Measurement of standard glucose solution using silver nanoparticle

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Abstract. This study aims to determine the effect of using silver nanoparticles on electrodes to measure standard glucose solutions using the voltammetry method. In this study, silver nanoparticles were used which have been present and have been synthesized and characterized by using the extract agent of water extract of Myrmecodia pendants and AgNO₃ as metal precursors. Detection of glucose with variations in concentration characterized by limit detection obtained a concentration of detection limit of 4.53 mM and sensor sensitivity of 1.91 A.mm⁻¹.mM⁻¹.

1. Introduction

The development of nanoparticle technology or often referred to as nanotechnology can provide special functions or modifications to various applications especially applications in sensors. Nanoparticles are particles with a nanometer size, which is about 1 - 100 nm [1]. This is because the nanoparticle material has a very small particle size and its surface properties can be easily adjusted and changed according to its utilization. The shape and size of nanoparticles is very important in determining optical, electrical, magnetic and catalyst properties. Silver nanoparticles are nanotechnology-based products that are currently developing and can be applied as catalysts and optical sensor detectors [2]. Factors that can influence nanoparticle size are solution temperature, salt concentration, reducing agent and reaction time [3]. The development of nanoparticles that have been applied as sensors by using plants as bioreductors.

The biosensor method is carried out because it has several advantages which include high selective and sensitive levels, high accuracy, easy operation, fast response and can be used continuously [4]. Determination of glucose in the blood using the biosensor method is often carried out and continues to develop. This method of determining glucose using biosensors was carried out by Uang dan Chou (2003) [5], where glucose was detected using a modified gold electrode with polypyrrole and glucose oxidase enzyme. Another study in determining glucose using silver electrodes modified with pasta. Modified electrodes have a good enough sensitivity to glucose and good stability. Mixing silica with hybrid material for glucose biosensors [6]. Mixing silica, carbon and pasta forming enzymes has been done to determine glucose. Silica and carbon are intended as a medium for transferring electrons, as well as the use of gold and silver in the form of nanoparticles as a conductive support material for transferring electrons properly. Modification of silica for coating magnetic materials from iron sand with aminobenzimidazole using the sol-gel method was successfully carried out [7]. The same study of 2-aminobenzimidazole (AB) and 1-(otolyl) biguanide (TB) modified silica coated with iron magnetic sand material (MM @ SiO2 / AB and MM @ SiO2 / TB has been synthesized and provides...
high selectivity to metals [8]. The synthesis and characterization of silver nanoparticles has been done previously to detect glucose in the blood [9]).

This inspired to make sensors from electrodes modified with silver nanoparticles. In this study the electrodes used to detect glucose were platinum electrodes modified with silver nanoparticles which were synthesized using bioreductors from the plant *Myrmecodia pendans*.

2. Materials and methods

2.1. Instrument

The tools that will be used in the research are analytic balance (Acculab), voltmeter (ED410), beaker, drop pipette, Erlenmeyer, measuring flask, stirring rod, spatula, petri dish, platinum wire and Ag / AgCl electrodes.

2.2 Materials

Some of the materials used in the study are glucose, silver nanoparticle solutions that have been synthesized in advance, PAA (Sigma Aldrich), aquabides, aluminum foil, and NaOH (Merck).

2.3 Procedure

2.3.1 Making a standard glucose solution. A standard glucose solution of 10 mM was prepared by dissolving 1.8 g of glucose with aquabides to 1000 mL. Next dilution is done to get glucose concentration with a variation of concentration between 1 mM - 10 mM.

2.3.2 Preparation of Silver Electrode. Platinum wire cut to 3 cm in length. The platinum electrode is washed using distilled water and dried. One surface of the electrode is cleaned with sandpaper. This electrode is called a platinum electrode without modification. Then this electrode is ready for use. The second working electrode was carried out by modifying platinum electrodes with silver nanoparticles. The deposition of silver nanoparticles was carried out by LBL technique (layer by layer), namely silver wire dipped in 1% polyacrylic acid solution for 30 minutes, then rinsed with aquabides, and dipped in silver nanoparticle suspension for 15 minutes, and rinsed with aquabides again. This cycle is repeated three times. Furthermore, this electrode is called the working electrode with modification.

2.3.3 Measurement of standard glucose solution. Measurement of standard glucose solutions is carried out by the voltammetric method [10]. The electrode assembly consists of unmodified electrode platina and electrodes with modifications as working electrodes, platinum wires as auxiliary electrodes, and Ag / AgCl electrodes (saturated electrodes) as comparative electrodes. Electrode measurements without and with modification were carried out on 0.1 M NaOH. The electrodes used were dipped into a glucose solution then measured by cyclic voltammetry at a potential of -1 to + 1V. The detection limit and sensitivity of the electrode are calculated using voltmeter.

