RESEARCH THEMES

The activities of the MATCAT team are dedicated to the eco-design of materials for catalytic processes in fields such as environmental remediation, energy and biomass valorisation. The team is organized around four areas of expertise directly related to materials science: (i) highly divided bulk materials; (ii) design of porous supports and surface functionalization; (iii) supported active phases; (iv) materials scaling-up and shaping. The main goal is to provide catalytic materials compatible with the notion of sustainable development, based on the understanding of the relationships between their formation mechanisms and their functional properties. The MATCAT team has specific skills in advanced sit-up/moloperando characterization of materials at each step of preparation, using surface spectroscopies and X-ray absorption spectroscopy. In addition, the group benefits from the scientific and technical competences of the “Chevreul Institute”, that gathers advanced characterization platforms such as transmission electron microscopy, in situ X-ray diffraction, electron paramagnetic resonance, high field solid state NMR, vibrational spectroscopies and combined surface analyses techniques.

Divided bulk materials - The group develops methods of nanoparticles synthesis using mechanochemistry and gelation in aqueous medium of divided complex oxides for environmental catalysis (gas-phase and liquid-phase applications) and fuel cells, based on abundant transition metals (Fe, Cu, Mn). The investigated approaches allow to control properties that are difficult to access by conventional methods, including: (i) Improvement of the thermal and chemical stabilities, (ii) Stabilisation of porous networks and (iii) Shaping of materials.

Ordered and hierarchical porous supports - From the textural properties point of view, the team explores synthesis routes for oxidic supports allowing a control of the critical properties of hierarchical porous materials including network interconnectivity and secondary network stability. The development of materials includes studies of mechanical and chemical stabilities, particularly during synthesis, activation and in representative catalytic conditions (hydrothermal conditions). From the synthesis point of view, we investigate the substitution of the petroleum-sourced porogens (block copolymers) by bio-sourced porogens (nanocellulosic derivatives with self-assembling properties), or their non-thermal elimination (chelation of metal salts).

TEAM LEADER FOREWORD

In agreement with the scientific strategy of the UCCS project, two new entities have been created in January 2016: the « Catalytic Materials - MATCAT » research team, and the « Up-scaling of Catalysts – UPCAT » transfer platform. Our research team is part of the heterogeneous catalysis axis of UCCS, through the development of materials to applications transversal projects along with the already existing VAALBIO, REMCAT, MODSPEC and CATEN research teams. MATCAT is composed of 5 permanent researchers and 7 young researchers/Ph.D. students, working on the development of non-conventional catalytic materials that exhibit robustness and durability in reaction, from the laboratory scale up to their shaping. Among the current strategies developed:

- The development of solvent-free synthesis routes to produce nanocrystalline mixed oxides with improved surface areas.
- The use of bio-sourced molecules as structure-directing agents for the production of single and mixed oxides with hierarchical porosity.
- The conception of precious metal-free catalytic formulations (iron, copper, manganese).
- The shaping of catalytic formulations.

KEY FIGURES

5 permanent researchers
25 publications in 2017
On-going projects: 1 national ANR project, 2 Hauts de France region projects, 2 European projects (H2020, INTERREG), 1 Hubert Curien program, 1 ERASMUS+ convention, 3 Ph.D. co-supervisions (China, Canada, Morocco), FEDER-CPER actions (UPCAT, « Matériaux et Catalyse »)
Supported nanoparticles - In this field, the group is focused on two main challenges: (i) the synthesis of noble metal-free mono- and multi-metallic nanoparticles (Fe, Cu, Mn and their combinations) with controlled properties (size, chemical composition and atomic surface distribution); (ii) the control of their thermal and chemical stability during the catalyst cycle of use (exposure to oxidative atmosphere, successive reaction cycles). The group is exploring synthesis routes that are ideally up-scalable (melt infiltration, deposition-precipitation, pre-functionalisation of supports and micro-reactors). By using advanced characterization tools (LEIS, X-ray Absorption Spectroscopy, HR-TEM, Atomic Probe Tomography), the group aims at shedding light on segregation mechanisms of metallic elements under gas atmospheres, in order to better stabilize nanoparticles and optimize their formulation.

TEAM FLAGSHIP PROJECTS

The MATCAT team participates in diversified national, regional, European and bilateral projects, and collaborates with several foreign laboratories: University of Oxford, Utrecht University, University Gheorghe Asachi of Iasi, Laval University, Wuhan University, Beijing University of Chemical Technology, University of Antioquia, Euro-Mediterranean University of Fez, Ghent University. Over the 2016-2017 period, members of the MATCAT team have obtained 4 Ph.D. co-supervisions, published more than 10 peer-reviewed articles with partner laboratories, and obtained various grants to support these activities.

UPCAT, Upscaling of Catalysts, a project representative of MATCAT dynamism:

UPCAT is a research and development platform devoted to the study of the elementary steps of the synthesis of pre-industrial catalytic processes. Equipped with last generation tools for materials synthesis (reactors for precipitation and sol-gel synthesis, autoclaves) and shaping at different scales and in different forms (spray-dryer, extruder, pelletizer, mixer-granulator), the platform ensures an adequate environment for the study of catalytic formulation scale-up (up to several kilograms) and shaping. This platform is able to take in charge the synthesis of a wide variety of materials and their structuration at different sizes, and will allow the UCCS to propose an integrated structure from the fundamental study to the pre-industrial validation. This equipment complements previously implemented equipments of the UCCS (REALCAT & Pilot Hall) and the recognized skills developed in the thematic teams of the laboratory.