# THE METHODS
# OF
# TEXTILE CHEMISTRY

## BEING THE SYLLABUS OF A LECTURE COURSE ADAPTED FOR USE IN TEXTILE LABORATORIES

BY

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# PREFACE

THE few books on textile chemistry which have thus far made their appearance, with one or two exceptions are available only in foreign languages. This is to many a source of deep regret, because while attention is given to the study of modern languages in this country, yet technical writing is better understood when the reader has it presented in his native tongue. In the following pages an attempt has been made to systematize approved methods of textile-chemical analysis which are at present only to be found in widely distributed and expensive special works and journals. These methods have for some time formed the syllabus of the author's lecture courses in textile chemistry. They therefore make no claim to completeness, although care has been taken to emphasize the essential points in each case. The student will do well to use some standard manual of chemical analysis such as "Newth" in conjunction with the present volume.

The author hopes that our now prosperous textile manufacturers and merchants may soon realize that accurate methods are not only interesting but necessary in these days of keen competition. At the same time this little volume is intended to be a source of information and ready reference for the textile chemist. To add to the readier understanding of calculations, practical examples have been inserted in many instances. The aim has been to cover the field of chemical and physical analysis of the textile fibers, yarns and fabrics. Dyestuffs, mordants, and finishing materials are treated of not as raw materials but as substances encountered on the finished goods.

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# PART I

# METHODS OF TEXTILE CHEMISTRY

## INTRODUCTION

THE word "analysis" as used at the present day includes all the processes and operations made use of by chemists in order to determine the constituent parts of any compound, or to enable them to identify the substance. The process may involve the breaking up of the body into its component parts, or may consist in the simple separation of a mixture. A reaction is a chemical change: if the change was effected only by heating the substance, it is termed a *dry reaction;* and if any of the substances used to bring about the change were in solution, we speak of a *wet reaction.* In the following is given a list of the reagents which will be required for the wet reactions; they should be made up as indicated in order to obtain the best results.

| | |
|---|---|
| 10% *Caustic potash* | Dissolve 10 grams of potassium hydroxide in 50 c.c. of water, cool and make up to a total volume of 100 c.c. |
| 1% *Caustic potash* | Dilute the above solution 1:10, i.e. to 10 cubic centimeters of the 10% solution add 90 c.c. of water. |
| 40% *Hydrochloric acid* | The concentrated chemically pure acid. Specific gravity 1.20 (24° Be). [100 c.c. of this acid weighs 120 grams.] |

10% *Hydrochloric acid*. Mix 25 c.c. of the above concentrated acid with 75 c.c. of water.

1% *Hydrochloric acid*. Dilute the 10% acid 1 to 10.

98% *Sulphuric acid*.... The concentrated chemically pure acid. Specific gravity 1.84 (66° Be).

10% *Sulphuric acid*.... Dilute the above solution 1 to 10.

100% *Nitric acid*...... The concentrated chemically pure acid. Specific gravity 1.559 (51.5° Be).

10% *Nitric acid*....... Dilute the above solution 1 to 10.

*Calcium hypochlorite*... A clear solution having a specific gravity of 1.01 (2° Tw) is prepared by rubbing down chloride of lime with water in a mortar. Add more water, allow to settle, and finally decant.

*Schweitzer's reagent*.... An ammoniacal solution of cupric oxide.

Cross and Bevan prepare this reagent as follows: 2 grams of copper sulphate are dissolved in 100 c.c. of water. Hydrated copper oxide is precipitated from this solution by adding a slight excess of a 10% solution of sodium hydroxide. Wash the precipitate entirely free from alkali, drain, and mix with a 10% solution of glycerol. Preserve in stoppered bottles, and when desired for use wash free from glycerol and dissolve in ammonia water of 20% strength.

Bronnert, Fremery & Urban prepare a Schweitzer's solution containing about 5% of copper and a relatively small amount of ammonia as follows: A cold solution of ammonia is poured over copper turnings in tall cylindrical vessels, and the whole is cooled down to 0 to 5° C. by placing in a freezing mixture. Cold air is now blown through this mixture of copper and ammonia for about 10 hours. The solutions so obtained are only stable at low temperatures, so that suitable precautions must be observed when using the same.

*Millon's reagent*....... An aqueous solution of mercurous nitrate.

Ten grams of mercury are treated with as much nitric acid as is necessary to dissolve it. An additional 10 grams of mercury is now added and the whole diluted with nine times its volume of water. As copious fumes of the red oxide of nitrogen are evolved, the solution of the mercury should take place under a hood.

*Molisch's reagent*...... A 20% solution of $\alpha$-naphthol in alcohol.

*Lassaigne's reagent*..... 5 grams of litharge and 5 grams of sodium hydroxide are dissolved in 100 c.c. of boiling water. $PbO + 2NaOH = Na_2PbO_2 + H_2O$.

*Liebermann's reagent*...One gram of Magenta (Fuchsin or Rosanilin) crystals is dissolved in 100 c.c. of water. To this is added ammonium hydroxide until the solution is just decolorized.

*Loewe's reagent*........An alkaline copper-glycerol solution.

10 grams of copper sulphate crystals are dissolved in 100 c.c. of water. To this are added 5 c.c. of glycerol and a solution of sodium hydroxide until the precipitate at first formed is just redissolved.

*Richardson's reagent*....An ammoniacal solution of nickel oxide.

25 grams of nickel sulphate crystals are dissolved in 300 c.c. of boiling water and precipitated with a slight excess of a 10% solution of sodium hydroxide. The precipitate is carefully filtered and washed, then rinsed into a 250 c.c. flask containing 125 c.c. of ammonia (sp. gr. = 0.88). The whole is now made up to 250 c.c. with water.

*Elsner's reagent*........A solution of basic zinc chloride.

100 grams of dry zinc chloride and 4 grams of zinc oxide are mixed with 85 c.c. of water.

*Hoehnel's reagent*......Solution I) One gram of potassium iodide dissolved in 100 c.c. of water, and iodine added in excess.

Solution II) Twenty cubic centimeters of glycerol are mixed with 10 c.c. of water. To this cold solution are added 30 c.c. of concentrated sulphuric acid.

The fiber is first treated with solution I, the excess of reagent is removed with filter paper, and after one or two minutes solution II is applied.

*Nickel's reagent*.......A solution of hydrazin sulphate in water.

*Zinc-chloride-iodine solution.* One gram of iodine crystals, 5 grams of potassium iodide, and 30 grams of zinc chloride are dissolved in 15 grams of water.

*Nitroprusside solution.* A 2 % solution of sodium nitroprusside in water The salt may be prepared as follows: A small quantity of potassium ferrocyanide crystals is boiled with strong nitric acid; finally dilute with water and neutralize the free acid with sodium carbonate. The salt is obtained in the form of deep-red crystals.

*Test Solutions for Lignin.* 1) Phloroglucol in 10% alcoholic solution. Dilute with an equal volume of 10% hydrochloric acid before using. 2) Anilin sulphate or hydrochloride in saturated solution. 3) Indol in 5% solution.

*Adamkiewicz's reagent.* A solution of glyoxalic acid in concentrated, sulphuric acid. Adamkiewicz's test may also be carried out as given under the reactions for wool (page 11).

*Fuchsin-bisulphite solution.* One gram of Fuchsin is dissolved in 1000 c.c. of distilled water. Sulphurous acid is now led into this solution (or a few drops of liquid sodium bisulphite is added) until the solution is *just* decolorized.

## ANALYTICAL CLASSIFICATION OF THE FIBERS.

The following arrangement of the fibers is based upon their chemical composition. Although this classification is one which has seldom if ever been adopted, it is not materially different from the usual arrangement. Such a classification reminds us that the fibers are chemical compounds, even though they may in some cases be extremely complicated.

| I. | II. | III. | IV. | V. |
|---|---|---|---|---|
| Wool.<br>Mohair. | Mulberry silk.<br>Tussah silk. | Jute.<br>Hemp. | Cotton.<br>Flax.<br>Ramie. | Lustre-celluloses: |
| Fibers from the Cashmere.<br>Thibet.<br>Alpaca.<br>Vicuna.<br>Llama.<br>Camel.<br>Cow.<br>Horse. | Eria.<br>Fagara.<br>False Tussah.<br>Muga.<br>Yamamai. | Bromelia.<br>Coir.<br>Esparto.<br>Gambo.<br>Manila.<br>New Zealand.<br>Raphia.<br>Sisal.<br>Sunn.<br>Vegetab. silk. | | Chardonnet.<br>du Vivier.<br>Lehner.<br>Pauly.<br>Stearns. |

Group 1. Animal fibers containing sulphur (keratinic fibers).

Group 2. Animal fibers containing *no* sulphur (silks).

Group 3. Vegetable fibers which respond to the lignin reaction (lignocelluloses).

Group 4. Vegetable fibers which do *not* respond to the lignin reaction (true celluloses).

Group 5. Artificial fibers or pseudo-silks (lustre-celluloses).

## GROUP I.

### *WOOL AND HAIR FIBERS.*

The chief analytical differences between these fibers lie in their physical properties. These will therefore be discussed separately, while the chemical reactions will hold good for the whole group.

DRY REACTIONS. When heated in a dry combustion tube the fiber seems to melt and then slowly decomposes with evolution of gases. These have a characteristic "empyreumatic" odor, resembling that of burning horn, due to the presence of sulphur and nitrogen. In fact, wool, hair, horn and feathers have one common constituent which has been given the name "keratin." A piece of red litmus paper held at the mouth of the combustion tube will turn blue owing to the ammonia vapors, while a paper moistened with lead acetate solution will be turned black owing to the vapors of hydrogen sulphide which are given off. Finally, a black residue insoluble in all media is observed in the tube; it is carbon. If wool which has been thoroughly washed with carbon tetrachloride be subjected to dry distillation in a vacuum at a temperature of 300° C., a bad-smelling liquid, consisting of ammonia water and various sulphur compounds, distills over. The gases given off include hydrogen sulphide and ammonia.

The "keratinic" fibers all contain carbon, hydrogen, oxygen, sulphur and nitrogen.

*Sulphur* may be detected: First, by heating the fiber with sodium carbonate and sodium nitrate in a combustion tube. The product of the reaction is dissolved in hydrochloric acid and the clear solution tested with barium chloride. A white precipitate of barium sulphate is obtained. Second, by boiling the wool with a mixture of caustic soda and lead acetate a black precipitate of lead sulphide is produced. Third, by heating the fiber with metallic sodium in a combustion tube, sodium sulphide is formed. Extract the product of the reaction with water and add sodium nitroprusside, when a violet coloration is obtained.

*Nitrogen* may be detected by heating in a strong tube with metallic sodium whereby sodium cyanide is formed. Boil with a small quantity of ferrous sulphate and ferric chloride solutions. On acidifying with hydrochloric acid a precipitate of Prussian blue is obtained.

*Carbon* may be observed as before mentioned, if the fiber be strongly heated in a combustion tube.

*Hydrogen and Oxygen.* The water vapor given off when perfectly dry wool is heated in a combustion tube is formed by the union of these two constituent elements of the fiber.

WET REACTIONS. Wool and other fibers obtained from the mammalia are insoluble in water, alcohol, ether, petroleum benzin, coal-tar benzene, carbon tetrachloride, etc. This fact is of value in removing the impurities from the fiber as the mineral matter is soluble in water and the fatty matters can be readily removed by these organic solvents.

*Potassium hydroxide* (also sodium hydroxide) in 5% solution dissolves the fibers on boiling. If cold dilute sulphuric acid be added to this solution a precipitate, containing more or less free sulphur, is obtained and hydrogen sulphide is evolved. If a 40% solution of caustic alkali be applied to the fibre at a temperature not above 20 degrees C. for 5 minutes, the fiber increases in tensile strength, becomes white and lustrous, and acquires a "silk scroop."

*Ammonium hydroxide* (also ammonium bicarbonate) in cold 10% solution does not affect the fiber to any marked extent.

*Calcium hydroxide* in saturated solution removes most of the loosely combined sulphur from the wool.

*Concentrated sulphuric acid,* if allowed to dry on the fiber, will rot the same. A warm 10% solution hardly affects the fiber in strength. By this treatment, however, the latter acquires an increased affinity for the acid dyes.

10% *Hydrochloric acid.* If wool be spotted with this solution and dried at 100° the fiber is hardly affected, owing to the volatility of the acid.

*Picric acid* in saturated aqueous solution dyes wool, etc., a greenish yellow.

*Nitrous acid* apparently diazotizes the amino groups of the wool molecule. The product of the reaction assumes different colors when developed with various phenols.

*Chlorine,* if allowed to act in the gaseous form, decomposes the fiber. Weak solutions of the gas are, however, used to impart a silk "scroop" to the fiber and to render it "non-shrinkable."

*Proteid reactions.* (1) Wool moistened with Millon's reagent and gently heated in a test tube assumes a brick-red coloration. (2) If wool be boiled with a 10% solution of copper sulphate, and after cooling, dilute sodium hydroxide solution be added, a violet coloration will be observed (Piotrowski's biuret reaction). (3) Wool moistened with a 50 % solution of nitric acid will at once be colored a canary yellow. If the sample be then dipped in a solution of an alkali the color will change to a deep orange (Xanthoprotein reaction). (4) On boiling wool with glacial acetic acid, cooling, and then adding concentrated sulphuric acid, a violet coloration is produced, and the solution fluoresces (Adamkiewicz's reaction). The use of a mixture of glyoxalic acid and concentrated sulphuric acid, in which the proteid is then boiled has been suggested for this reaction.

*Liebermann's reaction.* The fiber is boiled with the decolorized solution of magenta and afterward well washed. Animal fibers assume a pink color (distinction from all other fibers).

*Lassaigne's reaction.* When boiled with a solution of sodium plumbite, wool is colored a dark brown owing to the presence of sulphur.

*Molisch's reaction.* The fiber is treated in a test tube with 1 c.c. of water, a few drops of Molisch's reagent, and 1 c.c. of concentrated sulphuric acid. Solution takes place slowly, and a brown coloration is observed. Vegetable fibers dissolve immediately with a violet coloration.

*Furfurol reaction.* If wool be heated with a dilute solution of sugar acidified with sulphuric acid, a red coloration is obtained.

*Coloring matters.* All the fibers of this group have a decided affinity for substantive, acid, and basic dyes. Alizarin and a few other coloring matters will only adhere after a metallic oxide (like $Cr_2O_3$) has been fixed upon the fiber.

*The physical properties* upon which depends the valuation of wool and hair fibers are:

1. Elasticity.
2. Color.
3. Lustre.
4. Length.
5. Softness.
6. Uniformity in diameter.
7. Crimpiness.
8. Fineness (diameter).
9. Tensile strength.
10. Serrations per inch.

The microscopic examination of a fiber is generally sufficient for its identification, and should therefore form a part of every complete investigation.

## GROUP I(a). WOOLS.[1]

### *Wool (fine).*

This class includes the wool of the Merino[2] sheep of Spain, Silesia, and Australia as well as the Rambouillet sheep of France. It is the finest grade of wool, very elastic, white to gray in color, non-lustrous, short, very soft, crimpy, and fine.

Diameter: 0.013 mm. (0.0005 inch).

Length: 5 to 12 cm. (2 to 5 inches).

Serrations: 1100 per cm. (2800 per inch).

Microscope: The characteristic difference between wool and hair lies in the manner in which the scales forming the outer covering of the fiber are attached. The external walls of the wool fiber appear as thin horny plates or scales of irregular shape, the appearance of which has been compared to that of a shingle roof. The funnel-shaped scales seem to overlap one another, each one

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[1] It should be remembered that the data given concerning diameter, length, and serrations is approximate and is therefore not absolute and invariable.

[2] The terms, Merino, Lincoln, and Southdown are used in the United States to indicate certain grades of wool rather than the breed.

entirely surrounding the fiber. The edges resemble the edge of a saw with teeth set at a small angle. The central cylinder or medullary portion, sometimes called the pith of the fiber, is absent or invisible. The epidermal scales are attached to the cortical substance through only a small part of their length.

### *Wool (coarse).*

This class includes Lincoln, Leicester, and Cotswold wool and represents the diametrical opposite of the foregoing in almost every particular. The fiber is elastic, light in color, lustrous, long, straight, hairy, and coarse.

Diameter: 0.025 mm. (0.0010 inch).
Length: 12 to 20 cm. (5 to 8 inches).
Serrations: 230 to 550 per cm. (600 to 1400 per inch).
Microscope: Epidermal scales horny and attached firmly to the cortical structure.

### *Wool (medium).*

This class of wool is produced by the sheep of Southdown, the Cheviot Hills, Shropshire, Hampshire, Oxfordshire, and Dorsetshire. It stands midway between the two previous types.

Diameter: 0.020 mm. (0.0008 inch).
Length: 7 to 20 cm. (3 to 8 inches).
Serrations: 800 per cm. (2000 per inch).

## GROUP I(b). HAIRS.

### *Hairs of Goats.*

Mohair is obtained in Turkey from the Angora goat. It is very stiff, long, silky, lustrous, and almost pure white in color.

Diameter: 0.025 mm. (0.0010 inch).

Length: 10 to 25 cm. (5 to 10 inches).

Microscope: The scales can be observed only with high magnifying powers if at all. They are regular and encircle the whole hair. In most cases the pith is absent, although it is sometimes seen in the form of a canal occupying more than half of the diameter.

Less important goat hairs are obtained from the alpaca, vicuna and llama of South America, and from the Cashmere and the Thibet goats of China and India.

The term "alpaca" is frequently applied in a general sense to all South American goat hairs. The common varieties are brown and black. Cashmere is used in the manufacture of the famous "Cashmere shawls." The commercial varieties are gray and white.

### *Hairs of Other Mammals.*

Camel hair is obtained from Russia, Syria, and China. It is fine, crimpy, and soft (wool hair); or coarse, straight, and stiff (beard hair). It is used, among other things, in the manufacture of the "Jaeger normal fabrics."

Diameter: 0.015 to 0.075 mm.

Length: 5 to 10 cm.

Cow hair is obtained from Siberia, America, etc. It is short and irregular in diameter; black, white, or red in color. Under the microscope the hair-root can frequently be observed, as the fiber is obtained from the tanneries as "pulled hair." Coarse beard hairs, fine beard hairs, and wool hairs may be distinguished. This fiber is used to a large extent in the carpet industry.

Diameter: 0.080 to 0.180 mm.

Length: 1.5 to 5 cm.

Horse hair is used in the manufacture of "haircloth" linings, and upholstery fabrics. That obtained from the tail is about 65 cm. and that from the mane about 45 cm. in length. "Pulled" horse hair is approximately 3 cm. in length.

Diameter: 0.090 to 0.250 mm.

The hairs from the dog, cat, rabbit, and squirrel are also used to a limited extent in the textile and related industries (in the manufacture of hats, etc.).

In true hair the scales are firmly attached to the cortical fibrous substance throughout the greater part of their length, and only reveal themselves under the microscope as fine irregular transverse lines on the surface, and by notches at the edge of the hair. The internal arrangement of the cells of the fibrous substance shows a fairly distinct medullary axis. The shaft, or medulla, is usually firm and straight, and the scales are horny and dense. In wool fiber the scales are attached much less firmly, and their free margin is more prominent, being frequently notched in a more or less irregular manner. The serrations are distinct and the scales translucent.

NOTE. — *Some misleading terms used in trade are:*

Cheviot shirting: a fabric made totally of cotton.
Mohair cloth: a lining fabric containing cotton and mohair.
Cashmere: a fabric made of merino wool.
Alpaca cloth: a worsted fabric.
Vicuna: a worsted fabric.
Thibet: a worsted fabric.
Merino underwear: an article containing cotton and wool.

## GROUP II.

This group comprises two classes of silks; the one known as genuine cultivated or mulberry silk is the product of the insect *Bombyx mori*, while the most important representative of the wild variety is tussah silk, the product of *Antherea mylitta.* The color of the raw silk assists in some cases in its recognition, but the chemical reactions are almost identical for all the members of this group.

*Dry reactions.* The tests for carbon and nitrogen will be found under the tests for the wool fiber. The absence of sulphur in silk is a characteristic difference from wool. On heating silk in a dry tube an empyreumatic odor is noticed.

*Wet reactions.* All varieties of silk have the same physiological origin, so that it will not seem strange that they should all give the reactions of the proteids (see wool, page 10).

The pure silk fiber is not affected by any of the ordinary organic solvents.

*Sodium chloride* in aqueous solution if allowed to dry on the fiber has a decidedly tendering action. A common form of this chemical action is the effect of perspiration on silks prepared with the tin-phosphate-silicate weighting.

*Sodium hydroxide* (and potassium hydroxide) in hot concentrated solution dissolves the fiber in a short time. On acidifying this solution a precipitate is obtained.

*Sulphuric acid,* if concentrated, dissolves silk almost completely in 2 minutes. If immersed for only a few seconds, then washed and neutralized, the fiber shrinks considerably and loses most of its lustre.

*Hydrochloric acid,* cold —

in 25% solution contracts the fiber considerably.
in 30% solution dissolves the fiber in 10 minutes.
in 40% solution dissolves the fiber in 2 minutes.

*Furfurol reaction.* Allen gives the following particulars of this test: " If some cane sugar be dissolved in the not too dilute solution of a proteid and the liquid be then cautiously poured upon some strong sulphuric acid so as to avoid admixture of the two liquids, a fine violet coloration will be observed at the junction of the two strata."

*Chromic acid.* A saturated aqueous solution of chromic acid is diluted with an equal volume of water for use. Cultivated silk dipped in this solution and boiled for one minute dissolves completely, while the wild silk does not dissolve in three minutes (Hoehnel).

*Nitrous acid.* The fiber absorbs this acid from cold solutions and shows various colors on developing with different phenols (" diazo " reaction).

*Soap.* A boiling 10% solution of neutral olive oil soap removes the silk gum from raw silk completely. After being thus " boiled off " the fiber presents its characteristic lustrous appearance and loses about 25% of its weight by this "boiling-off" operation.

*Loewe's reagent* readily dissolves cultivated silks to a thick solution. (Distinction from wool, cotton, and lustre-cellulose.)

*Richardson's reagent* dissolves silk, while wool and cotton are unaffected.

*Elsner's reagent* dissolves silk in one minute.

### *Cultivated Silk (from Bombyx mori).*

Raw silk is rather dull in appearance, due to the covering of sericin[1] which is always to be found surrounding the fiber. It might be added that this encrusting matter increases the strength of the fiber considerably. Most of the

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[1] Sericin, silk glue and silk gum are synonymous terms.

silk obtained from Japan, China, Italy, and France is of a silvery white appearance, but there is also a large amount of the "yellow" silk produced in Italy and China. The golden yellow coloring matter is contained in the gum and may be removed by "boiling off." Under the microscope the silk fiber appears white, or yellowish white and lustrous. The thread is seen to consist of two distinct fibrils, between which is the sericin. The average diameter is 0.018 mm.

## *Wild Silk.*

The raw silk varies in color from light buff to dark brown. This coloring matter is distributed *through* the fiber, while in the case of cultivated silk the color is contained in the gum and may therefore be removed by boiling off. In the case of tussah silk the fiber must be thoroughly boiled off and then bleached with sodium peroxide. Owing to its large diameter (0.050 mm.) wild silk is much stronger than the cultivated variety. Under the microscope the fiber is seen to be very broad, while the cross-section appears wedge shaped. (Distinction from cultivated silk.) Longitudinal striations running obliquely across the fiber are plainly visible. Irregularly occurring coarser striations due to bundles of circular threads may also be noticed. The sericin cannot readily be distinguished from the fibroin.[1] The narrow side of the fiber appears dark gray with pink or light green spots, while the broad side is irregular in thickness, the thinner parts appearing bluish white or light brown.

The most important varieties of wild silk are:

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[1] The actual fiber-substance.

Tussah: — Obtained in India from Antherea mylitta (light brown in color).

Eria: — Obtained in India from Attacus ricini (white).

