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Technical Committee of Japan Chemical Fibre Association

Technical Committee of Japan Chemical Fibre Association  
Tokyo, Japan

PET. SYMP. 1/6

21 - 23 October 1969

## SILK LIKE FIBRES<sup>1/</sup>

Technical Committee of Japan  
Chemical Fibre Association  
Tokyo Japan

presented by

T. Betsuno

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# 1. General Description

## 1.1. Introduction

C. silk is a natural fibre, which is far the most fibrous fibre with its unique characteristics. It was the only dyed fabric history dating back to the 19th century. It has been used for a long time for a variety of purposes such as Japanese Kimono, Chinese paper, and European fabrics. There are all made of silk. In fact, silk production is still a big industry in the leather and cloth. The production of silk in the world has increased because of the inherent characteristics of silk. In 1950, silk production reached a peak of approximately 1,200,000 tons. In 1955, it had increased to 1,400,000 tons. In more recent years, it has decreased. In 1957, the production of silk in the world has received considerable attention. It is expected that in the future it will not be anticipated. In contrast, demand for silk is increasing year by year, thus making the silk market more valuable under these circumstances, many countries are starting to develop silk-like fibres. Recently, rapid advances in high polymer chemistry and in production techniques have brought a variety of new fibres to the market.

## 1.2. Characteristics of silk

The superior characteristics of silk are understood to result from a combination of the following properties:

- (1) Flexibility
- (2) High strength
- (3) Soft and smooth

Of this, the latter may concretely be expressed as follows:

- (1) High modulus and good recovery owing to moderately high tenacity strength.
- (2) Soft and heavy touch
- (3) Good recovery giving feeling as if fibres are caught on the skin surface
- (4) Soft and heavy touch
- (5) Easily readily deform but easily recover the shape when released
- (6) Good feeling.



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Development of the Petrochemical Industries  
in Developing Countries

PEP. SYMP. D/6

Baku, USSR, 20 - 31 October 1969

SUMMARY

SILK-LIKE FIBERS <sup>1/</sup>

presented by

T. Betsuno

Technical Committee of Japan Chemical Fibres Association  
Tokyo, Japan

We can recommend the traditional rayon filaments which have a long record of performances as silk-like fibers, such as rayon, cupro and acetate. In recent years, however, synthetic fibers have been developed and further silk-like filaments are being used.

Synthetic fibers, which have been produced in Japan for use of silk-like filaments, are nylon, polyester, acrylics and vinylon. In addition, there are a benzoate fiber and a copolymerization fiber of acrylonitril and protein. They are developed especially for the silk-like fiber.

To manufacture silk-like synthetic fibers, we strive to give a particular shape to the fiber, to employ a special spinning and to use special raw material for making fibers.

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<sup>1/</sup> The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

Nylon and polyester, when given modified cross-sections, have silk-like lustre and touch. By employing particular shapes of spinning nozzles, various cross-sections such as triangle, hexagon and hollow can be obtained.

Acrylics, which are mainly produced in the form of staple, have a small production of filament. In Japan, Asahi Chemical Industry Co., Ltd. started producing acrylic filament "Newlon" in 1968. "Newlon," which has a silk-like lustre and touch, has a pleasant feeling and is not waxy which is a characteristic of synthetic fibers.

The production of vinylon began with staple, which is produced by wet spinning. However, the development of dry spinning and the partial acetalization of raw material PVA have given the fiber acid dyeable property. These developments have made it possible to produce silk-like vinylon filament. Nihon Vinylon filament, which has even cross-section structure and no skin-core, can be produced in bright colors. Dry spinning, with water used as a solvent, provides the filament silk-like lustre and touch.

Benzene fiber "E-Tell" is also a silk-like fiber which has been produced by Nippon Rayon Co., Ltd. since 1968. The "E-Tell" is a fiber produced by polymerization of  $\alpha$ -oxyethoxybenzoic acid. This fiber has ether and ester linkages in its molecule, which gives the fiber a silk-like touch.

Production of "Chinon" which is the copolymerization fiber of acrylonitril and protein, has just begun by Toyobo Co., Ltd. in 1969. It is a unique silk-like fiber which has a general property similar to silk. It has better sunlight resistance than silk and also a silk-like lustre and touch.

Microscopic observation of the cross-section of silk shows that two triangular fibrils are covered with sericin. The sericin constitutes 20 - 25 % of the entire silk fiber. The fibril is said to have triangular cross-section and a layer structure. These give silk its elegant lustre.

