

Electrochemical properties of asymmetric supercapacitor based on optimized carbon-based nickel-cobalt-manganese ternary hydroxide and sulphur-doped carbonized iron polyaniline electrodes

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SUPPLEMENTARY INFORMATION

EXPERIMENTAL DETAILS

Synthesis of activated expanded graphite (AEG)

The AEG material was synthesized via a microwave irradiation technique as reported in our earlier work [1]. Briefly, graphite sample (grade ES 250 B5 from Qingdao Kropfmuehl Graphite) was expanded using a microwave oven at an irradiation power of 300 W for 5 min. About 1g of the expanded graphite (EG) was dispersed in 100 mL of 10 wt% Polyvinylpyrrolidone (PVP) and the mixture was sonicated for 12 h. 5 g of KOH was then added to the solution, and the mixture was further stirred for 2 h at 60°C. The solid precipitate obtained was collected and dried at 70 °C for 12 h. The dried solid precipitate was then placed in a horizontal tube furnace which was ramped from room temperature to 800 °C at 5 °C/min under argon and hydrogen gases flow and kept at this temperature for 2 h of carbonization. This procedure transformed the EG solid precipitate into flakes of carbon material denoted as activated expanded graphite (AEG). The black powder obtained was washed with 1 M HCl to remove the remaining KOH and subsequently with deionized water and dried at 60 °C.

Synthesis of Polyaniline (PANI)

A solution of aniline hydrochloride (2.59 g) in 50 ml deionized water was mixed with a solution of ammonium peroxydisulfate (5.71 g) in 50 ml deionized water. The resulting mixture was stirred for 30 min. and then left to standing overnight for complete polymerization. Thereafter, the recovered precipitate washed with DI water and dried at 60 °C under ambient condition for about 12 h.