Yamamai: — Obtained in Japan from Antherea yamamai (pale green).

Fagara: — Obtained in China from Attacus Atlas.

Muga: — Obtained in Japan from Antherea assama.

False tussah: — Obtained in northern China from Antherea pernyi (dark brown).

## GROUP III.

Of the fibers which respond to the "lignin test" (i. e., contain ligno-cellulose) jute and hemp are the most important representatives. They are both bast fibers, but jute gives much more intense color reactions than does hemp. The following reactions are used to identify the fibers of this group:

| Reagent. | Jute. | Hemp. |
|---|---|---|
| Anilin sulphate. | Golden yellow. | Pale yellow. |
| Iodine-sulphuric acid (Hoehnel). | Dark yellow. | Yellow to green. |
| Zinc-chloride-iodide sol. | Yellow. | Yellow. |
| Phloroglucol + HCl. | Intense crimson. | Pale brown. |
| Hydrochloric acid. | Yellow. | Yellow. |
| Basic dyestuffs. | Strong affinity. | Little affinity. |

### *Jute* (*Corchorus capsularis*).

*Chromic acid* followed by sulphuric acid : blue coloration.

*Hydrazin sulphate:* pale yellow. Concentrated hydrochloric acid changes this color to orange.

*Phenylhydrazin hydrochloride:* pale yellow coloration which changes to green after about one hour.

*Microscope :* The cells possess a peculiar appearance due to irregular thickening of the cell walls. The interior (lumen) appears at some places quite large and at others not wider than a single line. Not all commercial samples show this variation, however. The cell wall appears sharply defined by the lumen, the latter at times exceeding the cell wall in width. The varying thickness of the walls is probably the main reason for the small tensile strength of the fiber.

Length: maximum = 3.5 meters.
Diameter: 0.010 to 0.030 mm.
Color: pale yellow to brown.
Lustre: silky.

### *Hemp* (*Cannabis sativa*).

*Schweitzer's reagent* swells the fiber irregularly and finally dissolves it, leaving only the parenchymous tissue.

*Microscope:* The forked ends of this fiber serve to distinguish it from flax. The cells are irregular in shape, at times flat, and then again cylindrical. The inner canal is generally broad, diminishing in width toward the end of the fiber. The cell walls are much less regular than in the case of flax. The forked ends of the fiber terminate abruptly (*dist. from flax*), the walls are thick and no nodes are visible. The cross-sections have round edges which are colored yellow by iodine and sulphuric acid; they are devoid of contents.

Length: 15 to 25 mm.
Diameter: 0.016 to 0.025 mm.
Color: light buff.
Lustre: not pronounced.

The less important fibers of group III are:

| Common Name. | Source. | Botanical Name. |
|---|---|---|
| Bromelia. | South America. | Bromelia karatas. |
| Bowstring. | Africa. | Sanseviera guineensis. |
| Coir. | Tropics. | Cocus nucifera. |
| Esparto. | Spain. | Stipa — |
| Gambo. | East Indies. | Hibiscus cannabinus. |
| Kapok. | East Indies. | Bombax pentandrum. |
| Manila. | Philippines. | Musa textilis. |
| Mauritius | Tropics. | Mauritia flexuosa. |
| New Zealand. | California and New Zealand. | Phormium tenax. |
| Pita. | United States. | Agave americana. |
| Pineapple. | Philippines. | Ananas sativa. |
| Raphia. | Africa. | Raphia taetigera. |
| Sisal. | Mexico and Central America. | Agave rigida. |
| Sunn. | British India. | Crotolaria juncea. |
| Vegetable silk. | United States. | Asclepias cornutii. |
| Vegetable down. | Tropics. | Bombax ceiba. |

NOTE.—The terms New Zealand flax, New Zealand hemp, Sunn hemp, Manila hemp, etc., often lead to confusion. These materials are therefore preferably designated as: New Zealand fiber, Sunn fiber, Manila fiber, etc., reserving the term hemp for the fiber obtained from cannabis sativa.

## GROUP IV.

The chief members of this group are cotton, flax, and ramie. The best method for distinguishing between these fibers is by the use of the microscope. They are composed of nearly pure cellulose and therefore do not respond to the "lignin" reaction; on the other hand they give a pure blue color when subjected to Hoehnel's "iodine-sulphuric acid" test. Other reactions characteristic of cellulose are given below:

1. *Sodium hydroxide* in concentrated aqueous solution causes hydrolysis and consequent weakening of the fiber

if applied in the presence of air (see mercerized cotton). A boiling solution of ½% concentration suffices for the removal of the waxy matter which encrusts the cotton fiber. In concentrations of 12% under 10 atmospheres pressure caustic soda dissolves about 50% of cotton.

2. *Sulphuric acid.* Cellulose (e.g. filter paper) dipped in concentrated sulphuric acid for a moment, then thoroughly washed and dried, is converted into amyloid. This product is waterproof and much stronger than the original paper. Amyloid gives a blue color when moistened with iodine solution. Dilute sulphuric acid, if allowed to dry on the fiber, causes disintegration and the formation of hydrated cellulose. (Application in carbonization.)

3. *Hydrochloric acid.* Dilute solutions if allowed to dry on the fiber will weaken it considerably, while concentrated solutions effect immediate decomposition.

4. *Nitric acid* (sp. gr. = 1.4). Bleached cotton steeped for 15 minutes in this reagent, then washed and dried, shows a contraction of 24% and an increase in tensile strength of 78% (Knecht). Acid of sp. gr. = 1.5 oxidizes cellulose to oxalic acid, while the less concentrated acid converts it into oxy-cellulose. This latter substance may be recognized by its great affinity for the basic dyestuffs (e.g. methylene blue).

5. *Nitric acid and sulphuric acid.* On treating cellulose with a mixture of these acids various nitrated compounds are obtained (collodion, pyroxylin). The nature of the product depends on the proportion of the two acids used, the temperature and the duration of the reaction.

6. *Hydrofluoric acid.* This reagent converts cotton and flax as well as ramie into a transparent, tough, flexible, and waterproof substance.

7. *Non-volatile organic acids* (oxalic, tartaric, citric). If the fiber be dipped into the molten acid and then removed, the crystallization of the acid causes rupture of the cell walls, which manifests itself by the brittleness of the fiber.

8. *Zinc chloride.* In concentrated solutions this reagent readily dissolves cellulose. Cotton must be previously "boiled off" with caustic soda.

9. *Thymol reaction.* Cellulose treated with sulphuric acid to which a small crystal of thymol has been added, assumes a violet coloration.

10. *Furfurol reaction.* This is a general reaction for the pentoses and is therefore obtained with all fibers containing cellulose. The fiber is boiled with dilute sulphuric acid in a distilling flask and the whole is finally distilled over. On adding aniline and hydrochloric acid to the distillate an intense red coloration due to the presence of furfurol is observed.

11. *Calcium hypochlorite,* or "bleaching powder" in aqueous solution. If cellulose be immersed in a solution of this compound (of about 2° to 3° Tw.) and be then hung in an atmosphere of carbon dioxide, the liberated hypochlorous acid will convert the cellulose into oxycellulose (see No. 4).

12. *Schweitzer's solution.* This reagent if properly prepared will dissolve cellulose readily. Raw cotton must be previously "boiled off" with caustic soda in order to remove the waxy and pectic matters which surround the fibers.

13. *Coloring matters.* None of the fibers of this group possess great affinity for aqueous solutions of dyestuffs, the only exception to this being the substantive colors

(benzidines and diamines). These "salt colors," or "direct colors" as they are sometimes called, produce moderately fast shades on the vegetable fibers.

14. *Dry reactions.* If the fibers be heated to 150° C. decomposition takes place. When burnt in the Bunsen flame a sweet odor is given off and a very small amount of ash remains. Cellulose is a carbohydrate consisting of the elements carbon, hydrogen and oxygen [$n(C_6H_{10}O_5)$].

### *Cotton* (*Gossypium*).

The physical properties upon which depend the valuation of cotton are:

Length of staple; uniformity in length of staple; tensile strength; color; diameter of the fiber.

The characteristic varieties of cotton are:

1. *G. barbadense.* Including American Sea Islands cotton, which is strong, lustrous, fine, of uniform diameter and white in color; Egyptian (white in color); Peruvian (white in color).
2. *G. herbaceum.* Including India cotton (surat), which is white, and of uneven diameter; Egyptian (makko), strong, long, and buff colored.
3. *G. hirsutum.* Including American Uplands cotton (peeler) which is classed into short staple and long staple.
4. *G. arboreum or religiosum.* Including Chinese (nankin) which is short, harsh, and buff colored.
5. *G. peruvianum.* Including Peruvian (red), and Brazilian (white). These cottons are strong, wiry, and harsh.

The tables on the following page show the relative values for diameter, length, etc., of the several varieties.

| | Diameter in mm. | Relative Breaking Strength. | Length in cm. | Color. |
|---|---|---|---|---|
| Egyptian | 0.017 | 7.5 | 4 | White. |
| Peruvian | 0.021 | 5 | 3 | White. |
| Indian | 0.025 | 10 | 2.8 | White. |
| Sea Island | 0.009 | 8 | 4 | White. |
| Chinese | 0.025 | | 2 | Light brown. |
| Brazilian | 0.018 | | 3.5 | White. |
| Upland | 0.019 | | 2.5 | White. |

*Microscope:* Under the microscope, cotton as a seed hair appears as a single long cell, covered with a thin membrane — the cuticle, which is not altered by concentrated sulphuric acid. The lumen or inner canal contains air, or as is sometimes the case the fiber appears as a band pressed firmly together, so that the lumen disappears from view. The fiber in all cases appears as a broad band which has been twisted around its axis many times.

### *Flax* (*Linum usitatissimum*).[1]

Of the numerous tests which have been repeatedly recommended for distinguishing between flax and cotton only a few are worthy of mention.

*Frankenheim's test* (applicable only to bleached fibers containing no sizing). If the dry fibers be immersed in olive oil and then pressed between blotting paper, cotton remains opaque while linen becomes transparent.

*Kindt's test.* First remove the size from the sample by boiling and rubbing in distilled water. Then dry and place for about one-half minute in concentrated sulphuric acid.

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[1] The term *linen* should be limited to the yarns and fabrics made totally of the *flax* fiber.

Wash well, place in dilute ammonia water and then dry. By this treatment the cotton is turned into a gelatinous mass and may be removed by washing and rubbing. The success of this test is dependent on the complete removal of the size and upon the time of immersion in the acid.

*Schweitzer's solution* causes flax to swell up strongly; the fiber does not, however, dissolve completely.

*Microscope:* Under the microscope the fiber appears regular with a lumen which is in some cases not wider than a line. The end is pointed. The *characteristics* of the fiber are the dislocations or nodes which occur at rather regular intervals. These sometimes take the form of pronounced lines extending across the fiber at an angle of from 60 to 90 degrees. There is *no* cuticle.

Diameter: 0.05 mm. to 0.20 mm.

Length: 20 to 100 cm. This of itself often serves to distinguish the fiber from cotton, the maximum length of which is 5 cm.

Color: yellowish white to gray, but it may be bleached a pure white with potassium permanganate, chloride of lime, or by the "grass bleach." The bleached fiber is lustrous and can often be mistaken for silk at a rough glance.

### *Ramie* (*boehmeria tenacissima*).

*Microscope:* The interior canal occupies about two-thirds of the whole diameter. Very often lines may be noticed extending through the individual cells and a granular protoplasm is seen. The cell walls are regularly thickened so that the lumen is usually uniform. The extremes have thick-walled, round ends and striated lumen. Length : 5 to 100 cm. Diameter : 0.25 to 0.110 mm. (characteristic). The purified fiber is quite white, lustrous, generally tubular in form, with bast cells about 8 centimeters in length. The fiber is less elastic than wool, less flexible than cotton, and more lustrous than flax.

The chemical reactions are those of pure cellulose. Lignin seems to be entirely absent in the ramie fiber.

## GROUP V.

At this time there are as many as five varieties of imitation or "pseudo-silks" manufactured on a commercial scale. Those of Chardonnet, Lehner and du Vivier are made from nitrates of cellulose; Pauly silk is made from Schweitzer's solution of cellulose, and Stearns silk (Viscose) is made from cellulose thiocarbonate. All these products possess a distinctly metallic lustre and the property of being affected by water. On moistening these fibers a gain in elasticity and a loss in tensile strength is noticeable.

The *diameter* varies according to Massot from 0.028 mm. to 0.035 mm., the coarser numbers being sold as "artificial horsehair."

The *specific gravity* varies from 1.50 to 1.53, but in no case falls as low as that of natural silk (1.30 to 1.40).

The *relative tensile strength* of several varieties is given below:

| Name. | Tensile Strength. | | Relative strength (Silbermann). |
|---|---|---|---|
| | Wet. | Dry. | |
| **Chardonnet** | 2.2 | 12 | 50 |
| **Lehner** | 1.5 | 17 | 68 |
| **du Vivier** | 2.0 | 15 | 24 |
| **Pauly (Glanzstoff)** | 3.2 | 19 | — |
| **Stearns (Viscose)** | 3.5 | 21 | — |
| **Mulberry silk** | — | — | 100 |
| **Tussah silk** | — | — | 126 |

In the valuation of lustre-cellulose the following points should be considered: Tensile strength of the dry yarn; tensile strength of the moist yarn; diameter; uniformity in diameter; brilliancy; softness; elasticity.

*Diphenylamin reaction:* a few crystals of diphenylamin are dissolved in concentrated sulphuric acid. If pyroxylin silks are immersed in this reagent, they assume an intense blue color due to the presence of nitro groups. Stearns silk and Pauly silk are not made from nitrated cellulose and therefore do not give this reaction.

*Potassium hydroxide* imparts a yellow color to lustre-cellulose but does not dissolve it even on boiling. (Distinction from natural silk.)

*Loewe's reagent* does not dissolve lustre-cellulose even on heating. (Distinction from natural silk, quantitative separation.)

*Iodine-sulphuric acid* colors lustre-cellulose a blue. (Natural silk is colored yellow.)

*Coloring matters,* even the basic dyestuffs, are readily removed from their aqueous solutions by means of lustre-cellulose, particularly Chardonnet silk. This great affinity of lustre-cellulose for the dyestuff makes it necessary to observe great care when dyeing this material.

*Dry test.* Lustre-celluloses when held in the Bunsen flame ignite with a flash like that observed in the case of gun-cotton. No empyreumatic odor is noticeable.

*Microscope.* When examined under the microscope these fibers appear with deep longitudinal striations and distinct air bubbles. Examined in a ray of polarized light, they show double refraction.

*Schwalbe's test.* If Chardonnet, Pauly, and Viscose silk be treated in separate beakers with Fehling's solution, Chardonnet silk, owing to its reducing action, will impart a green color to the liquid. In the case of Pauly and Viscose silk the liquid will remain blue. Now prepare a reagent consisting of 20 g. zinc chloride, 2 g. potassium iodide, 0.1 g. iodine and 15 c.c. water. If Pauly and Viscose silk be then treated with this reagent, and well washed, it will be observed that Viscose silk retains its blue-green color while the Pauly silk quickly loses its color on washing.

## SUBSTANCES FOUND IN TEXTILE YARNS AND FABRICS.

### *Detection of Oils in Textiles.*

1. *Rosin oil.* This oil obtained by the distillation of colophony is sometimes found on waterproof fabrics or as a stiffening in lining fabrics. For these purposes the oil is diluted with some easily volatile solvent so that it may be applied to the fabric in a thin layer.

For its detection and estimation, a 5 gram sample of the fabric is extracted with petroleum benzin or coal-tar benzene in a Soxhlet apparatus for about 30 minutes. The extraction flask is finally disconnected and placed on a water-bath to drive off the solvent. The residue is placed in a test-tube with 1 c.c. of acetic anhydride and 0.5 c.c. of concentrated sulphuric acid, when a violet coloration will be observed if rosin is present (Storch-Morowski test).

2. *Mineral oils.* These oils are at times found on woolen yarns and fabrics, having been used as a lubricant for the yarns in the spinning process. They will seldom be encountered alone, some vegetable oil being generally admixed. In all cases their presence should be the cause

for complaint, for it is extremely difficult to remove them from the goods by the ordinary scouring methods. For their detection the sample is extracted with low-boiling ligroin (previously redistilled to remove tarry matter). The residue left in the flask after evaporating the solvent is boiled with a solution of alcoholic caustic potash. It is necessary to use *alcoholic* potash solution, as an aqueous solution readily emulsifies mineral oil. If mineral oils are present in the fabric they will be seen as small globules on the surface of the potash solution, for, being hydrocarbons, they are "unsaponifiable."

3. *Vegetable oils.* "Non-drying oils" or fats are found in all woolen fabrics to a greater or less extent, having been used for spinning the yarns.[1] To prove that the oil contained in a particular sample of goods is purely of vegetable origin it should be extracted and saponified with alcoholic potash solution. The result of this treatment should be a soap *completely* soluble in distilled water.

### *Detection of Mordants on the Fiber.*

Every finished article may contain dyes, mordants, sizes, and finishing materials in addition to the fiber of which it is constructed. The assistants used in the dyebath, such as tartar or glauber salt, do not come into consideration at all; "turkey reds," however, will be found to contain both the oil and the mordant (alumina). Finishing materials may as a rule be removed from the fiber by simple boiling with water; while the mordants, being more firmly fixed, are obtained after ignition of the fiber or on extraction of the fiber with various solvents.

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[1] In the spinning of worsted yarns on the "French System," no wool oil is used.

The ignition method is often found to be preferable as the dyestuffs are thereby destroyed. All the non-volatile inorganic constituents are found in the ash, and may be quantitatively determined by weighing the crucible before and after ignition.

The ash may contain aluminium, chromium, iron, manganese, lead, copper, antimony, tin, silicates, and phosphates. The color of the ash as well as its solubility in concentrated acids should be noted. Silica and stannic oxide are insoluble, and if present the ash must be fused in a silver crucible with potassium hydroxide. This is then added to the acid solution of the ash, and hydrogen sulphide passed through the mixture. Pb,Cu,Sb,Sn are precipitated and are separated in the usual manner.

*Phosphates* are detected by means of the ammonium molybdate reaction. Tannic acid and oleic acid will not be detected by the ignition method and must therefore be tested for separately.

*Tannic acid* (generally combined with antimony, tin, or iron) is removed from the fabric by (1) boiling with water; (2) treating with 2% sodium carbonate solution; (3) treating with 5% acetic acid solution. The three extracts are united, acidified and tested with ferric chloride, which gives the black "ink" reaction.

*Oleic acid compounds* (of alumina or some similar metal) are decomposed with boiling dilute hydrochloric acid, after which the separated fatty acid is filtered off and examined. A detailed examination is only of importance in the case of turkey reds in determining whether olive oil or turkey red oil has been used.

*Iron compounds* will be found in fabrics dyed black with logwood. In this case the dyestuff interferes with any color reactions so that the iron must be removed by treatment with 5% hydrochloric acid, after which the test with potassium ferricyanide may be applied.

*Tin compounds* are looked for in the ash as given above.

Another method for examining dark colored fabrics consists in immersing the sample in a solution of bleaching powder of 1° Be, whereby the dyestuffs are destroyed. If necessary the solution may be made of 2° Be, or it may be heated slightly, or it may be acidified with acetic acid. The appearance of the bleached fiber thus obtained will at times suggest the presence of chromium and iron. If it be white, aluminium or tin may be present. Confirm aluminium by dyeing in an alizarin bath.

### *Detection of Weighting on Silks.*

The weighting materials used for silk are either volatile (that is, organic) or non-volatile (inorganic), so that the determinations must be made accordingly. The volatile matter is removed from the fiber by means of various solvents, while the mineral matter is looked for in the ash.

Colored silks may contain antimony, zinc, aluminium, tin, phosphoric, silicic, or tannic acid; glue, oil, glucose, cane sugar, starch, dextrin, glycerol, or gum arabic.

Black silks may contain chromium, zinc, aluminium, tin, iron, lead, phosphoric or silicic acids, prussian blue, and organic matters.

1. Glue and tannic acids (if *not* combined with iron or tin) are soluble in water at 60° C. Both may be present. Tannin in aqueous solution gives a dark coloration or

precipitate with ferric chloride. Glue, if in solution alone, is precipitated by dilute solutions of tannic acid. If basic dyestuffs are present they must be removed before testing for glue. Tannin and glue are completely removed with 2% soda solution at 40° C.

2. Oils and fatty acids are extracted from the fabric with sulphuric ether or petroleum ether. By weighing the residue after evaporation of the solvent the quantity extracted may be determined. Fatty acids are due to decomposed soap and oils used in the brightening operation.

3. Sugar, dextrin, glycerol, and gum are removed by cold water.

Cane sugar is recognized (after inversion with dilute hydrochloric acid) by the reduction of Fehling's solution.

Starch is confirmed with iodine solution.

Glycerol is confirmed with the acrolein test (conc. sulphuric acid and heat).

4. Prussian blue is decomposed with 2% soda solution. Acidify with hydrochloric acid and add ferric-chloride. Prussian blue will be re-precipitated.

5. Tin, aluminium, iron (not present as prussian blue) tannic acid, and phosphoric acid are partly soluble in warm 5% hydrochloric acid.

6. The ash may contain silica, tin, aluminium, and phosphoric acid.

Mix the powdered ash with fluorspar and conc. sulphuric acid. Warm gently and detect the escaping silicon fluoride by means of a drop of water held in platinum loop. Now treat the ash several times with hot conc. hydrochloric acid and dilute the whole with water and pass hydrogen sulphide through a portion of it. Tin is thrown down as yellow stannic sulphide.

Add ammonium molybdate to a portion. A yellow precipitate indicates phosphoric acid.[1]

Add ammonium hydrate to a portion. A white gelatinous precipitate indicates aluminium.

### *Detection of Sizing on a Fabric.*

The sample is boiled with water for about two hours in order to remove stiffening materials, soluble salts, and earthy matter. Filter the extract.

I. The FILTRATE should be evaporated on the water bath in order to obtain a fairly concentrated solution for the following tests:

*Chlorides.* A small portion of the solution is acidified with nitric acid. If silver nitrate be added to this a white precipitate of silver chloride will be obtained. The chlorides usually present are those of zinc and magnesium.

*Sulphates.* To a small portion of the solution add hydrochloric acid and barium chloride. A white precipitate indicates a sulphate. The sulphates usually present are those of magnesium (Epsom salt) and sodium (Glauber salt).

*Metals* which may be present are magnesium, calcium, and zinc.

*Glue, gelatin,* dextrin, and gum are precipitated from the concentrated filtrate on the addition of alcohol. Glue if present will give a precipitate with tannic acid. Dextrine is detected when the filtrate is examined in the polariscope; it is dextro-rotary. Gums are precipitated by lead acetate in the cold.

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[1] The "molybdate" reaction is more delicate if ammonium nitrate is added to the almost neutral solution. A small quantity of hydrochloric acid is then added before testing with ammonium molybdate.

*Irish moss* gives *no* precipitate with the usual reagents.

*Cane sugar* is detected by heating the concentrated filtrate with hydrochloric acid, and after this inversion, testing with Fehling's solution.

*Glycerol.* — If the concentrated filtrate be heated with potassium bisulphate, irritating vapors of acrolein will be noticed.

II. The RESIDUE may contain starch, mineral matter or fats, etc.

*Starch* may be readily detected by the blue color which it gives with dilute solutions of iodine.

*Mineral matter.* Gypsum (calcium sulphate), Blanc fixe (barium sulphate) and China clay (aluminium silicate) are tested for by the usual methods of inorganic analysis.

*Fats and Colophony.* — An original sample of the fabric is boiled with a 10% solution of soda for 15 to 30 minutes. Filter the liquid and acidify the filtrate with hydrochloric acid. By this treatment the fatty acids will rise to the top while the sylvic acid (colophony) will appear as a precipitate.

