Original Research Article

A Comparison on the Voltage Output of Al-Cu Primary Battery with its Electrolyte being Coca Cola With and Without Sugar

Yantong Li*

The High School Affiliated to Renmin University of China, Beijing 100080, China. E-mail: 18310202563@163.com

Abstract: For the primary battery, different electrolyte will affect the voltage output of the battery. In this paper, the influence of sugar on the output voltage was studied by taking Coca Cola as an example. The results show that there is a certain difference between the effect of electrolyte with and without sugar, but the specific reason is not clear, because the formula of beverage is a secret. Further experiments are needed to draw a conclusion.

Keywords: Primary Battery; Voltage; Coca-Cola

1. Introduction

Primary battery gain electricity through the chemical reactions at the anode and the cathode which convert chemical energy into electrical energy. At the cathode, electrons are released due to oxidation, whereas at the anode, electrons are absorbed by the electrode due to reduction. The electrons travel between two electrodes via the electrolyte and form a flow of electrons, thereby generating current in the circuit[1]. The type of electrolyte affects the voltage of the primary battery. In this paper, different electrolytes (coke with and without sugar) are used and the voltage is measured and compared[2].

2. Experiment

2.1 Equipment

The equipment include an aluminum bar which the chromeplate on the outer surface is partially cleared (effective area of aluminum: 8cm * 1-2cm) cut from a Coca Cola can with a diameter of 5.5cm and a height of 14.5cm, volume of 330ml, a copper bar (effective: 3cm * 1.2cm * 1.5mm), a glass cup with inner diameter of 7.3 centimeters and inner height of 8 centimeters, and a PEAKMETER PM2018S Smart Digital multimeter. A stopwatch and four staples are needed. Coca cola with and without sugar at 10°C from thin-tall tin cans is needed as well[3].

2.2 Setting

Two staples are used to respectively connect the positive probe of the multimeter to the copper bar and the negative probe to the aluminum bar. Two staples are used to fix the anode and the cathode on the cup. The aluminum bar and the copper bar are fixed on two sides on the diameter of the cup. A ruler was erected beside the cup in order to control the volume of electrolyte added as shown in **Figure 1**. Coca cola with and without sugar was added separately into the cup and reach the five centimeter tick mark. The aluminum bar reaches the bottom of the cup, while 1.5 centimeter of the copper bar is submerged under the electrolyte[4].

doi: 10.18282/ims.v3i1.376

Figure 1. The set of the equipment

3. Method

Open the tin can, immediately add coca cola with sugar (CCS) into the cup and reach the five centimeter tick mark, start the stopwatch, measure and record the read on the multimeter every five seconds for 41 minutes. Stop the watch and return it to zero; clear, wash, and dry the cup; dry the electrodes[4]. Add coca cola without sugar (CC) into the cup and reach the five centimeter tick mark, start the stopwatch, measure the read on the multimeter every five seconds for 41 minutes. Keep room temperature 25℃.

4. Result

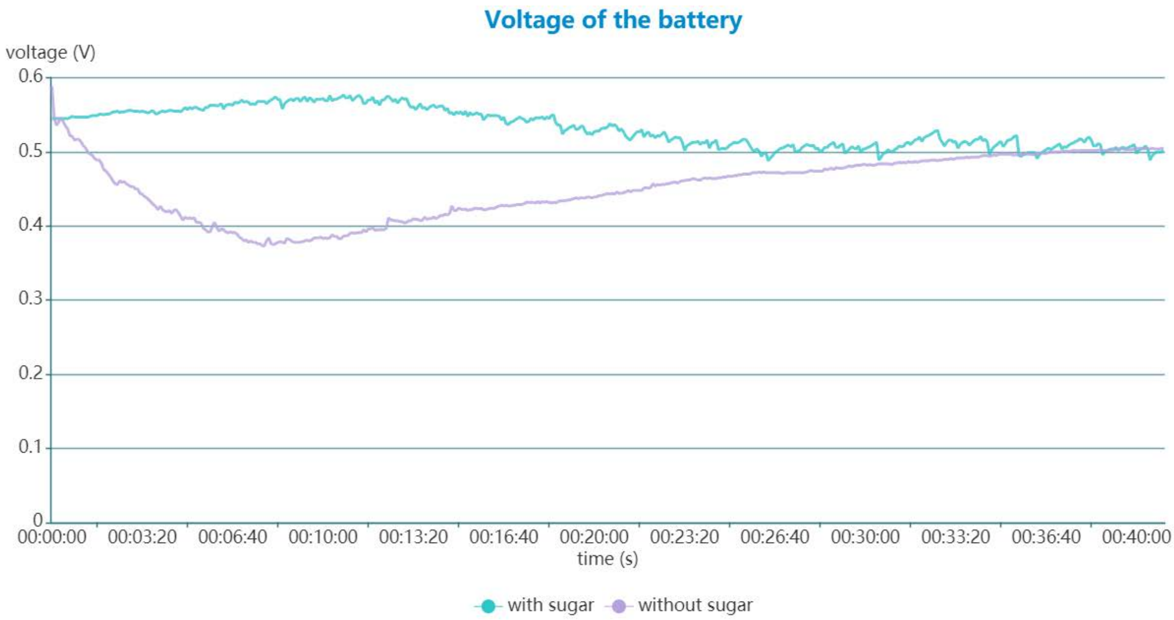

Figure 2.

