Supporting information (SI)
Micro-nanostructured CuO/C spheres as high-performance anode material for Na-ion batteries

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Fig. S1 XRD patterns of Cu-Cu$_x$O.
The main ingredients of the Cu-Cu$_x$O are Cu and Cu$_2$O. The broad peak at 24 degree is attributed to the carbon.
Fig. S2 TGA curves of 10-CuO/C and 40-CuO/C from room temperature to 600 °C in air. The curves are flat before 300 °C, indicating the samples are stable in air up to 300 °C. From 300 °C to 450 °C, the fast weight loss is attributed to the oxidation of carbon: C + O$_2$ → CO$_2$ (gas).
Fig. S3 Nitrogen adsorption–desorption isotherms of 10-CuO/C and 40-CuO/C. 
The isotherms show a typical type-IV behavior with a specific surface area of 262 m$^2$ g$^{-1}$ and 122 
m$^2$ g$^{-1}$, respectively. The large surface area of 10-CuO/C is beneficial to the contact between 
electrode and electrolyte, thus facilitating the electronic and ionic transports. This results in its 
excellent electrochemical performance.
Fig. S4 Particle size analysis of 10-CuO/C.
The 10-CuO/C nanocomposite has uniformly spherical morphology. The particle size distribution shows the average size of these spheres is about 210 nm.
Fig. S5 SEM images of CuO particles in different magnifications. The pure CuO particles were synthesized by the same aerosol spray process (compared with 10-CuO/C) without the addition of RF resin solution.
Fig. S6 SEM (a,b) and TEM (c,d) images of CuO/C composites obtained at different CuO contents (with the CuO content of 25% and 85 %, respectively.).

The different content of CuO composites were obtained through adjusting the content of Cu(NO$_3$)$_2$·3H$_2$O to 1.27 g and 6.03 g, respectively. The SEM and TEM images illustrate that the different contents of CuO influence the morphology and structure of the composites. Compared with 10-CuO/C, the high precursor concentration (Cu(NO$_3$)$_2$·3H$_2$O) shows similar CuO particle size (a,b). However, the rare distribution of CuO will not benefit for the electrochemical reaction. As shown in Fig. S5(c,d), the low precursor concentration of Cu(NO$_3$)$_2$·3H$_2$O leads to uneven morphology and severe aggregation.
The initial electrode (2.90V) shows the peaks of CuO (active material) and Cu foil (current collector, existed in every following tested electrode). The peaks of CuO gradually decrease during the discharge process. At the state of 0.54V, the peaks of Cu$_2$O are observed. These signals disappear and only Cu peaks are found when discharge to 0.01V. During the charging process, the peaks of Cu$_2$O again appear when charge to 1.30V. Finally, the fully charged (3.00V) product in the XRD pattern was only CuO. This result accord with reported before.
Fig. S8 (a) Charge-discharge curves at 1st, 2nd and 5th cycles of pyrolyzing carbon at 200 mA g\(^{-1}\), (b) Cycling performance of the pyrolyzing carbon at 200 mA g\(^{-1}\) between 0.01 and 3 V. The pyrolyzing carbon without CuO was synthesized as follows: 15.4 g resorcinol and 20 ml of formaldehyde were polymerized to form resorcinol formaldehyde (RF) resin solution. Then mix this solution into 280 mL of ethanol. Pass through an aerosol spray process. The reaction conditions were the same as the as-prepared composites before. The cycling curves shows that carbon provides a little of capacity in the whole composite. However, its outstanding cycling performance and firm structure can effectively contribute to our composite.
**Table S1** The discharge capacities of 10-CuO/C and 40-CuO/C at current densities of 50, 300, 500, 1000, and 2000 mA g\(^{-1}\).

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<thead>
<tr>
<th></th>
<th>50 mA g(^{-1})</th>
<th>300 mA g(^{-1})</th>
<th>500 mA g(^{-1})</th>
<th>1000 mA g(^{-1})</th>
<th>2000 mA g(^{-1})</th>
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<tbody>
<tr>
<td>10-CuO/C(mA h g(^{-1}))</td>
<td>654</td>
<td>477</td>
<td>426</td>
<td>314</td>
<td>304</td>
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<tr>
<td>40-CuO/C(mA h g(^{-1}))</td>
<td>413</td>
<td>262</td>
<td>218</td>
<td>131</td>
<td>126</td>
</tr>
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Reference: