CHEMIPAZ Technical Review

Chemicals for Household Paper

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1. Introduction

Household paper products such as toilet paper, tissue paper, and paper towels are essential items in our daily lives. While tissue paper and toilet paper are primarily used for personal hygiene such as blowing one's nose, they also serve as convenient tools for wiping up small spills and cleaning various surfaces. Tissue paper is not only useful for blowing our nose but also convenient for wiping up small liquid spills on desks and other surfaces. Furthermore, since 2020, the COVID-19 pandemic has raised awareness of hygiene, resulting in increased demand for paper towels.

Household paper products primarily serve the purpose of "wiping", and their manufacturing methods differ from other paper products such as writing paper used for notebooks, printing paper used for advertisements and catalogs, and cardboard used for packaging to fulfill this purpose.

Various combinations of chemicals are used in paper-making processes depending on the intended use. Manufacturing of household paper is not an exception. It even uses unusual chemicals that are not typically used in other types of paper.

In this report, we will first explain the differences between household paper and other types of paper, and then introduce the chemicals used in household paper products.

2. Differences between household paper and other types of paper

Household paper products often have a lower basis weight (weight per square meter of paper) and differ from other types of paper such as writing and printing paper, and paperboard used for cardboard. Table 1 shows the quality requirements for household paper products

Table 1. Differences in Quality Required for each Paper Type

	Household Paper	Paper	Paperboard
Types of Paper	Toilet paper, tissue paper, paper towels	Notebooks, books, textbooks, posters, catalogs, magazines	Cardboard liner, corrugating medium Base paper for paper tube
Basis Weight	Toilet paper: approx. 22g/m^2(single) approx. 16g/m^2(double) Paper towel: approx. 20g/m^2 Tissue paper: approx. 11g/m^2	52.3g/m^2 or more	100g/m^2 or more
Required Quality	Dry strength, wet strength (tear resistance when wet), dispersity in water (for flush toilets), water absorbency, bulk, softness, texture etc.	Printability (print quality, printing operability) Ink receptivity, dampening water resistance, surface strength, internal strength, stiffness, smoothness, opacity, etc.	Burst strength, compression strength, surface strength, internal strength, stiffness, smoothness, printability (print quality, printing operability) etc.

compared to other paper types. Unlike other paper types, household paper products have distinctly different quality requirements, such as tear-resistant when wet and smooth texture.

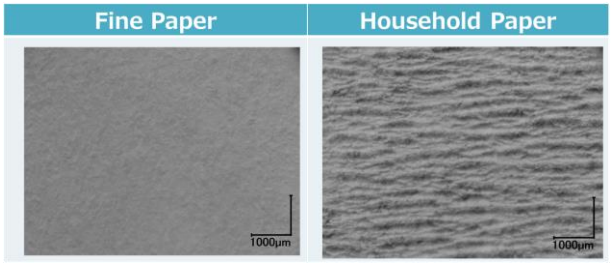


Fig. 1. SEM image of paper on the surface

In addition, household paper products have fine wrinkles called "crepe" applied to the paper (Figure 1). Application of crepe enhances softness and bulk, resulting in paper with superior texture.

The creping process consists of three stages that follow (Figure 2):

I The low-basis-weight wet web, which is formed at high speed, is adhered and dried on the surface of a rotating Yankee dryer.

II The adhered web is compressed by a doctor blade, during which the crepe is formed.

III The compressed web is peeled off from the dryer.

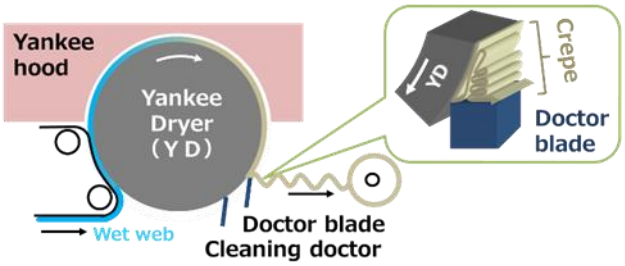


Fig. 2. Schematic diagram of the creping process

3. Chemicals Used in Manufacturing of Household Paper

As mentioned earlier, household paper products come in different types such as toilet paper, tissue paper, and paper towels, each requiring different quality specifications. The main chemicals used in household paper products are as follows:

・Wet strength agent: It provides wet strength to prevent paper from tearing apart when wet. It is added to pulp slurry before sheets of paper is formed.

