BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

FUNCTIONALIZATION STRATEGIES FOR MEDICAL DEVICES

Funded By	Dipartimento DIMEAS
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Context of the research activity	The demand of new smart and tailored materials for the design and fabrication of biomedical devices is continuosly growing. In this context the possibility to functionalize scaffolds/materials to improve mechanical properties or biological behavior in a tailorable manner opens new opportunities for researchers. This Ph.D. program is thus focused on the design and optimization of surface modification strategies to enhance biomaterial performance as well as on strategies to modify bulk biomaterials.
	Engineered scaffolds are the key factor not only in Tissue Engineering paradigm aiming to develop biological substitutes that restore, maintain, or improve tissue function, but also for the design of reliable in vitro models of healthy or pathological tissues, which can be employed for drug screening and the evaluation of new therapies, as well as the investigation of the complex phenomena regulating disease onset and progression. In this context, humans are continuously exposed to a huge amount and variety of potentially toxic chemicals present in the surrounding environment. One of the main classes of chemicals of this group are pesticides, commonly and widely used in the agricultural field. Additionally, residues and degradation products of various types of drugs have been detected in different

Objectives	environmental compartments, including surface water, groundwater, soil, air, and biota. The combined effects of chemicals and pharmaceuticals are still debated, with an unidentified mechanism of action. In vitro tissue models could be used to evaluate the toxicity of chemicals and their mixture in the vulnerable populations. Strong attention is increasingly paid to synthetic and natural polymers as they can be used to fabricate 3D complex scaffolds. On one hand, synthetic polymers can be tuned in terms of composition, rate of degradation, mechanical and chemical properties. On the other hand, naturally derived polymers provide structures extremely similar to living tissues such as stimulating a specific cellular response, which sometimes supersedes the advantages of synthetic polymers. Moreover, owing to their similarity with the extracellular matrix (ECM), natural polymers present higher biocompatibility in vitro and in vivo, but the possibility to induce immune reactions in humans and the limited processability are their main drawbacks. Despite some good results in the last years, the attention of research is moving to apply functionalization as a powerful tool able to increase scaffold/device performances. Two types of functionalization approaches are feasible to obtain bioartificial materials: 1. Bulk functionalization, by blending natural and synthetic polymers or by the synthesis of copolymers containing blocks based on synthetic and natural polymers. 2. Surface functionalization with natural polymers or their bioactive fragments (e.g., peptides) of synthetic polymer substrates. Surface functionalization could be even used to enhance the performance of commercially available devices in terms of tissue integration or antibacterial properties. In particular silicone based materials are widely used in the medical field for implantable devices, such as contact lenses, cochlear implants, urinary catheters, breast implants. However the material suffers from a lack of biocompatibility and is often subject to bacterial/microbial infections characterized by biofilm growth. In recent years, in accordance with the sustainable goals, the need and duty to develop environmentally friendly technologies has increasingly emerged. In this context some functionalization technologies, such as plasma treatment and bioinspired approaches, are solvent free or required mild condition processes. This Ph.D. program is thus focused on the design and optimization of innovative functionalization strategies for different biomaterials, to be applied both for scaffolds for tissue engineering and in vitro models, and commercial available devices, such as silicone based prostheses or hernia mesh devices. The developed strategies are expected to significantly advance the biomedical field, contributing to the definition of technology platform, which, in principle, could answer to the specific need of researchers, patients, surgeons, medical doctors and biomedical companies.

	Part of the Ph.D research activities will be included in two European research projects: EVPRO (Extracellular Vesicles Promoted Regenerative Osseointegration, Horizon 2020) and ALTERNATIVE (Building the Innovative Platform to Assess the Cardiotoxicity of Chemicals, Horizon 2020) The Ph.D. student will be responsible for: (i) The development and optimization of bulk functionalization strategies providing synthetic and natural polymers with additional bioactive and biomimetic features (e.g., the capability to induce hydroxyapatite deposition and improve cell adhesion); (ii) the surface functionalization with ECM-derived molecules by plasma treatment for 3D printed scaffolds designed and fabricated to mimic human-aged cardiac tissue to test the toxicity of chemical mixtures; (iii) the surface functionalization of commercially available devices through advanced technologies; (iv) the physicochemical and mechanical characterization of hydrogels and functionalized surfaces/scaffolds (e/o devices); (v) the in vitro trials to test the efficacy of the developed functionalization strategies. More in detail, the Ph.D. student will develop and validate functionalization strategies for scaffolds, for articular endoprostheses and for silicone-based prostheses.

Skills and competencies for the development of the activity	We are looking for talented and motivated candidates, preferably with a Master Degree in Biomedical Engineering and with previous experience in the fields of: • Biomaterials; • Surface functionalization and characterization; • Scaffold fabrication and characterization; The candidate should possess a good knowledge of English Language in both written and oral forms and be available to work in our network of biomedical laboratories in Alessandria and Turin, depending on the experimental needs.