

Effect of Electrolytes on the Formation and Stability of n-Dodecane Nanoemulsions by the Phase Inversion Temperature (PIT) Method

By

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Dedicated to my beloved father

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DECLARATION

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ABSTRACT

This research focuses on the effect of sodium chloride (NaCl) or calcium chloride (CaCl₂) on the formation and stability of n-dodecane/non-ionic surfactant/aqueous nanoemulsions produced by the Phase Inversion Temperature (PIT) method. It is because there are only few works done to investigate the effect of electrolyte on the production of nanoemulsions, especially those produced by the PIT method. Furthermore, in this research, the ability for ageing nanoemulsions to reverse their physical properties to freshly-prepared state has also been investigated..

The nanoemulsions were produced by heating aqueous-continuous emulsions (O/W) to oil-continuous (W/O) emulsions, followed by a quenching process to produce O/W nanoemulsions. Pure milliQ water and concentration from 0.001M to 0.1M NaCl or CaCl₂ were used as continuous phase. The non-ionic surfactants used were polyoxyethylene (4) lauryl ether (Brij30) and sorbitan monooleate (S80). The stability was determined by dynamic light scattering technique by measuring the growth of the droplet size and size distribution (PDI) before the nanoemulsions were phase separated, which was determined by visual observation. The reversibility testing was done by measuring the droplet size and PDI as a function of temperatures for a three-day ageing nanoemulsion system.

Droplet size as small as 65nm was produced from a brine system while there was 77nm in a pure milliQ water system, with PDI lower than 0.2. The PIT temperature was found to be depressed when: (1) oil or surfactant concentration increased; (2) HLB number of surfactant system decreased; and (3) NaCl or CaCl₂ was added. The transitional temperature (ΔT_{trans}), a temperature difference between the temperature for producing O/W and W/O emulsions, has linked with the stability of the nanoemulsions. The largest ΔT_{trans} in a emulsion system with low oil concentration (R=0.2) appeared at 7wt% Brij30 at pure milliQ water system but at 6wt% Brij30 at NaCl system, showing that the surfactant concentration used to produce the most stable nanoemulsions was reduced by the aid of compression effect from NaCl. When the oil concentration increased, more NaCl was needed to produce stable nanoemulsions. Nanoemulsions produced by a mixture of hydrophilic and hydrophobic non-ionic surfactant was extremely unstable, with a big difference in PIT temperature and ΔT_{trans} compared to a pure surfactant system. It was found that NaCl was a better electrolyte than CaCl₂ to produce nanoemulsions with smaller droplet sizes and PDI and higher stability. For the most stable nanoemulsions, 20°C was better than 10°C, to keep the sample from phase separation for more than 30 days. Additionally, the addition of CaCl₂ was found to have no difference in the production of nanoemulsions by adding it either before or after the emulsification process.

It has been found that only system with NaCl appeared to have the ability to revert the droplet size and PDI, from ageing to freshly-prepared nanoemulsions. Furthermore, the reversibility ability was governed by phase inversion process as only system experiencing heating process could be reverted. However, nanoemulsions with high stability were partially reversible, where only droplet size was reversible.

The positive effects (increasing stability, smaller droplet size and PDI, and reversibility ability) from the addition of NaCl could only be achieved at certain electrolyte and surfactant concentrations.

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TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENT.....	ii
ABSTRACT.....	iii
PUBLICATIONS.....	iv
TABLE OF CONTENTS	v
LIST OF FIGURES.....	viii
LIST OF TABLES.....	xiii
1.0 Introduction	1
2.0 Literature Review.....	4
2.1 Nanoemulsions by low energy methods	5
2.1.1 Emulsion Inversion Point (EIP) Method.....	8
2.1.2 Phase Inversion Temperature (PIT) Method.....	9
2.2 Emulsion stability.....	10
2.2.1 Instability in Nanoemulsions	12
2.3 Electrolyte effect	14
2.3.1 The Effect of Electrolytes on Macroemulsions	18
2.3.2 The Effect of Electrolytes on Nanoemulsions	19
2.4 Reversibility	20
3.0 Approach and Methods.....	22
3.1 Materials.....	22
3.2 Investigated system	23
3.3 Methods.....	24
3.3.1 Phase Behaviour.....	24
3.3.2 PIT Temperature Determination.....	25
3.3.3 Formation of Nanoemulsions.....	26

