ผลกระทบของสารผสมพอลิซอร์เบต-60 และลอเรต-7 ทำหน้าที่เป็นตัวทำอิมัลชันชนิดไม่มีประจุในอิมัลชันชนิดน้ำมันในน้ำ (O/W)

Effects of the Polysorbate-60 and Laureth-7 Mixtures as a Non-Ionic Emulsifier in Oil-in-Water (O/W) Emulsion

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บทคัดย่อ

สูตรโลชันนวดคลายเส้นชนิดน้ำมันในน้ำ (O/W) ประกอบด้วยสารสำคัญ ได้แก่ สารสกัดหยาบแคปไซซิน ซึ่งเตรียมด้วยเทคนิคการกลับเฟสโดยการเติมวัฏภาคน้ำ (ปริมาตรทั้งหมดมากกว่าร้อยละ 80) ลงในวัฏภาคน้ำมันที่อุณหภูมิ 70-80 องศาเซลเซียส อย่างช้าๆ ขณะปั่นและสารลดแรงตึงผิว 2 ชนิด ได้แก่ สารผสมพอลิซอร์เบต-60 (พอลิซอร์เบต 60/ไฮดรอกซีเอธิลอะคริเลต-โซเดียมอะคริโลอิลไดเมธิลทอเรตโคพอลิเมอร์ และไอโซเฮกซะ-เดกเคน) และสารผสมลอเรต-7 (พอลิอะคริลแอไมด์/C13-14 ไอโซพาราฟฟิน/ลอเรต-7) ซึ่งเป็นตัวทำอิมัลชันชนิดไม่มีประจุ ผลการทดลองพบว่า สูตรที่ใช้สารผสมพอลิซอร์เบต-60 ร้อยละ 1.4-2.2 จะทำให้ความหนืดของอิมัลชันค่อยๆ เพิ่มขึ้นเล็กน้อยจนกระทั่งปริมาณมากกว่าร้อยละ 2.2 ความหนืดและค่าความเป็นกรด-เบสจะคงที่ สำหรับสูตรที่ประกอบด้วยสารผสมลอเรต-7 ร้อยละ 0.5-2 อิมัลชันมีลักษณะเป็นเนื้อครีม มีความหนืดมากกว่าสูตรที่ประกอบด้วยสารผสมพอลิซอร์เบต-60 ที่ปริมาณร้อยละเดียวกัน สำหรับสูตรอิมัลชันที่มีส่วนประกอบของสารผสมพอลิซอร์เบต-60 ร้อยละ 2.2 ลักษณะเป็นโลชันและเป็นสูตรที่มีคุณภาพซึ่งยอมรับได้ โดยเกิดการแยกเพียงเล็กน้อยหลังจากนำไปเหวี่ยงที่ความเร็วรอบ 5,000 รอบต่อนาที เป็นเวลา 30 นาที ที่อุณหภูมิห้อง และไม่มีการปนเปื้อนของเชื้อจุลินทรีย์ นอกจากนั้นเมื่อนำสูตรโลชันดังกล่าวทดสอบความพึงพอใจกับกลุ่มผู้ทดสอบเฉพาะ โดยใช้แบบสอบถามความพึงพอใจ 3 ระดับ และมีข้อเสนอแนะแบบปลายเปิด ในหัวข้อความหนืด การซึมเข้าสู่ผิวหนัง ลักษณะของโลชันและการบรรเทาอาการปวดเมื่อยพบว่ามีค่าเฉลี่ยความพึงพอใจ เท่ากับ 2.7

คำสำคัญ : ตัวทำอิมัลชันชนิดไม่มีประจุ สารลดแรงตึงผิว พอลิซอร์เบต-60 ลอเรต-7 อิมัลชันชนิดน้ำมันในน้ำ

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Abstract

The formulation of the O/W tendon slacker emulsion containing the capsaicin crude as an active ingredient was prepared via a phase inversion technique. The water phase (>80% volume content) was slowly poured into the oil phase at 70-80ºC with continuous stirring. Two kinds of surfactants, the polysorbate-60 mixture (polysorbate-60/ hydroxyethyl acrylate-sodium acryloyldimethyl taurate copolymer and isohexadecane) and the laureth-7 mixture (polyacrylamide/C13-14 isoparaffin/laureth-7), were used as non-ionic emulsifiers. Consequently, a percentage of the polysorbate-60 mixture was increased at a range of 1.4-2.2% to affect the viscosity of emulsion to be slightly increased. In the mean time, using more than 2.2% of the polysorbate-60 mixture showed no effect on viscosity and pH. For the formulation composing of the laureth-7 mixture (0.5-2%), the emulsion was a cream which was more viscous than when the polysorbate-60 mixture was used at the same percentage without changing of the pH value. The emulsion containing the polysorbate-60 mixture at 2.2% would have sufficient quality to be acceptable to use as a lotion due to a small separation after centrifuge at 5,000 rpm for 30 min at room temperature and no contamination. The lotion was tested by a group of people who answered a 3-Heidonic scale satisfaction questionnaire with an opening comment on viscosity, permeation into skin, texture of the lotion and relieving for aches and pains. The result showed the objective sampling to be an average of 2.7.

