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

Supporting Information (SI)

Skin-inspired Antibacterial Conductive Hydrogels Customized for Wireless Flexible Sensor and Accelerated Wound Healing†

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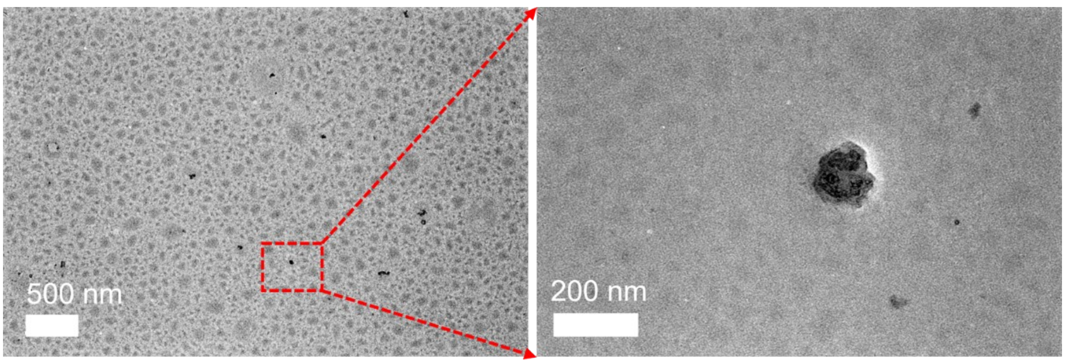

Fig. S1 The TEM image of SF@AgNPs particles.

SEM-EDX was applied to research the surface morphologies of PAS, PSAg, and PPMX hydrogels, as shown in **Fig. S2a-c**. Unlike the porous and fragile surfaces of pure PAS hydrogel (in **Fig. S2a**), PSAg hydrogel (in **Fig. S2b**) exhibited a smooth and flat surface with AgNPs embedded in the hydrogel matrix. Furthermore, a rough and wrinkled surface structure coated with 0 D SF@AgNP and 2 D MXene nanosheets was onto the surface of the PPMX hydrogel (in **Fig. S2c**). The above phenomenon demonstrated that the PDA@SF in the hydrogel was introduced into a covalent-crosslinked network to induce physical entanglement between PAS and SF chains, where the PDA chains chelating with Ag nanoparticles bridged the hydrogel matrix, resulting in a more stretchable and strong nano-enhanced hydrogel structure. Evidently, it is visible that MXene nanosheets endowed the hydrogel with a rough and hilly-like surface structure, which could withstand massive deformation and external force and retain its intrinsic mechanical characteristics for an extended time, allowing it to be used in wearable sensors to resist large deformation. Additionally, EDS element mapping analysis was used to analyze the elemental distribution of nanocomposite hydrogel. As shown in **Fig. S2**, C, N, O, Ag, S, Ti, and F were evenly distributed on the surface of PPMX hydrogel, indicating that MXene nanosheets and SF@AgNPs were uniformly dispersed in PPMX hydrogel.

