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Research Article

Effect of Nanoparticle Ag on Wet Accumulator Performance

Febri Rismaningsih[1,a] and ,Januar Widakdo [2,3b*]

[1]Civil engineering, Faculty of engineering, Universitas Islam Syekh-Yusuf, Tangerang, Indonesia
[2]Graduate Institute of Applied Science and Technology, Advanced Membrane Materials Research Center, National Taiwan University of Science and Technology, Taipei 10607, Taiwan
[3]Department of physics education, Universitas Negeri Yogyakarta, Bulaksumur, Yogyakarta, Indonesia

e-mail: [a]frismaningsih@unis.ac.id, and [b]D10722817@mail.ntust.edu.tw
* Corresponding Author

Abstract

Energy is the most important and inevitable requirement for humankind. The increasing energy demand has been connected with technological advances and population growth. One of the world's most serious problems is providing sustainable energy. New alternative energy sources and renewable energy technologies have become notable research subjects due to the wide availability of renewable energy sources in the world. However, most renewable energy sources do not provide uninterrupted energy to consumers. This study aims to determine the resistance of the Ag nanoparticle using the UV-Vis spectrophotometer test. It determines the wavelength of Ag absorption, the output voltage characteristics, and the light intensity of the lamp produced from a wet accumulator with the addition of Ag nanoparticles. This research was started by making a solution of Ag nitrate ($AgNO_3$) and a trisodium citrate ($Na_3C_6H_5O_7$) solution, then synthesizing Ag nanoparticles with a concentration of 3 mM, 4 mM, and 5 mM about 2 ml using the bottom-up method and chemical reduction. The results showed that Ag nanoparticles were suitable for use within three days and the Ag absorption wavelength was 328.1 nm. The output voltage on the wet accumulator without adding Ag nanoparticles lasts longer than the accumulator added by Ag nanoparticles. It can be seen clearly from the speed at which the voltage drops. For the light intensity produced by the pure wet accumulator, the H_2SO_4 solution was measured to be great and went out longer than the wet accumulator added with Ag nanoparticles. This research concluded that Ag nanoparticles with a concentration of 3 mM, 4 mM, and 5 mM in the H_2SO_4 solution reduce the performance of the wet accumulator.

Keywords: *Ag nanoparticles; wet accumulator; voltage; light intensity.*

Pengaruh Nanopartikel Ag Terhadap Kinerja Akumulator Basah

Abstrak

Energi adalah kebutuhan yang paling penting dan tak terelakkan bagi umat manusia. Kebutuhan energi yang semakin meningkat telah dikaitkan dengan kemajuan teknologi dan pertumbuhan penduduk. Salah satu masalah paling serius di dunia adalah menyediakan energi yang berkelanjutan. Sumber energi alternatif baru dan teknologi energi terbarukan telah menjadi subjek penelitian penting karena ketersediaan luas sumber energi terbarukan di dunia. Namun, sebagian besar sumber energi terbarukan *tidak menyediakan energi kepada konsumen. Penelitian ini bertujuan untuk mengetahui resistansi nanopartikel Ag menggunakan uji spektrofotometer UV-Vis. Hasil penelitian ini menentukan panjang gelombang serapan Ag, karakteristik tegangan keluaran, dan intensitas cahaya lampu yang dihasilkan dari akumulator basah dengan penambahan nanopartikel Ag. Penelitian ini dimulai dengan membuat larutan Ag nitrat ($AgNO_3$) dan larutan trisodium citrate ($Na_3C_6H_5O_7$), kemudian mensintesis nanopartikel Ag dengan konsentrasi 3 mM, 4 mM, dan 5 mM sekitar 2 ml menggunakan metode bottom-up dan reduksi kimiawi. Hasil penelitian menunjukkan bahwa nanopartikel Ag sesuai untuk digunakan dalam waktu tiga hari dan panjang gelombang serapan Ag adalah 328,1 nm. Tegangan keluaran pada akumulator basah tanpa penambahan nanopartikel Ag bertahan lebih lama dibandingkan dengan akumulator yang ditambahkan nanopartikel Ag. Hal ini dapat dilihat dengan jelas dari kecepatan penurunan tegangan. Untuk intensitas cahaya yang dihasilkan akumulator basah murni, larutan H_2SO_4 terukur lebih besar dan keluar lebih lama dibandingkan akumulator basah yang telah ditambahkan nanopartikel Ag. Dari penelitian ini disimpulkan bahwa nanopartikel Ag dengan konsentrasi 3 mM, 4 mM, dan 5 mM dalam larutan H_2SO_4 menurunkan kinerja akumulator basah.*

