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High-performance Graphene/PVA Spray-Coated Electrode for Wearable Triboelectric Nanogenerators

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Wearable mechanical energy generating and harvesting textiles have emerged in the past decade as potential power sources for wearable electronics. As a new energy harvesting strategy, textile-based triboelectric nanogenerators (TENGs) have received enormous attention due to their high flexibility, low cost, and lightweight. TENG works on the combined principle of triboelectrification and electrostatic induction, which can convert mechanical energy to electrical energy with high conversion efficiency. Two-dimensional (2D) materials are attractive for fabricating flexible and lightweight wearable TENG devices. As a monolayer of atomic carbon of crystal, graphene offers remarkable electrical properties due to its linear dispersed band structure near the Dirac point. The high stiffness and robustness of graphene enable it to be a good candidate for wearable e-textiles. Graphene is commonly deposited on wearable substrates with various methods, serving as the electrode in TENGs. Emphasizing the need for careful consideration during fabrication, we stress the importance of ensuring strong adhesion and uniformity of the graphene layer on wearable TENGs.

In this work, we proposed a cost-effective, large-scalable, and simple spray-coating technique to deposit graphene flakes on commercial cotton textiles, enabling the fabrication of 2x2 cm^2-sized electrodes. We demonstrated a graphene/PVA composition layer on the textiles with an overall half electrical resistance lower than the deposition of pure graphene layer via the spray-coating approach. The ultrasonication-assisted liquid phase exfoliation (LPE) is employed for the synthesis of graphene inks due to its compatibility with the main deposition processes. The low-boiling-point 2-propanol (IPA) and biocompatible PVP are introduced as solvents and stabilizers of the graphene, respectively. The homogeneous PVA solution was simply sprayed on the cotton textiles before spraying graphene ink. It offers the condition of establishing the hydrogen bond between PVA and PVP. The electrical measurements show that the overall electrical resistance value is improved from 8800 Ω to 4093 Ω with the assistance of the PVA. The average sheet resistance improved from 4742 Ω/sq. to 2701 Ω/sq. This electrode was tested in a TENG configuration and the graphene/PVA-deposited textile conductivity response to bending showed better stability concerning the pure graphene-deposited textile confirming the optimization of the structure by the PVA.