Study of cosmetic applications with unmodified cellulose fiber as novel gel type ingredient

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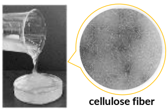
Introduction:

Cellulose fiber is a plant-derived next generation material. It is produced through chemical and mechanical processes from wood, etc. It has a high specific surface area and such characteristics, high strength, high modulus of elasticity despite its light weight. In addition, this material shows biodegradability, biocompatibility, and non-toxicity, namely being environmentally friendly. Recently, microplastic contamination appears as one of the world's environmental main concerns, so cellulose fiber is getting more and more attention as a raw material which is not categorized as a microplastic. Conventionally, in order to obtain cellulose fibers (CF) having uniform sized diameters, we must modify cellulose molecules with carboxylic and/or phosphoric groups. However, we have developed the novel process to obtain unmodified uniform sized CF (RCF) and the RCF shows excellent transparency in dispersing in water. In addition, we found that the RCF could be dispersed in mixture of water and BG with high concentration (in case of the water dispersion of commercialized modified cellulose fiber, the maximum concentration is around 2%). The purpose of this study is to clarify these physical characteristics, and the various properties when applied in the cosmetics.



Materials & Methods:

1. Properties of RCF and RCF gel

We analyzed a fiber diameter(1), pyrolysis temperature(2), dispersibility in the water(3) and emulsion(4) of RCF and compared with cellulose fiber which prepared by other methods and other thickener.

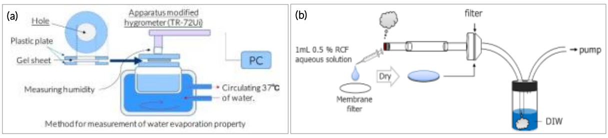
2. Properties of RCF film

We examined the potentials of RCF film after drying. Water evaporation(2) was measured with the apparatus modified hygrometer like figure 1a.
The trapping effects(3) of RCF film against tobacco smoke were examined by determining aldehyde compounds (ACs) and benzo(a)pyrene (BaP) in de-ionized water (DIW) diffused with tobacco smoke like figure 1b using fluorescence measurements.

3. Preparation of gel-type formulations

To address a possibility of RCF in cosmetics, we prepared aqueous formulations, sunscreen(1) and eyeliner(2).

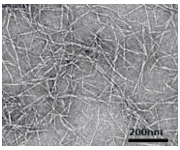
Figure 1. Methodology



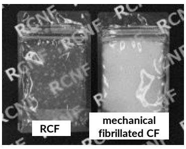
Results & Discussion:

1-1. RCF appearance and transparency

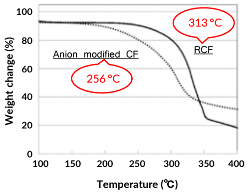
1-1-(a) TEM image



1-1-(b) water dispersion

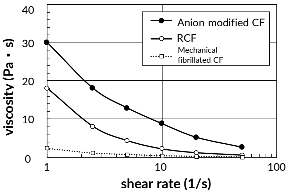


1-2. Pyrolysis temperature

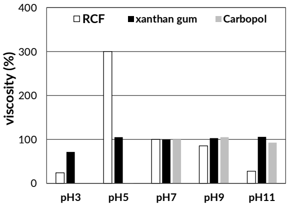


1-3. Influence of each parameter on RCF viscosity

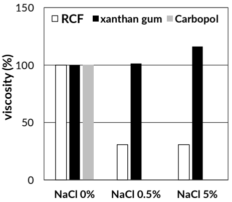
1-3-(a) shear rate



1-3-(b) pH



1-3-(c) NaCl



1-4. Emulsification property

Change added	RCF	Xanthan gum	Carbopol
(Emulsion type)	o/w	failed	o/w
Add 0.5% NaCl	failed	failed	failed
pH 3	failed	failed	failed
pH 5	emulsified	failed	failed
pH 7	emulsified	failed	emulsified
pH 9	emulsified	failed	emulsified
pH 11	emulsified	failed	emulsified

The emulsification of RCF, xanthan gum or Carbopol at 0.24%, water at 79.76% and squalane at 20% was tested.

RCF has excellent thinness, transparency, and rheological properties as a fiber made of pure cellulose without chemical modification, and it has pyrolysis stability similar to that of pulp. In addition, RCF could emulsify oil stable without surfactant.

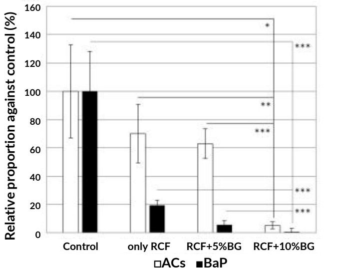
2-1. RCF film

2-2. Water evaporation through gel-sheets at the initial state

	Water evaporation rate (%/minute)	significance vs control	significance vs only RCF
Control	4.66±0.896	-	-
only RCF	3.72±0.425	ns	-
RCF+5%BG	2.98±1.329	ns	ns
RCF+10%BG	2.42±0.407	*	*

A water evaporation rate was calculated as humidity changes per minute.

2-3. Trapping effects of RCF-treated filters on ACs and BaP in tobacco smoke



The RCF-BG gel film was able to suppress water evaporation and showed excellent trapping effects both for ACs and for BaP compared to the control. We expected that RCF gel film when formed on the skin: suppressing water evaporation from the inside of the skin and acting as a barrier against external stimuli from the outside.

3-1. SUNSCREEN

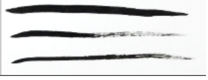
	Ingredients	RCF	Other cellulose	Xanthan gum	Carbopol
A	De-ionized water	80.75	84.20	85.70	86.40
A	RCF	1.00	-	-	-
A	microcrystalline cellulose and cellulose gum	-	2.00	-	-
A	hydroxypropyl methylcellulose stearoxy ether	-	0.15	-	-
A	xanthan gum	-	-	1.00	-
A	acrylates/C10-30 alkyl acrylate crosspolymer	-	-	-	0.20
A	AMPD	-	-	-	0.10
A	BG	7.95	3.35	3.00	3.00
A	Preservative	0.30	0.30	0.30	0.30
B	silica treated ultrafine TiO_2	10.00	10.00	10.00	10.00
	Viscosity (Pa・s)	**49.2**	**92.2**	**50.7**	**72.3**
	SPF/PA (UVA-PF)	**26.99/ PA++++ (22.05)**	**22.13/ PA++++ (17.81)**	**9.85/ PA+++ (8.42)**	**17.38/ PA+++ (13.99)**

Show excellent SPF performance !

3-2. EYELINER

	Ingredients	RCF	Xanthan gum
A	De-ionized water	57.55	58.50
A	RCF	0.20	-
A	Xanthan gum	-	0.20
A	BG	1.95	1.00
A	Preservative	0.30	0.30
B	Carbon black water dispersion	20.00	20.00
B	Emulsion of styrene/acrylates copolymer	20.00	20.00
	Viscosity (mPa・s)	**356**	**320**

Writing quality



The writing quality of the eyeliners were judged with 50 writings on paper.

Sunscreen containing RCF can also be prepared without any restrictions on ingredients, and as evidence of its excellent dispersibility and film forming property, it has a higher SPF than formulations using other thickeners. Eyeliner formulated with RCF, which maintains some viscosity, but its thixotropic properties make it writing quality.

Conclusions:

The novel RCF which is unmodified cellulose fiber will be very lucrative ingredient for cosmetics, especially gel type cosmetics such as skin care and make-up, and as a biodegradable ingredient.

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