Abstract

Development of Natural Iron-Based Nano-Rock Modulated Piezo-Responsive Membranes for Simultaneous Piezoelectric Energy Harvesting and Piezocatalytic Wastewater Remediation

Saheli Ghosh

Index No.: 91/22/Phys./27

Registration No.: SOPHY1109122

Abstract: The world faces a looming energy crisis due to dwindling fossil fuels, geopolitical conflicts disrupting supply chains, inadequate investments in renewables, and soaring global energy demand. Besides, rapid industrialization and growing population generate severe water pollution. Addressing this requires a shift to cleaner energy options and reconsidering production techniques to minimize environmental harm. To combat the situation this work encompasses the synthesis of iron-based nanostructures specifically natural α-hematite because of their nontoxicity, abundance, and biocompatibility in nature besides their exceptional other physicochemical properties. The doping of foreign materials into natural α-hematite such as rare-earth metals (Gadolinium), carbon nanotubes (CNT), etc. into the matrices of natural nano-rock and incorporation into the various polymer matrices (PVDF) unveils the structure-property correlation of such composite systems by enhancing energy harvesting efficacy, especially the piezo energy. As piezoelectric energy harvesting stands as a promising avenue to simultaneously address both the energy crisis and water pollution challenges. This innovative technology harnesses energy from mechanical vibrations, including movement in water bodies, to generate electricity. In this study, the naturally occurring α-hematite-based device can produce a voltage of 53.9V and a current of 011.6 μA with a hand-tapping (force of 14.99N). Even after 75 days, the efficiency remains relatively constant. In addition, the fabricated device generates up to 8V under the flow of water. As vibrations or mechanical stress occur, these materials can simultaneously facilitate catalytic reactions to break down pollutants present in water known as piezocatalysis which has also been employed in this work to degrade carcinogenic dyes like RhB, Congo red, etc. The membrane degrades RhB dye 98.7% under ultrasonic vibration of 33KHz and the membrane is also recyclable for up to 10 cycles without altering the efficacy. Hence integration of these two technologies following the same mechanisms can be a promising avenue to simultaneously address both the energy crisis and water pollution challenges. Thus, this study presents a dual solution by offering clean energy generation and mitigation of water pollution, showcasing the potential of innovative technologies like piezoelectric energy harvesting in tackling these interconnected global challenges.

Saheli Ghosh 28.5.24

Sukhen Das 28/05/2024

Ruma Basu 28/5/24

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