

Measuring dynamic properties of rubbers filled with silanized silica nanofiller

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Although static mechanical properties have a great role in the service life of tire tread, enough attention should be paid to dynamic properties. In fact, wearing of tire along with its performance are two sides of the same coin.

Fillers, when added to polymer systems, are known to cause a considerable change in dynamic properties, not only the dynamic modulus, both viscous (loss) modulus and elastic (storage) modulus, but also their ratio ($\tan \delta$), which is related to the portion of the energy dissipated during dynamic deformation (ref. 1). In practice, the energy loss in rubber products during dynamic strain is of great importance, as, for example, in vibration mounts and automotive tires, where it affects the service performance of these products with regard to heat generation and fatigue life for the former, and rolling resistance, traction and skid resistance for the latter. In fact, with regard to tire applications, it has been well established that repeated straining of the compound due to rotation and braking can be approximated as a process of constant energy input involving different temperature and frequencies (refs. 2-4).

Rolling resistance, for example, is related to the movement of the whole tire corresponding to deformation at a frequency of 10-100 Hz and a temperature of 50-80°C (ref. 1). In the case of skid or wet grip, the stress is generated by resistance from the road surface and movement of the rubber at the surface, or near the surface of the tire tread. The frequency is around 10^4 - 10^7 Hz at room temperature (refs. 3 and 4). It is, therefore, obvious that any change in dynamic hysteresis of the compounds at different frequency and temperature will alter the performance of the tire.

Since certain tire properties involve frequencies which are too high to be measured, these frequencies are reduced to a measurable level (1 Hz) at lower temperature by applying the time-temperature equivalence principle, even though in the case of filled vulcanizates, the shift factors for building the elastic (storage) modulus master curve are not exactly the same as those for the master curve of viscous (loss) (ref. 5),

hence of $\tan \delta$. However, the master curve for each property can be constructed experimentally according to the temperature-frequency principle.

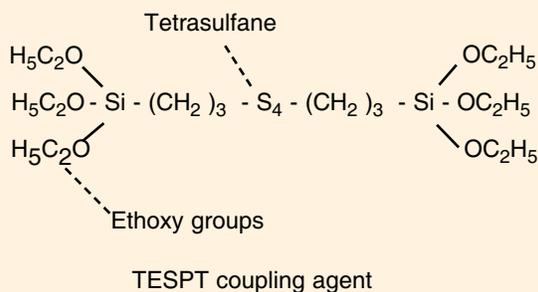
Ansarifard et al. (refs. 6-12) had a hard study on silanized pre-treated precipitated silica nanofillers. In accordance with his works, silanized (here, *bis*[triethoxysilylpropyl]-tetrasulfane, TESPT) pre-treated precipitated silica nanofiller (schemes 1 and 2) was a strong reinforcement agent, which improved the physical properties as well as dynamic performance of filled rubber better than other reinforcement agents, including carbon black. This silane (TESPT) possesses tetrasulfane and ethoxy reactive groups. The tetrasulfane groups are rubber reactive and react in the presence of accelerators at elevated temperatures, i.e., 140-240°C, with or without elemental sulfur being present, to form crosslinks in elastomers containing carbon-carbon double bonds (ref. 10). The ethoxy groups react with the silanol groups on the surface of silica during compounding, and this leads to the formation of stable silica/TESPT bonds (ref. 10).

In addition, pre-treated silanized precipitated silica nanofiller had so many advantages when compared with separate employment of liquid coupling agent and silica in rubber compounding (ref. 12).

The main objectives of blending two or more polymers with each other are cost reduction, along with physical (including static and dynamic) properties improvement.

To increase durability, performance and service life of rubber blended components, it is essential to optimize the interfacial adhesion strength between partially miscible rubbers such as polybutadiene and poly(styrene butadiene) copolymer. Moreover, this will help to minimize the risk of unexpected sudden joint failure in service, enhance materials selection and joint design, and improve environment and safety in service.

Scheme 1 - TESPT chemical structure



Scheme 2 - silica surface

