Supporting Information

An ultra-low hysteresis, self-healing and stretchable conductor based on dynamic disulfide covalent adaptable networks

Weibo Kong, [a] *Yunyun Yang,* [a,c] *Yanjun Wang,* [a] *Hongfei Cheng,* [d] *Peiyao Yan,* [a] *Lei Huang,* [a] *Jingyi Ning,* [a] *Fanhao Zeng,* [a] *Xufu Cai,* *[a] *and Ming Wang**[b]

I: Supplementary Tables and Captions

Table S1 Comparison of the state-of-the-art stretchable self-healing conductors

Matrix	Conductive materials	DH (%)	Stretchability (%)	Heal efficiency	Dynamic bonds	Heal temperature	Heal time
PDMS[1]	AgNWs	12	100	N/A	/	/	/
PDMS[2]	Liquid metal	0.075	100	N/A	/	/	/
Ecoflex[3]	Carbon black	2.41	200	N/A	/	/	/
PU[4]	Graphene	7.03	100	N/A	/	/	/
PU[5]	Liquid metal	52.84	500	78%	Hydrogen bonds	60°C	1.5 H
PU [6]	Au	49.71	200	100%	Quadrupolar hydrogen bonds	RT	48 H
PU[7]	AgNP layer	40.19	100	95%	Metal coordination bonds	70°C	48 H
PU[8]	Au	62.04	1130	90%	Hydrogen bonds and coordination bonds	RT	48 H
PNIPAM[9]	Graphene	22.78	300	96%	Hydrogen bonds	RT	2 H
Hydrogel[10]	Ionic	25.88	1000	90%	Hydrogen bonds	RT	80 Min
PAA[11]	GO/Ca^{2+}	33.54	800	88.%	Hydrogen bonds and coordination bonds	RT	20 H
ENR[12]	CNT layer	41.32	100	91%	Boroxine	RT	/
ENR[13]	CNT	70.41	100	93%	Hydrogen bonds	RT	/
PU (this work)	Au	3.8	100	100%	Hydrogen bonds and disulfide bonds	130°C	1H

PDMS：polydimethylsiloxane；PU: polyurethane; ENR: epoxidized natural rubber; PNIPAM: polyisopropylacrylamide; PAA: polyacrylic acid;

Table S2 The chemical composition of PUs

Sample	IPDI(g)	PTMG1000(g)	TEA(g)	HEDS(g)	HDO(g)
PU-0	6.23	10	0	1.5425	0.9453
PU-1	5.35	10	0.3978	1.5425	0
PU-2	6.23	10	0.7957	1.5425	0
PU-3	8.90	10	1.9892	1.5425	0
Control	6.23	10	0.7957	0	1.182

