Bi-Functional MOF-Based Electrocatalyst for Efficient and Cost-Effective Hydrogen Production From Seawater

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The interest in green hydrogen, produced from water, as a clean and efficient alternative to fossil fuels is hampered by the high cost of production and the need for desalinated water sources. Seawater makes up 96.5% of water reserves on the planet, presenting an abundant and largely untapped resource for hydrogen production. Efficient seawater electrolysis necessitates a robust, anti-corrosive, chlorine-impermeable catalyst that withstands seawater's harsh conditions. Herein, a novel modification of a zirconium and trimesic acid metal-organic framework, MOF-808, was developed to produce hydrogen directly from seawater. Iron (Fe) and reduced graphene oxide (rGO) were incorporated in situ into the MOF to enhance its electrocatalytic performance and stability. Several ratios of rGO@Fe@MOF-808 were synthesized solvothermally using DMF as the solvent and formic acid as the crystal modulator. The samples were characterized using XRD, SEM-EDX, TEM, and FTIR. The composite featured rGO sheets as scaffolds for Fe@MOF-808 nucleation growth. The best performance was achieved with a 0.05:1:4 (rGO:Fe:Zr) optimized molar ratio, reaching a current density of 10 mA/cm2 at 95 mV for the HER and 22 mA/cm2 at 1.5 V for the OER with a stability of 80 hours of seawater electrolysis. Compared to the benchmarked catalysts, this catalyst is 18% more efficient and 17 times less expensive than Pt for the HER, and 284% more efficient and 180 times less expensive than IrO2 for the OER. Titration tests indicated nearly-zero interference with hypochlorite evolution, confirming the catalyst's chloride-impermeability. This modification is expected to potentially unlock seawater resources for direct hydrogen production in industrial electrolyzers near the sea, thereby contributing to a greener planet.

Awards Won:

First Award of $5,000