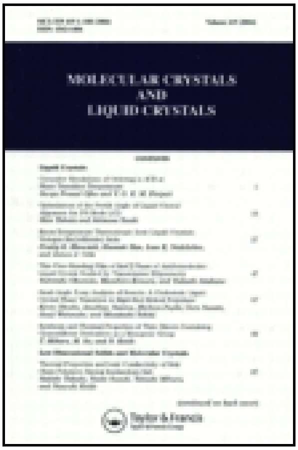

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Optimization of Liquid Crystal Concentration in the Dye-Sensitized Solar Cell for High Efficiency

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In this paper we optimize the liquid crystal (LC) concentration in the polymer electrolyte for high power conversion efficiency (PCE) of the DSSC. We measured the PCE of the dye-sensitized solar cell (DSSC) as a function of the concentration rate of the liquid crystal, E_7. The concentration of the LC has been mixed with 0, 5, 10, 15, and 20 wt% in the polymer electrolyte, respectively. In addition, we also measured current-voltage curve for measuring the fill factor of the DSSC in each concentration of the LC material. As a result, we found that the DSSC with 10 wt% of the LC concentration in polymer electrolyte can provide maximum PCE value for high photovoltaic performance in the experiment.

Keywords: dye-sensitized solar cell; liquid crystal; polymer electrolyte

1. INTRODUCTION

Currently, the concern of the sun energy became more important because users are strongly dependent on fossil fuel which is confronted by depletion. So many researchers are interesting solar cell which is possible environmentally harmless approach, so that the solar cell can provide the solution of the problems from the fossil fuels.

A Dye-sensitized solar cell (DSSC) is one form of the photoelectrochemical solar cell which chemically absorbs the dye receiving the light of the visible light area and makes the electron and hole in the semiconductor material surface having the wide energy band gap

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and improved the energy conversion efficiency. The manufacture cost is very cheaper than the existing silicon solar cell or the compound semiconductor solar cell. And an efficiency of the DSSC is normally higher than one of the organic solar cell. On the other hand, for the application in the real life, secure and efficiency enhancements of the long term stability are the problem of durability.

A Photo-electrochemical solar cell of high efficiency based on the photosynthetic principle was introduced in 1991. Researchers focused on the DSSC that was reported firstly by Grätzel group [1]. Recently, a quasi-solid-state DSSC that used polymer electrolyte containing the LC in order to increase PCE has been studied [2].

In this paper, we were mixed the LC in polymer electrolyte and measured the PCE and the fill factor of the dye-sensitized solar cell as a function of the concentration rate of the liquid crystal, E_7. Finally, we found optimization of LC concentration for high PCE in a quasi-solid-state DSSC.

2. THE MEASUREMENT OF PCE AS A FUNCTION OF CONCENTRATION OF LC

Generally, the DSSC has arrangement of sandwich that consists of TiO2 coated with dye and counter electrode. Inside of electrode is filled

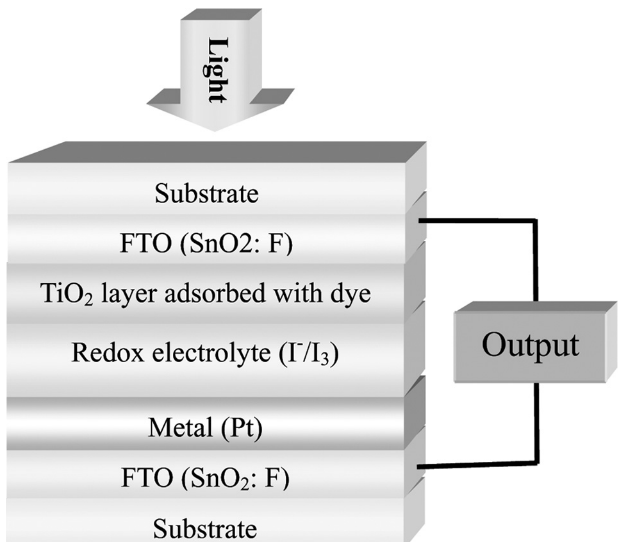

FIGURE 1 Structure of a dye-sensitized solar sell.

