MATERIALS SCIENCE AND TECHNOLOGY

IIT - Investigation of Safe and Sustainable Electrode and Electrolyte Materials for Next-Generation Energy Storage

Funded By	FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA [P.iva/CF:09198791007]
Supervisor	ELIA GIUSEPPE ANTONIO - giuseppe.elia@polito.it
Contact	ELIA GIUSEPPE ANTONIO - giuseppe.elia@polito.it Remo Proietti (IIT)
Context of the research activity	Materials for electrochemical energy storage and related electrochemical characterization and modelling
Objectives	Sustainable energy storage and production are essential for the survival and advancement of humankind, particularly due to concerns over global warming and related issues arising from over-dependence on environmentally hazardous approaches to energy production and use by industries and society. In the quest for a sustainable society, energy storage technology is vital and destined to play a central role in the future energy landscape. The use of materials and methods involving sustainable resources is becoming increasingly urgent to protect humankind from the most serious consequences of climate change. Rechargeable batteries of all forms will be required to follow this path. Currently, the European Commission is proposing to modernize EU legislation on batteries, with actions announced in the new Circular Economy Action Plan. Batteries that are more sustainable throughout their life cycle are key to achieving the goals of the European Green Deal and contributing to the zero-pollution ambition set in it. They promote competitive sustainability and are necessary for green transport, clean energy, and achieving climate neutrality by 2050. In such a scenario, the development of an energy storage platform based on abundant, cheap, and high-performing materials is needed to be integrated into a sustainable energy exploitation strategy of renewable sources. Batteries such as Li-ion batteries and post-Li energy storage systems are the most suited choices. However, safety remains an essential requirement, and problems related to the use of liquid electrolytes based on organic solvents (flammable, volatile, toxic) still need to be addressed. Among others, solid-state (polymer-based, hybrid, composite) electrolytes represent a truly suited option in this respect, and their development is fundamental for the future generation of safe, high-performing energy storage and conversion devices.

	Objectives The main objectives of this PhD are: - To investigate and develop new cathode and anode materials for use in next-generation batteries that offer higher energy density, longer cycle life, and improved safety compared to current state-of-the-art materials. - To develop and optimize new manufacturing and fabrication processes for battery components and materials, with a focus on scalability and cost-effectiveness. - To explore and optimize new battery architectures, such as solid-state batteries, lithium-sulfur batteries, and sodium-ion batteries, that offer improved performance and safety characteristics compared to conventional lithium-ion batteries. - To investigate the electrochemical behaviour of batteries under extreme conditions, such as high temperatures or high discharge rates, and develop strategies for improving the performance and safety of batteries under these conditions. - Characterization of synthesized materials and optimization of their physico-chemical, structural-morphological and electrochemical properties, such as X-ray diffraction, scanning electron microscopy, transmission electron microscopy, and thermal analysis. - Assembly of the synthesized materials in next-generation energy storage devices and their characterization in terms of electrochemical performance, compatibility and stability with different electrode/electrolyte materials. - Advanced characterization/modelling of the above materials and devices.

Skills and competencies for the development of the activity	Candidates with education in Chemistry or Materials Science are sought. Candidates should have a strong chemistry and/or materials preparation background and high motivation to learn through advanced research. Good knowledge of practical attitude for the lab activities and problem-solving skills are also appreciated. A background in characterization techniques and modelling of functional materials is also welcome. A background in electrochemistry and electrochemical characterization techniques, such as cyclic voltammetry and impedance spectroscopy, is also welcome. Good knowledge of English, both spoken and written, is required.