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***Corresponding author**

Charoen Nakason, Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, 84000, Thailand



Short Review

# Conductive Natural Rubber Composites Based on Carbon Nanotubes and its Hybrid Filler: A Short Review

**Charoen Nakason* and Skulrat Pichaiyut**

*Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, 84000, Thailand*

## Short Review

Natural Rubber (NR) composites are attractive novel materials due to being high molecular weight hydrophobic polymers with good elasticity and flexibility together with other important properties [1]. NR composites with various types of reinforcing fillers have been widely used in many industrial applications including tires, sports articles, sealing materials, and dairy rubber items [2]. NR is intrinsically insulator by nature of their molecular characteristics. However, conductive rubber materials are important in many industrial applications including computing, military, medical devices, and telecom sector. Also, conductive rubber gaskets are used in applications where an environmental seal is required and the material must possess moderate to excellent shielding effectiveness. Conductive rubber composites have been developed by adding electrically conductive fillers into the insulating rubber matrix. In recent years, a great deal of attention has been paid to Carbon Nanotubes (CNT). The CNT typically consists of rolled-up graphite sheets built from $sp^2$ hybridized carbon units, which contain one valence electron that is capable of moving around the CNT surfaces. This influences on enhancement of thermal and electrical conductivities [3]. Therefore, CNT has been extensively studied in rubber nanocomposites due to their unique structure and properties [4]. The CNT networks disperse in rubber matrix typically act as electrically conducting pathways to provide electrical conductivity of rubber composites [1]. Therefore, good dispersion of CNT particles in rubber matrix contributes to significant improvement of various mechanical properties including tensile strength, and tensile modulus [5]. The CNT networks in NR matrix with very low percolation threshold concentrations (eg, about 0.086 vol%) with high electrical conductivity and dielectric constant can be prepared [6].

Hybridization of CNT with other fillers (or so called hybrid filler) has been wildy investigated with the main aim to improve dispersion and to form high quality CNT networks in rubber matrix. For instance, decorating of CNT surface with metal nanoparticles for promoting the CNT network formation. These include gold nanoparticles (AuNP) decoration of CNT (CNT-AuNP) [7], CNT-cadmium sulfide (CdS) [8] CNT-silver nanoparticles (AgNP) [9], CNT- zinc nanoparticles [10], CNT-graphite [11], CNT-graphene oxide (GO) and CNT-GO-carbon black (CB) [12], CNT-silica hybrid systems [13], and. CNT-nanocellulose [14]. These hybrid composites generally provide synergistic effect on some properties including electric conductivities, mechanical strength and some cases thermal resistance and dynamic properties. For instance, in CNT- zinc nanoparticles [10], abruptly improves of electrical conductivity is clearly seen in Figure 1. Furthermore, the stress-strain relations (Figure 2) indicate enhancement of mechanical strength of the CNT-ZnO nanocomposites with some optimum loading of the filler [15].

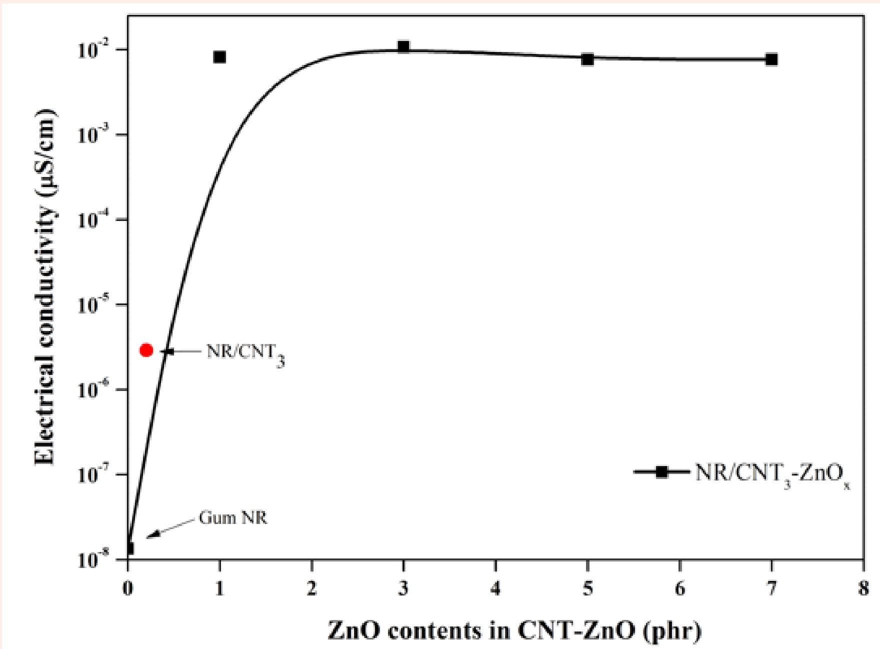


**Figure 1:** Electrical conductivity of gum NR, NR-CNT (3 phr) and NR/CNT-ZnO with different loadings of ZnO [10,15].

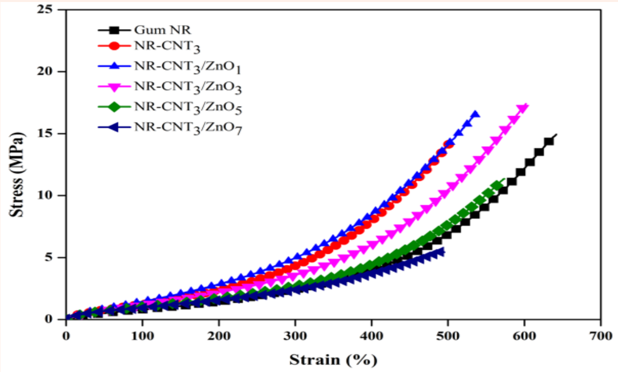


**Figure 2:** Stress-strain relations of gum NR, NR-CNT (3 phr) and NR/CNT-ZnO with different loadings of ZnO [10,15].

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