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Supporting Information

Mxene Reinforced Organohydrogel with Ultra-stable, High Sensitivity and Anti-freezing Ability for Flexible Strain Sensors

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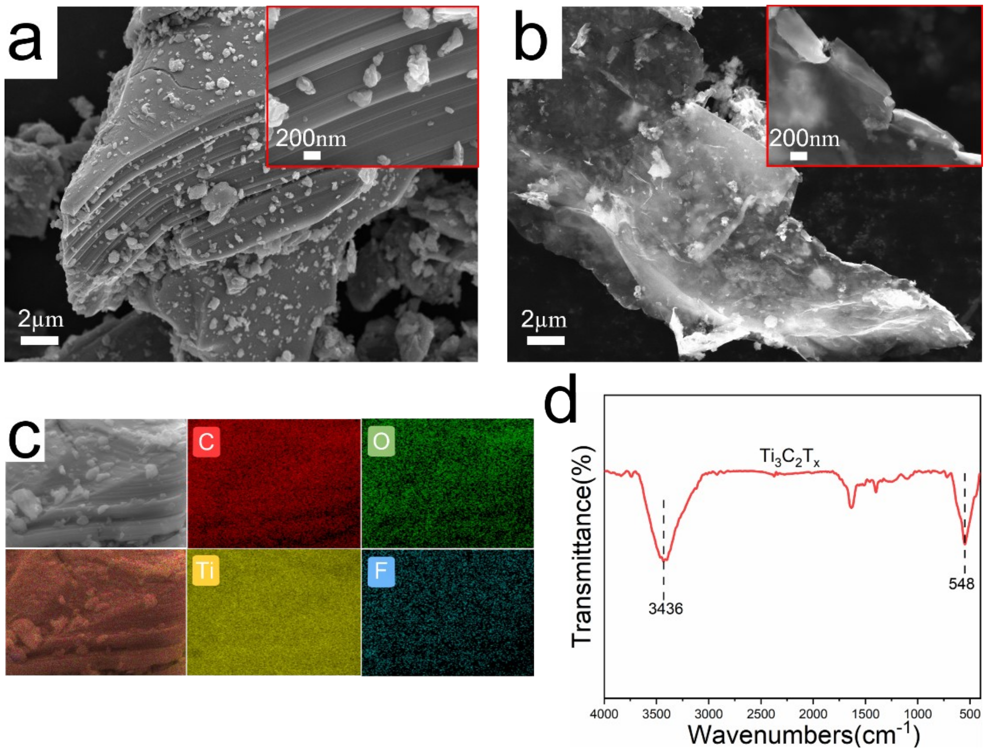

Figure S1. SEM images of (a) MAX and (b) MXene, the scale bar is 2 μm and 200nm. EDS element mapping of (c) MAX. FTIR of (d) MXene.

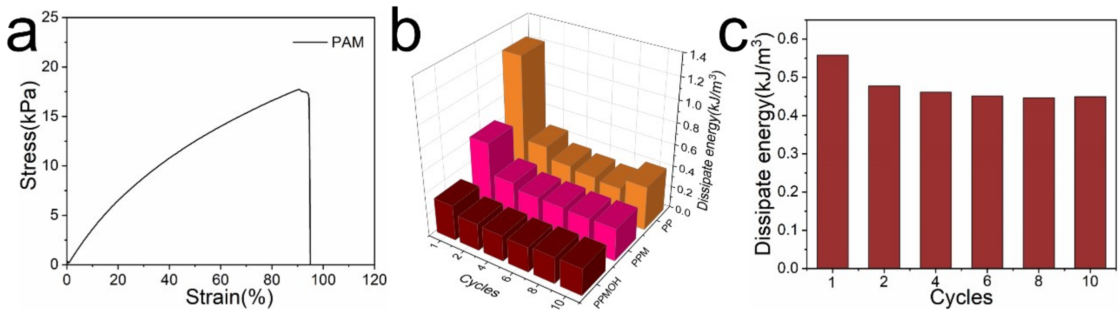

Figure S2. (a) Mechanical properties of PAM. Dissipate energy of (b) different hydrogels strain at 100% and (c) PPMOH sensor at 20% compression.

