REEN SYNTHESIS AND CHARACTERIZATION OF ZINC OXIDE FROM *Ixora Coccinea* LEAF EXTRACT AND ITS APPLICATION

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Abstract

Zinc oxide particle was synthesized from Ixora Coccinea Leaf (Pone Na Yeik) extract and zinc acetate by biological method. The product was confirmed by X-ray diffraction (XRD), and UV–Vis spectroscopy. Dye Sensitized Solar Cell (DSSC) was assembled by the green prepared ZnO and Ixora Coccinea petal (Pone Na Yeik flower) pigment. In this work, the green synthesis of zinc oxide was used as photoelectrode while carbon counter electrode was applied. After DSSC architecture, J_{SC} (short-circuit photocurrent), V_{OC} (open-circuit photovoltage), FF (fill factor) and η (efficiency) were investigated from the current - voltage (I-V) measurement.

Keywords: Green synthesis, Dye Sensitized Solar Cell, Photoelectrode, Fill factor and efficiency

Introduction

Among various semiconductor, Zinc Oxide is one of the most important semiconductor materials. It has with direct wide bandgap (3.2–3.37 eV) and it is a good transparency at room temperature. Moreover, due to large exciton binding energy of (60 meV), it has potential applications in optoelectronic devices such as solar cells (Barnali Ashe, 2011). Study of nano ZnO doped with various impurities has resulted in several publications leading to books, reviews and papers. Now most of the researchers are working on ZnO by changing the method of preparation to extract the novel character.(S. Yedurkar, C. Maurya, 2016).

Recently, the biosynthesis or green synthesis is an alternative synthesis method to prepare of ZnO using the plant extract. It depends on plant source and the organic compound in the crude leaf extract. Most plants have inherent capacity of reducing and capping of various metals and metal oxides nanoparticles which plays an important role in the bio-reduction and consequently formation of nanoparticles (C.M.Noorjahan, S.K.J Shahina, 2015). Synthesis of nanoparticles using different parts of the plants is quite novel, leading to truly green chemistry which is effective to low cost as there is no need to high pressure, energy, temperature and toxic chemicals (S. Yedurkar, C. Maurya, 2016).

Dye-sensitized solar cells (DSSCs) is a low-cost solar cell belonging to the group of thin film solar cells. They are based on the concept of photo sensitization of wide band gap mesoporous oxide semiconductor such as TiO_2, ZnO and SnO_2.

The performance of dye sensitized solar cells is mainly based on the dye as a sensitizer (Tao-Hua Lee, H J Sue ,2011).

Recently, there is a growing to develop environmentally friendly methods that does not use toxic materials in the synthesis procedures of ZnO particles. In this work, the biosynthesis of ZnO particles by using green Ixora Coccinea leaf extract was studied. These ZnO particles were used as photoelectrode of DSSC with Ixora Coccinea petal dye.

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Materials and Methods

Preparation of ZnO particles by biosynthesis method

Fresh leaves of Ixora Coccinea were cleaned with water to remove dust and other contaminations, followed by distilled water and air dried at room temperature. Leaves were finely chopped into small pieces. The aqueous extract of sample was prepared by boiling the freshly collected cut leaves (10 g), with 100 cm^3 of distilled water, at 60˚C for about 30 minutes, until the color of the aqueous solution changes from watery to light brown. Then the extract was cooled to room temperature and filtered using the filter paper.

For the synthesis of zinc oxide nanoparticles, 50 cm^3 of 0.5 M zinc acetate dihydrate solution was prepared using distilled water. 1 cm^3 aqueous leaf extract of Ixora coccinea was added into the above solution. In order to maintain the pH 12, 2.0 $mol \cdot dm^{-3}$ sodium hydroxide was used which resulted in a milky white aqueous solution. This was then placed in a magnetic stirrer for 2 hrs. The pale white precipitate was then taken out and washed over and over again with distilled water followed by ethanol to get free of the impurities. Then a pale white powder of zinc oxide particles was obtained after drying at 60˚C in oven about 6 hr. Graphical representation of the procedure is shown in Figure 1. The ZnO powder was checked by X-ray diffraction method (XRD) and to calculate the optical energy band gap by using UV-Vis spectroscopy method.

Ixora Coccinea Dye Extraction

25g petal of Ixora Coccinea (Pone Na Yeik) was ground and mixed with 50 ml of ethanol solvent. The extracted sample was stirred using magnetic stirrer about 30 min. The procedure continued with the filtration of the sample to remove residue. The absorption spectrum of these dye has been investigated by UV-Vis spectrophotometry.

