SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

Development of new nanostructures for CO2 reduction into valuable chemicals

Funded By	FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA [P.iva/CF:09198791007]
Supervisor	LAMBERTI ANDREA - andrea.lamberti@polito.it
Contact	Michele Ferri, michele.ferri@iit.it Ilka Kriegel, ilka.kriegel@iit.it Liberato Manna, liberato.manna@iit.it
Context of the research activity	Carbon dioxide (CO2) reduction is a promising strategy to solve the energy crisis and to take a step towards a circular economy. With this PhD we will develop new colloidal synthesis approaches to develop nanostructured catalysts for CO2 reduction (light-driven/electrocatalytic) with the major target of producing alcohols and hydrocarbons.
Objectives	Scholarship funded by IIT. Main seat to carry out the research: Istituto Italiano di Tecnologia, Genova Supervisors: Liberato Manna, liberato.manna@iit.it Ilka Kriegel, ilka.kriegel@iit.it Michele Ferri, michele.ferri@iit.it Contact: Iulia Manolache, iulia.manolache@iit.it One of the most critical points that limits progress and practical applications of CO2 reduction reactions (light-driven/electrocatalytic) is related to the poor product selectivity and the difficulty in producing high-added value C-based products such as alcohols and/or hydrocarbons. A deep understanding of the fundamental processes of CO2 reduction reaction mechanisms is the key to tune the product selectivity. In this project, the candidate will synthesize well-defined nanostructures capable of eliciting efficient CO2 reduction and with high selectivity toward specific products. Therefore, the project will consist of various activities: i) colloidal synthesis of nanomaterials; ii) advanced structural, surface and compositional characterization; iii) testing of the nanostructures for their capability to promote the CO2 reduction and specific products distribution, targeting high yield and product selectivity, high efficiency and catalysts' cyclability; iv) modeling (this latter step carried out in collaboration with a computational team). During the PhD, the candidate will develop colloidal synthesis approaches aimed at preparing nanocrystals having the desired composition, crystal

	phase, surface passivation, size and shape. This will be achieved via finely tuning the reactions parameters such as the reaction temperature, the reactivity of precursors, the type of surfactants, the polarity of solvents etc. A particular attention will be devoted to the synthesis of nano-heterostructures, that is nanocrystals composed of two or more domains of different materials. This will allow to exploit the synergy between different materials in catalyzing the CO2 reduction. Ligand exchange or stripping procedures will be also investigated in order to modulate the nanocrystals catalytic activity and to expose the reactive surface sites. For the catalytic part, the PhD candidate will test the photo-, photoelectro and electrocatalytic CO2 reduction performances of the synthesized materials. CO2 reduction testing will make use of photoreactors and/or electrochemical cells (both batch and flow-cells) with in-line analytical setups for CO2 reduction products identification and quantification. Pre- and post-catalytic tests characterization of the active materials will also be performed. Overall, by merging different photoelectrochemical tests, a thorough characterization of catalysts and, when relevant, theoretical calculations, it will be possible to unravel the underpinnings of the photoelectrocatalytic activity of the synthesized materials. Building on this knowledge, highly active, selective and durable CO2 reduction catalysts will be obtained. Strong collaboration with fellow PhD students of the same institute and PhD program is foreseen.

Skills and competencies for the development of the activity	Chemistry, physics, natural sciences, engineering or similar qualification Experience with colloidal synthesis, photocatalysis/electrocatalysis would be a plus Interest in learning new topics Collaborative working attitude Interdisciplinary research approach Ability to work in an international research environment