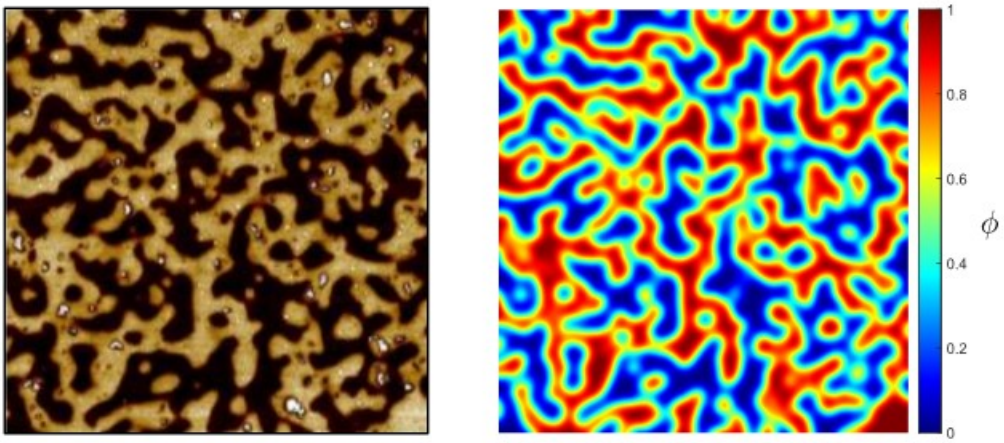
Deutsches Institut für Kautschuktechnologie e.V.

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

Project call: TPV-Modelling

Characterization and Modelling of Thermoplastic Vulcanizates (TPVs) for Sustainable High-Performance Applications



The application of sustainable materials is becoming increasingly important across industries, especially when it comes to reducing environmental impact and enabling energy-efficient manufacturing. In this context, thermoplastic elastomers (TPEs) are gaining attention due to their ability to combine the distinct properties of elastomers and thermoplastics within a single compound.

A particularly interesting subgroup of TPEs are thermoplastic vulcanizates (TPVs). In TPVs, the rubber phase is dynamically crosslinked during processing. Initially, the thermoplastic phase is dispersed within a rubber matrix. Upon the beginning curing process, a phase inversion takes place, resulting in the rubber phase being finely dispersed within a continuous thermoplastic matrix.

The final morphology of a TPV is highly dependent on the material composition and the degree of crosslinking. At low crosslinking degrees, rubber micro- or nanoparticles tend to grow and form aggregates. As the crosslinking progresses, these structures evolve into rubber agglomerates-clusters of smaller particles localized within the matrix. After all, the morphology plays a crucial role in defining the material's mechanical behaviour.

Objectives

The proposed research project aims to conduct a comprehensive investigation of thermoplastic vulcanizates (TPVs), with a particular focus on the dynamic-mechanical behaviour which is highly dependent on the existing microstructure. As a first step, we will examine how the morphology of TPVs evolves depending on material composition and the degree of crosslinking, using advanced microscopic and imaging techniques. Based on these observations, digital models, i.e. Representative Volume Elements (RVE) will be created to represent the microstructure of the TPVs. These RVEs will serve as the foundation for Finite-Element simulations of the material's behaviour.

Subsequently, the mechanical behaviour of the TPVs (and its single phases) will be characterized under dynamic, high-frequency cyclic loading conditions, with a special emphasis on capturing time- and frequency-dependent effects. This will be reconstructed within the FE simulations of the TPV using the RVE and previously defined viscoelastic material models for the single phases. The main idea is to detect dependencies of the material response with respect to the amount of phase ratios and the morphologic characteristics. Additionally, by using a diffuse interphase model it should be clarified, if the interphase between the TP and the elastomer phase is essentially affecting the dynamic properties of the TPV. The final stage of the project will involve validating the developed material models through experimental testing and evaluating their transferability to a wide range of TPV compound compositions.
Seven work packages are defined for this purpose, which are set as follows:

WP 1: Literature studies
WP 2: Compounding
WP 3: Physical characterisation
WP 4: Morphological characterisation
WP 5: Modelling and parameterisation
WP 6: Development and optimisation of the RVE
WP 7: Validation

Economic benefit

A better understanding of the relationship between the phase morphology and the dynamic behaviour of TPVs by means of theoretical models and experimental analysis contributes to development of more precise predictive methods with direct reduction of development time of new materials and costs. In addition, it allows a tailored design of TPV materials for different applications.

Time and project management

The project is designed for three years. Every four months, project meetings will take place between the research centre, the university and the project partners, which will report on the project interim situation. The research partners will also provide a conference call for these project meetings. The meetings are intended to coordinate the progress of the project and, if necessary, to adapt the work plan on the basis of existing results.

Project deliverables

Within the scope of the project, it is planned to deliver the following results to the partners:

- Experimental data of all tests
- Overview of main concepts
- Insights into the scope of application of the methods to be used
- Use of one compound per partner in the scope of the project for limited pool of studies
- An intermediate report (after 1 ½ years) and a final report (after 3 years)

Use of personnel and costs

The project will be carried out by two scientific co-workers (PhD-students) and will be supervised by Prof. Dr.-Ing. Daniel Juhre (Otto von Guericke Universität, Magdeburg) and Dr.-Ing. Andrej Lang (Deutsches Institut für Kautschuktechnologie e.V., Hannover).
The costs per partner and year will be 30,000.- € plus VAT if applicable. A minimum of six partners is required.

Information meeting and contact information

An information event is organized when the required number of participants is reached, in which more details about the project will be given. Participation in the event does not oblige to take part in the project.

Feel free to contact us in case of any questions!

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