The influence of material type and composition of TiO$_2$-ZnO on manufacturing of paste for the application of DSSC

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Abstract. Research, fabrication and material selection for the application of Dye-sensitized solar cell (DSSC) has been performed on glass FTO (Flour Tin Oxide). The material is used in the form of TiO$_2$ paste, TiO$_2$ powder and ZnO powder. Dye-sensitized solar cell (DSSC), is a fotoelektrokimia-based solar cells where the absorption process light done by the dye molecules and the process of separation of inorganic semiconductor materials by charge of Titanium dioxide (TiO$_2$) and Zinc oxide (ZnO). The purpose of this research is to know the exact composition of TiO$_2$ and ZnO materials in order to produce the best efficiency with DSSC. On this research was done making prototype dye-sensitized solar cell using dye Z 907, and semiconductor nanoparticles TiO2 and ZnO powder that is made into a paste by mixing different composition in two variations of samples: A = ZnO (powder) + 40% TiO2 (powder) and B = 60% TiO2 (powder) (40%) + TiO$_2$ (pasta) 60%. The second variation of this high efficiency is value at sample B i.e. TiO$_2$ (powder) + 40% TiO$_2$ (paste) of 60%.

1. Introduction
The main problems facing the developing countries is the energy crisis. Energy is required almost all areas, whereas the reserve source of energy available already thinning. As it is indispensable the existence of alternative energy sources. The use of renewable sources of energy currently has become the alternative energy to replace some of the energy that almost started thinning, this is done to keep the availability of sustainable energy can [1].
The many sources of renewable energy such as wind, biomass and hydro power, the use of energy through solar cell or solar cells is the most potential alternatives. The latest generation of solar cells are dye-sensitized solar cell or better known as DSSC. DSSC is one potential candidate next-generation solar cells, this is because it does not require a material with high purity so the cost of the production process is relatively low and the required materials can be derived from nature. Solar cells alternative-based dye-sensitized solar cell (DSSC) can use the sorts – range of substrates and environmentally friendly in the fabrication [2]. The dye molecules are already commonly used to dye is a type of DSSC research ruthenium complex. DSSC using layers TiO$_2$ and ZnO materials as for counter electrodes using a layer of Platinum (Pt), which are mounted on glass with sputtering techniques. TiO$_2$ and ZnO materials both of which can be either a paste or floured with nano-meter size. Both types of these materials each have advantages and disadvantages depending on the...
application being performed. One that is done on a nanoparticle TiO$_2$ and ZnO is heat treatment called Annealing, which is useful for improving maximum DSSC's performance. Improvement of annealing temperature affects the amount of grains, the ability of current density and coloring absorbance [3]. In order to attempt to improve the efficiency of DSSC needed some way to the material selection, fabrication techniques as well as the treatment of the material.

The existence of a layer of oxide semiconductors play an important role as the 'heart' of a DSSC system to convert light energy into electrical energy. TiO$_2$ and ZnO material have a large energy gap Ribbon so that it is able to absorb the energy of the photon at the majority of spectrum sun light [4]. For its application on a DSSC, TiO$_2$ anatase berfasa umunya used because it has a high fotoaktif capability. In addition TiO$_2$ with nanopori structure that is pore size in the nano scale would increase system performance because the structure nanopori has the characteristics of a high surface area, so it will increase the amount of dye absorbed the implication would sharply increase the amount of light absorbed.

The use of substance dye can influence the efficiency of the results of posting is obtained. Types of dye used can be either synthetic or natural dyes [5]. Natural dye that is derived from several types of leaves or fruit that has been extracted and taken the fluid. The use of these natural coloring price is cheaper, because it can be made but the results of their applications have yet to produce high efficiency against values obtained.

This research will be focused on making paste by mixing between the paste that has commercialization and paste that comes from nanometer-sized powder, as well as between the two different pasta. Expected results obtained can increase the value of efficient use of DSSC using pasta from powders.

