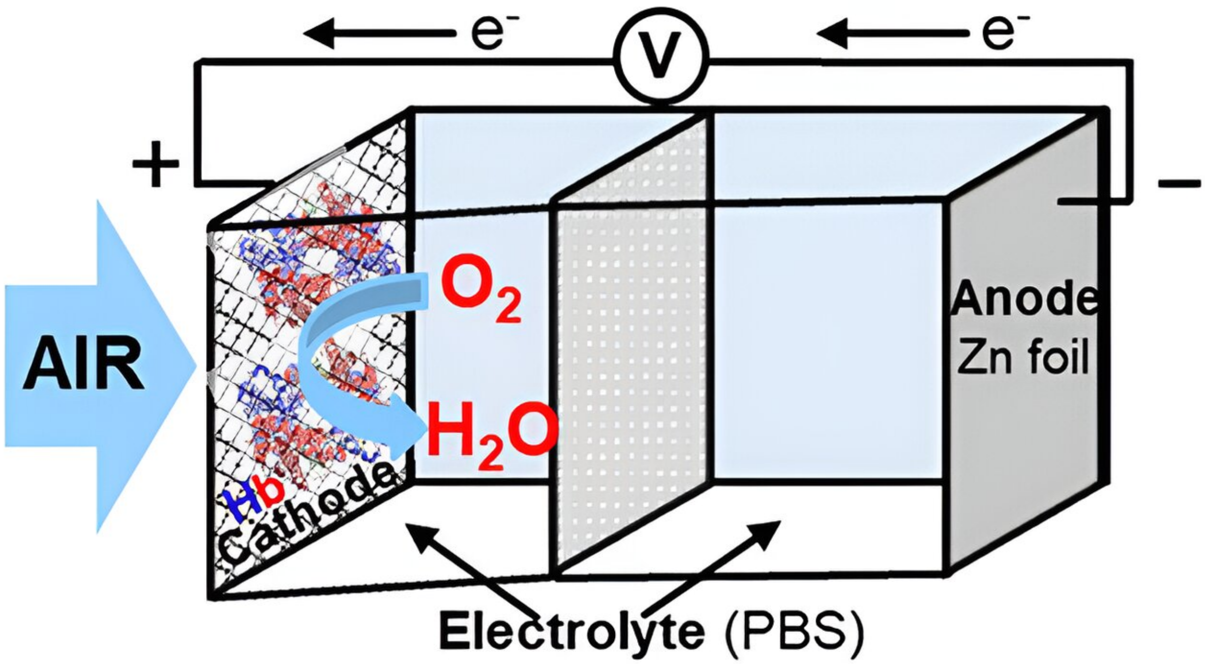
First battery prototype using hemoglobin developed

January 9 2024



Abstract. The use of human hemoglobin (Hb) as a catalytic component of the air electrode in a primary zinc–air battery with a neutral electrolyte has been investigated. Three different electrode modifications, using the drop-casting method, with Hb and Nafion were first tested in a three-electrode cell, obtaining the best oxygen electroreduction (ORR) performance and long-term stability with a Hb plus Nafion (Hb–Nafion)-modified electrode. The latter Hb–Nafion-based air electrode provided a higher specific capacity and discharge time than the opposite order (Nafion–Hb). Credit: *Energy & Fuels* (2023). DOI: 10.1021/acs.energyfuels.3c02513

A team with the Chemical Institute for Energy and the Environment (IQUEMA) at the University of Cordoba has come up with a battery that uses hemoglobin as an electrochemical reaction facilitator, functioning for around 20–30 days.

Hemoglobin is a protein present in red blood cells and is responsible for conveying oxygen from the lungs to the different tissues of the body (and then transferring carbon dioxide the other way around). It has a very high affinity for oxygen and is fundamental for life, but what if it were also a key element for a type of electrochemical device in which oxygen also plays an important role, such as zinc-air batteries?

This is what the Physical Chemistry (FQM-204) and Inorganic Chemistry (FQM-175) groups at the University of Córdoba (UCO) wanted to verify and develop, together with a team from the Polytechnic University of Cartagena, after a study by the University of Oxford and a Final Degree Project at the UCO demonstrated that hemoglobin featured promising properties for the reduction and oxidation (redox) process by which energy is generated in this type of system.

Thus, the research team developed, through a proof of concept project, the first biocompatible battery (which is not harmful to the body) using hemoglobin in the electrochemical reaction that transforms chemical energy into electrical energy.

Using zinc-air batteries, one of the most sustainable alternatives to those currently dominating the market (lithium-ion batteries), hemoglobin would be a catalyst in such batteries.

That is, it would be used as a protein that is responsible for facilitating the electrochemical reaction called the oxygen reduction reaction (ORR), causing, after the air enters the battery, oxygen to be reduced and transformed into water in one of the parts of the battery (the cathode or positive pole), releasing electrons that pass to the other part of the battery (the anode or negative pole), where zinc oxidation occurs.

As UCO researcher Manuel Cano Luna explains, "To be a good catalyst in the oxygen reduction reaction, the catalyst has to have two properties: it needs to quickly absorb oxygen molecules and form water molecules relatively easily. And hemoglobin met those requirements." In fact, through this process, the team got their prototype biocompatible battery to work with 0.165 milligrams of hemoglobin for between 20 and 30 days.

In addition to strong performance, the battery prototype they have developed boasts other advantages. First of all, zinc-air batteries are more sustainable and can withstand adverse atmospheric conditions, unlike other batteries affected by humidity and requiring an inert atmosphere for their manufacture.

Secondly, as Cano Luna argues, "The use of hemoglobin as a biocompatible catalyst is quite promising as regards the use of this type of battery in devices that are integrated into the human body," such as pacemakers. In fact, the battery operates at pH 7.4, which is a pH similar to that of blood. In addition, since hemoglobin is present in almost all mammals, proteins of animal origin could also be used.

The battery they have developed has some room for improvement, however. The main one is that it is a primary battery that only discharges electrical energy. Also, it is not rechargeable. Therefore, the team is already taking the next steps to find another biological protein that can transform water into oxygen and, thus, recharge the battery. In addition, the batteries would only work in the presence of oxygen, so they could not be used in space.

The study, published in the journal *Energy & Fuels,* opens the door to new functional alternatives for batteries in a context in which more and more mobile devices are expected, and in which there is a rising commitment to renewable energies, such that it is necessary to have devices that store excess electrical energy in the form of chemical energy.

Most importantly, the most common lithium-ion batteries today are saddled with lithium scarcity and its environmental impact as hazardous waste.

More information: Valentín García-Caballero et al, Human Hemoglobin-Based Zinc–Air Battery in a Neutral Electrolyte, *Energy & Fuels* (2023). DOI: 10.1021/acs.energyfuels.3c02513

Provided by University of Córdoba