Characterization of palladium nanoparticles produced by microwave-injured bacteria with enhanced catalytic activity

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ABSTRACT

Several studies have focused on the bacterial synthesis of palladium nanoparticles (Bio-Pd NPs) within the outer membrane, periplasmic space and bacterial cytoplasm, via uptake of Pd(II) ions and their enzymatic reduction to Pd(0). In this study, cells of *Desulfovibrio desulfuricans* (obligate anaerobe) and *Escherichia coli* (facultative anaerobe) were exposed to low-dose radiofrequency radiation (RF) (microwaves) and compared for Pd NPs production. Resting cells were exposed to microwave energy (MW) in two sets of experiments: i) before being challenged with Pd(II) ions and ii) during the Pd(II) sorption/uptake step. Subsequently, in both cases, the injured Pd(II)-treated cells (and uninjured controls) were contacted with H_2 to enable Pd(II) reduction. By using Scanning Transmission Electron Microscopy (STEM) associated with a High-Angle Annular Dark Field (HAADF) detector and energy dispersive X-ray (EDX) spectrometry the Pd NPs produced by the MW-treated and control cells of each were compared with respect to their size distribution, location, composition and structure. Differences in all features were observed in both bacteria.

For both bacterial strains, the most pronounced differences were observed via MW-injury prior to Pd(II) exposure. In the case of *D. desulfuricans*, the Bio-Pd NPs formed post-injury showed two NP populations with different size and morphologies. The first ones (mainly periplasmically-located), showed polycrystalline Pd nano-branches with different crystal orientations and size ranging between 20-30 nm. Meanwhile, the second population of Bio-Pd NPs was single crystals with sizes between 1-5 nm. In contrast, the Bio-Pd-NPs produced by injured cells of *E. coli* comprised single crystals with a homogeneous size distribution between 1-3 nm and were located mainly intracellularly. These differences will be discussed with respect to the different location of Pd(II)-reducing hydrogenases in the two organisms (periplasmically in *D.desulfuricans* and inner-membrane-bound in *E. coli*) and with respect to implications for the catalytic activity of the produced NPs following injury-associated steerage.