Electronic Supplementary Information

Facile oxidation-dehydration reaction-driven robust porous copper oxide nanobelt coating on copper foam for energy-saving and low-cost urea oxidization reaction

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Experimental Section

Materials

Cu foam(CF) was purchased from Latech Scientific Supply Pte. Ltd. $K_2S_2O_8$ (≥99.0%), KOH, ethyl alcohol and H_2SO_4(95-98wt%) were bought from Sigma-Aldrich Chemical Reagent Co.

Fabrication of CuO nanobelt coating

CuO nanobelt coating was synthesized as follows. In a typical preparation, to remove the oil on copper surface, CF was immersed into ethyl alcohol for 2 min at room temperature. Then CF was dipped into 5 volume% H_2SO_4 solution for 2min at room temperature to remove the oxide layer of copper substrate surface. At last, CF was immersed into chemical oxidization solution for 10min at 50℃. Chemical oxidization solution contains 2mol/L KOH and 0.05mol/L $K_2S_2O_8$. Please confirm that $K_2S_2O_8$ powder is completely dissolved and the as-prepared chemical oxidization solution is clarified. Moreover, deionized water was used to clean CF completely for several times among the above two processes.

Characterizations

ZEISS SEM Supra 40 was employed to observe the microstructure of different samples. XRD patterns were determined by Bruker D8 Advanced Diffractometer System. X-ray photoelectron spectroscopy (XPS, Kratos AXIS Ultra DLD) was carried out to detect the surface element analysis of varied samples.

Electrochemical measurements

The typical three-electrode cell connected to a Bio-logic VMP 3 was used to determine UOR process. In this cell, the CuO nanobelt/CF, Pt and Hg/HgO were employed as the working electrode (1×1cm^2), a counter electrode and a reference electrode, respectively. The electrolyte is 1M KOH solution (contain 0.5M urea) and the pH value of electrolyte is 14. According to $E(RHE)=E_{Hg/HgO}+0.059pH+0.098$ V, all the measured potential values were converted to reversible hydrogen electrodes (RHE) standard. LSV curves were determined with the scan rates of 1mV/s. Tafel slopes were calculated and derived from LSV curves. Notably, all the electrochemical datas were shown after 100% IR conpensation.

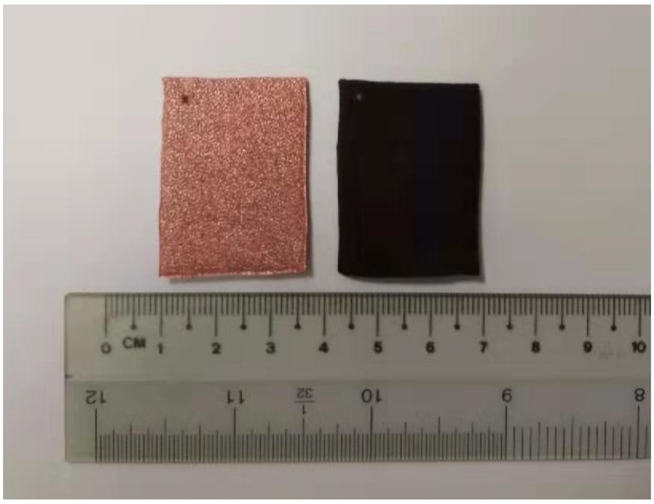
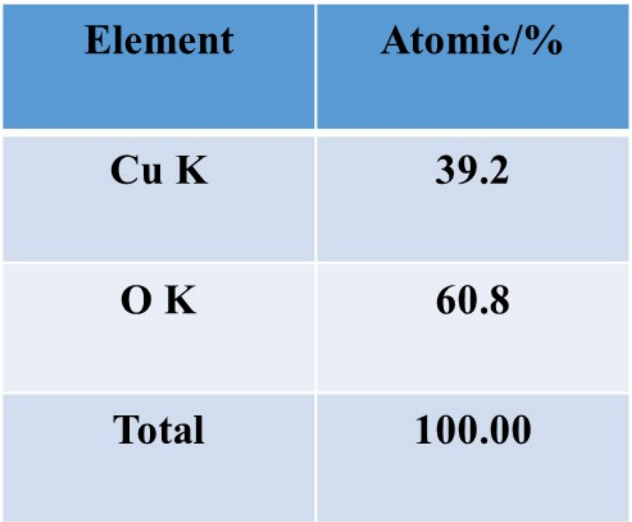


Figure S1 the digital photos of Cu foam after pretreatment(left) and CuO nanobelt coating(right)

Table S1 element atomic content of the surface layer of CuO nanobelt coating by XPS analysis.



