# Supplementary information

**Microwave-Assisted Hydrothermal Synthesis of Amino Acid-Loaded $Cu_2O$ Hybrid Particles for $CO_2$ Reduction Electrocatalysis**

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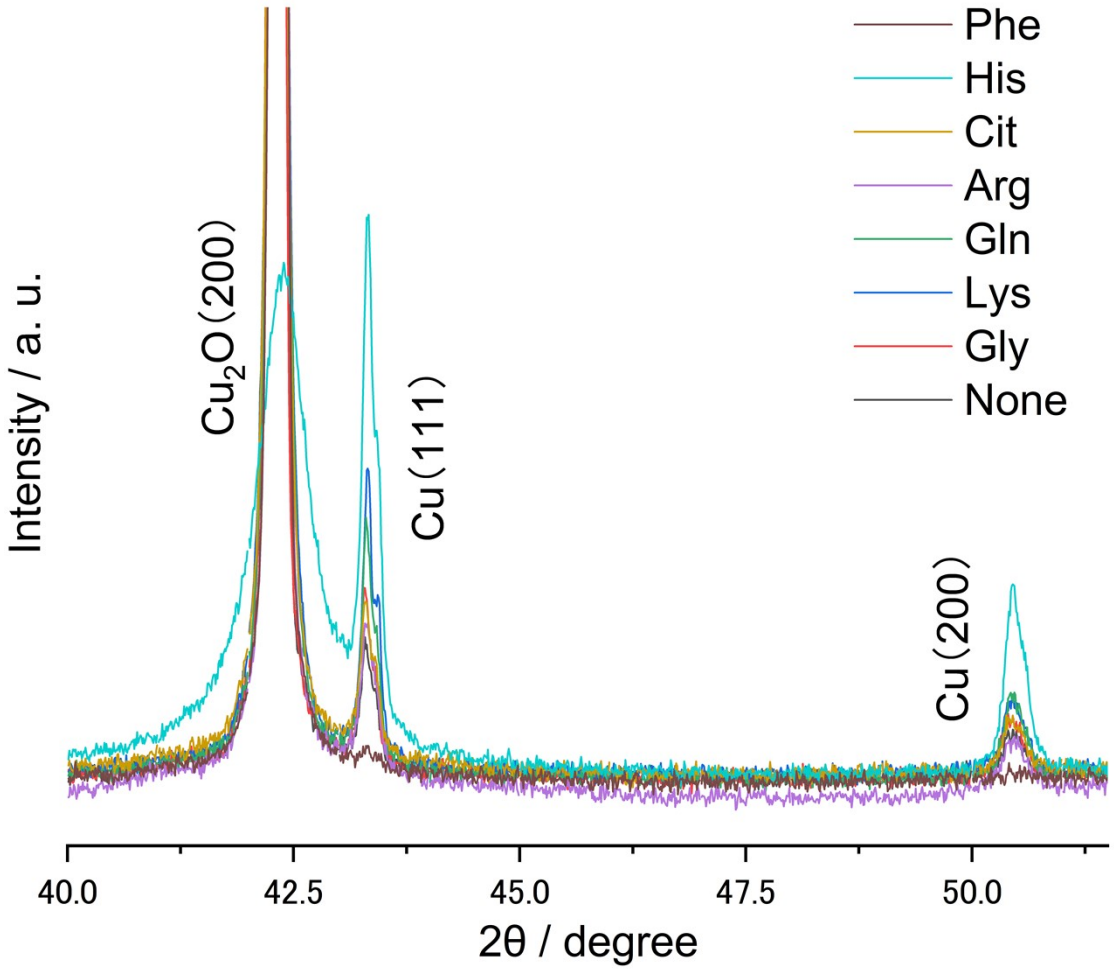


Fig. S1 Zoom-in XRD patterns in a 2$\theta$ range of 40.0–51.5°.