3.3.4	Stability and Reversibility Study	27
3.3.4.1	Study on Different Dilution Agent.....	28
3.3.5	Cryo-Scanning Electron Microscope (cryo-SEM).....	28
4.0	Results and Discussions.....	29
4.1	System consistency	29
4.2	Effect of heating rate	30
4.3	Phase behaviour.....	34
4.4	Effect of quality of the continuous phase.....	38
4.5	Effect of NaCl concentration at fixed oil and surfactant concentrations	40
4.5.1	Phase Inversion Process	40
4.5.2	Formation and Stability of Nanoemulsions	42
4.5.3	Reversibility of Nanoemulsions.....	49
4.6	Effect of NaCl concentration at different surfactant concentrations.....	53
4.6.1	Phase Inversion Process	53
4.6.2	Formation and Stability of Nanoemulsions	56
4.6.3	Reversibility of Nanoemulsions.....	64
4.7	Effect of NaCl concentration at different oil concentrations but fixed surfactant-to-oil ratio	66
4.7.1	Phase Inversion Process.....	67
4.7.2	Formation and Stability of Nanoemulsions	70
4.7.3	Reversibility of Nanoemulsions.....	73
4.8	Effect of sodium chloride in a mixed surfactant system	74
4.8.1	Phase Inversion Process	75
4.8.2	Formation and Stability of Nanoemulsions	79
4.8.3	Reversibility of Nanoemulsions.....	82
4.9	Effect of different electrolyte	82
4.9.1	Phase Inversion Process	82

4.9.2	Formation and Stability of Nanoemulsions	85
4.9.3	Reversibility of Nanoemulsions.....	88
4.10	Different dilution agent (sequence of the addition of electrolyte).....	89
4.11	Effect of storage temperature	91
5.0	Conclusion	97
6.0	Recommendations for Future Research.....	99
	References	100
	Appendix.....	105

LIST OF FIGURES

Figure 2.1: The structures of sodium dodecyl sulphate (SDS) and sorbitan monooleate (Span80).....	4
Figure 2.2: Schematic changes in the phase equilibrium of an emulsion system on raising the temperature. As the temperature increases, the emulsions are changed from O/W over the Winsor I region (a) to W/O over the Winsor II region (b), through the Winsor III region (b), (c), and (d) (Kabalnov, 1998).....	6
Figure 2.3: Schematic change in spontaneous curvature of surfactant layers in the process of phase inversion from O/W to W/O emulsions (Kunieda <i>et al.</i> , 1996)	7
Figure 2.4: Schematic representation of the break-down processes in emulsions (Tadros, 2004).....	11
Figure 2.5: Self-diffusion coefficient of the constituents of Winsor microemulsions as a function of the salt concentration (Bellocq, 1996).....	16
Figure 2.6: The stability of an emulsion system as a function of salinity and temperature, where $\log(\tau_{1/2})$ is the logarithm of macroemulsion lifetime.	16
Figure 2.7: Droplet size and the stability of O/W emulsions versus NaCl concentration in a aqueous dispersion for batch of equal volumes of methyl myristate and a 1.0wt% aqueous dispersion of P4VP/SiO ₂ microgel particles at pH 4 (Binks <i>et al.</i> , 2006). (\square , arithmetic mean diameter; \blacksquare , median diameter)	18
Figure 3.1: Schematic diagram for the setting of PIT determination.	26
Figure 3.2: A typical conductivity curve for an emulsion system experiencing phase inversion process. (R=0.2, 0.01M NaCl, 4wt% Brij30).	26
Figure 4.1: Dynamic conductivity curves for system with R=0.2, 0.01M NaCl, 4wt% Brij30 in the heating and cooling processes.	30
Figure 4.2: Dynamic conductivity value as a function of temperatures for an emulsion system containing 0.01M CaCl ₂ and 6wt% Brij30 in different heating rate. Oil/aqueous=20/80 w/w.....	31
Figure 4.3: Dynamic conductivity value as a function of temperatures for an emulsion system containing 0.01M CaCl ₂ and 6wt% Brij30 with heating rate is 0.005°C/s. Oil/aqueous=20/80 w/w.....	32
Figure 4.4: Dynamic conductivity value as a function of temperatures for systems with and without ethanol (1.2 vol%). Continuous phase is pure milliQ water and with 7wt% Brij30. Oil/aqueous=20/80 w/w.	34
Figure 4.5: Dynamic conductivity behaviour as a function of temperatures for emulsion system with R=0.2, 0.01M NaCl, 6wt% Brij30.	35

