Supporting Information

Ultrathin and permeable silver nanowires/polyvinyl alcohol epidermal electrode for continuous electrophysiological monitoring

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Table S1. Comparison of the ultrathin AgNWs/PVA epidermal electrode with recently reported ultrathin gel epidermal electrodes on thickness, gas permeability, skin adhesion, stretchability, tensile strength, durability, skin contact impedance and application for long-term, continuous health monitoring.

Materials	Thickness (μm)	Gas Permeability	Skin adhesion (method)	Stretchability (%)	Tensile strength (kPa)	Durability (cycle)	Skin contact impedance (100Hz)	Application (signals, continuous recording duration)	Ref.
AgNW/TPU	4.6	23 $mg/(cm^2 \cdot h)$	-	350	> 900	1000 (10% strain)	~ 10 kΩ	ECG (6 s), EMG (50 s)	[1]
Gelatin/Glycerol	< 7	1890.0 ± 134 $g/(m^2 \cdot d)$	87 μJ/cm² (peel-off test)	> 200	> 1000	500 (200% strain)	-	-	[2]
Gelatin/PU/Glycerol	10.3	1669.3 ± 23 $g/(m^2 \cdot d)$	176.8 μJ/cm² (peel-off test)	696	2500	1000 (100% strain)	31.3 kΩ	ABR (10 ms) ECG (12 h) EEG (10 s) EOG (10 s) MCV (10 s) VEP (300 ms)	[3]
PEDOT: PSS/ethylene glycol/PVDF-co-HFP	< 10	-	-	-	-	-	~ 20 kΩ	ECG (> 20 s)	[4]
PEDOT: PSS/PEO	< 1	32 $mg/(cm^2 \cdot h)$	-	48	-	-	48 kΩ	EMG (18 s), ECG (20 s)	[5]
PEDOT: PSS/PVA/PEG	20	46.3 $mg/(cm^2 \cdot h)$	-	24.3	3900	-	~ 80 kΩ	ECG (10 s), EMG (22 s)	[6]
SEBS/AgNWs	2−8	18.4 $mg/(cm^2 \cdot h)$	1.3 N (peel-off test)	> 60	-	-	~ 110 kΩ	ECG (10 s), EMG (60 s)	[7]
AgNWs/TPU	120	-	-	1019	2640	5 (50% strain)	-	motion monitoring (25s)	[8]
HPAN/PU/AgNW	15	1748.09 $g/(m^2 \cdot d)$	430.87 $mN\ cm^{-1}$ (peel-off test)	> 600	> 3000	-	~ 70 kΩ	EMG (24s) ECG (6 s)	[9]
PEDOT:PSS/PVA/d-sorbitol	2.5	-	51.4 $N\ m^{-1}$ (peel-off test)	> 50	-	1000 (40% strain)	< 200 kΩ	EMG (1 h) ECG (7 d)	[10]
AgNWs/PVA	14.7	0.03 $(cm^2 \cdot s \cdot cmHg)$	270.5 μJ/cm² (peel-off test)	662	1500	1000 (40% strain)	28.6 kΩ	ECG (> 3 h), EEG (10 min), EMG (10 s)	This work

Abbreviations: PEDOT: PSS: poly(3,4-ethylenedioxythiophene): poly(4-styrenesulfonate); PEO: polyethylene oxide; Aam: acrylamide; PU: polyurethane. ABR: auditory brainstem response; EOG: electrooculogram; VEP: visual evoked potential; MCV: motor conduction velocity; ERG: electroretinogram; PVDF-co-HFP: poly(vinylidene fluoride-co-hexafluoropropylene); PEG: polyethylene glycol; CMC: carboxymethylcellulose; SAM: sodium-poly([2(methacryloyloxy) ethyl] dimethyl-(3-sulfo-propyl) ammonium hydroxide-co-acrylamide); PVP: polyvinylpyrrolidone; PDA NPs: polydopamine nanoparticles; SEBS: styrene ethylene butylene styrene; TPU: thermoplastic polyurethane; HPAN: hydrolyzed-polyacrylonitrile.

