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Effect of Na-EDTA on electrical characteristics NaCl electrolyte battery charging solar panels

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ABSTRACT

This research investigates the problem of Cu-Zn electrode batteries with NaCl electrolyte. Previous studies have indicated problems with the electrolyte and electrodes after charging, such as turbidity and deposits in the electrolyte, as well as corrosion on the electrodes. Consequently, the battery can only be used once due to a decline in its electrical characteristics after the initial charging. Through this research, improvements were made to the electrical characteristics of the battery by adding Na-EDTA to enhance usage efficiency. The research method involved mixing NaCl solution with the highest electrical conductivity, using six pairs of Cu-Zn electrodes arranged in series. The physical conditions of the electrolyte and electrodes were observed, and electrical characteristics were measured. The research results indicate that the use of NaCl+Na-EDTA electrolyte produces a battery voltage of 4.20 volts with a current of 2 Ah and can be used twice. Charging with solar panels can be done in 1 hour, but the frequency is limited to two times.

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1. INTRODUCTION

One of the Indonesian government's efforts to reduce dependence on the use of fuel oil is through increasing the use of alternative renewable energy sources [1]–[3]. One of the renewable alternative energy sources is solar panels [4]–[9]. Solar panels are devices that convert sunlight energy into electrical energy [10], [11], through the photovoltaic effect [12]–[16]. However, the solar panel system cannot stand alone without a battery to store the electrical energy generated for use at night [17]–[19], so that the continuity of electricity supply is maintained [20]–[22].

Considering the importance of electrical energy storage in the electricity service system and in the context of energy conservation as stated in the Presidential Decree of the Republic of Indonesia Number 43 of 1991 concerning optimization in improving the efficiency of energy use [2], many studies have been conducted related to alternative energy sources through batteries. One of them uses a voltaic cell model with copper (Cu), iron (Fe), aluminum (Al), and zinc (Zn) electrodes and electrolyte salt solution. The electrode pairs tested were Cu-Al, Cu-Fe, Cu-Zn, Al-Zn, and Fe-Zn, with the best results in the Cu-Zn electrode pair. In addition, copper (Cu) and zinc (Zn) have better standard electrode potential values than other electrode pairs [23], [24]. Further research varying the concentration of NaCl on Cu-Zn voltaic cells, showed that the higher the NaCl concentration, the smaller the voltage produced, while the greater the electric current [25]–[27].

This research problem is motivated by a decrease in the electrical characteristics of alternative batteries after charging, where the NaCl electrolyte becomes cloudy and colored, and the electrodes are corroded. This can damage the battery electrolyte process and reduce its electrical quality, so the frequency of battery use is reduced [28]. The main causes of deterioration in electrical quality are rapid deterioration of the anode and cathode and the appearance of deposits on the electrolyte [29], [30]. Previous research shows that the use of Na-EDTA can prevent precipitation in electrolytes with Pb-PbO2 electrodes [31], [32], because Na-EDTA maintains the stability of the valence atoms in the mixture [33]–[36]. Electrolysis process, which converts electrical energy into chemical energy after charging [37], [38], causes decomposition of chemical compounds in the electrolyte solution and produces gas bubbles [39]–[41]. This study investigates the effects produced by Na-EDTA additives on batteries using NaCl electrolyte with Cu-Zn electrodes whether it is able to improve the physical and electrical characteristics of batteries. While previous research has explored the impact of NaCl electrolyte with Cu-Zn electrodes physically unable to last long in the process of loading and charging so that it has an impact on the quality of electricity [25]–[27].

2. METHOD

The number of battery electrodes used in this research was six pairs arranged in series. The form of the test is by mixing NaCl solutions with different molarities directly on six electrodes arranged in series. The battery is connected to a solar panel to get electricity supply. And then the battery will be connected to the load. The load used is an LED lamp. The alternative battery arrangement is shown in Figure 1. The conductor rods used are copper plates (Cu) and zinc plates (Zn) to achieve better results [23]–[27].

