Bleached, Kraft chemical pulp having increased hemicellulose content compared to conventional Kraft chemical pulps. In one embodiment, the pulp has a hemicellulose content greater than about 17 weight percent as measured by the 18% caustic solubility test. In another aspect, a method for making wood cellulose pulp having increased hemicellulose content compared to conventional Kraft chemical pulps. In the method, a lignocellulosic material is pulped in caustic sulfide to provide a first brownstock, which is treated with oxygen to provide a second brownstock, which is then bleached to provide the pulp product.
Fig. 1.
CELLULOSE PULP HAVING INCREASED HEMICELLULOSE CONTENT

FIELD OF THE INVENTION

[0001] The present invention relates to cellulose pulp and, more particularly, to chemical pulp having increased hemicellulose content.

BACKGROUND OF THE INVENTION

[0002] Pulp refers to cellulose fibers that have been liberated from wood or other lignocellulosic materials through physical and/or chemical processes. Pulp manufactured for papermaking applications is generally dispersed in water as a slurry and then reformed into a web or sheet.

[0003] Pulping methods include chemical, mechanical, and chemi-mechanical processes. While mechanical pulping methods rely on physical action and thermal energy to liberate fibers, chemical pulping methods rely on the effect of chemicals to separate fibers from raw materials. Generally, the more chemicals used in a pulping process, the lower the pulp yield and lignin content because chemical action degrades the wood and solubilizes wood components including lignin and hemicellulose. While mechanical pulp yields are typically greater than about 90 percent, chemical pulp yields are considerably lower, more often in the range from about 40 to about 65 percent.

[0004] Although chemical pulping methods result in lower pulp yields, these methods provide individual pulp fibers that are uncut, which is in contrast to fibers produced from mechanical pulping methods. Furthermore, pulp fibers produced by chemical pulping methods provide paper products having increased strength because lignin, which interferes with interfiber hydrogen bonding, is largely removed during the process. Of the chemical pulping processes, the Kraft process produces generally stronger pulps compared with the other major chemical pulping method, the sulfite process.

[0005] Chemical pulping of wood and other lignocellulosic materials results in delignification of the raw material. Delignification is the process of breaking down of lignin and rendering the breakdown products soluble in the cooking liquor (alkali), such that the lignin can be removed from the cellulose. A pulp's lignin content can be measured by kappa number. The higher the measured kappa number, the greater a pulp's lignin content. The kappa number is often used to monitor delignification during and after pulping processes. A similar test is the permanganate number.

[0006] Pulps produced by the Kraft pulping process have a light to dark brown color and, as a consequence, are bleached to increase the pulp's brightness.

[0007] Accordingly, there exists a need for a Kraft pulp that offers the advantage of strength associated with conventional Kraft pulps, while at the same time has improved yield and increased hemicellulose content compared to conventional Kraft chemical pulps. The present invention seeks to fulfill these needs and provides further related advantages.

SUMMARY OF THE INVENTION

[0008] In one aspect of the invention, a Kraft chemical pulp having increased hemicellulose content is provided. The Kraft chemical pulp is a wood pulp having increased hemicellulose content compared to conventional Kraft chemical pulps. In one embodiment, the pulp has a hemicellulose content greater than about 14 weight percent as measured by the 18% caustic solubility test. The pulp can be incorporated into sheets having initial (unrefined) tensile strengths significantly greater than sheets incorporating conventional Kraft chemical pulp fibers. The pulp is more readily refined than conventional chemical pulps and achieves strength/drainage properties at significantly less refining energy. The pulp can be produced in higher yield than other Kraft chemical pulps.

[0009] In another aspect, the invention provides a method for making cellulose pulp having increased hemicellulose content. In the method, a lignocellulosic material is pulped with a liquor, which includes sodium hydroxide (NaOH), sodium sulfide (Na2S), anthraquinone, and some residual sodium carbonate (Na2CO3) from the causticizing process, to provide a first brownstock. The first brownstock is treated with oxygen to provide a second brownstock, which is then bleached to provide the pulp product. The caustic sulfide includes polysulfide and anthraquinone. Chlorine dioxide is used in the bleaching.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0011] FIG. 1 is a flow diagram illustrating of a representative method for producing the pulp of the invention; and

