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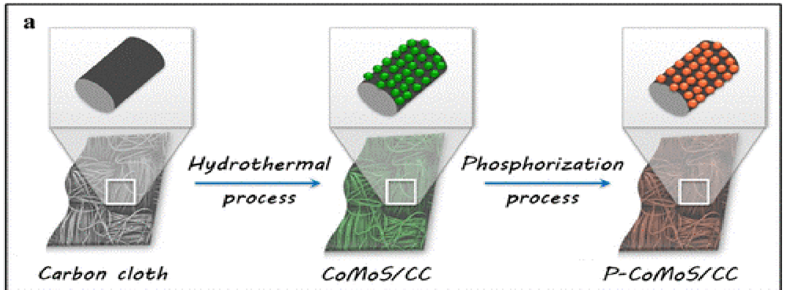
Introduction

The increasing demand for energy, coupled with the depletion of nonrenewable resources, has spurred research into renewable energy alternatives. Molecular hydrogen (H2) stands out as a sustainable energy source, particularly through water electrolysis, offering a secure and eco-friendly means of hydrogen fuel production. However, the high cost and scarcity of conventional catalysts like Pt/C and RuO2 hinder widespread adoption. To address this challenge, extensive efforts have focused on developing low-cost alternatives, including transition-metal-based compounds like MoS2 and CoP, as well as bimetallic nanomaterials. These materials offer improved catalytic performance and tunable properties. Nano structuring techniques further enhance catalyst efficiency by increasing surface area and conductivity. Here, we present a novel approach for fabricating a highly efficient water-splitting catalyst, phosphorus-incorporated cobalt molybdenum sulfide (P-CoMoS) nanocomposites on carbon cloth (CC). Through a two-step synthesis process, we achieve strong catalytic activity and durability, as demonstrated by superior performance in both hydrogen and oxygen evolution reactions. This innovative electrode design holds promise for advancing water electrolysis technology towards sustainable energy production.

Experimental Section

The P-CoMoS/CC nanohybrid was fabricated via a two-step synthesis protocol. In the first step (synthesis of CoMoS/CC), 2.5 mmol CoCl2·6H2O, 2.5 mmol Na2MoO4·2H2O, and 6.0 mmol thioacetamide (TAA) were dissolved in 50 mL of deionized (DI) water. In the second step, the P-CoMoS/CC was obtained after the phosphorization process. The CoMoS/CC and 0.25 g of NaH2PO2·H2O were placed at two separate positions in a porcelain crucible, with NaH2PO2 and CoMoS/CC at the upstream and downstream sides of the tube furnace, respectively.



Results and discussion

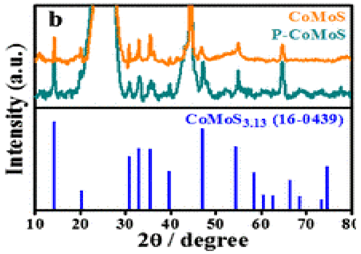


Figure-1

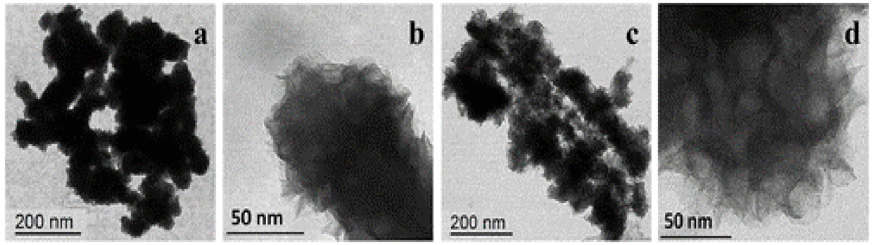


Figure-2

From the **figure 1** XRD confirms that peaks of CoMoS and P-CoMoS **Figure 2** shows Low- and high-magnification TEM images of (a,b) CoMoS and (c,d) P-CoMoS

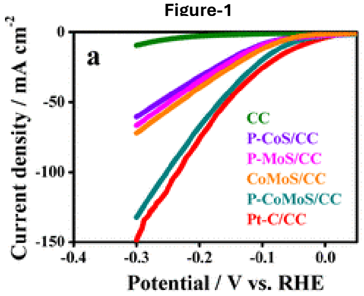


Figure-3

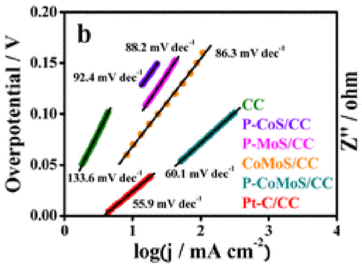


Figure-4

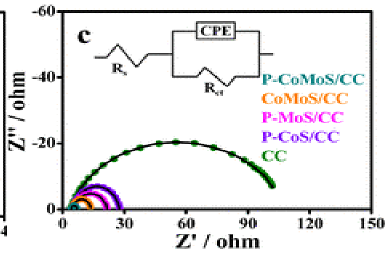


Figure-5

Figure (3,4,5) shows HER Polarization curve of P-CoMoS/CC recorded at 2 mV s−1 scan rate in 1.0 M KOH medium. The corresponding curves of Pt/C, CoMoS, P-CoS, P-MoS, and CC are presented for comparison. LSV curve-derived Tafel plots of the electrocatalysts. EIS Nyquist plots and fitting curves of the catalysts at -0.2 V vs RHE.

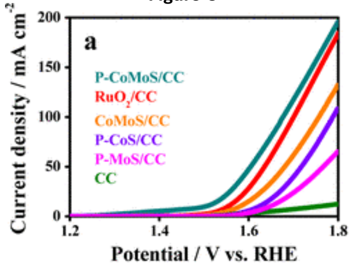


Figure-6

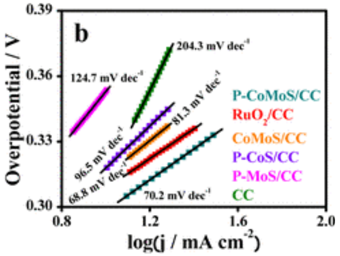


Figure-7

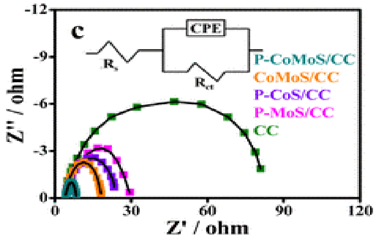


Figure-8

Figure (6,7,8) shows OER Polarization curve of P-CoMoS/CC recorded at 2 mV s−1 scan rate in 1.0 M KOH medium. The corresponding curves of Pt/C, CoMoS, P-CoS, P-MoS, and CC are presented for comparison. LSV curve-derived Tafel plots of the electrocatalysts. EIS Nyquist plots and fitting curves of the catalysts at 1.50 V vs RHE.

Conclusion

In summary, a highly efficient electrode for water splitting was developed by adjusting the cation/anion ratio, resulting in P-CoMoS/CC electrode with exceptional performance in both HER and OER. The improved catalytic activity and stability are attributed to unsaturated metal-based active sites and phosphorus substitution. With easy fabrication, low overpotential (η10 as low as 1.54 V), and excellent stability over prolonged electrolysis, the P-CoMoS/CC electrode shows promise for practical application in overall water splitting.

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References

- https://doi.org/10.1021/acsami.7b11192
- https://doi.org/10.1021/acs.chemrev.3c00005

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Abstract