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

Bio-inspired, Cross-scale, Hierarchical MXene Flame Retardant Nanocoating for Reliable, Ultrafast, Ultralong Fire Warning

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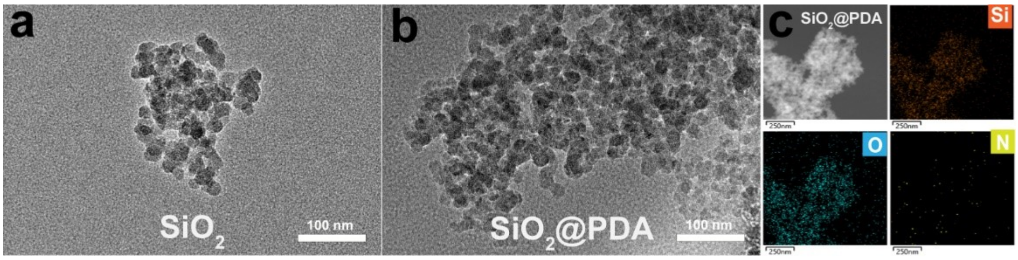

Figure S1. TEM image of a) SiO_2 and b) SiO_2@PDA. c) EDS mapping image of SiO_2@PDA.

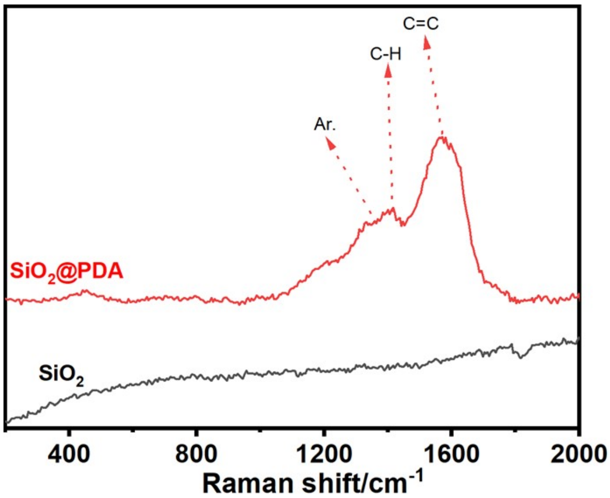

Figure S2. Raman spectrum of SiO_2 and SiO_2@PDA.

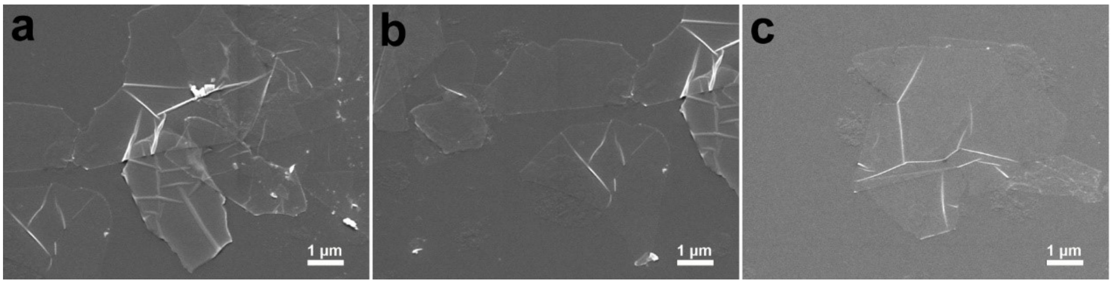

Figure S3. SEM images of Ti_3C_2 nanosheets.

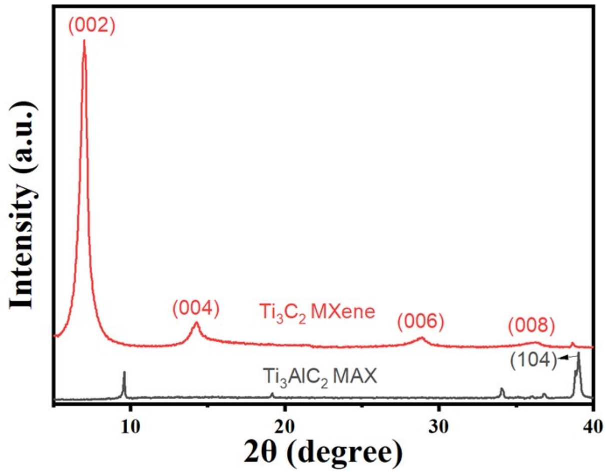

Figure S4. XRD spectrum of MXene and MAX phase.

