

# Fabrication of Al-doped ZnO microspheres as negative materials for superior cycling stability in nickel-zinc secondary batteries

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## Figure and Table Captions

**Figure S1.** Nitrogen adsorption-desorption isotherms and the corresponding pore size distribution of AZO<sub>0</sub> (a), AZO<sub>3</sub> (b), AZO<sub>10</sub> (c) and AZO<sub>15</sub> (d).

**Figure S2.** CV curves of pure AZO and AZO<sub>x</sub> electrodes at different scan rates. (a) pure ZnO, (b) AZO<sub>0</sub>, (c) AZO<sub>3</sub>, (d) AZO<sub>5</sub>, (e) AZO<sub>10</sub>, (f) AZO<sub>15</sub>.

**Figure S3.** GCD curves of the assembled Ni-Zn batteries based on pure ZnO and AZO<sub>x</sub> electrodes at different current densities. (a) pure ZnO, (b) AZO<sub>0</sub>, (c) AZO<sub>3</sub>, (d) AZO<sub>5</sub>, (e) AZO<sub>10</sub>, (f) AZO<sub>15</sub>.

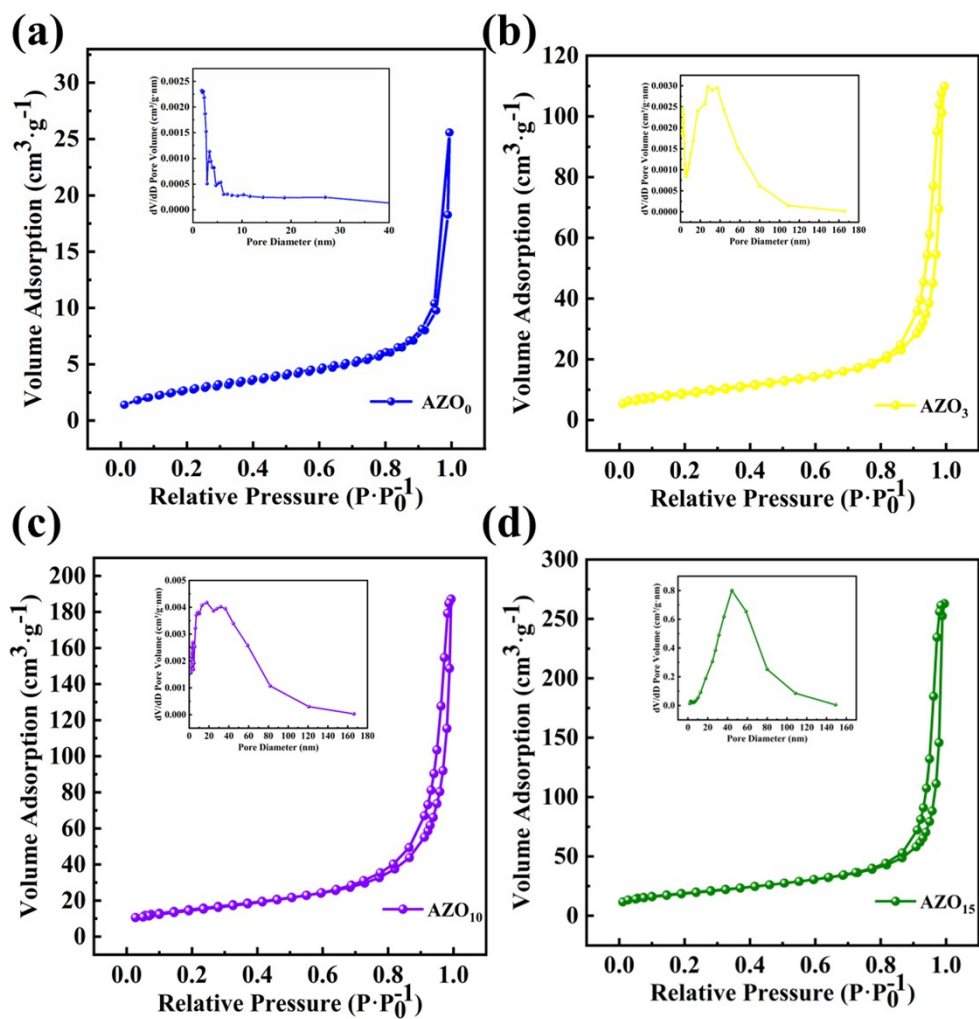
**Table S1.** Molar data of different aluminum doped zinc oxide samples

