



Abstracts

THE 35th CONGRESS on SCIENCE and TECHNOLOGY of THAILAND (STT 35)

การประชุมวิชาการวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย
ครั้งที่ 35 (วทท 35)

วิทยาศาสตร์และเทคโนโลยีเพื่ออนาคตที่ดีขึ้น
SCIENCE AND TECHNOLOGY FOR A BETTER FUTURE

*To Celebrate the 35th Anniversary of Faculty of Science, Burapha University
To Celebrate the 30th Anniversary of Ministry of Science and Technology*

October 15 - 17, 2009

Venue : The Tide Resort (Bangsaen Beach), Chonburi, Thailand.

15-17 ตุลาคม 2552 ณ เดอะ ไทด์ รีสอร์ท (หาดบางแสน) จังหวัดชลบุรี

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พฤติกรรมวิทยาของระบบที่ประกอบด้วยโอเลท-10 น้ำ น้ำมันและสารลดแรงตึงผิวร่วมชนิดต่างๆ

PHASE BEHAVIOR OF SYSTEMS COMPOSED OF OLETH-10, WATER, VARIOUS OILS AND COSURFACTANTS

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บทคัดย่อ: การศึกษาพฤติกรรมวิทยาของระบบที่ประกอบด้วยโอเลท-10 (สารลดแรงตึงผิวที่ไม่มีประจุ) น้ำ น้ำมัน และสารลดแรงตึงผิวร่วมชนิดต่างๆ โดยน้ำมันที่ศึกษาเปรียบเทียบกับ ได้แก่ น้ำมันซิลิโคนและน้ำมันถั่ว และศึกษาผลเปรียบเทียบระหว่างไอโซโพรพิลแอลกอฮอล์ (IPA), โพรไพลีนไกลคอล (PG) และซอร์บิทัน โมโนโอเลเอท (Span 80) แผนภาพวิทยาไตรภาคหรือไตรภาคเทียมของแต่ละระบบสร้างขึ้นโดยการเตรียมตัวอย่างในสัดส่วนของสารที่หลากหลาย ผลการศึกษาบ่งชี้ว่าพบโครงสร้างการรวมตัว เช่น อิมัลชัน เจล และสารกระจายตัวที่ไม่เสถียร แต่ไม่มีการเกิดไมโครอิมัลชันในระบบที่มีน้ำมันซิลิโคนเป็นวัฏภาคน้ำมัน เมื่อใช้น้ำมันถั่วเหลืองเป็นวัฏภาคน้ำมัน ระบบของน้ำ/น้ำมันถั่วเหลือง/โอเลท-10:IPA (9:1) ให้พื้นที่ไมโครอิมัลชันขนาดใหญ่ที่สุด สรุปว่าในระบบที่มีโอเลท-10 เป็นสารลดแรงตึงผิว น้ำมันถั่วเหลืองเหมาะที่จะใช้เป็นวัฏภาคน้ำมันในการผลิตไมโครอิมัลชันมากกว่าน้ำมันซิลิโคน ขณะที่ IPA เหมาะที่จะใช้เป็นสารลดแรงตึงผิวร่วมในการผลิตไมโครอิมัลชันมากกว่า PG และ Span 80

Abstract: The investigation of the phase behavior of systems composed of oleth-10 (nonionic surfactant), water, various oils and cosurfactants. Silicone oil and soybean oil as well as isopropyl alcohol (IPA), propylene glycol (PG) and sorbitan monooleate (Span 80) were used for comparisons. The ternary or pseudoternary phase diagram of each system was constructed by preparing a large number of samples of different compositions. The results indicate that association structures, e.g., emulsions, gels and unstable dispersions were observed but no microemulsions originated in the systems composed of silicone oil as oil phase. When soybean oil was used as oil phase, the system of water/soybean oil/oleth-10:IPA (9:1) provided the largest microemulsion region. It could be concluded that in oleth-10 containing systems, soybean oil was more suitable to be used as oil phase for microemulsion formation than silicone oil while IPA was more proper to be used as cosurfactant for microemulsion formation than PG and Span 80.

