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Enhancing Hydrogen Generation via Overall Water Splitting Using Au-Modified CoP and CoFeP

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INTRODUCTION & AIM

- Overall water splitting (OWS) is a clean and sustainable route for hydrogen production, requiring efficient, stable, and low-cost bifunctional electrocatalysts for HER and OER in alkaline media.
- Transition metal phosphides (TMPs) are recognized as highly effective electrocatalysts due to their abundance of active surface sites, excellent electrical conductivity, and strong chemical stability. These characteristics are derived from the intrinsic high electrocatalytic activity of the metal (M) centers and phosphorus (P) sites.
- To further enhance their performance, gold (Au) nanoparticles can be anchored onto TMPs, creating composite materials with superior catalytic properties.
- **Research Objective:** This research aims to develop Au-decorated CoP and CoFeP coatings on copper (Cu) substrate via electroless deposition and galvanic displacement method, and to evaluate their bifunctional electrocatalytic activity for overall alkaline water splitting using Linear Sweep Voltammetry (LSV).

METHOD

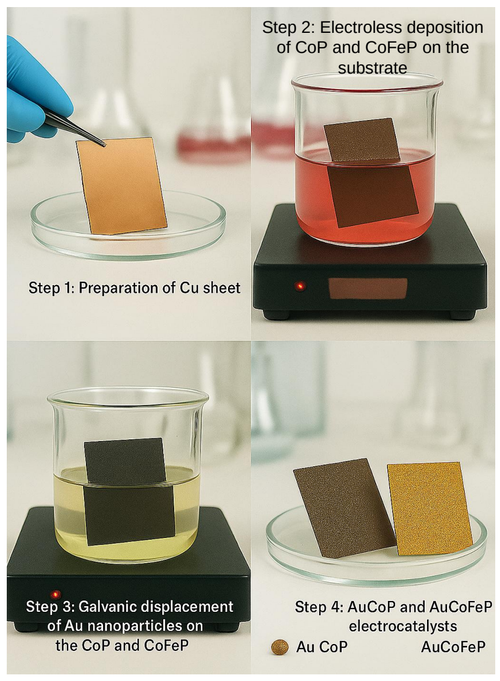

Table 1. Composition of plating baths and deposition parameters.

Coatings	Composition of the plating bath, mol L^{-1}				Deposition conditions		
	$CoSO_4 \cdot 7H_2O$	$NaH_2PO_2 \cdot H_2O$	$FeSO_4 \cdot 7H_2O$	Glycine	T, °C	*t*, min	pH
CoP/Cu	0.1	1.50	-	0.6	80	30	10.5
CoFeP/Cu	0.1	1.50	0.01	0.6	80	30	10.5

Table 2. Elemental composition of Co-based and Au-decorated coatings deposited on copper substrates, as determined by EDX analysis.

Catalyst	Wt. %			
	Au	Co	Fe	P
CoP/Cu	-	94.90	-	5.10
CoFeP/Cu	-	83.52	13.11	3.37
AuCoP/Cu	11.14	84.50	-	4.36
AuCoFeP/Cu	20.60	65.33	9.42	4.65

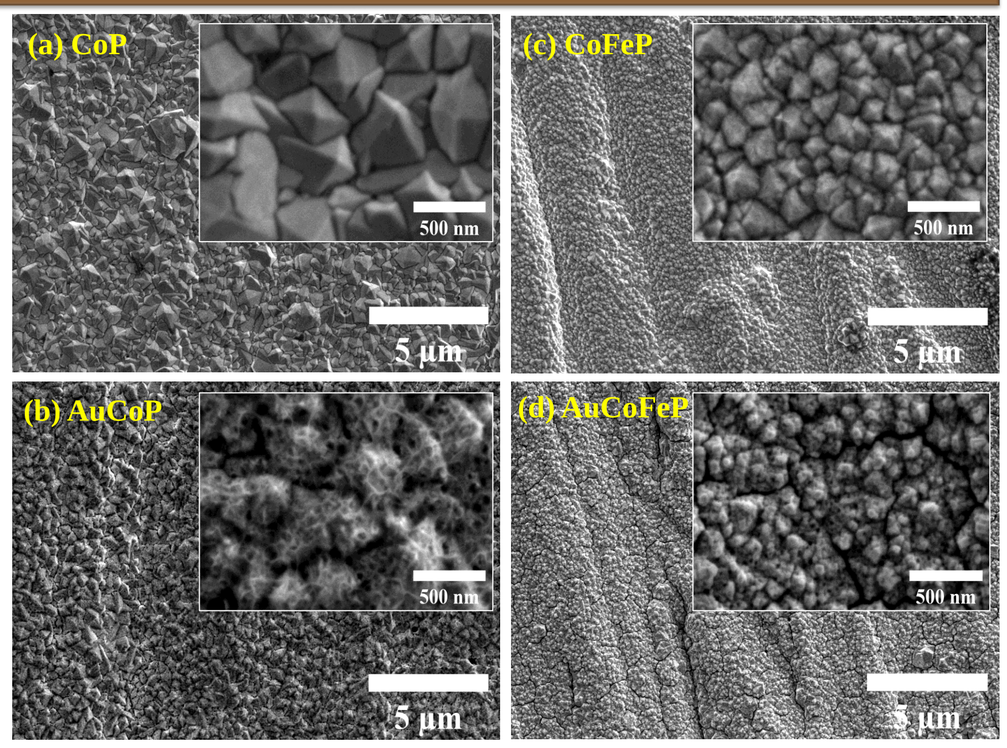

Fig. 1. The SEM images of CoP (a), AuCoP (b), CoFeP (c), and AuCoFeP (d) catalysts deposited on the Cu surface.

