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화장품 사용감과 레올로지 물성치 및 물리적인 특성값들에 대한 상관관계 연구

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A Study on the Correlation of the Skin Feeling with Rheological Parameters and Other Physical Properties

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요 약: 본 연구는 화장품 사용감을 기계적인 방법으로 측정하고자 하는 시도로써 계면활성제, 왁스, 고분자 점증제, 폴리올, 오일류들의 종류 및 함량에 따라 사용감(흡수속도, 끈적임, 잔여감의 가중치 환산값)의 변화가 어떻게 나타나며 이들의 점탄성적인 특성과는 어떤 상관관계가 있는가를 알아보았다. 계면활성제, 왁스, 고분자 점증제의 경우 사용감과 점탄성 물성치인 phase angle 값의 변화에 대하여 각각 강한 상관관계를 보였지만, 폴리올, 오일의 경우에는 사용감과 본 연구에서 측정한 점탄성 물성치와는 뚜렷한 경향성은 나타내지 못하였다. 이는 사용감이 특정 기기적인 측정값으로 완전하게 대응하는 것은 아닐 수 있음을 나타내며, 여러 물성치의 함수로 나타낼 수 있을 것으로 사료된다. 추가로 측정하고 있는 물성값(마찰력, 휘발도, 등등)을 이용하면, 더 좋은 상관관계를 찾을 수 있을 것으로 예측된다.

Abstract: This study was pursued to measure skin feeling of cosmetics by mechanical methods. For this attempt, skin feeling of cosmetics such as spreading properties, tackiness, and residual greasy feeling after skin application was explored with the amount and kinds of cosmetic compositions-emulsifiers, waxes, thickeners, polyols, and oils. Furthermore, the relationship between these cosmetic compositions and viscometry of cosmetic products was studied. In case of emulsifiers, waxes, and thickeners, they showed strong correlation with both skin feeling and the value of phase angle, the property of viscometry, respectively, while polyols and oils were observed a special tendency neither skin feeling nor the property of viscometry. It leads to the conclusion that skin feeling may be corresponded to not values of a mechanical measure completely but a function of several properties. We expect that a better correlation can be discovered with additionally measured properties such as friction, volatility, etc.

Keywords: *skin feeling, correlation, rheology*

1. Introduction

Cosmetic manufacturers place high standards for design and production of products in order to meet customer's expectations of the product quality. Sensory performance of cosmetic emulsions when applied on the skin is the core of our understanding of consumer acceptability. For this reason, the cosmetic companies have been interested in a relationship between the sensory data and rheological parameters, in order to understand and predict how the consumer acceptance for cosmetic application is influenced by product formulations. The consumer acceptance is governed by various physicochemical properties of the product, such as appearance, flavor, primary feeling on contact with the skin, spreading properties, tackiness, and residual greasy feeling after skin application. It is the formulator's desire for values conveying the clear-out relationship between the measurable properties of products and the customer's subjective evaluation, which is critical to the acceptance of a product[1-3].

Cosmetic emulsions are non-Newtonian complex fluid

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mixtures characterized by structural features which influence, and also are influenced by, their flow. When cosmetic emulsions shear, whether during manufacture, viscometry, or in application onto the skin, the structure is broken down by bonding cleavage within the emulsions, and the consistency decreases as the emulsions work soften. In this study, we investigated the relationship between the skin feeling of cosmetic lotions and the rheological parameters as a function of cosmetic compositions, such as oils, waxes, emulsifiers, thickeners, polyols, and their concentrations. The lotions were also evaluated by a group of trained panels on the basis of three sensory attributes of a cosmetic product: penetration, spreadability, and residual greasy feeling. By the comparisons of these data, we will discuss the objectification of the subjective skin feeling by using the fundamental rheological examination of a cosmetic[4,5].