3. Results and Discussion

3.1. Detection of glucose

The development of glucose sensors continues to be carried out by adding supporting components to improve the electrode response to glucose. The addition of nanoparticles can increase electron transfer. The electron transfer speed will affect the current produced. So that the presence of nanoparticles will display a voltammogram with a fairly high peak current [11]. The use of silver nanoparticles in this study serves as a modification of platinum electrodes which acts as a catalyst and mobilization platform. Silver nanoparticles catalyze the oxidation of glucose to form gluconate and peroxide acid, this reaction takes place under aerobic conditions so that oxygen is needed to oxidize glucose.
Wang (2007) [12] also explained that in improving the performance of glucose biosensors, many methods were used and one of them was the use of nanoparticles. The use of nanoparticles to improve electrocatalytic owned by biosensors. In this study, it was carried out by comparing the voltammogram 2 working electrodes namely working electrodes not coated with silver nanoparticles with electrodes coated with silver nanoparticles used in measuring glucose at a concentration of 1mM - 5mM. The results of the observation showed that the oxidation peak and reduction of voltamograms which were not coated with silver nanoparticles (Fig.1) tended not to appear clear and irregular. The relationship of current and glucose concentration to the working electrodes not coated with silver nanoparticles shows the irregularity of current patterns measured in various variations in glucose concentration.

![Figure 1. Voltamogram of working electrode without coating](image1)

Unlike the case with the results of observations on electrodes coated with silver nanoparticles, from the results of observations seen platinum electrodes coated with dyed silver nanoparticles experienced changes. The surface of the electrode becomes more black, this indicates that the deposition of nanoparticles on the electrode. The results of the voltamogram on the working electrode coated with silver nanoparticles (Figure 2) show an increase in current as the glucose concentration increases from 1 - 5 mM. Measurements of the working electrodes coated with silver nanoparticles were carried out in the range of 1–5 mM. This is shown from the linear curve of glucose concentration to the current at potential (Figure 3).

![Figure 2. Working electrode voltamogram with coating silver nanoparticles](image2)

Based on Figure 3 it is known that the current increases according to the increase in glucose concentration. This linear relationship shows that the concentration is proportional to the measured
increase in current. The higher the concentration of glucose, the higher the increase in current produced because more glucose is oxidized, and the electrons transferred during the measurement are getting bigger, indicated by higher currents. The regression coefficient obtained is equal to 0.8613, which means that ± 86.13% changes in flow are influenced by changes in glucose concentration, while ± 13.87% is influenced by other factors. The ability of biosensors to detect glucose is characterized by curve linearity, limit of detection, sensitivity, reproducibility and lifetime at optimum biosensor conditions [13].

![Figure 3. Linear curve of glucose concentration to current](image)

3.2. Limit detection
The limit of detection of a measurement method is the smallest concentration of analyte that can be measured by the tool properly. The smaller the concentration that can be detected, the better the characteristics of the sensor.

![Figure 4. Limit detection of coated work electrodes silver nanoparticles](image)

The limit of detection of working electrodes coated with silver nanoparticles in Figure 3 is determined by making tangents to the linear and non-linear linear functions. The intersection of the two lines was extrapolated to the x axis so that the concentration of detection limit was 4.53 mM. The limit of detection for glucose concentrations measured at 1-5 mM which still gives a response is calculated at 2.19 mM.

3.3. Sensitivity
The sensitivity test is determined by dividing the slope of the curva linearity with the surface area of the working electrode used. Sensitivity tests are conducted to determine the sensitivity of a sensor to
analytes. Based on the line equation $y = 0.961x + 0.495$, the sensor sensitivity value indicates that silver nanoparticle based sensors have a sensitivity of 1.91 A. mM$^{-1}$. mm$^{-2}$. The greater the sensitivity value shows the more sensitive the analysis method [13].

4. Conclusion
Sensor applications using plant bioreductors *Myrmecodia pendans* to detect glucose can be done. And based on the results of the research that has been done, it can be concluded that silver nanoparticle based sensors are good enough to be used in measuring glucose levels. The sensor measurement range is in the range of 1 mM - 5 mM with regression (R) 0.8613. Sensor detection limits at a concentration of 4.53 mM with sensor sensitivity of 1.91 A. mM$^{-1}$. mm$^{-2}$.

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