1. **Research Methods**

Research DSSC has plenty to do with the use of materials, fabrication method and analysis. Any results obtained in accordance with each characterization.

a. **Materials and the Preparation of the Paste**

On the research materials used include TiO$_2$ powder, TiO$_2$ paste, and ZnO powder, which coupled with Triton X-100, PEG (Polyethylen Glycol) and Ethanol. For the tinting process using Ruthenium Dye powder Z 907, Platinum (Pt) is used as a layer of the counter electrode and electrolyte solution are injected after a merger between the electrode and the counter electrode [6].

In this study the paste that is used in the form:

1. the mixture of two kinds of powder particles nano
2. nano powders mixed with nano-paste
The mixing produced two variations of the mixture forms a paste. Mixing the ingredients matched with a mix of comparisons performed. On the mix between A TiO$_2$ nano powders + ZnO nanopowders, mixture B between TiO$_2$ nano-paste + TiO$_2$ nano-powders. Material in the form of powder, processed into paste before the first at a temperature of sinterring 450$^\circ$C for 2 hours, then added other chemicals, then processed into paste [7]. On the establishment of a prior solution of paste done stirring using a stirrer for 5 hours.

b. Fabrication of Paste on glass FTO
Mixing paste has been made, then the fabrication is done on top of the FTO glass has been prepared. Paste has been fabrikated on FTO glass which has been cleaned, shaping paste done by doctor blade, active layer with dimensions 1 cm x 1 cm. Some variations of the pasta mixture that has been fabricated, then done drying with temperature 120$^\circ$C for 10 minutes in the oven. Then conducted Firing (burning paste lining in furnaces) and 500$^\circ$C temperature for 30 minutes. This process aims to form a porous paste lining is formed so that the surface has a large area and form the structure of anatase TiO$_2$.

c. Fabrication of Platinum (pt) Layer
Platinum Plating on glass done by sputtering techniques, this is the Platinum electrode layer opponent serves to accelerate the reaction of reduction of electrolytes on the cathode, and serves as a catalyst in the reaction of formation of triodida becomes iodide.

![Counter Electrode](image)

Figure 2 : Counter Electrode

d. Immersion in aqueous Dye
After firing at a temperature of 500 $^\circ$C, the next layer of DSSC done soaking in solution of the Dye. Research on solution of the Dye that is used in the form of ruthenium complex Z 907 dissolved in alcohol. Solution of the dye that has been made, further stirring is done, then the only solution is for 8 hours. Soaking is done for 24 hours, this is done in order to better absorb into ruthenium layer of TiO$_2$ and ZnO.

e. The Assembling
Process of assembling a DSSC, namely the unification between the electrode and the counter electrode layer by snapping face each other. After both sides poised between an electrode and the counter electrode is plated, and the Samurai affixed with adhesive leaves hole to fill liquid electrolyte.

3. Results and Discussion
The process of the preparation of the paste, fabrication and assembling has been done. Next do some characterization and measurements on the material that has been fabricated. Characterization in the form of SEM, UV-Vis and IPCE has done. Next up is done charging the electrolyte solution between the electrode and the counter electrode layer, once let sit a while, then do the measurement of I-V Sun simulator to find out the efficiency, voltage, current, and the fill factor produced from some fabrication DSSC has been done [8].
a. **SEM Characterization**

SEM characterization of this research was conducted to find out its homogeneity of powder and paste that has been fused, and performed a stirring for a few hours by using a stirrer. After subsequent fabrication done characterization, to find out the porosity of the materials used blend between TiO$_2$ and ZnO powder or a form of paste.

