Properties of LTV Vinyl Silicone Rubber-based Resilient Denture Base Liner and Directions for Use

by

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Abstract

The authors have developed a new type of resilient denture liner which consists of LTV vinyl silicone rubber as a principal component. The product's features include good resilience against mucosal supporting tissues and excellent properties of adhesion to the denture base resin. A further advantage is that it does not deteriorate, even after years of use. This article describes the properties of the material, the directions for its use, and several clinical examples.

Introduction

In daily clinical practice, denture-wearing patients often complain of oral mucosal pain during mastication. In such cases, the practitioner grinds the base of the denture or attempts occlusal adjustments to relieve the pain. However, in many instances, neither of these treatments alleviates the pain. The following conditions often result in oral mucosal pain due to friction with the rigid resin denture base during mastication. 1) Extreme resorption of the lower alveolar process. 2) An alveolar ridge with a sharp knife-like bone margin. 3) An alveolar ridge which is covered with thin and non-resilient soft tissue. 4) An alveolar ridge with a bulging projection or osteoma. Traditionally, dentists have treated these difficult cases by lining the resin denture base with a rubber-like, flexible and resilient material which serves as a cushion.

An ideal resilient denture lining material requires the following properties: 1) longevity without deterioration of physical properties, i.e., no change in flexibility or resilience; 2) stable and strong adhesion to the denture base resin; 3) biological stability with no detrimental effect on the oral mucosa; 4) high resistance to wear; 5) easy processing. On the other hand, denture base liners that were marketed in the past did not show longevity in the oral environment due to problems such as deterioration, discoloration, peeling off from the resin base, and failure to provide
an adequate cushion. Therefore, a new resilient denture liner which fulfilled these requirements was needed.

The authors of this article have developed a new type of resilient denture liner§ which complies with all of the above requirements. The product has an appropriate degree of resilience for oral mucosa and good adhesion to the denture base with no noticeable degeneration even after long use\(^{[1-3]}\). In addition to these benefits, its LTV (Low Temperature Vulcanization) vinyl silicone rubber-based material offers patients a highly resilient denture liner. We have been using this product in clinical experiments for more than three years, and our patients have expressed satisfaction with it\(^{[4]}\). The following is a summary of the characteristics and usage of this newly developed resilient denture liner.

### Composition and Properties

1. *Composition and vulcanization mechanism*

   This lining material is composed of a base paste and catalyst. The base paste is dimethylvinylsiloxy polydimethylsiloxane (Fig. 1) with a small amount of chloroplatinic acid (\(\text{H}_2\text{PtCl}_6\)) added and is thixotropic in form. The catalyst is a liquid-type polyhydromethylsiloxane (Fig. 2). The vulcanization mechanism is an addition reaction (Fig. 3), which does not produce any by-products and results in hardly any shrinkage.

2. *Mixing ratio*

   When forming this material from only the base paste and catalyst by a heating procedure, the mixing ratio should be 100:10 (by weight). This amount is defined as the standard ratio. When incorporating with methacrylate resin, a 100:15 mixing ratio is recommended. The useful life of the mixture is 24 hours at room temperature (25\(^\circ\)C).

3. *Vulcanization*

   There are two heating procedures for vulcanization. Both use a water bath in a stone mold, which is made in a dental flask. One method is to vulcanize the

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§: CF5005 Liner (manufacturing code number), Toray Silicone Co., Ltd., Tokyo, Japan
material at the time of curing with methacrylate resin. The material must first be heated for 60 minutes at a temperature of 70°C, and again for 120 minutes at 100°C. Another method is to heat only the base paste and catalyst. The material should be heated for 60–90 minutes at 100°C.

4. Physical properties and adhesive strength

Specimens were stored in water at 37°C and their physical properties and strength of adhesion to methacrylate resin were carefully monitored for a five-year period\(^2\). The results were as follows.

1) Physical properties of set product

The physical properties of the set product are shown in Figs. 4, 5, 6, 7 and 8. From these figures, it is clear that prolonged storage in water did not reduce the hardness, tensile strength, elongation or tearing strength of the material. The amount of water absorption was extremely small. This demonstrated that the material will retain its resilience in the oral environment for a prolonged period.
2) Strength of adhesion to the base resin

Figure 9 describes the strength of adhesion to methacrylate resin. There was no noticeable deterioration in adhesive strength despite storage in water for a long period. From this result, we are confident that the strength of adhesion to methacrylate resin would be more than adequate in the oral environment.

