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Polyphenol-assisted assembly of Au-deposited microneedles for surface-enhanced Raman scattering (SERS) sensing and antibacterial photodynamic therapy



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Abstract

3D SERS microneedles (MNs) with self-assembled AuNP formation were developed with tannic acid (chemical glue and reductant) on biocompatible polylactic acid microneedles for in-depth chemical and biomolecular analysis, being LOD below 200 ppb for small molecules (purine-based molecules, methylene blue, and rhodamine 6G) and 10^2 CFU/cm² for bacteria. MB/Au-combined MNs provided 650 nm light-activated photodynamic therapy with SERS-monitored photosensitizer degradation.

Concept



Fig 1. The preparation process of 3D SERS/PDT-active microneedles: Transparent polylactic acid microneedles (PLA MNs) are added tannic acid and HAuCl₄, forming (a) Au-deposited microneedles (AuMNs) for frontside/backside SERS detection, and subsequently coating with methylene blue to form (b) Au/MB-deposited microneedles (AuMNs-MB) for antibacterial photodynamic therapy.

SERS performance

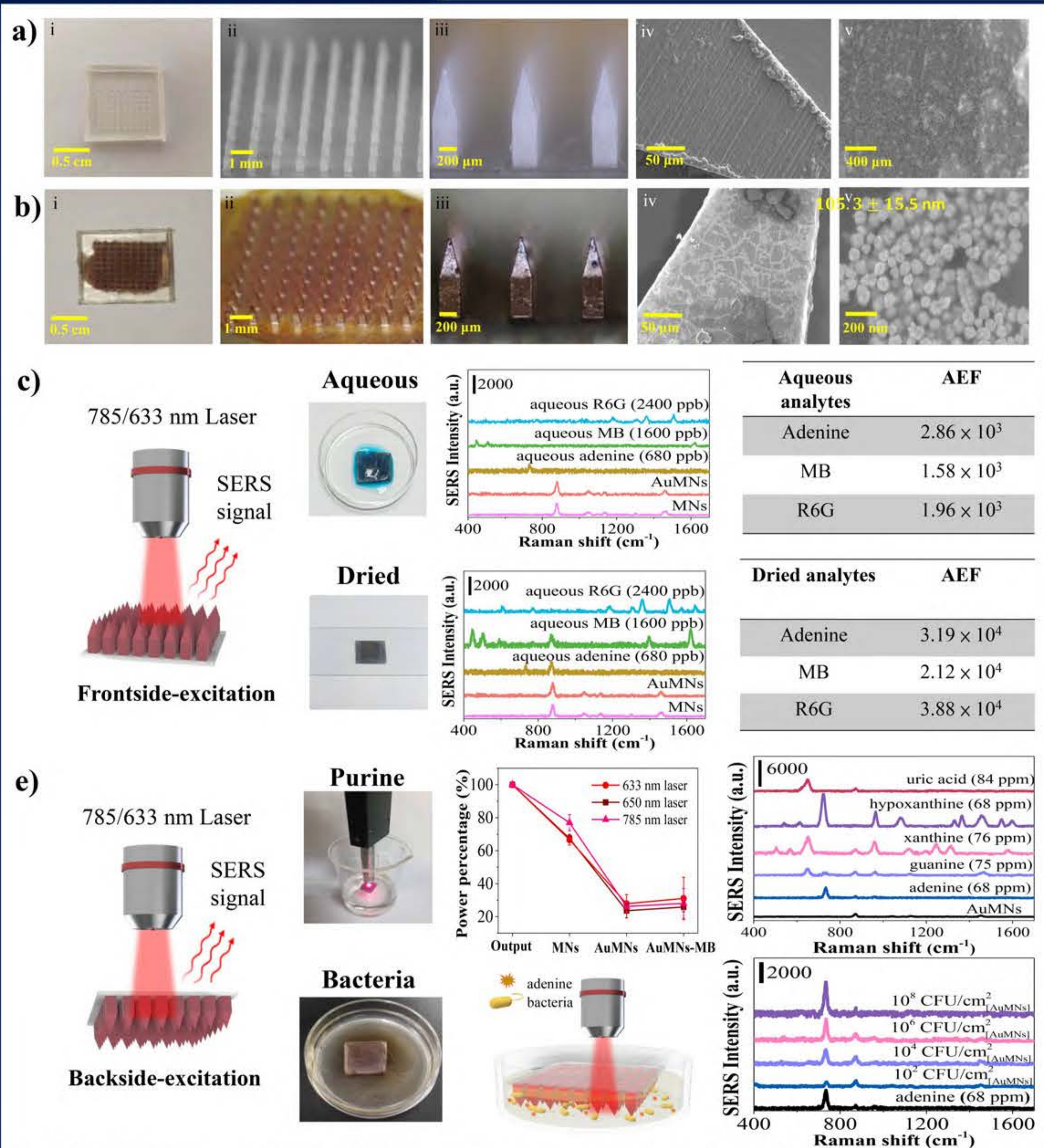


Fig 2. (a-b) SEM images. (c) Frontside SERS detection and (d) backside SERS detection for purine and bacteria (*S.aureus*).

