Supporting Information

Hierarchically Designed Ag@$Ce_6Mo_{10}O_{39}$ Marigold Flower-like Architectures: An Efficient Electrode Material for Hybrid Supercapacitors

*S. Chandra Sekhar,† Goli Nagaraju,†,‡ Bhimanaboina Ramulu,† and Jae Su Yu *,†*

†Department of Electronic Engineering, Institute for Wearable Convergence Electronics, Kyung Hee University, 1732 Deogyeong-daero, Gihung-gu, Yongin-si, Gyeonggi-do 17104, Republic of Korea

‡Department of Chemical Engineering, College of Engineering, Kyung Hee University, 1732 Deogyeong-daero, Gihung-gu, Yongin-si, Gyeonggi-do 17104, Republic of Korea.

*Address correspondence to jsyu@khu.ac.kr

Tel: +82-31-201-3820; Fax: +82-31-206-2820

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Section-I: Electrochemical properties of PAC/Ni foam:

The CV and GCD tests of PAC/Ni foam electrode were investigated in three-electrode system in 1 M KOH electrolyte. Fig. S1(a) shows the CV curves measured at different scan rates in the range of 10-100 mV/s in a potential window of -1.0-0 V. All CV curves demonstrating the rectangular behavior rather than strong redox peaks, indicating the EDLC behavior. Even at a high scan rate, the CV curve retained its rectangular shape, suggesting the high reversibility of PAC. The linear GCD curves presented in Fig. S1(b) again illustrating the EDLC behavior, which is good agreement with the CV curves. The areal capacitance values were calculated based on the discharge times (Fig. S1(c)) using Eqn. (2) and the values are 672, 615, 569.3, 548.4, 536.4, 532 and 528 mF/cm^2 at current density values of 2, 3, 5, 10, 15, 20 and 30 mA/cm^2, respectively.

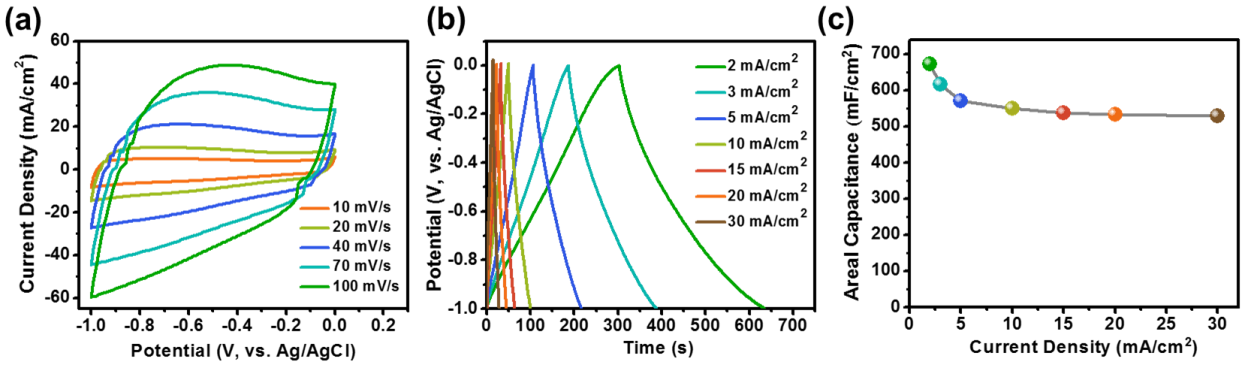

Fig. S1. (a-b) CV and GCD curves of PAC/Ni foam electrode measured at various scan rates and current densities, respectively. (c) Calculated areal capacitance values of PAC/Ni foam electrode.

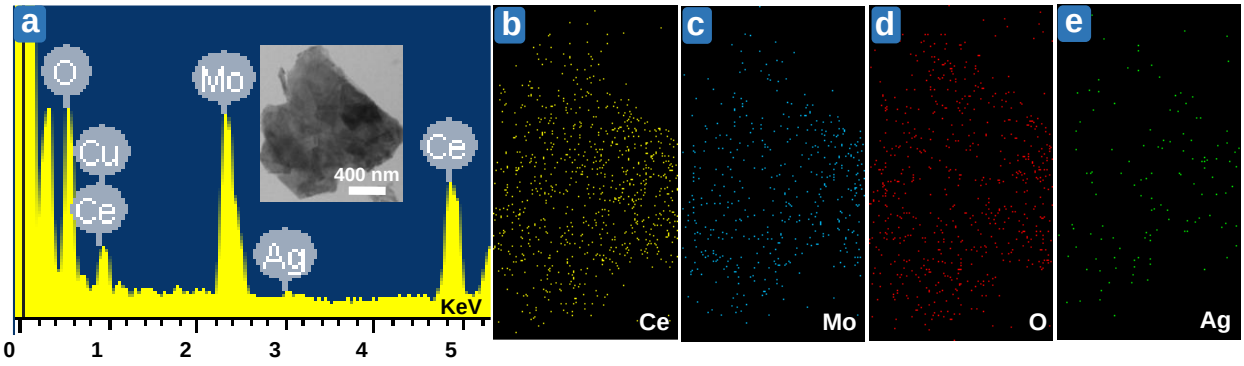

Figure S2. (a) EDX spectrum and (b-e) elemental mapping images of Ag NPs@CM MF sample.

