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Electronic Supplementary Information (ESI)

Stretchable Biofuel Cells
as Wearable Textile-based Self-Powered Sensors

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Table S1 *Optimization of PU layer for surface modification.*

	Printability	**Mechanical Properties**
10.0% PU in THF†	Hard to print, low viscosity, fast evaporation of solvent	Poor, thickness not enough to stress applied
12.5% PU in THF	Easy to print, good viscosity	Poor, thickness not enough to stress applied
15.0% PU in THF	Printable, fast evaporation (bubbles) when cured under temperature higher than 50 ˚C.	Good, enough thickness to stress applied even when stretched over 100%
15.0% PU in DMF‡	Easy to print, can be cured at higher temperature, less curing time, no bubbles over 50 ˚C	Good, enough thickness to stress applied even when stretched over 100%

† T_b of THF = 66°C

‡ T_b of DMF = 153°C

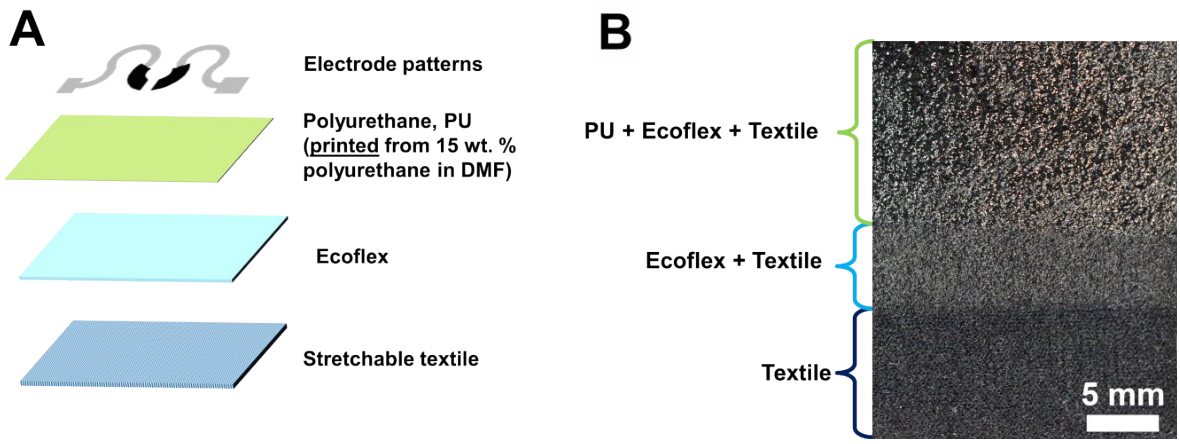

Figure. S1. *The fabrication process of the stretchable BFC device. (A) The process starts by delaminating the Ecoflex and PU layers on the stretchable Nylon- Spandex textile and then screen-printing the designed pattern onto the modified surface. (B) Optical image shows the surface of the pristine textile and modified layers.*