2. Experimental Methods

Emulsifier, wax, oil, polyol, and polymeric thickener were selected as a major experimental parameter affecting the rheological properties of cosmetic lotions. Three different emulsifiers were used: Tegocare 450, lecithin (Lipoid S75-3), Tween 60, and Arlacel 83. Four different oils were used: MOD, polydecene (Puresyn-4), cyclodemethicone (DC345, Dow Chemical., U.S.A.), and ODO. Five different waxes were used: cetos KD, multi wax, paraffin, vaseline, and stearic acid. Three different polyols were used: glycerine, 1,3-buthylene glycol, and konlub. Four different polymeric thickeners were used: carbopol 940, carbopol 941, carbopol ETD2020, and Pemulen TR-2. All materials used in this study are listed in Table 1.

Rheological measurements were performed on Bohlin rheometer with 40 mm parallel plate, 0.318 Hz of frequency, and 0.01~100 Pa of stress range in a dynamic stress sweep test. For the sensory evaluation of the lotions, 3 untrained persons accessed the lotions by rubbing them onto the skin of the forearm and quoting the lotions on the basis of three attributes: penetration (P), spreadability (S), and residual greasy feeling (R). Each attribute was evaluated by a quotation on an imposed scale form 0 to 10 and combined into an index, termed as the skin feeling score, which is defined as 10P + 9S + 8R.

3. Results and Discussion

As the shear stress increased, all of the lotions tested showed the decrease in the viscosity and the related increase in the loss angle, zero for an ideally elastic gel (all energy stored in the material) and 90° for an ideally viscous liquid (all energy dissipated as heat). This is referred to shear thinning, which is a nonlinear phenomena pronounced in concentrated polymer solutions. In this study, it is assumed that the shear thinning property is critical in inducing the sensory changes of cosmetic emulsions when applied and rubbed on the skin. A loss angle profile as a function of shear stress is very useful to compare the shear thinning properties of cosmetic emulsions. In particular, 45° of loss angle means the transition from the elasticity-dominant regime to the viscosity-dominant regime, and the corresponding shear stress, termed a critical shear stress (c.s.s.), can be used to compare the cosmetic lotions.

Nineteen different lotion formulations were prepared with five different major factors: a) emulsifier, b) oil, c) wax, d) polyol, and e) polymeric thickener. Table 2 shows the effect of emulsifiers on rheological properties and skin feeling score. Figure 1 also shows the viscosity and loss angle profiles as a function of shear

Table 1. Materials Used for the Preparation of Cosmetic Emulsions

Surfactant	Wax	Oil	Polyol	Polymer
Lecithin Tween60/Arlacel83 Tegocare450	Cetos KD Multiwax Paraffin wax Vaseline Stearic acid	MOD Puresyn 4 DC 345 ODO MOD	Konlub Glycerine 1,3-BG*	Carbopol 940 Carbopol 941 Pemulene TR2 Carbopol ETD2020

* 1,3-butylene glycol

Table 2. Effects of the Emulsifier on the Skin Feeling Score and c.s.s.

Emulsifier	Oil	Wax	Polyol	Polymer	Skin feeling score	c.s.s. ranking
Tegocare	MOD	-	-	Carbopol 941	7.7	3
Lecithin	MOD	-	-	Carbopol 941	6.5	2
T-A*	MOD	-	-	Carbopol 941	5	1

