Chemistry of 2D Transition Metal Carbides and Carbonitrides (MXenes)

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A large family of two-dimensional transition metal carbides and nitrides (MXenes) raises interest for many applications due to their high electrical conductivity, mechanical properties [1], potentially tunable electronic structure [2], nonlinear optical properties [3], and the ability to be manufactured in the thin film state [4]. However, their chemistry that is key to development of these applications, still remains largely terra incognita [5,6]. In this presentation we will discuss recent progress in understanding fundamental MXene chemistry and harnessing it for development of applications.

For example, during delamination and storage in ambient air environment, spontaneous oxidation of MXene flakes leads to formation of titanium oxide, a process that can be harnessed for simple, inexpensive, and environmentally benign manufacturing MXene–titania composites for optoelectronics, sensing, and other applications [7]. We show that partially oxidized MXene thin films containing the in situ formed phase of titanium oxide have a significant photoresponse in the UV region of the spectrum. The relaxation process of photoexcited charge carriers, which takes a long time (~24 h), can be accelerated in the presence of oxygen and water vapor in the atmosphere. These properties of spontaneously formed MXene-titania thin films make them attractive materials for photoresistors with memory effect and sensitivity to the environment, as well as many other photo- and environment-sensing applications.

Other selected examples illustrating connections between understanding MXene chemistry and development of their applications will also be considered.

References

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