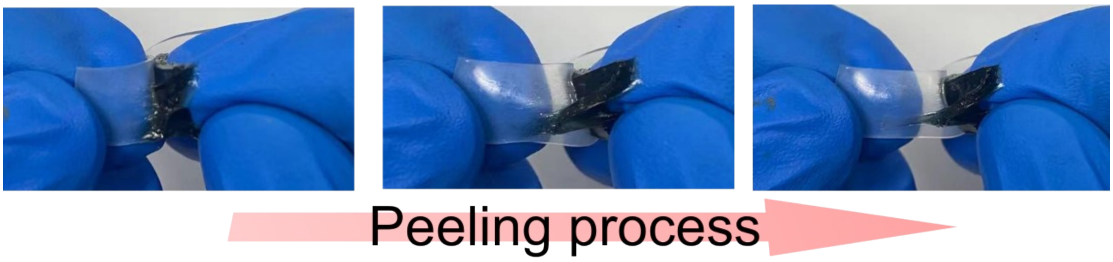

Figure S3. Peeling process between Ecoflex and PPMOH.

Based on Owens-Wendt method, the surface energy of Ecoflex, PPM and PPMOH can be calculated from the contact angle with the following equation [1]:

$$\gamma^{l}\left(1+cos\theta\right) = 2\left(\gamma_s^{\ d}\gamma_l^{\ d}\right)^{1/2} + 2\left(\gamma_s^{\ p}\gamma_l^{\ p}\right)^{1/2} \tag{1}$$

Meanwhile, the solid surface energy can be expressed by equation (2) [2].

$$\gamma^{s} = \gamma_s^{\ d} + \gamma_s^{\ p} \tag{2}$$

where, θ is the contact angle on the flat surface, γ^s is the solid surface tension, γ^l is the liquid surface tension, γ_s^d and γ_l^d are the dispersive component of solid and liquid, γ_s^p and γ_l^p are the polar component of solid and liquid.

Choose water (γ^l = 72.8 mJ/m^2, γ_l^p = 51.0 mJ/m^2, γ_l^d = 21.8 mJ/m^2) and ethylene glycol (γ^l = 48.0 mJ/m^2, γ_l^p = 19.0 mJ/m^2, γ_l^d = 29.0 mJ/m^2) of known γ_l^d and γ_l^p, dropped them onto the solid surface to obtained contact angle respectively, then combined equation (1) and (2) to calculate surface energy γ^s by substituting contact angle, γ_l^d and γ_l^p.

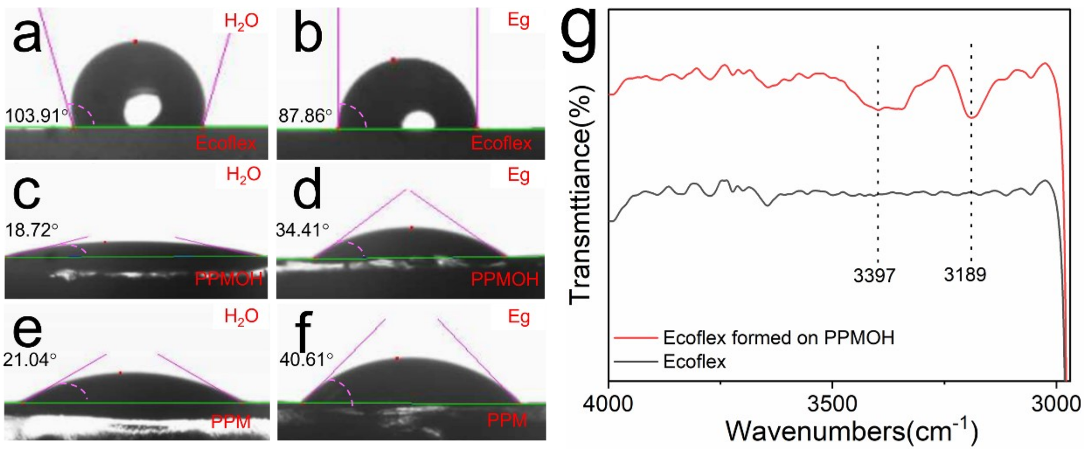

Figure S4. The contact angle of water to (a) Ecoflex, (c) PPMOH, (e) PPM and Eg to (b) Ecoflex, (d) PPMOH, (f) PPM. (g) FTIR spectra of the Ecoflex formed on PS plate and the Ecoflex formed on PPMOH.

