PhD in Chemical Engineering

Research Title: Development of nanostructured photo/electrocatalyst materials for the conversion of CO_2 to oxoproducts

Funded by	DISAT/Ateneo fondi CRT EU H2020 Project SunCoChem

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Context of the research activity	Greenhouse Gases (GHG) emissions (of which ~ 65% is constituted by CO_2) is one of the most challenging environmental issues to face in the 21st century. Currently, the European chemical Industry strongly depends on carbon feedstock imports for energy and chemical manufacturing processes, which are based over 95% on the use of fossil fuels. Besides, the EU energy system is 80% based on fossil fuels use that cause 80% of EU GHG emissions, and about 53% of the energy consumed in the EU is imported from outside countries. The introduction of sustainable chemistry using renewable resources and CO_2 to produce chemical products brings the opportunity of an efficient use of resources. It could reduce greenhouse gas emissions, in line with the commitments agreed in the 2015 United Nations Climate Change Conference (COP21). Carbon Capture and Utilization (CCU) is one of the major technologies that could be addressed worldwide to mitigate CO_2 emissions. Among different processes, the photo/electro-catalytic reduction of CO_2 is an attractive solution that can be exploited as an efficient route to convert CO_2 into chemical or fuels by using: renewable electricity, water as a source of protons (H^+) and electrons (e^-) in the so-called “artificial photosynthesis”. In this way, CO_2 can be used as a feedstock in a circular economy perspective, transforming waste into useful and value-added

	products to tackle both GHG emissions and energetic problems related to the dependence on fossil fuels. In this context, the EU financed project SunCoChem (https://suncochem.eu/) that will finance this PhD fellowship aims to provide a sustainable alternative to traditionally produce fossil-based chemicals by using sunlight as an energy source and reusing CO_2 as a raw material in a circular economy approach. The project aims to develop a photo/eletro-catalytic tandem reactor (TPER) to manufacture valuable chemical oxo-products (glycolic acid, valeraldehyde, Limoxal^{TM}) from renewable energies based on CO_2, H_2O and solar energy.

Objectives	The main objective of this PhD is to study novel nanostructured photo/electrocatalyst materials for the conversion of CO_2 to oxoproducts in a tandem photo/electro-catalytic tandem reactor. The expected outcomes of the studies that will be performed are: - Investigation of new tandem photo/electro-catalytic systems based on abundant, low-cost metal oxides and heteroatoms for the CO_2 conversion to oxoproducts. - Assess the role of each catalyst component on the CO_2 reduction activity and selectivity to tune novel photo/catalysts formulations. - Identify structural and/or chemical-physical changes in the photo/electrocatalyst, leading to its eventual deactivation to develop strategies to enhance its stability. Different instruments and characterization techniques (FESEM, XRD, XPS, UV-Vis spectroscopy) available at Polito-DISAT and CREST Group https://www.disat.polito.it/it/la_ricerca/gruppi_di_ricerca/crest (e.g. Solar-Fuels Lab) will be exploited for the chemical-physical characterization of the prepared catalysts in powder form and deposited on porous conductive substrates. A photo/electrochemical test-bench at DISAT, recently acquired in the regional project CO_2 Circle Lab framework, will be used for the macroscopic electrochemical activity tests. Products analysis will be performed by using analytical instruments, e.g. HPLC, GC-MSD with headspace, micro-GC, among others.

Skills and competencies for the development of the activity	- Knowledge of chemical engineering and/or industrial chemistry is required. - A good background or previous studies in electrochemistry and catalysts synthesis is of high importance. - Know-how and/or willing to learn electrochemical characterization techniques, electrocatalyst and electrodes preparation methods. - Good knowledge of standard practices and previous experience in chemical laboratories are desirable. Ability to set priorities, work in a multicultural and multidisciplinary team, and plan the work and respect deadlines are important.