A Novel, Generalized Lithium-Ion Battery with Enhanced Energy Density

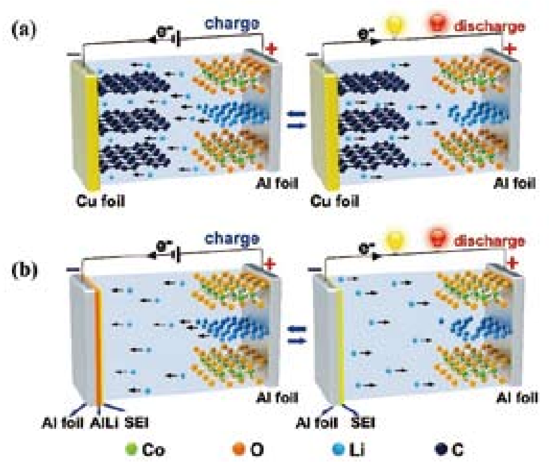
As one of the most widely used electrochemical energy storage devices, lithium-ion batteries (LIBs) have been extensively studied compared to other rechargeable battery systems. A traditional LIB consists of several main components, including the cathode, the anode, the positive and negative current collectors, the electrolyte, and the separator.

This basic battery configuration hasn't changed since its first appearance. The working mechanism of conventional LIBs include lithium ions deintercalating from the cathode material, migrating through the electrolyte to intercalate into the anode material (i.e. graphite) during the charging process, and discharging reverses the process. However, with the rapid development of portable devices and electric vehicles, most traditional LIBs are unable to meet the high energy density demands of such applications due to their limited packaged energy densities.

TANG Yongbing and his colleagues from the Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences have recently developed a novel and generalized LIB configuration, which can increase the energy density of the battery by utilizing an Al foil anode in combination with conventional cathode materials, including $LiCoO_2$, $LiFePO_4$, and $LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$.

In contrast to conventional LIBs, the Al foil in this configuration acts as both the anode and current collector directly, thus conventional anode materials are omitted from the design. The working mechanism of the battery is different from conventional LIBs as well: during the charging process, lithium ions deintercalate from the $LiCoO_2$ cathode and migrate to the Al foil anode to form an AlLi alloy. Conversely, in the discharge process, the lithium ions de-alloy from AlLi and migrate back to the $LiCoO_2$ lattice.

Owing to the elimination of conventional anode materials, the proportion of the electrode material in the total battery is larger, thus the energy densities of these batteries are dramatically improved. For the $LiCoO_2$-Al battery, the energy density reaches up to 263 Wh/kg at a power density of 216 W/kg, which is about 1.5 times greater than a conventional $LiCoO_2$-based LIB. For the $LiFePO_4$-Al battery, the energy density reaches up to 163 Wh/kg at a power density of 217 W/kg. For the $LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$-Al battery, the energy density reaches up to 258 Wh/kg at a power density of 275 W/kg.



(a) Traditional LIBs configuration, **(b)** Novel and generalized LIB configuration.

Additionally, the process for assembling this new battery design is simplified compared to typical LIBs, thus reducing production costs for making a promising candidate technology for next generation high performance batteries.

At present, the cycling stability of the new battery still needs improvement. TANG and his group believe that once the technique is commercialized, it will significantly enhance the performances of portable electronic devices, electric vehicles, and other renewable energy systems.

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