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M. Bashir, S. Riaz, Z.N. Kayani, S. Naseem



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Synthesis of Bone Implant Substitutes using Organic Additive Based Zirconia Nanoparticles and their Biodegradation Study

M. Bashir¹, S. Riaz¹, Z.N. Kayani² and S. Naseem^{1*}

¹Centre of Excellence in Solid State Physics, University of the Punjab, Lahore Pakistan

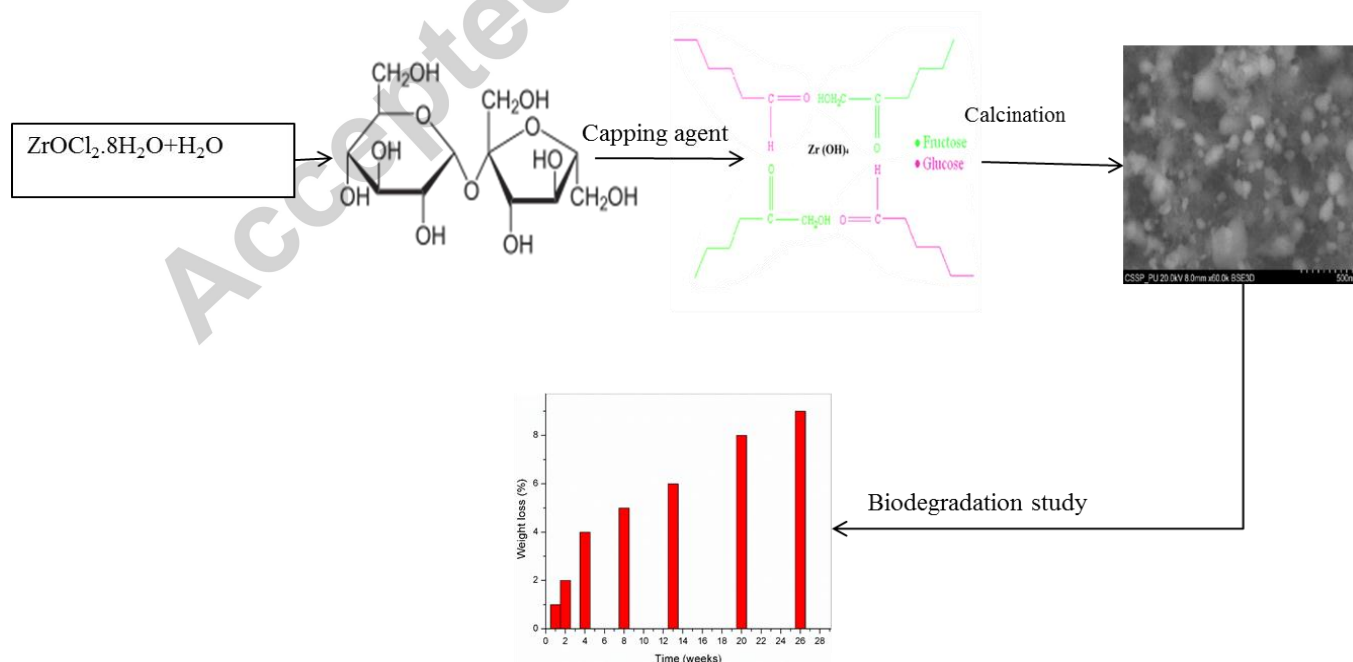
²Lahore College for Women University, Lahore, Pakistan

*shahzad.cssp@pu.edu.pk

Abstract

Zirconia, a hard-ceramic, is potential material for bone and dental implants. However, the problem limiting its application is inertness. This problem can be minimized using body compatible and non-toxic organic additives. Organic additives-based zirconia (OZ) nanoparticles are synthesized using sol-gel method. Zirconium oxychloride is used as precursor and water as solvent. OZ nanoparticles are calcined in temperature range of 100-1000°C. Transition from mixed zirconia phases to amorphous behavior is observed at 300°C. Phase-pure tetragonal ZrO₂ (t-ZrO₂) along with reduced crystallite size ~12.7nm is observed at 500°C. Mixed phases, started to appear at 800°C, exhibit increased monoclinic to tetragonal ratio at 900-1000°C. SEM images show OZ nanoparticles with ~50nm diameter at 500°C. Nanoparticles with ~50nm and ~70-75nm diameter along with nanowires (~8nm) are observed at 600-700°C. FTIR band at 500cm⁻¹ along with shoulder at 580cm⁻¹ and Raman band at 148 cm⁻¹ confirm the presence of t-ZrO₂ at 500-600°C. High value of hardness, ~15GPa, and dielectric constant (~55-68) suitable for bio-application, is observed for OZ nanoparticles calcined at 500°C. Optimized t-ZrO₂ is immersed in stimulated body fluid for 1, 2, 4, 8, 13, 20 and 26 weeks. Small degradation in weight and hardness is observed even after 26 weeks of immersion.

Graphical Abstract



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