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ABSTRACT

THESIS TITLE: "Piezoelectric and Triboelectric Nanogenerators: A Multifunctional Approach for Biomechanical Energy Conversion and Motion Sensing"

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Emerging energy harvesting technologies leverage biomechanical sources to generate electricity, offering promising prospects for sustainable energy solutions. Notably, Piezoelectric Nanogenerators (PENGs) and Triboelectric Nanogenerators (TENGs) stand out for their potential to integrate with wearable devices, facilitating electric energy harvesting and health monitoring applications. PENGs convert mechanical vibrations into electrical energy through the piezoelectric effect, exploiting materials' ability to generate electric fields under mechanical stress. TENGs, on the other hand, harness the triboelectrification phenomenon, where contact and separation of different surface charge layers result in electrical charging.

Polymer nanocomposites, particularly polyvinylidene fluoride (PVDF) due to its exceptional electroactive properties, offer a platform for tailored material design. By incorporating nanoparticles (e.g., ZrO_2, Er/ZrO_2, WO_3, Cus, NiO) and natural nanofibers, the potential of PVDF for energy harvesting and health monitoring applications can be further enhanced.

This proposal aims to develop TENGs for healthcare applications, focusing on Single Electrode TENGs (STENGs) based on polymer thin films with varied surface charges. Employing highly elastic and flexible polymers such as PDMS and Ecoflex, with polyamide or mica sheets for positive charges, enhances device performance. Incorporating nanoparticles into the polymer matrix improves electron transportation, thereby enhancing output performance.

Synthesis of nanoparticles will be conducted using methods like sol-gel and hydrothermal processes, while polymer nanocomposite thin films will be fabricated using drop-casting and

spin coating techniques. A variety of techniques will be employed to characterize the synthesized nanoparticles and fabricated polymer nanocomposite thin films. These techniques include sol-gel and hydrothermal synthesis for nanoparticle production, followed by drop-casting and spin-coating methods for thin film fabrication. The structural, morphological, and optical properties of the nanocomposites will be investigated using UV-visible spectroscopy, photoluminescence spectroscopy, micro-Raman spectroscopy, Fourier transform infrared spectroscopy, piezoresponse force microscopy (PFM), X-ray diffraction (XRD), electron microscopy (SEM, TEM), differential scanning calorimetry (DSC), differential thermal analysis (DTA), and LCR meter measurements. Furthermore, the optical properties (photocurrent, photovoltage, photoconductivity, photocatalytic effect) and electrical properties (capacitance, dielectric constant, dielectric loss, AC conductivity, resistivity, I-V characteristics, DC electrical conductivity, piezoelectricity, and polarization loops) of the nanocomposites will be comprehensively studied.

The flexible PENGs and STENGs, owing to their flexible and deformable nature, can be strategically placed on the human skin to monitor various physiological activities such as joint bending, extension, and body rotation. This project holds significant promise for advancing sustainable and safe biomechanical energy harvesting technologies with applications in real-time health monitoring systems. The ultimate goal is to develop a comprehensive health monitoring system that integrates a PENG and TENG-based self-powered device with wireless communication capabilities to not only monitor health parameters but also trigger alerts for potential health emergencies.

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