

FABRICATION OF TiO_2 NANOTUBE ARRAYS BY ANODIZATION AND ITS
APPLICATIONS IN PHOTOREDUCTION OF CHROMIUM(VI)

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Environmental Management

(Interdisciplinary Program)

Graduate School

Chulalongkorn University

Academic Year 2007

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาการจัดการสิ่งแวดล้อม (สหสาขาวิชา)
บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
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501372

Thesis Title	FABRICATION OF TIO ₂ NANOTUBE ARRAYS BY ANODIZATION AND ITS APPLICATIONS IN PHOTOREDUCTION OF CHROMIUM(VI)
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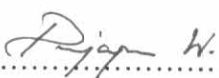

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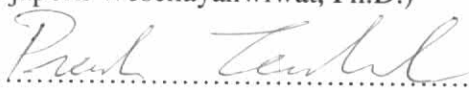
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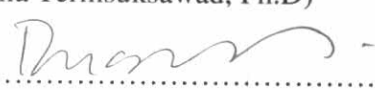

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วิไลวรรณ จันทรธัมมิ: การขึ้นรูปไททาเนียมไดออกไซด์แบบท่อนาโนด้วยวิธีอะโนไดเซชัน และการประยุกต์ใช้ในปฏิกิริยาโฟโตรีดักชันของโครเมียม (FABRICATION OF TiO₂ NANOTUBE ARRAYS BY ANODIZATION AND ITS APPLICATIONS IN PHOTOREDUCTION OF CHROMIUM (VI)) อ. ที่ปรึกษา : รศ. ดร. พวงรัตน์ จิตวิชานุกูล, อ. ที่ปรึกษาร่วม: ศ. ดร. คริสแนน ราเจสชวา. 165 หน้า.

งานวิจัยนี้มุ่งเน้นศึกษาการขึ้นรูปและวิเคราะห์คุณลักษณะของไททาเนียมไดออกไซด์แบบท่อนาโน ด้วยวิธีอะโนไดเซชัน โดยใช้ความต่างศักย์ไฟฟ้าทั้งบวกและลบบนแผ่นโลหะไททาเนียม ความต่างศักย์ที่ใช้ในการทดลองครั้งนี้มี 2 แบบด้วยกัน กล่าวคือ 20 โวลต์ สลับกับ -4 โวลต์ และ 20 โวลต์ สลับกับ 0 โวลต์ และมีการแปรเปลี่ยนระยะเวลาในการใช้ศักย์ไฟฟ้าลบและศูนย์ตั้งแต่ 2 วินาที ถึง 16 วินาที การขึ้นรูปไททาเนียมไดออกไซด์แบบท่อนาโนเกิดขึ้นในสารละลายแอมโมเนียมฟลูออไรด์ และ ส่วนประกอบอื่น ๆ ในสารละลาย (กริเซอรอล เอทิลีนไกลคอล หรือโพลีเอทิลีนไกลคอล) ผลการทดลองพบว่า การขึ้นรูปแบบใช้ความต่างศักย์ไฟฟ้าทั้งบวกและลบนั้น ทำให้ได้ไททาเนียมไดออกไซด์ ลักษณะ เป็นท่อขนาดเล็กในระดับนาโนเมตร และมีค่าการตอบสนองต่อปฏิกิริยาเคมีไฟฟ้าสูงกว่าการใช้เพียง ศักย์ไฟฟ้าบวกเพียงอย่างเดียวโดยสภาวะที่เหมาะสมที่สุด ในการขึ้นรูปไททาเนียมไดออกไซด์ แบบท่อนาโนคือ การใช้ศักย์ไฟฟ้า 20 โวลต์ สลับกับ -4 โวลต์และใช้ระยะเวลาในการใช้ศักย์ไฟฟ้าลบ 2 วินาที เนื่องจากศักย์ไฟฟ้าลบทำให้แอมโมเนียมไอออนในสารละลายสามารถเกาะติดผิวของไททาเนียมไดออกไซด์ ซึ่งจะทำหน้าที่ป้องกันการถูกทำลายของไททาเนียมไดออกไซด์จากฟลูออไรด์ไอออนที่มีอยู่ในสารละลาย นอกจากนี้ยังมีการศึกษาความสัมพันธ์และการเปลี่ยนแปลงต่อการตอบสนองต่อปฏิกิริยาเคมี และ ปฏิกิริยาโฟโตคะตะไลติกรีดักชัน เมื่อมีเติมโลหะไอออนและสารประกอบอื่น ๆ ในสารละลาย ซึ่งผลการทดลองพบว่า การเลือกใช้โลหะไอออนกับสารประกอบอื่น ๆ ที่เหมาะสมนั้น สามารถ ช่วยเพิ่มประสิทธิภาพของไททาเนียมไดออกไซด์แบบท่อนาโนในการตอบสนองต่อปฏิกิริยาเคมี และปฏิกิริยาโฟโตคะตะไลติกรีดักชัน โดยการทดสอบปฏิกิริยาโฟโตคะตะไลติกรีดักชันของโครเมียม ประจุบวก 6 ภายใต้การฉายแสงอัลตราไวโอเล็ต ได้ทำการทดสอบทั้งไททาเนียมไดออกไซด์แบบท่อนาโน และไททาเนียมไดออกไซด์แบบท่อนาโนที่มีการเติมไอออนโลหะ ผลการทดลองพบว่า ไททาเนียมไดออกไซด์แบบท่อนาโนที่มีการเติมไอออนนิกเกิลโลหะ และกลีเซอรอลให้ค่าควอนตัมยิวสูงถึง 3.2×10^{-2}

