Supplementary Information (SI) for Nanoscale Advances.

Elucidating Interfacial Charge-Transfer Dynamics of $Ti_3C_2T_x$ Electrodes via Advanced Distribution of Relaxation Times (DRT) Analysis

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Table S1. The inter-planar separation (d-spacing) of Ti_3AlC_2 MAX phase and $Ti_3C_2T_x$ MXene calculated with Bragg’s law.

Ti_3AlC_2 (MAX Phase)		**$Ti_3C_2T_x$ (MXene)**	
2θ	**d- Spacing**	**2θ**	**d- Spacing**
9.57706	9.227542	8.92692	9.898064
12.80438	6.908092	18.33966	4.833668
19.17237	4.625565	23.00505	3.862874
33.98769	2.635586	25.56701	3.481303
34.98404	2.562772	27.74141	3.213176
35.98039	2.494057	35.10773	2.554026
36.73849	2.444313	37.22321	2.413589
38.96945	2.309361	41.15307	2.191725
41.98016	2.150437	41.5186	2.17327
43.21477	2.091817	42.74418	2.113751
45.20748	2.004134	43.34321	2.085916
48.56475	1.873143	52.49351	1.741823
52.94004	1.728178	57.55191	1.600172
56.55723	1.62593	62.05853	1.494347
60.28272	1.534049	65.61571	1.421681
65.5244	1.423441	75.11873	1.263651
70.63611	1.332434		
73.99323	1.280062		

Table S2. EDS data of aluminum etching obtained from FESEM EDS.

Condition	Atomic wt. % of Aluminium
Before etching	18.29%
After etching	0.83%

Table S3. Capacitance values calculated from the CV curve at 50 mVs^{-1} for each electrolyte and each substrate given an effective area of the electrode of $1cm^{-2}$.

S. No.	Electrolyte/Substrate	Capacitance (mF/cm^2)
1.	H_2SO_4	89.36
2.	Na_2SO_4	126.67
3.	KOH	0.24
4.	FTO	68.95
5.	Carbon Paper	119.48
6.	Nickel Foam	176.29

Table S4. Comparative analysis of the per-unit cost of electrolytes (1 M H_2SO_4, 1 M Na_2SO_4, and 1 M KOH; calculated per 20 mL) and substrates (FTO, carbon paper, and nickel foam; calculated per cm^2) used in this study.

S. No.	Electrolyte/ Substrate	Source	Approximate Cost (in INR)
1.	1M H_2SO_4	Merck	78.8 per 20 ml
2.	1M Na_2SO_4	Merck	29.8 per 20 ml
3.	1M KOH	Merck	6.9 per 20 ml
4.	FTO	Sigma Aldrich	9.4 per cm^2
5.	Carbon paper	Sainergy Fuel Cell India Private Limited	13.6 per cm^2
6.	Nickel Foam	Sigma Aldrich	20.0 per cm^2

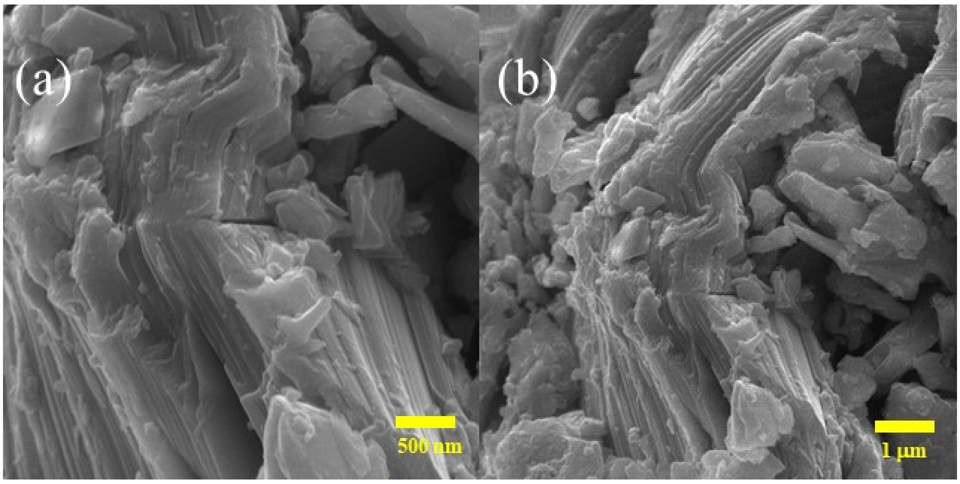


Figure S1.(a-b) FESEM image of the Ti_3AlC_2 MAX phase at different magnifications.

