From microbes to hydrogen fuel

March 24 2009, by Greg Bolt

Searching for an environmentally friendly way to produce cheap hydrogen as a fuel, researchers at Oregon State University are turning to microbes that have been doing the job for billions of years.

Their work could one day lead to a new kind of solar-derived energy that, instead of producing electricity directly through photovoltaics, would use the ancient process of photosynthesis to churn out the hydrogen to power clean-energy fuel cells. All it would take is sunlight, hydrogen-producing bacteria and a bit of high-tech coaxing.

Hydrogen power has become a holy grail in the alternative energy industry. In a hydrogen fuel cell, hydrogen combines with oxygen to give off energy and water. The problem the industry faces is that it needs a power source -- typically anything from coal or natural gas to nuclear or hydroelectric power -- to make hydrogen. The OSU team is hoping for an environmentally benign route to hydrogen production.

A team led by OSU's Roger Ely, a professor of biological and ecological engineering, has shown that the concept is feasible. Their work was published recently in the International Journal of Hydrogen Energy, and the team received a $938,000 grant to be split between researchers at OSU, the University of Oregon and Indiana University.

Catherine Page, a chemistry professor at UO, is one of the scientists working to develop the idea.

Ely and his colleagues are trying to harness blue-green algae -- a singlecelled organism known as cyanobacteria -- to produce hydrogen, which the bacteria has been doing happily for the past several billion years. But hydrogen is only a byproduct of the process, and Ely's team is hoping to learn enough about how the bacteria work to engineer ways to increase and harvest the hydrogen production.

"Nature's been working on this for about 3 1/2 billion years and so has a considerable head start on us with respect to the research and development," Ely said. "These processes go on around us all the time. There are millions of metric tons of hydrogen that are produced biologically in the world per year. It's really a matter of learning how we can tap into it, how we can harness it and try to make best use of it."

Cyanobacteria are busy organisms that typically reside in the ocean and use photosynthesis to take energy from the sun and carbon dioxide in the atmosphere to make the food it needs to grow. The major byproduct is oxygen -- which, a couple of billion years ago, gave us a breathable atmosphere -- but the process also leaves a little bit of leftover hydrogen.

The trick for researchers is to get the cyanobacteria to pay more attention to making hydrogen. That's a challenge because the microbe isn't really adapted for hydrogen production and doesn't take on the job readily.

Researchers are trying to get around that by "encapsulating" the bacteria in a solid matrix that limits growth. That way, they can direct the cell's energy into making hydrogen instead of the carbohydrates it would otherwise make to fuel growth.

"When we essentially milk them for hydrogen, it's sort of like a hydrogen milk cow in a sense. What we do is penalize them in terms of growth," Ely said. "So they don't like that. But if they're encapsulated they can't grow anyway. What were trying to do is take advantage of that."

The solid framework used to encapsulate the bacteria is material that resembles a glass sponge. It limits growth, isolates the microbes from the environment, and protects them from contamination so they can perform longer and make more hydrogen. But that's only the first step.

"Based on what we've done and seen so far, I think that we have proven the concept that you can encapsulate these cells, you can put them inside of this material and they survive and they make hydrogen," Ely said. "So that's good. The only question then is how far can we go with it and what are the limits. And we don't know yet what those are."

The ultimate goal is to engineer a relatively small package in which cyanobacteria take sunlight and produce useful quantities of hydrogen. There's still a lot of work to be done, but Ely believes that perhaps in five to seven years they could come up with a prototype.

One of the biggest advantages to a bacterial hydrogen production is that it carries few, if any, environmental downsides. And even though it would take some very high-tech advances to harness it, the process at its root is the same one used in nature. And that, Ely said, is a good way to go.

"One of the things that's really important is that we try to stay as close to natural process as we can," he said. "Because we have a lot of issues in the world related to environmental quality and environmental sustainability, and if we can try to stay close to natural processes and use solar energy directly in some way, I think that's an advantage."