Supplementary Information

Multifunctional additive biphenyl-4,4'-dicarboxylic acid enables high-performance aqueous zinc-ion batteries

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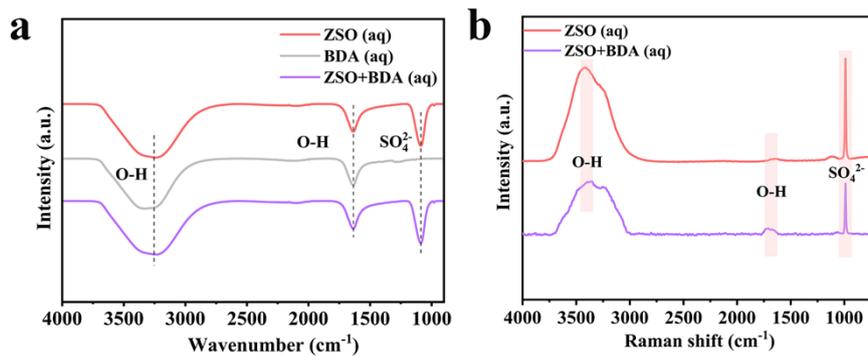
E-mail: zqzhu@hnu.edu.cn; yjg20140716@swu.edu.cn

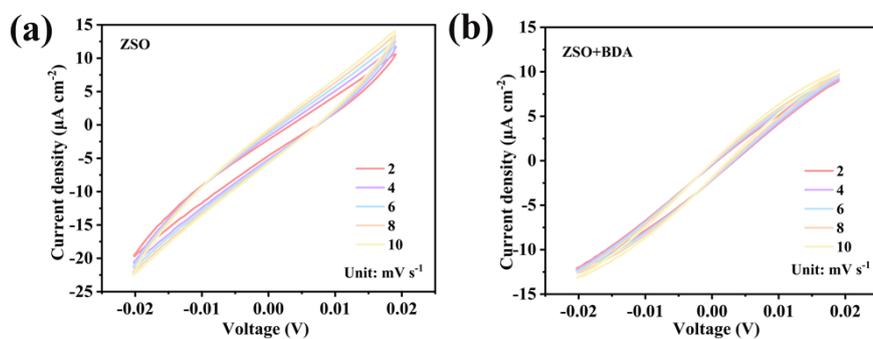Figure S1. (a) FTIR and (b) Raman spectra of different electrolyte solutions

Figure S2. CV curves of Zn‖Zn symmetric cells in (a) ZSO and (c) ZSO+BDA electrolytes at different scan rates in the voltage range of -20 mV to 20 mV
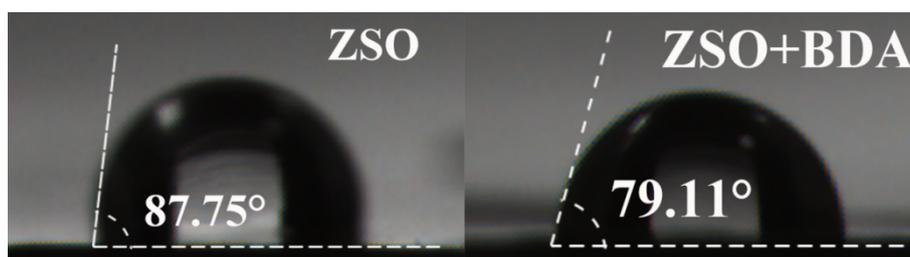

