POLITECNICO DI MILANO

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

PNRR_352 Research Field: DEVELOPMENT OF SENSORS FOR HALOGENATED POLLUTANTS

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	This research project acts in the framework of sustainability, specifically for the valorization of water as a fundamental need for life, which is strategic for institutional, environmental and economic point of view. The valorization of water fits the PNRR objective "Green Revolution and Ecological Transition" and represents an urgent need in the context of the drought emergency that Italy is currently experiencing. In this context, Poly- and PerFluoroAlkyl Substances (PFAS) are released during industrial manufacturing processes and from multisectorial products. They are omniphobic, highly stable, persistent, and resistant to biodegradation.Their accumulation in living systems and in the environment raises great concern. The Stockholm Convention in 2009 (http://chm.pops.int/) aimed to eliminate use of several PFAS worldwide. From 2020, the European Chemicals Agency (ECHA, https://echa.europa.eu/it/) prohibited manufacturing, commercialization and use of products containing perfluorooctanoic acid. The European Council of Ministers called for an action plan to reduce PFAS impact, particularly in drinking water. The applicability of EU directives demands suitable methods to quantify PFAS in water and extract them. Benchmark detection methods are chromatographic techniques coupled with mass spectrometry that, however, need a preconcentration step and are not in-field deployable. Thus, widespread monitoring of PFAS

	levels is not feasible with the existing technologies.The challenge of this PhD project is to build a knowledge-based technology platform enabling specific recognition and sensing of PFAS in water. In detail, the project includes the design, synthesis, and development of the active sensing layer, and the assembly and testing of sensors. Specifically, the proposed research plan aims to develop a PFAS sensor based on an Organic Field Effect Transistor (OFET), integrated with a microfluidics circuit admitting freshwater in. The aim is to respond to the need for rapid in-field-deployed monitoring of PFAS compounds in freshwater, in compliance with the increasingly stricter environmental regulations on the presence of these ubiquitous and pervasive pollutants.
Methods and techniques that will be developed and used to carry out the research	To valorize water, the OFET system will include a thin polymeric membrane, tailored with fluorinated groups for capturing PFAS from water, keeps water separated from a Sorption Fluid Layer (SFL). SFL is a perfluorinated liquid or an ionic liquid crystal endowed with C-F bonds that wets the gate electrode of the OFET at the bottom. Modulation of the affinity of SFL towards PFAS by tuning the gate potential drives the active transport of PFAS from the membrane to the OFET sensing interface. The sensing interface will be a conducting polymer functionalized with fluorinated chains exerting specific fluorous/fluorous interactions with the target analyte. Depending on the gate electrode functionalization, specific PFAS will be recognized by the change of polarization at the gate electrode surface. An array of PFAS-recognizing gate electrodes will allow to fingerprint the distribution of PFAS pollutants through the individual response of the OFET. The sensors may operate as a function of time, and as a chemical-time integrator of the total PFAS concentration.After a careful study of the scientific and patent literature, the PhD student will focus on the synthesis of the separation and sensing layers, that will be integrated in the OFET scheme described above. The performance of the assembled sensor will be tested against most widespread PFAS. Sensor performance will also be screened against other well-recognized pollutants, such as fluorinated NSAID (Non-Steroidal Anti-

	Inflammatory Drugs) and related compounds.The research work will be developed in collaboration with Pietro Fiorentini S.P.A which develops technology and solutions for a digital and sustainable world transition. It is an interdisciplinary project, which will promote collaboration with other academic institution aimed at the complete realization of the device.
Educational objectives	The proposed PhD project will provide an excellent training program to the PhD candidate, who will acquire advanced skills in water valorisation and pollutants sensing. In detail, these will include: • Design of specific layers for pollutants sensing • Preparation of Organic Field Effect Transistor with the designed layers • Optimization of pollutants removal and water valorization process. Moreover, the candidate will be trained to become and independent scientist, able to conduct original research, through the acquisition of multidisciplinary competencies and methodological expertise, such as the ability to work in a team and to effectively communicate research achievements.
Job opportunities	Through the creation of a network between the academic community and industrial companies operating in the field, the proposed PhD project will set the bases for future research-oriented careers at either university or industry, as well as in the regulatory field concerning man-derived pollutants.
Composition of the research group	3 Full Professors 3 Associated Professors 5 Assistant Professors 4 PhD Students
Name of the research directors	Prof. P. Metrangolo, Prof. C. Bertarelli

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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	0

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	PIETRO FIORENTINI S.P.A.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Tampere University, Finland
By number of months abroad	6

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

Confidentiality: 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 (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.