The fabrication of Ti$_3$C$_2$ and Ti$_3$CN MXenes by electrochemical etching

Supporting information

Bragg's law and the reciprocal-space metric tensor equation of hexagonal crystal lattices:

$$n\lambda = 2d\sin(\theta) \; ; \quad \frac{1}{d^2} = \frac{4}{3}\left(\frac{h^2 + hk + k^2}{a^2}\right) + \frac{l^2}{c^2}$$

Calculation of charge conducted during the electrochemical etching

$$\textit{Number of electron conducted during etching} = \sum_{t=24\,h}^{e^-} It.\ 6.24 \times 10^{18} C^{-1}$$

$$\textit{Number of MAX phases unit cell} = \frac{m_{MAX}}{M_w(MAX)} N_A$$

I= current; t= etching time; m_{MAX}= mass of MAX phases; $M_w(MAX)$= molecular weight of MAX phases;
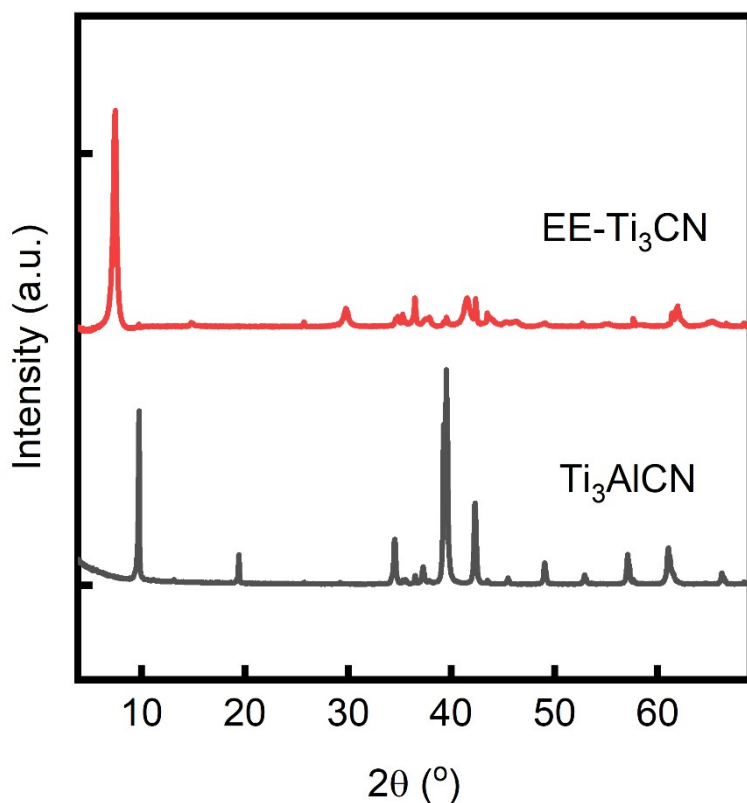
N_A =Avogadro constant

Figure S1. XRD spectrum of Ti$_3$AlCN precursor and electrochemically etched Ti$_3$CN. (Etching condition:
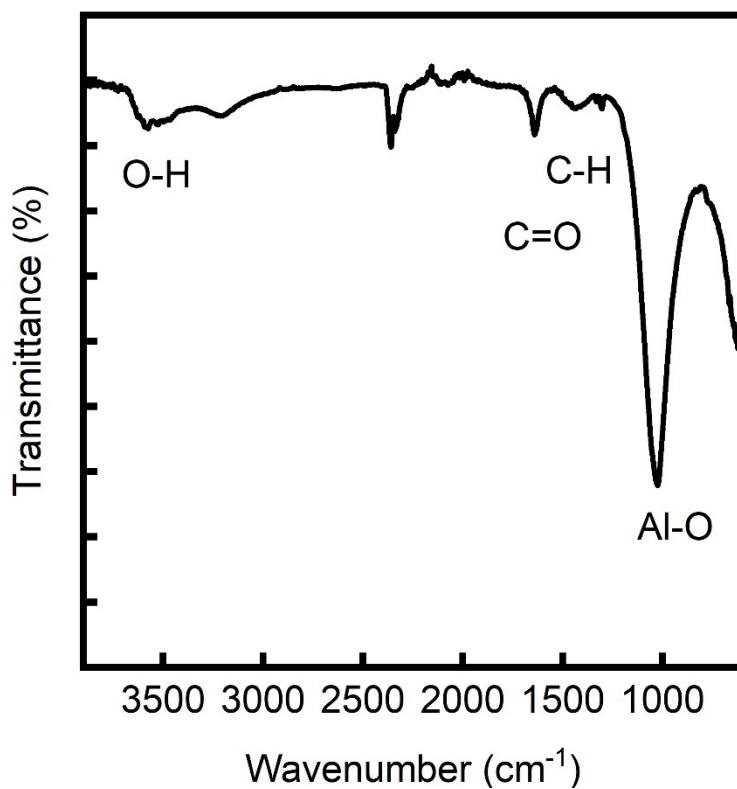
Figure S2. Infrared spectrum of the aluminium oxide precipitate after all HBF$_4$ electrolyte residue was evaporated.

