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# TiO<sub>2</sub> Dye Sensitized Solar Cells Cathode Using Recycle Battery

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**Abstract.** This paper proposed an alternative source of carbon material from recycled battery for the fabrication of cathode of a dye sensitized solar cell. Carbon from recycle battery is extracted and used to fabricate the cathode part of a dye sensitized solar cell by using TiO<sub>2</sub> as the anode. The both anode and cathode is fabricated on a 6 x 2cm<sup>2</sup> indium tin oxide (ITO) coated glass and then tested under the solar irradiance of 693.69 w/m<sup>2</sup> and average temperature 44.4 oC. Result shows that by using carbon from a recycle battery a Voc of 0.333V and short circuit current of 166.04  $\mu$ A is produce.

## 1. Introduction

Dye-sensitized solar cells (DSSCs) have been studied since the 1970s. The first DSSC design was based on single crystal zinc oxide. Due to the low film surface area for dye molecule adsorption, the performance of the first generation DSSC is 3 very poor with solar-to-electric conversion efficiencies less than 1%. In 1991, Grätzel and O'Regan modified the DSSC design. They used mesoporous TiO<sub>2</sub> nanoparticle film to replace the single crystal ZnO film to increase the dye loading. With this modification, the DSSC performance has been improved significantly to ~ 11%, which is nearly comparable to the performance of traditional solid state *p-n* junction solar cells. Different from the conventional solar cell systems, where the semiconductor performs both the task of light absorption and charge carrier transport, in DSSCs these two functions are separated into two different materials [1]. This fundamental difference has the practical consequence that the materials used in DSSCs do not need to be as defect-free as the crystalline silicon and DSSCs are more defect-tolerant than *p-n* junction solar cells. Therefore, DSSCs can be made with less expensive materials that can be produced using cheap methods such as low temperature solution crystallization and growth technique, which could eventually lower the solar cell fabrication cost [2].

With the increasing demand for utilization of energy resources, there has been a deflation in the availability of resources and there have been many methods of recycling of energy resources. Resources recycling has been an increasingly essential issue for the environmental protection and sustainable social development especially in the East Asia, one of the most rapid economic growth areas in the world.

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## 2. Methodology

### 2.1. Tools

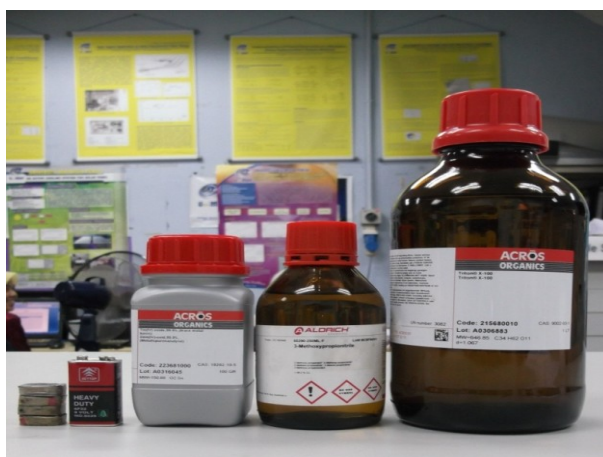
Equipment used in this study are a steel sheet, a transparent glass, binder clip, tape, cutter, glass beads, mortars (grinding), tissue paper, filter paper, alligator clip wire, glass beaker, pipette drops, mumps pipette, measuring cup, oven, furnace, blueberries, stirrer rod, aluminium foil, multimeter, as shown in Figure 1.



**Figure 1.** Equipments used in this study

### 2.2. Materials

The materials used in this study were nanotitanium dioxide  $\text{TiO}_2$  powder, triton X-100, Recycle battery, Methoxypropionitrile, Indium tin oxide coated glass slide, 30 ~ 60  $\Omega/\text{sq}$  surface sensitivity, as shown in Figure 2.



**Figure 2.** Materials used in this study

### 2.3. Proposed Technique

#### 2.3.1. Glass Preparation

This section focuses on the preparation of the glass substrates for those who would like to prepare their own electrodes from scratch. It includes cutting the glass to the desired size and gives advice for cleaning prior to making any deposition. The typical substrate for making Dye Solar Cells is a glass plate coated on one side with a Transparent and Conductive Oxide (TCO) layer. The most frequently used conductive material for that purpose is fluorine-doped tin oxide (FTO). The terms TCO or FTO glass are often used to refer to this kind of substrate [3].

