Scientists Are Generating Clean Electricity From... Chicken Feathers—And It Actually Works

Story by Arezki Amiri

A Dirty Secret From The Poultry Industry Is Now Helping Scientists Clean Up Global Energy. Credit: Shutterstock | The Daily Galaxy --Great Discoveries Channel© Daily Galaxy NZ

In a potential breakthrough for **green energy technology**, scientists at *ETH Zurich* and *Nanyang Technological University Singapore* (NTU) have developed a membrane for **hydrogen fuel cells** made from discarded chicken feathers—an abundant waste product in the global poultry industry.

The new membranes are made from **keratin**, a structural protein that makes up the bulk of feathers. Extracted and processed into amyloid fibrils, the keratin forms a thin, **proton-conductive layer** at the heart of a hydrogen fuel cell. According to the research team, the material could replace conventional membranes made with toxic, non-biodegradable fluorinated compounds.

The process, outlined in a study published in *ACS Applied Materials & Interfaces*in September 2023, offers a scalable, **low-cost alternative** with environmental benefits—both in terms of cleaner fuel cell production and reduced waste from poultry processing.

From Agricultural Waste to Clean Energy

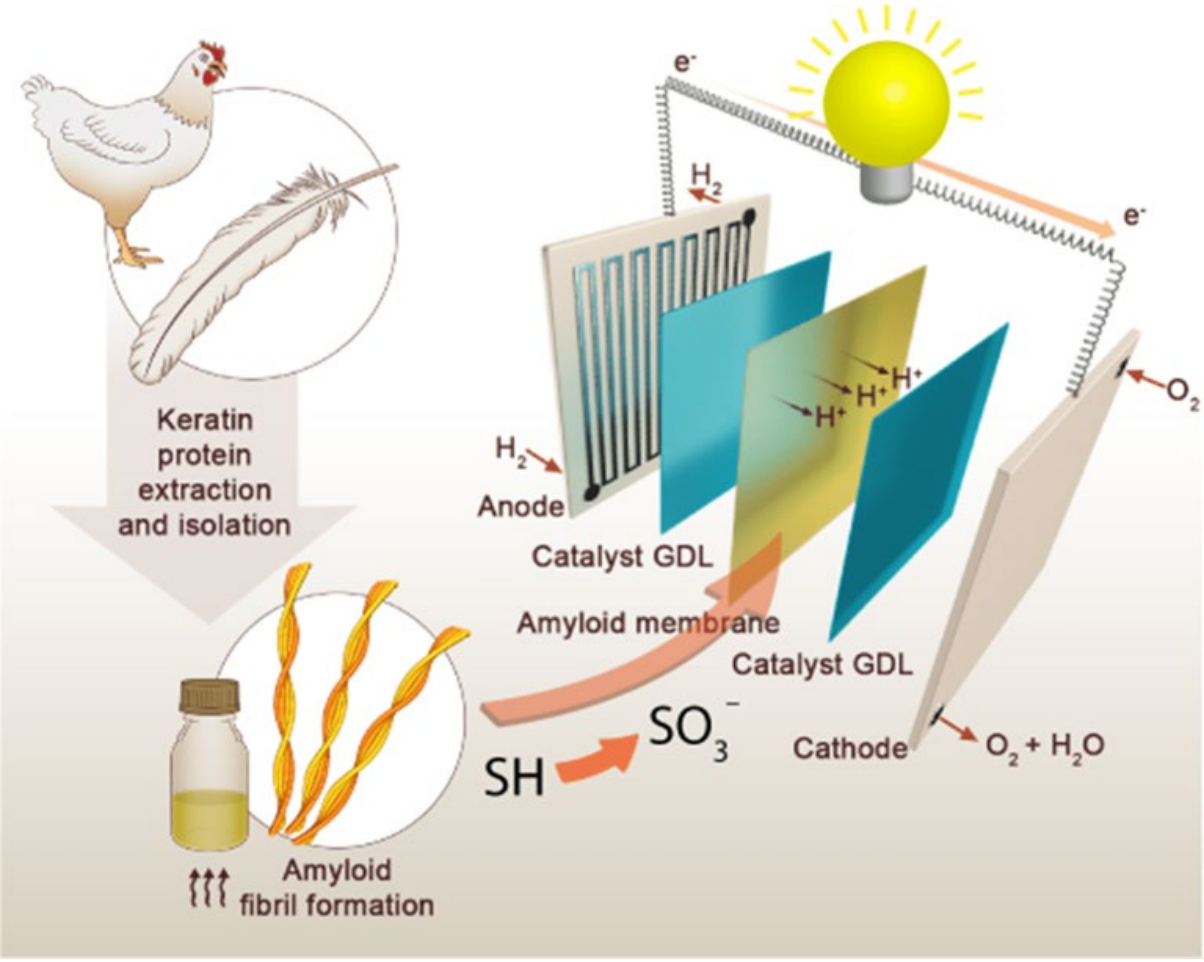
Globally, the poultry industry generates an estimated **40 million metric tons** of feather waste each year, most of which is incinerated. This releases carbon dioxide and toxic gases such as **sulfur dioxide**, contributing to air pollution and greenhouse gas emissions. Researchers at ETH Zurich and NTU say their method not only avoids these emissions but gives feathers a second life in **renewable energy infrastructure**.

