APRIL, 1942 BULLETIN 300

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

SYNTHETIC FIBERS AND TEXTILES

PRINTED BY KANSAS STATE PRINTING PLANT
W. C. AUSTIN, STATE PRINTER
TOPEKA, 1942
19-2870

TABLE OF CONTENTS

ILLUSTRATIONS

SYNTHETIC FIBERS AND TEXTILES[1]

HAZEL M. FLETCHER

All textile fabrics manufactured prior to 1884 were made of the natural fibers: wool, silk, cotton and linen. Since the invention of synthetic fibers many fabrics have been manufactured entirely of these fibers or mixed with the natural fibers.

Synthetic fibers now are playing a major role in the textile industry, due partly to the great variety of moderately priced fabrics which can be made from them. These include tablecloths, sheets, towels, draperies, dress crepes, sheers, velvets, hosiery, women's and men's suitings.

Classification of Synthetic Fibers and Textiles

RAYON

The rayons constitute by far the greater part of the synthetic fibers produced in the world today. Rayon is a textile fiber made from cellulose. It is manufactured chiefly from spruce wood and

FIG. 1.—Cotton linters, spruce wood chips and wood pulp are the raw materials used in the production of rayon.

cotton linters, the short fine fibers that cling to the cotton seed after the long fibers have been removed.

In the manufacture of rayon the spruce wood and cotton linters are dissolved to form a spinning solution about as thick as molasses. This solution is forced through small holes of a spinnerette, a small metal cap of platinum or platinum alloy about the size of a sewing thimble and containing usually as many as 13 to 270 holes. The streams of liquid from the spinnerette are drawn out and solidified into long continuous fine threads or filaments in a chemical bath or on exposure to air. The filaments from a single spinnerette are twisted slightly into a yarn which contains as many filaments as holes in the spinnerette. Rayon filaments can be made finer than those of silk or coarser than wool. This yarn made of continuous filament rayon can then be woven into cloth.

1. Contribution No. 101, Department of Home Economics.

The three rayons produced in the United States at present are viscose, cellulose acetate and cuprammonium. Each is manufactured by a different process. The viscose and cuprammonium rayons are both cellulose, and the acetate rayon is a derivative of cellulose.

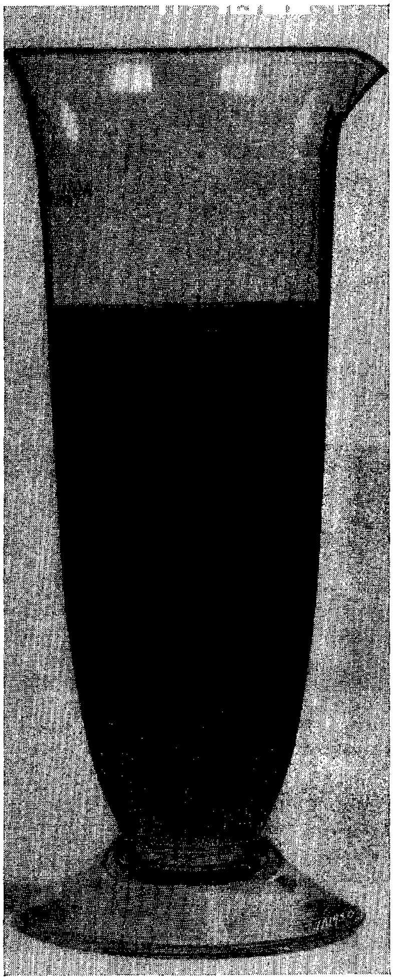


FIG. 2.—Spinning solution used to produce rayon filament.

Viscose rayon is the synthetic textile produced in the greatest abundance. Because it is cellulose it burns like cotton or paper. It is not as strong when wet as when dry, and consequently when laundered it should be handled with care. It does not scorch easily and can be ironed in much the same way as cotton.

Cellulose acetate rayon is next in importance to viscose rayon as far as the amount manfuactured is concerned. Fabrics made of cellulose acetate rayon yarns are usually sold as acetate or by some trade name such as Celanese. Cellulose acetate rayon behaves quite differently from the other two rayons in that it will dissolve in acetone, the base of nail polish remover; and it will melt when

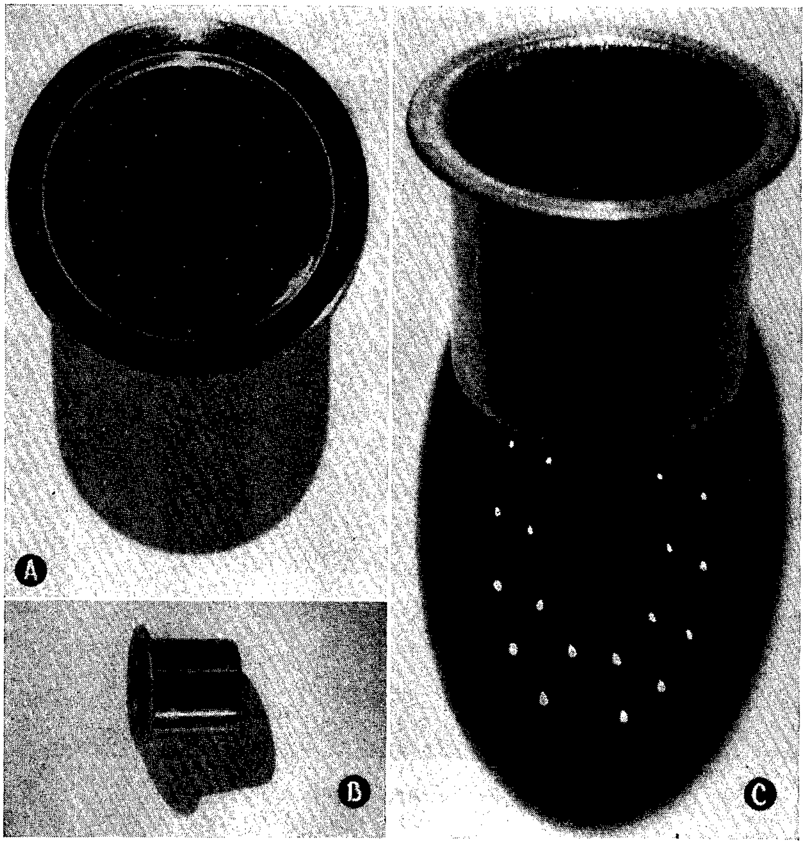


FIG. 3.—Spinnerettes used in "spraying" the synthetic solution. A and C are enlarged views, B shows an actual-sized view.

ironed with a hot iron. This rayon is not as strong when wet, and thus care must be used in laundering. Only a moderately hot iron should be used when ironing. When held in a flame it melts and a hard crisp ash forms in a ball.

Cuprammonium rayon constitutes a small part of the total rayon production. Fabrics made from cuprammonium rayon yarns are usually sold under the trade name of Bemberg, for example Bemberg sheer. Cuprammonium rayon is being used for women's knit lingerie, sheer dress fabrics and satins. Like the other rayons it is not as strong wet as when dry. It burns like paper or cotton and can be ironed with a hot iron.

Continuous filament rayon yarns are woven into a great variety of fabrics. These consist of crisp taffetas, shiny satins, heavy pebbly crepes, sheer dress crepes and knit jerseys. Figure 5 shows some of these materials. These fabrics are used widely in women's garments and also in household furnishings.

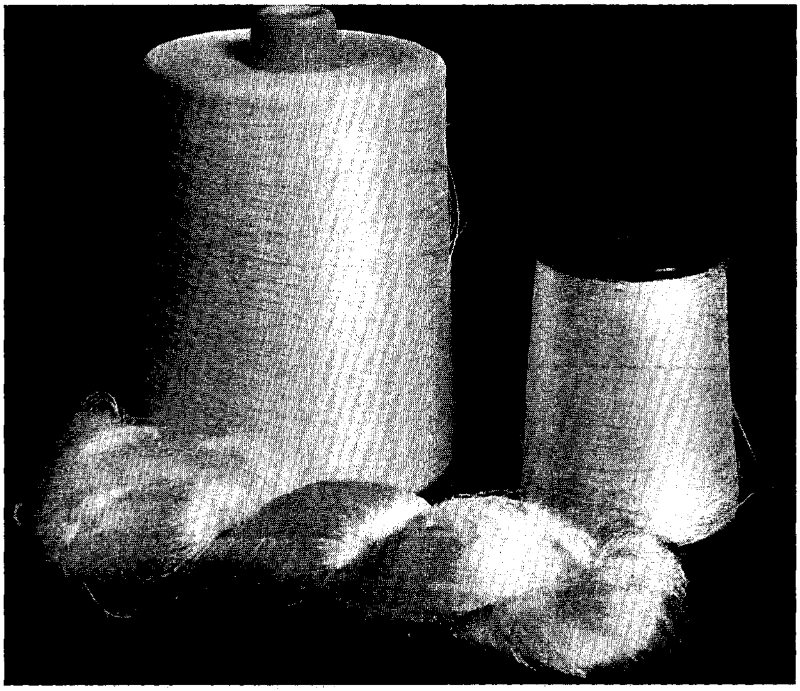


FIG. 4.—Rayon yarn shown in the shipping cone, spool and skein.

PROTEIN FIBERS

Synthetic fibers have been made from raw materials other than cellulose. These consist of protein fibers made from casein of milk and soybeans, nylon and vinyon made from synthetic resins of organic origin, and glass fibers.

Lanital, an Italian product, was the first successful commercial fiber made of milk casein. Protein fibers from casein, known as aralac, are produced in the United States. Chemically, lanital is quite similar to wool and can be dyed with the same kind of dyes, and like wool, it, is damaged readily by alkalies. It has a resilient wooly feel, but is not as strong and firm or as elastic as wool. Moths will not attack it, and it does not shrink as much as wool but mildews easily when damp. It burns with the same characteristic odor as wool, but does not have the surface scales that wool fibers have.

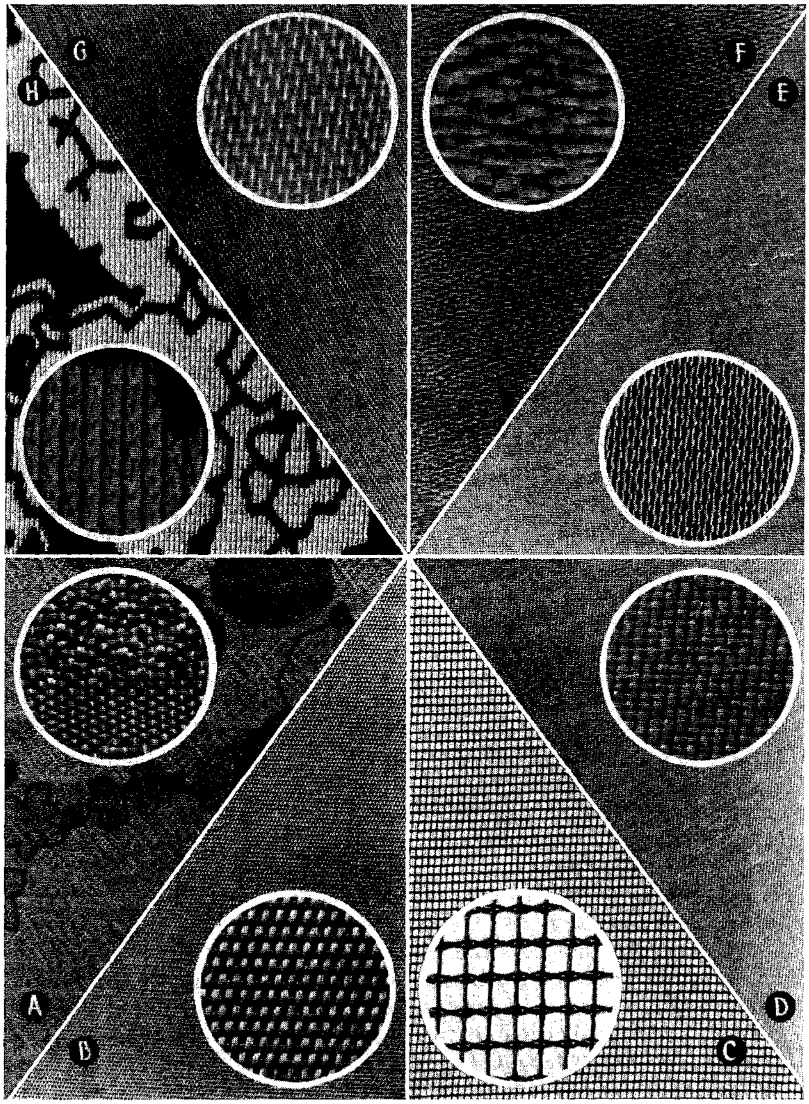


FIG. 5.—Fabrics made of continuous filament rayon: A, viscose crepe; B, viscose taffeta; C, viscose marquisette; D, cuprammonium twill; E, cuprammonium sheer; F, acetate granite cloth; G, acetate satin; H, acetate jersey. (Inserts magnified 4 ×.)

