Electronic Supplementary Information

Flexible, Robust, and Washable Bacterial Cellulose/Silver Nanowire Conductive Paper for High-Performance Electromagnetic Interference Shielding Effectiveness

Jie Wang [1,#], Xiangbo Zhu [1,#], Peixun Xiong [2], Junpin Tu [1], Zhiwei Yang [1], Fanglian Yao [3], Miguel Gama [4], Quanchao Zhang [1*], Honglin Luo [1,2,*], Yizao Wan [1,2,*]

[1] Jiangxi Key Laboratory of Nanobiomaterials, Institute of Advanced Materials, East China Jiaotong University, Nanchang 330013, China.

[2] School of Materials Science and Engineering, Tianjin University, Tianjin 300072, China.

[3] Department of Polymer Science and Key Laboratory of Systems Bioengineering of Ministry of Education, School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China.

[4] Centro de Engenharia Biológica, Universidade do Minho, Campus de Gualtar, P 4715-057 Braga, Portugal.

[#] J. Wang and X. Zhu contributed equally to this work.

*Corresponding authors.

E-mail: zhangquanchao2006@126.com; hlluotju@126.com; yzwantju@126.com

TG analysis was performed to determine the weight ratio of AgNW in the as-prepared BC/AgNW papers. The content of AgNW in BC/AgNW paper was calculated according to the TGA data using the following equation [S1]:

$$W_{AgNW} = \frac{W_b - W_a}{1 - W_a} \times 100\%$$

where W_{AgNW} is the weight ratio of AgNW in BC/AgNW, and W_{a} and W_{b} are the residual weight ratios of BC and BC/AgNW after thermal degradation, respectively.

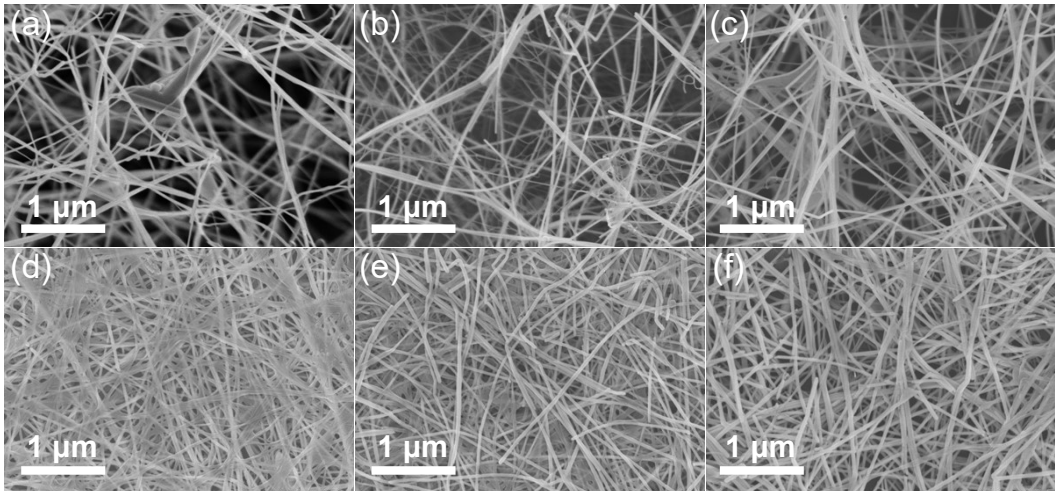

Figure S1. SEM images of the (a) BC/AgNW-1, (b) BC/AgNW-2, and (c) BC/AgNW-3 aerogels; SEM images of the (d) BC/AgNW-1, (e) BC/AgNW-2, and (f) BC/AgNW-3 papers.

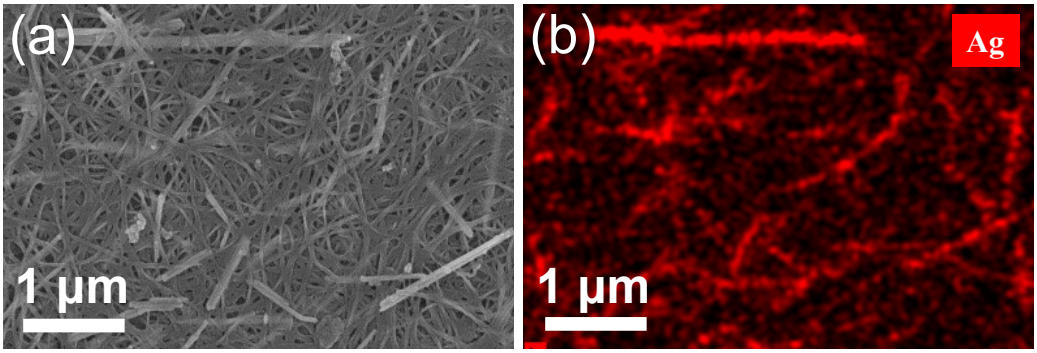

Figure S2. (a) SEM image of the BC/AgNW-4 paper and a corresponding EDX mapping of AgNWs.

