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ABSTRACT

MXenes: A diverse Platform to Explore the Potential of 2D Materials

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MXenes – transition metal-based carbides and (carbo)nitrides with the general chemical composition $M_{n+1}X_nT_x$ (*M* = early-to-mid transition metals, *X* = C and/or N, T_x = surface groups, *n* = 1-4) are an incredibly fascinating class of 2D materials that have left almost no potential application area untouched. As much research as is dedicated to exploring their unique properties, for example in the context of biomedicine, catalysis and energy storage, especially of Ti-MXenes, as little focus is dedicated to non-Ti-MXenes as well as their synthesis science. In this talk, I will discuss the synthesis of different V-MXenes derived from their MAX phase siblings. The preparation of the precursor MAX phases is not trivial as shown for MAX phase examples V_4AlC_3 and $(V/Mo)_5AlC_4$. MAX phases with minimal amounts of side phases as well as knowledge of their chemical composition are key to obtaining high-quality MXenes that allow for meaningful discussions of their properties. These aspects will be covered during my discussion of the "higher *n*" MXenes $V_4C_3T_x$ and $(V/Mo)_5C_4T_x$ including discussion of their electrocatalytic performance in the hydrogen evolution reaction (HER). I will highlight key synthetic chemistries during the exfoliation of V_2AlC [1] and $(V/Mo)_2AlC$ and show how the catalytic properties depend on the V/Mo ratio [2]. We take advantage of diverse synthesis and exfoliation tools ranging from conventional to microwave heating and aqueous acid as well as Lewis acid etching. All materials are characterized by diffraction (synchrotron/lab X-ray), microscopy and spectroscopy (lab/hard-X-ray photoelectron spectroscopy) techniques.

[1] R.M. Snyder, S. Sankar, P. Bhatt, A.A. Riaz, P.K. Thakur, T.-L. Lee, A. Regoutz, S. Susarla, **C.S. Birkel**, High-yield Delamination of Hydrothermally-Etched V_2CT_x, Inorg. Chem. 2025, accepted, DOI: 10.1021/acs.inorgchem.4c04546
[2] R.M. Snyder, T. Nguyen, P. Bhatt, A.A. Riaz, P.K. Thakur, T.-L. Lee, A. Regoutz, A.K. Jones, **C.S. Birkel**, $(V_{1-y}Mo_y)_2CT_x$ MXene Nanosheets as Electrocatalysts for Hydrogen Evolution, ACS Appl. Nano Mater. 2025, 8, 2, 1137-1146