"Our latest development closes a cycle: we're taking a substance that releases CO_2 and toxic gases when burned and used it in a different setting: with our new technology it not only replaces toxic substances, but also prevents the release of CO_2, decreasing the overall carbon footprint cycle," said *Raffaele Mezzenga*, professor of food and soft materials at ETH Zurich, in a statement from the university.

The process involves extracting keratin using heat and chemical treatments, forming it into **amyloid fibrils**, and assembling it into a thin, semipermeable membrane. In laboratory tests, these membranes demonstrated a **proton conductivity of 6.3 millisiemens per centimeter**—sufficient for use in fuel cells, water-splitting devices, and even **protonic transistors**.

Performance and Cost Advantages

While still in the prototype stage, the feather-derived membrane achieved a **peak power density of 25 milliwatts per square centimeter** when tested in a hydrogen fuel cell operating on hydrogen and ambient air.



Representation of the components of the fuel cell. In the center is the membrane made of keratin. To the left and right of the membrane is a catalyst. In the outer layer is the anode on one side and the cathode on the other.© Daily Galaxy NZ

This output is modest compared to commercial fuel cell systems, but the researchers point to other advantages: cost, availability, and biodegradability. Chicken feathers are composed of roughly **90% keratin**, making them an abundant, renewable feedstock. The membrane developed by ETH and NTU is already **up to three times cheaper** to produce than fluoropolymer-based alternatives, according to the ETH news release.

Conventional membranes, such as *Nafion*, rely on **perfluorinated compounds**—also known as **PFAS**, or "forever chemicals." These synthetic substances do not break down in the environment and are increasingly linked to serious health risks. In 2023, the U.S. Environmental Protection Agency proposed drinking water limits for several PFAS compounds, calling them a major threat to public health.

By contrast, the keratin membranes are **biocompatible**, **non-toxic**, and **environmentally degradable**, aligning with growing demand for safer materials in clean energy systems.

Broader Applications and Commercialization

Beyond fuel cells, the research team demonstrated the membrane's use in **electrolysis**—splitting water into hydrogen and oxygen—as well as in **protonic field-effect transistors**. The membrane's ability to support proton transfer without added acids or salts makes it suitable for **next-generation electrochemical applications**.

The team has filed a **patent** and is now exploring industrial partnerships for scale-up and commercialization. Before entering the market, the technology will need to prove its **durability**, **chemical stability**, and **long-term performance** under real-world conditions.

Still, the early results suggest that what was once considered waste—chicken feathers—could soon become part of the **clean energy toolkit**. As hydrogen technologies expand globally, innovations like this may help reduce both cost and environmental impact in the race to **decarbonize energy systems**.