Supplementary Information (SI) for Journal of Materials Chemistry A.

SUPPLEMENTARY INFORMATION

Amphiphilic Silane–MXene Hybrids for High-Performance Flexible Symmetric Supercapacitors via Additive-Free Processing

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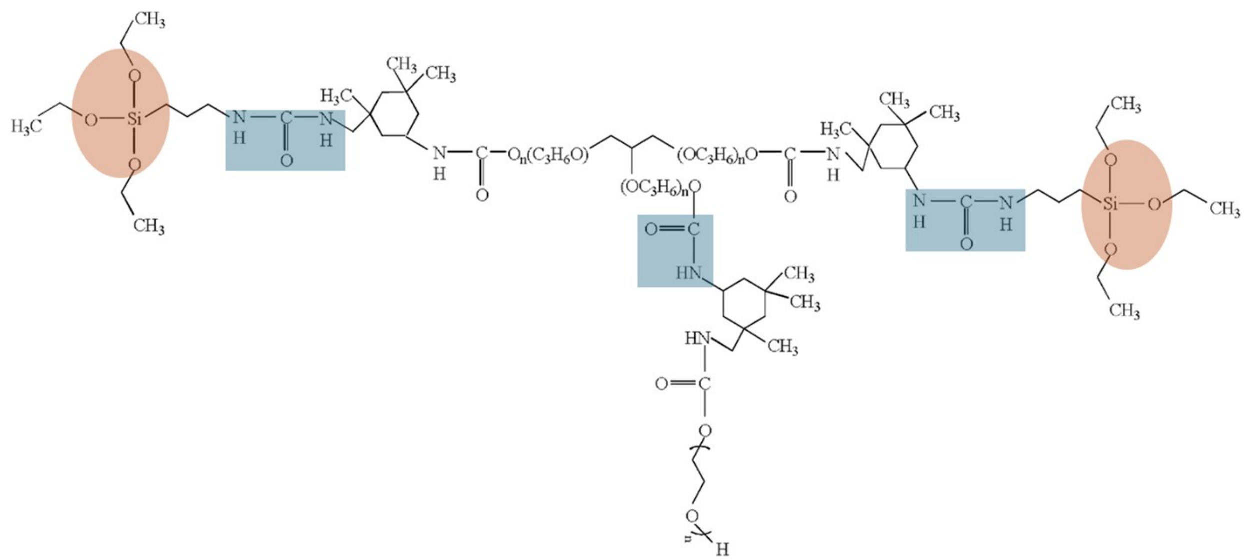

Figure S1. Chemical structure of alkoxysilane-based amphiphilic oligomer (AFAO)

