energies

Supporting information

One-Pot Hydrothermal Synthesis of Novel Cu-MnS with PVP Cabbage-Like Nanostructures for High-Performance Supercapacitors

S. Srinivasa Rao [1], Ikkurthi Kanaka Durga [2], Bandari Naresh [2], Bak Jin-Soo [2], T.N.V. Krishna [2], Cho In-Ho [2], Jin-Woo Ahn [1], and Hee-Je Kim [2,*]

[1] Department of Mechatronics Engineering, Kyungsung University, 309 Suyeong-ro, Nam-gu, Busan 48434, Korea; srinu.krs@gmail.com (S.S.R.); jwahn@ks.ac.kr (J.-W.A.)

[2] School of Electrical Engineering, Pusan National University, Busandaehak-ro 63beon-gil, Geumjeong-gu, Busan 46241, Korea; kanakadurga.ikkurthi@gmail.com (I.K.D.); naresh1.bandari@gmail.com (B.N.); imjsn17@pusan.ac.kr (B.-J.S.); vamsik.tirumalasetty@gmail.com (T.N.V.K.); whdlsgh92@icloud.com (C.I.-H.)

* Correspondence: heeje@pusan.ac.kr; Tel.: +82-51-510-2364; Fax: +82-51-513-0212

1. Capacitance Calculation of Single Electrode from CV Curves

The specific capacitance (*Cs*) and areal capacitance of the electrode could be calculated from their cyclic voltammetry curves by the following equations.

$$Cs = \frac{Q}{m} \times \Delta V = \int_{-v}^{v} \frac{I(V)dV}{mv\Delta V} \quad \text{(S1)}$$

$$Ca = \frac{\int_{-v}^{v} I\,(V)\,dV}{Sv\Delta V} \quad \text{(S2)}$$

Where *Cs* is the specific capacitance in F g-1, *Q* is the total charge obtained by integrating the positive and negative sweeps in a Curve (in coulomb, C), *v* is the scan rate in V/s, *V* is the voltage window between the positive and negative electrodes and m is the mass of the active materials electrodes (if the area *Ca* (mF/cm^2) is more important for specific applications can be substituted by the electrode area.

2. Calculation of Capacitance, Energy Density and Power Density from Galvanostatic Charge-Discharge Curves

$$Cs = \frac{i\Delta t}{m\Delta V} \quad \text{(S3)}$$

$$Ca = \frac{\int_{-v}^{v} I\,(V)\,dV}{Sv\Delta V} \quad \text{(S4)}$$

$$P = \frac{E}{t} = \frac{i\Delta V}{2m} \times 1000 \quad \text{(S5)}$$

Where *I* is the discharge current in mA or A,

Δt = discharge time difference in seconds

E = energy density (Wh g^{-1} or Wh cm^{-2} or Wh cm^{-3})

P = power density (W g^{-1} or W cm^{-2} or W cm^{-3})

3. Calculation of specific capacitance, energy and power density for symmetric supercapacitor cell

The areal capacitance (*Ca*) and specific capacitance (*Cs*) of the symmetric supercapacitor device were calculated from CV according to equations.

$$Cs = 4 \times \int_{-v}^{v} \frac{I(V)dV}{mv\Delta V} \tag{S6}$$

$$Ca = 4 \times \int_{-v}^{v} I(V)\frac{dV}{Sv\Delta V} \tag{S7}$$

Where *S* is the total geometrical area of the thin film electrodes in symmetric testing cell. If the area replaced by mass of two electrodes the specific capacitance *Cs* (F/g).

The *Cs* and *Ca* of the symmetric supercapacitor device were calculated from their GCD curves according to the following equations.

$$Cs = 4 \times \frac{I\Delta t}{m\Delta V} \tag{S8}$$

$$Ca = 4 \times \frac{I\Delta t}{S\Delta V} \tag{S9}$$

For the symmetric device, the power and energy densities were calculated according to the following equations.

$$E_D = C\frac{V^2}{2 \times 3.6(2m)} \tag{S10}$$

$$P_D = E_D \times \frac{3600}{T_s} \tag{S11}$$

Where *V* = voltage drop in the near-linear portion of the discharge curve after the IR drop (i.e. attainable cell voltage):

