MRI Active Gold Nanoshells for MRI Guided Localized Photothermal Therapy

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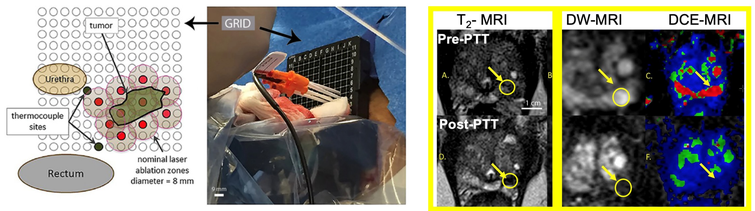
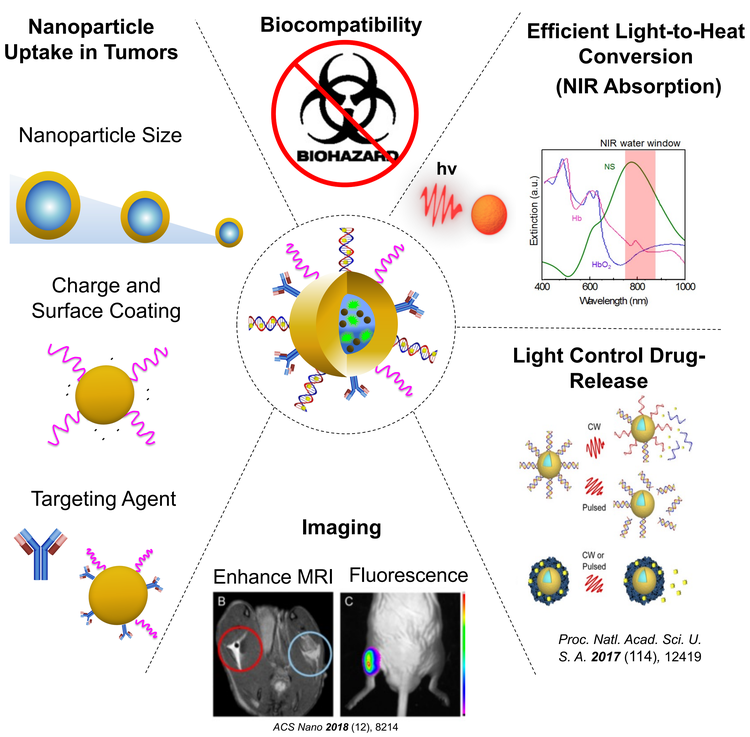
Overview



The purpose of this research is to develop a nanostructure that can induce localized photothermal therapy (PTT) in solid tumors and guide the therapy under magnetic resonance imaging (MRI), simultaneously. Clinical trial using Gold nanoshells (NSs) have shown promising results in photothermal ablate prostate tumor of 15/16 patients with minimum side effects. This is exciting, however, for better cancer treatment outcome, we need to address the distribution of NSs and the real-time thermal mapping within the ablation zone. To address these concerns and to further extend the functionality of gold NSs within clinic, we have designed MRI-active gold NSs that induce MRI-guided PTT under NIR illumination for better therapy outcome.

Gold-based Nanoparticles for Nano Therapy



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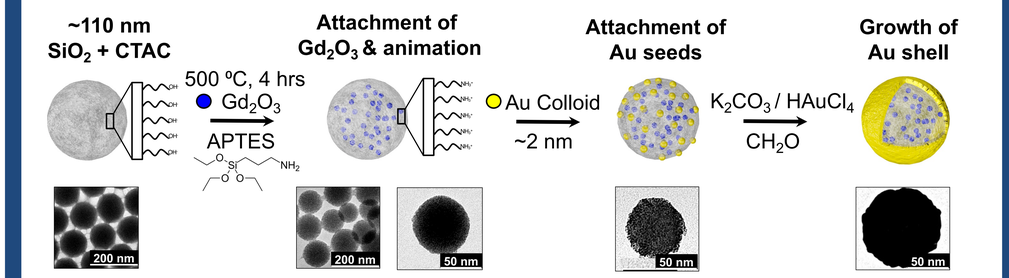
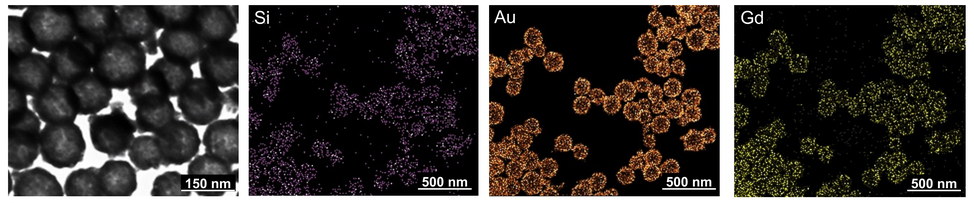
Gd_2O_3-Mesoporous Silica Nanoshells (MS NSs) Synthesis



Synthesis step process involving: (1) synthesis of mesoporous silica, (2) synthesis of ultra small Gd_2O_3 nanoparticles, (3) loading the mesoporous silica nanoparticles with the ultra small Gd_2O_3 nanoparticles, (4) growing a thin Au shell.

