Doctoral school scholarship

Campaign 2020

RESEARCH SUBJECT TITLE: Self-healing materials from nano- and micro-structured vitrimer alloys

Name of the laboratory: Laboratory of Chemistry, Catalysis, Polymers and Processes (C2P2, UMR 5265)
Website: http://c2p2-cpe.com/

Name of the research team: Team Catalysis Polymers and Processes (CPP)
Website: http://c2p2-cpe.com/research-lcpp.php

Name of the supervisors: Dr. Elodie Bourgeat-Lami & Dr. Damien Montarnal
University / Institution: University of Lyon, CNRS
E-mail : elodie.bourgeat-lami@univ-lyon1.fr, damien.montarnal@univ-lyon1.fr

Doctoral School: Chemistry Doctoral School (ED 206)

Lab Language: English / French

Minimum language level required:

- English: excellent written and oral skills (C2)
- French: None
- Other:

Abstract: Cross-linked networks constitute an outstanding class of polymer materials in which chemical bonds maintain a tri-dimensional permanent structure anchoring the polymer chains together. In comparison to thermoplastics made of linear polymers, cross-linked polymers display therefore far superior thermo-mechanical properties and solvent resistance, but are essentially intractable: after curing they adopt a permanent shape and cannot be further processed nor recycled. **Vitrimers** invented in 2011 and receiving tremendous attention since then, aim at overcoming these drawbacks by incorporating in the networks dynamic covalent crosslinks governed by reactions in chemical equilibrium.[1] At high temperatures or in the presence of catalysts, chemical equilibriums are fast enough to enable large-scale reorganization of the network and therefore stress relaxation and plastic deformation or welding/healing of the polymer.[2]

Yet, the network remains permanently cross-linked at all times. The university of Lyon is heavily involved in developing new vitrimer-based materials,[3,4] and will start coordinating in 2020 a large European-wide consortium that combines cutting-edge research projects and transfer of skills to the industry (VITRIMAT-Innovative Training Network - Training in VITRImers: high performance MAterials and Trainees for cutting-edge industrial applications). We have developed at C2P2 original methods to synthesize stable **vitrimer latexes by miniemulsion polymerization**,[5,6] and aim at exploring the vast possibilities offered by combining such vitrimer nanoparticles with thermoplastics in order to yield **self-assembled, nanostructured hybrid materials**. The PhD student will be immersed in a highly multidisciplinary environment that encompasses polymer synthesis & characterization, structural analysis of the materials and rheological mechanical characterization. Through the development of vitrimer alloys combining fast exchange dynamics and nanostructured morphologies, we aim at developing new thermoplastic elastomers combining excellent solvent resistance, toughness and self-healing properties.

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(2) Capelot, M.; Montarnal, D.; Tournilhac, F.; Leibler, L. Metal-Catalyzed Transesterification for Healing and Assembling of Thermosets. *Journal of the American Chemical Society* **2012**, *134*, 7664–7667.
(3) Obadia, M. M.; Mudraboyina, B. P.; Serghei, A.; Montarnal, D.; Drockenmuller, E. Reprocessing and Recycling of Highly Cross-Linked Ion-Conducting Networks through Transalkylation Exchanges of C-N Bonds. *Journal of the American Chemical Society* **2015**, *137*, 6078–6083.
(4) Obadia, M. M.; Jourdain, A.; Cassagnau, P.; Montarnal, D.; Drockenmuller, E. Tuning the Viscosity Profile of Ionic Vitrimers Incorporating 1, 2, 3-Triazolium Cross-Links. *Advanced Functional Materials* **2017**, *27*, 1703258.
(5) Tran, T. N.; Rawstron, E.; Bourgeat-Lami, E.; Montarnal, D. Formation of Cross-Linked Films from Immiscible Precursors through Sintering of Vitrimer Nanoparticles. *ACS Macro Letters* **2018**, *7*, 376–380.
(6) Reddy, V.; Dugas, P.-Y.; Rawstron, E.; Bourgeat-Lami, E.; Montarnal, D. Improved Malleability of Miniemulsion-Based Vitrimers through in-Situ Generation of Carboxylate Surfactants. *Polymer Chemistry* **2019**, *10*, 3001.

Key words: vitrimers, nanostructured polymer alloys, dynamic cross-linking, self-healing.