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Electrical effects in suspended particles in a fluid

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Abstract

In the present contribution we analyze the effects of interaction between pure copper nanoparticles and human cells (erythrocytes) in an aqueous medium (distilled water), in qualitative form.

Resumen

En la presente contribución se analizan los efectos de ineteracción entre nanopartículas puras y células humanas como eritrocitos, en un medio acuoso (agua destilada), en un forma previa cualitativa.

1. Toxicology of pure copper nanoparticles on cells

The field of nanoscience has experienced unprecedented growth during the last few years and as a result has received a great deal of attention from the public, regulatory agencies, and the science community. However, there are many challenges that must be overcome before we can apply nanotechnology to the field of nanomedicine or conduct science-based occupational or environmental exposure risk assessments. This resultant new field of nanotoxicology will continue to grow and emerge as new products are produced [1, p. iii]. Health effects of nanoparticles are attracting considerable and increasing concern of the public and government worldwide.

Nanoparticles (NPs) are not, as media report, a toxic entity per se, for example, just because of their size. Some NPs, because of their physicochemical features, including size, may constitute a serious hazard to human health. Because of their peculiar physical and chemical features, the study of NPs as potential toxic agents requires an interdisciplinary approach, involving multiple aspects ranging from physics and chemistry to biology and medicine. The main physicochemical determinants in particle toxicology are: the form of the particle, the chemical composition and related surface reactivity and the time of residence in a given body compartment generally defined as Biopersistence (a property related both to chemical factors, such as solubility, adsorption potential, and to the cellular and tissue response to it) [2]. Nanosized copper particles, herein after refer to as nano-copper, one of the manufactured nanoparticles,

are now industrially produced and available commercially. Recently, nano-copper particles are used as the additive in lubricants, polymers/plastics, metallic coating and inks, etc. In human body, copper is maintained in homeostasis. If the intake of copper exceeds the range of the human tolerance, it would cause toxic effects such as hemolysis, jaundice and even death, hepatocirrhosis, changes in lipid profile, oxidative stress, renal dysfunction and stimulation of mucous membrane of alimentary canal, etc. [3]. However, recent toxicological investigations of manufactured nanoparticles revealed such a nature that compared with the larger particles of the same chemical composition (on the identical mass basis), nanoparticles tends to exhibit quite different toxicological effects in vivo. Specifically, for nano-copper particles, compared with the micro-copper, their primary alteration in biochemical property is the higher reactivity originated from a larger specific surface area [4].

In this sense, in the present contribution we analyze the effects of interaction between pure copper nanoparticles and human cells (erythrocytes) in an aqueous medium (distilled water), in qualitative form.

2. Experimental setup

Experimentally we used a standard optical tweezers setup with a nominal Gaussian beam coming from a He-Ne laser emitting at 633 nm (Figure 1). The light beam was focused onto a sample cell by means of an oil-immersion 100x microscope objective with N.A.= 1.25. Our sample consisted of a mixture of nano-copper of different sizes (5-60 nm) and living cells (erythrocytes, 5-10 μm) suspended in water. The output power of the laser was from 10 to 30 mW. BS is a beamsplitter that directs the beam to the objective. The sample is illuminated with an incoherent light source and the particles are observed in real time through CCD camera. The filter is used to block the laser light and preventing the camera saturate. We show a sample cell expansion.