・Dry strength agent: It provides dry strength to prevent dry paper from tearing apart. It is added to pulp slurry before sheets of paper is formed.

・Softener: It improves paper's hand feel. Added to pulp slurry.

・Creping agent (Creping adhesive, creping release agent): It forms a coating film on the Yankee dryer to protect its surface. It also controls the degree of paper adhesion to the Yankee dryer. It is supplied to the Yankee dryer.

・Moisturizer: It provides moisture retention to paper. Applied to base paper.

・Pick-up adhesive: Glue used to attach one end of toilet paper to the column (paper tube).

・Tail-sealing adhesive: Glue used to fix tail end of toilet paper roll

Applications of these chemicals to different paper grades are summarized in Figure 3.

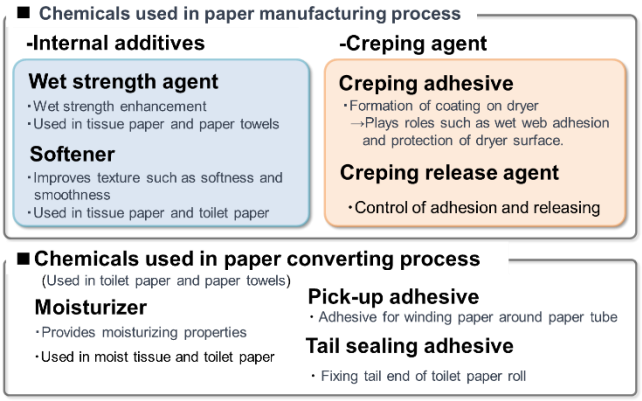


Fig. 3. Chemicals Used in Household Paper Manufacturing

In this review, we explain the chemicals used in household paper products, specifically wet strength agent, softener, and creping agent.

3-1. Wet Strength Agent

Tissue paper is commonly used for blowing one's nose. Paper towels, on the other hand, are often used to absorb spilled liquid on desks or wipe tables when moistened with water. For such applications, the paper needs to be tear-resistant even when it is soaked with water.

Paper is made up of pulp fibers that are aggregates of cellulose. Pulp fibers contain many hydroxyl groups (OH groups) that form hydrogen bonds that give the paper its strength. However, hydrogen bonds between cellulose fibers are interrupted by water, making the paper more prone to tearing (Figure 4).

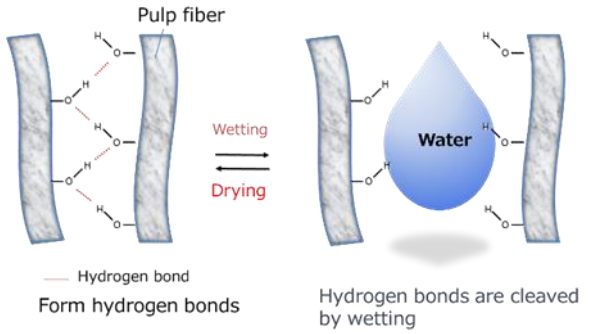


Fig. 4. Breaking of Hydrogen Bonds Between Pulp Fibers

Wet strength agent is used to prevent the breaking of bonds between pulp fibers due to water penetration. A well-known component used as a wet strength agent is a water-based resin called polyamide epichlorohydrin (abbreviated as PAE). PAE contains highly reactive azetidinium rings (abbreviated as AZR: Figure 5) that form covalent bonds with amino groups in the PAE and carboxyl groups present in cellulose fibers to prevents pulp fiber from breaking apart even when the paper gets wet (Figure 6).

