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Effect of natrium sulphate concentration on indoor lights photovoltaic performance

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Abstract. One of the electron suppliers in a indoor lights photovoltaic system is the Na_2SO_4 electrolyte system. The aim of this research is to know the effect of sodium sulfate concentration on photovoltaic performance of indoor lights photovoltaic. The method used is liquid electrolyte system and gel electrolyte system made with various concentration on planar photovoltaic cell design using $\text{Cu}_2\text{O}/\text{Al}$ electrode plate. The ability of the Photoreactor is evaluated to obtain the characteristic curve of I-V at each Na_2SO_4 concentration. The average daily average power produced at concentrations of 0.25 M (gel), 0.5 M (gel), 0.75 M (solution), and 1 M (solution) were 14.218 μwatt , 6.688 μwatt , 38.334 μwatt , and 23.715 μwatt , respectively. The electrode plate used thin plate $\text{Cu}_2\text{O}/\text{Al}$ is 0.00246804 m^2 . The most optimum indoor lights planar photo-reactor is at a concentration of 0.75 M, with a daily average power performance for each square meter of 15.532 mWatt. Maximum power produced Photoreactor is achieved at a concentration of 1 M, ie 37.83245 mwatt/m^2 .

1. Introduction

The energy that is continually generated from the natural process becomes the only solution to meet the ever-increasing human energy needs [1-3]. Until now, fossil fuels including coal, oil and natural gas are still the main suppliers of energy for human civilization in this industrial age. Most fossil fuels cause problems, among other things, air pollution from coal and petroleum combustion. Therefore, one of the efforts to overcome the current energy crisis is to seek alternative energy sources [4-6].

One of the electron suppliers in a photovoltaic system is an electrolyte solution, eg a sodium sulfate salt (Na_2SO_4) [7-10]. The electrolyte system provides electrons that can move in photovoltaic systems to generate electric current through photon and semiconductor $\text{Cu}_2\text{O}/\text{Al}$ interaction processes [11,12]. The design and modification of electrodes has been widely applied to activate the semiconductor surface in visible light [13-20]. The next design developed is a photoreactor that works effectively and efficiently on visible light, such as the planar wall design and hexagonal geometry [7,14].

The salt electrolyte solution Sodium Sulfate is one of the best sources of electrons for the transportation and energy transformation of liquid photovoltaic systems. The limitations of the electrolyte system in the liquid phase are transformed into the solid phase through the formation of gel electrolyte. This electrolyte modification aims to prevent solvent evaporation thereby decreasing the electrolyte's performance in supplying electrons into the photovoltaic system. Previous research on Sodium Sulphate electrolyte is at a concentration of 0.5 M in the gel electrolyte system [1,7,21-23].



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Meanwhile, the effects of photoreactor geometries have been widely developed to gain the performance of indoor lights photovoltaic in generating electrical energy. On the other hand, the effect of the electron supply concentration has not been further studied, either on the solution system or on the gel system. In this research we studied the effect of Na_2SO_4 electrolyte concentration at concentrations of 0.25 M, 0.5 M, 0.75 M and 1 M on the performance of light photoreactors looked with planar design.

2. Experimental Section

2.1. Tools and Materials

The materials used are Sodium Sulphate salt (Na_2SO_4 , Merck), aquades, silicon glue, copper pipe, flour agar (production of PT Satelit). The tool used is glass with a thickness of 3 mm (PT Asahimas), Multimeter (Heles), furnace and magnetic stirrer.

2.2. Procedure and Methode

2.2.1. Electrode Assembling. Electrode used is electrode $\text{Cu}_2\text{O}/\text{Al}$ with pipe-shaped. Making copper electrode is by using copper pipe and cut along 15 cm. Copper pipe is still reddish colored then calcined at a temperature of 400°C for 1 hour[10].

2.2.2. Power Measurement and Photoreactor Performance. The Na_2SO_4 solution of each concentration 0.25 M, 0.5 M, 0.75 M and 1 M were prepared as electrolyte solution. The $\text{Cu}_2\text{O}/\text{Al}$ Electrode Pipe is incorporated into the assembled design and contains the Na_2SO_4 electrolyte solution with various concentrations. The photovoltaic system that has been assembled is then observed for 4-5 days with varying measuring time ie, at 09.00 WIB, 12.00 WIB, and 15.00 WIB. During measurement, the light intensity of the indoor is measured by a light meter. Measurements made are the currents and strands generated by Planar Design Photoreactor 1 as shown in figure 1.

