

## The effect of denture cleansing solution (H<sub>2</sub>O<sub>2</sub>) on the water solubility of self-cured acrylic resin

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### ABSTRACT

**Introduction:** Denture cleanser must be able to remove bacterial plaque layers, eliminate food debris, with non-toxic properties. Denture cleansing was performed by immersing the denture into a solution of H<sub>2</sub>O<sub>2</sub>. Continuous denture wear can lead to plaque accumulation of *Candida albicans* colonies thus causes denture stomatitis. There was a slight dimensional stability difference of the self-cured acrylic base compared to the heat-cured after immersion in water. This study was aimed to analyse the effect of denture cleansing solution (H<sub>2</sub>O<sub>2</sub>) on the water solubility of self-cured acrylic resin. **Methods:** Twenty-four specimens of self-cured acrylic resin sized 15 x 20 x 2 mm, were divided into the control group (n = 12) and the treatment group (n = 12). All specimens were then immersed in the aquadest (control group) and H<sub>2</sub>O<sub>2</sub> (treatment group) for 6, 8, and 10 hours consecutively. **Result:** The average water solubility of self-cured acrylic resin soaked in H<sub>2</sub>O<sub>2</sub> solution at 6 hours was 0.0007 µg/mm<sup>3</sup>; at 8 hours was 0.0011 µg/mm<sup>3</sup>; and at 10 hours was 0.0013 µg/mm<sup>3</sup>. The average water solubility of self-cured acrylic resin soaked in aquadest solution at 6 hours was 0.0013 µg/mm<sup>3</sup>; at 8 hours was 0.0080 µg/mm<sup>3</sup>; and at 10 hours was 0.0125 µg/mm<sup>3</sup>. **Conclusion:** The water solubility of the self-cured acrylic resin immersed in the H<sub>2</sub>O<sub>2</sub> solution for 6, 8, and 10 hours was still below the ISO standard.

**Keywords:** Self-cured acrylic resin, H<sub>2</sub>O<sub>2</sub>, immersion time, water solubility

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### INTRODUCTION

The acrylic resin had been used in the field of dentistry since 1946. Approximately 98% of all

denture bases were made from polymeric materials or methyl methacrylate copolymers. Acrylic resin is one of the basic ingredients used to make denture bases because of the material availability,

relatively simple application technique, satisfying aesthetic results and well-known amongst dental practitioners.<sup>1-3</sup>

There are two types of acrylics according to ADA (American Dental Association), namely acrylic resin, which is polymerised by heat curing and chemical activation (self-curing acrylic).<sup>4</sup> The prosthetic bases made both those using self-curing acrylic, and acrylic heat curing is similar. However, each has advantages and disadvantages in the work process and the results obtained. The basic process of prostheses with self-curing acrylic manipulation is easier and the time needed is relatively shorter, because it does not use heat energy and can be done at room temperature, unlike acrylic heat curing which requires heat energy and a longer time.

Self-curing acrylic resin is one of the dental materials that has been widely applied for the manufacture of print spoons, tooth repair, addition of postdam on the base of the maxillary denture, and role in relining and rebasing with satisfactory results, both in terms of aesthetics and function.

The shortage of acrylic resins is that they have low strength and hardness so that the base can often crack or even fracture, bad thermic delivery, easy abrasion during cleaning or use. Even though it is in a small degree, acrylic resin can also absorb the liquid that enters the mouth because this type of resin also has porosity properties. Porosity on the denture base can occur due to bubbles/porosity on the surface of the acrylic resin plate which can affect the physical properties of the acrylic resin. The physical properties of acrylic resins are important for the accuracy and function of removable dentures. The mechanism of water absorption of acrylic resin self-curing occurs through diffusion. Diffusion is the transfer of a substance through the cavity. Methyl methacrylate polymers or copolymers absorb relatively little water when placed in a wet environment. However, this absorbed water has a real effect on the mechanical properties and dimensions of the polymer.<sup>5,6</sup>

Acrylic denture base resins are soluble in various solvents; acrylic base resins are generally insoluble in liquids found in the oral cavity. The American Dental Association specification no. 12 for denture base polymers formulates the testing of resin solubility; this procedure is soaking the

acrylic denture base in water, the plate is dried and reconsidered to determine weight loss.<sup>4</sup> By specification, the weight loss for the self-cure acrylic resin must not exceed 8.0 µg / mm<sup>3</sup> of the surface of the plate.<sup>7</sup>

Denture cleaners can be in the form of creams, pastes, gels or solutions made to clean full or partially removable dentures. The ideal denture cleanser generally has the ability to remove the bacterial plaque layer and prevent it from returning, can eliminate food debris or calculus, is not toxic, and so on. Cleaning of dentures can be done mechanically or chemically. Mechanical cleaning is done by brushing the denture with a brush or soap/denture cleaning paste. While chemically cleansing is done by soaking the dentures into chemicals in the form of disinfecting solutions or mouthwash, in the form of tablets or powder, one of which is H<sub>2</sub>O<sub>2</sub> solution.