**Table S2.** The pore structure parameters of pure ZnO and AZO<sub>x</sub> composites

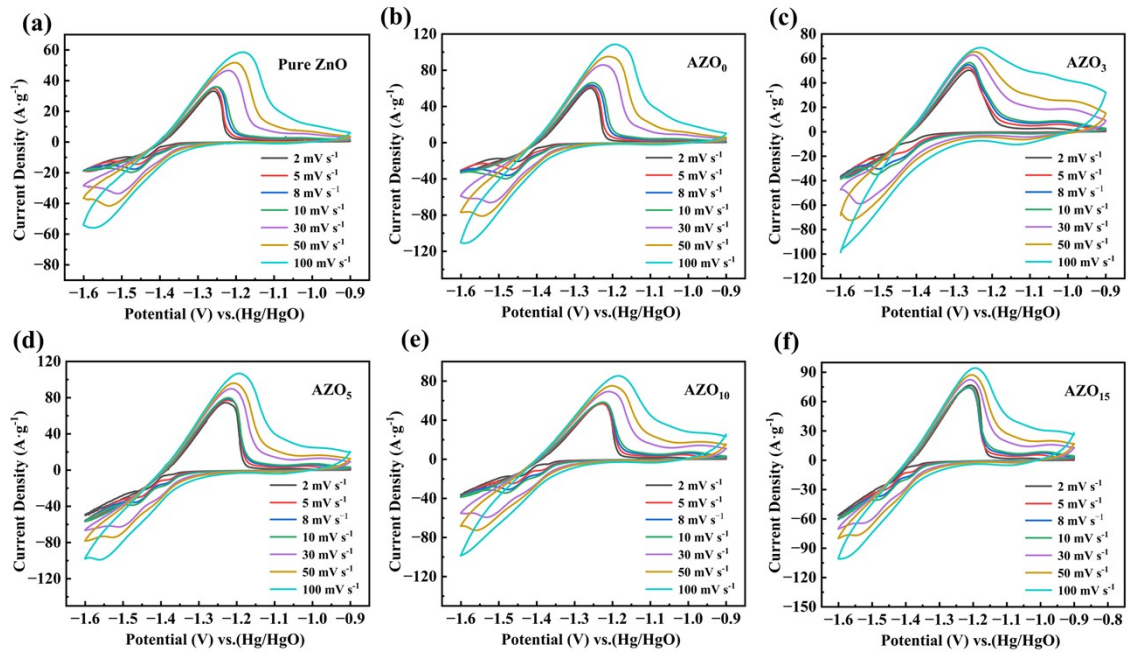
**Table S3.** The Tafel data of pure ZnO and five different AZO<sub>x</sub> electrode materials

