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Supporting Information

Highly durable textile-based sensor as human-worn material interface for long-term multiple mechanical deformation sensing

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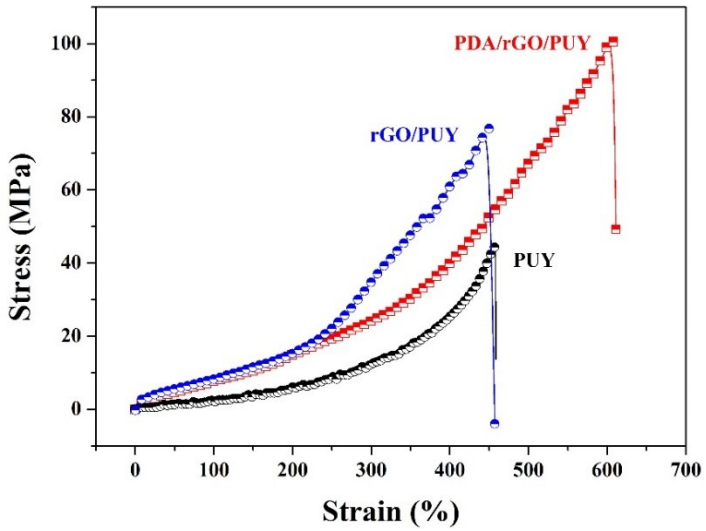

Fig. S1 The tensile stress versus strain curves of the PUY, rGO/PUY, and PDA/rGO/PUY obtained through the testing by using the machine of Instron 5944, with the gauge length of 10 cm and testing speed of 100 mm min^{-1}.

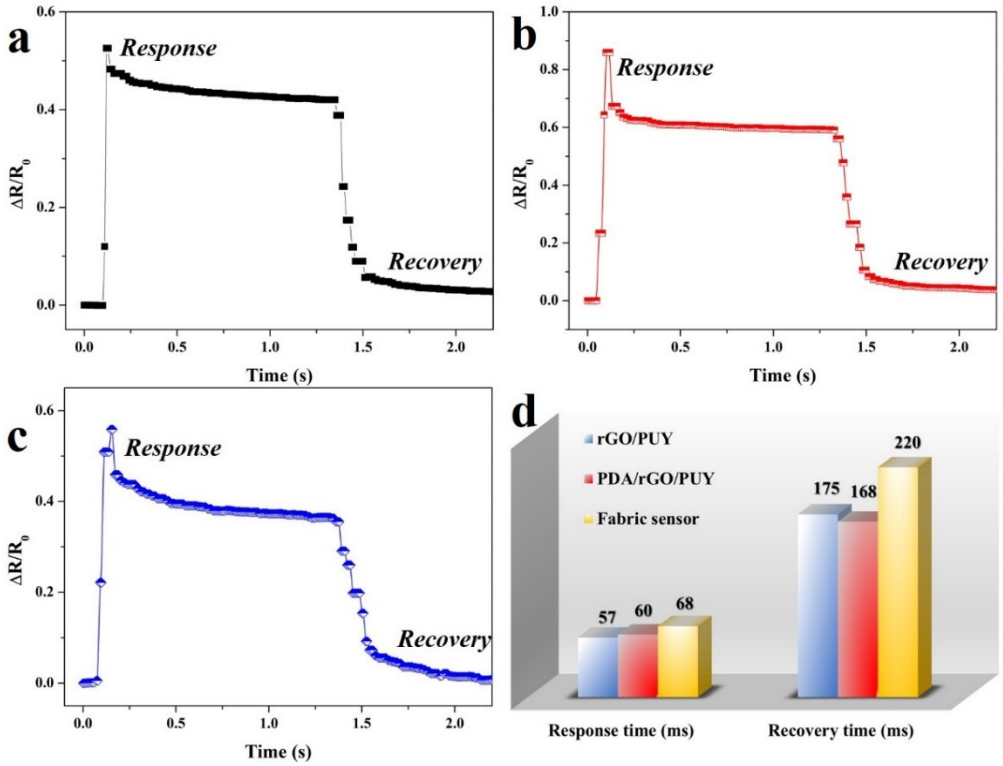

Fig. S2 The response and recovery curves of (a) rGO/PUY, (b) PDA/rGO/PUY, and (c) fabric sensors under a small strain of 5% and a testing speed of 600 mm/min. (d) Comparison of the response and recovery time between the three sensors.

