Dentistry and Practices

ISSN: 2581-4990

RESEARCH ARTICLE

Sorption and Solubility of Acrylic Resin Self polimer by 3 Process Techniques in Orthodontics

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Abstract

Sorption and aqueous solubility are proprieties that the acrylic resin haves and are present during his acrilization process.

Objective: To determine the properties of sorption and aqueous solubility of three processing techniques of the self-curing acrylic resin that is used for the creation of movable orthodontic prosthetics.

Material and Methods: An experimental study using a total of 30 samples of acrylic resin (diameter 25 mm ± 0.2 by 2.5 mm height), (n = 10) conventional techniques, pressure (n = 10) and heat pressure (n = 10) were elaborated) to be exposed to sorption and solubility tests according to ISO 1567. The data were analyzed using one-way analysis of variance followed by post hoc Tukey's test.

Results: Several Average water sorption values were: heat-pressure technique was 16.06 (± 0.48) µg / mm3, pressure 16.20 (± 0.71) µg / mm3 and conventional 16.72 (± 0.31) µg / mm3 and heat solubility- pressure was 0.46 (± 0.19) µg / mm3, pressure 0.52 (± 0.20) µg / mm3 and conventional 0.83 (± 0.18) µg / mm3. When comparing the three study groups, statistically significant differences were found for sorption ($p = 0.024$) and solubility ($p < 0.001$).

Conclusion: The techniques carried out showed an output of a variation in the sorption and solubility in the polymerization process of the acrylic resin is carried for, autopolymerisable orthodontics. Such technique has repercussions in the sorption and solubility tests of the material, presenting better results taking advantage of the pressure-heat technique.

Keywords: Sorption, Solubility, Process techniques, Acrilyc resin autopolimerizable

Introduction

Polymethylmethacrylate acrylic resin or PMMA is the mostly used material in removable, fixed and complete prostheses due to their improving aesthetics of the restoration. There are different acrylic resins in the market that can be polymerized by different physical means: (either thermopolymerisable or microwaveable) in addition of the chemical (self-curing) that is used in the preparation of temporary, dentures and removable prostheses [1]. The prognosis of the useful life of the acrylic resin is complex, since there are environmental factors that intervene and affect the hardness time [2].

Aqueous sorption is an inherent property of acrylics where water molecules are integrated into the mass of the polymer by modifying its volume. This phenomenon involves absorption and adsorption; the first one refers to the penetration of water to the innermost part of the resin and it is favored by the porosities and cracks of the material while the adsorption is a phenomenon of surface action, where water penetrates the surface layers of the resin acrylic. When there is adsorption (on the surface of the material) and absorption. There is uncertainty regarding such situations, however it is not known which of the two phenomena predominates is when the term sorption is used [3].

Sorption of water is a process that can lead to solubility; this is the ability of a substance or bodies to dissolve when mixed with a liquid. It can also cause dimensional changes, decrease the physicochemical properties and produce color changes in the material deteriorating its aesthetic appearance [4]. In addition, the material can release residual monomers that cause hypersensitivity and mucosal irritation [5]. Therefore, water absorption and solubility are the critical problems that affect

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Received: Oct 22, 2019; **Accepted:** Oct 29, 2019; **Published:** Nov 04, 2019

*This article is reviewed by "Li Pin Kao, USA; Xavier R, France; Nathan JE, USA"

durability. Similarly, water sorption and solubility participate in a variety of chemical and physical processes that could influence the structure and function of dental polymers [6].

Different studies have shown that if biocompatibility decreases there is a probability of presenting an allergic reaction including erythema, urticaria, burning sensation and pain [7, 8], in addition, due to overheating or insufficient pressure during polymerization can cause alterations such as color change, maladaptation, weakening, food residue retention and unpleasant odor which could reduce the resistance of the resin [9].

On the other hand, the self-curing acrylic resin can be processed by means of three techniques to produce removable orthodontic appliances; the conventional technique, pressure and heat pressure. To achieve the best polymerization, it is convenient to avoid contact of the resin with oxygen during its chemical reaction, since this element reacts rapidly with free radicals and its presence delays the polymerization, decreases the degree of conversion and quality and therefore its physicochemical properties. So, the objective of the present study was to determine the properties of sorption and aqueous solubility of three processing techniques of the self-curing acrylic resin that is used to produce removable orthodontic appliances.

