Alkaline electrolyser for green hydrogen production: the nickel-based catalyst and separator

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Hydrogen is a fuel that is able to replace fossil fuels unavailable naturally on the earth. However, it must be produced from a renewable source to replace fossil fuels. Hydrogen, also a feedstock for industry, is produced mostly by steam-forming natural gas, resulting in high CO_2 emissions. The fact that global warming is becoming visible and that energy demands must be addressed without releasing carbon dioxide into the atmosphere emphasizes the importance of the world's energy transition. Hydrogen in this energy transition has the potential to meet expectations as an energy carrier. It can be produced by electrolysis of water. Hydrogen production from the water will be possible with large electrolysis systems without carbon dioxide emission from renewable sources. Green hydrogen will have a wide range of uses, such as industry, transportation, heating, and power generation. In the hydrogen roadmap of the European Union, establishing at least 6 GW of renewable hydrogen (green hydrogen) electrolysers until 2024 has been determined as a strategic target [1]. The average investment cost of alkaline electrolysers, whose technology has been known since the 1800s, is 840 USD/kW. It is predicted to be 200 USD/kW in 2050 [2]. It is crucial for governments to develop and advance this technology using their own resources, especially in regard to their strategic objectives to build large-scale electrolysers all over the world. In particular, alkaline electrolysers with known technology are widely used due to the absence of the need for noble metal catalysts.

Anion exchange membrane (AEM) electrolyzers, which require lower electrolyte concentrations, draw attention for large electrolyzer plants due to developing anion exchange membranes. The most crucial parts of alkaline and AEM electrolysers for improving performance and lowering costs are the membrane, electrode, diaphragm and catalyst [2].

Catalysts and electrodes for alkaline electrolytes can be prepared nickel based instead of platinum group metals. Alkaline water electrolysis is an old technology using nickel-based transition metals catalysts. One of the most serious problems in this system is the degradation of the components and electrodes in the concentrated solution[3]. The development of ion-conducting solid electrolyte polymer membranes has received a lot of attention recently in an effort to solve these issues. Nafion®, which is the most used of these materials, is preferred as a membrane due to its thermal, chemical and mechanical stability. Nafion® is currently used in commercial proton exchange membrane (PEM) electrolysers and PEM fuel cells. However, PEM electrolysers have some drawbacks, such as high costs and the requirement to utilize noble metal catalysts[4]. As an alternative to PEMs, alkaline anion exchange membrane (AEM) electrolysers, nickel-based catalysts that do not require noble metal catalysts, are increasing in favour in recent years[5]. Thus, AEM-based systems are promising for large-scale commercial electrolyzers because of their fast electrochemical kinetics, use of non-noble metals, and advantages over PEM systems, including low-cost membranes. The new generation of high-performance, safer and sustainable anion exchange membranes are promising in the future electrolyser technology. Poly(arylene ether sulfone), poly(phenylene oxide), poly(ether sulfone ketone) and poly(vinyl alcohol) functionalized polymers with several quaternary ammoniums were developed and used as AEM materials[6].

In this study, nickel-based anode catalysts and cathode catalysts were prepared. OER effective $Co(OH)_2/Ni(OH)_2$ was prepared in the oxyhydroxide form as the anode catalyst, and HER catalyst was prepared to consist of nickel, copper, zinc and phosphorus as the cathode catalyst. Poly(diphenylmethane-co-diphenyl silane piperidine) ionomer was synthesized for an alkaline electrolyzer, and its ionic conductivity and AEMWE suitability were determined using the polarization technique and EIS technique.

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