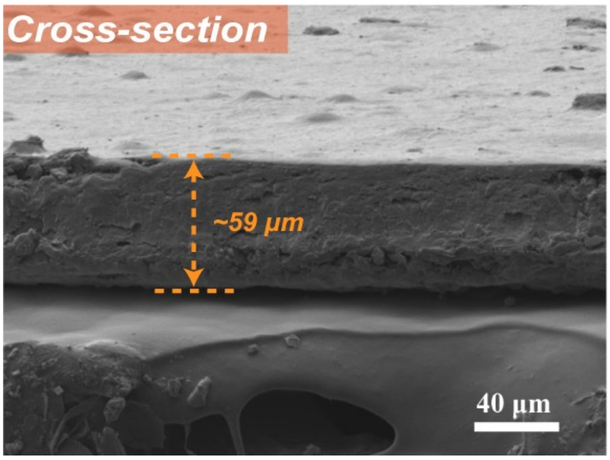

Figure S5. SEM images of PM nanocoatings (cross-section).

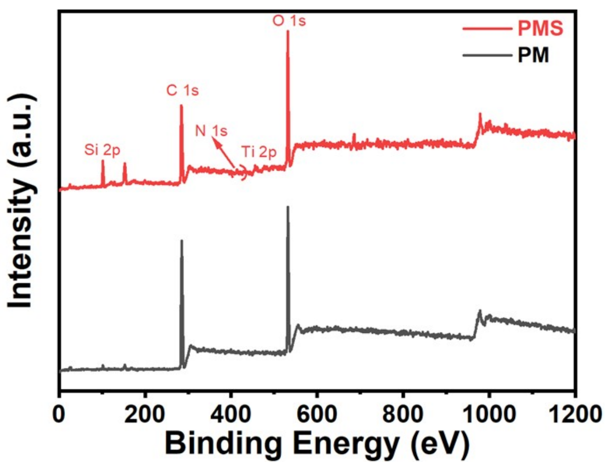

Figure S6. XPS spectrum of PM and PMS.

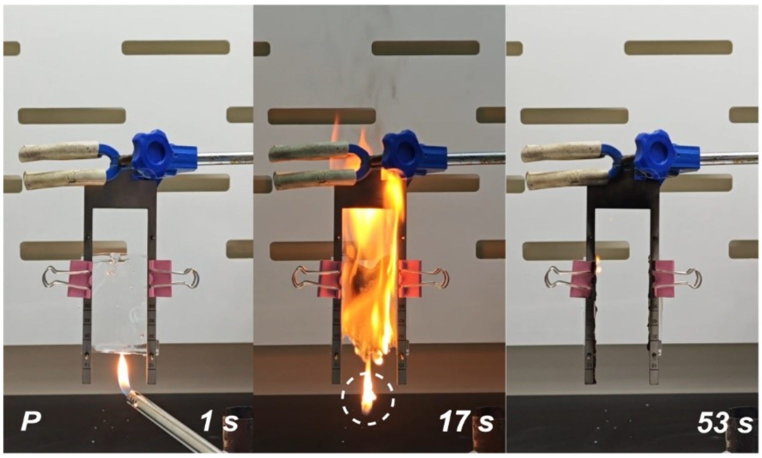

Figure S7. Digital photographs for vertical flammability test (VFT) of PVA nanocoating.

