High energy asymmetric supercapacitor based on nickel cobalt oxide ($NiCo_2O_4$) nanostructure material and activated carbon derived from cocoa pod

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RESULTS

Morphological and structural analyses of AC cocoa-700 sample

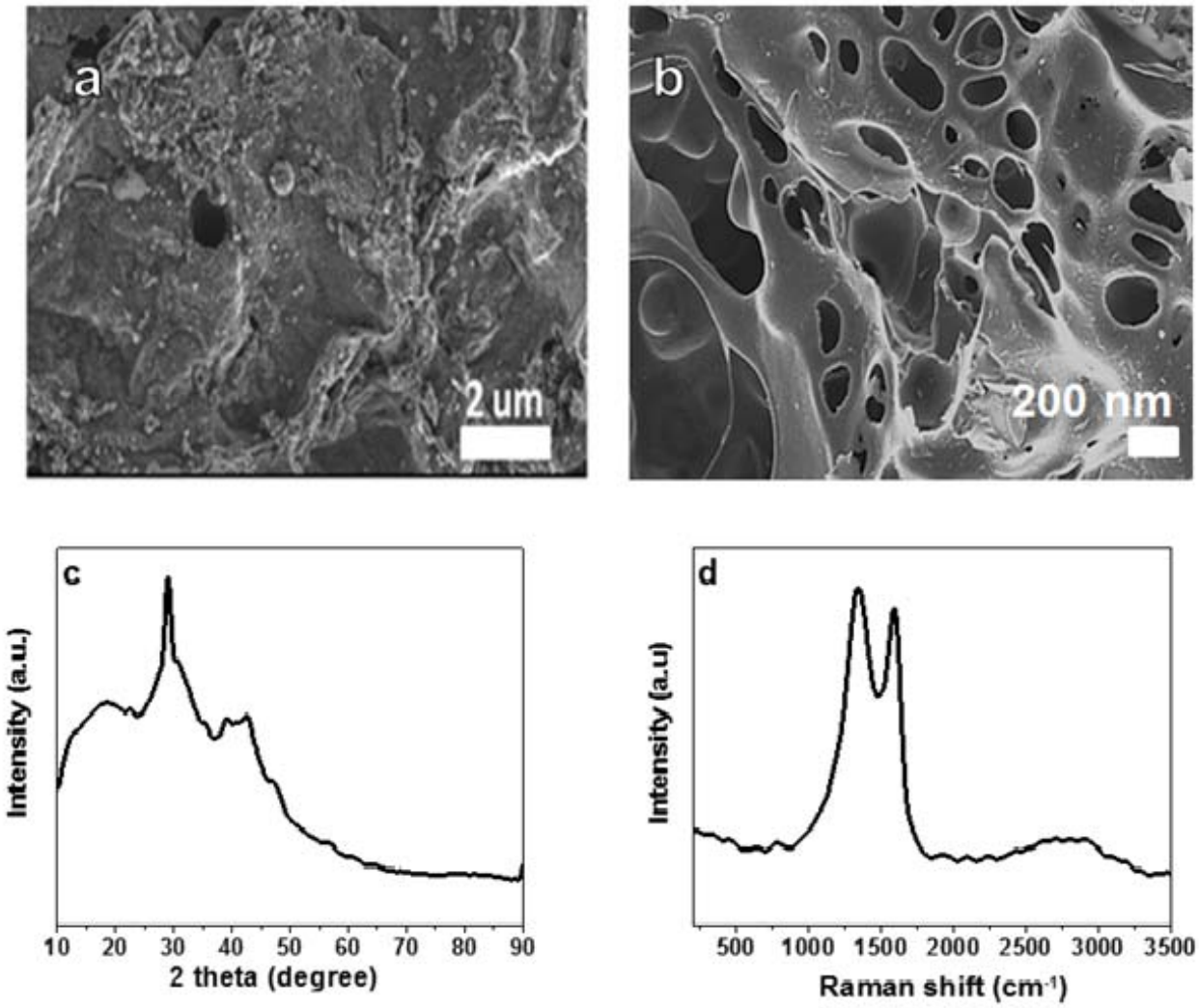

Fig. S1. (a-b) SEM image at low and high magnifications, (c) XRD pattern and (d) Raman spectrum of AC cocoa-700 material, respectively.

