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Determining effect of electrolyte concentration on battery in sodium ion battery

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Physics SL exploration paper

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Introduction: Sodium ion battery is a type of rechargeable metal-ion battery. It has very high potential in the power. Because sodium is far more abundant in the earth compare to the other metals which can be used to make up battery. Not like other metals, sodium can transport safety and the production of sodium ion battery might not produce pollution. Lithium-ion material is the most common metal which uses in produce battery, and sodium ion materials can be used same as the lithium-ion materials which means that Li-ion manufacturing can be used to make sodium ion battery. There will be many profits if we start to use sodium ion battery. But why there is still no one use sodium ion battery? I find some drawback for sodium battery. 1. Sodiation 2. If we use sodium battery, the volume of sodium battery will be too much bigger than lithium battery so that it is much heavier than lithium battery. The second one is very easy to search about, but the first is kind of hard, because I cannot know what sodiation exactly is. I asked my Chemistry teacher about sodiation, she thought it was a process for sodium ion turn into current. For research sodiation I have to make my own sodium battery.

Question: The disadvantages of sodium-ion battery.

Hypothesis: In my opinion, the concentration will influence the strength of current. I assume that the experiment which have higher concentration of salt should have bigger current anyway. Because the more salt in the solution means that the more free electrons in the battery, therefore the current should be higher.

Experiment: As I said before, in order to search about sodium-ion battery. I am going to make my own battery. Therefore I find sodium chloride. The solution which add sodium chloride must contain sodium ion. And then I choose to use vinegar to improve acidic or conductivity of solution, because I use pure water and pure water doesn't have very good conductivity. The battery should not only have electret, battery need conductor so that I use the pennies and nickels to transfer the current. Because they are produced by metal. Copper-plated zinc and cupronickel have very high conductivity. The electron can cross these metal to produce current. And the paper with vinegar and salt solution can offer the electron, because vinegar is a kind of acid and salt is mainly sodium chloride it has ionic bond. That means it must has pretty well conductivity and free electrons.

The experiment I am doing is mainly about the concentration of sodium ion. And I assume that concentration of sodium ion can influence the current strength. Because of the time limitation I can only do three experiments that change the concentration of sodium chloride in the solution in order to change the concentration of sodium ion. The masses of salt I want to use are 2.5g, 5g and 10g.

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Material:

Vinegar

Salt

Small bowl or glass

Pennies (4): Electrodes

Nickels (4): Electrodes

Aluminum foil (small strip)

Paper towels (2)

Small plate: to make sure the solution in paper won't be desorb by other thing else.

Ammeter: measure the current in the battery.

Lab notebook

Worth 1 cent: a penny is a copper-plated zinc coin.

Worth 25 cents: It is made of cupronickel.

Step of experiment (preparation):

1. I will mix vinegar, salt and pure water up to produce solution. Remember to calculate the concentration of the solution. The different groups use different masses of salt to change the concentration of solution. The masses of salt are 2.5g, 5g and 10g.

2. Find some panels and coins, and then wash them. Making sure there is not dirty or color on the surface of coins. Be careful some coins and panels may have patina on the surface. We would better not use these coins, because it might affect the experiment data.

3. And divide paper into seven parts and they should just cover the coin to make sure they have enough surface to touch between coins.

4. And use the small pieces of paper to absorb the solution and then put these between 1 cent coin and 25 cents coin. It just like building a tower. At the bottom of tower I put Aluminum foil so that we can touch the bottom and top of the battery to measure the current in battery.

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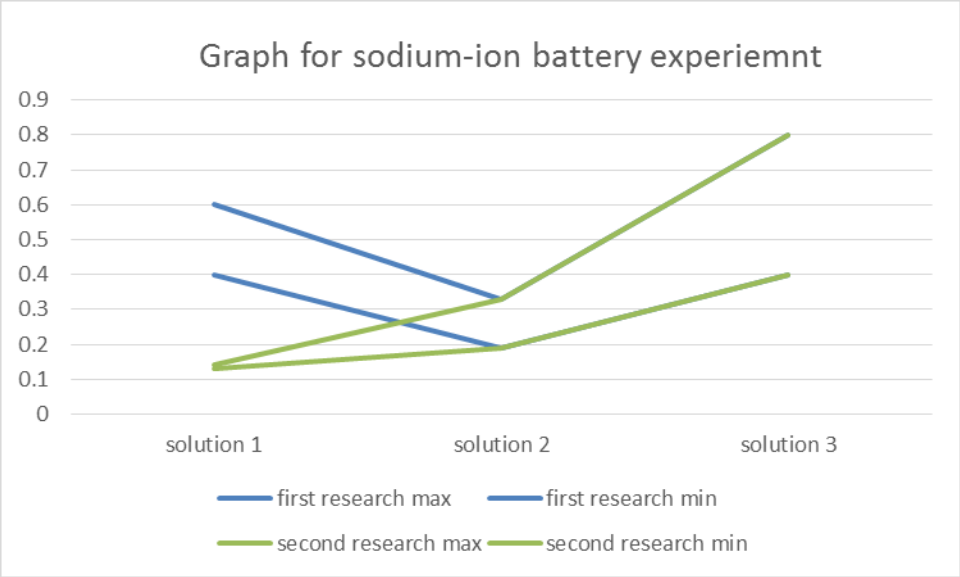
	concentration of vinegar	mass of sodium chloride (gram)	total valume of solution	mass of sodium ion
solution 1	20 ml 5% vinegar	2.5	50ml	0.982905983
solution 2	20 ml 5% vinegar	5	50ml	1.965811966
solution 3	20 ml 5% vinegar	10	50ml	3.931623932

