Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Morphology-controllable synthesis of rod-shaped $CuO@Co_3O_4$ derived from CuCo-MOF-74 for supercapacitors

Bo Sun [1], Man Li [1], Lifeng Cheng [2], Qijian Li [1], Xiaowen Chen[1], Shengqi Wang [2], Wenhua Yan [2], Lei Wang [2], Fuxiang Wei [1,], Qingliang Wang [1,*]*

[1] *School of Materials and Physics, China University of Mining and Technology, Xuzhou 221116, PR China*

[2] *Xuzhou Jinhong Steel Group Co., Ltd; Xuzhou 221116, PR China*

* *Corresponding Author*

Fuxiang Wei: weifuxiang2001@163.com, https://orcid.org/0000-0001-6467-4096

Qingliang Wang: wql889@cumt.edu.cn

Fabrication of asymmetrical supercapacitor (ASC)

A two-electrode asymmetrical supercapacitor (ASC) was assembled in 2 M KOH using the $CuO@Co_3O_4$ and commercial reduced graphene oxide (RGO) as positive and negative electrodes, respectively. The negative electrode was prepared as follow: reduced graphene oxide (RGO), acetylene black and polyvinylidene fluoride (PVDF) were dispersed by a mass ratio of 8: 1: 1 in N-methyl pyrrolidone (NMP) into the homogenous slurry. Then the slurry was coated on bare Ni foam (1 × 2 cm^2), dried in a vacuum and pressed under the pressure of 10 MPa.

The charge balance principle (equations 1 and 2) was used to determine the mass ratio of active materials between the two electrodes.

$$Q^+ = Q^- \tag{S1}$$

$$\frac{m^+}{m^-} = \frac{I_m^- \times \Delta t}{I_m^+ \times \Delta t} \tag{S2}$$

Where both $Q^+$and $Q^-$are stored charges in positive and negative electrodes (C) respectively; I_m^+ and I_m^- are discharge current of positive and negative electrodes; m^+ and m^- refer to their loadings of active substances (g).

The energy density (E (Wh kg^{-1})) and power density (P (W kg^{-1})) are calculated by following formulas:

$$E = \frac{\int Q\, dv}{3.6} = \frac{\int_{t_1}^{t_2} IV dt}{3.6} \quad (S3)$$

$$P = \frac{E}{t} \times 3600 \quad (S4)$$

All of the discharge time ($t_{discharge}$) and discharge voltages ($V_{(t)}$) are taken into account for the calculation after the initial IR drop. In Formula 2, t_1 is the time after the initial IR drop, t_2 is the moment for the discharge, and I is the constant current densities applied to the supercapacitor.

The details of electrochemical measurement

In the three-electrode system, 2 M KOH was used as the aqueous electrolyte, and CuO@Co_3O_4 were employed as the working electrode, where, both platinum plate and the saturated calomel electrode (SCE) were used as the counter and reference electrodes. The loadings for the positive and negative electrodes were 2.5 mg and 2 mg, respectively. The calculation of specific capacity (C_g (C g^{-1})) based on GCD curves by following equation:

$$C_g = \frac{It}{m} \quad (S5)$$

Where I (A), t (s), m (g), represent discharge current density, discharge time and loading mass, respectively.

