

SPECIALTY WOOD PRODUCTS

Objectives

Terms for Understanding

Fiber and Paper Industries

Career Option

Chemical Products

Biomass (Energy)

Looking Back

Questions for Discussion and Review

Learning Activities

Wood is only one of many forest products significant to the economy and the way of life we have come to expect in North America. Some forest products contribute in major ways to the economy, but trees are also important sources of substances we hear little about. Raw materials for the medical,

textile, and apparel industries come from forests. Foods, spices, and extracts for flavoring and coloring foods are obtained from trees. The forests of North America have proven to be sources for many products besides wood.

OBJECTIVES

After completing this chapter, you should be able to

- distinguish between a monosaccharide and a polysaccharide
- explain the significance of cellulose to the fiber and paper industries
- describe the different methods used to convert wood fiber to pulp
- suggest reasons why the mechanical pulping method is widely used in the paper and fiber industry
- distinguish the differences between the bleaching and brightening processes
- explain why different grades of wood pulp are sometimes blended together
- define the process by which wood is converted to ethanol
- identify products obtained by destructive distillation of wood
- name the different types of products extracted from wood using solvents, and explain the processes by which they are obtained
- discuss the importance of biomass as a fuel for generating electrical power

TERMS FOR UNDERSTANDING

carbonization
process
cellulose xanthate
chemical pulping
destructive
distillation
disk refiner
dissolving process

ethanol
extractive
fermentation
gasohol
gum naval stores
hemicellulose
hydrapulper
lignin

mechanical pulping
monomer
monosaccharide
naval stores
oleoresin
polymer
polysaccharide
saccharification

semichemical
pulp
sulfate naval stores
syngas
thermochemical
liquefaction
wood naval stores

FIBER AND PAPER INDUSTRIES

Half of the total annual harvest of timber is used for something besides wood. The largest consumer of wood for specialty products is the wood fiber industry. One-fourth of all harvested wood is converted into paper or cardboard products. Another 25% of the timber harvest is burned for energy production or used for chemical production.

Cellulose is the key component of plant cell walls, and is the most abundant raw material used in manufacturing paper and cardboard products. The percentage of cellulose is slightly higher in hardwoods (44%) than in softwoods (42%), but the length of wood

fibers is greatest in the softwoods making them more desirable for making paper. A cellulose molecule consists of a long chain of sugar molecules known as **monomers** or **monosaccharides**. A long chain of monomers formed by a plant as it grows is called a **polymer** or **polysaccharide**. Polysaccharides called **hemicelluloses** are also found in wood. They make up about 27-29% of the material found in wood. The other major component of wood (25%) is **lignin**. This is the material that binds wood components together.

Wood must be processed into wood chips before it can be used to make wood products. This is sometimes done at the processing plant, but much of the wood is now processed in the forest. Large tractor trailers specially designed to haul wood chips are used to transport the wood chips from the forest to the mill. Rail cars are also used for this purpose. Chip size is important because the length of the wood fibers must be preserved during the pulping process. Wood fibers that are too short do not yield strong paper.

Pulping Processes

Wood chips are converted to pulp using several different methods. One of these methods is **mechanical pulping**. This method is used to make paper of newsprint quality. A mechanical pulping system uses a stone grinder or a disk refiner to separate the wood fibers as they grind up the pulpwood bolts or wood chips. The fiber produced is mixed with water forming a slurry converted to wood pulp. This system causes damage to individual wood fibers making it necessary to add higher grade pulp to mechanical pulps to increase the strength of the paper. Most commercial newsprint consists of approximately 70% mechanical pulp and 30% chemical pulp. The big advantage gained from using mechanical pulping methods is that up to 95% of the volume of wood can be converted to paper.

It is becoming more common for wood chips to be pre-treated with chemicals and/or steam as part of the mechanical pulping process. This results in wood fiber that makes strong paper because it is not seriously damaged. Newsprint can be made with this mechanical pulping method strong enough for use without adding high quality chemical pulp to the mixture. Mechanical pulping methods preserve the hemicellulose and lignin components of wood in the pulp resulting in high yields of paper products.

