2015 International Nuclear Atlantic Conference - INAC 2015
São Paulo, SP, Brazil, October 4-9, 2015
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-06-9**

GOLD NANOPARTICLES SYNTHETIZED BY GAMMA RADIANTION AND STABILIZED BY BOVINE SERUM ALBUMIN

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ABSTRACT

Gold nanoparticles (AuNPs) are a new option for pharmaceutical and cosmetic industries due to their interesting chemical, electrical and catalytic properties. Research for cancer treatments have been developed using this promising radiotherapy agent. The challenge of gold nanoparticles is to keep them stable, due to metallic behavior. It is know that surface plasma resonance promotes agglomeration of metallic nanoparticles, but they are not stable. Stabilizers have been used to reduce agglomeration. The aim of this work is reduction of $HAuCl_4$ salt to AuNPs performed by gamma radiation ^{60}Co source and the stabilization of gold nanoparticles using bovine serum albumin (BSA) fraction V as stabilizer agent. AuNPs were characterized by UV-visible to verify the nanoparticles formation. Samples containing BSA and samples obtained by the conventional method (without stabilizer) were monitored for two weeks and analyzed. Results were compared.

1. INTRODUCTION

Nanoscience is defined as the study of phenomena and manipulation of materials at the atomic and molecular scale, and nanotechnology as the characterization, production and application of structures, devices and systems through the control shape and size at nanometer scale [1].

Gold nanoparticle has unique electronic, optical and biocompatibility properties; high surface area in proportion to the mass and high surface reactivity are useful in use for biomedical purposes [2]. They can be synthesized by an easy safe and inexpensive method; the ranging shape and size are between 2 to 500 nm. AuNPs allow coatings for various materials such as polymers, biomolecules or sugar, making it useful for applications such as biosensors [3] contrast agents [4], analyte detection [5], vehicle for delivering molecules into cells [2] and cancer therapy [6].

Bovine serum albumin (BSA) is widely used for load drugs because it is medical importance, abundance, low cost, easy purification and its wide acceptance in the pharmaceutical industry [7]. These properties and it is preferential uptake in receptor tumors and inflamed tissues, ready availability, biodegradability and low toxicity makes it an ideal candidate for biomedical use [8].

The use of ionizing radiation for the synthesis of metal nanoparticles is promising because of production of reactive species with high reduction potential. It is possible the control over size particle and its distribution due to adjustment of dose and consequently of the reactive species.
Gamma-radiation on aqueous metallic salt solutions induce radiolysis of both water and salt, mainly forming free very reactive radicals such as H and OH and the last one helps in the reduction of metal [9, 12].

The aim of this study was investigate the synthesis and stability of gold nanoparticles induced by gamma radiation, stabilized by BSA and without BSA. Also, compare with non-irradiate, heated sample stabilized by sodium citrate.

2. EXPERIMENTAL SECTION

2.1. Materials

Sodium tetrachloroaurate (III) dihydrate ($NaAuCl_4$. $2H_2O$) (99,9%) from Sigma-Aldrich, Bovine Serum Albumin fraction V from Sigma-Aldrich, Sodium citrate P.A. - A.C.S. from Synth, absolute ethyl alcohol, prior to use, glassware was cleaned with aqua regia (volume ratio HNO_3 - HCl = 1:3), HNO_3 and HCl from Sigma-Aldrich, and thoroughly rinsed with MilliQ water and dried.

2.2. Gold nanoparticles synthesis

A stock solution of 1mM $NaAuCl_4$ was prepared by salt dissolution in milliQ water.

The gold nanoparticles was prepared in addition of absolute ethyl alcohol and subjected to irradiation using a γ-irradiation source of ^{60}Co. The samples were stored under refrigeration (4 ºC) before and after irradiation. After that, a stock solution of Bovine Serum Albumin (45mg/ml) was prepared by dissolving the protein in MiliQ water and added to the previously irradiated sample.

Similary to the after process the gold nanoparticles were prepared mixing sodium citrate solution 0.039mM with gold solution, heating and stirring at 100 ° C for 10 minutes and then stirring for 15 minutes. The samples were stored under refrigeration (4 ºC) after synthesis.

The samples were prepared at different concentration and range doses, shown in Table 1.

Table 1: Samples preparation and doses applied.

