



IPRO 313

Refuelable Electric Cars

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Problem

- Oil Dependency
- Current Electric Vehicles
 - Cost vs. Efficiency
 - Recharge time
 - Service stations



Solution

- Alternative energy!
- Buses & cars
 - Zinc
 - Lithium
- Home & Office
 - Zinc generators





How It Works

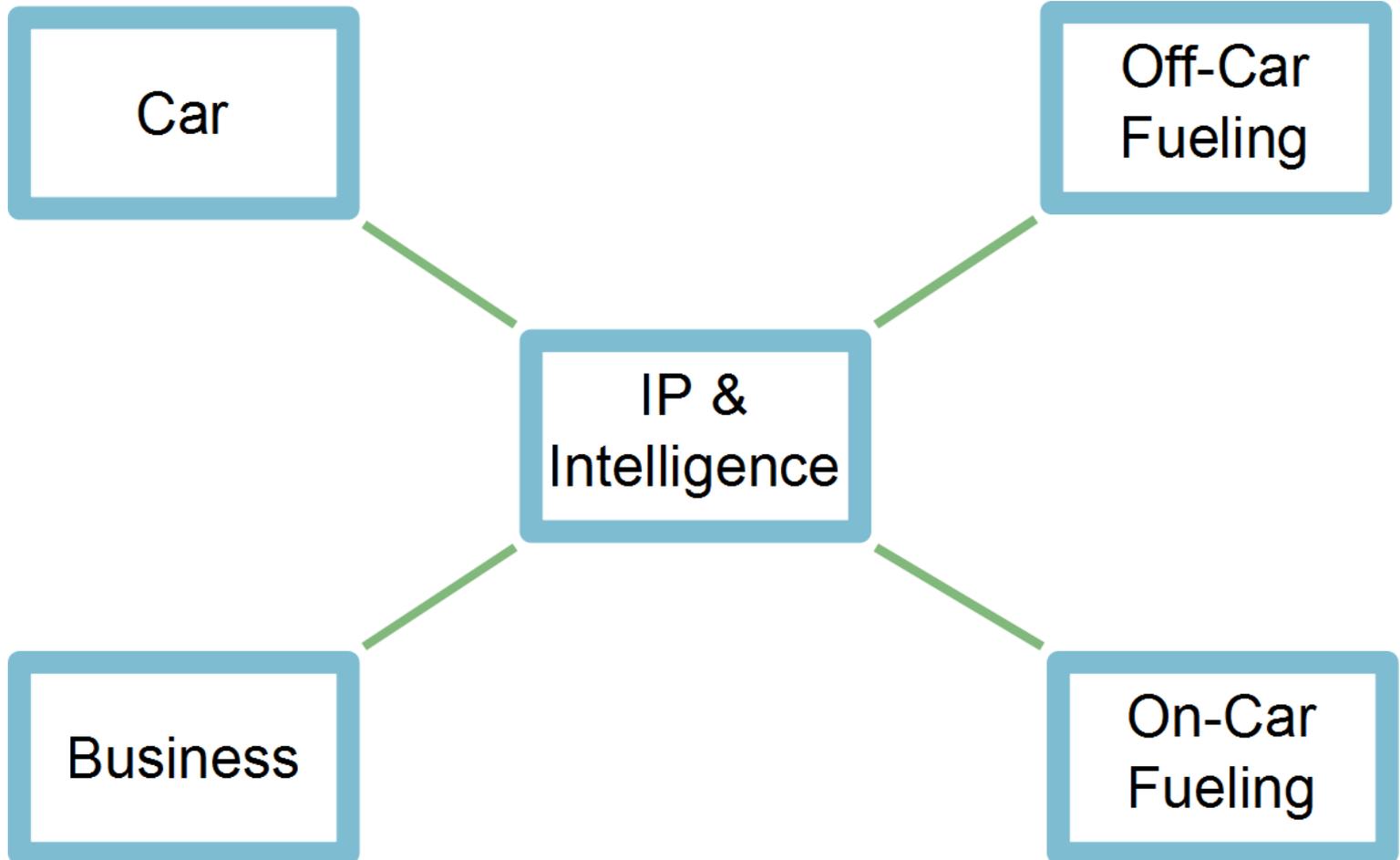
- Electric Car
 - AC motor
- Zinc-air Battery
 - Zinc pellets fed to fuel cell
 - Fuel is converted to electricity
 - Zinc oxide and electrolyte byproduct