Semichemical pulping is a process for producing wood pulp used mostly in the production of cardboard boxes. Wood is exposed to a mild chemical treatment to partially separate the fibers before it is processed through a disk refiner. A **disk refiner** is a machine that separates wood fibers between two mechanical disks as they rotate. When this method is used, the most common chemical treatment is a combination of sodium sulfite and sodium carbonate. This

process yields paper products equal to 70-85% of the volume of the wood used as raw material. The strength of the paper product produced by this process is higher than that produced strictly from mechanical pulp.

Paper products with high strength requirements are produced using a method called **chemical pulping**. This pulping method uses chemicals to dissolve the lignin component of wood. This is done by placing the wood and chemicals in a large container called a digester. Heat and pressure are applied to the mixture causing a chemical reaction that combines lignin with water. In this form, the lignin component of wood is removed along with the hemicelluloses. The wood fibers that remain are undamaged by the process, and they form strong paper that is of high quality. Most chemical pulping processes yield only 40-55% of the total wood volume as paper products. Several different chemical pulping processes have been developed. The Kraft process, developed in Germany in 1884, is the most used chemical pulping process in the United States.

In addition to the wood pulp obtained directly from wood, some pulp is recovered from recycled paper. Approximately 25% of used paper is recycled in the United States. Recycled paper is reduced to pulp in a machine called a **hydrapulper**. The recycled paper is mechanically processed in water to separate the wood fibers. Ink is removed by treating the pulp with sodium hydroxide, and the recycled pulp is screened to remove fine materials that reduce the strength of the paper. After the pulp has been cleaned, it is bleached. Among the uses of recycled paper are newsprint, tissues and paper towels.

Bleaching

Some pulping processes produce light colored pulp, but many produce pulp the color of cardboard. Wood pulp used to produce paper must be bleached or brightened to remove colored pigments. Lignin that remains in the paper pulp is often dark in color. Bleaching removes the lignin from the pulp. Brightening is a process that leaves the lignin in the pulp, but it is modified to form a compound lighter in color.

The bleaching process usually involves a series of processes to obtain whiteness. It is an expensive process that requires large investments in equipment, and maintenance cost for the equipment is high because the

chemicals used for bleaching are corrosive. Waste materials produced by the bleaching process require treatments to prevent pollution of the environment with highly toxic substances.

Paper Products

The production of paper from wood pulp begins with the preparation of paper stock. This is done by subjecting the pulp to a refining or beating process by which the pulp fibers are further separated, crushed and cut to uniform sizes. This is done using machines such as beaters and refiners that use abrasive action to enhance the fibers. This process improves the potential for strong chemical and ionic bonds to develop in the finished paper, holding the fibers together. Most paper products are blends of different kinds of paper pulp. Blends of pulp are obtained by mixing bales of dried pulp of the desired quality with liquefied pulp and reprocessing the mixture.

Paper is made by spreading the liquid pulp on the moving screen of a Fourdrinier paper machine. A smooth and uniform mat of liquid paper is formed on the screen by the machine. Excess water is drained off the paper that forms during this process. The continuous paper ribbon is pressed and dried by heated rollers and hot drum dryers. Surface coatings are applied to the better grades of paper that are to be used for printing or writing, and the paper is rolled under pressure to assure smoothness of the paper surfaces. The paper is then rolled up in huge rolls as the dried paper comes off the end of the machine in a continuous ribbon.

The final step in the production of paper products is to cut the paper into standard sizes or to form the paper into useful shapes, such as paper plates, cups, boxes, etc. This is followed by packaging the paper products for shipment.

CAREER OPTION: ENVIRONMENTAL QUALITY TECHNICIAN

A person who works as an environmental quality technician in the paper and pulp industry is responsible to monitor all phases of processing to identify areas within the processing plant where abnormal amounts of pollutants enter the water stream or escape into the atmosphere. He or she collects samples of water and air on a routine basis, submits samples for laboratory testing, and interprets the results of the water and air

quality tests. Environmental quality technicians work with process engineers to devise ways to monitor waste water outputs and smokestack emissions. It is the responsibility of the water quality technician to assure that government standards are met for water quality before the water is discharged from the plant. A college/university degree is usually required for employment in this career.

