Deanship of Graduate Studies
Al-Quds University

"Biocompatible Microemulsion: Formulation, Characterization and Indomethacin Solubilization"

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M.Sc. Thesis

Jerusalem-Palestine
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Dedication

I would like to dedicate this thesis to my parents for their diligent encouragement and believing in me all the time; my family; my friends; my Company Siniora.

Finally, this thesis is dedicated to all those who believe in the richness of learning.

Declaration:

I certify that this thesis submitted for the degree of master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed: ……………………

Ahmad "Mohy Al-Diyn" Mahmoud Shakarnah

Date: 13/5/2012

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Ahmad Shakarnah

Abstract:

Surfactants containing sugar components and fatty acids satisfy the quality standards for food application. The food grade sugar esters in this study are the commercial sucrose monolaurate (L1695), and sucrose oleate (O1570), PEG-7 glycerol cocoate (M159) and glycerol monooleate (M300K). The oil phase consists of cyclic oils including peppermint oil, α-ionone and R(+)-limonene oil, linear oil including isopropylmyristate and triglyceride oils including caprylic-capric triglyceride, olive oil, sesame oil and sunflower oil. Some of these microemulsion systems including a co-surfactants; the co-surfactants used are food, cosmetic and pharmaceutical grade that include ethanol, linalool, propionic acid, glycerol and its substitute propylene glycol. In this research we firstly studied the effect of different types and percentages of surfactants on the phase behaviour of the systems water/ mixed surfactant/ oil at different temperatures 25, 37 and 45°C and in order to explore the effect of mixing surfactants on the phase behaviour we studied the system water/mixed surfactant/oil and also we explored the effect of mixing oil on the phase behaviour and the area of the microemulsion region A_T (%).We also explored the effect of adding a cosolvant to the oil phase (ethanol, linalool, propionic acid and glycerol) and propylene glycol to water on the extension of microemulsion region. It was found that mixing surfactants is important to the water solubilization capacity in the microemulsions. Adding a cosolvent to the oil phase or to aqueous phase improves the water solubilization capacity in the microemulsion.

Several elucidated systems showed the presence of U-type microemulsions. A second objective is the use of optimal formulated microemulsion system to solubilise a pharmaceutical active ingredient (indomethacin). It was found that the solubilization capacity of the drug is structural dependent. Maximum drug solubilization was absorbed in the micelle system that decrease as the system passes to water-in -oil microemulsions and continues to decrease as the system passes to the bicontinuous and oil-in-water microemulsions. The extent of indomethacin solubilization is also dependent on the oil type used in the formulation of the microemulsion and on the presence of cosolvent. A third objective was to elucidate the properties of the microemulsion free and loaded with drug. The techniques used were electrical conductivity, density and ultrasonic velocity. Points of structured transitions from water-in-oil to bicontinuous to oil-in-water microemulsions were determined. Electrical conductivity and ultrasonic velocity found the three points depends on the mixed surfactants mixing ratio, and on the oil type, on the presence of cosolvent.

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Abbreviations, Symbols & Terminology:

$A_{T\,(\%)}$: Total one-phase microemulsion area (total monophasic area)

CCT: Caprylic-capric triglyceride oil

Co-S: Cosurfactant

DSC: Differential scanning calorimetry

EMDG: Ethoxylated mono-di-glyceride

EtOH: Ethanol

Gly: Glycerol

HLB: Hydrophilic-lipophilic balance

H_{o}: Spontaneous curvature

IFT: Interfacial tension

IND: Indomethacin

ION: α-Ionone

IPM: Isopropylmyristate oil

L1695: Sucrose monolaurate

LIM: R (+)-limonene oil

LNL: Linalool

M159: PEG-7 glyceryl cocoate

M300K: Glycerol monooleate

ME: Microemulsion

MNT: Peppermint oil

NaCl: Sodium chloride

nm: Nanometer

NMR: Nuclear magnetic resonance

O/W: Oil-in-water

O: Oil

O1570: Sucrose oleate

-OH: Hydroxyl group

OO: Olive oil

PAIs: Pharmaceutical active ingredien

PG: Propylene glycol

PIT: Phase inversion temperature

ProA: Propionic acid

RI: Refractive index

S: Surfactant

SB: Soybean oil

SE: Sucrose esters

SF: Sunflower oil

SO: Sesame oil

U.S.V: Ultrasonic velocity

W/O: Water-in-oil

W/W: Weight per weight

W: Water

Winsor I: Oil-in-water microemulsion coexists with excess oil

Winsor II: Water-in-oil microemulsion coexists with excess water

Winsor III: Bicontinuous middle phase microemulsion

Winsor IV: Microemulsion which is not in equilibrium with oil or water

γ: Interfacial tension

μm: micrometer

μS: microsiemens

ρ: Density

σ: Electrical conductivity

Chapter One

Introduction

Microemulsions are generally defined as isotropic, transparent, thermodynamically stable mixtures of at least three components: a water, oil and a surfactant; usually in combination with a cosurfactant, typically a short chain alcohol [Aboofazeli and Lawrence1994]. Microemulsions are infinite stability, where, the surfactant and the cosurfactant are principally located at the interfacial region separating the two immiscible liquids to stabilize their mutual dispersion [Bourrel and Schechter 1988]. An interesting characteristic of microemulsion is that when even a small amount of a mixture of surfactant and cosurfactant is added to biphasic water-oil system, a thermodynamically stable, mixture spontaneously forms [Ho et al., 1996].

When the components being used are safe for human consumption, microemulsions become important in fields such as foods, cosmetics and pharmaceuticals [Kunieda and Shinoda1982].

Microemulsions systems consist from oil, water, and an amphiphile (surfactant molecules) that brings down the water/oil interfacial tension (IFT) to a very low value. Originally, it was thought that there exists a negative IFT which imparts stability to microemulsion (Prince, 1977). It is accepted that the IFT between oil and water is reduced to a very low value by the presence of an amphiphile, but there are many instances though, where the amphiphiles do not bring the IFT down to the required very low value and another substances need to be added to obtain the required IFT for the formation of a stable microemulsion such as short chain alcohols. This means that in most cases the microemulsions are four component systems, these are water, oil, surfactant, and a short chain substance called a cosurfactant**.**

ME systems can be one of three types depending on the relative ratios of the constituting components: oil-in-water (o/w ME) systems comprise water as the continuous medium; water-in-oil (w/o ME), where oil is the continuous medium and bicontinuous microemulsion (Garti, Fanun, Aserin, et al, 2001), (Figure 1). The simplest representation of the (ME) microstructure is with reference to the droplet model in which an interfacial film comprising an amphiphile (surfactant/cosurfactant) molecules surrounds the dispersed droplets.

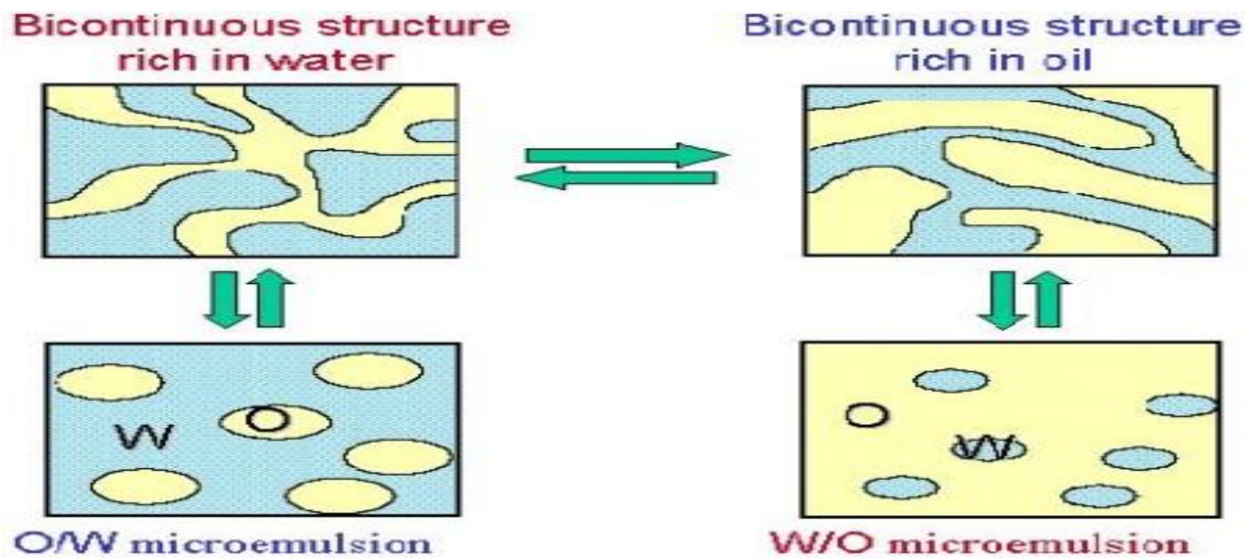


Figure 1.1: O/W, W/O and Bicontinuous Microemulsions

Sucrose esters surfactants have unique properties (biodegradable, nontoxic and capable of forming temperature-insensitive microemulsions), which make them suitable for a variety of food-based and pharmaceutical application. Sucrose contains in its structure eight-hydroxyl groups that can be esterified. If the esterification degree increases on the hydroxyl groups by fatty acids, the hydrophobicity will increase. Partial esterification will produce sucrose ester with amphiphilic properties. Mono, di and tri ester of sucrose usually used as emulsifier in foods, cosmetic, detergent, etc. (Garti, Clement, Laser, et al; 1999).

In our research, we will try to benefit from the unique properties of microemulsions that include the high mutual solubilization of water and oil to solubilize and control release of active pharmaceutical ingredients (indomethacin) that are normally highly sensitive to thermal and oxidative damages.

What makes microemulsions fundamental in the pharmaceutical field, apart from their high stability and ease of preparation, is their ability to increase considerably the bioavailability of sparingly water-soluble drugs (Malmsten, 1999),(Müller, Benita, Böhm, 1998).

Indeed, a large amount of a lipophilic drug can be dissolved in the microemulsion oil droplets, so that drug solubility in the whole system is considerably enhanced. Drug diffusion from the oil droplets to the living tissues can take place by crossing the surrounding aqueous medium which essentially acts as a barrier to drug transport owing to the very low drug solubility in water. In this case, microemulsion is used to retard drug delivery (Thiele, Rothen-Rutishauser, Wunderli-Allenspach, et al, 1997) and the oil-phase works as a reservoir, but it may also happen that microemulsion speeds up the drug uptake by the living tissues as in the case of oil droplets phagocytosis led by particular biological structures (Thiele, Rothen-Rutishauser, Wunderli-Allenspach, et al, 1999).

Moreover, drug-loaded microemulsions are fundamental for delivery systems devoted to topical and transdermal administration (Lapasin, Grassi, Coceani, 2001), (Gasco, Gallarate, Pattarino, 1991),(Osborne, Ward, 1998), for solid nanoparticles preparation (Viswanathan, Thomas, Pandit, et al,1999),(Song, Labhasetwar, Cui, et al, 1998) and for loading process of a lipophilic drug into hydrophilic carriers(Chiellini, Coceani, Bresciani,et al, 2000), technologies that have a wide employment in the treatment of many diseases and that could have a considerable impact also in the gene delivery field (Roy, Chu, McGrath, 1999).

Indomethacin is a member of the non-steroidal anti-inflammatory drugs (NSAIDs). It is used to reduce pain, swelling involved in osteoarthritis, rheumatoid arthritis, bursitis, tendinitis, gout, ankylosing spondylitis, and headaches *(*Sweetman, Martindale, 2005) The drug is described as poorly soluble and highly permeable (Class II) drug *(*Lobenberg, Amidon, 2000) Because water-insoluble drugs often show low absorption and weak bioavailability, improvement in dissolution rate and/or solubility are important for development of drug preparations (Hirasawa, Ishise, Miyata, et al, 2003).

The successful formulation of poorly-water soluble drugs is one of the major problems in pharmaceutical manufacturing. Indomethacin may show low and erratic oral bioavailability due to poor dissolution of the drug in the fluids of the gastrointestinal tract. Additionally, this undesirable physical property may increase the incidence of irritating side effects on the gastrointestinal tract because of a prolonged contact time with the mucosa (Alsaidan, Alsughayer, Eshra, 1998), (Hart, Boardman, 2008).

However oral administration of indomethacin produces serious gastrointestinal (GI) adverse effects upon chronic administration (Badawi, El-Laithy, El-Qidra, et al, 2008).Therefore an alternative route is required to eliminate these oral adverse effects. Transdermal route has been known to eliminate oral GI adverse effects and maintains the plasma drug level for longer period of time and suitable for long treatment of chronic diseases like arthritis (Baboota, Shakeel, Kohli, 2006). Therefore the aim of the microemulsion is to solve the anti-inflammatory effects, skin irritation and skin permeation mechanism of indomethacin from transdermally applied true microemulsion in order to eliminate its GI adverse effects.

Chapter two

Literature review

Formation and phase behaviour of microemulsion:

2.1-Types of microemulsion

The formation of oil-or water-swollen microemulsion depends on the packing ratio, property of surfactant, oil phase, temperature, chain length, type, and nature of cosurfactant.

2.1.1-Packing ratio

The hydrophilic lipophilic balance (HLB) of surfactant determines the type of microemulsion through its influence on molecular packing and film curvature.

2.1.2-Properties of surfactant, oil phase, and temperature

Type of surfactant also determines type of microemulsion formed. Surfactant contains hydrophilic head group, and lipophilic tail group. The oil component influences curvature by its ability to penetrate and hence swells the tail group region of the surfactant monolayer. Short-chain oils such as alkanes penetrate the lipophilic group region largely than long-chain alkanes, swelling of this region to a great extent results in an increased negative curvature. Temperature is extremely important in determining the effective head group size of non-ionic surfactants. Winsor studied the effect of temperature on the type of microemulsion formed. For the giving amount of components in ternary system with non-ionic surfactant, oil, and water, at relatively low temperature, type I system (an O/W with excess Oil) is formed. At intermediate temperature, type III system (microemulsion (Bicontinues) with excess of both oil and water) is present. At relatively higher temperature, type II (W/O microemulsion with excess water) system exists (Winsor, 1954, 1968).

2.1.3-Chain length, type, and nature of cosurfactant

Alcohols are widely used as cosurfactant in microemulsion. Addition of shorter chain cosurfactant (e.g., ethyl alcohol) gives positive curvature effect, as alcohol swells the head region more than the tail region favouring the formation of O/W type of system, while longer chain cosurfactant (e.g., cetyl alcohol) favors W/O type by alcohol swelling more in tail region than head region.

2.1.4-Alcohol concentration

Increasing the concentration of low molecular weight alcohol as a cosurfactant leads to the phase transition from W/O to bicontinuous and ultimately to O/W type microemulsion. Exactly opposite phase transition is noticed to case of high molecular weight alcohol.

2.1.5-Surfactant hydrophobic chain length

The increase in length of hydrophobic chain of the surfactant shows the change of O/Wmicroemulsion to W/O via bicontinuous phase.

Phase behavior

(Yaghmur, Aserin and Garti, 2002) investigated the phase phase behavior of systems based on Tweens (ethoxylated sorbitan esters), was compared with non-food-grade systems based on $C_{18:1}E_{10}$ (Brij 96v). Short-chain alcohol (ethanol in food-grade systems) together with polyols (glycerol and propylene glycol) when added to a three component system (oil–surfactant–water) Alcohols and polyols destabilize the liquid crystalline phase and extend the isotropic region to higher surfactant concentrations. The total monophasic area, A_T, at R(+)-limonene/ethanol of 1/1 (w/w) and aqueous phase of water/PG of 1/1 (w/w), was 73 and 64% of the total area of the phase diagram for Brij 96v and Tween 60, respectively. The transition from a W/O microemulsion into an O/W microemulsion happens gradually, and continuously without any phase separation. The total monophasic area depends also on the type of the oil, on the composition of the polar and apolar phases, and on the nature of the polyol. The results are discussed surfactant oil and surfactant cosolvent compatibility and the participation of the polyol at the interface. The difference in temperature sensitivity of PG-based and Gly-based microemulsions.

(Ceglie, DAS and Lindman, 2004) investigated the effect of oil on the microscopic structure having 5–16 carbon atoms and aromatic hydrocarbons with different substituents were used as oil. Oil penetration is dependent on chain length of the oil and surfactant.

(Fanun and Salah Al-Diyn, 2006) investigated the phase behavior of the system water/sucrose laurate/ethoxylated mono-di-glycerides/caprylic-capric triglyceride as function of temperature and oil content, they found that at low temperatures the mixed nonionic surfactants are soluble in water and two phases are observed, at high temperatures the mixed surfactants are soluble in oil and another two phases are observed and at low oil contents a one phase region is observed, this region extends for the range of temperatures from 7°C to 95 °C.

(Fanun and Salah Al-Diyn, 2006) investigated the phase behavior of the systems water/sucrose laurate/ethoxylated mono-di-glyceride/oil as function of temperature and the weight ratio of EMDG in the mixed surfactants. The oils were R(+)-limonene, isopropylmyristate, and caprylic-capric triglyceride, they found that, the phase inversion temperature (PIT) decreases and the efficiency of the mixed surfactants increase as the weight ratio of the EMDG in the mixed surfactants increases. R(+)-limonene gave lower phase inversion temperatures and higher efficiencies compared to isopropylmyristate, and caprylic-capric triglyceride. The solubilization capacity of the system water/sucrose laurate/oil increased upon the addition of ethoxylated mono-di- glyceride which stabilize the surfactant layer and increase the interfacial area.

(Fanun, 2008) investigated the pseudoternary phase behavior of the water/sucrose laurate/ethoxylated mono

the water+sodium chloride/sucrose laurate/ ethoxylated mono-di-glyceride/ peppermint oil/isopropylmyristate microemulsions at mixing ratios of both surfactants and oil equal-di-glyceride/R(+)-limonene system for different surfactants mixing ratios (w/w) at 25 °C, it was found that for surfactants mixing ratio (w/w) equals unity, the area of the one phase microemulsion region reaches its maximum.

(Fanun, 2008) studied the water + propylene glycol/sucrose esters/benzaldehyde + ethanol systems to determine the one phase microemulsion regions at 27°C, 37°C and 45°C, It was found that minor changes in the surfactant structure suffice to provoke a considerable change in the total monophasic area of the system and a one phase microemulsion region extending from the oil-rich region to the water-rich corner was observed in systems based on sucrose laurate and sucrose myristate at 27 °C.

(Fanun, 2009) studied unity and studied the properties of water + propylene glycol/sugar surfactant/peppermint oil + ethanol using electrical conductivity, it was found in all studies the same result; the electrical conductivity increases as the water volume fraction increases.

(Fanun, 2009) studied the systems studied were water/sucrose laurate/ethoxylated mono-di-glyceride/isopropylmyristate/peppermint oil. The solubilization capacity of water in the oils is dependent on the surfactants and oils mixing ratios (w/w). The transport properties (electrical conductivity and dynamic viscosity) were studied as function of water volume fraction. It was found that increasing the weight ratio of peppermint oil in the mixed oils improved the water solubilization capacity in the microemulsions. The molar ratios of mixed surfactants play an important role in determining the maximum water solubilization, this study reveals that the electrical conductivities increase with the increase water volume fraction.

(Fanun, 2010) investigated a combination of electrical conductivity, dynamic viscosity, dynamic light scattering and small angle X-ray scattering methods was used to study the properties of the water + propylene glycol/mixed nonionic surfactants/ peppermint oil + ethanol U-type microemulsions which can be diluted with any amount of water. The surfactants were sucrose laurate and ethoxylated mono-di-glyceride. The mixing ratios (w/w) of the mixed surfactants and peppermint oil/ethanol equal unity and that of water/propylene glycol equals to two. The electrical conductivity and periodicity of the microemulsions increases with the aqueous phase content while the dynamic viscosity decreases. The variations in the values of the correlation length with the aqueous phase contents indicate the onset of structural transitions. Structural transitions from the water-in-oil to a bicontinuous phase then inversion to oil-in-water occurs in the system.

Volumetric and Diffusion properties

(Fanun, Shakarnah, et al, 2011) studied sol-gel encaged $[(C_8H_{17})_3NCH_3][RhCl_4]$ catalyses the double bond isomerization in the flavoring agent 4-allylanisole in aqueous microemulsions. In order to provide optimal composition of the reaction medium water/n-propanol/surfactant/4-allylanisole micellar systems were formulated. The surfactants were sodium dodecyl sulfate, cetyltrimethyl ammonium bromide, sucrose monolaurate, and polyethylene glycol (7) glyceryl cocoate. The ratio (w/w) of n-propanol/surfactant equals 2/1. The micellar densities increase with the increase in the water volume fraction. Ultrasonic velocities increase with the increase in water volume fraction up to 0.8 then decrease. Ultrasonic velocities increase with temperature for water volume fractions below 0.8 and decrease for water volume fractions above 0.8. Quantitative analysis of the volumetric parameters enabled the characterization of structural transition along the micellar phase. The particle hydrodynamic diameter of the oil-in-water systems was determined as function of temperature. The particle hydrodynamic diameter of nonionic surfactants it increases.

Drug Solubilization

(Nandi, Bari, and Joshi, 2003) studied effect of alkanols and cyclodextrins on the phase behavior of an isopropyl myristate microemulsion system and to examine the solubility of model drugs. Triangular phase diagrams were developed for the microemulsion systems using the water titration method, and the solubility values of progesterone and indomethacin were determined using a conventional shake flask method. The water assimilation capacities were determined to evaluate the effective microemulsion formation in different systems. The alkanols showed higher microemulsion formation rates at higher concentrations. A correlation between the carbon numbers of the alkanol and water assimilation capacity in the microemulsions studied was observed; isobutanol and isopentanol produced the best results. The addition of cyclodextrins showed no effect or had a negative effect on the microemulsion formation based on the type of cyclodextrin used. In conclusion, microemulsion systems improve the solubility of progesterone and indomethacin. But the two types of cyclodextrins studied affected isopropyl myristate based microemulsion systems negatively and did not improve the solubilization of 2 model drugs.

(Taha, 2009) studied indomethacin (IND) self-nanoemulsifying drug delivery formulation (SNEDDF) have been prepared to enhance its dissolution which in turn could provide a better chance for IND oral absorption. IND SNEDDF have been prepared using different concentrations of castor oil as a solvent for IND, Cremophor RH 40 (Cr-40) as surfactant and

Capmul MCM-C8 (Ca-8) as co-surfactant. Droplets size and turbidity of IND SNEDDFs were measured. Ternary phase diagram was constructed to identify the self nanoemulsifying region after evaluation of IND SNEDDFs by the visual observation. The present study revealed that the SNEDDFs increased IND dissolution rate and has the potential to enhance its bioavailability without interaction or incompatibility between the ingredients.

Chapter three

Objectives

1. Formulation of microemulsion systems using different components that include biologically compatible oil phase (cyclic oils such as peppermint, R(+)-limonene and α-ionone oils, linear oil such as isopropylmyristate and triglyceride oils such as caprylic capric triglyceride oil, sunflower oil, olive oil and sesame oil), aqueous phase, single or mixed nonionic surfactants (food and pharmaceutical grade) with or without addition of co-surfactant or cosolvent at different temperature. This objective is accomplished by the investigation of multicomponent system phase behaviour.
2. Evaluation of the maximum water solubilization in the formulated microemulsion systems by evaluating the area of the one-phase microemulsion region (A_T).
3. Evaluation of the solubilization capacity of the pharmaceutical active ingredients (indomethacin) and to establish the relationship between the microstructure of the formulated microemulsions and the quantity of solubilized drug.
4. Exploring the microstructures of the formulated microemulsions by density, ultra sonic velocity (USV), and electrical conductivity (σ). These techniques will be used to study how changes in the relative amounts of the surfactant or oil, the presence of co-surfactant**,** cosolvent and the addition of water influence the microemulsion microstructure within the one-phase microemulsion region.

Chapter Four

Materials and methods

4.1 Materials

4.1.1 Surfactants (surface active agents)

4.1.1.1 Sucrose monolaurate (L1695)

The sucrose esters (SE) that are produced by a reaction between sucrose and fatty acids are surfactants with potential pharmaceutical applications because of their low toxicity, biocompatibility, and excellent biodegradability; also it has important applications in a variety of industrial processes including their use as biodegradable surfactants in the food and cosmetic industry. Currently sucrose esters are synthesized non-enzymatically at high temperatures, resulting in low specificity and side reactions with the formation of colored derivatives. The sucrose monolaurate (L1695) was obtained from Mitsubishi- Kasei Food Corp., (Mie, Japan). The purity of combined Lauric acid equals 95%, the ester compositions are 80% monoester and 20% di, tri and polyester, and Hydrophilic Lipophilic Balance equals 16. (See chemical structure in Figure 4.1).

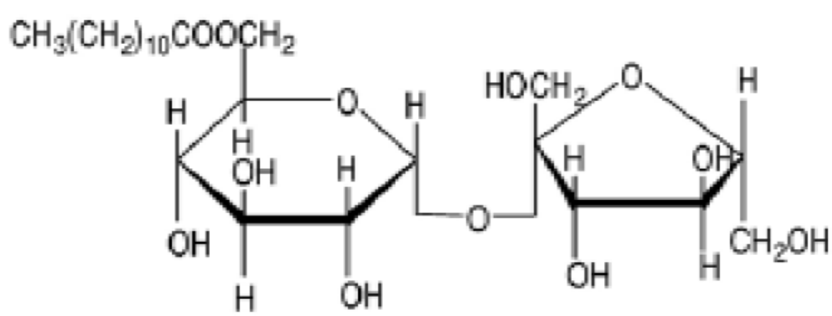


Figure 4.1: Chemical structure of sucrose monolaurate (L1695).

4.1.1.2 Sucrose oleate (O1570)

The sucrose oleate (O1570) was obtained from mitsubishi- kasei food corp., (Mie, Japan). (See chemical structure in Figure 4.2)

Table 4.1: The composition of sucrose ester used.

Surfactants	MF	Trade name	M.W	HLB	% monoester	di-moopolyester
Sucrose monolaurate	$C_{24}H_{44}O_{12}$	L1695	524.60	16	80	20
Sucrose oleate	$C_{30}H_{54}O_{12}$	O1570	607	15	70	30

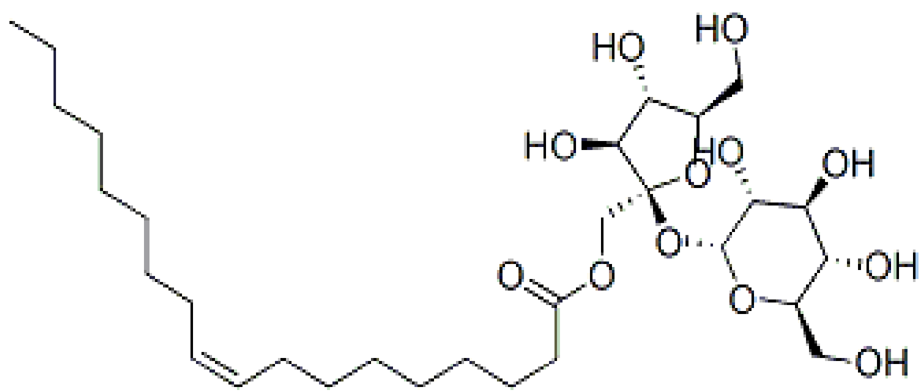


Figure 4.2: The chemical structure sucrose oleate.

4.1.1.3 Ethoxylated mono-di-glyceride (EMDG)

The ethoxylated mono-diglyceride is a mixture of stearate and palmitate partial esters of glycerin ethoxylated with approximately 20 mole of ethylene oxide per mole of alpha-monoglyceride reaction mixture and HLB equals 13.5. It is a pale yellow oily liquid or semi gel that has a faint characteristic odor and mild taste. This nonionic surfactant was obtained from BASF Corporation (Gurnee, Illinois, USA). (See chemical structure in Figure 4.3)

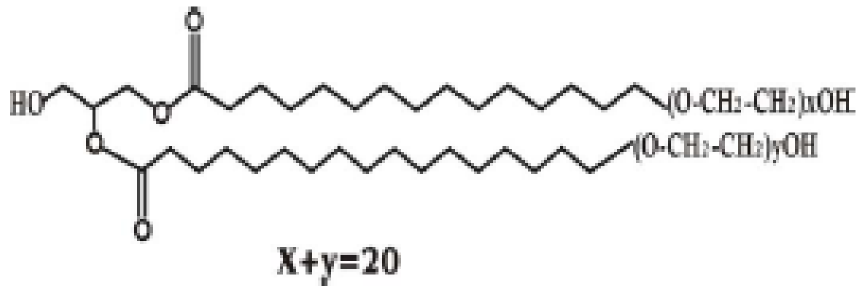


Figure 4.3: The chemical structure of ethoxylated mono-diglyceride (EMDG).

4.1.1.4 MAZOL 159 (M159)

MAZOL 159 is an excellent emollient developed for use in quality cosmetic formulations. Because of its molecular structure it can be used as a solubilizer for either aqueous or oil systems. The HLB Value of MAZOL 159 is approximately 13. The PEG-7glycerol cocoate (M159) was obtained from BASF Corporation (Gurnee, Illinois, USA).

4.1.1.5 MAZOL 300 K (M300K)

Glycerol monooleate (M300K) blend of glycerol monooleate and propylene glycol. Used in flavoring agents, baked goods, baking mix, beverage bases and processed meats. (See chemical structure in Figure 4.4). The glycerol monooleate (M300K) was obtained from obtained from BASF corporation (Gurnee, Illinois, USA).

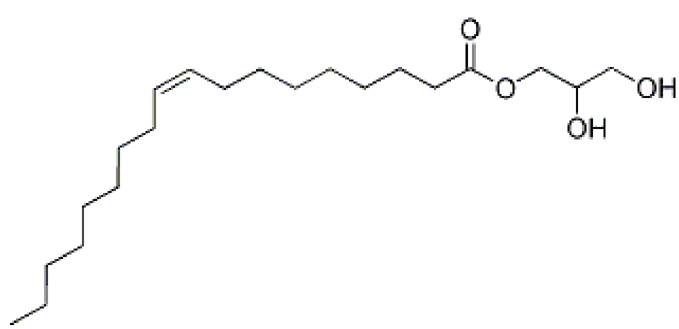


Figure 4.4: The chemical structure glycerol monooleate (M300K).

4.1.2 Cosurfactants or cosolvents

4.1.2.1 Propylene glycol (PG)

The co-surfactant used is 1,2-propandiol (propylene glycol, PG) (99.5%), was purchased from BDH (Poole, UK).

4.1.2.2 Ethanol (EtoH)

Ethanol was purchased from Sigma Chemicals Co. (St. Louis, USA).

4.1.2.3 Linalool (LNL)

Linalool (98%) is naturally occurring terpene alcohol chemical found in many flowers and spice plants with many commercial applications, the majority of which are based on its pleasant scent (floral, with a touch of spiciness). It has other names such as β-linalool, linalyl alcohol, linaloyl oxide, p-linalool, allo-ocimenol and 2,6-dimethyl-2,7-octadien-6-ol. Molecular formula $C_{10}H_{18}O$. It was purchased from Sigma Chemicals Co. (St. Louis, USA). (See chemical structure in Figure 4.5)

Figure 4.5: The chemical structure of linalool.

4.1.2.4 Propionic acid (ProA)

Is a naturally occurring carboxylic acid with chemical formula CH_3CH_2COOH. It is a clear liquid with a pungent odor. The anion $CH_3CH_2COO^-$ as well as the salts and esters of propanoic acid are known as propanoates (or propionates). It is used as inhibits the growth of mold and some bacteria at the levels between 0.1 and 1% by weight. Was purchased from sigma chemicals co. (St. Louis, USA). At (98%) purity, (See chemical structure in Figure 4.6).

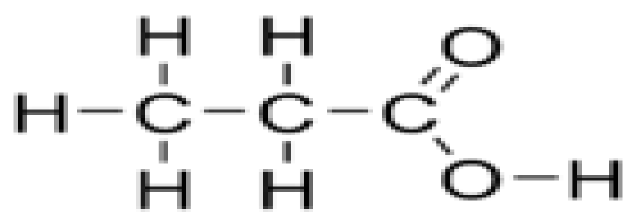


Figure 4.6: The chemical structure of propionic acid

4.1.2.5 Glycerol (Gly)

A Simple polyol compound, it is a colourless, odourless, viscous liquid that is widely used in pharmaceutical formulations. Glycerol has three hydrophilic hydroxyl groups that are responsible for its solubility in water and its hygroscopic nature. The glycerol backbone is central to all lipids known as triglycerides. Glycerol is sweet tasting and of low toxicity.

Like ethylene glycol and propylene glycol, glycerol dissolved in water disrupts the hydrogen bonding between water molecules such that the mixture cannot form a stable crystal structure unless the temperature is significantly lowered and increase of viscosity.

Glycerol was purchased from Sigma Chemicals Co. (St. Louis, USA) at (99%) purity.

4.1.3 Oil

4.1.3.1 Cyclic oils:

• **Peppermint oil (MNT)**, (98%) Purity was purchased from sigma chemicals co. (St. Louis, USA). (See chemical structure of menthol, the major compound of peppermint oil in Figure 4.7).

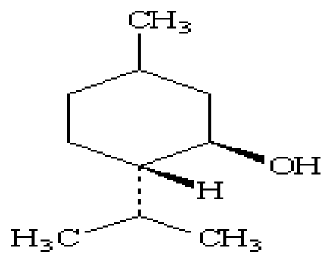


Figure 4.7: The chemical structure of menthol, the major compound of peppermint oil.

• **R (+)-limonene (LIM)**, (98%) was purchased from sigma chemicals Co. (St. Louis, USA). (See chemical structure in Figure 4.8).

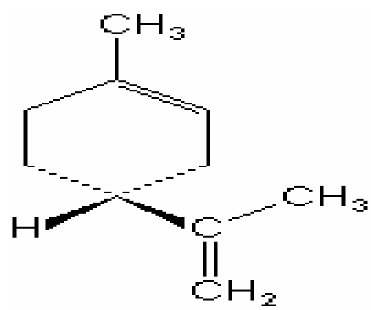


Figure 4.8: The chemical structure of R (+)-limonene.

• **α-ionone (ION)** (98%) was purchased from sigma chemicals Co. (St. Louis, USA). (See chemical structure in Figure 4.9).

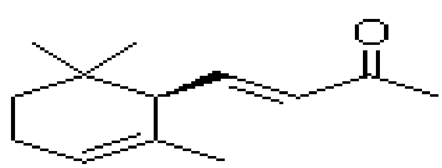


Figure 4.9: The chemical structure of α-ionone.

4.1.3.2 Linear oils:

Isopropylmyristate (IPM), tetradecanoic acid, 1-methyethyl ester (99%) was purchased from sigma chemicals Co. (St. Louis, USA). (See chemical structure in Figure 4.10).

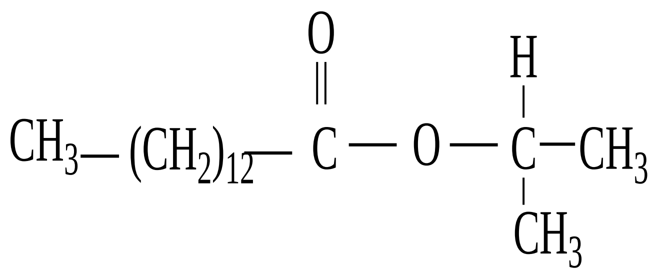


Figure 4.10: The chemical structure of isopropylmyristate oil.

4.1.3.3 Triglyceride oils: olive oil, sesame oil, sunflower oil, soybean oil and caprylic-capric triglyceride oil (CCT). (See chemical structure in Figure 4.11).

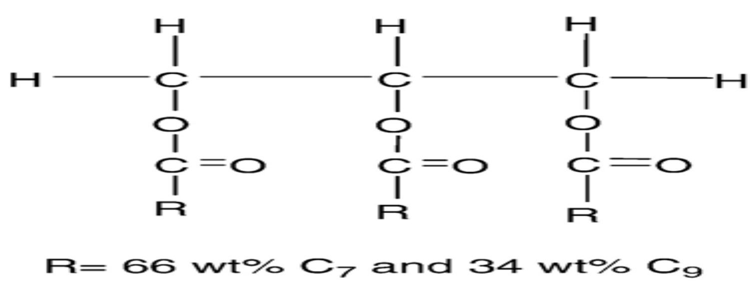


Figure 4.11: The chemical structure of caprylic-capric triglyceride oil

Table 4.2: The composition of triglyceride oils used in this research.

Fatty acids	Olive oil	Sesame oil	Sunflower oil	Soybean oil
Oleic (18:1)	**78 %**	**40.4-44.9%**	**14 - 40%,**	**23%**
Linoleic (18:2)	**7%**	**37.7-43.4%**	**48 - 74%.**	**51%**
Linolenic (18:3)	**1%**	**1%**	**-----------**	**7%**
Stearic (18:0)	**2%**	**4.8-6.1%**	**1 - 7%,**	**4%**
Palmitic (16:0)	**10%**	**9.1-9.8%**	**4 - 9%**	**10%**
Others	**2%**	**1%**	**1-2%**	**5%**

4.1.4Aqueous phase (water)

Aqueous solutions were prepared using deionized water supplied by a Milli-Q water purification system (Millipore system, Al-quds university) $\sigma < 3\ \mu S$.

4.1.5 Pharmaceutical active ingredient (PAI)

Indomethacin (IND) is a non-steroidal anti-inflammatory drug commonly used to reduce fever, pain, stiffness, and swelling. It works by inhibiting the production of prostaglandins, molecules known to cause these symptoms. It is marketed under many trade names; including Indocin, Indocid, Indochron E-R, and Indocin SR. Solubility in water equals 50µg/ml at 25°C (See chemical structure in Figure 4.12).

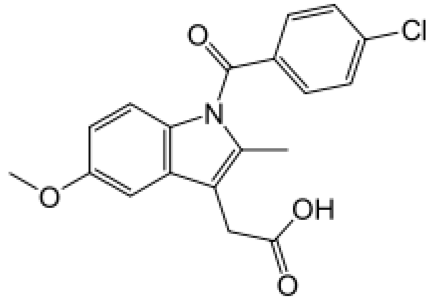


Figure 4.12: The chemical structure indomethacin **($C_{19}H_{16}ClNO_4$)**

Table 4.3 A summary of all material used in this research

Oil phase	**Surfactants**	**Co-surfactant**	**Aqueous phase**
Peppermint (MNT) R (+)-limonene (LIM) α-ionone (ION) Isopropylmyristate (IPM) Caprylic-capric triglyceride (CCT) Olive oil (OO) Sunflower oil (SF) Soybean oil (SO) Sesame oil (SO)	Sucrose monolaurate (L1695) Sucrose oleate (O1570) Ethoxylated mono-di-glyceride (EMDG) PEG-7glycerol cocoate (M159) Glycerol monooleate (M300K)	Prop ionic acid (ProA) Linalool (LNL) Propylene glycol(PG) Ethanol (EtoH) Glycerol (Gly)	MQ water

4.2 Methods

4.2.1 Construction of phase diagrams

The phase behaviour of the systems consisting of water (with or without co-surfactant), oil (or mixed oils), surfactant (or mixed surfactants) may be described on a phase tetrahedron whose apexes respectively represent the pure components.

1g of a mixture consisting of oil (or mixed oils), surfactant (or mixed surfactants) at different weight ratios were prepared in culture tubes sealed and stirred at high temperature (45°C) by vortex until clear solution was obtained.

Titration of these samples with M.Q water which was added dropwise until its solubilization limit was reached. Vigorous stirring followed all of the aqueous phase additions on a vortex mixer. The time for equilibration between each addition was typically, from a few minutes up to 24 h.

Phase transitions were detected visually by the appearance of cloudiness or sharply a separated phase.

All phase diagrams were investigated at three temperatures (25, 37 and 45°C).

The total monophasic area A_T (%) was calculated using the program AutoCAD 2007 software after drawing the phase diagrams using OriginPro 8.1 software.

Table 4.4: The materials used in the construction of phase diagrams of (single surfactants – single oil).

Aqueous phase	Single Surfactant	Oil phase
W	L1695	OO
W	L1695	SB
W	L1695	SO
W	L1695	SF
W+PG	O1570	MNT
W+PG	O1570	LIM
W+PG	O1570	ION
W+PG	O1570	IPM
W+PG	O1570	CCT
W+PG	O1570	OO
W+PG	O1570	SB
W+PG	O1570	SO
W+PG	O1570	SF
W	M159	MNT
W	M159	LIM
W	M159	ION
W	M159	IPM
W	M159	CCT
W	M159	OO
W	M159	SB

W	M159	SO
W	M159	SF
W	M300K	MNT
W	M300K	LIM
W	M300K	ION
W	M300K	IPM
W	M300K	CCT
W	M300K	OO
W	M300K	SB
W	M300K	SO
W	M300K	SF

Table 4.5: The materials used in the construction of phase diagrams of (mixed surfactants – single oil).

Aqueous phase	Mixed Surfactant	Oil phase
W	L1695+EMDG	ION
W	L1695+M159	MNT
W	L1695+M159	LIM
W	L1695+M159	ION
W	L1695+M159	IPM
W	L1695+M159	CCT
W	L1695+M159	OO
W	L1695+M159	SB
W	L1695+M159	SO

W	L1695+M159	SF
W	L1695+M300K	MNT
W	L1695+M300K	LIM
W	L1695+M300K	ION
W	L1695+M300K	IPM
W	L1695+M300K	CCT
W	L1695+M300K	OO
W	L1695+M300K	SB
W	L1695+M300K	SO
W	L1695+M300K	SF
W+PG	O1570+M300K	MNT
W+PG	O1570+M300K	LIM
W+PG	O1570+M300K	ION
W+PG	O1570+M300K	IPM
W+PG	O1570+M300K	CCT
W+PG	O1570+M300K	OO
W+PG	O1570+M300K	SB
W+PG	O1570+M300K	SO
W+PG	O1570+M300K	SF

Table 4.6: The materials used in the construction of phase diagrams of (mixed surfactants – mixed oils).

Aqueous phase	Mixed Surfactant	Mixed Oil phase
W	L1695 + M159	IPM + MNT
W	L1695 + M159	IPM+ LIM
W	L1695 + M159	IPM + ION
W	L1695 + M159	CCT + MNT
W	L1695 + M159	CCT + LIM
W	L1695 + M159	CCT +ION
W	L1695 + M300K	IPM + MNT
W	L1695 + M300K	IPM+ LIM
W	L1695 + M300K	IPM + ION
W	L1695 + M300K	CCT + MNT
W	L1695 + M300K	CCT + LIM
W	L1695 + M300K	CCT +ION

Table 4.7: The materials used in the construction of phase diagrams of (mixed surfactants – oil and cosurfactant mixture).

Aqueous phase	Mixed Surfactant	Cosurfactant	Oil phase
W	L1695 + M159	EtoH	IPM
W	L1695 + M159	LNL	IPM
W	L1695 + M159	ProA	IPM
W	L1695 + M159	Gly	IPM
W	L1695 + M159	EtoH	CCT

W	L1695 + M159	LNL	CCT
W	L1695 + M159	ProA	CCT
W	L1695 + M159	Gly	CCT
W	O1570 + M300K	EtoH	IPM
W	O1570 + M300K	LNL	IPM
W	O1570 + M300K	ProA	IPM
W	O1570 + M300K	Gly	IPM
W	O1570 + M300K	EtoH	CCT
W	O1570 + M300K	LNL	CCT
W	O1570 + M300K	ProA	CCT
W	O1570 + M300K	Gly	CCT

4.2.2 Determination of water solubilization capacity

The water solubilization capacity of different amphiphilic systems should be compared at optimal conditions (Garti, Clement, Fanun, et al, 2000). have employed as a solubilization parameter the area of the one-phase microemulsion region A_T (100) that is area limited by the microemulsification failure boundaries. In this research we used the one phase microemulsion region to compare the water solubilization capacity in the studied systems. The relative error in determining the A_T (%) was estimated to be ±1% for all of the systems studied. The following Figure presents a schematic phase diagram where we indicated the one phase region, the microemulsification failure and the multiple phase regions.

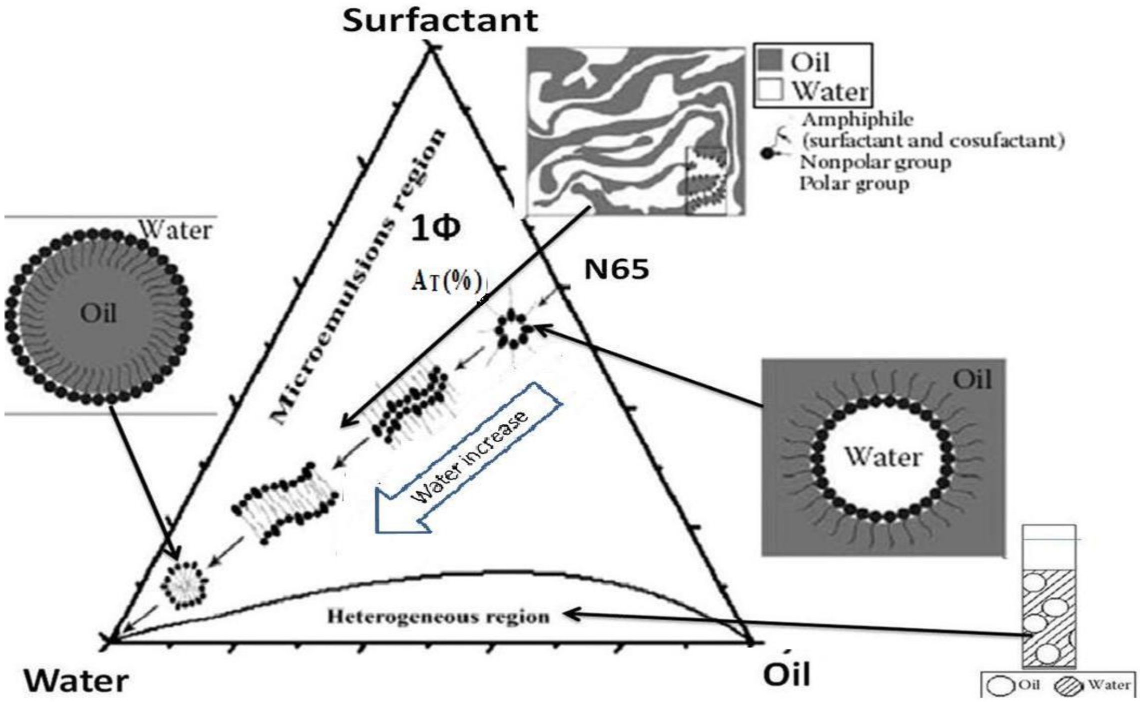


Figure 4.13: Schematic presentation of the structural transitions along the N65 dilution line.

4.2.3 Determination of drugs solubilization capacity

Solubilization of indomethacin has been studied in different microemulsion systems, 3 g of microemulsion was prepared in a test tube and then a small amount of indomethacin (about 10 mg in each step) was added and dissolution was performed by mixing through a vortex in water bath at 45°C for 120 min and then stored at 25°C in water bath. Samples which remained transparent for at least 5 days were loaded step-wise with additional IND to its maximum solubilization. The appearance of turbidity, or a precipitate, indicates that the microemulsions were drug saturated (or supersaturated). No further drug loading in such samples was done. The dissolved amount of IND was estimated by calculating the accumulate weight of IND which was added before the appearance of turbidity, or a precipitate, after they hold in water bath at 25 °C for at least 5 days.

Table 4.8: Table convention the system used for determination of indomethacin solubilization capacity along N65dulition line dilution line where the weight ratio of mixed surfactant / single oil or mix oil equal 65/35.

Aqueous phase	Co-Surfactant	Mixed Surfactant	Oil phase
W		L1695 + M159	MNT
W		L1695 + M159	LIM
W		L1695 + M159	ION
W		L1695 + M159	IPM
W		L1695 + M159	CCT
W		L1695 + M159	IPM + ION
W		L1695 + M159	CCT + MNT
W		L1695 + M159	CCT + LIM
W		L1695 + M159	IPM + MNT
W		L1695 + M159	IPM + LIM
W		L1695 + M159	IPM + ION
W		L1695 + M159	IPM + ION
W	PG	L1695 + M159	IPM
W	PG	L1695 + M159	CCT

Table 4.9: The system used for determination of the indomethacin solubilization capacity where the sample weight was 3 g.

Aqueous phase	Co-Surfactant	Mixed Surfactant
W		
W	PG	
	PG	
W		L1695/M159 (1/1)
W	PG	L1695/M159 (1/1)

Table 4.10: The system used for determination of indomethacin solubilization capacity where the sample weight was 1 g.

Oil phase
MNT
LIM
IPM
CCT
IPM/MNT (1/1)
IPM/LIM (1/1)
CCT/MNT (1/1)
CCT/LIM (1/1)

4.2.4 Electrical conductivity measurements

Conductivity measurements were performed at temperatures + 0.3°C on samples the compositions of which lie along the one phase channel, using conductivity meter, a model CDH222, conductivity meter using carbon rod with long life using separated probe is convenient for remote measurement. The range of application is between 2 mS/cm to 20 mS/cm with an accuracy of 3%, and the temperature range is from 0 to 120 °C. The electrode was dipped in the microemulsion sample until equilibrium was reached and reading becomes stable at 1 min. The conductivity meter has been calibrated during manufacture and was calibrated using standard KCl solutions at the beginning of every month during the Characterization.

4.2.5Density and sound velocity analyzer (DSA 5000)

The aqueous phase density is determined using an oscillating U-tube density meter at different temperature.

For each sample, the oscillation period of both the density and the velocity of sound measuring cells are measured. All further calculations are based on these two measurements.

1-The density is calculated from the quotient of the period of oscillations of the U-tube and the reference oscillator:

$$\text{density} = KA \times Q^2 \times f_1 - KB + f_2 \quad \text{……………………………………… equation (1)}$$

KA, KB .... Apparatus constants

Q .... Quotient of the period of oscillation of the U-tube divided by the period of oscillation of the reference oscillator

f_1, f_2 .... Correction terms for temperature, viscosity and nonlinearity

2-The sound velocity is calculated from the period of oscillation of the sound velocity measuring cell using this equation:

$$v = \frac{\text{original length} \times (1 + 1.6E\text{-}5 \times \Delta\text{temp})}{\frac{P_S}{\text{divisor}} - TAU \times f_3}$$ ………………………………… Equation (2)

original length	Path length of the sound velocity cell (factory default = 5000µm)
Δtemp	Temperature deviation to 20°C
P_S	Oscillation period of the sound velocity measurement
divisor	512
TAU	Apparatus constant for sound velocity
f_3	Correction term for temperature

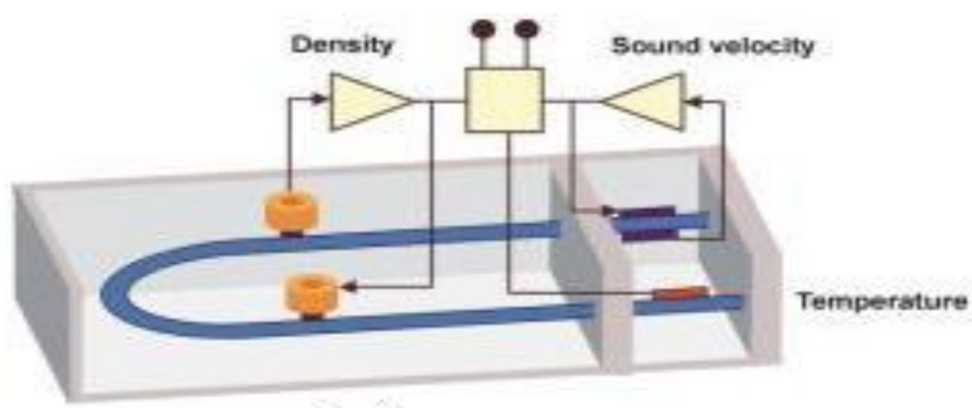


Figure 4.14: Schematic drawing of the mechanism density and sound velocity analyzer instrument at the colloid research laboratory at Al-Quds university- east Jerusalem.

Table 4.11: The system used for determination of density and sound velocity.

Aqueous phase	Mixed surfactant	Oil phase
W	L1695 + M159	LIM
W	L1695 + M159	IPM
W	L1695 + M159	IPM+MNT

Chapter five

Results

5.1 Formulation

5.1.1 Phase Behavior

For a good description of the microemulsion systems it is necessary to determine the phase diagram that describes the experimental conditions in which it is possible to combine the components in order to obtain transparent, one-phase and low-viscous systems.

A number of factors influence the water solubilization in mixed nonionic surfactants/oil mixtures. Among these factors the type of surfactants, surfactants mixing ratio, the presence of additives such as alcohols or electrolytes, temperature (Ogino, Abe, 1992).

The roles of alcohol in microemulsions are to delay the occurrence of liquid crystalline phases, to increase the fluidity of the interfacial layer separating oil and water, to decrease the interfacial tension between the microemulsion phase and excess oil and water and to increase the disorder in these interfacial layers as well as their dynamic character. The miscibility of water, oil, surfactant or mixed surfactants and cosurfactant is a composition dependent variable (Kunieda, Nakano, Pes, Ma, 1995),(Kunieda, Nakano, Akimura, 1995) and (Kunieda, Yamagata, 1993).

These oils influence the surfactant layer curvature in aggregates or self-organized structures when solubilized. Other authors (Fanun, 2007), (Fanun, Salah Al-Diyn, 2006),(Szekeres, Acosta, Sabatini, 2006) and (Mehta, Bala, 2000) studied cyclic hydrocarbons effect on microemulsions formation. The placement of the solubilized oil in the surfactant aggregates highly affects the change in surfactant layer curvature**.** If oil tends to penetrate in the surfactant palisade layer and locates near the interface of the water lipophilic surfactant moiety (unieda, Ozawa, Huang, 1998), the curvature would be less positive or negative. The curvature being defined as positive when the surfactant film is convex toward water.

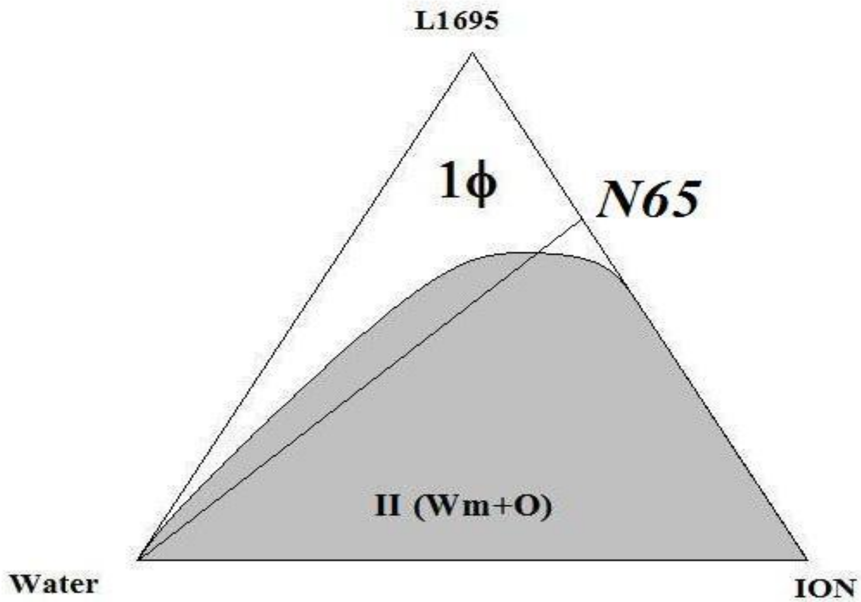
On the other hand, if oil is solubilized deep inside the aggregates and tends to form an oil pool (swelling), the opposite change in surfactant layer curvature is often induced (Kunieda, Umizu, Aramaki, 2000). It is known that the penetration tendency of amphiphilic or polar oils and cyclic hydrocarbons is large. Cyclic hydrocarbons tend to penetrate in the surfactant layer and widen the effective cross-sectional area per surfactant. As a result, the surfactant layer curvature becomes less positive or negative. On the other hand, the surfactant layer curvature tends to be more positive upon addition of the oils that do not penetrate in the surfactant layer.

However, high surfactant levels are often not acceptable for economic or performance reasons. For example, high surfactant levels in consumer product formulations may leave unacceptable residues on substrates. In chemical reaction media, high surfactant levels may constitute contaminants that need to be removed, resulting in unacceptable process costs.

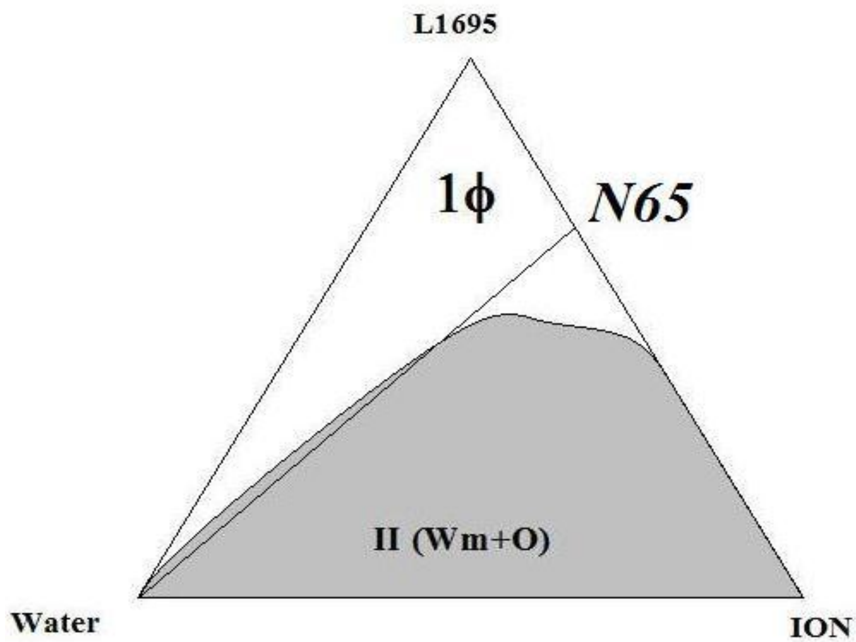
Ternary phase behavior

Sucrose monolaurate and single oil

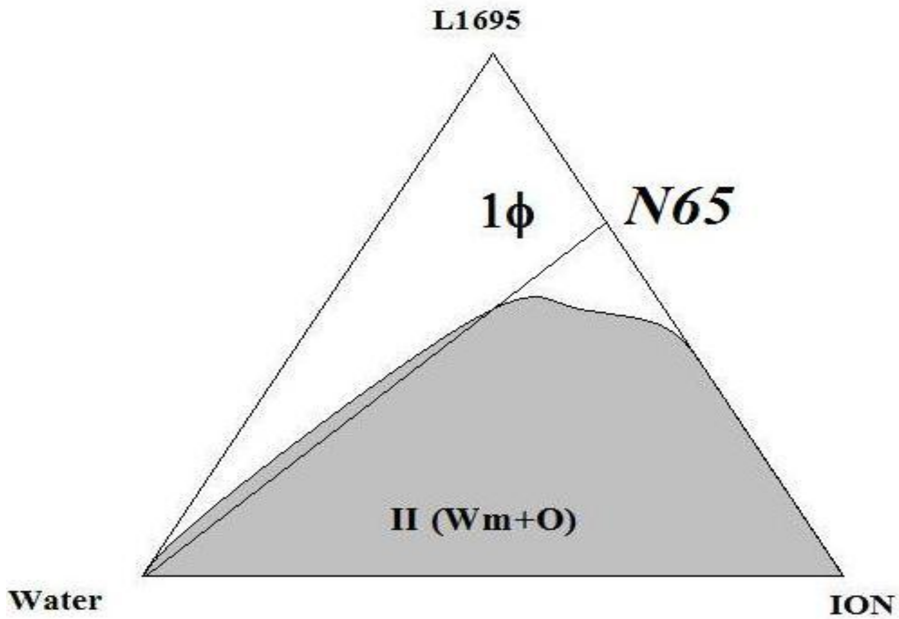
Figure 5.1 presents the phase diagrams of the system water/sucrose monolaurate/α-ionone at three temperatures (A) 25, (B) 37, (C) 45°C. At Figure 5.1(A) the single phase appears for surfactant contents above 60 wt% from the first addition of water. For surfactant contents below 60 wt% the system extend multiple phase regions, but in Figure 5.1(B) and 5.1(C) the single phase appears for surfactant contents above 45 wt% from the first addition of water.



(A)



(B)



(C)

Figure 5.1: Phase diagrams of the system: water/ sucrose monolaurate (L1695) / α-ionone (ION) at three temperatures (A) 25, (B) 37, (C) 45°C. [The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O)]. N65 is the dilution line where the weight ratio of mixed surfactant / single oil or mixed oils equals 65/35.

Figure 5.2 presents the phase diagram of the system water/sucrose monolaurate/soybean oil at 25°C. The single phase appears for surfactant contents above 80 wt% from the first addition of water. For surfactant contents below 80 wt% the system extend multiple phase regions.

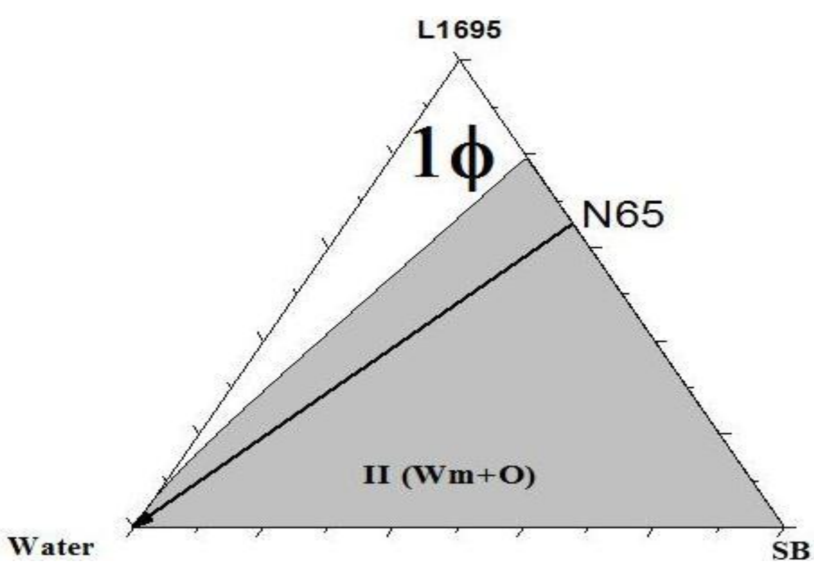


Figure 5.2: Phase diagram of the system: water/ sucrose monolaurate (L1695) / soya beans oil (SB) at 25°C.

Figure 5.3 presents the phase diagram of the system water/sucrose monolaurate/sunflower oil at 25°C. The single phase appears for surfactant contents above 85 wt% from the first addition of water. For surfactant contents below 85 wt% the system extend multiple phase regions.

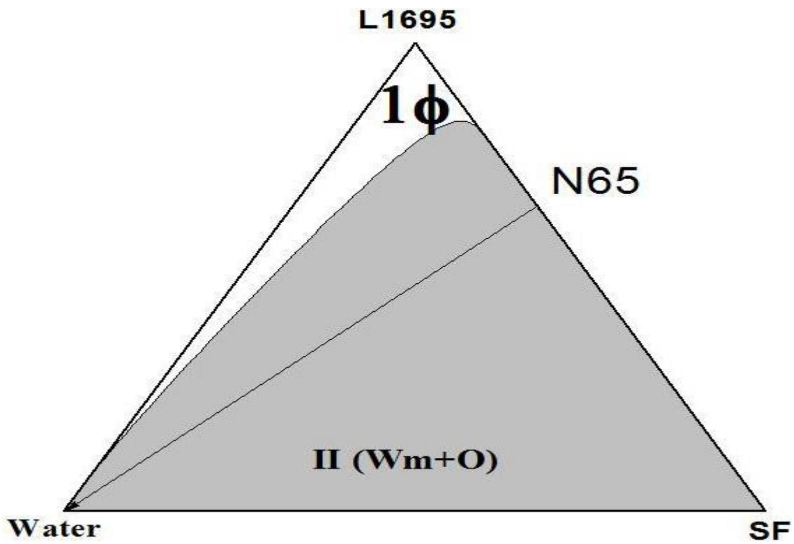


Figure 5.3: Phase diagram of the system: water/ sucrose monolaurate (L1695) / sunflower (SF) at 25°C.

Figure 5.4 presents the phase diagram of the system water/sucrose monolaurate/olive oil at 25°C. The single phase appears for surfactant contents above 85 wt% from the first addition of water. For surfactant contents below 85 wt% the system extend multiple phase regions.

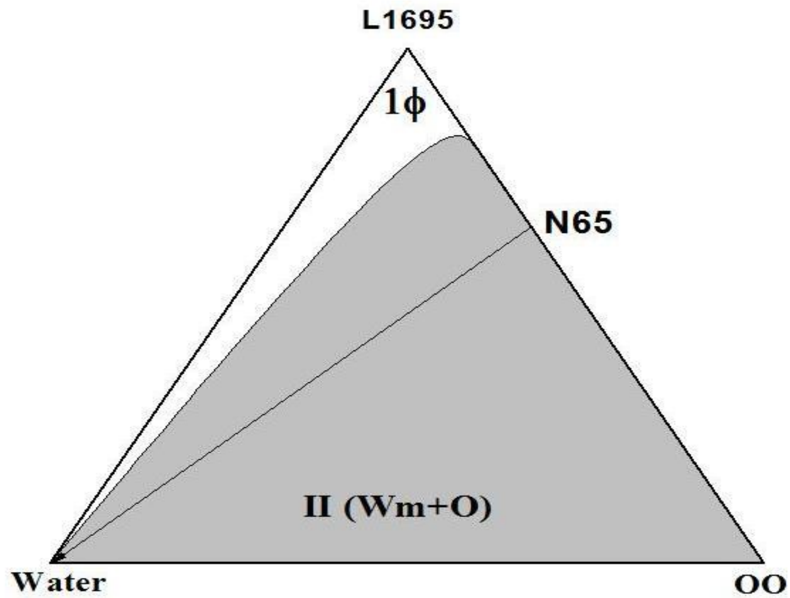


Figure 5.4: Phase diagram of the system: water/ sucrose monolaurate (L1695) / olive oil (OO) at 25°C.

Figure 5.5 presents the phase diagram of the system water/sucrose monolaurate/sesame oil at 25˚C. The single phase appears for surfactant contents above 85 wt% from the first addition of water. For surfactant contents below 85 wt% the system extend multiple phase regions.

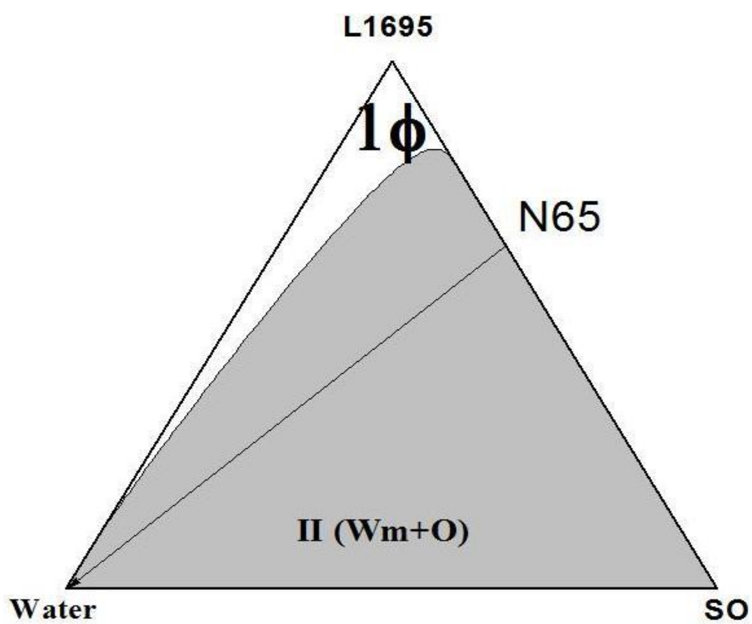


Figure 5.5: Phase diagram of the system: water/ sucrose monolaurate (L1695) /sesame oil (SO) at 25°C.

Table 5.1 The total monophasic area A_T (%) for the system W/L1695/single oil at different oil type and different temperatures.

	A_T (%)		
Oil	**25°C**	**37°C**	**45°C**
ION	24	33	33
SB	17	18	19
SF	8	8	8
OO	11	10	10
SO	8	8	8

The results presented in Table 5.1 we observe that, for microemulsion systems based on sucrose laurate (L1695) only α-ionone oil has the higher total monophasic area values compared to other oils studied. This refers to the cyclic structure of α-ionone oil which tends to penetrate in the surfactant layer and widen the effective cross- sectional area per surfactant.

Triglyceride oil has low total monophasic area because of their high molecular volume and so the ability to penetrate the interfacial film is very low and does not assist to obtain the optimum curvature of surfactants.

Sucrose oleate and single oil

Figure 5.6 presents the phase diagram of the system water+PG/sucrose oleate/ peppermint oil at 25°C. The one phase microemulsion region extend to approximately 35 wt% water and surfactant approximately 47 wt% along the dilution line N65.For water above 35 wt% the System extends multiple phase regions.

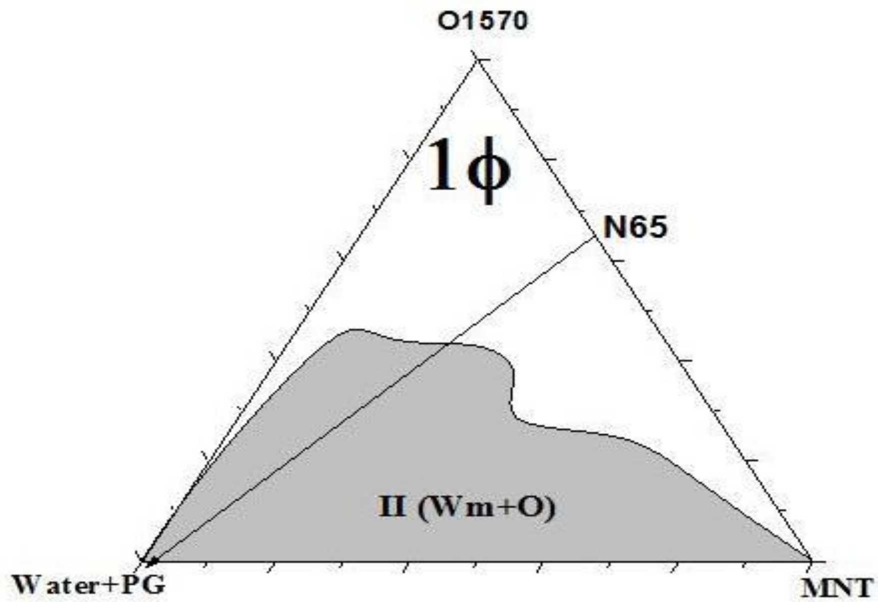


Figure 5.6: Phase diagram of the system: water+PG (2/1) /sucrose oleate (O1570)/ peppermint (MNT) at 25°C. [The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O)]. N65dulition line dilution line where the weight ratio of mixed surfactant / single oil or mix oil equal 65/35, the mixing ratio (w/w) of W/PG equals 2/1.

Figure 5.7 presents the phase diagram of the system water+PG/sucrose oleate/R(+)-limonene oil at 25°C. The one phase microemulsion region extend to approximately 35 wt% water and surfactant approximately 45 wt% along the dilution line N65.For water above 35 wt% the system extends multiple phase regions.

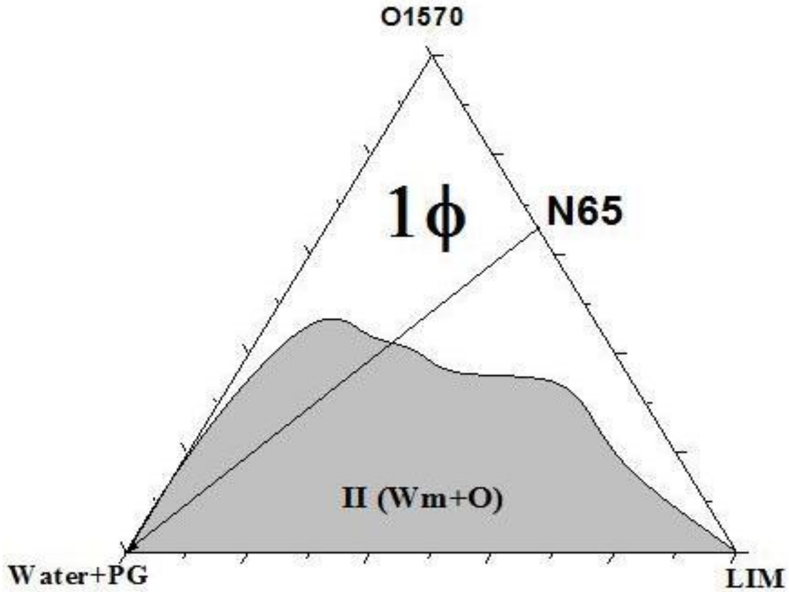


Figure 5.7: Phase diagram of the system: water+PG /sucrose oleate (O1570)/R(+)-limonene oil (LIM) at 25°C.

Figure 5.8 presents the phase diagram of the system water+PG/sucrose oleate/ α-ionone oil at 25°C. The one phase microemulsion region extend to approximately 35 wt% water and surfactant approximately 42 wt% along the dilution line N65.For water above 35 wt% the System extends multiple phase regions.

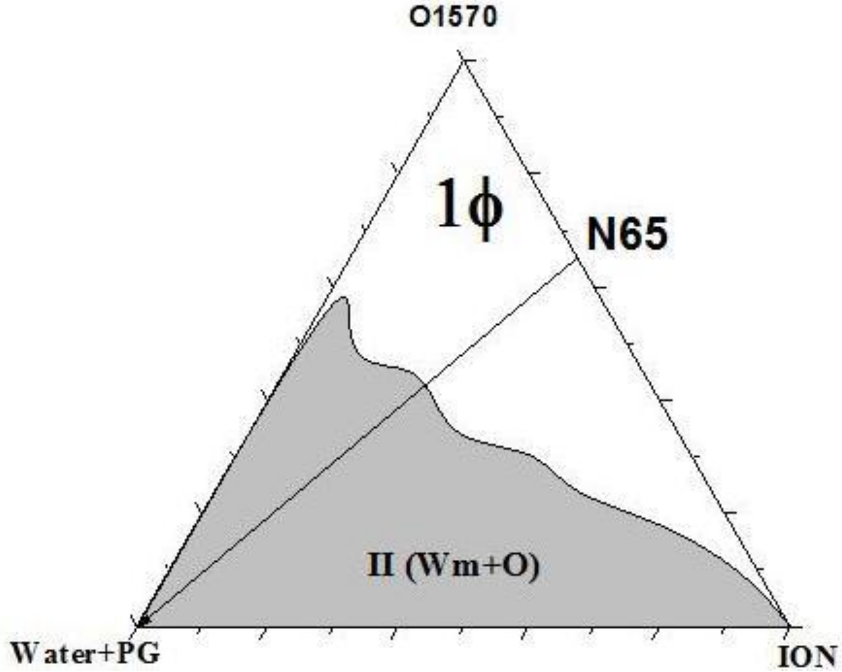


Figure 5.8: Phase diagram of the system: water+PG /sucrose oleate (O1570)/ α-ionone oil (ION) at 25°C.

Figure 5.9 presents the phase diagram of the system water+PG/sucrose oleate/ α-ionone oil at 25°C. The one phase microemulsion region extend to approximately 20 wt% water and surfactant approximately 55 wt% along the dilution line N65.For water above 20 wt% the System extends multiple phase regions.

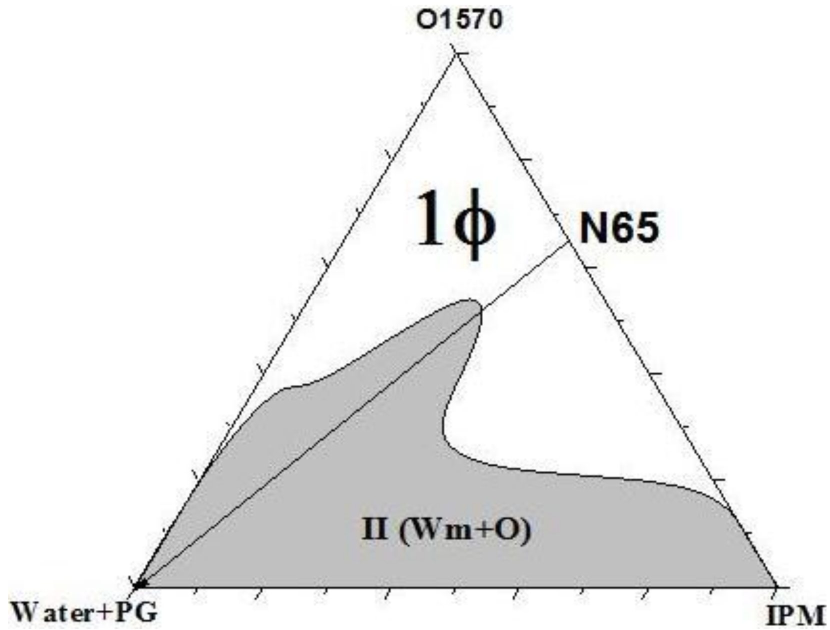


Figure 5.9: Phase diagram of the system: water+PG /sucrose oleate (O1570)/ isopropylmyristate oil (IPM) at 25°C.

Figure 5.10 presents the phase diagram of the system water+PG/sucrose oleate/caprylic-capric triglyceride oil at 25°C. The one phase microemulsion region extend to approximately 35 wt% water and surfactant approximately 45 wt% along the dilution line N65.For water above 35 wt% the System extends multiple phase regions.

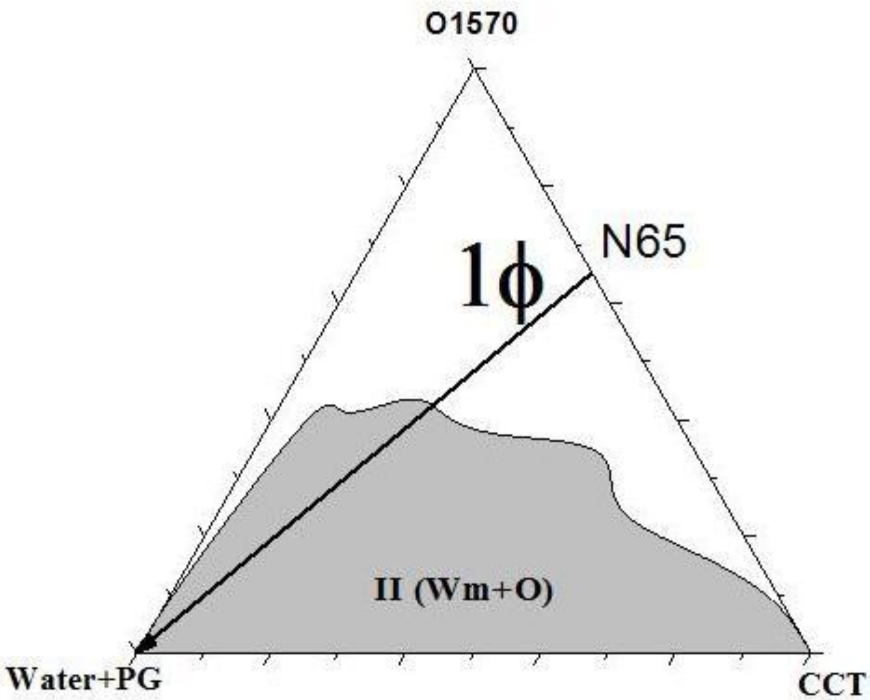


Figure 5.10: Phase diagram of the system: water+PG /sucrose oleate (O1570)/ caprylic-capric triglyceride oil (CCT) at 25°C.

Figure 5.11 presents the phase diagram of the system water+PG/sucrose oleate/ olive oil at 25°C. The one phase microemulsion region extend to approximately 18 wt% water and surfactant approximately 63 wt% along the dilution line N65.For water above 18 wt% the System extends multiple phase regions.

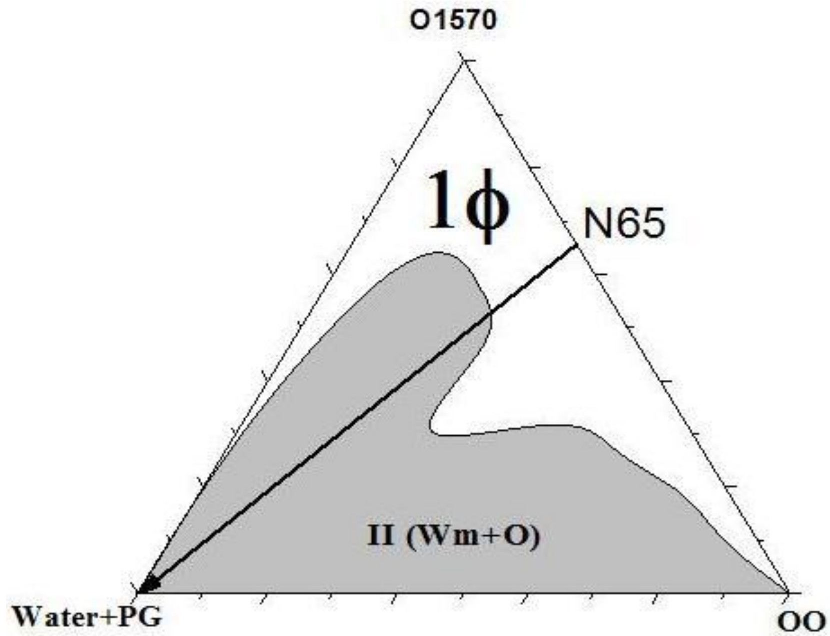


Figure 5.11: Phase diagram of the system: water+PG /sucrose oleate (O1570)/ olive oil (OO) at 25°C.

Figure 5.12 presents the phase diagram of the system water+PG/sucrose oleate/sesame oil at 25˚C. The one phase microemulsion region extend to approximately 15 wt% water and surfactant approximately 65 wt% along the dilution line N65.For water above 15 wt% the System extends multiple phase regions.

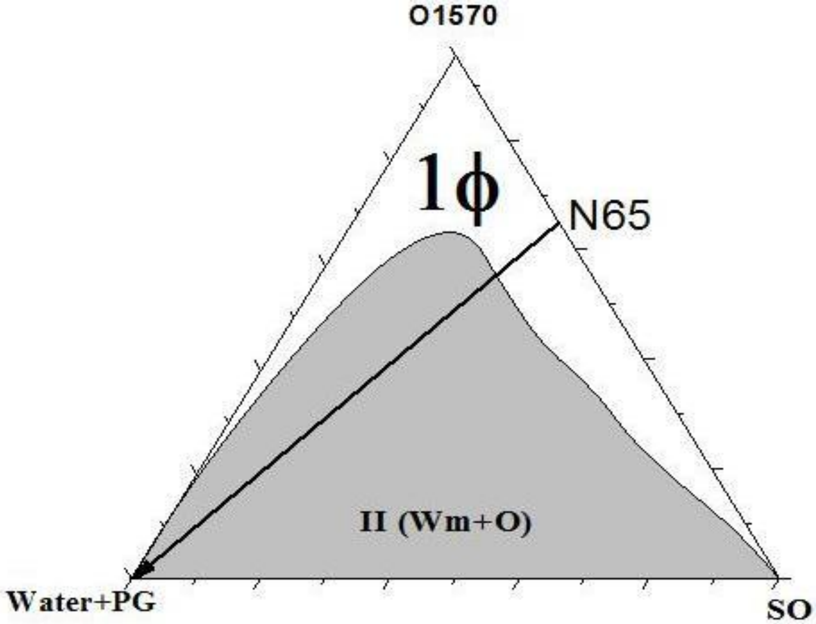


Figure 5.12: Phase diagram of the system: water+PG /sucrose oleate (O1570)/ sesame oil (SO) at 25°C.

Table 5.2: The total monophasic area A_T (%) for the system W+PG/O1570/single oil at different oil type and different temperatures.

	A_T (%)		
Oil	**25°C**	**37°C**	**45°C**
MNT	47	47	47
LIM	43	46	46
ION	44	45	46
IPM	47	47	47
CCT	45	45	45
OO	38	40	35
SO	28	28	30

From the results printed in the Table 5.2 we observe that the systems containing cyclic oils (MNT, LIM and ION) and linear oil (IPM), there is a difference in the behavior of their oils and triglycerides, and this is explained in terms of oil lipophilicity and penetration in the surfactants palisade layer. Solubilization and placement of polar oils in aggregates or self-organized structures influences the surfactant layer curvature and the structure of the self-assembled systems. If the oils have a tendency to penetrate in the surfactant palisade layer and locate near the interface of the water lipophilic surfactant moiety, the curvature would be less positive or negative (Kunieda, et al, 2001).

For microemulsion systems based on triglyceride oil, we observed that the total monophasic area A_T (%) in the system was less than other oils used in this study; cyclic and linear oils. This is due to that the two oils (OO and SO) are triglyceride with high molecular volume and so the ability to penetrate the interfacial film is low when compared with cyclic oils which are non triglycerides oils. Formation of microemulsion depends on the oil structure and oil penetration which is affected by molecular volume, triglycerides have bulky shape and high molecular volume which increases the difficulty to penetrate the interfacial film to assist the optimum curvature.

Phase diagrams present of the systems W/ single surfactant/ oil and W+PG/ O1570/ oil, the variation of the total monophasic region for oil at different temperature when change surfactant type the variation depend on surfactant chain length and HLB.

The observed temperature independence of the O1570 systems can be a consequence of the enhance solubility of the hydroxylated nonionic surfactant in the mixture of propylene glycol and water.

Ethoxylated mono-di-glyceride and single oil

Figure 5.13 presents the phase diagram of the system water/ethoxylated mono-di-glyceride / α-ionone oil at 25°C. The single phase appears for surfactant contents above 48 wt% from the first addition of water. For surfactant contents below 48 wt% the system extend multiple phase regions.

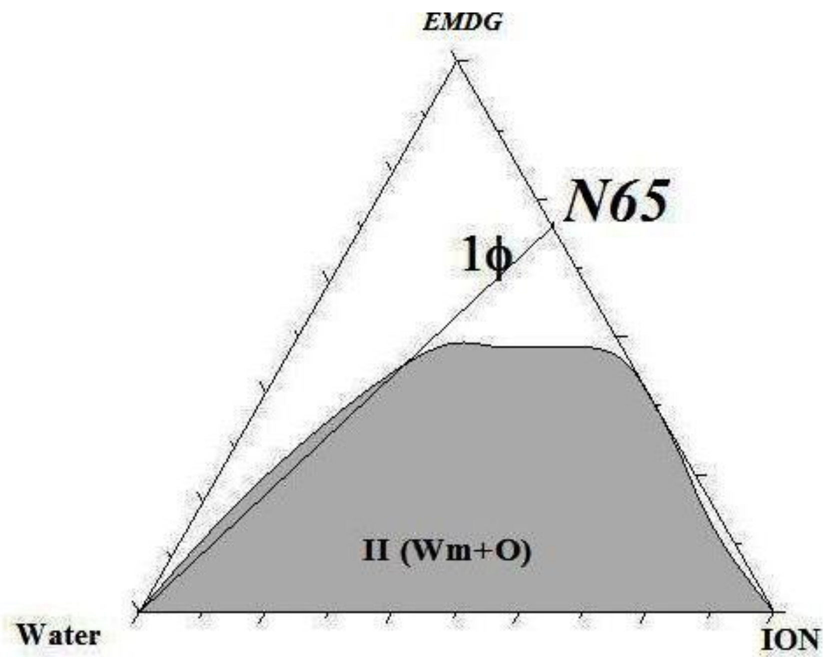


Figure 5.13: Phase diagram of the system: water/ethoxylated mono-di-glyceride (EMDG)/ α-ionone oil (ION) at 25°C. [The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O)]. N65dulition line dilution line where the weight ratio of mixed surfactant / single oil or mixed oil equals 65/35.

Table 5.3: The total monophasic area A_T (%) for the system W/EMDG/ION at different temperatures.

	A_T (%)		
Oil	**25°C**	**37°C**	**45°C**
ION	24	33	33

PEG-7 glyceryl cocoate and single oil

Figure 5.14 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/peppermint oil at 25°C. The single phase appears for surfactant contents above 72 wt% from the first addition of water. For surfactant contents below 72 wt% the system extend multiple phase regions.

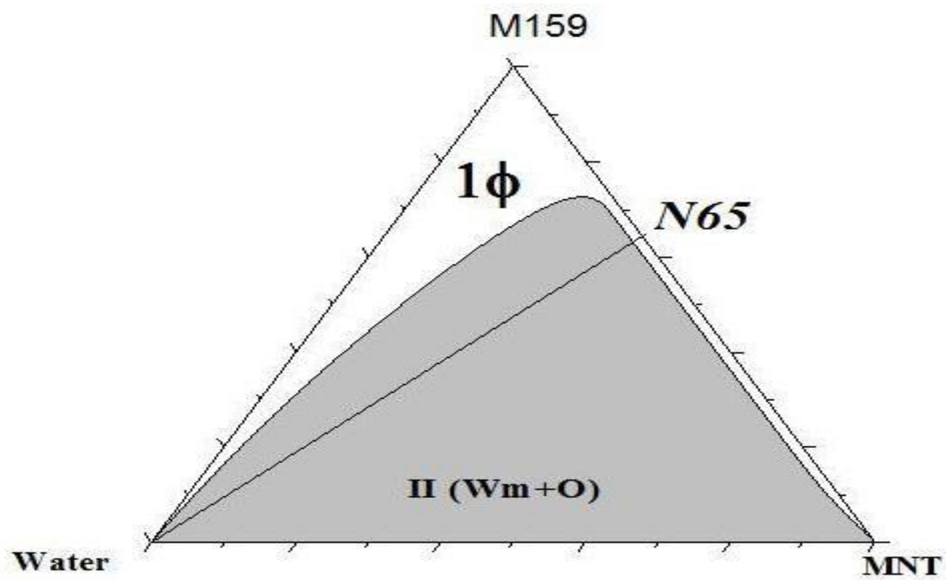


Figure 5.14: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159) / peppermint oil (MNT) at 25°C. [The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O)]. N65 is the dilution line where the weight ratio of mixed surfactant / single oil or mixed oils equals 65/35.

Figure 5.15 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/R(+)-limonene oil at 25°C. The single phase appears for surfactant contents above 65 wt% from the first addition of water. For surfactant contents below 65 wt% the system extend multiple phase regions.

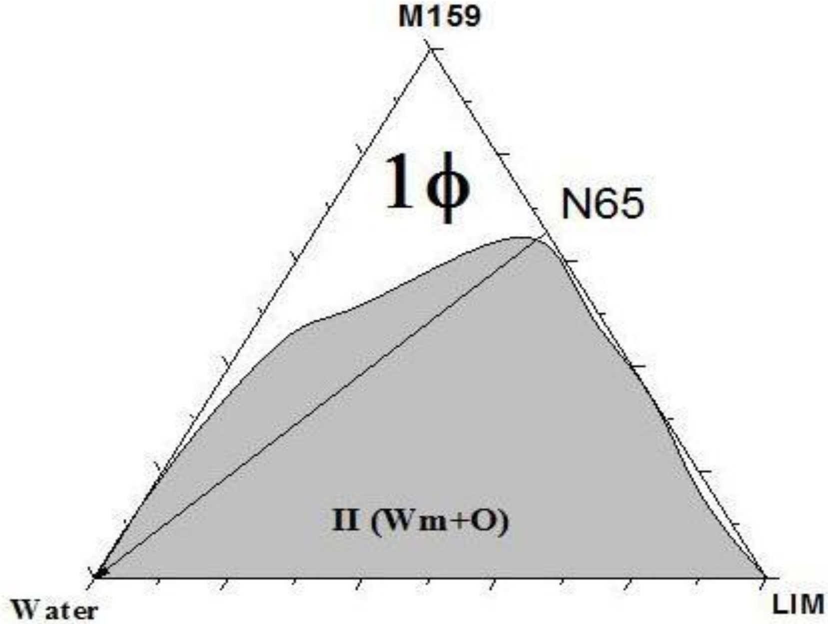


Figure 5.15: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/R(+)-limonene oil (LIM) at 25°C.

Figure 5.14 presents the phase diagram of the system W / M159/MNT at 25°C. **Figure 5.15** represents the phase diagram of the system W/M159/LIM system at temperature 25°C. For the system W/M159/MNT, the total monophasic area A_T (%) at 25°C equals 19%. For system W/M159/LIM, the total monophasic area A_T (%) at 25°C slightly increases equals 20%.

Figure 5.16 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/ α-ionone oil at 25°C. The single phase appears for surfactant contents above 75 wt% from the first addition of water. For surfactant contents below 75 wt% the system extend multiple phase regions.

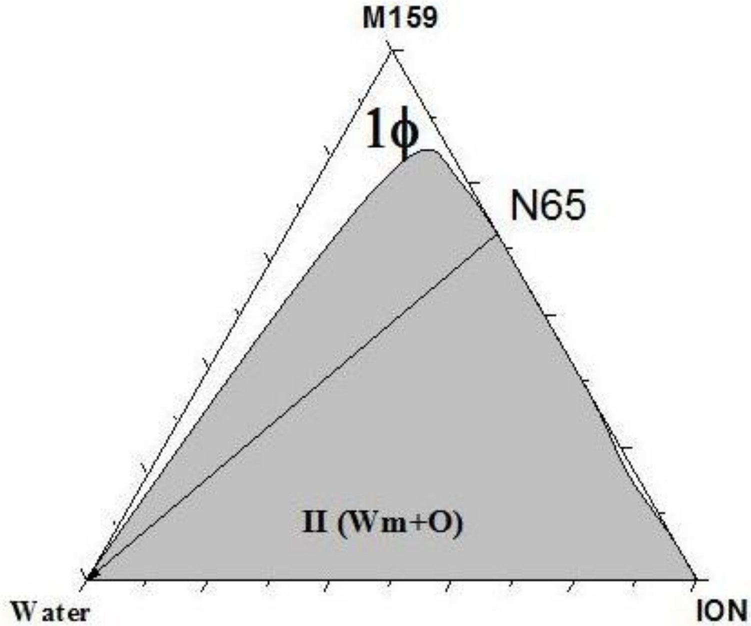


Figure 5.16: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/ α-ionone oil (ION) at 25°C.

Figure 5.17 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/ isopropylmyristate oil at 25˚C. The single phase appears for surfactant contents above 72 wt% from the first addition of water. For surfactant contents below 72 wt% the system extend multiple phase regions.

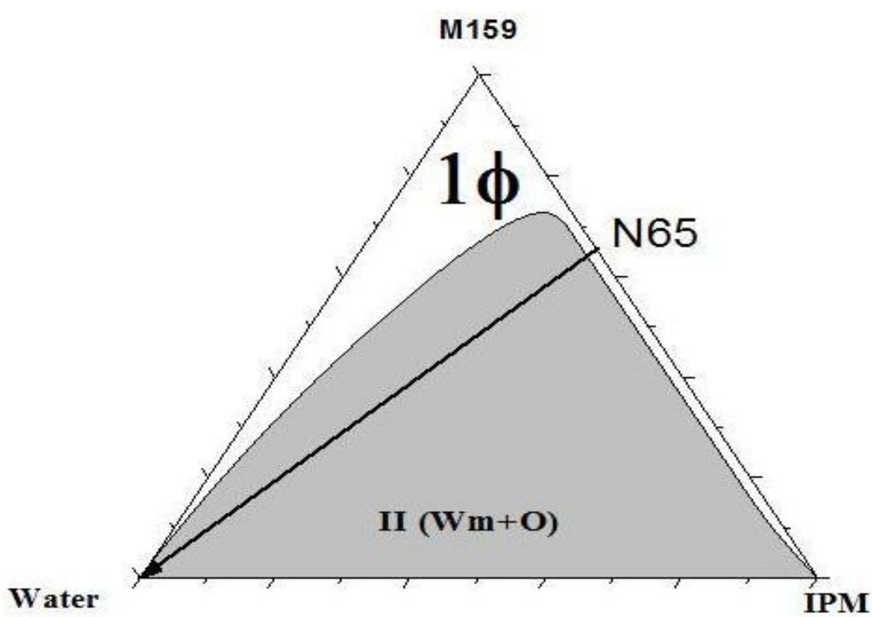


Figure 5.17: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159) (M159) / isopropylmyristate oil (IPM) at 25°C.

Figure 5.18 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/ caprylic-capric triglyceride oil at 25°C. The single phase appears for surfactant contents above 72 wt% from the first addition of water. For surfactant contents below 72 wt% the system extend multiple phase regions.

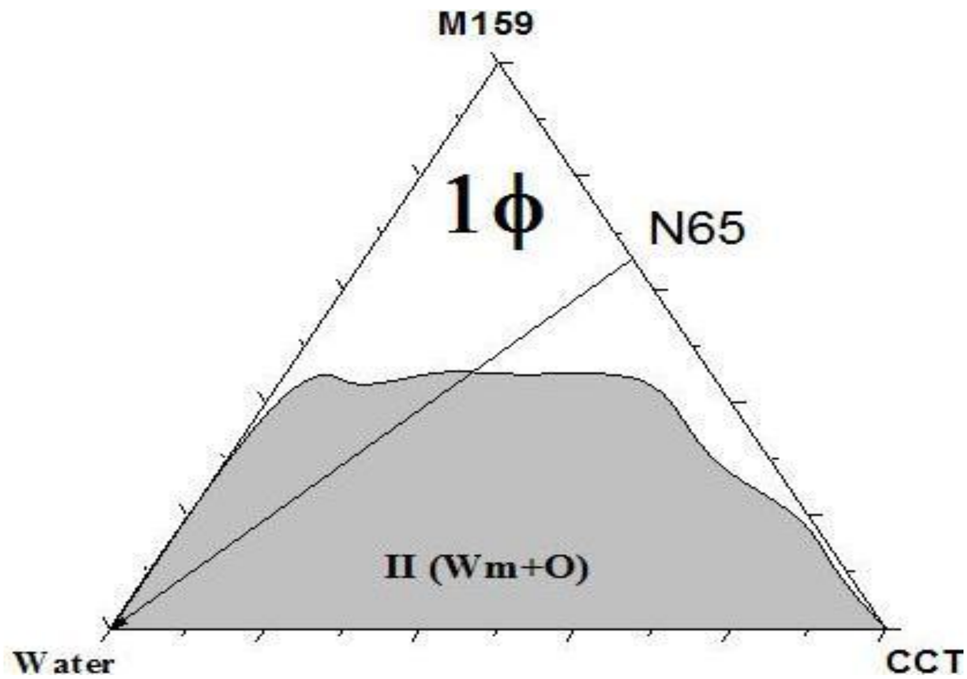


Figure 5.18: Phase diagram of the system: water/PEG-7 glyceryl cocoate (M159)/caprylic-capric triglyceride oil (CCT) at 25°C.

Figure 5.19 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/soybean oil at 25°C. The single phase appears for surfactant contents above 70 wt% from the first addition of water. For surfactant contents below 70 wt% the system extend multiple phase regions.

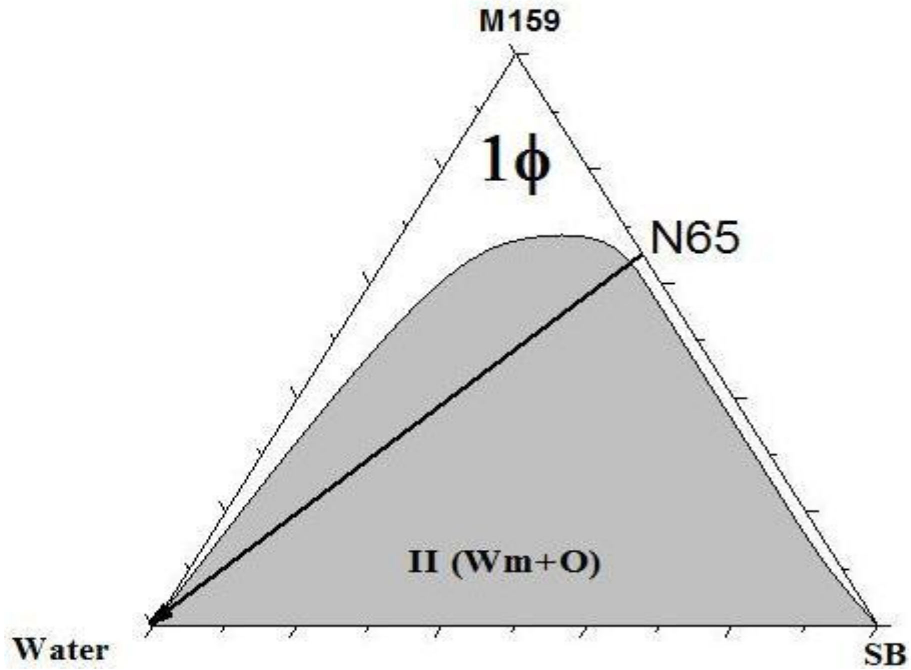


Figure 5.19: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/soybean oil (SB) at 25°C.

Figure 5.20 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/sunflower oil at 25°C. The single phase appears for surfactant contents above 70 wt% from the first addition of water. For surfactant contents below 70 wt% the system extend multiple phase regions.

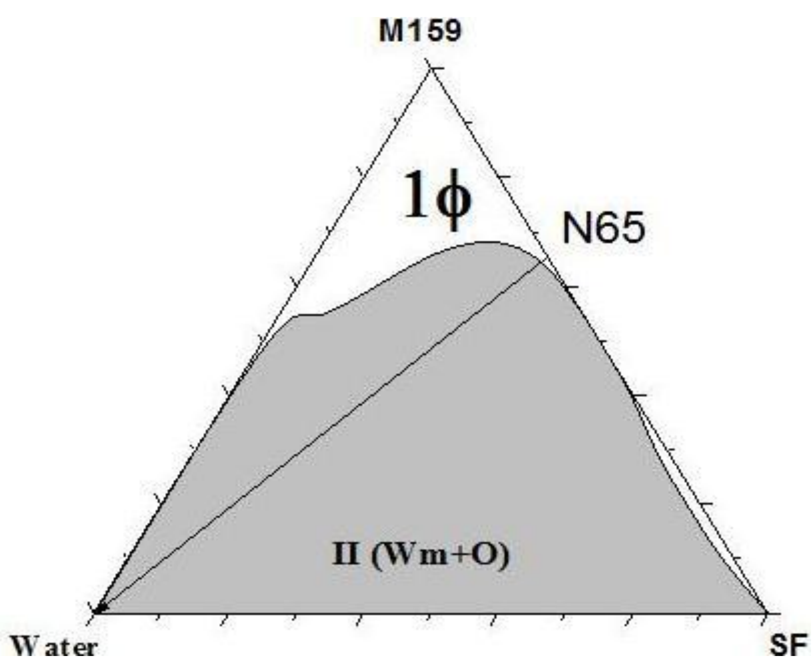


Figure 5.20: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/ sunflower oil (SF) at 25°C.

Figure 5.21presents the phase diagram of the system water/PEG-7 glyceryl cocoate/olive oil at 25°C. The single phase appears for surfactant contents above 80 wt% from the first addition of water. For surfactant contents below 80 wt% the system extend multiple phase regions.

