MXenes – Synthesis, Properties and Applications of Two-Dimensional Carbides and Nitrides, the Largest Family of 2D Materials

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Two-dimensional (2D) materials with a thickness of a few nanometers or less can be used as single sheets, or as building blocks, due to their unique properties and ability to assemble into a variety of structures. Graphene is the best-known example, but several other elemental 2D materials (silicene, borophene, etc.) have been discovered. Numerous compounds, ranging from clays to boron nitride (BN) and transition metal dichalcogenides, have been produced as 2D sheets. By combining various 2D materials, unique combinations of properties can be achieved which are not available in any bulk material. The family of 2D transition metal carbides and nitrides (MXenes) has been expanding rapidly since the discovery of Ti_3C_2 in 2011 [1,2]. Approximately 30 different MXenes have been synthesized, and the structure and properties of numerous other MXenes have been predicted using density functional theory (DFT) calculations [3]. Moreover, the availability of solid solutions on M and X sites, control of surface terminations, and the discovery of ordered double-M MXenes (e.g., Mo_2TiC_2) offer the potential for synthesis of dozens of new distinct structures. The versatile chemistry of the MXene family renders their properties tunable for a large variety of applications. They have very high strength, modulus of elasticity and electronic conductivity. Oxygen or hydroxyl- terminated MXenes, such as $Ti_3C_2O_2$, have been shown to have redox capable transition metals layers on the surface and offer a combination of high electronic conductivity with hydrophilicity, as well as fast ionic transport. This, among many other advantageous properties, makes the material family promising candidates for composites, energy storage and related electrochemical applications, but applications in optoelectronics, plasmonics, electromagnetic interference shielding, electrocatalysis, medicine, sensors, water purification/ desalination and other fields are equally exciting [4].

References

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Twoâ€dimensional (2D) materials, owing to their unique properties, have shown great potential for energy storage. Following the discovery of graphene, a new family of 2D transition metal carbides/nitrides, MXenes, derived from MAX phase precursors, have attracted extensive attention in recent years.Â MXenes, a family of 2D transition metal carbides and nitrides, were developed by a group of researchers from Drexel University. 7 MXenes can be prepared by selectively etching the reactive â€œAâ€ layers in laminated carbides or carbonitrides (also known as â€œMAXâ€ phases).Â The synthesis conditions remarkably influence the properties of the final products and thus directly affect the performances of MXenes in their applications. Yury Gogotsi Two-dimensional, 2D, materials, such as graphene, possess a unique morphology compared to their 3D counterparts, from which interesting and novel properties arise. Currently, the number of non-oxide materials that have been exfoliated is limited to two fairly small groups, viz. hexagonal, van der Waals bonded structures (e.g. graphene and BN) and layered transition metal chalcogenides.Â @inproceedings{Abdelmalak2014MXenesAN, title={MXenes: A New Family of Two-Dimensional Materials and its Application as Electrodes for Li-ion Batteries}, author={Michael Abdelmalak}, year={2014} }. Michael Abdelmalak. Published 2014. Materials Science. MXene is another young family of 2D materials that has received increasing attention due to many exciting physical and chemical properties [26, 27]. Until now the most studied MXene is $Ti_3C_2T_x$ and has been widely used [28]. $Ti_3C_2T_x$ is normally produced from $Ti_3C_2T_2$ through an HF etching process. The $Ti_3C_2T_x$ is terminated by T_x, where T represents O, OH, and/or F groups, while x is the number of terminating groups. Owing to its flexibility, superior structural stability, high electrical conductivity, and hydrophilic surfaces, $Ti_3C_2T_x$ has been widely used in supercapacitors, lithium ion batterie In recent years, a new large family of two dimensional transition metal carbides, carbonitrides, and nitrides, so-called MXenes, have grabbed considerable attention, owing to their many fascinating physical and chemical properties that are closely related to the rich diversity of their elemental compositions Recent Review Articles.Â In particular, it is easy for MXenes to form composites with other materials such as polymers, oxides, and carbon nanotubes, which further provides an effective way to tune the properties of MXenes for various applications.Â In this review, we summarize the synthesis and properties of MXenes and MXene-based composites and highlight their recent advances in environment-related applications.