RESULTS & DISCUSSION

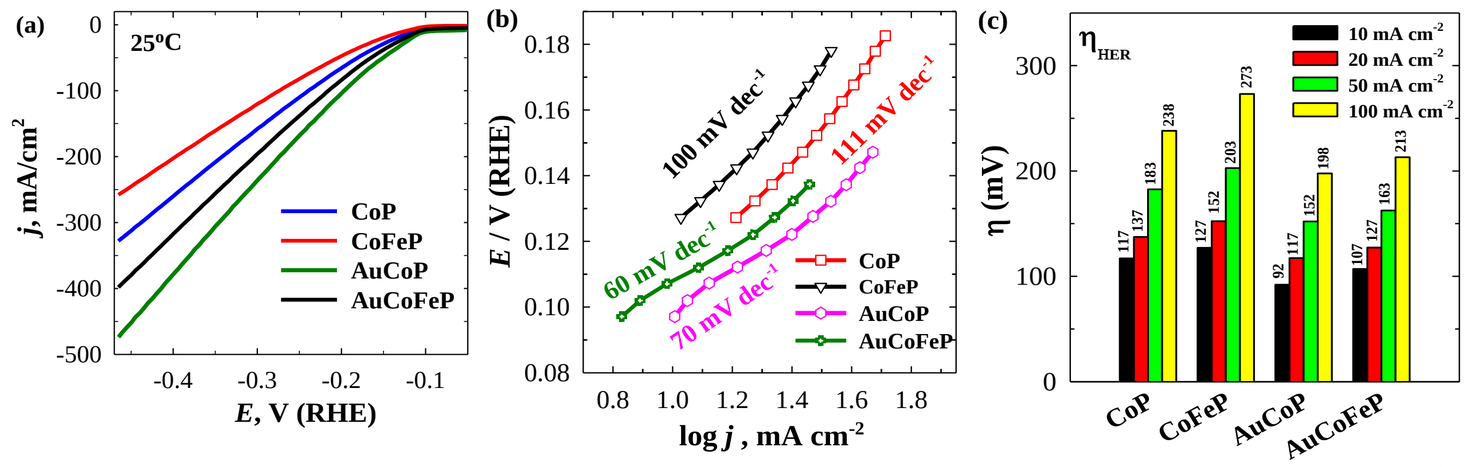

Fig. 2. The HER polarization curves recorded on catalysts in 1 M KOH solution at a potential scan rate of 5 mVs^{-1} and 25 °C temperature **(a)**. The corresponding Tafel slopes **(b)**. Bar columns of the corresponding overpotentials at 10, 20, 50, and 100 mA cm^{-2} **(c)**.

