

## Supporting Information for

# Functional Gold Nanoparticles as Potent Antimicrobial Agents against Multi-Drug-Resistant Bacteria

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### Nanoparticles synthesis

2 nm diameter gold nanoparticles were synthesized by the Brust-Schiffrin two-phase methodology<sup>1</sup> using pentanethiol as the stabilizer; these clusters were purified with successive extractions with ethanol and acetone. A Murray place exchange reaction<sup>2</sup> was carried out in dry DCM to functionalize the nanoparticles with each ligand.<sup>3, 4</sup> The monolayer-protected nanoparticles were redispersed in water and the excesses of ligand/pentanethiol were removed by dialysis using a 10,000 MWCO snake-skin membrane. The final concentration was measured by UV spectroscopy on a Molecular Devices SpectraMax M2 at 506nm according to the reported methodology.<sup>5</sup>

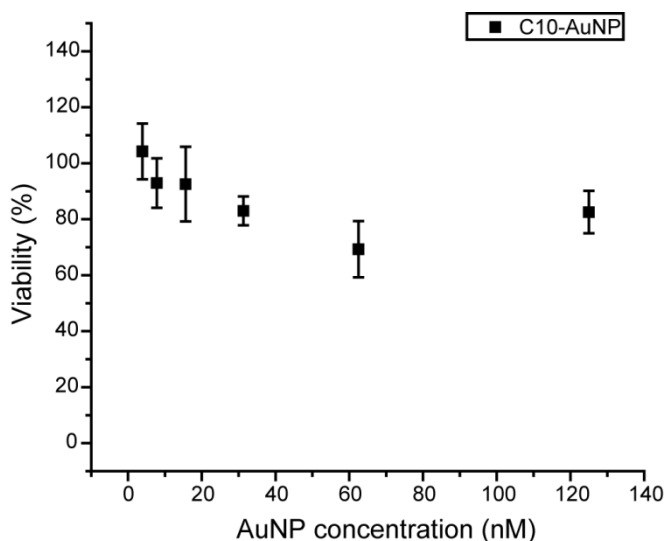
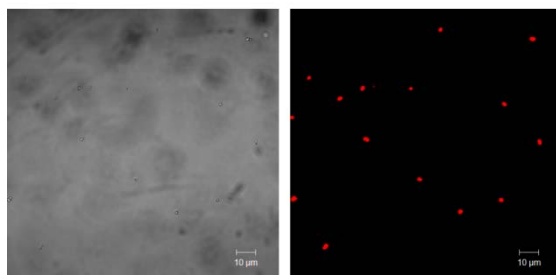


Figure S1. Viability of 3T3 mammalian cells after incubation with NP 3 (C10-AuNP) at different concentrations.

*E. coli* + C10-AuNP



*S. aureus* (MRSA) + C10-AuNP

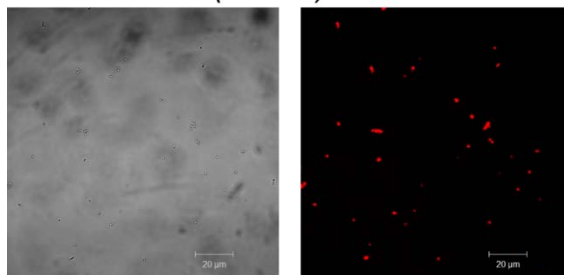


Figure S2. PI staining showing NP 3 (C10-AuNP)-induced bacterial cell membrane damage. Scale bar is 20 µm.

Table S1. Uropathogenic *E. coli* strain information. All strains were harvested and tested for susceptibility in Cooley Dickinson Hospital Microbiology Laboratory (Northampton, MA). S: Susceptible; I: Intermediate; R: Resistant.