* Tween 60/ Arlacel 83

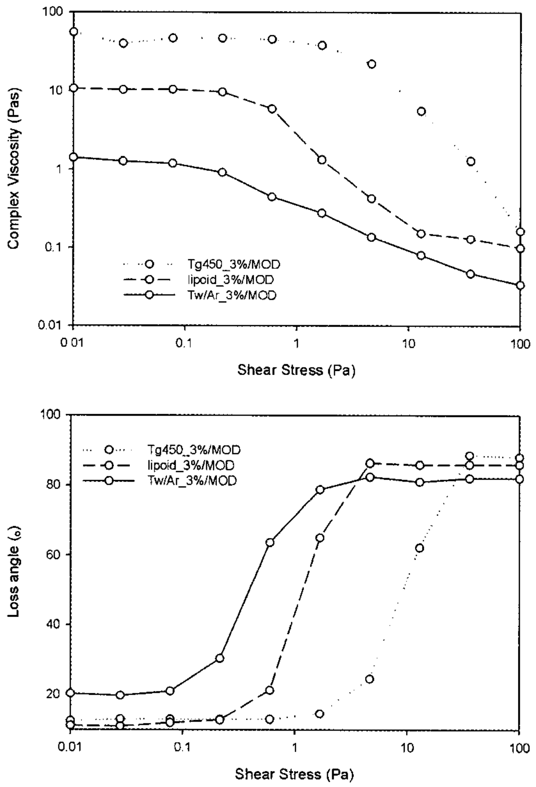

Figure 1. Viscosity (over) and loss angle (under) profiles of cosmetic lotions with different emulsifier compositions as a function of shear stress at room temperature.

stress. Interestingly, the skin feeling score was high in the order of tegocare 450 (7.7) > lecithin (6.5) > tween 60/arlacel 83(5.0), and the c.s.s. had the same trends: tegocare 450 > lecithin > tween 60/arlacel 83. It should be noted that the higher c.s.s. means the retarded transition of the lotions from an elastic solid-like state to a viscous liquid state. In addition, tegocare 450 had the highest value of zero shear viscosity.

Wax had the same tendency between the skin feeling score and the c.s.s., as listed in Table 3. The skin feeling score was high in the order of cetos KD > multiwax > paraffin > vaseline > stearic acid. Wax is solid at a normal temperature and insoluble in water and can increase the viscosity of the oil droplets in the oil-in-water emulsions, which might be related to the shear rupturing property in complex fluids, as presented by Mason *et al.* (1997)[3], because shear rupturing viscoelastic polydisperse emulsion in a thin gap can lead to a monodisperse emulsion of smaller droplets. In this regard, emulsifier and wax are an important factor in membrane curvature elasticity and deformation of droplets under shear flow. Therefore, it is expected that the internal oil phase and its interfacial properties also play an important role in determining the viscoelasticity of the total emulsion system, and in turn their skin feeling during application.

Polymeric thickeners are the main rheological modifier in cosmetic products. In this study, polyacrylic acid-based water-soluble polymers, Carbopol series, were used to thicken the aqueous phase. Interestingly, thickener had the same trends with emulsifier and wax between the skin feeling score and the c.s.s., as listed in Table 4. More elastic emulsion lotions showed the higher skin feeling scores.

In contrast, polyol and oil showed the unreliable tendency of the relationship between the skin feeling score and the c.s.s., as listed in Table 5 and 6. As for polyol, one possible explanation of this phenomenon is that high densities of hydroxyl groups in polyol molecules can facilitate their chemical interactions with other ingredients, such as thickeners, surfactants, etc., in cosmetic formulations. Therefore, it seems likely that polyols are involved in the chemical sub-system of cosmetics rather than in the physical sub-system, and their interactions affect the rheological properties of cosmetics in an indirect manner. It is worth noting that polyols themselves cannot be used to thicken the emulsions in the contrast to waxes and polyacrylic thickeners, which can augment the viscosity in the dispersed and continuous phase, respectively. As for oil,

Table 3. Effects of the Wax on the Skin Feeling Score and c.s.s.

Surfactant	Oil	Wax	Polyol	Polymer	Skin feeling score	c.s.s. ranking
T-A	MOD	Cetos KD	-	Carbopol 941	8.0	5
T-A	MOD	Multi Wax	-	Carbopol 941	6.3	4
T-A	MOD	Paraffin	-	Carbopol 941	5.7	3
T-A	MOD	Vaseline	-	Carbopol 941	4.8	2
T-A	MOD	Stearic Acid	-	Carbopol 941	6.5	1

Table 4. Effects of the Thickener on the Skin Feeling Score and c.s.s.

