



PhD in INGEGNERIA DEI MATERIALI / MATERIALS ENGINEERING - 38th cycle

**PNRR_351_DOTT_RICERCA Research Field: 3D PRINTING TECHNOLOGIES AND
MATERIALS FOR DRUG DELIVERY**

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**

3D printing is one of the "4.0 technologies" which may foster the innovation and digitization of the production system, as indicated by the M1C2 mission in PNRR. These production technologies are promising in several industrial fields: in the case of pharmaceuticals they are interesting for the personalization of drug products, in terms of type and dose of active ingredient conveyed, site of administration and release performance.

Many feasibility studies confirm the 3D printing potential, but the lack of systematic studies and scientifically sound guidelines limits the reliability and quality of the final drug products. The present projects focus on FDM and Binder jet, with the aim to identify structure-process-performance correlations to build a data-driven guide to be used in the development of high-quality drug products with a range of performances. These correlations will be investigated considering the material and process origins for a defined performance, taking also into account the final geometry of the pharmaceutical dosage form. This approach will lead to the proposal of optimized innovative drug delivery systems with a strong focus on therapy personalization.

Further, the approach will result in the proposal of a protocol entailing a set of characterization techniques to be carried out on starting formulations, inks or filaments, to speed up the rational design and development of future drug delivery systems. The project will give the PhD



	<p>candidate the opportunity to train in an international environment on an interdisciplinary topic which will strengthen her/his skills in Material Engineering and Pharmaceutical Technology</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>Despite 3D printing is a relatively recent technology for pharmaceuticals, a rich literature exists. Most of the available works are feasibility studies, which prioritize the fabrication of a desired dosage forms, over a deep investigation of structure-behavior correlations. This project aims at investigating those correlations by considering the material and process origins for a defined performance, taking also into account the final geometry of the pharmaceutical dosage form. A systematic evaluation of the literature will be first carried out. Depending on the release performance targeted (e.g. pulsatile, prolonged, immediate release), a summary of all formulations tested by researchers, highlighting the role of each component, will be built. Given the strict constraints related to safety of use, only approved pharmaceutical-grade ingredients will be then employed in the project, in view of their immediate application in pharmaceutical R&D labs. Both FDM, with an outlook towards 4D printing, and Binder Jet printing will be considered.</p> <p>After literature review, the research work will aim at demonstrating the structure-processing-performance correlations of the formulations tested, relying on three main steps: 1.a) from components to filaments; 2.a) from filaments to products and 3.a) from products to performance in case of FDM and 1.b) from components to inks and formulated powders; 2.b) from powders to products and 3.b) from products to performance in case of Binder Jet printing. The appropriate physico-mechanical characterization of the starting materials will be first carried out to identify which features would be the most relevant for processability and how these affect the associated operating conditions. Being able to predict the behavior of a particular formulation would also be advantageous for screening new ingredients, such as bio-based or waste-derived excipients, from a green chemistry approach.</p>



	<p>Finally, the effect of the 3D printed structure, both at the micro- and macro-scale, on the final system performance would be investigated. This evaluation would not simply entail structure-release correlations but will also consider the impact on the mechanical performance of the DDS under development. As evident from above, the project is highly interdisciplinary. As a consequence, the physico-mechanical and structural investigation will be carried out mainly at the Polymer Engineering Lab of Dipartimento di Chimica, Materiali and Ingegneria Chimica of Politecnico di Milano, while the 3D printing and release performance assessment will be carried out by the PhD student in the laboratories of the Contract Development and Manufacturing Center (under GMP) and Innovation Center (non-GMP) of the international research partner, Glatt GmbH, Germany. Università degli Studi di Milano will be also provided for the research.</p>
<p>Educational objectives</p>	<p>The project aims at training a researcher skilled in the fields of Materials Engineering and Pharmaceutical Technology, with a deep knowledge of advanced methods for the physico-mechanical characterization and 3D printing of polymers to develop drug delivery systems. Together with the technical skills, the candidate will strengthen her/his ability to critical thinking in analysing and proposing solutions, along with a strong attitude for innovation and technology transfer towards the industrial sector, also at international level.</p>
<p>Job opportunities</p>	<p>Given the interdisciplinary skills acquired and the research experience in the R&D division of an international group, a position in industrial research, development and innovation is indicated as a priority career outlet, both at a national and international level.</p>
<p>Composition of the research group</p>	<p>1 Full Professors 3 Associated Professors 1 Assistant Professors 4 PhD Students</p>
<p>Name of the research directors</p>	<p>Prof. Francesco Briatico Vangosa</p>



Contacts	
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<p>Francesco Briatico Vangosa: e-mail: francesco.briatico@polimi.it Polymer Engineering Lab: https://www.cmic.polimi.it/en/ricerca/elenco-gruppi-di-ricerca/polyenglab/</p>
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Additional support - Financial aid per PhD student per year (gross amount)	
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Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

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

National Operational Program for Research and Innovation	
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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)	Glatt Pharmaceutical Services GmbH & Co. KG (Werner-Glatt-Straße 1 - 79589 Binzen, Germany) https://www.glatt.com/en/
By number of months abroad	6

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

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.