Fig. S2 (a and b) shows the textural property of the AC cocoa-700 measured by adopting the N_2 adsorption-desorption isotherm that further confirmed the SEM morphologies displayed in Fig. S1 (a and b). Fig. S2 (a) is a behavioural peculiarity of a type-II, with H4-type hysteresis, depicting complex material constituting both micropores and mesopores [1,2]. A high quantity of gas absorbed by the AC cocoa-700 sample was estimated, which corresponds to the high specific surface area (SSA) of ~ 836 $m^2\ g^{-1}$ as indicated in Fig. S2 (a). Fig. S2 (b) depicts the pore-size distribution (PSD) analysis of as-prepared AC cocoa-700 sample, indicating clear peaks observed below and at

a pore diameter of 2.0 nm from the BJH PSD curve, which corresponds to the presence of micro-pores. A result that further affirm the observed result in the isotherm shown in Fig. S2 (a).

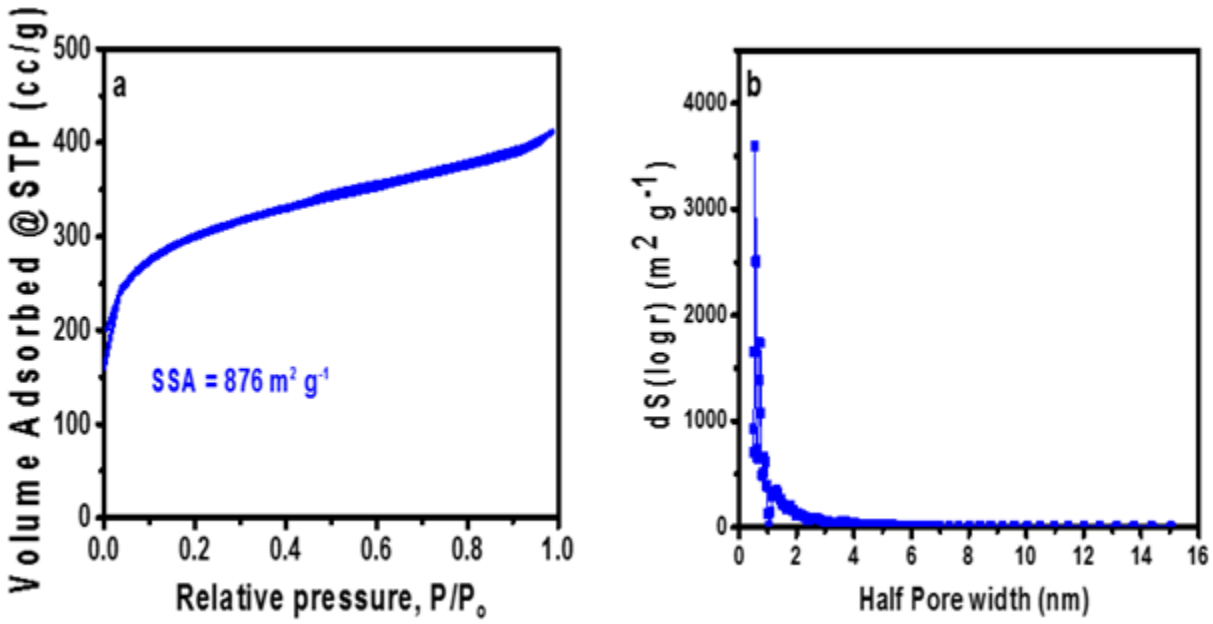

Fig. S2. (a) N_2 isotherm, and (b) Pore size distribution of AC cocoa-700 material, respectively.

Electrochemical measurements of Cocoa AC-700

The specific capacitance, C_s(F g^{-1}) of the nickel foam-supported negative electrode measured as the three-electrode over a potential, *E* (V), were estimated in line with the following equations:

$$C_s = \frac{I_d \times \Delta t}{\Delta E} \quad [\text{F g}^{-1}] \qquad \text{(SE 1)}$$

where I_d is applied specific current (A g^{-1}). *E* is the change in operating potential (V), and Δt is time (s) discharged by the electrode.