	Riley Strain Name	CD-2	CD-3	CD-19	CD-496	CD-549
	<b>Species</b>	<i>E. coli</i>	<i>E. coli</i>	<i>E. coli</i>	<i>E. coli</i>	<i>E. coli</i>
	<b>Date Isolated</b>	9/11/2011	9/11/2011	9/12/2011	1/3/12	1/9/12
	<b>Specimen</b>	UCC	UCC	UCC	UCC	UCC
	<b>Cfu/ml</b>	>100,000	>100,000	>100,000	>100,000	>100,000
	<b>Note</b>			2 morphologies of <i>E. coli</i> with different susceptibilities		
<b>Aminoglycosides</b>	<b>Amikacin (Amikin)</b>		S			S
	<b>Gentamicin (Garamycin)</b>	S	R	S	S	R
	<b>Kanamycin High Level</b>					

	<b>Tobramycin (Nebcin)</b>		I			R
<b>β-Lactam</b>	<b>Ampicillin (Omnipen, Polycillin)</b>	R	R	R	R	R
	<b>Ampicillin/sulbactam (Unasyn)</b>	I	I	R	I	R
	<b>Amoxicillin/CA (Augmentin)</b>					I
	<b>Aztreonam (Zithromax)</b>					R
	<b>Oxacillin (Prostaphlin)</b>					
	<b>Penicillin</b>					
	<b>Piperacillin (Pipracil)</b>					R
<b>Cephalosporin</b>	<b>Ceftazidime (Fortaz, Tazicef)</b>					
	<b>Cefaclor (Ceclor, Ceclor CD)</b>					R
	<b>Ceftriaxone (Rocephin)</b>	S	S	S	S	R
	<b>Cefotaxime</b>					
	<b>Cefazolin (Ancef, Kefzol)</b>	S	S	I	R	R
	<b>Ceftizoxime</b>					R
	<b>Cefepime (Maxipime)</b>	S	S	S	S	R
	<b>Cefoxitin (Mefoxin)</b>	S	S	S	S	R
	<b>Cefuroxime-Sodium</b>					
	<b>Cefuroxime-Axetil (Ceftin)</b>					R
<b>Carbapenem</b>	<b>Ertapenem</b>					
	<b>Imipenem (Primaxin)</b>				S	S
	<b>Meropenem (Merrem)</b>					

<b>Microlides</b>	<b>Azithromycin (Azactam)</b>					
	<b>Erythromycin</b>					
<b>Fluoroquinolone</b>	<b>Ciprofloxacin (Cipro)</b>	S	S	R	S	R
	<b>Levofloxacin (Levaquin)</b>	S	S	R	S	R
	<b>Ofloxacin (Floxin)</b>					
<b>Lincosamides</b>	<b>Clindamycin (Cleocin)</b>					
<b>Oxazolidinones</b>	<b>Linezolid (Zyvox)</b>					
<b>Antimycobacterials</b>	<b>Rifampin (Rifadin, Rimactane)</b>					
<b>Folate pathway inhibitors</b>	<b>Trimethoprim/Sulfa (Gantanol)</b>	S	R	S	S	R
<b>Tetracycline</b>	<b>Tetracycline</b>					R
<b>Glycylcyclines</b>	<b>Tigecycline</b>					S
<b>Glycopeptides</b>	<b>Vancomycin (Vancocin)</b>					

Table S2. Uropathogenic *E. cloacae* complex, *P. aeruginosa*, and *S. aureus* strain information. All strains were harvested and tested for susceptibility in Cooley Dickinson Hospital Microbiology Laboratory (Northampton, MA). S: Susceptible; I: Intermediate; R: Resistant.

	<b>Riley Strain Name</b>	CD-866	CD-1412	CD-1545	CD-1006	CD-23	CD-1578	CD-489
	<b>Species</b>	<i>E. cloacae</i> complex	<i>E. cloacae</i> complex	<i>E. cloacae</i> complex	<i>P. aeruginosa</i>	<i>P. aeruginosa</i>	<i>S. aureus</i>	<i>S. aureus</i> - MRSA
	<b>Date Isolated</b>	3/29/12	6/7/12	6/19/2012	4/23/12	9/12/2011	6/21/2012	1/3/12
	<b>Specimen</b>	UCC	UCC	UCC	UCC	UCI	UCC	UCS
	<b>Cfu/ml</b>	10-100,000	>100,000	>100,000	>100,000	>100,000	MODERATE	>100,000

