MATERIALS SCIENCE AND TECHNOLOGY

MUR DM 117/ENI - Plasmon-enhanced photocatalytic reduction of CO2 by hybrid catalysts

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Context of the research activity	CO2 reduction is an urgent need to fight climate change and guarantee a better environment, in line with the current PNRR program. To boost the CO2 reduction reaction under solar light, plasmonic metal nanoparticles (NPs) allow better activation of small molecules, increasing both the reaction rate and the selectivity. Typically, short-range effects (the generated charge carriers excite some electronic/vibrational levels of the adsorbed molecules) and/or long-range effects (thermal relaxation may induce localized heating and, thus, thermal catalysis) occur, sometimes hardly distinguishable from another. Using hybrid catalysts including engineering TiO2 and plasmonic NPs may favour CO2 reduction processes and consequent C-C coupling reactions. Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23002060004
Objectives	The use of hybrid catalysts including engineering titania and plasmonic NPs may favour carbon dioxide reduction processes and consequent C-C coupling reactions. Several parameters strongly affect such plasmonic effects: besides the NPs chemical composition (Cu, Ag and Au are active in the Vis and NIR regions, whereas Al is in the UV), the NPs shape/size, morphology and type of exposed crystalline faces can give rise to different phenomena: for instance, light absorption should be favoured over scattering by varying NPs dimensions and structure. In some cases, metal NPs may act both as plasmonic metals and as catalysts and/or may have a plasmonic effect of catalytic NPs or bi-metallic NPs can be obtained with both plasmonic and catalytic roles. Nonetheless, the NPs/TiO2 interface plays a prominent role in photocatalytic activity.

Objectives	Objectives of this fellowship: O1. To boost the photocatalytic activity under solar illumination of TiO_2 multi-polymorphic phases (i.e. anatase/brookite, anatase/rutile) doped with heteroelements (e.g. Fe) by using plasmonic NPs. Ambitions: to engineer Cu-based NPs to limit the use of (more expensive) Au; to use Cu-based (non-toxic) QDs/TiO_2/NPs hybrid systems with QDs acting as photosensitizers and metal NPs acting as antenna. O2. To avoid CO formation as the final product, using a photocatalytic system able to have mostly methanol (CH_3OH) and C-C containing moieties as final products. The research activities will be the synthesis and physicochemical characterization of TiO/Plasmonic NPs systems and their validation by testing the CO_2 reduction both in water and in the gas phase.

Skills and competencies for the development of the activity	The candidate should have a strong background in physical chemistry, physics and materials science, with expertise in materials synthesis and physicochemical characterization. Concerning soft skills, analytical thinking, research aptitude, and effective communication will be appreciated, as well as availability to spend a period abroad and in a company.