Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.


# Microwave-assisted selective heating to rapidly construct a nano-cracked hollow sponge for stretch sensing

Pengju Liu[a], Wenhua Chen[b, c*]

[a] *State Key Laboratory of Polymer Materials Engineering, Polymer Research Institute of Sichuan University, Chengdu 610065, China*

[b] *College of Architecture and Environment, Sichuan University, Chengdu 610065, China*

[c] *National Engineering Research Centre for Flue Gas Desulfurization, Chengdu 610065, China*

[*]Corresponding author, E-mail: scucwh@163.com (WH Chen)

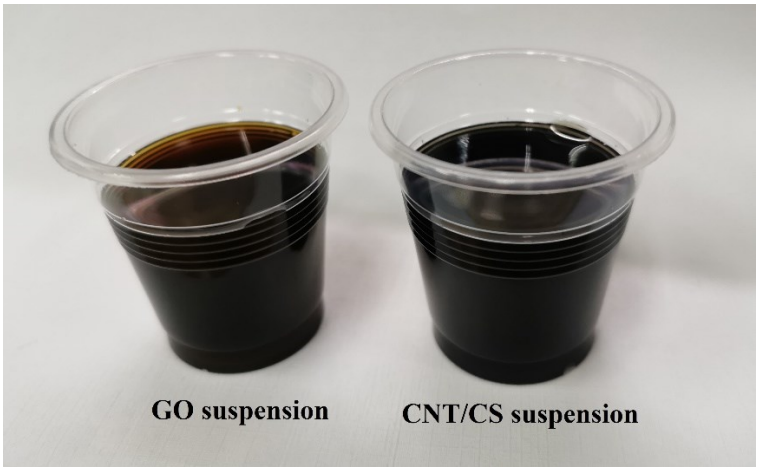


**Figure S1** Digital photos showing the uniform and stable GO and CNT/CS suspensions.

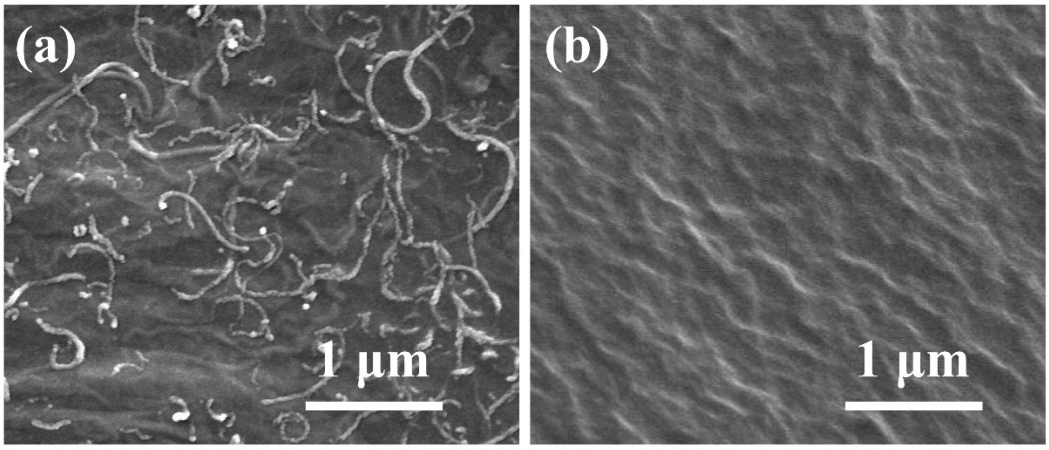


**Figure S2** Surface morphology of the coated backbone with one layer of GO/CNT (a) and neat ME backbone (b).

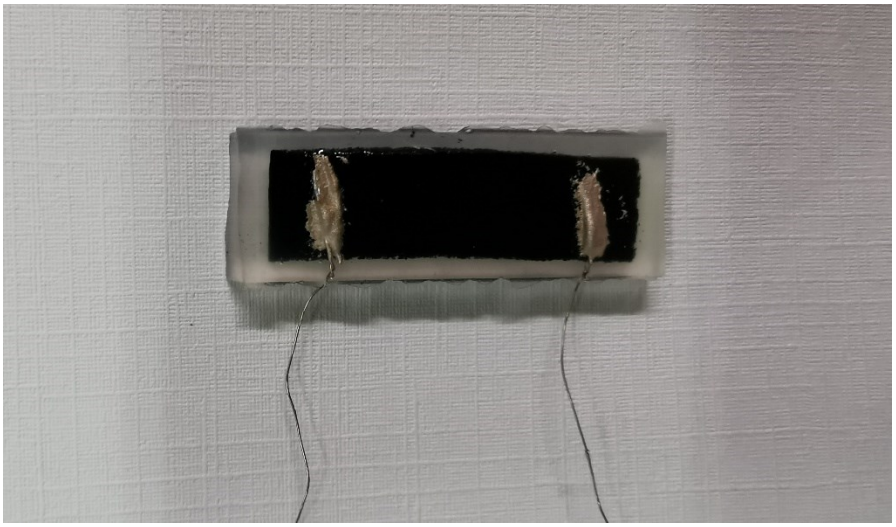

**Figure S3** Digital photo showing the integrated sensor (copper electrodes have been embedded in sensor).

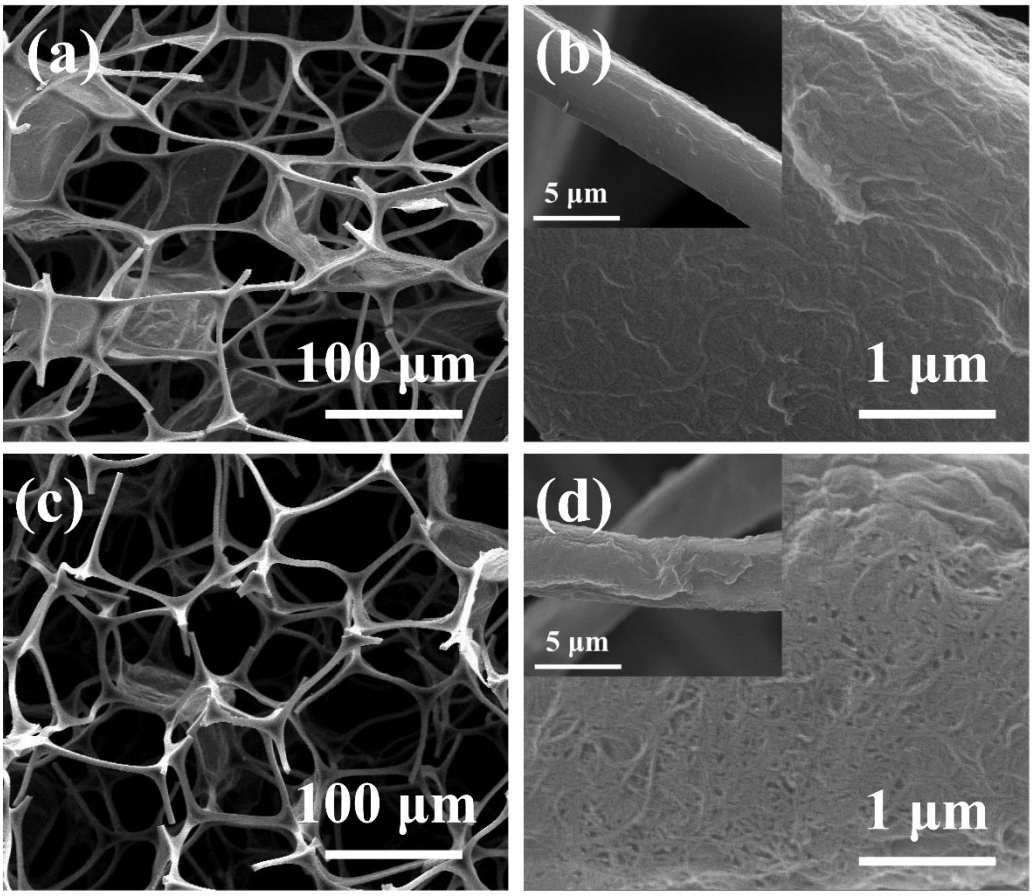


