Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Directly Embedded Ni_3S_2/Co_9S_8@S-Doped Carbon Nanofiber Networks as Free-standing Anode for Lithium-ion Batteries

Zizhou He,[a] Hui Guo,[a h] Jed D LaCoste,[a] Ryan A Cook,[a] Blake Hussey,[a] Xu Zhang,[c] Daniel Dianchen Gang,[c] Ji Hao,[d] Liang Chen,[e] Peter Cooke,[f] Hui Yan,[b] Ling Fei *[a]

a. *Department of Chemical Engineering, Institute for Materials Research and Innovations, University of Louisiana at Lafayette, Lafayette, LA 70504, United States E-mail: ling.fei@louisiana.edu*
b. *Department of Chemistry, University of Louisiana at Lafayette, Lafayette, LA 70504, United States*
c. *Department of Civil Engineering, University of Louisiana at Lafayette, Lafayette, LA, 70504, United States*
d. *National Renewable Energy Laboratory, Materials Science Center, Golden, CO 80401, United States*
e. *New Jersey Institute to Technology, Newark, NJ 07102, United States*
f. *Core University Research Resources Laboratory, New Mexico State University, Las Cruces, NM 88003, United States*
g. *School of Chemical Engineering, Zhengzhou University, Zhengzhou 450001, P.R. China*

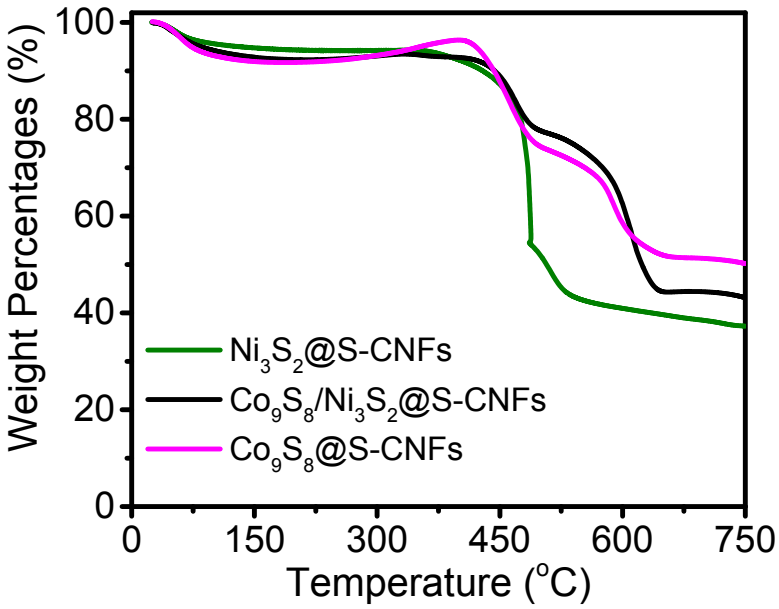

Figure S1. TGA analysis of all the samples under air atmosphere

To further confirm the composition of the as-prepared samples, we performed a TGA analysis under air atmosphere. The process involved combustion of carbon, oxidation-reduction reaction of metal sufides:

$$\text{Metal sulfide} + \text{Carbon nanofibers} + O_2 \rightarrow \text{Metal oxide} + CO_2 + SO_2$$

Where the metal sulfide composites were oxidized to NiO and Co_3O_4. Based on this formulation the weight percentages of Co_9S_8, Ni_3S_2/Co_9S_8, and Ni_3S_2 in the composites are calculated to be 50.7%, 41.5%, and 39.5%, respectively

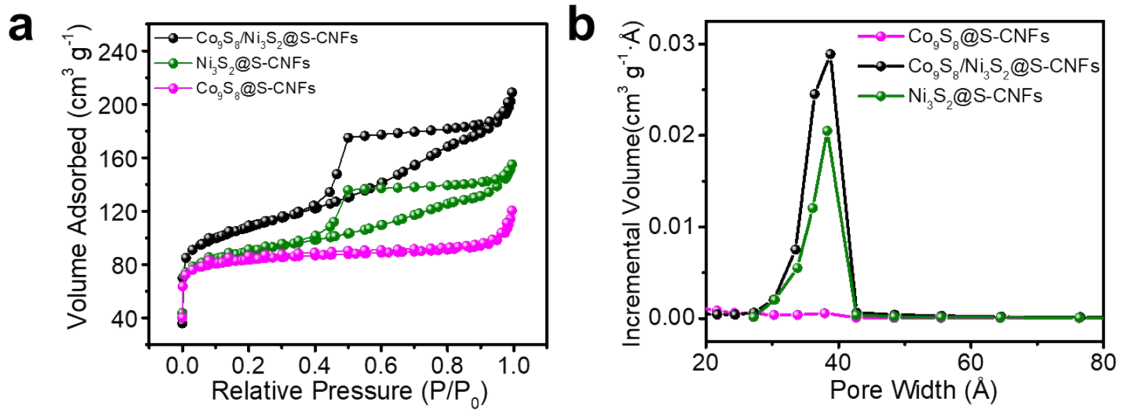

Figure S2. (a) nitrogen N_2 adsorption-desorption isotherms (b) pore-size distribution of the electrodes

