Supplementary Information

Distributed and multimodal strain sensing performance of flexible hydrogel functional optical fibers

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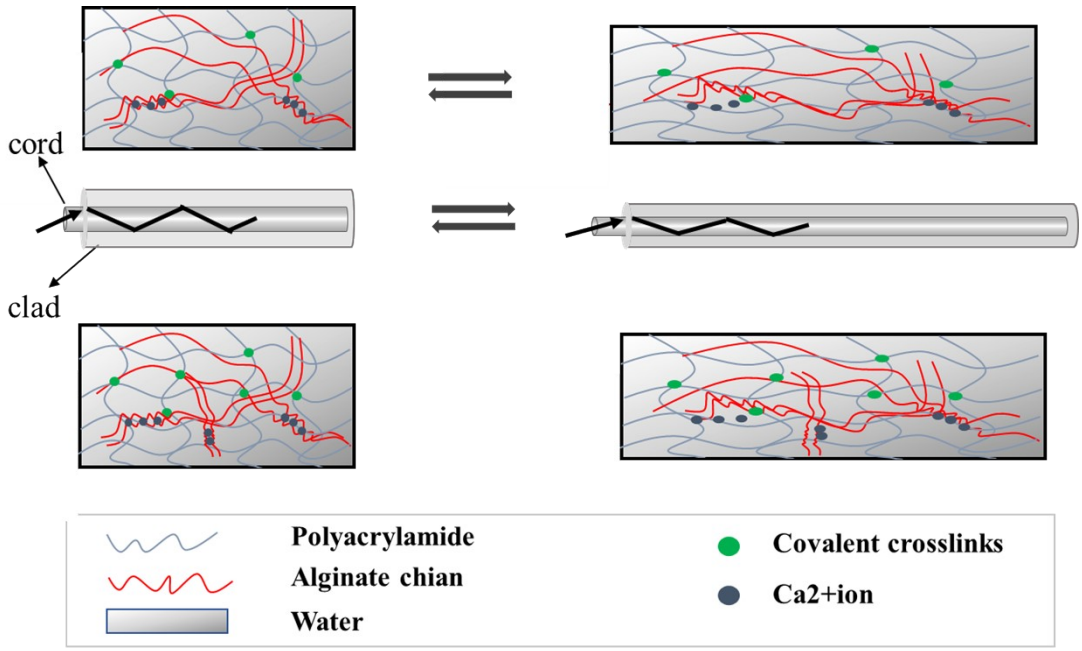


Fig. S1. Diagram of a step-shape alginate-polyacrylamide hydrogel. Covalently cross-linked long-chain polyacrylamide hydrogel network provides high elasticity, while ionically cross-linked alginate consumes mechanical energy during strain. The core and cladding are made from different concentrations of precursor solution, resulting in the refractive index of the core being greater than that of the cladding, thereby causing total reflection transmission at the interface between the core and cladding.

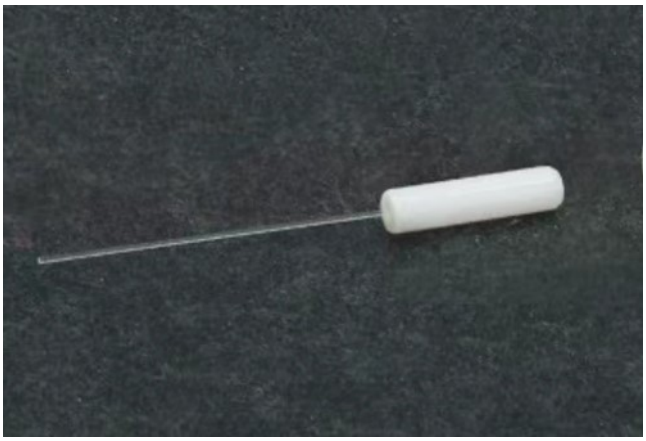


Fig. S2. The hydrogel fiber is coupled with an optical ceramic.

