Evidence of cannibalism during long-term biofilm-antimicrobials interaction

Maria Chiara Sportelli¹, Giada Caniglia², Ruggiero Quarto¹, Rosaria Anna Picca¹, Antonio Valentini³, Holger Bart⁴, Boris Mizaikoff⁵, Christine Kranz², and Nicola Cioffi¹

¹University of Bari, Chemistry Department, Italy (maria.sportelli@uniba.it)
²Institute of Analytical and Bioanalytical Chemistry, Ulm University, Germany
³University of Bari, Physics Department, Italy
⁴Institute of Pharmacology and Toxicology, Ulm University Medical Center, Germany

Biofilms are considered a major cause of serious health issues in human medicine and food industry, due to their resistance against harsh conditions and pharmacological treatment [1]. Biofilms are defined as three-dimensional structures encasing bacterial communities rooted in extracellular polymeric substances (EPS). These complex systems are strongly influenced by a variety of parameters including biofilm age, external conditions, nutrient deficiency, attack of exogenous agents [2]. Moreover, bacterial colonies may activate survival strategies when subjected to stress such as the presence of antimicrobial agents. Even cannibalistic behavior may occur [3], which involves the secretion of cannibalism toxins inducing the generation of lysed cells providing nutrients.

Several methodologies were developed for or adapted to biofilm formation studies enabling a more comprehensive understanding of biofilm physiology, structure, and composition. This information should facilitate the development of more effective eradication strategies. Infrared spectroscopy in attenuated total reflectance (IR-ATR) mode provides in-situ and close to real time monitoring of biofilm lifecycles providing molecular information on the various stages of biofilm formation. Given the antibiotic resistance of biofilms [4], it is of increasing importance to develop innovative methodologies for the treatment of biofilm-related infections. While our research team has shown the generic utility of antimicrobial nanoparticles (NPs) such as ZnONPs, AgNPs, CuNPs, etc. in the past [5], the current study focuses on AgNPs embedded within fluoropolymer matrices with tunable loading of the NPs. Next to morphological studies by TEM and AFM, detailed XPS investigations revealed the surface chemical composition. In addition, the kinetics of antimicrobial ion release enabled correlating the behavior of the nanocomposite to its swelling properties and 3D modification after immersion in liquids. Biofilm growth and inhibition was studied via AFM, optical microscopy and IR-ATR. The IR analysis of the biofilm allowed collecting molecular information on the biofilm behavior during long-term contact with antimicrobial surfaces. It was demonstrated that bacterial cells may re-colonize on top of dead biomass once the latter is thick enough to prevent direct interaction with the antimicrobial surface. In summary, this study represents an excellent foundation for developing an in depth understanding on the behavior of bacterial colonies and nascent biofilms in contact with surfaces decorated with nanomicrobials over extended periods of time. It is anticipated that an improved understanding on the stages of biofilm formation provides insight into the processes governing antimicrobial resistance phenomena. Finally, present antimicrobial material may be a useful strategy against Corona viruses. An outlook to this urging topic will be also presented.