CHEMICAL PRODUCTS

One process used to make wood pulp is the **dissolving process**. This process is used to dissolve cellulose into a viscous liquid called **cellulose xanthate**. This material is used to produce products like rayon, photographic films, and cellophane. Rayon is made by extruding a solution of cellulose xanthate through tiny holes and spinning the fibers together to produce thread and cloth. It can also be cast in thin layers to form cellophane or converted to an acetate product to produce photographic film. Other uses of cellulose include explosives such as dynamite or nitroglycerin. Cellulose is also the source of cellulose ethers used in the production of lacquers, adhesives, latex paints, pharmaceuticals and cosmetics.

Through a process called **saccharification**, the polysaccharides that make up the cellulose in wood are converted through hydrolysis to form simple sugars. This can be done commercially by treating wood chips with acids. **Fermentation** of these sugars produces **ethanol** which is a fuel-grade alcohol. All the simple sugars obtained from wood can be fermented to ethanol by using a combination of yeasts. When ethanol is mixed at the rate of 10% ethanol with 90% gasoline, a fuel called **gasohol** is produced. This fuel burns well in the internal combustion engines that provide power for cars and trucks. Another alcohol obtained by heating wood is methyl alcohol. It also works well as a fuel when it is blended with gasoline.

A number of gases can be recovered from wood by heating it above its combustion point in the absence of oxygen. This process is called **destructive distillation**, because the wood is reduced to charcoal and the volatile gases are released from the wood. The charcoal produced is a wood product high in its carbon content (74-81%) due to the concentration of carbon during the distillation process. For this reason, the destructive distillation of wood is also a **carbonization process**. The charcoal produced in this manner burns with a very hot, smokeless flame. When used as an industrial fuel, it is called coke. Among the end products collected by destructive distillation of wood are acetic acid, acetone, methane and tar.

An industrial oil similar to petroleum can be produced through a process called **thermo-chemical liquefaction**. Wood chips are heated under high pressure in a hydrogen gas or syngas atmosphere. Syngas is a synthetic gas produced from methane and carbon monoxide, both of which are recovered during the carbonization process. Oils produced by this process have potential for future use, but they are not economical at the present time.

Extracted Wood Products

Some valuable wood products called **extractives** can be extracted from wood using solvents. Water soluble extractives include a class of chemicals called tannins.

These chemicals are used to process animal hides into leather. They are extracted from the bark and heartwood of some varieties of trees by dissolving them in water heated to 80-12°C. Some tannins are also used in the production of adhesives.

Extractives obtained from wood using organic solvents include fatty acids, turpentine and rosin. These products are called **naval stores** due to their historic use in caulking and sealing wooden ships to prevent leaking. They form rich deposits in the heartwood of pine trees. **Wood naval stores** are obtained from the chipped or shredded wood from pine stumps and logs by dissolving them in organic solvents. **Gum naval stores** are obtained by injuring pine trees and collecting a mixture called **oleoresin** that flows from the wounds. The oleoresins are composed of oils, turpentine and rosin, and the different products are separated by distilling them. **Sulfate naval stores** are obtained as by-products from the Kraft pulping process.

Turpentine and rosin are important wood products. Turpentine is used for many things including the production of a synthetic pine oil used to make cough syrup. It is also the source of flavors and fragrances such as spearmint, lilac, peppermint, menthol, lemon and others. Rosins are used as a sizing agent for paper products to reduce their absorption of water. They are also used to manufacture some types of adhesives.

BIOMASS (ENERGY)

Biomass is defined as all the wood available in the stem, leaves, branches and roots of a tree. This unit will consider biomass as a fuel product. Wood is an efficient source of renewable energy, and biomass production is an efficient use of wood. This is because nothing is wasted when wood is used for biomass production. The entire tree can be used to produce heat, and most biomass fuels are used to produce steam. Most steam from this source is used to operate generators in the production of electrical energy.

Much of the wood used in biomass production grows in plantations where biomass is the intended crop. In addition to wood produced for this purpose, wood recovered from the waste materials in lumber mills is also called biomass. The forest industry has become much more efficient in the use of

wood by-products in recent years, and much of the wood once wasted is now used in reconstituted wood products or as biomass fuel in electrical generating plants.

Trees harvested for use as biomass are chipped or shredded. New varieties of fast growing trees have made it feasible to produce competitively priced electricity with the heat generated from burning biomass products. Fast growing hybrid varieties of trees have reduced the time required to produce a biomass crop, and research has demonstrated that high density plantings are capable of high yields of biomass products. Biomass production has great promise as a commercial crop.