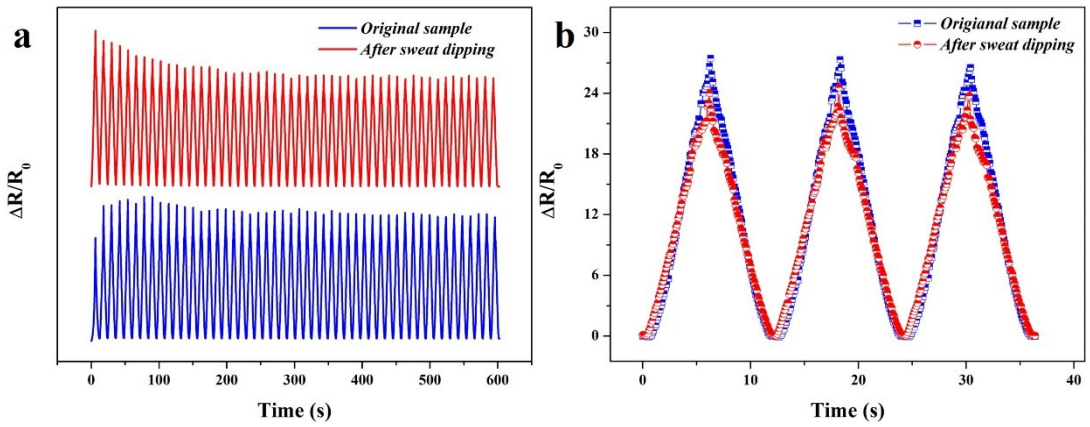

Fig. S3 Electro-mechanical curves of the sensing yarn before and after sweat dipping. (a) 50 cycles. (b) 3 cycles. (For the effect of sweat, the sensing yarn was dipped into an artificial sweat (pH 8.0) for 30 min at room temperature, and then the sensor was cleaned by deionized water and fully dried in the air.)

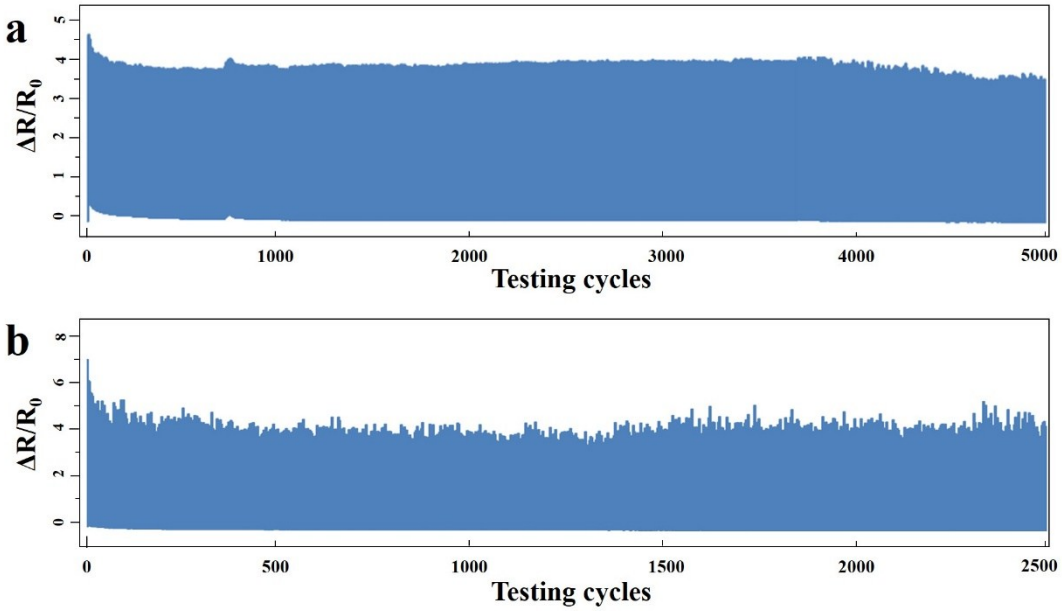

Fig. S4 Cyclic stability test of compressive bending of the sensing (a) yarn and (b) fabric under the displacement of moving pressure head of 10 mm and the movement speed of pressure head of 100 mm min^{-1}.

