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Antibacterial analysis and characterization of endotrachal probe of polyvinyl chloride with silver nanoparticles

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Abstract

This article was performed deposition of silver nanoparticles in an endotracheal tube of polyvinyl chloride (PVC) and was evaluated it antibacterial activity; synthesis of silver nanoparticles was performed by an electrochemical method, for which silver nitrate ($AgNO_3$) was used as precursor agent, glucose ($C_6H_{12}O_6$) as a reducing agent and sodium hydroxide (NaOH) as a stabilizing agent, to deposit nanoparticles PVC probe in a process of functionalization was performed with two coupling agents, 3-mercaptopropyl trimethoxysilane ($C_6H_{16}O_3SSi$) and 3-aminopropyl triethoxysilane ($C_9H_{23}NO_3Si$) incorporating nanoparticles was by direct immersion, the product was characterized by infrared spectrometry Fourier transform (FTIR) confirming the chemical functionalization on the probe by means of Scanning Electron Microscope (SEM) and Atomic Force microscopy (AFM) the presence of nanoparticles was observed and an average size of 25nm and is determined through testing antibacterial where PVC samples among E.Coli were exposed zones of inhibition were observed material.

Silver Nanoparticles, PVC functionalization, antibacterial

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Introduction

Today, in Mexico, it is estimated that the frequency of nosocomial infections in hospital units varies from 2.1 to 15.8% [1], a situation that becomes more aggravating in the area of intensive care, since this site produces 23% Of all such infections [2], this can be attributed to the fact that the patients in this room require endotracheal intubation for mechanical ventilation and airway insulation in order to avoid air loss and entry of non-invasive materials Safe to the lungs, however, the endotracheal PVC probe becomes a reservoir of microorganisms that adhere to its surface by developing a biofilm, which is highly resistant to the effects of antimicrobials and host defense mechanisms. This fact often makes it difficult to treat and eradicate such drug infections [3], causing a negative impact on hospital care and a significant increase in costs, since budgets for these infections exceed $ 160 million per year [4].

In the last decades the Nanosciences, with the study of the phenomena and the manipulation of materials at nanoscale has allowed that the nanotechnology that is the application of Nanosciences allows adequate control of biological systems [5,6] [5] [6]], Developing new materials, methods and techniques that have allowed an intervention on biological structures with molecular and atomic precision, in order to maintain and establish health [7].

The use of silver nanoparticles (NP's Ag) have been widely studied and used in diverse areas thanks to its wide applications, one of the areas of greatest interest is in the medical, since it has been proven that NP's Ag Have a wide bactericidal spectrum, especially to reduce the bacterial activity of Streptococcus mutans, Escherichia coli and Staphylococcus aureus [8,9].

This is why an endotracheal PVC probe was functionalized for the incorporation of Ag NPs, the modified probe was characterized and its antibacterial activity.

Materials and methods

The Tollens method for the synthesis of NP's Ag described by Yin et al [10] was used to carry out the functionalization. The endotracheal tube was cut in approximately 2 cm pieces, which were split in half and expanded In plate form using an electric grill. In addition, small sections of tubes of about 0.5 cm were cut to which no modification was made. For functionalisation of PVC, the surface of the material was modified by adding functional groups using sodium hydroxide (NaOH) and 3-Aminopropyltriethoxysilane (C9H23NO3S) for allowing the anchoring of silver nanoparticles [11]. The incorporation of the nanoparticles into the functionalized PVC tube was by direct immersion in the nanoparticle solution, PVC was characterized by Fourier Transform Infrared Spectrometry (FTIR) and electron microscopy (SEM), the Ag NPs were characterized by Atomic Force Spectroscopy and Inductively Coupled Plasma Optical Emission Spectrometry. (ICP-OES), incorporation was corroborated by SEM and elemental chemical analysis for the antibacterial tests was used the normed method.