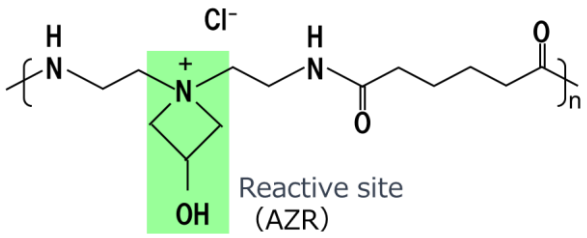


Fig. 5. Reactive sites of PAE

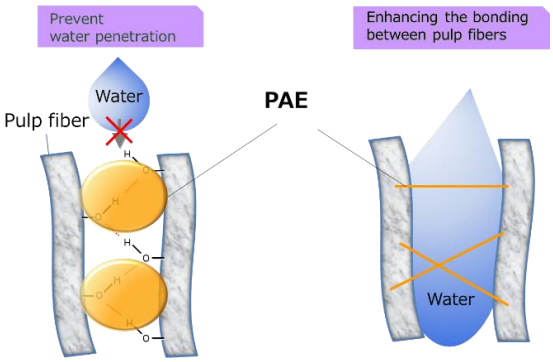
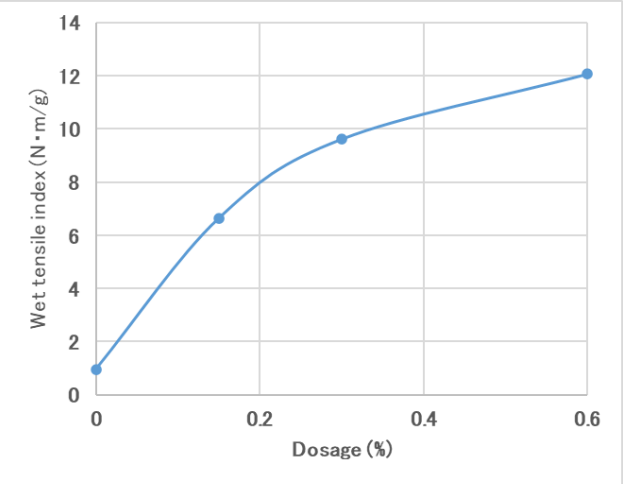


Fig. 6. Prevention of the breaking of fiber-to-fiber bonds by PAE

Figure 7 shows a graph of wet tensile strength of handmade paper when wet strength agent is added. The horizontal axis represents the dosage of wet strength agent, and the vertical axis represents the wet tensile strength. The graph shows that as the dosage of wet strength agent increases, the wet tensile strength increases.

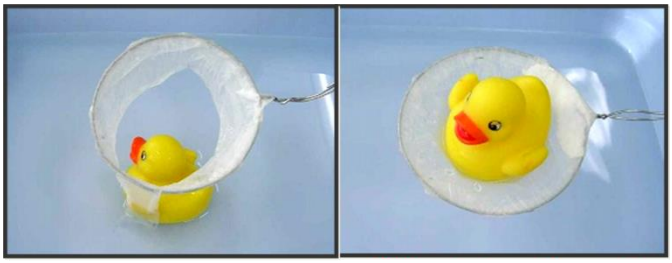
Figure 8 shows the images of one trying to scoop up a toy duck on water with a sheet of tissue paper made with and without wet strength agent. It is clear that adding wet strength agent makes the paper more resistant to tearing when wet. Therefore, wet strength agents are used in tissue paper and paper towels where resistance to tearing when wet is required.

However, because the use of wet strength agents makes paper more resistant to tearing when wet, it can clog up the toilet. For this reason, wet strength agents typically are not used in toilet paper.



【Paper-making conditions】
<Pulp> BKP(L/N=9/1), CSF410 <Process pH> :6.5
<Drying condition> 80deg-C, 120sec
<Cure condition> 105deg-C, 40sec

Fig. 7. Wet strength of paper with wet strength agent addition



Without wet strength agent With wet strength agent

Fig. 8. Comparison of wet tear resistance of paper that either contains or does not contain wet strength agent

Table 2 shows our representative wet strength agents. We offer a lineup tailored to various applications.