The mechanism of adhesion between the material and methacrylate resin is believed to include a secondary coupling due to interwound chains. In other words, as shown in Fig. 10, linear macromolecular chains from the methacrylate resin and the network of macromolecular chains from the vinyl silicone interlock with each other and create an IPN layer (Interpenetrating Polymer Network). This layer appears to function as an additional bond. Therefore, to enhance the strength of adhesion between vinyl silicone and methacrylate resin, it is important to create an IPN layer. Specifically, a mixture of silicone paste# and dough resin is made. Then, to achieve curing (vulcanization), this mixture is placed between the vinyl silicone layer and resin layer. This results in the creation of an interpenetrating layer, as shown in Fig. 10.

The adhesive strength of the silicone-resin mixture‡ and methacrylate resin is shown in Fig. 11. This strength is greater than that of silicone alone (Fig. 9). Therefore, this method is very effective for strengthening the adhesion between vinyl silicone and methacrylate resin.

5. Biological safety

This product produced no detrimental effects on any living tissue. The high safety level of silicone-based materials has already been documented in previous experiments. The safety of this material has also been proven by successful completion of test No. 434 as demanded by the Ministry of Health and Welfare (MHW) in Japan. Approval by the MHW means that the product does not contain any

# : Mixture of base paste and catalyst
‡ : Mixture of silicone paste and dough resin
Toxic or poisonous substance. Furthermore, patients wearing a tooth positioner, which has a basically similar composition to that of vinyl silicone rubber [5-8], and a further twenty-five patients (whose cases will be described later), used this liner with their dentures, and none of them reported any complaints or discomfort. During a three-year test period, no inflammation or swelling was observed among any of the former patients. All this evidence confirms that this material is biologically safe and does not produce any detrimental effects on oral mucosa.

Fig. 9 Adhesive strength of resilient material CF5005 Liner to methacrylate resin

Fig. 10 Diagram illustrating IPN

Fig. 11 Strength of adhesion of silicone-resin mixture to methacrylate resin
Lining Procedures

Lining procedures are as follows, and are basically the same as those for the processing of dentures using heat-curing resin. However, please note the distinctive features in steps 2 and 3. The differences in step 2 concern the method of filling the liner paste†, the way of making the liner-resin mixture‡ to ensure a stronger adhesive strength between the denture base resin and liner, and the method of filling. The major difference in step 3 is the heating procedure for joining the denture base resin and the liner.

Step 1. Take impression Prepare working model Prepare bite plate Mount on the articulator Prepare wax denture Conduct trial denture fitting Invest wax denture Take out wax from the mold Apply separation agent

Step 2. Fill dough resin in the mold Fill liner-resin mixture Fill liner paste Press

Step 3. Conduct heating procedures (resin and liner curing) Cool at room temperature Take out and polish Fit to patient

1. Preparation

Step 1 involves the usual procedures as described above (Figs. 12, 13). When taking an impression, the following precaution must be taken. As mentioned before, the liner is made of a resilient rubber material. Therefore, the tolerable degree of grinding performed to modify the shape must be strictly limited. Thus, it is extremely difficult to make any major adjustment at the denture base border after the denture has been completed. It is most important to take an accurate impression to determine the position of the denture base border, its thickness and size. This is done by using various functional impression techniques (Fig. 12).

†: Mixture of base paste and catalyst
‡: Mixture of liner paste and dough resin

Fig. 12 Impression-taking
2. Adjustment of Material

An example of the preparation of materials for a lower full denture is as follows:

(1) Denture base resin
   - Powder 20 g
   - Liquid 10 ml

(2) CF5005 Liner
   - Base paste 20 g
   - Catalyst 3 g (3 ml)

(3) Liner-resin mixture
   - Denture base resin
   - Powder 4 g
   - Liquid 2 ml
   - CF5005 Liner
   - Base paste 10 g
   - Catalyst 1.5 g (1.5 ml)

1) Mix 20 g of base paste with 3 g (3 ml) of catalyst. Since this mixture does not harden for about 24 hours at room temperature, neither mixing nor filling into the stone mold requires immediate action (Fig. 14).
2) Prepare a special mixture to create stronger adhesion between the denture base resin and liner (Fig. 15).
   (1) Mix 10 g of base paste with 1.5 g (1.5 ml) of catalyst.
   (2) Mix 4 g of denture base resin powder with 2 ml of liquid and wait until the mixture reaches the dough stage.
   (3) Fold the liner paste (1) above into the dough-like resin (2) above, to make a special mixture (liner-resin mixture), and store this mixture in a paper cup (Fig. 16).

