Researchers explore a sustainable bio-based chemical economy

24 August 2012, By Renee Meiller

With cyanobacteria, carbon dioxide and sunlight, a team of University of Wisconsin-Madison engineers aims to create a sustainable alternative source of commodity chemicals currently derived from an ever-decreasing supply of fossil fuels.

Funded through a $2 million grant from the National Science Foundation Emerging Frontiers in Research and Innovation program, the team will develop and evaluate a systems-level biorefinery strategy for using photosynthetic methods to produce chemical compounds. "The real issue is how do we develop a sustainable chemical economy," says Brian Pfleger, a UW-Madison assistant professor of chemical and biological engineering and lead researcher on the grant.

Although the major products of crude oil refineries are fuels such as gasoline and jet fuel, approximately 20 percent of crude oil is refined, in several complicated, energy-intensive steps, into petrochemicals. These chemicals permeate our daily lives in products ranging from candles and perfume to disposable diapers, toys, tires and plastic packaging, among many others.

As an alternative to crude oil, researchers around the world are studying ways to produce fuels and chemicals from renewable sources, including plant biomass and algae. Current production processes are energy-intensive and generate sugars or oils, which are "intermediate" products. "Then you would take those intermediates and do traditional processing, whether it's biological or chemical," says Pfleger.

Using cyanobacteria, which need only light, carbon dioxide and simple nutrients to thrive, Pfleger's team is aiming for an even more efficient, sustainable outcome.

He and his colleagues will engineer a fast-growing species of cyanobacteria to skip the intermediate processing step and directly produce model chemical compounds such as 3-hydroxypropionate, a precursor to acrylic acid and one of the top 12 chemicals the U.S. Department of Energy has identified as potential building blocks of a sustainable chemical economy.

As part of that process, they will study whether biorefineries can draw on municipal wastewater to provide the cyanobacteria with essential nutrients such as nitrogen and phosphorus—and in the process, produce clean water suitable for release into the environment.

The researchers also will create computer models that enable them to explore issues related to scaling lab experiments up to industrial-scale chemical production processes. With these models, they will study the economics of a sustainable chemical industry, considering factors such as cost, supply structure, and whether a different set of core chemicals is feasible. "And that brings back this whole question of biorefineries," says Pfleger. "Can you use a biological system to make not just fuels, but a whole suite of different chemicals?"

Provided by University of Wisconsin-Madison