1. Preparation of Deep Eutectic Conductive Hydrogels Anchored by MFC

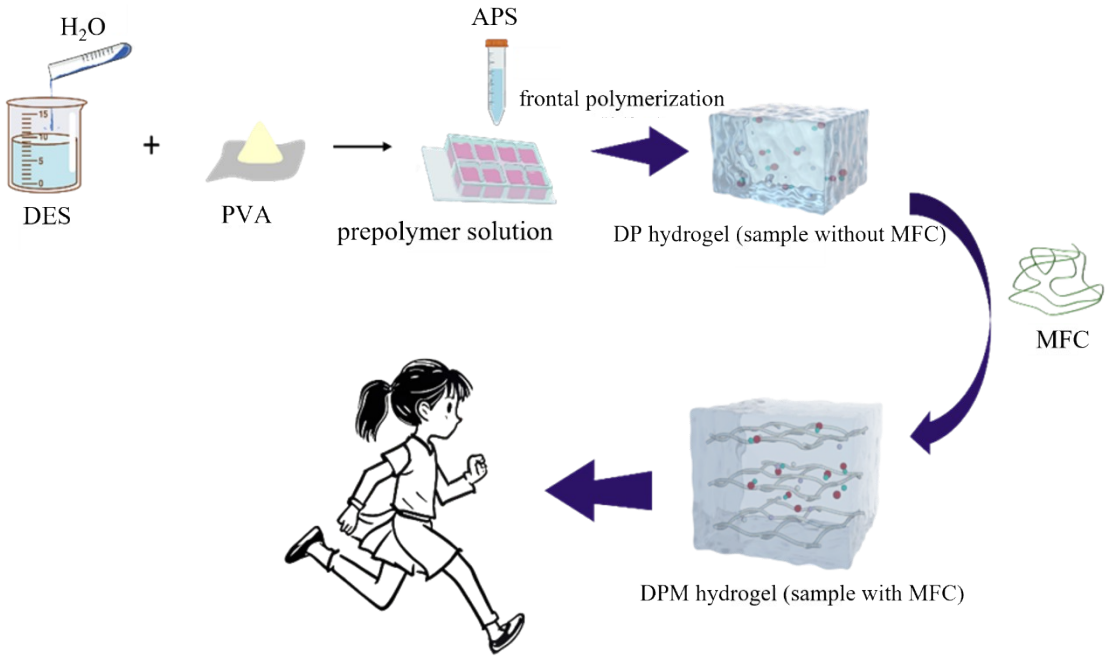

Figure 1 The experimental route map

Dissolve 0.04 g of APS in 3.96 g of water to obtain an APS aqueous solution, which is stored in a sealed container at room temperature and protected from light. Weigh a certain amount of PVA powder and mix it with a DES-water binary solvent. Stir at 95°C for 2 hours until PVA is fully dissolved. At room temperature, add a specific amount of APS aqueous solution to the mixture and stir for 30 minutes. Pour the resulting mixture into a polytetrafluoroethylene mold and expose it to UV light (365 nm, 50 W) for 5 minutes to obtain the control group. The deep eutectic conductive hydrogel containing MFC is prepared by adding different amounts of MFC simultaneously with APS aqueous solution during the mixing process. The specific material compositions for each sample group are listed in Table 1.

Table 1 Material composition of deep eutectic conductive hydrogels

Materials / Samples	DES (g)	distilled water (g)	PVA (g)	MFC (g)	APS (g)
DPM1-30-1	8.4	3.32	0.12	0.12	0.28
DPM1-30-3	8.4	3.32	0.12	0.36	0.28

DPM1-30-5	8.4	3.32	0.12	0.6	0.28
DPM1-30-7	8.4	3.32	0.12	0.84	0.28

Note: Samples without MFC are labeled as DP-x-y, while samples with MFC are labeled as DPM-x-y-z, where x represents the PVA content, y represents the water content, and z represents the MFC content

2 Preparation of MXene-Doped Deep Eutectic Conductive Hydrogels

Table 2 Material compositions of hydrogels with varying MXene concentrations

Materials / Samples	DES (g)	distilled water (g)	PVA (g)	MFC (g)	APS (g)	$AlCl_3$ (g)	MXene (g)
DPMA1	8.4	3.32	0.12	0.36	0.28	0.12	-
DPMA3	8.4	3.32	0.12	0.36	0.28	0.36	-
DPMA5	8.4	3.32	0.12	0.36	0.28	0.6	-
DPMA7	8.4	3.32	0.12	0.36	0.28	0.84	-
DPMA-MXene(0.1%)	8.4	3.32	0.12	0.36	0.28	0.36	0.012
DPMA-MXene(0.3%)	8.4	3.32	0.12	0.36	0.28	0.36	0.036
DPMA-MXene(0.5%)	8.4	3.32	0.12	0.36	0.28	0.36	0.06
DPMA-MXene(0.7%)	8.4	3.32	0.12	0.36	0.28	0.36	0.084

Note: Hydrogels with Al^{3+} are labeled as DPMA(x), while hydrogels with MXene are labeled as DPMA-MXene(y), where **y** represents the MXene content

The deep eutectic conductive hydrogel DPM1-30-3 was selected as the base, and Al^{3+} and MXene were incorporated to endow the hydrogel with self-healing capability and high sensitivity, respectively. The preparation procedure is as follows: A specific amount of PVA powder was mixed with a DES-water binary solvent and stirred at 95°C for 2 hours until PVA was completely dissolved. At room temperature, a certain amount of MFC and aluminum chloride powder were added to the mixture and stirred until the solids were fully dissolved. Then, a specific amount of MXene was added, and the mixture was sonicated. Afterward, an APS aqueous solution was added. The resulting mixture was poured into a polytetrafluoroethylene mold and exposed to UV light (365 nm, 50 W) for 15 minutes with the mold placed 25 cm beneath the light source to obtain the final product. The specific material compositions for each sample group are listed in Table 2.