Supporting Information

Ultrastretchable and Self-Healing Double-Network Hydrogel for 3D Printing and Strain Sensor

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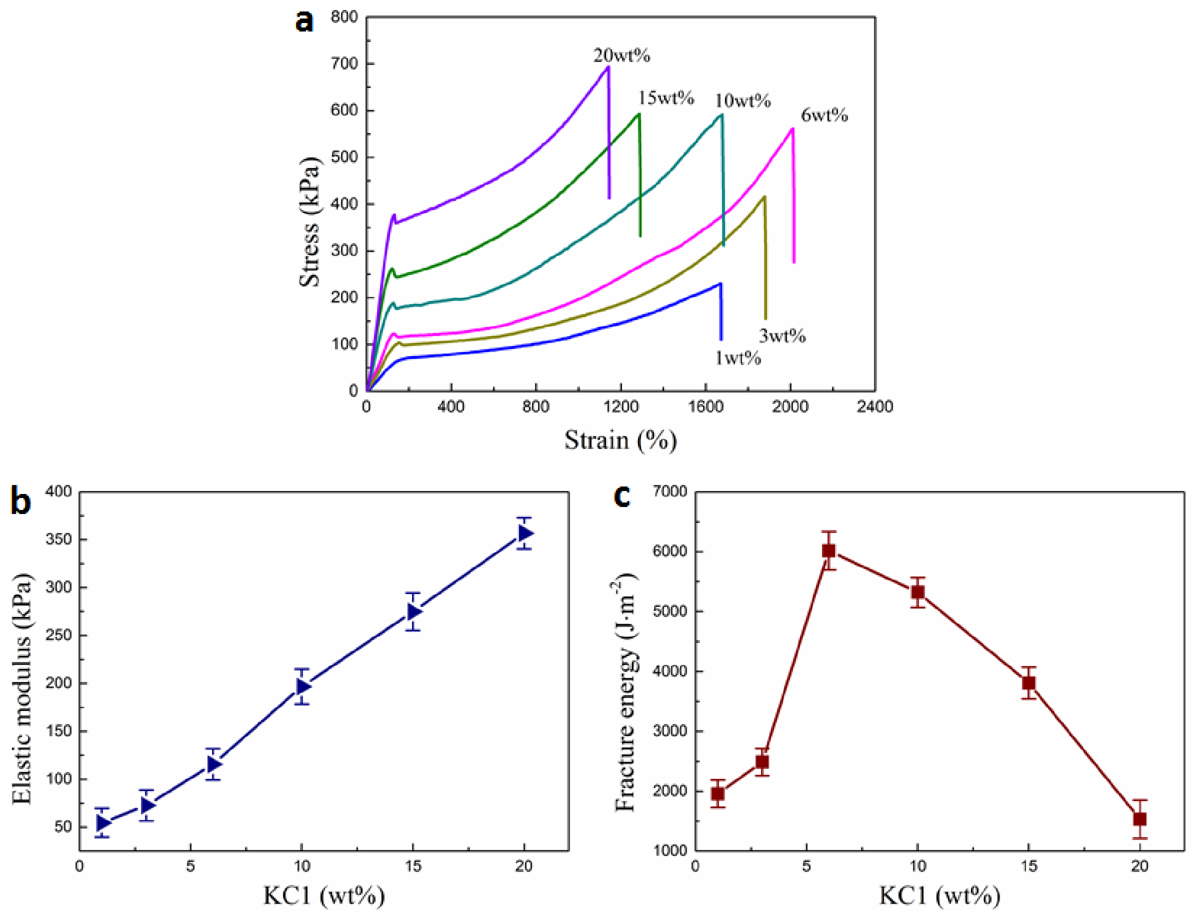

Figure S1. (a) Stress-strain curves of the κ-carrageenan/PAAm DN hydrogels with varying KCl contents. Effects of various weight percentages of KCl (KCl/κ-carrageenan, wt%) on (b) elastic modulus and (c) fracture energy. In the κ-carrageenan/PAAm DN hydrogel, the weight ratio of κ-carrageenan to AAm was fixed at 2:16, and the contents of MBA and UV-initiator were 0.05 wt% and 3 wt% based on AAm, respectively.

