Research makes the production of hydrogen cheaper and more efficient

Gabhriel Giordani / 18 de abril de 2024

Physics | Work carried out at UFRGS developed a low-cost catalyst to assist in the generation of an alternative to fossil fuels

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*Photo: Burning fossil fuels releases gasses such as carbon dioxide, which intensifies the greenhouse effect and contributes to climate change. (Fernando Frazão/Agência Brasil)

A doctoral thesis from the Physics Graduate Program at UFRGS developed an electrocatalyst based on bimetallic nanoparticles made from palladium and copper that can assist in the production of hydrogen – an alternative to fossil fuels – in a cheaper, efficient and renewable way. The study by researcher Demétrius Lima aimed to create a sustainable possibility to generate energy, reducing carbon emission and, in so doing, contributing to lessen the greenhouse effect and the global warming.

Worldwide, there still exists a strong dependence on fossil fuels, such as petroleum, natural gas and coal. According to a 2021 report from the International Energy Agency (IEA), linked to the Organization for Economic Cooperation and Development (OECD), approximately 80% of the total energy used on the planet in 2020 comes from non-renewable raw materials. Furthermore, a problem in the use of renewable energy is the dependence on favorable conditions (climate, temperatures, seasonal periods, etc.).

With that in mind, Demétrius has developed a low-cost catalyst to assist in the process of hydrogen production, a source of energy that can substitute fossil fuels, for example, in cars and trains.

Why hydrogen?

Currently, hydrogen is produced from fossil fuels: 96% of the world's hydrogen comes from non-renewable sources. Therefore, there is a necessity for the development of cleaner alternatives for this production. One of these alternatives is water electrolysis, the process through which electric energy is used to "split" water molecules into H_2 and O_2. Demétrius emphasizes that electrolysis is considered a sustainable process when the necessary electricity comes from a renewable source, such as solar or wind energy.

Since electrolysis requires the use of electrocatalysts (substances that reduce the energy required to break the molecule), the researcher selected the best materials for the process: palladium and copper. Demétrius explains that palladium is an excellent electrocatalyst, but it is a rare material and its production is costly. On the other hand, copper is not as efficient as palladium, but it is more affordable.

Demétrius synthesized nanoparticles containing these two elements in different proportions and characterized them using X-ray Photoelectron Spectroscopy (XPS). This technique allows for the identification of what is present in the thin layer of atoms located on the catalysts' surface.

> *"The XPS technique is very important because this type of information and equipment is not easily accessible. At UFRGS, we are able to conduct this study because we have the necessary equipment."*
> — *Demétrius Lima*

With the technique, Demétrius discovered that, during the hydrogen production process, copper oxide was removed from the surface of the nanoparticles, making them more abundant in palladium and more active during the reaction. With a higher presence of palladium, the production of hydrogen fuel became easier.

Additionally, the researcher experimented with different thermal treatments (processes of heating and cooling different materials in order to alter their mechanical and physical properties without changing the product's shape) to verify which ones further improved the performance of this catalyst.

Surprised with the results, Demétrius explains that he expected that the vacuum thermal treatment would present the best results among the analysis. However, it turned out to be just the opposite: due to the vacuum, the lack of oxygen in the atmosphere ended up degrading one of the substances, the chemical compound Nafion, which was used in the electrode. Consequently, the material experienced greater palladium oxidation, compromising the reaction.

Another surprise was the air thermal treatment. The researcher believed that this process would be less efficient, but there was more copper oxidation, which is favorable to the reaction. The air treatment increased the activity in the reaction, while the vacuum treatment reduced it. "This air treatment ended up being much more efficient when using that material for the catalyst study", highlights Demétrius.

The moment of change

The author of the thesis emphasizes that in the latest report by the Intergovernmental Panel on Climate Change (IPCC), it is stated that the excessive use of fossil fuels can lead to economic and ecosystemic collapses in the next 100 years. Therefore, the urgent decarbonization of the global energy matrix is crucial.

According to the researcher, we are in a key period to implement these industries on national soil. "This type of study, specifically to the hydrogen generation, is very hot right now because we are in a period of energy transition," reports the physicist.

He emphasizes that the subject is also relevant due to the war in Ukraine and the great need of energy across Europe, whose energy sector relies to a large extent on Russia. "Europe is investing here in Brazil for this production, and a significant amount of money is coming from abroad," says Demétrius.

"In Rio Grande do Sul, the part of the state that has a greater potential for hydrogen generation is the Campanha and the Southern Coast. With the implementation of wind farms, we could produce hydrogen and electricity, generating income and employment in these regions, which are historically less developed than the northern part of the state," highlights the researcher.

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Translated into English by **Enzo Sezar de Assis**, undergraduate student enrolled in the course "Supervised Translation Training II (English)" of the Undergraduate Program in Language and Literature, under the supervision and translation revision of Professor Elizamari R. Becker (P.h.D.) – IL/UFRGS.

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