The data is shown in **Appendix 1**. The voltage-time graph is shown here by **Figure 2.** While the potential difference generated with both types of electrolyte starts from about 0.55 V, the potential difference generated when CCS is used as electrolyte (the blue line) rises to 0.577 V at 0:10:45, then falls down to a minimum of 0.488 V at 0:26:25, and eventually floats above and around 0.5 V, oscillating throughout the whole process; the potential difference generate with CC (the purple line), on the other hand, falls rapidly to 0.373 V at 0:07:50, then slowly rises back to around 0.5 V in the end. It is unknown whether the purple line will continue to rise due to the limitation on the researcher's ability to keep focus and record data. Though not as significant as the blue line for CCS, the purple line of CC also shows an oscillating pattern during the decreasing stage (0:00:00 - 0:07:50) and the first one fifth of the increasing (0:07:50 – 0:13:55) stage. Little oscillating pattern can be observed on the purple line after 0:13:55 and the voltage begin to rise steadily[5].

5. Analysis

In this battery, the reaction at the anode and the cathode is

Anode: $2H^+ + 2e^- = H_2 \uparrow$

Cathode: $Al - 3e^- = Al^{3+}$

Overall reaction: $2Al + 6H^+ = 2Al^{3+} + 3H_2 \uparrow$

As shown in **Appendix 2**, the cell potential of this primary battery under standard condition is 1.336V, 0.786V higher than the measured initial voltage. The Nernst Equation may provide an explanation:

$$E = E_0 - \frac{RT}{nF} \ln Q$$

E = reduction potential

E_0 = standard potential

R = gas constant, which is 8.31 (volt-coulomb)/(mol-K)

T = temperature (K)

n = number of moles of electrons exchanged in the electrochemical reaction (mol)

F = Faraday's constant, 96500 coulombs/mol

Q = reaction quotient, which is the equilibrium expression with initial concentrations rather than equilibrium concentrations

When at 25 ℃, or 298K,

$$\Delta E = -\frac{0.0591V}{n} \ln Q$$

From the overall reaction, n = 6.

Thus,

$$-0.786V = -\frac{0.0591V}{6} \ln Q$$

$$\ln Q = 79.80$$

5.1 The oscillating pattern

The pattern results from the error of the mulimeter.

5.2 Flaws and error analyses

The areas that are in contact with the electrolyte of the two electrodes are not equal, which can affect the value of the potential difference generated. The 0.589 V at the beginning of the purple line is because the coca cola spread on the whole copper bar.

6. Conclusion

Using coca cola as the electrolyte, the 41-minute measurement of the voltage generated by a Cu/Al primary battery reveals a significant difference between the normal coke and sugar free coke. While normal coke electrolyte generates voltage in an increase-decrease pattern, sugar-free coke electrolyte generates voltage in the opposite decrease-increase pattern. Since the receipt of coke is unknown-and in fact, one of the safest secret on Earth-the exact reason for this difference in pattern is unknown. Whether the purple line representing the voltage generated with CC will continue to increase is unknown. Future research should focus on the capacity of the rise of the purple line.

References

1. Eleri OE, Azuatalam KU, Minde MW, *et al*. Towards high-energy-density supercapacitors via less-defects activated carbon from sawdust. Electrochimica Acta 2020; 362.
2. Zhang H, Xu H, Endres F, *et al*. Multi-color poly(3-methylthiophene) films prepared by a novel pre-nucleation electrodeposition grown method for enhancing electrochromic stability. Electrochimica Acta 2020; 362.
3. Pathak DK, Chaudhary A, Tanwar M, *et al*. Chronopotentiometric Deposition of Nanocobalt Oxide for Electrochromic Auxiliary Active Electrode Application. Physica Status Solidi (a) 2020; 217(19).
4. Gu C, Peng Y, Li J, *et al*. Supramolecular G4 Eutectogels of Guanosine with Solvent-Induced Chiral Inversion and Excellent Electrochromic Activity. Angewandte Chemie International Edition 2020; 59(42).
5. Balakrishnan A, Pattathil P. Nanostructured electrochromic materials for smart switchable windows. CRC Press; 2018.