Wood of all varieties tends to be very similar in its actual chemical make-up. A pound of

hardwood will produce approximately the same amount of heat as a pound of softwood (approximately 8,300 BTU). A pound of biomass has been demonstrated to produce about the same amount of heat as wood when both products are dry. Differences do exist in woods of different varieties, but the differences are in their densities. The volume of a pound of hardwood is less than the volume of a pound of softwood. On a per pound basis, biomass products, regardless

of variety, are very similar in the amount of energy they produce.

Biomass as an energy crop is destined to play an increasing role in power production because it is renewable and the yields are high. In a modern world where efficiency of production is valued, and the demand for electricity is rising, biomass can be expected to emerge as an important source of energy.

LOOKING BACK

Half of the annual timber harvest is used for something besides building materials. The cellulose contained in the cells of trees is valuable for paper products. It is processed by reducing wood to pulp from which paper products are made. The cellulose found in pulp is also converted into other products such as rayon photographic films, lacquers, adhesives, cosmetics, explosives, cellophane and many other products. Wood is also converted to charcoal through a carbonization process. Byproducts of this process include acetic acid, acetone, methane and tar.

An industrial oil is also obtained from wood using the process called thermochemical liquefaction. Naval stores and tannins are extracted from wood by dissolving these materials in solvents. Biomass is produced by chipping entire trees including stems, branches, roots and foliage. Electrical energy is generated by burning biomass obtained from plantation biomass crops and sawmill wastes.

QUESTIONS FOR DISCUSSION AND REVIEW

Essay Questions

1. What is the relationship between monosaccharides and polysaccharides?
2. Why is cellulose important to the fiber and paper industries?
3. What is the purpose of adding chemical pulp to mechanical pulp in the manufacture of newsprint?
4. Name the different pulping processes, and compare the methods that are used by each of them.
5. Explain the bleaching and brightening processes and describe the differences between them.
6. Describe the process by which wood is converted to ethanol.
7. What are the end products of the process called destructive distillation?
8. What are some extracted products and how are they obtained from wood?
9. List some commercial products that are obtained from naval stores.
10. What is biomass and how is it used commercially?

Multiple Choice Questions

1. Another name for a simple sugar that forms in long chains to make cellulose is:
a. monomer
b. Lignin
c. hemicellulose
d. polysaccharide
2. A pulping process in which wood fibers are separated from each other by grinding or abrasion is called:
a. chemical pulping
b. hydrapulping
c. mechanical pulping
d. semichemical pulping
3. A pulping process in which wood fibers are separated by dissolving the lignin that cements them together is called:
a. hydrapulping
b. chemical pulping
c. mechanical pulping
d. disk refining
4. A machine that is used to reduce recycled paper to pulp is the:
a. Fourdrinier
b. stone grinder
c. disk refiner
d. hydrapulper
5. A process that changes the lignin in paper pulp to a compound that is lighter in color is known as:
a. bleaching
b. brightening
c. coloring
d. blending
6. Which of the following products does not come from cellulose xanthate?
a. naval stores
b. photographic film
c. cellophane
d. rayon
7. A fuel that is composed entirely of the product that is obtained by converting cellulose to simple sugars and fermenting them to form alcohol is called:
a. methanol
b. charcoal
c. gasohol
d. ethanol

8. Oil can be produced from wood using a process called:
 - a. destructive distillation
 - b. saccharification
 - c. thermochemical liquefaction
 - d. fermentation
9. Oleoresin is a product that is obtained by collecting the sap from trees. Which of the following materials contains oleoresin?
 - a. wood naval stores
 - b. gum naval stores
 - c. sulfate naval stores
 - d. food grade margarine
10. Which of the following materials produces the hottest flame when it is burned?
 - a. hardwood
 - b. softwood
 - c. charcoal
 - d. biomass

LEARNING ACTIVITIES

1. Obtain microscopes with which to observe the structure of paper and paper products. Point out the overlapping structure of the fibers and explain to them that chemical and ionic bonds also attract and hold the wood fibers together.
2. Collect as many products as you can find that are obtained from wood. Assign pairs of students to make and display posters illustrating how the product was manufactured. Give each group of students an opportunity to discuss their product with the class. Keep the collection of products together to be used in future classes.