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Femtosecond Production of Gold Nanoparticles Suitable for Nanobrachytherapy

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Abstract: The present work approaches the production of AuNPs through femtosecond laser ablation of a solid in a liquid media. Aiming at oncological applications, the stabilization of the colloidal solution was performed with non-cytotoxic material. © 2022 The Author(s)

1. Introduction

Prostate and breast cancer are incidence leaders in Brazil [1-3]. These two neoplasms are usually treated by brachytherapy, as well as other varieties of the disease that are of high incidences, such as cervical cancer and skin cancer, in addition, it can be used to treat cancer in several other areas of the body [4]. Nanotechnology can play a crucial role in providing a shift in the way diagnostic and therapeutic drugs are administered, representing a considerable evolution in the general treatment of prostate, breasts, and various tumors.

Nano-sized particles have extraordinary capabilities to detect, image, or treat cancers at the cellular and molecular levels. Between metallic nanoparticles, gold nanoparticles (AuNPs) have extraordinary tumor retention capabilities due to their natural affinity for tumor vasculature [5,6].

Chanda et al. has demonstrated that complex polysaccharides and protein structures within Gum Arabic can effectively and irreversibly bind AuNPs in the protein matrix to produce non-toxic gold nanoparticulate constructs that are stable under in vitro conditions. vitro and in vivo for potential applications in therapeutic use in nanomedicine [7]. The main objective of this work was to produce GA-AuNPs using the laser ablation technique since when compared to chemical synthesis it is a much more suitable method for the production of ultrapure nanomaterials [8].

2. Materials and Methods

For the experiment, a sample of Gold with a purity of 99% and dimensions of 6×6 mm and 1.5 mm thick was used, being fixed inside a quartz cuvette. Support, intended for coupling the cuvette to the micromachining system, was designed and then machined in the 3D printer. In this support, a barrier was used as a contingency measure, so that the fluid used in the production of NPs would not come into contact with the micromachining system in the event of a possible leak.

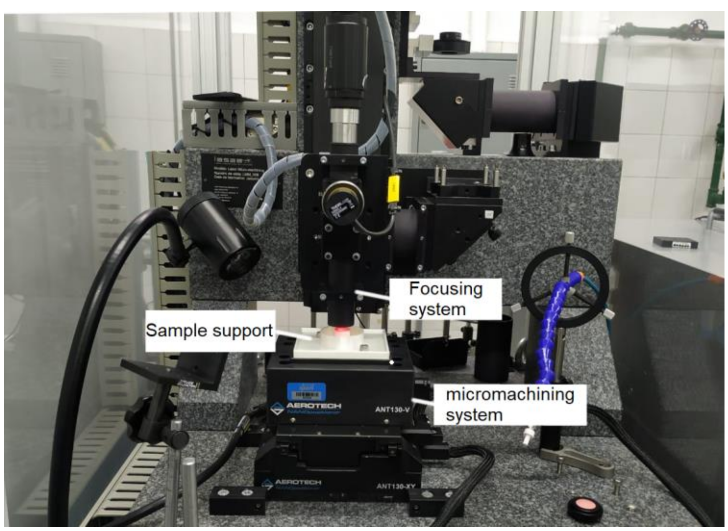

Figure 1. Initial setup for producing nanoparticles via PAL technique with femtosecond pulses.

The micromachining system is composed of XYZ nanotranslator modules (ANT130-XY and ANT130-V) and has a resolution of 2 nm. These nanotranslators are responsible for moving the sample, allowing its surface to be adjusted to the femtosecond laser focal point and its surface scanning during ablation. The femtosecond laser focusing system and the micromachining system used are shown in Figure 1. The Femtopower compact Pro laser emits pulses with a temporal width of 30 fs, a wavelength of 800 nm, a repetition rate of up to 10 kHz, and maximum energy of 60 μJ.

GA-AuNPs were produced with a fluence of 80 J/cm^2 and an overlap of 16 pulses. Gum Arabic diluted in ultrapure water was used as solvent and stabilizer, in a proportion of 15 mg/ml. To measure the size dispersion of NPs, a micro and nanoparticle analyzer, model Litesizer 500, from Anton Paar, was used. Meanwhile, the images were obtained using a transmission electron microscope (TEM), model JEM-2100, brand Jeol.

3. Results and discussion

DLS analyzes of the colloidal solutions provided the hydrodynamic size of the nanoparticles produced and stabilized with GA. Transmission electron microscopy (TEM) analysis provided the morphological aspects of the nanoparticles and the size of their Gold nuclei. Both analyzes provide crucial information about the stability of the nanoparticulate dispersion in aqueous solution. Figure 2 presents the DLS and TEM analyzes of the produced nanoparticles.

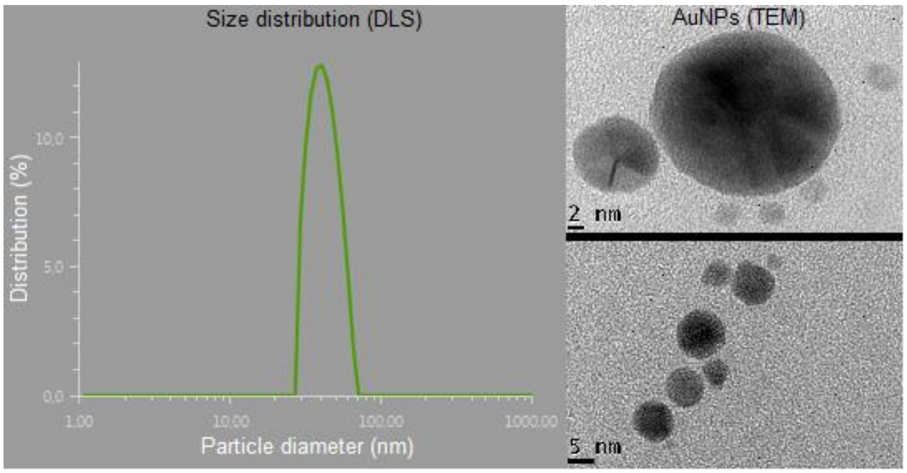

Figure 2. Size distribution e TEM imagens of GA-AuNPs laser-produced.

Through the TEM analysis, it was observed that the nanoparticles produced had a size smaller than 25 nm, therefore, the GA coating is responsible for the other 20 nm observed in the DLS analysis.

The GA-AuNPs produced showed a size distribution of 52 nm, with an average size of (45 ± 3) nm. This represents parameters similar to the nanoparticles produced in IPEN through chemical synthesis, allowing the application of these laser-produced nanomaterials in nanobrachytherapy studies.

4. Conclusions

In this work, gold nanoparticles could be produced through femtosecond laser ablation and stabilized with a non-cytotoxic material, having an average size and size distribution suitable for nanobrachytherapy applications.

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