



HIGH-TECH MATERIALS ALERT

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TECHNICAL INSIGHTS ALERT

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PROCESS CONVERTS WASTE INTO NANOPOWDER FOR HYDROGEN GENERATION FROM WATER

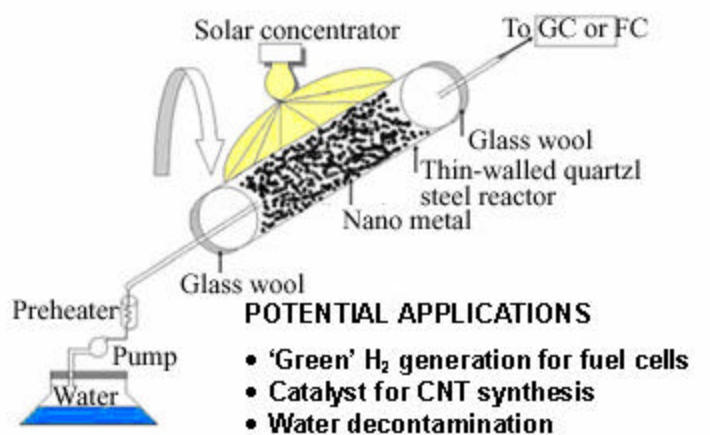
A critical technology hurdle against the development of fuel cell technology is the economic and safety concerns associated with the production, storage, transport, and supply of hydrogen. Researchers worldwide are working on the achievement of 'hydrogen economy' that would enable efficient, clean, and cost-effective hydrogen production. To address this need, a research group at the University of Toledo, Ohio has employed a well-known process--metal-steam reforming--as an economically viable and environmentally friendly method to generate high-purity hydrogen.

Metal-steam reforming basically deals with a reaction between heated iron and steam. However, the key significance of this work lies in the source of iron: the research group has utilized the so-called 'mill-scale' waste from steel industry, as an iron source. "There is huge inventory of steel mill waste in every country that produces steel. By converting this waste into nanoiron and utilizing it for hydrogen generation which can be fed into a fuel cell stack, the electricity thus produced can partially power the steel plant itself," relates Abdul-Majeed Azad, associate professor, Department of Chemical and Environmental Engineering, University of Toledo.

Mill-scale is magnetic in nature with iron content as high as 93%. It is a porous, hard, and brittle coating of several distinct layers of iron oxides formed during the fabrication of steel structures. This oxide coating is usually cleaned prior to sale, or use of such steel structures. Previously, the mill-scale waste has been converted into metallic iron via hydrogen reduction and by carbothermic reduction. However, these methods were plagued by limitations, as both the reduction processes are energy-intensive as they use high temperatures and one of them requires precious hydrogen. Thus, these processes have been considered to be unattractive in a commercial setting. Moreover, the use of high temperatures results in coarser iron that is not as active and hence not likely to generate hydrogen efficiently over several cycles.

The research group has developed a novel near room-temperature reduction technique whereby the mill-scale is first brought in solution by acidic dissolution wherein it is instantly converted into highly active nanoscale iron powder. This novel reduction technique obviates the issue of sintering and coarsening of the iron/iron oxide due to high temperatures and hence the possibility of deactivation during the cyclic operation of metal-steam reforming becomes a non-issue. Notably, it was observed that by modifying the

technique and conducting the reduction in the presence of a surfactant, even smaller (approximately 5 nm) iron particles were achieved.



Schematic of the hydrogen generating prototype device using solar concentrator as the heating source and Potential applications of this process

Picture Credit: Dr. Abdul-Majeed Azad, Department of Chemical and Environmental Engineering, University of Toledo.

"We have established that mill-scale waste can be efficiently converted into nanoscale iron particles, which we have demonstrated can generate high-purity hydrogen with yield as high as 95% to 98% theoretical. With a solar concentrator in place, it will be [an] even more attractive option for generating hydrogen in a 'green' way, in a sense that it does not require or emit any carbon-containing gaseous byproduct and hence is environmentally benign," says Azad.

Further, these zero valent iron (ZVI) nanoparticles are also relevant as key catalyst in the synthesis of carbon nanotubes and as an active decontaminant of drinking water. Due to smaller particle size and larger surface area, coupled with the advantage that ZVI can be obtained from relatively inexpensive source such as mill scale waste, the researcher believes that a strong commercial viability for this research exists.

Partial funding came from University of Toledo's internal University Research Award and Fellowship (URAF program). "Currently, partial funding is on its way from Edison Materials Technology Center (EMTEC), which will help us, design a prototype solar concentrator as an alternative heat source for the hydrogen generation," concludes the researcher.

Figure 1. Schematic of the hydrogen generating prototype device using solar concentrator as the heating source.

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