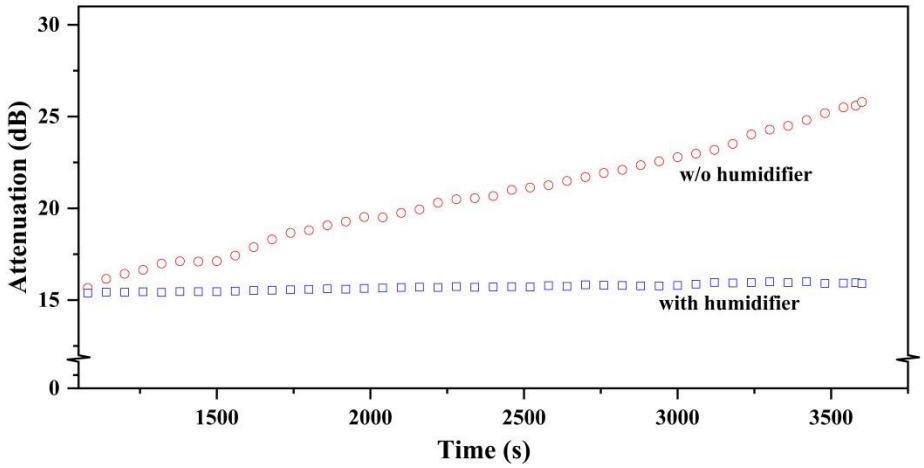


Fig. S3. Continuous 1 hour stability test.

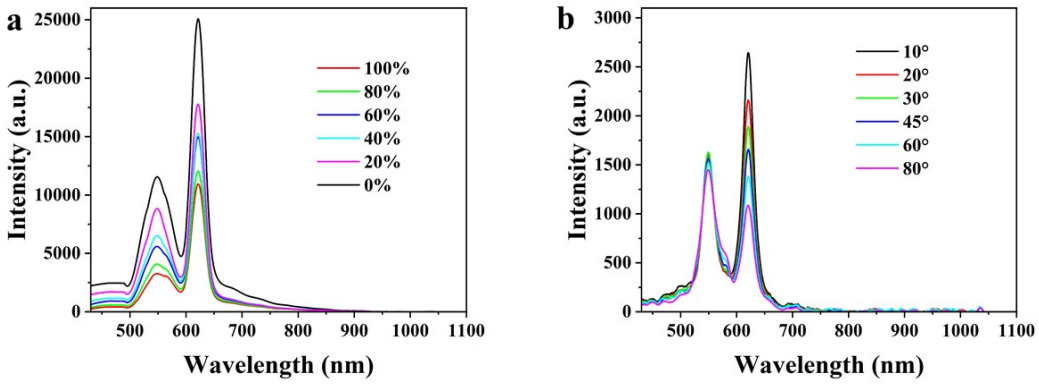


Figure S4: Spectrum acquired by the spectrometer when subjected to partial strain. a) Stretched strain, b) Bent strain.

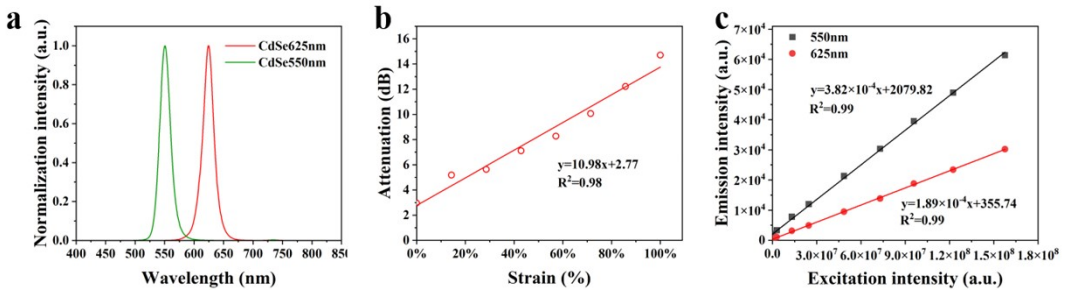


Fig. S5. a) Emission peaks of two CdSe quantum dots at 365 nm under excitation light. b) Decay at different stretching extents under 365 nm. c) Quantum point emission intensity corresponding to the corresponding 365 nm laser excitation strengths at different intensities.

To verify the stability of the hydrogel fiber, 20 cycles of tensile sensing tests were supplemented (100% strain), where it is obvious that the prepared hydrogel fiber has strong sensing stability over 20 cycles.

