Photosafe non-invasive detection of deep-seated lesions via transmission Raman spectroscopy

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ABSTRACT

Non-invasive localization of deep lesions remains a long-standing pursuit for clinical applications, and its key point lies in the detection and depth estimation of a single lesion in heterogeneous tissues. At present, full optical modalities are widely applied for biomedical sensing, diagnosis, and intraoperative guidance. However, due to the strong photon absorption and scattering of biological tissues, it is challenging to realize in vivo deep detections, particularly for those using the safe laser irradiance below biological maximum permissible exposure (MPE) [1].

We reported in vivo surface-enhanced transmission Raman spectroscopy (SETRS) to achieve the non-invasive and photosafe localization of deep lesion deeply hidden in either ex vivo thick tissues or in vivo mice model [2-4]. We synthesized the near-infrared SERS nanotags with single-nanoparticle detection sensitivity, and developed a home-built TRS system with an enlarged beam size to lower the laser power density to 0.264 W/cm^2, below the MPE criteria. By using the TRS system, we successfully demonstrated the detection of SERS nanotags through up to 14-cm-thick ex vivo porcine tissues, as well as in vivo imaging of "phantom" lesions labeled by SERS nanotags in an unshaved mouse under MPE. Furthermore, we theoretically and experimentally demonstrate a universal method to achieve the depth estimation of phantom lesions ex vivo tissues, and also realized in vivo accurate localization of deep sentinel lymph nodes in a live rat model. This work highlights the potential of transmission Raman-guided identification and noninvasive imaging toward clinically photosafe cancer diagnoses.

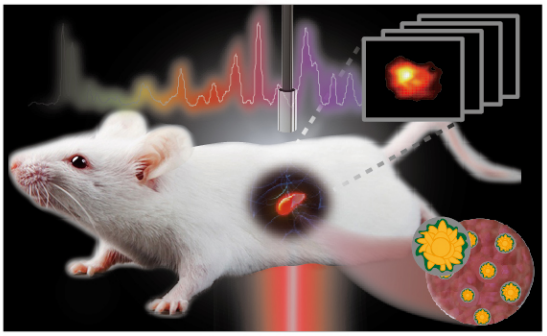

Figure: *Schematic of non-invasive in vivo imaging of deep-seated tumor through living mice by using a transmission setup and ultra-bright SERS contrast agent*

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