Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Electrochemical etching of Ti_2AlC to Ti_2CT_x (MXene) in low-concentration hydrochloric acid solution

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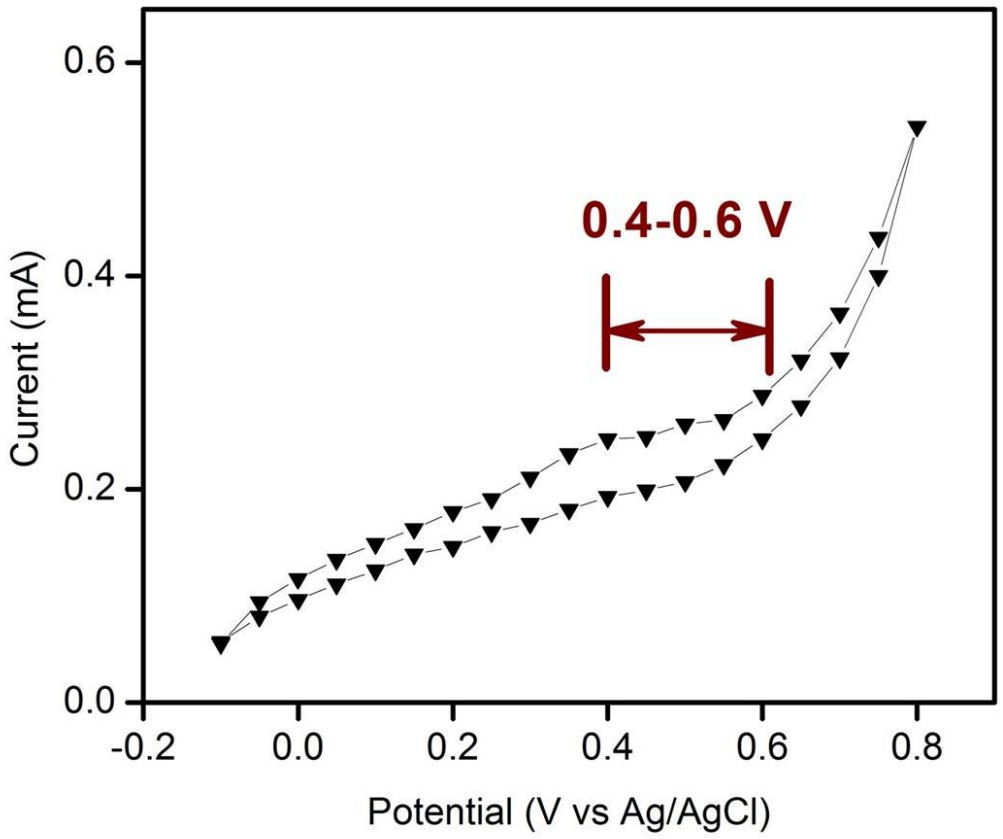

Figure S1. Cyclic voltammetry curves of Ti_2AlC in 2M HCl electrolyte.

