

# Development of white acrylic fibers having heat accumulation capability, heat retention capability, and electric conductivity

## 1. Introduction

Acrylic fibers have been widely used for clothing for autumn and winter as sweaters, jerseys and blankets and sleepwears. However, acrylic fibers produce static electricity and there was a strong demand for a method for eliminating the risk of fire and the unpleasant feeling when putting on or taking off a garment caused by electrostatic sparks made in dry atmosphere. In addition, there was a strong need for heat accumulation and heat retention capability in acrylic fiber clothing for cold environment.

Treatment with functional agents in after-processing and blending or kneading of functional fibers compounded with functional substances such as metals (compounds) or carbon black were conducted with the object of providing the above-described functional properties. We recently developed and commercialized **THERMOCATCH W**, white acrylic fibers having heat accumulation capability, heat retention capability, and electric conductivity, resulting in acrylic fiber products satisfying a variety of requirements relating to cost, feel to touch, external appearance, endurance, heat accumulation and retention capability, and permanent antistatic ability.

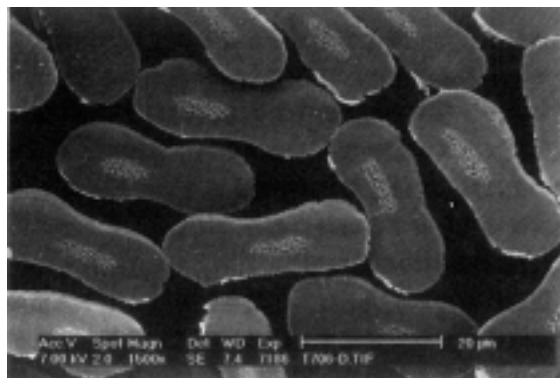


Photo 1a SEM image of **THERMOCATCH W** (cross section)

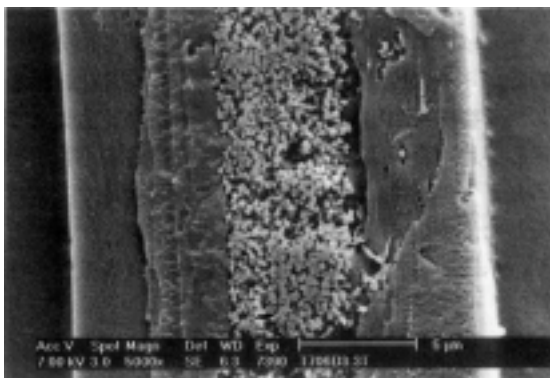


Photo 1b SEM image of **THERMOCATCH W** (vertical section)

## 2. Contents of Technology

### (1) Design of the fiber material

White ultrafine particles of electrically conductive ceramic having a photothermal conversion function were kneaded at a high concentration level with a core portion of core-sheath composite spun acrylic fibers, and the aggregates of the ultrafine particles were controlled to a size that had been difficult to obtain with conventional melt spinning. As a result, an electrically conductive path could be formed in the axial direction of the fibers and excellent electrical characteristics were realized.

Fig.1 shows the structure of functional fine ceramic particles. This fine particle has sub-micron diameter and is composed of  $\text{TiO}_2$  as core and ATO as shell. ATO, which has a plasma frequency in visible-near infrared region, is an oxide semiconductor. It is also transparent in the visible light region and has conductivity and heat accumulation-retention capability.



Photo-thermal and Electro-conductive Acrylic Fiber “Thermocatch-W”

YASUO YANAGI, HIROYUKI KOUCHI and HIROSHI HOSOKAWA\*

\*Acrylic Fibers Development Laboratory, Mitsubishi Rayon Co., Ltd.