Although the fibril is as fine as about 1 denier, it has high Young's modulus of  $650 - 1100 \text{ kg/cm}^2$  and high elasticity. In addition, the fibril is said to have elastic properties. The silk deprived of a part or the majority of the sericin through degumming, has voids among its fibres owing to the elastic properties of the fibril. This combination of properties is believed to account for the lustrous, fleshy, soft yet stiff and resilient handle peculiar to silk.

### 1.3. Development of silk-like fibres

The attraction of mankind for silk has acted as a challenge. It is no exaggeration to say that many man-made fibres have been developed with the aim of imitating and rivaling silk.

Recently, the relationship between the structure and the handle of silk fibres has been clarified as previously described. This, coupled with recent advances in fibre production and processing techniques, has led to the partial and partial modification of new high polymers, some new silk-like synthetic fibres have also made their appearance.

The silk-like synthetic fibres which have been described up to now in Japan can be generally classified as follows:

#### (1) Fibres made from new polymers

Benzenoid fibres

"A-Tell"

Nippon Rayon Co.

Acrylonitrile-protein copolymer

"Nihon"

Toyobo Co.

#### (2) Those derived from existing fibres

Modified cross-section polyester

"Silpearl"

Teijin Ltd.

"Dillool"

Toyo Rayon Co.

"Siltine"

Toyobo Co.

"Pefeel"

Nippon Rayon Co.

Modified cross-section nylon

"Silstar"

Teijin Ltd.

"Amicor"

Toyo Rayon Co.

"Corona"

Toyoda Co.

"Profile"

Nippon Rayon Co.

"Calmar"

Kanagafuchi Spinning Co.

Silk-like filaments

"Eucora"

Asahi Chemical Industry Co.

"Viny" Nitrocellulose

"Viny" Cellulose

Bihon Vinyon Co.

The total output of silk-like synthetic fibres is approximately 100,000 tons per month. This figure is already close to a half of the production of natural silk in Japan. Since plant extension and new construction work are being pushed, the silk-like fibres will continue to develop in the near future. In the fields previously reserved for silk, but also on their own account, with increasing demand for silk-like fibres.

The following table contains a brief description of each silk-like fibre in the market in Japan.

2.1.1.1.1

2.1.1.1.1.1

The difference in properties of synthetic fibres to produce silk-like fibres is due to the variation of the sequence of manufacture and the use of different nylon as well as the use of new materials, and the use of different base filaments. In the United States, the silk-like fibres produced for modification of nylon are known as "Silstar".

A number of excellent silk-like fibres have been developed by modification of nylon to give varying properties. Some of the fibres are made with modification of other synthetic fibres. In a sense, they are made to give a lustre and a certain degree of flexibility that are not found in the original nylon.



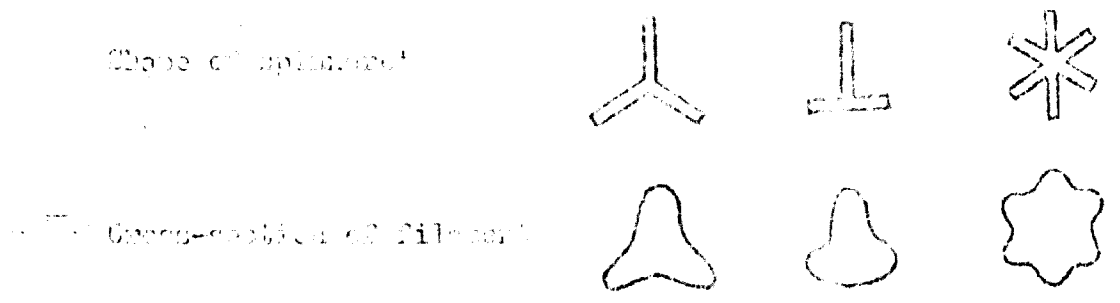
In Japan, synthetic materials are marketed. The material used is a mixture of wool and feel and is marketed under the name of "wool". The material is a mixture of wool and feel and is marketed under the name of "wool". The material is a mixture of wool and feel and is marketed under the name of "wool".

### 2.3 How to make the yarn

In the manufacture of filament yarn, the yarn is normally spun with bright spinning. It is then spun with the filament spinning. The modified process which gives the filament yarn is as follows. In the manufacture of filament yarn, the yarn is normally spun with bright spinning. It is then spun with the filament spinning. The modified process which gives the filament yarn is as follows. In the manufacture of filament yarn, the yarn is normally spun with bright spinning. It is then spun with the filament spinning. The modified process which gives the filament yarn is as follows.

1. Determination of spinneret shape to obtain the desired cross-section available in a particular problem. Some examples of spinneret shapes and the cross-section of filament are shown in figure 1.