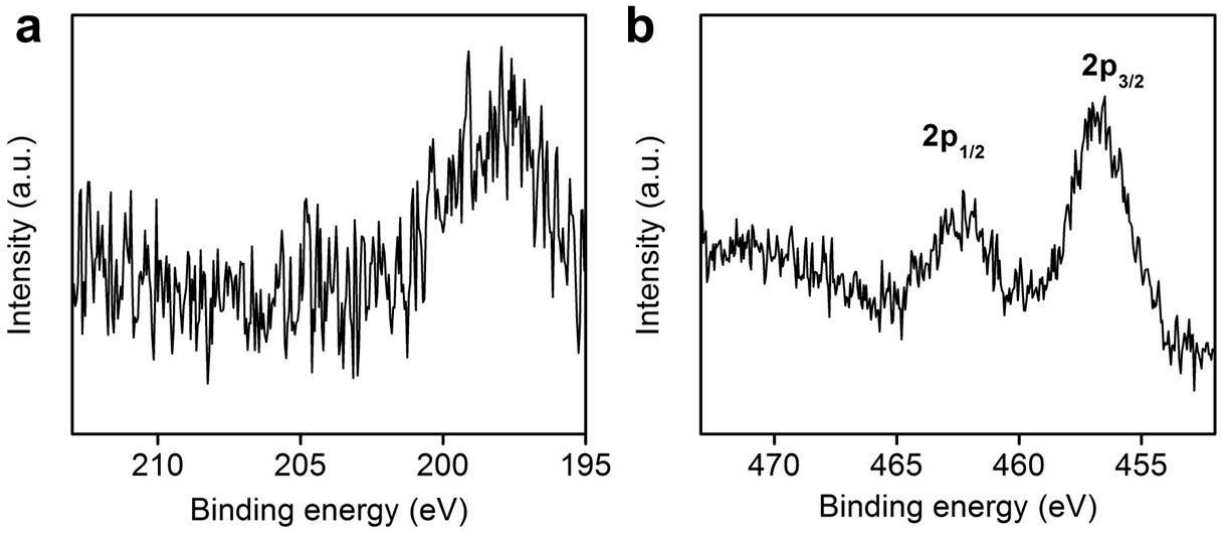

Figure S2. XPS high-resolution spectra of (a) the Cl 2p and (b) the Ti 2p.

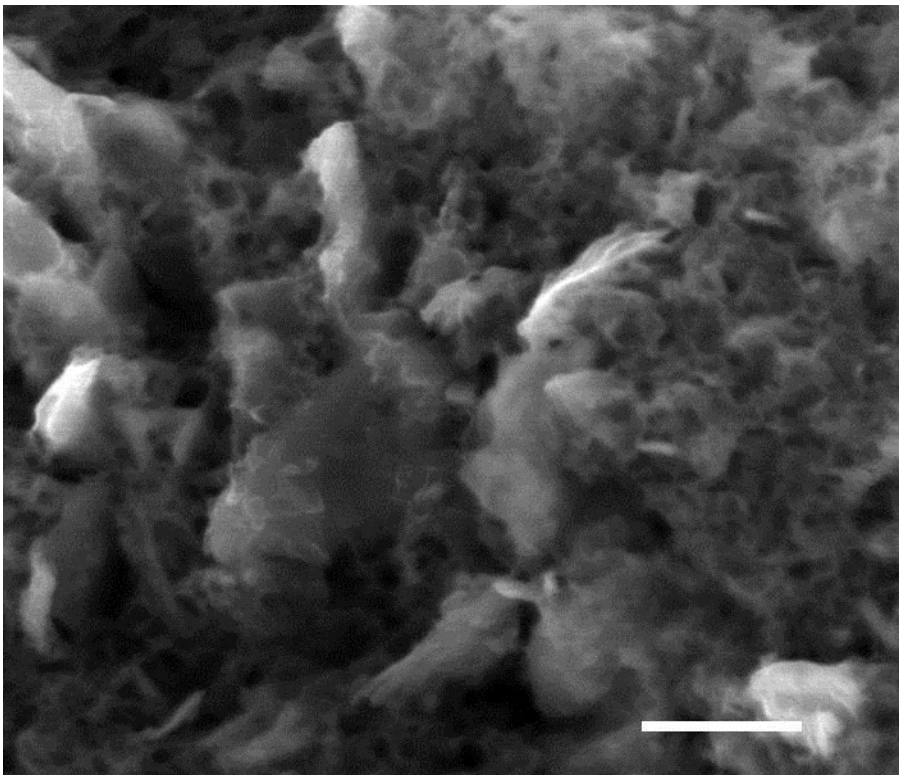

Figure S3. SEM image of EE-2M-0.6V-5Days-supernatant. The scale bar is 2 μm.