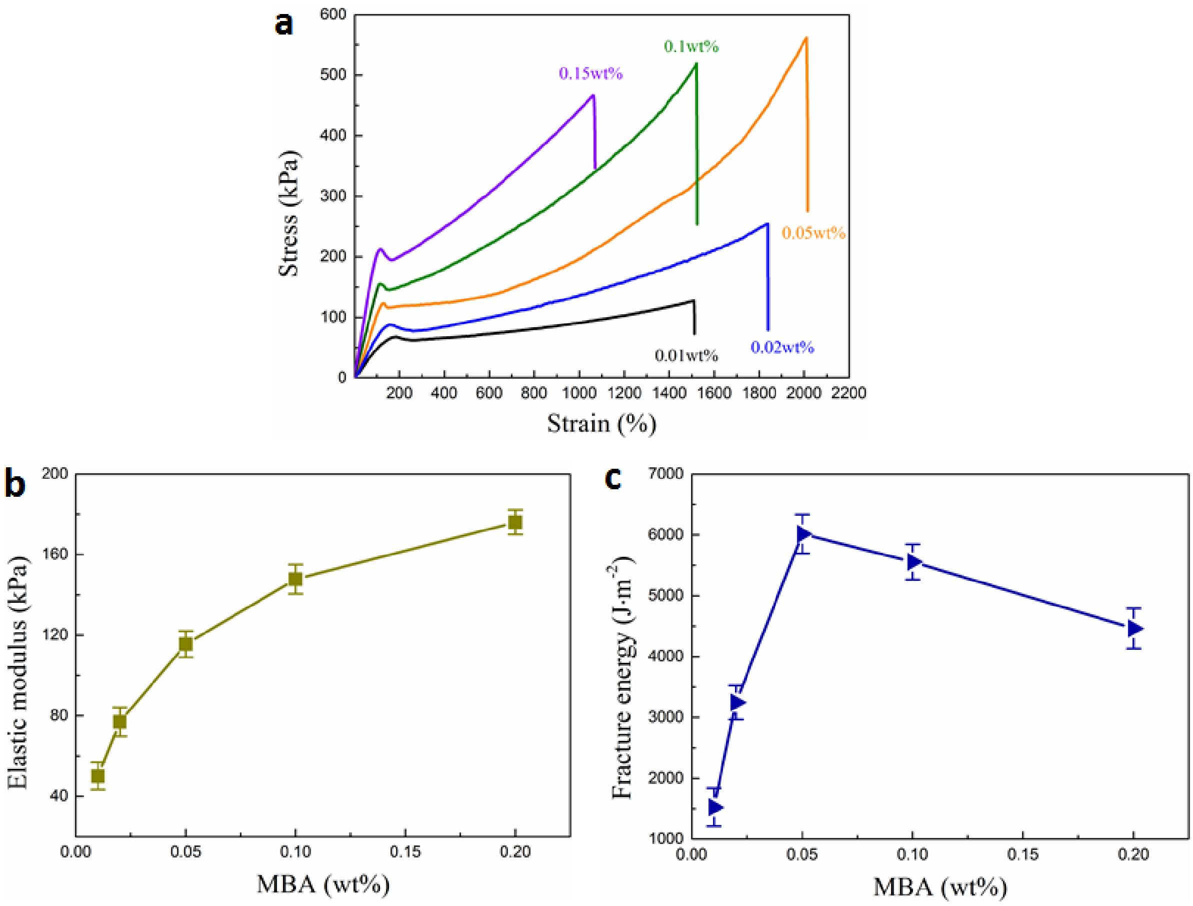

Figure S2. (a) Stress-strain curves of the κ-carrageenan/PAAm DN hydrogels with varying MBA contents. Effects of various weight percentages of MBA (MBA/AAm, wt%) on (b) elastic modulus and (c) fracture energy. In the κ-carrageenan/PAAm DN hydrogel, the weight ratio of κ-carrageenan to AAm was fixed at 2:16. The content of KCl was fixed at 6 wt% relative to κ-carrageenan, and the content of UV-initiator was fixed at 3 wt% based on AAm.

