SCIENCE & TECH

A leap forward in 'flow' batteries

A membrane-less fuel cell may enable cheaper, large-scale renewable energy storage

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The sources of power in the emerging renewable energy economy are intermittent. Wind energy is dependent on winds that are often capricious, and solar power is suboptimal on cloudy days. Such sources cannot be connected directly to the grid but instead to batteries which store power from them and then discharge continuously.

To better make use of renewable sources of power, these batteries must have a higher power density than normal batteries and must be very efficient. Existing options are competent, and scientists are continuously innovating to make them even better.

UNRELIABLE: Wind energy is dependent on winds that are often capricious and cannot be connected to the grid. – PHOTO: SPECIAL ARRANGEMENT

Research from the Massachusetts Institute of Technology (MIT), USA, has now demonstrated a quantum-leap in this arena: a membrane-less hydrogen-bromine fuel cell.

Conventional batteries include a porous membrane between the anode and the cathode to prevent short-circuits while facilitating charge-carrying ions to move between them. However, such membranes add to the battery's weight, reduce its efficiency and, depending on their material, bring along their share of structural defects and life-cycle limitations.

The MIT researchers removed the membrane, relying on a phenomenon called laminar flow, instead, to prevent short-circuiting. Their results appeared in *Nature Communications* on August 16. William Braff, a doctoral student at MIT, built a prototype of the battery, with a channel between the anode and cathode.

Through this channel, the group pumped liquid bromine over a graphite cathode and hydrobromic acid under a porous anode, while flowing hydrogen gas across the anode.

However, instead of pumping them turbulently, the researchers kept the flow rate low to achieve laminar flow, whereby a fluid flows in parallel layers without mixing. This scenario also prevents two fluids flowing next to each other from mixing with each other. Thus, a "natural" membrane is formed between the anode and cathode while still keeping the ion-transfer channel option.

"The key to sustaining laminar flow is to ensure that the flow velocity within the channel is maintained below a certain threshold. As it happens, our system operates at flow rates about 1,000 times lower than that threshold. Mechanically, the flow is driven by a small pump," Mr. Braff said via email.

Hydrogen and bromine react with the electrodes to store energy or release it via an external circuit. The paper notes that a voltage transfer efficiency of 92 per cent was measured at 25 per cent of peak power.

Mr. Braff's prototype is the first rechargeable membrane-less battery and promises a power density of 0.795 W/cm^2, an order of magnitude higher than that from lithium-ion systems, when operated at room temperature and pressure.

Mr. Braff and his colleagues estimate that their device may produce energy costing about $100 per kWh, factoring in structural and operational costs. This is value that could seem economically attractive to renewable energy utilities.

The researchers also developed a mathematical model of the membrane-less cell, providing a foundation for scientists to now scale up the battery to megawatts.