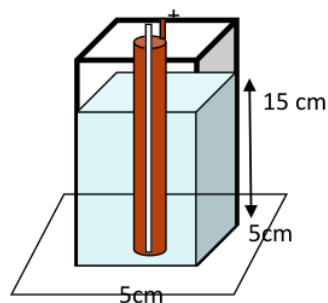


Figure 1. Design of photovoltaic $\text{Cu}_2\text{O}/\text{Al}$ Planar Model

3. Results and Discussion

Indoor lights exposed to photovoltaic cells causes an increase in electron excitation in Cu_2O semiconductors. In this study, photovoltaic cells were observed for 4-5 days, with different measurement times, ie; at 09.00 WIB, 12.00 WIB, and 15.00 WIB. The purpose of this 4-5 day measurement is to observe the stability of the photoreactor made. Optimum photovoltaic cell measurements on day 4. Furthermore, photovoltaic cells decreased in their ability.

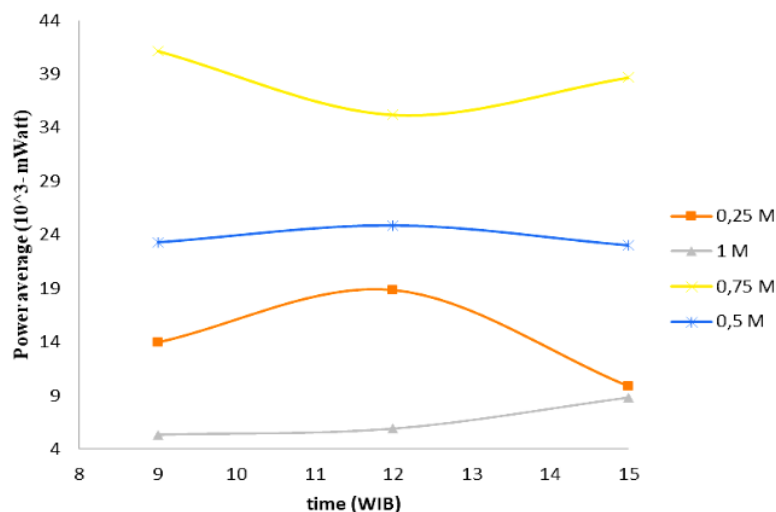


Figure 2. The performance of photovoltaic cells in various variations of Na_2SO_4 electrolyte concentration

In figure 2, the ability of photovoltaic cells increased at 12.00 WIB at concentrations of 0.25 M (gel), 0.5 M (gel), and 1 M (solution), but decreased at a concentration of 0.75 M (solution). This change can be explained as a result of molecular interactions between water molecular groups and ionic ions in the electrolyte system. Trimer-shaped water clusters, pentamer and heptamer will interact with Sodium ions and Sulfate ions in the electrolyte system. The degree of freedom of a specific species in the electrolyte system influences the ability of photovoltaic cells to transform light energy into electrical energy. At concentrations of 1 M, the concentration of the electrolyte system pushes the water molecules out of the system and tends not to move freely, thus decreasing the electrolyte's ability to respond to energy changes in the Photoreactor.

At 12.00 WIB (average flux of 4121.64 lx), the intensity of sunlight is higher than at 09.00 WIB (average flux of 4031.44 lx) and at 15.00 WIB (average flux of 3994.48 lx). The intensity of light measured on average shows an increase during the day (at 12.00 WIB), causing an increase in molecular vibration and translational movement as well as rotation of the specific species in the electrolyte system. The light intensity factor is what drives the increased power generated photoreactor at 12.00 WIB. The flow of electrons in a photovoltaic cell system causes the formation of voltage and electric current in visible light photovoltaic systems[13].

The stability of Planar Light Photoreactors appears to be tested for 4-5 days. The ability of photovoltaic cells to transform visible light into electrical energy can be seen in figure 3. Figure 3 shows the increase of photoreactor ability on day 2 at concentrations of 0.75 M and 1 M, and decreases on day 3. This decrease in ability occurs due to partial water molecules that transition from the liquid phase to the vapor phase, so that the movement of ionic ions in the electrolyte system decreases. At concentrations of 0.75 M and 1 M, the photovoltaic electrolyte system is a liquid phase or homogenous Na_2SO_4 solution. In this solution system, ion ions move more freely so that the process of converting light energy into electrical energy goes well.