Material and Method

This study was carried out in the Orthodontic department (Clinic) and DePel Dentistry laboratory school of the National Autonomous University of Mexico (UNAM).

Polyvinyl siloxane molds of 25 mm ± 0.2 mm diameter with a thickness of 2.5 mm ± 0.2 mm were used. N = 30 samples of acrylic resin for orthodontics of the brand NicTone® (MDC Dental® Jal. Mexico) were produced in green phosphorescent. The measures chosen for the samples for this study are not those established by the ISO 1567 norm but were elaborated according to the approximate thickness with which the removable and fixed orthodontic appliances are made.

The processing techniques for the polymerization of the acrylic resin that were used in this study were: Group 1 (Conventional), Group 2 (Pressure) and Group 3 (Pressure-heat); all the samples were elaborated by means of the dust-drip method; each group conformed to 10 samples.

Sample Processing

Group 1: After making the sample using the dust-drip technique, the mold was introduced with the acrylic in a hermetically sealed bag for 20 minutes to complete the polymerization.

Group 2: The samples were immersed in a hydraulic pressure cooker (Lang Acuapress, USA) with water at room temperature (23 ± 1 ° C) for 20 minutes.

Group 3: The samples were immersed in a pressure cooker or pressurizer at a temperature of 38 ° C, with a pressure of 40 Psi for 20 minutes to complete the polymerization.

Subsequently, the remaining acrylic was cut out from the samples with tungsten carbide cutter, polished with water sandpaper and finally with blanket discs using Pulecril® (Manufacture Dental Continental, Jal. Mexico) and Blanco de España for give the finished.

Method to Obtain Sorption and Solubility

Sorption and solubility were determined by the method described in Specification 12 of the American Dental Association (ADA) for base polymers for dentures [10]. To carry out the sorption and solubility tests, the samples previously were identified by group were placed in a rack inside a desiccator containing freshly dried silica gel. The desiccator was placed in an oven at 37 ° C ± 1.0 ° C for 23 hours, and then it was removed and left to cool for one hour until it reached room temperature (23 ° C ± 1 ° C). Each sample was weighed on an analytical balance with an accuracy of 0.2 mg; during the weighing process the desiccator was opened and closed as quickly as possible.

The above procedure was repeated until a constant mass, m1, called “conditioned mass” was obtained, that is, until the mass loss of each sample was less than 0.2 mg. The volume of each sample was calculated with the average of three measurements of the diameter and the average of 5 thickness measurements taken at the center and at four points equidistant from the circumference of each sample.

Subsequently, the samples were immersed in bidistilled water at 37 ° C ± 1.0 ° C for 7 days ± 2 h. After that period they were removed from the water with tweezers and dried with a cloth until they were free of moisture, then they were agitated in the air for 15 seconds and weighed one minute after they had been removed from the water, with an accuracy of 0.2. mg; this mass was recorded as m2. After weighing the samples were “reconditioned” in the desiccator following the procedure described above until achieving a constant mass, recording the mass of the “reconditioned” samples as m3.

The water sorption and water solubility per unit volume are determined according to ISO standards 1567: 1999 [5]. The value of the water sorption (Wsp) of each sample expressed in micrograms per cubic millimeter (μg / mm3) was calculated with the following equation: $W_{sp} = m_2 - m_3 / V$. Where m_2 is the mass of the disk in micrograms after immersion, m_3 is the reconditioned mass of the disk in micrograms and V is the volume of the disk in cubic millimeters. The soluble matter per unit volume was calculated where W_{sl} leached during the immersion, expressed in micrograms per cubic millimeter for each disk with the following equation: $W_{sl} = m_1 - m_3 / V$. In which m_1 is the conditioned mass of the disk in micrograms and m_3 and V are equal to the previous formula.

The three groups were kept in a desiccator until reaching a constant mass with the objective of eliminating any trace of humidity and being able to carry out the measurements of sorption and solubility tests with precision as established by ISO 1567. This conditioning period it lasted about a month until they reached a constant mass.

Statistical analysis of the variables studied is presented with their average and standard deviation. An analysis of variance (ANOVA) was performed to compare the averages of sorption and solubility of the different processing techniques examined. Subsequently, to identify the differences between the groups, the Bonferroni multiple comparison tests were used. All the tests were performed with a level of significance of $p < 0.05$ and the Stata V14 program was used for the analysis of the data.

