

The production of viscose rayon begins with purified cellulose. The major source of cellulose is specially processed wood pulp harvested from pine, spruce, or hemlock trees. Bamboo has recently become a popular source for cellulose in rayon manufacturing, favored because of its rapid growth cycle. Bamboo is commonly regarded as the world's fastest growing plant.

Regardless of whether wood or bamboo pulp is used, the raw material must be processed in caustic soda (sodium hydroxide) in order to extract and purify the cellulose. The purified cellulose is allowed to oxidize, and then treated with gaseous carbon disulfide ( $CS_2$ ) to form xanthate ester groups, or "yellow crumb." The yellow crumb is dissolved in an aqueous caustic solution to form a highly viscous material, or "viscose". The viscose is allowed to age or "ripen", breaking down the cellulose structures to produce uniform slurry.

After filtering and degassing, the viscose slurry is forced through a spinneret submerged in an acid bath; this process is called wet spinning. As the viscose exits the spinneret (imagine a large shower head with fine holes), it comes in contact with a solution of sulfuric acid, sodium sulfate and zinc sulfate. A chemical reaction takes place in the coagulation bath and forms fine filaments of cellulose, or rayon. The rayon fiber then proceeds through a drawing process which elongates and strengthens the fiber, and finally a washing process to remove impurities.

This complex process of chemically breaking down cellulose pulp to form regenerated cellulose fiber, or rayon, results in a great deal of environmental pollution. According to the epa.gov website, "The EPA has identified the Miscellaneous Viscose Processes source category and the Cellulose Ethers Production source category as including major sources of emissions of hazardous air pollutants (HAP), such as carbon disulfide ( $CS_2$ ), carbonyl sulfide, ethylene oxide, methanol, methyl chloride, propylene oxide, and toluene."<sup>1</sup>

Waste-gas emissions from the xanthation process and waste-water emissions associated with the wet spinning bath are of particular concern. Carbon disulfide gas is a hazardous air pollutant and linked to an increased risk of cardiovascular mortality among factory workers with exposure.<sup>2</sup> Zinc sulfate is highly soluble in water, and will bioaccumulate in frogs and fish. According to the Agency for Toxic Substances & Disease Registry (ATSDR), large doses of zinc ingested in humans can cause stomach cramps, nausea, and vomiting. Long term exposure can cause anemia and decrease the levels of good cholesterol.<sup>3</sup>

Of particular note, Tencel® is a cellulose-based fiber considered to be environmentally-friendly. Tencel® is manufactured by Lenzing in a closed-loop solvent spinning process. According to Lenzing's website, "the solvent is recovered up to 99.5% and the emissions, which remain, are decomposed in adapted biological purification plants."<sup>4</sup>

1 <http://www.epa.gov/fedrgstr/EPA-AIR/2002/June/Day-11/a12770.htm>

2 <http://www.inchem.org/documents/cicads/cicads/cicad46.htm>

3 <http://www.atsdr.cdc.gov/tfacts60.html>

4 <http://www.tencel.com/fibers/en/textiles/>