Appendix 1

Time	With sugar	Without sugar	**Time**	With sugar	Without sugar	**Time**	With sugar	Without sugar
0:00:00	0.545	0.589	**0:02:10**	0.552	0.466	**0:04:30**	0.555	0.421
0:00:10	0.545	0.536	**0:02:20**	0.554	0.457	**0:04:40**	0.555	0.418
0:00:20	0.545	0.546	**0:02:30**	0.553	0.461	**0:04:50**	0.557	0.408
0:00:30	0.545	0.535	**0:02:40**	0.554	0.46	**0:05:00**	0.557	0.41
0:00:40	0.546	0.522	**0:02:50**	0.556	0.455	**0:05:10**	0.558	0.41
0:00:50	0.547	0.516	**0:03:00**	0.555	0.453	**0:05:20**	0.56	0.405
0:01:00	0.547	0.517	**0:03:10**	0.555	0.45	**0:05:30**	0.557	0.404
0:01:10	0.547	0.508	**0:03:20**	0.555	0.443	**0:05:40**	0.56	0.395
0:01:20	0.547	0.499	**0:03:30**	0.553	0.438	**0:05:50**	0.563	0.392
0:01:30	0.549	0.495	**0:03:40**	0.555	0.432	**0:06:00**	0.563	0.405
0:01:40	0.549	0.489	**0:03:50**	0.551	0.426	**0:06:10**	0.563	0.393
0:01:50	0.551	0.484	**0:04:00**	0.554	0.427	**0:06:20**	0.558	0.395
0:02:00	0.551	0.474	**0:04:10**	0.554	0.42	**0:06:30**	0.564	0.391

Time	With sugar	Without sugar	**Time**	With sugar	Without sugar	**Time**	With sugar	Without sugar
0:06:40	0.563	0.391	**0:09:00**	0.572	0.378	**0:11:10**	0.572	0.39
0:06:50	0.566	0.389	**0:09:10**	0.568	0.378	**0:11:20**	0.576	0.391
0:07:00	0.57	0.383	**0:09:20**	0.574	0.38	**0:11:30**	0.565	0.395
0:07:10	0.568	0.381	**0:09:30**	0.573	0.38	**0:11:40**	0.57	0.396

0:07:20	0.564	0.38	**0:09:40**	0.567	0.384	**0:11:50**	0.574	0.398
0:07:30	0.564	0.378	**0:09:50**	0.571	0.384	**0:12:00**	0.569	0.395
0:07:40	0.568	0.376	**0:10:00**	0.572	0.383	**0:12:10**	0.57	0.395
0:07:50	0.568	0.373	**0:10:10**	0.569	0.383	**0:12:20**	0.574	0.397
0:08:00	0.568	0.384	**0:10:20**	0.569	0.388	**0:12:30**	0.572	0.408
0:08:10	0.572	0.375	**0:10:30**	0.571	0.386	**0:12:40**	0.571	0.407
0:08:20	0.571	0.378	**0:10:40**	0.574	0.383	**0:12:50**	0.57	0.406
0:08:30	0.558	0.378	**0:10:50**	0.573	0.387	**0:13:00**	0.571	0.404
0:08:40	0.568	0.383	**0:11:00**	0.576	0.39	**0:13:10**	0.564	0.407
0:08:50	0.571	0.38	**0:11:05**	0.569	0.391	**0:13:20**	0.561	0.41

Time	With sugar	With-out sugar	**Time**	With sugar	Without sugar	**Time**	With sugar	Without sugar
0:13:30	0.561	0.409	**0:15:40**	0.553	0.424	**0:18:00**	0.546	0.431
0:13:40	0.559	0.408	**0:15:50**	0.551	0.424	**0:18:10**	0.544	0.432
0:13:50	0.557	0.409	**0:16:00**	0.547	0.422	**0:18:20**	0.545	0.432
0:14:00	0.562	0.41	**0:16:10**	0.549	0.424	**0:18:30**	0.55	0.432
0:14:10	0.56	0.41	**0:16:20**	0.549	0.424	**0:18:40**	0.536	0.433
0:14:20	0.562	0.414	**0:16:30**	0.548	0.427	**0:18:50**	0.524	0.434
0:14:30	0.556	0.416	**0:16:40**	0.547	0.427	**0:19:00**	0.53	0.435
0:14:40	0.552	0.417	**0:16:50**	0.537	0.427	**0:19:10**	0.534	0.436
0:14:50	0.55	0.421	**0:17:00**	0.541	0.428	**0:19:20**	0.53	0.438