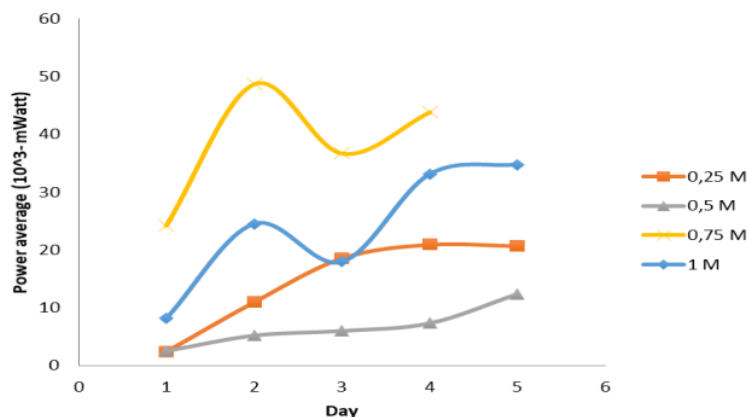


Figure 3. Stability of Planar Photoreactors

At concentrations of 0.5 M and 0.25 M, the photoreactor produces increased power up to the 3rd, 4th and 5th days. The increase in photoreactor performance is due to the electrolyte system at a concentration of 0.5 M and 0.25 M having a solid phase (gel). In this phase, the electrolyte system is in a rigid condition so that the molecular movement of water molecules and ion ions is localized to a particular region. The interactions between Sodium and Sulfate ion ions with water molecules do not take place independently, such as molecular interactions at concentrations of 1 M and 0.75 M. The inactivity of the electrolyte species of 0.5 M and 0.25 M interacts more freely, causing the limitation of the photoreactor's ability to generate electrical power. On the other hand, however, it is in the presence of this solid phase that it causes the electrolyte enhancement and stability to supply electrons to the visible planar light photoreactors.

At a concentration of 0.25 M in a solid phase, the Sodium and Sulfate ions are more freely moving and have the indoor to molecularly vibrate to provide a bridge to the process of electron migration in the photovoltaic process. Electrons derived from the valence band (PV) on the Cu_2O semiconductor will be excited to the Conduction Tape (PK). This excitation is triggered by a bluff of visible light photons. The electrons in the conduction band (PK) will be trapped in a sea of ion-rich ions from sulfate ions resulting in the flow of electrons in the photovoltaic cell. This is the electron flow that causes the electric current from the Photoreactor.

The performance of photovoltaic cells is maximally achieved at the concentration of 1 M Na_2SO_4 , as shown in the I-V characteristic curve (Flow-voltage) in figure 4. In this condition, the photoreactor produces a maximum voltage of 0.753 mV and a maximum current of 0.124 mA, resulting in 0.093372 mWatt power. Since the cross-sectional area of the $\text{Cu}_2\text{O}/\text{Al}$ pipe electrode is 0.00246804 m^2 , the maximum power per unit area is 37.83245 mWatt/ m^2 .

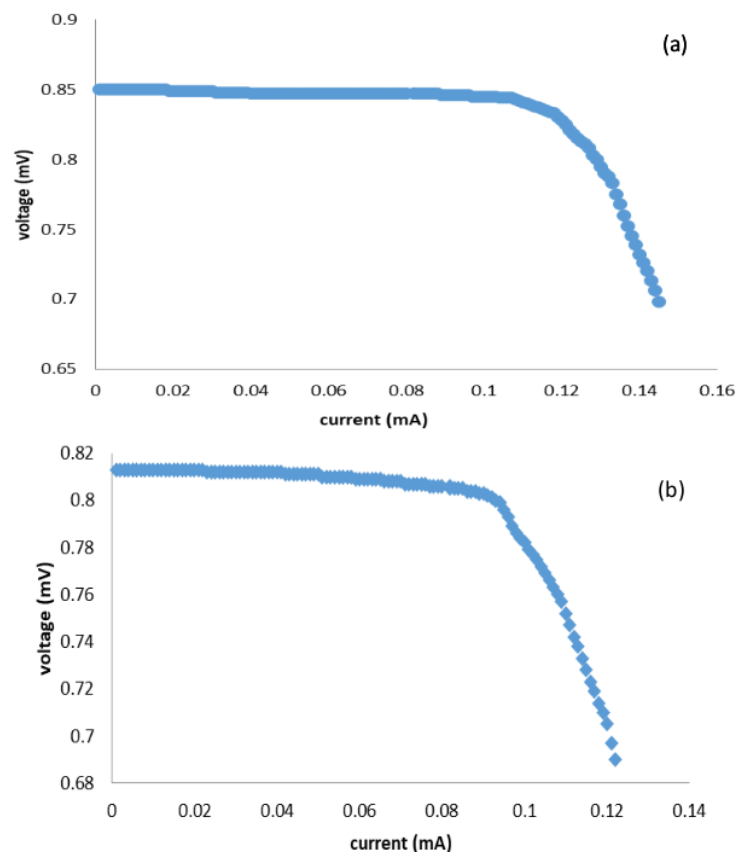


Figure 4. The characteristic curve of I-V Photoreactor at the concentration of Na₂SO₄ 1 M (a) and 0.75 M (b)

