

# Effect of Silane Coupling Agent Loading on the Properties of Silica/Carbon black-Reinforced Natural Rubber Tire Compounds

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## Abstract

Highly dispersible (HD) silica-reinforced tire tread compounds are used for a production of low rolling resistance or energy-saving tires with also an improvement in wet traction compared to conventional carbon black-filled compounds. Under optimized formulation and processing conditions, the silica-reinforced tire treads can give similar wear resistance to the level obtained by the use of carbon black. As some specific grade of carbon black is known to offer excellent wear resistance, the use of carbon black in combination with silica is of interest in this work aiming to obtain the synergistic reinforcing effect from the hybrid filler system. For silica technology, silane coupling agent is an essential ingredient to achieve the effective reinforcement through good filler dispersion and the bonding between the silica and the rubber. This work investigates the effect of bis-(triethoxysilylpropyl) disulfide (TESPD) loadings on the properties of natural rubber tire tread compounds reinforced with HD silica/carbon black (N134) (45/10 phr) by taking the compound with silica only (55 phr) as reference. The loadings of TESP were varied at 0, 1.2, 2.3, 3.2, 4.1, 5.0, 5.9 and 6.8 phr (i.e. 3.1, 5.1, 7.1, 9.1, 11.1, 13.1 and 15.1 wt% relative to silica). By increasing the TESP loadings in the silica/carbon black-filled compounds, the viscosities as indicated by Mooney viscosity and minimum cure torque ( $M_L$ ) are decreased, while Payne effect, flocculation rate constant, modulus at 100% and 300% strain, tensile strength, apparent crosslink density and loss tangent at 60°C are improved. Tear strength also increases with increasing TESP loading to the optimum point at 4.1 phr. With the optimum loading of TESP, the silica/carbon black-filled natural rubber compound shows lower Payne effect and flocculation rate constant and higher chemically bound rubber content compared to the silica-reinforced one that should provide beneficial effect on the abrasion resistance as well as other mechanical properties.

**Keywords:** natural rubber; silica; carbon black; silane coupling agent