Project call

Investigations of the potential of suitable polymer blends on thermal oxidative aging stability of polydienes

Introduction and Motivation

Elastomer materials are very important for the production of dynamically high loaded, temperatur- und media resistant products. The life time of elastomer products is depending to a great extend on material homogeneity beside their construction and the mechanical load and chemical exposure during use. The homogeneity is determined by the selection of raw materials, the processing and by irreversible material changes from exposure (aging). A special feature is the use of polymer blends, which is used in practice frequently to optimize the compound properties by the combination of the properties of two different rubbers, so far it is possible in a synergistic way. Irreversible function limiting material changes, for example from thermal-oxidative aging, are determined on one hand by the rubber micro structure (double bonds, branching, substituents or side groups) and on the other hand by compound ingredients especially antioxidants like p-phenylene diamines (e. g. 6PPD, IPPD), which show a combinative effect against oxygen and ozone. Especially 6PPD is in discussion and under high concern because of ecological and toxic aspects.

Besides the use of low-molecular-weight antioxidants, another possibility for stabilizing elastomers is the addition of a polymer with higher oxidative stability, e.g. with a saturated or appropriately substituted main chain. Thus, there is a high interest in comprehensive knowledge about the aging behavior of polymer blends. The blend ratio, the miscibility and also the phase morphology are crucial parameters for the aging properties, which can contribute to reducing the amount of antioxidants. Since the blend composition is also responsible in detail for the local oxygen consumption and the spatial distribution of oxidized or thermo-oxidative post-crosslinked areas in the material, corresponding effects are to be expected directly on the service life under dynamic load. Finally, the weakest link in the overall composite determines the sum of the properties.

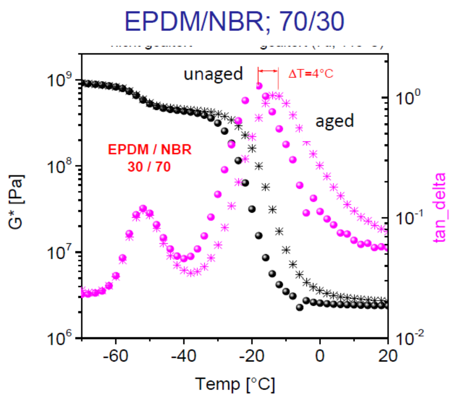

Fig.: Mechan.-dyn. characterization of aging behavior of single phases in a blend (project ZIM ZF4369801ST6).

Objective

The aim of the project is therefore to obtain a comprehensive understanding of the thermo-oxidative aging stability of practice-based elastomer blends as a function of the used rubber types, their concentration ratios and the phase morphology. Furthermore, the potential of stabilizing elastomers by using appropriate polymers as blend components is to be investigated in order to open up ways of saving or avoiding low-molecular and thus migrating antioxidants. For this, the kinetics and local aging effects of individual domains in combination with the effects on the mechanical and, in particular, the dynamic-mechanical behavior must be comprehensively determined. Sufficient co-crosslinking of the usually multiphase blend should also not be neglected here. Overall, these findings can be directly exploited to improve the functional reliability of elastomers based on unsaturated rubbers or blend systems under selected service conditions without any ecological or toxicological risks.

Approach
First blends based on polydienes (e.g. NR, SBR, IR) with polymer blend components of different oxidative stability (conc. of C=C double bonds, stabilizing substituents at the main chain) will be prepared. Phase morphology and concentration ratios will be adjusted under the consideration of solubilities and mixing process in combination with vulcanization or co-vulcanization (characterization methods e.g.: TEM; DSC, mechan.-dyn. analysis).
In addition to the characterization of the aging properties of the overall system by chemical analyses (e.g. chemiluminescence, FT-IR spectroscopy, DSC) and the investigation of the aging-dependent change in the physical property profile, local aging processes triggered by thermal oxidation will be characterized by using FT-IR microscopy, microindentation, atomic force microscopy (AFM), DSC and mechanical-dynamic analysis. Thereby, a special focus will be on the determination of the local aging progress from the surface into the interior of the material (DLO effect), since the gradient is, among other things, a decisive parameter for crack initiation under deformation. Furthermore, the reaction kinetics as (f(t), f(T)) are fundamental for long-term prediction and, if necessary, simulation.

Economic benefits
The economic benefits of the project include in particular savings on additives (antioxidants) and optimization of the quality of elastomers, which in turn means less complaints and more savings in the associated costs. If the same or improved aging resistance of an elastomer product with a lower proportion of antioxidant is achieved by optimizing the blend, a positive contribution can also be expected with regard to potential regulation of the use of, for example, p-phenylenediamines.

Conditions
- Funding of the project by industrial partners (consortium)
- Duration: 2.5 years
- Costs: 95,000 EUR/year, apportionment between partners, max. 20,000 EUR (plus VAT) per partner and year

If you are interested and for details please contact us until the 15th of July 2021.

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