

Supporting Information

Breathable, Flexible, and Durable Woven Fabric with Polyester/Carbon Nanotube-Wrapped Cotton Yarns for Wearable Electrothermal Heaters

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Video S1: Automatically weaving the CCY weft yarn and PET warp yarn into a conductive blended fabric.

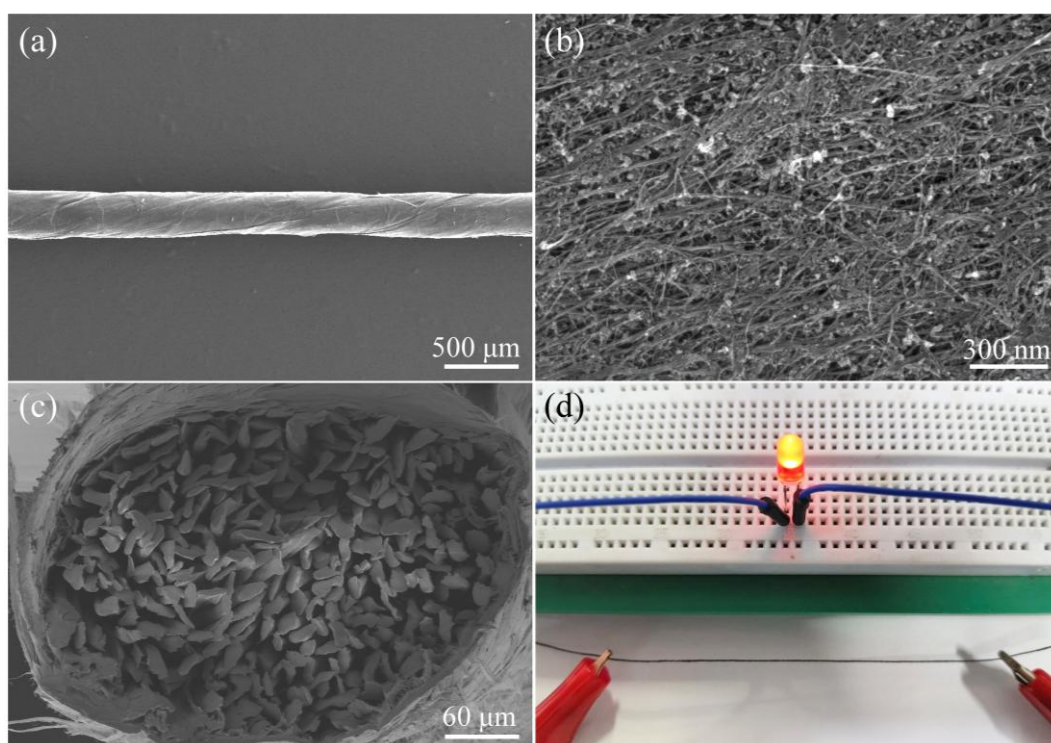


Figure S1. SEM images of (a, b) surface and (c) cross-section of the CCY. SEM images were acquired at an accelerating voltage of 5.0 kV and a working distance of 2 mm. (d) Photograph of a LED being lighted with the CCY as electric wire.

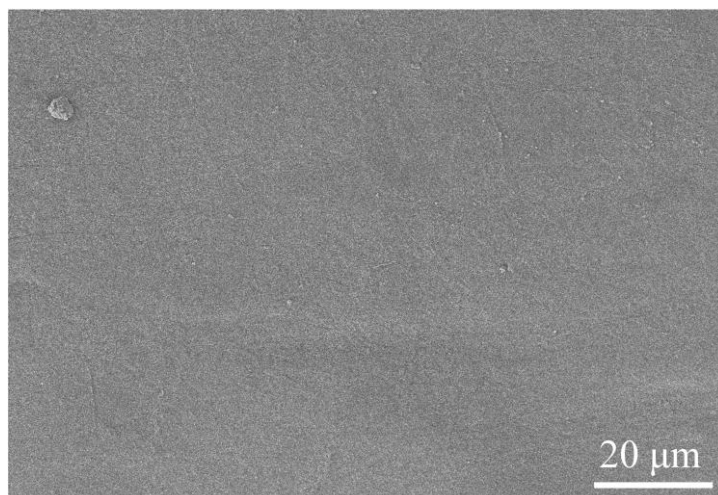


Figure S2. SEM image of the PET/CCY blended fabric. SEM images were acquired at an accelerating voltage of 5.0 kV and a working distance of 10-11 mm.

