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Hydrogel nanocomposites with silver nanoparticles

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Copolymer hydrogels based on acrylic monomers (primarily acrylamide and acrylonitrile) are synthesized and their physicochemical properties are investigated. Methods of incorporation of nanoparticles of gold and silver into hydrogel pores and methods of their stabilization using reagents of different nature are developed. Our studies showed pronounced bactericidal properties of the nanocomposites regarding gram-positive and gram-negative bacteria and, at the same time, their biocompatibility to stem cells.

Introduction

Hydrogel nanocomposites are spatially cross-linked polymer nets with uniformly distributed incorporated nanoparticles. Due to the presence of polar functional groups

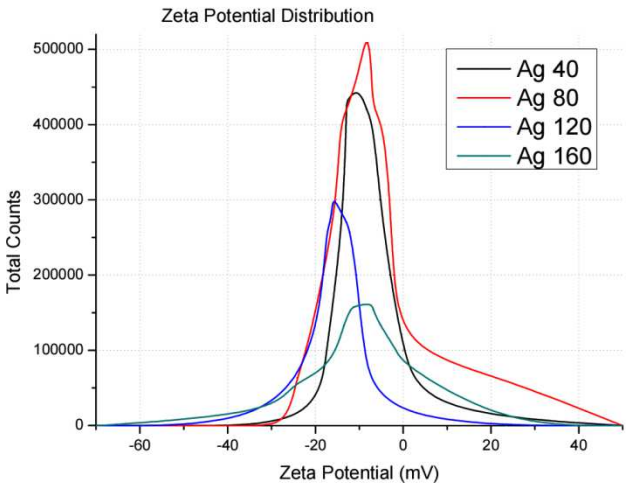

Fig 1. Zeta potential distribution of suspension of
silver nanoparticles

hydrogels can sorb significant quantities of water and some other solvents. It should be mentioned that for the so-called 'smart' hydrogels, phase transition between swollen and collapsed states accompanied by jump-like change of some other physico-chemical and working parameters reveals itself as a response to slight environmental changes (temperature, pH, and some others)[1]. The transition can also occur under the influence of physical factors of low intensity, such as light, electrical and/or magnetic field, etc)[2]. The composites based on 'smart' hydrogels that contain incorporated nanoparticles of various biomaterials, e.g. silver, magnetite, hydroxyapatite, carbon nanotubes appear to be most promising, especially for medicine due to cumulative combination of properties characteristic for a polymer matrix, that is combination of high biocompatibility, elasticity, ability to targeted

and prolonged release of medicines and inorganic filler properties: durability, hardness, bactericidal activity and magnetic properties control.

