

Supplementary Materials

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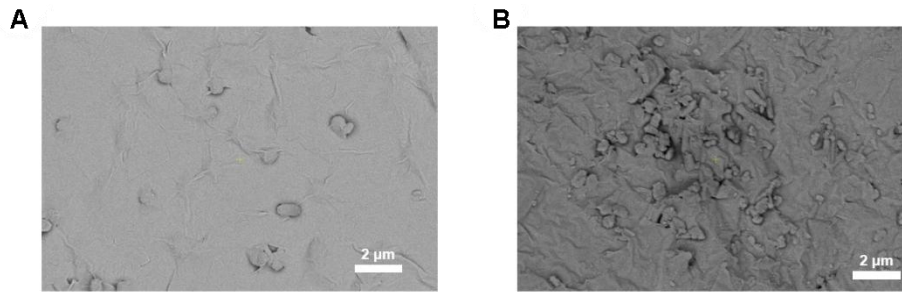
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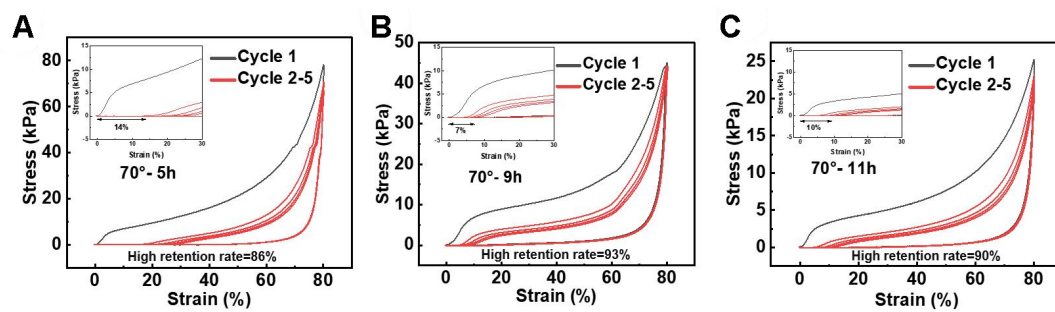
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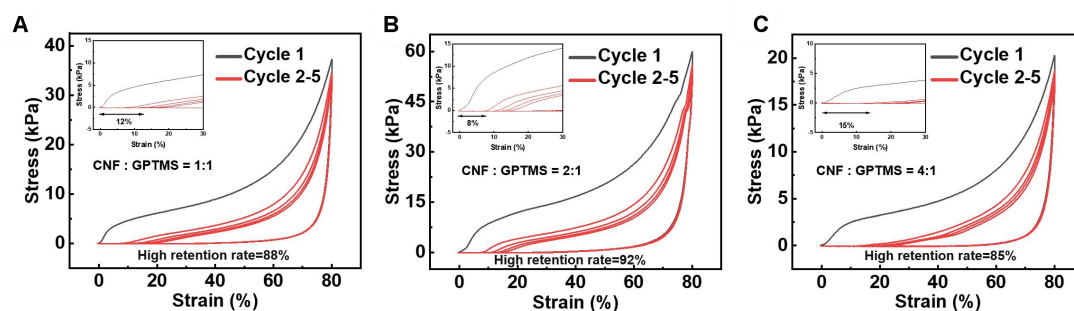
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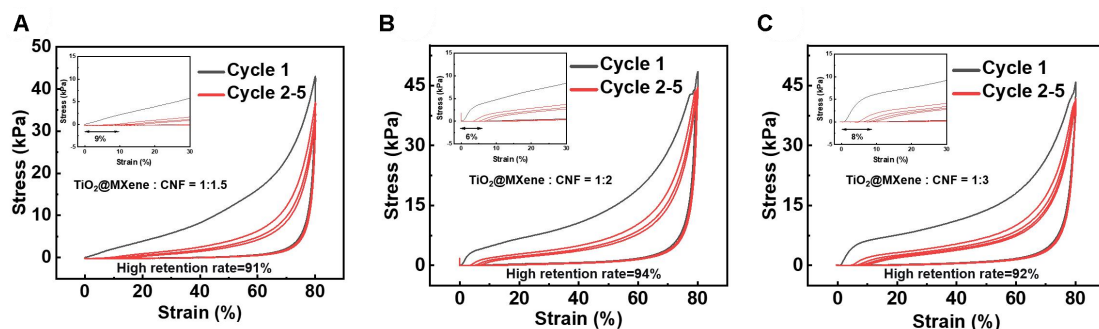
Supplementary Figure 1. (A) SEM image of MXene after 3 hours of oxidation. (B) SEM image of MXene after 15 hours of oxidation.