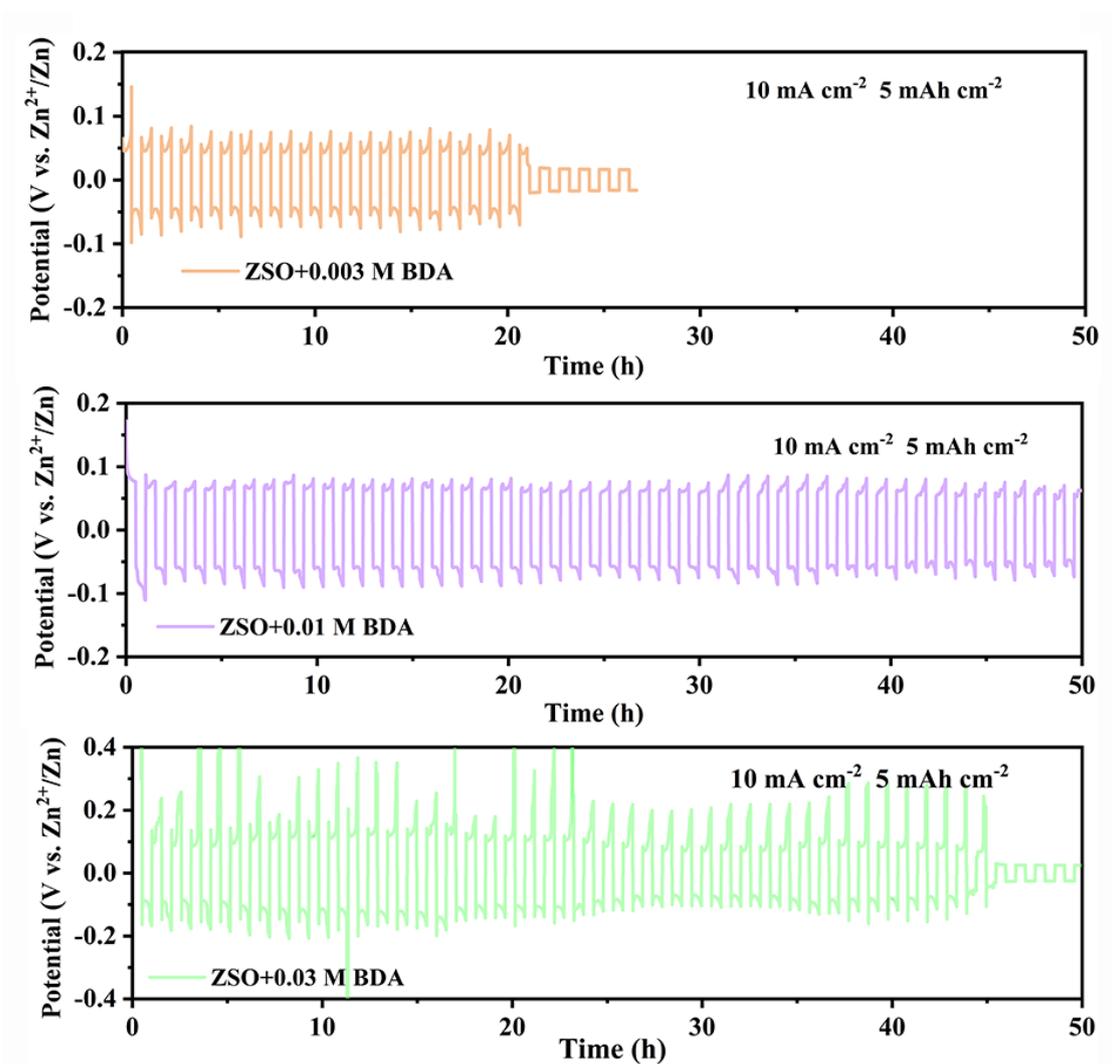Figure S3. Contact angles of ZSO and ZSO+BDA electrolyte on bare Zn anode

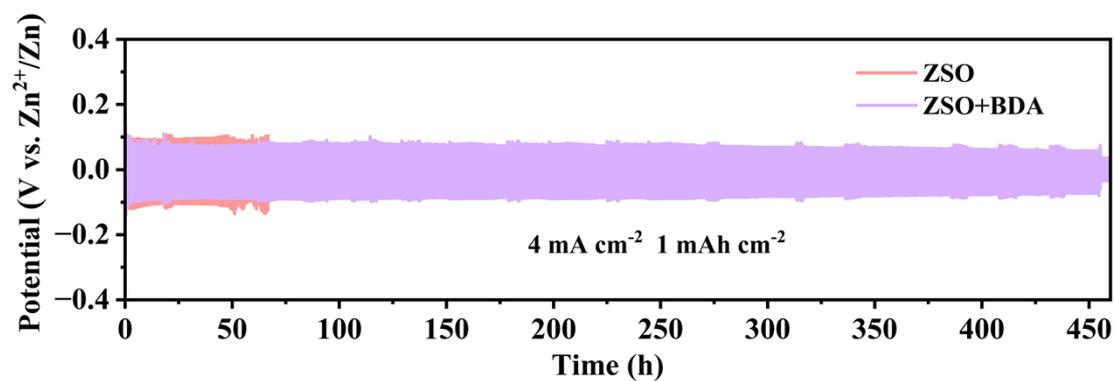Figure S4. Testing of ZSO+BDA electrolytes with different concentrations at a current density of 10 mA cm^{-2} to 5 mAh cm^{-2}

