Nanocatalysts for sustainable processes

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The sustainable development of the modern society requires the replacement of fossil compounds as fuels and raw materials for the production of commodities. In this context, great interest is devoted in the conversion of cheap and abundant gaseous compounds into high added-value products with the extensive use of solar light as primary energy source. Among them, the reduction of CO_2 or atmospheric N_2 into fuels and fertilizers represent an exciting challenge. The aim of this Ph.D. project is the development of innovative heterogeneous catalysts to be applied in the conversion of CO_2 into fuels (CH_4, CO, CH_3OH or HCCOH) and the fixation of N_2 into ammonia. The design and synthesis of innovative catalysts will take advantage of the bottom-up chemical methodologies that allow to control size and shape of the desired products and to combine different components into final nanocomposite materials. The photoactive semiconductors (TiO_2, CeO_2, WO_3, MoO_3 etc.) will be synthesized by hydro/solvothermal methods in the presence of adequate directing agents in order to control size and shape of the nanocrystals. These oxide materials will be coupled with carbon-based nanostructures (such as carbon nanotube and nanohorns or functionalized graphitic carbon nitride) to increase the electrical conductivity of the final nanocomposites. Adequate co-catalysts will be selected among metal nanoparticles (Pd, Pt, Au, Ru or their combination) or other oxides in order to promote electron mobility within the materials, favouring charge separation in photocatalytic reactions and electron transport in electrocatalytic applications. Post-synthetic treatments (H_2 reduction, adsorption of molecular dyes etc.) will allow the exploitation of visible light, improving the efficiencies of the investigated processes. The structure and morphology of the synthesized materials will be characterized by advanced microscopy and spectroscopic techniques, also within a network of collaborations with international research centres. The functional properties of the materials will be tested in photocatalytic and electrocatalytic reduction of CO_2 and N_2, opening the possibility of their application in photoelectrocatalytic devices.

Related publications:

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