Designing microbes that make energy-dense biofuels without sugar

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(Phys.org) -- With metabolically engineered microorganisms hungry for levulinic acid rather than sugar, a UW-Madison chemical and biological engineer aims to create more sustainable, cost-effective processes for converting biomass into high-energy-density hydrocarbon fuels.

Currently, commercial biofuels — for example, ethanol and biodiesel — are produced from such crops as sugarcane or corn, or derived from plant oils. However, existing production processes for these "first-generation" biofuels are energy-intensive and ill suited to meet future demand for alternative transportation fuels.

Brian Pfleger, a UW-Madison assistant professor of chemical and biological engineering, is among an emerging group of researchers that is capitalizing on modern biotechnology tools to engineer systems that efficiently and sustainably produce "drop-in" fuels—advanced biofuels interchangeable with today's fuels and compatible with existing infrastructure.

A synthetic biologist, Pfleger received a prestigious Faculty Early Career Development (CAREER) award from the National Science Foundation to support his research. With the award, Pfleger will study, engineer and test metabolic pathways in bacteria that can convert biomass to hydrocarbon fuels in a process that bypasses the difficult intermediate step of breaking down the natural sugars in plants.

Those sugars have a tendency to degrade into levulinic acid, which the

U.S. Department of Energy calls one of the top value-added chemicals from biomass. Exploiting that tendency, Pfleger will engineer an organism—for example, by adding or subtracting genes—that quickly and efficiently can break down levulinic acid into smaller molecules known as free fatty acids that, in turn, can be used to produce fuels and chemicals. This work complements advanced biofuel production research he has conducted at UW-Madison through the Great Lakes Bioenergy Research Center.

Pfleger's research also leverages the expertise of colleague James Dumesic, the Steenbock Professor of Chemical and Biological Engineering at UW-Madison who has made groundbreaking advances in using catalysts to convert levulinic acid into high-energy liquid fuels. However, capitalizing on the power of synthetic biology, Pfleger can tailor microorganisms that can produce specific — or a wider range — of fuels and chemicals.

"In a catalytic sense, you make a mixture of things; a microbe makes a particular compound," he says.

In addition to establishing a microbial fermentation facility for research and teaching, Pfleger is developing a laboratory-based course that will enable undergraduate seniors and graduate students to learn synthetic biology skills and techniques such as designing DNA molecules and incorporating those models into organisms.

This biochemical engineering laboratory course also will serve as a training ground for the UW-Madison iGEM team, a cross-disciplinary group of students who design functional biological systems to compete in the International Genetically Engineered Machine synthetic biology competition. Pfleger has been the team adviser since 2008.

He also will partner with the National Science Foundation-supported

Delta Program at UW-Madison to develop lectures, case studies, and experiments for educating public audiences and kindergarten through undergraduate-level students about sustainability, biofuels and synthetic biology.

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