electrolyte including redox mediator (I/I-). Figure 1 shows the general structure of the dye-sensitized solar cell [1,3,4]. The principle of the DSSC for generating the electricity starts from absorbing light by using the dye layers. Then excited electrons in the conduction flows to external circuit through the TiO_2 layer so that we can gain the electricity from the solar cell. Form the process, the oxidized dye by the moved electron to outer circuit promptly gains electron donors by redox mediator in the electrolyte and can return to the ground state soon. Metal layer in lower substrate (Pt) provides channels for providing the electrons from the outer circuit to the electrolyte for sufficient electron donors of the redox mediator. Finally we can reactivate the solar cell again [5–7].

As I mentioned before, there was the report which can improve the PCE by using the electrolyte containing the embedded liquid crystal in the dye-sensitized solar cell. Figure 2 shows a cartoon of a quasi-solid-state DSSC using the liquid crystal LC in the electrolyte. In the molecular dimension, generally, the liquid crystal molecules neighboring will be aligned to almost same direction in each other because the liquid crystal director can handle as a continuum. The embedded LC will increase the ordering strength in the electrolyte and enhance the transportation of redox species through the liquid crystal induced diffusion pathway in the quasi-solid-state DSSCs [2]. Generally, the

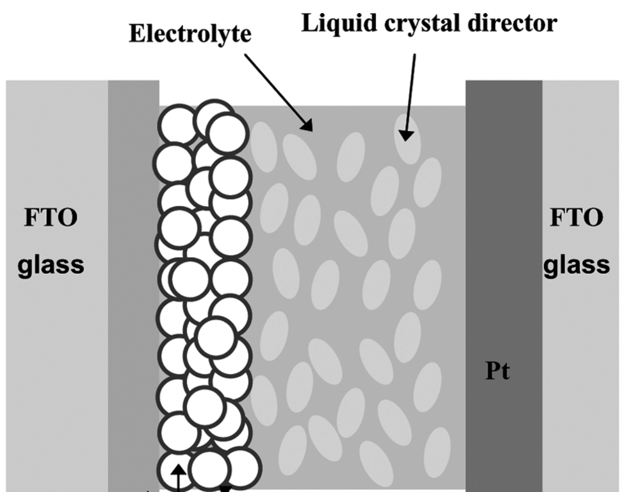

FIGURE 2 A section of dye-sensitized solar cell containing Liquid Crystal.

scalar order parameter of the used liquid crystals was measured in the range between 0.4–0.7 at room temperature.

In this work we optimized the concentration rate of the liquid crystal, E_7 for the high PCE of the dye-sensitized solar cell (DSSC). At first, a polymer electrolyte was kept in the control. The TiO_2 paste was coated on the prepared FTO conducting glass (TCO 22-15, Solaronix, ~15ohm/square, glass thickness of 2.2 mm). After it was dry in an atmospheric with 5 minutes, it sintered in 450°C for half an hour. For absorbing the dye layer into the TiO_2, the annealed nc-TiO_2 electrodes were immersed in absolute ethanol containing 0.5 mM of N 719 dye (Ru[LL'$(NCS)_2$], L = 2,2′-bypyridyl-4,4′-dicarboxylic acid, L' = 2,2′-bypyridyl-4,4′-ditetrabutylammonium carboxylate) for 24 h at ambient temperature. Pt counter electrodes can be formed by heating 7 mM of H2PtCl6 in 2-propanol solution on the glass at 400°C for 20 minutes. The polymer electrolytes consists of ethylene carbonate (EC), propylene carbonate (PC), acetonitrile (AN), tetrabutylammonium iodide (TBAI), iodine (I_2), 1-propyl-3-methylimidazolium iodide (PMII) and PAN. The used LC (E_7) has been mixed in the polymer electrolyte with 0, 5, 10, 15, and 20 wt% respectively. For appropriate mix of the electrolyte and the LC, we applied 80°C for 24 hours by magnetic stirrer [2].

