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Control of Ir oxidation states to overcome the trade-off between activity and stability for the oxygen evolution reaction

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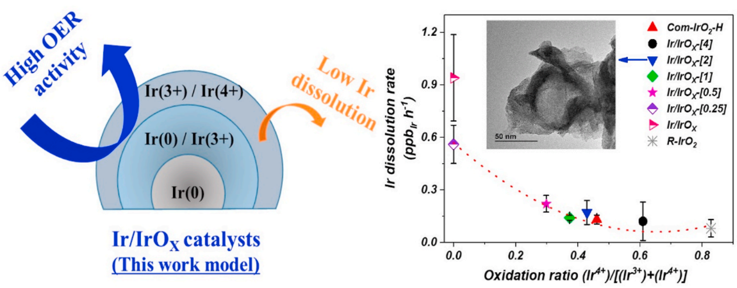
HIGHLIGHTS

- Self-assembled Ir/IrOx catalysts were prepared by a novel solution–reduction method.
- Ir/IrO_X catalyst has a feature of gradient distribution of oxidation states of Ir.
- Investigation of oxygen evolution reaction activity and stability parameters.
- Ir/IrO_X-[2] catalyst showed excellent OER performance.
- The durability of a single-cell with Ir/IrO_X exceeds that of commercial IrO_2.

GRAPHICAL ABSTRACT



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ABSTRACT

To improve the efficiency of polymer electrolyte membrane water electrolyzers (PEMWEs), catalysts with high activity and stability in the oxygen evolution reaction (OER) have been extensively investigated. In this study, using a novel solution-reduction process, self-assembled Ir/IrOx OER catalysts are prepared, with a controlled Ir oxidation-state ratios. Spectroscopic and electron microscopic analyses confirm that these catalysts have a gradient oxidation state, which gradually decreases from the shell to the core. In half-cell tests, before and after the accelerated stress test (AST) at 10 mA cm^{-2}, the optimized Ir/IrOx catalyst exhibits an overpotential change of approximately 21 mV_{RHE}, which is 3.3 times lesser than that of the state-of-the-art IrO_2 (approximately 69 mV_{RHE}). Further, quantification of the dissolved Ir content during the AST shows that the Ir/IrOx catalyst has a strong corrosion resistance under acidic OER conditions. Single-cell testing of the as-prepared OER catalyst demonstrates a remarkable cell performance of 1.73 V at 1.0 A cm^{-2}. After 48-h durability testing, the increase in the membrane electrode assembly cell voltage with the as-prepared OER catalyst is approximately 5.3 times lesser than that of the reference at 250 mA cm^{-2}. The proposed novel catalyst with high activity and stability can aid the development of cost-effective PEMWE systems.

1. Introduction

Polymer electrolyte membrane water electrolyzers (PEMWEs) have attracted attention as a means for producing green hydrogen using renewable electricity [1–3]. The oxygen evolution reaction (OER), which occurs in the anode of the membrane electrode assembly (MEA), is sluggish and proceeds under harsh conditions (e.g., low pH, high voltage); therefore, it uses noble metals such as Ir and Ru have been used

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