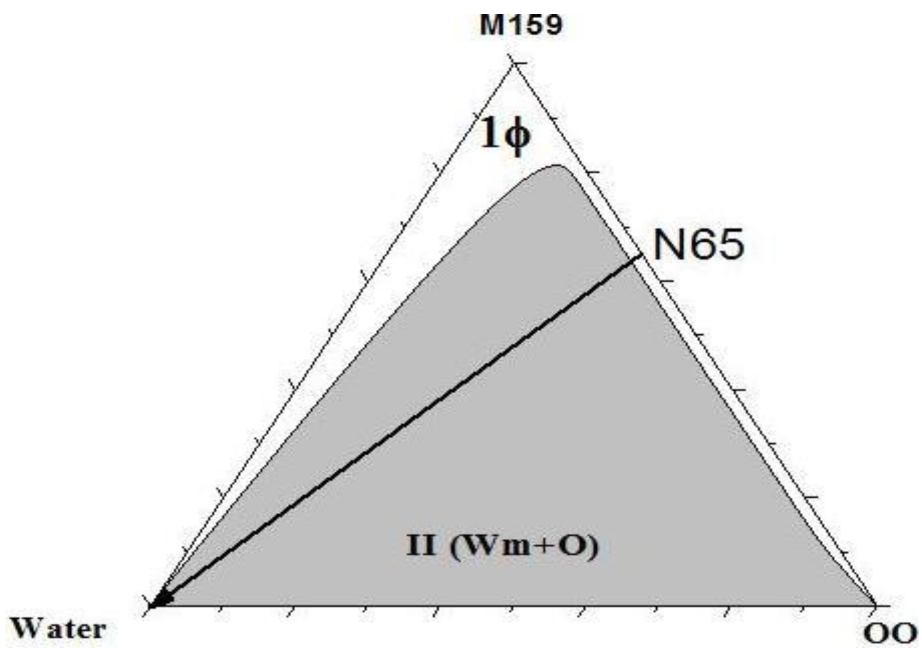


Figure 5.21: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/ olive oil (OO) at 25°C.

Figure 5.22 presents the phase diagram of the system water/PEG-7 glyceryl cocoate/ sesame oil at 25°C. The single phase appears for surfactant contents above 70 wt% from the first addition of water. For surfactant contents below 70 wt% the system extend multiple phase regions.

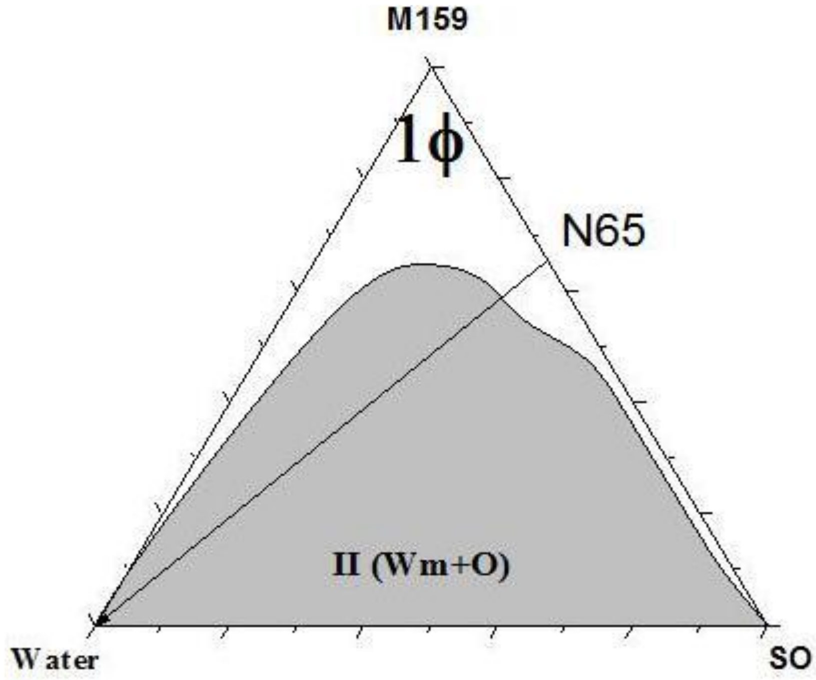


Figure 5.22: Phase diagram of the system: water/ PEG-7 glyceryl cocoate (M159)/ sesame oil (SO) at 25°C.

Table 5.4: The total monophasic area A_T (%) for the system W /M159/single oil at different oil type and different temperatures.

	A_T (%)		
Oil	**25°C**	**37°C**	**45°C**
MNT	19	22	22
LIM	20	19	20
ION	13	13	13
IPM	19	23	21
CCT	37	37	37
SB	19	21	20
SF	17	19	17
OO	14	14	14
SO	23	22	23

From the results printed in the Table 5.4 we observe that the systems containing cyclic oils (MNT, LIM and ION) and linear oil (IPM) and triglyceride oil ,we observed that the total monophasic area

A_T (%) in the microemulsion systems triglyceride oil was less than other oils used in this study; cyclic and linear oils. The result the same reasoning as result in page 48.

Glycerol monooleate and single oil

Figure 5.23 presents the phase diagram of the system water/ glycerol monooleate /peppermint oil at 25°C. The single phase appears for surfactant contents above 90 wt% from the first addition of water. For surfactant contents below 90 wt% the system extend multiple phase regions.

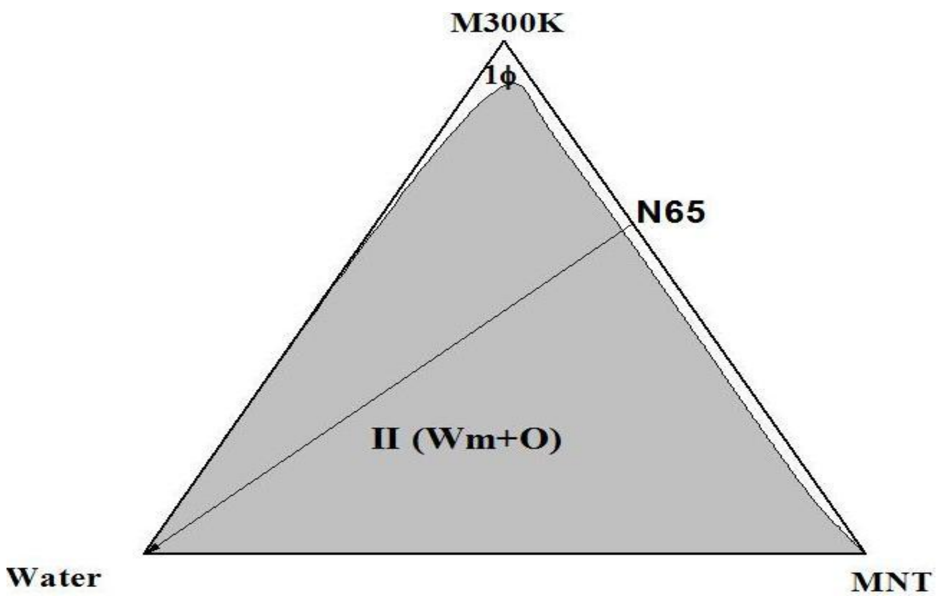


Figure 5.23: Phase diagram of the system: water/ glycerol monoolerol (M300K) / peppermint oil (MNT) at 25°C. [The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O)]. N65 is the dilution line where the weight ratio of mixed surfactant / single oil or mixed oils equals 65/35.

Figure 5.24 presents the phase diagram of the system water/ glycerol monooleate /R(+)-limonene oil at 25°C. The single phase appears for surfactant contents above 85 wt% from the first addition of water. For surfactant contents below 85 wt% the system extend multiple phase regions.

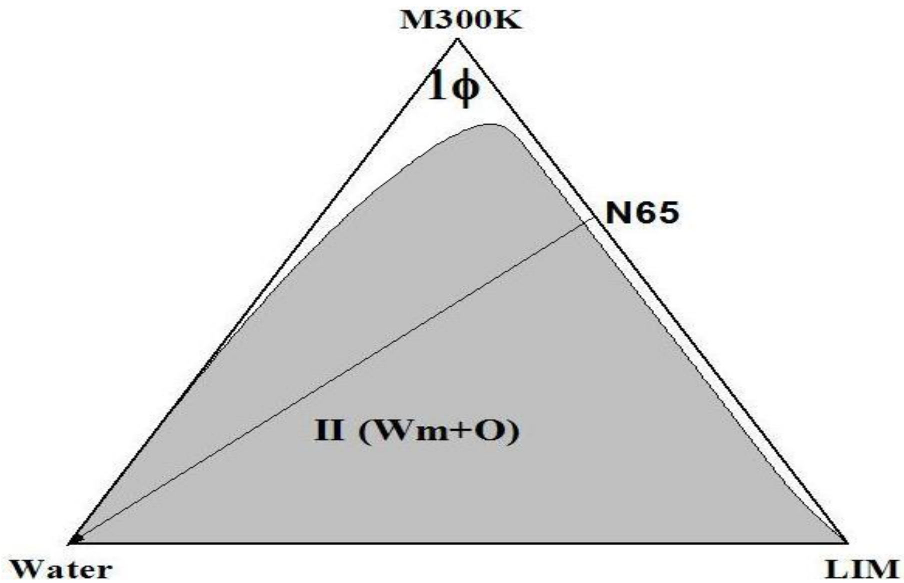


Figure 5.24 Phase diagram of the system: water/ glycerol monooleate (M300K)/R (+)-limonene oil (LIM) at 25°C.

Figure 5.25 presents the phase diagram of the system water/ glycerol monooleate /α-ionone oil at 25°C. The single phase appears for surfactant contents above 85wt% from the first addition of water. For surfactant contents below 85 wt% the system extend multiple phase regions.

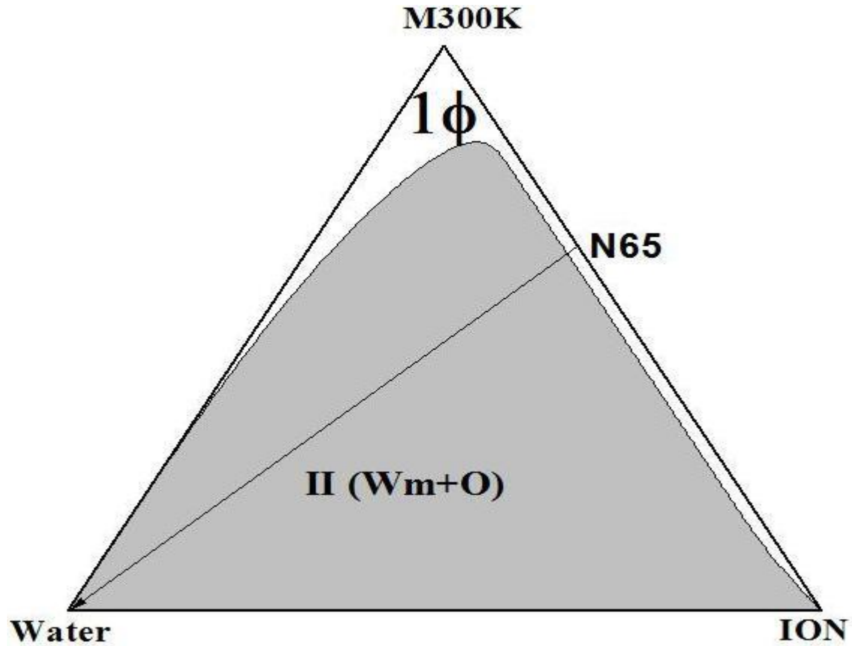


Figure 5.25: Phase diagram of the system: water/glycerol monooleate (M300K)/α-ionone oil (ION) at 25°C.

Figure 5.26 presents the phase diagram of the system water/ glycerol monooleate/isopropyl microstate oil at 25˚C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

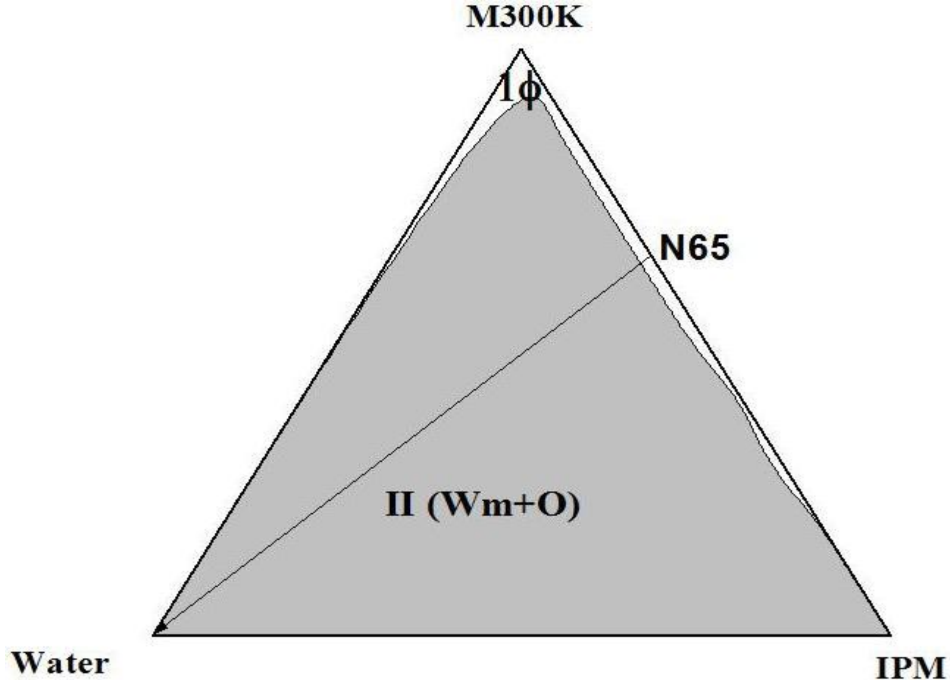


Figure 5.26: Phase diagram of the system: water/glycerol monooleate (M300K)/ isopropylmyristate oil (IPM) at 25°C.

. Figure 5.27 presents the phase diagram of the system water/ glycerol monooleate / caprylic-capric triglyceride oil at 25°C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

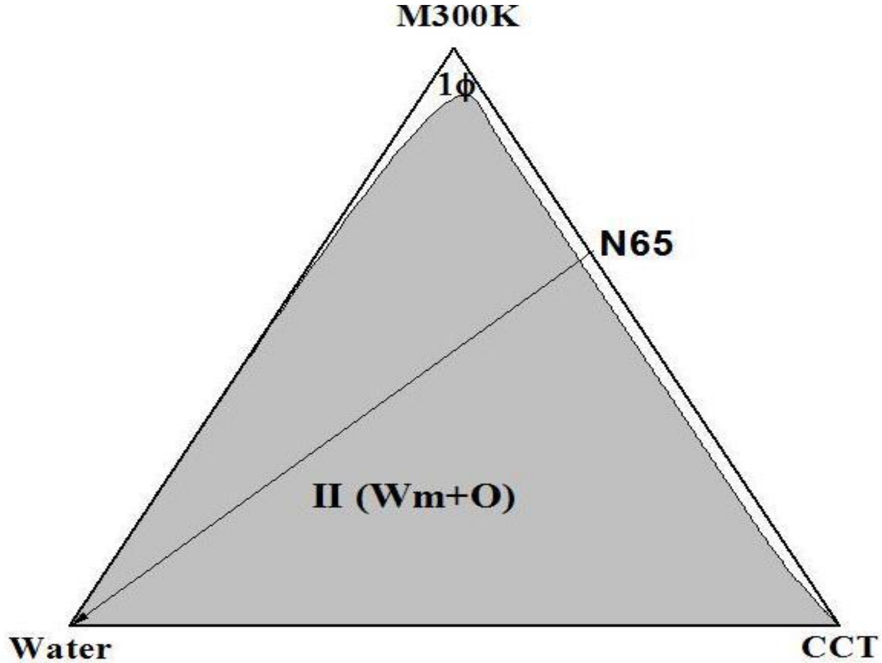


Figure 5.27: Phase diagram of the system: water/ glycerol monooleate (M300K) /caprylic-capric triglyceride oil (CCT) at 25°C.

Figure 5.28 presents the phase diagram of the system water/ glycerol monooleate / soybean oil at 25°C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

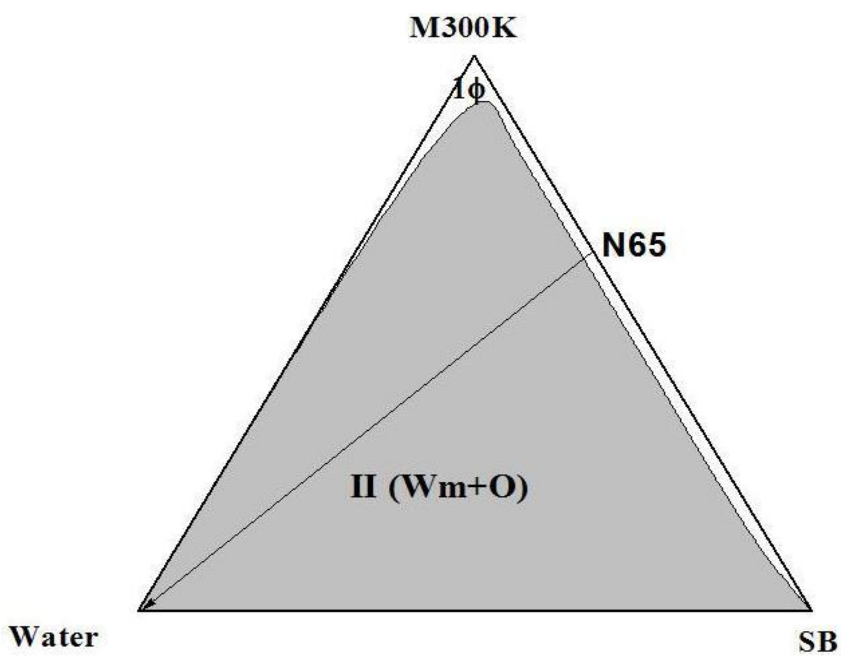


Figure 5.28: Phase diagram of the system: water/ glycerol monooleate (M300K) /soybean oil (SB) at 25°C

Figure 5.29 presents the phase diagram of the system water/ glycerol monooleate / sunflower oil at 25°C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

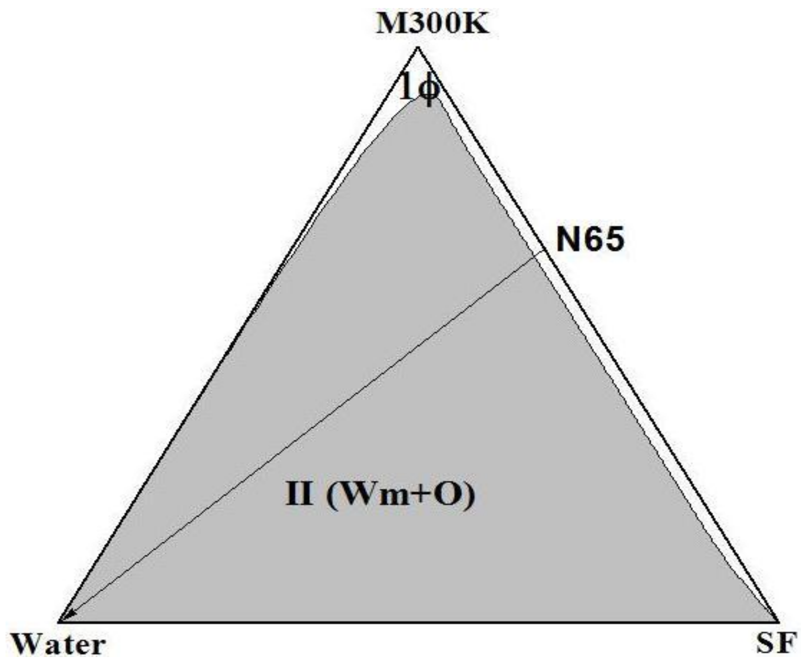


Figure 5.29: Phase diagram of the system: water/ glycerol monooleate (M300K) / sunflower oil (SF) at 25°C.

Figure 5.30 presents the phase diagram of the system water/ glycerol monooleate /olive oil at 25°C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

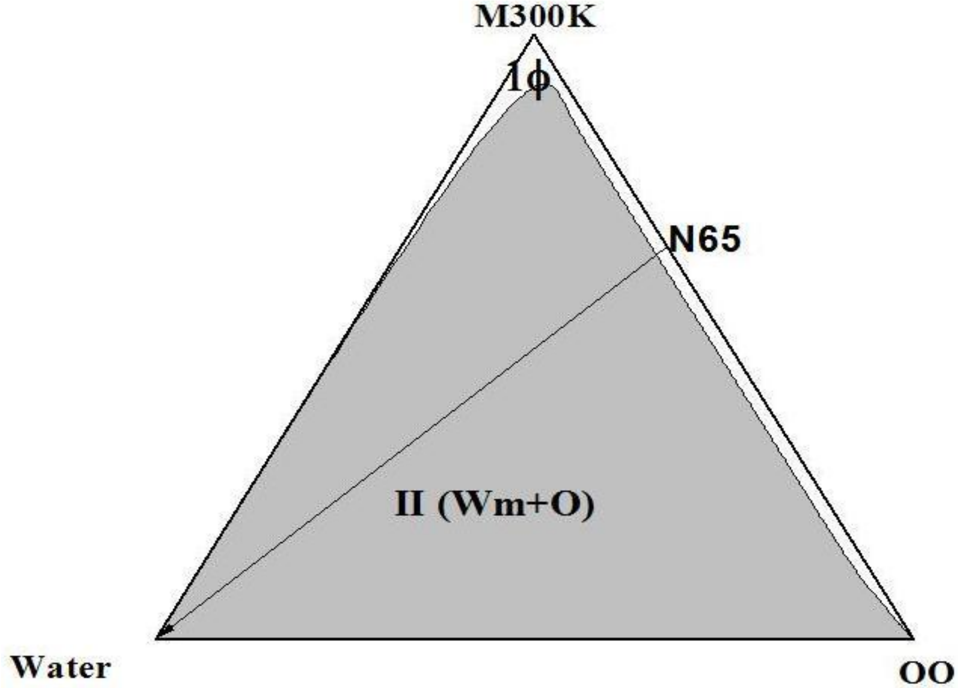


Figure 5.30: Phase diagram of the system: water/ glycerol monooleate (M300K) /olive oil (OO) at 25°C.

Figure 5.31 presents the phase diagram of the system water/ glycerol monooleate /sesame oil at 25°C. The single phase appears for surfactant contents above 95wt% from the first addition of water. For surfactant contents below 95 wt% the system extend multiple phase regions.

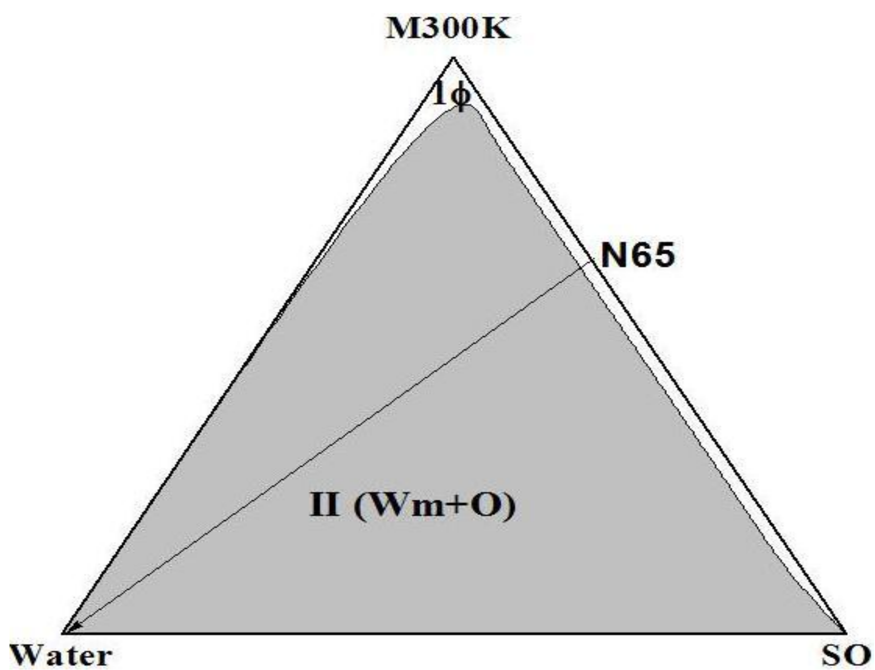


Figure 5.31: Phase diagram of the system: water/ glycerol monooleate (M300K) /sesame oil (SO) at 25°C.

Table 5.5: The total monophasic area A_T (%) for the system W/M300K/single oil at different type oil and different temperatures.

	A_T (%)		
Oil	**25°C**	**37°C**	**45°C**
MNT	4	4	4
LIM	7	7	7
ION	8	20	20
IPM	3	3	3
CCT	4	4	4
SB	4	4	4
SF	4	4	4
OO	4	4	4
SO	4	4	4

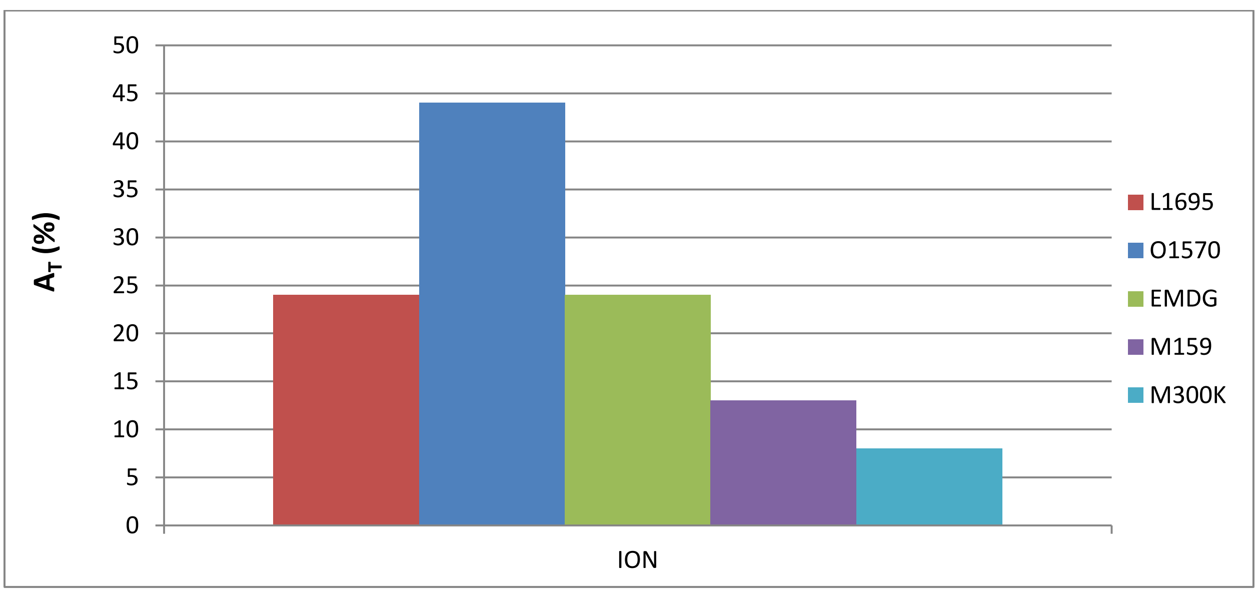


Figure 5.32: Variation of the total monophasic region A_T (%) as function of surfactants content in the α-ionone at temperature 25°C.

The results presented in Figure 5.32 we observe that for microemulsion systems based on different types surfactants and α-ionone oil has the higher total monophasic area values when used (O1570 and PG) that tend to other surfactants.

From the results shown in Table 5.5 different systems are observed. Solubilization of water in reverse micelle systems depends upon many factors, for example, type of surfactant (and Cosurfactants/second surfactant), oil, temperature, and additives (Liu, Ma, Cheng, et al, 1998). But the main driving force of such solubilization is the spontaneous curvature and the elasticity (or rigidity) of the interfacial film formed by the surfactant system (Leung, Shah, 1987). If the interfacial curvature and the bending elasticity are fixed, solubilization can be maximized by minimizing the interfacial bending stress of the rigid interface and the attractive interdroplet interaction (Chen, Evans, Ninham, 1984). The critical packing parameter (CPP, given by $P = v/al$ where v and l are respectively the volume and length of the hydrophobic chain and a is the area of the polar head group of the surfactant) of the surfactant plays an important role in water solubilization.

In the present study, addition of nonionic surfactants of different types and chemical structures (L1695, O1570, M159 and M300K) with different types and chemical structures produces synergism in their solubilization capacity. The highest and lowest total monophasic area A_T (%) values are obtained with the L1695/ION, O1570/ION, EMDG/ION, M159 and M300K/ION systems respectively, at corresponding total monophasic area A_T (%) values of 17, 44,24,13 and 8, whereas follows the order O1570 >EMDG >L1695 >M159 >M300K. Because of the interdependence of both the parameters the plausible mechanism for the solubilization phenomenon arising out of the hydrophilic–lipophilic balance (HLB) of the added nonionic surfactant, and For such systems, the solubilization capacity can be increased by any modification of the molecular structure of either the interface or continuos phase so that $R0$ is increased. Starting from a shortchain alkane, increasing the oil chain length would gradually reduce the cohesive interaction between the hydrocarbon chains of the interface and decrease the interfacial rigidity due to decreasing oil penetration. The solubilization for such systems thus increases due to the decrease in packing parameter (*P)* and consequent increase in natural radius. On the other hand, for systems with greater chain length alkanes, the interdroplet interaction governs the solubilization process. Consequently one would expect a decrease in solubilization in microemulsion with further increase in oil chain length (Paul, Mitra, 2005).

5.1.1.2 Phase behavior of mixed surfactants/ single oil systems

Effect of mixed surfactants weight ratios

The volume of microemulsion generated per weight of surfactant added to a water/oil is commonly described as the surfactant “efficiency”. Surfactant efficiency can be influenced by surfactant type, molecular weight, temperature, and a host of formulation variables (Biais, Clin, Laolanne, 1987).
In order to avoid superimposing the effects of domain curvature on efficiency measurements, surfactant efficiencies are typically determined at zero interfacial curvature (in the bicontinuous microemulsion state) at equal oil to water volumes.

5.1.1.2.i Mixed sucrose monolaurate and PEG-7 glyceryl cocoate.

For microemulsion systems W/L1695+M159/Oil, adding PEG-7 glyceryl cocoate (M159) to the system to enhances the formation of the one-phase microemulsion regions. This is explained by the mixture of surfactants enhance the surfactants partitioning at the interface, thus increasing the stability of the amphiphilic film. And the average HLB number of about 14.5, so that the blend of surfactants affect the packing parameter of the mixed surfactants in a manner that more water can be solubilized in the microemulsion droplets.

It is considered that the surfactant monolayers at the interface of water and oil domains inside the microemulsions are directly related to the solubilization of water and oil the monomeric solubilities of L1695 in both oil and water are low and this quite different from that of M159 which is completely soluble in both oil and water.

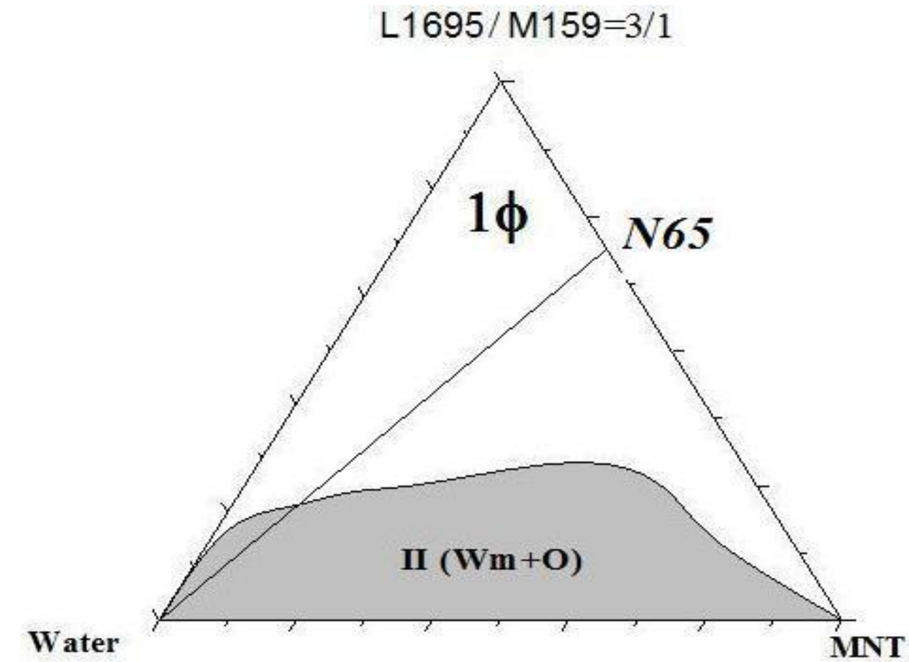
The maximum total aria A_T (%) in ratio between L1695/M159 is equal 1/1.

System#1 W/ L1695+M159/MNT

Figure 5.33 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / peppermint oil (MNT) system at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

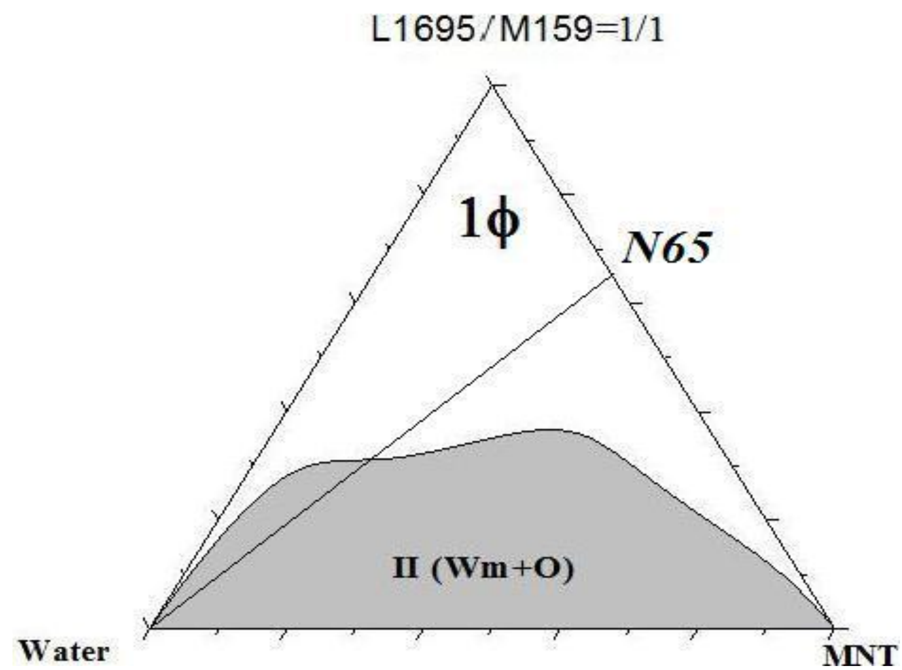
As show in Figure 5.33 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 75 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 80 wt% water.

For low mixed surfactants contents (below 30 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.33B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 35 wt%. In Figure 5.33C the one phase microemulsion region shrinks more compared to 5.33B.



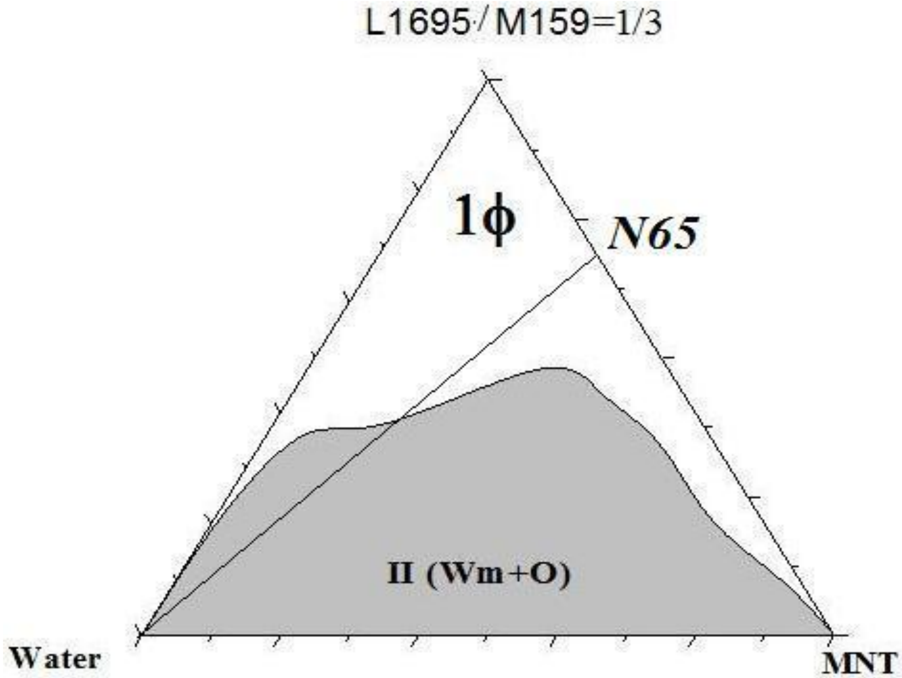
L1695/M159=3/1
1ϕ
N65
II (Wm+O)
Water
MNT

(A)



L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
MNT

(B)



(C)

Figure 5.33: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / pepper mint oil (MNT). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/MNT = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table 5.6 The total monophasic area A_T (%) for the system W /L1695+M159/ MNT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
25	56	58	58
50	48	50	50
75	39	43	43
100	19	22	22

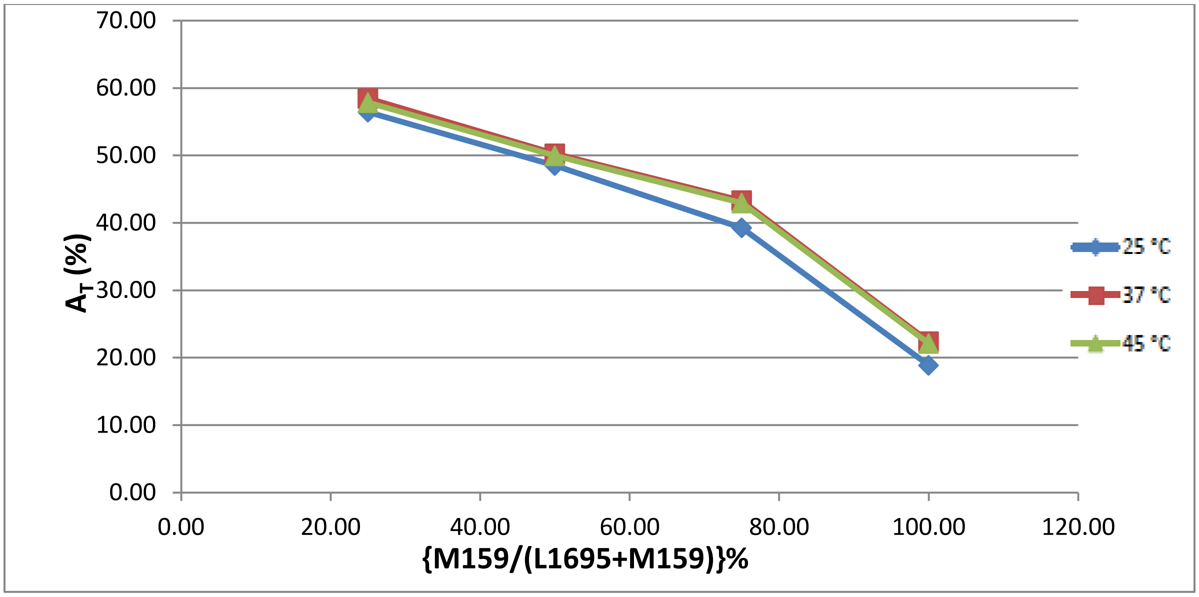


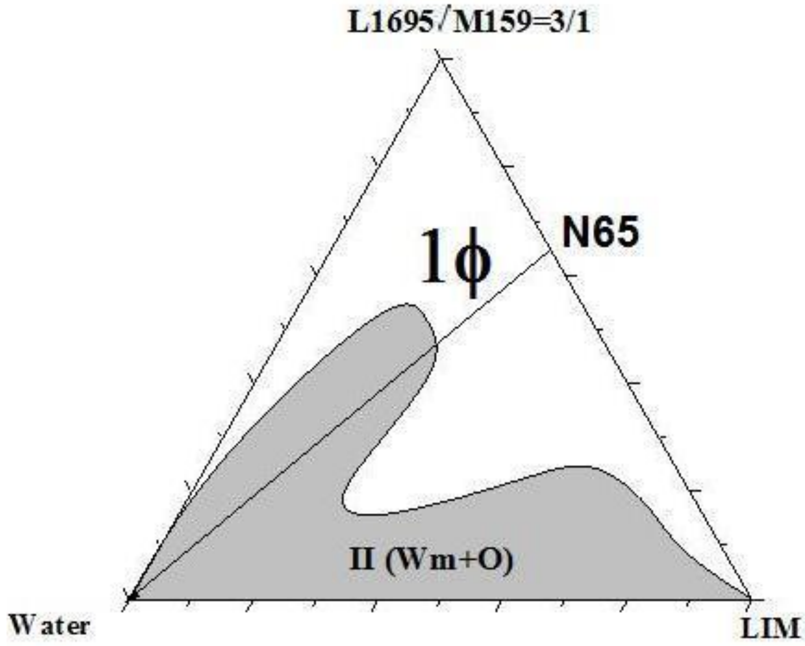
Figure 5.34: Variation of the total monophasic region A_T (%) as function of PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/ MNT.

System#2 W/ L1695+M159/LIM

Figure 5.35 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /R(+)-limonene oil (LIM) system at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

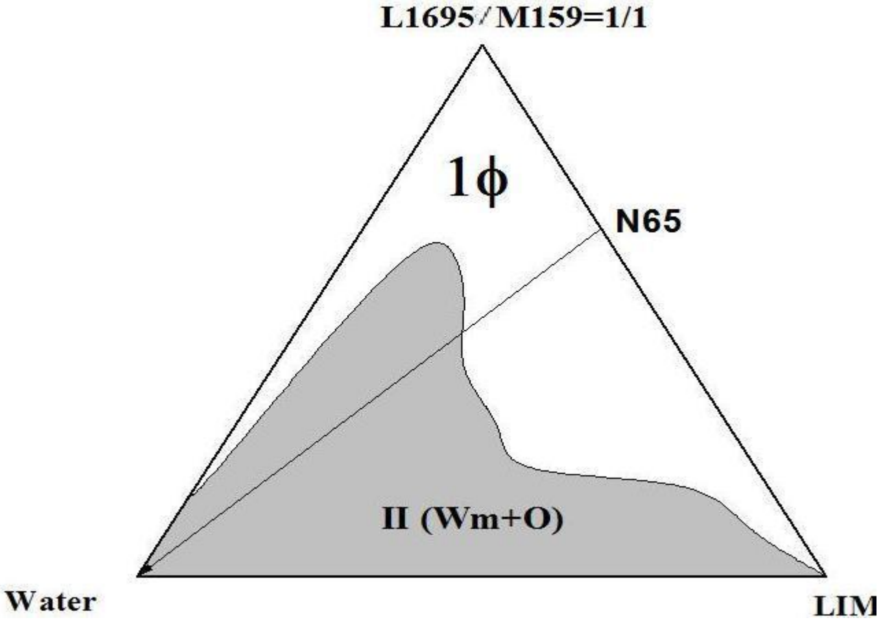
As show in Figure 5.35 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 30 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 60 wt% water.

For low mixed surfactants contents (below 30 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.35B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 55 wt%. In Figure 5.35C the one phase microemulsion region increase slowly compared to 5.35B.



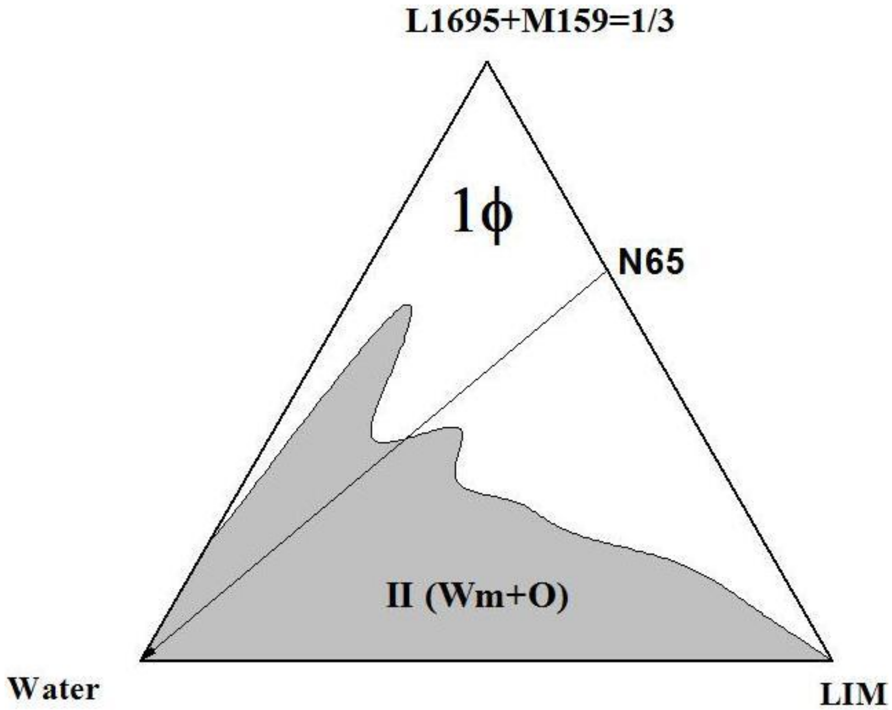
L1695/M159=3/1
N65
1ϕ
II (Wm+O)
Water
LIM

(A)



L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
LIM

(B)



(C)

Figure 5.35: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /R (+)-limonene oil (LIM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (**Wm**+**O**). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/LIM = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table 5.7: The total monophasic area A_T (%) for the system W /L1695+M159/ LIM at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
25	50	51	50
50	54	51	54
75	58	52	58
100	20	19	20

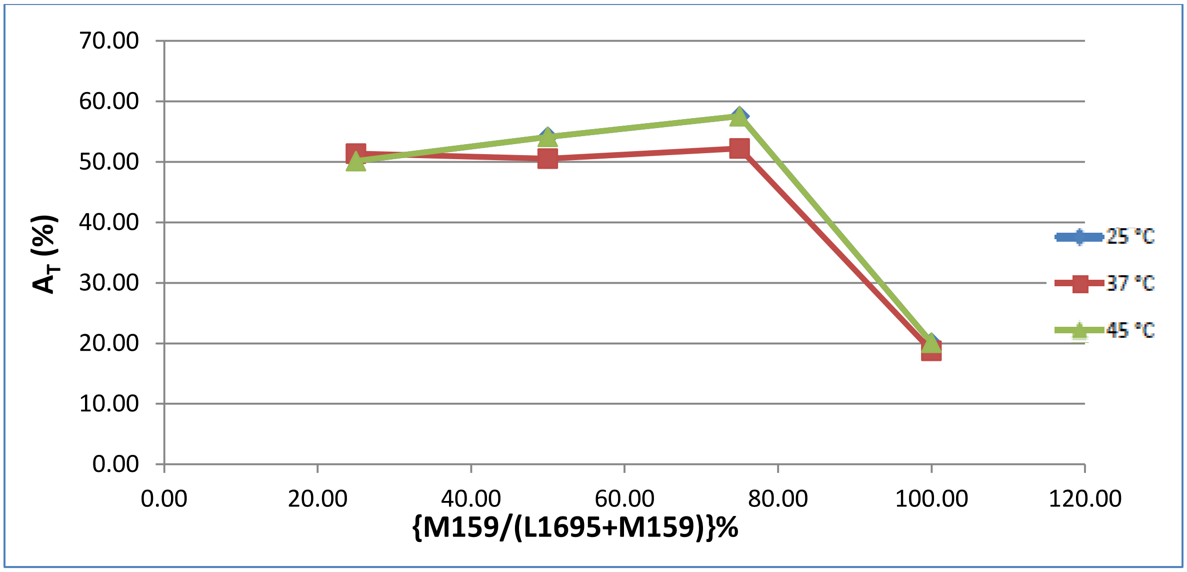


Figure 5.36: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/ LIM.

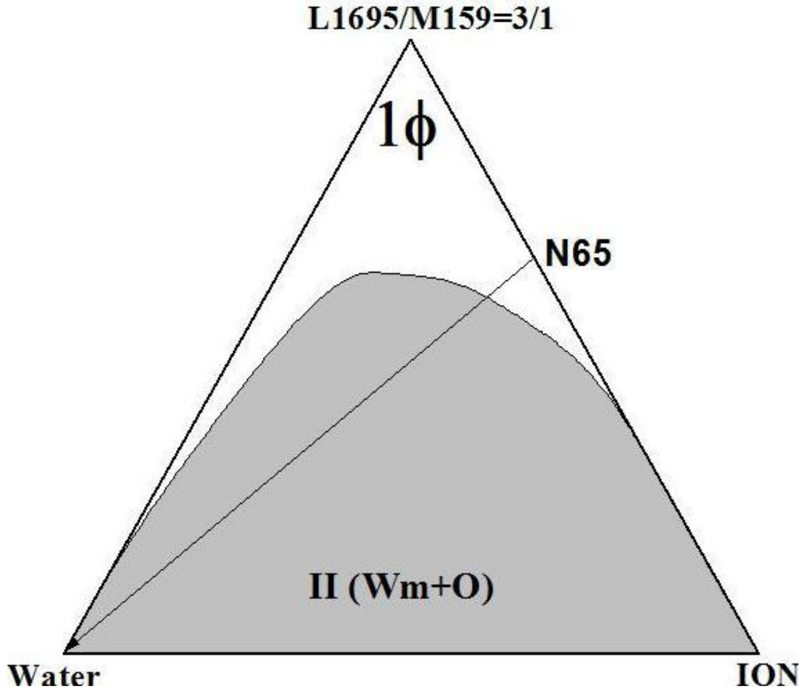
<u>System#3 W/ L1695+M159/ION</u>

Figure 5.37 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / α-ionon oil (ION) system at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

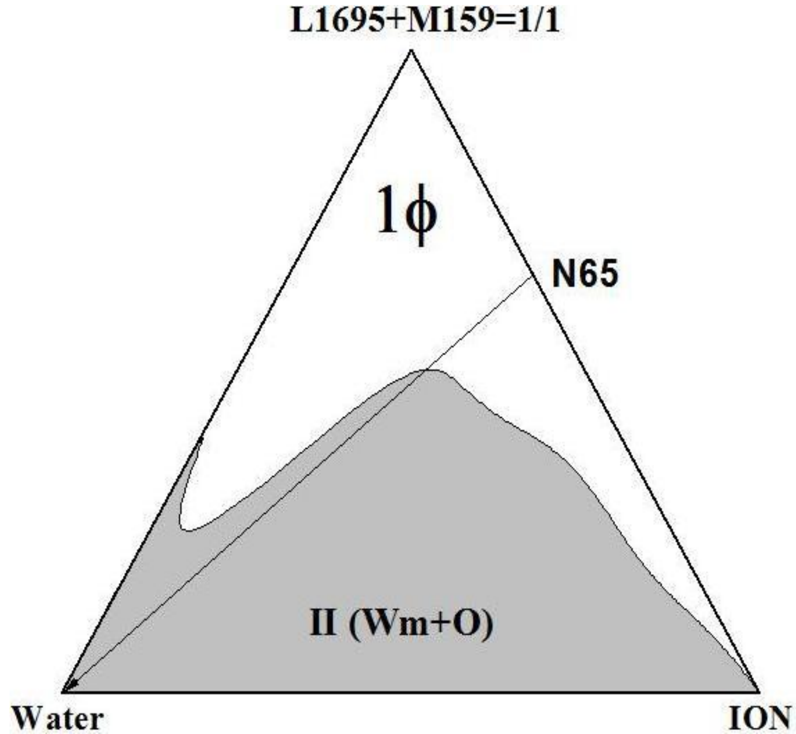
As show in Figure 5.37 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 12 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 62 wt% water.

For low mixed surfactants contents (below 55 wt %) a multiphase reign II (Wm+O) is observed.

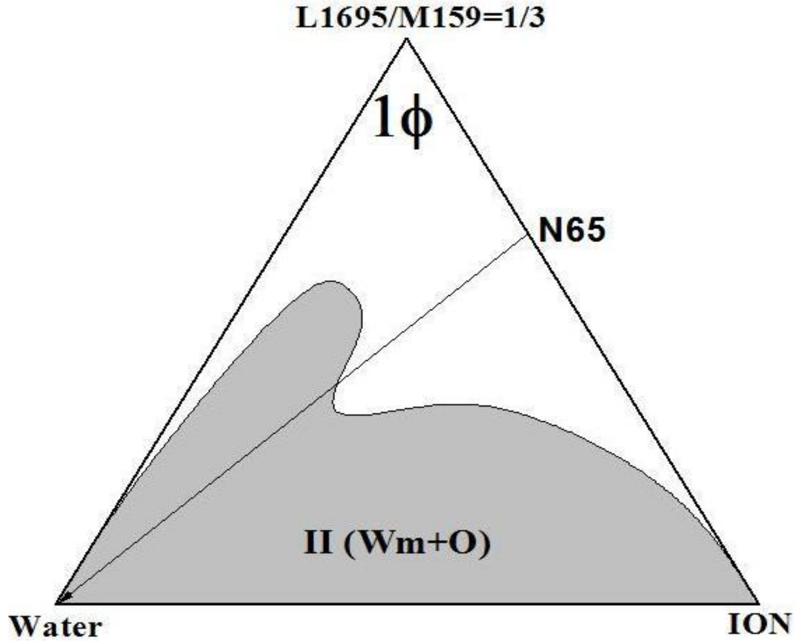
Some behavior is observed in Figure 5.37B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 55 wt%. In Figure 5.37C the one phase microemulsion region shrinks more compared to 5.37B.


L1695/M159=3/1
1ϕ
N65
II (Wm+O)
Water
ION

(A)


L1695+M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION

(B)



(C)

Figure 5.37: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / α-ionon oil (ION). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ION = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table 5.8: The total monophasic area A_T (%) for the system W /L1695+M159/ ION at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
25	20	21	20
50	52	46	52
75	42	41	42
100	13	13	13

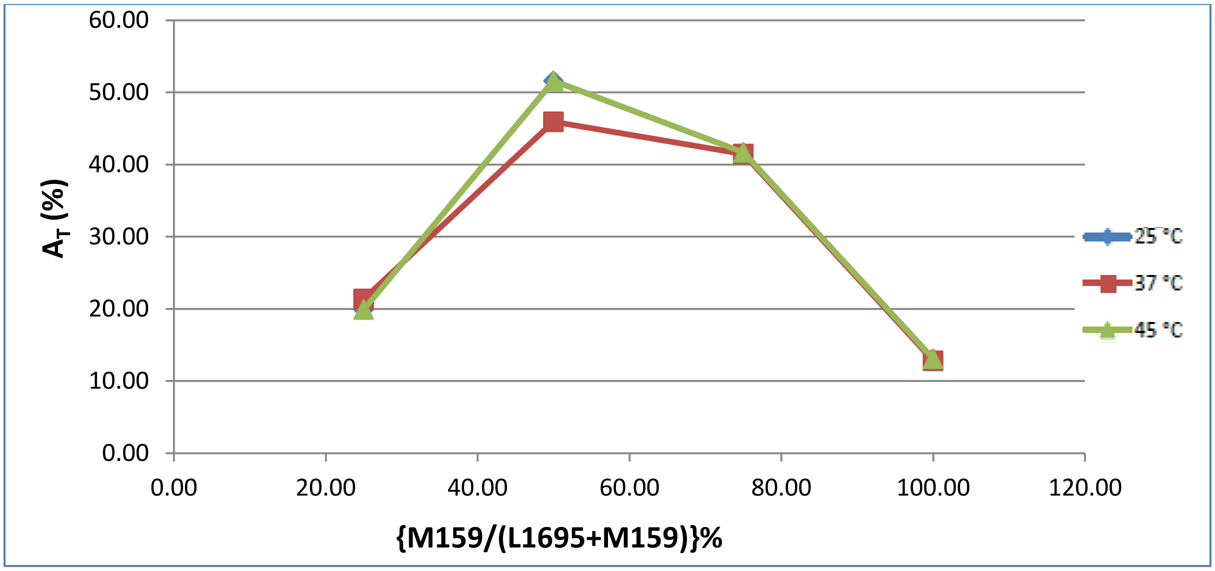


Figure 5.38: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/ ION.

Figures 5.33, 5.35 and 5.37 present the phase behaviors of the systems W/L1695+M159/ cyclic oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.34, 5.36and 5.38 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.9. From the data presented an Tables 5.6, 5.7 and 5.8 and Figures 5.33,5.35 and 5.37, about the values of the total monophasic area A_T (%), it apperes that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

Table 5.9 The mixed surfactants ratio and compared to maximum total monophasic area A_T (%) for the system W /L1695+M159/ oil at temperature 25°C.

Oil	Maximum A_T (%)	Mixed surfactants (M159/M159+L1695)
MNT	56	1/3
LIM	58	3/1
ION	52	1/1

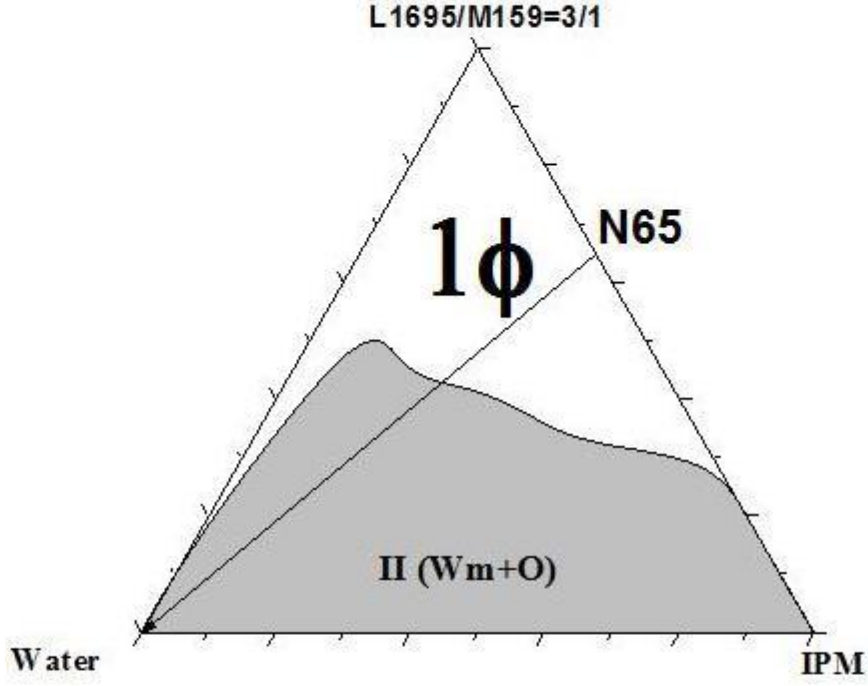
System#4 W/ L1695+M159/IPM

Figure 5.39 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyrstate oil (IPM). system at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

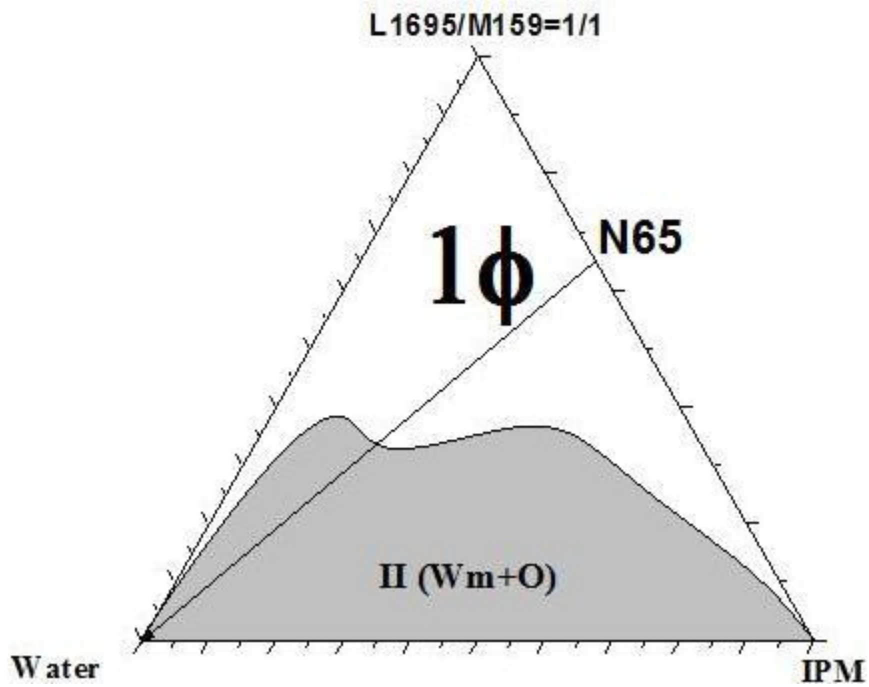
As show in Figure 5.39 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 35 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 58 wt% water.

For low mixed surfactants contents (below 42 wt %) a multiphase reign II (Wm+O) is observed.

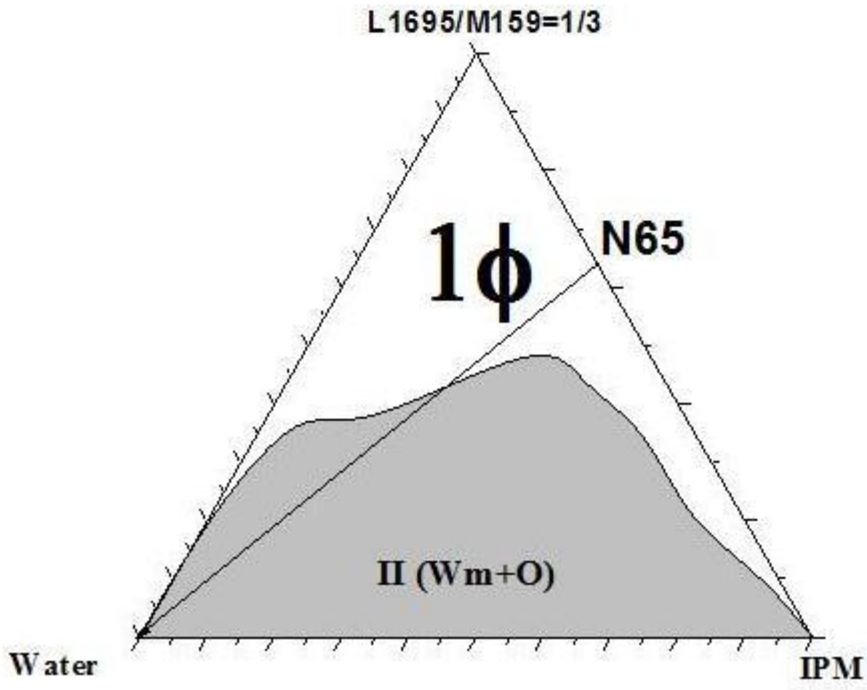
Some behavior is observed in Figure 5.39B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 42 wt%. In Figure 5.39C the one phase microemulsion region shrinks more compared to 5.39B.


L1695/M159=3/1
N65
1ϕ
II (Wm+O)
Water
IPM

(A)


L1695/M159=1/1
N65
1ϕ
II (Wm+O)
Water
IPM

(B)



(C)

Figure 5.39: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate oil (IPM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (**Wm**+**O**). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/IPM = 65/35, L1695/M159: **(A) 75% (B) 50 % (C) 25%.**

Table 5.10: The total monophasic area A_T (%) for the system W /L1695+M159/ IPM at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
25	38	38	34
50	48	50	50
75	39	44	43
100	19	23	21

Figures 5.39 present the phase behaviors of the systems W/L1695+M159/ linear oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.40 represent the variation of the

total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C. From the data presented in Tables 5.10 about the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

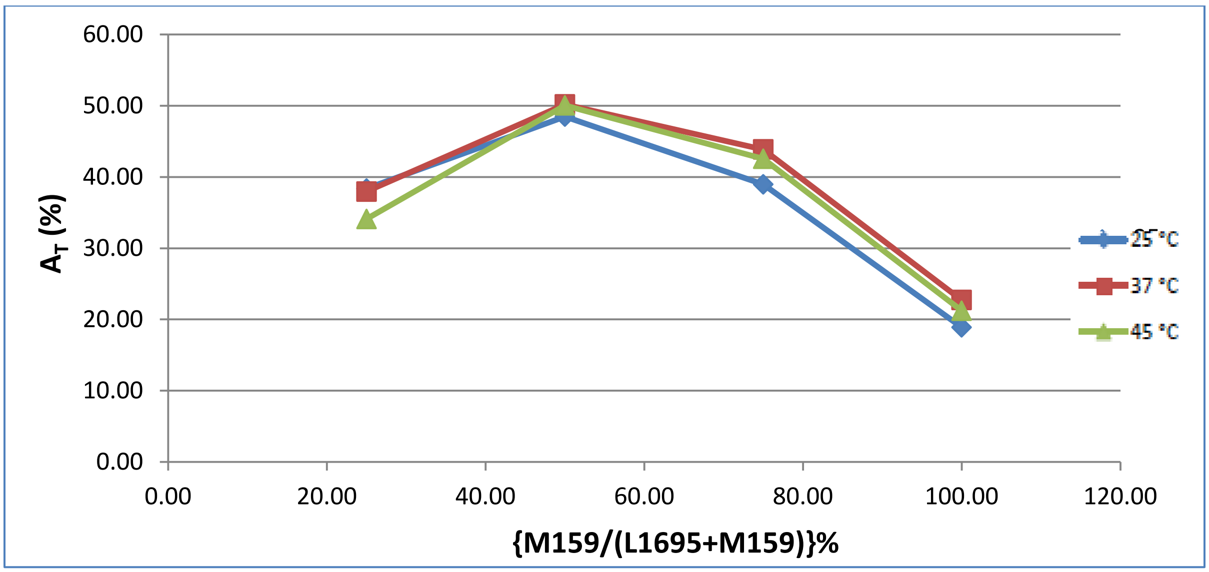


Figure 5.40: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/ IPM.

For the systems W/L1695/M159/IPM at 25°C the total monophasic area A_T (%) for the mixing ratios surfactant (M159/L1695=25%) equals 38, for the mixing ratios surfactant (M159/L1695=50%) equals and 48, for the mixing ratios surfactant (M159/L1695= 75%) decrease to 39. For M159 content equals 50 wt. % the total monophasic area A_T (%) equals 48% reads its maximum values.

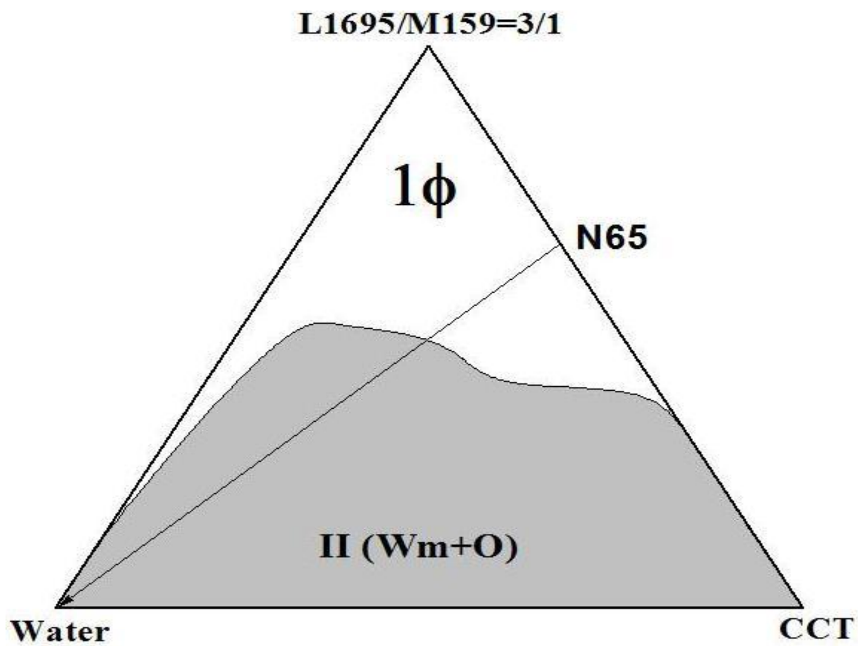
System#5 W/ L1695+M159/CCT

Figure 5.41 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glycerol cocoate (M159) /caprylic-capric triglyceride oil (CCT). system at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

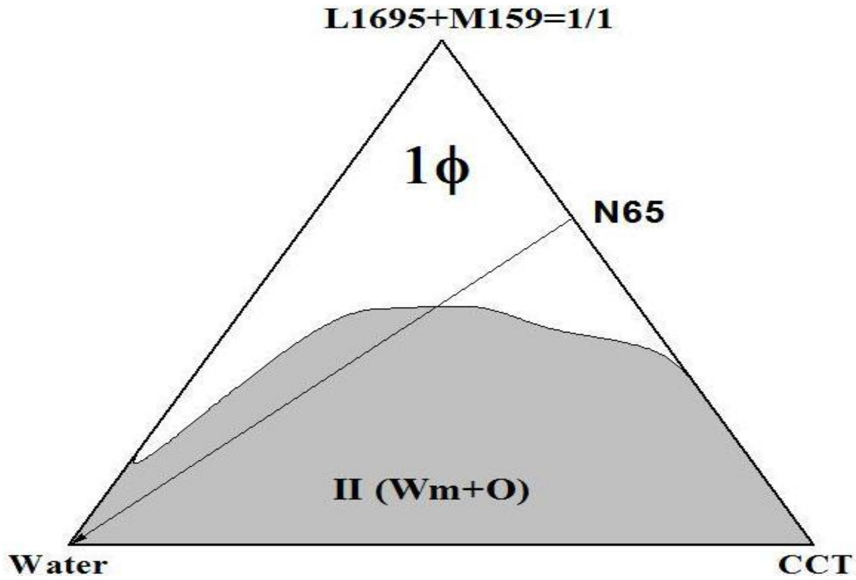
As show in Figure 5.41A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 28 wt% water.

For low mixed surfactants contents (below 48 wt %) a multiphase reign II (Wm+O) is observed.

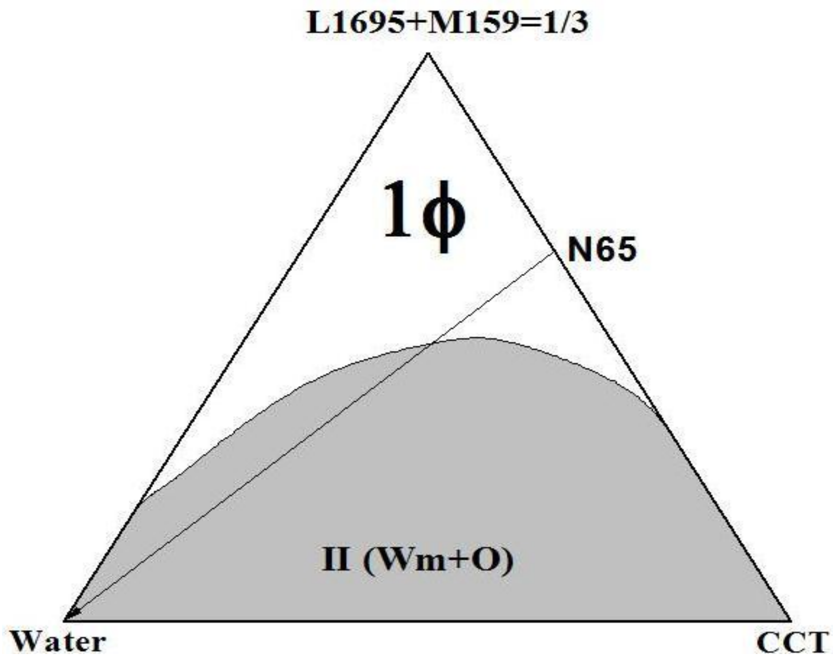
Some behavior is observed in Figure 5.41B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents below 50 wt%. In Figure 5.41C the one phase microemulsion region shrinks more compared to 5.41B.



(A)



(B)



(C)

Figure 5.41: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride oil (CCT). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (**Wm**+**O**). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/CCT = 65/35, L1695/M159: (A) 75% (B) 50% (C) 25%.

Table 5.11: The total monophasic area A_T (%) for the system W /L1695+M159/ CCT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
25	36	35	36
50	35	34	35
75	35	35	35
100	37	37	37

Figures 5.41 present the phase behaviors of the systems W/L1695+M159/triglyceride oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.42 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.11. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

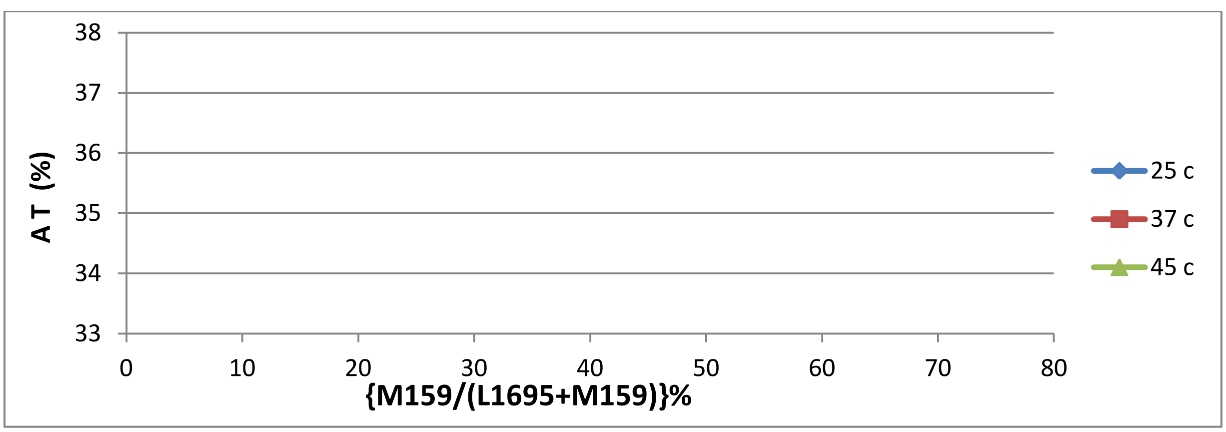


Figure 5.42: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/CCT.

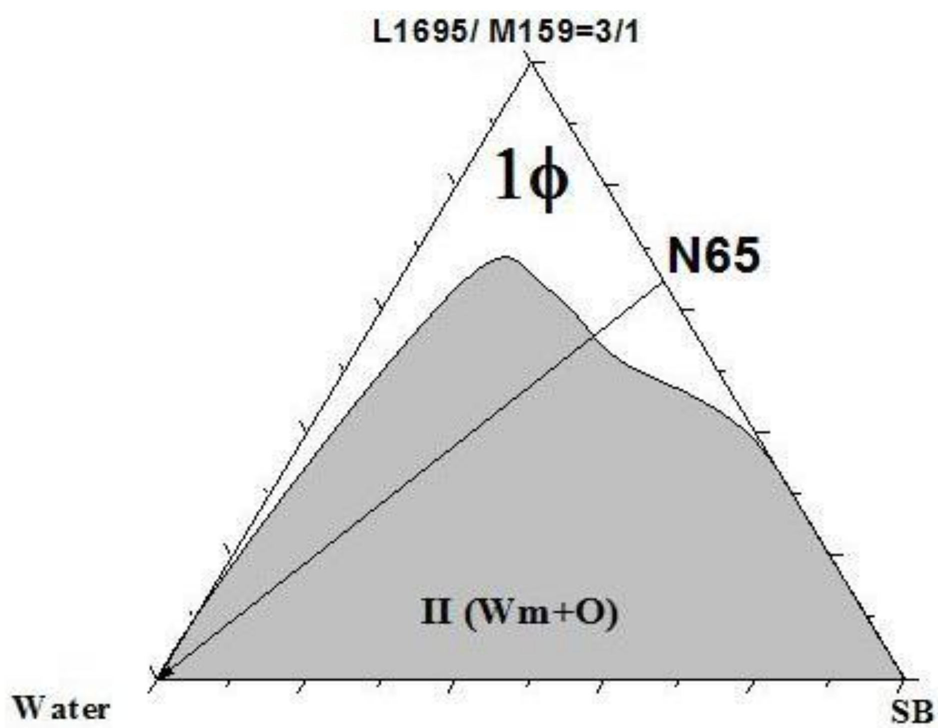
System#6 W/ L1695+M159/SB

Figure 5.43 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glycerol cocoate (M159) / soybean oil (SB). System at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

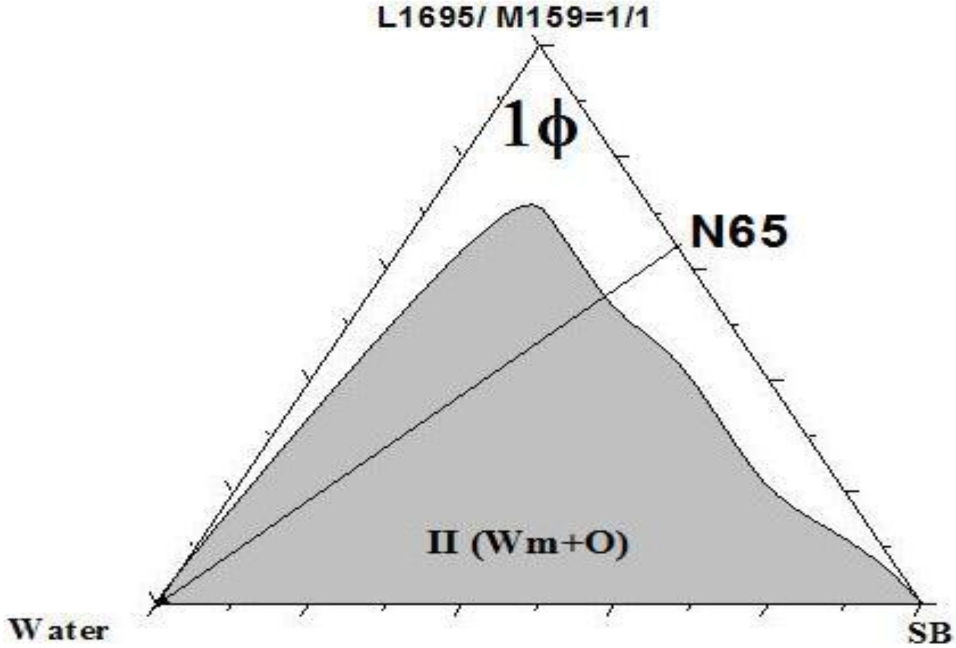
As show in Figure 5.43A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 14 wt% water along the dilution line N65.

For low mixed surfactants contents (below 62 wt %) a multiphase reign II (Wm+O) is observed.

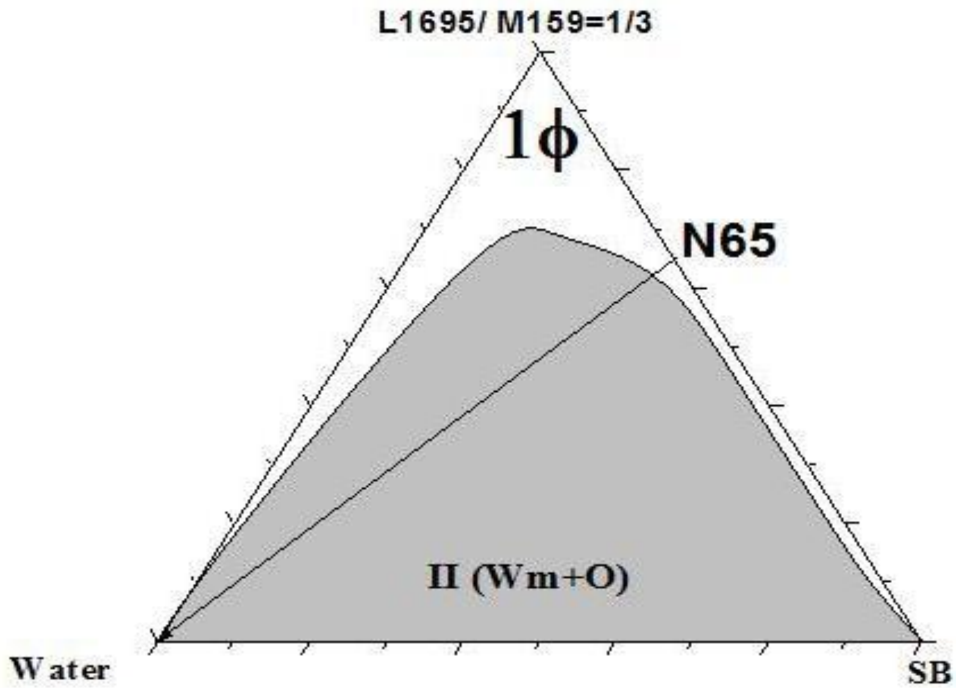
Some behavior is observed in Figure 5.43B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 55 wt%. In Figure 5.43C the one phase microemulsion region shrinks more compared to 5.43B.



(A)



(B)



(C)

Figure 5.43: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / soybean oil (SB). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/SB= 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table 5.12: The total monophasic area A_T (%) for the system W /L1695+M159/ SB at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
0	17	18	19
25	20	21	16
50	27	18	21
75	17	15	17
100	19	21	20

Figures 5.43 present the phase behaviors of the systems W/L1695+M159/triglyceride oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.44 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.12. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

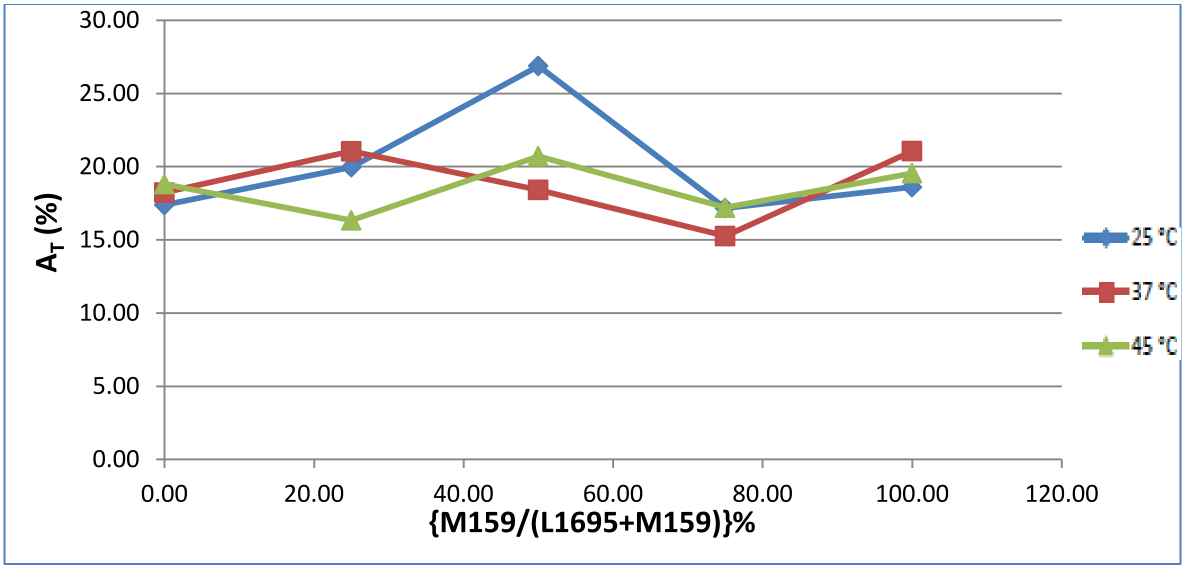


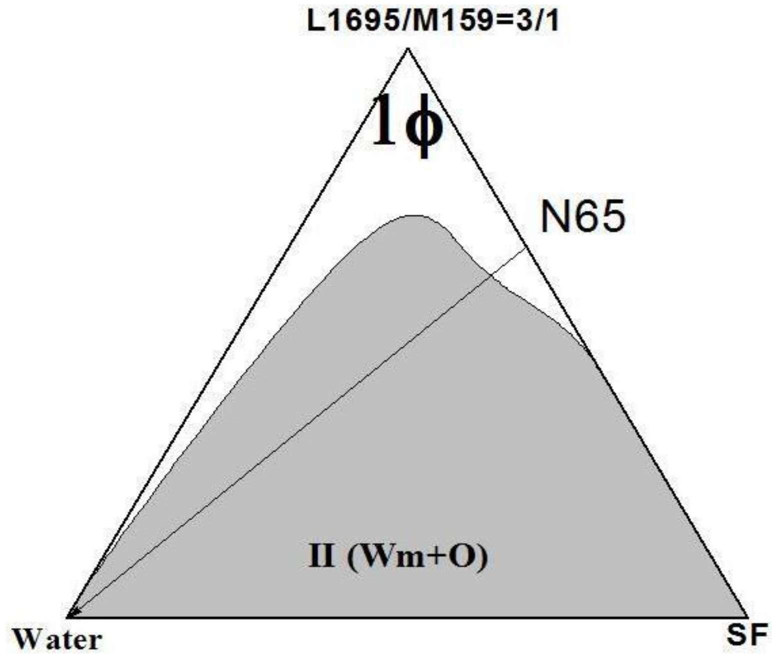
Figure 5.44: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/SB.

System#7 W/ L1695+M159/SF

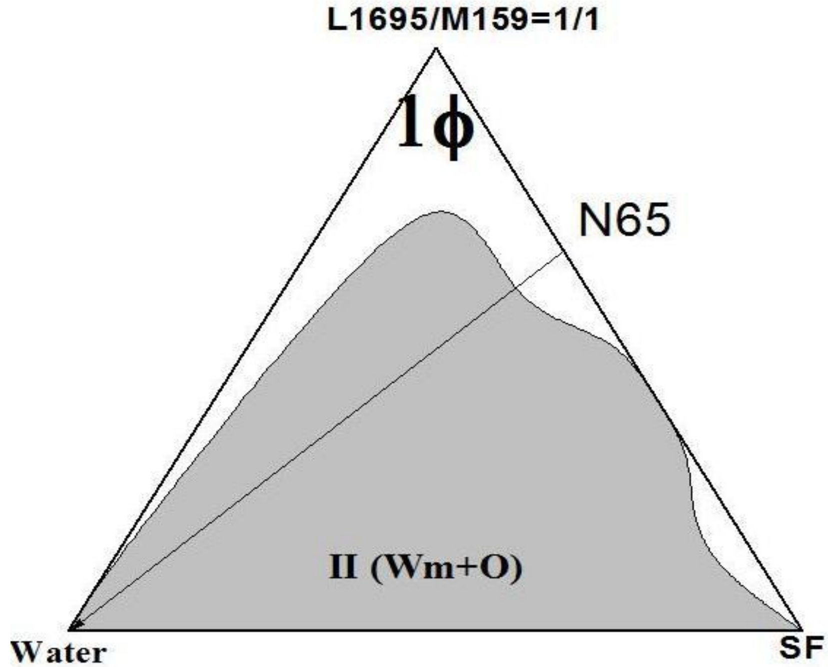
Figure 5.45 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glycerol cocoate (M159) / sunflower oil (SF). System at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

As show in Figure 5.45A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 9 wt% water along the dilution line N65For low mixed surfactants contents (below 60 wt %) a multiphase reign II (Wm+O) is observed.

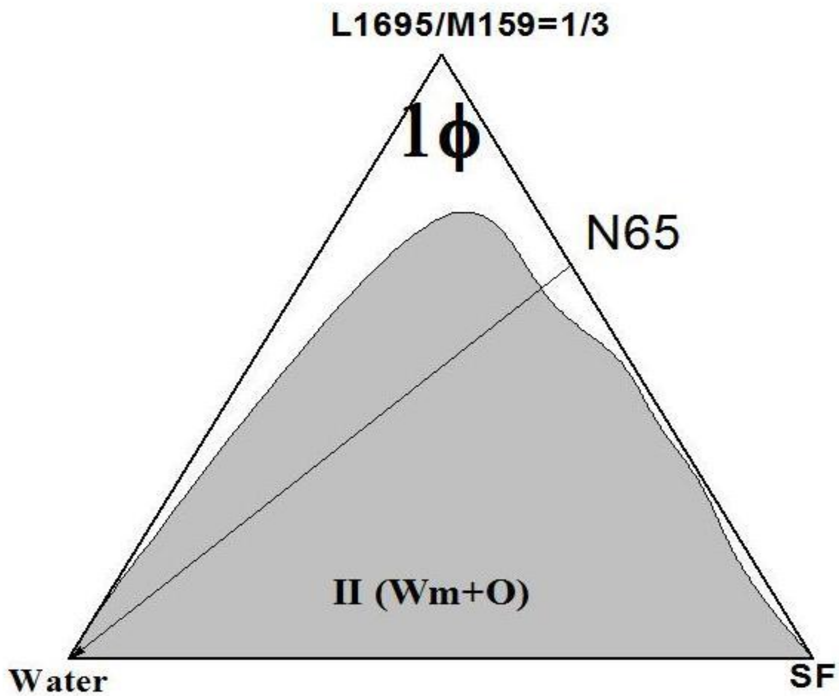
Some behavior is observed in Figure 5.45B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 60 wt%. In Figure 5.45C the one phase microemulsion region shrinks more compared to 5.45B.


L1695/M159=3/1
1ϕ
N65
II (Wm+O)
Water
SF

(A)


L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
SF

(B)



(D)

Figure 5.45: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / R(+)-limonene oil (LIM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/SF = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table5.13: The total monophasic area A_T (%) for the system W /L1695+M159/ SF at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
0	8	8	8
25	17	16	17
50	19	20	19
75	14	16	14
100	17	19	17

Figures 5.45 present the phase behaviors of the systems W/L1695+M159/triglyceride oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.46 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.13. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

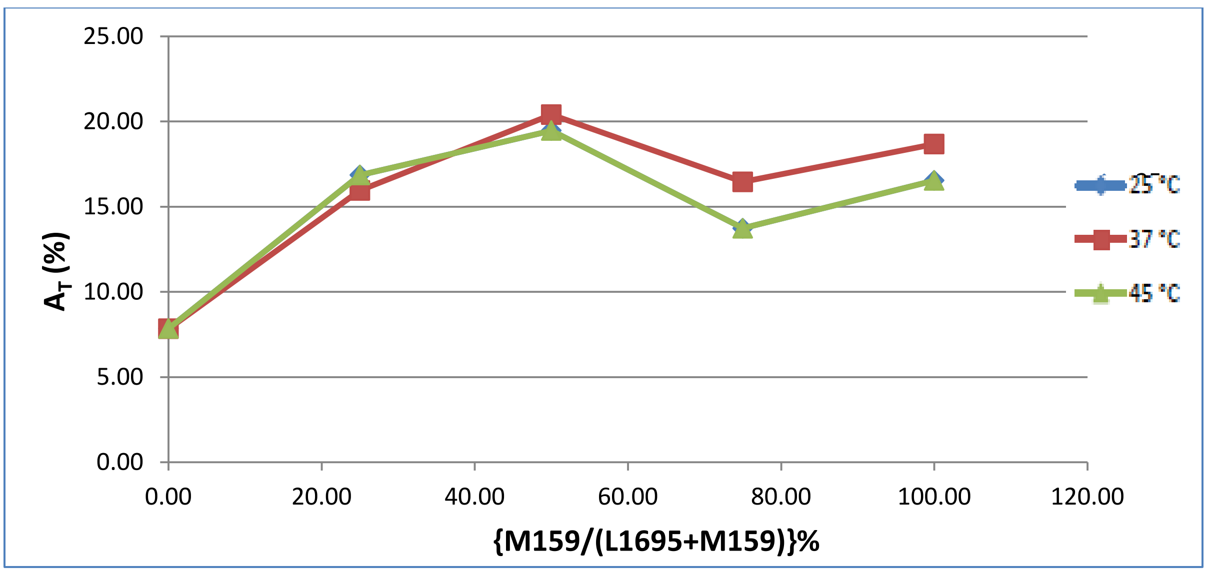


Figure 5.46: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/SF.

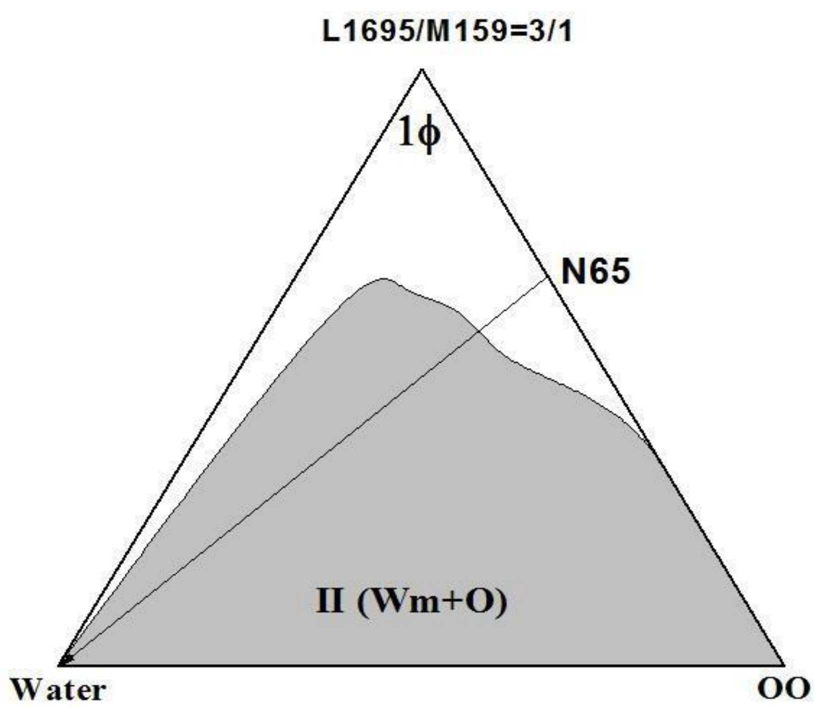
System#8 W/ L1695+M159/OO

Figure 5.47 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glycerol cocoate (M159) /olive oil (OO). System at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

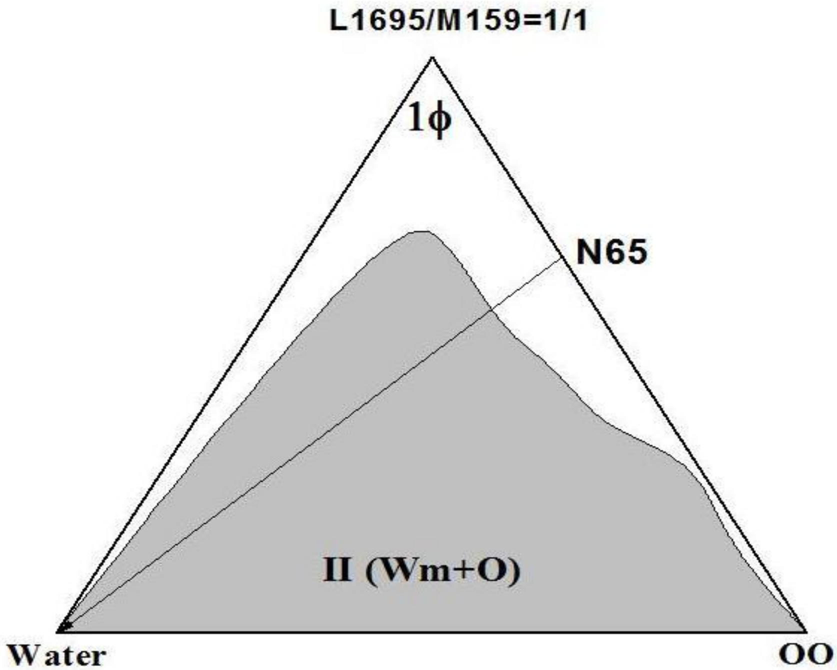
As show in Figure 5.47A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 12 wt% water along the dilution line N65.

For low mixed surfactants contents (below 58 wt %) a multiphase reign II (Wm+O) is observed.

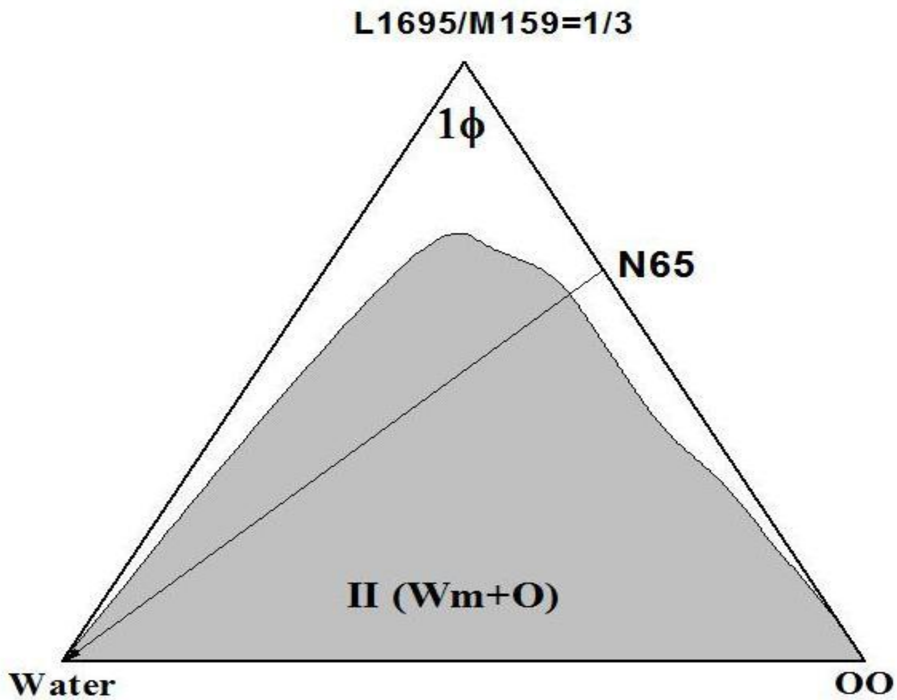
Some behavior is observed in Figure 5.47B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 57 wt%. In Figure 5.47C the one phase microemulsion region shrinks more compared to 5.47B.



(A)



(B)



(D)

Figure 5.47: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / olive oil (OO). The one phase region is designated by 1Φ, and the multiple phase

regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/OO = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table5.14: The total monophasic area A_T (%) for the system W /L1695+M159/ OO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
0	11	10	10
25	23	23	24
50	26	22	23
75	20	19	18
100	14	14	14

Figures 5.47 present the phase behaviors of the systems W/L1695+M159/triglyceride oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.48 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.14. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

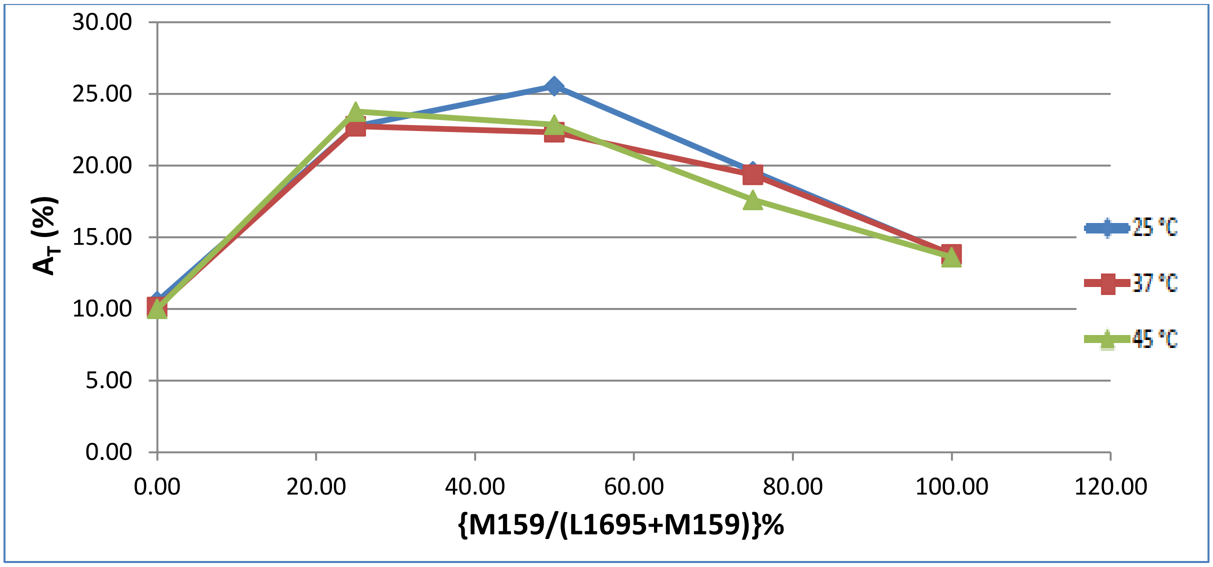


Figure 5.48: Variation of the total monophasic region A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/OO.

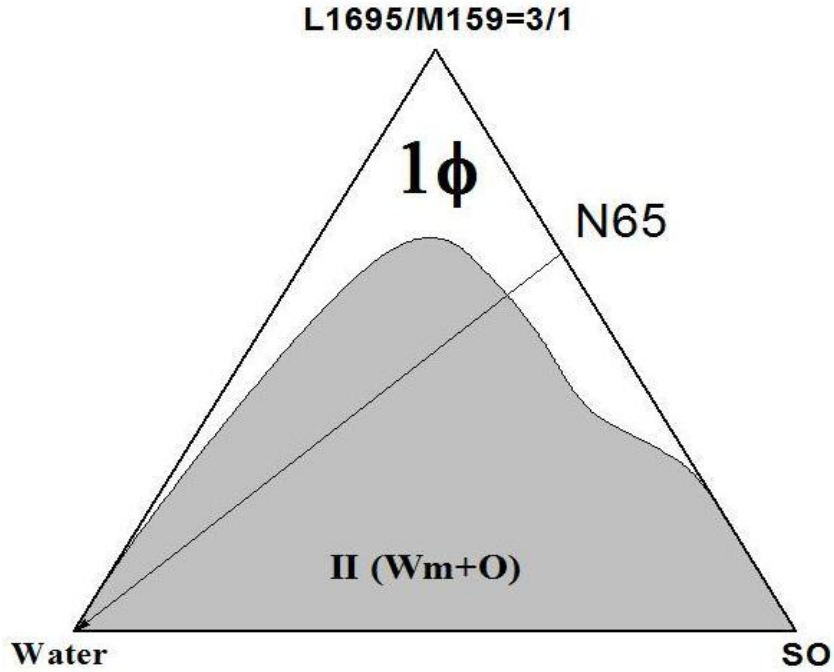
System#9 W/ L1695+M159/SO

Figure 5.49 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glycerol cocoate (M159) / sesame oil (SO). System at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

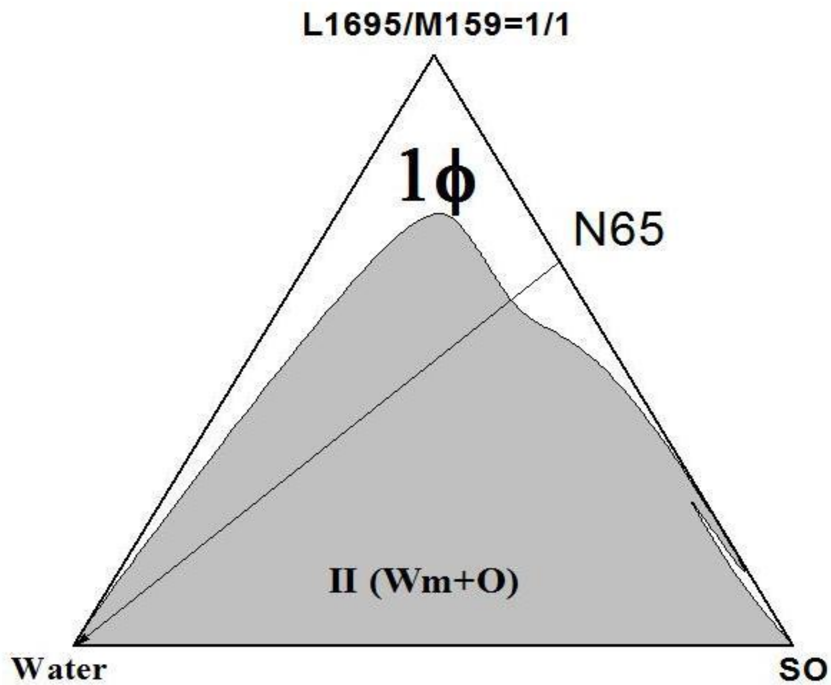
As show in Figure 5.49A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 10 wt% water along the dilution line N65.