II: Supplementary Figures and Captions

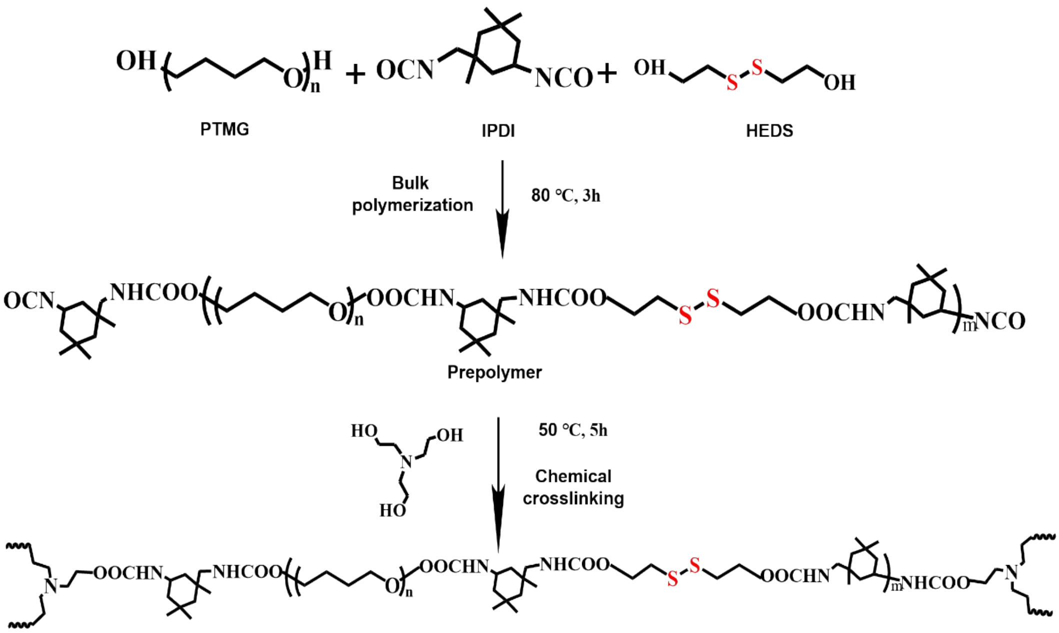

Fig. S1 The detailed synthetic route of PUs.

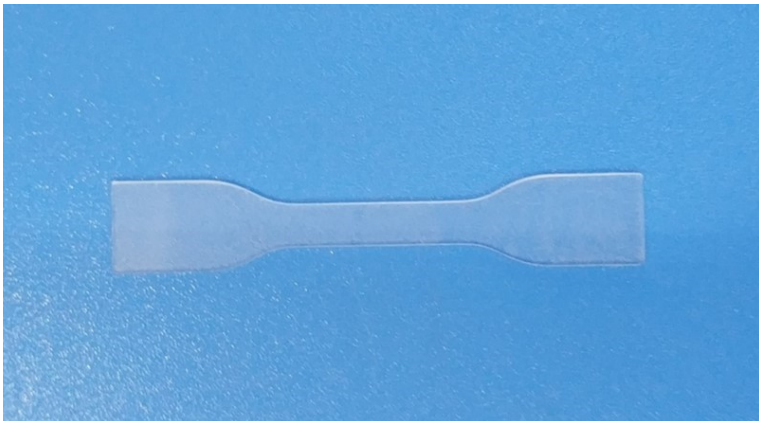

Fig. S2 The photograph of PU-2.

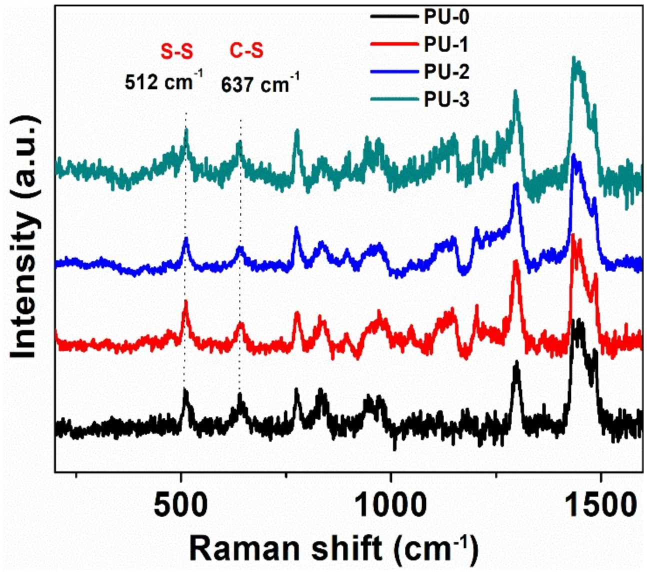

Fig. S3 Raman shift of the PU-0, PU-1, PU-2 and PU-3 samples with different weight ratios (0%, 2.30%, 4.29%, and 8.88%) of TEA crosslinkers.

