**Supplementary Information**

# A Flexible Solid-State Asymmetric Supercapacitor Device Comprising Cobalt Hydroxide and Biomass-Derived Porous Carbon

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**S1. Synthesis of Materials**

**S1.1 Chemicals used.** Cobalt nitrate hexahydrate ($Co(NO_3)_2.6H_2O$), Urea, and tri-sodium citrate were purchased from Merck, India. Sulphuric acid ($H_2SO_4$), Potassium Hydroxide (KOH), Methanol (HPLC grade), and ethanol were purchased from Fisher Scientific. Polyvinylidene difluoride (PVDF), acetylene black, N-methyl-2-pyrrolidinone (NMP), and polyvinyl alcohol (PVA) were purchased from Sigma-Aldrich. All the chemicals were used without further purification. Deionized water was used throughout the experiment.

**S2. Characterization and Instrumentation.** In this present work, the in-depth characterization of the synthesized materials were carried out by using the following characterization techniques: (i) X-ray diffraction (XRD) patterns were recorded using a powder X-ray diffractometer (Bruker D8 Advance) with Cu Kα (λ = 0.15405 nm) radiation at a scanning speed of 3 ° $min^{-1}$, (ii) Fourier Transform Infrared spectra (FTIR) were recorded in KBr by using spectrophotometer (IR Affinity-1, Shimadzu, Japan), (iii) Raman spectra were recorded on a Horiba via Raman microscope with a 633 nm laser excitation, (iv) Field emission scanning electron microscopy (FESEM) images of samples were obtained using Quanta 250 FEG (FEI), (v) High-resolution transmission electron microscopy (HRTEM) images were obtained by JEM-2100, (vi) Energy dispersive X-ray spectra (EDS) of the synthesized material was recorded using an EDAX ELEMENT electron microscope, (vii) XPS measurements were carried out by using a Thermo-Scientific ESCALAB $Xi^+$ spectrometer having a monochromatic Al Kα X-ray source (1486.6 eV) and a spherical energy analyzer that operates in the CAE (constant analyzer energy) mode. IVIUMSTAT (10V/5A/8MHz) workstation was used to perform the electrochemical studies.

**S3. Electrode preparation:**

To fabricate the working electrode, first, a viscous paste of 80 wt % active electrode material with 10 wt % poly(vinylidene fluoride) in N-methyl-2-pyrrolidinone and 10 wt % acetylene black was prepared, and then this paste was coated on the nickel foam with dimensions (1.5 cm × 1.5 cm) and dried at 80 °C for 24 h under vacuum to remove the residual solvent. Only one side of the Ni foam was coated in the case of the working electrode for the asymmetric cell.

**S4. Equations used:**

The values of specific capacitance ($C_s$) for the three-electrode cell and the two-electrode asymmetric cells were calculated by using the following equation:

$$C_s = \frac{i\Delta t}{m\Delta V} \quad \text{(S1)}$$

Where i represents the charge or discharge current in Ampere (A), Δt is the discharge time in seconds (s), m represents the mass of supercapacitive material in gram (g), and ΔV is the applied potential window.

For the two-electrode asymmetric cell, the energy density (E), and the power density (P) were determined by using the following equations:

$$E = \int_{t1}^{t2} I\,V(t)\,dt \times \frac{1000}{3600} \quad \text{(S2)}$$

$$P = \frac{E}{\Delta t} \times 3600 \quad \text{(S3)}$$

The Coulombic efficiency ($\eta$) was calculated from the equation given below:

$$\eta(\%) = t_d/t_c \times 100 \quad \text{(S4)}$$

where, $t_d$ is the discharging time, $t_c$ is the charging time.

**S5. Fabrication of an asymmetric supercapacitor (ASC) device.**

The voltammetric charges (Q) were calculated based on the following equations:

$$Q = C_{single} \times \Delta V \times m \quad \text{(S5)}$$

where m is the mass of the electrode (g), ΔV is the potential window (V), and $C_{single}$ is the specific capacitance (F $g^{-1}$) of each electrode measured in three-electrode setup (calculated from cyclic voltammograms at a scan rate of 10 mV $s^{-1}$).