#### 2.4. Identifying the Conductive Side

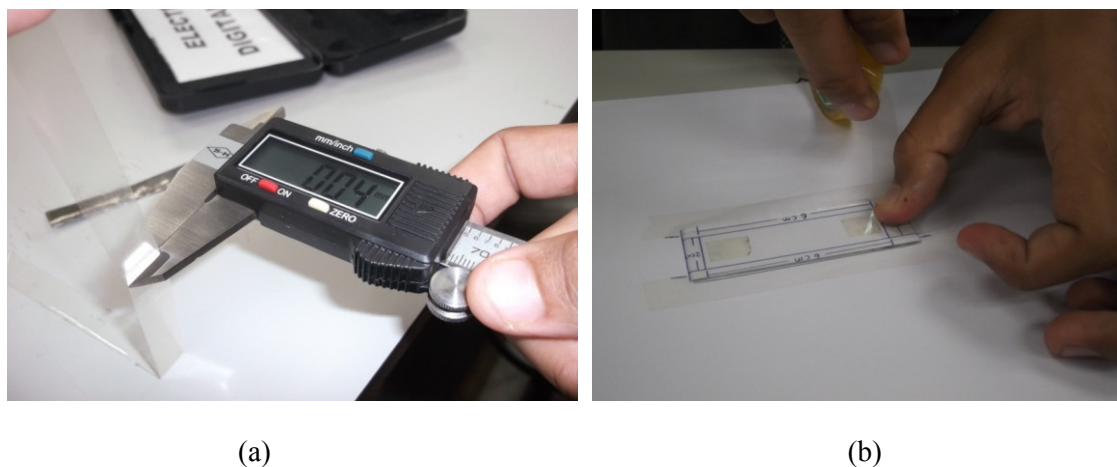
The TCO glass plates are only conductive on one side. Make sure to clearly identify the appropriate side while making your cells. The deposition of materials discussed in this tutorial will always be performed on the conductive side. A multimeter set to measure resistance should typically read about 58.4 Ohms when the two probe tips are placed one millimeter apart in the middle of the plate. This value may vary depending on the TCO glass type. There's also an easy trick that requires no instrument. This is particularly handy for identifying which is the conductive side at any time during the assembly. Scratch each side of the glass with a plastic spatula or even your fingernail. The conductive side is the one that feels a little sticky. The TCO coating has a rougher surface than bare glass. Visually, the coated side is also the one that looks hazy. Show in Figure 3.



**Figure 3.** Indium tin oxide coated glass slide, 30 ~ 60  $\Omega$ /sq surface sensitivity

#### 2.5. Preparing the Substrate for Deposition

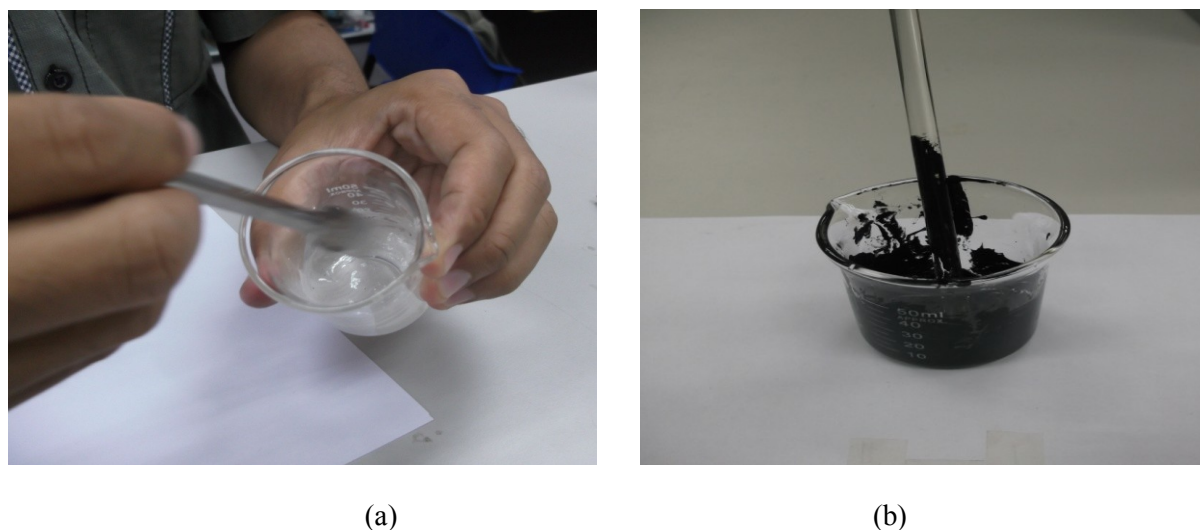
The simplest and most widely used method for depositing titania paste on a substrate is the so-called doctor-blade method. The technique is also known as slot-coating in its mechanized version. It uses a hard squeegee, or doctorblade, to spread a portion of titania paste onto the glass. With this technique, the thickness of the titania layer is determined by the thickness of a spacer placed on both sides [4]. Using the Scotch tape which has a thickness of about 0.04 mm, as shown in Figure 4. (a) with the conductive side facing up, apply two parallel strips of tape on the edges of the glass plate, covering about 5 to 7 mm of glass. The area of uncovered glass in the middle of the glass is where the titania will be deposited. Edges masked by the tape will give room for future sealing and electrical contacts. Take advantage of the adhesive tape to hold the glass plate in position on the workbench. This will prevent the plate from moving while making the deposition stroke, as shown in Figure 4 (b).



