Supporting Information

Customizing Three-Dimensional Elastic Barium Titanate Sponge for Intelligent Piezoelectric Sensing

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Figure S1. FT-IR spectra of hydroxylated BTO in 3000 ~ 2000 cm\(^{-1}\).
Cubic BaTiO$_3$ inherently has no Raman active modes; however, Raman active modes are expected for the non-centrosymmetric tetragonal structure$^1$. The spectrum of the as-prepared nanoparticles displays bands at 183 cm$^{-1}$ [A1(TO), E(LO)], 246 cm$^{-1}$ [A1(LO)], 304 cm$^{-1}$ [B1, E(TO+LO)], 516 cm$^{-1}$ [E, A1(TO)], and 715 cm$^{-1}$ [A1, E(LO)], all of which are suggestive of a tetragonal phase$^2$.

![Raman spectrum of the prepared hydroxylated BaTiO$_3$ nanoparticles.](image)

**Figure S2.** Raman spectrum of the prepared hydroxylated BaTiO$_3$ nanoparticles.
When small amounts of cellulose are added to slurry of BTO and WPU, the composite ink immediately becomes thickened, later possesses the printable ability. For instance, the below image shows the composite ink with 40 wt% BTO.

**Figure S3.** Optical images of BTO/WPU/CNF composite ink.
Figure S4. High stiffness properties exhibition of 3D printed composite sponge.
In order to prove the uniform dispersion of BTO particles in the composite sponge, we chopped the foam with 40% BTO content into small pieces and randomly selected three of them (named sample 1 to 3) for TG test. After the testing, it was found that remained BTO weight ratios of all samples were all around 40 %, which could further prove that BTO particles were uniformly dispersed in the sponge.

**Figure S5.** TG curves of the fabricated BTO-based sponge (with 40 wt% BTO).
Figure S6. The piezoelectric open-circuit voltage of the composite sponge by the above three frozen methods under the same impacting pressure.
Figure S7. The 3D printed BTO-based sponges under the a) compressing, b) bending and c) stretching mode.
Figure S8. Compressive stress–strain curve of the casted sponge.
**Figure S9.** a) Open-circuit voltages and b) short-circuit currents of the casted sponge under compressive strain from 1~12%.
Figure S10. Short circuit current response time of a) bulk sponge and b) lattice sponge under the compression strain of 12% at 1 Hz.
Figure S11. a) The image of piezoelectric composite-based kinetic motion sensors attached to the finger. b) Open-circuit voltages and c) short-circuit currents of different bending angles detecting finger motions.
References