Hydrogen peroxide, better known as H<sub>2</sub>O<sub>2</sub>, is an inorganic chemical, liquid, bluish clear, slightly acidic, dissolves well in water when it decomposes naturally it will produce water and oxygen. H<sub>2</sub>O<sub>2</sub> is also an oxidiser because it can produce active oxygen which can kill bacteria and anaerobic germs by oxidising it.<sup>7</sup>

Some literature has discussed a lot about the use of H<sub>2</sub>O<sub>2</sub> which among them is used in medical treatment as a disinfectant and cleanses wounds because it can kill bacteria and anaerobic germs and also functions to slow bleeding. However, if H<sub>2</sub>O<sub>2</sub> is too long in contact with wounds and skin, it can damage healthy granulation. Therefore, the use of H<sub>2</sub>O<sub>2</sub> in the wound must be done immediately and as quickly as possible. Also, H<sub>2</sub>O<sub>2</sub> can be used as a bleach for clothes, detoxification, defence of the body against poisons, bacteria, viruses and fungi. Whereas in the field of dentistry, H<sub>2</sub>O<sub>2</sub> is used in periodontal treatments such as curettage, denture cleaners and mouthwash.<sup>5,8</sup>

Often patients use their dentures continuously and do not remove them especially at night. The use of continuous denture can lead to accumulation of plaque which can increase the colonies of *Candida albicans* as one of the factors causing denture stomatitis. Denture stomatitis can be prevented by keeping the dentures from contaminating *Candida albicans* by soaking the denture with a cleaning solution, especially at night. This study was aimed to analyse the effect

of denture cleansing solution (H<sub>2</sub>O<sub>2</sub>) on the water solubility of self-cured acrylic resin.

## METHODS

The type of research used in this study was pure-experimental by the pretest and posttest control group design study. The specimens used were 15 x 20 mm and 2 mm thick, made of self-cured acrylic material (Hillom® brand). Specimens for 2 groups of immersion solution and 3 groups of immersion time so that each group amounted to 4 pieces, so the total specimens were 24 pieces.<sup>8</sup>

The making of acrylic plates and the measurement of colour changes were carried out at the Dental Material Laboratory of the Faculty of Dentistry of Prof. Moestopo University with the procedures as mentioned. Red plasticine specimens were made with a size of 15 x 20 x 2 mm as many as 24 pieces. Type 2 gips were made into dough, the comparison of casts with water for bottom cuvette is 300 grams: 90 ml, the mixture was stirred with a spatula and inserted into a cuvette that has been prepared on top of the vibrator so that air bubbles come out of the cuvette. Wax was placed on the cast dough which begins to harden (setting) inside the cuvette and waits for the cast to harden. The cast surface on the cuvette was smeared with vaseline, and the top cuvette was filled with a dough cast over the vibrator so that the air bubbles come out of the cuvette. After casting the setting, the wax was removed using cuvette soaked in hot water, then the cuvette opened, and the wax that was left behind removed. After drying, spread a cold mould seal.

Polymers and monomers were stirred in stellan pot porcelain with a ratio of 17 mg: 10 ml according to the manufacturer's instructions. The mould which has been smeared with the separator was filled full with acrylic resin dough. The plastic sling was placed between the top and bottom cuvettes, then closed and pressed slowly with a hydraulic press at a pressure of 1160 psi (80 bar). The cuvette was then reopened, and the excess acrylic is cut off, then the cuvette is closed again, on the pressing surface again, then the bolt is installed. The cuvette is stored at room temperature for 90 minutes, after which the cuvette was opened. The specimen was

removed from the cuvette and then trimmed to remove the sharp part using the Fraser bur. The specimens were then flattened and trimmed using a rotary grinder. The surface of the specimen was smoothed using a white stone bur, followed by using abrasive paper under water to produce a completely flat and smooth surface. After that, all the specimens were washed with water to remove the remnants of acrylic and stored in the desiccator for 24 hours.<sup>8-11</sup>

Then the specimens were treated, by dividing into 2 groups of immersion solution, each of the 4 specimens for the group soaked for 6, 8, and 10 hours in 3% H<sub>2</sub>O<sub>2</sub> solution (Akbar Citra Medical, Jakarta, Indonesia) and 4 more specimens for the group soaked for 6, 8, and 10 hours in distilled water solution. The specimens were removed and cleaned with water then placed on dry tissue at room temperature, and then the specimens were dried in a desiccator for 24 hours.

