Georgia Tech

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BUILDING A BETTER CATALYST: PROGRAM BOOSTS NEW PROCESS FOR MAKING CATALYSTS MORE SPECIFIC & EFFICIENT

To speed the development of a promising new technique for improving the selectivity and efficiency of industrial catalysts, the Georgia Institute of Technology has formed a Focused Research Program in Surface Science and Catalysis. In cooperation with its industrial sponsors, the program will advance the new technique while developing a better understanding of the complex chemical processes involved in industrial catalysis.

The key to the new technique is a better method for uniformly dispersing catalytically-active atoms across the surface of the catalyst. The Georgia Tech researchers believe their technique will give chemical engineers more control over catalytic properties, and provide the basis for a wide range of improved catalysts that are more specific, more efficient and less costly than existing materials.

Already widely used in chemical processes, catalysts may play a key role in helping industry develop manufacturing processes that produce fewer environmental problems.

"The ability to make highly-selective catalysts will become very important in the future as companies adopt a new strategy with regard to environmental concerns," said Dr. Mark White, director of the Focused Research Program and associate director of Tech's School of Chemical Engineering. "That will require some new strategies in catalyst design, driving us to make catalysts that are more selective to the desired product and less selective to any undesired by-product. Our technology holds out that hope."

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The Georgia Tech process relies on an inorganic process for uniformly dispersing the metal ions in solution, then binding them to the surface of the catalytic support. It uses a non-aqueous solvent to prevent atoms from forming clumps -- which reduce catalytic efficiency.

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The researchers have already developed three specific catalytic systems based on their technology, and are seeking industrial support to continue their basic research. The effort will involve a limited number of industrial partners who will share the research results.

Most catalytic films are created through a water-based process in which metallic salts are dissolved in water, then applied to their catalytic support. The process has important disadvantages, however.

"You have almost no control over the way those ions precipitate," explained White.

"We would be developing a background understanding that would be used by companies in developing their own catalyst process. We wouldn't take the place of their own research; we would supplement it with more basic research on the structure of these surfaces."

Dr. J. Aaron Bertrand

"They could precipitate as tiny groups of ions, while in other places they could precipitate as huge groups of ions. There is very little that can be done to control this."

Because the composition of the film cannot be controlled, the activity of the resulting catalyst is not predictable. And because the heat from industrial production processes often causes additional clumping, the catalytic efficiency declines over time, reducing the material's life.

By contrast, the Georgia Tech method relies on non-aqueous solutions of uniformly-dispersed metal complexes called "ensembles." These dispersed atoms bind to the surface of the catalyst through a reaction process, producing a uniform surface film without clusters, said Dr. J. Aaron Bertrand, professor of chemistry and a co-developer of the technique.

"When you have an uneven dispersion on the surface, you may be catalyzing a number of different kinds of reactions to give you a mixture of things going on at the same time," he explained. "But if we can make each site in the film a good catalyst for a particular reaction and not a side reaction, then we will have selectivity that does not create by-products that are of no use."

Though it has so far been used only with copper-based catalysts, Bertrand believes the technique could extend to virtually any metal useful for industrial catalysis.

The technique can also lower costs for catalytic reactions. In one system, White and Bertrand created a catalyst more than five times as active as traditional materials. The higher level of activity allowed the reaction to take place at lower pressure, reducing the costs of maintaining high pressure conditions.

Another catalytic system developed by the Georgia Tech team transforms methanol to higher molecular weight chemicals. Such a process could be useful in producing synthetic gasoline or other liquid fuels from coal.

While the researchers have a theoretical model for how their catalytic thin films work, they hope an improved understanding of the catalytic surfaces will help them refine and improve the technique. To help with the study of the catalytic films, they have enlisted the assistance of Dr. H. P. Gillis and Dr. Mark Mitchell, both specialists in spectroscopy.

Mitchell, a professor of chemistry at Clark-Atlanta University, will contribute expertise in vibrational spectroscopy. Gillis, an associate professor of chemistry at Tech, will apply electron spectroscopy to the problem.

Before the new technique can be put into commercial use, it will have to applied to the porous zeolite materials that now form the basis for most commercial catalysts. To gain the necessary zeolite experience, the Program will receive help from Dr. Tudor Thomas, director of the Zeolite Research Program in the Georgia Tech Research Institute.

Why would a company be interested in supporting the program?

"We would be developing a background understanding that would be used by companies in developing their own catalyst process," explained Bertrand. "We wouldn't take the place of their own research; we would supplement it with more basic research on the structure of these surfaces."

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