MICROSCOPIC STUDY OF EMULSION FLOW
IN POROUS MEDIA

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DEDICATION

I dedicated this Ph D Thesis to my lovely parents; Hj. A.Manan Hitam and Hjh. Hasnah Janom, to my parent-in-laws; Hjh. Habibah Sepit and late Hj. Maarof Rumit, to my wife; Nathrah, to my children; Pali, Munah and Ain, and to my other family members. Your deep understanding, patience and continuous support have encouraged me to complete this thesis.

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ABSTRACT

Emulsion applicability as an oil recovery agent has long been recognized in petroleum industry. However, investigations of emulsion flow in porous media for petroleum recovery applications are scarce; particularly the flow effects have not been explained in detail in term of events occurring at the pore level. Thus, this research was carried out to investigate the physics of emulsion flow in porous media. The objectives of the experiments are to study the behavior and mechanism of emulsion flow in porous media, to evaluate the effectiveness of emulsion as an oil recovery agent, and to determine the emulsion blocking processes. In this research, well characterized emulsions of water-in-oil emulsion (model oil of 86.5% dibutylphthalate + 13.5% n-heptane, and distilled water system) and oil-in-water emulsion (paraffin oil, distilled water, and Triton-X100 surfactant system) were injected into two-dimensional etched glass micromodels. Visualization experiments by using microscope on the micromodels were conducted to observe and record the emulsion droplet motion, captured mechanisms, and blockage processes. The results demonstrate the three possible flow regimes that may occur when emulsion flow in porous media are mainly due to the difference of emulsion droplet size to pore throat ratios. Flow phenomena of emulsion droplet formation, deformation and destruction, blob and rivulet were observed to be associated with less stable emulsion system. Other emulsion flow phenomena were the microstructures of droplets adhesion and entrainment from the solid surface, and droplets undergone snap-off and division from pore-to-pore. The results show that the emulsion droplets were found to be captured at the throat and the pore body according to straining and interception capture mechanisms. Also, the results indicate that wettability has a direct influence on the droplet capture mechanism. Emulsion water droplet colliding with the water-wet surface could easily adhere to the surface and formed thick water films. On the other hand, emulsion water droplet contacting oil-wet surface could be displaced from the surface by the continuous oil phase. Moreover, the results reveal that continuous emulsion injections could provide additional oil recovery, but by injecting smaller size emulsion slugs prior to water injection would result in insignificant additional oil recovery. Microscopic mobility control was found to contribute to the oil recovery processes in homogeneous porous media, while macroscopic mobility control due to the emulsion blocking effect would contribute to the oil recovery processes in heterogeneous porous media. The emulsion blockage process was observed to be accelerated with large ratio of emulsion droplet-to-pore throat, coalescence of captured droplet, low emulsion flow rate, more viscous emulsion droplets, and emulsion droplet wetting the solid surface. In conclusion, this research characterizes the physics of emulsion flow in porous media and demonstrates its application as an effective oil recovery agent through emulsion blocking mechanisms. The novelty is the revelation of the process for emulsion droplet blockage effects in porous media.

