



UNIVERSITI PUTRA MALAYSIA

***DESIGN AND DEVELOPMENT OF PALM OIL ESTER-BASED
NANOCOSMECEUTICALS***

NG SOOK HAN

FS 2012 26

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NANOCOSMECEUTICALS**



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**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2012

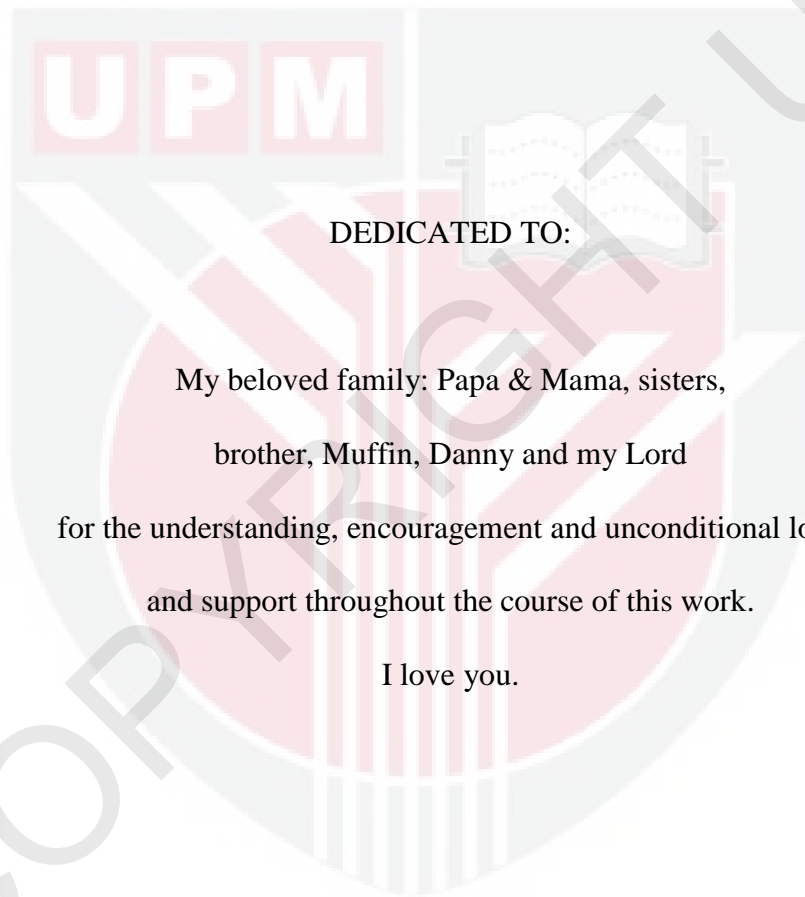
**DESIGN AND DEVELOPMENT OF PALM OIL ESTER-BASED
NANOCOSMECEUTICALS**



**By
NG SOOK HAN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfillment of the Requirement for the Degree of Doctoral of
Philosophy**

August 2012



DEDICATED TO:

My beloved family: Papa & Mama, sisters,
brother, Muffin, Danny and my Lord
for the understanding, encouragement and unconditional love
and support throughout the course of this work.

I love you.



Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia
in the fulfillment of the requirement for the degree of Doctor of Philosophy

**DESIGN AND DEVELOPMENT OF PALM OIL ESTER-BASED
NANOCOSMECEUTICALS**

By

NG SOOK HAN

August 2012

Chairman : Professor Mahiran Basri, PhD

Faculty : Science

Palm oil esters (POEs), esters derived from palm oil and oleyl alcohol have great potential in the cosmetic and pharmaceutical industries due to the excellent wetting behavior of the esters without the oily feel. Nonionic based emulsifiers such as polyoxyethylene sorbitan monostearate (Tween 60), polyoxyethylene sorbitan monooleate (Tween 80) and polyoxyethylene sorbitan trioleate (Tween 85) are widely used in the application of cosmetic products. These nonionic surfactants have excellent safety, mildness and effectiveness. Phase behaviors of palm oil esters were determined through the construction of ternary phase diagrams using nonionic surfactants.

