Electronic Supplementary Information (ESI)

Highly Stretchable, Self-Healable, and Self-Adhesive Ionogels with Efficient Antibacterial Performances for Highly Sensitive Wearable Strain Sensor

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Experimental section

Structure Characterizations

The Fourier transform infrared (FTIR) spectrum of ionogel samples were determined on a Perkin-Elmer FTIR spectrometer with a scanning number of 32 times and a resolution of 4 cm^{-1}. A UV-1800 spectrophotometer (Shimadzu) was utilized to measure the transparency of the ionogels. Morphology and structure of the Ag-Lignin NPs and the ionogel were detected on the XL-30 ESEM FEG microscope (FEI Company). The weight- and number-average molecular weights (M_w and M_n) and corresponding polydispersity (PDI) (M_w/M_n) were determined by GPC on a Waters 1515 at 35 °C. A series of monodisperse polystyrenes were used as the standard and THF as the fluent with a flow rate of 1.0 mL/min.

Mechanical properties tests

The Instron universal tensile testing machine (Instron 4465) was employed to measure the mechanical performances of the ionogels. Stress relaxation tests were also performed on this machine. Dynamic mechanical analysis (DMA) was utilized to the ionogels to carry out the temperature dependence of G' and G'' by a Q800 (TA Instrument). The heating rate was 3 °C/min and the frequency was 1 Hz.

Self-healing tests

In the experiment of self-healing, a rectangular ionogel was cut off completely in the middle part, followed observed by the polarizing optical microscope (POM, Leica, DM2500P) to qualitative evaluated the self-healing ability. The tensile properties of the ionogel before and after self-healing was also compared by the tensile tests.

Adhesive peeling tests

The texture analyzer (CT3-100, Brookfield) was used to determine the peel strength and interface toughness of ionogels. First, the test parameters were turned to a 90° peeling mode, a constant peel rate (5 mm/s) was adopted in the whole peeling process. Steel, wood, glass, hogskin, and polytetrafluoroethylene (PTFE) were used as the substrates. Experiments were conducted for three times for each sample to ensure values stability.

Anti-freezing and long-term weight-retain tests

The ionogel was stored in −20 °C for different time at first, and then stretched to different lengths to prove the flexibility of the ionogel at sub-zero temperature. The conductivities of the ionogel-based sensor at different temperature and stored at −20 °C for different time were also systematic measured, respectively. The weight of ionogel was monitored by placing it in ambient condition for different time to measure the long-term weight-retain property. Besides, the sensing properties of the ionogels for different condition (different storage time at room temperature or −20 °C) were determined as well.

Anti-UV tests

The UV-Vis spectrophotometer (UV-3600, Shimadzu) was utilized to characterize the anti-ultraviolet properties of ionogels by comparing the transmittance of ultraviolet light and visible light of ionogel. The wavelength ranged from 200 to 700 nm, and the thickness of sample was 1.5 mm. The ultraviolet radiation was also performed using the banknote to demonstrate the anti-ultraviolet performance of ionogel.

Anti-bacterial tests

The *Escherichia coli* (*E. coli*, Gram-negative bacteria) and *Staphylococcus aureus* (*S. aureus*, Gram-positive bacteria) were cultured with the sample to investigate the antibacterial properties of ionogels. An ASTM E 2149-2001 standard was utilized in the tests.

Ionogel sensors capability tests

Keithley DMM7510 digital multimeter was used to measure the ionic conductivity of the ionogels by using a two-probe measurement with two copper electrodes. The electrical conductivity σ was calculated by the following formulation:

$$\sigma = L/(\mathrm{R} \times \mathrm{S}),$$

where R is the resistance; L and S are the length and contact-area of the sample, respectively.

As an ionic skin, the ability of monitoring the human movements is essential, so a wireless system was used to real-time monitoring the movements of volunteers. The wireless system was supported by Hangzhou LinkZill Technology Co., Ltd. The Gauge Factor (*GF*) was then calculated by the ratio of relative change in electrical resistance R to the mechanical strain ε ($GF = \frac{(R - R_0)/R_0}{\varepsilon}$).