Figure 1: Shape of spinneret and cross-section of filament



2. If molten polymer, which has already been spun in melt spinner, is then transferred to a circular spinner, owing to surface tension, even if the shape of the spinner is non-circular. On any spinner, the change in the cross-section of filament is due to the viscosity of the molten



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3.2. Manufacturing process

For better strength, the raw material for poly... silk yarn should be bright polymer. For molting process...

of optical activity is used. If the manufacture of optically active cross-section yarn, a method of uniting specifically dependent on its composition.

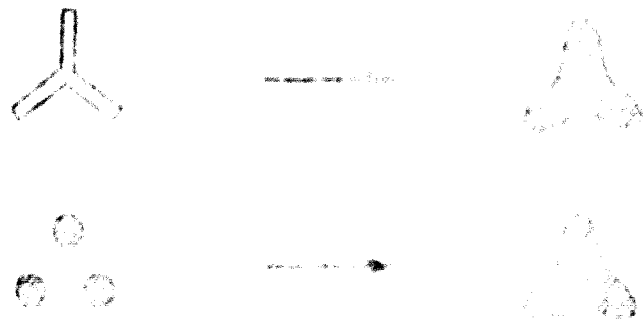





Fig. 1. Schematic representation of the structure of optically active cross-section yarn.

The optical activity of the cross-section yarn is determined by the optical activity of the individual components. The optical activity of the individual components is determined by the optical activity of the individual components. The optical activity of the individual components is determined by the optical activity of the individual components.

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Table 1 shows the properties of modified cross-section yarn and hollow yarn versus ordinary circular yarn.

Table 1. Properties of Modified Cross-section Yarn  
Versus Circular Yarn.

Conventional Circular Yarn	Modified Circular Yarn	Modified Hollow Cross- section	Modified Cross- section
			
Denier	20 - 150	20 - 100	30 - 150
Fineness (microns) $\mu$	1.0 - 1.0	4.0 - 6.0	1.0 - 1.0
Twist (turns/in)	25 - 40	25 - 30	25 - 30
Hollow yarn, %	-	10 - 20	-
Young's Modulus, gms/cm <sup>2</sup>	1000 - 1500	1000 - 1500	1000 - 1000
Elasticity (at 3% stretch)	100	100	100
at 3% stretch	95 - 100	95 - 100	75 - 100
Friction coefficient, 100 cm/sec	0.2 - 0.3	0.2 - 0.3	0.2 - 0.2
Friction coefficient, 300 cm/sec	0.2 - 0.3	0.2 - 0.4	0.2 - 0.2

The Honorable Members of the Council of the University of California

San Francisco, California

Dear Sirs:

I have the honor to acknowledge the receipt of your letter of the 10th inst. regarding the proposed changes in the curriculum of the College of Letters and Education, University of California, San Francisco.

The Board of Regents has considered the matter and has approved the proposed changes, subject to the approval of the Council of the University of California.

I am, Sir, very respectfully,  
Your obedient servant,

W. R. Hoagland, Secretary

University of California, San Francisco

San Francisco, California

Very truly yours,

W. R. Hoagland

Secretary

University of California, San Francisco

San Francisco, California

slightly pale in density.

Utilization such covered visual density through modification of cross-section, it is possible to give a two tone effect. Especially with certain film processes such as the color film process, a certain amount of color is produced by the use of a certain amount of color dye, but the color is not uniform, and the color is not uniform, and the color is not uniform.

### 3.7. Color film process

Color film process is a process which has developed a series of materials and processes, as a result of which, it is the most important material in the production of color film. The process is a series of a variety of materials and processes which are likely to be developed in the future.

## 4. DYEING

### 4.1. Dyeing process

A dyeing process is a process which has developed for production of film, they have a great deal of interest in the world, and it is a part of the dyeing process.

The dyeing process is a process which has developed in Japan, and it is a part of the dyeing process. The dyeing process is a process which has developed in Japan, and it is a part of the dyeing process. The dyeing process is a process which has developed in Japan, and it is a part of the dyeing process.

### 4.2. Dyeing process

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### 4.3. Dyeing process

Acrylic fibers and their dyeing processes are the dry-dyeing process and the wet-dyeing process.

The relationship between the two dimensions presented is shown in figure 2.

Figure 2. Relationship between the two dimensions of the test.

Figure 2

Figure 2

Figure 2

Figure 2

Figure 2

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Figure 2

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Figure 2



4.4. Type 7, Characterization and Properties

Type 7 acrylic filament, currently produced in Japan ranges from 50 denier to 200 denier. It is used generally and for woven fabrics and occurs in many different forms and grades.