Introduction: In present, the demand for cosmetic products has continuously grown with the tendency of the consumers to request high efficient products. Hence, the cosmetic scientists have attempted to develop the distinctive cosmetic products by manufacturing their products in new formulations for increasing the efficiency of the products, gaining the consumers' attraction and enlarging the market share.

Microemulsions are one of interesting novel vehicles using in cosmetics. They are optically transparent, low viscous and thermodynamically stable dispersions of oil and water stabilized by the interfacial film of a surfactant, usually in combination with a cosurfactant. Their advantages in cosmetics include good appearance, thermodynamic stability, high solubilization power and ease of preparation [1, 2]. Although microemulsions can form spontaneously and do not need high input energy in preparation process, there are many factors affecting the formulation of microemulsions as well as the properties of the obtained microemulsions. These factors are types and concentrations of surfactants [3], oils [3-5] and cosurfactants [6-10]. Thus, the problem of microemulsion formulation is that no simple satisfactory theory is available to aid in the choice of components. In addition, when oil, water, surfactant and cosurfactant are mixed, microemulsions are only one of a number of association structures that can form depending on the chemical nature and concentration of the components as well as temperature and pressure. The association structures include microemulsions, regular emulsions, micellar and mesomorphic phases of various constructions such as lamellar, hexagonal, cubic and various gels, and oily dispersions [9, 11]. To find the suitable types and amounts of each component to form microemulsion, the construction of a phase diagram is a useful approach to obtain the microemulsion regions. A ternary or pseudoternary phase diagram can be constructed by two methods: (i) titrating a mixture of two components with the third component and (ii) preparing a large number of samples of different ratios of components. If all mixtures reach equilibrium rapidly both methods give identical results. In contrast, if all mixtures do not reach equilibrium rapidly, the last method is recommended [12]. Therefore, this method was used in this study. Although microemulsions can provided a lot of benefits in cosmetic productions, the risk of skin irritation caused by microemulsions is quite high. Because microemulsions need high concentrations of a surfactant and a cosurfactant to reduce the interfacial tension and to increase the flexibility of the interfacial film, respectively. Thus, selection for amphiphiles in formulations of cosmetic microemulsions needs carefully contemplation [2]. The studied surfactant was oleth-10, a nonionic surfactant. Its other well-known names are C_{18:1}E₁₀, Brij 96, Brij 97 and polyoxyethylene-10-oleyl ether. It is widely used in topical pharmaceutical formulations and cosmetics primarily as an emulsifying agent for w/o and o/w emulsions. It has been also used in several microemulsion formulations [3, 4, 6, 9, 13, 14]. In the present work, we investigated the phase behavior of systems composed of oleth-10, water, various oils (i.e., silicone oil and soybean oil) and cosurfactants (i.e., isopropyl alcohol (IPA), propylene glycol (PG), sorbitan monooleate (Span 80)). All studied oils and cosurfactants are acceptable for cosmetic purposes. Therefore, the obtained microemulsions can be further incorporated with cosmetic active ingredients such as whitening agents, antioxidants, moisturizers, sunscreens and others in order to increase the product efficiency and respond to the consumers' demand.

Methodology: In each system, oleth-10 or the mixtures of oleth-10 and cosurfactant at fixed weight ratios were mixed with oil at the weight ratios of 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1. Calculated amount of purified water was added at 10% increment to obtain water concentrations in the range of 0-90% by weight. The samples were prepared by adding an appropriate amount of each component in the individual tubes and then vigorously mixing with a vortex mixer. The samples were stored at room temperature for at least 24 hours in order to reach equilibrium before further

investigation. The obtained samples were classified as microemulsions when they appeared as clear isotropic liquids, as emulsions when they appeared as milky or turbid liquids, as gels when they did not show a change in the meniscus after tilting to an angle of 90° and as unstable dispersions when they separated to two clear-liquid layers [3, 6, 9]. The microemulsion region of each system was constructed on a triangular graph as ternary or pseudoternary phase diagram using SigmaPlot software. A cut-and-weigh method was used to determine the percentage of the total area of the phase diagram covered by the microemulsions [15].

