Electrochemical Characterization of Hydrothermally Synthesized Ruthenium-Tin Oxides for Supercapacitors

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Introduction

Anhydrous and hydrous ruthenium oxides (i.e., RuO_2 and $RuO_2 \cdot nH_2O$) are well-known electrode materials for electrochemical supercapacitors which are unique devices of energy storage with the high pulse-power density and long cycle life [1,2]. Recently, the development of electroactive materials with large specific capacitance and high specific surface areas, such as nanostructured metal oxides and activated carbon-oxide composites [3-6], becomes a new trend because these materials provide combined advantages of double-layer capacitance and Faradaic pseudo- capacitance.

The useful method of nanoparticles synthesis is inevitably emphasis being place on scaling up procedures, such as sol-gel or hydrothermal process. However in industrial anodes, the RuO_2-SnO_2 binary oxide has been studied at the fundamental level by several researchers. In addition, the introduction of SnO_2 to RuO_2 could be considerable to increases the electrochemical stability of RuO_2 coatings. Based on the above viewpoints, binary Ru-Sn oxides in certain compositions with a nanocrystalline structure are expected to be a potential candidate for the applications of supercapacitors.

Results and Discussion

TEM morphologies and electron diffraction analysis of pristine $(Ru\text{-}Sn)O_x \cdot nH_2O$

Typical transmission electron microscopic (TEM) morphologies of pristine RuO_x and $Ru_{0.8}Sn_{0.2}O_x$ are shown in as Fig. 1a-1b, respectively. In Fig. 1a, a network structure, composed of many RuO_x nanoparticles, is clearly found. The particle size of this oxide ranges from 1.7 to 2.5 nm. Similar network structures are also found for the $Ru_{0.8}Sn_{0.2}O_x \cdot nH_2O$ binary oxide, demonstrating the typical nano-structure of oxides fabricated by a hydrothermal process. The mean particle size was decreased to 1.5 nm. Note that the particle size of $(Ru\text{-}Sn)O_x \cdot nH_2O$ is monotonously decreased with increasing the molar fraction of $SnCl_4 \cdot xH_2O$ in the precursor solutions. Therefore, oxide particles with their diameter equal to 1 nm are very stable in the meta-stable solutions. This phenomenon was also found for metallic particles without templates [7].

The crystalline information of RuO_x and $Ru_{0.8}Sn_{0.2}O_x$ samples was also analyzed by electrons diffraction and their typical results are shown in Fig. 1c-1d. Since there are no diffraction rings on all photographs, all pristine binary oxides are very likely to be amorphous. This result is similar to the amorphous structure of pristine $RuO_x \cdot nH_2O$ since hydrous oxides prepared by a modified sol-gel process generally showed amorphous structures [8].

References

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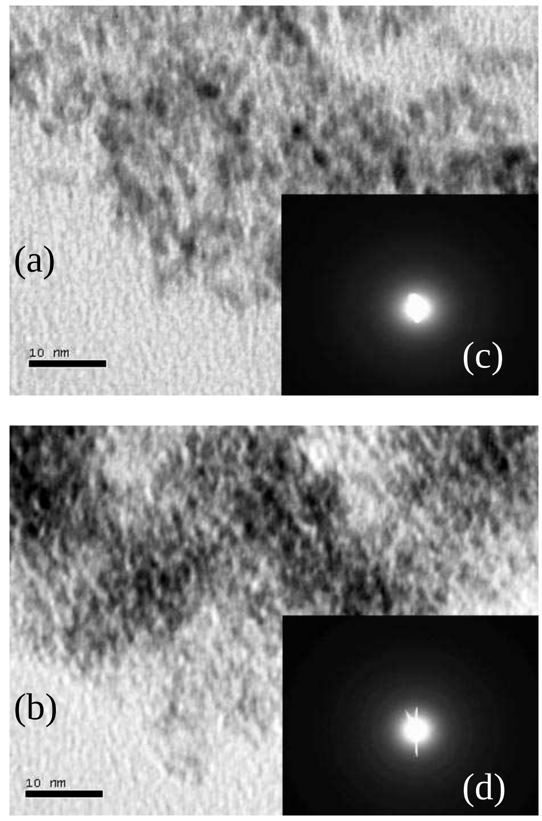

Fig. 1 (a, b) TEM and (c, d) electron diffraction photographs for pristine (a, c) RuO_x and (b, d) $Ru_{0.8}Sn_{0.2}O_x$ under a magnification of 1,400,000.