

The Little Nanoclay that Could : Natural Halloysite Nanotubes Functionalized for Selective and Superior Antibacterial Activity

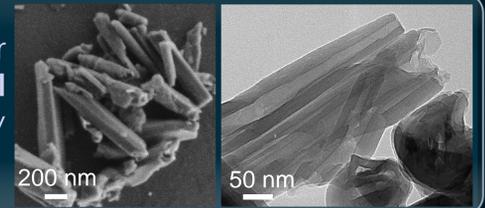
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Concept

Global surge in antibiotic resistance and the need to minimize antibiotic-associated dysbiosis call for more efficient and selective antibacterial solutions. We suggest the utilization of the **natural clay mineral Halloysite nanotubes (HNTs)**, functionalized with **antibodies (Ab-HNTs)**, as carriers for the selective delivery of (1) **ciprofloxacin (CIP)** – or – (2) **photothermal gold nanorods (AuNR)**



Antibody Surface Immobilization

Figure 1: High-throughput imaging flow cytometry indicates the selective binding of Ab-HNTs to target bacteria (*E. coli*) in a heterogenous culture

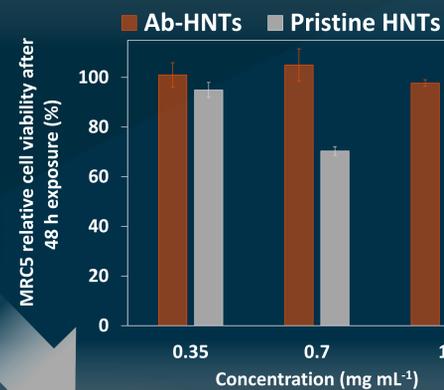
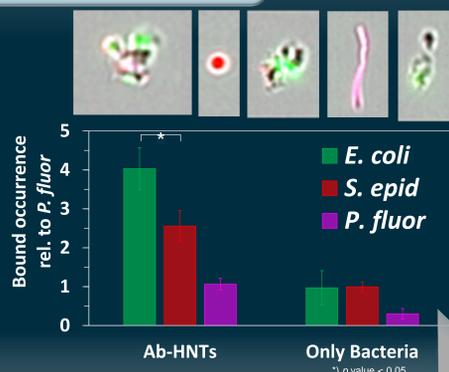


Figure 2: MRC5 cell viability assay suggests higher biocompatibility of Ab-HNTs in comparison to pristine HNTs after 48 h of exposure

Ciprofloxacin Loading

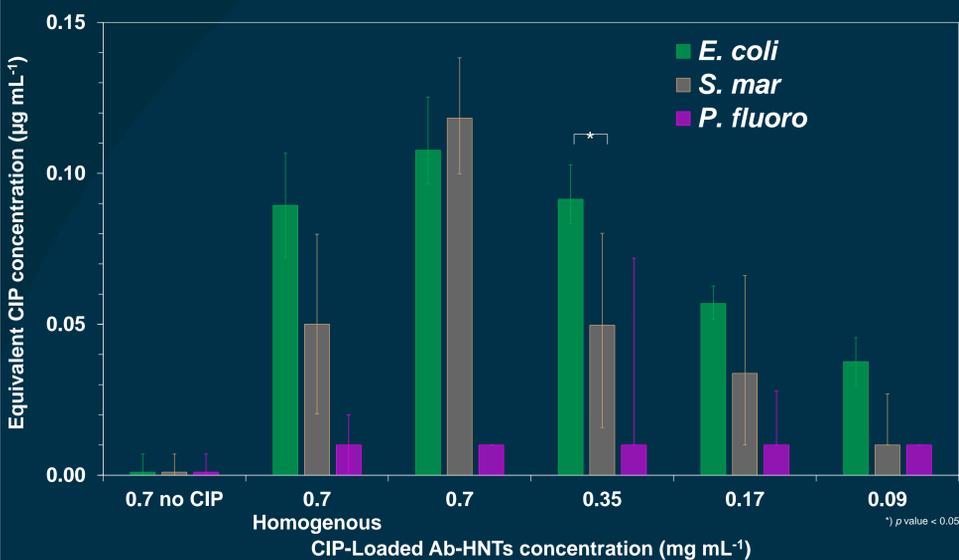
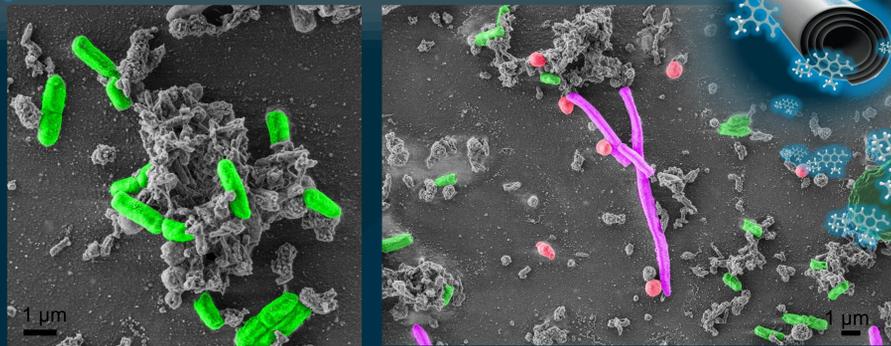