Keywords : non-ionic emulsifier, surfactant, polysorbate 60, laureth-7, O/W emulsion

Introduction

An emulsion is a thermodynamically unstable two-phase system consisting of two or more liquids, one of which is dispersed in the form of small droplets throughout the other, and an emulsifier, known as the surfactant. The dispersed liquid is called as the internal or discontinuous phase and the dispersion medium is called as the external or continuous phase. The boundary between the phased is called as the interface.

Different types of emulsions can be formed including, an oil-in-water (O/W) and a water-in-oil (W/O), which are single emulsion and a water-in-oil-in-water (W/O/W) which are a multiple emulsion. Normally, emulsions are inherently unstable and do not tend to form spontaneously. Therefore, the energy input through shaking, stirring and homogenizing *etc*. is needed to form emulsion. The mechanism of emulsification can be involved by reduction of interfacial tension between two phases or the emulsifying agent creates a film over one phase that form globules, that repel each other. The emulsifiers or surfactants are substances that stabilize an emulsion by increasing its kinetic stability. The surfactants are classified as anionic, cationic, non-ionic and amphoteric (or zwitterionic) based on the type of polar group (Pimporn, 1997).

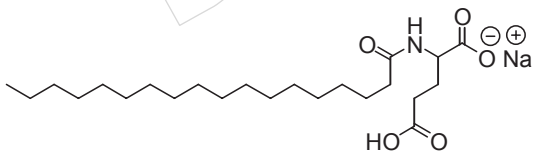
Capsaicin lotions are medicinal products consisting of capsaicin and methyl salicylate as an active constituent (Winter *et al*., 1995), not cosmetic products, since they are used for treatment of muscular pain.

For our original formula, the lotion containing 0.3% of sodium stearoyl glutamate (1) (Figure 1) as an anionic emulsifier had more bubbles, phase separation and not smooth texture when it was left at room temperature over time. The stability was referred to the ability of an emulsion to resist change in its properties. One of factors causing by emulsion stability was type and amount of emulsifiers or stabilizers beside of environmental stresses (*e.g*. pH, temperature, ionic strength) and homogenized conditions (*e.g*. pressure, heating) (Zaidel *et al*., 2013). Therefore, the objective of this research was to improve the quality of lotion especially its stability and texture -without change pH and viscosity- of the original lotion formula by using polysorbate-60 (2) and laureth-7 (3), as non-ionic emulsifiers, to be a mixture.

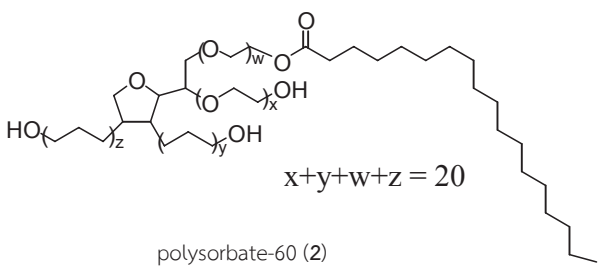
Materials and Methods

1. General Methods

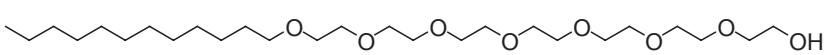
Emulsion was prepared using a high-shear mixer (model HT-120DX, Daihan Scientific Co., Ltd., Korea) with a spinning propeller. The ingredients, sodium polyacrylate



sodium stearoyl glutamate (**1**)



polysorbate-60 (**2**)



laureth-7 (**3**)

