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Comparative Study on the Effect of Substitution of Li and Mg Instead of Ca on Structural and Biological Behaviors of Silicate Bioactive Glass

Authors : Alireza Arab, Morteza Elsa, Amirhossein Moghanian

Abstract : In this study, experiments were carried out to achieve a promising multifunctional and modified silicate based bioactive glass (BG). The main aim of the study was investigating the effect of lithium (Li) and magnesium (Mg) substitution, on in vitro bioactivity of substituted-58S BG. Moreover, it is noteworthy to state that modified BGs were synthesized in 60SiO₂–(36-x)CaO–4P₂O₅–(x)Li₂O and 60SiO₂–(36-x)CaO–4P₂O₅–(x)MgO (where x = 0, 5, 10 mol.%) quaternary systems, by sol-gel method. Their performance was investigated through different aspects such as biocompatibility, antibacterial activity as well as their effect on alkaline phosphatase (ALP) activity, and proliferation of MC3T3 cells. The antibacterial efficiency was evaluated against methicillin-resistant Staphylococcus aureus bacteria. To do so, CaO was substituted with Li₂O and MgO up to 10 mol % in 58S-BGs and then samples were immersed in simulated body fluid up to 14 days and then, characterized by X-ray diffraction, Fourier transform infrared spectroscopy, inductively coupled plasma atomic emission spectrometry, and scanning electron microscopy. Results indicated that this modification led to a retarding effect on in vitro hydroxyapatite (HA) formation due to the lower supersaturation degree for nucleation of HA compared with 58s-BG. Meanwhile, magnesium revealed further pronounced effect. The 3-(4,5 dimethylthiazol-2-yl)-2,5 diphenyltetrazolium bromide (MTT) and ALP analysis illustrated that substitutions of both Li₂O and MgO, up to 5 mol %, had increasing effect on biocompatibility and stimulating proliferation of the pre-osteoblast MC3T3 cells in comparison to the control specimen. Regarding to bactericidal efficiency, the substitution of either Li or Mg for Ca in the 58s BG composition led to statistically significant difference in antibacterial behaviors of substituted-BGs. Meanwhile, the sample containing 5 mol % CaO/Li₂O substitution (BG-5L) was selected as a multifunctional biomaterial in bone repair/regeneration due to the improved biocompatibility, enhanced ALP activity and antibacterial efficiency among all of the synthesized L-BGs and M-BGs.

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