Results, Discussion and Conclusion: Figure 1 shows the regions of association structures in the pseudoternary phase diagrams of the systems of water and silicone oil at different weight ratios of oleth-10 and PG (1:1, 2:1 and 3:1). The results indicate that association structures, e.g., emulsions, gels and unstable dispersions were observed but no microemulsions originated in the systems composed of silicone oil as oil phase. Penetration of the oil molecule into the hydrocarbon portion of the surfactant interface would have the effect of increasing the hydrophobic portion volume of the interface (v) and subsequently causing an increase in the effective critical packing parameter (CPP) [3]. The CPP is defined by the ratio of the alkyl chain volume (v) to the area occupied at the interface by the polar head group (a_o) and the critical alkyl chain length (l_c). It is a predictive parameter of the type of association structures that are likely to form in the surfactant systems [11]. The chemical structure of silicone oil is a linear polydimethylsiloxane based on a backbone of repeating silicon and oxygen atoms, with hydrocarbon groups attached to the silica along its length, resulting in large molecular volume. Thus, the molecular volume of silicone oil might be too large to penetrate into the hydrocarbon portion of the surfactant interface; therefore no microemulsions occurred.

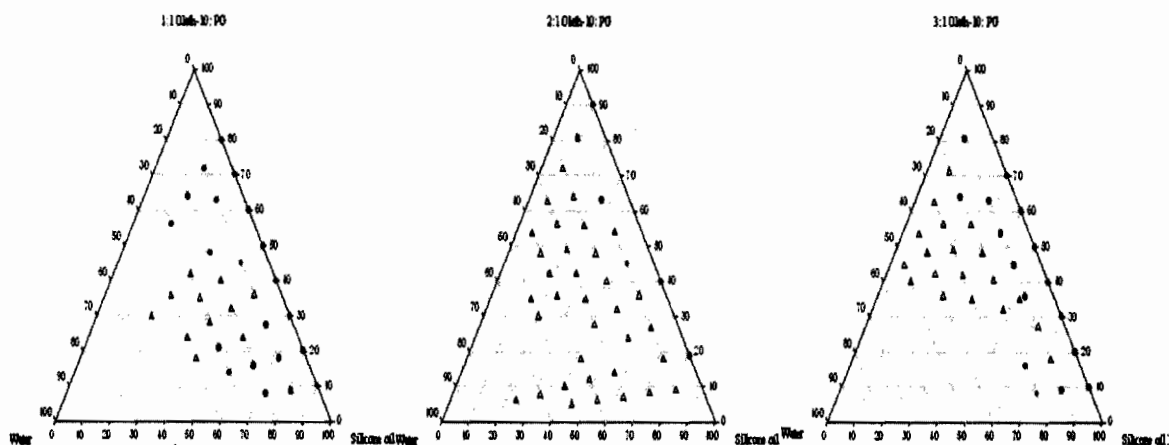


Figure 1 Pseudoternary phase diagrams of the systems of water and silicone oil at different ratios of oleth-10 and PG (1:1, 2:1 and 3:1); ●: emulsion, ▲: gel, white area: unstable dispersion.

Figure 2 exhibits the regions of association structures in the pseudoternary phase diagrams of the systems of water and soybean oil at different weight ratios of oleth-10 and PG (1:0, 1:1, 2:1, 5:1 and 8:1). The results suggest that at the same oleth-10:PG ratios, soybean oil provided the microemulsion existence while silicone oil could not.

According to their structures, soybean oil has smaller molecular volume than silicone oil. Microemulsions could originate in the cosurfactant-free system (1:0 oleth-10:PG) but no microemulsions occurred at 1:1 oleth-10:PG since there was too low surfactant in the system and excess polyhydroxy compound might partition to and act as aqueous phase. The microemulsion region increased when the amount of oleth-10 further increased (from 2:1 to 8:1 oleth-10:IPA); however, it could be noted that PG could not increase microemulsion region compared to the cosurfactant-free system.

