The Effect of Addition Fe3O4 on the rGO/Fe3O4 Composite on Glucose Biosensor Performance

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Abstract. The development of composites as biosensors is very broad, one of them is biosensors to absorb glucose. Composite materials characteristic as biosensors must fulfill the criteria including nanomaterials that have magnetic properties, electrical conductivity, and good catalytic properties. One of the composites that fulfill those criteria is rGO/Fe3O4. By varying the addition of Fe3O4 in the making of rGO/Fe3O4 composites, the composition of composites that have the most effective performance in absorbing glucose will be known. The variation of Fe3O4 addition in this study is 0.1 gram - 0.5 gram, with 0.5 gram of RGO. The characteristics of rGO, Fe3O4 and the rGO/Fe3O4 composite are known by the XRD and FTIR analysed based on relevant previous studies. Glucose biosensor absorbance was tested by UV-Vis, a composite with mass variations of Fe3O4 0.1 gram, 0.2 gram, 0.3 gram, 0.4 gram, and 0.5 gram. Peak absorption of the composite of 0.1 gram Fe3O4 shows high glucose concentration, it can be seen that the composite does not absorb glucose properly. The 0.2 gram composite has the lowest absorption peak so that this composite is the best biosensor. Because with the addition of Fe3O4 mass shows the peak absorption is also higher. So, composites have a maximum limit in absorbing glucose.

1. Introduction

Material technology is widely developed in science, one of which is reduced Graphene Oxide (rGO) which is widely used in the application of biosensors, supercapacitors, absorption of microwaves and good electrocatalytic. The material of rGO is currently being developed as biosensor glucose for therapy of diabetes mellitus because it has good electrical conductivity, a broad surface and good electrocatalytic [1]. Glucose biosensors with rGO / ZnO nanocomposites showed electro-chemicals with good catalytic activity on glucose oxidation [2]. A performance of biosensor will increase with added magnetic material which has good adsorption properties, good catalytic and electrical conductivity [3]. Magnetic Fe3O4 is one of the magnetic materials that have low toxicity properties but it is good in adsorption and biocompatibility properties that can be used to maintain biological and electrochemical activities of immobilized biomolecules [4].

The rGO/Fe3O4 composite shows that Fe3O4 can spread evenly and bind to the rGO surface, electron transfer and good electrocatalytic activity on glucose [5]. A synthesis using the solvothermal method shows the occurrence of redox and electrocatalytic reactions in glucose resulting in high and stable sensitivity [6]. The method of ex-situ wet mixing synthesis is carried out to determine the effect of adding Fe3O4 to the rGO/Fe3O4 composite. The results of this study were demonstrated using XRD
and FTIR to determine the characteristics of the material Fe₃O₄, rGO, and rGO/Fe₃O₄ composites. The using glucose biosensor can also be obtained by using a UV-Vis to determine the absorbance of glucose absorbed in the rGO/Fe₃O₄ composite. The research to obtain results better than previous studies and can be seen as the addition of the best Fe₃O₄ material that can be used for glucose biosensors.

2. Method
The main material used to make Fe₃O₄ material is nature iron sand, while for rGO it uses graphite as the basis. Other ingredients used are 37% HCl, 97% H₂SO₄, NH₄OH, NaNO₃, KMnO₄, alcohol, H₂O₂, hydrazine, glucose oxides, and distilled water. The tools have used all sizes of a beaker glass, spatula, stirrer, centrifugation, fresh dryer, mortal pestles, sieves, digital balance, XRD, FTIR and UV-Vis characterization tools.

In research, it using the wet mixing method for the synthesis of rGO/Fe₃O₄ composites with the addition of 10 ml alcohol to speed up the reaction process, stirred for 5 hours. The using of Fe₃O₄ mass variation is from 0.1 gram, 0.2 gram, 0.3 gram, 0.4 gram, and 0.5 gram with 0.5 gram of rGO mass. The composite that has been obtained, is dried so the rGO/Fe₃O₄ composite powder is obtained. The powder was weighed and dissolved in 1 mg/ml into a glucose solution containing 5 mg/ml. The solution was then precipitated for 4 hours for the immobilization process, after that the solution was taken and a UV-vis test was carried out to determine the absorbance of glucose.