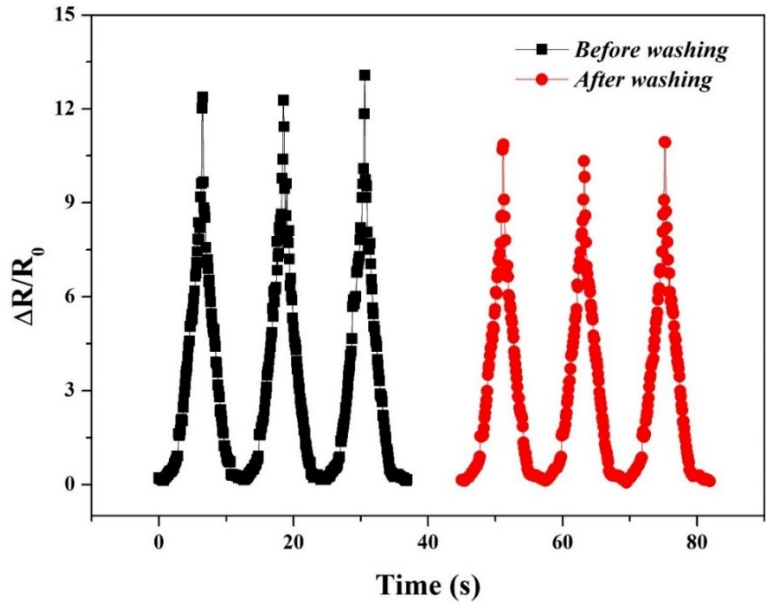

Fig. S5 Washability of the sensing fabric. (The sensing fabric was firstly soaked into the detergent solution for 2 min, where the solution contains 0.2 wt.% of 1993 AATCC Standard Reference Detergent. Then the solution was stirred at 27 °C and 200 r.p.m for 5 min to simulate the washing process. Thereafter, the sensing fabric was rinsed by cleaned water and fully dried in the ventilated hood at room temperature.)

Table. S1 Performance comparisons to recently reported 1D strain sensors

Materials	GF@strain	Durability (cycles@strain)	Linearity	Hysteresis	Weav-ability	Sensing function	Ref
PDA/rGO/PU	**50.0@50%**	**30000@50%**	**High**	**Low**	**High**	**Tension, Bending induced tension**	**This work**
rGO/(PU/PE)	10@1% 3.7@50%	10000@30/50%	Nonlinear	High	N/A	Tension, bending, torsion	S1
CNTs/PU	1.67@0-20% 1.24@20-100%	2000@50%	Nonlinear	N/A	N/A	Tension	S2
AgNWs/ Polyolefin	13920@64%	4500@10%	Nonlinear	N/A	N/A	Tension	S3
CNTs/PU	5@1500%	10@400%	Nonlinear	N/A	N/A	Tension	S4
(CB/PDMS)-(AgNWs/nylon& PU)	~2.8@20% ~0.7@100%	N/A	Two linear ranges	Low	high	Tension, flexion, pressure	S5
PEDOT/PE	0.76@20%	1000@20%	Nonlinear	N/A	N/A	Tension, pressure	S6

Note:

GF: gauge factor; rGO: reduced graphene oxide; PU: polyurethane; PE: polyester; CNTs: carbon nanotubes; AgNWs: Ag nanowires; CB: carbon black; PDMS: polydimethylsiloxane; GWF: graphene woven fabric; PEDOT: poly(3,4-ethylenedioxythiophene)

Table. S2 Performance comparisons to related state of the art 2D textile-based strain sensors

