Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.
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3D Nanoflower-liked and Core-Shell Structured MCo_2O_4@MCo_2S_4@Polypyrrole (M = Cu, Mn) Composites as Supercapacitors Electrode Materials with Ultrahigh Specific Capacitances

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KEYWORDS: MCo_2O_4@MCo_2S_4@Polypyrrole (M=Cu, Mn); 3D Self-supported electrode; Nanoflower structure; Core-Shell structure; Ultrahigh Specific Capacitance; Supercapacitors

In addition, the specific capacitances of the as-prepared samples were calculated by Equation S1:

$$C_A = \frac{I\int V\Delta t}{sV^2} \quad \text{(S1)}$$

Table S1 The C_s values of all as-prepared samples at 1 A g^{-1}.

Materials	Current density (A g^{-1})	C_s (F g^{-1})
CuC/NF	1	1098.7
CuC@CuS/NF	1	1513.88
CuC@CuS@PPy-8/NF	1	1750.44
CuC@CuS@PPy-16/NF	1	2978.1
CuC@CuS@PPy-24/NF	1	2479.3
MnC/NF	1	1145.4
MnC@MnS/NF	1	3186.8
MnC@MnS@PPy-8/NF	1	4278.2
MnC@MnS@PPy-16/NF	1	4713.4
MnC@MnS@PPy-24/NF	1	4003.5

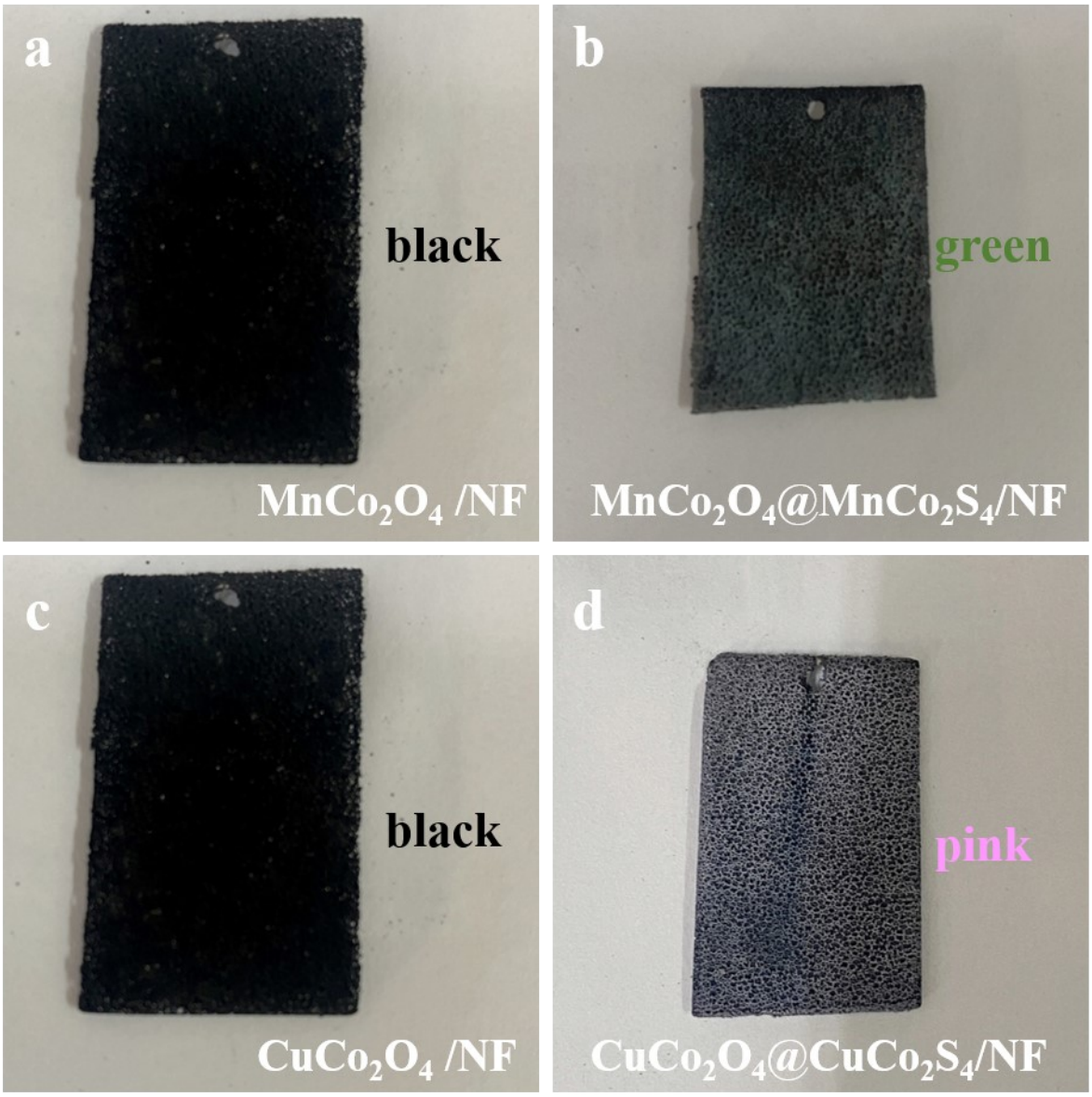


Figure S1 Optical photographs of (a) $MnCo_2O_4$/NF and (c) $CuCo_2O_4$/NF (the black one), (b) $MnCo_2O_4$@$MnCo_2S_4$/NF (the green one) and (d) $CuCo_2O_4$@$CuCo_2S_4$/NF (the pink one).