For low mixed surfactants contents (below 58 wt %) a multiphase reign II (Wm+O) is observed.

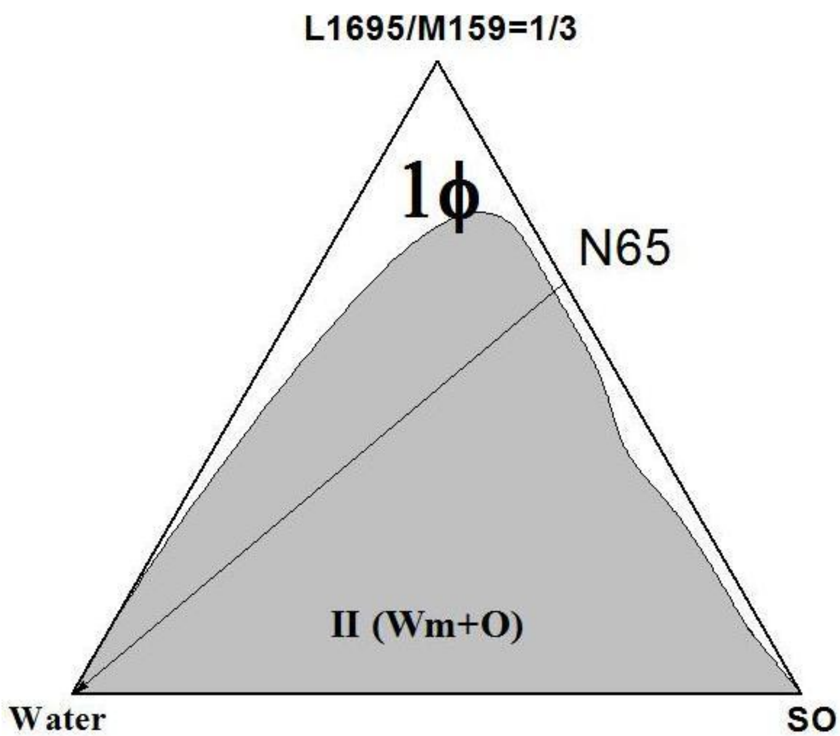
Some behavior is observed in Figure 5.49B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 59 wt%. In Figure 5.49C the one phase microemulsion region shrinks more compared to 5.49B.


L1695/M159=3/1
1ϕ
N65
II (Wm+O)
Water
SO

(A)


L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
SO

(B)



(C)

Figure 5.49: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / sesame oil (SO). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/SO = 65/35, L1695/M159: **(A) 75% (B) 50% (C) 25%.**

Table 5.15: The total monophasic area A_T (%) for the system W /L1695+M159/ SO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M159/L1695+M159)%	25°C	37°C	45°C
0	8	8	8
25	21	22	21
50	18	19	18
75	15	15	15
100	23	22	23

Figures 5.49 present the phase behaviors of the systems W/L1695+M159/triglyceride oil. The mixing ratio of (L1695/M159) equals (75, 50, and 25%) and Figures 5.50 represent the variation of

the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When PEG-7 glycerol cocoate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M159/L1695 equals maximum total area gave us the best result in Table 5.15. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperatures is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M159 with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

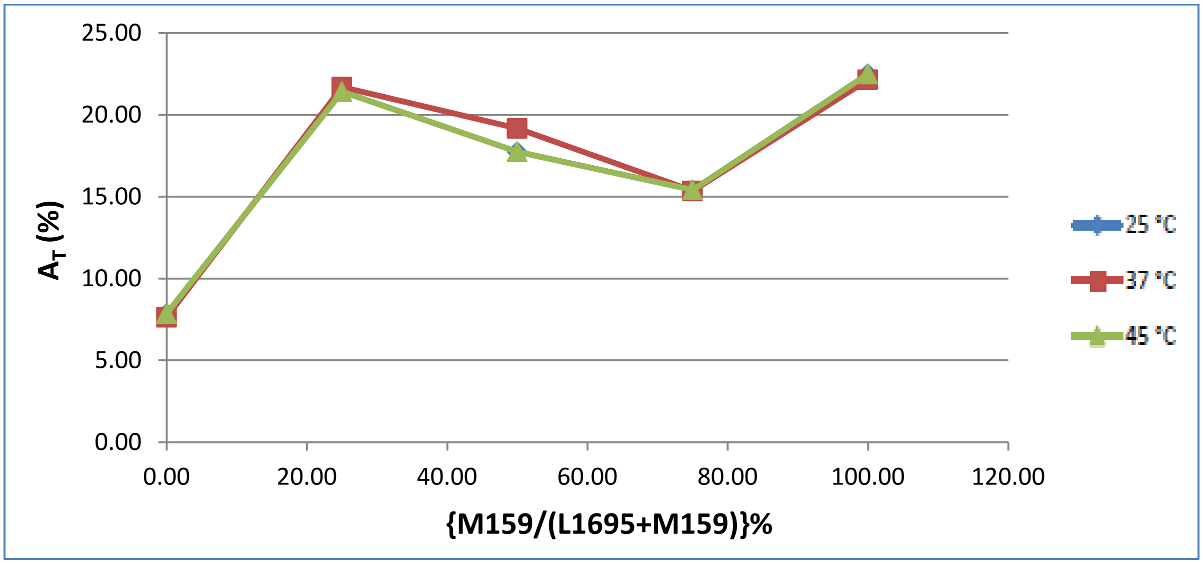


Figure 5.50: Variation of the total monophasic area A_T (%) as function PEG-7 glyceryl cocoate content in the surfactants mixture (L1695+M159) and as function of temperature for the system: W / L1695+M159/SO.

For the systems W/L1695/M159/triglycerides oil at 25°C the total monophasic area A_T (%) for the mixing ratios surfactant (M159/L1695=50%) the total monophasic area A_T (%) gave us the best result.

Table 5.16: The maximum total monophasic area A_T (%) for the system W /L1695+M159/ oil at mixed surfactant ratio at 25°C temperatures.

Oil	Maximum A_T (%) at 25°C	Mixed surfactant ratio that gave maximum A_T (%) value at 25°C M159/(M159+L1695)
MNT	56	1/3
LIM	58	3/1
ION	52	1/1
IPM	48	1/1
CCT	36	1/3
SB	27	1/1
SF	19	1/1
OO	26	1/1
SO	21	1/3

5.1.1.2.ii Mixed sucrose monolaurate and ethoxylated mono-di-glyceride

For microemulsion systems based on α-ionone (ION), adding ethoxylated mono-di-glyceride (EMDG) to the system W/L1695/ION enhances the formation of the one-phase microemulsion regions. This explained by the mixture of surfactants enhances the surfactants partitioning at the interface, thus increasing the stability of the amphiphilic film. It is considered that the surfactant monolayers at the interface of water and oil domains inside the microemulsions are directly related to the solubilization of water and oil. The monomeric solubilities of L1695 in both oil and water are low and this quite different from that of EMDG which is completely soluble in both oil and water so that the blend of surfactants affect the packing parameter of the mixed surfactants in a manner that more water can be solubilized in the microemulsion droplets. From Figures (5.51) presents the phase diagram of the system W/L1695+EMDG/ION at 25°C. Figure (5.52) represents the variation of the total one-phase area A_T (%) as function of ethoxylated mono-di-glyceride content in the mixed surfactants and as function of temperature for the W/L1695+EMDG/ION system the total monophasic area A_T (%) at 25°C L1695 content equals 24%, for EMDG content in the mixture of mixed surfactants equals 25 wt.% the total monophasic area A_T (%) equals 18%, at equal amounts of EMDG and L1695 in the surfactant mixture, the total monophasic area A_T (%) equals 33% and for EMDG content equals 75 wt.% the total monophasic area A_T (%) equals 41% and for EMDG equals equal 100 wt.% 35%.

The monomeric solubility of lipophilic surfactant (ethoxylated mono-di-glyceride) in α-ionone and its mixing with sucrose laurate enables us to obtain large solubilization capacity of water and oil observed that when the mixing ratio of nonionic surfactant L1695 and EMDG 1/3 unity.

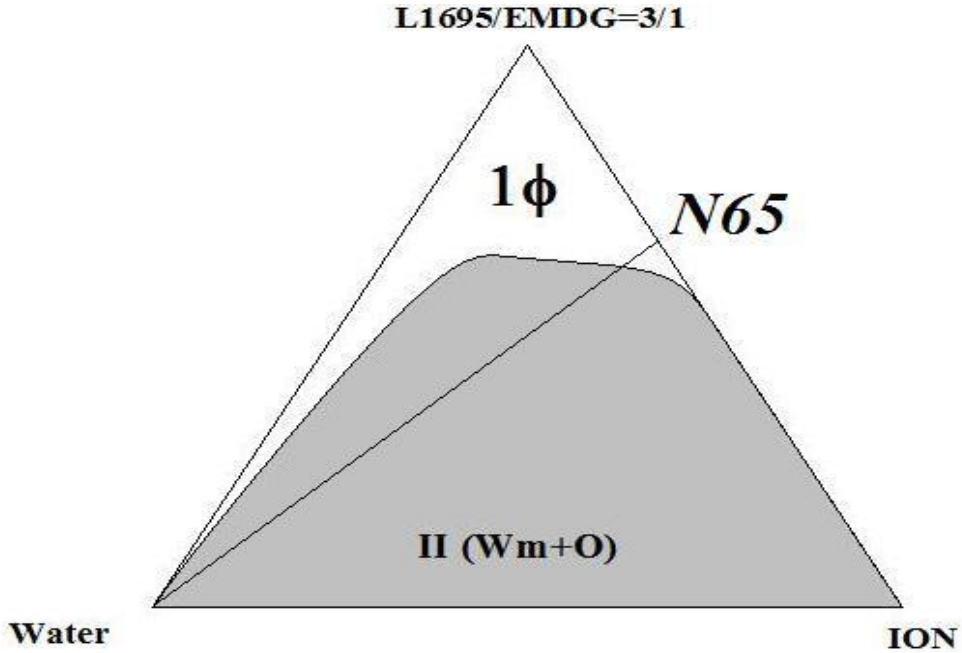
System#1 W/ L1695+EMDG/ION

Figure 5.51 present the phase diagram of the water/ sucrose monolaurate (L1695) + ethoxylated mono-di glyceride (EMDG)/α-ionone (ION). System at different weight ratios of L1695/M159 that are (A) 3/1 (B) 1/1 (C) 1/3.

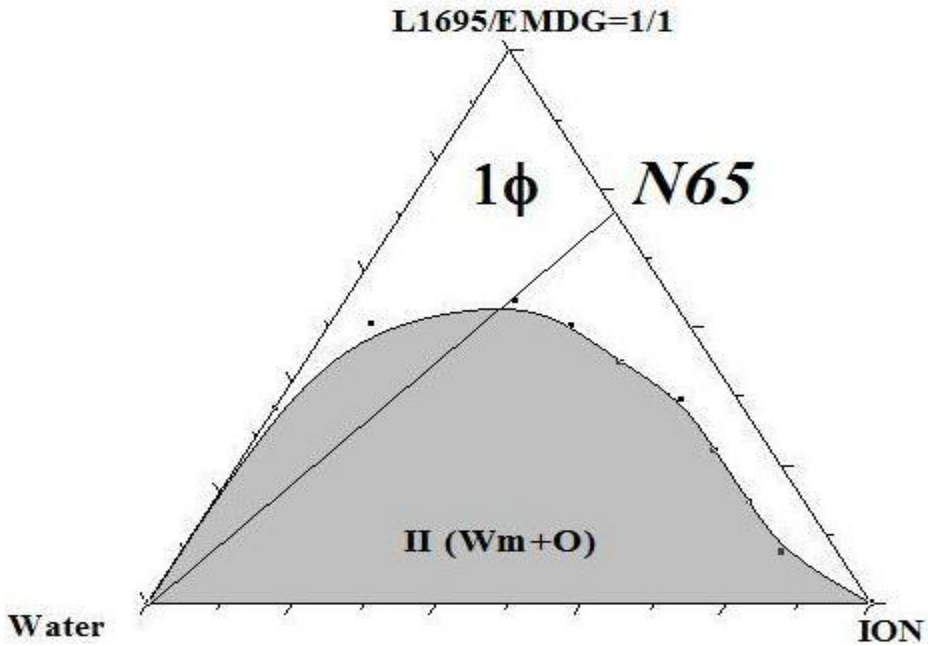
As show in Figure 5.51A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 9 wt% water along the dilution line N65.

For low mixed surfactants contents (below 60 wt %) a multiphase reign II (Wm+O) is observed.

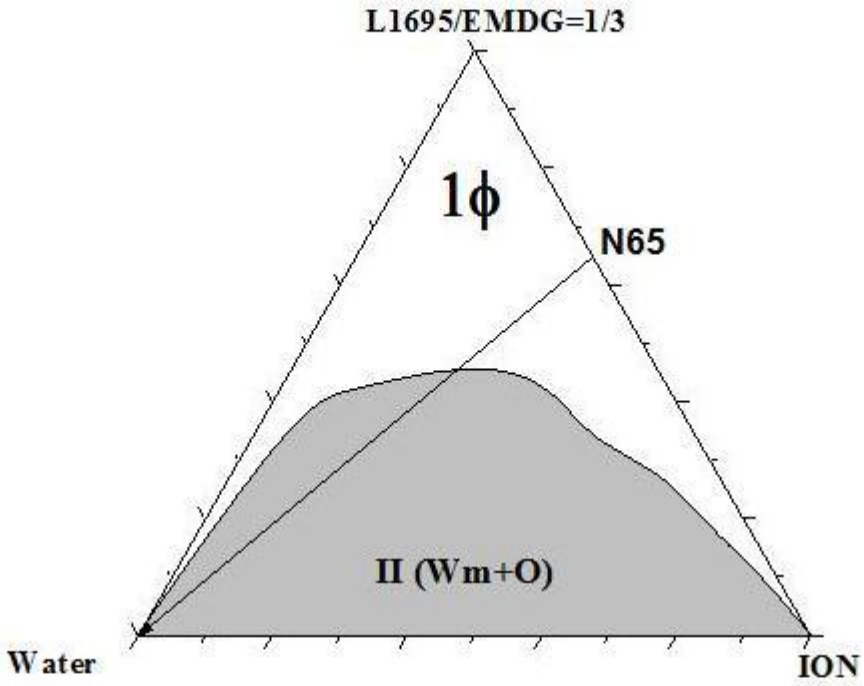
Some behavior is observed in Figure 5.51B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 52 wt%. In Figure 5.51C the one phase microemulsion region increase more compared to 5.51B.


L1695/EMDG=3/1
1ϕ
N65
II (Wm+O)
Water
ION

(A)


L1695/EMDG=1/1
1ϕ
N65
II (Wm+O)
Water
ION

(B)



(C)

Figure 5.51: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + ethoxylated mono-di glyceride (EMDG) / α-ionone (ION). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+EMDG)/ION = 65/35, L1695/EMDG: **(A) 75% (B) 50% (C) 25%.**

Table 5.17: The total monophasic area A_T (%) for the system W /L1695+EMDG/ ION at different mixing ratios of mixed surfactants and at different temperatures.

	(A_T) %		
(EMDG/L1695+EMDG)%	25°C	37°C	45°C
0	24	33	33
25	18	18	26
50	33	39	39
75	41	41	44
100	35	29	29

Figures 5.51 present the phase behaviors of the systems W/L1695+EMDG/ION. The mixing ratio of (L1695/EMDG) equals (75, 50, and 25%) and Figures 5.52 represent the variation of the total

monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When ethoxylated mono-di glyceride mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios EMDG/L1695 equals maximum total area gave us the best result in Table 5.17. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature sensitive system due to the ability of thermal motion upon heating and the hydrophilic-lipohilic balance of EMDG changes with temperature due to the dehydration of the polyethylene group which makes EMDG more lipophilic with increasing temperature. This behavior an advantage for this mixture of surfactants.

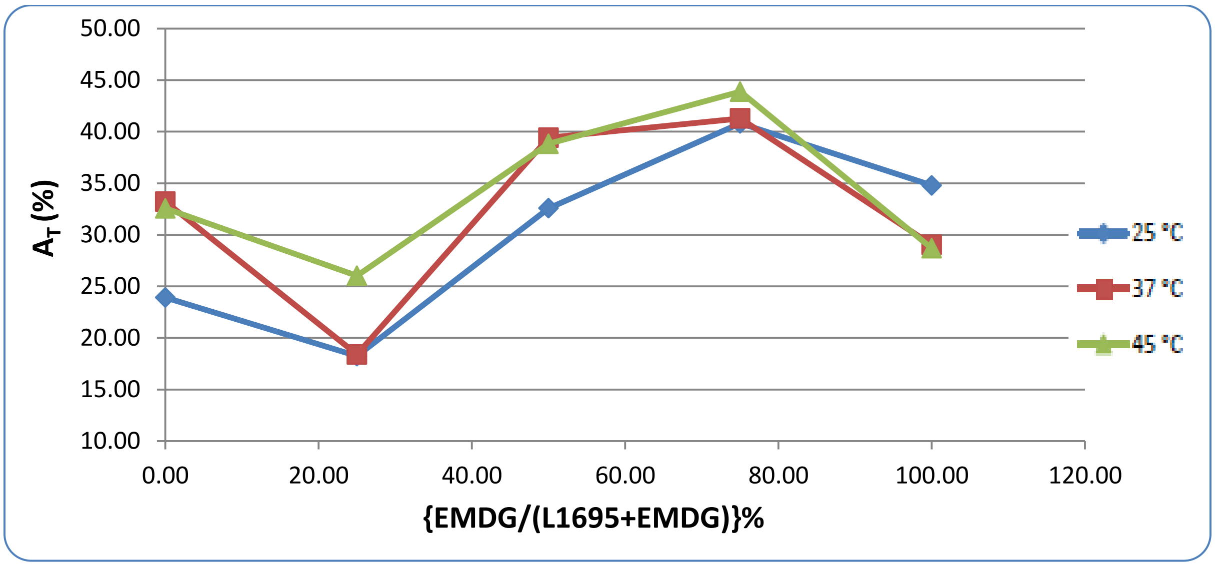


Figure 5.52: Variation of the total monophasic area A_T (%) as function of ethoxylated mono-di glyceride content in the surfactants mixture (L1695+EMDG) and as function of temperature for the system: W / L1695+EMDG/ ION.

For the systems W/L1695+EMDG/α-ionone oil at 25°C the total monophasic area A_T (%) reach's a maximum for at the surfactant mixing ratio (M159/L1695=75%).

5.1.1.2.iii Mixed sucrose monolaurate and glycerol monooleate.

The average HLB number of about 9.9 and the maximum total aria A_T (%) in ratio between L1695/M300K is equal 1/3 that mixing gave better solubilization behavior than prescribing one type of surfactant.

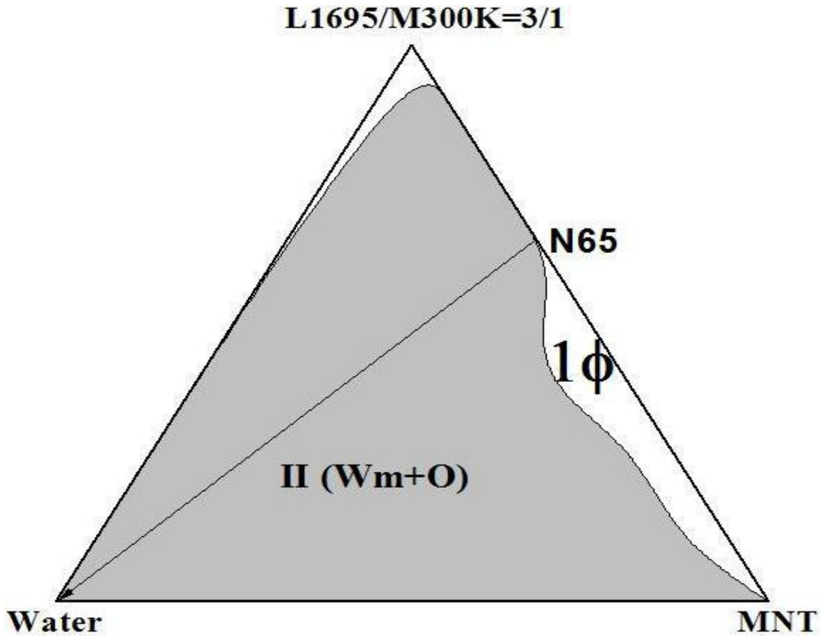
System#1W/ L1695+M300K/MNT

Figure 5.53 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/peppermint oil (MNT). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

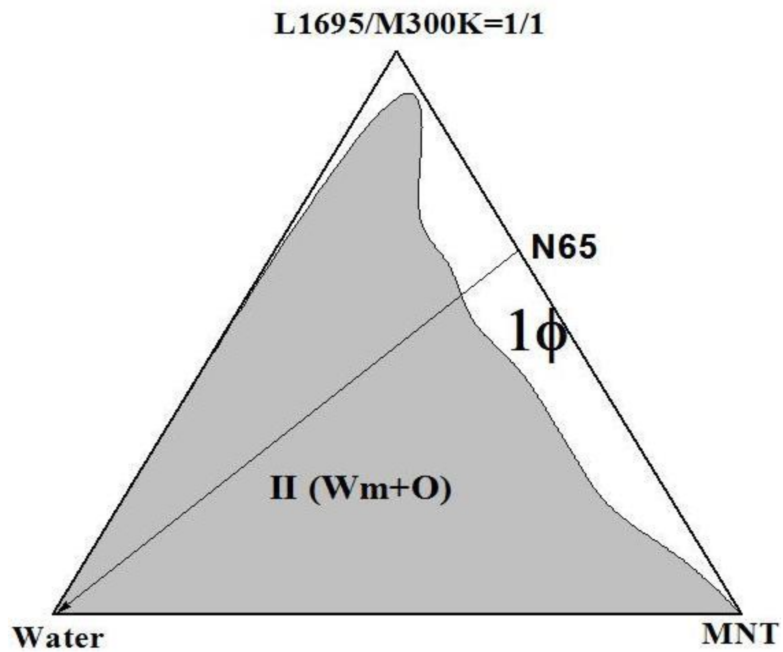
As show in Figure 5.53A, the one phase microemulsion region does not appear from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.

For low mixed surfactants contents (below 58 wt %) a multiphase reign II (Wm+O) is observed.

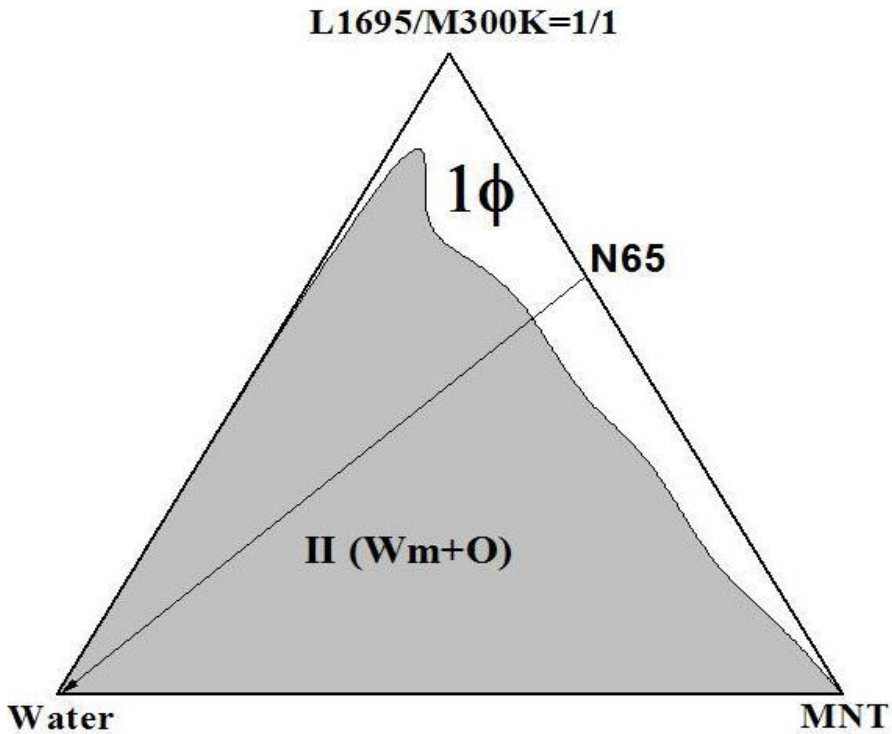
Some behavior is observed in Figure 5.53B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 58wt%. In Figure 5.53C the one phase microemulsion region not change compared to 5.53B.


L1695/M300K=3/1
N65
1ϕ
II (Wm+O)
Water
MNT

(A)


L1695/M300K=1/1
N65
1ϕ
II (Wm+O)
Water
MNT

(B)



(c)

Figure 5.53: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ peppermint oil (MNT). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/MNT = 65/35, L1695/ M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.18: The total monophasic area A_T (%) for the system W/L1695+M300K/MNT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	7	7	8
50	16	19	19
75	16	21	20
100	4	4	4

Figures 5.53 present the phase behaviors of the systems W/L1695+M300K/MNT. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.54 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.18. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

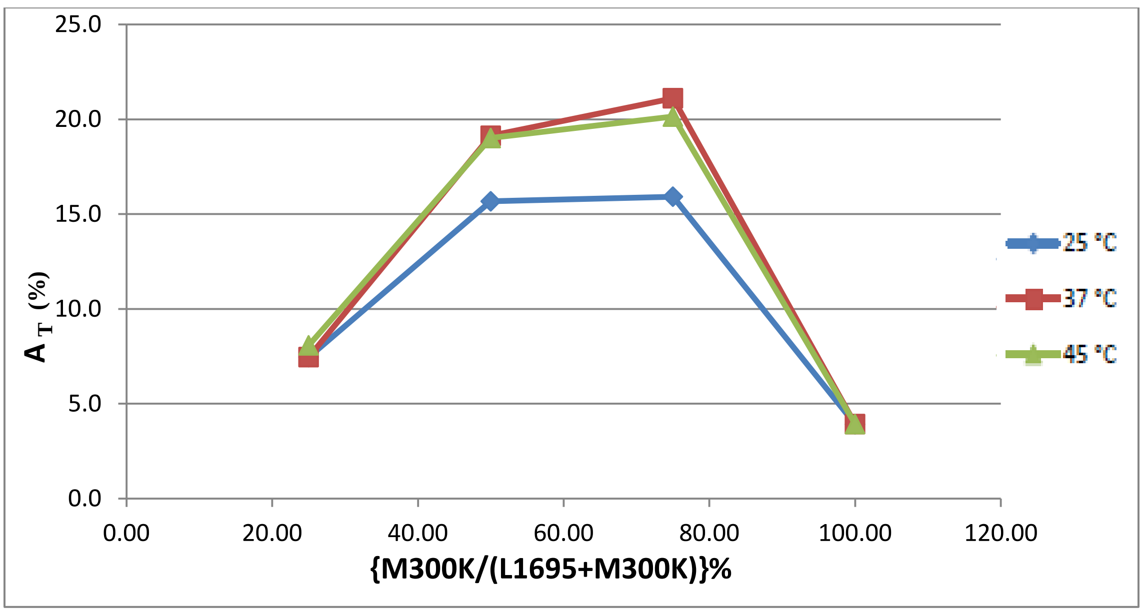
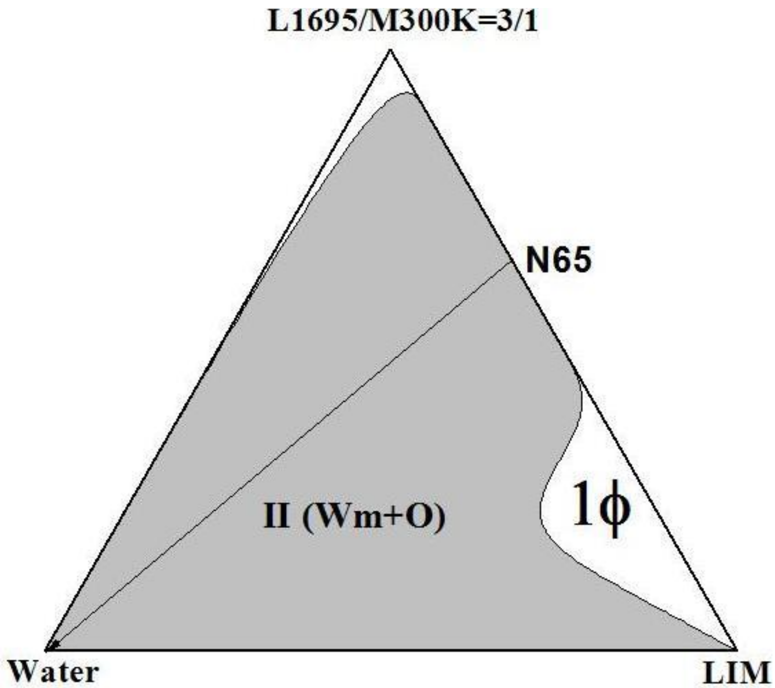


Figure 5.54: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/ MNT.

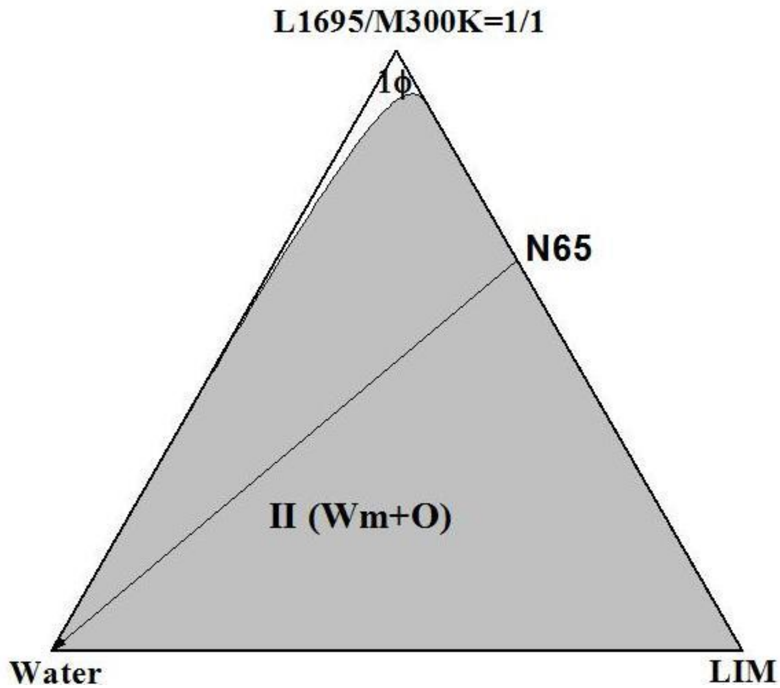
System#2W/ L1695+M300K/LIM

Figure 5.55 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/R(+)-limonene oil (LIM). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

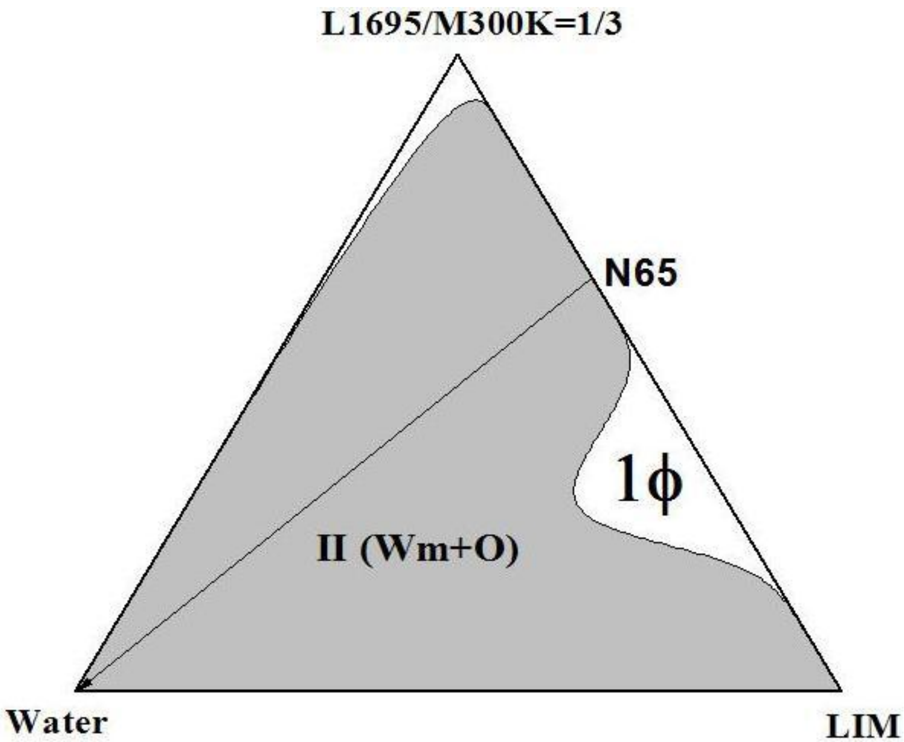
As show in Figure 5.55, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.



(A)



(B)



(C)

Figure 5.55: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ R (+)-limonene oil (LIM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/LIM = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table5.19: The total monophasic area A_T (%) for the system W/L1695+M300K/LIM at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	9	9	9
50	9	10	10
75	9	10	10
100	7	7	7

Figures 5.55 present the phase behaviors of the systems W/L1695+M300K/LIM. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.56 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.19. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

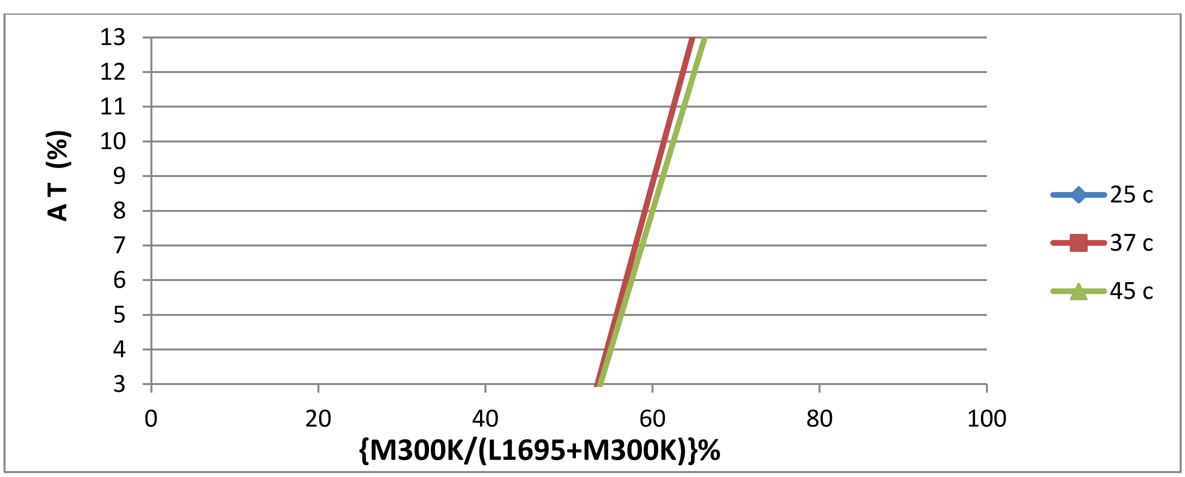
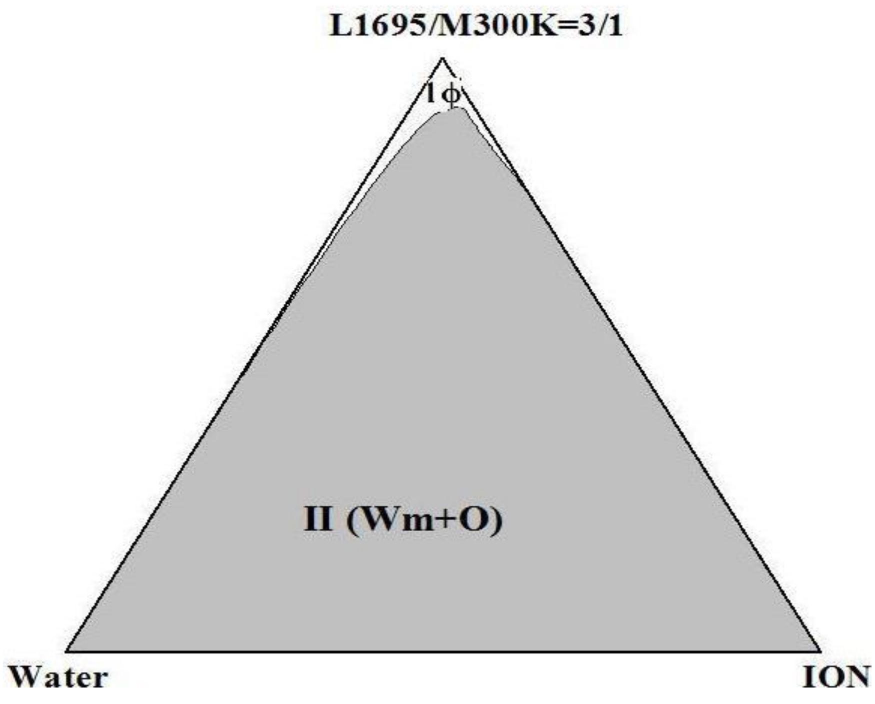


Figure 5.56: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/LIM.

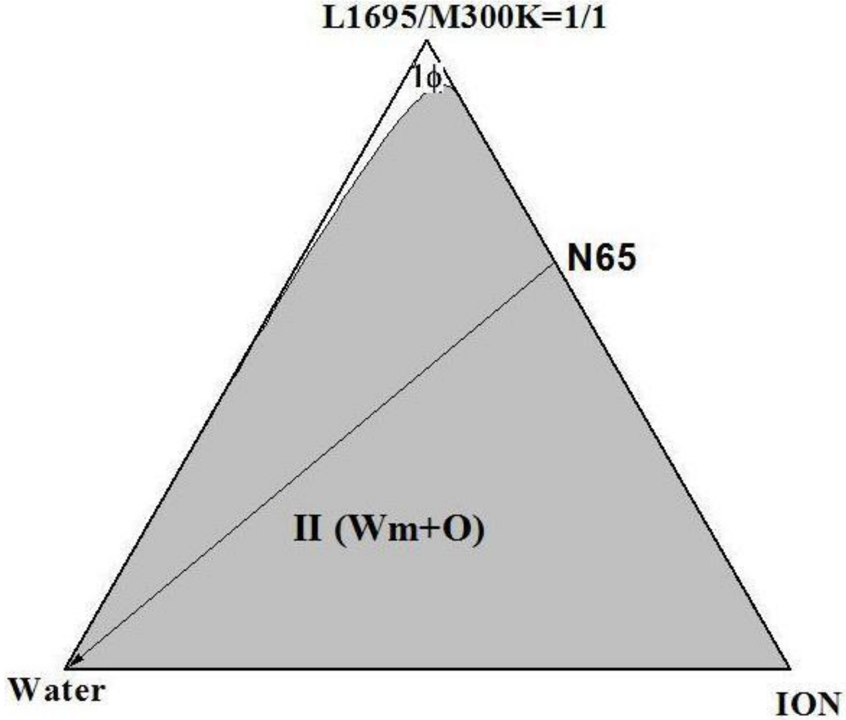
System#3W/ L1695+M300K/ION

Figure 5.57 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/α-ionone oil (ION). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

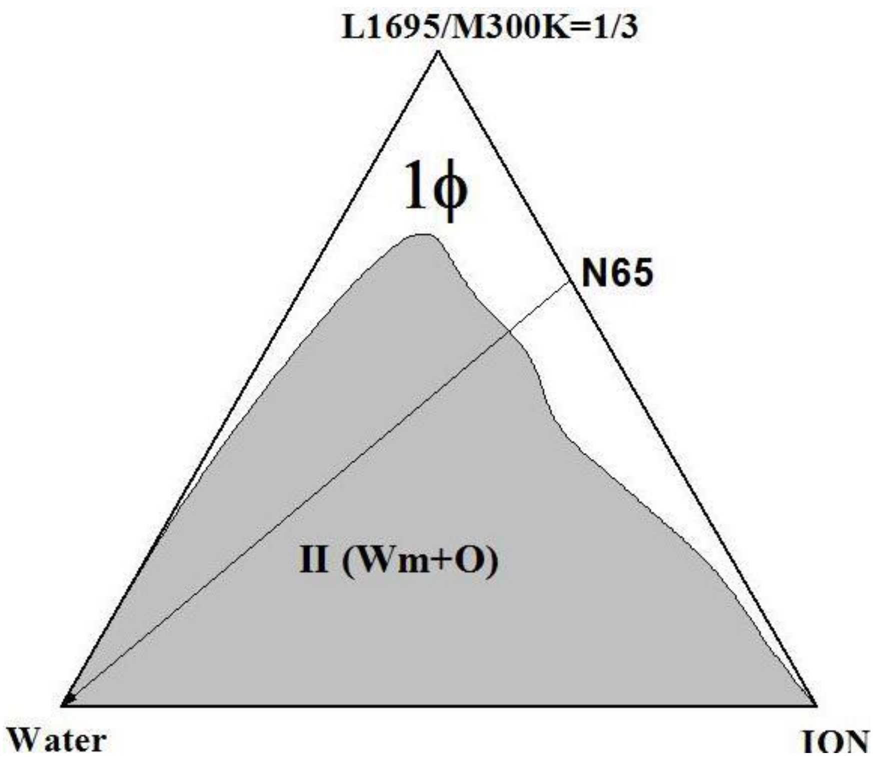
As show in Figure 5.57, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, but in Figure 5.59C show one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, for low mixed surfactants contents (below 58 wt %) a multiphase reign II (Wm+O) is observed.



(A)


L1695/M300K=1/1
1ϕ
N65
II (Wm+O)
Water
ION

(B)


L1695/M300K=1/3
1ϕ
N65
II (Wm+O)
Water
ION

(C)

Figure 5.57: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ α-ionone oil (ION). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/ION = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.20: The total monophasic area A_T (%) for the system W/L1695+M300K/ION at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	22	22	20
100	20	20	20

Figures 5.57 present the phase behaviors of the systems W/L1695+M300K/ION. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.58 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.20 when mixed M300K/L1695 equals 75 %. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

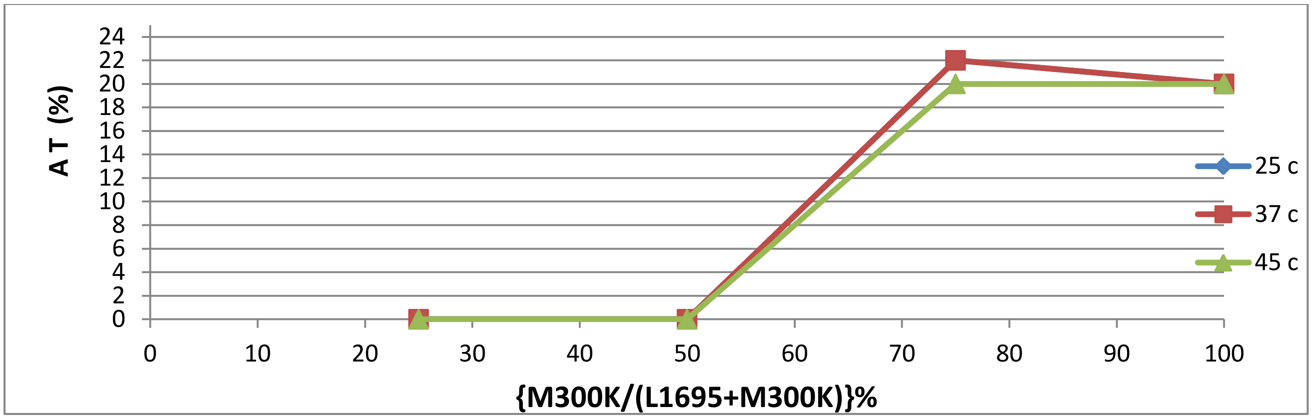
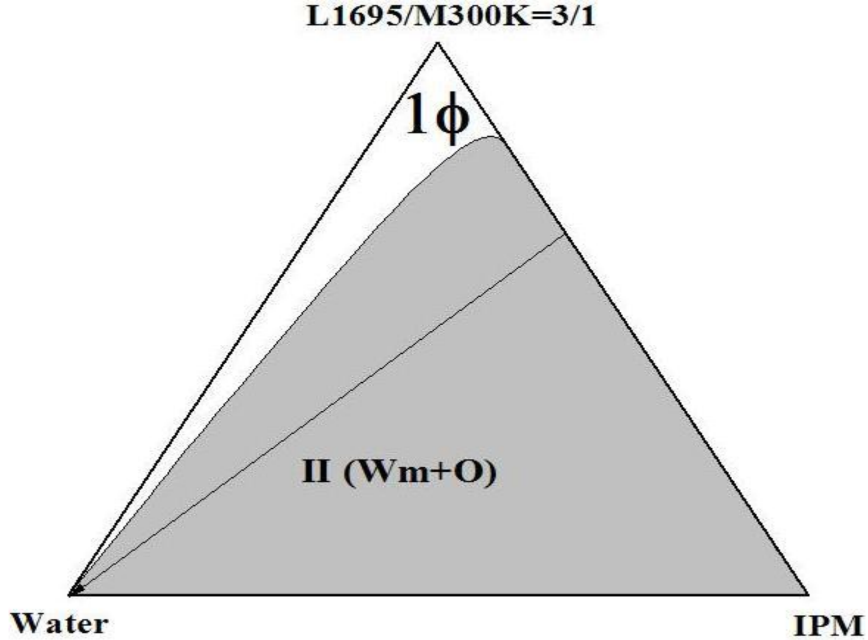


Figure 5.58: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/ION.

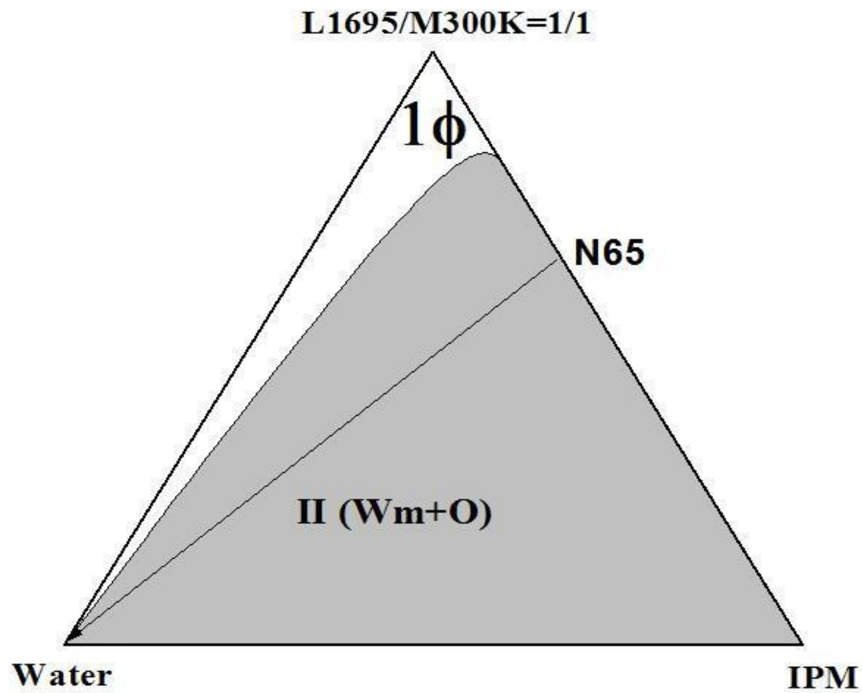
System#4W/ L1695+M300K/IPM

Figure 5.59 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ isopropylmyristate (IPM).System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

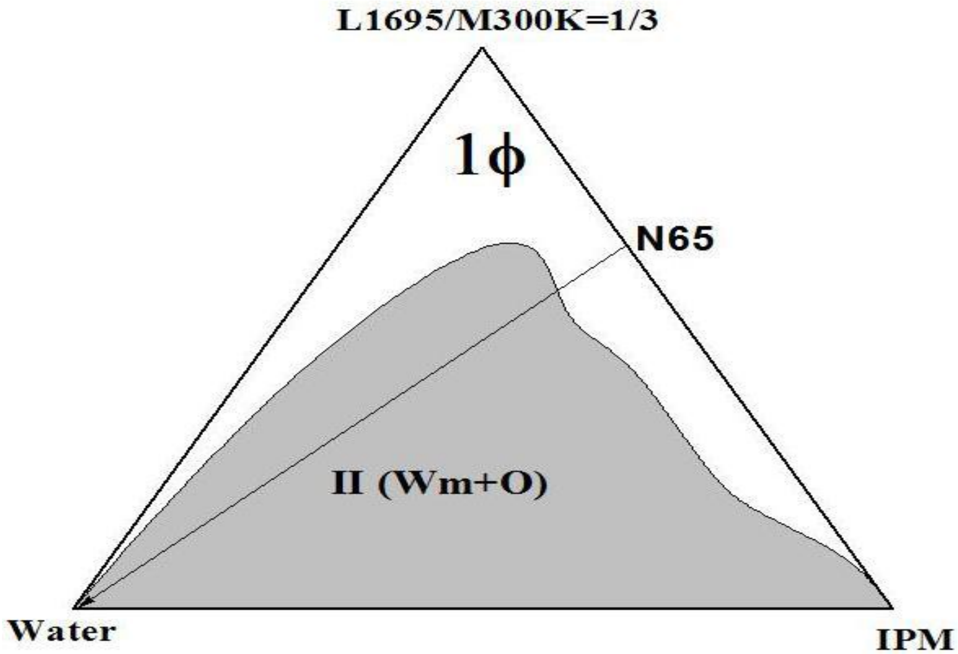
As show in Figure 5.59, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, but in Figure 5.59C show one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.


L1695/M300K=3/1
1ϕ
II (Wm+O)
Water
IPM

(A)


L1695/M300K=1/1
1ϕ
N65
II (Wm+O)
Water
IPM

(B)



(C)

Figure 5.59: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/isopropylmyristate (IPM).The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/IPM = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.21: The total monophasic area A_T (%) for the system W/L1695+M300K/IPM at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	18	18	16
100	3	3	3

Figures 5.59 present the phase behaviors of the systems W/L1695+M300K/IPM. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.60 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.21 when mixed M300K/L1695 equals 75 %. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

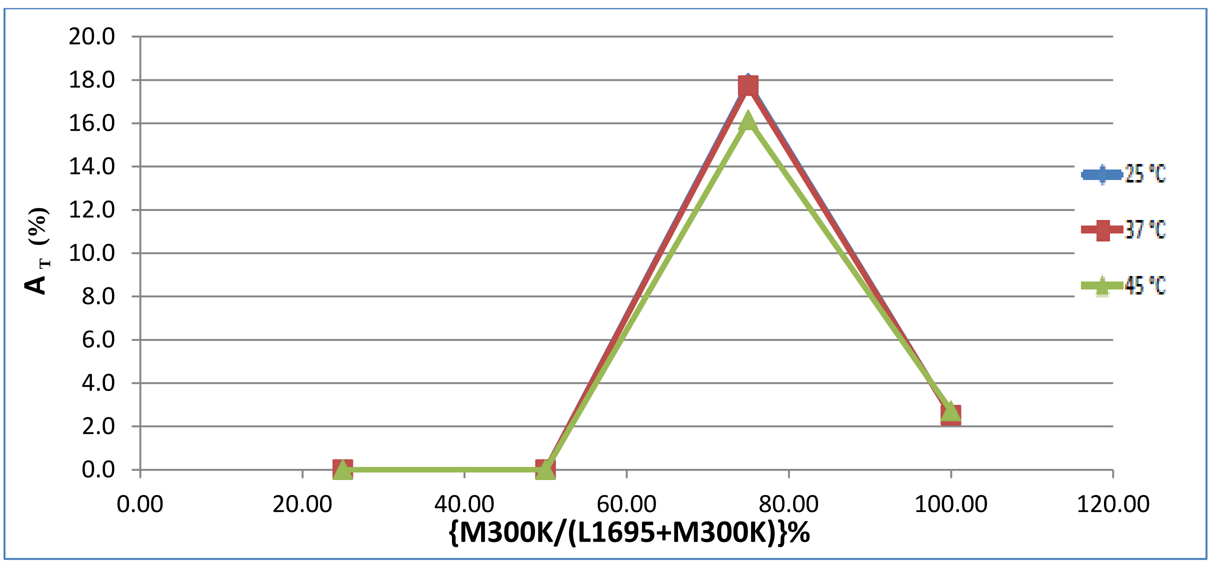
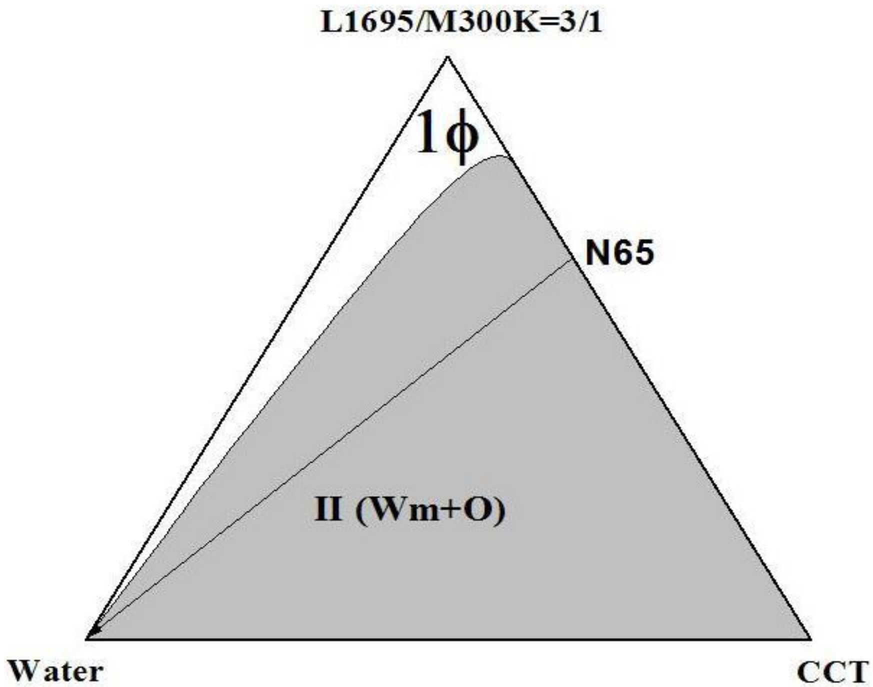


Figure 5.60: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/IPM.

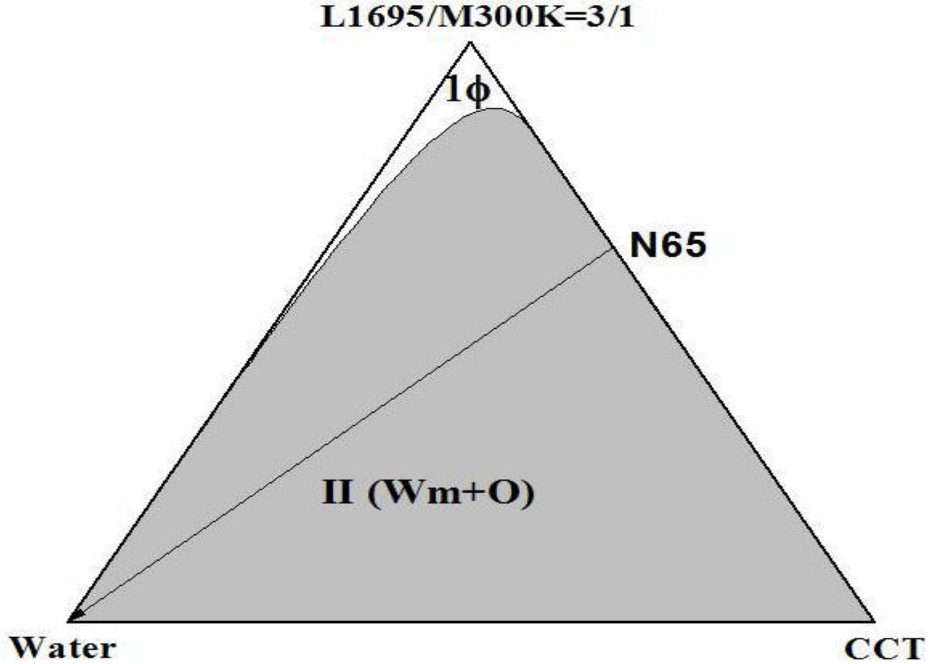
System#5 W/ L1695+M300K/CCT

Figure 5.61 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/caprylic-capric triglyceride oil (CCT). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

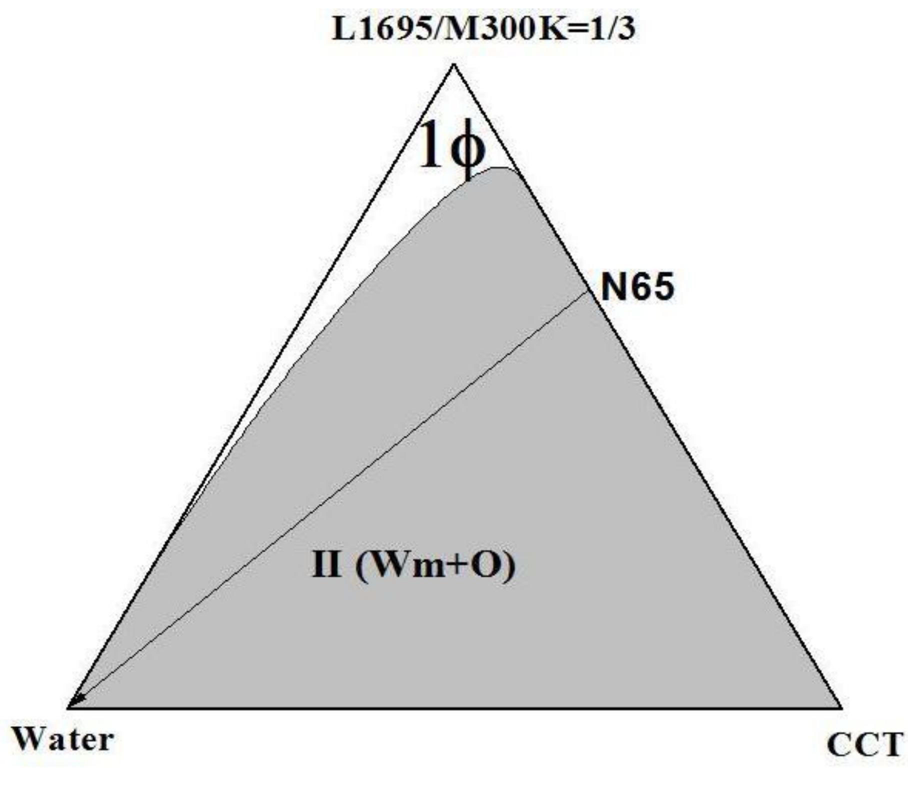
As show in Figure 5.61, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.



(A)



(B)



(C)

Figure 5.61: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/caprylic-capric triglyceride oil (CCT). The one phase region is designated

by 1Φ, and the multiple phase regions are designated by II (Wm+O).N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/CCT = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.22: The total monophasic area A_T (%) for the system W/L1695+M300K/CCT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	6	6	10
100	4	4	4

Figures 5.61 present the phase behaviors of the systems W/L1695+M300K/CCT. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.62 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.22 when mixed M300K/L1695 equals 75 %. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

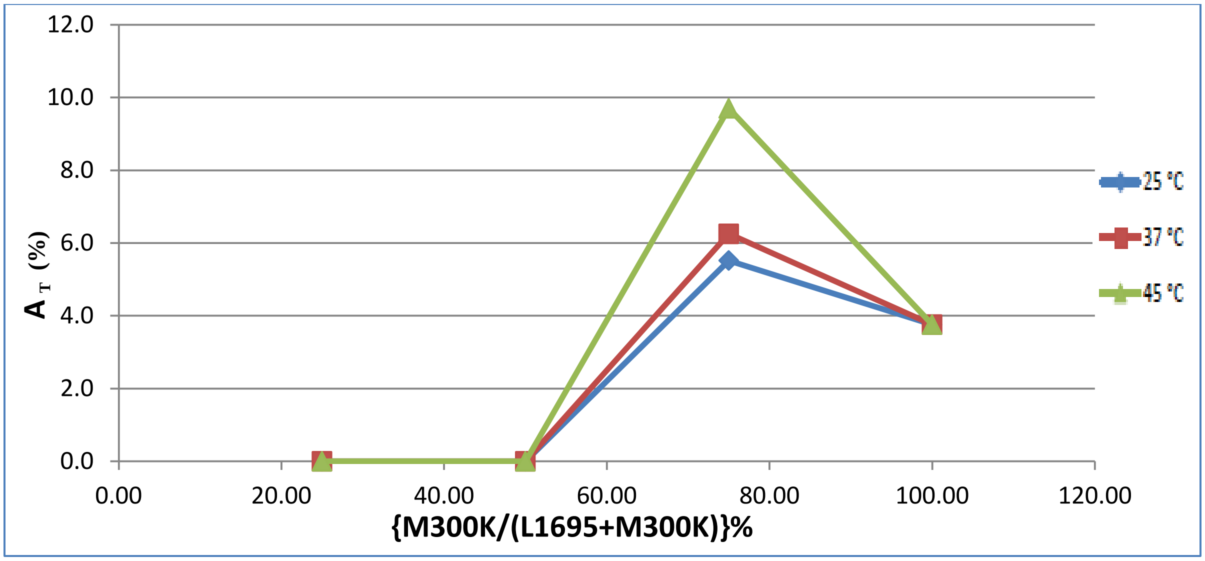
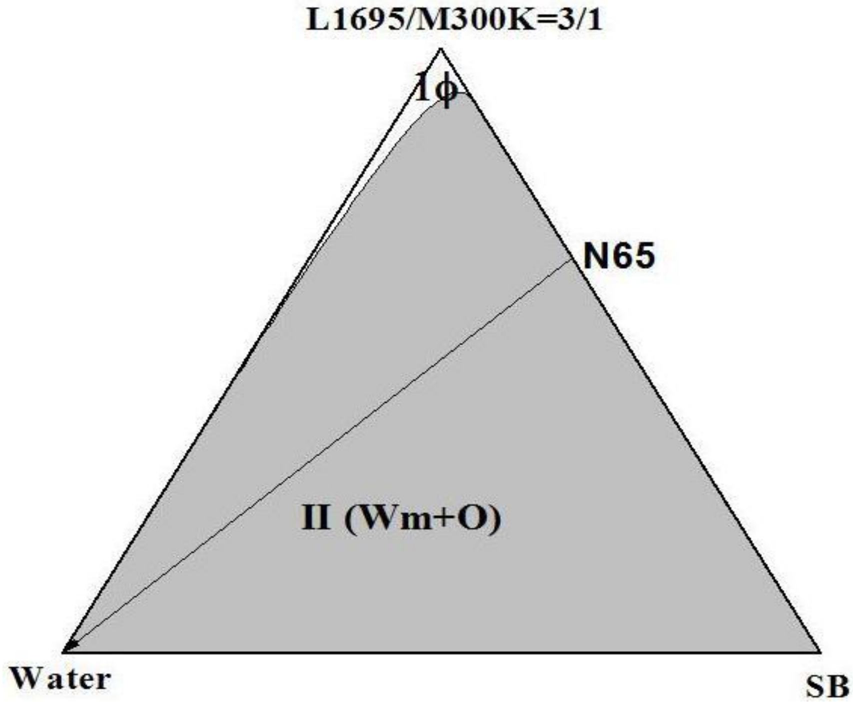


Figure 5.62: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/CCT.

System#6 W/ L1695+M300K/SB

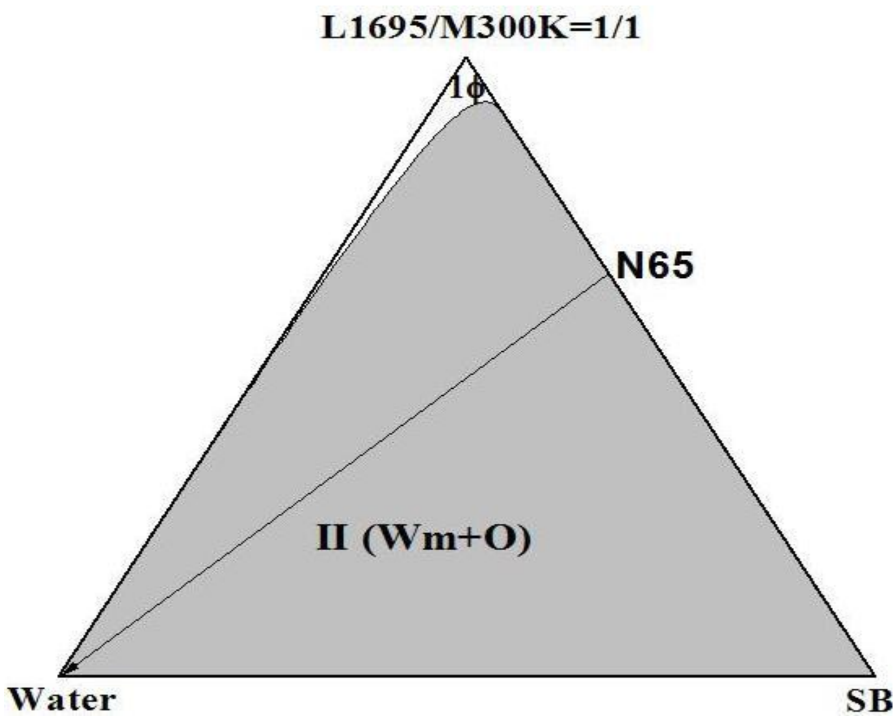
Figure 5.63 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ soya bean oil (SB). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

As show in Figure 5.63, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, but in Figure 5.63C show one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, for low mixed surfactants contents (below 62 wt %) a multiphase reign II (Wm+O) is observed.



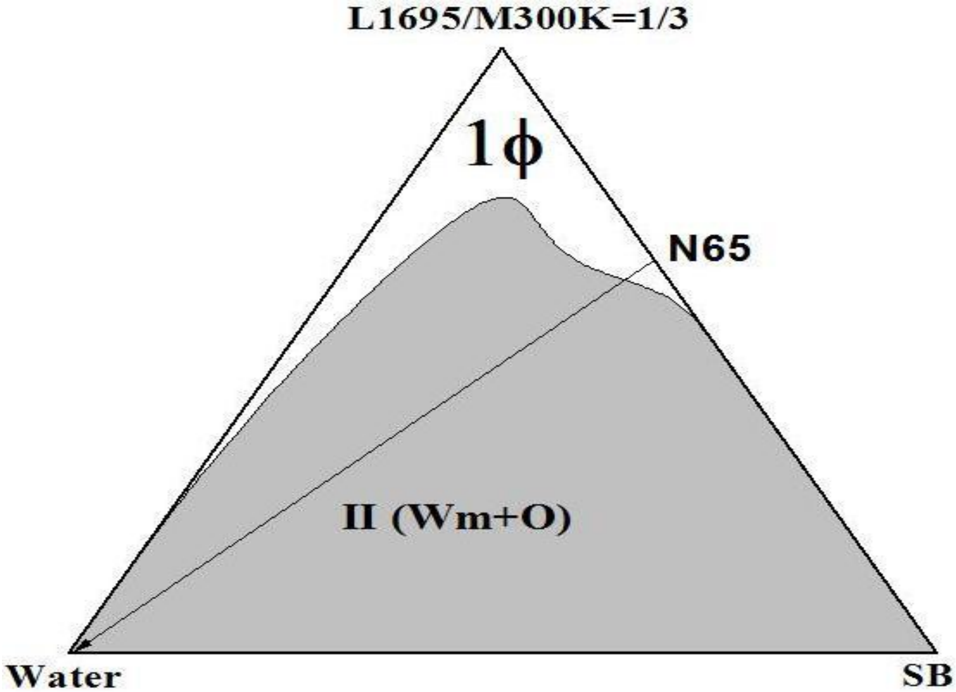
L1695/M300K=3/1
1ϕ
N65
II (Wm+O)
Water
SB

(A)



L1695/M300K=1/1
1ϕ
N65
II (Wm+O)
Water
SB

(B)



(C)

Figure 5.63: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/Soya bean oil (SB). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/SB = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.23: The total monophasic area A_T (%) for the system W/L1695+M300K/SB at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	13	13	13
100	4	4	4

Figures 5.63 present the phase behaviors of the systems W/L1695+M300K/SB. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.64 represent the variation of the total

monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.23 when mixed M300K/L1695 equals 75 %. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

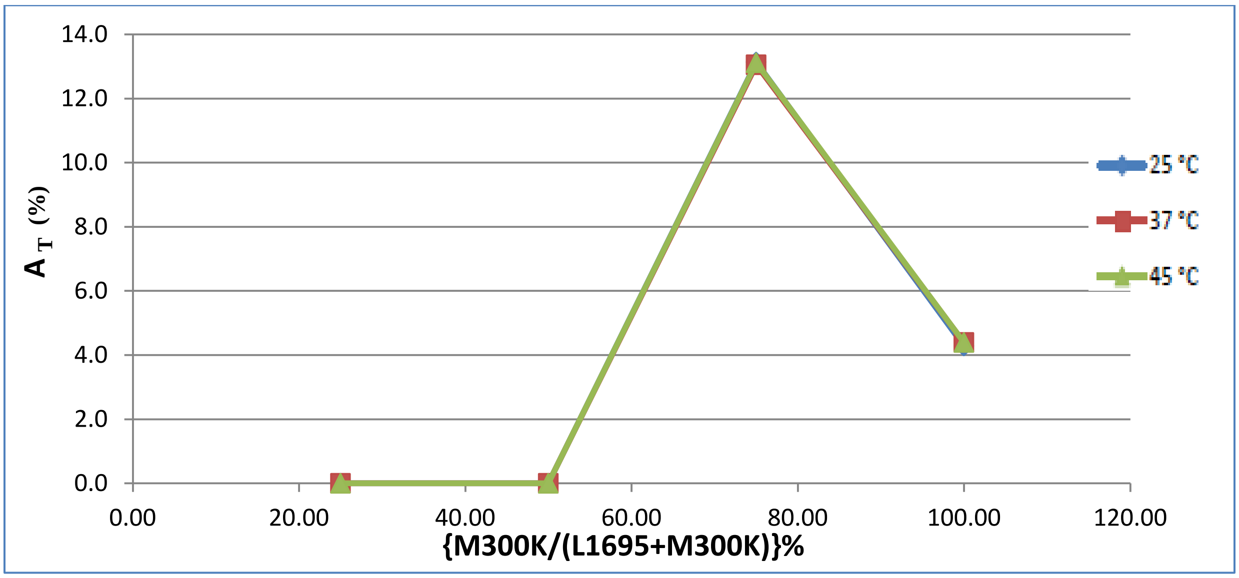
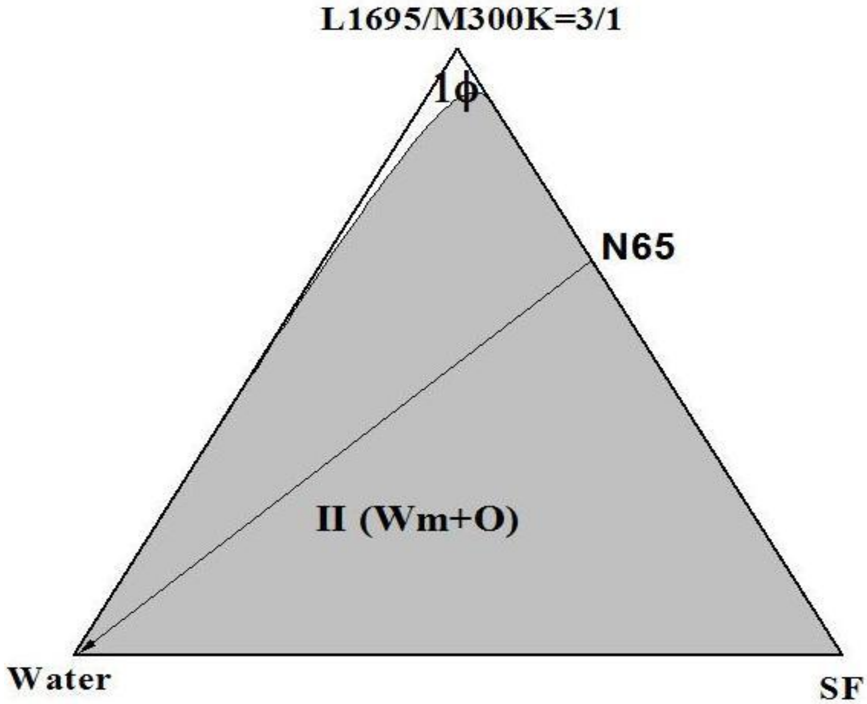


Figure 5.64: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/SB.

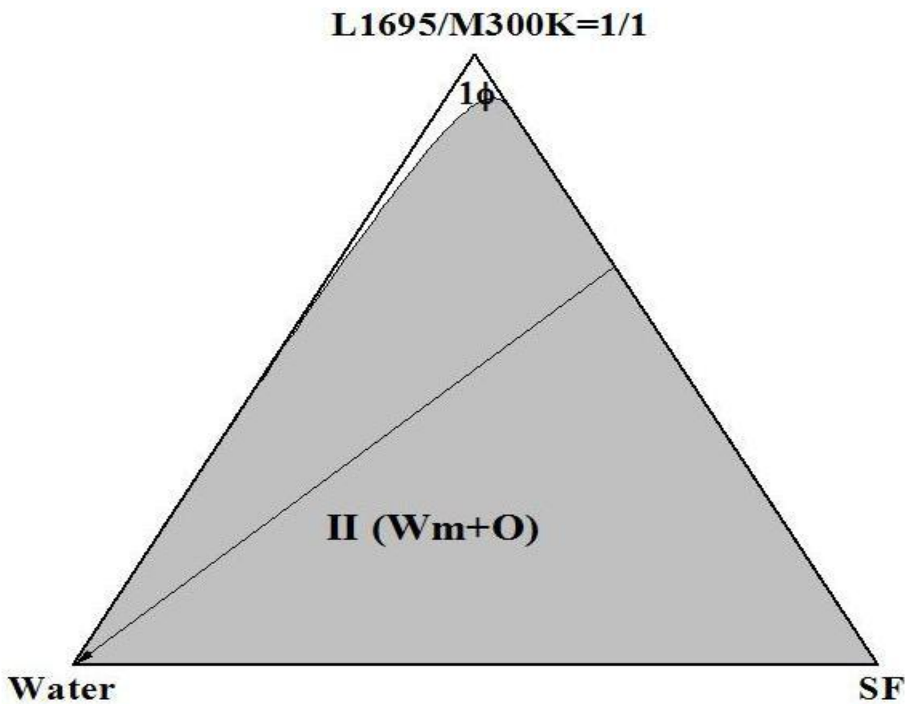
<u>**System#7 W/ L1695+M300K/SF**</u>

Figure 5.65 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ sun flour oil (SF). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

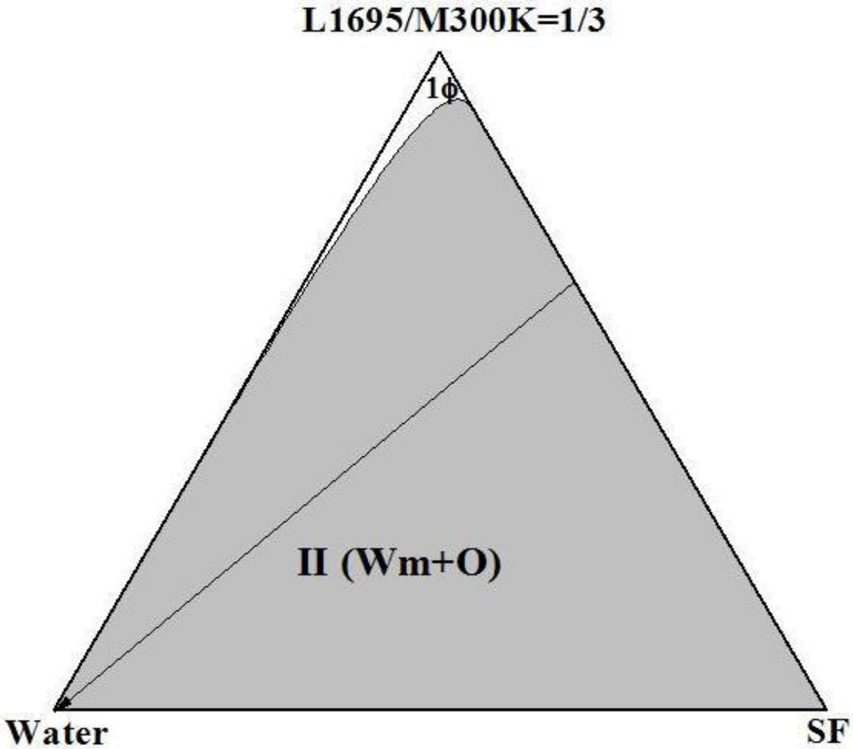
As show in Figure 5.65, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.



(A)



(B)



(C)

Figure 5.65: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/sun flour oil (SF). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O).N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/SF = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.24 The total monophasic area A_T (%) for the system W/L1695+M300K/SF at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	0	0	0
100	4	4	4

Figures 5.65 present the phase behaviors of the systems W/L1695+M300K/SF. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.66 represent the variation of the total

monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.24. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

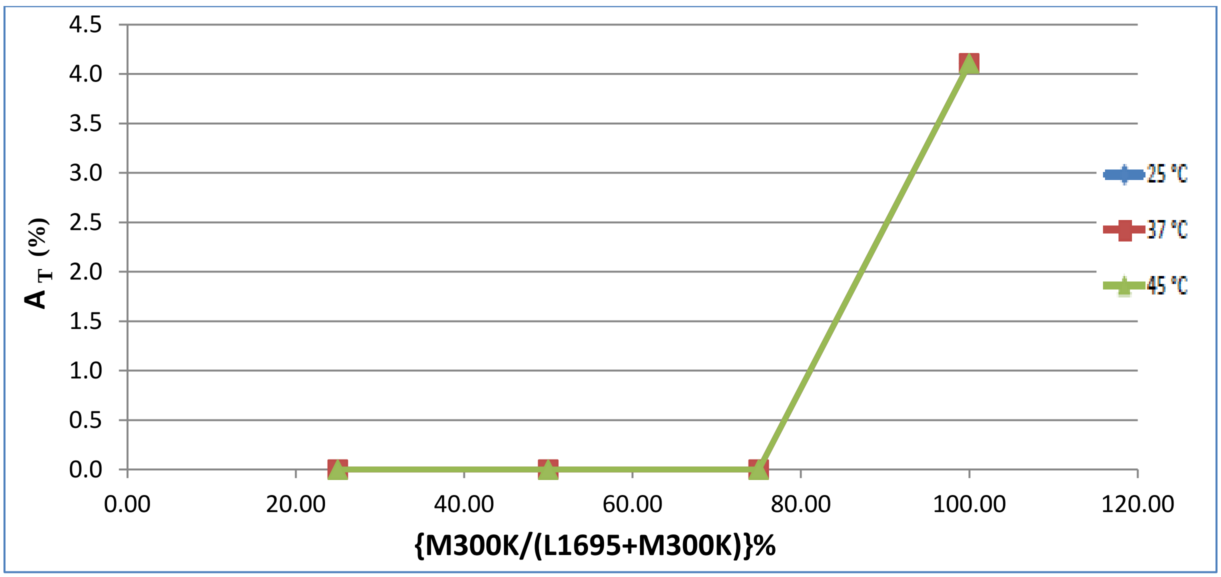
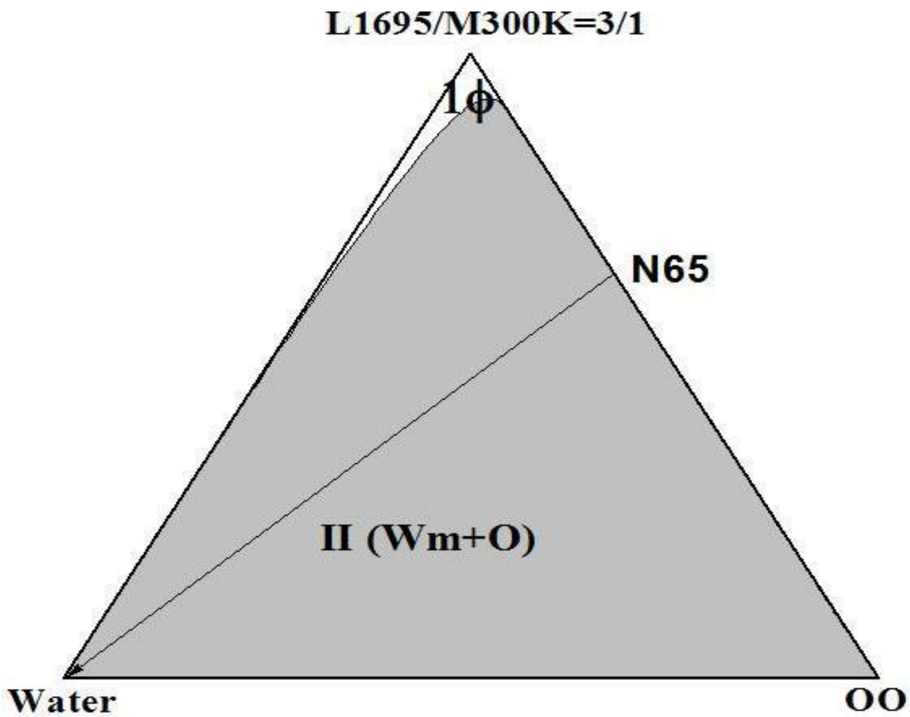


Figure 5.66: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/SF.

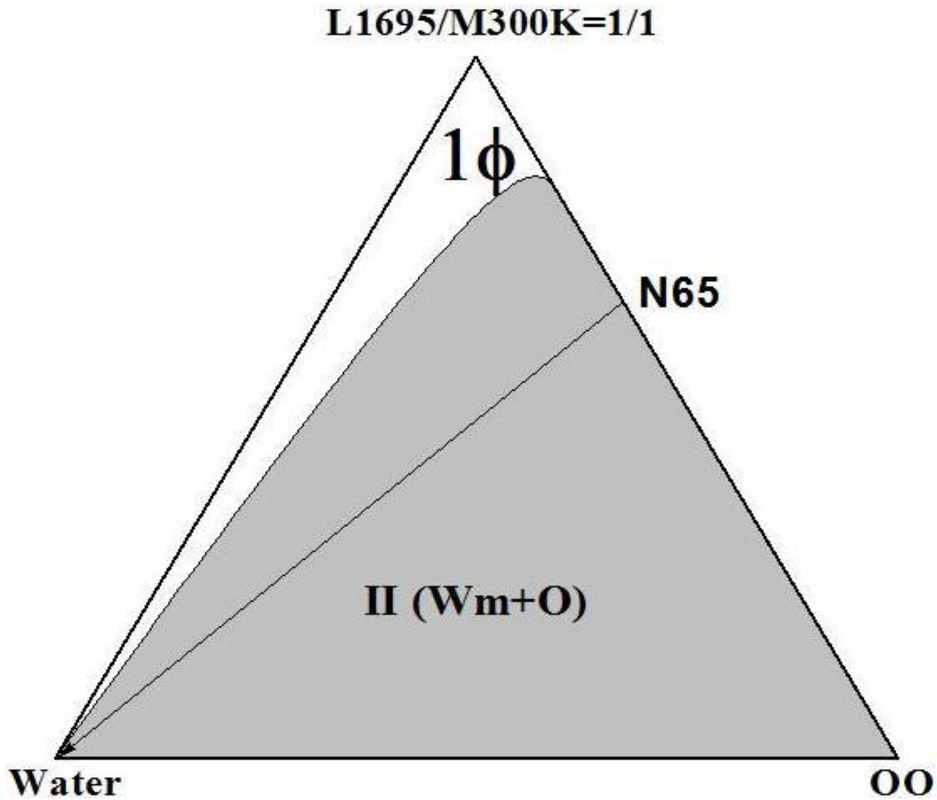
<u>System#8 W/ L1695+M300K/OO</u>

Figure 5.67 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ sun flour oil (SF). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

As show in Figure 5.67, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, but in Figure 5.67C show one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65, for low mixed surfactants contents (below 63 wt %) a multiphase reign II (Wm+O) is observed.

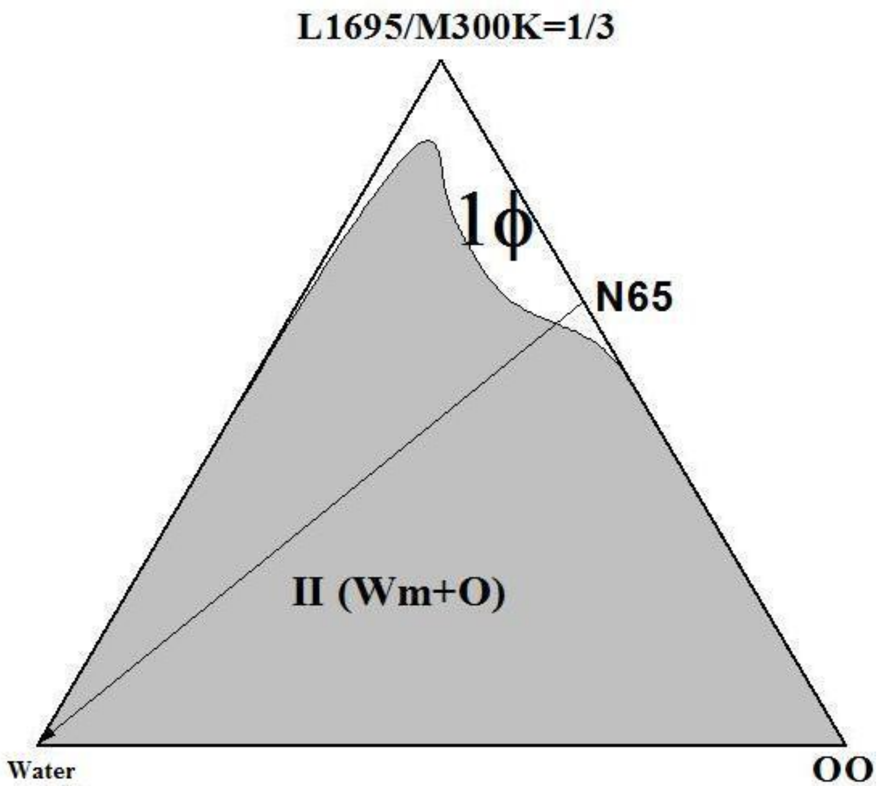


(A)



L1695/M300K=1/1
1ϕ
N65
II (Wm+O)
Water
OO

(B)



L1695/M300K=1/3
1ϕ
N65
II (Wm+O)
Water
OO

(C)

Figure 5.67: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ olive oil (OO). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/OO = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.25: The total monophasic area A_T (%) for the system W/L1695+M300K/OO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	20	22	22
100	4	4	4

Figures 5.67 present the phase behaviors of the systems W/L1695+M300K/OO. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.68 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.25 when mixed M300K/L1695 equals 75 %. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

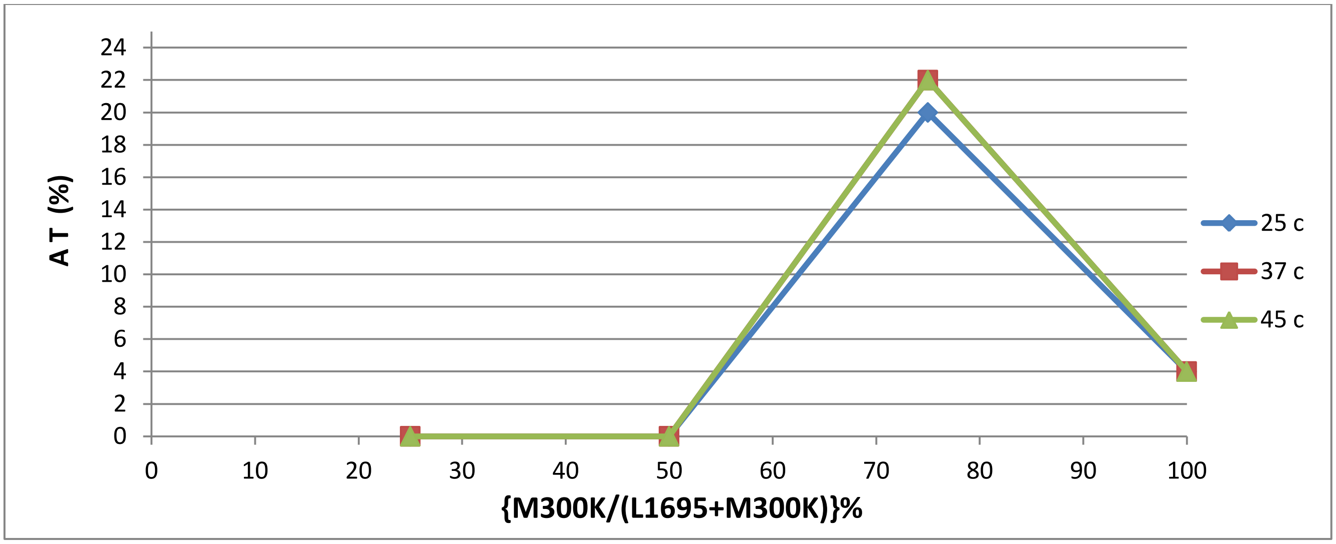
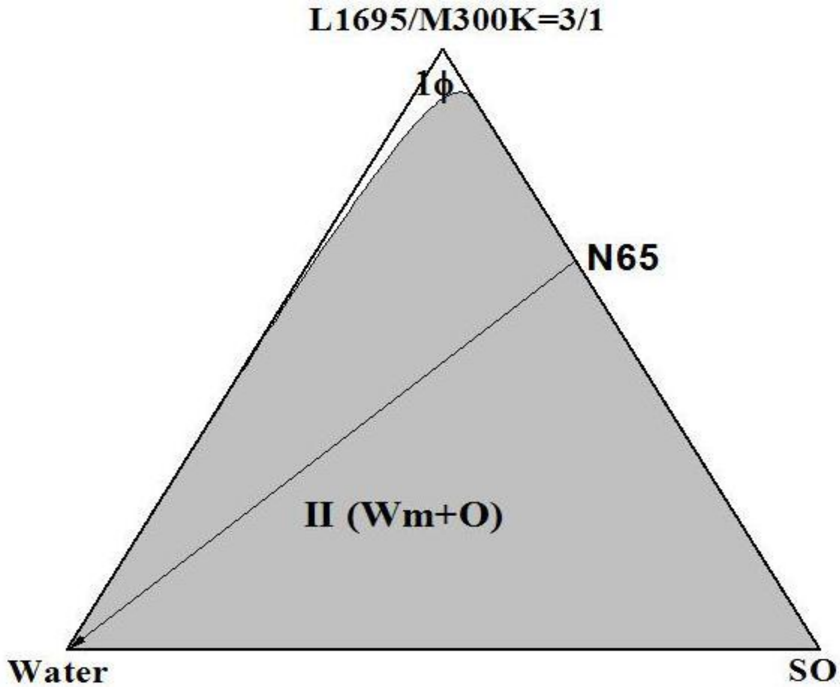


Figure 5.68: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/OO.

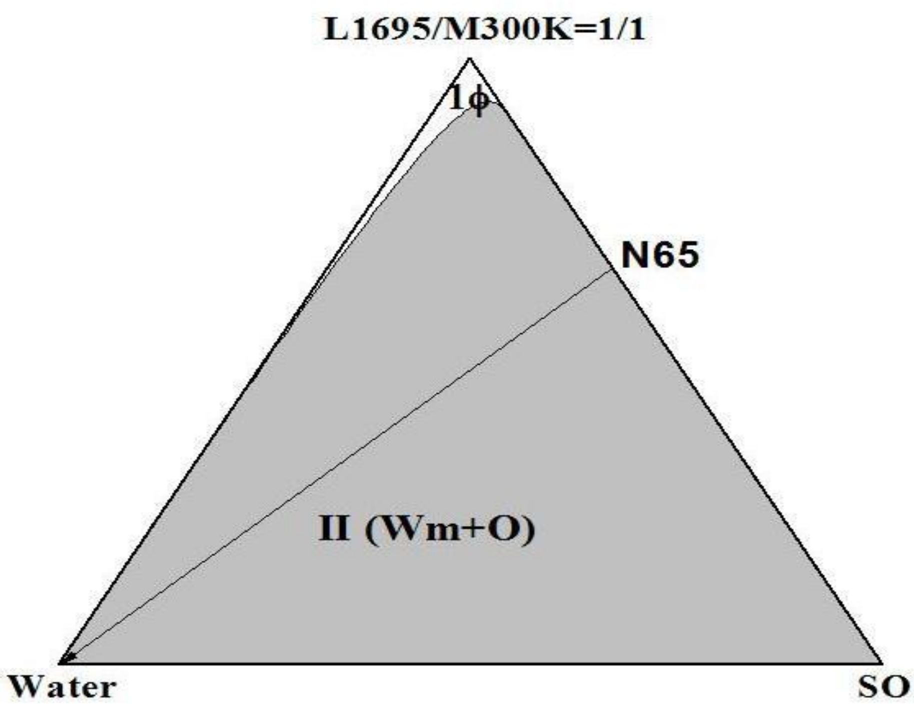
System#9W/ L1695+M300K/SO

Figure 5.69 present the phase diagram of the water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/ sesame oil (SO). System at different weight ratios of L1695/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

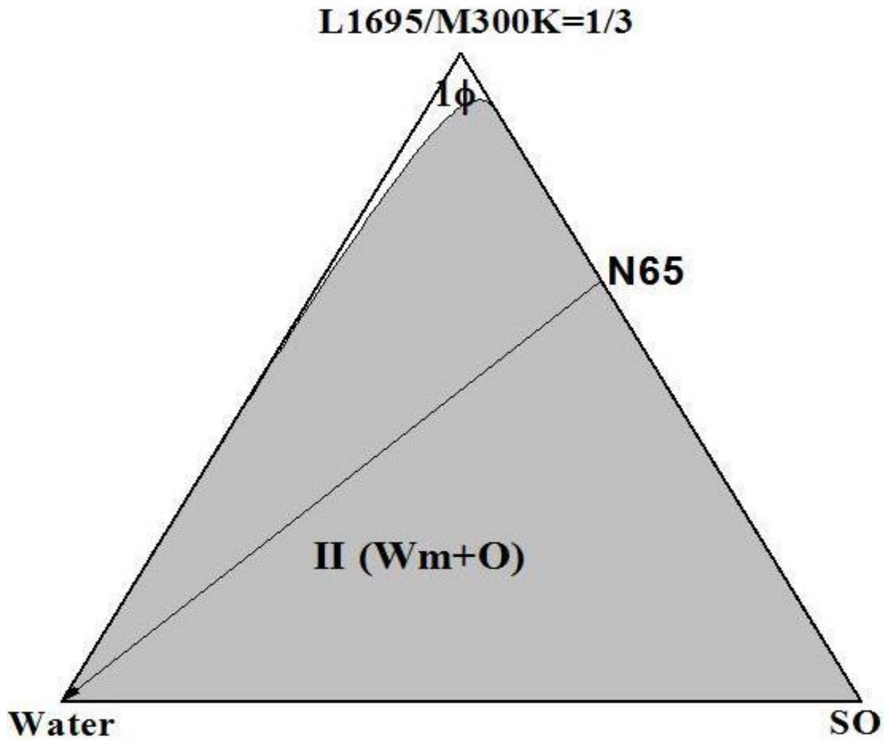
As show in Figure 5.69, the one phase microemulsion region not appears from the first addition of water along the mixed surfactants/ oil axis along the dilution line N65.


L1695/M300K=3/1
1ϕ
N65
II (Wm+O)
Water
SO

(A)


L1695/M300K=1/1
1ϕ
N65
II (Wm+O)
Water
SO

(B)



(C)

Figure 5.69: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + glycerol monooleate (M300K)/sesame oil (SO). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M300K)/SO = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.26: The total monophasic area A_T (%) for the system W/L1695+M300K/SO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/L1695+M300K)%	25°C	37°C	45°C
25	0	0	0
50	0	0	0
75	0	4	0
100	4	4	4

Figures 5.69 present the phase behaviors of the systems W/L1695+M300K/SO. The mixing ratio of (L1695/M300K) equals (75, 50, and 25%) and Figures 5.70 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose monolaurate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/L1695 equals maximum total area gave us the best result in Table 5.26. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with L1695 improves the water solubilization but did not affect the temperature insensitivity of L1695. This behavior an advantage for this mixture of surfactants.

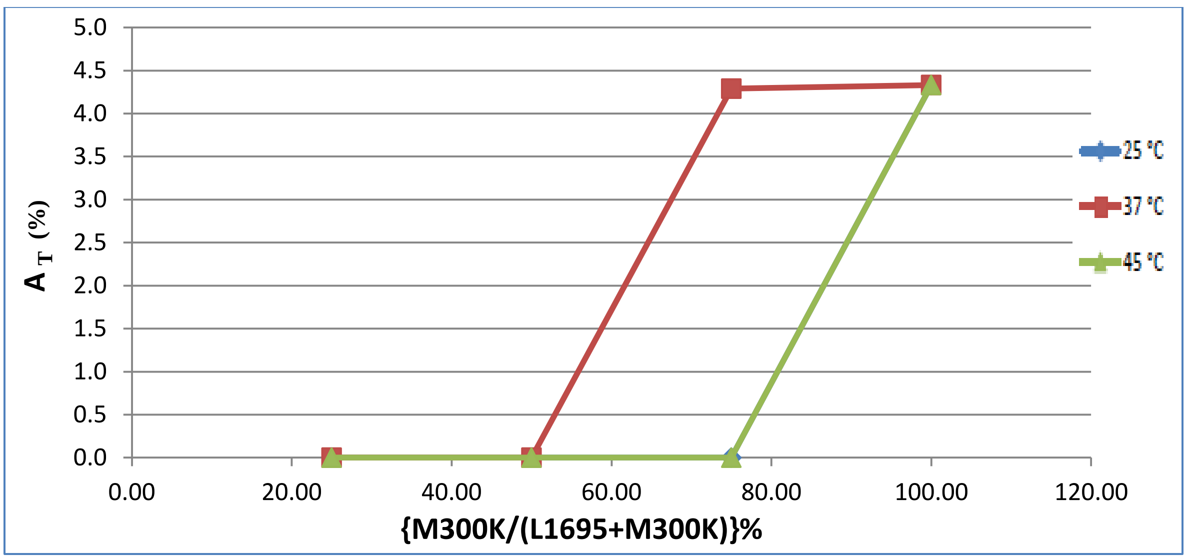


Figure 5.70: Variation of the total monophasic area A_T (%) as function glycerol monooleate content in the surfactants mixture (L1695+M300K) and as function of temperature for the system: W / L1695+M300K/SO.

The phase behaviors of the systems W/L1695+M300K/oil the total monophasic area A_T (%) at 25°C for the mixing ratios (M300K/L1695=75%) equals gave us the best result in all systems.

Table 5.27: The maximum total monophasic area A_T (%) for the system W /L1695+M300K/ oil at mixed surfactant ratio at 25°C temperatures.

Oil	Maximum A_T (%) at 25°C	Mixed surfactant ratio that gave maximum AT (%) value at 25°C M300K/(M300K+L1695)
MNT	16	1/1
LIM	8	3/1
ION	22	3/1
IPM	18	3/1
CCT	6	3/1
SB	13	3/1
SF	4	M300K only
OO	7	3/1
SO	4	M300K only

Temperature insensitive microemulsion were formulated by mixing M300K and L1695 with cyclic oil, linear oil and triglycerides

5.1.1.2.iv Mixed sucrose oleate and glycerol monooleate.

Some molecules are known to self-assemble in polar organic solvents like propylene glycol and glycerol. Propylene glycol like water form hydrogen bonds has relatively high dielectric constants and is immiscible with hydrocarbon solvents. The resulting penetration of propylene glycol into the surfactant interface leads to smaller or no liquid crystal phase regions when it is used as water substitute. It was reported that polyols such as propylene glycol provide a 'salting-in' effect (Garti, Yaghmur, Leser, et al, 2001; Yaghmur, Aserin, Garti, 2002; Martino, Kaler, Phys, 1990) . Therefore, we assume, in this study, that a considerable fraction of propylene glycol molecules are incorporated into the surfactant layer and thus increase the interfacial fluidity, while other fraction of the propylene glycol molecules resides in the water and decreases the polarity of the water. The surfactants become more soluble in the propylene glycol + water compared to their solubility in pure water alone.

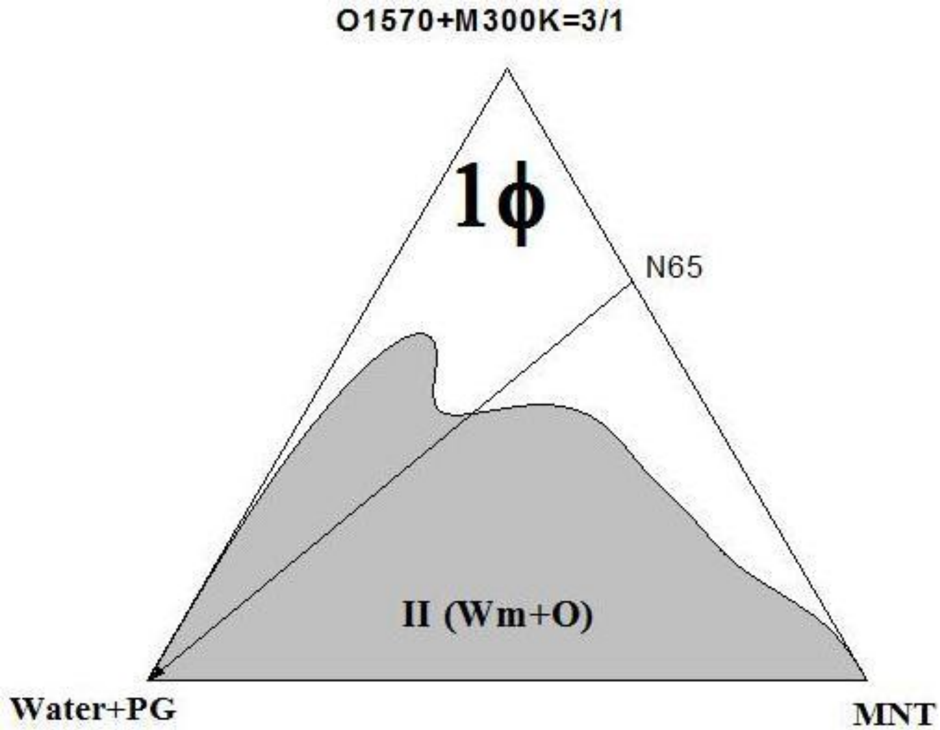
The average HLB number of about 9.4 and the maximum total aria A_T (%) in ratio between O1570/M300K is equal 3/1 that mixing gave better solubilization behavior than prescribing one type of surfactant.