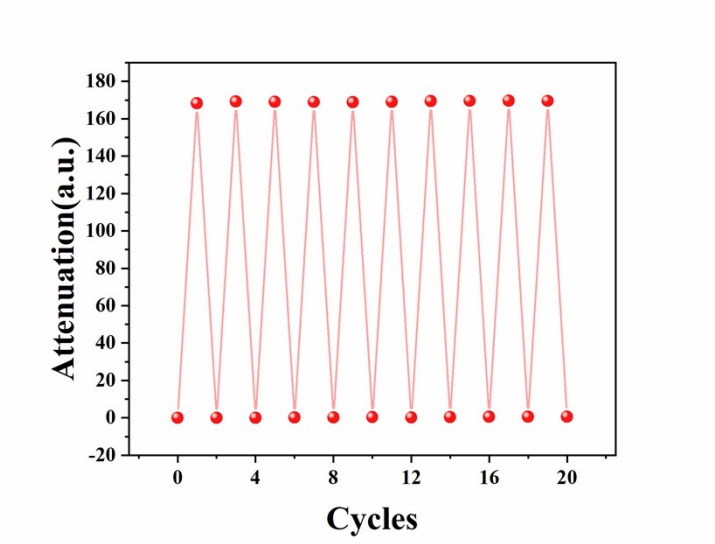


Fig. S6 A 20-cycle experiment for tensile sensing (100% strain).

In FT-IR experiments with hydrogel materials, the characteristic peaks of the hydrogel were characterized. Several of the typical characteristic peaks are as follows. In the sample, the peak at 3410 cm^{-1} corresponds to the tensile vibration of -NH_2, and that of N-H peaks at 3190 cm^{-1}. The peak at 1670 cm^{-1} was observed corresponding to tensile vibration at C=O bond, at 1600 cm^{-1} to -COO-, and finally the peak at 1120 cm^{-1} and 1030 cm^{-1} correspond to C-O-C.

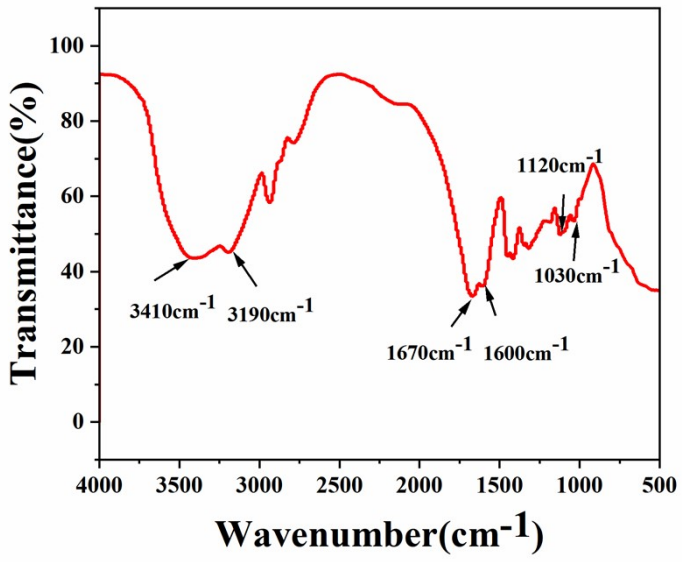
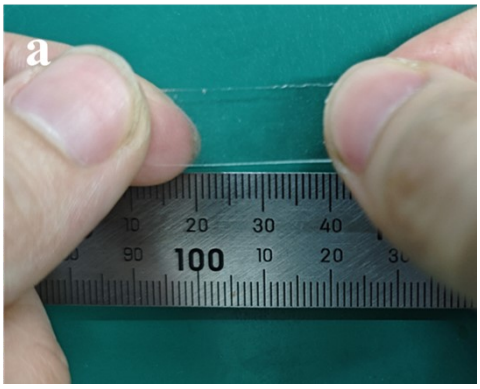


Fig. S7 FT-IR spectra of hydrogel.



