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MONTE CARLO SIMULATION OF MICELLE FORMATION IN MIXED SURFACTANTS AND PALM-KERNEL OIL ESTERS-BASED NANOEMULSION

RUZANNA BINTI YAHYA

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By

RUZANNA BINTI YAHYA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science.

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science.

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December 2014

Chairman : Roghayeh Abedi Karjiban, PhD

Faculty : Science

For several years, the experimental laboratory and Molecular Dynamics (MD) simulation works was used to determine the behaviour and structural properties of nanoemulsions. In order to solve the problems related to transdermal drug nano-delivery system, the palm-kernel oil esters (PKOEs) nanoemulsion can act as chemical penetration enhancers with the help of non-ionic surfactants properties. Here, the stochastic numerical methods or Monte Carlo (MC) was suggested to develop new configurations of a system of interest. The physical properties of the mixed surfactants and nanoemulsions formulation were studied using the Metropolis Monte Carlo (MMC) algorithm while grand canonical Monte Carlo (GCMC) simulation was applied to investigate the displacements of critical micelle concentration (CMC) for both systems. Seven set of mixed surfactants (Brij 92, Brij 96 and water) models and five simulation sets of PKOEs nanoemulsion (PKOEs, Brij 92, Brij 96, isopropanol as co-surfactant and water) which were adapted from the experimental phase diagram was simulated using MMC algorithm up to 10 and 20 million MC steps, respectively in order to determine the most suitable composition of mixed surfactants and PKOEs nanoemulsion with water molecules.

The chemical potential for both model systems were calculated using Reference Interaction Site Model (RISM) module. The most suitable composition from MMC simulations was then grouped to five systems of mixed surfactants and six systems for PKOEs nanoemulsion with a series of different values of temperature and chemical potential resulted from the histogram-reweighting. The latest model systems were used to simulate in grand canonical ensemble for 10 million MC steps with 50% of insertion and removal of molecules and 50% of reptation moves. From the results, the acceptance ratio for single atom moves of the mixed surfactants was increased as the percentage of surfactants was increased from 0.429 to 0.591 meanwhile the acceptance ratio for single atom moves for PKOEs nanoemulsion was decreased as the number of molecules increased from 0.600 to 0.587 due to the different composition of the surfactants and PKOEs nanoemulsion with water molecules where both systems formed spherical shape.

The physical properties of models such as radius of gyration, solvent accessible surface area, radial distribution function and total energy were also determined. The chemical potential for the mixed surfactants was produced at the range of 0.77 - 2.06 J/mol while for the PKOEs nanoemulsion the value was ranged from 3.17 - 5.00 J/mol. The displacement of CMC was increased while the insertion and deletion ratio movement were decreased as the temperature and chemical potential increased due to the drop of density in the cubic box during the simulation. Therefore these observations indicated that the physical properties of mixed surfactant and PKOEs nanoemulsion systems were adequately described by the simulation. The acceptance ratio for displacement movement critical micelle concentration (CMC) for the mixed surfactants and PKOEs nanoemulsion systems was also considered accepted with reasonable values produced.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains.

SIMULASI *MONTE CARLO* BAGI PEMBENTUKKAN MISEL DIDALAM CAMPURAN SURFAKTAN DAN NANOEMULSI YANG BERASASKAN ESTER MINYAK ISIRONG SAWIT

Oleh

RUZANNA BINTI YAHYA

Disember 2014

Pengerusi : Roghayeh Abedi Karjiban, PhD

Fakulti : Sains

Sejak beberapa tahun kebelakangan ini, kaedah ujikaji makmal dan simulasi Dinamik Molekul (MD) telah digunakan untuk mengkaji sifat dan struktur nanoemulsi. Bagi menyelesaikan masalah yang berkaitan dengan sistem nano-penghantaran ubatan melalui kaedah transdermal, nanoemulsi ester minyak isirong sawit (PKOEs) boleh bertindak sebagai bahan kimia peningkat penerobosan dengan bantuan sifat-sifat surfaktan bukan ion. Di dalam penyelidikan ini, kaedah berangka stokastik atau simulasi *Monte Carlo* (MC) telah dicadangkan untuk membangunkan konfigurasi yang baru bagi sistem yang dikehendaki. Sifat fizikal bagi formulasi campuran surfaktan dan nanoemulsi telah dikaji menggunakan kaedah algoritma *Metropolis Monte Carlo* (MMC) manakala simulasi *grand canonical Monte Carlo* (GCMC) telah digunakan untuk mengkaji sesaran kepekatan misel kritikal (CMC) bagi kedua-dua system. Tujuh set model campuran surfaktan (Brij 92, Brij 96 dan air) dan lima set simulasi nanoemulsi PKOEs (PKOEs, Brij 92, Brij 96, isopropanol sebagai ko-surfaktan dan air) yang berdasarkan gambar rajah fasa yang diperolehi daripada ujikaji makmal telah disimulasi menggunakan algoritma MMC selama 10 dan 20 juta langkah MC masing-masing untuk mendapatkan komposisi yang paling sesuai bagi campuran surfaktan dan nanoemulsi PKOEs dengan molekul air.

Keupayaan kimia bagi kedua-dua model sistem telah dikira menggunakan modul Rujukan Interaksi Tapak (RISM). Komposisi yang paling sesuai daripada simulasi MMC kemudiannya telah dibahagikan kepada lima sistem untuk campuran surfaktan dan enam system untuk nanoemulsi PKOEs menggunakan dengan bacaan suhu dan keupayaan kimia yang berbeza secara bersiri yang dihasilkan daripada *histogram-reweighting*. Sistem model yang terkini telah digunakan untuk simulasi bagi ensembel *grand canonical* untuk 10 juta langkah MC dengan penambahan dan penyingkiran molekul sebanyak 50% dan pergerakan *reptation* sebanyak 50%. Hasil kajian yang diperolehi menunjukkan nisbah penerimaan bagi pergerakan atom tunggal bagi campuran surfaktan telah meningkat seiring dengan peningkatan kepekatan surfaktan yang telah meningkat daripada 0.429 sehingga 0.591, sementara itu nisbah penerimaan bagi pergerakan atom tunggal untuk nanoemulsi PKOEs pula telah berkurangan daripada 0.600 sehingga 0.587 seiring dengan peningkatan bilangan molekul yang meningkat berdasarkan perbezaan komposisi surfaktan dan nanoemulsi PKOEs dengan molekul air yang mana bentuk sfera telah diperolehi daripada kedua-dua sistem.