Kata Kunci *: Nanopartikel Ag; Akumulator basah; Tegangan; Intensitas Cahaya.*

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I. INTRODUCTION

Nowadays, the development of nanotechnology continues to be carried out by researchers [1]. Researchers are competing to create new works in nanotechnology, either from the academic or industrial worlds [2,3]. An area of interest to many researchers is the development of nanoparticle synthesis methods. Nanoparticles can occur naturally or through the process of synthesis by humans [4-6]. Nanoparticle synthesis means the creation of particles with a size of less than 100 nm and simultaneously changing their properties or functions [7-10]. From an energy point of view, nanotechnology is considered a potential resource that will generate enormous amounts of thermal and mechanical energy and convert it into electrical energy [11-13]. Energy is a primary need in modern human life today. Almost all aspects of life require energy. Now, along with the development of science, energy requirements are increased [14-17]. Most of the energy used is a conventional energy source that comes from nature and cannot be renewed. Traditional energy sources that cannot be renewed are coal and natural gas. The increasing need for energy is currently causing energy sources for oil and coal to become increasingly depleted [18-21].

To deal with the energy supply that is getting depleted day by day, humans create various technologies to overcome this energy scarcity. One of them is by keeping energy using the battery. A battery can produce DC voltage by converting chemical energy into electrical energy through electrochemical reactions [22,23]. Various types of batteries are created, varying from those made from dry and wet elements [24].

One of the batteries made of wet elements is a battery or accumulator. The accumulator is a device that can store energy, generally electrical, in chemical energy [25]. The battery is a very vital component in motorized vehicles and automobiles. The development of accumulators is also fast until now. There are three types of battery generations created. The development of accumulator electrolyte solutions became the spotlight of researchers. The electrolyte solution for accumulator fillers from the first to the third generation is made from a mixture of water and sulfuric acid (H_2SO_4) [26,27].

In recent years, no studies have been modifying the electrolyte solution in wet accumulators. In fact, a solution of water and sulfuric acid (H_2SO_4) can improve its performance if mixed with a solution containing a good electric source.

Herein, we present the development of the battery. It combines Ag nanoparticles with an H_2SO_4 solution. This research was conducted to determine the effect of adding Ag nanoparticles to the accumulator electrolyte solution (H_2SO_4) on the measured output voltage and light intensity. Nanotechnology is considered a potential power source that will generate enormous amounts of thermal and mechanical energies and can convert them into electrical.

II. METHOD

This research broadly includes seven stages. The first is material preparation. The second is manufacturing $AgNO_3$ solutions with varying concentrations from 3 mM to 5 mM. The third is the manufacture of 1% $Na_3C_6H_5O_7$ solutions. The fourth is the synthesis of Ag nanoparticles. The fifth is Ag nanoparticle testing with the Tyndall effect and UV spectrophotometer. The sixth is the addition of Ag nanoparticles to all accumulator cells. Lastly, the measurement of light intensity and output voltage on the battery.

The material preparation was carried out by preparing the ingredients, namely $AgNO_3$, $Na_3C_6H_5O_7$, 30% H_2SO_4 solution, and distilled water. The first stage was making an $AgNO_3$ solution with a concentration of 5 mM. 0.85 grams of $AgNO_3$ is dissolved with 1000 ml of distilled water. After that, a variation of $AgNO_3$ concentration of 4 mM and 3 mM was made, for a concentration of 4 mM by adding a solution of $AgNO_3$ with a concentration of 5 mM using distilled water of 20 ml, as well as for a concentration of 3 mM by adding a 5 mM concentration of $AgNO_3$ solution using 10 ml of distilled water.