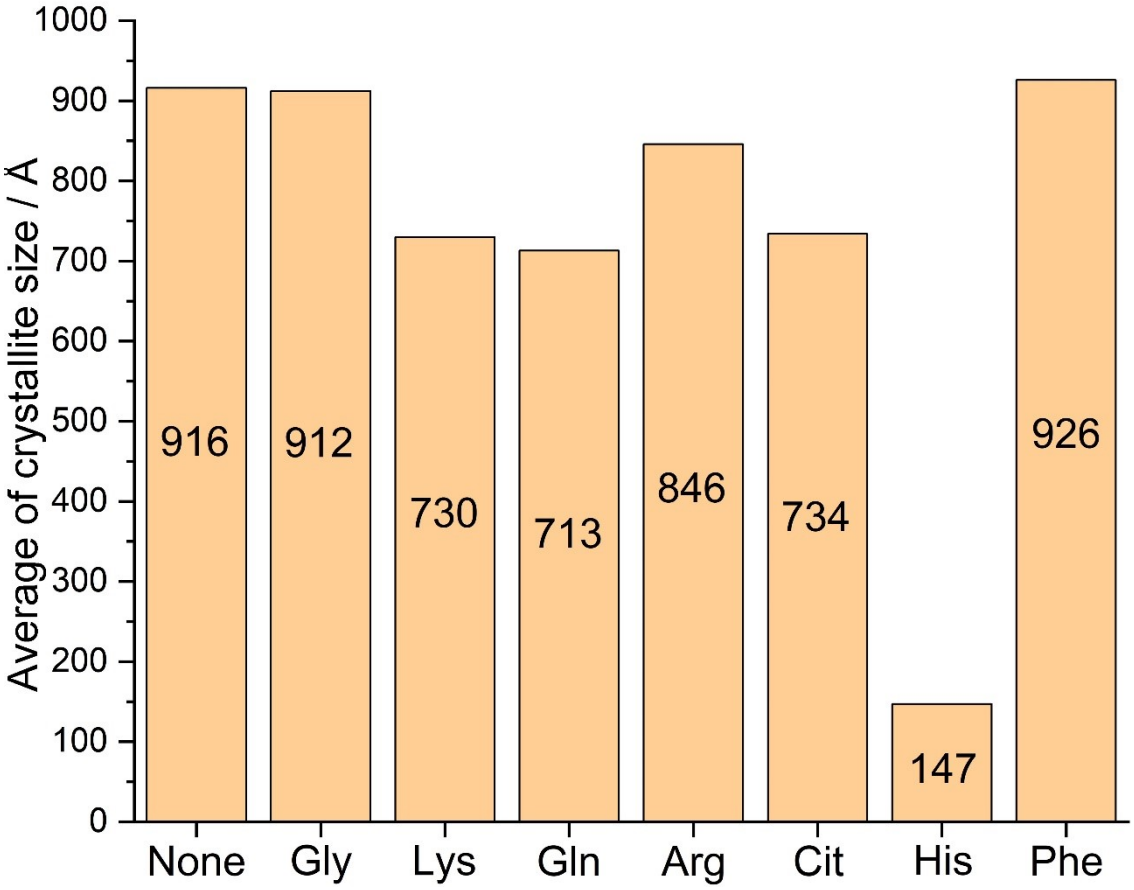


Fig. S2 Average crystallite size calculated by applying Scherrer equation for $Cu_2O$ (111) diffraction peak of the synthesized $Cu_2O$ with and without 5.0 mmol $dm^{-3}$ amino acids.