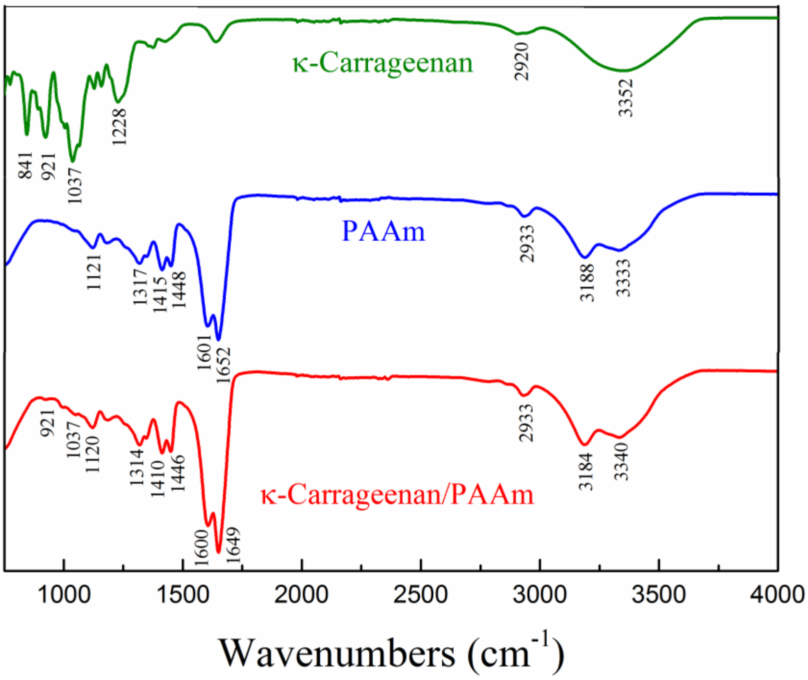

Figure S3. FTIR spectra of the κ-carrageenan, PAAm, and κ-carrageenan/PAAm gels. The samples for the FTIR tests were prepared by the freeze-drying method as follows: the hydrogels with a thickness of about 1 mm were frozen in a refrigerator at -20 ^{o}C for about 24 h. And then the frozen samples were quickly transferred into a vacuum freeze dryer (Telstar cryodos-80, Telstar industrial, Spain) and dried at -80 ^{o}C for about one week. FTIR spectra were recorded on a Shimadzu IR Prestige 21 FTIR spectrometer using the ATR mode in the wavelength range of 750 – 4000 cm^{-1}. For the κ-carrageenan and PAAm gels, the contents of κ-carrageenan and AAm were kept the same as those in the DN gel.

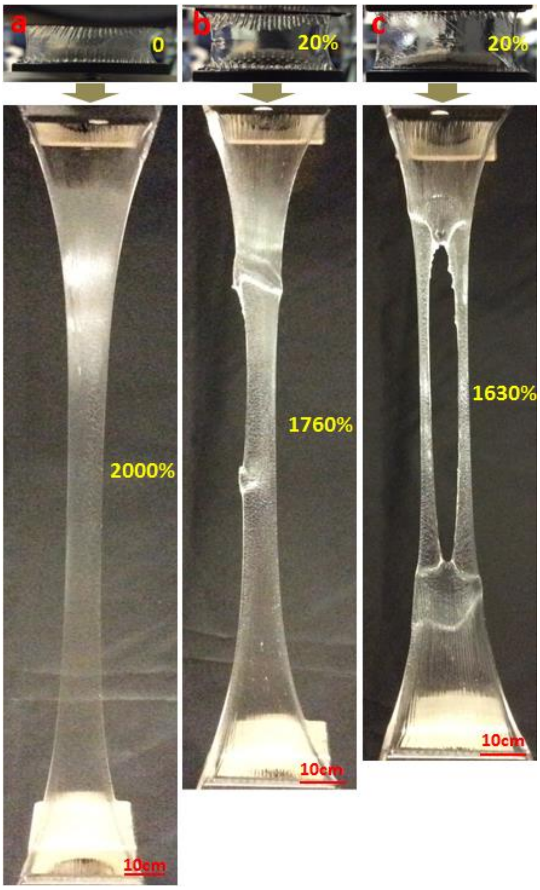

Figure S4. Photo images of the κ-carrageenan/PAAm DN hydrogels stretched with un-notch (a) and artificial notches at edge (b) and center (c). The notch with the width of 1 mm was made at the κ-carrageenan/PAAm DN hydrogel sheet (length: 3.0 mm, width: 25 mm, and thickness: 2.5 mm), and then the uniaxially stretch was carried out at a given rate of 100 mm/min.

