POLITECNICO DI MILANO

PhD in CHIMICA INDUSTRIALE E INGEGNERIA CHIMICA / INDUSTRIAL CHEMISTRY AND CHEMICAL ENGINEERING - 38th cycle

PNRR_351_DOTT_RICERCA Research Field: NOVEL HYBRID MATERIALS FROM RENEWABLE MATRICES FOR ADVANCED APPLICATIONS

Monthly net income of PhDscholarship (max 36 months)
€ 1325.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The design of new biomaterials has seen significant progress in the last few decades and it has grown to become an integral component in the modern-day improvement of human condition and quality of life. Biomaterials have a long story of medical use, from diagnostics (gene arrays and biosensors) and medical equipment (blood bags, surgical tools) to therapeutic medications (medical implants and devices) and emerging regenerative drugs (tissue-engineered skin and cartilage). In recent times, a great deal of attention has been paid to the development of biomaterials from natural polymers driven by the growing need of bio-based substitutes able to replace synthetic petrochemical source materials. In this scenario, cellulose, a naturally-occurring polysaccharide composed of Beta-(1 --> 4) linked d-glucose units, emerged as a strong candidate thanks to its abundant availability, biocompatibility, renewability, ease of chemical functionalization and its ability to assume different morphologies. Although these unique properties, cellulose itself does not possess all the necessary characteristics to perform ideally and meet the demands of desired applications. Therefore, one particular strategy consists in the development of hybrid or composite biomaterials to synergize the beneficial properties of multiple materials into a superior matrix. The aim of this project is to design and investigate novel hybrid

	biomaterials based on a combination of nanocellulose and self-assembling peptides. Among the different nanostructures obtained from peptide self-assembly, peptide nanofibrils are ubiquitous in nature and their formation is mainly due to regular cross-¿ sheet structures, often termed amyloid-like structures. Amyloid fibrils have recently gained attention as reinforcing components due to their intrinsic biocompatibility, high versatility, and intrinsic robustness of individual fibrils. Indeed, owing to the large network of interactions at play, the rigidity of the assemblies confers superior mechanical properties to amyloid fibrils, reaching Young¿s modulus values in the range 1-20 GPa. In this way, the mechanical properties of nanocellulose-based composites can be further enhanced by the addition of peptide nanofibrils, introducing at the same time additional functional sites to the system and enabling a greater level of biological control. This project would allow the development of innovative green materials with optimized properties to be employed in the production of biomaterials. Our strategy would fit two of the PNRR objectives, developing materials that can help in the urgent replacement of petrol derivatives (PNRR objective Green Revolution and Ecologic Transition) employable in the production of biomaterials (PNRR objective Health).
Methods and techniques that will be developed and used to carry out the research	This research project will include the development of several methodologies for the preparation of the hybrid materials and the use of advanced techniques for their characterization and the evaluation of their possible application in the biomedical field, among others. First, different types on cellulose-based matrices will be prepared, starting from fibrillar nanocellulose. The samples will be characterized in terms of structure and morphology, using a variety of spectroscopic and imaging techniques, such as infrared spectroscopy, X-ray crystallography, transmission and scanning electron microscopy, as standard within organic chemistry and material characterization. The mechanical properties will be assessed using rheology, tensile and indentation tests. Subsequently, some novel processing methods could be considered, such as wet spinning or electrospinning,

	allowing for the fabrication of scaffolds with tunable porosity and high surface area. Finally, in vitro biological assays, such as antioxidant potential, antimicrobial activity, biocompatibility (e.g., cytotoxicity, cell adhesion and proliferation), will be performed to assess the potential of the developed composites for wound healing and drug delivery applications. Notably the project will involve the collaboration of Aalto University, Finland, institution where several research groups study the development of bioinspired biomaterials and where excellent facilities for the characterization of such products are available. In particular, our project will benefit of the access to the Otanano Facilities, where advanced Microscopy techniques are available.
Educational objectives	The proposed PhD program will provide an excellent training program to the PhD candidate, who will acquire advanced skills in biomaterials design. In detail, these will include: • Selection of the renewable materials and the additives according to the material properties that need to be improved. • Co-formulate the biocomposite in a sustainable manner and characterize its micro- and nano-metric organization. • Fabrication of the hybrid materials (e.g., electrospinning, wet-spinning, etc.). • Characterize the material properties Moreover, the PhD candidate will be trained to become and independent scientist, able to conduct original research, through the acquisition of multidisciplinary competencies and methodological expertise. Through the stay at the Aalto University, the candidate will develop as the ability to work in an international team and to effectively communicate research achievements in different environments.
Job opportunities	• Engineering positions in fiber spinning companies. • R&D positions in fiber spinning companies.

	• Biomaterial engineer in polymer, chemical, and biomedical companies. • Engineering and R&D positions in chemical, polymer, and biomedical companies.
Composition of the research group	2 Full Professors 3 Associated Professors 5 Assistant Professors 4 PhD Students
Name of the research directors	Prof. P. Metrangolo, Dr.ssa C. Pigliacelli

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	662.5 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	Aalto University
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Confidentiality: since this is a thematic scholarship, the management of Confidential Information, Results and their publication is subordinate to the restrictions agreed upon with the funding company. Upon acceptance of the scholarship, the beneficiary must sign a specific commitment. **Individual budget for research** (during the 3 years): about 5.400 euro

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial of for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities within the limits allowed by the regulation.