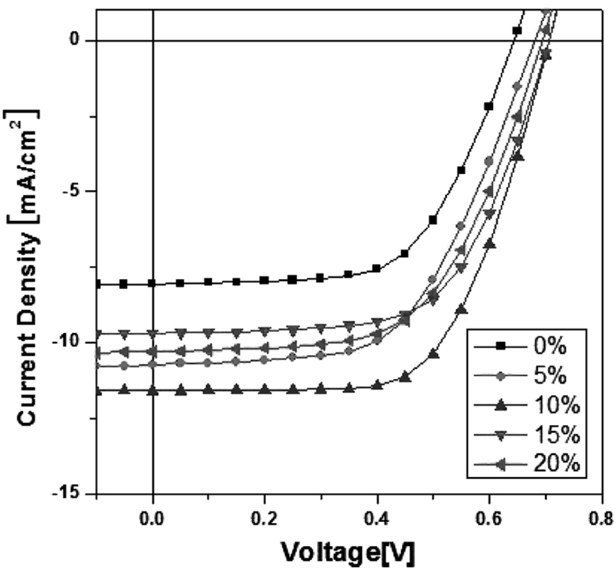

FIGURE 3 Measured voltage-current density curves of the DSSC as a function of the LC concentration.

TABLE 1 Calculated Fill Factor as a Function of the LC Concentration

Concentration [wt%]	Conventional of fill factor [%]	Correction data of fill factor [%]
0	25.397	52.442
5	26.419	60.952
10	31.812	63.156
15	30.139	60.091
20	28.168	60.434

Figure 3 shows the measured voltage to current density curve as a function of the LC concentration and we can achieve the fill factor, which is directly related to PCE of the DSSC. The fill factor can be defined as a divided value of multiplied value of the current density and the voltage at the maximum power point by multiplied value of the open circuit voltage and the short circuit current. Therefore, the fill factor is directly related to the PCE value of the solar cell. From the Figure 3, we can calculate the fill factor of the DSSC as a function of the LC concentration. Table 1 is calculated fill factor as a function of the LC concentration in DSSC. In the calculation, the fill factor of the DSSC with 10 wt% of the LC shows the maximum value (63%) and we can recognize that it can provide 20% improvement compared to the DSSC without LC material on fill factor. From this, we can expect the improved PCE of the DSSC by using the embedded LC material.

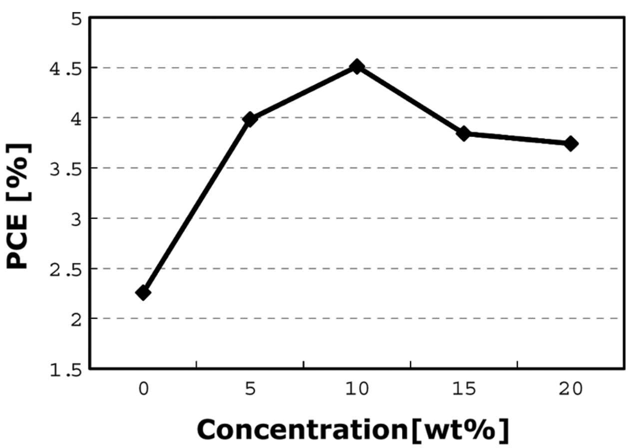

FIGURE 4 Measured PCE of DSSC with respect to the LC concentration.

Figure 4 shows the measured PCE of DSSC with respect to the LC concentration. In the Figure 4, we can find that the DSSC with 10 wt% of the LC concentration provides the maximum photovoltaic performance with the 4.52% of the PCE of the DSSC.

3. CONCLUSION

In this paper, we studied the effect of the LC concentration on PCE of the dye-sensitized solar cell. We measured the PCE of the dye-sensitized solar cell (DSSC) as a function of the concentration rate of the liquid crystal. As a result of measuring, we found that the highest efficiency (4.52%) of the PCE could be gained in the case of 10 wt% of the LC concentration. We believe that the experiment performed in this paper can provide the improvement method for the higher photovoltaic performance even if we could not achieve the maximum PCE value as much as values published before.

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