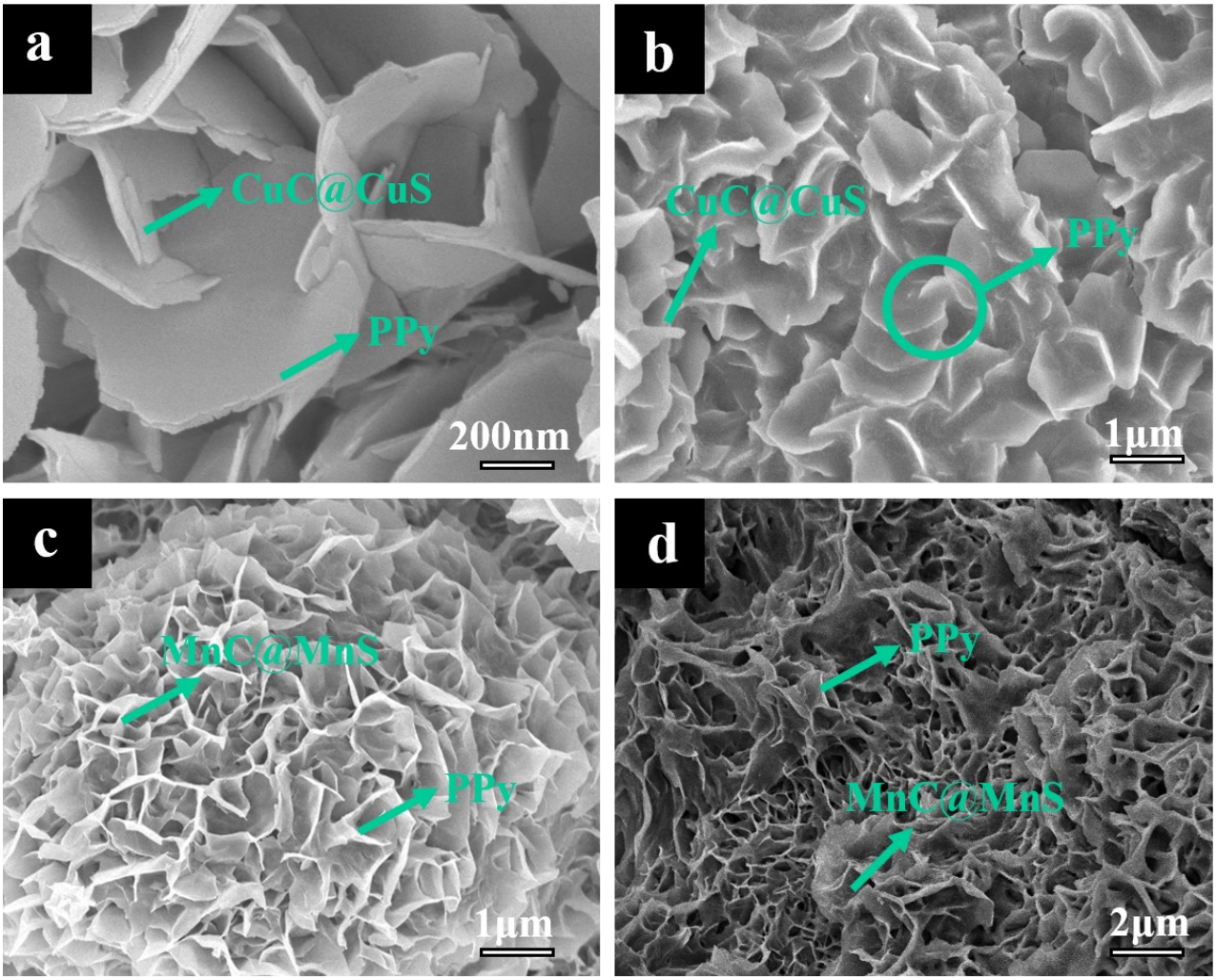
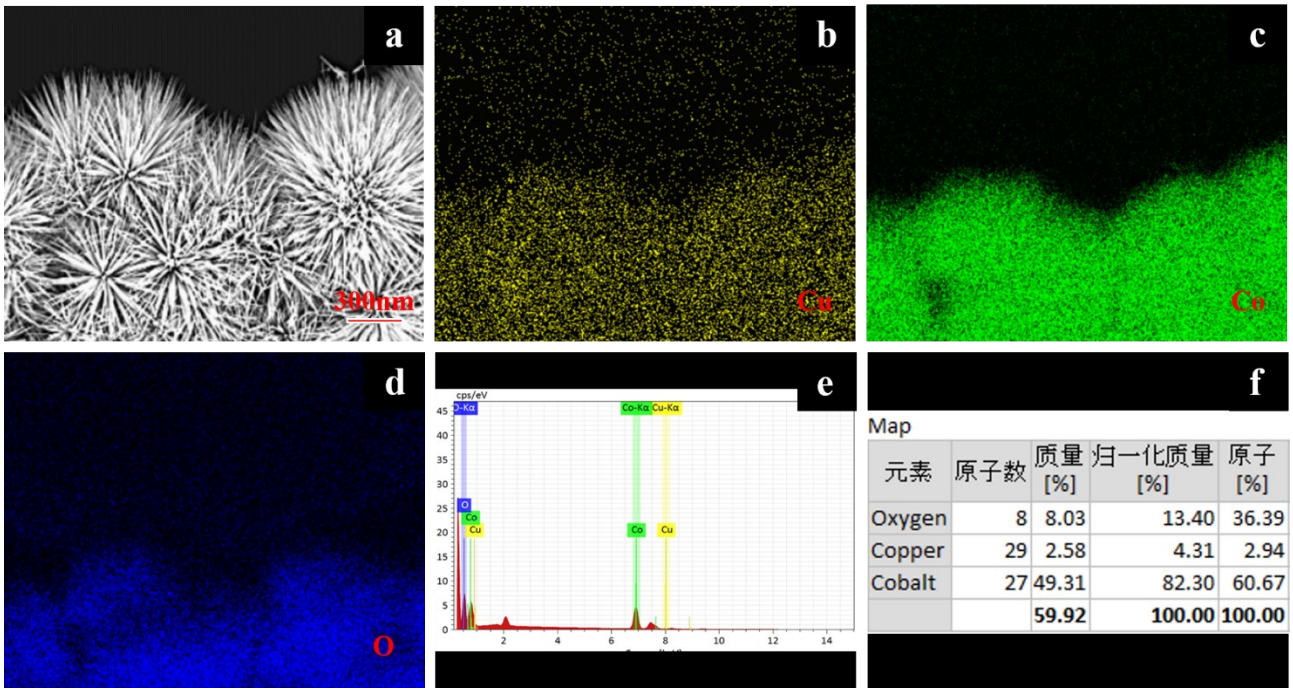


Figure S2 SEM images of (a) CuC@CuS@PPy-8, (b) CuC@CuS@PPy-24, (c) MnC@MnS@PPy-8 and (d) MnC@MnS@PPy-24 at different magnifications.



