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Wearable Triboelectric Nanogenerator for Energy-harvesting and Self-powered Sensors

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1. Introduction

The regular operation of intelligent wearable electronics requires power sources, and traditional batteries have limited lifespan and can lead to potential environmental pollution. The ideal generator should be able to derive energy from the surrounding environment. Triboelectric nanogenerator (TENG) can be defined as a self-sufficient power device that converts tiny mechanical motion into electricity by the coupling of triboelectrification and electrostatic induction. Therefore, developing a wearable TENG is an interesting and challenging endeavor. In this study, a kind of wearable, solvent-resistant TENG was fabricated, which can be used for not only energy harvesting but also fabric identification sensors.

2. Experimental

Herein, polyetherimide–Al_2O_3 (PAl) and polyvinylidene fluoride-co-hexafluoropropylene (PVDF-HFP, PH) nanofiber membranes were used as tribo-positive and tribo-negative materials, respectively. Phytic acid-doped polyaniline (PANI)/cotton fabric (PPCF) and ethylenediamine (EDA)-crosslinked PAl (EPAl) nanofiber membranes were used as triboelectrode and triboencapsulation materials, respectively. PAl and PH nanofiber membranes were prepared by electrospinning as the TENG friction layer. PPCF prepared by in situ polymerization was used as the electrode layer of TENGs, and EPAl nanofiber membranes were prepared as the encapsulation layer.

3. Results and discussion

Traditional methods of fabric identification require a variety of methods, such as burning, dissolving, and dyeing. Because different fabrics have different charge affinities, the use of TENGs to detect the material composition of fabrics is a simple and non-destructive method. The single-electrode-mode PH-based TENG can be used as a sensor to detect fabric. PAl nanofiber membrane, and textiles of polyamide, wool, silk, cotton, polyester, acetate, lyocell, polypropylene, as well as modacrylic were cut into 5×5 cm^2. Subsequently, a circular wearable TENG with a radius of 1 cm was prepared, and the composition of the fabric was determined by testing the wearable TENG with different fabrics. The influence of the textiles on the V_{oc} of the wearable TENG is shown in **Fig. 1(a)**. PAl nanofiber membrane, and textiles of polyamide, wool, silk, cotton, polyester, acetate, lyocell, polypropylene, as well as modacrylic produced different open circuit voltages of 19.1, 5.0, 4.4, 3.8, 3.2, 3.0, 2.8, 2.6, 2.1, and 1.4 V, respectively. Therefore, TENGs can be used as self-powered sensors for the detection of textiles. It is also an evidence that PAl can be considered as an excellent tribo-positive material. As shown in **Fig. 1(b)**, the wearable TENG could be used as a self-powered system for light LEDs.

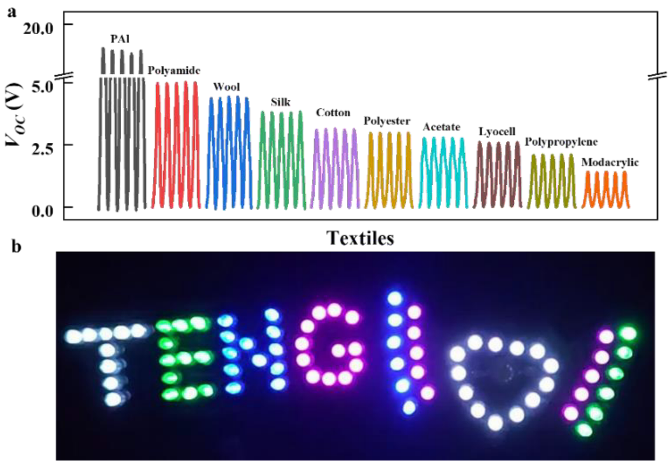

Fig. 1 The application and prospects of TENG. (a) The influence of textiles on the open-circuit voltage of wearable based TENG. (b) Wearable TENG could be used as a self-powered system for light LEDs.

4. Conclusion

In summary, PAl and PH nanofiber membranes were prepared by electrospinning as the TENG friction layer, PPCF prepared by in situ polymerization was used as the electrode layer of TENGs, and EPAl nanofiber membranes were prepared as the encapsulation layer. The wearable TENG could be used as a fabric sensor to detect fabric composition. Wearable TENG also could be used to charge light emitting diodes (LEDs).

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