Characterization of Type 7 acrylic filament:

- (1) It is a high modulus filament, but has no way to follow parallel fibers.
- (2) It is a high modulus filament, but has no way to follow parallel fibers.
- (3) It is a high modulus filament, but has no way to follow parallel fibers.
- (4) It is a high modulus filament, but has no way to follow parallel fibers.

Characterization of Type 7 acrylic filament, and the form in which it is used.

Table 4.4.1. Properties of Type 7 acrylic filament.

Tensile strength (g/denier)	1.5 - 2.0
Tensile modulus (g/denier)	1.5 - 2.0
Young's modulus (g/denier)	1.5 - 2.0
Specific gravity	1.18
Offhand appearance	1.18

4.5. Type 8, Characterization and Properties

Silberfil is a high modulus filament, but is little used for knitted fabrics.

The mounting of a public filament affords combination of lightness  
and strength not obtainable with other filaments. It is a good in-  
dicator of the filament's strength. It is a good indicator of the fil-  
ament's strength. It is a good indicator of the filament's strength.

The filament is made of a very fine wire, which is drawn from a  
rod of the same material. The filament is then coated with a  
thin layer of a special material, which is then drawn out into  
a fine filament.

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a fine filament.

Advantage of the above procedure over the spectroscopic method in the main is that it is simpler and less expensive. It follows:

- (1) The amount of material used is small (e.g. 0.1 g).
- (2) The method is simple and does not require special apparatus.
- (3) The method is rapid and does not require long waiting periods.
- (4) The method is accurate and does not require special skills.

The above method is suitable for the determination of the amount of a substance in a mixture. It is also suitable for the determination of the amount of a substance in a solid sample.

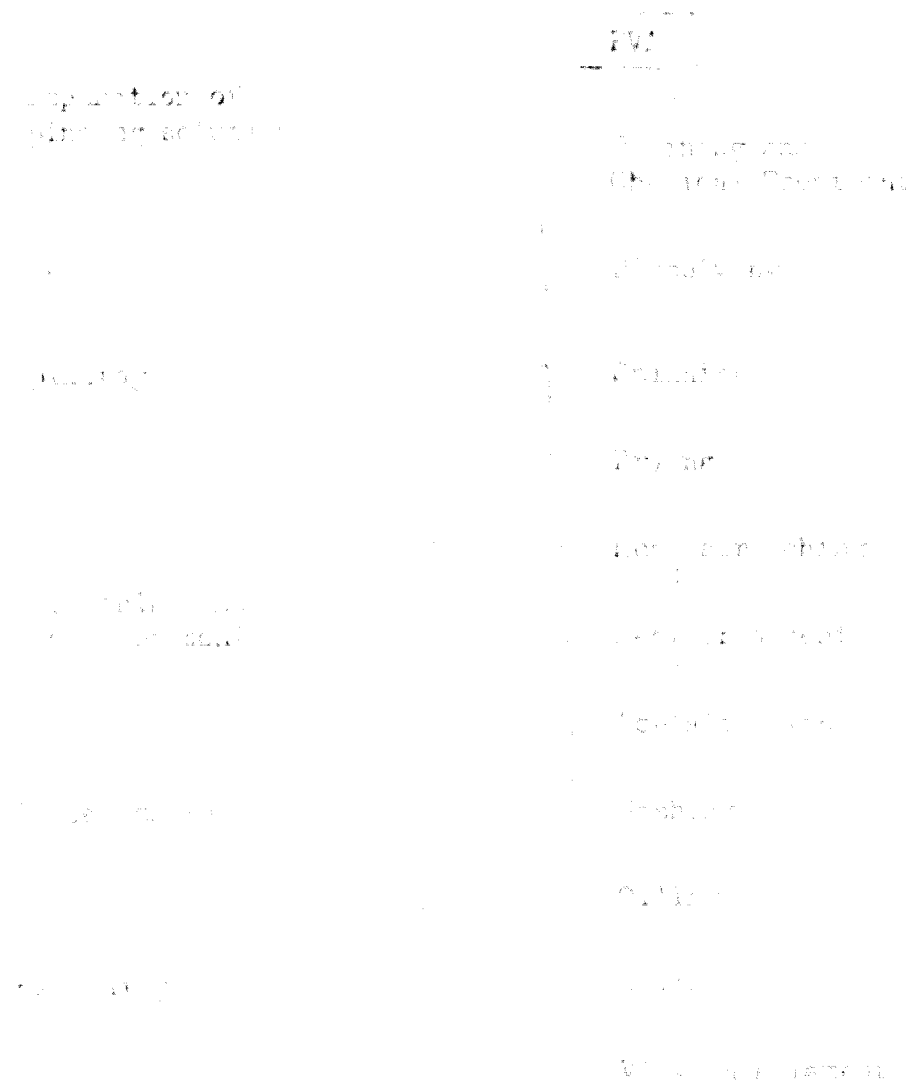
The above method is also suitable for the determination of the amount of a substance in a liquid sample. It is also suitable for the determination of the amount of a substance in a gas sample.