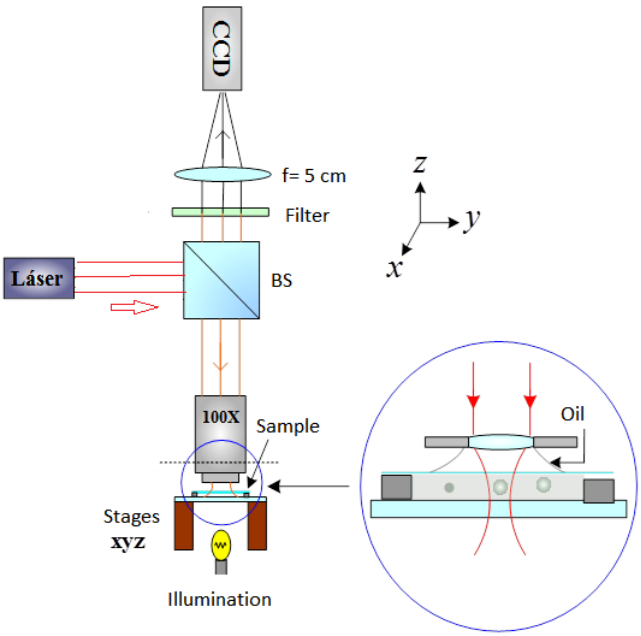

Figure 1. Typical optical tweezers setup.

The objective of this experiment was to observe directly the effects of the interaction between the copper nanoparticles and blood cells in aqueous solution. In the figure 2, we see a sequence of images, where the mixture is appreciated. We observed inmediately that the nanoparticles adhere to the cells causing apparent damage such as destruction. We think that due to the physicochemical properties of the NP and the direct contact with the cells, they attack cell membranes, causing them to break their walls.

Then, we project the laser beam on the sample, in order to study the mechanical response of clusters to highly focused optical field. Also intended to trap and micromanipular the clusters. We note some strange phenomena we are studying quantitatively (these are just previous results). In fig. 2 (b), we can see the beam focused on one of the clusters (bright circle) and (c) - (d) one estrange effect , like cavitation , is observed. We believe that due to high absorption of laser radiation by the metallic nanoparticles, as well as by the cellular material, a thermal effect of great relevance in the illumination zone is generated, since the energy density in this area is also very high. The type cavitation effect is of interest because these are generally produced by laser pulses in pure liquids. In our case, the fluid is extrinsic. The energy released by the bubble, is finally collapsed due to the properties of the medium. Other mechanical effects such as radiation pressure due to the reflected light clusters, have also been observed.

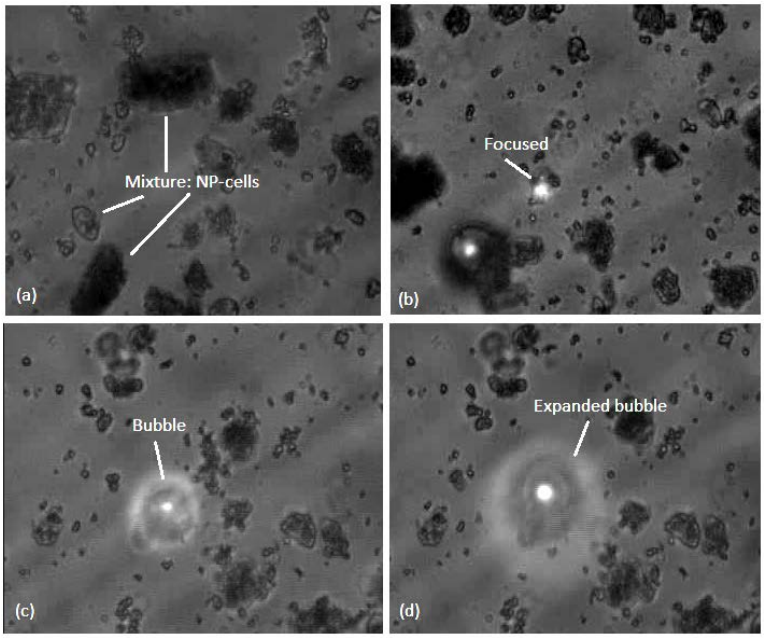

Figure 2. (a)-(d). Clusters of cells and NP. We can see the focused beam on one of the clusters (bright circle). (c)-(d) One estrange effect, like cavitation, is observed.

3. Conclusions

We have observed that invasive effects of copper NP on cells are evident. When are combined in the liquid medium, a phenomenon of adhesion between these particles occurs forming clusters. In these clusters, the cells remain physically damaged by the

harmful effects of NP. We also observed a type cavitation induced by continuous wave laser effect. All these phenomena are of interest to the field, so now, are playback objects and study.

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