Mesoscopic organised nanomaterials: Synthesis – Characterisation – Applications

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In the future, nanomaterials will become more and more important for many applications including photovoltaics, electrochemical energy storage systems , catalytic devices and sensors. An interdisciplinary work with connections between different groups, from synthesis to applications, is needed to get well controlled and efficient materials. The goal in this project is to study mesoporous metal oxides (TiO_2, SiO_2, Fe_2O_3) or nanocomposite systems (Au-TiO_2, $Li_4Ti_5O_{12}$, TiO_2-SiO_2….) with particle size 20-500nm and controlled porosity or pore connectivity. In this presentation, we focus on the study of TiO_2 and Au-TiO_2 materials. They have been investigated both in catalysis and electrochemistry. The synthesis methods allow a large range of nanostructured functional materials. It is performed through two different ways: micro-emulsion and colloides self-organisation by condensation of inorganic species in presence of templates. Transmission electron microscopy has been used to give some information about morphology in 2D and 3D, crystallographic structure and elemental composition of these materials. It leads to the optimisation and understanding of structural properties and morphology of the materials. The Au-TiO_2 material has possible applications in heterogeneous catalysis such as CO oxidation for example. Catalytic performances depend on the Au/TiO_2 ratio, size of Au nanoparticles, dispersion in the TiO_2 matrix and the nanostructure of the composite. On the other hand, TiO_2 anatase is expected to be used as negative electrode for Li-ion batteries. Indeed, it is well known that TiO_2 can accommodate lithium reversibly. The insertion de-insertion mechanism is governed by particles morphology and nanostructuration. The electrochemical characterisation allows us to determine the influence of nanostructuration on different parameters such as potential, capacity, reversibility and stability. Here we focus especially on nanostructured mesoporous anatase TiO_2 electrochemical performances and its possible application as anode material for Li-ion batteries.