MXenes in the world of the 2D-based hybrid nanomaterials

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Abstract

Two-dimensional (2D) solids, such as graphene, transition metal dichalcogenides, and phyllosilicates belonging to the clay minerals family, are of increasing interest for the preparation of functional nanomaterials, including hybrids and bionanocomposites. Among 2D solids, an outstanding emerging group of transition metal carbides and carbonitrides termed MXenes, discovered in the last decade (1), are derived from ternary transition metal carbides and/or carbonitrides ($M_{n+1}AX_n$, n = 1-3) named "MAX phases" (1). MXenes are receiving enormous attention due to their physicochemical properties, in some aspects close to clay silicates but showing high electrical conductivity (1,2). In fact, they are also known as "conductive clays" (2), although in our view the use of "clays" to refer to MXenes should be avoided.

In this communication we will present a comparative study between layered clay minerals and MXenes, emphasizing aspects related to their structural, physical and chemical characteristics, with special emphasis on the ability of both types of 2D solids to act as host materials for the intercalation of various organic compounds, including polymers, thus giving rise to functional hybrids and nanocomposites. Both 2D inorganic hosts exhibit several common properties (e.g., exfoliation/intercalation, hydrophilic character, ion exchange capacity and biocompatibility). However, Mxenes are conductive solids unlike clays. The simultaneity of electrical conductivity and hydrophilicity is a very rare feature in inorganic solids endowed with colloidal properties, which can be of great interest for innovative technological applications such as energy storage, sensor devices or bioactive materials for advanced biomedical uses among other applications (3).

Herein, several recent examples of nanoarchitectured hybrids based on carbon composites, bioinspired and bionanocomposite materials based on both Clay Minerals and MXenes will be presented and discussed, illustrating their behavior as superabsorbents, antimicrobial hemostatic materials, piezoelectric sensors, among other potential applications (4).

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