Abstract

Background:

As the exposure to heat stress increases due to environmental changes such as the aggravation of global warming and increasing outdoor activities, consumers' interest in skin moisturizing is keep increasing. The aim of this study is to show the developed moisture and the sensory properties of urea in a hydrogel, utilizing the urea's hygroscopic and endothermic characteristics.

Methods:

The hydrogel was divided into an aqueous phase first agent and a powdery second agent containing urea. The endothermic properties of the urea were confirmed by uniformly mixing the two agents to make a hydrogel.

Results:

A higher temperature change was shown when urea was added to be evenly dispersed in the hydrogel than when urea was added to a general aqueous formulation. In addition, it exhibits higher water-containing effects even at high temperatures.

Conclusion:

In order to apply the endothermic and water-containing properties of urea, it is important to distribute the urea evenly. When applied to hydrogels, it exhibits higher endothermic and hygroscopic effects than adding urea to typical aqueous formulations.

Keywords: (4-6 keywords separated by a semicolon).
Urea, hydrogel, cooling agent, moisturizing, sensory effect

Introduction.

Urea, as a component of the Natural Moisturizing Factor(NMF), is a hygroscopic material that attracts and retains water molecules. In addition, urea lowers the surrounding temperature through an endothermic reaction when it is dissolved in water and changes its phase into an aqueous solution. As the exposure to heat stress increases due to environmental changes such as the aggravation of global warming and increasing outdoor activities, consumers' interest in skin moisturizing is keep increasing. The aim of this study is to show the developed moisture and the sensory properties of urea in a hydrogel, utilizing the urea's hygroscopic and endothermic characteristics.

Materials and Methods.

* Measurement of temperature change according to dissolution of urea

Dissolve the pellets of urea in deionized water 50g and measure the real-time temperature changes using a probe thermometer.

* Hydrogel composition and preparation

The hydrogel was separated into the first agent and the second agent. The first agent is an aqueous phase which made in 3% solution of sodium alginate, and the second agent is a powder phase containing calcium and urea.

To second agent into powder, milling is performed twice for 30 seconds in a grinder (HGR-2000, hibell).

* Measurement of temperature change real-time in hydrogel formulations

The temperature of the first hydrogel agent before mixing was measured using a probe thermometer, and the temperature immediately after mixing the second agent including urea was measured. Hydrogels made of second agent that do not contain urea were also measured in the same way.

* Dry content determination

Using Halogen Moisture Analyzer (METTLER TOLEDO), 10 g of hydrogel was gelled in the same size in a sample pan, and then the amount of water evaporation (%) of the hydrogel was measured when heated at 50℃ for 30 minutes.

Results.

In order to determine the heat of dissolution of urea, urea was added to deionized water by concentration and temperature change according to the concentration was measured. As a result, it was confirmed that the higher amount of the urea addition, the greater the temperature drop, and the characteristic was directly proportional to content. (figure 1, table 1)