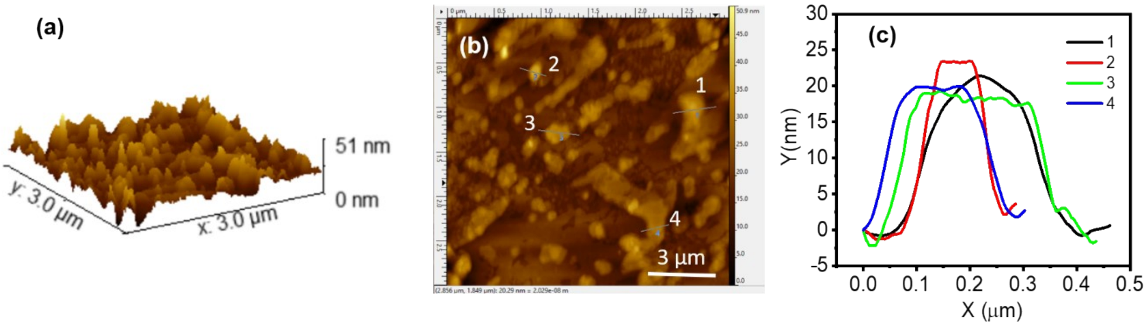


Figure S2. Atomic force microscopy images of $Ti_3C_2T_x$ (a) Three-dimensional image, (b) showing four arbitrarily different selected regions for analysis, and (c) height profile corresponding to four different regions.

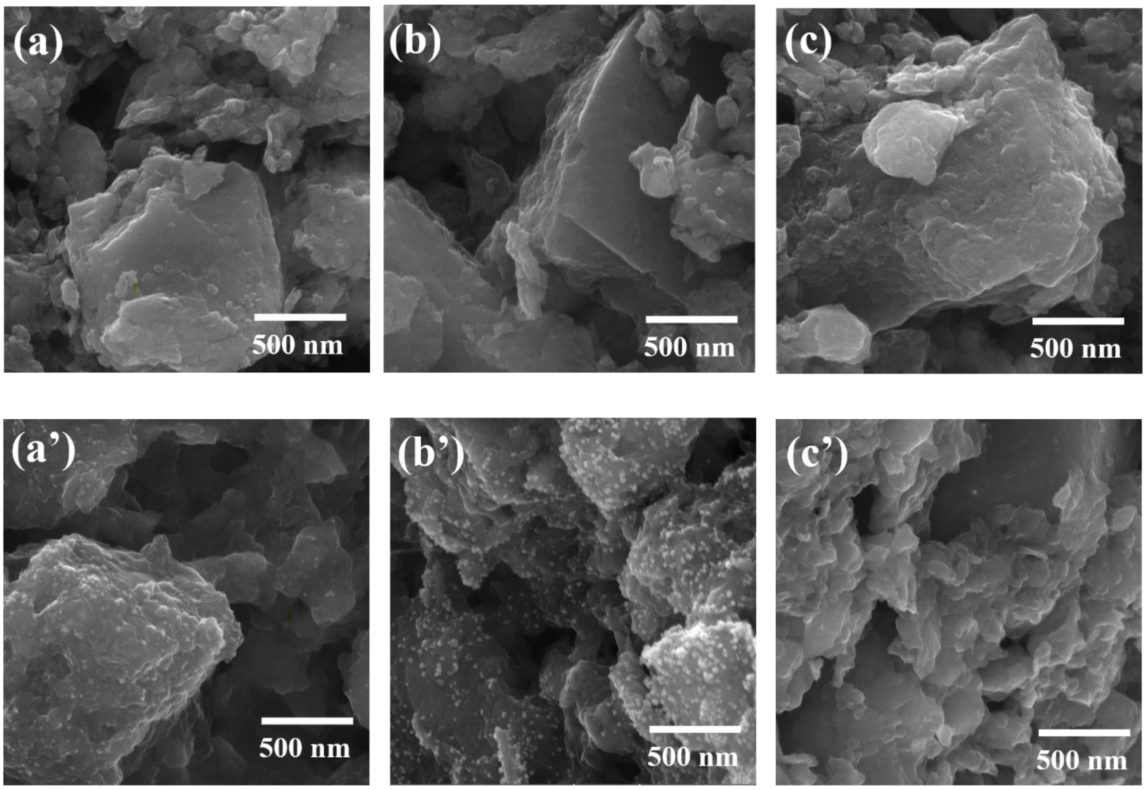
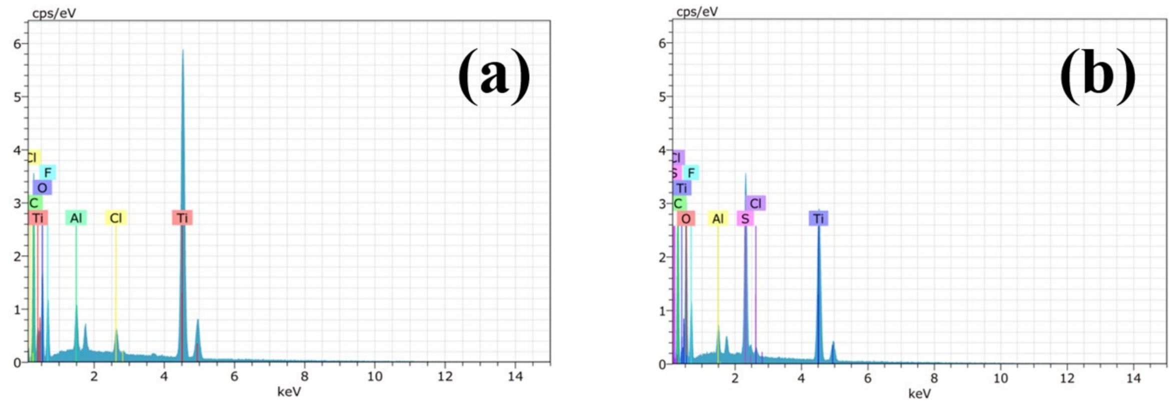


