Supporting Information

Environment-friendly, durable, electro-conductive, and highly transparent heaters based on silver nanowire functionalized keratin textile

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S1. The FT-IR spectroscopy, differential scanning calorimetry (DSC), and thermo-gravimetric analysis (TGA) of NFs.

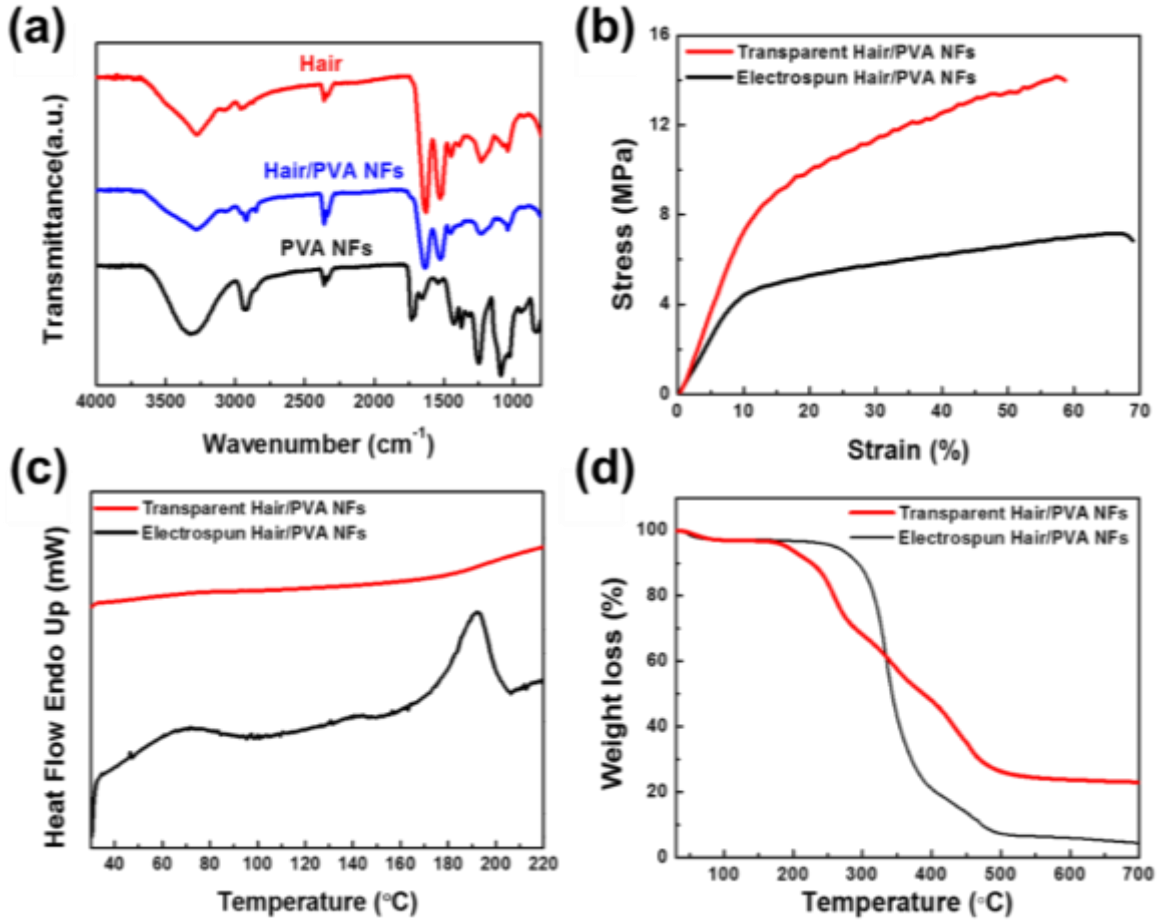

Figure S1. The FT-IR spectroscopy, differential scanning calorimetry (DSC), and thermo-gravimetric analysis (TGA) of NFs.

Studies of FT-IR spectroscopy demonstrated the main chemical structure of human hair, PVA NFs, and Hair/PVA NFs as shown in Figure S1(a). These include the typical characteristic peaks of keratin exhibited at 1,625 cm^{-1}, 1,520 cm^{-1}, and 3,300 cm^{-1}, corresponding to the elastic vibration of the C=O bond, bending deformation of the C-N-H bond, and the N-H stretching vibrations of the amine group, respectively. The characteristic peak of keratin at 3,300 cm^{-1}