Background

- Three previous semesters
- Similar team structure
- Accomplishments
 - Truck
 - Zinc
 - Majority turnover

The Teams



Business & Publicity

- Public relations
 - Alumni newsletter
 - Website
 - Facebook
 - NBC

The screenshot shows the Facebook interface for the page 'IPRO 313 - Refuelable Electric Car'. At the top, there is a blue navigation bar with the Facebook logo, a search bar, and login fields for email and password. Below the navigation bar, a green 'Sign Up' button is visible. The main content area features a profile picture of a silver car on a green field. The page name 'IPRO 313 - Refuelable Electric Car' is displayed with a 'Like' button. The location 'University - Chicago, Illinois' is shown below the name. The page has a cover photo showing a car and a diagram of a fuel cell. The 'Wall' section contains a post from 'IPRO 313 - Refuelable Electric Car' with the text 'Mark I against a pleasant background suitable for presentations and posters.' and a photo of a fuel cell. The post is dated 'February 12 at 9:34pm' and has 'Like' and 'Comment' options. The left sidebar includes navigation links for 'Wall', 'Info', 'Photos', and 'Discussions', an 'About' section, and a '13 people like this' notification.

Business & Publicity

- Finances
 - IPRO funding
 - MMAE research competition

Fuel Systems Design for IPRO 313: Zinc-Air Refuelable Electric Car
 Dr. Francisco Ruiz
 ILLINOIS INSTITUTE OF TECHNOLOGY

Introduction

- Internal Combustion (IC) engines cause air pollution.
- Dependence on foreign oil—political liability
- Alternatives to IC are expensive and do not solve the air pollution problem

	Zn/Air	EV	IC
Range	300 miles	50-100 miles	300+ miles
Refueling time	~5 minutes	30mins - 8 hrs	~5 mins
Price (MSRP)	\$27,500	\$30k - \$75k	\$30k and up

Zinc mined in the US, high heat contained due to better technology, high vehicle variety, high environmental impact.

Refuelable Zinc-Air batteries can provide the necessary power to operate a vehicle, will produce zero emissions, and can be safe and cost effective.

Driving Profiles

Highway profile is used to calculate mass of Zn fuel needed to travel 300 miles.

Power consumption vs time data is collected for the highway profile.

Energy of the highway profile is obtained by integrating power.

Once the energy is obtained, the Gibbs free energy is found to find the mass of Zn needed to travel 300 Miles in = 92kg.

Car Fueling

- Using 90kg of Zn required to run 300 miles in the city along with 4.3kg of kg/m^3 of density of Zinc pellets of 2mm diameter, the volume required to contain the Zn can be calculated. The volume turns out to be approximately 0.0289 $\text{m}^3 = 1.02 \text{ ft}^3$.
- A specific flexible screw conveyor is utilized to fuel the car with Zn pellets.
- Within the flexible screw conveyor, the gap between the spiral and tube must be less than 1mm, so that the zinc pellets may pass with ease and not fall through.
- With the typical time constant of 5-10 minutes in order to fuel the car, the volume flow rate is calculated using the flow and the mass required to fuel the tank. The volume flow rate comes out to be 0.162 m^3/hr .