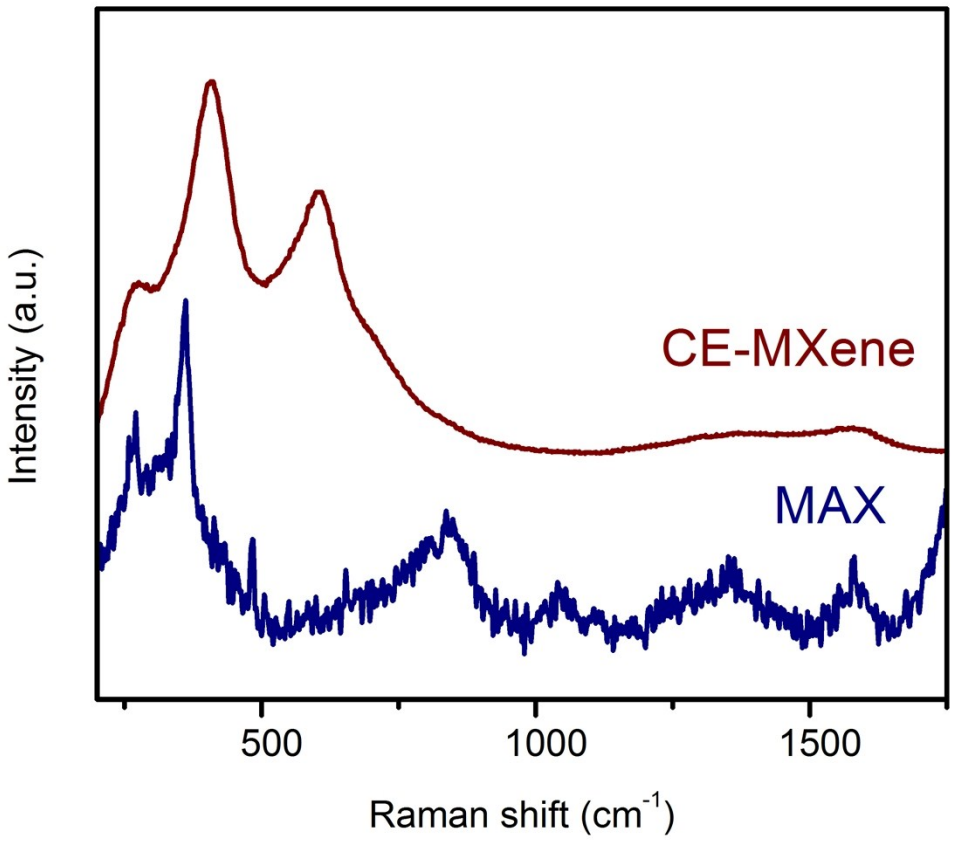

Figure S4. Raman spectra of Ti_2AlC (MAX) and chemically etched Ti_2CTx sample (CE-MXene)

After chemical etching of Al, signature peaks (~275 and ~350 cm^{-1}) of Ti_2AlC (MAX), which present the vibrations of Al in Ti_2AlC, are weaker in CE-MXene sample. Meanwhile, two pronounced peaks (~410 and ~612 cm^{-1}) show up in CE-MXene sample, and these peaks imply B_{1g} and E_g vibration of Ti-O in TiO_2[1,2]. The detection of TiO_2 suggests the tendency of oxidation of MXene in air, which is consistent with previous report[3].

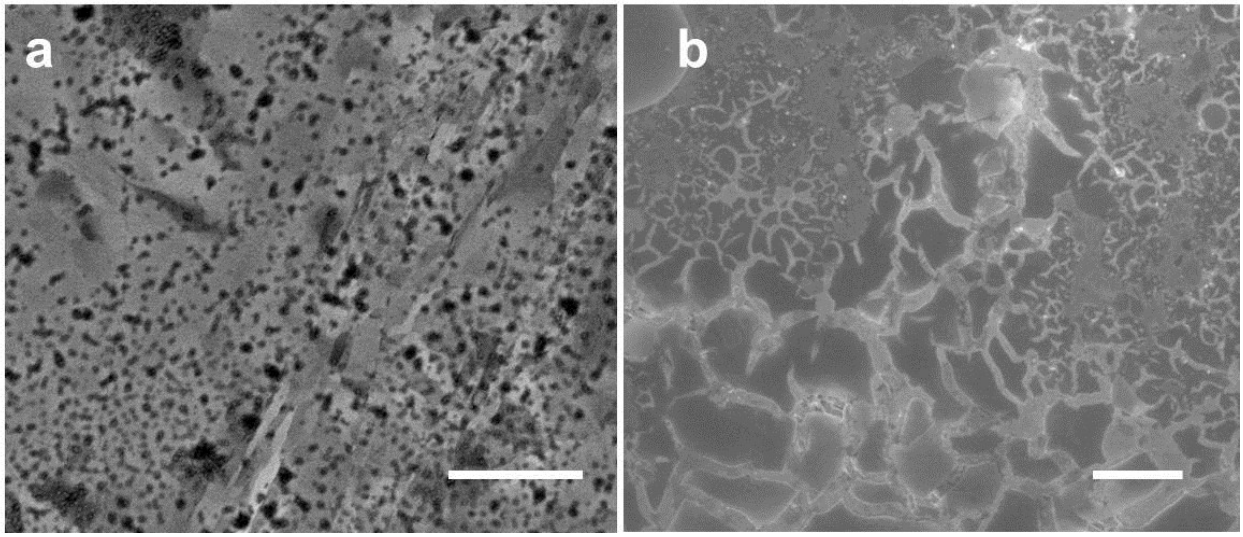

Figure S5. SEM images of Pt foils from different etching conditions. (a) Pt-1M-0.6V-1Day. (b) Pt-2M-0.6V-5Days. The scale bars are 5 and 10 μm, respectively.