元素	原子数	质量 [%]	归一化质量 [%]	原子 [%]
Oxygen	8	8.03	13.40	36.39
Copper	29	2.58	4.31	2.94
Cobalt	27	49.31	82.30	60.67
		59.92	100.00	100.00

Figure S3 EDS mapping patterns (a-d) and EDS quantitative analysis spectra (e, f) of $CuCo_2O_4$/NF.

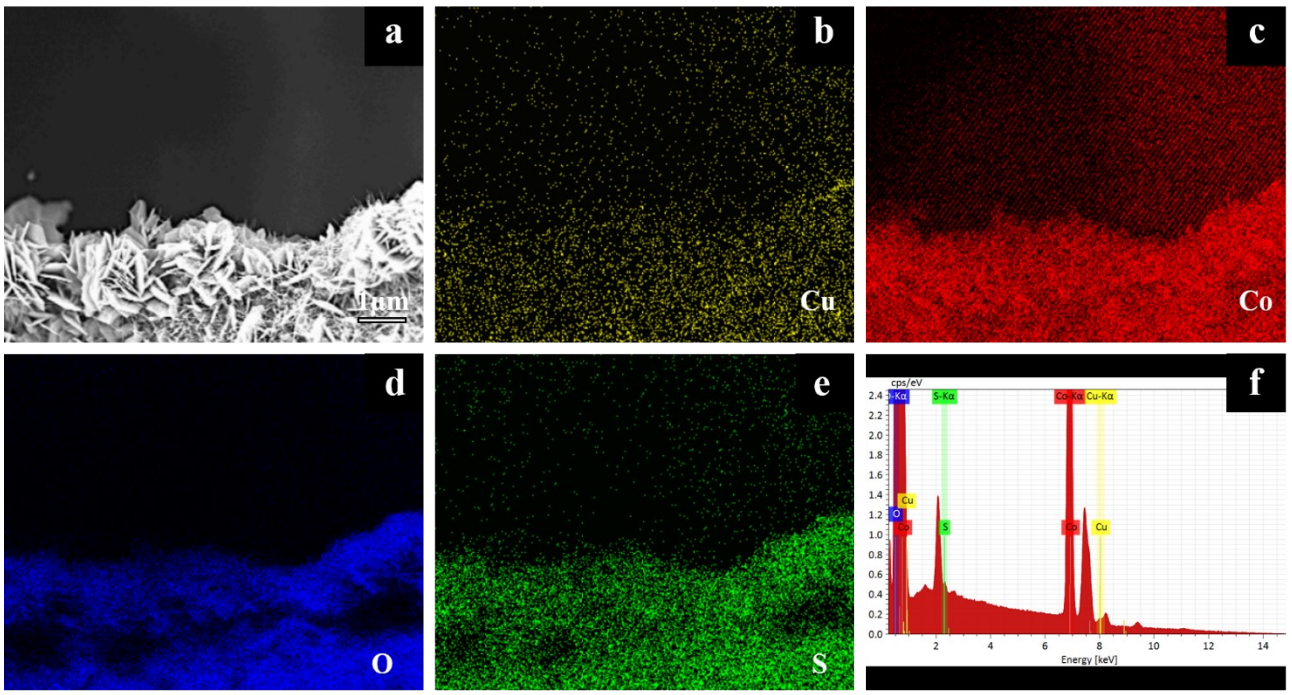


Figure S4 EDS mapping patterns (a-e) and EDS quantitative analysis spectra (f) of $CuCo_2O_4$@$CuCo_2S_4$/NF.

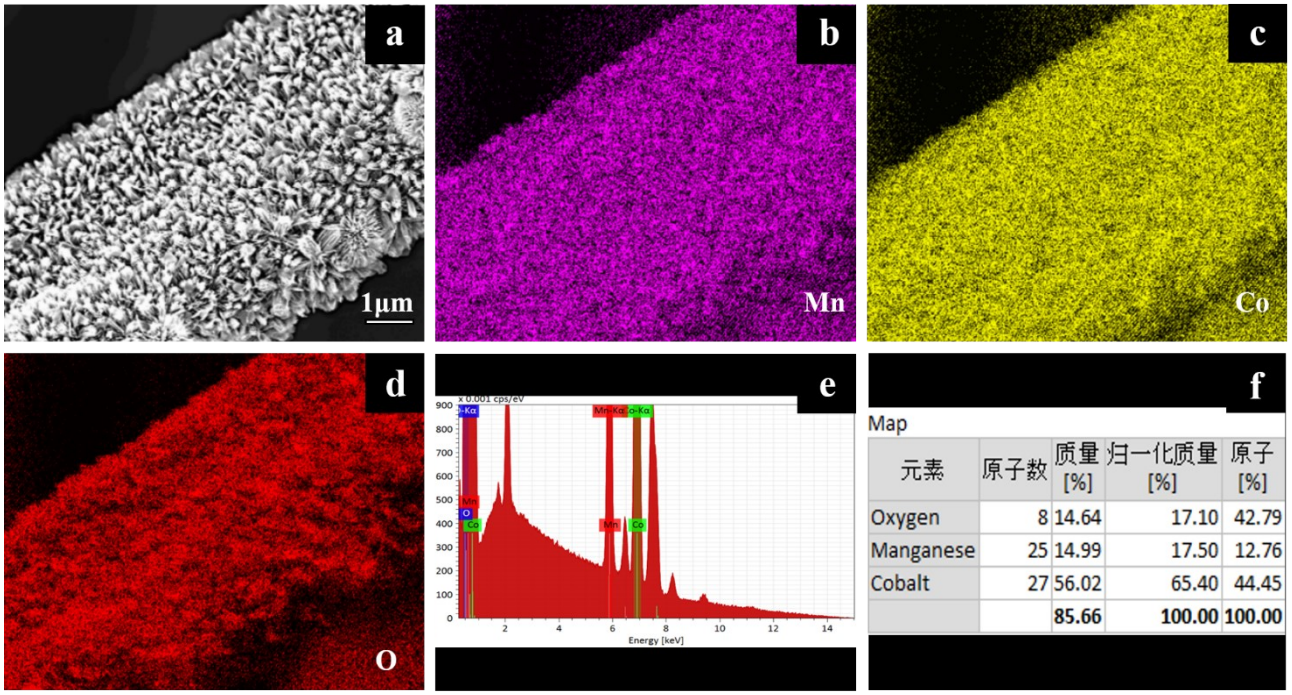


Figure S5 EDS mapping patterns (a-d) and EDS quantitative analysis spectra (e, f) of $MnCo_2O_4$/NF.

