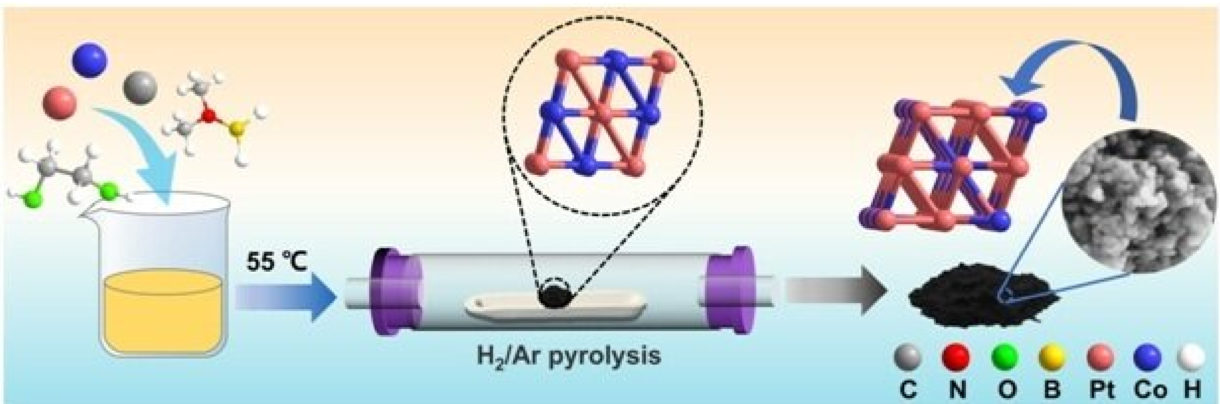
# Nano-scale platinum-cobalt alloy particles to slash cost of next-gen fuel cells

December 15 2022




Highly ordered $Pt_3Co$ nanoparticles were prepared by a two-step reduction strategy. The half wave potential of $Pt_3Co/C$ reached 0.87 V, showing excellent ORR performance. Credit: Zhonghua Xiang, Beijing University of Chemical Technology

The precious metal platinum is a key catalyst for the chemical reactions at the heart of the next generation of more compact, high-performing hydrogen fuel cells. But platinum's high cost is preventing widespread adoption of this technology.

Researchers, however, have devised a nano-scaled alloy of platinum and cobalt to use as catalyst, sharply reducing the amount of platinum needed to achieve the same—or even better—performance.

A description of this novel platinum-cobalt electrocatalyst and the technique used to produce it was published in the journal *Particuology* on December 15.

Hydrogen fuel cells will be needed in the clean transition for those parts of the economy, in particular heavy transport, that are hard to electrify using battery technology. Unfortunately, the most commonly used fuel cell, the alkaline fuel cell, remains quite bulky, limiting its application in those sectors such as shipping and aviation where space is at a premium.

The next generation of fuel cell, the proton exchange membrane fuel cells (PEMFCs—sometimes called the polymer electrolyte membrane fuel cell), is far more compact.

Sadly, the main catalyst—substances that help speed up chemical reactions—used in a key reaction involved in PEMFCS (the oxygen reduction reaction, or ORR) is the rare and thus expensive metal platinum. The high cost of platinum is already one of the biggest barriers to wider PEMFC adoption. According to data from the U.S. Department of Energy, platinum-group metal catalysts in fuel cells currently account for more than 40% of their cost. Indeed, half of all platinum production in the world is used by the automobile industry.

"This means that even as the high cost of platinum is limiting adoption of fuel cells in vehicles, should any wider adoption occur, this would only exacerbate the problem as there would be even greater demand, and thus higher prices, for this rare metal," said Zhonghua Xiang, the author of the paper and an electrochemist with the Beijing University of Chemical Technology.

Thus any pathway to wider adoption of fuel-cell technology necessarily involves some reduction of the amount of platinum required, either by swapping it out for some other catalyst material, or by reducing the amount of platinum needed without compromising on performance.

A great deal of research has focused on the latter approach. Researchers have particularly focused on alloying platinum with cobalt, in effect diluting the amount of platinum required to achieve the same result. The reason for this is that various platinum-cobalt alloys have a higher "active surface area"—the spaces on the molecules of the catalyst where the relevant chemical reactions can take place.

However, fine-tuning the degree of alloying to achieve optimum ORR performance has remained a great challenge.

So Professor Xiang synthesized a platinum-cobalt-carbon precursor (the compound that works to produce a second compound, in this case the platinum-cobalt alloy) by using dimethylamine borane (DMAB) as the reducing agent (a substance that donates electrons to another one in a chemical reaction). This precursor was heated to a high temperature in an environment of hydrogen and argon gas in order to produce a platinum-cobalt alloy involving three platinum atoms to every cobalt one in the form of nano-scale particles.

The structure of the electrons in this particular platinum-cobalt alloy permits a high amount of activity on the membrane surface of the electrodes in the fuel cell. As a result, fuel cell performance is enhanced and a great stability for the fuel cell is achieved. This latter benefit was demonstrated by only mild deterioration of performance after 10,000 cycles of the fuel cell. Further testing within single fuel cells showed their approach was considerably exceeding the requirements of U.S. Department of Energy standards.

Having demonstrated a reduction of the amount of platinum required to achieve superior PEMFC performance, Prof Xiang now wants to see if he can replace the platinum-based catalyst entirely, by using nonprecious metals as the catalyst, again while maintaining or improving performance and long-term stability.

**More information:** Secondary reduction strategy synthesis of Pt-Co nanoparticle catalysts towards enhanced the activity of proton exchange membrane fuel cells, *Particuology* (2022). DOI: 10.1016/j.partic.2022.11.010

Provided by Particuology