**Table 4.** The EIS data of pure ZnO and five different AZO<sub>x</sub> electrode materials

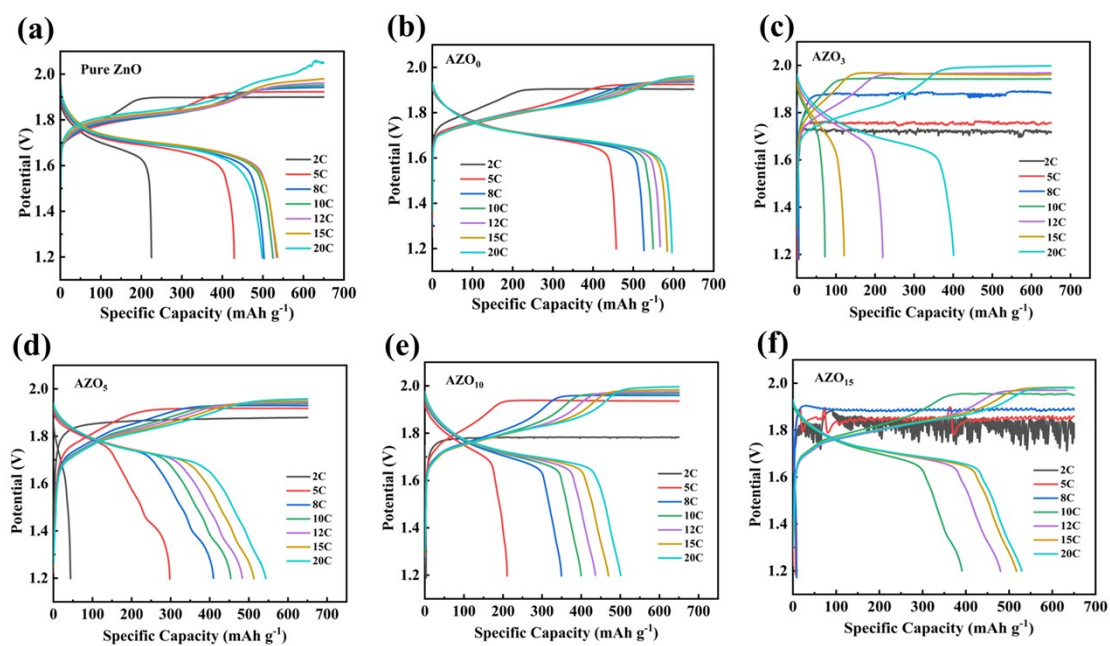
**Table S5.** Comparison of cycle performance between Al-doped AZO<sub>5</sub> composites and some reported anode materials for Ni-Zn batteries



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**Table S1.** Molar data of different aluminum doped zinc oxide samples

<b>Sample</b>	<b>Percentage of Al doping (%)</b>	<b>Zn(Ac)<sub>2</sub>·2H<sub>2</sub>O Amount (mmol)</b>	<b>CO(NH<sub>2</sub>)<sub>2</sub> Amount (mmol)</b>	<b>C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>·H<sub>2</sub>O Amount (mmol)</b>	<b>Al(NO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O Amount (mmol)</b>
<b>AZO<sub>0</sub></b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>20</b>	<b>0</b>
<b>AZO<sub>3</sub></b>	<b>0.3</b>	<b>9.7</b>	<b>30</b>	<b>20</b>	<b>0.3</b>
<b>AZO<sub>5</sub></b>	<b>0.5</b>	<b>9.5</b>	<b>30</b>	<b>20</b>	<b>0.5</b>
<b>AZO<sub>10</sub></b>	<b>1.0</b>	<b>9.0</b>	<b>30</b>	<b>20</b>	<b>1.0</b>
<b>AZO<sub>15</sub></b>	<b>1.5</b>	<b>8.5</b>	<b>30</b>	<b>20</b>	<b>1.5</b>

**Table S2.** The pore structure parameters of pure ZnO and AZO<sub>x</sub> composites

<b>Material</b>	<b>Specific surface area (m<sup>2</sup>·g<sup>-1</sup>)</b>	<b>Average pore diameter (nm)</b>
<b>Pure ZnO</b>	<b>3.543</b>	<b>9.054</b>
<b>AZO<sub>0</sub></b>	<b>9.925</b>	<b>14.521</b>
<b>AZO<sub>3</sub></b>	<b>32.277</b>	<b>22.861</b>
<b>AZO<sub>5</sub></b>	<b>35.387</b>	<b>28.817</b>
<b>AZO<sub>10</sub></b>	<b>53.987</b>	<b>22.724</b>
<b>AZO<sub>15</sub></b>	<b>68.108</b>	<b>26.129</b>

