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Utilization of Conventional Battery Framework with Bioelectrolyte Based on Blood Shell and Sugarcane Bagasse

Renita Manurung[1*], Aufa Nurul Khadijah[1], Intan Rahayu[1], Alwi Gery Agustan Siregar[1*]

[1] Department of Chemical Engineering, Faculty of Engineering, Universitas Sumatera Utara, Medan 20155, Indonesia

* Corresponding author's e-mail: renita.manurung@usu.ac.id

ABSTRACT

Batteries are electric cells that use a reversible electrochemical process. One of the important components in the battery is the electrode. Electrodes in conventional batteries generally contain the B3 material. This study aimed to produce and characterize the bioelectrolytes made from blood clam shells and sugarcane bagasse. This study consisted of four stages, namely the stage of calcination of blood clam shells, the stage of hydrolysis of sugarcane bagasse, the stage of making bioelectrolyte paste, and the stage of test parameters. The test parameters performed included calcined blood clam shell morphology analysis using SEM, composition and mineral analysis on blood clam shell ash using XRF (X-Ray Fluorcence), analysis using UV-Vis spectrophotometry, and analysis using FTIR spectrophotometry. The characterization of the bioelectrolytes was tested using an AVOmeter or a multimeter connected using a connecting cable and an alligator clip. The best bioelectrolyte results were obtained using a reaction time of 90 minutes and a concentration of acid solution 30% (v/v) with a mixture of shell ash and sugarcane bagasse paste in 1:1 ratio. The best power produced was 0.02 watts.

Keywords: bioelectrolytes, blood clam shells, electrolytes, sugarcane bagasse.

INTRODUCTION

The industrial sector continues to grow, especially the energy industry, the national energy demand until 2050 continues to increase. Along with the increasing demand for energy, the reserves for energy supply will decrease. This is the reason for the development of new and renewable energy (EBT) as a substitute for substituting energy supply. One source of embodiment for NRE is bioenergy. Utilization of bioenergy, in addition to increasing energy security, can also contribute to the provision of environmentally friendly energy for the community. Biobattery is one of the bioenergy types that can be pursued to support the need for new and renewable energy. One of the important components in the battery is the electrode. Electrodes in conventional batteries generally contain the B3 material. Therefore, a new electrode was developed that is free from the B3 materials and comes from biomass waste. These electrodes can be made by utilizing calcium carbonate from blood clam shells and cellulose from sugarcane bagasse. Blood clams with a binomial name (*Anadara granosa*) are one of the easiest types of clam to find. The number of clam that are quite abundant, will be proportional to the amount of shell waste. Clam shell contains chemical compounds consisting of chitin, calcium carbonate, calcium hydrocypatite, and calcium phosphate. Calcium carbonate ($CaCO_3$) obtained through the calcination process, physically has pores that have the ability to adsorb or absorb other substances into the pores of its surface [Yoon et al, 2021].

Sugarcane bagasse or is a waste generated from the initial process of making sugar which contains about 90.73% organic matter [Vats et al, 2019]. The organic matter derived from biowaste can be applied as an electrode material [Darkwa et al, 2019]. This electrolyte will later produce an electric current in the battery [Paus et al, 2019]. Utilization of sugarcane bagasse is

done by converting sugarcane bagasse cellulose into glucose, which has the potential to be used as raw material for electrolyte paste.

MATERIALS AND METHODS

In this study, the blood clam shell samples were washed and then reduced in size with a ball mill. Furthermore, they were calcined to obtain CaO at a temperature of 500°C in 240 minutes with a particle size of 150 mesh through a muffle furnace vacuum and gas max 1000°C type furnace. The analysis carried out was morphological analysis of blood clam shells using SEM type ZEISS/EVO MA 10 and XRF (X-Ray Fluorescence) to determine the composition and minerals in the ash content. In addition, the sugarcane bagasse samples were reduced in a blender to a 40 mesh size and then hydrolyzed using Merck glacial acetic acid at 121°C with variations in reaction times of 30, 60, and 90 minutes and the concentration of the acid solution was 10%, 20%, and 30% (v/v) in 50 ml. The analysis of glucose groups was carried out with UV-VIS Shimadzu type and FTIR (Fourier Transform Infrared) Agilent/FTIR Cary 630 type. Furthermore, the manufacturing of bioelectrolyte paste with a ratio of clam ash : sugarcane bagasse paste is 1:1; 1:4; 2:3; 3:2; and 4:1, with a total mass of 5 grams.