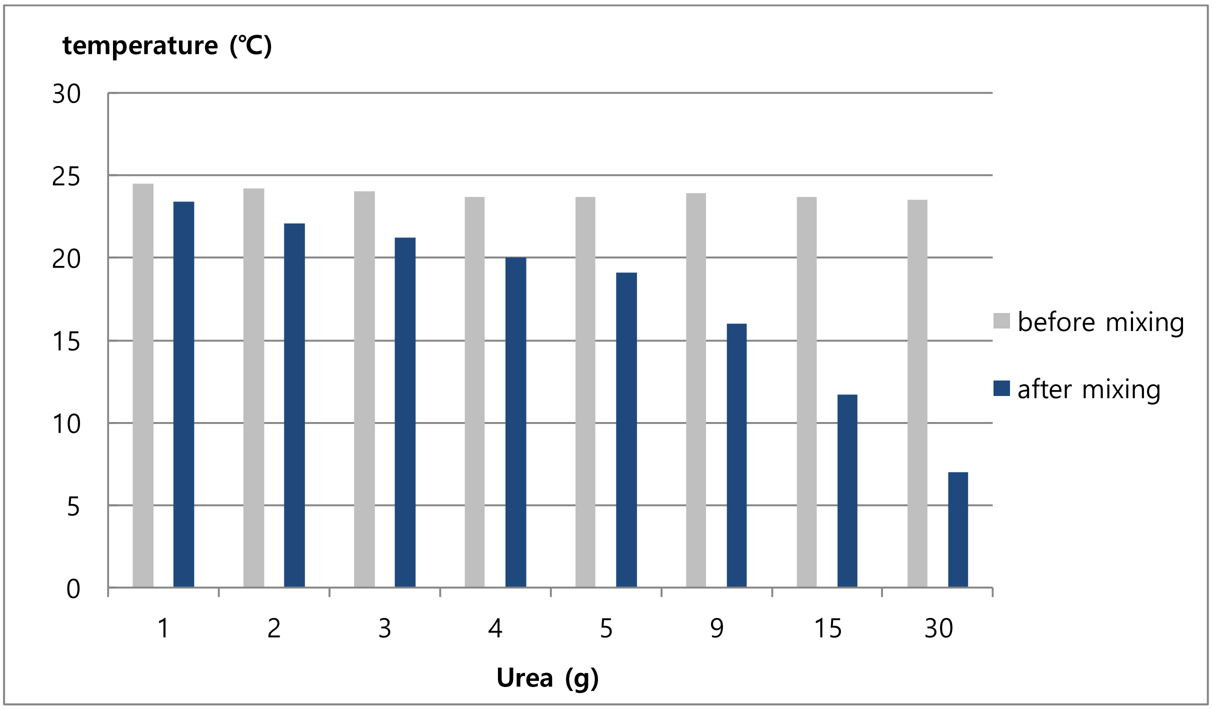
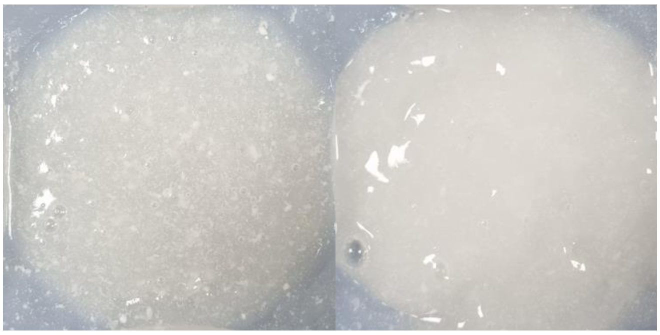


Figure 1. Temperature change before and after urea addition

UREA (%)	2.0%	3.8%	5.7%	7.4%	9.1%	15.0%	23.1%	37.5%
ΔT (℃)	1.1	2.1	2.8	3.7	4.6	7.9	12	16.5
melting time (s)	80	100	103	88	78	125	180	660

Table 1. Temperature change according to urea concentration

In order to add urea to the hydrogel formulation, the hydrogel was separated into a first agent and a second agent. The first agent was composed of a material that is the basis of the hydrogel, such as sodium alginate, and the second agent was added with urea and calcium that hardens the hydrogel as gelling agent. However, when urea is separated into powder, the powder is agglomerated due to the hygroscopic properties of urea, and it is difficult to disperse the powder in an aqueous solution and interferes with the formation of a hydrogel. (Figure 2, left) To solve such agglomeration, glucose was added to the second agent as bulking agent which prevent agglomeration of the powder due to the hygroscopicity characteristic of urea and facilitate dispersion. (Figure 2, right)



(Figure 2. Effect of bulking agent of powder phase to form Hydrogel. Left – mixed hydrogel without bulking agent, Right – mixed hydrogel with bulking agent)

In order to find out the endothermic effect of adding urea to the hydrogel, the temperature change was compared by measuring the temperature before and after mixing agents 1 and 2, which is the process of making the hydrogel. As shown in Figure 2, using a bulking agent, the second agent, made to facilitate dispersion and dissolution of urea, was added to the first agent and mixed to make a hydrogel. As a result, first agent, which was 22℃ before mixing, decreased to 14℃ after mixing, showing a drop of 8 degrees. (Table 2. A) In Table 1, the hydrogel exhibited an endothermic effect more than about 2.9 times when compared to the 2.8 degree drop when urea was 5.7%. Also, when only the gelling agent and urea were added, the drop was about 2.7 degrees (table 2 B), and when only the gelling and bulking agent were included, only a drop of 1.7 degrees was seen (Table 2 C).

