

TECHNICAL NOTE NUMBER 217

FOREST PRODUCTS LABORATORY - U. S. FOREST SERVICE - MADISON, WISCONSIN

THE MANUFACTURE OF RAYON OR CELLULOSE SILK

Rayon, formerly called artificial silk, is a soft, pliable, multifilament textile fiber produced from some form of plant cellulose such as cotton or wood pulp. In the manufacturing process, the cellulose is dissolved to a viscous solution and forced through minute apertures corresponding to the spinnerets of the silk worm. The fine threads or filaments coming through these apertures are coagulated either in a fixing bath or by a process of evaporation, and several of them formed simultaneously are twisted into the strand or yarn for spinning.

The name "artificial silk" is somewhat misleading. Rayon has a silky luster, but chemically it is quite unrelated to real silk. Real silk consists of a core of so-called fibroin covered with a shell of sericin or silk albumin. Both of these compounds contain nitrogen. Rayon, on the other hand, is simply fine threads of cellulose or a cellulose ester. Its peculiar physical appearance is due to the solution processes which alter the normal appearance of the cellulose by what is termed "hydration." It contains no nitrogen or, at most, only traces of this element.

The term "rayon" has recently been coined to distinguish "cellulose silks" from the natural product and to eliminate the confusion which has always existed regarding the two materials. This name has been endorsed by both manufacturers and consumers of the product in the United States and England, and it should eventually get into common usage. It succeeds a host of names among which are "glos," vegetable silk, glanztoff, fibersilk, and collodion silk.

Four types of rayon are now being manufactured on a commercial scale. The methods used differ chiefly in

the chemical solvents used. The products were formerly differentiated as Chardonnet, cuprammonium, viscose, and acetate silks. The Chardonnet process is the oldest; the viscose process is the most important commercially. All four processes are used in the United States.

In the Chardonnet process cotton cellulose is converted to a nitro-cellulose by treatment with nitric and sulphuric acids. The nitrocellulose is dissolved in an alcohol-ether mixture, and threads are formed by forcing the solution through the spinnerets into a coagulating bath of water. The product undergoes various refinements including denitrification with an alkaline sulphide before finally going to the looms. It has been variously known as Chardonnet, Lehner, tubize, collodion, pyroxylon, or nitrocellulose silk.

The cuprammonium or Despeissis process also starts with cotton, using ammoniacal copper oxide (Schweitzer's reagent) as a solvent. The solution is forced through capillary tubes into a mixture of sulphuric acid and water. Rayon made by this method has been known as cuprammonium, Despeissis, Pauly, or glanzstoff silk.

In the viscose process either cotton linters or wood pulp is ground up with caustic soda and then treated with carbon disulphide, making an "alkali cellulose-xanthate," which is soluble in water. A viscous water solution of this compound is converted into thread in the usual way, the cellulose being regenerated and coagulated usually in a formic acid bath.

Acetate or celanese silk is the latest type of rayon to be produced on a commercial scale. Unlike the other cellulose silks, acetate silk is an ester of cellulose. Cellulose acetate is prepared by treating wood pulp or cotton with acetic anhydride in the presence of a suitable catalyst, and precipitating and redissolving in a solvent such as chloroform, acetic acid, or acetone. The coagulating bath is either water, alcohol, or benzene, depending on the solvent used.

The viscose process, by which nearly seven-eighths of the domestic output is produced, operates almost exclusively on wood pulp. Cotton linters have been used recently in increasing quantities, however, and may eventually be used more extensively than wood. The wood pulp is principally high-grade bleached sulphite made from spruce. Pulp from balsam fir and tamarack has also been reported satisfactory, and probably a pure pulp from any coniferous wood can be used. Whether the raw material is cotton linters or wood pulp, it must be free from vegetable greases, coloring matters, and similar impurities, and in all processes a preliminary alkali cleansing treatment is necessary. One requirement seems to be the use of the stable or alpha-cellulose. Cotton normally is practically pure alpha-cellulose, but in wood pulp other lower or more unstable forms are present. The alkali pulping process eliminates these and renders the pulp suitable for use.

The manufacture of rayon is one of the most rapidly developing cellulose industries. Established during the present century it has attained a position of outstanding importance. By way of comparison the production of raw or reeled silk in the silk-crop year of 1923-24 was approximately 110,000,000 pounds as against an estimated world production of 108,800,000 pounds of rayon in 1923. In 1927 the rayon production had increased to 250,000,000 pounds.

Successful operation of a mill producing rayon involves a large capitalization and a high degree of technical skill. A factory must be well equipped and in good location with respect to markets. It must have a constant supply of good, cheap water free from lime, iron, or other materials requiring filtration or distillation.

The best cost figures available indicate that an investment of about \$1,000,000 is needed for each thousand pounds of daily production. Authorities apparently agree that 15,000 pounds per week is the minimum eco-

nomical scale of operation. The investment necessary will therefore be at least \$2,500,000.