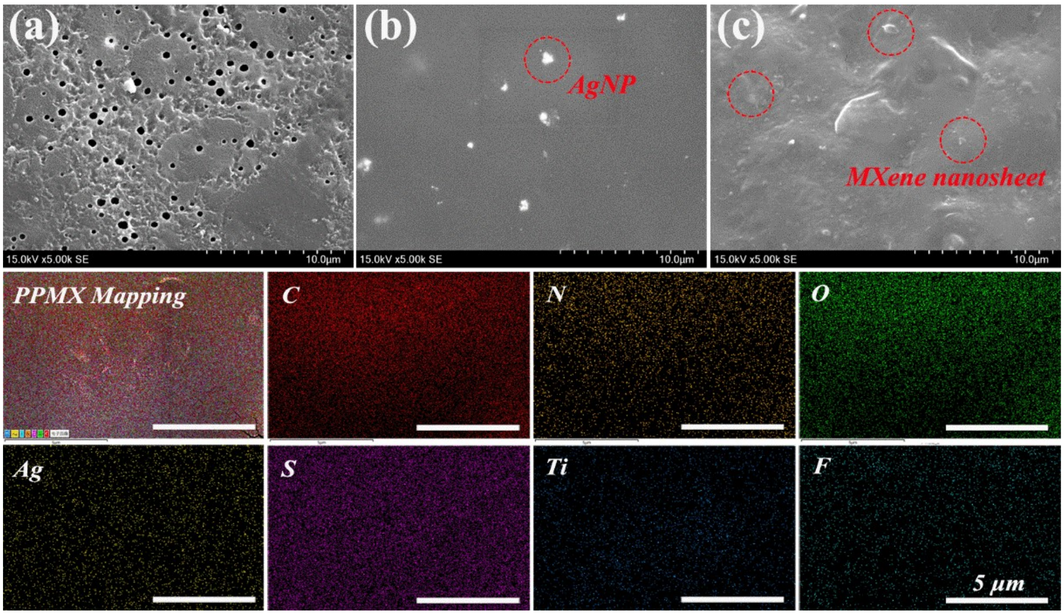

Fig. S2. Microstructure characterization. (a) SEM images of PAS hydrogel, (b) PSAg hydrogel, and (c) PPMX hydrogel; Corresponding EDX element mapping of PPMX hydrogel, including carbon (red), nitrogen (orange), oxygen (green), sliver (yellow), sulfur (violet), titanium (indigo), and fluorine (dark green).

Stress-strain loops of stretch-release cycles were tested in Fig. S3. The result shown the residue strain was zero.

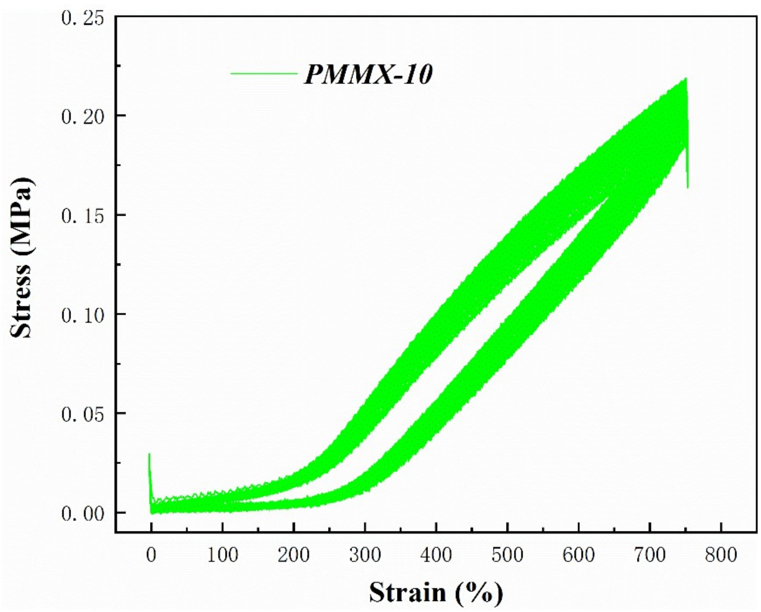

Fig. S3 100 stress-strain loops of stretch-release cycles.

As observed in Fig. S4, as the addition amount of SF@AgNPs increases, the conductivity of PPMX-x hydrogel gradually increases from 0.64 mS/cm, 1.16 mS/cm, 1.32 mS/cm, 1.48 mS/cm, to 1.77 mS/cm. Whereas, the conductivity of PSAg-5 hydrogel is 0.78 mS/cm. Above results prove that SF@AgNPs and MXenes both improve the conductive properties of hydrogel.

