SINCHEM PhD Subject

Development of advanced catalysts to store renewable energy by converting CO_2

Home institution: University of Messina (Prof. S. Perathoner, Prof. G. Centi)

1st Host Institution: RWTH AACHEN Univ. (Germany) to be confirmed

2nd Host Institution: Politecnico di Torino or a company (in definition)

This project aims to develop advanced catalysts to convert CO_2 to methane or methanol as two alternative routes to store and transport renewable energy sources, the first applied to store excess electrical energy produced by wind turbines to develop solutions which may integrate into advanced smart grid solutions (so called Power-to-Gas technology - P2G - for storage of renewable electricity in the natural gas infrastructure) and the second as a solution to transport from remote sources renewable energy. Both these technologies have a large potential use, but require to develop advanced catalyst formulations.

There are current many challenges in catalyst development for both lines of activity:

1. Although CO_2 methanation (Sabatier reaction) is known from several years, it is necessary to develop catalyst active at lower temperature, stable under real feed conditions (no dilution rather than very low CO_2 concentrations) and in the presence of high hop-spots (methanation reaction is highly exothermic; the catalyst composition has to be optimized in relation to the different type of possible reactor configurations). Catalysts have to be also scalable and formed into suitable shapes (foams, for example) for industrial development. Based on the definition of an optimal methanation process scheme and type of reactor (in collaboration with other partners), the objective of the work is to analyze the optimal design of a structured catalyst for the methanation reaction in order to meet the requirements of a high productivity at low temperature, stable operations and optimal fluidodynamics for heat/mass transfer. As part of this design, specific catalytic tests in a lab-scale reactor unit (including eventually high-throughput tests) will be made to select the optimal composition (for productivity and selectivity as well) and to optimize catalyst morphology, shape and other characteristics to improve heat/mass transfer and stability (in particular, regarding soot formation). Aspects investigated for catalyst optimization will regards the type/geometry of carrier materials, metal dispersion, pore size distribution and particle shape.
2. Catalysts for methanol production are optimized for the use of syngas with limited amounts of CO_2 (around 3%), but the use of CO_2-only feeds requires the development of new catalysts with higher productivity, lower sensitivity to CO_2 concentration, lower inhibition by water content and better stability. As in the case of the first line, the objective is to first screen different catalysts composition to optimize the performances with respect to these aspects (in a lab reactions, including tests in a high-throughput system) and then with respect to the scale-up for industrial reactors, including microreactors ones.