Ternary nanocomposite cathode material composed of $LiMn_2O_4/MnO_2$/carbon black with high performance and long-term stability via low-temperature synthesis on flexible conducting carbon fibers current collector

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Lithium-ion batteries (LIBs) are one of the great successes of modern materials electrochemistry. Although LIBs can provide higher energy density than other secondary battery systems, their power density remains too low for high power applications, such as hybrid electric vehicles. Power density can be improved by a suitable choice of positive and negative electrode materials leading to a higher voltage and to higher charge/discharge rates. There are generally two methods to increase the charge/discharge rates. One method is to reduce the crystallite size of the electrode materials, which as a consequence of shortened electron and lithium ion diffusion paths lead to enhance charge/discharge rates. Another method is to add conductive additives to the electrode material to make composite, which could enhance the charge/discharge rates due to improved electronic conductivity of the electrode. However, the large surface area will promote larger amount of side reactions at the electrolyte/electrode interfaces. Therefore, the development of nanoelectorde materials should focus on direction of the optimized properties balancing the advantages and disadvantages.

The cathode is a key component in LIBs, one leading alternative cathode material of LiCoO2 is LiMn2O4 for its low cost, higher electrochemical potential vs. graphite, and its improved thermal stability. The electrochemical properties of $LiMn_2O_4$ are strongly dependent on the synthetic methods. $LiMn_2O_4$ materials are usually prepared by solid-state reaction at high temperature, where the products typically have good crystallinity but broad particle size distribution as well. These $LiMn_2O_4$ are common in large particle sizes, and usually exhibit low power density at high current density due to their low electronic conductivity and the slow lithium diffusion in the solid active materials. Another challenging issue with cathodes made of $LiMn_2O_4$ is that capacity decays significantly with charge-discharge cycling, which has been a major problem prohibiting $LiMn_2O_4$ from commercial application.

In this work, we have designed the outstanding ternary nanocomposite cathode material composed of $LiMn_2O_4$, MnO_2, and carbon black (CB) via hydrothermal reaction at 383 K for 8 h on the surface of conductive carbon fibers (CFs), utilized as promising flexible current collector. $LiMn_2O_4/MnO_2$/CB nanocomposite cathode materials exhibit a high capacity of 106 $mAhg^{-1}$ and excellent cycling stability with capacity retention of 99% after 10,000 cycles at a current density of 100 C-rate, while operating temperature is 50 ◦C. These results can be explained by considering that CB nanoparticles enhance the bare electric conductivity of $LiMn_2O_4/MnO_2$ and moreover, the improved long-term stability and inner electric conductivity of $LiMn_2O_4/MnO_2$ by conductive CFs. Such formation of unique ternary $LiMn_2O_4/MnO_2$/CB nanocomposite cathode material by using conductive CFs as current collector are great interest both for application and scientific research.

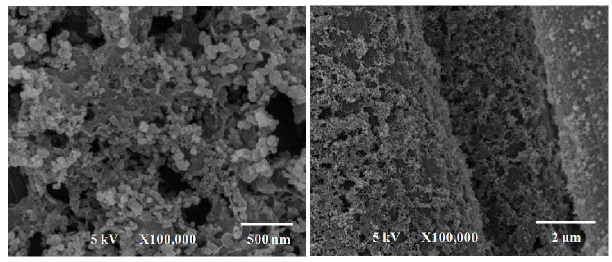

Figure 1. SEM images of $LiMn_2O_4/MnO_2$/CB nanocomposite cathode after cycling stability tests of 100 C-rate for 10,000 cycles at 50◦C.

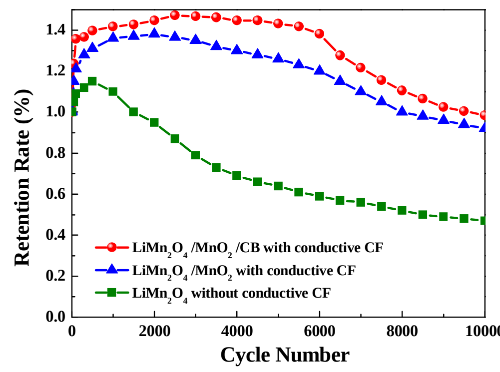

Figure 2. Long-term cycling stability of contenting-$LiMn_2O_4$ at a current density of 100 C-rate at 50 ◦C.