



Green Synthesis of Nanomaterial Zinc Oxide with Anthocyanin Extract *Hylocereus polyrhizus* for DSSC Application

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Abstract

Photovoltaic technology as an alternative to dye-sensitized third-generation solar cells is known as Dye-Sensitized Solar Cell (DSSC). DSSC is a device that can convert solar energy into electrical energy. Natural dye is used because it is relatively cheap and environmentally friendly. The type colour commonly used in DSSC are chlorophyll and anthocyanin. In this study the anthocyanin extract *Hylocereus polyrhizus* was used because it has a high absorption value. Nanoparticles ZnO is used because it has a relatively large energy gap value and can absorb sunlight optimally. The method used in this research is a spin coating, this method uses the procedure of making a thin film on the substrate. The characterizations were carried out using X-ray diffraction (XRD) to determine the crystal size of the ZnO nanoparticles, to know morphology nanoparticle can use scanning electron microscope (SEM), ultraviolet visible (UV-Vis) spectrometer is used to determine the value of the band gap energy and solar cell simulator test to determine the efficiency value. The XRD result had a crystal size 30.74 nm. The SEM results that the shape of the particles is oval and homogeneous by agglomeration. The band gap value is 3.67 eV. The efficiency in the solar cell simulator test for the DSSC nanomaterial ZnO with anthocyanin extract *Hylocereus polyrhizus* was 0,29%.

Keywords: *Hylocereus polyrhizus*, ZnO, DSSC, Spin Coating

1. Introduction

Photovoltaic technology as an alternative to dye-sensitized third-generation solar cells is known as Dye-Sensitized Solar Cell (DSSC) [1],[2]. DSSC consists of several components, namely a substrate (a conductive substrate or a substrate coated with a conductive film) such as FTO (fluorine Doped Thin Oxide) [3], a semiconductor nanostructure as a photoanode [4], a sensitizer as a dye, an electrolyte and a counter electrode coated with a catalyst [5]. The most important part in the absorption of the DSSC is carried out by the dye molecules and the charge separation by the semiconductor particles [6].

Deadly separation by semiconductor nanoparticles that have band gap, such as zinc oxide (ZnO) with a band gap 3.37 eV [7]. So that it can absorb sunlight optimally and is suitable for application as solar cells [8]. Furthermore, there is a dye the most important part of the DSSC which can absorb light and send electrons to the conduction band of the semiconductor. Dye affects the effectiveness of DSSC [9]. Ruthenium and porphyrin based dyes have shown good performance as sensitizers. However, the availability of ruthenium and porphyrin is scarce, expensive and the production is quite dangerous [10]. Therefore, a dye which is cheaper, environmentally friendly, abundantly available, and has good efficiency, is using natural dye [11]. Types of natural dyes that have been explored for sensitizer applications in DSSC are betanin or betalain, chlorophyll [12],[13] and anthocyanins [14], [15].

Anthocyanins are dyes that are widely distributed in plants. Strong colored pigment and can be dissolved in water causes almost all the pink, red, purple, and purple colors in the petals, leaves, and fruit of higher plants [16]. In addition, anthocyanin can absorb the spectrum of sunlight at a wavelength of 500 nm, very sensitive to light and can be decomposed by microbes so that they do not harm the environment [17]. In a study the fabrication of Dye-Sensitized Solar Cell (DSSC) has succeeded in using organic material extracted from dragon fruit skin with a maximum wavelength of 538 nm [22].

the DSSC electrical test, dragon fruit peel produced the largest electrical value [23]. This study, it can be said that prototype was successful in converting sunlight well [22]. Therefore, the use of anthocyanin extract from dragon skin as a dye and Zinc Oxide are good to use to improve the performance of DSSC.

2. Method

Zinc asetat Dehydrate is dissolved with ethylene glycol and added with glycerol followed by DEA (diethanolamine) to obtain homogeneous sol. Then let stand 24 hours. The manufacture of dye is done by cleaning the skin of dragon fruit and smoothing it. The next step, the sample added with ethanol PA and allowed to stand for 3 days. Zinc oxide preparation and Dye – Sensitized Solar Cell fabrication were carried out by dropping the FTO substrate with ZnO and rotating it with spin coating. Then annealed at 550°C. deposit TiO₂ pasta on block layer using screen printing. Sampel soaked TTP AIP and 2 propanol, for 30 minutes. Next, the ZnO photoelectrode immersed into anthocyanin extract *hylocereus polyrhizus*.

Samples were characterized using X-ray Diffractometer (XRD) to determine the crystal size of the sample. Furthermore, the shape and morphology characterization using SEM (Scanning Electron Microscope). The band gap characterization using UV-Vis. The electrical conductivity test was characterized using an I-V to know the value of efficiency.

3. Result and Discussion

3.1. XRD Characterization Results

XRD characterization results of ZnO with anthocyanin extract *hylocereus polyrhizus* can be seen in figure 1.