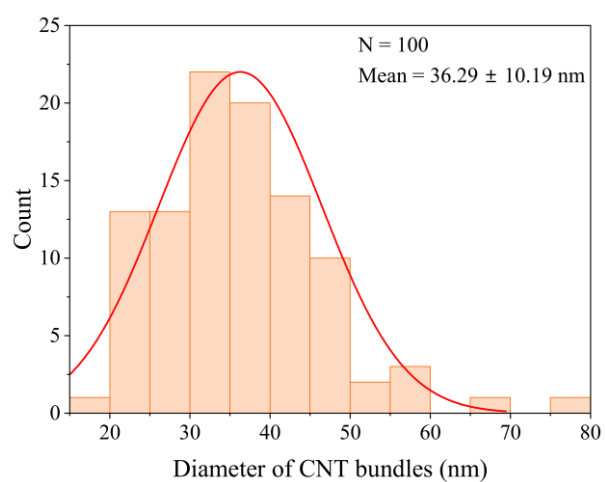


Figure S3. Diameter distribution histogram of CNT bundles on the surface of CCY, measured from SEM images using ImageJ (N = 100). The solid red line represents the Gaussian fitting curve.

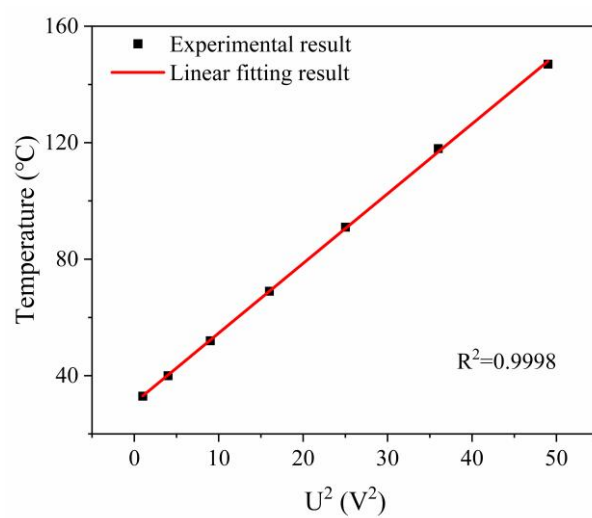


Figure S4. Experimental data and linear fitting of the saturation temperature *versus* the square of the applied voltage (U^2).

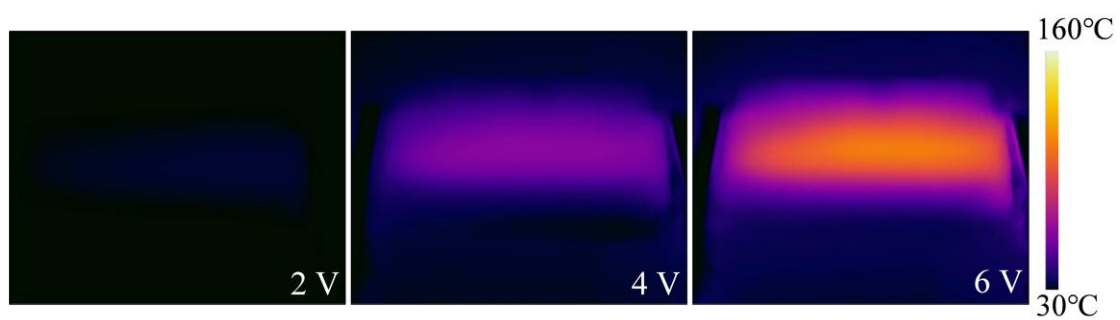


Figure S5. The infrared images of the PET/CCY blended fabric at the voltages of 2 V, 4 V, and 6 V.

