Title: Chiral nanocatalysts for plasmonic activity

Background and description

The continued interest in renewable energy sources has intensified the research on materials and methods to improve the energy harvest efficiency and storage. One key approach is the utilization and conversion of light energy to chemical energy via a photocatalyst. In this way, we can store, for example, solar power into chemical energy (e.g. green hydrogen), which can be used on-demand. Commonly employed photocatalysts, such as $SrTiO_3$,[1] suffer from low light absorption capacity. A promising pathway to enhance their light absorption capacity is to combine them with materials exhibiting plasmonic activity.

While plasmonically active materials are not necessarily catalytically active themselves, they allow the absorption of lower energy photons (visible range) in wide band gap photocatalysts, which absorb photons of higher energy (ultraviolet range). In the Group for Electrochemistry, we have recently developed a new synthesis method for supported, well-adhered and plasmonically-active nanoparticles (NPs), such as gold (Au NPs) that are embedded in the surface of the host photocatalyst, e.g. $SrTiO_3$.[2,3] Apart from an increase in the light energy harvesting ability of the composite material (Au NPs-modified $SrTiO_3$) we have now gained a better control over the desired morphology at the nanoscale.

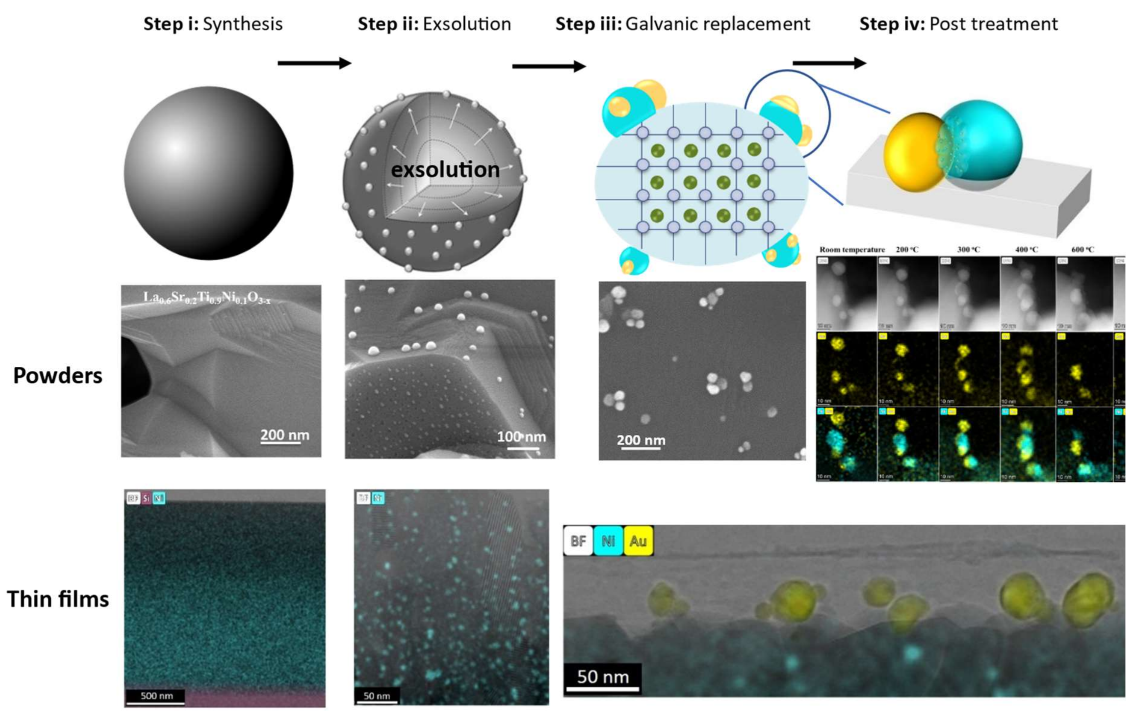

Figure 1: Schematic representation of the synthesis steps of the UiO platform method for the synthesis of catalysts for energy conversion applications. Two distinct examples involving powders and thin films of Au NPs-modified $SrTiO_3$are shown.[2,3]

The versatility in our methodology can enable the synthesis of other exotic structures with unprecedented properties. In this project, we would like to explore and develop a new class of

[1] H. Nishiyama, *et al.*, Nature, 2021, 598, 304
[2] X. Kang, K. Both, A. Chatzitakis, *et al.*, Small, 2022, 18 (29), 2201106
[3] K. Both, A. Chatzitakis, *et al.*, Catalysis Today, 2022, in press

nanomaterials based on *chirality*. Chirality or handedness (left or right) is an intrinsic property of molecular and biological systems and plays a key role in life science and technology. Chiral molecules exist in two enantiomeric forms that are mirror images of each other, as are our left and right hands. Chiral nanostructures combined with plasmonic materials are recently receiving interest due to unprecedented optical properties that could find applications in photocatalysis, chiral molecule recognition and handedness-dependent optical response for light sensing applications.

Hypothesis: To synthesise chiral NPs in this project, we will introduce, at certain synthesis steps, chiral organic molecules (such as, (*R*) - 2,2´-bis(diphenylphosphanyl)-1,1´-binapthyl – (*R*)-BINAP) that can act as "guide" molecules for the further growth of inorganic NPs to chiral and plasmonically-active NPs with certain orientation dictated by the "guide" organic molecule.

Expected outcomes and deliverables: Develop advanced materials for energy conversion applications and in this case for plasmonically-driven photocatalysis. The project will deliver catalysts in the form of powders and/or thin films that will contain chiral NPs. Optical and structural characterization will be performed to visualize the new structures and verify the main hypothesis.

Suggested literature: i) X. Kang, K. Both, A. Chatzitakis, *et al.*, Small, 2022, 18 (29), 2201106, ii) K. Both, A. Chatzitakis, *et al.*, Catalysis Today, 2022, in press, iii) H.E. Lee, *et al.*, Nature Communications 2020, 11, 263, iv) G. Gonzales-Rubio, *et al.*, Science, 2020, 368, 1472.

This project is well-aligned with UiO:Energy's research area for new and improved "Materials for Energy" and will contribute to innovation and sustainability for energy conversion applications, such as plasmonic photocatalysis.

Additional information

Name of supervisors: Athanasios Chatzitakis and Kevin Gregor Both (Electrochemistry group, Department of Chemistry, SMN)

Preferred background of the candidate: Materials science, structural chemistry and physics

Number of available projects: 1

Preferred project period: 6 weeks starting before or after July