At a concentration of 0.25 M, the Photoreactor produces a maximum voltage yield of 0.330 mV and a current of 0.06 mA. The maximum power generated in per unit area is 8.02256041 mwatt/m². At 0.5 M Na₂SO₄ concentration, a maximum voltage of 0.656 mV and a maximum current of 0.121 mA, with a maximum power of 32.1615533 mwatt/m². At a concentration of 0.75 M Na₂SO₄, the photovoltaic cell produces a maximum voltage of 0.747 mV and a maximum current of 0.128 mA. Maximum power at this concentration of 0.75 M reaches 38.7416736 mwatt/m². Based on the I-V curve as shown in figure 5, the Photoreactor characteristics produce maximum power achieved at 1 M concentration. This is because, the higher the electrolyte salt concentration, the higher the photovoltaic performance converts light to electrical energy[8].

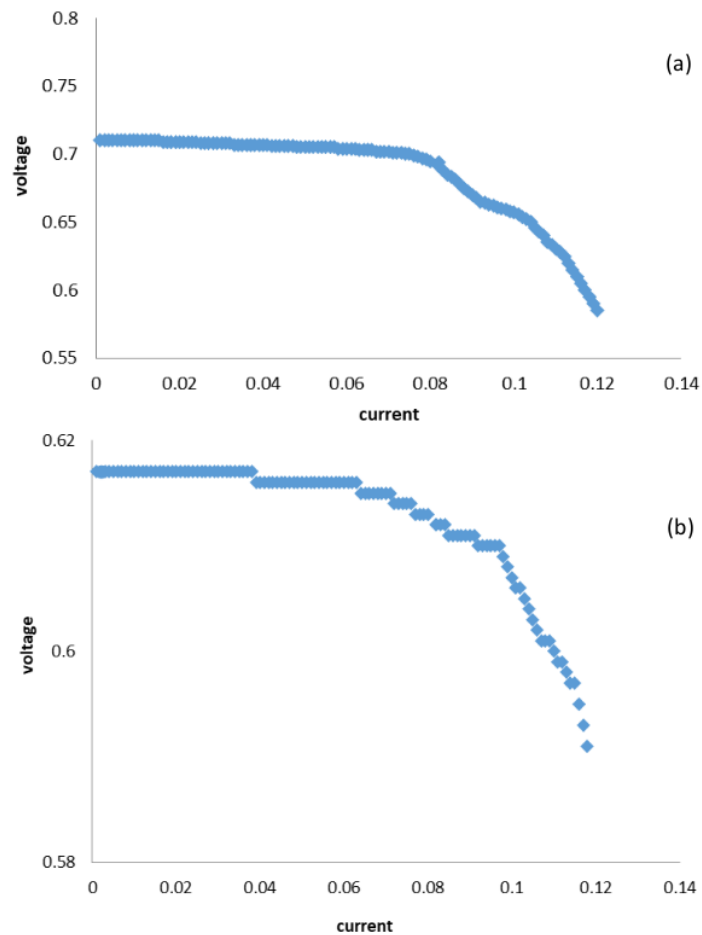


Figure 5. I-V characteristic curve Photoreactor at Na_2SO_4 concentration 0.5 M (a) and 0.25 M (b)

4. Conclusions

The indoor lights planar photoreactor with the design as shown in Fig. 1 is capable of producing a maximum power of $38.7416736 \text{ mwatt/m}^2$ at a concentration of 1 M Na_2SO_4 M. Natrium Sulphate concentration is instrumental in increasing the photoreactor's performance to convert visible light to electrical energy. The concentration effect is related to the role of ionic ions in supplying electrons for the occurrence of photovoltaic effects in the electrolyte system. The availability of water becomes a variable in cell stability, which causes the most optimum photoreactor performance to be achieved at a concentration of 0.75 M.

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