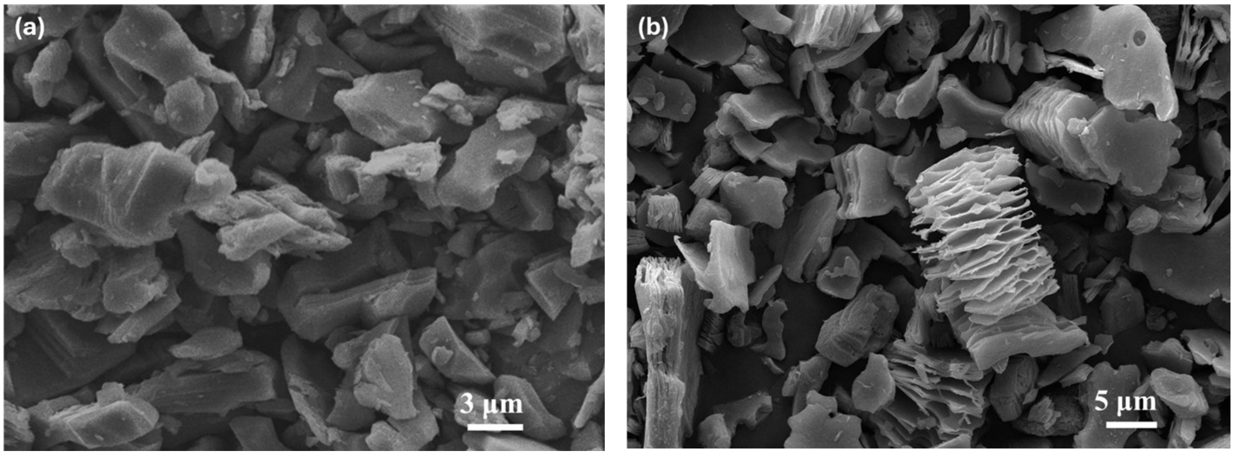

Figure S2. SEM images of (a) MAX phase Ti_3AlC_2 and (b) Multilayer $Ti_3C_2T_x$

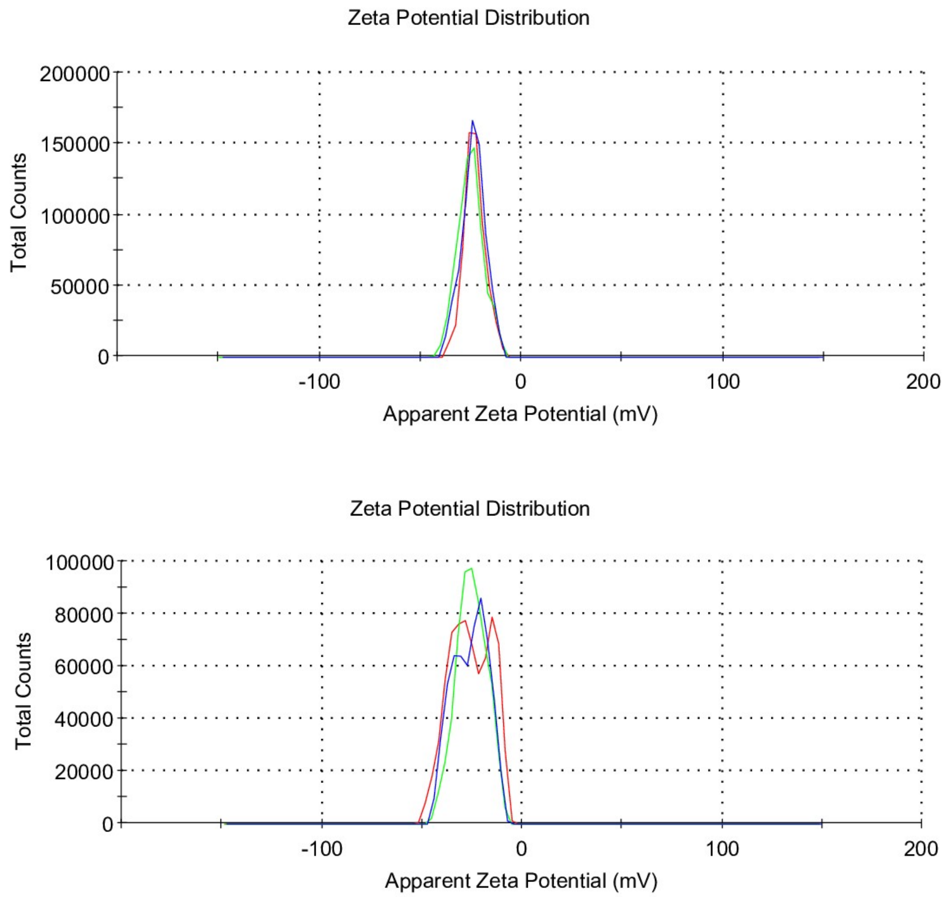

Figure S3. Zeta potential of pristine MXene and AFAO-MXene

