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DYE-SENSITIZED SOLAR CELLS UTILIZING ZINC SULPHIDE-COATED TITANIUM DIOXIDE FILMS PHOTOANODE: EFFECT OF IMMERSION TIME ON ITS PERFORMANCE

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Abstract: This work deals with the use of ZnS-coated TiO₂ films as photoanode in a dye-sensitized solar cell (DSSC). The effect of immersion time of ZnS precursor on the photovoltaic parameters of the device has been investigated. The immersion time has been varied from 30 to 90 minutes at 15 minutes interval. The sample prepared with 60 minutes of immersion time shows the highest optical reflection in the visible region while the sample prepared with 45 minutes of immersion time possesses the highest optical absorption in the UV region. The DSSC utilizing the photoanode prepared with 60 minutes of immersion time demonstrated the highest η of 0.80%, Jsc of 2.990 mA cm⁻², Voc of 0.650 V and FF of 0.412. This is due to this device has the smallest charge transfer resistance at the interface of Pt/electrolyte (Rct₁) of 0.480 Ω.

Keywords: dye-sensitized solar cells, photoanode, ZnS-coated TiO₂

INTRODUCTION
The performance of dye-sensitized solar cell can be improved by utilizing modified metal oxide photoanode. The photoanode can be modified via several ways, namely, coating photoanode with another metal oxide, introducing composite structure consisting of two metal oxides and doping metal oxide with metal or metal. In this work, TiO₂ films have been coated with ZnS and then utilized as a photoanode of the device.
OBJECTIVE
The objective of this work is to investigate the effect of immersion time of ZnS precursor that is zinc nitrate hexahydrate on the optical properties of ZnS-coated TiO₂. The next objective is to study the effect of immersion time of zinc nitrate hexahydrate on the photovoltaic parameters of the device has been investigated.

LITERATURE REVIEW
Hu and his group reported that the recombination of electrons with holes was depressed by introducing strontium oxide (SrO) shell coating on TiO₂ and consequently increased the power conversion efficiency of the device [2]. Zhu and his co-workers found that the efficiency of the device was improved upon utilizing graphene-TiO₂ composite photoanode due to the increase in photocurrent density and voltage [3]. Dong and his co-researchers employed silver-loaded TiO₂ composite as a photoanode of DSSC and found a significant increase in the efficiency of the device [4]. TiO₂-coated ZnO has been applied as photoanode of DSSC and demonstrated the power efficiency of 5.65% [5]. TiO₂-coated ZrO₂ has been employed as a photoanode of the device and the short-current density (Jsc) has been improved by two times compared with the device utilizing TiO₂ potoanode [6]. The DSSC employing TiO₂-coated Nb₂O₅ demonstrated the efficiency of 7.23% due to the significant increase in the short-circuit current density [7].

METHODOLOGY
TiO₂ films were grown twice on ITO substrates via liquid-phase deposition technique [8]. The ITO substrates were immersed in a solution containing 0.2 M boric acid, H₃BO₃ and 0.1 M ammonium hexafluorotitanate, (NH₄)₂TiF₆ for 25 h. The growth temperature was maintained at 30 °C. After 25 h, the TiO₂ samples were left to dry. ZnS solution was prepared separately by dissolving zinc nitrate hexahydrate and thiourea in ethanol with molarity ratio of 1:1. Then, the TiO₂ Samples were immersed in 0.01 M ZnS solution for 30 min. Finally, the sample was annealed at 400 °C for 1 h. These procedures were repeated for preparing ZnS-coated TiO₂ with other precursor immersion times, namely, 45, 60, 75, and 90 minutes. The samples were characterized by UV–Vis to study its optical absorption and reflection.

0.5 mM of N719 dye solution was prepared as the photoanode sensitizer. ZnS-coated TiO₂ films were immersed in the dye solution for 15 h at room temperature. The counter electrode of the device was
platinum film grown on FTO substrates. Redox electrolyte containing iodide/triiodide was injected into the space between TiO2/ ZnS-coated N719 and platinum counter electrode. The devices with an active area of 0.23 cm² were tested in dark and under the illumination of 100 mW cm⁻² light. The light source used was tungsten halogen lamp. The electrochemical impedance spectroscopy (EIS) was performed on the devices to determine the charge transport properties and carrier lifetime.

FINDINGS
The use of ZnS-coated TiO₂ has been found to improve the performance of the DSSC. The performance of the device is significantly influenced by the immersion time of zinc nitrate hexahydrate.

CONCLUSIONS
The ZnS-coated TiO₂ has successfully been prepared via liquid phase deposition technique assisted spin coating technique and employed as photoanode of DSSC. The device utilizing the photoanode prepared with 60 minutes of immersion time demonstrated the highest η of 0.80% and Jsc of 2.990 mA. This is due to this device has the smallest charge transfer resistance at the interface of Pt/electrolyte (Rct1) of 0.480 Ω.

SELECTIVE REFERENCES