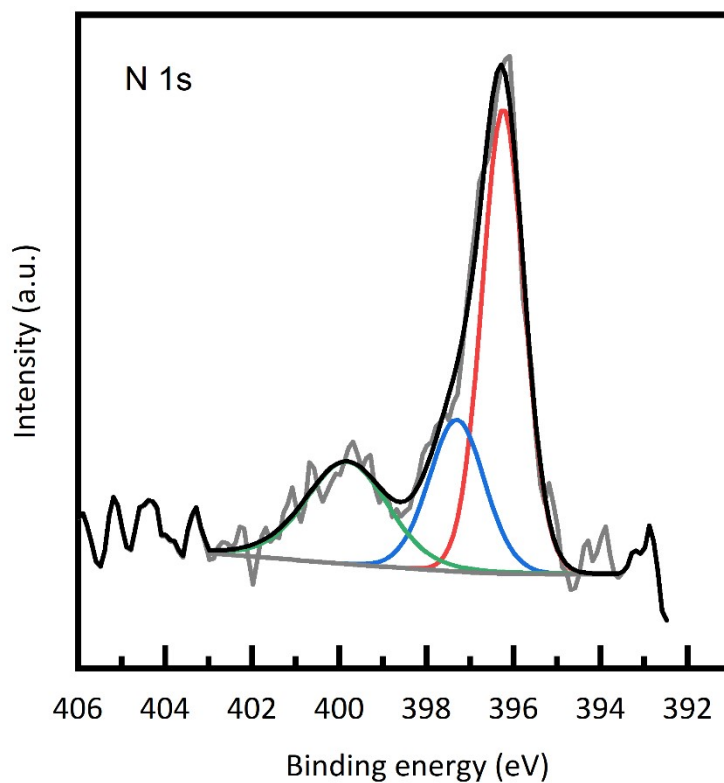*Figure S3. XPS N 1s spectrum of EE-Ti$_3$CN. Peaks located at 396.4, 397.1, 399.5, and 402.4 eV*
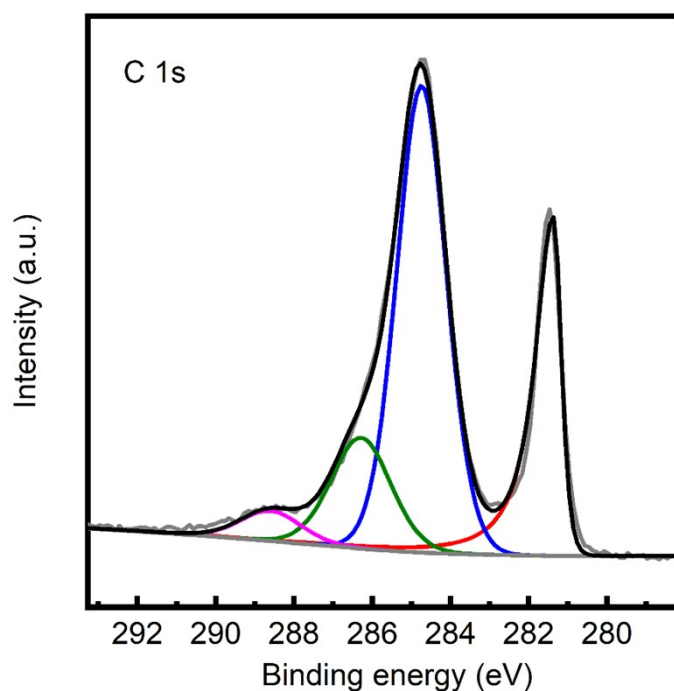
are assigned for N-Ti, N-C, CH₃CN, and NH₄NO₃

