

Subnanowires-driven Polymer Composite Systems: Systematic Exploration from Interfacial Interaction Mechanisms to Trans-scenario Applications

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Abstract

Subnanowires (SNWs), with sub-1 nm size, polymer-like flexibility, and ultrahigh specific surface area, emerge as ideal fillers to address critical challenges in inorganic/organic composites, including poor interfacial compatibility, discontinuous interfacial interactions, and difficult synergistic performance optimization. This report presents systematic explorations on SNW/polymer composite systems, verifying their universal performance enhancement and multi-scenario applications: (1) GdOOH SNWs-based elastomers exhibit high elasticity, impact resistance, and excellent triboelectric performance for efficient energy harvesting from human motion, water droplets, and ocean waves. (2) Ca-POM SNWs-based flexible hydrogels exhibit high fracture stress and toughness for wearable sensors and piezoelectric sensors, and achieve 100% accurate human motion recognition when integrated into smart insoles with machine learning. (3) Sr-POM SNWs-based bioactive piezoelectric films exhibit high output voltage, toughness, antibacterial activity, and capabilities to induce dental pulp stem cell differentiation and continuous mineralization, successfully applied in dentin regeneration via the piezoelectric microenvironment and sustained stimulation. These studies demonstrate that the size matching between SNWs and polymer chains enables molecular-level entanglement and continuous interfacial interactions, solving the synergistic optimization challenge of mechanical strength, functional activity, and environmental stability in composites, and providing a universal strategy for designing next-generation flexible electronics, biomedical materials, and energy devices.

Keywords

Subnanowires, Polymer Composites, Multi-performance Enhancement, Energy Harvesting, Biomedical Applications