Table S1. Quantitative results for Ti, Al, C, O, and Pt in Pt foils from EDS

	Pt-1M-0.6V-1Day	Pt-2M-0.6V-5Days
Ti atomic %	0.00	3.49
Al atomic %	79.60	11.34
C atomic %	0.00	26.80
O atomic %	19.60	20.10
Pt atomic %	0.90	38.27

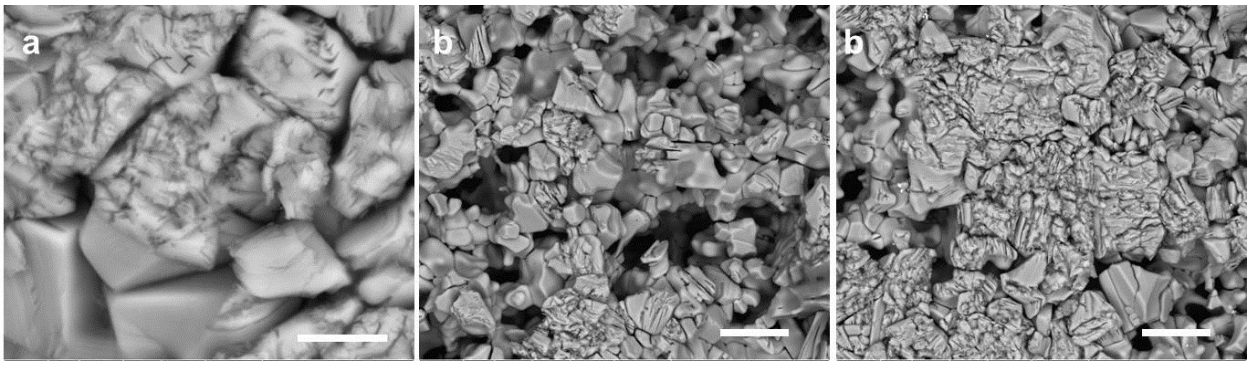

Figure S6. SEM images of samples from different etching voltages. Samples that are etched in 2M HCl for 3 days at (a) 0.5 V, (b) 0.6 V, and (c) 0.7 V. The scale bars are 5, 20 and 20 μm, respectively.

Table S2. Quantitative results for Ti, Al, C, O, and Cl in samples etched at different voltages in 2M HCl for 3 days from EDS

	0.5 V	0.6 V	0.7 V
Ti atomic %	31.20	29.18	9.74
Al atomic %	13.31	12.04	4.19
C atomic %	47.74	49.98	79.15
O atomic %	7.66	8.61	6.23
Cl atomic %	0.09	0.19	0.70
Ti/Al	2.34	2.42	2.32