[0012] FIG. 2 is a graph comparing percent yield as a function of kappa number for pulps made by the method of the invention (A) and for pulps made by conventional cooking (B), digester yields for the methods are also illustrated (C and D, respectively).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] In one aspect, the present invention provides a wood cellulose pulp having increased hemicellulose content. The Kraft chemical pulp of the invention is a wood pulp having increased hemicellulose content compared to conventional Kraft chemical pulps. Because hemicellulose imparts flexibility to a fiber, the pulp fibers of the invention are more flexible in papermaking systems and exhibit greater interfiber bonding compared to conventional Kraft chemical pulps. The increased flexibility and interfiber bonding of the fibers renders sheets or webs that incorporate these fibers stronger than sheets or webs incorporating conventional Kraft chemical pulp fibers. The pulp of the invention provides sheets having initial (unrefined) tensile strengths significantly greater than sheets incorporating conventional Kraft chemical pulp fibers.

[0014] As a result of the pulp fiber's flexibility and increased hydrogen bonding potential, the amount of refining required to achieve a particular sheet strength (tensile strength) or advantageous drainage property (Canadian Standard Freeness, CSF) is greatly reduced. Thus, the pulp of the invention can be refined to a predetermined point.
more readily than a conventional Kraft chemical pulp making the pulp of the invention more attractive from a refining energy requirement basis. The pulp of the invention is more readily refined than conventional Kraft chemical pulps and achieves strength/drainage properties at significantly less refining energy.

[0015] Because the pulp of the invention has increased hemicellulose content compared to other Kraft chemical pulps, the pulp is produced in higher yield than other Kraft chemical pulps.

[0016] The pulp of the invention is a fully bleached pulp suitable for paper grade market pulp.

[0017] Hemicellulose Content. As noted above, the pulp of the invention advantageously has an increased hemicellulose content compared to conventional chemical pulps. In one embodiment, the pulp of the invention has a hemicellulose content greater than about 17 percent as measured by the 18% caustic solubility test described below. The hemicellulose content of the pulp of the invention is about 2 percent greater than conventional chemical pulps. Other conventionally produced softwood Kraft pulps have a hemicellulose content less than about 16 percent as measured by the 18% caustic solubility test.

[0018] The hemicellulose content of pulp can be measured by several methods. One empirical method is the 18% caustic solubility method (TAPPI T-235 CM-40). In this method, a weighed quantity of pulp (1.5 g) is soaked in 18 percent by weight aqueous sodium hydroxide (100 mL) for 1 hour. During the soak, the pulp fibers swell and the pulp's hemicellulose dissolves into solution. The pulp is then filtered, and 10 mL of the filtrate is mixed with 10 mL of potassium dichromate and 30 mL sulfuric acid. This solution is titrated with ferrous ammonium sulfate. The percent alkali solubility is then calculated using the amounts of the various solutions and the amount of pulp. The method is usually an underestimate of hemicellulose content because not all of the hemicellulose is dissolved and removed from the pulp during this procedure. Hemicellulose content for a pulp may also be determined by sugar analysis of completely digested pulp. Such a determination would generally provide a higher hemicellulose content value than the 18% caustic solubility method.

[0019] Sheet Tensile Strength. The pulp of the invention has an unrefined sheet tensile strength significantly greater than other Kraft chemical pulps. Conventional chemical pulps provide sheets having initial tensile breaking length from about 2.5 to about 4.0 km as measured by the TAPPI T 220. The pulp of the invention provides sheets having initial tensile strengths of from about 4.5 to about 5.5. In one embodiment, the pulp provides a sheet having an initial tensile strength of about 5, which is at least a 20 percent increase compared to conventional Kraft chemical pulps.

[0020] Yield. Due at least in part to the pulp's increased hemicellulose content, the pulp of the invention is produced in greater yield than other conventional Kraft chemical pulps. The yield provided by the method of the invention is at least about 3.0 to about 3.5 percent greater than for conventional Kraft pulps. FIG. 2 is a graph that compares percent yield as a function of kappa number for pulps made by the method of the invention (e.g., cooked with polysulfide and anthraquinone and treated with oxygen) (Curve A in FIG. 2; from about 47 to about 51 percent) and for pulps made by conventional cooking followed by oxygen treatment (Curve B in FIG. 2; from about 45 to about 47 percent). Digester yields for these processes are also illustrated (Curves C and D, respectively, in FIG. 2). Yields are based on the weight of oven-dried chips introduced to the digester. For the pulps made by the method of the invention, the digester kappa was 33, 38, and 43. For the pulps made by conventional methods, the digester kappa was 34, 38, and 44.

