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Electronic supplementary information

Reducing hydrated protons co-intercalation to enhance cycling stability of CuV_2O_5 nanobelts: A new anode material for aqueous lithium ion batteries

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S1. XRD pattern of the as-prepared CuV_2O_5 nanobelts after anneal

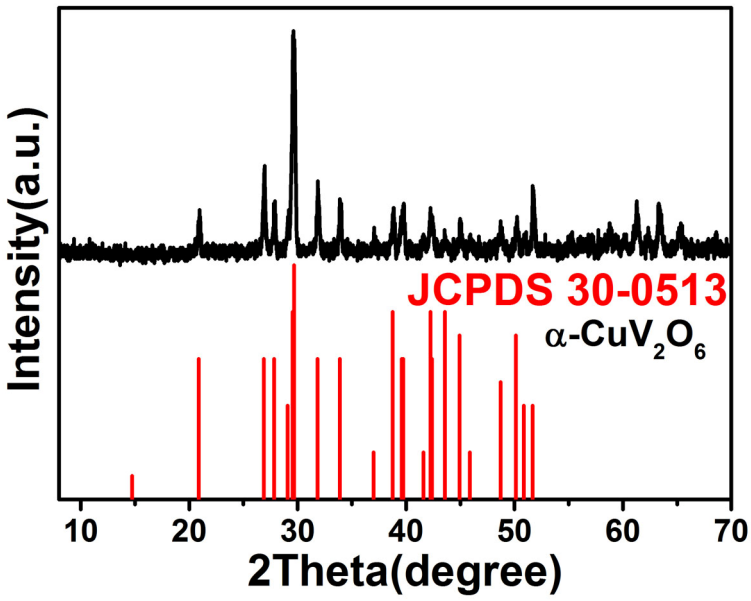

Figure S1 XRD pattern of the as-prepared CuV_2O_5 nanobelts annealed at 500 °C for 3h in atmosphere

The XRD pattern of the product annealed at 500 °C for three hours in atmosphere can be indexed to pure α-CuV_2O_6 (JCPDS 30-0513) without any feature peaks of

V_2O_5 or CuO, confirming the primary product of the hydrothermal reaction is pure CuV_2O_5.The corresponding chemical equation can be described as follows:

$$CuV_2O_5 + 1/2\ O_2 \rightarrow CuV_2O_6\ (500\ °C,\ 3h,\ atmosphere)$$

Otherwise:

$$Cu_{1+x}V_2O_5 + (1/2 + x/2)\ O_2 \rightarrow CuV_2O_6 + x\ CuO\ (500\ °C,\ 3h,\ atmosphere,\ x>0)$$

$$Cu_{1-x}V_2O_5 + (1/2 - x/2)\ O_2 \rightarrow (1 - x)\ CuV_2O_6 + x\ V_2O_5\ (500\ °C,\ 3h,\ atmosphere,\ x>0)$$

