POLITECNICO DI MILANO

PhD in CHIMICA INDUSTRIALE E INGEGNERIA CHIMICA / INDUSTRIAL CHEMISTRY AND CHEMICAL ENGINEERING - 39th cycle

PNRR 117 Research Field: NANOCELLULOSE-DERIVED ADDITIVES FOR PAPER AND PAPERBOARD-BASED PACKAGING

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 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	Cellulose is a natural biopolymer and an almost inexhaustible raw source, whose interesting chemical-physical properties allow it to be widely used in industry. Furthermore, it can be extracted from waste biomass, following the guidelines of the circular economy. Its supramolecular structure and organization can be advantageously exploited. In particular, it is possible to cleave the hierarchical structure of native cellulose through mechanical or chemical approaches, promoting nanofibrillation and the consequent production of nanocellulose (NC), in the form of cellulose nanocrystals (CNC) or cellulose nanofibers (CNF). The use of NC has already been suggested for several applications, including food science, packaging, catalysis, development of energy storage devices. Following the recommendations of the Green Nanoscience Principles, which encourage the design of safer nanomaterials possibly from bio-based sources, this research aims to provide sustainable pathways for the production of NC and its further modification for the synthesis of additives to be used in the paper and paperboard-based packaging, also intended for food use.Specifically, the research activity will be aimed at the development of a) new additives and new formulations designed to improve the mechanical properties (both wet and dry) of various paper supports selected by weight and intended use, and b) new

	additives and new formulations designed to improve the barrier properties (to oxygen, water vapor, gases) of various paper supports selected by weight and intended use.In particular, the activity aims to replace the traditional additives currently in use, typically deriving from fossil sources, with more sustainable additives. Given the specificity of the performance requirements sought, these additives will be destined a) to be applied in the wet phase of the paper/board production cycle, and b) to be applied in coating in the paper/paperboard production cycle.The collaboration will also provide, in parallel, the analytical support aimed at the characterization of cellulosic derivatives, especially those intended for the production of paper and paperboard supports in contact with food.
Methods and techniques that will be developed and used to carry out the research	The production of biobased materilas and products will follow the safe-by-design and eco-design guidelines already well consolidated in the hosting research group. They consist into considering all the aspects related to the environmental and ecological impact of the production strategy since the early stage of design at laboratory scale. This result will be pursued thanks to several national and international collaborations, leading the PhD students in a multidisciplinary research.NC will be extracted, produced and functionalized following different approaches (enzymatic, chemical, mechanical, and a possible combination of these strategies) also considering the use green solvents (I.e. ionic liquids and deep eutectic solvents).The products will be completely characterized from a chemical (NMR, IR, UV), morphological (SEM, TEM, X-Ray diffraction) and mechanical point of view, thanks to the large facilities present in the Department.Moreover, the collaboration with the Chemical Company (Mare SpA), which will host the PhD student for the stage period in its R&D Laboratory, will allow both testing the performances of new biobased additives for searched purposes (i.e tests for measuring dry and wet strength of paper and board and test for verifying potential synergies among chemical additives produced by the company and the new bio-based solutions), and investigating and realizing the scale-up of selected NC-based products.

Educational objectives	1) To achieve competences for the design of environmentally and economically sustainable organic synthetic processes; 2) to learn how to face scale-up issues for large scale productions; 3) to gain competences in different analytical techniques; 4) to develop soft skills for team working.
Job opportunities	PhD degree for Chemists and Chemical Engineers who want to operate in R&D is mandatory. The demand for bio-based products is constantly growing. Mare Spa is one of the largest European based manufacturers and suppliers of chemical solutions in the market today, and its R&D team is continuously expanding.
Composition of the research group	1 Full Professors 4 Associated Professors 2 Assistant Professors 4 PhD Students
Name of the research directors	Prof. C Punta - Prof. A. Sacchetto

Contacts
Department of Chemistry, Materials, and Chemical Engineering "G. Natta" *Politecnico di MilanoVia Mancinelli 7-20131, Milano* *Office Phone: 00390223993026* *Lab Phone: 00390223993061* O^{SCM}Lab: https://www.cmic.polimi.it/en/ricerca/elenco-gruppi-di-ricerca/organicscm_lab/

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	700.0 €
By number of months	0

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	MARE S.p.A via S. A. M. Zaccaria 1 c.a.p. 20122 Milano http://www.mare.com/
By number of months at the company	6

Institution or company where the candidate will spend the period abroad (name and brief description)	University of Girona, Department of Chemical and Agricultural Engineering and Agrifood Technology, Girona, Spain Building P1, C/ Maria Aurèlia Capmany, 61 Campus Montilivi 17003, Girona https://www.udg.edu/en/depeqata/el-departament
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Confidentiality (in case of DM 117 ? Agreement with company): 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** (5.700 euro):1st year: 1.900 euro; 2nd year: 1.900 euro; 3rd year: 1.900 euro **Teaching assistantship (availability of funding in recognition of supporting teaching activities by the PhD student):** there are various forms of financial 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.