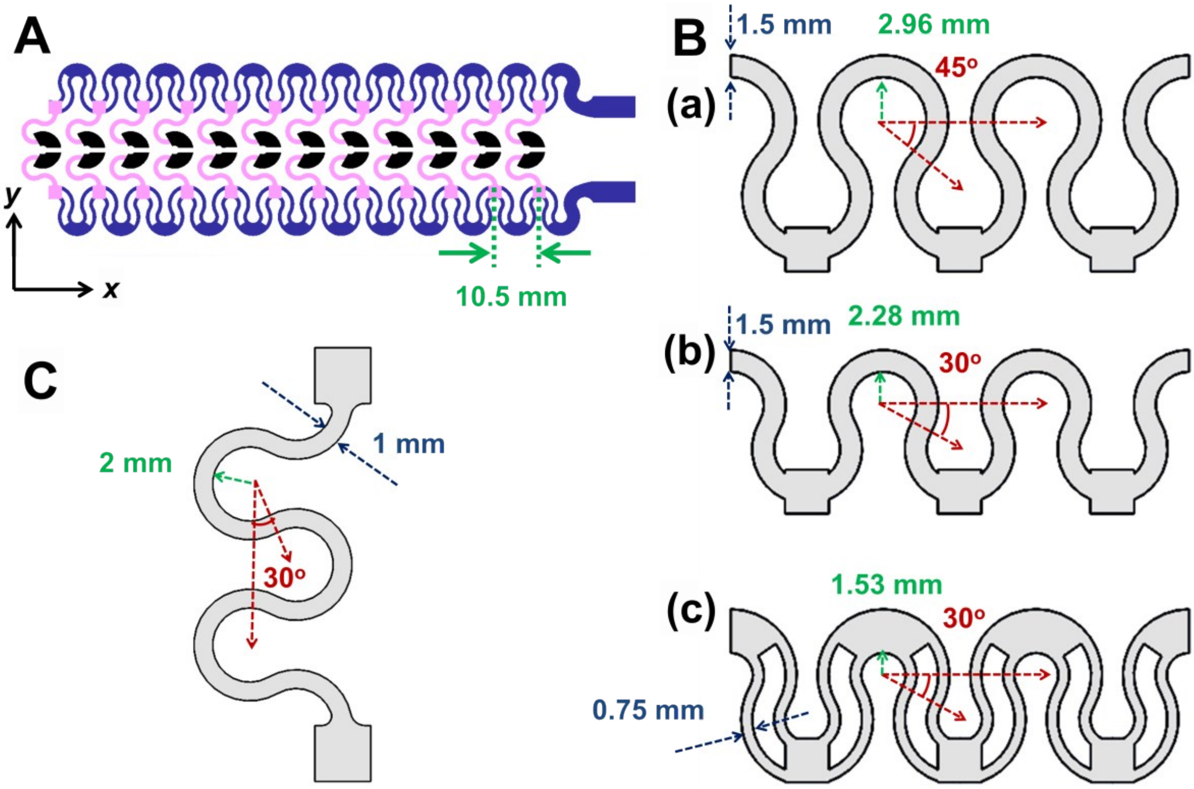

Figure S2. *Illustration of the designs. (A) An example of designed pattern for stretchable BFC array. This design is for accommodating multi-directions of external strains: x-direction (blue) and y-direction (pink). (B) Designed patterns for accommodating external strain in x-direction: (a) 45-degree design (45°); (b) 30-degree design (30°); and (c) separated trace design. (C) Designed patterns for accommodating external strain in y-direction.*

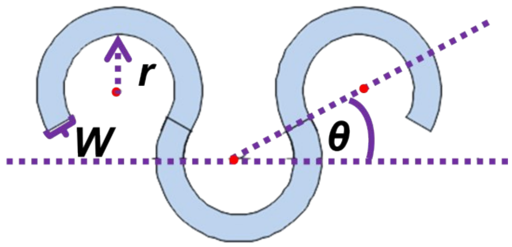

Figure S3. *Definition of parameters for the arc of the serpentine interconnects. The parameters are connecting angle (θ), width (W), and inner radius (r).*

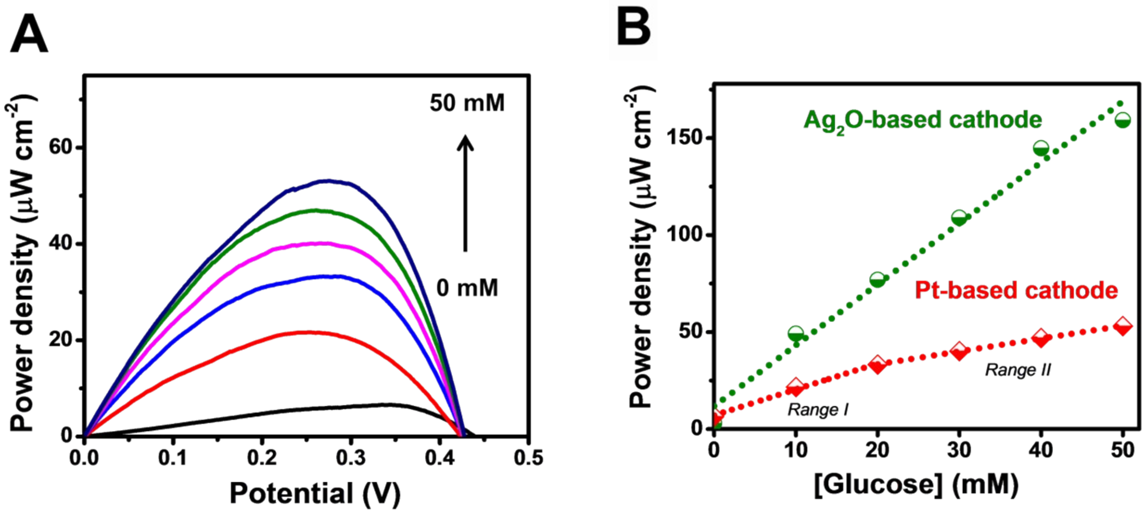

Figure S4. *(A) Plot of power density vs potential plots of the assembled GOx bioanode/Pt-based cathode BFC when varying glucose concentrations (0–50 mM) in 0.1 M KPBS (pH 7.0). (B) Corresponding power–concentration calibrations obtained from glucose BFCs with different cathodes: Ag_2O-based cathode (green circle) and Pt-based cathode (red square).*

