Shape and Surface Effects on the Cytotoxicity of Gold Nanospheres and Gold Nanostars

Pelagie M. Favi[1], Ming Gao[2], Liuda J. S. Arango[3], Sandra P. O. Alvarez[3], Mariana M. Valencia[4], and Thomas J. Webster[1,5]
[1]Department of Chemical Engineering, Northeastern University, Boston, MA, USA
[2]Department of Pharmaceutical Sciences, Northeastern University, Boston, MA, USA
[3]Institute of Biology, University Research Headquarters, University of Antioquia, Medellín, Antioquia, Colombia
[4]Department of Medicine, University of Antioquia, Medellín, Antioquia, Colombia
[5]Center of Excellence for Advanced Materials Research, King Abdulaziz University, Jeddah, Saudi Arabia

Abstract

Statement of purpose: Gold nanoparticles are biocompatible materials with unique optical properties that have made them very attractive for biomedical applications including drug and gene delivery, cancer treatment, and medical imaging. Recently, researchers have suggested that the shape, size, surface charge, surface chemistry and cell type influence the cytotoxicity of cells. It has also been reported that cell culture media contains proteins and electrolytes that adhere to the surface of nanoparticles affecting their surface charge, surface chemistry, and size. With the increasing discoveries of novel techniques to synthesize nanoparticles for biomedical applications, the safety and performance of these new nanomaterials must be systematically assessed before use. In this study, we aim to: (1) synthesize gold nanostars (AuNST) with multi-branched surface structures following a green chemistry method, and (2) assess the influence of surface charge, chemistry, and shape of the AuNST on the cytotoxicity of human skin fibroblasts and rat fat pad endothelial cells (RFPECs), compared to gold nanospheres (AuNSP) with un-branched surfaces.

Materials and methods: AuNST were prepared in HEPES buffer solution using hydrogen tetrachloroaurate ($HAuCl_4$) [1]. AuNSP were obtained commercially. The morphology of the nanoparticles was assessed using a transmission electron microscope (TEM). The optical, chemical, sized distribution, and surface charge properties of the nanoparticles were evaluated prior to and after the addition of cell culture media. The cytotoxicity of these nanoparticles was investigated in fibroblasts and RFPECs using the colorimetric MTS assay and phase contrast microscopy *in vitro*. Cell cytotoxicity was assessed following 1 and 4 days exposure to the nanoparticles.

Results: The morphologies of AuNST and AuNSP are illustrated in Fig. 1. The diameter of the synthesized AuNST (39.1 ± 0.4 nm) was less than the diameter of the commercially obtained AuNSP (65.6 ± 0.6 nm). After the addition of media, the diameter of the AuNST and AuNSP both increased in size. Following the addition of media, the surface charges of AuNST and AuNSP increased compared to the surface charges of the native nanoparticles. AuNSP indicated higher toxicity after both 1 and 4 days compared to AuNST. Increasing the exposure time did not increase the cytotoxicity of both nanoparticles. After 4 days of exposure, the IC_{50} values (50% inhibitory concentration) of AuNSP seeded with RFPEC cells was 40.9531 μg/mL. An increase in AuNSP concentration resulted in an increase in fibroblast cell toxicity, although an IC_{50} was not reached. Up to a concentration of 40 μg/mL, there was no observed adverse effect of the concentration on RFPEC and fibroblasts seeded with AuNST, after both 1 and 4 days of exposure.

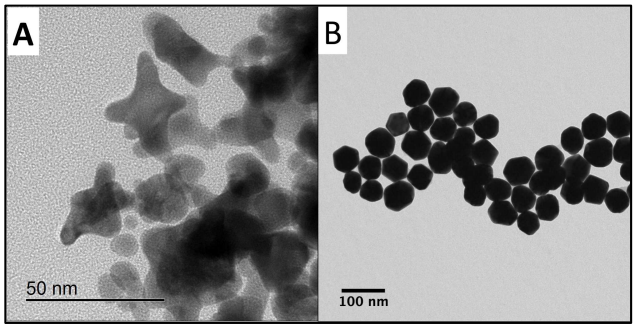

Figure 1. Transmission electron micrographs of AuNST (A) and AuNSP (B).

Conclusions: Results of this study indicated that the RFPEC and fibroblasts were more sensitive to the AuNSP than the AuNST as shown using MTS assay and phase contrast microscopy. Results from this study can be used to assess future potential use of AuNSP and AuNST for biomedical applications. Coupled with the improved activation and surface area of AuNST for functionalization, this study provides significant promise for the medical use of AuNST (such as for cancer treatment).

References:

1. Xie, JP. Chem Mat. 2007; 19:2823-2830.

Acknowledgments:

This study was supported by Northeastern University. Pelagie Favi is grateful for Northeastern University's ADVANCE Future Faculty Postdoctoral Fellowship Program (sponsored by NSF Grant #0811170). Mariana Valencia is thankful for the Northeastern University-University of Antioquia Summer School Program.