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Silver modified nanomaterials for enhanced photodynamic therapy

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Photodynamic therapy (PDT) is an alternative antimicrobial treatment developed nowadays for combating the pathogenic microorganism like bacteria, fungi or viruses, including the most dangerous strains such as methicillin-resistant Staphylococcus aureus (MRSA), cephalosporin-resistant Escherichia coli, vancomycin-resistant Enterococcus (VRE) or antibiotic-resistant Gonorrhea which cause the severe problems in the healthcare sector [1,2]. PDT has been primarily developed as a treatment for cancerous diseases, however it can be as well successfully applied to different infectious diseases such as wound, skin and burn infections, bacterial cystitis and keratitis, dental and periodontal pathogens, ophthalmological infections, localized tuberculosis, or some fungal and viral infections.

The therapy uses different types of biocompatible photoactive dyes called photosensitizers which can generate the free oxygen atoms and radicals to kill microbial cells during irradiation by ultra violet or visible light [3]. Bacterial strains, as well as other microorganisms, are susceptible to photodynamic therapy and, so far, there no resistance mechanism to this therapy has been reported in the literature [4,5]. At present, PDT is considered as more beneficial in comparison to the classic antibiotic therapy mainly due to targeted uptake of the photosensitizers by cells, direct exposure of a cured region to the illumination, and its safety. This is caused by low toxicity outward the illuminated area as the non-irradiated photosensitizers' molecules stay inactivated [6]. Moreover, the therapy outcome can be observed almost directly, while pharmacological therapy requires longer time [7].

In this study we investigated silver modified nanomaterials with antibacterial activity that may find applications in disinfection and photodisinfection. We found that the photodynamic therapy' effectiveness can be enhanced by materials which contain both, silver nanoparticles and photoactive photosensitizers. This combination leads to the reduction of the photosensitizers' concentration which may be caused by the fact that silver nanoparticles interact with cells' walls and organells and thus inhibit microbial growth [8,9].

For the purpose of this research the silica- and titania-based nanopowders were prepared. Next, both types of materials were used as the support for immobilization of silver nanoparticles by use of modified Tollen's method. The morphological parameters of materials were studied by use of TEM. Moreover, the examination of optical properties of nanopowders doped with silver nanoparticles and photolon was conducted. Various concentrations of photolon solutions and nanomaterials were investigated in order to find the maximum absorption peak. Furthermore, the microbiological study was carried out to check the efficacy of antibacterial activity against chosen pathological strains. It was found that the photosensitizer solutions absorption is dependent on the concentration of silver nanoparticles. Antibacterial study showed moreover, that silver doped silica- and titania-based materials reveal antibacterial activity which can be enhanced by the presence of photolon.

Concluding, decribed here tailored antimicrobial nanomaterials can be applied to support the photodynamic therapy and thus give the opportunity to create a new way of managing the hospital acquired infections, especially combat the growing number of antibiotic resistant bacteria. Altogether, the nano-silver-silica-photolon and nano-silver-titania-photolon present powerful combination of both, antibacterial activity and photoactivity.

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