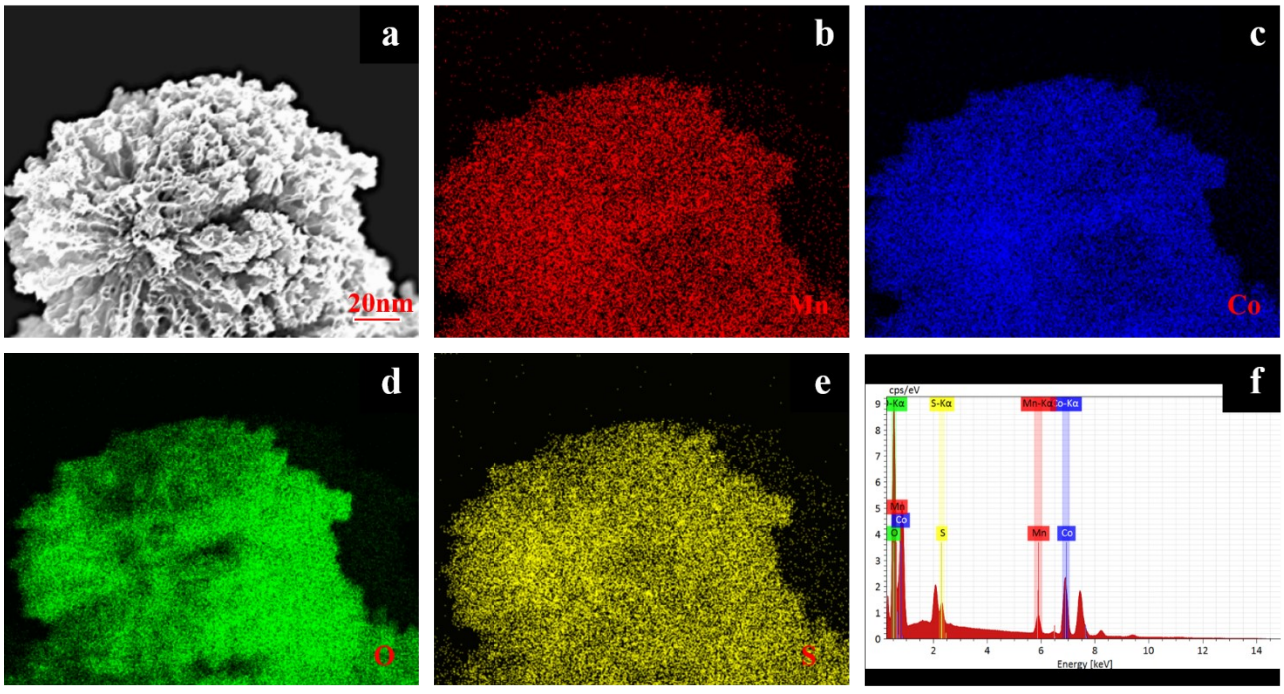


Figure S6 EDS mapping patterns (a-e) and EDS quantitative analysis spectra (e) of $MnCo_2O_4$@$MnCo_2S_4$/NF.

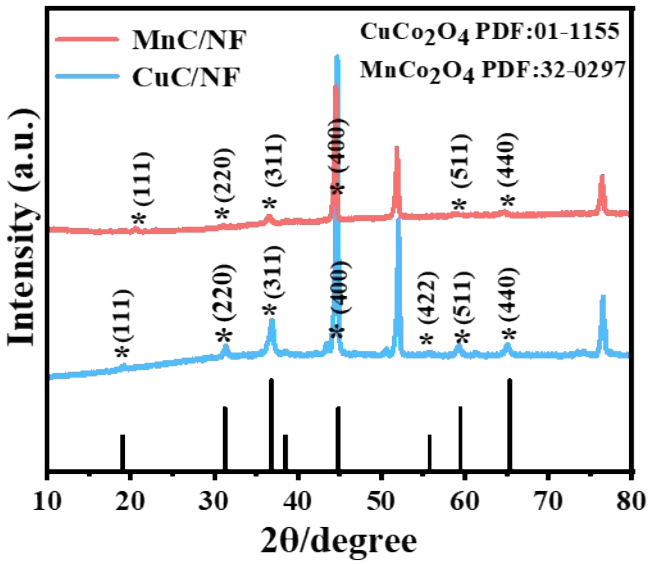


Figure S7 The XRD patterns of MnC/NF and CuC/NF.

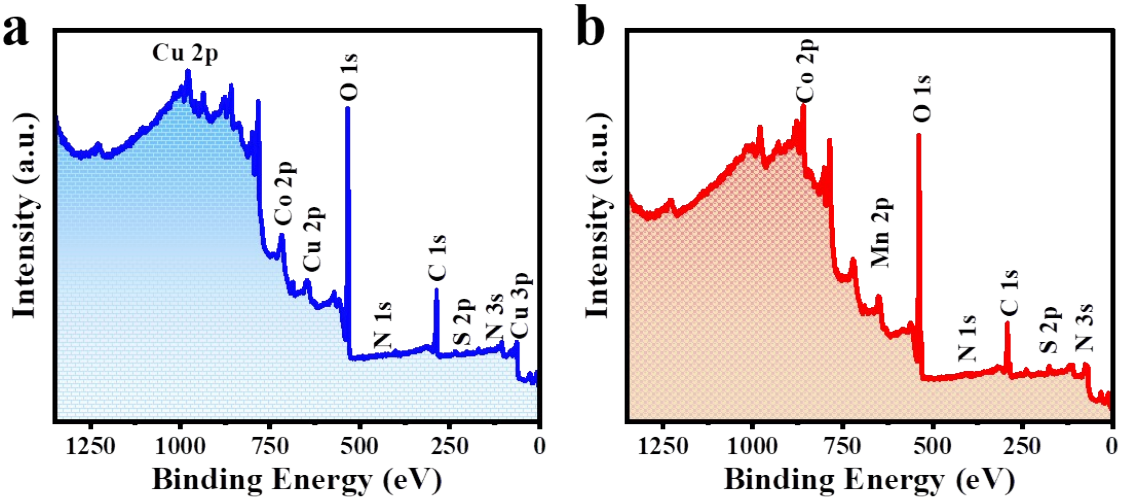


Figure S8 XPS survey spectrums of (a) $CuCo_2O_4$@$CuCo_2S_4$@PPy-16/NF and (b) $MnCo_2O_4$@$MnCo_2S_4$@PPy-16/NF.