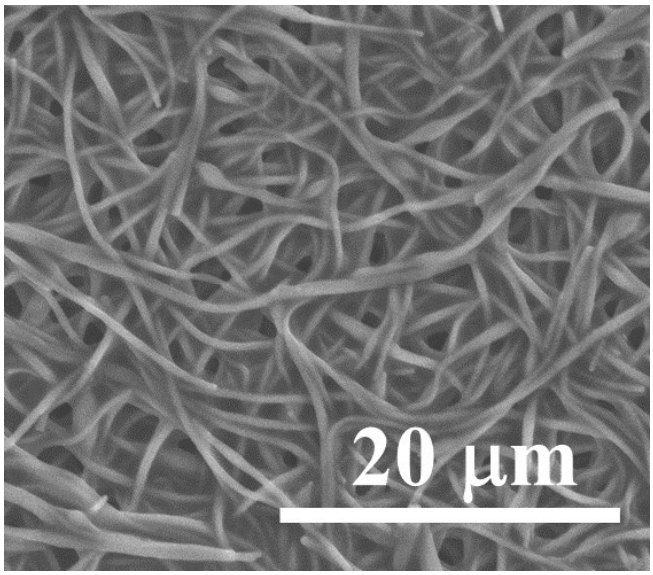

Figure S3. SEM image of Ni_3S_2/Co_9S_8@S-CNFs anode after 200 cycles at a current density of 1 A g^{-1}

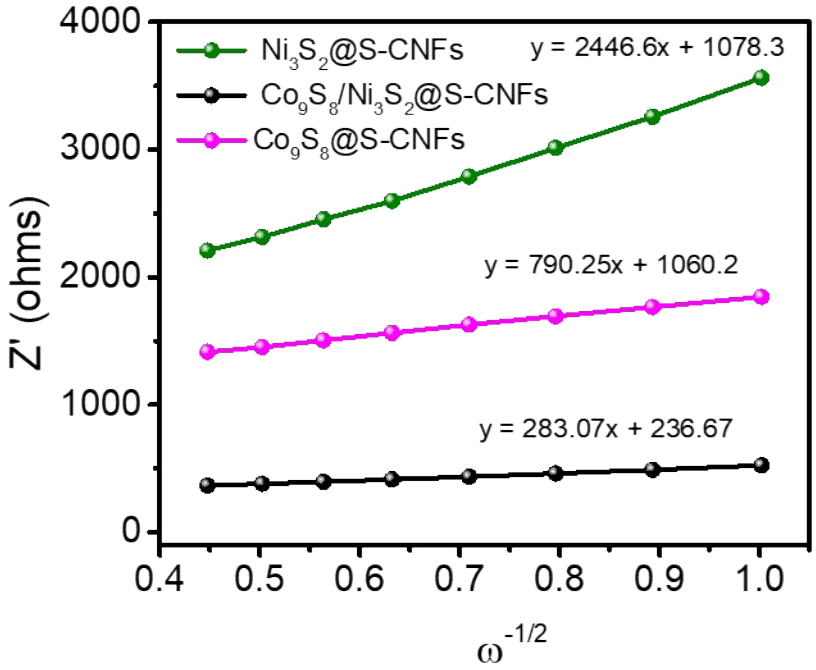

Figure S4. The relationship plot of Z′ versus $\omega^{-1/2}$ at low-frequency region.

The Li diffusion kinetics was analyzed via EIS by using the following equation:

$$D = \frac{R^2T^2}{2A^2n^2F^4C^2\sigma^2} \qquad \text{Equation S1}$$

Where R is the gas constant, T represents the temperature, A is the surface area of electrode, F is the Farady constant, *n* is the number of electrons per molecule attending the charge-discharge reaction, C is the concentration of lithium ion in the electrode, and σ is the slop of the line Z'-$\omega^{-1/2}$. Based on the equation, the lithium ions diffusion coefficient is inversely proportional to σ (shown in Figure S4).