Supplementary Information

Enhanced Ion Transport in Nanochannels of MXene by Mg^{2+} Pre-Intercalation

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1. Experiment Section

1.1 Preparation of $Ti_3C_2T_x$ Solution

$Ti_3C_2T_x$ nanosheets were obtained from T_3AlC_2 MAX phase by selective etching.[1] Specifically, 2.0g MAX phase powder was added into 20 mL 40% HF solution in a Teflon beaker, followed by stirring for 24h at room temperature. After etching by HF solution, the obtained solution was washed several times by ultrapure water (UP water) until its pH value reached 6. Sediment of the centrifuge was dispersed into 20 mL of Tetramethylammonium hydroxide (TMAOH) and stirred at 1600 rpm for 72 h. After intercalation, the TMAOH was washed with UP water, then the sediment was

dispersed into 200 mL UP water. Then the solution was sonicated with Ar bubbling and ice bath at 200 W for 1 h. The dispersion was centrifuged at 2500 rpm for 30 min, and the upper layer was slowly poured out to obtain a colloidal solution of monolayer MXene.

1.2 Preparation of MXene Membranes

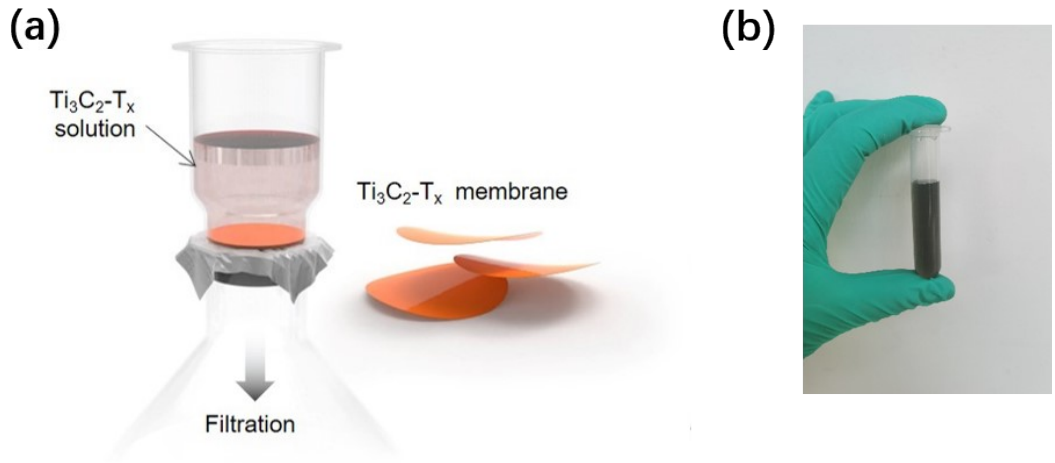

Fig. S1 (a) Schematic diagram preparation of MXene films. (b) Optical photograph of MXene solution at low concentration.

As shown in Fig. S1a, MXene films were obtained by vacuum-assisted filtration using 20 mL $Ti_3C_2T_x$ solution through a Celgard 3501 polypropylene membrane. Diameter of the films is 46 mm and the mass loading of $Ti_3C_2T_x$ is 20 mg. Individual MXene film with a diameter of 16 mm was obtained with a mass loading of 1.21 mg.

1.3 Pre-Intercalation of MXene Membranes

The MXene film was immersed in 1M chloride salt solutions of different metal cations for 1 h. After immersing, the film was washed by UP water to remove the residual salt solution on its surface. After vacuum drying for 1h, the MXene film intercalated by metal ions was obtained, called as X-$Ti_3C_2T_x$ film (X stands for Li, Na, K, Mg, Ca). To exclude the influence caused by intercalation of other cations, HF solution was used for etching instead of the mixture of LiF and HCl solution in synthesis of MXene solution.