Sifat-sifat fizikal bagi model seperti jejari putaran, permukaan boleh akses pelarut dan fungsi taburan radial dan jumlah tenaga juga telah ditentukan. Keupayaan kimia bagi campuran surfaktan yang diperolehi ialah dalam julat 0.76510 – 2.05767 J / mol manakala nilai bagi nanoemulsi PKOEs adalah dalam julat 3.17152 – 5.00000 J / mol. Nilai sesaran CMC telah meningkat sementara nisbah penambahan dan penyingkiran pergerakan telah menurun selaras dengan peningkatan suhu dan keupayaan kimia berdasarkan kepada penurunan ketumpatan didalam kotak kubik semasa simulasi. Oleh itu, hasil pemerhatian menunjukkan bahawa sifat fizikal bagi sistem campuran surfaktan dan nanoemulsi PKOEs telah berjaya dibincangkan dengan menggunakan kaedah simulasi. Nisbah penerimaan bagi sesaran CMC untuk sistem campuran surfaktan dan nanoemulsi PKOEs juga telah dapat diterima dengan penghasilan nilai yang munasabah.

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I certify that an Examination Committee has met on 15th December 2014 to conduct the final examination of Ruzanna binti Yahya on her thesis entitled "Monte Carlo Simulation of micelle formation in mixed surfactants and Palm-Kernel Oil Esters-based nanoemulsion" in accordance with 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 Master of Science.

Members of the Thesis Examination Committee were as follows:

Mohamed Ibrahim Bin Mohamed Tahir , PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Emilia Binti Abd Malek, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Tan Yen Ping, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Rohana Binti Adnan, PhD
Associate Professor
Pusat Pengajian Sains Kimia
Universiti Sains Malaysia
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 19 March 2015

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Roghayeh Abedi Karjiban, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Mohd Basyaruddin Abdul Rahman, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

Mahiran Basri, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

BUJANG KIM HUAT, PhD
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Declaration by Members of Supervisory Committee:

This is to confirm that:

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Name of Chairman of Supervisory Committee:

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Signature: _____

Name of Member of Supervisory Committee:

Mohd Basyaruddin Abdul Rahman, PhD

Signature: _____

Name of Member of Supervisory Committee:

Mahiran Basri, PhD

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABNR	adopted basis Newton-Raphson
ARM	Acceptance Ratio Method
ASAXS	anomalous small-angle X-ray scattering
Brij 92	Polyoxyethylene (2) oleyl ether
Brij 96	Polyoxyethylene (10) oleyl ether
CG-MD	Coarse-grained Molecular Dynamics
CHARMM	Chemistry at Harvard Macromolecular Mechanics
CMC	Critical Micelle Concentration
CPE	Chemical Penetration Enhancer
DOMC	Dynamically Optimized Monte Carlo
GAMESS	General Atomic and Molecular Electronic Structure System
GCMC	Grand Canonical Monte Carlo
HLB	Hydrophile-lipophile balance
LJ	Lennard-Jones
MC	Monte Carlo
MD	Molecular Dynamics
MMC	Metropolis Monte Carlo
MOFs	Metal-organics Frameworks
MOI	Moment of Inertia
NMF	Natural Moisturizing Factor
O/W	Oil in water emulsion
PKOEs	Palm-kernel Oil Esters
PME	Particle Mesh Ewald
POEs	Palm Oil Esters
RESP	Restrained Electrostatic Potential
RISM	Reference Interaction Site Model
SANS	Small Angle Neutron Scattering
SASA	Solvent Accessible Surface Area
SAXS	Small Angle X-ray Scattering
TTAB	Tetradecyltrimethylammonium Bromide
W/O	Water in Oil emulsion

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Nanoemulsions of palm-kernel oil wax esters (PKOEs) is considered as active ingredients' carriers and chemical penetration enhancers (CPEs) due to their amphiphilic esters properties (Keng *et al.*, 2009; Salim *et al.*, 2011). The palm-kernel oil esters based nanoemulsions can be described structurally as dispersions of self-assembled structures of surfactant molecules and palm kernel oil esters in water as a result of solubilization of surfactant aggregates in the nanoemulsions' formulation. For example, it has been shown that spherical and cylindrical micelles are superior for acting as a good CPE due to their size (permeability), the mobility of the drug and the release of drug (Peltola *et al.*, 2003).

Micelle is known as an inexactly bound aggregation of several tens or hundreds of atoms, ions, or molecules to form a colloidal molecule. An aggregation of micelles can adequately reduce vascular leakage at inflamed spots due to the suitability of micelle as nanocarriers for several anti-flammatory compounds and local delivery of drugs (Rosen, 2004). The main properties of micelles are the critical micelle concentration (CMC) values, the aggregation number, size, and shape. The micelle shape depends on the temperature, the concentration, and the type of surfactants used during nanoemulsion formulation. The size of micelles allows their selective accumulation in sites with leaky vasculature, through upgraded permeability and maintenance effect (Husseini and Pitt, 2008).

Surfactants are chemical compounds that can possibly change the properties of fluid interfaces. For example surfactants will diffuse in water and absorb at the interface between oil and water, in the case where water is mixed with oil. Surfactants molecules can lower the surface tension between two liquids or liquid and solid phase. This can be done by re-orientating of the surfactant molecules inside the water system and disturb their bonding so that the electrostatic forces will be decreased. Surfactants are categorized into four groups which are anionic, nonionic, cationic, and amphoteric or zwitterionic. The categorizations of surfactants depend on whether the polar head group can be dissociated in water or not (Yu *et al.*, 2008). Surfactants show several important properties such as foaming or anti-foaming, emulsifying, dispersing, and wetting behaviours. They are widely used in the management of soil water repellence (Kostka, 2000), petroleum industry (Schramm, 2000), personal care, cosmetics, food industry, pharmaceuticals, and agrochemical (Tadros *et al.*, 2004).

