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Evaluation of Some of the Properties of Stellon QC-20 Acryl

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Abstract: For improvement of dental services, quality control of dental material such as denture resins seems to be necessary. By quality enhancement of these products, both patient and dentist will be satisfied. The purpose of this study was to assess some practical properties of Stellon QC-20 denture base resin (made by Dentsply Co.) according to ISO 1567. This research was an experimental study according to ISO 1567. Test methods and number of samples were determined in ISO. Assessed parameters were: homogeneity, packing plasticity, color stability, translucency, porosity, bonding to synthetic teeth, residual monomer and flexural strength. Acryl in homogeneity, packing plasticity and translucency passed the experiments. But, the color wasn't stable according to ISO 7491. Also, it was failed in bonding to synthetic teeth. Residual monomer content of 8 sample solutions was more than 2.2%. So, it was failed in this property. The manufacturer should improve the properties of this material which were failed in the experiments.

Key words: Denture base resin, ISO 1567, bonding to synthetic teeth, residual monomer, packing plasticity

INTRODUCTION

The material most commonly used in the construction of dentures is poly (methyl methacrylate). Attempts to improve the properties of this material have taken the researcher through many avenues and the reinforcement of denture base materials has been reviewed (Jagger *et al*., 1999).

In an attempt to shorten the processing time of heat-cured denture base resins, modified pour-type materials were developed (Soni *et al*., 1997). While, processing time was shortened to less than 1 hour, these resins exhibited a color change with time. In response to this, manufacturers developed rapid cure heat-activated resins (Keng *et al*., 1979; Austin and Basker, 1982; Taylor and Frank, 1950). These materials can be polymerized in less than ½ h and this has appeal to dentists and laboratory technicians who prefer heat-activated resins.

The doughing and manipulation times of a range of acrylic resin denture base polymers were evaluated in a study by Mutlu *et al*. (1992). They were examined 4 ways for evaluating rheological properties including standards. As a result, they showed a fast and accurate way except standard for this matter. So, the standards should be renewed in related to packing plasticity (Mutlu *et al*., 1992).

Academy of Denture Prosthetics stated that for a denture to be hygienically acceptable it should be non-porous because porosity will detrimentally affect the resistance of the material to staining, calculus deposition and adherent substances (The Academy of Denture Prosthetics, 1968). Porosity of poly (methyl methacrylate) denture bases also results in high internal stress and vulnerability to distortion and warpage (Craig, 2000).

ADA for the porosity of denture base polymers states, "there shall be no bubbles or voids when viewed without magnification (ADA, 1975).

Compagnoni *et al*. (2004) found that a denture base resin specifically designed for microwave poly-merization was not affected by different poly-merization cycles. Porosity was similar to the conventional heat-polymerized denture base resin tested.

May *et al*. (1996) evaluated the color stability of conventional and microwave heat-cured denture base materials processed with the microwave method. The results of this study revealed that color changes occurred after accelerated aging in heat-cured denture base resins and microwave acrylic resins processed with the microwave method. When color changes occurred, the materials became lighter and less chromatic.

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According to ISO, the pulling arrangement, being un-dimensioned would give rise to a series of loading conditions. Although, the testing procedure in this specification tends to simulate a more clinical situation, the small batch size and the loading arrangement would make repeat experiments difficult to execute and the results impossible to quantify (Synthetic Polymer Teeth, 2000).

Amin (2002) stated that if the tensile bond strength of acrylic teeth to denture base polymers is a critical property of these materials, it would appear that the use of heat-cured denture base resin for replacing or adding acrylic teeth to existing dentures and for rebasing oral prostheses would result in a longer lasting bonds between acrylic teeth and denture bases.

According to Dogan *et al*. (1995), for heat-cured resins, the longer curing times improved the tensile strength and decreased the level of residual monomer. However, the percentage elongation didn't change much (Dogan *et al*., 1995).

MATERIALS AND METHODS

This research was an experimental study according to the international organization for standardization (ISO 1567).