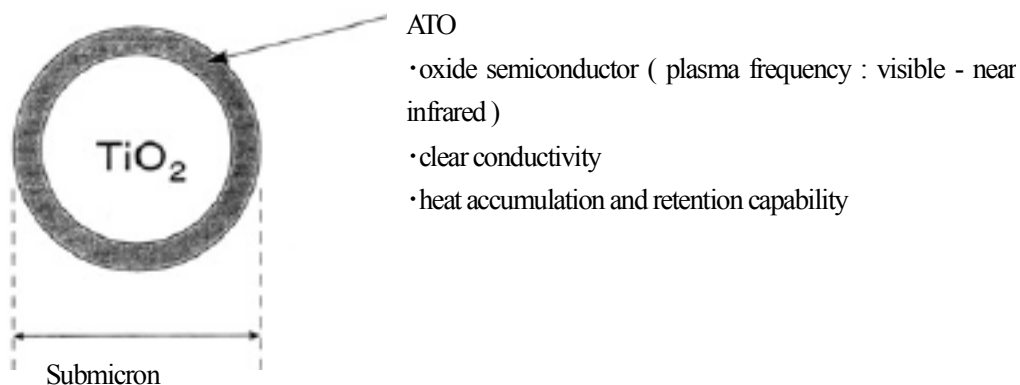


Fig. 1 The structure of functional fine particles ceramic

## (2) Technology for the manufacture of the fiber material

We have established a technology for the preparation of a spinning solution in which ultrafine functional particles are dispersed with high stability to a high concentration level, a technology of core-shell composite spinning meeting the requirements placed on spinability determined by minimization of a core ratio, whiteness of the fibers, feel to touch, and cost, and a specific stretching and relaxation technology providing for required electric conductivity, yarn properties, and dyeability.

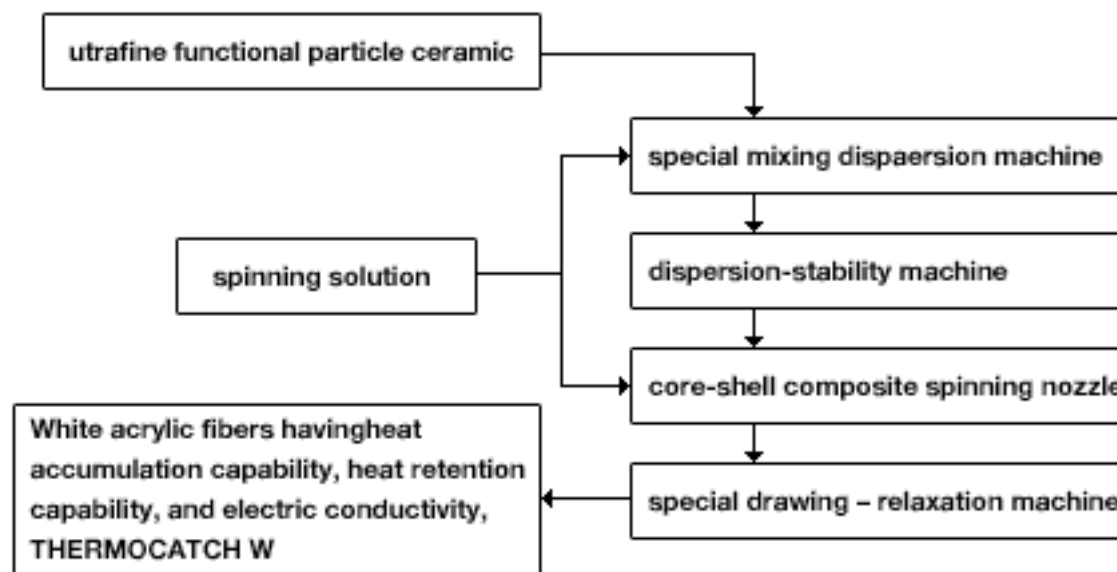


Fig.2 Production process scheme of THERMOCATCH W

## 3. Product features

### (1) Photothermal conversion function (heat accumulation and retention capability)

The fibers react not only to natural light (sunlight), but also to thermal ray sources such as incandescent lamps and IR lamps, demonstrating a photothermal conversion function. Blending about 10% of these fibers with standard fibers results in a 2-8°C temperature increase under thermal ray irradiation. As a result, not only do clothes made from these fibers have a warming function, but they dry in 2/3 the usual time when drip drying after washing and spinning (dryability).

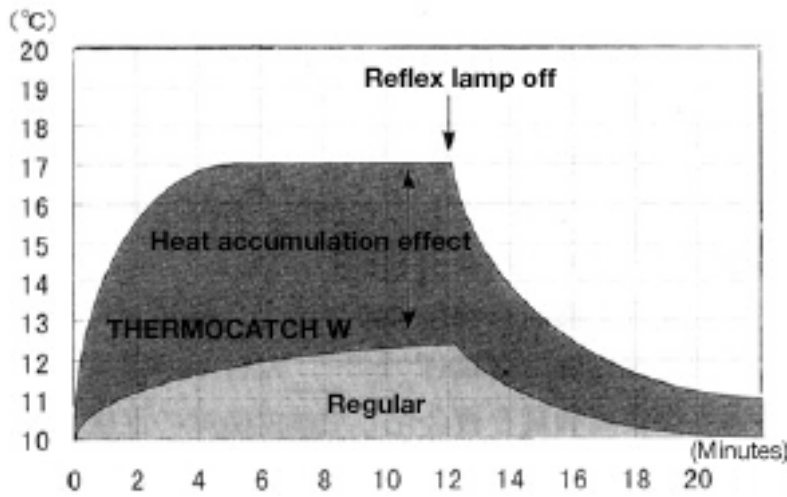
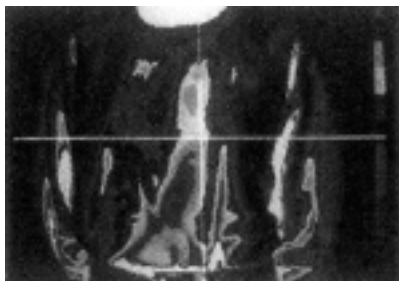