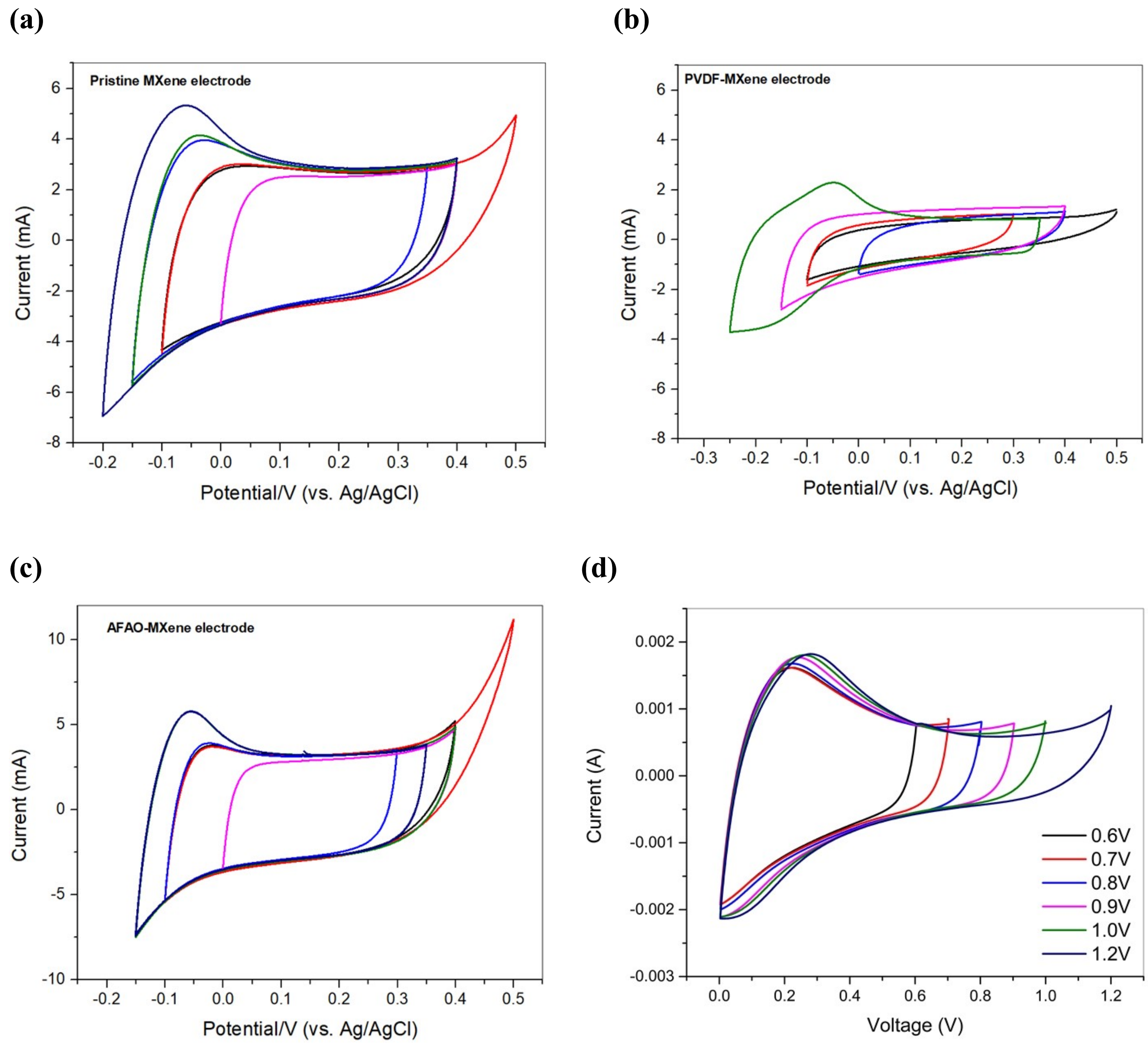

Figure S4. Cyclic voltammetry (CV) measurements of (a) pristine MXene electrode, (b) PVDF-MXene electrode, (c) AFAO-MXene electrode, and (d) AFAO-SSC under different voltage windows at 25 mVs^{-1}.