Figure S3. FESEM image of the electrode before and after using in (a and a’) H_2SO_4, (b and b’) Na_2SO_4, and (c and c’) KOH.



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Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Titanium  K-series  46.72   42.90   18.91            4.14
Carbon    K-series  24.48   22.48   39.49            9.25
Oxygen    K-series  22.35   20.53   27.07            9.12
Fluorine  K-series  12.34   11.33   12.59            5.27
Chlorine  K-series   1.25    1.15    0.68            0.21
Aluminium K-series   1.76    1.62    1.27            0.33
-----------------------------------------------------------
             Total: 108.90  100.00  100.00
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Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Oxygen    K-series  30.05   29.57   33.31           11.43
Carbon    K-series  29.70   29.23   43.86           11.30
Titanium  K-series  22.98   22.62    8.52            2.09
Fluorine  K-series   9.98    9.82    9.32            4.32
Sulfur    K-series   7.54    7.42    4.17            0.88
Chlorine  K-series   0.41    0.40    0.21            0.13
Aluminium K-series   0.94    0.92    0.62            0.22
Hydrogen  K-series   0.00    0.00    0.00            0.00
-----------------------------------------------------------
             Total: 101.60  100.00  100.00
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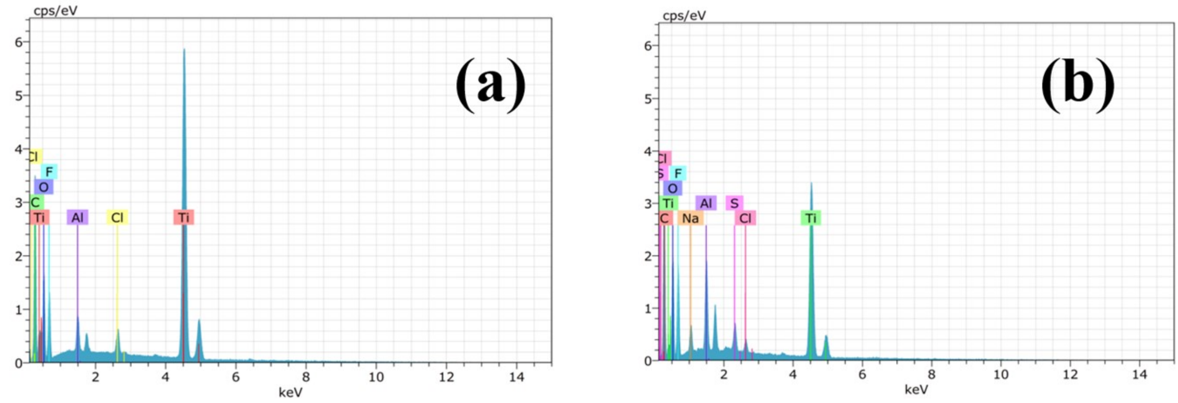
Figure S4. EDS of the electrode before (a) and after (b) using the H_2SO_4 electrolyte.