The above method is also suitable for the determination of the amount of a substance in a solid sample.

The above method is also suitable for the determination of the amount of a substance in a liquid sample. It is also suitable for the determination of the amount of a substance in a gas sample.

Figure 1. Diagram illustrating the procedure for the determination of the amount of a substance in a solid sample.

Figure 3 Flow Sheet for the Manufacture of Vinyon  
Filament by Dry Spinning Method



The spinning solution is prepared by dissolving the polymer in a suitable solvent. The spinning cone (chamber) spinning is a process in which the spinning solution is fed into a spinning cone (chamber) and the filament is spun. The filament is then twisted and drawn to the required strength and length. The drawing and drawing process is used to draw the filament to the required length and to draw it to the required strength. The drawing and drawing process is used to draw the filament to the required length and to draw it to the required strength.

Advantages of Vinyon filaments are:

- (1) Owing to the uniform representation of the fibres, without skin and core layers, the effect of dye is extremely bright.
- (2) The dyeing is done with water and solvent make fibre surface matt and the dyeing is done in 10-15 minutes to the depth of mill.
- (3) It is not affected by acids and alkalis and is highly resistant to acids and alkalis.
- (4) It is better in all other than other synthetic fibres: for example, it does not develop a static charge in humid atmosphere and does not get yellowed.

Properties of various filament forms are shown in Table 3.

Table 3 Properties of Vinyon filaments

Form	Denier	Properties	
		Improved type	At present type
Tensile strength (g./dtex)	100	3.0 - 3.5	3.0 - 3.5
	400	1.1 - 1.2	1.1 - 1.1
Wet strength (g./dtex)		70 - 70	70 - 70
Long stretch (%)		4.5 - 5.0	3.0 - 3.5
Creep (g./dtex)		2.2 - 2.0	1.4 - 1.1
Tensile modulus (g./dtex)	100	17 - 21	17 - 21
	400	17 - 21	17 - 21
Electric strength (kV/cm)		12 - 12	12 - 12
Young's modulus (g./dtex)		100 - 50	40 - 22
Softening point (temp. °C)		115 - 118	105 - 110
Softening point (temp. °C)		210 - 220	
Specific Gravity		1.26 - 1.30	
Moisture regain (%)	at 100%	5.0	
	(1)	(3) (at present condition)	
	25°C, 65% RH	3.5 - 4.5	
	20°C, 65% RH	1.2 - 1.0	1.0 - 1.0
	20°C, 95% RH	15.0 - 1.0	5.0 - 10.0

### 5.5. Applications

Virgin filaments are widely accepted in the field of high grade apparel owing to their excellent durability, silk-like luster and handling.

#### (1) High grade "habutae"

Fabrics of 100% synthetic filaments or mixed with silk, wool and other natural fibers are used for high grade silk fabrics such as "habutae", "chirashi", "chirashi", "obi", small pieces for "kimono".

#### (2) Women's suit cloth

Fabrics of 100% synthetic filaments or mixed with silk are used for women's suit cloth, including, "habutae", "chirashi", "chirashi", "obi", "satin", "georgette", "tulle", "voile", etc.

#### (3) High grade sportswear

Applications are being developed for women's suit cloth, men's polo sweaters, "chirashi", etc. using 100% vinyon filaments of elastane type.

#### (4) Tricot

With a very high water and moisture absorbency, tricot fabrics of 100% synthetic filaments are used in the field of underwear including "tricot", "chirashi", etc.

### 5.6. Processing Methods

#### (1) Weaving as a structure

Virgin filaments have a higher moisture absorbency than other synthetic fibers, and a significant change in yield stress by humidity, and therefore, strict control of tension, temperature and humidity is essential.

#### (2) Dyeing

Almost all dyestuffs commonly used may be used. Of them acid dyes in particular are best suited.

Other synthetic dyes are disperse dyes and metal complex dyes which are used as per usual depending on applications and required color.

Temperature dependency of dyeing affinity is great. Except acids

dyes and a part of disperse dyes, abrupt dye absorption occurs in dyeing at a temperature of 80 - 90° C.