For several years, experimental laboratory researchers have been estimating the shape and structural properties of nanoemulsions by observing the spectrum data using the Small Angle Neutron Scattering (SANS) and Small X-ray Neutron Scattering (SAXS). However, the data cannot precisely describe the physical properties of these systems (Thomas and Olivier, 2010). Hence, computational simulation techniques can be an alternative approach to produce a detail description of nanoemulsions systems.

The structural properties of swollen micelles of oleyl oleate (OE) at different micelle composition, and also an addition of OE and surfactants were used to investigate the molecular dynamics (MD) simulations that produced valid results to be compared with the experimental data (Abdul Rahman *et al.*, 2010). Wahab *et al.* (2001) proved that the behaviour of the chemical penetration enhancers could be successfully predicted and simulated by computational approach.

The size and the ability of different aggregation numbers of the palm-oil esters (POEs) and surfactant molecules were also observed through the Molecular Dynamic simulation (Abdul Rahman *et al.*, 2009). Therefore, the stochastic numerical methods or Monte Carlo (MC) can be suggested to develop new configurations of a system of interest. Sampling method can be employed to examine the behaviour of a deterministic system based on Monte Carlo or stochastic numerical experiments. As a result, the structural and translational degrees of freedom of the model systems can be obtained (Woo *et al.*, 2004). The average properties of molecular system were effectively contributed to generate new configuration of states. The acceptance ratio is equivalent to the proportion of their weight at equilibrium which is an example of each configuration that can produce from previous state with transition probability (Hu *et al.*, 2006).

In Monte Carlo, the configurations are selected regardless of bias and the important consideration is to evaluate the energetic of the model system. Furthermore, this can be a good advantage of MC in comparison with other molecular simulation methods, for example molecular dynamics (MD) where the calculation of the first derivative of force is done and it is time consuming, especially when the model system is so big or complex. The reason is that, during MC calculation a single particle is moved in each step, so that the energy associates with this move will be calculated based on the total energy that obeys the Metropolis probabilities for the molecular system. Hashemianzadeh *et al.* (2008) implemented the Metropolis Monte Carlo (MMC) simulation of surfactants aggregation in binary mixtures of water and an ionic surfactant that resulted in decreasing critical micelle concentration (CMC) as the surfactant chain length increased and the CMC increased with an enhancement in solvent dipole moment.

For several years, the micellization process was used to examine using lattice Monte Carlo simulation method. Poorgholami-Bejarpasi *et al.* (2010) studied a model of two surfactants molecules with similar structures. The results show that the thermodynamic properties could be likely affected by the interactions between head groups or tail groups. Grand canonical Monte Carlo simulation was used to study the micelles formation in larger surfactant model system hence the size distribution of micellar aggregates was investigated using appropriate chemical potential values (Floriano *et al.*, 1999). Mixed amphiphile systems using three-dimensional lattice-based Monte Carlo simulations showed that the interaction between head to head could affect the CMC value in addition to the aggregate structure and size (Zaldivar and Larson, 2003).

This research investigated the mixed surfactant behaviour in water and the self-assembly of palm-kernel oil esters (PKOEs) nanoemulsions using MC technique. The experimental phase diagram was consisted of PKOEs, nonionic surfactants (Brij 92 and Brij 96) with an additional of isopropanol and water molecules (Chong, 2013). The PKOEs are usually applied as an oil phase in nanoemulsions formulation because of their unique wetting behaviour without any creamy feeling. Additionally, PKOEs are colourless liquids with low viscosity with a lot of applications in cosmetic and pharmaceutical products (Park *et al.*, 2000). Furthermore, it was shown that PKOEs could effectively penetrate the skin during drug delivery (Mahdi *et al.*, 2011).

In the formulations of nanoemulsion, nonionic surfactants were used to reduce the interfacial tension between oil phase and water phase due to their amphiphilic properties. The nonionic surfactants used in this research were Polyoxyethylene (2) oleyl ether, Brij 92, and Polyoxyethylene (10) oleyl ether, Brij 96. The Brij 92 and Brij 96 mixtures can produce the hydrophilic-lipophilic balance (HLB) value ranging from 4.9 to 12.4 to stabilize the nanoemulsion formulation. A maximum stability were observed when a mixture of two different nonionic surfactants was used at a certain HLB (Seiller *et al.*, 1970) and these surfactants have been widely used in pharmaceutical industry as a drug carrier (Lawrence, 1994). The isopropanol was proposed as cosurfactants to improve the common dispersion of PKOEs and water in the present of Brij® surfactants because alcohol shows poor solubility in PKOEs but high solubility in water (Acharya *et al.*, 2002).

1.1 Research Objectives

The main objective of this project was to model the self-assembly of the palm-kernel oil esters (PKOEs) nanoemulsion system using Monte Carlo technique. Therefore, the following specific objectives were undertaken:

1. To determine the physical behaviour of mixed nonionic surfactants (Brij 92 and Brij 96) in aqueous solution.

2. To study the self-assembly of palm kernel oil-based nanoemulsion system using experimentally determined phase diagram.

3. To estimate the shape and physical properties of the selected model systems.

4. To calculate the displacement of critical micelle concentration (CMC) for the surfactants mixture and nanoemulsion system.

REFERENCES

Abdul Rahman, M.B., Huan, Q.-Y., Tejo, B.A., Basri, M., Salleh, A.B., and Abdul Rahman, R.N.Z. (2009). Self-assembly formation of palm-based esters nano-emulsion: A molecular dynamics study. *Chemical Physics Letters*, 480(4–6): 220-224.

Abdul Rahman, M.B., Latif, M.A.M., Basri, M., Salleh, A.B., & Abdul Rahman, R.N.Z. (2010). Molecular dynamics simulation of oleyl oleate swollen micelles system. *Molecular Simulation*, 36(5): 403-407.