Figure 4.6: Optical micrograph (Leica As LMD) of emulsions undergoing a phase inversion, between crossed polarizer and analyser. The system contains 0.01M NaCl, 6wt% Brij30, 18.8wt% n-Dodecane. Temperatures are (a) 14°C, o/w emulsions, (b) 18°C, close to 1st maximum, (c) 22°C, 1st falling, (d) 24°C (polarised), close to 1st minimum, (e) 25°C, close to 2nd maximum, (f) 26°C, 2nd falling, and (g) 30°C, concentrated w/o emulsions. The scale bars indicate 50µm except in (a) is 20µm.37

Figure 4.7: Dynamic conductivity as a function of temperatures in n-dodecane/brine emulsions with different quality of water at 19.2wt% of oil, 4wt% of Brij30 and 0.01M NaCl.....38

Figure 4.8: Dynamic conductivity as a function of temperatures in n-dodecane emulsion system with 19.2wt% of oil, 4wt% of Brij30 and different salt concentrations.41

Figure 4.9: PIT and transitional temperatures as a function of salt concentrations of an emulsion system with 19.2wt% n-dodecane and 4wt% Brij30.....42

Figure 4.10: Initial size distribution (PSD) curve for emulsions with 19.2wt% n-dodecane, 4wt% Brij30 and from 0 to 0.1M NaCl. The measurement was done at 20°C.....44

Figure 4.11: Initial number average droplet diameter and polydispersity index (Pdl) for emulsions with 19.2wt% n-dodecane, 4wt% Brij30 and from 0 to 0.1M NaCl. The measurement was done at 20°C.44

Figure 4.12: Size distribution (PSD) curve for 3-day ageing emulsions with 19.2wt% n-dodecane, 4wt% Brij30 and from 0 to 0.1M NaCl. The measurement was done at 20°C.....46

Figure 4.13: Plot of r_n^3 as a function of storage time (20°C) in aqueous-continuous nanoemulsions system with 19.2wt% n-Dodecane, 4wt% Brij30 and different NaCl concentrations.47

Figure 4.14: Plot of $1/r^2$ as a function of time in aqueous-continuous nanoemulsions with 19.2wt% n-dodecane, 4wt% Brij30 and different NaCl concentrations. The samples were stored and measured at 20°C.48

Figure 4.15: The reversibility testing on PSD in n-dodecane nanoemulsions with (a) No NaCl, (b) 0.03M NaCl and (c) 0.1M NaCl. The systems contain 19.2wt% n-dodecane and 4wt% Brij30. All presented results were measured at 20°C.50

Figure 4.16: The reversibility testing on droplet size (—) and polydispersity indices (PdI) (---) at (a) 0M, (b) 0.03M and (c) 0.1M NaCl nanoemulsions with 19.2wt% n-dodecane and 4wt% Brij30. The storage periods are: freshly prepared (■), 1 day (▲) and 3 days (●). The measured temperature sequence is 20°C→10°C→20°C→30°C→20°C.....51

Figure 4.17: Dynamic conductivity values as a function of temperatures for emulsion systems (R=0.2) with pure milliQ water (top) and 0.001M NaCl (bottom) and with 4-8wt% of Brij30.....54

Figure 4.18: PIT temperature as a function of surfactant concentrations in different sodium chloride concentrations. Oil/aqueous=20/80 w/w.	55
Figure 4.19: Width of transitional zone as a function of surfactant concentrations for system containing different sodium chloride concentrations. Oil/aqueous=20/80 w/w.	56
Figure 4.20: Initial size distribution at 20°C for n-dodecane nanoemulsions with some selected systems. Oil/aqueous=20/80 w/w.	57
Figure 4.21: Initial droplet size and polydispersity index (Pdl) as a function of surfactant concentrations at 20°C for n-dodecane nanoemulsions with different sodium chloride concentrations. Oil/aqueous=20/80 w/w. Solid line: Droplet Diameter; Dashed Line: Pdl.....	58
Figure 4.22: (a) The stability for n-dodecane nanoemulsions containing 4wt% of Brij30 with different sodium chloride concentrations; (b) the most stable nanoemulsions within the investigated systems (Circle: No NaCl, 7wt% of Brij30; Square: 0.001M NaCl, 6wt% of Brij30; Triangle: 0.01M NaCl, 6wt% of Brij30; Diamond: 0.1M NaCl, 6wt% of Brij30). (Solid line: mean droplet diameter; Dashed line: Pdl).....	59
Figure 4.23: Plot of (a) r^3 and (b) $1/r^2$ as a function of storage time in aqueous-continuous nanoemulsions with $R=0.2$ and 4wt% Brij30. Storage and measured temperature was 20°C.	60
Figure 4.24: SEM images: (top) aged nanoemulsions (2 days) with $R=0.2$, 6wt% Brij30, No NaCl, (bottom) aged nanoemulsions (9 days) with $R=0.2$, 7wt% Brij30, No NaCl. Storage temperature is 20°C.	62
Figure 4.25 Dynamic conductivity values as a function of temperature for system with pure milliQ water, $R=0.5$ and fixed surfactant-to-oil ratio (0.3763).	67
Figure 4.26: Dynamic conductivity values as a function of temperatures for systems with (a) pure milliQ water and (b) 0.001M NaCl and with different oil concentrations but fixed surfactant-to-oil ratio ($R_{so}=0.3191$).	68
Figure 4.27: PIT temperature as a function of oil and sodium chloride concentrations with fixed surfactant-to-oil ratio.	69
Figure 4.28: Width of transitional zone for system containing different oil and sodium chloride concentrations with fixed surfactant-to-oil ratio.....	70
Figure 4.29: Initial size distribution at 20°C for n-dodecane nanoemulsions with (a) $R=0.2$ and (b) $R=0.3$ and two different fixed R_{so}	71
Figure 4.30: Initial droplet size and polydispersity index (Pdl) as a function of oil concentrations (R) at 20°C for n-dodecane nanoemulsions with two R_{so} . Solid line: droplet diameter; dashed line: Pdl.	72

