# MXene, Graphene and Their Hybrids

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**Abstract**

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. 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 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 [4,5]. There are many applications in which MXenes outperform graphene (pseudocapacitors, EMI shielding, antennas, etc.), in some other areas graphene may still doing a better job, or offer a less expensive solution (rGO). There are also situations when a MXene-rGO hybrid can perform better than those materials alone [6]. This presentation will provide a comparison of properties and potential applications of MXenes and their hybrids [7] in comparison to graphene-based materials.

**References**

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