SEMICHEMICAL PULP

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What is semichemical pulp? How does it compare with conventional wood pulps? Can semichemical pulp be bleached? These are some of the questions frequently asked by pulp and paper technologists during the last few months. Their curiosity is a reflection of the renewed interest in one of our oldest but little-practiced (and, apparently, little-known) branches of the wood pulping industry. A review and appraisal of the semichemical pulping situation as it exists today is, therefore, timely.

Semichemical Pulping Defined

Semichemical pulping can be broadly defined as a two-stage pulping process involving chemical treatment to remove part of the lignocellulose fiber-bonding material and mechanical refining to complete the pulping action. Semichemical pulping usually refers more particularly, however, to the process whereby wood chips are given a mild cooking with a conventional pulping agent followed by disintegration (fiberizing) of the softened chips in a suitable refiner. Among the conventional pulping agents are acid sulfite, neutral sulfite, soda, and sulfate liquors, and the general term of semichemical pulping refers to the use of any one of these reagents. A consistent nomenclature for complete identification of semichemical pulp is to prefix the term with the particular liquor used (for example, neutral sulfite semichemical pulp).

Interpreted broadly, the definition above would include processes such as the grinding of steamed wood or the refining of chips at relatively high pressures because the hydrolytic action of water under heat and pressure causes a certain dissolution of lignocellulose, even though this action is incidental to the main aim of softening the binding material. In the same way the grinding of chemically treated wood is a kind of semichemical pulping, even though the chemical action is confined to the outer regions of the wood block. In its broadest sense, likewise, the definition above would include certain sulfite and sulfate pulping operations where yields of 55 percent or more are purposely striven for and the product requires more or less mechanical defibering. However, these raw pulps, when produced in yields of less than 60 percent, are generally not classed as semichemicals and for the purpose of this discussion none of the processes described in this paragraph are considered to be true semichemical processes.

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Significance of Semichemical Pulping

For purposes of wood conservation and cost reduction, pulp technologists have attempted for years to develop a pulping process that would give pulps with strengths approaching those of full chemical pulps but with yields near groundwood. As early as 1874 Mitscherlich patented the softening of wood chips with sulfurous acid or bisulfites followed by disintegration by rubbing or grinding to a pulp in 90 percent yield. Numerous proposals have been made in the intervening years. Applications of the semichemical process have been limited, however, to corrugating and liner board, insulating board, and some wrappings. Sodium sulfite liquor is mostly used for the preparation of the pulps; sulfate and soda liquors are used less extensively. The rather limited applications may be due mainly to incomplete understanding of the full possibilities of the process and to inadequate development of the methods and equipment needed for its successful operation.

Recently semichemical pulping has taken on renewed significance because of the increasing recognition of hardwoods (particularly suitable for semichemical pulping) as an important factor in our pulpwood economy and because of the discovery that bleached neutral sulfite semichemical pulp probably offers our nearest practical approach to recovering the whole carbohydrate fraction (holocellulose) from wood. In addition, improvements in semichemical pulping methods and equipment, particularly refining, promise to overcome many former difficulties. Thus, there is good reason to believe that in the future semichemical pulping will find increasing application because of advantages in cost and utilization of less desirable species.

Semichemical Pulping Procedures

Neutral sulfite semichemical pulp, the main semichemical pulp produced commercially (approximately 150,000 tons annually), is made on the basis of the procedure developed by Rue Wells, Rawling, and Steidl at the Forest Products Laboratory, as follows: Wood chips are given a mild cooking in a globe rotary (kraft digesters converted to purpose used in one instance) with a liquor containing sodium sulfite (60 to 80 grams per liter), buffered with sodium bicarbonate (22 to 30 grams per liter), and made by sulfiting soda ash. Byproduct sodium sulfite buffered with soda ash is also used in some cases. The chemical for cooking can be added directly in a very high liquor-wood ratio or in an impregnation stage using an excess of liquor, the excess being drawn off when sufficient chemical is absorbed. The cooking is performed at 150° to 160° C. with 7 to 15 percent chemical and a cycle of 4 to 6 hours, depending on the yield and species. Yields of 70 to 85 percent are obtained. The softened chips may be fiberized in rod mills, disk refiners, or other suitable types, followed in some cases by jordans. A small amount of neutral sulfite and soda semichemical pulp is also made by a patented process in which wood chips are given a brief cooking at elevated temperature and pressure in a continuous manner and the treated chips fiberized under pressure in a type of disk refiner.
In acid sulfite, soda, and sulfate semichemical pulping, lower concentrations and chemical consumptions and shorter cooking times or lower temperatures in comparison with full chemical pulping are used to produce the softened chips. Waste or black liquors have also been used.