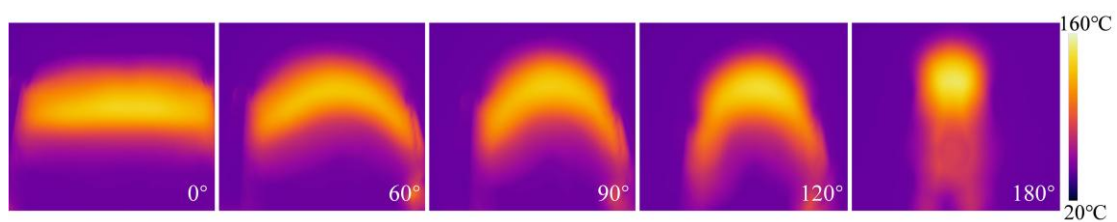


Figure S6. The infrared images of the PET/CCY blended fabric at various bending angles.

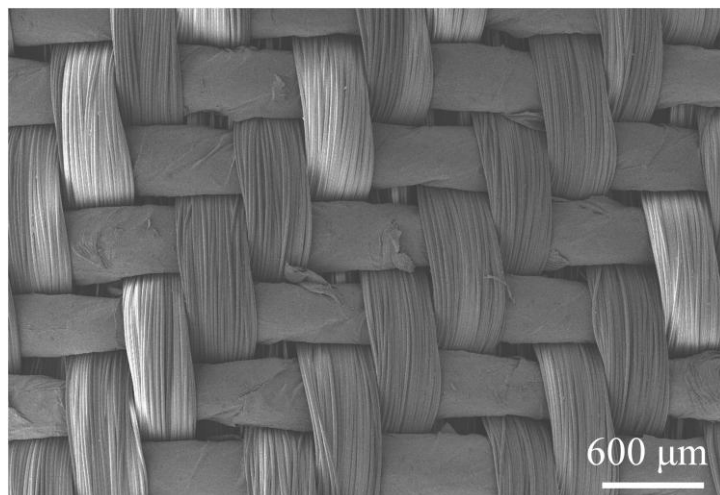


Figure S7. SEM image of the PET/CCY blended fabric after folding for 500 cycles. SEM images were acquired at an accelerating voltage of 5.0 kV and a working distance of 10-11 mm.

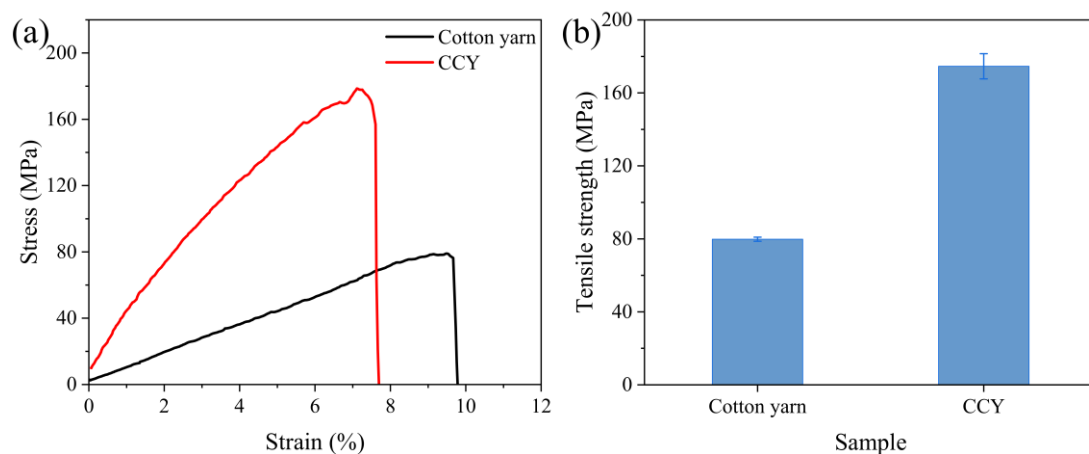


Figure S8. Mechanical properties of pristine cotton yarn and CCY. (a) Typical stress-strain curves of pristine cotton yarn and CCY. For each group, the representative curve was selected from five specimens based on the smallest deviation in tensile strength and elongation at break from the group mean. (b) The average tensile strength of pristine cotton yarn and CCY.