**Figure S4** The microstructure and morphology of MW-treated sponge upon 2 (a, b) and 4 s (c, d) irradiation.

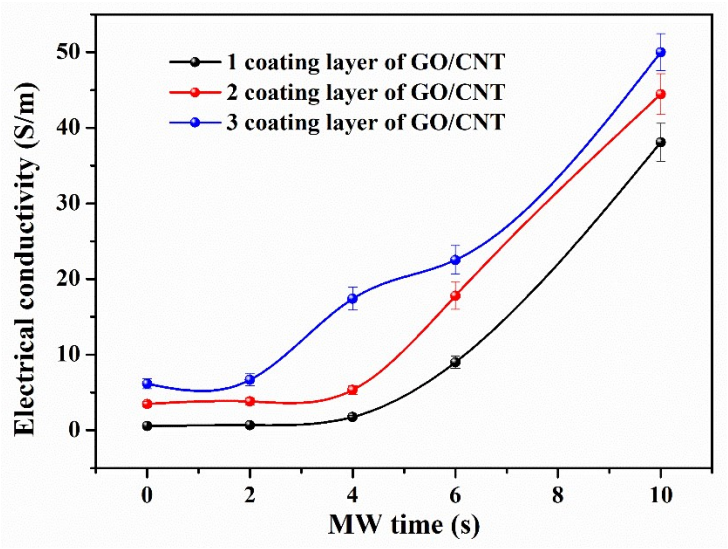


**Figure S5** The electrical conductivity of MW-treated coated sponge with different coating layer of GO/CNT as a function of irradiation time.

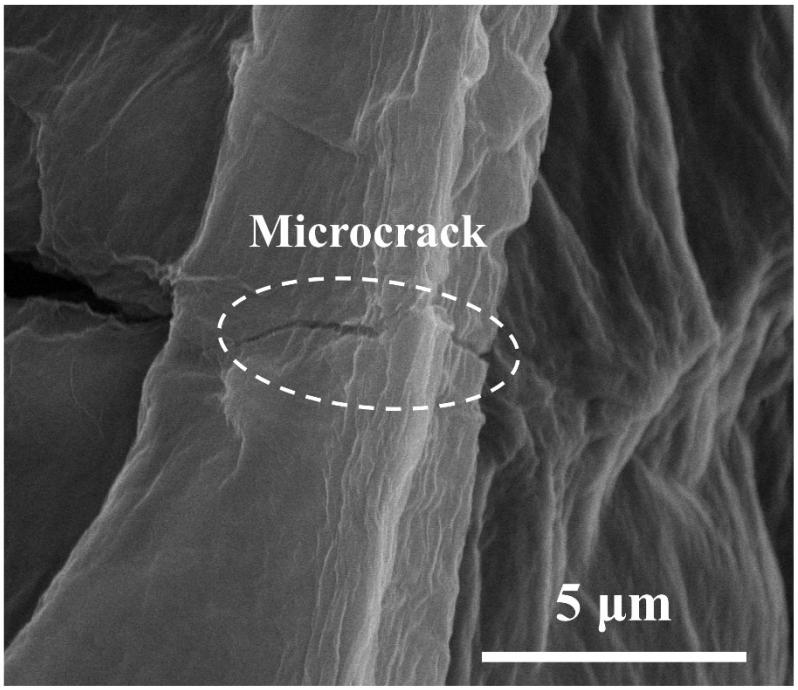


**Figure S6** SEM image showing the skeleton with microcrack caused by MW heating.

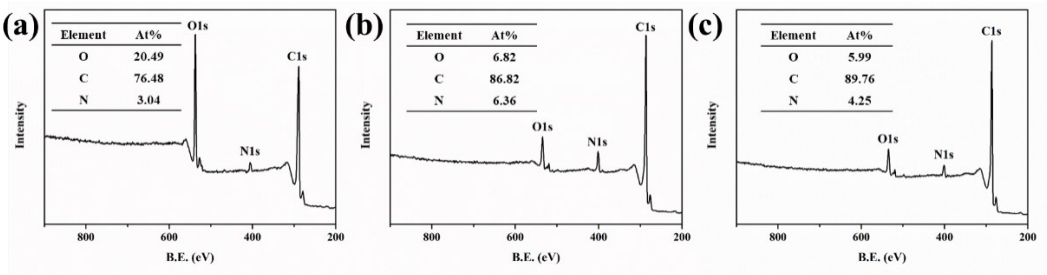


**Figure S7** XPS results showing the element composition of GO/CNT@ME sponge upon 0 (a), 6 (b) and 10 s (c) MW irradiation.