ABSTRAK

Kegunaan emulsi sebagai agen perolehan minyak sudah lama diiktiraf dalam industri petroleum. Walau bagaimanapun, penyiasatan tentang aliran emulsi di dalam media poros dalam aplikasi perolehan minyak masih berada pada tahap yang kurang sempurna; terutama kesan aliran emulsi yang masih tidak dijelaskan secara terperinci dari aspek perlakuan kejadian pada tahap liang. Oleh itu, penyelidikan ini dijalankan untuk menyiasat perlakuan fizik aliran emulsi di dalam media poros. Objektif kajian adalah untuk mengkaji tingkahlaku dan mekanisme aliran emulsi di dalam media poros, menilai emulsi sebagai agen perolehan minyak yang berkesan, dan menentukan proses penyekatan emulsi. Dalam penyelidikan ini, emulsi air-dalam-minyak (sistem model minyak 86.5% dibutilfatalat + 13.5% n-heptana, dan air suling) dan emulsi minyak-dalam-air (sistem minyak parafin, air suling, dan surfaktan Triton-X100) yang mempunyai ciri tertentu disuntik ke dalam mikromodel gelas tersurih dua dimensi. Ujian gambaran dengan menggunakan mikroskop ke atas mikromodel dilakukan untuk memerhati dan merakam pergerakan titisan emulsi, mekanisme pemerangkapan, dan proses penyekatan. Keputusan ujian menunjukkan bahawa tiga jenis regim aliran boleh berlaku terutama bila emulsi mengalir di dalam media poros adalah berpunca daripada perbezaan nisbah saiz titisan emulsi terhadap leher liang. Fenomena aliran misalnya pembentukan titisan emulsi, ubah bentuk dan pemusnahan, titisan besar, dan sungai titisan emulsi hanya berlaku pada sistem emulsi yang kurang stabil. Tingkahlaku aliran emulsi yang lain ialah terdapat mikrostruktur rekatan dan pembebasan titisan emulsi dari permukaan pepejal, dan titisan emulsi mengalami pemutusan dan pembahagian dari satu liang ke liang yang lain. Keputusan menunjukkan bahawa titisan emulsi terperangkap di leher liang dan jasad liang berdasarkan mekanisme penyekatan dan pemintasan. Keputusan juga mempamerkan bahawa keterbasahan mempunyai kesan langsung terhadap mekanisme pemerangkapan titisan. Titisan air emulsi berlaga dengan permukaan basah air mudah terekat pada permukaan dan membentuk lapisan air yang tebal. Sebaliknya, titisan air emulsi yang berlaga dengan permukaan basah minyak dianjakkan dari permukaan oleh fasa minyak yang berterusan. Selanjutnya, keputusan mendedahkan bahawa suntikan emulsi secara berterusan mampu menghasilkan perolehan minyak tambahan, tetapi suntikan slug emulsi yang kecil sebelum suntikan air tidak memberi kesan terhadap perolehan minyak. Kawalan pergerakan secara mikroskopik didapati menjurus kepada proses perolehan minyak dalam media poros homogen, sementara kawalan pergerakan secara makroskopik yang disebabkan oleh kesan penyekatan emulsi menjurus kepada perolehan minyak dalam media poros tak homogen. Proses penyekatan emulsi mampu dipercepatkan oleh nisbah titisan emulsi terhadap leher liang yang besar, penautan titisan yang terperangkap, kadar aliran yang rendah, titisan emulsi yang lebih likat, dan titisan emulsi yang membasah permukaan pepejal. Kesimpulannya, penyelidikan ini berjaya mencirikan fizik aliran emulsi di dalam media poros dan menunjukkan kegunaannya sebagai agen perolehan minyak yang berkesan melalui mekanisme penyekatan emulsi. Keaslian kajian ialah pendedahan kesan penyekatan emulsi di dalam media poros.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMENCLATURE

Roman Letters

w/o	water-in-oil emulsion
o/w	oil-in-water emulsion
o/w/o	oil-in-water-in-oil multiple emulsion
w/o/w	water-in-oil-in-water multiple emulsion
ppm	part per million
k	permeability
L	length or distance
p or P	pressure
q or Q	flow rate
v	velocity
r or R	radius
h	height
m	matrix
mN/m	millinewton per meter
g	gravity constant
a	acceleration

Greek Letters

σ	surface tension or interfacial tension
θ	contact angle
υ	settling velocity
η, μ	viscosity
ρ	density

Δ	differential
ϕ	porosity

Subscripts

o	oil phase
i	initial or internal
t	total
f	fiber
1 and 2	leading and trailing curvatures
c	capillary or continuous
e	external
wo	water-in-oil
ow	oil-in-water
w	water
ri	initial relative permeability
sb	surface solid and phase b
sa	surface solid and phase a
ab	surfaces a and b
oi	relative to oil

Superscripts

o	degree

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Emulsion flows in porous media can take place in many instances for practical applications, both in petroleum or non-petroleum related processes. Emulsion flows through oil reservoirs are important in secondary oil recovery methods, such as the use of high viscosity emulsions to displace oil, the use of emulsion slugs as boundaries between the driven fluid (oil) and the driving fluid (water) in conventional water-flooding operation, the combination of a soluble-oil slug and a slug of emulsions, and the use of microemulsions (Uzoigwe and Marsden, 1970). Similar situations occur in enhanced oil recovery techniques, such as emulsion flow during micellar-polymer flooding and alkali-surfactant-polymer flooding (Gogarty, 1974; Gogarty, 1978; Jennings *et al*., 1974; Grude and Johnson, 1974). Other emulsion applications are in heavy-oil reservoirs as a blocking agent or mobility control agent to improve sweep efficiency (Fiori and Farouq Ali, 1989; McAuliffe, 1973a; Schmidt *et al.*, 1984; Romero *et al*., 1996), in steam-flooding processes (Decker and Flock, 1988; French, 1986; Garthoffner, 1979), and in retarding mineral dissolution rate of matrix acidization processes (Hoefner and Fogler, 1985).

