Nano World: Microbes can make nanocatalyst

February 7 2006

Bacteria can salvage precious metals from electronics and automotive waste and with them create crystals that are nanometers or billionths of a meter wide that in future could serve as toxin removing catalysts, experts told UPI's Nano World.

"One man's waste is another man's treasure," said Amanda Mabbett, a microbial physiology researcher at the University of Queensland in Brisbane, Australia. "Everyone in society stands to benefit from this research, as a cleaner, greener and less wasteful environment is better for everyone."

Scientists at the University of Birmingham in Britain targeted palladium, which is used in catalytic converters and circuit boards and is very expensive. "The demand for such metals like palladium generally exceeds supply on an annual basis," Mabbett said.

The researchers experimented with the bacteria Desulfovibrio desulfuricans and Escherichia coli. Prior studies revealed that these bacteria could, in the presence of hydrogen gas or the organic molecule formate, take palladium from solution and deposit it as nanocrystals on their cell surfaces.

Mabbett and her colleagues at bioremediation researcher Lynne Macaskie's lab at the University of Birmingham flowed wastewater from spent catalytic converters and electronic scrap disposal operations past the microbes. The resulting palladium crystals, roughly 50 nanometers

wide, were half the size of those generated by conventional industrial means. The bacteria also pulled out aluminum, platinum and silver from the waste as nanocrystals.

The researchers then used these dead nanocrystal-coated bacteria in bioreactors where they flowed industrial waste past loaded with a carcinogenic form of chromium known as chromium-VI. These bioreactors were capable of transforming chromium-VI into the non-carcinogenic chromium-III version that could get extracted out. Mabbett and her colleagues published their findings in the Feb. 1 issue of the journal Environmental Science & Technology.

"This research should definitely impact on the mining and scrap metal industries," Mabbett said. "Instead of just implementing methods to clear up their waste end products, these industries could undertake a two-fold process of 'clean up and manufacture,'" and "both industries could potentially make profit from what was once waste." She estimated it could take five to 10 years for such bacterial nanocrystals to reach the market.

The bacterial nanocrystals continued to work even after operating nonstop for three months, while palladium catalyst generated by conventional means lasted for just one week. To achieve such results, the researchers did first have to enrich the wastewater they gave the bacteria with a palladium solution, but the total amount of palladium used to create the bacterial nanocrystals remained less than that used in the conventional catalyst, Mabbett said.

Mabbett credits this improvement to the fact that the nanocrystals the bacteria made are smaller than those produced by conventional industrial processes, thus presenting more surface area to react with given the same volume. Moreover, the other metal nanocrystals may have aided in reducing chromium-VI to chromium-III. The cell surfaces the crystals

rested on may have assisted too, by assuring the catalytic sites were all properly exposed and not just clumped together.

"The fact that you could with these microbes use waste to treat other waste is quite nice," said Piet Lens, an environmental engineer at the University of Wageningen in The Netherlands, who did not participate in this study.

The palladium-loaded bacteria might also help break down widespread organic pollutants known as PCBs, the researchers noted. Lens added the nanocatalysts could also target runoff from insecticides and pesticides as well as contaminants known as PBDEs, which are difficult to degrade and linked to damage to the liver and to developing nervous systems.

"I should stress that the research is in its very early stages," Mabbett cautioned. Future research should examine if or how varying the chemistry of the wastewater they give the bacteria affects the efficiency of the resulting catalyst. Better understanding the biochemical pathways the microbes use to create the nanocrystals could help scientists manipulate them "to form a certain product," she added.

Given the vast range of bacterial species that exist in the world, "there are endless possible combinations of their physiological processes and cell structures that could be harnessed to synthesize interesting novel materials," Mabbett said. Lens added the nanocatalysts might be able to help clean industrial exhaust gases of pollutants as well.