m = mass of active material on one electrode

C = total capacitance measured from the two-electrode system

Ts = is the discharge time

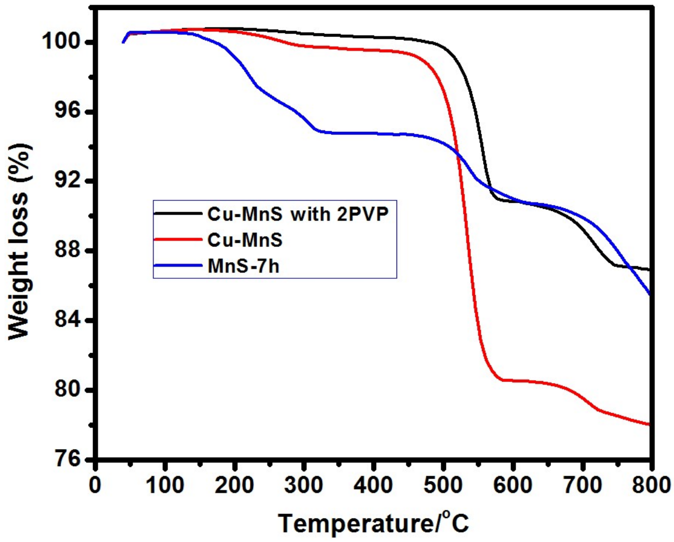

Figure S1. Thermogravimetric images of as-prepared MnS, Cu-MnS and Cu-MnS with 2PVP samples.

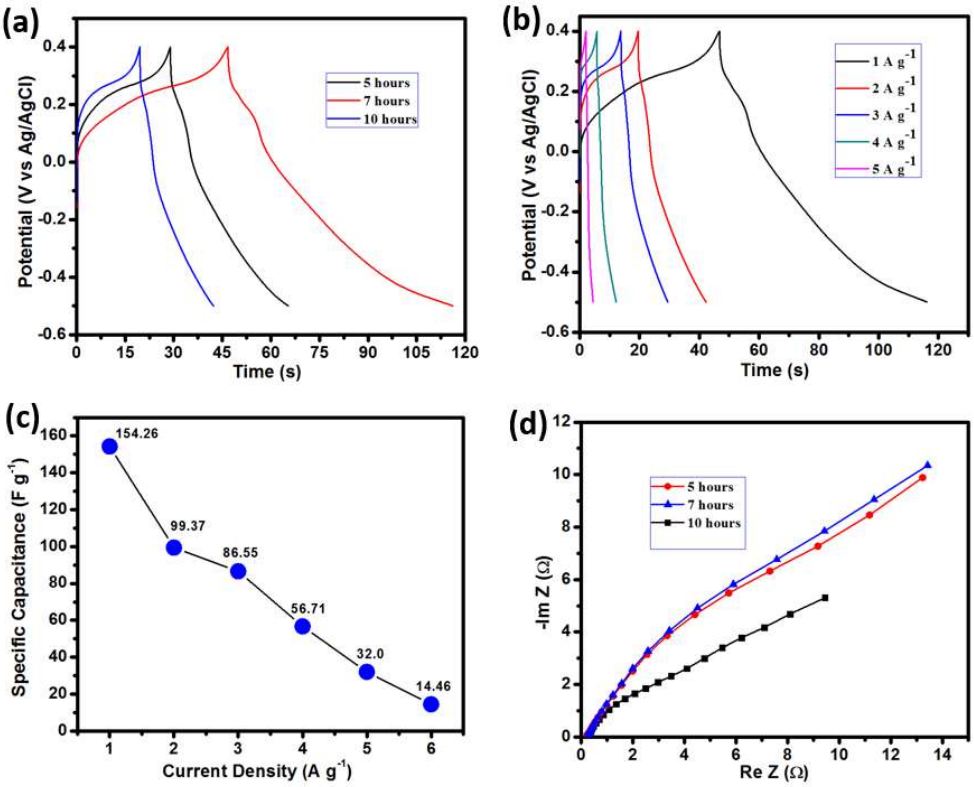

Figure S2. (**a**) Galvanostatic charge-discharge curves of supercapcitors using MnS material with different preparation time. (**b**) GCD curves of MnS-7 hours at different current densities. (**c**) Specific capacitance calculated from the GCD curves of MnS-7 hours as a function of current densities. (**d**) Nyquist curves in 2 M KOH solution at frequency range from 100 kHz to 0.1 Hz.

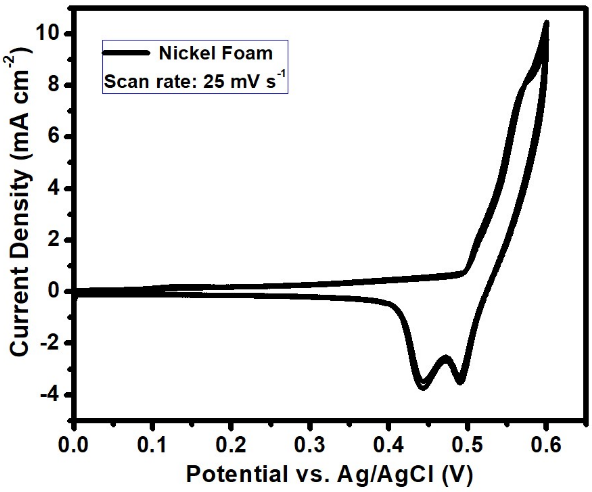

Figure S3. CV curve of bare nickel foam in KOH electrolyte at scan rate of 25 mV s^{-1}.