System#1W+PG/ O1570+M300K/MNT

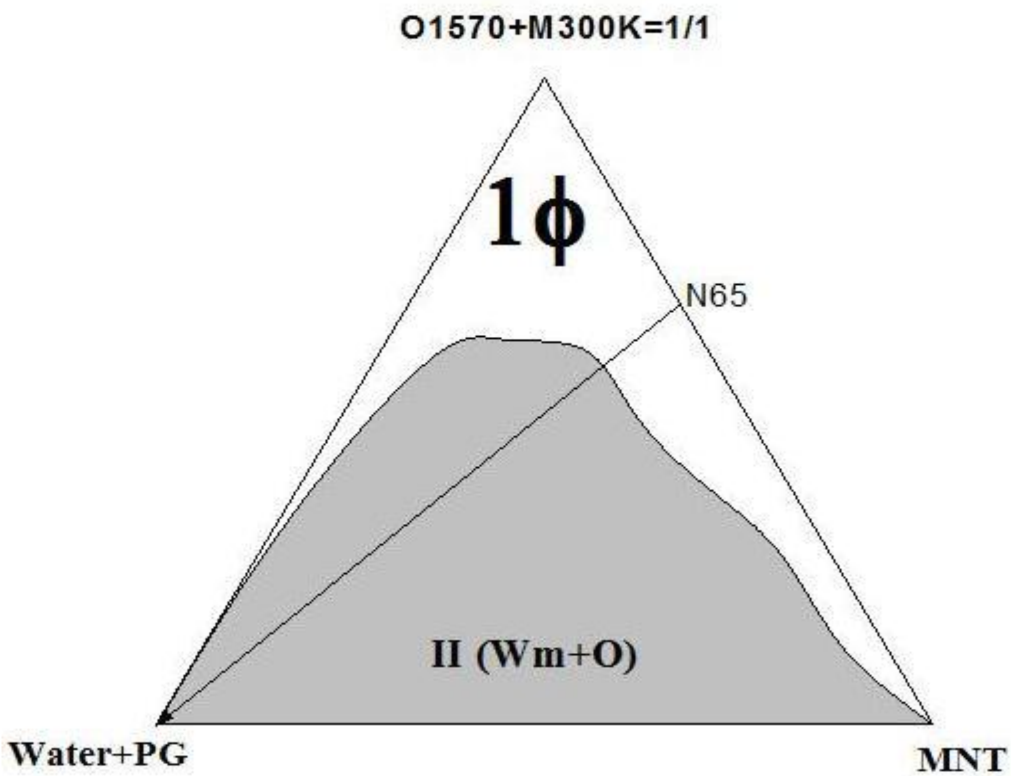
Figure 5.71 present the phase diagram of the water/ sucrose oleate (O1570) + glycerol monooleate (M300K) / peppermint oil (MNT) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

As show in Figure 5.71A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 42 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 62 wt% water.

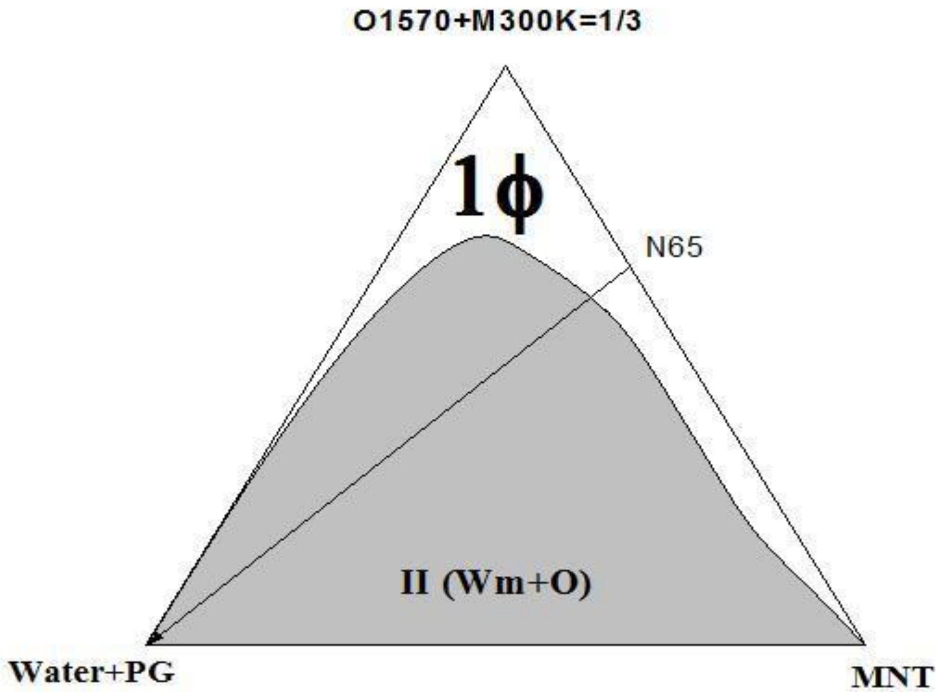
For low mixed surfactants contents (below 42 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.71B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 55 wt%. In Figure 5.71C the one phase microemulsion region shrinks more compared to 5.71B.


O1570+M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
MNT

(A)


O1570+M300K=1/1
1ϕ
N65
II (Wm+O)
Water+PG
MNT

(B)



(C)

Figure 5.71: Phase diagrams of the system: water**+** propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) /peppermint oil (MNT). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/MNT = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.28: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/MNT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	47	47	46
25	36	37	38
50	30	30	31
75	19	21	21

Figures 5.71 present the phase behaviors of the systems W+PG/O1570+M300K/MNT. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.72 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function

of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 (25%) equals maximum total area gave us the best result in Table 5.28. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

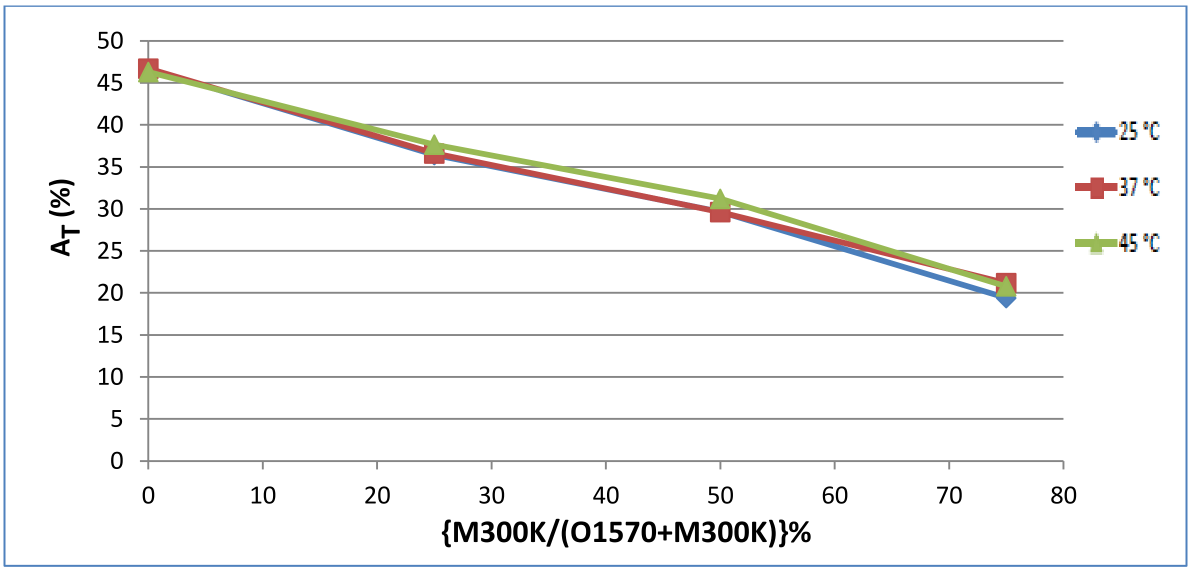


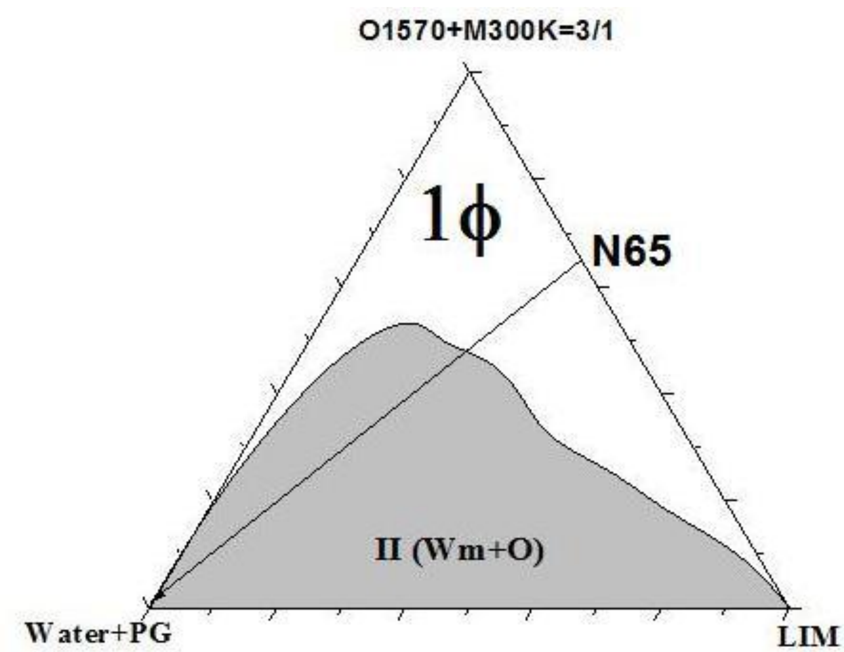
Figure 5.72: Variation of the total monophasic area A_T (%) as function of M300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/MNT.

<u>System#2W+PG/ O1570+M300K/LIM</u>

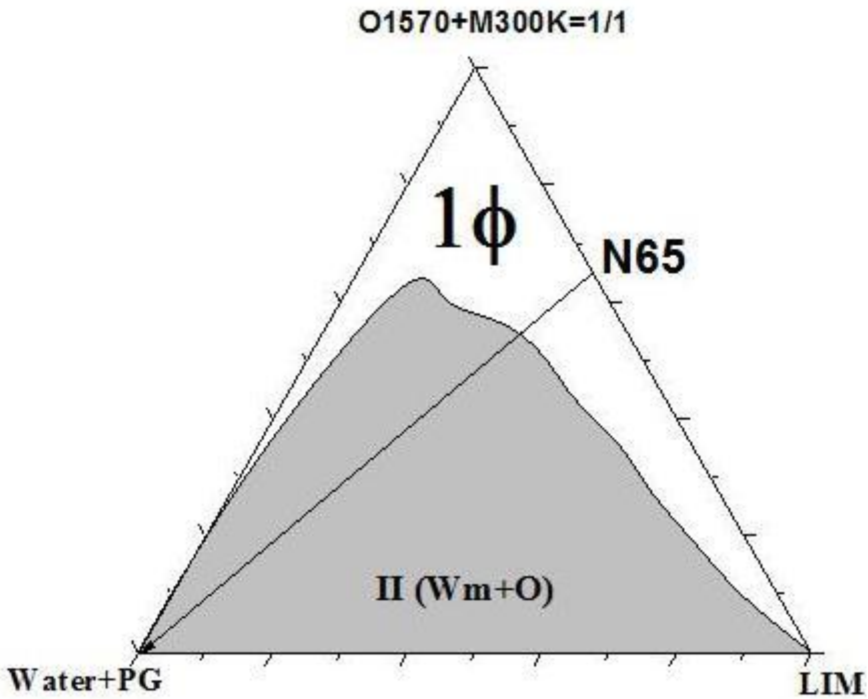
Figure 5.73 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) /R(+)-limonene oil (LIM) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

As show in Figure 5.73A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 9 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 46 wt% water.

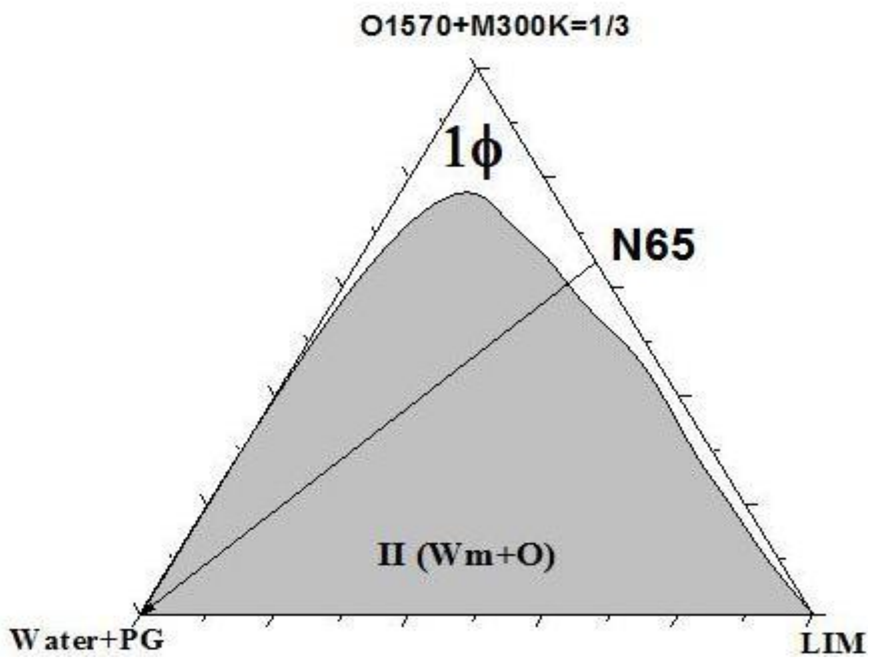
For low mixed surfactants contents (below 46 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.73B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 48 wt%. In Figure 5.73C the one phase microemulsion region shrinks more compared to 5.73B.



(A)



(B)



(C)

Figure 5.73: Phase diagrams of the system: water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) /R(+)-limonene oil (LIM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the

dilution line where the mixing ratio (w/w) of (O1570+M300K)/LIM = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.29: The total monophasic area A_T (%) for the system W+PG /O1570+M300K /LIM at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	43	46	46
25	40	41	41
50	30	31	32
75	13	13	15

Figures 5.73 present the phase behaviors of the systems W+PG/O1570+M300K/LIM. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.74 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 equals maximum total area gave us the best result in Table 5.29. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

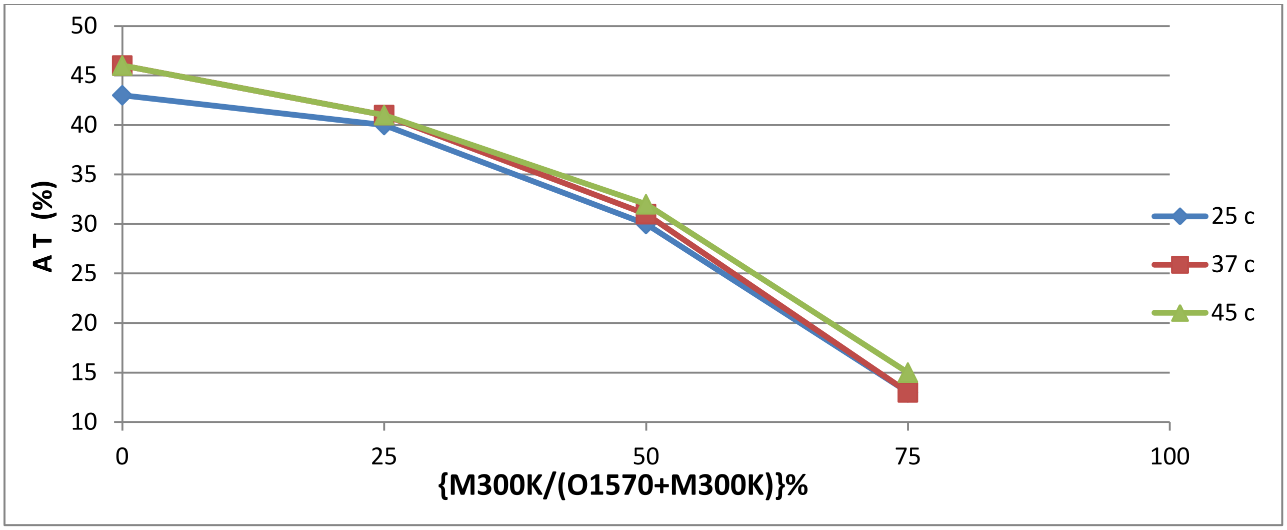


Figure 5.74: Variation of the total monophasic area A_T (%) as function of M300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/LIM.

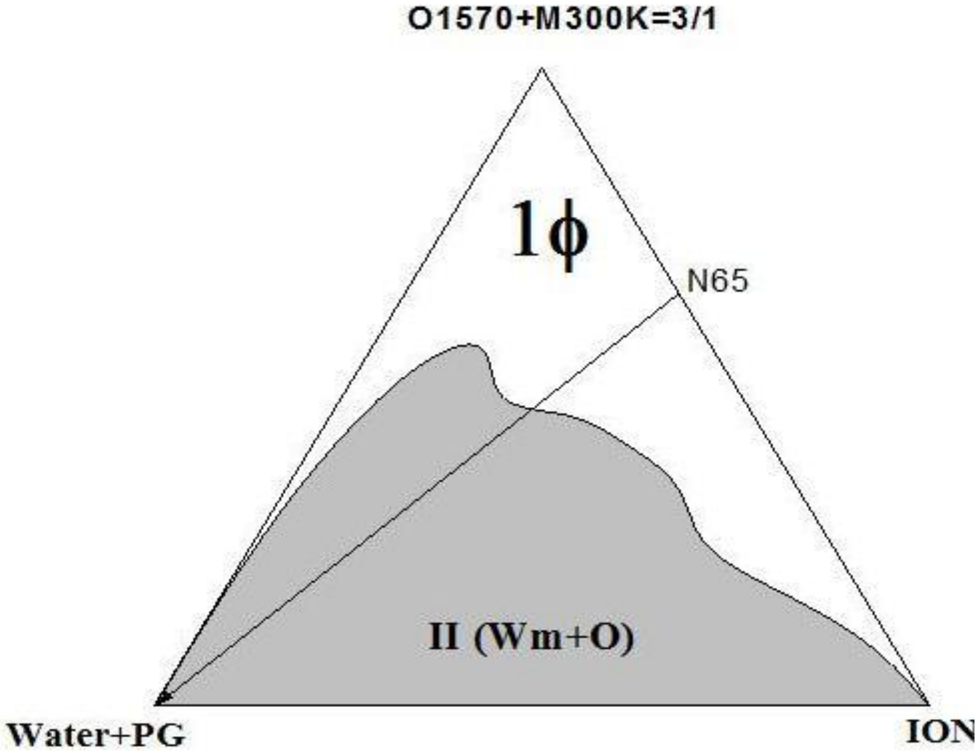
<u>System#3W+PG/ O1570+M300K/ION</u>

Figure 5.75 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) / α-ionone (ION) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

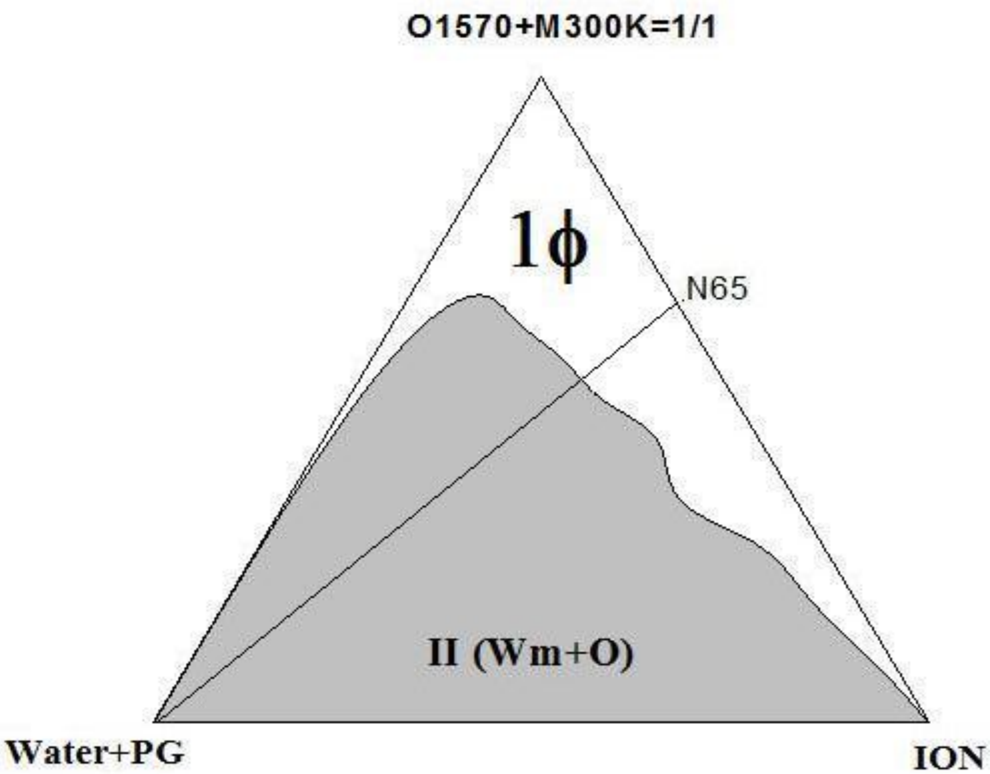
As show in Figure 5.75A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 30 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 60 wt% water.

For low mixed surfactants contents (below 60 wt %) a multiphase reign II (Wm+O) is observed.

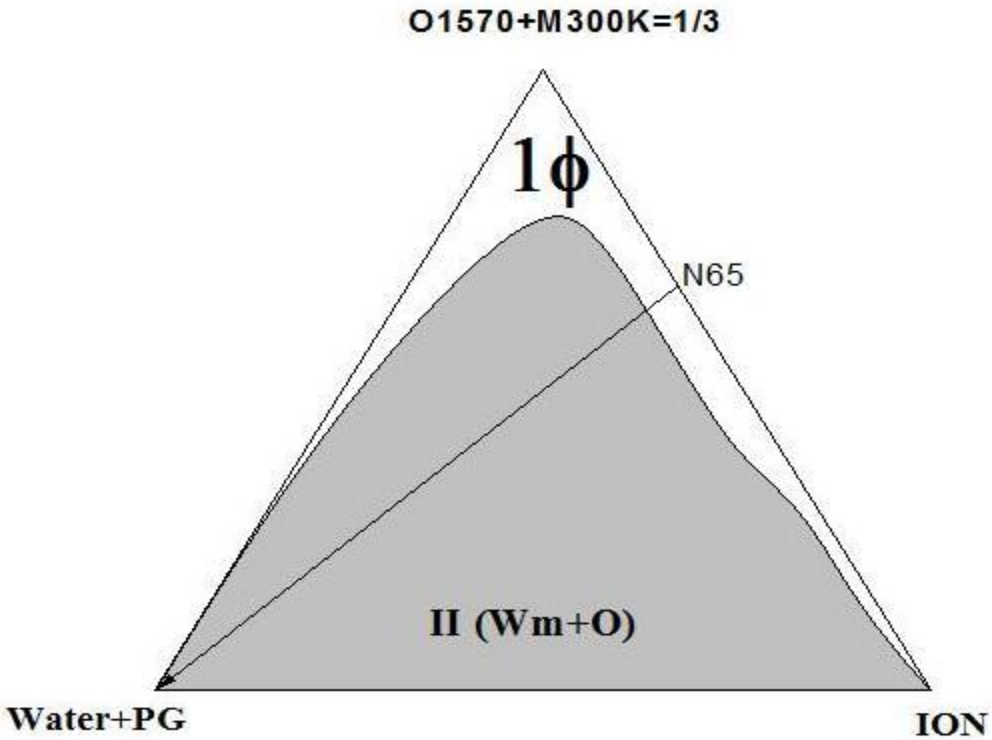
Some behavior is observed in Figure 5.75B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 53 wt%. In Figure 5.75C the one phase microemulsion region shrinks more compared to 5.75B.


O1570+M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
ION

(A)


O1570+M300K=1/1
1ϕ
N65
II (Wm+O)
Water+PG
ION

(B)



(C)

Figure 5.75: Phase diagrams of the system: water+ propylene glycol (PG) /sucrose oleate (O1570) + glycerol monooleate (M300K) α-ionone (ION). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/ION = 65/35, O1570/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.30: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/ION at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	44	45	46
25	38	40	40
50	28	28	30
75	16	15	18

Figures 5.75 present the phase behaviors of the systems W+PG/O1570+M300K/ION. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.76 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 (25%) equals maximum total area gave us the best result in Table 5.30. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

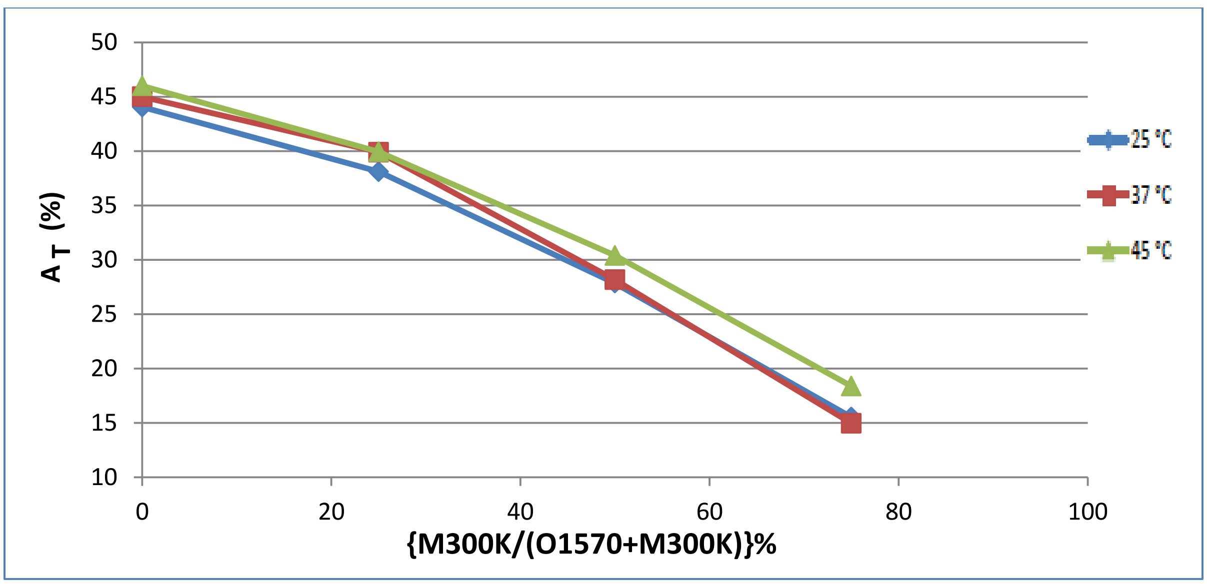


Figure 5.76: Variation of the total monophasic area A_T (%) as function of M 300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/ION.

The phase diagrams of a system W+PG/O1570+M399K/ oil at different temperature. Decrease microemulsion phase region was observed the total one-phase area A_T (%) when in glycerol monooleate (M300K) increase when mix with sucrose oleate (O1570).

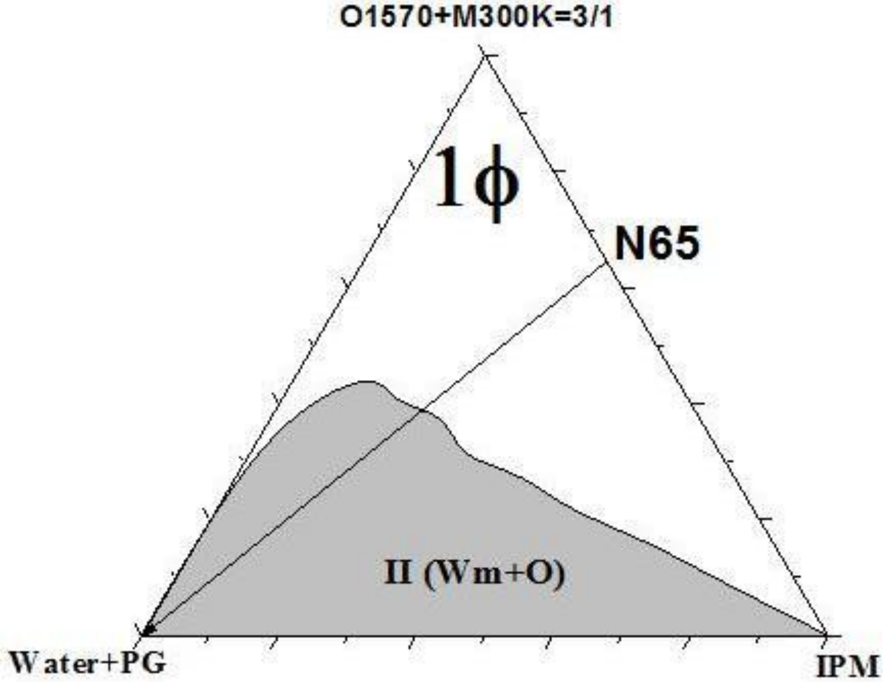
System#4W+PG/ O1570+M300K/IPM

Figure 5.77 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) / isopropylmerstate oil (IPM) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

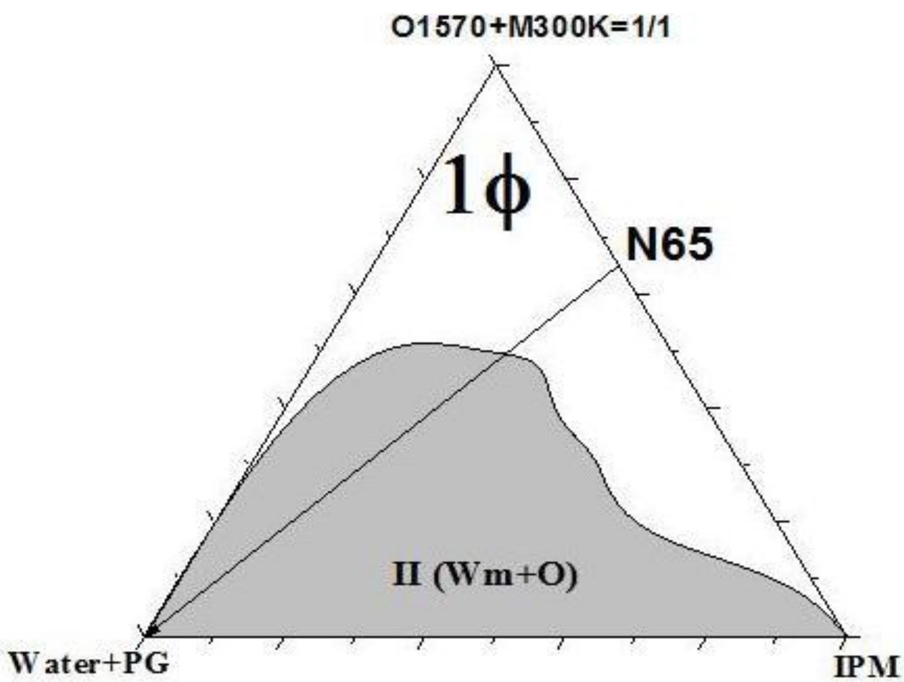
As show in Figure 5.77A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 40 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 60 wt% water.

For low mixed surfactants contents (below 60 wt %) a multiphase reign II (Wm+O) is observed.

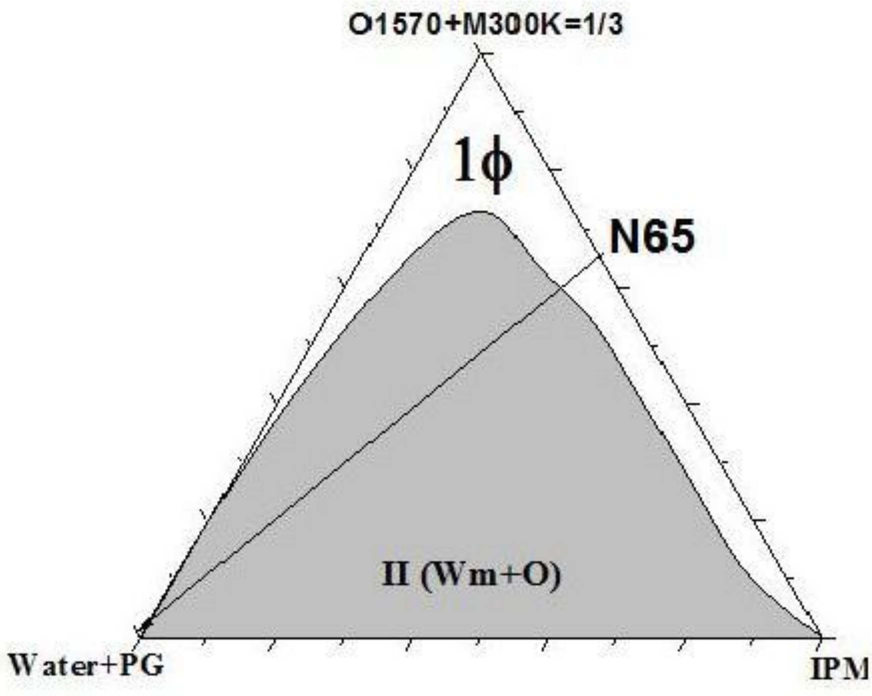
Some behavior is observed in Figure 5.77B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 50 wt%. In Figure 5.77C the one phase microemulsion region shrinks more compared to 5.77B.


O1570+M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
IPM

(A)


O1570+M300K=1/1
1ϕ
N65
II (Wm+O)
Water+PG
IPM

(B)



(C)

Figure 5.77: Phase diagrams of the system: water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/isopropylmyristate oil (IPM). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/IPM = 65/35, O1570/M300K: **(A) 75% (B) 50% (C) 25%.**

Table5.31: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/ IPM at different mixing ratios of mixed surfactants and at different temperatures.

	AT		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	47	47	47
25	53	51	53
50	42	47	43
75	20	26	23

Figures 5.77 present the phase behaviors of the systems W+PG/O1570+M300K/IPM. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.78 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 (25%) equals maximum total area gave us the best result in Table 5.31. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

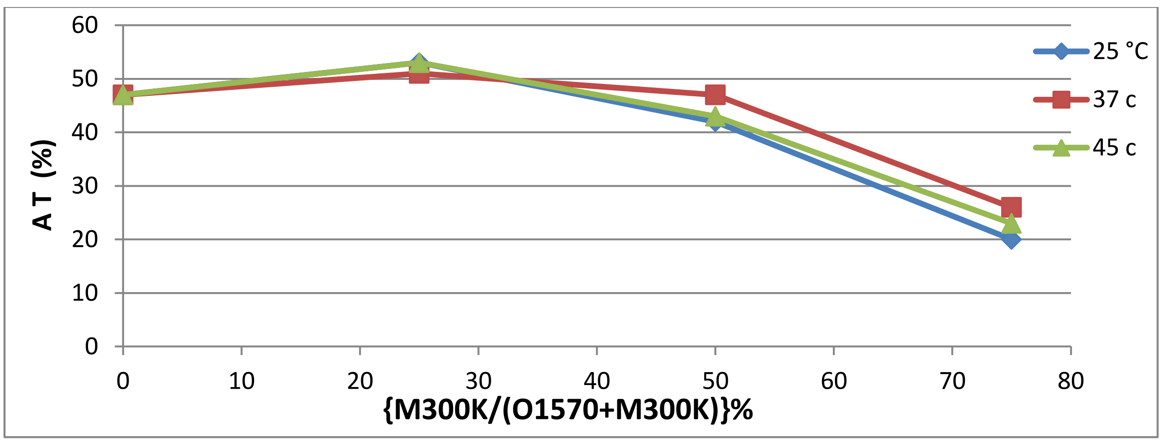


Figure 5.78: Variation of the total monophasic area A_T (%) as function of mazol 300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/IPM.

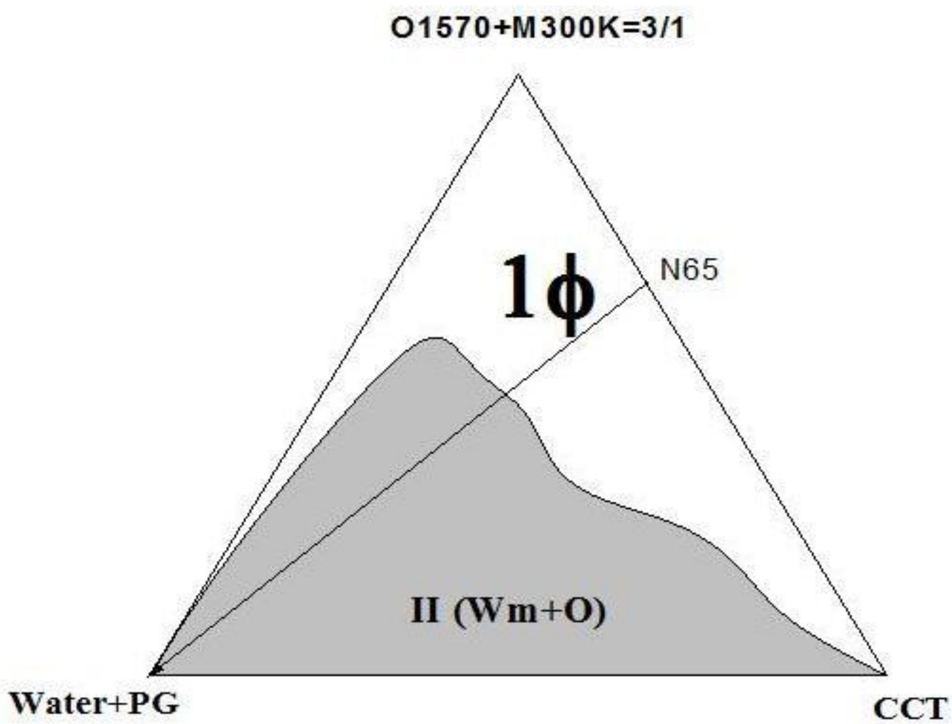
<u>System#5W+PG/ O1570+M300K/CCT</u>

Figure 5.79 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) / caprylic-capric triglyceride oil (CCT) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

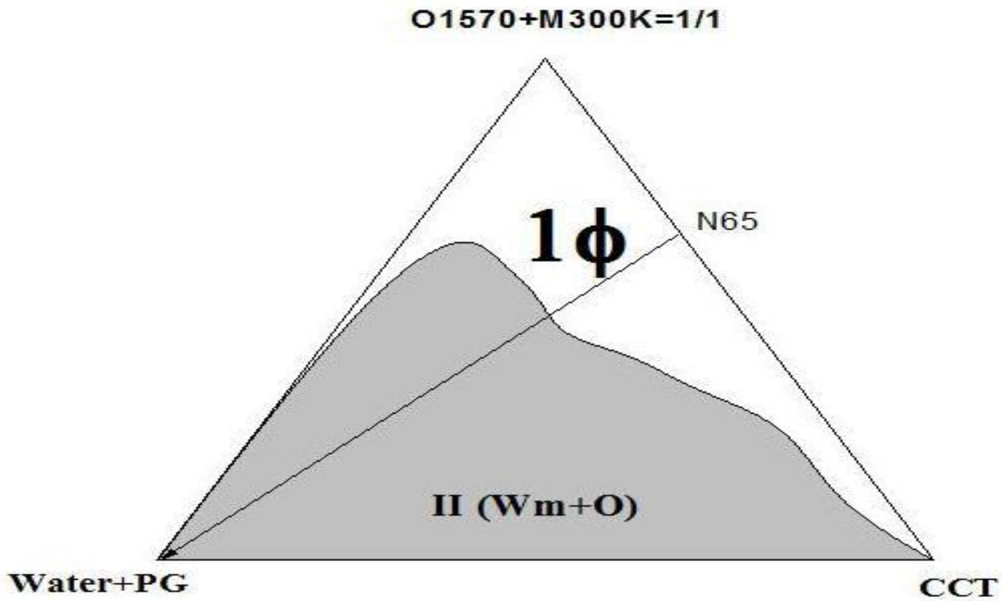
As show in Figure 5.79A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 24 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 48wt% water.

For low mixed surfactants contents (below 48 wt %) a multiphase reign II (Wm+O) is observed.

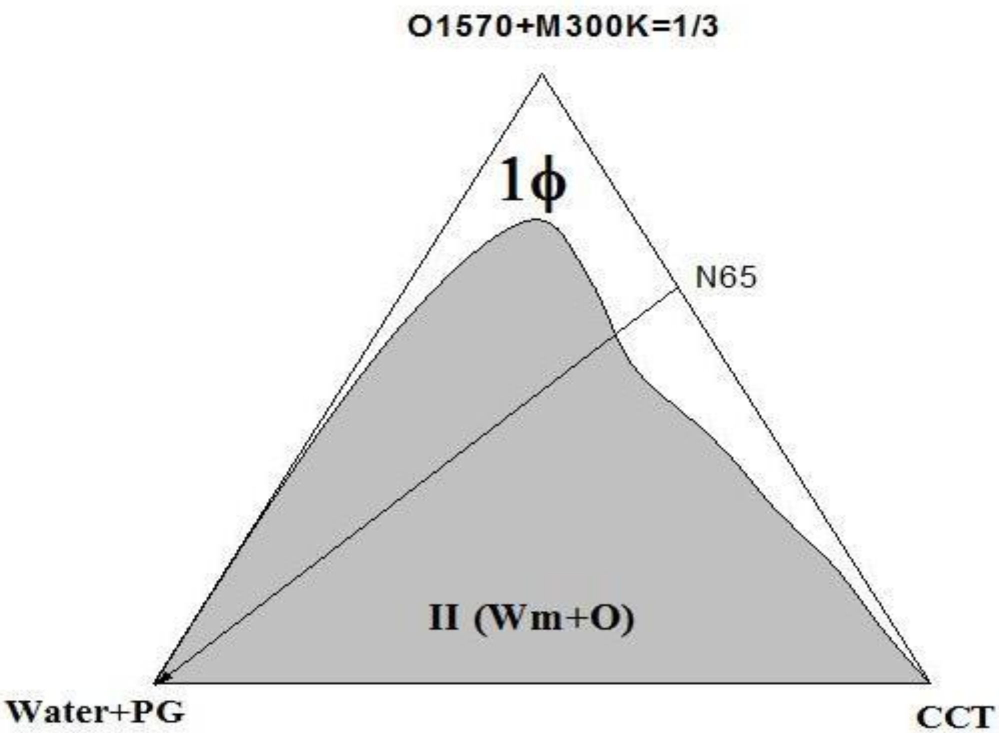
Some behavior is observed in Figure 5.79B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 50 wt%. In Figure 5.79C the one phase microemulsion region shrinks more compared to 5.79B.



(A)



(B)



(C)

Figure 5.79: Phase diagrams of the system: water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) caprylic-capric triglyceride oil (CCT). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is

the dilution line where the mixing ratio (w/w) of (O1570+M300K)/CCT = 65/35, O1570/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.32: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/CCT at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	45	45	45
25	43	43	44
50	32	31	32
75	19	22	22

Figures 5.79 present the phase behaviors of the systems W/O1570+M300K/CCT. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.80 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 (25%) equals maximum total area gave us the best result in Table 5.32. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

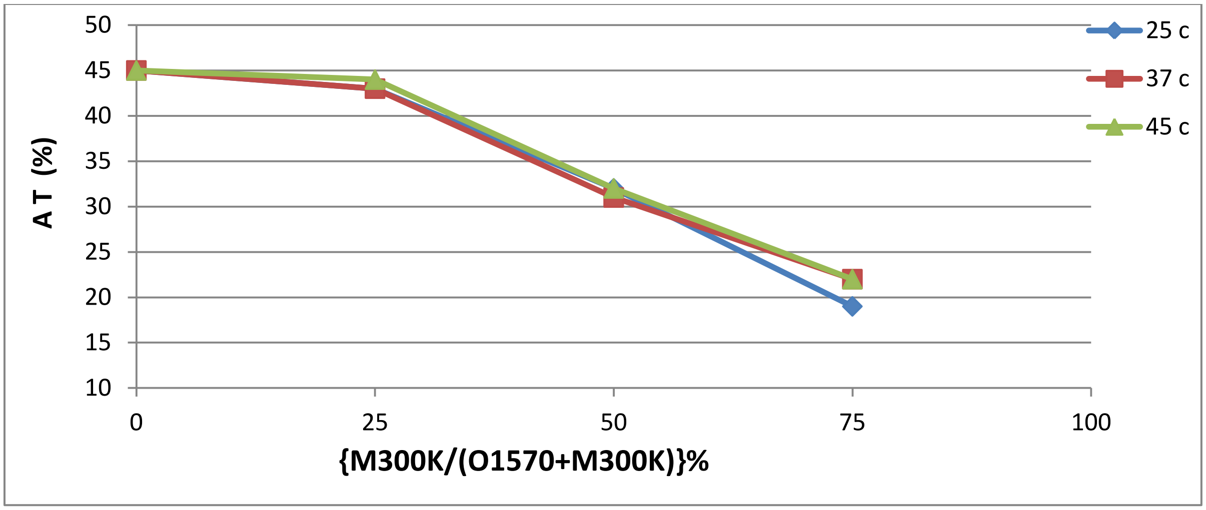


Figure 5.80: Variation of the total monophasic area A_T (%) as function of mazol 300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/CCT.

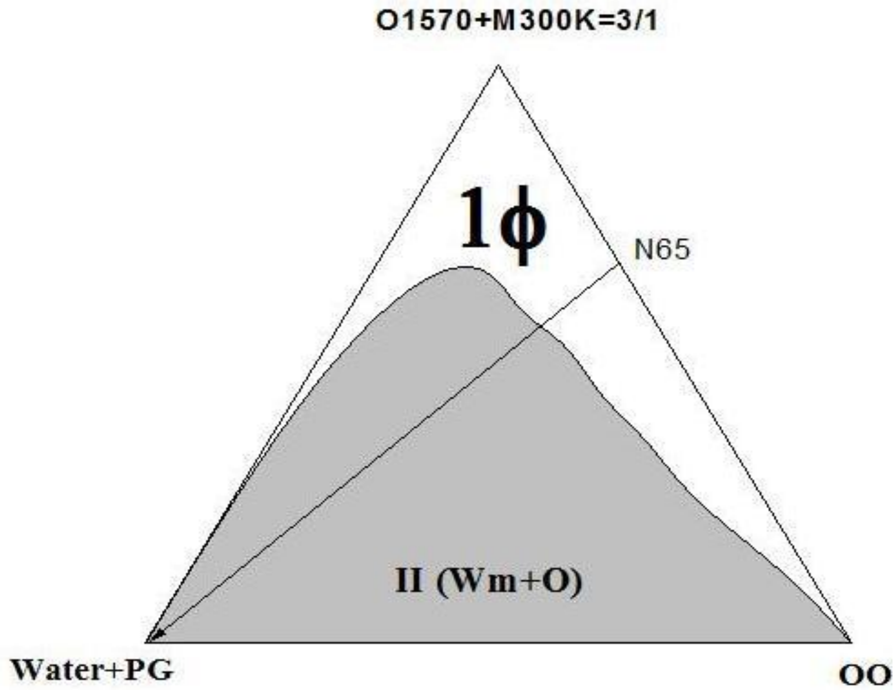
<u>System#6 W+PG/ O1570+M300K/OO</u>

Figure 5.81 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) / caprylic-capric triglyceride oil (CCT) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

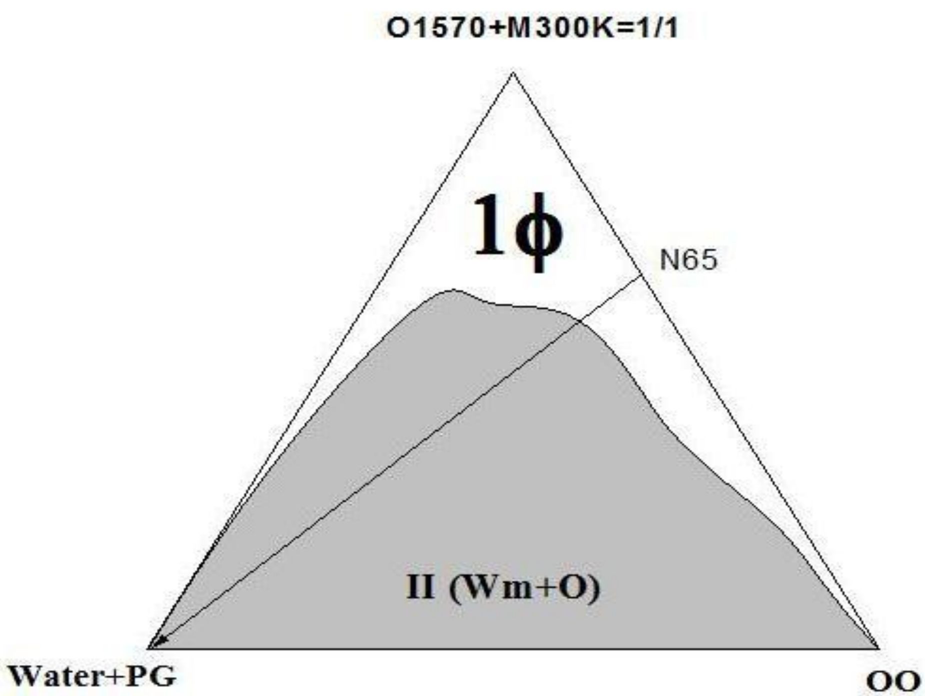
As show in Figure 5.81A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 12 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 49wt% water.

For low mixed surfactants contents (below 49 wt %) a multiphase reign II (Wm+O) is observed.

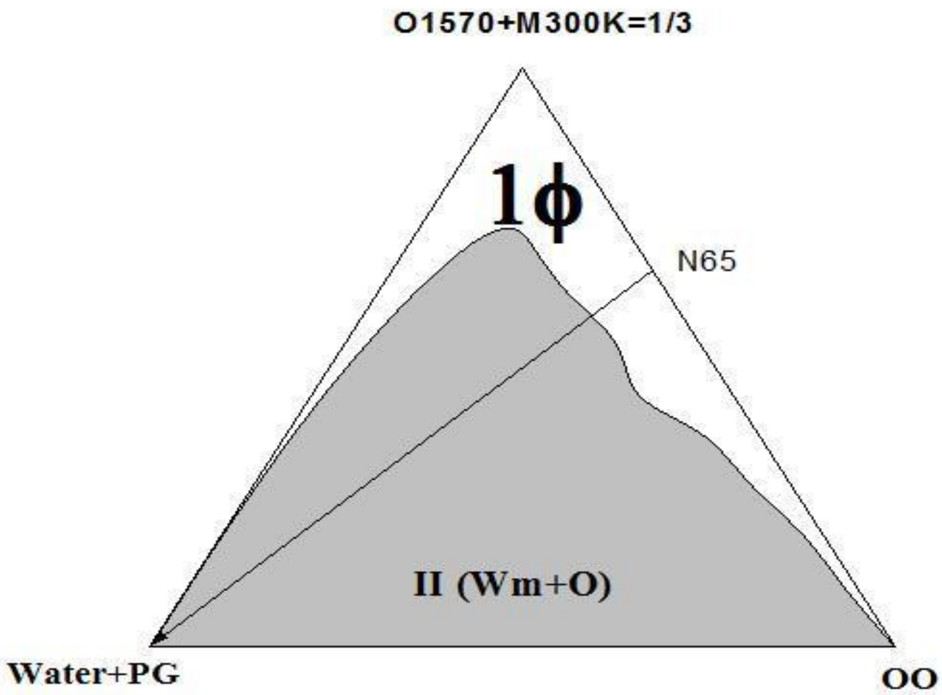
Some behavior is observed in Figure 5.81B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 42 wt%. In Figure 5.81C the one phase microemulsion region shrinks more compared to 5.81B.


O1570+M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
OO

(A)


O1570+M300K=1/1
1ϕ
N65
II (Wm+O)
Water+PG
OO

(B)



(C)

Figure 5.81: Phase diagrams of the system: water**+** propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) /olive oil (OO). The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/OO = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table 5.33: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/OO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	38	40	35
25	28	28	29
50	23	25	27
75	22	23	23

Figures 5.81 present the phase behaviors of the systems W/O1570+M300K/OO. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.82 represent the variation of the total

monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 equals maximum total area gave us the best result in Table 5.33. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

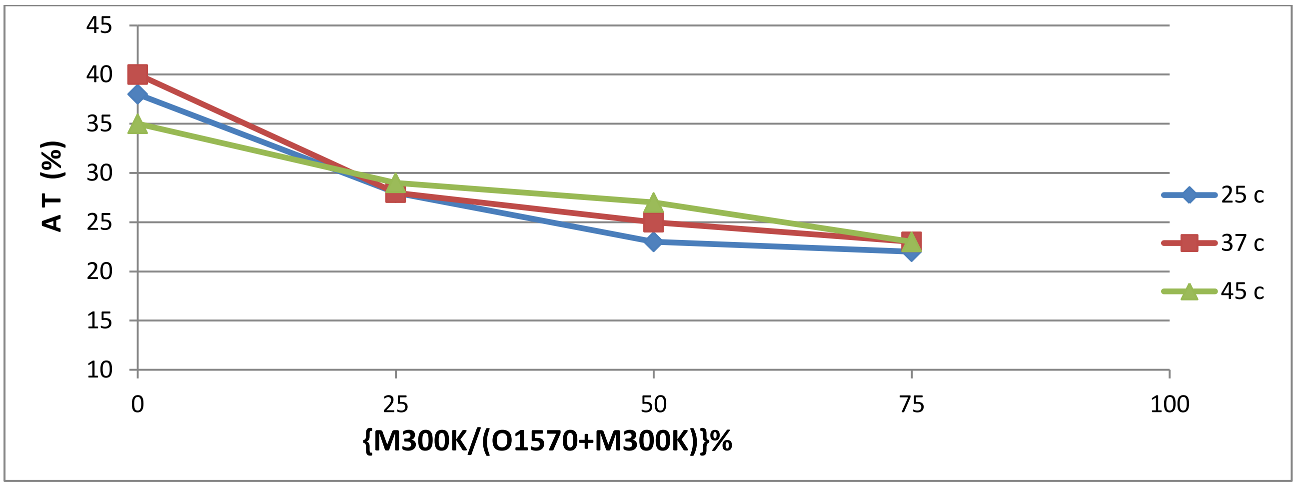


Figure 5.82: Variation of the total monophasic area A_T (%) as function of mazol 300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/OO.

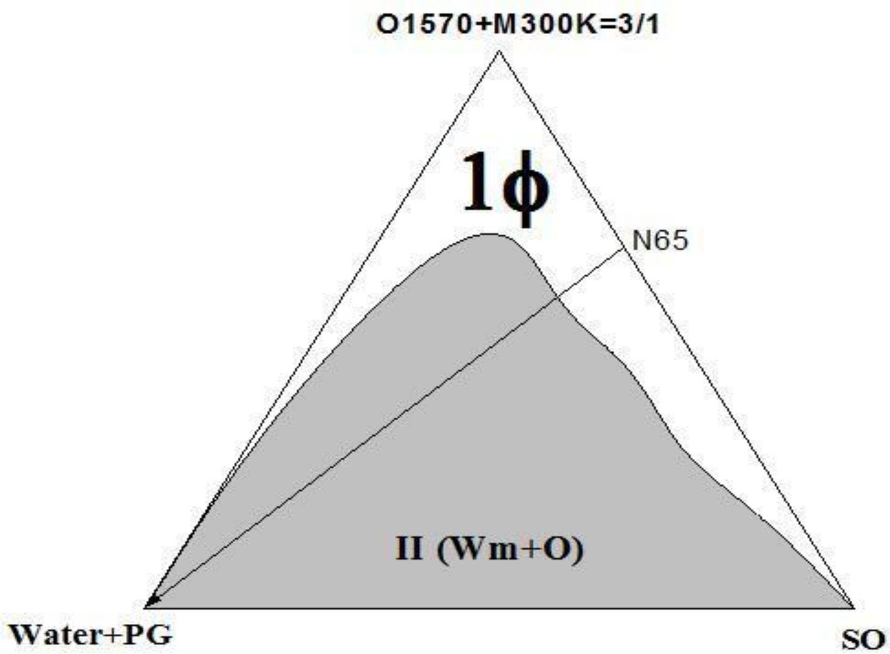
<u>System#7W+PG/ O1570+M300K/SO</u>

Figure 5.83 present the phase diagram of the water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) / sesame oil (SO) system at different weight ratios of O1570/M300K that are (A) 3/1 (B) 1/1 (C) 1/3.

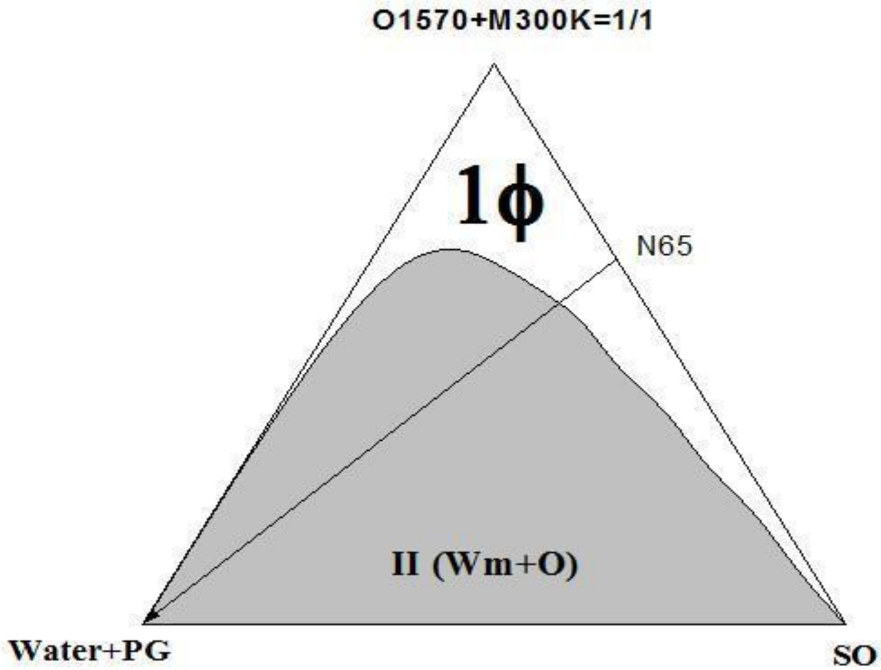
As show in Figure 5.83A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 13 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 42wt% water.

For low mixed surfactants contents (below 42 wt %) a multiphase reign II (Wm+O) is observed.

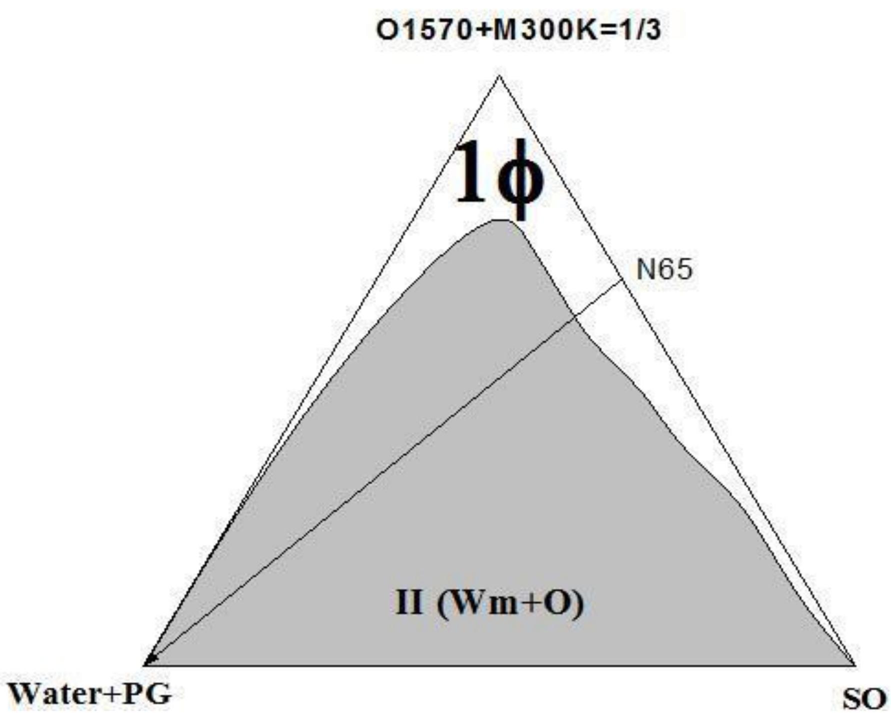
Some behavior is observed in Figure 5.83B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 42 wt%. In Figure 5.83C the one phase microemulsion region shrinks more compared to 5.83B.



(A)



(C)



(D)

Figure 5.83: Phase diagrams of the system: water+ propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K) /sesame oil (SO). The one phase region is designated by

1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/SO = 65/35, L1695/M300K: **(A) 75% (B) 50% (C) 25%.**

Table5.34: The total monophasic area A_T (%) for the system W+PG /O1570+M300K/SO at different mixing ratios of mixed surfactants and at different temperatures.

	A_T (%)		
(M300K/O1570+M300K)%	25°C	37°C	45°C
0	28	28	30
25	26	25	28
50	22	23	24
75	18	18	19

Figures 5.83 present the phase behaviors of the systems W/O1570+M300K/SO. The mixing ratio of (O1570/M300K) equals (75, 50, and 25%) and Figures 5.84 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different surfactant and as function of temperature .When glycerol monooleate mixed with sucrose oleate, the total monophasic area A_T (%) at 25°C for the mixing ratios M300K/O1570 (25%) equals maximum total area gave us the best result in Table 5.34. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing M300K with O1570 improves the water solubilization but did not affect the temperature insensitivity of O1570. This behavior an advantage for this mixture of surfactants.

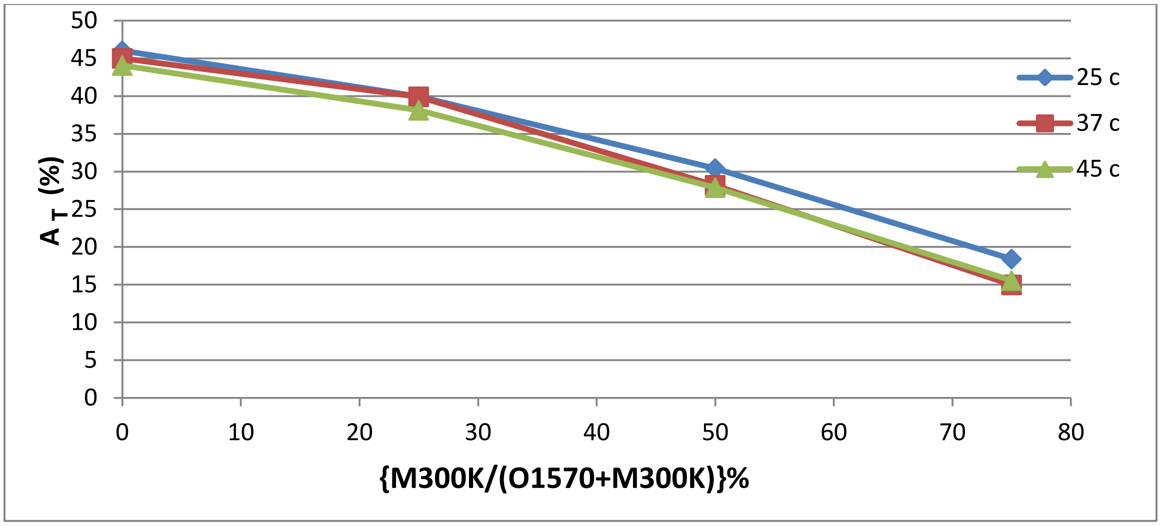


Figure 5.84: Variation of the total monophasic area A_T (%) as function of M300 K content in the surfactants mixture (O1570+M300K) and as function of temperature for the system: W+PG/ O1570+M300K/SO.

Table 5.35: The maximum total monophasic area A_T (%) for the system W+PG/O1570+M300K/ oil at mixed surfactant ratio at 25°C temperatures.

Oil	Maximum A_T (%) at 25°C	Mixed surfactant ratio that gave maximum A_T (%) value at 25°C M300K/(M300K+O1570)
MNT	47	**O1570**
LIM	43	**O1570**
ION	44	**O1570**
IPM	53	1/3
CCT	45	**O1570**
OO	38	**O1570**
SO	28	**O1570**

Temperature insensitive microemulsions were formulated. Mixing M300K with O1570 does not improve the water solubilization.

Chain length of the oil

In order to better understand the role that the oil chain length plays in the solubilization capacity of the microemulsions. It was our intention to replace R(+)-limonene by non-food grade linear saturated hydrocarbons (C*n*H2*n*+2) with different chain lengths (C6–C16) in order to determine and to evaluate more quantitatively the effect of the nature of the oil on the solubilization capacity. The effect of the molecular volume of the oil on the values of A_T (%) for the systems based on Surfactant is illustrated in Figure 5.85 for systems in which the oil/ethanol weight ratio (1/1) and the water/PG weight ratio was also kept constant (1/1). There is a rapid decrease in the solubilization with the increase in the molecular volume of the linear hydrocarbons. The isotropic area progressively reduces from 47.3 to 20.4% as the hydrocarbon chain length increases from number of carbon C6 to C16 (Fig. 5.85).

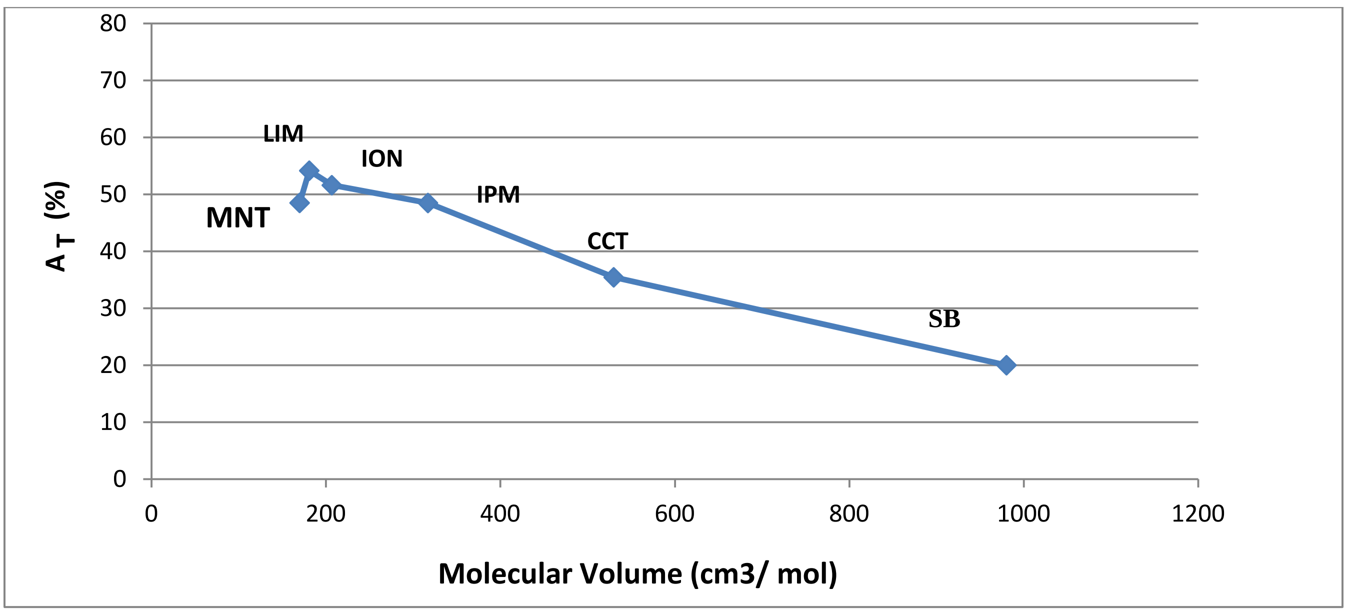


Figure 5.85: Effect of oil molecular volume at 25°C on A_T (%) for the systems based on L1695+M159 (1/1) with the different oil types and water.

The molecular volumes of MNT, LIM, ION, IPM, CCT and SB are 170, 181, 207,317, 530 and

980 cm^3/ mol respectively.

Large molecular volume oils are considered to form a core in the centre of the surfactant aggregate, and this can cause one of two effects depending upon the initial shape of the droplet. If the droplet was already spherical, the presence of oil hardly alters the head group area and the hydrophobic volume of the surfactant, thereby allowing the aggregate to still maintain nearly the same degree of curvature and consequently a similar PIT as the corresponding micellar solution (Aveyard and Lawless, 1986).

Obviously the definition of a ’small’ and ’large’ molecular volume oil is relative to the surfactant being studied, although it is generally considered that a small oil is one that has a chain length less than that of the hydrophobe of the surfactant.

In contrast, at low concentrations, the smaller molecular oils act in much the same way as a cosurfactant, increasing the effective hydrophobe volume (and decreasing the effective length of the hydrophilic head group) of the surfactant, thereby encouraging the formation of more asymmetric aggregates with lower spontaneous curvature and higher intermicellar interactions, and consequently lowering the PIT (Monduzzi et al., 1997). At higher concentrations the small molecular volume oils are thought to go into the core of the droplet, where they have little effect on the hydrophobe volume of the surfactant, transforming the asymmetric droplets to more symmetrical aggregates and restoring the PIT. The molecular volume of oil appeared to be more important in determining phase behaviour than its polarity (Aboofazeli et al., 1995).

$$V_m = \frac{M}{\rho}$$ ……..……………………………………………Equation no. (5)

These results are in a good agreement with systems (Hou, Shah, Langmuir, 1987). They reported that the solubilization process is limited either by the radius of the spontaneous curvature of the interface, *R*0 (curvature effect) or by the critical radius of the droplets, *R*c (effect of attractive interaction among the droplets). They found that the solubilization capacity decreased by increasing the molecular volume of the oil, due to an increase in the attractive interaction among droplets. Therefore, solubilization of systems consisting of tetradecane or hexadecane, seems to be limited by the critical droplet radius, R_c, through attractive interactions between droplets. It was reported that this change in the solubilization capacity is due to the compatibility of the hydrophobic part of the surfactant with the oil, the alcohol, and the hydrocarbon in the system (Garti, Aserin, Ezrahi, Wachtel, 1995), (Shiao, Chhabra, Patist, et al, 1988). Ethanol is too soluble in short-chain oils such as hexane and water. As the oil chain length increases, the concentration of ethanol in the oil phase decreases, forcing the ethanol to penetrate into the interfacial region and to the aqueous phase, and it is likely that more of the ethanol partitions to the aqueous phase taking with it additional surfactant, thus decreasing the stability of the interface. (Eastoe, Hetherington, Sharpe, Dong, Langmuir, 1996).

The solubilization capacity of the system with R(+)-limonene consisting of cyclic hydrocarbon with double bond was significantly higher than that of systems with linear hydrocarbons. This difference is at present not fully clear but could be attributed in part to better compatibility between the hydrophobic chain of the surfactant and the oil phase. The mutual miscibility between the hydrophobic part of the surfactant and the oil will affect the degree of oil penetration into the amphiphilic film and will also affect the spontaneous curvature. The solubilization mechanism of perfume oils such as R(+)-limonene by nonionic surfactants has been studied (Tokuoka, Uchiyama, Abe, Christian,1995),(Kanei, Tamura, Kunieda,1999). It was found that perfume molecules tend to be solubilized in the vicinity of the interface of the water–hydrocarbon moieties of the surfactant or the surfactant palisade layer. Their results are good indication that also in our microemulsions the improved solubilization in R (+)-limonene is related to its compatibility with the surfactant and its partial penetration into the surfactant film at the interface.

5.1.1.3 Phase behavior of mixed surfactants/ mixed oils

i - Constant weight ratio of mixed surfactants W/L1695+M159/mixed oil

In this section we investigated the effect of mixing oils at different mixing ratios (oil1/ oil2) which equal 1/2, 1, 2 and 3 on the formation and properties of biocompatible microemulsions based on the mixed sucrose monolaurate (L1695) and PEG-7 glyceryl cocoate (M159) at different temperatures (25, 37 and 45°C). The mixing ratio (w/w) of L1695 /M159 used in this study equals unity surfactants mixture so that we fixed the mixing ratio of mixed surfactants at mixing ratio (wt/wt) equals unity give best A_T (%). In this section we presented the phase diagrams for the systems which contain the mixing ratio (w/w) of oil1/oil2 equal (A) 1/2 (B) 1 (C) 2 (D) 3.

Mixing effect of oils

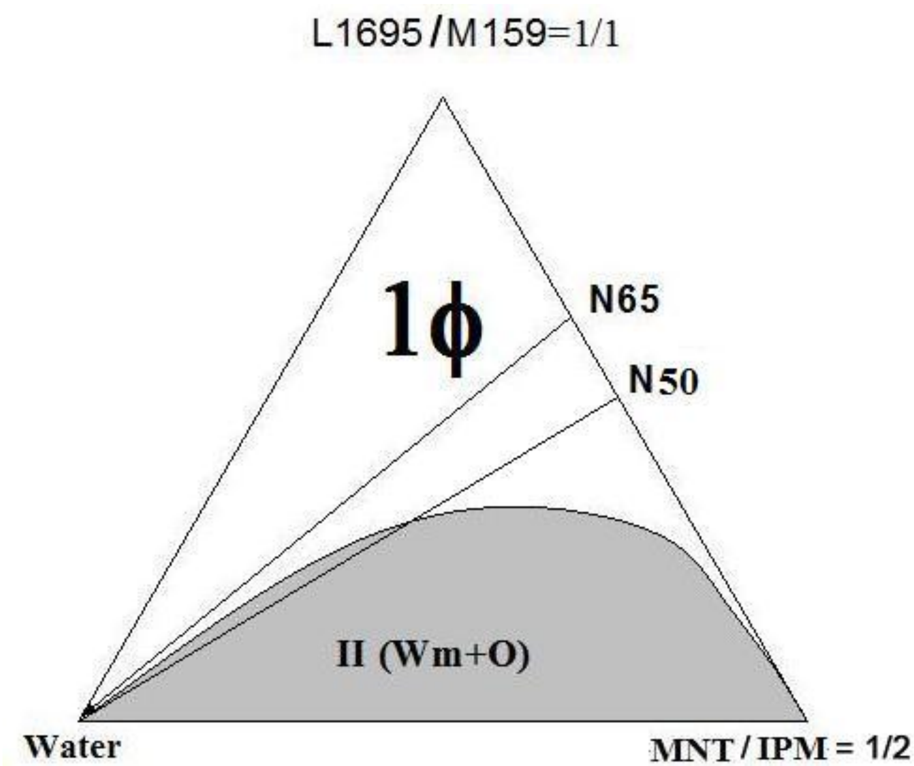
We have also found that mixing oils gave better oil surface tension polarity and solubilization behavior than prescribing one type of oil in some cases. Figure 5.86 shows the results when isopropylmyristate oils were mixed with peppermint oil. As can be seen, the mixing effect was observed for each combination. The most effective mixing ratio was 1:1 of IPM, CCT and Oil **2**.

W/L1695+M159/IPM+MNT

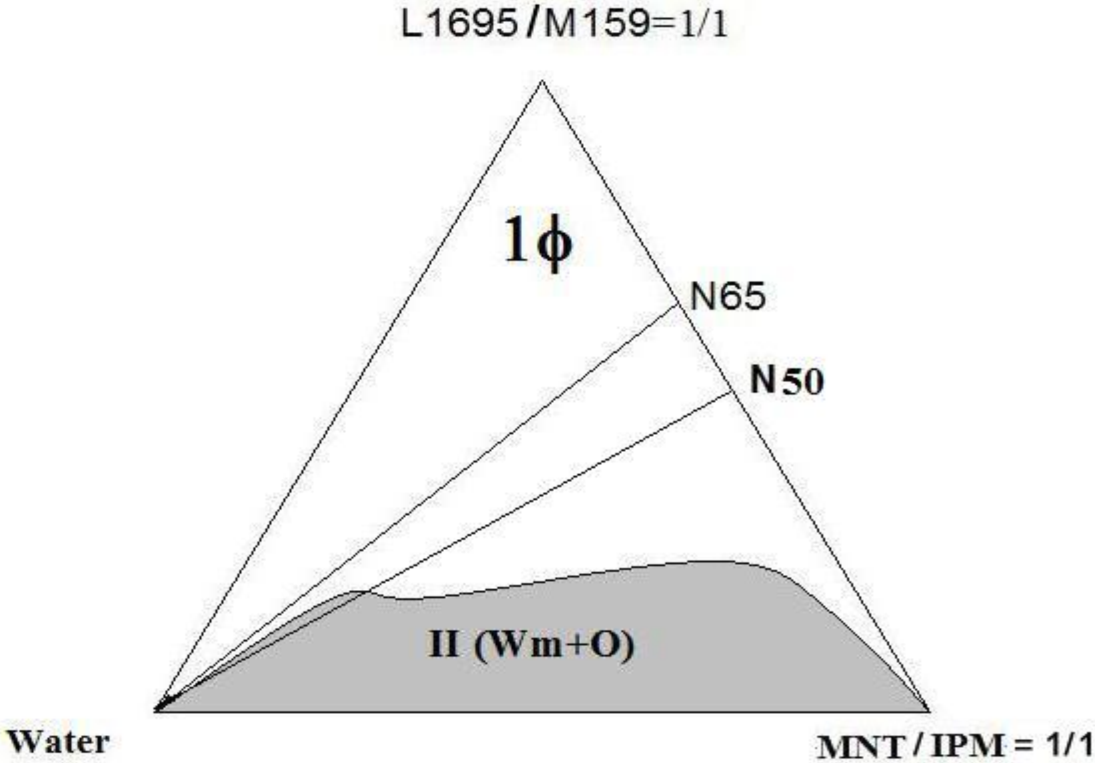
Figure 5.86 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) / isopropylmyristate (IPM) +peppermint oil (MNT) system at different weight ratios of MNT/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.86 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 100 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 72 wt% water.

For low mixed surfactants contents a multiphase reign II (Wm+O) is not observed at dilution line N65.Some behavior is observed in Figure 5.86B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.86C the one phase microemulsion region shrinks more compared to 5.86B and 5.86D.

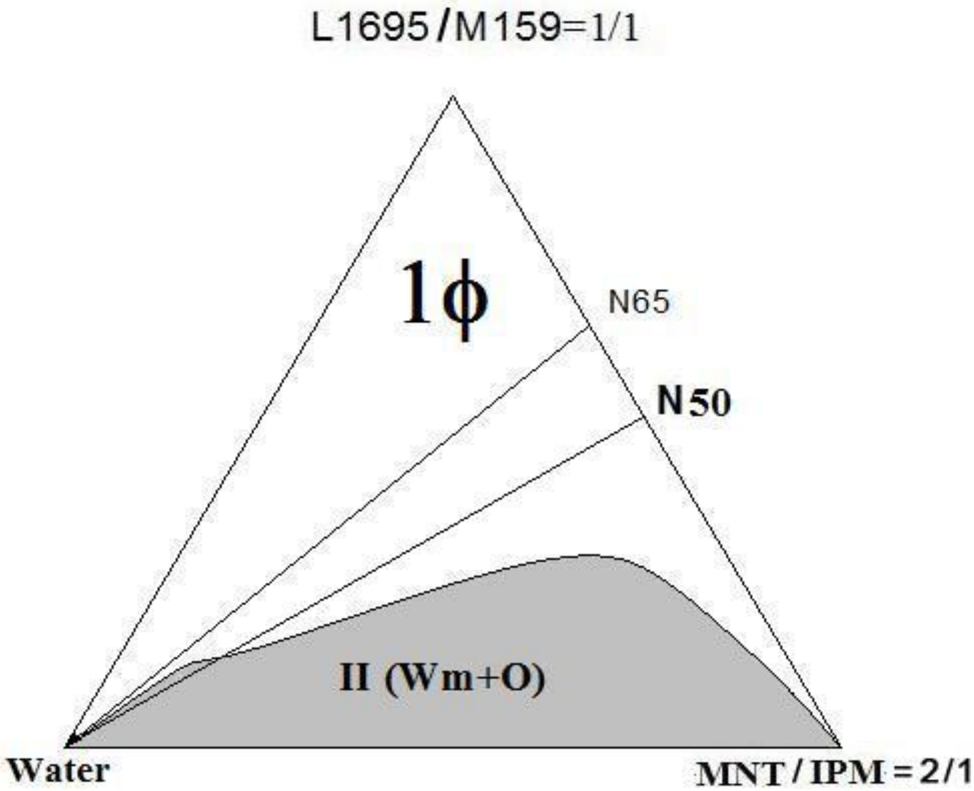


(A)



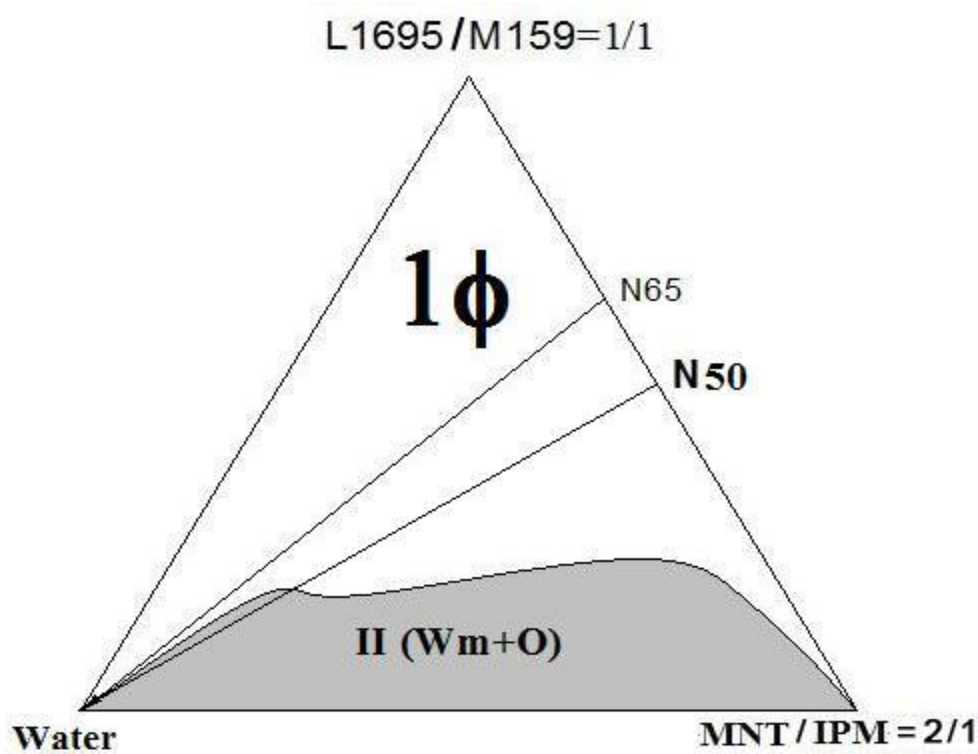
L1695/M159=1/1
1ϕ
N65
N50
II (Wm+O)
Water
MNT / IPM = 1/1

(B)



L1695/M159=1/1
1ϕ
N65
N50
II (Wm+O)
Water
MNT / IPM = 2/1

(C)



(D)

Figure 5.86: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +peppermint oil (MNT) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+MNT) = 65/35, MNT/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Figure 5.86 presents the phase behavior of the system W/L1695+M159/IPM+MNT. Figure 5.87 and Table 5.36 represents the variation of the total monophasic region A_T (%). as function of mixing ratios of different mixed oil and as function of temperature. When peppermint oil is mixed with isopropylmyristate oil, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=1/2) equals 50%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%). increase to 63%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%). decrease slightly equals 55%, for mixing ratio (oil2/oil1=3) the total monophasic area A_T (%). increase again to 63%.So that mixing peppermint oil with isopropylmyristate oil at mixing ratio (oil2/oil1=1or 3) gave us the best result.

Table 5.36: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1) / IPM + MNT at different mixing ratios of mixed oil and at different temperatures.

(MNT/IPM)	A_T (%) 25°C	37°C	45°C
0.5	50	49	49
1.0	63	59	56
2.0	55	57	58
3.0	63	63	62

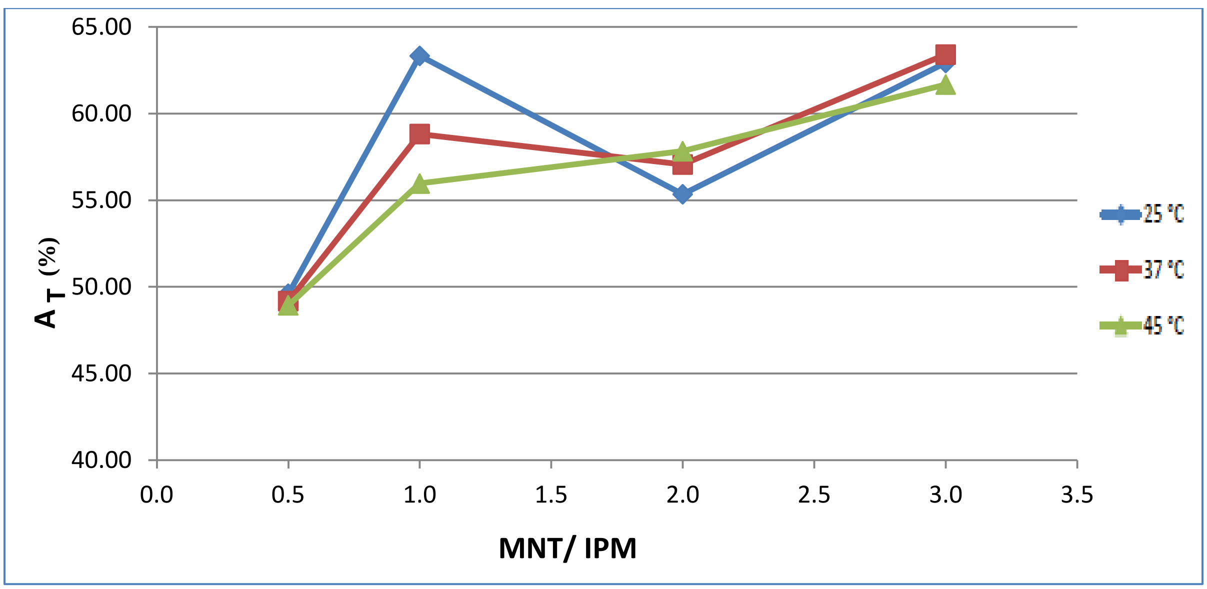


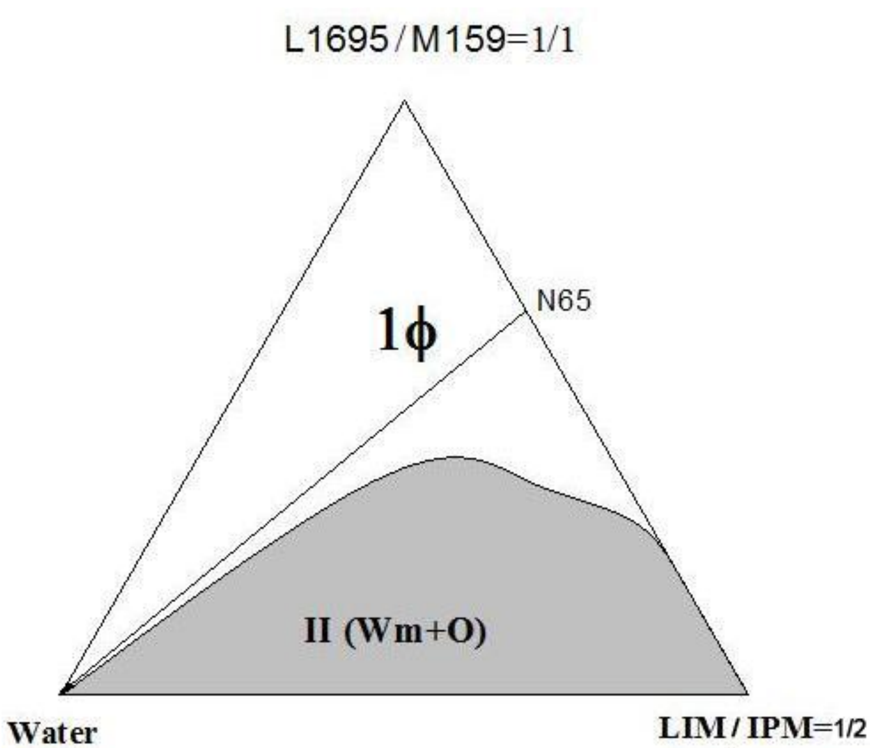
Figure 5.87: Variation of the total monophasic area A_T (%). as function of weight ratio of peppermint and isopropylmyristate and as function of temperature for the system: W/ L1695+M159/IPM+MNT.

W/L1695+M159/IPM+LIM

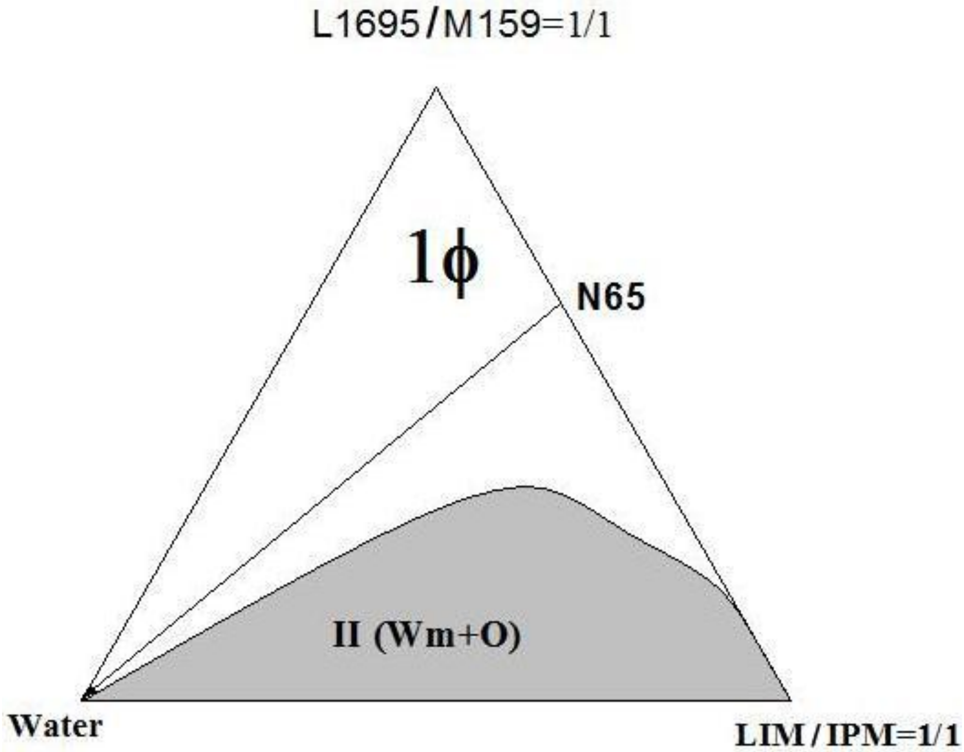
Figure 5.88 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) / /isopropylmyristate (IPM) +R(+)-limonene (LIM) system at different weight ratios of LIM/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.88 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 100 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 60 wt% water.

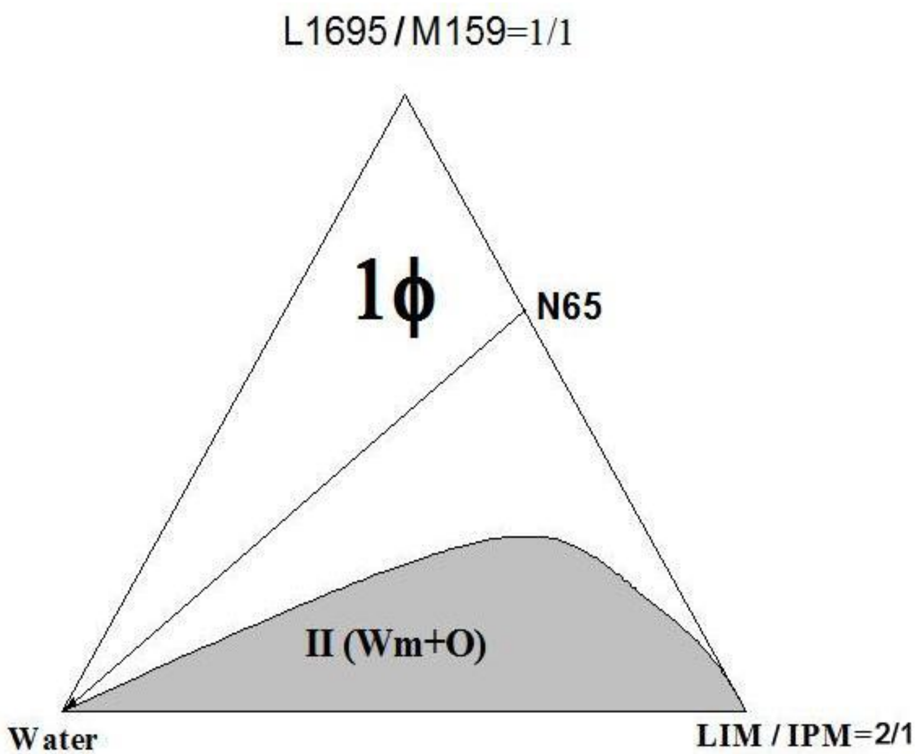
For low mixed surfactants contents a multiphase reign II (Wm+O) is not observed at dilution line N65.Some behavior is observed in Figure 5.88B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.88C the one phase microemulsion region increased more compared to 5.88B and 5.88D.



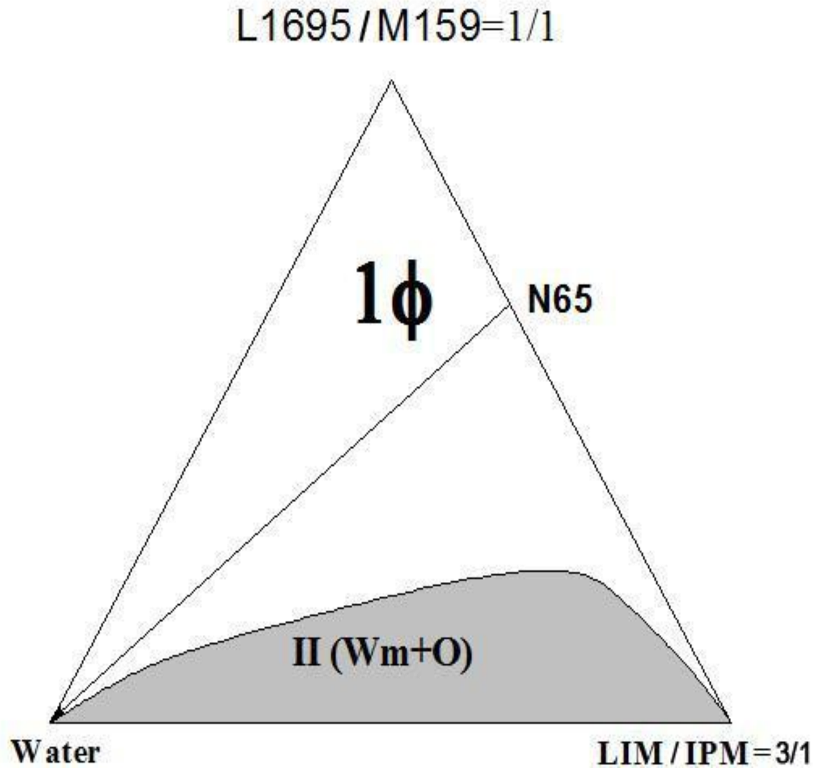
(A)


L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
LIM/IPM=1/1

(B)


L1695/M159=1/1
1ϕ
N65
II (Wm+O)
Water
LIM/IPM=2/1

(c)



(D)

Figure 5.88: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159)/isopropylmyristate (IPM) +R(+)-limonene (LIM) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+LIM) = 65/35, LIM/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.37: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM+ LIM at different mixing ratios of mixed oil and at different temperatures.

	A_T (%)		
(LIM/IPM)	25°C	37°C	45°C
0.5	48	46	33
1.0	52	53	53
2.0	56	58	57
3.0	47	50	51

Figures 5.88 present the phase behaviors of the systems W/L1695+M159/IPM+LIM. The mixing ratio of (L1695/M159) equals 1/1 and Figures 5.89 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different oil and as function of temperature .When R(+)-limonene mixed with isopropylmyristate, the total monophasic area A_T (%) at 25°C for the mixing ratios LIM/IPM equals maximum total area gave us the best result in Table 5.37. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing LIM with IPM improves the water solubilization.

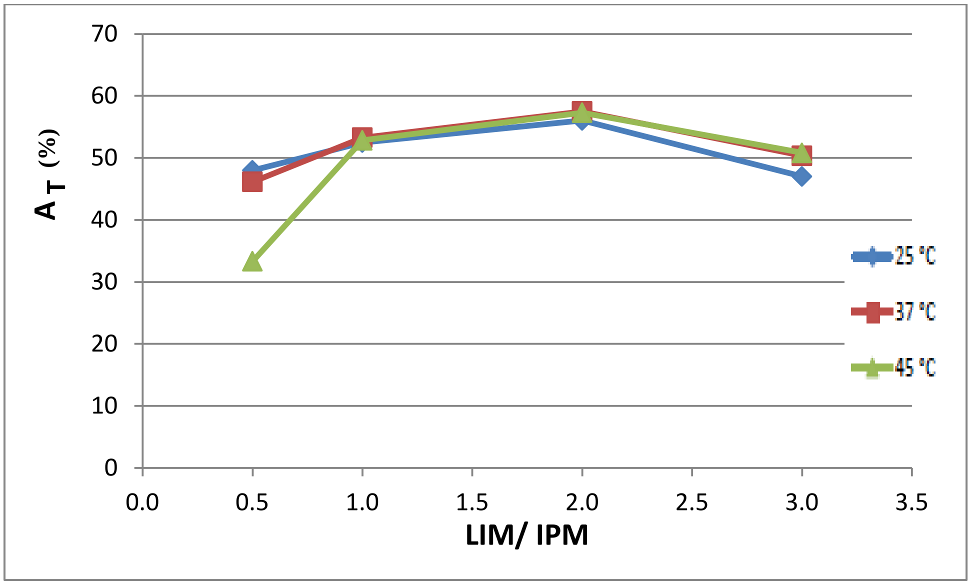


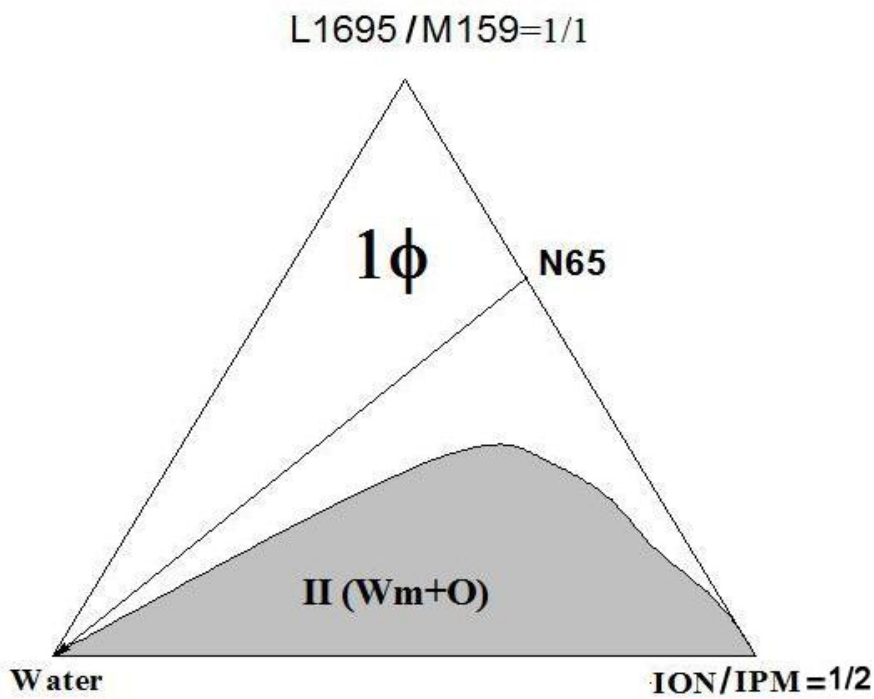
Figure 5.89: Variation of the total monophasic area A_T (%) as function of R(+)-limonene oil content in the oil mixture (IPM+LIM) and as function of temperature for the system: W/ L1695+M159/IPM+LIM.

W/L1695+M159/IPM+ION.

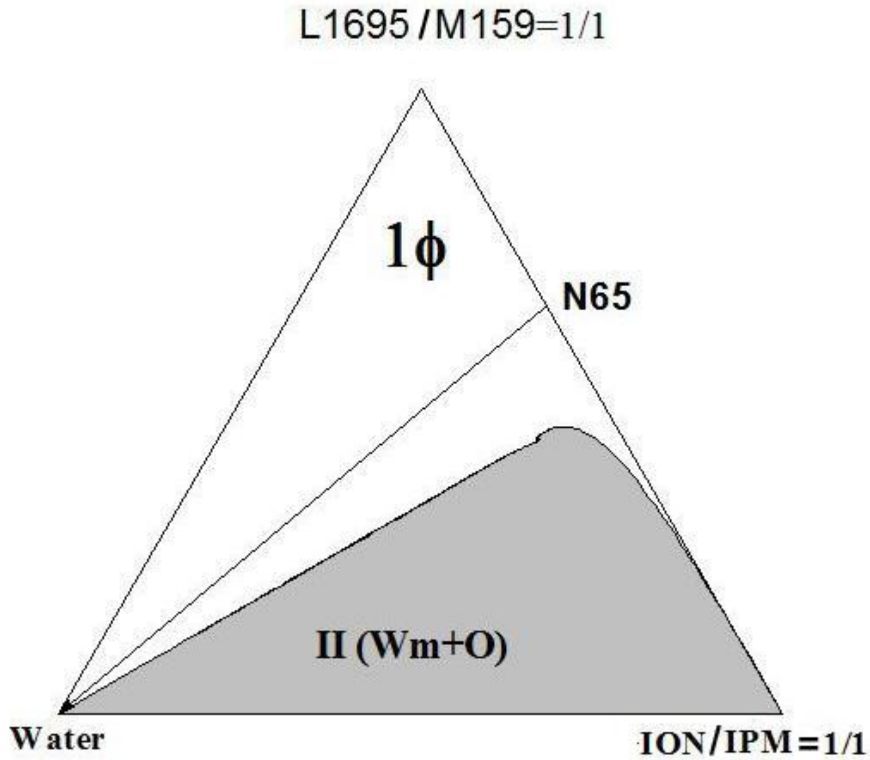
Figure 5.90 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) / isopropylmyristate (IPM) +α-ionone (ION) system at different weight ratios of ION/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.90 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 100 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 62 wt% water.

