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Effects of Electromagnetic Fields on Colloidal Nano Silver for Applications in Nano Medicine

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Authors' contributions

This work was carried out in collaboration between both authors. Author II designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author CD managed the analyses of the study. Author II managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Colloidal Silver in European Union is food additive. The aim of the study is to show the common effects of colloidal nano silver and electromagnetic fields. The influence on colloidal nano silver with concentration of 30 ppm was studied using the method of Drossinakis in electromagnetic waves in the range of v=20 -70 Hz. The research was performed with the methods for spectral analyses Nonequilibrium energy spectrum (NES) and Differential nonequilibrium energy spectrum (DNES). The study was performed with research of parameters of pH and oxidation reduction potential (ORP). The control sample is the sample with colloidal nano silver. The sample was taken after the influence with electromagnetic fields on the sample with colloidal nano silver.
The effect of electromagnetic fields is connected with increasing of the effects of colloidal nano silver. There are proofs with differences between samples and control sample with parameters of NES, DNES, pH, ORP.

Keywords: Colloidal nano silver; electromagnetic waves, spectral analyses; NES; DNES; pH; ORP.

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1. INTRODUCTION

The anti-inflammatory properties of colloidal nano silver have been known for years. Antibacterial effects have been shown. Effects have been reported with coronavirus SARS-CoV-2. There is evidence for decreasing of SARS-CoV-2 with different concentrations of colloidal nano silver.

The research of effects of electromagnetic fields with Drossinakis' method was performed with the following bacteria – *Escherichia coli, Enterococci, Coliforms* and *Clostridium perfringens* [1].

In different studies there are proofs for the effects of Nanoparticles Silver against *Escherichia coli* and *Enterococci* in gastrointestinal tract [2]. Silver ions inhibited the oxidation of glucose, glycerol, fumarate, succinate, D- and L-lactate, and endogenous substrates by intact cell suspensions of *Escherichia coli* [3].

Basic research with anti bacterial effects has been done by Bulgarian team with silver nano particles (AgNPs) and polyvinylpyrrolidone (PVP) [4].

The anti bacterial activity of the synthesized AgNPs/PVP against etalon strains of three different groups of bacteria— *Escherichia coli* (*E. coli*; gram-negative bacteria), *Staphylococcus aureus* (*S. aureus*; gram-positive bacteria), *Pseudomonas aeruginosa* (*P. Aeruginosa)*. The research was performed for non-ferment gram-negative bacteria), as well as against spores of *Bacillus subtilis (B. subtilis)*. AgNPs/PVP were studied for the presence of fungicidal activity against different mold and yeasts such as *Candida glabrata*, *Candida krusei*, *Candida albicans*, *Candida tropicalis*, and *Aspergillus brasiliensis* [4].

In Japanese study there are proofs that Nanoparticle Silver inhibiting extracellular SARS-CoV-2 at concentrations ranging between 1 and 10 ppm while cytotoxic effect was observed at concentrations of 20 ppm and above [5]. The effects are in extracellular water. The mechanism of colloidal nano silver influence was explained in the following studies [6-11].

The proofs with effects of electromagnetic range v=20 -70 Hz with Drossinakis method how the possibility for the common effects between colloidal nano silver with concentration of 30 ppm in electromagnetic waves.

The effect of electromagnetic fields is connected with increasing of the effects of colloidal nano silver with higher energies of hydrogen bonds and atoms of colloidal nano silver. Other effect is with increasing of number of free electrons and negative charges with anti inflammatory and anti oxidant and anti tumor effects. There are results with antioxidant and anti tumor effects of colloidal nano silver [12,13].

2. METHODS AND MATERIALS

2.1 Method for Colloidal Nano Silver with Electrolysis (Mosin, Ignatov, 2013)

In order to obtain colloidal silver with method of electrolysis [7,8,9] the following ingredients are required:

1. Silver electrode with a purity of 99.99%;
2. *Tetra-n-butylammonium bromide* (TBAB)-ammonium salt with bromide;
3. *Acetonitrile* – coloured liquid solution with chemical formula CH_3CN

The obtaining of colloidal silver can occur via electrolysis (Mosin, Ignatov, 2013). The synthesis method uses tetra-n-butylammonium bromide in acetonitrile as a liquid medium for electrolysis. he method of Mosin-Ignatov obtains colloid silver with sizes of 2–7 nm in a solution of tetra-n-butylammonium bromide in acetonitrile. The anode is silver, and the cathode from graphite.