[0021] Brightness and Lignin Content. The pulp of the invention is a fully bleached pulp (i.e., brightness greater than 89% ISO). There are two principal types of measurements to determine the completeness of the pulping or bleaching process: the degree of delignification and the brightness of the pulp.

[0022] There are many methods of measuring the degree of delignification of the pulp. Most are variations of the permanganate test. The normal permanganate test provides a permanganate or K number that is the number of milliliters of 0.1 N potassium permanganate solution consumed by one gram of oven dry pulp under specified conditions (see TAPPI Standard Test T-214). The kappa number is similar to the permanganate number, but is measured under carefully controlled conditions and corrected to be the equivalent of a 50 percent consumption of the permanganate solution in contact with the sample. The test gives the degree of delignification of pulps through a wider range of delignification than does the permanganate number. The kappa test measures the consumption of permanganate ion by lignin. The kappa number is the number of milliliters of 0.1 M potassium permanganate consumed by one gram of pulp in 0.5 N sulfuric acid after a 10 minute reaction time at 25° C. under conditions such that one-half of the permanganate remains unreacted (see TAPPI Standard Test T-236). The kappa number for the pulp of the invention is described below in reference to the pulping process.

[0023] There are also a number of methods of measuring pulp brightness. Brightness is a measure of reflectivity and its value is expressed as a percent of some scale. Brightness can be measured by TAPPI Method T 525 OM-92.

[0024] The brightness of the product pulp of the invention is in the range from about 75 to about 95% ISO. In one embodiment, the pulp’s brightness is from about 88 to about 92% ISO. In another embodiment, the pulp has a brightness of about 90% ISO.

Pulping/Bleaching Methods

[0025] In another aspect of the invention, a method for making a cellulose pulp having increased hemicellulose content pulp is provided. The method includes the steps of Kraft chemical pulping, oxygen delignification, and bleaching. The combination of steps in the method provides for delignification while maintaining hemicellulose content to improve yield and provide a chemical pulp having the advantageous characteristics noted above.

[0026] A flow diagram illustrating a method for producing the pulp of the invention is illustrated in FIG. 1. Referring to FIG. 1, wood chip supply 10 provides wood chips to digester 20. Liquor is provided to the digester from white liquor supply 70 through polysulfide/anthraquinone proces-
The polysulfide/anthraquinone processor provides liquor containing polysulfide and anthraquinone to the digester. White liquor and brownstock from the digester are provided to oxygen reactors 30. The oxygen treated pulp from the oxygen reactors is then provided to bleach stages 40. The bleached pulp from the bleaching stage is then provided to pulp machine 50. At the pulp machine, the pulp is deposited onto a foraminous support (e.g., Fourdriner), water is withdrawn, the wet pulp pressed, and then dried to provide the pulp product.

[0027] Chemical Pulping. Pulping is the process in which wood chips or other wood particulate matter is converted to fibrous form. Chemical pulping requires cooking of the chips in solution with a chemical, and includes partial removal of the coloring matter such as lignin associated with the wood. The pulp of the invention can be prepared by the Kraft process as described herein. In general, the pulping process useful in making the pulp of the invention is a full chemical pulping method using sodium hydroxide and sodium sulfide at a pH greater than about 12, at a temperature from about 160 to about 180°C for about 0.5 to about 5 hours.

[0028] The cooking liquor useful in the pulping process of the invention includes polysulfide. Polysulfide has the formula NaS(S)ₙSNa, where n=4-6. The polysulfide is used in the process to mitigate alkaline peeling (i.e., to improve the quality of the cellulose and increase pulp yield by reducing the occurrence of destructive chemical reactions referred to as "peeling"). In one embodiment, in the practice of the method, a polysulfide process system provides the digester with between about 4 to about 9 g/L polysulfide (as sulfur). In another embodiment, a polysulfide process system provides the digester with between about 5.0 to about 6.5 g/L polysulfide at about 25 to 37 percent sulfidity.