Figure 4.31: Conductivity values as a function of temperatures for systems with (a) pure milliQ water and (b) 0.01M NaCl and with different types of surfactant. Oil/aqueous=20/80 w/w.....	77
Figure 4.32: PIT temperature as a function of sodium chloride concentrations. Surfactant concentrations are 6wt% and 7wt% for mixed-surfactant (90/10w/w Brij30/S80) emulsion system and pure-surfactant (Brij30) emulsion system. Oil/aqueous=20/80 w/w.....	78
Figure 4.33: Width of transitional zone for systems containing different sodium chloride concentrations. Surfactant concentrations are 6wt% and 7wt% for mixed-surfactant system (90/10w/w Brij30/S80) and pure-surfactant (Brij30) emulsion system. Oil/aqueous=20/80 w/w.....	78
Figure 4.34: Initial size distribution at 10°C for n-dodecane nanoemulsions with different sodium chloride concentrations and in a mixed surfactant system (90/10w/w Brij30/S80). Surfactant concentrations are 6wt% and 7wt% for pure milliQ water system while only 6wt% for brine systems. Oil/aqueous=20/80 w/w.....	80
Figure 4.35: Initial droplet size and polydispersity index (PDI) as a function of sodium chloride concentrations at 10°C for n-dodecane nanoemulsions in different surfactant systems. The total surfactant concentration is 6wt%. Oil/aqueous=20/80 w/w. (Solid line: droplet diameter; dashed line: PDI).....	81
Figure 4.36: Dynamic conductivity value as a function of temperatures for systems with different calcium chloride concentrations. Surfactant concentration is 6wt% of Brij30. Oil/aqueous=20/80 w/w.....	83
Figure 4.37: PIT temperature as a function of different electrolyte and electrolyte concentrations. Surfactant concentration is 6wt% of Brij30. Oil/aqueous=20/80 w/w.....	84
Figure 4.38: Width of transitional zone as a function of electrolyte concentration for systems containing different electrolyte. Surfactant concentration is 6wt% of Brij30. Oil/aqueous=20/80 w/w.....	84
Figure 4.39: Initial size distribution of n-dodecane nanoemulsions (R=0.2, 6wt%[Brij30]) at 20°C with different calcium chloride concentrations. Oil/aqueous=20/80 w/w.....	85
Figure 4.40: Initial droplet size and polydispersity index (PDI) as a function of electrolyte concentrations at 20°C for n-dodecane nanoemulsions with 6wt% of Brij30. Oil/aqueous=20/80 w/w. (Solid line: droplet size; dashed line: PDI).....	86
Figure 4.41: The stability of n-dodecane nanoemulsions containing 6wt% Brij30 and different calcium chloride concentrations. Oil/aqueous=20/80 w/w. All measurement was done at 20°C. (Solid line: droplet size; dashed line: PDI).....	87
Figure 4.42: Droplet size and Pdl for calcium chloride-continuous nanoemulsions with different dilution agents. Oil/aqueous=20/80 w/w and 6wt% Brij30.....	90

Figure 4.43: The growth of (a) mean droplet diameter; (b) PDI; and (c) $1/r^2$ as a function of time for nanoemulsions (6wt% Brij30 and $R=0.2$) with different electrolyte and electrolyte concentrations. Storage and measuring temperature = 10°C92

