Fabrication of Two ColumnsDye-sensitized Solar Cell

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***Abstract*— A two columns dye-sensitized solar cell has been fabricated using dye extract from teak leaves. This solar cell was assembled with two 20-30 ohms conductive glasses (one for TiO_2 coated electrode and another for carbon coated electrode), TiO_2 nano-powder P25, iodide electrolyte solution and soft graphite pencil for carbon coating. It was found that the open circuit voltage V_{oc} was 0.688V and the short circuit current I_{sc} was 0.724 mA.**

***Keywords*— DSSC, Nanocrystalline TiO_2, teak leaves dye, z-type series connection**

I. INTRODUCTION

A photovoltaic module refers to an array of identical solar cells which are all interconnected in series. In series connection, the voltage of the individual cells adds up, while the current of the module is the same as the current of single cell. Thus, to achieve a high utilizable voltage, cells must be interconnected in series forming a module. A module may contain several numbers of cells. In this work, a two columns dye sensitized solar cell unit which is, in fact, the basic structural unit of a module has been fabricated. This research paper includes two parts: fabrication of two columns dye-sensitized solar cell and characterization of dye-sensitized solar cell.

There are many kinds of dye extract from natural leaves or fruits such as citrus leaves, raspberries and black berries used in dye-sensitized solar cell (DSSC). This research work shows that dye extract from teak leaves can also be used in DSSC. It is usually used in Myanmar traditional food preparation because of its non-toxic property.

Teak is used extensively in many countries to make doors and window frames, furniture and columns and beams in old type houses. It is very resistant to termite attacks. Mature teak fetches a very good price. It is grown extensively by forest departments of different states in forest areas. Abundant yield of teak leaves which may be obtained as by-product waste in wood production is also one of the facts to utilize teak leaf dye as low cost sensitizer.

This is, in fact, a novel use of teak leaves dye in addition to its conventional use in textile industries to color their products.

II. EXPERIMENTAL PROCEDURES

A. Fabrication of two columns dye-sensitized solar cell

The first part is study on the internal connection of two dye-sensitized solar cells. The integrated series connection for DSSC modules can be designed in 3 ways: Z-connection, W-connection and Monolithic connection. Among these 3 ways, the Z-connection has been chosen as the favored type of integrated series connection because it was found in literature that the highest efficiencies can be attained with this design.

Fig.1 schematically shows the fabrication of a series connection of Z-type. First the transparent conducting oxide (TCO) layer on the glass substrate is structured by laser scribing. Then, the TiO_2 layer, the silver lines and the glass frit are screen-printed on the substrate and dried. The glass frit is screen printed as a protective barrier on both sides of the silver lines. After sintering both electrodes are positioned on top of each other and fused at high temperatures. Thus, the glass frit forms a hermetic seal around the silver. It was provided that the layer thickness of the glass frit and the silver match, the electrical Z -contact is formed during the glass fusing process.

1) Preparation of TiO_2 suspension

The 5 g of TiO_2 nano-powder P25 was used to make colloidal suspension. 1 mL nitric acid solution (pH 3 - 4) was incrementally added to it while grinding with a pestle until a colloidal suspension with a smooth constancy was obtained. The mixture was kept to equilibrate at room temperature for about 15 minutes.

2) Preparation of TiO_2 film for two columns cell

Using a multimeter the conducting side was identified. By placing the conducting side of tin oxide coated glass plate up, the glass was taped with Scotch tape, with a 0.25cm wide strip at four edges of the plate and 1.2cm wide strip in the middle of the plate. Some titanium dioxide (TiO_2) suspension was put on the glass and quickly spread it over the surface using a glass rod. The tape was then carefully removed without scratching the TiO_2 coating. The coated plate was dried for 1 minute in a covered Petri dish. The glass plate was heated in a home-made tube furnace about 25 minutes until a white titanium dioxide coating was formed. The glass plate was then slowly cool by turning off the furnace.

3) Staining TiO_2 film

The dye solution extracted from teak leaves was poured into a rectangular shape plastic tray. The TiO_2 electrode was dipped into the dye solution with the coated side down for 24 hours until no white TiO_2 can be seen on either side of the glass. The glass plate then appeared as brownish red color. It was first washed in H_2O, and then in ethanol in order to remove water from the porous TiO_2. Any residue was wiped off with a tissue, blotting gently to dry.