[0029] In addition to polysulfide, the pulping process of the invention also includes anthraquinone to mitigate alkaline peeling. Anthraquinone is added to the polysulfide in the polysulfide system (see polysulfide/anthraquinone processor 80 in FIG. 1). Anthraquinone is a pulping additive useful to increase delignification, decrease carbohydrate degradation, and improve pulp yield. Anthraquinone achieves these advantageous properties through a chemical cycle that leads to the lignin reduction and the oxidation of cellulose’s reducing endgroup aldehyde to a carboxylic acid. Anthraquinone is typically used in an amount up to about 0.10 percent by weight based on the total weight of wood. In one embodiment, anthraquinone is used from about 0.03 to about 0.07 percent by weight based on the total weight of wood. Modified anthraquinones, such as 1,4-dihydro-9,10-di hydroxyanthracene (DDA, or soluble anthraquinone, SAQ), can also be used.

[0030] Lignin content is typically measured during chemical pulping to monitor the degree of cooking (i.e., delignification) or to measure residual lignin before bleaching and between bleaching stages to monitor the process. As noted above, lignin can be measured indirectly by measuring the amount of oxidant consumed by lignin in the sample.

[0031] After digesting, the pulp has a kappa number in the range from about 20 to about 65. In one embodiment, the kappa number after digesting is about 34 to 45. In one embodiment, the kappa number after digesting is about 36 to 43. In a further embodiment, the kappa number after digesting is about 38.

[0032] The products from the pulping or digesting are black liquor and brownstock. Black liquor is the waste liquor from the pulping process and contains the original cooking inorganic elements and the degraded, dissolved wood substances. Black liquor contains lignin and lignin byproducts and is separated from the brownstock and directed to a recovery system that separates the lignin and byproducts from the residue cooking chemicals, which can be recycled back to the digester. After separating from black liquor, the pulp produced from the digestion is washed to provide brownstock. Screening may occur before or after oxygen delignification. In the process of the invention, brownstock is introduced into the oxygen delignification system.

[0033] Oxygen Delignification. The oxygen delignification system useful in producing the pulp of the invention achieves from about 40 to about 50 percent delignification.

[0034] Oxygen delignification is the delignification of pulp using oxygen under pressure in aqueous alkali. Pressures typically range from about 550 to about 700 kPa (about 80 to about 120 psi). The alkali is typically sodium hydroxide present in about 3 to about 5 percent by weight based on the weight of pulp. Delignification can be carried out at temperatures from about 90 to about 130°C for a period of time from about 20 to about 60 minutes. The oxygen stage can be carried out in a single vessel or in a two-vessel system. The oxygen delignification step may include the use of magnesium ion in an amount from about 0.05 to about 0.25 percent by weight based on the weight of pulp to mitigate extensive carbohydrate degradation.

[0035] After oxygen delignification, the pulp has a kappa number in the range from about 8 to about 35. In one embodiment, the kappa number after oxygen delignification is about 18 to 22.


[0037] The pulp produced by the oxygen delignification step is introduced to the bleaching stage.

[0038] Bleaching. Bleaching is the treatment of pulp fibers with chemical agents to increase their brightness. Brightness is a term used to describe the whiteness of pulp or paper on a relative scale. Bleaching of chemical pulps is achieved by lignin and color removal.

[0039] Chemical pulp bleaching can be accomplished using various chlorine- and/or oxygen-containing compounds (e.g., chlorine dioxide) in combination with alkali (e.g., sodium hydroxide) extractions in several stages. Bleaching of chemical pulps tend to involve the use of chemicals that are more specific to lignin removal than to carbohydrate degradation. Each stage includes a bleaching step and a washing step to provide progressively bleached pulp. Each stage includes a pump and a mixer to mix the pulp with a bleaching chemical, a retention tower to allow time sufficient for the pulp and bleaching chemical to react, and a washer to remove the bleaching chemical and solu-
bibilized pulp components from the bleached pulp. The bleaching chemical and solubilized pulp components are typically washed from the pulp with either fresh “mill water” or filtrate from another bleach stage in a counter current wash flow to save the use of fresh water. The wash water may be alkaline or acid depending on the stage being washed.

