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RELATED MATERIAL

November 1, 2011

Elucidation of softening mechanism of clothing fabric softeners

This is an English translation of a news release in Japanese on November 1, 2011

■Findings presented here are the first to show that water molecules remaining on the surface of cotton fibers after washing and natural drying are the cause of hardening of cotton fabrics such as towels and clothes, in which the water functions as an adhesive agent between fibers.
■Fabric softeners were found to have an important role in preventing this adhesion and bringing about “softness”.
■These findings were applied for development of an ultra-compact fabric softener.

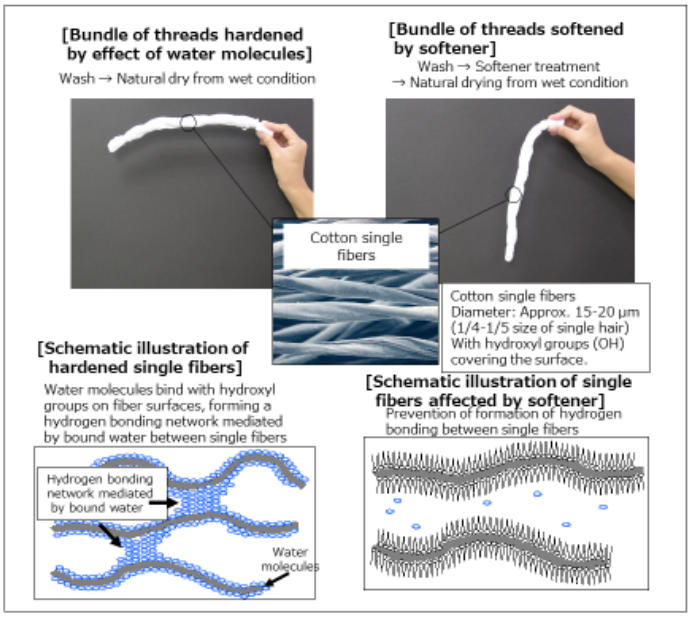
The Fabric and Home Care Research Center and Household Products Research Laboratories of Kao Corporation (President: Motoki Ozaki) performed scientific research to elucidate the softening mechanism of fabric softeners for cotton fabrics. The results showed that capillary adhesion between single fibers and yarns is caused by water called “bound water”, with unusual characteristics.

Initially, this research focused on a new perspective to determine why wet cotton towels harden when naturally dried and also for clarification of why they become soft with use of softener.

The results revealed that such a hardening condition is caused by residual water molecules (bound water) forming a layer between cotton single fibers, which then function as an adhesive to glue the fibers together and form strong bonds (hydrogen bonding network mediated by bound water covering all threads and cloth). This phenomenon caused by bound water was further confirmed by experimental results showing that hardened fibers recovered their softness when the water molecules were completely removed. It was clarified that use of a fabric softener softens cotton fabrics by preventing formation of the hydrogen bonding network between single fibers (Data 1).

Based on these findings, development of fabric softener from a new and different point of view for “preventing formation of hydrogen-bonding networks” has become possible. The results of this study were applied for development of the ultra-compact fabric softener Humming Neo.

These research results were presented at the 63rd Divisional Meeting of the Division of Colloid and Surface Chemistry (September 7-9, 2011) and 43rd Symposium on Cleaning (October 26-27, 2011).



Data 1. Cotton hardening mechanism and effect of softener

■Background

The softening mechanism in fabric softeners has been generally attributed to a decrease in frictional force between fibers or yarns, though related details have not been revealed.

In the present study, we focused on the phenomenon of hardening of cotton towels and clothes after washing and natural drying, which is resolved with use of a fabric softener. Cotton cloth is composed of cotton threads, which are made by twisting fine single fibers. It is extremely difficult to directly observe the state of single fibers for detailed investigation of the causes of hardening or action of fabric softeners. Thus, we attempted to clarify the mechanism by examining hardness data obtained in bending tests of cotton and polyester threads.

An additional purpose was to elucidate the fundamentals of the softening mechanism of fabric softeners using a new investigative method for development of new agents with higher performance.

■Results

Hypotheses regarding the cause of hardening of cotton clothes as well as the action mechanism of fabric softeners were supported by a bending test (Data 3). The hardness of experimental samples prepared with cotton threads that had been naturally dried after wetting (Data 2) was measured by subjecting samples to repeated bending.

By this bending test, the physical characters of the hydrogen-bonding network were clarified, which showed that the hardness value decreased with repeated bending or by treatment with softener. Thus, the collapse or prevention of "water-mediated" hydrogen bonding networks was determined to be strongly associated with loss of hardness.

■Cause of hardening of cotton clothes after washing and natural-drying

The results of the bending tests noted above revealed that the hardening condition of cotton is caused by hydrogen bounding networks between single cotton fibers. When polyester thread samples, which adsorb nearly no water, were examined, no change of bending force was observed.

As for natural-dried and hardened cotton thread samples, from which water molecules were completely removed by drying under high temperature and a reduced pressure (vacuum) condition, they changed from hard to soft and became fluffy. In both cases, no formation of a hydrogen-bonding network was possible.