The starchy matter in a fabric may be removed by the malting operation. For this purpose an infusion of malt is prepared by steeping 10 grams of ground malt in 1000 c.c. of water at 60 to 65° C. The fabric is immersed in this infusion for two or three hours, after which it is thoroughly washed in order to free it from the dissolved starch. Within the last two years a special preparation of malt has appeared in commerce under the name of "diastafor." This can be used in a concentration of one gram per hundred cubic centimeters of water.

## REACTIONS OF THE MOST IMPORTANT ORGANIC FINISHING MATERIALS (MASSOT).

| | Alcohol. | Fehling's Solution. | Dilute Sulphuric Acid. | Tannin Solution. |
|---|---|---|---|---|
| Glucose | Precipitated from strong solutions by large excess of alcohol. | On warming, a deposit of red copper sub-oxide. | | |
| Cane sugar | As above. | | On boiling in aqueous solution inverted to glucose. | |
| Dextrin. | Precipitated on the addition of five or six volumes of alcohol. | In dilute solutions, even on boiling, no change. In concentrated solutions warming or boiling gives red copper sub-oxide. | As with cane sugar. | In dilute solutions no change. In concentrated solutions a white turbidity more marked on addition of hydrochloric acid. |
| Starch | A loose, white precipitate. | | Glucose formed on boiling the aqueous solution. | Milky turbidity or precipitate. |
| Gum arabic | Five or six volumes of alcohol give a flocculent white precipitate, especially in the presence of hydrochloric acid. Dilute solutions become turbid. | No change either cold or on boiling. On shaking with excess of sodium hydrate, light blue flocks. | On boiling, substances are produced capable of reducing Fehling's solution. | |

| | | | | |
|---|---|---|---|---|
| Gum tragacanth..... | When poured into an excess of strong alcohol, a thready, flocculent precipitate. | Clear blue solution. On standing or boiling, deposit of red copper sub-oxide. | As above. | |
| Vegetable mucilages.. | Their aqueous solutions give, with excess of alcohol, flocculent or gelatinous precipitates. | Clear blue solution. Frequently, on boiling, red copper oxide separates. | As above. | Iceland moss gives turbidity increased by hydrochloric acid. Agar-agar gives only on the after-addition of hydrochloric acid a flocculent precipitate. Flax seed gives turbidity only on the after-addition of acid. |
| Glue (gelatin)....... | In strong aqueous solutions a tenacious, pasty precipitate. Dilute solutions become turbid. Soluble in hydrochloric acid. | Biuret reaction. (Violet coloration.) | | An excess of a neutral solution yields a lumpy precipitate becoming tenacious on warming. |
| Albumen solutions... | With much alcohol a white precipitate. (Coagulation.) | Yields the biuret reaction on gradual addition. | | An excess yields a copious precipitate. |
| Solid albumen....... | On protracted treatment with alcohol becomes insoluble in water. | Biuret reaction. | | |

## REACTIONS OF THE MOST IMPORTANT ORGANIC FINISHING MATERIALS. — *Continued.*

| | Iodine solution. | Copper Sulphate and Sodium Hydrate. | Copper Acetate and Acetic Acid. | Basic Lead Acetate. |
|---|---|---|---|---|
| Glucose | | Clear blue solution. On boiling, a deposit of red copper sub-oxide. | After boiling red copper, sub-oxide separates on standing. | |
| Cane sugar | | Clear blue solution unchanged on boiling. | | |
| Dextrin | Brown to purple coloration, disappearing on heating. | Clear blue solution unchanged on standing. On warming, a gradual separation of red copper sub-oxide, which, with dilute solutions, only develops after long standing. | After boiling and long standing no appearance of sub-oxide, or at most the merest trace. | |
| Starch | Blue coloration unstable to heat. | Bright blue flocculent precipitate which does not blacken on boiling unless an excess of copper sulphate has been added. | | Becomes turbid. |
| Gum arabic | | Bright blue flocculent or gelatinous precipitate, remains blue on boiling. | | White gelatinous precipitate. |

|  |  |  |  |  |
|---|---|---|---|---|
| Gum tragacanth | At times yields a weak blue coloration, due to the presence of starch in small amount. | Lumpy blue precipitate unaltered on boiling. Seldom yields a deposit of red copper sub-oxide. |  | Similar to gum arabic. |
| Vegetable mucilages | Iceland moss gives a blue coloration owing to its starch content. | Blue, lumpy precipitate. On long boiling many mucilages yield the sub-oxide. |  | Precipitate. |
| Glue (gelatin) |  | One or two drops of copper sulphate solution to an alkaline glue solution give the biuret reaction, especially on warming. |  | Turbidity in very strong solutions. |
| Albumen solutions |  | Biuret reaction as above. |  | White turbidity or precipitate. |
| Solid albumen |  | Biuret reaction. |  |  |

Potassium ferrocyanide and acetic acid gives with albumen solutions white precipitates.
Millon's reagent gives a white precipitate which assumes a pink color on boiling.
Solid albumen shows the same reaction.
Dilute nitric acid poured slowly on albumen solution produces a white ring at the point of contact. Solid albumen turns yellow in this case.
Mercuric chloride gives a white precipitate with albumen solution as well as with glue.
Adamkiewicz's reagent (10 c.c. conc. sulphuric acid + 20 c.c. glacial acetic acid) gives a violet coloration with solid albumen.

### *Survey of Finishing Materials used for Textiles.*

1. For Stiffening. — The starch of wheat, potato, rice, corn, and sago; flour, dextrin, glue, gelatin, glucose, gum arabic, gum tragacanth, gum tragasol, Iceland moss, Irish moss.

2. For Softening. — Turkey red oil, soaps, tallow, stearin, paraffin, olive oil, Japan wax, spermaceti.

3. Hygroscopic Agents. — Ammonium chloride, magnesium chloride, zinc chloride, calcium chloride, glycerol, glucose, cane sugar.

4. For Filling. — Kaolin (or China clay, an hydrated silicate of alumina), gypsum (calcium sulphate), talc (magnesium silicate), whiting (calcium carbonate), blanc fixe (barium sulphate).

5. Colored Weighting Agents. — Ultramarine (a mixture of sodium-aluminium silicate with polysulphides of soda), prussian blue $Fe_4(FeC_6N_6)_3$, smalt (finely powdered cobalt silicate), ochre (a mixture of silica, clay, and hydrated oxide of iron), indigo carmin (soluble sulphate of indigo).

6. Illuminating Agents. — Copper, brass, silver and aluminium in a finely powdered condition; powdered metallic sulphides.

7. For Waterproofing. — Aluminium, magnesium and lead soaps, gelatin, tannin, paraffin, caoutchouc, ceresin (purified ozokerite), waxes and oils, beeswax.

8. For Fireproofing. — Sodium tungstate, sodium biborate, sodium silicate, ammonium phosphate.

9. Antiseptic Agents. — Salicylic acid, carbolic acid, formic acid, boric acid, borax, camphor.

# PART II

# QUANTITATIVE ANALYSIS

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## PART II .

### MIXED FABRICS IN GENERAL.

FABRICS are made in a variety of grades or qualities in order to meet the varying demands of the consumer. It is a very common thing in textile manufacturing to vary the grade of a fabric for this reason only. This is particularly true in America, where the fabrics must at the same time be cheap and pretty. As a result the manufacturer is compelled to bend the quality to the price instead of being able to command a fair price for a higher grade article. The price is met by making the goods lighter in weight, using poorer yarns, making the cloth narrower, or finally by supplying a deficiency in weight by chemicals called filling materials. A person who thinks he is buying the same fabric for 12½ cents as for 15 cents is as a rule badly mistaken. "All wool" fabrics, in which the warp lies on the face, are frequently found to contain a fine worsted fiber in the warp and a much cheaper wool or shoddy yarn for filling.* "India linon" contains no flax at all; it is made of combed cotton yarns. "Linen mesh" underwear has been produced solely from cotton yarns, and "cotton-worsteds" contain no trace of wool. Goods made of linen and cotton can be finished with a beetle and so made to look like "all linen." Then again two mohair fabrics which at a rough glance appeared

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* See NOTE, page 15.

to be identical were offered at 50 cents and $1.25 per yard. The analysis showed that the first contained 50% cotton, while the second contained 25% of the vegetable fiber. These are but a few of the many examples of falsification, or rather substitution, which serve as illustrations at this point. One flagrant abuse of a term has been observed in recent years in the case of "merino." This name was originally applied only to the wool obtained from sheep bearing the same name. It is one of the finest wools at the disposal of the textile industry. After a while the term merino was applied to mixtures of wool and cotton containing from 5 to 50% cotton, and now to avoid the disputes which arose from this second usage we may buy in our drygoods stores "pure merino underwear" which contains *cotton* only. The "wooly" effect is obtained by napping or "raising" the fabric. There are three different ways in which fibers may be mixed in a fabric so that by the use of one or more of these, various effects may be obtained.

1. *The raw fibers are mixed before spinning.* Underwear fabrics made of "merino yarns," and certain umbrella cloths containing silk and cotton, will serve to illustrate this method.

2. *Two "single" yarns are twisted together.* This may often be noticed in cheap suitings, where a black shoddy yarn is twisted with a fine white cotton yarn, producing what is known as a "pepper and salt" effect. In better-class goods this same effect is obtained with silk and worsted yarns.

3. *Two different fibers are used in warp and filling.* Cotton or linen being stronger is generally chosen for the warp, while wool, worsted, or silk is used for the filling.

As examples of this manner of mixing we have umbrella cloths, farmers' satin, and lansdowne.

In the analysis of weighted fabrics the sizing and finishing materials should in all cases be previously removed by boiling with hydrochloric acid (2 or 3%) for 10 minutes. The iron weighting on silks can thus be totally removed provided it does not form more than 25% of the sample.

## ANALYSIS OF A WOOL-COTTON FABRIC.

The analysis of this class of fabrics may be made according to a variety of methods depending on,— (1) the solubility of wool in caustic alkalis; (2) the destruction of the cotton by mineral acids; (3) the solubility of cotton in Schweitzer's solution; (4) the mechanical separation of the warp and filling threads.

*Method I.* The fabric is boiled for about 15 minutes in a 5% solution of caustic potash. The residue, which is cotton, is washed well to remove the alkali, then dried and weighed. In ordinary analysis the results obtained with *air-dry* material will be close enough. If, however, the moisture in the sample is determined, it must be remembered that the average amount for cotton is 8%, and for wool 15%.

EXAMPLE:

| | | |
|---|---|---|
| Weight of the sample (air-dry) | | 5·32 grams |
| Weight of the sample (after treating) | | 2.27 |
| Loss (-wool) | | 3·05 |
| Percentage of wool | 57·3 | |
| Percentage of cotton | 42.7 | |

NOTE.—Owing to the fact that cotton is slightly attacked by this treatment, an amount equal to 5% of the weight of the cotton found is added and a corresponding amount subtracted from the wool figure; for example:

5% of 42.7 = 2.13 and 42.7 + 2.13 = 44.83% cotton
and 55.17% wool

*Method II.* Finishing materials are first removed from the sample by boiling in 1% solution of hydrochloric acid followed by rinsing in a solution of sodium carbonate (0.5 g. per liter). The sample is now immersed in 80% sulphuric acid for 12 hours. It is finally washed well in 50% alcohol and filtered off, using alcohol for washing the residue. The weight after drying in the air represents wool.

*Method III.* This method finds very limited application because of the difficulty with which ordinary cotton dissolves in the ammoniacal solution of cupric oxide. The insoluble residue left after treatment represents wool.

*Method IV.* The mechanical analysis of fabrics is in many cases quite as satisfactory as the separation of the fibers by chemical means. For this method it is however essential that the yarns be made wholly of one fiber: the warp may for instance be of cotton and the filling totally of wool. The sample is cut exactly parallel to the warp and filling, weighed, picked apart, and the warp and the filling threads weighed separately.

*Method V.* Pinagel has devised the following modification of the caustic soda method. The analysis requires about 5 hours: (1) remove all grease by extraction with a volatile solvent; (2) remove finishing materials by treatment with hot 2% hydrochloric acid for 15 minutes. Wash thoroughly with distilled water, dry in a weighing bottle at 110° C. and weigh; (3) remove the wool by boiling in a 2% caustic soda solution for 15 minutes, occasionally adding water to replace the loss by evaporation. Rinse the remaining cotton in water, hydrochloric acid and distilled water. Dry and weigh. The following constants are used for the calculations.

| | Per cent |
|---|---|
| Cotton loses on boiling with caustic soda... | 3.5 |
| Scoured wool loses on boiling with water... | 1.0 |
| Average moisture in wool.................. | 17.0 |
| Average moisture in cotton................ | 8.5 |

**Example:**

| | | |
|---|---|---|
| Weight of dry sample after degreasing.............. | | 9.5590 g. |
| Weight of sample after NaOH boil ..... | 5.2437 g. | |
| Add 3.5%.......................... | 0.1835 | |
| Dry cotton.............................. | 5.4272 | 5.4272 |
| Add 8.5%.......................... | 0.4613 | |
| Normal cotton........................... | 5.8885 | |
| Wool removed by NaOH .............. | 4.1318 | 4.1318 |
| Add 1%............................ | 0.0413 | |
| Dry wool ............................... | 4.1731 | |
| Add 17%........................... | 0.7094 | |
| Normal wool............................. | 4.8825 | |

The weight of the fabric with the normal amount of moisture is then equal to 4.8825 + 5.8885, or 10.7710 grams, and from this we calculate.

| | Per cent |
|---|---|
| Cotton.................................. | 54.7 |
| Wool.................................... | 45.3 |
| | 100.0 |

Note.—In the United States the amount of moisture in "normal" wool is usually taken as 15% instead of 17%. (Compare page 68.)

## Analysis of a Silk-wool Fabric.

*Method I.* Treat the sample with dilute hydrochloric acid and then with sodium carbonate, in order to remove finishing materials, etc. Dry and weigh. A concentrated solution of hydrochloric acid (40%) is now heated to 50° C. and into this the sample is dipped for 2 or 3 minutes. By this treatment the wool is hardly affected, while the silk is dissolved. Dilute with water, and filter. The weight of the dried residue represents the amount of wool present.

*Method II.* The silk is dissolved by immersion in an ammoniacal nickel hydroxide solution for 5 minutes at 20° C. (Richardson). It will usually be found that the nickel hydroxide cannot be completely dissolved by the proportion of ammonia stated in the list of reagents. If this is the case the mixture of hydroxide and ammonia should be thoroughly shaken before using. After boiling the sample in this turbid liquid for 5 minutes it is removed, rinsed and then thoroughly washed with 1% hydrochloric acid in order to remove the adhering hydroxide. The residue of wool is then rinsed again, dried, and weighed.

*Method III.* The silk is dissolved in a boiling solution of basic zinc chloride. If dipped in this solution for not longer than one minute, the wool will remain unaffected. The residue (wool) is finally well washed with 1% hydrochloric acid, washed with water, dried and weighed.

### ANALYSIS OF A SILK-COTTON FABRIC.

*Method I.* The previously weighed sample is immersed in Loewe's alkaline-copper-glycerol solution at a temperature of 50° C. for 15 minutes. The residue of cotton is then rinsed, dried and weighed.

*Methods II and III.* — See analysis of silk-wool fabric.

### ANALYSIS OF A WOOL-SILK-COTTON FABRIC.

*Method I.* *a.* Remove moisture by heating in the oven to 105° C. to constant weight.

*b.* Remove finishing materials and dyestuffs by boiling in 3% hydrochloric acid for ten minutes.

*c.* Remove the silk with ammoniacal nickel hydroxide solution, or remove the silk by dipping in a boiling solution of basic zinc chloride for one minute. Wash well with acidulated water.

*d.* Remove the wool by boiling in 5% caustic soda.

If the sample be weighed before and after each operation the amount of each constituent may be determined. The final residue of cotton will in both cases be found to be somewhat below the actual percentage present, so that 4% should be added to the weight of the residue and subtracted from the weight of the wool.

*Method II* (*von Remont*). *a.* Weigh out 4 samples of the air-dry fabric of 2 grams each (weight *a*).

*b.* Boil 3 of the samples in a 3% solution of hydrochloric acid, decant and repeat with a fresh solution of hydrochloric acid. Size and coloring matter are hereby removed.

*c.* Rinse well in order to remove all the acid (residue *b*).

*d.* Two of the samples obtained by the above operation are placed for two minutes in a boiling solution of basic zinc chloride in order to dissolve silk.

*e.* Wash well with 1% hydrochloric acid and distilled water (residue *d*).

*f.* One of the two samples left after the above operation is boiled for 15 minutes with 5% caustic soda in order to remove any wool. Wash well with water. (residue *f*).

We will now have one residue from *b*, one from *d* and one from *f*. These are dried in the air for 10 hours and then weighed.

The first loss represents finishing material; the second loss, silk; the third, wool, and the residue is the cotton.

## ANALYSIS OF A SILK IMITATION-SILK FABRIC.

Fabrics containing both genuine silk and lustre-cellulose (imitation-silk) may be analyzed by treatment with Loewe's reagent. Genuine or mulberry silk dissolves in this solution at room temperature in 30 minutes, while lustre-cellulose is not affected. The residue left after treating a weighed sample will therefore represent lustre-cellulose.

## EXAMINATION OF WATERPROOF CLOTHS.

The increasing number of so-called "raincloths," for which the claim is made that they resist the penetration of water, brings with it the necessity for accurate methods for comparing the value of such fabrics. The two chief articles for which waterproof fabrics are demanded are raincoats and umbrella covers. Three other articles which may be considered here are sailcloths, bookbinder cloth, and rubber-coated cloths. The methods of preparing fabrics in order to make them water-resistant, are:

1. Impregnation with metallic salts.
2. Coating with oils, fats, and waxes.
3. Coating with solutions of rubber.
4. Superficial solution by means of Schweitzer's reagent.

The first method finds application in the dressing of sailcloth. The material is impregnated with alum and acetate of lime and is then entered in a "fixing-bath" containing waterglass. For some classes of goods this latter bath consists of a soap solution, in which case an insoluble aluminium or lime soap is formed in the fabric.

The second method is used for raincloths, signcloths, imitation leather, etc. The fabric is passed between hot rollers and then over the block of wax. By another method the wax is dissolved in benzin and the fabric padded with this solution. As the latter method is much more expensive it is generally limited to high-class ladies' dress goods.

In the third method the rubber is dissolved in carbon disulphide, chloroform and the like. The goods may be either coated or padded with the solution. As examples of this class of fabrics we have gossamer cloth, mackintosh cloth, bathing caps, etc.

The fourth method has found application in the manufacture of bookbinders' cloth and "Willesden canvas." It consists in passing the fabric through an ammoniacal solution of cupric oxide, which dissolves the cotton on the surface to a slight extent. A passage between hot rollers completes the operation.[1]

The determinations to be made in the examination of waterproof fabrics include, —

1. The amount of wool, cotton, and silk present.
2. The weight of the fabric per square yard.
3. The amount of matter soluble in 3% hydrochloric acid.
4. The amount of matter soluble in ether.
5. The amount of ash.
6. The waterproof value.

1. Wool is separated from cotton by the usual method of boiling in a 5% solution of caustic potash for 15

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[1] If a solution of cellulose in Schweitzer's reagent is used in place of the ordinary ammoniacal solution of cupric oxide, a still better finish is obtained.

minutes. Four per cent is added to the weight of the cotton residue. The difference between this and 100% then represents the amount of wool present. Wool is separated from silk by immersing the sample in concentrated hydrochloric acid for 3 minutes at 50° C., whereby the silk is dissolved. Linen is separated from silk by treating with an alkaline glycerol-copper solution, whereby the silk is dissolved.

Fine quality "cravenettes" are made of pure wool whilst the lower grade cloths consist of wool and cotton or all cotton. The " pepper and salt " effects often observed in raincoats are produced by twisting a black worsted yarn with a white thread of cotton, worsted, or silk. The term "gloria" is generally limited to fabrics made of wool and silk, or linen and silk. The impervious quality of these umbrella cloths is due more to the weave than to any finishing materials. However, in the case of heavily weighted silk covers, the loading materials assist materially in rendering the fabric waterproof.

2. The weight of the fabric may be determined by weighing a sample containing 10 square cm. (2 × 5). For example, 10 sq. cm. of one fabric which was examined weighed 0.4 gram; one square meter would then weigh 1000 × 0.4 = 400 g. This may readily be changed to ounces per square yard by multiplying by the constant 0.02949, thus:

$$400 \times 0.02949 = 11.8 \text{ ounces per square yard.}$$

The factor 0.0295 is sufficiently accurate for technical work. It is derived as follows:

1 gram = 0.03527 ounce av.
1 sq. meter = 1550 square inches.
1 sq. yard = 1296 square inches.

$$0.03527 \times \frac{1296}{1550} = 0.02949.$$

*Rule: If the weight in grams of one square meter of a fabric be multiplied by* 0.0295 *the result will be the weight in ounces of one square yard of the same fabric.*

3. By treatment with a 3% solution of hydrochloric acid for 15 minutes any soaps which may be present will be decomposed and the inorganic matter will to a large extent be dissolved. Weigh the sample before and after treating.

4. The fats which remain in the fabric after washing and drying the residue of the previous determination are soluble in ether and can therefore be estimated by extracting the sample in a Soxhlet apparatus.

5. The ash is determined by igniting a weighed sample in a porcelain crucible until all the organic matter has been oxidized or burnt off. The weight of the residue represents non-volatile mineral matter.

6. The waterproof value of the fabric may be determined by the following method, which has given good results:

A sample about two and one-half inches square is stretched across the mouth of an ordinary thistle tube,[1] taking care that the sample contains no selvage, as this is generally more pervious than the fabric proper. Fasten the sample securely by means of a string around the neck of the tube so that the face of the goods will be toward

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[1] If the diameter of the mouth of the thistle tube is 3 cm., the area of cloth exposed to the water will be: 3 × 3 × 0.7854 = 7.06 sq. cm.

the inside, i.e., toward the water. The thistle tube filled with distilled water at 20° C. is supported by a clamp above a graduated cylinder, and the amount of water passing through in 5 hours and in 10 hours is measured in cubic centimeters. A fabric which allows no water to pass through in 10 hours is considered first class. Another point which may be observed is the time which elapses before the appearance of the first drop on the outer surface.

The examination of rubbercoated cloths includes several special tests which are given below.

7. The percentage of "rubber and coating materials" is determined by immersing the goods in solvent naphtha or carbon disulphide for several hours in order to soften the coating; this is then removed by scraping with a blunt knife edge and the last particles removed by treatment with boiling carbon disulphide for 30 minutes. By weighing the sample before and after treatment, the loss, i.e., the percentage of coating material, may be determined. A sample five inches square should be used for the test.

8. The tensile strength of the fabric is determined *before* and *after* the coating has been removed, as the coating of rubber is very often depended upon to cover up a poor piece of cloth. For this test the ordinary cloth testing machines of Schopper or Kohl may be used.

9. The drying test should give some idea of how a rubber cloth will wear when subjected to high temperatures. For this purpose the sample is placed in a drying oven heated to 50° C. for 5 hours and then allowed to lie in the air again for one hour. The "feel"

of the cloth at the end of this test will show whether it has become brittle and lost its elasticity.

10. A qualitative test for the mineral matter is sometimes desired and may then be carried out according to the usual methods of inorganic analysis. The substances which may be encountered are: sulphur; sulphides of sodium, lead, and antimony; oxides of magnesium and zinc; chalk, gypsum, and vermilion. Most of these substances may be detected by careful incineration in a porcelain crucible. Sulphur is determined quantitatively by burning the sample in a current of oxygen and leading the sulphur dioxide so formed into water acidulated with nitric acid. The sulphuric acid so obtained is determined by means of barium chloride and calculated to sulphur. If metallic sulphides are present the sample should be heated in a crucible with sodium carbonate and potassium nitrate in order to form potassium sulphate. The sulphuric acid is then precipitated in the form of barium sulphate as before.

