



PhD in INGEGNERIA DEI MATERIALI / MATERIALS ENGINEERING - 39th cycle

**PNRR 117 Research Field: FUNCTIONALIZED PAPER BASED PACKAGING: ANALYSIS,
AND EVALUATION OF BARRIER PROPERTIES AND RECYCLABILITY**

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**

Nowadays, packaging materials are facing significant sustainability issues. The recent changes in the regulatory panorama both at a national and at an international level require businesses to innovate at 360° their materials and products. Specifically, cellulose-based materials are required to provide high barrier yet minimizing non-cellulosic content. To do so, researchers need to innovate both on the technological and material side functional materials to be applied on the surface of cellulosic substrates. Monomaterial paper and board packaging (<5% w/w non-cellulosic content) raised industry interest in contrast to multimaterials to possibly increase fiber recovery yield at a paper mill. However, coatings' effective recyclability and possible composting isn't that straightforward. Indeed, new technologies and coating formulations should be assessed to ensure practical recyclability, absence of microplastic release, and to be successfully screened before the production of secondary raw materials. Similarly, certain packaging applications might require compostable packaging, specially when related to food applications. However, researchers need to be aware that new solutions require an evaluation of their life cycle impacts to be compared to existing industrial standard materials. The final aim of this research is to evaluate the performance of functional layers on fibre-based substrates from both a barrier and an end-of-life point of view – recyclability and composting properties. At the end of his/her doctoral studies, the professional figure



	will be highly skilled and trained to strengthen applied research and development among academia, public administration, and corporates, implementing innovation and technological transfer to sustain Italian economy and industrial resilience. Fondi PNRR DM 117/2023, Missione 4, Componente 2, Dalla Ricerca all'impresa.
Methods and techniques that will be developed and used to carry out the research	The research will be divided in different activities: 1. Analysis of the state of art related to both industrial products and academic research about coating technologies and materials. Such phase will be aimed to frame the existing solutions as well as cutting edge advancements; moreover, particular attention may be given on existing theoretical models that explain barrier phenomena, as well as possible recyclability behavior of fiber-based coated packaging; 2. Study and selection of different coating application processes, according to possible industrial availability or implementation. The selection process will include the material matrix definition according to possible different formulations or commercial grades; 3. Characterization of the materials by means of different techniques, to evaluate, e.g., morphological, barrier, and converting properties. This phase will include several techniques to assess possible coating defects, homogeneity, and morphology, as well as the determination of barrier properties to liquids and gases and mechanical properties of coated substrates; 4. Recyclability, biodegradability, and composting tests according to the most recent standards and methodologies of the most promising solutions based on evidence from previous phases; 5. Life Cycle Analysis to assess the impacts of best performing configurations to be compared to existing industrially-widespread solutions.
Educational objectives	The candidate will become familiar with all the aspects



	related to the development, production, and characterization of innovative cellulose-based packaging materials. The candidate will participate to international conferences and will carry his/her research both in a company and abroad.
Job opportunities	The PhD graduate will have high-quality theoretical and technological expertise in the field of innovative barrier materials for packaging. The professional figure of the PhD will allow him/her to best integrate in the Italian industrial sector.
Composition of the research group	3 Full Professors 3 Associated Professors 3 Assistant Professors 6 PhD Students
Name of the research directors	Proff.sse MP Pedferri, B. Del Curto

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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	700.0 €
By number of months	6

National Operational Program for Research and Innovation

Company where the candidate will attend the stage (name and brief description)	Innovhub SSI – Stazioni sperimentali per l'industria Via Giuseppe Colombo, 79, 20133 Milano MI https://www.innovhub-ssi.it/
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	RI.SE - RESEARCH INSTITUTES OF SWEDEN Stockholm https://www.ri.se/
By number of months abroad	6



Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Confidentiality (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.