Figure 1 Structure of emulsifiers

as a thickener (Grabowska & Holtzer, 2009; Shakhashiri, 1989), dicaprylyl ether as a skin conditioning and an emollient, mineral oil as an emollient (Special Chem., 2013), methyl salicylate as a pain and an ache relieving (Winter *et al*., 1995), peppermint oil as an aromatherapy, DmDm hydantoin as a preservative (Lonza, 2012), menthol as a cooling agent and a flavoring agent, sodium stearoyl glutamate as an ionic emulsifier and a skin conditioning (Special Chem., 2013), were obtained from Huang Huad shop (Bangkok, Thailand). Simulgel FL™, that was a mixture of hydroxyethyl acrylate/sodium acryloyldimethyl taurate copolymer as a stabilizer, a thickener and an opacifying agent, isohexadecane as an emollient and polysorbate-60 as a non-ionic emulsifier, and Sepigel 305™, that was a mixture of laureth-7/polyacrylamide/C13-14 isoparaffin as a non-ionic emulsifier, a thickening agent and an emollient, were available from Seppic Co., Ltd. (Seppic, 2012). The capsaicin crude extract was obtained by soaking crushed bird chili at room temperature to give the ethanolic extract which then was concentrated using a rotatory evaporator under reduced pressure.

2. Preparation of O/W emulsion

The formulation consisted of three parts. All weighted ingredients of each part as shown in Table 1 were mixed together. Parts A and B, covered with an aluminum foil in order to prevent water evaporation, were heated at approximately 70-80ºC using a water bath with continuous stirring until homogeneous. Then, part A was slowly poured into part B under mixing using a high-shear mixer set speed at 570 rpm for 5 min to give the emulsion. Then capsaicin crude extract (part C) was also added. Finally, the emulsion was cooled down to room temperature in an ice bath.

For each developed formula, the emulsion would be evaluated for the preliminary quality including pH value, viscosity, texture and stability. Only those with adequate quality would be further surveyed for user satisfactory and total microbes.

3. Evaluation of the prepared emulsion

pH value: A electrode of pH meter (model Index ID1000, USA) was directly immersed into the emulsion. The pH value was recorded at constant reading.

Table 1 The ingredients of emulsion formulae

Parts/Ingredients	Formulae (%)			
	I	II	III	IV
A. sodium polyacrylate	0.4	0.4	0.4	0.4
Simulgel FL™	-	1.4-3[a]	-	2.2
Sepigel 305™	-	-	0.5-2[b]	-
dicaprylyl ether	3	3	3	3
mineral oil	4	4	4	4
methyl salicylate	4	4	4	4
pappermint oil	1	1	1	1
B. deionized (DI) water	e.q. 100	e.q. 100	e.q. 100	e.q. 100
DmDm hydantoin	0.6	0.6	0.6	0.6
menthol	5	5	5	5
sodium stearoyl glutamate	0.3	-	-	0.3
C. capsaicin crude extract	0.05	0.05	0.05	0.05

The specification is 0.6-3%[a] and 0.5-2%[b].

Viscosity: The viscosity of emulsion was measured in a bottle with diameter 4 cm and high 5 cm of emulsion by model Brookfield DV–I Prime with spindle no. 0.7S which should be centered and recorded at constant reading. Do not allow air bubbles to be formed.

Texture testing: The emulsion was put on the top of an opaque white plastic and then swept down with a spatula.

Emulsion stability: The emulsion was monitored as a mechanical method for its shelf life prediction by using centrifugation at 5,000 rpm at room temperature for 30 min (Pimporn, 1997).

To satisfy testing: The quality formula was only surveyed the satisfaction by twenty volunteers who answered a 3-Heidonic scale questionnaire, (1) = should be improved, (2) = moderate and (3) = good, with an opening comment on viscosity, permeation into skin texture of the lotion and relieving of muscular aches and pains. Statistical data analysis was evaluated by t-test.

Total microbes: The quality formula was only tested at four concentrations, 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4} %v/v, during one week for a total microbe assay against fungi, bacteria and yeast (John & James, 1999.; Rippere, 1978). The total microbes were counted as Colony Forming Unit (CFU)/g. When the amount of CFU was too dense to count, it was recorded as TNTC (Too Numerous to Count).

Results and Discussion

For the process of the tendon slacker lotion, a water phase was slowly added into an oil phase as internal phase that had not more than 74% volume content leading to O/W emulsion via the Phase Inversion technique (PIT).

Sodium stearoyl glutamate (1) as an anionic surfactant had both a hydrophilic (or polar) and a hydrophobic (or nonpolar) portion in theirs structure. The polar one was attracted to the water or other polar compounds, and another was oriented toward the oil or other nonpolar compounds. Realizing, it was adsorbed at the interface in a monolayer like a micelle (Chern, 2006). Usually, the anionic surfactants have relatively the high water solubility and thus generally make O/W emulsion. Unfortunately, sodium stearoyl glutamate could not enhance the stability of micelle by creating a charge on the droplet surface, subsequently reducing the physical contact between the droplet and decreasing the potential of coalescence. The emulsion with 0.3% of sodium stearoyl glutamate (formula I) has non-smooth texture and showed a phase separation from centrifugation at 5,000 rpm for 30 min.

