Synthesis of MXenes by Selective Etching and Chemical Vapor Deposition (CVD)

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MXenes are potentially the largest family of 2D materials with diverse properties. They have a general chemical formula of $M_{n+1}X_nT_x$, where M represents a transition metal (Ti, Mo, Nb, V, Cr, etc.), X is either carbon and/or nitrogen (n=1, 2, 3 or 4), and T_x stands for surface terminations (O, OH, halogens, chalcogens, etc.).[1] More than 100 stoichiometric $M_{n+1}X_n$ structures (not including surface terminations) have been predicted. Availability of solid solutions on the M site (including high-entropy MXenes) and X site (carbonitrides and oxycarbides) and control of surface terminations, create an opportunity for the atomistic design of numerous new structures and compositions. More than 40 stoichiometric MXenes and dozens of solid solutions and MXenes with various terminations have been reported.

In the past years, a major progress has been achieved in synthesis of MXenes, with wet chemical selective etching of MAX phases being supplemented by electrochemical etching, etching in Lewis acid molten salts, extraction of A element by gaseous halogens and CVD synthesis from inexpensive precursors such as titanium chlorides and natural gas.[1-4] Some of those methods offer a cleaner and less expensive alternative to HF etching.[3] Even more important, materials produced using different methods have different properties. For example, MXenes from etching in acidic solutions are hydrophilic due to mixed O and OH terminations, while the same $M_{n+1}X_n$ MXenes with Cl terminations resulting from the molten salt etching are hydrophobic.[4] The surface composition allows one to control properties of MXenes and tune their electronic conductivity, optical, electrochemical and mechanical properties.

References

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