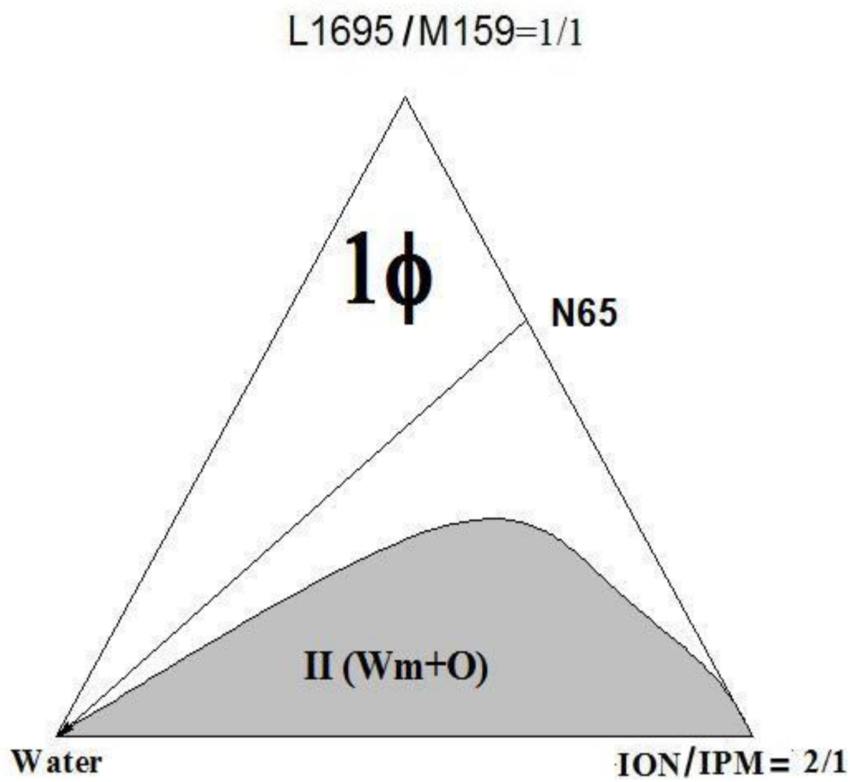
For low mixed surfactants contents a multiphase reign II (Wm+O) is not observed at dilution line N65.Some behavior is observed in Figure 5.90B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.90C and 5.90D the one phase microemulsion region shrinks more compared to 5.90B.



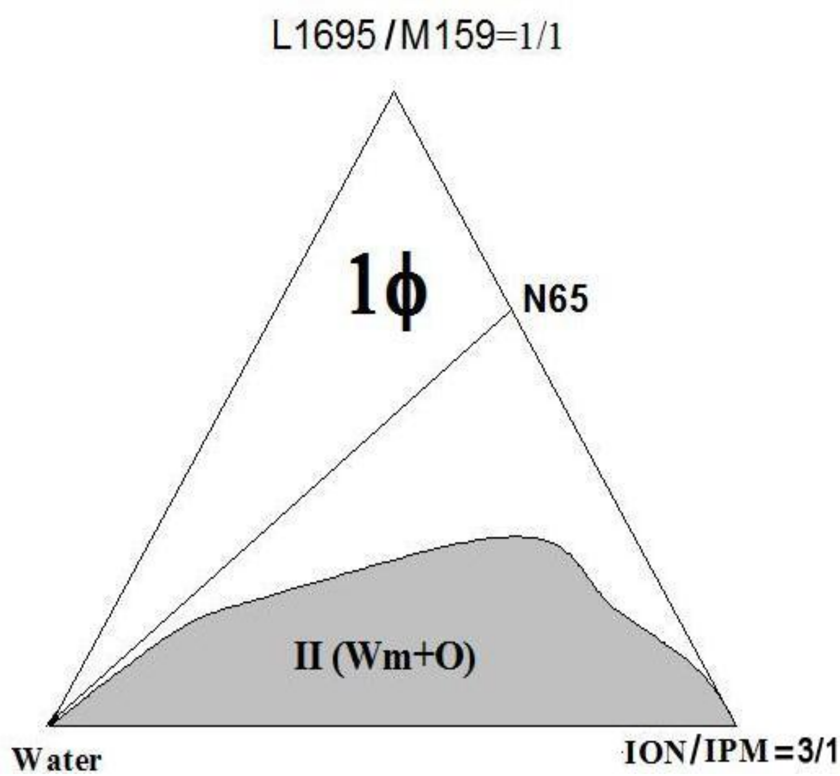
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION / IPM = 1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION / IPM = 2/1

(C)



(D)

Figure 5.90: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +α-ionone (ION) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+ION) = 65/35, ION/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.38: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM + ION at different mixing ratios of mixed oil and at different temperatures.

	A_T (%)		
(ION/IPM)	25°C	37°C	45°C
0.5	54	55	55
1.0	51	51	54
2.0	49	50	47
3.0	51	51	48

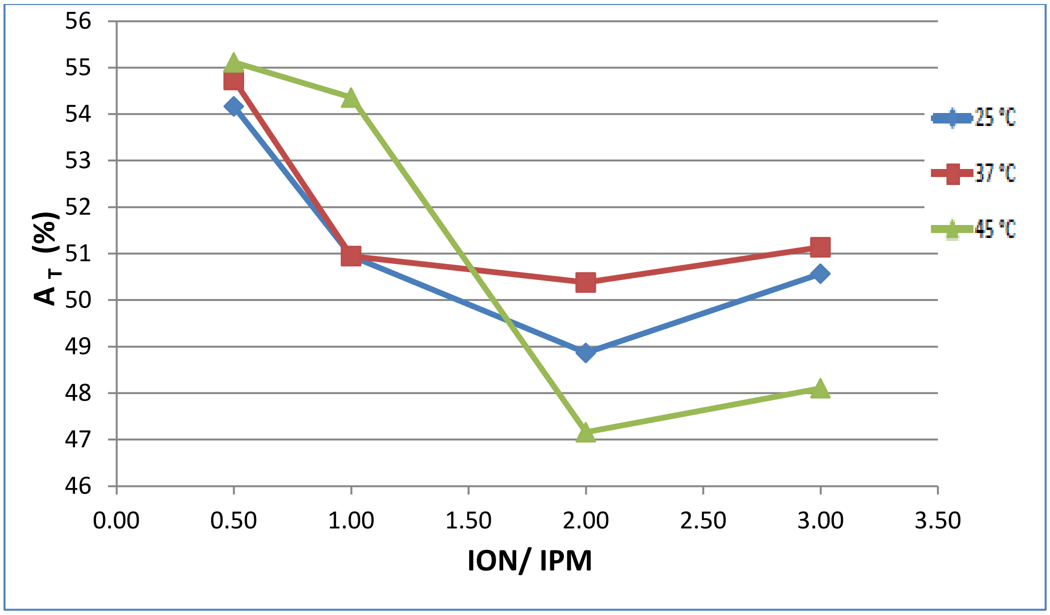


Figure 5.91: Variation of the total monophasic area A_T(%) as function of α-ionone content in the oils mixture (IPM+ION) and as function of temperature for the system: W/ L1695 +M159 / IPM+ ION.

W/L1695+M159/CCT+MNT.

Figure 5.92 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) /caprylic-capric triglyceride +peppermint oil (MNT) system at different weight ratios of MNT/CCT that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

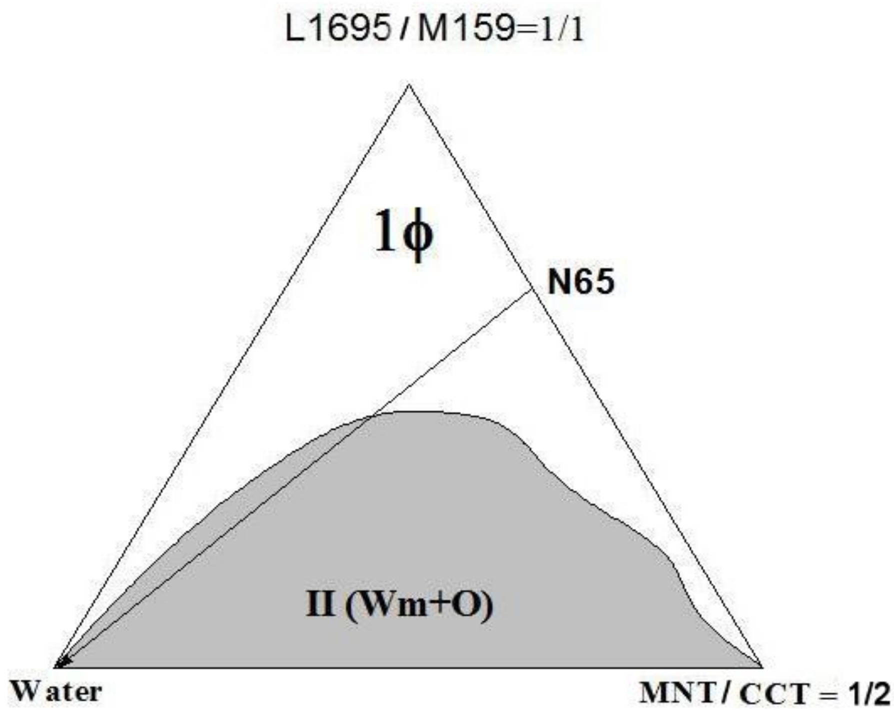
As show in Figure 5.92 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/oil axis. The one phase microemulsion region extend to approximately 33 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 60 wt% water.

For low mixed surfactants contents (below 60 wt %) a multiphase reign II (Wm+O) is observed at dilution line N65.Some behavior is observed in Figure 5.92B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 63 wt%. In Figure 5.92C the one phase microemulsion region increase slowly compared to 5.92B.

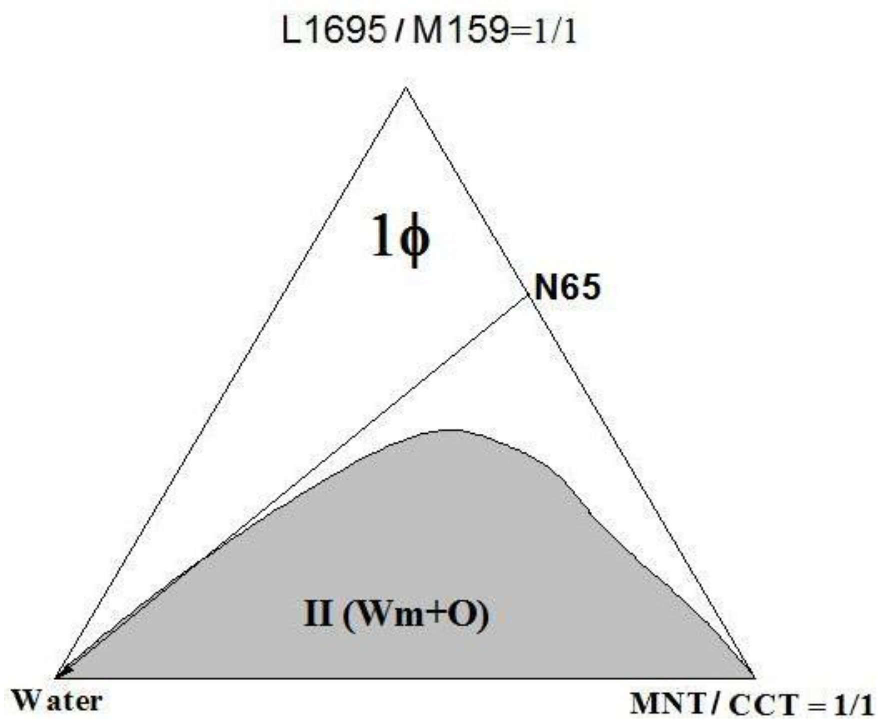
With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.92 the one phase microemulsion region increase more with increase peppermint oil.

Figure 5.92 presents the phase behavior of the system W/L1695+M159/CCT+MNT. The mixing ratio of (CCT/MNT) equals 1/2. Figure 5.93 and Table 5.39 represents the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oil and as function of temperature. When peppermint oil mixed with caprylic-capric triglyceride oil, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=0.5) equals 43%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increase to 45%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) decrease slightly equals 56%, for mixing ratio (oil2/oil1=3) the total monophasic area A_T (%) increase again to 58%.So that mixing peppermint oil with caprylic-capric triglyceride oil at mixing ratio (oil2/oil1= 3) gave us the best result.

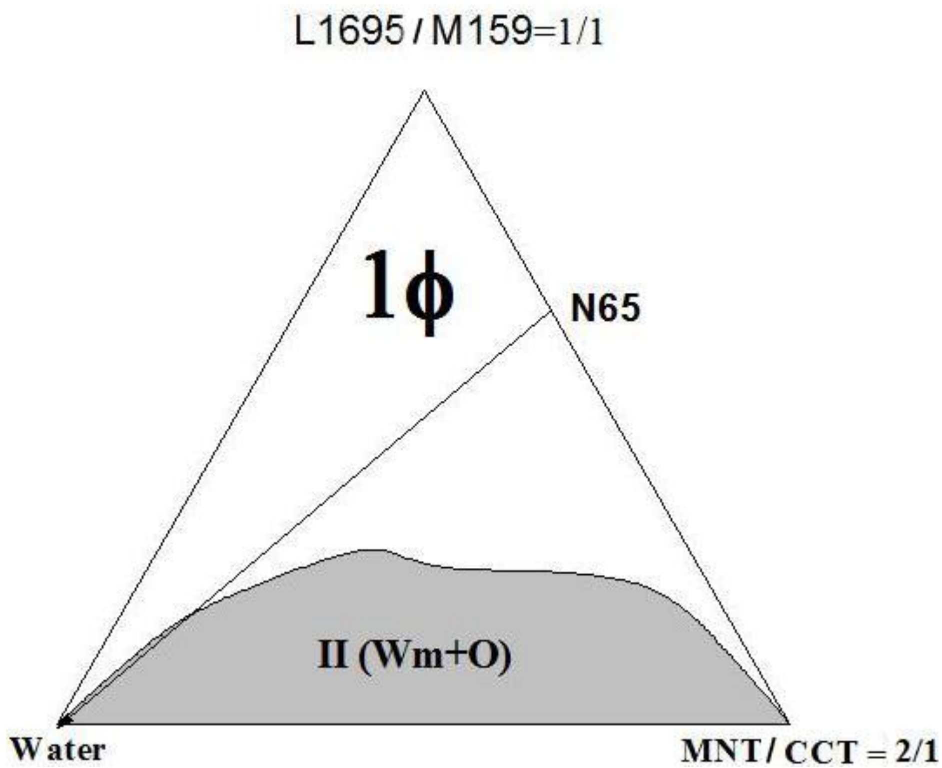
So mix peppermint oil with isopropylmyristate oil give total aria grater when mix with caprylic-capric triglyceride, because CCT have molecular volume large than IPM and IPM make as penetration enhancer.


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
MNT / CCT = 1/2

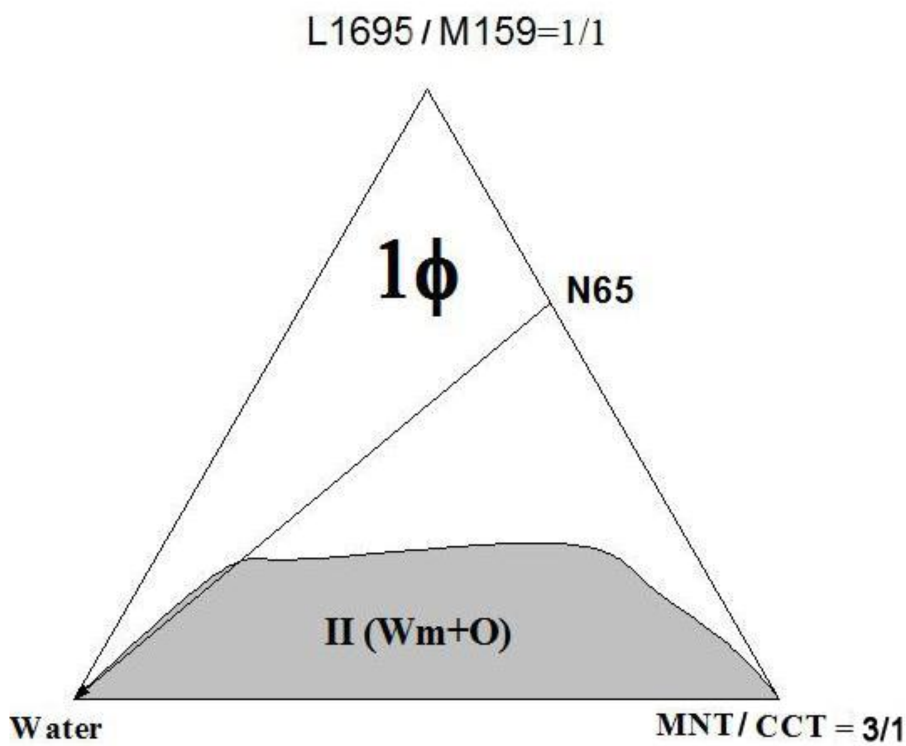
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
MNT / CCT = 1/1

(B)



(C)



(D)

Figure 5.92: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) + peppermint (MNT) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and

the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+MNT) = 65/35, MNT/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.39: The total monophasic area A_T (%) for the system W/L1695+M159(1:1)/CCT +MNT at different mixing ratios of mixed oil and at different temperatures.

	A_T (%)		
(MNT/CCT)	25°C	37°C	45°C
0.5	43	44	45
1.0	44	46	48
2.0	56	57	56
3.0	58	55	53

Figures 5.92 present the phase behaviors of the systems W/L1695+M159/CCT+MNT. The mixing ratio of (L1695/M159) equals 1/1 and Figures 5.93 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different oil and as function of temperature .When peppermint oil mixed with caprylic-capric triglyceride, the total monophasic area A_T (%) at 25°C for the mixing ratios MNT/CCT equals maximum total area gave us the best result in Table 5.39. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing MNT with CCT improves the water solubilization.

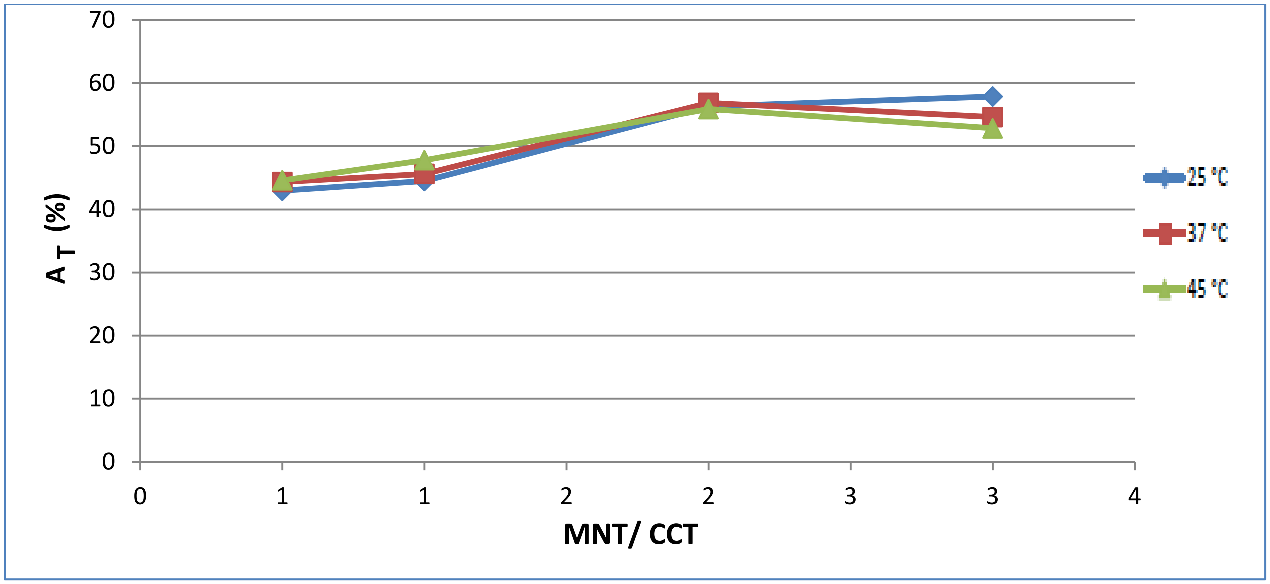


Figure 5.93: Variation of the total monophasic area A_T (%) as function peppermint content in the mixture (CCT+MNT) and as function of temperature for the system: W / L1695+ M159/CCT+ MNT.

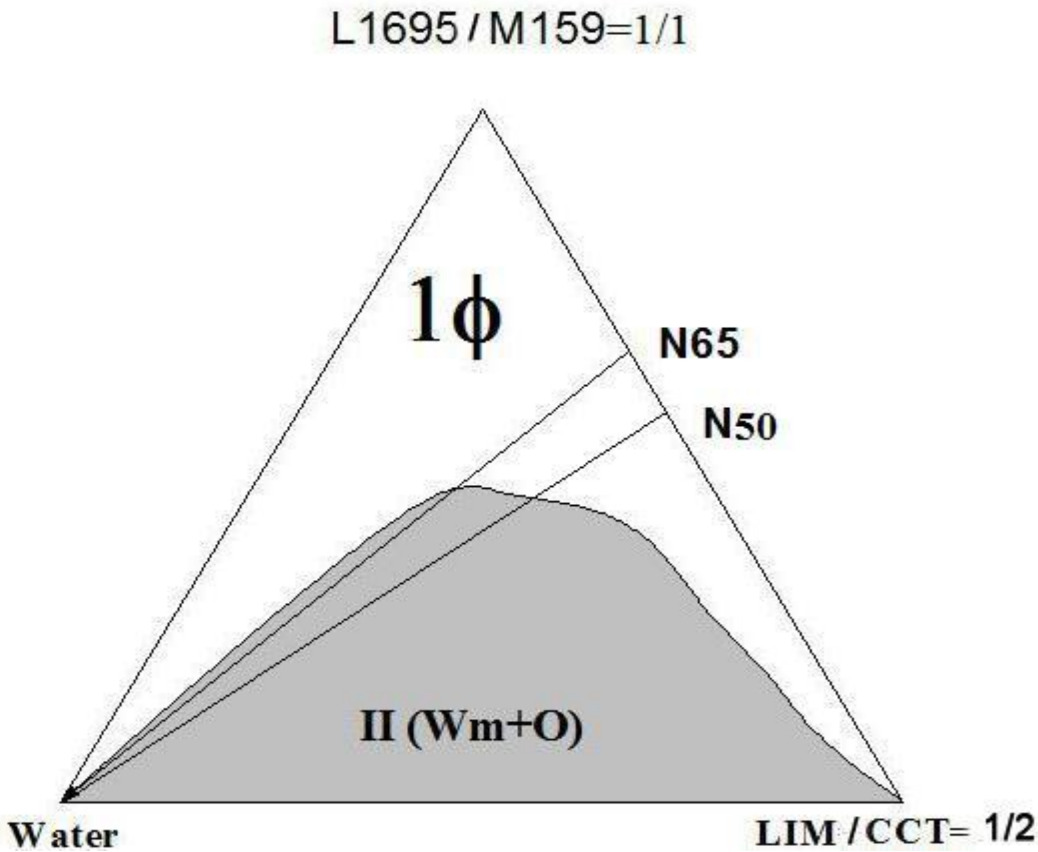
<u>W/L1695+M159/CCT+LIM:</u>

Figure 5.94 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) /caprylic-capric triglyceride + R(+)-limonene oil (LIM) system at different weight ratios of LIM/CCT that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

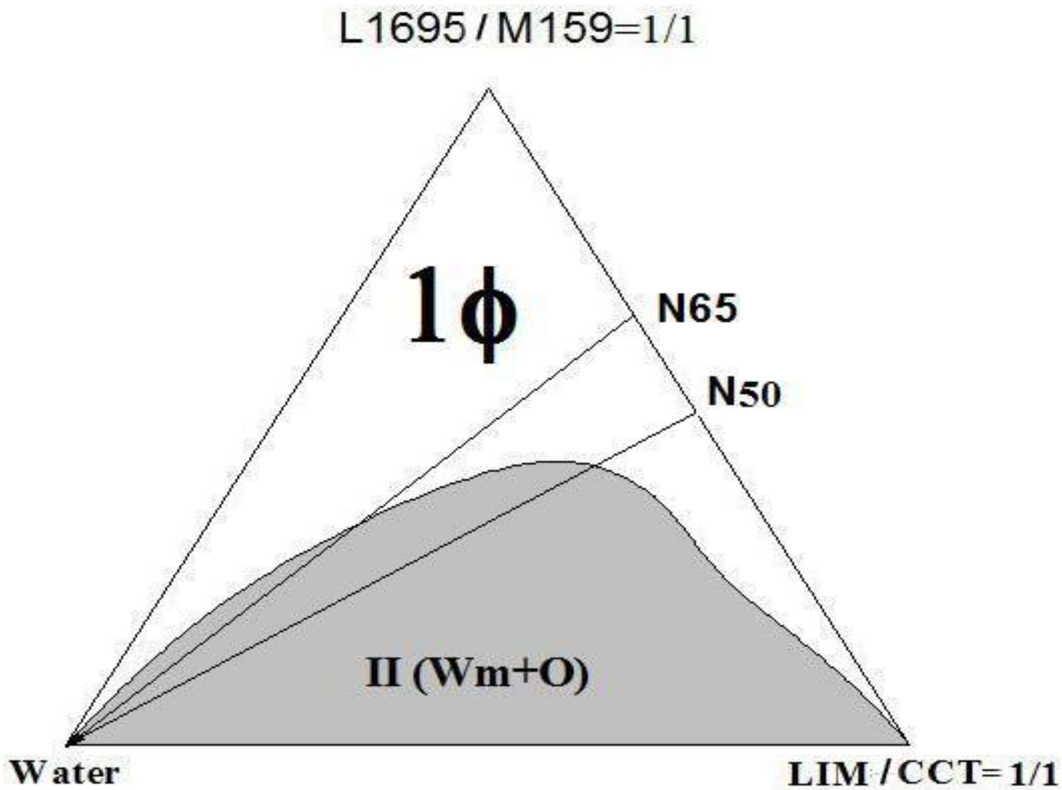
As show in Figure 5.94 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/oil axis. The one phase microemulsion region extend to approximately 30 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 58 wt% water.

For low mixed surfactants contents (below 42 wt %) a multiphase reign II (Wm+O) is observed at dilution line N65.Some behavior is observed in Figure 5.94B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 63 wt%. In Figure 5.94C the one phase microemulsion region increase slowly compared to 5.94B.

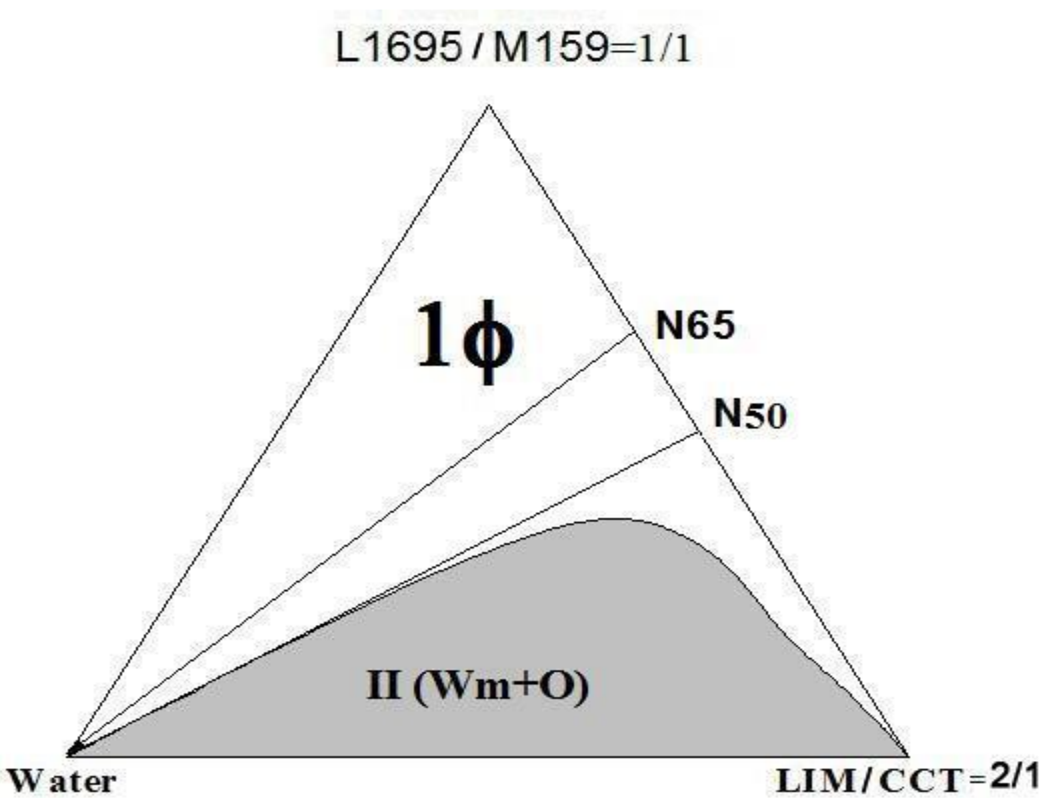
With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.94 the one phase microemulsion region increase more with increase R(+)-limonene oil in Figure 5.94C. In Figure 5.94D the one phase microemulsion region shrinks more compared to 5.94C.



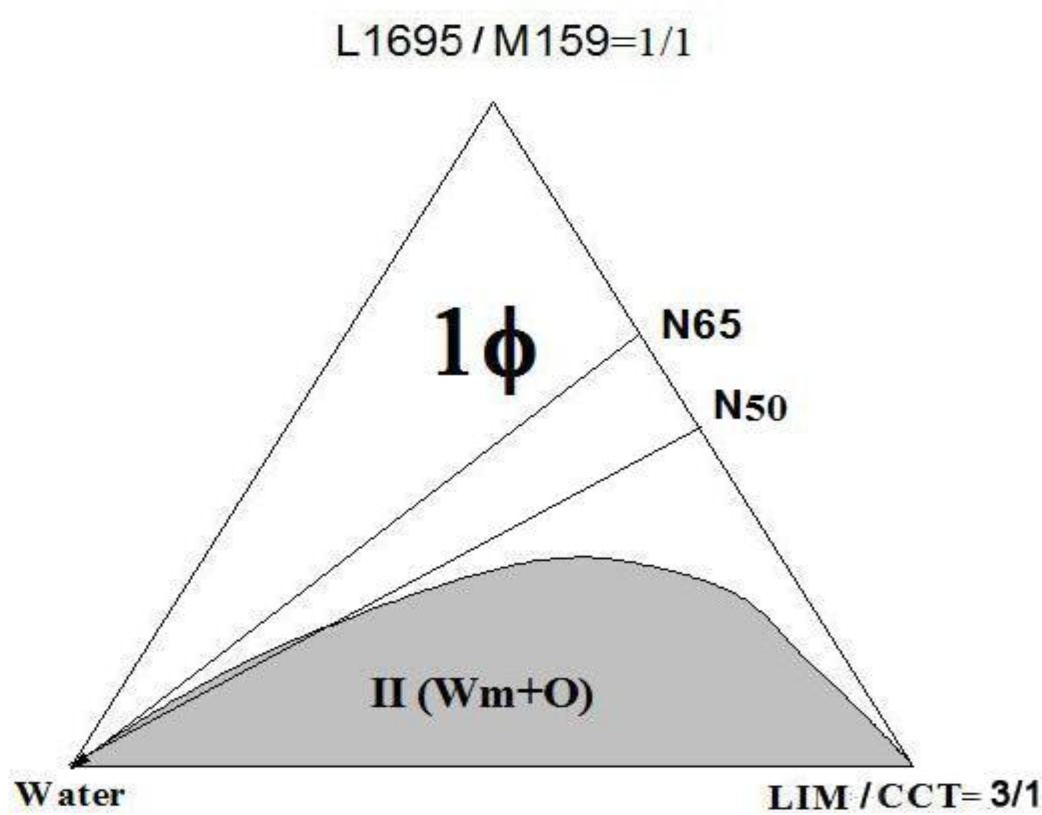
(A)


L1695 / M159=1/1
1ϕ
N65
N50
II (Wm+O)
Water
LIM / CCT= 1/1

(B)


L1695 / M159=1/1
1ϕ
N65
N50
II (Wm+O)
Water
LIM / CCT = 2/1

(C)



(D)

Figure 5.94: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) + R(+)-limonene (LIM) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+LIM) = 65/35, LIM/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.40: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ LIM at different mixing ratios of mixed oil and at different temperatures.

	A_T (%)		
(LIM/CCT)	25°C	37°C	45°C
0.5	40	40	40
1.0	42	43	44
2.0	44	46	46
3.0	41	40	40

Figures 5.94 present the phase behaviors of the systems W/L1695+M159/CCT+LIM. The mixing ratio of (L1695/M159) equals 1/1 and Figures 5.95 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different oil and as function of temperature .When R(+)-limonene mixed with caprylic-capric triglyceride , the total monophasic area A_T (%) at 25°C for the mixing ratios LIM/CCT equals maximum total area gave us the best result in Table 5.40. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing LIM with CCT improves the water solubilization.

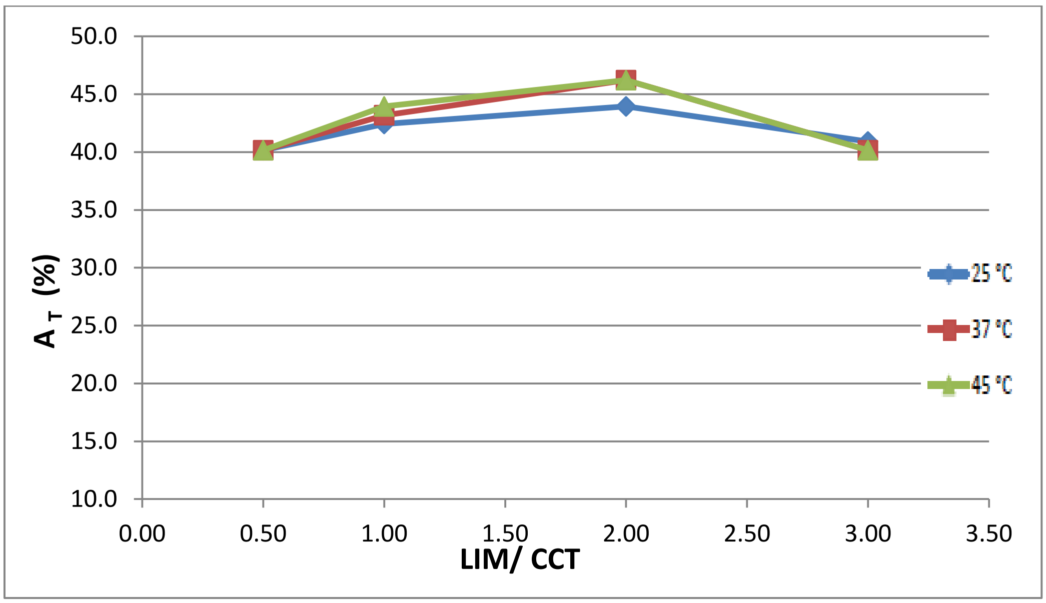


Figure 5.95: Variation of the total monophasic area A_T (%) as function R(+)-limonene content in the mixture (CCT+LIM) and as function of temperature for the system: W / L1695+ M159/ CCT +LIM.

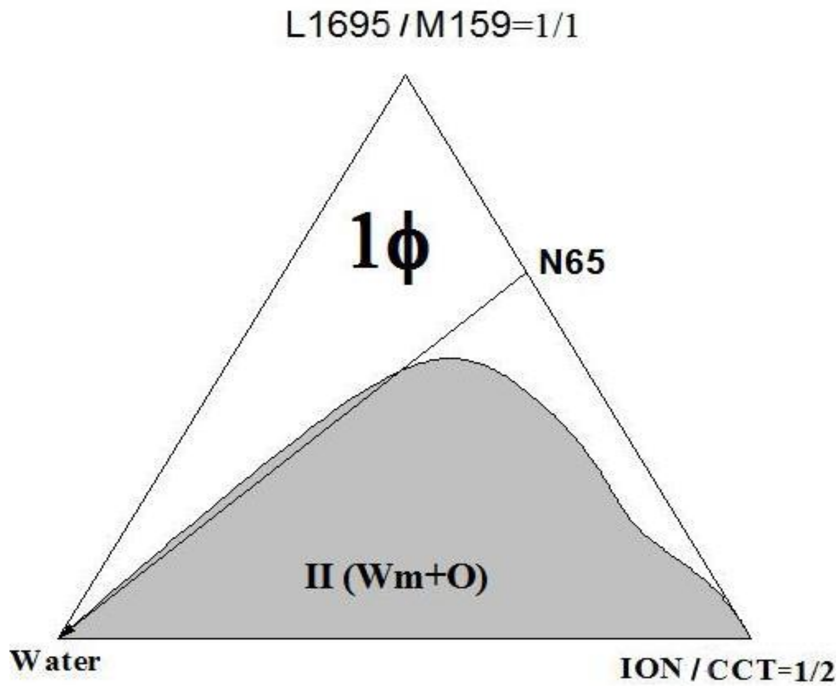
W/L1695+M159/CCT+ION:

Figure 5.96 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1) /caprylic-capric triglyceride + α-ionone oil (ION) system at different weight ratios of ION/CCT that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

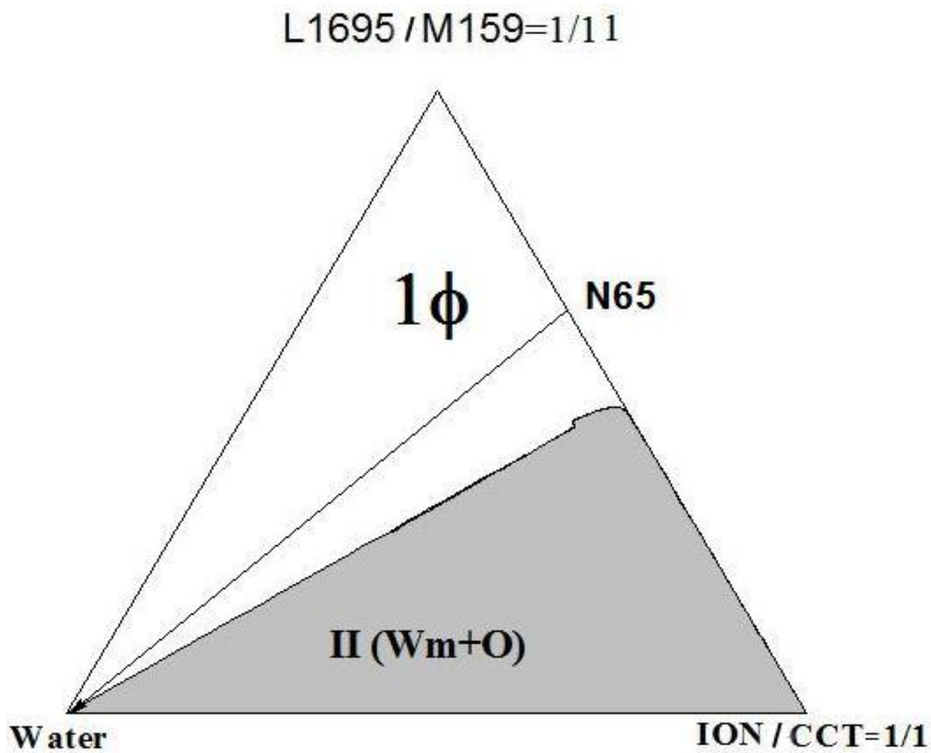
As show in Figure 5.96A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/oil axis. The one phase microemulsion region extend to approximately 25 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 52 wt% water.

For low mixed surfactants contents (below 48 wt %) a multiphase reign II (Wm+O) is observed at dilution line N65.Some behavior is observed in Figure 5.96B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents below 52 wt%. In Figure 5.96C the one phase microemulsion region decrease slowly compared to 5.96B.

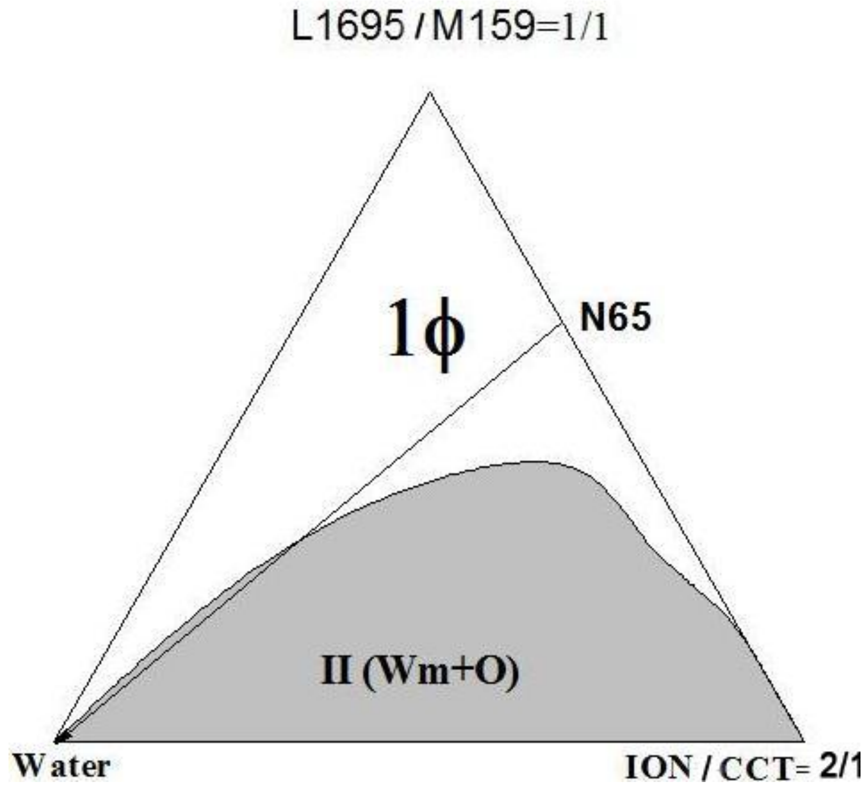
With the difference that the area of the one phase microemulsion region decrease since the multiphase region is extended to mixed surfactants at dilution line N65. In Figure 5.96C and Figure 5.96D the one phase microemulsion region shrinks more compared to 5.96B.


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION / CCT=1/2

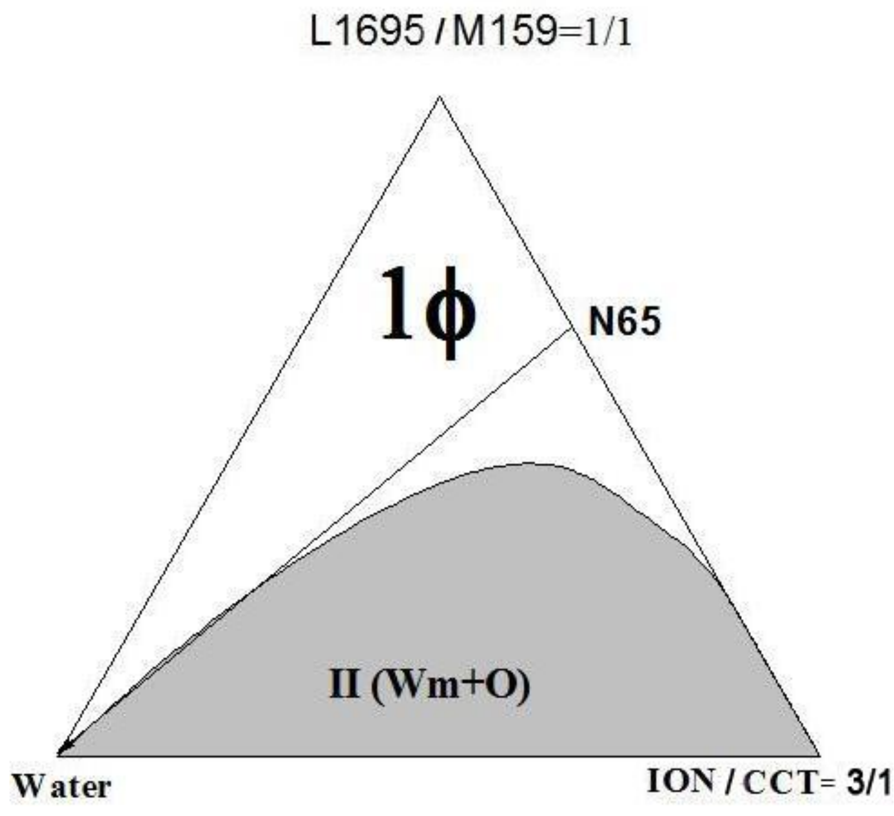
(A)


L1695 / M159=1/11
1ϕ
N65
II (Wm+O)
Water
ION / CCT=1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION / CCT= 2/1

(C)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ION / CCT= 3/1

(D)

Figure 5.96: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) + α-ionone (ION) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+ION) = 65/35, ION/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.41: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ ION at different mixing ratios of mixed oil and at different temperatures.

	A_T (%)		
(ION/CCT)	25°C	37°C	45°C
0.5	42	42	42
1.0	50	51	51
2.0	37	39	41
3.0	35	40	45

Figures 5.96 present the phase behaviors of the systems W/L1695+M159/CCT+ION. The mixing ratio of (L1695/M159) equals 1/1 and Figures 5.97 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different oil and as function of temperature .When α-ionone mixed with caprylic-capric triglyceride, the total monophasic area A_T (%) at 25°C for the mixing ratios ION/CCT equals maximum total area gave us the best result in Table 5.41. About the values of the total monophasic area A_T (%), it appears that the variation in A_T (%) values with temperature is small indication the formation of temperature insensitive microemulsions. This behavior indicates that mixing ION with CCT improves the water solubilization.

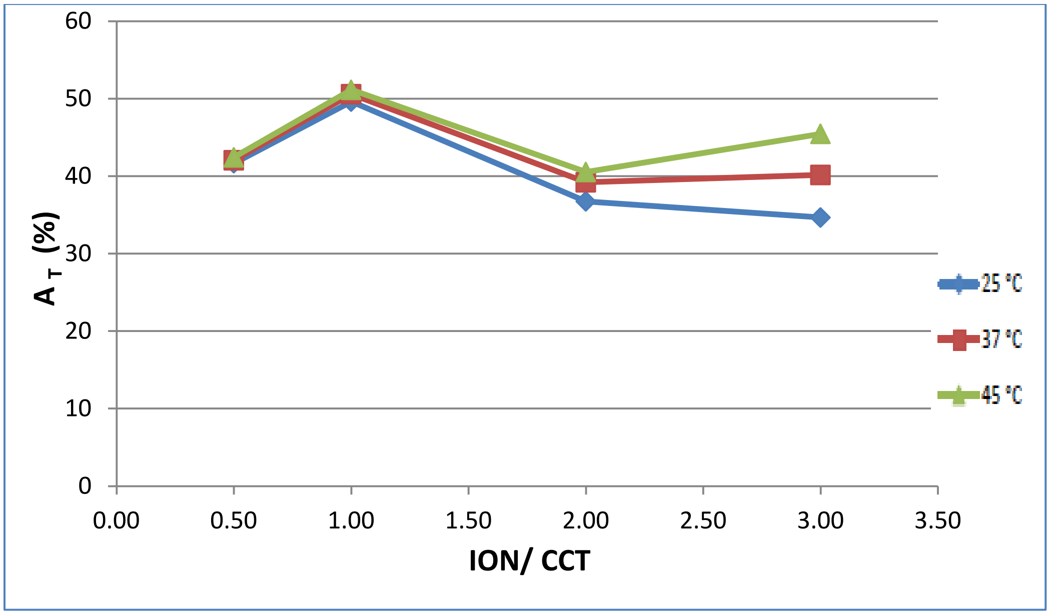


Figure 5.97: Variation of the total monophasic area A_T (%) as function α-ionone content in the mixture (CCT+ION) and as function of temperature for the system: W / L1695+ M159/CCT+ ION.

Table 5.42: The maximum total monophasic area A_T (%) for the system W/L1695+M159/mixed oils at 25°C temperatures.

Oil 1	Oil 2	A_T (%) at 25°C	Mixed oil ratio where maximum A_T (%) is obtained at 25°C
IPM	MNT	63	1/1
	LIM	56	2/1
	ION	51	1/1
CCT	MNT	58	3/1
	LIM	44	2/1
	ION	50	1/1

The mixing ratio of oils equals 1/1 is the optimum mixing ratio to be chase for their formulations the increase in the water solubilization for higher mixing ratios is not significant cause an increase the amount of one oil or the other.

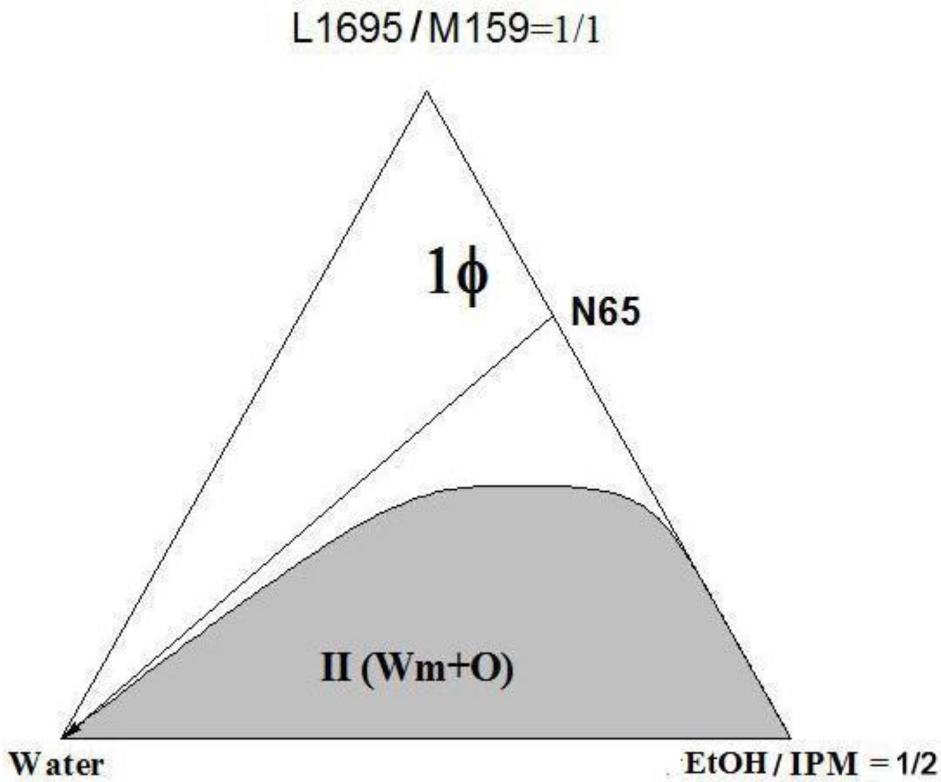
Phase behaviors of mixed surfactants/oil/ cosurfactants/systems

W/ L1695+M159/IPM+EtOH

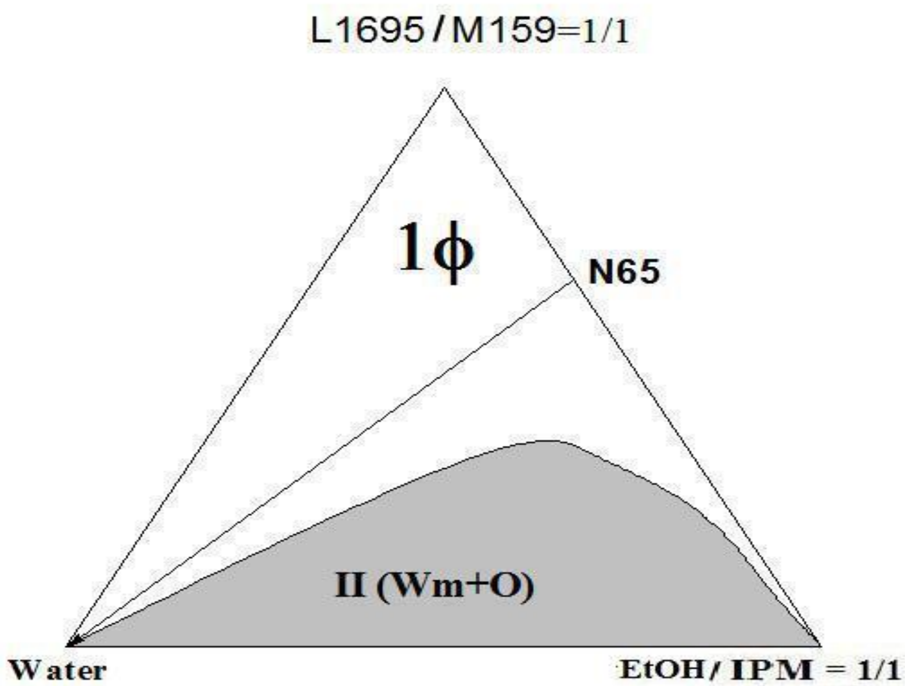
Figure 5.98 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/ isopropylmyristate (IPM)+ ethanol (EtOH) system at different weight ratios of EtOH/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figures 5.98, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/mixed cosurfactants and oil axis. The one phase microemulsion region extend to approximately 100 wt% water along the dilution line N65.

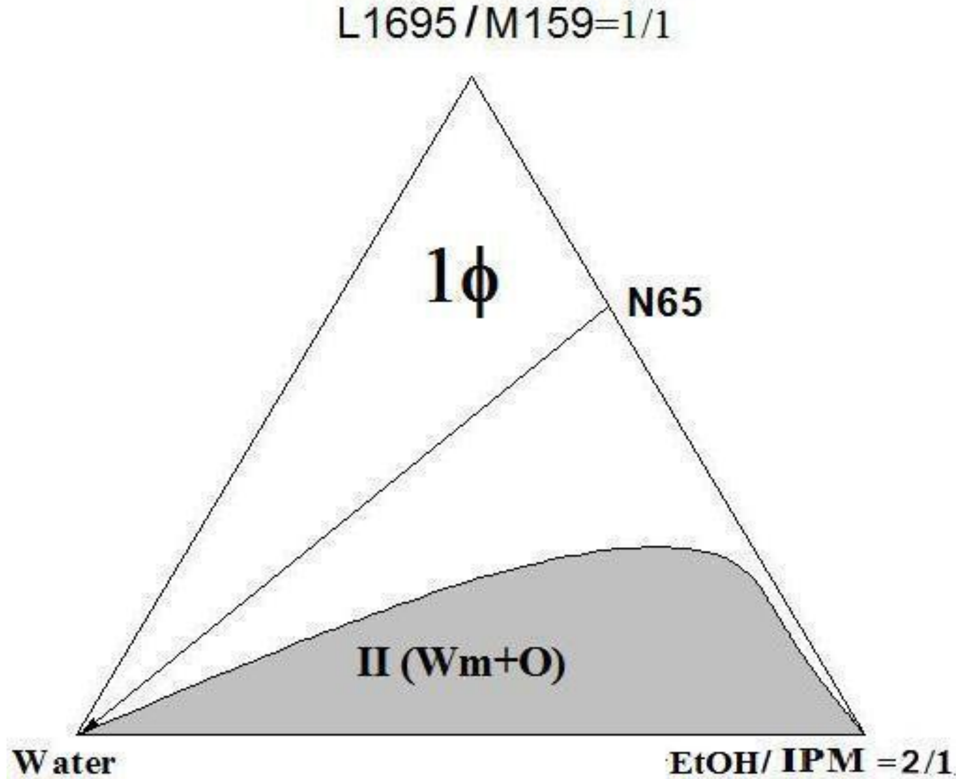
With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.98 the one phase microemulsion region increase more with increase ethanol.


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtOH / IPM = 1/2

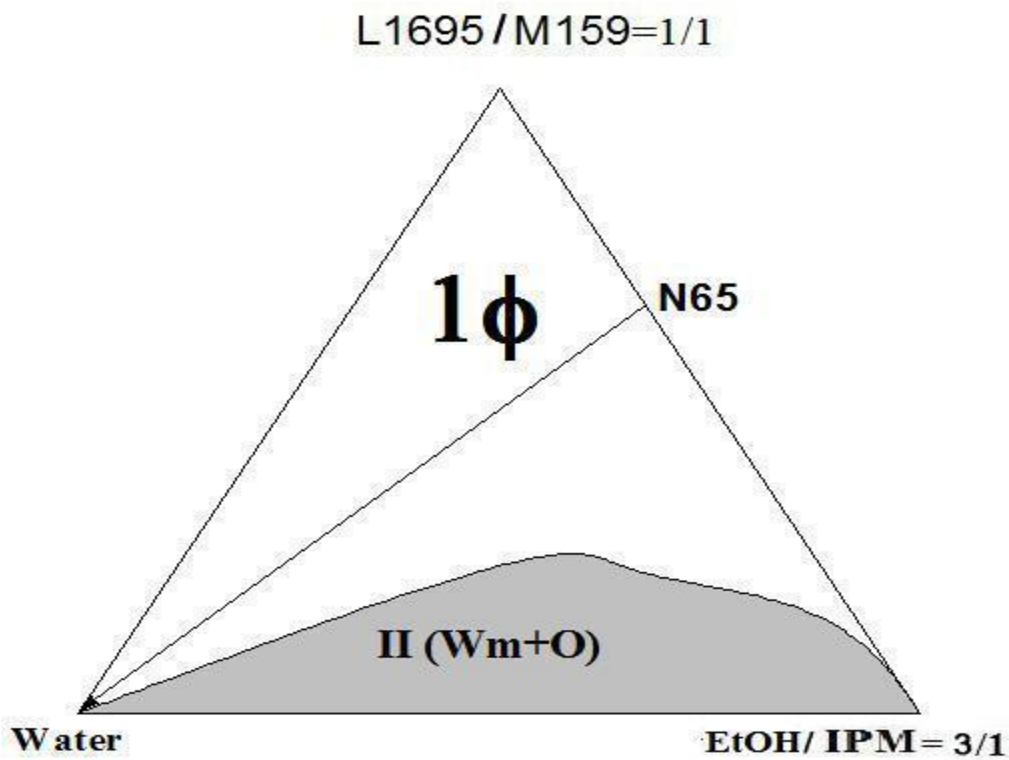
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtOH / IPM = 1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtOH/ IPM =2/1

(C)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtOH/ IPM = 3/1

(D)

Figure 5.98: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +ethanol (EtOH) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+EtOH) = 65/35, EtOH/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.43: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM+EtOH at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(EtoH/IPM)	25°C	37°C	45°C
0.5	47	47	47
1.0	56	57	57
2.0	64	65	65
3.0	64	68	68

Figures 5.98 present the phase behaviors of the systems W/L1695+M159/IPM+EtOH. The mixing ratio of (L1695/M159) equals unity and that of (EtOH /IPM) equal 1/2, 1, 2, 3. Figures 5.99 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oils and as function of temperature for the systems W/L1695+M159/IPM+EtOH respectively. When Isopropyl myristate oil mixed with Ethanol, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=1/2) equals 47%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increases to 56%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) increase to 64% and for mixing ratio (oil2/oil1=3) the value increases to 66%, so that mixing IPM oil with ethanol at mixing ratio (oil2/oil1=3) gave us the best value.

Increase ethanol causes increase total aria A_T (%), and increase temperate causes increase total aria A_T (%),investigated the phase behavior of the system W/L1695+M159/Oil+EtOH, it was found that the solubilization capacity of water in the oil is dependent on the surfactants and ethanol/oil mixing ratios (w/w).

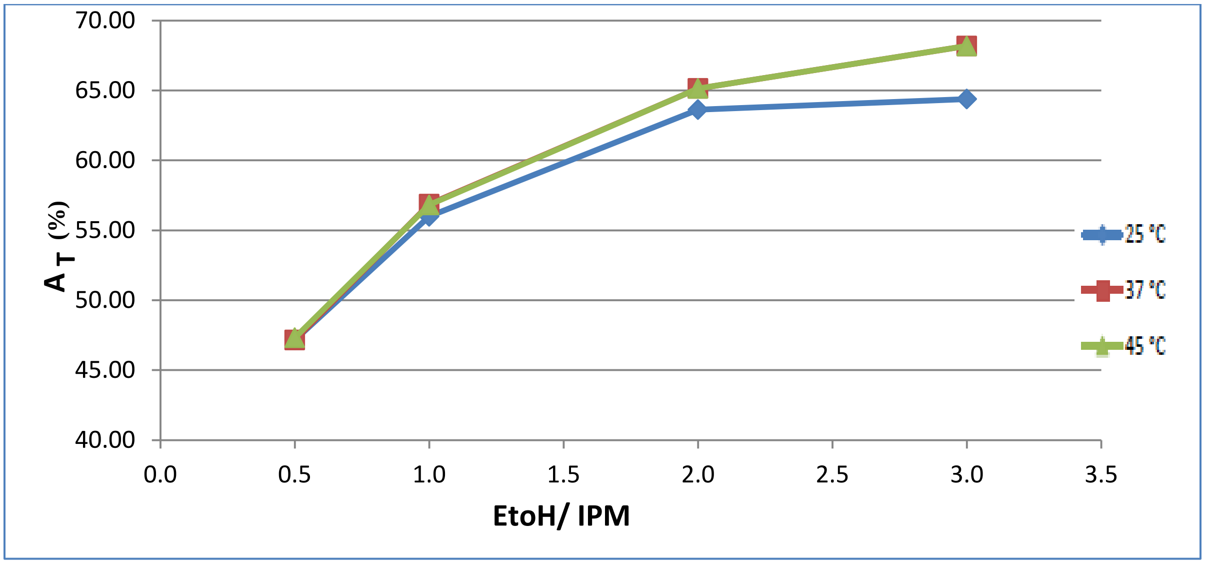


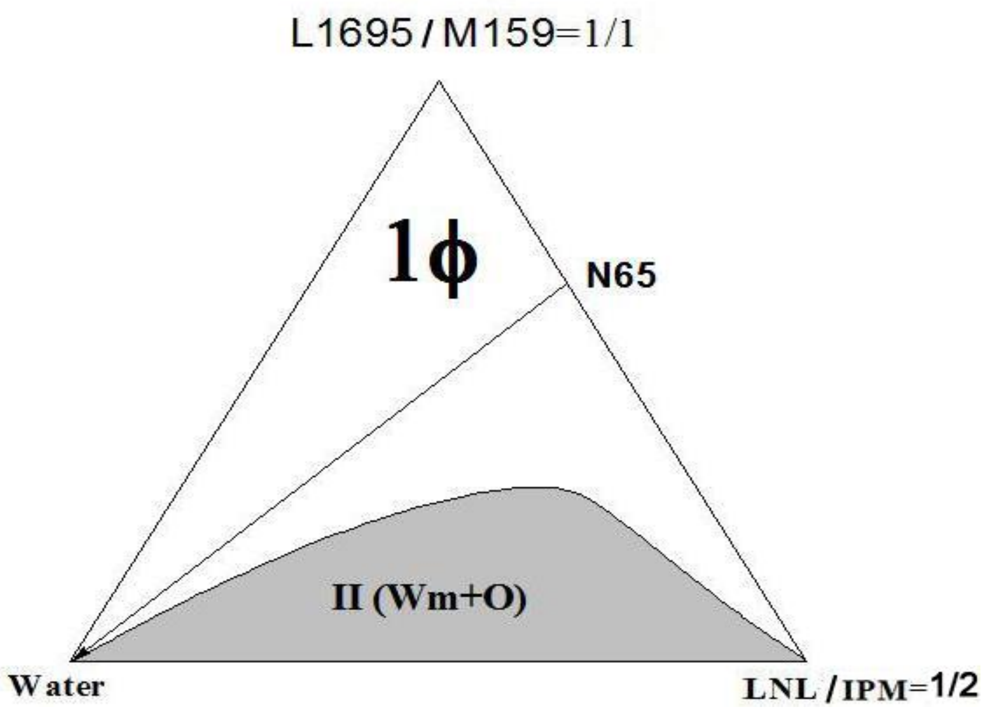
Figure 5.99: Variation of the total monophasic area A_T (%) as function of ethanol content in the oil+ ethanol mixture (IPM+EtOH) and as function of temperature for the system: W/ L1695+M159/IPM+EtOH.

W/ L1695+M159/IPM+LNL

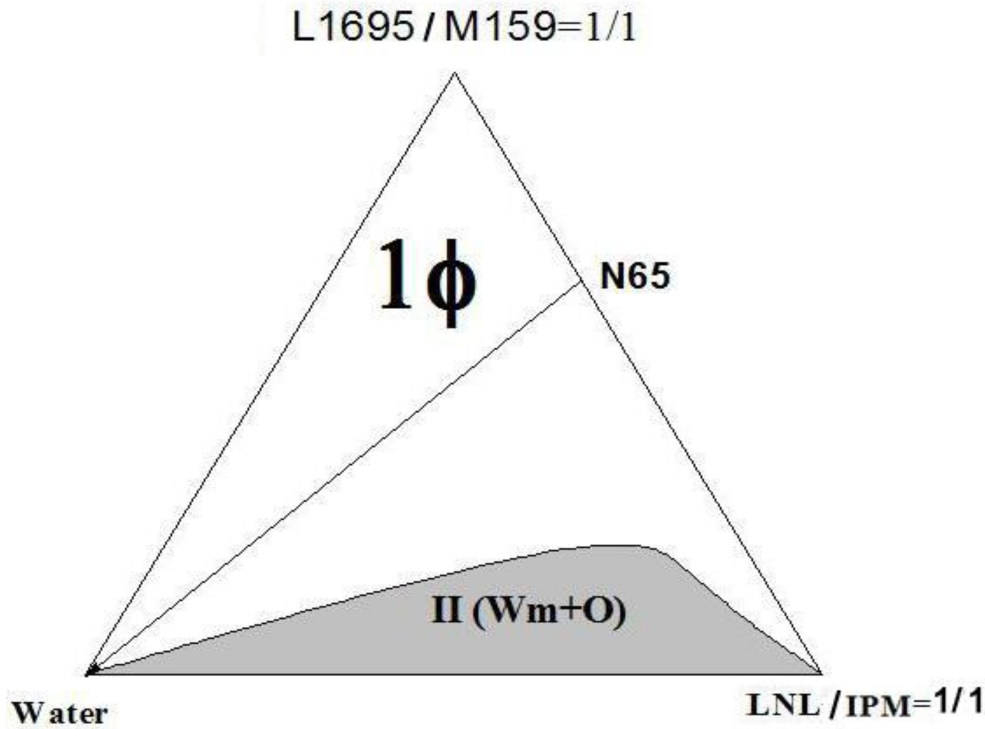
Figure 5.100 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/ isopropylmyristate (IPM)+linalool (LNL) system at different weight ratios of LNL/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figures 5.100, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/mixed cosurfactants and oil axis. The one phase microemulsion region extend to approximately 100 wt% water along the dilution line N65.

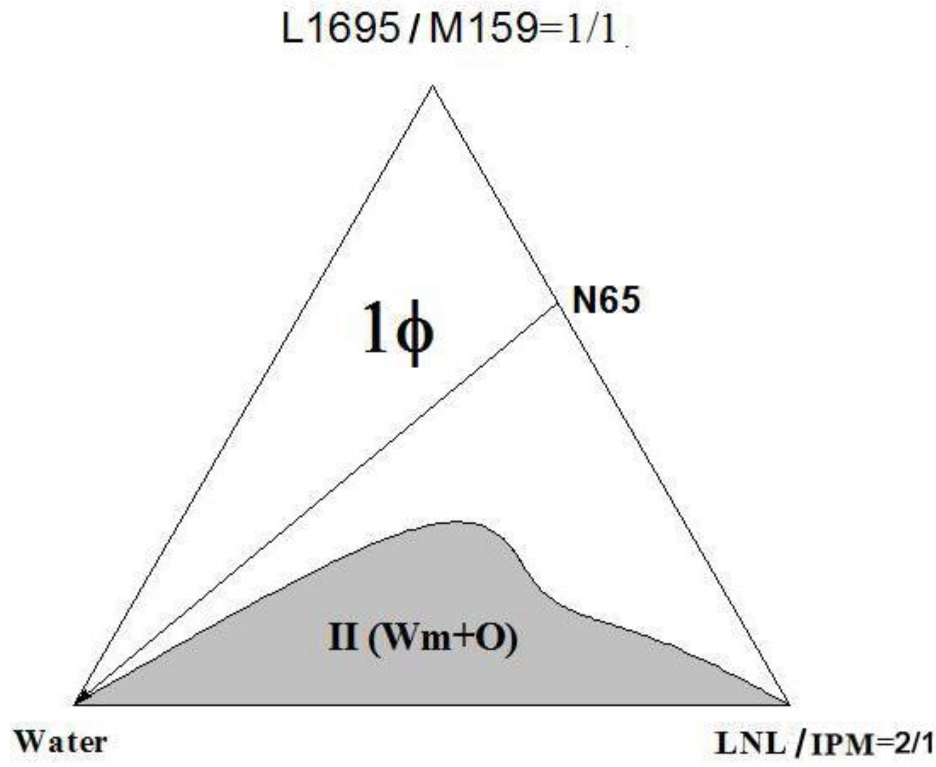
With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.100B the one phase microemulsion region increase more than other percents.



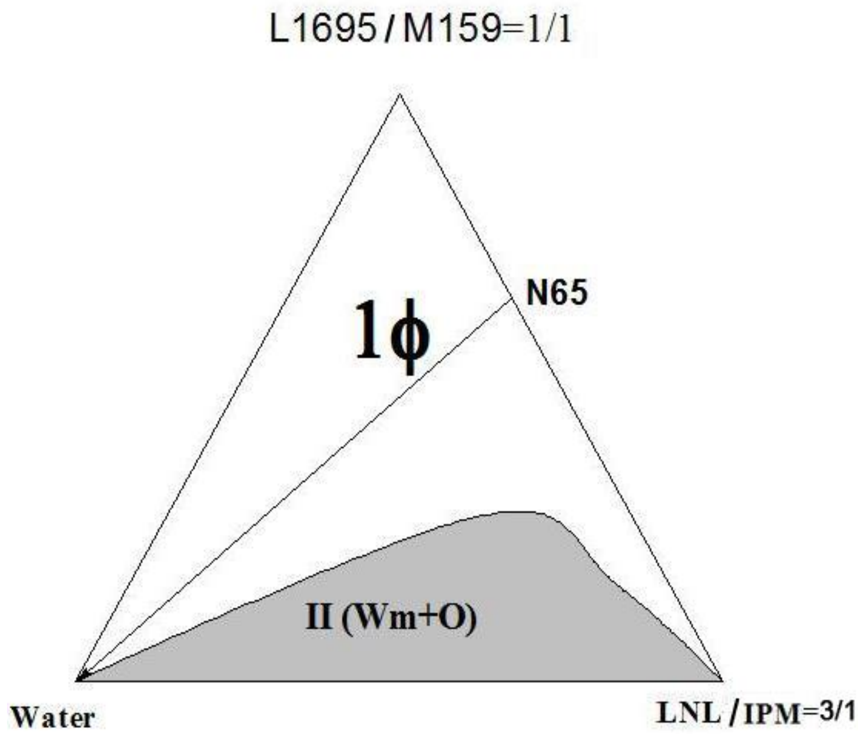
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
LNL / IPM=1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
LNL / IPM=2/1

(C)



(D)

Figure 5.100: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +linalool (LNL) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+LNL) = 65/35, LNL/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.44 The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM+ LNL at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(LNL/IPM)	25°C	37°C	45°C
0.5	52	60	60
1.0	75	71	74
2.0	69	66	64
3.0	66	66	67

Figures 5.100 present the phase behaviors of the systems W/L1695+M159/IPM+LNL. The mixing ratio of (L1695/M159) equals unity and that of (LNL/IPM) equal 1/2, 1, 2, 3. Figures 5.101 the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oils and as function of temperature for the systems W/L1695+M159/IPM+LNL. When isopropylmyristate oil mixed with linalool, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=1/2) equals 52%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increases to 75%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) decrease to 69% and for mixing ratio (oil2/oil1=3) the value decreases to 66%, so that mixing IPM oil with LNL at mixing ratio (oil2/oil1=1) gave us the best value.

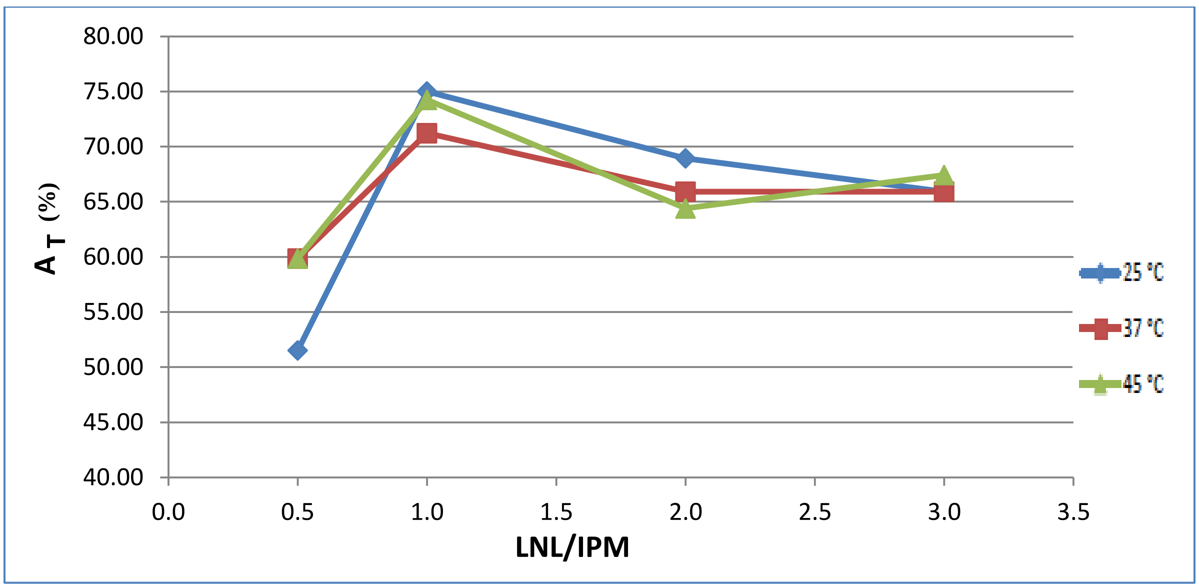


Figure 5.101: Variation of the total monophasic area A_T (%) as function of linalool content in the oil and linalool mixture (IPM+LNL) and as function of temperature for the system: W/ L1695+M159/IPM+LNL.

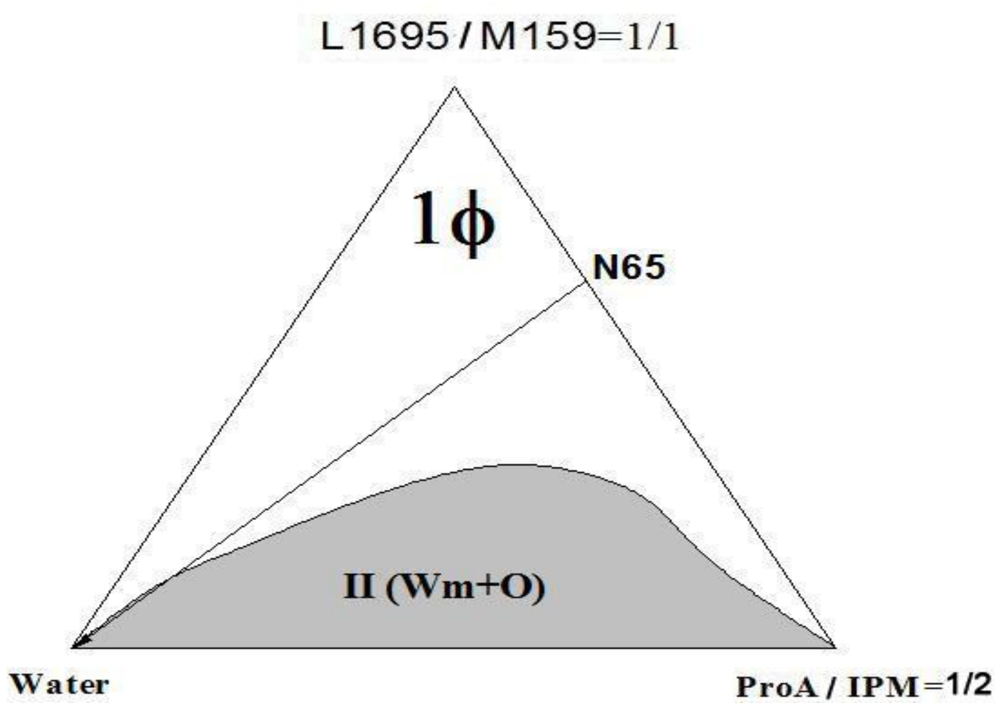
W/ L1695+M159/IPM+ProA

Figure 5.102 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/ isopropylmyristate (IPM)+propionic acid (ProA) system at different weight ratios of ProA/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

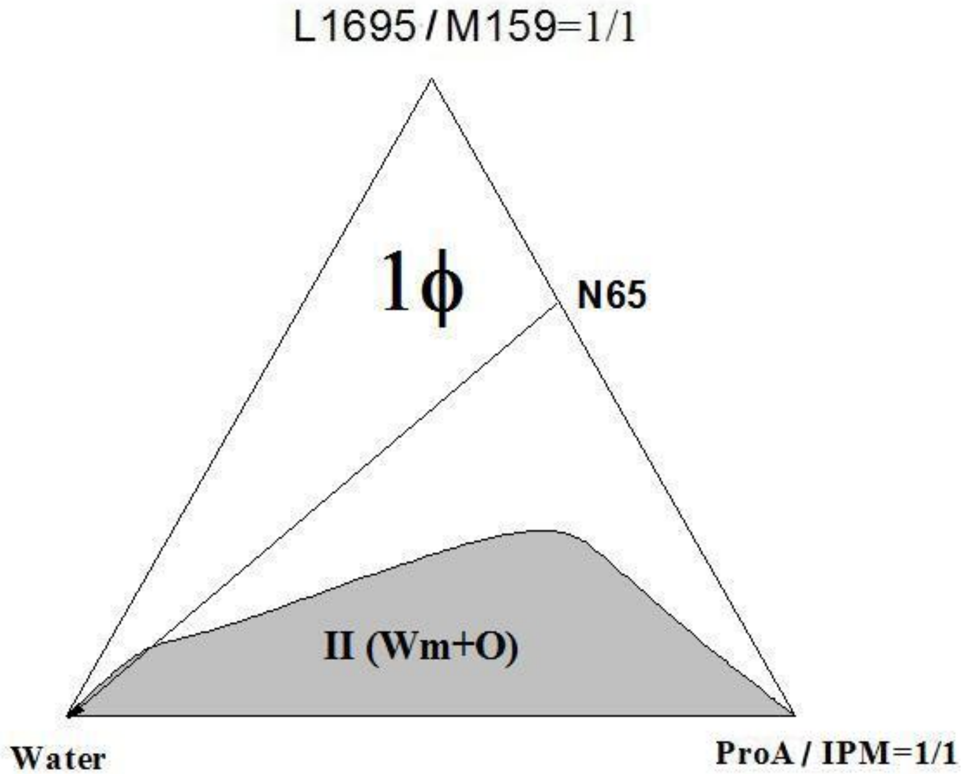
As show in Figure 5.102A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/mixed cosurfactants and oil axis. The one phase microemulsion region extend to approximately 76 wt% water along the dilution line N65.

For low mixed surfactants contents (below 24 wt %) a multiphase reign II (Wm+O) is observed.

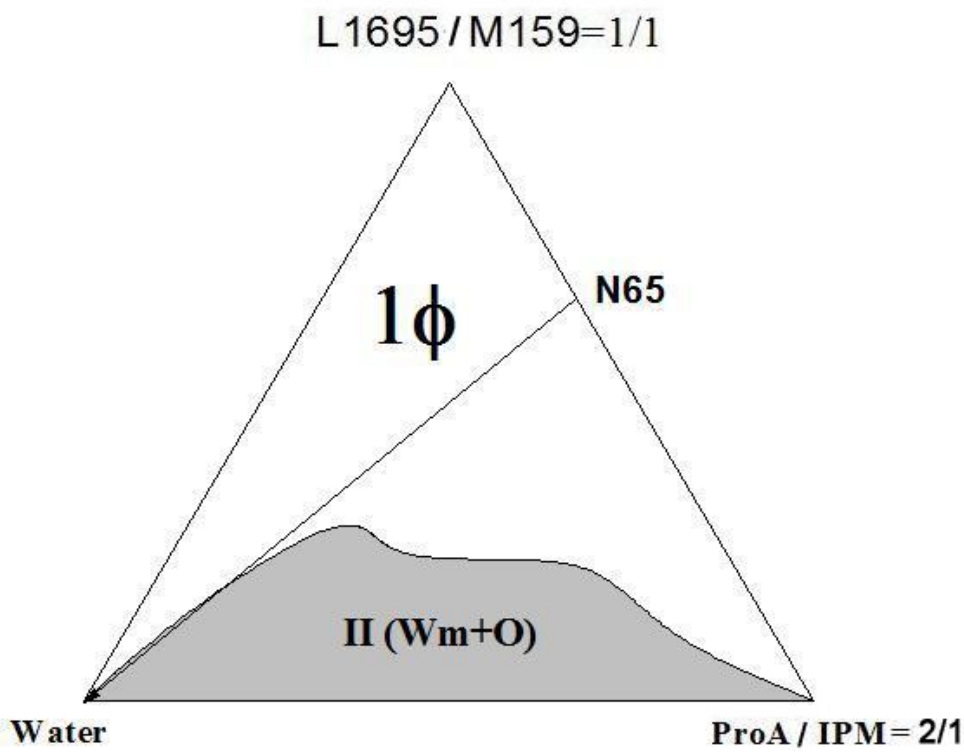
Some behavior is observed in Figure 5.75B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 24 wt%. In Figure 5.102C the one phase microemulsion region shrinks more compared to 5.102B.



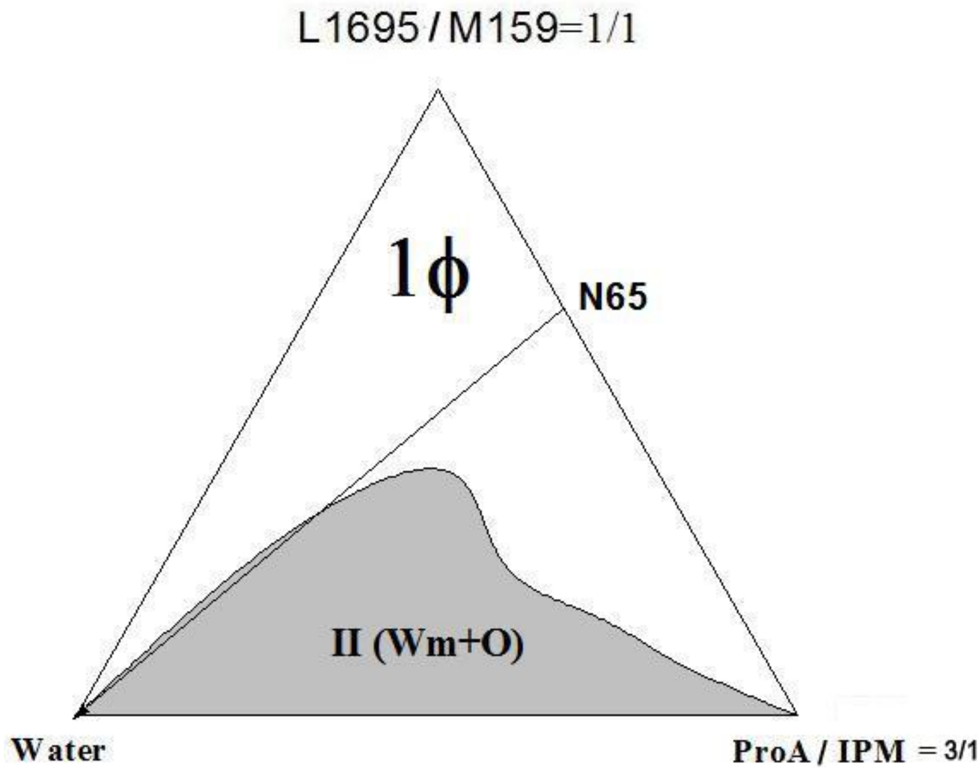
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ProA / IPM=1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ProA / IPM= 2/1

(c)



(D)

Figure 5.102: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +propionic acid (ProA) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+ProA) = 65/35, ProA/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table5.45: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM+ PrpA at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(PrpA/IPM)	25°C	37°C	45°C
0.5	56	48	49
1.0	53	55	56
2.0	52	58	57
3.0	55	55	55

Figures 5.102 present the phase behaviors of the systems W/L1695+M159/IPM+ProA. The mixing ratio of (L1695/M159) equals unity and that of (ProA /IPM) equal 1/2, 1, 2, 3. Figures 5.103 the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oils and as function of temperature for the systems W/L1695+M159/IPM+ProA. When Isopropyl myristate oil mixed with propionic acid, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=1/2) equals 56%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) decreases to 53%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) decrease to 52% and for mixing ratio (oil2/oil1=3) the value increases to 55%, so that mixing IPM oil with ProA at mixing ratio (oil2/oil1=1/2) gave us the best value.

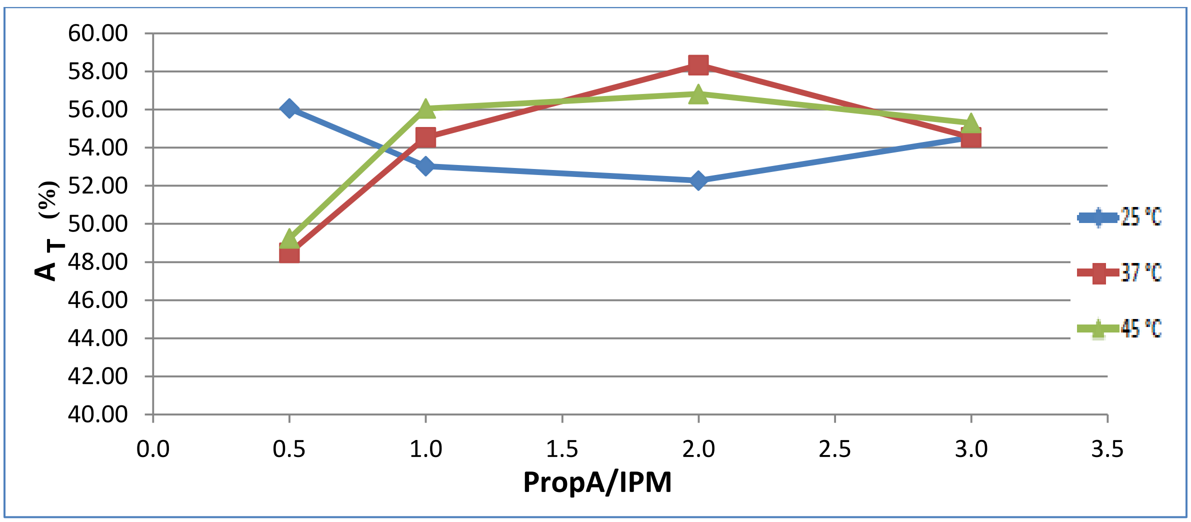
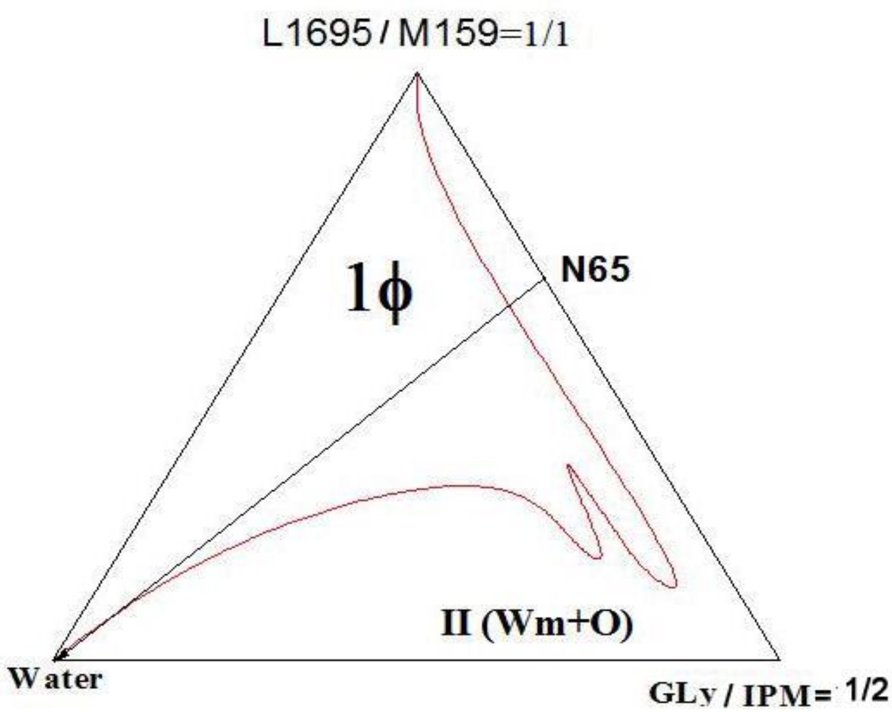


Figure 5.103: Variation of the total monophasic area A_T (%) as function of propionic acid content in the oil and propionic acid (IPM+PropA) and as function of temperature for the system: W/ L1695+M159/IPM+PropA.

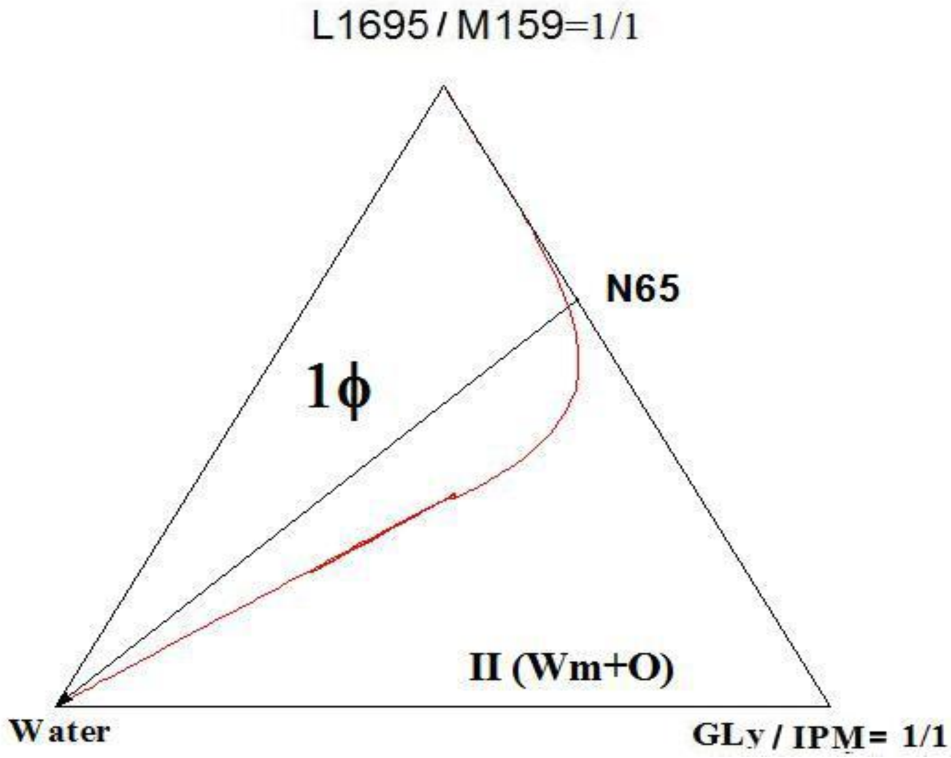
W / L1695+ M159/IPM+Gly:-

Figure 5.104 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/ isopropylmyristate oil (IPM)+glycerol (GLy) system at different weight ratios of GLy/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

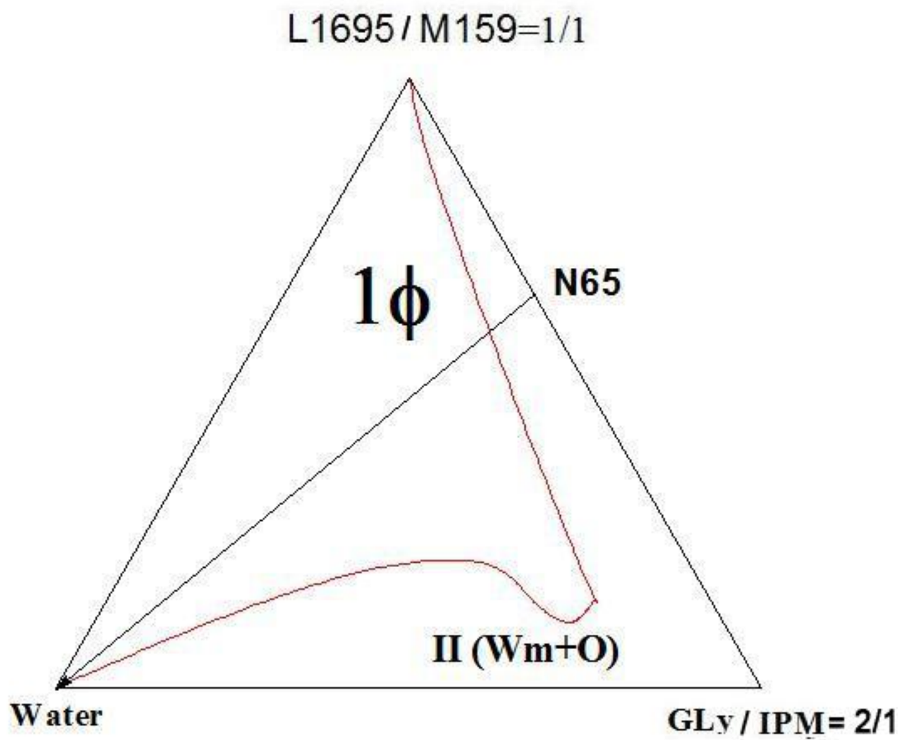
As show in Figure 5.104A, the one phase microemulsion region appears from the one phase microemulsion region first extend to approximately from 8 wt% to 85 wt% water along the dilution line N65. Addition of water along the mixed surfactants/mixed cosurfactants and oil axis. For low mixed surfactants contents (below 25 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.104B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents from 2 wt% to 100 wt% water. In Figure 5.104C and 5.104D the one phase microemulsion region increase more compared to 5.104B with increase glycerol.



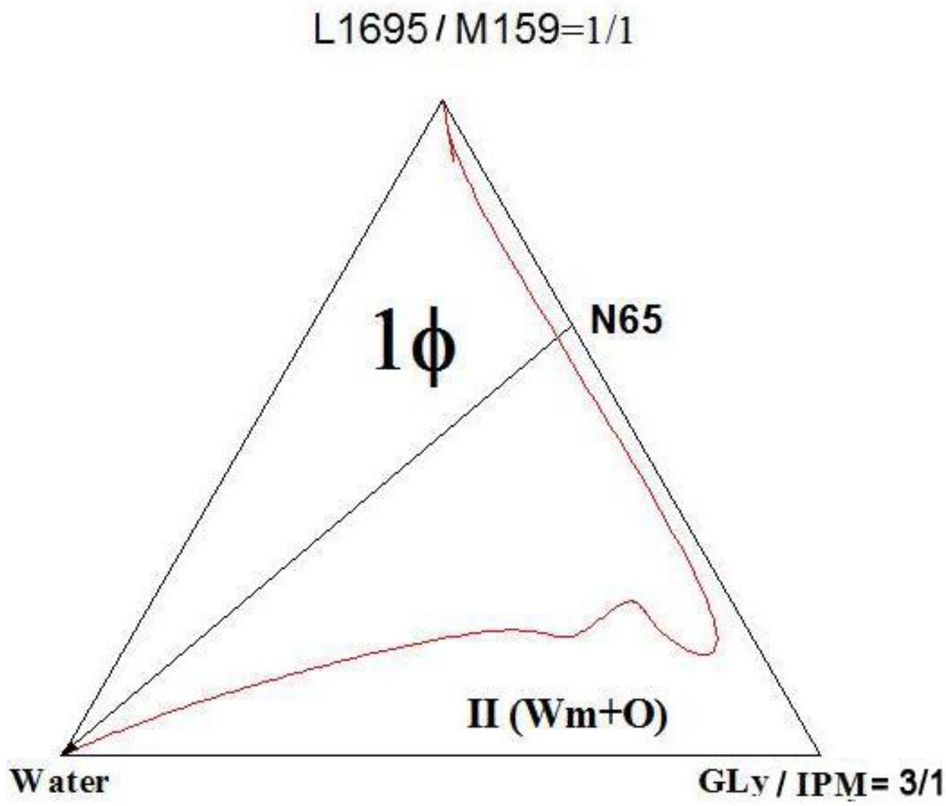
(A)


L1695 / M159=1/1
N65
1ϕ
II (Wm+O)
Water
GLy / IPM= 1/1

(B)


L1695 / M159=1/1
N65
1ϕ
II (Wm+O)
Water
GLy / IPM= 2/1

(C)



(D)

Figure 5.104: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) /isopropylmyristate (IPM) +Glycerol (GLy) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (IPM+GLy) = 65/35, GLy/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table5.46: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/IPM+ Gly at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(Gly/IPM)%	25°C	37°C	45°C
0.5	47	48	51
1.0	48	53	53
2.0	53	59	58
3.0	62	70	69

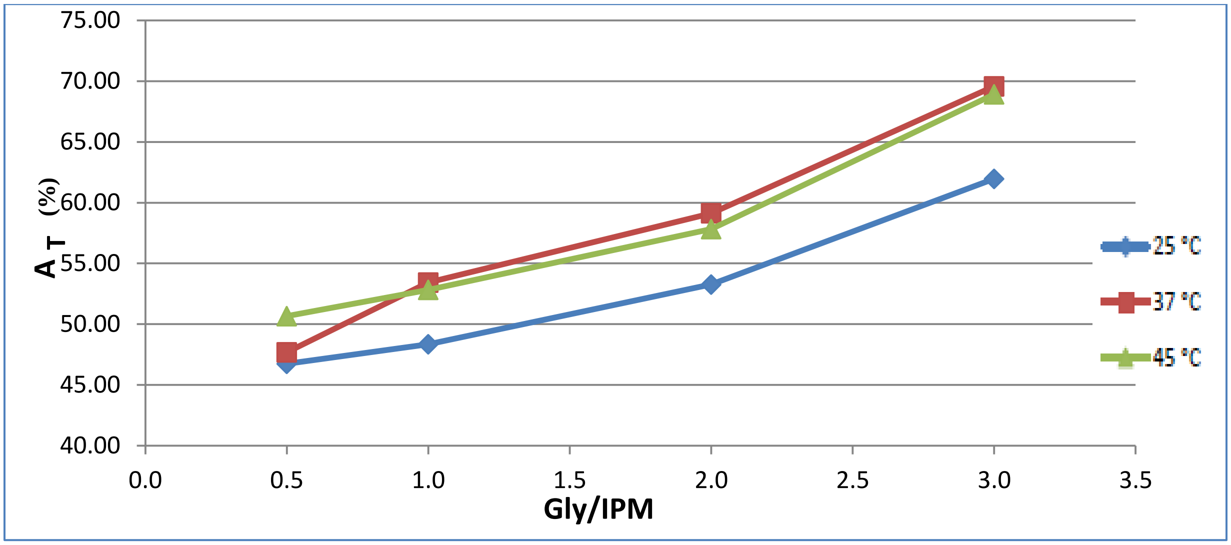


Figure 5.105: Variation of the total monophasic area A_T (%) as function of glycerol content in the oil and glycerol mixture (IPM+GLy) and as function of temperature for the system: W/ L1695+M159/IPM+GLy.

Two-phase equilibrium (turbid liquid crystal+excess aqueous phase) has been observed at 25 °C with higher surfactant and lower oil contents (see the dilution lines 65). The volume fraction of the upper turbid liquid crystal. **Fig.5.104** shows how this two-phase equilibrium in the surfactant-rich region is turned into a single-phase microemulsion by increasing the temperature and water content. It might be that the solubility of the surfactant in the aqueous phase is directly proportional to the increase in temperature and the thermal motion of the surfactant in the upper phase increases and when increase water content causes to transfer from turbid L.C to bicontinues 1Φ (Garti, Yaghmur, Leser, et al, 2001).

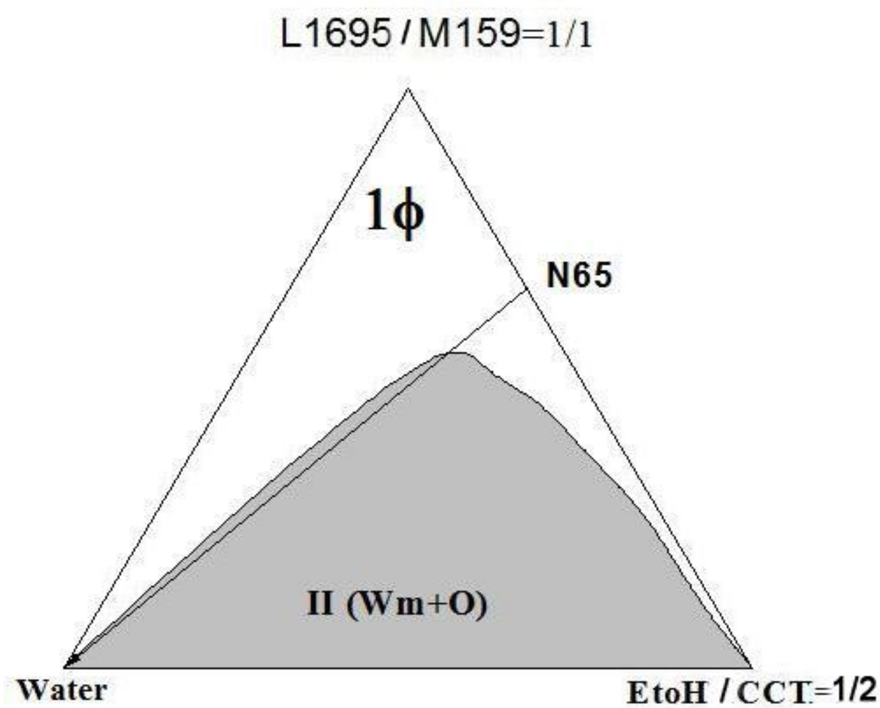
W L1695+ M159/CCT+EtOH:-

Figure 5.106 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/ caprylic-capric triglyceride (CCT) + ethanol (EtOH) system at different weight ratios of EtOH/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

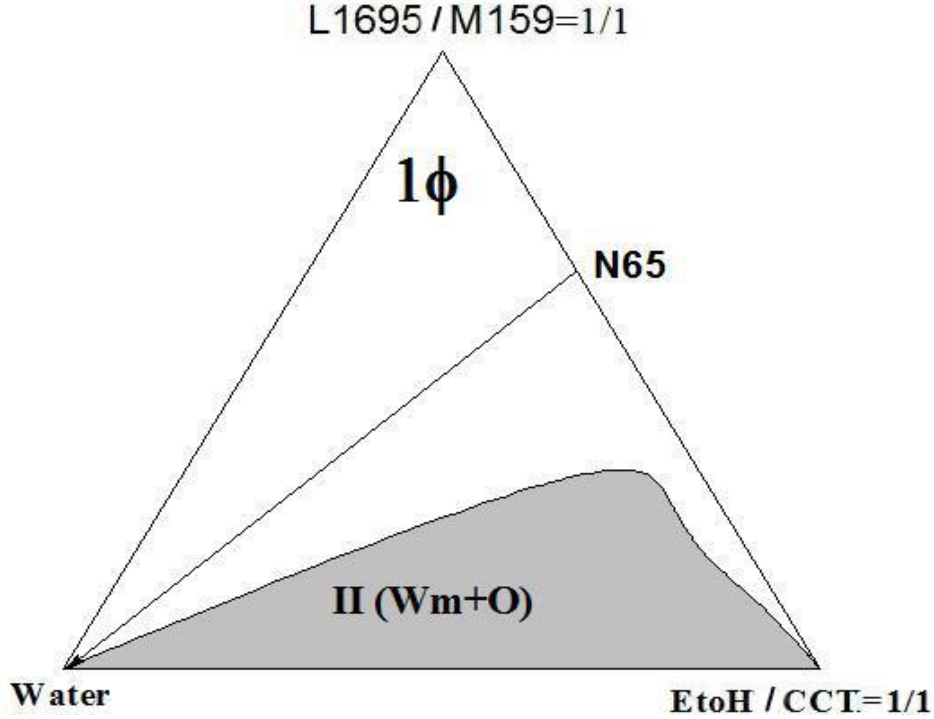
As show in Figures 5.106, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/mixed cosurfactants and oil axis. The one phase microemulsion region extend to approximately 20 wt% water along the dilution line N65.

