Scaling Up Production of a Promising Catalyst for Water Electrolysis: $AlFe_2B_2$

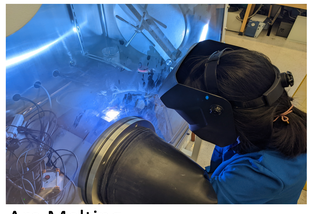
Valeriya Shipulya, **Ian Campbell**, **Michael Shatruk**

Department of Chemistry & Biochemistry, Florida State University, Tallahassee, Florida 32306

Abstract

Sustainable water electrolysis aims to provide a source of hydrogen fuel to combat the environmental problems associated with the use of fossil fuels, global warming and pollution. The Oxygen Evolution Reaction (OER) is one of the two half-reactions of water electrolysis. Recent studies by the Shatruk group[1] identified $AlFe_2B_2$ as a promising OER electrocatalyst whose activity is comparable to that of the state-of-the-art IrO_2 and RuO_2 catalysts under conditions of alkali electrolysis. In contrast to these expensive catalysts, $AlFe_2B_2$ is composed of inexpensive earth-abundant elements. Our goal is to scale up the synthesis of this material to a multi-gram scale and confirm whether the catalytic activity is maintained at the larger scale. We synthesized a one-gram sample of $AlFe_2B_2$ and isolated it as a pure single-phase product that was confirmed by powder X-Ray diffraction. It was then ball-milled to increase the surface area and converted to an ink to test the catalytic activity using cyclic voltammetry. Next, we have increased the synthesis scale to 5 g. Scaling up to even larger amounts can be achieved via a parallel synthetic process. We tested this catalyst on a commercial electrolyzer and it showed performance comparable to the industrial standards, although further optimization of the catalyst is required.

Methods

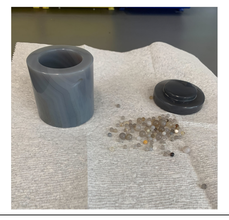


Arc-Melting

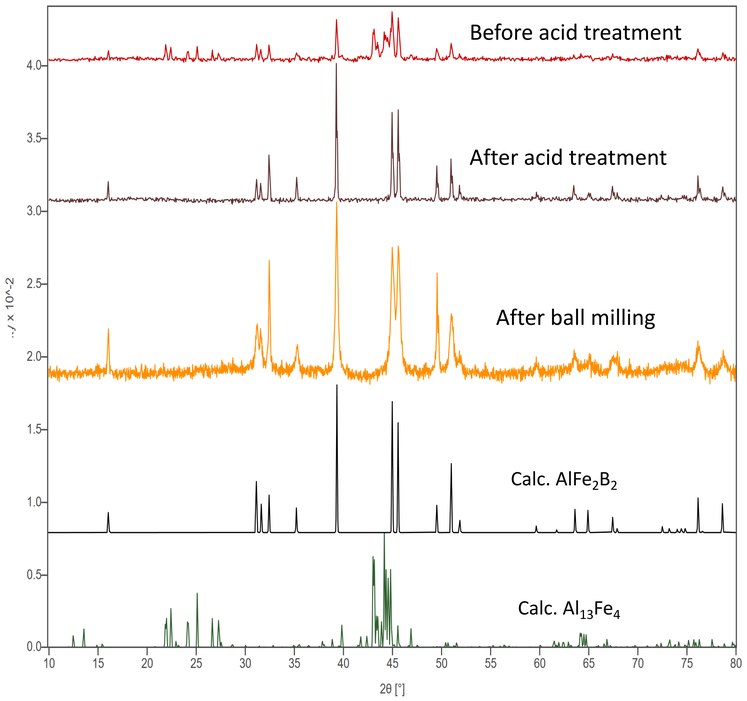
$3Al + 2Fe + 2B \xrightarrow{900\ °C\ for\ 7\ days} AlFe_2B_2 + Al_{13}Fe_4$

1:1 HCl for 5 minutes

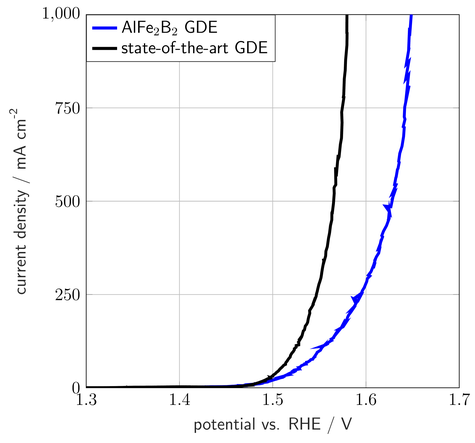
$AlFe_2B_2$ → Ball Mill → 50-200 nm crystallites



Results



Catalytic performance test in an industrial-scale electrolyzer



Discussion

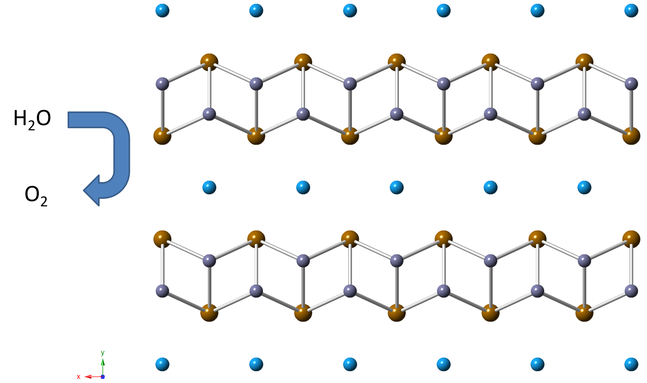
A phase-pure sample of $AlFe_2B_2$ was successfully produced on a 1-g scale. The synthesis required arc melting followed by high-temperature annealing and acid treatment to remove $Al_{13}Fe_4$ byproduct. Parallel reactions using multiple arc-melted 1-g pellets of $AlFe_2B_2$ were annealed in the same silica tube sealed under vacuum, to isolate the pure phase ion a 5-g scale.

The ball milling of the sample decreases the particle size significantly, thus increasing the surface area to allow for higher surface activity during the OER electrocatalysis.

Our next steps will focus on further scale-up of this synthesis. We believe that increasing the amount of product to 10 g is possible via parallel reactions.

Catalytic testing was performed on an industrial electrolyzer which showed good catalytic performance comparable to the current state-of-the-art.

The straightforward synthesis, cheap starting materials, and good catalytic performance suggest that $AlFe_2B_2$ has the potential to replace the industrial standards currently used to catalyze the OER.



References

1. Mann, D.; Shatruk, M.; et al. Electrocatalytic water oxidation over $AlFe_2B_2$. *Chem. Sci.* **2019**, *10*, 2796-2804.

This project is supported by the FSU Council on Research and Creativity through a GAP grant