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A Research First

University of Dayton, Ohio (url: http://www.udayton.edu/index.php)

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11.17.2009 | Research Engineers at the University of Dayton Research Institute have developed the first solid-state, rechargeable lithium-air battery, a breakthrough designed to address the fire and explosion risk of other lithium rechargeable batteries and pave the way for development of large-size lithium rechargeables for a number of industry applications, including hybrid and electric cars, the researchers said. Their achievements will be reported in the 2010 Issue 1 of the *Journal of the Electrochemical Society*, due out in December, and is currently available in the journal's Web site.

“We have successfully fabricated and tested the first totally solid-state lithium-air battery, which represents a major advancement in the quest for a commercially viable, safe rechargeable battery with high energy and power densities and long cycle life,” said Binod Kumar, a distinguished research engineer and leader of UDRI's electrochemical power group. In addition to increasing the battery's energy density (the ratio of energy to battery weight), the development is designed to mitigate the volatile nature of traditional lithium rechargeables, such as those used in cell phones and laptops, which can overheat and catch fire or rupture.

Kumar said there is enormous demand in defense and industry for safer, lighter lithium rechargeable batteries for applications ranging from electric cars to unmanned aerial vehicles, adding that billions of federal stimulus dollars have already been directed for research, development and manufacturing of lithium batteries.

“We believe this breakthrough represents a great opportunity to companies who are eager to incorporate significantly higher energy, longer-life and safer batteries into their products,” he said.

Rechargeables commonly found in today's portable consumer electronic devices are lithium-ion batteries. They are considered superior to other types of rechargeables, such as nickel cadmium, because of their high energy-to-weight ratios, slow discharge when not in use, and absence of “lazy battery effect,” a phenomenon which causes a battery to lose maximum energy capacity when it is repeatedly charged after only partial discharge.

Because of their lighter weight and high energy capacity, lithium-ion batteries are increasingly used in aerospace and automotive applications, but their full potential for larger applications remains untapped because of technological challenges – primarily related to safety.

“There have been a number of accidents and a large number of recalls involving lithium batteries,” Kumar said. “Most batteries use a liquid electrolyte, which creates a number of problems. They are corrosive and can leak. A short circuit or excessive heat from exposure to direct sunlight or use in a poorly vented laptop, for example, not only shortens battery life, but can cause the battery to rupture, ignite or explode.”

Because of their volatility, restrictions exist for ground and air transport of lithium batteries.

Kumar and his colleagues addressed the safety issues by developing an entirely solid-state lithium battery – no liquid is present in the cell.

“We've replaced the liquid electrolyte with a solid electrolyte that works just as well, but is far safer,” Kumar said. "The primary component of the new electrolyte is a glass-ceramic material which is very stable, even when in contact with water."

The researchers applied innovations on solid electrolytes to develop the new technology in the form of a lithium-air battery, rather than a lithium-ion, because they are much lighter and have the potential to be the most energy-dense and most environmentally friendly rechargeables.

In traditional lithium batteries, all the chemicals that power the battery are stored inside, Kumar said. In a lithium-air battery, one of the chemicals – oxygen – is left out. Instead, the battery is specially designed to draw oxygen from the air around it. By extracting oxygen, rather than storing it, and by using lithium metal as an anode, lithium-air batteries are 10 to 15 times more

energy dense than other lithium rechargeables.

“We made and tested more than three dozen lithium-air batteries during the last year, and each exhibited superior performance – even at temperatures as high as 225 degrees Fahrenheit,” Kumar said. As development of the technology continues, researchers will also focus on cycle life – the number of times a battery can be discharged and recharged. “We’re currently at a cycle life of 40, with a goal of 4,000, which is significantly greater than the cycle life of current lithium batteries.”

Kumar and his colleagues have focused on electrolyte research for two decades and hold a number of patents in the field. Research to develop the new lithium battery was funded in part by the Air Force Research Laboratory’s Propulsion Directorate at Wright-Patterson Air Force Base.

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