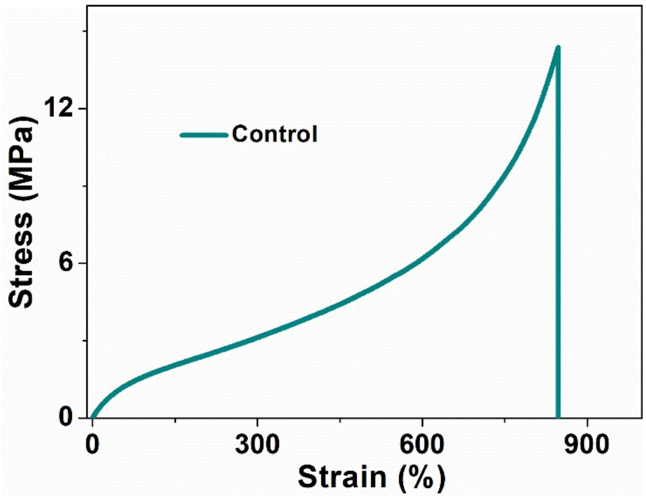

Fig. S4 The stress-strain curve of control sample under the stretching rate of 40 mm/min at room temperature.

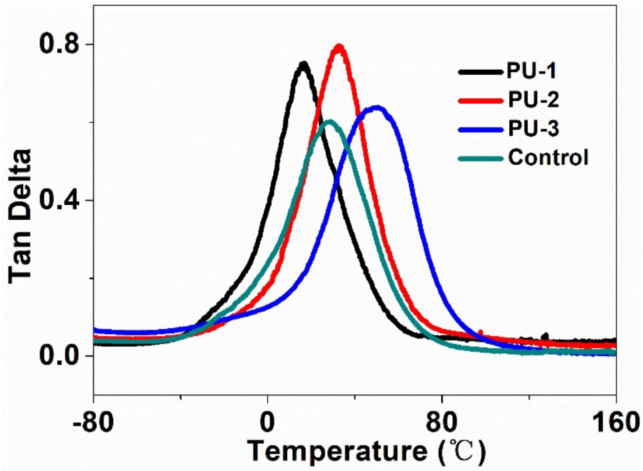

Fig. S5 Tan delta of PUs and control sample detected by DMA multiple strain model under heating rate of 5 ℃/ min in temperature range of -80 ℃ ~ 160 ℃.

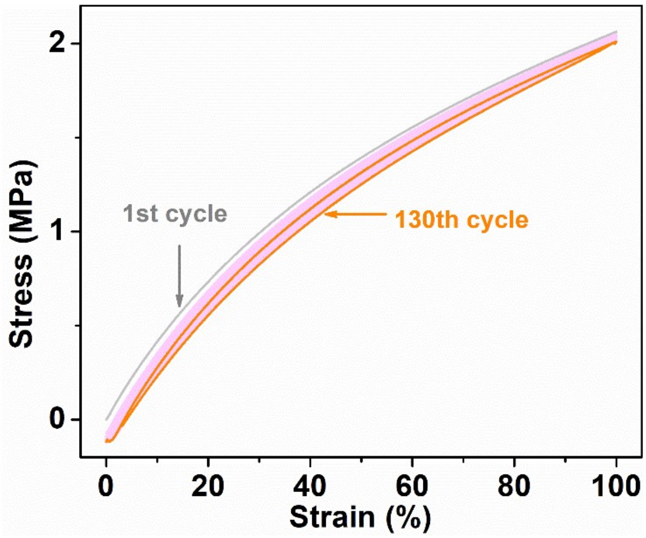

Fig. S6 Cyclic test of PU-2 at strain of 100% for 130 times.