### 5.7. Future Developments

Along with the advance in processing techniques, the recently developed elasticity-improved type, conjugated paraffin modified cross-section, types which are expected to be developed in the future, triylon filament can be expected to make a further progress as fibres for apparel use.

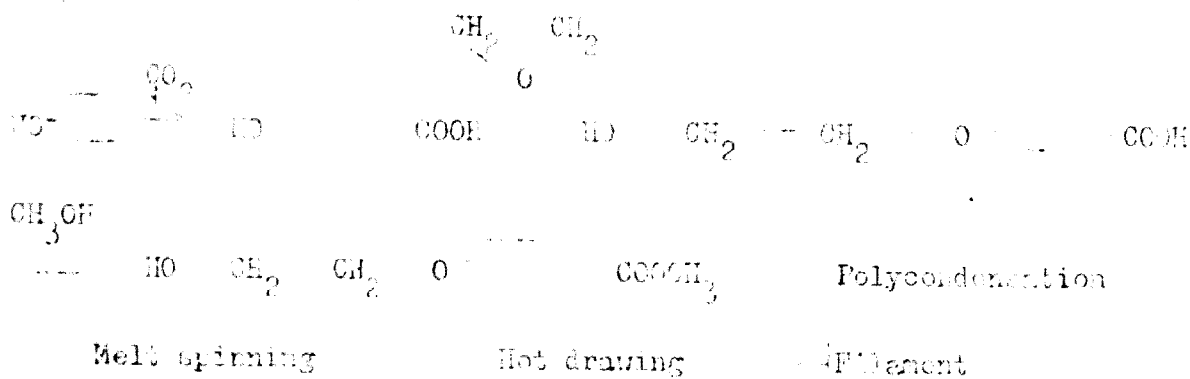
## 6. BENZOATE FIBRES

### 6.1. Introduction

Benzoate fibre is a new synthetic fibre developed and brought into production under the trademark of "A-tell", by Nippon Rayon Co. in May, 1964. The benzoate fibre is made from phenol and ethylene oxide. In its molecular structure ether bonds and ester bonds are regularly repeated. This type of synthetic fibre is unique in the world today and is manufactured by purely Japanese techniques. It is a new fibre which is available closely resembling silk. It has a high tenacity and easy care properties not found with other synthetic fibres.

### 6.2. Raw Material and Manufacturing Process

The starting material for benzoate is phenol which is made in large volume at a low cost by the sulfonating, chlorination of carbon dioxide and subsequent hydrolysis of the resulting phosgene benzoate. It is ethylene oxide which is used to react to make polyethylene benzoate which is then esterified with methanol to produce monomer. This monomer undergoes polycondensation under suitable conditions. It is then extruded by melt-spinning and is further processed to produce filaments.



6.2. Types

Benzoate fibres can be made in filament of a variety of types by combining filaments of different lengths, neckings, cross-sectional shape and lengths.

- (1) low shrink
- (2) high shrink
- (3) low shrink with high shrink

Filament lengths are as follows:

- 303/1 fil, 303/2 fil, 303/3 fil, 303/4 fil, 303/5 fil,
- 36 fil, 48 fil, 60 fil, 72 fil, 84 fil, 96 fil, 108 fil, 120 fil

6.3. Properties of Benzoate Fibres

- (1) Chemical stability

It is a fibre which is more resistant to fibre versus silk.

It is a fibre which is more resistant to fibre versus silk.

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Table 4 Characteristics of Benzoate Fiber versus Silk Fiber

		Benzoate Fiber	Silk
Specific gravity		1.34	1.33 - 1.45
Equilibrium moisture regain (%)		0.4	9
Tensile strength (g/d)	dry	4.0 - 5.3	3.0 - 4.0
	wet	4.0 - 5.3	2.1 - 2.3
Tensile elongation (%)	dry	15 - 30	15 - 25
	wet	15 - 30	37 - 33
Flaming point at 3% stretch		95 - 100	-
Young's modulus ( $10^9/\text{cm}^2$ )		700 - 900	650 - 1,000
Melting point ( $^{\circ}\text{C}$ )		Approx. 225	-

(2) Weathering and Sunlight Resistance

Benzoate fibers are so resistant to weathering and sunlight that unlike silk it will never suffer yellowing or degradation.

It is also highly durable under outdoor exposure.