4) Carbon-coated counter electrode

Another glass plate was first washed with ethanol. Then, using a multimeter the conducting side was identified. By scratching thoroughly with a soft graphite pencil, a thin carbon coating was put on the conductive side of the glass plate.

5) Preparation of liquid electrolyte

10 mL of water-free Ethylene Glycol was put in a container. Then, 0.127g of Iodine and 0.83g of Potassium Iodide were added to it. They were mixed together stirring with a clean glass rod. All the bottles and the containers were kept tightly capped when not in use.

6) Assembling the solar cell

For two columns cell, the silver line and the two thermally conductive silicone grease lines are screen printed on the respective substrates. The silicone grease is screen printed as a protective barrier on both sides of the silver lines. Thus, the silicone grease forms a hermetic seal around the silver.

The carbon-coated glass plate was placed with the coated-face down on the TiO_2 coated glass plate. The two glass plates were stacked slightly off set. The plates were bound together with the binder clips on each side of the longer edges.

Then, two to three drops of iodide electrolyte solution were put on one edge of the plates. Each side of solar cell was then made slightly open and closed alternately so that the electrolyte solution was drawn in and wet the TiO_2 film, thus making all the stained area to be in contact with the electrolyte solution.

B. Characterization of dye-sensitized solar cell

1) Measuring the electrical output

After making point contact, the open circuit voltage V_{oc} (volt) and the short circuit current I_{sc} (mA) were measured for each column cell, with a multimeter (Fig.2a, Fig.2b). And then for two columns cell, the open circuit voltage V_{oc} (volt) and the short circuit current I_{sc} (mA) were measured with a multimeter (Fig.2c, Fig.2d).

2) Characterization technique

2.1) Energy dispersive X- ray fluorescence investigation

The sample is characterized by using powder X-ray diffraction (EDX-700). Fig.3a shows EDXRF spectra of teak leaves powder and Fig.3b shows EDXRF spectra of teak leaves dye liquid.

2. 2) X-ray diffraction investigation

The sample is characterized by using powder X-ray diffraction (XRD: RIGAKU-RINT 2000 X-ray Diffractometer). Fig.4a shows XRD pattern of teak leaves powder and Fig.4b shows XRD pattern of teak leaves dye liquid.

III. RESULTS AND DISCUSSION

The followings are the quantitative results of teak leaves powder and teak leaves dye liquid.

TABLE.1 WEIGHT PERCENTAGE OF DIFFERENT ELEMENTS OF TEAK LEAVES POWDER

Element	Weight %
K	60.890
Ca	18.680
P	10.204
S	3.837
Fe	2.245
Rb	1.136
Mn	0.936
Cu	0.869
Ni	0.433
As	0.424
Sr	0.346
Total	100

TABLE.2 WEIGHT OF DIFFERENT ELEMENTS OF TEAK LEAVES DYE LIQUID

Element	Weight mg/l
K	3227.712
P	435.445
Ca	380.413
Mn	114.496
Fe	104.797
Cu	47.359
Y	39.654
Zn	30.567
Ni	27.831
Cr	24.132

It was found that the open circuit voltages V_{oc} were 0.426V and 0.4V and the short circuit current I_{sc} were 0.832 mA and 0.75 mA, respectively for each column of two columns cell.

For the internal series connection of two columns cell, it was found that the open circuit voltage V_{oc} was 0.688V and the short circuit current I_{sc} was 0.724 mA. The result shows the successful internal connection, and so the first step of DSC solar module was well accomplished.

