SILVER NANOPARTICLES AND THEIR BACTERICIDAL EFFECT

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Abstract

Nanotechnology is expected to open new avenues to fight and prevent disease using atomic scale tailoring of materials. Rapid development of bio-nanotechnology and material research lead to the new way in the combating of bacteria and to searching specific properties of nanomaterials. The study of bactericidal nanomaterials is particularly timely considering the recent increase of new resistant strains of bacteria to the most potent antibiotics.

The present work studies the bactericidal effect of silver nanoparticles in the range of 10-30 nm on Gram-negative bacteria and Gram-positive bacteria. The colloid silver nanoparticles were prepared by the modified Türkewitsch’s method. These colloid particles have the specific properties resulting in a bactericidal effect.

Keywords: silver nanoparticles, bactericidal effect

1. INTRODUCTION

Nanotechnology is expected to open new avenues to fight and prevent diseases using atomic scale tailoring of materials. Rapid development of bio-nanotechnology and material research leads to a new way in combating bacteria and searching specific properties of nanomaterials. Presently, the increased resistance of bacteria against strong antibiotics offers to nanomaterial research a chance to help alleviating this problem.

2. MATERIALS AND METHODS

2.1 Materials, chemical method

Reagents were purchased from Fluka or Penta and used as received.

Silver nanoparticles were synthesized by modified Türkewitsch’s method [1]. 0.1 mmol solution of AgClO\textsubscript{4} was prepared and then heated to boiling point during vigorously stirred. To this solution, trisodium citrate (4.5.10^{-5}M) was added drop by drop. At the end, silver nanoparticles were reduced by sodium borohydride. Solution was mixed during the process. The color of solution has changed to yellow. Subsequently it was removed from the heating element and stirred until cooled to the room temperature.
2.2 Characterization of prepared particles

Prepared silver nanoparticles were characterized by localized surface plasmon resonance (Fig. 1) and by SEM microscope (Fig. 2). Size distribution of silver nanoparticles was calculated from SEM characterization, studied particles were distributed in size varying from 10 nm to 30 nm.

![Fig. 1: Absorption spectra of silver nanoparticles](image1)

![Fig. 2: TEM characterization of silver nanoparticles](image2)

2.3 Microbiological techniques

To test the bactericidal activity of Ag nanoparticles, laboratory strain Escherichia coli K12 C 600, Candida albicans and Enterococcus faecalis (EFCA) were used in this study [2]. Cells were grown in Lysogeny Broth (LB) [3] medium and plated on Luria-agar plates (LA; LB with addition of 15% of agar). The overnight cultures were diluted in LB such that the final concentration of cells was \((1-3) \times 10^7\) cells/mL and used for antimicrobial assays.

Cells from 1 mL of a cell suspension \((10^7\) cell/mL) were mixed with 1 mL solution of Ag nanoparticles \((10^{11}\) particles/mL) - the first experimental series with variously cells (graph 1). Second series presented an experiment with cells from 1 mL of a cell suspension mixed with 1 mL solution of Ag nanoparticles with different concentration (graph 2). The mixtures had been shaken at 37°C for 1 h. Subsequently, the samples were serially diluted and plated on LA plates. Third series presented time dependence of bacterial efficacy of silver nanoparticles. Cells from 1mL of a cell suspension of Escherichia coli were mixed with 1mL solution of Ag nanoparticles and plated on LA plates in different time during shaking (graph 3).
3. EXPERIMENTAL RESULTS

Bactericidal experiments of Ag nanoparticles were performed using the bacteria as described in Section 2.3. The overnight cultures, diluted on concentration of cells $10^7$ /mL, were mixed with analyzed Ag nanoparticles solutions. After 1 h of shaking at 37 °C the mixtures were analyzed for the number of living (surviving) cells by plating them on LA plates.

After overnight cultivation a number of colonies representing the number of living (surviving) cells were calculated. The bactericidal efficacy of Ag nanoparticles on bacteria was estimated according to the formula [4].
The results in graph 1 and graph 2 show efficiency of silver nanoparticles in the interaction of different bacteria and interaction between different concentration of silver and bacteria, respectively. Graph 3 presents time dependence of bacterial efficacy of silver nanoparticles. The mixture was analyzed after 7 minutes, 15 minutes, 20 minutes and then every 10 minutes during shaking.

4. CONCLUSIONS

The colloid silver nanoparticles were prepared in the range of 10-30 nm and studied their specific properties resulting in a bactericidal effect. The results show bactericidal effect of silver nanoparticles in the interaction with all the used laboratory strain. In the experiments, it is possible see the bactericidal effect of silver nanoparticles depending on number of particles and time dependence of interaction between silver particles and bacteria.

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