Considering the charge/mass ratio for both anode and cathode, balancing of charge was carried out by substituting above equation as:

$$\frac{q+}{q-} = \frac{m+}{m-} = \frac{Csp- \times \Delta V-}{Csp+ \times \Delta V+} \quad \text{(S6)}$$

Where $C_{sp-}$ is the $C_S$ value obtained for the anode material in the potential window $\Delta V^-$, $C_{sp+}$ is the $C_S$ value obtained for the cathode material in the potential window $\Delta V^+$.

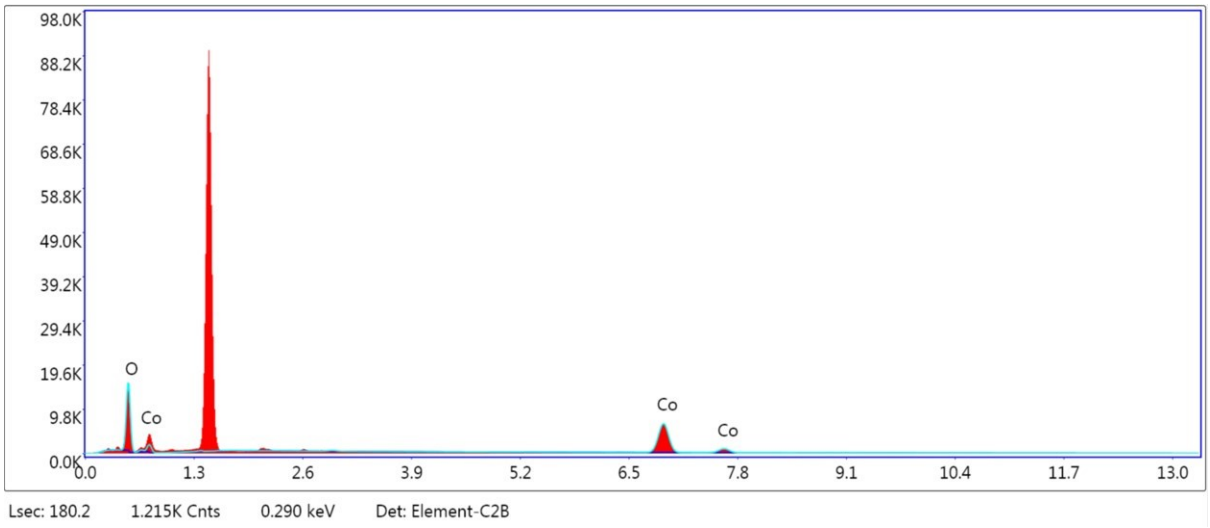


