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Enhancing the Moisturizing Ability of the Skin Softener using Nanoemulsion Based on Phospholipid Liposome

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Abstract

In this paper, we present the improvement in low moisturizing ability and stability that existing skin softeners have due to the low oil content, by developing skin softener using nanoemulsion of phospholipid liposome, based on the properties of nanoemulsion in cosmetic formulation. In this study, two types of oil; dimethicone (DC 200/6cs) or medium chain triglyceride (MCT), and two kinds of lecithin; unsaturated or saturated were respectively applied to produce nanoemulsion. In the particle size analysis of nanoemulsion, the droplet size of nanoemulsion containing DC200/6cs and unsaturated lecithin was the smallest, and all nanoemulsion showed high stability in the measurement of zeta potential. Therefore, with the smallest particle size and high stability, moisture contents and trans epidermal water loss(TEWL) were measured using the skin softener of DC200/6cs and unsaturated lecithin contained nanoemulsion, and the measurement was compared with the non-oil skin softener and the skin softener with only small amount of oil. The results showed that the moisture content of the skin softener using nanoemulsion increased greatly than other two skin softeners, showing high hydration ability and water retention capacity, and TEWL decreased greatly, therefore preventing the evaporation of moisture from the skin. As a result, the oil content and stability of the skin softener was improved by utilizing nanoemulson based of phospholipid liposome, and it is expected to be used in various ways in cosmetic industry.

Keywords: *Nanoemulsion, Phospholipid Liposome, Cosmetics, Skin Softener, Moisturizing Ability*

1. Introduction

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering [1].

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Nanotechnology also has been utilized diversely in cosmetic formulation, in terms of efficacy, usability and stability, such as nanoemulsion, polymeric nanoparticles and solid lipid nanoparticles. Nanoemulsion is referred to emulsion with a particle size of 50 to 200nm, and because of the properties that nanoemulsion possesses, it has been studied in various areas of cosmetics [2]. By the submicrometric size of nanoemulsion, a destabilization factor of emulsion system, i.e. flocculation, is averted, which extends the shelf-life of products. As the consequence of reduced gravity force and Brownian motion, another premature destabilization is avoided, which leads to the zero sedimentation during preservation [3]. Moreover, nanoemulsion demonstrates better penetration effect of the components because of the large surface area and low surface tension of the entire emulsion system [4], therefore only 3-10% of surfactants are needed for process [5]. Consequentially, nanoemulsion appear more fluid, with presenting attractive physical properties and feeling of the skin. It also prevents phenomena caused by destabilization, such as creaming or sedimentation, flocculation and coalescence that typically exerts influence on emulsion [6], as a result of considerable steric stabilization among the minuscule particle size [7].

To produce minute droplet size of nanoemulsion, or to change the formulation, various ways to emulsify nanoemulsion have been studied, including inversion emulsification, phase inversion temperature (PIT), and high-pressure homogenization, etc [8]. Formulating by microfluidization, form microscopic emulsions at much reduced surfactant-to-oil ratio (SOR<0.1) [9], and shear, impact and cavitation effects colligated with high pressure excellently emulsifies the fluid [10]. Therefore, microfluidizer (MF) is used to develop the new formulation for controlling stabilization and absorption of the skin.

In this study, based on these characteristics of nanoemulsion, we applied microfluidizer on existing skin softener which had general solubilization system and relatively low hydration because of insufficient oil content, to develop high moisturizing and stable skin softener containing high amount of oil.