Photodynamic therapy

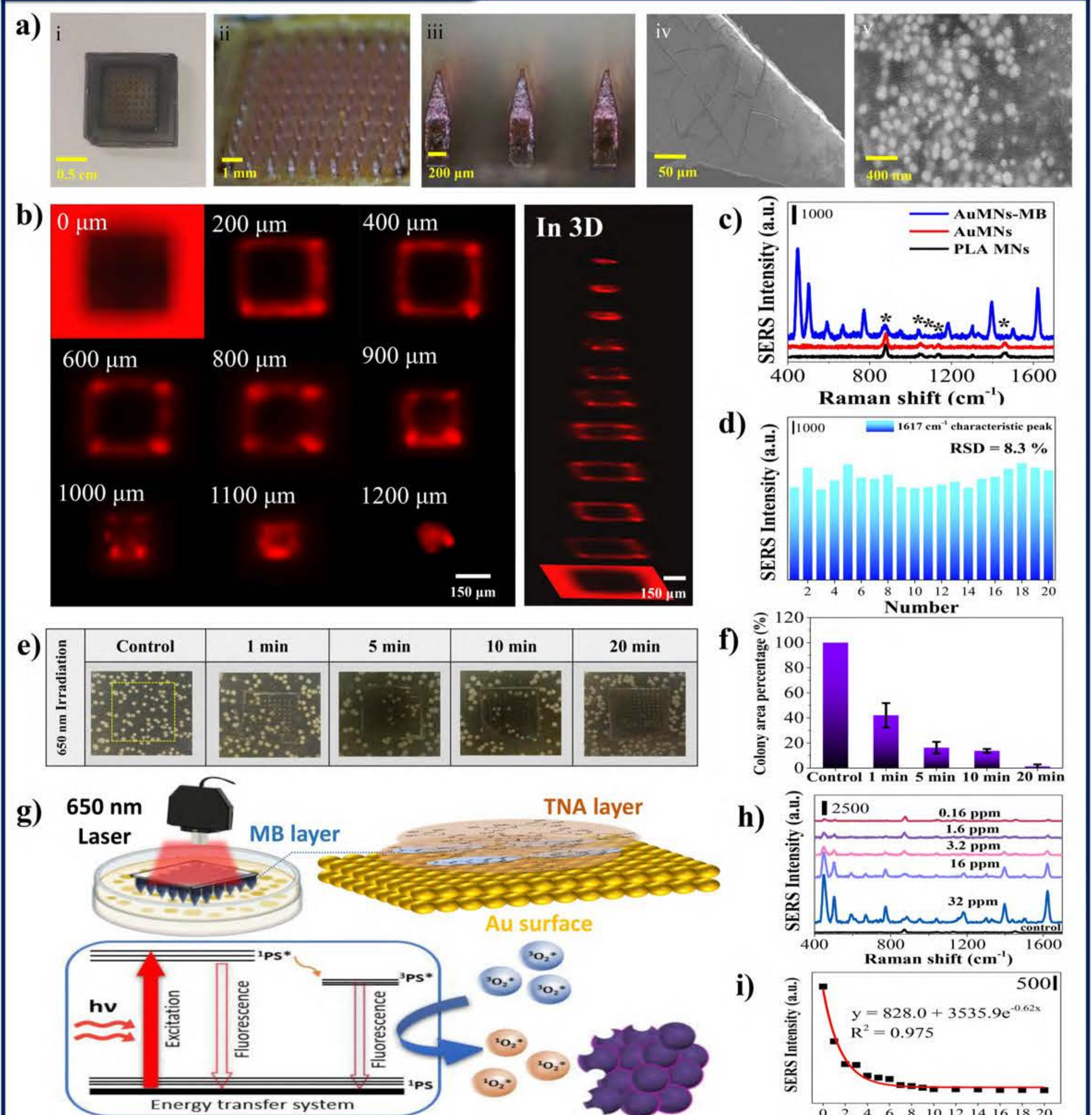


Fig 4. (a) SEM images, (b) cross-sectional SERS images, (c) SERS spectra and its signal reproducibility, (e-f) Bacterial inhibitions by AuMNs-MB with 1-20 min of 650 nm irradiation. (g) Scheme of AuMNs-MB proposed structure for PDT. (h) Detection during PDT.

Conclusion

A simple green reagent-based synthesis was developed to fabricate Au-based 3D SERS-functional MNs. The Au/TNA layer on SERS-active MNs is able to detect small molecules or purine-based metabolites from bacterial. The TNA/MB-hybridized layers were used for SERS-combined PDT, allowing antimicrobial growth in colonies and the detection of residual MB during PDT.

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