Advancing Nanoplastic Separation with Niobium Dicarbide Composite Electro-Membranes

Mariam Ouda, Shadi W. Hasan
Khalifa University, Abu Dhabi, UAE
mariam.ouda@ku.ac.ae

Abstract

Water scarcity and pollution by micro- and nanoplastics (MNPs) are pressing global challenges that threaten water security and ecosystem health. These pollutants, prevalent in aquatic systems, compromise the efficiency and longevity of water purification technologies due to their resistance to traditional filtration methods. This study introduces a pioneering approach to water treatment through an electro-membrane filtration system featuring niobium-based MXene (Nb_2CT_x) integrated into sulfonated polyether sulfone (SPES) membranes, aimed at effectively separating nanoplastics and improving the sustainability of water purification systems. The integration of Nb_2CT_x into the SPES membranes results in marked improvements in their physiochemical properties, particularly in enhancing hydrophilicity, porosity and conductivity. The optimized membrane with 5 wt% Nb_2CT_x demonstrates superior water flux, attributable to the synergistic effects of increased hydrophilicity and porosity. The application of an electric field during the filtration process significantly enhances the removal efficiency of PMMA nanoplastics. This electrocoagulation mechanism, promoted by the electric field, facilitates nanoplastic aggregation and floc formation, reducing fouling. Figure 1 shows the effect of applied electric field on the flux and rejection, and outlines the mechanism that leads to this result. This study establishes a new benchmark for the efficiency and sustainability of water treatment technologies by utilizing the properties of 2D materials.

Figures

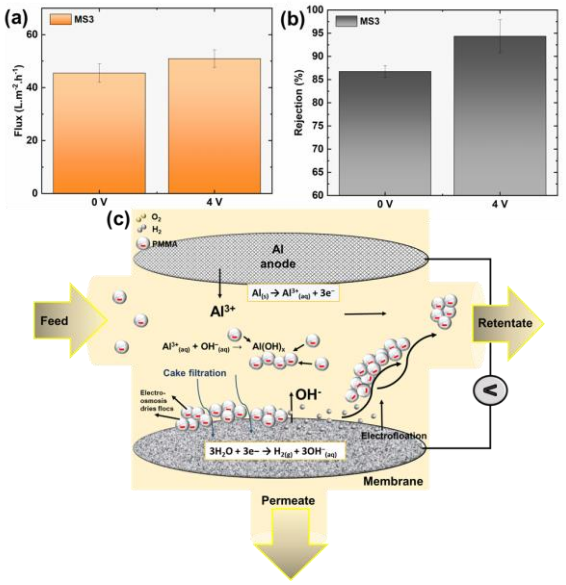

Figure 1: (a) Flux and (b) rejection with and without electric field; (c) Schematic representing the removal mechanism due to electric field.