2. Materials and Methods

1. Materials

In this study, to investigate the particle size and the stability of nanoemulsion, two types of lecithin, saturated and unsaturated, were used, which were obtained from Neuropid Co. (Jeollanam-do, Korea). Two types of oil were used to check the difference in hydration and usability, DC200/6cs (dimethicone) obtained from Dow Corning Co. (USA) and MCT (medium chain triglycerides, caprylic/capric triglyceride) obtained from Ewoo Chemical Co. (Seoul, Korea). Water was self-supplied using Water Purification (Romax, Human Science Co., Gyeonggi-do, Korea). Glycerin from Daejung Chemical Co. (Gyeonggi-do, Korea), and 1,2-hexanediol from Activon Co. (Gyeonggi-do, Seoul) were also used. Adenosine and alcohol were purchased from Daejung Chemical Co. (Gyeonggi-do, Korea), Butylene glycol from Kyowa Co. (Japan), PEG-60 hydrogenated castor oil (Nikkol HCO60) from Nikko Chemicals Co. (Japan), phenyl trimethicone (KF-56) from Shin-Etsu Co. (Japan), methyl paraben (Danisol M) from Danil Fine Chemicals Co. (Gyeonggi-do, Korea), and perfume was obtained from French Korean Aromatics Co. (Gyeonggi-do, Korea). Except for the 95 percent pure alcohol, all materials are 99 percent purified. The equipment used in the experiment is as follows. Microfluidizer (Picomax High Pressure Homogenizer, Micronox Co., Gyeonggi-do, Korea), particle size analyzer and zeta potential (Stabino®, Particle Metrix Co., Germany), corneometer (CM825, CK electronic GmbH, Germany) and tewameter (TM210, CK electronic GmbH, Germany).

2. Formulations and Method of Nanoemulsion

Producing nanoemulsion was classified into four different formulations using two types of oil; DC200/6cs or MCT and two kinds of lecithin; saturated or unsaturated lecithin. In this study, nanoemulsion contained 60% of glycerin, 5% of lecithin, 8% of deionized water, 2% of 1,2-hexanediol and 25% of oil. Pre-emulsion was first prepared by using homogenizer, then put into microfluidizer to produce nanoemulsion. To form pre-emulsion, purified water, glycerin, lecithin and 1,2-hexanediol were uniformly dissolved in water phase at 70℃ using agitator. After homo-mixing at 2,400 rpm for 15 minutes, pre-emulsion was put into microfluidizer at high pressure of approximately 1,000 bar, to produce nanoemulsion [11].

3. Formulations of Skin Softener

Three skin softener formulations are presented in Table 1. It shows formulation of skin softener-0 which contains no oil, skin softener-1 with 0.15% of phenyl trimethicone (oil) and skin softener-2 with 20% of nanoemulsion containing 25% oil (DC200/6cs or MCT). Deionized water, adenosine, glycerin and 1,3-butylene glycol were included in water phase of formulation, and 95% alcohol, PEG-60 hydrogenated castor oil, phenyl trimethicone, methyl paraben and perfume were included in alcohol part. Alcohol part was heated to 50℃ for transparent solubilization, then put into water part and was mixed at 1,000 rpm. Nanoemulsion was added to skin softener-2 at room temperature then was agitated at 1,000 rpm.

Table 1. Skin softener formulations (%)

Ingredients	Skin Softener-0	Skin Softener-1	Skin Softener-2
Deionized water	89.33	89.18	69.33
Adenosine	0.04	0.04	0.04
Glycerin	3.00	3.00	3.00
1,3 Butylene glycol	2.00	2.00	2.00
Alcohol, 95%	5.00	5.00	5.00
PEG-60 hydrogenated castor oil	0.50	0.50	0.50
Methyl paraben	0.10	0.10	0.10
Perfume	0.07	0.07	0.07
Phenyl trimethicone	-	0.15	-
Nanoemulsion (25% oil content)	-	-	20.00

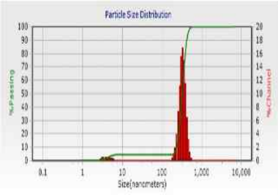
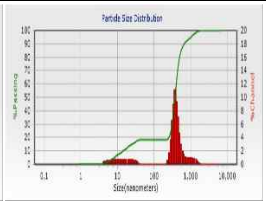
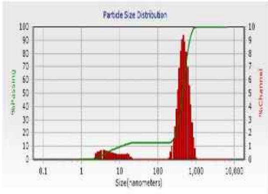
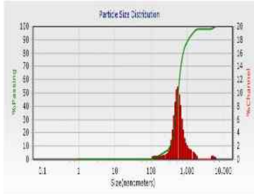
3. Results and Discussion