During the process of electrolysis a partial dissolving of the silver anode occurs that leads to saturation of the solution with Ag^+ . At given parameters of the electric current and tension over the electrode, the concentration of Ag^+ solution is determined by the working time of the electricity source, and the quantity of the aqueous solution.

2.2 NES and DNES Spectral Analyses

The device with author A. Antonov [14] for spectral analysis with methods NES and DNES is based on an optical principle. The evaporation of water drops is in hermetic camera with a glass plate and water-proof transparent pad, which consists of thin mylar foil.

The parameters are:

1. Monochromatic filter with wavelength λ = 580±7 nm (yellow color in visible spectrum);

2. Angle of evaporation of water drops from 72.3^0 to 0^0;
3. Temperature (+22–24^0C);
4. Range of energy of hydrogen bonds among H_2O molecules is λ=8.9–13.8 μm; E=-0.08– -0.1387 eV;

The energy ($E_{H...O}$) of hydrogen O...H-bonds among H_2O molecules in water sample is measured in eV. The function f(E) is called spectrum of distribution according to energies. The energy spectrum of water is characterized by a non-equilibrium process of water droplets evaporation and this is non-equilibrium energy spectrum (NES) and is measured in eV^{-1}. DNES is defined as the difference

Δf(E) = f (samples of water) – f (control sample of water),
DNES is measured in eV^{-1} where *f(*)* denotes the evaluated energy.

2.3 Electrical Measurements

For the research of Oxidation Reduction Potential (ORP) in mV and pH was applied the following device – HANNA Instruments HI221 meter equipped with Sensorex sensors.

The Range of HANNA Instruments HI221 meter is:

pH - (2.00-16.00 ±0.01)
ORP (±699.9±0.01 – ±2000±0.1) mV

3. RESULTS AND DISCUSSION

3.1 Results with Methods NES and DNES

The difference *Δf(E) = f (samples of water) – f (control sample of water)* is called the "differential nonequilibrium energy spectrum of water" (DNES). The average energy ($\Delta E_{H...O}$) of hydrogen H…O-bonds among individual molecules H_2O was calculated for colloidal nano silver with electromagnetic waves and colloidal nano silver as a control sample by NES- and DNES-methods. We studied the distribution of local extremums in colloidal nano silver with electromagnetic waves and colloidal nano silver as a control sample. The average result with 10 measurements for colloidal nano silver with electromagnetic waves in the NES-spectrum is E=-0.1282 eV with influence of Drossinakis, and E=-0.1272 eV with influence of Bettina Maria Haller. For the control sample the average result with 10 measurements of colloidal nano silver is E=-0.1228 eV. The calculations of $\Delta E_{H...O}$ for electromagnetic waves (Drossinakis) with the DNES method compiles to (-0.0054±0.0011 eV), and for electromagnetic waves (Haller) it is (+0.0044±0.0011 eV).

T-criteria of Student was applied with 10 measurement of effects of electromagnetic fields on colloidal nano silver. There is statistical significant difference between the two groups of results with the effects of electromagnetic fields according to the t-criterion of Student at level $p < 0,05$. These results suggest the restructuring of $\Delta E_{H...O}$ values among individual H_2O molecules with a statistically significant increase of local extremums in DNES-spectra of colloidal nano silver after influence with electromagnetic waves. The local extremums (eV^{-1}) are in the function of distribution of energies of hydrogen bonds.

For the colloidal nano silver with influence with electromagnetic fields give the biggest extremum was detected at (E = -0.1212 eV)(λ=10.23 μm)($\tilde{\nu}$=978 cm^{-1}).

The local extremums Δf in the DNES-spectrum at E = -0.1212 eV were detected with the positive values. They are 32.0 (Haller) and 29.5 eV^{-1} (Drossinakis).

