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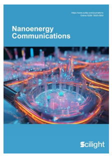

Editorial

Hybridized and Coupled Nanogenerators as Sustainable Energy Solutions

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The rapid increase in global energy demand is primarily driven by the widespread electrification of the transport and industrial sectors, the expansion of 5G networks, the rising number of data centers, and the accelerating pace of urbanization [1]. Despite advancements in energy technologies, fossil fuels remain the dominant energy source, resulting in continued reliance on carbon-intensive energy. This dependence, coupled with the surge in energy consumption, significantly exacerbates climate change and global warming, creating urgent environmental challenges that require immediate attention. In response, policymakers and researchers have long prioritized the transition to renewable energy as a fundamental solution.

Our surroundings are abundant with various forms of energy, such as light, wind, and water energy from oceans, rivers, lakes, and even raindrops, as well as mechanical energy generated by human movement. Over the past decade, the development of nanogenerators—including triboelectric, piezoelectric, and so on—has revolutionized the way we harness these energy sources [2]. This progress has been fueled by several critical factors: the relatively low fabrication costs, the availability of diverse materials for device construction, and the ability of these devices to efficiently convert multiple forms of energy into electricity. Specifically, nanogenerators can harness solar, wind, wave, thermal, and mechanical energy, converting them into electrical power through various transduction mechanisms, including light intensity variations, mechanical motion, temperature gradients, magnetic field fluctuations, etc.

Despite their potential, individual nanogenerators often struggle to deliver sufficient and continuous power for practical applications due to their limited energy output and reliance on a single energy source [3]. To overcome this challenge, researchers have developed hybridized and coupled nanogenerators, which are designed to harvest energy from multiple sources simultaneously. A hybridized nanogenerator combines distinct energy-scavenging units, such as piezoelectric and triboelectric components, into a single system. In contrast, a coupled nanogenerator utilizes a unified structure that integrates multiple energy conversion effects [4], such as piezoelectric, photovoltaic, and thermoelectric mechanisms. These multi-source energy harvesting strategies not only enhance overall conversion efficiency but also significantly increase power output. As a result, they broaden the applicability of nanogenerators, making them more viable as sustainable energy solutions.

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Conflicts of Interest

The author declares no conflict of interest.

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