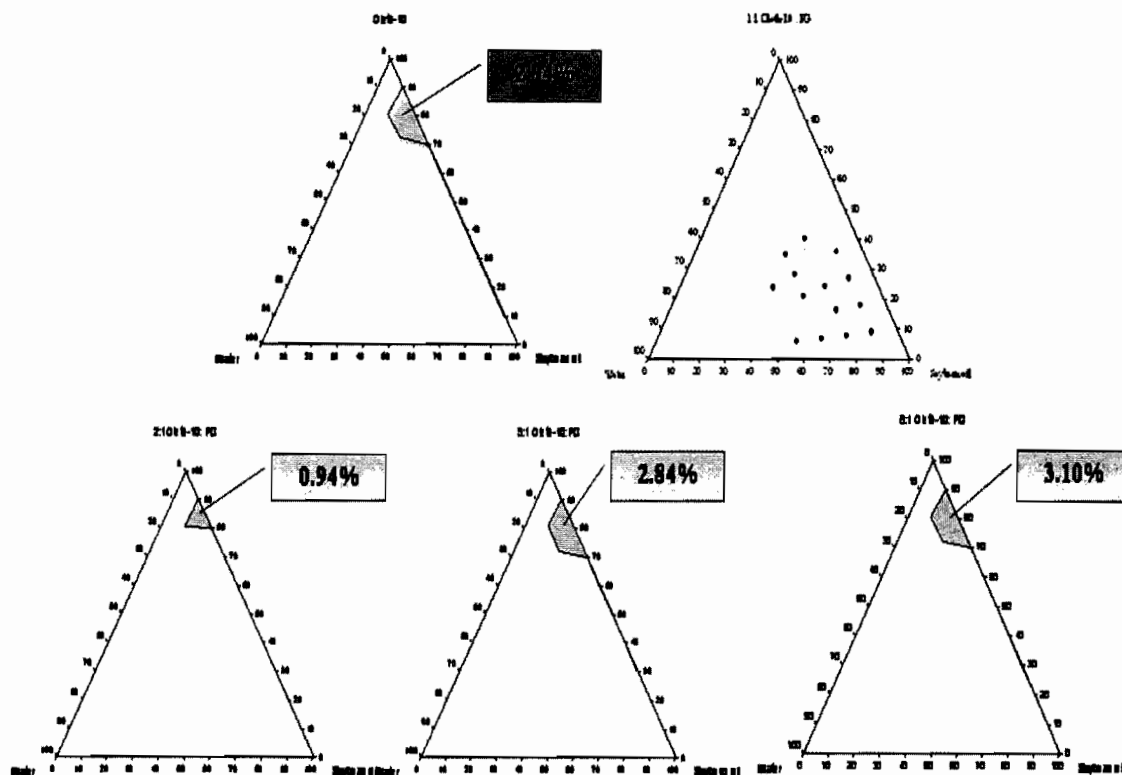


Figure 2 Pseudoternary phase diagrams of the systems of water and soybean oil at different ratios of oleth-10 and PG (1:0, 1:1, 2:1, 5:1 and 8:1); ●: emulsion, white area: unstable dispersion, shaded area: microemulsion.

Figure 3 presents the regions of association structures in the pseudoternary phase diagrams of the systems of water and soybean oil at different weight ratios of oleth-10 and IPA (1:0, 1:1, 5:1, 7:1, 8:1 and 9:1). The results indicate that microemulsions were found in the cosurfactant-free system (1:0 oleth-10:IPA) but no microemulsions were seen at 1:1 oleth-10:IPA since there was too low surfactant in the system and excess short chain alcohol might partition to and act as aqueous phase. The microemulsion region increased when the amount of oleth-10 further increased (from 5:1 to 9:1 oleth-10:IPA). The largest microemulsion region was obtained at 9:1 oleth-10:IPA. These results can be explained that as the amount of surfactant in the system is increased, a greater interfacial area is possible and the oil is distributed among a greater number of micelles. Small amount of IPA could increase flexibility of interfacial film, leading to larger microemulsion regions. The weight percent of oxygen content (%O) of IPA (C_3H_7OH) is lower than that of PG ($C_3H_8O_2$). This descriptor of cosurfactants was reported to affect to the microemulsion formation [8, 9].