	solution 1	solution 2	solution 3
first research	0.6ma~0.4ma	0.33ma~0.19ma	0.8ma~0.4ma
second research	0.13ma~0.14ma	0.33ma~0.19ma	0.8ma~0.4ma



The first question is in solution 1 group, there is a big difference between two results about solution 1. As we saw in the table, it is not good in the first research, because it doesn't suit my assumption. The result for solution 1 is bigger than solution 2's in first research. And then I did the second research, the data looks reasonable, the solution 1 which has less sodium chloride make a weakest current strength battery. Same as my assumption that the more concentration of sodium ion the stronger current strength.

While I was analysis data, I found there is a big question. According data, the result I collected in experiment clearly shows that there is big between the results such as solution 3 bigger result is double smaller result. I thought that might be the definition of the sodiation. When sodium-ion battery is discharging, the sodium ion causes the current suddenly bigger than normal and then return to normal. Also I search it in internet I found that sodiation is a phenomenon which sodium ion can cause the anode

of battery to swell by as 420 percent and then return to normal while battery is charging or discharging. Therefore the first research for solution 1 might not wrong because sodation. Maybe I measure the max current in the process sodiation. So that I got disadvantage of sodium battery is unstable current. Unstable current might damage machine and it is hard to control especially when we have more powerful sodium-ion battery. This is the first drawback for sodium-ion battery.

Second research:

First I want to resistance for my battery-ion battery. I thought we can use the solution 1 to be electrolyte so that the current won't change so much in sodiation. And then we make a circuit include sodium ion battery, resistance, ammeter and voltmeter. Because I don't have enough time, I want only make some equation. So assume the voltage of battery which we can measure by voltmeter is V_{max}. And the current of battery measured by ammeter is $A_{max.}$ The resistance for resistor is R_1.

$V_{max} \div A_{max} = R_{total}$

$R_{total} - R_1 = R_{battery}$

$3V \div R_{battery} = A_1$

Because current is the charge which pass conductor cross section per second. So that we can use A_1 to know the mass of electrolyte for sodium ion and lithium ion. And then I can compare mass of sodium ion electrolyte and lithium ion electrolyte. And then I found easier way to do this.

In order to compare the mass of battery, I need to calculate how much solution I need to use as electrolyte. I want to measure the mass and volume of electrolyte for

Cl2 + 2 e = 2 Cl- . . . Eo = 1.360 V

Na+ + e = Na . . . Eo = -2.714 V

Li+ + e = Li . . . Eo = -3.040 V

The voltage of sodium chloride battery is 2.0.34V. If we need to get 3V battery we need 1.4749 mole of sodium chloride. The molecular mass of sodium chloride is 23+35.5=58.5, the mass of 3V sodium chloride battery is $58.5 \times 1.4749 = 86.2831g$. Remember this is only for the sodium chloride we still need to make solution and metal shell for sodium chloride battery. The 3V batteries in our normal life are button cells, and the most of them is less than 1 gram. Even though sodium chloride is not standard battery electrolyte, we can saw how heavy if we use the sodium ion to make current. No one want to bring almost 100g 3 voltage battery walk around.

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Conclusion: The mass and unstable current or voltage make the sodium cannot be spread. Sodium ion battery might not be able to use in our normal life, but we can apply to big electric power plant so that we don't need to pay attention to its huge mass and volume. We might be able to use sodium-ion battery such as make we have the tidal power plant, we might be able to have some sodium ion from sea. Well it might break economical balance for ocean, but we might be a solution for running sodium ion power plant. Sodiation is a mainly drawback for sodium ion battery, it makes current and voltage hard to control. We need resistor which can change its resistant very sensible (maybe light resistor we use the light to show the strength of current) when current and voltage are changing. Sodium ion battery has a very big potential, but people still need to improve their technology to apply this. Also the plentiful of sodium not means we can waste sodium, the plentiful of sodium exactly shows us how important sodium in our nature. We have to take care about this application.

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