Original Research Article

Effects of Electromagnetic Fields on Colloidal Nano Silver. Effects for Applications in Nano medicine

Abstract
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 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.

Key words: *colloidal nano silver, electromagnetic waves, spectral analyses, NES, DNES, ORP.*

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 Nanoparticle 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 antibacterial 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 show the possibility for the common effects between colloidal nano silver with concentration of 30 ppm in electromagnetic waves.

2. Methods and matherials

2.1. NES and DNES Spectral Analyses

The device with author A. Antonov (12) 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 ^{0}C);
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.

2.2. 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 result 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 of colloidal nano silver it 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). 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 (13, 14, 15). 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 Figure 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 nano silver with influence with electromagnetic fields.

-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

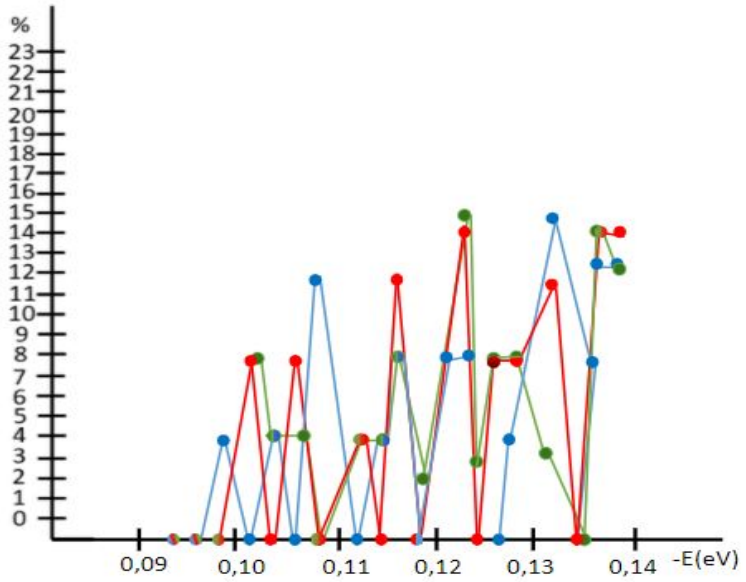

Figure 1 Mathematical Models Results of spectral analyses with methods NES and DNES of colloidal nano silver with influence with electromagnetic fields (Christos Drossinakis, red color) and (Bettina Maria Haller, green color), control sample (green color).

Notes:

For (E=-0.1112 eV)(λ=11.15 μm)(ṽ=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)(ṽ=978 cm^{-1}) is the local extremum for anti-inflammatory effect.

For (E=-0.1387 eV)(λ=8.95 μm)(ṽ=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) (ṽ = 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)(ṽ=1117 cm^{-1}) for inhibition of development of tumor cells at the molecular level (16, 17).

3.3. Study of pH and ORP of samples of nano silver with influence with electromagnetic fields

The obtained results with pH and ORP are shown in the following Table 2.
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

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 (18, 19).

4. Conclusion
A study of the effect of electromagnetic fields in the range ν = 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) (ṽ = 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 ν = 20 -70 Hz.