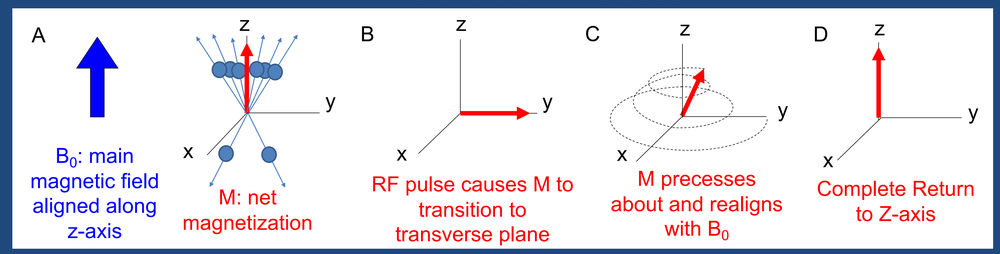
STEM-HAADF Energy Dispersive X-ray Mapping



Gd_2O_3 -MS NSs were loaded into the interior channels or adsorbed on the surface

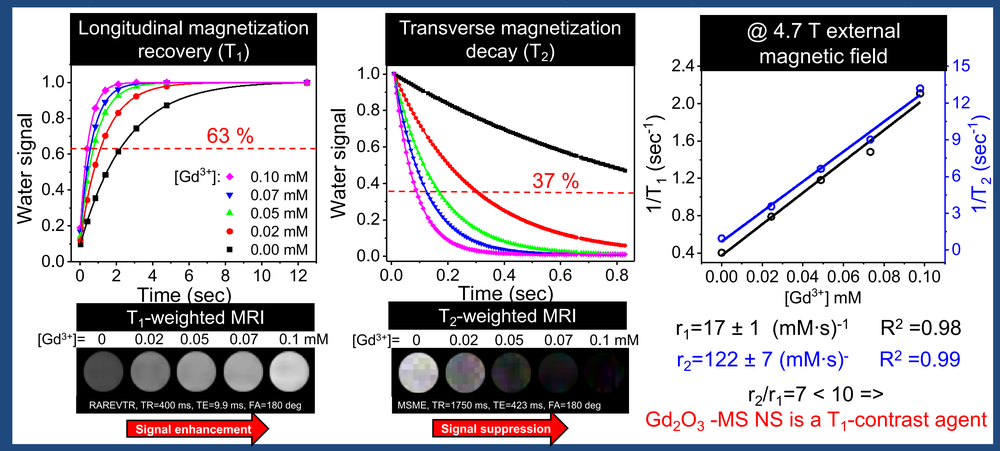
STEM-HAADF- Scanning transmission electron microscopy high-angle annular dark-field images

MRI Relaxation Process

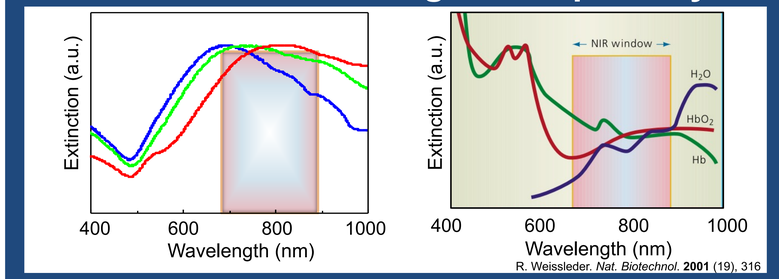


Gd_2O_3 -MS NS Relaxation Rates (r_1 & r_2)

(100 nm MS core, 22 nm Au shell, $(3.3 \pm 0.1)\times10^6$ Gd^{+3}/NS)



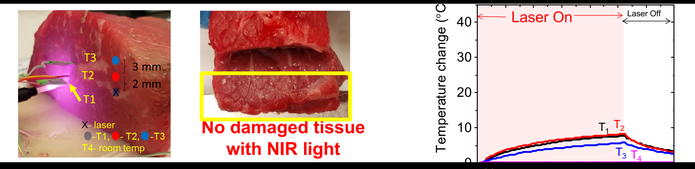
Strong Near-infrared (NIR) Resonance where Tissue has High Transparency



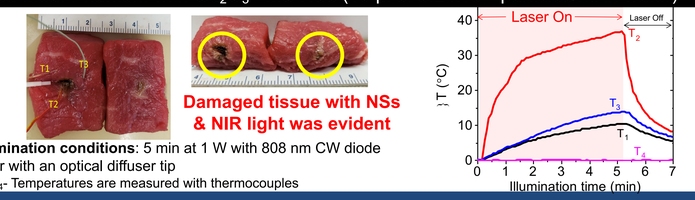
R. Weissleder. *Nat. Biotechnol.* **2001** (19), 316

Gd_2O_3-MS NSs Assisting Localized PTT

Red Meat Phantom without NSs



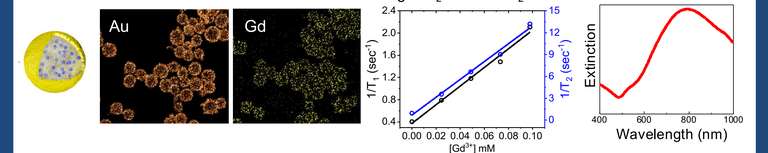
Red Meat Phantom with Gd_2O_3 –MS NSs (10 µl of 8.2 x10^{11} particles/ml in water)



Illumination conditions: 5 min at 1 W with 808 nm CW diode laser with an optical diffuser tip
T_1-T_4- Temperatures are measured with thermocouples

Conclusion

- We have successfully synthesized and characterized Gd_2O_3-MS NSs



- No tissue damaged was detected with NIR light, but an evident tissue damaged was observed with both NIR illumination and NSs presence.
- Gd_2O_3-MS NSs enable both MRI visualization and NIR photothermal therapy which is ideal for MRI-guided localized PTT of solid tumors.

This study demonstrates a valuable new dual-function capability that will quickly translate the usage of "See and Treat" MRI-active gold NSs into the clinic.

Future work: PTT condition optimization (NS concentration, laser power, illumination time, etc.) *in vitro* under MRI guidance for an effective treatment and better outcome.

References

References Y. Kadria-Vili, et al., manuscript in preparation.

Internship Partnership for Careers in Cancer Science & Medicine