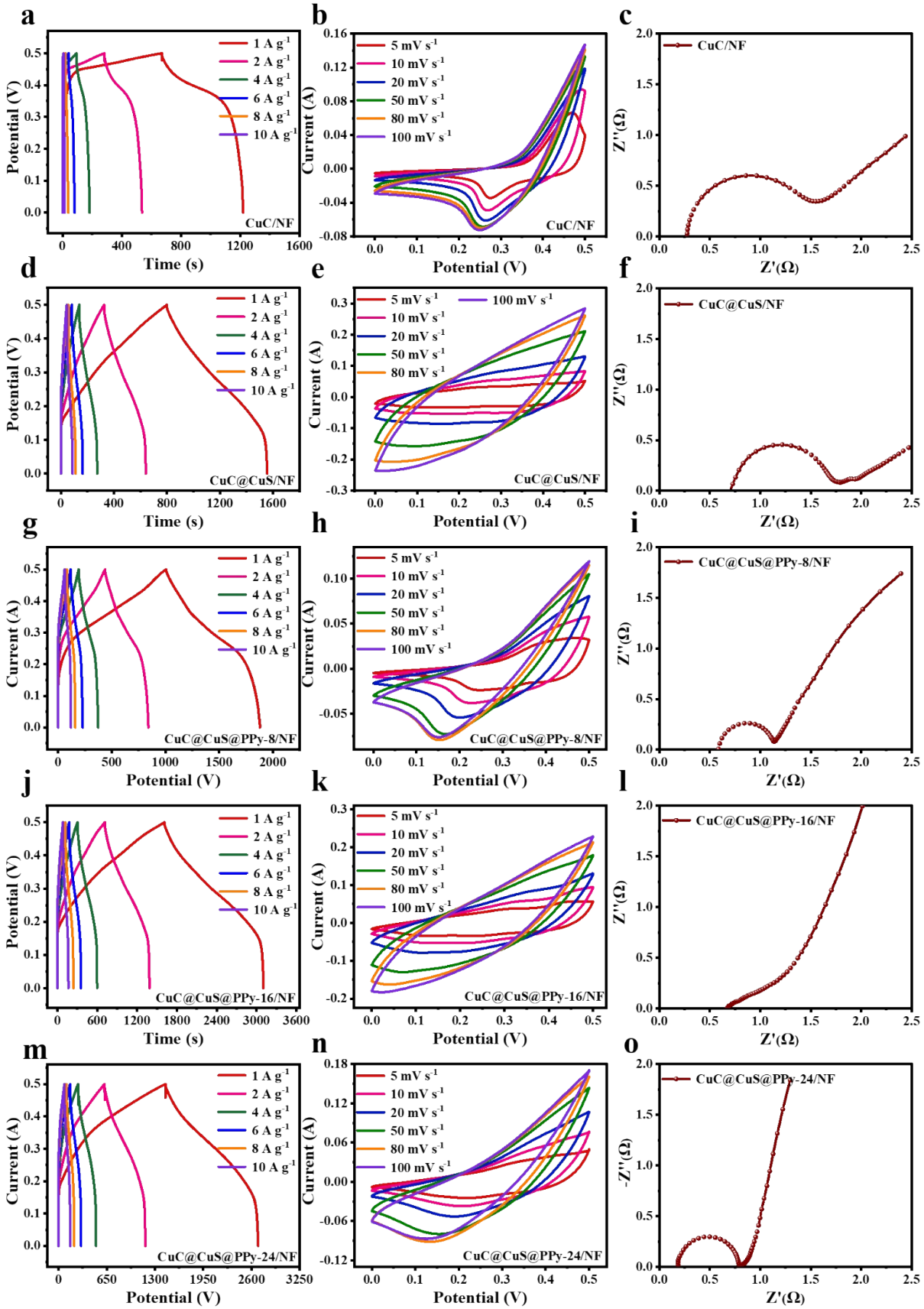

a
Potential (V)
Time (s)
1 A g-1
2 A g-1
4 A g-1
6 A g-1
8 A g-1
10 A g-1
CuC/NF
b
Current (A)
Potential (V)
5 mV s-1
10 mV s-1
20 mV s-1
50 mV s-1
80 mV s-1
100 mV s-1
CuC/NF
c
Z''(Ω)
Z'(Ω)
CuC/NF
d
Potential (V)
Time (s)
CuC@CuS/NF
e
Current (A)
Potential (V)
CuC@CuS/NF
f
Z''(Ω)
Z'(Ω)
CuC@CuS/NF
g
Current (A)
Potential (V)
CuC@CuS@PPy-8/NF
h
Current (A)
Potential (V)
CuC@CuS@PPy-8/NF
i
Z''(Ω)
Z'(Ω)
CuC@CuS@PPy-8/NF
j
Potential (V)
Time (s)
CuC@CuS@PPy-16/NF
k
Current (A)
Potential (V)
CuC@CuS@PPy-16/NF
l
Z''(Ω)
Z'(Ω)
CuC@CuS@PPy-16/NF
m
Current (A)
Potential (V)
CuC@CuS@PPy-24/NF
n
Current (A)
Potential (V)
CuC@CuS@PPy-24/NF
o
-Z''(Ω)
Z'(Ω)
CuC@CuS@PPy-24/NF

Figure S9 (a), (d), (g), (j) and (m) GCD curves of as-prepared samples at various current densities. (b), (e), (h), (k) and (n) CV curves of as-prepared samples at different scan rates. (c), (f), (i), (l) and (o) Nyquist plots of as-prepared samples.

