One-step catalyst-coated membrane (CCM) preparation

Electrocatalysis
APPLICATION NOTE

Keywords: electrocatalysis, PEM, water electrolysis, catalyst-coated membranes, iridium

Ir-based electrocatalysts for PEM water-splitting

The development of current water electrolysis technologies is essential to efficiently generate green hydrogen and enable the transition towards a sustainable hydrogen-based economy. Proton exchange membrane (PEM) electrolyzers are a key technology in unlocking industrial green hydrogen production. An essential component of a PEM cell is the catalyst coated membrane (CCM) that are generally composed of a flexible polymeric membrane (e.g. Nafion, Aquivion) coated with a catalyst layer on the anode (Ir-based) and cathode (mostly Pt-based) sides.

Challenge

PEM electrolysers rely on the use of scarce and expensive noble metal catalysts (e.g Ir, Pt). Although progress has been made in cathode optimization, the required amount of Ir at the anode still remains too high for industrialization. Furthermore, the complexity of CCM manufacturing hinders their commercialization. Conventional CCM manufacturing processes are multi-step and primarily ink-based. Steps include ink preparation (from metallic nanoparticles), ink application onto a proton exchange membrane (PEM) to yield the catalyst-coated product, and several intermediate drying stages.

TECHNICAL INPUT	
Particle Source	VSP-G1
Deposition Method	Printing
Deposition System	VSP-P1
Deposition Parameters	Varying power, 2 L/min Ar
Sample	Polymeric substrates (e.g. Nafion, Aquivion)
Material	Ir electrodes
Application	Electrocatalysis
Analysis technique	Cyclic voltammetry, HR-TEM, SEM, XRD, XPS

Solution & Results

Combining the VSP-G1 Nanoparticle Generator and the VSP-P1 NanoPrinter enables researchers to deposit Ir nanoparticles directly onto Nafion 115 in a single process step and without the need for a catalyst ink.

The CCMs prepared *via* spark ablation comprised of a dense, porous layer of amorphous IrO_2 nanoparticles with an average particle size of 2 nm. Polarization curves show that CCMS prepared via spark ablation can achieve better performance (higher current densities at lower voltage) for PEM water electrolysis than the commercial standard (Figure 1). This improved performance is achieved at lower Ir loadings and without compromising durability.

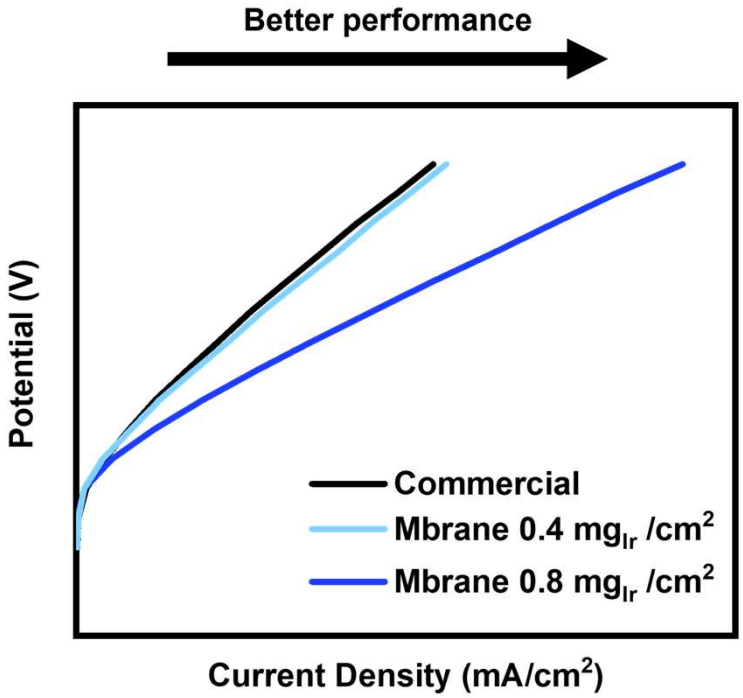

Figure 1: Polarization curves of commercial (2.0 mg Ir/cm^2) and spark ablation-based (0.4 and 0.8 mg Ir/cm^2) CCMs for PEM water electrolysis showcasing higher current densities at lower voltages (based on third-party lab tests).