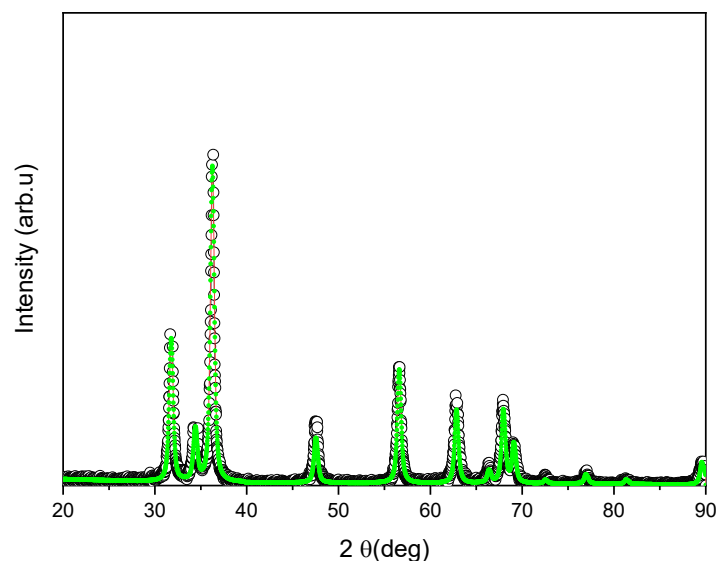


Figure 1. XRD Results ZnO with anthocyanin extract *hylocereus polyrhizus*

The crystal size can be obtained using the Scherrer equation, such as Equation (1).

$$D = \frac{k\lambda}{\beta \cos \theta} \quad (1)$$

Where is the wavelength of Cu-K α , β is the FWHM indicating half the peak width and half the maximum, θ is the Bragg angle or diffraction angle. The value of k is 0.9 where it is obtained from the fitting results that depend on the shape of the crystal. The FWHM value is affected by the intensity of the crystal plane, which is obtained from the highest peak and the FWHM value must be in radians. The crystal size of the sample is 30.74 nm. This is in accordance with research conducted by Almaida *et al.* who have succeeded in synthesizing ZnO by an eco-friendly tapioca-assisted route and produces particle sizes in the range of 22 - 41 nm [18].

3.2. SEM Characterization Results

SEM (Scanning Electron Microscope) characterization was used to determine the morphology and distribution of particles in the sample. Figure 2 is the result of the ZnO SEM with the spin coating

method using substrate. It is known from the SEM results that the grain size and shape of the particles are oval and homogeneous by agglomeration. The factor that effects the particle size is the annealing temperature, the time of stirring and the type of materials [19]. Distribution of nanoparticles of ZnO with anthocyanin extract *hylocereus polyrhizus* is ± 31 nm. It has a fairly high crystallinity value as evidenced by figure (a).

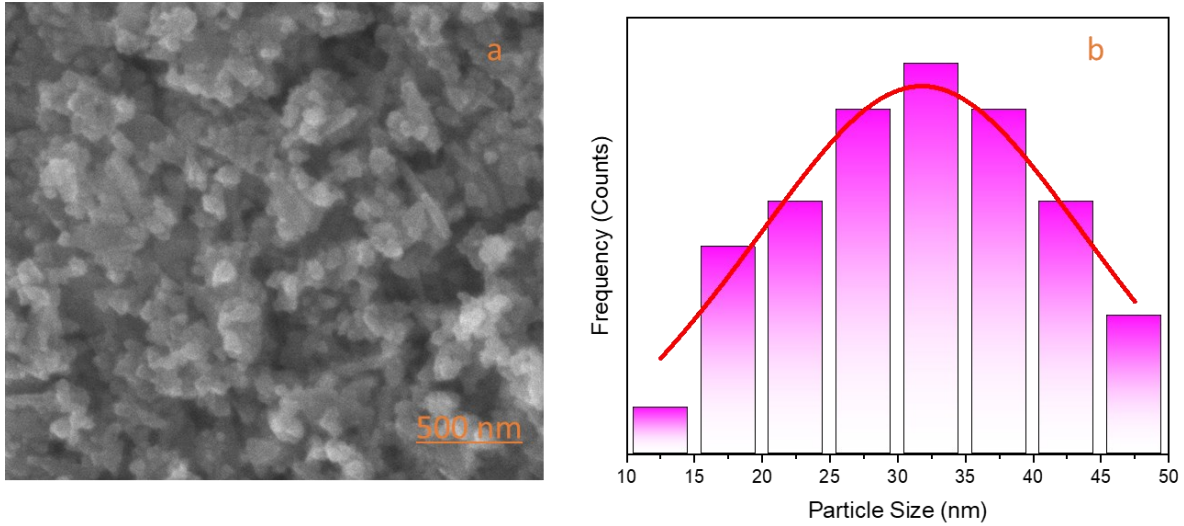


Figure 2. (a) SEM image of ZnO with anthocyanin extract *hylocereus polyrhizus* and (b) Particles Distribution

3.3. UV-Vis Characterization Results

Synthesis nanoparticle ZnO with with anthocyanin extract *hylocereus polyrhizus* was successfully carried out and the result of UV-Vis characterization can be seen in figure 3.

