Polystyrene Waste-ZnO nanocomposite film for energy harvesting via hydrophobic triboelectric nanogenerator: Transforming waste into energy

ABSTRACT

This research aimed to generate electricity from polystyrene waste materials combined with zinc oxide (ZnO) nanomaterials. Developing alternative polystyrene waste materials for generating electricity in triboelectric nanogenerator (TENG) could be beneficial in a circular economy and sustainable development. With the motivation to reduce environmental pollution by using polystyrene waste, a recycled polystyrene-ZnO nanocomposite film (rPS-ZnO NF) was synthesized and served as a triboelectric material for energy harvesting applications. ZnO nanopowder was produced by a low-temperature solution immersion method in conjunction with a simple film-casting method to prepare the rPS-ZnO NF. The effects of varying amounts of toluene as a solvent medium and the immersion time in stearic acid (SA) solution treatment on the structural properties, wettability behavior, surface morphology, chemical bonding properties, surface characteristics, and TENG performance were investigated. In this work, rPS film, rPS-ZnO NF, and SA-treated rPS-ZnO NF were paired with Kapton film as the opposite triboelectric material in constructing the vertical contact-separation mode TENG. Compared to rPS TENG, the rPS-ZnO TENG exhibited a two-fold enhancement in performance (8.2 V) in output voltage and ~4.5 fold enhancement (28.1 μW/cm2) in power density. Furthermore, following SA treatment, the triboelectric performance further improved, reaching the highest open circuit voltage of ~8.8 V and the highest power density of 32.0 μW/cm2 for repeated 2 N-solenoid tapping force. The hydrophobic behavior was also improved with the highest water contact angle of 134.7 (when the SA treatment immersion time was 1 h). These findings demonstrate that SA-treated rPS-ZnO NF could be a promising candidate for efficient mechanical energy harvesting with high electrical output and excellent surface wettability. This research not only exhibits an excellent output performance of SA-treated rPS-ZnO TENG, but it also sheds new light on the sustainable approach of converting polystyrene waste into energy-harvesting material.