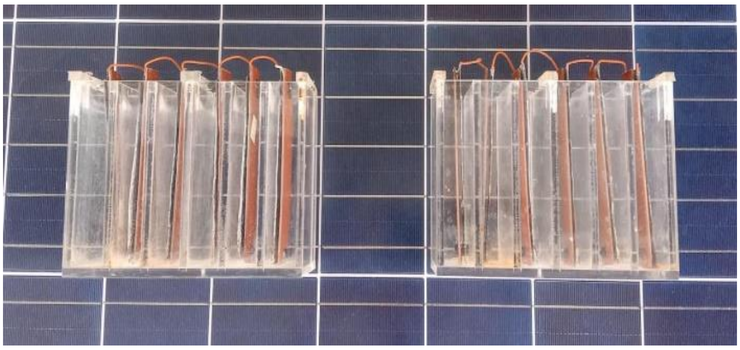


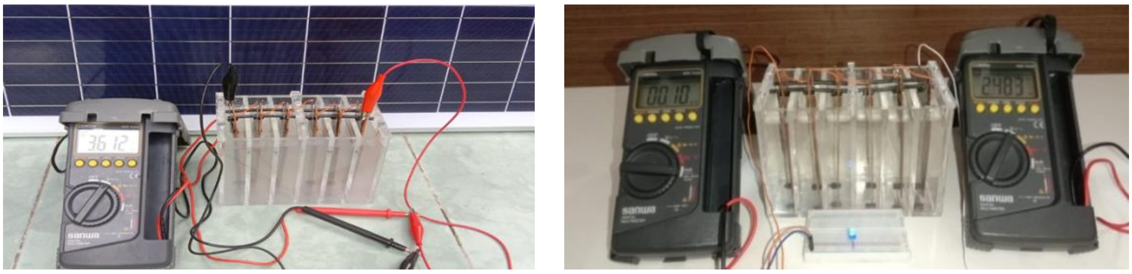
Figure 1. Physical form of an alternative battery Cu-Zn electrolyte NaCl electrode

There were several experiments carried out, namely:

a. Determine the relationship between the molarity of the NaCl solution and the electrical conductivity, temperature of the solution, and the voltage generated
b. The solution using NaCl is carried out:
   - Battery testing with LED load (1st load)
   - Battery charging (1st Charging) uses a solar panel system
   - Battery testing with LED load (2nd load)
c. A solution using NaCl+Na-EDTA electrolyte is carried out
   - No-load testing
   - The 1st load on battery life is given the LED load
   - Battery charging (1st charging) uses a solar panel system
   - Battery testing with LED load (2nd load)

A series of battery experiments with NaCl solution, and under no-load conditions (LED) as shown in Figure 2(a). In this experiment a digital conductivity meter was used to obtain battery electrical conductivity data. Battery voltage is measured using a digital multimeter.

For a series of experiments with a loaded battery as shown in Figure 2(b). The load here uses a 5 mm blue LED, voltage 3.2–3.4 volts, current 18–20 mA, and brightness 4,000-6,000 mcd. Figure 3 shows the battery charging process using a solar panel system. The solar panel system used for charging is as follows: 100-watt solar panel, 500-watt pure sine wave inverter, maximum power point tracking solar charge controller (MPPT SCC) 12/24 V 40 A, 6 V/500 mA adapter, and MCB C2. Next, the same experimental process was carried out by adding Na-EDTA to the NaCl solution.



(a) (b)

Figure 2. A series of battery experiments using NaCl solution with conditions (a) without load and (b) using LED load

Figure 3. Battery charging process using a solar panel system

3. RESULTS AND DISCUSSION

From the experiments carried out, several data were obtained as shown in Figure 4. Figure 4 shows a graph of molarity-vs-electrical conductivity, voltage, and temperature and it can be seen that the change in electrical conductivity is very significant and increases with the molarity of the NaCl solution. Where at the molarity of the NaCl solution, 3M, the electrical conductivity reached 173.5 mS/cm, and the battery voltage was 4.20 volts for a battery temperature of 30.7 °C. with increasing NaCl concentration and causing an increase in voltage [25]–[27]. From the results of voltage and current measurements with time in the process of loading 1 battery with NaCl electrolyte solution and NaCl+Na-EDTA electrolyte solution, it is shown in Figure 5.

