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Lignin-Derived Carbon and NiO Hybrid Nanospheres with Exceptional Li-ion Battery and Pseudocapacitive Properties

AUTHORS

Zeping ZHOU / ZHEJIANG UNIVERSITY OF TECHNOLOGY, NO.18 CHAOWANG ROAD, HANGZHOU

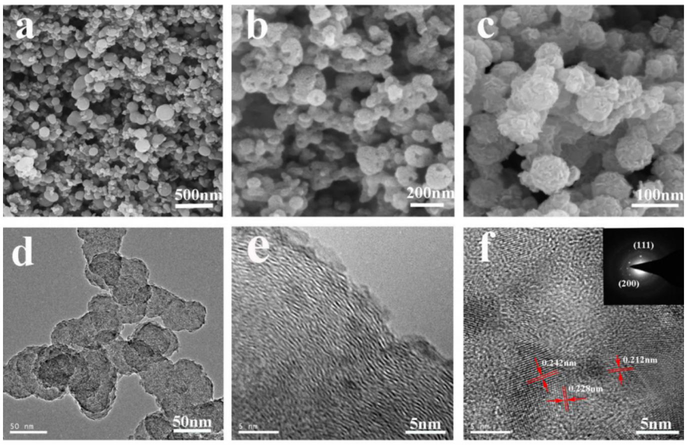
PURPOSE OF THE ABSTRACT

In recent years, transition metal oxides which can go fast and reversible faradic redox reaction, have attracted extensive attention as the alternative anode materials with superior electrochemical performance. However, most high capacity anode materials expand significantly during charging, such anodes must contain sufficient porosity or tough protective layer in the discharged state to enable the expansion, yet not excess porosity or low-conductivity mass, which lowers the overall energy density.

Since lignin is derived from biomass and usually discarded as waste, it is prominent to use lignin as a cheap alternative material in woody materials.In nature, lignin is one of the most abundant and important macromolecules in organic matter that is second only to cellulose. it has many attractive properties such as high carbon content, high thermal stability, biodegradability and antioxidant. Our group reported the successful synthesis of hierarchical mesoporous carbon (HMPC) material from lignosulfonate[1,2].

Herein, we present a high capacity anode consisting of hierarchical mesoporous carbon nanospheres without any additives, which are derived from lignosulfonate and has excellent supporting for in-situ embedding NiO nanoparticles of 11 wt%.The system is green, as it using natural lignosulfonate as the carbon precursor in water solution. The Ni-based HMPC intermediate obtained can be simply converted into highly crystalline NiO/HMPC NSs via thermal annealing without significant changes in morphology. The annealed product is shown to be phase-pure NiO and highly graphitized carbon with a high surface area. The hybrid structure has a high specific surface area (852 m2?g-1) and hierarchical pores, which can enhance Li-ion transportation in the electrode, increase the conductivity, and suppress the deformation of NiO. Importantly, the hybrid nanosphere anode exhibited a high discharging capacity of 863 mAh?g-1 at 0.1 A?g-1 and was retained after 100 cycles for a Li-ion battery. When evaluated as an electrode material for supercapacitors, the as-prepared hybrid nanospheres manifest exceptional performance with a usually high pseudocapacitance of 508 F?g-1. Remarkably, about 92% of the initial capacitance can be retained after 2000 charge/discharge cycles. This approach generates a strategy to combine metal oxide nanoparticles with nanostructured carbon derived from biomass, which is expected for a broad set of possible electrode chemistries.

FIGURES



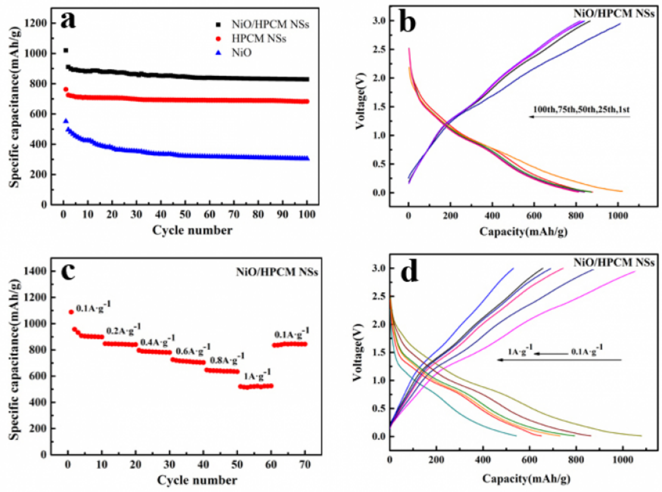


FIGURE 1

Characterization fig.1

SEM images of (a) LS NSs, (b) HMPC NSs and (c) NiO/HMPC NSs; The high-resolution TEM images of (d,e) HMPC NSs and (f) NiO/HMPC NSs. The inset in (f) shows a magnified view on NiO nanoparticle.

FIGURE 2

fig.2 Electrochemical performance

(a) Comparative cycling performance at a current density of 0.1 A•g-1 of pure NiO, HMPC and NiO/HMPC; (b) Charge-discharge voltage profiles of NiO/HMPC; (c) Rate performance of NiO/HMPC electrode; (d) Charge-discharge voltage profiles of NiO/HMPC electrod

KEYWORDS

Hierarchical pores | Carbon/NiO | Lignin | Electrochemical energy storage

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