Fig.3 Heat accumulation and retention capability of THERMOCATCH W



THERMOCATCH W



Regular acrylic fiber

Fig.4 Wear test

Room temperature:0°C  
 Reflex lamp:500W(5,500K)  
 Distance:40cm

**(2) Nonlinear electric characteristic**

The fibers have a nonlinear electric characteristic such that a high electric conductivity is demonstrated only in a region of high electric field intensity where static damage is a problem, and a conversion rule is valid between the content of ultrafine electrically conductive ceramic particles in the fibers core and the intensity of the applied electric field. This nonlinearity is believed to be derived from the high electric field conductivity of a thin polymer membrane present on contact boundaries of ultrafine electrically conductive particles.

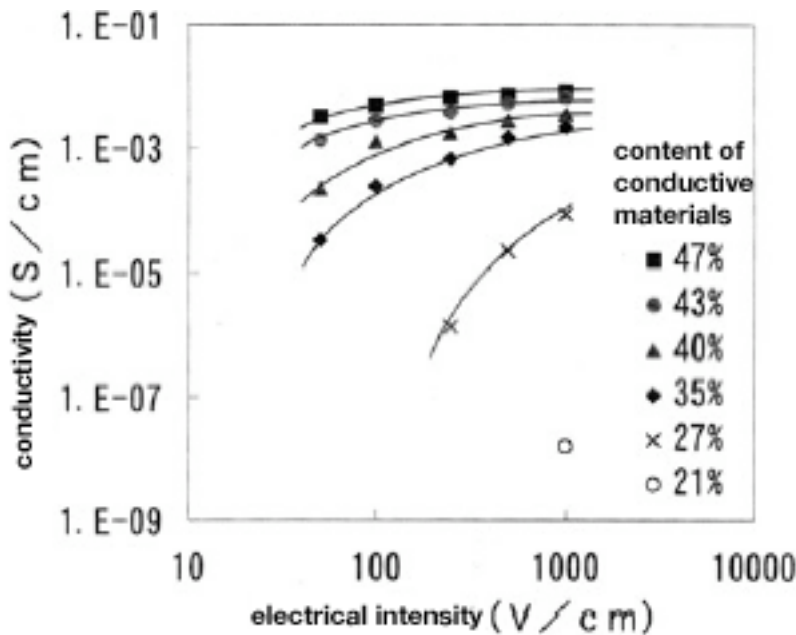


Fig.4a Electric characteristic(1)  
 (The content of ultrafine electrically conductive ceramic particles in the fibers core and electric field intensity)