References

1. Valcheva, N,, Ignatov, I. Microbiological Research of the Effects of Electromagnetic Fields of the Bacteria *Escherichia coli, Enterococci, Coliforms and Clostridium perfringens,* Microbiology Research Journal International, 2020;
2. Le, A-T. et al. Powerful Colloidal Silver Nanoparticles for the Prevention of Gastrointestinal Bacterial Infections, Advances in Natural Sciences: Nanoscience and Nanotechnology, 2012; 3(4).
3. Bragg, P., Rainnie, D. The effect of silver ions on the respiratory chain of *Escherichia coli,* Canadian Journal of Microbiology, 1974;
4. Bryaskova, R., Pesheva, D., Nikolov, S., Kantatdjiev, T., Synthesis and comparative study on the antimicrobial activity of hybrid materials based on silver nanoparticles (AgNps) stabilized by polyvinylpyrrolidone (PVP), Journal of Chemical Biology, 2011; 4: 185.
5. Jeremiah et al. Potent Antiviral Effect of Silver Nanoparticles on SARS-CoV-2, Biochemical and Biophysical Research Communication, 2020; 533 (1): 195-200.
6. Dondysh, L.M. Inhibitory Effect of Silver on Some Enzymatic Systems. Questions and Exogenous Organic Neuropsychiatric Disorders/ in Materials of Scientific Conf., State Institute of Psychiatry USSR, Ministry of Health. – Moscow: State. Institute of Psychiatry USSR Ministry of Health, 1964; 2: 143–165.
7. Ignatov, I., Mosin, O.V. Methods for the Preparation of Colloidal Silver Nanoparticles and Spheres of Their Practical Application Field, Bulletin of Science and Education, 2013;3; 30–42.
8. Mosin, O. V., Ignatov, I. Preparation of Nanoparticles of Colloid Silver and Spheres of Their Practical Using, Nanoengeneering, 2013; 5: 23-30.
9. Mosin, O.V., Ignatov, I. Methods for the Preparation of Colloidal Silver Nanoparticles, Nano and Microsystems, 2014
10. Ignatov, I. Antiviral Effects of Nano Colloidal Silver, Water Catholyte, Oxidal with Methylene Blue. Possible Effects of Influence over Coronavirus SARS-CoV and SARS-CoV-2 with Disease COVID-19, Global Congress on Infectious Diseases, SciTech Infectious Diseases 2020.
11. Ignatov, I. (2020) Antibacterial and Antiviral Effects of Water Catholyte, Oxidal with Methylene Blue and Colloidal Silver, Journal of Medicine, Physiology and Biophysics, Vol. 65, pp. 26-31.
12. Antonov, A. Research of the Non-equilibrium Processes in the Area in Allocated Systems, Dissertation thesis for degree “Doctor of physical sciences”, Blagoevgrad, Sofia. 1995;1-254.
13. Ignatov, I., Mosin, O. V. Structural Mathematical Models Describing Water Clusters, Journal of Mathematical Theory and Modeling, 2013; 3 (11): 72-87.
14. Ignatov, I., Gluhchev, G., Karadzhov, G., Yaneva, I., Valcheva, N., Dinkov, G,, Popova, T., Petrova, T., Mehandjiev, D., Akszjonovich, I. (2020) Dynamic Nano Clusters of Water on Waters Catholyte and Anolyte: Electrolysis with Nano Membranes, Physical Science International Journal. Vol. 24, No.1, pp. 46-54.
15. Ignatov. I., Gluhchev. G., Huether, F. Dynamic Nano Clusters of Water on EVODROP Water, Physical Science International Journal, 2020; 24 (7): 47-53.
Toshkova, R., Ignatov, I., Zvetkova, E., Gluhchev, G., Drossinakis, Ch. Bioinfluence with Infrared Thermal and Electromagnetic Fields as a Therapeutic Approach of Hamsters with Experimental Graffi Myeloid Tumor, Journal of Natural Sciences Research, 2019; 9 (4): 1-11.
16. Toshkova, R.; Ignatov, I.; Zvetkova, E.; Gluhchev, G.; Drossinakis, Ch. Beneficial Effects of Drossinakis Bio-influence (With Infrared Thermal and Electromagnetic Fields) on the Development of Experimental Graffi Myeloid Tumors in Hamsters. Hematological Studies, Journal of Medicine, Physiology and Biophysics, 2019; 54: 13-17.

17. Toshkova, R., Zvetkova, E., Ignatov, I., Gluhchev, G. Effects of Catholyte Water on the Development of Experimental Graffi Tumor on Hamsters, Bulgarian Journal of Public Health, 2019; 11 (3): 60-73.
18. Oschman, J., Can Electrons Act as Antioxidants? J Altern Complement Med. 2007;13(9):955-67

19. Oschman, J., Charge Transfer in the Living Matrix, Journal of Bodywork and Movement Therapies, 2009;13 (3); 215-228.