PhD Thesis

Institut Charles Gerhardt de Montpellier (ICGM)

Subject: Recyclable elastomers based on stabilized N,S-acetals (ElastoRec)

Keywords: Elastomers – Covalent Adaptable Network – Depolymerisation – Exchange reaction
Starting date: October 2026
Duration: 36 months
Application end date: May 29 2026
Supervisors: Dr. Eric LECLERC – Dr. Vincent LADMIRAL
Funding Agency/ Employer: Institut Carnot Chimie Balard/ Ecole Nationale Supérieure de Chimie de Montpellier

Summary

The Elasto-Rec project aims at developing recyclable elastomers, a very timely challenge for industry requiring both performance and low environmental impact. The target materials will be endowed with high solvent resistance and on-demand degradation properties, but also reshaping ability. Combining stabilized N,S-acetal functions, able to undergo decrosslinking, degradation and exchange reactions, and highly polar polymer segments will be the key strategy for these novel materials.

Context and objectives

Elastomers, often also simply called rubbers, are crucial materials to a wide range of industries and applications, for their superior mechanical properties (low young modulus and high failure strain). However, when they are chemically crosslinked via covalent bonds, their recyclability is very limited; and they are usually only grinded and used as low value fillers in other materials. Improving the recyclability of elastomer while maintaining performance is thus a highly desirable goal.

In recent years, the need for recyclable/reprocessable as well as degradable polymeric materials has increased along with the need to limit the accumulation of plastic wastes once these materials have fulfilled their first purpose. In this context, covalent adaptable networks (CANs), covalently crosslinked networks, able to reshape via exchange reactions, which behave somewhat like a compromise between thermoplastics and thermosets, have emerged as a potential solution to this issue.[1] Our group has recently developed an original strategy, based on neighboring group participation, and consisting in the incorporation of precisely located electron-withdrawing groups to enhance the rate of various exchange reactions and to design efficient catalyst-free CANs. Among these, N,S-acetal stabilized by a CF_3 or CO_2R group, showed high exchange rate and depolymerization opportunities.[2,3]

We wish to apply this last approach to develop recyclable elastomers based on the following key elements :

1-The use of highly polar/ionic flexible chains to provide fluorine-free materials with solvent resistance and elastomeric properties (tunable Tgs).

2-The presence of cross-links featuring N,S-acetal functions stabilized by an ester group to grant the materials with recyclability/degradability (solvolysis) and dynamic properties (reprocess).

Candidate profile

The candidate must be graduated (master or engineering school degree), specialized in organic and/or polymer chemistry. He/she should be familiar with classical characterization techniques (NMR, IR). He/she should have a strong interest in research and shows autonomy and initiative.

Application

The internship will take place in the D1 and D2 departments of the Institut Charles Gerhardt de Montpellier. Applications should include CV and cover letter, addressed electronically to Eric Leclerc (eric.leclerc@enscm.fr).

References

[1] M. Sun et al. “Covalent Adaptable Networks: Reprocessable Cross-Linked Polymers” *Chem. Rev.* **2026**, *126*, 1829–1948. [2] S. Laviéville et al. “Trifluoromethylated N,S -Acetal as a Chemical Platform for Covalent Adaptable Networks: Fast Thiol Exchange and Strong Hydrostability for a Highly Transparent Materia” *Macromolecules* **2024**, *57*, 10311–10323. [3] S. Laviéville et al. “Ethoxycarbonyl-Stabilized N,S -Acetals as a Fast Exchange Platform for Catalyst-Free Covalent Adaptable Networks” *Macromolecules* **2025**, *58*, 13059–13073.