SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

Advanced hybrid and organic materials for redox flow battery application (RFB)

Funded By	C.N.R. - CONSIGLIO NAZIONALE DELLE RICERCHE [P.iva/CF:02118311006]
Supervisor	LAMBERTI ANDREA - andrea.lamberti@polito.it
Contact	Alessandra Di Blasi (diblasi@itae.cnr.it)
Context of the research activity	The research activity is focused towards electrode materials development based on organic/inorganic (or hybrid) or purely organic materials, for Aqueous Organic redox flow battery (AORFB) for stationary application
	Scholarship financed by Consiglio Nazionale delle Ricerche – Istituto Tecnologie Avanzate per l'Energia "Nicola Giordano" (CNR ITAE) Main seat to carry out the research: CNR ITAE (Messina) Supervisor: Alessandra Di Blasi (diblasi@itae.cnr.it) The "Conference of the Parties", held in Paris in 2015 (COP 21), marks the decisive start towards all the initiatives aimed at encouraging the decarbonisation process in the energy sector in 2030-2050, through "low carbon emission" processes/products. A real "energy transition" is underway in which all the most energy-intensive sectors are involved. Above all in Europe in the stationary sector at the level, we are witnessing substantial changes in the electricity transmission networks. Electrochemical storage systems (ESS) become fundamental in support of the new decentralized model. Italy agrees with the European Community (EU) approach aimed at accelerating and encouraging actions focused on the decarbonization process in the energy sector by implementing the recent "Piano Nazionale Integrato per l'Energia ed il Clima (PNIEC)" whose targets consisting in a 33% reduction by 2030 from 2005 levels of greenhouse gases (GHG) and carbon-neutrality in the long term (2050). The strategy is entirely consistent with the recent actions planned within the "Piano Nazionale di Ripresa e Resilienza (PNRR)" that tends to intensify the "energy transition phase" through the so-called "Missione 2-Rivoluzione Verde e Transizione Ecologica-Componente 2 (M2C2). Among the current ESS, the Redox Flow Batteries (RFB) represent the most promising system for energy storage for stationary applications thanks to the high number of cycles, fast response times, and separation between power and capacity. However, in order to undergo the decisive push towards market entry, it is still essential to improve fundamental aspects such as low energy density and low electrocatalytic

Objectives	activity responsible for the electrochemical parameters of the cell. Moreover, the recent Batteries Europe (BE) roadmap shows a direction change towards more available and sustainable technologies in terms of chemistry and materials. Nowadays, actual commercial materials for ESS represent an important limit for enhancing the battery performance both in terms of reversibility and durability. Therefore, the scope of the research is focused towards advanced and sustainable materials development that become priorities and require responsible choices. Despite vanadium RFB (VRFB) being the most competitive among the RFBs, the low earth abundance, high cost, and volatile price limit its widespread commercial adoption. Such techno-economical drawbacks are also related to the challenges of traditional electrolytes, including corrosivity, toxicity, and severe crossover through the separator. Therefore, the activity objectivies are addressed towards cost-effective, more sustainable, not toxic, and readily available materials, i.e., organic/inorganic (or hybrid) or purely organic materials, in terms of electrodes for Aqueous Organic RFB (AORFB). In particular, the poor electrocatalytic activity and reversibility are critical aspects of all RFB; the commonly utilized electrode for RFB is carbon-based material such as CF and carbon modified by oxygen and nitrogen functional groups able to reach a current density of 20-100 mA/cm2. Therefore, the research activity targets are mainly focused towards hybrid and organic electrocatalyst materials development for improving the AORFB electrochemical parameters in terms of energy efficiency (EE), voltage efficiency (VE) and coulomb efficiency (CE). Composite materials based on transition metal oxides and CNFs coming from organic polymer as well as materials from biomasses conversion represent the activity goal. Physico-chemical and electrochemical tests allow to evaluating the cell performance with respect to the SoA. This represents a strategic and ambitious research activity that looks towards the next future.

Skills and competencies for the development of the activity	Preferrable Degree in Chemistry and knowledge of several physico-chemical (XRD, SEM, TEM ecc.) and electrochemical characterization devices (cyclic voltammetry (CV), electrical impedance spectroscopy (EIS), electron conductivity etc..)