significant statistically in all the groups ($p<0.001$).

Discussion:

In the present study, the method that recommended by ISO for measuring water sorption and solubility was used. The water sorption was determined according to increase

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in mass per unit volume. Also water solubility was determined according to loss of mass from polymers.[16, 17]

In this study four brands of commercially available heat cure denture base resin A to D were selected. Since commonly available materials are usually used by the general practitioner, this study will be beneficial from the clinical point of view.

The polymethyl methacrylate absorbs water relatively in small amount over a period of time when placed in aqueous environment. This may be due to polarity of polymethyl methacrylate molecules. Because water interacts with the polymer chains, it may produce some effects such as reversible loosening or effective plasticization of the structure, salvation or reversible rupture of weak interchain bonds, and irreversible disruption of the polymer matrix. Therefore, the water sorption and solubility are the critical problems that affect durability.[18] Takahashi *et al*[4] found that water molecules spread between the macromolecules of the material, forcing them apart. This behavior affects dimensional behavior and denture stability; therefore, water sorption and solubility of these materials should be as low as possible.[3]

Table 2 showed the mean analysis of water sorption of various denture base resins from A to D. It was found that the material B showed the maximum value of water sorption (0.7534 µg/cmm) while D the minimum (0.235 µg/cmm), thus, the descending order of value was B> A> C> D. The minimum value of D might be due to the presence of micro dispersed rubber phase polymers. When compared with the result by previous study,[17,18] the water sorption value of B was nearly equal with the present finding, while in A slightly lesser value was found. This might be attributed to towards the differences of various procedural techniques.

Table 4 showed the mean analysis of water solubility of A to D. The maximum mean value was found with A (0.0452) while minimum with D (0.015), thus the descending order was

Acrylin "H"> Trevalon > Detrey Stellon > Trevalon "HI"

The minimum value of D might be due to inclusion of micro dispersed rubber based polymers.

Although, few investigations had been performed earlier, the result obtained from the study, provide valuable information about each of the heat-cured denture base resin tested. The selection of the proper material to obtain the optimum property can be of great help in the clinical practice of dentistry. However, the study included only few brands of heat-cured denture base resin materials commercially available in India. Hence, it is suggested that further studies involving larger number of denture base materials should be undertaken to evaluate the proper selection of the material.

Conclusions:

Based on the above observations, statistically analyzed and discussed, it was concluded that:

1. There was maximum water sorption with the Detrey Stellon and minimum with Trevalon "HI" among the four materials. The descending order of water sorption was as:

Detrey Stellon (B) > Acrylin "H" (A) > Trevalon (C) > Trevalon "HI" (D)

2. There was maximum water solubility with Acrylin "H" (A) and minimum with Trevalon "HI" (D) among all materials. The descending order of water solubility was as:

Acrylin "H" (A) > Trevalon (C) > Detrey Stellon (B) > Trevalon "HI" (D)

3. Among the materials A to D, Trevalon "HI" (D) was the best of all and Trevalon (C) was worst of all.

Figure 1- Mounted stainless steel die on Hanau flask

Figure 2- Sample plate of acrylic resin

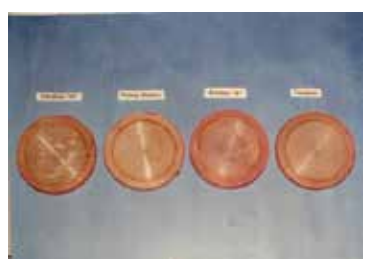

Figure 3- Dessicator

Table-1 Showing brand name and manufacturers of denture base resins

S. No.	Code No.	Brands of materials	Manufacturer´s name and address
1	A	Acrylin "H"	Asian Acrylates 4,Vora House, Bombay
2	B	Detrey Stellon	Dental Product of India Limited, 9, Wallace Street,Bombay
3	C	Trevalon	Dentsply G-7, Saket, New Delhi-110017
4	D	Trevalon "HI"	Dentsply G-7, Saket, New Delhi-110017

Table-2 showing the mean analysis of water sorption of various materials with SD and SE values

Code No.	A	B	C	D
No. of specimens	2	2	2	2
Mean(in µg/cmm)	0.4384	0.7534	0.4193	0.235

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SD	0.0384	0.0459	0.0381	0.0242
SE	0.0172	0.0206	0.0171	0.0108

Table-3 Showing the comparison of water sorption among the materials with "t" and "p" values

Materials	" t"	"p"
A Vs B	14.3045	‹ 0.001
A Vs C	16.4546	‹ 0.001
A Vs D	31.3663	‹ 0.001
B Vs C	10.6031	‹ 0.001
B Vs D	22.4731	‹ 0.001
C Vs D	11.8221	‹ 0 .001

Table-4 Showing the mean analysis of water solubility of various materials with SD and SE values

Code No.	A	B	C	D
No. of specimens	2	2	2	2
Mean(in µg/cmm)	0.0452	0.0262	0.0324	0.0150
SD	0.0024	0.0011	0.0014	0.0013
SE	0.001	0.0004	0.0006	0.0006

Table-5 Showing the comparison of water solubility among the materials with "t" and "p" values

Materials	" t"	"p"
A Vs B	16.5526	< 0.001
A Vs C	21.6881	< 0.001
A Vs D	25.4482	< 0.001
B Vs C	9.3010	< 0.001
B Vs D	15.1268	< 0.001
C Vs D	4.8155	< 0 .001

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