EXAMPLE. — *Analysis of a high grade "cravenette."*

Warp and filling: worsted yarn, 92.4%
Weight per square yard: 10.4 ounces.
Breaking strain: 30.2 pounds (sample 5 in. long and 2 in. wide).
Matter soluble in 3% HCl: 2.7%
Matter soluble in ether: 1.9%
Ash (mineral matter): 3.0%
Waterproof value: After five hours the water had completely passed through the fabric. Drops of water were visible on the outside of the fabric 15 minutes after starting the test.

## Analysis of Textile Fibers.

The *ultimate* analysis of fibers is as yet of no practical value. Cross and Bevan have spent much time[1] in examining into the chemical constitution of cellulose but have come to no final conclusions. Cellulose forms the essential constituent of all vegetable fibers and belongs to the group of organic compounds known as carbohydrates. The empirical formula $C_6H_{10}O_5$ has been calculated from the analysis:

| | Per cent |
|---|---|
| Carbon | 44.4 |
| Hydrogen | 6.2 |
| Oxygen | 49.4 |

Bowman, Schuetzenberger, and Williams have independently examined into the chemical nature of wool. It is termed a "keratinic" fiber and seems to be a proteid containing one or more *amino* groups. The average composition is:

| | Per cent |
|---|---|
| Carbon | 51.0 |
| Hydrogen | 7.0 |
| Oxygen | 21.0 |
| Nitrogen | 18.0 |
| Sulphur | 3.0 |

Mulder, Silbermann, Vignon, and Richardson have at different times observed interesting reactions of the silk fiber and seem to agree that it is a proteid possessing the nature of an amino-acid. The average composition of fibroin is:

| | Per cent |
|---|---|
| Carbon | 48.5 |
| Hydrogen | 6.5 |
| Nitrogen | 19.0 |
| Oxygen | 26.0 |

---

[1] Vignon has proposed a formula for cellulose (see Matthews, 216). See also: Green and Perkin (J. Chem. Soc., 1906, page 811).

All of the investigators have proposed formulæ for the silk-fibroin, but the approximate empirical formula seems to be $C_{48}H_{78}O_{20}N_{16}$.

## ANALYSIS OF RAW VEGETABLE FIBERS.

For the *proximate* analysis of these fibers Cross and others have proposed the following determinations:

1. Moisture.
2. Mineral matter.
3. "Boiling-off" loss.
4. "Hydrolysis" loss.
5. "Mercerization" loss.
6. "Nitration" gain.
7. "Purification" loss.
8. Percentage of cellulose.
9. Percentage of carbon.

1. A 5-gram sample of the fiber is dried in an oven at 110° C. until its weight is constant. The loss in weight is calculated as per cent of the *original* sample.

2. The mineral matter or ash is determined by igniting a weighed sample in a porcelain crucible. Care should be taken that the organic matter is completely oxidized. It will be found to be low in true celluloses (cotton) and high in the pectocelluloses (raw flax), while the lignocelluloses (jute) occupy an intermediate position.

3. By this is meant the loss in weight incurred on boiling the fiber for 5 minutes with a 1% solution of sodium hydroxide. The result will show the alkali-soluble portion of the fiber.

4. This is carried out in order to estimate the effect

of bleaching, scouring, and frequent washing of the fiber. It is determined by boiling the sample in 1% sodium hydroxide for one hour, whereby the fiber is hydrolyzed.

5. The fiber is placed in a 30% solution of potassium hydroxide for one hour at a temperature not exceeding 20° C. The change in tensile strength and microscopic appearance should be noted.

6. The fiber is treated for one hour with a cold mixture of 50 c.c. nitric acid and 50 c.c. sulphuric acid.

7. The fiber is boiled with 20% solution of acetic acid for 30 minutes, washed with alcohol, then with water, and finally dried. By this treatment the acid-soluble impurities are removed without affecting the fiber materially.

8. This is of course the most important determination, for, after all, the cellulose is the most valued constituent of the fiber. Boil for 5 minutes in a 1% solution of sodium hydroxide; wash well with water and then expose for one hour to the action of chlorine gas at ordinary temperatures, remove, wash and treat with a boiling alkaline solution of sodium sulphate for 5 minutes. Now wash successively with water, dilute acetic acid and water. The residue, which represents cellulose, is dried and weighed.

9. The fiber obtained by purification with acid (7) is analyzed in the ordinary combustion oven or in the wet way by means of chromium trioxide ($CrO_3$) and sulphuric acid. In the latter case the mixture of carbon monoxide and dioxide is obtained and measured in the gaseous form. The percentage of carbon found may vary from 40 to 43% for pectocelluloses to 44.4% for cotton cellulose, and 45 to 50% for ligno-celluloses.

The analysis of raw cotton shows approximately:

| | Per cent |
|---|---|
| Cellulose | 87.0 to 91.0 |
| Water | 7.0 to 8.0 |
| Fat and wax | 0.5 to 0.4 |
| Intercellular matter | 0.05 to 0.7 |
| Ash | 0.12 to 1.7 |

The analysis of raw flax shows approximately:

| | Per cent |
|---|---|
| Cellulose | 71.0 to 83.0 |
| Water | 8.0 to 11.0 |
| Fat and wax | 0.5 to 2.4 |
| Intercellular matter | 2.5 to 9.5 |
| Ash | 0.5 to 5.0 |

## ANALYSIS OF RAW WOOL.

The examination of raw wool includes the determination of —

1. Moisture.
2. Grease.
3. Matter soluble in water.
4. Matter insoluble in water (sand and earth).
5. Wool fiber.

1. The water is determined by the usual method of drying at 105° C. in a stream of dry hydrogen.

2. The grease is preferably determined *before* steeping the sample in water, as otherwise some of the fatty matter is removed. The weighed sample is extracted with ethyl-ether or with benzene and the residue of wool-fat weighed after evaporation of the solvent in the flask.

NOTE. — If it is desired to estimate the amount of alkaline oleates present, this may be done by shaking up the ethereal extract with water in a separatory funnel.

3. After the removal of the grease the wool is agitated in distilled water at a temperature of about 30° C. This removes the dried perspiration (suint, schweiss or yolk) and at the same time the mechanically adhering sand and earth.

4. The insoluble mineral matter removed in the previous operation is filtered off on a weighed filter, dried and weighed.

5. The wool finally obtained is dried and weighed.

The following figures will give some idea of the percentage composition of raw wools.

| | Low Grade. | High Grade. |
|---|---|---|
| | Per cent | Per cent |
| Moisture | 23 | 12 |
| Grease | 7 | 15 |
| Matter soluble in water | 21 | 22 |
| Matter insoluble in water | 6 | 30 |
| Wool fiber | 43 | 21 |
| | 100 | 100 |

*Method of Maercker and Schulz.* 1. Determine moisture by drying in a stream of hydrogen gas at 105° C.

2. Determine wool-fat by extraction with ether and afterward shaking extract with water in order to remove oleates. Separate the two solutions, evaporate the ether to dryness and weigh the fatty residue. Evaporate the wash water to dryness, weigh this residue and add to the "matter soluble in water."

3. Wash the ether-extracted wool with cold distilled water several times. Evaporate the solution to dryness and add this weight to the "matter soluble in water"

found in the previous determination. The combined weight represents the alkaline oleates. Finally wash with alcohol in order to remove the last traces of alkaline oleates.

4. The *earthy oleates* are decomposed by washing the wool with 5% hydrochloric acid. Wash with water to remove the acid, dry and finally extract with ether and alcohol. The solvents are evaporated and the residue weighed.

5. The wool which remains after these operations is dried, well shaken and then teased out by hand over a large sheet of paper in order to remove dirt, sand, etc. It is then again dried and subsequently weighed.

6. Sand and dirt are determined by difference.

## ANALYSIS OF RAW SILK.

Owing to the great value of silk ($4 to $7 per pound) and the fact that shipments from China and Japan are at times found to be adulterated with large quantities of fat, the examination of this material is very desirable.

The commercial value of such an examination will be easily realized when it is stated that one lot which was examined contained 9% of fat in place of the 1% usually found in natural silk.

Although Mulder was the first chemist to investigate the nature of raw silk his methods and results have been given a rather low rating by Silbermann. The latter investigator has spent much time in the chemical study of the silk fiber, a subject in which he is unquestionably the leading authority. A typical analysis of a white mulberry silk by this author is given on the following page: —

| | Per Cent |
|---|---|
| Water | 11.00 |
| Salts | 0.30 |
| Wax and Fat | 1.36 |
| Sericin | 22.01 |
| Fibroin | 76.20 |
| Ash of Fibroin | 0.09 |

### *Analysis.*

1. Moisture can be determined in the raw silk according to the usual method of drying a weighed sample at 105° C. to constant weight.

2. The salts soluble in water may be determined by steeping a weighed portion of the dried sample in water at a temperature of 50° C. for 30 minutes. It is then rinsed in warm water, dried at 105° C. and reweighed. The loss in weight gives the amount of salts present.

3. The sample left from the previous estimation is dried and extracted in a Soxhlet apparatus with ethyl-ether or with C. P. benzene for about 5 hours. The solvent in the flask is evaporated by means of a current of warm air on a steam bath and the residue weighed in the flask. The difference between this weight and the original weight of the flask will represent the amount of wax and fat in the sample.

4. The silk residue from (2) is now "boiled off" in a bath containing 10 grams of perfectly neutral olive oil soap per liter of distilled water. After boiling for one hour it is washed in distilled water and dried at 105° C. The amount which the silk loses in weight represents silk gum (sericin).

5. The residue obtained after all the previous operations have been performed is almost pure fibroin. The percentage obtained varies from 70 in Canton and 76 in Italian silk to 84 in Japan silk.

### DETERMINATION OF THE "BOILING-OFF" LOSS OF RAW SILK.

*Crefeld Method.* A bath is prepared with 5 to 7 grams of perfectly neutral olive oil soap per liter of distilled water. In this solution the silk is boiled for about one hour. It is finally washed well in distilled water and dried at 105 to 120° C. The difference between this weight and that of the original *dry* silk shows the "boiling-off" loss. For example:

| | |
|---|---|
| Raw silk dried at 115° C. .................... | 48.7 grams |
| Boiled-off silk dried at 115° .................. | 38.9 grams |
| Loss = gum .......................... | 9.8 grams |

$$\frac{9.8 \times 100}{48.7} = 20.1\% \text{ gum.}$$

TABLE OF ACTUAL RESULTS OBTAINED FROM VARIOUS SILKS.

(Crefeld Conditioning House, Average Values for 1906.)

| | Boiling-off Loss. | Standard.[1] | Washing-out Loss. | Standard.[1] |
|---|---|---|---|---|
| Lombardy organzine yellow. | 23.6 | 24.0 | 1.08 | 1.20 |
| Japan organzine........... | 18.86 | 20.0 | 1.27 | 1.30 |
| French organzine.......... | 25.29 | 25.5 | 1.64 | 1.65 |
| Bengal (through France) ... | 25.52 | ......... | 5.94 | ......... |
| Grege..................... | 21.93 | 22.5 | 0.43 | 0.50 |
| Chappe.................... | 4.65 | 4.0 | ......... | ......... |
| China..................... | 20.43 | 24.0 | 2.25 | 4.80 |
| Canton.................... | 25.28 | 24.0 | 2.78 | 2.50 |

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[1] These figures are those usually used in calculations and represent the average values of a very large number of determinations.

The highest boiling-off loss was observed in the case of a Canton silk (30.69%). The lowest (excluding Chappe) was observed in the case of a Japan silk (15.62%).

## DETERMINATION OF THE "WASHING-OUT" LOSS OF RAW SILK.

*Crefeld Method.* A weighed sample of raw silk is boiled for about one hour in a bath of distilled water at about 50° C. Rinse, dry, and re-weigh. Example:

| | |
|---|---|
| Raw silk dried at 115° C ...................... | 45.2 grams |
| Washed silk dried at 115° C. .................. | 44.1 grams |
| Loss ................................. | 1.1 grams |

$$\frac{1.1 \times 100}{45.2} = 2.43\%.$$

## DETERMINATION OF THE "SHRINKAGE" OF RAW WOOL.

By the "shrinkage" of raw wool is meant its loss in weight after passing through the usual processes of scouring. An experienced wool sorter acquires a rather accurate idea of this loss by examination of the fleeces. The approximation should come within one or two per cent in order to be of any value. Other things being equal, the money value of two wools offered at the same price will be inversely proportional to the shrinkage which they suffer on scouring. Thus if a wool which shrinks 50% costs 45 cents the value of a similar wool which shrinks 40% would be 56¼ cents.

$$\frac{45 \times 50}{40} = 56\tfrac{1}{4}.$$

To find the percentage of shrinkage of a wool:

*Rule: Subtract the weight of the scoured wool from the weight of the raw wool. Divide the remainder by the weight of the raw wool and multiply by* 100.

Example: If 128 pounds of raw stock yield 60 pounds of wool on scouring, what is the percentage of shrinkage?

$$\frac{(128-60)}{128} \times 100 = 53.1\% \text{ (or a yield of } 46.9\%).$$

To find the cost of wool at a given shrinkage:

*Rule: Divide the cost per pound of the "wool in grease" by the yield stated in per cent.*

Example: If a wool in grease costs 24 cents per pound and shrinks 40%, what is the cost of the scoured wool?

$$100 - 40 = 60\% \text{ yield.} \quad \frac{24}{60} = 0.40.$$

The scoured wool costs 40 cents per pound.

In the table below are given a few "shrinkage" values of "domestic" wools.

WASHED WOOLS.

| Grade. | Cost. | Yield. | Price "Clean." |
|---|---|---|---|
| | Cents. | Per cent. | Cents. |
| XXX | 34 | 64 | 53 |
| XX | 36 | 45 | 80 |
| X | 34 | 46 | 73 |
| Half-blood | 34 | 50 | 68 |
| Three-eighths-blood | 33 | 60 | 56 |
| Quarter-blood | 34 | 72 | 47 |
| Common | 31 | 82 | 73 |

UNWASHED WOOLS.

| Grade. | Cost. | Yield. | Price "Clean." |
|---|---|---|---|
| | Cents. | Per cent. | Cents. |
| XXX | 27 | 30 | 90 |
| XX | 27 | 34 | 80 |
| X | 27 | 36 | 75 |
| Half-blood | 28 | 43 | 65 |
| Three-eighths-blood | 27 | 54 | 50 |
| Quarter-blood | 27 | 62 | 43 |
| Common | 24 | 65 | 37 |

"Washed wools" are those which have had part of their yolk removed by washing while still on the back of the sheep.

The shrinkage of a raw wool may be determined experimentally as follows: — Several samples are drawn from various parts of the bulk, and portions of this are carefully selected so as to obtain a fair average sample. A quantity equal to 1000 grams is accurately weighed and thoroughly scoured. For this purpose it is first agitated in soft water of 50° C. for 15 minutes, then squeezed and well washed in two successive baths containing 5 grams of Solvay soda and 2 grams of soap per liter of water. The complete removal of the grease may take from 30 to 60 minutes. Care should be taken that the temperature does not rise much above 50° C.

The wool is finally dried at 105° C. and the standard regain added to the dry weight in order to obtain the "yield."

Pulled wools, i. e., those obtained from tanneries by the brushing or liming process, shrink anywhere from 15 to 55%.

## DETERMINATION OF MOISTURE IN TEXTILES.

The determination of moisture in textile fibers is technically called "conditioning." This estimation is of especial importance in the case of the more valuable fibers such as wool and silk. The apparatus required consists of —

1. An oven of cylindrical shape constructed with an inner and outer case, about 40 inches high and 30 inches in diameter (outside measurement). A space of 1½ inches

is allowed between the two cases to permit the heated air to circulate freely.

2. A pair of scales sensitive to 0.1 gram firmly fixed to the oven in such a position that one extreme end of the beam is exactly over the centre of the oven and from which is suspended a reel or cage containing the sample. The reel and cage are of equal weight and when in position exactly balance the pan and *chains* at the other end of the beam.

3. One reel and one cage mentioned above, the former for tops and yarns and the latter for wool, noils, and loose material.

4. A thermometer with a scale ranging from 100° to 250° F. (40 to 120° C.).

5. A Bunsen gas-burner.

The following data are taken from the pamphlet of the Bradford Conditioning House and may therefore with propriety be quoted as the

*Bradford Method.* To insure the complete removal of the moisture in the oven the temperature must not be raised above 230° F. Cotton cannot be heated higher than 220° F. as it is easily scorched.

The samples are drawn, in the case of tops, from the centre, middle, and outside of the ball and are weighed immediately. The sample should weigh about 500 grams but its exact weight is determined to $\frac{1}{10}$ gram. The *sample of top* is placed on the reel or in the cage and the whole suspended from the balance. The time required to expel all the moisture will vary with the quality, age, and condition of the tops. The heating in the oven is continued until the sample ceases to lose weight and the needle of the balance remains stationary for about

5 minutes. The drying operation may take from 3 to 5 hours. The wool is now "bone dry," and the weight is recorded as follows:

| | |
|---|---|
| Weight of wool "air-dry" | 512 grams |
| Weight of wool "bone-dry" | 420 grams |
| Loss (= moisture) | 92 grams |
| Percentage of moisture | $\frac{92}{512} \times 100 = 17.9\%$ |

After years of observation it has been found that the various fibers contain an amount of moisture which is fairly constant for each fiber, and as the results of many tests the following percentages have been fixed as representative of the amount of moisture which a perfectly dry sample will take up: (Bradford constants).

| | |
|---|---|
| Wools | 16 % |
| Tops (in oil) | 19 % |
| Tops (without oil) | 18¼% |
| Cotton yarns | 8½% |
| Silk yarns | 11 % |
| Linen yarns | 12 % |

These percentages represent "regain." For example let us say that a regain of 16% is allowed on the sample tested above. 16% of 420 grams = 67.2 grams. 420 + 67.2 = 487.2 grams of "normal wool." If the dealer had in this case charged for 512 grams of "normal wool" he would be selling 24.8 grams of water at the price of wool. The essential part of the conditioning is the determination of the amount of "absolutely dry wool" in the sample. From this the amount of dry wool in the whole lot can then be readily calculated.

Example: How much "bone-dry" wool in a 1000-pound lot which gave the above test?

$$512 : 420 :: 1000 : x$$

$$x = 820.3 \text{ pounds dry wool.}$$

How much "normal wool" in a 1000-pound lot which gave the above test?

$512 : 487.2 : 1000 : x$

$x = 951.5$ pounds "normal wool."

Below are recorded the results of tests made on various lots of worsted tops in the Philadelphia district. The average for this territory appears to be about 13%, but whether 13 or 15 or the European standard of 18¼% be chosen as the American standard is quite immaterial as the price of worsted tops or of any other textile material is regulated in all cases by the amount of "bone dry" material which the seller knows or *estimates* the lot to contain.

*Results of the Tests.*

| | Per cent. |
|---|---|
| Low grade top | 15.8 |
| High grade top combed in oil | 13.8 |
| Medium grade top combed dry | 13.5 |
| Top combed in oil | 12.8 |
| Top combed in oil | 12.0 |
| Top combed in oil | 11.3 |
| Tops direct from comber | 9.2 |

## DETERMINATION OF MINERAL MATTER IN TEXTILES

The term mineral matter as thus used means the ash which remains on igniting a weighed sample of the fabric until all the organic matter is completely *volatilized.* It will be readily seen that the volatile inorganic salts such as ammonium chloride will not be found in the crucible. For the determination a 5 gram sample should be cut up in small pieces and placed in a weighed porcelain crucible. Heat with a good Bunsen flame until all the black, carbonaceous matter disappears. After allowing to cool in a *desiccator* the crucible is reweighed. The matter remaining in the crucible is the ash and is calculated to percentage.

EXAMPLE:

| | | |
|---|---|---|
| Crucible (after drying and cooling) | 5.5643 | grams |
| Crucible (with sample of fabric) | 10.4653 | " |
| Fabric (air dry) | 4.9010 | " |
| Crucible (with ash) | 5.9644 | " |
| Ash (after deducting weight of cruc.) | 0.4001 | " |

Percentage of ash $\frac{0.4001 \times 100}{4.9010} = 8.16\%$

In certain cases it is interesting to know the moisture content of the sample, and so the following preliminary weighings are made:

| | | |
|---|---|---|
| Weight of sample air-dry | 4.9010 | grams |
| Weight of sample after drying in an oven at 105° C. for one hour | 4.4000 | |
| Loss (= moisture) | 0.5010 | |
| Percentage of moisture | 10.2% | |

The complete report of this analysis would then read:

Name of fabric: fireproof cloth.

| | |
|---|---|
| Moisture | 10.2% |
| Non-volatile matter (ash) | 8.16% |
| Volatile matter (fibers, etc.) | 81.64% |
| | 100.00% |

The estimation of the mineral matter is of especial importance in the examination of such fabrics as:

Waterproof raincloths (aluminium, magnesium, and metallic oxides).

Window shade cloths (Hollands) (prussian blue, ultramarine, ochre and other pigments).

Bookbinders' cloths (gypsum and dye-lakes).

Fireproof cloths (sodium-biborate, -silicate, -tungsstate; phosphates).

Heavily weighted silks (tin, iron, etc).

Sign cloths (calcium acetate, alum, water glass, lead, etc.)

Fabrics used for flour and salt bags (kaolin, talc, gypsum, etc.)

A qualitative analysis of the ash may be made according to the usual methods of inorganic analysis. (See also page 40, where a survey of the finishing materials is given.)

## Determination of Oil and Grease in Textiles.

This determination is made in the case of tops and "yarns spun in oil" and in the examination of finishes on fabrics. A weighed sample of the fabric or "top" is placed in a Soxhlet extractor which is connected with a weighed flask. For the extraction, sulphuric ether or petroleum ether may be used. After about one hour the extraction should be complete. The flask is put in a warm place in order to drive off the solvent, after which the weight of the oil is determined. From this the percentage of oil in the air-dry fabric may be readily calculated. In the case of tops it is convenient to weigh out a sample of about 10 grams *just before* conditioning. After the percentage of moisture has been determined it will be easy to calculate exactly how much absolutely dry top the weighed sample represents.

EXAMPLE:

| | | |
|---|---|---|
| A sample of tops was found to contain moisture....... | 13.2% | |
| Hence, fiber + grease =........................ | 86.8 | |
| | 100.0% | |
| A small sample taken just before conditioning weighed | 8.4607 | grams |
| Hence, fiber + grease.......................... | 7.3438 | " |
| After extraction the flask + grease weighed....... | 28.3490 | grams |
| The flask weighed............................. | 27.9610 | " |
| Therefore grease weighed....................... | 0.3880 | " |

$$\frac{0.3880}{7.3438} \times 100 = 5.2\% \text{ grease.}$$

## DETERMINATION OF ARSENIC IN TEXTILES.[1]

At the present day there will seldom be any necessity for making this determination as the causes have been removed. Thus the use of arsenic in the preparation of artificial dyestuffs is now obsolete. The commercial sulphuric acid used in the dyehouse usually contains traces of arsenic but as this is either washed off or deposited on the fiber as an insoluble compound this source of arsenic is of little importance. The third and most common source of the arsenic found on woolen goods are the " sheep dips " applied to sheep for the cure of the scab disease. Thus 1000 grams of a wool flannel were found to contain 5 milligrams of arsenious oxide.