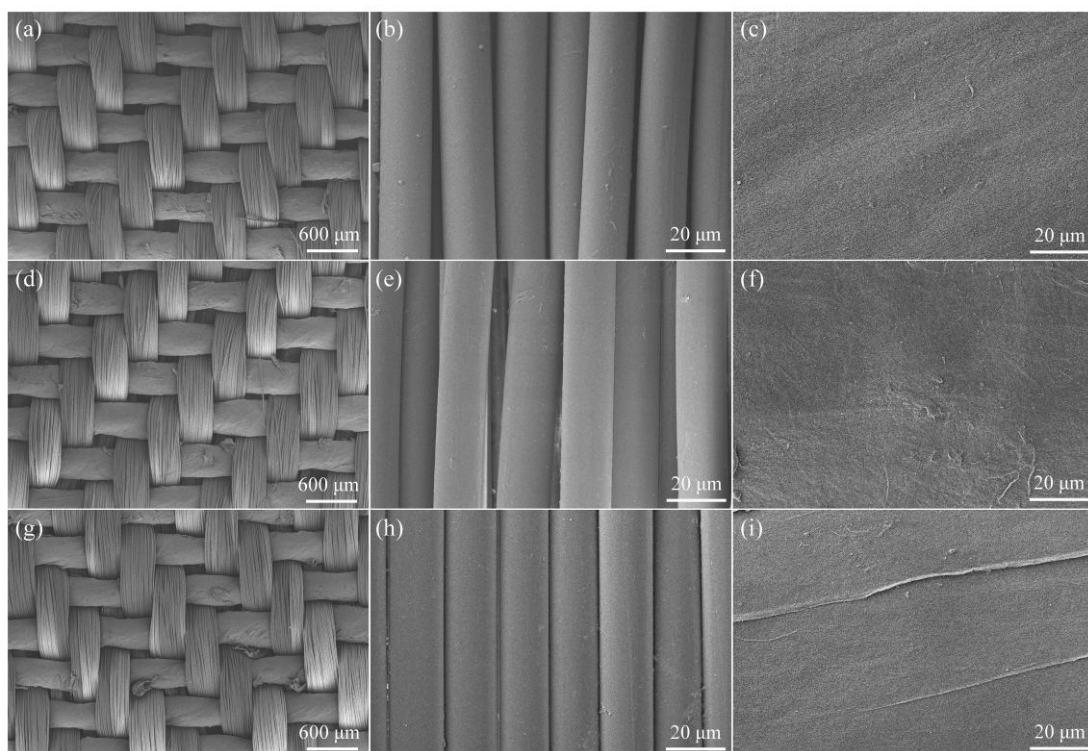


Figure S9. SEM images of the PET/CCY blended fabric after washing for (a-c) 20, (d-f) 40, and (g-i) 60 cycles. SEM images were acquired at an accelerating voltage of 5.0 kV and a working distance of 10-11 mm.

