Politecnico di Torino

ENERGETICS

VERSALIS - Study of the conversion of CO2 to chemicals of interest to the chemical industry by means of solid oxide electrolysis technology – SOEC

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Context of the research activity	The issue of climate change and consequently the reduction of carbon impact is of fundamental importance for the chemical industry, considered a "hard to abate" production sector, especially following the significant energy intensity of the production processes. CO2 is also a possible feedstock for the chemical production chain, to be used as an alternative to traditional feedstocks of fossil origin - above all virgin naphtha - as a source of carbon, but the main difficulty to face is its poor reactivity, which makes its conversion is therefore a scientific and technological challenge. In particular, it is necessary to orient conversion processes towards energetically favorable approaches, such as to have a low carbon impact. Among the many technologies being studied today, electrochemical processes are certainly of particular interest, which - using electricity from renewable or nuclear sources - can guarantee this last requirement - low carbon impact. In particular, electrochemical processes are implementers of the trend towards the electrification of end uses (consistently with the growing electrification of primary sources) which can also be considered of growing interest for the chemistry sector. In these processes the CO2 is reduced to the cathodic section by reaction with the hydrogen of the water (or, preferably, with its ionic form deriving from the anodic oxidation reaction of the water), to give less oxygenated products, until reaching hydrocarbon compounds completely devoid of oxygen. The CO2 reduction reaction is thermodynamically unfavorable compared to the water reduction reaction, which occurs at lower potentials, and therefore it is necessary to use an appropriate catalytic system that overcomes this thermodynamic limit. Furthermore, also with regards to the technological structure of the electrolytic cell, there are various solutions under study, each with specific pros and cons, as is normal in these cases. Among the possible solutions, the one that is the subject of this doctoral thesis is solid oxide cell technology (Solid Oxides Electrolysis Cell - SOEC).

	The PhD activity will be carried out mainly at the HySyLab/CO2 Circle Lab of

Objectives	Politecnico di Torino. In particular, the scientific activity will be developed in close collaboration with the VERSALIS-ENI Research Center in Mantova (co-funding the activity). The activity is also developed in the framework of the EU PathFinder Project ECOLEFINS (DENERG-POLITO Partner). Among the possible technologies useful for reducing the carbon impact in the chemical industry, the Solid Oxides Electrolysis Cell - SOEC have thermodynamic and kinetic characteristics that allow the production of H2 and the electrochemical reduction of CO2 to produce H2/CO syngas with high efficiencies. SOECs can give rise to thermal integration solutions with downstream synthesis processes, improving system efficiency for industrial uses. The doctorate involves the development of a SOEC system which (as a further innovation) involves the co-ionic conduction of H+ ions migrating from the anode to the cathode and available there in ionic form for the reduction reaction of CO2, and of O2- ions resulting from the cathodic reduction of CO2 and removed from the cathode by migration towards the anode. In this context, the cathode electrode must be designed to develop CO2 reduction mechanisms via H+ protons for the direct production of totally deoxygenated hydrocarbons. The study involves the design of the cathode electrode and the co-ionic conductive electrolyte layer, the development and testing of the cell layers, the design, production and testing of an SRU (Single Repeating Unit) and possibly of a subsequent short- stack. The target is to obtain, on a laboratory scale, a proof of concept of the process, and a rough evaluation, through theoretical simulation, of an industrial solution.

Skills and competencies for the development of the activity	• Ceramic materials • Electro-catalysis • Kinetic • Thermodynamics • Heat transfer • Experimental capabilities on electrochemical technologies and processes • Modeling capabilities in terms of multi-physics phenomena (electrochemical, thermal, mass transport)