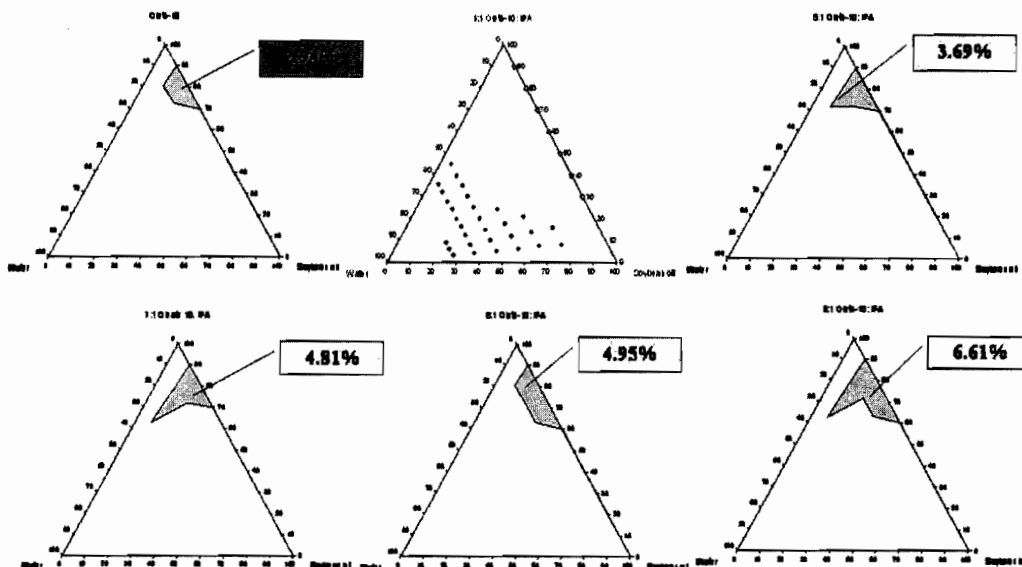


Figure 3 Pseudoternary phase diagrams of the systems of water and soybean oil at different ratios of oleth-10 and IPA (1:0, 1:1, 5:1, 7:1, 8:1 and 9:1); ●: emulsion, white area: unstable dispersion, shaded area: microemulsion.

Figure 4 shows the regions of association structures in the pseudoternary phase diagrams of the systems of water and soybean oil at different weight ratios of oleth-10 and Span 80 (1:0, 1:1 and 5:1). The hydrophile-lipophile balance (HLB) values of oleth-10 and Span 80 are 12.4 and 4.3, respectively. The results show that the suitable amount of Span 80 (5:1 oleth-10:Span 80) could enlarge area of microemulsion existence due to proper obtained HLB. However, Span 80 could not increase a capability of water solubility in the microemulsion system because of its lipophilicity.

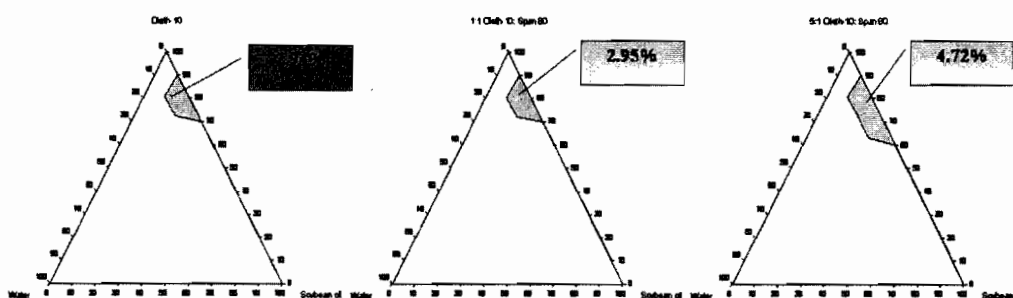


Figure 4 Pseudoternary phase diagrams of the systems of water and soybean oil at different ratios of oleth-10 and Span 80 (1:0, 1:1 and 5:1); white area: unstable dispersion, shaded area: microemulsion.

It could be concluded that the component types and ratios in oleth-10 systems would affect the characteristics of the obtained products and that the existence of microemulsion regions would depend on molecular structure and concentration of oils and cosurfactants. Among studied systems, water/soybean oil/oleth-10:IPA (9:1) provided the largest microemulsion region. The obtained microemulsions were thermodynamically stable and could be further incorporated with cosmetic or cosmeceutical active ingredients.

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Keywords: phase behavior, phase diagram, microemulsion region, oleth-10 and microemulsions

Acknowledgements: This research is supported by Graduate School and Faculty of Pharmaceutical Sciences, Prince of Songkla University.