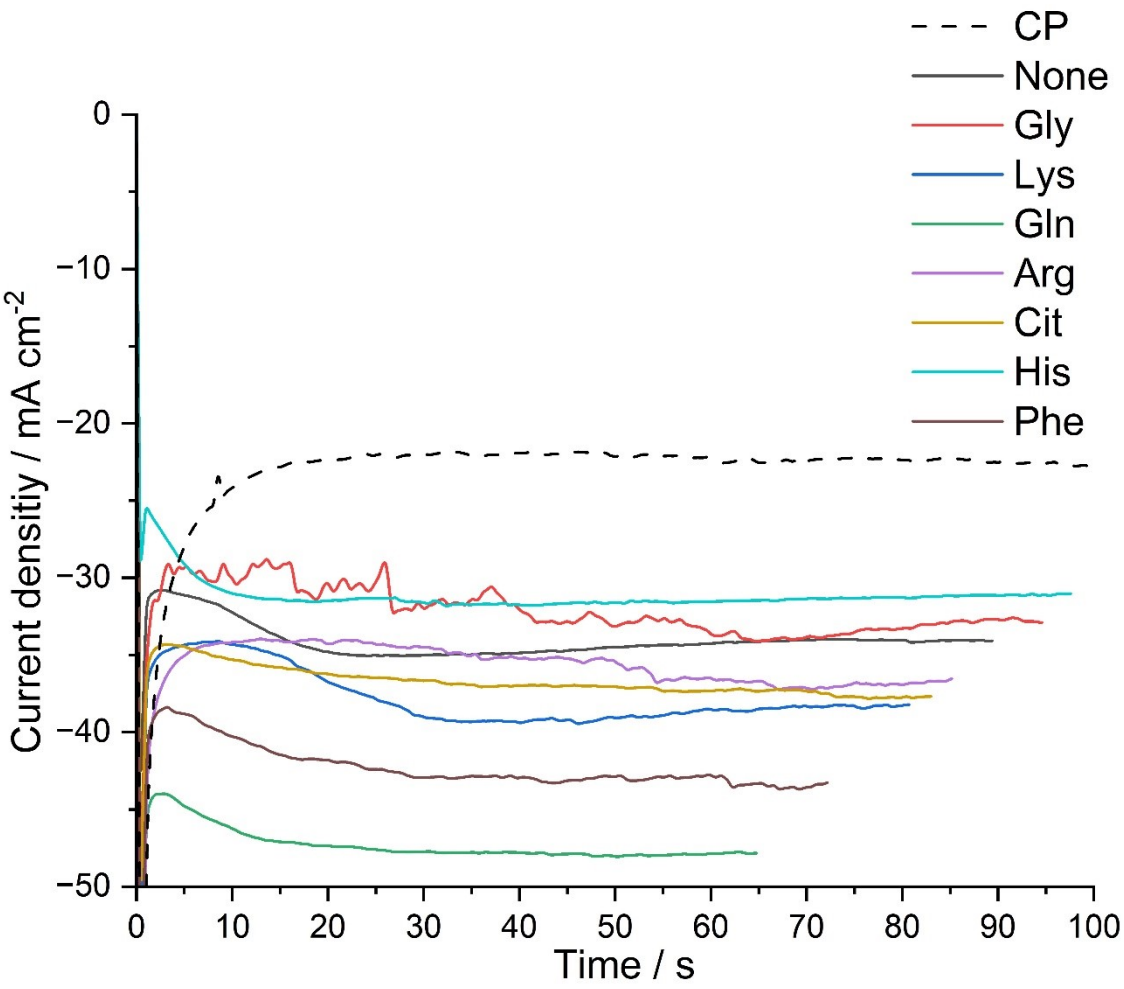


Fig. S3 Chronoamperogramas measured during $CO_2$ electrolysis under an applied potential of −1.27 V vs. RHE at 3.0 C in a $CO_2$-purged 0.5 mol $dm^{-3}$ aqueous $KHCO_3$ solution (pH ≈ 8.75) using unloaded and amino acid-loaded $Cu_2O$ electrodes synthesized with 5.0 mmol $dm^{-3}$ amino acids and CP with Nafion ionomer.