2. Characterization

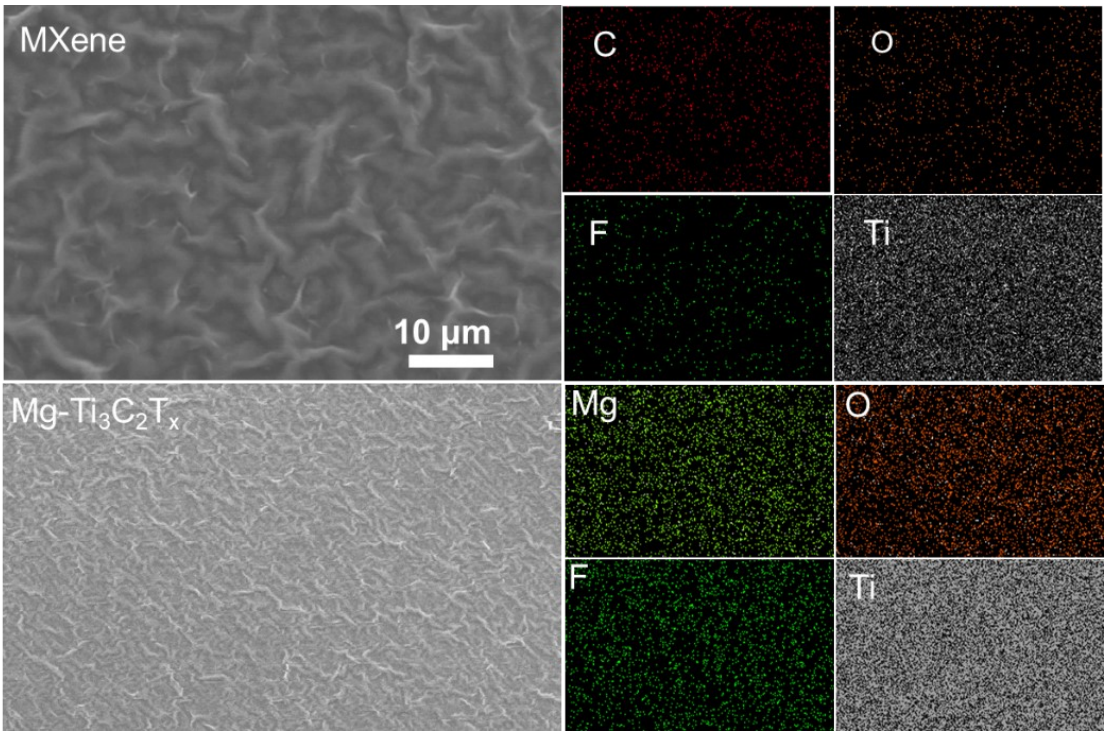

Fig. S2 SEM and EDS images of the surface of $Ti_3C_2T_x$ film and Mg-$Ti_3C_2T_x$ film.

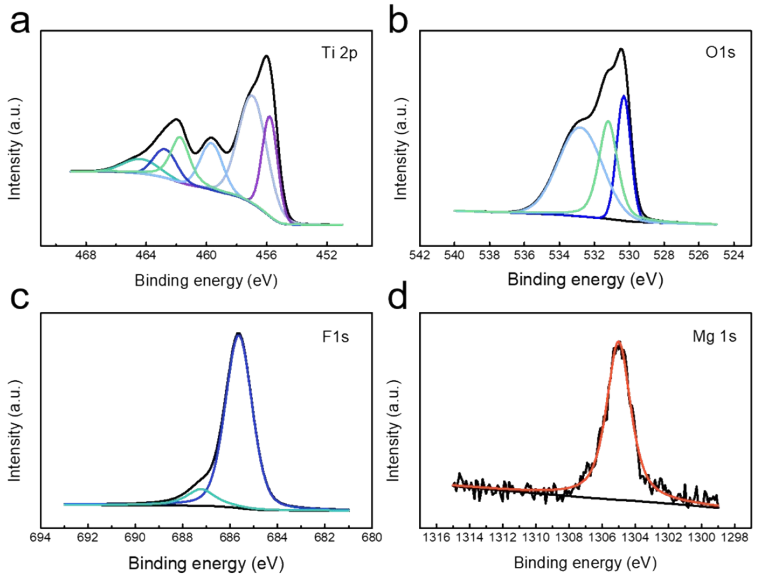

Fig. S3 XPS spectra of Mg-$Ti_3C_2T_x$ film: (a) Ti, (b) O, (c) F and (d) Mg.

