

**THE ZnO/QUANTUM DOTS WITH MIXED NATURAL DYES SYSTEM  
FOR DYE-SENSITIZED SOLAR CELLS**

Warunya Junhom

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**By:** Warunya Junhom  
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**Thesis Advisor:** Assoc. Prof. Rathanawan Magaraphan


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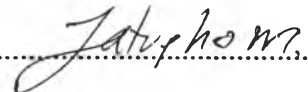
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..... College Dean  
(Asst. Prof. Pomthong Malakul)

**Thesis Committee:**

  
.....  
(Assoc. Prof. Rathanawan Magaraphan)

  
.....  
(Asst. Prof. Boonyarach Kitiyanan)

  
.....  
(Assoc. Prof. Jatuphorn Wootthikanokkhan)

## ABSTRACT

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Keywords: Mixed dyes/ Yellow cotton/ Red orchid/ Spirulina/ Indigo/ Quantum dots/ Kinetic adsorption/ Isothermal adsorption/ Zinc oxide

This work aims to study the effect of natural dyes and quantum dots on performance of dye sensitized solar cells (DSSCs). ZnO was used as a semiconductor and photoanode that was fabricated by the doctor blade method. The yellow cotton, red orchid, spirulina and indigo were used as a sensitizer. For optical properties of dyes, the maximum absorption wavelength of red orchid, spirulina, indigo and yellow cotton extract was 519, 620, 626 and 488 nm which were obtained from pelargonidin, *c*-phycocyanin, indigo and quercetin, respectively. Then the conversion efficiency was obtained. It was found that indigo showed the highest conversion efficiency equaled to 0.0200%. Then the method that dyes used to adsorb on ZnO was investigated. The results indicated that the dyes exhibited pseudo-second-order model for kinetic study. Moreover, both the Langmuir and the Freundlich model were used for an isothermal study. In order to enhance the conversion efficiency, the mixed dyes and QDs were chosen for a further study on optical properties and photovoltaic performance. The results illustrated that the absorption and emission intensities increased with the dipping time of QDs. For mixed dyes systems, it was found that the use of a combination of yellow cotton-spirulina resulted in the DSSC with the highest conversion efficiency value of 0.0145% by varying the dipping time of producing QDs on ZnO, it was found that the ZnO/CdS, prepared by using the dipping time of 9 min showed the highest conversion efficiency of 0.0345%.

## บทคัดย่อ

วรรณญา จันทอม : จุดควอนตัมบนซิงค์ออกไซด์ และสีย้อมธรรมชาติผสม สำหรับเซลล์แสงอาทิตย์ชนิดสีย้อมไวแสง (The ZnO/Quantum Dots with Mixed Natural Dyes for Dye-Sensitized Solar Cells) อาจารย์ที่ปรึกษา : รศ.ดร. รัตนวรรณ มกรพันธุ์ 94 หน้า

งานวิจัยนี้นำเสนอเกี่ยวกับผลกระทบของสีย้อมธรรมชาติและจุดควอนตัมต่อประสิทธิภาพการเปลี่ยนพลังงานแสงอาทิตย์เป็นพลังงานไฟฟ้าของเซลล์แสงอาทิตย์ชนิดสีย้อมไวแสง ในงานวิจัยนี้เซลล์แสงอาทิตย์ทำมาจากสารกึ่งตัวนำซิงค์ออกไซด์ที่เตรียมได้จากวิธีการปาดแบบดอกเตอร์ (doctor blade) ดอกสุพรรณิการ์ กล้วยไม้สีแดง สาหร่ายเกลียวทอง และครามถูกสกัดเพื่อใช้เป็นสารไวแสง จากการศึกษาสมบัติทางแสงของสีย้อมธรรมชาติ แสดงให้เห็นว่าสีย้อมมีค่าการดูดกลืนแสงที่มากที่สุดเท่ากับ 519, 620, 626 และ 488 นาโนเมตร ซึ่งสอดคล้องกับองค์ประกอบทางเคมีภายในคือ พีลาโกนิน (Pelargonidin), ซี-ไฟโคไซยานิน (C-phycoocyanin), อินดิโก (Indigo) และ เคอร์เซทิน (Quercetin) ตามลำดับ จากนั้นได้วัดประสิทธิภาพของเซลล์พบว่าเซลล์แสงอาทิตย์ชนิดสีย้อมไวแสงที่ใช้อินดิโกเป็นองค์ประกอบให้ค่าประสิทธิภาพของเซลล์สูงที่สุดซึ่งมีค่าเท่ากับ 0.0200% จากการศึกษาวิธีที่สีย้อมใช้ในการยึดเกาะบนซิงค์ออกไซด์พบว่าสีย้อมใช้ปฏิกิริยาซูล์ฟไฮไดรด์อันดับที่สองเมื่อศึกษาในด้านของจลศาสตร์ ส่วนด้านของอุณหภูมิจลศาสตร์พบว่าสีย้อมใช้รูปแบบทั้งของแลงเมียร์ (Langmuir) และฟรอนด์ลิค (Freundlich) ในการยึดเกาะบนซิงค์ออกไซด์ เพื่อที่จะเพิ่มค่าประสิทธิภาพของเซลล์แสงอาทิตย์ชนิดสีย้อมไวแสง สีย้อมผสมและจุดควอนตัมถูกเลือกมาเพื่อใช้ในการศึกษานี้ จากการศึกษาสมบัติทางแสง จากการศึกษาสมบัติทางแสงซึ่งให้เห็นว่าค่าความเข้มจะสูงขึ้นเมื่อเวลาในการจุ่มเพื่อสร้างจุดควอนตัมเพิ่มขึ้น สำหรับสีย้อมผสมพบว่าค่าประสิทธิภาพของเซลล์ในระบบสีย้อมดอกสุพรรณิการ์ผสมกับสีย้อมสาหร่ายเกลียวทองให้ค่าประสิทธิภาพของเซลล์สูงที่สุดซึ่งมีค่าเท่ากับ 0.0145% แล้วระบบการผสมสีย้อมนี้ถูกนำมาใช้ในการศึกษาผลกระทบของจุดควอนตัมต่อประสิทธิภาพของเซลล์โดยการเปลี่ยนเวลาที่ใช้ในการจุ่มซิงค์ออกไซด์เพื่อสร้างจุดควอนตัม พบว่าแคดเมียม (II) ซัลไฟด์บนซิงค์ออกไซด์ที่เวลาการจุ่ม 9 นาทีให้ค่าประสิทธิภาพของเซลล์ที่สูงที่สุดมีค่าเท่ากับ 0.0345%

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**ABBREVIATIONS**

CBD	Chemical bath deposition
DSSC	Dye-sensitized solar cell
FF	Fill factor
FTO	Fluorine-doped tin oxide
HOMO	Highest occupied molecular orbital
I <sup>-</sup>	Iodide
I <sub>2</sub>	Iodine
I <sub>3</sub> <sup>-</sup>	Triiodide
LiI	Lithium iodide
LUMO	Lowest unoccupied molecular orbital
NIR	Near infrared
PV	Photovoltaic
TiO <sub>2</sub>	Titanium dioxide
QDs	Quantum dots
UV	Ultraviolet
Vis	Visible
ZnO	Zinc oxide

**LIST OF SYMBOLS**

$J$	Current densities
$J_m$	Maximum-current point
$J_{sc}$	Short-circuit current
$V$	Voltage
$V_{oc}$	Open-circuit voltage
$V_m$	Maximum-voltage point
$P$	Power density
$\eta$	Conversion efficiency