[0040] In one embodiment of the method, the bleaching process is an Elemental Chlorine Free (ECF) bleaching process. In the process, chlorine dioxide is the bleaching agent and aqueous sodium hydroxide is the alkali extractant. In one embodiment, the bleaching method includes three stages. Examples of representative stages include: D(Eop)D; D(Eop)D, DED; D(Ep)D; D(Eop)P; D(Eop)P; D(Eop)DE; D(Eop)PP; D(Eop)DE; D(Eop)DE; or D(PaP)(Eop)DEDP, among others. For these stages, D refers to chlorine dioxide bleaching, E refers to extraction, Eo refers to extraction including oxygen, P refers to bleaching with hydrogen peroxide, Eop refers to alkaline extraction including oxygen and peroxide, and PaP refers to Papricycle.

[0041] In one embodiment of the method, the bleaching sequence includes the following: (1) chlorine dioxide treatment, (2) sodium hydroxide treatment with oxygen and peroxide, (3) chlorine dioxide treatment, (4) sodium hydroxide treatment, and (5) chlorine dioxide treatment.

[0042] In another embodiment of the method, the bleaching process is a Total Chlorine Free (TCF) bleaching process (i.e., a process that does not include chlorine).

[0043] There are many other bleaching sequences that can be used in the method of the invention. Listings of these sequences may be found in the standard texts. Other stages include bleaching with chlorine, chlorine dioxide, hydrogen peroxide, or a hypochlorite. These stages are interspersed with alkali extraction and/or washing.

[0044] After bleaching, the pulp is directed to a headbox in which the bleached pulp is slurried, deposited onto a forming wire (e.g., fourdriner forming wire), and dried to provide a web of bleached pulp.


Pulp Products

[0046] The pulp of the invention can be advantageously incorporated into absorbent products such as tissue and towel products. Tissue and towel products typically include a combination of fibers.

[0047] A representative tissue product can include from about 10 to about 40 percent by weight of the pulp of the invention. The tissue can further include other pulp, for example, bleached northern or southern softwood Kraft pulp, bleached northern or southern hardwood Kraft pulp, and chemi-thermomechanical pulp (CTMP), among others.

[0048] A representative towel product can include from about 30 to about 75 percent by weight of the pulp of the invention. The towel can further include other pulp, for example, bleached northern or southern softwood Kraft pulp and chemi-thermomechanical pulp (CTMP), among others.

[0049] The pulp of the invention can also be used in making saturating base paper in which the base paper that includes the pulp of the invention is saturated with a material such as, for example, melamine or latex.

[0050] The pulp of the invention can also be advantageously incorporated into flexible packaging paper grades and other technical grade papers.

[0051] While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A bleached, chemical pulp having a hemicellulose content greater than about 17 weight percent as measured by the 18% caustic solubility test (TAPPI T-235 CM-00).

2. The pulp of claim 1, wherein the digestor pulp has a kappa number in the range from about 20 to about 65.

3. The pulp of claim 1, wherein the pulp has a brightness in the range from about 75 to about 95.

4. The pulp of claim 1, wherein the pulp has an initial tensile strength in the range from about 4.5 km to about 5.5 km.

5. A tissue product, comprising a bleached, chemical pulp having a hemicellulose content greater than about 17 weight percent as measured by the 18% caustic solubility test (TAPPI T-235 CM-00).

6. The tissue product of claim 5, wherein the pulp is present in the tissue in an amount from about 10 to about 40 percent by weight based on the total weight of the tissue.

7. The tissue product of claim 5 further comprising a second pulp.

8. The tissue product of claim 7, wherein the second pulp is at least one of a northern bleached Kraft pulp, southern bleached Kraft pulp, or a chemi-thermomechanical pulp.

9. A towel product, comprising a bleached, chemical pulp having a hemicellulose content greater than about 17 weight percent as measured by the 18% caustic solubility test (TAPPI T-235 CM-00).

10. The towel product of claim 9, wherein the pulp is present in the towel in an amount from about 30 to about 75 percent by weight based on the total weight of the tissue.

11. The towel product of claim 9 further comprising a second pulp.

12. The towel product of claim 11, wherein the second pulp is at least one of a northern bleached Kraft pulp, southern bleached Kraft pulp, or a chemi-thermomechanical pulp.

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