Table 2. Wet Strength Agents WS Series

Product	Solids (%)	Viscosity (mPa・s)	pH	Features
WS4035	25	50-250	2.5-4.5	General purpose
WS4040	25	30-250	2.5-4.5	High wet strength
WS4027	25	15-35	2.5-4.5	Low viscosity
T-WF102	18	30-130	2.5-4.5	Low AOX

3-2. Softener

Softeners are chemicals that are typically added to pulp slurry to impart softness, bulk, smoothness, and moisture feel to paper. Our company offers FS8006, a micellar product that prioritizes softness, and GT8022, an emulsion product that excels in smoothness (Table 3).

Table 3. Softeners FS8006, GT8022

Softener	FS8006	GT8022
Appearance	Yellow liquid	Milky white liquid
Ionicity	Cationic	Amphoteric
Active concentration (%)	90	40
Viscosity(mPa・s/25deg-C)	≤500	≤300
pH	–	9.0±1.0
Features		
Softness	◎	○
Bulk	○	◎
smoothness	○	◎
Effect on paper strength	Tends to decrease	Not decrease much

Softeners mainly consist of surfactants with both hydrophilic and hydrophobic groups that form micelles when added to pulp slurry. The softening effect is achieved through the following mechanisms (Figure 9)[1]:

I Micelle-formed softeners are attracted to pulp fibers

II Adsorbed softeners cover the hydrophilic pulp fibers

III While wet web is dried on the dryer, softener prevents the pulp fibers from getting close to each other

IV By inhibiting hydrogen bonding between pulp fibers, softness and bulk increase. Softeners also act as lubricants on pulp fibers, increasing smoothness.

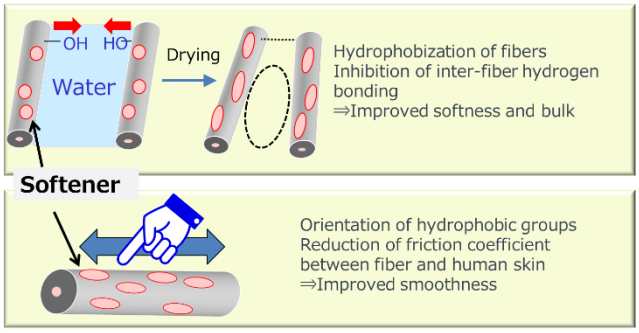


Fig. 9. Mechanism of Softening Effect

FS8006 is a micellar type softener that excels in providing softness to paper, but it sacrifices paper strength at the same time. In contrast, GT8022 is an emulsion type softener that has minimal side effect on paper strength and excels in providing smoothness and bulk.

Because FS8006 is prepared as small micellar particles with relatively large surface area, it covers a larger surface area of pulp fibers when fixed. This interferes with hydrogen bonding between pulp fibers, resulting in softness. On the other hand, GT8022 is prepared as large emulsion particles with smaller surface area compared to FS8006, which results in smaller coverage area when fixed to pulp fibers. Therefore, GT8022 does not fully interfere with hydrogen bonding between pulp fibers, resulting in minimal paper strength reduction. Additionally, GT8022 is designed to be more hydrophobic, which provides smoothness and bulk to the paper (Figure 10).

