# MATERIALS SCIENCE AND TECHNOLOGY

## DISAT - Versatile materials for batteries and electrocatalysis

| | |
|---|---|
| **Funded By** | Dipartimento DISAT |
| **Supervisor** | BELLA FEDERICO - federico.bella@polito.it |
| **Contact** | |
| **Context of the research activity** | This PhD position concerns the design of multipurpose materials for electrocatalytic nitrogen reduction, lithium-sulfur and potassium batteries, with a special focus on electrochemical properties and sustainability.<br>The growing demand for sustainable and cost-effective energy storage and conversion technologies is fostering the development of innovative electrochemical systems beyond conventional lithium-ion batteries. Among emerging alternatives, potassium-ion batteries are gaining momentum due to the earth-abundance and global availability of potassium, combined with favorable electrochemical characteristics. In parallel, lithium-sulfur batteries are being intensively explored as a next-generation solution, offering high theoretical energy densities and the potential for low-cost, lightweight storage.<br>Furthermore, electrocatalytic processes—particularly the reduction of nitrogen-based species to ammonia—are receiving increasing attention as a route to sustainable chemical production, leveraging battery-inspired architectures and hybrid energy systems. The PhD activity will be carried out within an interdisciplinary research environment, addressing the design of advanced materials, scalable fabrication approaches, and coupled energy conversion/storage concepts. The candidate will contribute to projects at the intersection of battery chemistry and electrocatalysis, with the goal of enabling novel technologies for a low-carbon future.<br>The activity is granted by the projects:<br>- From M1 to M3: SuN2rise [54_RE120BEF02, CUP E12F20000470006]<br>- From M4 to M12: LOTUS [54_RID24_BEF01, CUP E13C22002510005]<br>- From M13 to M36: GREEN2MOVE [54_RID24_BEF01, CUP E13C24000310001]. |
| | The PhD student will work on the design, synthesis, and optimization of advanced materials for next-generation electrochemical energy systems, with a primary focus on potassium-ion and lithium-sulfur batteries, as well as electrocatalytic ammonia synthesis. The research will involve the development and structural–electrochemical characterization of active materials and electrodes, with the aim of improving performance, cycling stability, and compatibility with scalable fabrication methods.<br>Particular emphasis will be placed on digital twins approaches and water/dry- |

| | |
|---|---|
| **Objectives** | based synthetic protocols to tune morphology, porosity, and interfacial properties. These techniques will be explored to enhance electron transport, adhesion, and catalytic activity in both battery and electrocatalytic architectures. The student will employ a range of tools—including electrochemical testing, electron microscopy, and spectroscopy—to correlate processing parameters with functional outcomes.<br>In the context of lithium-sulfur batteries, the work will target strategies to mitigate the polysulfide shuttle effect and improve the reversibility of the sulfur redox reactions. For the electrocatalytic reduction of nitrogen-based species, the candidate will investigate electrode designs capable of promoting selective ammonia production, drawing inspiration from battery electrode architectures.<br>The project will include both lab-scale experimentation and evaluation of scalability, aiming to bridge fundamental research with industrial applicability. The expected outcomes are high-performance electrode materials and processes compatible with sustainable, next-generation energy and chemical conversion systems. |

| | |
|---|---|
| **Skills and competencies for the development of the activity** | The following skills and competencies are requested for the development of the activity:<br>• Candidates are required to have defended a MSc Thesis in: Chemical Engineering, Materials Engineering; Industrial Chemistry; Chemistry; Materials Science; Energy Engineering; Industrial Biotechnologies.<br>• Previous activities of the candidates in the field of battery materials design and/or related materials chemistry methodologies or synthetic approaches constitute a preferential skill for the selection process.<br>• Capacity to work in a multidisciplinary team and to organize the own work for accomplishing deadlines.<br>• Regularly write project reports and papers in agreement with supervisors' schedule. |