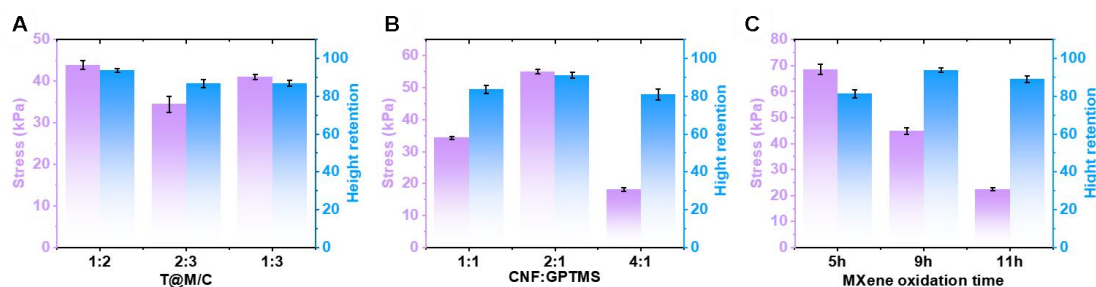
Supplementary Figure 2. Determination of MXene oxidation time for achieving the highest height retention rate of aerogel. (A) Oxidation at 70°C for 5 hours. (B) Oxidation at 70°C for 9 hours. (C) Oxidation at 70°C for 11 hours.



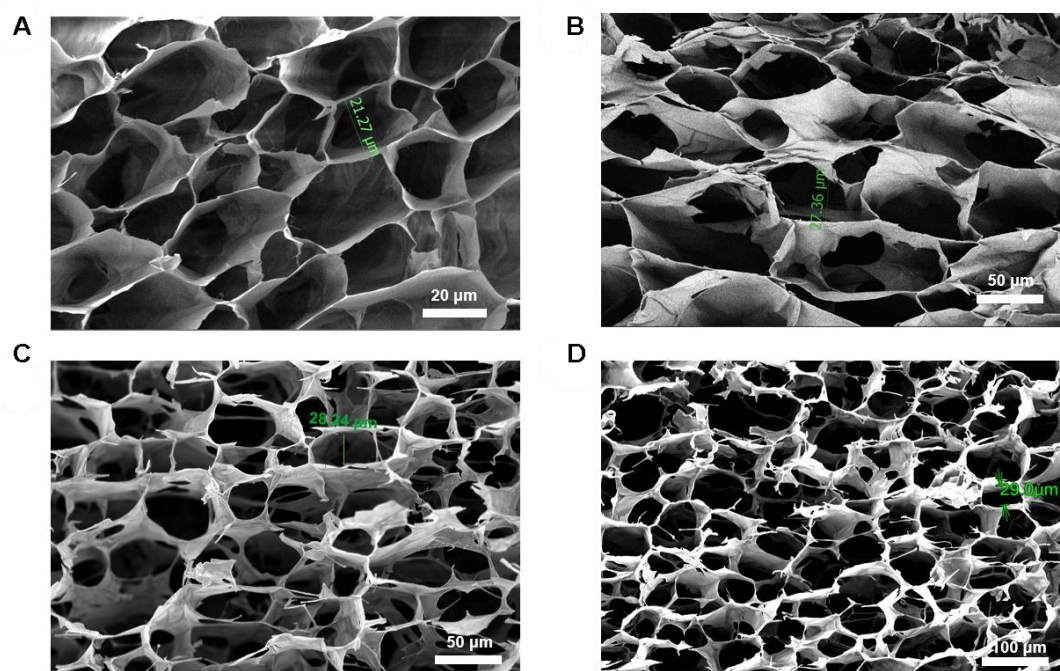
Supplementary Figure 3. Determine the CNF-to-GPTMS ratio to achieve the highest height retention rate for the aerogel. (A) CNF : GPTMS = 1:1. (B) CNF : GPTMS = 2:1. (C) CNF : GPTMS = 4:1.