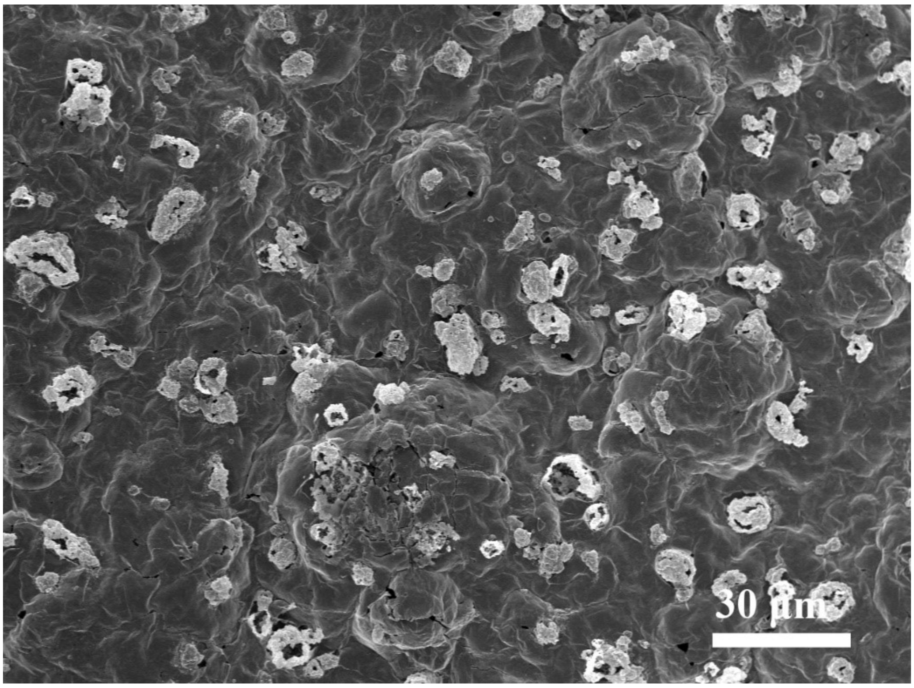

Figure S8. Typical surface SEM image of PMS nanocoating after 60 s flame attack.

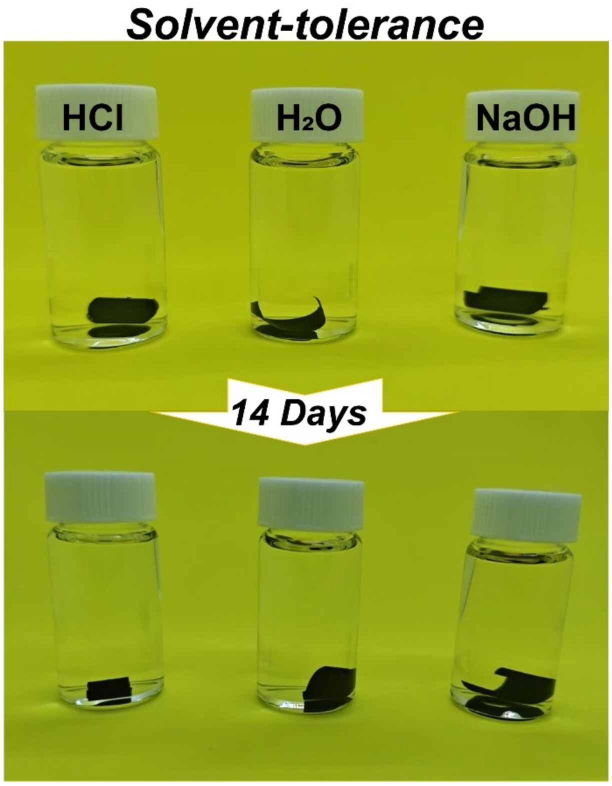

Figure S9. Structure stability of PMS nanocoating before and after being immersed in various solutions for 14 days.

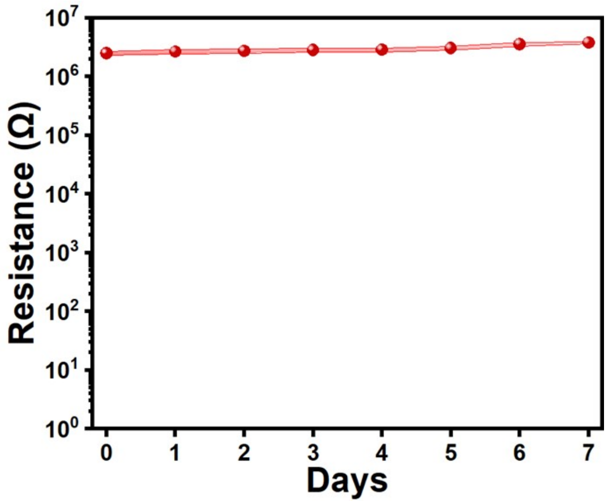

Figure S10. Resistance changes of PMS nanocoatings in accelerated oxidation experiments

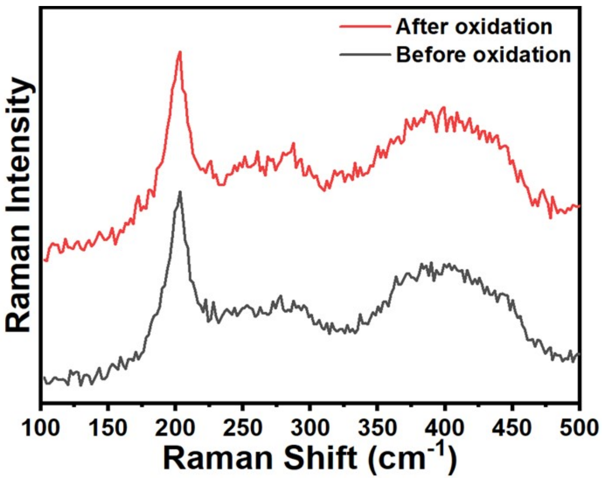

Figure S11. Raman spectra of PMS nanocoatings before and after accelerated aging experiment