With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.106B the one phase microemulsion region increase more with ethanol.

In Figure 5.106C and Figure 5.106D the one phase microemulsion region shrinks more compared to 5.106B.

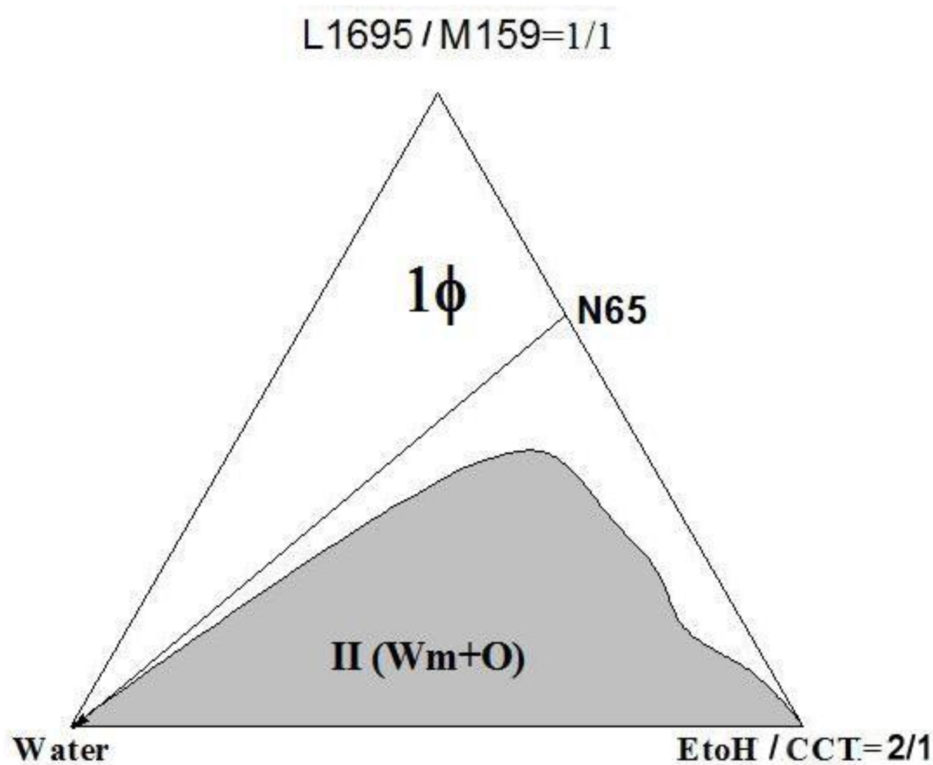


(A)



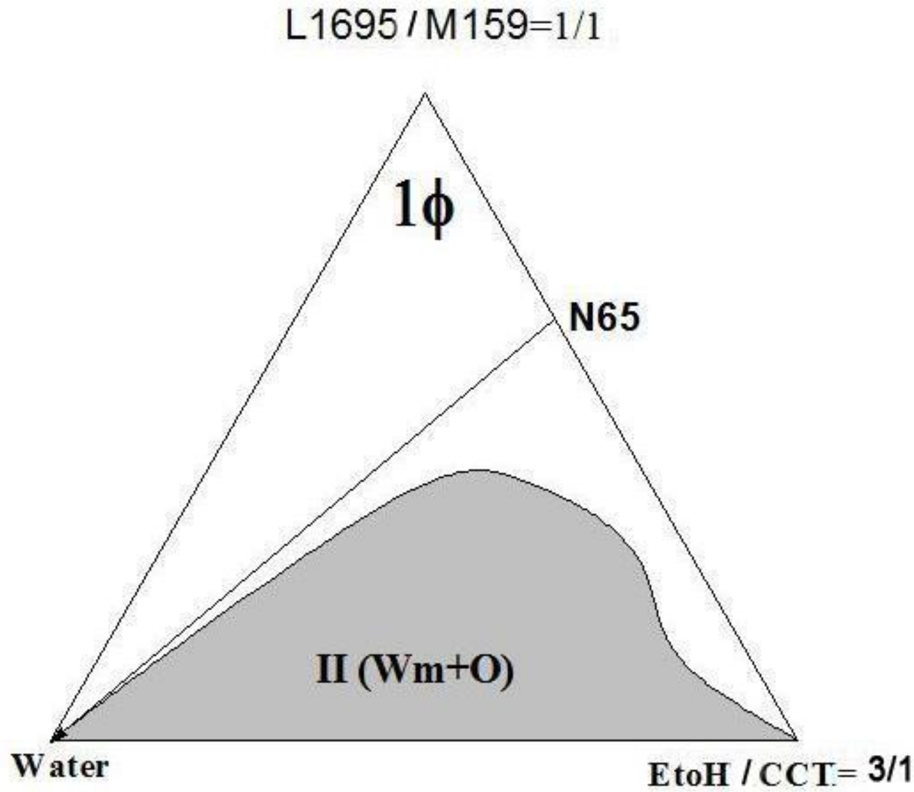
L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtoH / CCT=1/1

(B)



L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
EtoH / CCT=2/1

(C)



(D)

Figure 5.106: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) +ethanol (EtOH) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+EtOH) = 65/35, EtOH /CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.47: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ EtOH at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(EtoH/CCT)%	25°C	37°C	45°C
0.5	33	34	36
1.0	50	50	50
2.0	45	46	46
3.0	46	47	47

Figure 5.106 phase beaver when ethanol mixed with caprylic-capric triglyceride oil, Figure 5.107 the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=0.5) equals 33%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increase to 50%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) decrease to 48% and for mixing ratio (oil2/oil1=3) the value increases to 46%, so that mixing ethanol with CCT oil at mixing ratio (oil2/oil1=1) gave us the best result, can be see also the variation of the total monophasic region A_T (%) as function of co-surfactant with linear and triglyceride oil.

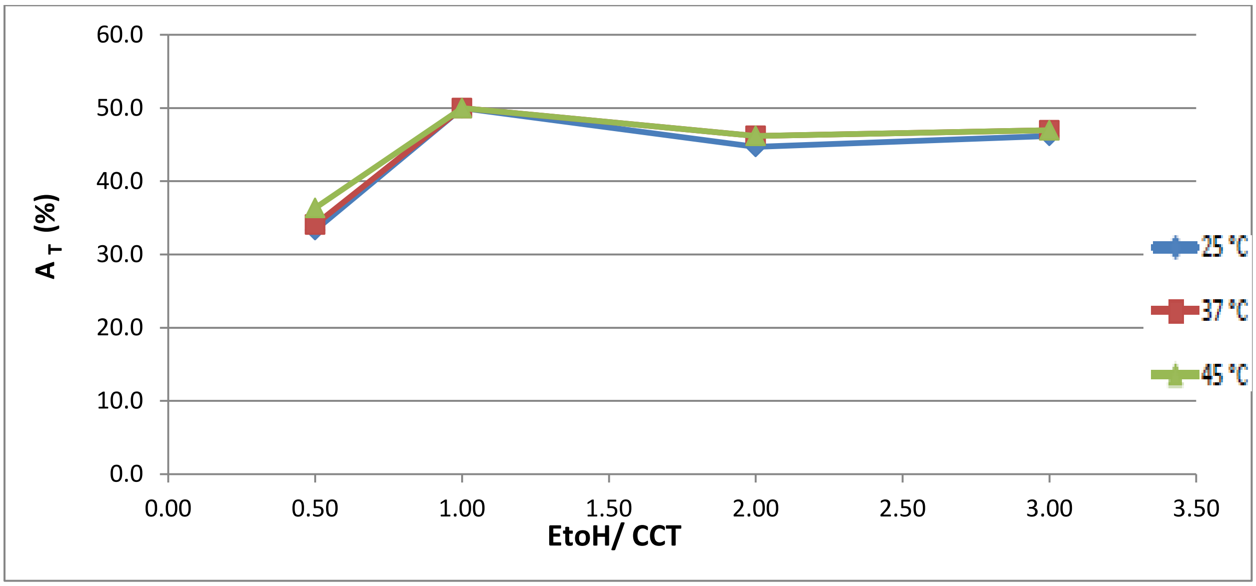


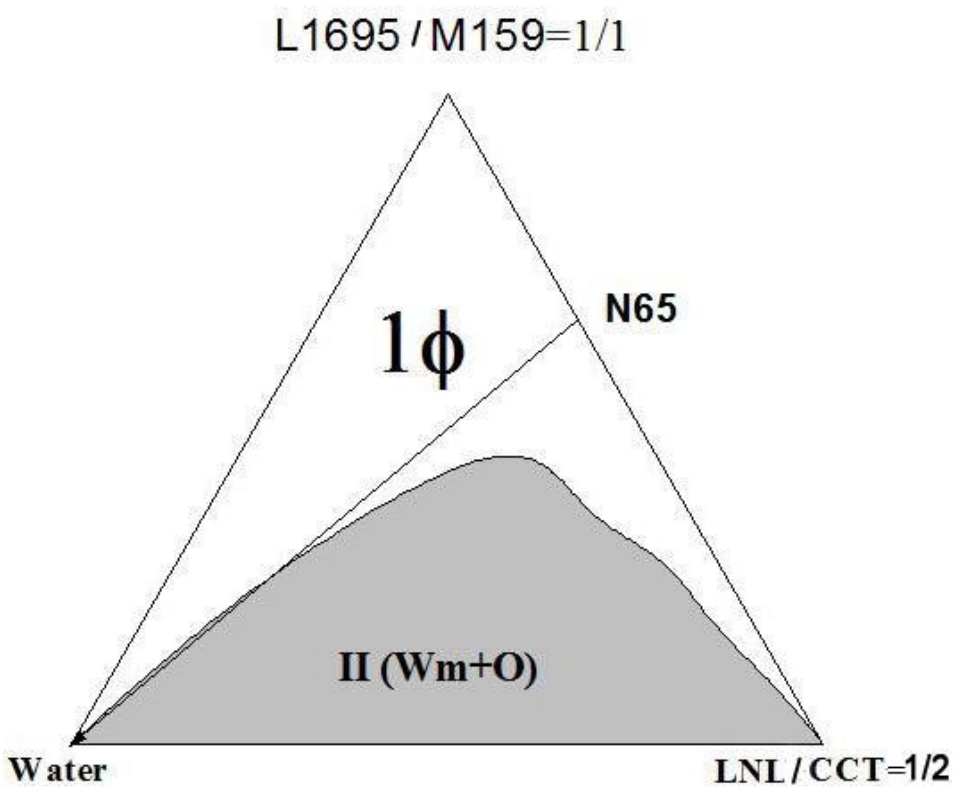
Figure 5.107: Variation of the total monophasic area A_T (%) as function ethanol content in the oil and ethanol mixture (CCT+EtOH) and as function of temperature for the system: W/ L1695+ M159/CCT+EtOH.

W / L1695+ M159/CCT+LNL:-

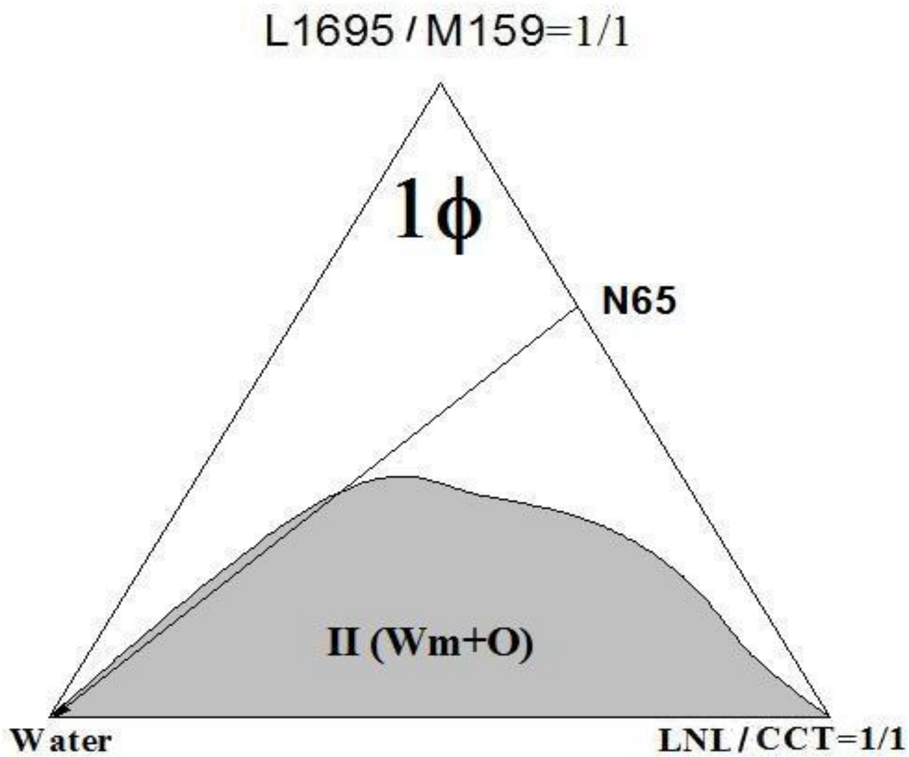
Figure 5.108 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/caprylic-capric triglyceride (CCT)+linalool (LNL) system at different weight ratios of LNL/CCT that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figures 5.108, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/mixed cosurfactants and oil axis. The one phase microemulsion region extend to approximately 62 wt% water along the dilution line N65.

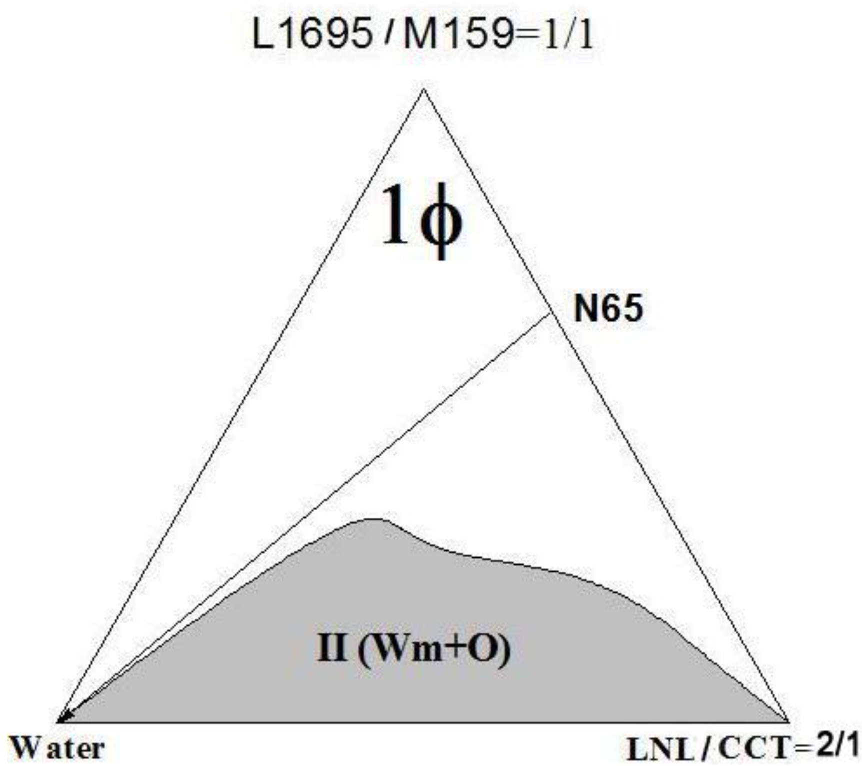
With the difference that the area of the one phase microemulsion region increase since the multiphase region is not extended to mixed surfactants at dilution line N65. In Figure 5.108D the one phase microemulsion region increase more than other percents.



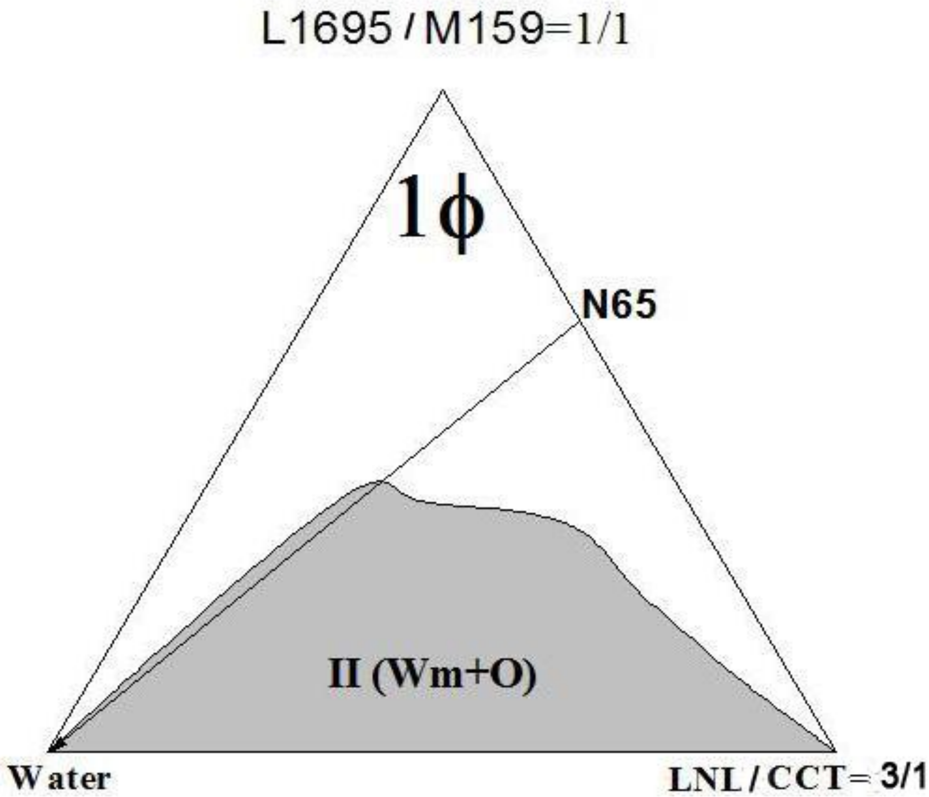
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
LNL / CCT=1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
LNL / CCT=2/1

(C)



(D)

Figure5.108: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) +linalool (LNL) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+LNL) = 65/35, LNL/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table5.48: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ LNL at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(LNL/CCT)%	25°C	37°C	45°C
0.5	35	42	43
1.0	38	42	46
2.0	43	43	45
3.0	45	46	46

Figures 5.108 present the phase behaviors of the systems W/L1695+M159/CCT+LNL.The mixing ratio of (L1695/M159) equals unity and that of (LNL /CCT) equal 1/2, 1, 2, 3. Figures 5.109 represent the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oils and as function of temperature for the systems W/L1695+M159/CCT+LNL, respectively. When Linalool mixed with caprylic-capric triglyceride oil, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=0.5) equals 35%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increase to 38%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) increase to 43% and for mixing ratio (oil2/oil1=3) the value increases to 46%, so that mixing Linalool with CCT oil at mixing ratio (oil2/oil1=3) gave us the best result, can be see also the variation of the total monophasic region A_T (%) as function of co-surfactant with linear and triglyceride oil.

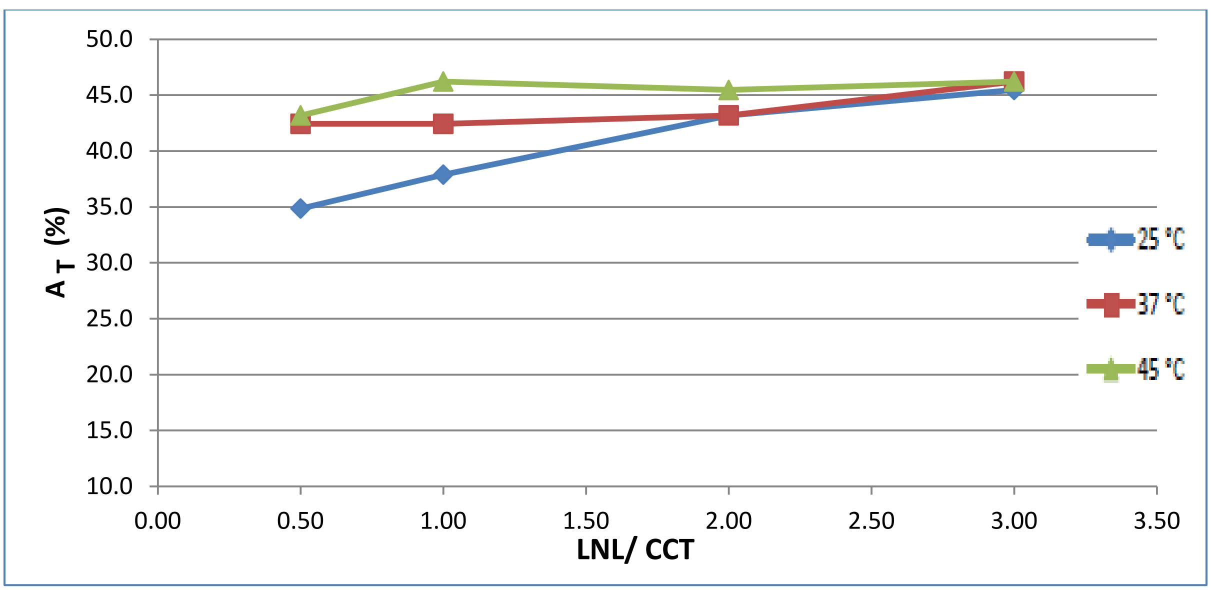
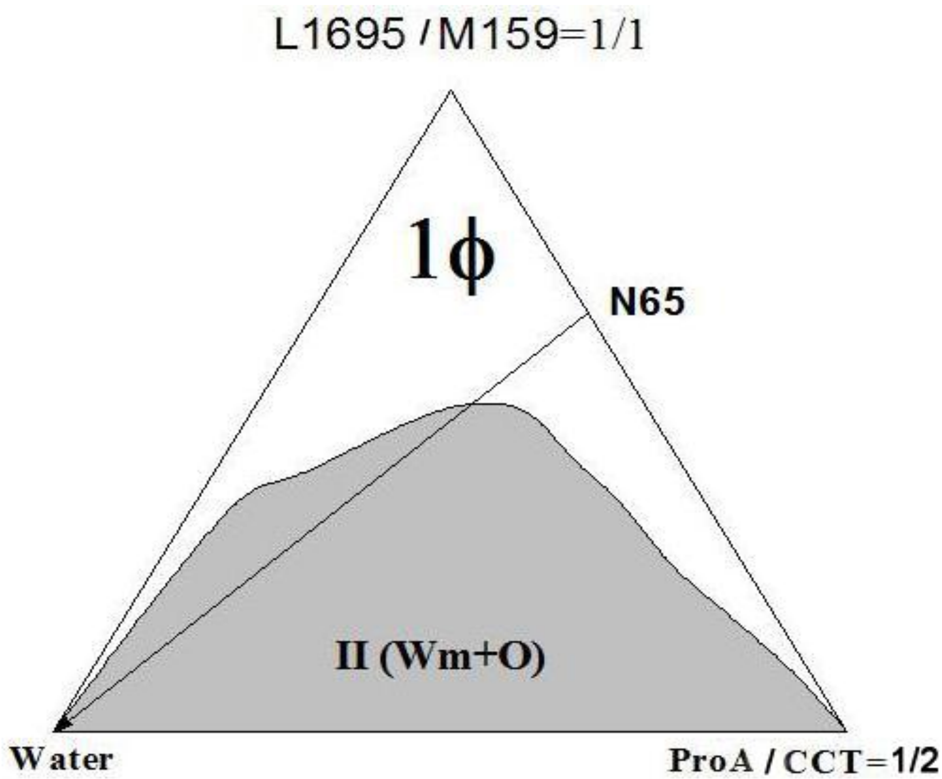


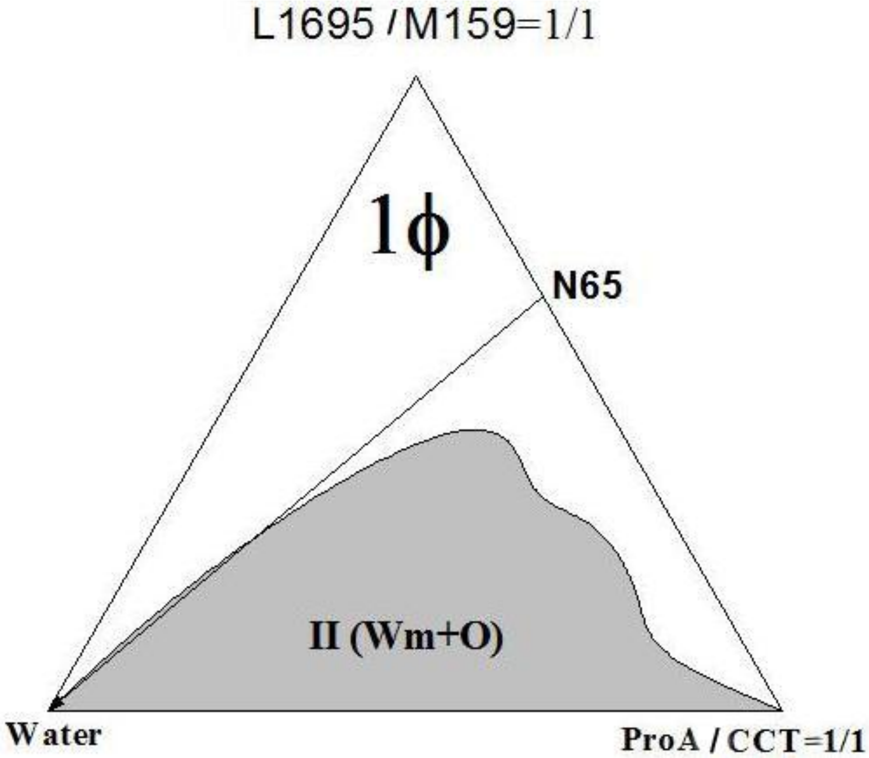
Figure 5.109: Variation of the total monophasic area A_T (%) as function linalool content in the oil and linalool mixture (CCT+LNL) and as function of temperature for the system: W/ L1695+ M159/CCT+ LNL.

W / L1695+ M159/CCT+ProA:-

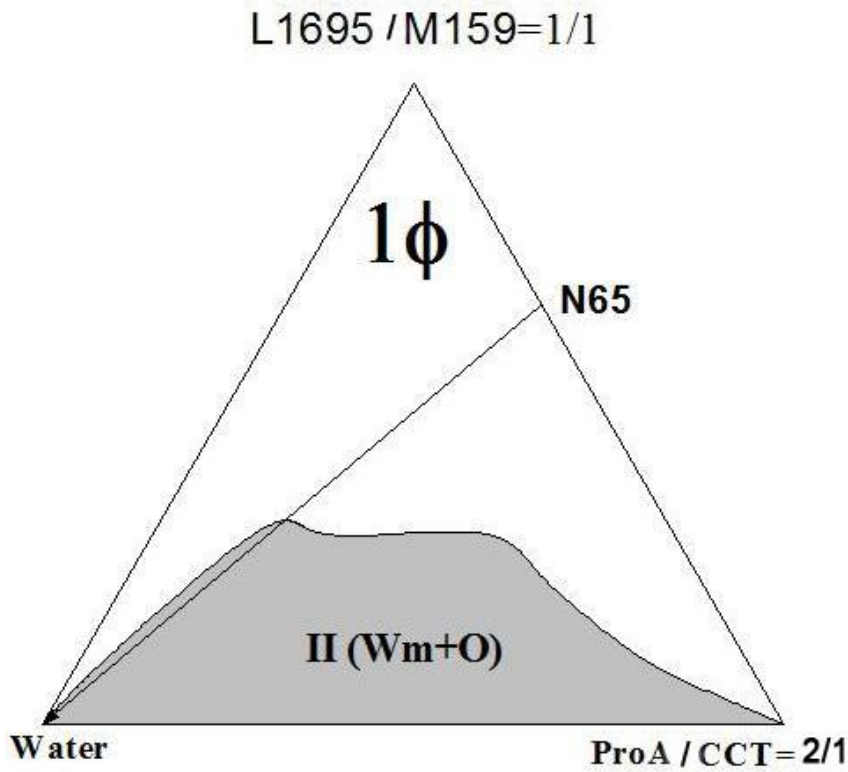
Figures 5.110 present the phase behaviors of the systems W/L1695+M159/CCT+ProA. The mixing ratio of (L1695/M159) equals unity and that of (ProA /CCT) equal 1/2, 1, 2, 3. Figures 5.111 the variation of the total monophasic region A_T (%) as function of mixing ratios of different mixed oils and as function of temperature for the systems W/L1695+M159/CCT+ProA, respectively. when propionic acid mixed with caprylic-capric triglyceride oil, the total monophasic area A_T (%) at 25°C for the mixing ratios (oil2/oil1=1/2) equals 33%, for mixing ratio (oil2/oil1=1) the total monophasic area A_T (%) increase to 42%, for mixing ratio (oil2/oil1=2) the total monophasic area A_T (%) Increase to 54% and for mixing ratio (oil2/oil1=3) the value increases to 54%, so that mixing propionic acid with CCT oil at mixing ratio (oil2/oil1=2 and 3) gave us the best result, can be see also the variation of the total monophasic region A_T (%) as function of co-surfactant with triglyceride oil and different temperature.



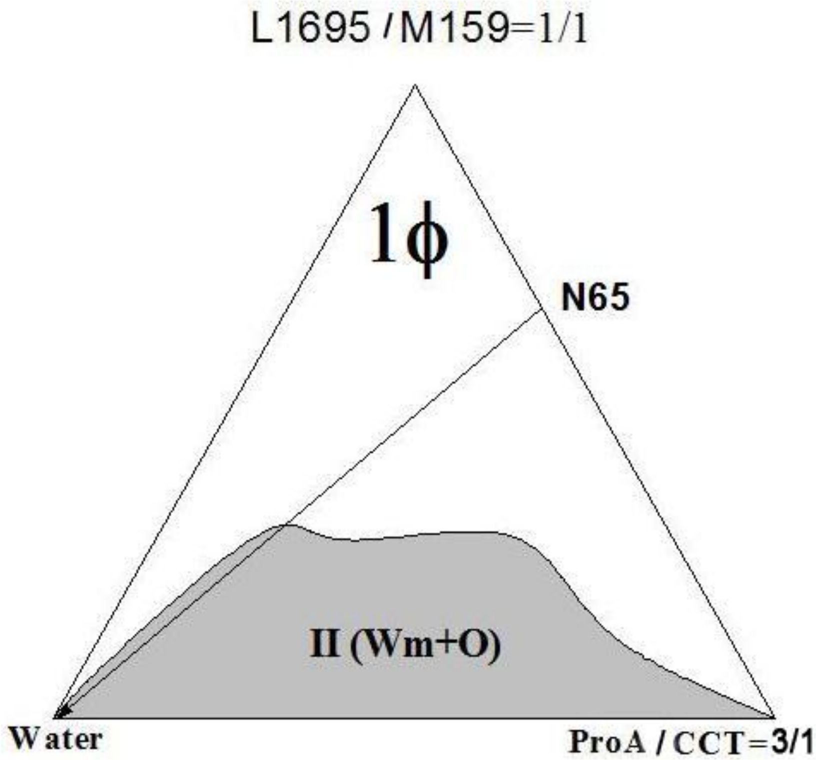
(A)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ProA / CCT=1/1

(B)


L1695 / M159=1/1
1ϕ
N65
II (Wm+O)
Water
ProA / CCT= 2/1

(C)



(D)

Figure5.110: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) / caprylic-capric triglyceride (CCT) +propionic acid (ProA) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+ProA) = 65/35, ProA/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table5.49: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ ProA at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(ProA/CCT)%	25°C	37°C	45°C
0.5	33	35	36
1.0	42	44	44
2.0	54	49	52
3.0	54	55	55

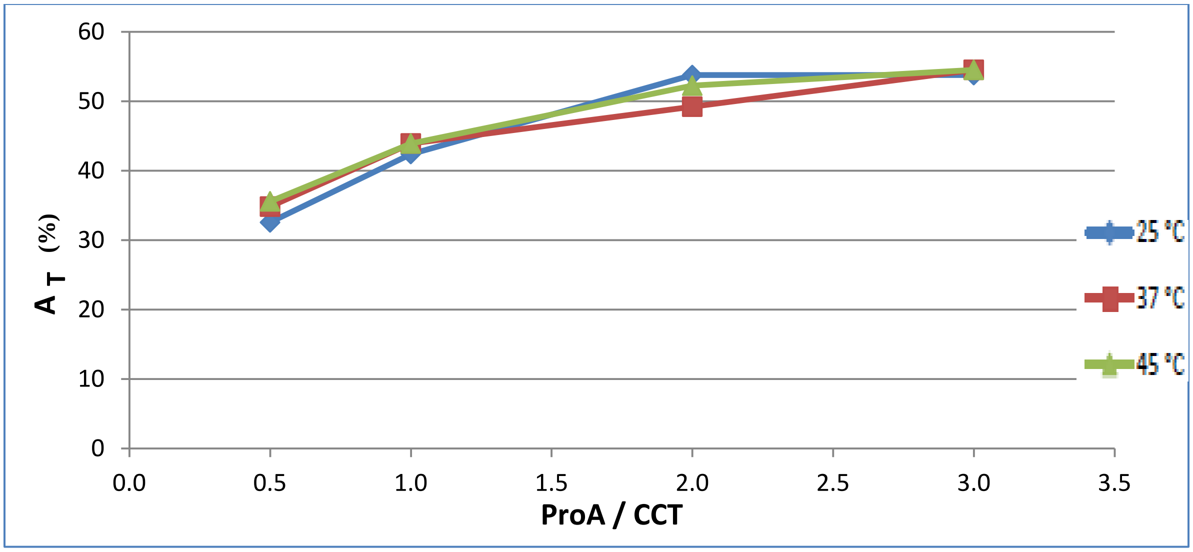
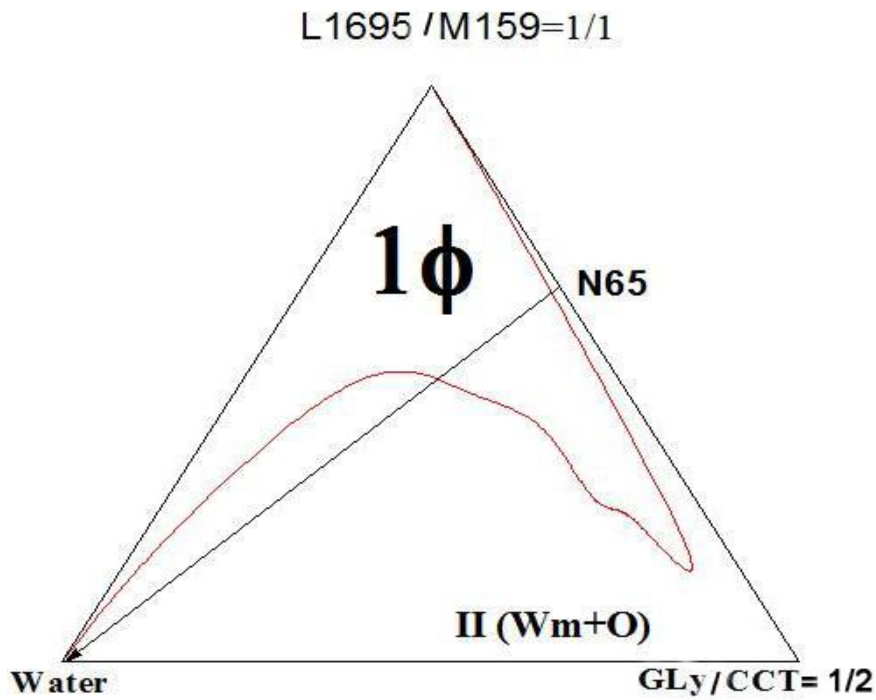


Figure 5.111: Variation of the total monophasic area A_T (%) as function propionic acid content in the mixture (CCT+ProA) and as function of temperature for the system: W / L1695+ M159/CCT+ ProA.

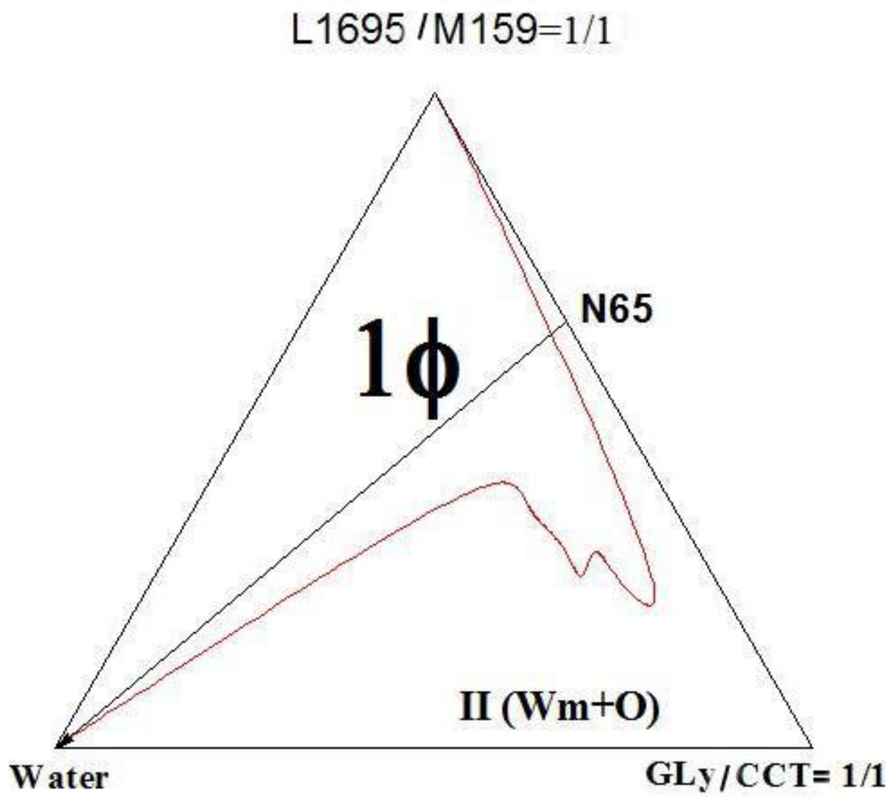
W / L1695+ M159/CCT+GLy:-

Figure 5.112 present the phase diagram of the water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159) (1:1)/caprylic-capric triglyceride (CCT)+glycerol (GLy) system at different weight ratios of GLy/CCT that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

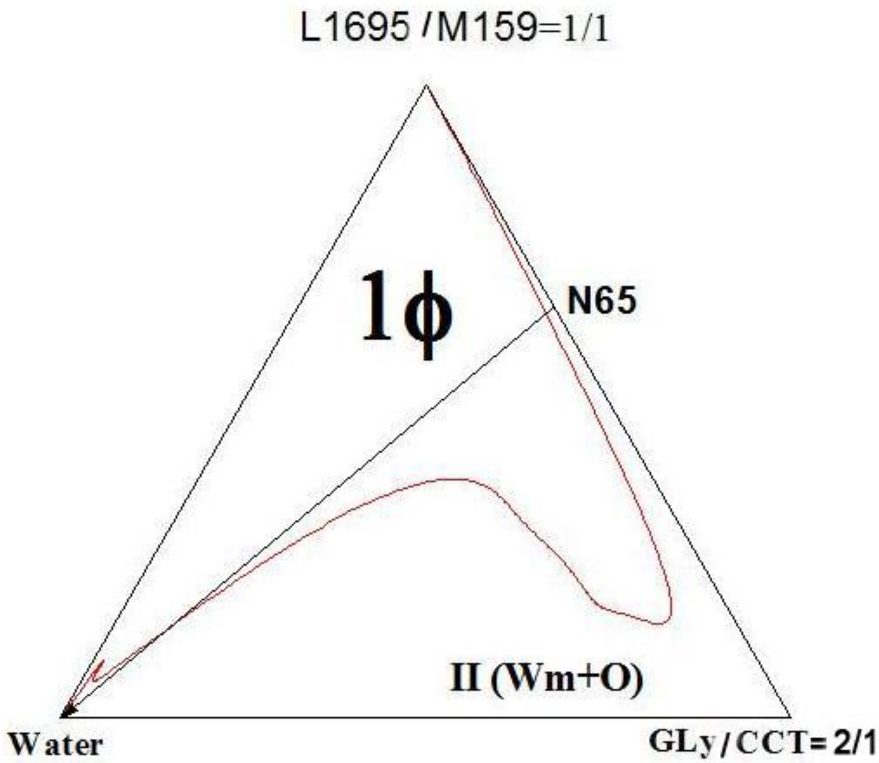
As show in Figure 5.112A, the one phase microemulsion region appears from the one phase microemulsion region first extend to approximately from 3 wt% to 23 wt% water along the dilution line N65. Addition of water along the mixed surfactants/mixed cosurfactants and oil axis. For low mixed surfactants contents (below 55 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.112B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents from 5 wt% to 100 wt% water. In Figure 5.112C and 5.112D the one phase microemulsion region increase more compared to 5.112B with increase glycerol.


L1695 /M159=1/1
1ϕ
N65
II (Wm+O)
Water
GLy / CCT= 1/2

(A)

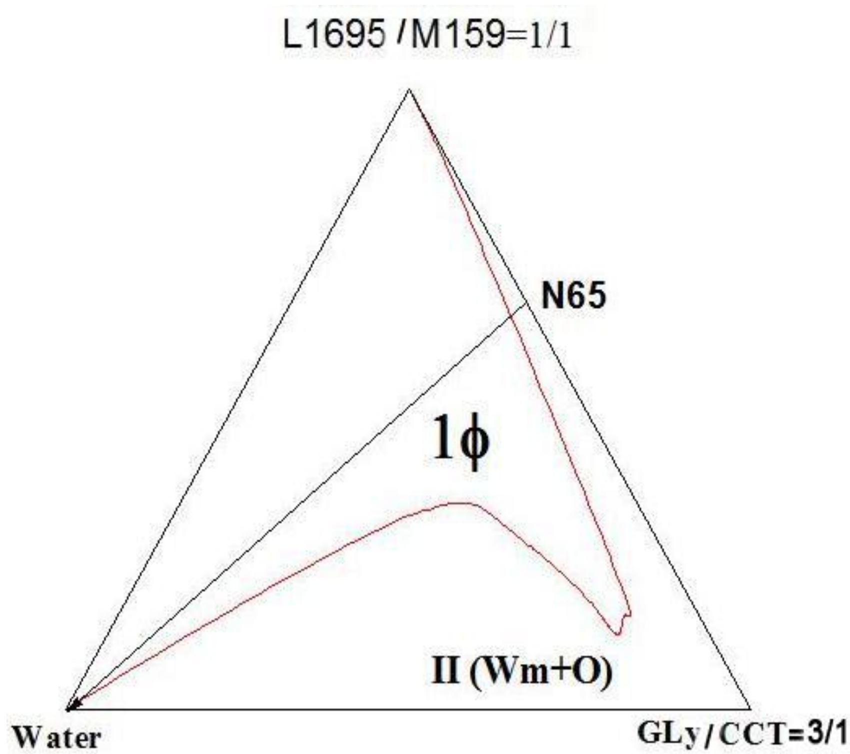

L1695 /M159=1/1
1ϕ
N65
II (Wm+O)
Water
GLy / CCT= 1/1

(B)



L1695 /M159=1/1
1ϕ
N65
II (Wm+O)
Water
GLy / CCT= 2/1

(C)



L1695 /M159=1/1
N65
1ϕ
II (Wm+O)
Water
GLy / CCT=3/1

(D)

Figure 5.112: Phase diagrams of the system: water/ sucrose monolaurate (L1695) + PEG-7 glyceryl cocoate (M159)/caprylic-capric triglyceride (CCT)+glycerol (GLy) at 25°C. The mixing ratio (w/w) of L1695/M159 equals unity. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (L1695+M159)/ (CCT+GLy) = 65/35, GLy/CCT: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.50: The total monophasic area A_T (%) for the system W/L1695+M159 (1:1)/CCT+ Gly at different mixing ratios of mixed oil and surfactant, at different temperatures.

	A_T (%)		
(GLy/CCT)%	25°C	37°C	45°C
0.5	36	50	37
1.0	49	50	49
2.0	53	53	53
3.0	56	56	56

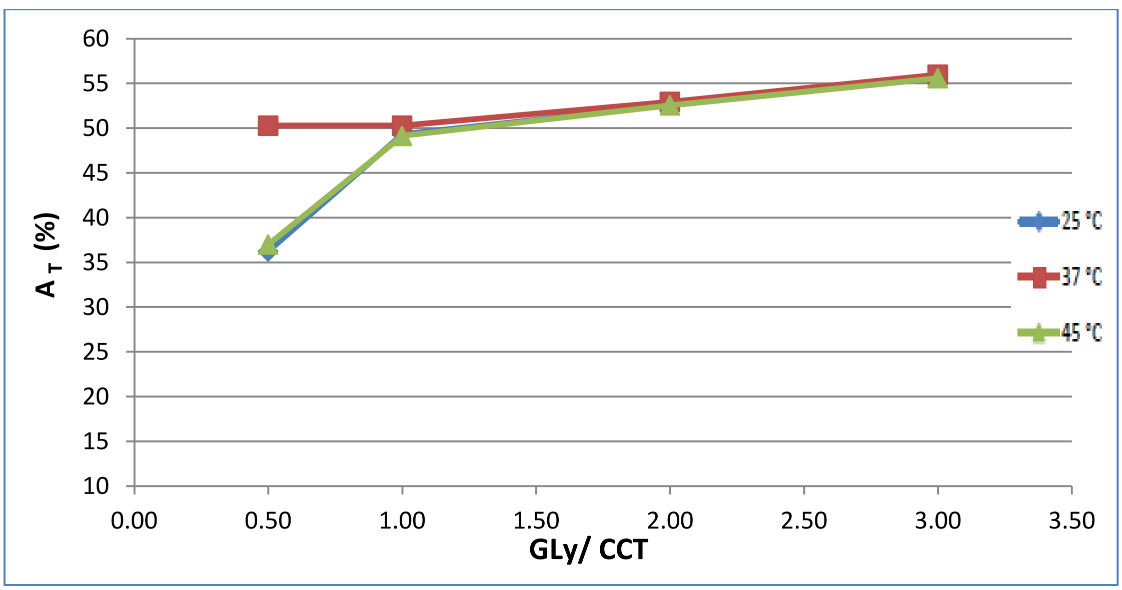


Figure 5.113: Variation of the total monophasic area A_T (%) as function propionic acid content in the mixture (CCT+GLy) and as function of temperature for the system: W / L1695+ M159/CCT+ GLy.

Table 5.51: The maximum total monophasic area A_T (%) for the system W/L1695+M159/ mixed oils at 25°C temperatures.

Oil 1	Cosurfactant	A_T (%) at 25°C	Mixed oil ratio where maximum A_T (%) is obtained at 25°C
IPM	EtOH	4	2/1
	LNL	75	1/1
	ProA	53	1/1
	GLy	62	3/1
CCT	EtOH	50	1/1
	LNL	45	3/1
	ProA	54	2/1
	GLy	56	3/1

Mixing ratio of oil and cosurfactant equals unity gave optimum water solubilization. For cosurfactant with low molecular volume (EtOH, ProA and LNL) the % ratio. For cosurfactant with higher molecular volume (Gly) higher oil/cosurfactant ratio there unity gave better water solubilization. For the purpose of our future for worker the 1/1 ratio will be use

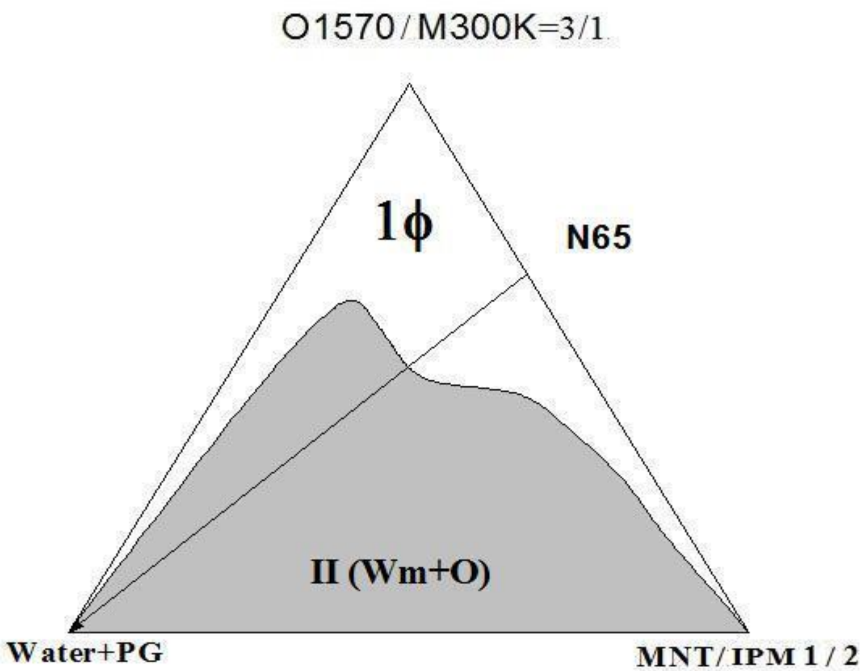
ii - Mixed surfactants W/O1570+M300K/Mixed Oil

W +PG/O1570+M300K/IPM+MNT:-

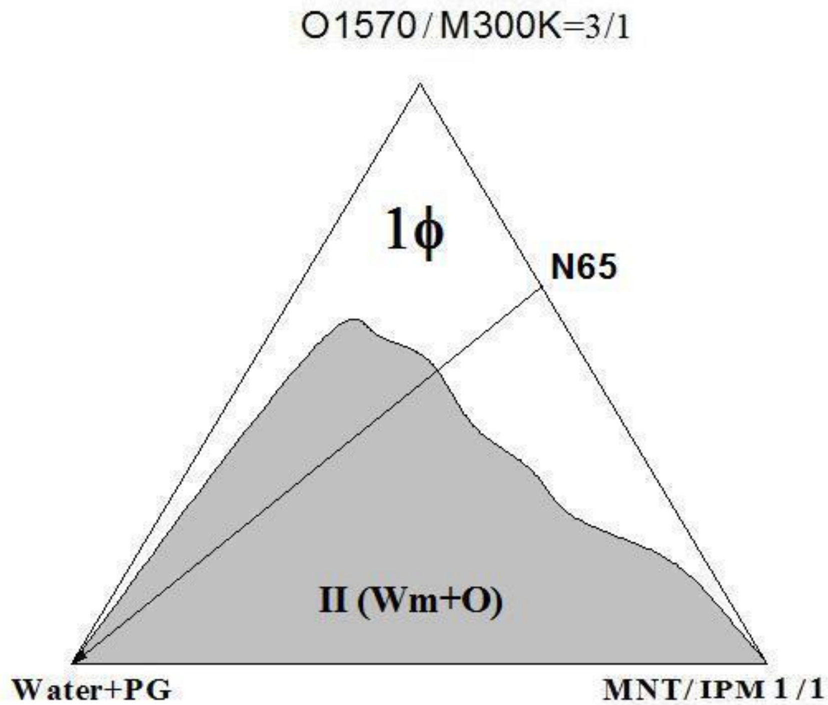
Figure 5.114 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate (IPM) +peppermint oil (MNT) system at different weight ratios of MNT/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.114 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 25 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 50 wt% water.

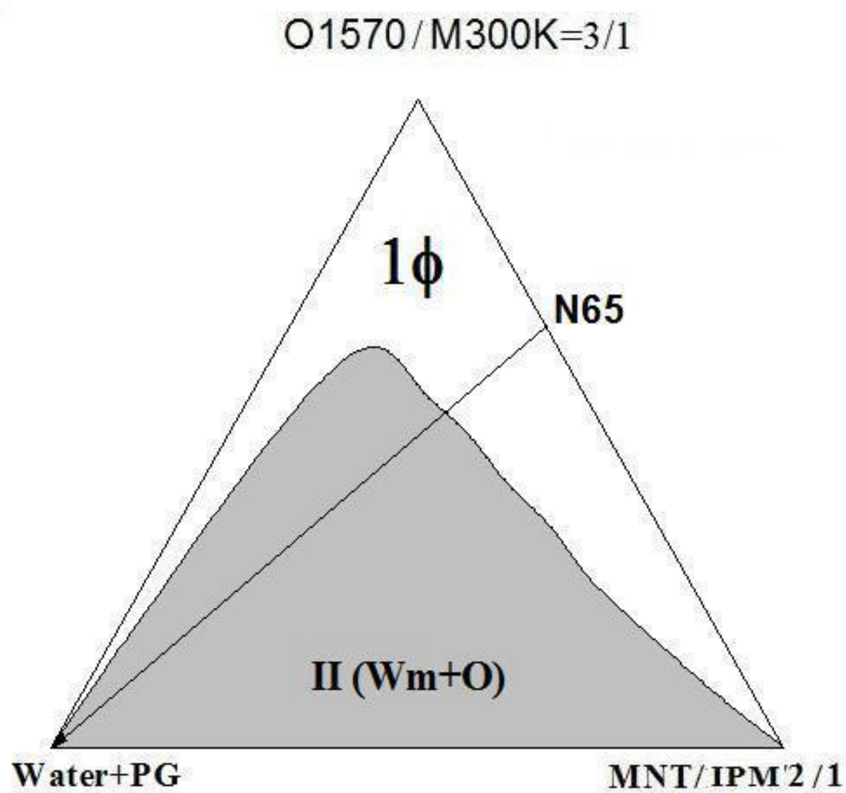
For low mixed surfactants contents (below 46 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.114B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents above 52 wt%. In Figures 5.114C and 5.114D the one phase microemulsion region shrinks more compared to 5.114B.



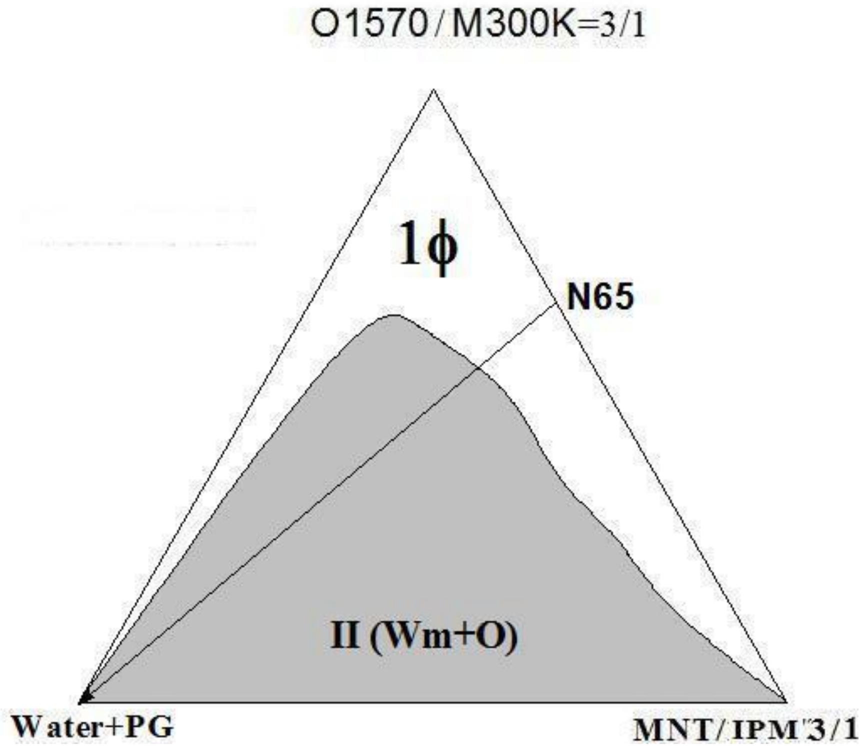
(A)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
MNT/ IPM 1 /1

(B)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
MNT/ IPM 2 /1

(C)



(D)

Figure 5.114: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570)+glycerol monooleate (M300K)/isopropylmyristate oil (IPM)+peppermint (MNT) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+MNT) = 65/35, MNT/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.52: The total monophasic area A_T (%) for the system W+PG/O1570+M300K (3:1)/IPM+MNT at different mixing ratios of mixed oils and at different temperatures.

	A_T (%)		
(MNT/IPM)%	25°C	37°C	45°C
0.5	33	33	35
1.0	38	39	40
2.0	36	37	38
3.0	33	33	34

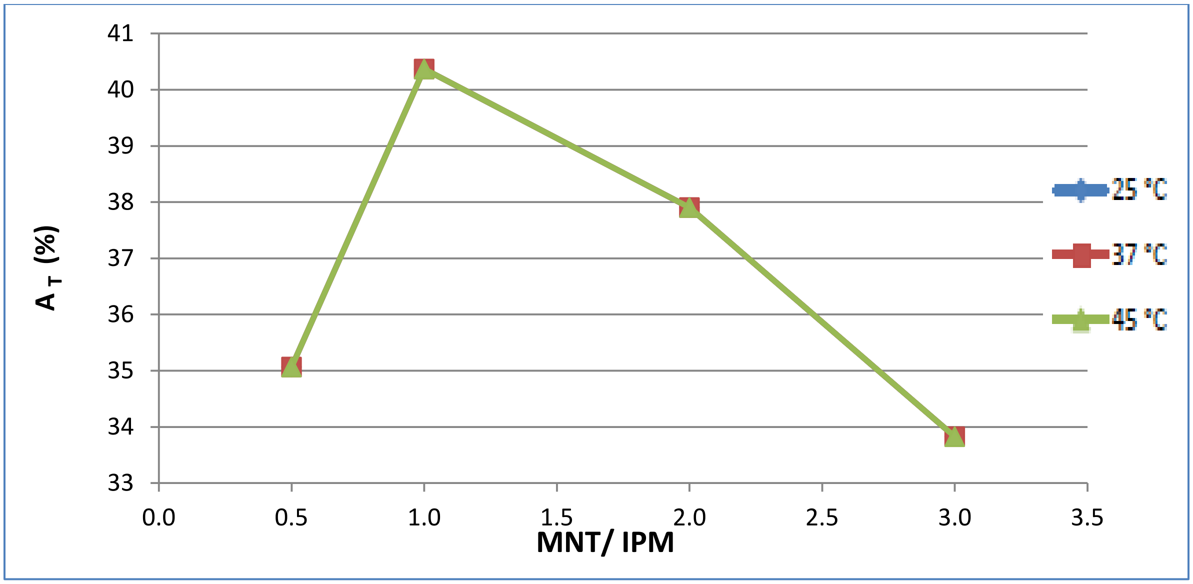


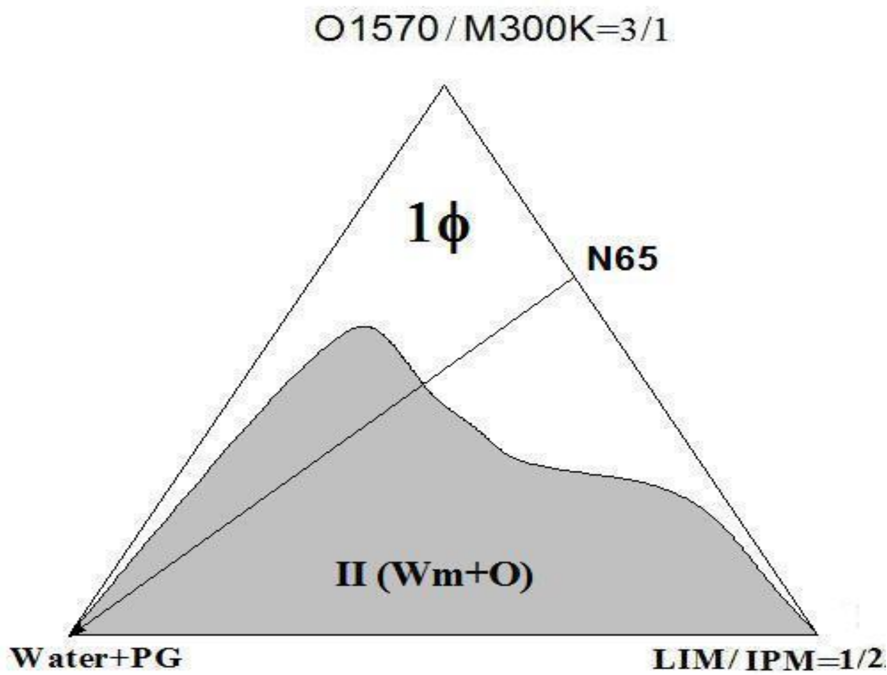
Figure 5.115: Variation of the total monophasic area A_T (%) as function peppermint oil content in the mixture (IPM+MNT) and as function of temperature for the system: W+PG / O1570+ M300K/IPM+ MNT.

<u>W +PG/O1570+M300K/IPM+LIM:-</u>

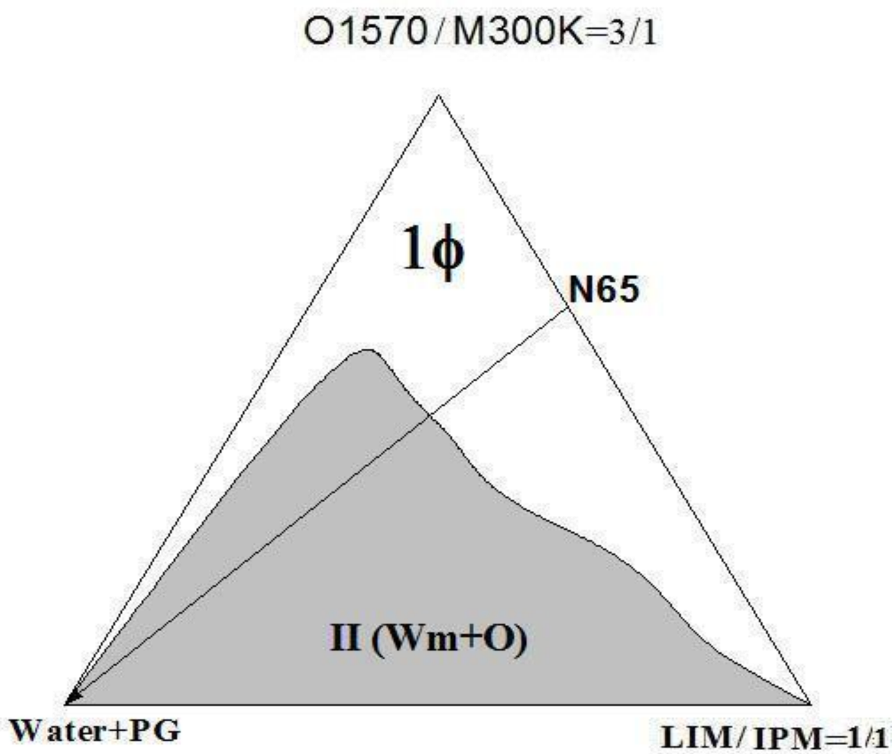
Figure 5.116 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate (IPM) +R(+)-limonene oil (LIM) system at different weight ratios of LIM/IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.116 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 30 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 52 wt% water.

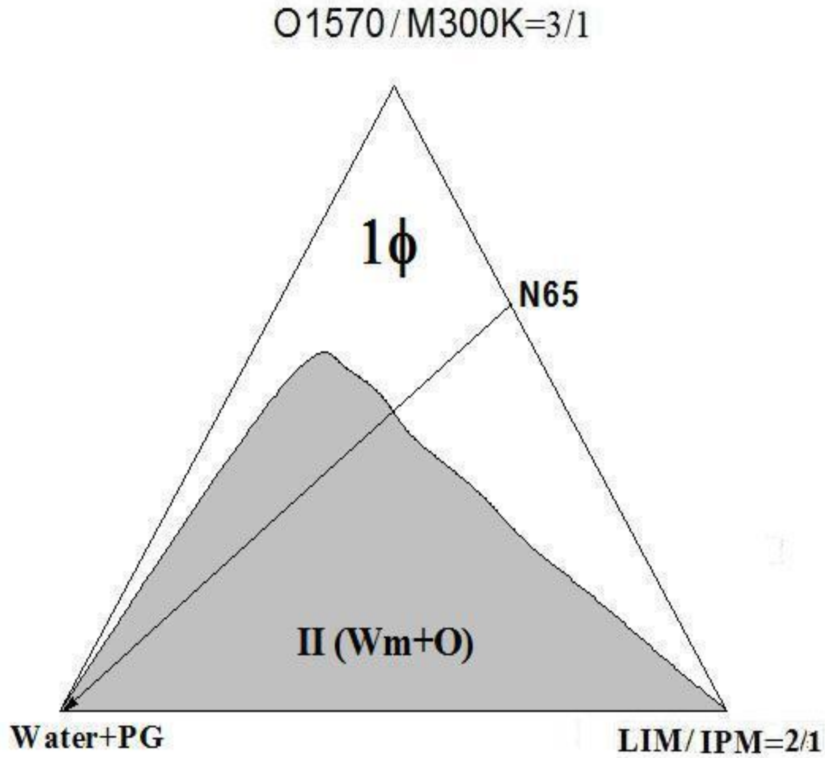
For low mixed surfactants contents (below 48 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.116B, with the difference that the area of the one phase microemulsion region increased since the multiphase region is extended to mixed surfactants contents above 55 wt%. In Figures 5.116C and 5.116D the one phase microemulsion region increase more compared to 5.116B.



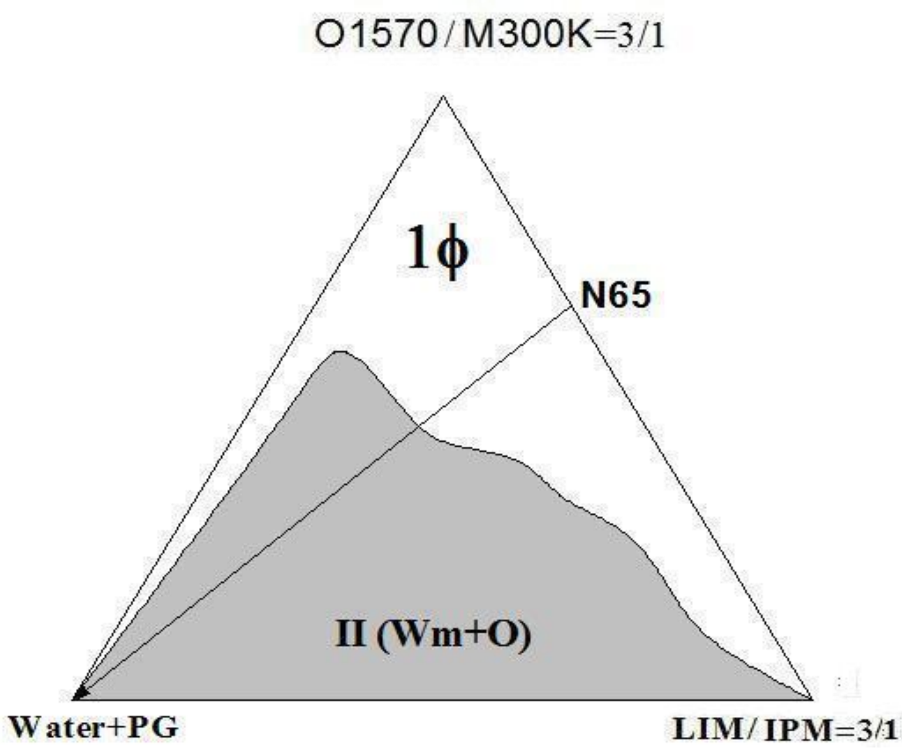
(A)



(B)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
LIM/ IPM=2/1

(C)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
LIM/ IPM=3/1

(D)

Figure 5.116: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+R(+)-limonene (LIM) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+LIM) = 65/35, LIM/IPM: **(A) 1/2 (B) 1 (C) 2 (D) 3.**

Table 5.53: The total monophasic area A_T (%) for the system W+PG/O1570+M300K (3:1)/IPM+LIM at different mixing ratios of mixed oils and at different temperatures.

	A_T (%)		
(LIM/IPM)%	25°C	37°C	45°C
0.5	43	43	43
1.0	42	42	42
2.0	43	43	43
3.0	44	44	44

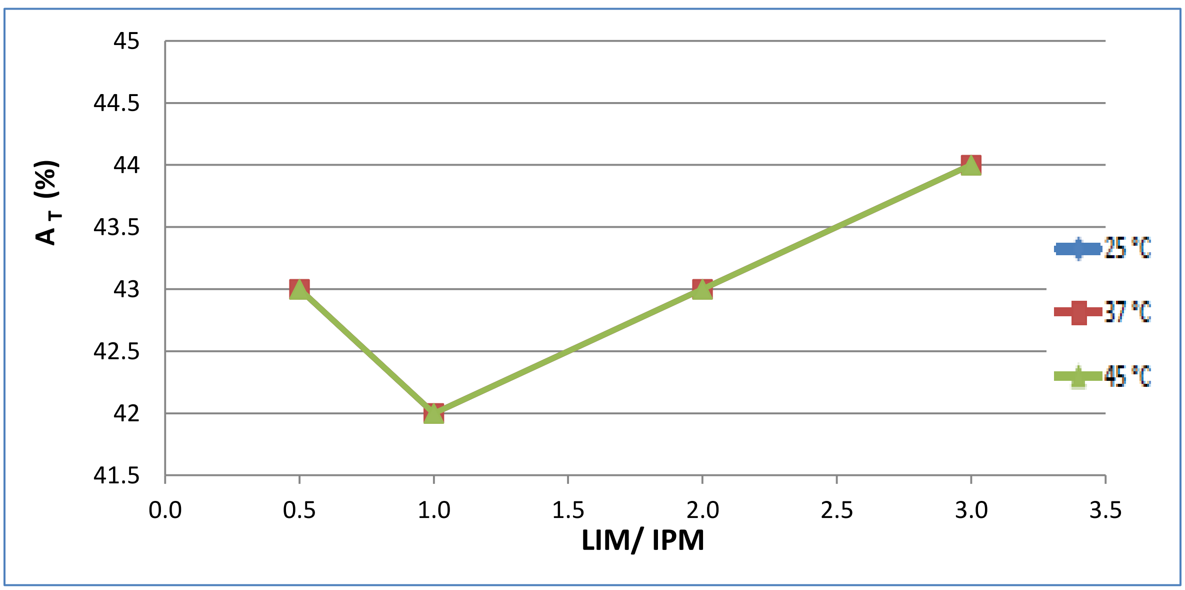


Figure 5.117: Variation of the total monophasic area A_T (%) as function R(+)-limonene oil content in the mixture (IPM+LIM) and as function of temperature for the system: W+PG / O1570+ M300K/IPM+ LIM.

W +PG/O1570+M300K/IPM+ION:-

Figure 5.118 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate (IPM) +α-ionone oil (ION) (1:1).

As show in Figure 5.118, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 25 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 55 wt% water.

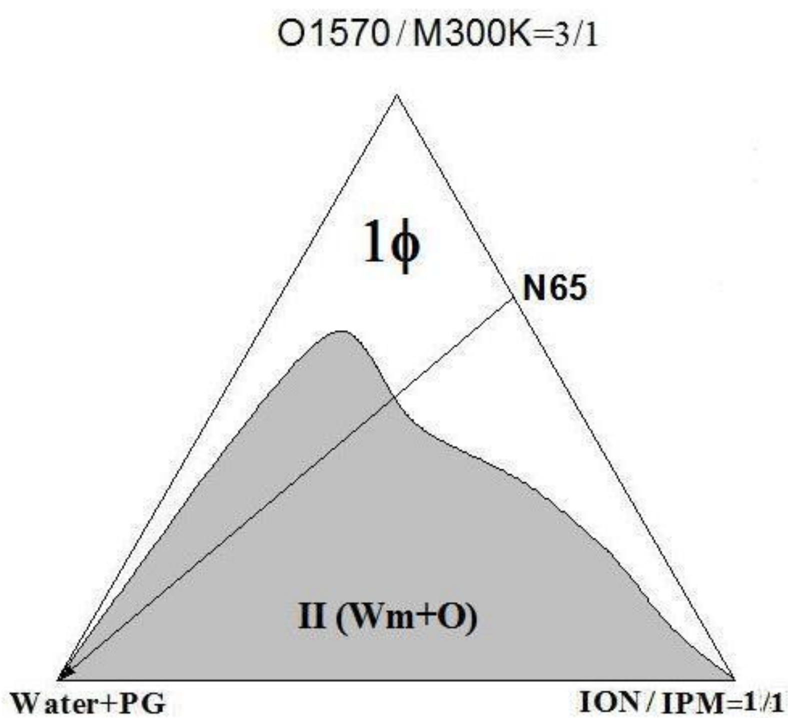


Figure 5.118: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+ α-ionone oil (ION) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+ION) = 65/35.

W +PG/O1570+M300K/CCT+MNT:-

Figure 5.119 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / caprylic-capric triglyceride (CCT) + peppermint oil (MNT) (1:1).

As show in Figure 5.119, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 20 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 52 wt% water.

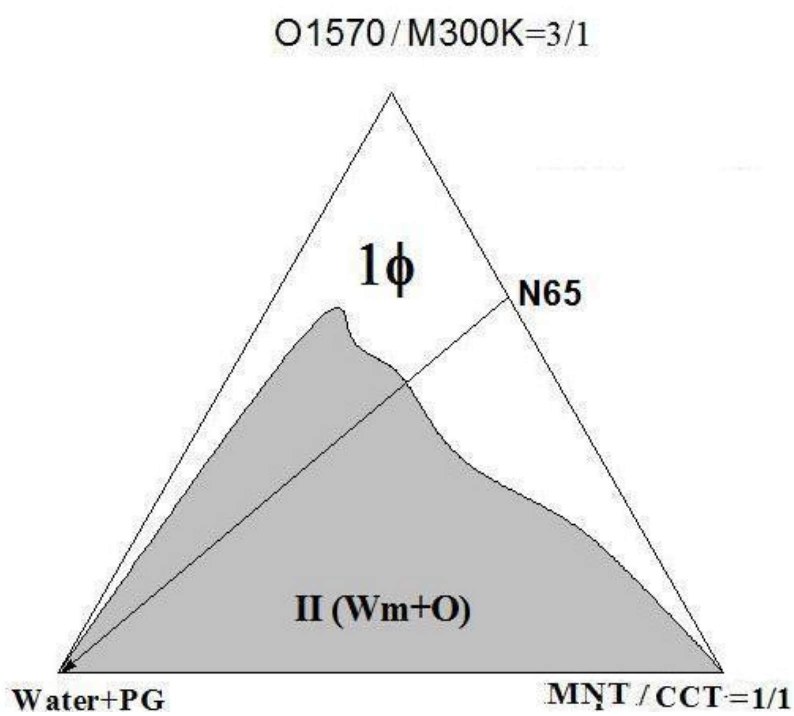


Figure 5.119: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+peppermint (MNT) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is

designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+MNT) = 65/35.

W +PG/O1570+M300K/CCT+LIM:-

Figure 5.120 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / caprylic-capric triglyceride (CCT) + R(+)-limonene oil (LIM) (1:1).

As show in Figure 5.120, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 18 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 48 wt% water.

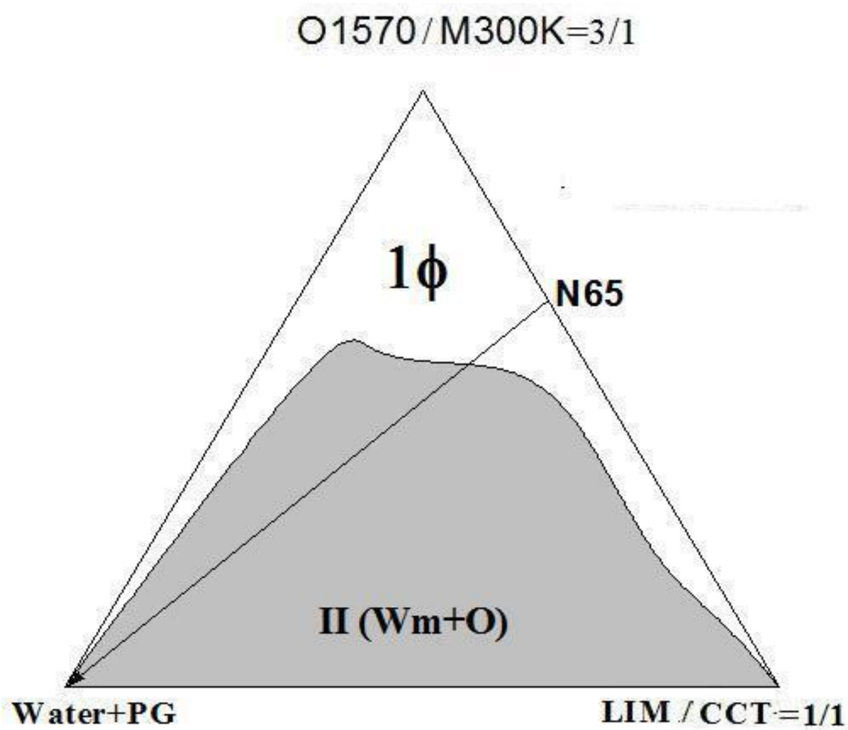


Figure 5.120: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+R(+)-Limonene

(LIM) at 25°C. The mixing ratio (w/w) of O1570+ M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+LIM) = 65/35.

W +PG/O1570+M300K/CCT+ION:-

Figure 5.121 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / caprylic-capric triglyceride (CCT) +α-ionone oil (ION) (1:1).

As show in Figure 5.121, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 21 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 48 wt% water.

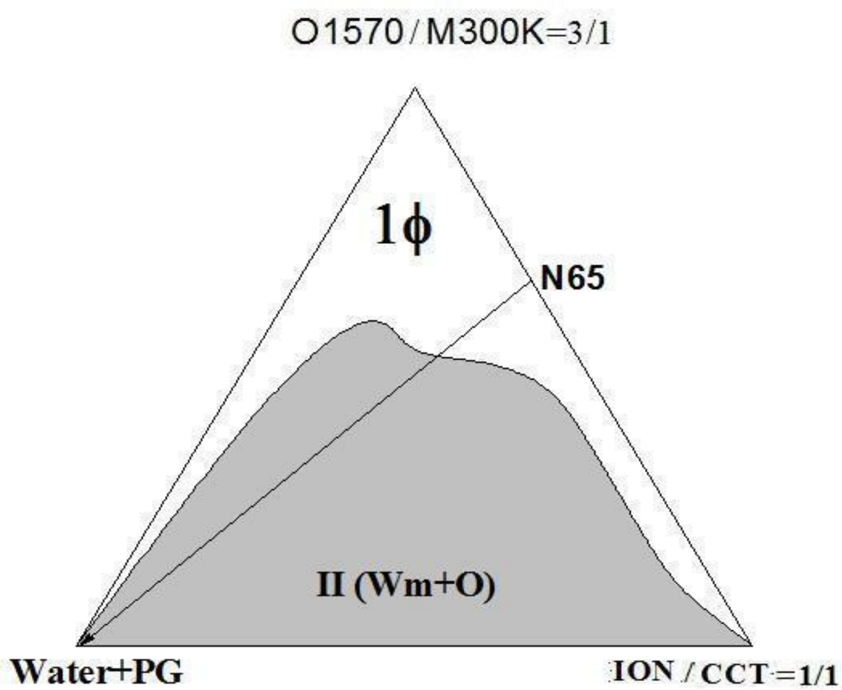


Figure 5.121: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+α-ionone (ION) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+ION) = 65/35.

Table 5.54: The total monophasic area A_T (%) for the system W+PG/O1570+M300K /O1+O2 At different type mixed oils and at different temperatures.

	A_T (%)		
(O2/O1) 1/1	25°C	37°C	45°C
(ION/IPM)	38	38	39
(ION/CCT)	32	32	32
(MNT/CCT)	37	36	38
(LIM/CCT)	30	30	30

Table 5.55: The maximum total monophasic area A_T (%) for the system W+PG/O1570+M300K/ mixed oils at 25°C temperatures.

Oil 1	**Oil 2**	**A_T (%) at 25°C**	**Mixed oil ratio where maximum A_T (%) is obtained at 25°C**
IPM	**MNT**	**38**	**1/1**
	LIM	**44**	**3/1**
	ION	**38**	**1/1**
CCT	**MNT**	**37**	**1/1**
	LIM	**30**	**1/1**
	ION	**32**	**1/1**

We have demonstrated the effect of mixed oil on total aria enhances partitioning film, and enhances the solubilization of water and oil. This also will decrease the phase inversion temperature and increases the efficiency of the mixed surfactants. we also demonstrated the effct of the carbon number of oil or its molecular volume on the phase inversion temperature and found that when the same mixed oil are present; increase the molecular volume of the oil will shift the phase inversion temperature toward higher temperature.

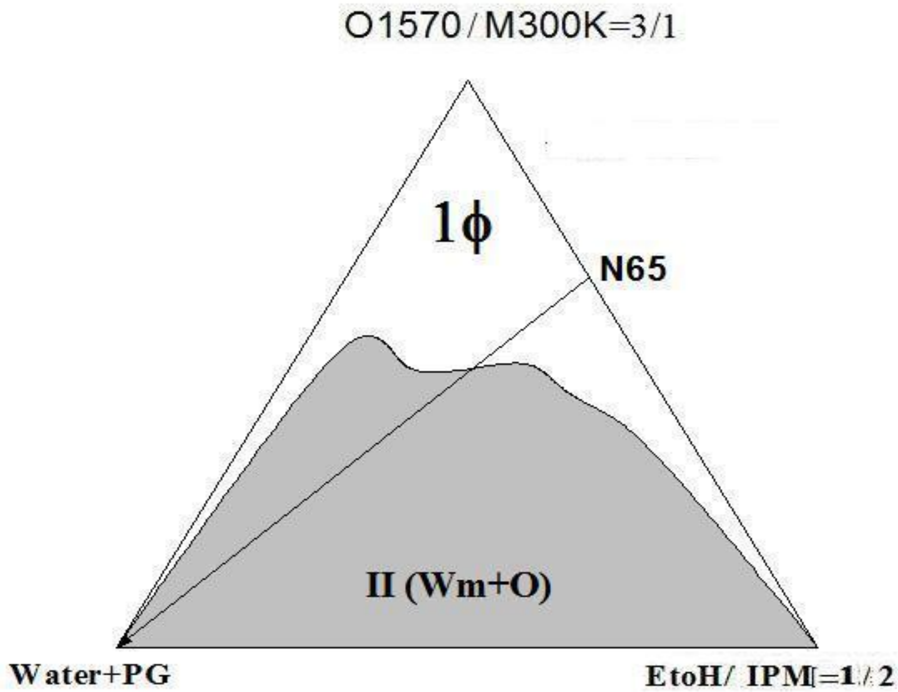
Phase behaviors of mixed surfactants/oil/ cosurfactants systems

W +PG/O1570+M300K/IPM+EtOH:-

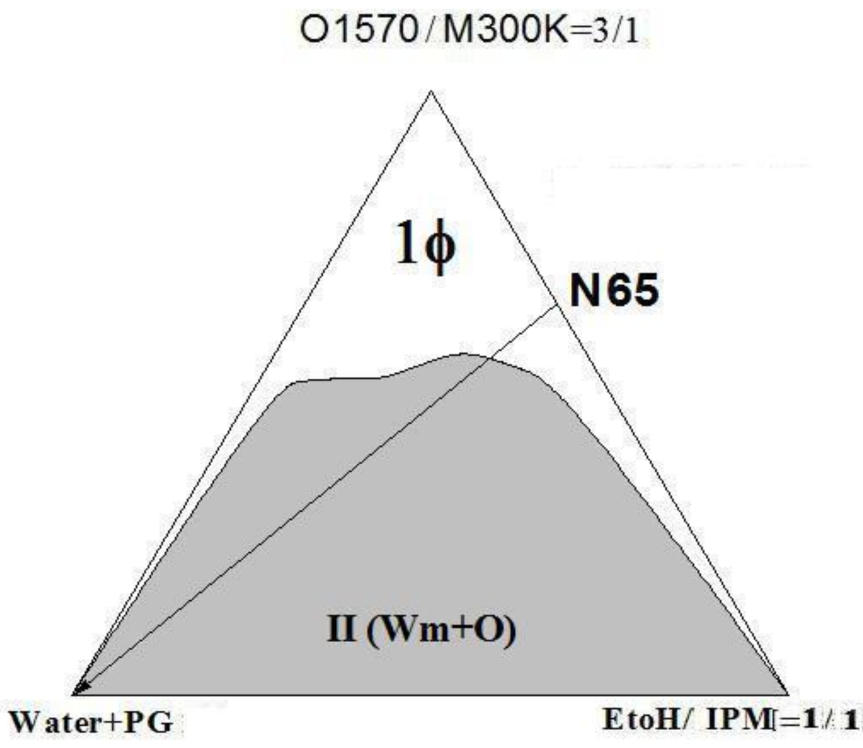
Figure 5.122 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate oil (IPM)+ethanol (EtOH) system at different weight ratios of EtOH /IPM that are (A) 1/2 (B) 1/1 (C) 2 (D) 3.

As show in Figure 5.122 A, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/cosurfactant and oil axis. The one phase microemulsion region extend to approximately 28 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 48 wt% water.

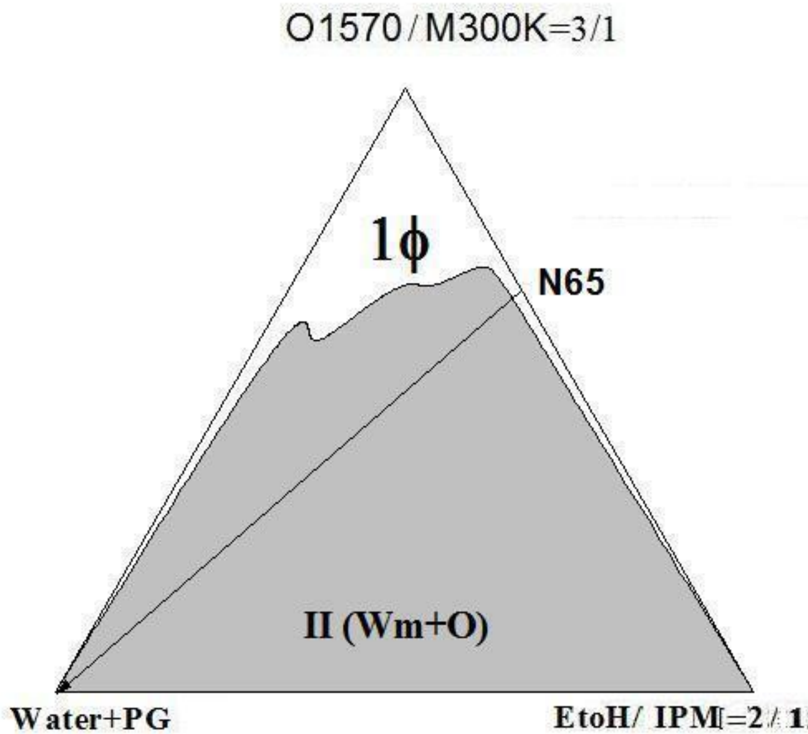
For low mixed surfactants contents (below 52 wt %) a multiphase reign II (Wm+O) is observed. Some behavior is observed in Figure 5.122B, with the difference that the area of the one phase microemulsion region decreased since the multiphase region is extended to mixed surfactants contents above 48 wt%. In Figures 5.122C and 5.122D the one phase microemulsion region shrank more compared to 5.122B.


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
EtoH/ IPM[=1/ 2

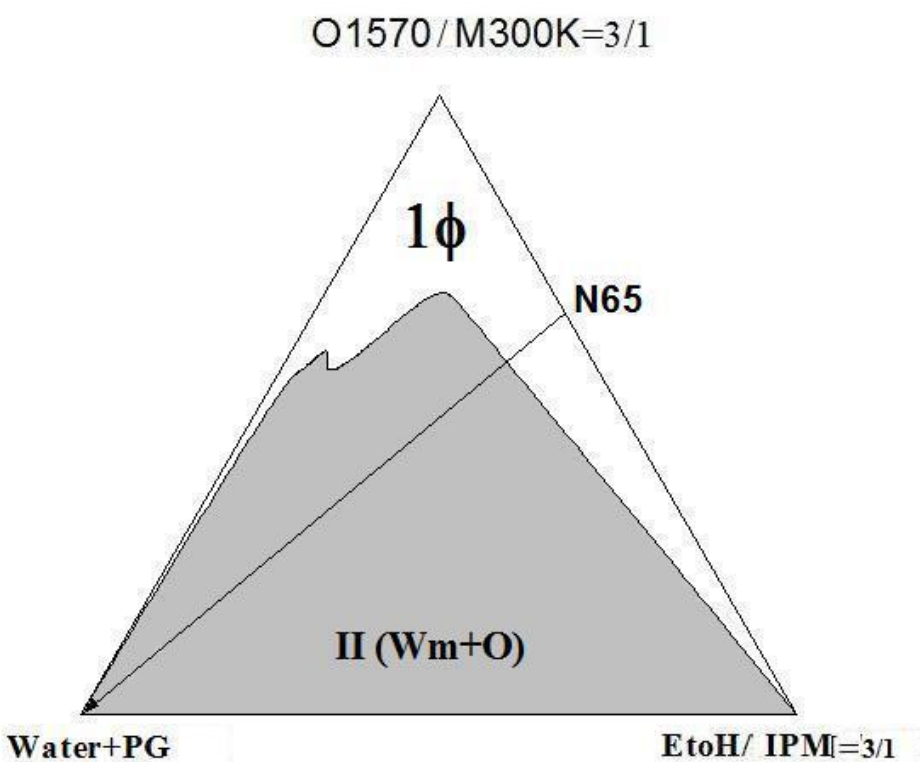
(A)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
EtoH/ IPM[=1/ 1

(B)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
EtoH/ IPM=2/1

(C)


O1570 / M300K=3/1
1ϕ
N65
II (Wm+O)
Water+PG
EtoH/ IPM=3/1

(D)

Figure 5.122: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+ethanol (EtOH) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+EtOH) = 65/35,EtOH/IPM: **(A) 1/2(B) 1 (C) 2 (D) 3.**

Table 5.56: The total monophasic area A_T (%) for the system W+PG/O1570+M300K /IPM EtOH at different mixing ratios of mixed oils and at different temperatures.

	A_T (%)		
(EtoH/IPM)%	25°C	37°C	45°C
0.5	32	34	34
1.0	27	27	27
2.0	15	17	17
3.0	24	20	20

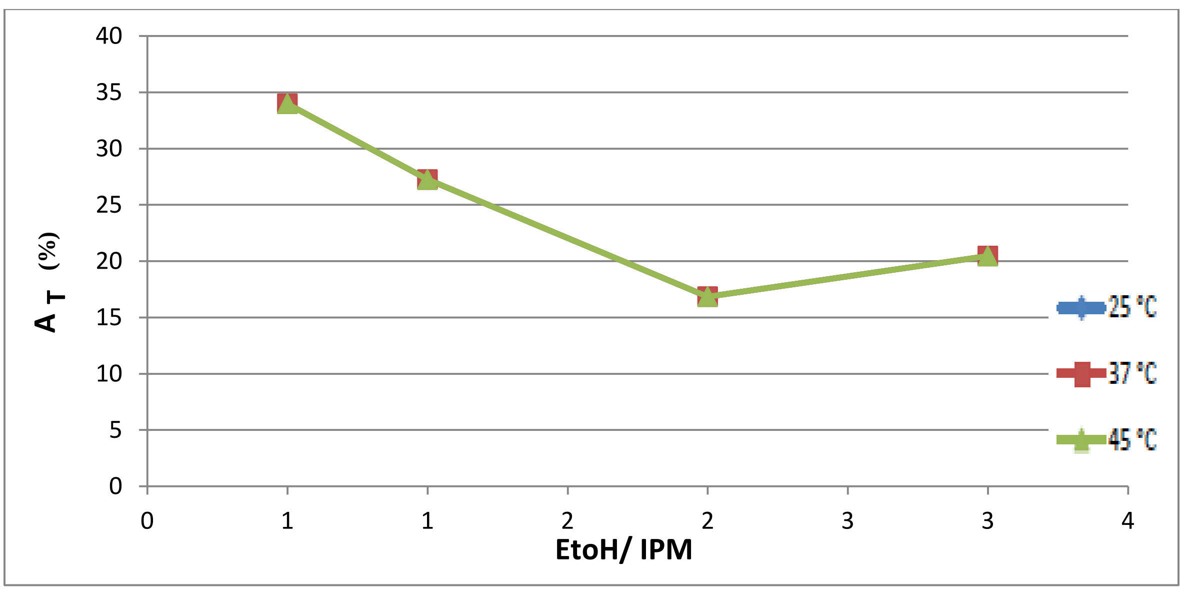


Figure 5.123: Variation of the total monophasic area A_T (%) as function ethanol content in the mixture (IPM+EtOH) and as function of temperature for the system: W+PG/O1570+ M300K/IPM+EtOH.

The change in phase behavior caused by the addition of ethanol and PG can be interpreted in terms of film properties that is, the flexibility of the surfactant film is increased because the LC phase is destabilized in favor of a microemulsion phase that even connects the aqueous with the oil phase. In addition, the increase in interfacial fluidity for the formation of isotropic microemulsions from organized structure (LC) is clearly an important factor.

W +PG/O1570+M300K/IPM+LNL:-

Figure 5.124 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate oil (IPM)+linalool (LNL) (1:1).

As show in Figure 5.124, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 15 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 48 wt% water.

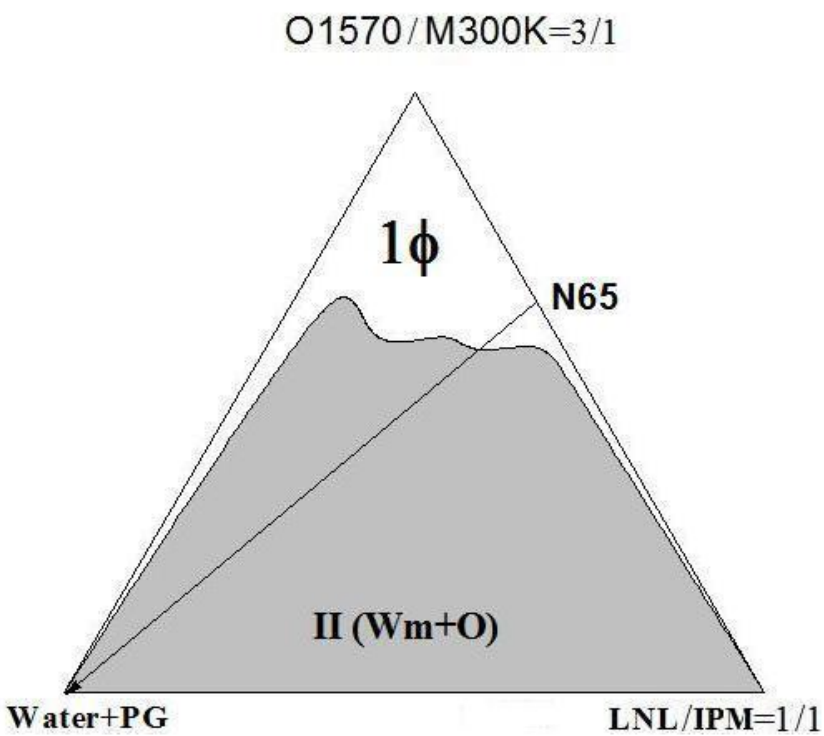


Figure 5.124: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+linalool (LNL) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+LNL) = 65/35,LNL/IPM: **1:1**

W +PG/O1570+M300K/IPM+ProA:-

Figure 5.125 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) /isopropylmyristate oil (IPM)+propionic acid (ProA) (1:1).

As show in Figure 5.125, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 18 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 45 wt% water.

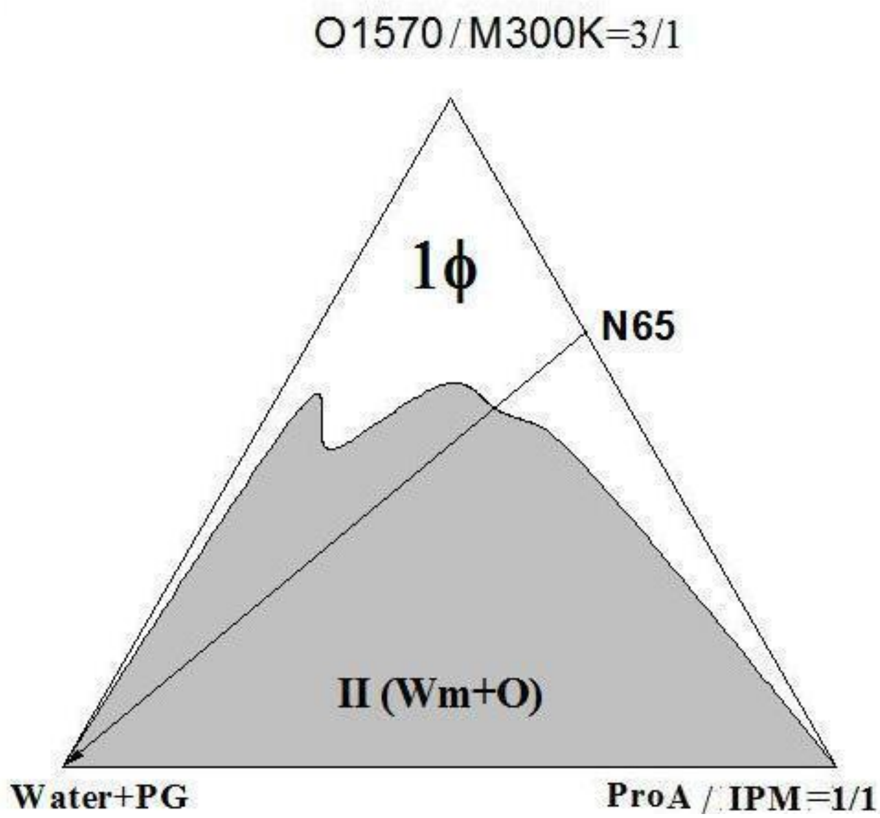


Figure 5.125: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+propionic acid (ProA) at 25°C. The mixing ratio (w/w) of O1570+M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+ProA) = 65/35, ProA /IPM: **1:1**

W +PG/O1570+M300K/IPM+GLy:-

Figure 5.126 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) / isopropylmyristate oil (IPM)+ glycerol (GLy) (1:1).

As show in Figure 5.126, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 8 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 40 wt% water.

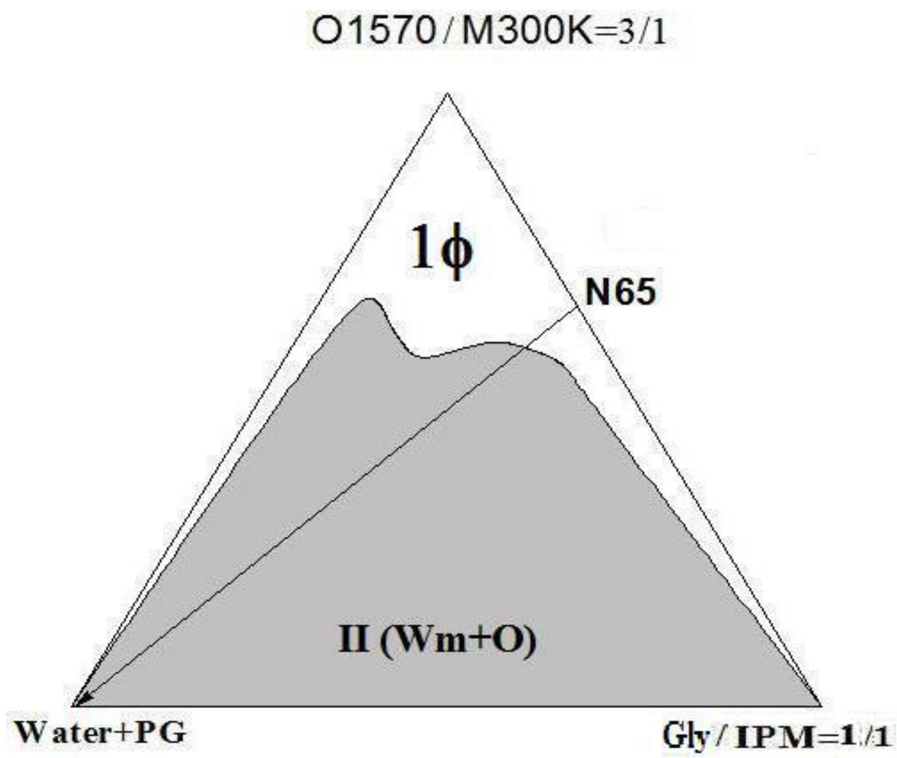


Figure 5.126: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ isopropylmyristate oil (IPM)+glycerol (GLy) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(IPM+GLy) = 65/35, GLy /IPM: **1:1.**

W +PG/O1570+M300K/CCT+EtOH:-

Figure 5.127 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) /caprylic-capric triglyceride oil (CCT)+ ethanol (EtOH) (1:1).

As show in Figure 5.127, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 8 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 18 wt% water.

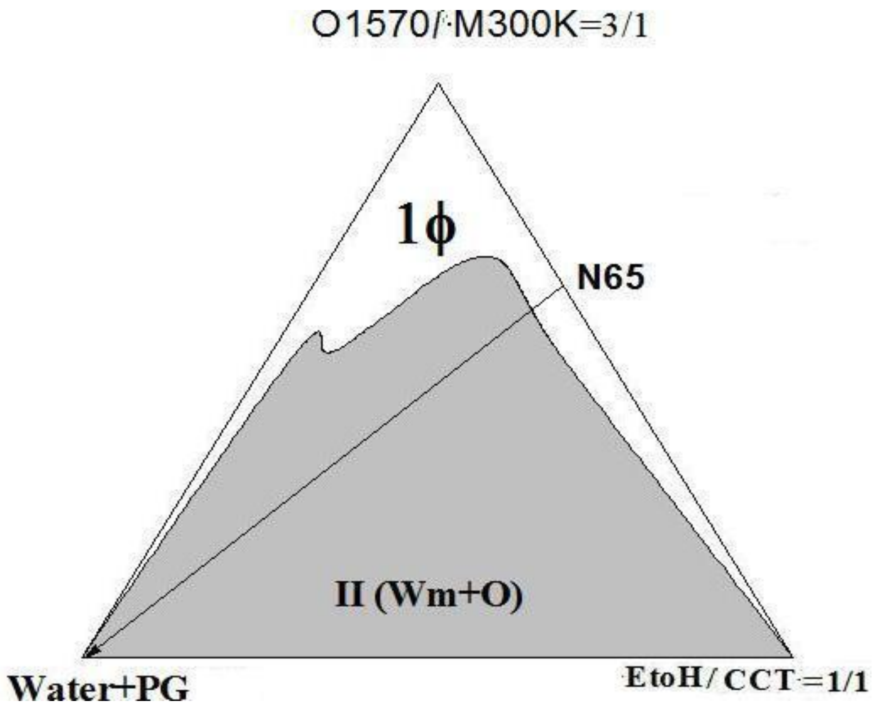


Figure 5.127: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+ethanol (EtOH) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+EtOH) = 65/35, EtOH /CCT: **1:1.**

W +PG/O1570+M300K/CCT+LNL:-

Figure 5.128 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) /caprylic-capric triglyceride (CCT)+ linalool (LNL) (1:1).