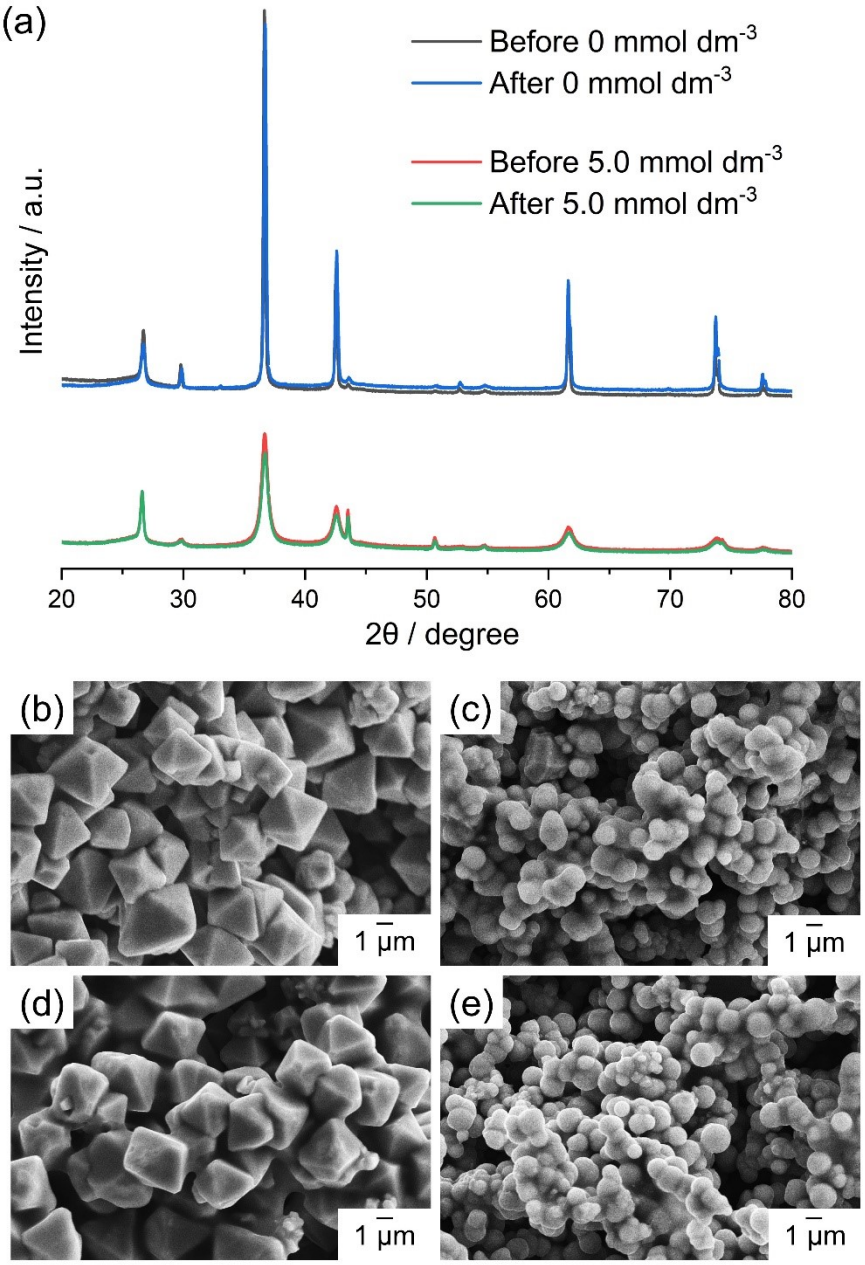


Fig. S4 XRD patterns (a) and SEM pictures of fabricated electrodes applied unloaded (b, d) and His-loaded $Cu_2O$ particles synthesized 5.0 mmol $dm^{-3}$ His (c, e) before (b, c) and after (d, e) $CO_2$ electrolysis.