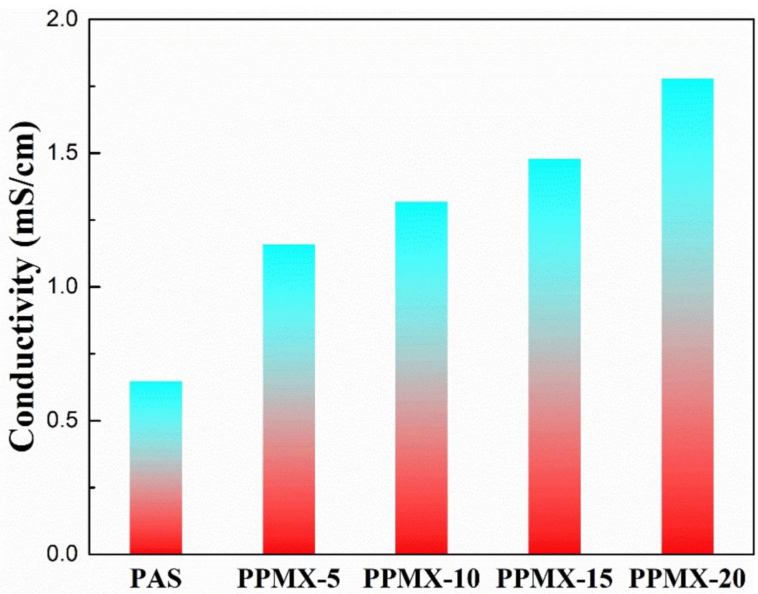

Fig. S4 The conductivity experiment of PPMX-x hydrogels

Generally, the sensitivity (S_p) of the pressure sensor is calculated by $S_p = \delta(\Delta I/I_0)/P$; the sensitivity ($S_s$) of the strain sensor is calculated by $S_s = \delta(\Delta I/I_0)/\varepsilon$. Here, I_0 and I represent the initial current of the sensor without loading and the output current under pressure, respectively. Besides, ΔI is the relative change in current (I - I_0). Additionally, P is the external pressure applied to the sensor and ε is the external elongation applied to the sensor.