3. Results and Discussion
The crystal structure of the material is characterized using X-ray Diffraction with analysis using the Match application. Figure 1 shows the diffraction peaks of the Fe₃O₄ material obtained at angles 2θ with 30,170, 35,340, 42,800, 54,470, 56,880 and 62,510, which correspond to reflections (220), (311), (400), (422), (511) and (440), in sequence. The results of the rGO/Fe₃O₄ composite are shown in Figure 2, where rGO which has a diffraction peak at an angle of 2θ identified at 23.40° [7] affects the intensity and size of the crystals in the Fe₃O₄ particles. The peak of rGO diffraction will disappear so that the peak of Fe₃O₄ diffraction will be seen which shows that the synthesis of rGO/Fe₃O₄ has been successfully synthesized with good crystallinity, graphene peaks which disappear due to the amorphous properties of rGO.
FTIR is used to determine the functional groups of material by showing the relationship between wavenumbers and transmittance. Characteristic peak analysis is adjusted with relevant prior research. Figure 3 shows the graph of GO, rGO and rGO/Fe$_3$O$_4$ composite characterizations. On the GO chart, it can be seen that the absorption peak of 3396.76 nm$^{-1}$ is shown as a functional group of O-H. The peak of 1708.99 nm$^{-1}$ and 1620.26 nm$^{-1}$ can be seen that there is functional group C=O which is a carboxyl group. The C-O-H group can also be obtained at the absorption peak at 1203.62 nm$^{-1}$ and the C-O group can be seen at the absorption peak at 1087.89 nm$^{-1}$.

In the rGO material, it can be shown that the absorption peaks are 1714.88 nm$^{-1}$ and 1645.09 nm$^{-1}$ which are the absorption peaks of C=O and C=C respectively. The presence of an aromatic bond C=C indicates that rGO has been formed [8]. The absorption peak in the rGO/Fe$_3$O$_4$ composite can be obtained in 1947.61 nm$^{-1}$ which is a functional group C=O and 433.82 nm$^{-1}$ as the Fe-O group. The absorption peak at GO and rGO will disappear or the intensity decreases with the reduction process of the rGO/Fe$_3$O$_4$ composite, but the removal of some oxygen-containing groups on GO is happening. It is because the oxygen-containing functional group in GO shows up as a holding site and Fe$_3$O$_4$ particles are covalently bound to rGO during redox reactions [5]. Based on the results of research conducted by Hoan [9], Chen [10] and Prasad [11] that the RGO/Fe$_3$O$_4$ composite was successfully synthesized.
Glucose biosensors can be known as their absorption using a UV-Vis with immobilization in glucose. The peak glucose absorption appeared at 563 nm, while the spectrum of the rGO/Fe$_3$O$_4$ composite with a Fe$_3$O$_4$ mass variation of 0.1 gram, 0.2 gram, 0.3 gram, 0.4 gram, and 0.5 gram appears at 563 nm, 565 nm, 563 nm, 564 nm, and 565 nm. The absorption peak of pure glucose and rGO/Fe$_3$O$_4$ composite has almost the same peak, this shows that the rGO/Fe$_3$O$_4$ composite can capture glucose.

Figure 3. shows that the variation of Fe$_3$O$_4$ mass as much as 0.2 grams, the lowest absorption peak, it can be seen that glucose can be trapped properly in the composite, while the composite with a mass of 0.1 gram shows the highest absorption peak so that the glucose concentration that is not absorbed high. The addition of Fe$_3$O$_4$ mass by 0.2 gram, 0.3 gram, 0.4 gram, and 0.5 gram shows the peak of absorption is higher along with the addition of Fe$_3$O$_4$ mass. Glucose absorbance on composites with the addition of 0.2 gram of Fe$_3$O$_4$ mass has the best glucose absorption due to the least residual concentration, whereas in small Fe$_3$O$_4$ masses shows poor absorbance with high glucose concentration. The higher the mass of Fe$_3$O$_4$, the higher the glucose that is not absorbed, this indicates that the rGO/Fe$_3$O$_4$ composite has a maximum limit as a biosensor.

Figure 2. The results of FTIR on Materials of GO, rGO and rGO/Fe$_3$O$_4$ Composite
Figure 3. The results of UV-Vis with Mass Variation of Fe$_3$O$_4$

4. Conclusion
The results of this study indicate that the rGO/Fe$_3$O$_4$ composite material can capture glucose. Mass variation of Fe$_3$O$_4$ in composites of 0.2 grams shows that the mass variation can absorb glucose well. While the 0.1 gram mass variation shows that the peak absorption is high, it can be seen that glucose is not trapped properly because the remaining glucose concentration is high. The addition of Fe$_3$O$_4$ mass indicates the higher concentration of glucose that is not trapped. This is because composites have a maximum limit in absorbing glucose.

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