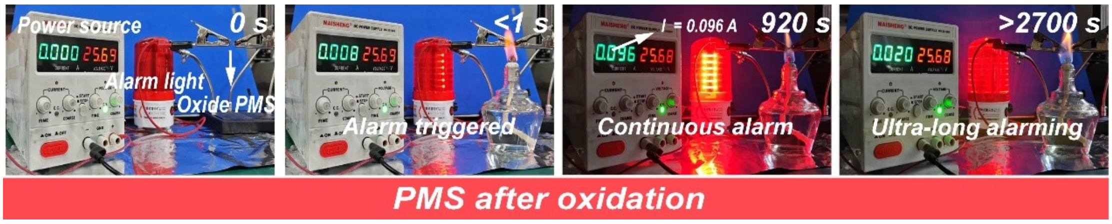

Figure S12. Digital photographs of flame detection and alarming processes of PMS nanocoating after accelerating oxidation experiment.

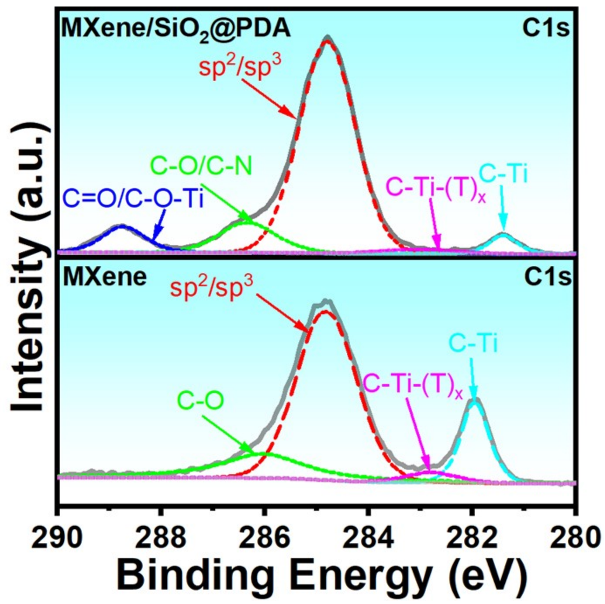

Figure S13. XPS C1s spectra of MXene and MXene/SiO_2@PDA.

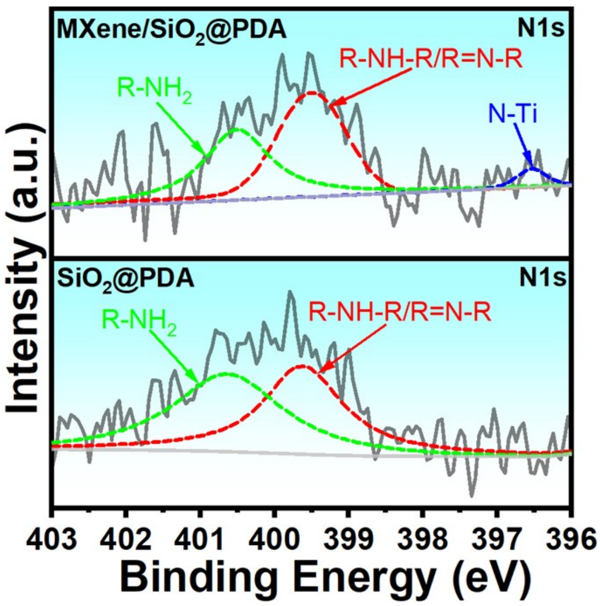

Figure S14. XPS N1s spectra of SiO_2@PDA and MXene/SiO_2@PDA.