As show in Figure 5.128, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 5 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 37 wt% water.

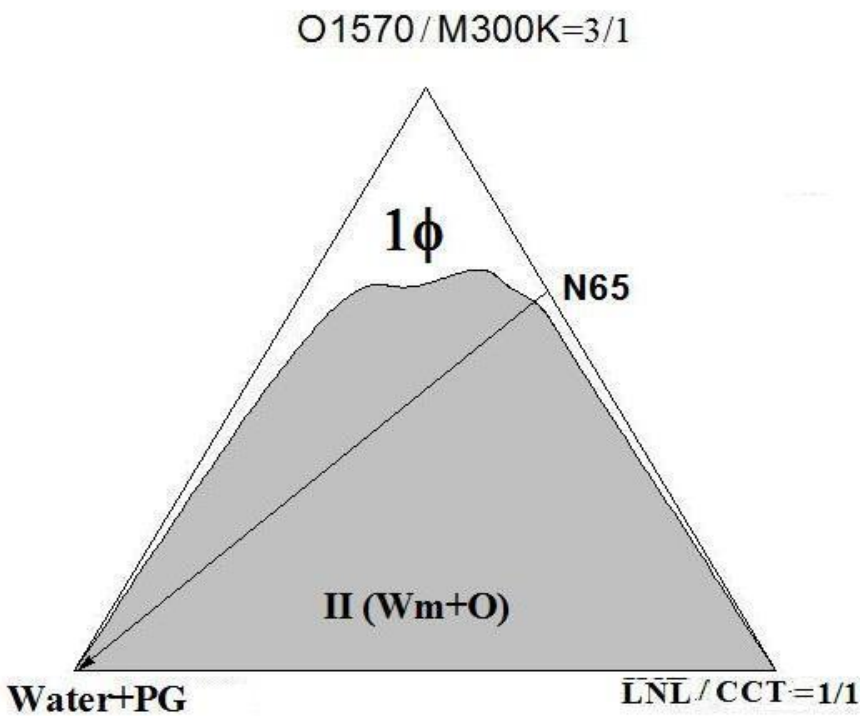


Figure 5.128: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+linalool (LNL) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is designated by

1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+LNL) = 65/35, LNL /CCT: **1:1.**

W +PG/O1570+M300K/CCT+ProA:-

Figure 5.129 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) /caprylic-capric triglyceride (CCT)+ propionic acid (ProA) (1:1).

As show in Figure 5.129, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 7 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 41 wt% water.

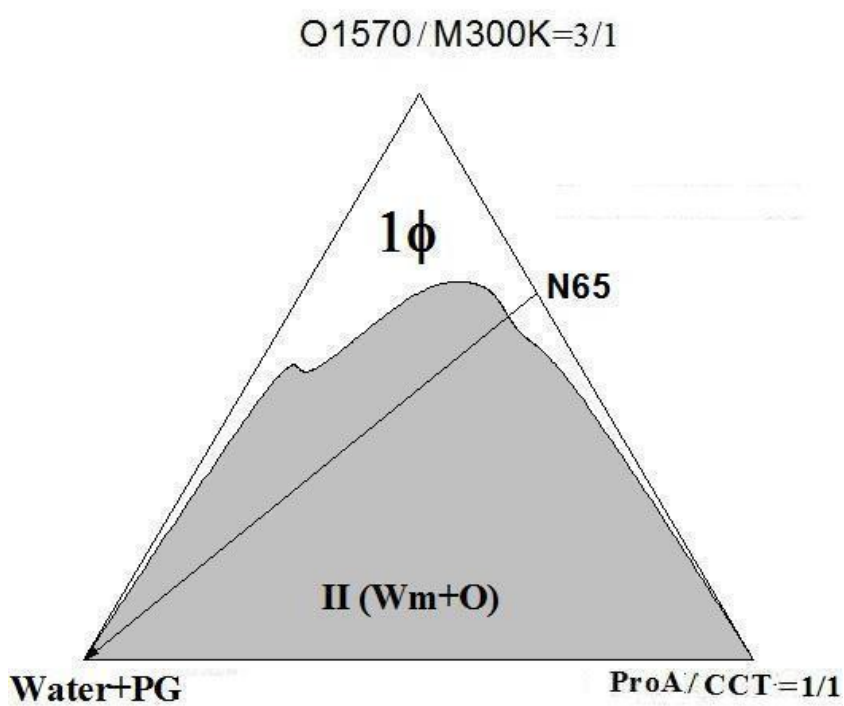


Figure 5.129: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate (O1570) + glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+propionic acid (ProA) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is

designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/ (CCT+ ProA)) = 65/35, ProA)/CCT: **1:1.**

<u>W +PG/O1570+M300K/CCT+GLy:-</u>

Figure 5.130 present the phase diagram of the water+propylene glycol (PG)/ sucrose oleate (O1570) + glycerol monolaurate (M300K) (3:1) /caprylic-capric triglyceride (CCT)+ glycerol (GLy) (1:1).

As show in Figure 5.130, the one phase microemulsion region appears from the first addition of water along the mixed surfactants/ oil axis. The one phase microemulsion region extend to approximately 6 wt% water along the dilution line N65. For higher mix surfactant contents the one phase microemulsion region could extend to about 35 wt% water.

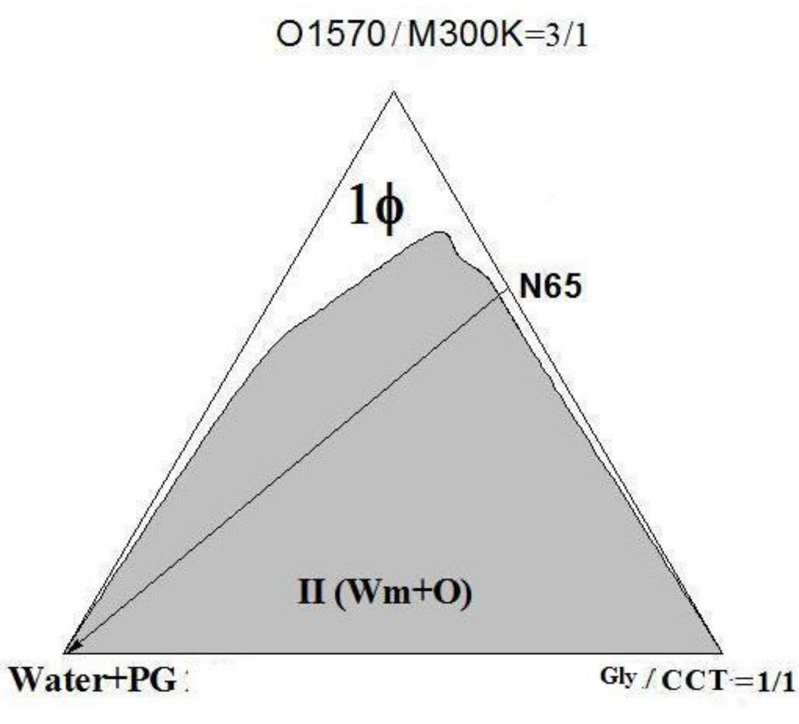


Figure 5.130: Phase diagrams of the system: water+propylene glycol (PG) / sucrose oleate

(O1570)+glycerol monooleate (M300K)/ caprylic-capric triglyceride oil (CCT)+glycerol (GLy) at 25°C. The mixing ratio (w/w) of O1570/M300K equals 3/1. The one phase region is designated by 1Φ, and the multiple phase regions are designated by II (Wm+O). N65 is the dilution line where the mixing ratio (w/w) of (O1570+M300K)/(CCT+ GLy) = 65/35, GLy /CCT: **1:1.**

Table 5.57: The total monophasic area A_T (%) for the system W+PG/O1570+M300K /oil+ cosurfactant at different mixing ratios of mixed oils and at different temperatures.

	A_T (%)		
(Co-surfactant/oil)% 1/1	25°C	37°C	45°C
LNL/IPM	30	30	30
ProA/IPM	20	20	20
GLy/IPM	24	24	24
EtoH/CCT	22	22	22
LNL/CCT	21	21	21
ProA/CCT	19	19	19
GLy/CCT	15	15	15

5.2 Indomethacin solubilization

Microemulsions characteristic enable them to be used as drug carriers for topical, oral, parenteral and other administration routes. Due to the small size of the dispersed droplets(Less than 100 nm) and their high specific surface, high percentages of surfactants are required. Skin damages then could be induced (Thevenin, Grossiord, Poelman, 1996).

Drug research is very concerned in microemulsions (Ziegenmeyer and Fuhrer, 1980; Bhargava et al., 1987; Gasco et al., 1994) but safe systems should be used. A new step in microemulsion formulation should be reached with the use of mild surfactants of natural origin which could reduce skin injuries (Thevenin, Grossiord, Poelman, 1996).

Interest has been reported on M159 in different type of oil microemulsion but the use of sucrose esters in order to overcome the irritating potency has not yet been proposed.

Compared with sucrose esters, M159 and M300K all the surfactants are non ionic, approved by FAO/WHO, in japan , the USA, the EU, as food additives owing to their high safety and excellent properties (Akoh,1992). Such surfactants, non-toxic and biodegradable could be helpful to formulate new microemulsion systems for food and pharmaceutical use.

Over the years, a variety of solubilization techniques have been studied to improve the solubility, dissolution rate and the subsequent bioavailability of drugs which induces:

I. Modifying the drug properties at the molecular level by using salt forms of drugs.

II. Using colloidal drug delivery systems, or

III. By modifying the properties of drugs at the particulate level.

The most studied pharmaceutical microemulsion systems for drug delivery have been through the topical route. Development of microemulsion systems useful for the other routes is required.

Microemulsions were suggested during the last decades as a vehicle for cutaneous release of drugs for both hydrophilic and hydrophobic drugs. Compounds which are able to form nontoxic microemulsions and solubilize high quantity of the drug are the most suitable for application in pharmaceutical formulations. Solubilization and deposition of the drug in the microemulsion depend on the microstructure of these microemulsions.

The increased absorption of solubilized drugs in microemulsions for topical applications is attributed to the enhancement of penetration through the skin by the carrier. Topical drug delivery has much compensation over the oral route of administration because it evades hepatic metabolism, the administration is easier and more convenient for the patient and there is the possibility of immediate removal of the treatment if required. In this section we investigated the solubilization capacity of indomethacin in different microemulsion systems (water)/ mixed nonionic surfactants (L1695laurate and M159)/ oil.

Solubilization Capacity (SC)

The solubilization capacity (SC) of indomethacin at 25°C in the different sample is presented in **Table 5.58** and **Figure 5.131** respectively.

Table5.58: Solubilization indomethacin in different pure substances.

Tube #	System Name	(S.C) of the indomethacin (mg/g)
1	Water	3
2	PG	16
3	W/PG	4
4	W/L1695+M159	14
5	W+PG/L1695+M159	15
6	MNT	34
7	LIM	13
8	IPM	9
9	CCT	15
10	IPM+MNT	73
11	IPM+LIM	13
12	CCt+MNT	37
13	CCT+LIM	12

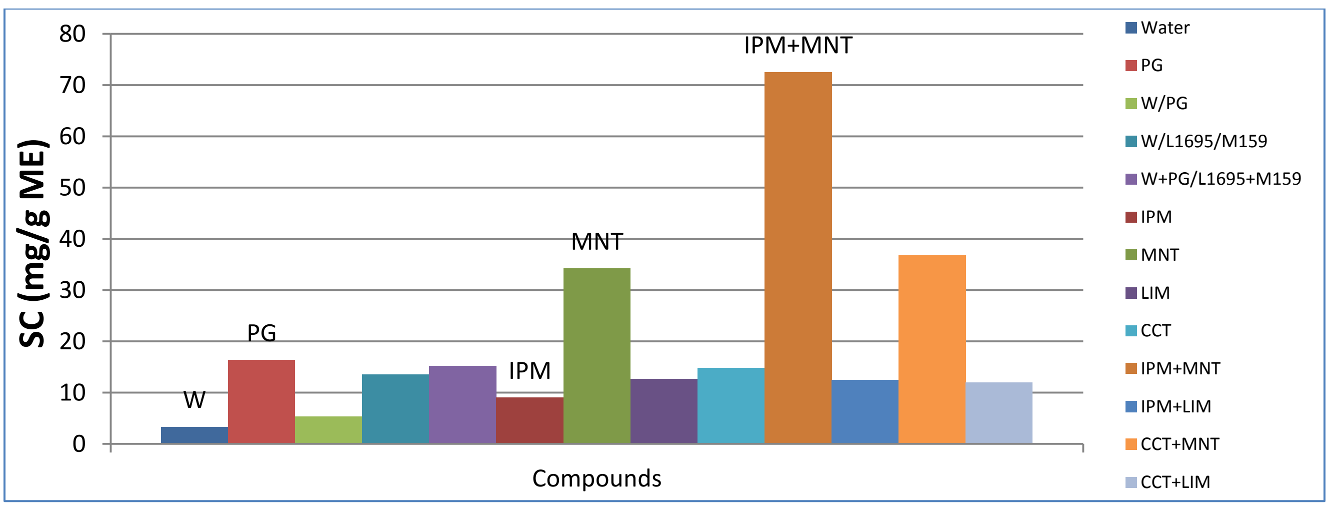


Figure 5.131: The solubilization capacity (SC) of indomethacin (mg drug/ g) as function of compounds content at 25°C. The weight ratio of (L1695/M159) and (O_1/O_2) equals unity.

Microemulsions containing peppermint oil significantly improved solubilization and have high amount of indomethacin solubilization and mixing oil enhances the solubilization capacity compared to single oils based systems.

Indomethacin solubilization capacity in W/L1695+M159/MNT

N65 Solubilization

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.59 and Figure 5.132. Two different regions can be identified the phase diagrams is presented in Figure 5.33.

Table 5.59: The SC (mg/g) for the system W/L1695+ M159/ MNT at different water contents.

	S.C(mg/g)
W/L1695+M159/MNT	25°C
0	46
10	43
20	28
30	29
40	25
50	18

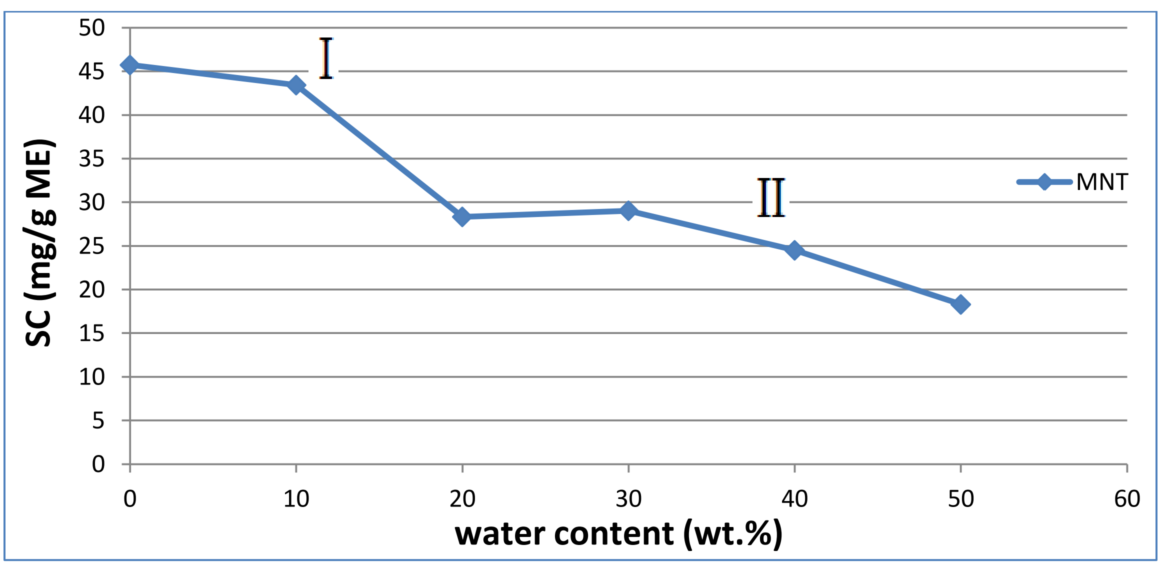


Figure 5.132: The solubilization capacity (SC) of indomethacin (mg drug/ g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.33 at 25°C in the system W/ L1695+M159/MNT. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity decrease from 46mg/g microemulsion at water content equal 0 wt.% to about 28mg/g at water content equal 20 wt.% in the first region, in the second region the solubilization capacity decrease dramatically from 28mg/g at water content equal 20 wt.% to about 18mg/g microemulsion at water content equals 50 wt.%.

W/ L1695+M159/ LIM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.60 and Figure 5.133. Two different regions can be identified the phase diagrams is presented in Figure 5.35.

Table 5.60: The SC (mg/g) for the system W/L1695 (50%) + M159 (50%)/ LIM at different water contents.

	S.C(mg/g)
W/L1695+M159/LIM	25°C
0	21
10	24
20	21
30	18
40	13
50	10

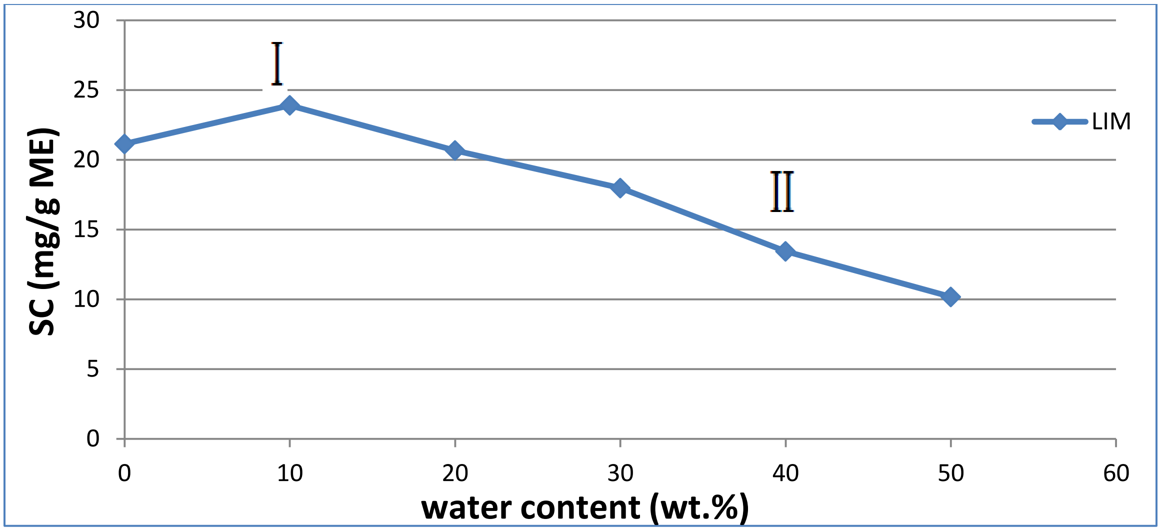


Figure 5.133: The solubilization capacity (SC) of indomethacin (mg drug/ g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.35 at 25°C in the system W/ L1695+M159/LIM. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity increase from 21mg/g microemulsion at water content equal 0 wt.% to about 24mg/g at water content equal 10 wt.% in is the first region. In the second region the solubilization capacity decrease dramatically from 24mg/g at water content equal 10 wt.% to about 10mg/g microemulsion at water content equals 50 wt.%.

W/ L1695+M159/ ION

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.61and Figure 5.134. Two different regions can be identified the phase diagrams is presented in Figure 5.37.

Table 5.61: The SC (mg/g) for the system W/L1695+ M159/ ION at different water contents.

	S.C(mg/g)
W/L1695+M159/ION	25°C
0	37
10	11
20	10

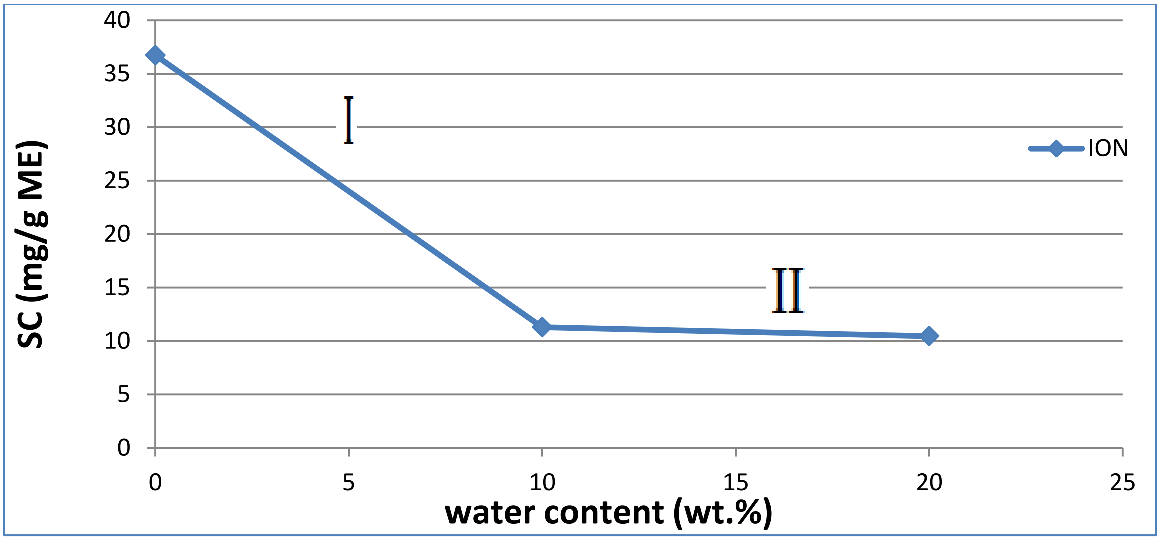


Figure 5.134: The solubilization capacity (SC) of indomethacin (mg drug/ g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.37 at 25°C in the system W/ L1695+M159/ION. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity decrease from 37mg/g microemulsion at water content equal 0 wt.% to about 11mg/g at water content equal 10 wt.% and this is the first region, in the second region the solubilization capacity decrease from 11mg/g at water content equal 10 wt.% to about 10mg/g microemulsion at water content equals 20 wt.%.

W/ L1695+M159/ IPM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.62 and Figure 5.135**.** Two different regions can be identified the phase diagrams is presented in Figure 5.39.

Table 5.62: The SC (mg/g) for the system W/L1695+ M159/ IPM at different water contents.

W/L1695+M159/IPM	S.C(mg/g) 25°C
0	17
10	22
20	19
30	17
40	14

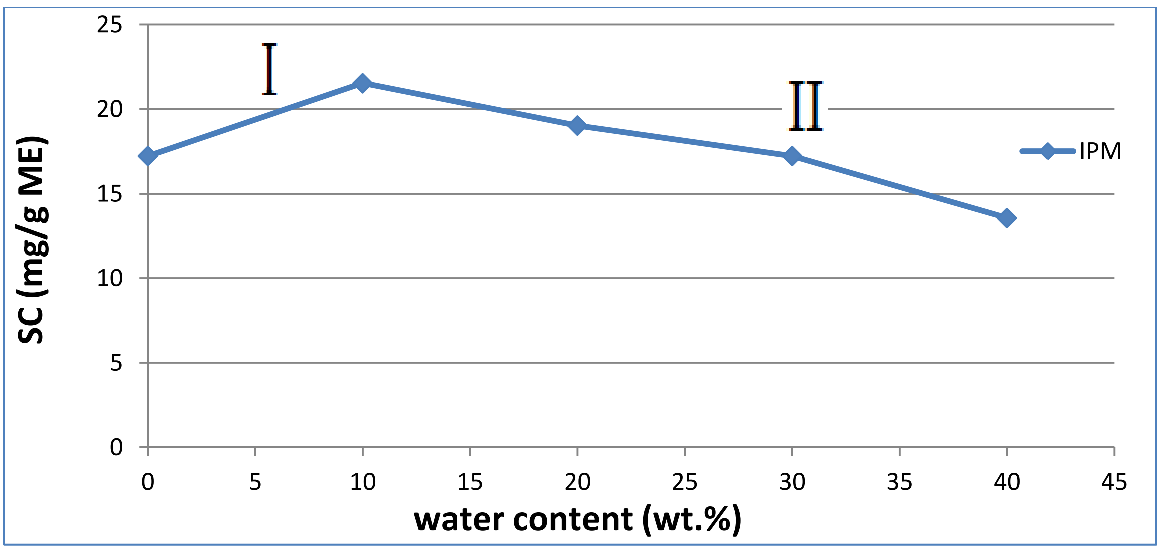


Figure 5.135: The solubilization capacity (SC) of indomethacin (mg drug/ g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.39 at 25°C in the system W/ L1695+M159/IPM. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity increase from 17mg/g microemulsion at water content equal 0 wt.% to about 22mg/g at water content equal 10 wt.% and this is the first region, in the second region the solubilization capacity decrease dramatically from 22mg/g at water content equal 10 wt.% to about 14mg/g microemulsion at water content equals 40 wt.%.

W/ L1695+M159/ CCT

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.63 and Figure 5.136. Two different regions can be identified the phase diagram is presented in Figure 5.41

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Table 5.63: The SC (mg/g) for the system W/L1695+ M159/ CCT at different water contents.

	S.C(mg/g)
W/L1695+M159/CCT	25°C
0	27
10	7
20	7
30	7
40	7

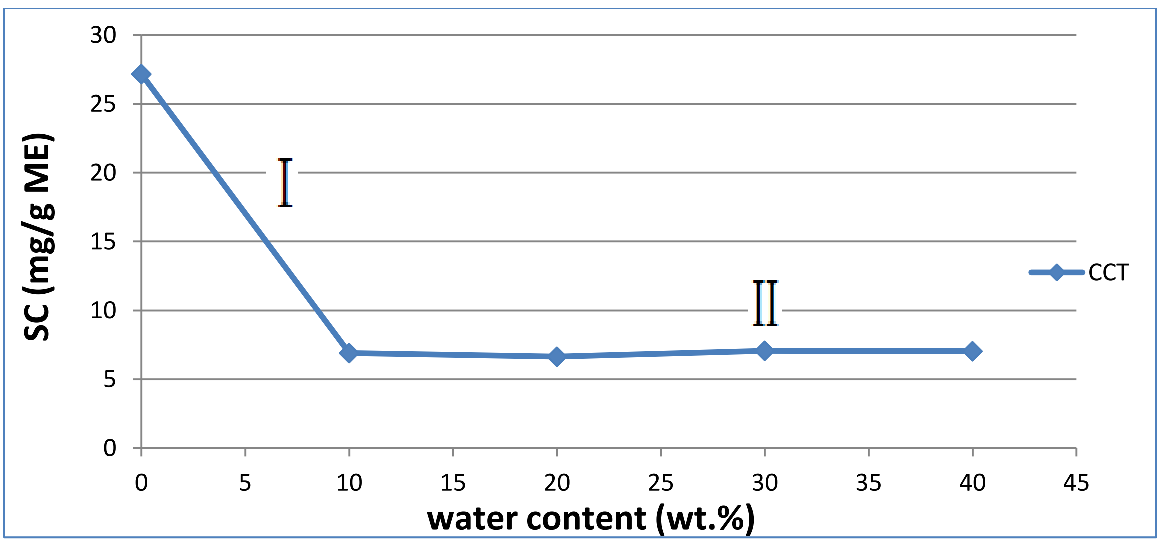

Figure 5.136: The solubilization capacity (SC) of the indomethacin (mg drug/ g microemulsion) as function of water content along the dilution line N65 the phase diagram is presented in Figure 5.41 at 25°C in the system W/ L1695+M159/CCT. The weight ratios of (L1695/M159) equal unity.

The solubilization capacity decrease from 27mg/g microemulsion at water content equal 0 wt.% to about 7mg/g at water content equal 10 wt.% and this is the first region, in the second region the solubilization capacity stability from 7mg/g at water content equal 10 wt.% to water content equals 40 wt.%.

W/ L1695+M159/ IPM+MNT

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.64 and Figure 5.137**.** Two different regions can be identified the phase diagrams is presented in Figure 5.86

Table5.64: The SC (mg/g) for the system W/L1695+ M159/ IPM+MNT at different water contents.

	S.C(mg/g)
W/L1695+M159/IPM+MNT	25°C
0	29
10	27
20	24
30	25
40	20
50	14
60	10
70	10
80	11
90	10

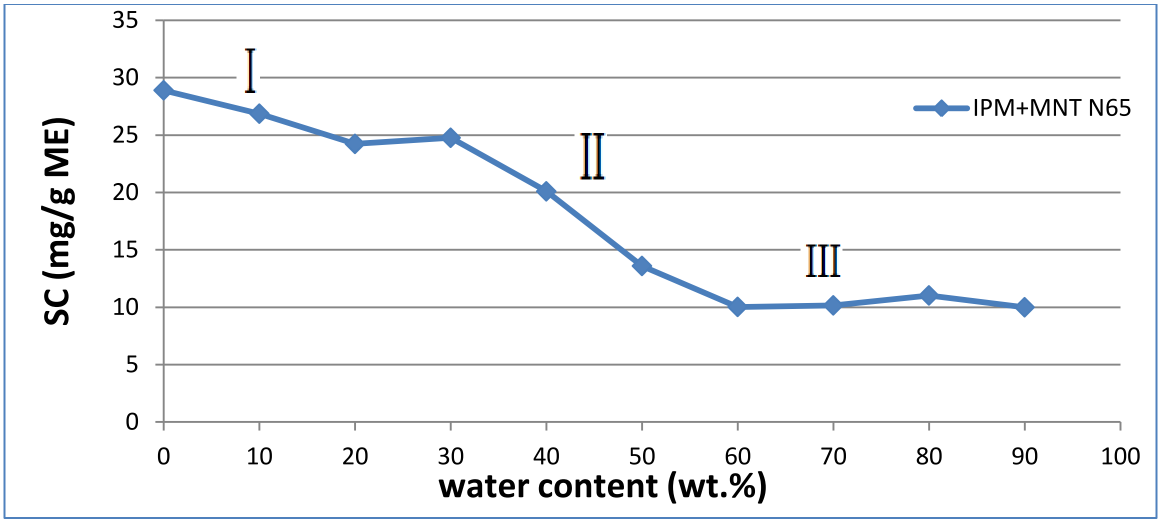

Figure 5.137: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.86 at 25°C in the system W/ L1695+M159/IPM+MNT. The weight ratio of (L1695/M159) equals unity.

the solubilization capacity decreases from 29mg/g microemulsion at water content equal 0 wt.% to about 24mg/g at water content equal 20 wt.% and this is the first region, in the second region the solubilization capacity decrease dramatically from 24mg/g at water content equal 20 wt.% to about 10mg/g microemulsion at water content equals 60 wt.%, then the amount of drug solubilized stabilize to 10mg/g microemulsion at water content 90 wt.% and this is the third region.

W/ L1695+M159/ IPM+LIM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table5.65 and Figure 5.138. Two different regions can be identified the phase diagrams is presented in Figure 5.88.

Table 5.65: The SC (mg/g) for the system W/L1695+ M159/ IPM+LIM at different water contents.

	S.C(mg/g)
W/L1695+M159/IPM+LIM	25°C
0	29
10	27
20	25
30	21
40	17
50	10
60	11
70	10
80	7
90	7

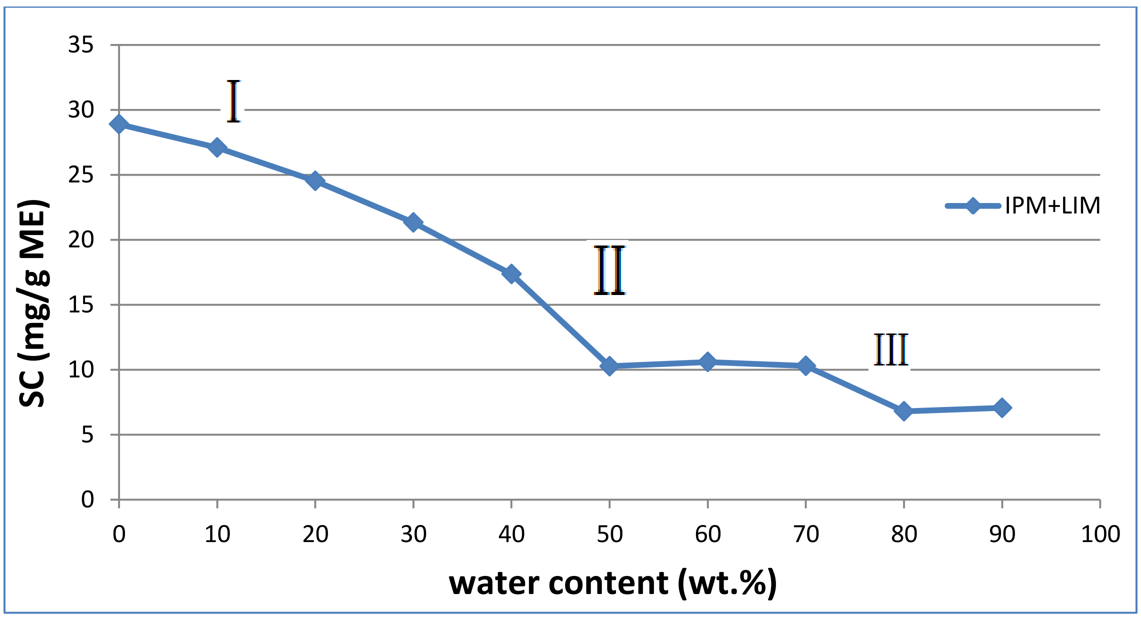

Figure 5.138: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.88 at 25°C in the system W/ L1695+M159/ IPM+LIM. The weight ratio of (IPM/LIM) and (L1695/M159) equals unity.

The solubilization capacity decreases from 29mg/g microemulsion at water content equal 0 wt.% to about 21mg/g at water content equal 30 wt.% in the first region. In the second region the solubilization capacity decrease dramatically from 21mg/g at water content equal 30 wt.% to about 10mg/g microemulsion at water content equals 70 wt.%, then the amount of drug solubilized decrease to 7mg/g microemulsion at water content 90 wt.% in the third region.

W/ L1695+M159/ IPM+ION

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.66 and Figure 5.139. Two different regions can be identified the phase diagrams is presented in Figure 5.90.

Table 5.66: The SC (mg/g) for the system W/L1695+ M159/ IPM+ION at different water contents.

	S.C(mg/g)
W/L1695+M159/IPM+ION	25°C
0	39
10	29
20	18
30	21
40	18
50	15
60	12
70	12
80	7
90	3

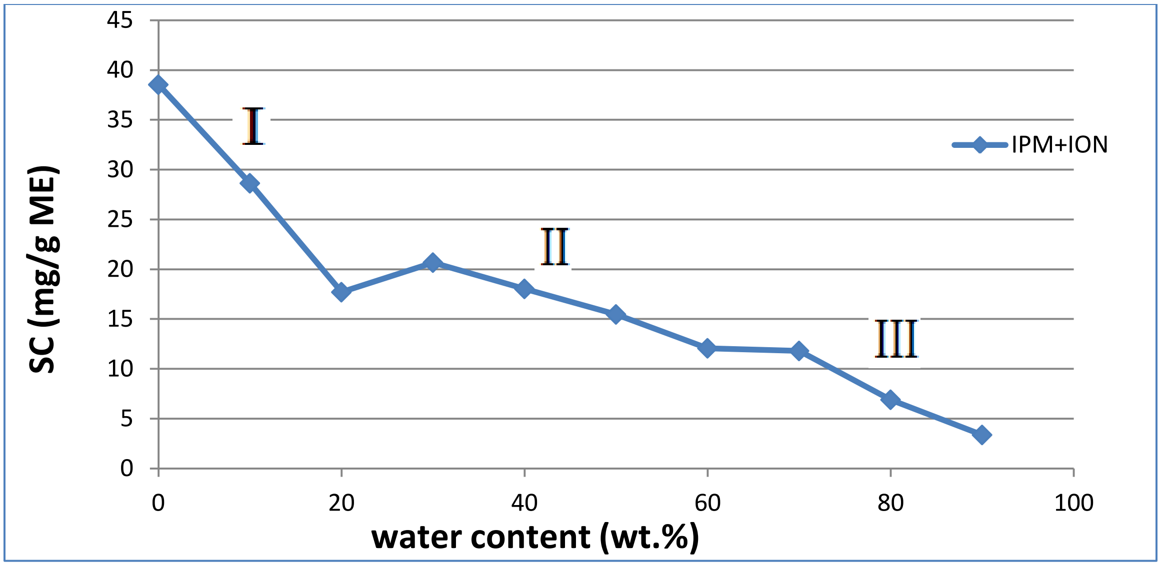

Figure 5.139: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.90 at 25°C in the system W/ L1695+M159/IPM+ION. The weight ratio of (IPM/ION) and (L1695/M159) equals unity.

The solubilization capacity decreases from 39mg/g microemulsion at water content equal 0 wt.% to about 18mg/g at water content equal 20 wt.% in the first region. In the second region the solubilization capacity decrease dramatically from 18mg/g at water content equal 20 wt.% to about 12mg/g microemulsion at water content equals 70 wt.%, then the amount of drug solubilized decrease to 3mg/g microemulsion at water content 90 wt.% in the third region.

W/ L1695+M159/ CCT+MNT

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.67 and Figure 5.140. Two different regions can be identified the phase diagrams is presented in Figure 5.92.

Table 5.67: The SC (mg/g) for the system W/L1695+ M159/ CCT+MNT at different water contents.

	S.C(mg/g)
W/L1695+M159/CCT+MNT	25°C
0	42
10	46
20	29
30	28
40	21
50	17
60	13

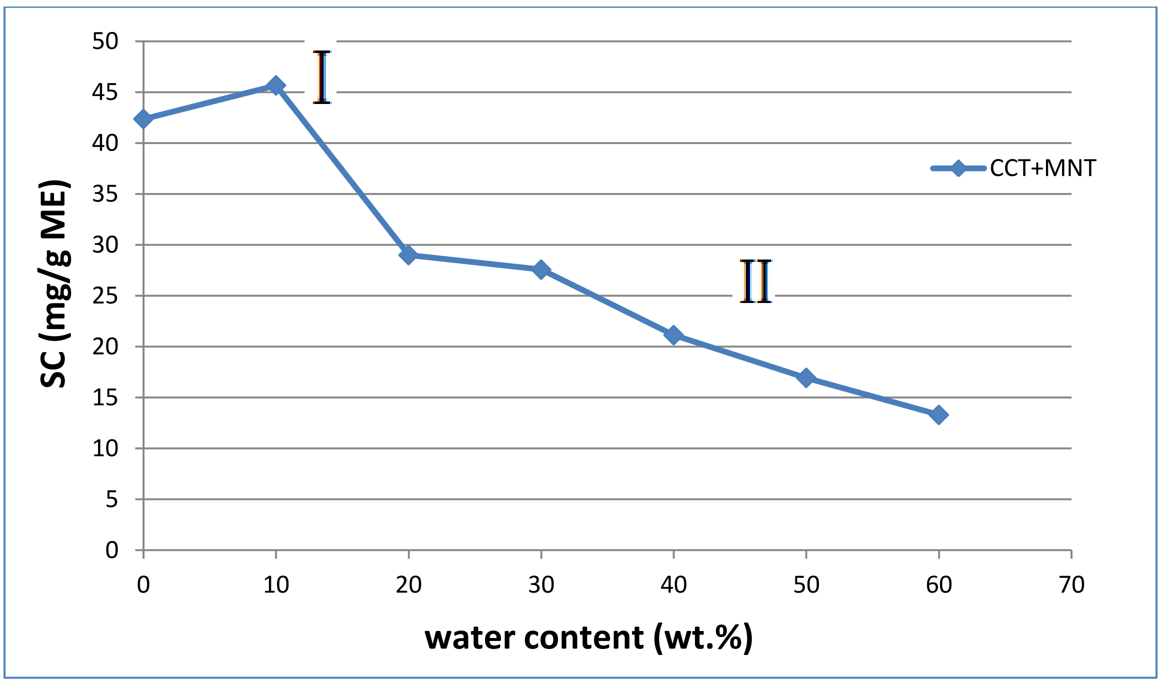

Figure 5.140: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.92 at 25°C in the system W/ L1695+M159/CCT+MNT. The weight ratio of (CCT/MNT) and (L1695/M159) equals unity.

The solubilization capacity decreases from 42mg/g microemulsion at water content equal 0 wt.% to about 29mg/g at water content equal 20 wt.% and this is the first region, in the second region the solubilization capacity decrease dramatically from 29mg/g at water content equal 20 wt.% to about 13mg/g microemulsion at water content equals 60 wt.%.

W/ L1695+M159/ CCT+LIM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.68 and Figure 5.142. Two different regions can be identified the phase diagrams is presented in Figure 5.94.

Table 5.68: The SC (mg/g) for the system W/L1695+M159/CCT+LIM at different water contents.

	S.C(mg/g)
W/L1695+M159/CCT+LIM	25°C
0	42
10	31
20	21
30	21
40	18

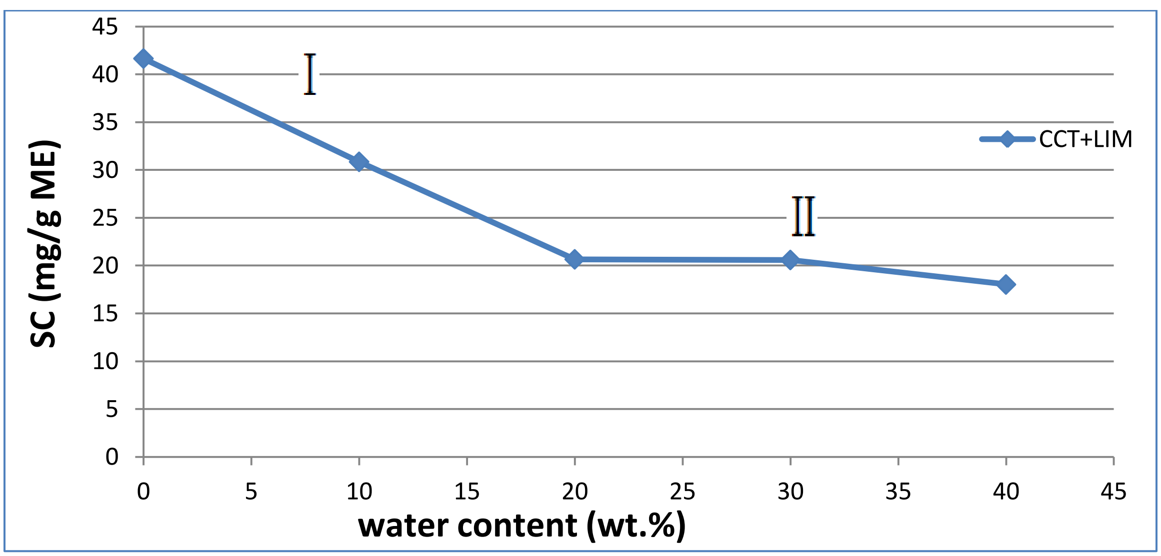

Figure 5.141: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.94 at 25°C in the system W/ L1695+M159/CCT+LIM. The weight ratio of (CCT/LIM) and (L1695/M159) equals unity.

The solubilization capacity decreases from 42mg/g microemulsion at water content equal 0 wt.% to about 21mg/g at water content equal 20 wt.% in the first region. In the second region the solubilization capacity decrease dramatically from 21mg/g at water content equal 20 wt.% to about 18mg/g microemulsion at water content equals 40 wt.%.

W/ L1695+M159/ CCT+ION

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.69 and Figure 5.142**.** Two different regions can be identified the phase diagrams is presented in Figure 5.96.

Table 5.69: The SC (mg/g) for the system W/L1695 + M159/ CCT+ION at different water contents.

	S.C(mg/g)
W/L1695+M159/CCT+ION	25°C
0	23
10	5
20	4
30	3
40	4
50	3
60	3
70	3
80	4
90	3

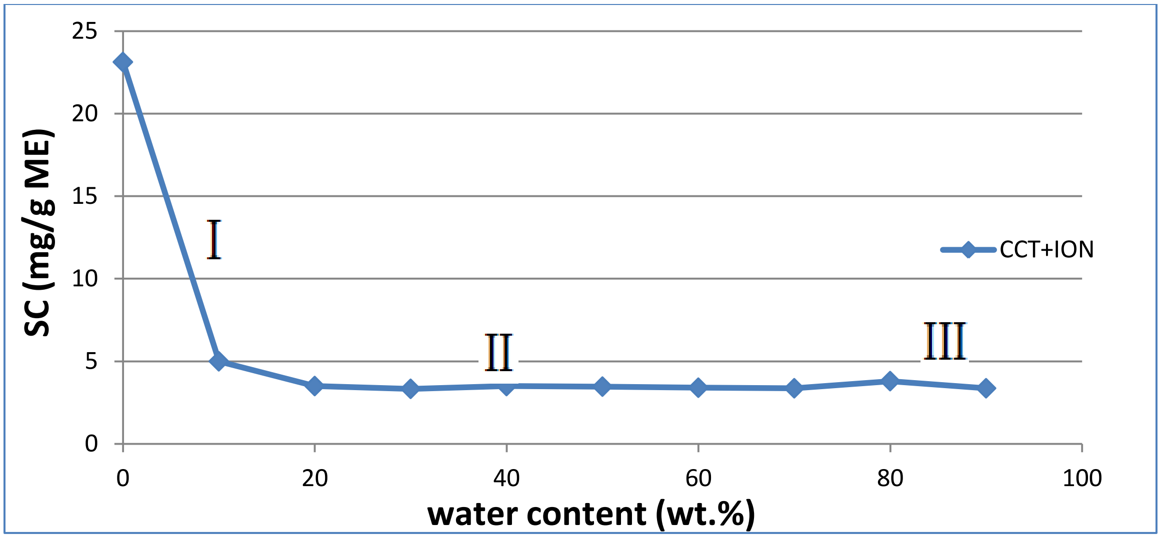

Figure 5.142: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.96 at 25°C in the system W/ L1695+M159/CCT+ION. The weight ratio of (CCT/ION) and (L1695/M159) equals unity.

The solubilization capacity decreases from 23mg/g microemulsion at water content equal 0 wt.% to about 4mg/g at water content equal 20 wt.% in the first region. In the second region the solubilization capacity decrease from 4mg/g at water content equal 20 wt.% to about 3mg/g microemulsion at water content equals 70 wt.%, then the amount of drug solubilized 3mg/g microemulsion at water content 90 wt.% in the third region.

N50 Solubilization

W/ L1695+M159/ IPM+MNT

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N50 is presented in Table 5.70 and Figure 5.165. Two different regions can be identified the phase diagrams is presented in Figure 5.86, the initial mixed surfactant/oil weight ratio equals 50/50.

Table 5.70: The SC (mg/g) for the system W/L1695+ M159/ IPM+MNT at different water contents along the dilution line N50.

	S.C(mg/g)
W/L1695+M159/IPM+MNT	25°C
0	35
10	28
20	30
30	24
40	18

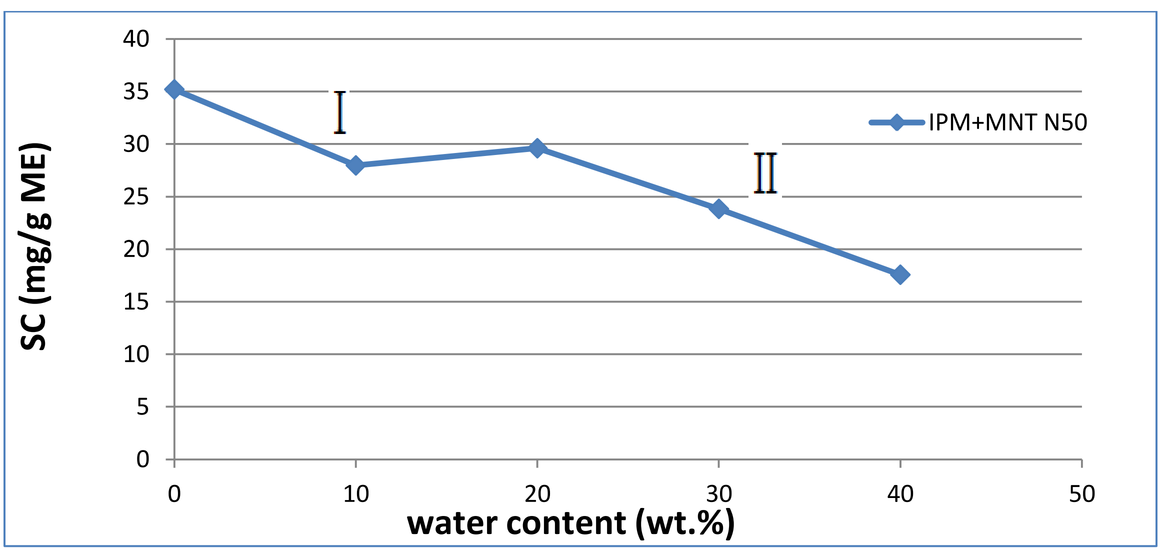

Figure 5.143: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N50 the phase diagrams is presented in Figure 5.86 at 25°C in the system W / L1695+M159/IPM+MNT. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity decreases from 35mg/g microemulsion at water content equal 0 wt.% to about 30mg/g at water content equal 20 wt.% in the first region. In the second region the solubilization capacity decrease dramatically from 30mg/g at water content equal 20 wt.% to about 18mg/g microemulsion at water content equals 40 wt.%.

W/ L1695+M159/ CCT+LIM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N50 is presented in Table 5.71 and Figure 5.144. Two different regions can be identified the phase diagrams is presented in Figure 5.94

Table 5.71: The SC (mg/g) for the system W/L1695 + M159 / CCT+LIM at different water contents along the dilution line N50.

	S.C(mg/g)
W/L1695+M159/CCT+LIM	25°C
0	27
10	24
20	7
30	7
40	7

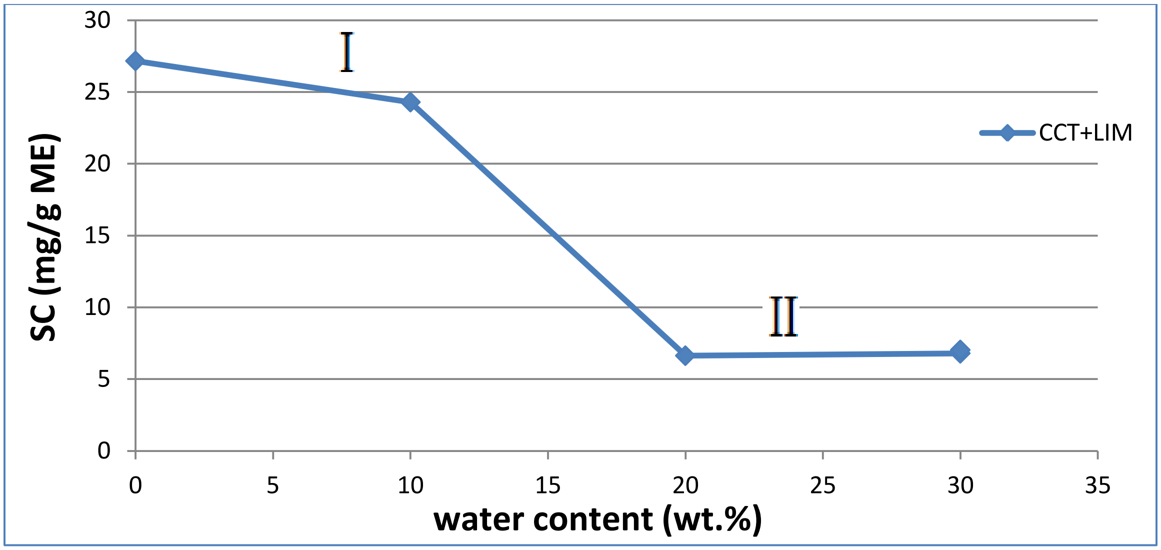

Figure 5.144: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N50 the phase diagrams is presented in Figure 5.94 at 25°C in the system W / L1695+M159/CCT+LIM. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity decreases from 27mg/g microemulsion at water content equal 0 wt.% to about 24mg/g at water content equal 10 wt.% in the first region. In the second region the solubilization capacity decrease dramatically from 24mg/g at water content equal 10 wt.% to about 7mg/g microemulsion at water content equals 40 wt.%.

W+PG/ L1695+M159/oil

W+PG/ L1695+M159/ IPM

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.72 and Figure 5.145. Two different regions can be identified.

Table 5.72: The SC (mg/g) for the system W+PG/L1695+ M159/IPM at different water contents.

	S.C(mg/g)
W+PG/L1695+M159/IPM	25°C
0	85
10	86
20	87
30	65
40	53
50	50

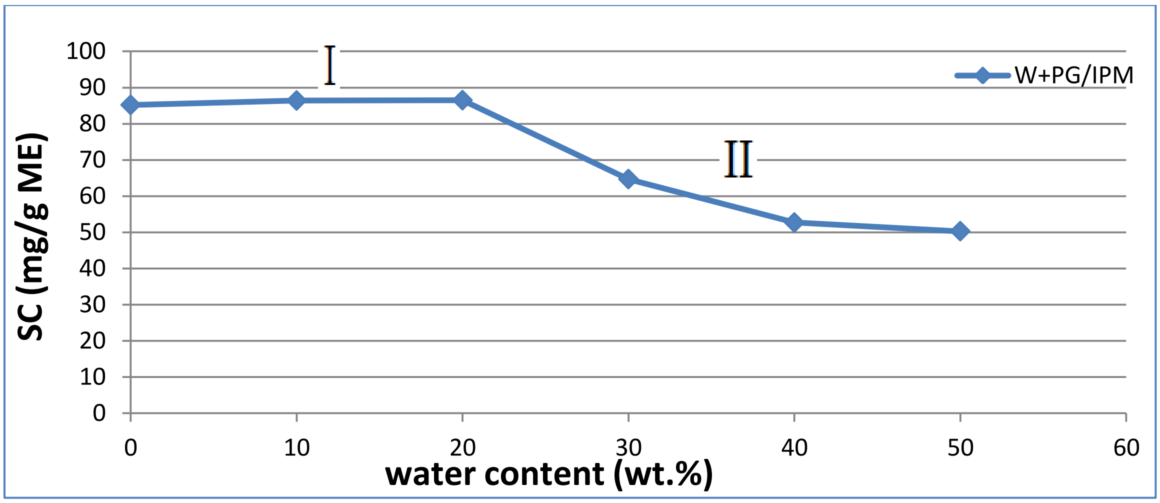

Figure 5.145: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 at 25°C in the system W+PG/ L1695+M159/IPM. The weight ratio of (L1695/M159) equals unity.

The solubilization capacity increases from 85mg/g microemulsion at water content equal 0 wt.% to about 87mg/g at water content equal 20 wt.% and this is the first region, in the second region the solubilization capacity decrease dramatically from 87mg/g at water content equal 20 wt.% to about 50mg/g microemulsion at water content equals 50 wt.%.

W+PG/ L1695+M159/CCT

The solubilization capacity (SC) of indomethacin at 25°C as function of aqueous phase content along the dilution line N65 is presented in Table 5.73 and Figure 5.146. Two different regions can be identified.

Table 5.73: The SC (mg/g) for the system W+PG/L1695+ M159/CCT at different water contents.

	S.C(mg/g)
W+PG/L1695+M159/CCT	25°C
0	93
10	10
20	10
30	10

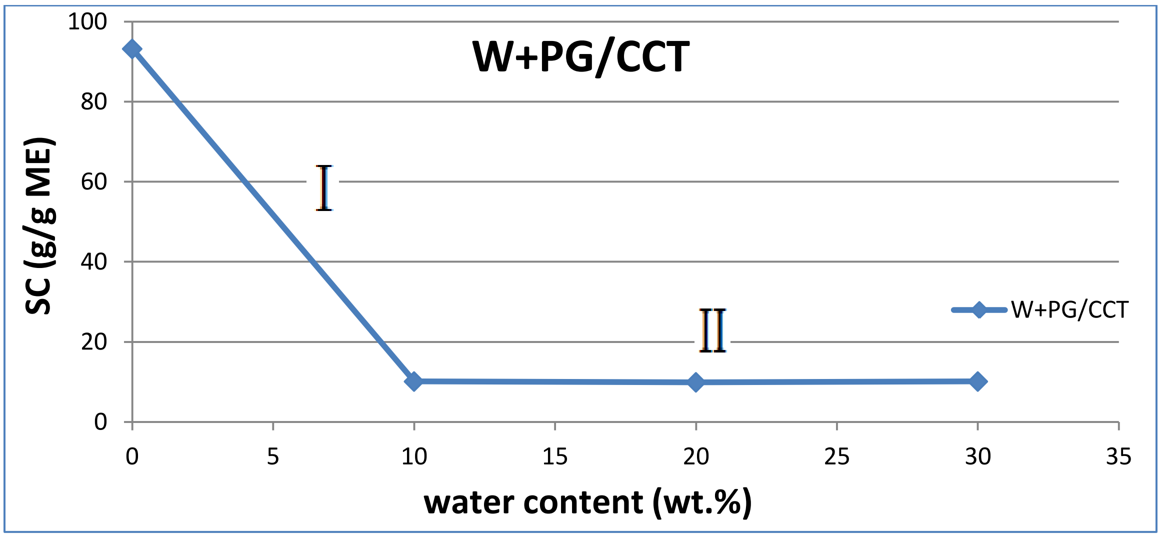

Figure 5.146: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 at 25°C in the system W+PG/ L1695+M159/CCT. The weight ratios of (L1695/M159) equal unity.

The solubilization capacity decreases from 93mg/g microemulsion at water content equal 0 wt.% to about 10mg/g at water content equal 10 wt.% in the first region. In the second region the solubilization capacity equal 10 mg/g.

In the following Figures 5.147 and 5.148 we compare between different microemulsion systems where the aqueous phase is propylene glycol absent and in others its water mixed with propylene glycol. Figure 5.147 and Figure 5.148 presents in the solubilization capacity indomethacin for the systems W/ L1695+M159/ IPM and W/ L1695+M159/ CCT. From this figures we observe that adding propylene glycol to the system improve the solubiliztion capacity of indomtethacin.

When propylene glycol added to the system W+PG/ L1695+M159/ IPM, then the solubilization increase from17mg/g to 85mg/g, and propylene glycol added to the system W+PG/ L1695 + M159/ CCT, then the solubilization increase from27mg/g to 93mg/g.

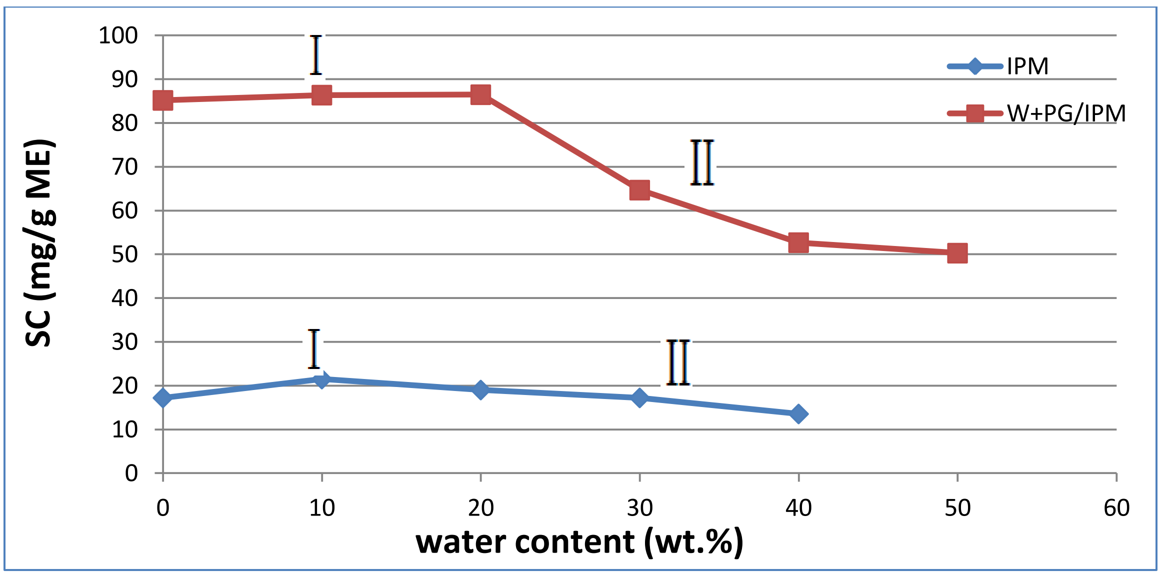

Figure 5.147: The solubilization capacity (SC) of the indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 at 25°C in the system W+PG/ L1695+M159/IPM and W/ L1695+M159/IPM The weight ratio of (L1695/M159) equals unity.

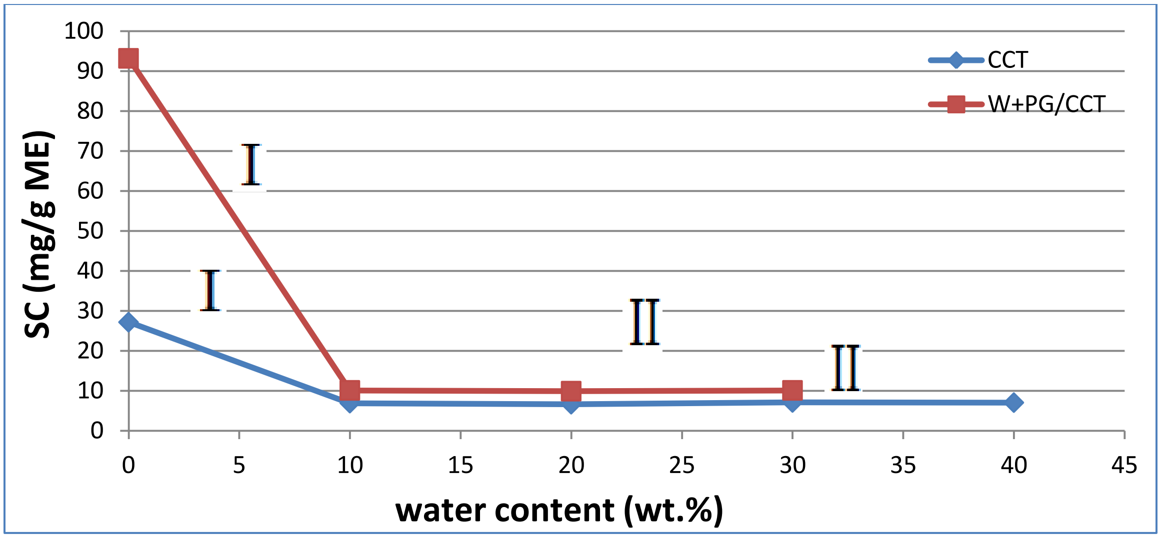

Figure 5.148: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 at 25°C in the system W+PG/ L1695+M159/CCT and W/ L1695+M159/CCT the weight ratio of (L1695/M159) equals unity.

In the following Figures 5.149 and 5.150 we compare between the indomethacin solubilization capacity along the dilution lines N65 and N50 in the systems based on mixed oils.

Figure 5.149 presents the variation in the solubilization capacity for indomethacin in the systems W/L1695+M159/IPM+MNT at different dilution line N65and N50. From this figure we observe that, adding effect increase oil phase in system N50 to improve the solubility for example at water content 0wt%, the solubilization capacity equal 35mg/g, but in dilution line N65 decrease to 29mg/g.

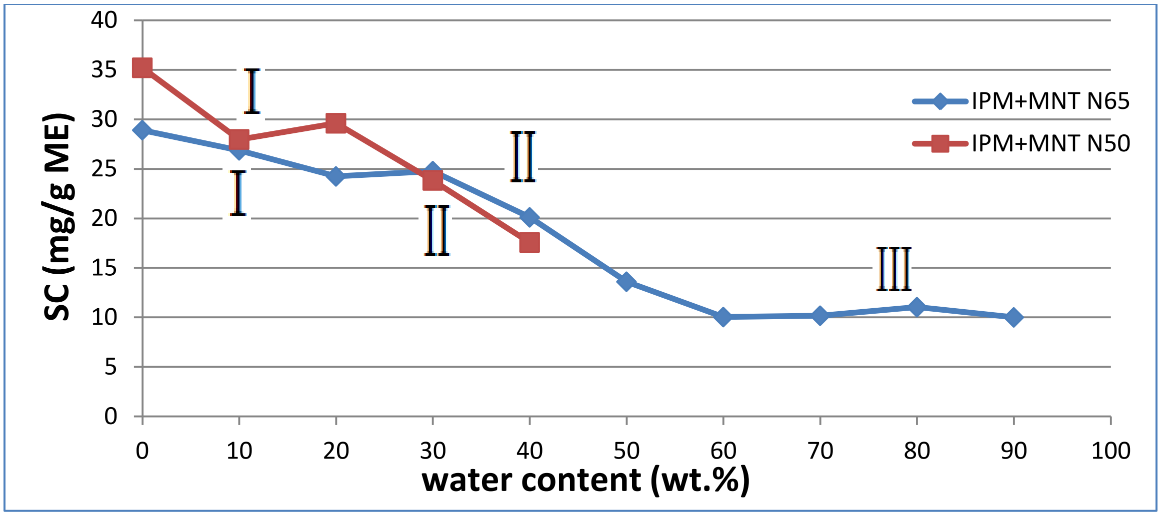

Figure 5.149: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 and N50 the phase diagrams we presented in figures 5.86 at 25°C in the system W/ L1695+M159/ IPM+MNT. The weight ratio of (IPM/MNT) and (L1695/M159) equals unity.

Figure 5.150 presents the variation in the solubilization capacity for indomethacin in the systems W/L1695+M159/CCT+LIM at different dilution line N65and N50. From this figure we observe that, adding effect increase oil phase in system N50 to improve the solubility for example at water content 0wt%, the solubilization capacity equal 27mg/g, but in dilution line N65 increase to 42mg/g. The phase diagrams we presented in figures 5.94.

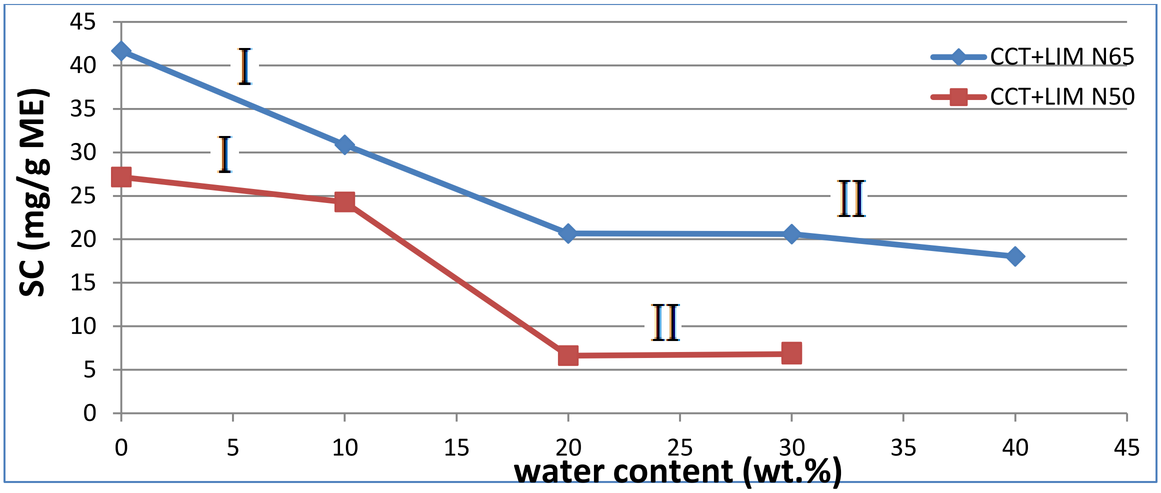

Figure 5.150: The solubilization capacity (SC) of indomethacin (mg drug/g microemulsion) as function of water content along the dilution line N65 and N50 the phase diagrams we presented in figures 5.94 at 25°C in the system W/L1695+M159/CCT+LIM. The weight ratio of (L1695/M159) equals unity.

5.3 Physicochemical Characterization

Microemulsion domain structures are often characterized as water-continuous, oil-continuous or bicontinuous. These structures are influenced both by the water to oil ratio and by the preferred curvature of the surfactant, which results from the interactions of the surfactant layer with the oil and water phases (J. Biais, B. Clin, P, 1987). For example, increasing the net affinity of the oil phase for the surfactant tail or the repulsion of surfactant tail groups from each other drives the microemulsion into a more oil continuous structure (M. Bourrel, R. S. Schechter, 1988.) while increasing the size of a non-ionic surfactant's head group drives the microemulsion into a more water continuous structure.

In this section we characterize related microemulsion systems using electrical conductivity, ultrasonic velocity and density.

5.3.1 Electrical conductivity

Electrical conductivity measurements are performed to determine the type of microemulsion droplets formed (i.e. water-in-oil (W/O), Bicontinues, or oil-in-water (O/W)).

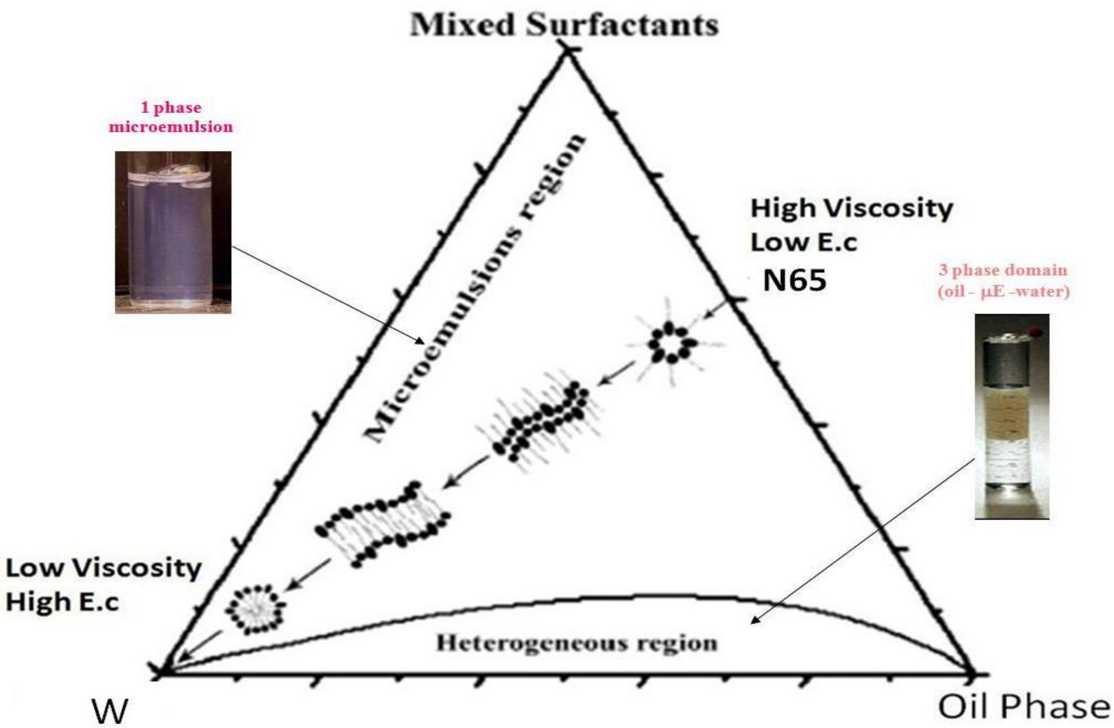

Figure 5.151: Schematic presentation of the structural transitions and the change n the electrical conductivity along the N65 dilution line.

Conductivity measurements provide a means of determining whether a microemulsion is oil continuous or water-continuous as well as providing a means of monitoring percolation or phase inversion phenomena. The electrical conductivity "σ" selected unloaded and drug loaded microemulsion samples were measured.

5.3.1.1-Mixed surfactant/ single oil systems

W/ L1695+M159/MNT

The electrical conductivity was measured for the system W/ L1695+M159/ MNT where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figures 5.33. Figures 5.152 and Table 5.74 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.74: The electrical conductivity (σ) for the system W/ L1695+M159/MNT at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt. %)	25°C	37°C	45°C
0	0.2	0.2	0.7
1	0.2	0.3	1.1
2	0.2	0.6	1.7
4	0.8	1.6	4.1
6	1.8	3.3	7.9
8	3.6	5.8	13.9
10	6.1	9.5	23.3
15	17.5	26.8	53
20	35	42	90.4
25	53.3	61.5	116.3

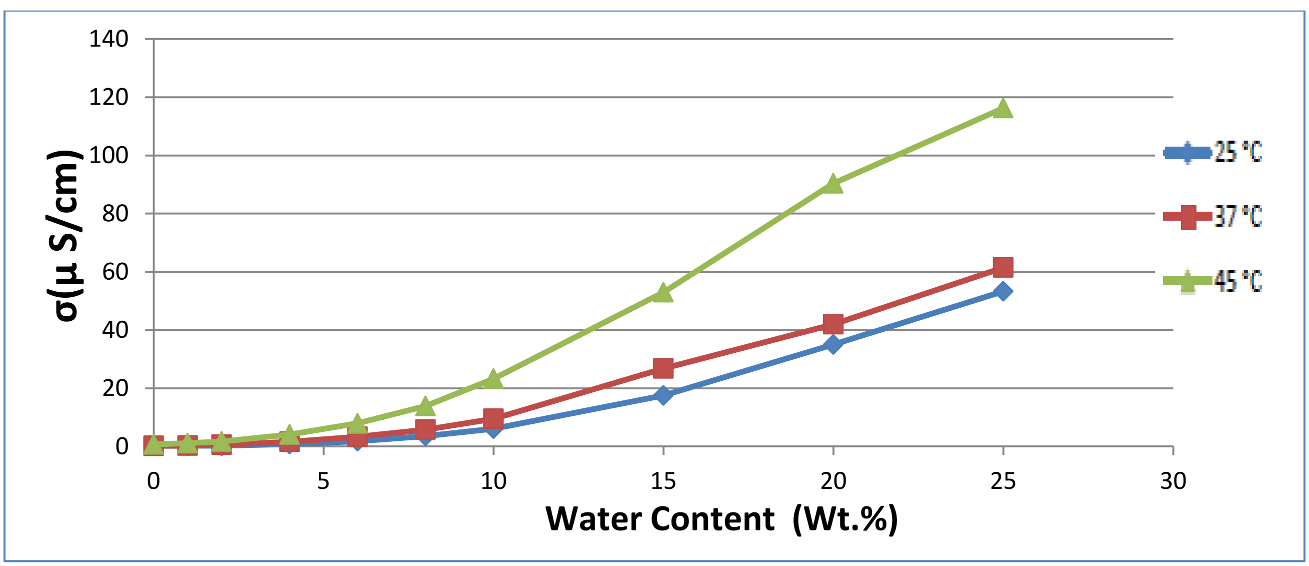

Figure 5.152: Variation of the electrical conductivity (σ) of the system W/ L1695+M159 /MNT as function of water content along the dilution line N65 the phase diagrams is presented in Figures 5.33 at different temperatures (25, 37 and 45°C).The mixing ratio of (L1695/M159) equal unit.

At water content smaller than 10 wt. %, samples along the dilution line N65 tested, the system W/ L1695+M159/MNT as shown in the following Figures 5.152, have low values of electrical conductivity, the low conductivity in this region indicates restricted water mobility, then the values of the electrical conductivity increase continuously with the increase in the water content. High electrical conductivity above 10 wt. % water content on the N65 line, suggests that the system undergoes a structural inversion to bicontinues microemulsion. Conductivity was increases as temperature increases in steadily fashion at water content higher than 10 wt %.

W/ L1695+M159/LIM

The electrical conductivity was measured for the system W/ L1695+M159/LIM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figures 5.35. Figures 5.153 and Table 5.75 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.75: The electrical conductivity (σ) for the system W/ L1695+M159/LIM at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.1	0.4
1	0.2	0.3	0.9
2	0.2	0.5	1.6
4	0.6	1.6	4.9
6	0.7	2.4	6.4
8	0.8	2.6	6.8
10	0.8	2.2	7.5
15	4	5.9	15.5
20	9	14.4	35.1
25	14.4	22.2	49.2

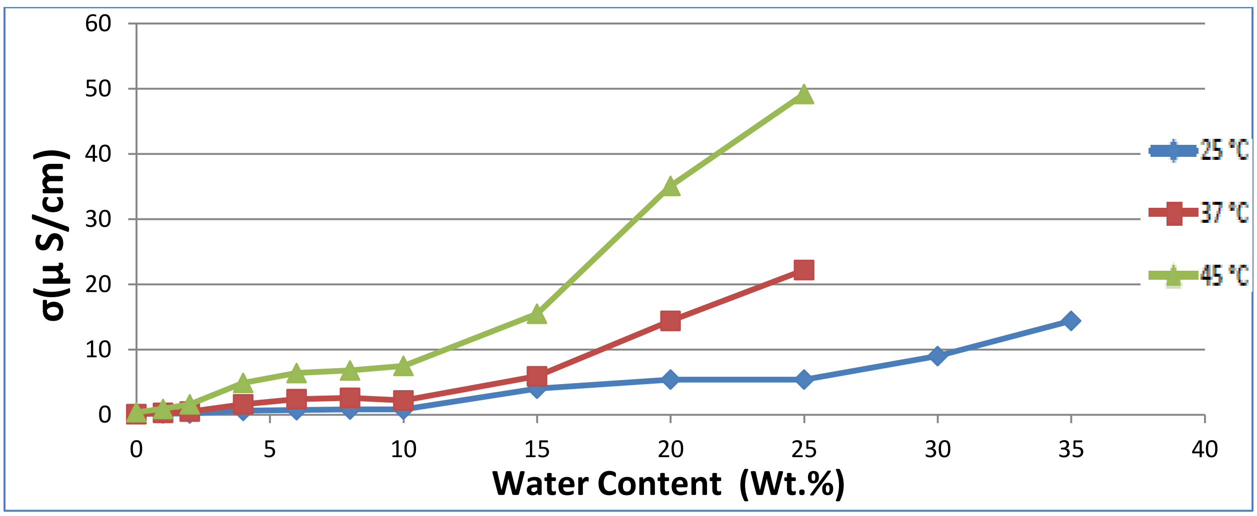

Figure 5.153: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/LIM as function of water content along the dilution line N65 the phase diagrams is presented in Figures 5.35 at different temperatures (25, 37 and 45°C).

W/ L1695+M159/ION

The electrical conductivity was measured for the system W/ L1695+M159/ION where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figures

5.37. Figures 5.154 and Table 5.76 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.76: The electrical conductivity (σ) for the system W/ L1695+M159/ION at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.2	0.2	0.6
1	0.2	0.3	1
2	0.3	0.4	1.3
4	0.6	1.4	3.4
6	1.6	2.7	6.9
8	3.4	5.4	10.8
10	5.6	8.6	19.3
15	28.3	37.9	97.8

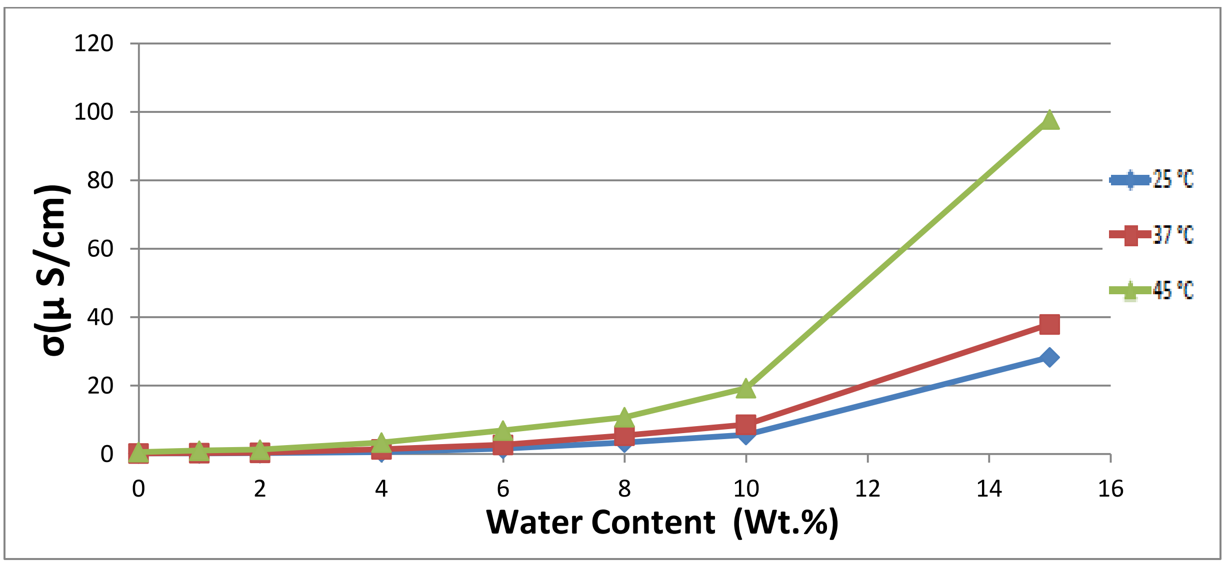

Figure 5.154: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ ION as function of water content along the dilution line N65 the phase diagrams is presented in Figures 5.35 at different temperatures (25, 37 and 45°C).

W/ L1695+M159/IPM

The electrical conductivity was measured for the system W/ L1695+M159/IPM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figures 5.37. Figures 5.155 and Table 5.77 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.77: The electrical conductivity (σ) for the system W/ L1695+M159/IPM at different water contents and different temperatures.

	σ (µS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0	0.1	0.3
1	0.2	0.2	0.6
2	0.2	0.5	1.5
4	0.3	1.5	5.5
6	1.7	2.2	6.2
8	5.4	8.1	20
10	11	16.6	39
15	33.5	40.1	91.1
20	61.8	80.1	175
25	70.1	91	203

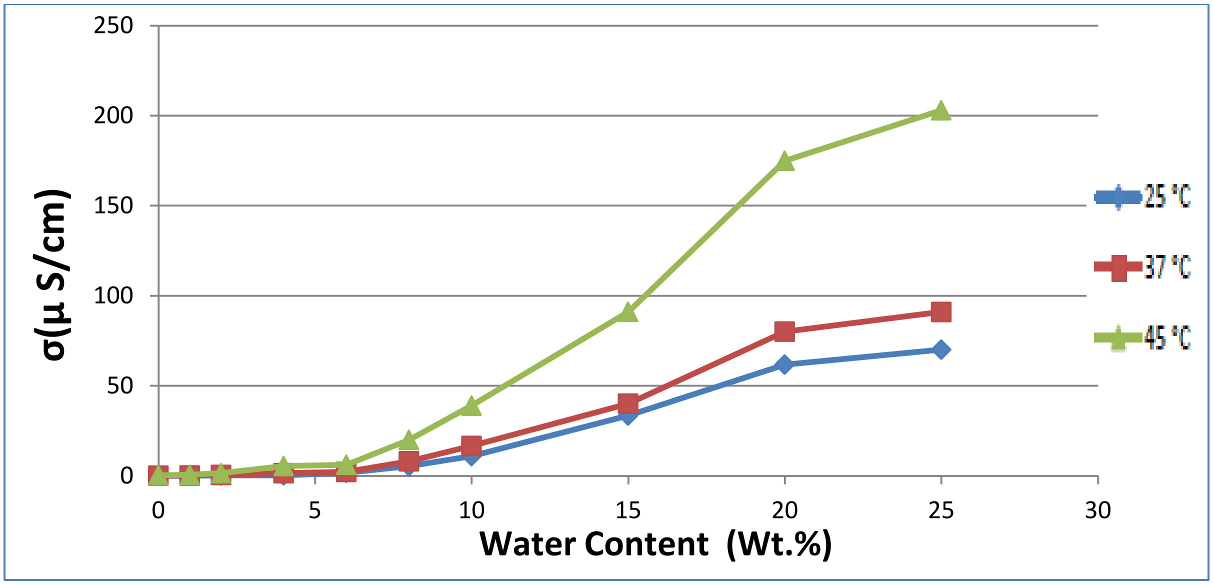

Figure 5.155: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/IPM as function of water content along the dilution line N65 the phase diagrams is presented in Figures 5.37 at different temperatures (25, 37 and 45°C).

1-The effect of water content

For the three previous systems investigated, as the water content increases, the electrical conductivity increases exponentially. The increase in the electrical conductivity as function of water content is due to the increase in the fraction of sodium chloride ions that are not enclosed in the core of the microemulsions. The high values of electrical conductivity at high-water volume fractions are explained by the fact that the sodium chloride ions are present in the external phase, which is the water and these results permit to distinguish between w/o and o/w microemulsions.

2-The effect of temperature

Electrical conductivity increased with temperature in steadily fashion at water content higher than 20 wt. % for the previous systems; this is due to increase in kinetic energy cause increase the collision between droplet and increase of movement of ions. Steadily fashion in conductance indicates to no structural transformation. By raising the temperature, the collision probability between the droplets increases and the opening and reforming of droplets will increase the mobility of water and the electrical conductivity will again rise with temperature. In addition, the possibility of percolation becomes larger and the formation of water channels will also increase the electrical conductivity of the system.

The relatively high values of electrical conductivity of the microemulsions studied can be explained by the chemical structure of the oils and its capability to penetrate between the chains of surfactants to the interface. So that in this section we compare between different chemical structures of oils used in this section, and the results can be explained as follows, increasing the molecular volume of the oils decrease the capability of the microemulsions to incorporate water and decrease the mobility of the water in the droplets and hence the electrical conductivity decreases.

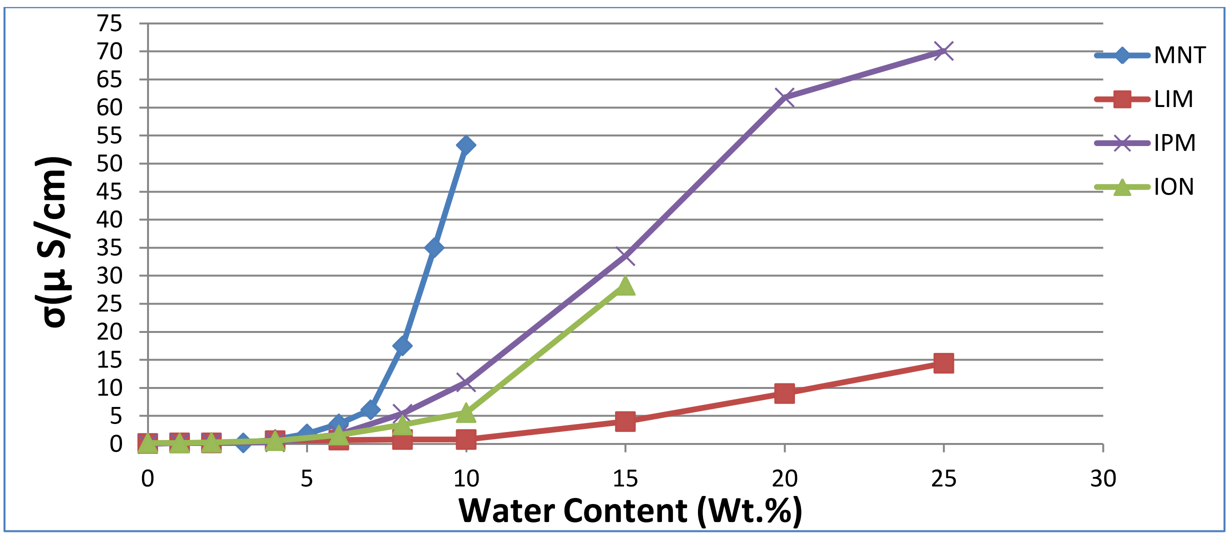

Figure 5.156: Variation of the electrical conductivity (σ) as function of water content along the dilution line N65 for different oils (IPM, ION, MNT, LIM) at 25°C. The phase diagrams are presented in Figures 5.33, 5.35, 5.37and 5.39.

In Figure 5.156 is based on mixed surfactants (L1695+M159), we observed that cyclic hydrocarbons oils (MNT) have higher electrical conductivity values than other oils different in their structure, and this due to peppermint oil which have a cyclic structure contains hydroxyl group will improve the mobility of water and this will increase the conductivity, because there is enough space for water to move around the droplets (micelles), also this hydroxyl group affect the hydrophobicity and affecting on the penetration of oils molecules to the interface which facilitating water mobility within the microemulsions.

IPM and ION have ketones group that is soluble in water, carbonyl compounds they can hydrogen-bond to water through the carbonyl oxygen, but ketones decrease solubility in water when the increase in molecular volume, IPM make in microemulsion as penetration enhancer its causes to increase electrical conductivity of system IPM.

For R(+)-limonene oil the high viscosity microemulsion are observed for water content lower than 20% because that LIM have lower electrical conductivity values, so that LIM tends to form gel microemulsion, so the viscous microemulsion have low electrical conductivity because the structure more network form between water and surfactant the movement of water between the droplets is low, microemulsion gel containing stabilized by PEG-7 glyceryl coccoate (M159).

W+NaCl/ surfactant /MNT

The electrical conductivity was measured for the system W+NaCl/L1695+M159/ MNT where the mixing ratios (w/w) of PEG-7 glyceryl coccoate /sucrose laurate variation equal (25%, 50%, 75% and 100%).At along the dilution line N65. The concentration of sodium chloride in water is 0.01 M. Are presented in **Figures 5.157 to 5.160** displays the influence of water content with temperatures on the electrical conductivity (σ).

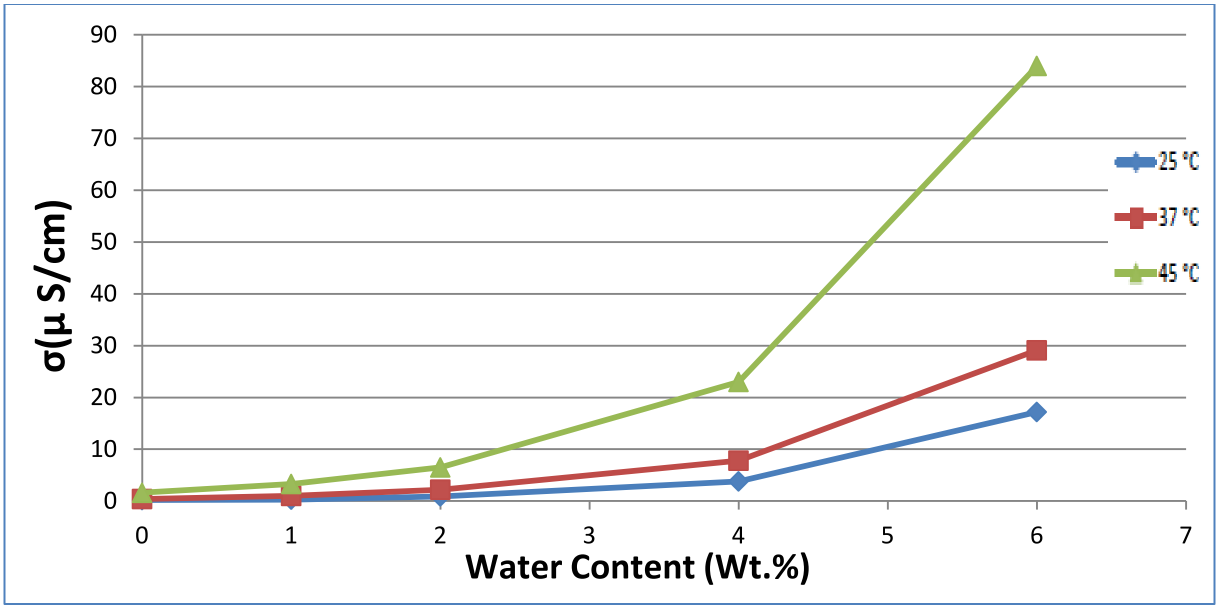

Figure 5.157: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ MNT The mixing ratio (w/w) of L1695+M159 equals 3/1.As function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C). Sodium chloride concentration in the microemulsions is 0.01M.

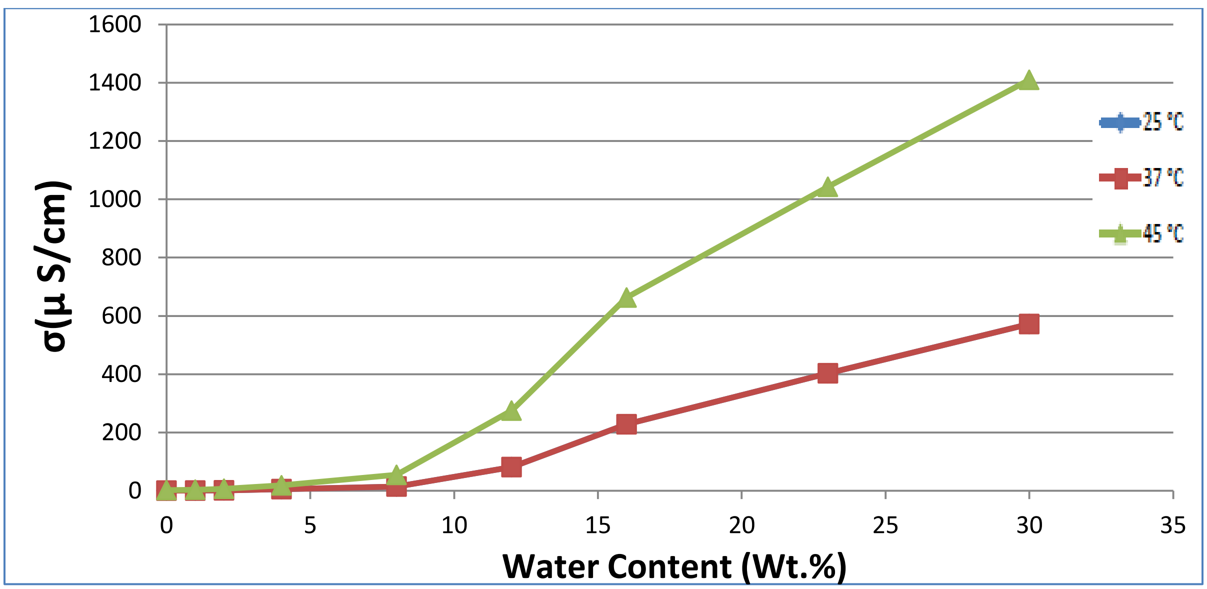

Figure 5.158: Variation of the electrical conductivity (σ) of the system W+NaCl/ L1695+ M159/ MNT. The mixing ratio (w/w) of L1695+M159 equals 1/1.As function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C). Sodium chloride concentration in the microemulsions is 0.01M.

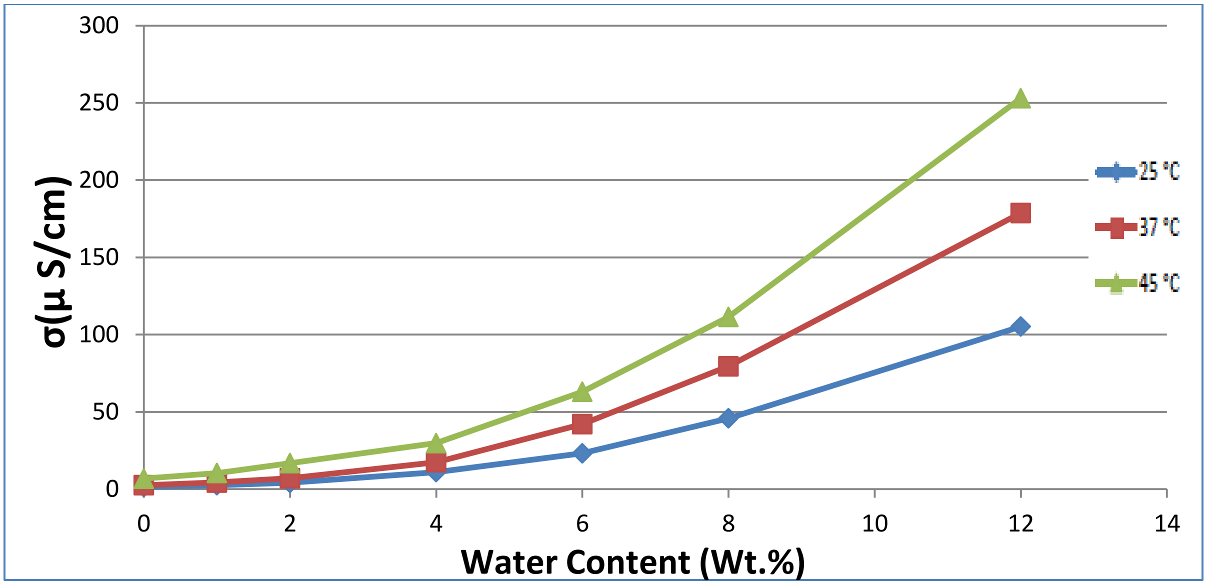

Figure 5.159: Variation of the electrical conductivity (σ) of the system W+NaCl/ L1695+ M159/ MNT. The mixing ratio (w/w) of L1695+M159 equals 1/3.As function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C). Sodium chloride concentration in the microemulsions is 0.01M.

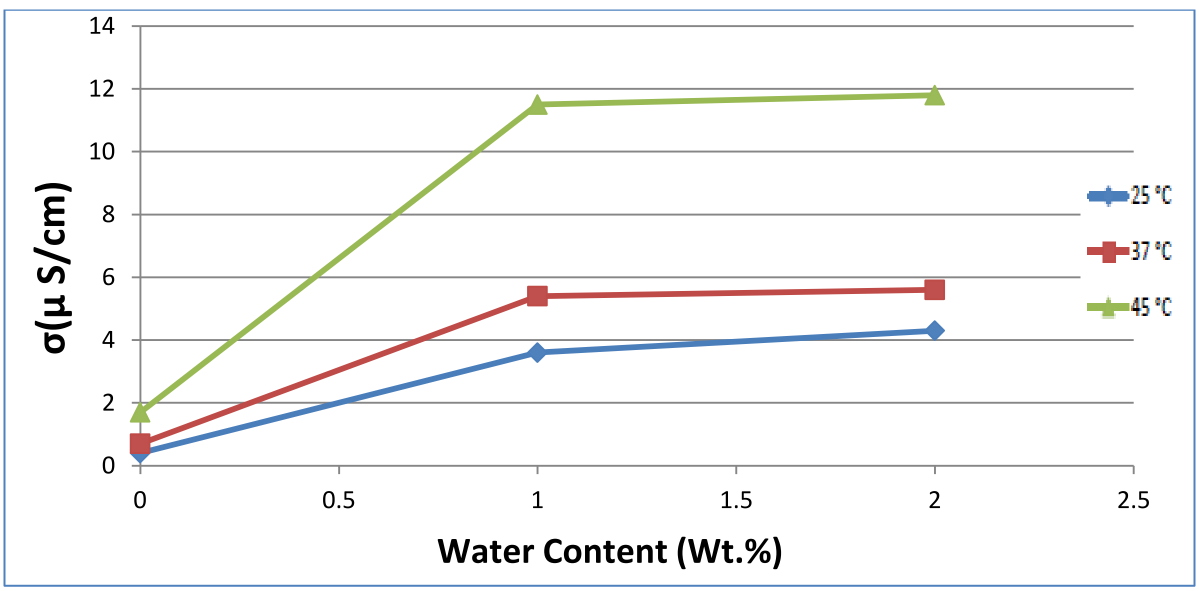

Figure 5.160: Variation of the electrical conductivity (σ) of the system W+NaCl/M159/MNT. As function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C). Sodium chloride concentration in the microemulsions is 0.01M.

The electrical conductivities increase with the aqueous phase volume fraction. The conductivity profile reveals the existence of three regions. The reverse micelles that are formed in the oil phase slowly swell and distort upon addition of aqueous phase, and at a certain point the water migrates out of the inner phase and sponge-like domains are formed termed the bicontinues phase. Upon further dilution, full inversion occurs and the water captured within the oil becomes a continuous phase. Structural transition, from the water-in-oil to a bicontinues phase and oil-in-water. From Figure 5.158 we observe that the presence of (L1695+M159=1/1) in a microemulsion system gave us the higher electrical conductivity values comparing with other mixture surfactant percent. Mixing M159 surfactant with sucrose laurate (L1695) at mixing ratio (w/w) equals 1/1 gave us higher electrical conductivity values, this large rise in conductivity could be attributed to the large attractive interaction forces among the droplets leading to the permeation of the electrolyte.

5.3.1.2-Mixed surfactant/ mixed oil microemulsion systems

W/ L1695+M159/IPM+MNT

The electrical conductivity was measured for the system W/L1695+M159/IPM+MNT where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.86. Is presented in Figures 5.161 and Table 5.78 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.78: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+MNT at different water contents and different temperatures.

	σ (µS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.2	0.7
10	7.4	11.3	27.1

20	27.7	33.2	68.9
30	91.8	123	291
40	198	218	424
50	241	249	467
60	253	267	493
70	250	260	481
80	193	195	447
90	106	92.8	366

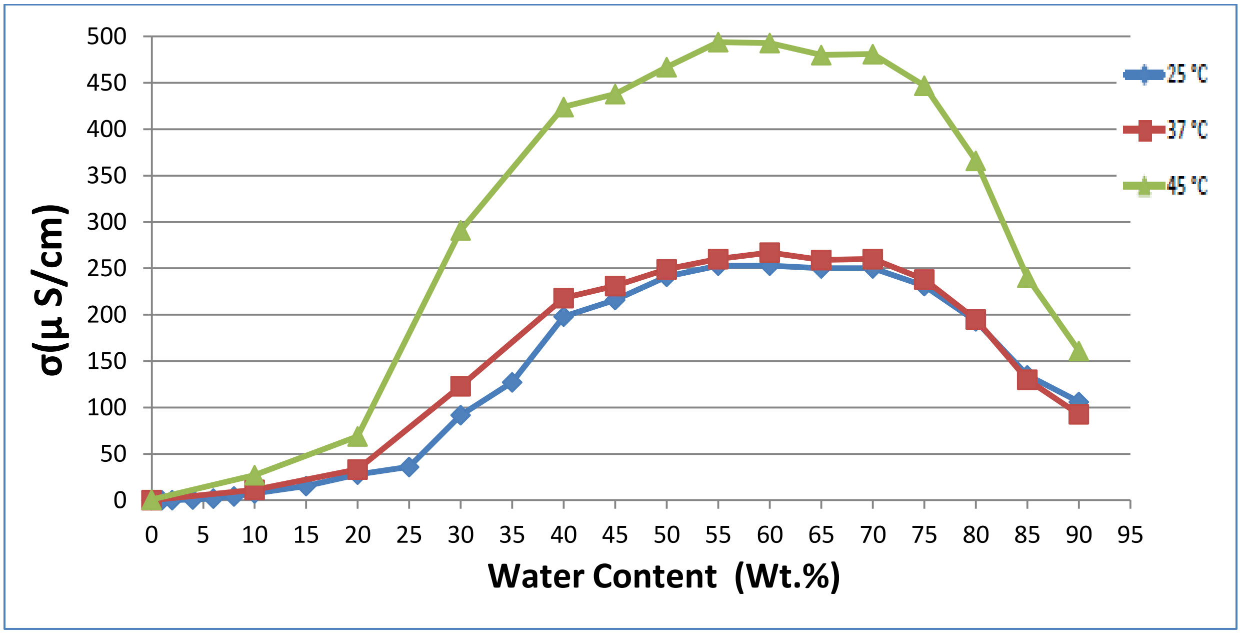

Figure 5.161: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+MNT as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.86 at different temperatures (25, 37 and 45°C).