The increase of Hydrophilic Lipophilic Balance (HLB) value of the surfactants gave larger homogeneous and isotropic region in ternary phase diagrams. Three types of nonionic surfactants were selected, namely, Tween 60, Tween 80 and Tween 85. Phase diagrams of POEs:Tocotrienol/T60/water, POEs:Tocotrienol/T80/water and POEs:Tocotrienol/T85/water systems were constructed at room temperature. The results showed that the POEs:Tocotrienol/T80/water system gave better performance than the other two individual surfactant systems. It was observed that the POEs:Tocotrienol/T80/water system exhibited better solubility of water to produce a larger isotropic region as compared to the other system.

Solubilisant gamma, a type of co-surfactant was added in the ternary phase diagram of POEs:Tocotrienol/T80/water system. The ratio of 1:0.5 of POEs + Tocotrienol:solubilisant gamma was selected in contribution for enlargement of the isotropic region. Furthermore, as the regions moved to high oil content compositions, more homogeneous regions were observed as compared to single surfactant. Binary surfactants showed better mixing between components and hence better stability.

Compositions from the ternary phase diagrams were selected as pre-formulated emulsions. The emulsions were then subjected to rotor-stator, followed by ultrasound cavitation to obtain nano-size emulsions. Nanoemulsions with 10%,

20% and 30% (w/w) oil phase concentration were chosen for further studies. The influence of oil and surfactant concentrations to the stability and rheological behavior of the palm oil esters stabilized with nonionic surfactant was evaluated. The stability of the nanoemulsions system was examined with respect to the mean droplet size and zeta potential for over 3 months. The increase in oil phase concentration from 10 to 30% (w/w) showed no distinct changes in the particle size. This indicated the nanoemulsions were stable regardless of the emulsifiers' types used.

The rheological property of nanoemulsions was investigated using oscillatory measurements and viscometry test. The droplet size of the nanoemulsions was found to decrease with the increase in the oil and surfactant concentrations which give effect on the viscosity and yield stress of the nanoemulsions. The flow curve of the emulsions exhibited shear thinning behavior and obeys the Power Law viscosity. The Power Law Index was found to be decreased when the oil, surfactant concentrations and acoustic amplitudes were increased due to the smaller droplet size and narrower size distribution.

The dynamic properties of the nanoemulsions were also affected by the oil and surfactant content which indicated stronger structural integrity and greater interdroplets interactions. The viscoelasticity of the nanoemulsions was enhanced by the increase in the oil and surfactant concentrations. The

nanoemulsions with higher oil phase concentration (30% (w/w)) showed greater elasticity which implied strong dynamic rigidity of the nanoemulsion. It was the most stable with longest shelf-life.

All the formulations were stable after undergoing thaw cycles test, storage at room temperature and 45°C for more than 4 months. The stable nanoemulsions also showed sedimentation rates at earth gravity of 5.2, 3.0 and 2.6 mm/month for 10%, 20% and 30% (w/w) oil phase, respectively. The TGA thermograms showed two major weight losses due to the evaporation of water content and destruction of oil phase. The palm oil esters nanoemulsions containing tocotrienol gave higher Trolox Equivalent Antioxidant Capacity (TEAC) values which implied higher antioxidant capability. Nanoemulsion with 10%, 20% and 30% (w/w) oil phase concentration showed an antimicrobial effect against selected microorganisms and fungal growth.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi syarat untuk mendapatkan ijazah Doktor Falsafah

**REKA BENTUK DAN PEMBANGUNAN NANOKOSMECEUTIKAL
BERASASKAN MINYAK SAWIT ESTER**

Oleh

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Ogos 2012

Pengerusi : Profesor Mahiran Basri, PhD

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Minyak sawit ester (POEs) adalah ester yang dihasilkan daripada minyak sawit dan oleyl alkohol yang mempunyai potensi tinggi dalam industri kosmetik and farmasi kerana sifat basahan ester yang baik tanpa rasa berminyak. Pengemulsi berasaskan tak-ionik seperti polioksietilen sorbitan monostearate (Tween 60), polioksietilen sorbitan monooleate (Tween 80) dan polioksietilen sorbitan trioleate (Tween 85) telah digunakan dengan meluas di dalam barangan kosmetik. Surfaktan tak-ionik ini mempunyai tahap keselamatan, kelembutan dan keberkesanan yang tinggi. Sifat fasa minyak sawit ester telah

ditentukan melalui pembinaan rajah tiga fasa menggunakan surfaktan tak-ionik.