3.2 Mathematical Models of Colloidal Nano Silver with Electromagnetic Waves and Colloidal Nano Silver as a Control Sample

Mathematical models were performed (Ignatov, Mosin, 2013) of a number of H_2O molecules with different values of distribution of energies [15,16,17]. The mathematical models of a sample of colloidal nano silver with influence with electromagnetic fields give the valuable information for the possible number of hydrogen bonds as percent of H_2O molecules with different values of distribution of energies. The control sample is with colloidal nano silver (Table 1 and Fig. 1). These distributions are basically connected with the restructuring of H_2O molecules having the same energies.

Table 1. Mathematical Models Results of spectral analyses with methods NES and DNES of colloidal nano silver with influence with electromagnetic fields (Christos Drossinakis, red color) and (Bettina Maria Haller, green color), control sample (blue color)

-E(eV) x-axis	Colloidal Nanosilver E.M. waves (Drossinakis) (%((-E_{value}) */ (-$E_{total\ value}$)**	Colloidal Nanosilver E.M. waves (Haller) (%((-E_{value}) */ (-$E_{total\ value}$)**	Colloidal Nanosilver (control sample) (%((-E_{value}) */ (-$E_{total\ value}$)**	-E(eV) x-axis	Colloidal Nanosilver E.M. waves (Drossinakis) (%((-E_{value}) */ (-$E_{total\ value}$)**	Colloidal Nanosilver E.M. waves (Haller) (%((-E_{value}) */ (-$E_{total\ value}$)**	Colloidal Nanosilver (control sample) (%((-E_{value}) */ (-$E_{total\ value}$)**
0.0912	0	0	0	0.1162	11.5	8.1	8.1
0.0937	0	0	0	0.1187	0	2.0	0
0.0962	0	0	0	0.1212	**14.1**	**15.0**	8.1
0.0987	0	0	4.0	0.1237	0	4.0	8.1
0.1012	7.7	8.1	0	0.1262	7.7	8.1	0
0.1037	0	4.0	4.0	0.1287	7.7	8.1	4.0
0.1062	7.7	4.0	0	0.1312	11.5	3.4	15.0
0.1087	0	0	12.2	0.1337	0	0	8.1
0.1112	**3.8**	**4.0**	0	0.1362	14.1	15.0	12.2
0.1137	0	4.0	4.0	0.1387	**14.2**	**12.2**	12.2

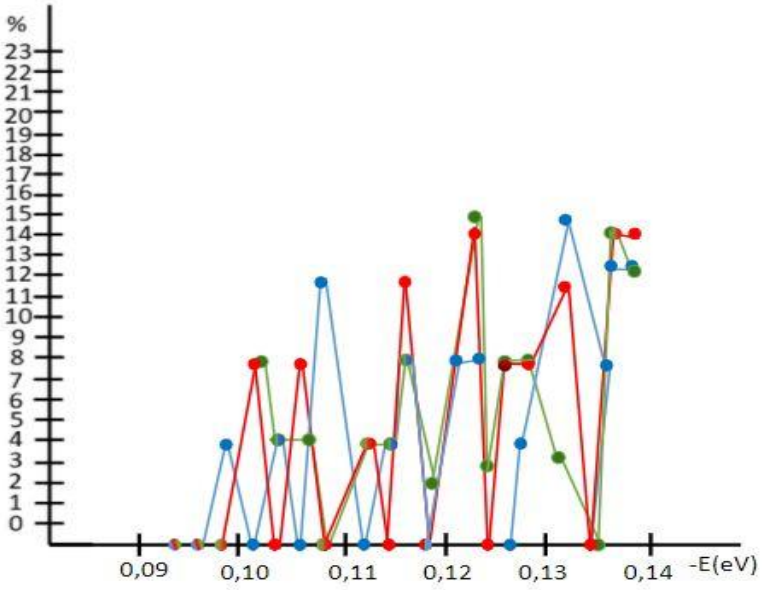

Fig. 1. Mathematical Models Results of spectral analyses with methods NES and DNES of colloidal nano silver with influence with electromagnetic fields (Christos Drossinakis, red color) and (Bettina Maria Haller, green color), control sample (blue color)

Notes:

For (E=-0.1112 eV)(λ=11.15 μm)(ῡ=897 cm^{-1}) is the local extremum for stimulating effect on the nervous system and improvement of nerve conductivity.
For (E = -0.1212 eV)(λ=10.23 μm)(ῡ=978 cm^{-1}) is the local extremum for anti-inflammatory effect.
For (E=-0.1387 eV)(λ=8.95 μm)(ῡ=1117 cm^{-1}) is the local extremum for inhibition of development of tumor cells at the molecular level.