Surfactant	Oil	Wax	Polyol	Polymer	Skin feeling score	c.s.s. ranking
T-A	MOD	Cetos KD	-	Carbopol 940	6.5	1
T-A	MOD	Cetos KD	-	Carbopol ETD 2020	6.3	3
T-A	MOD	Cetos KD	-	Carbopol TR-2	6.0	2
T-A	MOD	Cetos KD	-	Carbopol 941	4.8	4

Table 5. Effects of the Polyol the Skin Feeling Score and c.s.s.

Surfactant	Oil	Wax	Polyol	Polymer	Skin feeling score	c.s.s. ranking
T-A	MOD	Cetos KD	Glycerine	Carbopol 941	5.0	1
T-A	MOD	Cetos KD	1,3 BG	Carbopol 941	4.0	2
T-A	MOD	Cetos KD	Konlub	Carbopol 941	2.3	3

Table 6. Effects of the Oil on the Skin Feeling Score and c.s.s.

Surfactant	Oil	Wax	Polyol	Polymer	Skin feeling score	c.s.s. ranking
T-A	MOD	-	-	Carbopol 941	6.5	4
T-A	Puresyn-4	-	-	Carbopol 941	5.8	3
T-A	DC345	-	-	Carbopol 941	5.5	2
T-A	ODO	-	-	Carbopol 941	4.7	1

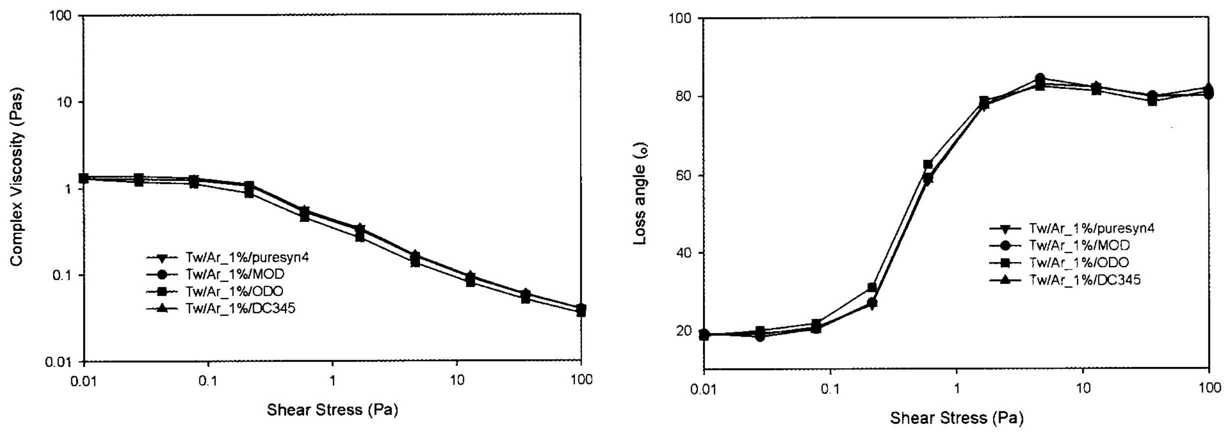

Figure 2. Viscosity (left) and loss angle (right) profiles of cosmetic lotions with different oil compositions as a function of shear stress at room temperature.

no significant effects on rheological and sensory data were found.

4. Conclusions

This study demonstrated that the basic relationships shown in the effect of emulsifiers, waxes, and polymeric thickeners, were similar in that each relates a good skin feeling score to a higher critical shear stress and elastic modulus. However, the relationship was not applicable to the cases of polyols and oils, where no reliable tendency was observed. It is expected that a major challenge is to get to the bottom of the complexity of the skin feeling property, which is intrinsically a composite of the interactions of two or more parameters.

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