Electronic Supplementary Material

Bioelectronic protein nanowire sensors for ammonia detection

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This PDF file includes

Figures S1 to S5
References

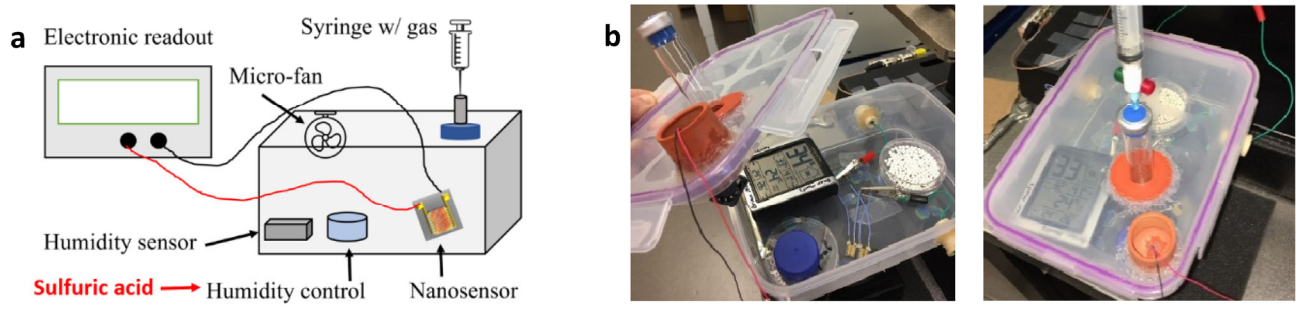

Figure S1 (**a**) Schematic of custom-built vapor chamber testing system and electronic readout. (**b**) Photograph of vapor chamber system before (open-lid, left) and after (closed-lid, right) exposing the sensor to gas.

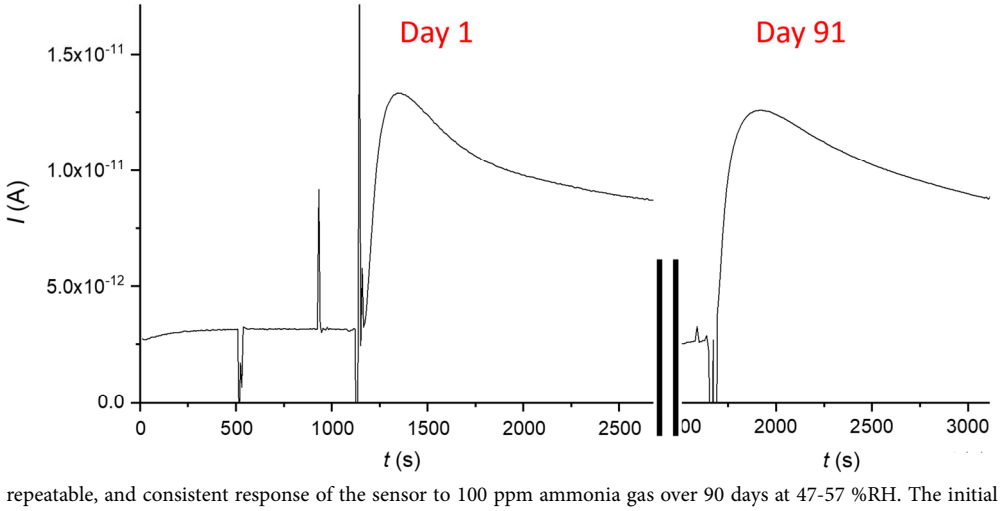

Figure S2 Stable, repeatable, and consistent response of the sensor to 100 ppm ammonia gas over 90 days at 47-57 %RH. The initial sharp spikes were artifacts (e.g., mechanical perturbation to contacts/connections) during gas injection.

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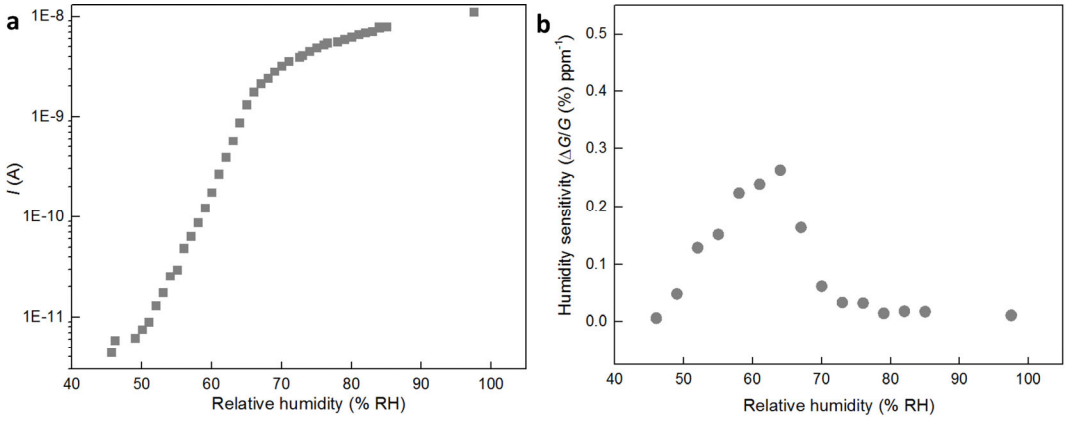

Figure S3 (**a**) Current output of a protein nanowire device measured as a function of relative humidity in the vapor chamber environment. (**b**) Converted humidity sensitivity. Temperature was kept constant at 23˚C.