The stage of making 1% $Na_3C_6H_5O_7$ solution is dissolving 0.5 grams of $Na_3C_6H_5O_7$ with 50 ml of distilled water. Next, the 2 ml Ag nanoparticle synthesis stage was followed by inserting the $AgNO_3$ solution into a test tube, after which it was heated at 100 ℃ for ± 10 minutes. After 10 minutes, 5 drops of 1% $Na_3C_6H_5O_7$ solution were added using a dropper, then waited for the color of the solution to turn yellow (see Figure 1).

Next is the testing of Ag nanoparticle solution with Tyndall effect and UV-Vis spectrophotometer. Tyndall effect test was conducted to determine the quality of $AgNO_3$ solution, which has formed nanometer-sized colloidal particles. After that, it was re-tested quantitatively using a UV-Vis spectrophotometer. The UV-Vis spectrophotometer test shows the absorbance value of a solution with a particular wavelength.

The next step is mixing the Ag nanoparticle solution with a battery solution (30% H_2SO_4). The mixing is carried out outside the accumulator cell before being inserted into each comparator. After being included in all accumulator comparators, the next step is to measure the output voltage and the light intensity of the lamps produced by the accumulator.

III. RESULTS AND DISCUSSION

Based on the research result, the synthesized Ag nanoparticles change color to yellowish (Figure 1).

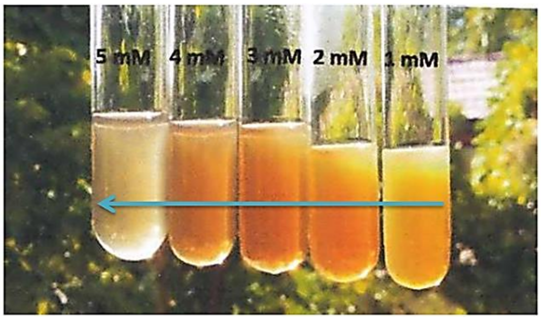

Figure 1. Ag Nanoparticles with Different Concentrations

Solution of Ag nanoparticles was tested using the Tyndall effect. This test aims to see the colloidal particles formed after the synthesis [28]. The results of the Tyndall effect can be seen in Figures 2 a-b. The laser beam shot at the Ag nanoparticle solution is scattered to show bright red scattering in the solution. The solution contains colloidal particles, which are expected to be nanometers in size. However, Figure 2b showed the Ag nanoparticle agglomerated and became a particle that settled below. It is assumed that the quality of the liquid is not good and will then be proven by the UV-Vis test.

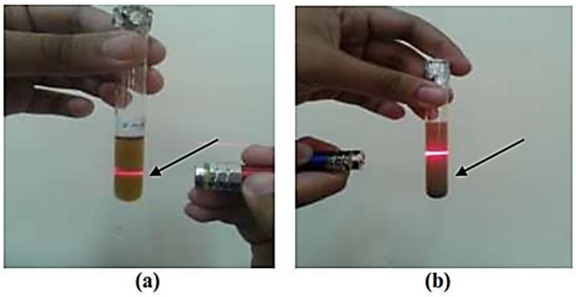

Figure 2. **Testing with The Tyndall Effect Method on 5 mM of Ag Nanoparticles Solution on (a) the First and (b) Seventh Days**

