A device based on aerogel silica: physicochemical characterization and antimicrobial test

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Chlorhexidine has been widely used in endodontic therapy due to its antimicrobial efficacy, highly substantivity and few adverse effects when used in low concentrations. To improve its implementation, the aim of this work was to prepare, characterize and evaluate the kinetics of release, the antimicrobial activity and cytotoxicity of a composite containing a chlorhexidine controlled release system based on nanoparticle porous silica (SiO2) containing chlorhexidine acetate (CxA) or gluconate (CxG), and its inclusion compounds with β-cyclodextrin (βcd).

Methods: Two inclusion compounds were prepared in 2:1 molar ratio, βcdCxA and βcdCxG, and four release systems based on porous silica (S): SCxA, SCxG, SβcdCxA and SβcdCxG. The inclusion compounds were characterized by infrared spectroscopy, thermal analysis TG/DTG and DSC, X-ray diffraction and nuclear magnetic resonance 1H and NOESY. The results showed the interactions between the drug and βcd, confirming the inclusion compounds formation. The controlled release systems and modified composites were physico-chemically characterized and compared on the release kinetics of chlorhexidine by UV-vis spectroscopy. The silica matrix degradation was performed by plasma ionization measuring the total silicon. Cx controlled release systems were also submitted to morphological analysis by scanning electron microscopy and textural characterization by N2 adsorption/desorption. The release systems in vitro effectiveness was evaluated against the Enterococcus faecalis (E.f.) and Candida albicans (C.a.) by the "pour plate" method.

Results: All systems and pure antimicrobial agents were biologically active against the tested microorganisms. However, the SβcdCxG system showed the lowest inhibitory concentration, 25 µg/mL, against E. f, and facing C. a., all systems had the same inhibitory concentration of 50 µg/ mL. In a second step, the silica systems containing Cx or its inclusion compounds were incorporated in the autocure resinous cement, Cement-Post Angelus® (C), producing the following modified composites: CSCxA, CSCxG, CSβcdCxA and CSβcdCxG, and to compare the cement was also modified by the addition of pure antimicrobial agents forming CCxA, CCxG, CβcdCxA and CβcdCxG. The systems SCxA and SβcdCxA showed higher drug incorporation rates and degradation of the silica matrix when compared to SCxG and SβcdCxG, and all difratograms exhibited an amorphous profile. The antimicrobial effectiveness of modified cements with chlorhexidine and its inclusion compounds incorporated or not in the porous silica was evaluated by the agar diffusion method against E.f. and C.a. In this test all modified composites exhibited inhibition of microbial growth.

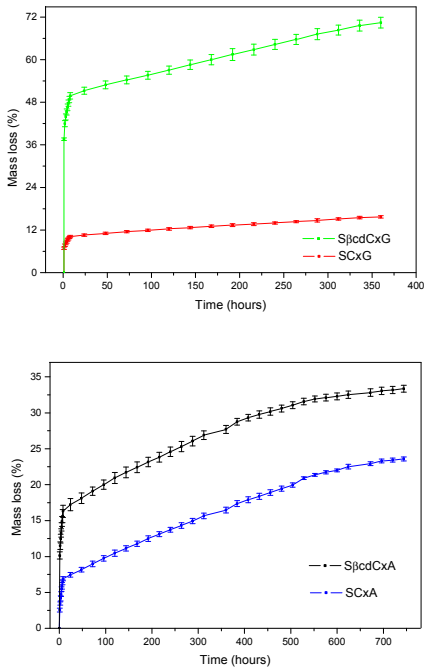

Fig. 1 Cumulative release of the clorexidine system incorporate based on aerogel silica

The microorganisms were very susceptible to the modified composite with free gluconate, CCxG, and βcd included acetate, CβcdCxA, showing inhibition zones of 18 and 16mm, respectively. The cytotoxicity of pure materials, inclusion compounds, silica systems and pure and modified cements, in a primary culture osteoblasts was determined by the MTT assay. The assay showed the silica biocompatibility and no cytotoxic effect on osteoblasts was observed and pure cement reduced cell proliferation by 22%. All values for modified composites are higher than those presented by systems and pure antimicrobial agents. There was statistically significative difference between groups (ANOVA, $p < 0.05$).

Conclusions: The release systems based on porous silica are able to maintain a constant release of chlorhexidine, both in free form, as in the inclusion compound form, and the inclusion in βcd did not influence the kinetic model. The composites modified by the systems incorporation showed controlled release, effective antimicrobial activity and low cytotoxicity when compared to the pure cement, and those are promising for use in vivo. Although, it must be also study their physical and mechanical properties.

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