**Figure S1.** EDS survey spectra of $Co(OH)_2$.

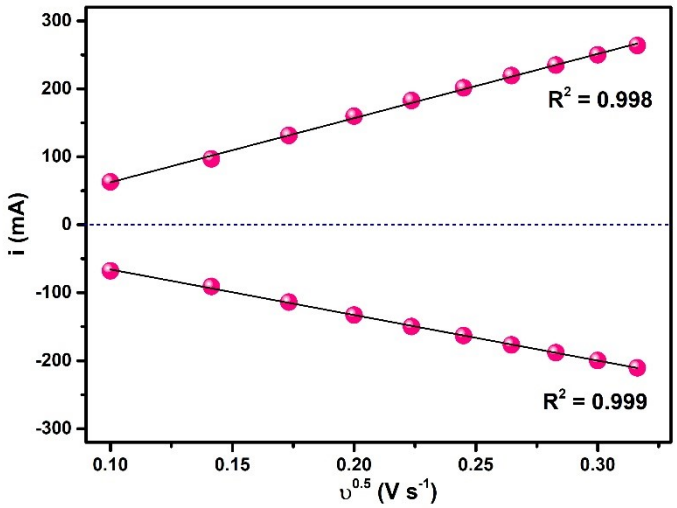


**Figure S2.** Randles-Sevcik plot of $Co(OH)_2$.

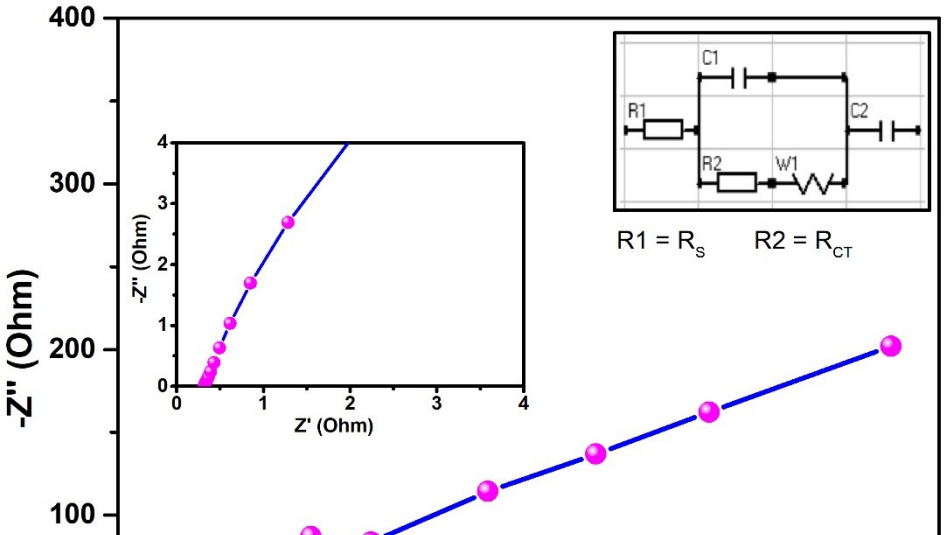

**Figure S3.** Nyquist plot of $Co(OH)_2$.

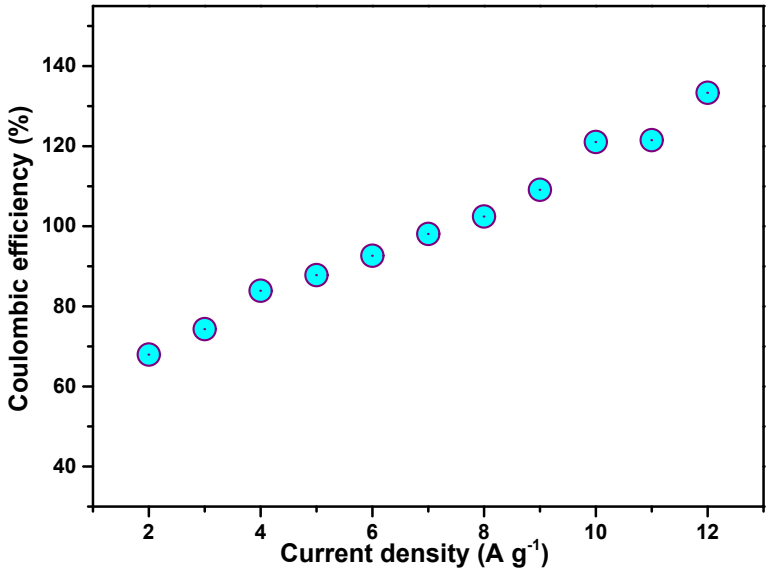


**Figure S4.** Coulombic efficiency (%) with the increased current densities of $Co(OH)_2$//PC ASC device.

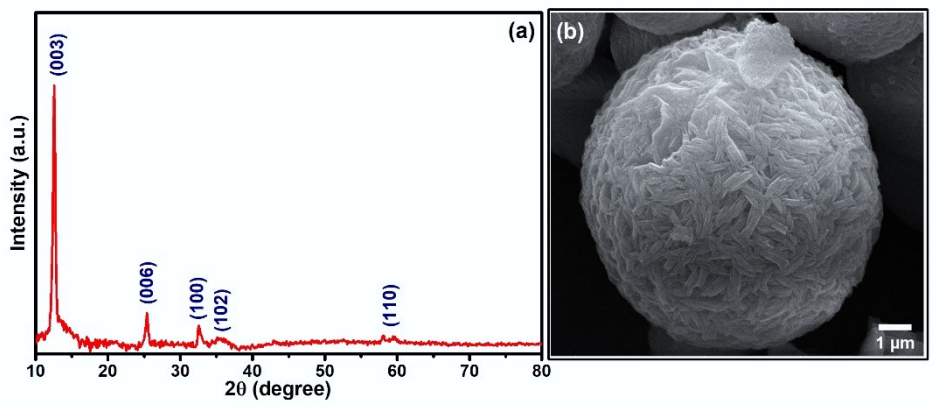


**Figure S5.** (a) XRD and (b) FESEM image of the $Co(OH)_2$ after cyclic stability test.