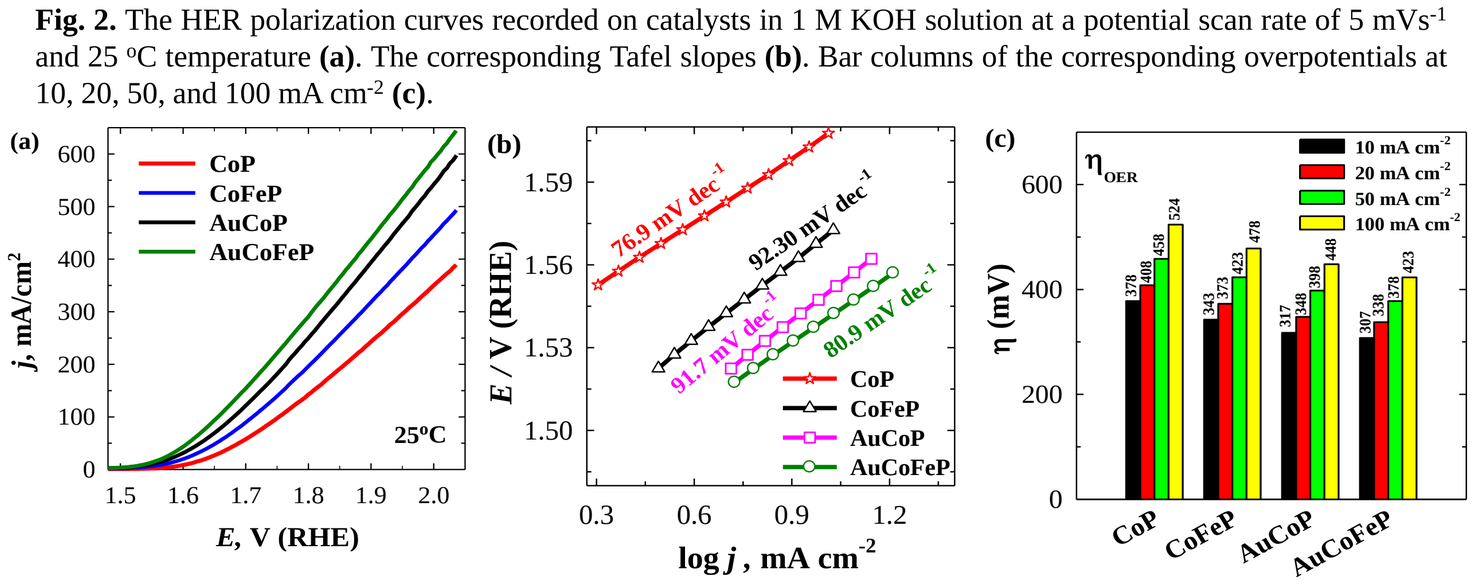

Fig. 3. The OER polarization curves recorded on catalysts in 1 M KOH solution at a potential scan rate of 5 mVs^{-1} and 25 °C temperature **(a)**. The corresponding Tafel slopes **(b)**. Bar columns of the corresponding overpotentials at 10, 20, 50, and 100 mA cm^{-2} **(c)**.

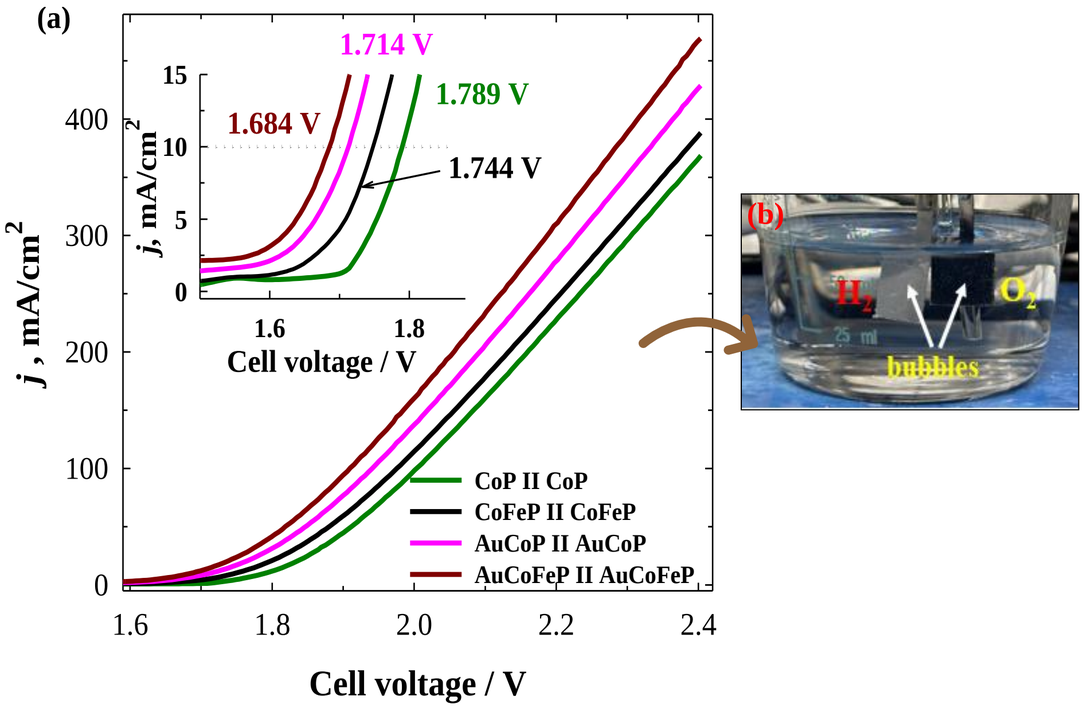

Fig. 4. Polarization curves of the CoP, CoFeP, AuCoP, and AuCoFeP catalysts as both anode and cathode for overall water splitting performance in the two-electrode setup at the scan rate of 5 mV s^{-1} **(a)**. Photograph of OWS on Co-based catalysts as cathode and anode **(b)**.

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CONCLUSION

- **HER activity:** AuCoP/Cu exhibited the lowest overpotential (92 mV at 10 mA cm^{-2}, 25 °C), confirming its superior hydrogen evolution activity.
- **OER activity:** AuCoFeP/Cu showed the lowest overpotential (307 mV at 10 mA cm^{-2}, 25 °C), establishing it as the most efficient OER catalyst in the series.
- **Overall water splitting:** The electrolyzer using AuCoFeP as both cathode and anode achieved 10 mA cm^{-2} at 1.684 V, outperforming AuCoP due to the synergistic effect of Co, Fe, and Au.
- **Summary:** The Au-decorated CoP and CoFeP catalysts demonstrate excellent bifunctional electrocatalytic activity, combining low overpotentials, high efficiency, and strong stability. These properties make them promising candidates for sustainable hydrogen production and clean energy applications.