Nanotube Thermocells Hold Promise For Converting Heat Waste To Energy

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(PhysOrg.com) -- A study published in the American Chemical Society's journal *Nano Letters* reveals that thermocells based on carbon nanotube electrodes might eventually be used for generating electrical energy from heat discarded by chemical plants, automobiles and solar cell farms.

The research was a joint collaboration between Baratunde Cola, assistant professor in the George W. Woodruff School of Mechanical Engineering at Georgia Tech, and an international team of researchers from the U.S., Australia, China, India and the Philippines.

Cola, director of Georgia Tech's NanoEngineered Systems and Transport Research Group (NEST), described the study as a breakthrough in efficiently harvesting electrical energy from various sources of exhaust or wasted heat.

"Our NEST Lab was fortunate to team with Dr. Ray Baughman's NanoTech Institute at UT Dallas and Dr. Gordon Wallace's Intelligent Polymer Research Institute in Wollongong, Australia, in the final year of a long collaboration that solved key technical problems," he said. "We brought fresh eyes, as well as our knowledge and experience with heat transfer engineering from the nanoscale to the scale of practical devices to the problem, which provided a key missing link. The team will together work to enable additional breakthroughs that are required for this technology to reach its full commercial potential."

Efficiently harvesting the thermal energy currently wasted in industrial

plants or along pipelines could also create local sources of clean energy that in turn could be used to lower costs and shrink an organization's energy footprint.

The new thermocells use nanotube electrodes that provide a threefold increase in energy conversion efficiency over conventional electrodes.

One of the demonstrated thermocells looks just like the button cell batteries used in watches, calculators and other small electronics. One key difference, however, is that these new thermocells can continuously generate electricity, instead of running down like a battery. The research netted other thermocells, as well, including electrolyte-filled, textile-separated nanotube sheets that can be wrapped around pipes carrying hot waste streams from manufacturing or electrical power plants. The temperature difference between the pipe and its surroundings produces an electrochemical potential difference between the carbon nanotube sheets, which thermocells utilize to generate electricity.

The research team estimates that multi-walled carbon nanotubes in large thermocells could eventually produce power at a cost of about $2.76 per watt from freely available waste energy, compared with a cost of $4.31 per watt for solar cells, which can only be used when the sun is shining. On a smaller scale, button cell-sized thermocells could be used to power sensors or electronic circuits.

The new thermocells take advantage of the exceptional electronic, mechanical, thermal and chemical properties of carbon nanotubes. The nanotubes' giant surface area and unique electronic structure afforded by their small diameter and nearly one-dimensional structure offer high current densities, which enhance the output of electrical power and the efficiency of energy harvesting.

"Georgians have worked with state support, and in partnership with

initiatives such as the Strategic Energy Institute at Georgia Tech, to realize significant gains in renewable energy production," Cola said. "But to become a leading energy state, we must increasingly explore new ways to extract and utilize all forms of energy. Harvesting waste heat as electricity is one direction our NEST Lab takes with international partners to help provide increased renewable energy options for Georgia and the world."

This research was sponsored by the Office of Naval Research, the National Science Foundation, The Welch Foundation and the Australian Research Council.

Cola recently received the 2009 Defense Advanced Research Projects Agency (DARPA) Young Faculty Award for his work on solar energy conversion. As director of the NEST Lab, his research focuses on realizing the benefits of nanoscience in applications related to waste thermal energy harvesting, solar energy conversion, and thermal management of electronics and energy systems.

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