Supporting Information

Ultrathin and flexible PDA modified MXene/bacterial cellulose composite film with densely lamellar structure for enhanced electromagnetic interference shielding performance

Cuilian Wen [a,*], Hao Liu [a,*], Lijin Luo [b], Zhou Cui [a], Xiong Li [a], Junhao Jin [a], Siqing Yan [a], Peng Lin [a], Baisheng Sa [a,*]

[a]*Multiscale Computational Materials Facility & Materials Genome Institute, School of Materials Science and Engineering, Fuzhou University, Fuzhou 350100, China.*

[b]*Fujian Institute of Microbiology, Fuzhou 350007, China*

Corresponding authors:

E-mail addresses: clwen@fzu.edu.cn (C. Wen), liuhao2092023@163.com (H. Liu), bssa@fzu.edu.cn (B. Sa)

Compared with previous reported functional materials (Table S1), the PM/BC composite film synthesized in this work has superior mechanical properties, showing great potential in practical applications of electronic products.

Table S1. The comparison of mechanical properties of PM50/BC composite film and other reported composites.

Sample	Materials	Tensile strength (MPa)	Strain (%)	Refs.
1	$Ti_3C_2T_x$/ANF	197.1	9.80	1
2	Nacre	135.0	0.85	2
3	RGP/CNF	156.5	3.90	3
4	$Ti_3C_2T_x$/CNF	112.5	4.30	4
5	$Ti_3C_2T_x$/PVA	91	3.70	5
6	RGP/MG/PVA	62.4	4.50	6
7	PPy@ $Ti_3C_2T_x$/BC	46.0	4.40	7
8	LG	54.0	3.20	8
9	GP/TiO_2-epoxy	75.0	1.20	9
10	Cellulose/GP/PPy	90.8	10.00	10
11	$Ti_3C_2T_x$ film	22.0	1.00	5
12	PM50/BC	178.1	6.90	This work

In MXene/BC composite film, there is a noticeable void structure between the randomly arranged MXene nanosheets and BC substrate. This void structure significantly affects the compactness of the internal film structure. Additionally, the surface of MXene/BC composite film appears highly uneven, with clear delamination phenomena observed, which can result in the separation of MXene nanosheets and detachment from BC substrate during practical applications (Fig. S1).

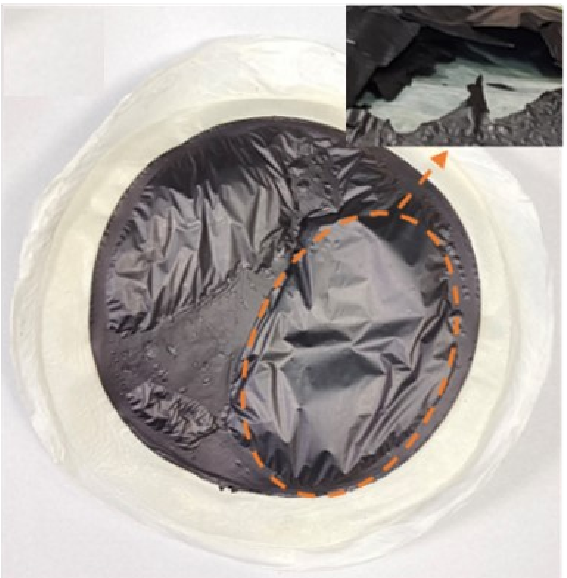

Fig. S1. The digital photograph of the MXene/BC composite film.

The FTIR result in Fig. S2 reveals that the surface of MXene contains -OH, -F, and -O functional groups, which are mainly dominated by hydroxyl groups. It is noted that the shifts in the -OH functional groups on the PDA/MXene surface, confirm a distinct interaction between PDA and MXene nanosheets. This plays a crucial role in determining the surface chemistry and reactivity of MXene, facilitating interactions with PDA and BC, leading to enhanced bonding and composite formation.

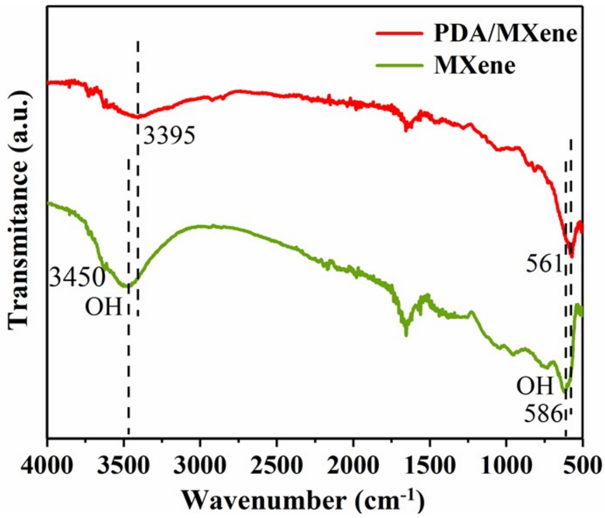

Fig. S2. The FTIR spectra of the $Ti_3C_2T_x$ MXene and PDA/MXene.