Figure 4.44: Size distribution as a function of storage period for n-dodecane nanoemulsions ($R=0.2$, 6wt% Brij30) at 10°C with aqueous 0.01 CaCl_2 as continuous phase. Storage and measuring temperature = 10°C92

Figure 4.45: The change of r^3 as a function of time at 10°C for nanoemulsions with 6wt% Brij30, $R=0.2$ and different electrolyte and electrolyte concentrations.....93

Figure 4.46: Microscope image for ageing nanoemulsions at 10°C with (a) 0.01M CaCl_2 and 6wt% Brij30 ; and with (b) pure miliQ water and 7wt% Brij30. Oil/aqueous=20/80 w/w. Storage period = 5 days.95

LIST OF TABLES

Table 2.1: Categorisation of emulsions.	5
Table 2.2: Applications of surfactants based on their HLB number (Brooks <i>et al.</i> , 1998).....	8
Table 3.1: List of materials.	22
Table 3.2: List of experiments.	24
Table 4.1: Important data extracted from Figure 4.1 to determine PIT temperatures for heating and cooling processes.....	30
Table 4.2: PIT temperature and width of transitional zone for systems with different heating rate or for systems with and without ethanol.	33
Table 4.3: Some important properties in dynamic conductivity behaviour of system with R=0.2, 0.01M NaCl, 6wt% Brij30 and their corresponding temperatures. The third column shows the chosen temperatures to investigate the phase inversion under optical microscopy.....	36
Table 4.4: Some significant characteristics from phase inversion process in emulsions with different water quality as continuous phase. (19.2wt% n-dodecane, 4wt% Brij30 and 0.01M NaCl)	39
Table 4.5: Stability of nanoemulsions with 19.2wt% n-Dodecane, 4wt% Brij30 and with different NaCl concentrations. The measurement was done and the samples were stored at 20°C.....	45
Table 4.6: The regression and the Ostwald Ripening rate of nanoemulsions with 19.2wt% dispersed phase (n-dodecane) and 4wt% Brij30, as a function of sodium chloride concentrations. The measurement was done at 20°C.....	48
Table 4.7: Days taken for phase separation for n-dodecane nanoemulsions (oil/aqueous=20/80 w/w) stored at 20°C with different sodium chloride and surfactant concentrations.	58
Table 4.8: Zeta potential of nanoemulsions with pure milliQ water, 0.01M and 0.1M NaCl and with different surfactant concentrations. Oil/aqueous=20/80 w/w. Measurement temperature is 20°C.....	63
Table 4.9: Reversibility testing for nanoemulsions with oil/aqueous=20/80 w/w after three days storage time. The test was done in a temperature sequence: 20°C→10°C→20°C→30°C→20°C.....	65
Table 4.10: Reversibility testing for the most stable nanoemulsions with oil/aqueous=20/80 w/w after three days storage time. The test was done in a temperature sequence: 20°C→10°C→20°C→30°C→20°C. The thermal equilibrium time is 5minutes and 10 minutes in the heating process.....	66

Table 4.11: Days taken for phase separation for n-dodecane nanoemulsions with different R and two fixed R_{so} . Storage temperature=20°C.....	73
Table 4.12: Reversibility testing for selected systems with R=0.3 and different sodium chloride concentrations but (R_{os} (0.3191)) after three days storage time. The test was done in a temperature sequence: 20°C→10°C→20°C→30°C→20°C.	74
Table 4.13: Days taken for phase separation for n-dodecane nanoemulsions (oil/aqueous=20/80 w/w) stored at 10°C with different sodium chloride concentrations. Surfactant mixing ratio is 90/10 Brij30/S80 (in weight).	82
Table 4.14: Zeta potential for some selected nanoemulsions with sodium chloride and calcium chloride and with different electrolyte concentrations. Oil/aqueous=20/80 w/w and surfactant concentration is 6wt% Brij30. Storage temperature=20°C.	88
Table 4.15: Reversibility testing for the nanoemulsions with oil/aqueous=20/80 w/w and 6wt% Brij30 after three days storage time. The test was done in a temperature sequence: 20°C→10°C→20°C→30°C→20°C. Storage temperature = 20°C.	89
Table 4.16: Zeta potential at 10°C for nanoemulsions (5-day ageing) with sodium chloride and calcium chloride while the electrolyte concentration was 0.01M. Oil/aqueous=20/80 w/w and with 6wt% Brij30.	93
Table 4.17: Time to turn milky, regression and Ostwald ripening rate (ω), of nanoemulsions with 6wt% Brij30 (R=0.2) and with different electrolyte and electrolyte concentrations. Storage and measurement temperature = 10°C.....	96