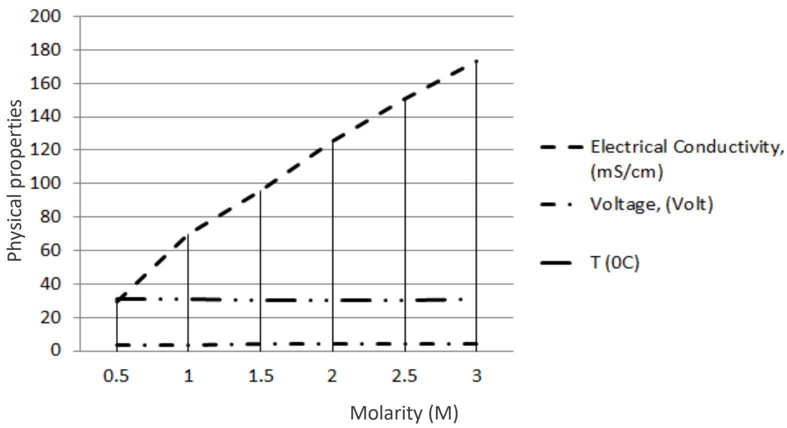


Figure 4. Molarity-vs-electrical conductivity, voltage, and temperature

Figure 5 shows that the battery voltage in the NaCl+Na-EDTA electrolyte solution is slightly greater than in the NaCl electrolyte solution. However, at 50 minutes the voltage between the NaCl and NaCl+Na-EDTA electrolyte solutions was almost the same. Figure 6 shows that the battery current in the NaCl+Na-EDTA electrolyte solution is slightly greater than in the NaCl electrolyte solution. However, at 40 minutes the current between the NaCl and NaCl+Na-EDTA electrolyte solutions is almost the same and close to zero or in other words the battery is empty. In this situation, there is a physical change in the battery electrolyte after the 1st loading, where the condition of the electrolyte appears increasingly thicker and grayish and precipitates begin to appear in the NaCl electrolyte solution and can be seen in Figure 7(a). Meanwhile, the NaCl+Na-EDTA electrolyte solution remains clear, as shown in Figure 7(b).

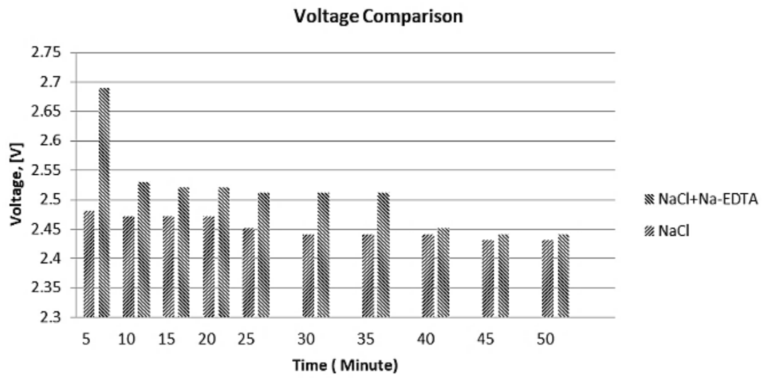


Figure 5. Comparison of voltage at 1st load of battery between NaCl and NaCl+Na-EDTA electrolyte solutions

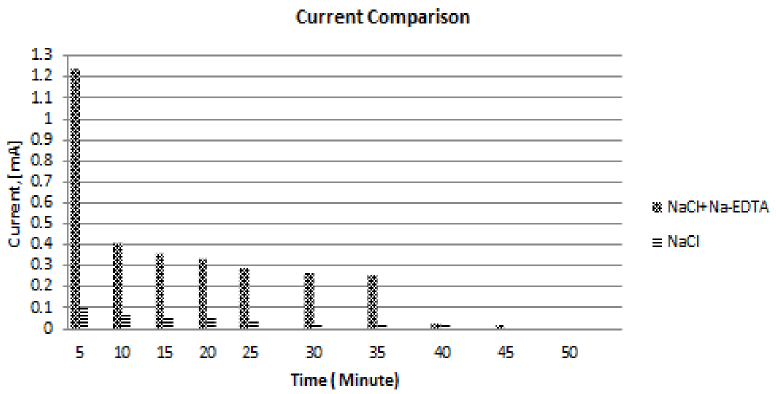


Figure 6. Comparison of current at 1st load of battery between NaCl and NaCl+Na-EDTA electrolyte solutions

(a) (b)

Figure 7. Physical condition of the battery electrolyte after the 1st loading with conditions (a) NaCl electrolyte solution (b) NaCl+Na-EDTA electrolyte solution

An overview of the LED conditions and the physical conditions of the solution are shown in Figures 8(a) and 8(b). From Figure 8(a), the condition of the LED in the first 20 minutes for the NaCl+Na-EDTA electrolyte solution is still on and bright compared to the NaCl electrolyte solution which is starting to become less bright even though it remains on. In the last 40 minutes the condition of the LED in the NaCl electrolyte solution was very dim while in the NaCl+Na-EDTA electrolyte solution it started to get very dim starting at the 45th minute. Figure 8(b) shows the physical condition of the battery electrolyte where the NaCl electrolyte solution has started to become cloudy. In the first 5 minutes to the 20th minute and starts to have slightly sedimentary in the 25th to 50th minute. This is occurs rapid erosion of the anode and cathode of the [29], [30]. Meanwhile, in batteries with NaCl+Na-EDTA electrolyte solution from the first 5 minutes to the last 50 minutes the electrolyte solution still remains bright. This shows that the addition of Na-EDTA is very good for preventing coagulants and deposits and does not interfere with the reaction formation of other compounds [31], [32].