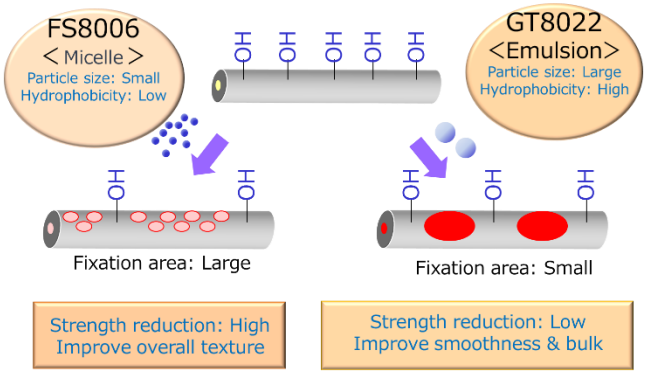
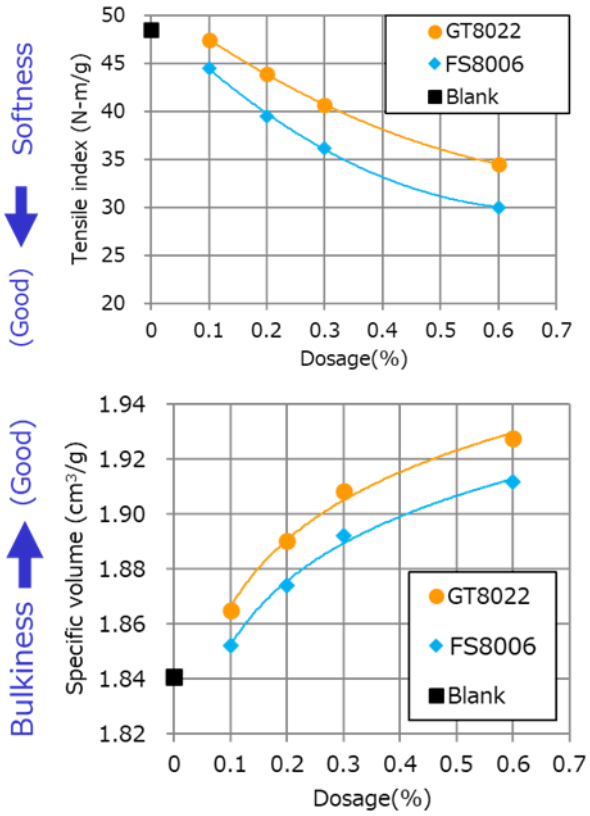


Figure 10. Differences between FS8006 and GT8022

Figure 11 shows the improvements in texture of handmade paper prepared using either FS8006 or GT8022. The softness was evaluated by the tensile strength and the bulk by the specific volume. That is, low tensile strength indicates softer texture, and high specific volume indicates greater bulk. Both FS8006 and GT8022 improve softness and bulk with FS8006 being superior in enhancing softness. On the other hand, GT8022 particularly improves bulk while being less likely to reduce paper strength.



【Paper-making conditions】
<Pulp>BKP(L/N=9/1), CSF=379
<Process pH> 7.5
<Drying condition> 100deg-C, 100sec
<Basis weight>40gsm

Fig. 11. Effects of Softener

3-3. Creping Agent

There are mainly two types of creping agents: creping adhesives (coating agents) and creping release agents (release agents). These chemicals are sprayed onto the Yankee dryer and form a film on the dryer. The film is believed to have a two-layer structure consisting of a protective layer formed by the hardening of the creping adhesive on the dryer surface, and a soft adhesive layer formed near the interface with the wet web from adhesive and release agent components. The protective layer functions to protect the Yankee dryer from the doctor blade while the adhesive layer functions to attach the wet web to the dryer (Figure 12)[2].

PAE, as explained in the wet strength resin section, or polyethyleneimine (PEI) resins are commonly used as creping adhesives. Our creping adhesive contains PAE resin as the main component.