slightly shifted to the left side and appeared broader due to the formation of hydrogen bonds. It improved the electrospinning ability between the keratin and PVA molecules, which was in good accordance with the results from the XRD observations. Furthermore, these results were in agreement with the stress-strain results in Figure S1(b). After the “dip and dry” process, the mechanical properties of Hair/PVA NFs were enhanced (14 MPa). The enhanced mechanical strength of transparent Hair/PVA NFs presented a possible explanation for the enhanced formation of hydrogen bonding between PVA, glyoxal, and keratin without chemical modifications. Similar results were shown in the DSC analysis as shown in Figure S1(c). There was no endothermic peak after complexation, and the thermal transition of molecules such as melting or sublimation shifted or disappeared. After the “dip and dry” process, the TGA curves of transparent Hair/PVA NFs declined at approximately 200 ℃, shifting to lower temperatures compared to the as-electrospun Hair/PVA NFs, as shown in Figure S1(d). Under an inert atmosphere, the as-electrospun Hair/PVA NFs were completely degraded from 300~550 ℃ (weight loss 85%), while transparent Hair/PVA NFs were degraded from 200~550 ℃ (weight loss 75%) and produced an amount of residue. The thermal decomposition of transparent Hair/PVA NFs commenced at a lower temperature, probably due to the evolution of water. This resulted in increased thermal stability, as indicated by the molecular conformation caused by cross-linking. This thermal behavior is in good agreement with the FT-IR observations. Textile based transparent Hair/PVA NFs were obtained with superior characteristics after the “dip and dry” process based on a variety of technique.

S2. Atomic force microscopy (AFM) images of as-electrospun NFs.

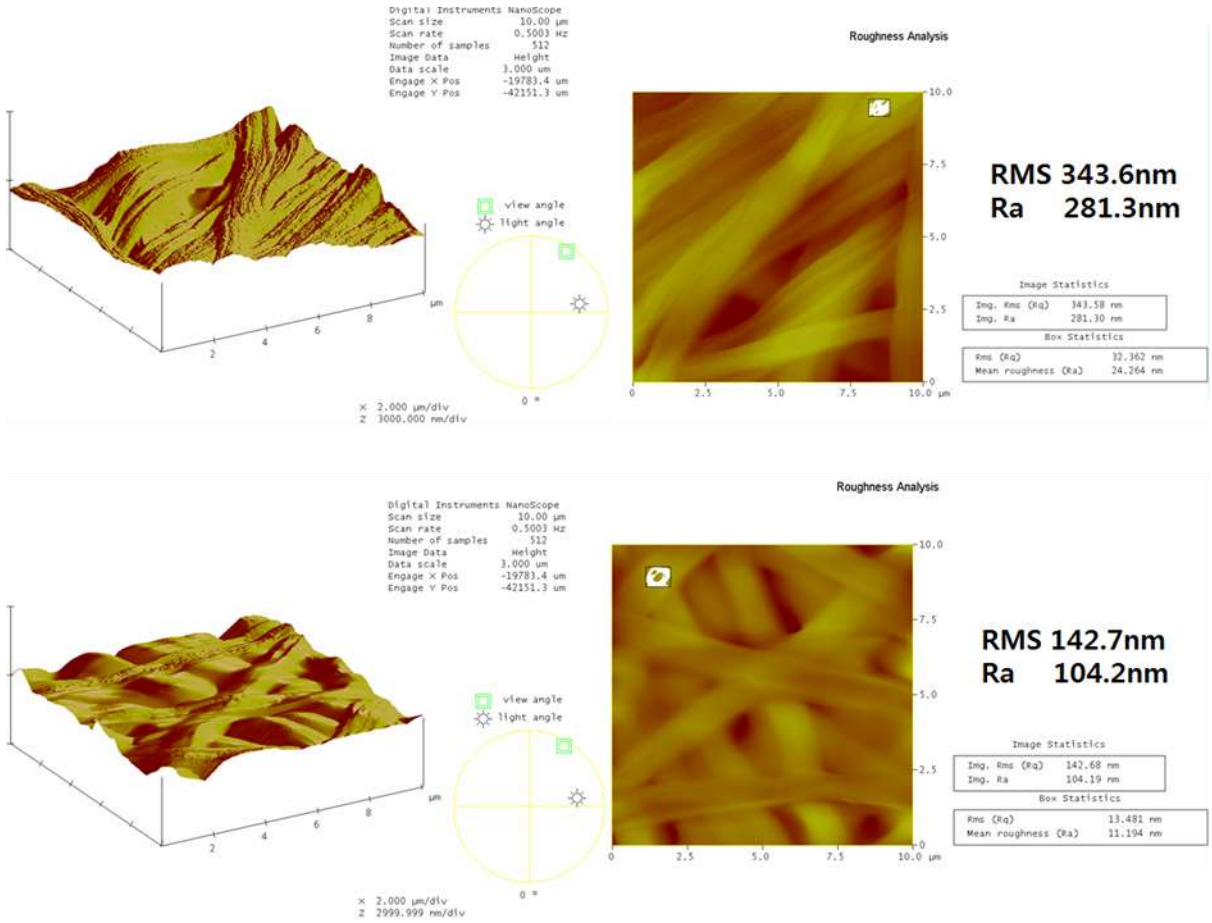

Figure S2. Atomic force microscopy (AFM) images of as-electrospun NFs.