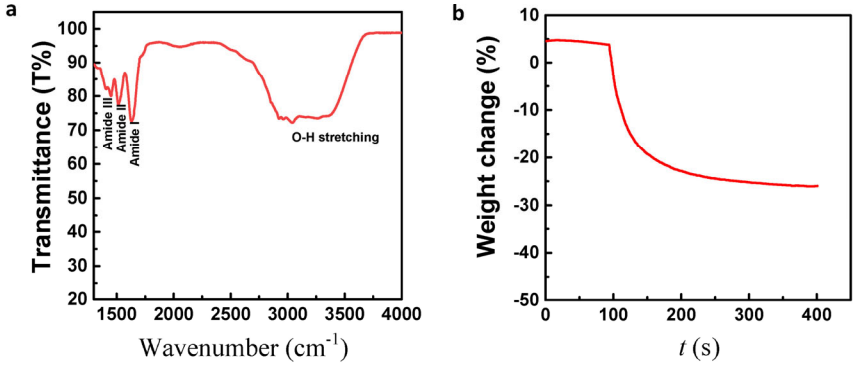

Figure S4 Moisture-adsorption measurement in thin films. (**a**) Fourier-transform infrared spectroscopy (FTIR) spectrum of a protein nanowire film (~200 nm thickness) at relative humidity (RH) of 40%. The broad peak ~3400 cm^{-1} corresponds to the O-H stretching band in free water.[1] (**b**) Weight percentage of adsorbed moisture in a protein nanowire film measured by quartz crystal microbalance (QCM; 400C, CH Instruments). The protein nanowire film was first deposited on the quartz crystal resonator (right top) by drop-casting. The mass sensitivity of the QCM originates from the dependence of the oscillation frequency on the total mass of the metal-coated crystal, including any deposited material. The mass change was determined by $\Delta m = -\Delta f \cdot A \cdot \frac{\sqrt{\mu\rho}}{2f_0^2}$, where f_0, A, ρ, μ are resonant frequency of crystal's fundamental mode, area of the gold disk on the crystal, crystal's density (2.684 $g{\cdot}cm^{-3}$) and shear modulus of quartz (2.947×10^{11} $g{\cdot}cm^{-1}{\cdot}s^{-2}$), respectively.[2] We first determined the mass of the film (W_{film}) in a RH~40% environment by QCM. Then the film was exposed to a RH~0% environment by constant flow of dry air to drive out the adsorbed moisture. During the process, the mass change (ΔW_{film}) that corresponds to the amount of moisture adsorption in the film was continuously monitored (reflected by the resonant-frequency change in QCM). The moisture weight percentage $W_{H_2O}\%$ in the film was determined by: $W_{H_2O}\% = \Delta W_{film}/W_{film}\times100\%$.

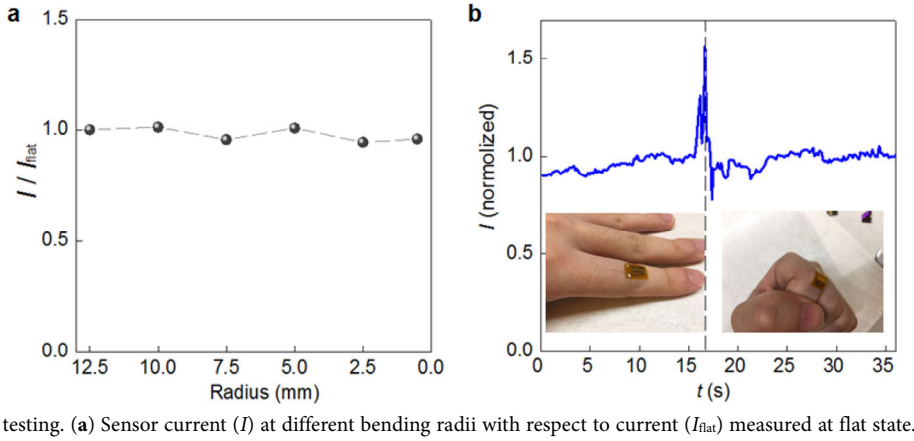

Figure S5 Mechanical testing. (**a**) Sensor current (I) at different bending radii with respect to current (I_{flat}) measured at flat state. (**b**) Current change in the sensor attached to a bending finger joint. The overall current fluctuation largely came from local RH fluctuation experienced during the bending events. The spike signal came from mechanical perturbation to, *e.g.*, wiring to contacts.

References

[1] Kong, J.; Yu, S. *Acta. Biochim. Biophys. Sin*. **2007**, 39, 549-559.
[2] http://www.chinstruments.com/chi400.shtml.