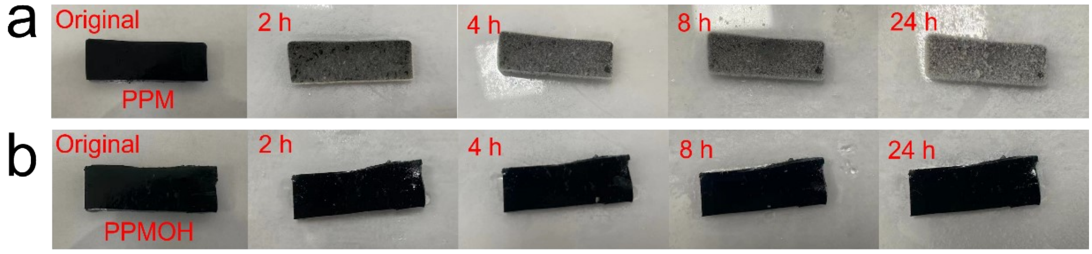

Figure S5. Morphology of (a) PPM and (b) PPMOH under -20 °C for 0 h, 2 h, 4 h, 8 h, 24 h.

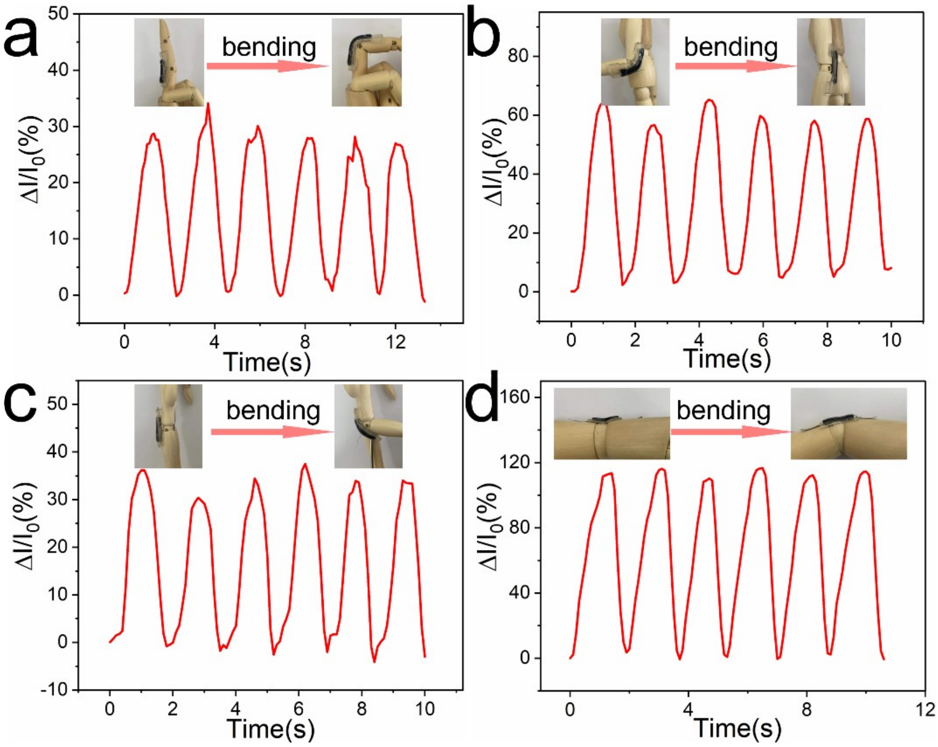

Figure S6. Monitoring response of current changes to different model parts movements: (a) finger, (b) elbow, (c) knee, (d) wrist.

