POLITECNICO DI MILANO

PhD in CONSERVAZIONE DEL PATRIMONIO COSTRUITO / BUILT HERITAGE CONSERVATION - 40th cycle

PNRR 630 Research Field: THE USE OF NANOCELLULOSE AS AN ADDITIVE IN RESTORATION MORTARS

Monthly net income of PhDscholarship (max 36 months)
€ 1300.0 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 proposed research intends to investigate the behaviour of mortars containing permanently chemically modified **nanocellulose.** The main objective of the research is to improve the hydrophobicity of mortars through the addition of different types and proportions of modified nanocelluloses, and simultaneously to study the mortars' physical and mechanical behaviour. Another objective of the research is to evaluate the durability of materials treated with different types of nanocelluloses by subjecting them to accelerated ageing tests. Recent studies have shown that through the addition of plant fibers in mortars, an increase in hydrophobicity, a reduction in plastic shrinkage, improved workability and changes in physical-mechanical characteristics (porosity, mechanical strength and elastic modulus) can be obtained, conisiting of the important parameters for the design of restoration mortars . The nanocelluloses tested so far in the laboratory were obtained from hydrophilic cotton and cotton waste through two different chemical treatments: oxidation by TEMPO (CH2)3 (CMe2) 2NO and acid hydrolysis. As a result, the nanocelluloses obtained have different functional properties and hydrophobicity behaviour. To modulate the hydrophobicity of the nanocelluloses, functionalization with glycidyl methacrylate via the Fenton

	reaction (hydrogen peroxide and iron salts) will be carried out. Hydrophilic and hydrophobic behaviour will be measured through capillary absorption tests, porosity tests using a mercury porosimeter and contact angle. Cross-linking reactions with acrylic derivatives and with citric acid will also be studied, as well as functionalization designed both to modulate the hydrophobicity and to modify the physical and mechanical properties of the mortars. The functionalization proposed is suitable for giving nanocellulose properties of absorption and gradual release of active ingredients. Several nanocelluloses are commercially available, so it is possible to procure them in industrial quantities. On the other hand, since it is possible to obtain nanocellulose from any waste/waste containing cellulose, its is intended to pursue its obtainment from waste, with a view to an increasingly circular economy. It is also planned to study and use nanocellulose as a consolidating agent or surface treatment on other building materials (wood, stone, concrete, etc.).
Methods and techniques that will be developed and used to carry out the research	The proposal closely correlates the field of conservation of the built heritage with building materials, bringing together the skills and knowledge required to analyse materials and their durability characteristics over time. The research combines knowledge and technical methodologies of material characterization with methodological and applicative research, through the identification of methods and techniques, to be implemented both in the laboratory and in situ through case studies.
Educational objectives	The didactic objective is to provide the candidate with the technical and critical basis for the development of sustainable products to be used in conservative restoration. Particular attention will be paid to the combination of sustainable and compatibility. The use of green technologies often involves the partial use of waste or recycling materials that do not always find practical use in restoration. Therefore the research is aimed at raising awareness of the green world with use in

	the common practice of restoration.
Job opportunities	Graduates of the PhD programme have often found employment in public sector and conservation institutions, as well as in professional practices and in the business world, in specific specialized fields. PhD candidates from abroad find job in their native countries at University or in Cultural Heritage Institutions. As regards Italy, the relationship with Italian Ministry of Cultural Heritage (Mibact), has been definitely fruitful especially when we consider that many among the best PhDs in Preservation of Architectural Heritage have been hired as officers and executives to the above ministry: recently twelve PhD from this Programme won the competitive exam to become public officers in the Ministry of Cultural Heritage and most of them are now responsible in prestigious seats.
Composition of the research group	11 Full Professors 17 Associated Professors 0 Assistant Professors 48 PhD Students
Name of the research directors	Cristina Tedeschi

Contacts

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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	650.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	NANOCHEMP SRL
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 Malta
By number of months abroad	6

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

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

1. National Technical University of Athens (N.T.U.A.), Greece
2. Departamento de Historia del Arte, Universitat de València, Spain
3. Department of Architectural Composition, Universidad de Castilla-La Mancha
4. École Nationale supérieure d'architecture de Paris-La Villette (ENSAPLV), France
5. Faculdade de Arquitectura da Universidade do Porto, Portugal
6. Université Paris I - Pantheon - Sorbonne, Parigi, France
7. Universidad de Sevilla, Departamento de Historia de América, Spain
8. ISPC-CNR Istituto di Scienza del Patrimonio Culturale (Italy)
9. ISCR Istituto Superiore per la conservazione e il restauro (già ICR), Roma

Educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences):financial aid per PhD student("DOTE"): *total amount for the three years program:* ***5.300,25 euro***

1st year: max ***1.766,75 euro***
2nd year: max ***1.766,75 euro***
3rd year: max ***1.766,75 euro***

Teaching assistantship *(*availability of funding in recognition of supporting teaching activities by the PhD student)
There are various forms of financial aid supporting the teaching practice.
The PhD candidate is encouraged to take part in these activities, within the limits allowed by the

regulations.

Workspace:
In the CPC PHD room at Bldg. 14 in Leonardo Campus, are available workstations for shared use. All the Ph.D. students can use their laptops with a wireless connection.
Workstations and other equipment are available in the various departmental laboratories (Dastu) linked with the doctoral Program.