

CONDENSATION SILICONES: DO NEW MATERIALS REALLY PRESENTS BETTER DIMENSIONAL STABILITY?

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ABSTRACT

The aim of this study was evaluate the dimensional stability of some condensation silicones. The following materials were studied: Coltex/Coltoflax® - Coltène, Speedex® - Coltène, and Optosil Comfort/Xantopren VL Plus® - Kulzer.

They were evaluated by dimensional analysis and gas chromatography (GC) performed at the following times: T0, T1, T2, T3, T4, and T5 (immediately after setting, thirty minutes, two hours, twenty four hours, seventy two hours, and seven days after setting, respectively). The dimensional changes were

measured directly in the molds using a Mitutoyo microscope. The Coltex® fine/Coltoflax® and Optosil® Comfort/Xantopren® VL Plus materials presented dimensional stability for up to thirty minutes after molding, while the Speedex® material remained stable for up to two hours after molding.

The gas chromatography experiment demonstrated that these materials release ethanol even after clinical setting.

Key words: Dental Impression Materials, Polydimethylsiloxane Gas Chromatography.

SILICONAS DE CONDENSAÇÃO: NOVOS PRODUTOS REALMENTE APRESENTAM MELHOR ESTABILIDADE DIMENSIONAL?

RESUMO

Com o intuito de avaliar a estabilidade dimensional de algumas siliconas de condensação, foi realizada uma análise dimensional e um teste de cromatografia gasosa dos seguintes materiais: Coltex/Coltoflax® - Coltène, Speedex® - Coltène e Optosil Comfort / Xantopren VL Plus® - Kulzer.

Tanto as medidas de alteração dimensional quanto a cromatografia gasosa foram feitas nos seguintes tempos: T0, T1, T2, T3, T4 e T5 (imediatamente após a presa, trinta minutos, duas horas, vinte e quatro horas, setenta e duas horas e sete dias após a presa, respectivamente). A alteração dimensional foi medida

diretamente nos moldes em um microscópio comparador. As medidas de alteração dimensional demonstraram que os materiais Coltex® fine/Coltoflax® e Optosil® Comfort/Xantopren® VL Plus apresentaram estabilidade dimensional por até trinta minutos após a moldagem, enquanto o material Speedex® apresentou-se estável por até duas horas após a moldagem.

O experimento de cromatografia gasosa demonstrou que esses materiais liberam etanol mesmo após a presa clínica.

Palavras-chave: Materiais de Moldagem odontológicos, Polidimetilsiloxano, Estabilidade Dimensional, Cromatografia Gasosa

INTRODUCTION

The properties, indications, and clinical procedures recommended for each impression material must be known and observed by dentists in their own clinical practices in order to obtain precise molds.

Dimensional stability determines the time interval at which the plaster should be poured over the mold. Among the impression materials, those that polymerize without by-products (addition silicones and polyethers) have greater dimensional stability, given that the molds made from these materials can be cast up to seven days after molding. In contrast, molds cast using

materials that polymerize by condensation (polysulfides and condensation silicones), should be poured within the first 30 minutes after molding, considering that by-products are generally released during storage. In Brazil, according to findings Mello et al.¹ and Almeida et al.², 78% of all dental professionals choose to adopt condensation silicones even though they may present a lower level of dimensional stability. This demonstrates that the advantages of the materials that polymerize by addition were not enough to eliminate the use of condensation silicones on the market. Such behavior justified the appearance of two condensa-

tion silicones on the market (Speedex® - Coltène and Optosil® Comfort/Xantopren® VL Plus - Hearaeus Kulzer), which provide a prolonged dimensional stability, given that the molds can be stored for up to seven days with no loss in precision.

The dimensional stability announced by manufacturers has raised condensation silicones to a higher level in this property, reaching the level of materials that polymerize by addition. But, to the best of our knowledge, there are few studies that prove the differential behavior of the new silicones, which would be essential to allow an effective comparison among products available on the market. In this light, the aim of this study is to evaluate the dimensional stability of these materials by means of measurements carried out directly within the molds, stored at different times and check, by means of Gas Chromatography (GC), whether or not ethanol is released during the same storage times.