In the AFM images of figure S2, RMS refers to the mathematical root mean square (RMS), which is an average of the peaks and valleys in a material surface profile, and Ra stands for roughness average. The experimental results demonstrated that the surface roughness of transparent Hair/PVA NF mats decreased after the "dip and dry" process from a RMS of 343.6 nm and a Ra of 281.3 nm to a RMS of 142.7 nm and a Ra of 104.2 nm.

S3. The Infra-red images of Ag NWs/NFs heater at different voltages.

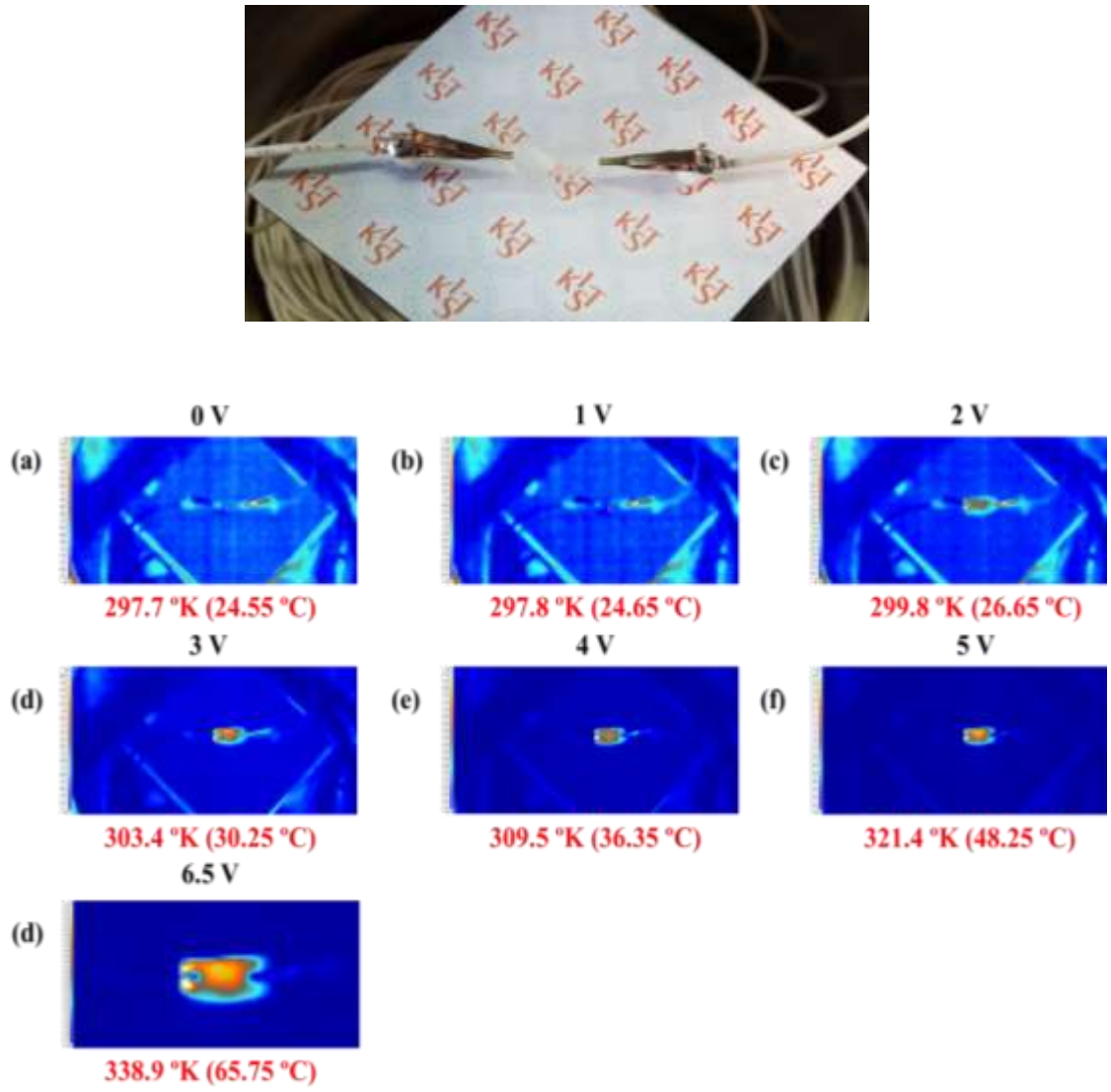

Figure S3. The Infra-red images of Ag NWs/NFs heater at different voltages applied from 1 to 6.5V.

In the infra-red (IR) images of figure S3, transient temperature evolution of Ag NWs/NFs heater at stepwise voltage rise from 0 to 6.5 V and temperature field captured by an IR camera at each applied voltage. The experimental results demonstrated that the heat of the Ag NWs/NFs heater

gradually started at 2V (26.65 ℃), showing 30.25 ℃ at 3V, 36.35 ℃ at 4V, 48.25 ℃ at 5V and finally 65.75 ℃ at 6.5V.