

Advanced Two-Dimensional Nanomaterials for Environmental and Sensing Applications

2D MXenes nanomaterials for removal of organic wastewater contaminants

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The research and development of two-dimensional (2D) materials was prompted and advanced after the discovery of the remarkable physical properties of single/multiple layered graphene. This hastily encouraged more research on 2D materials in the form of manipulating the structure of graphene through exfoliation, altering the starting material with readily available layered precursors such as graphite-like hexagonal boron nitride or dichalcogenides or even layered oxides [1]. This then stimulated the development of more 2D materials including the birth of MXenes. MXenes are a group 2D transition metal carbides, carbonitrides, and nitrides discovered in 2011 [2]. Their single flakes are denoted by a chemical formula $M_{n+1}X_nT_x$ ($n = 1$ to 4), which designates transition metals alternating layers (M) enclosed by carbon/nitrogen (X) layers with attached terminations T_x (-O₂, -F₂, -OH₂, -Cl₂) on the external transition metal surfaces [3]. Due to their intriguing electrical and optical properties, they play numerous roles in photodetectors. Additionally, their distinctive mechanical, chemical, and physical properties allow MXenes to be altered by various surface terminations and transition metals. The atomically narrow structure of 2D MXenes makes it an appropriate alternative material for water purification technologies. Additionally, its large surface area, excellent mechanical strength, and numerous functional groups on their surfaces make it a suitable candidate for the uptake of contaminants from aqueous medium [4]. MXenes water purification interest is facilitated by its unique adsorptive, antibacterial, and reductive properties, which are further augmented by high electrical conductivity. With the intensive industrialization and vast agricultural systems, the release of toxic contaminants into ground and surface water continues to be a strain on the environment. In this chapter, the potential use of 2D MXenes derivatives for organic contaminants (such as dyes, antibiotics, and pharmaceuticals) removal is addressed. This entails mechanistic pathways of using MXene-based materials as adsorbents, water purification membranes, and photocatalysts. The ability of MXenebased composites in showing catalytic activity toward diverse pollutants and superior selectivity toward specific pollutants will be discussed.