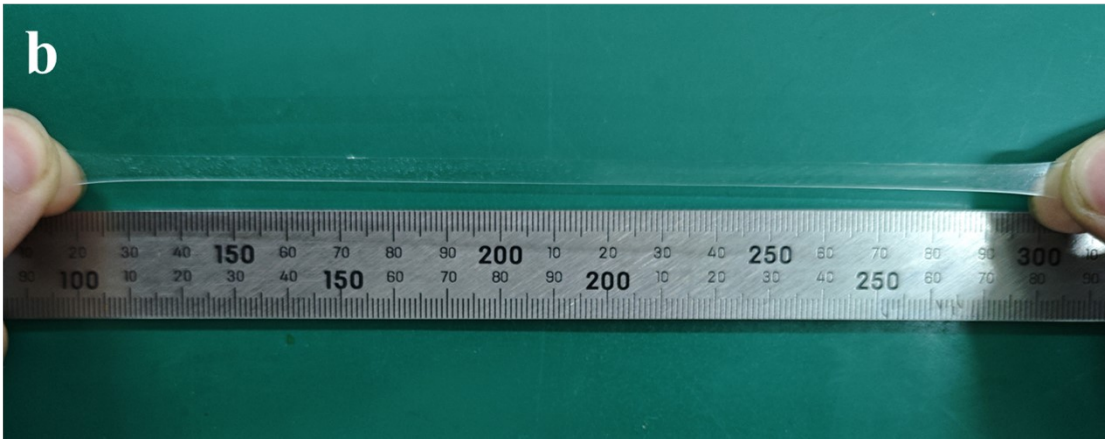


Fig. S8 a) The hydrogel film before stretching；b）After the stretching of the hydrogel thin film.

The prepared hydrogel optical fiber (diameter: 1 mm) hardly affects the original mechanical properties of the material, maintaining a tensile strain of nearly 800%.

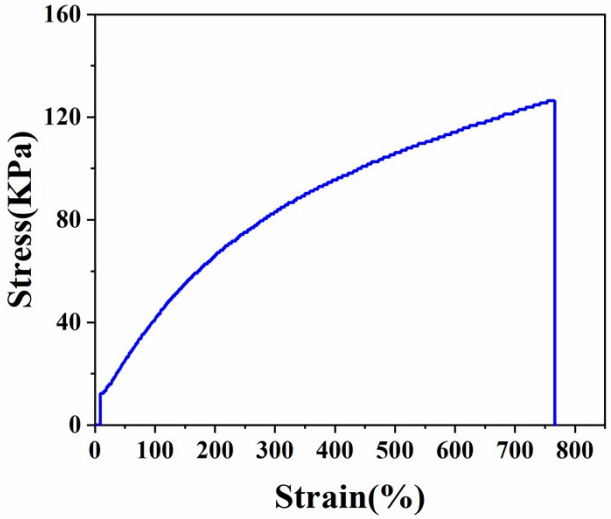


Fig. S9 Stress-strain curves of the hydrogel optical fibers (Diameter: 1 mm) .

The influence of different concentrations of QD on the photophysical properties of hydrogel fibers was explored, the QD solution with 0.001mg/ml, 0.005mg/ml, 0.1mg/ml, 0.2mg/ml, 0.4mg/ml concentration was selected, and the fluorescence intensity contrast experiment was performed. As shown in Figure S10, the quantum dot solution with 0.1 mg / ml concentration had the best physical and optical properties, so this concentration was chosen as one of the criteria for the preparation of hydrogel fibers.

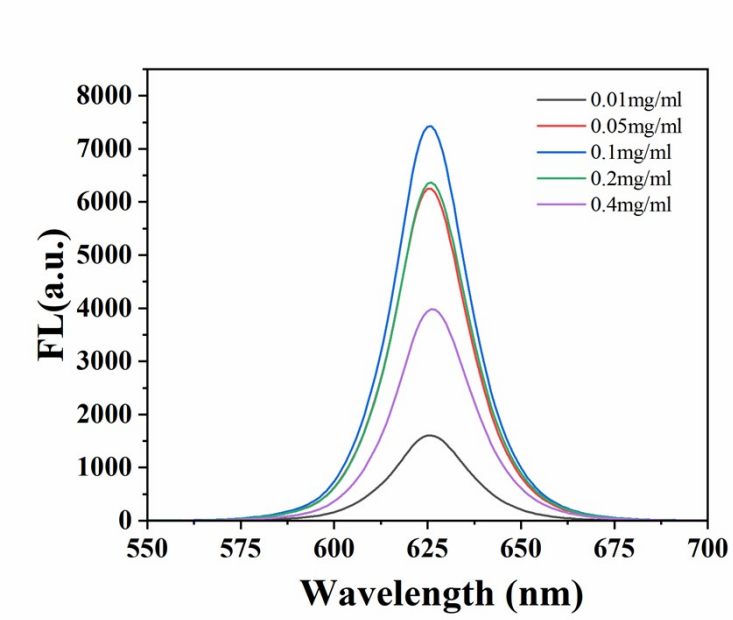


Fig. S10 Fluorescence emission spectra of CdSe with different concentrations (0.01 mg/ml, 0.05 mg/ml, 0.1 mg/ml, 0.2 mg/ml, 0.4 mg/ml).