$NaAuCl_4$ (1mmol L^{-1})	BSA	EtOH	Dose (kGy)	Sodium Citrate
5.0 mL	-	-	-	-
5.0 mL	-	-	5	-
5.0 mL	-	-	7,5	-
5.0 mL	-	-	10	-
1.25 mL	2.25 mL	1.5 mL	-	-
1.25 mL	2.25 mL	1.5 mL	5	-
1.25 mL	2.25 mL	1.5 mL	7,5	-
1.25 mL	2.25 mL	1.5 mL	10	-
4.975 mL	-	-	-	0.025 mL

2.3. Gold nanoparticles characterization

The AuNPs were characterized by UV–visible spectroscopy in the Spectrophotometer SpectraMax I3 Molecular Devices to confirm the peak surface plasmon resonance of the AuNPs at λ = 540 nm, approximately. Solutions containing nanoparticles will be analyzed and compared by two weeks.

3. RESULTS AND DISCUSSION

After irradiation, the initially colorless solution becomes red, its UV–visible spectra exhibiting an absorption band around 530 – 540 nm. This absorption band is characteristic in the surface plasmon resonance phenomenon shown by gold nanoparticles [10].

The total radiation energy applied to the solution is not distributed evenly, instead, most of that energy is deposited in both water and molecules, this process is called radiolysis of water. In that process occurs excitation and ionization of water molecule generating reducing and oxidizing species as reducing aqueous electrons ($e^{'aq}$.), hydrogen radical (H ·), and the most important oxidizing specie the hydroxyl radical (OH ·), responsible for the reduction of the gold particle [11].

Fig. 1 shown the formation of gold nanoparticles using gamma radiation as reducing agent. It was observed that nanopartices reduced by gamma radiation has a great stability after 2 weeks even without a stabilizer agent. Results using different radiation doses (5 kGy, 7.5 kGy and 10kGy) shown a little influence of the dose on formation and stability of the AuNPs.