Supplementary Figure 4. Determine the $\text{TiO}_2@\text{MXene}$ -to-CNF ratio to achieve the highest height retention rate for the aerogel. (A) $\text{TiO}_2@\text{MXene}:\text{CNF} = 1:1.5$. (B) $\text{TiO}_2@\text{MXene}:\text{CNF} = 1:2$. (C) $\text{TiO}_2@\text{MXene}:\text{CNF} = 1:3$.



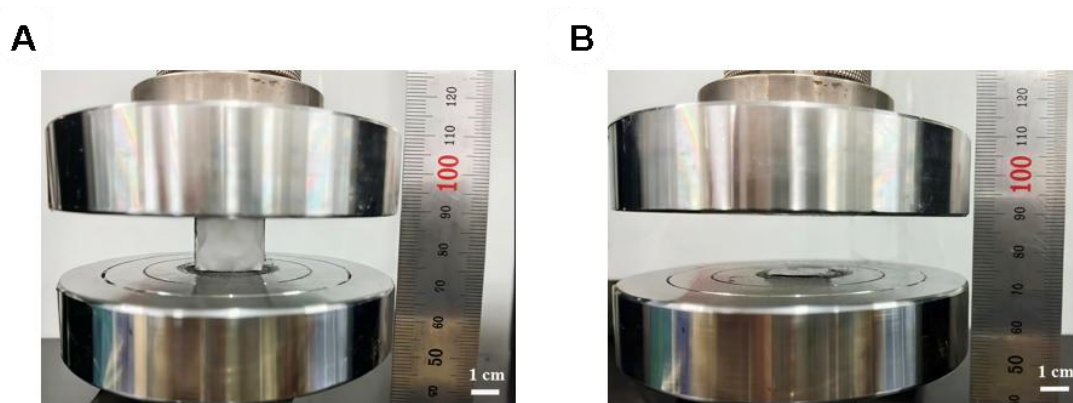
Supplementary Figure 5. Repeatability data for compressive strength and height retention with (A) different ratios of T@M to C , (B) different ratios of CNF to GPTMS , and (C) different oxidation time for MXene . The error bars represent the standard deviation of the data obtained from three independent replicates (n=3).



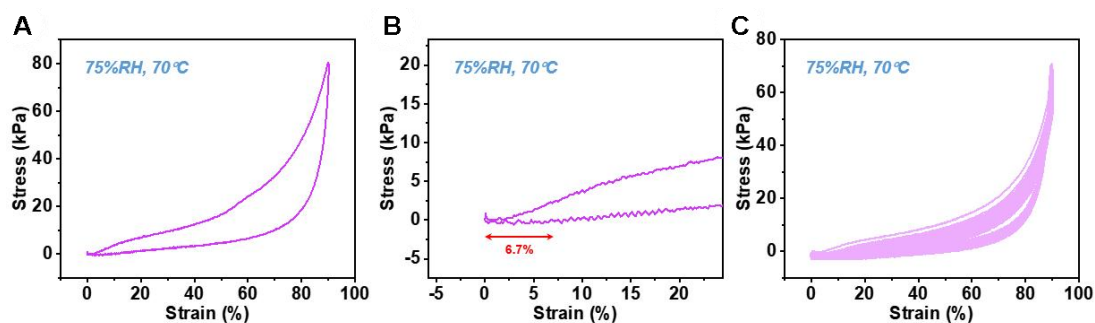
Supplementary Figure 6. (A) SEM image of pure CNF aerogel. (B) SEM image of MXene/CNF aerogel. (C) SEM image of G-M/C aerogel. (D) SEM image of G-T@M/C aerogel.