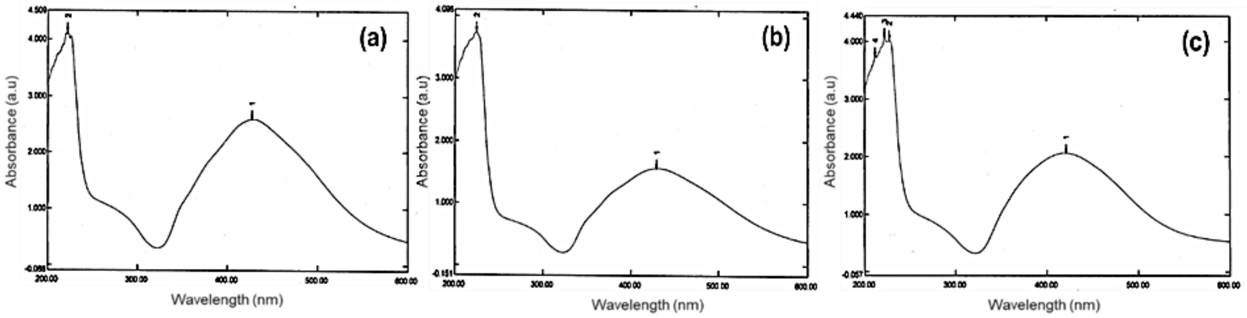

Figure 3. Comparison of UV-Vis Spectrophotometer Results in 2 ml of Ag Nanoparticle Solution with Various Concentrations of (a) 3 mM, (b) 4 mM, (c) and 5 mM

UV-vis spectroscopy results of 3 mM, 4 mM, and 5 mM Ag nanoparticles

Figure 3 shows the UV-Vis test with different Ag nanoparticle concentrations. Ag nanoparticle solutions had absorbance peaks at different wavelengths. UV-Vis results of Ag nanoparticle solution with a concentration of 3 mM had an absorbance value of 2.593, at a wavelength of 427.50 nm. The UV-Vis results of the Ag nanoparticle solution with a concentration of 4 mM had an absorbance value of 1.563 at a wavelength of 429.50 nm [29,30]. The UV-Vis results of the Ag nanoparticle solution with a concentration of 5 mM had an absorbance value of 2.064 at a wavelength of 421.50 nm [31,32]. From the results obtained, it can be seen that Ag nanoparticles with a concentration of 3 mM tended to be more absorbent than Ag nanoparticles with a concentration of 5 mM. This absorbance value indicates that nanometer-sized colloid particles have been formed, and some particles can absorb light at a particular wavelength. Ag^+ ion concentrations (5 mM), and relatively larger particle size (3 and 4 mM) distributions were observed [32].

Moreover, Figures 4a-c show the UV-Vis result of Ag nanoparticle samples continuous for three days. Continued testing of Ag nanoparticle samples aims to determine how long the sample can last in nanometer size and determine the suitability of the sample for use in a solution of battery (30% H_2SO_4).

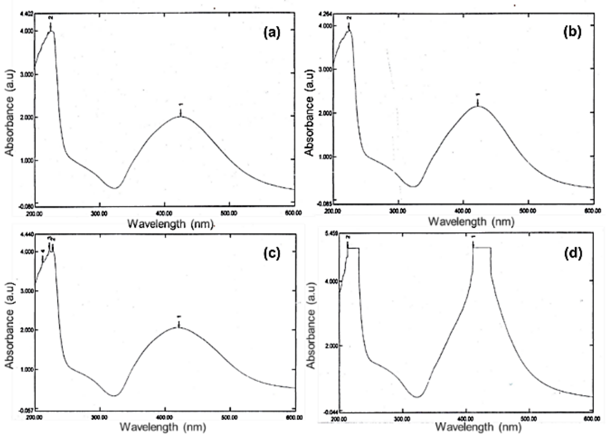

Figure 4. Comparison of UV-Vis Spectrophotometer Results in 2 ml Ag Nanoparticle Solution with a Concentration of 5 mM (a) Ag Nanoparticles on the First, (b) Second, (c) Third, and (d) Seventh Day

From Figures 4a-c it can be analyzed that the solution can be used for three days from the first day. The feasibility of the sample is shown from the UV-Vis results graph, which shows that the first day to the third day still has one graph peak. The difference in the absorbance value was clear. With more days, the absorption is getting higher. Ag nanoparticles were tested using UV-Vis spectrophotometry for three days of continuous testing to the seventh day.