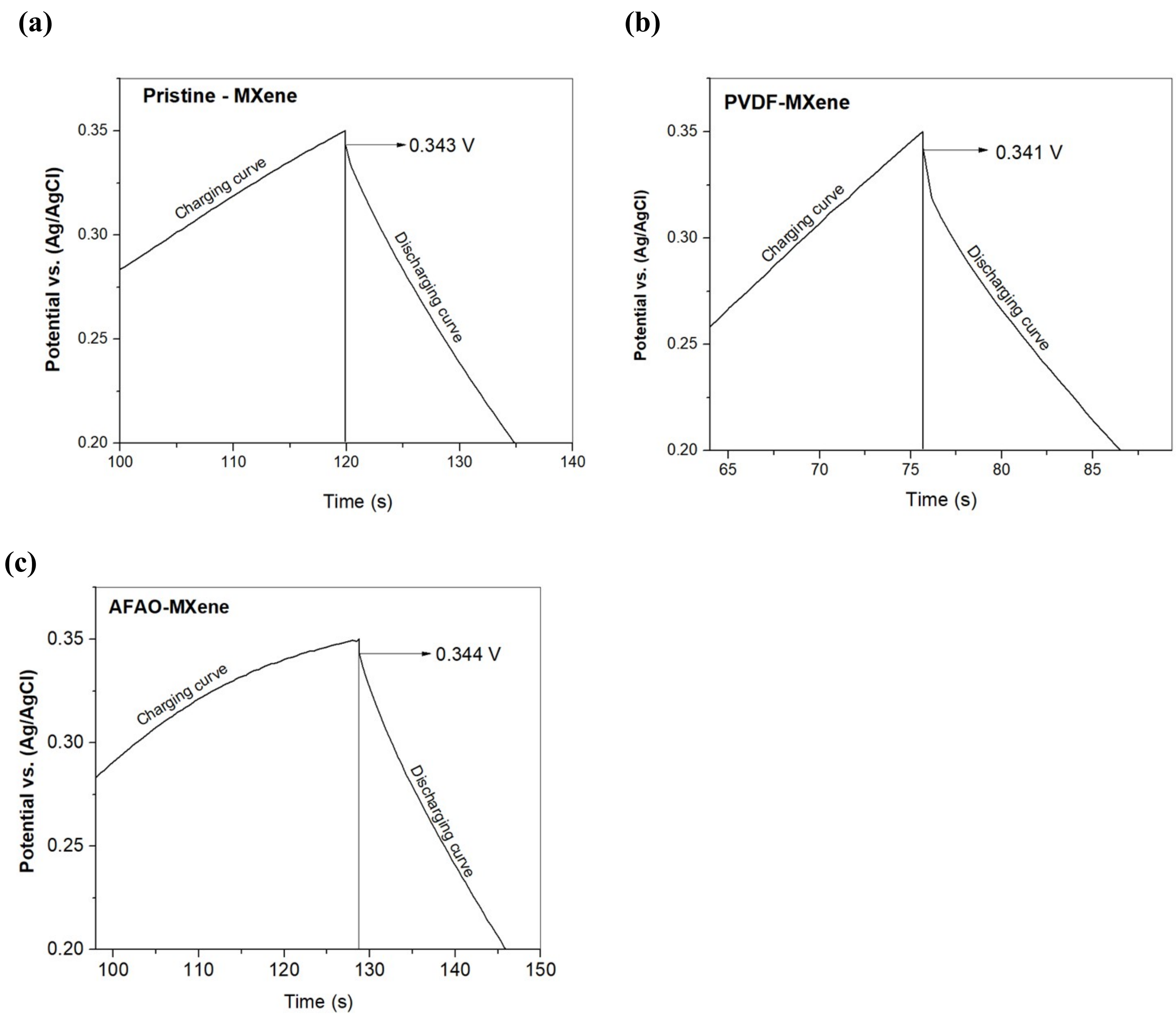

Figure S5. Charge-Discharge profile for (a) Pristine-MXene, (b) PVDF-MXene, and (c) AFAO-MXene, in 1 M H_2SO_4 electrolyte at a current density of 1 A/g.

