Manganese oxide mesoporous sphere as supercapacitor for electrochemical deionization

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Abstract:

In this study, we used aerosol-assisted self-assembly (AASA) process to fabricate manganese oxide microspheres with mesopores as supercapacitor for electrochemical deionization. The heat treatment was a critical factor on the properties of manganese. With different treatment temperatures, especially at about 450 ℃, the obtained samples were from the crystalline phase to the valence state, for example, the formation of a melt from MnO_2 as Mn_2O_3. It can be seen from the XPS data that during the process of electrosorption, the state of manganese dioxide on the surface of the electrode has a change in the valence state, indicating that the capacitive effect of the MOS250 during the electrosorption is not only the electrical double layer effect but also from the pseudo-capacitance contributions.

Keywords:. Mesoporous、Manganese oxide、Aerosol-Assisted Self Assembly

1. Introduction

Recently, numerous studies have focused on water desalination by capacitive deionization to create the advantages of low-cost, non-secondary polluted and clean water. In order to realize the situation of charged particle absorbed by electric field between two electrodes, varieties of model have been put forward. Researchers considered the material of electrode as most important factor for desalination capacity. As a trend, an increase in the capacitance of electrode results in a higher salt adsorption capacity. Activated carbon (AC) is the commonly used material, as it is the most cost efficient option and it has a high specific surface area. A few researches find that porous material modified by metal oxides could increase cell electrosorption by combined pseudocapacitance and double-layer capacitance both contribute inseparable to the total capacitance value.

The technologies most commonly used commercially are reverse osmosis (RO), multistage flash (MSF), multi-effect distillations (MED, sometimes called multi-effect evaporation or MEE).In this study, we use Capacitive deionization (CDI) which novel technology on water treatment. The external voltage is applied to the electrode to form the relative electric property, and the charged ion is adsorbed on the electric double layer by using the method of electrosorption. It has the advantages of high desalting efficiency, low energy consumption and environmental friendliness, which will help to solve the global shortage of fresh water resources.

2. Experimental

In this study, manganese oxide mesoporous sphere (MOS) were synthesized by a rapid AASA (Aerosol-Assisted Self Assembly) process which different from traditional process. Then we prepared film drop on titanium plate as electrode by combined porous sphere with carbon black and PTFE binder. We applied 0.8 voltage for the CDI cell and the opposed ions are forced toward the electrode surfaces. The MOS were characterized by SEM, TEM, BET, XRD, TPR and XPS for its structure and morphology. Then film were experimented for electrochemical properties by CV, CP, EIS and electrosorption.

3. Results and discussion

According to characterization, when the temperature of MOS calcined from 250 ℃ to 650 ℃, the crystalline structure of MOS been changed with different oxidation state. As calcined temperature equal to 250 ℃, the surface area were 102.2 (m^2/g) and most of them were manganese dioxides. As temperature increased, the oxidation number of manganese ions were decreased. We could find the surface of material

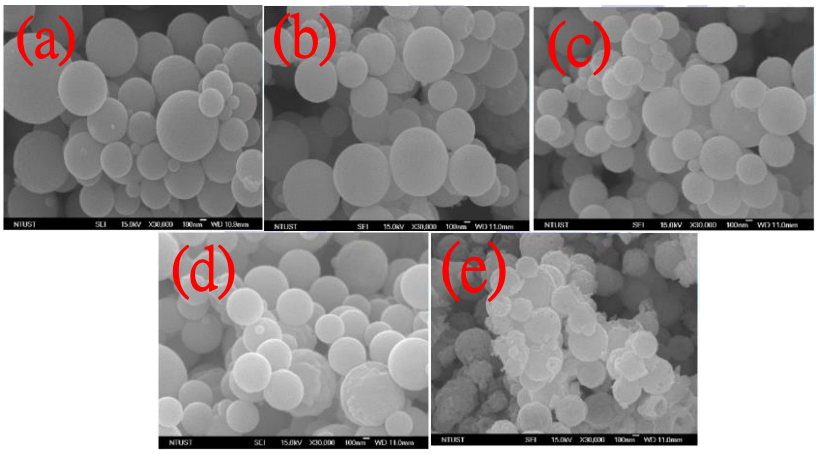

Figure 1. The images of SEM (a)MOS250, (b) MOS350, (c) MOS450, (d) MOS550, and (e) MOS650

The capacitance of material also effected by calcined temperature. In conclusion, the MOS250 has maximum capacitance, stability and electrosorption were obtained for high surface area and more manganese dioxide. XPS was used to distinguish between double-layer capacitance and pseudocapacitance by electrode after eletrosorption. As a result MOS250 has both capacitance but pseudocapacitance much more than double-layer capacitance. It's caused MOS250 have good performance in desalination.

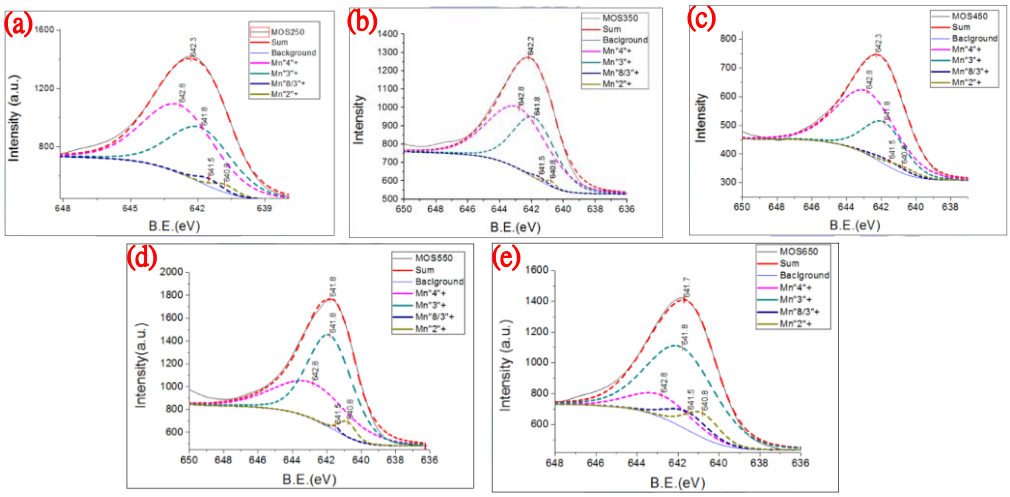

Figure2. XPS of Mn 2p 3/2 for (a)MOS250, (b) MOS350, (c) MOS450, (d) MOS550, and (e) MOS650

4. Conclusions

In this study, aerosol-assisted self assembly process was established to produce manganese oxide microspheres with mesopores as supercapacitor for electrochemical deionization. Analysis of composite materials and electrode electrochemical results show that the following conclusions can be obtained: (i) The heat treatment has a considerable impact on the properties of manganese, from the crystalline phase to the valence state, corresponding to different treatment temperatures, especially at about 450 ℃, which results in the formation of a melt from MnO_2 as Mn_2O_3. Reduce the surface area, the electrochemical activity will have a corresponding impact. (ii) It can be seen from the XPS data that during the process of electrosorption, the state of manganese dioxide on the surface of the electrode has a change in the valence state, indicating that the capacitive effect of the MOS250 during the electrosorption is not only the electrical double layer effect but also from the pseudo-capacitance contributions.

References

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