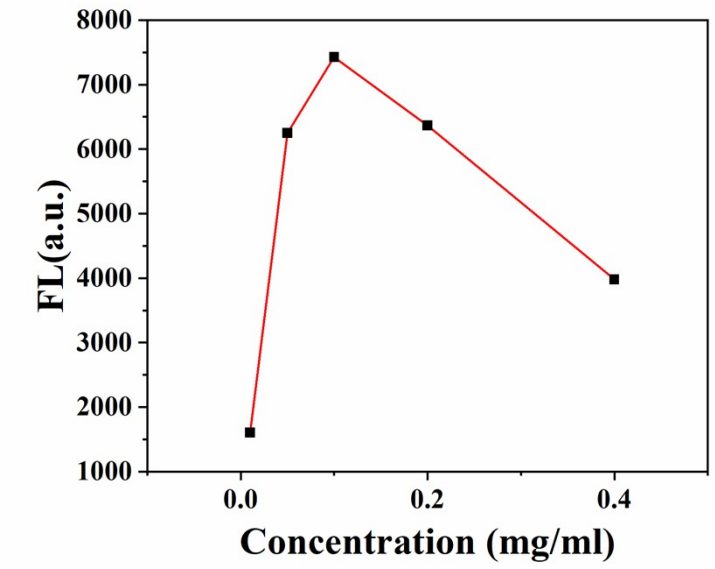


Fig. S11 Comparison of the fluorescence intensities of the CdSe solutions at different concentrations (0.01mg/ml, 0.05mg/ml, 0.1mg/ml, 0.2mg/ml, 0.4mg/ml).

To more accurately show the microscopic mechanism of the hydrogel fibers, two cross-sectional EM images were performed of the hydrogel fibers with different magniations. As shown in Figure S12, the structural scale of the hydrogel fiber cladding is about 50-100 μm, and we can clearly see the fiber core coating structure of the hydrogel optical fiber.

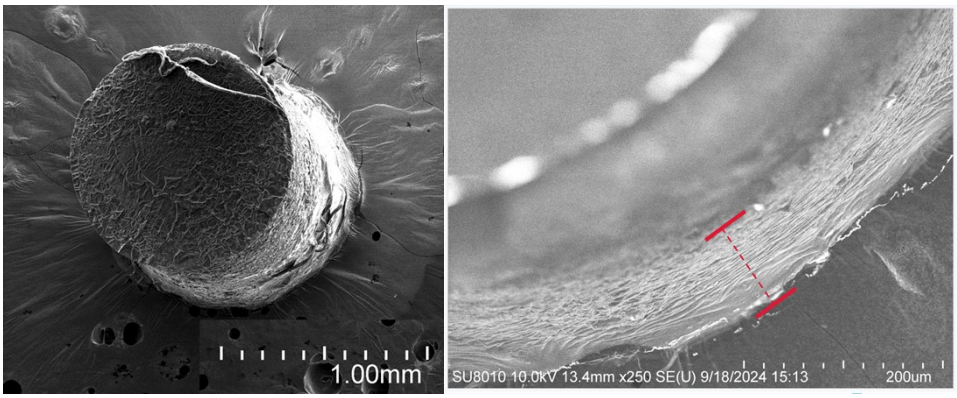


Fig. S12 The SEM image of the hydrogel optical fiber (The SEM image scales from left to right are, respectively：1mm, 200 μm).