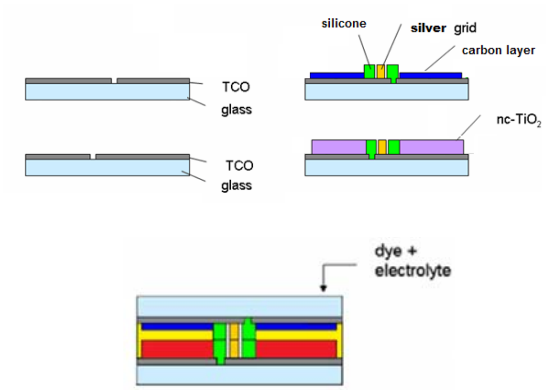

Fig.1 Fabrication of a series connection of Z-type

Fig.2a

Fig.2b

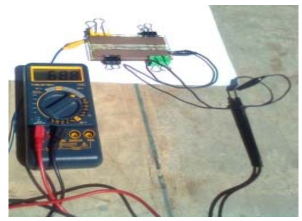

Fig.2c

Fig.2d

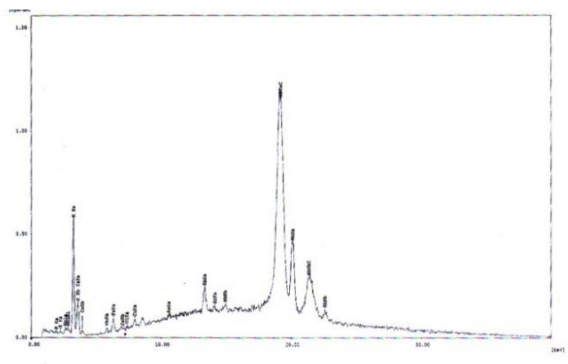

Fig.3a EDXRF spectra of teak leaves powder

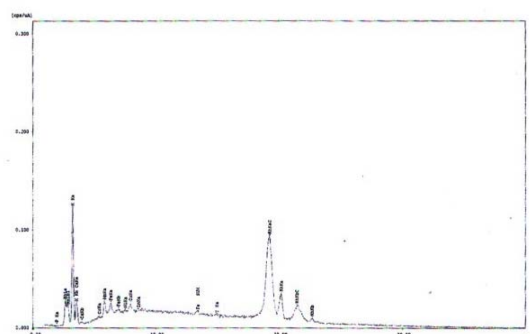

Fig.3b EDXRF spectra of teak leaves dye liquid

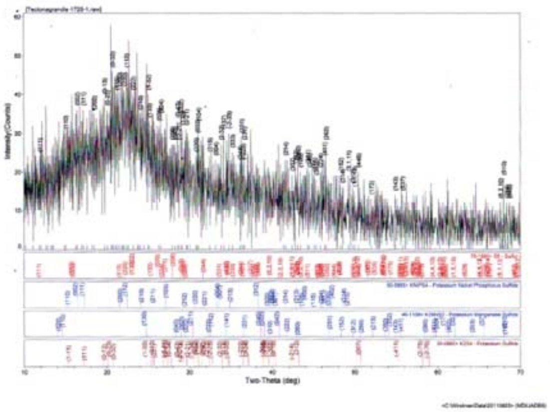

Fig.4a XRD pattern of teak leaves powder

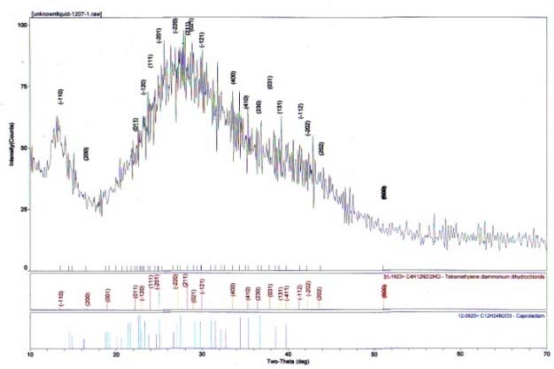

Fig.4b XRD pattern of teak leaves dye liquid

IV. CONCLUSIONS

It should be concluded that the internal connection is better than the external connection because of less connection error. But the following drawbacks are still showing.

The voltage and hence the current decreased with time. And the color of the cell also became pale. After some electrolyte was added, the color of the cell became bright and the voltage and the current were found to increase again.

Nevertheless, the dye-sensitized solar cell is at present the only serious competitor to solid state junction devices for the conversion of solar energy into electricity. This research shows that the use of natural herbal extract dyes as sensitizers for these devices could lead to achieve dye solar cells with higher efficiencies, holding great potential for further cost reduction and simplification of the manufacturing.

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