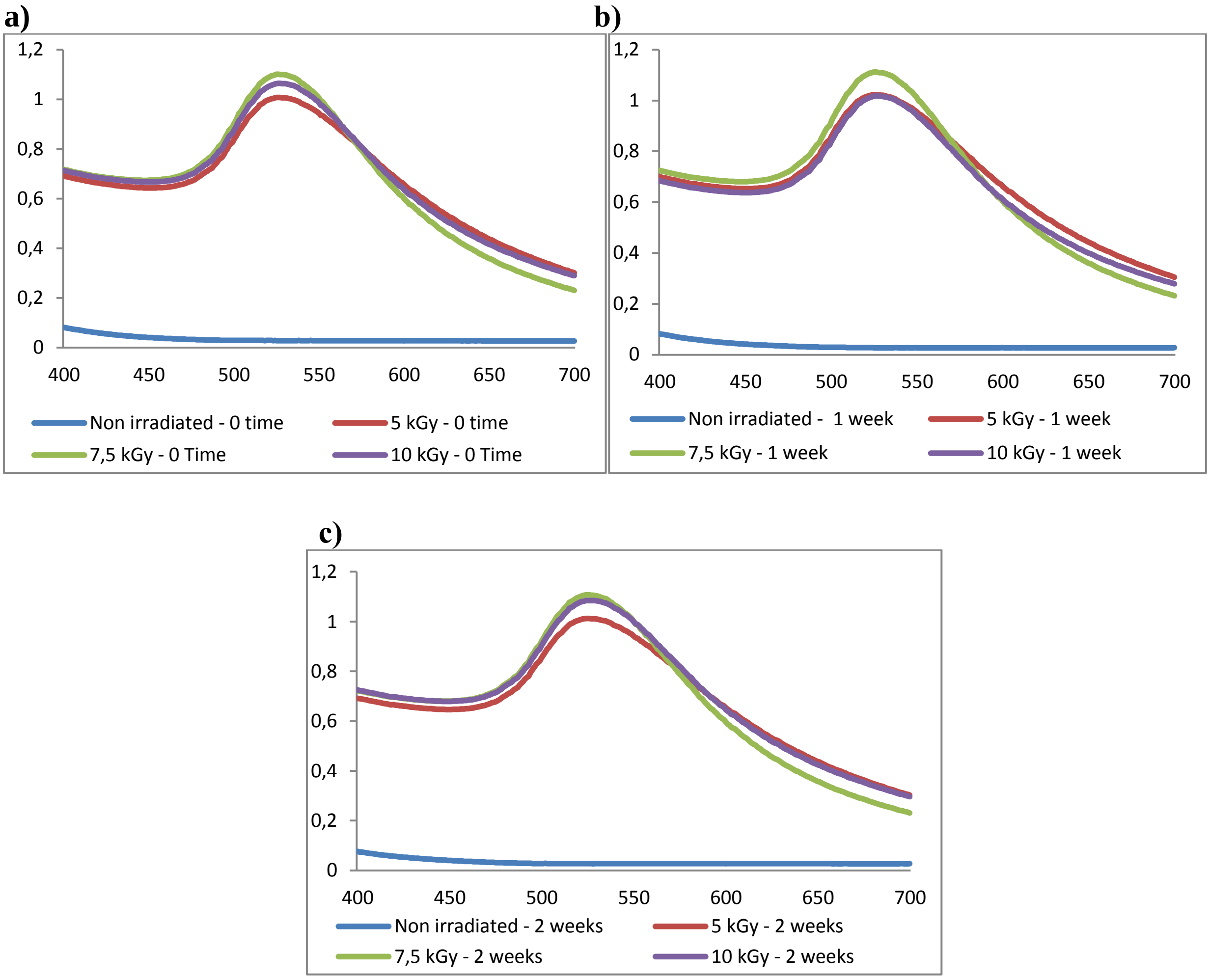

Figure 1: UV-Vis spectra of gold nanoparticles solution reduced by gamma radiation with different doses. (a) Au reduced on the first time (b) Au reduced after 1 week (c) Au reduced after 2 weeks.

After irradiation was observed color change solution from colorless to red, the results of UV-Vis absorption spectra in Figure 1 and Figure 2 show peaks around of 535–540 nm, indicating the formation of AuNPs in both process [10].

Fig. 2 shows the use of BSA as stabilizer agent. It was observed that nanoparticles obtained by gamma radiaton in presence of BSA solution has a great stability as compared with gold nanoparticles obtained by radiation without stabilizer agent.

On the analysis of the UV-Vis curves, it is possible to see that BSA was able to maintain stable the gold nanoparticles almost for 2 weeks.

