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Research Article

Special Issue

PROPOSAL OF NAALO$_2$ AS AN ELECTROLYTE OF ALUMINUM-AIR BATTERY

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ABSTRACT

This study is aboutthe electrolyte of aluminium-air battery. The purpose of this research is to make battery more safety and improve the performance. Today a lithium-ion battery is the mainstream in rechargeable battery. And an alkaline battery is mainstream in primary battery. There is aluminium-air battery following lithium-ion and alkaine. Aluminium is famous for energy capacity. So we tried to make same or high spec batteries. That battery electrolyte is $NaAlO_2$aq. Because $NaAlO_2$ is more safety in aluminium-air battery. We compared with NaOH at the same concentration. And we tried to experiment of the power generation characteristics using a current regulative diode. It was confirmed that aluminium-air battery using $NaAlO_2$, give result equality or any more performance than battery using NaOH by this experiment.

Keyword: aluminum-air battery, NaOH, $NaAlO_2$,

I. INTRODUCTION

Today, we troubled by worldwide shortage of resources. Japan has caused a serious power shortage because of 3.11(The Great East Japan Earthquake).Electronic machine such as a mobile device needed energy. We know that battery can store the energy. So battery is most important part as the system to carry electric power of an electronic machine such as a mobile device. Today, the battery is desired safety, a longer life, temperature resistance, cost and time of charge.

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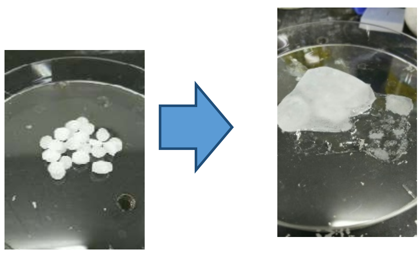
The lithium ion battery is mainstream. The lithium ion battery and alkaline batteries have the limit. That limit is safety and the life expectancy at present. Lithium is sometimes dangerous. For example lithium ion battery was exothermic during use and has led to fire. So we paid attention to big energy content at alminium.

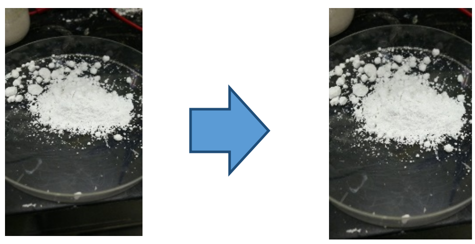
There is an aluminium-air battery in a battery with aluminium [1]-[11]. The mechanism is that the electrons are taken out by dissolving the aluminum plate in the electrolytic solution, and the aluminum ion and the acid combine. It is all.

The performance of the aluminium air battery depend on electrolyte. NaCl and NaOH are used for an electrolyte, but there are loss power generation and NaOH is inferior to NaCl in a safety. NaCl can generate electricity only about 0.7 V by the theoretical value.The reaction between NaOH and H_2O reacts abruptly and generates heat.It is dangerous if it adheres to the skin.Fig.1 shows the time course when NaOH is left in the atmosphere. NaOH even in the atmosphere it will react. NaOH reacted with H_2O and turned into a liquid at 24hour. Fig.2 showsthe time course when $NaAlO_2$ is left in the atmosphere. $NaAlO_2$ is even if left in the atmosphere it hardly changed in 24 hours.Fig. 3 shows that an aluminum plate remains in the electrolytic solution of NaOH and $NaAlO_2$.NaOH began to melt in 0.5 hour.In the case of NaOH, aluminium disappeared in 24 hours.But the case of $NaAlO_2$, aluminium remained even after 24 hours.