Even though casein fiber lacks certain desirable qualities of wool, it shows promise of considerable usefulness. Because of its lower cost it is used to replace wool. It is combined with other fibers such as wool and rayons.

Soybean fiber is white to light tan in color and has an appearance and texture similar to silk and wool. It has a warm, soft feel, a natural crimp, and a high degree of resiliency. It is about four-fifths as strong as wool; it does not absorb moisture as easily as wool or casein fiber; and thus will not mold as readily as the casein fiber. The chemical and dyeing properties of soybean fiber are similar to wool.

Soybean fiber shows promise of usefulness in the textile field. The fiber blends well with wool and cotton and has been woven and knitted into goods by the usual textile methods. Upholstery fabrics for automobiles made from this fiber have proven satisfactory. It is suited to be used in blends with wool for weaving suitings as well as upholstery fabrics. Using it with cotton and spun rayon in the development of new materials and with wool in the production of felt has been proposed. The protein fibers do not resist wear and deterioration like the natural fibers and the other synthetic fibers.

SYNTHETIC RESIN FIBERS

Nylon differs radically in its physical and chemical properties from other synthetic fibers. It resembles silk more closely than it does any of the other natural fibers. The great strength, elasticity, and wearing qualities claimed for it have aroused considerable interest. The advantages of nylon are its high strength and elasticity, its lack of sensitivity toward moisture and various chemical agents, and its ability to be spun into fine filaments. It is stronger and more elastic than silk. It is nearly as strong when dry as when wet. Because it does not absorb moisture readily, garments made of it dry quickly. Mineral acids deteriorate it and phenol and formic acids are active solvents. No common dry cleaning solvents affect it, and it is quite resistant to alkalies even in concentrated form and also to mildew, molds and moths. Nylon does not burn. When held in an open flame it reacts similarly to silk, wool or acetate rayon. The fibers melt and fuse into a glassy round-shaped mass.

Varied commercial uses have been made of nylon, and it probably will replace silk to a great extent in the textile field. This fiber can be made into fine hosiery and other knit goods such as underwear. Some other uses are sewing thread, brush bristles, racquet and violin strings, surgical sutures, fishing lines, woven dress goods and velvets.

Vinyon is a synthetic fiber having remarkable properties. It is thermoplastic and when heated above 117° F. will shrink. If held in a flame it melts and chars but does not burn. Concentrated acids or alkalies will not injure vinyon fabrics. The fabric does not absorb moisture, consequently it will not mildew and will be quite useful in damp climates. This fiber has high elasticity and breaking strength; and because it is not affected by water, its strength is the same wet as when dry.

Vinyon has been put to many uses. Short fibers of vinyon have been mixed with cotton, wool, glass or other fibers to form felts. The most extensive use is for industrial filter cloth because of its high dry and wet breaking strength and its resistance to acids and alkalies. Some other uses are fish lines, nets, seines, acid and alkali-resistant clothing, electric insulation, shower curtains, bathing suits, waterproof clothing, fireproof awnings and curtains. Vinyon

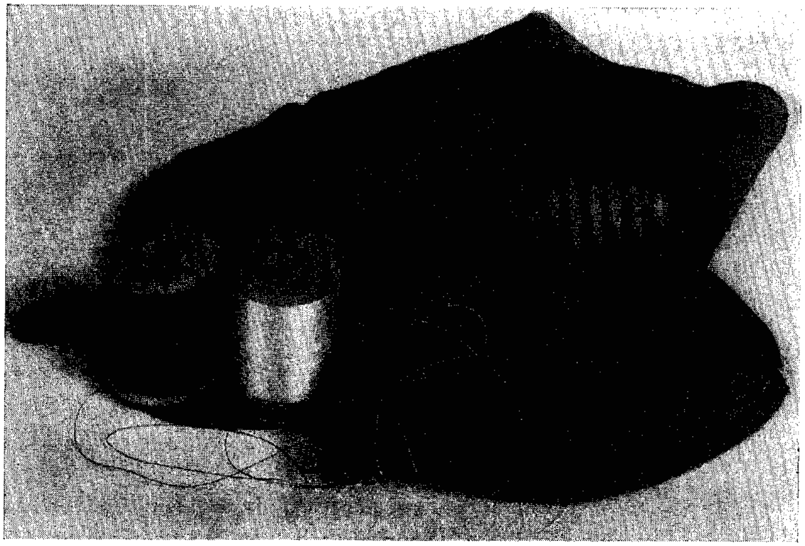


FIG. 6.—Nylon used for toothbrush bristles, hose and sewing thread.

has also been used for shoe fabrics and gloves. Stains are readily removed from vinyon fabrics in a soap solution, and the material dries quickly.

GLASS FIBERS

Glass fibers are smaller than other textile fibers. Glass in its solid form has hardness, strength, cleanliness, great durability, and is plastic when molten. Glass fiber has all these desirable attributes of solid glass. The properties of glass fiber make it of value in many ways. It is a poor conductor of heat and electricity, and thus is used extensively for heat and electrical insulation. It can be subjected to temperatures of 1,000° F. without melting. It is inorganic and does not absorb moisture; consequently it resists decay, does not mildew, and vermin will not eat it. Glass fibers are very resistant to alkalies, acids and other chemicals.

Damasks, brocades, satins, taffetas and sheer nets—all of varying textures, handles and sheens—are being made of glass. These are for overdrapes, glass curtains, shower curtains, bedspreads, lampshades, awnings and other articles. Glass fiber is not suitable for dress fabrics. For wearing apparel it is used in shoes, hats, belts, neckties, handbags and other dress accessories.

The new glass fabrics have advantages over fabrics of rayon or natural fibers because they are color fast, durable, will not shrink, are resistant to heat, and are practically soil proof. Dust or dirt can be wiped off with a damp cloth. Tablecloths and other articles when laundered should be flexed and rubbed as little as possible because the brittle fibers lose strength when abraded.

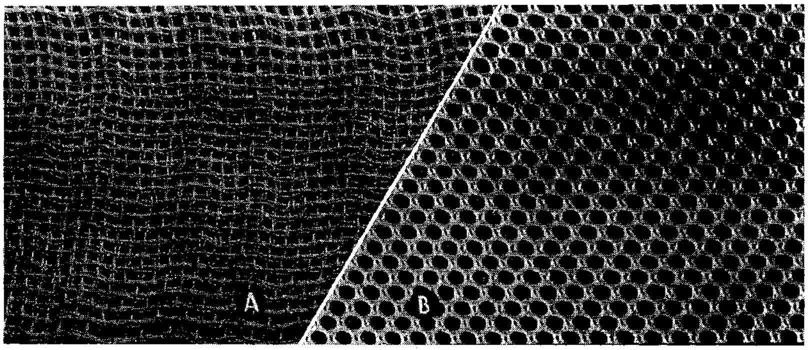


FIG. 7.—(A) Glass cloth used for draperies and (B) vinyon net used in shoes.

MODIFIED FIBERS

Fibers made by the usual rayon processes have been modified to meet specific uses. Strong viscose rayon is used for automobile tire cords because it is much stronger than cotton, especially at high temperatures. A viscose staple fiber that resembles wool has been developed. It has a rough surface and a permanent kink or crimp like wool.

Animalized fibers are modified viscose fibers which possess wool dyeing properties due to the fact that some protein as casein has been added to the spinning solution. Viscose to which synthetic resin has been added is similar to the animalized fibers, for it also has dyeing properties similar to wool.

Teca is a cellulose acetate staple fiber which has a permanent kink or waviness and closely resembles wool. It can be used alone or in blends with other fibers to produce fabrics of wool-like appearance.

A new viscose fiber with permanent crimp, known as Fiber D, offers promise to rug manufacturers. It is round in cross section like wool, but has a smooth surface. It feels and has an appearance like that of coarse wool used in rugs and carpets.

FIBER IDENTIFICATION

It has become difficult to ascertain the fiber content of fabrics by their appearance and handle or by chemical and burning tests. Formerly, it was a simple matter to determine whether a fabric was silk, cotton, linen, or rayon. Many of the new finishes give the synthetic fabrics the appearance of wool, linen, or silk. Furthermore, there has been an increasingly large production of fabrics composed of two or more kinds of fibers. Experienced textile workers have frequently been unable to determine fiber content without using exacting methods of identification. Because the kinds of fibers used cannot be determined without reliable laboratory techniques, fabrics on the market should have labels stating accurately the fiber content. Such accurate statements of the fiber content would enable the consumer to exercise proper care in dry cleaning and laundering and would be of particular value to those who are allergic to certain textiles.

The textile technologist employs many tests to identify fibers. The burning tests are the easiest to use, but are not exacting, especially for mixed fabrics. Chemical tests are often helpful, but these are usually not applicable except in a chemical laboratory. The microscopical identification of fibers is the most reliable and satisfactory. For this a microscope of high magnification must be available. Also, one must be equipped with the necessary apparatus to make mounts of the fibers both in longitudinal and cross-sectional views.

Viscose and cuprammonium rayons can be distinguished from cellulose acetate by the burning test. The acetate rayon melts to a crisp black bead, and the other rayons burn quickly like paper or cotton with no odor and no ash. Viscose and cuprammonium rayons are difficult to distinguish by chemical means, for they are both regenerated cellulose. They are best identified by the shape of their cross sections. Figure 8 shows photomicrographs of the three rayons. All three fibers appear like smooth glass rods, but the cross sections have characteristic shapes. The cuprammonium fiber is round; the acetate has a clover-leaf appearance with three or four lobes; and the viscose has sawtooth edges.

Acetate rayon is easily distinguished from the natural and synthetic fibers because it is readily dissolved in acetone and the others, except vinyon, are not. Acetone is the base of nail polish remover and a drop of remover on an acetate rayon or vinyon fiber will dissolve it, but has no effect on the other fibers. Strong acids will attack acetate rayon, but will not attack vinyon.

