Environmental Engineering and Management Journal March 2012, Vol.11, No. 3, Supplement, S117
http://omicron.ch.tuiasi.ro/EEMJ/

"Gheorghe Asachi" Technical University of Iasi, Romania

Posters

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EFFECT OF STABILIZERS ON THE ANTIBACTERIAL PROPERTIES OF SILVER NANOPARTICLES PLACED INTO NATURAL WATER

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Abstract

Nanotechnology is an emerging and fast-developing technology. Silver nanoparticles (AgNPs) are currently one of the most common metal nanoparticles found in consumer products. It is unavoidable that AgNPs will be released into natural water bodies. However, few studies have investigated the impacts of AgNPs on the natural aquatic microbial activity in an environmentally relevant context.

Physical, chemical and biochemical properties of AgNPs strongly depend on their size, shape, size distribution and stabilizers located on their surface. Stabilizers allow to control the process of their growing and then prevent their aggregation. Our study focused on two typical stabilizers: citrates−low molecular ions protecting the nanoparticles by electrostatic repulsion, and polyvinylpyrrolidone − a hydrophilic, neutral, high molecular polymer protecting the particles by steric stabilization.

Silver nanoparticles were prepared in water solution by a chemical reaction of silver nitrate ($AgNO_3$) with sodium borohydride (NaBH4) in the presence of one of the stabilizers: polyvinylpyrrolidone (AgNPs-PVP) or sodium citrate (AgNPs-cit). Reference solutions containing the same composition except for silver nanoparticles were prepared using HNO_3 instead of $AgNO_3$. All solutions were aged for a few days, then pH was set at 7, and the solutions were diluted to obtain the concentration of Ag equal to 100 ppm. In this study, natural bacterioplankton was collected from an eutrophic, downtown lake and exposed to five concentrations (0.1–5 ppm) of AgNPs-PVP and AgNPs-cit. Responses were monitored after 1, 3, 5 and 7 days of exposure, by evaluating the survival rate of bacteria, the general activity of extracellular esterases and respiratory activity. Survival of bacteria was characterized by using the fluorescent markers targeting the cell membrane integrity (LIVE/DEAD®BacLight™ Bacterial Viability Kit). The activity of esterases was investigated by measuring the rate of fluorescein release from fluorescein diacetate. Respiration activity of bacteria was examined using a manometric respirometric equipment - OxiTop Control 12 system.

A slightly better (greater) survival rate of bacterioplankton was ascertained in the water with an addition of AgNPs-cit. Inhibition of extracellular esterases was observed only in samples containing AgNPs-PVP. The inhibitory effect increased proportionally with the concentration of AgNPs-PVP applied. Within the studied concentration range, there was no statistically significant inhibition of bacterioplankton respiratory activity by AgNPs-PVP and AgNPs-cit.