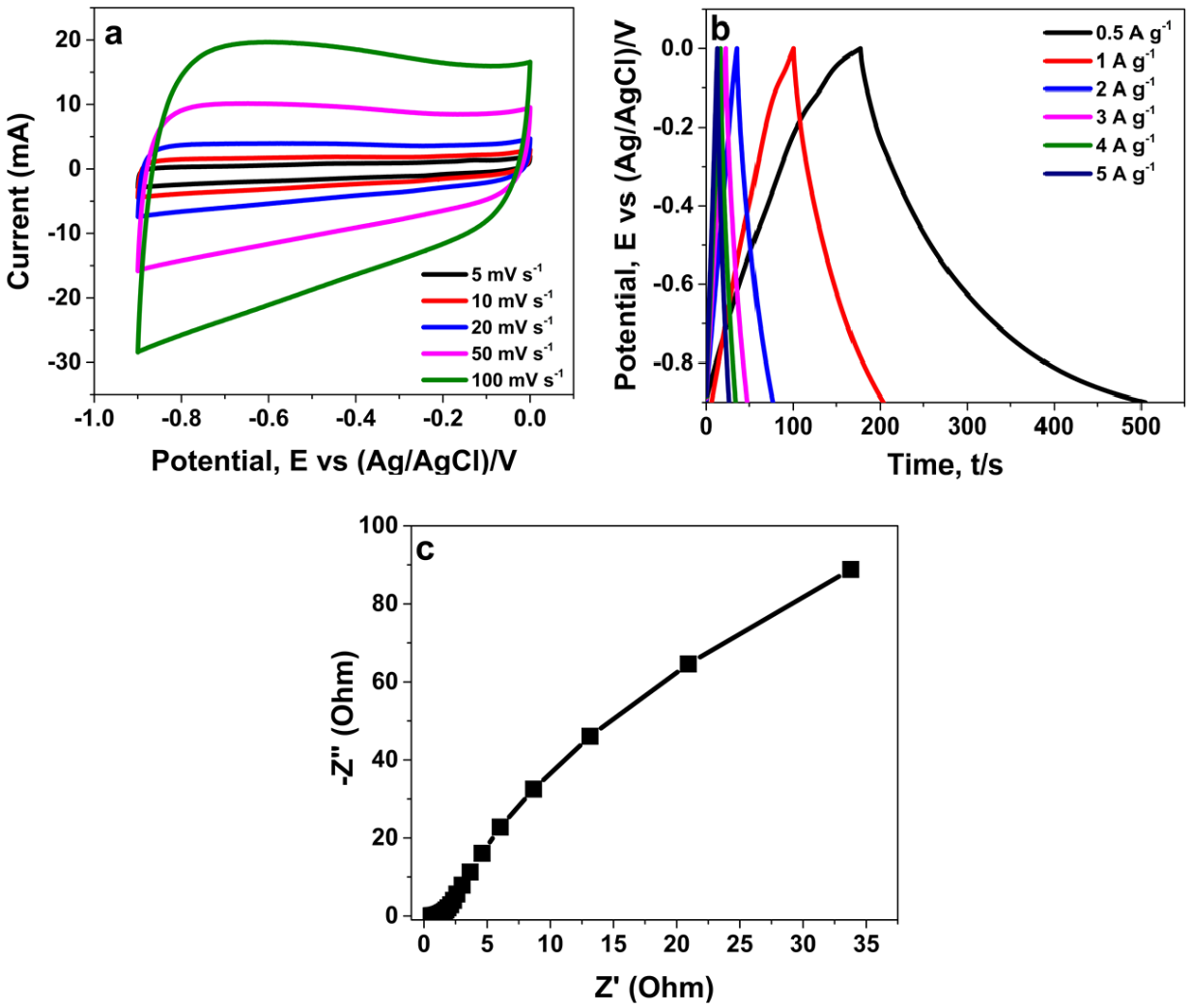

Fig. S3. (a) CV curves at various scan rates (b) CD profiles at various current densities (c) EIS Nyquist plot (d) Plot showing specific capacitance values against the current densities.

References

(1) Oyedotun, K. O.; Barzegar, F.; Mirghni, A. A.; Khaleed, A. A.; Masikhwa, T. M.; Manyala, N. Examination of High-Porosity Activated Carbon Obtained from Dehydration of White Sugar for Electrochemical Capacitor Applications. *ACS Sustain. Chem. Eng.* **2019**, *7* (1), 537–546. https://doi.org/10.1021/acssuschemeng.8b04080.

(2) Kruk, M.; Jaroniec, M. Gas Adsorption Characterization of Ordered Organic-Inorganic Nanocomposite Materials. *Chem. Mater.* **2001**, *13* (10), 3169–3183. https://doi.org/10.1021/cm0101069.