MATERIAL AND METHODS

The dimensional stability analysis was carried out on Optosil® Comfort / Xantopren® VL Plus - Kulzer, Speedex® - Coltène and Coltoflax® / Coltex® fine- Coltène materials, by means of direct measurements of molds using a Mitutoyo microscope. The molds were obtained by molding a master plate to a perforated plate tray, using the double molding technique. The plate tray contained perforations to retain the molding material and to fit into two dif-

ferent positions on the plate tray in such a way as to supply a 2.00 mm space for the first molding, using putty material, and a 4.00 mm space for the second molding, using light material (Fig. 1).

On the master plate, two parallel lines were drawn with a 10.0 mm space between them. Next, five more lines were drawn perpendicular to the first lines. The distances between the intersection points were then measured.

The materials were proportioned and manipulated according to manufacturer instructions. During the molding process, the plate trays were maintained in position manually, and the fittings on the master plate guaranteed the most appropriate position.

The setting time for putty materials was 4 minutes, while that for light materials was 8 minutes, at which time the plate tray was manually removed. The molds adhered to the plate trays during the entire study.

Measurements were performed using a MITUTOYO microscope, in triplicate, by two trained observers at six times intervals: T0, T1, T2, T3, T4, and T5 (immediately after setting, 30 minutes, 2 hours, 24 hours, 3 days, and 7 days after the setting). During the measurement intervals, the bodies-of-evidence were stored at an average temperature of 25°C.

In the present study, as calculated in a pilot study, the number of bodies-of-evidence needed was eight for each material. The percentage of dimensional change was calculated by the following formula:

$$\% = 100 \times (L_1 - L_2) / L_2$$

In which L_1 represents the measurement (mm) at time T0, and L_2 represents the measurement (mm) at the times to be compared (T1, T2, T3, T4, or T5), which is similar to the calculation formulated by Fano, Gennari and Ortalli³.

The Kruskal Wallis non-parametric test (significance 0.05) was used to compare the materials at the different analysis times. To compare the times studied for each material, the Friedman test (significance 0.05) was used, while the Wilcoxon test (significance 0.003) was used to identify the differing time intervals among them^{4,5}.

The GC was applied to the putty and light polymerized materials in an attempt to detect the release of ethanol from the samples at times T0, T1, T2, T3, T4, and T5.

The silicones were proportioned by weight, manipulated, and spread on 6 X 1 cm glass plates, which were placed inside hermetically sealed tubes (Vaccuet®), with

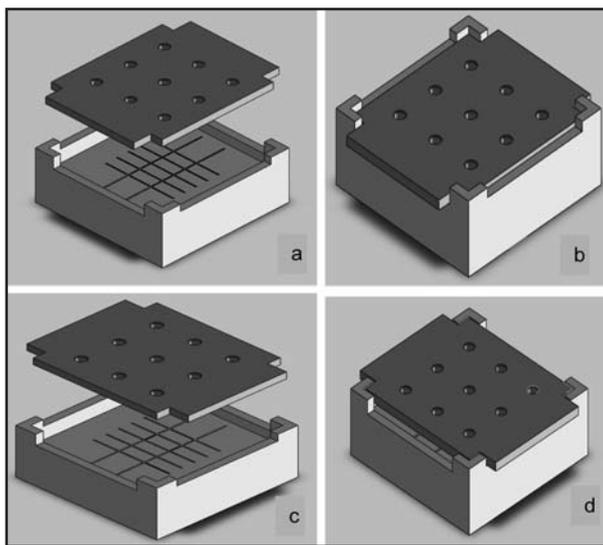


Fig. 1: Plate tray and master plate in two different positions to supply a 2.00 mm space for the dense material impression (a, b) and a 4.00 mm space for the second molding (c, d) using fluid and dense materials.

an appropriate location set in the rubber for needle puncture. Six plates and six tubes, one for each analysis time, were used for each material. The tubes were stored at room temperature of approximately 25°C and heated to 50°C for five minutes before extraction. The analyses were carried out in a VARIAN CP-3380 Gas Chromatograph, Column: SE30 30m x 0.25mm (Alltech), with the following temperatures: Column: 50°C, 5 min; Injector: 100°C, split 1/100; Detector FID: 100°C; and an injection volume of 500µl. The carrier gas used was hydrogen at a flow rate of 2ml/min.

RESULTS AND DISCUSSION

In the dimensional analysis, the Kruskal Wallis test demonstrated the p-values (0.377; 0.369; 0.504; 0.599; 0.911; 0.653 respectively at times T0, T1, T2, T3, T4, and T5). Therefore, all materials studied presented a similar behavior during the storage of their respective molds, i.e., they underwent dimensional changes. The Friedman test detected differences among the six times of interest for each material (p-values = 0.000).

