Manganese doped-Holey Graphene-Nickel Disulfide Nanocomposites for Bifunctional Oxygen Electrocatalysts: A Novel electrolysis setup for efficient gas separation

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Abstract

The ever-increasing need for energy resources forces us to look for alternative energy storage and conversion solutions. Technologies utilizing hydrogen energy are expected to tackle future energy challenges since they can lessen reliance on fossil fuels and greenhouse gas emissions. Therefore, a crucial industrial method to maximize energy efficiency is the direct creation of pressurized hydrogen using PEM water electrolysis without the use of an external compressor. Herein, we use a hydrophobic gas diffusion layer (hydrophobic-GDL) to show how a novel water electrolysis cell functions at high inlet water pressure. With this setup, we can separate the gases from the water at the electrode, allowing us to produce pressurized, water-free gases, which is one of the limitations of conventional water electrolysis.

Bifunctional oxygen electrocatalysts are therefore important in the fields of fuel cells, water electrolysis, and metal-air batteries since they are abundant on Earth and affordable. We demonstrated that manganese anchored on nickel disulfide-nitrogen-doped holey graphene hybrid (Mn-NiS_2/NHG) was produced using a simple hydrothermal approach and verified its material properties by various physicochemical techniques. Notably, as prepared Mn-NiS_2/NHG has an admirable catalytic activity for oxygen electrodes (ORR and OER), and its observed onset potentials were 0.95 and 1.38 V. These results reveal that the Mn-NiS_2/NHG hybrid has superior oxygen electrode activity of 0.83 V at 10 mA cm^{-2} current density and half-wave potential and excellent durability of nearly 1000 cycles. Holey graphene plays a critical role in boosting the ionic transport between the electrode and electrolyte interface, thus improving catalytic activity and durability. Despite widespread acceptance of PGM-based electrocatalysts, their higher operating costs and restricted availability pose significant obstacles to large-scale future applications. Manganese is, therefore, a far better option than Pt, IrO_2, and RuO_2 (PGM)-based catalyst materials because it is less expensive, and a better choice in terms of practical use.

References

1. *Sun et al., Science 356, 599-604 (2017).*
2. *Fei et al., Nature Catalysis 1, 63-72 (2018).*