Biological activity of metal nanoparticles as basis for development of bio- and nanosensors

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Introduction

Nanomaterials, especially metal nanoparticles, are actively used today in the creation of modern bio- and nanosensors for the detection of pathogens, toxins, blood markers etc. [1,2]. The use of nanomaterials usually is limited by their physicochemical properties (surface plasmon resonance, electrical conductivity, magnetic properties etc.). At the same time, high biological activity of certain metal nanoparticles can be the basis for development and improvement of the diverse bio- and nanosensors.

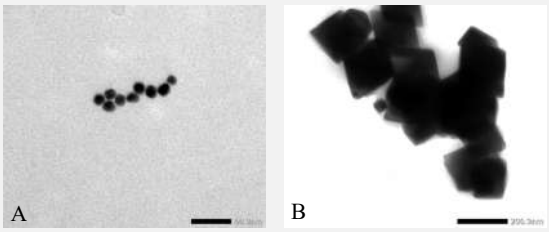
Aims

To study the biological activity of the synthesized metal nanoparticles (gold AuNPs, silver AgNPs, iron FeNPs) when contacting with enzymes and bacteria cells, which can be useful in development of electrochemical and optical bio- and nanosensors.

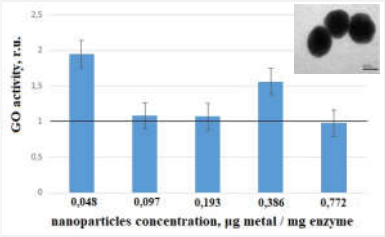
Methods

Methods of preparative, analytical and physical biochemistry; molecular biology; classical microbiology, colloidal chemistry were used in the study.

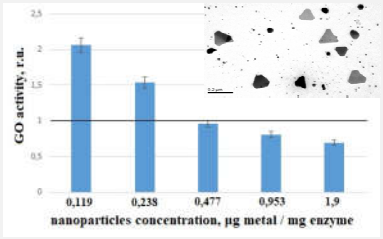
Results



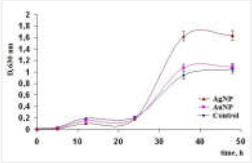
TEM images of 20 nm AuNP in 20 mM phosphate buffer (A) and after contact interaction with glucose oxidase (B) - the active binding of gold nanoparticles and glucose oxidase.



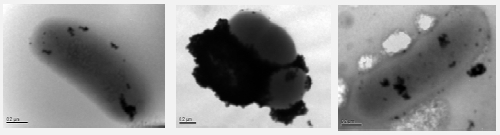
Glucose oxidase (GO) activity (A/A_0, relative units) in a model glucose solution under the influence of spherical AuNP 30 nm (A_0 - the value of GO activity established in the absence of nanoparticles influence).



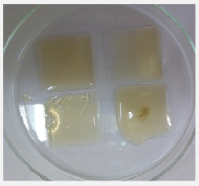
Glucose oxidase (GO) activity (A/A_0, relative units) in a model glucose solution under the influence of AgNP with triangular shape (A_0 - the value of GO activity established in the absence of nanoparticles influence).



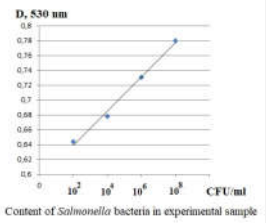
Growth curve of *P. multocida* 877 strain under the influence of AuNP and AgNP in comparison with control.



TEM images of pathogen bacteria cells with accumulated metal nanoparticles.



Chromogenic reactions using AuNP (3.0 μg/ml metal) for *Salmonella enteritidis* detection.



Optical density of experimental samples (mixture of AuNP conjugate and model solution) at a wavelength of 530 nm depending on the content of *Salmonella* bacteria cells in the model solution.

Conclusion

Metal nanoparticles of certain nature, size and shape are possessed by high biological activity. For instance spherical AuNP (d=30 nm) at a concentration of 0.386 μg metal / mg enzyme and 0.048 μg metal / mg enzyme can form electroactive complexes with glucose oxidase with stimulation of the enzymatic activity by 56% and 95% respectively.

Revealed peculiarities can be used in the development of a sensitive element of the electrochemical bio- and nanosensors based on the enzymes and metal nanoparticles.

When contacting with bacteria it was shown that the synthesized metal nanoparticles with certain size and shape were actively accumulated both on the surface and inside the cells changing the main physiological and biochemical characteristics of the microorganisms like growth rate and enzyme activity. Established biological effects of the certain synthesized FeNP, AgNP and AuNP give opportunity, for example, to accelerate the time of the officially recommended chromogenic reactions by 6-9 times with the sensitivity 1×10^3 CFU/ml. Such properties of the synthesized metal nanoparticles can be effectively used in the development of simple, sensitive optical nanosensors to rapid determination of various pathogens.

References

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2. Mustafa F., Hassan R.Y.A., Andreescu S. Multifunctional Nanotechnology-Enabled Sensors for Rapid Capture and Detection of Pathogens // Sensors (Basel). – 2017. – 17(9). – 2121

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