RESULTS AND DISCUSSION

Results of analysis of blood shell ash composition

The ash from the calcined blood clam shell was then tested by XRF to identify its chemical composition. The results of the XRF spectrum analysis can be seen in Figure 1. On the basis of Figure 1, it can be seen that the element that has the most content is Ca in the skin. Seen in the spectrum, the appearance of the peaks of other substances detected at the maximum energy of the element with respect to the Y axis is the elements Fe, Cu, Sr, and Lu each of 0.26%; 0.046%; 0.87%; and 0.20%. The results of the characterization are shown in Table 1. On the basis of the results of XRF analysis, it can be seen that the largest component contained in the ash of blood clam shells is calcium (Ca) which is 98.64% or in the form of oxide (CaO) of 98.88%. This high calcium oxide content can be used as an electrolyte paste in biobatteries because CaO is an active component for adsorbing toxic compounds [Insani & Rahmatsyah, 2021]. On the basis of the results of XRF in previous studies, the Ca content of the research preparation had a level of 98.49% [Pratomo et al, 2020], while the blood clam shell prepared in this study had a Ca content of 98.64% or 0.18% higher to produce high levels of Ca is more in the filling of bioelectrolytes.

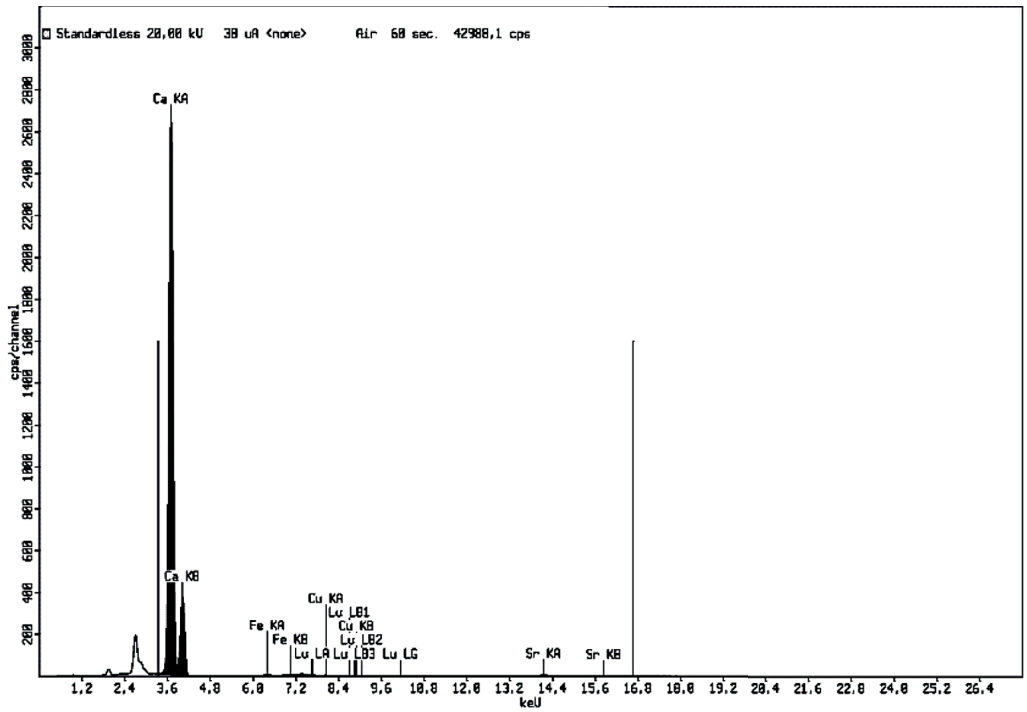


Figure 1. Spectrum XRF analysis of blood clam shells

Table 1. XRF result of blood shell ash

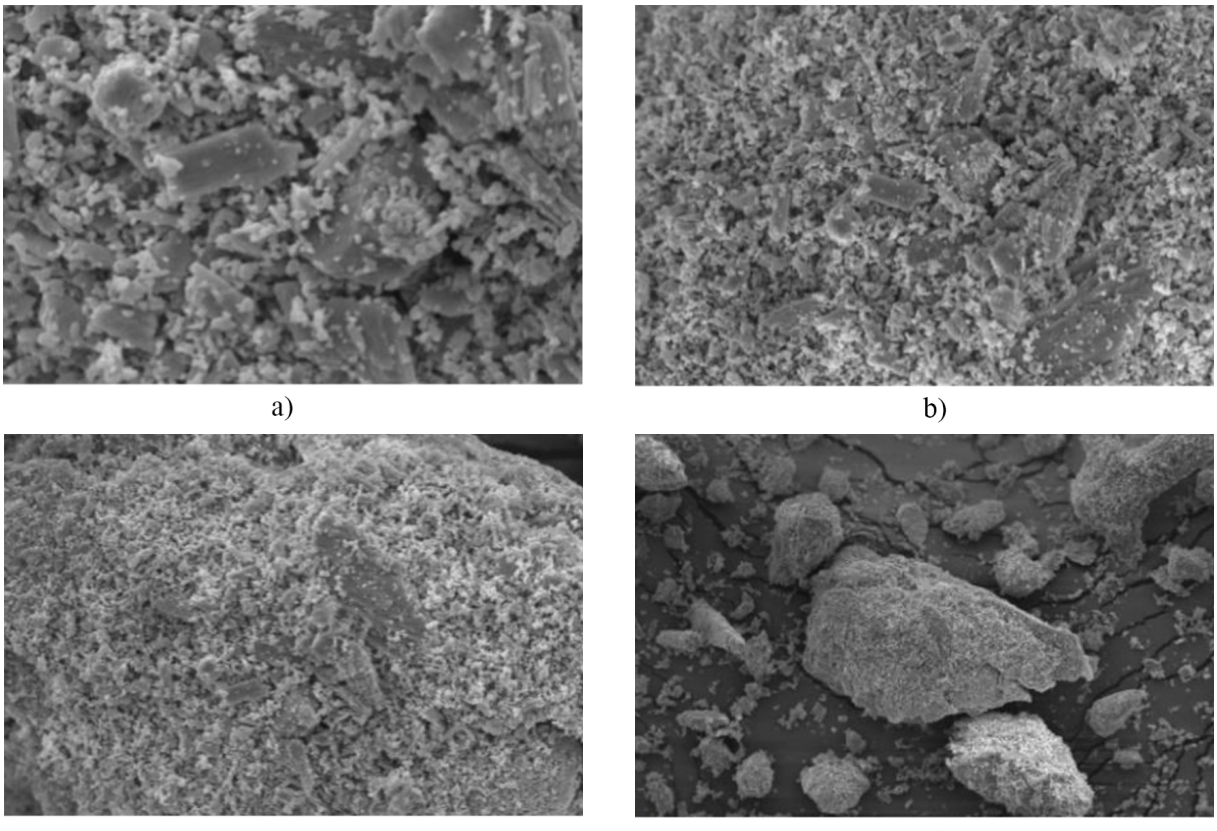
Component	Percentage (%)	Oxide component	Percentage (%)
Ca	98.64	CaO	98.88
Fe	0.26	Fe_2O_3	0.25
Cu	0.046	CuO	0.038
Sr	0.87	SrO	0.68
Lu	0.20	Lu_2O_3	0.16

Morphological analysis of blood shell ashes

Figure 2a shows a magnification of 10 000× with a morphological size of 2 µm, showing the shape of a small rod in the form of a typical structure of $CaCO_3$ although the image looks irregular. Meanwhile, in Figures 2b and 2c with a morphological size of 2 µm, the surface shape is still not uniform but the surface looks smoother. Figure 2d with 1000× magnification has a morphological size of 10 µm showing a rough and irregular shape. From the results of SEM characterization, it can be concluded that the calcined shells showed a crystalline form in the form of rods at a magnification of 10 000×.