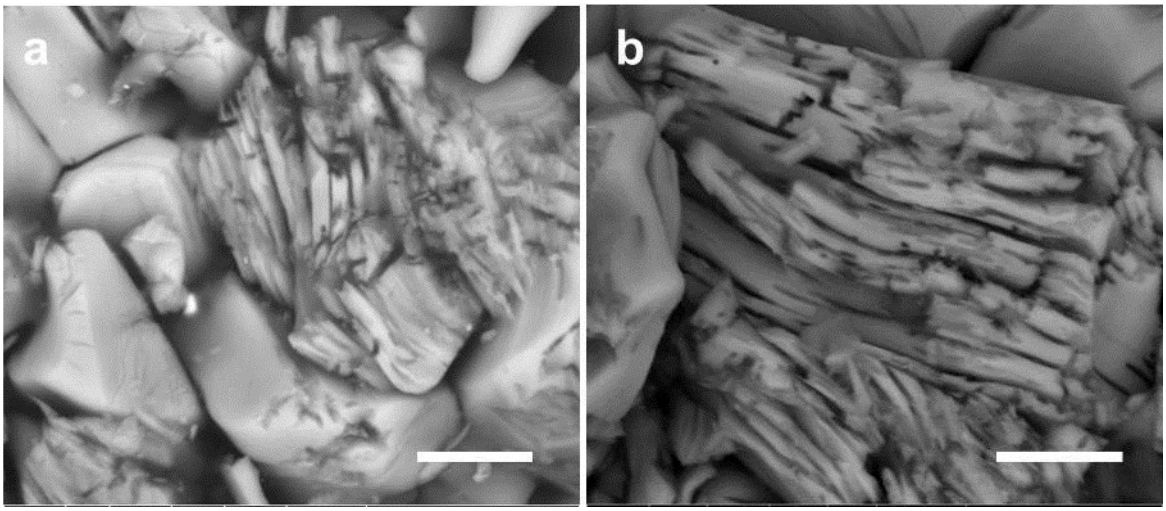

Figure S7. SEM images of samples from different concentration of HCl. Samples that are etched at 0.6 V for 5 days in (a) 1M HCl and (b) 2M HCl. The scale bars are both 5 μm.

Table S3. Quantitative results for Ti, Al, C, O, and Cl in samples etched in different concentrations of HCl at 0.6V for 5 days from EDS

	1M HCl	2M HCl
Ti atomic %	21.10	21.47
Al atomic %	9.30	8.94
C atomic %	58.10	63.15
O atomic %	9.40	6.12
Cl atomic %	1.10	0.32
Ti/Al	2.37	2.40

We also compared Ti_2AlC samples at different etching conditions. As shown in the SEM images (Figure S8), longer etching times resulted in more pronounced cracks on the surface of Ti_2AlC, and these longer etching times all result in similar Ti/Al ratio (Table S4). These comparable Ti/Al ratios indicate a longer etching time does not result in complete removal of Al. During the etching process, Ti is removed along with Al, forming a layer of CDC on the surface of MXene.

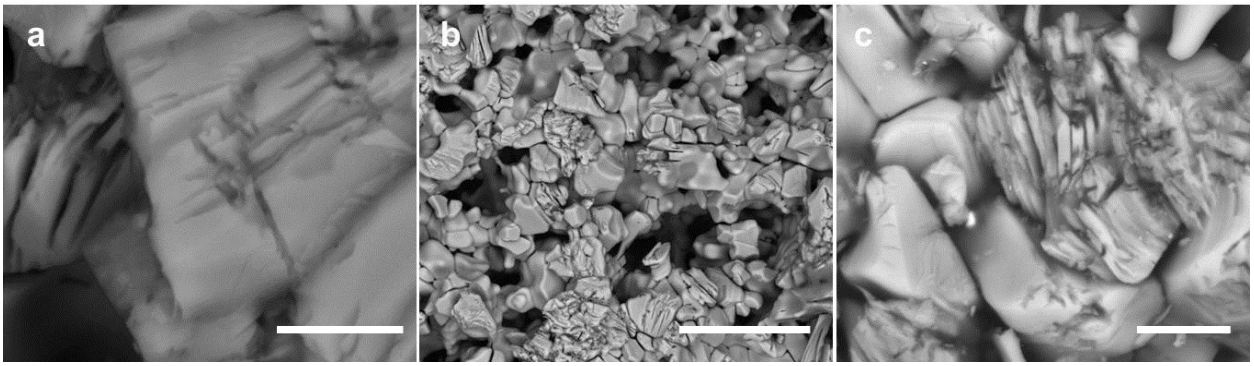

Figure S8. SEM images of samples from different etching time. Samples that are etched in 2M HCl at 0.6 V for (a) 1 day, (b) 3 days, and (c) 5days. The scale bars are all 5 μm.

Table S4. Quantitative results for Ti, Al, C, O, and Cl in samples etched for different time in 2M HCl at 0.6 V from EDS.

	1 day	3 days	5 days
Ti atomic %	35.15	29.18	22.10
Al atomic %	14.58	12.04	9.30
C atomic %	41.97	49.98	58.10
O atomic %	8.30	8.61	9.40
Cl atomic %	0.00	0.19	1.10
Ti/Al	2.40	2.42	2.37

1 R. Syamsai, P. Kollu, S. Kwan Jeong and A. Nirmala Grace, *Ceram. Int.*, 2017, 1–8.

2 H. Ha, M. Yoshimoto, H. Koinuma, B. Moon and H. Ishiwara, *Appl. Phys. Lett.*, 1996, **68**, 2965–2967.

3 S. Shah, T. Habib, H. Gao, P. Gao, W. Sun, M. Green and M. Radovic, *Chem. Commun.*, 2016, **53**, 400–403.