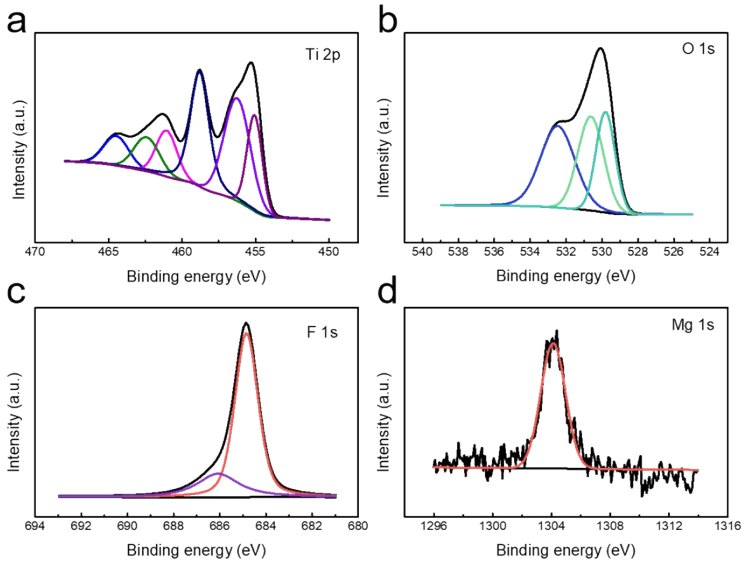

Fig. S4 XPS spectra of Mg-$Ti_3C_2T_x$-Li film: (a) Ti, (b) O, (c) F and (d) Mg.

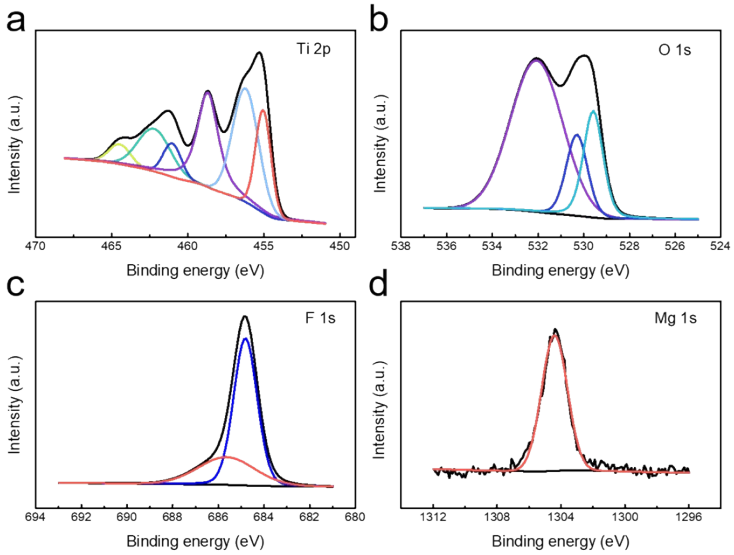

Fig. S5 XPS spectra of $Ti_3C_2T_x$-Mg film: (a) Ti, (b) O, (c) F and (d) Mg.