Peningkatan nilai keseimbangan sifat suka air dan minyak (HLB) surfaktan memberikan fasa homogen dan isotropik yang lebih luas di dalam rajah tiga fasa. Tiga jenis surfaktan tak-ionik telah dipilih, polioksietilen sorbitan monostearate (Tween 60), polioksietilen sorbitan monooleate (Tween 80) dan polioksietilen sorbitan trioleate (Tween 85). Gambarajah fasa bagi sistem POEs:Tocotrienol/T60/air, POEs:Tocotrienol/T80/air dan POEs:Tocotrienol/T85/air telah dibina pada suhu bilik. Keputusan menunjukkan bahawa sistem POEs:Tocotrienol/T80/air telah memberikan hasil yang lebih baik jika dibandingkan dengan dua sistem individu surfaktan yang lain. Pemerhatian menunjukkan bahawa sistem POEs:Tocotrienol/T80/air memberikan kadar keterlarutan di dalam air yang tinggi dan menghasilkan fasa isotropik yang besar jika dibandingkan dengan sistem yang lain.

Solubilasi gamma, sejenis ko-surfaktan telah ditambah ke dalam sistem tiga fasa POEs: Tocotrienol/T80/air. POEs + Tocotrienol:solubilasi gamma dengan nisbah 1:0.5 telah dipilih untuk memperbesarkan kawasan isotropik. Tambahan pula, peningkatan komposisi kandungan minyak menghasilkan fasa homogen yang besar jika dibandingkan dengan sistem yang menggunakan surfaktan

tunggal. Surfaktan binari telah menunjukkan percampuran yang baik antara komponen dan dengan itu meningkatkan kestabilan.

Komposisi daripada gambarajah fasa telah dipilih sebagai pre-formulasi emulsi. Emulsi didedahkan kepada mesin pengemulsi, diikuti dengan mesin ultrasonik untuk menghasilkan emulsi bersaiz nano. Nanoemulsi dengan kepekatan 10%, 20% dan 30% (w/w) kandungan minyak sawit ester telah dipilih untuk dikaji. Pengaruh kepekatan minyak dan surfaktan terhadap kestabilan dan sifat rheologi minyak sawit ester yang distabilkan dengan surfaktan tak-ionik telah dikaji. Penilaian terhadap kestabilan sistem nanoemulsi telah dijalankan melalui saiz titisan dan keupayaan zeta dalam tempoh melebihi 3 bulan. Peningkatan komposisi kandungan minyak daripada 10 hingga 30% (w/w) menunjukkan tiada perubahan terhadap saiz titisan dalam tempoh masa 3 bulan. Ini menunjukkan nanoemulsi memberikan kestabilan terhadap surfaktan yang digunakan.

Ciri rheologi nanoemulsi telah dikaji dengan menggunakan teknik ricihan secara berayun dan ujian viskometrik. Saiz titisan nanoemulsi didapati menurun apabila kepekatan kandungan minyak dan surfaktan yang digunakan meningkat. Ini memberi kesan pada kelikatan dan tegasan alah nanoemulsi tersebut. Lengkungan aliran bagi nanoemulsi tersebut mempamerkan sifat penipisan secara ricihan dan mematuhi kelikatan Power Law. Indek Power

Law didapati menurun apabila kandungan minyak, kepekatan surfaktan dan amplitud akustik meningkat disebabkan oleh saiz titisan yang lebih kecil dan taburan saiz titisan nanoemulsi yang lebih sempit.

Sifat dinamik bagi nanoemulsi juga dipengaruhi oleh kandungan minyak dan surfaktan yang menunjukkan kekuatan integriti struktur dan interaksi antara titisan nanoemulsi yang lebih besar. Sifat viskoelastik bagi nanoemulsi dapat dipertingkatkan dengan meningkatkan kepekatan minyak dan surfaktan. Nanoemulsi dengan kepekatan fasa minyak yang tertinggi (30% (w/w)) memberikan sifat keanjalan yang lebih besar dan menunjukkan kekuatan ketegaran dinamik nanoemulsi. Ini merupakan emulsi yang paling stabil dengan tempoh penyimpanan yang terpanjang.