Preparation of electrode

ZnO film on ITO substrate were deposited as follows, 1 g of biosynthesized ZnO powder and 3 ml ethanol were mixed well in agate mortar for one hour. The final mixture was stirred to obtain the desired ZnO paste. The electrode was immersed in the dye solution and then kept overnight at room temperature. Carbon powder was used as carbon catalyst counter electrode.

3 ml of ethanol was poured drop by drop into 1 g of carbon. After grinding for 1h, the carbon solution was obtained. The deposited carbon paste was dried on the hot plate for 15 min.

DSSC Architecture

The dye-sensitized ZnO electrode and the carbon counter electrode were assembled to form a solar cell. A drop of iodide electrolyte solution was sandwiched between the two slides and clipped together to form a complete cell. The conversion efficiencies were recorded under simulated solar light conditions.

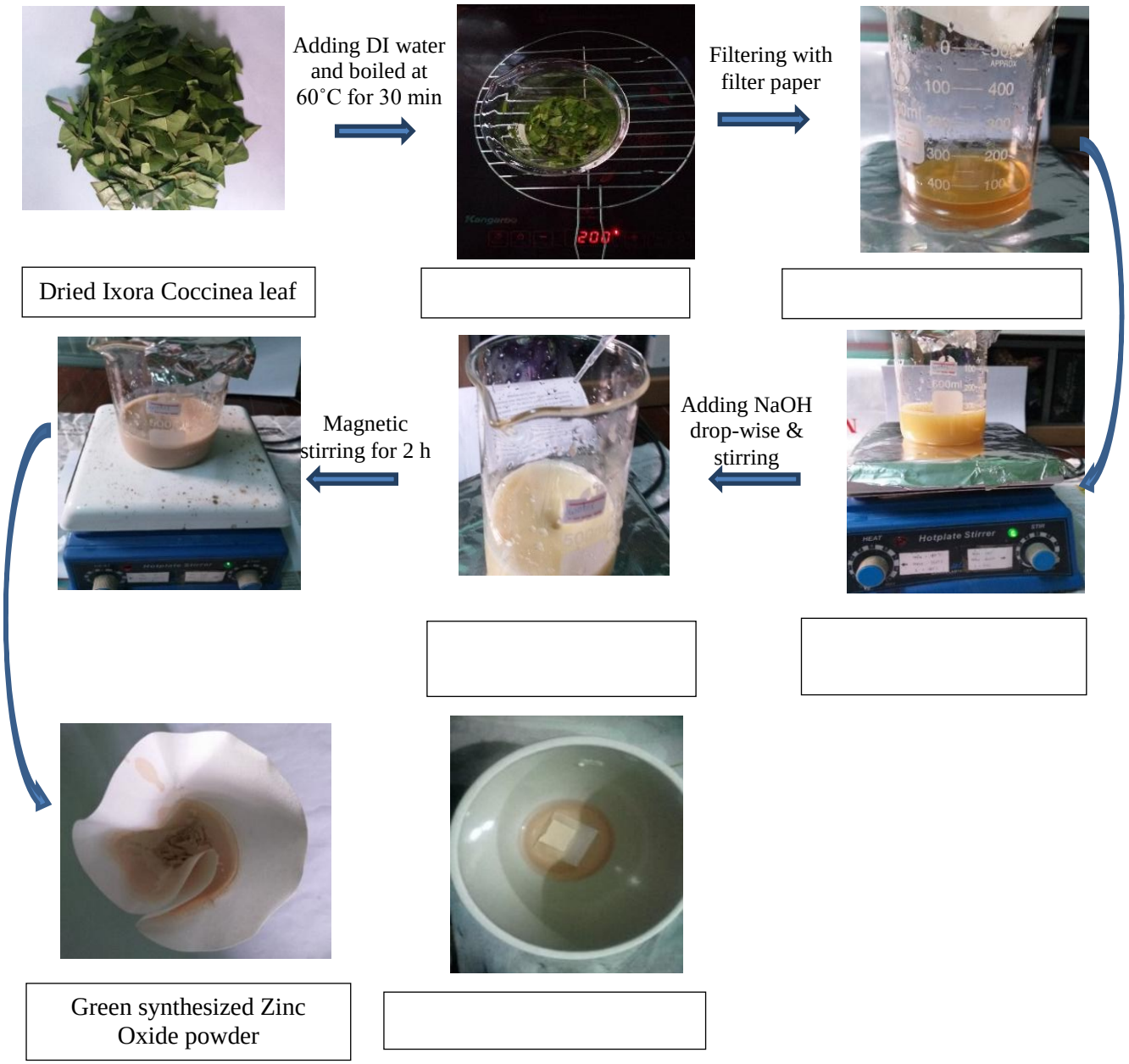

Figure 1 Experimental procedure of the preparation of green synthesized ZnO particles

Results and Discussion

XRD Analysis of biosynthesized ZnO powder

The XRD spectrum of biosynthesized ZnO powder is shown in Figure 2. Simple was scanned from 10°C to 70°C in diffraction angle 2θ. Seven distant peaks such as (100), (002), (101), (102), (110) ,(103)and (112) are formed on the profile. All of diffraction patterns were well match with JCPDS in ZnO library file. The sharp peaks of the XRD pattern indicated that the synthesized sample were well crystalline.