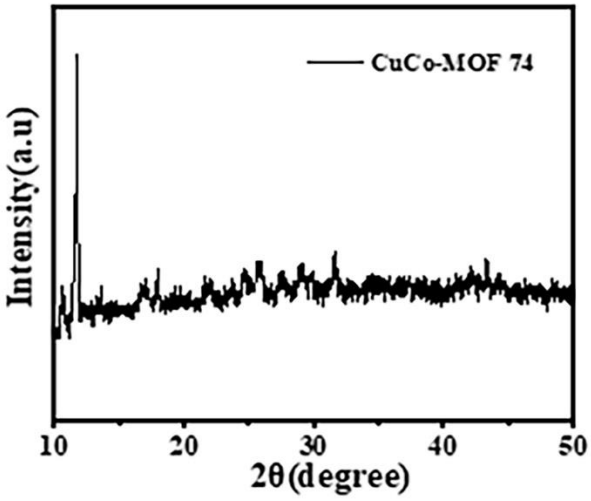

Fig. S1 XRD pattern of CuCo-MOF-74

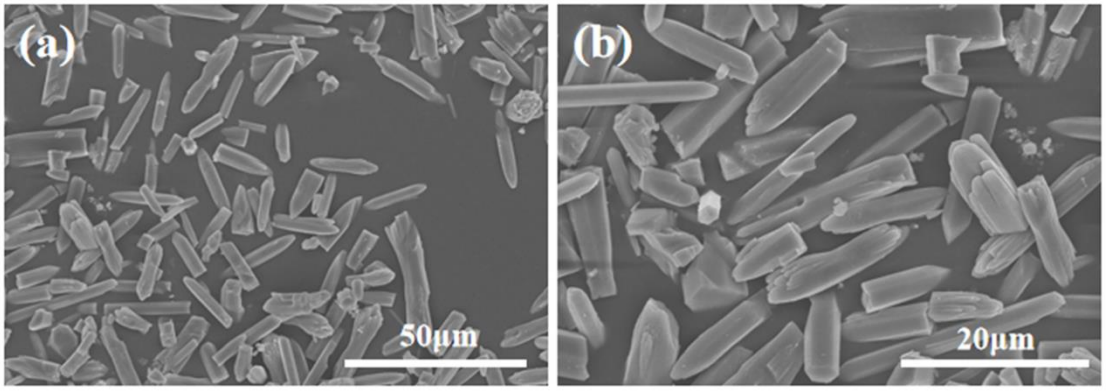

Fig. S2 SEM image of CuCo-MOF-74

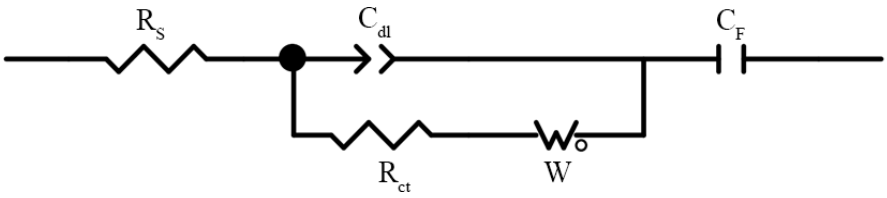

Fig. S3 Equivalent circuit for three-electrode configuration cell

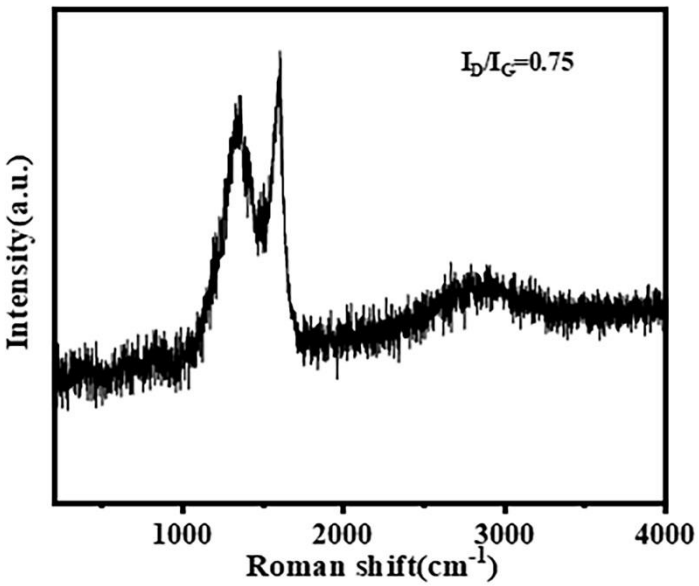

Fig. S4 Raman spectra of CuO@Co_3O_4

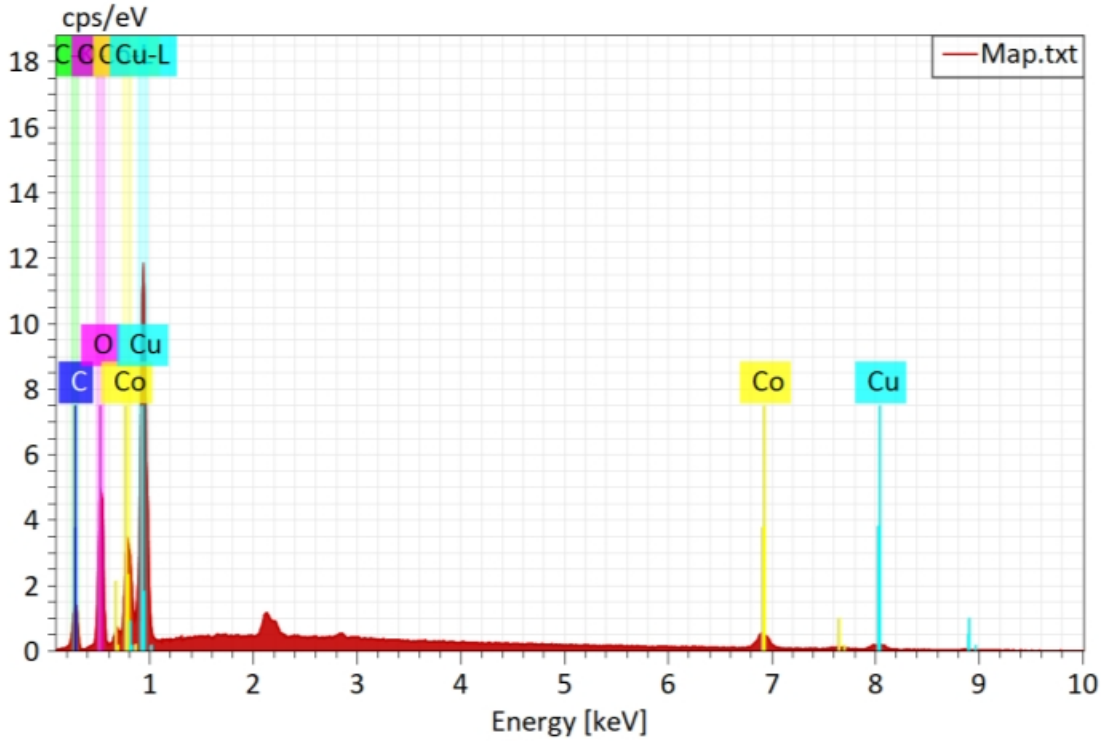

Fig. S5 EDS spectra of $CuO@Co_3O_4$

The GCD curves of $CuO@Co_3O_4$ (400 ℃) are shown in Fig. S6a, with specific capacitances of 409.1, 393.3, 388.6, 374.8, 354.3, and 332.1 F g^{-1} at current densities of 1, 2, 3, 5, 8, and 10 A g^{-1}, respectively. The GCD curves of $CuO@Co_3O_4$ (600 ℃) are shown in Fig. S6b, with specific capacitances of 423.5, 415.9, 393.6, 385.8, 376.3, and 355.1 F g^{-1} at current densities of 1, 2, 3, 5, 8, and 10 A g^{-1}, respectively.

