Tailoring 3D printed HA scaffolds by the addition of cellulose-based sustainable biopolymer

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In bone regeneration field, porosity is a key parameter that directly affects the tissue recovery process, making its control essential in the biomaterials design. Additive Manufacturing techniques have been widely used to customize implants to the patient requirement but also to create the adaptable porous and biodegradable structure. Among AM techniques, material extrusion (FDM/FFF) is one of the most simple and inexpensive techniques, highly implemented in the biomedical sector. However this 3D printing techniques cannot achieve the porosity range indispensable for bone regeneration purposes. The main objective of this work is to modify the porosity and degradation rate of a biodegradable printed structures based on polylactic acid (PLA) reinforced with hydroxyapatite (HA) by adding a material capable of generating porosity in the matrix, such as nanofibrillated cellulose (NFC).

To introduce NFC into the composite material, a colloidal processing approach is chosen to improve and ensure its compatibility with the polymeric matrix. Its proper inclusion in the matrix was characterized, as well as its physico-chemical and rheological properties, which enable processing through extrusion for filament fabrication. Once the composition was obtained, tests were conducted to characterize the achieved porosity degree and quantify the modification of its degradation rate. This study has demonstrated that the addition of NFC in the composite material generates a beneficial heterogeneity of pores in the polymeric matrix, promoting both cell proliferation and biodegradation. Degradation tests confirm that an increase in the percentage of NFC in the matrix is directly proportional to an increase in the degradation rates. These results represent a significant improvement in personalized medicine, where the design of biodegradable biomaterials with hierarchical and controlled porosity opens new paths in the development of therapies and treatments personalized for each patient. This allows for a more precise and effective approach in the field of biomedical applications.