## EXAMINATION OF WEIGHTED SILKS.

The weighting on a black silk may vary from zero to 250%. The values of 300 and 400% sometimes mentioned in text books are now seldom if ever encountered. The weighting number, for example, 80%, is given with reference to the weight of the raw silk (this latter weight is known in Europe as the "par" weight). Thus if 100 pounds of "raw" silk yield 75 pounds of "boiled-off" silk the dyer must add 25 pounds of " weighting " in order that he may return 100 pounds to the mill. If now the mill requests that the silk be weighted 80% the dyer applies an additional 80 pounds of weighting making a total of 180 pounds. From this we see that a " weighting of 80% " may actually represent a silk containing 105 pounds of

---

[1] For further information on this subject see: Arsenic in papers and fabrics, by J. K. Haywood, Bulletin 86, Bureau of Chemistry, U. S. Department of Agriculture. Also: Textil chemische Untersuchungen, Paul Heermann, Berlin, 1903.

foreign matter in each 180 pounds of the finished product. The data given below will serve to illustrate the point:

Example: If the weight of the raw silk = 60 pounds and the boiling-off loss of the silk = 25% and the weighting = 80%,

To find the weight of the finished goods,

$$60 + (60 \times 0.80) = 108 \text{ (pounds)}.$$

To find the weight of the fibroin in the raw silk,

$$60 - (60 \times 0.25) = 45 \text{ (pounds)}.$$

To find the percentage of fibroin in the finished goods,

$$100 \times \frac{60 - (60 \times 0.25)}{60 + (60 \times 0.80)} = 41.67\%.$$

To find the percentage of weighting in the finished goods,

$$100 - 41.67\% = 58.3\%.$$

The proximate analysis of weighted silks includes a determination of Prussian blue, silica, tin and phosphoric acid. See: Luehrig, Chemiker Ztg., 1902, 87, page 1039; also Gnehm & Bænziger, Faerber Ztg., 1897, page 1.

In the United States the weighting on silk is indicated by stating the "ounces of weighting" which have been added to each pound of *raw* silk. As the "charge," or quantity of weighting material which the silk has taken up, varies slightly the dyer states it within certain limits. Thus it has become a trade custom to allow a variation of two ounces. For example, if we speak of a 30/32 weighting, it is understood that 16 ounces of raw silk have been loaded until the weight has reached approximately 32 ounces.

Such a weighting is known as "100% above par." To recapitulate:

| | |
|---|---|
| Original weight of the raw silk...... | 16 ounces. |
| Weight of the boiled-off silk ........ | 12 ounces. |
| Weight of the loaded silk .......... | 32 ounces. |

32 ounces therefore represents an increase of 100% above 16 ounces.

The results of the chemical analysis will show the amount of actual silk fiber present. From this the amount of weighting is calculated by difference and reported in "ounces per pound." This can be done with the aid of the table prepared by Matthews:

| Per cent Weighting. | Ounces.[1] | Per cent Weighting. | Ounces.[1] |
|---|---|---|---|
| 0–13 | 12/14 | 142–158 | 30/32 |
| 13–29 | 14/16 | 158–174 | 32/34 |
| 29–45 | 16/18 | 174–190 | 34/36 |
| 45–61 | 18/20 | 190–206 | 36/38 |
| 61–77 | 20/22 | 206–222 | 38/40 |
| 77–93 | 22/24 | 222–238 | 40/42 |
| 93–109 | 24/26 | 238–254 | 42/44 |
| 109–125 | 26/28 | 254–270 | 44/46 |
| 125–142 | 28/30 | 270–286 | 46/48 |

To illustrate the use of the table:

A commercial sample of silk was dried at 105° C. and then weighed 0.45 grams. The weighting was removed, the remaining fibroin was dried at 105° C. and found to weigh 0.31 grams.

Weighted silk = 0.45 grams
Fibroin = 0.31 grams
Weighting = 0.14 grams

$$\frac{0.14 \times 100}{0.31} = 45\% \text{ weighting.}$$

[1] See page 73.

From the table we see that this corresponds to 18/20 ounces (or an average of 19 ounces). These 19 ounces of weighted silk represent 16 ounces of "raw" (unweighted) silk, or 12 ounces of "pure" silk, and by subtraction we find that 19 ounces of the commercial silk contain 7 ounces of foreign matter. (19 – 12 = 7.)

## DETERMINATION OF THE WEIGHTING IN SILK.

*Gnehm's Method.* (Not applicable to silks containing tannin and iron.)

1. Determine the water in a two gram sample of the silk.

2. Treat in a platinum dish with 100 c.c. of a 5% solution of hydrofluosilicic acid and agitate frequently during one hour at ordinary temperatures.

3. Decant the solution and treat the sample with another 100 c.c. of the acid as before.

4. Decant, and wash the silk several times with large quantities of distilled water for about 15 minutes.

5. Place the sample in a tared weighing bottle and dry at 95 to 105° C. to constant weight. The weighing bottle must have a ground glass stopper as the silk is extremely hygroscopic. The difference between the last weight of the silk and the weight of the original *dry* sample represents the weighting. The action of the fluorine acids on silk is inconsiderable and may therefore be neglected.

EXAMPLES:

| | | |
|---|---|---|
| Air-dry silk | = 2.1264 g. | |
| Anhydrous silk | = 1.9384 g. = | 8.85% moisture |
| After extracting and drying | = 0.9176 g. = | 43.15% fibroin |
| Difference | = 1.0208 g. = | 48.00% weighting. |

If the "boiling-off" loss be taken at 20% we have the proportion: $43.15 : 48 :: 80 : x$

$$x = 88.9.$$

Therefore the sample examined contains:

80.0 parts fibroin (equal to 100 parts of raw silk)
88.9 parts weighting
168.9

which means that the silk has been weighted 68.9% *above* par.

*Moyret's Method.* 1. Water. Dry a ten gram sample at 125° C. to constant weight. Moisture in excess of 15% indicates the presence of hygroscopic substances.

2. Substances soluble in water. Boil with distilled water. Glycerol, sugar and epsom salt will be dissolved. Dry and weigh.

3. Substances soluble in petroleum ether. Treat a dried sample with the solvent and examine the residue after evaporation. (Fats and oils will be dissolved.)

4. Substances soluble in hydrochloric acid. Treat for 15 minutes in a bath of 5% hydrochloric acid at 40° C. Aluminium, chromium and iron mordants will be dissolved.

5. Substances soluble in 5% solution of sodium carbonate. Tannins, etc.

6. Ash. Ignite a sample of the silk in a porcelain crucible. Silica, etc.

7. Determination of the nature of the dyestuffs.

*Koenig's Method.* 1. Water. Dry at 125° C. to constant weight.

2. Fats and oils are extracted with petroleum ether.

3. Silk glue. Boil with a solution of 5 grams soap in 100 grams of water.

4. Prussian blue. Treat the residue from (3) with sodium hydroxide. The sodium ferrocyanide obtained

is reprecipitated with ferric chloride. Ignite the precipitate and oxidize with a drop or two of nitric acid. 1 gram of $Fe_2O_3$ = 1.5 grams of prussian blue.

5. Stannic oxide is determined in the ash of the silk.

Calculate as catechu-tannate of tin.

1 gram of $SnO_2$ = 3.33 grams of catechu-tannate.

6. Ferric oxide. The total iron is estimated as ferric oxide. Now subtract from this the iron present as prussian blue and 0.5 g. iron naturally present in silk.

The remaining iron is calculated to tannate.

1 gram $Fe_2O_3$ = 7.2 grams of ferric tannate.

*Mueller and Zell's Method.*[1] This method is based on the solvent action of hydrofluoric acid on silicic acid and is therefore suitable only for the tin-phosphate-silicate weighting.

1. Place about 2 grams of the silk sample in distilled water for 5 minutes at 100° C.
2. Place the sample in a 1½% solution of hydrofluoric acid for 15 minutes at 60° C.
3. Without washing place the silk in a 5% solution of hydrochloric acid at 50 to 60° C. for 10 minutes.
4. Rinse well in hot water.
5. Treat with a boiling 3% solution of Marseilles soap for one hour in order to remove any sericin which may be present in case the original silk was ecru or souple.
6. Wash in a 1% solution of sodium carbonate for 15 minutes to remove the soap.
7. Rinse well in hot distilled water.
8. Dry and weigh.

---

[1] For Steiger and Gruenberg's table for the calculation of the weighting see Appendix I.

The substance obtained at the end of this procedure is practically pure fibroin.

*Nitrogen Method* (Steiger and Gruenberg). This method is based upon Kjehldahl's observation that nitrogenous matter gives off ammonia quantitatively if it be first decomposed with concentrated sulphuric acid and afterward treated with caustic soda. This is applied in textile analysis to the determination of nitrogen in silk after all other nitrogenous bodies have been removed. These substances include glue, ammonium salts, amino dyestuffs, and silk gum. It should be remarked that the success of the determination depends upon extremely careful manipulation. The nitrogen found is calculated to fibroin and then to raw silk.

1. An air-dry sample of the silk (about 2 grams) is accurately weighed out.
2. Boil for one or two hours with a 3% solution of Marseilles soap. This removes dyestuffs and any sericin which may be in the silk.
3. Treat with a 1% solution of sodium carbonate for 10 minutes at 60° C. to remove soluble salts.
4. Boil with a 1% solution of alcoholic-hydrochloric acid to remove all foreign matter.
5. Wash with a weak alcohol-ammonia solution.
6. Rinse thoroughly and dry.
7. *Determination:* The silk obtained at the end of the above treatment is treated with 30 to 50 c.c. of sulphophosphoric acid[1] in a round-bottomed flask; 0.5 g. of metallic mercury is added and the whole is heated cautiously until the black color entirely disappears, only a

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[1] Pure sulphuric acid containing 10 to 20% phosphorus pentoxide. Specially prepared by Kahlbaum.

pale yellow remaining. Heat for one-half hour longer to insure the completion of the reaction.

8. After allowing to cool the contents of the flask are transferred to an Erlenmeyer flask with about 400 c.c. of water. Add sodium sulphide to precipitate the mercury, and pumice stone to prevent bumping in the subsequent distillation. Now add caustic soda solution *very carefully* (to avoid any loss of ammonia). Connect the flask with a condenser and conduct the distillate into a receiver containing 25 c.c. of normal sulphuric acid. To prevent any caustic soda from going over, a bulb tube is used to connect the distilling flask with the condenser. The mixture in the flask is boiled for about one hour, after which time the residue in the flask is tested for ammonia by means of litmus paper.

9. The contents of the receiver are titrated with normal caustic soda and from this the amount of sulphuric acid used (the amount of ammonia obtained) is calculated and figured to nitrogen.

1 c.c. of normal sulphuric acid used = 0.017 g. $NH_3$ (ammonia) = 0.014 g. N (nitrogen) = 0.07638 pure fibroin.

CALCULATION:—

| | | |
|---|---|---|
| If the hygroscopic moisture in silk = | 11.00% | |
| the boiling-off loss (silk gum) = | 24.00% | |
| fibroin = | 76.00% | |
| the nitrogen content of pure fibroin = | 18.33% | |
| then one gram of nitrogen is equal to | 5.455 | grams fibroin |
| and 0.014 gram of nitrogen is equal to | 0.07638 | " " |

For example:

| | | |
|---|---|---|
| weight of the original sample | 1.0000 | gram |
| weight of the nitrogen found | 0.0672 | " |
| which is equivalent to fibroin | 0.366576 | " |
| equivalent to silk gum = 0.366576 × $\frac{24}{76}$. | 0.11576 | " |
| therefore weight of raw silk = 0.366576 + 0.11576 = | 0.48233 | " |
| add 11% for moisture | 0.5354 | " |

hence weighting above par $= \frac{1 - 0.5354}{0.5354} \times 100 = 86.77\%$

*Nitrogen Method*[1] (alternative estimation). The pure fibroin is placed in a 200 c.c. round-bottom flask, and treated with 30 c.c. concentrated sulphuric acid. A small amount of anhydrous copper sulphate is then added and the whole heated for about 5 hours. The end of the reaction is shown by the solution turning green. Remove the heat and add potassium permanganate until a deep green color is obtained. After allowing to cool add water carefully. Allow to cool again and pour the whole into a copper distilling flask, using plenty of water in transferring it. Add excess of caustic soda, distill off the ammonia and absorb in U tubes with standard acid.

The percentage of "charge" is usually stated with reference to raw silk containing 11% of moisture. For example a charge of 40% above par means that 100 grams of raw silk yielded 140 grams of weighted silk. The amount of bast or gum in raw silk varies within several per cent, so that it is advantageous to know which variety has been used in the sample. In the table below are given the average values which are usually accepted:

| | |
|---|---|
| Italian (yellow) | 24% |
| Japan | 20 |
| China (white) | 24 |
| Canton | 24 |
| Chappe | 4 |

If Japan silk had been used in the example given above, the fibroin figure would then be multiplied by $\frac{20}{80}$ instead of $\frac{24}{76}$.

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[1] For other methods of determining nitrogen see U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletin 107. For Steiger and Gruenberg's table for the calculation of the weighting see Appendix I.

## DETERMINATION OF THE FINISHING MATERIALS IN A COTTON FABRIC.

The analysis of a finished cotton fabric containing no mineral matter includes the determination of,

1. The percentage of filling materials. A weighed sample of the fabric is boiled consecutively in distilled water, 1% caustic soda solution and 1% hydrochloric acid; each operation should be continued for about one hour. If the sample be finally washed and dried to constant weight at 105° C. the result will give the amount of absolutely dry fiber present. Add 8% to obtain the "normal" air-dry weight.

2. The percentage of moisture in the air-dry fabric is determined by drying to constant weight at 105° C.

3. The percentage of fats and waxes is determined by extraction in the Soxhlet apparatus.

4. The percentage of starch, etc., is determined by difference as shown below:

| | | |
|---|---|---|
| Total filling materials | | 22% |
| Moisture | 12% | 17% |
| Fats, etc. | 5% | |
| Starch, etc. | | 5% |

The qualitative test for mineral matter in the fabric is the ash which remains after ignition of the fabric in a crucible. The filling material may be soluble in water, e. g., the chlorides of zinc, calcium, magnesium, and sodium. The insoluble portion may consist of China clay, barytes, gypsum, chalk, talc, lime or aluminium soaps. These latter compounds will of course be decomposed on heating.

## DETERMINATION OF TENSILE STRENGTH.

The determination of the tensile strength of yarns and fabrics affords an excellent method for the control of those textile processes which tender the fiber to greater or less extent. Among these processes may be mentioned,

1. The dyeing of aniline black. In the drying and ageing operations high temperatures and a dry atmosphere should be avoided in order to prevent the hydrochloric acid from attacking the fiber. For this purpose the development of the green should also be carefully observed.

2. The dyeing of "mixed goods" with sulphur colors. Sodium sulphide has an injurious action on animal fibers; an excess should therefore be avoided. The dyeing should also be done at the lowest possible temperature.

3. The dyeing of turkey-red by the old "method." After the yarn has been impregnated with oil and dried the hanks should not be piled up too tightly, as in this case they might be "burnt" by a rise in temperature with a consequent weakening of the fiber.

4. The production of mercerized cotton. If properly carried out this process increases the tensile strength of the material, but care must be taken that the temperature of the liquor does not rise above 65° or 70° F.

5. The production of non-shrinkable wool. It has been observed that caustic soda of 42° Bé produces a yarn of decidedly increased tensile strength, while less concentrated liquors have a decidedly weakening effect on the wool. Here again the temperature must be kept low and the immersion extended over not more than 5

minutes. If a solution of bleaching powder be used to render the wool non-shrinkable, concentrated liquors must also be avoided.

6. Artificial silk. As this product loses greatly in tensile strength on coming in contact with water, tensile strength determinations of the dry and moist material should be made on all lots.

7. Waterproof cloths. The waterproof effect is often obtained by impregnating with solutions of metallic salts which sometimes corrode the fiber; raincloths, umbrella-cloths and rubber-coated cloths should therefore be examined in this particular.

8. Sized yarns. The object of sizing is to strengthen the yarn so that it may be used for weaving without danger of breaking. The elasticity of the yarn depends on the staple, the evenness of the thread, the twist per inch, the percentage of size on the yarn, and the percentage of moisture contained in the yarn at the time it is being tested.

9. Shoddy yarns. The carbonization of the vegetable fiber invariably affects the tensile strength of the wool fiber, even though the acid and soda have been thoroughly removed.

10. Bleached cotton yarn and fabrics. The action of chloride of lime is in no case without its injurious effects on the fiber. In order to ascertain the relative loss in tensile strength and so observe the "tendering" action the raw and the bleached cotton should be tested.

The determinations are made with specially designed apparatus made for testing fibers, yarns, and fabrics. It is encouraging to note that governmental contracts for the delivery of yarns and fabrics are now in almost all cases based on a definite strength of materials, so that in this case also we will soon observe the "survival of the fittest."

*Tensile strength* is defined as the resistance which a solid body offers to being pulled apart. It is proportional to the area of the cross-section and independent of the length of the body, and is measured by the number of kilograms required to tear apart a body having a cross-section area of one square millimeter. In the case of cloths and yarns it is practically impossible to obtain a definite cross-section, so that in this case the term "breaking strain" is preferred.

*Elasticity* is defined as a property possessed by solids to return to their former shape after deformation. The elongation which a thread suffers is —

Proportional to the pulling force exerted;
Proportional to the length of the thread; and
Inversely proportional to the cross-section area of the thread.

*The coefficient of elasticity* is a fraction which expresses the increase in length suffered by a piece of the material having a length of one meter and a cross-section of one square millimeter, when a weight of one kilogram is attached to the end. Under these conditions a silver wire stretches 1/7400 or 0.014% of its length. That is to say, a weight of 7400 kilograms is necessary to stretch the wire to twice its original length.

The tensile strength of fibers is determined by means of very delicate apparatus as the values are much smaller than for yarns. In the following table are given extreme

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NOTE. — Tensile strength testing apparatus is manufactured by Louis Schopper (Leipzig), Max Kohl (Chemnitz), Henry Baer (Zuerich), Tarnogrocki (Essen). For the testing of fibers the machine built by A. S. Mackenzie (Philadelphia) yields excellent results. It is the only one which has come into extended use.

values which have been observed, the numbers indicating kilograms per square millimeter.

| | | |
|---|---|---|
| Cotton from | 30 (Upland) | to 40 (Egyptian) |
| Wool from | 20 (Lincoln) | to 40 (merino) |
| Silk from | 35 (boiled-off) | to 45 (raw) |
| Jute from | 30 (bleached) | to 50 (raw) |
| Flax from | 30 | to 36 (Courtrai) |
| Hemp from | 40 | to 45 (Italian) |

In recording tensile strength determinations it is well to make a complete analysis of the fabric in order that the results obtained may be more intelligently interpreted, e. g.:

Name of fabric.
Weight per square yard in ounces.
Picks per inch (filling).
Ends per inch (warp).
Breaking strain in pounds.

NOTE.—The length of the sample between the jaws of the two vises should be 5 inches and the width 1 inch. Knitted fabrics may be cut in widths corresponding to ten wales.

Yarns and fibers are reported as follows:
Name of the fiber.
Diameter of the fiber.
Tensile strength of the fiber.
Elasticity of the yarn or fiber.
Size (or count) of the yarn.
Breaking strain of the yarn.

The tensile strength of yarns of the same material will vary with the " count " of the yarn, the length of the "staple" of the constituent fibers, and the "twist per inch" applied in spinning. The following table showing the results of tests with carded cotton yarn is of interest at this point:

| | 32s Twisted American. | 40s Twisted American. | 50s Twisted Egyptian. | 60s Twisted Egyptian. | 70s Twisted brown Egyptian. | 80s Twisted brown Egyptian. |
|---|---|---|---|---|---|---|
| Average number of fibers in cross-section of yarn.. | 120 | 100 | 110 | 100 | 74 | 60 |
| Strength of each fiber in grains.................. | 140 | 140 | 146 | 146 | 150 | 150 |
| Calculated strength of yarn in pounds.............. | 200 | 160 | 184 | 167 | 127 | 103 |
| Actual strength of yarn in pounds................ | 50 | 36 | 46 | 34 | 28 | 24 |

## DETERMINATION OF HUMIDITY.

This determination is of especial importance in the spinning, winding, carding, and weaving of cotton and in the oxidation or "ageing" of anilin black. The amount of moisture contained in the air can be ascertained by means of an instrument known as a hygrometer, the form commonly used being known as a wet and dry bulb hygrometer. The wet bulb consists of a thermometer, around the bulb of which is wrapped one end of a wick. The other end of the wick dips into a small bottle of distilled water. If the air is very warm and dry the water on this bulb will evaporate quickly with the result that a lower temperature is indicated. The dry bulb is an ordinary thermometer suspended within a few inches of the wet bulb. The temperature on the dry bulb is read and then from a table is ascertained the amount of moisture which the air is capable of holding *at* this temperature. By means of the same table we can ascertain how much moisture the air is capable of holding at the temperature indicated by the wet thermometer.

The figure corresponding to the wet thermometer is known as the absolute humidity (A).

The figure corresponding to the dry thermometer is known as the maximum humidity (M).

The fraction $\frac{A}{M}$ represents the relative humidity and is expressed in percentage. For example:

The dry thermometer indicates 77° F. and the wet thermometer 68° F. From the table we see that

At 77° F. the air is capable of holding 10 grains of water per cubic foot.

At 68° F. the air is capable of holding 5.9 grains of water per cubic foot, and

$$\frac{5.9}{10} \times 100 = 59\%.$$

## DETERMINATION OF SPECIFIC GRAVITY.

*A.* In the dyehouse it is often necessary to determine the strength of a bath of a tannin extract or of some acid by a quick and fairly accurate method. In this case a densimeter is used. As its name indicates, this instrument is used to ascertain the density and therefore the concentration of the liquid. The common forms of densimeter are the specific gravity spindle, Twaddell's hydrometer and Baumé's hydrometer. In the reference table[1] it will be noticed that Twaddell's scale bears a direct relation to the specific gravity scale and is therefore preferable to the

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[1] See Appendix.

scale of Baumé. Twaddell divided the space between the specific gravity 1 and 2 into 200 parts or degrees.

$$\text{Conversion:} \quad \frac{(168^\circ \text{ Tw} \times 5) + 1000}{1000} = 1.84 \text{ sp. gr.}$$

*B.* Some years ago Vignon suggested that the weighting of silk could be calculated from the specific gravity of the sample. Although this application is of no value, the specific gravity of fibers may in some cases form a basis for judging the quality of a fiber. A good example of this is furnished by imitation silk or lustre-cellulose, which should possess a density very near to that of cotton.

For obtaining the following data an ordinary balance is required:

Specific gravity of a sample of pure coal-tar benzene (Db).
Weight of the fiber in air (use from 0.5 to 1 gram) (Wa).
Weight of the fiber in the benzene (Wb).

Then Wa − Wb = loss of weight in the benzene, and

$$\frac{Wa}{Wa - Wb} \times Db = \text{the specific gravity of the sample.}$$

The average values obtained by Vignon and others are given below:

| | Per cent. |
|---|---|
| Raw silk | 1.30 to 1.37 |
| Boiled-off silk | 1.25 |
| Wool | 1.30 |
| Cotton | 1.52 |
| Lustre-cellulose | 1.52 |
| Linen | 1.52 |
| Hemp | 1.48 |
| Jute | 1.48 |
| Ramie | 1.52 |

## Determination of the Fastness of Dyed Fabrics.

The tests which will receive consideration at this point include fastness to

alkalis
air
acids
boiling-off
chlorine
carbonization
crocking
finishing
fulling
greening
hot-pressing
light
perspiration
peroxides
rain
sponging
stoving
soda
street-dust
weather
washing.

*Alkalis.* Cotton. Immerse the sample for 2 minutes in 10% ammonia solution. Dry without rinsing. In place of ammonia a 10% soda solution may be used.

Wool. — Immerse the sample in a 20% solution of soda crystals. Squeeze and dry without rinsing.

*Air, light, and weather.* The samples are affixed to a board of convenient size. They are then covered with a strip of cardboard so that only one-half of the sample is exposed to the influence of the air, light, and weather. If a standard sample be exposed at the same time under the same conditions the relative fastness of the two colors can readily be observed. If only the fastness to light is to be tested the experiment must be carried out under a glass cover. By removing the glass and exposing the sample to the air protected from the action of dust and rain the fastness to air may be observed. The fastness to all three influences can be determined by subjecting the sample to the action of light, and exposing it to the action of the air, dust, and rain at the same time.

*Acid.* Cotton. 1. Spot the sample with dilute hydrochloric acid containing 100 c.c. of the (sp. gr. = 1.18) acid per liter. Allow the acid to act for 10 minutes.

