Impact of silver nanoparticles on the mechanical properties of *Aquabacterium* biofilms

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Biofilms comprise bacteria embedded in a matrix consisting of polysaccharides, extracellular DNA, proteins and lipids.[1] Aquatic biofilms play an important role in sediment stabilization in riverine systems. The antimicrobial properties of silver nanoparticles (AgNP) led to a wide range of applications in consumer products.[2] As a consequence there is an increasing release of AgNP into aquatic environments.[2] AgNP are supposed to be a continuous source for silver ions (Ag^+) [3] which can bind to functional groups of the biofilm constituents, leading potentially to a decrease in the number of possible intermolecular interactions and, thus, reduced stability of the network. An impairment of the sediment stabilization due to enrichment of the AgNP in the biofilms might be detrimental to the whole ecosystem.

Hence we studied the mechanical properties of *A. citratiphilum* biofilms by means of rheology. The bacterium chosen is representative for a numerically dominant group of bacteria in different freshwater habitats. The biofilms were exposed to environmenally relevant concentrations of AgNP. In order to distinguish physical effects, resulting from the presence of the nanoparticles in the biofilms, from effects, due to the activity of the Ag^+-ions, we studied biofilms exposed to Ag^+-ions as reference. The impact of the AgNP and Ag^+-ions on the mechanical properties of the biofilms were in particular analyzed by means of creep and recovery tests at various stress levels.

Creep and recovery could be described by a modified Burgers model. The tests revealed that the relaxation of the biofilms in response to a stress step function is characterized by a fast and slow relaxation process and viscous flow. Ag^+-ions and AgNP lead to an increased viscosity of the biofilms. The presence of the AgNP causes a softening of the biofilms due to a destruction of the physical crosslinks responsible for the fast relaxation process. As a consequence the dissipative portion in the recovery curve increases. This is not observed for the biofilms loaded with Ag^+-ions. Neither AgNP nor Ag^+-ions affect the slow relaxation process.

The presence of the AgNP indeed perturbs the cohesion of the biofilms, but the detrimental effect is not due to the release of Ag^+-ions but is most likely due to the particulate character of the nanoparticles.

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