Acharya, A., Moulik, S.P. and Sanyal, S.K. (2002). Physicochemical investigations of microemulsification of coconut oil and water using polyoyethylene 2-cetyl ether (Brij 52) and isopropanol or ethanol. *Journal of Colloid and Interface Science*. 245:163-170.

Allen, M.P., and Tildesley, D.J. (1989). *Computer simulation of liquids*, Oxford University Press.

Anton, N., and Vandamme, T.F. (2009). The universality of low-energy nano-emulsification. *International Journal of Pharmaceutics*, 377(1–2): 142-147.

Atagana, H.I., Haynes, R.J., & Wallis, F.M. (2003). The use of surfactants as possible enhancers in bioremediation of creosote contaminated soil. *Water, Air, and Soil Pollution*, 142(1-4): 137-149.

Bagatolli, L., and Kumar, P.S. (2009). Phase behavior of multicomponent membranes: Experimental and computational techniques. *Soft Matter*, 5(17): 3234-3248.

Banfelder, J., Speidel, J., and Mezei, M. (2009). Automatic determination of stepsize parameters in monte carlo simulation tested on a bromodomain-binding octapeptide. *Algorithms*, 2(1): 215-226.

Bayly, C.I., Cieplak, P., Cornell, W., and Kollman, P.A. (1993). A well-behaved electrostatic potential based method using charge restraints for deriving atomic charges: the RESP model. *The Journal of Physical Chemistry*, 97(40): 10269-10280.

Berg, B.A., and Zhou, H.-X. (2005). Rugged Metropolis sampling with simultaneous updating of two dynamical variables. *Physical Review E*, 72(1): 016712.

Bernardes, A.T., Henriques, V.B., and Bisch, P.M. (1994). Monte Carlo simulation of a lattice model for micelle formation. *Journal of Chemical Physics*, 101(1): 645-650.

Bernini, M.C., Fairen-Jimenez, D., Pasinetti, M., Ramirez-Pastor, A.J., and Snurr, R.Q. (2014). Screening of bio-compatible metal–organic frameworks as potential drug carriers using Monte Carlo simulations. *Journal of Materials Chemistry B*, 2(7): 766-774.

Bhanot, G. (1988). The Metropolis algorithm. *Reports on Progress in Physics*, 51(3): 429.

Bibette, J., Calderon, F.L., and Poulin, P. (1999). Emulsions: basic principles. *Reports on Progress in Physics*, 62(6): 969.

Bode, B.M., and Gordon, M.S. (1998). A graphical user interface for GAMESS. *Journal of Molecular Graphics and Modelling*, 16: 133-138.

Bouzida, D., Kumar, S., and Swendsen R.H. (1992). Efficient Monte Carlo methods for the computer simulation of biological molecules. Physical Review A, 45(12): 8894-8901.

Brooks, B.R., Bruccoleri, R.E., Olafson, B.D., States, D.J., Swaminathan, S., and Karplus, M. (1983). CHARMM: A program for macromolecular energy, minimization, and dynamics calculations. *Journal of Computational Chemistry*, 4(2): 187-217.

Brooks B.R., Brooks III C.L., Mackerell Jr A.D., Nilsson L., Petrella R.J., Roux B., Won Y., Archontis G., Bartels C., Boresch S., Caflisch A., Caves L., Cui Q., Dinner A.R., Feig M., Fischer S., Gao J., Hodoscek M., Im W., Kuczera K., Lazaridis T., Ma J., Ovchinnikov V., Paci E., Pastor R.W., Post C.B., Pu J.Z., Schaefer M., Tidor B., Venable R.M., Woodcock H.L., Wu X., Yang W., York D.M., Karplus M. (2009). CHARMM: The Biomolecular simulation program, *Journal of Computational Chemistry*, 30: 1545-1614.

Brooks, J.E., Blumenthal, R., and Gingeras, T. (1983). The isolation and characterization of the Esherichia Coli DNA adenine methylase (dam) gene. *Nucleic Acids Research*, 11(3): 837-851.

Chandler, D. Editted by Montroll, E.W., and Lebowitz, J.L. (1982). The liquid state of matter: Fluids, simple and complex. *North Holland Publishing Company*, 275-340.

Cheong, D.W., and Panagiotopoulos, A.Z. (2006). Monte carlo simulations of micellization in model ionic surfactants: application to sodium dodecyl sulfate. *Langmuir*, 22(9): 4076-4083.

Chong K.H. 2013. Palm-*based transdermal nanodelivery system for ibuprofen*, PhD Thesis, Universiti Putra Malaysia

Cramer, C.J. (2005). Essentials of computational chemistry: theories and models. *John Wiley & Sons*.

Daful, A.G., Avalos, J.B., and Mackie, A.D. (2012). Model shape transitions of micelles: spheres to cylinders and disks. *Langmuir*, 28: 3730-3743.

Davis, J.R., and Panagiotopoulos, A.Z. (2009). Micellization and phase separation in binary amphiphile mixtures. *Molecular Physics*, 107(22): 2359-2366.

Davis, J.R., Piccarreta, M.V., Rauch, R.B., Vanderlick, T.K., and Panagiotopoulos, A.Z. (2006). Phase behavior of rigid objects on a cubic lattice. *Industrial & Engineering Chemistry Research*, 45(16): 5421-5425.

Devarajan, V., and Ravichandran, V. (2011). Nanoemulsions: As modified drug delivery tool. *International Journal of Comprehensive Pharmacy*, (1): 1-6.

Dinner A.R., Lazaridis, T., and Karplus, M. (1999). Understanding β-hairpin formation. *Proceedings of the National Academy of Sciences*, 96(16): 9068-9073.

Earl, D., and Deem, M. (2008). Monte carlo simulations. In a. Kukol (ed.), *Molecular Modeling of Proteins* (pp. 25-36). Humana Press.

Feig, M., Karanicolas, J., and Brooks 3rd, C.L., (2004). MMTSB Tool Set: enhanced sampling and multiscale modeling methods for applications in structural biology. *Journal Molecular Graphic Modelling*, 22(5): 377-395.