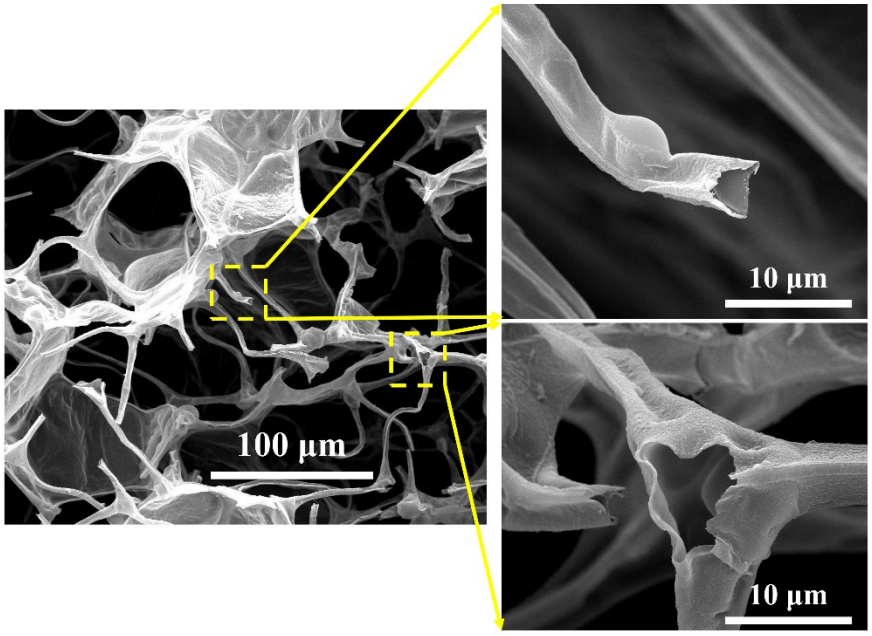


**Figure S8** SEM images showing the hollow backbones in MW-treated sponge after the degradation of ME matrix.

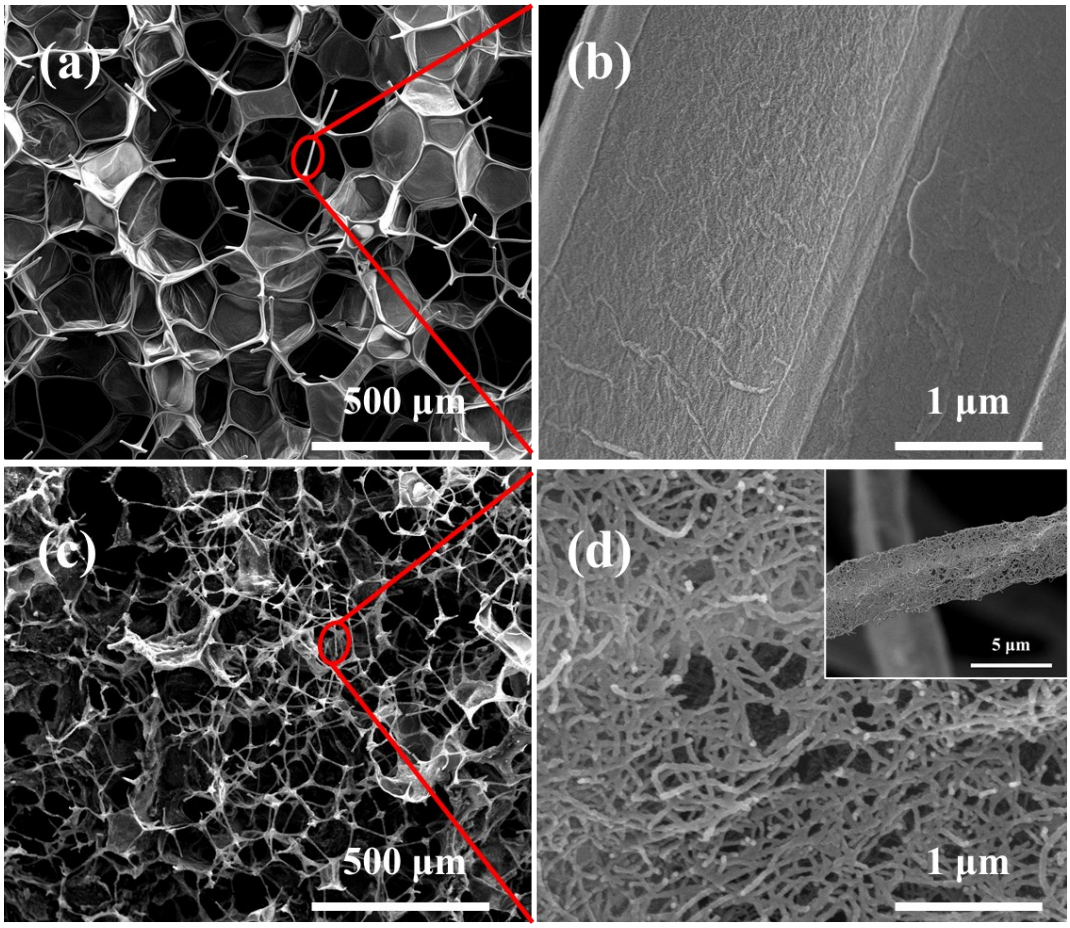


**Figure S9** SEM images showing the structure of GO@ME (a, b) and CNT@ME (c, d) sponge after 10 s MW irradiation.