3) Mix the denture base resin, powder (20 g) and liquid (10 ml), and let it set until it becomes dough-like.

3. Preparation of Spacer
   The spacer which determines the lining thickness can be made with paraffin wax or heavy-bodied silicone rubber. Press 2 or 3 sheets of paraffin wax onto the fitting surface of the saddle and cover with polyethylene film (Fig. 17).

4. Filling with dough resin
   1) Fill the stone mold with dough resin and conduct trial closure over the spacer which is placed on the fitting surface of the saddle.
   2) Remove the spacer and then eliminate the flash. Remove the dough resin to about 5 mm from the base border (Fig. 18).

Fig. 15  Mixing liner paste with dough resin
Fig. 16  Liner-resin mixture
5. **Filling with liner-resin mixture**

Carefully press the liner-resin mixture from the edge of the base border toward the center with a spatula to ensure that no air bubbles enter the liner-resin mixture, which should have a thickness of 1–1.5 mm. Then, remove the excess portion to a level of 2–3 mm from the base border (Fig. 19).

In circumstances where the base cannot be as thick as desired, such as the case with upper dentures, the liner-resin mixture need not be used. In this case, filling with the dough resin followed by the liner paste and pressing is sufficient. This procedure results in strong and stable adhesion (see Fig. 9).

6. **Filling with liner paste**

Since liner paste is thixotropic, it can be easily injected into the mold by syringe or placed in layers with a spatula. As already mentioned, there is no need to rush the filling procedure since the liner paste has a 24-hour useful life.

1) Inject the liner paste along the base border and level with a spatula (Figs. 20, 21).

2) Inject liner paste into the fitting surface of the saddle along the base border.
7. **Pressing**
   1) A pressure of 40 kg/cm² is more than adequate (Fig. 22).
   2) The excess portion of liner paste should be wiped off.
   3) The flask must be locked with a clamp.

The flash is extremely thin (30–50 µm) and should not affect the occlusal position.
8. **Curing (Vulcanization)**

   The standard curing will occur in the water bath under the following conditions:
   
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   \begin{align*}
   70^\circ C & \quad 60 \text{ minutes} \\
   100^\circ C & \quad 120 \text{ minutes}
   \end{align*}
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9. **Removing and polishing**

   The denture removal process after curing is as usual. Hardly any polishing

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**Fig. 23** Left: Lined denture immediately after removal from the mold  
Right: Completed lined lower full denture

**Fig. 24** Lower full denture for a patient with extreme resorption

**Fig. 25** Special upper full denture for a patient with torus
is needed, except for slight correction with carborundum point and sandpaper cone where flash has been removed by scissors (Fig. 23).

10. Cases

For a patient with extreme resorption of the lower alveolar process or torus, special dentures are prepared, as shown in Figs. 24 and 25. As of October 1986, twenty-five patients with dentures of this type were under observation. Reports from these patients have been highly favorable, i.e., relief from the pain and discomfort of wearing dentures. After three years of use by patients, no staining, discoloration or peeling off from the denture base resin has been observed. In addition, there is no wear despite brushing the surface of the liner, as we recommend in order to minimize the accumulation of plaque.

Postscript

In this article the authors have introduced the physical properties of, and the directions for using LTV vinyl silicone rubber-based resilient denture liner. We hope that this article has demonstrated the value and special features of this product, specifically, its lack of deterioration after prolonged use and its sustained strength of adhesion to the denture base resin. We also believe that the lining process for the denture base is a very simple and secure procedure. Currently, the material is being used in many clinical applications, and we are pleased to learn that the patients concerned are reporting no complaints. We hope that continued use of the product will result in new and expanded applications.

References