Emulsion flows in porous media may also be encountered during produced water reinjection into subsurface formations (Mendez, 1999), and during chemical process in fixed-bed catalytic reactors involving two immiscible liquids (Trambouze, 1990). Flow of emulsions can also occur in the separation of emulsions by porous media coalescers (fibrous or granular coalescers). Reported applications of porous coalescers include the separation of water from aviation fuel (Bitten, 1970; Bitten and Fochtman, 1971), desalination of crude oil and bilge water treatment (Douglas and Elliot, 1962), separation of emulsified oil from water (Sareen *et al*., 1966), break-up of freon from water (Johnson, 1980), and oil recovery from oil spill emulsions on the sea surface and from refinery sludges (Anklam, 1997). Most of the porous coalescer applications are for unstable and dilute emulsion systems, which the dispersed phase contents are usually less than 0.1 % v/v (1000 ppm). Anklam (1997) was among the few people who used concentrated emulsion systems of 65 to 96% in his study.

Having mentioned the importance of emulsion flow in porous media, this author is interested to study further the flow behavior of emulsion in porous media in petroleum reservoir applications. The particular areas of interests are emulsion as a mobility control, a blocking agent and/or a plugging agent in secondary and tertiary waterflooding to improve swept efficiency and to increase oil recovery (Romero *et al*., 1996; Thomas and Farouq Ali, 1989). Emulsion flows in porous media are also always being associated with the overall permeability impairment of the porous media. Thus, this study investigates and explains the physics at pore scale level and pore network level behind the magnitude, extent and rate of permeability reductions as emulsions flow through the porous media.

The physics of emulsion flows in porous media is very complicated because they involve a complex emulsion system and extremely complex porous media geometry. Therefore, the knowledge of the nature and properties of emulsions, the characteristics of porous media, and the basic mechanisms involved in the flow of simpler fluids in porous media are important in order to understand the behavior of emulsion flow in porous media (Kokal *et al*., 1992). Table 1.1 indicates area of study in the understanding of emulsion flow in porous media, both qualitative and quantitative aspects.

Table 1.1 : Area of Study in the Understanding of Both Qualitative and Quantitative Aspects for Emulsion Flow in Porous Media (Kokal *et al.*, 1992).

Area of Interest	Important Parameters to Consider
• Emulsion Characteristics	• Stability • Quality • Droplet size distribution • Rheology
• Porous Medium Characteristics	• Average pore size • Pore size distribution • Wettability • Porosity • Permeability • Specific surface area • Chemical composition
• Fluid-rock interaction	• Emulsion-rock interaction • Simultaneous flow of emulsion • Bulk dispersed phase
• Hydrodynamic	• Flow velocity
• Theoretical analysis	• Taking into account all of the aforementioned

1.2 Emulsion Applications in Oil Recovery

Emulsion flow in porous media occurs in petroleum reservoirs during the production of oil from underground reservoirs containing oil, water, and gas. Emulsions may form naturally during simultaneous flow of oil and water in porous rock formations, or they may be promoted by injection of external chemicals. In emulsion flooding for heavy-oil recovery, externally generated emulsions are injected into the reservoir. A good review of the fundamentals and applications of emulsions in petroleum industry can be found in the advanced chemical series edited by Schramm (1992).

Emulsions could be formed in the reservoir rock itself, particularly, within the porous rock near the well bore where the velocity gradients were very high. Emulsions within the porous medium are formed as a result of the presence of surface active-agents, either native or externally added, and shear by the movement of fluid through pore to the throats. Natural emulsifiers exist in oil reservoirs from the following materials: asphaltic and resinous materials found in crude; asphaltenes found in heavy crude; oil-soluble organic acids such as napthenic acids; fatty acids or aromatic acids; cyclic compounds (cyclic aromatic) such as toluene, benzene, decalin, methylcyclohexane and cyclooctane in crude oils (Khambharatana, 1993); and some finely divided insoluble materials (Uzoigwe and Marsden, 1970). These emulsifiers absorb at the oil-water interface and form a film that prevents the coalescence of the droplets in natural oil field emulsions. The emulsifiers also decrease the interfacial tension of the oil and water, which plays a dominant role in the emulsification of these liquids in porous media (Raghavan and Marsden, 1971).