Supplementary Table 1. Summary of the pore sizes and densities of different samples

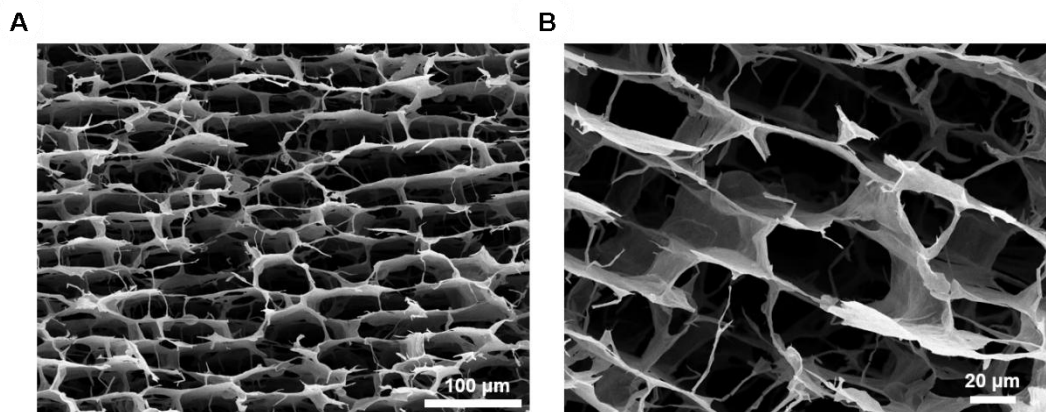
Sample	Pore size (μm)	Density (mg/cm^3)
Pure CNF	21.27 μm	16.32
MXene/CNF	27.36 μm	12.52
G-M/C	28.24 μm	11.76
G-T@M/C	29.00 μm	11.11



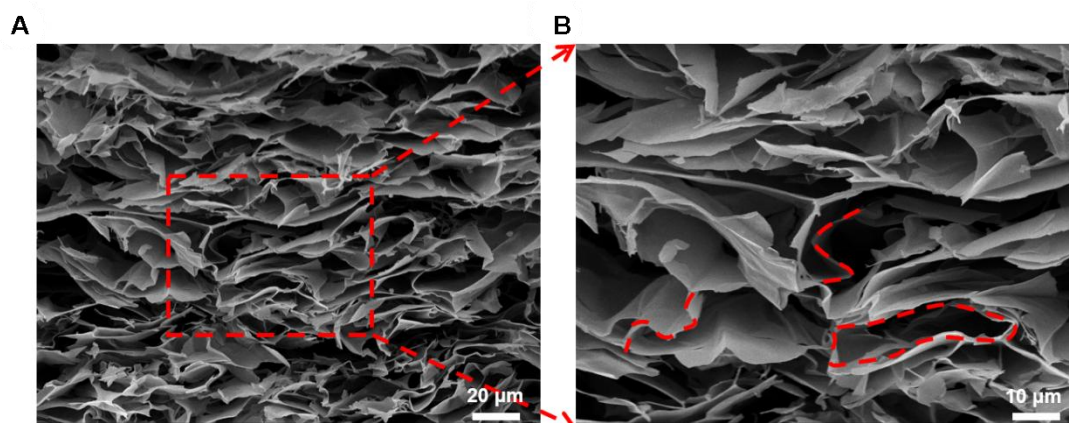
Supplementary Figure 7. Schematic diagrams of pure CNF (A) before compression and (B) after compression.