The casein fibers cannot be distinguished from wool fibers by chemical or burning tests. They have practically the same chemical composition as wool and both have the odor of feathers when burned, leaving a black crisp ash. Both wool and casein fibers are easily dissolved in alkalies and are resistant to acids. The wool fiber is readily distinguished from other fibers under a microscope

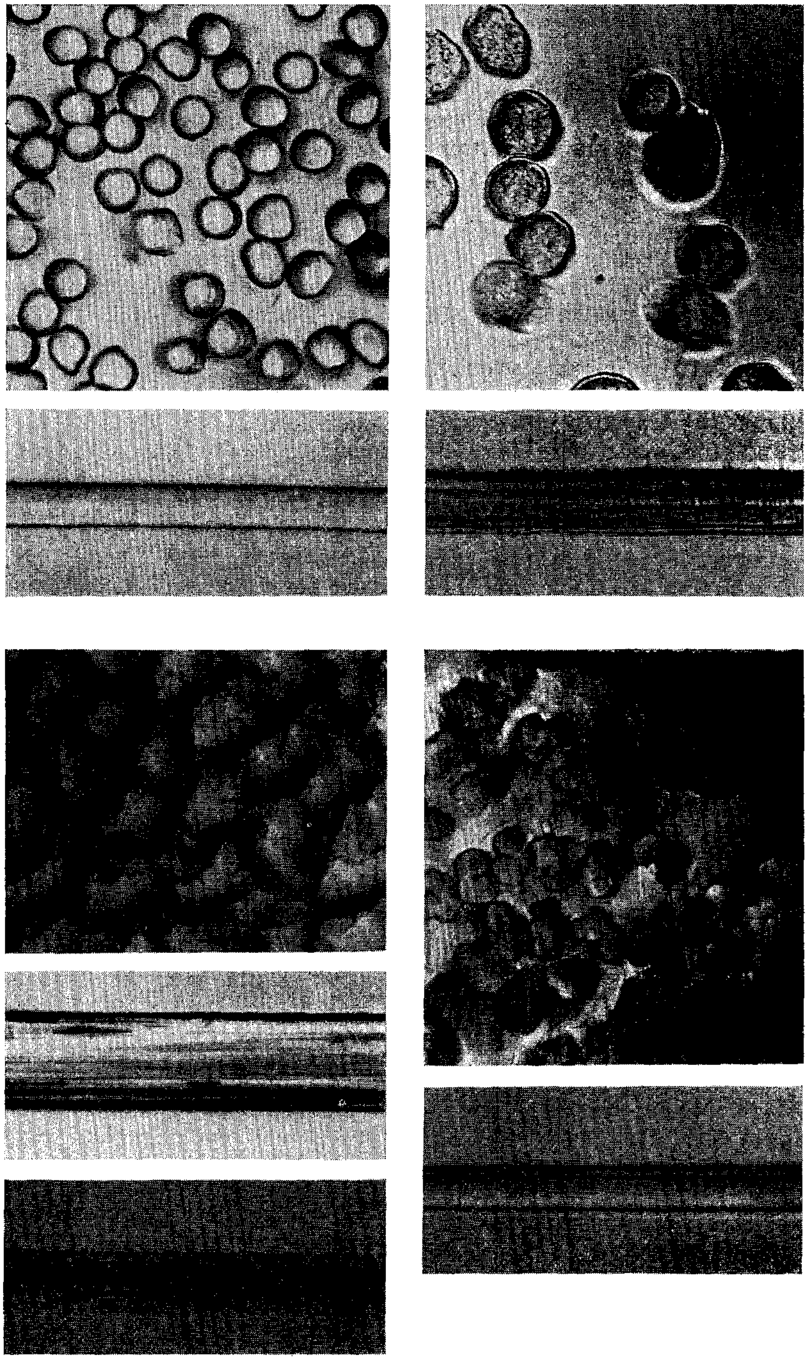


FIG. 8.—Photomicrographs of cross-section and longitudinal views of different synthetic fibers. Upper left—Cuprammonium. Upper right—Lanital. Lower left—Viscose, with longitudinal views of lustrous and delustered fibers. Lower right—Acetate. (All cross sections magnified 380 diameters. Longitudinal views 350 diameters.)

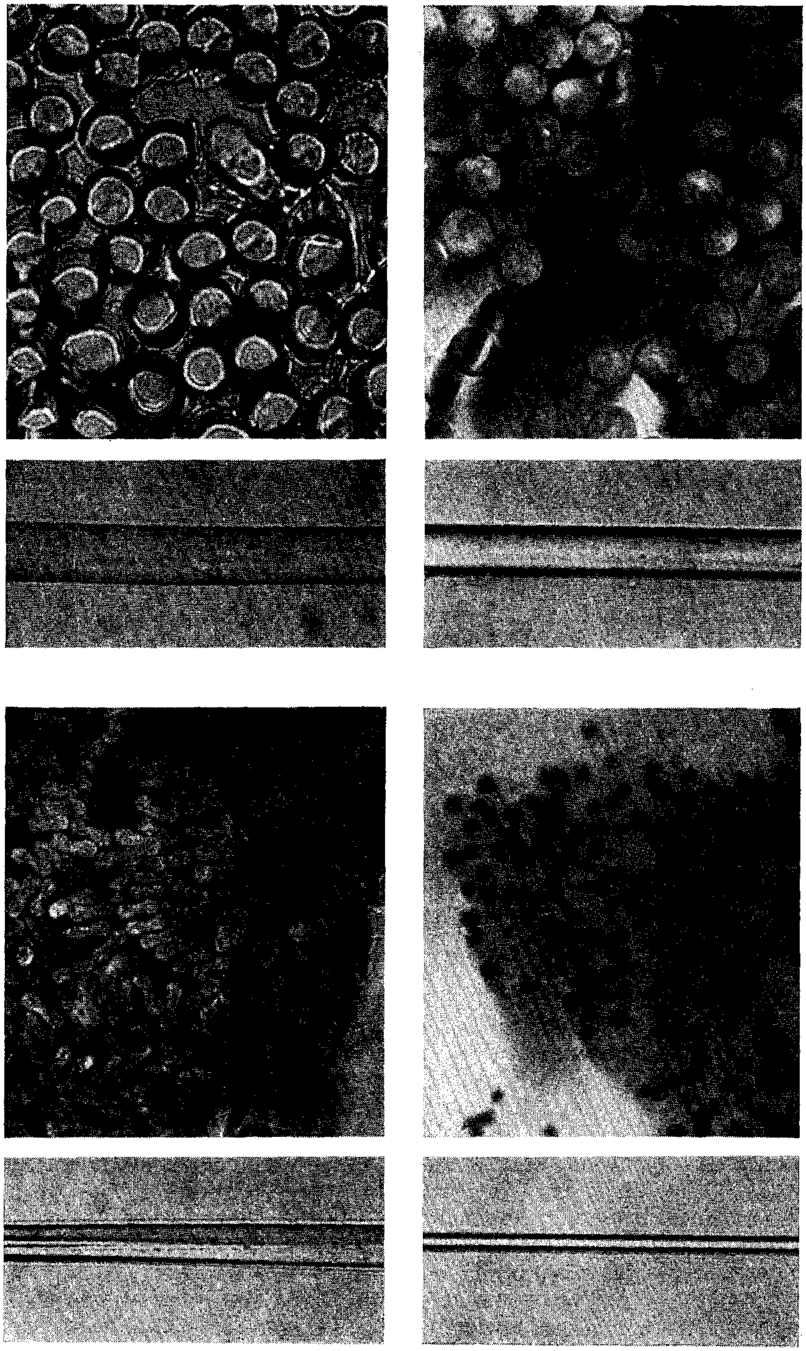


FIG. 9.—Photomicrographs of cross-section and longitudinal views of different synthetic fibers. Upper left—Soybean. Upper right—Nylon. Lower left—Vinyon. Lower right—Glass. (All magnifications 335 diameters.)

because it has scales on the surface which is not characteristic of any other fiber. The surface of lanital is smooth and the cross section is round. (Fig. 8.)

Soybean fibers react similarly to casein fibers and wool by chemical and burning tests. The fiber is smooth in appearance and has no scales. (Fig. 9) The cross section is round.

Both nylon and vinyon melt at high temperatures and are practically nonflammable. They are easily distinguished by the shape of their cross sections. Nylon is round, and vinyon is shaped like a dumbbell. (Fig. 9.) Vinyon is not attacked by either strong acids or alkalies; nylon is resistant to alkalies, but is injured by strong acids.

Glass fibers are readily identified because when held in a flame they will not burn or melt, except at extremely high temperatures of over 1,000° F. All other fibers when held in a flame will either burn or melt. Glass fiber has a round cross section and is the smallest of all the textile fibers. (Fig. 9.)

SPUN RAYON

The extensive use of rayon staple fiber has come about since 1930. Staple fiber is made by spinning rayon filaments and then cutting them after they leave the spinnerette into short uniform lengths, usually from about one to six inches. These short lengths spun into yarn is known as spun rayon. Most of the staple rayon is made by the viscose process; it is also produced by the acetate and cuprammonium methods.

Textile mills spin staple rayon into spun rayon yarns by the cotton, wool, spun-silk or linen spinning systems. Fibers from one to two inches long can be spun on cotton machinery; fibers cut into three-to-five inch lengths on the spun-silk system of spinning. If the rayon staple fibers are to be mixed with a natural fiber such as wool, they are cut into lengths approaching the length of the natural fibers.

Staple rayon really constitutes another textile raw material, and is a recent development of major importance in the textile industry. Spun rayon has increased in importance until fabrics made of this yarn are becoming more numerous and more in the fashion spotlight.

Spun rayon has made possible a wide variety of fabrics. It may be made and blended with wool, hair, silk, linen and cotton to form an infinite range of new and unique fabrics. Staple rayon may be combined with the natural fibers as well as with continuous filament rayon, When used alone or mixed with other fibers it can be woven into soft challies, heavy suitings, crepe fabrics, plushes and coatings. These fabrics can be given both crisp and soft finishes. It can be made into fabrics resembling linens, cottons or woolens, in addition to an endless variety of new textures. They are made into fabrics such as hopsacking, light-weight sheers, smooth serges and poplins, gabardines, worsted-like suitings, shantung and poplin shirtings.

TABLE 1.—*Key to identification of synthetic fibers*

KIND OF FIBER.	Burning test.	Microscopical appearance.	Chemical properties.	Physical properties.
Viscose rayon.	Burns like cotton with flame, no odor, little ash.	Cross section has sawtooth edges.	Dissolves in strong acids.	Breaking strength decreases when wet, not very elastic.
Cellulose acetate rayon.	Melts when burned and forms crisp black bead.	Cross section has lobes similar to clover leaf.	Dissolves in acetone and strong acids.	Wet breaking strength does not decrease as much as viscose, more elastic.
Cuprammonium rayon.	Burns like cotton.	Resembles glass rod, cross section is round.	Dissolves in strong acids.	Similar to viscose.
Casein.	Burns like wool with odor of burning hair.	No surface scales, cross section is round.	Damaged readily by alkalies.	Not as strong or as elastic as wool, mildews easily.
Soybean.	Burns like wool.	Cross section is round.	Damaged readily by alkalies.	Similar to casein fiber, mildews less easily.
Nylon.	Melts and forms round hard bead.	Resembles glass rod, cross section is round.	Damaged by acids, quite resistant to alkalies.	High dry and wet breaking strength, great elasticity.
Vinyon.	Melts and forms hard irregular bead.	Resembles glass rod, cross section shaped like a dumbbell.	Resistant to acids and alkalies, dissolves in acetone.	High dry and wet breaking strength, very elastic.
Glass	Does not burn.	Smallest of all fibers, cross section is round.	Resistant to chemicals.	Strong, brittle, does not absorb moisture.

Spun rayon may be of increasing importance in the manufacture of upholstery, draperies, decorative fabrics and domestics such as sheets, towels and tablecloths. Figure 10 shows some spun rayon fabrics.