Materials	Fabrication method	GF@strain	Durability (cycles@strain)	Linearity	Hysteresis	Effects on textile	Capability for long-term use	Ref
(PDA/rGO/PU) /elastic fabric	**Weaving**	**25.3@50%**	**10000@50%**	**High**	**Low**	**Little**	**High**	**This work**
CNT/Spandex	Knitting	0.25@100%	1000@100%	High	Low	Low	N/A	S7
PPy/nylon lycra fabric	In situ polymerization	~ -3.3@20% ~ -0.7@60%	N/A	Nonlinear	Low	Low	N/A	S8
PEDOT:PSS/ PU	Wet-spinning knitting	~ -0.7@50% ~ -0.3@200%	500@100%	Nonlinear	N/A	High	N/A	S9
Carbonized silk/Ecoflex	Carbonization	5.8@0-1% 9.6@250% 37.5@250-500%	6000@100%	Two linear ranges	Low	High	Low	S10
Ag ink/PU	Printing	~13.3@30%	1000@30%	Nonlinear	Differ with different structures	Low	N/A	S11
Pen ink/cupra fabrics	Dip-coating	2.63@23%	5@2-4%	High	Low	Low	N/A	S12
rGO/PE	Dip-coating reduction	-1.7@15% -26@8%	500@7.5/5%	High	Low	High	N/A	S13
GWF/PDMS	CVD	500@2% 10000@8%	1000@2%	Nonlinear	N/A	High	Low	S14
rGO/ (nylon & PU)	Dip-coating reduction	18.5@10% 12.1@10-18%	120@3%	Linear below 10%	Low	Low	N/A	S15

Note:
CVD: chemical vapor deposition; PPy: polypyrrole; PSS: poly(styrenesulfonate);

Table. S3 Specifications of the sensing sateen fabric.

Weave repeat	Yarn count (Ne)		Fabric density (Threads cm^{-1})		Fabric cover factor (%)		
	Warp	Weft	Warp	Weft	Warp	Weft	Total
8×8	80/2	21	32	27	45	50.2	73

References

S1 Y. Cheng, R. Wang, J. Sun, L. Gao, *Adv. Mater.* 2015, 27, 7365-7371.

S2 Y. Li, B. Zhou, G. Zheng, X. Liu, T. Li, C. Yan, C. Cheng, K. Dai, C. Liu, C. Shen, *J. Mater. Chem. C* 2018, 6, 2258-2269.

S3 W. Zhong, C. Liu, C. Xiang, Y. Jin, M. Li, K. Liu, Q. Liu, Y. Wang, G. Sun, D. Wang, *ACS Appl. Mater. Interfaces* 2017, 9, 42058-42066.

S4 Q. Fan, Z. Qin, S. Gao, Y. Wu, J. Pionteck, E. Mäder, M. Zhu, *Carbon* 2012, 50, 4085-4092.

S5 J. Ge, L. Sun, F. R. Zhang, Y. Zhang, L. A. Shi, H. Y. Zhao, H. W. Zhu, H. L. Jiang, S. H. Yu, *Adv. Mater.* 2016, 28, 722-728.

S6 J. Eom, R. Jaisutti, H. Lee, W. Lee, J.-S. Heo, J.-Y. Lee, S. K. Park, Y.-H. Kim, *ACS Appl. Mater. Interfaces* 2017, 9, 10190-10197.

S7 J. Foroughi, G. M. Spinks, S. Aziz, A. Mirabedini, A. Jeiranikhameneh, G. G. Wallace, M. E. Kozlov, R. H. Baughman, *ACS nano* 2016, 10, 9129-9135.

S8 J. Wu, D. Zhou, C. O. Too, G. G. Wallace, *Synth. Met.* 2005, 155, 698-701.

S9 S. Seyedin, S. Moradi, C. Singh, J. M. Razal, *Appl. Mater. Today* 2018, 11, 255-263.

S10 C. Wang, X. Li, E. Gao, M. Jian, K. Xia, Q. Wang, Z. Xu, T. Ren, Y. Zhang, *Adv. Mater.* 2016, 28, 6640-6648.

S11 T. G. La, S. Qiu, D. K. Scott, R. Bakhtiari, J. W. Kuziek, K. E. Mathewson, J. Rieger, H. J. Chung, *Adv. Healthc. Mater.* 2018, 7, 1801033.

S12 S. Bi, L. Hou, H. Zhao, L. Zhu, Y. Lu, *J. Mater. Chem. A* 2018, 6, 16556-16565.

S13 Z. Yang, Y. Pang, X.-l. Han, Y. Yang, J. Ling, M. Jian, Y. Zhang, Y. Yang, T.-L. Ren, *ACS nano* 2018, 12, 9134-9141.

S14 T. Yang, W. Wang, H. Zhang, X. Li, J. Shi, Y. He, Q.-s. Zheng, Z. Li, H. Zhu, *ACS nano* 2015, 9, 10867-10875.

S15 G. Cai, M. Yang, Z. Xu, J. Liu, B. Tang, X. Wang, *Chem. Eng. J.* 2017, 325, 396-403.