2D-Materials and Hydrogels for Energy Harvesting and Self-Powered Sensing

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The increasing demand for novel wearable, flexible, conformable devices has boosted the search for sustainable energy sources different from batteries. New low power technologies require only few tens of μW up to few mW of power supply to operate. This aspect enables their sustainable integration with energy harvesters that can scavenge the otherwise wasted environmental energy.

Among mechanical energy harvesters, triboelectric nanogenerators (TENGs) are novel low-cost and green energy solutions that can efficiently convert the widely distributed and dispersed mechanical energy into a sustainable electrical power source. Various approaches have been explored to boost TENGs power, including novel device architectures design, tailoring tribomaterial chemical composition and surface area, interlayer and electrode engineering. [1, 2]

Here, we present our contribution to the field, showing how the electrode work function and capacitance, and in particular the electrochemical capacitance, are relevant factors to be considered for improving TENGs power output, a main aspect which has often been overlooked.[4,5] We will also highlight the fundamental role played by the optimal engineering of the interface between the triboelectric material and the electrode by the introduction of doped graphene and 2D-transistion metal dichalcogenides.[6] We will provide novel insights on the composition-function-structure relationships, that contribute to the design of novel hydrogels to be integrated into TENGs based tactile sensors and e-skin.[7] The specific role of adhesion forces, water entrapment and electrolytic capacitance will be highlighted and clarified.

Briefly we will also highlighted the technological advantage of 2D-topological insulators for thermal energy harvesting.

Overall, this contribution intends to provide guidelines for the future design of novel materials and self-powered electronic devices, thus fostering the integration of sustainable energy harvesters and promoting a transition towards biodegradable, biocompatible technologies.

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[6]G. Pace et al, *Advanced Materials* **35**, (2023) 2211037.
[7]G. Pace et al, *Advance Materials* (2024) 2403366.