Figure 3: Selective binding and antibacterial activity of CIP-loaded Ab-HNTs. **Top)** Electron microscopy micrographs depicting mixtures of bacteria and antibiotic-loaded clay nanotubes. **Bottom)** Antibacterial effect, expressed as equivalent CIP concentration, measured by plate count on selective media

Summary

- Halloysite nanotubes functionalized with antibodies selectively bind to target bacteria.
- The potency of ciprofloxacin, loaded onto the functionalized clay, is selectively enhanced.
- Gold nanorods, incorporated onto Ab-HNTs, exert a superior antibacterial photothermal effect to that of free AuNR.
- The natural clay could be loaded with various antimicrobial payloads and tailored against any microorganism in the future by facile Ab adjustment

Gold Nanorods Incorporation

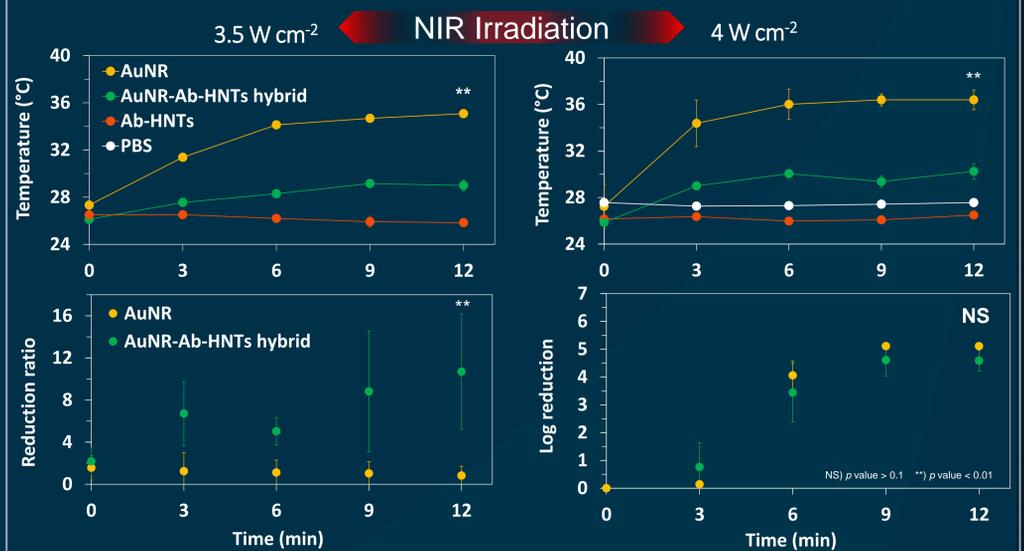
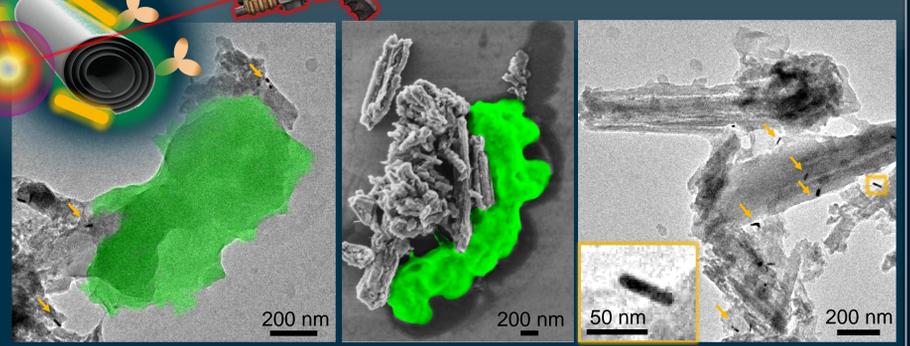


Figure 4: Superior antibacterial photothermal effect by AuNR-Ab-HNTs hybrids. **Top)** Electron microscopy micrographs of clay-gold hybrids (AuNR indicated by yellow arrows) and their irradiated mixtures with *E. coli*. **Bottom)** Temperature profiles and the corresponding antibacterial effect upon NIR irradiation