Results

Characterization of NP's Ag

In figure 1, the image is shown by atomic force spectroscopy of the synthesis of NP's Ag, in which one can observe semi-agglomerates of silver particles dispersed at nanoscale with semi-spherical shapes, according to the bell of Distribution, it can be defined that the particle size has an average of 30.55 nm according to the literature review the synthesis process was developed correctly, since the particle size is less than 50 nm [12, 13]

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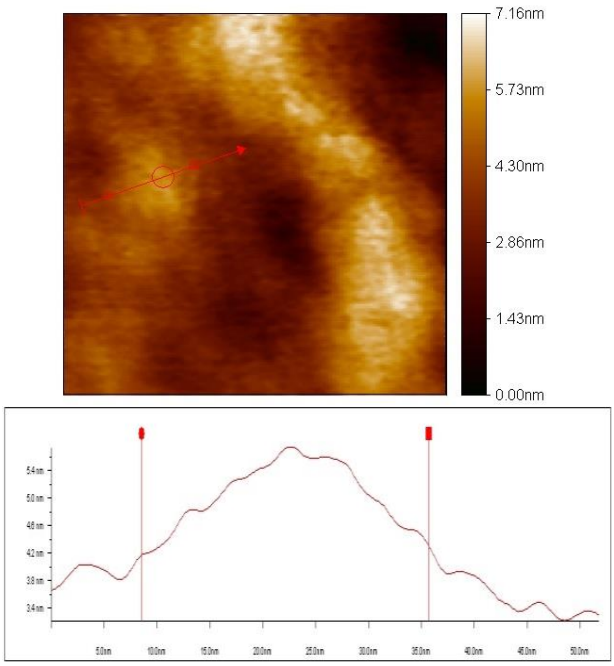

Figure 1 NPs Ag by Atomic Force Spectroscopy

Characterization by ICP-OES

According to the results obtained by ICP-OES, and with a sampling of six solutions, it was obtained that the concentration of silver in the sample is 0.614 mg / L, with a correlation index of 99.94% indicating a high correlation.

Material	Results ICP	Units
NP´s Ag	0.614	Mg/L

Tabla 1 ICP-OES síntesis de NP´s Ag

PVC Functionalization

The characterization of the polyvinyl chloride probe by FTIR allows to appreciate the changes that have been generated by the functionalization, observing that the contact with the solution of Sodium Hydroxide (NaOH) form ester groups (COO-) which will allow the union with Silver ions (Ag +), in addition to the formation of a salt (NaCl).

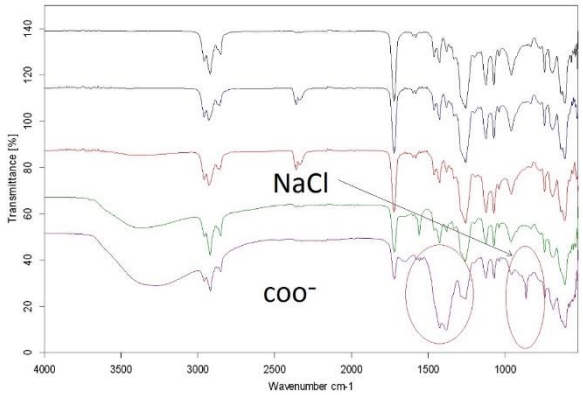

Figure 2 FTIR spectra obtained from PVC probe samples functionalized with NaOH

The SEM characterization visually shows the modification of the polyvinyl chloride probe, and it is verified that the functionalization obtained with 5M Sodium Hydroxide (NaOH) solution has a better distribution on the surface of the material, compared to the hydroxide treatment Of sodium (NaOH) 1N (Figure 3a and 3b). For this reason the anchoring of the silver particles on the surface of the material will be homogeneously dispersed.

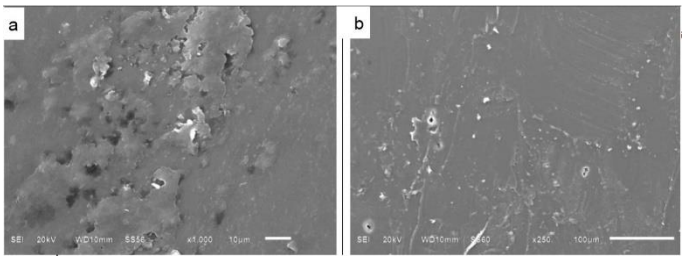

Figure 3 Functionalization by 5M NaOH (a) and 1N NaOH (b)

NP's Ag incorporation

The presence of NPs Ag in the form of flakes on the surface of the PVC can be observed through scanning electron microscopy (SEM), echo corroborated by the elemental chemical analysis (EDS) showing the presence of silver in the analyzed area (Figure 4).

