Supplementary information for

Morphology-controlled CuO nanoparticles for electroreduction of CO$_2$ to ethanol

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1. Materials and Instruments

All reagents were used as received.

Potentiostatic electrolysis was performed using a CHI 600a electrochemical Station (Shanghai Chenhua Instruments Company) with the catalysts being loaded on carbon paper (CP, TGP-H-060, Toray).

Liquid phase products were analyzed by Gas Chromatography-Flame Ionization Detector (GC-FID) (SHIMADZU, GC-2014C).

Microstructure and morphology of CuO were analyzed using Hitachi S-4800 field emission Scanning Electron Microscope (FE-SEM).

X-ray diffraction (XRD) patterns were recorded by a Ultima IV X-ray powder diffractometer using Cu Kα radiation (k= 1.5406 Å).

N$_2$ adsorption was carried out at 77 K on a BELSORP-MAX instrument after outgassing the samples for 10 h under vacuum at 573 K.

2. General methods

2.1. Synthesis of CuO nanoparticles

Sample a: 10 mL 0.25 M copper acetate and urea aqueous solution were mixed and
transferred to a Teflon-lined reactor. The reactor was kept in an oven at 130 °C for 1 h. The reaction solution was centrifuged. Dark precipitate was obtained after being washed three times with distilled water and drying at 60 °C for 12 h.

Sample b: The method was the same as sample a except for 0.025 M copper acetate and urea aqueous solution.

Sample c: The method was the same as sample a except that 10 mL 1 M cupric nitrate and sodium carbonate aqueous solution were mixed and the reaction time was 4 h.

Sample d and e were synthesized by the methods described in [1].

2.2. Electrosynthesis of CO$_2$

A typical potentiostatic electrolysis was carried out in 0.2 M KI aqueous solution in a divided glass cell under a CO$_2$ atmosphere, with a CuO loaded carbon paper cathode, a Pt counter electrode and a SCE reference electrode. Each experiment condition was performed for 5 times and the average values were used.

3. Characterization of CuO nanoparticles
**Fig. S1** FE-SEM patterns of CuO nanoparticles. (a-1), (a-2): sample a; (b-1), (b-2): sample b; c: sample c; (d-1), (d-2): sample d; (e): sample e.

**Fig. S2** b-e: X-ray diffraction (XRD) patterns of CuO nanoparticles after 1 h electrolysis of sample b to e.
Fig. S3 Current density for CO$_2$ reduction at various potentials for the electrode loaded with sample a.

Fig. S4 Stability test of sample a, b, c, d and e in electrolysis performed at -1.7 V in 0.2 M KI saturated with 1 atm CO$_2$. 
Reference