Moreover, the higher intensity peak observed at 2θ = 37˚ of the standard chart, referring to (101) reflection, confirms that the degree of crystallinity increased. The average crystallite size

(D), calculated from the most intense X-ray diffraction peak (101) using Scherrer's equation is 29 nm. The lattice parameters of the ZnO powders were a = b = 3.2549 nm, c= 5.2185 nm. The sample powder was successfully obtained with hexagonal structure. Thus, ZnO powder was successfully formed under these conditions by biosynthesis method.

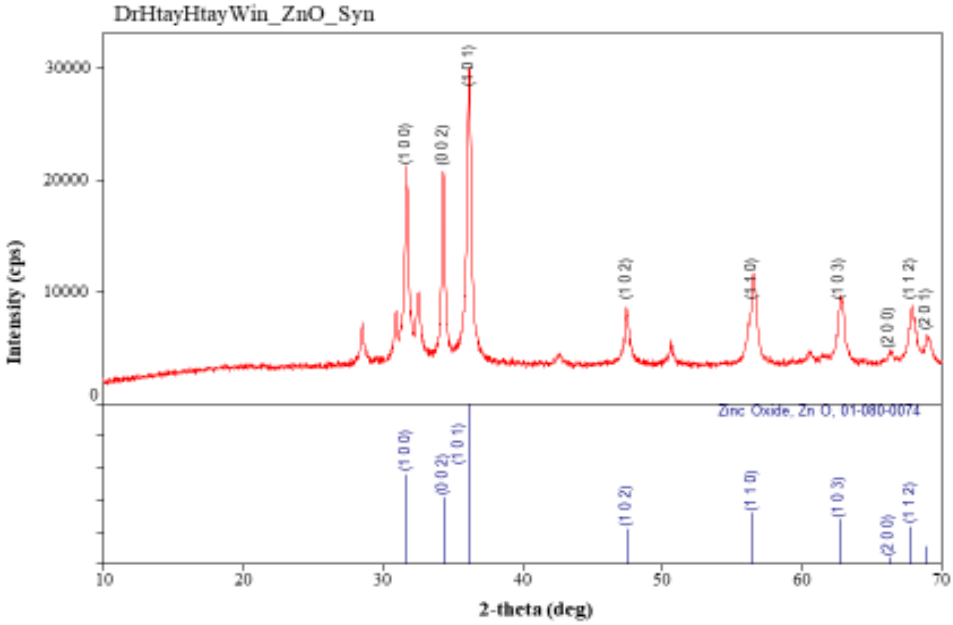

Figure 2 XRD spectrum of Zinc Oxide

UV-Vis Analysis of biosynthesized ZnO powder

The optical spectrum of biosynthesized ZnO powder is shown in Fig. 3 (a). In this figure, the optical absorption spectrum was well accepted and the absorption band was observed near ultraviolet region. The absorption peak located at 374.5 nm. The estimated optical band gap of ZnO powder is 3.31 eV.

Optical properties of Ixora Coccinea petal Dye

Fig. 3(b) showed the optical absorption spectrum of Ixora Coccinea petal dye. The maximum absorption peak was founded at 450 nm for Ixora Coccinea petal dye. So the absorption peak was in visible range. The energy band gap of these dye is 2.76 eV.

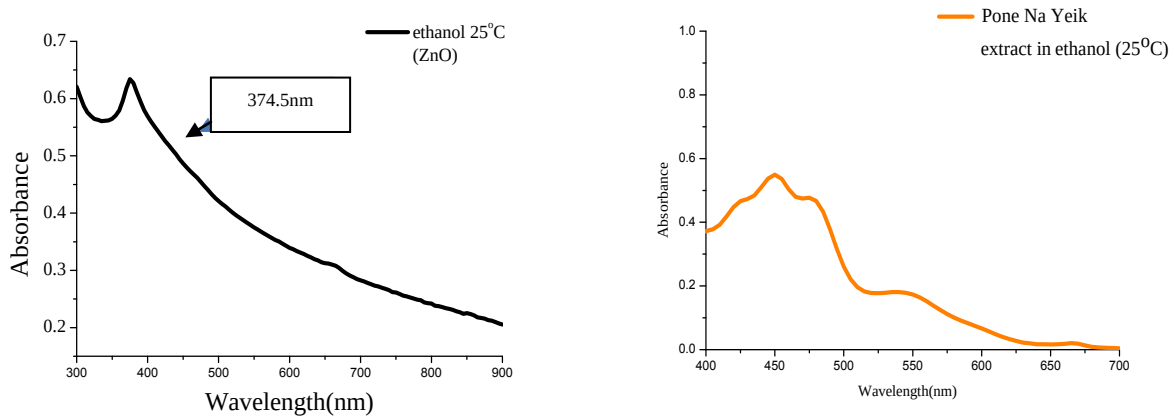

Figure 3(a) Optical absorption spectra of Zinc Oxide **(b)** Ixora Coccinea dye solution