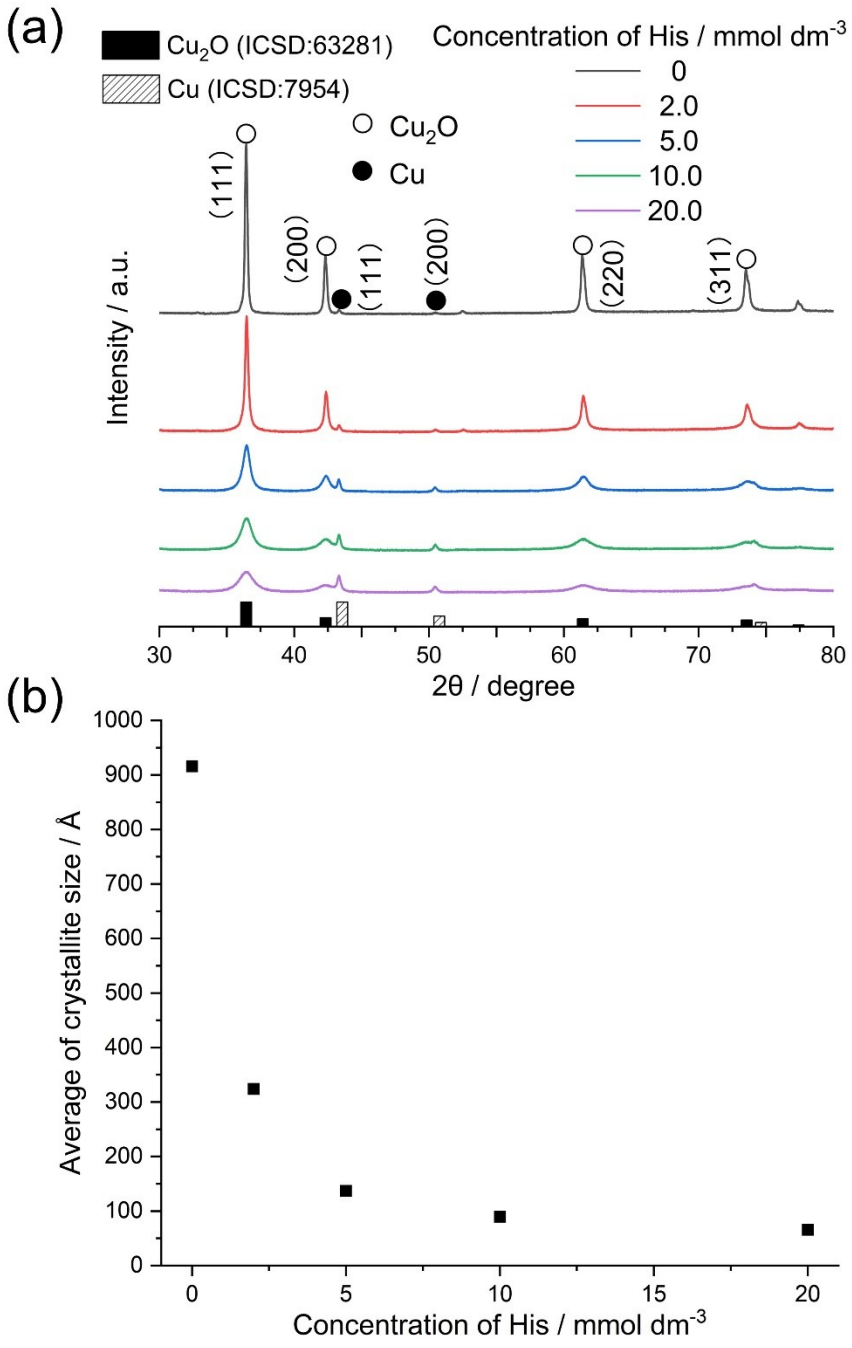


Fig. S5 XRD patterns and average of crystallite size of the His-loaded $Cu_2O$ hybrid partiles synthesized with 0, 2.0, 5.0, 10.0 and 20.0 mmol $dm^{-3}$ of His.

