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Commercial anion exchange membrane water electrolyzer stack through non-precious metal electrocatalysts

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ABSTRACT

Ni-based electrocatalysts for replacement of precious metal electrocatalyst, the cathode materials of anion exchange membrane water electrolyzer (AEMWE), are seriously unstable and low activity at hydrogen production conditions. This study develops a high-performance, durable non-precious metal electrocatalyst for AEMWE, which show improved activity and durability. First, Ni/C was alloyed with Co and supported on carbon cloth coated with microporous carbon layer to improve the electrocatalytic activity of the hydrogen evolution reaction (HER) electrocatalyst; then, oxide (Ni/Co-O) was locally formed on the synthesized NiCo/C to increase its activity and durability. Specifically, this oxide increased the coverage of OH^- ions, formed hydrogen spillover channels, and promoted the HER. Further, its improved electrochemical durability was attributed to the high bond dissociation energy of the metal oxide. The electrocatalyst was also evaluated as the cathode in single-cell (1-cell) and stack cell (5-cell) AEMWE systems to demonstrate that this superior performance would translate to the commercial scale.

1. Introduction

As the hydrogen production paradigm shifts from grey hydrogen using fossil fuels to green hydrogen without carbon emission using renewable energy and water electrolysis technology [1–4]. Thus, water electrolysis is becoming increasingly popular as a method for producing hydrogen from water [5,6]. Accordingly, the importance of further developing this technology is increasing. Water electrolysis only requires electricity and water, and utilities without balance of plant are less complicated than fuel cells; however, the development of highly efficient, low-cost water electrolysis technology is key to its wide deployment. The water electrolysis systems that are currently used are alkaline water electrolyzers (AWEs) and proton exchange membrane water electrolyzers (PEMWEs) [7–11]. AWEs are already on the market and have been proven to be commercially feasible owing to their advantages of high technology intensity and ease of use [12]. However, owing to the use of a liquid electrolyte, there have disadvantages such as low efficiency and corrosion problems caused by high concentration of alkaline media solutions (e.g., KOH), leakage problems, and difficulties in operating under high pressure and facility maintenance [7,13]. In contrast, PEMWEs, which are based on a solid electrolyte, are excellent in terms of their high efficiency and stability, and above all, the high purity hydrogen they provide [14,15]. In addition, they enable high-pressure charging. However, because these systems operate in an acidic media, they require expensive precious metal catalysts used, so problems with cost continue to arise [14]. Anion exchange membrane water electrolyzers (AEMWEs) have been developed to simultaneously overcome the shortcomings of AWEs and PEMWEs [16–18].

AEMWEs combine the electrode reaction of AWEs and the structure and operation scheme of PEMWEs and are an aggregate of various scientific technologies such as electrocatalysts, membranes, electrode reactions, and membrane electrode assembly processes [19,20]. In

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