CNT composite electrode materials for lithium storage application

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Lithium ion batteries (LIBs) have enjoyed significant growth during last two decades, becoming the main power source in portable electronics such as mobile phones and laptops. With recent rapid developments in automotive and energy storage system applications, development of LIBs with higher energy and power density than currently available has been enthusiastically pursued to meet the future demand.

Recently, metal oxides emerge as a key type of electrode materials for energy storage application in fields such as rechargeable batteries and supercapacitors. Many transition metal oxides MeO$_x$, such as Co$_3$O$_4$, MnO$_x$, MoO$_2$, and Fe$_3$O$_4$ have been extensively investigated, and they have shown a capacity up to 600–1000 mAh g$^{-1}$, twice or even threefold that of graphite. These metal oxides adopt a conversion mechanism to store large amount of Li$^+$ ions, in contrast to the typical intercalation mechanism occurring in graphite. During discharge process, the oxides were reduced to metal in accompanying with formation of Li$_2$O, and vice versa upon recharge process. Hence, the total process can be written as MeO$_x$ + 2xLi $\leftrightarrow$ Me + xLi$_2$O. However, these materials experience sluggish kinetics upon electrochemical process, and the poor lattice conductivity is regarded as one of the major causes for this.

Due to superior mechanical strength, high aspect ratio and unique electrical properties, carbon nanotubes (CNTs) are the ideal form for constructing composite materials [1]. In this work, we report our recent progress on the CNT-based composite electrode, focusing on Mo and Fe-based oxides. A series of CNT composite oxides such as CNT-MoO$_3$, CNT-MoO$_{3-x}$, CNT-Fe$_3$O$_4$ are engineered and fabricated through a simple soft-chemistry route and their Li storage capability is investigated [2-4]. The CNT provides efficient electron wiring and porous scaffold facilitating electron and Li$^+$ ion transportation. Also, it serves as flexible buffer towards the strain of active material upon Li insertion/extraction. Compared with the neat materials, these composites afford larger capacity, longer cycle stability and higher power density, thereby indicating their potential for rechargeable battery application (Fig. 1 and Fig. 2).

**Fig. 1** (left) Schematic illustration and (right) electrochemical Li-storage capability of CNT-wired MoO$_3$ nanostructures.

**Fig. 2** (left) Schematic illustration of synthesis and (right) electrochemical Li-storage capability of Fe$_3$O$_4$ hollow particles anchored on CNT.

**Reference**