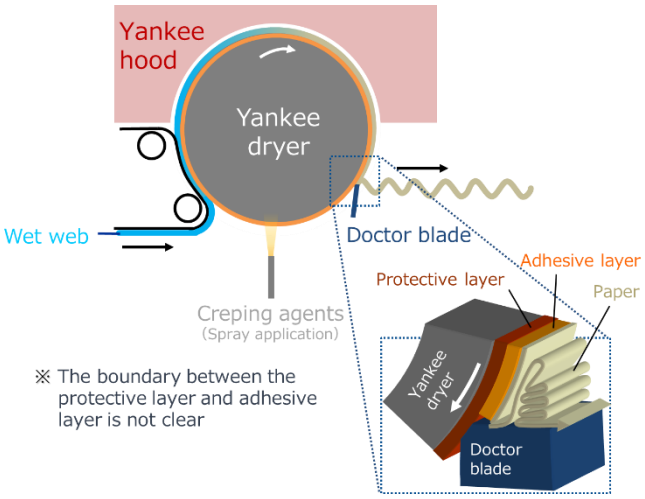


Fig. 12. Film Formation on Yankee Dryer

PAE-based creping adhesives can be broadly categorized into reactive and non-reactive types based on the presence or absence of azetidinium (AZR) groups as the reactive sites. Table 4 shows representative grades of our CA series creping adhesives. Non-reactive types are PAE-based creping adhesives that do not contain AZR groups, and their molecular weight is thought to remain largely unchanged on the dryer, forming films with low film hardness and excellent wet paper adhesion. In contrast, PAE-based creping adhesives containing AZR groups are called "reactive types," and undergo crosslinking reactions on the dryer leading to increased molecular weight. Compared to the non-reactive type creping adhesives, the reactive types have higher film hardness and superior water resistance.

When wet strength resins are added to pulp

slurry, as with tissue paper and paper towels, the coating film formed on the Yankee dryer may become excessively hard. Therefore, in such cases, it is preferable to use non-reactive type creping adhesives with relatively low film hardness. On the other hand, when softeners are added to pulp slurry to impart softness and smoothness to paper, wet paper adhesion decreases and the film on the Yankee dryer surface becomes softer. In particular, if the coating film hardness becomes excessively low, the coating film may be scraped off by the doctor blade, and in such cases, it is preferable to use reactive type creping adhesives that form relatively hard films.

Furthermore, in pursuit of creping adhesives of even higher performance, we investigated the combined use of non-reactive/reactive type adhesives and found that the combined use of these adhesives achieved superior effects not attainable with either of these adhesives. Applying this formulation leads to stabilized creping process operations and high-quality crepe. For details, refer to our Technical Review published in August 2022 3).

Table 4. Creping Adhesive CA Series

	Solids (%)	Viscosity (mPa·s)	pH	Type	Suitable paper types
CA6003	10	40	9	Non-reactive	Tissue paper Paper towel
CA6006	15	40	3	Reactive	Toilet paper

Regarding release agents, the mineral oil-based type is mainstream for crepe applications. Table 5 shows the representative grades of our CR series release agents for crepe. Crepe release agents are used in combination with creping adhesives to control paper adhesion to the dryer. CR6106 expresses a mild release effect, making it relatively easy to control adhesiveness. In contrast, CR6157 excels in release performance, enabling significant release effects with small amounts of release agent (Figure 13).

Table 5. Release Agents CR Series

	Viscosity(mPa·s)	Fire Service Act Classification
CR6106	≤ 150	Hazardous material
CR6157	≤ 150	Non-hazardous material

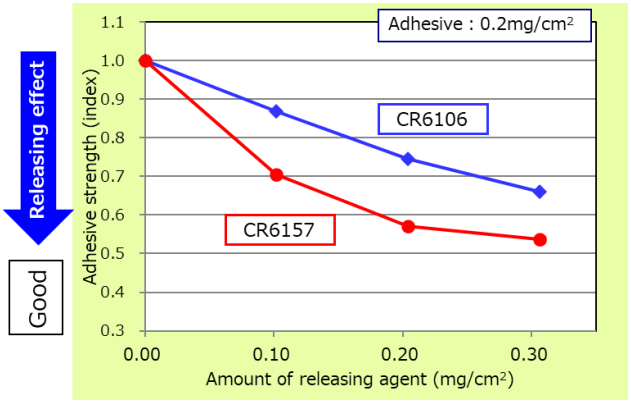


Fig. 13. Effect of Release Agents

4. Conclusion

In this review, we introduced some chemicals used in household paper. It has been explained that the required quality of household paper varies, and the paper-making agents suitable to each situation differ accordingly.

As mentioned at the beginning, household paper is indispensable in our daily lives. We continue to develop chemicals for household paper applications, contributing to quality improvement through rapid identification of market needs.

<References>

1) Koji Yoshitani, Japan TAPPI Journal, Vol. 68 (No. 11)

2) Koji Yoshitani, Pulp & Paper Technology Times, July 2018 issue

3) Yukie Suzuki, Hiroshi Suzuki, CHEMIPAZ CORPORATION Website, Technical Review August 18, 2022 issue

Profile

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