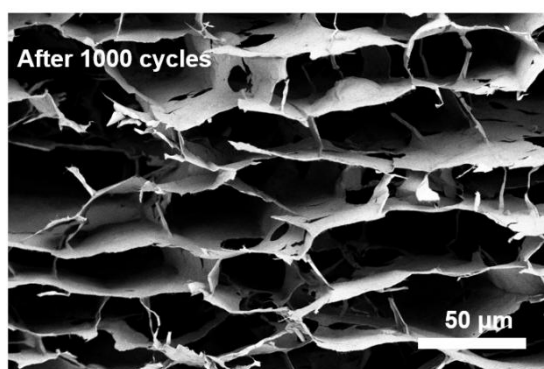
Supplementary Figure 8. Aged test data collected at 75% humidity and 70°C for a 12-hour period. (A) Stress-strain curve of 90% compression after at 75% humidity and 70°C for a 12-hour period. (B) Partial enlargement of (A). (C) Stress-strain curve for 90% compression after at 70°C and 75% humidity for a 12-hour period, after 100 cycles.



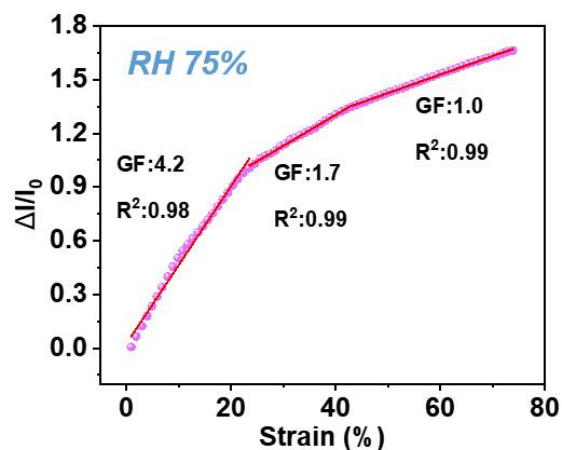
Supplementary Figure 9. (A) The SEM images of the G-T@M/C aerogel in the original state. (B) is a partial enlarged view of (A).



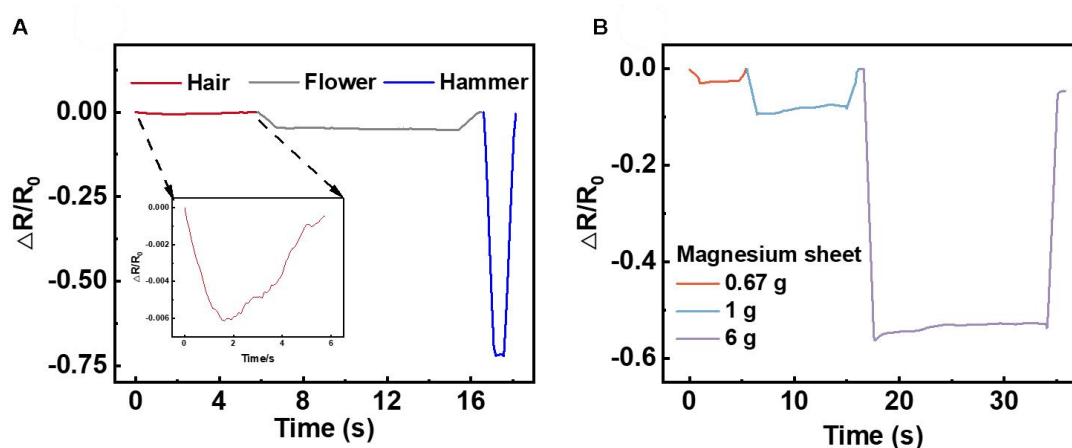
Supplementary Figure 10. (A) The SEM images of G-T@M/C aerogel at 90% compression strain. (B) is a partial enlarged view of (A).