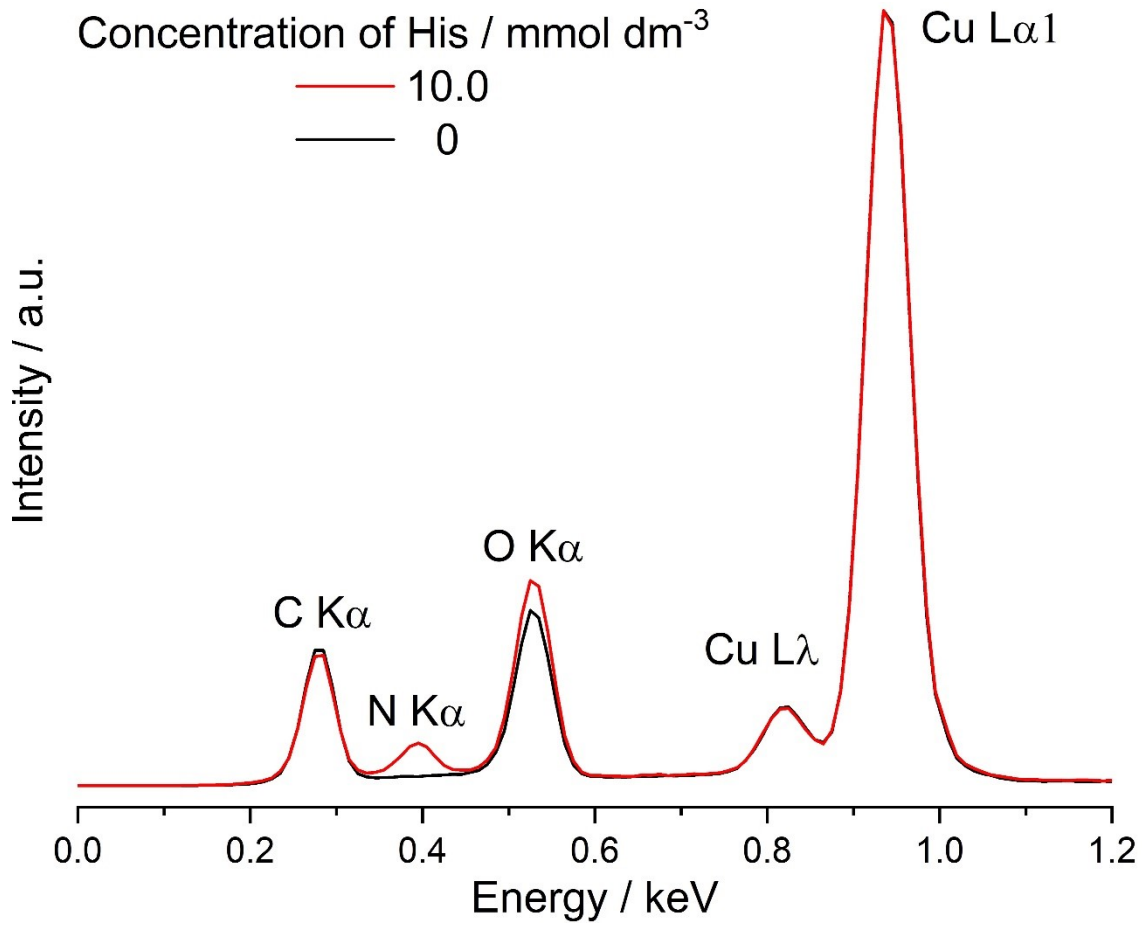


Fig. S6 EDS spectra of His-loaded $Cu_2O$ hybrid particles synthesized with 0 and 10 mmol $dm^{-3}$ L-His. Spectra were normalized to the intensity of the Cu Lα1 peak.

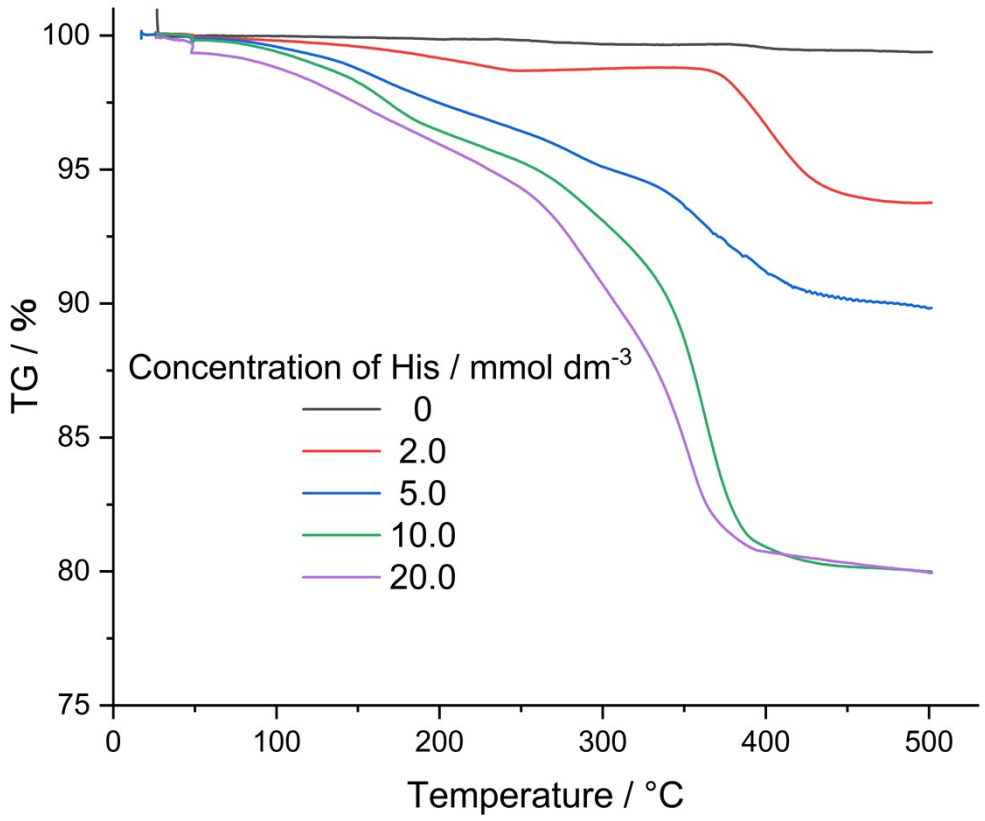


Fig. S7 TG curves of His-loaded $Cu_2O$ hybrid particles synthesized with 0, 2.0, 5.0, 10.0 and 20.0 mmol $dm^{-3}$.