Vittotos (1990) and Chen *et al*. (1991) have shown that in-situ emulsification can be formed in porous media. Their studies have shown that during a cyclic steam flooding, part of the produced water flows as a single phase, and part of the water will flow as an emulsion with the oil. This finding is different from the normal phenomena of the flow of water and oil in which the two phases are considered to be flowing separately. The implication of emulsion flow in porous media is that the immiscible displacement should be modified to allow for the mixing of the two phases to flow as an emulsion. Table 1.2 lists the differences and similarities between the flow of emulsion and the simultaneous flow of oil and water in a porous medium. Vittotos (1990) also suggested that flow of water-in-oil emulsions in porous media should get more attention with the recognition that it may be an important factor in controlling the oil-water ratio in the production from steam stimulated wells.

Table 1.2 : Differences and Similarities between the Flow of Emulsion and the Simultaneous Flow of Oil and Water in a Porous Medium (Schramm ,1992; Kokal *et al.*, 1992).

Simultaneous flow of oil and water	Flow of emulsions
• Both oil and water occupy a continuous but separate flow channel	• Both oil and water (emulsion) occupy the same flow channels
• The non-wetting phase is discontinuous at its residual saturation and it ceases to flow	• The dispersed phase consists of very small droplets and about the same size of the pore sizes, these droplet are surrounded by the continuous phase
• Total relative permeabilities of oil and water in the porous medium is equal to one	• At the same wetting phase saturation, the relative permeabilities to water and oil are quite different
• Oil droplets or ganglia become trapped in the porous medium by the process of snap-off of oil filament at the pore throats	• Dispersed phase become trapped by the mechanism of straining capture at the pore throat smaller than the dispersed phase drop

Other in-situ emulsifications in enhanced oil recovery methods are carbon dioxide flooding, chemical flooding and thermal flooding. Spontaneous emulsification occurs during chemical flooding when there is a mass transfer of surfactant between the oil and water phases under sufficient shearing action at the oil/water interface (Cash *et al.*, 1975). In micellar-polymer flooding and alkali-surfactant-polymer flooding, in-situ emulsification and entrapment of emulsion droplets occur to result in reduced water mobility, which in turn improves both vertical and areal sweep efficiencies (Jenning *et al.*, 1974; Taylor and Hawkins, 1992). Similarly, in immiscible carbon dioxide flooding, an emulsion bank formed seems to improve oil displacement efficiency without pressure drop increases.

Soo and Radke (1984), Alvarado and Marsden (1979), McAuliffe (1973a) and Deveraux (1974b) have conducted the most relevant experimental investigations related to the flow of emulsion in porous media. They evaluated some pore plugging mechanisms associated with the injection of emulsified oil droplets into fully brine-saturated cores. They have also found out that the stability of emulsions in porous media is affected by a number of factors such as drop size to pore size ratio, concentration of the droplets, flow rate, wettability and the surface chemistry of the porous medium. For dilute, surfactant-free o/w emulsions, solid surface behaves more like a filter and is not affected by wettability. Emulsion instability due to droplet coalescence then arises from the captured droplets coming into contact with each other, and from the effects of surface chemistry alterations may be due more to electrostatics than wettability (Basu, 1993; Jachowicz and Berthiaume, 1989). For w/o emulsions with low dielectric oils, the electrostatic interactions will be negligible compared to other colloidal interactions and wettability to have a large effect on coalescence.

Mendez (1999) has experimented similar core flow experiments but he investigated the effect of the flow of emulsions in porous media containing residual oil saturation. He has compared the flow of emulsion in porous media in deep-bed filtration processes to emulsion flows occurring in oil recovery. Oil reservoirs, as compared to filters, usually have fairly low permeabilities. So the ratio of emulsion droplet to pore size is larger than that in standard filtration processes.