Results

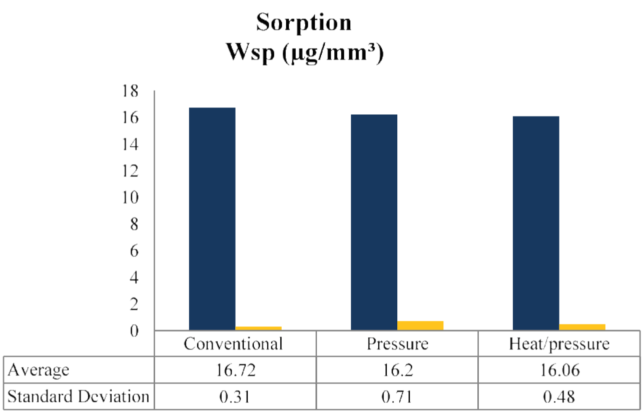
Ten samples were used in each group: conventional, pressure and pressure-heat as shown in Table 1, according to the processing technique used with the NicTone® acrylic resin. The general averages in the water sorption test of 30 Study samples were 16.3 $\mu g/mm^3$ (± 0.58) and in solubility it was 0.60 $\mu g/mm^3$ (± 0.24). The average values for sorption were 16.72 $\mu g/mm^3$ for group 1, 16.20 $\mu g/mm^3$ group 2 and 16.06 $\mu g/mm^3$ in group 3. When comparing the sorption average of the three study groups, statistically significant differences were found ($p=0.024$).

When performing the post-hoc tests, it was found that between group 1 and group 2 there are no significant differences ($p=0.114$); on the other hand, significant differences were found between group 1 compared to group 3 ($p=0.030$). In Graph 1, it is observed that group 3 showed a lower sorption compared to the other two groups.

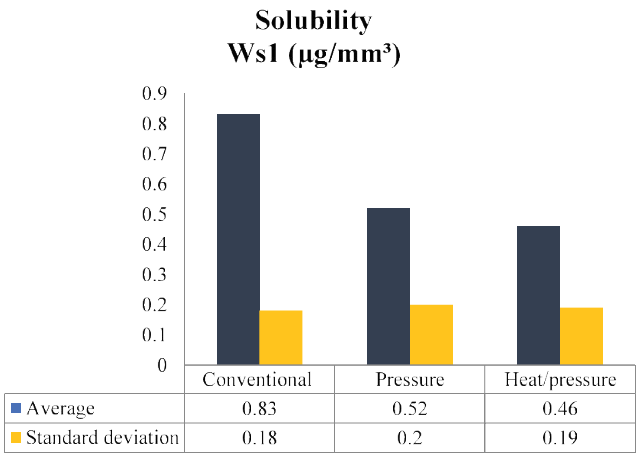
Regarding the results of the solubility test it was observed that the heat-pressure technique obtained the lowest results (0.46 $\mu g/mm^3$), the pressure technique (0.51 $\mu g/mm^3$) and the conventional one (0.82 $\mu g/mm^3$) showing statistically significant differences when comparing the solubility averages

Table 1: Distribution of the study groups by polymerization technique.

Group	Technique	Acrylic Resin NicTone
1	Conventional	10
2	Pressure	10
3	Heat-pressure	10



Graph 1: Aqueous sorption in three study groups of different polymerization techniques of the acrylic resin.



Graph 2: Solubility (Ws1) of the self-curing acrylic resin processed under three different techniques.

($p < 0.001$). When performing the post-hoc tests, it was found that between group 1 and group 2 there were statistically significant differences ($p = 0.003$), and between group 1 and group 3 significant differences were observed ($p = 0.001$). In Graph 2 the conventional technique had a higher average solubility compared to the other two groups.

Discussion

In the present study, lower values were found in the sorption and solubility tests in groups two and three processed under pressure and heat-pressure techniques. These low values can be related to the low pressure with which the acrylics resins were processed because the pressure modifies the conversion of monomers to the polymer chain producing less residual monomer [11]. In other studies it has been reported that there could be a correlation between the residual monomer and the weight loss determined by the solubility test [4].