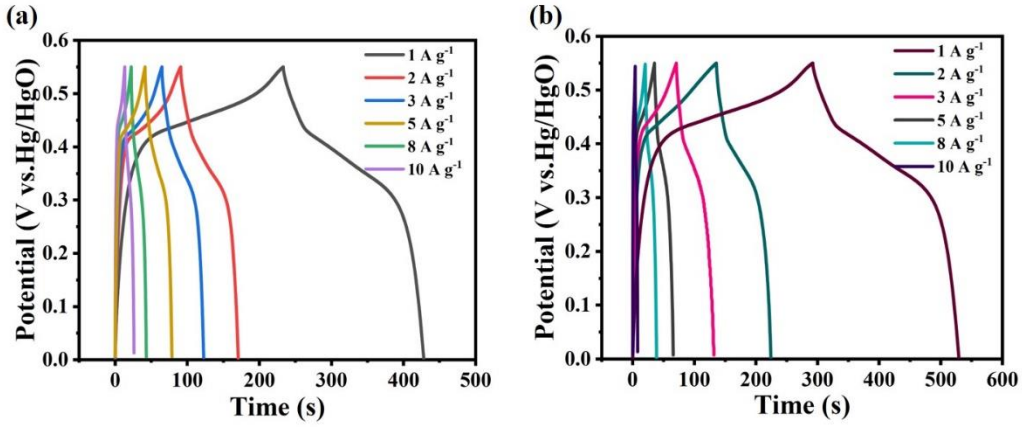

Fig. S6 (a) GCD curves of $CuO@Co_3O_4$ (400 ℃), (b) GCD curves of $CuO@Co_3O_4$ (600 ℃)

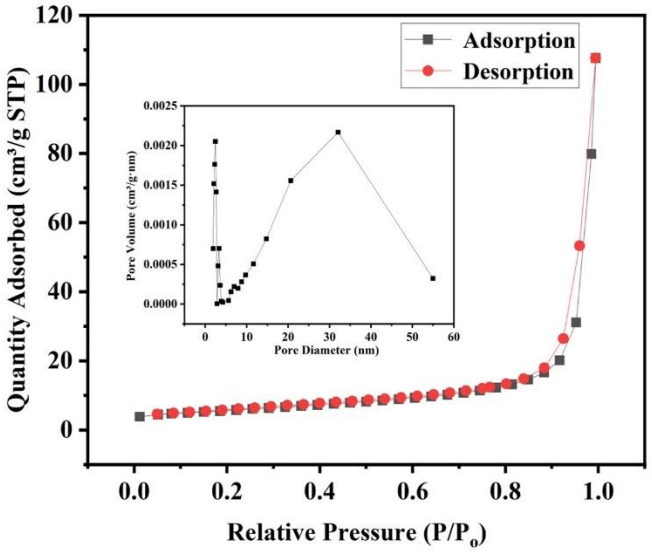

Fig. S7 Nitrogen adsorption-desorption isotherms of the CuO@Co_3O_4 (500 ℃) sample and the inset is pore size distribution curve

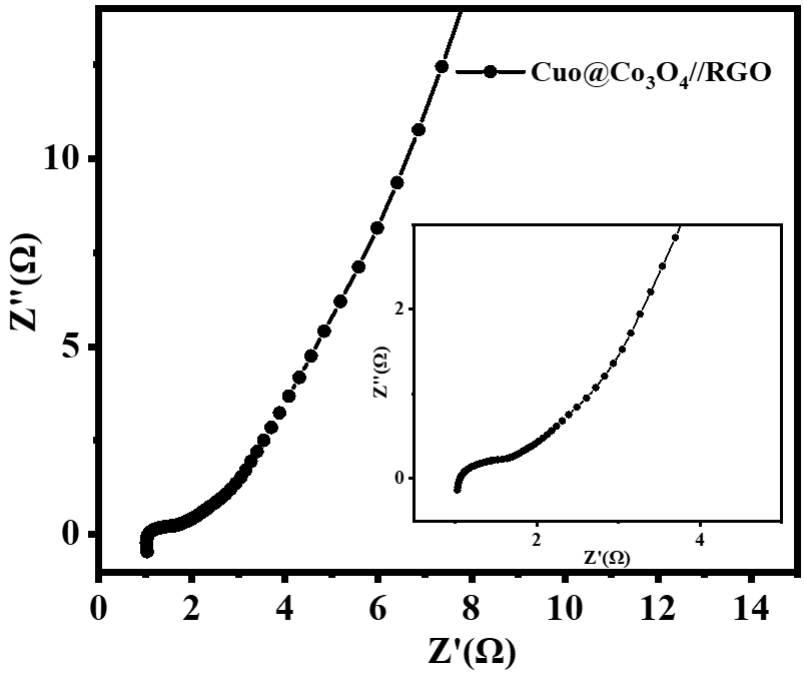

Fig. S8 EIS curves of CuO@Co_3O_4 (500 °C)//RGO