Converting Water and CO2 into Fuel

Researchers are trying to duplicate the natural process of photosynthesis. If successful, we can use the “evil” carbon dioxide emitted by power plants and industrial units to good use. This way, industrial units don’t have to establish new subsidiary units for the treatment of carbon dioxide. Researchers at Sandia National Laboratories have developed a prototype machine that utilizes the sun’s energy to convert water and carbon dioxide into the molecular building blocks that can be utilized as transportation fuels. If researchers can make this device produce twice the energy generated by the natural process of photosynthesis, it will do great service to environment. It will pave the way to recycle CO2.

Till now devices imitating the photosynthesis process are not a great success. But a hand-built demonstration machine was successfully tested this fall. Researcher Rich Diver, inventor of the device, affirms, “This is a first-of-its-kind prototype we’re evaluating.”

James Miller who is a chemical engineer with Sandia’s advanced materials laboratory, says, “In the short term we see this as an alternative to sequestration.” Miller is of the opinion that if we think beyond just pumping CO2 underground for permanent storage and utilize the sun’s abundant energy for “reverse combustion” that will help in converting carbon dioxide back into a fuel. Miller explains, “It’s a productive utilization of CO2 that you might capture from a coal plant, a brewery, and similar concentrated sources.”

The machine resembles a cylinder and is christened as Counter-Rotating-Ring Receiver Reactor Recuperator (CR5). It is dependent on concentrated solar heat to activate a thermo-chemical reaction in an iron-rich composite material. The material is designed in such a way that when exposed to extreme heat, it gives up an oxygen molecule and then retrieves an oxygen molecule once it cools down.

The machine has two chambers, one on each side. One side is hot, the other cool. In the center is a set of 14 Frisbee-like rings rotating at one revolution per minute. The outer edge of each ring carries an iron oxide composite supported by a zirconium matrix. Scientists also installed a solar concentrator to heat the inside of one chamber to 1,500 º C. This results in giving up of oxygen molecules by the iron oxide on one side of the ring. Now the affected side of the ring rotates to the opposite chamber. Slowly it looses its heat and carbon dioxide is pumped in. This cooling helps the iron oxide to get back oxygen molecules from the CO?, leaving behind carbon monoxide.

The process is repeated continuously using up an incoming supply of CO_2 and giving out stream of carbon monoxide.

Miller is of the opinion that hydrogen can be produced by using the same process. The only difference will be that water, instead of carbon dioxide, is pumped into the second chamber. The two gases namely hydrogen and carbon monoxide can be then mixed together to make syngas. This syngas can be used to make a “drop-in replacement” for traditional fuels.

Diver had hydrogen economy in mind when he originally designed the machine. He wanted to bypass the inefficiency of electrolysis and utilize a solar heat engine that could produce hydrogen and oxygen directly. This will cut down electricity as the middleman. The same approach is being adopted by researchers in Japan, France, and Germany. But the Sandia team soon realized the drawback of the process as it was converting CO_2 into carbon monoxide. They are paving the way to lessen the ill effects of the fossil fuels we consume. Their device will limit the impact of burning coal and natural gas for electricity and other industrial processes.

Diver feels that if he wants his device to benefit the common man he has to improve the efficiency of the system. If the Sandia team can show higher efficiency, “it could be a significant step forward,” said Vladimir Krstic. Vladimir Krstic is the director of the Center for Manufacturing of Advanced Ceramics and Nanomaterials at Queen’s University in Kingston, Ontario.

Scientists are of the view that people have to wait for at least 15 to 20 years before the technology is ready for market. They are planning to develop a new-generation prototype every three years with the aim of showing an increase in solar-to-fuel conversion efficiency and a decrease in cost. They want to attain the above-stated goal by developing new ceramic composites that release oxygen molecules at lower temperatures. This will help in converting more of the sun’s energy into hydrogen or carbon monoxide.

Miller states, “Our short-term goal is to get this to a few percent efficiency. It might seem like a low number, but we like to compare that to photosynthesis, which is actually a very inefficient way to use sunlight.” He also points out the drawback of the process that the theoretical maximum efficiency for photosynthesis is around 5 percent, but in the actual world it tends to fall to around 1 percent. He defines his goals clearly, “So we may be starting very low, but we’d like to keep it in the context of what we have to beat. Ultimately, we believe we have to get in the range of 10 percent sunlight-to-fuels, and we’re a long way from doing that.”