MIXED FABRICS

Rayon staple fiber has made possible the manufacture and increasing use of mixed fabrics. Combination of the natural fibers—heretofore unmixed—with synthetic fibers has made available a

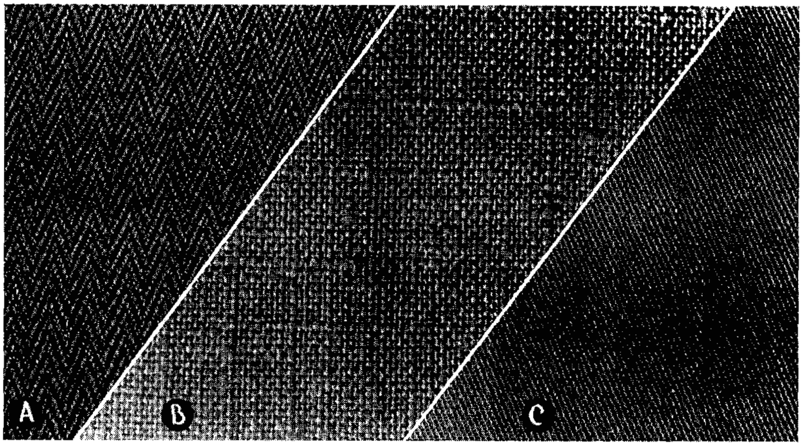


FIG. 10.—Specimens of spun rayon fabrics. A is acetate (Teca) herringbone twill; B is viscose rayon simulating linen; and C is a viscose gabardine.

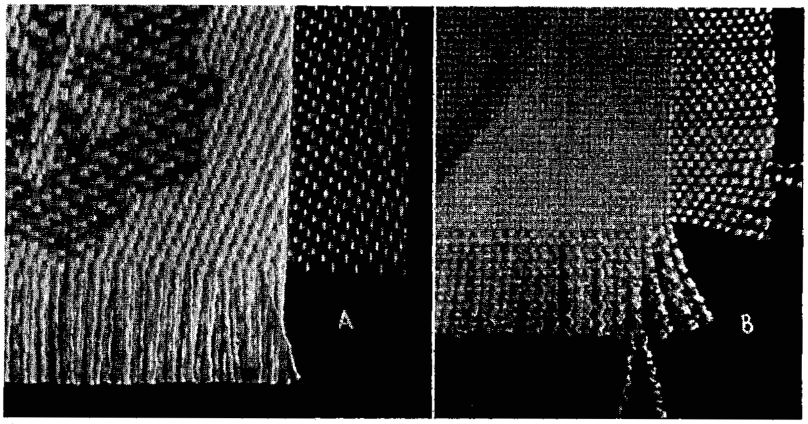


FIG. 11.—Tablecloths of viscose rayon and cotton. (A) Cotton warp and rayon filling. (B) Warp and filling of two-ply yarns, one of rayon and the other of cotton. (Magnification 2 ×.)

greater variety of novelty fabrics and lower priced fabrics, since the new fibers are less expensive and more abundant than natural fibers.

Two or more kinds of fibers can be mixed or blended before they are spun into yarn. In this way a yarn is composed of different kinds of fibers blended before spinning. Yarns may be made of two or more single or ply yarns. One ply may be made of one kind of fiber and another of a different kind. Also, mixed fabrics may have the warp yarns of one kind of fiber and the filling of another. Tablecloths may be made of viscose rayon and cotton. (Fig. 11.) Specimen A has a cotton warp and rayon filling; specimen B has two-ply yarns in both warp and filling. The smaller ply shown raveled and untwisted is cotton and the larger rayon.

Fabrics made of staple rayon fiber and wool have been made popular by manufacturers of women's suitings and cloakings, cre-

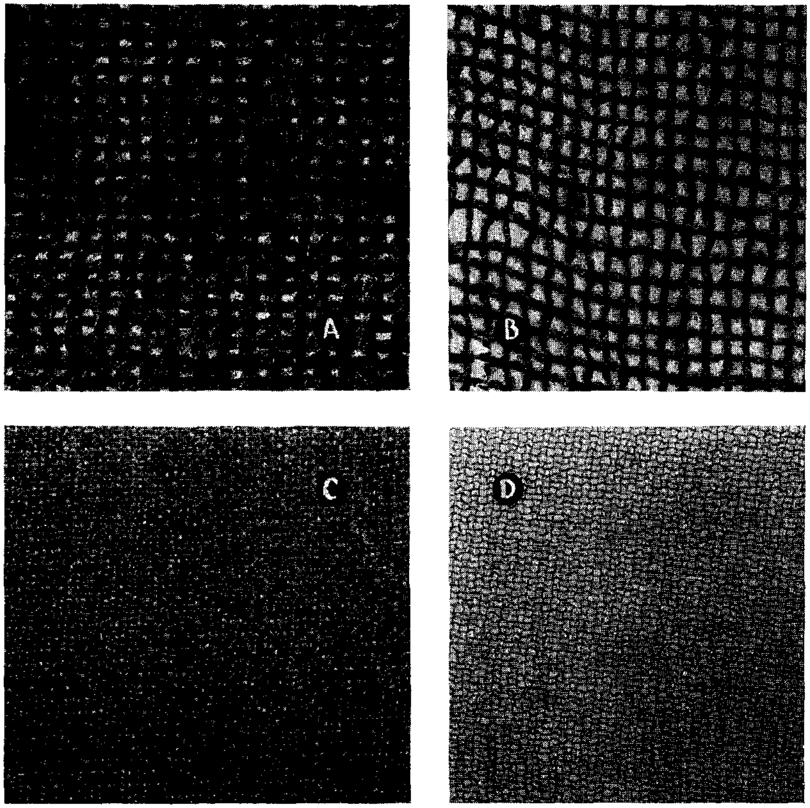


FIG. 12.—Mixed fabrics: (A) Novelty mixture of 52 percent wool and 48 percent viscose rayon. (B) Fabric A after the wool had been removed. (C) Rayon alpaca of 58 percent acetate and 42 percent viscose yarn. (D) Fabric C after the acetate rayon was removed. (Magnification 2 ×.)

ating fabrics of increasing attractiveness which are lighter in weight than an all-wool material. Specimen A in figure 12 shows a wool and rayon mixture suitable for suits and coats, and specimen A in figure 13 shows a serge of lanital and wool. The nap of the upholstery fabric in figure 13 is a blend of wool and soybean fiber.

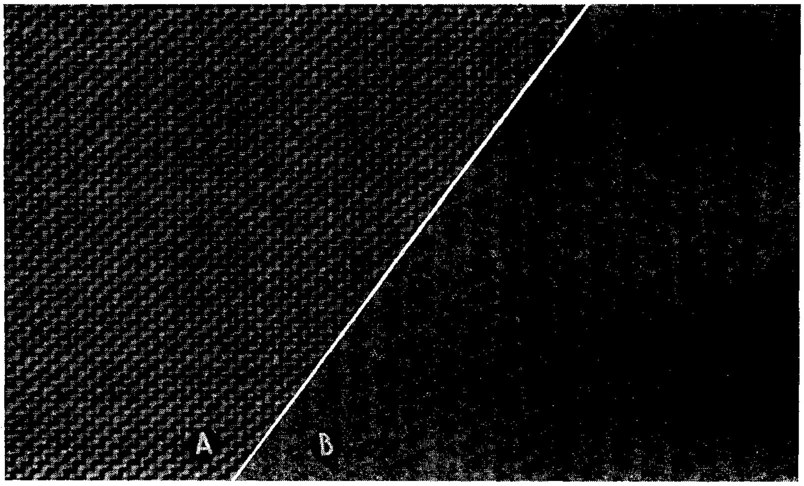


FIG. 13.—Soybean and lanital mixed fabrics. (A) Serge containing 50 percent wool and 50 percent lanital. (B) Upholstery fabric containing soybean fiber.

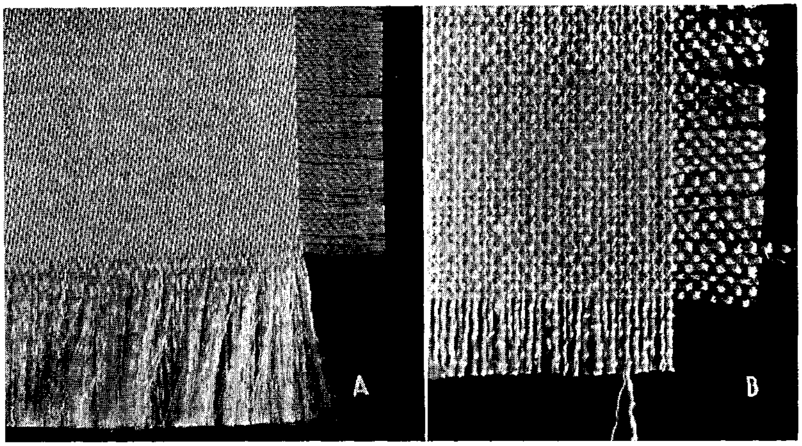


FIG. 14.—(A) Satin with silk warp and rayon filling, 55 percent cuprammonium, 45 percent silk. (B) Medium weight dress fabric of rayon and cotton ply yarns, 75 percent viscose, 25 percent cotton. (Magnification 2 ×.)

The silk dress that the American woman has been wearing in past years has, in many cases, become a silk and rayon or an all rayon dress of today. The "silk trade" has now become a "fine fabric trade" which may completely disappear because of the in-availability of raw silk from Japan. For many years the silk flat crepe, sheer and satin were the product of the busy looms. There was little need for showing originality in weave. The introduction of acetate rayon yarns, however, offered a wide field of new ideas, and silk manufacturers have recognized the possibilities of rayon in fine quality fabrics. One of these, specimen A in figure 14, a satin with a silk warp and cuprammonium rayon filling has re-

FIG. 15.—Velvet with rayon pile and silk back, 80 percent viscose, 20 percent silk. (Magnification 2 ×.)

placed to a large extent, the all-silk satin which for years has been used for the manufacture of high-grade slips and pajamas. The other rayons have been used in combination with silk.

Cellulose acetate and viscose rayons are frequently combined. Many of the alpacas, crepes and satins which many people believe to be silk are made of acetate and viscose rayons. In these fabrics the warp yarns may be acetate and the filling yarns viscose rayon. Yarns of two ply are often used, one ply of continuous filament acetate rayon with only a little twist and the other of a tightly twisted viscose rayon. Specimen C in figure 12 shows an alpaca with wrap and filling of two-ply yarns. Specimen D shows the fabric after the ply of acetate rayon has been removed.

Some of the light weight dress and suit fabrics for women are mixed fabrics. Hopsackings are made of viscose rayon and cotton and some of viscose rayon, silk and wool. Attractive dress fabrics are woven of ply yarns, one ply linen and the other cotton or one ply cotton and the other rayon. Specimen B in figure 14 is such a fabric. The smaller ply shown raveled and untwisted in both warp and filling is cotton and the larger viscose rayon. Rayon staple fiber is othen blended with linen. The light weight velvets usually have a silk back and a rayon pile. The velvet in figure 15, suitable for dresses, has a viscose rayon pile and a silk back which can be seen through the pile.

Woolen novelty fabrics are often made with wool blended with rabbit fur or feathers. Challies, alpacas, and flannels are made of blends of viscose rayon and wool. Many tweeds and novelty mixtures are made of wool and silk.

Finishes Used on Synthetic Fabrics

Rayons in the 1920's had many shortcomings. At that time this shiny, sleazy fiber was regarded as a substitute for silk, and it was not desirable for many uses. Rayon garments would often fall to pieces when laundered. Dry cleaning and laundering caused the fabrics to shrink or stretch excessively. Yarn slippage and pulling at seams were common complaints, and the high gloss of the rayon yarns was particularly objectionable for certain fabrics. Rayon fabrics have been made more useful by being given various finishes and treatments.

DELUSTERING

A dull finish to shiny rayon can be given by cutting it into staple lengths, by incorporating chemicals in the spinning solution or by coating the surface of the yarns after they are spun. In the first method when short lengths are spun into yarn the reflection of the light is broken up. Fabrics made of continuous filament rayon is highly lustrous, and those of spun rayon are dull. Titanium dioxide, a white inert chemical substance added to the spinning solution, is used extensively for producing dull rayon. A viscose rayon fiber which,has been delustered by incorporating chemicals in the spinning solution is shown in figure 8.

