Antibacterial activity of commercial nAg against beads-grown *P. putida* biofilms: A chip-calorimetric study

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Nanomaterials are expected to improve our lives in many ways. Photoactive metal oxides and metallic nanomaterials have attracted great attention due to their broad antibacterial capabilities and have now penetrated the consumer and medical products market. This, in turn, has led to the growing concern over the potential impact of these nanomaterials on the natural environment since production, use and disposal will inevitably lead to discharges to air, soils and aquatic systems [1].

Although the bactericidal mechanism of metallic nanomaterials such as nanosilver (nAg) is still under discussion, ROS generation and release of silver ions which penetrate the cell membranes seem to be important. However, a profound understanding of the effects of nanomaterials in complex systems is still lacking. In this respect, biofilm communities are a more pertinent model system for consideration of nanomaterial toxicity in environmental systems than planktonic cells [2].

While nanomaterial effects on planktonic bacteria can be easily quantified by conventional methods (e. g. optical density, cfu), biofilm analysis however represents a complex issue requiring more sophisticated approaches due to the inhomogeneous nature of the samples. This problem is amplified if kinetic information on the toxic effect is required. In general, currently used methods are invasive and comprise several time consuming operational steps. In this context, it becomes clear that calorimetry may represent an interesting alternative. Coupling with the *Segmented Flow* technique [4] allows an automatic transport of aggregated samples in plugs whilst increasing sample throughput and maintaining the advantages of our chip calorimeters at the same time.

In the presented work, we studied the concentration-dependent effect of commercial nAg and $nTiO_2$ on growth and inactivation of *P. putida* mt-2 biofilms cultivated on glass beads ($d \leq 106$ µm). It will be demonstrated that calorimetry is ideally suited to overcome the inhomogeneity that is typically associated to biofilm samples and is a major challenge for all other test methods.

[1] Y. Ju-Nam and J.R. Lead, Sci. Total Environ. 400 (2008) 396-414.

[2] A. L. Neal, Ecotoxicology 17 (2008) 362-371.

[3] T. Hartmann, N. Barros, A. Wolf et al., Sens. Actuators B 201 (2014) 460 – 468.