Ferrenberg, A.M., and Swendsen, R.H. (1988). New Monte Carlo technique for studying phase transitions. *Physical Review Letters*, 61(23): 2635-2638.

Ferrenberg, A.M., and Swendsen, R.H. (1989). Optimized monte carlo data analysis. *Physical Review Letters*, 63(12): 1195-1198.

Fichthorn, K.A., and Weinberg, W.H. (1991). Theoretical foundations of dynamical Monte Carlo simulations. *Journal Chemical Physics*, 95(2): 1090-1096.

Floriano, M.A., Caponetti, E., and Panagiotopoulos, A. Z. (1999). Micellization in model surfactant systems. *Langmuir*, 15(9): 3143-3151.

Frenkel, D., and Smit, B. (2002). *From Algorithms to Applications*. Academic Press, San Diego, USA.

Frenkel, D. (2004). Introduction to monte carlo methods. *Computational Soft Matter: From Synthetic Polymers to Proteins*, 23: 23-59.

Fryd, M.M., and Mason, T.G. (2012). Advanced Nanoemulsions. *Annual Review of Physical Chemistry*, 63(1): 493-518.

Gharibi, H., Behjatmanesh-Ardakani, R., Hashemianzadeh, S.M., Mousavi-Khoshdel, S.M., Javadian, S., and Sohrabi, B. (2006). Study of thermodynamic parameters in amphiphilic systems by lattice Monte Carlo: effect of tails and heads. *Theoretical Chemistry Accounts*, 115(1): 1-17.

Girardi, M., and Figueiredo, W. (2003). Monte Carlo simulations for a model of amphiphiles aggregation. *Physica A: Statistical Mechanics and its Applications*, 319(0): 421-431.

Gompper, G., and Schick, M., edited by *Domb* C. *and Lebowitz J.L.* (1994). *Self-Assembling Amphiphilic Systems*. Academic London, *16*.

Griffin, W.C. (1955). Calculation of HLB values of non-ionic surfactants. *American Perfumer and Essential Oil Review*, 65(5), 26-29.

Gubbins, K.E., and Moore, J.D. (2010). Molecular modeling of matter: Impact and prospects in engineering. *Industrial & Engineering Chemistry Research*, 49(7): 3026-3046.

Gunawan, E.R., Basri, M., Abdul Rahman, M.B., Salleh, A. B., and Abdul Rahman, R.N.Z. (2005). Study on response surface methodology (RSM) of lipase-catalyzed synthesis of palm-based wax ester. *Enzyme and Microbial Technology*, 37(7), 739-744.

Guy, R.H. (2010). Transdermal drug delivery. *Handbook Experiment Pharmacol*, (197): 399-410.

Hansen, J.P., and Mcdonald, I.R. (1986). *Theory of Simple Liquids*. Academic Press 2nd Edition.

Hashemianzadeh, S.M., Gharibi, H., Mousavi-Khoshdel, S.M., Sohrabi, B., and Safarpoor, M.A. (2008). Lattice Monte Carlo simulation of dilute ionic surfactants. *Journal of Molecular Liquids*, 138(1–3): 147-154.

Hayryan, S., Hu, C.-K., Skřivánek, J., Hayryane, E., and Pokorný, I. (2004). A new analytical method for computing solvent-accessible surface area of macromolecules and its gradients. *Journal of Computational Chemistry*, 26(4): 334-343.

Heinzelmann, G., Figueiredo, W., and Girardi, M. (2012). Micellar dynamics and water–water hydrogen-bonding from temperature-jump Monte Carlo simulations. *Chemical Physics Letters*, 550(0): 83-87.

Hirata, F., and Rossky, P.J. (1981). An extended rism equation for molecular polar fluids. *Chemical Physics Letters*, *83*(2): 329-334.

Hirata, F., Rossky, P.J., and Pettitt, B.M. (1983). The interionic potential of mean force in a molecular polar solvent from an extended RISM equation. *Journal of Chemical Physcis*, *78*(6): 4133-4144.

Howes, A.J., and Radke, C.J. (2007). Monte carlo simulation of mixed lennard-jones nonionic surfactant adsorption at the liquid/vapor interface. *Langmuir*, 23(23): 11580-11586.

Hu, J., Ma, A., and Dinner, A.R. (2006). Monte Carlo simulations of biomolecules: The MC module in CHARMM. *Journal of Computational Chemistry*, 27(2): 203-216.

Husseini, G.A., and Pitt, W.G. (2008). Micelles and nanoparticles for ultrasonic drug and gene delivery. *Advanced Drug Delivery Reviews*, 60(10): 1137-1152.

Humphrey, W., Dalke, A. and Schulten, K., (1996). VMD - Visual Molecular Dynamics. *Journal of Molecular Graphics*, 14.1: 33-38.

Huzil, J.T., Sivaloganathan, S., Kohandel, M., and Foldvari, M. (2011). Drug delivery through the skin: molecular simulations of barrier lipids to design more effective noninvasive dermal and transdermal delivery systems for small molecules, biologics, and cosmetics. *Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology*, 3(5): 449-462.

Im, W., Seefeld, S., and Roux, B. (2000). A grand canonical monte carlo–brownian dynamics algorithm for simulating ion channels. *Biophysical Journal*, 79(2): 788-801.

Israelachvili, J.N. (1992). *Intermolecular and surface forces*, Academic Press, London.

Israelachvili, J.N., Mitchell, D.J., and Ninham, B.W. (1976). Theory of self-assembly of hydrocarbon amphiphiles into micelles and bilayers. Journal of the Chemical Society, *Faraday Transactions 2: Molecular and Chemical Physics*, 72(0): 1525-1568.

Jensen, F. (2007). *Introduction to computational chemistry*. John Wiley & Sons.

Jorgensen, W.L., and Tirado-Rives, J. (1996). Monte carlo vs molecular dynamics for conformational sampling. *Journal of Physical Chemistry*, 100(34): 14508-14513.