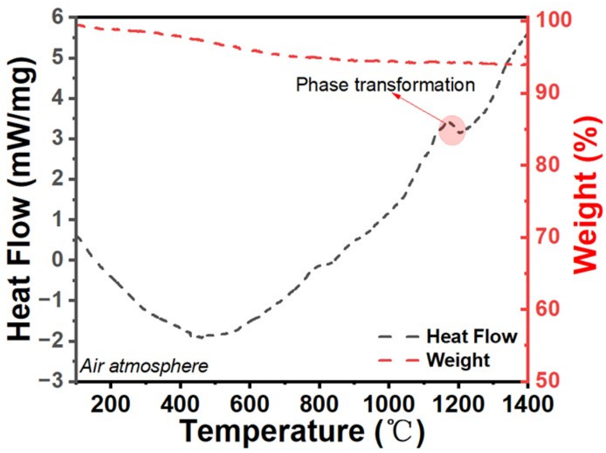

Figure S15. TG-DSC curves of SiO_2@PDA nanoparticles under air atmosphere.

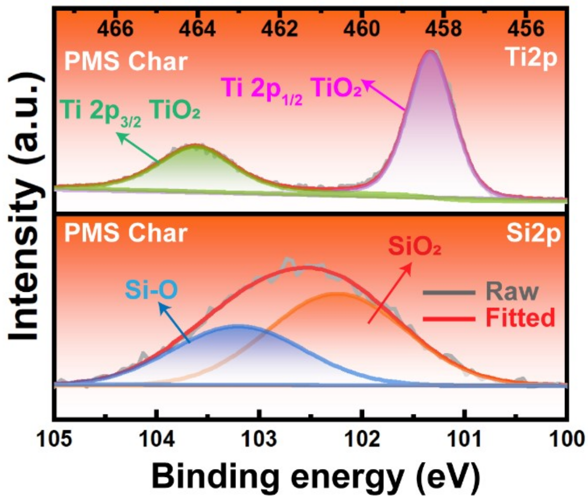

Figure S16. TG-DSC curves of SiO_2@PDA nanoparticles under air atmosphere.

Table S1 Components of MXene, PM, PMS_2, and PMS_8

Samples	PVA/ mg	MXene/ mg	SiO_2@PDA/ mg
P	100.0	0.0	0.0
PM	70.0	30.0	0.0
PMS_2	68.6	29.4	2.0
PMS (PMS_8)	64.4	27.6	8.0

Table S2 Mechanical properties of MXene, PM, PMS_2, and PMS_8

Samples	Tensile strength/ MPa	Young's modulus/ GPa	Strain to failure/ %
MXene	6.90	1.43	0.48
PM	15.01	2.03	0.39
PMS_2	30.81	1.51	3.87
PMS_8	46.54	3.50	2.37

Table S3 TGA data of various coatings under N_2 atmosphere

Samples	T_s/ ℃	T_{max1}/ ℃	W_{max1}/ %	T_{max2}/ ℃	W_{max2}/ %	Char residue / %
P	273.09	294.57	70.96	476.59	11.13	0.05
PM	279.92	302.73	85.56	460.31	41.83	33.58
PMS	282.57	328.35	79.79	459.81	52.69	43.79

Table S4 Comparison of resistance-type FAS performance among MXene-based materials

Composition and type of composite materials	MXene content/ wt%	Alarm response time/ s	Alarm period time/ s	Ref
GO/MXene/CS Aerogels	38.5	1	120	[1]
CNC/CNF/MXene /AHEDPA polyHIPEs	50.0	3	5	[2]
APP/PA@FA/MXene Fabrics	33.5	1	480	[3]
MXene/AgNW@BP/Ca^{2+}/Cotton fabrics	40	2	22	[4]
TiO_2@MXene/P, N-containing polyimine nanocomposite	8	0.81	120	[5]
APP/MXene/MXene@Bamboo	60	2	NM	[6]
SA/TOChNs/MXene	40	0.6	492	[7]
MXene/ChNCs/ATP	15	0.78	290	[8]
Casein/MXene/TA	30	0.98	93	[9]
PDA/APP/C-MXene	NM	2.1	NM	[10]
Lignocellulose nanofibril/gelatin/MXene	50	1	NM	[11]
MXene/PVP	50	0.9	2700	[12]
MXene@AgNW@BP@Cotton	20	2	300	[4]
MXene/TA/$CaCl_2$/Cotton	32	3	NM	[13]
SFMF	4	1	30	[14]
ANF/MXene	40	0.4	900	[15]
MXene/APP/EP/Bamboo	NM	5	225	[16]
MXene/Vermiculite/Sodiul alginate	50	3.6	NM	[17]
PA@MGO	20	2	NM	[18]
MXene/PEI/APP	NM	4	NM	[19]
PVA/MXene/SiO_2@PDA	27.6	0.85	2930	This work

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