UV-Vis testing on Ag solution, which was allowed to stand on the seventh day, can be seen in Figure 4d. The UV-Vis spectrophotometry test was very different from the first, second, and third days. The seventh-day chart shows that two absorbance peaks are the same but at different wavelengths. Researchers can assume that the samples on the seventh-day show Ag nanoparticles still exist but very few because the nanoparticles formed are at the required wavelengths in the range of about 435-480 nm and because the Ag nanoparticles solution is dark yellow.

Performances of Wet Accumulator

The measurement of the pure accumulator output voltage can be seen in Figure 5(a) and Table 1. The voltage drop rate in a wet accumulator without adding Ag nanoparticles is 0.49 V/min. After that, when adding Ag nanoparticles with concentrations of 5 mM, 4 mM, and 3 mM, the value of the increase in the voltage drop rate increased to 0.56 V/min, 1.01 V/min, 1.08 V/min, respectively.

Table 1. The Quantitative Data of Gradient Voltage After Adding Ag Nanoparticles

Ag nanoparticle concentrations in Accu	Time starting constant (min)	Gradient or speed of voltage drop (V/min)
3 mM	09	1.08 ± 0.03
4 mM	11	1.01 ± 0.01
5 mM	17	0.56 ± 0.02
Without Ag nanoparticles	20	0.49 ± 0.01

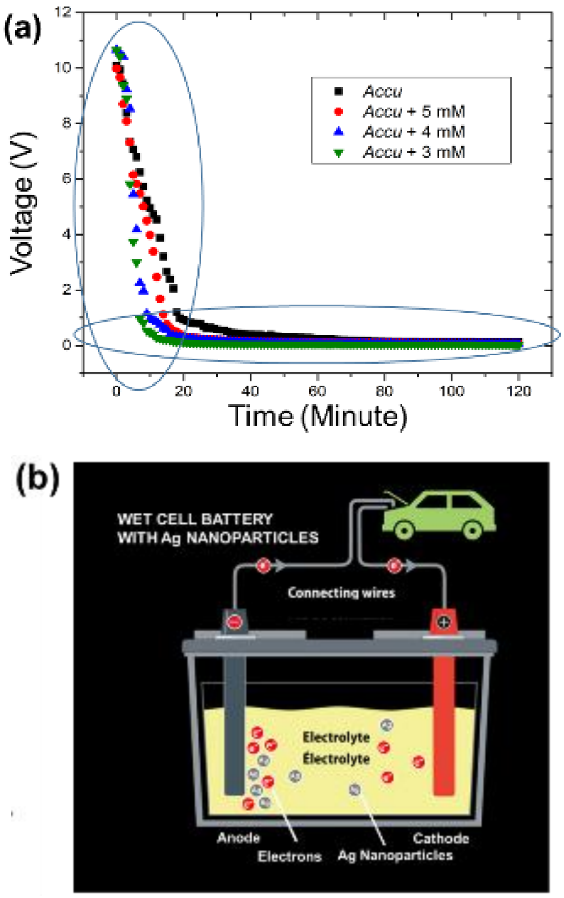

Figure 5. (a) The graph of The Comparison of the Output Voltage Produced by the Wet Accumulator with The Added Variation of The Silver Nanoparticle Concentration, and (b) Schematic Figure of Ag Nanoparticle in Wet Accumulator

The battery output voltage data results show that the output voltage speed decreases with the addition of Ag nanoparticles. The addition of Ag nanoparticles caused a significant decrease compared to the absence of Ag nanoparticles. However, the reduction in voltage is inversely proportional to the concentration of Ag molarity. The higher the molarity, the slower the voltage drop. The voltage reduction rate for a concentration of 3 mM Ag nanoparticle is greater than the concentration of 4 mM, 5 mM, and without adding nanoparticles.

Figure 5(b) shows the schematic of Ag nanoparticles on the system. Ag will interact with electrons from the H_2SO_4 solution and inhibit electron movement through the anode to the cathode.