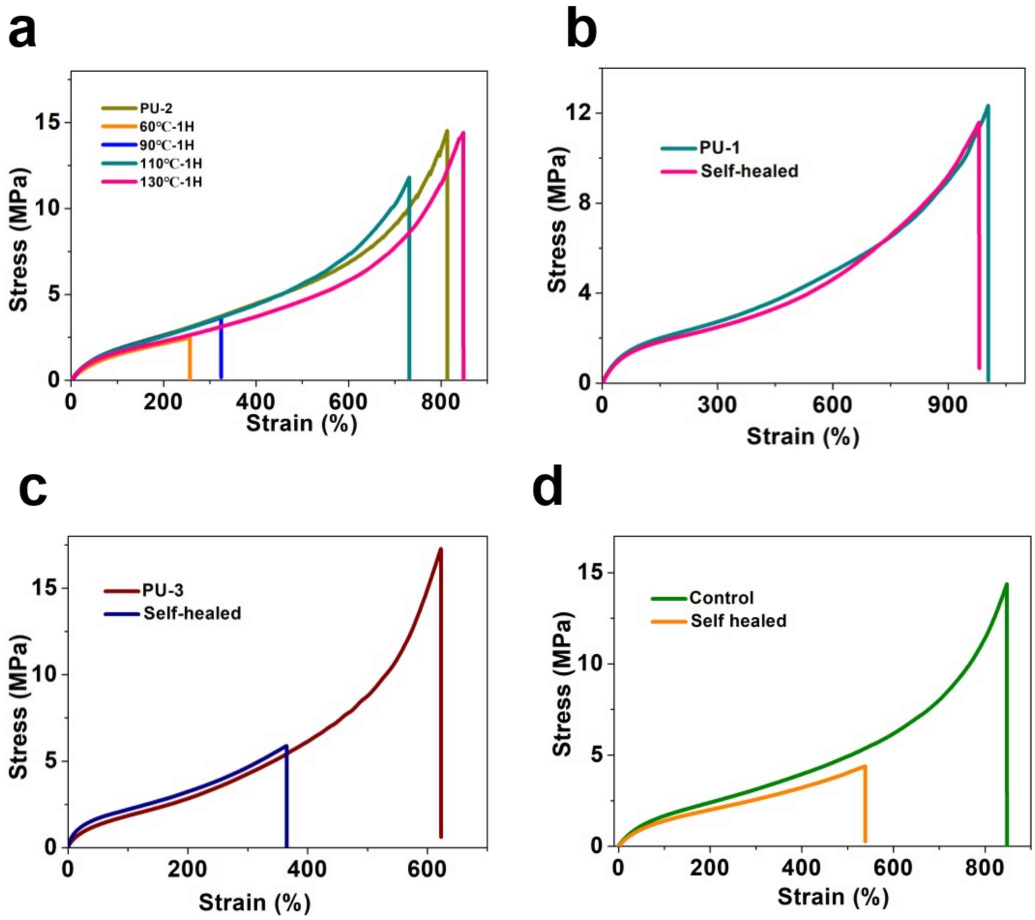

Fig. S7 (a) Stress-strain curves of the healed PU-2 at different temperature. (b)-(c) Stress-strain curves of original and self-healed PU-1 (b), PU-3 (c) and control (d) samples.

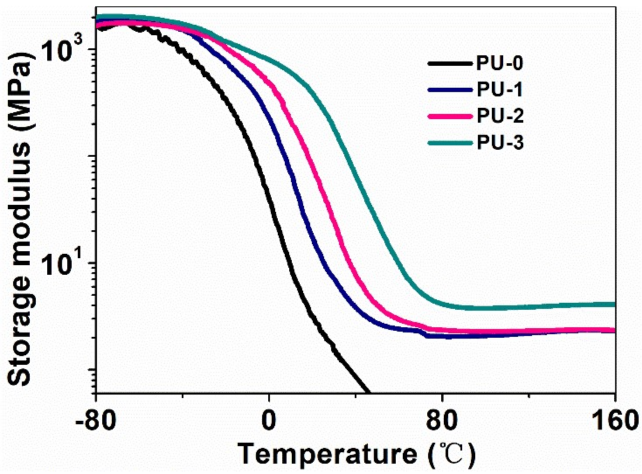

Fig. S8 Storage modulus of the PUs in the temperature range of -80 ℃ ~ 160 ℃ at a heating rate of 5 ℃/min under 1 Hz.

