Researchers hope better catalysts lead to better ways of converting biomass to fuel

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"The power of the collaboration comes from uniting different perspectives and expertise around the same problem," Argonne's Chris Marshall said. "No single investigator or single lab could reasonably expect to complete this kind of work alone."

(Phys.org) —Scientists and entrepreneurs of old spent millennia trying to transmute lead into gold. Today, a new and more intellectually rigorous kind of alchemy has begun to produce important benefits for an economy that still relies heavily on fossil fuels.

For the past four years, Argonne chemist Chris Marshall and his colleagues at the Argonne-led Institute for Atom-Efficient Chemical Transformations (IACT) have been searching for ways to improve the efficiency and selectivity of catalysts – precisely tailored chemicals that help to carry out a vast array of reactions.

IACT was originally founded by the U.S. Department of Energy (DOE) in 2009 as a special Energy Frontier Research Center (EFRC), in which scientists from both academic institutions and government labs were asked to team up to discover better ways of converting biomass – plant sugars from corn or sugarcane – into combustible diesel fuel, jet fuel or gasoline.

In order to successfully convert biomass into fuel, Marshall and his colleagues have developed a roadmap of chemical reactions. Each of these reactions requires either a different catalytic material or a different set of reaction conditions to work effectively.

"The problem with biomass is that it's loaded with oxygen, while the fuels we're trying to create are much more oxygen-poor and hydrogen-rich," Marshall said. "Hydrogen is an expensive commodity; if we're going to use it, we need to use it judiciously."

IACT researchers spend most of their time trying to improve the selectivity of different catalysts, which involves making atomic-level modifications to these chemical processes so they will work as efficiently as possible. While all catalysts degrade over time, scientists are constantly on the hunt for new ways to keep them working reliably for as long as possible.

"The goal is to be able to use the same catalyst for months or even years, as opposed to minutes or hours," Marshall said.

One of the most notable discoveries that the IACT consortium has made involves the use of a technique called "overcoating," in which scientists add a dome-like sheath of protective material on top of the metal catalyst.

Overcoating can prevent the degradation of the catalyst by a substance known as "supercritical water," a phase of water that occurs under certain conditions in which it exhibits properties in between that of a liquid and a gas. Supercritical water quickly oxidizes the metal surface of a catalyst in a process similar to how a car rusts when it is left out in the rain.

In order to overcoat a catalyst, Argonne scientists use a method known as atomic layer deposition (ALD). ALD allows researchers to deposit extremely thin and uniform sheets of material on different surfaces; typically these layers are only a few atoms thick.

"One of the major advantages of overcoating is that the protective layers can be penetrated by the good molecules but not by the ones we don't want," Marshall said.

Finding new solutions – like overcoating – to catalytic challenges frequently involves collaboration between scientists who specialize in quite different areas. According to Marshall, IACT's mission is broken down into four distinct priorities: designing and synthesizing new catalysts, evaluating new designs, computational analysis, and characterization of new chemistries. Additionally, several IACT scientists spend time trying to come up with theoretical predictions of new materials and conditions that could provide better results.

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Currently, IACT involves 21 principal investigators and 55 total scientists at five institutions: Argonne, Brookhaven National Laboratory, Northwestern University, Purdue University and the University of Wisconsin-Madison.

Marshall eventually hopes to move into examining catalytic processes involving biological molecules other than cellulose.

"We hope to expand our research into substances like lignin, which could open up even more possibilities for reducing our dependence on foreign petroleum as well as diminishing greenhouse gas emissions," he said.

Provided by Argonne National Laboratory

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