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Short Communication

Antifungal efficiency of chemically and thermally-activated acrylic resins after surface treatment using poly (diallyldimethylammonium chloride)

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Abstract

Introduction: Acrylic resins are used in the preparation of facial prostheses and may be colonized by fungi. Here, we verified the antifungal efficacy of this material after surface treatment using poly (diallyldimethylammonium chloride). **Methods:** Acrylic resin specimens with and without surface treatment were subjected to tests for fungistatic and fungicidal activities. Standard strains of *Candida albicans* and *Aspergillus niger* were used. **Results:** After surface treatment, the fungistatic and fungicidal efficacies of the resins against *C. albicans* and fungistatic action against *A. niger* were verified. **Conclusions:** The surface treatment was a determinant of the antifungal activity of the material.

Keywords: Acrylic resins. Biocide. Dental materials.

Acrylic resins are widely used for various applications due to their favorable characteristics, such as biocompatibility, ease of processing, polishing capacity, and low cost. In dentistry, these materials are used to rehabilitate facial and stomatognathic structures affected by pathologies, trauma or surgery, restore aesthetics and function, and assist in psychological therapies[1,2].

However, the susceptibility of these resins to the adhesion of microorganisms, particularly in cases of poor patient hygiene, is the main cause of infections and inflammation of the area in contact with the prosthetic material[3,4].

Given this situation, there is a worldwide trend of testing antimicrobial agents together with the dental and medical materials in order to avoid its colonization with bacteria and fungi[5-8]. The results, however, are quite varied and the antimicrobial mechanisms of some agents, such as poly (diallyldimethylammonium chloride) (PDADMAC), used for the surface treatment in dentistry, are still not fully understood,.

PDADMAC has quaternary ammonium salts in its structure and is classified as a biocide. Some of its advantages include low cost and biocompatibility and, currently, it is being used on a large scale for water purification[9,10,11]. In 2016, Silva et al. observed that these resins, upon surface treatment (TS), became efficacious against bacteria, but were not tested against fungi[8].

Therefore, the present work aimed to evaluate the antifungal potential of the PDADMAC biocide when applied on the surface of a chemically activated acrylic resin (CAAR) and thermally activated acrylic *resin* (TAAR).

Round test samples measuring 3 cm in diameter were made with CAAR and TAAR of the Clássico® brand (São Paulo, SP). The TAAR was activated in long cycles at a low temperature (60ºC for 3 h and 70ºC for 9 h). The test specimens were separated into four groups as shown in the flowchart (**Figure 1**). Two of these groups were subjected to TS by the application of PDADMAC (Chemical Institute, University of São Paulo, Brazil) at concentration of 4% weight per 10 mL of

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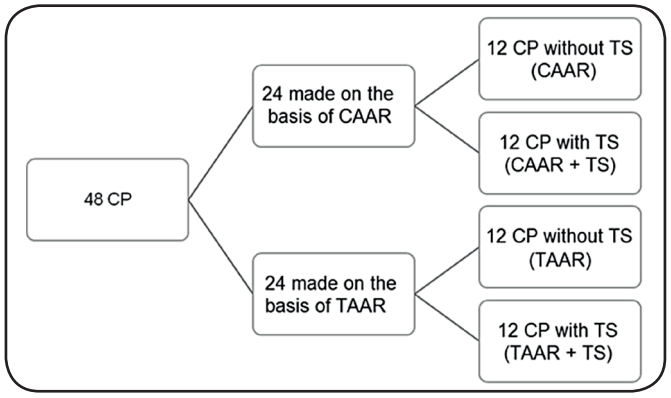

FIGURE 1: Flow chart demonstrating the preparation of test specimens. **CAAR:** Chemically activated acrylic resin; **TAAR:** Thermally activated acrylic resin; **TS:** Surface treatment.

tetrahydrofuran solvent (Labsynth, Diadema, SP). The drying time was set as ten minutes. The other groups did not undergo TS with the compound.

Totally 48 test specimens were subjected to sterilization with gamma radiation at a dosage of 25 KGy[12]. A culture suspension of 100 µL *Candida albicans* (ATCC 10231) and *Aspergillus niger* (ATCC 16404) at a concentration of 10^6 UFC were spread on the agar surface. Mycological tests were performed as per the protocols of the American Association for Testing and Materials for assessing the antifungal properties of the material against the standard strains using a Biorad brand spectrophotometer. The conidia and blastoconidia of *A. niger* and *C. albicans* were used to perform the tests.

The fungistatic property was verified by the G21-15 test[13], where the test bodies were placed in contact with petri dishes containing Sabouraud dextrose agar (Sigma, USA) and the two fungi mentioned above. The results were recorded after 7, 14, and 28 days of incubation and depending on the extent of fungal growth, a visual classification score was established as follows: 0 (no growth), 1 (growth traits), 2 (mild growth), 3 (moderate growth), 4 (abundant growth). This test was performed in triplicates.

The fungicidal properties were analyzed by the E2149-13[14] method in which the fungal solution was cultured in 50 mL of phosphate buffer and the experimental materials were placed into it. This solution was collected at two different timepoints as follows: initial concentration of viable microorganisms (0 hours) and final concentration (1 hour) followed by determination of the percentage reduction of the colony forming units (CFU). The test was performed in triplicates.

The Shapiro-Wilk test was used to check the assumption of normality of the data distribution of the fungicidal tests. A Student's t test was used to observe the differences between the control and TS groups and the test for repeated measures was applied in order to observe the differences between the initial and final measurements of each of these groups. A significance level of $p < 0.05$ was established.

