Using elements in plants to increase fuel cell efficiency while reducing costs

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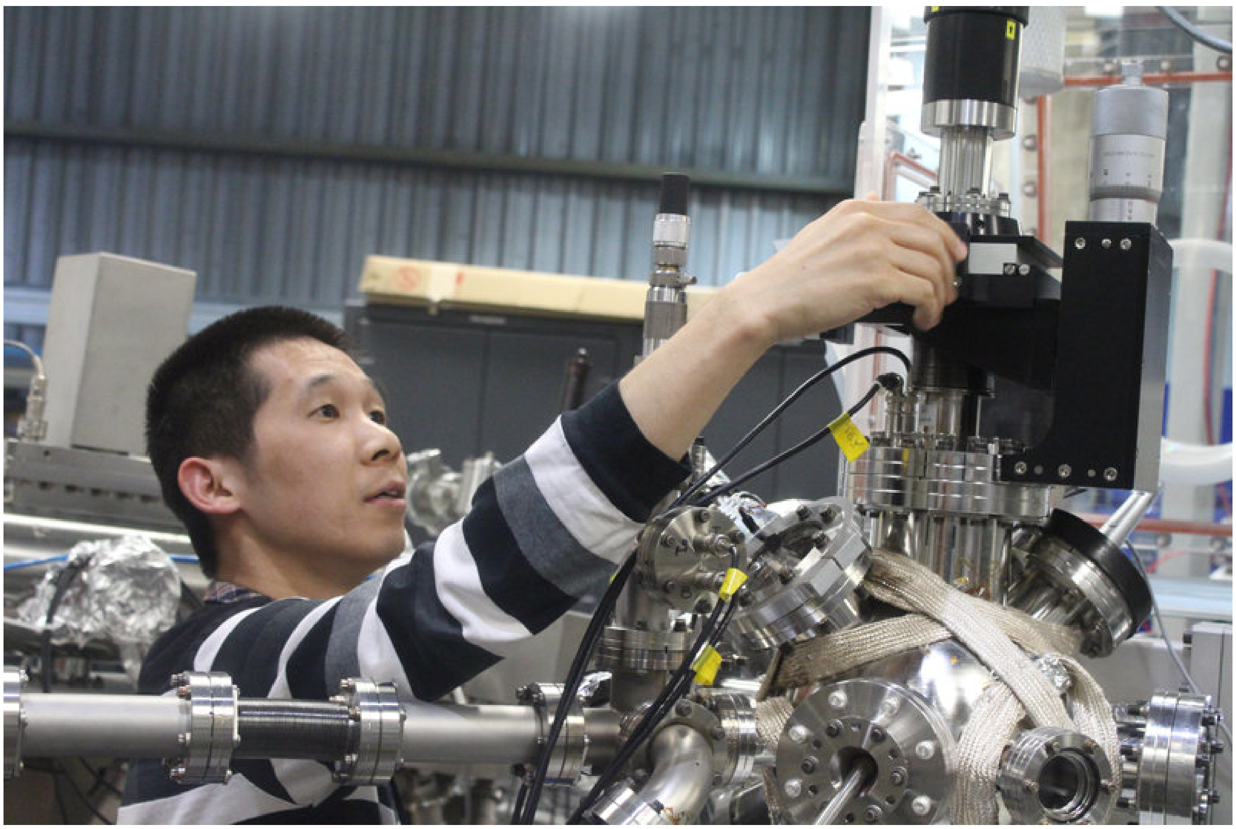

Qiliang Wei working on a Canadian Light Source beamline. Credit: Canadian Light Source

Researchers from the Institut National de la Recherche Scientifique, Québec are looking into reeds, tall wetlands plants, in order to make cheaper catalysts for high-performance fuel cells.

Due to rising global energy demands and the threat caused by environmental pollution, the search for new, clean sources of energy is on.

Unlike a battery, which stores electricity for later use, a fuel cell generates electricity from stored materials, or fuels.

Hydrogen-based fuel is a very clean fuel source that only produces water as a by-product, and could effectively replace fossil fuels. In order to make hydrogen fuel viable for everyday use, high-performance fuel cells are needed to convert the energy from the hydrogen into electricity.

Hydrogen fuel cells use platinum catalysts to drive energy conversion, but the platinum is expensive, accounting for almost half of a fuel cell's total cost according to Qiliang Wei, a Ph.D. student in Shuhui Sun's group from the Institut National de la Recherche Scientifique – Énergie, Matériaux et Télécommunications who studies lower-cost alternatives to platinum catalysts.

This is where reeds enter the picture. As was published in Wei's recent paper, "An active and robust Si-Fe/N/C catalyst derived from waste reed for oxygen reduction," reeds are high in silicon, and as an organic material, they are also a source of carbon.

One potential replacement for the platinum catalyst consists of iron, nitrogen and carbon compounds, and while it is promising, it does have some issues. It is much less stable than platinum, and while much cheaper, the materials necessary to obtain carbon can still be expensive. Silicon, like that found in reeds, could improve the activity of the catalyst by allowing more nitrogen to group with iron, and it also promotes graphitization, the process of forming carbon into graphite in another material, which could enhance the stability of the catalysts.

The discovery of silicon's usefulness in this process also helps to address the issue of cost, by using reeds and leftover withered reed stems that occur naturally at the end of the plant's life cycle as a source of both carbon and silicon. Wei was able to use reed waste biomass to produce the iron-nitrogen-carbon catalysts and, using the Canadian Light Source, was able to confirm silicon's role in these catalysts by characterizing their performance with and without the addition of silicon.

However, Wei's work is not done yet. The composition of the catalyst needs to be optimized, then using these reed waste-derived catalysts in fuel cells might be viable. It could create opportunities for new forms of batteries as well. Metal-air batteries use the same platinum catalysts as fuel cells in order to use elements in the air as the positive terminal, rather than a more costly metal.

"For the work in this paper, we only tested half-cell performance. In the next step, we will apply it to a real fuel cell stack, which is closer to the real application," said Wei. "Sometimes the catalyst is very good for a half cell, but may not be very efficient for a full cell. When we are trying to use it with the full fuel cell, we may need to optimize more parameters, like the carbon structure."

"If we can convert waste to add value to materials, it will be of great interest to industry. Our experiment here provides a promising route that can be used to design highly active and stable catalysts for fuel cells," said Wei.

More information: Qiliang Wei et al. An active and robust Si-Fe/N/C catalyst derived from waste reed for oxygen reduction, *Applied Catalysis B: Environmental* (2018). DOI: 10.1016/j.apcatb.2018.05.046

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