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Supplementary Information

Self-bonding conductive electrode triggered by water-induced structure reconfiguration

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Experimental section

Preparation of cotton-derived cellulose nanofibers

Briefly, 12 g cotton, 20 ml 1 wt% 2,2,6,6-tetramethylpiperidin-1-oxyl (TEMPO) aqueous solution and 20 ml 10 wt% NaBr aqueous solution were added in 700 ml deionized water. The mixture was stirred with an agitator to yield a homogenous solution. Then, 100 g NaClO (Cl conc. 8 %) was slowly added in the above mixture solution. During this process, the pH of the mixture solution was maintained at 10.5 by adding 3 M NaOH. After the reaction, the oxidized cotton fibers were washed with deionized water and treated with mechanical shearing. Afterward, the cotton-derived cellulose nanofibers were achieved.

Preparation of conductive electrode

The flexible conductive electrode was prepared by combining the cotton-derived cellulose nanofibers and silver nanowires. The silver nanowire suspension was

dispersed in the cotton-derived cellulose nanofibers aqueous suspension by magnetic stirring to form a homogeneous mixture with a weight ratio of 1:5. The mixture was then assembled into flexible conductive electrode via filtration. The pore size and material of the used filtration membrane are 0.2 μm and polytetrafluoroethylene (PTFE), respectively.

Water-assisted bonding of conductive electrode

Healing damage: Conductive electrode was cut with scissors, and then water was applied to the damaged area. Followed by natural drying, the damaged area of the conductive electrode was healed.

Bonding separated pieces: First, two segments of conductive electrodes were overlapped, and then spreading water on the conductive electrodes. After drying naturally, the conductive electrodes were bonded together. The square and letter shapes were assembled via the similar water wetting-air drying process.

Direct Bonding on Substrates: Spraying water and placing the conductive electrodes on the PVA substrate. After drying naturally, the conductive electrodes were bonded on the PVA substrate. Following the similar water wetting-air drying process, the conductive electrodes were bonded on cellulose film, paper and glass.

Material characterizations

The morphology of samples was examined by scanning electron microscopy (SEM, JSM-7001F, JEOL) and transmission electron microscopy (TEM, JEM-2100F, JEOL). The surface modification was measured using Fourier transform infrared spectra (FTIR, Bruker Vector-22). The square resistance was tested by four-probe resistivity meter (ST2258C). The tensile property was evaluated by a universal testing machine (CMT6103).

Figures and discussion

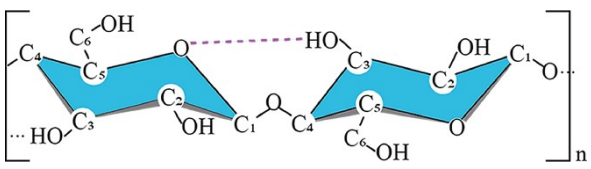

Fig. S1 Cotton cellulose chemical structure.

There are two types of hydroxyl groups on the cotton cellulose chains, i.e., C6-primary hydroxyl groups and C2, C3-secondary hydroxyl groups [1], as shown in Fig. S1.

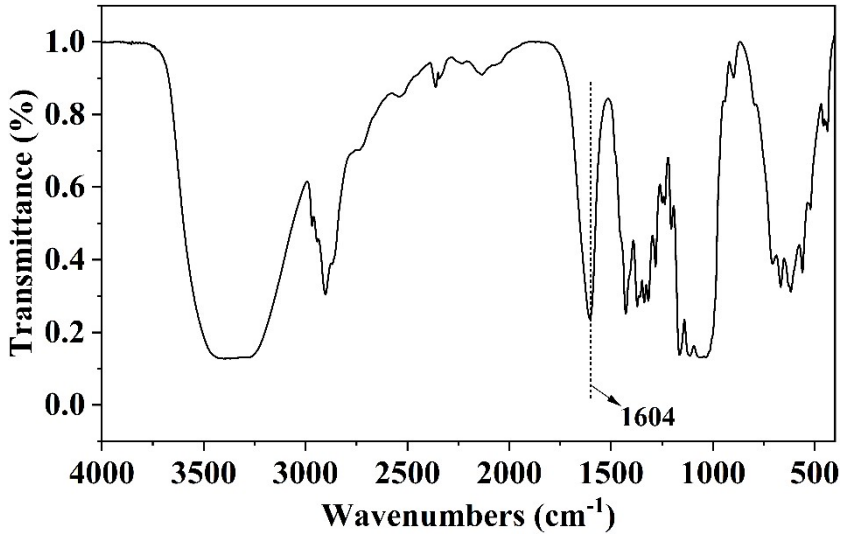

Fig. S2 FTIR spectra of the cotton-derived cellulose nanofibers.

Fig. S2 shows the FTIR spectra of the obtained cotton-derived cellulose nanofibers, the peak at 1604 cm^{-1} is related to the stretching carbonyl groups (COO-) and the peak observed from 3200 to 3500 cm^{-1} is related to O-H stretching vibration [2-6]. The carboxyl groups make cellulose nanofibers highly charged and creates repulsive force between cellulose nanofibers, preventing the formation of larger cellulose bundles. The obtained smaller and finer cellulose fibers will help to enhance the transparency of the conductive films. In addition, the adsorption effect of carboxyl groups to silver nanowires facilitates the transportation of silver nanowires along with cellulose nanofibers during the healing process, which is beneficial for the reconstruction of nanostructure conductive networks.

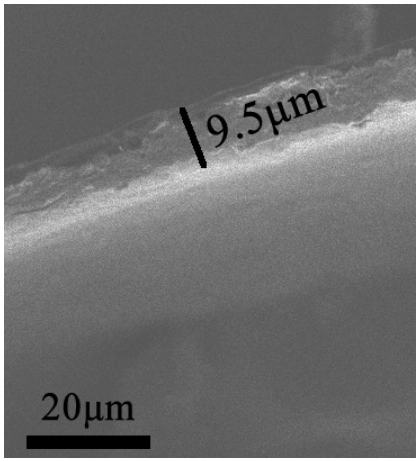

Fig. S3 Cross-sectional SEM image of the conductive electrode.

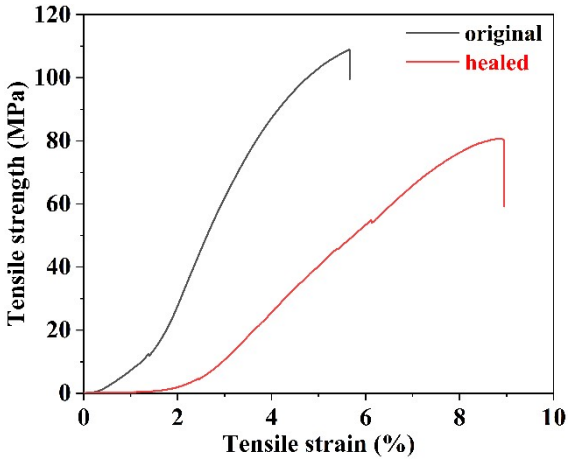

Fig. S4 Tensile stress-strain curves of original and healed conductive electrodes.

The tensile strength of the original and healed conductive electrode are 108.9 MPa and 80.8 MPa, respectively (Fig. S4). Compared to the original conductive electrode, the healed conductive electrode still retains 74.2 % of the tensile strength.

Notes and references

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