(3) Chemical Resistance

Benzoate fiber is impervious to virtually all inorganic and organic chemicals. It shows high resistance to strong acids such as sulfuric acids and nitric acids. It is unaffected by strong alkalis such as caustic soda. Also it is impervious to bleaching agents such as sodium hypochlorite, hydrogen peroxide and hydrosulfide. Of organic solvents, phenol-based solvents dissolve the benzoate fiber, but the majority of organic solvents do not dissolve it unless by heating. The organic solvents which dissolve the benzoate fiber are *m*-cresol and *o*-chlorophenol.

(4) Elasticity and Elastic Recovery

Elasticity and elastic recovery are the important factors which determine handle and feel. Nylon is the fibre having by far the best in this regard. Elastic recovery is equal, but acetate fiber has an advantage in that recovery against the force is that of nylon. The recovery of acetate fiber is equal to that of nylon. Acetate fiber has a high resistance against repeated stretching and recovery. Acetate fiber possesses excellent wearing qualities and is a desirable fiber.

(5) Handle

Factors which are important for handle fiber are soft and elastic with little weight. Nylon is a desirable fiber in this respect. Cotton fiber is soft and elastic, but lacks in strength, elastic recovery in both directions, crease resistance, and elastic compressions to maintain shape. Nylon and silk fabrics which are soft and elastic provide almost the same handle as wool.

(6) Thermal Properties

Nylon has a melting point at about 250°C and a softening point at 200°C. It is stronger than wool of synthetic fibers with the exception of polyacrylate. This fibre does not require ironing or dry cleaning by heat. Polyester requires dry cleaning or ironing. It is a good fiber for heat set, but it is not as soft and elastic as wool. Polyester has a lower temperature of softening than nylon. It is a good fiber for wearing qualities.

(7) Dyeability

Acetate fiber can be dyed into a natural and fast color via disperse dyes. It is a good fiber for disperse dyes; whereas that of polyester for which also the disperse dyes are used. An excellent dye temperature of 130°C is used, at which temperature the dye is easily penetrable. Moreover, the dyeability of the polyestered at 130°C is almost equal to that of polyester dyed at 130°C.

#### 6.4. Applications

Owing to the handle of the benzocete fiber almost similar to that of silk, instead of coarse fabrics of 100% benzocete fiber of mixed with silk, to some extent, it is fitted for use in the same high grade clothing.

Some of the possible applications are given below. These are as follows:

Men's shirts, suits, trousers, blouses

Children's dresses, blouses, dresses, sweaters, polo shirts

General work wear, uniforms, curtains, men's socks, school cloth

#### 6.5. Future Development

Since the benzocete fiber is similar to silk in the characteristics of silk with the superior appearance of synthetic fiber, not found with silk, it will be suitable for new applications, not only in the fields where silk is used, but also in the field of high grade apparel as the highest quality synthetic fiber.

### 7. SYNTHETIC FIBER OF POLYMER OF 1,4-DIPHENYLENE

#### 7.1. Introduction

1,4-Diphénylene polymer fiber (hereinafter called "1,4-DP fiber") has been developed after 1950 as a result of extensive study by Toyko Co. This fiber is a synthetic fiber which is very similar to silk. The fiber is very similar to silk very much in the same way as silk. The fiber is made by the polymerization of 1,4-diphénylene and polyacrylonitrile. The fiber is similar to silk in many respects, but there are some differences. The fiber is silk-like fiber.

#### 7.2. Properties

The 1,4-DP fiber is reported to be produced in the range from 20 denier through several hundred denier up for the present. 40 denier is standard. In general, when fibers consist of two polymer, the properties of both constituents in the fiber are more or less preserved. With the 1,4-DP fiber, however, no definite separation of polymer and polyacrylonitrile takes place. The structure is relatively simple.

As shown in Fig. 5, the structure of the 1,4-DP fiber is very similar to those of silk. The properties of the fiber are also very similar to those of silk. The fiber is very similar to silk in many respects.

extremely pure preparation, but the wool fiber exhibits excellent fiber properties, a minimum of shrinkage, and a high percentage of protein providing a substantial amount of the value of the wool.

The following table compares wool and silk.

		Wool fiber	Silk
Tenacity (lb./sq. in.)	Wool	4.0 - 5.0	4.0 - 4.0
	Silk	2.0 - 2.5	2.1 - 2.8
Elongation (%)	Wool	20 - 25	15 - 25
	Silk	10 - 12	27 - 33
Modulus (lb./sq. in.)		1.0 - 1.4	2.0
Denier (g./9000 yds)		600 - 1000	650 - 1200
Shrinkage (%)		5	9
Specific gravity		1.30	1.33 - 1.40
Moisture regain (%)		2.5 - 4.0	0 - 1

(1) Strength and Durability

Wool is stronger than silk, and more elastic than silk.