First weighing was performed towards the initial mass of each acrylic specimen using analytical balance (Adventurer, Excellent Scale, China). Prepare 15 small pots for each soaking. Each one is filled with 10 ml of liquid. In one group of liquid, all 15 pots were divided into 3 groups, each group has 4 labelled pots. Each pot group was marked for 6 hours, 8 hours, and 10 hours immersion consecutively. The immersion period was counted using a stopwatch – the second weight was calculated without drying with silica gel (m<sub>2</sub>). Immersion was carried out in 2 types of solutions, namely Aquadest (control group) and H<sub>2</sub>O<sub>2</sub> (treatment group). Drying was performed using silica gel in a closed place that has been coated with mosquito wire for 24 hours – the third weight was calculated after drying with silica gel (m<sub>3</sub>). The water solubility value (Wsl) of each acrylic resin specimen was later calculated using the formula:  $Wsl = (m_1 - m_2) / V$ ; where m<sub>2</sub> is the mass of acrylic resin after immersion in the solution, m<sub>1</sub> is the initial mass of acrylic resin prior to the immersion, and v is the volume of acrylic resin specimen. The mass unit was µg and volume was mm<sup>3</sup>.

The univariate and bivariate analysis was performed in the form of a two-way ANOVA test using the SPSS® program. Univariate analysis was performed to see the average resin water solubility in 6, 8, and 10 hours. The Shapiro Wilk

One-Sample test was used to see whether the data distribution was normal or not; if normal, then the parametric statistical test can be carried out, if not, the Kruskal Wallis test must be performed.

**RESULT**

The weight difference of the self-cured acrylic resin before immersion (m1) and after immersion (m3) in Aquadest or H<sub>2</sub>O<sub>2</sub> solution was then divided by the weight of the specimen to obtained the water solubility data of each self-cured acrylic resin specimen. The following Figure 1 is a graphic of data from the results of water solubility of each self-cured acrylic resin specimen immersed in Aquadest and H<sub>2</sub>O<sub>2</sub> solution.

Data from the observation on the immersion of self-cured acrylic resin in the H<sub>2</sub>O<sub>2</sub> solution are presented in Figure 1. The average water solubility of self-cured acrylic resin immersed in H<sub>2</sub>O<sub>2</sub> solution at 6 hours was 0.0007 µg/mm<sup>3</sup>, then at 8 hours was 0.0011 µg/mm<sup>3</sup>, and finally reached 0.0013 µg/mm<sup>3</sup> at 10 hours.

Figure 1 shows a change in the water solubility value of self-cured acrylic resin after immersion in 3% H<sub>2</sub>O<sub>2</sub> solution for 6, 8, and 10 hours. Based on these data, a normality test was conducted on the solubility of water self-cured acrylic resin in aquadest (control group) and 3% H<sub>2</sub>O<sub>2</sub> solution. The results of the Shapiro-Wilk normality test showed a significant value of p > 0.05 even though the data transformation had been done to obtain a p-value < 0.05 (Table 1),

thus the statistics used was the non-parametric test, namely the Kruskal-Wallis hypothesis test, to find out whether there were significant differences between the water solubility groups after the Mann-Whitney test was conducted to determine which time group had a significant difference (Table 2). Thus, it can be concluded that the

Table 1. Normality test (Shapiro-Wilk test) results of water solubility in aquadest and 3% H<sub>2</sub>O<sub>2</sub> solution

Significant	Aquadest water solubility	3% H <sub>2</sub> O <sub>2</sub> solution water solubility
6 hours	0.001*	0.406
8 hours	0.007	0.051
10 hours	0.003*	0.001*

\*significant: p < 0.05

Table 2. Mann-Whitney test of water solubility in the immersion with 3% H<sub>2</sub>O<sub>2</sub> solution (6 hours, 8 hours, and 10 hours groups)

Significant	6 hours	8 hours	10 hours
6 hours	---	0.037*	0.044*
8 hours	0.037*	---	0.741
10 hours	0.044*	0.741	---

Table 3. Mann-Whitney test of water solubility in the immersion with aquadest solution (6 hours, 8 hours, and 10 hours groups)

Significant	6 hours	8 hours	10 hours
6 hours	---	0.617	0.874
8 hours	0.617	---	0.762
10 hours	0.874	0.762	---

