Zinc Oxide nanoparticles in natural rubber vulcanizates

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This study involved the incorporation of various types of ZnO nanoparticles into natural rubber compounds, which were subsequently vulcanized to create NR carbon black-filled composites. ZnO nanoparticles of differing shapes and aspect ratios were utilized in a carbon black-filled rubber composite. The quantities of ZnO used in the compounds were 1.5 phr, 2.0 phr, 2.5 phr, and 7.0 phr, compared to 45 phr of carbon black. Additionally, the aspect ratios of ZnO nanoparticles employed were 0.97, 2.78, and 5.57, with each aspect ratio corresponding to different shapes. To minimize particle agglomeration within the organic natural rubber matrix while ensuring compatibility, the ZnO nanoparticles were capped with Si-69.

The composites produced were analyzed for their mechanical and electrical properties. A decrease in resistivity was observed with an increase in aspect ratio of ZnO particles. This phenomenon could be attributed to the connection of carbon black particles through the rubber matrix, enhancing electrical conductivity given the concentration of carbon black in the composite is 45 phr. It is well-established that carbon black can conduct electricity when the particles are interconnected.

The composite containing ZnO with an aspect ratio of 2.5 exhibited slightly higher values for tensile properties compared to the composite with an aspect ratio of 5.5. This suggests the particle shape, particularly the number of sharp edges in the particle, plays a significant role rather than the aspect ratio. There is no reinforcing effect from ZnO nanoparticles; instead, they influence the vulcanization reaction as usual by acting as activators. This indicates that the conductivity increases results from carbon black, with ZnO nanoparticles serving as connectors between the carbon black particles.