(2) Appearance

In appearance, the wool fiber, because of its luster, is very similar to silk. It is, however, more resistant to soiling and discoloration for apparel purposes.

(3) Comfort

Its softness is greater than that of silk.

It is more resistant to wear and tear, and provides greater recovery of the fiber.

(4) Maintenance

Wool is more resistant to light than silk, and is less susceptible to the effects of alkalis, but it is more susceptible to acid damage. It is the best of all synthetic fibers in this respect.

(5) Appeal to the senses

The characteristics of the 'mf' fibre which appeal to the senses including handle and lustre, show a very close resemblance to those of silk. More specifically, it makes fabrics with soft feeling, smooth drape, lustrous and elegant lustre, increased reflectance, slipperiness, cool and refreshing feeling, and satiny lustrous finish with normal synthetic fibres.

(6) Drape

Drape is said to have important connection with feel of fabrics. The 'mf' fabric has beautiful drape and softness most similar to those of silk.

(7) Lustre

Lustre of fabrics made resembles to that of silk, and this is shown out by functional test.

7.3. Weavability

(1) Weaving and Twist Yarn

Tenacity of 'mf' fibre yarn is far higher than that of silk. So no problem with weavability. Its friction coefficient is much lower than that of other synthetic fibres. Therefore, the stresses at yarn ends are minimum. Yarn twist in fabric is 10% less than silk fabric. It means if hard twist yarn is given unmade fabric. Also the same twist yarn of the 'mf' fibre can make woven fabric with the same handle as that of silk and this is one of the advantages of this fibre.

(2) Sizing

The 'mf' fibre is a copolymer of protein and vinylidene. Its characteristics essentially show high adhesion to various sizing agents. As a result, the 'mf' fiber permits far easier sizing than other synthetic fibres.

Excellent wet finish can be given with just a little size pick-up. This is also one of the important advantages of this fiber.

#### 7.4. Processibility

##### (1) Scouring

The AnF fibre does not require intensive scouring which is required for natural fibres such as wool and cotton containing plenty of impurities. As with other synthetic fibres scouring of the AnF fibre need only go to the extent of removing the oil on fibres or removing the size picked up in the weaving step. Since water soluble sizes like FW are used with the AnF fiber, desizing and scouring may be done simultaneously.

##### (2) Creping

Hard twist yarn of the AnF fiber provides smaller untwist torque than the hard twist yarn of silk, but it can be satisfactorily creped by the use of mechanical supplementary means or softening agents in bath.

##### (3) Dyeing

Since the AnF fiber is a copolymer of protein and acrylonitrile, it combines the advantages of natural fibres and synthetic fibres. It is the fiber having properties of protein which shows affinity to anionic dyes, direct dyes and chrome dyes and those of polyacrylonitrile which shows affinity to cationic dyes and disperse dyes. Therefore it is dyable with any type of dyestuffs.

Table 6 shows the affinity of the AnF fiber to various dyestuffs compared with silk. As shown, the AnF fibres exhibits affinity to various kinds of dyestuffs, but the dyestuffs principally used in practice are acids dyes.

Table 6 Affinity to various dyestuffs and fastness.

Dyes	Acid Dyes	Metal Complex dyes 1:2	Chrome dyes	Direct dye	Catio- nic dyes	Disperse dyes	Affinity and Fastness
Affinity							
Build-up							
Fastness to sunlight							
Fastness to washing							
Fastness to rubbing							
Good		Rather poor			Poor		

In its dyeability with acid dyes knit fibre resembles silk but is unlike other silklike fibres and this is one of the important advantages of this fibre. Other dyes are also applicable depending on use. For example, cationic dyes are used where bright late or fluorescent color is required and chrome dyes are used for black color, and disperse dyes for light colors.

In dyeing, high temperature dyeing or carrier dyeing is not required. Dyeing at 95 - 100°C under normal pressure can develop sufficiently deep color. The absorption curves by temperatures are mild, which implies difficulty of causing uneven dyeing.

Comparison in color development characteristics and stimulus purity between the 100% fibre and silk shows that the 100% fibre is not at all inferior to silk.

The color fastness of the 100% fibre is about equal to that of silk. The 100% fibre is even better in the case of light and better fastness to perspiration, bleaching, hair dyes, and wet rubbing. The selection of best stuffs is therefore not a problem.

#### 4.5. Application and Use

The 100% fibre can be used in all fields where silk is now used. Even if there are some problems in the fields of textured yarn and knitted fabrics, these problems can be solved and have not penetrated deeply into the field. With the progress of fibre production and development, it will be possible to bring into various products of great beauty.







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