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Editorial

Special Issue on Nano-Systems for Antimicrobial Therapy

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1. Introduction

Antibacterial materials and surfaces designed and built using the toolbox of nanotechnology are becoming the object of an increasingly boosting interest, responding to the pan-drug resistant bacteria emergency [1]. This menace intensifies every day because of the misuse of antibiotics in the recent years, and antimicrobial resistance is causing millions of deaths every year, with a huge economic and social impact. A further, intrinsic limit to the use of traditional antibiotics is their poor effectiveness against biofilms. Biofilms are strongly resistant sessile microbial communities, often constituted by Gram-positive strains. These bacterial strains produce an extracellular polymer matrix that embeds the colonies, protecting them from the antibacterial action of drugs and making traditional therapies ineffective. Biofilm-related nosocomial infections, especially those involving an infection on the surface of a medical device, are one of the leading causes of medical implant failure, as well of other severe nosocomial diseases [1–3].

So far, the most popular and widely exploited antibacterial nanomaterial has been silver nanoparticles (AgNP). Antibacterial activity, in this case, is mainly (but not solely, since direct contact between cells and NP also has an effect) based on the release of Ag^+ cations, which show an intrinsic antimicrobial behavior. Silver ions have a wide range of effectiveness and are associated with a limited insurgence of resistant strains [2–7]. Several other kinds of biocides can be used after loading, embedding, or grafting onto almost every kind of surface or scaffold. Nevertheless, the general problem of biocide-releasing surfaces is always present: surfaces tends to lose their effectiveness as the antibacterial substances are released. Once the quantity of active molecules released becomes lower than the minimum inhibitory concentration (MIC), the coating will not have antibacterial properties anymore [8].

Anyway, the nanotechnology arsenal offers a wide range of alternative weapons. For example, inorganic nanoparticles made of silver [9], gold [10], CuS [11], Prussian blue [12], just to name a few selected nanomaterials, can be used to prepare antibacterial surfaces exploiting a completely different approach, i.e., hyperthermia given by the photo-thermal effects connected to their strong extinction bands (due to a localized surface plasmon resonance or to other types of electron transition) [13], and this can be used to efficiently kill bacteria [14].

Moving from these considerations, we were honored to guest edit a Special Issue devoted to new approaches in the endless fight towards harmful microbes.

2. In This Issue

Looking into the plethora of shapes of nano-objects which can be synthesized, 1-D materials are gaining an increasing attention because of the multiplicity of interesting proprieties. Silver nanowires, for example, can be used in a wide range of biomedical applications, besides having useful optical and conductivity features. The review reported in this Special Issue describes the state of the art of silver nanowires research, at the same time showing the potential of this material to become even more effective than other silver nano-objects and encouraging more interest in this specific morphology of nano-structured silver [15].

Among the scaffolds which can be used to support or embed antibacterial nanoparticles, electrospun nanofibers have gained a prominent importance in the last decade, mainly because of their easy and low-cost realization, the wide range of polymeric materials which can be used, and the possibility of including active components. The review here reported critically describes the literature published on this topic, with a particular attention to the inclusion of inorganic nanoparticles with well-known antibacterial properties [16].

Another interesting strategy to support nanoparticles is the preparation of composite nanomaterials. This allows to join together the typical antibacterial features of loaded nanoparticles with the peculiar properties of the chosen supporting material: porous carbon materials loaded with silver nanoparticles can be considered as a smart example of this strategy. In the example provided in this Special Issue, the large specific area, nature of micropores, and absorption performances typical of exfoliated graphite were used to prepare a new antibacterial composite loaded with silver nanoparticles [17].

Another possibility to obtain antibacterial materials and surfaces is to combine materials with antimicrobial functions with surfaces having antiadhesive properties. It is known that strongly hydrophilic surfaces may render the adhesion of proteins and bacteria extremely difficult by forming a hydration layer [18]; in addition, super-hydrophobicity of surfaces was widely described as a tool which can be exploited for the same task. In this perspective, the idea to exploit biosynthesized surfactants can be considered a promising approach to coat biomedical implants in order to inhibit biofilm formation, and one important contribution to this field is reported in this Special Issue [19].

Switching from nanoparticles to coordination compounds, it has been demonstrated, since the rise of coordination chemistry, that metal ions containing complexes can often act as microbicidal agents, both in solution and grafted on surfaces [20], and thus the search for new drugs in this class is advisable. In the example reported in this Special Issue, nanotechnology was involved using magnetic NP as catalysts for the synthesis of Schiff base ligands employed in the formation of new cobalt complexes, which showed an interesting antibacterial activity [21].

As explicitly pointed out in the review from Bertoglio and coworkers here reported [22], many challenges still await to be addressed by the multidisciplinary scientific community which is involved in the battle towards bacterial infection and biofilms growth: understanding of the mechanisms of antibacterial action, evaluation of long-term interactions of nanomaterials with the human body, reproducibility and scalability of the preparations for a large-scale use, just to name a few. Nevertheless, authors state that antimicrobial nano-systems "hold a great potential for future developments, and their impact on the healthcare systems will be considerable", and we have to agree with them.

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