Comparison of the Several Semichemical Processes

The various modifications of semichemical pulping (acid and neutral sulfite, soda, and sulfate) show somewhat different pulping action. Average results for a number of hardwoods produced in yields of 75 percent gave the following comparison. Alkaline reagents reacted rapidly with the alkali soluble wood constituents and the resulting pulps had very high lignin contents. Acid sulfite liquors removed considerable amounts of lignin and tended to degrade the cellulose. Neutral sulfite liquors also removed considerable lignin (30 to 50 percent of that originally present in the wood) but showed relatively little reaction toward cellulose and hemicellulose. Sulfate and neutral sulfite pulps were, on the whole, appreciably stronger than soda or acid sulfite pulps. The acid and neutral sulfite pulps were much brighter than the alkaline pulps.

Hardwoods More Suitable than Softwoods

All woods can be reduced to semichemical pulps having more or less desirable qualities by the various semichemical pulping processes. The hardwoods have been found, however, to be more suitable than the softwoods because the semichemical pulp strengths obtained from the latter are not commensurate with their fiber lengths. The hardwoods, on the other hand, produce semichemical pulps with strengths much higher than would be expected from their shorter fiber lengths. For example, soda and sulfate semichemical pulps from Southern pine were shown recently to have slightly lower strength properties than the same kinds of pulp from a number of southern hardwoods. Again, aspen neutral sulfite semichemical pulp has strength properties in the same range as a similar kind of pulp from spruce.

The favorable reaction of many hardwoods toward semichemical pulping is particularly important in view of the growing importance of using these species.

Properties and Uses of Semichemical Pulps

Neutral sulfite semichemical pulp from spent chestnut chips has been for many years well-known to have qualities making it highly suitable for 9-point corrugating paper, particularly that of stiffness. This type of pulp from gum has also been used successfully for butchers' paper and like grades. Sulfate semichemical pulps have also been used successfully in paperboard.

Report No. RI477

-3-
A property limiting the usefulness of semichemical pulp is its relatively low brightness. Alkaline semichemicals are dark-colored like kraft pulps, and acid and neutral semichemicals vary with the color of the wood. Pulps from the lighter colored woods have been proposed as a replacement of the chemical constituent in newsprint pulps. Blending semichemical pulp with groundwood tends to counteract the tendency of semichemical (especially neutral sulfite) to be hard (tinny), although this property can be controlled to some extent by the refining. Hardwood sulfate and neutral sulfite semichemicals, because of their short fiber, are relatively low in tearing strength, but have bursting and tensile strengths equal to many softwood sulfites.

**Bleached Semichemical Pulp**

The limitations of hardwood semichemical pulp (particularly brightness) have stimulated research on its bleaching in spite of its high lignin content (and, hence, high bleach consumption). Considerable progress has been made with improvements in refining and bleaching procedures. Mill-scale demonstrations have shown that the production of bleached neutral sulfite semichemical pulp is a definite possibility from both technological and cost standpoints. Modern multistage bleaching procedures have been applied with success to suitably refined neutral sulfite semichemical pulps from several woods, including aspen. Aspen is especially suited because of its relatively low lignin and high cellulose contents and excellent strength properties. Yields of bleached pulp of 58 percent can be obtained and the pulps are equal in most strength properties to bleached softwood sulfites. Birch and gum neutral sulfite semichemical pulps also show promise for bleaching.

The neutral sulfite process is generally the best suited of the several semichemical methods for producing pulp for bleaching because in it the chemical action is mainly one of lignin removal with relatively little effect on cellulose and hemicellulose. The residual lignin, amounting to from 10 to 15 percent of the pulp, can be readily removed by chlorine bleaching methods. Since the wood undergoes no drastic cellulose or hemicellulose attack in either the semichemical pulping or bleaching stages, the yield of bleached pulp is exceptionally high, and the over-all process is believed to be the nearest practical approach to the recovery of the carbohydrate fraction of wood. The resultant pulp has been indicated as being quite versatile. Experimental papers ranging from glassine to bond and including groundwood book papers with substantial portions of bleached semichemical have been made. Caustic purification treatment of the bleached pulp produces a high yield of high-grade alpha pulp. Because of the mild nature of the pulping and bleaching operations the alpha pulp suffers little degradation in its production and may be suitable for uses where this property is valuable. Since a large proportion of the hemicelluloses originally present in the wood are removed in the caustic purification stage, their recovery and subsequent utilization may be possible.