CARBON FOR ENERGY STORAGE: EXPLORING THE EFFECTS OF METAL OXIDE NANOPARTICLE SIZE AND CONFINEMENT

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Description :

Nanostructured materials have triggered tremendous attention due to both fundamental interest and potential applications, especially in energy field. However, the synthesis of nanoparticles (NPs) with small and uniform size is very chalenging taking into consideration their instability and their tendency to aglomerate. To overcome these issues, porous carbons have proved to be ideal scaffolds through their porosity able to act as confining nanospaces for NPs, thereby limiting their growth during synthesis [1]. In addition, they provide electronic conductivity and high surface area, inducing better performances and broadened application domains. In typical applications such as batteries and supercapacitors, the charge storage is strongly depending on both carbon and metal oxide species. The reduction of NP size leads to a variety of exciting phenomena resulting from their enhanced surface-to-volume ratio and reduced transport lengths. Thermodynamical, kinetical and diffusional modifications are the most reported effects of downsizing particle size. For example, it has been shown that typical battery oxide-type electrodes based on niobium oxide [2] exhibits supercapacitor type behaviour when downsizing particle size. Recently, we also showed that confining tin oxide NPs in the mesopores of carbon allows to achieve higher capacity, stability and longer term life in a battery [1]. Therefore, a better understanding of the physical mechanisms underlying charge storage in nanoscale complex materials is increasingly important, both fundamentally and in view of the development of novel innovative energy storage devices.
The aim of this thesis is to explore nanoscaled metal oxide particles insertion in carbon pores/walls *via* confinement approach for supercapacitors applications. This requires the development of novel synthesis routes allowing both size control (NPs/carbon support), as well as a deep assessment of oxide crystallinity (XRD), carbon porosity (gas adsorption) and surface chemistry (XPS). In a first part, the carbon support will be optimized (surface area, pore size, surface chemistry, morphology and electronic conductivity). Once this has been achieved, the metal NPs oxides will be synthesized using soft synthesis approches. Systematic investigations of electrochemical performances of several types of oxides exhibiting different NPs size/confinement will be conducted in the aim of understanding nanoscale effect and charge storage mechanisms operating in these nanocomposite materials (electrochemical profiles, stablilty over cycling, redox reactions).

Références :

[1] A Jahel, C Ghimbeu, L Monconduit, C Vix-Guterl, Adv Energ Mater **4** (2014) 1400025
[2] J W Kim, V Augustyn, B Dunn, Adv. Energy Mater. **2** (2012) 141–148