World Academy of Science, Engineering and Technology
International Journal of Pharmacological and Pharmaceutical Sciences
Vol:17, No:11, 2023

Identification of the Antimicrobial Property of Double Metal Oxide/Bioactive Glass Nanocomposite Against Multi Drug Resistant Staphylococcus aureus Causing Implant Infections

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Abstract : The use of antibiotics is essential in reducing the occurrence of adverse effects and inhibiting the emergence of antibiotic resistance in microbial populations. The necessity for a novel methodology concerning local administration of antibiotics has arisen, with particular focus on dealing with localized infections prompted by bacterial colonization of medical devices or implant materials. Bioactive glasses (BG) are extensively employed in the field of regenerative medicine, encompassing a diverse range of materials utilized for drug delivery systems. In the present investigation, various drug carriers for imipenem and tetracycline, namely single systems BG/SnO2, BG/NiO with varying proportions of metal oxide, and nanocomposite BG/SnO2/NiO, were synthesized through the sol-gel technique. The antibacterial efficacy of the synthesized samples was assessed through the utilization of the disk diffusion method with the aim of neutralizing Staphylococcus aureus as the bacterial model. The current study involved the examination of the bioactivity of two samples, namely BG10SnO2/10NiO and BG20SnO2, which were chosen based on their heightened bacterial inactivation properties. This evaluation entailed the employment of two techniques: the measurement of the pH of simulated body fluid (SBF) solution and the analysis of the sample tablets through X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier transform infrared (FTIR) spectroscopy. The sample tablets were submerged in SBF for varying durations of 7, 14, and 28 days. The bioactivity of the composite bioactive glass sample was assessed through characterization of alterations in its surface morphology, structure, and chemical composition. This evaluation was performed using scanning electron microscopy (SEM), Fourier-transform infrared (FTIR) spectroscopy, and X-ray diffraction spectroscopy. Subsequently, the sample was immersed in simulated liquids to simulate its behavior in biological environments. The specific body fat percentage (SBF) was assessed over a 28-day period. The confirmation of the formation of a hydroxyapatite surface layer serves as a distinct indicator of bioactivity. The infusion of antibiotics into the composite bioactive glass specimen was done separately, and then the release kinetics of tetracycline and imipenem were tested in simulated body fluid (SBF). Antimicrobial effectiveness against various bacterial strains have been proven in numerous instances using both melt and sol-gel techniques to create multiple bioactive glass compositions. An elevated concentration of calcium ions within a solution has been observed to cause an increase in the pH level. In aqueous suspensions, bioactive glass particles manifest a significant antimicrobial impact. The composite bioactive glass specimen exhibits a gradual and uninterrupted release, which is highly desirable for a drug delivery system over a span of 72 hours. The reduction in absorption, which signals the loss of a portion of the antibiotic during the loading process from the initial phosphate-buffered saline solution, indicates the successful bonding of the two antibiotics to the surfaces of the bioactive glass samples. The sample denoted as BG/10SnO2/10NiO exhibits a higher loading of particles compared to the sample designated as BG/20SnO2 in the context of bioactive glass. The enriched sample demonstrates a heightened bactericidal impact on the bacteria under investigation while concurrently preserving its antibacterial characteristics. Tailored bioactive glass that incorporates hydroxyapatite, with a regulated and efficient release of drugs targeting bacterial infections, holds promise as a potential framework for bone implant scaffolds following rigorous clinical evaluation, thereby establishing potential future biomedical uses. During the modification process, the introduction of metal oxides into bioactive glass resulted in improved antibacterial characteristics, particularly in the composite bioactive glass sample that displayed the highest level of efficiency.

Keywords : antibacterial, bioactive glasses, implant infections, multi drug resistant
Conference Title : ICBSAATAR 2023 : International Conference on Broad-Spectrum Antibiotics, Antibiotic Therapy and Antimicrobial Resistance
Conference Location : Amsterdam, Netherlands
Conference Dates : November 06-07, 2023