PhD Project

Degradation of organic pollutants by a new eco-compatible process

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Context

Organic contaminants are widely spread in the environment through activities related to energy production (hydrocarbons), agriculture (pesticides), chemical industry (chlorinated solvents, plasticizers). In addition, so-called emerging contaminants such as pharmaceuticals, cosmetics and steroid hormones are currently the subject of particular attention. The identification of eco-compatible chemical reactions leading to the efficient degradation of these organic contaminants and their byproducts represents a major environmental challenge for water treatment and the preservation of the quality of natural environments. To meet these challenges, the IMPMC (Guillaume Morin, CNRS) and the LRS (Xavier Carrier, Sorbonne University) are collaborating to identify new mechanisms capable of degrading a wide range of organic pollutants, without strong oxidants, under physicochemical conditions compatible with natural environments (soils, aquatic environments).

Work program

The proposed PhD will have two parts: 1) A synthesis part which will consist in producing eco-compatible substrates capable of sorbing and degrading organic molecules on their surface, based on the know-how already well established at the IMPMC, 2) A spectroscopic analysis part which will aim to determine in situ, on the surface of these new substrates, the degradation kinetics of three priority model pollutants, from the most to the least polar. The disappearance of the molecule and the formation of degradation products on the surface of the solid will be followed by Fourier transform infrared spectroscopy in attenuated total reflection mode (FTIR-ATR). This technique will allow the direct detection of molecules adsorbed on the surface of the nanoparticle film deposited on the ATR crystal and covered with circulating water at a fixed pH. The main advantage of FTIR-ATR spectroscopy is that it only probes molecules on or near the surface region of the sample. In this configuration, in contrast to the transmission mode, IR becomes a surface sensitive technique and ATR-IR is perfectly adapted to the study of interfacial phenomena for solid-liquid reactions since it excludes most of the contribution of water used as a solvent. This second part, focused on in-situ monitoring of degradation kinetics, will first permit to precisely evaluate the efficiency of different substrates for the degradation of priority pollutants. In addition, by varying the physicochemical conditions of the experiment, the kinetic monitoring will allow progress in the understanding of the reaction mechanisms involved at the solid-liquid interface. This work will be completed with another spectroscopic approach dedicated to quantify reactive oxygen species produced by minerals synthesized during the PhD using O_2 as an electron acceptor. EPR (Electron Paramagnetic Resonance) along with spin-trapping will be used since this technique is both sensitive and specific for the detection of reaction intermediates. Promising results have already been obtained in preliminary experiments.

The outcome of this PhD work should allow us to design eco-compatible and efficient materials for pollution remediation in soils and aquatic environments for large-scale applications.

Qualifications

We are looking for a motivated PhD candidate with a background in materials chemistry, spectroscopy and surface chemistry. Knowledge in environmental (geo)chemistry would be an asset.