Abstract

Scientists are trying to mimic human bones in terms of structure and composition to replace and repair the same at the time of injury and diseases. Though metal and polymers have been in use, they don't have structural and chemical similarities to bones. Ceramics is another class of materials that can be used for bone-related applications. However, the synthetically produced ceramic has some limitations in terms of biocompatibility and availability. Moreover, the production and material costs of these ceramics are very high. Considering the complex structure and intricate design of the bone shape and size, 3D printing is the only way to fabricate custom-made implants, prostheses, or inserts for bone therapy. 3D printing is competitive over conventional methods in terms of handling complex designs, materials, easiness in fabrication, reduced cost, and time. 3D printing more particularly extrusion-based 3D printing i.e. direct ink writing (DIW) is used to print the prepared slurry or paste extracted from the chicken bone. This chicken bone extract (CBE) is biocompatible, biodegradable and biowaste which is abundantly available in nature. The extraction of these biowastes is cost-effective, easy, green and sustainable. CBE has similar chemical and structural properties to human bone content which is rich in calcium, popularly known as hydroxyapatite.

To replicate the human bones in terms of design and materials, the DIW technique is used for the development of samples for characterizations. Initially, the process parameters such as nozzle diameter, flow rate and concentration of DIW are optimized. In the subsequent chapter, bioceramics was successfully extracted from chicken bone and a slurry was prepared using preink to print and characterize the samples in their green form. Later, it was mixed with different weight percentages of eggshell (ES) and SiC to prepare a variety of composites to enhance the strength of the printed samples. Post-treatment such as heat treatment was also carried out to further enhance and optimize the strength and biocompatibility of the samples.

Finally, a piezoelectric device was 3D printed using CBE to demonstrate the sustainable way of energy harvesting along with its effect on the bone healing process. Overall, pre-ink preparation, construction of 3D structures and fabrication of bio-devices were successfully conducted and demonstrated using novel CBE. Though the strength obtained from the CBE and its composite is at par with cancellous bones still this finding can be a new direction in utilizing biowaste to fulfill the ever-demand of bioceramics in the field of biomedical/orthopedics/dental and energy harvesting with controlled tunable properties.

Keywords: DIW, CBE, ES, SiC, piezoelectricity, mechanical strength, biocompatibility, hard tissue application