Hawai‘i Natural Energy Institute Research Highlights

Electrochemical Power Systems

Transition Metal Carbide Catalysts for Electrochemical Applications

OBJECTIVE AND SIGNIFICANCE: The objective of this project is to develop transition metal carbide catalysts for electrochemical applications. These carbide catalysts have the potential to improve the performance of a variety of electrochemical devices including fuel cells, water electrolyzers, and vanadium redox flow batteries.

BACKGROUND: The commercial application of a number of electrochemical technologies would benefit from the availability of low cost, efficient, and durable catalysts. Pt-group-metal catalysts are used in most commercially available fuel cells and water electrolyzers. Unfortunately, they have the short-comings of high cost, low earth abundance, and limited lifetime. Transition metal carbides are attractive candidates because they possess an electronic structure similar to Pt which promotes high activities, good electrical conductivity, low cost, high abundance, and outstanding thermal and chemical stabilities. However, carbide synthesis is a challenge for achieving high surface area particles due to the inevitable aggregation during the high-temperature carburization.

PROJECT STATUS/RESULTS: This work is exploring a simple and environmentally friendly synthesis process for carbides that involve in situ carburization of a metal precursor and a carbon material. Considering the excellent electrochemical stability of TiC, the commercially available TiC was chosen as the carbon source and support to increase the stability of carbides. SEM/EDS was used for catalysts morphological and elemental analysis. SEM images revealed the existence of nanoflakes in vanadium carbides and composite oxides (Figure 1). EDS elemental mapping indicated the presence of carbon (C) and vanadium (V) (Figure 1). The thermal stability of carbides and composite oxides in air was conducted using thermogravimetric analysis (TGA).

As shown in Figure 2, TGA results indicated that vanadium carbides and titanium vanadium composite oxides had good thermal stability and oxidation resistance up to 350 and 450°C in air, respectively. Both carbides and carbon supports exhibited increased hydrogen evolution reaction (HER) catalytic activity after up to 1.4 V cycling verified by two types of counter electrodes (i.e., Pt and graphite rod).

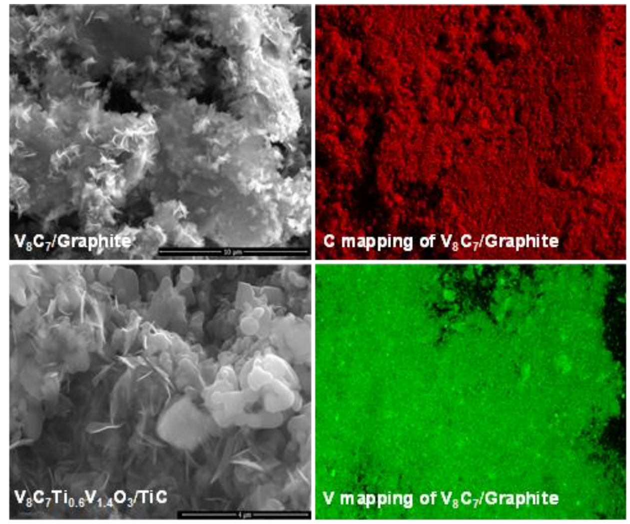

Figure 1. SEM images and EDS elemental mappings.

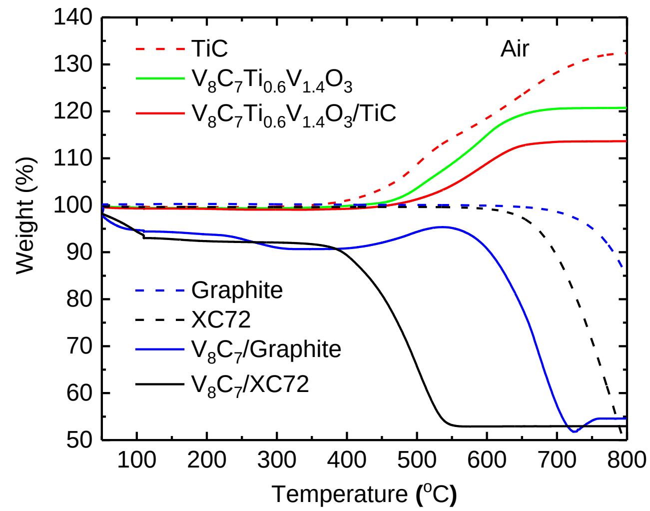

Figure 2. Thermogravimetric curves in air.

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