CREASE RESISTANCE

Rayon fabrics, especially those made of spun rayons, crush and wrinkle easily just as cottons and linens. When these fabrics are allowed to hang, wrinkles and folds will not come out as they do in silk and wool fabrics which are resilient and thus have much resistance to creasing. Chemical treatment's to rayon fabrics have produced crease resistant finishes. These finishes impart a wooly handle, and as a result spun rayon can be changed into a wool-like material.

Synthetic resins are employed in treatments for crease resistance. The resins most popular at present are the urea formaldehyde resins, a substance produced by dissolving urea, a white crystalline organic substance, and formaldehyde in water. These chemicals are colorless and soluble in water, but when applied to the fabric with a heat treatment they coat the fibers with a transparent, thin film which is little affected by dry cleaning and laundering. Synthetic resins give many finishes to fabrics, depending upon how they are applied. They set dyestuffs and render fabrics more resistant to light and laundering. They also can be used to give a crisp, permanent starch-like finish.

PREVENTION OF YARN SLIPPAGE

The prevention of yarn slippage within the cloth has been brought about by the synthetic resins. At first rayons were often undesirable because of the great amount of pulling at the seams. Excessive fraying is eliminated as well by treating the fabrics with synthetic resins.

WATER-REPELLENT FINISHES

The substances used in the finishes to render fabrics resistant to water coat the fibers or cloth so they will not absorb moisture. If the fabrics are treated by the older methods in which wax, gums and metallic soaps are used they lose their water resistant property upon being laundered or dry cleaned because the finish is removed. These older finishes would not only make the fabrics treated impervious to water but to air as well. The new water-repellent finishes, produced by treating the fabrics with synthetic resins, are permanent to washing and dry cleaning. The fibers are coated with a colorless resin which leaves the cloth porous to air. Dresses, coats, hosiery, draperies treated with this type of finish resist spotting by mud, beverages, ink and common stains. Textiles thus treated retain their original freshness.

FIREPROOFING

Some textile fabrics such as viscose and cuprammonium rayons burn readily when held in a flame. Chemicals can be applied to these to render them fire resistant, forming a gas which keeps the oxygen away from the fabric, and consequently the flame is smothered. Other chemicals used in these finishes melt and form a nonflammable coating over the fibers. Some of these chemicals are removed by laundering and dry cleaning, and others can be made permanent. Fireproof fabrics will char but not blaze. Curtains, drapery materials and carpets are often treated to combat the fire hazard.

MILDEWPROOFING

Fabrics used and stored in damp climates and those that must withstand weathering are likely to mildew, especially in warm weather. Awnings and shower curtains often mildew. Chemicals can be applied to fabrics which will prevent mildew. Many of the mildew treatments are not permanent to laundering and dry cleaning.

SHRINKPROOFING

Cottons and linens have been given treatments for some time that would render them free from shrinking. This is done by wetting the fabrics and allowing them to dry when held under a small tension which is not sufficient to stretch them. Fabrics so treated are designated as preshrunk or "sanforized." The excessive stretching and shrinking of rayons cannot be overcome by this treatment. An outstanding development in the finishing of textile fabrics, however, has recently been perfected to shrinkproof rayons, and rayon fabrics can be made as shrinkproof as sanforized cotton. This is done with a chemical treatment of a synthetic resin and a modified sanforizing operation. This chemical finish will not wash out.

Most of these new finishes — shrinkproofing, waterproofing, crease resistant finishes, slip-proofing, delustering, fireproofing, and crisp starchlike finishes — are obtained largely by chemical treatments. The progress in the synthetic organic chemical industry is largely responsible for the advances made in textile finishes. By means of the great variety of new finishing materials made available by the chemist, the textile finisher has been able to produce effects heretofore unobtainable.

Care of Synthetic Textiles

Garments made of rayon and other synthetic textiles will dry-clean and many can be laundered successfully. The yarn in these fabrics can be cleaned with soap and water, but often the construction of the cloth and the dyestuffs prevent these fabrics from being laundered. If they rapidly lose their color when laundered they should be dry-cleaned only. Some dyes are fast to dry cleaning, some to laundering and others only to sunlight. Few dyes are equally fast to all treatments. Rough crepes, sheers, georgettes, transparent, velvets, rough novelty fabrics and other materials often shrink excessively when wet. These should be dry-cleaned and not laundered.

It is a good practice to experiment with a small piece of the fabric before the entire material is cleaned. If a small piece is laundered by hand it can readily be seen whether the fabric fades, shrinks or stretches unduly. If the fabrics are not washable they should be sent to a competent dry cleaner. Soiled, spotted and stained garments should be cleaned as soon as possible in order to avoid "setting" of the stain. Dry cleaners should be informed of the kind of fiber of which a cloth is made and the type of stain in order to know what cleaning methods to use.

Garments made of rayon or other synthetic fabrics which are washable should be given the same kind of care as those made of other fine fabrics. Some synthetics have superior qualities, but many will not withstand abuse any better than the natural fibers. Many ready-to-wear garments carry a tag or label giving specific washing instructions. If no information is given the following suggestions may be followed for laundering most synthetic fabrics.

A neutral soap and lukewarm, not hot, water should be used Dissolve soap thoroughly in water before fabric is dipped in it. Colored garments should be washed separately and never soaked. Squeeze the sudsy water through the garment, and do not twist, wring, rub or handle it roughly, because rayons and most synthetics lose strength when wet but recover it when dry. Rinse thoroughly in lukewarm water. Squeeze out moisture, roll in a towel to take out excess moisture, then unroll immediately. Stretch garment to proper dimensions and allow it to dry quickly in the shade. It is better to dry many garments, particularly knitted ones, on a flat surface. Never hang on sharp wires or pegs, and do not allow them to be blown by the wind. Press when nearly dry on the wrong side with a warm, not hot, iron.

Many white viscose and cuprammonium rayon garments can be laundered in much the same way as cotton garments. They are weaker when wet, and care must be taken not to wring, pull, or rub them vigorously. They can be ironed at as high a temperature as cotton. Acetate rayon or mixed fabrics containing acetate rayon must never be ironed with a hot iron.

Rayon fabrics can be dry-cleaned in the home. The same precautions should be followed here as in any dry cleaning. The ingredients of dry cleaning solvents used on acetate rayon should be known, because cleaning solutions containing chloroform, ether or acetone will injure the fabric.

Special precautions should be followed in caring for some of the newer synthetic fabrics. Nylon hose can be washed and cared for just as silk hose.

Lanital and other casein fabrics may be laundered in the same manner as wool. They lose strength when wet and must be handled gently. The fabrics should not be kept damp for a long time because they mildew quickly.

Vinyon fabrics can be washed with soapy water not hotter than 149° F. At higher temperatures they will shrink and melt. Consequently, they must be pressed with a cool iron.

Fabrics of glass fiber can be easily laundered and quickly dried because they do not absorb moisture. These fabrics can be soaked and dipped up and down in hot soapy water. They should never be rubbed or wrung. The fabrics are rinsed by dipping them up and down in clear water to which has been added one or two tablespoons of olive or mineral oil. They should be smoothed out to dry on a flat surface. Wrinkles may be pressed out with a moderately hot iron. Glass fabrics should not be folded under pressure when stored, for the brittle fibers may break.

Serviceability of Synthetic Fabrics

The wide use of synthetic textiles has made it desirable for the consumer to know the relative serviceability of fabrics made of the synthetic and the natural fibers. Fabrics of the natural fibers are not always superior to synthetic fabrics. Tests can be made in the laboratory that will predict the usefulness of fabrics. Several studies have been made in the Department of Clothing and Textiles at Kansas State College to ascertain the serviceability of synthetic fabrics.

EFFECT OF LIGHT AND HEAT ON THE COLOR AND DETERIORATION OF RAYON FABRICS

It has long been known that light and heat will change the color and decrease the breaking strength of textile fabrics. White silk and wool will become yellow in color when kept in the light for long periods of time, and both can be scorched easily with a hot iron. Sunlight weakens silk considerably. It has been found that light and heat affect the color and breaking strength of viscose, acetate and cuprammonium rayons (1.) Light does not decrease the strength of these fabrics as it does the strength of silk, however. Exposures of 100 hours decreased the strength of the rayon only about one-tenth. Light had no effect on the color of the white rayons, for they were equally as white after they were exposed to light. All three rayons turned yellow when placed in an oven at 270-280° F., but none of them turned as much as silk or wool. The acetate rayons changed less in color and decreased less in breaking strength when exposed to heat than the viscose and cuprammonium rayon fabrics. Consequently, in cases where fabrics must be subjected to light and heat for many hours, rayons would be more serviceable than silk.

SERVICEABILITY OF SILK AND RAYON FABRICS

Although rayons have not been as serviceable as pure dye silks, they are generally considered as serviceable as is desired for dress fabrics in this period of rapidly changing fashions. Moderately weighted silks are also generally considered to have sufficient serviceability for satisfactory use as dress fabrics.

ALL SILK AND ALL RAYON DRESS FABRICS

The serviceability of taffeta, flat crepe, and satin crepe fabrics made of pure dye silk, weighted silk; viscose rayon, and cellulose acetate rayon[2] was determined by laboratory tests. It was found that the breaking strength of viscoserayon was the greatest of the taffetas; the acetate rayon in the flat crepes; and pure dye silk in

2. Stout, Evelyn Emma, M. S. Thesis, in Home Economics, Kansas State College (1941).

the satin crepes. The satin crepes shrank more than the taffetas and flat crepes. Dry cleaning did not affect the breaking strength of any of the fabrics. Fabrics of no particular kind of fiber stood out as superior throughout the various tests.

The perfection of finer rayon yarns has resulted in fabrics of extraordinary beauty and quality. Rayon yarns, except acetate, can be highly twisted and made into crepe, giving a deeper pebble and a greater variety of crepe effects than is possible with silk. The rayon crepes are difficult to distinguish from silk crepes in appearance and handle.

SILK AND VISCOSE RAYON DRESS CREPES

The comparative serviceability of viscose rayon crepes with silk crepes (2) was studied. The breaking strength of the silk crepes was approximately twice as large as the rayon. Also, the silk fabrics had greater elongation, greater resistance to creasing and less shrinkage than the rayon. Dry cleaning did not affect the breaking strength or the color of either. Both possessed a comparable degree of color fastness to light, but the silk crepes showed greater resistance to fading from perspiration. None of the fabrics showed any slippage. There was no relationship between the price of the material and the durability of the fabrics. This study showed that the pure dye silk crepes were more serviceable than the rayon.

Rayon is being used in the manufacture of all rayon satin and crepe suitable for women's slips. Crepe and satin fabrics are also being made with silk warp and rayon fillinga.

SILK AND RAYON SLIP FABRICS

Crepe and satin slip fabrics of all silk, all rayon and rayon and silk mixed have been tested (2). The breaking strength of the silk fabrics was greater than the rayon and also greater than the mixtures. Laundering did not decrease the breaking strength of the slip fabrics. The rayon fabrics shrank more than the silk or mixtures. The appearance and handle of the fabrics showed a change after ten launderings and even greater change after twenty launderings. The all silk satin showed only a slight loss of color, but the all or part rayon satins and crepes faded to a marked degree. The white silk showed a tendency to turn yellow after launderings, whereas the all rayon crepes retained their original whiteness. The all silk satin and crepe lost much of their body after the laundering, probably because of the loss of soluble weighting. The all- or part-rayon fabrics lost some of their softness after the launderings. The all rayon fabrics acquired harsh handle that lessened their desirability. The all rayon satin was the only fabric which lost its silk-like appearance. This satin became shiny, and lost entirely its softness after the laundering. The silk-and-rayon mixed fabrics retained their body and pleasing handle. The only unsatisfactory change in these mixed fabrics was the loss of color.

