CERAMIC BONE SCAFFOLDS BASED ON ZIRCONIUM OXIDE NANOPARTICLES PREPARED USING PHOTOCHEMICALLY INITIATED 3D PRINTING

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Photochemistry and consequently radiation-initiated polymerization processes play an extremely important role in materials engineering. Photopolymerization processes are widely used in many industries including biomedical engineering, automotive and dentistry. These processes are currently rapidly expanding with technologies related to forming 3D models using light-initiated 3D printing. One more interesting application of photoinitiated 3D printing is its deployment for obtaining photo-curable polymer nanocomposites.

Additive manufacturing of polymers with nanoparticles using Digital Light Processing (DLP) is a relatively new area of research that has attracted significant attention in recent years. This technique offers high resolution, speed, and accuracy, making it an attractive option for various applications including biomedical engineering. Using this technique, the liquid resin can be easily mixed with a variety of nanofillers for the manufacture of functional nanocomposite materials. Nanofillers incorporation in a polymer matrix can improve the mechanical and thermal properties of the final material.

The application of three-dimensional printed polymer scaffolds in repairing bone defects is a promising strategy. Zirconium dioxide (ZrO_2) nanopowder can enhance the hydrophilicity of polymer materials. At the same time, the elastic modulus of ZrO_2 is matched with human bones, has high mechanical strength and fracture toughness has excellent osteointegration, and can be combined with living bone. The good hydrophilicity of nano-zirconia particles can improve the biocompatibility of composite materials. The good mechanical properties of the zirconia material are used to improve the mechanical properties of the composite material so that the composite material can meet the mechanical properties required by the bone scaffold. Finally, combined with 3D printing, a composite scaffold with a regular grid structure was constructed to be used in bone tissue engineering repair.

The suggested bio-inspired ceramic bone scaffolds have enormous potential for applications in bone tissue engineering and regenerative medicine. The combination of 3D printing technology and zirconium oxide nanoparticles offers a promising route to producing patient-specific scaffolds with enhanced biological functionality and improved mechanical properties. This nanocomposite could serve as a potential candidate to be used for bone tissue engineering. The 3D scaffolds were printed utilizing DLP technology (Lumen X, Cellink). For analysis of microstructure, phase composition, and mechanical properties of printed scaffolds, the following research techniques were applied: scanning electron microscopy (SEM), thermogravimetric analysis (TGA), and mechanical tests.

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