Project proposal

Energy-saving, emission-free crosslinking of polydienes with high temperature and ageing stability

1 Initial situation

For the application of elastomers, e.g. in the field of "mobility", there are increasingly high demands on media, temperature and oxidation stability with simultaneously good mechanical and dynamic-mechanical values as well as service life. These requirements can only be met at a relatively low property level by conventional sulphur crosslinking due to the comparatively low bonding stability of the crosslinking sites. Even the use of elastomers based on rubbers with a saturated main chain in conjunction with special cross-linking systems, e.g. based on peroxides or reactive resins, is often unsatisfactory in this case. The physical properties of sulphur-cured elastomers are characterised by high elasticity, high tensile strength and good dynamic load-bearing capacity. The weak points, however, are low thermal resistance due to the low binding energy of S-S and C-S bonds and the resulting changes in the network nodes over longer periods of time under thermal or dynamic stress. In contrast, elastomers based on peroxide-crosslinked rubbers, particularly those with a saturated main chain such as HNBR, silicone, FKM, ACM, EPDM and EVA, have a comparatively high temperature and oxidation stability, which can also be attributed to the C-C and C-O-C cross-linking points formed by peroxide. Vulcanisates cross-linked with peroxide also have very low compression set. For a sufficiently high cross-linking density in conjunction with physical properties at a level appropriate to the application, higher proportions of cross-linking chemicals are often necessary. A disadvantage, however, is that the reaction products, consisting of ketones and aldehydes, are often irritating and odour-intensive substances and the low rubber solubility of these components, as well as that of the peroxides themselves, lead to efflorescence and heterogeneous networks with corresponding impairment of the dynamic-mechanical properties and tear resistance. Especially when using modern materials in the automotive sector, interiors or in the medical sector or in contact with drinking water and food, freedom from emissions or a low migration value is also crucial. A residual content of unreacted peroxide is also an ideal starter for ageing reactions. In addition, systems cross-linked with peroxide generally have poorer dynamic properties compared to sulphur systems.

For these reasons, there is an overall interest in the development and optimisation of new crosslinking systems.

2 Objectives

2.1 Technical objectives

Based on the increasingly high demands on technically used elastomers with regard to physical properties, service life, media and temperature resistance as well as sustainability and low contribution to the CO_2 footprint, the main objective of the project is to develop a crosslinking system with the highest possible crosslinking efficiency and the possibility of covalent filler bonding based on an emission-free addition mechanism, which contributes to optimally fulfilling the above-mentioned requirements for modern elastomers. The sub-goals are sufficiently high process reliability in vulcanisation, no emissions from the vulcanisation system and an overall high level of physical properties, in particular service life under dynamic load. The area of application of the cross-linking system is in principle with rubbers containing vinyl groups.

According to customer requirements, commercially available BR, SBR or EPDM types are to be used. Furthermore, the crosslinking system is to be used to covalently bond specially modified silica as a filler to the polymer matrix without ethanol emission. The latter is an essential aspect for improving wear behaviour, strength and service life.

2.2 Economic objectives

From an economic point of view, a highly efficient cross-linking system leads to a reduction in costs for raw materials and energy (heating time, temperature) with high product quality and high product safety and service life. In particular, the expected energy savings (vulcanisation also possible at temperatures below 100 °C) are an extremely important parameter in terms of sustainability and CO2 footprint requirements, both now and in the future.

3. Solution

Taking the objective into account, the aim is to crosslink e.g. vinyl-BR or -SBR or - EPDM via the mechanism of hydrosilylation. The binding energies of the crosslinking points produced are significantly higher than those of sulphur crosslinking, which means that high thermal stability can be expected. A prerequisite for the mechanism is a sufficient concentration of vinyl groups. Commercially available non-molecular bifunctional components are to be used as crosslinkers. The principle and the influencing parameters such as crosslinker structure (functionality), crosslinking temperature and time, polymer matrix (vinyl group concentration), crosslinker concentration and the concentration of a necessary catalyst should be carried out systematically. Setting the necessary process reliability in the form of a sufficient incubation time is another key step in the solution. The coupling of vinyl-modified silica is investigated by varying the vinyl content of the silica in comparison to non-functionalised silica. Based on the results of the above-mentioned fundamental investigations, the results are to be transferred to practical elastomers which contain compound components such as conventional plasticisers, antioxidants and processing aids etc. With regard to the physical properties to be achieved, the focus is on dynamic-mechanical properties and service life under dynamic load.

4 Project organisation

The project is planned as an industry-funded project with a duration of 30 months. Results and progress of the work will be discussed and reported with the client(s) in regular meetings.

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