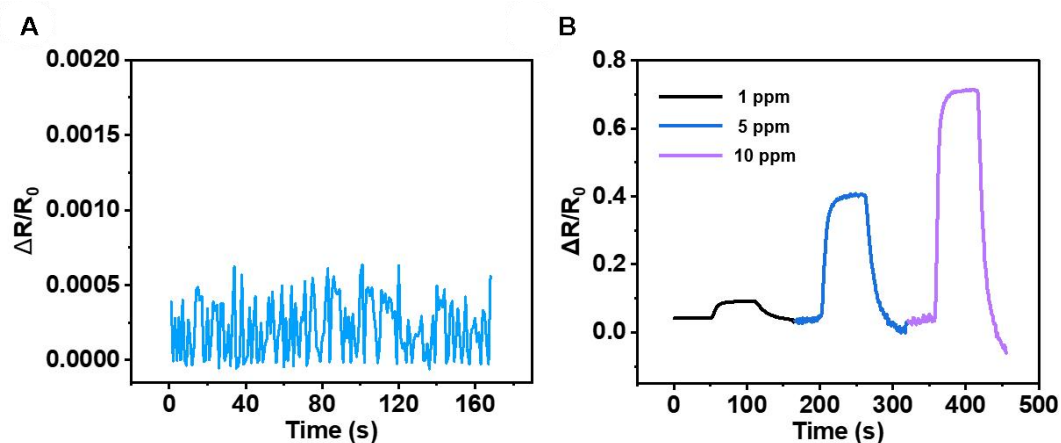
Supplementary Figure 11. The SEM image of G-T@M/C aerogel after 1000 cycles at 90% compressive strain.



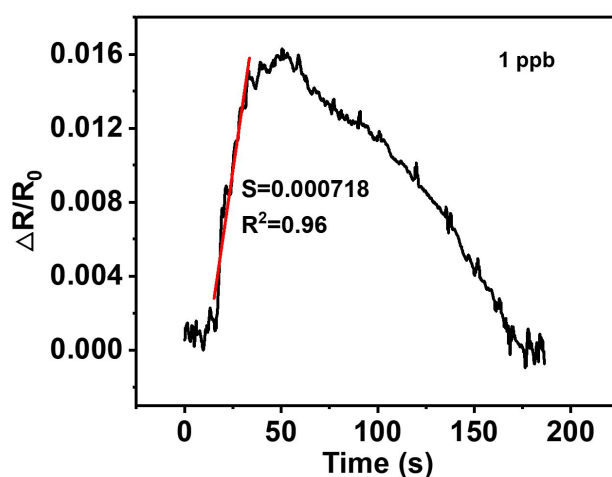
Supplementary Figure 12. Relative current variation curve of G-T@M/C at 75% humidity within a strain range of 0% to 80%.



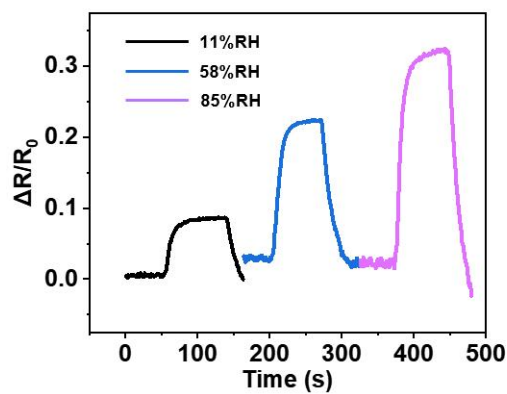
Supplementary Figure 13. G-T@M/C aerogel distinguishes between different objects and different masses of the same object. (A) Resistance changes when hair, flower, and hammer were placed on G-T@M/C aerogel. (B) Resistance changes when magnesium sheets of different masses were placed on G-T@M/C aerogel.