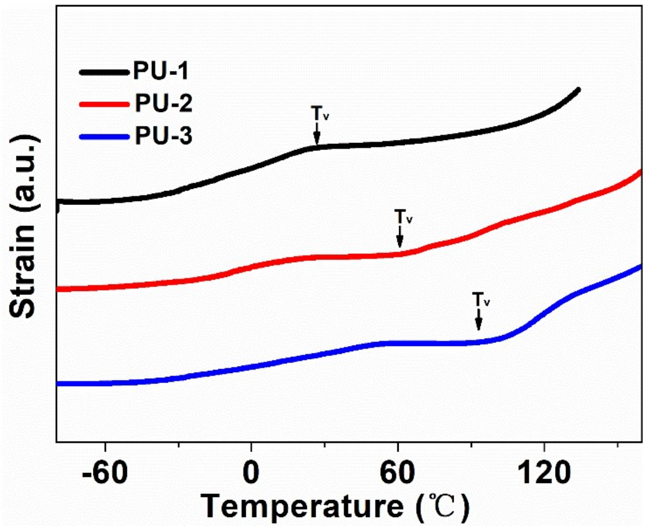

Fig. S9 Dilatometry tests of PUs under the DMA controlled force model under 0.1 MPa.

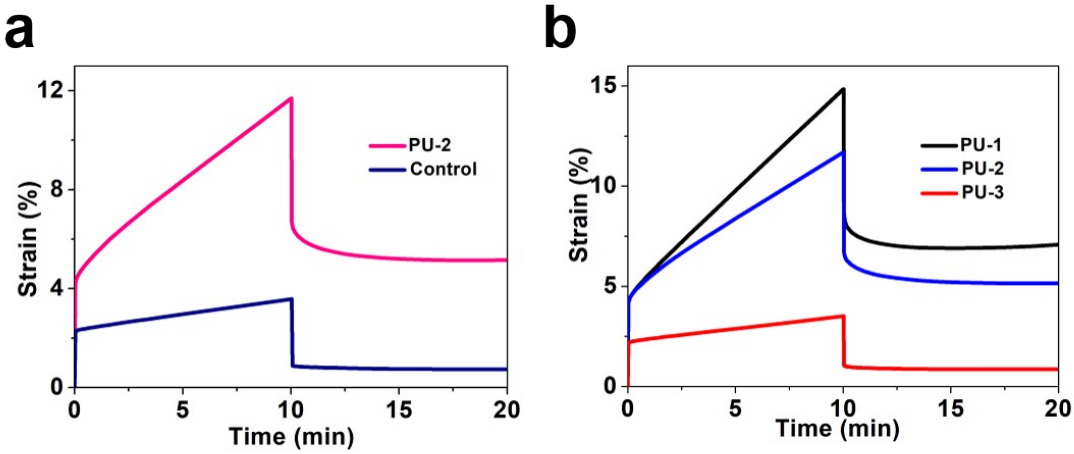

Fig. S10 reep curves of control sample (a) and PUs samples (b) at 150 ℃.

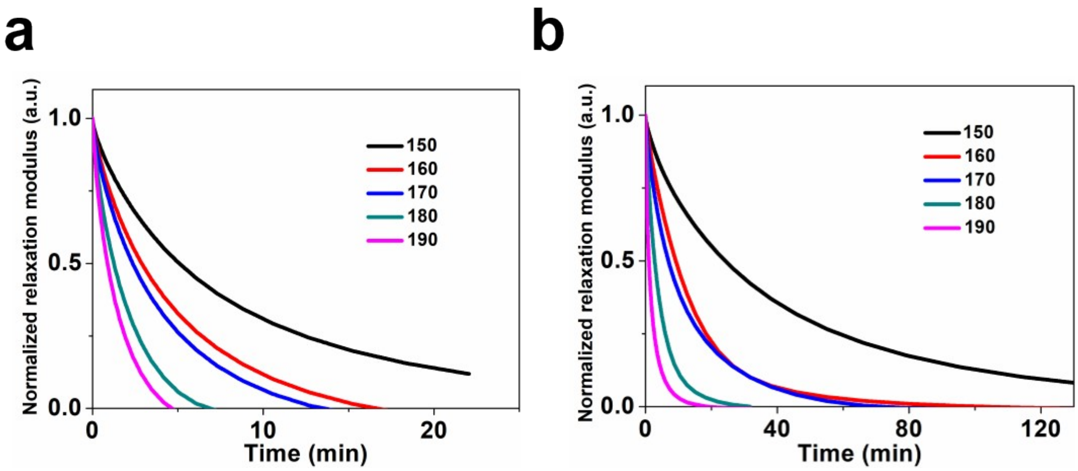

Fig. S11 Normalized stress relaxation curves of PU-1 (a) and PU-3 (b) under 5% of strain at different temperature.

