LEAD-FREE PEROVSKITE/POLYMER NANOCOMPOSITE AS TRIBOELECTRIC NANOGENERATOR

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Introduction:

A novel polymer material, nanocomposites, exhibits features substantially different from traditional filled polymers. Lead-free halide perovskites, like Cs3Bi2Br9, are gaining popularity in photovoltaic and energy harvesting applications due to their exceptional optical and electrical properties and lower toxicity. This work synthesizes Cs3Bi2Br9 perovskite polymer composites, devoid of lead, and investigates their efficacy in triboelectric energy harvesting when doped in an EVA/PMMA blend. The lead-free nanoparticle is synthesized using anti-solvent crystallization, confirmed by X-ray diffraction (XRD) and scanning electron microscope (SEM). Nanocomposites with 80% EVA, 20% PMMA, and various Cs3Bi2Br9 concentrations (0.0, 0.5, 1.0, 2.0, 4.0 wt.%) were prepared. Surface topography was evaluated using SEM, and microstructural properties were examined using XRD. UV-visible spectroscopy probed the optical properties. The electrical analysis assessed the materials' applicability for mechanical energy harvesters via the triboelectric phenomenon. The output voltage and current were measured for self-powered applications, charging capacitors, and lighting LEDs, demonstrating great promise for future wearables and portable devices. This opens the door for high-performance nanogenerators using lead-free halide perovskites.

Objectives:

1. Synthesis of lead-free perovskite nanoparticles (Cs3Bi2Br9/Cs3BiBr6).
2. Incorporation of the prepared perovskite nanoparticles into the hydrophobic polar polymer (PVDF/PMMA/PDMS/PVDF-EVA).
3. Fabrication of triboelectric nanogenerator (TENG) device in contact and separation mode.
4. Examining the output current and voltage with respect to frequency, resistance, and percentage of perovskite nanoparticles added.
5. Testing the efficiency of fabricated TENG devices for different applications.

Methodology:

Chemical/Materials:

Cesium bromide (CsBr, 99.9%), and Bismuth bromide (BiBr3, 99.9%) were procured from Sigma Aldrich, Isopropanol (IPA, 99.9%) and Dimethyl Sulphoxide (DMSO, 99.9%) were purchased from SD Fine Chemicals LTD. All reagents are AR grade and used without further purification.

Synthesis of Cs3Bi2Br9 NPs:

Synthesis of Cs3Bi2Br9 NPs was carried out by a simple ligand-free antisolvent crystallization process. In a typical batch synthesis, the precursor solution was prepared by dissolving 1.2 mmol of CsBr, and 0.8 mmol of BiBr3 in 10 ml of DMSO. The solution was stirred at room temperature for 2h to obtain a uniform phase. The as-prepared precursor solution was added swiftly into 250 ml of IPA taken in a round bottom flask under vigorous stirring. After reaction for 1 min a bright yellow suspension was obtained. The suspension was then centrifuged at 6000 rpm for 10 mins and washed 2-3 times with IPA. The obtained precipitate was dried overnight in a vacuum oven at 70˚C and stored in an inert atmosphere.

Conclusion:

The lead-free nanoparticle is synthesized by using anti-solvent crystallisation and the formation the Cs3Bi2Br9 was confirmed by X-ray diffraction (XRD) and scanning electron microscope (SEM), UV-Vis Spectroscopy and PL Spectroscopy. Poly(methyl methacrylate) (PMMA) and poly(ethylene-co-vinyl acetate) (EVA) nanocomposites with 80% EVA, 20% PMMA blend, with various concentrations of lead-free Cs3Bi2Br9 viz., 0.0, 0.5, 1.0, 2.0 and 4.0 wt/wt% is to be prepared. To probe the optical properties of the prepared nanocomposites UV-visible spectroscopy is employed.

Innovation in the project:

The innovation in this project lies in the development and application of Cs3Bi2Br9@EVA/PMMA nanocomposites as a novel triboelectric material. This is significant because it introduces lead-free halide perovskites into the field of triboelectric energy harvesting, leveraging the exceptional optical and electrical properties of Cs3Bi2Br9 while maintaining lower toxicity. By doping these perovskite nanoparticles into an EVA/PMMA polymer matrix, the study explores a new composite material that enhances the efficiency and effectiveness of triboelectric generators. This novel material demonstrates promising potential for self-powered applications, including charging capacitors and lighting LEDs, paving the way for advanced wearables and portable electronic devices.

Scope for future work:

1. ***Material Development and Characterization:*** Synthesis, integration, and analysis of lead-free Cs3Bi2Br9 perovskite nanoparticles within EVA/PMMA blend to optimize their structural and functional properties.
2. ***Performance and Durability Testing:*** Fabrication of nanogenerators and rigorous testing of their triboelectric performance, electrical output, and long-term stability under various environmental conditions and mechanical stresses.
3. ***Application and Prototype Development:*** Exploration and testing of practical applications in wearable electronics, portable devices, and industrial sensors, including the creation and real-world validation of prototypes.
4. ***Scalability and Environmental Impact:*** Development of scalable manufacturing processes, economic feasibility studies, and comprehensive assessments of environmental and health impacts to ensure sustainability and market readiness.