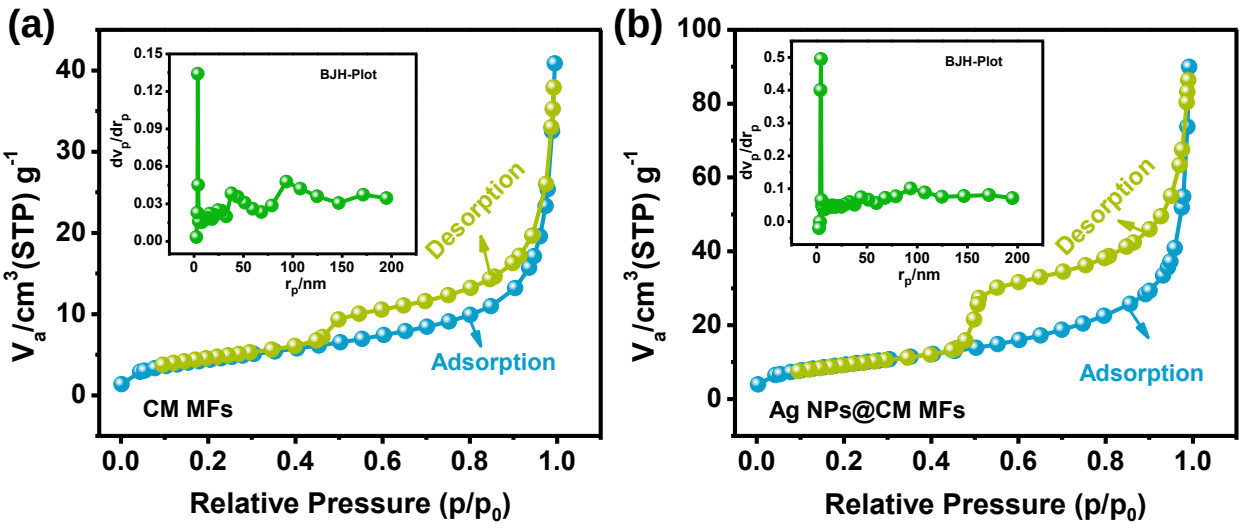

Figure S3. Nitrogen adsorption and desorption isotherms of (a) CM MF and (b) Ag NPs@CM MF samples. Insets in (a) and (b) show the pore size distribution plots of CM MF and Ag NPs@CM MF samples, respectively.

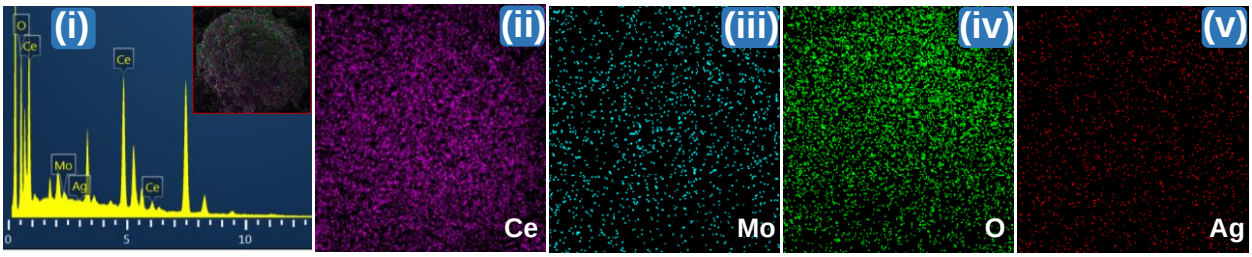

Figure S4. (i) EDX spectrum and (ii-v) elemental mapping images (Ce, Mo, O and Ag elements, respectively) of Ag NPs@CM MF sample measured after cycling test.