The percentage of Simugel FL™, the polysorbate-60 mixture, at 1.4-3% (formula II) were formulated instead of sodium stearoyl glutamate at 0.3%. It was found that the viscosity of emulsion (about 750-2,000 cP) was slightly increased as well as pH value (pH 7.2-7.6) at the range of 1.4-2.2% of Simugel FL™ (Figure 2). Using polysorbate-60 mixture more than 2.2% did not affect the viscosity and pH of the formulations. All formulations, especially that using 2.2% of Simugel FL™, showed smooth texture without any bubbles and appeared to contain the same size of droplets and consistant density (Figure 3) leading to its higher stability than the original lotion formula, containing 0.3% of sodium stearoyl glutamate. The viability of the emulsion was further affirmed with the preliminary stability testing. The result showed a small but acceptable separation.

On the other hand, using Sepigel 305™, the laureth-7 mixture, at concentration of 0.5-2% (formula III) the viscosity gradually increased at low concentration until up to 1.7%. Increasing concentration beyond 1.7% no longer affected viscosity of formulations (Figure 4). Also, it did not change the pH value which was found to be pH 7.6-8 within the range of the emulsion specification (pH 6-8). In contrast, the texture of the emulsion was fluid at 0.5-1.1% and became a smooth cream at >1.4% without separation.

As mentioned above, both 2.2% of Simulgel FL™ and 1.7% of Sepigel 305™ provided more a quality

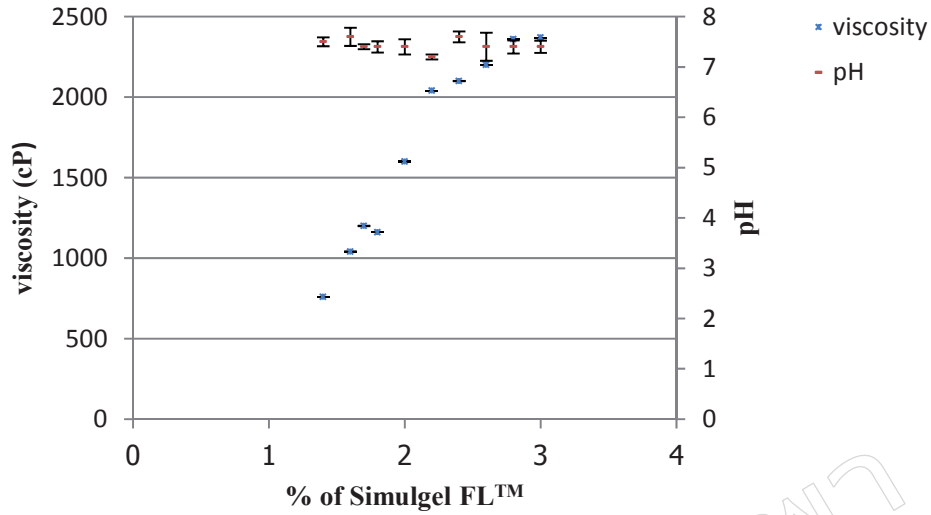
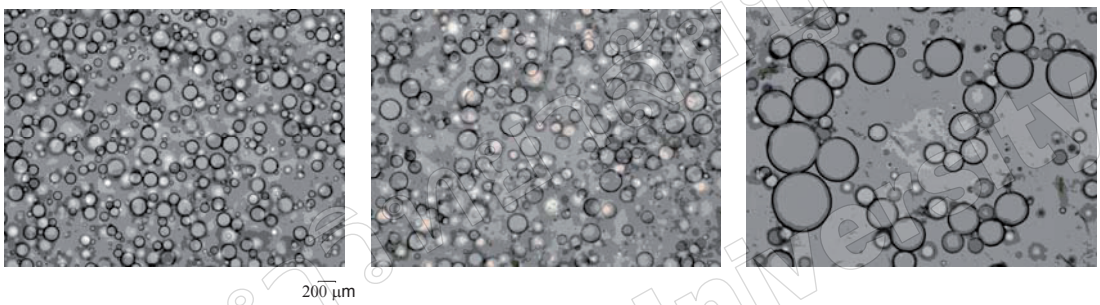