The average percentage of dimensional change obtained for the measurements of all intersections of the molds is presented in Fig 2.

The negative values in the graph represent expansion, while the positive values represent contraction. From time T0 to the molding storage time of 30 min (T1), expansion was observed in the Colt看® fine/Coltoflax® material, contraction in the Optosil® Comfort/Xantopren® VL Plus material, yet practically no dimensional change in the Speedex® material was observed. For the three materials studied, the Wilcoxon statistical test demonstrated that no significant difference in this storage time was observed (p-values 0.129; 0.150; 0.536 for Colt看® fine/Coltoflax®, Optosil® Comfort/Xantopren® and Speedex® respectively). Thus, all materials can have their molds stored for 30 minutes before casting the models.

From 30 min to 2 h storage, all materials contracted. According to the Wilcoxon test, the dimensional change in the measurements taken immediately after molding (T0) up to 2 h of storage (T2) was considered to be statistically significant for the Optosil® Comfort/Xantopren® VL Plus and Colt看® fine/Coltoflax® materials (p-value 0.000). The Speedex® material did not show the same outcome (p-value 0.044). Accordingly, only

the Speedex® material molds can be stored for up to 2 h after molding, with no loss of precision.

As of 24 h, significant statistical differences were observed between T0 and all other storage times for all materials studied (p-value 0.000). It is therefore not recommended to cast models in up to 7 days using Optosil® Comfort/Xantopren® VL Plus and Speedex® materials, as laid out in manufacturer instructions.

In addition, the materials presented characteristics of different dimensional behavior, which reinforces the report by Craig *et al.*⁶ that despite generalizations made about the properties of the different types of elastomeric impression materials not all of the products of the same type and class possess the same qualities. Thus, the material should be selected based on experimental values and not on the general type of molding materials.

For Chen SY *et al.*⁷, the choice of material is the factor which could most affect precision. In addition, dimensional changes are caused mainly by reactions among components. The safest time to cast models for the Colt看® fine/Coltoflax® and Optosil® Comfort/Xantopren® VL Plus materials continues to be up to 30 min maximum, as reported in the literature by a great majority of authors for condensation silicones⁸⁻¹³. In contrast, the Speedex® molds can be stored for up to 2 hours with no loss of precision. These results are in agreement with findings from Guimarães *et al.*¹⁴ and Nishioka *et al.*¹⁵.

Of the materials studied, the Colt看® fine/Coltoflax® materials presented the lowest level of dimensional stability, with diverse changes of both contraction

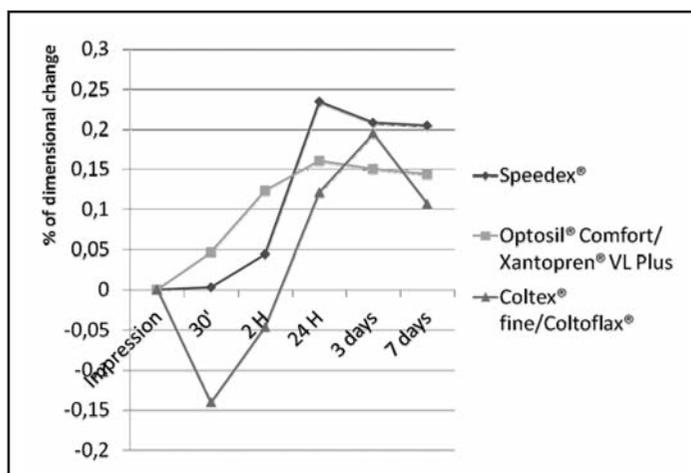


Fig. 2: The average percentage of dimensional change obtained for three materials, at times T1, T2, T3, T4 and T5 (30 minutes, 2 hours, 24 hours, 3 days and 7 days after setting) in relation to T0 (immediately after setting).

