Laboratoire Softmat–Equipe P3R
Chimie des colloïdes, polymères et assemblages complexes

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Thesis Proposal

"Synthesis and study of new Covalent Adaptable Networks"

In the field of materials science and engineering, polymers play a crucial role due to their wide range of applications. However, in light of growing environmental concerns, there is an urgent need to develop more sustainable polymer materials. While thermoplastics offer recyclability and reshaping capabilities, they often lack the necessary mechanical performance for demanding applications. On the other hand, thermosets offer superior mechanical properties but are not recyclable or reusable, raising increased concerns regarding waste. To address this dilemma, a new class of polymer materials called Covalent Adaptable Networks (CANs) has recently been developed. These materials bridge the gap between thermosets and thermoplastics by offering both cross-linked structures and recyclability. CANs feature reversible covalent bonds, primarily based on the cleavage and reformation of bonds such as ester-alcohol (transesterification) or amine-imine (transamination). Recently, a new exchange reaction has been discovered in our team, providing an opportunity to develop and study a whole new range of CANs. In this project, we propose to explore this new family of materials through the synthesis of CAN's constitutive monomers and their utilization. We will also study exchange mechanisms and mechanical properties of the obtained CANs.

In the first part of the project, the constitutive monomers of CANs will be synthesized and used both for CAN formation and in model reactions to finely study, at the molecular level, exchange mechanisms. This will enable us to develop a second generation of monomers bearing various chemical functions to modify the steric and electronic environment near the reactive sites where dynamic exchange occurs, aiming to modulate/control this exchange and influence material properties.

A second part of the project will focus on studying the mechanical and thermomechanical properties of CANs, and correlating the results obtained with model exchange studies to understand, or even predict, the behavior of our materials depending on the monomers used. Finally, studies aiming to evaluate the potential of these new CANs in their reprocessing/recycling will also be undertaken to have a complete view of the potential of these materials, from monomer to recycling.

The doctoral candidate will work within the Softmat Laboratory: Chemistry of Colloids, Polymers, and Complex Assemblies at the University of Toulouse III Paul Sabatier campus. The research activities of the laboratory (UMR CNRS 5623) cover the study of self-organized molecular or macromolecular systems, from the synthesis of each constitutive element, through physicochemical characterization, to applications. The doctoral candidate will be integrated into the P3R team, which has solid expertise in polymer chemistry, degradable polymers, and dynamic chemistry materials such as covalent adaptable networks (CANs)/vitrimers.

We are looking for a highly motivated student with a master's degree in organic chemistry and/or polymer. Expertise in dynamic materials or vitrimers would be an asset. Teamwork skills and good English proficiency are required. Candidates are invited to send a complete CV, a letter of motivation, and at least one letter of recommendation to Olivier Coutelier and Marc Guerre (olivier.coutelier@univ-tlse3.fr, marc.guerre@cnrs.fr). Additionally, an official application must be completed on the SDM doctoral school website (https://doctorat.univ-toulouse.fr/faire-un-doctorat-a-toulouse). The expected start date is October 1, 2024.

References:
(1) Guerre, M.; Taplan, C.; Winne, J. M.; Prez, F. E. D. Vitrimers: Chem. Sci. 2020, 11 (19), 4855–4870. https://doi.org/10.1039/D0SC01069C. (2) Guggari, S.; Magliozzi, F.; Malburet, S.; Graillot, A.; Destarac, M.; Guerre, M. ACS Sustainable Chem. Eng. 2023, 11 (15), 6021–6031. https://doi.org/10.1021/acssuschemeng.3c00379.