**Figure 4.** (a) Thickness of 1 layer scotch tape; (b) Tape the transparent glass on four sides using Scotch tape

#### 2.6. Preparation of $TiO_2$ and carbon suspension

$TiO_2$  and carbon from recycle battery powder as much as 3 grams of crushed using a mortar and then added into it as much as 0.2 mL of triton X-100. This mixture was stirred until evenly distributed. Then stirring to evenly. If it has been uneven. Settling of the titania paste can occur over time [5]. Make sure to start with a homogenous paste, stir well before use with a glass rod or similar tool, as shown in Figure 5.

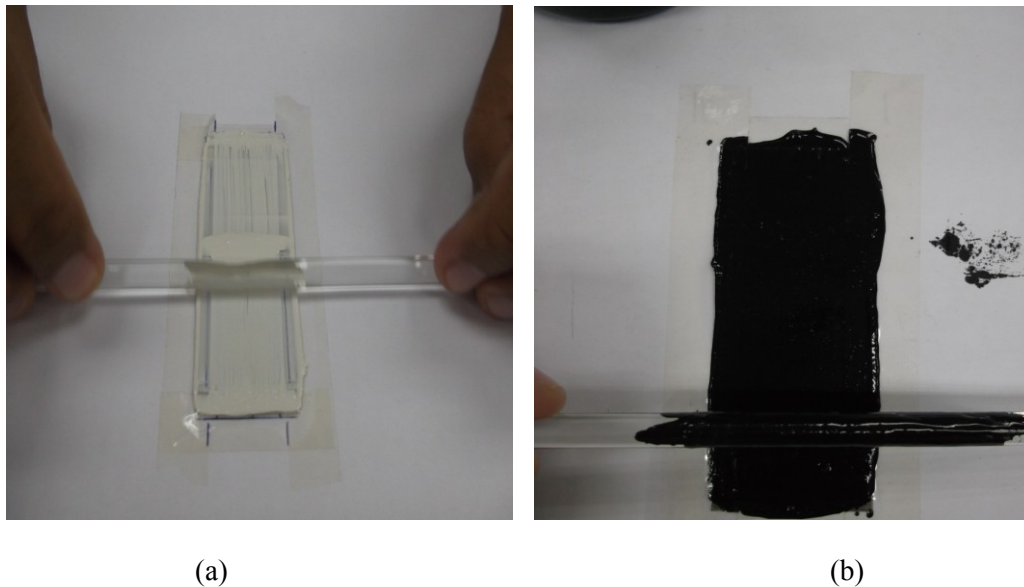


**Figure 5.** (a)  $TiO_2$  mixture was stirred; (b) Carbon of recycle battery mixture until evenly distributed

#### 2.7. Doctor-blading the titania paste

Apply a portion of paste near the top edge of the TCO glass between the two pieces of tape. With a rigid squeegee, such as a microscope slide or a glass rod, spread the paste across the plate with the support of the adhesive tapes on both sides. The gap between the strips of tape should be filled with a layer of titania paste. Repeat the operation until you have a reasonably homogenous layer. Coating was done by using doctor-blade until it reaches one thickness of Scotch tape [6], The cathode of a Dye

Solar Cell is made with carbon also. is easier and cheaper to realize. This makes carbon electrodes of great interest for research purposes. From a recycle battery of making a carbon counter-electrode are described here, as shown in Figure 6 (a) and (b).