Preparation of Pt-based cathode

Stretchable CNT ink was used as underline layer of cathode. After printed and dried, the cathode was modified by drop casting solution of 5 µL of 5 mg mL^{-1} OH-CNTs dispersed in 10 mg mL^{-1} of Platinum black ethanol solution. Then, 2 µL of 0.5% Nafion® solution was dropped after overnight.

Table S2. *BFC performance obtained from Ag_2O-based and Pt-based cathodes*

Cathode	Sensitivity (µW cm^{-2} mM^{-1})	R^2
Ag_2O-based cathode	3.14 ± 0.20	0.980
Pt-based cathode	Range I: 1.34 ± 0.10	0.988
	Range II: 0.66 ± 0.01	0.999

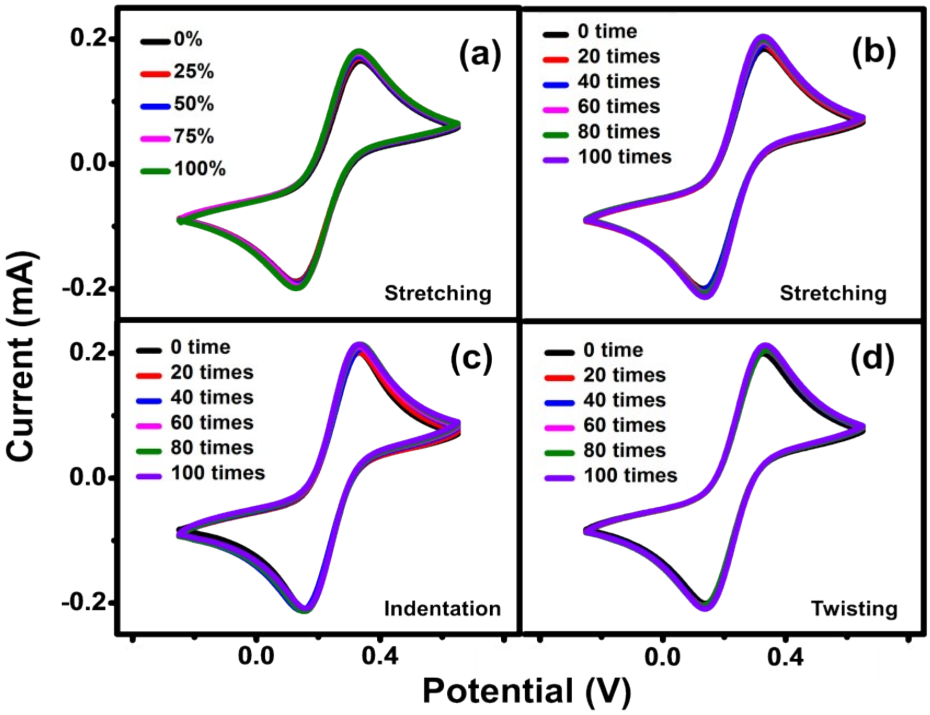

Figure S5. *CVs recorded when (a) applying increasing levels of strain (repeated 20 cycles for each) from 0 to 100% with increments of 25%. (b) applying 20 repeated 100% stretching cycles for a total of 100 iterations (c) 20 repeated indentations (5 mm) for a total of 100 repetitions (d) 20 torsional 180º twisting cycles for a total of 100 iterations. The working electrode is the stretchable CNT-based electrode.*