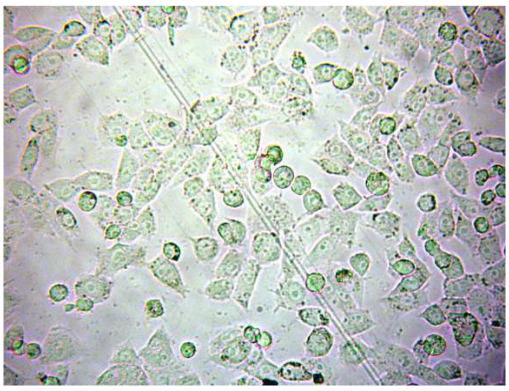

Fig 2a. Morphology of cells on the surface of a petri dish

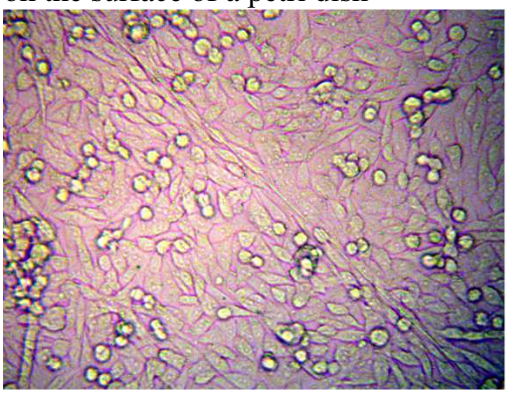

Fig 2b. Morphology of cells on the surface of the hydrogel with silver 25 μg/g

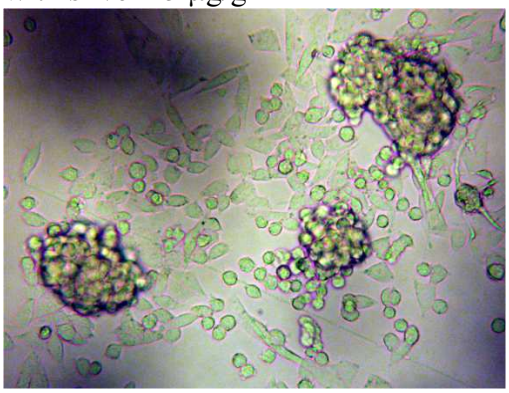

Fig 2c. Morphology of cells on the surface of the hydrogel containing silver 250 μg/g

Results and discussion

Colloid-chemical properties of silver particles stabilized dispersions were analyzed using Zeta Sizer "Malvern". It is shown that the developed method of synthesis provides a stabilized dispersion with a particle size of about 10 nm, the magnitude of the zeta potential is about -25 mV.(Fig 1.)

Microbiological researches showed high anti-microbial activity of colloidal silver incorporated hydrogel nanocomposites towards a wide range of microorganisms. There were also synthesized matrices with non-stabilized colloidal silver. Proliferation of cells over such matrices was investigated, cells were cultured for 3 and 6 days. Cell culture - Primary fibroblast human skin.

The study found that hydrogels based on acrylamide and acrylonitrile are the most suitable for the cultivation and propagation of cells that form monolayer. on the surface (Fig 2.)

Conclusions

Methods of obtaining and stabilizing the hydrogel nanocomposites containing noble metals in nanoscale state were developed. Synthesized materials are promising in terms of use in medicine such as antimicrobial wound coverings and artificial skin equivalents with immobilized stem cells for healing burns.

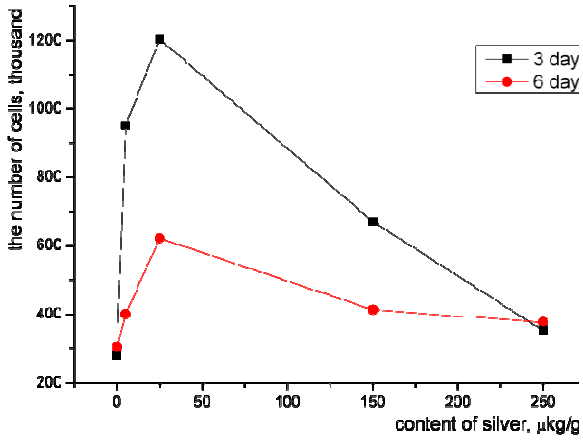

Fig 3. Dependence of the number of cells over hydrogels on
the total concentration of silver within the hydrogel

Experimental part

In order to obtain hydrogel nanocomposites with the colloidal silver, its water dispersions were synthesized and stabilized in advance. Silver nitrate solution was reduced by sodium boron hydride on the ice bath. Silver dispersions stabilized by polyvynilpyrrolydone (40 000 Da) were obtained in the concentration interval from 0 to 250 µg/g. Then pre-stabilized silver dispersions were mixed in certain proportions with relevant monomers, cross-linking agent *(N,N*-methylene-*bis*-acrylamide) and a redox initiating system (potassium persulfate - sodium metabisulfite).

Radical polymerization was carried out in-between flat and parallel plates for 1 hour at 20 °C followed by washing off residual quantities of unreacted substances using long extraction in distilled water with many-times change of the latter.

References

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