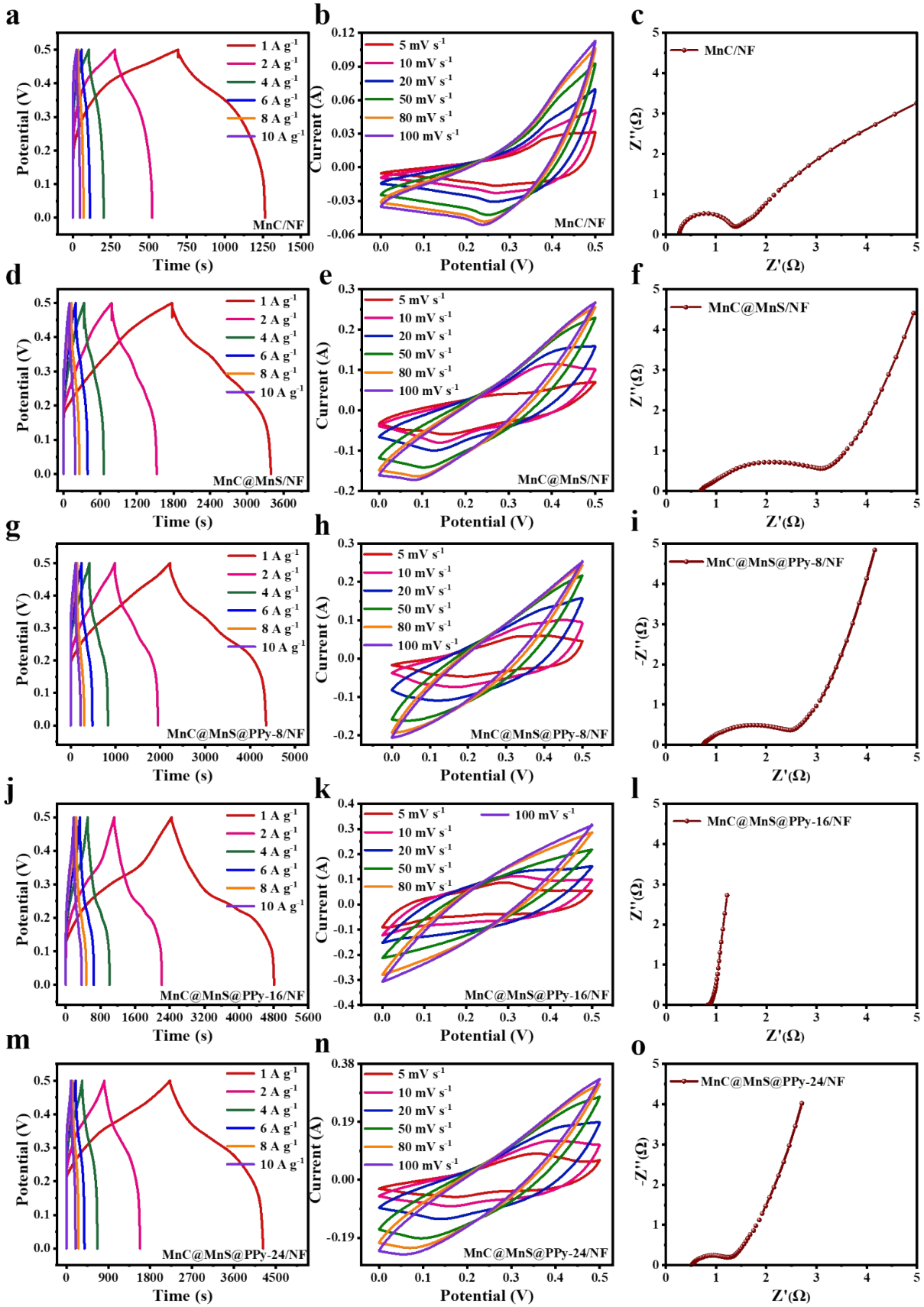

a
Potential (V)
Time (s)
1 A g-1
2 A g-1
4 A g-1
6 A g-1
8 A g-1
10 A g-1
MnC/NF
b
Current (A)
Potential (V)
5 mV s-1
10 mV s-1
20 mV s-1
50 mV s-1
80 mV s-1
100 mV s-1
MnC/NF
c
Z''(Ω)
Z'(Ω)
MnC/NF
d
Potential (V)
Time (s)
MnC@MnS/NF
e
Current (A)
Potential (V)
MnC@MnS/NF
f
Z''(Ω)
Z'(Ω)
MnC@MnS/NF
g
Potential (V)
Time (s)
MnC@MnS@PPy-8/NF
h
Current (A)
Potential (V)
MnC@MnS@PPy-8/NF
i
-Z''(Ω)
Z'(Ω)
MnC@MnS@PPy-8/NF
j
Potential (V)
Time (s)
MnC@MnS@PPy-16/NF
k
Current (A)
Potential (V)
MnC@MnS@PPy-16/NF
l
Z''(Ω)
Z'(Ω)
MnC@MnS@PPy-16/NF
m
Potential (V)
Time (s)
MnC@MnS@PPy-24/NF
n
Current (A)
Potential (V)
MnC@MnS@PPy-24/NF
o
-Z''(Ω)
Z'(Ω)
MnC@MnS@PPy-24/NF

Figure S10 (a), (d), (g), (j) and (m) GCD curves of as-prepared samples at various current densities. (b), (e), (h), (k) and (n) CV curves of as-prepared samples at different scan rates. (c), (f), (i), (l) and (o) Nyquist plots of as-prepared samples.

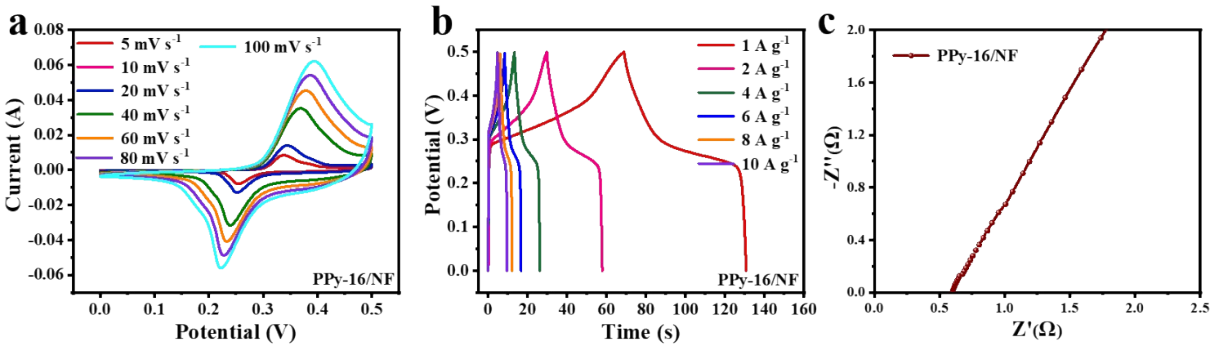


Figure S11 CV curves (a) of PPy-16/NF electrode at different scanning speeds under the potential windows of 0-0.5 V, GCD curves (b) of PPy-16/NF electrode at various current densities within 0-0.5 V and Nyquist plots (c) of PPy-16/NF electrode.

