CHAPTER I

INTRODUCTION

Among the alternative energy resources, the solar energy is more notable because of its low environmental impact. Therefore, the research on photovoltaic cell has attracted considerable interest. Particularly, the dye-sensitized solar cell (DSSC) proposed by O'Regan and Grätzel (O'Regan and Gratzel., 1991) have attracted much attention since 1991. The dye-sensitized solar cell (DSSC) based on nanoporous TiO_2 electrodes divectly convert sunlight into electrical energy. This is attributed to its properties, low manufacturing cost, relatively high energy conversion efficiencies, easy fabrication, portability and flexibility when compared to conventional silicon solar cells (Green et al., 2007). To date, the highest solar to electric conversion efficiency of over 11% was achieved using a photoelectrode containing 20 nm TiO_2 nanoparticles film sensitized by a ruthenium-based dye (Gratzel et al., 2003).

The dye-sensitized solar cell (DSSC) possesses three major components: (i) nanostructured metal oxide material to transport electrons efficiently, (ii) dye sensitizer in order to harvest solar energy and generate excitons, and (iii) redox electrolyte or hole transporting material, to support the performance of dye and metal oxide (Thavasi et al., 2009). Many efforts have been made to improve the energy conversion efficiency of the dye-sensitized solar cell (DSSC) by developing novel photoelectrodes, dyes, and electrolytes (Jung et al., 2010). The photoactive electrode of the dye-sensitized solar cell (DSSC) is a transparent conductive oxide glass coated with nanoporous TiO_2 sensitized with dyes for visible light harvesting, while the counter electrode is a transparent conductive oxide glass coated with platinum. The gap between the two electrodes is filled with an electrolyte containing an iodide/tri-iodide (I^-/I_3^-) redox couple. The TiO_2 electrode in the dye-sensitized solar cell (DSSC) has a large surface area and provides sufficient anchoring sites for the dye sensitizers to provide effective light harvesting and electron injection. However, electron transfer from ruthenium complex dye does not work perfectly because many electrons recombine with the holes at the interface between TiO_2 and the electrolyte. Efficient operation of the dye-sensitized solar cell (DSSC) device relies on minimization of the possible recombination pathways occurring at the TiO_2|dye|electrolyte interface.

In order to reduce the recombination, many researchers have proposed devices that include the use of insulating metal oxides with higher band gaps such as MgO (Jung et al., 2005), Al_2O_3 (Liu et al., 2005), SrO (Yang et al., 2002), Nb_2O_5 (Xia et al., 2007), $CaCO_3$ (Lee et al., 2007), and $MgTiO_3$ (Yang et al., 2009) between the TiO_2 and the dye interface. Recently, Ganapathy and coworkers. (2010) proposed that the modification of TiO_2 by Al_2O_3 using atomic layer deposition could increase the efficiency of dye-sensitized solar cells. A layer of Al_2O_3 on TiO_2 surface reduced the loss of electrons by suppressing their recombination, resulting in a significant increase in the short-circuit current and the overall power conversion efficiency.

This research focuses mainly on improving the power conversion efficiency for dye-sensitized solar cells through modification of TiO_2 electrode. Another oxide, namely, Al_2O_3 or MgO, was mixed with TiO_2 sol and the thin film mixed oxide electrode is prepared. The effects of several preparation parameters on the cell efficiency were investigated, including the calcination temperature and the double-layer structure.

Objectives

1. To enhance the efficiency of a dye-sensitized solar cell by adding Al_2O_3 or MgO to the TiO_2 electrode.
2. To study of the effect of calcination temperature of Al_2O_3/TiO_2 electrode layer on the efficiency of a dye-sensitized solar cell.
3. To improve efficiency of a dye-sensitized solar cell by employing double-layer structure of the thin film electrode.

Research scopes

Part I

- Titanium dioxide (TiO_2), Al_2O_3 and MgO is prepared by sol-gel methods.
- Al_2O_3 or MgO is added to TiO_2 in the amount ranging from 0 to 2 % (w/w).
- The mixed oxide electrode is characterized by several techniques.
    - X-ray diffractometry (XRD)
    - Nitrogen physisorption
    - UV-visible diffuse reflectance spectroscopy
    - Inductively coupled plasma optical emission spectrophotometer
    - Zeta potential measurement
    - Fourier Transform Infrared Spectroscopy (FT-IR)
- The efficiency of dye-sensitized solar cell is measured by an I-V tester.

Part II

- Study the effect of calcination temperature of the dye-sensitized solar cells with mixed oxide electrode from Part I on their efficiencies.
- Study the effect of using double-layer thin film electrode that possesses similar specific surface area to that of a single-layer one.
- Characterize the electrode and the cell using several techniques already mentioned in Part I.

This thesis is arranged as follows:

Chapter I presented the introduction of this study.

Chapter II presented the structure and operation principles of dye-sensitizer solar cell (DSSC).

Chapter III presented the literature reviews of previous works related to this research.

Chapter IV presented the synthesis of the TiO_2 sol and modified TiO_2 via sol-gel methods.

Chapter V presented and discussed experimental results.

In the last chapter. Chapter VI presented overall conclusion and recommendations for the future studies.