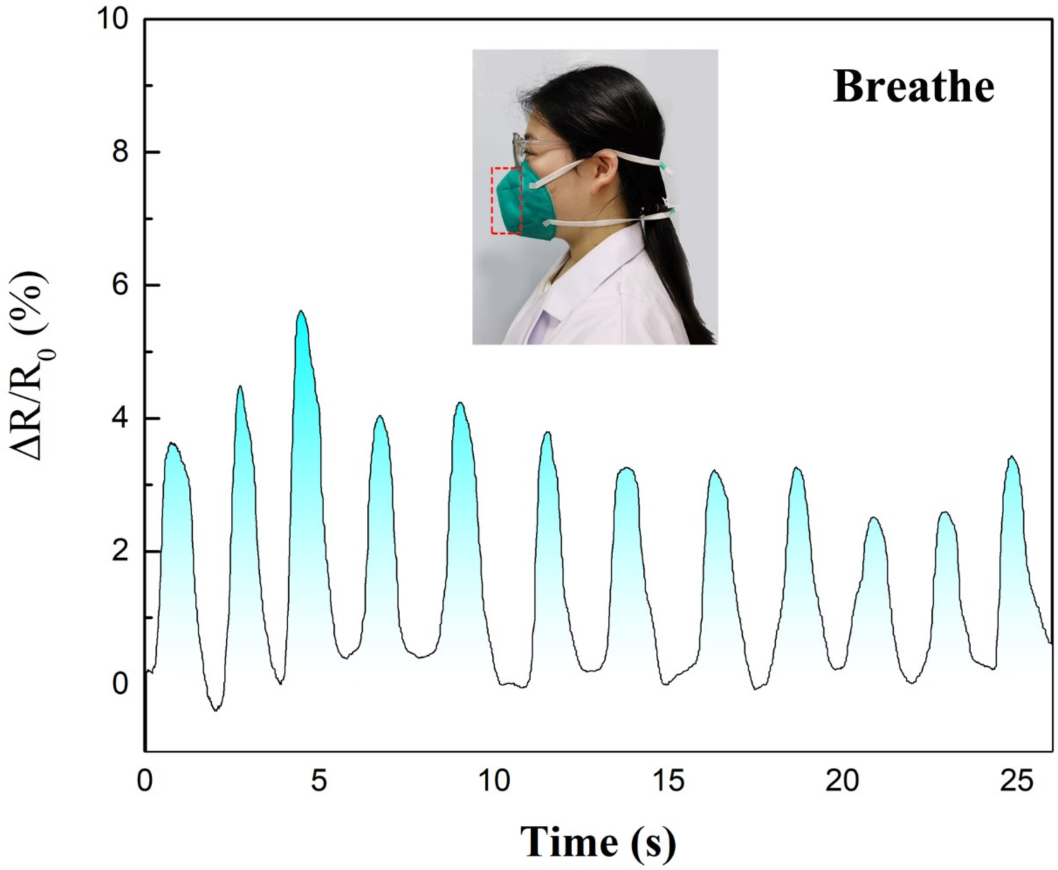

Fig. S5 The PPMX sensors for respiratory monitor.

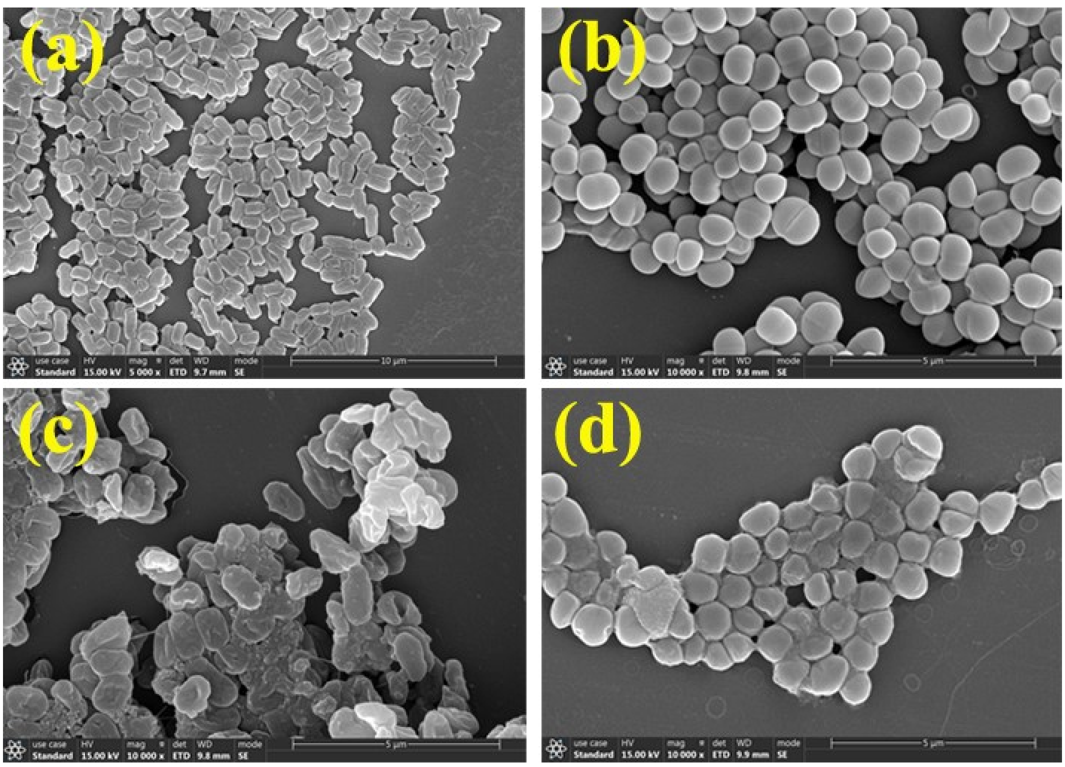

Fig. S6 SEM images of *E. coli* and *S. aureus* cells in contact with the blank (a and b), and PPMX (c and d) hydrogel.

Table S1. The compositions of the PPMX nanocomposite hydrogels.

Code	AM (g)	SF@AgNPs (g)	MXene (mg)	APS (mg)	MBAA (mg)	TEMED (μL)	Water (g)	Water content (wt%)
PAS	4	0	10	80	4	20	10	71.4
PPMX-5	4	0.5	10	80	4	20	10	69.0
PPMX-10	4	1.0	10	80	4	20	10	66.7
PPMX-15	4	1.5	10	80	4	20	10	64.5
PPMX-20	4	2.0	10	80	4	20	10	62.5

Table S2. Performance summary of representative adhesive hydrogels-based sensors.