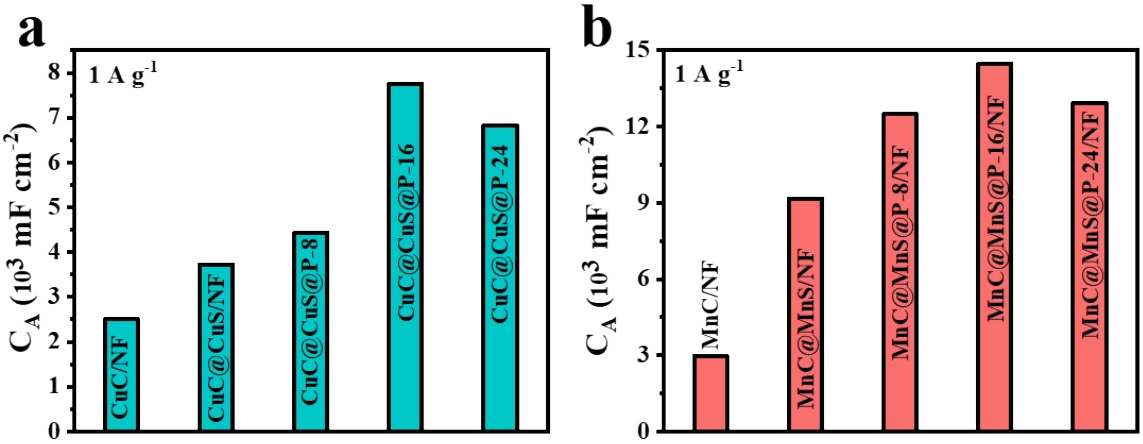


Figure S12 Areal capacitance curves of all prepared electrode materials at a low current density of 1 A g^{-1}.

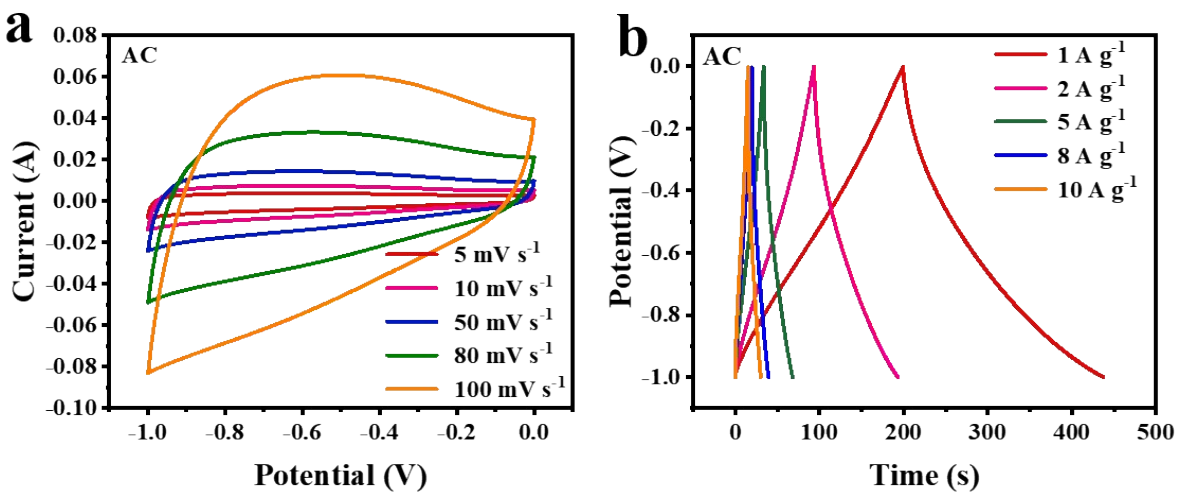


Figure S13 CV curves (a) of AC electrode at different scanning speeds under the potential windows of -1.0-0 V and GCD curves (b) of AC electrode at various current densities within -1.0-0 V.