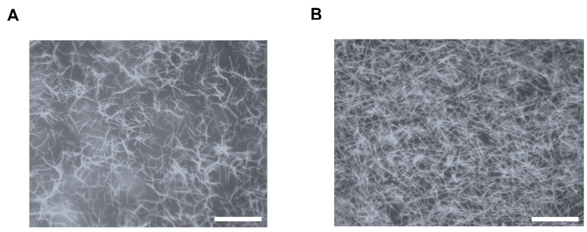

Fig. S1 Optical images of AgNWs/PVA gel loading with (A) glutaric dialdehyde and (B) phosphoric acid. Scale bar, 50 μm.

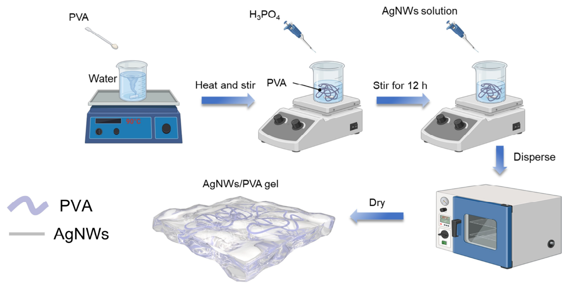

Fig. S2 Schematic fabrication process of the AgNWs/PVA gel.

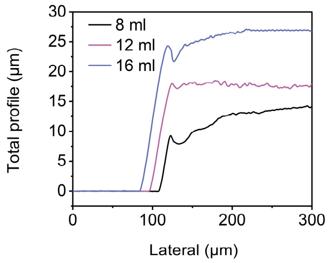

Fig. S3 Effect of precast volumes on the thickness of AgNWs/PVA gel.

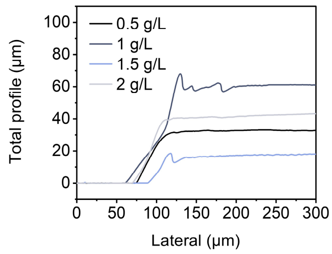

Fig. S4 Effect of AgNWs concentrations on the thickness of AgNWs/PVA gel.

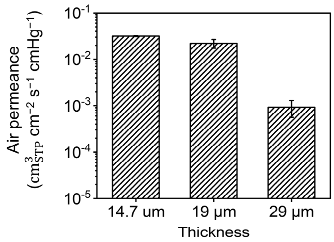

Fig. S5 Effect of thickness of AgNWs/PVA gel on the air permeance.

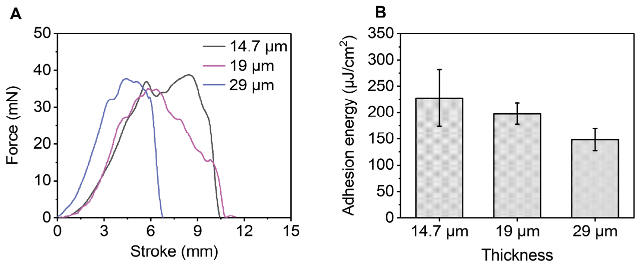

Fig. S6 Effect of thickness of AgNWs/PVA gel on the adhesion. (A) Force stroke curves of AgNWs/PVA gel under different thickness. (B) Adhesion energy of AgNWs/PVA gel under different thickness.

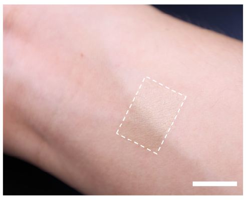

Fig. S7 Photograph of ultrathin AgNWs/PVA gel attached on the wrist. Scale bar, 1 cm.