**Table S3.** The Tafel data of pure ZnO and five different AZO<sub>x</sub> electrode materials

<b>Electrode Material</b>	<b>Corrosion Potential <math>E_{\text{corr}}</math> (V)</b>	<b>Corrosion Current Density <math>I_{\text{corr}}</math> (<math>\times 10^{-2}</math> mA cm<sup>-2</sup>)</b>
<b>Pure ZnO</b>	<b>-1.396</b>	<b>0.173</b>
<b>AZO<sub>0</sub></b>	<b>-1.385</b>	<b>0.141</b>
<b>AZO<sub>3</sub></b>	<b>-1.374</b>	<b>0.157</b>
<b>AZO<sub>5</sub></b>	<b>-1.373</b>	<b>0.151</b>
<b>AZO<sub>10</sub></b>	<b>-1.379</b>	<b>0.151</b>
<b>AZO<sub>15</sub></b>	<b>-1.378</b>	<b>0.220</b>

**Table S4.** The EIS data of pure ZnO and five different AZO<sub>x</sub> electrode materials

<b>Electrode Material</b>	<b>Rs (<math>\Omega</math>)</b>	<b>Rct (<math>\Omega</math>)</b>
<b>Pure ZnO</b>	<b>0.652</b>	<b>8.387</b>
<b>AZO<sub>0</sub></b>	<b>0.606</b>	<b>4.755</b>
<b>AZO<sub>3</sub></b>	<b>0.997</b>	<b>13.090</b>
<b>AZO<sub>5</sub></b>	<b>0.565</b>	<b>3.543</b>
<b>AZO<sub>10</sub></b>	<b>0.868</b>	<b>8.057</b>
<b>AZO<sub>15</sub></b>	<b>0.597</b>	<b>4.962</b>

**Table S5.** Comparison of cycle performance between Al-doped AZO<sub>5</sub> composites and some reported anode materials for Ni-Zn batteries

<b>Material</b>	<b>Rate Capability</b>	<b>Cycle Number</b>	<b>Average Specific Discharge Capacity (mAh g<sup>-1</sup>)</b>	<b>References</b>
<b>ZnO/carbon nanotube</b>	<b>1 C</b>	<b>600</b>	<b>410</b>	[1]
<b>ZnO@RGO</b>	<b>1 C</b>	<b>300</b>	<b>510</b>	[2]
<b>Prismatic carbon-coated ZnO</b>	<b>1 C</b>	<b>300</b>	<b>489</b>	[3]
<b>NC@ZnO composite</b>	<b>1 C</b>	<b>945</b>	<b>531</b>	[4]
<b>ZnO@In<sub>2</sub>O<sub>3</sub></b>	<b>2 C</b>	<b>80</b>	<b>520</b>	[5]
<b>ZnO@ZIF-8</b>	<b>5 C</b>	<b>1150</b>	<b>590</b>	[6]
<b>ZnO@SnO<sub>2</sub></b>	<b>10 C</b>	<b>1000</b>	<b>584</b>	[7]
<b>ZnO@TiC</b>	<b>6 C</b>	<b>1500</b>	<b>520</b>	[8]
<b>ZnO@Bi/C</b>	<b>1C</b>	<b>180</b>	<b>627</b>	[9]
<b>ZnO@ZnSe</b>	<b>10C</b>	<b>1460</b>	<b>577</b>	[10]
<b>ZnO@NC</b>	<b>15C</b>	<b>900</b>	<b>595</b>	[11]
<b>ZnO@MXene</b>	<b>10C</b>	<b>1500</b>	<b>594</b>	[12]
<b>Al-doped AZO<sub>5</sub> composites</b>	<b>12 C</b>	<b>1400</b>	<b>570</b>	<b>In this work</b>

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