Kesemua formulasi adalah stabil pada suhu bilik, 45°C dan selepas menjalani ujian kitaran mencair melebihi 4 bulan. Nanoemulsi yang stabil juga menunjukkan kadar pemendapan pada graviti bumi iaitu 5.2, 3.0 dan 2.6 mm/bulan untuk 10%, 20% dan 30% (w/w) kandungan minyak masing-masing. Gambarajah haba TGA menunjukkan dua pengewapan berlaku iaitu pengewapan air dan penguraian fasa minyak. Nanoemulsi minyak sawit ester yang mengandungi tocotrienol memberikan nilai Trolox Equivalent Antioxidant Capacity (TEAC) yang tinggi dan ini menunjukkan keupayaan sebagai antioksidan yang tinggi. Nanoemulsi yang mengandungi 10%, 20% dan

30% (w/w) kepekatan fasa minyak menunjukkan kesan antimikrobia terhadap pertumbuhan mikroorganisma dan kulat terpilih.



ACKNOWLEDGEMENTS

I would like to take the opportunity to express my appreciation to people that have made this dissertation possible. My deepest and sincere appreciation is to my supervisor, Prof. Dr. Mahiran Basri for her valuable guidance, brilliant discussion, supervision, patience and advice throughout the course of this research. My appreciation also goes to my co-supervisors, Prof. Dr. Abu Bakar Salleh, Prof. Dr. Raja Noor Zaliha Raja Abd Rahman and Prof. Dr. Mohd Basyaruddin Abdul Rahman for their valuable time, comments and encouragements.

Special thanks to Universiti Putra Malaysia for giving me generous financial support through Graduate Research Fellowship towards my PhD studies. My heartfelt appreciation also goes out to all lecturers and staff in the Department of Chemistry and also the Universiti Putra Malaysia management.

My sincere appreciation is also extended to Dr Zahariah Ismail from Sime Darby Research Sdn. Bhd., Carey Island for her advice and guidance throughout my research. I would also like to thank Ms Diyana, Ms Nabilah and Mr Yusree for their assistance in the operation of instruments used in Sime Darby Research Sdn. Bhd. Without their helpful hand, it was impossible for me to complete the research.

I am also grateful to Advanced Oleochemical Technology Division (AOTD) and my laboratory members; Dr Salwa, Uswatun, Syila, Malahat and Lim for their support, encouragement and inspiration on all these years. Last but not least, I would like to extend my deepest gratitude to my beloved parents and my sisters for their strong support and understanding.



I certify that a Thesis Examination Committee has met on **3rd August 2012** to conduct the final examination of Ng Sook Han on her thesis entitle "**Design and Development of Palm Oil Ester-Based Nanocosmeceuticals**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy Degree.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

(NG SOOK HAN)

Date: 3 August 2012

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vii
ACKNOWLEDGEMENTS	xii
APPROVAL	xiv
DECLARATION	xvi
LIST OF TABLES	xxii
LIST OF FIGURES	xxiv
LISTS OF ABBREVIATIONS	xxix
CHAPTER	
1 INTRODUCTION	1
Problem Statements	5
Objectives	5
2 LITERATURE REVIEW	6
Cosmeceuticals	6
Cosmeceuticals and their Market Share	6
Skin Cosmeceuticals	8
Human Skin Structure	10
Stratum Corneum	11
Epidermis	11
Dermis	12
Skin Delivery Systems	13
Dermal Skin Delivery System	13
Transdermal Skin Delivery System	13
Delivery Systems	14
Vesicular Systems	15
Particulate Systems	16
Fibrous Matrices	18
Emulsions	18
Nanoemulsions	19
Advantageous of using Nanoemulsions	21
Formation of Nanoemulsions	23
Methods of Emulsification	25
Stability of Nanoemulsions	28
Coalescence	32
Aggregation	33
Creaming	35

Nanoemulsions in Cosmetics	35
Factors Affecting Emulsion Size and Re-Coalescence	36
Role of the Emulsifier	37
Energy Input during Emulsification	41
Dispersed-phase Concentration	42
Temperature	43
Viscosity of the Emulsion	44
Compositions of Nanoemulsion for Cosmeceutical Formulations	46
Fat Esters	47
Palm Oil Esters	47
Surfactants	48
Nonionic Surfactants	51
Selection of Surfactants	52
Hydrophilic Lipophilic Balance (HLB)	53
Antioxidant Actives	54
Tocotrienol (Vitamin E)	56
Tocotrienol Antioxidant Property	57
Antioxidant Activity Assay	58
Preservatives	60
Penetration Enhancers	61
Rheology Modifiers	62
Xanthan Gum	63
Carbopol Polymers	64
Rheology	65
3 MATERIALS AND METHODS	69
Materials	69
Construction of Ternary Phase Diagram	70
Phase Behavior of Palm Oil Esters with Respect to Different Nonionic Surfactants	71
Effect of Addition of Solubilisant Gamma® 2429 in Ternary Phase Diagram	71
Selection of Compositions from the Ternary Phase Diagram	72
Preparation of Emulsions	72
Low-Energy Emulsification Method	72
Spontaneous Emulsification	72
High-Energy Emulsification Method	73
Rotor-Stator Emulsification	73
Acoustic Emulsification	74
Modification of the Nanoemulsions System	75
Effect of Xanthan Gum Concentration on Droplet	75