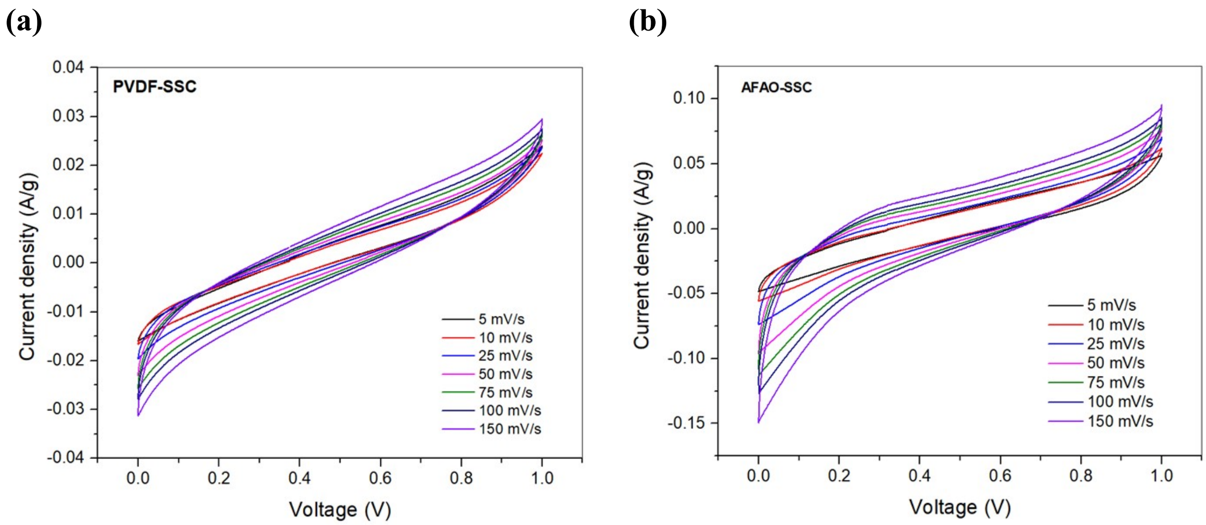

Figure S6. CV scanning of (a) PVDF-SSC and (b) AFAO-SSC at different scan rates

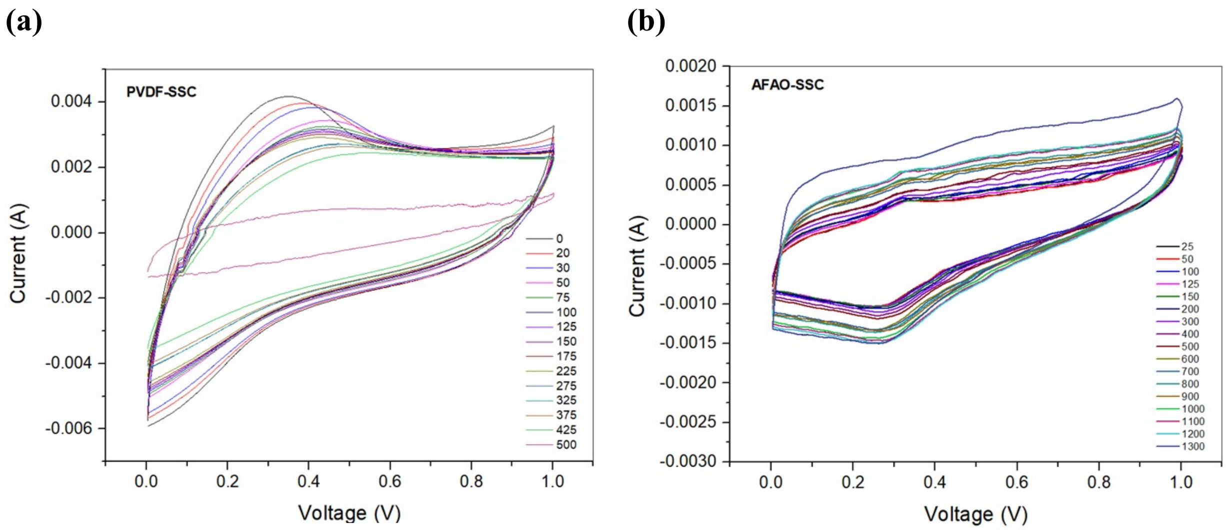

Figure S7. Cyclic voltammetry (CV) measurements of PVDF-SSC and AFAO-SSC were conducted at various bending cycles under a 180° bending angle