2. Spot the sample with a 50% solution of acetic acid. Allow the acid to act for 10 minutes.

Wool. Spot the sample with dilute hydrochloric acid containing 300 c.c. of the (sp. gr. = 1.18) acid per liter. Allow the acid to act for 2 hours.

*Boiling-off or degumming.* Silk is sometimes dyed in the raw state, woven up with cotton and afterward boiled off. In this operation the goods are treated in a boiling soap solution containing 15 grams of soap per liter, for two hours.

*Chlorine.* Cotton. Immerse the sample for one hour in a solution of chloride of lime. Two experiments should be carried out, one with a 1° Bé and another with a 0.1° Bé solution. Printed colors are frequently subjected to an after-chloring, so that the test is of especial importance in this case.

*Carbonizing.* Wool. Treat the sample with sulphuric acid (3.5% strength). Squeeze and dry in the oven for 2 hours at 80° C. Neutralize with dilute soda solution. Rinse, dry, and examine. In order to observe the degree of carbonization to which the sample has been subjected it is advisable to sew the sample with a few threads of cotton.

*Crocking.* Wool. This test may be carried out by rubbing the sample on a white linen cuff or other suitable white surface.

*Finishing.* The varied nature of the finishing processes makes it necessary to alter the test to suit the particular case. As one example we might take the following: Prepare a paste containing 20 grams of potato starch per liter and acidify this with acetic acid. The sample is rubbed in this at a temperature of about 50° C. The excess of paste is scraped off and the sample dried on a hot drum or with a hot iron.

*Fulling or milling.* Wool. The sample of yarn is plaited with white wool and white cotton, then thoroughly rubbed in a strong solution of soap at 30° C. (25 g. neutral soap + 25 g. soda ash per liter). A second experiment is carried out with a solution containing 50 g. neutral soap per liter.

For Hats. In the manufacture of felt hats the acid milling is used, so that in this case the test should be modified, using a solution of 5 c.c. sulphuric acid in 1000 c.c. of water.

Cotton. In this case the test is carried out by rubbing in a solution of soft soap *or* by immersing in a 1% soap solution for 12 hours *or* by immersing in a soda solution (15 g. soda ash per liter). In all cases the yarn should be plaited with white wool and white cotton.

*Greening.* This test is applied to dyeings of anilin black on cotton. The natural test is to subject the sample to the action of air, light, and weather and observe the changes taking place in 4, 8, and 12 weeks. The laboratory test may be carried out according to Noelting and Lehne: 20 grams of sodium bisulphite solution (38° Bé) are mixed with 20 grams of hydrochloric acid (21° Bé) and 500 grams of water. The sample is immersed in this for 10 minutes, rinsed thoroughly with distilled water, dried, and examined.

*Hot-pressing.* Cotton. The sample is ironed with an iron which has been well heated and the change of color is noted.

*Light.* (See under *Air.*) When stating the fastness to light it is of importance to note whether sunlight or diffused daylight has acted on the sample. Furthermore the time of exposure should be noted.

*Perspiration.* The sample of cloth should be suspended about the neck of a white person for 10 days. The sample may be examined each day in order to note any change which has taken place. The laboratory test is carried out with a solution containing 50 grams of 50% acetic acid and 100 grams of sodium chloride per liter. Another perspiration substitute which has been suggested consists of 50 c.c. of 50% acetic acid + 25 c.c. butyric acid per liter of distilled water. Whatever solution is used the sample is dried after each immersion. The fabric is examined each day in order to note any change which has taken place.

*Peroxides.* Cotton and silk. Fabrics made of these two fibers (satins and other mixed fabrics) sometimes contain threads of mercerized cotton in the weave. This dyed yarn must be able to withstand the subsequent operations of degumming and bleaching to which the silk is subjected. As the bleaching operation is now generally carried out with peroxides it is important to know what action these chemicals have on the coloring matters.

The test is made to suit the particular case in hand.

*Rain.*— Fabrics intended for flags, umbrella covers and raincoats should be colored with dyestuffs capable of resisting the action of this agency. The sample is sewed to a piece of white wool, another sample is sewed to white cotton, and a third to white silk.

The samples so prepared are subjected to the action of rain and then dried. After repeating this 5 times the samples are compared with the standard.

*Steaming.* This test is best carried out by placing the sample between two layers of a cloth which is about to pass through the actual steaming operation in the works. A small piece of undyed fabric should be simultaneously steamed in the case of wool, as this fiber is sometimes yellowed during the steaming process.

*Stoving.* Wool. — The sample is washed in soap water, wrung out, and then placed in a sulphur box for 12 hours. The sample should be previously plaited with white wool yarn and white cotton yarn. These should finally be examined to see if the color has bled. The fumes of sulphur dioxide may be generated by burning sulphur or by decomposing sodium bisulphite with sulphuric acid.

*Soda.* Cotton. — The sample is plaited with white cotton yarn and boiled for one-half hour in a solution of 2 grams soda ash per liter. Notice whether the color has bled or become paler.

Wool. — The sample is plaited with white wool and white cotton and immersed for 6 hours in a solution of soda ash (20 g. per liter).

*Street dust.* Wool and silk. — A milk of lime is prepared by rubbing down 200 grams of lime with 1500 c.c. of water. The sample is spotted with this mixture, then allowed to dry, and finally brushed.

*Weather.* This has already been discussed under *Air.*

*Washing.* Cotton. — The sample is treated with a solution containing 2 grams neutral soap per liter for one-half hour. Two experiments are carried out, one at

60° C. and the other at 100° C. The change in shade of the sample is noticed.

Wool. — The sample is treated with a solution containing 2 grams soap and 0.5 g. soda ash per liter for 15 minutes. The change in shade is noted.

In carrying out the tests above outlined it must be remembered that the term "fastness" is in every case meant to be "relative fastness." There are up to the present time no instruments which enable us to draw absolute comparisons between two dyestuffs on the fiber. Of all properties, the fastness to light is probably the most important, so that this should be determined in every case, while the other tests may be applied as the necessity for the same may arise.

# PART III.

# PART III.

## MATERIALS, PROCESSES, AND PRODUCTS.

THE matter presented in this section is but an outline of the chemical technology of a few important textile processes. The complete analysis of "materials" has been omitted as being a subject not peculiar to the textile industry.[1] The enumeration of the various operations performed in the individual processes it was thought would be of value for obtaining a survey of the subject and so make possible a more logical chemical control. The three main points of each operation which have been specified as far as possible are the concentration of the bath, the temperature of the bath, and the duration of the treatment.

### COTTON BLEACHING.

#### *Materials.*

*Bleaching powder.* (Chloride of lime, Chemic.) Determine calcium chloride, calcium oxide, calcium carbonate, and available chlorine. The latter may be determined by titration with arsenious acid. The main constituent of bleaching powder is calcium hypochlorite ($CaCl_2O_2$). The best commercial article contains about 40% available chlorine.

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[1] Those desiring more complete data concerning the analysis of dyers' materials will find the volume "Faerberei-chemische Untersuchungen" by Paul Heermann, Julius Springer, Berlin, 1907 (second edition), a valuable help.

*Water.* — The most desirable water for bleaching purposes is what is technically known as an upland surface water. Such mountain water is preferred because it has not yet drained through any limestone and therefore contains a negligible amount of impurities. Hard water (i. e., water which contains lime and magnesium salts in solution) will form insoluble compounds when used in conjunction with soap. These insoluble compounds then remain in the fabric only to spoil the appearance of the bleach and render the goods harsh. The presence of iron in the water makes it totally unfit for use in bleaching, owing to the red-brown color of iron compounds.

*Lime.* — The removal of the wax from the fiber in the boiling-off operation is sometimes effected with lime. A good quality of lime ("fat lime") should contain only small amounts of magnesia and alumina and be *free* from iron.

*Caustic potash and caustic soda.* — Determine chlorides, sulphates, carbonated alkali, caustic alkali, and water. The caustic alkalis are used for removing the cotton wax in the boiling off of raw cotton.

*Rosin* (colophony).— This is the solid residue left after the crude turpentine has been distilled. It should be brittle, tasteless, and have a smooth shiny fracture. Fifty grams of rosin and 5 grams of caustic soda boiled in 30 c.c. water for 15 minutes should yield a clear solution. Rosin is sometimes used in the boiling-off operation because of its supposed cleansing action.

*Muriatic acid* (hydrochloric acid). — This acid is used in preference to "oil of vitriol" for the souring of the goods after the chemic bath, as calcium chloride is soluble in water, whereas calcium sulphate is only slightly soluble. The acid used in the bleach process should contain not more than 0.03% iron.

*Antichlor.* — Substances bearing this name are at times used in place of the acid bath for souring the goods and at the same time removing the excess of chlorine. Sodium bisulphite and sodium thiosulphate are most suitable for this purpose. The commercial products may be valuated by titration with iodine.

*Sulphonated oils.* — Turkey-red oil and other oils "soluble in water" are used in the wetting out of cotton in conjunction with caustic soda. The best turkey-red oil is made from castor oil (acetyl number *above* 140). Determine total fat, neutral fat, fatty acids, solubility in distilled water, solubility in hard water containing 400 parts $CaCO_3$ per million. The effect of the oil is to produce a better white and give the goods a soft feel.

*Soap.* — After the goods have been bleached they are soaped in order to remove any harmful substances and give the goods a soft feel. The soap used for this purpose should be neutral and free from filling materials. If free (uncombined) fat is present decomposition will soon take place and the fiber will be tendered or at least be turned yellow.

### *Processes.*

1. *Boiling off.* The goods are boiled in a kier for 6 or 7 hours with a solution of caustic soda or caustic potash having a concentration of 0.5% (1 pound soda to 200 pounds, or 24 gallons, water).

2. *Rinsing.* The greater part of the caustic liquor is removed by washing with cold water.

3. *Bleaching.* The bleach or chemic bath consists of

a clear chloride of lime solution having a concentration of 0.7° to 2° Bé. The goods may be left in this bath for ½ hour to 2 hours, depending on the concentration of the liquor. The bleaching takes place in the cold, and care must be taken that no solid particles of lime get into the bath, as these may cause spots.

4. *Rinsing.* The greater part of the chemic solution is removed by rinsing in cold water.

5. *Souring.* In order to complete the bleach the goods are often passed direct into a weak bath of hydrochloric acid without previous washing. Three pounds of acid of 22° Bé. may be used for every 12 gallons of water and the goods left in this cold solution for about 2 hours. The bath should have a specific gravity of about 1.005.

5a. *Antichlor.* In some cases a bath of bisulphite of soda is used instead of the acid. The commercial "bisulphite" of 38° Bé. is used in the proportion of 2 pounds for every 100 pounds of goods. The goods are entered in this bath after the fourth operation and worked in the cold until all the free chlorine has been removed from the goods.

6. *Rinsing.* After the antichlor or the acid bath the goods must be thoroughly washed in cold water.

7. *Soaping.* In order to give the goods a soft feel they are now passed through a weak soap solution. For this purpose a good neutral soap is desirable and the temperature of the water should be about 100° F. (use 3 pounds soap per 100 pounds goods).

8. *Rinsing.* This final operation is frequently resorted to in order to avoid any discoloration of the goods after storing. *Soft* water at a temperature of 100° F. must be used.

## *Products.*

The analytical tests applied to bleached goods include the determination of,

1. The tensile strength of the fabric before bleaching.
2. The tensile strength of the fabric after bleaching.
3. The fatty matter.
4. The lime-soaps.
5. The ash.
6. The detection of oxycellulose.
7. The detection of free chlorine in the goods after the acid or antichlor bath.
8. The detection of free acid in the goods after rinsing (before drying).
9. The detection of lime, resin, and bleach spots.
10. Comparison of the color of the bleached goods with accepted standards.

As tests 1 and 2 have been fully discussed in the chapter on tensile strength the reader is referred to that article.

3. The estimation of the fats, resins, and waxes which have been left in the fabric is carried out with a sample weighing about 10 grams. This is extracted in a Soxhlet apparatus with petroleum ether which has been recently distilled to remove any tarry matter. The amount of solvent necessary is found by filling the Soxhlet extractor until the contents siphon off freely. Some excess should be allowed for loss by evaporation. The dry extraction flask should be accurately weighed before use. If the extractor has siphoned off regularly the operation will be finished in about 90 minutes. The extraction flask is now

placed on a water-bath, whereby the solvent distills off and the fats remain. The increase in weight of the flask will show the amount of fats and the like present in the weighed sample. The amount of fatty matter permissible in well-bleached goods is usually taken as .05 per cent, but it is quite possible to produce cloth with as little as .025 per cent. The amount of fatty matter present may also be calculated from the loss in weight of the fabric. In this case the sample must be dried at 110° C. and accurately weighed both before and after extraction.

4. The ideal bleached fabric contains no appreciable amount of lime soaps. As, however, nearly all natural water contains some lime salts in solution the formation of a small quantity of this insoluble soap can hardly be avoided; another cause of their presence is the boiling off of the cloth in the kiers. If lime is used, the waxy matters which are softened by the process are very prone to combine with it to form a soap. A third source of the trouble is the imperfect washing of the goods before bleaching. The estimation of the amount of calcium soap present is carried out as follows:

A sample which has been thoroughly degreased in a Soxhlet extractor is immersed for thirty minutes in a mixture of 5 grams of concentrated hydrochloric acid and 95 c.c. of distilled water and then well washed and dried. By this operation the lime is converted into soluble calcium chloride, while the free fatty acid remains on the fabric. The sample is dried and extracted with petroleum ether as before. The fatty acids may be weighed and reported as such. They may in addition to this be dissolved in alcohol and titrated with $\frac{1}{20}$ normal caustic potash solution, using phenolphtalein as an indicator. The maximum amount of fatty acid in the form of lime soap permissible in properly bleached goods is .05 per cent. If this amount is exceeded the souring and rinsing operations require investigation.

5. Although the raw cotton lint contains as much as 1.65 per cent of ash, pure cellulose leaves on ignition no ash at all. This gives another method by which to determine the perfection of the bleach, for the object in bleaching is to remove all extraneous matter and obtain the cellulose in as pure a form as possible. Whether or not the operation has been successful may be judged by the amount of mineral matter which a sample of the fabric leaves on ignition. Take about a 5-gram sample, determine its weight accurately, cut into small pieces and place in a porcelain crucible. Now burn off the organic matter until the remaining ash is white or light gray. The increase in weight of the crucible will show the amount of mineral matter present in the sample taken; it should not exceed 0.1 per cent. This ash consists essentially of calcium oxide and a small amount of silicates. The former is due to the lime soaps in the fabric, while the latter is attributed by some to mechanically adhering matter with which the raw cotton is sometimes willfully adulterated.

6. The detection of oxycellulose is of extreme importance, as careful tests have shown that its presence not only interferes with the dyeing of level shades but also considerably affects the tensile strength of the fabric. This weakening of the fiber becomes especially evident in the subsequent treatment of the fabric with alkalies or soap, so that it may escape notice until the goods are finally sold at retail. The housewife then discovers to

her dismay that the goods appear rotten after the first washing.

The formation of the oxycellulose is generally caused by undue exposure of the goods to light and air after removal from the bleach bath; then again it may result from the use of very strong bleach baths, but the chemical change which takes place is in both cases an oxidation. The test usually recommended to determine the presence of this oxidation product depends upon its affinity for the basic coloring matters. Five grams of methylene blue are dissolved in 1000 grams of boiling water. The previously moistened fabric is now immersed in this for about ten minutes and then washed. The presence of oxycellulose in the fabric is indicated by spots or stripes which have been dyed a bright blue, while the rest is only slightly tinged. This test, though apparently simple, requires some experience if the results obtained are to be properly interpreted.

Another excellent test is carried out as follows: Boil the fabric thoroughly in water in order to remove any finishing material. Then squeeze and boil for five minutes in a mixture of 30 c.c. of Fehling's solution and 20 c.c. of water. A red color on the fabric due to the deposited cuprous oxide ($Cu_2O$) indicates the presence of oxidized cellulose. This latter oxidation product may be prepared artificially by saturating a fabric with bleach solution and then exposing in an atmosphere of carbon dioxide.

7. In order to obtain a purer white and to remove the excess of chlorine from the fiber the goods are passed through the acid bath. As this treatment with muriatic acid often leaves the goods harsh many bleachers prefer to use sodium hyposulphite ($Na_2S_2O_3$) or sodium bisul-

phite ($NaHSO_3$) to insure a "soft feel." If used in sufficient quantity these substances effectually remove the chlorine which remains in the goods after the bleach bath, according to the following reactions:

$$2\ Na_2S_2O_3 + 2\ Cl = 2\ NaCl + Na_2S_4O_6.$$

$$NaHSO_3 + 2\ Cl + H_2O = 2\ HCl + NaHSO_4.$$

To determine whether all the chlorine has been removed the washed fabric is immersed in a 10 per cent solution of potassium iodide to which a few drops of boiled starch solution have been added. The appearance of a blue color indicates the presence of free chlorine. This in turn shows that an insufficient quantity of "antichlor" has been used.

8. The presence of free mineral acid in cotton goods which are to be exposed to high temperatures is extremely detrimental to the strength of the fabric. The goods may be tested by moistening with a few drops of a yellow solution of methyl orange. Free acid will turn the color to red.

9. The detection of the presence of lime and of resin spots in a lot of goods is especially important in case they are to be afterward dyed with alizarine colors. The best test is to dye a 10-gram sample of the bleached goods with alizarine red according to the usual method, whereby the spots will show up distinctly.

Finally reference should be made to a test which is serviceable in the examination of bleached linen cloth. Well-bleached linen should not be discolored when steeped in a 10 per cent solution of ammonia. If the linen is colored at all yellow by this treatment it is an indication that the pectin and waxy matters have not been properly removed.

10. When observing the color of bleached cloth, i. e., the purity of the white attained, the cloth should always be laid double and examined in a good north light, otherwise a dark background may detract from the appearance of the goods. Two lots of the same goods bleached consecutively may yet appear of different tints, even though the bluing was the same in both cases. This is often due to a difference in the yarn used. The cream white, which is usually undesirable, is corrected by tinting with ultramarine or methyl-violet. The fact that various coloring matters are at present used for this purpose makes it difficult at times to compare bleached garments purchased at different establishments. Before concluding that one fabric is more valuable than another because of the purity of the white it would be well in some cases to make a comparative test of the tensile strength of the two samples.

NOTE. Cotton which has become discolored by undue exposure to rain and frost can not be bleached a perfect white ("Blue benders cotton").

## TURKEY-RED.

### *Materials.*

The chemical control of the materials used in the turkey-red dyehouse includes the examination of

1. *The water used for dyeing.* This should be free from iron, otherwise a black ink will be produced in the fiber when the goods are worked in the tannin or sumac bath. Moreover the iron-alizarine lakes are much darker than the aluminium lakes, so that shades would be obtained varying in dullness according to the amount

of iron present. For the same reason the other chemicals used must be practically *free* from this impurity. On the other hand the water used for dyeing should contain a certain amount of lime salts in order that the formation of the aluminium-lime-alizarine lake may take place. In the case of soft water whiting or in some cases acetate of lime (*free from iron*) is added. Excellent results are obtained with water of the hardness of 9° (French).[1] If the water is too hard it must be previously softened with acetic acid. The alkalinity of the water is determined by titrating 1000 c.c. with decinormal hydrochloric acid. The amount of acetic acid necessary to soften the water is then ascertained from a table. The water used in the final operations of clearing or brightening should be soft, otherwise the soap used will be precipitated as insoluble lime soap. A pale gray bloom is thereby imparted to the fabric and the brilliancy of the color is in most cases ruined.

2. *Turkey-red oil.* This is used as a fixing agent for the aluminium salts as it makes the colors fast to soaping. It is preferably made of good quality castor oil, but it should in every case be made from a non-drying oil. It must show no turbidity when added to hard water of 20° (French) after adding ammonium hydroxide to alkaline reaction. A turbidity or precipitate indicates that impure castor oil, rape, cotton or olive oil has been used. The oil should be slightly alkaline or neutral and should contain at least 50% fatty acids.

3. *Olive oil* (called tournant oil or Gallipoli oil when fermented), used in the emulsion process for turkey-red.

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[1] One degree hardness (French scale) indicates one part calcium carbonate in 100,000 parts of water (10 parts per million).

4. *Castor oil*, used for making sulphated oils. For this purpose only the pure oil should be used; castor oil foots are unsuitable. The red oil prepared from the latter material causes turbidity when used with hard water.

5. *Marseilles soap*, used for the final brightening bath, should be perfectly neutral and free from filling materials.

6. *Sumac* assists in fixing the alumina and causes the alizarin to be taken up evenly.

7. *Tannic acid*, used as a substitute for sumac in pale shades. The presence of tannic acid in some form or other is essential for the production of reds fast to chlorine.

8. *Glue* is added to the dyebath in case the fabric contains a white reserve in order to prevent any bleeding of the color.

9. *Starch paste*, used in the dyebath because of the cleansing action which it exerts on the color lakes.

10. *Aluminium sulphate*, used for mordanting. This material should not contain more than 0.001% of iron.

11. *Aluminium acetate* (red liquor), used as a mordant in steam alizarin red on calico. The commercial "liquor" of 6° Bé. must not contain more than 0.005% iron.

12. *Calcium acetate*, used for hardening the water of the dyebath in order to make possible the formation of the lake.

13. *Soda ash* (sodium carbonate), used for neutralizing part of the acid in the alum mordant bath.

14. *Sodium stannate*, used for brightening and as an adjunct in the oiling operation.

15. *Whiting* (calcium carbonate), used for hardening the water in the dyeing operation.

16. *Tin crystals* (stannous chloride), used in some cases in place of sodium stannate for brightening.

## PROCESSES.[1]

### 1. *Old Style or Emulsion Method.*

In this process the *yarn* is treated as follows:

1. Boil off with soda ash to remove impurities.

2. Impregnate with a cold emulsion of tournant oil and soda whereby the alkali salts of the fatty acids are deposited on the fiber.

3. Wring out.

4. Dry at about 50° F. for 12 hours. Hereby the deposited alkali salts are probably oxidized into salts of the oxy-fatty acids.

5. Rinse thoroughly with water of 50° F. in which a small amount of soda ash is dissolved, in order to remove any unchanged fat.

6. Place the yarn in an infusion of sumac leaves at 50° F. for 5 hours. For this purpose a 15% infusion having a sp. gr. of 1.0075 is prepared.

7. Mordant in a 12% solution of aluminium sulphate for 24 hours at 50° F. The alum, which should be pre-

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[1] Among the numerous processes for dyeing turkey-red may be mentioned the following:

1) Old style, emulsion process with olive oil emulsion.
2) Old style, Steiner process with clear hot olive oil.
3) New style, sulphated oil process with dry mordant.
4) New style, sulphated oil process with wet mordant (Wesserling).
5) Sulphite-alizarine red (Hoechst) dyed with sodium pyrosulphite.
6) The aluminate processes (Schlieper and Baum).

viously neutralized with soda, should be free from iron. The concentration of the bath should correspond to a sp. gr. of 1.04.

8. Rinse in hard water in order to neutralize any acid remaining in the yarn from the mordant bath.

9. Dye in a bath containing alizarin, sumac and bullocks' blood. Work at 212° F. for one and one half hours. The water used in this operation should not contain any iron but should possess a hardness of about 9 to 10 degrees (French).

10. The clearing operation consists in boiling the yarn under ¼ atmosphere pressure with 3% soda ash (to remove impurities).

11. The yarn is brightened by boiling under a pressure of ¼ atmosphere with 3% palm soap and 0.1% tin crystals, or by

11a. Passing the yarn through a cold solution of tin crystals and then soaping.

12. The yarn is finally subjected to a thorough washing in cold water.

### *New Style or Sulphated Oil Method (dry).*

1. Boil off the yarn with 3% soda ash.
2. Rinse and wring.
3. Impregnate with a mixture of turkey-red oil and sodium stannate and wring.
4. Steam under 5 pounds pressure for one hour.
5. Mordant with aluminium sulphate (free from iron) previously neutralized with sodium carbonate. Sp. gr. of the bath 1.0500; wring.
6. Dry at 120° F. and then hang in the air.