S2. Structure model of the CuV_2O_5 nanobelt

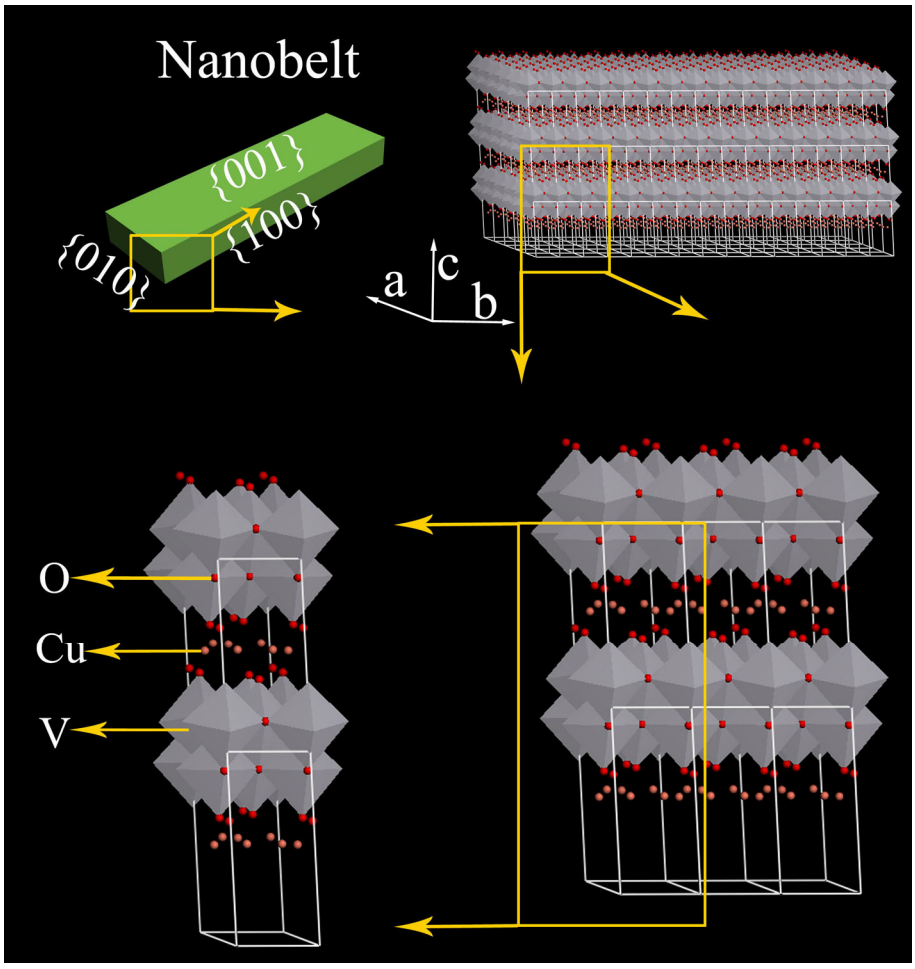

Figure S2 Corresponding structural model of the CuV_2O_5 nanobelt.

This schematic model shows that the layered structure CuV_2O_5 nanobelt is prefer to expose {001} facets, which is in well accord with the SAED result and the strongest (003) peak in the XRD pattern.

S3. Typical discharge curve of CuV_2O_5 at constant temperature

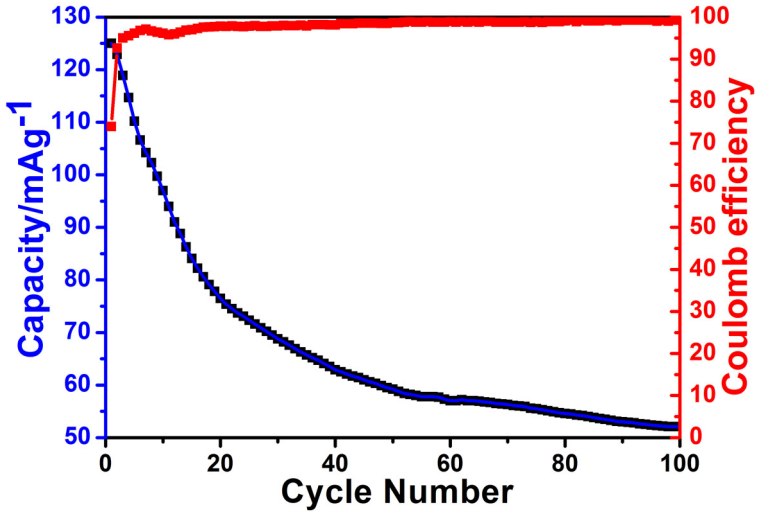

Figure S3 Discharge capacity and coulomb efficiency versus cycle number curves for as prepared nanobelt structure $CuV_2O_5/LiMn_2O_4$ cell between 1.6 and 0.5 V, the aqueous solution including 5 M $LiNO_3$ and 0.001 M LiOH (pH~6.5), the test apparatus were placed in a constant temperature water bath of 25 °C.

In the constant temperature test, the curve is basically smooth and the wave of the capacity disappeared, confirming the wave resulted from the wave of the temperature. Furthermore, we calculated the time interval between the two nearest wave-crests/wave-troughs in the waved discharge cures in Figure 8a and most were about 24 h, just a daytime and night time.