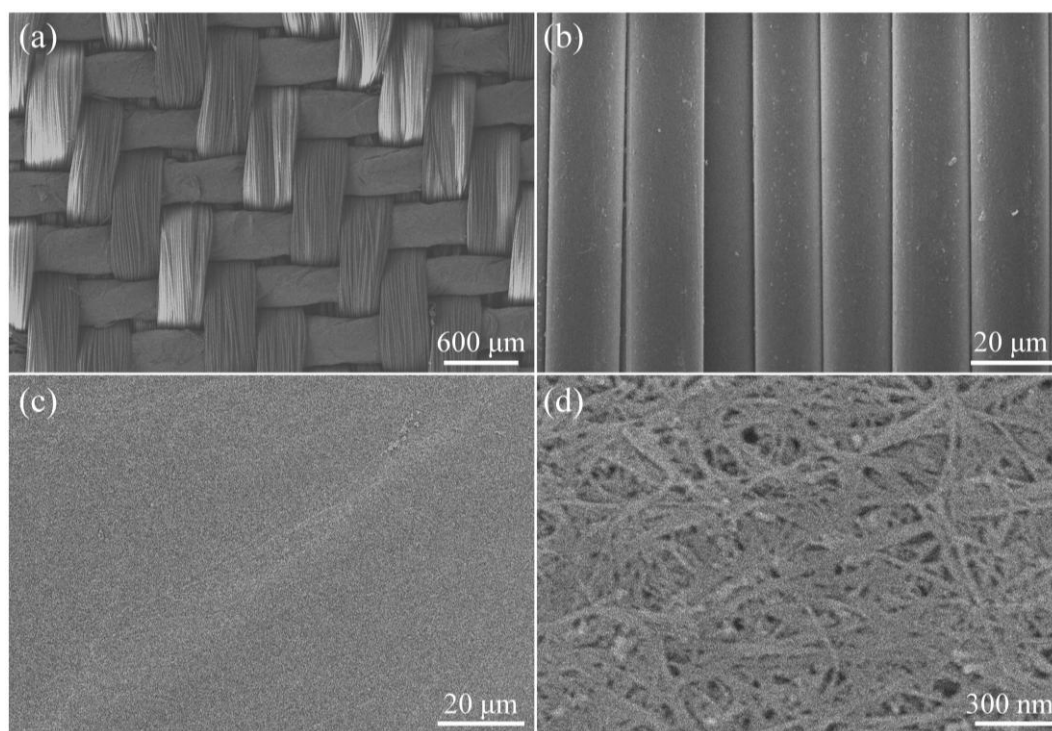


Figure S10. SEM images of the PET/CCY blended fabric after 12 weeks of continuous exposure to the atmospheric conditions. SEM images were acquired at an accelerating voltage of 5.0 kV and a working distance of 9 mm.

Table S1. Detailed information of all materials.

Material	Source/Supplier	Purity	Concentration	CAS number
Ethanol	Sinopharm Chemical Reagent Co., Ltd.	AR	98.8 wt.%	64-17-5
Ferrocene	Sinopharm Chemical Reagent Co., Ltd.	AR	0.6 wt.%	102-54-5
Thiophene	Afaisa (China) Chemical Co., Ltd.	AR	0.6 wt.%	110-02-1
Nitrogen	Jin Hong Gas Co., Ltd.	99.999%	-	7727-37-9
Cotton yarn	Shandong Jin Yue Textile Co., Ltd.	-	-	-
PET yarn	Joyful Home Textiles Co., Ltd.	-	-	-

Table S2. Yarn specifications.

Yarn type	Linear density	Twist direction/ level	Single/ply yarn specification
		Z twist/	
Cotton yarn	Approximately 59 Tex/531 Denier	Twist level was not provided by the supplier	20S/2, two-ply yarn
PET yarn	Approximately 29.5 Tex/266 Denier	No twist direction or twist level was provided by the supplier	20S/1, single yarn

Table S3. Performance comparison of our PET/CCY blended fabric-based wearable heater with previously reported fabric-based wearable heaters.

