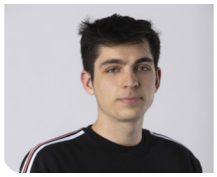
Aluminium-Air Galvanic Cell

Challenging the Limits of Efficiency, Power and Duration

Graduate



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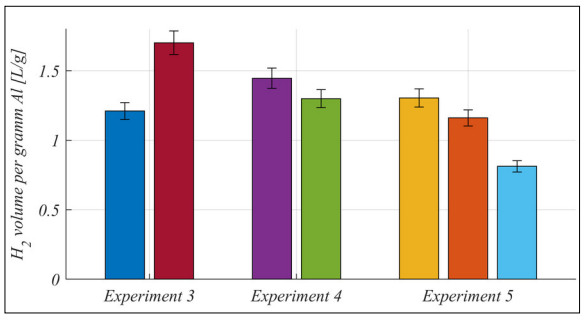
Initial Situation: Aluminum-air batteries present a promising technology for energy storage. Thanks to aluminum's high energy density, its abundance in the Earth's crust, and low cost, these batteries hold the potential for new types of batteries that may outperform other technologies for seasonal storage. Aluminum reacts with water and oxygen, generating electricity, hydrogen, and heat. The produced hydrogen can further be utilized in a fuel cell to generate additional electrical energy and heat.

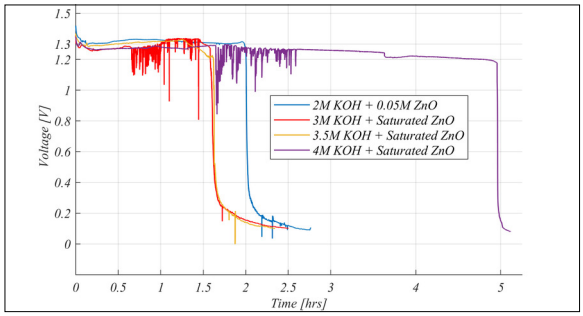
Approach: This research builds upon the work of a previous student, where the feasibility of constructing an aluminum-air battery from easily accessible materials was demonstrated. However, potential for improvements in voltage, energy density, and efficiency were detected. Experiments were conducted using an alkaline electrolyte based on KOH to enhance the battery's voltage. Various concentrations ranging from 0.5 to 4 M were tested. To reduce aluminum corrosion caused by the alkaline electrolyte, the effect of using ZnO as an inhibitor was tested. ZnO spontaneously deposes onto the aluminum surface and builds a protective layer. Different combinations of KOH and ZnO concentrations were explored to determine the optimal configuration. Starting with a 2M-KOH solution ("A", see histogram below), ZnO was introduced to achieve a 0.05M concentration ("B"). Subsequently, KOH concentration was elevated to 2.5M ("C") and 3M ("D"). In other tested solutions, ZnO reached saturation, and KOH was increased up to 4M (Solutions E-H).

Result: Thanks to the combination of the new KOH electrolyte with ZnO, the open-circuit voltage was increased to 1.7 V. The battery generated an average discharge voltage of approximately 1.3 V over a maximum duration of 5 hours, using a 4 M-KOH electrolyte saturated with ZnO. (Solution "G")
The obtained electric energy density reached 1.42 Wh/g in the best experimental run. The use of ZnO as an inhibitor successfully reduced hydrogen production, decreasing from a maximum of 1.7 L per gram of Al, to a minimum of 0.8 L/g.

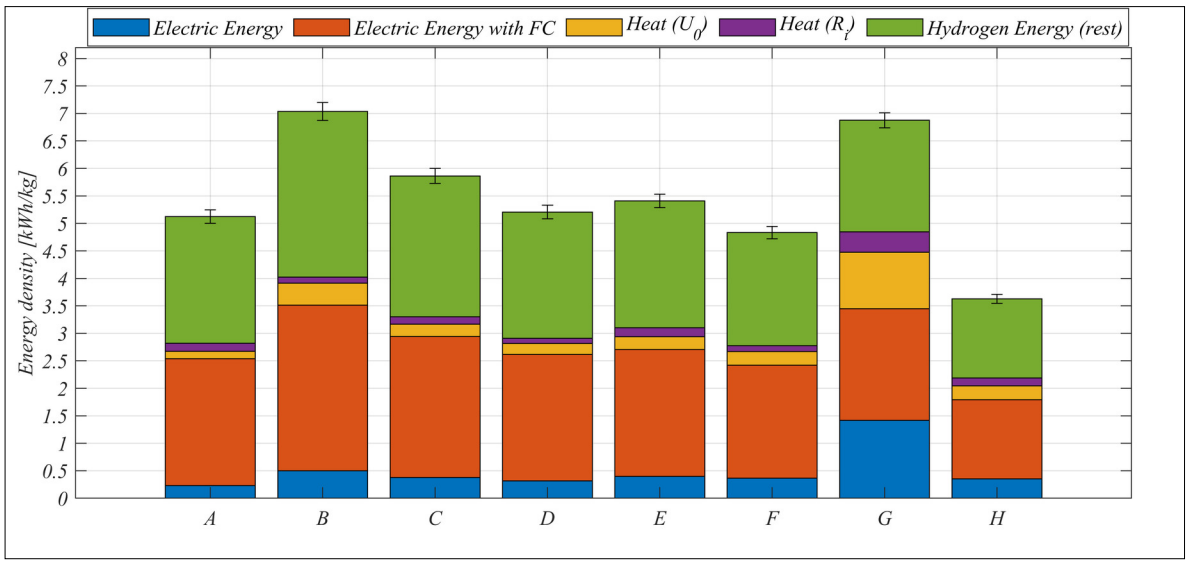
Generated Hydrogen volume with different KOH and ZnO conc. Exp. 3 & 4: KOH and 0.05M ZnO, Exp. 5: Sat. ZnO.
Own presentment



Battery discharge with different KOH and ZnO concentrations in the electrolyte.
Own presentment



Energy generated with solutions with different KOH and ZnO concentrations, values for fuel cell calculated.
Own presentment



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Subject Area
General energy technology