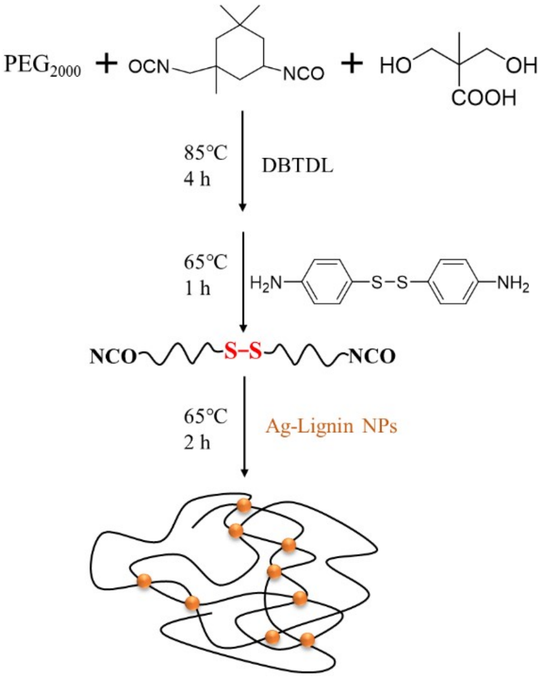

Figure S1. The preparation routine of pre-polyurethane

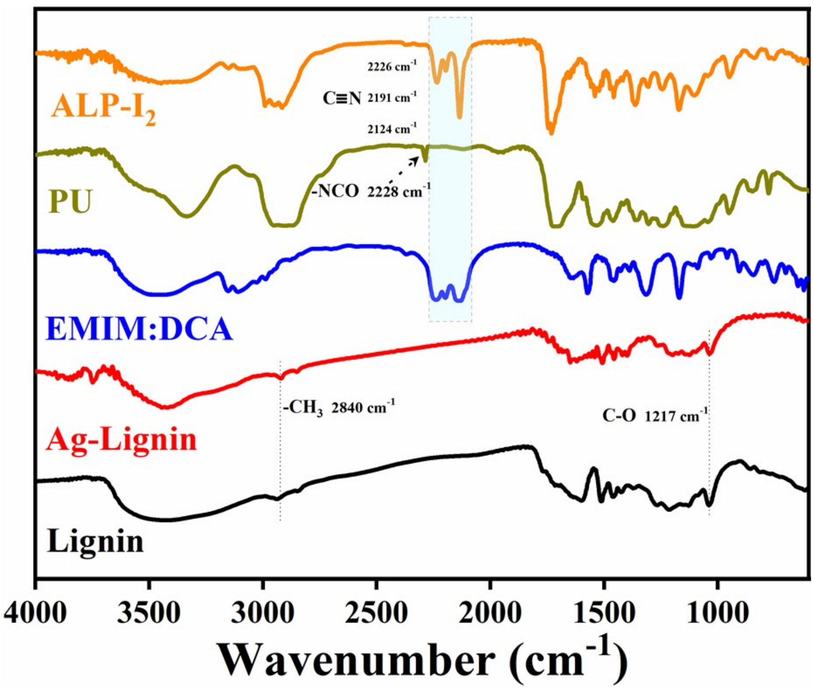

Figure S2. The FT-IR spectrum of the ionogels (wavelength range: 400 - 4000 cm^{-1}).