		A	B	C
second agent	UREA (%)	5.93	8	-
	gelling agent (g)	1	1	1
	bulking agent (g)	17.5	-	17.5
temperature	before mixing (℃)	22	22.7	22.7
	after mixing (℃)	14	20	21
	ΔT (℃)	8.0	2.7	1.7

Table 2. Changes in temperature before and after mixing according to the ingredients included in the second agent

As a result of the loss-of-drying test in the hydrogel containing urea and the hydrogel not containing urea, the amount of drying in the hydrogel containing urea was less than that of the hydrogel not containing it (table 3, figure 3). As a result of the loss-of-drying test in the hydrogel containing urea and the hydrogel not containing urea, the amount of drying in the hydrogel containing urea was less than that of the hydrogel not containing it (table 3, figure 3).

	without urea	with urea
Start Weight	10.623 g	10.187 g
Dry Weight	9.194 g	8.928 g
End Result	13.45 %MC	12.36 %MC

table 3. Loss on drying test of hydrogel according to urea-containing conditions

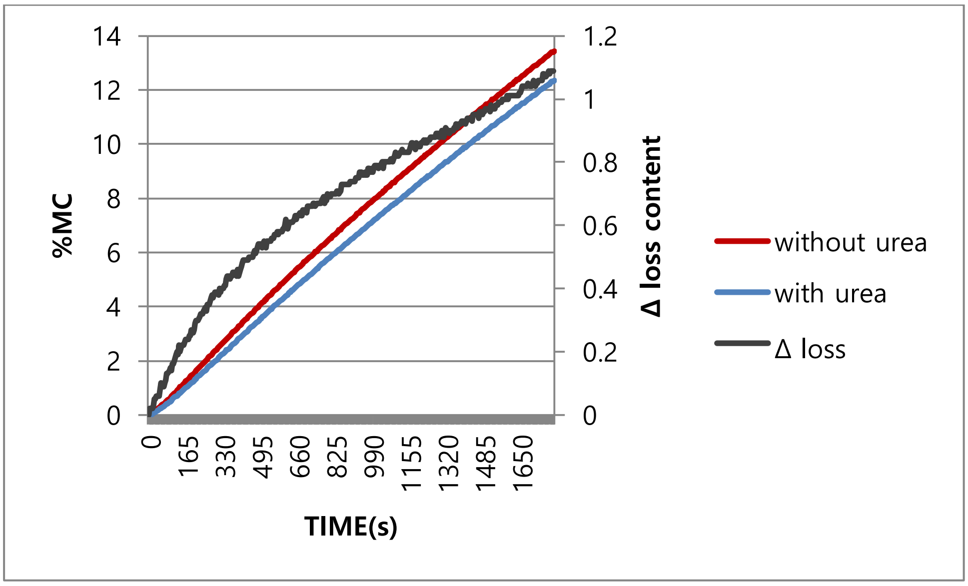


Figure 3. Change of moisture dry content with time of urea-containing/non-urea-containing hydrogel

Discussion.

Since urea rapidly dissolves in water and absorbs energy, the phases were divided to take advantage of the change in enthalpy. But due to the hygroscopic nature of urea, the powder gradually absorbs moisture and aggregates. In this study, we added a bulking agent to solve the problem, but as the content increased, the proportions of the phases change, giving a difference in texture and the rate of hydrogel formation. In addition, since urea is known to have a keratolytic effect at a high concentration, it is likely that appropriate content is necessary rather than simply adding a large amount for the cooling effect.

Conclusion.

When incorporated into hydrogels to apply the endothermic and water-containing properties of urea, it exhibits higher endothermic and water-containing effects than adding urea to a normal aqueous formulation.

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