Multifunctional Triboelectric Nanogenerator for Benzene sensing and Monitoring System

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1. Introduction

Globally, the use of fossil fuel by the population resulting in the declining amount of fossil fuels. The scientist across the world are focusing on the development of sustainable energy harvesting devices. Triboelectric nanogenerator (TENG) is on such an approach which is widely explored by researchers due to the advantage of being cheap, easy to design, and has reasonable efficiency [1]. TENG works on the principle of electrostatic induction and contact electrification. The TENG can be used for various applications like sensors, drug delivery, smart toys, etc. The various efforts are made to enhance the performance of TENG [2]. In this work, we employed phase inversion chemistry and charge trapping with a high dielectric material to improve the output for TENG. For this purpose, non-piezoelectric TiO_2 is selected as the dielectric material. PVDF is an excellent choice for negative layer in the TENG. The β-phase of PVDF can be enhanced by phase inversion, which creates a porous structure. The voltage and current output exhibit 7- and 10-times enhancement, respectively. The as-fabricated device is demonstrated for biomechanical and wind energy harvesting. The volatile organic compounds are highly toxic. Finally, a self-powered benzene sensing and monitoring system are detected [3].

2. Body of abstract

The waste energy is widely available in our environment in the form of body motion, vibration and wind, etc. The TENG is one of the approaches that can be used to harness the waste mechanical energy and leads to sustainable development. The TENG is easy to design, a cheap, wide range of materials and has high voltage output [2].

Here in this work, we demonstrated the effect of incorporating high dielectric material and phase inversion chemistry on the performance of TENG. The TiO_2 (5, 10, 15 wt.%) included in cellulose acetate is selected as the positive layer for the device. The phase inversed PVDF is selected as a negative layer for the device. The FT-IR analysis confirms the enhance β-phase of phase inversed PVDF. The FE-SEM confirms the formation of the porous film after phase inversion. The high β-phase content and porous structure are highly advantageous for the performance of the TENG device. The PVDF-10-TiO_2/CA device voltage and current output are enhanced by 7 and 10 times, respectively. The device can act as multifunctional energy harvester by harvesting biomechanical as well as wind energy harvesting. For wind energy harvesting a simple slider crank based mechanism was used to convert the rotational motion to linear motion [4]. Finally, we demonstrated the volatile organic compound (VOCs) monitoring sensing by coupling the device with Arduino. The benzene is one of the most toxic VOC in the environment which creates serious health issues. The device was successfully utilized for benzene sensing with a sensitivity of 0.29176 V/sccm or 0.0035 V/ppm. The device integrated with Arduino triggers the alarm in the presence of the benzene. We believe, this work can be extended for multi VOC sensing and the design, the concept can be used for the development of other sensors.

3. Figures

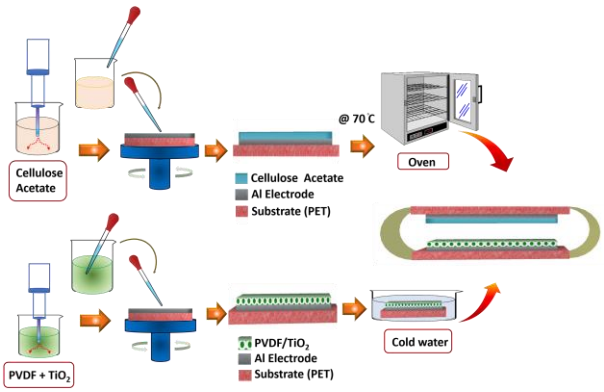

Fig.1. Device fabrication mechanism

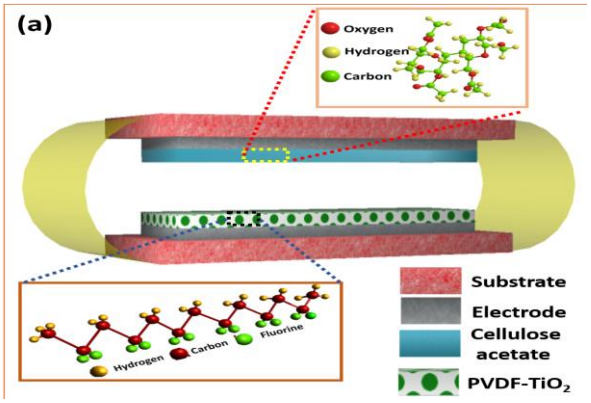

Fig. 2. The 3D illustration of the vertical contact-separation mode PVDF-TiO_2/CA TENG.

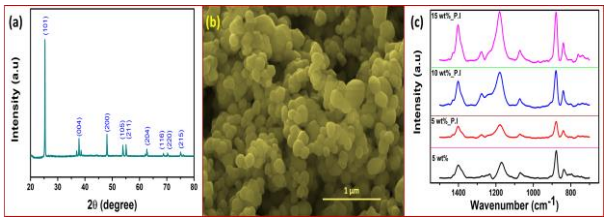

Fig. 3. (a) The XRD spectra if TiO_2 microparticles. (b) The FE-SEM image of the TiO_2 microparticles. (c) FT-IR spectra of the films with different TiO_2 concentration.

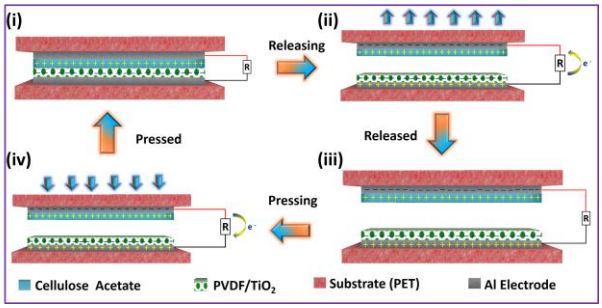

Fig. 4. The device mechanism in vertical contact-separation mode with releasing, released, pressing and pressed conditions.

Acknowledgment

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