Pouch Cell Battery Project

Introduction:

Batteries are devices that harness electrochemical potential differences (measured as voltage) between materials in order to generate a stream of electrons (i.e. current). These reactions are often classified as oxidation-reduction (redox) reactions. Because batteries are galvanic cells, reduction (gaining electrons) occurs at the cathode and oxidation (losing electrons) occurs at the anode. Through careful selection of materials, scientists can maximize the voltage and current of their batteries.

The current drive in the battery industry is to make small, lightweight batteries that hold a considerable charge, and can be recharged multiple times. One of the techniques researchers use to achieve these goals is the use of a pouch cell—a thin, lightweight battery often used in devices like phones and other small electronic devices. It is this technique that we will mimic in order to create our batteries for this project.

The Challenge:

Your challenge is to make a series of lightweight pouch cells capable of powering a small, DC motor. Your aim is to power the motor to lift the heaviest load your batteries can manage without making your batteries too heavy. You will be limited to 4 pouch cells, and each group's results will be based on the weight of the maximum load lifted and the weight of their pouch cells.

Materials:

- Various metals (copper, iron, zinc, magnesium, aluminum, tin) and their sulfates
- Agar
- Alligator clips
- Small DC motors (1-6V)
- Vacuum seal food saver bags
- Hair straightener
- Glassware
- Petri dishes
- Scissors
- NaCl or KCl
- Small weights (coins, etc).

General Procedures:

Part 1: Creating the Electrolyte Gel - Once you have decided which metals you will use for your battery you will need to create the anodic and cathodic solutions. Start with a 0.5M 1% agar solution (procedure below) and adjust as necessary

1. Use a graduated cylinder to measure out 15 mL of DI water. Transfer to a 40 mL beaker and begin heating the water on a hot plate.
2. Once the water is close to boiling, add 1.5 g of agar powder. Stir with a glass rod to prevent clumping.
3. Continue to stir the solution for 1-2 more minutes before adding enough sulfate solution to make a 0.5 M solution.
4. Stir the solution until all the salt dissolves and a uniform solution is made.
5. Remove the beaker from the hot plate and pour the contents into a clean petri dish. Set the petri dish somewhere level to cool. The gel will set up in 5 minutes or less if the gelling process was

successful. If the gel does not set, try heating the water + agar solution for longer, or consider decreasing the molarity of the solution (especially for zinc sulfate).

Part 2: Making the Pouch Cell (Figure 1)

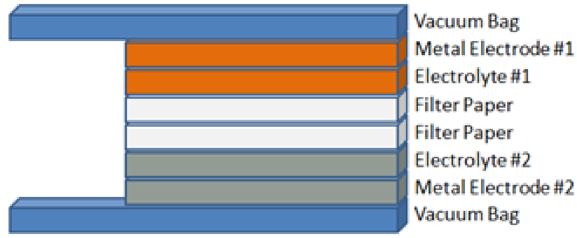
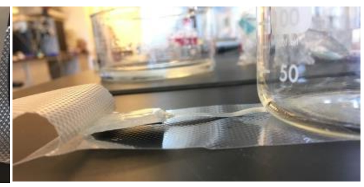
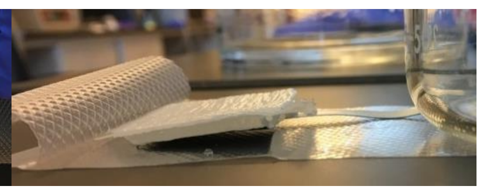


Figure 1 – Side-view of completed pouch cell

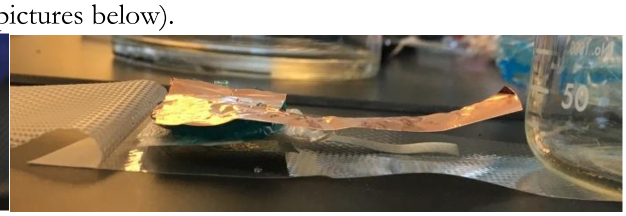
1. Cut a strip of vacuum sealing bag wide enough to comfortably fit your metal electrodes (you can always cut excess plastic at the end). Cut that strip in half so that you have two pieces sealed on one side.
2. Cut your metal electrodes near the top to create "tabs" for your pouch battery (this will also prevent the metals from touching).
3. Prepare a saturated solution of KCl/NaCl in a 40 mL beaker.
4. Carefully scrape your sulfate gel onto your first metal electrode, keeping your electrolyte as smooth and flat as possible. Carefully place the bottom of the electrode inside your piece of vacuum seal bag as close to the sealed edge as possible (see pictures below).



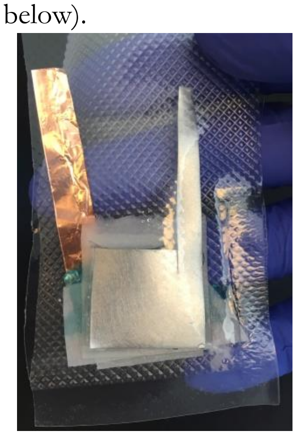
5. Cut two or three strips of filter paper wide enough and long enough to just hang over the edge of your electrodes. Soak the filter paper in the saturated KCl/NaCl solution. When the filter paper is thoroughly soaked, layer the two pieces of filter paper on top of the electrode in the vacuum seal bag (see pictures below).