Figure S4. XPS C 1s spectrum of EE-Ti₃CN. peak located at 281.5, 284.7, 286.4, and 288.6 eV are assigned for X-Ti, C-C, C-O, and C=O, respectively.
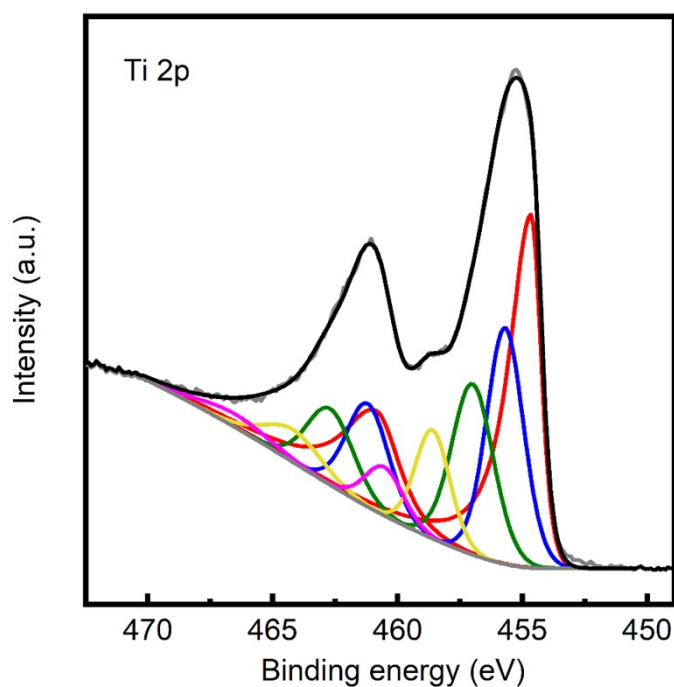

Figure S5. XPS Ti 2p spectrum of EE-Ti₃CN. Peaks located at 455.0(461.2), 455.9 (461.4), 457(462.7), 458.6(464.2), 460.2(466.2) eV are assigned for titanium metal in

the oxidation state of +1 to +3, TiO₂, and X-Ti-F, respectively.

MAX phase
Powder

EE-Ti₃C₂ multilayer
powder

EE-Ti₃C₂
dispersion

Figure S6. Photographs of Ti₃AlC₂ precursor, EE-Ti₃C₂ multilayer powder, dispersion of TMAOH treated EE-Ti₃C₂ in water.
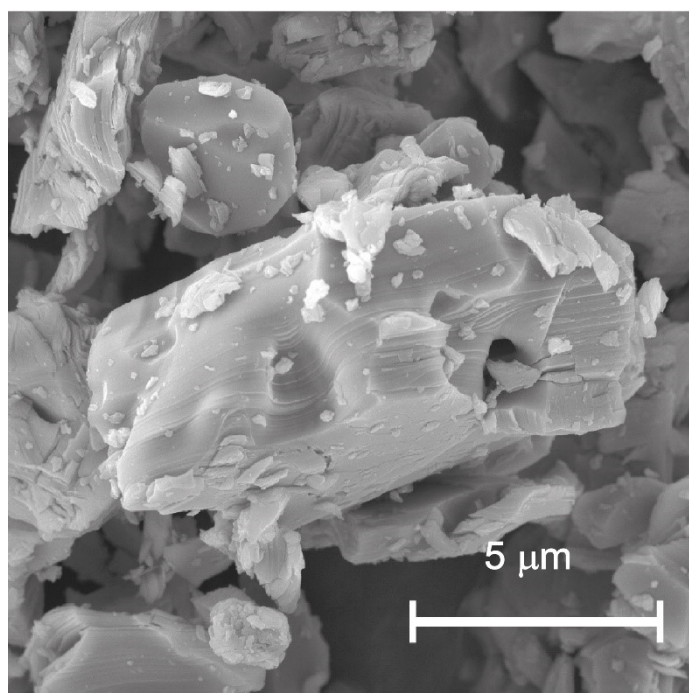