1. Particle size

Nanoemulsion was classified into four different formulations (Formulation 1 with unsaturated lecithin and DC200/6cs; Formulation 2 with unsaturated lecithin and MCT; Formulation 3 with saturated lecithin and DC200/6cs; Formulation 4 with saturated lecithin and MCT) which are represented in Table 2.

We made aqueous solution to measure the particle [12, 13]. Nanoemulsion and purified water was homo-mixed at a ratio of 1:8 at 2,300 rpm. 'Formulation 1' with unsaturated lecithin and DC200/6cs was measured the smallest among 4 formulations, with the particle size of 326 nm. The results of the particle size are shown in Table 2.

Table 2. Particle size of nanoemulsion aqueous solution

	Formulation 1 (Unsaturated lecithin & DC200/6cs)	Formulation 2 (Unsaturated lecithin & MCT)	Formulation 3 (Saturated lecithin & DC200/6cs)	Formulation 4 (Saturated lecithin & MCT)
Particle size	 320.0 ± 3.0 nm	 381.0 ± 9.8 nm	 424.6 ± 20.0 nm	 675.6 ± 60.6 nm

2. Zeta potential

For measuring zeta potential, nanoemulsion aqueous solution was also made as the same with measuring particle size. Figure 1 shows zeta potential results of nanoemulsion aqueous solution. Zeta potential of ‘Formulation 2’ with unsaturated lecithin and MCT showed the highest rate. Although the tendency of zeta potential was not proportional to the particle size results, all four nanoemulsion marked high zeta potential rates, and are considered to hold high stability in formulation [14].