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4889673020 : MAJOR ENVIRONMENTAL MANAGEMENT

KEY WORD: TiO₂ / PULSE ANODIZATION / TiO₂ DOPING / PHOTOELECTROCHEMICAL RESPONSE / TITANIUM NANOTUBE / CHROMIUM / ZINC PORPHYRIN / TiO₂ DYE SENSITIZED/ PHOTOCATALYSIS /

WILAIWAN CHANMANEE: FABRICATION OF TiO₂ NANOTUBE ARRAYS BY ANODIZATION AND ITS APPLICATIONS IN PHOTOREDUCTION OF CHROMIUM (VI). THESIS ADVISOR: ASSOC. PROF. PUANGRAT KAJITVICHYANUKUL, Ph.D., THESIS CO-ADVISOR: PROF. KRISHNAN RAJESHWAR, Ph.D., 165 pp.

This research focuses on preparation and characterization of TiO₂ nanotube arrays prepared by anodic oxidation of Ti substrates using pulse voltage waveforms. Voltages were pulsed between 20 V and -4 V or between 20 V and 0 V with varying durations from 2 to 16 seconds at the lower limit of the pulse waveform. Ammonium fluoride were used as the electrolyte with or without added medium modifier (glycerol, ethylene glycol, or poly (ethylene glycol) (PEG 400)) in these experiments. The pulse waveform was optimized to electrochemically grow TiO₂ nanotubes and chemically etch their walls during its cathodic current flow regime. The resultant TiO₂ nanotube arrays showed a higher quality of nanotube array morphology and photoresponse than samples grown via the conventional continuous anodization method. Films grown with a 20 V/-4 V pulse sequence and pulse duration of 2 s at its negative voltage limit afforded superior photoresponse compared to other pulse durations. Specifically, the negative voltage limit of the pulse (-4 V) and its duration promote the adsorption of NH₄⁺ species that in turn inhibits chemical attack of the growing oxide nanoarchitecture by the electrolyte F⁻ species. The co-doping effects by metal cations on photoelectrochemistry properties were also observed on photocatalysis reduction. Thus, it was found that transition metal doping into photocatalysts with wide band gaps was effective for the development of photoelectrochemical response and photocatalytic activity if a suitable combination of dopant-codopant is chosen. Finally, photocatalytic reduction of hexavalent chromium were studied under ultraviolet light using anodically growth Ti/TiO₂ and metal modified TiO₂ nanotube show quantum yield up to 3.2×10^{-2} obtain by film were prepared with NiF₂ and used glycerol as dopant.

Field of study Environmental Management
Academic year 2007

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ACKNOWLEDGEMENTS

I would like to gratefully acknowledge my thesis advisors, Assoc. Prof. Dr. Puangrat Kajitvichyanukul and Prof. Dr. Krishnan Rajeshwar, for his extraordinary guidance and encouragement throughout my research period.

I wish to extend my warm and sincere thanks to my committee members Manaskorn Rachakornkij, Associate Professor Wanpen Wirojanagud, Punjaporn Weschayanwiwat, Preecha Termsuksawad, and Associate Professor Duangrat Inthorn for their helpful comments and advice.

I wish to give special thanks to Drs. Norma Tacconi and C. R. Chenthamarakshan for their priceless help and discussions. Thanks also go to all members of our research group (Yogeeswaran Ganesan, Walter Alexander Morales, Hari Krishna Timmaji, Marly Eiko Osugi, Samantha de Zoysa and Sashikala Somasundaram and especially Apichon Watcharenwong) for their help and support.

This work was supported in part by a grant from the U.S. Department of Energy (Office of Basic Energy Sciences) and partially granted by the National Research Center for Environmental and Hazardous Waste Management (NRC-EHWM) Program, Thailand. Without these financial supports, my achievement should not become true.

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NOMENCLATURES

Ti	=	titanium
TiO ₂	=	titanium dioxide
NH ₄ F	=	ammonium fluoride
NaF	=	sodium fluoride
N ₂	=	nitrogen gas
O ₂	=	oxygen gas
PEG	=	polyethylene glycol
EG	=	ethylene glycol
CO ₂	=	carbon dioxide gas
H ⁺	=	hydrogen ions
OH ⁻	=	hydroxide ion
h	=	hour
min	=	minute
M	=	molar
k _{app}	=	apparent rate constant
r _{initial}	=	initial reaction rate
t _{1/2}	=	half life
Φ _{app}	=	apparent quantum yield
j _{ph}	=	photocurrent density