Bacterial-Nanoparticle Interactions

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

Bionanotechnology is an intersection between biology and nanotechnology, a field in which novel applications for very small materials are being realised at an alarming rate. Nanoparticles have 3 dimensions that can be measured in nanometers, their small size conferring upon them different properties from individual atoms or the bulk material. The interactions between these unique materials and microorganisms are often toxic, thus have been exploited for antimicrobial applications. However, there is a considerable paucity of data for the underlying molecular mechanisms. This study has been carried out to investigate the interactions that occur between nanoparticles and bacteria with the objective of identifying these toxicological mechanisms and novel nanoparticle effects, using the model Gram negative organism *Escherichia coli* K12. This study has identified metal nanoparticles that are a superior vehicle for the delivery of toxic metal ions to *E. coli*. The nanoparticles associate with the bacterial surface, but do not cross the cell wall. They then dissolve, releasing a concentration of metal ions that accumulate at the bacterial-nanoparticle interface, enhancing the antibacterial efficacy compared to the concentration of metal ions in the bulk solution phase. Measurement of the whole transcriptome response to silver nanoparticles in comparison to the silver ion indicates that the different modes of ion delivery may induce a differential stress response. Moreover, this data identifies molecular mechanisms that are involved in the toxicity of this metal that is now becoming increasingly prevalent in society. The dissolution based toxic effects of zinc oxide nanoparticles are augmented by an interaction with ultra-violet light, offering an alternative mode for nanoparticle toxicity.

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