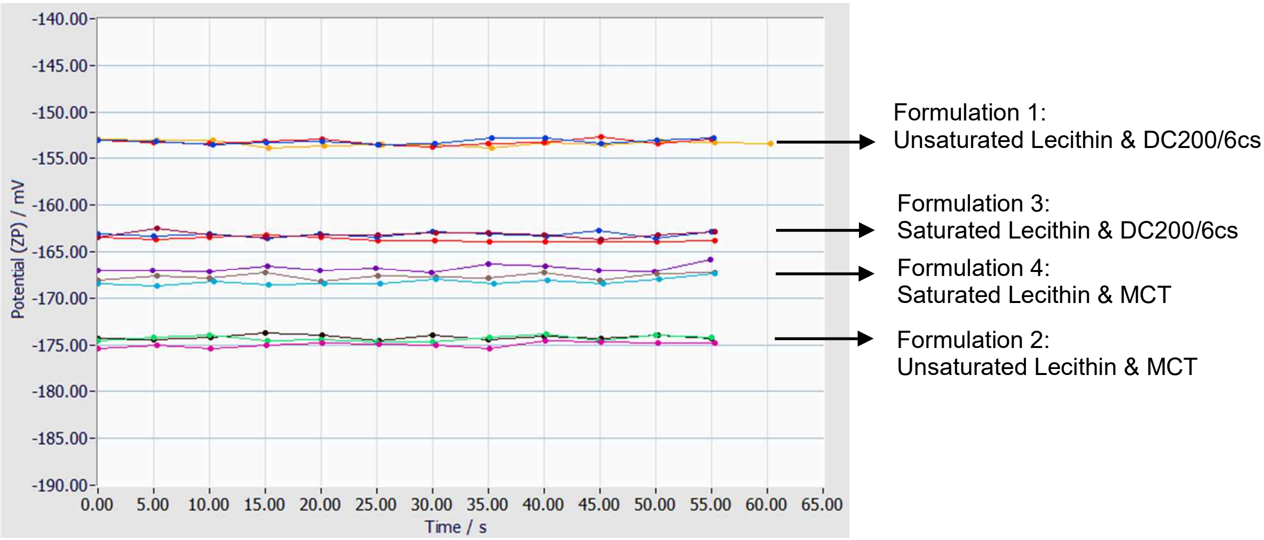


Figure 1. Zeta potential of nanoemulsion aqueous solution

3. Moisture content

Measuring moisture content of the skin was proceeded at 20-24°C and humidity level of 40-60%, following the guide lines from ‘Korean Ministry of Food and Drug Safety’. With 10 subjects, one arm of each subject was divided into three parts and measured each part with corneometer probe for three times at the same pressure to obtain an average value. We measured three times for each skin softener, before applying the skin softener, right after applying it, and after 20 minutes.

We used three skin softeners to measure skin moisture content, skin softener-0 and skin softener-1 for comparison group, and skin softener-2 which showed the smallest droplet size and high stability. Figure 2 shows the average increase in the moisture content right after applying skin softener compared to before applying. Figure 3 shows the average decrease in the moisture content 20 minutes after compared to skin softener applied right after. The skin softener-2 containing nanoemulsion showed the average increase of 55.33 arbitrary unit (a.u.), improved considerably compared to skin softener-0 and 1. Moreover, the average moisture content of skin softener-2 after 20 minutes decreased only by 8.56 a.u., noticeably less reduced than other two skin softeners, indicating that skin softener-2 has high water retention ability even after a certain period of time.

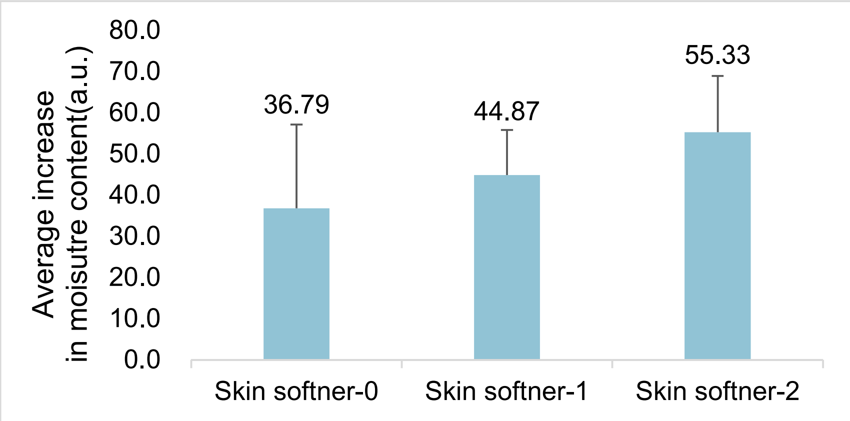


Figure 2. Average increase in the moisture content right after applying skin softener compared to before applying

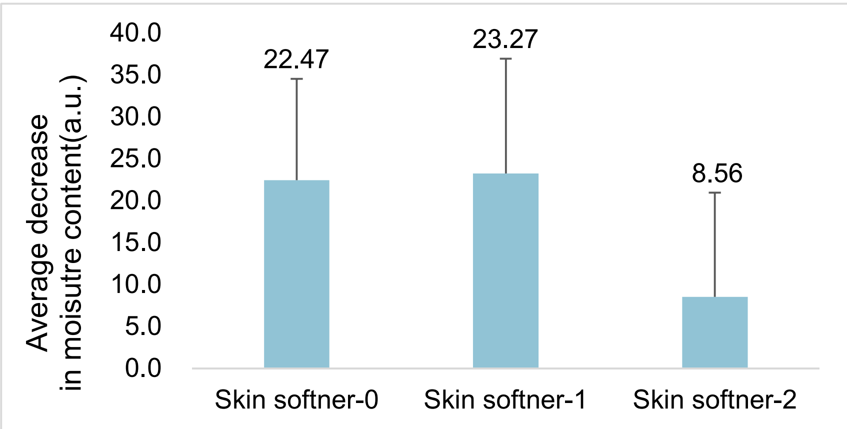


Figure 3. Average decrease in the moisture content 20 minutes after compared to skin softener applied right after