Qualitative analysis of hydrolysis products

The FTIR test was used to analyze the functional groups. The results of the functional group analysis on the hydrolyzed sugarcane bagasse are shown in Figure 3. The FTIR spectrum uses a wave number of 500–3500 cm^{-1}. In Figure 3, it can be seen that the wave number is 1717.27 cm^{-1} which indicates the presence of a C=O bond, and the wave number is 1278.24 cm^{-1} which indicates the presence of a C-O bond. The absorption at wave numbers 1391.59 cm^{-1}, 771.65 cm^{-1}, and 705.13 cm^{-1} indicates the presence of C-H bonds. The absorption at wave numbers 2623.24 cm^{-1} and 3589.77 cm^{-1} indicates O-H bonds formed in the hydrolysis



a) b) c) d)

Figure 2. Results of SEM characterization of blood clam shells with the following magnification: (a) 10 000×, (b) 5000×, (c) 3500×, (d) 1000×

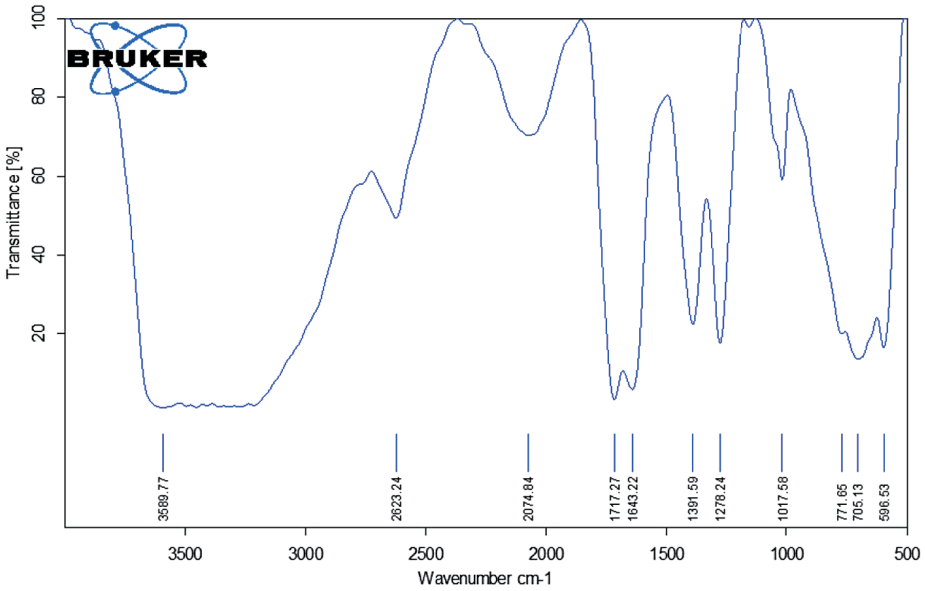


Figure 3. FTIR spectrum of hydrolysis products

product and C=C bonds are also indicated at absorption wave numbers 1643.22 cm^{-1}. After hydrolysis, the O-H group changes, from hydrogen bonds to carboxylic acids. This is due to the hydrolysis process using acetic acid solution and indicates the formation of glucose. The presence of glucose is indicated by the absorption at wave number 1278.24 cm^{-1}, which indicates the presence of C-O bonds. On the basis of this peak, it was concluded that the hydrolysis product contains glucose.