The operations 2 to 6 are now repeated if it is desired to produce a more fiery red which is also much faster to soaping.

7. Chalk in a bath containing 4 pounds of whiting per 100 gallons of water. Temperature of the bath 115° F.

8. Rinse and wring.

9. Dye for 2½ hours at 140° F. in a bath containing 15 pounds alizarin, 2 pounds calcium acetate, per 100 pounds of yarn.

10. Wring and dry.

11. Steam under one atmosphere pressure for two hours (the shade is hereby brightened).

12. The brightening proper is done in a bath containing 1000 pounds of water (120 gals.), 2 pounds Marseilles soap, 0.3 pound soda ash and 0.1 pound sodium stannate. Boil under two atmospheres pressure for two hours.

13. Rinse thoroughly and dry in the open air.

NOTE. The steam pressures given indicate pressure in excess of normal atmospheric pressure. One "Atmosphere" is equivalent to a pressure of 14.7 pounds per square inch.

### *Products.*

1. Examination of the bleached goods before dyeing. If the goods have been improperly bleached so that lime remains in them, these portions will attract the coloring matter more readily than the rest of the yarn or fabric so that unevenness will result. Calico intended for turkey-red is not given the full madder bleach, as no white ground is necessary and the bleaching powder might cause the formation of oxycellulose and uneven shades.

2. Detection and determination of aluminium, calcium, and tin in the finished fabric. A normal red, according to Liechti and Suida, has the composition expressed by the formula $Al_2O_3 \cdot CaO \cdot (C_{14}H_6O_3)_3$, and one square meter of the goods should contain 0.198 gram $Al_2O_3$ and 0.099 gram of calcium oxide. The commercial turkey-reds, however, contain much more alumina without any additional fastness or beauty. In fact the harshness of fabrics dyed with turkey-red oil seems to be due to the formation of aluminium soaps with the fatty acids. Tin will be found as oleate of tin in old-style turkey-reds, as in this process the final brightening is done with palm soap and tin crystals.

3. Examination of the red for purity of shade. Alizarin reds dyed by the sulphated oil process will have either a yellow or a blue cast, depending upon the particular method pursued. Thus if the goods are oiled slightly after the dyeing operation a blue red will result; if, however, the goods are well oiled before mordanting and again after dyeing, or if tin crystals be used for brightening, a yellowish red will be obtained. Bluish reds are also obtained by the use of Para soap.[1]

4. Fastness of the red to various agencies. A good turkey-red should be fast to chlorine; this is of especial importance in the case of towels which are afterwards to be bleached. The red should also be fast to light soap, acids, and to crocking.

5. Tests to distinguish turkey-red from other cotton reds.

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[1] Para soap is an ammonium compound of sulphated castor oil, manufactured by the Hoechst Color Works.

*Turkey-red.*

Baryta water: changes it to violet on boiling.
Nitric acid: produces a yellow spot.
Chromic acid: bleaches it.
Concentrated hydrochloric acid: changes the color to orange or pale yellow.
10% caustic soda: produces a violet spot.
Stannous chloride: in cold, acid solution, does not affect the color.

*Paranitraniline red.*

The color penetrates the whole fabric, whereas in the case of alizarin red the dye is superficially deposited. Para-red is not so fast to light and weather as is turkey-red.
Concentrated sulphuric acid: deep red which changes to brown on dilution.
Concentrated hydrochloric acid: almost no change.
Concentrated nitric acid: color changes to carmin.
Ammonia: almost no change.
10% caustic soda: dark brick red.
Stannous chloride and hydrochloric acid: decolorized.

*Direct red* (benzo, diamine, congo, etc.).

Boiling water: color partly removed.
Acetic acid: color turns black; returns on applying ammonia.
Concentrated sulphuric acid: deep blue.
Concentrated hydrochloric acid: bright blue.
Concentrated nitric acid: yellow to light brown.
Ammonia: no change.

## ANILIN BLACK.

### *Materials.*

*Anilin oil.* The analysis of this substance should include a quantitative determination of anilin, toluidin, nitrobenzol, and water. The specific gravity and boiling point should also be determined.

*Anilin salt.* This should be neutral and free from toluidin.

*Hydrochloric acid* is used in the dyebath as a solvent for the anilin oil.

*Potassium chlorate*
*Copper sulphate* } are used in the dyebath as oxidizing agents.

*Ammonium vanadate*
*Copper sulphide* } are used in the dyebath as carriers of oxygen.

*Ferrous sulphate* is added to the dye liquor to prevent "after-greening" of the black. In the liquor it is quickly changed to ferric sulphate, which then acts as the oxidizing agent.

*Ammonium chloride* is added to the impregnating liquor to provide moisture for the oxidizing chamber.

*Potassium ferrocyanide* is used in Prudhomme's black to render the hydrochloric acid harmless.

*Potassium bichromate* is used for finally developing the emeraldin to anilin black.

*Soaps, oils, and softeners* are used for the final washing in order to give the goods a soft feel, as they would otherwise be very harsh to the touch.

### *Processes.*

1. Dyeing. The goods are impregnated with the anilin liquor in the tom-tom at a temperature of about

60° F. Below is given an example of a padding liquor:

60 lbs. of anilin salt dissolved in 32 gals. of water.
2.75 lbs. copper sulphate dissolved in 6 gals. of water.
19 lbs. sodium chlorate dissolved in 4 gals. of water.
2 lbs. sal ammoniac dissolved in 1 gal. of water.
25. lbs. aluminium acetate liquor (16° Tw.).
Add water to bring the bath to 12° Tw. = sp. gr. 1.06.

2. Extracting. The goods are placed in the whizzer in order to remove the excess of liquor.

3. Drying, and

4. Ageing. These two operations take place in the so-called "oxidizing cage," and require from 3 to 8 hours, depending on the temperature of the chamber. The thermometer should not rise above 120° F. and the development and intensity of the green should be observed from time to time.

In order that the process in the oxidizing chamber may take place rapidly and properly a moist atmosphere is necessary. This may be attained by passing steam into the compartment directly or by means of a steam pipe leading into a box of water. For the determination of the amount of moisture in the room an instrument known as the hygrometer[1] or psychrometer is used. This consists essentially of two thermometers (a dry and a wet bulb). The dry bulb indicates as usual the temperature of the room and the wet bulb indicates indirectly the amount of moisture in the room. On a foggy day the two thermometers, if placed outside, will show the same temperatures, as no evaporation can take place.

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[1] See page 86.

A suitable condition in the ageing room is: wet bulb 90° F., dry bulb 95° F. equal to a relative humidity of 86%.

Some dyers, using a larger proportion of anilin oil than others, allow: wet bulb 115° F., dry bulb 120° F. equal to a relative humidity of 86%.

5. Tumbling. This operation has for its purpose the removal of the protruding fibers, and is performed after the goods have dried in the cage.

5a. Singeing (takes the place of tumbling for fine work). The "lisle finish" is given to stockings by passing them very rapidly over gas flames in the singeing machine, in order to remove the protruding fibers.

6. Chroming. At this stage of the process the emeraldin is converted into the black nigranilin by working the goods in a bath containing 3 lbs. of potassium bichromate for each 100 lbs. of goods. Work for 15 to 30 minutes at 120° F.

7. Rinsing. The goods are well washed with water in order to remove the excess of chrome.

8. Softening. The goods are entered in a bath containing olive-oil, olive-oil soap, and sodium carbonate. Agitate in this bath at 190° F. for 15 minutes.

9, 10, 11. Rinse, whizz, and dry.

NOTE. Since the formation of anilin black is due to an oxidation process which is energetic and proceeds with considerable rapidity, there is great danger of the formation of oxycellulose and a tendering of the fiber. Attention should therefore be paid to the temperature of the dyebath and the ageing chamber, the degree of moisture in the ageing chamber and the duration of the oxidizing operation.

### *Products.*

1. Determine the tensile strength of the fabric before and after dyeing.

2. Determine the amount of mineral matter in the finished fabric.

In goods which have been imperfectly washed chromium will be found. Logwood blacks leave an ash containing iron, and can therefore be readily distinguished.

3. Determine the fastness of the finished black to soap, soda, light, "greening," acids, perspiration, and crocking.

4. Examine the black for its quality. The various blacks found on cotton goods dyed by different methods have blue, red, or green casts. The intensity of the black depends among other things on the amount of anilin oil used.

5. Tests for blacks encountered on cotton goods, as compared with anilin black:

Bleaching powder: A ½° Tw. solution intensifies anilin black. A 4° Tw. solution turns anilin black a red brown. Characteristic reactions.

Stannous chloride (with hydrochloric acid) — color not affected. Distinction from sulphur black.

Sodium hydrosulphite — color removed but returns on washing. Distinction from diazo-blacks.

Boiling water — color unaffected and water remains clear. Distinction from direct blacks.

Boiling dilute sulphuric acid — color does not turn red. Distinction from logwood black.

## MERCERIZATION.

### *Materials.*

*Turkey-red oil, sodium silicate, soap,* used for boiling off .the yarn previous to mercerizing.

*Caustic soda,* used in a concentration of 55 to 60° Tw. (1.3 sp. gr.) at 65° F. for mercerizing.

*Alcohol* and *glycerol,* added to the mercerizing liquor to facilitate the uniform impregnation of the yarn. Use about 5% on weight of goods.

*Glucose* and *ether,* added to the mercerizing liquor to avoid the necessity of exerting tension (obsolete).

*Zinc oxide,* an adjunct to the mercerizing liquor.

*Ammonia,* added to the rinsing water to neutralize any free acid.

*Acetic acid* and *tartaric acid,* used for giving the yarn the effect of the "silk scroop."

*Sulphuric acid,* used for neutralizing the excess of caustic soda liquor which remains in the goods after washing.

### *Process.*

1. The yarn is boiled off with soap, soda or sulphated oil, *not* with caustic alkalis.
2. Rinse and whizz.
3. Mercerize under tension (temperature never above 65° F.).
4. Rinse in fresh water.
5. Rinse in water acidified with acetic acid or sulphuric acid (cold).
6. Rinse thoroughly with fresh water.
7. If mineral acids have been used the goods are now soaped.
8. Dry.

It is preferable to singe the yarn *before* mercerizing and bleach the yarn *after* it has been mercerized.

### *Products.*

1. Examination of the cotton fiber before mercerization; long stapled Egyptian or Sea Island cotton is best adapted for purposes of mercerization.

2. Determination of the tensile strength of the raw yarn before mercerizing.
3. Determination of the tensile strength of the yarn after mercerizing.
4. Examination of the product for the quality of the lustre.
5. Examination of the product for the silk-scroop.
6. Examination of the product for the affinity for dyes.

## CARBONIZATION.

### *Materials.*

Carbonizing agents: Sulphuric acid of sp. gr. — 1.025.
Hydrochloric acid in the gaseous form.
Aluminium chloride of sp. gr. 1.050.
Magnesium chloride of sp. gr. 1.075.
Sodium silicate.
Sodium bisulphate of sp. gr. 1.050.
Sodium carbonate, used for neutralizing the acid left in the goods after carbonization.

### *Process.*

1. Impregnate with sulphuric acid of 5° Tw. (1.025 sp. gr.) at ordinary temperatures for about two hours.
2. Extract in the whizzer.
3. Dry at 100° F. and finally at 150° F. for 5 hours.
4. Rinse in fresh water.
5. Neutralize any free acid which may have remained in the goods by working in a bath of sodium carbonate of 3° Tw.
6. Rinse thoroughly.

### *Products.*

1. Detection of acid spots. These are due to imperfect neutralization of the sulphuric acid by the soda bath and give rise to uneven dyeing.

2. Detection of soda spots. These are due to imperfect washing of the goods after the soda bath.

3. The analysis of regenerated wool (shoddy). Determine

Water, by drying at 105° C. to constant weight.
Grease, by extracting with ether.
Ash, by igniting in a porcelain crucible.
Cotton, by dissolving the wool with caustic soda.
Length of fiber by measurement.

# APPENDICES

# APPENDIX I

## AREOMETRY OR HYDROMETRY.

### COMPARISON BETWEEN THE SPECIFIC GRAVITY, BAUMÉ DEGREES AND TWADDLE DEGREES.

| Tw. | Bé. | Sp. Gr. | Tw. | Bé. | Sp. Gr. | Tw. | Bé. | Sp. Gr. |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1.000 | 32 | 19.8 | 1.160 | 64 | 35.0 | 1.320 |
| 1 | 0.7 | 1.005 | 33 | 20.3 | 1.165 | 65 | 35.4 | 1.325 |
| 2 | 1.4 | 1.010 | 34 | 20.9 | 1.170 | 66 | 35.8 | 1.330 |
| 3 | 2.1 | 1.015 | 35 | 21.4 | 1.175 | 67 | 36.2 | 1.335 |
| 4 | 2.7 | 1.020 | 36 | 22.0 | 1.180 | 68 | 36.6 | 1.340 |
| 5 | 3.4 | 1.025 | 37 | 22.5 | 1.185 | 69 | 37.0 | 1.345 |
| 6 | 4.1 | 1.030 | 38 | 23.0 | 1.190 | 70 | 37.4 | 1.350 |
| 7 | 4.7 | 1.035 | 39 | 23.5 | 1.195 | 71 | 37.8 | 1.355 |
| 8 | 5.4 | 1.040 | 40 | 24.0 | 1.200 | 72 | 38.2 | 1.360 |
| 9 | 6.0 | 1.045 | 41 | 24.5 | 1.205 | 73 | 38.6 | 1.365 |
| 10 | 6.7 | 1.050 | 42 | 25.0 | 1.210 | 74 | 39.0 | 1.370 |
| 11 | 7.4 | 1.055 | 43 | 25.5 | 1.215 | 75 | 39.4 | 1.375 |
| 12 | 8.0 | 1.060 | 44 | 26.0 | 1.220 | 76 | 39.8 | 1.380 |
| 13 | 8.7 | 1.065 | 45 | 26.4 | 1.225 | 77 | 40.1 | 1.385 |
| 14 | 9.4 | 1.070 | 46 | 26.9 | 1.230 | 78 | 40.5 | 1.390 |
| 15 | 10.0 | 1.075 | 47 | 27.4 | 1.235 | 79 | 40.8 | 1.395 |
| 16 | 10.6 | 1.080 | 48 | 27.9 | 1.240 | 80 | 41.2 | 1.400 |
| 17 | 11.2 | 1.085 | 49 | 28.4 | 1.245 | 81 | 41.6 | 1.405 |
| 18 | 11.9 | 1.090 | 50 | 28.8 | 1.250 | 82 | 42.0 | 1.410 |
| 19 | 12.4 | 1.095 | 51 | 29.3 | 1.255 | 83 | 42.3 | 1.415 |
| 20 | 13.0 | 1.100 | 52 | 29.7 | 1.260 | 84 | 42.7 | 1.420 |
| 21 | 13.6 | 1.105 | 53 | 30.2 | 1.265 | 85 | 43.1 | 1.425 |
| 22 | 14.2 | 1.110 | 54 | 30.6 | 1.270 | 86 | 43.4 | 1.430 |
| 23 | 14.9 | 1.115 | 55 | 31.1 | 1.275 | 87 | 43.8 | 1.435 |
| 24 | 15.4 | 1.120 | 56 | 31.5 | 1.280 | 88 | 44.1 | 1.440 |
| 25 | 16.0 | 1.125 | 57 | 32.0 | 1.285 | 89 | 44.4 | 1.445 |
| 26 | 16.5 | 1.130 | 58 | 32.4 | 1.290 | 90 | 44.8 | 1.450 |
| 27 | 17.1 | 1.135 | 59 | 32.8 | 1.295 | 91 | 45.1 | 1.455 |
| 28 | 17.7 | 1.140 | 60 | 33.3 | 1.300 | 92 | 45.4 | 1.460 |
| 29 | 18.3 | 1.145 | 61 | 33.7 | 1.305 | 93 | 45.8 | 1.465 |
| 30 | 18.8 | 1.150 | 62 | 34.2 | 1.310 | 94 | 46.1 | 1.470 |
| 31 | 19.3 | 1.155 | 63 | 34.6 | 1.315 | 95 | 46.4 | 1.475 |

COMPARISON BETWEEN THE SPECIFIC GRAVITY, BAUMÉ DEGREES AND TWADDLE DEGREES. — *Continued.*

| Tw. | Bé. | Sp. Gr. | Tw. | Bé. | Sp. Gr. | Tw. | Bé. | Sp. Gr. |
|---|---|---|---|---|---|---|---|---|
| 96 | 46.7 | 1.480 | 122 | 54.7 | 1.610 | 148 | 61.4 | 1.740 |
| 97 | 47.1 | 1.485 | 123 | 55.0 | 1.615 | 149 | 61.6 | 1.745 |
| 98 | 47.4 | 1.490 | 124 | 55.2 | 1.620 | 150 | 61.8 | 1.750 |
| 99 | 47.8 | 1.495 | 125 | 55.5 | 1.625 | 151 | 62.1 | 1.755 |
| 100 | 48.1 | 1.500 | 126 | 55.8 | 1.630 | 152 | 62.3 | 1.760 |
| 101 | 48.4 | 1.505 | 127 | 56.0 | 1.635 | 153 | 62.5 | 1.765 |
| 102 | 48.7 | 1.510 | 128 | 56.3 | 1.640 | 154 | 62.8 | 1.770 |
| 103 | 49.0 | 1.515 | 129 | 56.6 | 1.645 | 155 | 63.0 | 1.775 |
| 104 | 49.4 | 1.520 | 130 | 56.9 | 1.650 | 156 | 63.2 | 1.780 |
| 105 | 49.7 | 1.525 | 131 | 57.1 | 1.655 | 157 | 63.5 | 1.785 |
| 106 | 50.0 | 1.530 | 132 | 57.4 | 1.660 | 158 | 63.7 | 1.790 |
| 107 | 50.3 | 1.535 | 133 | 57.7 | 1.665 | 159 | 64.0 | 1.795 |
| 108 | 50.6 | 1.540 | 134 | 57.9 | 1.670 | 160 | 64.2 | 1.800 |
| 109 | 50.9 | 1.545 | 135 | 58.2 | 1.675 | 161 | 64.4 | 1.805 |
| 110 | 51.2 | 1.550 | 136 | 58.4 | 1.680 | 162 | 64.6 | 1.810 |
| 111 | 51.5 | 1.555 | 137 | 58.7 | 1.685 | 163 | 64.8 | 1.815 |
| 112 | 51.8 | 1.560 | 138 | 58.9 | 1.690 | 164 | 65.0 | 1.820 |
| 113 | 52.1 | 1.565 | 139 | 59.2 | 1.695 | 165 | 65.2 | 1.825 |
| 114 | 52.4 | 1.570 | 140. | 59.5 | 1.700 | 166 | 65.5 | 1.830 |
| 115 | 52.7 | 1.575 | 141 | 59.7 | 1.705 | 167 | 65.7 | 1.835 |
| 116 | 53.0 | 1.580 | 142 | 60.0 | 1.710 | 568 | 65.9 | 1.840 |
| 117 | 53.3 | 1.585 | 143 | 60.2 | 1.715 | 169 | 66.1 | 1.845 |
| 118 | 53.6 | 1.590 | 144 | 60.4 | 1.720 | 170 | 66.3 | 1.850 |
| 119 | 53.9 | 1.595 | 145 | 60.6 | 1.725 | 171 | 66.5 | 1.855 |
| 120 | 54.1 | 1.600 | 146 | 60.9 | 1.730 | 172 | 66.7 | 1.860 |
| 121 | 54.4 | 1.605 | 147 | 61.1 | 1.735 | 173 | 67.0 | 1.865 |

The determination of the strength of acids and alkalis by means of the hydrometer or spindle is as a rule open to objection as the solution may contain salts in addition to the particular acid or alkali which is being tested for. The safe method is to make a titration with a standard or deci-normal solution of hydrochloric acid or sodium hydroxide, as the case may be.

# APPENDIX II

## STEIGER AND GRUENBERG'S TABLE.

FOR the calculation of the weighting when the percentage of nitrogen in the silk is known. The figures for Japan silk are based on a content of 20% of gum while the figures for yellow Italian silk correspond to 24% of gum.

| Nitrogen Found, per cent. | Equivalent to a Weighting. | | Nitrogen Found, per cent. | Equivalent to a Weighting. | |
|---|---|---|---|---|---|
| | Japan Silk, per cent. | Yellow Italian, per cent. | | Japan Silk, per cent. | Yellow Italian, per cent. |
| | Under par | Under par | | Above par | Above par |
| 18.33 | 27.9 | 31.5 | 7.00 | 88.5 | 79.8 |
| 17.0 | 22.3 | 26.1 | 6.75 | 95.8 | 86.0 |
| 16.0 | 17.4 | 21.5 | 6.50 | 103.2 | 93.1 |
| 15.0 | 11.9 | 16.3 | 6.25 | 111.4 | 100.9 |
| 14.0 | 5.7 | 10.3 | 6.00 | 120.3 | 109.2 |
| 13.0 | 1.6 | 3.4 | 5.75 | 130.1 | 118.4 |
| | Above par | Above par | | | |
| 12.0 | 10.1 | 4.6 | 5.50 | 140.2 | 128.3 |
| 11.0 | 20.1 | 14.1 | 5.25 | 151.6 | 139.2 |
| 10.0 | 32.1 | 25.6 | 5.00 | 164.3 | 151.1 |
| 9.5 | 39.1 | 32.2 | 4.75 | 178.2 | 164.2 |
| 9.0 | 46.9 | 39.5 | 4.50 | 193.8 | 179.2 |
| 8.5 | 55.4 | 47.7 | 4.25 | 210.8 | 195.4 |
| 8.0 | 65.1 | 56.9 | 4.00 | 230.3 | 213.9 |
| 7.75 | 70.5 | 62.0 | 3.50 | 277.1 | 258.6 |
| 7.50 | 76.2 | 67.4 | 3.00 | 340.6 | 318.5 |
| 7.25 | 82.1 | 73.2 | 2.50 | 428.6 | 402.2 |

NOTE. By "par weight" of the silk is meant the weight of the raw silk.

# APPENDIX III

## YARN COUNTS (NUMBER OR TITRE).

BY the "count" of a yarn is meant the number of hanks of a given length which weigh one pound.

*Cotton yarn* single 1's contains 840 yards per hank and this hank weighs one pound. Single eighties (1/80's) cotton yarn is so fine that one pound contains 80 hanks or 80 × 840 = 67,200 yards. Two eighties or eighties two-ply (2/80's) is a yarn composed of two threads of 1/80 twisted together. One yard of this yarn will therefore weigh twice as much as 1/80, and is equal in weight to one yard of 1/40. Single forties cotton yarn contains 40 × 840 = 33,600 yards per pound. As an example of the use to which the various sizes are put we have 2/150, which is used for sheer organdies, and 2/5 which is used for upholstery goods.

*Worsted yarn* single 1's (1/1's) contains 560 yards per pound; therefore 2/60's (= 1/30) will contain 30 × 560 = 16,800 yards per pound.

*Woolen yarn* — "cut system," single 1's (called one cut) contains 300 yards per pound; therefore 30's cut is a yarn of which 30 × 300, or 9000 yards, weigh one pound. These yarns are as a rule "single."

*Woolen yarn* — "run system," single 1's (called one run) contains 1600 yards per pound; therefore 2/60's run (= 1/30 run) indicates a yarn of which 30 × 1600, or 48,000, yards weigh one pound.

*Silk yarn* — thrown. The size of these yarns is always given for their weight "in gum"; that is, their condition before boiling-off and dyeing.