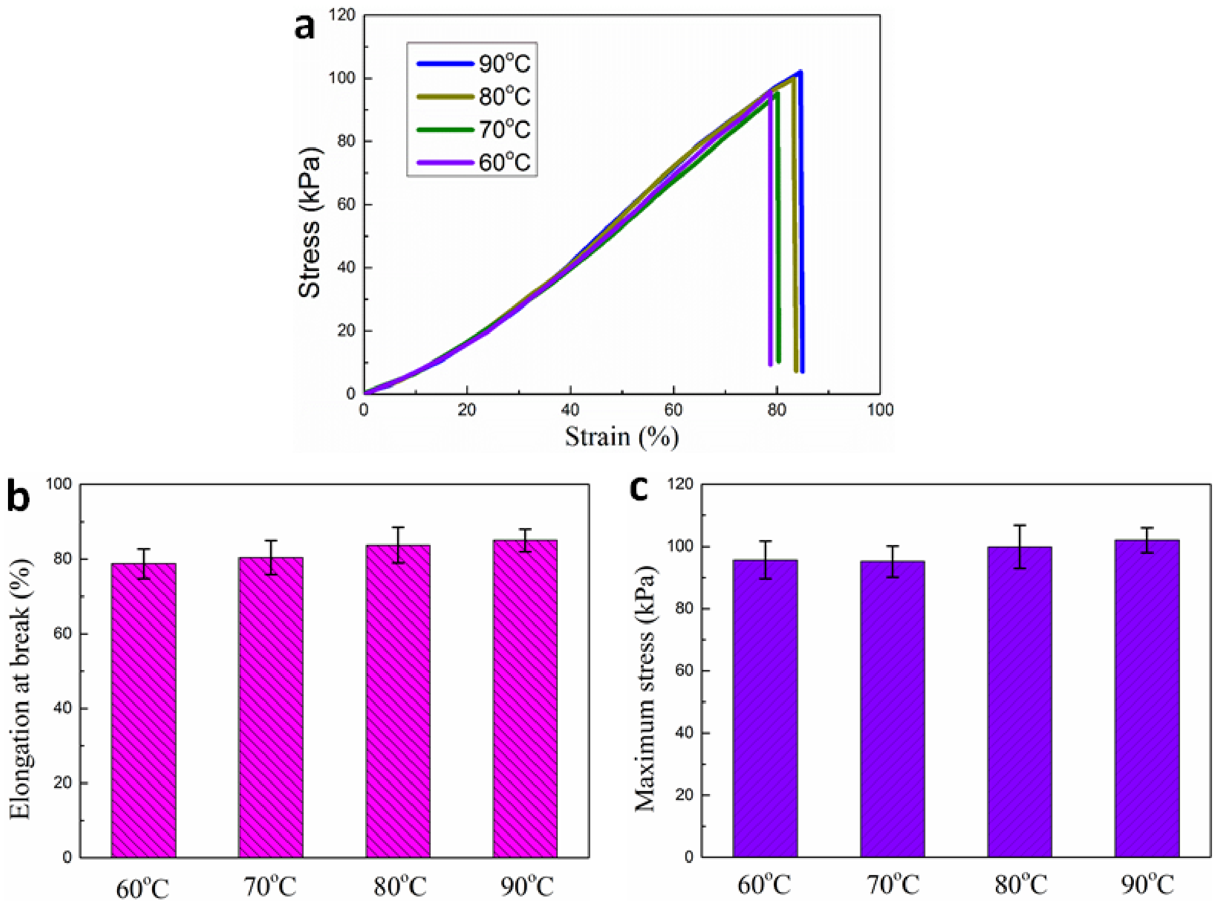

Figure S5. (a) Effects of water bath temperatures on the stretch-strain curves of self-healed DN hydrogels. Depndences of (b) elongation at break and (c) maximum stress on water bath temperatures when the self-healed DN hydrogels were held at water bath for 20 min.