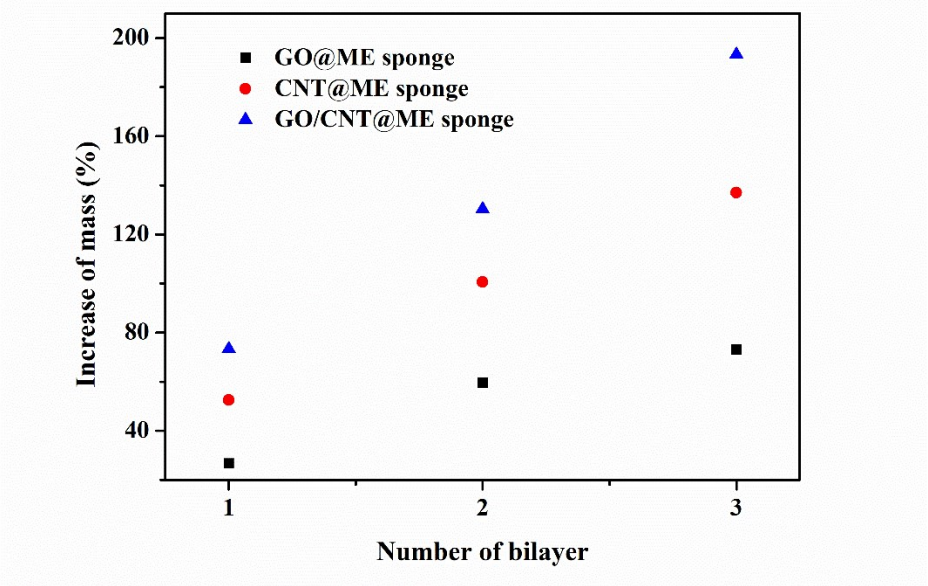


**Figure S10** Relative increase of GO, CNT, and GO/CNT coating mass on ME sponge with different number of bilayer.

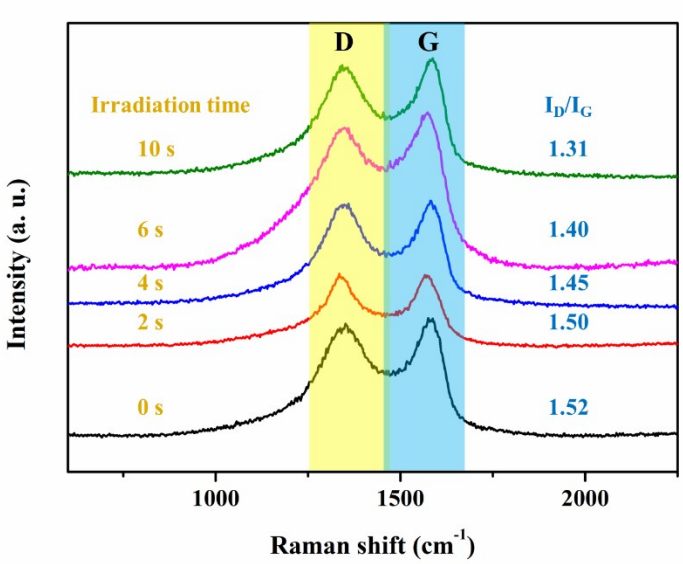


**Figure S11** Raman spectra of MW-treated GO/CNT@ME