SERVICEABILITY OF WOOL, RAYON, AND MIXED WOOL-AND-RAYON FABRICS

Significant, differences have been found (3) in the characteristics of wool, rayon and mixed wool-and-rayon fabrics. The materials studied were dress fabrics of all wool, all rayon and wool and viscose rayon mixtures. The all rayon and mixed fabrics had greater breaking strength than the wool, and the mixtures were not affected as much by abrasion as either the wool or the rayon. Dry cleaning did not affect the breaking strength. The wool had the greatest elongation and rayon the least. The difference in shrinkage of the wool and rayon was not significant. The mixed fabrics shrank much more than either the wool or rayon. The wool and mixed fabrics were similar in resistance to creasing, and both were much more crease resistant than the rayon. The appearance of all the fabrics was satisfactory after dry cleaning. None showed change in color except the white wool which became somewhat yellow.

SERVICEABILITY OF COTTON, LINEN, AND RAYON MIXED FABRICS

Spun rayon is used for the production of fabrics similar in appearance to linen, and it is also mixed with cotton and linen for dress materials which can be laundered.

LINEN AND RAYON DRESS FABRICS

In a study (4) of all linen, all viscose rayon, and viscose rayon and linen mixed fabrics it was found that the breaking strength of the linen was greater than the rayon or the mixtures. There was enough linen in the mixed fabrics to diminish the decrease in the wet breaking strength. Thus, these fabrics of linen and rayon had a greater wet breaking strength than those of all rayon. The linen was least resistant to wear. The mixtures shrank the most and the linens the least. The average shrinkage in the warp of the mixtures and rayon fabrics was 8.6 and 6.0 percent respectively which was excessive; and that of the linen was only 2.7 percent. All the fabrics retained their color and had a desirable appearance after laundering. The laundering decreased the breaking strength.

COTTON AND RAYON DRESS FABRICS

All viscose rayon and viscose rayon-and-cotton mixed fabrics have been compared (4) in breaking strength; the rayon was stronger than the rayon-and-cotton mixed fabrics, and both groups were equally resistant to wear. There was enough cotton in the mixed fabrics to diminish the decrease in the wet breaking strength. The average shrinkage in the warp of rayon and rayon and cotton mixtures was 4.1 and 3.5 percent, respectively. Both groups of fabrics laundered satisfactorily. Laundering did not diminish the breaking strength of these fabrics.

THE EFFECT OF RESIN FINISHES ON RAYON FABRICS

Two groups of viscose rayon gabardines were tested for their serviceability.[3,4] One group had a synthetic resin finish, and the other had not. The resin finishes were not removed by dry cleaning or laundering. The resin finished fabrics faded slightly, but many of the nonresin finished fabrics showed marked degrees of fading. In laundering the shrinkage of the gabardines without resin finish varied from 6.0 to 13.0 percent, and those with resin finish varied from 0.3 to 4.0 percent. The two groups showed differences in breaking strength. The ones with the resin finish had much greater breaking strength. The treated fabrics had a firmer handle than the untreated fabrics and had a better appearance after dry cleaning and laundering. These fabrics did not become sleazy after repeated dry cleanings and launderings. The serviceability of the rayon gabardines was considerably increased by resin finishes.

Conclusion

Synthetic fibers were first made to simulate silk. Textile technologists endeavored to produce fibers with characteristics of the natural fibers, silk, wool, cotton and linen. Now they are attempting not to imitate these fibers, but to create fibers with characteristics which are distinctive from the natural fibers. The natural fibers have definite physical and chemical properties which cannot be changed at will, but the synthetics can be made with a variety of properties. Some of the newer synthetic fibers have properties quite different from the natural fibers. No doubt others will be created having still more varied characteristics.

Improvement of production has enabled the textile manufacturer to vary the properties of synthetic fibers. The fibers and yarns are uniform when produced under exacting conditions. The size of filaments has been varied and made considerably smaller.

The finer yarns of various lusters have aided in the almost universal use of rayons for fine dress goods. Many designers and dress manufacturers have chosen a particular construction in rayon rather than silk. Versatile rayon has made possible the development of many new fabrics that never existed before. This has been an inspiration to the designer.

The synthetic fibers not only make possible fabrics of great variety, but some also have qualities that are superior to the natural fibers. Many of the synthetic textiles have been in use long enough to prove their desirable qualities which have made them preferred to those of the natural fibers.

If a textile fiber with certain properties is needed, the scientist will endeavor to create it; and judging by past achievements he will be reasonably successful. No one dares to predict the appearance, characteristics and uses of the new synthetic textiles of the future, or from what raw materials they will be made.

---

3. Hay, Wilda Marguerite, M. S. Thesis, in Home Economics, Kansas State College (1941).
4. Surratt, Andrea Jean, M. S. Thesis, in Home Economics, Kansas State College (1942).

APPENDIX

Discovery and Development of Synthetic Fibers

INTRODUCTION

Before the commercial production of synthetic textile fibers many persons had the idea that textile fibers might be made in the laboratory. Robert Hooke (1635-1703), an English experimental philosopher, stated in his work, "Micrographia" (1664) that an artificial glutinous substance similar to the liquid gum which the silk worm excretes and spins into silk filaments might be found, and that "if such a composition were found it was certainly an easier matter to find very quick ways of drawing it out into small wires for use." He also prophetically mentioned the "sufficiently obvious benefit which was likely to accrue to the finder."

In 1710 René A. F. de Reaumur (1683-1757), a French philosopher, suggested methods by which an artificial silk resembling the natural product might be produced. In his "History of the Insects," he proposed using liquid gums and resins for making silky filaments.

No real progress was made in creating synthetic textiles until about the middle of the nineteenth century. A patent was granted in 1884 by the French government to Count Hilaire de Chardonnet (1840-1924) of Besacon, France, for making of artificial silk from nitrocellulose. In 1891 this became the first synthetic textile to be produced on a successful commercial basis.

Developments of synthetic fibers were spectacular and rapid both in the United States and the European countries. The late Dr. Arthur D. Little (1863–1935) of Boston, Mass., one of the pioneer textile chemists, in 1921 spun silk-like fibers in his laboratory made from pig's ears which were in turn woven into fabric for a purse, thus refuting the ancient proverb that "You can't make a silk purse out of a sow's ear."

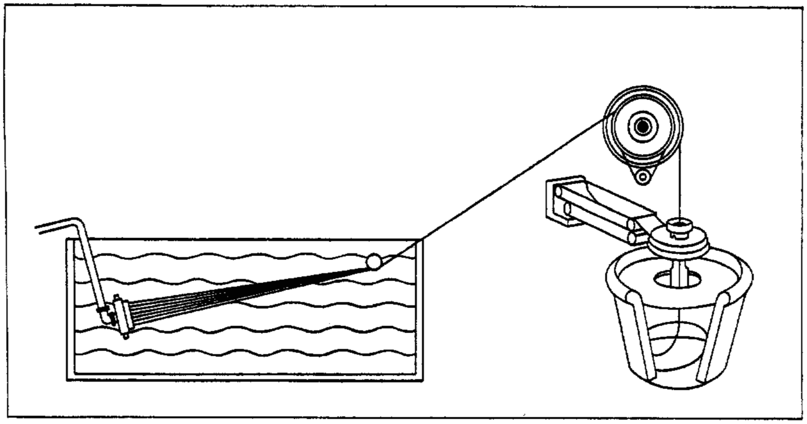
After the factories were set up in France to produce synthetic textiles, chemists and physicists in Germany, England and the United States worked to perfect a fiber. The product at first was undesirable and went under the name of "artificial silk" because it resembled silk and was regarded as a cheap substitute for this superior fiber. The synthetic textile fibers by 1920 had made a place for themselves and now are not regarded as substitutes for the natural fibers. They have inherent values of their own; some are superior and even preferred to the natural fibers. Physicists, chemists and textile designers endeavor to determine and produce a fiber with properties to meet a specific need.

RAYON

The term "rayon" was adopted in the United States in 1924 for the various kinds of synthetic textile yarns which were known as artificial silk. This word was chosen by committees representing producers, weavers and knitters of the yarn, and the National Retail Dry Goods Association. In 1937 the Federal Trade Commission defined rayon as: "the generic term for manufactured textile fiber or yarn produced chemically from cellulose or with a cellulose base—and for thread, strands or fabrics made therefrom, regardless of whether such fiber or yarn be made under the viscose, cuprammonium, acetate, nitrocellulose or other process."

The period of 1884 to 1939 saw the development of rayons from cellulose. Both chemists and physicists made intensive study of cellulose and finally continuous filaments were spun from cellulose and cellulose derivatives. Spruce wood and cotton linters, chief sources of rayon manufacture, are converted into a spinning solution by dissolving in suitable solvents, and the liquid is spun into long continuous filaments by forcing it through the small holes in spinnerettes.

There are four kinds of rayon: nitrocellulose, viscose, cuprammonium and cellulose acetate. All are made from a cellulose base, but each is manufactured by a different process. The first three are regenerated cellulose rayons because the cellulose solution is regenerated or solidified back into pure cellulose in the form of filaments. The cellulose acetate rayon is a nonregenerative cellulose rayon, for the cellulose solution has not been changed back to pure



—*Courtesy E. I. du Pont de Nemours Co.*

FIG. 16.—Diagram showing the spinning in the manufacture of viscose rayon yarn.

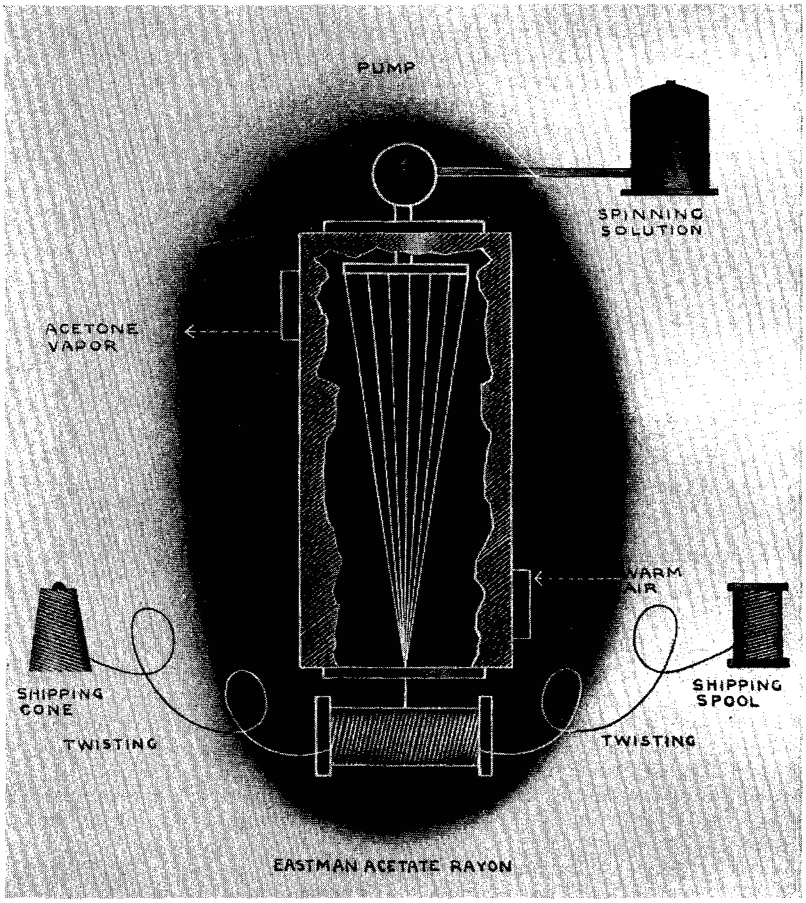
cellulose, but is a derivative of cellulose. Nitrocellulose fiber is not manufactured commercially now in the United States. Approximately 573,000,000 pounds of rayon fiber were consumed in the United States in 1941. Of all the synthetic fibers produced in this country about 63 percent is viscose rayon; 32 percent, cellulose acetate rayon; 2 percent, cuprammonium rayon; and 2 percent, nylon, vinyon, etc.

