Manipulated Bacteria Interactions with Functionalized Gold Nanoparticles for Rapid Bacteria Detections and Infection Control

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Statement of Purpose:

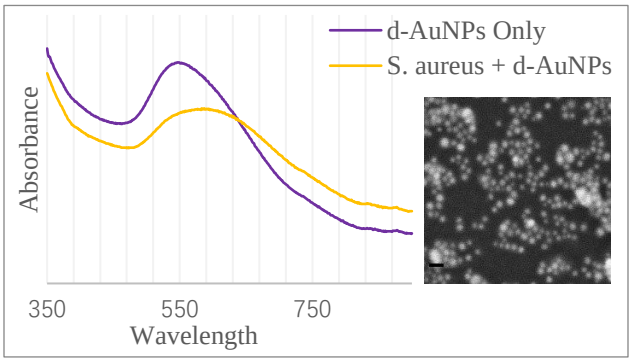
Early detection and control of bacterial infections are very important but challenging. Gold nanoparticles (AuNPs) possess chemical inertness, biocompatibility, and somehow antibacterial effects. Functionalized AuNPs for diagnosis and antibacterial applications have drawn great attention in the past decade[1, 2]. Our laboratory has developed dopamine functionalized AuNPs with controlled self-assembly properties [3]. Through well controlled synthesis, dopamine functionalized AuNPs (d-AuNPs) with defined chemistry and predicted interactions with bacteria were obtained. Potential applications of d-AuNPs in rapid bacteria detections and infection control were explored.

Methods:

Au NPs were synthesized from gold (III) chloride (HAuCl4) using sodium borohydride (NaBH4) as the reducing agent. Dopamine with borate protected hydroxyl groups was linked to pre-formed AuNPs through carbon disulfide (CS_2) mediated conjugations. The reactions were precisely controlled in order to create d-AuNPs with defined surface chemistry and properties. The chemical, physical, and biological properties of d-AuNP were studied using UV-Vis spectroscopy, dynamic light scattering (DLS), electron microscopies (SEM/TEM), Fourier-transform infrared spectroscopy (FTIR), and confocal microscopy. Interactions of d-AuNPs with bacteria were investigated in detail using gram-negative and gram-positive bacteria. Effects of d-AuNPs on bacteria growth and dividing were also studied.

Results:

The d-AuNPs with tunable chemical and physical properties were obtained. The d-AuNPs with defined surface chemistry proceeded self-assembly and attachment onto material surfaces as well as cell membranes in a controllable manner. Reaction and interaction of d-AuNPs with bacteria showed altered spectrometric profiles (Figure 1), it was used for rapid bacteria detection and identification. In addition, d-AuNPs of different chemistries also demonstrated certain antibacterial activity by inhibiting bacteria growth or causing cell death. Therefore, we explored the possibility of utilizing d-AuNPs for improved infection control and management.



Peak Value	Wavelength	Absorbance
d-AuNPs Only	555nm	0.456
S. aureus + d-AuNPs	590nm	0.358

Figure 1. SEM image of d-AuNPs coated surface (right, scale bar = 20nm) and UV-Vis spectrum (left) of d-AuNPs and d-AuNPs incubated with *S. aureus.*

References:

1. Boisselier, E. and D. Astruc, *Gold nanoparticles in nanomedicine: preparations, imaging, diagnostics, therapies and toxicity.* Chem Soc Rev, 2009. **38**(6): p. 1759-82.
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3. Liu, T., et al., *Adhesive Gold Nanoparticles for Easy and Controlled Surface Coating.* Langmuir, 2019. **35**(7): p. 2728-2737.

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