Figures 9(a) and 9(b) show the physical condition of the battery electrolyte after the 1st charging. From Figure 9(a), it can be seen that the physical condition of the NaCl electrolyte is cloudy and there are lots of deposits after the 1st charging with a measured voltage of 2.44 volts. Meanwhile in Figure 9(b) the battery (NaCl+Na-EDTA) after the 1st charging has a measured voltage value of 4.09 volts and the physical condition remains clear but slightly bubbly. Battery testing with LED (2nd Loading) is shown in Figures 10 and 11. And the 2nd loading is carried out after the 1st post-charging. Figure 10 shows that the battery voltage in the NaCl+Na-EDTA electrolyte solution is slightly greater than in the NaCl electrolyte solution in the first 10 minutes. However, at the 15th minute, the voltage in the NaCl electrolyte solution had reached zero, whereas in the NaCl+Na-EDTA electrolyte solution, the voltage remained constant until the 50th minute. Figure 11 shows that the battery current in the NaCl+Na-EDTA electrolyte solution is greater than in the NaCl electrolyte solution. However, at the 10th minute the current in the battery with the NaCl electrolyte solution ends at zero, while in the battery with the NaCl+Na-EDTA electrolyte solution it approaches zero at the 45th minute.

<table>
<tr><th>1st Loading</th><th>NaCl</th><th>NaCl+Na-EDTA</th></tr>
<tr><th>Time (Minute)</th><th>LED Condition</th><th>LED Condition</th></tr>
<tr><td>5
10</td><td>On, a little bright</td><td rowspan="2">On, bright</td></tr>
<tr><td>15
20</td><td rowspan="2">On, dim</td></tr>
<tr><td>25
30
35</td><td>On, a little bright</td></tr>
<tr><td>40</td><td rowspan="2">On, very dim</td><td>On, dim</td></tr>
<tr><td>45
50</td><td>On, very dim</td></tr>
</table>

(a)

<table>
<tr><th>1 st Loading</th><th>NaCl</th><th>NaCl+Na-EDTA</th></tr>
<tr><th>Time (Minute)</th><th>Electrolite phisical condition</th><th>Electrolite phisical condition</th></tr>
<tr><td>5
10
15
20</td><td>Cloudy</td><td rowspan="2">Clear</td></tr>
<tr><td>25
30
35
40
45
50</td><td>Cloudy + slightly sedimentary</td></tr>
</table>

(b)

Figure 8. LED conditions and physical changes in the solution at the 1st loading between the NaCl electrolyte solution and the NaCl+Na-EDTA electrolyte with conditions (a) condition of the LED and (b) physical condition of the electrolyte

(a) (b)

Figure 9. Display of the physical condition of the battery electrolyte after the 1st charging with conditions (a) NaCl electrolyte solution (b) NaCl+Na-EDTA electrolyte solution

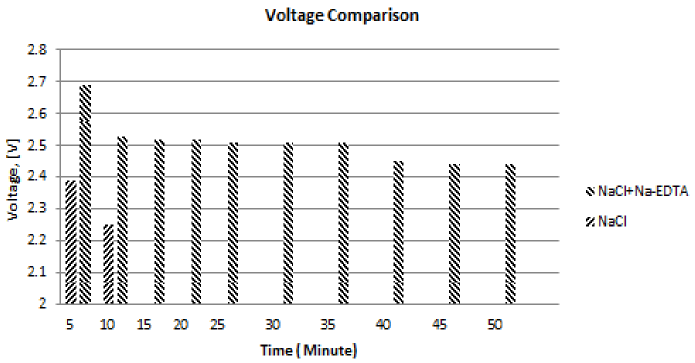


Figure 10. Comparison of voltage at 2-load of battery between NaCl and NaCl+Na-EDTA electrolyte solutions

