University of Genoa

XXXII Doctorate Cycle in Science and Technology of Chemistry and Materials

Curriculum: Chemical Science and Technology

Stefano Alberti

Tutor:

Prof. Ferretti Maurizio

Thesis Title:

Synthesis, characterization, optimization and application of TiO_2-based photocatalytic devices for environmental applications related to emerging pollution.

Abstract:

This PhD thesis deals with the exploitation of heterogeneous photocatalysis, as an Advanced Oxidation Process, for environmental issues caused by the emerging pollution, that is for wastewater remediation and bacterial decontamination. During this PhD project, several photocatalytic devices will be synthesized by coupling semiconductor (TiO_2) nanoparticles (both bare and doped) to different supporting materials, e.g. polymeric materials (PDMS membranes), porous materials (sepiolites and zeolites), glassy materials (glass beads), magnetic materials (Fe_3O_4 nanoparticles, magnetic zeolites obtained from waste recovery) and persistent luminescence materials ($3ZnO:Ga_2O_3:2GeO_2:Cr^{3+}$, $SrAl_2O_4:M^{n+}$ (M= Dy, Eu)).

In particular, TiO_2 can be synthesized through the sol-gel technique, both in the doped and undoped form (for example with Cu, Fe, N, etc.), while supporting materials can be processed with different synthetic techniques such as: sol-gel synthesis, solid state synthesis, hydrothermal/solvothermal synthesis and electrospinning technique. Some of these devices are investigated using a chemometric approach: that is the possibility to exploit an Experimental Design model in order to study the optimal conditions in terms of enhanced photocatalytic efficiency (within the experimental domain).

All synthesized samples are submitted to a physical-chemical characterization, by means of: XRD, SEM, BET, DLS, DSC, diffuse reflectance, magnetic susceptibility, rheological measurements, mechanicals tests, luminescence properties and photocatalytic efficiency. In particular, the latter is evaluated by means of methylene blue solutions degradation over time, with different initial concentrations (as expected by ISO NORM 10678:2010), in order to get the kinetic behaviour of the photocatalysts. For MB quantification, a UV-Vis spectrophotometer will be used and samples will be tested in triplicate. Furthermore, a 1L container prototype is available for a first evaluation of the industrial scale-up. All these tests will be adapted according to the supporting material employed: for example, with persistent luminescence materials, dark conditions will be investigated. Eventually, chromatographic techniques, e.g. LC-MS, GC-FIS, GC-MS, will be used for the identification and quantification of transformation by-products involved in photocatalytic processes.

National and International collaborations will give scientific credit to the project: Department of Chemistry-University of Pavia, will give a contribution on chemometric models and on photo-tests on emerging pollutants (Ofloxacin, fluoroquinolones family); Department of Chemistry-University of Kuwait, will give a contribution on recovery tests and surface charge characterizations; Department of Environmental Engineering-Technical University of Crete will host me as visiting student and will give a contribution on analytical methods and techniques for transformation by-products and matrix effects on emerging pollutants in real samples (parabens and nicotine, LC-MS, GC-FID, GC-MS); Department of Microbiology-University of Genoa will give a contribution on bacterial cultivation for antimicrobial evaluations and CNR-IMEA and CNR-ISM for magnetic materials production and characterization (magnetic zeolites from waste recovery).