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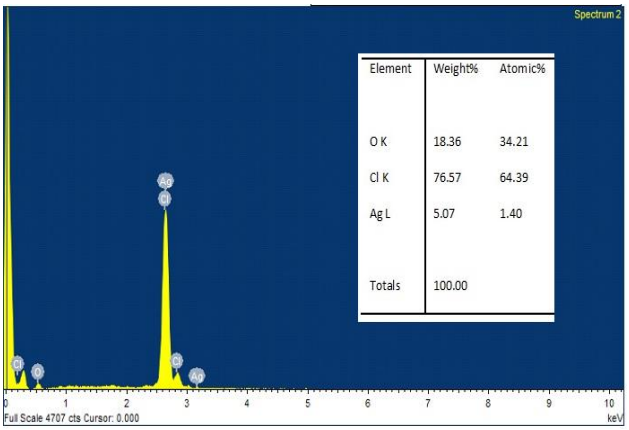

Figure 4 PVC Probe EDS with NPs Ag

The functionalization of PVC by Sodium Hydroxide solution (NaOH) generates esters groups, allowing the silver (Ag +) ions to be anchored, this anchoring is done in greater proportion in the 5M solution of NaOH due to the greater surface change of the material of support.

Antibacterial test

The antibiograms facilitate the determination of a material with better antibacterial property, so in the comparison of inhibition halos generated by the samples presented in table 6, it reflects that the sample 7 and 22 has better antibacterial properties being the solution samples of However, there are also inhibition halos in the 1N solution at a lower radius, these radii can be observed in Figure 5, according to the extended or oval shape of the PVC tubes there is no difference in the adhesion of the Nanoparticles on the PVC support.

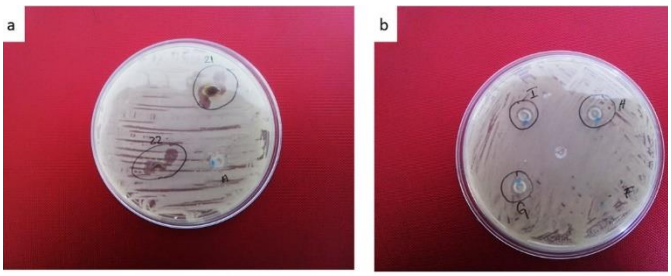

Figure 5 Inhibition Halo 5M NaOH solution (a) and 1N NaOH solution (b)

#	Shape	Radius	#	Shape	Radius
1	Circular	1mm	19	Circular	1mm
2	Circular	1mm	21	Circular	1mm
3	Circular	1mm	22	BiCircular	4 y 3 mm
4	Circular	1mm	23	Circular	1mm
5	Circular	1mm	24	Circular	1mm
6	Circular	1mm	25	Circular	1mm
7	Cyst	4 y 3 mm	26	Circular	1mm
8	Circular	1mm	28	Circular	1mm
12	Circular	1mm	30	Circular	1mm
18	Circular	1mm		Shape	

Table 2 Form and radius of NP inhibition Ag

Conclusions

The synthesis of NP's Ag by the Tollens method is a method that allows to obtain particle sizes between 8 and 36 nm with a concentration of 0.614 mg / L.

The formation of the ester groups (COO-) on the surface of the PVC probe confirms its functionalization, allowing it to function as a support for the nanoparticles.

The direct immersion as a method of incorporation of NP's Ag in the functionalized probe of PVC allows the adhesion of up to 5% in the surface of the support

The tests with the highest inhibition halo correspond to the samples functionalized by 5M NaOH solution with a radius of up to 5mm in its outer part, whereas the tests with 1N NaOH solution have a smaller inhibition halo with a radius of 1mm .

The incorporation of the NP's Ag is not linked to the extended or oval shape of the PVC pipe.

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