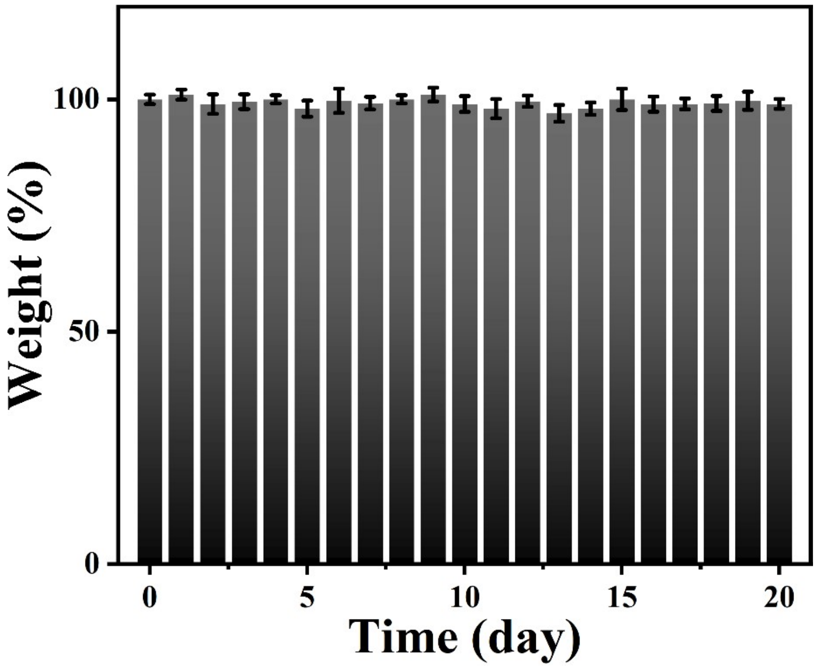

Figure S3 Variation curve of ionogel weight with time

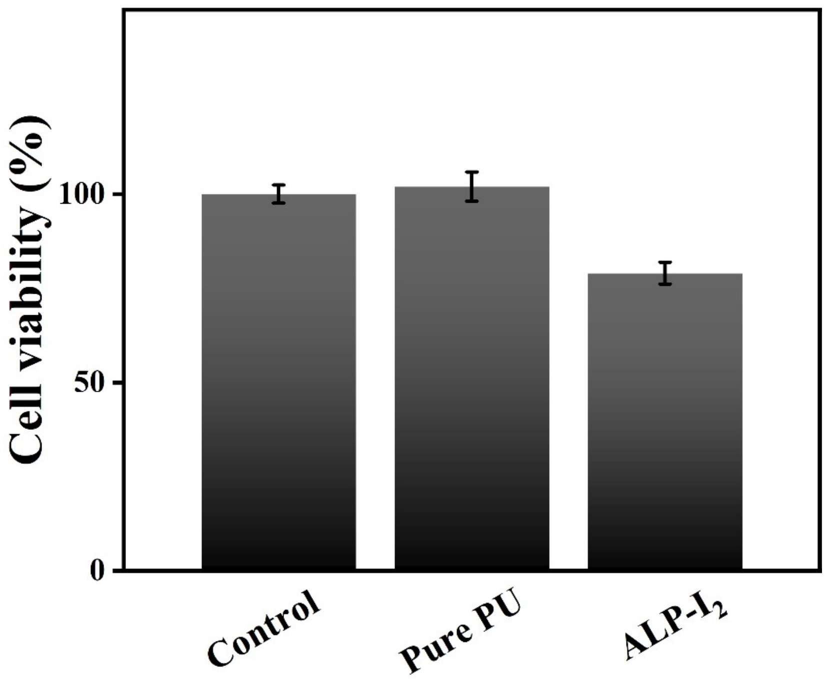

Figure S4. The cytocompatibility of the ionogel.

