Extensive Investigation on the Effect of Niobium Insertion on the Physical and Biological Properties of 45S5 Bioactive Glass for Dental Implant

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Dental implants have been widely recognized as a reliable and predictable therapeutic option in oral surgery. However, failure cases are reported due to the formation of bacterial biofilms on the implant surface. This study aims to address this issue by developing a biomaterial for implant coatings utilizing 45S5 Bioglass® modified by the insertion of different amounts of niobium pentoxide (Nb_2O_5), from 0 to 8 mol%. Structural analysis using XRD and FTIR indicated that incorporating Nb_2O_5 did not alter the structure of the glass. Raman spectroscopy identified the presence of NbO_4 and NbO_6 structural units associated with the incorporation of Nb_2O_5. Since the bioglass demonstrated the ability to be polarized, enhancing its osseointegration effectiveness, the electrical properties of the prepared bioglasses were investigated using impedance spectroscopy. The Fractional conversion of NbO_6 network modifier units into NbO_4 network formers affects the electrical properties of the glasses and leads to a reduction in bioactivity and antibacterial effects. The bioglass with 2 mol% of Nb_2O_5 exhibited the highest percentage of NbO_6 units, resulting in a higher dissolution rate and, consequently, superior bioactivity demonstrating a maximal growth of Ca-P rich layer on its surface within the first 24h of Simulated body fluid immersion. Furthermore, the antibacterial properties of the bioglass containing 2 mol% of Nb_2O_5 against Gram-positive and Gram-negative bacteria revealed the most significant antibacterial effect. Therefore, it is considered the ideal coating material for dental implants without being harmful to mammalian cells.

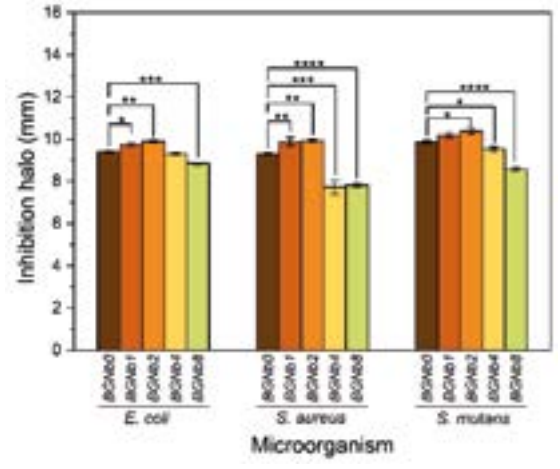

FIGURE 1
Measurements of inhibition halo diameter of the Bioglasses against E. coli, S. aureus, and S. mutans bacteria.

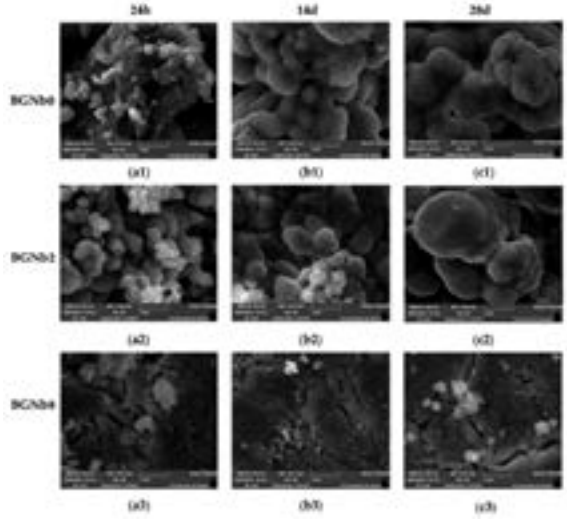

FIGURE 2
SEM micrographs of the surface of bioglasses after immersion in SBF.