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## Microbial Accumulation and Transformation of Nanoscale Elemental Selenium Particles

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### INTRODUCTION

Nanomaterials have unique physiochemical and biological properties that are primarily based on quantum effects of small particle size and larger surface area, which provide great driving forces for diffusion and increased reactivity in the environment. Due to the rapid development of nanotechnology in recent years, more Se nanoparticles (SeNPs) have been applied in various medical, nutritional, industrial, and remediation processes (Huang et al. 2015; Wang et al. 2015). Because SeNPs are one of several contaminants of emerging concern, their environmental impacts could be significantly different from bulk elemental Se and other Se compounds. Thus, the transport and fate of Se in the environment can be significantly affected by the presence of nanoscale elemental Se particles.

Soil microorganisms play an important role in determining the ecotoxicity of Se in the environment. Although previous studies have demonstrated the toxicity of SeNPs to different microbes (Li et al. 2008), little is known about microbial accumulation and transformation of chemically synthesized SeNPs in the environment. Thus, it was hypothesized that, compared with bulk elemental Se, SeNPs Se might be bioavailable for bacterial accumulation and transformation. The specific objective of this study was to (1) determine the bioaccumulation of SeNPs in a plant-associated soil bacterium, and (2) determine the extent of biotransformation of SeNPs by the presence of a soil microbe.

### MATERIALS AND METHODS

**Synthesis of selenium nanoparticles:** The chemical synthesis of SeNPs was conducted using a mixed surfactant template method (Li and Hua 2009). In brief, selenious acid ( $\text{H}_2\text{SeO}_3$ ) was reduced by ascorbic acid ( $\text{C}_6\text{H}_8\text{O}_6$ ) to form nanoscale elemental Se particles that were coated with surfactant, a mixture of sodium dodecyl sulfate and polyvinyl alcohol. Nanosight LM 10 and Malvern ZetaSizer Nano were used to characterize SeNPs in the solution. The bacterial strain for this study was *Pseudomonas sp.* that was previously isolated from the rhizosphere soil of *Stanleya pinnata*. To determine the effect of SeNPs (~75 nm) on the bacterial growth, the optical density at 600 nm ( $\text{OD}_{600}$ ) of a bacterial cultural solution (LB broth) that was treated with different levels of SeNPs was measured to establish a bacterial growth curve. The cultural solutions were centrifuged and bacterial pellets were washed and collected.

Concentrations of Se were analysed using ICP-MS. In addition, the cultural solutions were also treated with  $\text{Na}_2\text{SeO}_4$ ,  $\text{Na}_2\text{SeO}_3$ , elemental SeNPs, or  $\text{C}_5\text{H}_{11}\text{NO}_2\text{Se}$  (SeMet) at 5  $\mu\text{g}/\text{ml}$ . Each treatment had three replicates. Selenium speciation analysis of SeNP-treated bacterial solution was conducted using HPLC-ICP/MS, including Se standards of selenate, selenite, SeNPs, SeMet, selenocysteine (SeCys), and S-methylselenocysteine.

### RESULTS AND DISCUSSION

Compared with the control, the SeNP treatments of 10 and 25 mg/L significantly ( $p > 0.05$ ) reduced the growth of the bacterial strain during an 8-hour experimental time period, while the SeNP treatment of 1 and 5 mg/L significantly enhanced the bacterial growth. *Stanleya pinnata* is a Se hyperaccumulator species, and *Pseudomonas sp.* has relatively high tolerance to Se in the growth substrate. Thus, high SeNP concentrations of  $>5$  mg/L might result in impairments on the soil microbial community. The concentration

of SeNP in the bacterial pellets increased with increasing concentrations of SeNPs in the growth substrate. The highest Se concentration was observed in the 10 mg/L treatment, which might result in lower bacterial growth.

The effects of different Se chemical forms (selenate, selenite, bulk elemental Se, SeNPs, and SeMet) in the culture solution were evaluated at the 5 mg/L treatment level. The SeNP treatment showed the highest Se concentration in bacterial cells, followed by bulk elemental Se. Compared to SeNPs, the selenate, selenite, or SeMet treatments showed considerably lower Se concentrations in bacterial cells. Although bacterial cell pellets were washed twice using fresh culture solution (LB broth), high Se concentrations in bacterial cells from the SeNP and bulk elemental Se treatments were likely due to elemental Se deposition on cell surfaces. The speciation analysis showed that the dominant chemical forms of Se in the supernatant of the SeNP-treated bacterial solution included SeCys and one unidentified Se compound, but no SeNPs were observed.

## REFERENCES

- Huang L, Tong X, Li Y, Teng J, Bai Y. 2015. Preparation of a novel supported selenium nanoparticles adsorbent and its application for copper removal from aqueous solution. *J. Chem. Eng. Data*. 60(1): 151–160.
- Li H, Zhang J, Wang T, Luo W, Zhou Q, Jiang G. 2008. Elemental selenium particles at nano-size (nano-Se) are more toxic to Medaka (*Oryzias latipes*) as a consequence of hyper-accumulation of selenium: A comparison with sodium selenite. *Aquat. Toxicol.* 89(4):251-256.
- Li ZL, Hua PM. 2009. Mixed surfactant template method for preparation of nanometer selenium. *E-Journal of Chemistry*, 6, S1: S304-S310.
- Wang Q, Larese-Casanova P, Webster TJ. 2015. Inhibition of various gram-positive and gram-negative bacteria growth on selenium nanoparticle coated paper towels. *Int. J. Nanomedicine*, 10: 2885–2894.