RESULTS

Morphological analyses

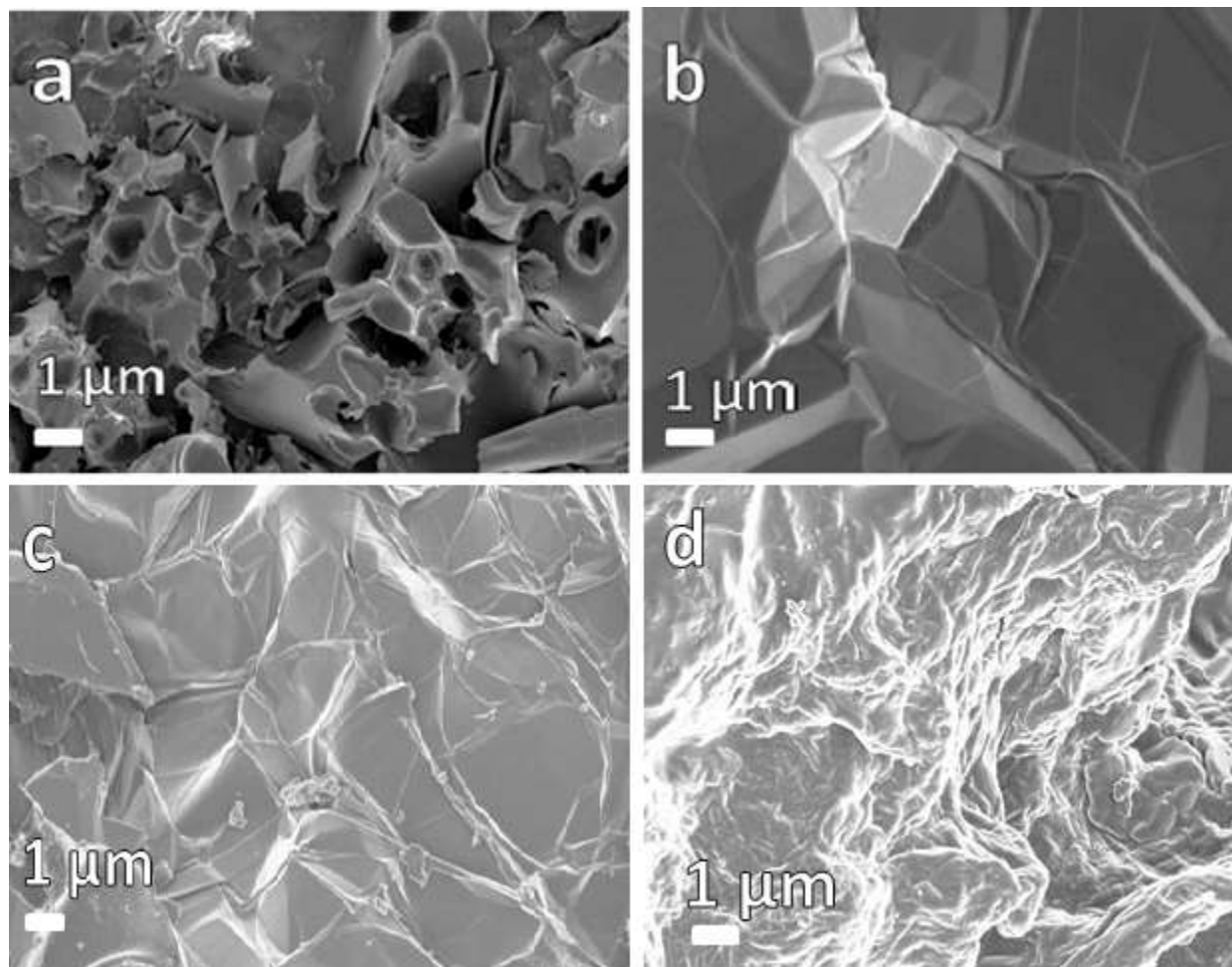


Fig. S1: SEM images of (a) Activated carbon (AC), (b) Graphene foam (GF), (c) Activated expanded graphite (AEG) and (d) Graphene oxide (GO) used for the synthesis of NiCoMn-TH/AC, NiCoMn-TH/GF, NiCoMn-TH/AEG and NiCoMn-TH/GO composite materials, respectively.

