

## Nano World: Nanocatalysts for oil, drugs

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New York, NY, Mar. 25 (UPI) -- The catalysts on which more than 20 percent of world industrial production is based -- including the expensive platinum employed to scrub clean the exhausts of millions of vehicles and the molecules pharmaceutical giants use to manufacture drugs -- soon could be replaced in large part by more effective nanotechnology upgrades, experts told UPI's Nano World.

"There's the potential to dramatically lower costs. If we find that we can use 30 cents worth of nanoscale nickel to replace \$7 worth of platinum, that would be pretty significant," said Darrell Brookstein, managing director of The Nanotech Company, an analysis firm in San Diego.

Catalysts are molecules that can quicken the pace of a chemical reactions by factors of billions.

"A surprisingly large fraction of all the products that surround us are made by one or several catalysts," said theoretical physicist Jens Norskov of the Technical University of Denmark in Lyngby. "All oil products, plastics, fertilizers with ammonia, the glue that sticks together all the sheets in plywood -- and you can go on and on."

Nanotechnology is science and engineering on the scale of nanometers or billionths of a meter. Reducing catalytic substances to nanometers in size greatly increases the surface area available per gram, which in turn boosts the level of catalytic activity.

"There is the potential for a catalyst to go from, say, 60-percent efficiency to 90-percent efficiency just by virtue of making it a nanoparticle material," Brookstein said. "You could see cost savings in materials used or savings in the time it takes to perform a process. Maybe tools and equipment and labor are used less. You can generate cost savings on down the whole manufacturing line."

Headwaters NanoKinetix recently announced a nanocatalyst that can increase the gasoline octane number by five.

"The number you see when you pump gas with regular is 87, and the highest one is 93 -- premium. So basically, our catalyst can give you premium at the same cost as regular, and this catalyst can make premium fuel just by switching out the existing oil reforming catalyst the industry uses, with no big machinery added," materials scientist Bing Zhou, chief technology officer of Headwaters NanoKinetix in South Jordan, Utah, told Nano World.

At least three companies in California are developing nanomaterials for improved catalytic converters, Albert Lin, a scientific consultant at The Nanotech Company, told Nano World. They include Catalytic Solutions of Oxnard, Nanostellar of Menlo Park and QuantumSphere of Costa Mesa, he said.

Catalytic Solutions seems the better funded of the three, with 13 investors backing it, including JPMorgan, GE and Honda, but "it's a huge market, with billions pumped into catalytic converters," Lin said. "It's big enough for more than one player."

In the near term, "the chemical industry will be more environmentally friendly because nanotechnology can make catalysts 100 percent selective to the desired product," Zhou said. "One of the chemical industry's biggest problems in the last century were reactions that were not completely selective to the desired product and producing too much waste and environmentally harmful materials "

Zhou and colleagues have developed a nanocatalyst to generate hydrogen peroxide, the chemical often used as a bleach that finds use in manufacturing materials such as polyurethane.

"Whenever you make hydrogen peroxide with conventional methods, you use a really complicated process with starting materials that are toxic and the process cost is high," he explained. "Using a nanocatalyst, you can just combine hydrogen and oxygen -- two very clean and simple molecules to procure -- to produce hydrogen peroxide, and that's with 90 percent selectivity in large-scale tests, much higher than any other catalysts used to make hydrogen peroxide."

Headwaters NanoKinetix is working with the largest specialty chemicals company in the world, Degussa, of Dusseldorf, Germany, for a hydrogen-peroxide plant by 2007 or 2008.

This increased specificity can lead to safer drugs also.

"Often in making pharmaceuticals, you make a lot of side products also, some of which are really toxic and can cause health problems," Zhou said. "You can design a nanocatalyst at the molecular level that is more selective and will only deliver the drug molecule you want."

At the nanoscale, substances can demonstrate catalytic activity where they once did not.

"Gold is famously inactive," Zhou said, "but when we make gold less than 6 nanometers, it becomes an active catalyst, helping oxygen combine with carbon monoxide to make carbon dioxide."

The ability of nanotechnology to enhance catalytic activity opens the potential to replace expensive catalysts with cheaper nanocatalysts.

"We quite often use molybdenum as a catalyst," Zhou continued, "but it's really becoming more and more expensive. We're working (with) iron to (make it) a mimic of molybdenum. Of course, when you want a nanocatalyst with the properties of a high-cost metal, sometimes you cannot use one low-cost metal, but two or three for alloys."

Future designs of nanocatalysts could rely increasingly on computer simulations, Norskov noted. Computer power and software have advanced far enough to calculate the complexities of how the hundreds of atoms on a nanocatalyst's surface, with their many electrons, might react with chemicals.

In the Jan. 28 issue of the journal *Science*, Norskov and colleagues demonstrated how their advanced calculations could predict, with a fair degree of accuracy, how well ruthenium nanoparticles in a range of sizes could catalyze ammonia synthesis.

"This opens up the possibility that we don't need to do so many very costly experiments every time we need to test an idea, and simply do calculations instead," he said, adding that he expects the next five years to bring dramatic improvements in the design of nanocatalysts using software.

Another major future direction for nanocatalysts is helping to make hydrogen fuel cells a reality for automotive applications. "We'll really need better catalysts for those to become economically viable," Norskov said.

Lin noted the Bush administration "is really pushing hydrogen fuel cells to come through, and the dynamics of the whole automobile industry is really changing right now. If it were 10 years ago and someone came with these nanocatalysts, I think you'd hear from the automobile industry that, 'We have tried-and-true solutions, (so) leave us alone,' but with the boom towards new and emerging technologies, I think nanocatalyst companies will have a bit of an open door to get into the system."

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Nano World is a weekly series examining the exploding field of nanotechnology, by Charles Choi, who covers research and technology for UPI Science News. E-mail: [sciencemail@upi.com](mailto:sciencemail@upi.com)