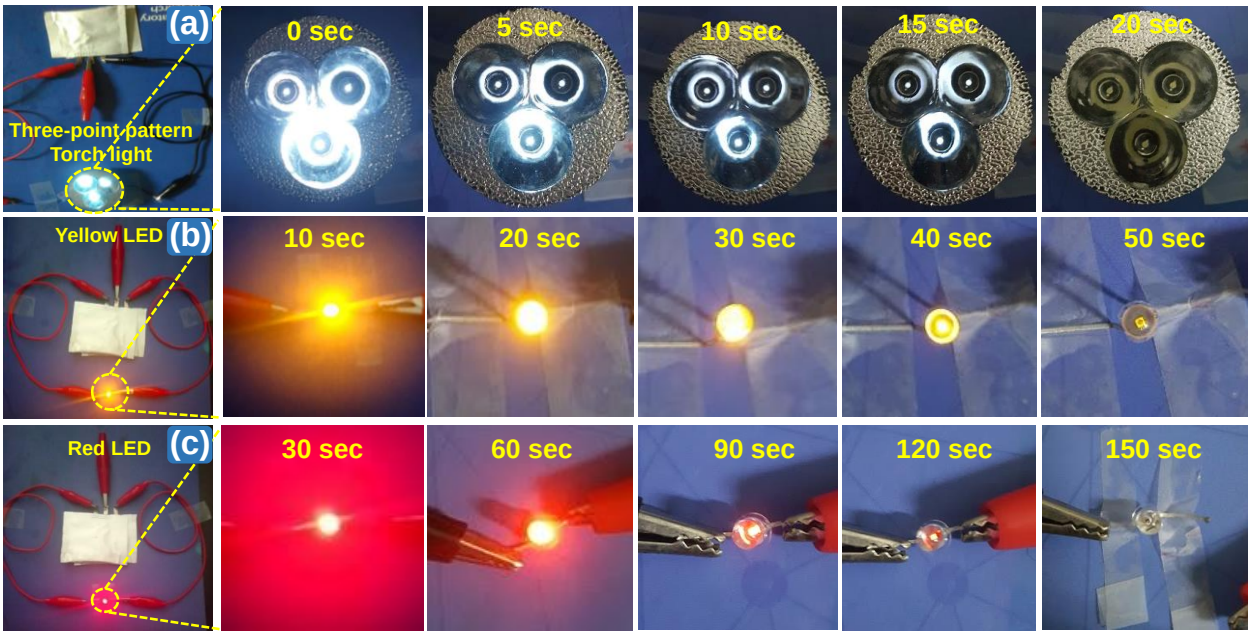

Figure S5. Real-time applicability of the fabricated HSC. The two HSCs in series-connection successfully powered (a) three-point pattern torch light, (b) yellow LED and (c) red LED.

Table S1. Comparative capacitive performance of our Ag NPs@CM MFs/Ni foam electrode with the previously reported metal oxides/molybdate based materials in a three-electrode system.

Active material	Current collector	Electrolyte	Test condition	Electrochemical performance	Ref.
Graphene-$NiMoO_4 \cdot nH_2O$	Glassy carbon	6 M KOH	1.5 mA/cm^2	13.75 μAh/cm^2	S1
NiO Nanoflakes	Graphite sheet	2 M KOH	0.5 mA/cm^2	40.1 μAh/cm^2	S2
$CoMoO_4$/C	Nickel foil	3 M KOH	1 mA/cm^2	54.16 μAh/cm^2	S3
Graphene/Cerium Oxide nanoparticles	Stainless steel plate	3 M NaCl	5 mV/s	11.09 F/g	S4
$CoMoO_4$ nanostructures	Stainless steel substrate	1 M NaOH	5 mV/s	98.3 F/g	S5
$CoMoO_4$/MWCNTs	Glassy carbon disc	1 M KOH	1 A/g	96 F/g	S6
$CoMoO_4$ nanorods	Ni foam	2 M KOH	1.2 mA/cm^2	70 μAh/cm^2	S7
Ag decorated $Ce_6Mo_{10}O_{39}$ marigold flower-like structures	Ni foam	1 M KOH	2 mA/cm^2	62 μAh/cm^2 (109.1 F/g)	This work

References:

[S1] Ghosh, D.; Giri, S.; Das, C. K., Synthesis, Characterization and Electrochemical Performance of Graphene Decorated with 1D $NiMoO_4 \cdot nH_2O$ Nanorods. *Nanoscale* **2013**, 5 (21), 10428-10437.

[S2] Vijayakumar, S.; Nagamuthu, S.; Muralidharan, G., Supercapacitor Studies on NiO Nanoflakes Synthesized Through a Microwave Route. *ACS Appl. Mater. Interfaces* **2013**, 5 (6), 2188-2196.

[S3] Padmanathan, N.; Razeeb, K. M.; Selladurai, S., Hydrothermal Synthesis of Carbon- and Reduced Graphene Oxide-Supported $CoMoO_4$ Nanorods for Supercapacitor. *Ionics* **2014**, 20 (9), 1323-1334.

[S4] Sarpoushi, M. R.; Nasibi, M.; Golozar, M. A.; Shishesaz, M. R.; Borhani, M. R.; Noroozi, S., Electrochemical Investigation of Graphene/Cerium Oxide Nanoparticles as an Electrode Material for Supercapacitors. *Mater. Sci. Semi. Proc.* **2014**, 26, 374-378.

[S5] Veerasubramani, G. K.; Krishnamoorthy, K.; Kim, S. J., Electrochemical Performance of an Asymmetric Supercapacitor based on graphene and cobalt molybdate electrodes. *RSC Adv.* **2015**, 5 (21), 16319-16327.

[S6] Xu, Z.; Li, Z.; Tan, X.; Holt, C. M. B.; Zhang, L.; Amirkhiz, B. S.; Mitlin, D., Supercapacitive Carbon Nanotube-Cobalt Molybdate Nanocomposites Prepared via Solvent-Free Microwave Synthesis. *RSC Adv.* **2012**, 2 (7), 2753-2755.

[S7] Dam, D. T.; Huang, T.; Lee, J.-M., Ultra-Small and Low Crystalline $CoMoO_4$ Nanorods for Electrochemical Capacitors. *Sustainable Energy & Fuels* **2017**, 1 (2), 324-335.