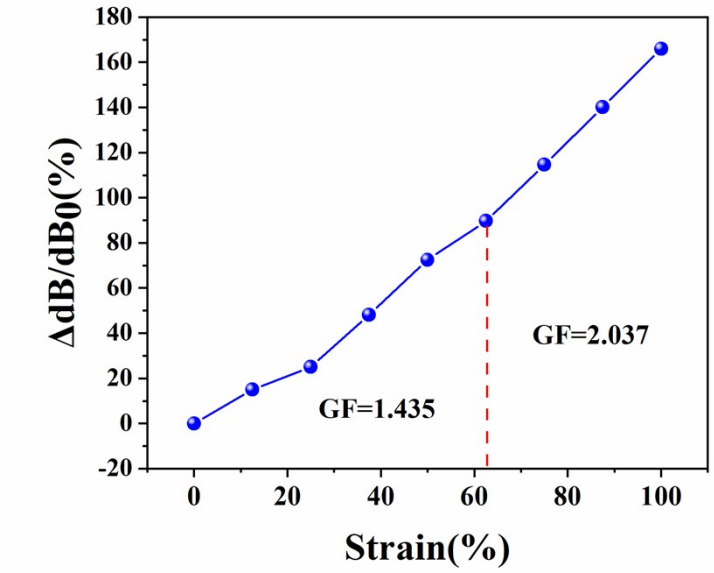


Fig. S13 Reversible changes in relative damping with strain under cyclic stretching-releasing up to a strain of 100%.

The hydrogel fiber was dried and expanded again after seven days, and the sensing sensitivity was almost unaffected (Fig. S14) .

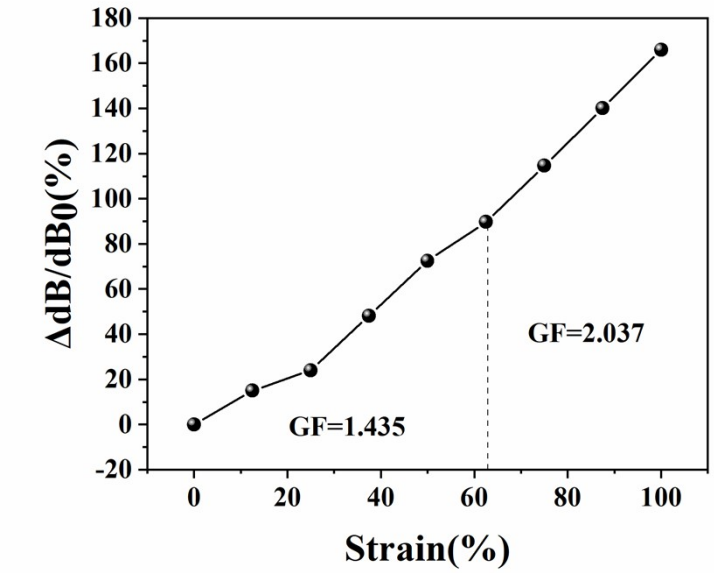


Fig. S14 Change of GF value of hydrogel fiber after seven days.

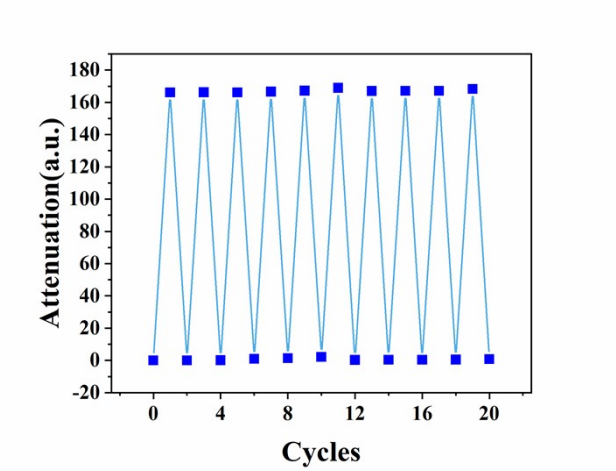
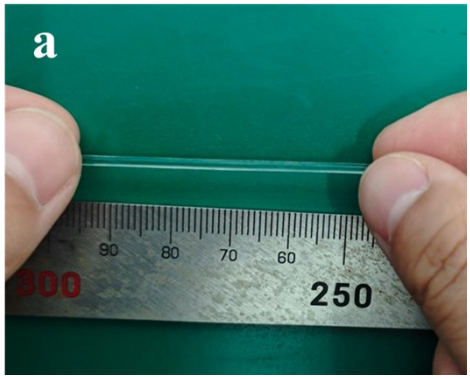


Fig. S15 A 20 cycles of stretch sensing experiments (100% strain) after seven days of the hydrogel fiber.



