Effect of Synthesis on Properties of MXenes

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2D carbides, nitrides, and carbonitrides of early transition metals known as MXenes are the most chemically and structurally diverse family of inorganic materials discovered this century. MXenes are among the few nanomaterials that have jumped into the limelight not only because of their exotic structure or attractive properties but also because of numerous practical applications [1]. The family of MXenes has been expanding rapidly since the discovery of Ti_3C_2 at Drexel University in 2011. About 50 different stoichiometric MXenes have been reported, dozens of solid solutions have been made, and the structure and properties of numerous other MXenes have been predicted. The availability of solid solutions on M and X sites, multi-element high-entropy MXenes, control of surface terminations, and the discovery of out-of-plane ordered double-M *o*-MXenes (e.g., Mo_2TiC_2), as well as in-plane ordered *i*-MAX phases and their *i*-MXenes offer the potential for producing an almost infinite number of new 2D materials. This presentation will describe the state of the art in the synthesis of those MXenes by wet chemical and molten salt etching of MAX phases, CVD, and topochemical transformation of graphite and oxides. Their delamination into single-layer 2D flakes and assembly into films [2-4] will also be covered. Synthesis-structure-properties relations of MXenes will be described [3]. Hydrophilic surfaces of wet chemically etched MXenes allow environmentally friendly and scalable manufacturing and processing of MXenes from dispersions in water, with no surfactant or binder added. The hydrophobic halogen-terminated MXenes are better dispersible in organic solvents [4]. The versatile chemistry of the MXene family renders their properties tunable for a large variety of energy-related, electronic, optical, biomedical, and other applications, but the synthesis method, surface termination and delamination largely determine the properties and the range of applications of MXenes.

References

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