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Biorecovery of PGMs: Electron donor and metal loading controls microbial Pd nanoparticle size, location and catalytic properties

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The biosynthesis of metal nanoparticles supported on microbial cells has attracted recent interest as an economical, scalable, and green biotechnology [1]. Microorganisms can recover precious metals, such as Pd, from waste sources, and the subsequent Pd nanoparticles supported on microbial cells (Bio-Pd) are active as heterogeneous catalysts for industrially important reactions such as hydrogenation, and C-C coupling such as Heck and Suzuki reactions [2]. Bio-Pd is synthesised via enzymatic reduction of Pd(II) to Pd(0) at ambient temperature, and requires only microbial cells, a Pd(II) source, inexpensive buffer solutions, and an electron donor. However, the effect of these synthesis conditions on the properties of bio-Pd nanoparticles is not well understood. This study utilised the model metal-reducing bacterium *Geobacter sulfurreducens* supplied with different electron donors, and under different loadings of Pd(II) to investigate the effects of these parameters on the physical and chemical properties of bio-Pd nanoparticles. HAADF-STEM was performed on ultrathin sections of resin embedded bio-Pd samples to establish the size distribution and location of bio-Pd within the cell structure. XRD and XPS were used to measure the oxidation state and nanocrystallinity of bio-Pd. Bio-Pd's catalytic activity was assessed for the reduction of 4-nitrophenol. The choice of electron donor and the initial Pd load on the bacteria resulted in differences in size, cellular location, Pd(II):Pd(0) ratios, and catalytic properties of the resulting Pd nanoparticles. The best performing bio-Pd catalysts performed comparably to a commercial 5% Pd/C catalyst. These insights could be used in future to design metal recovery systems using microbes that revalorise Pd from waste streams into bio-Pd catalysts.

References

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