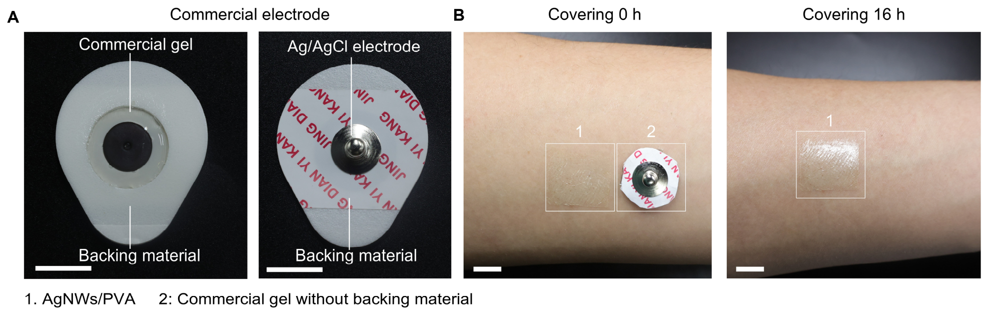

Fig. S8 Wear duration test. (A) Commercial gel structure. Scale bar, 1 cm. (B) Comparison of AgNWs/PVA gel and commercial gel adhered to the arm at different times. Scale bar, 1 cm.

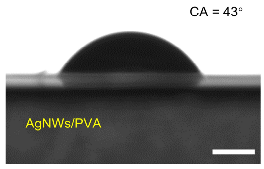

Fig. S9 Contact angle of the ultrathin AgNWs/PVA gel. Scale bar, 50 μm.

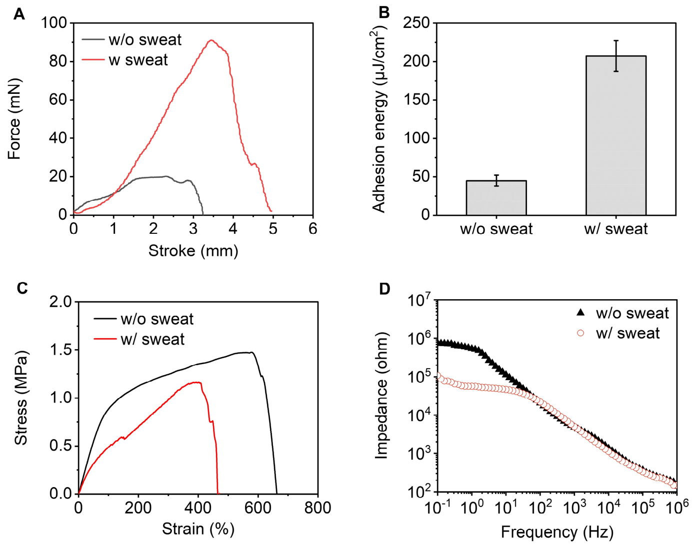

Fig. S10 Effect of artificial sweat on the mechanical and electrical properties of AgNWs/PVA gel. (A) Force stroke curves of AgNWs/PVA gel w/ and w/o artificial sweat. (B) Comparison of the adhesion energy for AgNWs/PVA gel w/ and w/o artificial sweat. (C) Tensile stress curves of AgNWs/PVA gel w/ and w/o artificial sweat. (D) Skin contact impedance of AgNWs/PVA gel w/ and w/o artificial sweat.

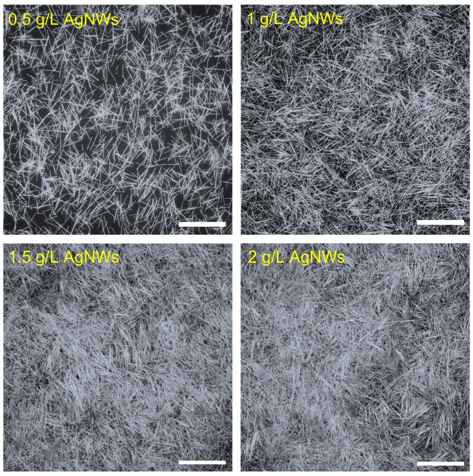

Fig. S11 3D confocal laser microscope images of AgNWs/PVA gel with different AgNWs concentrations. Scale bar, 50 μm.

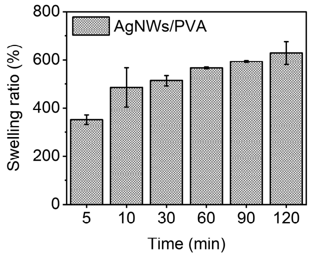

Fig. S12 Swelling ratio of AgNWs/PVA gel as a function of water absorption time.

