Electricity from seawater: New method efficiently produces hydrogen peroxide for fuel cells

May 20 2016, by Lisa Zyga

Credit: Mr. William Folsom, NOAA, NMFS

(Phys.org)—Scientists have used sunlight to turn seawater (H_2O) into hydrogen peroxide (H_2O_2), which can then be used in fuel cells to generate electricity. It is the first photocatalytic method of H_2O_2 production that achieves a high enough efficiency so that the H_2O_2 can be used in a fuel cell.

The researchers, led by Shunichi Fukuzumi at Osaka University, have published a paper on the new method of the photocatalytic production of hydrogen peroxide in a recent issue of *Nature Communications*.

"The most earth-abundant resource, seawater, is utilized to produce a solar fuel that is H_2O_2," Fukuzumi told *Phys.org*.

The biggest advantage of using liquid H_2O_2 instead of gaseous hydrogen (H_2), as most fuel cells today use, is that the liquid form is much easier to store at high densities. Typically, H_2 gas must be either highly compressed, or in certain cases, cooled to its liquid state at cryogenic temperatures. In contrast, liquid H_2O_2 can be stored and transported at high densities much more easily and safely.

The problem is that that, until now, there has been no efficient photocatalytic method of producing liquid H_2O_2. (There are ways to produce H_2O_2 that don't use sunlight, but they require so much energy that they are not practical for use in a method whose goal is to produce energy.)

In the new study, the researchers developed a new photoelectrochemical cell, which is basically a solar cell that produces H_2O_2. When sunlight illuminates the photocatalyst, the photocatalyst absorbs photons and uses the energy to initiate chemical reactions (seawater oxidation and the reduction of O_2) in a way that ultimately produces H_2O_2.

After illuminating the cell for 24 hours, the concentration of H_2O_2 in the seawater reached about 48 mM, which greatly exceeds previous reported values of about 2 mM in pure water. Investigating the reason for this big difference, the researchers found that the negatively charged chlorine in seawater is mainly responsible for enhancing the photocatalytic activity and yielding the higher concentration.

Overall, the system has a total solar-to-electricity efficiency of 0.28%. (The photocatalytic production of H_2O_2 from seawater has an efficiency of 0.55%, and the fuel cell has an efficiency of 50%.)

Although the total efficiency compares favorably to that of some other solar-to-electricity sources, such as switchgrass (0.2%), it is still much lower than the efficiency of conventional solar cells. The researchers expect that the efficiency can be improved in the future by using better materials in the photoelectrochemical cell, and they also plan to find methods to reduce the cost of production.

"In the future, we plan to work on developing a method for the low-cost, large-scale production of H_2O_2 from seawater," Fukuzumi said. "This may replace the current high-cost production of H_2O_2 from H_2 (from mainly natural gas) and O_2."

More information: Kentaro Mase *et al.* "Seawater usable for production and consumption of hydrogen peroxide as a solar fuel." *Nature Communications*. DOI: 10.1038/ncomms11470