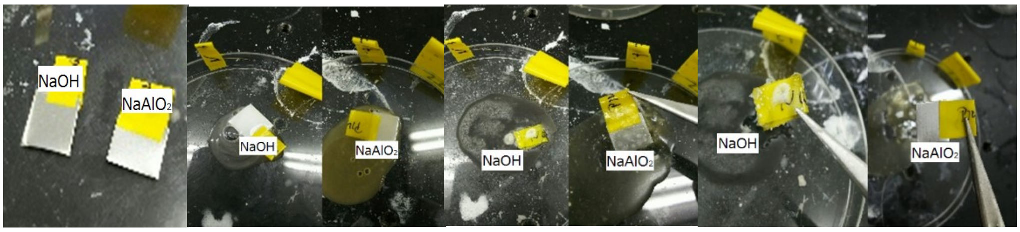
(a)0h (b) 24h

Fig.1. NaOH time course



(a)0h (b) 24h

Fig.2. $NaAlO_2$ time course



(a)0h (b)0.5h (c)24h (d)24h & cleaning

Fig.3. The difference in effect on aluminium at NaOH and $NaAlO_2$ (Left:NaOH,Right:$NaAlO_2$)

It is easy to understand $NaAlO_2$ is more safety than NaOH fromFig1,Fig2 and Fig3. And we succeeded to make special battery. That battery has equal or any more performance. When if it adheres to the skin, it is easy to deal with. Because $NaAlO_2$ is safety.$NaAlO_2$ also degrades almost no protein. Safety can be secured now without sacrifice the performance.

II. THEORY

Generally the aluminium air battery chemical formula is next. The mechanism is that the electrons are taken out by dissolving the aluminium plate in the electrolytic solution, and the aluminium ion and the acid combine to complete.[1][2][3]

・The anode oxidation half-reaction is Al + 3OH− → Al(OH)3 + 3e⁻

・The cathode reduction half-reaction is O2 + 2H2O + 4e⁻ → 4OH−

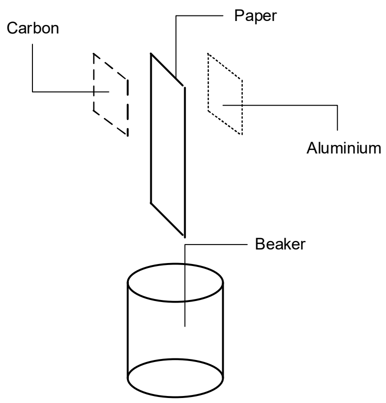
・The total reaction is 4Al + 3O2 + 6H2O → 4Al(OH)3

This formula used by make battery at NaOH or KOH. And the theoretical value of the voltage which can be taken is said to be about 1.4V(NaOH),1.2V(KOH) (open circuit voltage). According to the theory, NaCl output about 0.7V(open circuit voltage). NaCl is very safety but it is low voltage. So NaCl is limited to use with emergency or multi cells. The theoretical formula for $NaAlO_2$ is the same. $NaAlO_2$aq has aluminium-ion.This aluminium-ion helps ion delivery. It becomes profitable as a result. As a result we measured 1.57V max at $NaAlO_2$(open circuit voltage)[4][5][6]

III. EXPERIMENTAL PROCEDURES

A. Making method of a battery

At first, we make some electrolytes with different concentrations.2patterns of density was prepared to water that capacity is 20ml(10%,20%).For example, if you will make 10% of electroryte,20ml water and $NaAlO_2$(wako) 2.22g are mixed. If it completely dissolves it is finished. And we create NaOH in the same way. Next, we prepare the aluminium board (0.5mm×30mm×30mm). And we prepare the carbon paper(30mm×30mm). The last, we soak a paper towel to created electrolyte. The paper towel size is120mm×180mm. And fold in four. We pick up the paper towel when the electrolyte equality penetration. And we sandwich that between aluminium plate and carbon paper. Fig. 4 shows battery parts used in this study. Paper towel is sandwiched between aluminum plate and carbon parper. And we set it the beaker. Aluminium is anode. Ccarbon parper is cathode.Fig.5 shows the battery completed. It connects and ends. The electrode is connected to an aluminium plate and carbon paper.