Effect of acid solution concentration on glucose levels of hydrolysis products

The results of the research on the hydrolysis of sugarcane bagasse in the variation of reaction time with the concentration of the acid solution on the resulting glucose levels can be seen in Figure 4. Glucose is an organic component that can function as an electrolyte for biobattery electrolyte paste. Figure 4 shows that the addition of the concentration of the acid solution has an impact on the increase in the level of glucose produced. The use of 30% acid solution concentration gave the highest glucose for each reaction time. The glucose produced by using a 30% acid solution concentration was 0.875 mg/l; 1.217 mg/l; and 2.051 mg/l for reaction times of 30 minutes, 60 minutes, and 90 minutes. Meanwhile, the concentration of 20% acid solution for the reaction time of 30, 60, and 90 minutes was 0.533 mg/l, respectively; 1.203 mg/l; 1,285 mg/l; and at a concentration of 10% acid solution produces

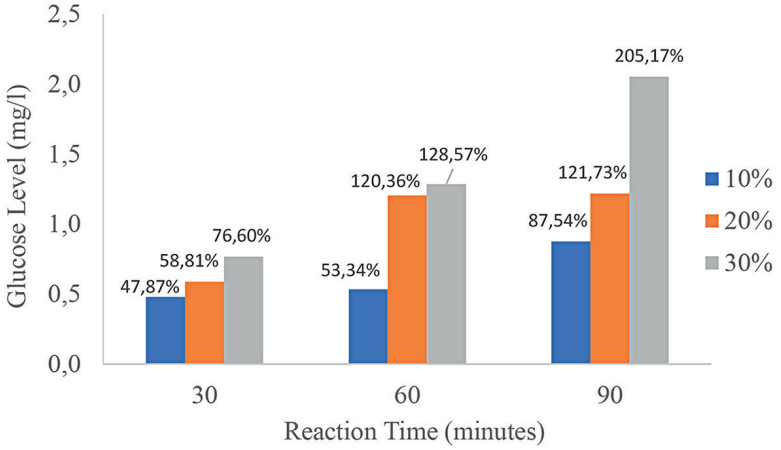


Figure 4. Concentration of acid solution to glucose level

glucose levels of 0.478 mg/l; 0.588 mg/l; 0.765 mg/l for reaction times of 30, 60, and 90 minutes. In the hydrolysis reaction, the acid serves as a catalyst which aims to speed up the reaction. Acid will affect the decrease in activation energy, so that the reaction runs quickly and the glucose produced will be higher. In Figure 4, it can be seen that the relation between the concentration of the acid solution and the glucose level is that the greater the concentration of the acid solution used, the higher the glucose level will be. With an increase in the concentration of the acid solution or the more concentrated the acid used, it means that the amount of acid available to break down the polysaccharides contained in the sugarcane bagasse into glucose monomers will increase [Ge et al, 2020]. Glucose levels increase with a longer reaction time for hydrolysis [Manurung et al, 2018] which is also shown in Figure 4 by increasing the reaction time, the resulting glucose levels also increase higher.

The use of different concentrations of acid solutions will produce different pH values. At a concentration of 10% and 20% acid solution, pH 3 is produced, and at a concentration of 30% acid solution, pH 2 is obtained. This is because the higher the pH of the immersion solution, the lower the concentration of the acid solution absorbed by the material during immersion, and the other way around [Bernal et al, 2018]. This is in accordance with the results obtained, where at a concentration of 30% acid solution produces a pH of 2 which affects the hydrolysis process in producing the highest glucose levels. At this concentration, sugarcane bagasse absorbs more acid so that the resulting pH is low.

Effect of ash ratio of blood clam shells and sugarcane pulp paste on bioelectrolyte characterization

The prepared bioelectrolyte is inserted into a conventional battery frame with a zinc anode (Zn) and a carbon cathode (C), then the voltage is measured using a multimeter. There are 5 mass ratios of shell ash: sugarcane bagasse paste used as bioelectrolytes. The results of measuring the effect of the ratio of shell ash: sugarcane bagasse paste on the voltage produced by bioelectrolytes are presented in Figure 5.

In Figure 5, the results of the measurement of the bioelectrolyte voltage appear to have decreased for all ratios of shell ash and sugarcane bagasse paste for 3 days. The highest voltase on day 1 was found in the ratio of shell ash : sugarcane bagasse paste 4:1 and the lowest voltase on day 1 was found in the ratio of shell ash : sugarcane bagasse paste 2:3. Overall, for each ratio shell ash : sugarcane bagasse paste 1:1; 1:4; 2:3; 3:2; 4:1 during the 1st day to 3rd day of measurement there was fluctuation or a difference in voltage when the measurements were made, but for the trend of each ratio during the 1st day to the 3rd day it decreased and the ratio of shell ash : paste Sugarcane bagasse 2:3 on day 1 and day 2 experienced a constant decrease in the visible result of voltage. After the voltage measurement is obtained, the next step is to measure the resistance in the bioelectrolyte to be able to calculate the amount of power generated. The measurement of bioelectrolyte resistance can be seen in Figure 6.