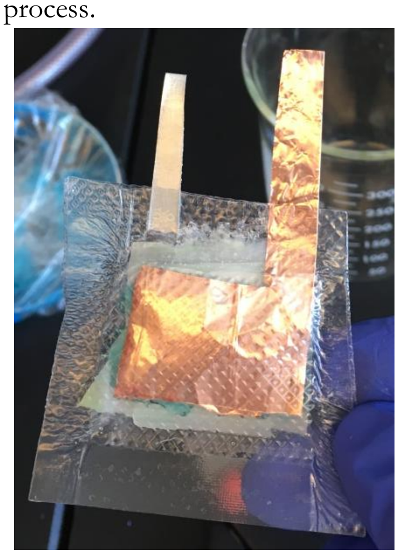
6. Turn on the hair straightener to 310 F.
7. Carefully scrape your sulfate gel onto your second metal electrode, keeping your electrolyte as smooth and flat as possible. Carefully place the electrode on top of the filter paper, ensuring that the two electrodes do not come in contact with each other (see pictures below).



8. Seal one side of the pouch cell just below the "tabs" at the top of the electrodes by clamping the hair straightener for ~10 seconds (see picture below).



9. Carefully ensure that your electrodes are packed into the corner of vacuum seal bag that you've just made. Using the hair straightener, seal the other side of your pouch cell.
10. Carefully trim the plastic on the final unsealed side of the pouch cell to allow the electrode "tabs" to stick out of the top of the plastic. Carefully remove as much air as possible from your pouch cell, then seal the top of the pouch cell using the hair straightener (see picture below). You may hear some sizzling. If it looks like your gel is liquefying/boiling, increase the length of the electrode "tabs" so that the hair straightener is further from the gels during the final sealing process.



Deliverables:

Each group needs to create **at least** two prototypes of their pouch cells. At the end of the project, each group will turn in the following:

After testing **each prototype**, answer the following questions:

1. Describe two specific things that worked well? Describe two specific things that **didn't** work well?
2. What could you change to make the battery better? Identify the variable/aspect of the battery you will change. Explain why you're changing it and how that will affect the battery's output.

After you've created your **final prototype**, answer the following questions:

1. Justify your choice of the two metals used (with supporting calculations) and concentrations of electrolytes (with calculations) in your batteries.
2. What **should** the voltage of your cells be vs. what is the **actual** voltage?
    a. Propose an explanation for the discrepancy.
3. How did the viscosity of your electrolyte affect your battery? Propose an explanation for why.
4. What mass were you batteries able to lift with the motor? What was the overall mass of your battery pouches? How did your batteries compare to other groups' batteries?
5. What are two **specific** changes you would make to your batteries in order to improve their efficacy (i.e. lift a heavier load)?

Create a general diagram of your pouch cell. Label each component of your pouch cell and write a 1-2 sentence description of the purpose/function of each component of the battery.

Section	Meeting	Approaching	Beginning	Score
Prototype Reflection(s)	• Reflection includes two **specific** components that worked well and did not work well in the battery • A specific component/variable of the battery is identified as something to change • A complete, scientifically accurate explanation is given for how the manipulation of this variable will change the battery's output	Reflection is missing one or more specific components that worked/didn't work OR Reflection is vague about what worked/didn't work OR Explanation for how the manipulation of the identified variable is vague/scientifically inaccurate	Reflection is missing two or more components things that worked/didn't work OR No variable is identified for change OR Explanation for how the manipulation of the identified variable is confusing or wildly inaccurate	/ 12
Final Reflection – Part 1 (#1-2)	• Metals used in battery are clearly identified and justified using scientifically sound reasoning • Concentrations of electrolyte solutions used are explained using clear calculations and all numbers have units • Differences between expected and actual voltage of batteries is clearly identified and is explained completely and scientifically accurately	Metals used in battery are identified, but explanation for the choice is confusing or scientifically inaccurate OR Calculations for the concentration of the electrolyte solutions are mostly complete, but missing one or two pieces OR Calculations for the concentration of the electrolyte solution are inaccurate/erroneous	Metals used in battery are identified, but no explanation is given OR Explanation for metals used is wildly inaccurate OR Calculations for the concentration of electrolyte solutions mostly missing	/ 15

Section	Meeting	Approaching	Beginning	Score
Final Reflection – Part 2 (#3-5)	• A relationship between viscosity of electrolyte and battery's output is identified and explained completely and scientifically accurately • Mass lifted by batteries, mass of batteries, and a discussion of how your battery compared to other groups is present • Reflection includes two **specific** things that worked well and did not work well in the battery	A relationship between viscosity of electrolyte and battery's output is identified, but the explanation contains some scientific errors OR Reflection is missing one or more specific things that worked/didn't work OR Reflection is vague about what worked/didn't work	No relationship is identified between viscosity of electrolyte and battery's output OR Explanation of relationship between viscosity of electrolyte and battery's output contains many scientific errors OR Reflection is missing two or more specific things that worked/didn't work OR No variable is identified for change	**/ 15**
Diagram	• Diagram is neat and legible • Each component of the battery is labeled accurately • The purpose/function of each battery component is scientifically accurate and explained completely	Diagram is difficult to read OR One or more components of the batter are labeled incorrectly OR The purpose/function of one or more battery components is inaccurate or the explanation is confusing	Diagram is impossible to read OR Two or more components of the battery are labeled incorrectly OR The purpose/function of two or more battery components is inaccurate or the explanation is confusing	**/ 6**
			Sub:	**/ 48**
			Total: (Subtotal x 0.83)	**/ 40**