Analysis of photochemical properties

Photochemical properties of fabricated DSSC were characterized by current voltage measurement. The experiment was carried under simulated solar light conditions. The current voltage characteristic of sample was showed in figure 4. From this figure, it was observed that the solar cell behavior. Ixora Coccinea extraction is favoured well attach of the dye to the semiconductor layer. Parameters such as short circuit current density (J_{sc}), maximum voltage (V_m), open circuit voltage (V_{oc}), conversion efficiency (η) and fill factor (FF) of DSSC immersed in natural dye tabulated in table 1.

Table 1 Photovoltaic performance of DSSC cell

Substrate	**ITO glass**
Photoelectrode	Biosynthesized ZnO
Counter electrode	carbon
Dye	Ixora Coccinea
J_m (mA/cm^2)	0.009
V_m (V)	0.240
J_{sc} (mA/cm^2)	0.017
V_{oc} (V)	0.461
Fill factor	0.276
Efficiency (%)	1.367

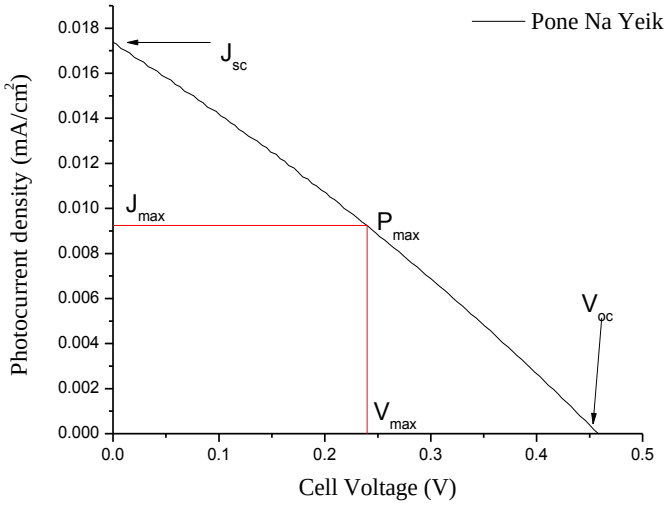

Figure 4 J-V characteristics of Ixora Coccinea dye sensitized ZnO based DSSC

Conclusion

In this paper, biological synthesis of zinc oxide sample using leaf extract of Ixora coccinea provided an environmental friendly, simple and efficient road for synthesis of the sample. Zinc Oxide sample has been successfully synthesized by using this method. X-ray diffraction confirmed the formation of a hexagonal phase which was the most stable form of zinc oxide at ambient conditions. The average crystallite size (D), calculated from the most intense X-ray diffraction peak (101) was 29 nm. The lattice parameters of the ZnO powders were

a = b = 3.2549 nm, c= 5.2185 nm. The energy band gap of these powder was 3.31 eV. The natural dyes extracted from Ixora Coccinea petal was used to build dye-sensitized solar cells. The dyes showed sharp absorption peaks in the visible region, 400 – 700 nm. The maximum absorption peak was founded at 450 nm for Ixora Coccinea petal dye. The energy band gap of these dye was 2.76 eV. According to the experimental data resulted from energy band gap of the dyes extracted were quite promising candidates for dye sensitizers of DSSC. The conversion efficiency of fabricated cell was observed to be about 1.367 %. The solar energy to electrical conversion efficiency is very less, but the result obtained is academically interesting. From the experimental results, it was founded that the fabricated DSSC with green synthesis method for the preparation of crystalline zinc oxide targeted on the requirements for DSSC of low cost and eco-friendly.

Acknowledgements

We would like to thank Professor Dr Khin Khin Win, Head of Department of Physics, University of Yangon for her kind permission to carry out this work.

We also like to thank to all respectable Professors of Physics Department, University of Yangon for useful their advice me. We would like to give my special thanks to Professor Dr Yin Maung Maung, Department of Physics, University of Yangon and Professor Dr Than Than Win Department of Physics, Pinlon University for their encourage and support me during the undertaking of this work.

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