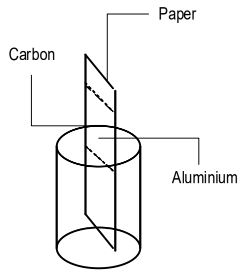


Fig.4. system parts of experimentFig.5system of experiment

B. Measurement method

We used Labview (National instrument) program for measurement.Fig.6 is system configuration. This system is using some module, DAQ assistant, timer, and output. We use DAQ (USB-6211 National instrument) for a record of data.Fig.7 shows connection of each device. Connected item is using CRD and DAQ, target of battery. We connected each item for parallel. The first way, we measured open circuit voltage with DAQ(USB-6211 National Instruments).The second way, we measured finished time using CRD (SEMITEC.co [E-501]).The measurement end voltage was set to 0.4V. The last, we calculated mA/hcm^2.

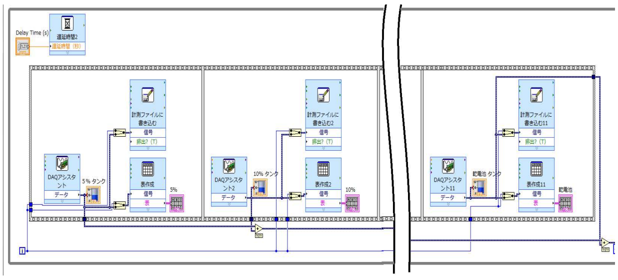


Fig.6. Labview program for measurement

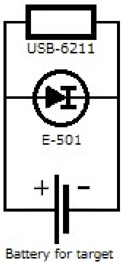


Fig.7. Item connection

Ⅳ. RESULTS AND DISCUSSION

A. Open circuit voltage

Fig.8 shows open circuit voltage graph at NaOH. In NaOH, it was measured about 12hours. That result was approximately constant value. Starting value is 1.27V(10% concentration) and 0.95V(20% concentration).Finishing value is 1.30V(10% concentration) and 1.25V(20% concentration).Output average value is 1.258V(10%) and1.245V(20%).Fig. 9 shows open circuit voltage graph at NaAlO2. In NaAlO2, it was measured about 12hours. That result were approximately constant value. Start value is 1.39V(10% concentration) and 1.28V(20% concentration). End value is 1.31V(10% concentration) and 1.35V(20% concentration). Output average value is 1.267V(10% concentration) and 1.274V(20% concentration).