Count Hilaire de Chardonnet produced commercially the first artificial silk which was made from nitrocellulose. Nitrocellulose is formed by treating cellulose with nitric acid. This was the chief method of rayon manufacture in Europe for a period of twenty years after it was first started in 1891, and one company in the United States manufactured this rayon from 1920 to 1934. Because nitrocullulose is highly inflammable, this process had many hazards.

Nitrocellulose rayon was first considered superior to the other three rayons. Due to the technological and economic disadvantages of Chardonnet's nitrate process, however, and to the improvement in qualities of the viscose and acetate rayons, nitrocellulose rayon is not available commercially.

Viscose rayon, the leading synthetic textile fiber, was discovered by the English chemists Charles F. Cross and E. J. Bevan, who secured a patent for the process in 1892.

In this process sheets of cellulose from spruce wood or cotton linters are treated with sodium hydroxide and carbon bisulphide. The compound thus formed is cellulose xanthate and to it more sodium hydroxide is then added to form the spinning solution which is a golden yellow liquid. This solution is forced through tiny holes in the spinnerette and then solidified into fine



—*Courtesy Tennessee Eastman Corporation.*

FIG. 17.—Diagram showing the spinning in the manufacture of cellulose acetate rayon yarn.

strands on contact with acid in the hardening bath. Figure 16 shows how viscose rayon is spun. The spinning solution is forced through the spinnerette which is immersed in the hardening bath. The filaments travel over a rotating glass wheel down into a bucket which revolves very rapidly. The filaments are slightly twisted on entering the bucket and collect in the form of a circular cake. The final product is cellulose, and thus viscose rayon is regenerated cellulose. The name viscose is used to designate this rayon because of the viscosity of the various solutions made in this process.

Cellulose acetate was discovered in 1869 by the German chemists, Naudin and Schutzenberger. At first it was only used in plastics. Cross and Bevan, discoverers of viscose, patented the acetate process in 1894. In 1902 the first acetate rayon was made in the United States.

This rayon is made by treating purified cotton linters with acetic acid and acetic anhydride. The compound thus formed, an acetic ester of cellulose, is dissolved in acetone. The clear liquid solution, thick as molasses, is pumped through the spinnerettes. In this process the spinnerette is not in a hardening bath, but is at the top of a tall shaft. (Fig. 17.) The cellulose acetate comes through the spinnerette in fine streams and solidifies when it passes through the warm air of the shaft which evaporates the acetone. The filaments formed from the spinnerette are twisted into a strand of yarn.

The cuprammonium solution, an ammonical solution of copper hydroxide, from which cuprammonium rayon is made was discovered by Schweitzer, a German chemist, in 1857. A French chemist, Louis Henri Despaissis, was granted the first patent for making cuprammonium rayon yarns in 1890. The first factory to produce it commercially was built in Germany in 1897, and in 1924 it was manufactured in United States.

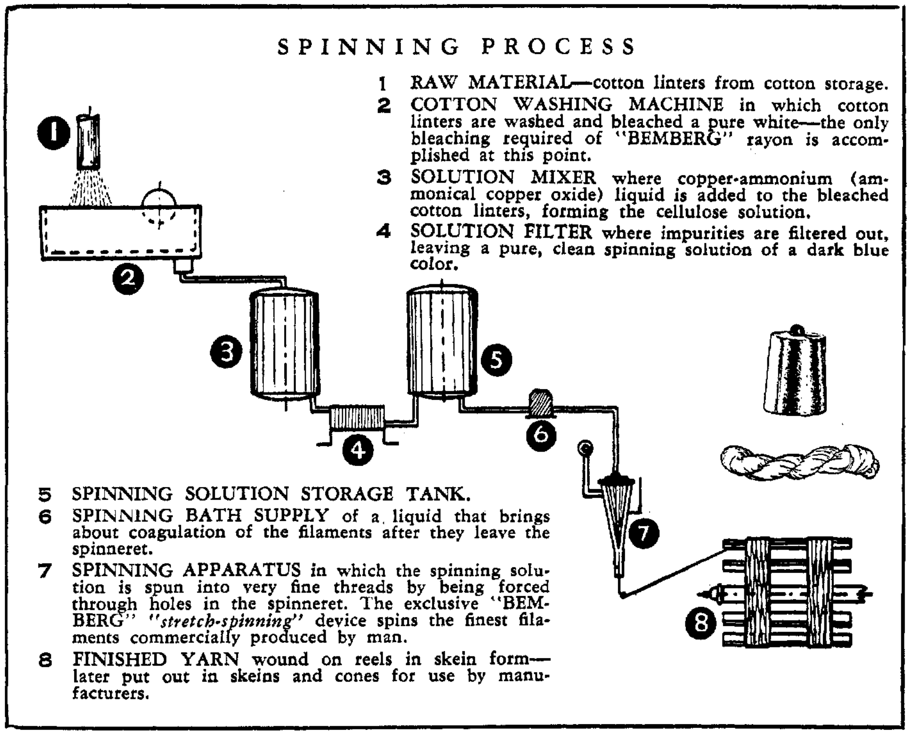
This rayon is made mostly from cotton linters which are converted into a spinning solution by treatment with copper sulphate and ammonium hydroxide and is spun by a method similar to the viscose process, known as the "stretched spinning device." When the liquid is ready for spinning it has a dark blue color and is about the consistency of honey. The liquid is pumped through the holes of a spinnerette into a glass funnel in which flows soft water. As the filaments pass through the funnel into a hardening bath of weak sulphuric acid they are "stretched." After the filaments leave the bath, this yarn is wound on reels to form skeins. This "stretch-spinning" method gives the filaments remarkable strength, fineness and suppleness. This process of rayon production is shown in figure 18.

CLASSIFICATION OF ALL SYNTHETIC FIBERS

Practically all synthetic textiles manufactured on a commercial basis from 1891 to 1938 were rayon, which is all kinds of synthetic fibers made from cellulose. Experimenters turned to sources other than cellulose from which to produce fibers. Casein from milk, and soybeans are used to make protein fibers in much the same way as cellulose is utilized for rayon. The synthetic fibers which have attracted the most interest are those produced from plastics or resins. These are produced by completely synthetic methods, for they are made from raw materials such as coal, oil, natural gas, or other sources of organic compounds.

The following classification of synthetic textiles has been proposed:

1. Rayons—Fibers made from a natural cellulose base: viscose, acetate, cuprammonium.
2. Prolons—Fibers made from a natural protein base: casein, soybean.
3. Synthons—Fibers made from organic substances which have been synthesized from simple raw materials: nylon, vinyon.
4. Glass—Fibers of fine glass filaments.
5. Miscellaneous—Fibers made from other natural bases: alginate, chitin.



Courtesy American Bemberg Corporation.

FIG. 18.—Diagram showing the manufacture of cuprammonium rayon yarn.

PROTEIN FIBERS

Numerous research workers and inventors have attempted to produce a textile fiber from the casein of milk. Todtenhaupt, a German chemist, took out a series of patents in about 1904 for such a fiber, but he was not able to perfect it so it could be used commercially. These fibers would swell, soften and stick together during the dyeing process. Much research was done to overcome these difficulties before a desirable fiber was produced.

Lanital was the first successful fiber made of milk casein. Antonio Ferretti was granted a patent for this fiber from the Italian government in 1935. Workers later in other countries have also succeeded in making a synthetic fiber from silk. In producing this casein fiber, the casein of the milk is extracted and reduced to dry, granulated crystals. The casein crystals are then dissolved in an alkaline solution which is then spun into continuous filaments by forcing it through spinnerettes and coagulating them in an acid bath. These long strands are then cut into short lengths known as staple fiber. These are then spun by themselves or blended with other fibers to form mixed yarns.

A patent in 1938 was granted to the United States Department of Agriculture for making of casein fiber by a somewhat different method than that used in making lanital. In 1940 a casein fiber known as aralac was announced. The physical and chemical properties are similar to the Italian product, lanital.

More recently, fiber R-53 has appeared. "R" stands for "research" and 53 indicates that it was the 53d fiber tested in a search for a fiber which was suitable to manufacture felt hats. This fiber is finer than aralac, and is used to blend with rabbit fur in making of felt for hats.

The soybean fiber is the first textile filament to be spun from the protein of vegetable origin. The soybean is exceptionally rich in protein, of which it contains about 50 percent.

In the manufacture of the fiber the bean is crushed under pressure and the oil is extracted. The protein in turn is extracted by passing the meal through a saline solution, and it is then combined with various chemicals to form a liquid about as thick as molasses to be used as a spinning solution. This is forced through a spinnerette containing as many as 500 holes, and the filaments are hardened in an acid bath.

The scientist as yet has not been able to produce firm, tough protein filaments which will resist wear and deterioration like the natural fibers and the other synthetic fibers. This is probably due to the arrangement of the molecules, for the prolon fibers do not have a structure like the natural fibers which are made up of long chain molecules.

SYNTHETIC RESIN FIBERS

Dr. Wallace H. Carothers (1896-1937) directed the program of fundamental research which resulted in the discovery of nylon in the research laboratories of E. I. du Pont de Nemours and Co. Nylon first appeared on the market in the form of brush bristles and sewing thread, and in 1940 hose made of this yarn were available. Scientists defined "nylon" as a name applied to all materials that are "synthetic fiber-forming polymeric amides having a protein-like chemical structure, derivable from coal, air, and water or other substances and characterized by extreme toughness and strength." It has been said to be the first synthetic organic fiber manufactured entirely from raw materials of the, mineral kingdom. It is truly a synthetic and is a thermoplastic synthetic resin.

There are many intricate processes necessary to produce this substance called nylon which contains the same elements as silk—carbon, hydrogen, oxygen and nitrogen—and which are arranged in much the same way. After extensive heat treatment the substance in the form of white ribbons is formed. These are broken up into chips and melted into a water-clear liquid which looks like thick glycerine. This is squirted through tiny nozzles to form filaments of extsemely small size, finer than any other synthetic fiber produced with the exception of glass fibers.

The patent for vinyon was granted by the United States government in 1937. This new textile fiber, a polyvinyl resin, has many possibilities; and it may prove to be a worthy competitor of the polyamide resin, nylon. It is a result of extensive research and is a copolymer of vinyl chloride and vinyl acetate. The principal raw product is natural gas. The vinyl resin which is a dry powder is dissolved in acetone, and this is forced through a spinnerette to form filaments in much the same way as rayon filaments are produced,

GLASS FIBERS

Glass fiber is not a new textile fiber. The flexibility and other properties of fine glass fibers have been known for many years. Only within the last few years has glass fiber been developed. Glass fiber has two forms, a wool form which is used for thermal insulation purposes, and a textile fiber form. The textile fibers are made as continuous filaments or as staple fibers of eight to fifteen inches in length.

In both the continuous filaments and the staple fiber processes glass marbles are fed into an electrically heated furnace. In the continuous filament process the molten glass is drawn down by gravity through tiny holes from which the glass filaments emerge. Several of these filaments can be combined to make a strand, and a number of strands can be plied together to form a yarn.

In the production of staple fibers the molten glass is forced down through holes of the same type along with steam under pressure which tears the stream of glass and draws the particles into long smooth fibers. The fibers gather upon and are drawn from a revolving drum, and in turn are spun into yarn in much the same way as wool fibers. Glass filaments as small as .00025 of an inch have been produced. Yarns of glass fiber can be used to make cloth of any weave.

OTHER SYNTHETIC FIBERS

The rayons are the synthetic textiles chiefly used. Nylon, vinyon, casein, soybean, and glass fiber are the other synthetics produced in greatest amounts. Others are being produced, however, some of which are only made as yet on an experimental basis. Perhaps some of these new textiles will never be of any real use to mankind. Others, no doubt, will be superior to the natural fibers and to the synthetics already in use.

Textile fibers are being made from protein bases other than milk casein and soybeans. One of these is produced from zein, a material derived from corn meal. Animal bones, hides and muscles are sources of protein which have been used. Silk waste and fish, also, have been utilized as raw materials.