The polymer powder used in this study was Stellon QC-20 (Dentsply). The liquid component used was methyl methacrylate containing 0.01% hydroquinone. The liquid shall consist essentially of monomeric material compatible with the powder. It shall be clear and free of deposit or sediment when inspected. The liquid shall show no thickening or discoloration when compared with the original sample, after being maintained at 60±2°C for 24 h in a closed container in the absence of light.

All samples were prepared according to manufacturers recommendation with 50±10% of humidity and 23±2°C of temperatures.

Packing plasticity test: A sample of resin with a mass of 8-10 g was prepared in accordance with the manufacturer's instruction. Immediately prior to the recommended initial packing time, it was shaped to a thickness of approximately 5 mm, placed on the upper surface on the perforated brass die and was covered with a sheet of polyester film. At the recommended packing time, the glass plate and weight carefully was placed on top. After 10 min, the weight was removed. When the material was firm, the depth of penetration with a precision of 0.2 mm was recorded by measuring from the lower surface of the brass die to the intruded polymer and subtracted this from the thickness of the brass die. The test was repeated at the maximum working time recommended by the manufacturer. The number of holes penetrated to a depth of not less than 0.5 mm was reported.

Color stability: The resin was mixed and packed into the mould with the polyester film against the steel cover of the mould. The mixture was processed in accordance with the manufacturer's instructions, but the polyester film retained during the processing cycle. Each specimen disc had a diameter of 50±1 mm and a thickness of 0.5±0.1 mm and the top and bottom surfaces were flat.

One specimen was stored in the dark at ambient temperatures and the second one in water at 37±1°C for 24 h prior to exposure. Half of the second specimen disc was blanked off with aluminum foil and transferred to the radiation chamber. The specimen was immersed in water 37±5°C when exposed to the radiation for 24 h in accordance with ISO 7491. After exposure, the metal foil was removed before color comparison of the specimens including the unexposed specimen. Test specimens shall not show more than a slight change in color, perceptible with difficulty.

Translucency: The model of the specimen plate was invested in the denture flask. Capsulated materials were prepared in accordance with the manufacturer's instructions. The resin was prepared, packed and processed in accordance with the manufacturer's instructions. Two specimen plates were prepared using separate mixes. The specimens' plates were removed from the flasks. An opaque disc with a diameter of 10 mm was placed against one side of a polished transverse test specimen plate and was illuminated with a 40 W forsted electric light bulb placed 500 mm from the opposite side of the specimen plate. The illuminated opaque disc should be visible from opposite side of the test specimen plate.

Freedom from porosity: Six specimen strips shall be prepared. Each plate lengthwise was seeing into 3 equal strips, 64 mm long, 10±0.03 mm wide and 2.5±0.03 mm depth. The strips on the edges and equally from both molded surfaces were machined. It should be avoided overheating the specimen. All faces and edges were grinded smooth and flat on the metallographic grinding paper to the required width and thickness. They should be without any porosity. If at least 5 of them will be free of porosity, the material passes the examination.

Transverse deflection: the specimen strip prepared in the previous test was taken from water storage (37±1°C for 50±2 h) and immediately laid the flat surface symmetrically on the supports of the rig immersed in the water bath maintained at a temperature of 37±1°C. The force of the loading plunger was increased from zero, uniformly, at a constant rate of 5±1 mm min^{-1} until the specimen broke.

Bonding test: In this specification for measuring synthetic resin teeth bond strength describes a method as follows. A set of ground anterior teeth is processed against resin held in a metal form simulating gum fitting dentures. The bond is determined by subjecting the teeth to a shear-tensile (or peeling) load. The bond shall be deemed satisfactory if the fracture does not follow the tooth surface and some denture base resin remains attached to the tooth. No guide is given as to how much resin should remain attached.

