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AgNPs embedded in silica matrix: a way to impair the microbial adhesion on dielectric surfaces

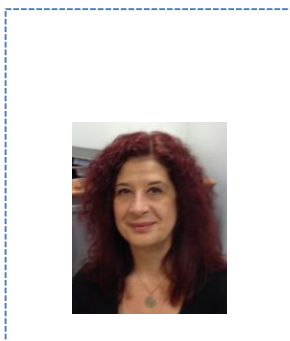
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Abstract

The emergence and selection of antibiotic-resistant bacteria is an ever increasing Public Health problem. Microbial adhesion and subsequent biofilm formation are at the origin of hospital-acquired infections (HAIs), known also as healthcare-associated infections (HAIs), often leading to septic complications and even lethal issues and entailing large economical losses for the health-care systems. This threat is of particular concern when compared with the very limited number of new antimicrobial agents in the pipeline of the pharmaceutical industry and the ability of micro-organisms to be less sensitive under biofilm organization. In this context, new strategies oriented to the prevention of environmental contamination of medical devices, catheters, implants, etc., are under scrutiny. A possible solution is related to silver nanoparticles (AgNPs)-containing surface coatings as antimicrobial agents. The AgNPs are embedded in the coating and progressively conducted to the surface, thus providing continuous inhibition of the microbial adhesion over long term.

Silver, and particularly AgNPs, exhibit inherent antimicrobial properties. Recently, the AgNPs proved the largest antimicrobial activity against bacteria, viruses and eukaryotic micro-organisms. The biological activity of AgNPs is closely related to ionic Ag (Ag^+) release or to direct contact of the micro-organisms with AgNPs, resulting in protein denaturation at different cell locations. On the other hand, the uncontrolled use of AgNPs hides environmental risks due to the AgNPs-toxicity. Modulation of the silver ion release from AgNPs allows delivery of the appropriate dose of Ag^+ for biomedical uses and environmental protection. The successful and sustainable use of nanocomposite materials containing AgNPs is mostly supported by the knowledge of how to use them safely prior to their large distribution. To that end a better understanding of the molecular mechanisms of interaction of AgNPs with micro-organisms, considering also the environment (presence of proteins of different nature), is highly demanded in order to better describe the AgNPs antimicrobial activity.

In this work we exploit the multifunctionality of AgNPs as plasmonic antenna when embedded at a controlled nanometric distance from the free surface of thin SiO_2 layers and as biocide agents because

of their strong toxicity towards micro-organisms to study the adhesion of *Candida albicans* IP48.72 on dielectric surfaces. The present study focuses on evaluation of the shear-induced detachment of the yeast *C. albicans* in contact with plasma mediated thin silica (SiO₂) layers containing AgNPs. The experiments are performed in presence of two different proteins, Bovin Serum Albumin (BSA) and Fibronectin (Fn), to assess their respective contributions. The environment alters the *C. albicans* adhesion on solid surfaces depending on the protein nature. Through the release of Ag⁺ ions, the AgNPs embedded close to the SiO₂ surface strongly reduce the adhesion forces of *C. albicans* and lead the dead of adhered cells. Surprisingly, cell death does not weaken the major impact of protein nature on cell adhesion. Further work will be directed to consideration of more complex protein organizations, such as intermixed proteins/proteins and proteins/micro-organisms systems.

Short Bio

Kremena MAKASHEVA is Senior Researcher at CNRS, Laboratory on Plasma and Conversion of Energy (LAPLACE), Toulouse, France. She obtained a Ph.D. degree on Plasma Physics from Sofia University, Bulgaria, 2002, for her work on surface wave sustained plasmas. In 2003 she joined Université de Montréal, Canada for almost 4 years to work on surface wave plasmas at atmospheric pressure and particularly to study the contraction phenomenon of electrical gas discharges. In 2007 she moved to Toulouse, France to work in LAPLACE laboratory on modeling microwave plasmas sustained by dipolar plasma sources. Since 2009 she works on plasma deposition of nanostructured thin dielectric layers, their characterization and analysis in relation with the dielectric charging phenomenon. Multifunctionality of silver nanoparticles (AgNPs) is in the heart of her research. In 2015 she and her colleagues proposed AgNPs-based blocking nanocomposite layer to control the transport of injected charges in thin dielectrics. Her research activities are currently directed to the study of reactive plasmas, design and elaboration of plasma deposited nanostructured dielectric materials containing AgNPs for biomedical, optical and electrical engineering applications. She serves IEEE Nanotechnology Council (IEEE NTC) with different actions, as General Chair of the 11th IEEE Nanotechnology Materials and Devices Conferences - IEEE NMDC 2016 in Toulouse and of the 16th IEEE NMDC 2021 in Vancouver, as Vice-Chair of the IEEE NTC Summer School on Nanotechnology for electronics in 2017, as Program Chair of the 20th IEEE International Conference on Nanotechnologies - IEEE NANO 2020 Virtual. Currently she is IEEE NTC Vice-President for Technical Activities 2020-2021.