Seaweeds which are found in abundance in some countries is a new source of raw material from which textile fibers have been made. These plants are rich in alginic acid which is the material used for the spinning solution. Alginate fibers are fireproof and are nearly as strong as those of rayon.

Chitin is another material from which textile fibers have been spun. This substance is found in shells of lobsters, crabs, and certain insects.

RULINGS ON FIBER CONTENT OF TEXTILES

Some attempts have been made to state the fiber content of textiles. The Federal Trade Commission adopted a ruling on May 26, 1930, that "the word 'wool' shall not be used in any way in labeling, advertising, merchandising, or selling of knit underwear unless the percentage by weight of wool contained in the garment be stated" (6). A commercial standard for wool and part-wool blankets (6) became effective April 1, 1933, which provided for the labeling of part-wool blankets with the guaranteed minimum wool content, and one for wool and part-wool fabrics (7) became effective January 1, 1938.

The Federal Trade Commission on October 27, 1937, issued its ruling of fair-trade practices for the rayon industry (8). The new rules define rayon as "the generic term for manufactured textile fiber or yarn produced chemically from cellulose or with a cellulose base." Also, "it is an unfair trade practice to cause such fiber or yarn or thread, strands or fabric made therefrom to be sold, offered for sale, distributed, advertised, described, branded, labeled or otherwise represented: (a) as not being rayon; or (b) as being something other than rayon; or (c) without disclosure of the fact that such material or product is rayon." In case of mixed goods containing rayon, "such disclosure of the fiber content of said products shall be made by accurately designating and naming each constituent fiber thereof in the order of its predominance by weight, beginning with the least single constituent." It is recommended that in mixed goods that percentages of the constituent fibers be given.

New rules by the Federal Trade Commission were promulgated November 4, 1938, for the silk industry (9). These rules define silk as "the natural fiber derived from the cocoon of the silkworn." It is an unfair trade practice to use the term or phrase "Pure Silk," "Pure Dye" or the unqualified word "Silk" if (a) the fiber content is not silk exclusively; or (b) the silk product contains any metallic weighting whatsoever; or (c) the product contains loading or adulterating materials exceeding ten percent. Likewise, in mixed fabrics which contain silk the kinds of fibers must be given on labels with the largest single constituent named first. It is recommended that the percentage of the constituent fibers be stated in these goods.

The Wool Products Labeling Act of 1939 (10) was passed by Congress and signed by President October 14, 1940, and became effective July 14, 1941. This act defines "wool" as a fiber (from sheep, Angora, Cashmere goat, camel or vicuna, etc.) that has never been reclaimed from a woven or felted product. It makes misbranding of wool products unlawful. Wool products must be labeled and the percentage of wool, reprocessed wool, and reused wool, and any and all other fibers more than five percent must be shown.

ADEQUACY OF LABELING OF TEXTILE FABRICS WITH REGARD TO FIBER CONTENT

Information concerning the fiber content of mixed fabrics and synthetic fabrics is least reliable of all fabrics. This was learned in an investigation (11) made in the Department of Clothing and Textiles at Kansas State College to ascertain to what extent authentic information was available to the purchaser.

The fabrics tested in this investigation were purchased during 1937-1938 in 18 different stores in seven towns and cities of the Midwest. These fabrics were piece goods and not ready-made garments. At the time of purchase any information on the labels with regard to fiber content was noted. When the fiber content was not stated on the label, as much information as possible was obtained from the salesman. In the laboratory, tests were made to determine the fiber content. When a fabric was composed of one kind of fiber, only the fiber identification was needed. When a fabric contained two or more kinds of fibers, a quantitative analysis was necessary to determine the percentage of each kind of fiber,

In each case the information on the label and that given by the clerk were compared with determinations made in the laboratory. Ordinarily the salesmen gave no further information if the fiber content of the textile was stated on the label. In this survey an acetate rayon fabric was considered accurately labeled if given as Celanese rayon, acetate rayon, or acetate, and only partially accurate if given as rayon or Celanese. The information with regard to fiber content of a fabric of cuprammonium rayon was considered accurate if given as cuprammonium rayon, cuprammonium, or Bemberg rayon, and partially accurate if given as Bemberg or rayon. In the case of viscose rayon, viscose rayon or viscose was counted as accurate, and rayon as partially accurate.

A mixed fabric was considered to be accurately labeled if the kinds of fibers that it contained were given as stated above. If the percentage of fiber content was stated, the information was considered accurate if the percentage was correct within ten percent. It was considered partially accurate if one kind of fiber contained in the fabric was given, and the others were not.

The results of the examination of all the fabrics are given in table 2.

The fabrics made of cotton, linen, silk, and wool were commonly accurately labeled, and salesmen, in the main, gave accurate information about these fabrics bearing no label concerning fiber content. In regard to the fabrics made

TABLE 2. *Adequacy of information secured from labels or salesmen concerning identity and percentage of fiber content of fabrics composed of one kind of fiber or of mixed fibers*

FABRICS OF ONE KIND OF FIBER

Fabrics analyzed.		Fabrics that were—				Fabrics regarding salesmen gave—			
KIND.	Number.	Labeled.	Labeled accurately.	Labeled partly accurately.	Labeled inaccurately.	Information.	Accurate information.	Partly accurate information.	Inaccurate information.
		Number.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
Cotton	4	2	2	0	0	2	1	1	0
Linen	3	3	3	0	0	0	0	0	0
Silk	26	11	11	0	0	16	13	2	1
Wool	14	5	5	0	0	9	8	0	1
Acetate rayon	16	7	1	5	1	9	2	7	0
Cuprammonium rayon	13	5	1	4	0	8	1	7	0
Viscose rayon	57	24	0	23	1	35	0	31	4
Total	133	57	23	32	2	79	25	48	6
		Percent.	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*
Proportion	....	100	40.4	56.1	3.5	100	31.6	60.8	7.6

FABRICS OF TWO OR MORE KINDS OF FIBERS

KIND.	Number.	Labeled.	Labeled accurately.	Labeled partly accurately.	Labeled inaccurately.	Information.	Accurate information.	Partly accurate information.	Inaccurate information.
		Number.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
Cotton and wool	11	2	0	2	0	11	4	5	2
Cotton and viscose	15	3	0	3	0	13	0	11	2
Cotton and linen	6	5	0	5	0	2	0	2	0
Wool and rabbit fur	3	0	0	0	0	3	1	2	0
Wool and viscose	21	4	0	4	0	19	0	18	1
Wool and silk	5	2	0	2	0	5	1	4	0
Silk and viscose	7	2	0	2	0	5	0	5	0
Acetate and viscose	43	12	0	12	0	31	0	30	1
Various fabrics composed of two kinds of fibers	6	1	0	1	0	5	2	3	0
Various fabrics composed of three kinds of fibers	18	3	0	3	0	16	1	14	1
Totals	135	34	0	34	0	110	9	94	7
		Percent.	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*	*Percent.*
Proportion	....	100	....	100	....	100	8.2	85.4	6.4

of one kind of fiber, the information concerning the three types of rayon was found to be least accurate. These fabrics were often represented as "rayon," but they were usually not designated as acetate, viscose, or cuprammonium rayon. The word "Celanese" was often used instead of acetate; Bemberg and Bemberg rayon were always used instead of cuprammonium rayon; and rayon was used instead of viscose rayon. Of the 133 fabrics of one kind of fiber analyzed 57 were labeled, and 40.4 percent of these were accurate. Salesmen gave information of 79, and 31.6 percent of these were accurate. Thus the information on the label was found to be more accurate than that given by the salesmen.

In case of the 135 mixed fabrics, 117 were made of two kinds offibers, and 18 were of three kinds. Many of these had warp yarns of one kind and filling of another. Some were made of yarns which were blends and others of ply yarns composed of plies of different kinds of fibers. Cellulose acetate rayon and viscose rayon were most frequently found in combination. Only one fabric of each of the following combinations were found: viscose and linen, linen and wool, acetate and cuprammonium rayons, acetate rayon and silk, wool and cuprammonium rayon, and wool and mohair.

Little information was obtained concerning the percentage of fiber content, either from the labels or from the salesmen. Only one fabric bore a label stating the percentage of fiber present. The label stated that the fabric contained 25 percent of wool, but analysis showed only 15 percent to be present. The clerks gave percentages for fiber content for 12 fabrics, of which one was accurate, ten partially accurate, and one wrong.

Only 34 of the 135 mixed fabrics were labeled; and all of these were only partially accurate. The clerks gave information concerning 110, of which 8.2 percent were accurate, 85.4 percent partially accurate, and 6.4 percent wrong.

It is apparent that more of the fabrics of one fiber are labeled, and more of the information accurate than of mixed fabrics, but in case of the labeled fabrics of one kind of fiber the accuracy was only 40.4 percent. The accuracy of the information, from labels and from salesmen, for both groups of fabrics was inadequate.

The information concerning fiber content was usually partially accurate. Approximately 60 percent was partially accurate in case of the fabrics of one kind of fiber, and over 90 percent of the mixed fabrics. In both groups less than 10 percent was inaccurate. In many cases this lack of accuracy was due to the failure of the rayon fabrics to be designated as viscose, acetate or cuprammonium rayon. This information is of importance to the consumer in order that proper precautions may be taken in the care of the fabrics which has already been explained.

REFERENCES

(1) FLETCHER, HAZEL, and HOUSTON, MIRIAM H. Effect of Light and Heat on Color and Deterioration of Viscose, Acetate, and Cuprammonium Fabrics. *Textile Research.* XI: 4-11. 1940.

(2) FLETCHER, HAZEL; CARLSON, BULA; PLATT, HELEN KING. Comparison of Some Physical Properties Affecting the Serviceability of Certain Silk, Rayon, and Silk and Rayon Mixed Fabrics. *Rayon Textile Monthly.* XXII: 425-426, 471-474. 1941.

(3) FLETCHER, HAZEL; BOYER, MARY CAROLINE; FLOERSCH, SISTER MARY CATHERINE. Comparison of Some Physical Properties Affecting the Serviceability of Certain Wool, Rayon, and Wool and Rayon Mixed Fabrics. *American Dyestuff Reporter.* 30:491-495. 1941.

(4) FLETCHER, HAZEL M.; SHELDEN, MARTHA GENE; ZINK, CATHARINE EVA. Physical Properties of Cotton, Linen and Rayon-Mixed Fabrics Compared with All-Linen and All-Rayon Fabrics. *Rayon Textile Monthly.* XXII: 735-737. 1941; XXIII: 29-30. 1942.

(5) (United States) Federal Trade Commission. Statement. . . . Trade Practice Conference, Knit Underwear Industry. July 7, 1930. (Mimeographed).

(6) United States Bureau of Standards. Wool and Part-Wool Blankets, Recorded Standard of the Industry. U. S. Nat'l Bur. Standards Com. Standard CS39-32, 10 p. 1932.

(7) United States Bureau of Standards. Wool and Part-Wool Fabrics, Recorded Standard of the Industry. U. S. Nat'l Bur. Standards Com. Standard CS65-38, 17 p. 1938.

(8) Code of Federal Regulations of the United States of America. Vol. 4, pp. 868-872. Washington. U. S. Government Printing Office. 1939.

(9) Code of Federal Regulations of the United States of America. 1938 Supplement, pp. 700-706. Washington. U. S. Government Printing Office. 1940.

(10) United States Statutes at Large. Vol. 54, Part I. pp. 1128-1133. Washington. U. S. Government Printing Office. 1941.

(11) FLETCHER, HAZEL, and DENNHARDT, LOIS. Adequacy of Labeling of Certain Textile Fabrics with Regard to Fiber Content. *Journal of Agricultural Research.* 58:895-903. 1939.

PRINTED BY KANSAS STATE PRINTING PLANT
W. C. AUSTIN, STATE PRINTER
TOPEKA, 1942
19-2870