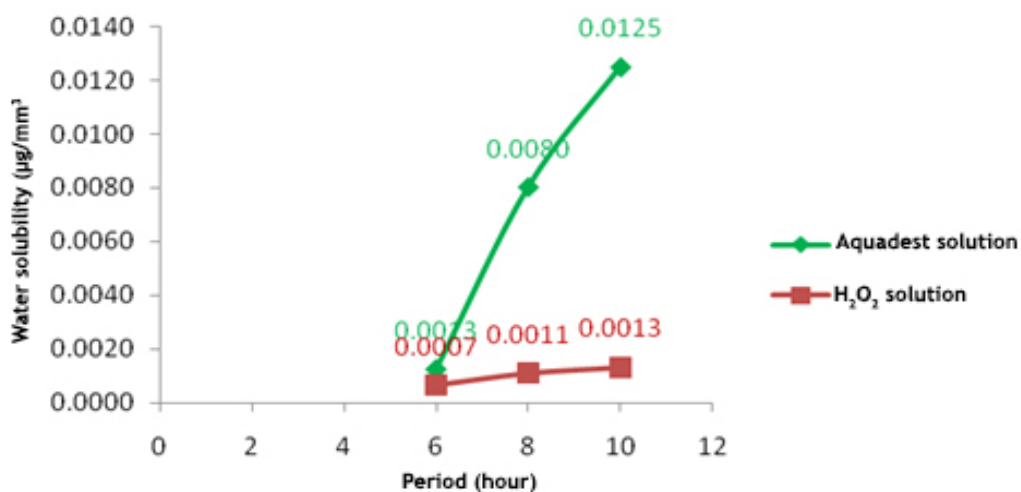


Figure 1. Graph of water solubility value of self-cured acrylic resin immersed in Aquadest and H<sub>2</sub>O<sub>2</sub> solution

group with no significant difference ( $p > 0.05$ ) was the group of 8 hours and 10 hours. This result showed that there was no difference in the water solubility of self-cured acrylic resin, between the 8-hours immersion time and 10-hours immersion time in the H<sub>2</sub>O<sub>2</sub> solution. However, the difference result between the 6-hours and 8-hours immersion time group, also, between 6-hours and 10-hours immersion time group were in the  $p$ -value  $< 0.05$ . These results mean that there were significant differences in the water solubility of self-cured acrylic resin between the 6-hours and 8-hours immersion time group, also, between 6-hours and 10-hours in the H<sub>2</sub>O<sub>2</sub> solution.

## DISCUSSION

Figure 1 shows that the water solubility of the self-cured acrylic resin was higher in aquadest compared with H<sub>2</sub>O<sub>2</sub>, this was because aquadest is faster to dissolve free monomers in self-cured acrylic resin, while the results in Table 2 show significant differences between immersion in 6 and 8 hours and between 6 and 10 hours. This condition can occur because the content of H<sub>2</sub>O<sub>2</sub> as a cleaning solution for dentures (specimens) plays a more significant role in producing oxygen bubbles, especially after immersion in 10 hours. The oxygen produced by H<sub>2</sub>O<sub>2</sub> is exposed to an acrylic resin longer so that the chemical bonds in the acrylic resin become tenuous and some break up so that the possibility of water entering the oral cavity is increasing. Water solubility is increasing along immersion time. This result probably explains that the longer the acrylic resin immersed in the H<sub>2</sub>O<sub>2</sub> solution, the more self-cured acrylic components dissolved in the H<sub>2</sub>O<sub>2</sub> solution. Generally, self-cured acrylic resin components that dissolve are MMA (methyl methacrylate) which is a residual monomer that can cause allergic reactions in patients.

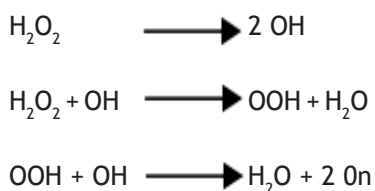
Variable solubility of the acrylic resin after immersion in aquadest and H<sub>2</sub>O<sub>2</sub> solution can occur because the solubility of the acrylic resin occurs due to the process of absorption of water by acrylic resin through a diffusion process. Water (H<sub>2</sub>O) is an autoionization which can ionise itself into negative hydroxyl (OH<sup>-</sup>) and hydrogen (H<sup>+</sup>) ions. During immersion, OH<sup>-</sup> ions will diffuse into an acrylic resin. The OH<sup>-</sup> ion that enters causes

a rapid increase in mass until the acrylic resin approaches the saturation state. The more OH<sup>-</sup> ions diffuse, the more relaxation occurs between the polymer chains. Continuous relaxation will keep the distance between the atomic bonds away, and at this time the polymeric bonds will break off, resulting in hydrolysis degradation and dissolution of the remaining monomers.