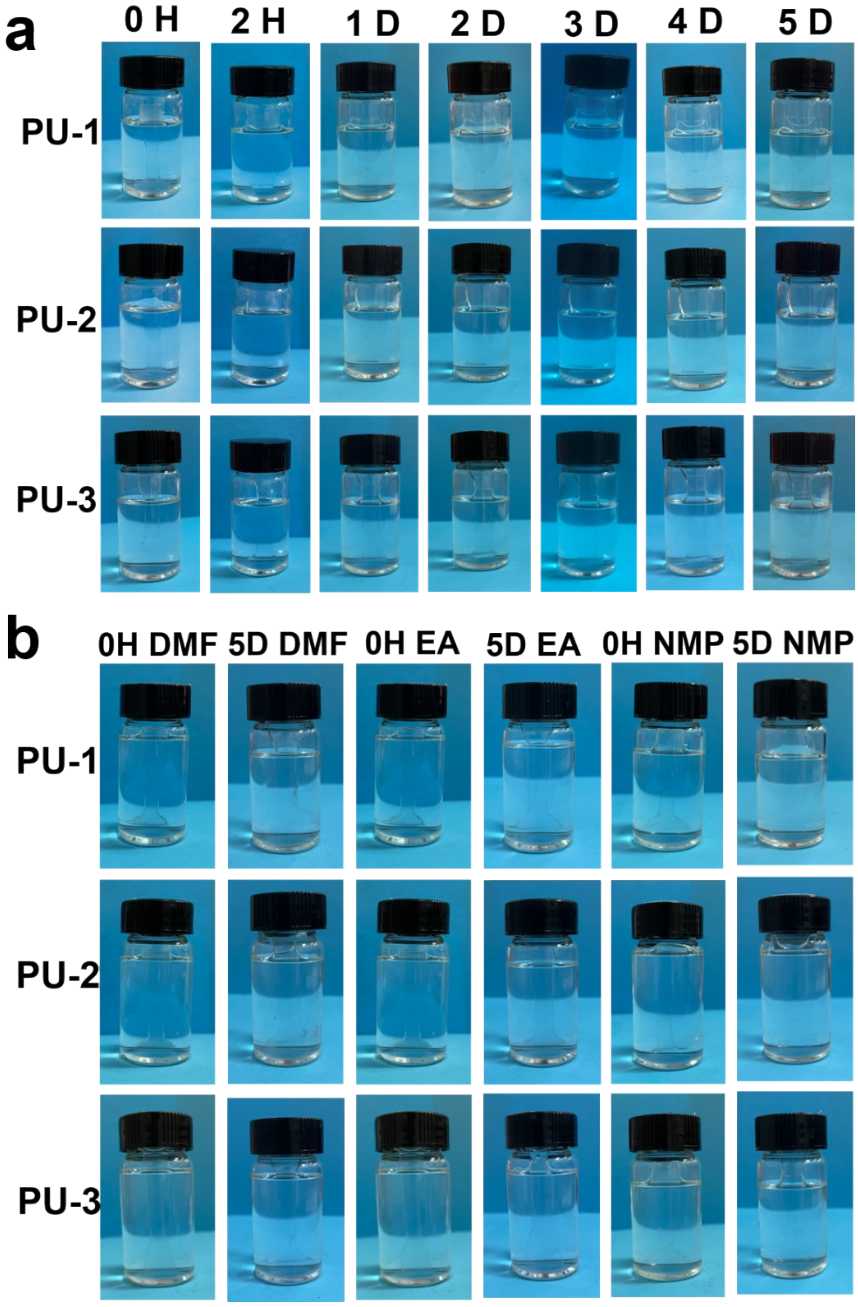

Fig. S12 (a) The photographs of PU-1, PU-2 and PU-3 in THF for different time. (b) The photographs of PU-1, PU-2 and PU-3 in DMF, EA and NMP for 5days.