0:15:00	0.552	0.424	**0:17:10**	0.545	0.429	**0:19:30**	0.534	0.438
0:15:10	0.55	0.422	**0:17:20**	0.545	0.429	**0:19:40**	0.528	0.438
0:15:20	0.548	0.421	**0:17:30**	0.54	0.432	**0:19:50**	0.526	0.439
0:15:30	0.55	0.422	**0:17:40**	0.545	0.432	**0:20:00**	0.527	0.439
Time	With sugar	Without sugar	**0:17:50**	0.546	0.431	**Time**	With sugar	Without sugar
0:20:10	0.528	0.441	**Time**	With sugar	Without sugar	**0:24:40**	0.504	0.465
0:20:20	0.532	0.442	**0:22:30**	0.524	0.456	**0:24:50**	0.504	0.466
0:20:30	0.534	0.444	**0:22:40**	0.521	0.457	**0:25:00**	0.509	0.467
0:20:40	0.535	0.444	**0:22:50**	0.516	0.458	**0:25:10**	0.513	0.468
0:20:50	0.534	0.446	**0:23:00**	0.52	0.459	**0:25:20**	0.513	0.469
0:21:00	0.531	0.444	**0:23:10**	0.519	0.46	**0:25:30**	0.517	0.47
0:21:10	0.521	0.446	**0:23:20**	0.502	0.461	**0:25:40**	0.513	0.47
0:21:20	0.516	0.446	**0:23:30**	0.51	0.462	**0:25:50**	0.503	0.472
0:21:30	0.524	0.448	**0:23:40**	0.513	0.464	**0:26:00**	0.504	0.472
0:21:40	0.527	0.448	**0:23:50**	0.514	0.462	**0:26:10**	0.494	0.472
0:21:50	0.52	0.451	**0:24:00**	0.513	0.464	**0:26:20**	0.499	0.472
0:22:00	0.527	0.451	**0:24:10**	0.516	0.464	**0:26:30**	0.492	0.472
0:22:10	0.523	0.457	**0:24:20**	0.512	0.464	**0:26:40**	0.499	0.472
0:22:20	0.522	0.456	**0:24:30**	0.516	0.464	**0:26:50**	0.504	0.472

A more thorough data can be viewed at https://drive.google.com/file/d/1QbrhcC8ZbtBW49scW2T9ceBR8Dc4al24/view?usp=sharing

Appendix 2

(No.)	Electrode process	$E^{Å}$/V
1	$Ag^{+}+e=Ag$	0.7996
2	$Ag^{2+}+e=Ag^{+}$	1.98
3	$AgBr+e=Ag+Br^{-}$	0.0713
4	$AgBrO_3+e=Ag+BrO_3^{-}$	0.546
5	$AgCl+e=Ag+Cl^{-}$	0.222
6	$AgCN+e=Ag+CN^{-}$	-0.017
7	$Ag_2CO_3+2e=2Ag+CO_3^{2-}$	0.47
8	$Ag_2C_2O_4+2e=2Ag+C_2O_4^{2-}$	0.465
9	$Ag_2CrO_4+2e=2Ag+CrO_4^{2-}$	0.447
10	$AgF+e=Ag+F^{-}$	0.779
11	$Ag_4[Fe(CN)_6]+4e=4Ag+[Fe(CN)_6]^{4-}$	0.148
12	$AgI+e=Ag+I^{-}$	-0.152
13	$AgIO_3+e=Ag+IO_3^{-}$	0.354
14	$Ag_2MoO_4+2e=2Ag+MoO_4^{2-}$	0.457
15	$[Ag(NH_3)_2]^{+}+e=Ag+2NH_3$	0.373
16	$AgNO_2+e=Ag+NO_2^{-}$	0.564
17	$Ag_2O+H_2O+2e=2Ag+2OH^{-}$	0.342
18	$2AgO+H_2O+2e=Ag_2O+2OH^{-}$	0.607
19	$Ag_2S+2e=2Ag+S^{2-}$	-0.691
20	$Ag_2S+2H^{+}+2e=2Ag+H_2S$	-0.0366
21	$AgSCN+e=Ag+SCN^{-}$	0.0895
22	$Ag_2SeO_4+2e=2Ag+SeO_4^{2-}$	0.363
23	$Ag_2SO_4+2e=2Ag+SO_4^{2-}$	0.654

24	Ag_2WO_4+2e═2Ag+WO_4^{2-}	0.466
25	Al_3+3e═Al	-1.662
26	AlF_6^{3-}+3e═Al+6F^-	-2.069
27	$Al(OH)_3$+3e═Al+3OH^-	-2.31
28	AlO_2^-+2H_2O+3e═Al+4OH^-	-2.35
29	Am^{3+}+3e═Am	-2.048
30	Am^{4+}+e═Am^{3+}	2.6