Abstract

THESIS TITLE: Bio-Compatible Nanoparticles Based Electroactive Polymer Thin Films: Characterizations and Applications to Energy Harvesting from Environmental Mechanical Sources via Piezoelectric and Triboelectric Effect

Submitted by: Debmalya Sarkar

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With the rapid growth of human civilizations, fossil fuels are limiting day by day. For this, human society will face some serious energy crises in the upcoming days. Along with this, the regular requirement of power in our daily life activities is increasing quickly. Also, the cumulative growth of the human population accelerates the daily requirement of power. Therefore, to solve the problem of the energy crisis and fulfil the daily need of power, alternative energy sources become the most suitable solution to these problems. Among different types of alternative energy sources, nanogenerators have gained tremendous attention owing to their capability to harvest energy from environmental friendly mechanical sources and convert them into electrical energy. Therefore, the primary objectives of the research work are to develop self-powered energy harvesting devices with the help of piezoelectric and triboelectric effects and utilize them in electricity generation from environmentally available mechanical and biomechanical energy sources. Also, polymeric nanocomposites have been used in the development of these nanogenerators. To reduce environment pollution and maintain the fabrication cost, naturally available cotton pappus has been utilized in the fabrication procedure of a piezoelectric nanogenerator (PENG). The presence of the hydroxyl group and the amino group inside cotton pappus assist in the generation of stress-induced polarization and improve the piezoelectricity. Owing to these exceptional properties, cotton pappus has been incorporated into polydimethylsiloxane (PDMS) matrix and fabricated the polymeric nanocomposite, which has been further utilized in the designing process of PENG. Moreover, the capability of the fabricated PENG in harvesting biomechanical energy sources has been investigated by illuminating LEDs and charging capacitors. Besides this, the effect of the β-crystalline phase of electroactive polymers on the output performance of PENG has been monitored theoretically and experimentally. The formation of the β-crystalline phase inside the matrix of electroactive polymers (PVDF, PVDF-HFP, PVDF-TrFE) has been performed by

incorporating semiconducting materials for example C-dot, $MoTe_2$, Bi_2Se_3 etc. inside the polymer matrix. Furthermore, the sensitivity of the PENG has been utilized in harvesting energy from human blood flow and sensing objects with different masses. Alongside, some fabrication methods including solution casting, electrospinning etc are adapted to develop polymeric nanocomposites. The morphological, structural and electrical properties of these composites have been investigated with the support of FESM, XRD, FTIR, XPS, LCR meter, DSO etc.

Piezoelectric nanogenerators have some drawbacks including low sensitivity, difficulties in harnessing small-scale energies and moderate output performances. To solve these challenges, triboelectric effect has been utilized in the development of self-powered energy harvesting devices. To improve the output performance of the triboelectric nanogenerator (TENG), surface modification techniques have been performed in the designing of TENG. Along with this, 2D materials are used in the fabrication process of TENG to prevent the charge recombination process inside the device, which further results in better current density and output results. The utility of the TENG in tracking human physiological signals and detecting artificial finger movements is also monitored. To get a better sensitivity compared to PENG, another method, the piezo-tribo coupling effect has been utilized during the development of TENG, which assists in harnessing energy from biomechanical and small-scale energy sources and generates electrical energy.

Therefore, the developed self-powered piezoelectric and triboelectric nanogenerators will be impactful in green mechanical and biomechanical energy harvesting applications. Also, the outstanding sensitivity and energy-harvesting ability of the devices will become an essential asset in human health monitoring applications and human-machine interfaces.

Sukhen Das
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Ruma Basu
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Prof. Sukhen Das
Department of Physics,
Jadavpur University
Kolkata - 700 032

Dr. Ruma Basu
Associate Professor
Physics Department
Jogamaya Devi College
92, S. P. Mukherjee Road
Kolkata - 700 026

Debmalya Sarkar