Facile Synthesis of HEA-250Ni as Active Electrocatalyst for Water electrolysis

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Background

In order to meet the challenge of climate change and solve the climate crisis, countries all over the world are making commitments and efforts to achieve carbon neutrality as soon as possible. As a clean and carbon free secondary energy, hydrogen energy can not only make up for the energy storage problems of photovoltaic power generation and wind power generation, but also play a vital role in transportation and industrial production.

In this study, the oxygen evolution electrode catalyst HEA-250Ni (250mM $NiSO_4$ solution) was synthesized based on high entropy alloy (HEA) by a simple corrosion engineering. It was found that the HEA-250Ni only needs the overpotentials as low as 247, 313 and 362 mV to reach the current densities of 10, 50 and 100mA·cm-2, respectively. It has good stability and better performance than the current commercial oxygen evolution electrode catalyst ruthenium dioxide (RuO_2).

In addition, the innovative preparation method of high entropy alloy electrode catalyst prepared by 3D printing technology and corrosion engineering also opens up a new way for industrial mass production.

Principle

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$$\overset{+1\ -2}{2H_2O} \xrightarrow{\triangle catalyst} \overset{0}{O_2}\uparrow + \overset{0}{2H_2}\uparrow$$

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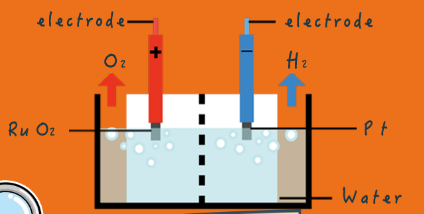
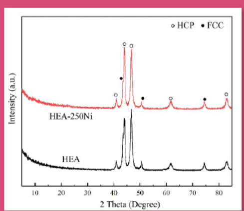


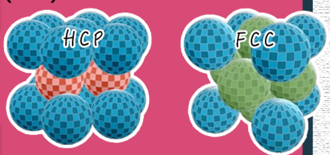
Preparation

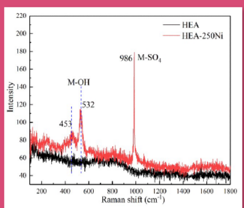
The the bulk $Fe_{50}Mn_{30}Co_{10}Cr_{10}$ (molar ratio) high entropy alloy(HEA) was prepared by 3D printing. Then they were cut into small bulk, and were put into a solution of 250 mmol/L nickel sulfate ($NiSO_4$) for reaction, and after 24 h, the materials were removed and cleaned and oven dried. Labeled as HEA-250Ni.

Characterization

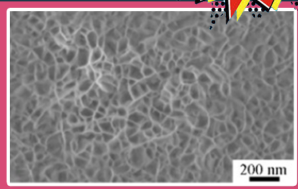


The X-ray Diffraction results show the composition of the HEA-250Ni is composed of hexagonal close-packed (HCP) and face-centered cubic (FCC).

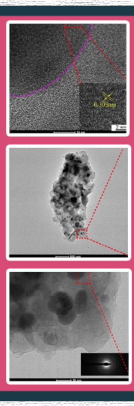


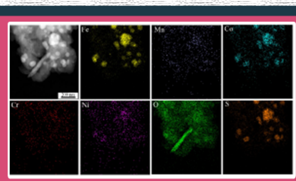


The Raman results show that the surface of the HEA-250Ni is mainly composed of the hydroxides and the residual sulfate.



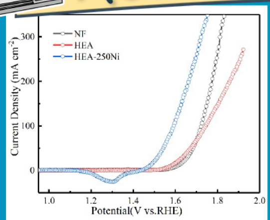
The Scanning Electron Microscope shows that the nanostructures on the surface of HEA-250Ni were composed of nano honeycomb which provides rich specific surface area and active sites.



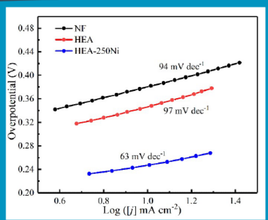


The Transmission Electron Microscope shows that the nanosheets are mainly polymetallic hydroxides and the nanoparticles are residual polymetallic sulfates.

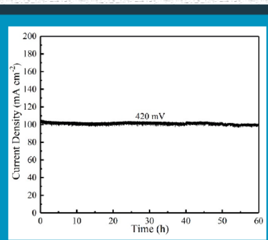
Measurment



The Linear Sweep Voltammetry shows that HEA-250Ni has the best catalytic activity, with the overpotentials as low as 247, 313, and 362 mV, reaching 10, 50, and 100 mA cm-2.



The Tafel slope shows that HEA-250Ni has a lower Tafel slope of 63 mV·dec-1. It means that the HEA-250Ni has excellent electrocatalytic activity for oxygen evolution reaction.



At a constant overpotential of 420mV, HEA-250Ni maintained a current density of 100mA/cm2 for over 60 hours. It indicating that HEA-250Ni material has very good stability.

Conclusion

We provide a simple and low-cost preparation method for large-scale preparation of electrocatalysts, and through this method, electrode materials with excellent electrocatalytic performance have been prepared. We believe that this new preparation method will improve the efficiency of water electrolysis for hydrogen production, reduce the cost of industrial hydrogen production, make water electrolysis hydrogen production the mainstream of industrial hydrogen production, truly realize green hydrogen production, and contribute to the realization of "zero carbon production" in my country.

謝謝
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