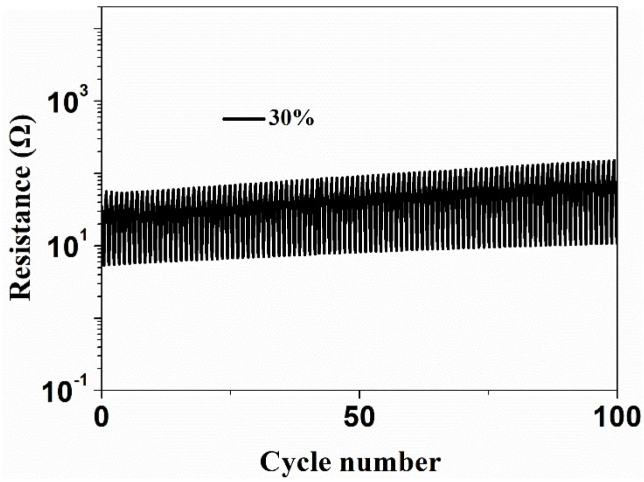

Fig. S13 Durability tests of 100 cycles at a maximum tensile strain of 30% for PU-2-based stretchable conductors.

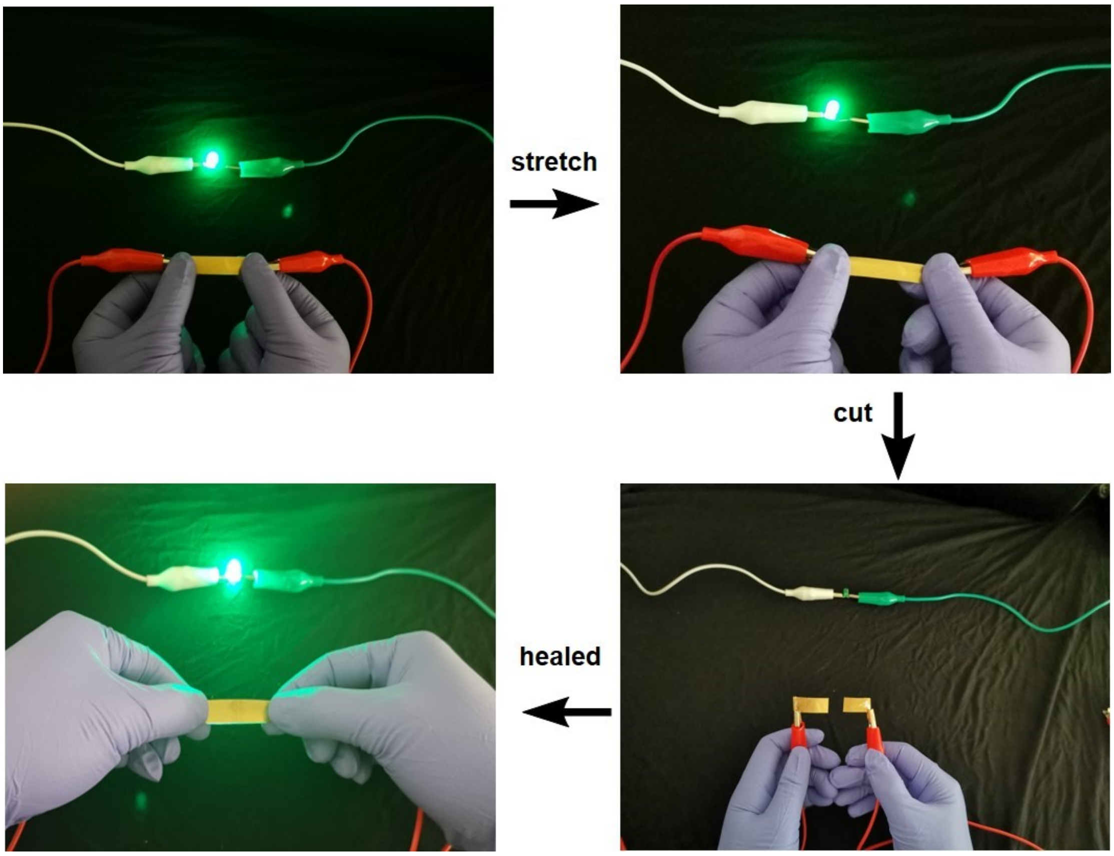

Fig. S14 Demonstration of the self-healing process of fabricated conductor connect with LED.