Notes:

* The result ($-E_{value}$) is the result of hydrogen bonds energy for one parameter of (-E)
** The result ($-E_{total\ value}$) is the total result of hydrogen bonds energy
The local extremum is strongly expressed at (E = -0.1212 eV) (λ = 10.23 μm) (ῡ = 978 cm^{-1}). It is associated with anti-inflammatory effects.

There are effects of electromagnetic fields with Method of Drossinakis with local extremum at (E=-0.1387 eV)(λ=8.95 μm)(ῡ=1117 cm^{-1}) for inhibition of development of tumor cells at the molecular level [18,19,20].

3.3 Study of pH and ORP of Samples of Nano Silver with Influence with Electromagnetic Fields

The obtained results with pH and (oxidation reduction potential) ORP are shown in the following Table 2.

The results from Table 2 with pH and ORP show the difference with influence of electromagnetic waves on nano silver with influence with electromagnetic fields and control sample with colloidal nano silver.

The effects of electromagnetic fields with pH and ORP show effects with negative charge. This charge is connected with anti oxidant and anti inflammatory effects [21,22].

Table 2. The obtained results with pH and ORP

Parameters	ORP (mV) Sample	pH Sample
Colloidal Nano Silver	+45	7.45
Colloidal Nano Silver with E.M. waves	-53	8.05
Difference	-88	0.6

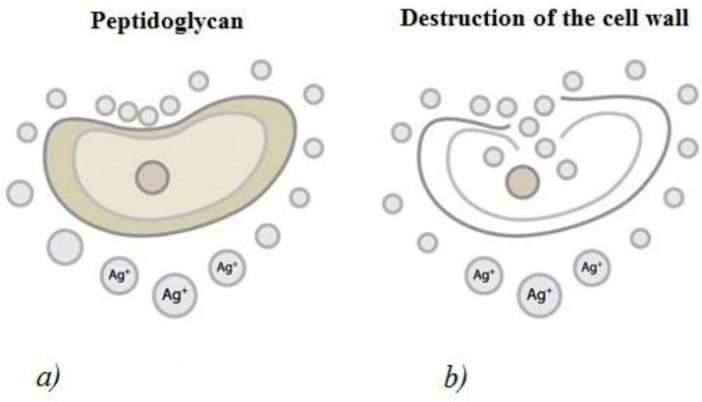

Fig. 2. Mechanism of antibacterial and antiviral action of colloidal nano silver

3.4 Antibacterial and Antiviral Effects of Colloidal Nano Silver

The mechanism of antibacterial and antiviral action is shown at Fig. 2. The mechanism is in the process of replication. For the coronavirus gets replicated via copying of the genetic material using the enzyme RNA-dependent RNA polymerase.

In such a way it prevents the further alteration of the enzyme. The results are "in vitro", on the enzyme in a solution. The colloidal silver is possible Ag^+ inhibits such copying, and in this way the effects of COVID-2019 are neutralized.

3.5 Applications of Colloidal Nano Silver in Nano Medicine

The results show application of colloidal nano silver in dental medicine [23], anti bacterial [24,25,26,27,28] and antiviral activity.

The research show effects with colloidal nano silver with electromagnetic waves.

4. CONCLUSION

A study of the effect of electromagnetic fields in the range v = 20 -70 Hz was performed. The research was performed with the methods for spectral analyzes Nonequilibrium energy spectrum (NES) and Differential nonequilibrium energy spectrum (DNES). The study was conducted using oxidation reduction potential (ORP). The methods NES, DNES and ORP show a significant difference between the parameters with colloidal nano silver and colloidal nano silver when it is exposed to electromagnetic fields.

The local extremum is strongly expressed at (E = -0.1212 eV) (λ = 10.23 μm) ($\tilde{\nu}$ = 978 cm^{-1}). It is associated with anti-inflammatory effects.

It is recommended in practice to activate colloidal nano silver with electromagnetic fields in the range v = 20 -70 Hz.

The results show application of colloidal nano silver in dental medicine, anti bacterial and antiviral activity.

The research show effects with colloidal nano silver with electromagnetic waves.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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