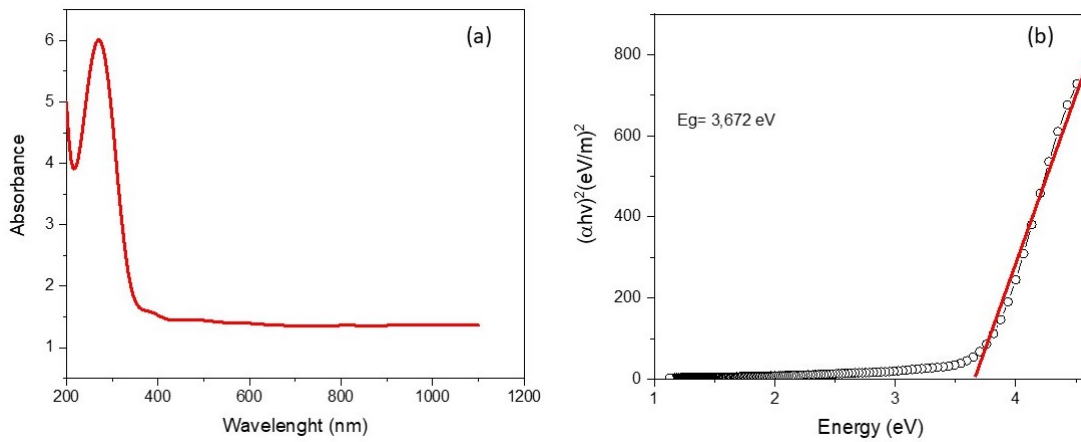


Figure 3. (a) Absorbency and (b) Direct Band Gap Nanoparticles ZnO with Anthocyanin Extract *Hylocereus polyrhizus*

Based on figure 3 (a) absorption of energy at a wavelength of 217 nm with absorbance value 3,86 included in the UV ray region. (b) the band gap energy value of ZnO nanoparticle with with anthocyanin extract *hylocereus polyrhizus* is 3.67 eV. The band gap value of ZnO nanoparticles obtained is greater than that of ZnO in bulk form, namely (3.37 eV) [20].

3.4. I-V Characterization Results

The characterization of the I-V to determine the value of the efficiency of the sample. The efficiency and fill factor for DSSC are calculate by following formulas [21].

$$FF = \frac{I_m \times V_m}{J_{SC} \times V_{OC}} \quad (1)$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{J_{SC} \times V_{OC} \times FF}{P_{in}} \quad (2)$$

Based on figure 4, can be seen that the efficiency value of 0.29 %. The short circuit current density (J_{SC}) and open circuit voltage (V_{OC}) is a row are 1.76 mA/cm² and 0.46 V. The value of fill factor (FF) is 0.36.

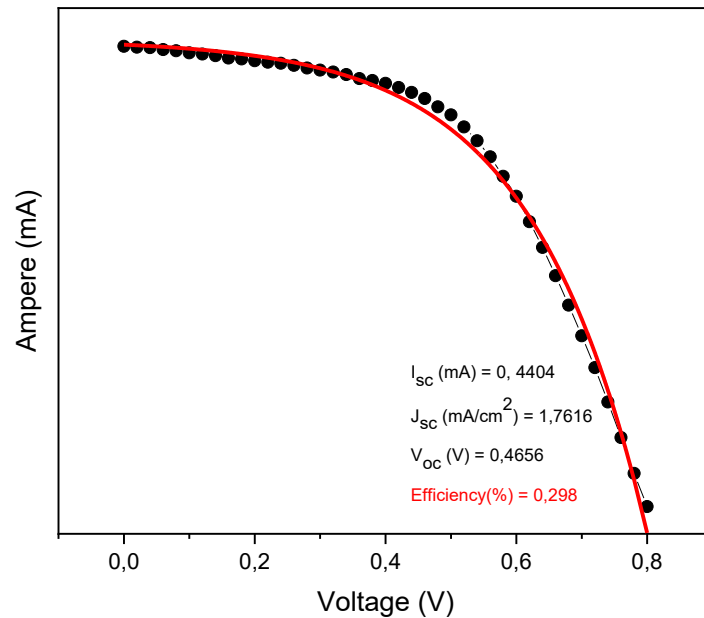


Figure 4. Efficiency of DSSC Nanoparticles ZnO with Anthocyanin Extract *Hylocereus polyrhizus*

4. Conclusion

The effect of ZnO with anthocyanin extract *hylocereus polyrhizus* on DSSC on crystal size is 30.74 nm. The grain size and shape of the particles are oval and homogeneous by agglomeration. The absorption of energy at a wavelength of 217 nm and the band gap energy value of ZnO nanoparticle with with anthocyanin extract *hylocereus polyrhizus* is 3.67 eV. Solar cell simulator tests gives the efficiency value of 0.29 %.

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