Postdoctoral position in Physical Chemistry of Polymer, UMET University of Lille

"Relationships between morphology, cross-linking heterogeneities and mechanical behaviour of elastomer blends"

Context

Blends of natural rubber (NR) and poly(butadiene) rubber (BR) are widely used in the automotive/tire industries and, more precisely, for the design of tire treads and anti-vibration devices displaying high mechanical performances. The advantage of blending poly(butadiene) with natural rubber is that BR improves both the thermo-oxidative ageing behavior and the abrasion resistance of NR. From an industrial point of view, a significant number of additional components, such as fillers, cross-linkers, accelerators or antioxidants are involved in the formulations of the NR/BR blend-based materials. Then, these formulations mostly undergo a vulcanization step which allows to form covalent links between elastomer chains.

The BR chain microstructure is a crucial parameter that governs the NR/BR blend morphology. In the case of partially miscible or immiscible NR/BR mixtures, the partitioning of the crosslinking system (crosslinker and accelerator) between the different phases plays an important role, but this issue has received relatively little attention in the literature. In particular, the difference in local concentration of the cross-linking compounds between the two phases can lead to a different crosslinking density between them, and thus significantly affect the mechanical behavior of the formulated materials after crosslinking. Indeed, such heterogeneities are expected to influence elastic modulus and high-strain behavior on a macroscopic scale.

In this context, the aim of the SHINE project (funded by the French National Research Agency (ANR, SHINE project, 2023-2027) is to investigate the relationships between the blend morphology, the cross-linking of NR and BR chains and the mechanical behaviour of these materials. The final goal is to better identify the blend preparation conditions (nature and composition of blend components, processing conditions) required to achieve given mechanical performances for the final materials.

This collaborative research project involves the Laboratoire de Chimie de la Matière Condensée de Paris (LCMCP, Sorbonne University), the Hutchinson Research and Innovation Centre (Châlette-sur-Loing) and the Unité Matériaux et Transformations Laboratory (UMET, University of Lille).

Mission

The main work of the post-doctoral position will be to characterize the structural evolution of NR/BR blends upon uniaxial stretching at room temperature by means of *in situ* Small- and Wide-Angle X-ray Scattering (SAXS & WAXS, respectively) analyses. Indeed, it is well-known that neat NR is able to crystallize at room temperature as soon as chains are uniaxially stretched above a critical strain. This is the so-called strain-induced crystallization (SIC). In the present context of NR/BR blends, an important question to address concerns the influence of the BR component on the SIC of the NR phase within the rubber blends. In particular, the effect of different parameters such as blends compositions,

loading conditions on the nature of the crystalline phase induced, the degree of crystallinity as well as the crystal size will be determined. In addition, the morphology of the blends will also be investigated by Fourier transform infrared microspectroscopy experiments. Depending on the candidate's profile, this characterization would be completed by Atomic Force Microscopy (AFM) analyses. In parallel the mechanical and viscoelastic behavior of the materials will be examined in order to determine the structure-mechanical properties relationships of these materials.

Main-tasks:

- Structural characterization of the rubber blends by means of Small- and Wide-Angle X-ray scattering techniques. (ex-situ and in-situ experiments under uniaxial stretching)
- Morphological characterization of the rubber blends (Fourier transform infrared microspectroscopy, and AFM analysis).
- Characterization of the viscoelastic properties by means of Dynamic Mechanical Analysis.
- Determination of the mechanical behavior upon monotonic and cyclic loading.

Profile

The candidate should have a PhD in materials science with skills and knowledge dealing with the physical chemistry of polymers. In particular, the candidate should have knowledge regarding the morphology and (micro) structure of polymers and skills in terms of polymer characterization techniques. Experience with structural characterization by diffraction and / or X-ray scattering and/or AFM characterization would be highly appreciated. Finally, the candidate must show a marked interest in experimental and applied research and demonstrate curiosity, dynamism and autonomy.

Relevant details

- Job location: UMET (Villeneuve d'Ascq – 59) with occasional travels to project's partners laboratories.
- Duration: CDD of 18 months.
- The position is open from January 2025.
- Salary: the employer being the University of Lille, the salary will be defined according to the official grids depending on diplomas and experience of the candidate.

Contact

For any information please contact:

- Grégory STOCLET (UMET): gregory.stoclet@univ-lille.fr
- Valérie GAUCHER (UMET) : valerie.gaucher@univ-lille.fr

In order to apply a CV and a brief description of your research activities have to be sent to the two aforementioned.