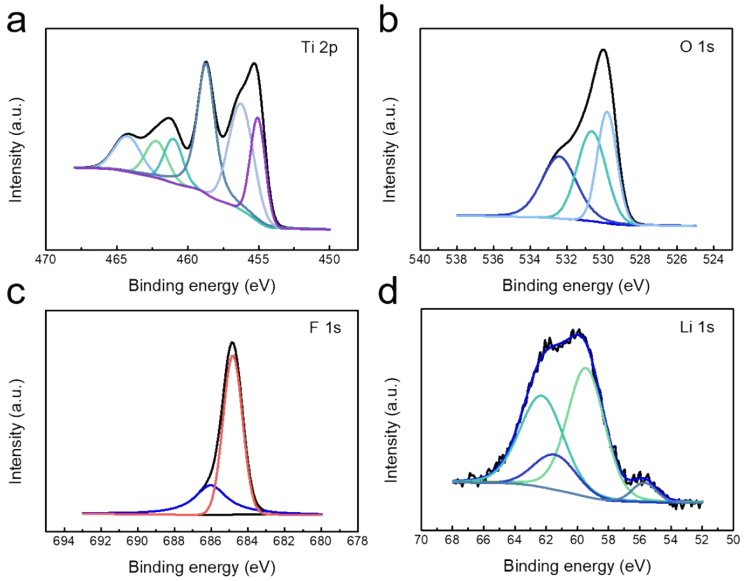

Fig. S6 XPS spectra of $Ti_3C_2T_x$-Li film: (a) Ti, (b) O, (c) F and (d) Li.

3. Additional Experiment

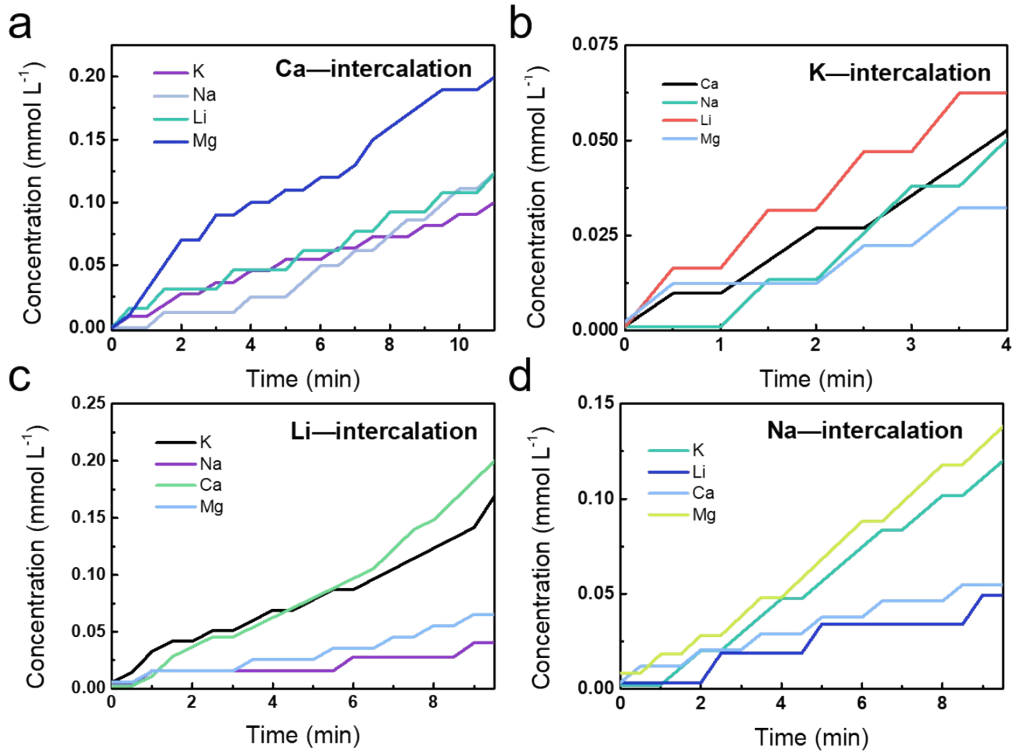

Fig. S7 Ion transport rate tests of different ions pre-intercalation: (a) Ca-intercalation, (b) K-intercalation, (c) Li-intercalation and (d) Na-intercalation.