Jusufi, A., Hynninen A.-P., Haataja, M., and Panagiotopoulos, A.Z. (2009). Electrostatic screening and charge correlation effects in micellization of ionic surfactants. *Journal of Physical Chemistry B*, 113: 6314-6320.

Jusufi, A., Sanders, S., Klein, M.L., and Panagiotopoulos, A.Z. (2011). Implicit-solvent models for micellization: nonionic surfactants and temperature-dependent properties. *Journal of Physical Chemistry B*, 115(5): 990-1001.

Jusufi, A., Kohlmeyer, A., Sztucki, M., Narayanan, T., and Ballauff, M. (2012). Self-assembly of charged surfactants: full comparison of molecular simulations and scattering experiments. *Langmuir*, 28(51): 17632-17641.

Kanikkannan, N., Kandimalla, K., Lamba, S.S., and Singh, M. (2000). Structure-activity relationship of chemical penetration enhancers in transdermal drug delivery. *Current Medical Chemistry*, 7(6): 593-608.

Karande, P., Jain, A., and Mitragotri, S. (2004). Discovery of transdermal penetration enhancers by high-throughput screening. *Nature Biotechnology*, 22(2): 192-197.

Kelmann, R.G., Kuminek, G., Teixeira, H.F., and Koester, L.S. (2007). Carbamazepine parenteral nanoemulsions prepared by spontaneous emulsification process. *International Journal of Pharmaceutics*, 342(1–2): 231-239.

Keng, P.S., Basri, M., Zakaria, M.R.S., Abdul Rahman, M. B., Ariff, A.B., Abdul Rahman, R. N. Z., and Salleh, A. B. (2009). Newly synthesized palm esters for cosmetics industry. *Industrial Crops and Products*, 29(1): 37-44.

Kesarwani, A., Yadav, A.K., Singh, S., Gautam, H., Singh H. N., Sharma, A., and Yadav, C. (2013). Theoretical aspects of transdermal drug delivery system. *Bulletin of Pharmaceutical Research*, 3(2):78-89.

Khan, A., and Marques, E.F. (1999). Synergism and polymorphism in mixed surfactant systems. *Current Opinion in Colloid & Interface Science*, 4(6): 402-410.

Kim, S.H., and Jo, W.H. (2001). A Monte Carlo simulation for the micellization of aba- and bab-type triblock copolymers in a selective solvent. *Macromolecules*, 34(20): 7210-7218.

Kim, S.-Y., Panagiotopoulos, A.Z., and Floriano, M.A. (2002). Ternary oil-water-amphiphile systems: self-assembly and phase equilibria. *Molecular Physics*, 100(14): 2213-2220.

Kincaid, R.H., and Scheraga, H.A. (1982). Acceleration of convergence in Monte Carlo simulations of aqueous solutions using the metropolis algorithm. Hydrophobic hydration of methane. *Journal of Computational Chemistry*, 3(4): 525-547.

Koch, C., Panagiotopoulos, A. P., Verso F. L., and Likos C. N. (2013). Phase behavior of rigid, amphiphilic star polymers. *Soft Matter*, 9: 7424-7436.

Kogan, A., and Garti, N. (2006). Microemulsions as transdermal drug delivery vehicles. *Advances in Colloid and Interface Science*, 123–126(0): 369-385.

Kosmidis, K., Argyrakis, P., and Macheras, P. (2003). A reappraisal of drug release laws using monte carlo simulations: the prevalence of the weibull function. *Pharmaceutical Research*, 20(7): 988-995.

Kostka, S.J. (2000). Amelioration of water repellency in highly managed soils and the enhancement of turfgrass performance through the systematic application of surfactants. *Journal of Hydrology*, 231–232(0): 359-368.

Kroese, D.P., and Rubinstein, R.Y. (2012). Monte Carlo methods. *Wiley Interdisciplinary Reviews: Computational Statistics*, 4(1), 48-58.

Lachet, V.R., Boutin, A.A., Tavitianb, A.B., and Fuchsa, A.H. (1997). Grand Canonical Monte Carlo simulations of adsorption of xylene molecules in faujasite zeolites. *Faraday Discuss*, 106: 307-323.

Lange H. (1953). Über die mizellenbildung in mischlösungen homologer paraffinkettensalze. *Kolloid-Zeitschrift*, 131(2):103.

Lawrence M. J. (1994). Surfactant system: their use in drug delivery. *Chemical Society Reviews*, 6:363-441.

Leach, A.R. (2001). *Molecular modelling: principles and applications*. Pearson Education.

Lísal, M., Hall, C.K., Gubbins, K.E., and Panagiotopoulos, A.Z. (2002). Micellar behavior in supercritical solvent–surfactant systems from lattice Monte Carlo simulations. *Fluid Phase Equilibria*, 194–197(0): 233-247.

Lo, I., Florence A. T., Treguier, J-P., Seiller, M., and Puisieux, F., (1976). The influence of surfactant hlb and the nature of the oil phase on the phase diagrams of nonionic surfactant-oil-water systems. *Journal of Colloid and Interface Science*, 59(2): 319-327.

Lovelyn, C., and Attama, A.A. (2011). Current state of nanoemulsions in drug delivery. *Journal of Biomaterials and Nanobiotechnology*, 2(5A): 626-639.

Mahdi, E.S., Noor, A.M., Sakeena, M.H., Abdullah, G.Z., Abdulkarim, M.F., and Sattar, M.A. (2011). Formulation and in vitro release evaluation of newly synthesized palm kernel oil esters-based nanoemulsion delivery system for 30% ethanolic dried extract derived from local Phyllanthus urinaria for skin antiaging. *International Journal Nanomedicine*, 6: 2499-2512.

Mahynski, N. A., Irick, B., and Panagiotopoulos, A. Z. (2013). Structure of phase-separated athermal colloid-polymer systems in the protein limit. *Physical Review E*, 87(2): 022309.

Mackie, A. D., Panagiotopoulos A. Z., and Szleifer I. (1997). Aggregation behavior of a lattice model for amphiphiles. *Langmuir*, 13: 5022-5031.