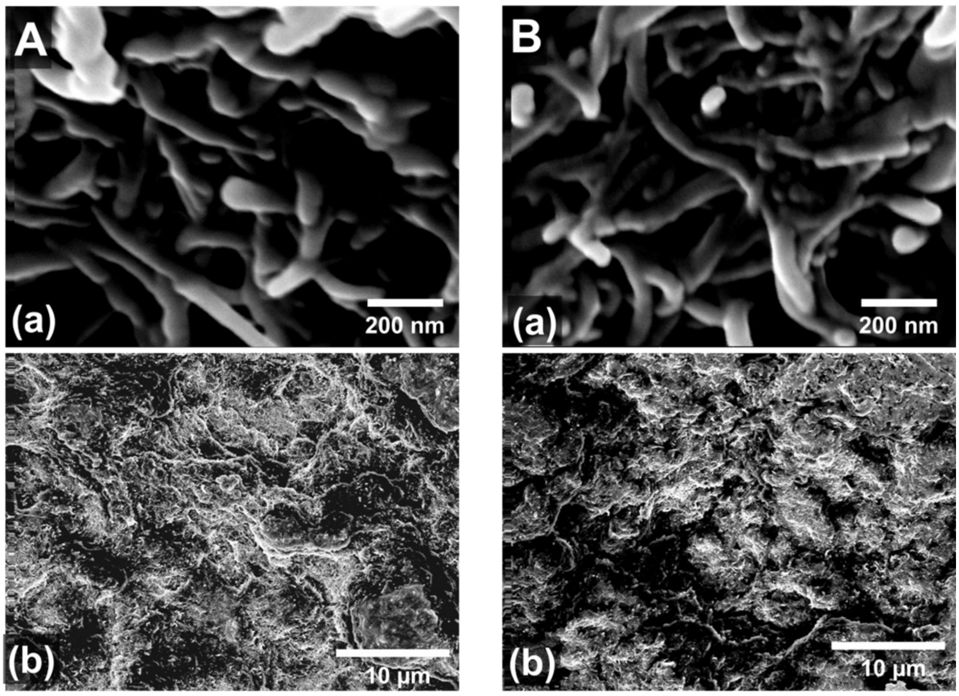

Figure S6. *SEM image of stretchable CNT-based anode (A) before and (B) after repeated stretching at 100% strain for 100 times. (a) High magnification and (b) low magnification SEM images.*

Figure S7. *The fully integrated system for wearable lactate biosensing showing the "scavenge-sense-display" concept. The stretchable BFC arrays were printed on (A) the wearable underwear textile and (B) the stretchable strap. (C) Illustration of a 'green' model and photographs of wearable energy harvesting system and self-powered BFC array printed on conventional textiles and different body-worn accessories, such as stretchable headbands, straps and socks .*

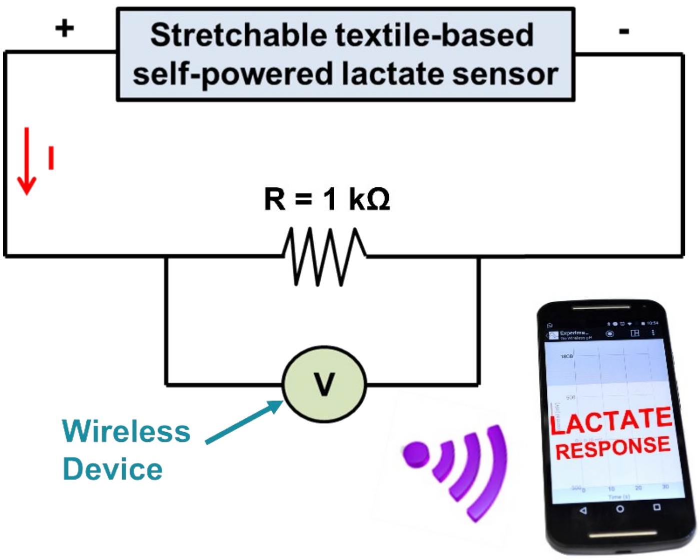

Figure S8. *The scheme shows the circuit system for lactate monitoring. This allows reading and real-time wireless recording by using a smartphone and a compact wireless device. The compact wireless device with an integrated rechargeable battery was used to perform on-body measurements.*

Video 1. and Video 2. *Videos showing applications of repeated linear and multi-dimensional strains, bending, twisting, and indentation to the stretchable textile-based devices.*

Video 3. *Versatility of our approach to obtain mechanical compliant BFC arrays for energy harvesting and wearable self-powered sensing systems. The integrated "scavenge-sense-display" system was demonstrated toward lactate solution.*

Video 4. *Applicability to sock-based BFC and self-powered biosensor and mechanically compliant operations was demonstrated on a human foot.*