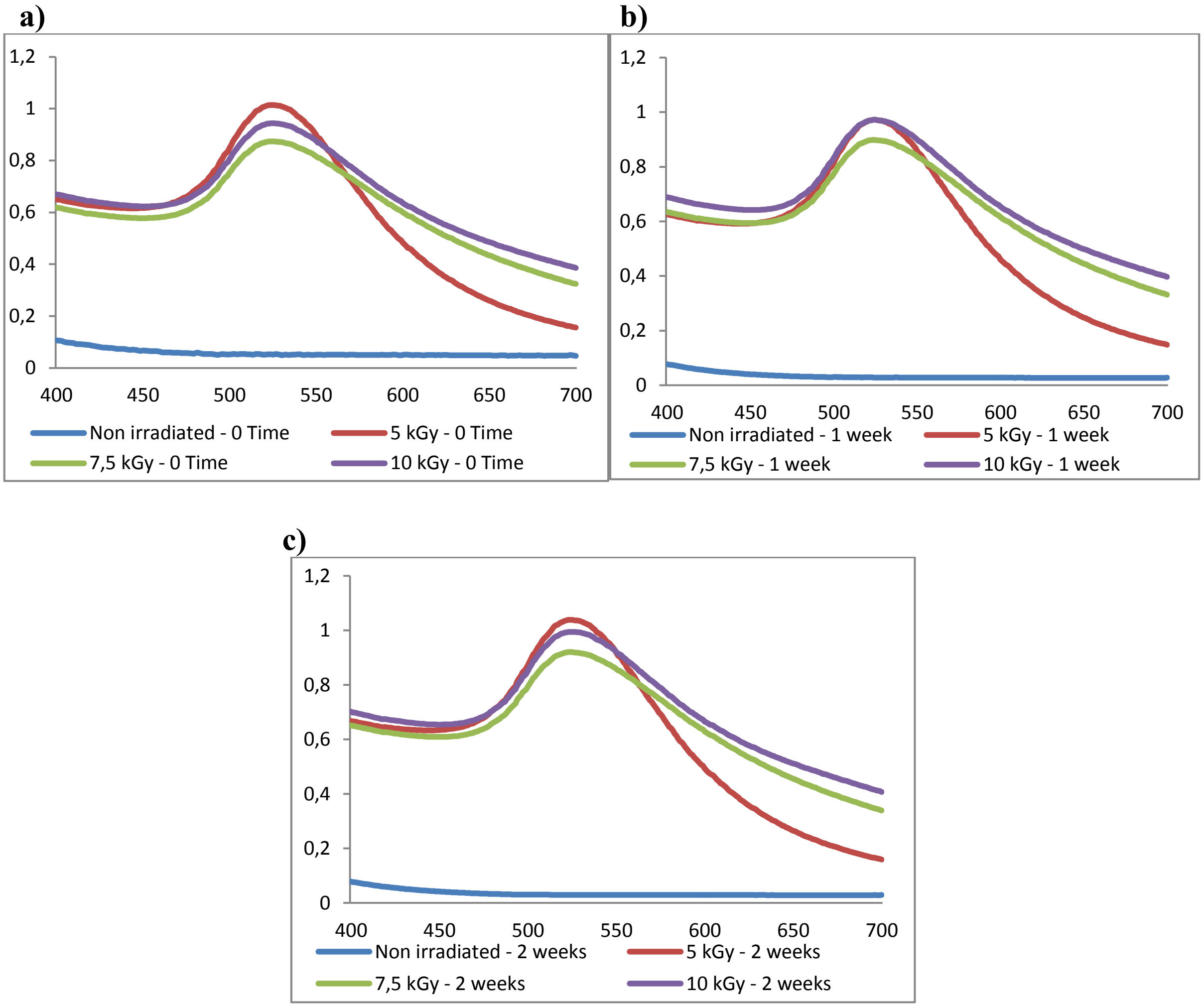

Figure 2: UV-Vis spectra of gold nanoparticles solution reduced by gamma radiation with BSA and Ethanol with different doses. (a) Au-BSA on the first time, (b) Au-BSA after 1 week, (c) Au-BSA after 2 weeks.

Non-iradiated samples were heated at 100°C and was observed that the initially colorless solution turn out to be red similar to the irradiated samples, confirming nanoparticles formation. The results of UV-Vis absorption spectra show peaks around 535–540 nm, confirming the formation of AuNPs [10].

Fig. 3 shows the use of sodium citrate as reducing agent in synthesis of AuNPs. It was observed that nanoparticles formed by heating demonstrated less stability when compared with gold nanoparticles obtained by radiation synthesis along two weeks of analisys.

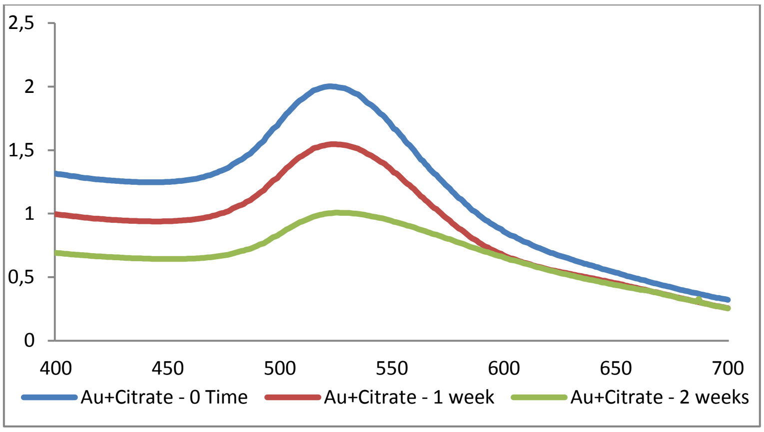

Figure 3: UV-Vis spectra of gold nanoparticles solution reduced by sodium citrate and heating without stabilizer agent.

4. CONCLUSIONS

The gold nanoparticles using gamma radiation in presence or without Bovine serum albumin as stabilizer agent and the samples of gold nanoparticles obtained by heating in presence of sodium citrate achieved red color solution indicating the formation of AuNPs. A peak in 540 nm approximately in the UV-Vis spectra was found, determining that the nanoparticles were formed in all samples except in no-irradiated and samples where sodium citrate was no added. These nanoparticles are stable when stored at low temperatures (4 °C) for almost 2 weeks. Gold nanoparticles were more stable when synthetized by gamma radiation along two weeks with or without BSA compared with samples in presence of sodium citrate.

ACKNOWLEDGMENTS

The authors wish to thank CAPES, and are grateful to the Multipurpose Gamma Irradiation Facility at the Radiation Technology Center - IPEN.

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