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Effects of hydrogen-bonding strength on water-responsiveness of *Bacillus subtilis* cell walls

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Water-responsive (WR) materials that produce significant energy when they deform in response to relative humidity (RH) changes can be used as high-energy actuators for soft robotics, smart structures, and energy harvesting devices. Notably, the cell walls of *Bacillus* (*B.*) *subtilis* have recently shown a record-high WR energy density, which could be attributed to the super-viscous water confined within the cell walls. Here, we present that *B. subtilis* cell walls' WR behaviors highly correlate with the hydrogen-bonding strength of their nanoconfined liquids. To vary the hydrogen-bonding network, we introduce Hofmeister salts, potassium iodide (KI) and potassium sulfate (K_2SO_4), which can weaken and strengthen the H-bonding network, respectively. Cell walls treated by a 10 mM K_2SO_4 solution show a dramatically increased energy density of 101.8 MJ m^{-3}, which is higher than those of the untreated cell walls (83.2 MJ m^{-3}) and all conventional actuator materials. However, cell walls treated with K_2SO_4 solutions with higher concentrations (30-50 mM) or KI solutions show decreased WR pressure and energy densities. Our observations suggest that there is a certain range of the hydrogen-bonding strength, leading to optimal WR performance of cell walls. This study also demonstrates a cheap and scalable method of using Hofmeister ions to control and improve hygroscopic materials' WR performance.