Solubility Chart, Explanations

- Zinc needs to precipitate in order to separate from ZnO electrolyte solution in the hydrocyclone. It must be filtered in order to be able to reuse the electrolyte in the battery.
- Solubility continues with temperature data for ZnO in KOH ($\text{pH} = 14$) is needed to obtain information to separate the solution.
- Once data is obtained, a precipitation temperature will be derived from the data and will be used in the heat extraction calculation.

ZnO Extraction Process From Solution

Heat extraction

Heat extraction required to reach T_2 by evaporating the solution can be calculated using the equation:

$$Q = h_c A (T_1 - T_2)$$

assuming a heat convection coefficient, h_c of anywhere from 10-100 $\text{W/m}^2\text{K}$.

More data is needed in order to more accurately approximate the heat convection coefficient.

Hydrocyclone

A hydrocyclone is a device to classify, separate or sort particles in a liquid suspension based on the densities of the particles. A hydrocyclone may be used to separate solids from liquids.

As Zn oxidizes, it turns into a powder. Assuming diameter of powder = 2 microns, % recovery of 3 hydrocyclone:

$$R = \frac{d_p^{18} - 1}{d_p^{18} + 2} = 55\%$$

In order to achieve 95% efficiency, 4 hydrocyclones are needed.

Next Step

Design a heat exchanger to accommodate adequate heat transfer that will lower the temperature of the solution in order to separate ZnO by precipitation.

References

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- Michael, Robert. Zinc Electrolysis. Science, Design, and Tech. Project. IP. ILLINOIS INSTITUTE OF TECHNOLOGY. Web. 25 Mar. 2011.
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Precipitate Extraction

- Once the car is fueled with Zinc pellets, ZnO must be removed from the car along with possibly 1% of electrolytes. The ZnO is removed in the form of somewhat wet powder.
- A dual chamber inside the car will receive the ZnO pellets while extracting the collected ZnO. In order to remove the ZnO from the car a flexible screw conveyor will be used. The amount of ZnO can be calculated through stoichiometry using the chemical reaction.

IPRO 313 Zinc-Air Refuelable Car Project

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IPRO 313 SPRING GROUP



Thank You to our Sponsors!

Ethics

- Ethics versus law
- Proprietary information
 - Zinc Air, Inc.
 - Patents
- Misrepresentation
 - Students
 - “Green” technology