Some researchers have concluded that the formation of stable macroemulsions in the oil fields is considered undesirable and can cause severe problems. Strange and Talash (1977), Whiteley and Ware (1977), and Widmyer *et al*. (1977) have reported poor oil recovery due to problems associated with stable emulsions. They were right with respect to a very high energy is required to flow a high viscosity emulsions formed in the reservoir of homogeneous permeability. However, McAuliffe (1973a) and Khambharatana *et al.* (1997) have shown beneficial effects of macroemulsions in oil recovery as their injection into sandstone cores increased sweep efficiency. Emulsions (o/w or w/o emulsions) offer considerable promise as effective oil recovery agents. Emulsions can provide mobility control in certain situations, and may even serve as blocking agents. The results show that the emulsion drop retained – hence mobility control – is rate-dependent and related to pore size distribution. According to the process, the emulsion droplets must be larger than the pore-throat constrictions in the porous media in order for the emulsion to be most effective. The injected emulsion enters the highly permeable zones, which in turn reduces the channeling of water. Therefore, water starts to flow into low permeable zones, resulting in greater sweep efficiency. A field test for emulsion flooding process conducted in the Midway Sunset field, California, has showed an improvement in oil recovery, an increase in sweep efficiency, and a lower in water-oil-ratio (McAuliffe,1973b).

Most of the research works conducted so far have been carried out on core flooding or analytical and numerical simulations, and sometimes alongside field trials. The behaviors of emulsion flow in porous media, permeability reduction and oil recovery have been empirically investigated using core displacement experiments, and generally with water-wet cores. Although micromodel techniques have become more accepted and have grown rapidly for fluid displacement study, a very limited micromodel visualization study of emulsion flow in porous media has been carried out to directly observe the physical processes taking place in the porous media. Most micromodel studies of emulsion flow in porous media were in the emulsion separation in porous coalescers (fibrous or granular) for unstable and dilute emulsion systems, and at very low emulsion droplet-to-pore size ratio. Soo and Radke (1984) have used a micromodel of Ottawa sand sandwiched between two glass plates to study o/w emulsion flow. They only described the flow profiles of the injected emulsion in micromodel, but they did not produce any photograph of the pore level events in their report.

For possible implementation of an emulsion flooding/injection, the prior performance and recovery predictions for economic evaluation are needed by using a reliable simulation incorporating proper reservoir fluid and rock description which reflect the actual physics of the emulsion flow realistically. 2-D glass micromodel experiments were performed to test a series of emulsion flow in porous media to observe and record the flow processes and measure the model fluid saturations and recoveries. The results of this study can be used in the future by others to verify the accuracy of the predictions made by the network model simulator (the network model simulation is not part of this study).

1.3 Problem Statement

It is understood that emulsion flow in porous media has significant engineering applications in oil recovery processes. A great deal of work has been conducted on the flow (transport) of emulsions in porous media. The primary problem of interest in this study is the emulsion flooding for oil recovery technique. A review of the literature indicates that there has been limited micromodel experimental work done on determining the pore level behaviors of porous media when emulsions are flooded into the formation. Emulsions have been shown to be effective blocking agents (Bragg, 1999; Varadaraj *et al*., 2004; Zeidani *el al*., 2006), but limited work has been reported on their use at waterflooding. In this study, microscale studies are conducted to investigate the emulsion flow behavior through porous media. The microscale flow study will demonstrate the pore level mechanism and micro structure of the emulsion droplets.

A number of questions are addressed with respect to the micromodel flow experiments in this study.

(a) What are the mechanisms responsible for the permeability reduction of emulsion flow in porous media at different emulsion quality, emulsion flow rate, emulsion droplet size, emulsion stability, and droplet-to-pore size ratio?

(b) What is the nature of emulsion at pore level and at pore network level? Does it consist of single or multiple droplet straining and interception captured mechanisms at the pore throat and at the pore body? Are there any preferred conditions that emulsion droplet will under goes re-entrainment and displacement?

(c) How wetting interaction of the emulsion droplets with the porous media surfaces lead to different flow phenomena, and how does wettability influences the emulsion stability? Will droplet spreading on the surface and droplet wetting film on the solid substrate be more likely to coalesce with the droplets than the droplets to coalesce with other free droplets?

(d) How flow rate and emulsion quality are important, how do these parameters effect emulsion distribution in the porous media?

(e) How the two systems of stable dilute and stable concentrated emulsions provide different flow mechanism in porous media?

(f) How emulsions can assist in oil recovery from the porous media? It is through mobility improvement or profile improvement?

