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Putting the 'fuel' in biofuels

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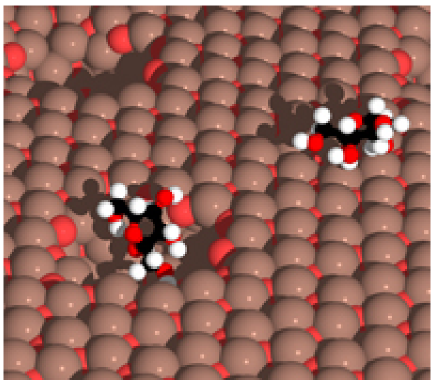

This molecular schematic of “nanobowls” illustrates an example of a new catalytic paradigm that may help in the development of new biofuels.

(PhysOrg.com) -- Recent discussions of methods by which biomass -- grasses, trees, and other vegetation -- could be turned into fuel makes a lot of sense in theory. Plant matter is composed of energy-intensive carbohydrates, but even now scientists still don't have the perfect solution for converting plant sugars into combustible fuels.

"There's a real challenge in the catalysis and conversion process that we face, which is that nature and evolution have already fashioned far better catalysts than we could create on our own—namely enzymes," said materials scientist Christopher Marshall, who leads the Institute for Atom-Efficient Chemical Transformations (IACT) at the U.S. Department of Energy's (DOE) Argonne National Laboratory. "In order to aid the transition away from a petroleum-based economy, we have to take our cues from the catalysts that have existed for millions of years."

Using actual biological enzymes would not be a workable solution, since enzymes work too slowly to be effective. For the purposes of converting biomass to biofuels, researchers need to synthesize biologically-inspired inorganic catalysts that balance the need for molecular specificity and high reaction rates.

"When it comes to catalyst discovery, everything's based around a particular set of trade-offs," Marshall said.

Potential catalysts for biofuel production have traditionally come from the precious metals and their elemental cousins. According to Marshall, scientists have found an increasing spectrum of applications first for platinum, and then for a platinum-molybdenum hybrid. "Slightly different chemistries can produce dramatically different results both in terms of efficiencies and specificities," he said. "We're really just trying to fashion the best molecular jigsaw pieces we can to fit this larger puzzle."

IACT was founded in 2009 as part of the DOE's effort to establish a set of several dozen Energy Frontier Research Centers (EFRCs) around the country that would contain five-year interdisciplinary programs focused around discrete scientific challenges. As part of the overall effort to transform the energy economy, Argonne also leads research into improved lithium-ion battery technology and new photovoltaic devices that can better capture solar energy.

Converting biomass to biofuels requires the use of a great deal of hydrogen, an element that Marshall said can be hard to manufacture. "The current methods of getting the hydrogen we need to do the conversion require the input of just as much energy as we'd get out of the fuels we'd be trying to create," he said. "In order to really get biofuels to take off, we first have to tackle the problem of where we're going to get all the hydrogen we need."

Because hydrogen is contained within the carbohydrate backbone of plant matter, ideally scientists hope to find a self-sustaining process in which the hydrogen needed for the conversion of biomass to biofuels can be extracted from the biomass itself. To do so requires the development of robust inorganic materials based on nanotechnology that can improve the multistep process of going from woodchipper to gas tank.

Researchers who collaborate in the IACT come from a variety of different technical backgrounds, including materials design, synthesis and characterization, theoretical chemistry and computational studies. "By combining all of these approaches, we hope to gain an understanding of how these key reactions work and how we can optimize the effectiveness of these catalysts both in terms of their selectivity and their rate of reaction. We want to use these catalysts as scalpels, not chainsaws," Marshall said.

Provided by Argonne National Laboratory