	Note		Urine from nephrostomy tube			Extended panel of susceptibilities for the P. aeruginosa		
Aminoglycosides	Amikacin (Amikin)		S	S				
	Gentamicin (Garamycin)	S	I	I	S	I	S	S
	Kanamycin High Level							
	Tobramycin (Nebcin)		R	R		S		
β-Lactam	Ampicillin (Omnipen, Polycillin)				S	R		
	Ampicillin/sulbactam (Unasyn)				S	R	S	R
	Amoxicillin/CA (Augmentin)					R	S	R
	Aztreonam (Zithromax)							
	Oxacillin (Prostaphlin)						S	R
	Penicillin						R	R
	Piperacillin (Pipracil)					S		
Cephalosporin	Ceftazidime (Fortaz, Tazicef)							
	Cefaclor (Ceclor, Ceclor CD)						S	R
	Ceftriaxone (Rocephin)	S	S	S	S	R	S	R
	Cefotaxime						S	R
	Cefazolin (Ancef, Kefzol)	R	R	R	S	R		
	Ceftizoxime					R		

	<b>Cefepime (Maxipime)</b>	S	S	S	S	I		
	<b>Cefoxitin (Mefoxin)</b>	R	R	R	S	R		
	<b>Cefuroxime- Sodium</b>						S	R
	<b>Cefuroxime- Axetil (Ceftin)</b>					R		
<b>Carbapenem</b>	<b>Ertapenem</b>							
	<b>Imipenem (Primaxin)</b>	S			S	S	S	R
	<b>Meropenem (Merrem)</b>							
<b>Microlides</b>	<b>Azithromycin (Azactam)</b>						R	
	<b>Erythromycin</b>						R	
<b>Fluoroquinolone</b>	<b>Ciprofloxacin (Cipro)</b>	S	S	R	S	R		
	<b>Levofloxacin (Levaquin)</b>	S	S	R	S	R	S	R
	<b>Ofloxacin (Floxin)</b>							
<b>Lincosamides</b>	<b>Clindamycin (Cleocin)</b>						R	
<b>Oxazolidinones</b>	<b>Linezolid (Zyvox)</b>		S	S			S	S
<b>Antimycobacterials</b>	<b>Rifampin (Rifadin, Rimactane)</b>						S	S
<b>Folate pathway inhibitors</b>	<b>Trimethoprim/ Sulfa (Gantanol)</b>	S	R	R	S	R	S	S
<b>Tetracycline</b>	<b>Tetracycline</b>					R	S	S
<b>Glycylcyclines</b>	<b>Tigecycline</b>							
<b>Glycopeptides</b>	<b>Vancomycin (Vancocin)</b>						S	S

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<sup>1</sup> Brust, M.; Walker, M.; Bethell, D.; Schiffrin, D. J.; Whyman, R. Synthesis of Thiol-derivatised Gold Nanoparticles in A Two-Phase Liquid-Liquid System. *J. Chem. Soc., Chem. Commun.* **1994**, 7, 801-802.

<sup>2</sup> Templeton, A. C.; Wuelfing, M. P.; Murray, R. W. Monolayer Protected Cluster Molecules. *Acc. Chem. Res.* **2000**, 33, 27-36.

<sup>3</sup> Miranda, O. R. *et al.* Enzyme-Amplified Array Sensing of Proteins in Solution and in Biofluids. *J. Am. Chem. Soc.* **2010**, 132, 5285-5289.

<sup>4</sup> De, M. *et al.* Sensing of Proteins in Human Serum Using Conjugates of Nanoparticles and Green Fluorescent protein. *Nat. Chem.* **2009**, 1, 461-465.

<sup>5</sup> Liu, X. O.; Atwater, M.; Wang, J. H.; Huo, Q. Extinction Coefficient of Gold Nanoparticles with Different Sizes and Different Capping Ligands. *Colloid. Surface. B* **2007**, 58, 3-7.