In Figure 6, it can be seen that there was an increase in the bioelectrolyte resistance on the 2nd

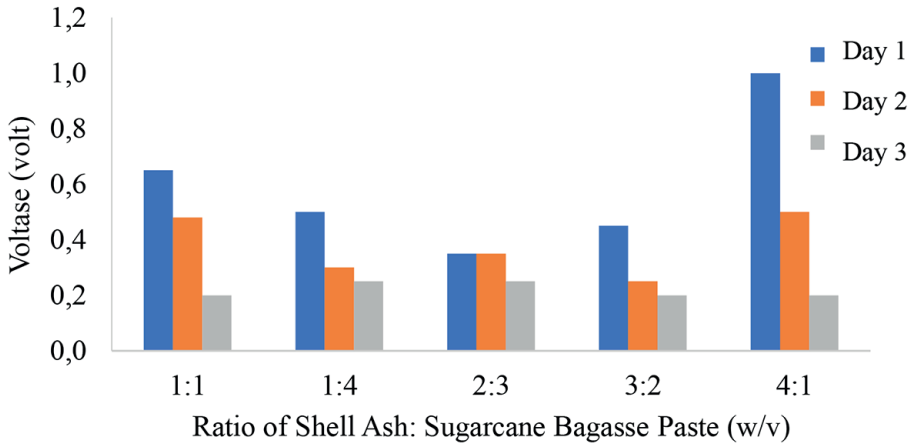


Figure 5. Bioelectrolyte voltage measurement results

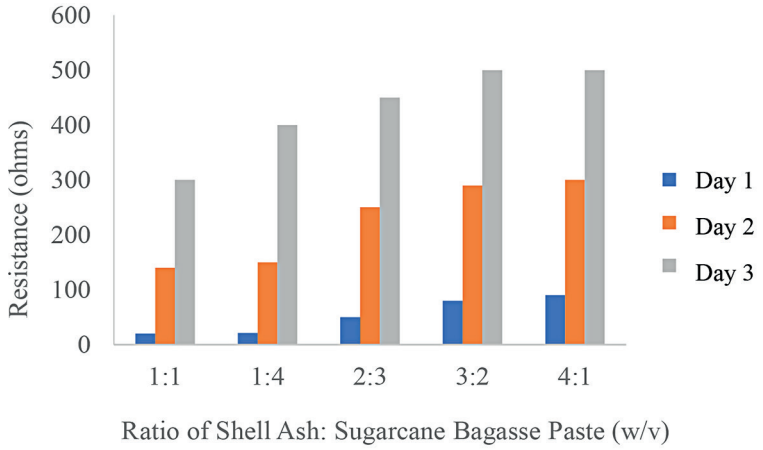


Figure 6. Results of measurement of bioelectrolyte barriers

and 3rd days. This increase occurred in all ratios of shell ash : sugarcane bagasse paste 1:1, 1:4, 2:3, 3:2, and 4:1, respectively. The greater the shell ash ratio used in the bioelectrolyte paste, the greater the resistance value. Where the resistance values on day 1 for each ratio are 20 ohms, 21 ohms, 50 ohms, 80 ohms, and 90 ohms. Meanwhile for the second day, they are 140 ohms, 150 ohms, 250 ohms, 290 ohms, and 300 ohms. The highest resistance was obtained on the 3rd day, namely 300 ohms, 400 ohms, 450 ohms, and 500 ohms.