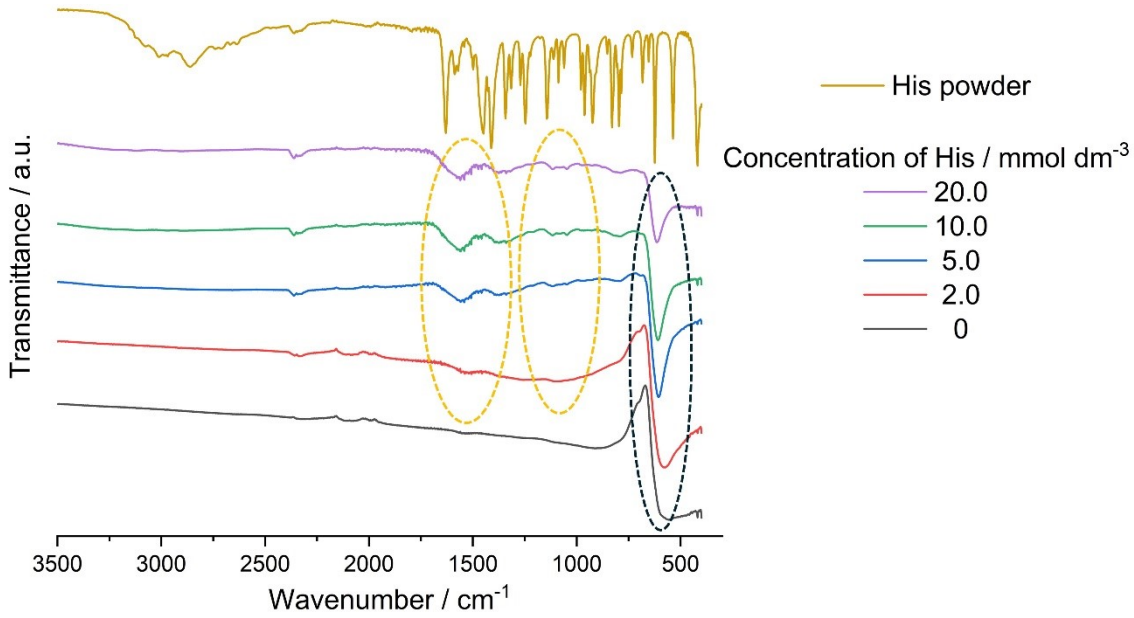


Fig. S8 IR spectra of His-loaded $Cu_2O$ hybrid particles synthesized with 0, 2.0, 5.0, 10.0 and 20.0 mmol $dm^{-3}$ of His and commercializing His powder. Black dashed circle means originated to $Cu_2O$ peaks and yellow ones are peaks appeared by loading His.