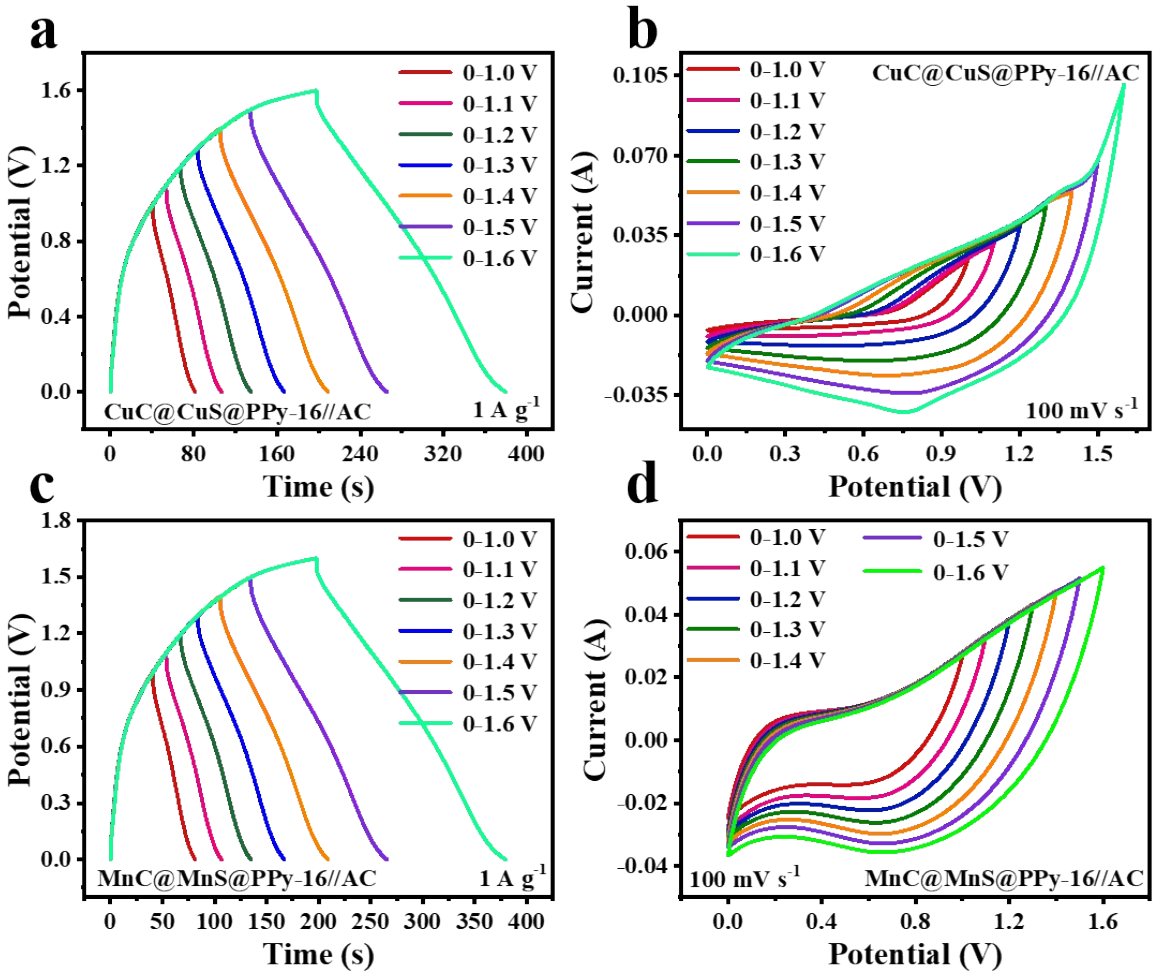


Figure S14 CV curves (a, c) and GCD curves (b, d) of MC@MS@PPy-16/NF//AC ASCs device (M=Cu, Mn) at different potential windows from 0-1.0 V to 0-1.6V.

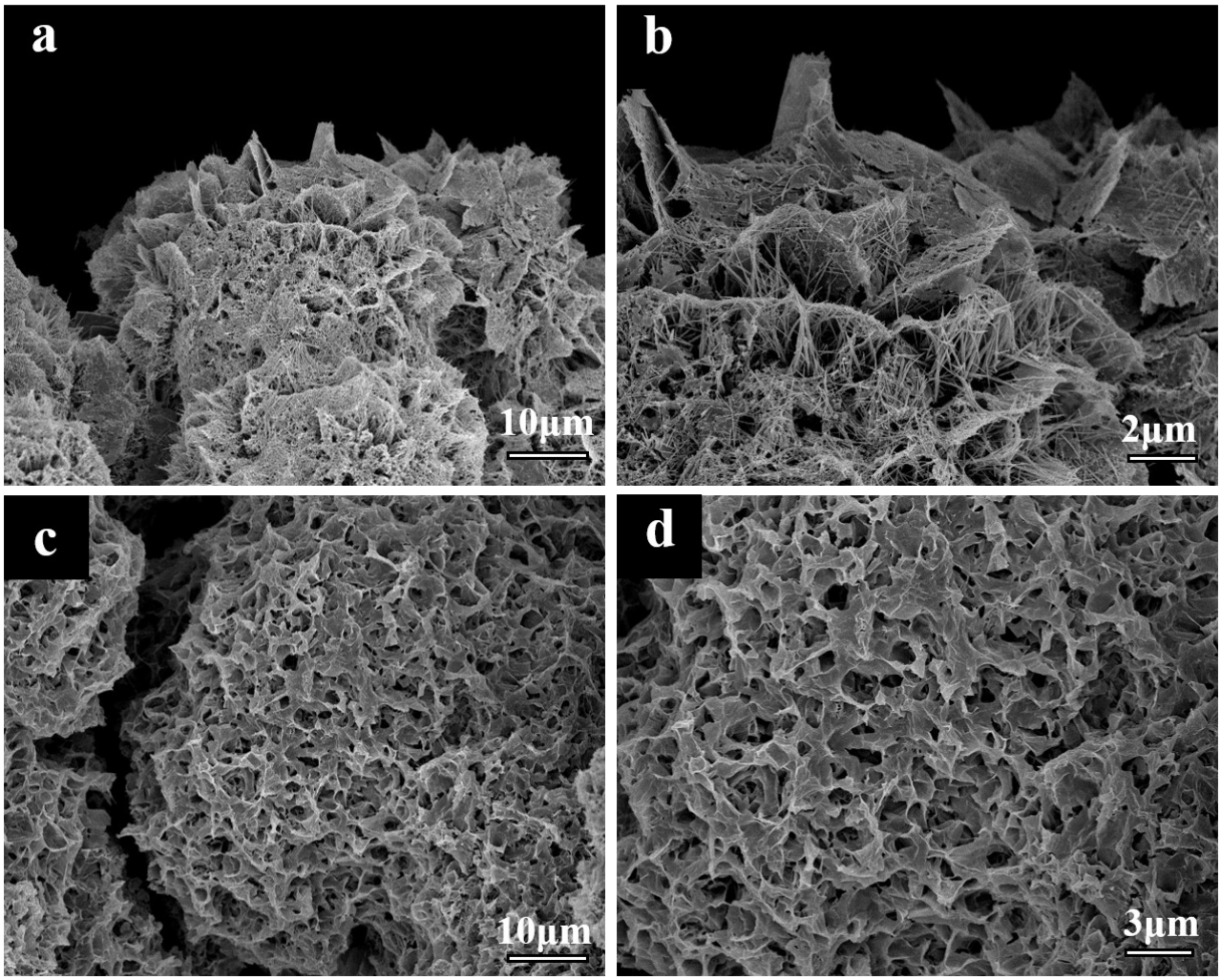


Figure S15 (a, b) SEM images of CuC@CuS@PPy-16/NF electrode and (c, d) MnC@MnS@PPy-16/NF electrode at different magnifications after 10000 GCD cycles.