



# 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 shortcomings 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.

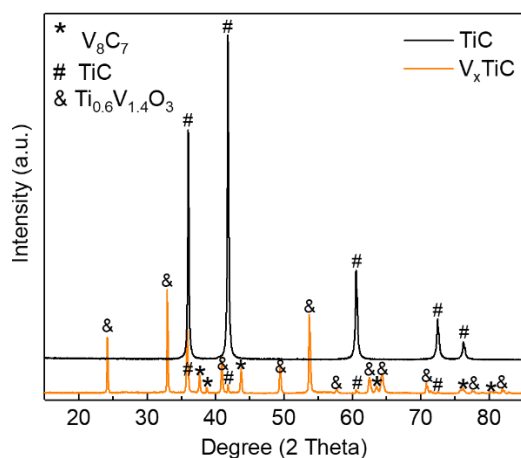


Figure 1. X-ray diffraction patterns.

**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 vanadium carbide. By modifying the synthesis and treatment approaches,  $V_xTiC$  was synthesized. As shown in Figure 1,  $V_xTiC$  contains Ti-V oxide ( $Ti_xV_{1-x}O_3$ ),  $V_8C_7$ , as well as some unreacted TiC.  $V_xTiC$  exhibited excellent electrochemical stability up to 1.4 V (Figure 2) and better catalytic activity toward hydrogen evolution reaction (HER) than  $V_xC$  (Figure 3). Both  $V_xC$  and  $V_xTiC$  showed increased HER catalytic activity after up to 1.4V cycling.

Further electrochemical tests will be performed using carbides incorporated on carbon substrate as the working electrode. SEM/EDS will be used for morphological and elemental analysis. TEM will be used to investigate particle size and structure.

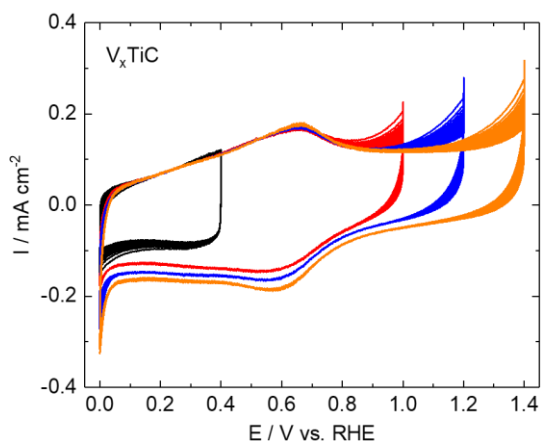


Figure 2. Cyclic voltammograms at  $100\text{mV s}^{-1}$  in  $N_2$ -saturated  $0.5\text{M H}_2\text{SO}_4$  at  $25^\circ\text{C}$ .

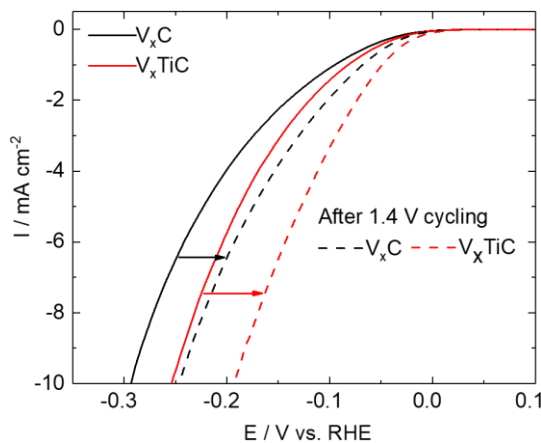


Figure 3. Polarization curves with a rotation rate of  $1600\text{rpm}$  at  $2\text{mV s}^{-1}$  in  $N_2$ -saturated  $0.5\text{M H}_2\text{SO}_4$  at  $25^\circ\text{C}$ .

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*Contact:* Jing Qi, [qijing@hawaii.edu](mailto:qijing@hawaii.edu)

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