S4. Ex-situ XRD and XPS of O 1s of the anode at pH~8.5

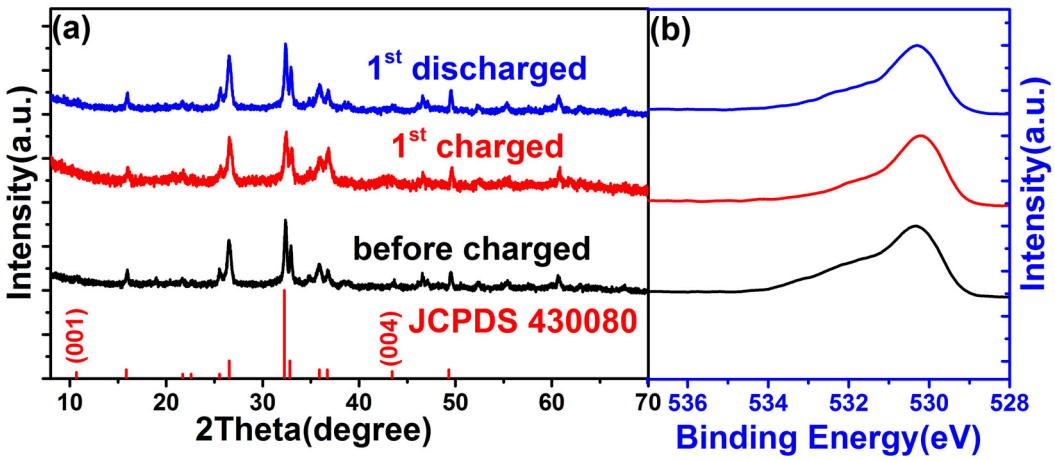

Figure S4 Ex-situ (a) X-ray diffraction and (b) XPS of O 1s of the nanobelt structure CuV_2O_5 anode at different charge/discharge stages, and the CuV_2O_5/$LiMn_2O_4$ cell was charged/discharged between 1.6 and 0.5 V, the aqueous solution including 5 M $LiNO_3$ and a certain amount of LiOH (pH~8.5).

The ex-situ test results at pH~8.5 reveal the (001) and (004) peaks in the XRD patterns and the peak of O1s in the XPS spectra at 531.9 eV didn't obviously strengthen after the charge process, indicating that the hydrated protons didn't obviously insert into the layered structure of CuV_2O_5 electrode during the charge process at pH~8.5, which was quite different from the situation at pH~6.5.

S5. The XRD patterns of the CuV_2O_5 anode after 100 cycles

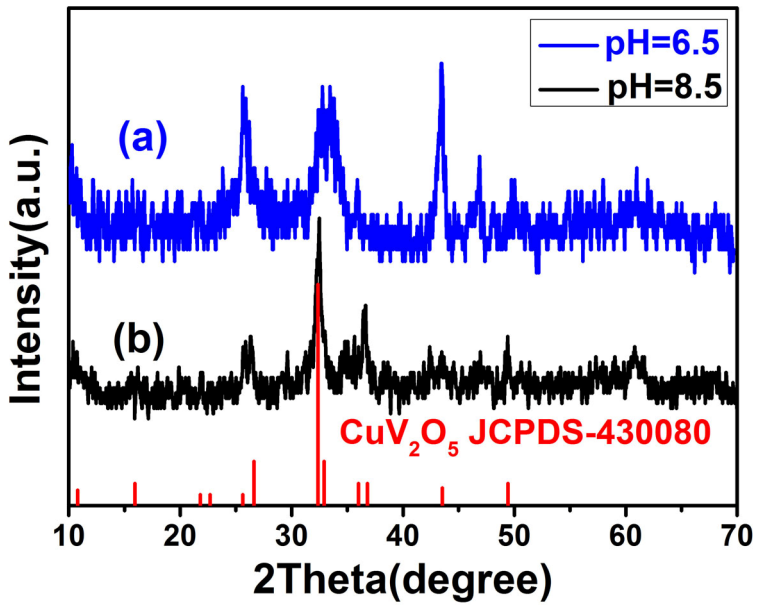

Figure S5 XRD pattern of the as-prepared nanobelt structure CuV_2O_5 anode after 100 cycles tests: (a) pH~6.5, (b) pH~8.5

The XRD patterns of the CuV_2O_5 after 100 cycles show that the structure of CuV_2O_5 at pH~8.5 remained unchanged, while at pH~6.5 there took place some irreversible phase collapse with some amorphization, which would take responsibility for the bad cycling performance at lower pH values.

S6. The XRD patterns of the CuV_2O_5 using different copper sources

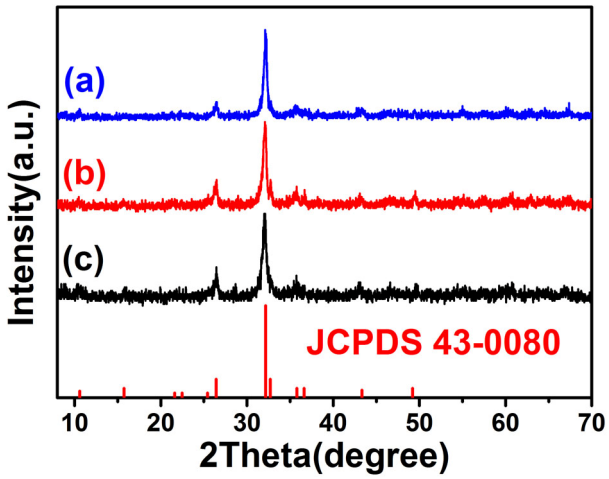

Figure S6 XRD patterns of the CuV_2O_5 nanobelt using various soluble copper sources: (a) $Cu(NO_3)_2$, (b) $Cu(CH_3COO)_2$, (c) $CuCl_2$.

The XRD patterns of the CuV_2O_5 using various soluble copper sources show that all the products are pure monoclinic CuV_2O_5 (JCPDS No. 43-0080), indicating that the Cu^{2+} cations are critical for the formation of CuV_2O_5, while the anion species seems no effect on the final product.