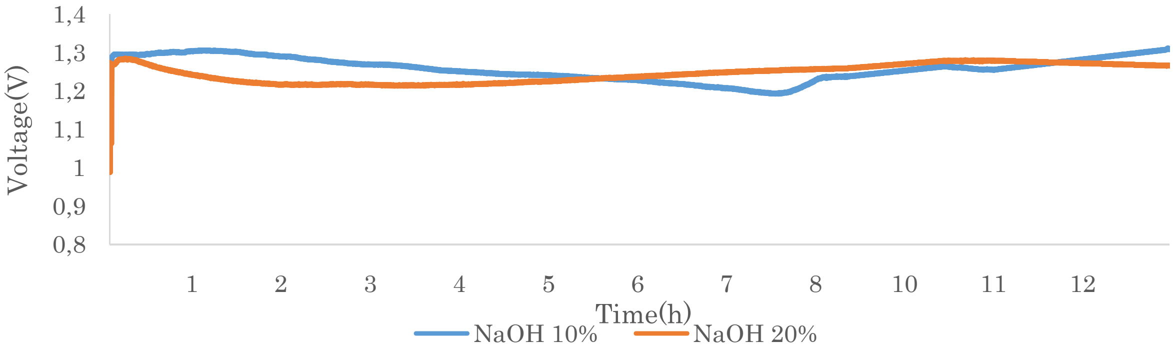


Fig.8. NaOH open circuit voltage

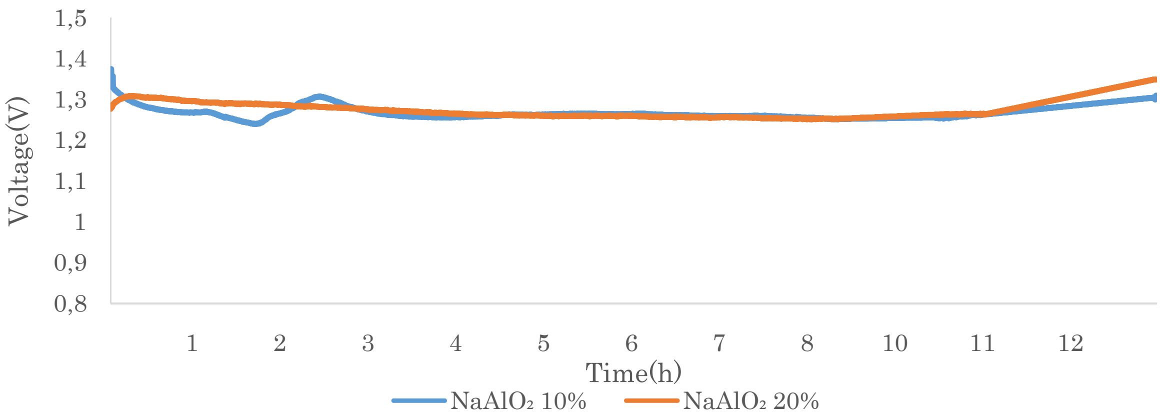


Fig.9. $NaAlO_2$Open circuit voltage

B. CRD voltage

Fig.10 shows CRD voltage graph at NaOH. In NaOH, the battery lasted 63 hours. The end time condition is CRD voltage falls below 0.15V.This time, we set two concentrations. The value is 10% and 20%. The more powerful battery was 10%.

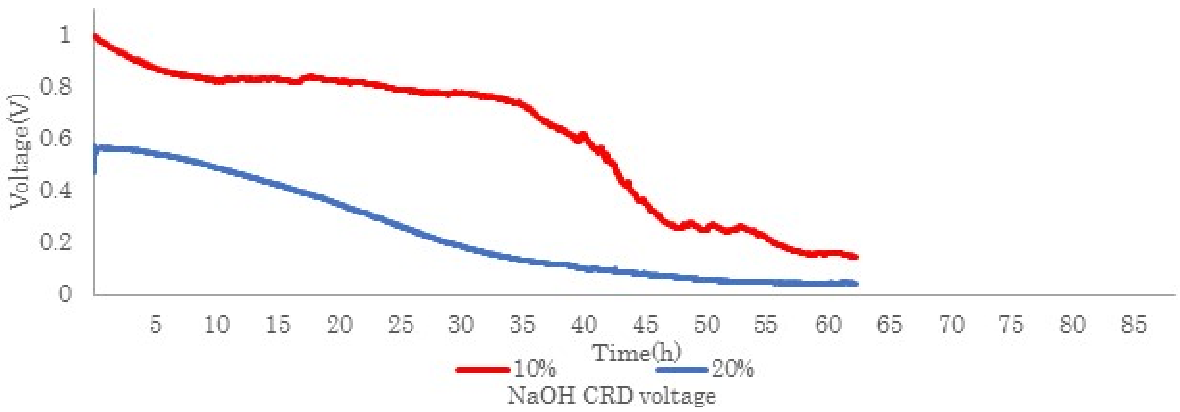


Fig.10. NaOHCRD voltage

Fig.11 shows CRD voltage graph at $NaAlO_2$.In $NaAlO_2$, the battery lasted 87 hours. The end time condition is CRD voltage falls below 0.15V. This time, we set two concentrations. The value is 10% and20%. The more powerful battery was 20%.