Car

- Design motor bracket
 - Modifications
- Prep for batteries

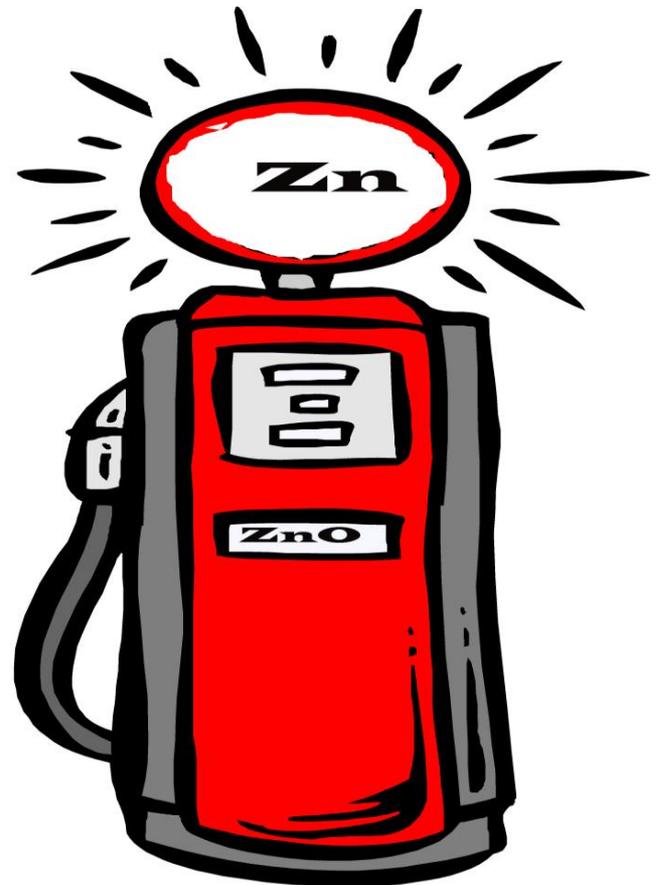


Car



Fueling Systems

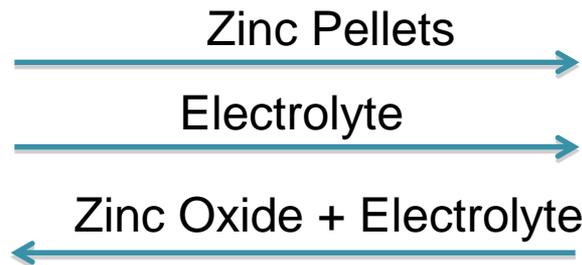
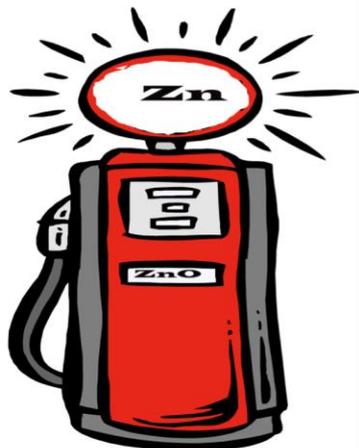
- Goal: 90 kg of zinc = 300 miles driving
- On-car fueling
- Off-car fueling
- Zinc Air, Inc.



Off-Car System

- System components:
 - Zinc tank
 - Zinc feeder
 - Electrolyte pump

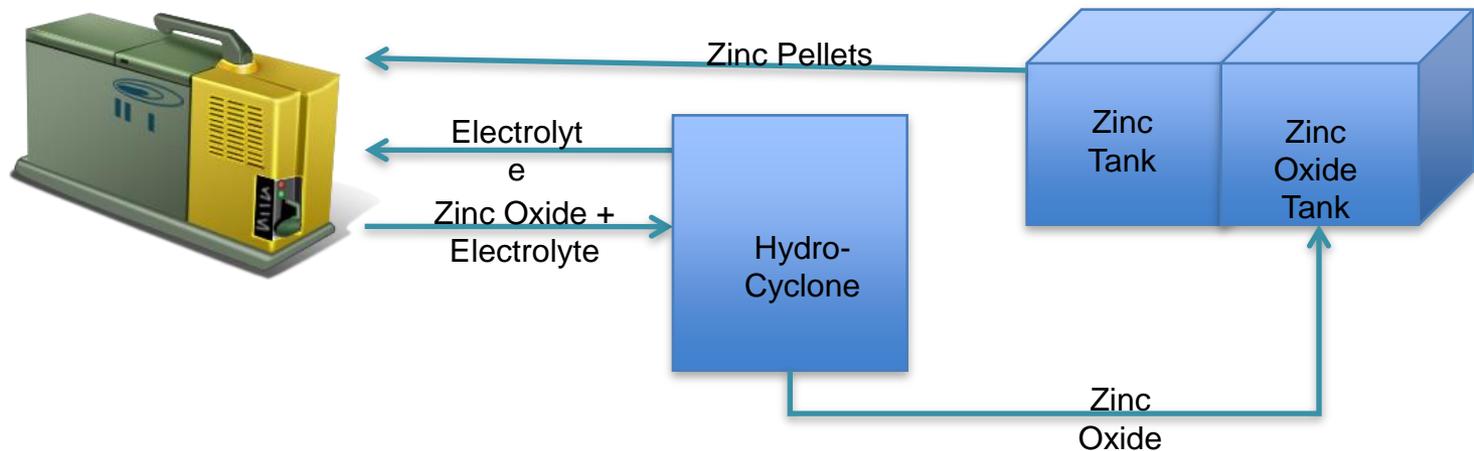
- Zinc oxide tank
- Zinc oxide extractor



