

ABSTRACT

The present investigation deals with the influence of cations and anions associated with the metal organic adhesion promoters on the physical and dynamic mechanical properties, processability, cure kinetics and adhesion behaviour of steel cord skim compound. The interfaces between brass coated steel cord and rubber compound have also been analysed. In general, addition of metal organic adhesion promoter helps in achieving higher level of curing, enhances crosslink density, and reduces thermal and oxidative stability of the rubber compound. All the viscoelastic properties are influenced by the presence of these adhesion promoters to different extents depending on the nature of the associated cations and anions. These promoters are unable to resist the compound degradation due to steam ageing, though cobalt and nickel salts offer a degree of protection against salt ageing. The compounds show pseudoplastic flow behaviour. The decrease in viscosity with an increase in the cobalt stearate concentration is found to follow a linear equation. The activation energy of the melt flow process increases with the rate of shear in most cases. The cure kinetics study reveals that these adhesion promoters invariably influence cure reaction, the state of cure and the activation energy depending on the nature of the cations and the anions present. Incorporation of the adhesion promoters influences Young's modulus of the compound, cord pull-out force and adhesion energy. The performance of the promoter depends on the stability of the promoter, its participation in the rubber curing and the modification of the interfacial film responsible for adhesion. The difference in activity of cations and anions is also indicated by XPS/AES-studies.

Scanning electron microscopy (SEM) studies reveals that the cobalt boroacylate leads to more cohesive failure of the rubber (about 88% of the cord area covered by the rubber as compared to 73% by the control), due to its degradative effects on rubber and higher adhesion energy. Energy dispersive X-ray (EDX) analysis indicates that the failure mostly occurs at the Cu/Zn and $\text{Cu}_x\text{S}/\text{ZnS}$ sub layers. The study points towards the supremacy of cobalt ion among the cations and boroacylate ion among the anions studied, considering the overall good performance and the protection offered against various hostile environments. A new dynamic test method has been developed in this study. The adhesion between steel cord-rubber skim formulation has been evaluated using this method.

Key-words

Steel cord skim compound, Steel tyre cord, Brass coating, Metal organic adhesion promoter, Resin former, Crosslink density, Aerobic ageing, Anaerobic ageing, Salt and steam ageing, Viscosity, Rheology, Extrudate swell, Shear rate, Shear stress, Die swell, Vulcanisation, Energy of activation, Enthalpy, Differential scanning calorimeter, Kinetics, Adhesion, Adhesion energy, Pull-out force, Young's modulus, Interface, X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), Atomic concentration, Scanning electron microscopy (SEM), Energy dispersive X-ray (EDX), Dynamic adhesion, Cyclic flexing.