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TEM Study of Cellular Uptake of Gold Nanoparticles by MC3T3-E1 Bone Cells

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Application of gold nanoparticles (AuNPs) in variety of biomedical fields have recently garnered increasing interest [1-2], especially as potential drug-delivery vehicles [3-4]. Studies of the uptake of nanomaterials by the eukaryotic cells will offer a great deal of information required for many applications, especially the optimal physical and chemical characteristics of nanoparticle (e.g. shape, concentration and charge). The optimization of such experimental parameters is critical for drug delivery, because it maximizes the number of nanoparticles that will accumulate inside the cell, for any biomedical applications.

In the present study, the uptake mechanisms of AuNPs (concentrations of 10 and 160µg/ml and an average diameter of 12.2 ± 1.3nm) (Fig.1) by the Mouse osteoblast MC3T3-E1 cells are compared. MC3T3-E1cells were exposed to particles for 6, 24 and 96 hours of incubation. At 160µg/ml, each sampling time (6, 24 and 96 hrs) endocytized vacuoles of AuNPs could be easily observed, and more than one vesicle containing gold nanoparticles were observed within a single cell. Only large aggregates of AuNPs were internalized and the particles aggregated inside the vesicle. Some of the extracellular AuNPs clusters attached to the surface of the plasma membrane, and with increasing incubation time, more clusters settled on the external surface of the cellular plasma membrane. The cells were found to be covered with large aggregates of AuNPs (Fig. 2). At the same time the cells exposed to lower concentration of AuNPs (10µg/ml) have small clusters of AuNPs localized in the cytoplasm. The intercellular vesicles are smaller and less numerous compared to the high concentration (160µg/ml) situation. After 24 and 96 hrs of incubation (Fig. 3), more AuNPs were internalized than after 6 hrs, when no AuNPs aggregates were found to be attached to the apical surface of the plasma membranes.

The time-dependence of AuNPs cluster sizes in the biological environment was also studied to elucidate the role of the cluster growth in the solution. AuNPs were incubated for 1 to 5760 min in the culture medium free of cells. The results showed no significant change in cluster size with increased incubation time. Our results suggest that the cells engulf clusters of gold nanoparticles by endocytosis mechanism at high concentration while at low concentration, it seem that gold nanoparticles diffuse through the plasma membrane. When they accumulate in the cytoplasm the cells enclose them, as any foreign material, inside small vesicles. We concluded the uptake mechanism of gold nanoparticles by MC3T3 is a concentration-dependent process.

References

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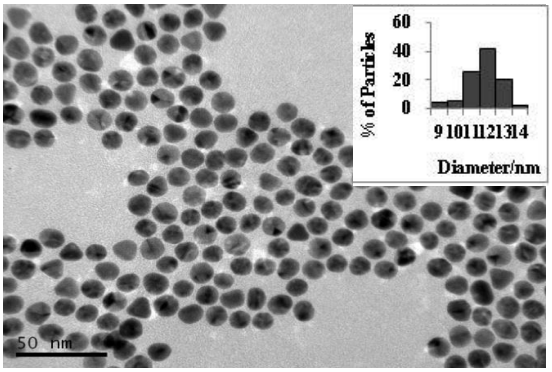

Fig. 1 TEM micrograph of as-synthesized gold-nanoparticles and inset is the corresponding size distribution of particles

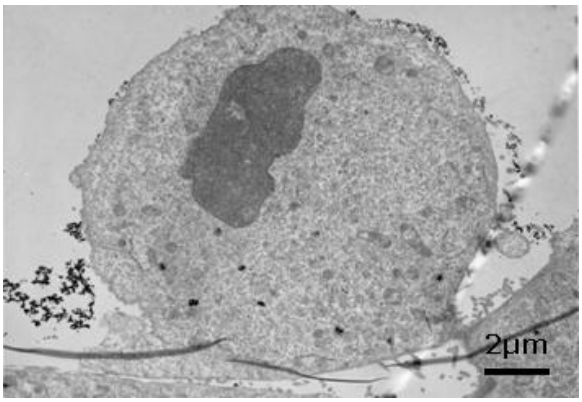

Fig. 2 TEM image of an MC3T3 cell after 96hrs of incubation with 160µg/ml of AuNPs

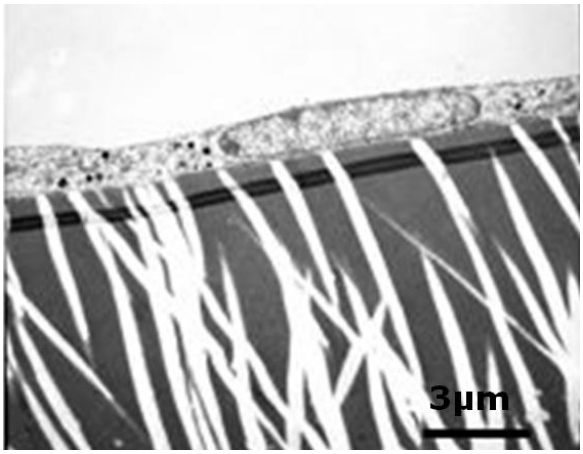

Fig. 3 TEM image of an MC3T3 cell after 96 hrs of incubation with 10µg/ml of AuNPs

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