Element	Atomic/%
Cu K	39.2
O K	60.8
Total	100.00

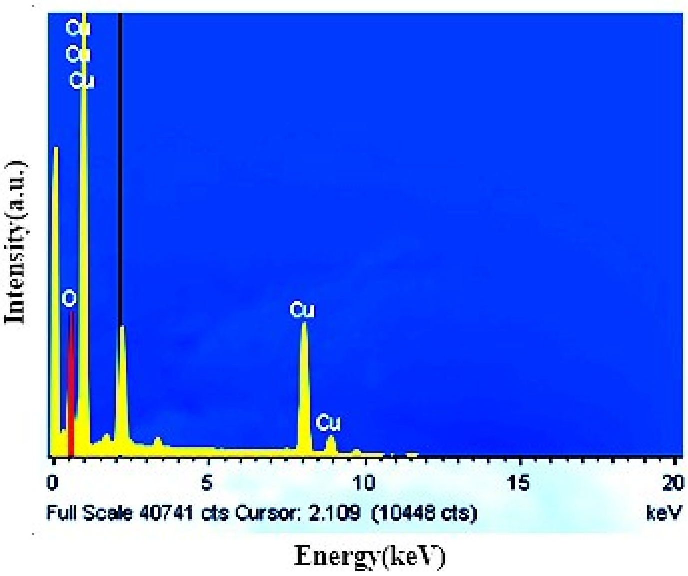


Figure S2 EDS test results of CuO nanobelt coating

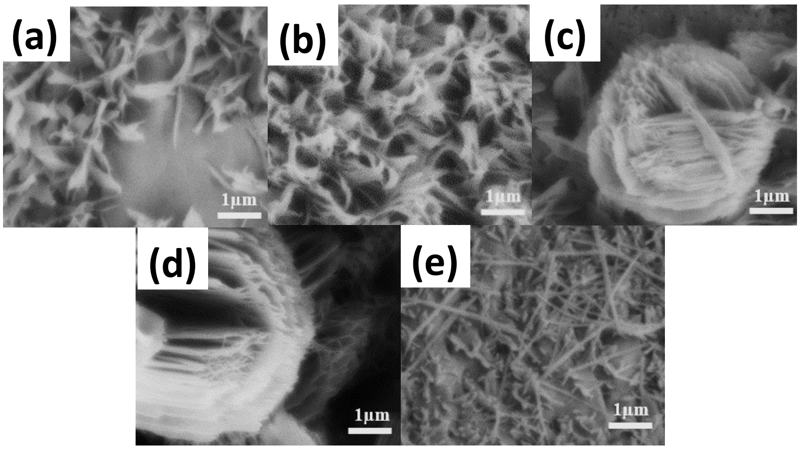


Figure S3 The influence of different reaction time on the morphology of CuO nanobelt coating (a) 5min (b) 10min (c) 20min (d) 40min (e) 80min

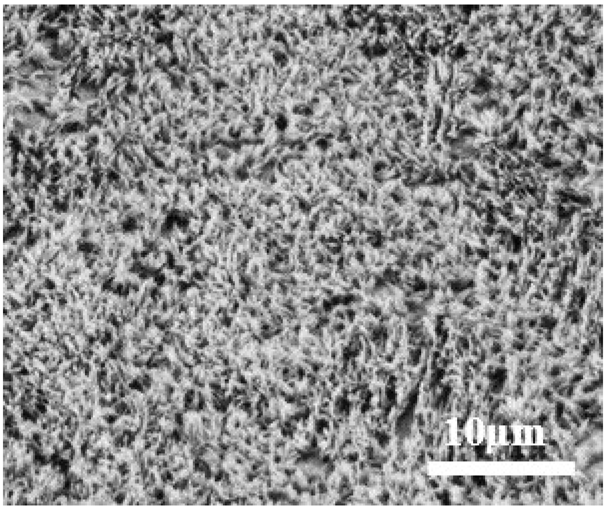


Figure S4 SEM image of CuO nanobelt coating after UOR stability test(15mA/cm^2×10h).

Supplementary METHODS

Calculation of electrochemically active surface area ($ECSA$)

According to the below equation:

$$C_{dl} = J_c \div \upsilon \quad \textbf{(1)}$$

The electrochemical double-layer capacitance C_{dl} of electrode is calculated.

The charge current J_c was derived from CV curves in the non-Faradaic capacitance current range. υ is the scan rate as shown in **Fig 4a**.

Fig 4b shows that C_{dl} value of CuO nanobelt/CF electrode is 8.38mF.

According to as-reported literatures, the electrochemically active surface area $ECSA$ of electrode is determined as the below equation:

$$ECSA = C_{dl} \div C_s \quad \textbf{(2)}$$

According to the literatures, the specific capacitance value of the sample C_s is 0.040 mF/cm^2, so the $ECSA$ of CuO nanobelt/CF electrode is 209.5cm^2.

Table S2. Summary of UOR catalysis activity of CuO nanobelt coating and as-reported UOR catalysts in 1M KOH+0.5M urea electrolyte

Catalyst	*j* [mA /cm^2]	potential (vs RHE)[V] @*j*	Tafel slope (mV /dec)	Substrate	Ref
CuO Nanobelt	10	1.39	28	CF	This work
	100	1.43			
Pt	10	1.50	-	Ti foil	*Chem. Commun., 2009, 32, 4859.*
Rhodium-Ni	10	1.47	-	Ni foil	*J. Appl. Electrochem. 2012, 42, 925*
r-NiMoO$_4$/NF	100	1.50	32.5	NF	*ACS Catal. 2018, 8, 1*
Ni$_2$P NF/CC	100	1.51	49	CC	*J. Mater. Chem. A, 2017, 5, 3208.*
Ni-Mo alloy	10	1.36	22	NF	*Nano Energy 2019,60,894*
	100	1.44			
MnO$_2$/MnCoO$_4$@Ni foam	10	1.33	72±0.94	NF	*J. Mater. Chem. A, 2017, 5, 7825.*
	100	1.44			
NF/NiMoO-Ar	10	1.37	19	NF	*Energy Environ. Sci., 2018, 11, 1890.*
	100	1.42			
NiCoP/CC	10	1.30	49	CC	*J. Mater. Chem. A, 2019, 7, 9078.*
	100	1.57			

S-MnO_2-G-NF	10	1.33	75	NF	*Angew. Chem. Int. Ed. 2016, 55, 3804.*
	100	1.47			
CoS_2-MoS_2	10	1.29	32	NF	*Adv. Energy Mater. 2018, 8, 1801775*
	100	1.33			

Note: Pt and Rhodium-Ni for UOR (electrolyte:5M KOH+0.33M urea)
NF: nickel foam,
CC: Carbon cloth
CF: copper foam

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