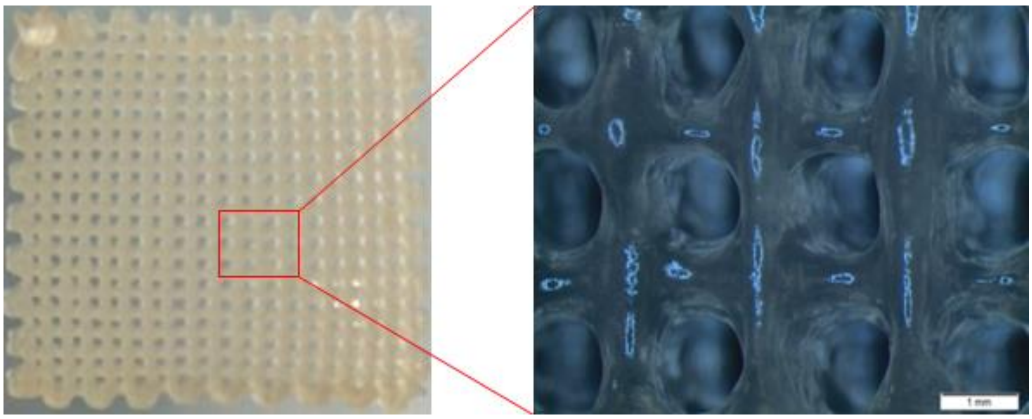

Figure S6. 3D printed κ-carrageenan/PAAm DN hydrogel with mesh pattern and its optical microscope image.

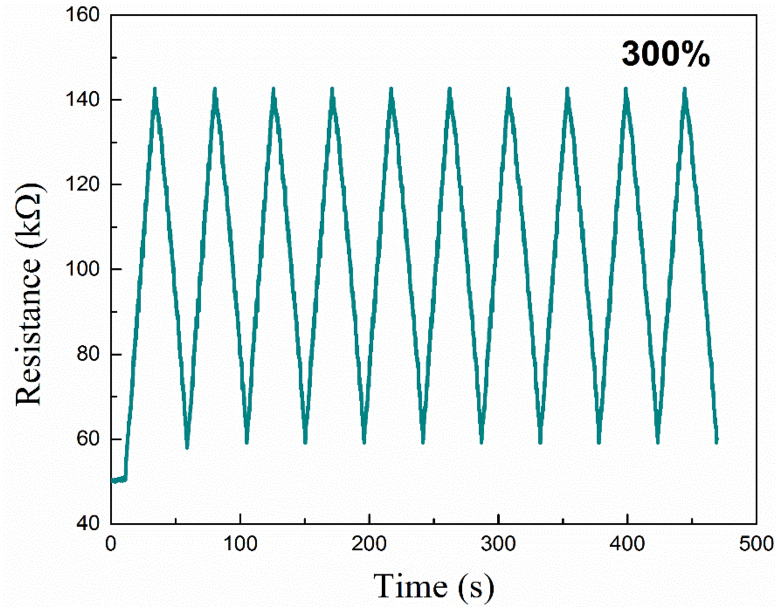

Figure S7. Stability of the κ-carrageenan/PAAm DN hydrogel by repeatedly applying strain of 300 % for first 10 cycles.

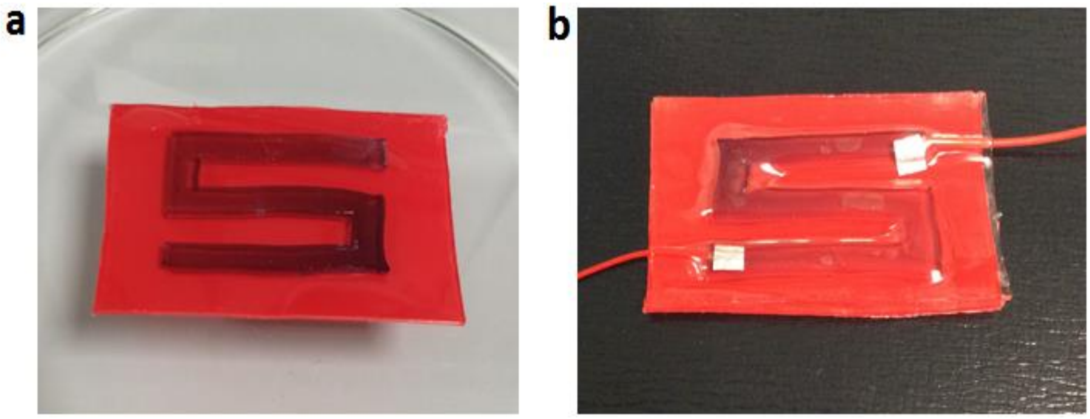

Figure S8. (a) 3D printed κ-carrageenan/PAAm DN hydrogel sample with the shape of number "S", and (b) 3D printed κ-carrageenan/PAAm DN hydrogel based strain sensor assembled by 3D printed κ-carrageenan/PAAm DN hydrogel as conductor and VHB tape as elastomeric substrates and encapsulant.