Figure S5. Cycling performance using ZSO ands ZSO+BDA electrolyte at the condition of 4 mA cm^{-2}/1 mAh cm^{-2}
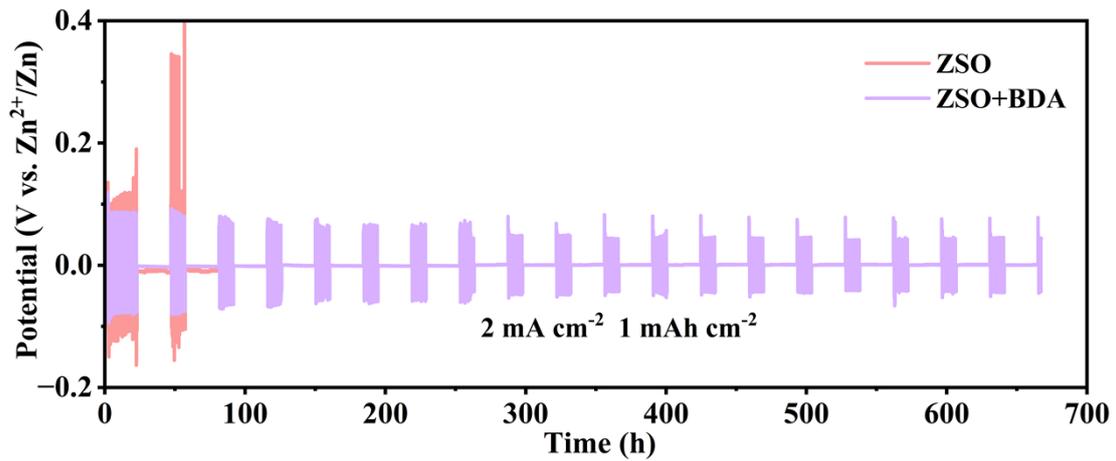
Figure S6. Electrochemical performance of Zn||Zn batteries with alternate cycling and resting process
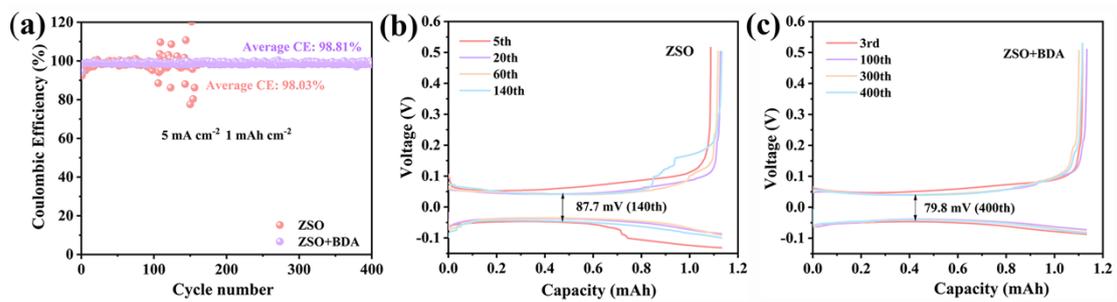