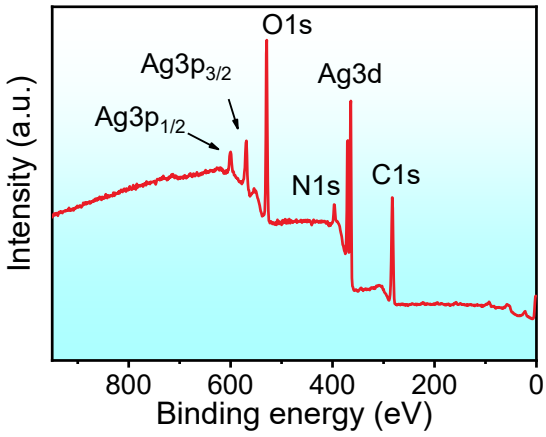

Figure S3. XPS survey spectrum of the BC/AgNW-4 paper.

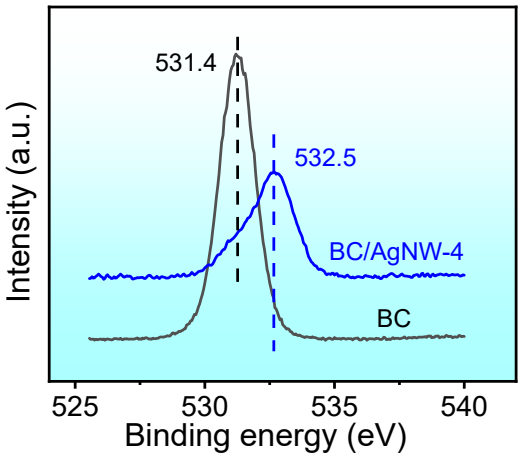

Figure S4. High-resolution XPS spectrum of O1s of the BC and BC/AgNW-4 papers.

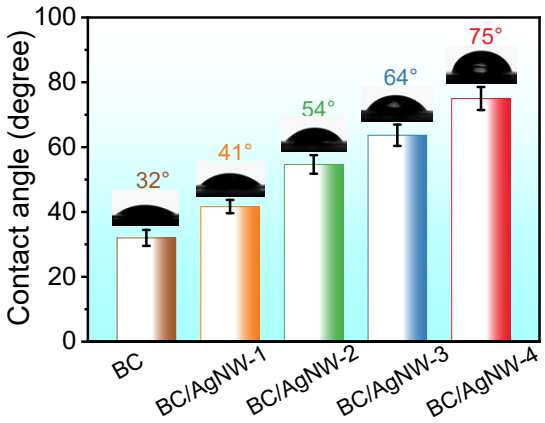

Figure S5. Water contact angles of the bare BC and BC/AgNW papers.

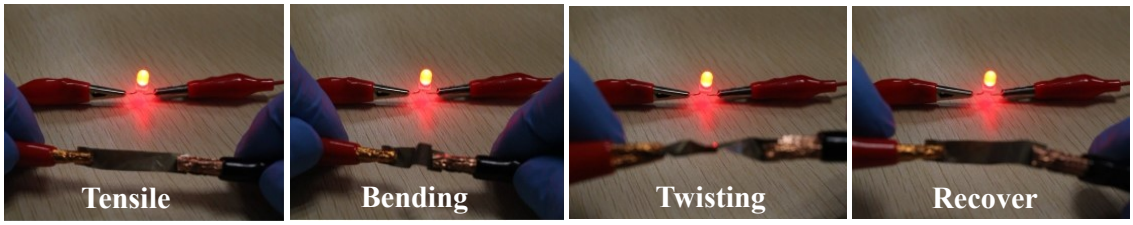

Figure S6. The brightness of the LED lamps does not change when the BC/AgNW-4 paper experienced tensile, bending, and twisting.

