UBC Chem-E-Car 2016 - Zinc Air Attack

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Introduction

Zn/Air Battery Details

Anode: $Zn_{(s)} + 4OH^-_{(aq)} \rightarrow Zn(OH)^{2-}_{4\,(aq)} + 2e^-$ $E_0^{298K} = -1.25\ V_{SHE}$

Electrolyte: $Zn(OH)_4 2^-_{(aq)} \rightarrow ZnO(s) + H2O_{(l)} + 2OH^-_{(aq)}$

Cathode: $O_{2\,(g)} + 2H2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$ $E_0^{298K} = 0.34\ V_{SHE}$

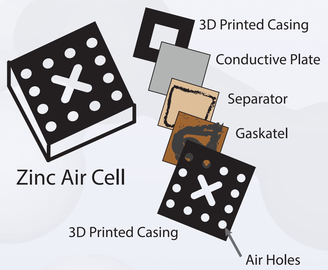
Overall: $2Zn_{(s)} + O2_{(g)} \rightarrow 2ZnO_{(s)}$ $E_0^{298K} = 1.59\ V$

A zinc/air battery operates by oxidizing zinc on the anode and reducing oxygen on the cathode. The anodic reaction releases electrons which passes through an external circuit and travels to the cathode where oxygen is reduced to form water. Zinc/air cells are notable for their high energy density.

Environmental & Safety Concerns

- Zn is a non-precious metal and is naturally abundant in the environment
- MnO2 is environmentally benign
- Zn/Air battery by-products, ZnO, is non-toxic, and has many applications such as: baby powder, ceramics, food additives, etc. This requires neutralization before repurposing ZnO
- 6 M KOH solution is highly corrosive but it is contained in an anode compartment designed for safe usage
- Wire connections are insulated with heat shrink
- The following MSDS symbols are for those reagents used in both the iodine clock reaction and the Zn/Air battery:

Methods



Zn/Air Batteries

Anode: SS-116 plate in contact with Zn powder in 6 M KOH to form a paste

Cathode: Commercial MnO2/catalyst layer supported on gold plated nickel mesh (manufactured by Gaskatel) [1]

Separator: Viledon 2227 filter paper manufactured by Freudenberg

Iodine Clock Reaction

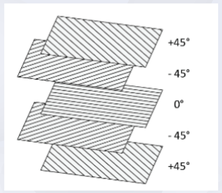
I^- Oxidation: $H_2O_2 + 2I^- \rightarrow I_2 + 2H_2O$

I_3^- Redution: $I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2}$

Complex Formation:

I_3^- + Amylose -> Amylose-tri-iodide complex (color change)

Carbon Fibre Body

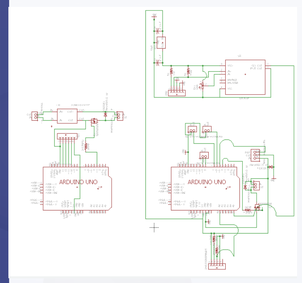


Carbon fibre is a composite material made of resin and carbon fibers.

Carbon fibers are micrometers in diameters and are woven into a fabric

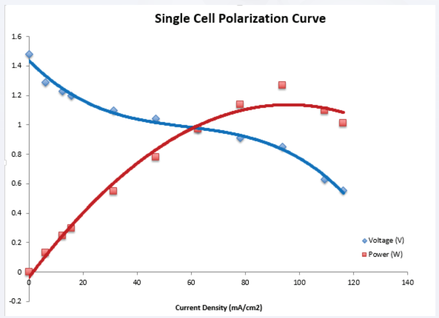
Layers are set into molds for the desired shape; every later is rotates to maximize stress distribution

Control Mechanism: Circuitry



- Photoreceptor senses the color change within the Iodine clock and Arduino turns the motor off
- Both the photoreceptors & the internal microcontroller clock allows for data to be collected on distance and time travelled, which is then recorded to a micro USB card allowing for fast and reliable data collection
- PCBs were designed in EAGLE software, exposed to UV light and finally additional parts were soldered on

Results



- Stable open-cell voltage of 1.4 V
- Low cell internal resistance of 140 mOhms
- Continuous constant current discharge at 250mA up to 6 hours

References

[1] J. Helmke, "Gaskatel - BiPlex Gas diffusion electrodes", Gaskatel.de, 2016. [Online]. Available: http://www.gaskatel.de/eng/produkte/biplex/eng_biplex_index-.html. [Accessed: 08- Apr- 2016].

[2]J. Plachy, "USGS Minerals Information: Zinc", Minerals.usgs.gov, 2016. [Online]. Available: http://minerals.usgs.gov/minerals/pubs/commodity/zinc/. [Accessed: 13- Apr- 2016].

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