Residual monomer: To determine the amount of residual monomer, 3 specimen discs, 50 mm in diameter and 3 mm thick were prepared from 3 separate mixes of the material according manufacturers' instructions. The specimens were stored in dark laboratory conditions for 24 h, then ground to a thickness of 2 mm with an automatic grinding and polishing unit under water cooling. Acetone solution (acetone and 0.02 g hydroquinone, total volume 1 L) was added to the specimens in a volumetric glass flask until the total volume was 10 mL. Specimen-containing solutions were agitated by magnetic stirring for 72 h at room temperature. To assess released residual MMA monomer in the acetone solution, the dissolved polymer must be precipitated out of the solution.

RESULTS

The powder and liquid were being free of deposit or extraneous material. Acryl could penetrate in more than 2 holes with the depth of >0.5 mm. The number of holes in initial and final packing time was 9 and 5, respectively.

The results of this study revealed that color changes occurred in this material and that was confirmed by all three observers. The illuminated opaque disc was visible from the opposite of the test specimen plate. All 9 acrylic strips were free of porosity.

The transverse deflection of one of samples was under 65MPa. Because this experiment wasn't according to standard, these results should be compared with other studies.

Cohesive failure occurred only in 3 teeth. So, that isn't according to standard.

From 9 samples, only one of them had fewer than 2.2% monomer.

DISCUSSION

Packing plasticity: Packing test in ADA and British standards is similar to ISO. There was some problem doing this test, like, recognizing the penetration of dial guge probe in resin. The study has highlighted the need for updating the current standards specification for packing plasticity of denture base polymers. Any specification test should fulfil the following being:

- Practical.
- Reproducible.
- Undertaken using inexpensive equipment.
- As simple and efficient as possible.
- Suitable for all currently available materials.

Color stability and translucency: Stellon QC-20 didn't have color stability in this research, but it was translucent. The method of color comparison is very simple in the ISO comparing new technologies to date.

Hersek *et al*. (1999) evaluated the color stability of 5 commercially available denture base acrylic resins (one of them was QC-20) in front of 3 types of artificial food dyes. All materials tested were acceptable from the standpoint of color stability for long-term exposure to this food colorants.

An *in vitro* study compared the color stability, stain resistance and water sorption of 4 materials (like QC-20) commonly used for gingival flange prostheses (Lai *et al*., 2002). All flange materials tested demonstrated color stability in air and water, but no in coffee and tea. In spite of different methods with our research, the results were similar to the above studies.

Porosity: ISO standard for the porosity of denture base polymers states, "there shall be no bubbles or voids when viewed without magnification." There is possibility that we can't see the minor porosity with eyes. It suggests that viewing with magnification shall be done or using other methods like measuring acryl in air and water for determination porosity.

Transverse strength: According to Orsi and Andrade (2004) research, among the mechanically and chemically polished specimens, transverse strength was not affected after immersion in the disinfectants for the immersion periods tested (10-60 min.). Chemically polished control and experimental (immersed in all solutions) QC-20 specimens showed significant differences in transverse strength values.

The result of our study on QC-20 in dry environment is similar to mechanical group in above research.

Bond strength: The important steps in obtaining a consistently high value denture tooth bond are thorough dewaxing of the tooth surface followed by the application of suitable resin cement. The monomer containing the greater amount of cross-linking agent gives the greatest increase in strength (Cunningham and Benington, 1999).

Suggestions for increasing bond strength:

- The use of resin cements to prime the tooth bonding surface.
- It is advisable to treat denture teeth with dichloromethane prior to denture base processing.
- Making groove in bonding surface for increasing the surface.
- Grinding the ridge lap surface.

Residual monomer: Based on this study, stellon QC-20 has a high level of residual monomer. In a study by Dogan *et al.* (1995) the curing of several commercial powder/liquid mixtures of acrylic denture base materials was carried out at different temperatures and curing times. It was found that for auatopolymerizing resins, the level of residual monomer decreased with an increase in temperature when the curing time is kept constant. For heat-cured resins, the longer curing times decreased the level of residual monomer.

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