Electronic Supplementary Material (ESI) for RSC Advances.

Electronic Supplementary Information

Self-template synthesis of porous $ZnCo_2O_4$ microspheres for high-performance quasi-solid-state asymmetric supercapacitors

Yansong Gai, Yuanyuan Shang, Liangyu Gong,* Linghao Su, Long Hao, Fengying Dong, Jianzhong Li

College of Chemistry and Pharmaceutical Sciences, Qingdao Agricultural University, Qingdao 266109, PR China

*Corresponding author: Liangyu Gong E-mail: lygong@163.com

Caculation

The specific capacitance is calculated by the following equation:

$C = (I \times \Delta t) / (m \times \Delta V)$ (1)

Where I is the discharge current, Δt is the discharge time, ΔV is the voltage range and $\boldsymbol{m}$ is the mass of the active material.

In order to optimize the electrochemical performance of asymmetrical capacitor, the mass ratio of positive and negative electrodes should follow the charge balance theory ($q_+ = q_-$). The charge stored (q) by each electrode depends on the specific capacitance (C), the voltage range (ΔV) and the mass of the electrode (m) following equation:

$q = C \times \Delta V \times m$ (2)

Thus, the optimal mass ratio between the two electrodes can be expressed as follows:

$m_+/m_- = (C_- \times \Delta V_-) / (C_+ \times \Delta V_+)$ (3)

The power density (P) and energy density (E) of the supercapacitor devices were calculated based on the total mass of the active materials following equations:

$E = 0.5 \times C \times \Delta V^2$ (4)

$P = E / \Delta t$ (5)

Where C is the specific capacitance of the supercapacitor measured from the eq (1), ΔV refers to the potential change within the discharge time Δt.

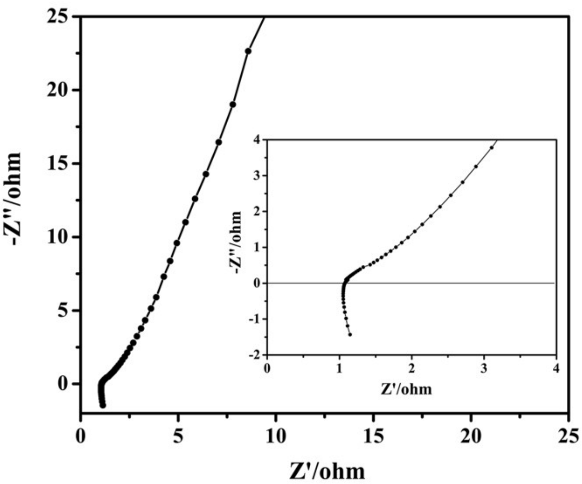

Fig. S1 Nyquist plots of $ZnCo_2O_4$ microspheres.

To further investigate the electrochemical performance of $ZnCo_2O_4$ microspheres electrode electrochemical impedance spectroscopies (EIS) analysis was measured at frequency range from 0.01 to 10^5 Hz at open circuit potential. Evidently, the impedance spectra of the $ZnCo_2O_4$ microspheres electrode consist of a small semicircle (R_{CT}, which reflects the charge-transfer resistance) in the high-frequency region and a straight line with a certain slope (Warburg impedance, which indicates the diffusion process taking within the structure of the material) in the low-frequency region.[1,2] The intercept on the Z real axis (the inset of Figure 5E) in the high-frequency region reveal the equivalent series resistance (ESR) of the electrochemical system, denoted as R_S, which are contributed by the Ohmic resistance of the electrolyte, the internal resistance of electrode materials, and contact resistance at the interface between current collector and active material.[3,4] The R_S values of $ZnCo_2O_4$ microspheres electrode was 1.06 Ω, indicating a particularly low internal resistance. The negligible semicircle diameter in high frequency and the high slope value of straight line in low frequency imply the fast charge transportation and the easy penetration of the electrolyte within the electrode, indicating a high electrical conductivity. And that can be attributed to the high specific surface area and the mesoporous structure of the interconnected $ZnCo_2O_4$ mecrospheres.

References

1. F. Lu, M. Zhou, W. Li, Q. Weng, C. Li, Y. Xue, X. Jiang, X. Zeng, Y. Bando and D. Golberg, *Nano Energy*, 2016, **26**, 313-323.
2. V. H. Nguyen and J.-J. Shim, *Electrochimica Acta*, 2015, **166**, 302-309.
3. T. Zhu, J. Wang and G. W. Ho, *Nano Energy*, 2015, **18**, 273-282.
4. S. Gao, F. Liao, S. Ma, L. Zhu and M. Shao, *J. Mater. Chem. A*, 2015, **3**, 16520-16527.