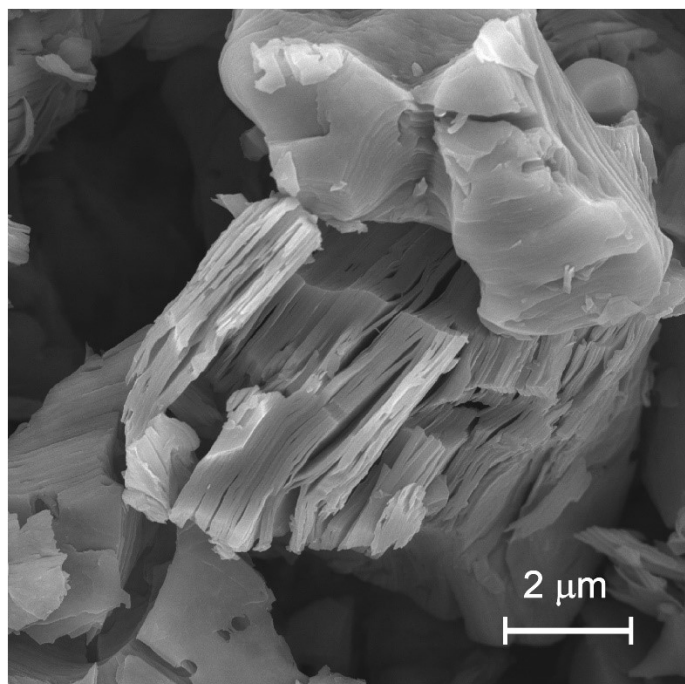
Figure S7. SEM images for Ti₃AlC₂ MAX phase.

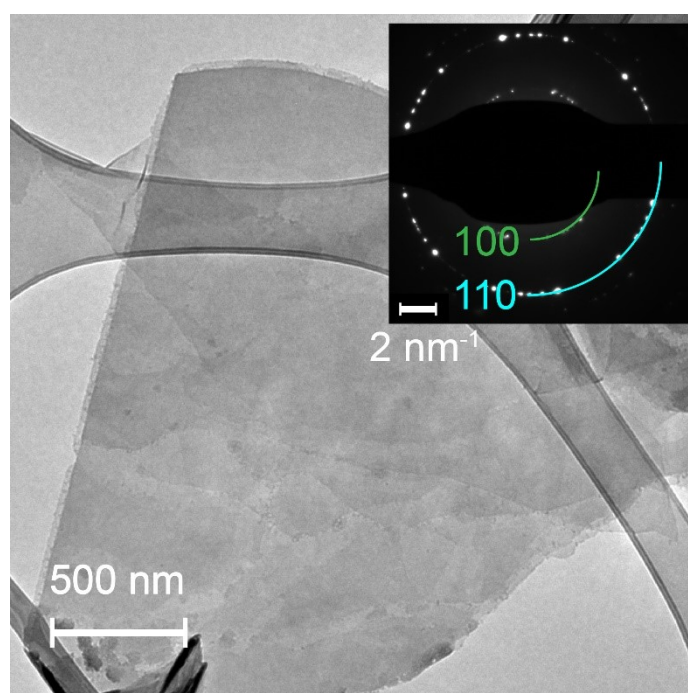*Figure S8. SEM image for EE-Ti₃CN.*

Figure S9. TEM image for EE-Ti₃CN delaminated flakes. (110) diffraction= 1.51 Å. (100) diffraction= 2.58 Å.