Magnetic field dependence of the current flowing in the spin-coated chlorophyll thin films

J R P Aji, Kusumandari, B Purnama
Physics Department Sebelas Maret University, Jl. Ir. Sutami 36A Keningan Jebres Surakarta 57126, INDONESIA
E-mail: bpurnama@mipa.uns.ac.id

Abstract. The magnetic dependence of the current flowing in the spin coated chlorophyll films on a patterned Cu PCB substrate has been presented. Chlorophyll was isolated from *Spirulina* sp and deposited by spin coated methods. The reducing of current by the change of magnetic field (magneto conductance effect) was performed by inducing the magnetic field parallel to the inplane of film at room temp. The magnetoconductance ratio decreases as the increase of voltage. It was indicated that the origin of carrier charge in chlorophyll films should be different with the carrier charge injection (electron).

1. Introduction
Organic material has attracted many researchers because its weak molecules bond in the solid state can make organic materials as insulators and semiconductors. Semiconductors based organic has various advantages compared to semiconductors based inorganic in applications of the optics and electronics devices. Furthermore, the manufacture of semiconductors based organic is simple and cheap [1,2].

One of the most common organic materials studied in electronic application is chlorophyll. The chlorophyll forms a nanometer-discrete layer as a result of a surface substrate interaction [3-5]. So that, recently the chlorophyll thin films is the one of the important part in the electronics based nano hybrid system [6-8].

Chlorophyll is commonly isolated using chromatography method from natural materials such as spinach or micro-algae [9]. The products of isolation become the source materials of thin layer that can be prepared by various methods such as evaporation, vapor deposition, spin coating, and Langmuir Blodgett deposition technique [10].

In this paper, the magnetic dependence of current flowing in chlorophyll films is discussed. The isolated solution of chlorophyll was confirm by UV-Vis spectroscopy and the electrical property was evaluated by I-V measurement.

2. Experimental

2.1 Preparation of natural chlorophyll.
Fabrication of natural chlorophyll coating was done through isolation process including extraction, chromatography, and evaporation stage as experimental procedures that had been done before [11]. The material used was *Spirulina* sp fresh water production of PT Neo-algae Sukoharjo, Central Java, Indonesia.
2.2 Growth and characterization of thin layers
The *Spirulina* sp solution was deposited on the PCB substrate. The PCB Cu Substrate Pattern is shown in Fig. 1. Before using the PCB, its surface must be cleaned. PCB was conducted by washing it with 99% alcohol and acetone via ultrasonic cleaner for 15 minutes. Then, PCB was allowed to dry at room temperature conditions.

![Figure 1. The modified substrates of Cu PCB used in the experiment.](image)

The layer growth of chlorophyll was carried out by Chemat Technology KW-4A spin coating. Deposition process was done at using 2000 rpm rotational speed for 30 s, then followed by heating process at temperature of 70°C for 90 s.

The characterization of this research included observing the curve of absorbance performed UV-Vis Spectrometer. Finally, the IV meter was carried out to observe the magnetic field effect of current flowing samples (magneto conductance effect) shown as in Fig. 2.

![Figure 2. The experimental set up of magnetoconductance measurement.](image)
3. Results and Discussion
UV-Vis characterization was performed to confirm the existence of chlorophyll in *Spirulina* sp solution. Fig. 3 shows the typical of absorbance profile for chlorophyll solution. As the results, two peaks of absorbance curve at $\lambda = 430.50$ and $662.50$ nm are confirmed as chlorophyll [12].

![Absorbance Profile for Chlorophyll Solution](image)

**Figure 3.** The absorbance of isolated chlorophyll from microalgae *Spirulina* sp.

The reducing current $I$ within the increasing magnetic field $H$ is displayed by Fig. 4. The current $I$ is maximum at zero magnetic field and then gradually decrease with the increase of the magnetic field. After exceeding a given magnetic field, the current tends to be constant. It clearly observed by Fig. 4 that the typical reduce of the current change for different voltage used for supply current. In case of $V = 0.4$ volt, at $H = 0$ mT, the current of 0.478 nA is obtained. The current is reduced to 0.317 nA when the field of 20 mT is applied. At $V = 0.8$ volt and $H = 0$ mT, the current obtained is 0666 nA and it tends to be constant at 0.435 nA at magnetic field $H$ of 15 mT.

![Current vs Magnetic Field Graph](image)

**Figure 4.** Graph of the current as a function of magnetic field evaluated at $V = 0.4$ and 0.8 volt.
Figure 5. The MC ratio with the increase of magnetic field evaluated for various voltage of chlorophyll film with N = 9.

Fig. 5 shows the reduced current as a function of magnetic field evaluated for various voltages. The reduced current in applied magnetic field is defined as magnetoconductance (MC), so the MC ratio may express as MC = [I(H)−I(H=0)]/I(H=0) in which I(H) and I(H=0) are the current when the magnetic field is applied and zero magnetic field, respectively. Fig. 5 presents the MC ratio decrease as the increase of voltage. The increase of voltage means the increase of supplying of carrier charge into the samples. It should be noted that the supplying of the carrier charge caused by the increase of the voltage is electron with negative carrier charge. The reduction of the MC ratio with the increase voltage should indicate that the dominant carrier charge of the chlorophyll films is different to carrier charge supplied by the increase voltage. So, the response of the available carrier charge pair to the induction of the magnetic field is the recombination, with in result the reduction of the MC ratio.

4. Conclusion

The magnetic dependence of the current flowing in the spin coated chlorophyll films on a patterned Cu PCB substrate has been presented. The reducing of current by the change of magnetic field (magneto conductance effect) was performed by inducing the magnetic field parallel to the inplane of film at room temp. The magnetoconductance ratio decreases as the increase of voltage. It is indicated that the origin of carrier charge in chlorophyll films should be different with the carrier charge injection (electron).

References
[1] Bloom F L, Wagemans W, Kemerink M, and Koopman B 2007 Phys. Rev. Let. 99 257201
[2] Punke M, Mozer S, Stroisch, Gerken M, Bastian G, Rabus D, and Henzi P 2006 SPIE 6185 618505-1
[3] S Boussad, A Tazi, and R M Leblanc 1999 J. Colloid Interface Sci. 209 341-346
[4] S Boussad, J A DeRose, and R M Leblanc 1995 Chem. Phys. Let 246 107-113
[5] M Crevecoeur et al 2000 Protoplasma 212 46-55
[6] P Bombelli et al 2012 Phys. Chem. Chem. Phys 12 12221-12229
[7] S Y Chen et al 2013 Carbon 63 23-29
[8] Patrascu et al 2014 Beilstein J. Nanotech. 5 2316-1325
[9] Jubert C and Bailey G 2007 J. Chromatography 1140 95-100
[10] El- Nahass M M, Farag A A M, El-Metwally M, Samaha F.S.H.A, and Elesh E 2014 Synthetic Metals 195 110-116
[11] Elvira F F 2014 Jurnal Fisika dan Aplikasinya 2 99-102
[12] Li Y, Scales N, Blankenship R E, Willows R D, and Chen M 2012 Bio et Biophy Acta 1817 1292–1298