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Sol-Gel Derived 58S Bioglass Substituted by Li and Mg: A Comparative Evaluation on in vitro Bioactivity, MC3T3 Proliferation and Antibacterial Efficiency

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Abstract : Modified bioactive glass has been considered as a promising multifunctional candidate in bone repair and regeneration due to its attractive properties. The present study mainly aims to evaluate how the individual substitution of lithium (L-BG) and magnesium (M-BG) for calcium can affect the in vitro bioactivity of sol-gel derived substituted 58S bioactive glass (BG); and to present one composition in both of the $60SiO_2$–$(36\text{-}x)CaO$–$4P_2O_5$–$(x)Li_2O$ and $60SiO_2$–$(36\text{-}x)CaO$–$4P_2O_5$–$(x)MgO$ quaternary systems (where x= 0, 5, 10 mol.%) with improved biocompatibility, enhanced alkaline phosphatase (ALP) activity, and the most efficient antibacterial activity against methicillin-resistant Staphylococcus aureus bacteria. To address these aims, and study the effect of CaO/Li_2O and CaO/MgO substitution up to 10 mol % in 58S-BGs, the samples were characterized by X-ray diffraction, Fourier transform infrared spectroscopy, inductively coupled plasma atomic emission spectrometry and scanning electron microscopy after immersion in simulated body fluid up to 14 days. Results indicated that substitution of either CaO/ Li_2O and CaO/ MgO had 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 had a more pronounced effect. The 3-(4, 5dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) and alkaline phosphatase (ALP) assays showed that both substitutions of CaO/ Li_2O and CaO/ MgO up to 5mol % in 58s-BGs led to increased biocompatibility and stimulated proliferation of the pre-osteoblast MC3T3 cells with respect to the control. On the other hand, substitution of either Li or Mg for Ca in the 58s BG composition resulted in improved bactericidal efficiency against MRSA bacteria. Taken together, sample 58s-BG with 5 mol % CaO/Li_2O substitution (BG-5L) was considered as a multifunctional biomaterial in bone repair/regeneration with improved biocompatibility, enhanced ALP activity as well enhanced antibacterial efficiency against methicillin-resistant Staphylococcus aureus (MRSA) bacteria among all of the synthesized L-BGs and M-BGs.

Keywords : alkaline, alkaline earth, bioactivity, biomedical applications, sol-gel processes
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