Martinez, L., Andrade, R., Birgin, E.G., and Martinez, J.M. (2009). PACKMOL: a package for building initial configurations for molecular dynamics simulations. *Journal of Computational Chemistry*, 30(13): 2157-2164.

Mason, T.G., Wilking, J., Meleson, K., Chang, C., and Graves, S. (2006). Nanoemulsions: formation, structure, and physical properties. *Journal of Physics: Condensed Matter*, 18(41): R635.

Metropolis, N., Rosenbluth, A.W., Rosenbluth, M.N., Teller, A.H., and Teller, E. (1953). Equation of state calculations by fast computing machines. *Journal of Chemical Physic*, 21(6): 1087-1092.

Metropolis, N., and Ulam, S. (1949). The Monte Carlo method. *Journal of the American Statistical Association*, 44(247): 335-341.

Mosayeb, A., and Abedini, R. (2012). The effect of non-ionic surfactants on the interfacial tension between crude oil and water. *Petroleum & Coal*, 54(2): 110-113 s

Mou, D., Chen, H., Du, D., Mao, C., Wan, J., Xu, H., and Yang, X. (2008). Hydrogel-thickened nanoemulsion system for topical delivery of lipophilic drugs. *International Journal of Pharmaceutics*, 353(1–2): 270-276.

Nakagawa, N., Maeda, S., Ishii, S., and Ohno, K. (2007). A monte carlo simulation of the formation of micelles in a ternary system of water, oil and amphiphilic polymers. *Materials Transactions*, 48(4): 653-657.

Nelson, P.H., Rutledge, G.C., and Hatton, T.A. (1997). On the size and shape of self-assembled micelles. *Journal of Chemical Physics*, 107(24): 10777-10781.

Oh, S.Y., and Bae, Y.C. (2011). Liquid–liquid equilibria for ternary polymer mixtures. *Chemical Physics*, 379(1–3): 128-133.

Panagiotopoulos, A.Z. (2000). Monte Carlo methods for phase equilibria of fluids. *Journal of Physics: Condensed Matter*, 12(3): R25.

Panagiotopoulos, A.Z., Floriano, M.A., and Kumar, S.K. (2002). Micellization and phase separation of diblock and triblock model surfactants. *Langmuir*, 18(7): 2940-2948.

Panagiotopoulos, A.Z., Wong, V., and Floriano, M.A. (1998). Phase equilibria of lattice polymers from histogram reweighting monte carlo simulations. *Macromolecules*, 31(3): 912-918.

Park, E.S., Chang, S.Y., Hahn, M., and Chi, S.C. (2000). Enhancing effect of polyoxyethylene alkyl ethers on the skin permeation of ibuprofen. *International of Pharmaceutical*, 209(1-2): 109-119.

Patel, S., Mackerell, A.D., and Brooks, C.L. (2004). CHARMM fluctuating charge force field for proteins: II Protein/solvent properties from molecular dynamics simulations using a nonadditive electrostatic model. *Journal of Computational Chemistry*, 25(12): 1504-1514.

Pathan, I.B., and Setty, C.M. (2009). Chemical penetration enhancers for transdermal drug delivery systems. *Tropical Journal of Pharmaceutical Research*, 8(2).

Peltola, S., Saarinen-Savolainen, P., Kiesvaara, J., Suhonen, T.M., and Urtti, A. (2003). Microemulsions for topical delivery of estradiol. *International Journal of Pharmaceutics*, 254(2): 99-107.

Pool, R., and Bolhuis, P.G. (2010). The influence of micelle formation on the stability of colloid surfactant mixtures. *Physical Chemistry Chemical Physics*, 12(44): 14789-14797.

Poorgholami-Bejarpasi, N., Hashemianzadeh, M., Mousavi-Khoshdel, S.M., and Sohrabi, B. (2010). Role of interaction energies in the behavior of mixed surfactant systems: a lattice Monte Carlo simulation. *Langmuir*, 26(17): 13786-13796.

Prausnitz, M.R., and Langer, R. (2008). Transdermal drug delivery. *Nature Biotechnology*, 26(11), 1261-1268.

Rodríguez-Guadarrama, L.A., Talsania, S.K., Mohanty, K.K., and Rajagopalan, R. (1998). Thermodynamics of aggregation of amphiphiles in solution from lattice Monte Carlo simulations. *Langmuir*, 15(2): 437-446.

Rosen, M.J. (2004). Micelle formation by surfactants. *Surfactants and Interfacial Phenomena* (pp. 105-177). John Wiley & Sons, Inc.

Rosenbluth, M.N., and Rosenbluth, A.W. (1955). Monte carlo calculation of the average extension of molecular chains, *Journal of Chemical Physics*, 23(2): 356-359.

Roux, B., and Simonson, T. (1999). Implicit solvent models. *Biophysical Chemistry*, 78(1–2): 1-20.

Salager, J.L., 2002 Surfactants Types and Uses. Retrieved 19 December 2013 from http://www.nanoparticles.org/pdf/Salager-E300A.pdf

Salim, N., Basri, M., Abdul Rahman, M.B., Abdullah, D.K., Basri, H., and Salleh, A.B. (2011). Phase behaviour, formation and characterization of palm-based esters nanoemulsion formulation containing ibuprofen. *Journal of Nanomedicine and Nanotechnology*, 2:113(4): 5.

Schmidt, M. W., Baldridge, K. K., Boatz, J. A., Elbert, S. T., Gordon, M.S., Jensen, J.H.,Koseki, S., Matsunaga, N., Nguyen, K.A., Su, S.W., Theresa L., Dupuis, M. and Montgomery, J.A. (1993). General atomic and molecular electronic structure system. *Journal of Computational Chemistry*, 14(11): 1347-1363.

Schramm, L. L. (2000). *Surfactants: Fundamentals and Applications in the Petroleum Industry*. United Kingdom: Cambrigde University Press.

Seiller, M., Legras, T., Puisieux, F., and Le Hir, A. (1970). Fluid emulsions. 3. Influence of the chemical nature of emulsifying agents upon the critical HLB of a paraffin oil. *Annales Pharmaceutical Francaises*, 28(6): 425-436.