4. Trans epidermal water loss (TEWL)

Measuring TEWL was also proceeded at 20-24°C and humidity level of 40-60%, following the guide lines from 'Korean Ministry of Food and Drug Safety'. With 10 subjects, one arm of each subject was divided into three parts and measured each part with the tewameter probe for 20 seconds to obtain an average value. In this case, we measured twice for each skin softener, before applying and after 20 minutes.

We used the same three skin softeners, skin softener-0, 1 and 2 for the same reason as corneometer measurement, to measure TEWL of the skin. Figure 4 shows average decline in TEWL 20 minutes after applying skin softener compared to before applying. While skin softener-2 was decreased remarkably in TEWL by average 1.8 h/hm², TEWL of skin softener-0 and 1 on the contrary increased after applying skin softener.

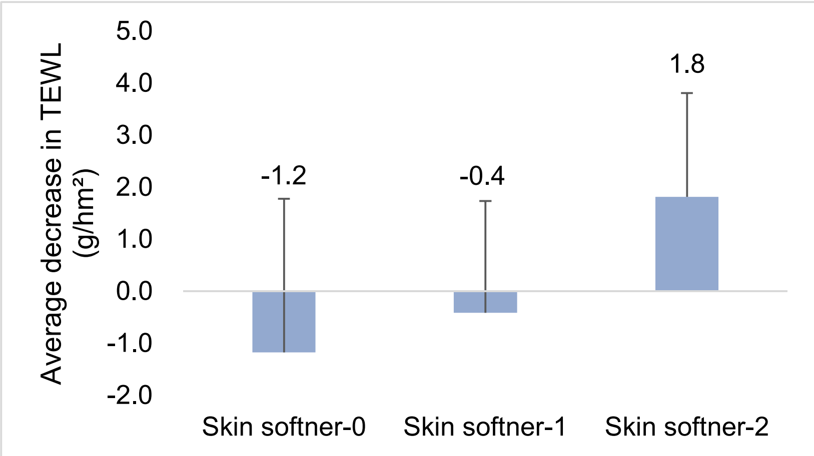


Figure 4. Average decrease in TEWL 20 minutes after applying the skin softener compared to before applying

4. Conclusions

The purpose of this study was to enhance moisturizing ability and stability of skin softener by increasing the oil content, using nanoemulsion. Therefore we used two types of oil, DC200/6cs and MCT, with saturated and unsaturated lecithin to form phospholipid liposome based nanoemulsion and applied it to skin softener.

The nanoemulsion using DC200/6cs and unsaturated lecithin was the smallest in particle size analysis with 326 nm of the droplet size, and marked high zeta potential rate, which shows high stability. Therefore, this nanoemulsion was applied to the skin softener and measured moisture content and TEWL of the skin.

In the measurement of moisture content using corneometer, skin softener-2 containing nanoemulsion had a greater increase in moisture content after applying skin softener, compared to non-oil skin softener-0 and 0.15% oil skin softener-1. Also, skin softener-2 marked remarkably low decrease of the moisture content after 20 minutes compared to other skin softeners. In TEWL measurement using tewameter, for skin softener-2, the TEWL of the skin 20 minutes after applying skin softener declined significantly.

In case of existing skin softener, such as skin softener-1, if more than 0.15% of oil is added, it becomes unstable. By utilizing nanoemulsion, like skin softener-2, it is possible to contain 5% of oil, which leads to enhancing the moisturizing ability and stability of existing skin softener.

In this research, we developed the skin softener with increased oil content and stability using nanoemulsion based on phospholipid liposome. Through this process, we could examine the availability of nanoemulsion once more in cosmetic formulation, and applications to cosmetics combined with various fields are also expected.

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