Nanomaterials by Design: A New Chapter in Catalysis

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Nanomaterials based on noble metals, such as silver (Ag), gold (Au), palladium (Pd), and platinum (Pt), are widely employed as catalysts for a myriad of transformations that are relevant to the chemical and pharmaceutical industries. Nanomaterials that display both high catalytic activities and selectivity are of tremendous importance in the field of heterogeneous catalysis, as they enable one to potentially reduce the metal loading (several catalysts are based on noble metals) and minimize the formation of side products, and thus the need for several purification steps. While it has been shown that catalytic properties can be optimized by careful control over particle size, shape, surface composition, and structure, the synthesis of nanocatalysts in which these parameters are tightly controlled remains limited in terms of large-scale production and manufacturing robustness. Therefore, progress in the field of heterogeneous catalysis has been mainly made via a collected knowledge, trial and error, and interpretation of results approach. In this context, controlled nanomaterials are imperative to enable a transition from an observation-driven to a design driven approach in catalysis. The first part of our talk will show how the control over composition, surface morphology, size, and metal-support interactions can lead to improved performances in a variety of liquid-phase and gas-phase transformations.

Nanostructures based on Ag and Au also display remarkable optical properties in the visible region as a result of the surface plasmon resonance (SPR) excitation, which has enabled applications in the areas of surface-enhanced Raman scattering (SERS) diagnostics, novel contrast agents, optical labeling, phototriggered drug delivery and photothermal therapies. Moreover, it has been established that the SPR excitation in plasmonic nanostructures can be put to work to mediate and/or enhance a variety of chemical transformations. Thus, in addition to the "classical" heterogeneous catalysis, plasmonic catalysis has emerged as a relatively new frontier in the field which enables the utilization of visible light an eco-friendly energy input to drive and control chemical reactions. Therefore, in the second part of our talk, we will focus on how the control over these physical and chemical parameters can also be put to work to obtain improved performances in catalytic transformation mediated by the Surface Plasmon Resonance excitation in plasmonic nanoparticles.