Shell, M.S. (2012).Monte Carlo other ensembles. Retrieved 27 December 2013 from http://www.engr.ucsb.edu/~shell/che210d/Monte_Carlo_other_ensembles.pdf

Shinoda, K. (1954). The critical micelle concentration of soap mitures (Two-component mixture). *Journal of Physical Chemistry*,58(7):541-544.

Shinoda, W., DeVane, R., and Klein, M.L. (2010). Zwitterionic lipid assemblies: molecular dynamics studies of monolayers, bilayers, and vesicles using a new coarse grain force field. *The Journal of Physical Chemistry B*, 114(20): 6836-6849.

Solans, C., Izquierdo, P., Nolla, J., Azemar, N., and Garcia-Celma, M.J. (2005). Nano-emulsions. *Current Opinion in Colloid & Interface Science*, 10(3–4): 102-110.

Som, I., Bhatia, K., and Yasir, M. (2012). Status of surfactants as penetration enhancers in transdermal drug delivery. *Journal of Pharmacy and Bioallied Sciences*, 4(1): 2-9.

Svaneborg, C., and Pedersen, J.S. (2000). A Monte Carlo study on the effect of excluded volume interactions on the scattering from block copolymer micelles. *Journal of Chemical Physics*, 112(21): 9661-9670.

Tadros, T.F. (2005). Surfactants in nano-emulsions applied surfactants (pp. 285-308): Wiley-VCH Verlag GmbH & Co. KGaA.

Tadros, T.F., Vandamme, A., Levecke, B., Booten, K., and Stevens, C.V. (2004). Stabilization of emulsions using polymeric surfactants based on inulin. *Advances in Colloid and Interface Science*, 108–109(0): 207-226.

Tanguy, D. (2011). Monte Carlo methodology for grand canonical simulations of vacancies at crystalline defects, *Applications of Monte Carlo Method in Science and Engineering*.

Theodorou, D.N. (2010). Progress and outlook in Monte Carlo simulations. *Industrial & Engineering Chemistry Research*, 49(7): 3047-3058.

Thomas, Z., and Olivier, D. (2010). What can we learn from combined SAXS and SANS measurements of the same sample containing surfactants? *Journal of Physics: Conference Series*, 247(1): 012002.

Torres, L.G., Rojas, N., Bautista, G., and Iturbe, R. (2005). Effect of temperature, and surfactant's HLB and dose over the TPH-diesel biodegradation process in aged soils. *Process Biochemistry*, 40(10): 3296-3302.

Usón, N., Garcia, M.J., and Solans, C. (2004). Formation of water-in-oil (W/O) nano-emulsions in a water/mixed non-ionic surfactant/oil systems prepared by a low-energy emulsification method. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 250(1–3): 415-421.

Vanommeslaeghe K., Hatcher E., Acharya C., Kundu S., Zhong S., Shim J., Darian E., Guvench O., Lopes P., Vorobyov I., and Mackerell Jr A.D. (2010). CHARMM general force field: A force field for drug-like molecules compatible with the CHARMM all-atom additive biological force fields. *Journal of Computational Chemistry*, 31(4): 671-690.

Verso, F.L., Panagiotopoulos, A.Z., and Likos, C.N. (2010). Phase behavior of low-functionality, telechelic star block copolymers. *Faraday Discussions*, 144(0): 143-157.

Vyas, T.K., Shahiwala, A., and Amiji, M.M. (2008). Improved oral bioavailability and brain transport of Saquinavir upon administration in novel nanoemulsion formulations. *International Journal of Pharmaceutics*, 347(1–2): 93-101.

Wahab, M., Mogel, H. J., & Schiller, P. (2001). Indirect interaction of inclusions in mixed membranes. *Molecular Physics, 99*(24): 2045-2053.

Wallin, T., and Linse, P. (1997). Monte Carlo simulations of polyelectrolytes at charged micelles. 3. effects of surfactant tail length. *Journal of Physical Chemistry B*, 101(28): 5506-5513.

Wilding, N. (2011). Accurate simulation estimates of phase behavior in ternary mixtures with prescribed composition. *Journal of Statistical Physics*, 144(3): 652-662.

Woo, H. J., Dinner, A. R., and Roux, B. (2004). Grand canonical Monte Carlo simulations of water in protein environments. *Journal of Chemical Physics*, 121(13): 6392-6400.

Wu, P. C., Tsai, M. J., Huang, Y. B., Chang, J. S., and Tsai, Y. H. (2002). In vitro and in vivo evaluation of potassium chloride sustained release formulation prepared with saturated polyglycolyed glycerides matrices. *International Journal of Pharmaceuticals*, 243(1-2): 119-124.

Yu, Y., Zhao, J., and Bayly, A. E. (2008). Development of surfactants and builders in detergent formulations. *Chinese Journal of Chemical Engineering*, 16(4): 517-527.

Yukawa H. (1935). On the interaction of elementary particles. *Proceedings of the Physico-Mathematical Society of Japan*, 17:48.

Zaldivar, M., and Larson, R. G. (2003). Lattice monte carlo simulations of dilute mixed micelles. *Langmuir*, 19: 10434-10442.

Zehl, T., Wahab, M., Mögel, H. J., and Schiller, P. (2006). Monte carlo simulations of self-assembled surfactant aggregates. *Langmuir*, 22(6): 2523-2527.

Zehl, T., Wahab, M., Schiller, P., and Mögel, H. J. (2009). Monte carlo simulation of surfactant adsorption on hydrophilic surfaces. *Langmuir*, 25(4), 2090-2100.

Zheng, F., Chen, G., Zhang, X., and Wang, W. (2009). A Monte Carlo study of crowding effects on the self-assembly of amphiphilic molecules. *Journal of Chemical Physics*, 130(20): 204701.

Zorec, B., Préat, V., Miklavčič, D., and Pavšelj, N. (2013). Active enhancement methods for intra-and transdermal drug delivery: a review. *Slovenian Medical Journal*, 82(5).