Supporting Information

Plasmonic MXene/Au@Ag Core-Shell Heterostructures: A Unified Platform for Electromagnetic Stealth, Antimicrobial Action, and Environmental Remediation

Hong Wang [a#], Xin Yang [a#] Tong Zhu [a], Xiao Su [a], Liang Xiao [b], Qianqian Yu [a], Pingan Liu [b*], LinGe Wang [a*]

[a] South China Advanced Institute for Soft Matter Science and Technology, School of Emergent Soft Matter, Guangdong Provincial Key Laboratory of Functional and Intelligent Hybrid Materials and Devices, Guangdong Basic Research Center of Excellence for Energy & Information Polymer Materials, South China University of Technology, Guangzhou 510640, China.

[b] School of Materials Science and Engineering, South China University of Technology, Guangzhou 510640, China.

[#] H. Wang and X. Yang are contributed equally to the work.

*Corresponding authors: paliu@scut.edu.cn (P. A. Liu), lingewang@scut.edu.cn (L. G. Wang).

Figure Captions

Fig. S1. TEM image of MXene/Au and MXene/Ag.

Fig. S2. C_0 values of MXene/Au, MXene/Ag, MXene/Au@Ag composite material.

Fig. S3. RL curves of MXene/Ag, MXene/Au, and MXene/Au@Ag composites at different thicknesses.

Fig. S4. Quantitative analysis of bacterial biofilm experiment.

Antibacterial experiment

Plate Coating: *E. coli* and *S. aureus* were inoculated into LB liquid medium and cultured with shaking at 37 °C for 6 hours. Groups were established: blank control (no material, no light), light control (no material, with light), material experimental group (with material, no light), and material-light experimental group (with material, with light). MXene/Au@Ag material was added to the material and material-light experimental groups, and 1 mL of bacterial suspension was co-incubated for 12 hours. The light and material-light groups were then subjected to light treatment, with the material-light group exposed to different light durations. Subsequently, the bacterial suspension was diluted 10^4-fold with sterile physiological saline. A 50 μL aliquot of the diluted suspension was evenly spread on the surface of luria-bertani (LB) solid medium. The plates were incubated at 37 °C for 24 hours, after which they were photographed to assess the antibacterial effect.

Alamar Blue Quantification: A 100 μL aliquot of bacterial suspension co-incubated with the material for 12 hours and subjected to light treatment was transferred to a 96-well plate. Each well was supplemented with 10 μL of Alamar Blue reagent. The absorbance was measured at 590 nm using a microplate reader, and the bacterial survival rate was calculated.

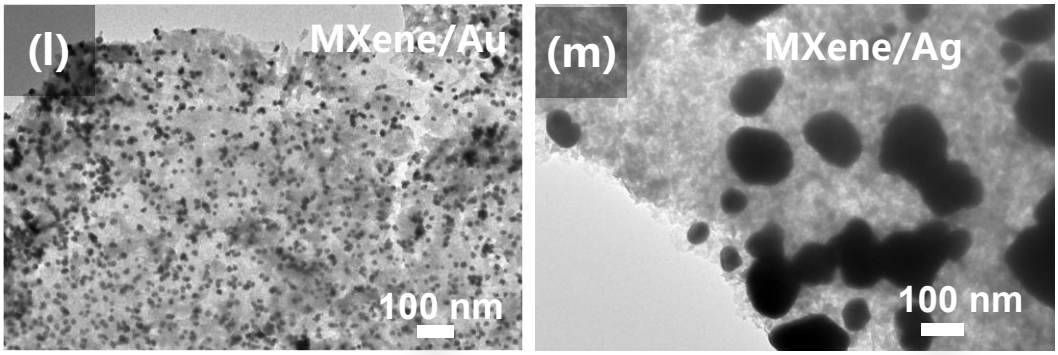
AO/EB Live/Dead Staining: A 10 μL aliquot of bacterial suspension co-incubated with the material and subjected to light treatment was mixed with 10 μL of AO/EB staining solution (AO: EB= 1:1:8) and stained in the dark at room temperature for 5 minutes. The stained suspension was placed on a glass slide, covered with a coverslip, and observed under a fluorescence microscope. Live cells exhibited green fluorescence (AO staining), while dead cells showed red fluorescence (EB staining).

SEM Morphological Characterization: A 500 μL aliquot of bacterial suspension co-incubated with the material and subjected to light treatment was centrifuged (3000 rpm, 4 min), and the supernatant was discarded. The sample was washed with PBS and fixed with 2.5% glutaraldehyde solution for 30 minutes. Dehydration was performed using a graded ethanol series (30%, 50%, 70%, 90%, 100%), with each step lasting 10 minutes. The sample was dried, sputter-coated with gold, and observed under SEM to

examine morphological changes in the bacteria on the material surface.

Biofilm Experiment: For the anti-biofilm experiment, the target strains were inoculated into liquid medium and cultured with shaking at 37 °C until the logarithmic growth phase. The bacterial suspension was diluted 10^4-fold with medium. The test material was added to a 24-well plate, with 1 mL of bacterial suspension added to each well and subjected to light treatment. The plate was incubated statically at 37 °C for 24 hours to observe biofilm formation. For the biofilm disruption experiment, the target strains were diluted 10^4-fold and added to a 24-well plate, with 1 mL of bacterial suspension added to each well and cultured with shaking at 37°C for 24 hours to form a biofilm. The material was added to the 24-well plate and co-incubated for 12 hours, followed by light treatment. The extent of biofilm disruption was observed. The biofilm was gently rinsed with PBS buffer and stained with 0.1% crystal violet solution for 15 minutes. Excess dye was removed by rinsing with deionized water. The crystal violet was dissolved with 95% ethanol, and the absorbance was measured at 570 nm using a microplate reader to assess the amount of biofilm formed.