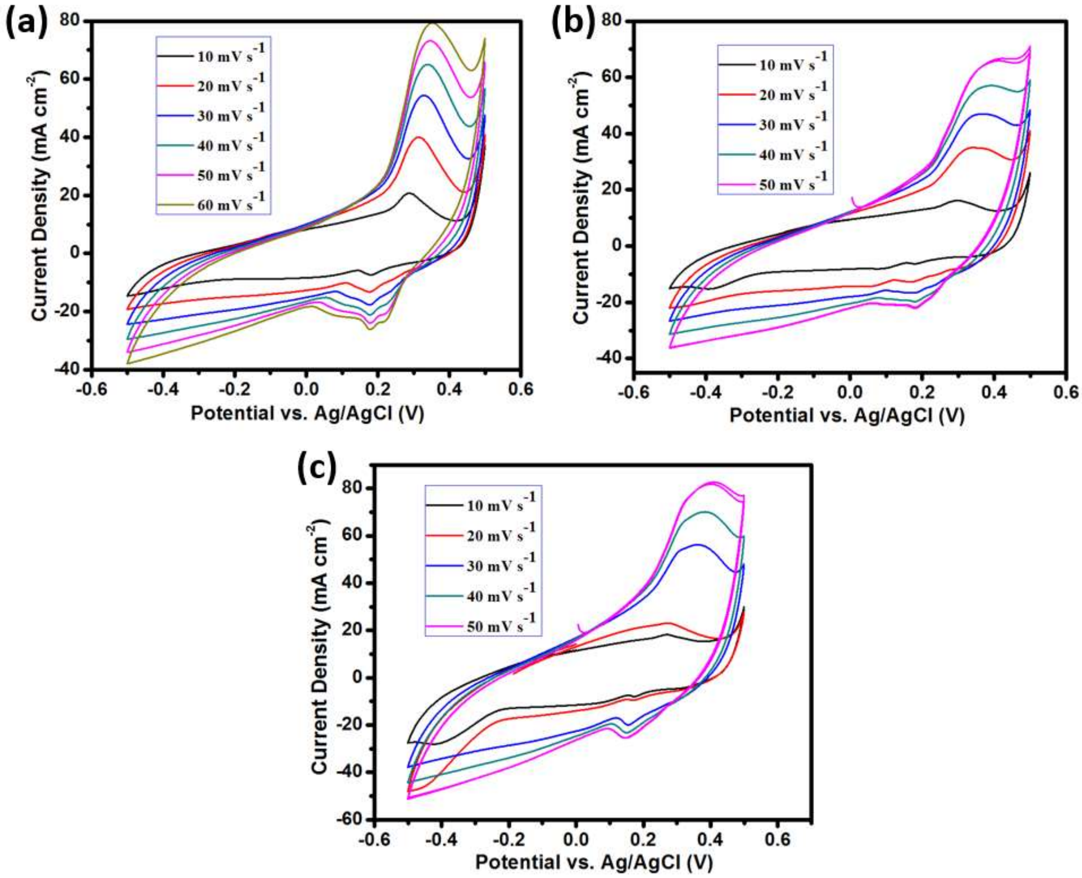

Figure S4. Cyclic voltammetry of (**a**) Cu-MnS, (**b**) Cu-MnS with 1PVP and (**c**) Cu-MnS with 3PVP with different scan rates in 2 M KOH solution.

