Rational Design of Carbon-Supported Tungsten Carbide Electrocatalysts for pH-Universal Hydrogen Evolution Reaction

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Dihydrogen (H_2) is a clean energy carrier and sustainable alternative to traditional fossil fuels for meeting future energy demands.[1] However, around 95% of global H_2 comes from the steam reforming process, leading to greenhouse gas emissions.[2] The development of new routes toward generating carbon-free H_2 is a major challenge to be addressed for a successful hydrogen economy.[3] Electrochemical water splitting is a promising approach to produce eco-friendly H_2 involving a hydrogen evolution reaction (HER) at the cathode and an oxygen evolution reaction (OER) at the anode, utilizing renewable energy sources such as wind or solar power.[3] In recent years, remarkable efforts have been made to replace expensive noble metal-based electrocatalysts (Pt/Pd for HER and IrO_2/RuO_2 for OER).[4] Transition-metal carbides (TMCs) have been explored as alternatives, particularly tungsten carbide (WC) is known for its Pt-like catalytic properties due to similar d-band electronic density of states and has been explored as earth-abundant alternative electrocatalysts for HER in both acid and alkaline conditions.[5]

Herein, we report on a facile approach to prepare carbon-supported WC electrocatalyst on nickel foam (NF) from the thermal reduction of a sucrose-impregnated self-deposited tungsten trioxide (WO_3) precursor.[6] Different sucrose concentrations and reduction temperatures were tested to achieve an optimized material exhibiting the best electrocatalytic efficiency for HER in the full pH range. The optimal electrocatalyst (WC@C/NF) was obtained from the precursor impregnated with 50% sucrose and thermally reduced at 800°C. WC@C/NF requires low overpotentials of 0.124, 0.208, and 0.298 V to achieve a current density of -10 mA/cm^2 in alkaline, acidic and neutral pH respectively. Furthermore, WC@C/NF was found to be stable during controlled-current density electrolysis tests for 40 h. The presence of excess amorphous carbon embedding WC was beneficial to improve the conductivity and the dispersibility of the electrocatalyst, and consequently its HER activity. Our findings demonstrate that robust and efficient WC-based binder-free HER electrocatalysts can be produced easily from spontaneously deposited WO_3 film and sugar as the carbon/carbide source.

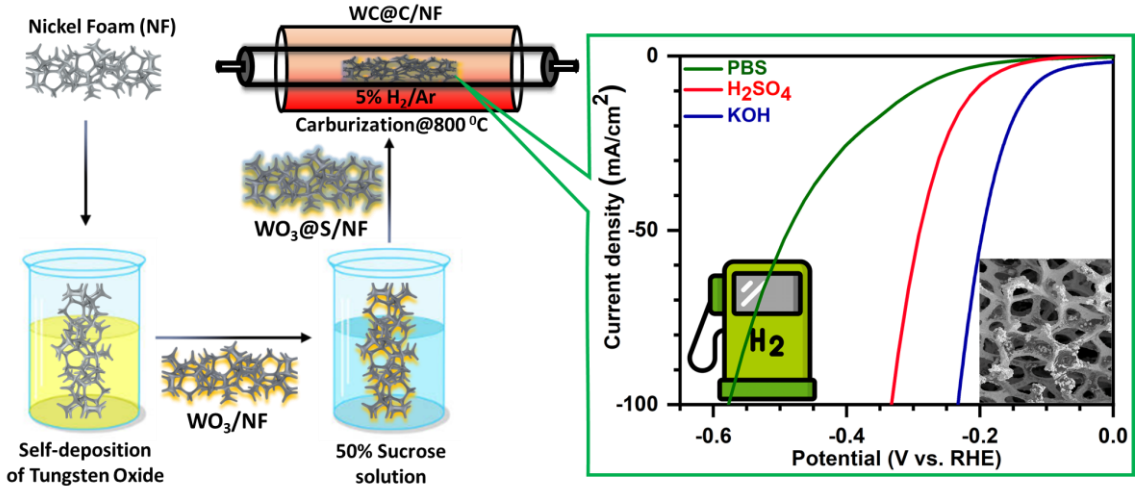

Figure. Scheme showing the workflow from synthesis to the electrocatalytic activity for HER.

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