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Investigating the Formation of Nano-Hydroxyapatite on a Biocompatible and Antibacterial Cu/Mg-Substituted Bioglass

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Abstract : Multifunctional bioactive glasses (BGs) are designed with a focus on the provision of bactericidal and biological properties desired for angiogenesis, osteogenesis, and ultimately potential applications in bone tissue engineering. To achieve these, six sol-gel copper/magnesium substituted derivatives of 58S-BG, i.e. a mol% series of 60SiO₂-4P₂O₅-5CuO-(31-x) CaO/xMgO (where x=0, 1, 3, 5, 8, and 10), were synthesized. Afterwards, the effect of MgO/CaO substitution on the in vitro formation of nano-hydroxyapatite (HA), osteoblast-like cell responses and BGs antibacterial performance were studied. During the BGs synthesis, the elimination of nitrates was achieved at 700 °C that prevented the BGs crystallization and stabilized the obtained dried gels. The structural and morphological evaluations were performed with X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). These characterizations revealed that Cu-substituted 58S-BG consisting of 5 mol% MgO (BG-5/5) slightly had retarded the formation of HA. In addition, Cu-substituted 58S-BGs consisting 8 mol% and 10 mol% MgO (BG-5/8 and BG-5/10) displayed lower bioactivity probably due to the lower ion release rate of Ca–Si into the simulated body fluid (SBF). The determination of 3-(4, 5 dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) and alkaline phosphate (ALP) activities proved that the highest values of both differentiation and proliferation of MC3T3-E1 cells can be obtained from a 5 mol% MgO substituted BG, while the over addition of MgO (8 mol% and 10 mol%) decreased the bioactivity. Furthermore, these novel Cu/Mg-substituted 58S-BGs displayed antibacterial effect against methicillin-resistant Staphylococcus aureus bacteria. Taken together, the results suggest the equally-substituted BG-5/5 (i.e. the one consists of 5 mol% of both CuO and MgO) as a promising candidate for bone tissue engineering, among all newly designed BGs in this work, owing to its desirable cell proliferation, ALP activity and antibacterial properties.

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