Chemical Engineering Doctoral Defense

Structural and Functional Studies of Protein-Nanoparticle Complexes and their Interactions

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Abstract

The list of applications of plasmonic nanoparticles in the fields of energy research, sensing, and diagnostics and therapeutics is continuously growing. Synthesis of the nanoparticles for such applications should incorporate provision to easily functionalize the particle formed and should ideally not use toxic reagents. The traditional methods of synthesis are generally energy inefficient, requires stringent conditions such as high temperature, pressure or extreme pH and often produces toxic byproducts. Using biomolecules helps to keep synthesis biocompatible while also combining the step of functionalization of the nanoparticle with its synthesis through the biomolecule itself. The presentation focuses on studying the bio-templated synthesis of two such noble metal nanoparticle which have biomedical applications: gold and platinum. Gold Nanoparticles (GNP), with long-term stability, were synthesised using Maltose Binding Protein (MBP) as templating agent. The site of gold interaction on MBP was identified by X-ray crystallography. A novel gold binding peptide was designed based on the orientation of the residues in the gold binding site, identified through crystallography. This designed peptide was also shown to have stabilised and affected the growth rate of GNP formation, in similar manner to MBP. Further, a nanosensor was formulated using a variation of this GNP-MBP system, to detect and measure ionizing radiation dose for cancer radiation therapy. Upon exposure to therapeutic levels of ionizing radiation, the MBP-based sensor system formed gold nanoparticles with a dose-dependent color that could be used to predict the amount of delivered X-ray dose.Further, a similar system of protein templated synthesis was introduced for platinum nanoparticle (PtNP). Here, GroEL protein was used as templating and stabilizing agent for reduction of K2PtCl4 ions to form PtNP. To understand how GroEL interacts with the PtNPs a 3.8-Å resolution 3D cryo-EM map of GroEL depicting the location of PtNP inside its central cylindrical cavity was obtained. Fitting a GroEL model to the map revealed Arginine-268 from two adjacent subunits of GroEL interacting with the PtNP surface. Finally, a solution to the potential issues of single particle data processing on protein nanoparticle complexes, specifically with 2D classification, was developed by creating masking algorithms.

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Zoom Link: https://asu.zoom.us/j/92111480735