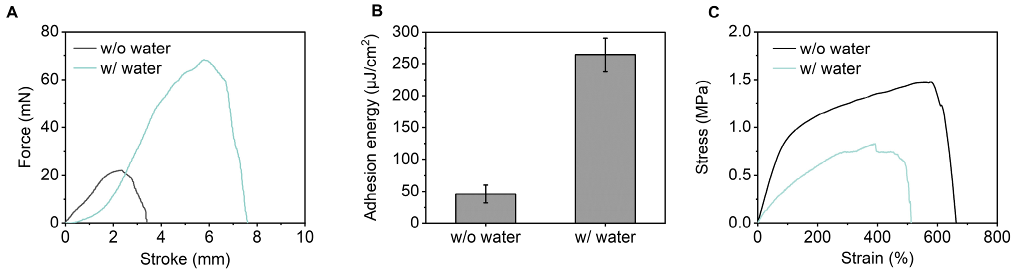

Fig. S13 Effect of water on the mechanical properties of AgNWs/PVA gel. (A) Force stroke curves of AgNWs/PVA gel w/ and w/o water. (B) Comparison of the adhesion energy for AgNWs/PVA gel w/ and w/o water. (C) Tensile stress curves of AgNWs/PVA gel w/ and w/o water.

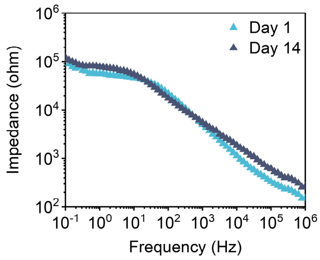

Fig. S14 Effect of placement time on skin contact impedance of AgNWs/PVA gel.

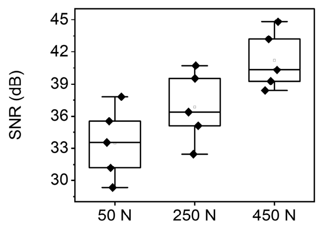

Fig. S15 SNR of EMG signals recorded by AgNWs/PVA gels under different grip forces.

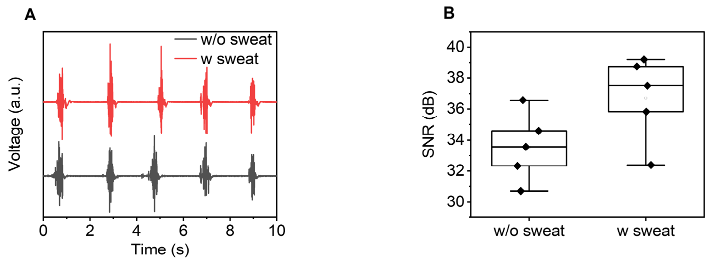

Fig. S16 Effect of artificial sweat on the EMG monitoring by AgNWs/PVA gel. (A) EMG monitoring by AgNWs/PVA gel w sweat and w/o artificial. (B) SNR of EMG signals by AgNWs/PVA gel w and w/o artificial.

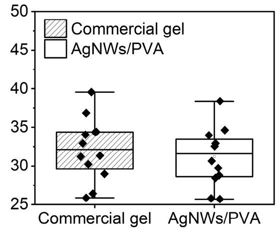

Fig. S17 SNR of ECG signals measured by commercial gel and ultrathin AgNWs/PVA gel.

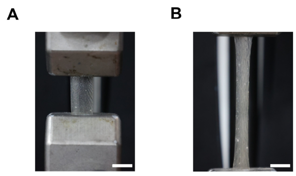

Fig. S18 Photographs showing AgNWs/PVA gel during tensile testing experiments. (A) original and (B) stretched states. Scale bar, 1 cm.

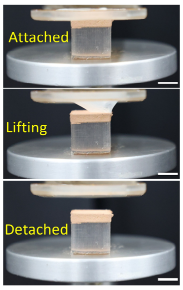

Fig. S19 Photographs showing the process of separating AgNWs/PVA gel from artificial skin in a tack separation experiment. Scale bar, 5 mm.

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