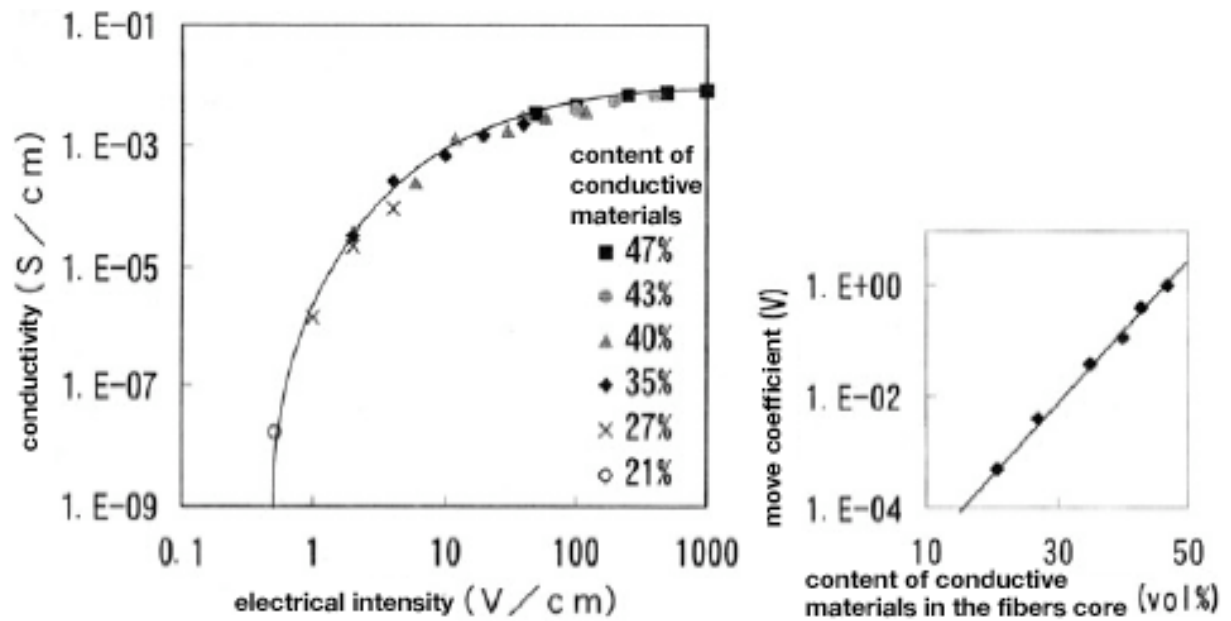


Fig.4b Electric characteristic(2) (Relation between the conductivity and electrical intensity)

**(3) Electrostatic prevention function (permanent antistatic property)**

Spun yarns obtained by blending about 3% of the present fibers with standard fibers demonstrate electrostatic prevention function (permanent antistatic property) which is believed to be based on a corona discharge mechanism. Cloth composed of the antistatic spun yarn conforms to standards for antistatic work clothes under the guidelines of the Industrial Safety Institute of the Ministry of Health, Labour and Welfare and therefore can be used in an explosion-preventing environment. In the present fibers, ultrafine functional ceramic particles are kneaded with the core portion of the fiber. Therefore, the fibers are not easily affected by the usual after-processing, washing, and repeated wearing and retain their properties for a long period.

