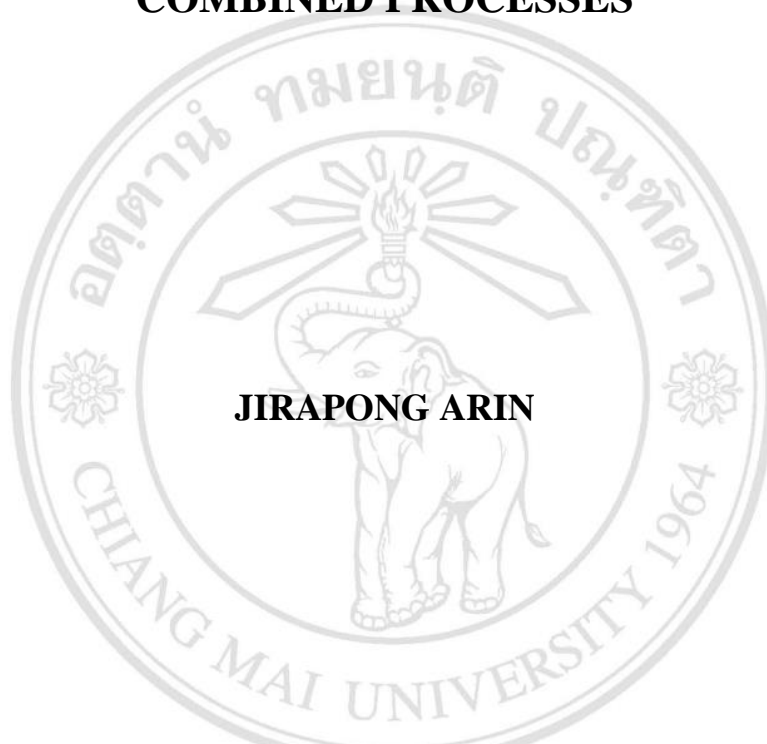


**CHARACTERIZATION OF ZINC OXIDE – TITANIUM
DIOXIDE AND ZINC TITANATE NANOSTRUCTURES
PREPARED BY HYDROTHERMAL – CALCINATION
COMBINED PROCESSES**



JIRAPONG ARIN

DOCTOR OF PHILOSOPHY

IN CHEMISTRY

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

**GRADUATE SCHOOL
CHIANG MAI UNIVERSITY
DECEMBER 2016**

**CHARACTERIZATION OF ZINC OXIDE – TITANIUM DIOXIDE
AND ZINC TITANATE NANOSTRUCTURES PREPARED BY
HYDROTHERMAL – CALCINATION
COMBINED PROCESSES**



JIRAPONG ARIN

**A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN CHEMISTRY**

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

**GRADUATE SCHOOL, CHIANG MAI UNIVERSITY
DECEMBER 2016**

CHARACTERIZATION OF ZINC OXIDE – TITANIUM DIOXIDE
AND ZINC TITANATE NANOSTRUCTURES PREPARED BY
HYDROTHERMAL – CALCINATION
COMBINED PROCESSES


JIRAPONG ARIN

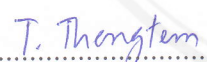
THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN CHEMISTRY

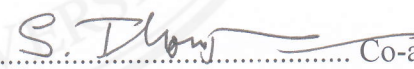
Examination Committee:

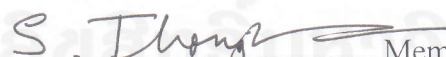
Advisory Committee:

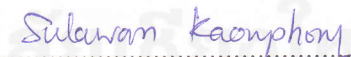

..... Chairman
(Asst. Prof. Dr. Anukorn Phuruangrat)

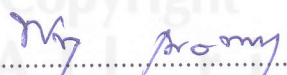

..... Advisor
(Assoc. Prof. Titipun Thongtem)

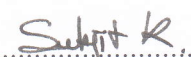

..... Member
(Assoc. Prof. Titipun Thongtem)