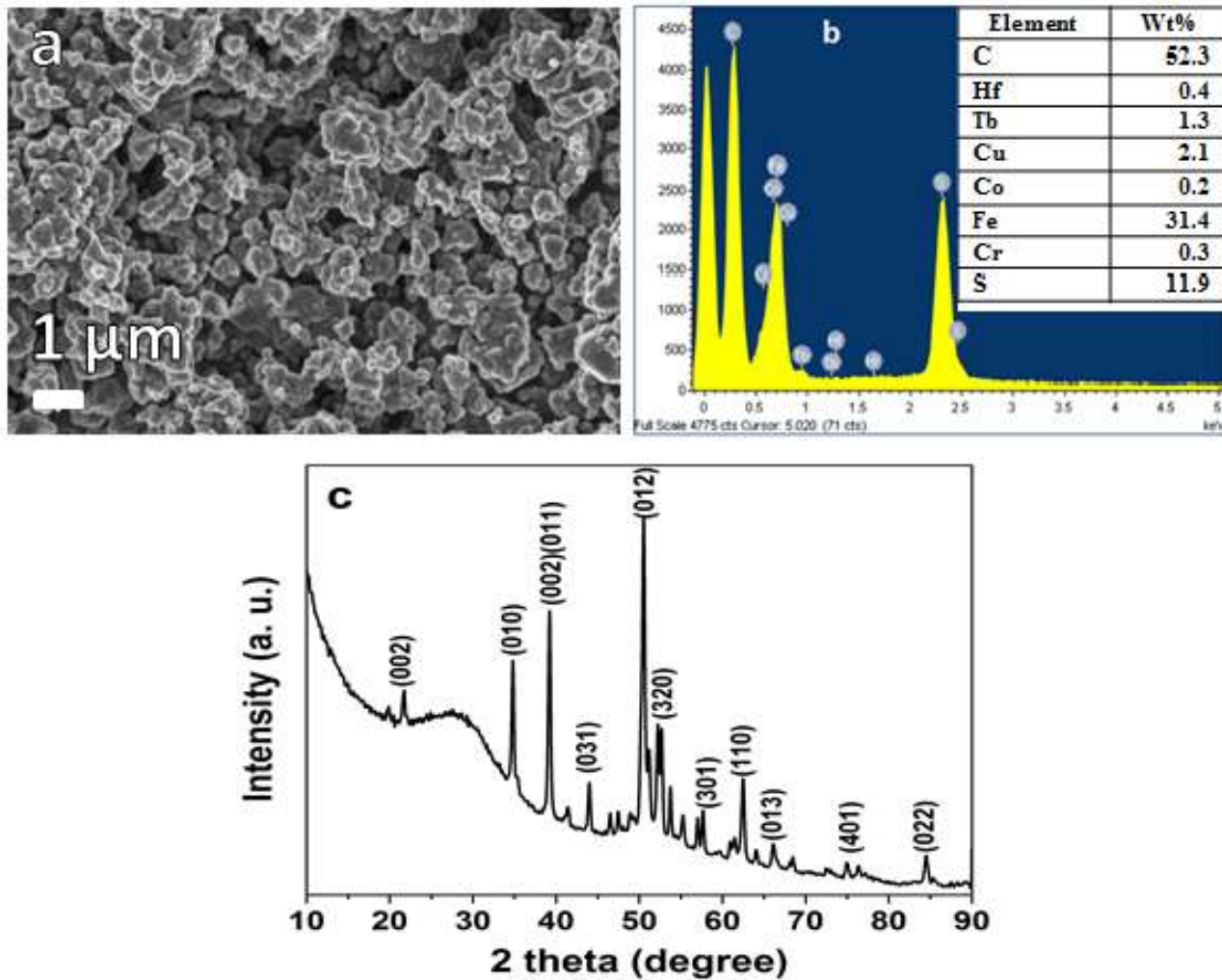


Fig. S2: (a) SEM image, (b) EDX and (c) XRD spectra of the as-prepared sulphur-doped carbonized iron PANI (CFP-S) negative electrode material, respectively.

Electrochemical measurements

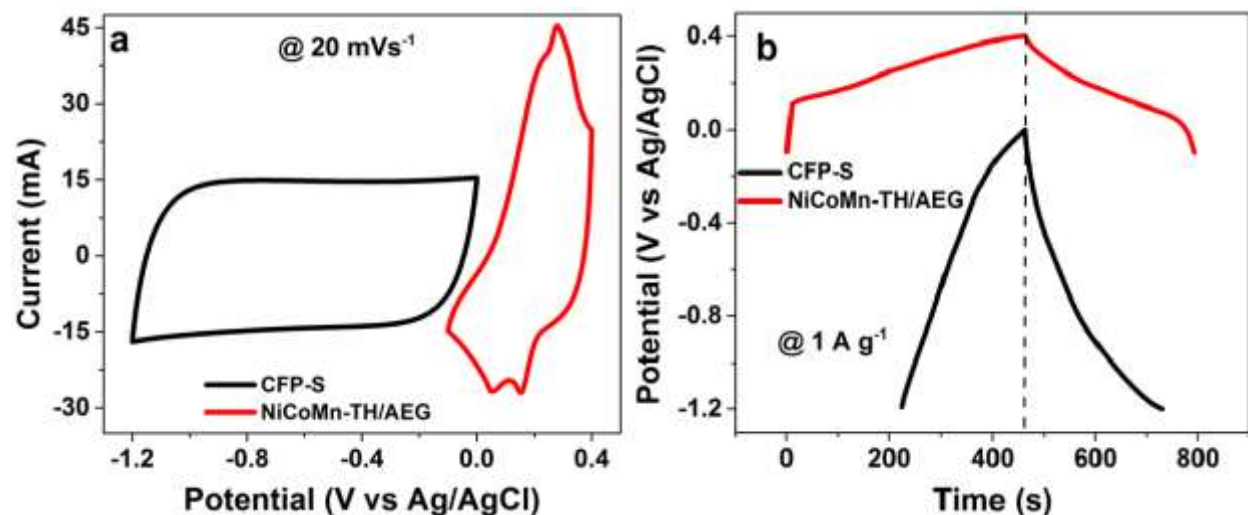


Fig. S3. (a) CV curves of NiCoMn-TH/AEG nanocomposite and CFP-S at 20 mV s⁻¹, and (b) CD curves of NiCoMn-TH/AEG nanocomposite and CFP-S at 1 A g⁻¹, respectively.

Table S1: Evaluated values of R_1 , R_2 , R_3 , R_4 , and Q fitted parameters via ZFIT fitting of the experimental Nyquist impedance spectra according to the equivalent circuit in the Fig. 5(a).

Electrode material	R_1 (Ω)	Q_1 (F.s ^(a-1))	Q_3 (F.s ^(a-1))	R_2 (Ω)	Q_4 (F.s ^(a-1))	R_3 (Ω)	R_4 (Ω)
NiCoMn-TH/AEG	0.118	0.032	0.327	2.717	-0.116	1.018	-5.888

$$X^2 = 0.0705; X/N^{1/2} = 0.04096; a \equiv n.$$

Table S2: Estimated values of EIS R_s , and R_{CT} , via the cell's Nyquist spectra in the Fig. 7 (d).

Cell parameter	R_s (Ω)	R_{CT} (Ω)
Before cycling	3.7	5.8
After cycling	2.6	7.2
After floating test	1.8	4.7

REFERENCES

- [1] F. Barzegar, A. Bello, D. Momodu, M. J. Madito, J. Dangbegnon, N. Manyala, Preparation and characterization of porous carbon from expanded graphite for high energy density supercapacitor in aqueous electrolyte, *J. Power Sources*. 309 (2016) 245–253. doi:10.1016/j.jpowsour.2016.01.097.