



Biological accumulation of tellurium nanorod structures via reduction of tellurite by *Shewanella oneidensis* MR-1

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HIGHLIGHTS

- ▶ *Shewanella oneidensis* MR-1 reduced tellurite to elemental tellurium.
- ▶ Crystal Te(0) nanorods accumulated intracellularly.
- ▶ Te(IV) caused changes in cell membrane rigidity by shifting the compositions of lipid components.
- ▶ *Shewanella* may provide an alternative method for Te(0) nanorod preparation.

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ABSTRACT

The dissimilatory metal-reducing bacterium, *Shewanella oneidensis* MR-1, reduced tellurite (Te(IV), TeO₃²⁻) to elemental tellurium under anaerobic conditions resulting in the intracellular accumulation of needle shaped crystalline Te(0) nanorods. Fatty acid analyses showed that toxic Te(IV) increased the unsaturated fatty acid composition of the lipid components of the cell membrane, implying a deconstruction of the integrity of the cellular membrane structure. The current results suggest that dissimilatory metal reducing bacteria such as *S. oneidensis* MR-1 may play an important role in recycling toxic tellurium elements, and may be applied as a novel selective biological filter via the accumulation of industry-applicable rare materials, Te(0) nanorods, in the cell.

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1. Introduction

Recently, tellurium and tellurium-containing compounds have been used extensively in various fields such as petroleum refining, electronics, optics, glass production, and sensor production (Sen et al., 2009; Tang et al., 2006; Turner et al., 2012; Wang et al., 2011). However, expanded use of tellurium has increased the likelihood of environmental contamination (Chasteen et al., 2009). In the environment, tellurium exists as elemental tellurium (Te(0)), in inorganic forms such as telluride (Te(II), Te²⁻), tellurite (Te(IV), TeO₃²⁻), and tellurate (Te(VI), TeO₄²⁻), and in organic forms such as dimethyl telluride (CH₃TeCH₃). The elemental state, Te(0), is insoluble in water and has low bioavailability and toxicity, however its soluble oxyanions tellurite and tellurate, particularly Te(IV), are highly toxic to both eukaryotic and prokaryotic cells at concentrations as low as 1 µg/ml (Chasteen et al., 2009; Zannoni

et al., 2007). Another issue is that studies pertaining to the functional role of tellurium in biological systems has lagged behind that of selenium (Se) which is located in the same column of the periodic table – this lack of research has occurred because of the lower crustal abundance, oxyanion solubility, and biospheric mobility of Te (Chasteen et al., 2009). This point is even more significant when compared to the amount of research that has been conducted on other metals and metalloids in the context of the environment, such as chromium, mercury, cadmium, and copper, which become toxic at concentrations about 100-fold higher than Te(IV) (Chasteen et al., 2009). It has been recently discussed that the reduction of Te(IV) to insoluble and less toxic Te(0) is considered to be a potentially effective strategy for relieving the high toxicity of Te(IV) in the environment (Wang et al., 2011; Zannoni et al., 2007).

Since biological interactions with inorganic tellurium compounds were first reported (Chasteen et al., 2009), a number of different species of Te(IV)-resistant bacteria were isolated from tellurium-contaminated environments (Baesman et al., 2009; Borsetti et al., 2003; Ollivier et al., 2008) that possessed genetic determinants (Te^R) for Te(IV) resistance on the bacterial chromosomes or on plasmids (Chasteen et al., 2009; Taylor, 1999; Trutko

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