Figure 2 The viscosity and pH of emulsion containing Simugel FL™ at concentration 1.4-3%



(a) 2.2% of Simugel FL™ (b) 1.7% of Sepigel 305™ (c) 0.4% of sodium stearoyl glutamate

Figure 3 The droplet size of emulsion via a microscope (x10)

emulsion than 0.3% of sodium stearoyl glutamate. For the mechanism, it was expected that the poysorbate-60 and laureth-7 as non-ionic surfactants in the mixture had improved theirs physical stability since they had reduced the oil-water interfacial tension and formed to be a protective membrane around the oil droplets, which prevented them to be aggregation. A Na^+ ion of sodium stearoyl glutamate was incompatibility with mostly non-polar ingredients of formula and/or a droplet of emulsion was combined into a larger one (Pimporn, 1997; Tauer *et al*., 2005). This reason supposed to sodium stearoyl glutamate affecting to destabilization of emulsion. As assumption, the formula containing sodium stearoyl glutamate and Simulgel FL™ at a ratio of 0.05:2.2, 0.1:2.2 and 0.3:2.2 as a co-emulsifier (formula IV) were proved to display not smooth texture of all formulae but they gave a less phase separation than the formula I (0.3% of sodium stearoyl glutamate).

Therefore, the best formula of the tendon slacker emulsion should be contained 2.2% of Simugel FL™, the polysorbate-60 mixture, whose viscosity as a lotion was nearby the original product than using 1.4% of Sepigel 305™, which was further surveyed a satisfaction with twenty volunteers who had pains and aches by using a 3-Heidonic scale satisfaction questionnaire with an opening comment on its viscosity, permeation into skin, texture of lotion and relieving of muscular aches and pains (Table 2). The results showed an average satisfactory level

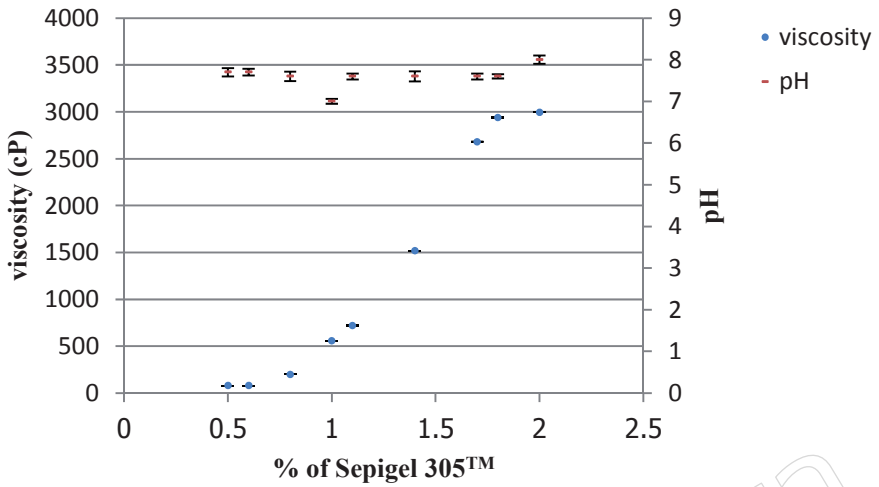


Figure 4 The viscosity and pH of emulsion containing Sepigel 305™ at concentration 0.5-2%

Table 2 The satisfaction of twenty volunteers using a 3-Heidonic scale questionnaire

litems	A satisfaction/Formula	
	2.2% Simugel FL™	0.3% sodium stearoyl glutamate
Viscosity	2.8	1.9
Permeation into skin	2.7	2.1
Texture	2.9	2.1
Relieving of pains	2.5	2.5
average	**2.7**	**2.2**

of 2.7 (out of 3) by comparison with the original lotion formula, composing of 0.3% sodium stearoyl glutamate, with an average score of 2.2.

Additionally, the result of the total microbes of the lotion showed no contamination of fungi, bacteria and yeast. However, formula must be further evaluated for shelf life prediction by accelerating method in reasonable time during product design (Pimporn, 1997).

Conclusion

The emulsion formulae containing 2.2-3% of polysorbate-60 mixture and 1.7-2% of laureth-7 mixture as non-ionic emulsifiers provided not change pH value, smooth texture and homogeneous with a small phase separation, but they were acceptable. The polysorbate-60 mixture had less viscosity than laureth-7 mixture. The lotion composing of polysorbate-60 mixture 2.2% led to the best quality, that showed more satisfaction and no contamination.

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