Smart flexible nanocomposites: Energy, robotics, biomedicine.

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Introduction

Flexible thermoelectric nanocomposites built with multi-walled carbon nanotubes and MXene perform really well for self-powered applications. This involves creating materials that can generate electricity from heat efficiently, and because they're flexible, they're perfect for things like wearable electronics or other gadgets that need a compact, resilient power source [1].

Shape memory polymer nanocomposites are reviewed for their latest advancements, covering new materials, how they're structured, and their potential uses. These smart materials can change shape in response to stimuli, and adding nanoparticles makes them even stronger and more versatile, opening doors for fields like soft robotics or biomedicine [2].

Flexible polymer-based thermoelectric nanocomposites are overviewed, highlighting recent breakthroughs and future perspectives. They are exploring how to combine polymers with nanomaterials to create flexible devices that can convert waste heat into electricity, which is huge for sustainable energy solutions and next-generation electronics [3].

A review on bio-inspired self-healing nanocomposites for biomedical applications indicates that by mimicking natural healing processes, these smart materials can repair damage autonomously. This is a game-changer for implants, drug delivery systems, and regenerative medicine, promising longer-lasting and safer medical devices [4].

Flexible MXene-based smart materials are explored, specifically for wearable electronic applications. MXenes, a class of 2D transition metal carbides, can be crafted into highly flexible and conductive nanocomposites. This makes them ideal candidates for next-generation wearables like health monitors or smart textiles, offering both performance and comfort [5].

Inorganic/organic halide perovskite nanocomposites are covered for thermoelectric uses. The core idea is combining the excellent properties of perovskites with organic materials at the nanoscale to create highly efficient thermoelectric generators. This approach is showing great promise for converting waste heat into usable energy, which is a big deal for energy recovery [6].

Stimuli-responsive hydrogel nanocomposites are highlighted for biomedical applications. Researchers are creating smart hydrogels loaded with nanoparticles that can react to changes in their environment, like pH or temperature. These are crucial for targeted drug delivery, tissue engineering, and diagnostics, offering precise control in biological systems [7].

Metal-organic frameworks (MOFs) and their derived nanocomposites are examined for thermoelectric applications. MOFs, with their highly tunable structures, can be engineered at the nanoscale to optimize heat-to-electricity conversion. This offers a new direction for designing materials with superior thermoelectric properties, essential for efficient energy harvesting [8].

Recent progress in piezoelectric polymer nanocomposites for flexible sensors and actuators is detailed. Embedding piezoelectric nanoparticles into polymers creates flexible devices that generate electrical signals from mechanical stress, or vice-versa. This is critical for developing advanced wearables, soft robotics, and smart infrastructure for sensing and control [9].

Flexible polymer dielectric nanocomposites are considered for high-performance energy storage. Integrating nanoparticles into flexible polymer matrices can significantly boost their dielectric constant and breakdown strength. This leads to smarter, more compact, and efficient capacitors, which are vital for portable electronics, electric vehicles, and renewable energy systems [10].

Conclusion

Flexible thermoelectric nanocomposites, leveraging multi-walled carbon nanotubes and MXene, perform well for self-powered applications, efficiently generating electricity from heat for wearable electronics. Shape memory polymer nanocomposites show advancements in materials and structures for soft robotics and biomedicine, changing shape in response to stimuli. Flexible polymer-based thermoelectric nanocomposites explore combining polymers with nanomaterials to convert waste heat into electricity, crucial for sustainable energy. Bio-inspired self-healing nanocom-

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posites for biomedical applications mimic natural healing, autonomously repairing damage for longer-lasting medical devices. Flexible MXene-based smart materials, 2D transition metal carbides, are crafted into highly flexible and conductive nanocomposites for wearable electronic applications. Inorganic/organic halide perovskite nanocomposites combine perovskites with organic materials at the nanoscale for efficient thermoelectric generators, promising much for energy recovery. Stimuli-responsive hydrogel nanocomposites involve smart hydrogels with nanoparticles that react to environmental changes for targeted drug delivery and tissue engineering. Metal-organic frameworks (MOFs) optimize heat-to-electricity conversion through tunable structures, offering a new direction for superior thermoelectric properties. Piezoelectric polymer nanocomposites embed nanoparticles into polymers, creating flexible devices for advanced wearables and soft robotics. Flexible polymer dielectric nanocomposites integrate nanoparticles into matrices to boost dielectric constant for high-performance energy storage, vital for portable electronics and electric vehicles.

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