



PhD in CHIMICA INDUSTRIALE E INGEGNERIA

CHIMICA / INDUSTRIAL CHEMISTRY AND CHEMICAL ENGINEERING - 39th cycle

PNRR 117 Research Field: MINERALIZATION AND RECYCLING OF FLUORINATED MOLECULES, POLYMERS, AND MATERIALS

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

Objective of the present research contract will be the mineralization and recycling of several classes of fluorinated molecules, polymers, and materials by the use of various methods. Fluoropolymers are used in a wide range of applications, in which, typically, materials stability in severe thermal and chemical conditions is required. However, this stability makes recycling process difficult to be achieved and, therefore, standard decomposition techniques cannot be applied conveniently to fluorinated materials, in general. Reactions using subcritical or supercritical water are considered environmentally benign in chemical engineering because these reactions can form useful products or transform undesirable compounds into environmentally harmless compounds. Based on the literature screening, the final goal of this project is to identify and test the optimal reaction conditions and methods for the full mineralization and recycling of several classes of fluorinated molecules, polymers, and materials.

Methods and techniques that will be developed and used to carry out the research

This research project will first include an experimental study regarding the optimization of the conditions for the mineralization of partially-hydrogenated fluoropolymers, for example polyvinylidene fluoride (PVDF) among others, by the use of subcritical water, *i.e.*, using conditions below water critical point of 373°C and 22.1 MPa. The effect of the addition of various alkali metal and alkaline earth



	<p>metal bases will be tested, along with the use of various oxidants. Different reaction times will be evaluated. The experimental part will regard the optimization of the methods for the mineralization of fully-fluorinated fluoropolymers (perfluoropolymers), in particular polytetrafluoroethylene (PTFE), and perfluororubbers and membranes. Also, small molecules such as perfluorosurfactants will be tested. Finally, other solid-state mineralization methods will be studied, such as those based on mechanochemistry. An important part of the project will be devoted to characterization, separation and analytical techniques thereof, which encompass centrifugation, ion chromatography, total organic content determination, HPLC, powder X-ray diffractometry (XRD), and Fourier-transform Infrared spectroscopy (FT-IR), among others. The final goal is the complete mineralization of the fluorinated material and the optimized recovery of the starting material CaF_2, <i>i.e.</i>, fluorite, which is nowadays classified as a critical raw material.</p>
<p>Educational objectives</p>	<ul style="list-style-type: none"> • Learn about the unique chemical-physical properties of fluorinated materials • Learn about the main applications of fluorinated materials • Learn the principles of circular economy and chemical recycling • Learn the fundamentals of reactions in sub-/super-critical conditions • Learn the fundamentals of mechanochemistry • Learn the principles of characterization, separation, and analytical techniques
<p>Job opportunities</p>	<ul style="list-style-type: none"> • R&D positions in chemical companies • Fluorinated materials specialist in chemical companies • Researcher in chemical and materials departments in academia, research institutes, and chemical agencies • Product Application Specialist in various sectors using fluorinated materials



Composition of the research group	2 Full Professors 3 Associated Professors 5 Assistant Professors 6 PhD Students
Name of the research directors	Prof. P. Metrangolo, Dr. S. Millefanti

Contacts	
POLITECNICO pierangelo.metrangolo@polimi.it (+39-02-23993041) SOLVAY stefano.millefanti@solway.com (+39-02-29092760)	

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)	Solvay Specialty Polymers - Viale Lombardia 20A, 20021 Bollate (MI) - https://www.solway.com/en/
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	InVerTec e.V. - Gottlieb-Keim-Strasse 60, D-95448 Bayreuth, Germany
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>Confidentiality (Agreement with company): since this is a thematic scholarship, the management of Confidential Information, Results and their publication are subordinate to the restrictions agreed upon with the funding company. Upon acceptance of the scholarship, the beneficiary must sign a specific commitment.</p> <p>Individual budget for research (4.500 euro): 1st year: 1.500 euro; 2nd year: 1.500 euro; 3rd year: 1.500 euro</p> <p>Teaching assistantship (availability of funding in recognition of supporting teaching activities by the PhD student): there are various forms of financial aid 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.</p>