Dielectric Engineering for Enhancing Triboelectric Performance of Nanogenerators

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Abstract

Triboelectric nanogenerators (TENGs) have emerged as promising sustainable energy technologies capable of providing environmentally friendly power sources for wearable electronics while contributing to the reduction of carbon emissions associated with modern communication networks. In this work, we developed a new class of TENGs based on electrospun nanofibres engineered with core–sheath architectures, functional nanofillers, and multilayer assemblies incorporating surface energy gradients. These structural innovations were designed to enhance triboelectric charge generation, mitigate the degradation commonly caused by humidity, and ultimately improve device robustness and performance. The resulting nanocomposite based TENGs demonstrated substantial improvements in electrical output. Specifically, the devices achieved an open circuit voltage of 1944 V and a short circuit current of 40.3 μA—corresponding to enhancements of 284% and 783%, respectively, compared with TENGs fabricated from pristine nanofibre materials [1]. Such significant gains confirm the effectiveness of combining nanofiller engineering with controlled microstructural design in triboelectric interfaces. Beyond energy harvesting, the engineered TENG platforms also show strong potential for human–machine interface (HMI) applications. The triboelectric signatures generated during user interactions were employed for user identification, achieving an average recognition accuracy of up to 86%. Additionally, bilayer Janus nanofibre based TENGs demonstrated reliable performance in monitoring fall events, highlighting their relevance for elder care and safety focused wearable systems. Taken together, these advancements illustrate the multifunctional potential of next generation triboelectric materials. By synergizing materials engineering, structural optimization, and advanced sensing capabilities, this work paves the way for machine learning assisted HMIs powered by TENGs. Such developments hold promise for future sustainable communication networks in which self powered, adaptive, and environmentally conscious devices play an increasingly central role.

Keywords

Energy Harvesting, Triboelectric Nanogenerator, Nanofibres