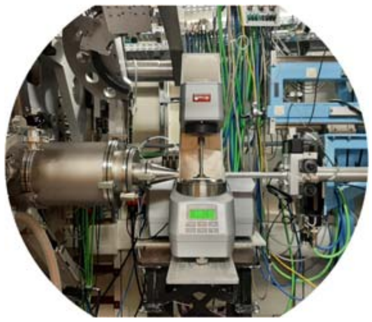
Sujet de thèse : Coupled evolution of the physical properties of filled elastomers for smart damage detection.



Application deadline: 12 Mai 2024

Starting date: October 2024

We seek to fill a PhD position at the physics department (Laboratoire Charles Coulomb, U Montpellier), in collaboration with IMP Lyon, on the characterization of dynamical features in filled elastomers as smart tools for early, in-situ, non-destructive detection of fatigue damage. Material failures may have catastrophic consequences, with significant management, repair, and recycling costs. A promising strategy to reduce the environmental impact is to develop new predictive maintenance methods with the aim of extending the operating time. Our project proposes the development of a methodology for the real-time electrical detection of damage in filled elastomers.

The main technique will be dielectric spectroscopy, coupled with small-angle X-ray scattering and mechanical testing. Dielectric spectroscopy will be used, as e.g. applied by us to percolation mechanisms of nanoparticles. The collaborating group has provided evidence by electrical measurements for the existence of the Mullins and Payne stress softening, which are related to the efficiency of a polymer piece. Both Mullins and Payne effects involve microstructural changes of the macromolecular chains and/or the nanoparticle network (carbon black, silica). Their understanding is the key to improve the performance of rubber mounts. Concerning X-ray scattering and its analysis, we have developed models and applied them successfully to different nanocomposites. Finally, we are also equipped with rheometers in both labs, and we have started coupling SAXS measurements on synchrotron beamlines with in-situ shear, and fast acquisition dielectric measurements with rheology. All these techniques will serve in this project, and be further exploited by fully coupling the three techniques.

This project aims at controlling the destruction of the nanofiller network during deformation and its subsequent recovery (flocculation). These phenomena can be traced by the electrical conductivity due to the destruction/formation of conductive pathways. The influence of temperature, nanofiller content and polymer-filler interactions will be considered. Correlating the electrical conductivity with the microstructure will reveal the structure-properties-relationship under deformation. The goal is to understand the damage mechanisms picked up by in-situ electrical measurements, in order to detect fatigue in real time, and thus predict the mechanical failure.

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