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Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Titanium  K-series  45.07   43.19   19.15            3.99
Carbon    K-series  22.73   21.78   38.49            8.60
Oxygen    K-series  21.31   20.43   27.10            8.67
Fluorine  K-series  12.62   12.09   13.51            5.31
Chlorine  K-series   1.22    1.17    0.70            0.21
Aluminium K-series   1.39    1.34    1.05            0.28
-----------------------------------------------------------
             Total: 104.35  100.00  100.00
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```
Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Carbon    K-series  27.12   27.98   43.73           10.18
Titanium  K-series  27.83   28.71   11.26            2.51
Oxygen    K-series  21.07   21.75   25.52            8.39
Fluorine  K-series  15.15   15.63   15.45            6.10
Sodium    K-series   1.17    1.21    0.99            0.31
Aluminium K-series   2.87    2.96    2.06            0.48
Chlorine  K-series   0.58    0.60    0.32            0.14
Sulfur    K-series   1.13    1.16    0.68            0.21
-----------------------------------------------------------
             Total:  96.91  100.00  100.00
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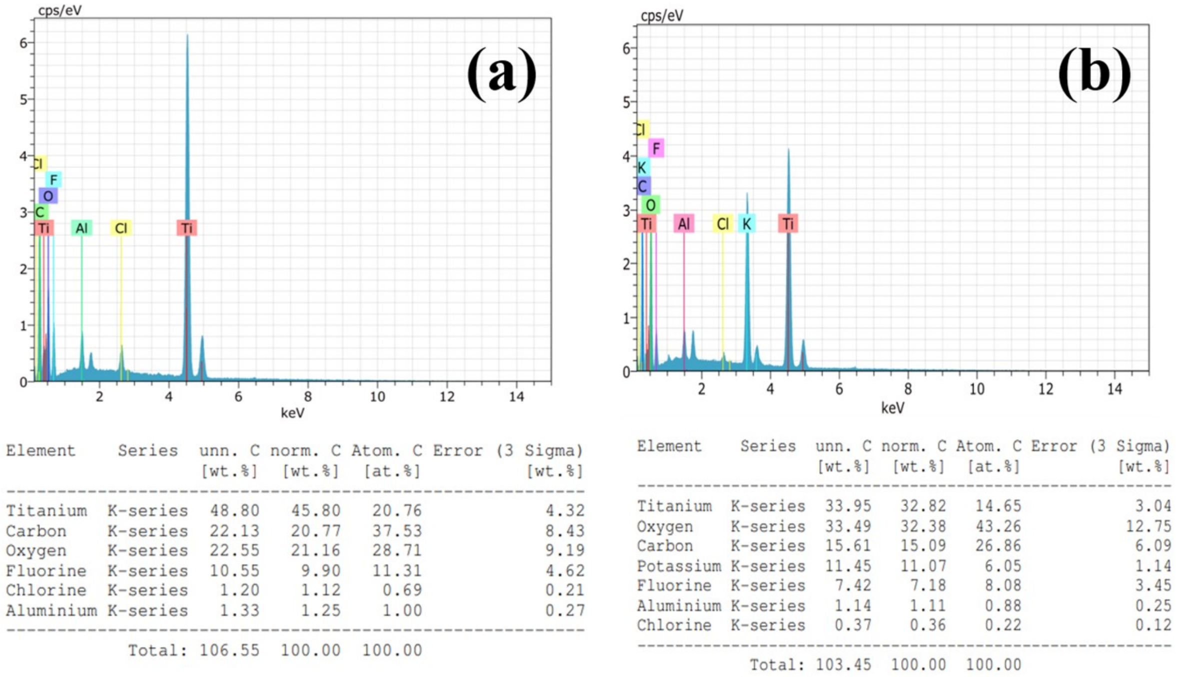
Figure S5. EDS of the electrode before (a) and after (b) using the Na_2SO_4 electrolyte.



