

MASTER'S THESIS

Encapsulation of magnetosomes in lipid vesicles

Liu, Shuk Yi

Date of Award:
2004

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

Encapsulation of Magnetosomes in Lipid Vesicles

LIU Shuk Yi

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Philosophy

Principal Supervisor: Dr. HU Gang

Hong Kong Baptist University

September 2004

Abstract

Usual magnetoliposomes are giant lipid vesicles filled up homogeneously with an aqueous ferrofluid and suspended in a nonmagnetic aqueous phase. Using double emulsification techniques, we have developed a method to encapsulate ferrofluid emulsion droplets into giant lipid vesicles. By transferring the double emulsion (O1/W/O2) droplets originally suspended in an oil phase into a water phase, we are able to assemble asymmetric vesicles containing monodisperse submicron-sized emulsion droplets, which are made of an oil-based ferrofluid. The stability of the system against a changing environment is enhanced by the compartment structure. Under a magnetic field, the ferrofluid emulsion droplets inside a vesicle form magnetosomes and induce a large shape deformation of the vesicle. We describe our process to prepare double emulsions with a controlled size distribution and the flexibility to assemble lamella vesicles by two independently-formed monolayers. Results of the magnetic field-dependent shape transformation, stability of the bilayers of vesicles under shear flow and ionic strength situation are reported. The application of encapsulation of active particles in vesicles facilitates further investigations of physical properties of biological membranes and is aimed to improve drug delivery and cosmetics products.

Table of Contents

Declaration		
	i	
Abstract		
	ii	
Acknowledgements		iii
Table of Contents		
	iv	
List of Tables		viii
List of Figures		x
Chapter 1 Introduction		
1		
1.1 Background of Liposomes, Magnetoliposomes and Magnetosomes in Lipid Vesicles		1
1.2 Literature Review		
	2	
1.3 Outline of the Research		4
Chapter 2 Theory		
	7	

2.1 Vesicle

7

2.1.1 Packing parameter of surfactant

7

2.1.2 Different classes of vesicles

9

2.1.3 Free energy of bending of a bilayer system

9

2.1.4 Various ways of forming vesicles

11

2.2 Emulsion

13

2.2.1 Emulsification and emulsion definition

13

2.2.2 Methods of stabilizing emulsions

14

2.2.3 How surfactant responds in an emulsion?

15

2.2.4 Forming emulsion usually requires mechanical energy

17

2.2.5 Pressure gradient during the mixing process governs

17

droplets size

2.3 Microscopic colloidal behaviors

18

2.3.1 Brownian motion and diffusion

18

2.3.2 Optical microscopy of dispersions

19

2.3.3 Principle of differential interference contrast microscope 20

2.3.4 Light scattering in dispersion

22

2.3.5 Dynamic light scattering

22

2.4 Particle Interaction

25

2.4.1 Structural change of ferrofluid under magnetic field 25

2.4.2 Orientation distribution due to interaction energy of

28

magnetic dipoles

Chapter 3 Research Methodology

33

3.1. Preparation of monodisperse sample

33

3.1.1 Formation of ferrofluid emulsion

34

3.1.2 Formation of ferrofluid double emulsion

36

3.1.3 Formation of ferro-vesicle

39

3.2. Determination of particle size	
	43
3.3. Image analysis by optical microscopy	
	44
3.3.1 Preparation of sample cell	
	45
3.3.2 Magnetic field perpendicular or parallel to the cell surface	45
3.3.3 Image Processing	
	47
Chapter 4 Results and Discussion	
	49
4.1 Observation under Optical Microscope	
	49
4.1.1 Structure Formation of Ferrofluid Emulsion	
	49
4.1.1.1 Under parallel magnetic field	49
4.1.1.2 Under perpendicular magnetic field	
	51
4.1.2 Structure Formation of Ferrofluid Double Emulsion	
	52
4.1.3 Structure formation of ferro-vesicle	
	55
4.1.3.1 Translational motion of ferro-vesicle under magnetic field	56
4.1.3.2 Shape deformation of irregular-shaped ferro-vesicle	57

	by magnetic field	
59	4.1.3.3 Burst of ferro-vesicle under ionic strength situation	
62	4.1.3.4 Burst of ferro-vesicle under shear flow	
	4.2 Calculations	
	63	
	4.2.1 Calculation for the concentration of surfactants are needed to make the fixed sized vesicles	63
	4.2.2 Calculation for the terminal velocity of fixed size ferrofluid emulsion in the process of fractionation	68
	4.2.3 Calculation for the velocity of fixed size ferro-vesicle in the process of sedimentation	70
	4.2.4 Shear rate of the vesicle under the application of B-field	72
	4.3 Problems and limitations of the production of vesicle technique	74
	4.3.1 The stability of the emulsion	
	75	
	4.3.2 Equilibration of the oil-water interface and emulsions	
82		
	4.3.3 Controlling the size of the emulsion	
84		
	4.3.4 Transfer of emulsion droplets into vesicles	
86		

Chapter 5 Conclusion
89

Reference
90

Curriculum Vitae
93