At water content smaller than 20 wt. %, samples along the dilution line N65 tested, the system W/ L1695+M159/IPM+MNT as shown in the following Figure 5.161, have low values of electrical conductivity, the low conductivity in this region indicates restricted water mobility, then the values of the electrical conductivity increase continuously with the increase in the water content. High electrical conductivity above 20 wt. % water content on the N65 line, suggests that the system undergoes a structural inversion to bicontinues microemulsion. Decrease the electrical conductivity above 65% suggests that the system undergoes a structural inversion to O/W. Conductivity was increases as temperature increases in steadily fashion at water content higher than 20 wt %.

W/ L1695+M159/IPM+LIM

The electrical conductivity was measured for the system W/L1695+M159/IPM+LIM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.88. Figures 5.162 and Table 5.79 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.79: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+LIM at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0	0.1	0.1
10	3.6	5.5	13.1
20	68.5	84.3	176
30	106	123	260
40	213	233	427
50	273	280	518
60	281	289	539
70	264	272	523
80	195	206	395
90	112	112	204

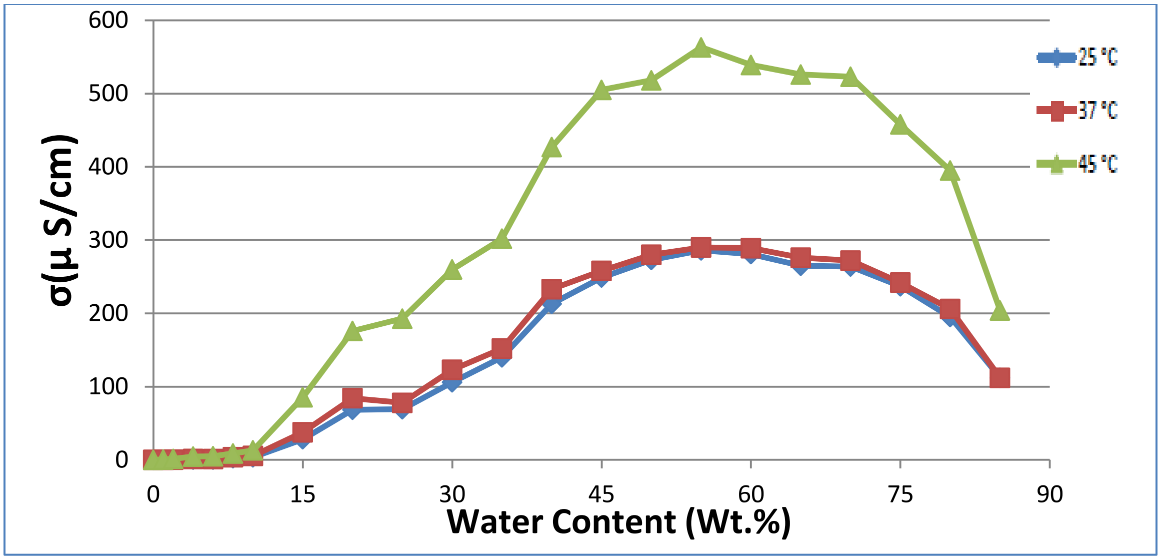

Figure 5.162: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+LIM as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.88 at different temperatures (25, 37 and 45°C).

W/ L1695+M159/IPM+ION

The electrical conductivity was measured for the system W/L1695+M159/IPM+ION where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.90.Is presented in Figures 5.163 and Table 5.80 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.80: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+ION at different water contents and different temperatures.

	σ (µS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.2	0.2	0.5
10	4.1	12	32.4
20	43	55.9	145
30	154	171	330
40	239	251	458

50	289	296	560
60	302	292	560
70	298	304	580
80	235	241	449
90	166	161	310

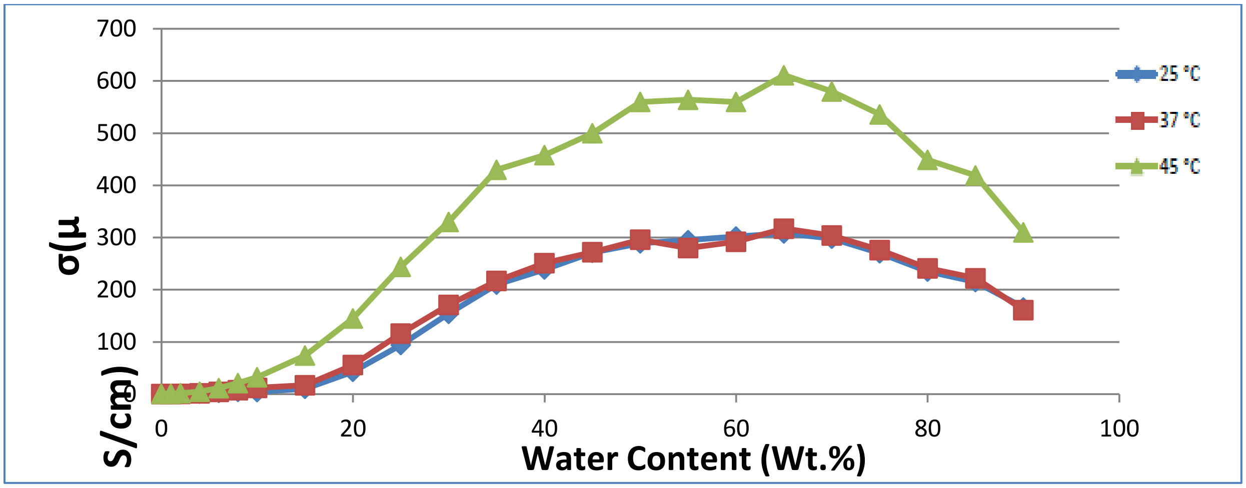

Figure 5.163: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/IPM+ION as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.90 at different temperatures (25, 37 and 45°C).

W/ L1695+M159/CCT+MNT

The electrical conductivity was measured for the system W/L1695+M159/CCT+MNT where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.92.Is presented in Figures 5.164 and Table 5.81 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.81: The electrical conductivity (σ) for the system W/ L1695+M159/CCT+MNT at different water contents and different temperatures.

Water content (wt.%)	σ (μS/cm)		
	25°C	37°C	45°C
0	0.2	0.2	0.9
10	8	11.9	27.9
20	59.2	73.9	170
30	154	172	340
40	227	237	474
50	290	307	580
60	333	342	649
70	327	329	601

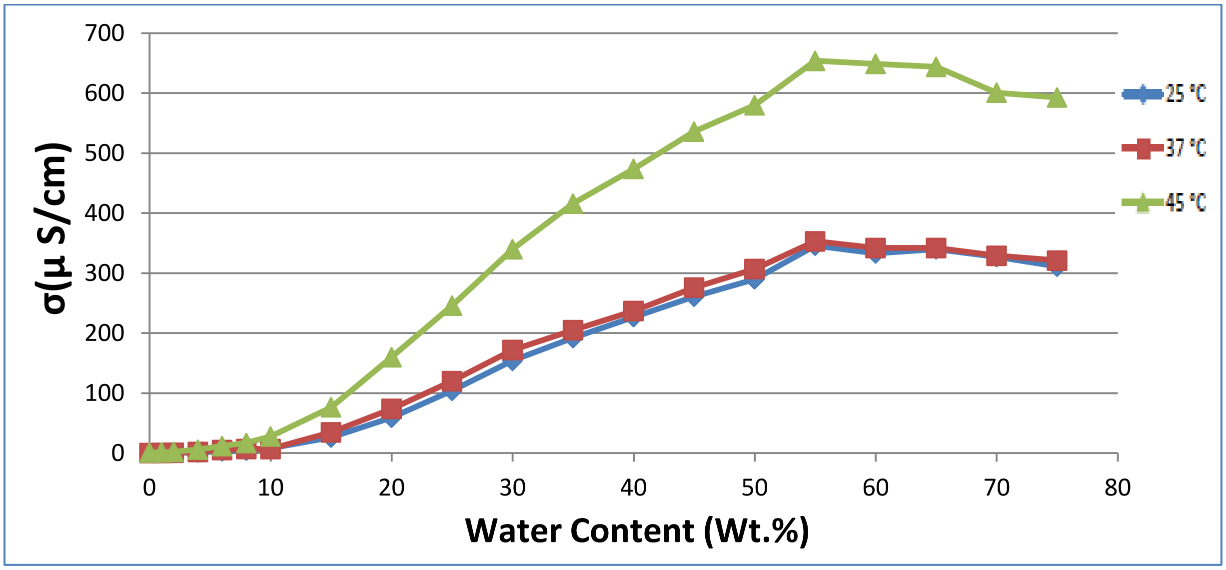

Figure 5.164: Variation of the electrical conductivity (σ) of the system W/ L1695+M159 /CCT+MNT as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.92 at different temperatures (25, 37 and 45°C).

W/ L1695+M159/CCT+LIM

The electrical conductivity was measured for the system W/L1695+M159/CCT+LIM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.94. Figures 5.165 and Table 5.82 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.82: The electrical conductivity (σ) for the system W/ L1695+M159/CCT+LIM at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.1	0.3
1	0.1	0.2	0.7
2	0.3	0.5	1.5
4	0.9	1.6	5
6	1.5	4.9	11.8
8	5.3	9.2	22.6
10	9	14.6	37.8

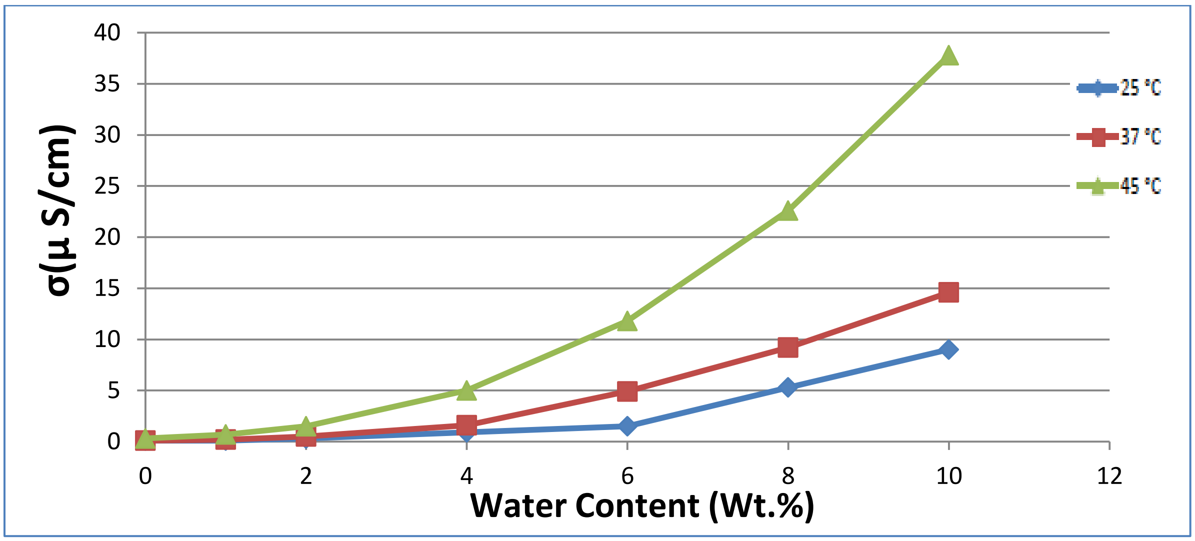

Figure 5.165: Variation of the electrical conductivity (σ) of the system W/ L1695+M159 /CCT+LIM as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.94 at different temperatures (25, 37 and 45°C).

: W/ L1695+M159/CCT+ION

The electrical conductivity was measured for the system W/L1695+M159/CCT+ION where the mixing ratio of surfactant equal 1/1 along the dilution line N65 the phase diagrams is presented in Figure 5.96. Is presented in Figures 5.166 and Table 5.83 display the influence of water content and temperature on the electrical conductivity (σ).

Table5.83: The electrical conductivity (σ) for the system W/ L1695+M159/CCT+ION at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.2	0.5
1	0.2	0.4	0.9
2	0.3	0.6	2
4	1.3	2.1	5.1
6	3.4	4.8	12.4
8	6.4	8.6	22
10	10.8	17	37.4
15	31.2	38.5	83.8
20	63.8	78.2	158.9

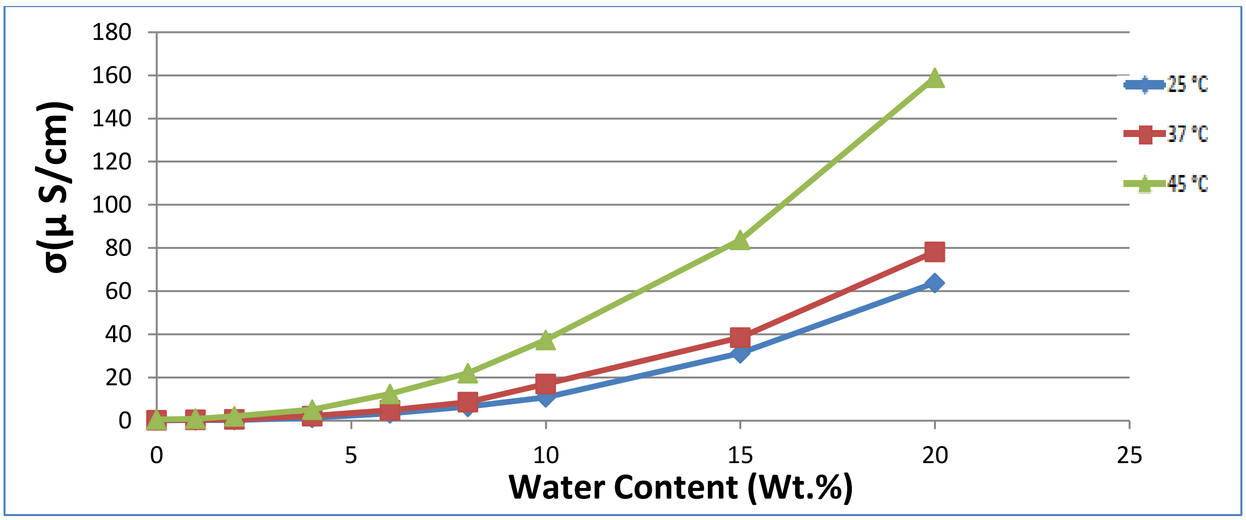

Figure 5.166: Variation of the electrical conductivity (σ) of the system W/ L1695+M159 /CCT+ION as function of water content along the dilution line N65 the phase diagrams is presented in Figure 5.96 at different temperatures (25, 37 and 45°C).

At aqueous phase content equals 0 wt%, the electrical conductivity is very low and when the aqueous content increase from 0 wt % to 20 wt % the electrical conductivity has been slightly increased in steadily fashion due formation reverse micelles (water-in-oil microemulsion). A sudden increase in the electrical conductivity happens at water content above 20 wt%, this is may be due to formation of bicontinuous structure in which the electrical current passes through internal channels. Conductivity was increased as temperature increases in steadily fashion at water content higher than 20 wt %, but decrease the electrical conductivity happens at water content above 70 wt %, this may be due to formation O/W structure due formation micelles.

This study reveals that the electrical conductivities increase with the increase water volume fraction. Static percolation was observed in these systems. The diffusion data suggest that the variations in the properties of the systems with the increase in the water volume fraction are correlated to structural transition from water-in-oil to bicontinues to oil-in-water microemulsions (Fanun, 2009).

The electrical conductivity has been attributed to either hopping of ions from droplet to droplet within droplet clusters or transfer of counter ions from one droplet to another through water channels opening between droplets during sticky collisions through transient merging of droplets (Mathew, Patanjali, Nabi, et al, 1988)**.** Conductivity increases as temperature increases in steadily fashion for the systems.

In the following Figures we compare between different microemulsions systems where the IPM mixed with cyclic oils.

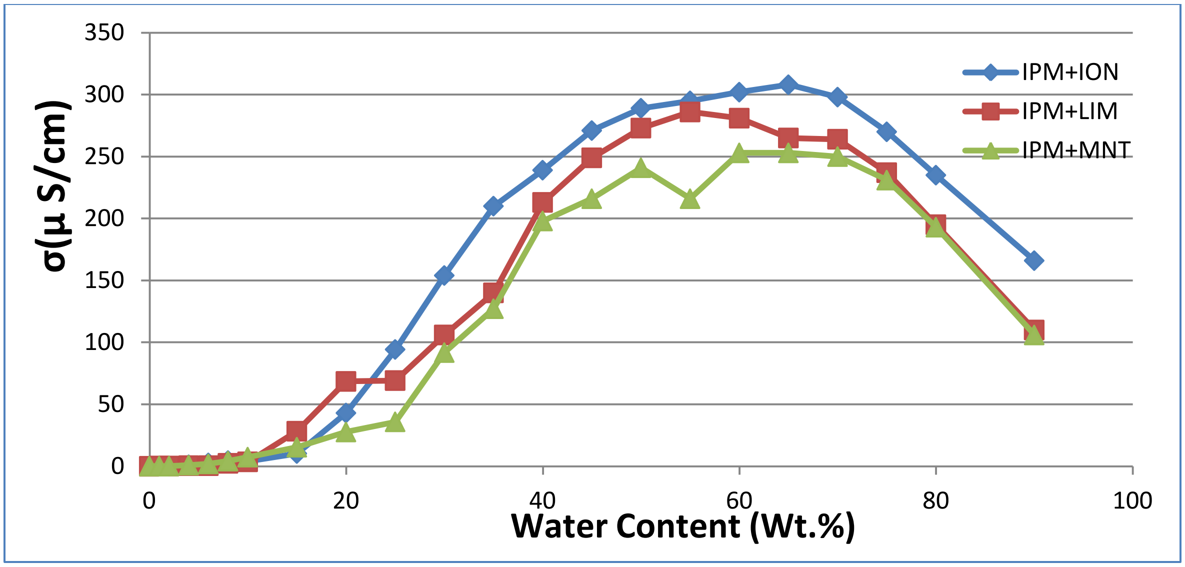

Figure 5.167: Variation of the electrical conductivity (σ) as function of water content at 25° C in the systems W/L1695+M159/ Oil along the dilution line N65 the phase diagrams is presented in Figures 5.86, 5.88 and 5.90. The oils used were IPM+MNT, IPM+LIM and IPM+ION. The mixing ratio of O1/O2 equals unity.

Figure 5.167 shows the variation of electrical conductivity behavior as function of water content for three microemulsion systems; we can observe from this Figure that mixing α-ionone with caprylic-capric triglyceride has higher electrical conductivity values than mixing with other type cyclic oil, because the ionone have ketones group its soluble in water, carbonyl compounds they can hydrogen-bond to water through the carbonyl oxygen.

R (+)-limonene oil with caprylic-capric triglyceride has higher electrical conductivity values than mixing peppermint oil with caprylic-capric triglyceride.

This is explained by the fact that α-ionone hydrophobic molecules containing double bond in their structure and oxygen nonbonding which solubilized preferentially in the hydrophobic core so that there are more space for water to move between the droplets and this will increase the conductivity compared with R(+)-limonene oil containing double bond between two carbon in their structure peppermint oil which located in the palisade layer or close to the surfactant head group.

The difference in electrical conductivity between the different oils in these two systems not much, higher electrical conductivity values than when mix cyclic oil with caprylic capric triglyceride.

In the following Figures we compare between different microemulsions systems where the CCT mixed with cyclic oils.

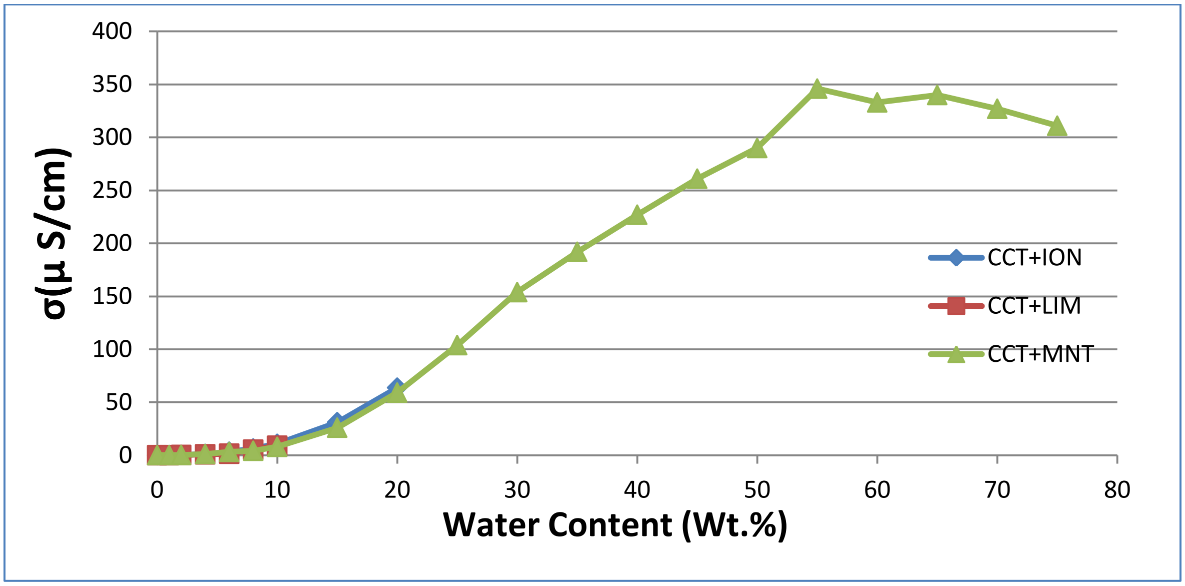

Figure 5.168: Variation of the electrical conductivity (σ) as function of water content at 25°C in the systems W/L1695+M159/Oil along the dilution line N65 the phase diagrams is presented in Figures 5.92, 5.94 and 5.96. The oils used were CCT +MNT, CCT+LIM and CCT+ION. The mixing ratio of O1/O2 equals unity.

In the following Figure 5.169 we compare between the IPM+MNT and CCT+MNT shows the variation of electrical conductivity behavior as function of water content for two microemulsion systems; we can observe from this Figure that mixing peppermint oil with caprylic-capric triglyceride has higher electrical conductivity values than mixing peppermint oil with isopropylmyristate oil triglyceride.

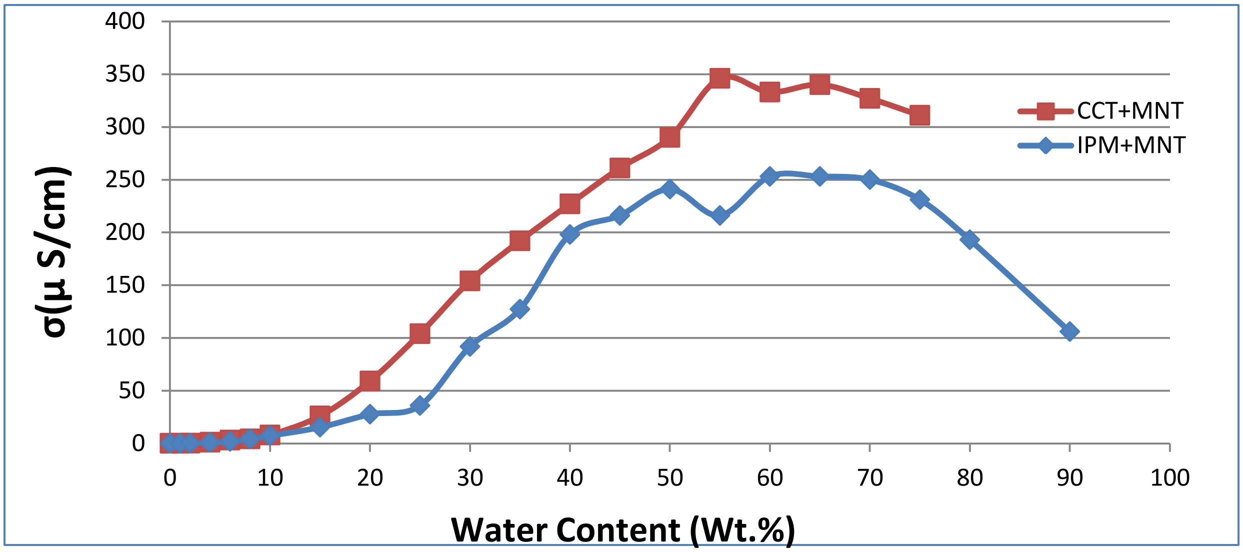

Figure 5.169: Variation of the electrical conductivity (σ) as function of water content at 25° C in the systems W/L1695+M159/ Oil along the dilution line N65 the phase diagrams is presented in Figures 5.86 and 5.92. The oils used were IPM+MNT and CCT+MNT. The mixing ratio of O1/O2 equals unity.

When use mixture caprylic-capric triglyceride has molecular weight greater than mixture isopropylmyristate oil, we can observe from this Figure 5.169 that peppermint oil with caprylic-capric triglyceride oil has higher electrical conductivity values than mixing with peppermint oil with caprylic-capric triglyceride oil, because CCT undergoes to O/W fast than IPM, more hydrated head group and less oil penetration.

5.3.2 Electrical conductivity measurements for microemulsion loaded with indomethacin

W/ L1695+M159/MNT

The electrical conductivity was measured for the system W/L1695+M159/MNT where the mixing ratio of surfactant equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.170 and

Table 5.84 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.84: The electrical conductivity (σ) for the system W/ L1695+M159/MNT with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.2	0.6
10	5.2	7.7	19.7
20	21.6	29.8	53.3
30	46.7	51.1	103.1

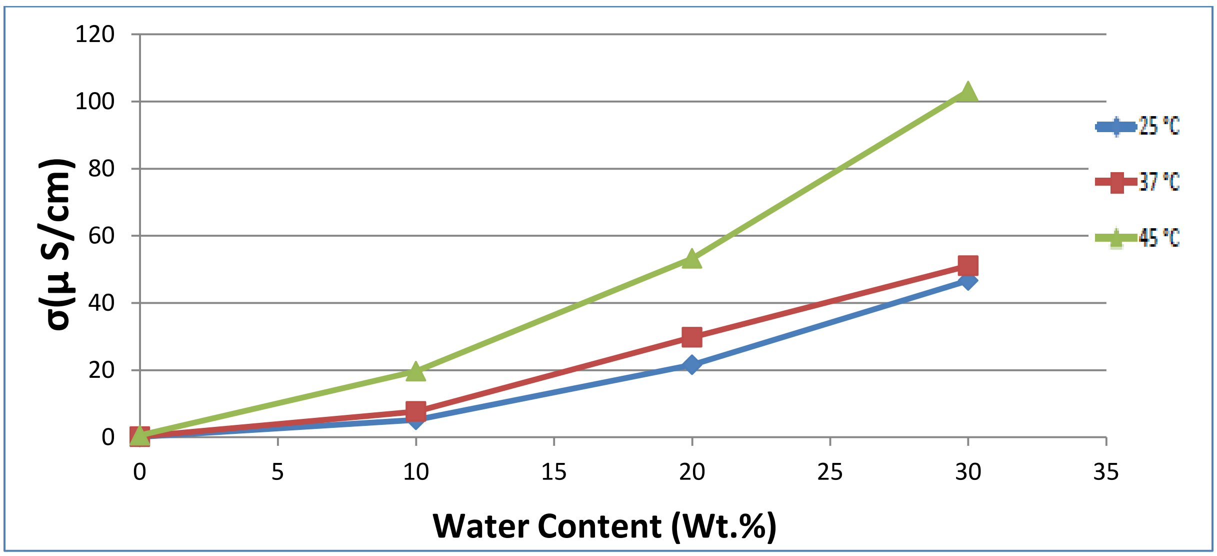

Figure 5.170: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ MNT as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 equal unity. The phase diagrams are presented in Figures 5.33.

W/ L1695+M159/LIM

The electrical conductivity was measured for the system W/L1695+M159/LIM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.171 and

Table 5.85 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.85: The electrical conductivity (σ) for the system W/ L1695+M159/LIM with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.2	0.2	0.6
10	1.3	2.4	6.8
20	12.9	16.1	29.8

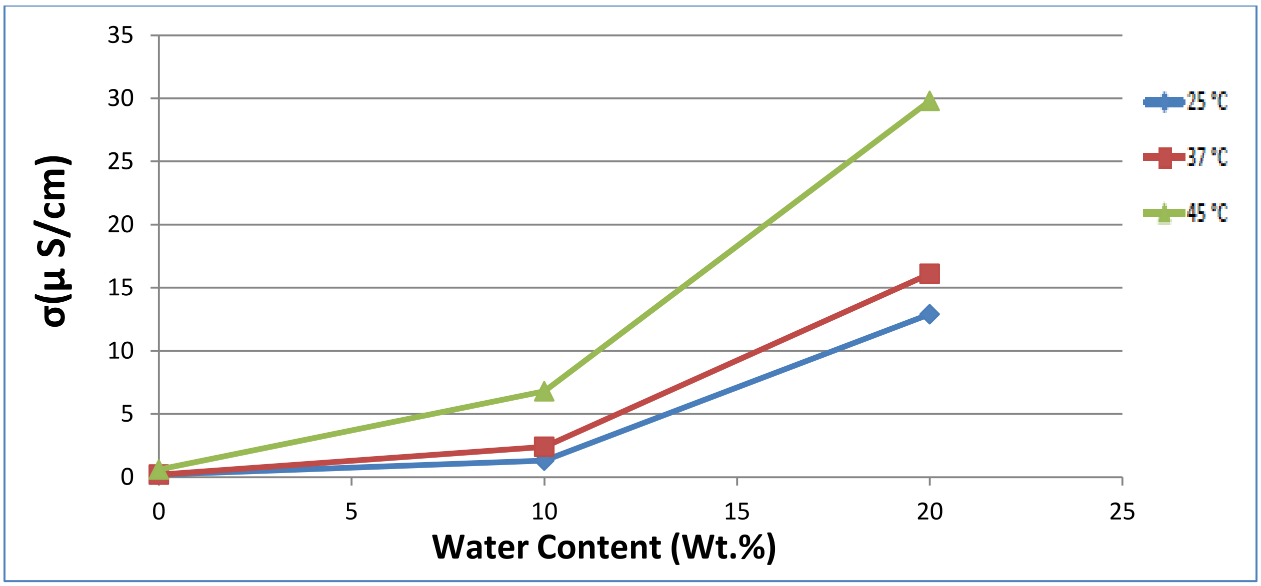

Figure 5.171: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ LIM as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratio of L1695/M159 equals unity. The phase diagram are presented in Figures 5.35.

W/ L1695+M159/ION

The electrical conductivity was measured for the system W/L1695+M159/ION where the mixing ratio of surfactant equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.172 and Table 5.86 displays the influence of water content and temperature on the electrical conductivity (σ).

Table 5.86 The electrical conductivity (σ) for the system W/ L1695+M159/ION with 2% indomethacin at different water content and different temperatures.

	σ (µS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.2	0.2	0.8
10	6.2	8.2	19.2
20	27.5	42.3	93.1

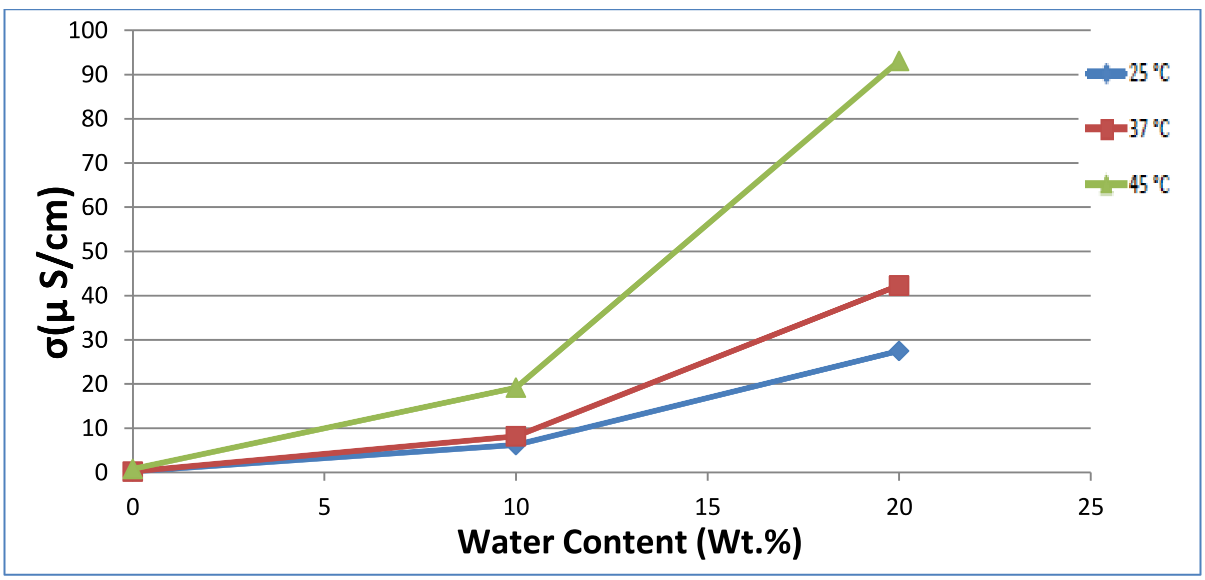

Figure 5.172: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ ION as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 equal unity. The phase diagram are presented in Figures 5.37.

W/ L1695+M159/IPM

The electrical conductivity was measured for the system W/L1695+M159/IPM where the mixing ratio of surfactant equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.173 and Table 5.87 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.87: The electrical conductivity (σ) for the system W/ L1695+M159/IPM with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0	0.1	0.3
10	0.1	18.8	40.2
20	0.3	64.2	161

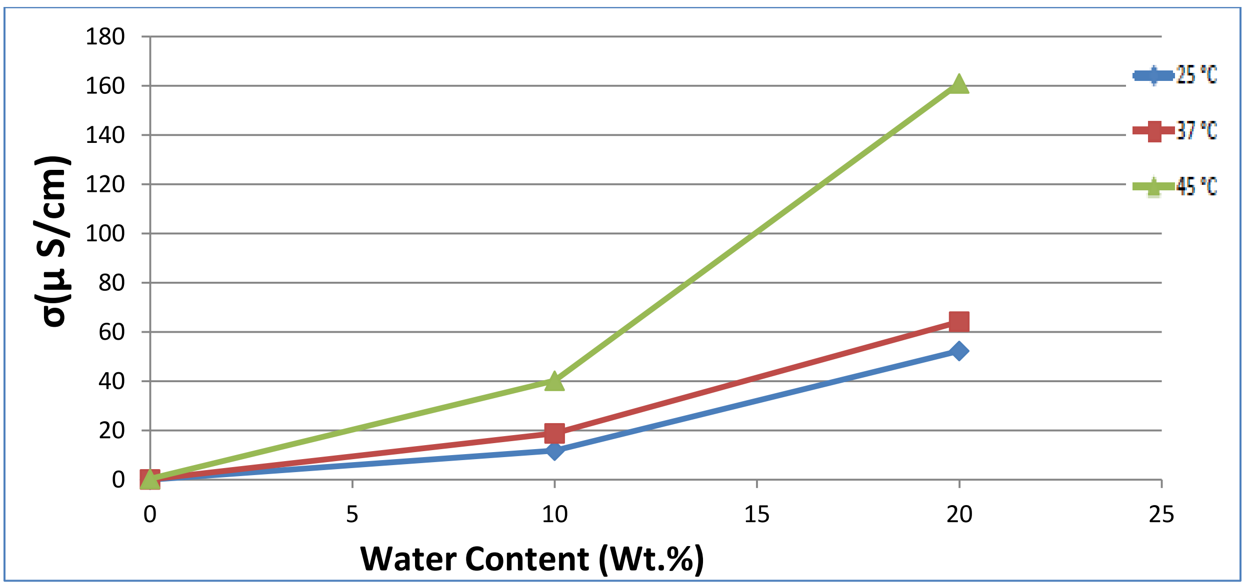

Figure 5.173: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratio of L1695/M159 equals unity. The phase diagram are presented in Figures 5.39.

W/ L1695+M159/IPM+MNT

The electrical conductivity was measured for the system W/L1695+M159/IPM+MNT where the mixing ratio of surfactant and oil equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.174 and Table 5.88 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.88: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+MNT with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.1	0.3
10	6.8	10.2	25.4
20	23.9	50.1	106
30	168	177	354
40	232	224	416
50	255	257	496
60	263	260	287
70	253	242	257
80	200	204	218
90	107	94.1	186

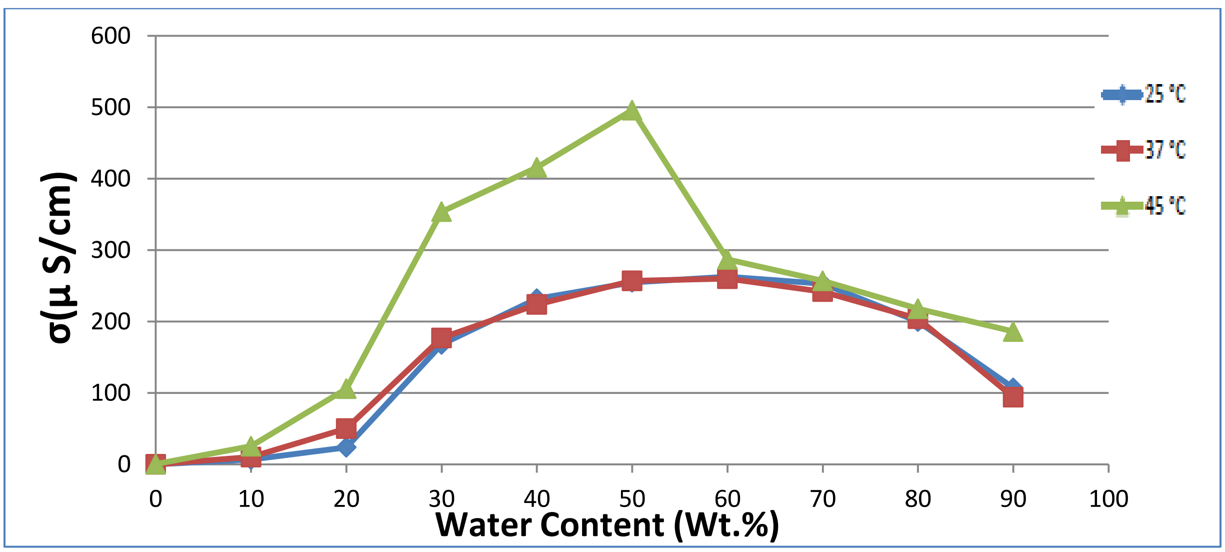

Figure 5.174: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+MNT as function of water content along the dilution line N65 with 2% indomethacin at

different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 and that of MNT/IPM equals unity. The phase diagram are presented in Figures 5.86.

W/ L1695+M159/IPM+LIM

The electrical conductivity was measured for the system W/L1695+M159/IPM+LIM where the mixing ratio of surfactant and oil equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.175 and Table 5.89 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.89: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+LIM with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.1	0.3
10	9.6	14	32.7
20	52.4	55.5	153
30	141	149	300
40	223	242	480

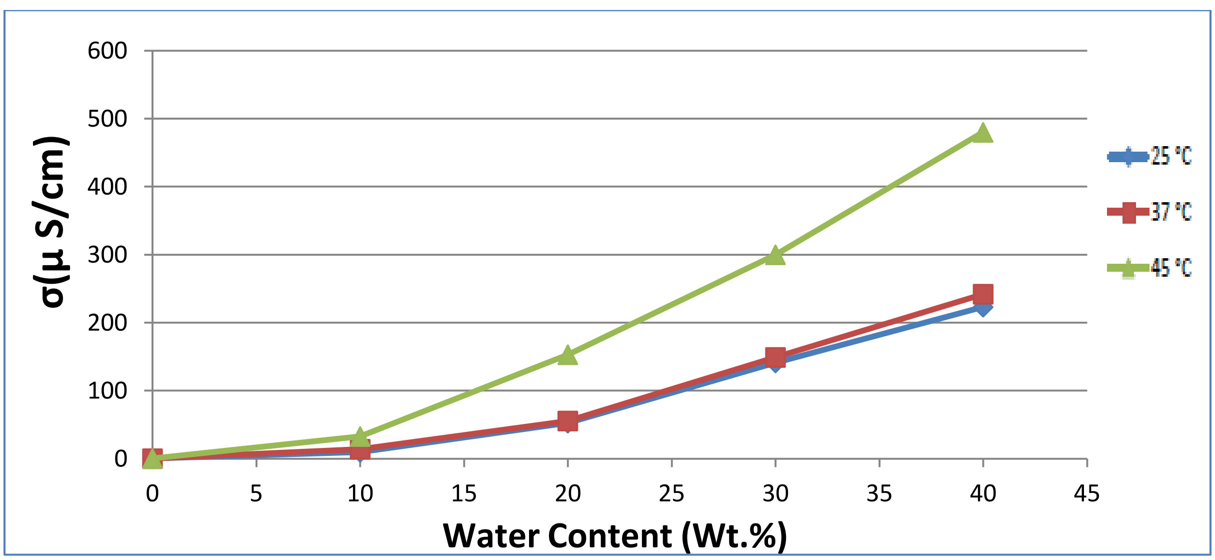

Figure 5.175: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+LIM as function of water content along the dilution line N65 with 2% indomethacin at

different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 and that of LIM/IPM equal unity. The phase diagram are presented in Figures 5.88

W/ L1695+M159/IPM+ION

The electrical conductivity was measured for the system W/L1695+M159/IPM+ION where the mixing ratio of surfactant and oil equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.176 and Table 5.90 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.90: The electrical conductivity (σ) for the system W/ L1695+M159/IPM+ION with 2% indomethacin at different water contents and different temperatures.

	σ (µS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0	0.1	0.4
10	6.4	10.1	34.1
20	14.2	20.4	115.4
30	116	124.3	303
40	224	233	418

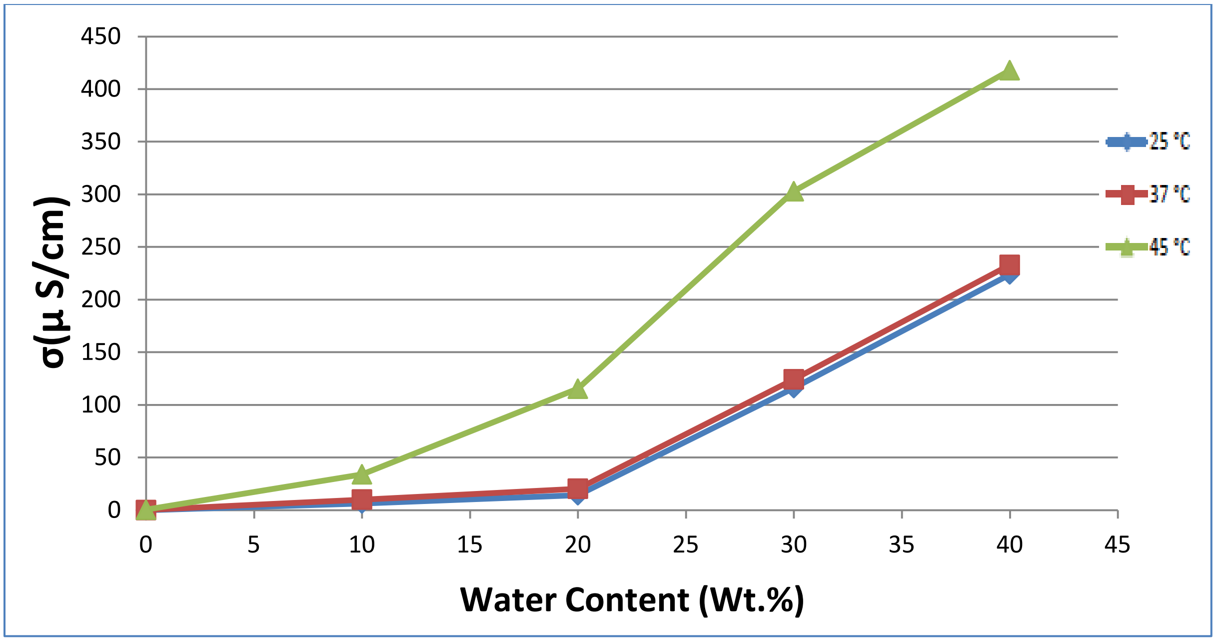

Figure 5.176: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+ION as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 and that of ION/IPM equal unity. The phase diagram are presented in Figures 5.40.

W/ L1695+M159/CCT+MNT

The electrical conductivity was measured for the system W/L1695+M159/CCT+MNT where the mixing ratio of surfactant and oil equal 1/1 along the dilution line N65 with 2% indomethacin. Figures 5.177 and Table 5.91 display the influence of water content and temperature on the electrical conductivity (σ).

Table 5.91: The electrical conductivity (σ) for the system W/ L1695+M159/CCT+MNT with 2% indomethacin at different water contents and different temperatures.

	σ (μS/cm)		
Water content (wt.%)	25°C	37°C	45°C
0	0.1	0.1	0.3
10	6.4	9.4	22.9
20	47.7	56.1	115
30	122	130	260
40	190	197	380
50	237	243	445

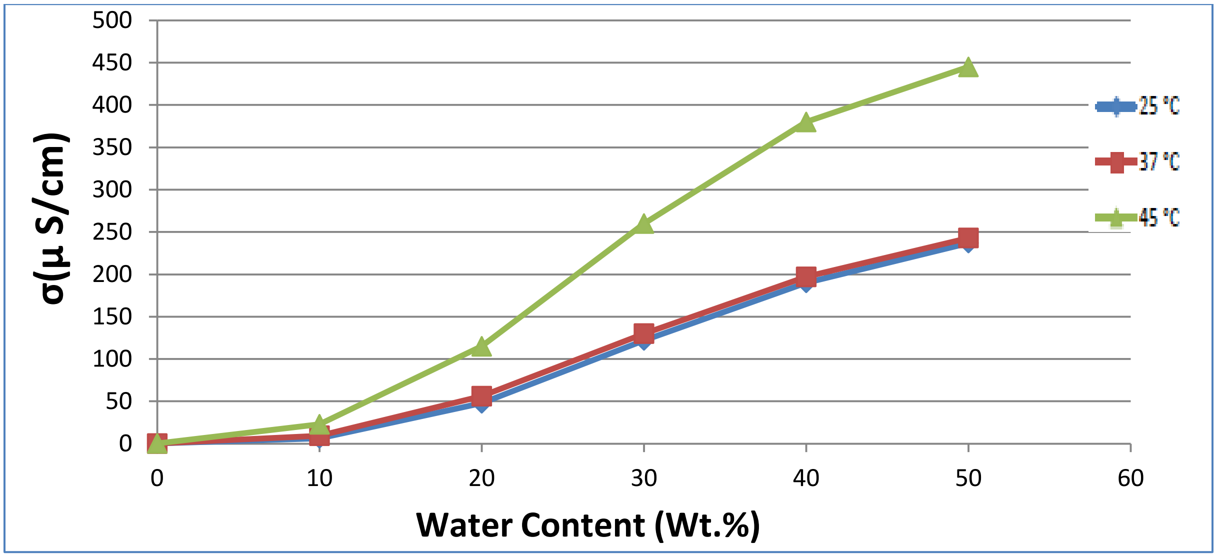

Figure 5.177: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ CCT+MNT as function of water content along the dilution line N65 with 2% indomethacin at different temperatures (25, 37 and 45°C). The mixing ratios of L1695/M159 and that of MNT/CCT equal unity. The phase diagram are presented in Figures 5.92.

In the following Figure 5.178 we compare between the variation of the electrical conductivity (σ) of the system W/ L1695+M159/MNT (free and loaded with drugs) as function of water content along the dilution line N65 at 25°C. The electrical conductivities increases with the increase in the water content, adding indomethacin to the microemulsion system increases the electrical conductivity of the system compared to the drug- free system

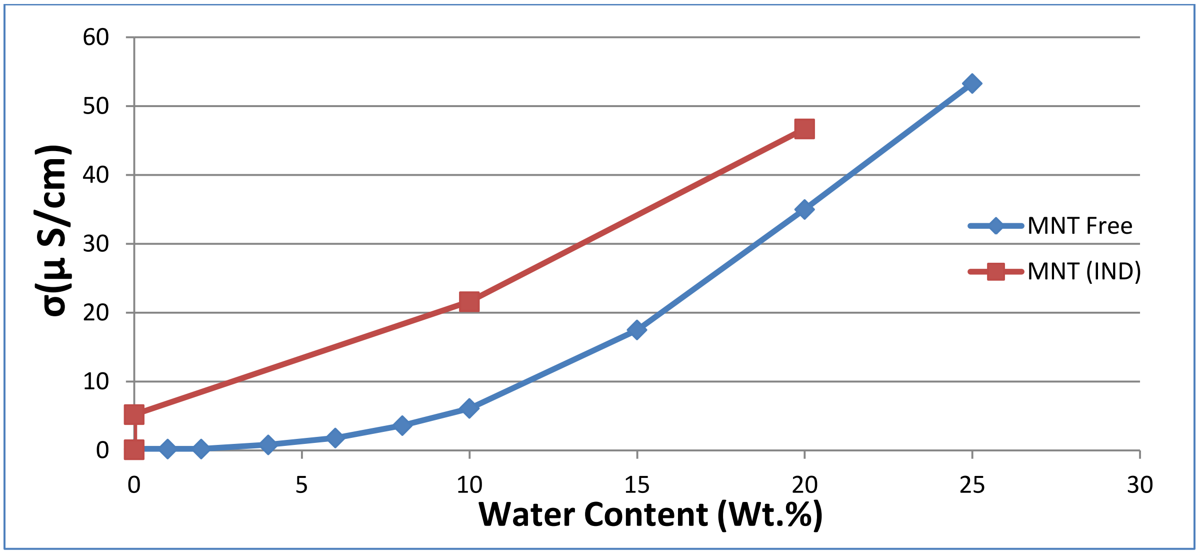

Figure 5.178: Variation of the electrical conductivity (σ) of the system W/ L169+M159/ MNT as function of water content along the dilution line N65 at 25°C for different cases; without drug and with 2% indomethacin. The mixing ratio (w/w) of M159/L1695 equal unity. The phase diagram are presented in Figures 5.33.

From studying the electrical conductivity different microemulsion systems, we compared between them in case of when adding indomethacin to the systems, to see how indomethacin affects the electrical conductivity.

Figure 5.178 presents the variation in the solubilization capacity for indomethacin for the systems W/ L1695+M159/MNT. From this figure we observe that, adding indomethacin to the system W/ L1695+MNT/MNT increase the amount of electrical conductivity in this.

In the following Figure 5.179 we compare between the variations of the electrical conductivity (σ) of the system W / L1695+M159/ IPM+MNT (free and loaded with drugs) as function of water content along the dilution line N65 at 25°C.

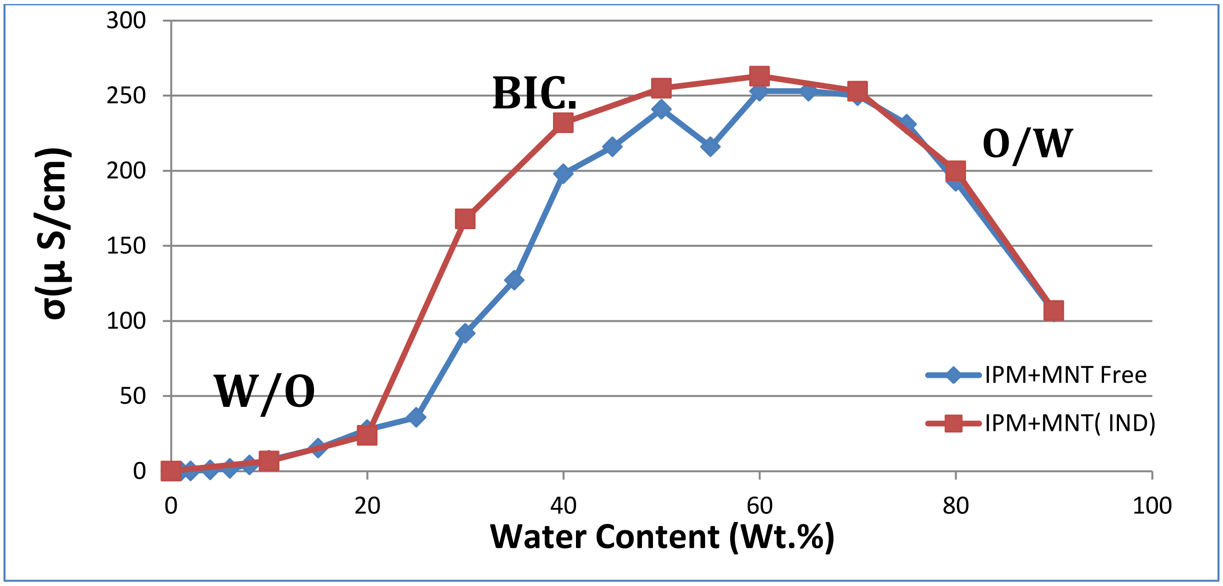

Figure 5.179: Variation of the electrical conductivity (σ) of the system W/ L1695+M159/ IPM+MNT as function of water content along the dilution line N65 at 25°C for different cases; without drug and with 2% indomethacin. The mixing ratio (w/w) of M159/L1695 and MNT/IPM equal unity. The phase diagram are presented in Figures 5.86.

Figure 5.179 presents the variation of the electrical conductivity (σ) of the system W / L1695+M159/ IPM+MNT (free and loaded with drugs) as function of water content along the dilution line N65 at 25°C. The electrical conductivities increase with the increase in the water content, adding pharmaceutical active ingredients (indomethacin) to the microemulsion system increases the electrical conductivity of the system compared to the drug- free system, just increase in bicontinues above 20%(w/w) water to 70% (w/w).

In the following Figure 5.180 we compare between the variations of the electrical conductivity (σ) of the system W / L1695+M159/ CCT+MNT (free and loaded with drugs) as function of water content along the dilution line N65 at 25°C.

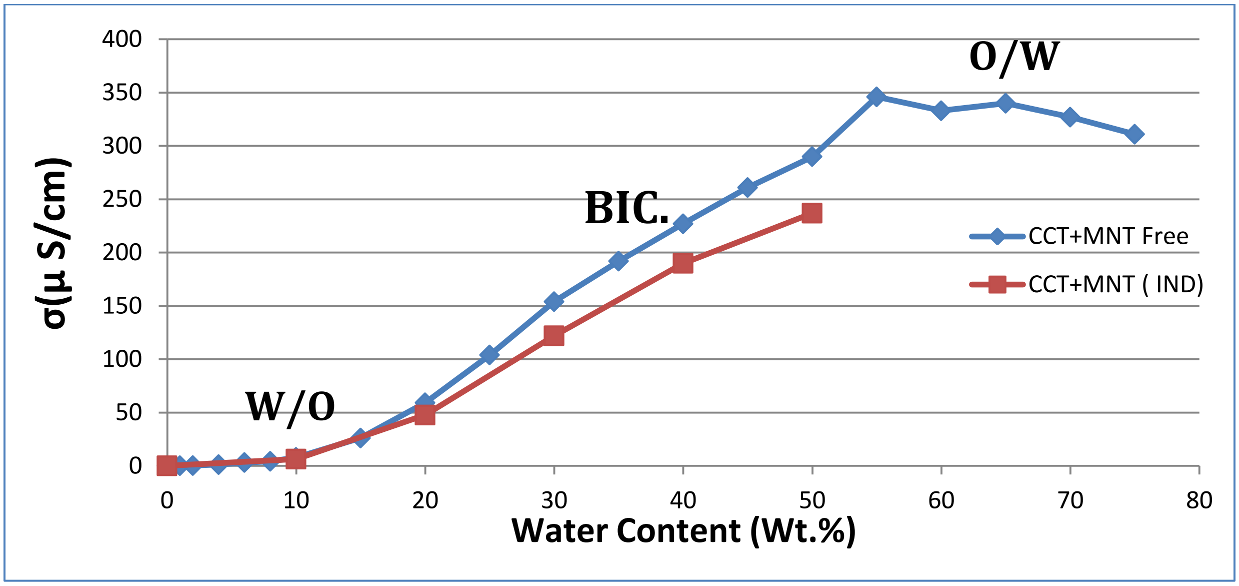

Figure5.180: **v**ariation of the electrical conductivity (σ) of the system W/L1695+M159/CCT+MNT as function of water content along the dilution line N65 at 25°C for different cases; without drug and with 2% indomethacin. The mixing ratio (w/w) of M159/L1695 and MNT/CCT equal unity. The phase diagram are presented in Figures 5.92

Figure 5.180 presents the variation of the electrical conductivity (σ) of the system W/L1695+M159/ CCT+MNT (free and loaded with drugs) as function of water content along the dilution line N65 at 25°C. The electrical conductivities increase with the increase in the water content, adding pharmaceutical active ingredients (indomethacin) to the microemulsion system decrease the electrical conductivity of the system compared to the drug- free system, just decrease in bicontinues above 20%(w/w) water.

The effect of solubilization drugs on the electrical conductivity is small when water content is low this due to that water is entrapped in the core of the reverse swollen micelles, but it becomes more pronounced once the continuous phase is water and the hydrophilic portion of the drug faces the water. From the conductivity profiles we observe that there are different solubilization regions.

The effect of drug on phase behavior, this is despite the fact that a large number of drug molecules are themselves surface active(Attwood, Florence, 1983) and as such would be expected to influence phase behavior. Figure 5.181 shows the effect of the presence of drug on the different microemulsion.

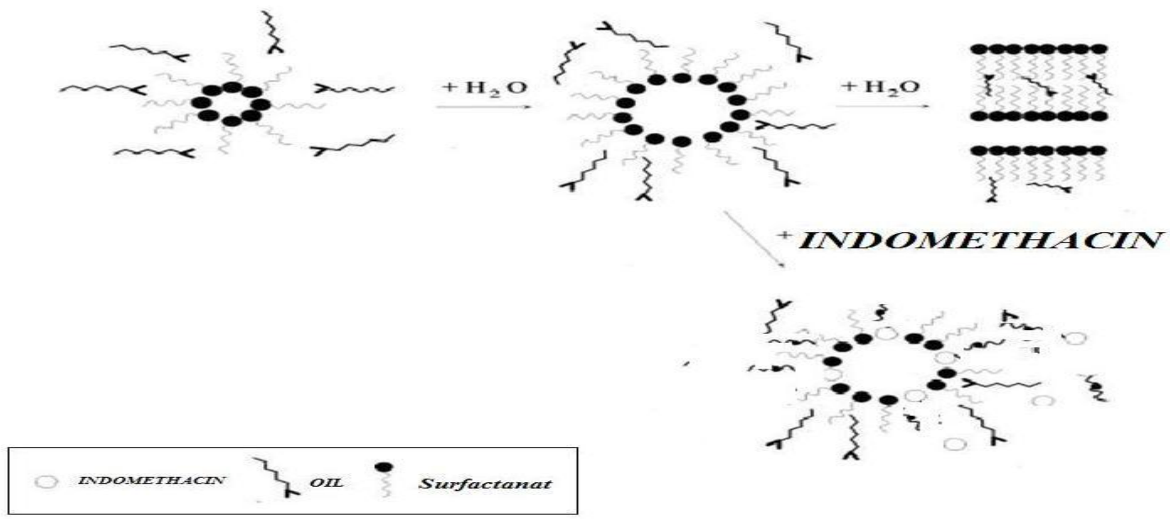

Figure 5.181**:** Schematic representation of the effect of drug on the association in caprylic-capric triglyceride (CCT) system. Top, from left to right: Surfactant molecules in oil in the absence of water and drug form reverse micelles, increasing the amount of water present causes these aggregates to transform first into rod-like micelles and then finally lamellar liquid crystals.

Bottom, from left to right: drug solubilisation either in its indomethacin form causes a change in shape of the colloidal aggregates with indomethacin rod like micelles transform into more spherical ones, with indomethacin rod-like micelles transform into extremely long rods.

Solubility of drug in oil phase and in interfacial tension cause change micelles from liquid crystals to spherical micelles, indomethacin present as active ingredient without salt and it’s not causes increase in electrical conductivity, just effect in penetration of oil in interfacial tension.

5.3.3 Density and ultrasonic velocity measurements

Ultrasonic velocity and density measurement instrument (DSA 5000) of the instrument is the first oscillating U-tube density and velocity of sound meter which measures to the highest accuracy in wide viscosity and temperature ranges.

These methods used to characterization of microemulsion by obtaining information about micellar interactions.

Density measurements

W/ L1695+M159/ LIM

The density was measured for the system W/ L1695+M159/LIM where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.182 and Table 5.92 display the influence of water content and temperature on the density (**ρ**). The phase diagram is presented in Figure 5.35

Table 5.92: The density (ρ) for the system W/L1695+M159/LIM With 2% indomethacin at different water content and different temperatures.

	ρ (g/cm³)		
Water content (wt.%)	25°C	37°C	45°C
0	1.10	1.09	1.09
10	1.10	1.09	1.08
20	1.09	1.08	1.07
30	1.08	1.07	1.06
40	1.07	1.06	1.05
50	1.05	1.04	1.04

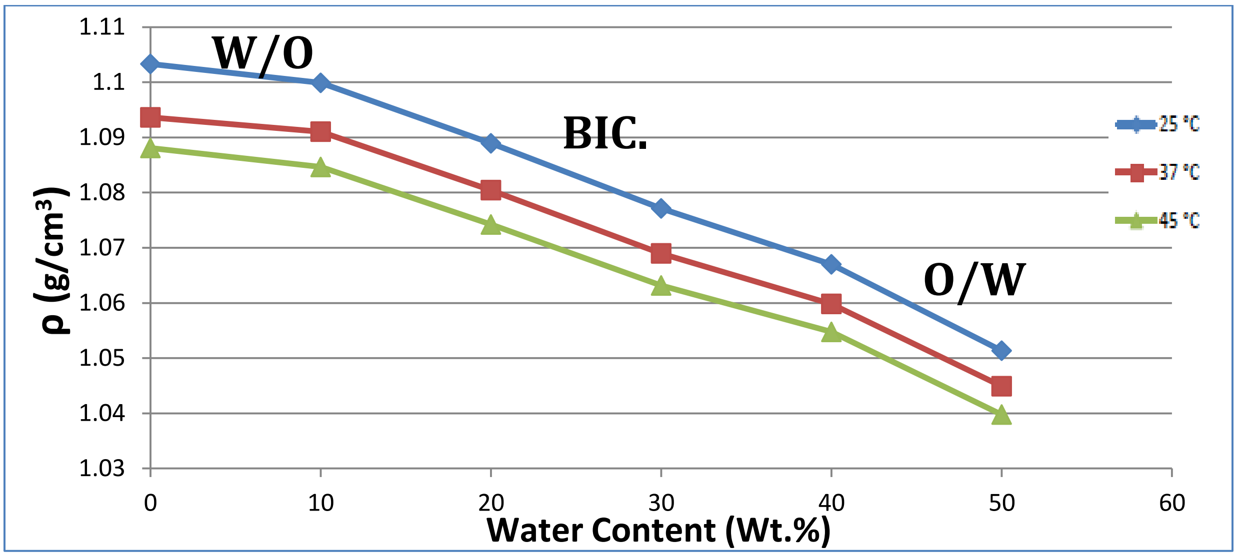

Figure 5.182: Variation of density as function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C). In the system W / L1695+M159/LIM and indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figure 5.35.

W/ L1695+M159/ IPM

The density was measured for the system W/ L1695+M159/IPM where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.183 and Table 5.93

display the influence of water content and temperature on the density (*ρ*). The phase diagram is presented in Figure 5.39

Table 5.93: The density (*ρ*) for the system W/L1695+M159/IPM With 2% indomethacin at different water contents and different temperatures.

	ρ (g/cm^3)		
Water content (wt.%)	25°C	37°C	45°C
0	1.05	1.04	1.03
10	1.03	1.02	1.01
20	1.03	1.02	1.02
30	1.03	1.02	1.02
40	1.02	1.02	1.01

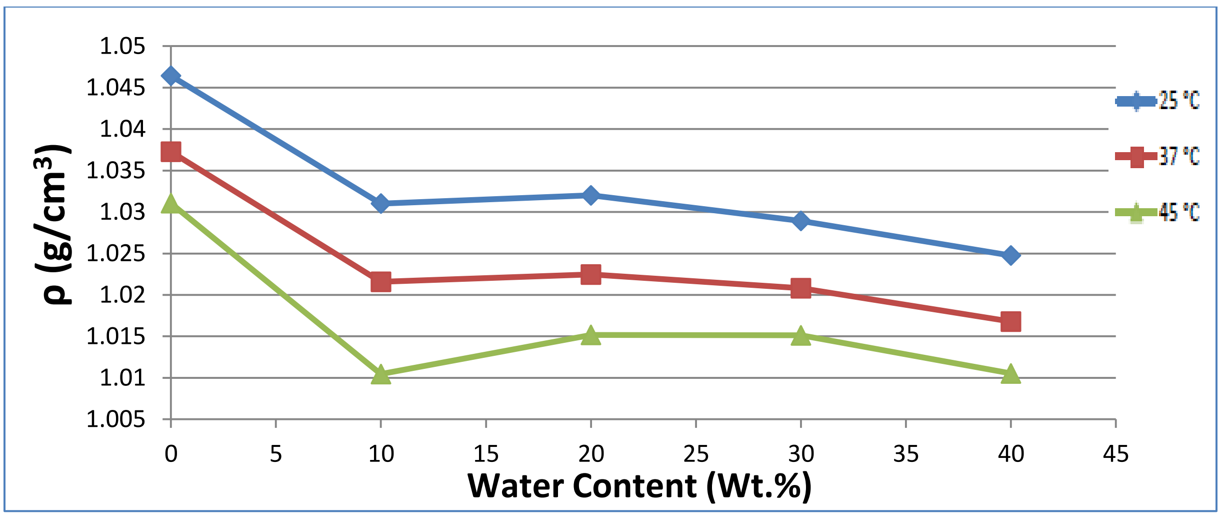

Figure 5.183: Variation of density as function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C) in the system W / L1695+M159/IPM including indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figure 5.39.

W/ L1695+M159/ IPM+MNT

The density was measured for the system W/ L1695+M159/IPM+MNT where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.184 and Table 5.94 display the influence of water content and temperature on the density (***ρ***). The phase diagram is presented in Figure 5.86

Table 5.94: The density (***ρ***) for the system W/L1695+M159/IPM+MNT with 2% indomethacin at different water contents and different temperatures.

	ρ (g/cm^3)		
Water content (wt.%)	25°C	37°C	45°C
0	1.047	1.038	1.032
10	1.045	1.035	1.028
20	1.046	1.037	1.030
30	1.042	1.033	1.026
40	1.038	1.030	1.025
50	1.030	1.023	1.018
60	1.022	1.015	1.010
70	1.019	1.013	1.009
80	1.014	1.009	1.005
90	1.005	1.000	0.997

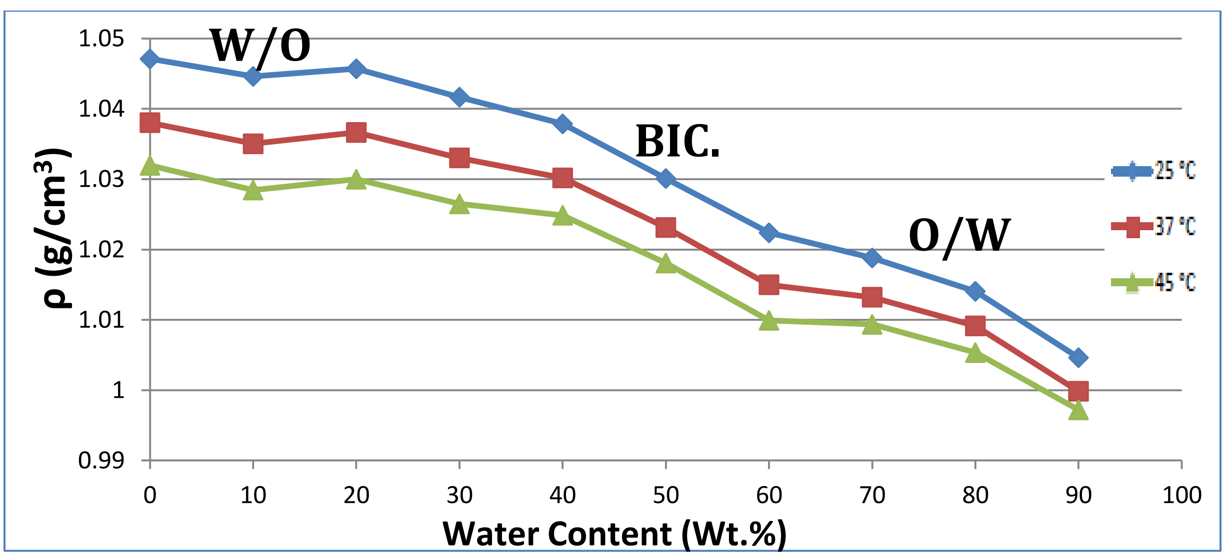

Figure 5.184: Variation of density as function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C) in the system W / L1695+M159/ IPM+MNT including indomethacin (2%). The mixing ratios of L1695/M159 and that of MNT/IPM equal unite. The phase diagram is presented in Figure 5.86.

The density measurement of the microemulsions studied can be explained by the chemical structure of the oils and its molecular weight of oil and solubilization capacity of indomethacin. So that in this section we compared between different chemical structures of oils used in this section and different temperature Figure 5.184, and the results can be explained as follows, increasing the molecular weight of the oils and solubilization capacity increase the density, And capability of the microemulsions to incorporate water in the droplets and hence the density decreases.

In the following Figures (5.185, 5.186 and 5.187) we compare between the densities of different microemulsions systems based on oil IPM+LIM and IPM+MNT.

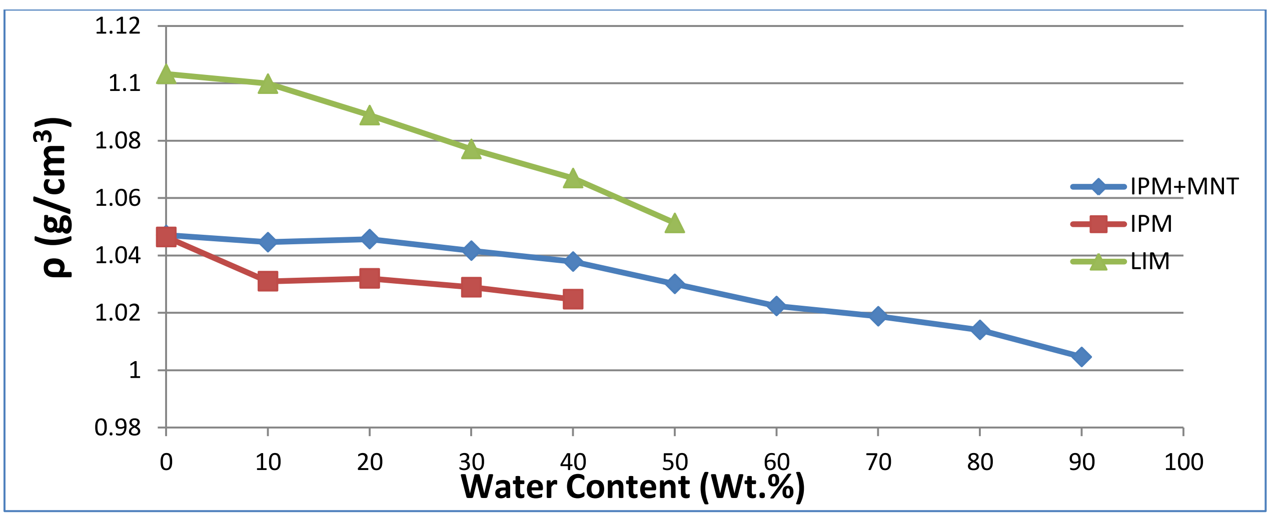

Figure 5.185: Variation of density as function of water content along the dilution line N65 at 25 °C in the system W / L1695+M159/oil for (IPM+MNT, IPM, LIM) including indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figures 5.35, 5.39 and 5.86.

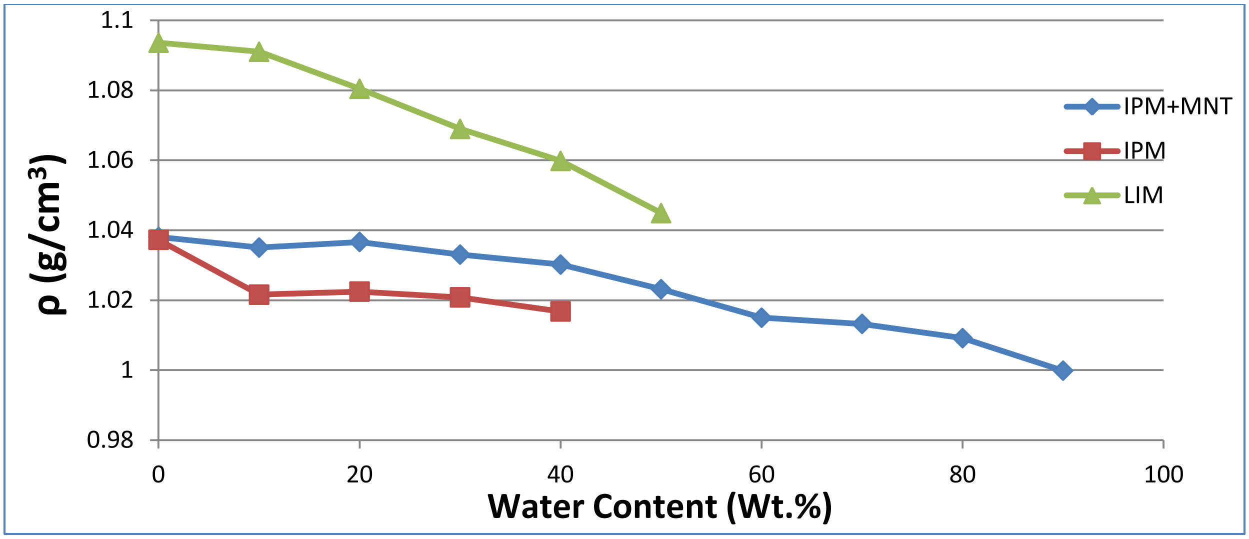

Figure 5.186: Variation of density as function of water content along the dilution line N65 at 37°C in the system W/L1695+M159/oil for (IPM+MNT, IPM, LIM) including indomethacin (2%). The mixing ratio of (L1695/M159) equals unity. The phase diagram is presented in Figures 5.35, 5.39 and 5.86.

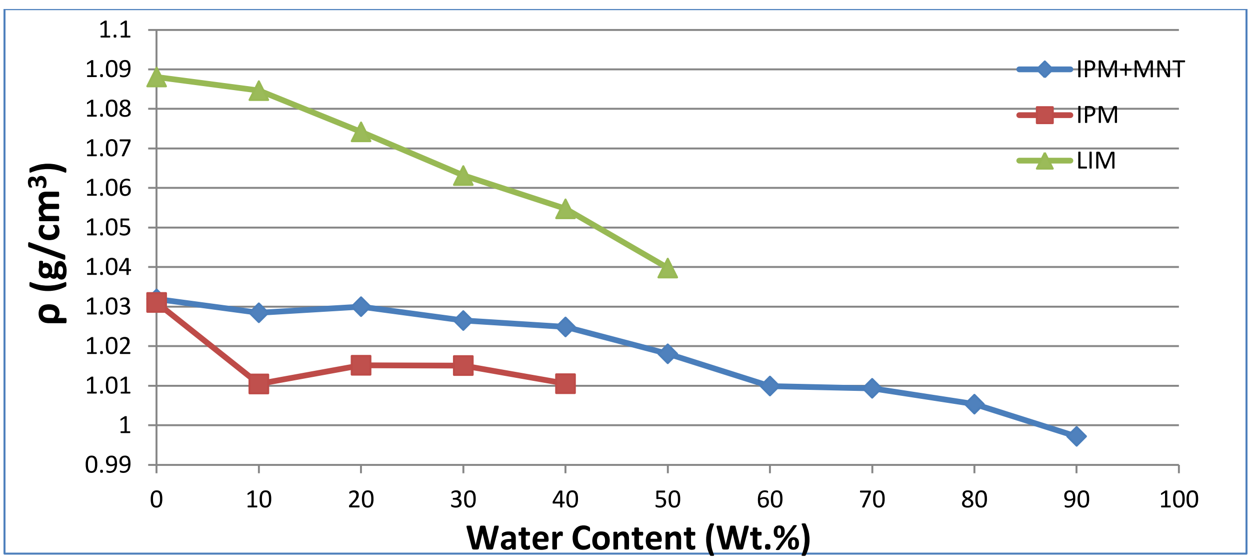

Figure 5.187: Variation of density as function water content along the dilution line N65 at 45°C in the system W / L1695+M159/oil for (IPM+MNT, IPM, LIM) including indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figures 5.35, 5.39 and 5.86.

Ultrasonic velocity measurement

W/ L1695+M159/ LIM

The ultrasonic velocity was measured for the system W/ L1695+M159/LIM where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.188 and Table 5.95 display the influence of water content and temperature on the U.S.V (m/s)

Table 5.95: The U.S.V (m/s) for the system W/L1695+M159/LIM with 2% indomethacin at different water contents and different temperatures.

	U.S.V (m/s)		
Water content (wt.%)	25°C	37°C	45°C
0	1377.62	1484.02	1563.98
10	1536.55	1497.08	1471.44
20	1553.32	1521.92	1503.11
30	1551.83	1528.3	1512.33
40	1545.06	1529.92	1518.13
50	1534.66	1530.62	1524.69

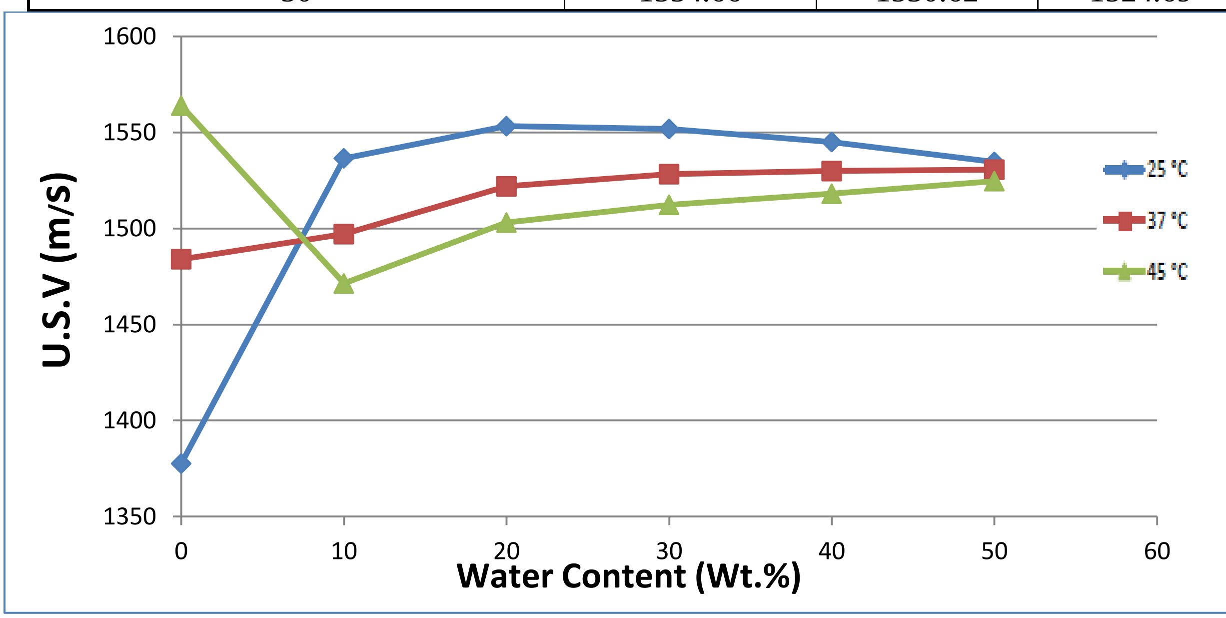

Figure 5.188: Variation of ultrasonic velocity as function water content along the dilution line N65 at different temperatures (25, 37 and 45°C) in the system W/L1695+M159/LIM including

indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figure 5.35.

W/ L1695+M159/IPM

The ultrasonic velocity was measured for the system W/ L1695+M159/IPM where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.189 and Table 5.96 display the influence of water content and temperature on the U.S.V (m/s)**.**

Table 5.96: The U.S.V (m/s) for the system W/L1695+M159/IPM with 2% indomethacin at different water contents and different temperatures.

	U.S.V (m/s)		
Water content (wt.%)	25°C	37°C	45°C
0	1435.76	1391.9	1364.72
10	1437.68	1398.15	1372
20	1452.7	1417.32	1393.95
30	1458.52	1429.41	1409.61
40	1466.6	1445	1429.38

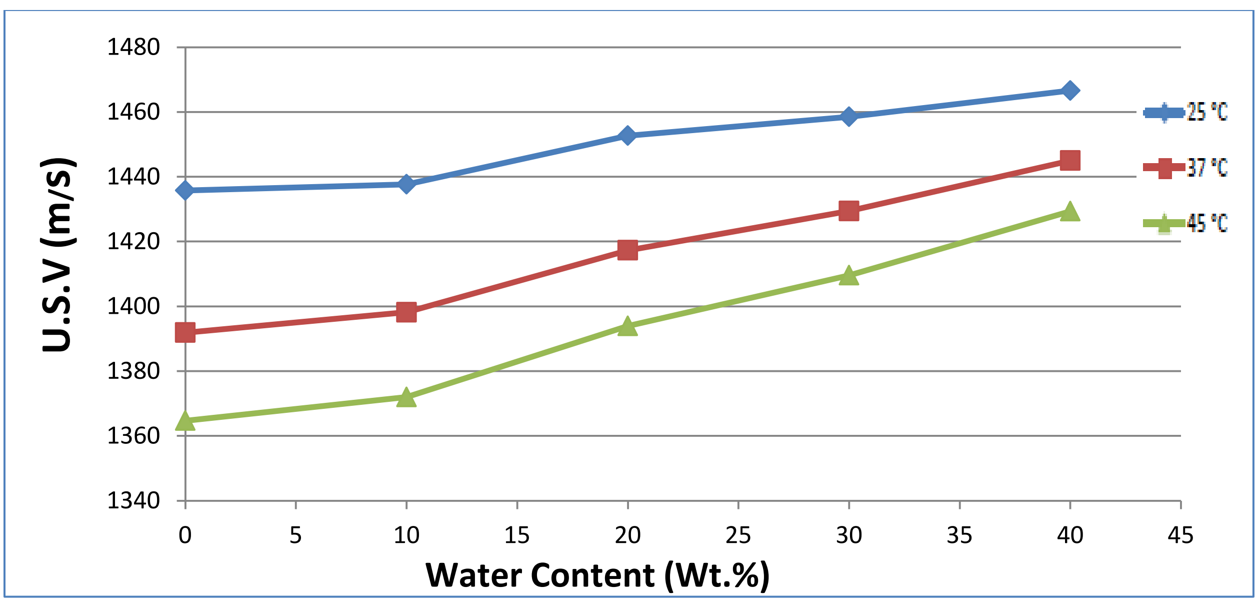

Figure 5.189: Variation of ultrasonic velocity as function of water content along the dilution line N65 at different temperatures (25, 37 and 45°C) in the system W/L1695+M159/ IPM including indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figure 5.37.

W/ L1695+M159/IPM+MNT

The ultrasonic velocity was measured for the system W/ L1695+M159/IPM+MNT where the mixing ratio (w/w) of L1695/M159 variation equal (1/1) along the dilution line N65. Figures 5.190 and Table 5.97 display the influence of water content and temperature on the U.S.V (m/s)**.**

Table 5.97: The U.S.V (m/s) for the system W/L1695+M159/IPM+MNT with 2% indomethacin at different water contents and different temperatures.

	U.S.V (m/s)		
Water content (wt.%)	25°C	37°C	45°C
0	1442.63	1400.18	1373.5
10	1451.18	1412.42	1387.31
20	1464.64	1429.61	1402.65
30	1478.26	1449.42	1428.47
40	1483.62	1462.63	1447.05
50	1486.73	1474.93	1464.74
60	1498.11	1496.43	1492.64
70	1497.67	1503.79	1503.55
80	1498.53	1511.4	1515.57
90	1500.44	1521.87	1531.48

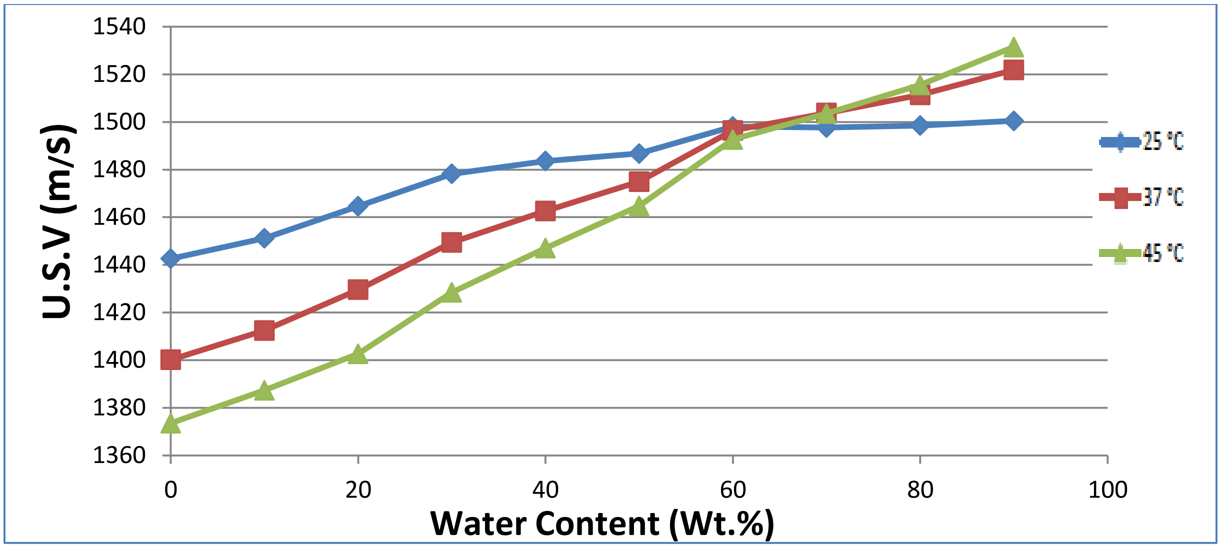

Figure 5.190: Variation of ultrasonic velocity as function of water content along the dilution line N65 at different (25, 37 and 45°C) in the system W / L1695+M159/ IPM+MNT including indomethacin (2%).The mixing ratio of (MNT/IPM) and that of (L1695/M159) equal unity. The phase diagram is presented in Figure 5.86.

In Figure 5.191 we compare the velocity of ultrasonic velocity for different microemulsion types based on LIM, IPM and mixed IPM+MNT

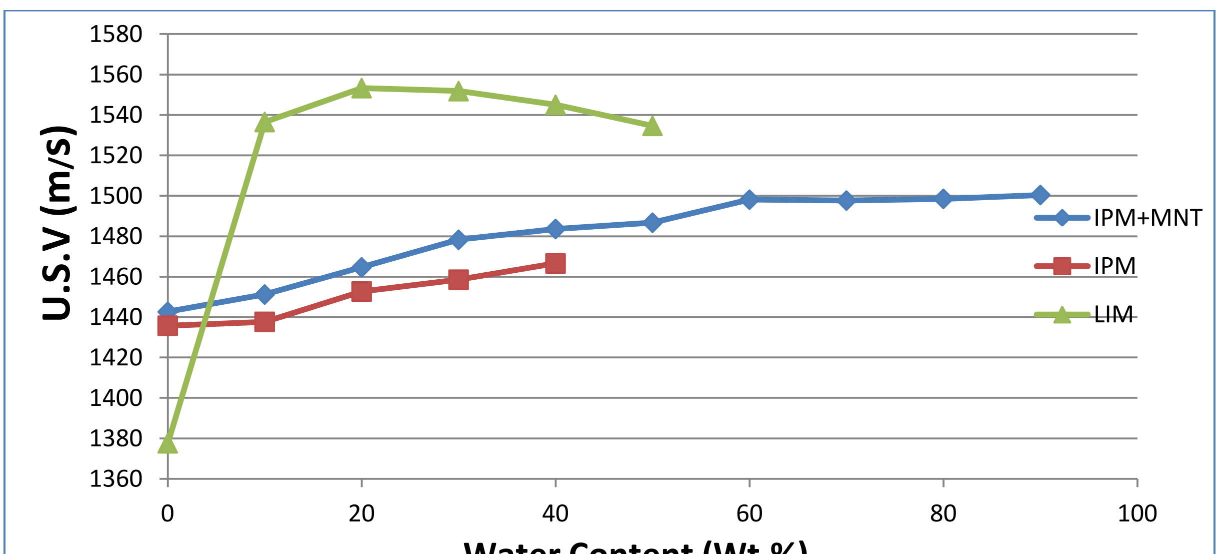

Figure 5.191: Variation of ultrasonic velocity as function of water content along the dilution line N65 at 25°C in the system W / L1695+M159/oil for (IPM+MNT, IPM, LIM) including indomethacin (2%). The mixing ratio of (L1695/M159) equal unity. The phase diagram is presented in Figures 5.35, 5.37 and 5.86.

Microemulsion densities decrease with the increase in the water volume content. Ultrasonic velocities increase with the increase in water content. Ultrasonic velocities decrease with temperature for water content below 60% and increase for water content above 60%. Quantitative analysis of the volumetric parameters enabled the characterization of structural transition along the micellar phase. For low water contents below 20% water in oil microemulsions are present. For water contents between 30-60 wt% bicontinues microemulsions are present. For water content above 60 wt% to 80 wt%, are inversion occurs to inverse microemulsions. For water contents above 80 wt% oil in water microemulsions are present.

Conclusions

Robust microemulsions with low surfactant levels can be formulated via the use of efficient surfactants, interfacially active cosurfactants, and proper formulation conditions (e.g., low electrolyte content). Microemulsions formulated according to these strategies have advantages of very high microemulsification capacity, low surfactant residue, and low cost. This approach has been used to reduce the cost and improve the performance of several consumer product formulations. Similarly, interfacial chemical reactions can be facilitated using microemulsion-forming surfactants, in combination with indigenous cosurfactants. This strategy has been used to identify improved, simple, novel routes to solubilize industrially useful materials such as Indomethacin.

It is concluded that food-grade microemulsions diluted to infinity both with oil (W/O) and water (O/W) are easy to prepare once the compatibility between the structure of oil and the surfactant is granted and (glycerol or propylene glycol) together with alcohol are added.

In this work new microemulsions were developed using natural oils such as peppermint oil, R(+)-limonene oil and α-ionone alone or mixed with a isopropylmyristate oil and common edible oils (soybean, sesame, sunflower, caprylic-capric triglyceride, olive oil), different surfactants such as sucrose monolaurate, sucrose oleate, ethoxylated mono-di-glyceride, PEG-7 glycerol cocoate and glycerol monooleate an aqueous solution (water or water and propylene glycol) without or with ethanol, linalool, propionic acid and glycerol as cosurfactants or cosolvents. The solubility of indomethacin in these microemulsion systems was investigated.

In the following we redraw the general conclusions varied from these subjects; the water solubilization capacity study revealed that mixed surfactants improve the water solubilization capacity in the microemulsions compared to the microemulsion systems based on single surfactants. The molar ratios of mixed surfactants play an important role in determining the maximum water solubilization; the use of mixed surfactants (L1695+EMDG) at weight ratio equals unity (1:1), (L1695+M159) weight ratio equals unity (1:1), (L1695+M300K) weight ratio equals unity (1:3) and (O1570+M300K) weight ratio equals unity (3:1) increases the water maximum solubilization indicating a synergistic effect. The synergism phenomenon may be a result of better interface organization (orientation) of the mixed surfactants around the oil droplets that allows better interfacial solubilization (enhanced partitioning of the surfactant at the interface), mix surfactant depend on molecular weight and HLB of mix surfactant. The chemical structure of the oil affects its penetration in the surfactants palisade layer and determines the extent of water solubilization. Results are reported on the formulated biocompatible microemulsions based on mixed surfactants and the mixed oils; it was found that using the weight ratio of mixed oils equal (1/1) improved the water solubilization capacity in the microemulsions.

1. -Mixed surfactants improve the water solubilization capacity in the microemulsions compared to the microemulsion systems based on single surfactants, indicating a synergistic effect. The synergism phenomenon may be a result of better interface organization (orientation) of the mixed surfactants around the oil droplet that allows better interfacial solubilization (enhanced partitioning of the surfactant at the interface). Comparing the phase diagrams with and without cosurfactants, it is clear that cosurfactants does play a role in solubilizing oil as the ratio of (oil+ cosurfactants)/mixed surfactants increases; that are; it displaces the emulsification failure line towards samples with less surfactant.
2. - Molar ratios of mixed surfactants play important role in determining the maximum water solubilization.
3. - Adding cosurfactant to the system improves the water solubilization capacity of the microemulsions and makes the system more organized.

The results of electrical conductivity, density and ultrasonic velocity probes allow following structural evolution and transitions in these microemulsion systems from aqueous-poor to aqueous rich regions without encountering phase separation. Along the aqueous dilution line examined, self-diffusion coefficients, electrical conductivity, density and Ultrasonic velocity measurements confirm that the system undergoes a continuous structural transition of microemulsions from W/O via bicontinues phase to O/W.

Micelles densities decrease with the increase in the water volume fraction. Ultrasonic velocities increase with the increase in water volume fraction. Ultrasonic velocities decrease with increase temperature for water content below 60% and increase for water content above 60%. Quantitative analysis of the volumetric parameters enabled the characterization of structural transition along the micellar phase. The particle hydrodynamic diameter of the oil-in-water systems was determined as function of temperature.

We have demonstrated the design process of microemulsion formulation for oral administration and shown that various types of surfactants and oil are capable of forming microemulsions. The mixing of different types of oils enhanced the solubilization capacity significantly. This interesting observation was explained by a hypothesis assuming non-ideal mixing of the oil and their penetration into surfactant layers. These formulations should help improve the bioavailability of poorly soluble drugs.

The solubilization capacity of indomethacin in microemulsion systems was higher than any single component that formed the microemulsion. It was found that the solubilization curves for indomethacin showed different regions, region at low water content (0wt% to 30wt.%) which is a w/o microemulsion, in this region the solubilization capacity was the highest due to high surface area and high oil content. Region which contains bicontinuous microemulsion and this region extent from 30wt% to 70wt% water content, in this region the solubilization capacity almost remains constant due to the fact that surface area remains constant at this stage and the region which contains o/w microemulsion and this region extent from 70wt% to 100wt% water content, in this region the solubilization capacity was sharply deceased due to that small amount of oil exist in the core of droplets and the interface became convex toward the oil resulting in very low solubility in the core and poor accommodation of the drugs at the hydrophilic interface. The solubilization capacity of indomethacin for the different microemlsions system and this due to its chemical structure of oil, However, as most drugs are thought to be at least partially solubilized in the head group region of the surfactant aggregate, the present results suggest that it is best to use large molecular volume polar oils in microemulsion preparations, because they are not going to deleteriously alter packing of the hydrophilic head groups and because they will probably exhibit a solubilization capacity for the drug significantly above that of the equivalent hydrocarbon oil making up the surfactant hydrophobe. (Malcolmson, Sratra, Kantaria, et al, 1997).

After the incorporation of the drug, the microemulsion system remained stable and optically clears showing no phase separation. The solubility of the drug was confirmed using conductivity measurements which indicated that the drug may be present at the interface of the oil and aqueous phase.

We can conclude that our microemulsion system helps increase the solubility of the hydrophobic drug with the help of hydrophobic component of microemulsion and lipophilic part of the surfactant.

Several microemulsion systems were prepared by using different natural oils such as peppermint oil alone or mixed with a common oils (caprylic-capric triglyceride or isopropylmyristate oil), different surfactants such as sucrose monostearate, Sucrose oleate, PEG-7 glyceryl cocoate, glycerol monooleate and an aqueous solution (water, 0.01M NaCl) without or with cosurfactant. The solubility of indomethacin in these microemulsion systems was investigated studied by electrical conductivity, density and ultrasonic velocity.

The obtained results can be concluded as follows:

1- Microemulsions could be prepared by using oil, nonionic surfactant and water without Co-surfactant

2- Microemulsions were also prepared by using these components with cosurfactant and the optimum amount of water in this case increased with increasing the cosurfactant content.

3- Microemulsions prepared using edible triglyceride oils as lipophilic phase and surfactant the total area less than use linear or cyclic oil.

4- Using O1570 with M300K has greatly affect on the solubilization of water in the mixture to prepare microemulsion, where the maximum amount of water miscible with the system was considerably remarkable compared to that when using propylene glycol with water with mix oil.

5- Generally, the solubilization capacity for aqueous phase in case of using mix (L1695+M159) as surfactant was higher than that in case of using (O1570+M300K).

6- Solubility of indomethacin in microemulsions containing mixed oil as lipophilic phase was markedly higher than that in single oil indomethacin solubility also increased when the surfactant content in the microemulsion decrease (N50 higher solubilization than N65). Indomethacin solubility also increased when propylene glycol was added to the water.

7- Mixing ProA with both IPM and CCT in the presence of mixing surfactants included the maximum water solubilization obtained in this study.

Finally, Microemulsions could be prepared by using suitable components for food applications and pharmaceutical. These microemulsions could be used to improve the solubility of indomethacin and other natural food compound which are insoluble in water and poorly soluble in vegetable oils.

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كمضاد للبكتيريا والينالول يستخدم بمواد التجميل ةالجليسرول الذي يزيد من الزوجة.أما الزيوت المستخدمة و التي تناولتها هذه الدراسة هي: **أولا** زيوت عطرية حلقية مثل زيت نعنع (MNT) و وزيت الحمضيات (LIM)، **ثانيا** زيوت خطية التركيب مثل الأيزوبروبيل مريستيت (IPM)، **ثالثا** زيوت ثلاثية الجليسيرايد مثل الكابريلك-كابرك ثلاثي الجليسريد(CCT)، زيت الزيتون، زيت السمسم ، زيت الصويا وأخيرا زيت عباد الشمس.

استخدام خليط من المركبات المستحلبة بنسب مختلفة عوضا عن مركب منفرد في تكوين المستحلبات الدقيقة حيث وجد أن استخدام خليط من هذه المركبات يعطي مساحة وحيدة الحالة على منحني الرسم اكبر بالمقارنة مع استخدام مركب منفرد، كما وجد أن خليط من خوافض التوتر السطحي (EMDG + L1695) على نسبة 1:1 أعطى أحسن مساحة للمستحلبات الدقيقة على درجات الحرارة المدروسة.وعند استخدام (L1695+M159) بنسبة 1:1اعطى اكبر كمية مساحة وحيد الطبقة، اما في حال استخدام (L1695+M300K) كانت عند خلط بنسبة 1:3، وعند خلط (O1570+M300K) كانت اعلى قيمة عند الخلط بنسبة 3:1 وذلك عن طريق حساب المساحة الكلية للمنطقة المكونة من طبقة واحدة A_T (%).

وتم استكشاف مدى قدرة المستحلبات الدقيقة على إذابة عقاقير(ذات ذائبيّة منخفضة جدا في الماء) مثل الاندوميثاسين في تركيبها الداخلي والمبنية في تركيبها على مزيج من المركبات المستحلبة (السكروز أحادي اللوريت و المازول 159) حيث وجد أن سعة الذائبية للعقاقير المستخدمة في الدراسة تقل مع زيادة محتوى الماء في المستحلب الدقيق وهذا دليل على حدوث تغير في التركيب الداخلي للمستحلبات الدقيقة.

وتم دراسة و توضيح البناء الجزيئي الدقيق للمنطقة المكونة من طبقة واحدة، وذلك باستخدام جهاز التوصيل الكهربائي، وكذلك قياس الكثافه والسرعة فوق الصوتية، حيث وجد أن التوصيل الكهربائي للمستحلبات الدقيقة سواء كانت مبنية من مركب مستحلب منفرد أو مزيج من المستحلبات تعتمد بشكل أساسي على محتوى الماء داخل المستحلبات الدقيقة. كذلك وجد أن أعلى قيمة للتوصيل الكهربائي للمستحلبات الدقيقة التي تم دراستها تحدث عندما تزيد كمية الماء على الزيت مما يدلّ على تحول في شكل التركيب الدقيق للمستحلبات الدقيقة من (ماء في زيت) إلى (زيت في ماء)، كما لوحظ أيضا بالنسبة لجميع الأنظمة التي تم دراستها أن قيم التوصيل الحراري تزيد بزيادة درجة الحرارة وتقل القيمة بعد تحولها الى(زيت في ماء) ولكن بقيمة قليلة.

المستحلبات الدقيقة متوافقة حيويا:تصنيع ووصف واذابة الاندوميثاسين

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ملخص البحث:

تهدف هذه الدراسة إلى تكوين مستحلبات دقيقة (Microemulsions) من مواد تدخل في الصناعات الغذائية ودراسة تأثير درجة الحرارة عليها ثم تشخيصها بطريقة التوصيل الحراري والكثافة والسرعه فوق الصوتيه للتعرف على تركيبها الداخلي ومن ثم إذابة أدوية فيها كنوع من أنواع التطبيقات العملية لهذه الأنظمة. هذه المستحلبات الدقيقة تتكون من مواد لا تذوب ببعضها (زيت وماء) لكن وجود مادة ثالثة وهي المستحلبات (خوافض توتر سطحي تجعل الزيت والماء بالعين المجردة كأنهم حالة واحدة (مادة واحدة) لكن داخليا فإن هذه الأنظمة تحتوي على جزيئات صغيرة جدا ذات حجم أقل من 0.2 ميكرومتر و كذلك تراكيب معقدة. المستحلبات الدقيقة تختلف عن المستحلبات العادية كالحليب مثلا في أنها ثابتة (ثيرموميكانيكيا) و لمدة طويلة من الزمن، شفافة، قليلة اللزوجة، التوتر السطحي لها صغير جدا وكذلك بكمية المستحلب المستخدم وهي تعتبر مذيب جيد للمواد خاصة تلك قليلة الذوبان بالأوساط المائية والمذيبات العضوية.

الأنظمة التي تناولتها هذه الدراسة تتكون من**:** ماء/ خوافض توتر سطحي لاأيونية/ مساعدات خوافض التوتر السطحي/ زيت. خوافض التوتر السطحي المستخدمه في هذه الدراسة هي سكروز استر (سكروز أحادي اللوريت L1695) وسكروزالاوليات(O1570) و اثوكسيلاتد احادي وثنائي الجليسريد (EMDG) والمازول 159 (M159) ومازول 300 ك(M300K) تعتبر هذه المواد خوافض توتر سطحي لاأيونيه و تختلف فيما بينها بتركيبها البنائي ومدى قابليتها للذوبان في الماء، أما مساعدات خوافض التوتر السطحي المستخدمة في هذه الدراسة والتي أيضا تدخل في مجالات الغذاء ومواد التجميل والصناعات الدوائية فهي مادة البروبلين جلايكول (PG) التي تتميز بسهولة ذوبانها في الماء،وكذلك الايثانول وحمض بروبيونك الذي يستعمل كذلك