Figure S7. a) CE and the corresponding voltage curves of Zn||Cu cells in b) ZSO and c) ZSO+BDA electrolytes at 5 mA cm^{-2} and 1 mAh cm^{-2}
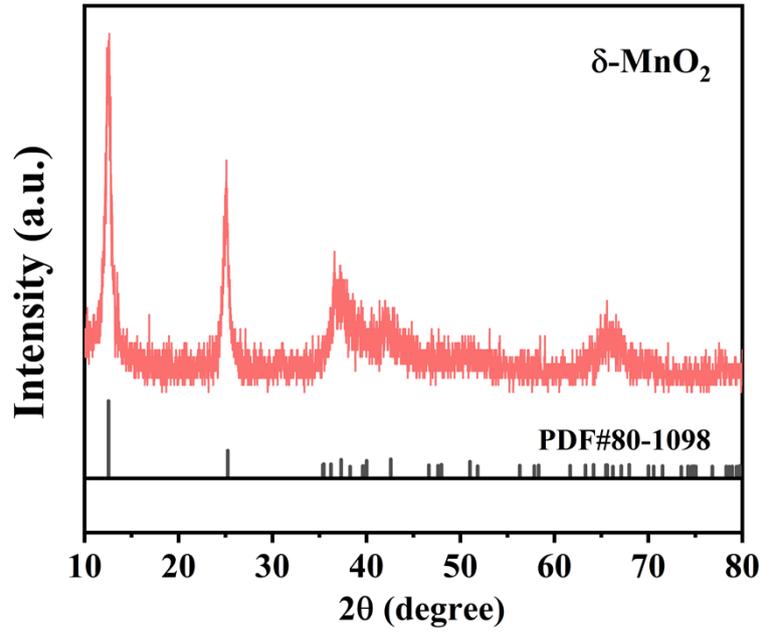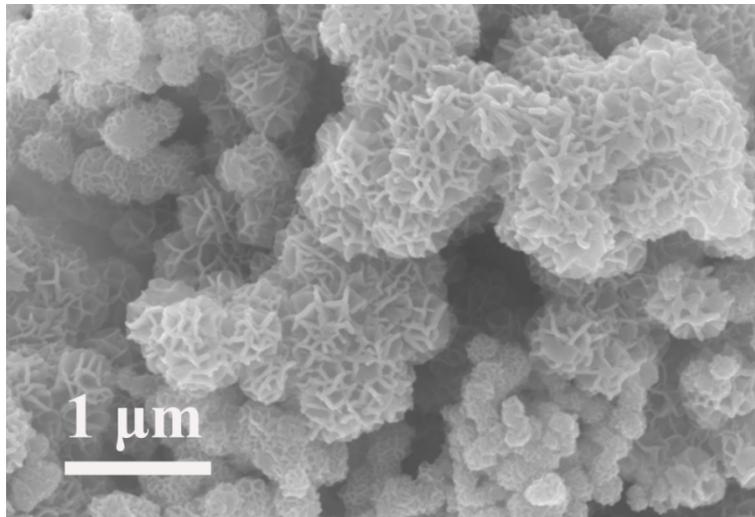
Figure S8. XRD pattern of δ-MnO$_2$

Figure S9. SEM of δ-MnO$_2$

Table S1. Surface roughness parameters (Ra and Rq) of zinc deposits from ZSO and ZSO+BDA electrolytes obtained by AFM measurements

	Ra (nm)	Rq (nm)
ZSO	74.3	94.1
ZSO+BDA	58.9	74.7

Table S2. The Zn^{2+} transference number

	R_I (Ω)	R_S (Ω)	t_{Zn2+}
ZSO	323.50	839.20	0.31
ZSO+BDA	270.50	445.70	0.51

The electrochemical impedance spectroscopy (EIS) for evaluating Zn^{2+} transference number was collected within 10^{-2}~10^{5} Hz in a symmetric Zn‖Zn testing system. The chronoamperometry measurement was implemented by imposing a bias voltage of 10 mV for 4000 s, followed by another AC impedance measurement. The Zn^{2+} transference number (t) was calculated by the following equation:

$$t = \frac{I_S(\Delta V - I_I R_I)}{I_I(\Delta V - I_S R_S)}$$

(2)

Where ΔV is the bias voltage, R_I and R_S are the initial and steady-state charge transfer resistances of the electrode, and I_I and I_S are the initial and steady-state current, respectively.

Table S3. Comparison of cycling performance

Additives	Symmetric cells			Asymmetric cells			Ref.
	Current (mA cm^{-2})	Capacity (mAh cm^{-2})	Time (h)	Current (mA cm^{-2})	Current (mA cm^{-2})	Cycle number	
MSA	1	1	1300	5	1	880	[43]
Mlz	1	1	1500	1	1	90	[44]
β-CD	1	1	1000	1	1	530	[45]
TA-Na	0.5	0.25	1500	0.2	0.1	1000	[11]
PGA	2	1	1600	4	1	1250	[14]
CP	1	1	1000	5	2.5	500	[46]
MES	0.5	0.5	1600	2	0.5	500	[39]
C$_3$N$_4$QDs	1	1	1200	2	1	200	[47]
xylitol	1	1	1100	1	1	100	[22]
TU	1	1	1200	1	1	700	[48]
BDA	1	1	1200	1	0.5	2000	**This**
	10	5	350	5	1	400	**work**

Table S4. The pH values of the ZSO and ZSO+BDA electrolytes

	ZSO	ZSO+BDA
pH	3.4	3.2