AFM CHARACTERIZATION OF SMALL NOBLE METAL NANOPARTICLES

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Since nanoparticles (NPs) exhibit physical properties different from bulk materials that result largely dependent on their size and structure, a good structural characterization becomes essential in order to understand their physical properties and the role of size effects. High Resolution Electron Microscopy (HREM) is nowadays the most powerful technique to characterize those structures[1], giving accurate data about the size, shape and internal crystallographic structure. Although Atomic Force Microscopy (AFM) characterization can not substitute HREM studies, it gives complementary information as it allows the observation of aggregation states, the possibility of characterizing the size of the protecting shell, and, being a non invasive technique, enable a way to check if the preparation and measurement processes using the energetic electron beam modify the size of the NPs. AFM analysis of nanostructures with size of tens of nanometers is well established[2,3], but the observation of small NP (below 5 nm size) is not straightforward because the size of the NPs is about the limit of the technique resolution.

We present a detailed method to observe noble metal nanoparticles (with size below 5nm) with a standard AFM equipment. By achieving a good dispersion of the nanoparticles in dissolution it is possible to image them individually using an AFM. Moreover, this technique enables measuring the size of the particle, considering the particle height, as the width is distorted by the AFM tip geometry.

Using a slide of commercial mica as the substrate, we analyze Pd, Au and Ag nanoparticles with sizes in the 1 to 5 nm range and capped with different chemical species. A Standard Nanoscope III AFM microscope from Nanotec was used on the so-called “tapping mode” that measures the modification of the tip oscillation amplitude due to the tip-sample interactions. The “contact mode” is not suitable for these experiments, as the lateral force of the tip may displace the NPs along the surface, thus we used this tapping mode in order to avoid this “sweeping” effect.

Figure 1 shows an AFM image of Au thiol-capped NPs, with the corresponding 3D representation, the height profile and the corresponding particle size histogram; and in figure 2 two AFM images of Au NPs demonstrating the potential of this technique characterizing NPs aggregates.

References:

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Figures:

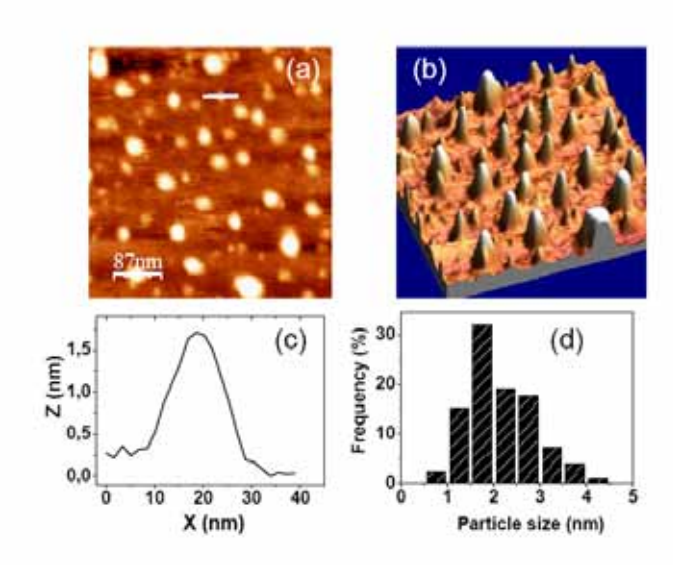

Figure 1. (a) AFM image from Au thiol-capped NPs and (b) the 3D representation. (c) Height profile along the line indicated in (a). (d) Particle size histogram obtained from the height of the NPs.

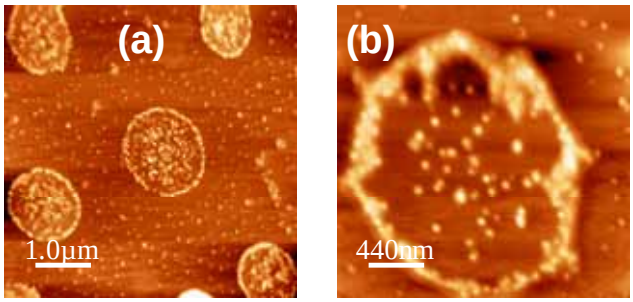

Figure 2. AFM images from Au NPs protected by ammonium salts showing aggregation rings.