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Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Titanium  K-series  48.80   45.80   20.76             4.32
Carbon    K-series  22.13   20.77   37.53             8.43
Oxygen    K-series  22.55   21.16   28.71             9.19
Fluorine  K-series  10.55    9.90   11.31             4.62
Chlorine  K-series   1.20    1.12    0.69             0.21
Aluminium K-series   1.33    1.25    1.00             0.27
-----------------------------------------------------------
              Total: 106.55  100.00  100.00
```

```
Element    Series   unn. C norm. C Atom. C Error (3 Sigma)
                    [wt.%]  [wt.%]  [at.%]          [wt.%]
-----------------------------------------------------------
Titanium  K-series  33.95   32.82   14.65             3.04
Oxygen    K-series  33.49   32.38   43.26            12.75
Carbon    K-series  15.61   15.09   26.86             6.09
Potassium K-series  11.45   11.07    6.05             1.14
Fluorine  K-series   7.42    7.18    8.08             3.45
Aluminium K-series   1.14    1.11    0.88             0.25
Chlorine  K-series   0.37    0.36    0.22             0.12
-----------------------------------------------------------
              Total: 103.45  100.00  100.00
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Figure S6. EDS of the electrode before (a) and after (b) using the KOH electrolyte

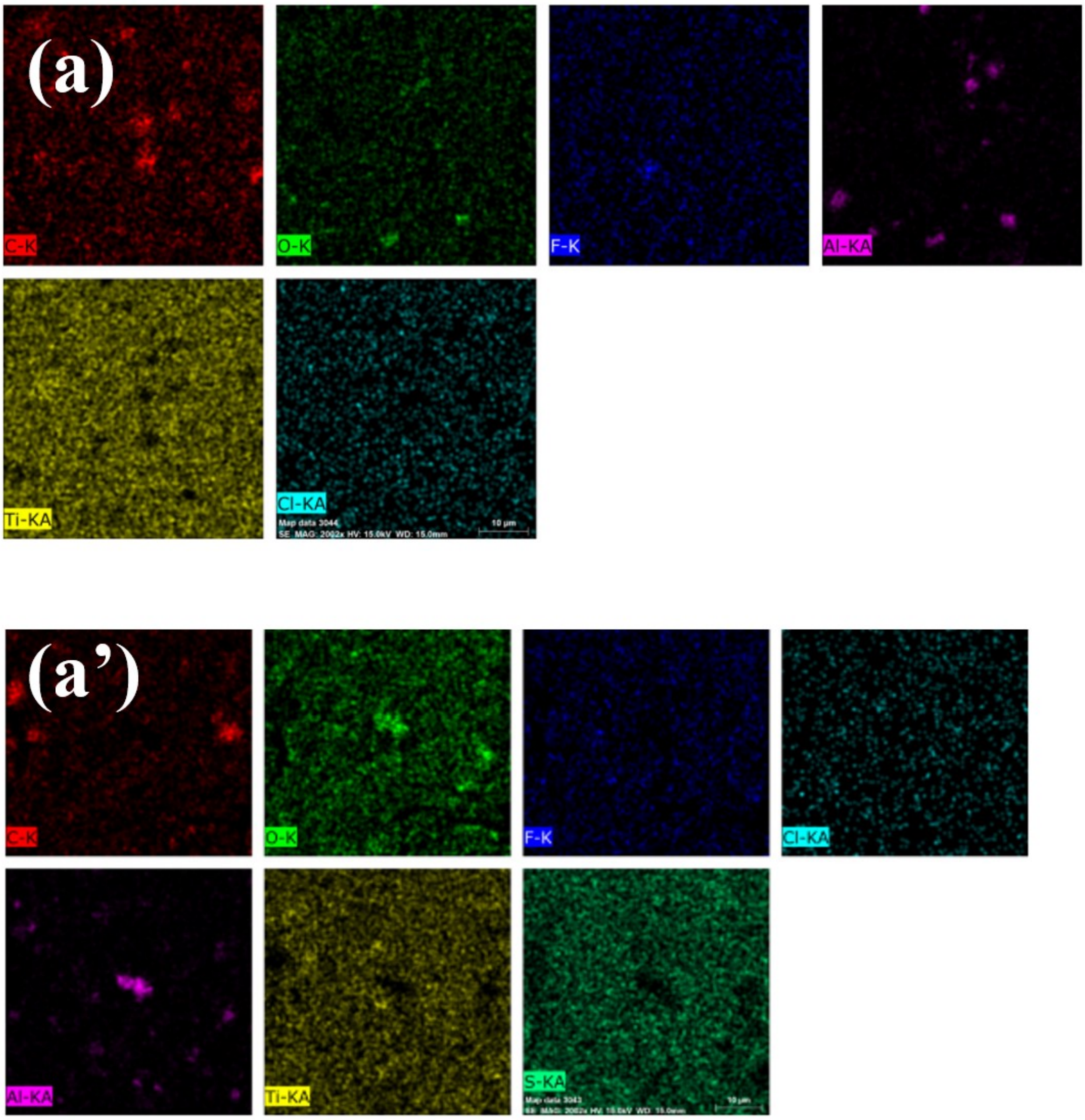

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Figure S7. Mapping of the electrode before (a) and after (a') electrochemical experiments in H_2SO_4 electrolyte.

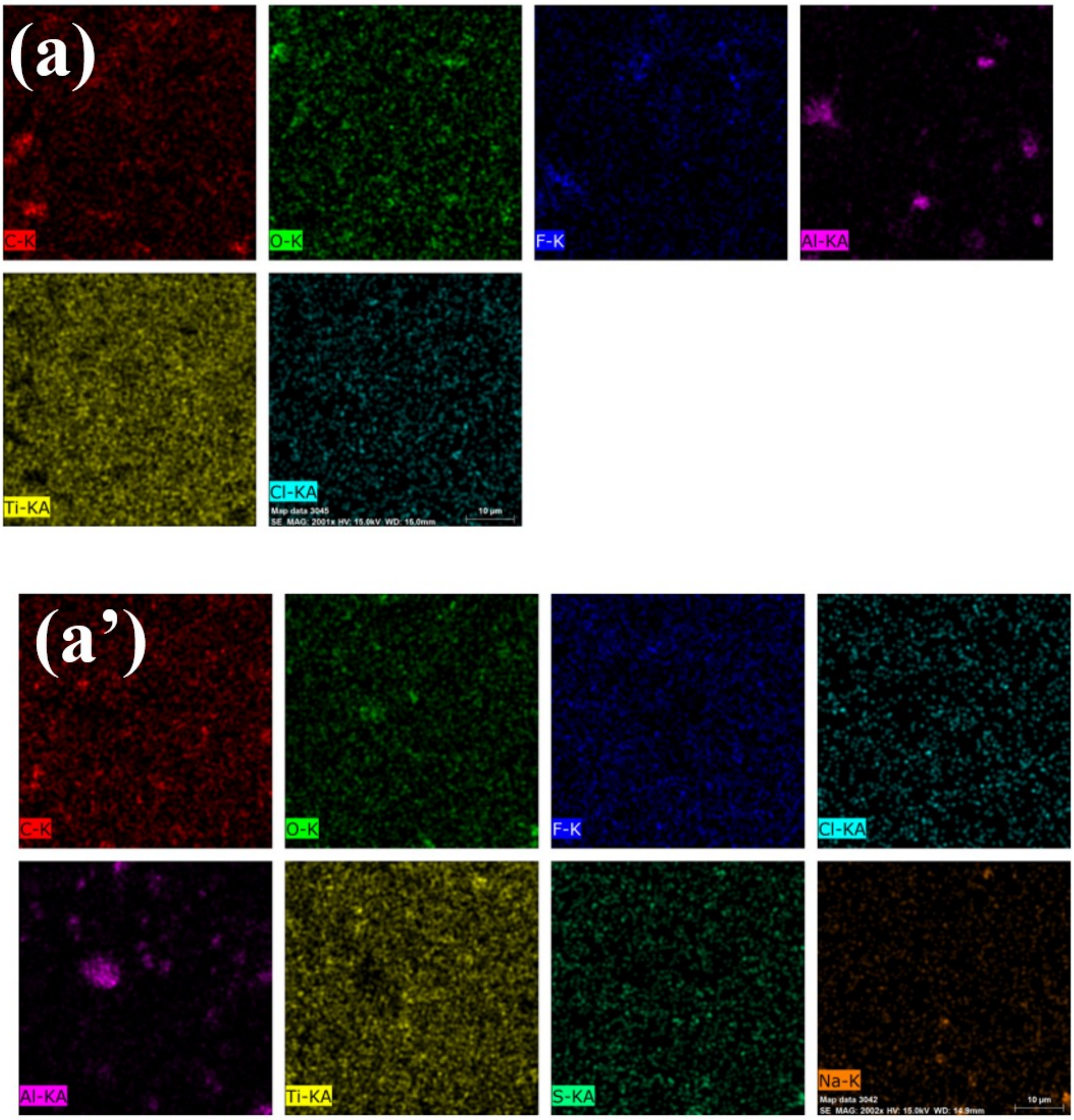

Figure S8. Mapping of the electrode before (a) and after (a') electrochemical experiments in Na_2SO_4 electrolyte.

