Abstract

The research explores the use of Alumina Toughened Zirconia (ATZ) composites enhanced with biowaste-derived materials, Rice Husk Ash (RHA), and Animal Waste Bone (AWB), to develop affordable, sustainable biomaterials. This approach addresses environmental challenges by converting agricultural and animal waste into valuable resources, promoting biocircularity and a bioeconomy.

RHA, a rich silica source, is studied for its impact on silica-based composites. When heated to 400–800°C, RHA forms amorphous silica, while crystalline silica emerges at 800–900°C. Amorphous silica provides better phase conversion, resulting in higher relative density and strength after sintering, though crystalline silica achieves higher green density. The silica compacts exhibit bulk densities of 1.59–1.97 g/cm³ and compressive strengths ranging from 20 to 52 MPa.

In ATZ composites, RHA-derived amorphous silica enhances mechanical properties, grain growth, and hydrothermal aging resistance, particularly at 1 wt% doping. Higher silica content can form a protective glassy layer, boosting aging resistance but reducing strength. Compared to crystalline silica, amorphous silica improves densification and aging resistance due to favorable grain development and microstructure refinement. The bioactivity of silica-doped ATZ is enhanced, as shown by hydroxyapatite layer formation.

The study also integrates AWB into ATZ to create a Hydroxyapatite/Tricalcium Phosphate/Whitlockite-ATZ biocomposite. Although AWB slightly reduces mechanical performance, the composite still meets biomaterial standards and demonstrates superior

bioactivity and osteoconductivity for bone regeneration. Key properties include bulk densities of 3.7-5.2 g/cm³, porosities of 3.6–17%, hardness of 2-9 GPa, and bending strengths of 620-1000 MPa.

Overall, the study showcases the potential of RHA and AWB in enhancing ATZ composites, offering an eco-friendly, cost-effective solution for biomaterials development while addressing waste disposal and fostering environmental and socioeconomic benefits.