Similarly, Pfeiffer P & Rosenbauer EU [12], reported in an in vitro study sorption values between 16 and 23 $\mu g/mm^3$ like those found in the present study for group two and three (16.20 $\mu g/mm^3$ and 16.06 $\mu g/mm^3$), respectively. In the present study the samples processed by means of the conventional technique showed greater solubility in relation to the other two techniques.

Likewise, Sainiet et al [2]. in a study where he compare the sorption and solubility of self-curing and heat-curing acrylic resins in different solutions, found that average sorption values varied from 17.5 to 27.2 $\mu g/mm^3$ for heat curing and 12.7 to 19.7 $\mu g/mm^3$ for the self-cure in the different solutions, finding significant differences ($p < 0.001$), and for solubility it had variations between 0.25 to 6.5 $\mu g/mm^3$. In the present study, the average values of sorption and solubility showed variation in the three groups, finding statistically significant differences. This variation in sorption and solubility could be since acrylic resins slowly absorb water during a certain period due to the polar properties of the resin molecules [2].

Similarly, the high water absorption can soften the resin since the water absorbed can act as an acrylate plasticizer and reduce the strength of the material [13]. It is also important to mention that the residual monomer could leak into the buccal fluids and cause tissue irritation, which is why a low solubility of these resins is required.

Acrylic resins contain polar carbonyl groups that entrain water molecules, in turn the water molecules diffuse between intermolecular holes of polymers that separate them slightly and gradually infiltrate the resin, so the result of this interaction in the sorption of water is the dimensional change, which produces a change in the vertical dimension of the previously determined occlusion [14-16].

On the other hand, in the present study the samples elaborated under the pressure-heat technique, recorded the best results of the tests carried out so that, in addition to the pressure and water temperature (40-46°C) is the processing technique allows the material to present better characteristics which can be related to the glass transition point (at low temperatures are hard, rigid, fragile and vitreous, at high temperatures are rubbery or leathery) that does not occur abruptly and allows the accommodation molecular is more ordered.

In orthodontics acrylic resin provides the means to hold the hooks or attachments of the devices, and one of its objectives is to provide stability and retention, as well as adhesion to the mucosa, it is important that the device made with a resin-based material Acrylic autopolimerizable present the best physical and mechanical properties to increase the likelihood of success in the treatment, as well as better acceptance by the patient.

Although the porosity test was not carried out in this study, it could be thought that due to the high values of sorption and solubility of the group 1 samples, these could have a higher porosity. Also, the highest values of water sorption observed in the group 1, that could be related to a low content of residual monomer and a higher degree of conversion. Figuerôa RMS et al., in his study where evaluated porosity, sorption and water solubility in acrylic resins found that during the cycles of polymerization cycles were found significant differences between groups for these two properties ($p < 0.013$) [17].

It is important to mention that there is little information about the physical properties of self-curing acrylics for use in orthodontics, so information was taken from tests performed on acrylic resins for dentures (thermocurables) where more information was found, in a study conducted where the soption and solubility of the water of 2 autopolymerizing acrylic resins (Duraliner II and Kooliner) and 1 acrylic thermal polymerization resin (Lucitone 550) was compared, it was found that the Duraliner II acrylic resin showed a significantly lower water sorption than the Kooliner and Lucitone 550, that is the reason why the acrylic resins autopolimerizantes fulfill with the requirements of sorption and solubility of the water [18, 19].

Conclusions

The pressure-heat processing technique used in the polymerization of NicTone® self-curing acrylic resin for the use in orthodontics is the shows the best performance, however, the pressure technique had an adequate behavior as well. On the other hand, the samples processed by the conventional technique presented disadvantages in comparison with the other two techniques.

Eventually, in this study, it was demonstrated that the conditions under which the polymerization process of the acrylic resin was carried out, which is self-polymerizing for orthodontics, has an impact on the sorption and solubility properties of the material.

Acknowledgments

We appreciate the help given by the faculty of dentistry of the National Autonomous University of Mexico for the realization of this study

Conflicts of interest

The authors declare no have conflicts of interest.

Ethical committee

Such approval is not needed.

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Citation: Laura MO, Paulina ROJ, Jizhel BCM, Alvaro GP (2019) Sorption and Solubility of Acrylic Resin Self polimer by 3 Process Techniques in Orthodontics. Dent Pract 2: 001-005.