The increase in resistance for each addition of clam shell ash is due to the smaller particle size causing the movement of electrons in the sample to be more limited so that the electrical resistance obtained will be even greater. The small particle size makes it more difficult for the particles to conduct electric current. The smaller the size, the greater the capacitance produced [Ren et al, 2018]. This is appropriate, where the added blood clam shell ash has a relatively small size, because it passes through the calcination stage. The higher the calcination temperature, the greater the particle size is [Akbarzadeh et al, 2019]. From the measurement of the voltage and resistance obtained on the bioelectrolyte, it can be calculated the amount of power generated. The power generated by the bioelectrolyte can be seen in Figure 7. On the basis of Figure 7, the results of the measurement of bioelectrolyte power appear to have decreased in the measurement period of 3 days. The highest power values were obtained on the first day of measurement for all ratios of shell ash: sugarcane bagasse paste, namely 0.02 watts; 0.01 watts; 0.002 watts; 0.0007 watts; and 0.01 watts for the ratio of shell ash : sugarcane bagasse paste 1:1, 1:4, 2:3, 3:2, and 4:1. At a ratio of shell ash : sugarcane bagasse paste 1:1 produces the highest power value of 0.02 watts and at a ratio of shell ash : sugarcane bagasse 1:4 and 4:1 produces the same power with a value of 0.01 watts while at a ratio of 2:3 and 3: 2

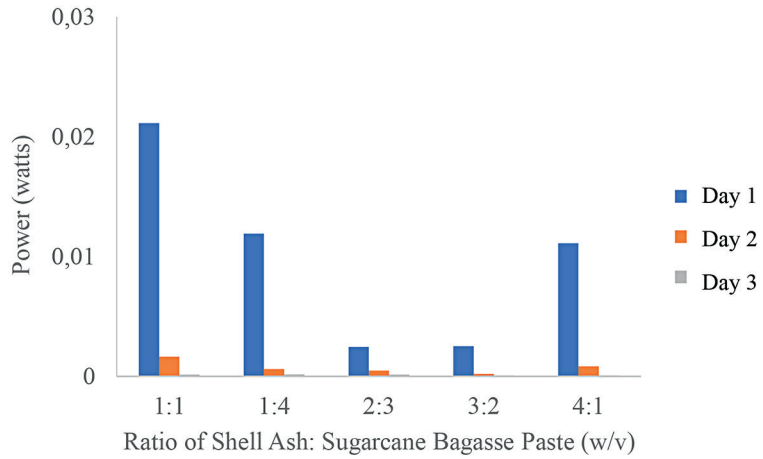


Figure 7. Bioelectrolyte power measurement results

experienced a very significant decrease in power, namely 0.002 watts and 0.0007 watts.

In general, the ratio of shell ash : sugarcane bagasse paste is 1:2; 1:4; 2:3; 3:2; and 4:1 on day 1 to day 3 experienced a decrease in power. However, for each ratio on day 1 to day 3, it fluctuated. This power fluctuation is caused by the value of the voltage and resistance produced by the bioelectrolyte. At a 1:1 ratio, the bioelectrolyte has a uniform electrolyte paste composition so that the density of ion mobility is stable, which in turn is able to produce the highest power of 0.02 watts. At a ratio of 4:1, the bioelectrolyte produces 0.01 watts of power, where at this ratio the shell ash becomes the dominant filler of the bioelectrolyte paste, thus providing a high density of ion mobility. The ratio 1:4 with the same power of 0.01 watts is due to the fact that the distance between the ions of a polymer should not be too close, because ions can combine and form neutral ion pairs that do not contribute to conductivity [Kim et al, 2018]. This is because the addition of the dominant sugarcane bagasse paste to the electrolyte paste makes the paste ions fill the space in the bioelectrolyte and causes the conductivity to increase.

CONCLUSIONS

Reaction time and concentration of acid solution affect the sugarcane bagasse glucose levels. The glucose levels increase with the length of reaction time and the high concentration of acid solution. The best glucose level is produced by using a reaction time of 90 minutes and an acid solution concentration of 30% (v/v). The results of blood clam shell calcination showed a change in sample weight which indicated successful calcination and produced 98.88% of CaO levels. The highest bioelectrolyte power produced is by using bioelectrolyte paste with a mixture of shell ash : sugarcane bagasse paste 1:1. The power generated is 0.02 watts.

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