Wearable heaters	Air permeability (mm s ⁻¹)	Moisture permeability (g m ⁻² day ⁻¹)	Voltage (V)	Temperature (°C)	Response time (s)	Flexibility	Washability	Long-term durability	Ref.
PET/CCY blended fabric	1104.09 ± 7.69	2536.67 ± 25.45	7	147	45	Yes	60 cycles (30 h)	84 days	This work
PA-PEI-rGO textile	NA	NA	3	141	NA	Yes	NA	NA	[1]
PTFE/CNT fiber woven textile	NA	NA	5	145	>500	NA	NA	NA	[2]
TPU/graphene/AgNWs @textile	NA	NA	4	104	~125	NA	12 h	NA	[3]
Cotton fabric@PANI/AgNWs/PDMS	NA	4272	1.1	127	180	Yes	NA	NA	[4]
Cotton@PDA/CNTs/PFOTES	NA	NA	6	>85	<175	Yes	NA	NA	[5]
Composite graphene/CNT-based fabric	331.35	NA	5	65	28	Yes	24 h	NA	[6]
MXene-coated cellulose fabric	NA	NA	6	100	16	Yes	NA	25 days	[7]
MXene@PU/PET blend fabric	295.87	1355.03	NA	49.6	1800	NA	20 cycles	10 days	[8]
PI/TPU/AgNWs membrane	2.7 ± 0.6	NA	NA	<50	NA	Yes	10 h (5 times)	NA	[9]
Sericin-MXene-coated silk fabric	315.16	NA	13	74.6	25	NA	50 min	NA	[10]
Nanofibrillated cellulose-graphene	NA	NA	NA	60	180	Yes	NA	NA	[11]
RGO/MXene@cotton fabric	NA	NA	12	66.7	<60	NA	NA	NA	[12]
CNT-nanofibrillated cellulose membrane	NA	NA	7.8	67.3	NA	Yes	NA	NA	[13]
Graphene/nanocellulose films	NA	NA	10	145	150	NA	NA	NA	[14]
Holocellulose nanofibrils/CNTs/cellulose aerogel fiber textile	NA	NA	2.5	179.6	40	NA	NA	NA	[15]
MXene/silver composite cellulose-based fabric	NA	NA	12	128.8	30	Yes	NA	NA	[16]
Cotton/TA/Ag NPs/PDMS textile	260.7 ± 6	NA	2	118.7	<300	NA	NA	NA	[17]
Cotton/PEDOT: PSS textile	NA	NA	40	94	90	Yes	NA	NA	[18]
CNT/cellulose/CuNW/cotton fabric	15.92	NA	1.8	70	80	NA	NA	NA	[19]
MXene-coated fabric	NA	NA	5	263	76	NA	NA	NA	[20]

MXene coated PET textile	250-300	NA	3.5	174	25	NA	100 min	NA	[21]
PANI-coated PET fabric	NA	NA	12	30.3	<80	NA	NA	NA	[22]
CNT@silks fabric	NA	NA	25	42.8	<125	Yes	NA	NA	[23]
Graphene@PET fabric	NA	NA	14	80	<70	Yes	NA	NA	[24]
Graphene@cotton fabric	NA	NA	14	~60	60	NA	NA	NA	[25]
PPy@cotton fabric	NA	NA	8	51	NA	Yes	NA	NA	[26]
PPy/MXene-decorated PET textile	~150	NA	4	79	NA	NA	NA	NA	[27]
Weft-knitted carbonized fabric	NA	NA	4	>160	NA	NA	NA	NA	[28]
CNT-PDA cotton fabrics	NA	NA	6	120	20	NA	NA	NA	[29]
PEDOT-coated cotton fabric	NA	NA	6	45	NA	NA	NA	NA	[30]
Silica nanoparticle/cellulose acetate/silver@cotton cloth	NA	$\sim 2.34 \times 10^{-2}$	0.5	34.1	NA	NA	NA	NA	[31]
Copper nanoparticles/nylon 6 woven fabric	NA	NA	2	208.8	90	Yes	50 times (25 h)	30 days	[32]
PET yarn (warp) /MXene wire (weft) blended fabric	NA	NA	30	140	NA	Yes	24 h	NA	[33]
Cotton yarn (warp)/PEDOT: PSS@MXene@cotton yarn (weft) blended fabric	<1000	NA	2.5	196.8	NA	Yes	10 times (50 min)	120 days	[34]
PU/CB/Cu fibers (weft) /PET sewing threads (warp) blended fabric	299.42	2624.96	30	38	<150	NA	NA	NA	[35]

PET: polyester; PA: polyamide; PEI: polyethyleneimine; rGO: reduced graphene oxide; PTFE: polytetrafluoroethylene; CNT: carbon nanotube; TPU: thermoplastic polyurethane; AgNWs: Ag nanowires; PANI: polyaniline; PDMS: polydimethylsiloxane; PDA: polydopamine; PFOTES: 1H,1H,2H,2H-perfluorooctyltriethoxysilan; PU: polyurethane; PI: polyimide; TA: tannic acid; Ag NPs: silver nanoparticles; PEDOT:PSS: poly(3,4-ethylenedioxythiophene)-poly-(styrenesulfonate); CuNW: copper nanowire; PPy: polypyrrole; CB: carbon black.

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