Table S1. Summary of XPS fit peak of O1s of pristine MXene and AFAO-MXene

O 1s		**Pristine Mxene**			**AFAO-Mxene**		
Peak	Reference Peak position	Peak decomposition			Peak decomposition		
		Peak	Area	**Content (%)**	Peak	Area	**Content (%)**
TiO_2	529.9	529.88	48281.2	26.15%	529.98	23127.07	16.70%
C-Ti-Ox	531.2	530.9	80142	43.40%	530.8	38734.12	27.98%
Ti-O-Si	**532**	-	-		**531.5**	39183.56	28.30%
H_2O	532.8	532.3	56229.7	30.45%	532.8	37408.76	27.02%

Table S2. Fitted equivalent circuit elements of pristine MXene, PVDF-MXene and AFAO-MXene electrodes

Electrode materials	**Parameters**		
	Rs	**Rct**	**Warburg coefficient (σ)**
	Ohm	*Ohm*	$Ohm.s^{(-1/2)}$
Pristine Mxene	4.886	1.657	1.339
PVDF Mxene	6.163	3.149	1.963
APAS Mxene	3.67	0.673	1.202

Table S3. Comparison of the cyclic performance of different MXene-based electrodes

No	Electrode Material	Capacitance retention	Cycles number	Reference
1	MnO_2/MXene/CNT	91 %	5000	(Liu et al., 2020)
2	SnO_2/Na–SnO_2@Mxene	89 %	3000	(Gautam et al., 2025)
3	MXene-$NiCo_2S_4$@NF	80.4 %	3000	(Li et al., 2020)
4	MnO_2@$Ti_3C_2T_x$/CNF	81 %	5000	(Wang et al., 2023)

5	La_2O_3/MXene	96 %	1000	(Khan et al., 2023)
6	$NiCo_2Se_4/Ti_3C_2Tx$	93.9 %	3000	(Liu et al., 2022)
7	**Silane-$Ti_3C_2T_x$ hybrid**	**92 %**	**5000**	**This study**
8	**$Ti_3C_2T_x$ -PVDF**	**84.2 %**	**5000**	

Table S4. Fitted equivalent circuit elements of PVDF-SSC and AFAO-SSC before and after bending at 180°.

Symmetric supercapacitor	**Parameters**			
	R_s	**R_{ct}**	**R_L**	**Warburg coefficient (σ)**
	Ohm	*Ohm*	*Ohm*	*Ohm.s$^{(-1/2)}$*
PVDF-SSC (B)	6.47	25.13	1.349	34.87
AFAO-SSC (B)	18.29	11.70	5.67	63.77
PVDF-SSC (A)	15.47	109.7	25.17	208.4
AFAO-SSC (A)	53.24	3.3473	4.417	64.8

(B: Before bending, A: After bending)

Table S5. Comparison of the bending cyclic performance of different MXene-based supercapacitors

No	Electrode Material	Capacitance retention	Bending cycles	Bending angle	Reference
1	$Ti_3C_2T_x$/VS4	91.9 %	2000	150°	(Niu *et al.*, 2024)
2	$Ti_3C_2T_x$/Carbon fiber	97. 7%	2500	180°	(Sun, Fu and Pan, 2021)
3	$Ti_3C_2T_x$/Ni-Fe oxide	88.9 %	50	90°	(Zhang *et al.*, 2020)
4	$Ti_3C_2T_x$	95.1 %	500	-	(Li *et al.*, 2021)
5	$Ti_3C_2T_x$/Carbon Nanotube	100.0 %	1000	90°	(Wang *et al.*, 2018)
6	**Silane-$Ti_3C_2T_x$ hybrid**	**211.9%**	**1500**	**180°**	**This study**

Reference

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