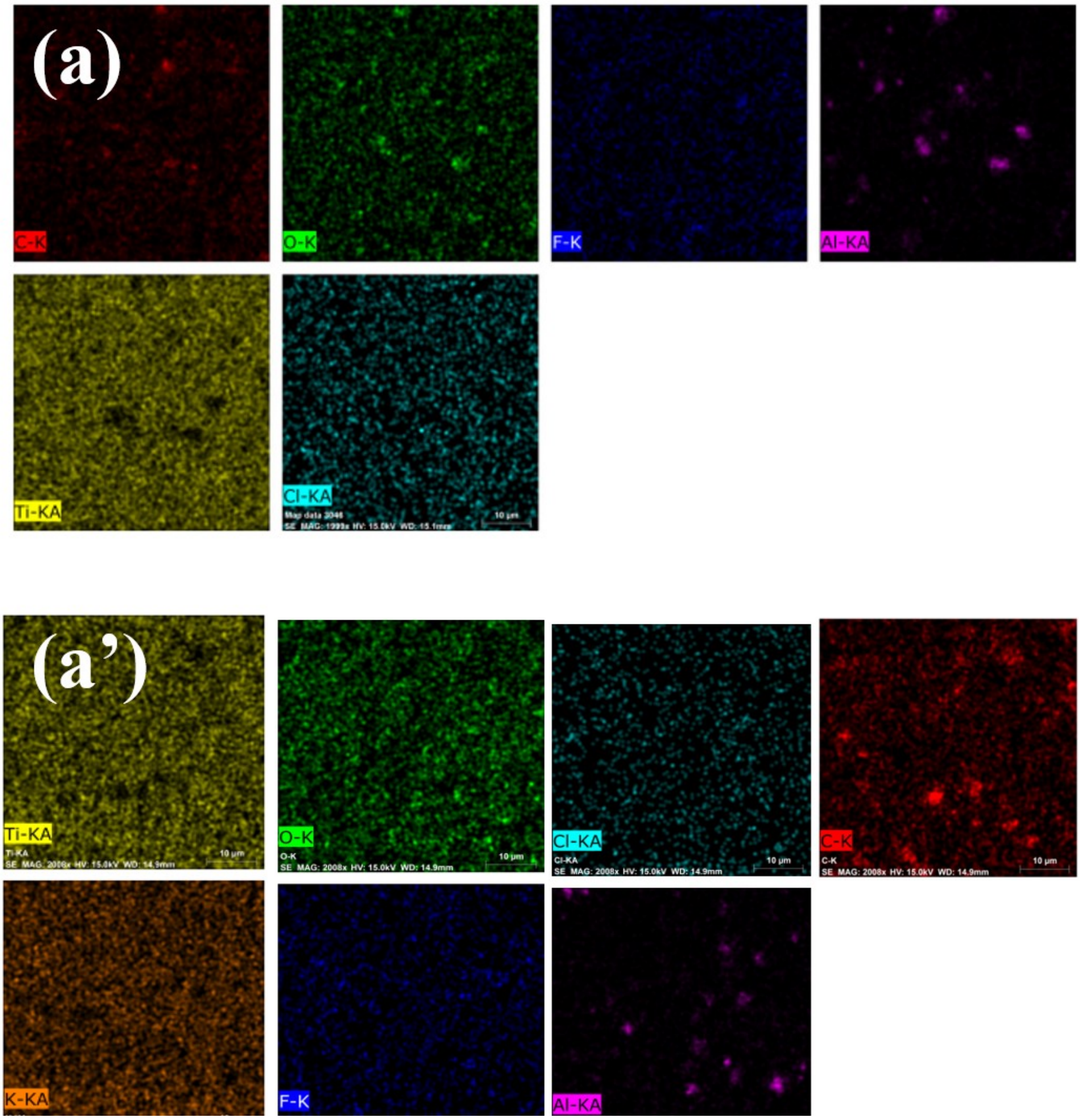

Figure S9. Mapping of the electrode before (a) and after (a’) electrochemical experiments in KOH electrolyte.