# Researchers obtain patent for new process that converts waste heat into hydrogen

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Researchers from the Department of Civil and Environmental Engineering at Penn State have discovered an effective method to convert waste heat into hydrogen gas without the use of fossil fuels.

They were awarded a U.S. patent on Aug. 18 for their efforts.

"Existing methods are already very effective at making hydrogen gas," said Bruce Logan, Evan Pugh Professor of Environmental Engineering. "The problem is that these methods consume fossil fuels in order to generate enough energy to create the hydrogen gas."

In response to this dilemma, Logan, along with former graduate student Roland Cusick, assistant professor at the University of Illinois, and postdoctoral researcher Younggy Kim, assistant professor at McMaster University, in Hamilton, Ontario, discovered a new method for making hydrogen gas that does not require the use of fossil fuels. In this method, the researchers are able to effectively produce hydrogen gas using energy stored in ammonium bicarbonate (a heat regenerable salt) and solar heat or waste heat (like that available at power plants).

"Since the new system runs on waste heat, it is effectively carbon neutral and fossil fuel neutral," Logan said.

The patent, U.S. patent number 9,112,217, "Reverse electrodialysis supported microbial fuel cells and microbial electrolysis cells," describes the process.

Ammonium bicarbonate and water are separated into high and low salt concentration streams using distillation, much like the process for distilling alcohol. Those streams are then fed into a reverse electrodialysis stack, which consists of a series of alternating charge (cation and anion) ion exchange membranes. This process creates an electrochemical reaction that splits the water forming both oxygen and hydrogen at the other electrode.

That hydrogen can then be used on site, for example to make ammonia, or it can be compressed and containerized for a variety of other purposes.

Previous similar systems have been designed to create electrical power from high and low salt concentration solutions, such as freshwater and seawater solutions. However, this is the first device created specifically for hydrogen gas production.

"Many countries are limiting carbon emissions, and thus new carbon neutral methods are needed to produce transportable fuels," Logan said. "This process can help with both of those goals."

The new method can be used on a large scale but is not yet economical due to the cost of the membranes. The researchers hope to find more economical solutions to this problem.

"The next step is the development of very inexpensive membranes that can be produced in large amounts, similar to that done today for reverse osmosis membranes used for drinking water," Logan said. "The production of such low cost membranes could help stimulate a new industry in sustainable hydrogen gas production."

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