Application Note

Poseidon™

Imaging gold nanoparticles of different sizes in liquid using TEM

Introduction

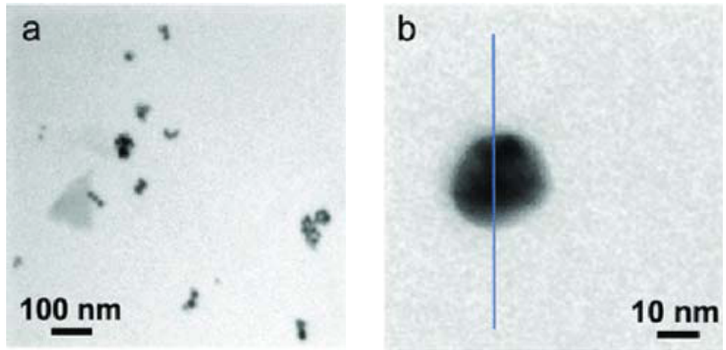
Imaging wet specimens using electron microscopy is an area of interest for a wide range of disciplines. Understanding the mechanisms that control dynamic processes such as nucleation, growth, and self-assembly will enable application-specific tailoring of nanomaterial properties. The ability to image nanoparticles in liquid with electron microscopy is a key step in understanding these mechanisms.

In this study, citrate stabilized gold nanoparticles of different sizes were imaged in liquid using Protochips' Poseidon liquid TEM holder. Poseidon provides a self-contained, maintainable liquid environment within the electron microscope during imaging.

Experiment

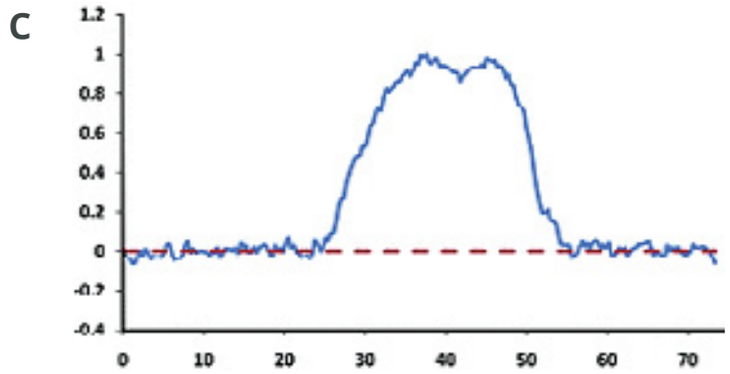
Gold nanoparticles were deposited on an E-chip™, by dispensing a 0.5 µL droplet of solution containing 1.4 nm and 10 nm gold nanoparticles on the surface of the silicon nitride. The solvent was allowed to evaporate and the presence of gold nanoparticles on the silicon nitride window was confirmed using scanning TEM. For liquid imaging, the E-chip was placed in the Poseidon holder and a 0.8 µL droplet of 10% phosphate buffered saline was dispensed onto the E-chip.

A second E-chip containing a spacer was placed on the first E-chip and the entire chamber was closed resulting in a vacuum tight seal. A continuous flow of buffer solution was applied to the sample at a flow rate of 50 nL/s. The aqueous nanoparticles were imaged using an FEI CM200FEG TEM operating at 200 kV. The liquid thickness was measured to be ~ 0.8 µm.



Discussion

TEM bright field images of the gold nanoparticles are shown in Figures A and B. The gold nanoparticles



appear dark against the bright background of the liquid, as evident at lower magnification (A), and exhibit a combination of amplitude (mass-thickness) and diffraction contrast.

Diffraction contrast manifests itself in the appearance of intensity variations, particularly in large crystalline particles, that are inconsistent with the smooth, symmetric variation that would be expected from an incoherent signal; such variations in the gold particle can be seen both in the bright field image (B) and the corresponding inverted intensity profile shown in Figure C. The obtained resolution was measured to be ~ 5 nm.

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Applications

The Poseidon TEM holder is available in 2 or 3 port configurations. The 2 port configuration allows a constant flow of liquid across the sample while the 3 port configuration provides a method for introducing and mixing reagents during imaging. Thus a wide range of dynamic processes such as nucleation, growth, self-assembly, and particle-particle interactions can be observed. Contact us to discuss the Poseidon's full range of capabilities. We can be reached at (919) 377-0800 or contact@protochips.com.

Reference:
K. Klein., I. Anderson, and N. de Jonge. Journal of Microscopy, 242: 117–123. (2011)

Protochips