Abstract

A Study on Natural Clay Decorated Self-Poled Polymeric Membranes for Piezocatalytic Wastewater Remediation and Piezoelectric Energy Harvesting

Dhananjoy Mondal

Index No.: 89/22/Phys./27 **Registration No.: SOPHY1208922**

Abstract: In recent years, increasing population, urbanization, and industrialization have caused an energy crisis and fatal water pollution levels, which have harmed the ecological balance. Organic pollutants like carcinogenic dyes and pharmaceuticals are discharged from various industries creating a deficiency of potable water and harming the waterbodies. Researchers are putting efforts into different technologies for combating such issues. Different nanomaterials are gaining interest owing to their functionality in the nano regime. Conventional piezo-responsive nanomaterials have come in the front row in the last few decades for their capability in energy generation and wastewater remediation under mechanical stress. However, these types of chemically derived nanomaterials are suffering from biocompatibility, toxicity, and extraction from the medium. In order to fix these issues scientists and technologists are trying to develop various types of membrane-based piezocatalyst exploiting the conventional piezo-materials. However, a minimal amount of interest has been paid so far on natural material-based piezocatalysts. Keeping this in mind the present work focuses on the development of natural clay-based (Kaolinite, Aluminosilicate clay namely China clay) polymeric piezocatalyst for energy generation from external stimulus and simultaneous wastewater remediation. In this work, several techniques i.e., nanonization, structural modification, and foreign element incorporation have been used to enhance the physicochemical properties of the natural clays to develop polymeric piezocatalysts. Kaolinite poses very good surface properties i.e., high surface charge and surface area which enhances the piezo-response of the Polyvinylidene fluoride (PVDF, a potential fluoropolymer that is synthetic in nature), and Chitosan (a bio-polymer). Polymer-based (PVDF & chitosan) clay nanocomposites successfully eradicated 96 % rhodamine B (RhB), and 88 % Congo red organic dyes under ultrasound (33 kHz) in 1 h. Piezoelectric nanogenerator device (PENG) has also been fabricated by these nanocomposite membranes which generate the highest 6.5 V, 1.5 μA

(PVDF-based), and 34.6 V, 1.9 μA (chitosan-based) output responses, respectively corresponding to the thrust of falling water droplets (force 4.79 N) and the impact of hand tapping (force 14.97 N) as mechanical stress. Additionally, the catalytic behavior of the membranes has also been used to eradicate pathogenic coliform *E. coli* (gram-negative) and *E. faecalis* (gram-positive) bacteria which are other available pollutants of wastewater, and found the efficiency of 100 % and 97 % under soft ultrasound (15 KHz) in less than an hour. Henceforth, these energy generation and wastewater eradication abilities of the fabricated biocompatible, cost-effective, self-poled polymer-based nanocomposite membranes can open up new avenues for the sustainable development of our nation in the field of wastewater treatment and non-invasive energy generation technologies.

Sukhen Das
05/04/2024

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

Soumyaditya Sutradhar
05/04/2024

Dr. Soumyaditya Sutradhar
Assistant Professor
Department of Physics
Jadavpur University
Kolkata-700032

Dhananjoy Mondal.
05/04/2024.