**Figure 6 (a) and (b)** A reasonably homogenous layer titanium dioxide and carbon of recycle battery

The titania electrode is completed by firing the deposited layer. The vehicle of the paste burns away, leaving the titania nanoparticles sintered together. This process ensures electrical contact between particles and good adhesion to the TCO glass substrate. Sintering can occur in an oven, or on a programmable hotplate. First remove any adhesive tapes used for doctorblade deposition, and place the freshly coated glass plate in or on the heating device at room temperature. Set the desired temperature to 230°C. While heating up, you may observe that the titania layer turns brown/yellow and releases fumes. This corresponds to the evaporation and combustion of the non-toxic chemicals used in the paste formulation. After 40 to 45 minutes at 230°C, the baked titania layer looks white again or transparent, indicating that the sintering process is over. Allow the heating device to cool down before removing the fired electrode. A sudden change in temperature can cause the glass to break. The resulting nanoporous layer made from the sintered particles can absorb moisture from ambient air, make sure to store the sintered electrodes in a sealed environment soon after firing [7].

### 2.8. Staining the titania

Titanium dioxide is a white semiconductor that doesn't absorb visible light. Therefore, it is necessary to colour, or sensitize, the titania electrode with a dye that can absorb as much light as possible in the visible light spectrum. This section discusses the different methods for staining a titania electrode with a sensitizing dye.

### 2.9. Staining with a natural dye

Green plants and their fruits are a fantastic source of natural dyes that absorb visible light. The red pigments found in blueberries can work especially well in Dye Solar Cells. Red fruits are very handy for experimenting. The sensitization of titanium dioxide by natural dyes consists of soaking the titania electrode in mashed fruits [8]. Complete staining can take from several minutes to several hours, while the dye molecules from the fruit juice naturally adsorb onto the titania particles. The longer the



electrode soaks in the dye, the better dyed the titania will be. Start crushing fresh fruits in a petri dish or similar container. The fruits must be juicy enough to get the titania electrode completely soaked. Place the electrode onto the mashed fruits with the titania surface facing down. If necessary, apply slight pressure on the glass plate so that the whole titania area is soaked by the mixture. The sensitization process takes an hour or more. Wait as long as possible, so that more dye molecules can attach to the titania. Remove the stained electrode and clean it carefully with tissue. Wait a few minutes for the ethanol to evaporate or use a hair-dryer to gently dry the electrode faster. The resulting stained titania should now look red almost all over its surface. If not, put it back in the fruit juice for further dyeing. Note that the mashed fruits don't offer a homogenous medium, and may cause a pattern on the stained titania electrode. This is not a problem with the operation of the solar cell. Place the Scotch tape around the titania area on the anode. The dimensions of the gasket and the stained titania shall match but not overlap. There should be one edge of the electrode that's not completely covered by the gasket to leave room for electrical contacts.

### 2.10. Putting electrodes together

Have seen how to prepare a titania anode and a counter-electrode made from carbon. Now let's see how to assemble the two electrodes into a solar cell. When the electrodes are put together, the active sides of the anode and the cathode will be facing each other. In other words, the stained titania will face the platinum or carbon of the counter-electrode. The gap left between the two glass plates will be filled with electrolyte during the next step.

This step can be accomplished using two different approaches [9]. First, electrodes can be pressed together, and the electrolyte soaked in the resulting stack by capillary effect. Second, the two electrodes can be sealed together and the electrolyte injected via gap two glass, as shown in Figure 7. (a) and (b).



(a)