DCFH-DA (2',7'-Dichlorodihydrofluorescein Diacetate) Reactive Oxygen Species (ROS) Detection: DCFH-DA was dissolved in DMSO to prepare a 10 mM stock solution, aliquoted, and stored at -20°C in the dark. The stock solution was diluted to a working concentration (10 μM), and the diluted DCFH-DA solution was added to the material. The sample was irradiated with a xenon lamp, with an excitation wavelength of 488 nm and an emission wavelength of 525 nm. The fluorescence intensity was proportional to the ROS level. The fluorescence emission intensity of the solution was recorded at different time intervals, and statistical analysis was performed to compare ROS levels among different experimental groups.



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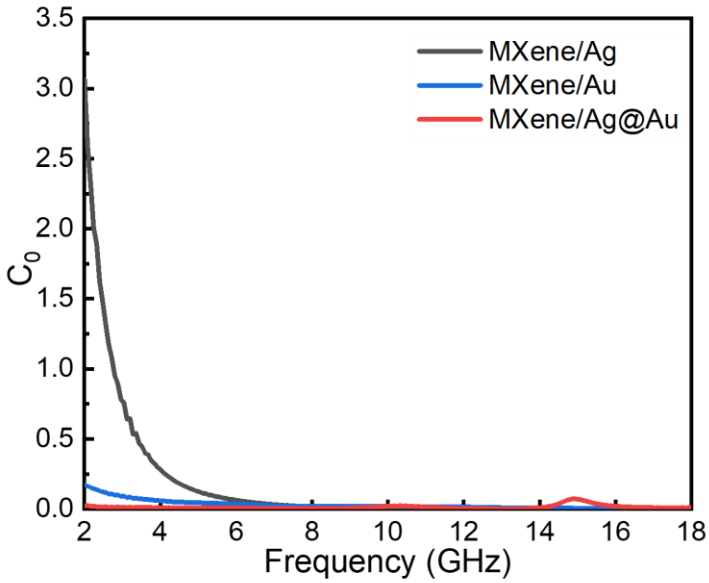


Fig. S2. C_0 values of MXene/Au, MXene/Ag, MXene/Au@Ag composite material.

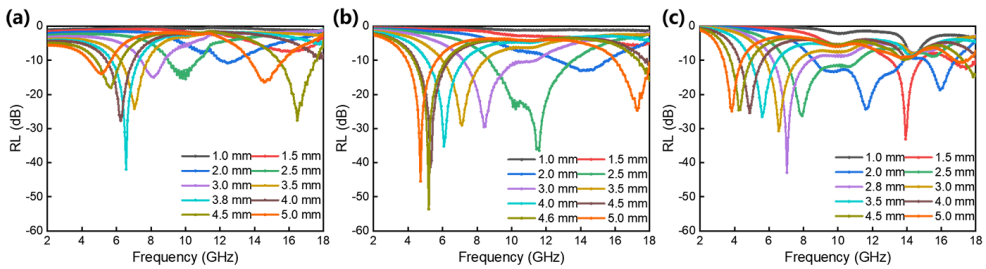
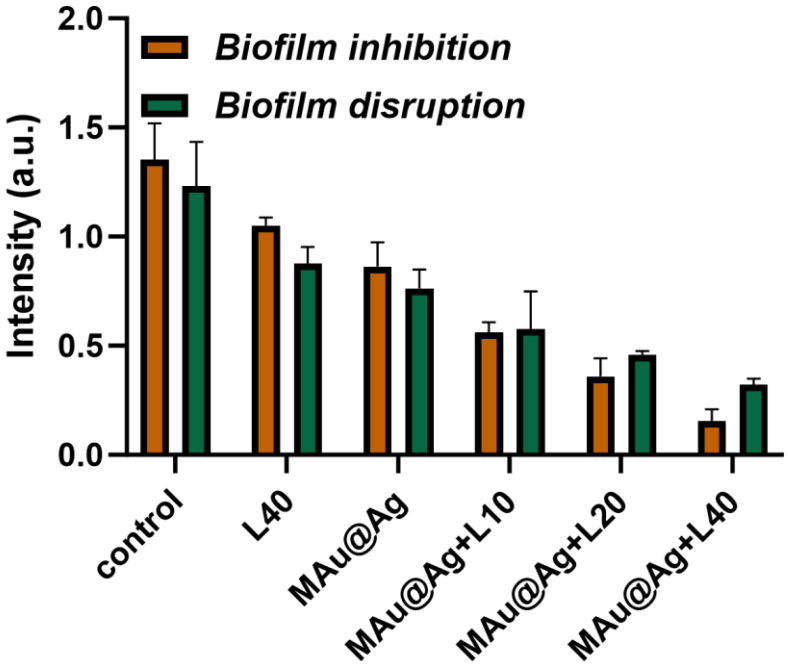


Fig. S3. (a) RL curves of MXene/Ag, (b) RL curves of MXene/Au, and (c) RL curves of MXene/Au@Ag composites at different thicknesses.



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