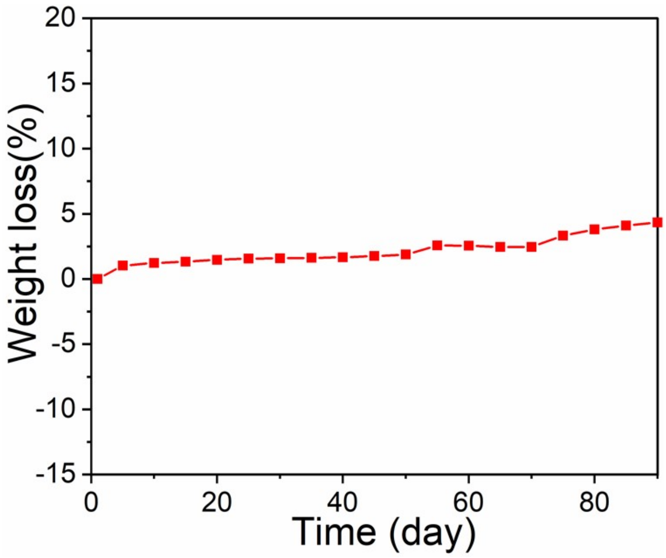

Figure S7. The weight loss of PPMOH sensor in 90 days.

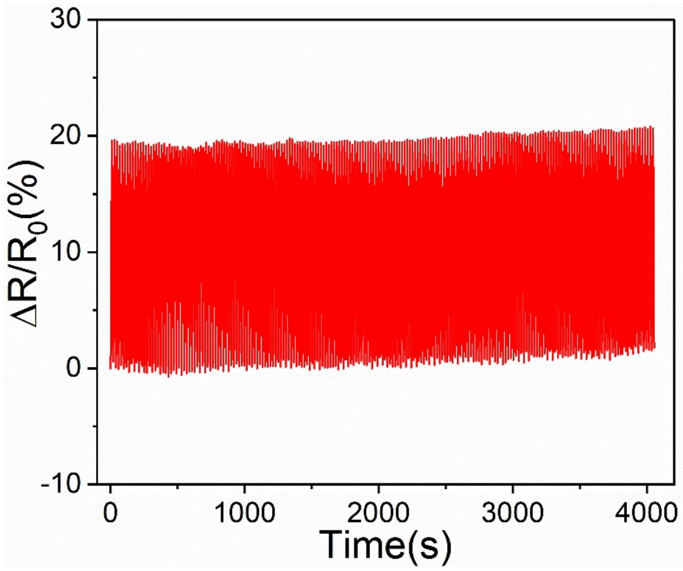

Figure S8. 200 load-unload cycles under 20 % compress after immersing in water for 24 h.

Table S1. Comparison in the properties of hydrogel-based strain sensors based on different materials.

Flexible sensor composition	Long-term stability	Strain (%)	Response time (ms)	Sensitivity	Ref.
PAM/PEDOT:PSS/MXene organohydrogel	90 days	891	100	0-300%, 4.71 300-500%, 10.69	This work
PVA/CNF organohydrogel	30 days	696	130	0-100%, 0.96 100-300%, 1.57	Carbohyd. Polym, 2022 [3]
TA@CNF/PAAm/MXene organohydrogel	7 days	1500	-	0-250%, 4.15 250-500%, 8.21	Adv. Funct. Mater, 2020 [4]
PDA–rGO/ SA/PAM organohydrogel	-	312	200	0-250%, 2.09	J. Mater. Chem. C, 2021 [5]
PVA/gelatin/TA@CNC-Al^{3+} organohydrogel	20 days	519.7	240	0-100%, 1.86 100-250%, 2.64 250-400%, 4.23	Compos Part B-Eng, 2021 [6]
PVA/MXene/ PEDOT:PSS/PDA	-	650	630	0-500%, 2.55	J. Mater. Chem. A, 2021 [7]
PVA/ MXene/Zn^{2+} organohydrogel	-	247	-	0-50%, 3.42 50-100%, 4.77 100-180%, 5.82	Adv. Funct. Mater, 2021 [8]

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