The fungistatic tests G21-15 against *C. albicans* showed that the TS samples maintained a score of 0 at the three evaluation timepoints, demonstrating significant efficacy. Contrarily, the score of the control samples increased gradually, indicating that fungal growth was not prevented. The results were similar to those observed for *A. niger*. The efficacy of TS samples was significantly different from that of the control (**Figure 2**).

The fungicidal tests E2149-13 showed that the control samples were not able to reduce fungal growth. In the TS samples, a reduction of about 99.99% against *C. albicans* strains and 0% against *A. niger* strains (**Table 1**), was found for both the resins.

The antifungal effect in acrylic resins is widely evaluated in literature. Several antimicrobial agents have already been tested in dental and medical devices. Amal and Amani, in 2016[6], have shown that the addition of henna powder to the acrylic resin prosthesis may be effective in controlling the proliferation of *C. albicans* on its surface, but further studies are required

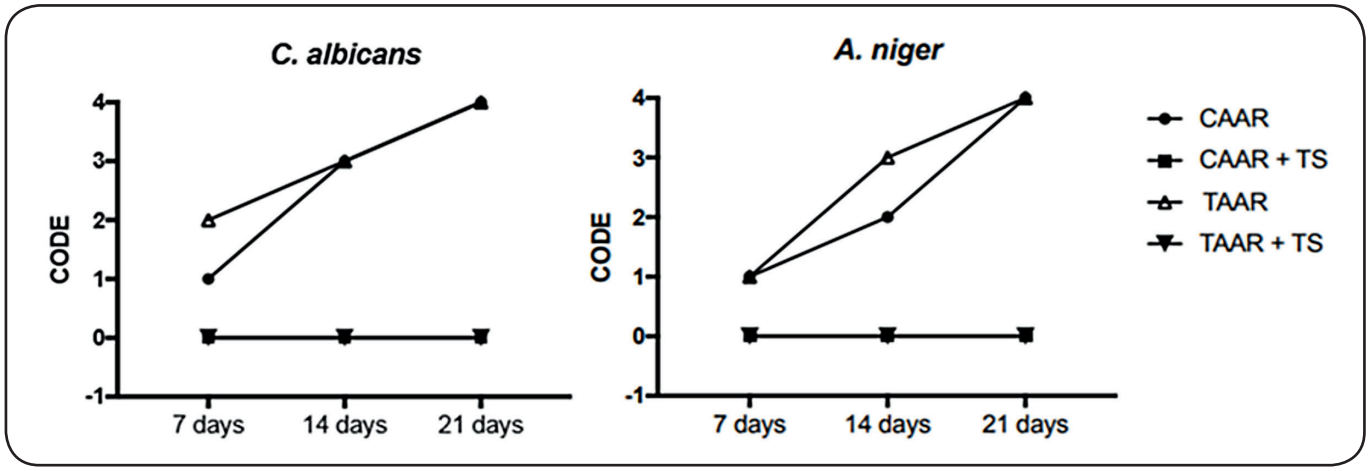

FIGURE 2: Intensity of fungal growth of *Candida albicans* and *Aspergillus niger* represented by the G21-15 test codes analyzed at three different times. **CAAR:** Chemically activated acrylic resin; **TAAR:** Thermally activated acrylic resin; **TS:** Surface treatment.

TABLE 1: Fungi Count for *Candida albicans* and *Aspergillus niger*.

	Candida albicans					*Aspergillus niger*				
	Initial Average	Final Average	Logarithmic reduction or increasing	% of Reduction	p-values	Initial average	Final average	Logarithmic reduction or increasing	% of Reduction	p-values
CAAR	2.2×10^5	2.3×10^5	+0.02	-	0.0572	1.5×10^5	1.6×10^5	+0.05	-	0.1835
CAAR + TS	2.2×10^5	1.6×10	-4.16	99.99	<0.0001*	1.5×10^5	1.6×10^5	+0.05	-	0.0377
TAAR	2.2×10^5	2.5×10^5	+0.06	-	0.0634	1.5×10^5	1.8×10^5	+0.07	-	0.0153
TAAR + TS	2.2×10^5	1.4×10	-4.21	99.99	<0.0001*	1.5×10^5	1.8×10^5	+0.06	-	0.0198

CAAR: Chemically activated acrylic resin; **TAAR:** Thermally activated acrylic resin; **TS:** Surface treatment. *Statistically significance: p<0.05.

to determine its physical properties. Jain in 2013[8] tested the application of delmopinol on the surface of the thermally activated acrylic *resins* and obtained a higher reduction in the adherence of *C. albicans* after contamination when compared to that before the application of delmopinol.

The effect of the PDADMAC biocide in acrylic resins has been described in a few studies. However, in these studies, it has not been used for dental applications and therefore the influence of different types of polymerization types of this material have not been considered.

Sanches in 2015[15] evaluated the acrylic resin with PDADMAC using nanoparticles and positive results were observed with respect to its antifungal activity against *C. albicans*. However, in this study, a polymethylmethacrylate resin was synthesized together with PDADMAC. Similar to the study by Amal and Amani[7], these studies have constructed a type of inclusion that can interfere with the physical properties of the material. Our study, however, did not require an evaluation of the physical and mechanical properties of the material since a surface treatment of the resins was carried out.

Additionally, the materials are biocompatible because there is no molecular interaction between the PDADMAC and the resins. However, this lack of interaction implies a limitation, since, in environments with secretion interferences such as saliva, the biocide could leach and consequently its antifungal properties could be lost. Thus, to understand the impact of these interferences, new studies are being conducted.

The surface treatment using PDADMAC was a determinant of the antifungal activity and this activity was not influenced by the type of resin treatment. Its action was proven in thermally activated acrylic resins and when it was chemically activated against *C. albicans*. Contrarily, only its fungistatic action was proven against the fungus *A. niger*.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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