CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The conversion efficiency from sunlight energy into electricity of DSSC was investigated. The components of DSSC are essential which influenced the efficiency of DSSC. The natural dyes which were used as the sensitizer for DSSC are the alternative to synthetic dyes because of the cost-effective and environmental concern. In this research, the natural dyes extracted from sappan wood, safflower, black rice, sunflower and noni leaves show different absorption spectrum, these differences are attributed to different chemical substances in natural products. Among them, the noni leaves is found to be the most efficient sensitizer for ZnO-based DSSC. The green color from noni leaves is chlorophyll and absorbed both visible and near infrared wavelength region. It is important to notice that the sensitizer which has the absorption spectrum near infrared wavelength region improves the efficiency of DSSC, owing to the low excited energy need and the increase in electron in excited state of sensitizer.

In addition, a semiconductor is one of components that used in DSSC photoanode. ZnO is one of the attractive semiconductor materials in solar energy conversion. This material has a band gap similar to that of TiO_2 at 3.2 eV and higher electron mobility 115- 155 $cm^2/V s^2$ than that of TiO_2 (Chou *et. al.*, 2007). There are several methods of preparing ZnO photoanode, such as the doctor blade method, screen printing, sol-gel technique, and electrophoretic deposition (EPD). The electrophoretic deposition method (EPD) is one of suitable techniques for fabricating photoanode film for DSSC because this method can control the film thickness of photoanode by changing the applied voltage and deposition time. The film thickness is one parameter that affects to the conversion efficiency of DSSC. It was observed that ZnO thickness increased as the applied voltage and deposition time and consequently, the short-circuit current increased and the enhancement of the efficiency of DSSC. This is result from the increment of ZnO contents and dye loading. However, the open-circuit deceased as the

film thickness because the additional of charge recombination; recapture of electrons between the oxidized sensitizer (or electron in the conduction band of oxide layer) and the oxidized form (I_3^-) of redox couple in electrolyte occur more easily before reaching the FTO glass.

However, the efficiency of ZnO-dye sensitized solar cell was still not high. One possible reason is the charge recombination or the dark current reaction of DSSC. In order to improve the conversion efficiency of DSSC, the polythiophene layer was introduced into the photoanode. The polythiophene layer was synthesized by electrochemical method (potentiostatic condition) and the electrochemical technique is attention both because of the simplicity and the advantage of obtaining a conductive polymer being simultaneously doped. The efficiency of hybid polythiophene-ZnO DSSC which ZnO layer was fabricated by doctor blade and electrophoretic deposition method were investigated. Their conversion efficiencies improved from 4.6 m% to 5.8 m% and from 3.7m% to 4.8m%, respectively. Furthermore, the V_{oc} value increased in the presence of the polythiophene layer. This phenomenon is attributed to the polythiophene layer acts as the charge energy barrier which suppressed the dark current reaction. However, the J_{sc} value decreased because of the thicker polythiophene layer and then the increment of resistance of the DSSC and the decrease in the visible light transmittance. Therefore, the thickness of polythiophene layer should not too thick in order to enhance the efficiency of DSSC.

7.2 Recommendations

Based on what have been discovered in this study, the following recommendations are suggested.

(1) The polythiophene layer which polymerized by electrochemical creates the poor contact problem between oxide layer film and the conducting glass electrode when the polymerization is performed on the electrode covered with the oxide film. Therefore, in situ photopolymerization was suggested to deposit a very thin film of polythiophene homogeneously around the ZnO nanoparticles.

(2) The mix natural dyes were suggested to improve the absorbance spectrum and consequently, enhance the efficiency of DSSC.

(3) The ZnO particles size and appearance such as nanosphere, nanorod or nanowire affect the the dye loading and the efficiency of DSSC.