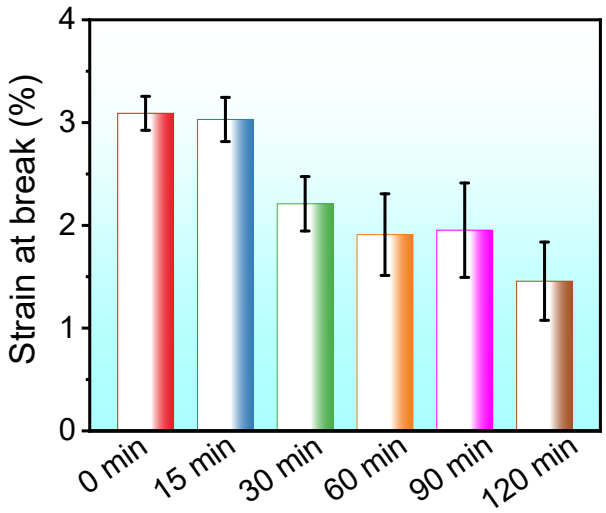

Figure S7. Strain at break of the BC/AgNW-4 paper after washing with water.

Movies:

Movie S1: Variation in electrical resistance of the BC/AgNW-4 paper under bending state for many times.

Movie S2: Variation in electrical resistance of the BC/AgNW-4 paper under folding state for many times.

Movie S3: Variation in electrical resistance of the BC/AgNW-4 paper after exposure to water, brine, ethanol, and vegetable oil.

Movie S4: The washing experiment for the BC/AgNW-4 paper with a stirring speed of 200 rpm.

Table S1. Comparisons of electrical conductivity between BC/AgNW and other AgNW-based materials.

Materials	AgNW content (wt.%)	Conductivity (S m^{-1})	Ref.
BC/AgNW-1	11.4	67718	this work
BC/AgNW-2	23.8	121649	
BC/AgNW-3	30.4	330046	
BC/AgNW-4	36.5	608365	
H-AgNW/cellulose	8.1	3369	[S1]
AgNW/PPy/PDA	50.0	120672	[S2]
AgNW/CNT/cellulose	2.0	283	[S3]
AgNW/C	67.0	363	[S4]
AgNW/PU	3.0	1227	[S5]
PU-AgNW/CFF	5.5	15390	[S6]
AgNW/cellulose	9.6	6751	[S7]
AgNW/PVDF	0.5	26500	[S8]
AgNW/MXene/CNF	5.0	274360	[S9]
AgNW/Mxene/CNF	20.0	37378	[S10]
AgNW/NiNP/cellulose	2.7	6331	[S11]
AgNW/cellulose	50.0	557100	[S12]
AgNW/Nanocellulose	50.0	200000	[S13]
AgNW/GO	7.8	225580	[S14]
AgNW/BMF	51.4	1800	[S15]

Table S2. Comparisons of shielding effectiveness (SE) and specific shielding effectiveness (SSE) between BC/AgNW and other AgNW-based materials.

Materials	AgNW content (wt.%)	SE (dB)	Specific EMI SE (dB mm^{-1})	Ref.
BC/AgNW-1	11.4	9.6	960.0	This work
BC/AgNW-2	23.8	36.9	3690.0	
BC/AgNW-3	30.4	53.3	5330.0	
BC/AgNW-4	36.5	64.0	6400.0	
H-AgNW/cellulose	8.1	46.1	271.0	[S1]
AgNW/PPy/PDA	50.0	48.4	2420.0	[S2]
AgNW/CNT/cellulose	2.0	23.8	2.0	[S3]
AgNW/C	67.0	70.1	38.0	[S4]
AgNW/PU	3.0	63.9	107.0	[S5]
PU-AgNW/CFF	5.5	106.0	294.0	[S6]
AgNW/cellulose	9.6	48.6	240.0	[S7]
AgNW/PVDF	0.5	107.2	1093.9	[S8]
AgNW/MXene/CNF	5.0	51.8	8633.3	[S9]
AgNW/MXene/CNF	20.0	55.9	1597.1	[S10]
AgNW/NiNP/cellulose	2.7	88.4	382.7	[S11]
AgNW/cellulose	50.0	101.0	2270.0	[S12]
AgNW/Nanocellulose	50.0	70.5	35.0	[S13]
AgNW/GO	7.8	62.0	7750.0	[S14]
AgNW/PHBV	5.3	45.9	2550.0	[S16]
AgNW/PDMS	3.1	74.7	74.7	[S17]
AgNW/PI	20.5	23.5	5.0	[S18]
AgNW/WPU	28.6	64.0	28.0	[S19]
AgNW/Silk/MXene	16.0	54.0	450.0	[S20]
AgNW/PANI	43.4	48.0	3830.0	[S21]
AgNW/ANF-MXene	1.8	48.1	1069.0	[S22]

References

[S1] F. Ren, H. Guo, Z. Guo, Y. Jin, H. Duan, P. Ren, D. Yan, *Polymers*, **2019**, *11*, 1486.

