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Enabling Efficient Water Splitting with Advanced Materials Designed for High pH Membrane Interface

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Abstract

This research focuses on durable, high-performance materials and interfaces for advanced water splitting, enabling a clear pathway for achieving $<\$2/Kg_{H_2}$ (on scale) via anion exchange membrane (AEM)-based electrolysis. We aim to advance this goal via an improved fundamental understanding of both hydrogen and oxygen evolution reactions (HER/OER) leading to platinum group metal (PGM)-free catalyst materials. Here, we use NiFeCo and NiMo as OER and HER catalysts, respectively, in a full alkaline electrolysis cell. A thermally stable, multi-cation AEM is used to operate the cell at elevated temperatures thereby lowering the operating potential by increasing the kinetics of the respective catalytic reactions. The transition metal catalysts, paired with this novel AEM, have been used to achieve an operating potential of 1.79 V at 1 A/cm^2. This potential is 300 mV lower than similar electrolysis cells equipped with PGM-based catalysts. We have also demonstrated the efficacy of the less caustic potassium carbonate solution as a replacement for potassium hydroxide as an electrolyte. By using a carbonate-based electrolyte, the hydroxide ion required for the anodic reaction is continuously replenished by re-establishing an equilibrium with water. This consideration, coupled with the reduced alkalinity of the carbonate solution, yields an electrolysis cell capable of sustained operation with minimal increase in operating potential.