Materials	Sensing mode	Max adhesive strength (kPa)	Tensile strength (kPa)	Strain (%)	Refs
AgNP@GCOL/PAA	strain sensor	42.8	123	916	S1
TEDI	strain sensor	52.85	54	7300	S2
PAAc/SiO_2-g-PAAm	strain/pressure sensor	68	64	1600	S3
LPC	Piezoresistive sensor	66.6	16.2	2408	S4

γ-PGA/PEDOT: PSS	strain/pressure sensor	53	385	652	S5
P(AAm-co-HEA)/Laponite XLG	strain/pressure sensor	32.24	145.6	1209.46	S6
LNP@Ag–Fe-PAA	strain sensor	18	37.8	1360	S7
AxNyMCz	strain sensor	109.3	664	1732	S8
β-CD-g-(pAAm/pHMAm)	strain/pressure sensor	50.1	88	6000	S9
PASU-Zn	strain sensor	610.6	790	1061	S10
Poly(AM-co-SBMA)/SF@AgNPs/MXene	strain/pressure sensor	998.98	669.2	1884.7	This work

Table S3. Performance summary of representative hydrogels-based sensors.

Materials	Sensing mode	Sensing range (kPa)	Pressure sensitivity (kPa^{-1})	Refs
EG/MoS_2-PAAM-Fe^{3+}	pressure sensor	1 to 13	0.06	S11
PBA-co-PEGDA/LiTFSI	/	0.94 to 140	2.871	S12
PVA-GA/P(AA-co-Am)	strain/pressure sensor	0 to 2.74	2.14	S13
EMCP	Piezoresistive	8×10^{-4} to 3	133.1	S14

	sensor			
PAM/PC	strain/pressure sensor	0 to 400	0.035	S15
PVA/SA/BC/MCC	strain/pressure sensor	0 to 337	0..033	S16
Gel/PAM/NaCl/O-β-CD	strain/pressure sensor	0 to 250	0.56	S17
PVA/HPS-PA	strain/pressure sensor		3.6	S18
CS-PHEAA	strain/pressure sensor	0 to 136	0.023	S19
PAM/NFC/Ag	strain/pressure sensor	0 to 50	9.5	S20
PVA/Lig-Ag NPs	piezoresistive pressure sensor	0 to 1	3.63	S21
PAM/SF/PEDOT： PSS	strain/pressure sensor	0.5 to 119.4	0.0137	S22
PVA/C-Chitosan/*f*-CD	capacitive pressure sensor	0 to 300	135.4	S23
CS−P(AM-co-AA)/Fe^{3+}	strain/pressure sensor	0 to 250	0.208	S24
P(AA-co-	/	/	0.018	S25

AM)/catechol−Fe^{3+}				
CNTs/HAPAAm	strain/pressure sensor	0 to 50	0.127	S26
PAM/PVA/KCl	pressure sensor	0 to 7	0.05	S27
PAM/SA/Ca^{2+}	capacitive pressure sensor	0.0025 to 2	3.19	S28
P(AM-co-AEMA)/F127-CHO/LiCl	strain/pressure sensor	0 to 30	0.25	S29
PVA/PANI	capacitive pressure sensor	0 to 7.4	7.7	S30
PVA/CNF/NaCl	strain/pressure sensor	0 to 35	0.22	S31
[EMI][TFSA]/P(VDF-HFP) ionic gel	capacitive pressure sensor	0 to 50	41.64	S32
[EMIM][TFSI]/P(VDF-HFP) ionic gel	capacitive pressure sensor	1 to 140	54.31	S33
[EMIM][TFSI]/P(VDF-HFP) ionic	capacitive pressure sensor	0.4 to 50	145.45	S34

gel				
PAM/SA/MXene/ Zn^{2+}	strain/pressure sensor	0 to 60	782.7	S35
PAM/PSAg/MXene	strain/pressure sensor	0 - 12	860.6	This work

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