"One dram" silk is that of which 1000 yards weigh one dram avoirdupois; hence one pound contains 256,000 yards.

| Weight in drams of 1000 yards....... | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Yards per pound avoirdupois...... | 256,000 | 128,000 | 85,333 | 64,000 | 51,200 | 42,667 |
| Weight in drams of 1000 yards....... | 7 | 8 | 9 | 10 | 11 | 12 |
| Yards per pound avoirdupois...... | 36,571 | 32,000 | 28,444 | 25,600 | 23,273 | 21,333 |

The unit of the "international" silk skein (legal in France) is 500 meters in length and weighs 0.05 gram. This is known as one "denier." A silk skein marked 20 deniers would then contain 500 meters and would weigh 20 × 0.05 or 1.0 grams.

*Silk yarn* — spun. The count indicates the number of hanks in a pound, and one hank is equal to 840 yards. 2/30's spun silk is made by twisting together two threads of 1/60's.

*Flax yarns* — machine spun. In the English system the count of the yarn indicates the number of leas in a pound and one lea is equal to 300 yards. Thus number 20 linen yarn is that size of which 20 × 300 or 6000 yards weigh one pound.

# GLOSSARY

# GLOSSARY

## Wool Terms.

**Australian wools.** — Those obtained from the various districts of the Australian continent. Arranged in the order of their quality they are Geelong, Port Philip, Sidney, Adelaide, Tasmania, New Zealand. Other types of Australian wool are Brisbane, Melbourne, Botany, Victoria, Queensland, South Australian, New South Wales.

**Blood.** — "Full blood," "half blood," "three-eighths blood," "quarter blood," are terms used to denote the proportion of merino blood in a sheep. They are at present used arbitrarily to designate particular grades of wool.

**Braid wool.** — The lowest grade of wool. It is more lustrous and crimpy than "common wool."

**Britch wool.** — One of the lower grades of wool.

**Burry wool.** — Applied to certain South American wools because of a spiral burr which is entangled in the wool. It can be removed only by carbonization. Some wools from the western United States contain large burrs, but these are removed in the combing process. The burrs are then found in the noils, from which they are removed by carbonizing.

**Carpet wool** (foreign wools). — Coarse wools from southern Europe, China, Persia, Russia, Scotland, Turkey, etc.

**Carbonized wool.** — *See* Regenerated wool.

**Carding wool.** — Short-fiber wool, suitable for spinning yarn on the woolen system. It is possible to spin these wools to 60's cut, but in practice they are seldom spun finer than 30's.

**Clothing wool.** — *See* Carding wool.

**Combing wool.** — Long as well as medium length wool which is suitable for the manufacture of worsted yarn. Formerly only the very long fibers could be used and they were called "combing wools" to distinguish them from the short or "clothing wools." In the modern combing processes all fibers less than 1½ inches in length are rejected as "noils."

**Colonial wool.** — That produced in Australia, New Zealand, and Cape of Good Hope.

**Common wool.** — One of the lower grades of wool.

**Cotted fleece** (cots). — One in which the fibers have become much entangled. Such fleeces are not in demand, as the wool is very difficult to card and spin.

**Dead wool.** — Wool which has been removed from the skin of the dead animal (obsolete). *See* Pulled wool.

**Defective fleece.** — A fleece obtained from old, sick, neglected, improperly fed sheep or such as have been exposed to sudden changes of temperature. The wool lacks strength and elasticity.

**Delaine.** — 1. *See* Combing wool.

2. "Muslin delaine" is a fabric made of cotton warp and wool filling.

3. "Moussline de laine" is a light worsted fabric made from fine, strong, and long-stapled wool.

**Discolored wool.** — *See* Stained wool.

**Domestic wool.** — That produced in the United States. The two main classes are:

Territory wools (including those from Wyoming, Montana, Utah, the Dakotas, Idaho, Nevada, New Mexico, Arizona, Colorado, Oregon) and fleece wools (including those from Ohio, New York, Pennsylvania, Michigan, Wisconsin, Indiana, Virginia, Illinois, Kentucky, Missouri, Texas, California).

**Extract.** — *See* Regenerated wool.

**Fleece-washed wool.** — That which has been washed while on the back of the sheep.

**Fleece wool.** — That shorn from the living animal. (*See* Pulled wool.) Also applied to wools not classed as territory wools.

**Flocks.** — The short material obtained in the operation of shearing worsteds. They are used for adding weight to fabrics. For this purpose they are added to the liquor in the fulling of woolens, being inclosed and felted by the protruding fibers.

**Foreign wool.** — As types of these may be mentioned Awassi, Aleppo, Bokhara, China, Cordova, Donskoi, Joria, Kandahar, Karadi, Khorassan, Mossul, Pyrenean, Vickanier. The majority of these are used in the manufacture of carpets.

**Garnetted stock.** — Yarn waste and the like which has been put through a garnetting machine in order to open the stock so that it may be respun.

**Grades of wool.** — The method of grading wool varies somewhat with the particular district in which it is done. Some domestic grades are xxx, xx, x, ½ blood, ⅜ blood, ¼ blood, and common.

**Hair.** — The term used in general to designate the epidermal covering of various mammals. It may be divided into three distinct classes:

1. Wool which is obtained from the several varieties of sheep.
2. Fur obtained from the rabbit and the cat. It is too smooth to be spun by the usual methods.
3. True hair obtained from goats, etc., may be classified as
   Soft wool hair, from the alpaca, llama, vicuña, camel, cow
   Stiff beard hair and soft beard hair, from Russian cows.
   Short body hair, long mane and tail hair, from the horse.

**Hog wool** (teg wool). — The first fleece from a sheep which has not been shorn as a lamb.

**Kemps.** — Short fibers of uneven diameter, deficient in crimp, strength, felting power, and lustre. They are obtained from diseased sheep, from low-bred sheep, as well as from the "leg and neck" wool of good merino sheep. The microscopic examination shows the medulla and the scales of the fibers to be imperfectly developed. It is for this reason that dyes and mordants are not attracted by the fiber.

**Lamb's wool.** — That taken from animals before they are six months old.

**Lustre wools.** — A synonym for the Lincoln and Leicester types of wool. They are, as the name indicates, unusually lustrous. Some wools possess so smooth a surface that they are very difficult to dye. Lustre wools are straight, smooth, and stiff.

**Merino.** — 1. The name of a breed of sheep. The wool produced by these sheep has always served as a standard for comparison, — thus the proportion of merino blood in a sheep is indicated by the terms ½ blood, ⅜ blood, ¼ blood, etc. As prominent types we have Spanish, Silesian, Saxon, and Australian merinos. The wool is strong, elastic, and wavy.

2. The term applied to yarn made of a mixture of wool and cotton. It was originally understood to be a 50/50 mix, that is, half wool and half cotton, but the term is at present applied to undergarments containing no wool at all. The "wool" effect is obtained by "raising the nap."

3. The name of a fabric made of a very soft wool such as is obtained from merino sheep.

**Mohair.** — The fiber obtained from the Angora goat. The best grades are obtained from Turkey, while good grades are obtained from Cape Colony (Africa). The mohair produced in the United States is much coarser than the oriental product, due to the fact that the breeding is carried on rather indiscriminately.

**Mungo.** — *See* Regenerated wool.

**Non-lustre wools.** — Applied to the merino wools because of their deficiency in this respect. These wools possess much more curl than the lustre wools.

**Non-shrinkable wool.** — Wool which has been treated with a solution of bleaching powder. When examined under the microscope the scales appear fused to the main cylinder. The wool has lost to a great extent its felting property — in other words, it cannot shrink. The fiber obtained by this treatment has an increased affinity for dyestuffs, is more lustrous, stronger, and in some cases acquires a "silk scroop."

**Noils.** — *See* Tops.

**Nubs.** — A term used in the spinning of novelty yarns.

**Overgrown wool.** — Individual dead fibers occurring in fleece wool having been forced out by the roots previous to the time of shearing. They are harsh, weak, and difficult to dye.

**Pitchy wool.** — *See* Unwashed wools.

**Pulled wools.** — Those obtained from tanneries. They may be "brush pulled" or "lime pulled." The former are obtained by allowing lukewarm water to run over the hide and the wool whereby the fibers are loosened. The wool is then cleaned by a revolving brush and removed by hand. In the lime method the skins are put through a sweating process, after which they are immersed in a bath of lime water. The pores of the skin are thus opened, and the wool may be readily removed by pulling. Owing to the fact that the lime removes part of the sulphur, the " lime-pulled " wools are always more or less brittle. When examined under the microscope the medulla, the endpoints of the cortical layer, and the space between the scales are seen to be stopped up with solid particles of lime. All pulled wools may be recognized under the microscope by the presence of the ovoid hair root.

**Raw wool.** — *See* Unwashed wools.

**Regenerated wool.** — The products found in trade under the names of Shoddy, Mungo, and Extract. The fibers vary in length from 0.5 to 2.5 centimeters. They are obtained from knitting-mill waste, from tailor clippings, and from old clothes, — Shoddy from fabrics which have not been felted, Extract from half-wool fabrics, and Mungo from goods which have been fulled. Examined under the microscope a variety of colors can frequently be observed, the ends are in most cases frayed, and the scales are either missing or corroded. These products are sometimes termed carbonized wool, as the cotton is removed from the rags by treatment with sulphuric acid. The vegetable fibers are thereby destroyed and carbonized, and may be dusted from the dry residue of wool.

**Rambouillet.** — The name of a breed of French sheep. They have been crossed with merino sheep, so that those found at the present day in the United States are not full-blooded. The wool is fine, but short and weak.

**Seedy wool.** — That obtained from sheep which have been fed on timothy and the like. The result is that the seed has become embedded in the fleece.

**Shearlings.** — A term used in grading pulled wools. Wools which have been pulled a month or two after the animal has been sheared.

**Southern wools.** — Those produced in New Mexico, Arizona, and Colorado.

**South American wools.** — These are mostly crossbreed wools found in trade as: Buenos Ayres, Rio Platte, Punta Arena, Montevideo.

**Shoddy.** — *See* Regenerated wool.

**Stained wool.** — Wool which has been discolored by urine or other excrements.

**Tanner's wool.** — *See* Pulled wool.

**Territory wool.** — That produced in the Dakotas, Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Wyoming.

**Teg wool.** — *See* Hog wool.

**Tops and Noils.** Terms used to designate the product and by-product obtained in the manufacture of worsted yarns. The source of the raw material may be sheep, goats, or camels. Tops is the name applied to the slubbing which comes off the combs; the staple varies in length from 1½ to 7 inches. Noils represent the short, burred, and nopped fibers which are eliminated during this process.

**Unwashed wools.** — Those from which the major portion of the dried sweat and grease has not been removed while the wool was on the sheep's back. They are also known as "*raw wools*," or "*wool in grease*," or "*pitchy wools*."

**Vigogne.** — A term applied to yarn made of a mixture of wool and cotton. The name is now applied to yarn containing nothing but cotton. The wooly appearance may be obtained by dyeing the cotton with substantive colors in the loose state, i.e., before it is spun.

**Washed wools.** — Those which have been washed while the fleece was still on the back of the sheep.

**Wether wool.** — That which is cut from sheep after the first or "hog" fleece has been removed.

**Wool.** — The soft, hairy covering of the skin of the sheep.

## COTTON TERMS.

**Absorbent cotton.** — Natural cotton from which the waxy and pectic matter has been removed by saponification and emulsion with boiling caustic soda. After the removal of this encrusting matter the fibers absorb water very readily, so that this product finds extensive use in surgery.

**Animalized cotton.** — That which is prepared by coating cotton yarn with a solution of albumin, and then steaming in order to coagulate the coating. Other substances which have been recommended for this purpose are tannic acid, gelatin, casein, and wool dissolved in caustic soda. The object in all cases is to produce a yarn which may be dyed fast shades with the substantive as well as with the basic dyes, in a single bath.

**Bearded motes.** — The dark fragments of immature or imperfect seeds observed in cotton yarns.

**Bender's cotton.** — Any cotton grown in the bends of the Mississippi river. It is of good quality and good length of staple. Much of it is doubtless " Peeler." The variety known as "blue bender's" is the result of exposure to storm and weather.

**Bleached cotton.** — That which has been treated with chloride of lime in order to destroy those coloring matters which cannot be removed by " boiling off."

**Boiled-off cotton.** — That from which the waxy and pectic matter has been removed, e.g., by boiling in a ½% solution of caustic soda.

**Carded cotton.** — Cotton as delivered by the carding engine in the form of a sliver.

**Colored cotton.** — This term is sometimes applied to the buff colored Egyptian fiber, the brown nankin cotton of China, and the terra-cotta colored cotton obtained in Peru.

**Combed cotton.** — That which has been prepared in a combing machine in order to bring all the fibers parallel to each other. The yarns made by this method are much more even and may be spun into much finer numbers than those spun from " carded cotton."

**Cotton.** — The white, downy seed-hairs which envelop the seeds of the cotton plant.

**Cotton-worsted.** — A term applied to fabrics made totally of cotton, but which are finished so that the fabric closely resembles the cloth made of worsted yarn.

**Dead Cotton.** — The term applied to fibers which have not ripened and in which therefore the cells have not yet separated. They are straight without any twist, and the lumen has entirely disappeared. The cross-section shows the inner canal to be stopped up or at times collapsed. As these fibers are weak and have no affinity for dyestuffs they are almost worthless, and should therefore be detected if present.

**Defective cotton.** — Cotton which is unripe, imperfectly developed, dead, tinted, or stained.

**Egyptian cotton.** — That produced in Egypt (especially *Gossypium barbadense*). It is characterized by a long staple, silky fiber, and great strength. Ashmouni, Mitafifi, Bamia, Abbasi, Gallini, are names given to the several varieties. Egyptian cotton is either white or light buff in color.

**Gassed.** — A term applied to cotton yarns which have been passed by a gas flame in order to remove the protruding fibers. The most modern method is to pass them rapidly over a piece of platinum foil which is heated to a white heat by electricity.

**Gun cotton.** — That which has been nitrated with a mixture of concentrated sulphuric and nitric acids. It is the most highly nitrated compound of cellulose, very explosive, and insoluble in alcohol and ether.

**Immature cotton.** — *See* Unripe cotton.

**Indian cotton.** — That produced in India by *Gossypium herbaceum*. It occurs in trade as Bengal, Comptah, Dharwar, Dhollerah, Broach, Oomrawuttee, Hingunghat and Surat.

**Kekchi cotton.** — That cultivated in Guatemala by the Kekchi Indians.

**Kidney cotton.** — A synonym for *Gossypium peruvianum*, cultivated in Brazil and Peru. Cotton in which the seeds of each cell are closely adherent in an oval mass, hence the name.

**Lint.** — The cotton fiber with the seed, in the condition as it is removed from the boll.

**Linters.** — The short fibers left on the seed after the first ginning. They are used for the manufacture of gun-cotton, lustre-cellulose, and cotton batting.

**Lisled cotton.** — *See* Gassed. The "lisle finish" on cotton hosiery is produced in a similar manner.

**Makko cotton.** — The first variety of cotton which was cultivated in Egypt (from Maco-Bey, a cotton planter). The term is also applied to underwear made of buff-colored Egyptian cotton.

**Maranham cotton.** — A variety of cotton produced in South America by *Gossypium peruvianum*.

**Mature cotton.** — When viewed under the microscope mature cotton is seen to resemble an irregularly twisted ribbon with thick rounded edges. The thickest part of the fiber is at the root end.

**Mercerized cotton.** — Cotton in the form of yarn or fabric which has been subjected to hydrolysis by the action of caustic soda of about 60° Tw. (30% NaOH). If this be done while the yarn or fabric is under tension, a fiber much more lustrous and stronger than natural cotton will result. The so treated fiber also possesses an increased affinity for the basic dyes. When examined under the microscope it appears as a cylinder without any twist. It is this cylindrical form, very probably, to which its great lustre is due. Mercerized cotton gives the following reaction, which is characteristic of hydrated cellulose. Prepare two solutions:

1. Five grams of potassium iodide and 0.5 gram of iodine crystals are dissolved in 16 grams of water.
2. Twenty-five grams of zinc chloride are dissolved in 12 grams of water. Mix the two solutions, allow to settle, and decant.

If mercerized cotton and natural cotton be immersed in this solution for about 3 minutes, both samples will be colored brown. Place in a dish filled with distilled water (previously boiled and cooled) and wash until the brown iodine solution has been removed, leaving a dark, blue-black color. Place in fresh water, — natural cotton will lose its color in about 5 minutes, while mercerized cotton retains its color for about one hour. The samples must be kept under water during the test, as they otherwise discolor, owing to oxidation of the iodine.

**Mock Egyptian cotton.** — Ordinary white cotton which has been tinted a light buff in imitation of the genuine Egyptian cotton.

**Nankeen cotton.** — A cotton fabric woven on handlooms in Shanghai (China).

**Nankin cotton.** — A yellowish-brown cotton produced in China by *G. religiosum.*

**Neps.** — Small white specks in the baled cotton, very difficult to remove in spinning and often appearing in the completed fabric as white dots. They are tangled, weak, and undeveloped fibers, due in part to picking the cotton before maturity. They are also obtained from bolls which have been forced open to extract the lint, and which have therefore not had the necessary exposure to the sun. Neps are further obtained from diseased bolls.

**Nun's cotton.** — A variety of cotton produced in India by *G. religiosum.* This cotton was formerly picked by nuns and has for ages been used in the manufacture of clothing for the Brahmins, — the religious caste of Hindoo society. The seed is small and closely surrounded by the fiber, so that the cotton cannot be cleaned by the ginning process. (Synonyms, " Nurma " and " Deo.")

**Peeler cotton** and Allen cotton are varieties of long staple upland cotton of 1¼ inches staple, cultivated in Mississippi.

**Pernam cotton.** — That obtained from *Gossypium peruvianum* in the mountain districts of the Andes (Peru).

**Raw cotton.** — The cotton fiber as it appears in trade, the seeds having been removed by ginning. The raw cotton fiber is surrounded by waxy and pectic matter which must be removed by " boiling off " before dyeing.

**Santos cotton.** — The Orleans variety of cotton grown in Brazil.

**Schreinerized cotton** — A cotton fabric to which a lustre has been imparted by passing the goods between heavy, engraved calenders under pressure.

**Sea Island cotton.** — That produced in the Barbadoes Islands, near the coast of Georgia and the Carolinas, by *G. barbadense.* It is strong, long, and lustrous.

**Seed cotton.** — 1. The fiber as taken from the plant before the seeds have been removed.

2. Cotton which has been grown in order to obtain good seeds for replanting.

**Short staple cotton.** — Cotton fiber ⅝ to 1⅛ inches in length.

**Singed cotton.** — *See* Gassed yarns.

**South American cotton.** — As types of this group may be mentioned Pernam, Santos, and Ceara.

**Stained cotton.** — That which has been exposed to frost with the result that the fiber is colored a pale buff, resembling Egyptian. It is not so valuable as carefully cultivated white cotton.

**Staple cotton.** — A synonym for long staple upland cotton.

**Surat cotton.** — Collective name for the cottons of India.

**Tinged cotton.** — That which has been exposed to rain and storm and so discolored.

**Unripe cotton.** — That obtained from immature bolls after the plant has been killed by frost. The fiber possesses little twist and the ribbon is very flat. It is brittle, weak, and incapable of taking up dyestuffs.

**Upland cotton.** — That grown in the interior upon the higher lands of the states. This grade is divided into short staple uplands and long staple uplands (Allen, Peeler).

## SILK TERMS.

**Bourette silk.** — Silk yarn spun from the shorter waste fibers. (Bourre = the external floss of the cocoons).

**Boiled-off silk.** — That which is obtained by complete removal of the gum from raw silk. The average yield is 12 ounces boiled off silk from 16 oz. raw silk.

**Carded silk.** — Waste silk which has been boiled off and passed through the carding machine. It is used for the manufacture of spun silk.

**Chappe silk.** — Yarn spun from waste silk which has not been boiled off.

**Cuit silk.** — Prepared from raw silk by thoroughly "boiling off" in a bath containing 10 to 15 grams of soap per liter. When examined under the microscope it is seen to be devoid of the granular layer of gum and composed of but one fiber. It is much more lustrous than raw silk.

**Ecru silk.** — Silk from which only 3 to 4% of the gum has been removed by washing in a very weak soap bath. *Compare* Cuit.

**Florette silk.** — A silk yarn spun from the longer waste fibers.

**Floss silk.** — *See* Waste silk.

**Grege.** — *See* Raw silk.

**Noil.** — The product obtained in the carding of waste silk.

**Organzine.** — Raw silk prepared from the choicest cocoons. It consists of two or more threads separately twisted in the same direction, then doubled and retwisted in the opposite direction. It is used for warps.

**Raw silk** (grege or reeled silk). — The product of the reeling machine. It is used in the manufacture of tram and organzine.

**Recotti.** — The final waste in the manufacture of yarn from silk waste.

**Reeled silk.** — *See* Raw silk.

**Silk Shoddy.** — The fiber regenerated from fabrics containing silk and cotton. (*See* Regenerated wool.)

**Spun silk.** — Yarn made from waste silk by carding and spinning it like cotton. It may often be recognized by the irregular structure of the filaments and by patches of sericin or silk glue surrounding the fiber.

**Souple silk.** — Raw silk from which 8–10% of the gum has been removed by partial boiling off. *Compare* Cuit.

**Strussa.** — Waste obtained from double cocoons.

**Tram.** — Raw silk usually prepared from inferior cocoons. It consists of two or more single untwisted threads, which are then doubled and slightly twisted. It is used for weft (filling).

**Thrown silk.** — That produced by "throwing together" and slightly twisting two or more threads of raw silk. The product may be either tram or organzine.

**Waste silk.** — That obtained from the reeling rooms, from cocoons spoiled in steaming, from perforated or otherwise imperfect cocoons, from the extreme interior and exterior parts of the cocoon.

**Weighted silk.** — Silk yarns or fabrics which have been treated with solutions of metallic salts or tannin which are readily absorbed by the fiber. The original intention was to restore the weight which was lost in the boiling-off operation. Thus 100 ounces of raw silk yielded about 75 ounces of boiled-off silk; in order to return 100 ounces to the customer it was necessary to treat the silk in order to make up the 25 ounces. At the present day 100 ounces of raw silk in many cases come out of the dyehouse weighing 200 or 300 ounces.

**"In gum."** — A term applied to raw silk, that is, such as has not been boiled off.

**Frissonnets.** — Waste obtained in reeling the cocoons.

## FLAX TERMS.

**Bleached flax.** — That from which the natural coloring matter and the incrusting pectic matter have been removed by boiling off and subsequent bleaching on the grass or by means of chloride of lime. Linen yarns found in trade are classed as "full white," "three-quarters white," and "half white."

**Broken flax.** — That which has been subjected to the second operation in the manufacture of linen yarn. The brittle woody center of the stalk is broken up into small pieces by being passed through a series of fluted rollers. (Operation 2).

**Combed flax.** — *See* Hackled flax.

**Codilla.** — The waste fibers obtained in scutching.

**Dressed flax.** — *See* Hackled flax.

**Gray flax.** — Yarn which has been boiled off but not bleached.

**Hackled flax.** — That which has been well cleaned by being "combed." The fibers are hereby brought to lie almost parallel. The product obtained by the hackling operation is dressed flax (line) and hackling tow, which is short and more or less tangled. (Operation 4.)

**Line.** — *See* Hackled flax.

**Retted flax.** — That from which the central woody portion of the stem (shive, shore, boon) as well as the gummy matter has been removed by fermentation. Flax may be thus treated by dew retting, tank retting, or river retting. (Operation 1.)

**Scutched flax.** — That which has been beaten with a strong wooden scutching blade in order to remove the particles of woody matter adhering to the fiber. The products obtained by this scutching operation are scutched flax and scutching tow or codilla. (Operation 3.)

**Tow.** — The short fibers which are eliminated in the operation of combing or hackling flax. It should not be confounded with scutching tow, which is properly known as codilla.

**Waterslain flax.** — That which has been wholly deprived of its gum. It may result toward the end of the retting, when that portion of the gummy matter which should remain in the fibers is reduced to a mucilaginous state and therefore readily removed by too strong a flow of water.

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