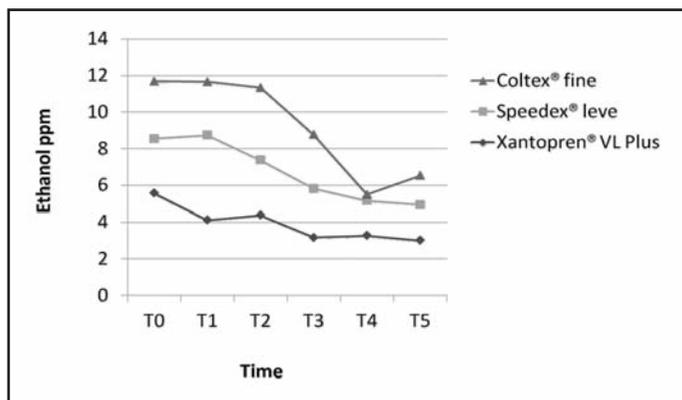


Fig. 3: Ethanol release (ppm) from fluid materials, at times T0, T1, T2, T3, T4 and T5.

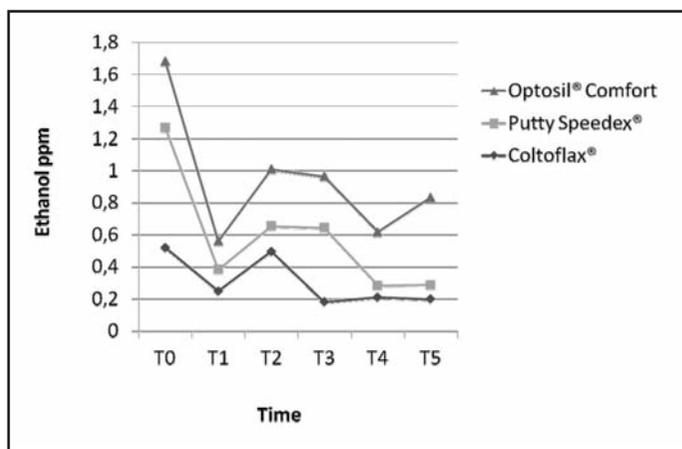


Fig. 4: Ethanol release (ppm) from dense materials, at times T0, T1, T2, T3, T4 and T5.

and expansion. A delay in the molding process using these materials can bring about greater consequences concerning the precision of the models. Brown¹⁶ listed a number of factors that may affect the dimensional stability and precision of the molding materials, among which are thermal effects stemming from the difference between the temperature of the oral cavity and room temperature, the tissue's absorption of water while taking the impression, and the elastic recovery, mainly when molding retentive areas. Brown considers that these factors often occur concurrently, making it difficult to individualize the contribution of each as regards dimensional changes. In the present case study, only two factors mentioned by Brown regarding dimensional factors were actually observed: continuing polymerization and the loss of volatile constituents after polymerization, during storage of the molds, which is also supported by the findings of Fano, Gennari, and Ortalli³.

According to the literature, the main reason behind the low dimensional stability of the condensation silicones lies in the formation of ethyl alcohol as a byproduct during the polymerization reaction, which may continue even after the setting of the material. Thus, the evaporation of the by-product, and the consequent contraction due to polymerization, would remain continuous^{1,13,17-19}.

The results of the GC are shown in Fig 3 and 4. These graphs show that ethanol was released from all materials at the evaluated times. The putty materials released less ethanol than the light materials. This outcome was expected, given that the quantity of the polymeric matrix is proportionally lower due to the quantity of the load added to it to provide an appropriate working consistency, Anusavice¹³, Craig and Powers²⁰ emphasized that the putty materials would undergo a lesser level of polymerization contraction than would the light materials, due mainly to the load added to these materials. The values obtained using the GC technique did not comply with a defined release standard. One possible explanation is the absorption of ethanol by the polymer, or even the imprisonment of ethanol in the polymeric mass, hindering its release within the tubes. This premise is consistent and may well explain the expansion found in the dimensional analysis for the Coltex® fine/Coltoflax® material at the time intervals of T0 to T1, as well as for the other two silicones studied at the final storage times.

The results of this study demonstrate that there is no mandatory contraction during the storage of condensation silicones; however, a dimensional change is observed, which may cause the loss of precision of the prosthetic work should there be a delay in the pre-set times for modeling.

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CONCLUSIONS

Production of ethanol in the polymerization of condensation silicones is observed, even after their clinical setting.

The Coltex® fine/Coltoflax® and Optosil® Comfort/Xantopren® VL Plus materials presented dimensional stability for up to 30 minutes. Thus, they should be modeled within a maximum of 30 minutes after molding. Modeling of Speedex® material can be delayed for up to two hours after molding.

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