BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

Natural-derived biopolymers for 3D printed bone

Funded By	UNIVERSITA' DEGLI STUDI DI TORINO [P.iva/CF:02099550010]
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Context of the research activity	Bone defects are a major health concern all over the world as a result of aging, disease or sports-related injuries to bone tissue. Bone tissue engineering is an innovative and interdisciplinary approach that is directly used to repair bone defects/tissue for transplantation while having a significant impact on the patient's quality of life. Scaffolds play a crucial role in bone tissue engineering. They are three-dimensional structures that serve as a template for cell adhesion during the development of bone tissue. Pore size, physicochemical characteristics, and mechanical strength are all essential criteria that affect scaffold performance.
	Porous bone scaffolds are manufactured using a variety of techniques. Among these, 3D printing technology has sparked a lot of interest due to its potential to disrupt manufacturing. The key advantages of this technique include design freedom, mass customization, waste minimization, and the capacity to make complicated structures without additional cost, as well as fast prototyping. Numerous medical fields, including dentistry and otolaryngology/maxillofacial surgery, have been impacted by 3D printing. In dentistry, for example, practically all production items, including crowns, bridges, drill guides, and so on, are shifting to digital processes. In addition, digital workflows now play an important role in reconstructive maxillofacial surgery. Cost barriers have contributed to orthopaedics lagging behind fields, such as otolaryngology and dentistry, in terms of adoption. The use of larger devices with higher

Objectives	structural requirements poses a problem in orthopaedics. In this sense, the introduction of polymer materials has greatly lowered costs when compared to alternative materials. The mechanical performances of the polymer scaffold, on the other hand, remain a challenge. In general, many industrial 3D printers have been used to manufacture porous scaffolds for bone tissue engineering all throughout last decade, and 3D printing technologies have already been termed the third industrial revolution, with the number of new publications increasing. Poly (acrylonitrile butadiene styrene) (ABS) and polycaprolactone (PCL) are two polymer materials commonly utilized for tissue engineering scaffolding because of their low cost and lightness. More in detail, ABS has been used for bone and PCL for tendon repair. However, several limitations have to be addressed before 3D printing can be implemented as a mainstream manufacturing process and reach its full potential. The lack of a wide range of environmentally safe and printer-compatible materials is a major barrier to widespread adoption of 3D printing technologies. The exploration of natural-derived and renewable biopolymers, rather than fossil oil-based plastics, for diverse product manufacturing has attracted considerable attention, in line with the present focus on the sustainable economy. In this light, the mission of this PhD programme is to design and prepare novel scaffolds using 3D printing technology by means of eco-friendly natural derived biopolymers. The principal aim of the work is to i) develop a widely available, reliable and low-cost material for restoring the bone tissue and ii) promote the manufacturing in a sustainable way. The focus will be put on polymers derived by waste that alone or in blend with other polymers can be 3D-printed. The use of eco-friendly fillers for imparting suitable mechanical property will be also taken into account. The research has several aims both at a candidate and at a scientific/clinical level. Candidate: To develop the profile of an expert in new scaffold materials based on natural derived biopolymers obtained by 3D printing To develop a cutting-edge bone tissue engineering research curriculum To develop the theoretical and practical knowledge in bone tissue field, facilitating the setting up of a multi-disciplinary network involving orthopaedics, bio-engineers, bio-technologists and chemists. Scientific:/clinical: To identify the best materials to be used for preparing scaffolds by 3D printing . Polymers will be printed alone or in blend and with and without reinforcing filler and the processing conditions will be optimized. Different techniques for mixing polymers/fillers will be taken into account in order to obtain a uniform mixture able to be printed in a scaffold. To characterize the scaffolds in terms of pore size, physicochemical and mechanical properties. Structure and morphology will be related with mechanical performances allowing the selection of the best processing conditions and scaffold compositions.

	To conduct biological assay of the developed scaffolds in vitro by using different cell lines. Luminescent Cell Viability Assay will be considered as well established and robust method to estimate the number of viable cells grown on a given material through the quantification of ATP. The biological behaviour will be correlated with the morphology, wettability and roughness. To help the setting-up of a multidisciplinary network for the clinical implementation of such novel 3D printed materials.

Skills and competencies for the development of the activity	Industrial biotechnology, Chemistry and Industrial Chemistry degree Experience in conducting scientific research in a team Background in bio-derived materials from waste Background in characterization tools of polymer materials: DSC, TGA, DMTA, mechanical tests. English language and preferably another foreign language knowledge