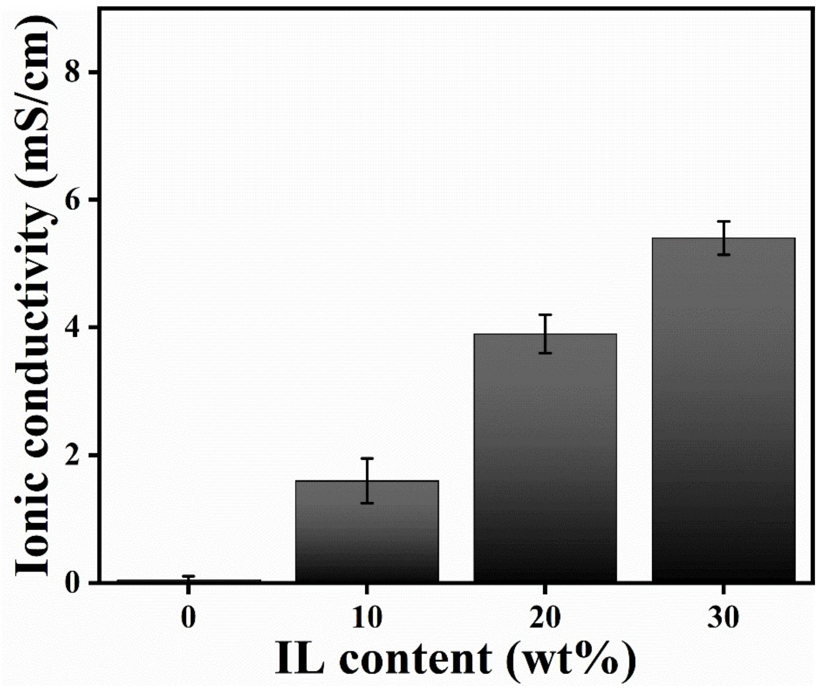

Figure S5. The conductivity of the ionogels with different ILs loadings

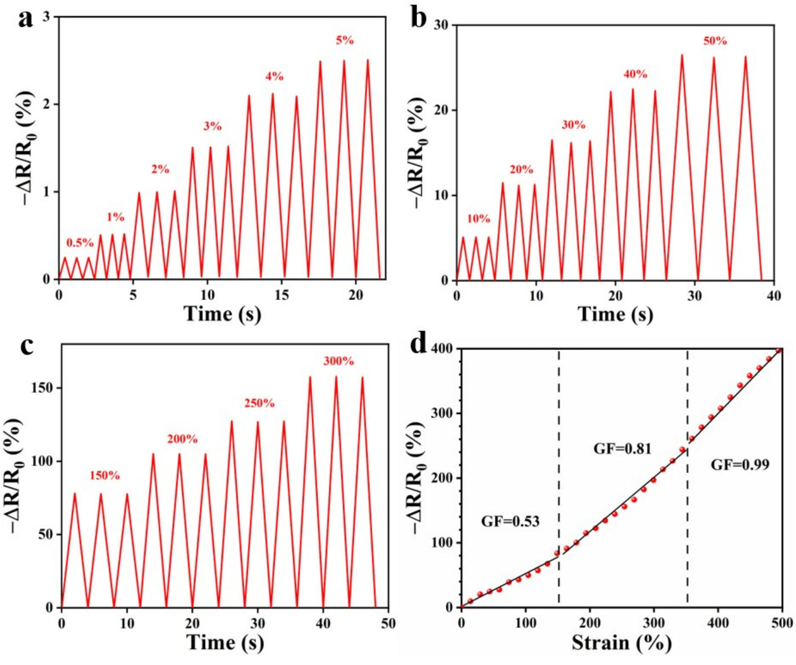

Figure S6. The sensing performance of the ionogel after self-healed

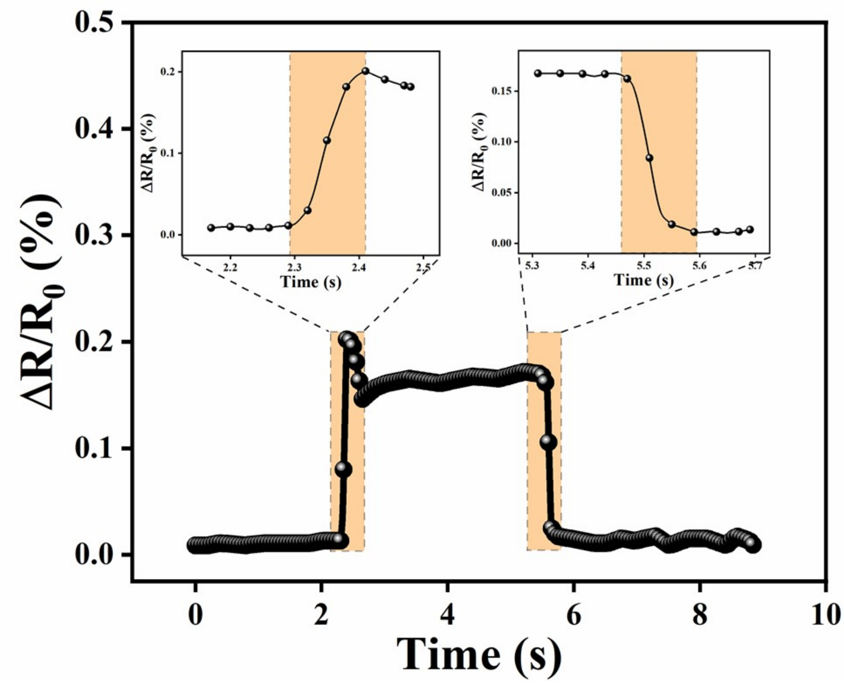

Figure S7. The response time of ionogel sensor