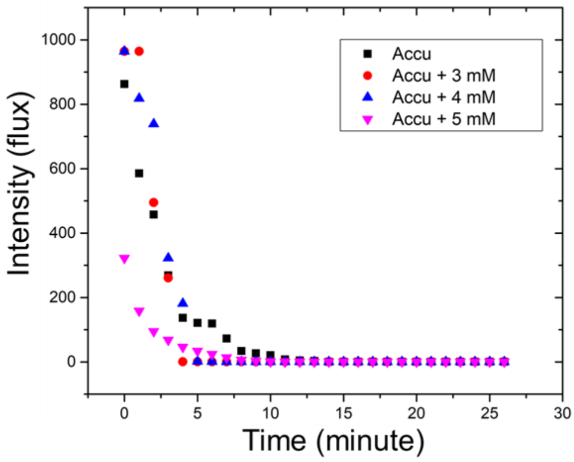

Figure 6. The Graph of the Comparison of Light Intensity Produced by The Wet Accumulator with The Added Variation of The Ag Nanoparticle Concentration

Figure 6 illustrates the graph of the intensity of the lamplight generated from the accumulator with Ag nanoparticles and without the addition of Ag nanoparticles. From the resulting graph, it can be physically interpreted that the lamp's intensity without adding Ag nanoparticles decreased significantly compared to the presence of Ag nanoparticles. The change in the lamp's flame is directly proportional to the current of electrons flowing in the solution from the cathode to the anode. Ag nanoparticles are assumed to accelerate the process of chemical reactions in the solution because Ag nanoparticles are catalytic agents.

After measuring the light intensity, a graph of the time when the lights go out is obtained. It can be seen that the accumulator given the nanoparticles extinguishes faster than the accumulator, which is pure only H_2SO_4 solution. But the impact of Ag nanoparticles is concentration-dependent. The smaller the Ag nanoparticle concentration, the quicker the light goes out. After conducting experiments on the light intensity and the output voltage generated from the accumulator, it was found that the tendency of Ag nanoparticles with a concentration of 3 mM, 4 mM, and 5 mM added to the H_2SO_4 solution was more inhibited the output voltage of the accumulator. Still, it cannot be concluded whether the solution with a concentration greater than 5 mM can increase the performance of the battery or not. Additional research is needed to strengthen further the assumption that Ag nanoparticles with all variations of molarity can affect these batteries.

Table 2 shows a table comparison of the degradation (discharge) of wet accumulators using several methods. In the table shown, impregnating electrolytes using $(C_2H_5)_4NBF_4$ have a fairly stable degradation voltage of 2.5 V/min. They were followed by this study using $AgNO_3$ of 1.08 V/m.

Table 2. The Comparison Data for Degradation Volt with Other Studies

Method	Materials	Degradation of voltage (V/min)	Reference
Sol-Gel Pyrolysis	$Pb(NO_3)_2$	0.003	[33]
Electrolytes impregnating	$(C2H5)_4NBF_4$	2.5	[34]
Mixed additives materials	($Ca(OH)_2$, PbO and PEG)	0.006	[35]
Conducting polymer solution	PAni	0.7	[36]
Mixed solution	$AgNO_3$	1.08	This work

IV. CONCLUSION

Ag nanoparticles in free air will last about three days from the first day of manufacture before being added to the battery. After more than seven days, Ag nanoparticles could not be used anymore because the UV-Vis test results showed damage to the sample. Also, the Tyndall effect test showed precipitation in the solution. Adding Ag nanoparticles to the wet accumulator provides a more incredible speed of dropping the output voltage than the accumulator without Ag nanoparticles. The light intensity of the lamp produced by pure H_2SO_4 solution is greater than the intensity with Ag nanoparticles. However, the lowest concentration of Ag nanoparticles gave low intensity. This is directly proportional to the time when the lights go out. Thus, Ag nanoparticles are unsuitable to be inserted into the accumulator due to the nanoparticles only acting as a catalyst, which is a reaction rate inhibitor.

The limitation of this research is the lack of references or research that has been done previously. For this reason, the sustainability of this research will always try to innovate using various types of nanoparticles that can be mixed in a wet accumulator solution to improve the performance. The impact of this research is that it can be a reference for future researchers who focus on physics with battery specifications.

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