In-Car System

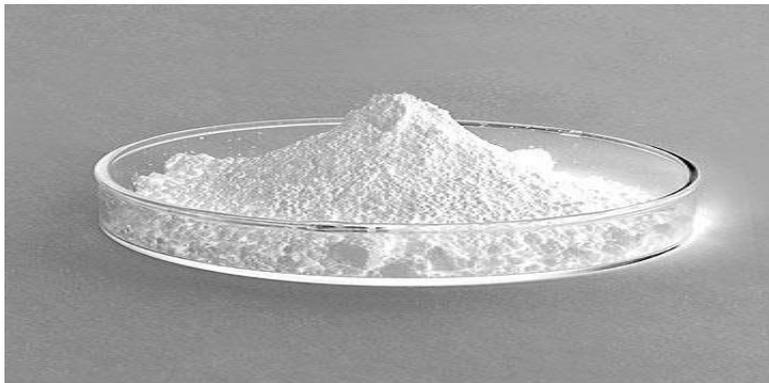
- System components:

- Zinc conveyor
- Zinc to zinc oxide tank
- Zinc-air fuel cell
- Electrolyte tank
- Electrolyte pump
- Hydrocyclone filters



In-Car System

- Precipitation extraction
 - Zinc oxide is removed
 - Electrolyte is removed
 - Zinc oxide is converted back to zinc



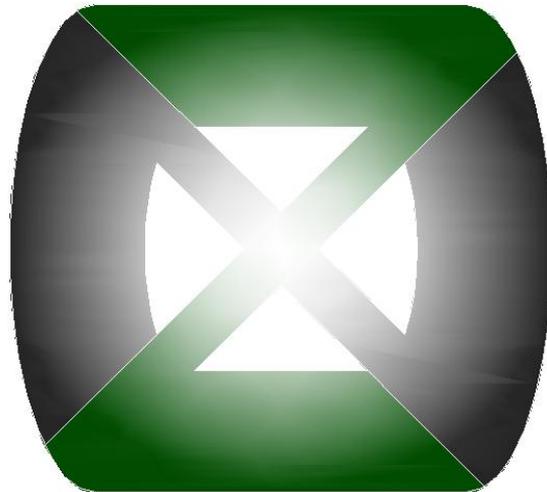
Intellectual Property

- Patent research
- Competitive intelligence
- Act as team liaison
- IPRO deliverables



Results

- Completed motor bracket
- Battery specifications
- Preliminary fueling systems designs
- LinkedIn group, Facebook
- Website in progress





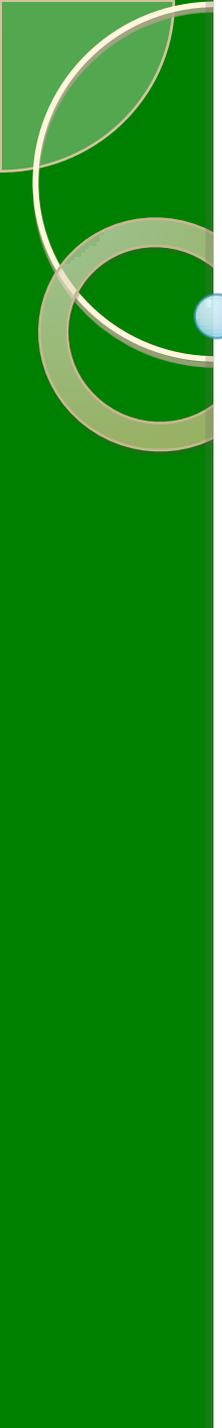
Future Work

- Continue collaboration with Zinc Air, Inc.
- Continue to seek funding & sponsors
- Commercial implementation plans
- Finalize & test fueling designs
- Patent final fuel system designs



Acknowledgments

- The IPRO Office
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- Rich Carroll
- FVEAA



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Any questions?