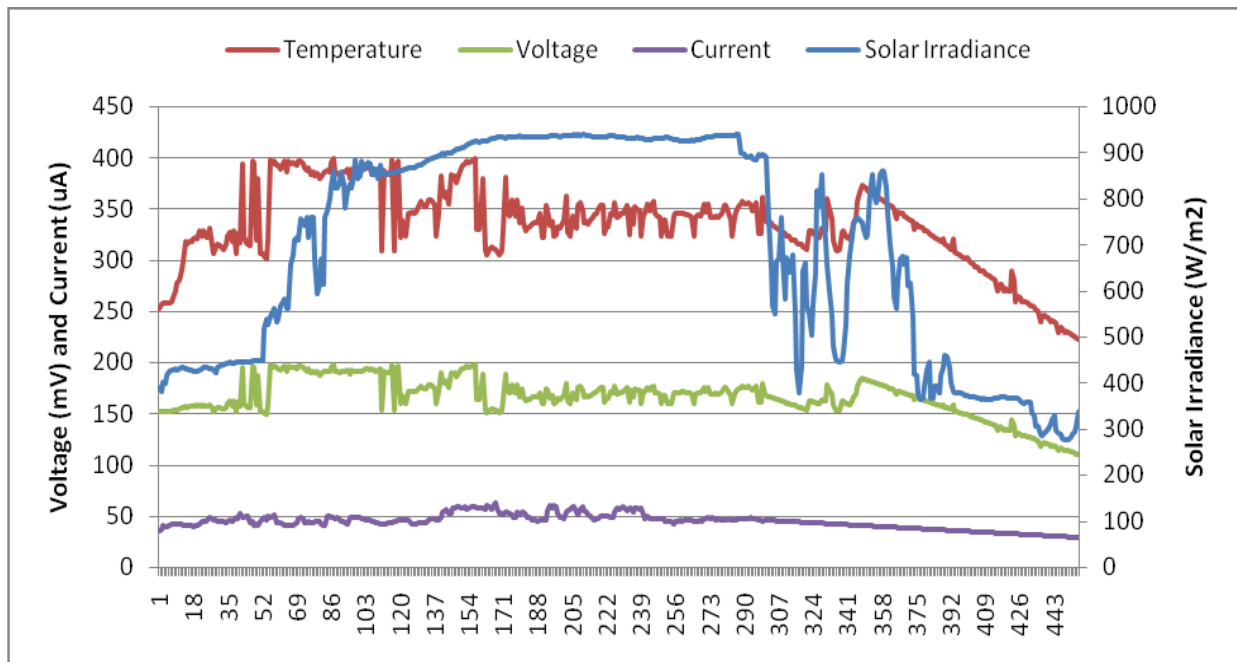
(b)

