Development of a Novel Luminescent Para-Rubber Composite Beyond PDMS for Light-Energy Applications via Mechanical Stretching

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Abstract

This research investigates the mechanical and luminescent properties of vulcanized deproteinized natural rubber (VDPNR) composites incorporated with ZnS:Cu phosphor particles. Composites with varying ZnS:Cu weight fractions were fabricated and characterized to evaluate their tensile behavior, microstructure, chemical integrity, and mechano-luminescent response. Mechanical testing revealed significant enhancements in elastic modulus, ultimate tensile strength, elongation at break, and toughness compared to pure VDPNR, demonstrating the reinforcing effect of ZnS:Cu particles within the rubber matrix. FT-IR analysis confirmed that the addition of ZnS:Cu did not alter the chemical structure of the VDPNR, while Electron Scanning Microscopy (SEM) observations indicated generally good particle dispersion throughout the matrix. However, SEM analysis revealed non-uniform particle distribution across the sample thickness, attributed to gravitational settling during fabrication. Mechano-luminescence measurements showed that composites containing 40 wt% ZnS:Cu exhibited the highest light emission intensity (~0.2lux) under uniaxial tension. The luminescence mechanism is attributed to interfacial stress, friction, and charge separation generated between ZnS:Cu particles and the surrounding DPNR matrix during mechanical loading. Compared with PDMS-based ZnS:Cu composites, the DPNR-based composites displayed lower luminescent intensity due to reduced matrix transparency, despite superior mechanical performance. These findings highlight the potential of VDPNR–ZnS:Cu composites for mechanically robust, stretch-induced luminescent applications, while indicating the need for improved particle dispersion and optical transparency in future designs.

Keywords

Deproteinized natural rubber (DPNR), ZnS:Cu phosphor, mechano-luminescence pararubber, pararubber composites.

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