sponge after different irradiation time and the related values of $I_D/I_G$

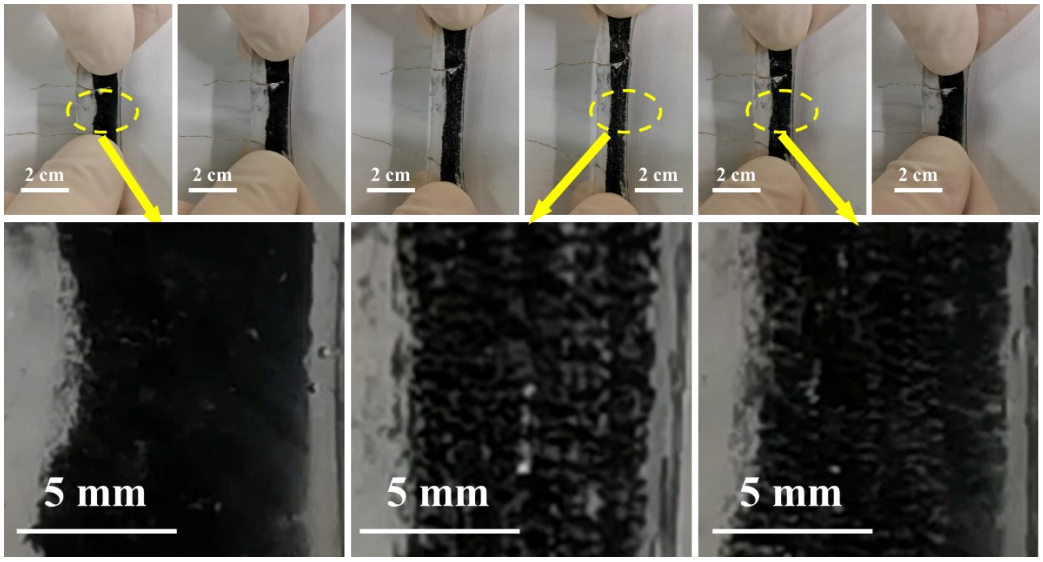


**Figure S12** The formation and recovery of cracks in sensor during stretching-release process (bright regions representing the formed cracks among backbones).