[S2] Y. Wang, F. Gu, L. Ni, K. Liang, K. Marcus, S. Liu, F. Yang, J. Chen, Z. Feng, *Nanoscale*, 2017, ***9***, 18318-18325.

[S3] H. Choi, T. Lee, S. Lee, J. Lim, Y. Jeong, *Compos. Sci. Technol.*, 2017, ***150***, 45-53.

[S4] Y. Wan, P. Zhu, S. Yu, R. Sun, C. Wong, W. Liao, *Small*, 2018, ***14***, 1800534.

[S5] L. Jia, K. Ding, R. Ma, H. Wang, W. Sun, D. Yan, B. Li, Z. Li, *Adv. Mater. Technol.*, 2019, ***4***, 1800503.

[S6] L. Jia, L. Xu, F. Ren, P. Ren, D. Yan, Z. Li, *Carbon*, 2019, ***144***, 101-108.

[S7] T. Lee, S. Lee, Y. Jeong, *ACS Appl. Mater. Interfaces*, 2016, ***8***, 13123-13132.

[S8] J. Qian, Z. Zhang, R. Bao, Z. Liu, M. Yang, W. Yang, *Polym. Compos.*, 2021, **42**, 522-531.

[S9] Q. Liu, Y. Zhang, Y. Liu, Z. Liu, B. Zhang, Q. Zhang, *J. Alloy. Compd.*, 2021, **860**, 158151.

[S10] B. Zhou, Q. Li, P. Xu, Y. Feng, J. Ma, C. Liu, C. Shen, *Nanoscale*, 2021, **13**, 2378-2388.

[S11] Y. Zhan, X. Hao, L. Wang, X. Jiang, Y. Cheng, C. Wang, Y. Meng, H. Xia, Z. Chen, *ACS Appl. Mater. Interfaces*, 2021, **13**, 14623-14633.

[S12] C. Liang, K. Ruan, Y. Zhang, J. Gu, *ACS Appl. Mater. Interfaces*, 2020, **12**, 18023-18031.

[S13] Z. Zeng, T. Wu, D. Han, Q. Ren, G. Siqueira, G. Nyström, *ACS Nano*, 2020, ***14***, 2927-2938.

[S14] H. Jia, X. Yang, Q. Kong, L. Xie, Q. Guo, G. Song, L. Liang, J. Chen, Y. Li , C. Chen, *J. Mater. Chem. A*, 2021, **9**, 1180-1191.

[S15] C. Weng, G. Wang, Z. Dai, Y. Pei, L. Liu, Z. Zhang, *Nanoscale*, 2019, ***11***, 22804-22812.

[S16] S. Yang, Y. Wang, Y. Song, L. Jia, G. Zhong, L. Xu, D. Yan, J. Lei, Z. Li, *J. Mater. Chem. C*, 2021, **9**, 3307-3315.

[S17] X. Yu, X. Liang, T. Zhao, P. Zhu, R. Sun, C. Wong, *Mater. Lett.*, 2021, **285**, 129065.

[S18] J. Ma, M. Zhan, K. Wang, *ACS Appl. Mater. Interfaces*, 2015, *7*, 563-576.

[S19] Z. Zeng, M. Chen, Y. Pei, S. Shahabadi, B. Che, P. Wang, X. Lu, *ACS Appl. Mater. Interfaces*, 2017, ***9***, 32211-32219.

[S20] L. Liu, W. Chen, H. Zhang, Q. Wang, F. Guan, Z. Yu, *Adv. Funct. Mater.*, 2019, ***29***, 1905197.

[S21] F. Fang, Y. Li, H. Xiao, N. Hu, S. Fu, *J. Mater. Chem. C*, 2016, ***4***, 4193-4203.

[S22] Z. Ma, S. Kang, J. Ma, L. Shao, Y. Zhang, C. Liu, A. Wei, X. Xiang, L. Wei, J. Gu, *ACS Nano*, 2020, ***14***, 8368-8382.