1.4 Objective of Research

This research is aimed at visualizing the fundamental mechanism of the permeability impairment caused by the flow of emulsions in porous media of two-dimensional glass-etched micromodels with novel design, and quantifying some of the observation results. This research was carried out with the objective of investigating the problems of the flow nature of emulsions through porous media as specifically stated below.

a) To observe, elucidate and identify the main microscopic mechanisms involved in the permeability reduction phenomena of the flow of emulsions in porous media, and to evaluate the factors such as, dispersed phase contents, emulsion flow rates, and wettability conditions that may affect such a process. The initial conditions of the flow models are dry (100% air filled), fully water-saturated, and filled by residual oil saturations.

b) To observe the emulsion blocking phenomena in micromodel by identifying the blockage processes.

c) To quantify some of the observations by employing digital image analysis techniques to measure the relative saturation of the phases in the micromodels.

These results are examined and produced at three scale levels: (i) at the pore scale observation, using individual pores; (ii) at the target area, comprising a number of representative elementary volumes (REV); and (iii) at the bulk model, i.e., the entire model domain.

The overall objective of this research is to contribute to the understanding of the fundamental scientific principles of emulsion flow phenomena and mechanisms, the factors that control them, and the emulsion stability in the porous media. This understanding is important in providing the information of the behaviors of emulsions within a porous medium.

1.5 Scope of Research

In order to materialize the objectives, this research is interested both in the mechanical behavior of the complex system of emulsions during flow, and the stability of the emulsion during flow. The experimental works involved the investigation of emulsion flow behaviors in the micromodel. All experiments are conducted at room conditions of about 27^{o}C and 14.65 psia. Visualization study of microscopic model would use 2-D- etched glass flow models as its porous media. The detail descriptions of these micromodels are presented in Chapter 4.

The oil system of Model Oil of a mixture of 86.5% Dibutyphtalate and 13.5% n-Heptane, and paraffin oil are used for this study. The aqueous phases are distilled water. Surfactant Triton-X100 was added in the paraffin oil emulsion. The emulsion systems are prepared with the dispersed phase contents ranging from 0.5% to 10% v/v. The emulsion flow rates are from 0.01 ml/min (about 1 ml/hr) to 2 ml/min. Flow rate of 2 ml/min would give very high terminal fluid velocity in the micromodel, however the flow test at this high flow rate is needed to see whether pressure drop affected not only by emulsion droplet but also by the hydrodynamic forces.

The wetting conditions generated are water-wet, oil-wet and mixed-wet with reference to the dispersed droplets. Qualitatively, the degree of wettability of the porous media surfaces against the dispersed phase droplet and surrounded by external phase are determined by contact angle measurements.

The results of emulsion flowing through etched glass micromodels can provide visual observation of the mechanisms, the fluid distributions and the fluid flow behaviors in situ of porous media. The emulsions are allowed to flow continuously through the porous media up to several pore volumes. Pressure drop (permeability reductions) across the model and the droplet distributions at outlet of the model are measured as a function of the number of pore volumes of emulsion passed through the micromodel.

However, some limitations of this study are identified as follow.

(a) The results of the micromodel tests were not represent the actual reservoir conditions of high pressure and high temperature. The measured average properties in micromodels, such as permeability and fluid saturations can be valuable in a relative rather in absolute sense.

(b) The studies are more interested in the local pore-level physics of 2-D rather than the topological of fluid flow behavior in 3-D.

(c) The emulsion was injected under a constant flow rate. Therefore, any obstruction of the emulsion flow in the micromodel would cause an increase of pressure drop.

(d) The current design characteristics and techniques of the 2-D glass micromodel fabrication produce large pore and throat sizes as compared to emulsion droplet sizes. So, droplet straining capture mechanisms were hardly observed under the microscope in the experiments.

1.6 Overview of Thesis Contents

This thesis consists of seven chapters, where in Chapter 1, the background, the research problem statements, the objective and scope of research and the importance of research were discussed. Chapter 2 would summarize all aspects of fundamental theory of emulsions, and their flows in porous media and the factors that affect their flow behaviors. The literature review for the emulsion study, particularly for emulsion flow in porous media, is presented in Chapter 3. Research methodology and experimental setups and requirements are given in Chapter 4. Chapter 5 would provide the results and discussion of emulsion characterizations, while in Chapter 6 discussed the results of the experimental works of emulsion displacement flow in micromodels. Finally, Chapter 7 would give the overall summary of the works, the conclusions of the research and the recommendation for future works.