

Low rolling resistance tire tread via improved mixed filler dispersion

In the development of tire tread compounds, one often encounters two competing scenarios. First, fillers must be dispersed to the scale of a few hundreds of nanometers to obtain the largest window of mechanical reinforcement. Although at times, product developers are happy to accept much coarser scale of dispersion, e.g., mean particle size of around a micrometer. At this latter scale, the particles serve as defects. Second, particle networks experience periodic agglomeration and break-up due to large strains experienced by the tread, although otherwise, the compound performance is quite acceptable. This latter event gives rise to what is known as hysteresis and is the primary, responsible factor behind high rolling resistance. One may then argue that eliminating the possibility of particle network formation should also automatically reduce the hysteresis loss. However, a degree of particle networking is required for mechanical stiffness of the compound. These scenarios involving carbon black and silica-filled rubber compounds are pursued in our work.

Achieving fine scale dispersion of silica and carbon black (CB) particles in tire tread compounds is highly desirable for superior mechanical toughness and wet track resistance. The polar nature of silica surfaces requires treatment with silane-type coupling agents while good quality dispersion of CB particles is achieved without the use of designated coupling agents. A higher rolling resistance is attributed to hysteresis loss which in turn is governed by particle network breakdown and agglomeration during high strain deformation. In this context, our strategy is to subdue carbon particle network breakdown by encasing the particles with sustainable materials such as lignin or by engaging them in arene-perfluoroarene interactions with novel polymeric coupling agents. The results show significant promise for reduction of loss tangent at 60 °C by 10-20% while maintaining the loss tangent at 0 °C almost unchanged. In another part of our work, we introduce novel polymeric coupling agents that promote dispersion of carbon black and silica via two entirely different routes – the former via arene-perfluoroarene interactions and the latter via formation of Si-O-Si linkages. The tensile and viscoelastic properties are analyzed as function of dispersion quality and the molecular architecture of the novel coupling agents.