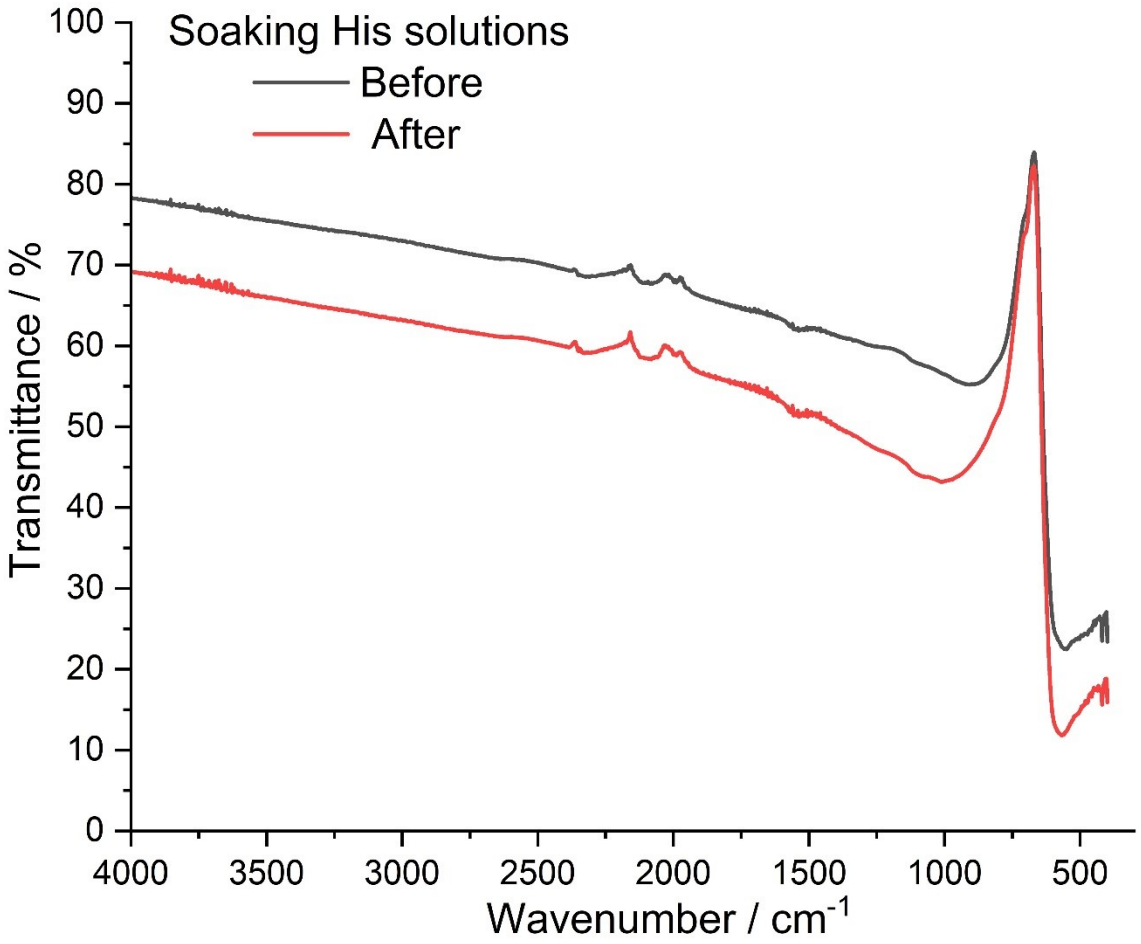


Fig. S9 FT-IR spectra of synthesized unloaded $Cu_2O$ before and after soaking 60 min in the 10.0 mmol $dm^{-3}$ His aqueous solutions.

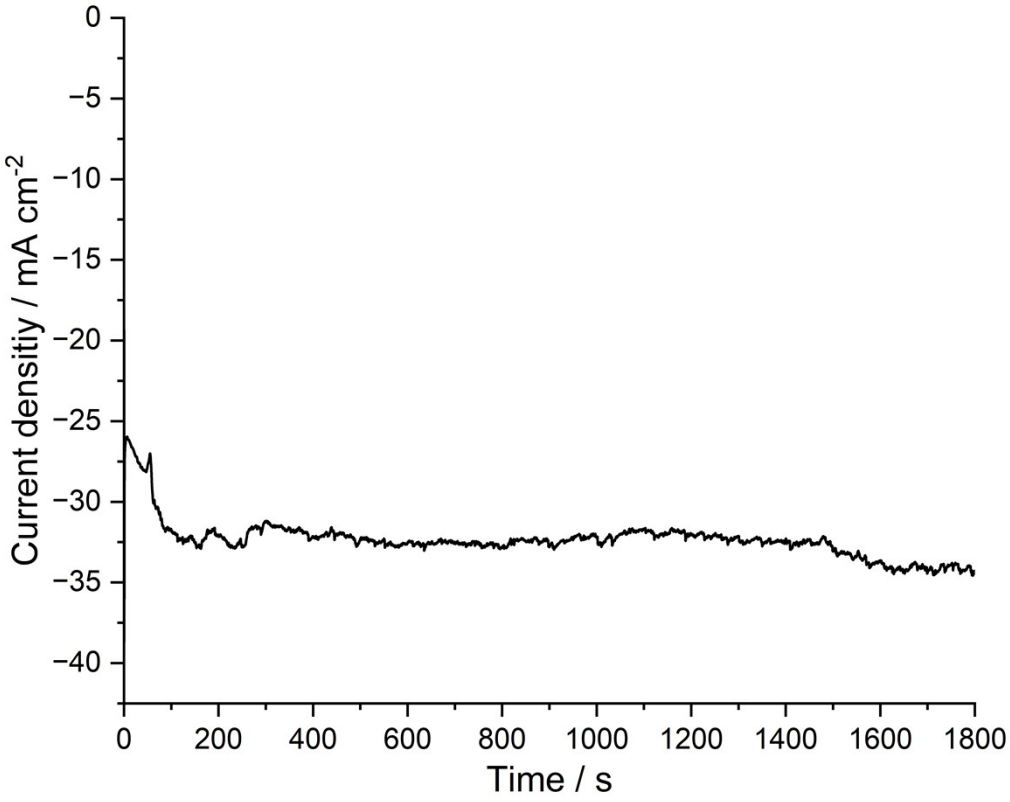


Fig. S10 Chronoamperogram during $CO_2$ electrolysis for 1800 seconds in a $CO_2$-purged 0.5 mol $dm^{-3}$ aqueous $KHCO_3$ solution (pH ≈ 8.75) using His-loaded $Cu_2O$electrocatalysis synthesized with 5.0 mmol $dm^{-3}$ His.