Effect of Volume Fraction of Oil Phase on Droplet	75
Effect of Surfactant Concentration on Droplet	76
Effect of Addition of Naturally and Synthetically Derived Rheology Modifier on Droplet	76
Effect of Concentration of Preservative on the Nanoemulsions System	77
Physico-Chemical Analysis of Nanoemulsions	77
Droplet Size Distribution Analysis	77
Surface Charge (Zeta Potential)	78
Creaming Rate Determination	79
Rheology Measurement	80
pH Measurement	81
Transmission Electron Microscopy (TEM) Analysis	81
Thermogravimetric Analysis (TGA)	82
Conductivity Measurement	83
<i>In-Vitro</i> Antioxidant Activity	83
Preparation of Trolox and Standard Solutions	83
Preparation of Radicals	84
Determination of the Antioxidant Activity of ABTS ^{•+} at 734 nm	84
<i>In-Vitro</i> Dermal Skin Irritation	85
Safety Evaluation Test	86
<i>In-Vitro</i> Microbiology Test	86
Preparation of Inocula and Media	86
Inoculation of Test Plates	87
Direct Spread Method	88
Stability of the Nanoemulsions System	88
Storage at 25°C and 45°C and Freeze-Thaw Cycle Test	88
Sedimentation Behavior	89
4 RESULTS AND DISCUSSION	91
Phase Behavior of Palm Oil Esters	91
Phase Behavior of POEs:Tocotrienol/Tween 60/Water	91
Phase Behavior of POEs:Tocotrienol/Tween 80/Water	94
Phase Behavior of POEs:Tocotrienol/Tween 85/Water	98
Effect of Addition of Solubilisant Gamma® 2429 In Ternary System	100
Phase Behavior of POEs:Tocotrienol:	

Solubilisant Gamma/Tween 80/Water	100
Selection of Compositions from the Ternary Phase Diagram	102
Preparation of Emulsions	103
Static-Mixer Emulsification	103
Effect of Emulsification Time on Disperse Characteristics	103
Rotor-Stator + Static-Mixer Emulsification	108
Rotor-Stator + Acoustic Emulsification	111
Effect of Acoustic Amplitudes on the Emulsions System	111
Modification of the Nanoemulsions System	117
Effect of Xanthan Gum Concentration on Droplet	117
Effect of Volume Fraction of Oil Phase on Droplet	120
Effect of Surfactant Concentration on Droplet	123
Effect of Addition of Naturally and Synthetically Derived Rheology Modifier on Droplet	130
Effect of Concentrations of Preservative on the Nanoemulsions System	132
Physico-Chemical Characteristics of Palm-Based Nanoemulsions	136
Rheological Properties of Nanoemulsions System	136
Steady-State Flow: Evolution of the Apparent Viscosity η_0	136
Steady-State Flow: The Sensitivity of Nanoemulsions to Shearing	143
Shear Stress versus Shear Rate Profile	147
Oscillatory Measurements: Strain Sweep Profile	151
Oscillatory Measurements: Frequency Sweep Profile	161
Time-Dependence Viscometry	171
Transmission Electron Microscopy Characterization	173
Thermogravimetric Analysis of Nanoemulsions System	177
Conductivity Measurement of Nanoemulsions System	179
pH Measurement of Nanoemulsions System	182
<i>In-Vitro</i> Antioxidant Activity	184
<i>In-Vitro</i> Dermal Skin Irritation	191
Safety Evaluation Test	194
<i>In-Vitro</i> Microbiology Test	194

Stability of the Nanoemulsions System	201
Aging Effect of Palm-Based Nanoemulsions System	201
Storage at 25°C and 45°C and Freeze-Thaw Cycle Test	204
Sedimentation Behavior	205
5 CONCLUSIONS	212
Recommendations for Further Studies	214
REFERENCES	216
APPENDICES	237
BIODATA OF STUDENT	280