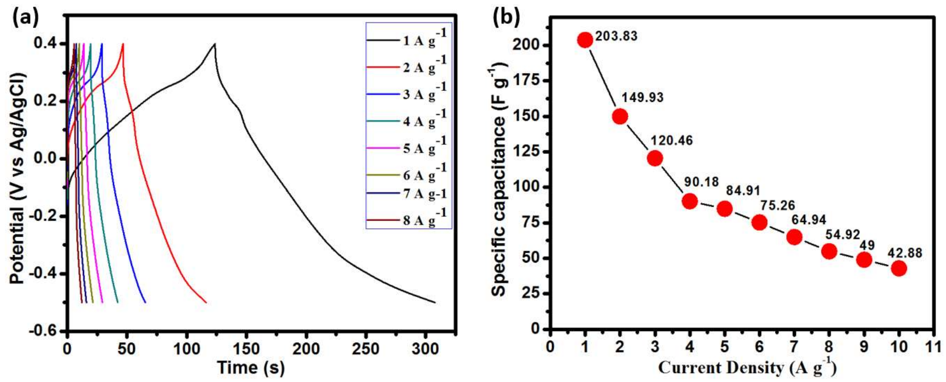

Figure S5. (**a**) Galvanostatic charge-discharge curves of Cu-MnS at different current densities in 2 M KOH solution. (**b**) Specific capacitance of Cu-MnS electrode calculated from the GCD curves as a function of current densities.

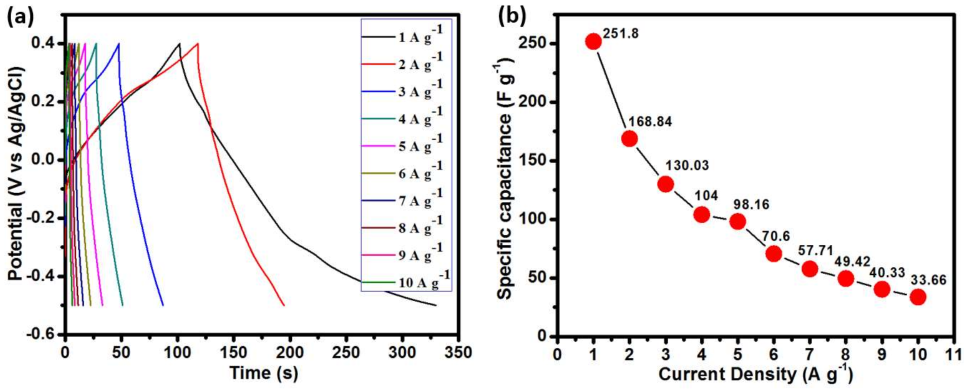

Figure S6. (**a**) Galvanostatic charge-discharge curves of Cu-MnS with 1PVP at different current densities in 2 M KOH solution. (**b**) Specific capacitance of Cu-MnS electrode calculated from the GCD curves as a function of current densities.

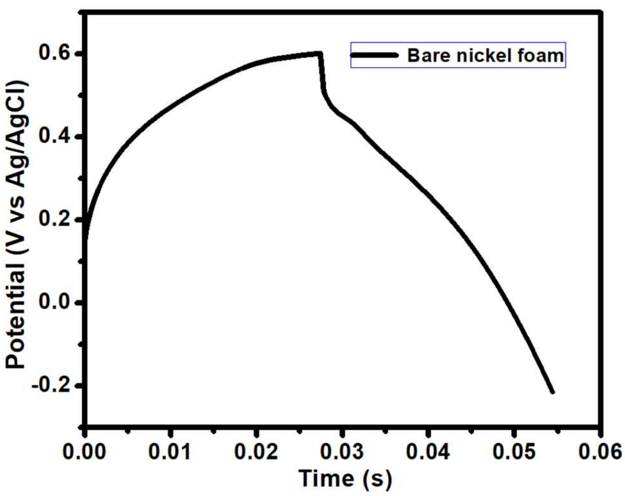

Figure S7. GCD curve of bare nickel foam in KOH electrolyte.

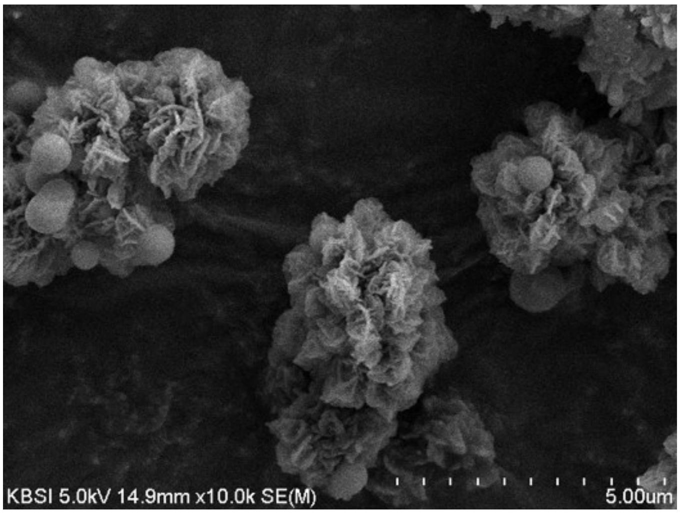

Figure S8. HR-SEM image of Cu-MnS with 2PVP after stability test.