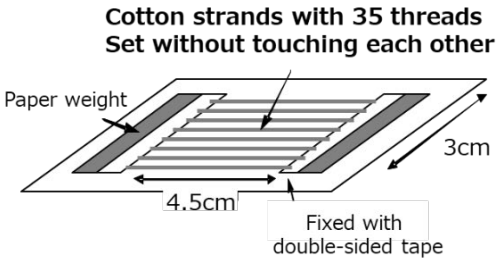
Accordingly, the hardening mechanism was considered to occur in the following steps:

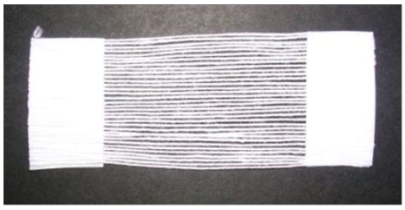
1. During the course of drying of wet cotton threads and cloth, the distance between single fibers become closer, as a capillary force (meniscus force) makes the distance between them very small.
2. The surface of a single cotton single fiber has a high affinity for water molecules and the nature of water on the surface of the fiber is different from ordinary water, which remains even after drying (bound water). A hydrogen-bonding network mediated by bound water is thus formed between single fibers.,

■Action mechanism of fabric softeners (Data 3)

When softener was added at full dosage to experimental samples, hardening from the formation of a hydrogen-bonding network was not observed. The softening mechanism of fabric softeners when applied to cotton cloth can thus be attributed to "prevention of formation of a hydrogen-bonding network mediated by bound water". This action is considered to result from covering the surface of single fibers with the hydrophobic moiety of fabric softener molecules.

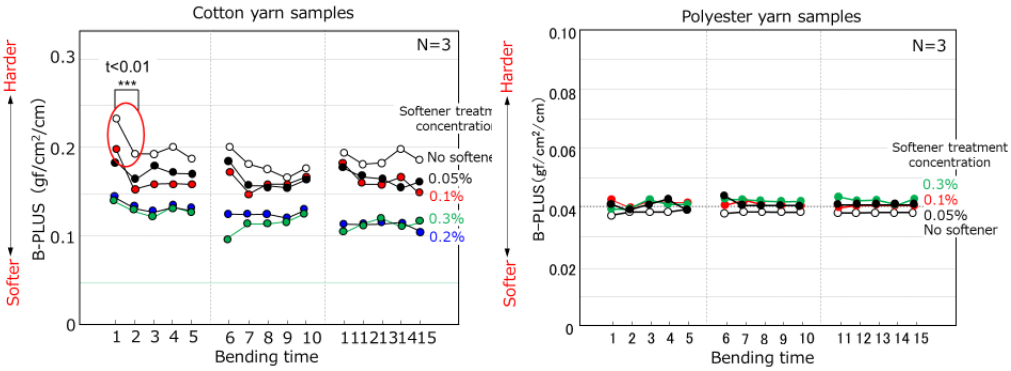
This study showed that the major mechanism of fabric softeners is not a direct "decreased friction between fibers", but rather "prevention of formation of a hydrogen-bonding network between single fibers mediated by bound water", which can be used for development of new types of softeners.





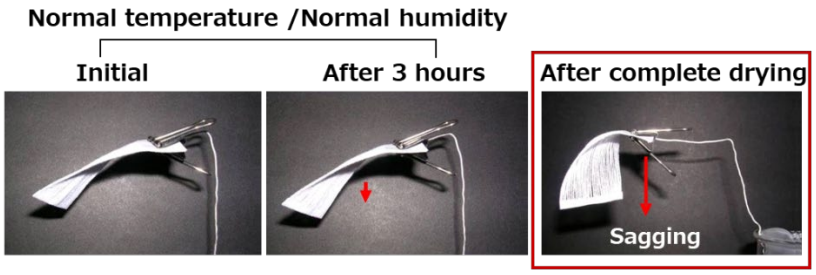
Sample preparation: 35 threads (20#) prewashed with adequate amount of solvent to remove textile treatment agent, then set in a parallel manner so that they do not contact and fixed with double-sided (adhesive) tape. After wetting with water once, the threads are dried statically for 2 days at 25°C and 50% humidity to harden.

Data 2. Experimental sample



Samples were loaded on the tester and bent to 270° repeatedly 15 times. Changes in hardness were examined in detail. The results showed the following:
Hardness was largely decreased after the initial bending and ② became nearly constant. Along with the increase in amount of softener, the hardness of both the initial and subsequent bends decreased in a dose-dependent manner. Furthermore, with polyester threads, which adsorb nearly no water, the phenomena in ① and ② did not occur (no hardening or softening).

Data 3. Bending test



A sample fixed at one end was dried at normal temperature and humidity for 3 hours, and observed. After 3 hours of drying, hardness was maintained without sagging. Then, after complete drying at 110°C under highly reduced pressure to remove water molecules, the sample became softer and showed sagging. In a sensory test of softness, all expert panelists (n=5) evaluated the sample as softer and more fluffy to the touch after complete drying.

Data 4. Complete drying test