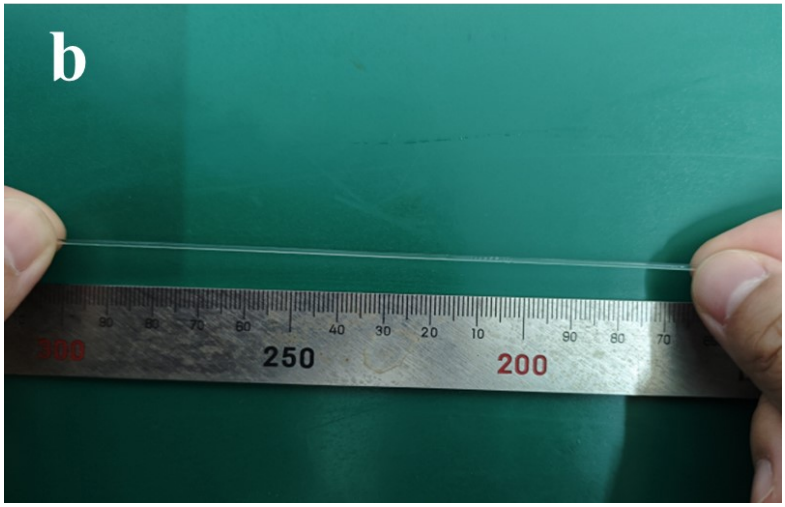


Fig. S16 Changes in the mechanical properties of the hydrogel optical fibers after seven days of placement.

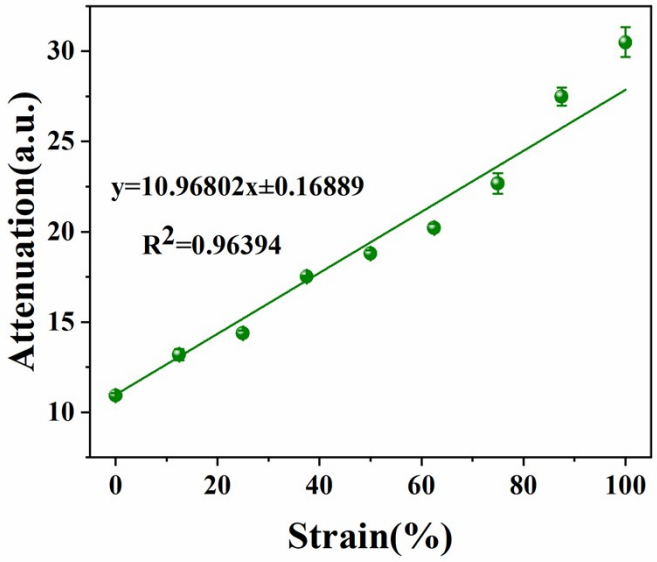


Fig. S17 Changes in the sensing performance of the hydrogel optical fibers after seven days of placement.

To verify the performance difference of CdSe and fluorescent dyes, fluorescence intensity validation was performed, as shown in Figure S18. The fluorescence excitation intensity of cadmium selenide at the same concentration (0.1 mg/ml) far exceeded rhodamine, demonstrating the excellent properties of the quantum dots used.

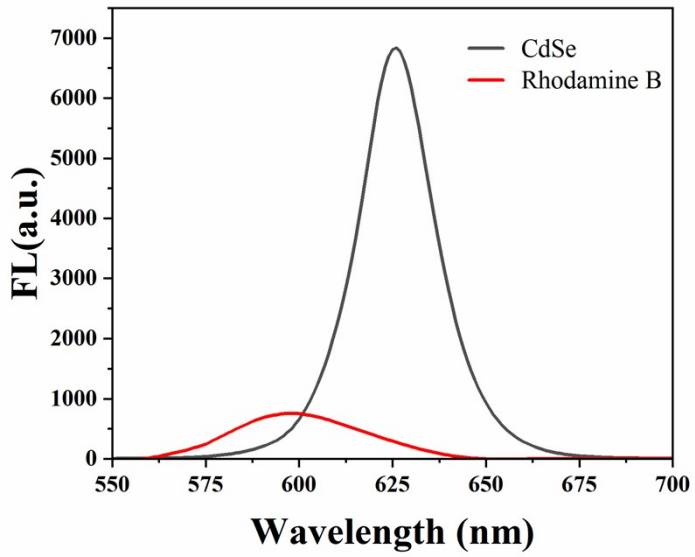


Fig. S18 CdSe Solution versus rhodamine dye solution (0.1 mg/ml).