Ph.D. Subject for 2024

Chemical depolymerization of plastic waste by catalytic cleavage of C–O and C-N bonds

Building a sustainable chemical industry and providing answers to current environmental challenges (climate change, pollutions…), requires to replace fossil raw materials with renewable carbon sources but also to recover and valorize the carbon content of our waste. As these resources are often oxidized, it is necessary to develop new reduction methods using efficient catalysts. Since the 1950's, the production of plastics, mainly petroleum-based, has increased from 2Mt/y to 460 Mt/y today and is expected to reach 1.2 billion tons/y by 2060. Highly emitting CO_2, this industry also generates lasting pollution of the environment due to a bad use of materials (short time life) and a virtual absence of waste management. So, how can we face the gigantic outgoing flows of plastic materials ? Within the framework of New European directives and the anti-waste law for a circular economy, it would be appropriate to no longer burn (energy recovery) these plastics but to "recycle" or valorize them mechanically and chemically. Chemical recycling appears to be a promising way to recover the carbonaceous matter of plastics but requires the development of new efficient and attractive processes to treat each of these numerous polymers. The depolymerization of these materials to enter a circular economy and selectively produce convenient and usable molecules, which would no longer be produced from fossil resources, remains challenging.

Objectives and method

The aim of this project is to develop new molecular catalytic systems for the depolymerization, in the presence of reactive or reducing agents, of oxygenated and nitrogenated plastics (such as polyesters, polyamides and polyurethanes) into their monomers or derived molecules. The project will focus on the use of new metal molecular complexes (aluminium, zirconium, rare earths, etc.) that are simple, inexpensive and selective in the depolymerization of various plastics (polyesters, polycarbonates, polyurethanes and polyamides) in the presence of conventional mild reducers such as hydrosilanes or hydroboranes, but also with H_2, formic acid or other sources acting by transfer hydrogenation, and which operate under mild conditions.[1-5]

This PhD project will enable the PhD student to develop advanced skills in homogeneous catalysis (possibly under pressure, GPC, NMR and GC/MS analyses), coordination chemistry under inert atmosphere (vacuum-silver lines, glove boxes), characterization (NMR, X-ray diffraction, UV/Vis, IR) and organic synthesis (synthesis of substrates and ligands). Possible interaction with the laboratory's permanent staff will give the PhD student an introduction to theoretical calculation.

Bibliographic references of the laboratory :

[1] E. Feghali, T. Cantat, *ChemSusChem* **2015**, 8, 980-984
[2] E. Feghali, G. Carrot, P. Thuéry, C. Genre, T. Cantat, *Energy. Environ. Sci.* **2015**, 8, 2734-2743
[3] L. Monsigny, E. Féghali, J.-C. Berthet and T. Cantat, *Green Chem*. **2018**, 20, 1981-1986
[4] M. Kobylarski, L. J. Donnelly, J.-C. Berthet, T. Cantat, *Green Chem.* **2022**, 24, 6810 -6815
[5] X. Liu, M. Kobylarski, J.-C. Berthet, T. Cantat, *Chem. Commun*., **2023**, 59, 11228

To apply, please send your CV, covering letter, 2 recommendation letters, diploma and report cards to:

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