Functional PDA-coated MXene-Based Membranes for Targeted Antibiotic Purification in Hospital Effluents

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Abstract

Two-dimensional (2D) lamellar membranes, particularly those incorporating mixed matrix MXene-based surfaces, have earned significant interest in water purification applications. Despite this interest, many 2D mixed matrix membranes face substantial challenges, including high instability, elevated internal resistance, low selectivity, and inadequate anti-fouling properties. This study introduces a novel approach to address these drawbacks by fabricating highly stable and charge-tunable modified MXene membranes. The membranes exhibit over 98% separation capabilities for various pharmaceuticals (tetracycline, and sulfamethoxazole) and demonstrate notable anti-fouling performance. The fabrication process involves the creation of high-performance MXene membranes with stable and tunable lamellar nanochannels through facile self-assembly. This process utilizes negatively charged 2D MXene ($Ti_3C_2T_x$) nanosheets. Importantly, the MXene's charge tunability is achieved through a one-step missile step-inspired sieve base addition reaction during functionalization. Various characterization techniques, including XRD, FT-IR, Raman, TGA, XPS, Zeta-potential, SEM, and SEM-EDS, were employed to confirm the successful synthesis and gain insights into the physical and chemical properties of the nanomaterials and membranes. The impact of increasing functionalized MXene loading was investigated at levels of 0.5wt%, 1wt%, and up to 6wt%. Membrane stability, tested over one month, revealed enhanced stability in membranes containing functionalized MXene compared to unmodified MXene.

Figures

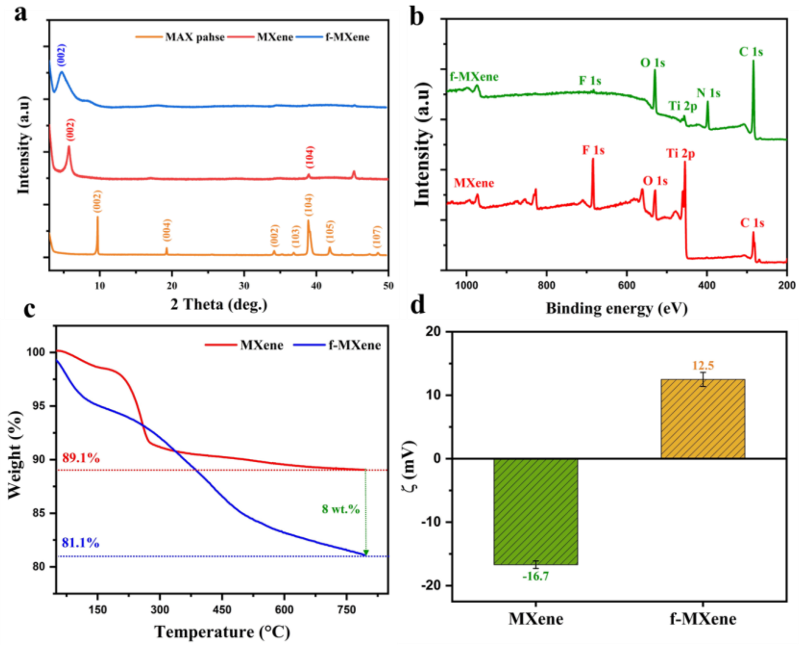

Figure 1: Characterization of MXene and f-MXene nanocomposites (a) XRD spectra; (b) XPS survey; (c) TGA data and (d) zeta potential (ζ; mV).