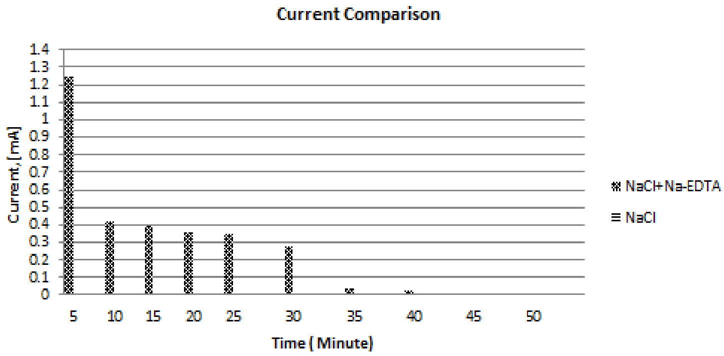


Figure 11. Comparison of the current on 2-load of batteries between NaCl and NaCl+Na-EDTA electrolyte solutions

Figure 12(a) shows the condition of the LED in the loading process-2. On a battery with a NaCl electrolyte solution at the 10th minute the LED goes out, whereas on a battery with a NaCl+Na-EDTA electrolyte solution it still stays on until the 50th minute even though it is very dim. In Figure 12(b), the physical condition of the battery electrolyte with NaCl electrolyte is cloudy and has a lot of sediment, whereas the battery with NaCl+Na-EDTA electrolyte solution is still clear but has air bubbles. The physical condition of the electrolyte is increasingly cloudy and the erosion of the electrode is increasingly visible, as shown in Figure 13(a). By looking at the physical condition of the electrolyte and battery electrodes after the second load, the battery cannot be charged again because the construction is damaged. As happened in previous research [28]. In Figure 13(b) shows the physical conditions of the NaCl+Na-EDTA electrolyte remaining clear but the bubbles are increasing.

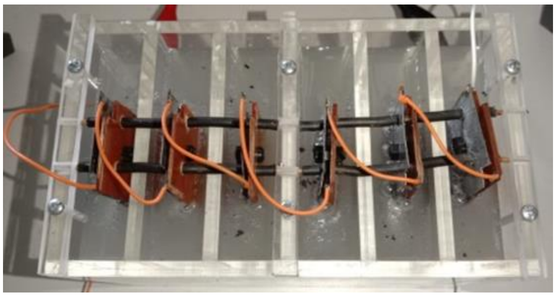
2nd Loading	NaCl	NaCl+Na-EDTA
Time (Minute)	LED Condition	LED Condition
5	On, only light point	On, bright
10	Off	
15		
20		
25		
30		On, dim
35		
40		
45		On, very dim
50		

(a)

2nd Loading	NaCl	NaCl+Na-EDTA
Time (Minute)	Electrolite phisical condition	Electrolite phisical condition
5	Cloudy and lots of sediment	Clear, bubbly
10		
15		
20		
25		
30		
35		
40		
45		
50		

(b)

Figure 12. LED conditions and physical changes in the solution in the 2nd loading between the NaCl electrolyte solutions and the NaCl+Na-EDTA electrolyte with conditions (a) condition of the LED and (b) physical condition of the electrolyte



(a)

(b)

Figure 13. Physical condition of battery electrolyte after 2nd loading with conditions (a) NaCl electrolyte solution and (b) NaCl+Na-EDTA electrolyte solution

Figure 14 showing the physical condition of the battery electrolyte (NaCl+Na-EDTA) after the 2nd charging with a measured voltage value of 1.82 volts and the physical condition remains clear and there are more and more bubbles but the Cu electrode has decomposed while the Zn electrode still does not appear to be in decomposed condition. From the results of the measurements taken it can be seen that the effect of Na-EDTA as a battery electrolyte additive using Cu-Zn electrodes can improve the physical and electrical characteristics of the battery, where the NaCl electrolyte does not cloud quickly and the electrodes do not corrode quickly, then for the resulting voltage value of 4.20 volts with a current capacity of 2Ah while the previous study only produced a voltage of 0.78 volts/cell with a current of 0.044 Ah. However, the most superior thing about this research is that the frequency of battery use can be used twice for loading and recharging conditions compared to previous research that can only be used once.

Figure 14. Physical condition of battery electrolyte (NaCl+Na-EDTA) after 2nd charging

4. CONCLUSION

Recent observations show that by adding Na-EDTA to the NaCl electrolyte solution, the voltage generated in the battery is 4.20 volts with an increase in current of 2 Ah with an electric load of 0.5 watts. Then the frequency of use of the battery can be used twice and twice charging using solar panels, while the electrolyte solution that only uses NaCl can only be used once and cannot be discharged again even though it has been charged once. In addition, charging using solar panels is also able to charge electricity for 1 hour with a charging frequency that can only be done twice.

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