Nanotechnology-powered approaches against antimicrobial resistance and bacterial biofilms

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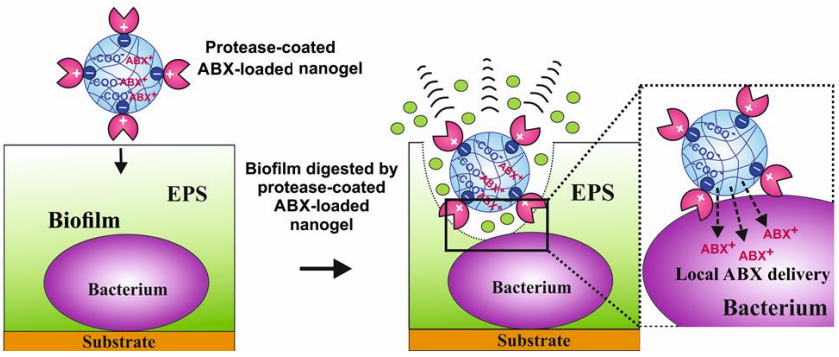
Multidrug-resistant pathogens are prevalent in chronic wounds. In this lecture, I will discuss how metal or metal oxide nanoparticles [1-4], nanogels [5] and nanocarriers of biocompatible materials [6-7] have been increasingly explored as efficient antimicrobials themselves as well as delivery platforms for enhancing the effectiveness of existing antibiotics. I will also focus on several examples of these nanocarrier-platforms that were recently developed in my research group. We developed a novel functionalized polyacrylic copolymer nanogel carrier for two cationic antibiotics, tetracycline and lincomycin hydrochloride, which can overcome antibiotic resistance [5]. We applied this strategy for boosting the action of other cationic antimicrobial agents [6,7] by encapsulating them into surface functionalized nanocarriers for more effective antimicrobial formulations against resistant bacteria. We also demonstrate that beta-lactamase inhibitor-loaded nanocarriers in co-treatments with either free or nanocarrier-loaded beta-lactam antibiotics can enhance their effectiveness further than when used alone. Recently, we also used surface functionalized shellac/Poloxamer 407-stabilized antibiotic nanocarriers on *P. aeruginosa*, which is susceptible to ticarcillin but is resistant to amoxicillin. We show an amplification of the antibiotic effect of amoxicillin and ticarcillin-loaded in shellac nanoparticles, both alone and as a co-treatment with free or nanocarrier-loaded clavulanic acid [8].

I will also discuss a novel type of formulation of copper oxide nanoparticles which have been covalently functionalized 4-hydroxyphenylboronic acid (4-HPBA). As the boronic acid groups on the nanoparticle surface can form reversible covalent bonds with the diols groups of glycoproteins that are expressed on the bacterial cell surface, they can strongly bind to the bacterial cells walls resulting in a very strong enhancement of their antibacterial action which is not based on electrostatic adhesion [1-3]. Such nanotechnology-based approaches may enhance the effectiveness of a wide variety of existing antibiotics, offering a potentially new mechanism to overcome antibiotic resistance. nanotechnology-based approach could lead to the development of more effective wound dressings, disinfecting agents, antimicrobial surfaces and smart antiseptic formulations.

Keywords: nanocarriers, antibiotics, bacteria, antimicrobial resistance, nanotechnology



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BIOGRAPHY

Professor Paunov received his PhD in Physical Chemistry in 1997 from the University of Sofia. He spent 20 years as a Professor of Physical Chemistry and Advanced Materials at the University of Hull, UK. He is currently working as a professor and Chair of the Department of Chemistry at Nazarbayev University, Astana, Kazakhstan. Prof Paunov does highly interdisciplinary research in nanoscience and bio-nanomaterials. His research interests include smart surfaces, stimulus triggered release of actives, directed cell assembly, tissue engineering, bioimprints and antimicrobial nanocarriers. He has published over 190 scientific papers with a current h-index of 59 and over 12600 citations.

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