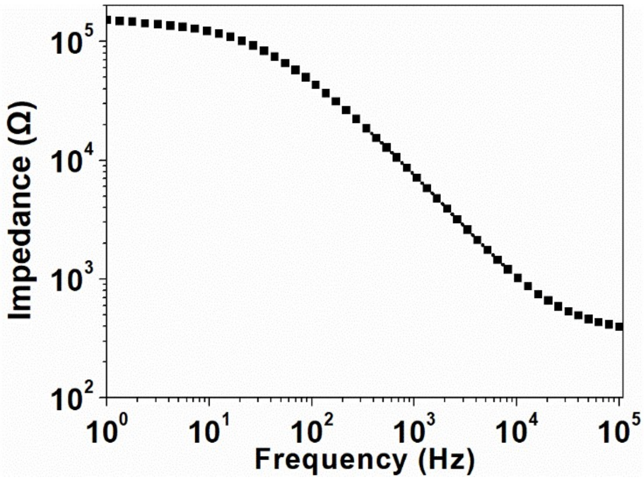

Fig. S15 The fabricated stretchable conductor showing low interfacial impedance with skin.

References:

[1] H. Kim, A. Thukral, C. Yu, *ACS Appl. Mater. Inter.,* 2018, **10**, 5000.

[2] Y. Wu, Y. Zhou, W. Asghar, Y. Liu, F. Li, D. Sun, C. Hu, Z. Wu, J. Shang, Z. Yu, R. Li, H. Yang, *Adv. Intell. Syst*., 2021, 2000235.

[3] P. Lugoda, J. C. Costa, L. A. Garcia Garcia, A. Pouryazdan, Z. Jocys, F. Spina, J. Salvage, D. Roggen, N. Münzenrieder, *Adv. Mat. Technol.,* 2021, **6**, 2000780.

[4] X. Li, T. Hua, B. Xu, *Carbon*., 2017, **118**, 686.

[5] J. Kang, D. Son, G. J. N. Wang, Y. Liu, J. Lopez, Y. Kim, J. Y. Oh, T. Katsumata, J. Mun, Y. Lee, L. Jin, J. B. H. Tok, Z. Bao, *Adv. Mater.,* 2018, **30**, 1706846.

[6] X. Yan, Z. Liu, Q. Zhang, J. Lopez, H. Wang, H. Wu, S. Niu, H. Yan, S. Wang, T. Lei, J. Li, D. Qi, P. Huang, J. Huang, Y. Zhang, Y. Wang, G. Li, J. B. H. Tok, X. Chen, Z. Bao, *J. Am. Chem. Soc.,* 2018, **140**, 5280.

[7] J. Fan, J. Huang, Z. Gong, L. Cao, Y. Chen, *ACS Appl. Mater. Inter.,* 2021, **13**, 1135.

[8] X. Wu, J. Wang, J. Huang, S. Yang, *ACS Appl. Mater. Inter.,* 2019, **11**, 7387.

[9] S. Yan, G. Zhang, H. Jiang, F. Li, L. Zhang, Y. Xia, Z. Wang, Y. Wu, H. Li, *ACS Appl. Mater. Inter.,* 2019, **11**, 10736.

[10] H. Qiao, P. Qi, X. Zhang, L. Wang, Y. Tan, Z. Luan, Y. Xia, Y. Li, K. Sui, *ACS Appl. Mater. Inter.,* 2019, **11**, 7755.

[11] Y. Wang, Q.Chang, R. Zhan, *J. Mater. Chem. A,* 2019, **7**, 24814-24829.

[12] Q. Guo, B. Huang, C. Lu, T. Zhou, G. Su, L. Jia, X. Zhang, *Mater. Horizons.,* 2019, **6**, 996.

[13] J. Cao, C. Lu, J. Zhuang, M. Liu, X. Zhang, Y. Yu, Q. Tao, *Angew. Chem. Int. Ed.,* 2017, **56**, 8795.