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Triboelectric nanogenerators: from fundamental concepts to applications in harsh environments

Micro and nano-generators, able to harvest energy from the environment, have been attracting large interest because they are green, sustainable and cost-efficient energy sources that can be easily integrated in common electronic gadgets. A major breakthrough in the field of mechanical energy harvesting occurred in 2012 when the first triboelectric nanogenerator (TENG) was invented. TENGs are based on the coupling between triboelectric and electrostatic processes that generate a charge distribution at the interface of materials that come into contact. They show very high efficiency (up to 75%), power densities above 500 W/m², record voltage outputs above 1200 V, wide material choice, simple design, easy manufacturing and integration. Their applications are almost infinite because of the possibility to use all flexible and dynamic surfaces like cloth or shoes, touchable electronics or even the human body, to produce electricity. Here, we will discuss the basic phenomena behind triboelectric nanogenerators and their applications as novel energy harvesters for extreme conditions (high temperatures up to 150°C and pressures up to 830 bar) for the oil & gas industry and as blue energy devices able to transform wave and currents energies into useful electrical power.