**Figure 7.** (a) TiO<sub>2</sub> as anode and Carbon as cathode; (b) Assembled with two clip paper

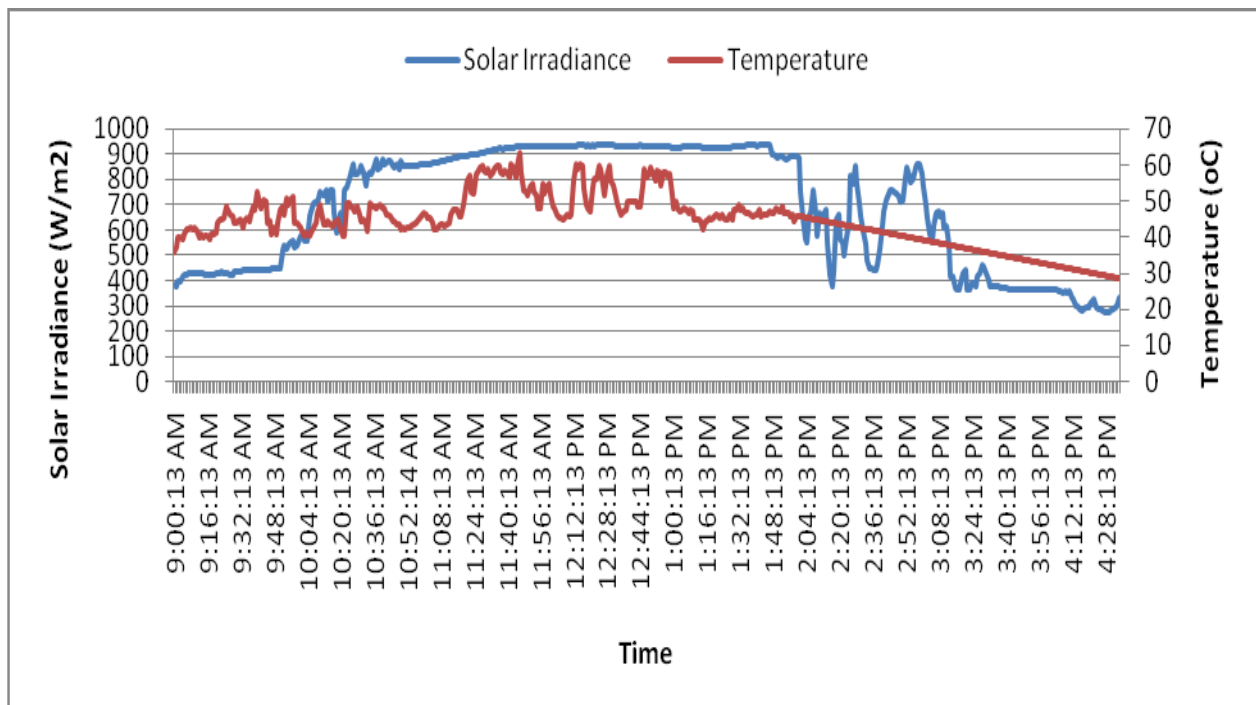
## 3. Results

### 3.1. Performance of dye sensitized solar cells using recycle battery

The performance of dye sensitized solar cells using recycle battery has been measured from 09.00AM ~ 04.30 PM ( Malaysia Time ) with Graphtec and Solar power meter and get the result, given in Figure 8, Figure 9 and table 1.



**Figure 8.** Graphic TiO<sub>2</sub> dye sensitized solar cells performance using recycle battery as function of solar irradiance and temperature



**Figure 9.** Grafic solar irradiance and tempereture as function of time

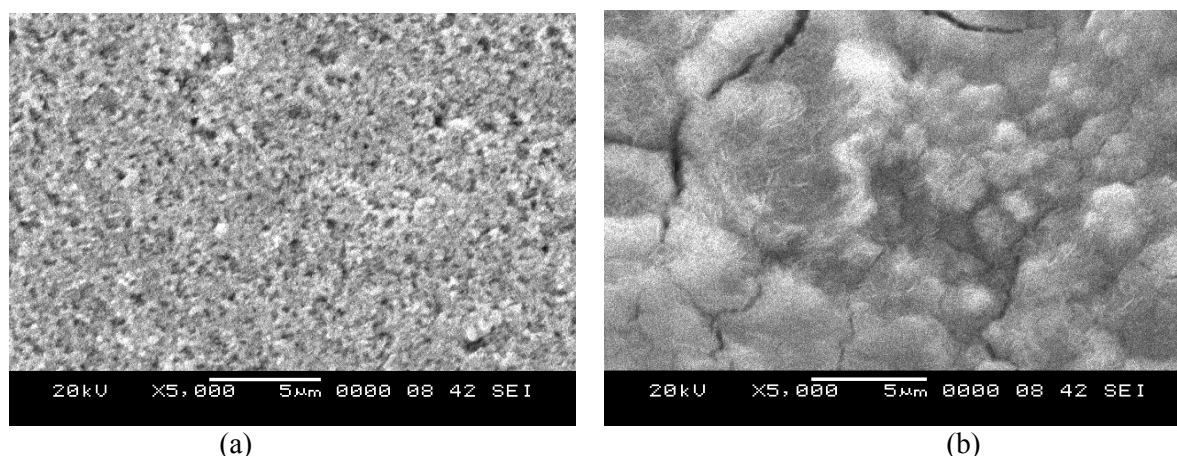


**Table 1.** Measurement result of dye sensitized titanium dioxide solar cells using recycle battery

Size of solar cells	Average		FF ( Fill Factor )	Temperature ( $^{\circ}$ C)	Solar Irradiance ( $\text{w/m}^2$ )
	Voc (Volt )	Isc ( $\mu\text{A}$ )			
6 x 2 $\text{cm}^2$	0.33	166.04	1.19	44.49	693.69

### 3.2. Scanning Electron Microscope ( SEM )

Titanium dioxide coated and Carbon coated with thickness 0.04 mm was image by scanning Electron Microscope, show in Figure 10 (a) and (b).



**Figure 10 (a).** SEM image of Titanium dioxide surface at zoom x 5,000 and 5  $\mu\text{m}$ ; **(b).** SEM image of carbon surface at zoom x 5,000 and 5  $\mu\text{m}$

### 4. Conclusions.

1. In this paper has been successfully created a dye sensitized solar cells using recycle battery which is used to convert solar energy into electrical energy.
2. Battery recycling can reused to make it as enhancing performance of dye-sensitized solar cells, and this is a green energy that utilizes recycled. of the results obtained for dye sensitized titanium dioxide solar cells using recycle battery can get 0.33 Volt with an average solar irradiance 693.69  $\text{w/m}^2$  and average temperature 44.4  $^{\circ}\text{C}$ .
3. Carbon from a battery can produce negative electrode called cathode, which serves as the provider of electron, electrons from the carbon will increase the amount of energy produced by the solar cell.
4. Scanning Electron Microscope (SEM) showed that Titanium dioxide surface and carbon surface on tin oxide coated glass by naked eyes can not see it, so it can help us in research.

## Acknowledgement

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