Harnessing everyday motion to power mobile devices (w/ video)

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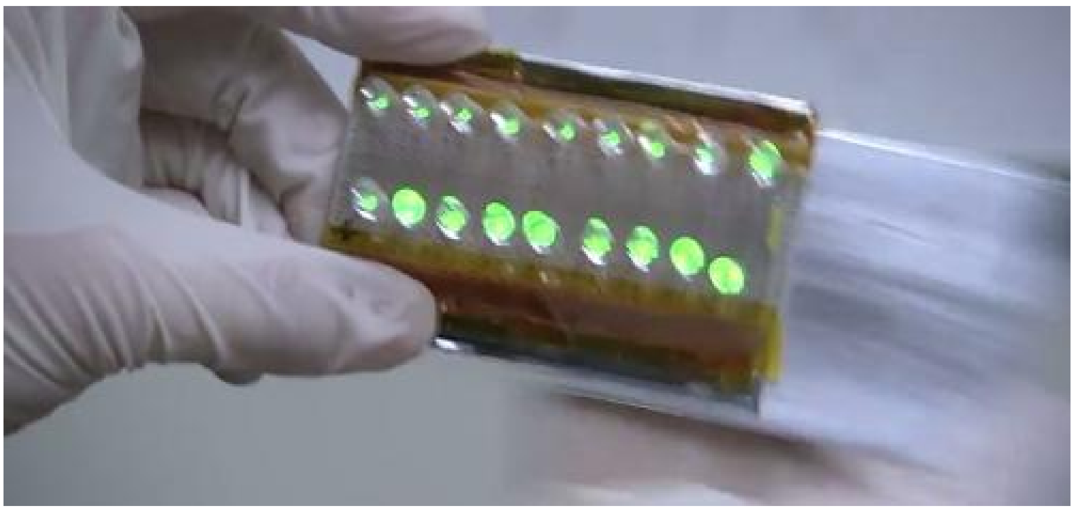

Imagine powering your cell phone by simply walking around your office or rubbing it with the palm of your hand. Rather than plugging it into the wall, you become the power source. Researchers at the 247th National Meeting & Exposition of the American Chemical Society (ACS) presented these commercial possibilities and a unique vision for green energy.

The meeting, attended by thousands of scientists, features more than 10,000 reports on new advances in science and other topics. It is being held at the Dallas Convention Center and area hotels through Thursday.

Zhong Lin Wang, Ph.D., and his team, including graduate student Long Lin who presented the work, have set out to transform the way we look at mechanical energy. Conventional energy sources have so far relied on century-old science that requires scattered, costly power plants and a grid to distribute electricity far and wide.

"Today, coal, natural gas and nuclear power plants all use turbine-engine driven, electromagnetic-induction generators," Wang explained. "For a hundred years, this has been the only way to convert mechanical energy into electricity."

But a couple of years ago, Wang's team at the Georgia Institute of Technology was working on a miniature generator based on an energy phenomenon called the piezoelectric effect, which is electricity resulting from pressure. But to their surprise, it produced more power than expected. They investigated what caused the spike and discovered that two polymer surfaces in the device had rubbed together, producing what's called a triboelectric effect—essentially what most of us know as static electricity.

Building on that fortuitous discovery, Wang then developed the first triboelectric nanogenerator, or "TENG." He paired two sheets of different materials together—one donates electrons, and the other accepts them. When the sheets touch, electrons flow from one to the other. When the sheets are separated, a voltage develops between them.

Since his lab's first publication on TENG in 2012, they have since boosted the power output density by a factor of 100,000, with the output power density reaching 300 Watts per square meter. Now with one stomp of his foot, Wang can light up a sheet with a thousand LED bulbs.

His group has incorporated TENG into shoe insoles, whistles, foot pedals, floor mats, backpacks and ocean buoys for a variety of potential applications. These gadgets harness the power of everyday motion from the minute (think vibrations, rubbing, stepping) to the global and endless (waves). These movements produce mechanical energy that has been around us all along, but scientists didn't know how to convert it directly to usable power in a sustainable way until now.

The key to the huge leap in output and future improvements is the chemistry.

"The amount of charge transferred depends on surface properties," Wang explained. "Making patterns of nanomaterials on the polymer films' surfaces increases the contact area between the sheets and can make a 1,000-fold difference in the power generated."

With those improvements, Wang said his group is now working on commercializing products to recharge cell phones and other mobile devices using TENG. Down the road, he envisions these nanogenerators can make a far bigger impact on a much larger scale. Researchers could use the technology to tap into the endless energy of ocean waves, rain drops and the wind all around us—with tiny generators rather than towering turbines—to help feed the world's ever-growing energy demand, he said.

More information: Abstract

Harvesting energy from our living environment is an effective approach for sustainable, maintenance-free, and green power source for wireless, portable, or implanted electronics. Our group has recently invented a triboelectric nanogenerator (TENG) to convert mechanical energy into electricity based on the coupling of triboelectrification and electrostatic induction. In the internal power-generation unit, a potential difference is created due to the charge transfer between two thin films that exhibit opposite triboelectric polarities; in the external load, electrons are driven

to flow between two electrodes attached on the back sides of the films to balance the potential difference. The TENG has been investigated with three basic operation modes: vertical contact-separation mode, in-plane sliding mode, and single-electrode mode. Ever since the first report of the TENG in January 2012, the output power density of the TENG has been improved 5 orders of magnitude within 12 months. The area power density reaches 313 W/m2, volume density reaches 490 kW/m3, and a conversion efficiency of ~60% has been demonstrated. The TENG can be applied to harvest all kinds of mechanical energy that is available but usually wasted in our daily life, such as human motion, wind vibration, rotating tire, flowing water, and more. Alternatively, the TENG can also be used as a self-powered sensor for actively detecting the static and dynamic processes arising from mechanical agitation using the voltage and current output signals of the TENG, respectively, with potential applications for touch pad and smart skin technologies. The output performance of the TENG could be enhanced through numerous ways, including rational selection of materials, physically-modified surface morphologies, or chemically functionalized nanostructures. The TENG is not only useful for self-powered portable electronics, but also provides us a new technological solution to the world's energy issue in the near future.

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