ELECTROCATALYSTS FOR HYDROGEN AND OXYGEN EVOLUTION

This special issue of the Journal of Materials Research contains articles that were accepted in response to an invitation for manuscripts.

Introduction

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Hydrogen is one of the most valuable energy carriers and a clean and renewable energy supply. Electrolysis of water, that is, water splitting into hydrogen and oxygen gases under an electrical bias, offers a near-term and long-term solution for the production of hydrogen gas as fuel and for chemical products with large-scale capability. Coupling electricity from photovoltaic or wind farms and hydropower plants with electrolysis can provide a sustainable energy supply without creating environmental problems.

Worldwide, researchers and technologists are working towards improvement of materials which increase the energy conversion efficiency and lower the cost of components and systems for renewable energy conversion and storage. The progress is encouraging. The Materials Research Society has been a platform for the diffusion of knowledge and dissemination of results in renewable energy technology, including electrocatalysis for many years.

Since the first report of electrolysis in 1800 by William Nicholson and Anthony Carlisle, many industrial systems have been developed, such as alkaline electrolyzers, solid polymer electrolyte electrolyzers, and solid-oxide water electrolyzers. All of these systems require practically large voltages (e.g., 1.7 – 2.4 V for an alkaline electrolyzer at 25 °C) for splitting water into hydrogen and oxygen. This is considerably higher than the well-known thermodynamic minimum of 1.23 V for water electrolysis at standard conditions, that is, 25°C and 1.0 atm pressure. This indicates that the current water electrolysis technologies only have electricity-to-hydrogen efficiency between 50-70%, wasting 30-50% electricity. Similar voltage requirements also limit the solar-to-hydrogen efficiency and therefore post high price tags for practical renewable energy applications.

Electrocatalysts are critical assistants in electrolysis, largely determining its energy conversion efficiency, cost, lifetime, etc. The large voltage for water splitting comes from the ohmic resistance, and anode and cathode overpotentials. Many efforts have been devoted to developing catalysts with small overpotentials. Rare noble metals and their oxides are state-of-the-art electrocatalysts for hydrogen evolution reaction (HER) and oxygen evolution reaction (OER), respectively, with good efficiency and lifetime. Their scarcity, however, causes high prices and limited usage, severely restricting the deployment of electrolysis technology for large-scale fuel production. Research has turned to development of earth-abundant, low-cost and highly active catalysts, such as NiFe layered double hydroxide for OER, non-noble metal dichalcogenides and phosphides for HER. Since electrolyzers with the same electrolyte have a much simpler structural design than bipolar electrolyzers with two electrolytes, it is therefore desirable to have both HER and OER catalysts active in the same electrolyte environment, either acidic or basic electrolyte. Recent years have witnessed a burst of research results in the search for good electrocatalysts. In this Focus Issue, we present some of the broad spectrum of research in this field. We hope readers will find this issue to be informative on its rapid advancement.

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We are very grateful to both the authors and reviewers of the high-quality manuscripts submitted to this *Journal of Materials Research* Focus Issue.

ON THE COVER:

The cover of this Focus Issue shows a generic diagram of water splitting on the surface of a catalyst, where water molecules are broken into hydrogen and oxygen molecules.