..... Co-advisor
(Prof. Emeritus. Dr. Somchai Thongtem)


..... Member
(Prof. Emeritus. Dr. Somchai Thongtem)

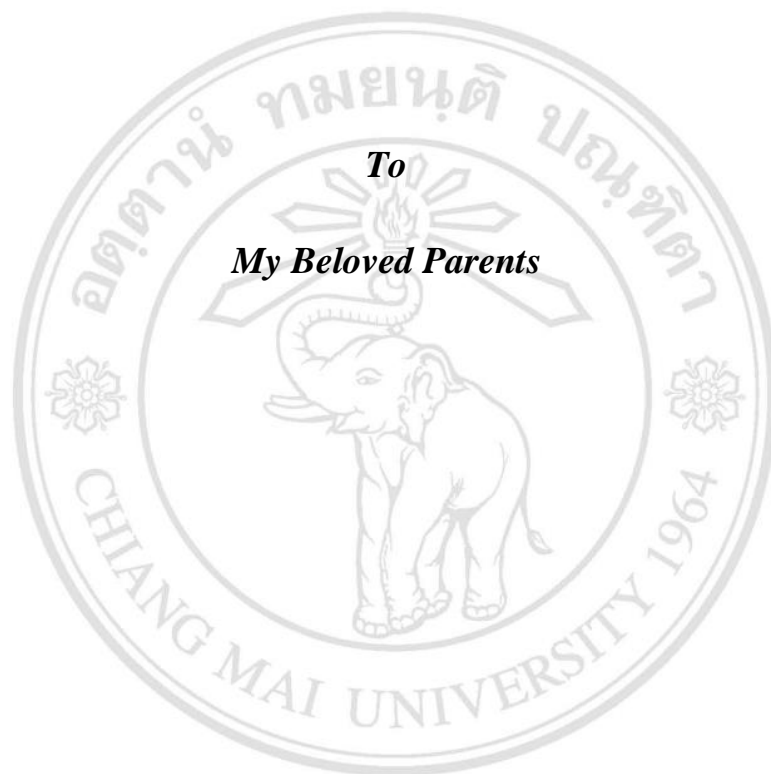

..... Co-advisor
(Asst. Prof. Dr. Sulawan Kaowphong)


..... Member
(Asst. Prof. Dr. Wonchai Promnopas)


..... Member
(Dr. Sukjit Kungwankunakorn)

19 December 2016

Copyright © by Chiang Mai University



To
My Beloved Parents

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to Assoc. Prof. Titipun Thongtem, for my great opportunities of her supervision, valuable guidance, and encouragement throughout my Ph.D program. Second, I would also like to Special thank to Emeritus. Prof. Dr. Somchai Thongtem for all kindly advices, helpful suggestions and valuable information about all of thesis since I was undergraduate student. I would like to special thanks to committee members Asst. Prof. Dr. Sulawan Kaowphong, Asst Prof. Dr. Wanchai Promnopas and Dr.Sukjit Kungwankunakorn and the external committee, Asst. Prof. Dr. Anukorn Phuruangrat for their strong constructive valuable comments and serve in the examination committee.

I gratefully acknowledge the Department of Chemistry, Faculty of Science, Chiang Mai University, Thailand for serving all the facilities, knowledge and valuable experience, including the Human Resource Development Project in Science Achievement Scholarship of Thailand (SAST), Graduate School of Chiang Mai University (CMU), and Nanoscience and Nanotechnology Center - CMU, for financial support throughout my study, including Electron Microscopy Research and Service Center - CMU for the electron microscopy analysis.

Finally, I like to give thanks Mrs. Srinaul Arin, Mrs. Verada Arin and Mrs. Sanglei Pinyo - my parents and my best friends Mr. Shayagone Nimmanwattana for their love, kindness, support and encourage to me all the time.

Jirapong Arin