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Novel biogenic catalysts with catalytic applications in bioenergy processes

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Bacteria can manufacture supported nano-catalysts from solutions of precious metals (PMs), waste leachates and industrial processing solutions as an economic alternative to the use of primary-sourced PM catalysts in high volume/low value applications. Metal deposition occurs via nucleation of soluble metal ions to cellular ligands followed by enzymatically-catalysed growth of nanoparticles (NPs), to form templated, structured nanomaterial. This can self-immobilize onto a carrier for easy catalyst recovery, multiple re-use and in continuous-flow processes. Monometallic structures like Pd-NPs have multiple applications but faster reactions and higher selectivity can be achieved with a second metal to make alloys or core-shell nano-patterned structures. The second metal coupling is abiotic; importantly, no live bacteria remain in the material, while the catalysts can be made directly from highly acidic leachates in order to 'bio-refine' precious metal (PM) scraps, overcoming the economic barrier to use of PMs for large or sacrificial operations. Examples will describe the use of such neo-catalysts in fuel cells and also applications in upgrading of intermediates produced in the thermochemical processing of organic materials to a platform chemical and fuel precursor; the use of catalysts bio-refined from road dusts in the catalytic upgrading of heavy fossil oils (reduced viscosity, levels of impurities and coking)1 and in the catalytic hydrodeoxygenation of pyrolysis oil from biomass2. Throughout, the bio-derived catalysts performed comparably to commercial catalysts and favourable oil distillation curves were obtained. In addition, when upgrading 5-hydroxymethyl furfural extracted from biomass hydrolysate the commercial catalyst was ineffective although a bio-Pd/Ru equivalent achieved the conversion. For economy at scale, similar results were obtained using 'second life' bacteria left over from another bioprocess, while the catalysts were bio-refined from PMs from high volume wastes (road dusts). The latter has been subjected to a life cycle assessment showing process viability at scale.

Biography

L E Macaskie did her BSc and PhD in Microbial Biochemistry (University of London) in the 1970s, moving to the University of Oxford (postdoctoral, then faculty staff in Department of Biochemistry) until 1991 when she took up a lectureship, then personal Chair, at the University of Birmingham in Applied Microbiology. Her dual interests center on bacterially manufactured nanoparticles and bio-nano minerals for nuclear decontamination processes and precious metal neo-catalysts for clean energy, green chemistry and environment. Needing hydrogen to feed her bacteria. She developed a process to make bio-H2 via fermentation of food wastes, outperforming other renewable energy processes in terms of energy balance.

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