# DEVELOPMENT OF A SANITIZING SOLUTION BASED ON SILVER AND COPPER NANOPARTICLES: SYNTHESIS AND EVALUATION OF EFFICACY.

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**Abstract**

Copper (CuNPs) and silver (AgNPs) nanoparticles have attracted significant interest in the medical field due to their unique properties derived from their nanometric size, such as high surface-to-volume ratio and quantum confinement, which confers enhanced reactivity and bioactivity compared to their bulk counterparts. In the medical field, silver nanoparticles are recognized for their potent antimicrobial properties, allowing them to be used as sanitizers in hospital settings, antimicrobial coatings for medical devices, and agents for the treatment of infections [1]. On the other hand, copper nanoparticles also exhibit antimicrobial properties. Additionally, CuNPs have shown potential in wound healing, angiogenesis, and as antitumor agents [2]. This work presents the results of the synthesis of silver nanoparticles and copper nanoparticles of different sizes and compositions, and the evaluation of their antimicrobial activity. The synthesis of copper nanoparticles (CuNPs) and silver nanoparticles (AgNPs) was carried out chemically using salts of the metals of interest and ascorbic acid as a reducing agent. The antimicrobial effect of sanitizing products containing the synthesized Ag and Cu nanoparticles was evaluated. The product was studied on different representative Gram+ bacterial species, and the antiviral activity of the developed formulations was studied. Figure 1 shows the histogram obtained from Dynamic Light Scattering (DLS) graphs and Surface Plasm Resonance (SPR) spectrum for solutions of copper nanoparticles in water, showing that the CuNPs dispersed in solution have an average hydrodynamic radius of 2.5 nm and exhibit a SPR at 740 nm. Similar sizes were found for AgNPs. In tables 1, 2, 3 and 4 we can observe that when the suspension of the Staphylococcus aureus bacteria is added to the antibacterial solution of Ag and Cu, a reduction in the bacterial titer occurs to values lower than 10 CFU/mL in the case of silver nanoparticles, except for the concentration of 200 ppm in which a bacterial titer of $1x10^4$ CFU/mL was obtained with respect to the initial concentration of $10^8$ CFU/mL. Regarding the sanitizing solution with copper nanoparticles, it was observed that in all concentrations a bacterial titer in the order of $10^5$ and $10^7$ was obtained. For the sanitizing solution and the target with AgNPs, it was obtained that the logarithmic reduction on the evaluation in Staphylococcus aureus was 7 units and for the solution containing CuNps it was 1 or 3 units, the same occurs with the target, thus determining that the sanitizing solution with silver nanoparticles inhibits 99.999% of the bacterial growth of Staphylococcus aureus (Gram+); in addition, it reduces by 5 or more logarithmic units with respect to the bacterial titer of the control series and its effect is bactericidal or biocidal against the microorganism tested, which suggests that the sanitizing solution formulated with silver nanoparticles has a specific effect on Gram+ bacteria, demonstrating that AgNPs are good antibacterial materials, because they have the ability to reduce or eliminate pathogenic microorganisms, this action is carried out through an irreversible mechanism that affects vital cellular structures or their function and is known as a bactericidal effect [3,4]. For the sanitizing solution with copper nanoparticles, the concentration of the microorganism is reduced but it does not eliminate it completely, so we can say that they have less activity than AgNPs, since it is not capable of reducing 5 logarithmic units with respect to the count of the control series, this response is known as the bacteriostatic effect, which is carried out through a mechanism that generates a metabolic injury in the pathogens which is reversible after its elimination or neutralization [3,4].

## References

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## Figures

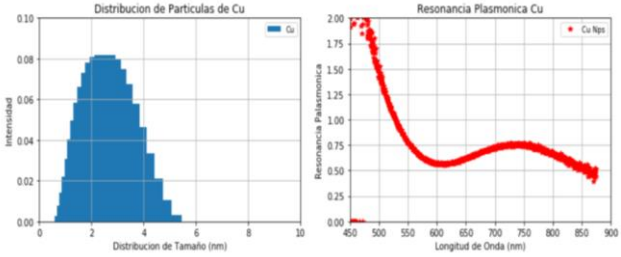


**Figure 1.** Dynamic Light Scattering and Surface Plasmonic Resonance Spectra for Copper Nanoparticles.

**Table 1**

Effectiveness test of the Silver (Ag) nanoparticle sanitizing solution evaluated at different concentrations.

| Microorganismo/ Concentración | Título Sol. Madre (UFC/ml) | log | Título de la solución Sanitizante | log | Reducción logarítmica | Título del blanco | log | Reducción logarítmica |
|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* / **50 ppm** | 6X $10^8$ | 8.78 | <10 | 1 | 7.78 | <10 | 1 | 7.78 |
| *Staphylococcus aureus* / **100 ppm** | $6x10^8$ | 8.78 | <10 | 1 | 7.78 | <10 | 1 | 7.78 |
| *Staphylococcus aureus* / **200 ppm** | $6x10^8$ | 8.78 | <10 | 1 | 7.78 | <10 | 1 | 7.78 |

**Table 2**

Effectiveness test of the silver (Ag) nanoparticle sanitizing solution at different concentrations using the plate count method.

| Microorganismo/ Concentración | Título Sol. Madre (UFC/ml) | log | Título de la solución Sanitizante | log | Reducción logarítmica | Título del blanco | log | Reducción logarítmica |
|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* / **50 ppm** | 6X $10^8$ | 8.78 | <10 | 1 | 7.78 | <10 | 1 | 7.78 |
| *Staphylococcus aureus* / **100 ppm** | $6x10^8$ | 8.78 | <10 | 1 | 7.78 | <10 | 1 | 7.78 |
| *Staphylococcus aureus* / **200 ppm** | $6x10^8$ | 8.78 | $1x10^4$ | 4 | 4.78 | <10 | 1 | 7.78 |

**Table 3**

Effectiveness test of the sanitizing solution of copper (Cu) nanoparticles evaluated at different concentrations.

| Microorganismo | Título Sol. Madre (UFC/ml) | log | Título de la Solución Sanitizante | log | Reducción logarítmica | Título del blanco | log | Reducción logarítmica |
|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* / **50 ppm** | $6x10^8$ | 8.78 | $3x10^6$ | 6.48 | 2.3 | $5x10^6$ | 6.70 | 2.08 |
| *Staphylococcus aureus* / **100 ppm** | $6x10^8$ | 8.78 | $3x10^5$ | 5.48 | 3.3 | $9x10^6$ | 6.95 | 1.83 |
| *Staphylococcus aureus* / **200 ppm** | $6x10^8$ | 8.78 | $7x10^6$ | 6.84 | 1.94 | $9x10^6$ | 6.95 | 1.83 |

**Table 4**

Effectiveness test of the sanitizing solution of copper (Cu) nanoparticles at different concentrations by the plate count method.

| Microorganismo | Título Sol. Madre (UFC/ml) | log | Título de la Solución Sanitizante | log | Reducción logarítmica | Título del blanco | log | Reducción logarítmica |
|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* / **50 ppm** | $6x10^8$ | 8.78 | $4x10^7$ | 7.60 | 1.18 | $3.6x10^7$ | 7.56 | 1.22 |
| *Staphylococcus aureus* / **100 ppm** | $6x10^8$ | 8.78 | $4x10^6$ | 6.60 | 2.18 | $2x10^7$ | 7.30 | 1.48 |
| *Staphylococcus aureus* / **200 ppm** | $6x10^8$ | 8.78 | $2x10^7$ | 7.30 | 2.18 | $3.7x10^7$ | 7.56 | 1.22 |