Supplementary Figure 14. (A) Resistance response of the sensor when exposed to different concentrations of sulfur dioxide. (B) Resistance response of the sensor when exposed to different concentrations of nitrogen dioxide.



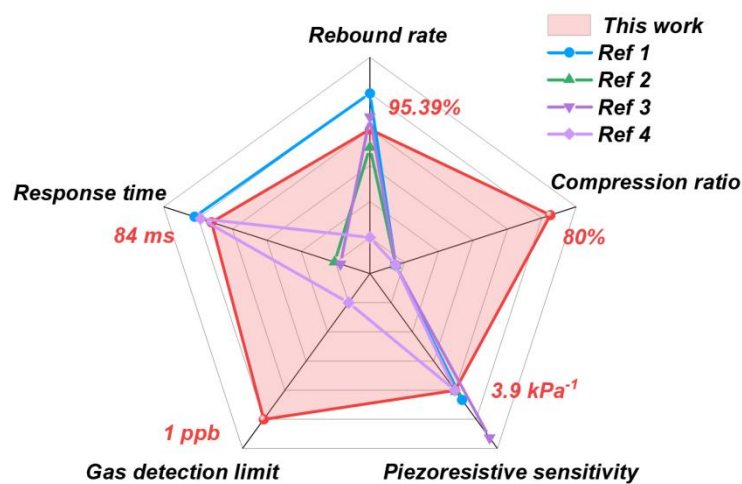
Supplementary Figure 15. Noise Analysis of the 1 ppb Ammonia Response



Supplementary Figure 16. Resistance response when 10 ppm ammonia gas is introduced into environments with different humidity levels.

Supplementary Table 2. Summary of Related Article Data

Reference	Rebound rate (%)	Compression ratio (%)	Piezoresistive sensitivity (kPa ⁻¹)	Gas detection limit (ppb)	Response time (ms)
<i>Adv. Sci.</i> 12 (26) (2025) 2502797 ^[1]	98	50	167	/	4.71
<i>ACS Sustainable Chem. Eng.</i> 2023, 11, 8, 3208–3218 [[] 2]	95	50	25.6	/	480
<i>Nano-Micro Lett.</i> 15 (2023) 98 ^[3]	96.7	50	817.3	/	500
<i>ACS Appl. Nano Mater.</i> 2025, 8, 14, 7407–7417 [[] 4]	90	50	/	5	/
This work	95.39	80	3.9	1	84



Supplementary Figure 17. Comparison of the performance of the G-T@M/C composite aerogel against previously reported bimodal sensors.

Supplementary Video 1. The cushioning test of an egg dropped from a height of 100 cm when G-T@M/C aerogel was used as a cushioning material.

Supplementary Video 2. G-T@M/C aerogel causes the light to illuminate when detecting ammonia gas leaks.

REFERENCES

1. Wang, A.; Gao, Z.; Wu, S., et al., Superelastic and Ultra-Soft MXene/CNF Aerogel@PDMS-Based Dual-Modal Pressure Sensor for Complex Stimuli Monitoring. *Advanced Science* **2025**, *12*, 26. <http://dx.doi.org/10.1002/advs.202502797>.
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3. Xu, T.; Song, Q.; Liu, K., et al., Nanocellulose-Assisted Construction of Multifunctional MXene-Based Aerogels with Engineering Biomimetic Texture for Pressure Sensor and Compressible Electrode. *Nano-Micro Letters* **2023**, *15*, 1. <http://dx.doi.org/10.1007/s40820-023-01073-x>.
4. Lu, Z.; Kou, Y.; Hua, L., et al., Porous and Flexible Aramid Nanofiber/MXene Nanosheet Composite Aerogel for Rapid Ammonia Sensing at Room Temperature. *ACS Applied Nano Materials* **2025**, *8*, 14, 7407-7417. <http://dx.doi.org/10.1021/acsanm.5c01678>.