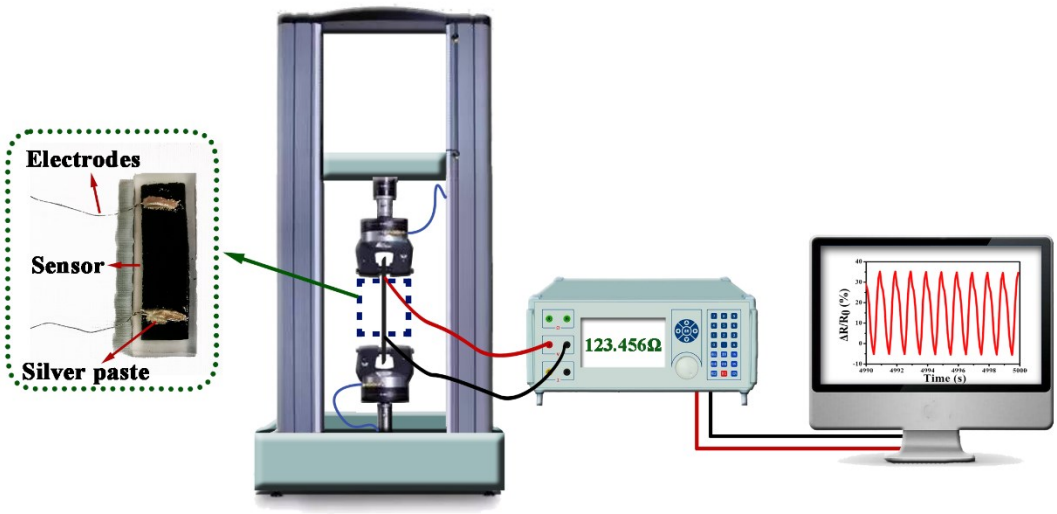


**Figure S13** A self-build equipment for evaluating the stretch sensing behavior of MW-treated sponge sensors.

**Table S1** Electrical conductivity of GO@ME, CNT@ME and GO/CNT@ME sponge before and after MW irradiation (10 s)

| Sample | Conductivity before MW irradiation (S/m) | Conductivity after MW irradiation (S/m) |
|---|---|---|
| GO@ME sponge | $< 10^{-6}$ | $< 10^{-6}$ |
| CNT@ME sponge | 5.3±0.2 | 4.0±0.5 |
| GO/CNT@ME sponge | 0.57±0.06 | 38.1±3.0 |

**Table S2** The comparison of sensitivity and durability of our sensor with other stretching sensors

| Sensor | Minimum detected strain (%) | Durability (cycle) | Ref |
|---|---|---|---|
| rGO/CNT sponge | ~1 | >10000 | This work |
| Carbonized silk fabric | ~1 | >10000 | [1] |
| Fish-scale-like graphene | ~0.1 | >5000 | [2] |
| MWCNTs/elastomer | - | >5000 | [3] |
| SWNT/MWNT/TPU yarn | - | >2000 | [4] |
| GnPs/silicon rubber | ~2 | >1000 | [5] |
| Graphene/AgNPs/TPU | 0.5 | >1000 | [6] |
| Binary rubber/graphene | ~20 | >300 | [7] |
| TPU/CNTs/PDMS | <30 | >700 | [8] |
| CNT/TPU | 0.5 | >10 000 | [9] |

Note: SWNT, single-walled carbon nanotube; TPU, thermoplastic polyurethane; GnPs, graphene platelets; PDMS, polydimethylsiloxane.

## REFERENCES


1. C. Wang, X. Li, E. Gao, M. Jian, K. Xia, Q. Wang, Z. Xu, T. Ren and Y. Zhang, *Advanced Materials*, 2016, **28**, 6640-6648.
2. Q. Liu, J. Chen, Y. Li and G. Shi, *ACS Nano*, 2016, **10**, 7901-7906.
3. L. Li, Y. Bai, L. Li, S. Wang and T. Zhang, *Advanced Materials*, 2017, **29**, 1702517.
4. Y. H. Li, B. Zhou, G. Q. Zheng, X. H. Liu, T. X. Li, C. Yan, C. B. Cheng, K. Dai, C. T. Liu, C. Y. Shen and Z. H. Guo, *Journal of Materials Chemistry C*, 2018, **6**, 13.
5. G. Shi, Z. H. Zhao, J. H. Pai, I. Lee, L. Q. Zhang, C. Stevenson, K. Ishara, R. J. Zhang, H. W. Zhu and J. Ma, *Advanced Functional Materials*, 2016, **26**, 7614-7625.
6. S. Chen, Y. Wei, X. Yuan, Y. Lin and L. Liu, *Journal of Materials Chemistry C*, 2016, **4**, 4304-4311.
7. Y. Lin, S. Q. Liu, S. Chen, Y. Wei, X. C. Dong and L. Liu, *Journal of Materials Chemistry C*, 2016, **4**, 6345-6352.
8. L. Wang, Y. Chen, L. W. Lin, H. Wang, X. W. Huang, H. G. Xue and J. F. Gao, *Chemical Engineering Journal*, 2019, **362**, 89-98.
9. Y. J. Zhou, P. F. Zhan, M. N. Ren, G. Q. Zheng, K. Dai, L. W. Mi, C. T. Liu and C. Y. Shen, *ACS Appl. Mater. Interfaces*, 2019, **11**, 7405-7414.