Electron Microscopy of Metal and Alloy Nanoparticles for Possible Medical Applications

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One of the possible important applications of metal nanoparticles is in the medical field, for instance in the early detection and treatment of cancer, Because of the dimensions involved, electron microscopy techniques are essential to characterize the particle structure and to visualize their attachment to cancer cells. The presence of the latter is detected by sensitive physical measurement such as magnetometry or Raman spectroscopy. This article reviews our recent work in this regard, correlating the physical measurements with the nanoparticle structures and distribution.

Magnetic alloy nanoparticles are clearly based on the ferromagnetic elements. However ensuring their stability in different environment (e.g. corrosive) is essential to their long-term performance. We have developed a synthesis method whereby the nanoparticles are produced by a reduction of the appropriate proportions of one of their chemical salts in a methane environment, which encapsulates the particles with a few layers of chemically inert graphite. Nanoparticles made this way included Fe, Co, CoFe and AuFe, and their sizes were in the 5-15nm range. All are confirmed to be superparamagnetic from their magnetic hysteresis loops and zero-field cooling experiments, and their respective crystal structures were established from high resolution transmission electron microscopy (TEM) images (e.g. [1-3]).

Noble metal nanoparticles (e.g. Ag, Au) are useful because of their ability to produce surface-enhanced Raman spectroscopy (SERS) intensities. Accordingly coating the nanoparticles with an appropriate Raman dye (e.g. Acridine Orange) yields characteristic signals in the Raman spectrum. Functionalizing them further with an antibody allows attachment of the particles to targeted cancer cells, which can thereby be detected from the enhanced Raman signal. An example of silica-coated gold nanoparticle attached to a T-cell, as revealed by backscattered scanning electron microscopy (SEM) is shown in Figure 1, with a TEM image of the particles inset [4]. The procedures for obtaining such images are described fully elsewhere [5], and some recent applications will be described in the current work.

In summary, SEM and TEM techniques are invaluable in revealing details of nanoparticles and their attachment to cells.

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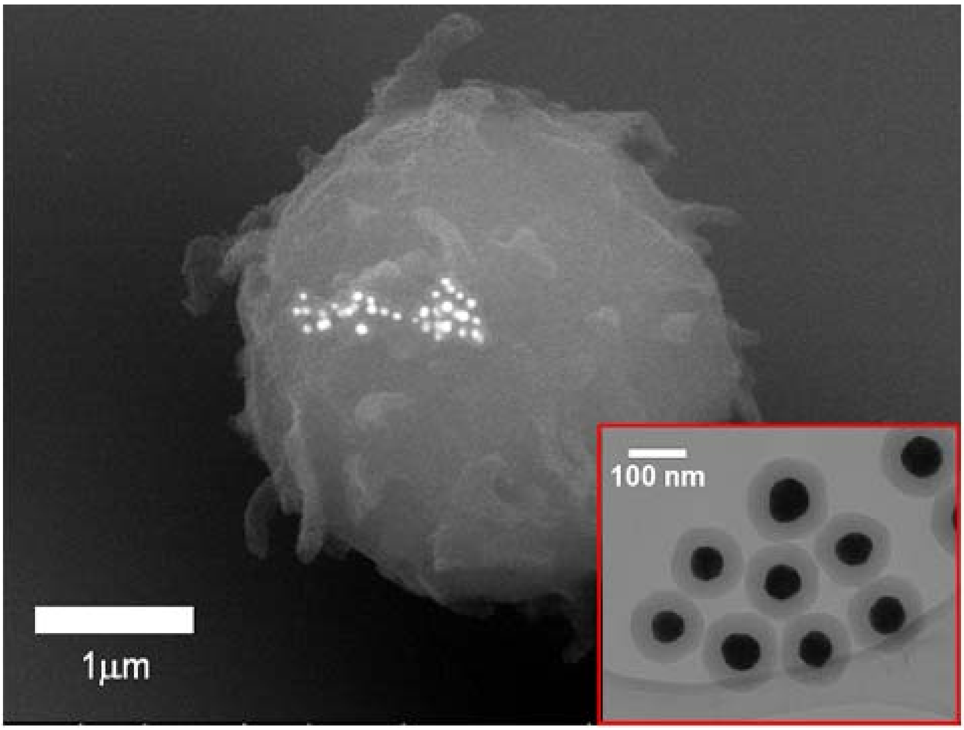

Figure 1. SEM backscattered electron image of gold-silica core-shell nanoparticles (Nanoplex™ Biotags) on the surface of a T-cell, with a corresponding bright field TEM image of the particles inset.

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