To elucidate the fracture mechanism of the PM/BC composite film, we scrutinized the fracture surface of the PM50/BC composite. Fig. S3a shows a tightly packed multilayer structure characterized by 'zigzag' cracks in the BC substrate. These cracks are a testament to the robust hydrogen bonding and the efficient absorption of external forces by the BC nanofibers. Conversely, the PMXene layer displays 'plane' cracks, indicative of a brittle fracture behavior, as depicted in Fig. S3b.

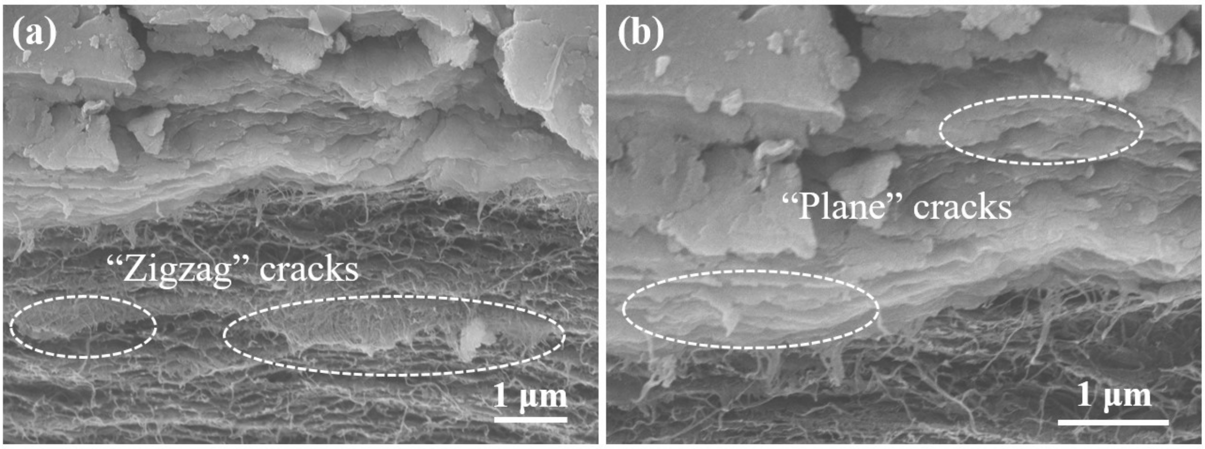

Fig. S3. (a) SEM image of the fracture section of PM50/BC composite film and (b) the corresponding enlarged morphology.

References

1. F. Xie, F. Jia, L. Zhuo, Z. Lu, L. Si, J. Huang, M. Zhang and Q. Ma, *Nanoscale*, 2019, **11**, 23382-23391.
2. A. P. Jackson, J. F. V. Vincent and R. M. Turner, *J. Mater. Sci.*, 1990, **25**, 3173-3178.
3. W. Yang, Z. Zhao, K. Wu, R. Huang, T. Liu, H. Jiang, F. Chen and Q. Fu, *J. Mater. Chem. C*, 2017, **5**, 3748-3756.
4. B. Zhou, Z. Zhang, Y. Li, G. Han, Y. Feng, B. Wang, D. Zhang, J. Ma and C. Liu, *ACS Appl. Mater. Interfaces*, 2020, **12**, 4895-4905.
5. Z. Ling, C. E. Ren, M. Q. Zhao, J. Yang, J. M. Giammarco, J. Qiu, M. W. Barsoum and Y. Gogotsi, *Proc. Natl. Acad. Sci. U.S.A.*, 2014, **111**, 16676-16681.
6. B. Yuan, C. Bao, X. Qian, L. Song, Q. Tai, K. M. Liew and Y. Hu, *Carbon*, 2014, **75**, 178-189.
7. Q. C. Song, Z. Y. Zhan, B. X. Chen, Z. H. Zhou and C. H. Lu, *Cellulose*, 2020, **27**, 7475-7488.
8. Y.-J. Wan, P.-L. Zhu, S.-H. Yu, R. Sun, C.-P. Wong and W.-H. Liao, *Carbon*, 2017, **122**, 74-81.
9. A. Kumar, R. Anant, K. Kumar, S. S. Chauhan, S. Kumar and R. Kumar, *RSC Adv.*, 2016, **6**, 113405-113414.
10. J. Chen, J. Xu, K. Wang, X. Qian and R. Sun, *ACS Appl. Mater. Interfaces*, 2015, **7**, 15641-15648.