Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Fabrication of composite material of $RuCo_2O_4$ and graphene on nickel foam for supercapacitor electrodes

Jingjing Meng, Shixiang Lu*, Wenguo Xu, Shuguang Li and Xiuqi Dong

School of Chemistry and Chemical Engineering, Beijing Institute of Technology, Beijing 100081, P.R. China

Corresponding author, E-mail: shixianglu@bit.edu.cn *(Shixiang Lu)*

Experimental

S1： Synthesis of GO

GO was synthesized according to a modified Hummers method. First, in an ice-water bath, 9 g of graphite powder, 9 g $NaNO_3$ and 240 mL H_2SO_4 were added to a beaker and mixed. While stirring the mixed solution, 27 g $KMnO_4$ was slowly added, and the reaction system was allowed to react below 10 °C for 1 h. Then, the mixture was heated to 40 °C under water bath conditions and stirred for 1.5 h. Subsequently, 400 mL ice water was added, and the temperature was raised to 85 °C again and stirred for 1 h. Then, 1000 mL deionized water and 60 mL 30 % H_2O_2 solution were added to the solution, which turned yellowish-brown in color and was left overnight. After that, the mixture was washed twice with 400 mL 6 M HCl solution and three times with 1000 mL 1.2 M HCl solution to remove sulfate ions. The solid mixture was obtained by filtration. The filter cake placed for 3 days was transferred to a beaker, 700 mL deionized water was added, and the filter cake was dispersed in an ultrasonic water bath for 5 h and centrifuged for 0.5 h. The resulting liquid was filtered through a PVDF membrane, and the water was changed every 3 days until the solution was neutral. Finally, the GO suspension in the dialysis membrane was poured into an evaporation dish, put into an oven at 40 °C, dried for approximately one week, ground and set aside after complete drying.

S2: Preparation of $RuCo_2O_4$@NF

In this process, firstly, 0.4 mmol $RuCl_3$, 0.8 mmol $Co(NO_3)_2 \cdot 6H_2O$ and 1.0 mmol urea were weighed into a beaker, 15 mL deionized water was added, and magnetic stirring was performed for 40 min. Subsequently, the acidity of the above solutions was adjusted to neutral with KOH solution. The weighed NF was put into an autoclave of 25 mL, poured into the above mixed solution, and heated in an oven at 120 ℃ for 15 h. After the reaction was cooled to room temperature, the samples were washed with

deionized water and ethanol, and then dried in an oven at 90 ℃ for 4 h. Finally, $RuCo_2O_4$@NF electrodes were obtained by annealing in a muffle furnace at 300 ℃ for 2 h.

S3: Preparation of rGO@NF

Here, 7.5 mL GO solution was mixed with 7.5 mL distilled water, stirred for 40 min and adjusted to neutral. The weighed NF was put into the reactor, the above solution was poured in and reacted at 120 °C for 15 h. After the reaction kettle cooled to room temperature, the sample was taken and washed it with ethanol and deionized water, dried at 90 °C for 4 h, and annealed at 300 °C for 2 h to get rGO@NF electrode.

All electrode materials in the experiments were prepared under the same experimental conditions, and the test temperature was room temperature. The mass loading of the electrode is defined by weighing the mass of the nickel foam before and after loading the active material, and calculating the mass difference. Among them, only a small part of pure NF participated in the reaction during the preparation process, and the mass change was not obvious. The rGO@NF electrode was loaded with very little graphene, about 1 mg/cm^2. The load mass of $RuCo_2O_4$@NF and $RuCo_2O_4$/rGO@NF electrode composites is about 1.5 mg/cm^2.