![SEM images of ZnO and TiO$_2$](image1)

**Figure 3:** ZnO (serbuk) + TiO$_2$ (serbuk)
40% : 60%

**Figure 4:** TiO$_2$ (serbuk) + TiO$_2$ (pasta)
40% : 60%

From Figure 3 the results of SEM characterization of ZnO powder and mix namely pasta TiO$_2$, visible grain of the two particles not mixed evenly. From the image still visible two different particle size. The difference in grain and the presence of a difference in space could increase the value of the I-V Sun Simulator generated by a DSSC.

b. **UV–Vis Characterization**

![UV–Vis spectra](image2)

**Figure 5:** ZnO (powder) + TiO$_2$ (powder)
40% : 60%

**Figure 6:** TiO$_2$ (powder) + TiO$_2$ (paste)
40% : 60%
Figure 5 and 6 are the result of UV-Vis characterization of two kinds of mixed—an ZnO powder and pasta TiO2. Figure 5 is a characterization of ZnO (powder) + TiO2 (powder) ---- 40%: 60% and Figure 6 is a characterization: TiO2 (powder) + TiO2 (paste) ---- 40%: 60%. Characterization of the second image above shows the differences are not that great.

c. I-V Sun Simulator Characterization
I-V Sun Simulator characterization is done to find out the capabilities of fabricating the results of DSSC’s work. This characterization of the obtained measurement results in the form of efficiency, voltage, current, and fill factor. UV-Vis spectrophotometry is the measurement of the wavelength and intensity of the ultraviolet rays of visible light that is absorbed by the sample. Ultraviolet light and visible light has enough energy to promote-the electrons in the outer shell to a higher energy level. This characterization is obtained from the measurement results in the form of efficiency, voltage, current, and fill factor. Ultraviolet light is at a wavelength of 200-400 nm, while visible light is at a wavelength of 400-800 nm. The results of the characterization work efficiency refers to the ability of the DSSC has been made.

As for the paste made for fabrication above the glass substrate is a mixture between the paste and powder prolific nano particles. Mix first: ZnO (powder) + TiO2 (powder) with comparison 40:60, the value of the measured efficiency of 0.221. The mix second: TiO2 (powder) + TiO2 (paste) with comparison of 40:60, generating efficiency of 0.530. As for the graphics I-V measurement results can be seen in the picture below.

\[ \text{Figure 7 : I-V ZnO (powder) + TiO2 (Powder) -- 40% : 60%} \]

\[ \text{Figure 8 : I-V TiO2 (powder) + TiO2 (paste) -- 40% : 60%} \]

From the graph of figure 7 generated eff = 0.221, Vmax = 0.325 Volt, Isc = 0.450 mA, ff = 0.532 and from the graph of figure 8 above generated eff = 0.530, Vmax =0.366 volt, Isc = 0.144 mA, ff = 0.385.
The results of the measurement of I-V Sun simulator of the second mix, resulting in greater efficiency in the mix: TiO$_2$ (powder) + TiO$_2$ (paste) with 40 : 60, i.e. comparison of 0.530. This is due to paste on the mix contains a TiO$_2$ paste particles smaller (nano-shaped).

4. Conclusion

From the measurement result and analysis of the characterization, can be conclude:

a. Analysis of SEM obtained that granular particle derived from (TiO$_2$ powder + TiO$_2$ Paste) producing granular particle smaller invinite dimensional nano and more evenly.

b. Characterization UV-Vis for ZnO (powder) + TiO$_2$ (powder)-----40% : 60% and TiO$_2$ (powder) + TiO$_2$ (paste) ---- 40% : 60% show results characterization UV-Vis TiO$_2$ (powder) + TiO$_2$ (paste) ---- 40% : 60% is better.

c. Characterization IV Sun Simulator for ZnO (powder) + TiO$_2$ (powder) by comparison 40% : 60%, the efficiency of the observable of 0,221. The mixed TiO$_2$ (powder) + TiO$_2$ (paste) by comparison 40% : 60% it rewards efficiency of 0,530.

d. Of the three conclusion above that the result of the characterization TiO$_2$ (powder) + TiO$_2$ (paste) ---- 40% : 60% is better.

5. Reference

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