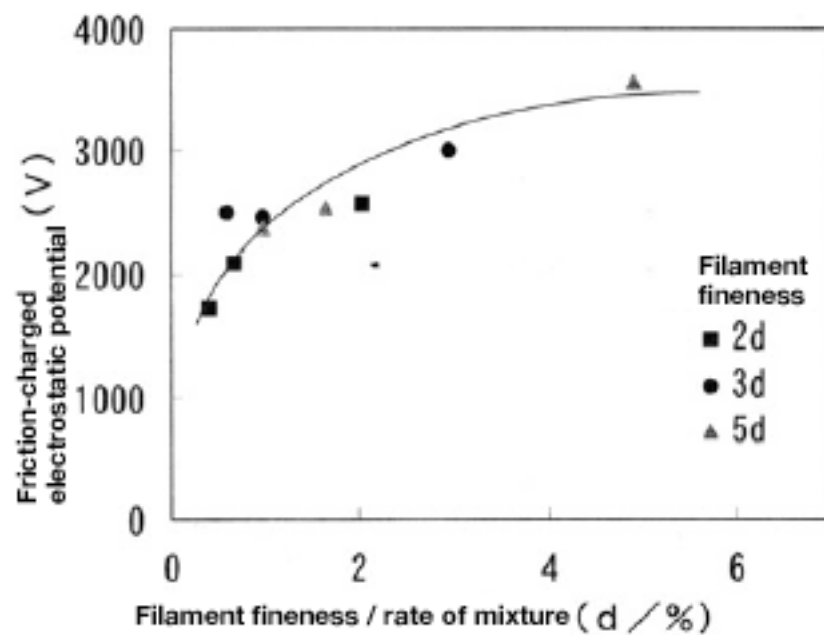


Fig.5 Friction-charged electrostatic potential and cotton wool fineness

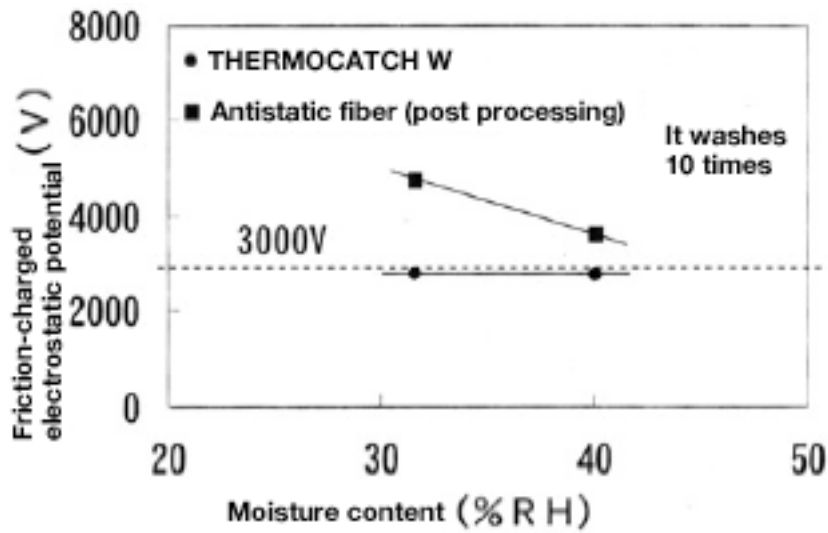


Fig.6 Friction-charged electrostatic potential and moisture content

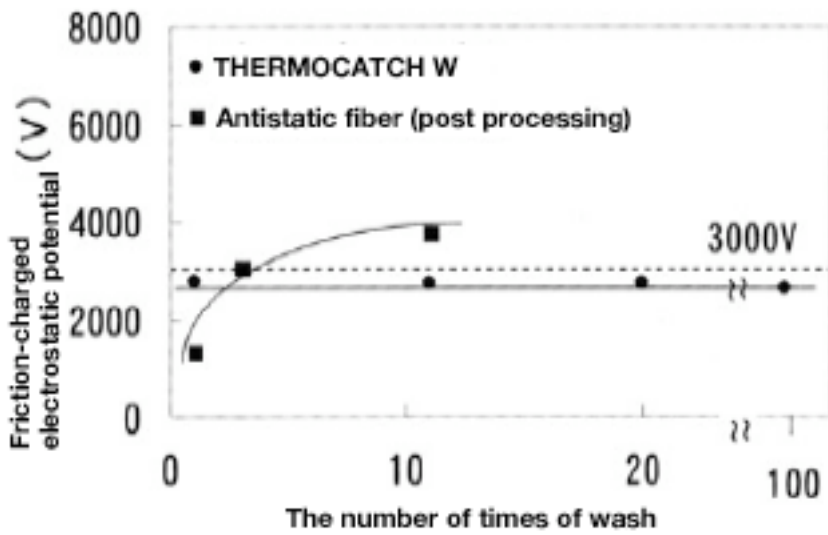


Fig.7 Friction-charged electrostatic potential and the number of times of wash

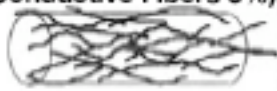





Table 1 Electrical charge


Sample	Electrical charge of products	Electrical charge of fiber
	(JIS, T8118)	(JIS, L1094C)
Safety standard of Ministry of Labor	$<0.6 \mu C/\text{product}$	$<7 \mu C/\text{m}^2$
<b>THERMOCATCH W</b>	0.23	3.68
Present acrylic fibers	0.81	8.70

Sample : Acryl 70%/wool 30% 1/39 2P14G rib knitted fabric

Measurement : It washes 5 times, Friction fabric : Nylon

Table 2 Pattern of conductive fibers

Fabric	Pattern	Model	Rate of mixture
Knit	Spun yarn (Conductive Fibers 3%) 		3%
	Spun yarn (Conductive Fibers 100%) 		
Cloth	Conductive continuous fiber 		0.1%
	Spun yarn (Conductive Fibers 100%) 		



**(4) Utility**

Because the present fibers are white, a vivid colorability similar to that of the usual acrylic fibers can be obtained with standard dyeing. Because they demonstrate their functions even when only a small amount is used, the fibers can be easily combined with other functional fibers and thus these multifunctional composite fiber products have high versatility. For the same reasons, permanent antistatic properties can be obtained in products other than those from acrylic fibers. The main fields of applications can be expanded to include fields similar to those for usual acrylic fibers, including sweaters, innerwear, leggings, garments for men and women, shorts and skirts and other apparel, and products for the interior such as carpets, sheets, curtains, and blankets.

**4. Future developments**

**THERMOCATCH W** is a unique white acrylic fiber with heat accumulation and retention capability and electric conductivity. It has paved the way for creating acrylic fiber products with high safety, good heat accumulation and retention capability, and permanent antistatic properties, and satisfying requirements in terms of fashion capability, functionality, and cost. Because small amounts of such fibers provide fiber products with the required functions, they are expected to find applications across a wide array of fields.