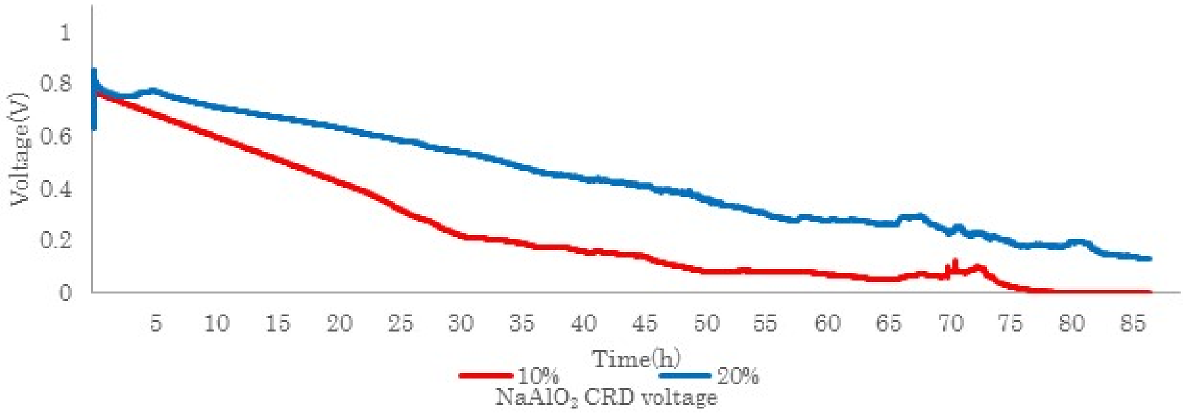


Fig.11. $NaAlO_2$ CRD voltage

Table 1 shows the results of calculating mA/hcm^2 from the measured data. As can be seen from the table, NaOH is 40.72mA/hcm^2(best value) but $NaAlO_2$ is 51.61mA/hcm^2(best value). So $NaAlO_2$ has the same or greater than the spec with NaOH.

Table1. Comparison NaOH and $NaAlO_2$ at various prices

NaOH

Concentration	10%	20%
mA/hcm^2	40.72	18.61

$NaAlO_2$

concentration	10%	20%
mA/hcm^2	13.56	51.61

IV. CONCLUSION

We verified the advantages and potential of $NaAlO_2$ in aluminum air battery from experimental result. It would be possible to show safety and equality or any more performance by using $NaAlO_2$. In terms of safety, as you can see from the images of Fig.1, Fig. 2and Fig. 3, $NaAlO_2$ is a very safety electrolyte. It has the same or greater than the other batteries specs in power generation characteristics.

REFERENCES

[1] A.A. Mohamad, "Electrochemical properties of aluminum anodes in gel electrolyte-based aluminum-air batteries" Corrosion Science 50 (2008) 3475–3479

[2] Liang Fan, Huimin Lu , Jing Leng “Performance offine structured aluminum anodes in neutral and alkaline electrolytes for Al-air batteries”. Electrochimica Acta 165 (2015) 22–28

[3] D.R. Egan, C. Ponce de León , R.J.K. Wood, R.L. Jones, K.R. Stokes, F.C. Walsh,” Developments in electrode materials and electrolytes for aluminiumeair batteries Electrochemical Engineering Laboratory” Journal of Power Sources 236 (2013) 293-310

[4] Renaud Revel, Thomas Audichon, Serge Gonzalez, Non-aqueous aluminiumeair battery based on ionic liquid electrolyte. Journal of Power Sources 272 (2014) 415-421.

[5] M. Pino, J. Chac, E. Fat, P. Oc' “Performance of commercial aluminium alloys as anodes in gelled electrolyte aluminium-air batteries” Journal of Power Sources 299 (2015) 195-201

[6] M. Pino, D. Herranz, J. Chac, E. Fat, P,“Carbon treated commercial aluminium alloys as anodes for aluminium-air batteries in sodium chloride electrolyte”. Journal of Power Sources 326 (2016) 296-302

[7] Ryohei Mori "A new structured aluminium–air secondary battery with a ceramic aluminium ion conductor". RSC Adv., 2013, 3, 11547–11551

[8] Ryohei Mori "Semi-rechargeable Aluminum–Air Battery with a TiO2 Internal Layer with Plain Salt Water as an Electrolyte”, Journal of ELECTRONIC MATERIALS, Vol. 45, No. 7, 2016

[9] D. Gelman, B. Shvartsev and Y. Ein-Eli "Aluminum–air battery based on an ionic liquid electrolyte." The Royal Society of Chemistry (2014) 20237–20242

[10] Ryohei Mori "Capacity recovery of aluminium–air battery by refilling salty water with cell structure modification" J Appl Electrochem (2015) 45:821–829

[11] M. Klisˇkic. I. Smoljko • S. Gudic´ • N. Kuzmanic´. "Electrochemical properties of aluminium anodes for Al/air batteries with aqueous sodium chloride electrolyte". J Appl Electrochem (2012) 42:969–977

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