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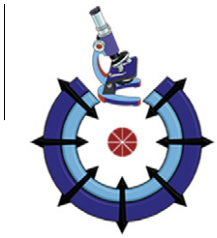

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ARTICLE

Effect of incorporation of nano bioactive silica into commercial Glass Ionomer Cement (GIC)

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Abstract Four types of bioactive nano-silica were prepared by different methods, and were used to improve commercial dental Glass Ionomer Cement (GIC) bioactivity. The prepared powder samples were characterized by X-ray diffraction (XRD) to identify the formed phase; particle size and morphology were assessed by transmission electron microscope (TEM). The bioactivity of the prepared powder samples and its dental cement blends were applied in simulated body fluid (SBF). The change in surface morphology and composition after soaking in SBF after week at 37 °C were determined by scanning electron microscopy with energy dispersive spectroscopy (SEM with EDS) and Fourier transform infrared analyses (FTIR). Our results confirmed that the prepared silica powder exists in nano-scale. Precipitations of carbonate–apatite on the silica surface were observed by FT-IR spectroscopy and scanning electron microscopy. Silica dissolution and re-precipitation phenomena were also observed from SEM. The relationship between both phenomena during the in vitro test is discussed mainly in terms of structural and microstructural

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features of the silica. Combination of bioactive nano-silica with dental cement improves its bioactivity, which may be helpful to overcome marginal gap formation which is major disadvantage of the commercial dental cement.

1. Introduction

Tooth decay is one of the most common diseases and accounts for almost half of all tooth extractions. Dental restorations do not last forever; over 60% of all restorative dentistry is for the replacement of restorations.

Secondary caries detection after placement of a restoration in a cavity may be due to one or more of many factors involving the material, the cavity, the patient and the operator or technique. In the absence of clearly defining factors involved in the occurrence or recurrence of the carious process, the presence of secondary caries is often interpreted as a function of the material properties if all other confounding factors are kept to minimum [1]. New restorative materials are often marketed and introduced into practice with limited evidence on their long-term clinical performance. Glass Ionomer Cement is commercial dental cement. The use of Glass Ionomer Cements has some limitations in very specific circumstances, like physical strengths, water sensitivity which leads to formation of marginal gap due to shrinkage of the dental cement.

The first Bioglass was invented by Hench [5]. Because of the good bioactivity, osteoconductivity and biodegradability [17,23], bioactive glasses have been used in clinic for more than 10 years, as bone repair materials [23,4]. In the last decade studies showed that the degradation products of bioactive glasses could stimulate the production of growth factors, cell proliferation and activate the gene expression of osteoblast [11,22]. Moreover, bioactive glass is the only one, which could bond to hard and soft tissue [6].

The in vitro behavior of bioactive silica-based materials obtained by sol–gel was mainly attributed to two factors. Li et al. [10] proposed that the high concentration of SiOH groups on the sample surface could promote hydroxyl carbonated apatite nucleation. On the other hand, the surface microstructure of the silica-gel samples has also been related to in vitro bioactivity. Pereira et al. [18] reported that those silica-gel samples with high porosity volume and pore size >2 nm are suitable for inducing in vitro HCA formation in simulated body solutions. Bioactive silica-gel samples evaluated by Li et al. [10] which induce HCA deposition also presented nano-size to a great extent. Furthermore, these samples also presented a particular interconnected microstructure with micrometric pores, but no comments were made about the influence of the sample microstructure on their in vitro response. The porous structure resulted from the hydrolysis and polycondensation of silicon alkoxides in the presence of an organic, non-reactive polymer. The presence of the polymer induces phase separation simultaneously with the polycondensation of alkoxide, and the resultant structure can be controlled from the synthesis parameters and initial composition of the reactive system [12].

Concerning the mechanism of the apatite formation on the surfaces of bioactive glasses and glass–ceramics, it has been proposed that hydrated silica developed on their surfaces in the body induces nucleation of the apatite. Experimentally it was confirmed that pure silica gel prepared by hydrolysis and polycondensation of tetraethoxysilane in aqueous solution containing polyethylene glycol induces the formation of the apatite layer on its surface when the gel is soaked in a simulated body fluid (SBF). These results suggest that the silanol group formed on the surface of the silica gel in the SBF could be responsible for the apatite nucleation. On the other side, recently West et al. proposed that; on the basis of molecular orbital calculation, only the silanol group forming trigonal siloxane can induce the apatite nucleation. However, this has not been proved experimentally [3,15].

In this work we aim to come over the disadvantage of GIC by incorporating nano-silica with little quantities prepared by different methods. The synthesis and in vitro evaluation of

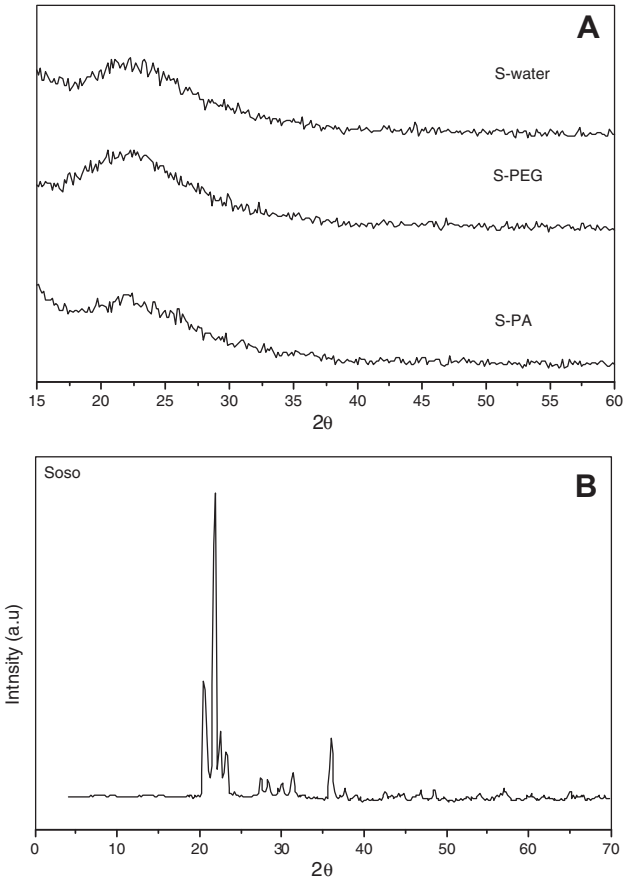

Figure 1 Represents X-ray diffraction patterns of (a): three kinds of pure silica gels S-water, S-P amide, and S-PE prepared by hydrolysis and polycondensation of TEOS in different media precursors and heated at 600 °C for 2 h and (b): shows X-ray diffraction pattern of pure silica powder prepared by hydrolysis and polycondensation of sodium silicate precursor and heated at 900 °C for 2 h sample Soso.