Anusavice in 2003 stated that the process of water absorption in heat cured acrylic resin diffusion using water molecules penetrating the polymethyl methacrylate mass and occupying a position between the polymer chains. As a result, the disrupted polymer chain is forced to separate.<sup>11</sup> The change in the solubility value of this self-cured acrylic resin can also occur due to the presence of bubbles/porosity on the surface of the acrylic resin plate which can affect the physical properties of the acrylic resin. Porosity tends to occur in thicker denture bases. Porosity is caused by evaporation of unreacted monomers and low molecular weight of the polymer and improper stirring between polymer components and monomers. The emergence of porosity can also occur because the acrylic resin dough is not homogeneous, the use of a comparison of polymers and monomers is not appropriate, the stirring procedure is not well controlled, and the timing of filling the material into an improper mould.<sup>6,12</sup>

Acrylic resins soaked in a solution will be affected by their physical properties. The soaking solution is capable of penetrating the acrylic resin microporous space and influencing the bond between the molecules. The bond between molecules decreases which can reduce the strength of acrylic resin including transverse strength.<sup>3,13</sup>

The presence of H<sup>+</sup> ions in this solubility will cause instability in the chemical bonds of acrylic resin. The H<sup>+</sup> ion causes degradation of the polymer bonds so that some of the monomers from acrylic resin break, which is accompanied by the release of existing fillers. H<sup>+</sup> ions in H<sub>2</sub>O<sub>2</sub> (as shown in the equation below) will cause degradation of polymer bonds so that some bonds will break. The existence of this release will create the empty spaces between the polymer matrices to increase to facilitate the diffusion of H<sub>2</sub>O<sub>2</sub> solutions from the outside into the resin. The solution penetrates the polymer bonds and occupies a position between



the polymer chains so that the polymer chain is disrupted and separated.<sup>13,14,15</sup>

Acrylic resins as other polymers have two types of bonds namely primary bonds and secondary bonds. Primary bonds are bonds between atoms in a chain while secondary bonds are bonds between chains. The primary bond of acrylic resin has good strength, but the secondary bond is weak. This weak secondary bond is thought to cause low resistance of acrylic resin. The longer the immersion period, the more solution particles can penetrate the acrylic resin microporosity space. The effect that occurs on this bond will reduce its mechanical strength, including its transverse strength.<sup>16</sup>

Water plays an essential role in hydrolytic degradation and erosion of resin material by stretching bonds in polymers. Polymer-based materials can absorb water into the matrix through a controlled (continuous) diffusion process. Water absorption that occurs will cause solution particles to penetrate and affect chemical bonds. The longer the immersion, the more solution can penetrate the microporous space. The incoming solvent molecule will penetrate and occupy a position between the polymer chains, resulting in a separate polymer chain. This separation of the polymer chain can weaken the chemical structure so that the polymer strength can decrease. Based on the theory of matrix degradation, resins soaked in water absorb water molecules and penetrate the intermolecular space of the polymer chain so that polar interactions decrease, this causes the distance between polymers to increase, then matrix expansion occurs, then the matrix softens so that resin strength decreases.<sup>14</sup>

At this time there was a noticeable reduction in the mass of acrylic resin caused by the dissolved acrylic resin component. The water solubility of self-cured acrylic resin after immersion in the  $\text{H}_2\text{O}_2$  solution also does not exceed the American Dental Association specification no. 12 for denture base polymers, and there is no effect of  $\text{H}_2\text{O}_2$  denture cleaning solution on the water solubility value of self-cured acrylic resin for up to 10 hours.

Hydrogen peroxide has the effect of dissolving self-cured acrylic resin when soaked for up to 10 hours. Significant differences were seen in groups between 6 hours and 8 hours and groups with 6 hours with 10 hours. However, this solubility is still lower than the solubility in distilled water. This result may be caused by the small concentration of hydrogen peroxide so that only a few can diffuse into the self-cured acrylic resin polymer bond.

In the control group, aquadest dissolved the self-cured acrylic resin faster because  $\text{H}_2\text{O}$  in aquadest directly caused a degradation process in the self-cured acrylic resin whereas in  $\text{H}_2\text{O}_2$  the decomposition process first became  $\text{H}_2\text{O}$ , a degradation effect in the self-cured acrylic resin began.

## CONCLUSION

The water solubility of the self-cured acrylic resin immersed in the  $\text{H}_2\text{O}_2$  solution for 6, 8, and 10 hours was still below the ISO standard.

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