

## **Project 3.2 Nanoengineering of multicomponent metal-free carbonaceous materials for biooil upgrading through ultrasound-assisted selective redox photo-catalysis in continuous-flow reactors**

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**WWW:** <https://photo-catalysis.org/>

### **Background:**

Climate change mitigation has become the focus of incoming worldwide initiatives and policies with the first and foremost mission of disrupting the strong reliance of our society on fossil fuels to guarantee sustainable development. Establishing a biorefinery model capable of feeding the entire industry with the key bulk and fine carbon-based chemicals that otherwise rely on petrochemical processes is the cornerstone for this technological transition. Lignocellulosic and sea-food-based organic wastes have been recognized early on as the ideal feedstock not only for being the largest renewable source of carbon not competing with food reserves but also for its unique chemical composition; being made up of a nitrogen-containing polysaccharide-based fraction (chitosan derived from partial deacetylation of chitin which is coming from the sea-food waste) and sulphur-containing complex aromatic polymer (e.g., Kraft lignin), such biomass could potentially give access to an immense portfolio of key molecules and materials. Currently, only the carbohydrate fraction is effectively used in lignocellulosic biorefineries, while a large side-stream of lignin (technical lignin) is discarded in the process by delignification treatments, serving at most as a low-grade fuel or low-value resins and lubricants given the lack of effective valorization routes for this component. From the side of chitin, which is a straight-chain biopolymer, it is also an underutilized resource due to its inherent insolubility in common (organic) solvents and the expensive and wasteful methods employed for the extraction of chemicals from it.

### **Aim:**

This project aims to develop a novel method for the transformation of lignin and chitosan into valuable metal-free nitrogen(N)- and/or sulphur(S)-containing carbonaceous photocatalysts. New catalytic materials possessing excellent sonophotocatalytic redox properties to assist continuous flow photo-redox processes in obtaining high-value chemicals from bio-oil-based molecules upgrading. The objective is to prepare metal-free carbon-based photocatalytic materials through the physicochemical effects of low/high-frequency sonication (e.g., effective mass transfer, microstreaming, cross-linked radical polymerization, etc, effects often inaccessible through conventional methods) as a promising pre-treatment step before ending the synthesis of the materials under hydro(solvo)thermal conditions. It will be carried out the study of the physicochemical properties of carbon-based materials (before and after (sono)-(photo)-catalytic test reactions), and testing them in the selective sonophotocatalytic oxidation and C-C sonophoto-reductive coupling of bio-oil-inspired model compounds (in flow liquid-phase) as a futuristic approach of bio-oil-based molecules valorization. Systematic basic research of the effect of green and unconventional source of ultrasonic energy on the pre-treatment of chitosan (precursor of C, N, O) and lignin (precursor of C, S, O, aromaticity) and its effect on the final material obtained after optimization of hydro(solvo)thermal conditions, will be carried out. To get insight into the mechanism of ultrasound-assisted hydro(solvo)thermal method, the whole spectrum of materials characterization techniques and basic kinetic studies and photocatalysts' stability/recycling studies (using the appropriate flow (sono)-(photo)-reactors) will be carried out. The use of ultrasound-based

procedures offer a facile, versatile synthetic tool for the preparation of nanophotocatalysts, often inaccessible through conventional methods.

**Requirements:**

- Expertise sought from a Ph.D. student: Graduates of chemistry, physics, materials science, and related university faculties, holding a Master of Science or equivalent degree (obtained recently, approx. < 3 years before starting this project) with an aptitude and passion for natural and exact sciences, with good knowledge of English and outstanding motivation and open mind for interdisciplinary research at the border of chemistry-physics are invited to join this project research group.

Additionally:

- CV
- Copy of MSc diploma
- Distinctions granted by virtue of scientific research, grants, awards and scientific experience acquired outside your own research work place in the country or abroad; participation in workshops and scientific trainings; participation in research projects.
- Experience in conducting scientific research in the field of catalysis, organic synthesis and materials characterization.
- At least the opinions of two independent research scientists, specialists in the field of chemistry and related sciences.
- Very welcome are publications in reputable publishing houses / scientific journals