Title: DEGUMMING AND SCOURING OF BAST MATERIAL FOR PRODUCTION OF TEXTILE AND PULP-QUALITY FIBER

Abstract: A method for degumming bast fibers comprising soaking a source of bast fiber in a saline solution. The source of bast fiber may be soaked in a saline solution having a concentration ranging between less than 1 part per thousand to about 200 parts per thousand. The saline concentration may vary as the source of bast fiber is soaking, or by alternating bast fiber between aqueous solutions of differing ionic concentrations. In one embodiment, the source of bast fiber is soaked in seawater, wherein the saline concentration varies by alternating the salinity using a tide. The source of bast fiber may be hemp.
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DEGUMMING AND SCOURING OF BAST MATERIAL FOR PRODUCTION OF TEXTILE AND PULP-QUALITY FIBER

Background of the Invention

Cellulosic bast fibers harvested from plants like hemp, flax and sisal are composed of large proportions of undesired material other than cellulose, including lignin, pectin and hemicellulose, known collectively as gum. Gum serves as a natural glue adhering cellulose fibers together to provide the plant with structural rigidity. For cellulose and fiber manufacturing purposes, gum is undesired. Its presence is detrimental to the manufacturing apparatus and product quality, and undermines the efficient conversion of raw bast into marketable cellulose fiber.

Processing bast-derived cellulose fiber requires the removal of gum through chemical and mechanical means, also known as degumming. Chemical treatments seek to target non-cellulosic molecules with minimal damage to cellulose polymers composing the fibers themselves.

Mechanical treatment is meant to enhance chemical transport as well as physically separate gum from its cellulose structure. Historically and generally, bast fiber degumming utilizes natural processes and ambient conditions to render the raw cellulose fiber and separate it from the rest of the plant - referred to as retting. Retting takes various forms but generally utilizes natural microbiological and chemical activity for degumming. For field retting, cut stalks are left exposed in the field for some time. In water retting, stalks are placed in ponds or streams.

Neither method guarantees consistent production of marketable textile fiber, creating uncertainty for markets. As recently as April 4, 2019, in the Wall Street Journal, page D3, Jeffrey Silberman, a professor and chairperson of textile development at the Fashion Institute of Technology in New York, stated that it takes a specific type of processing equipment to turn hemp into a fiber, and that type of machinery is still scarce. He is quoted as saying “New York state doesn’t have the processing equipment for it, at least as far as I can tell. I haven’t found a spinning mill that can handle hemp.”

The fibers obtained by conventional field and water retting yield a silver-grey colored fiber due to the byproducts and staining of biological processing. Enzymatic methods and other chemical methods result in a slightly yellow or blonde to white fiber.
Industrial scale quality-controlled degumming involves the formulation of chemical reagents and catalysts to specifically target gum and can generate problematic waste products, as well as fibers that are difficult to process.

The art is in need of a process whose effluents are readily reusable, or reducible to an environmentally inert form with minimal impact on water quality. A successful process execution should yield suitable cellulose fibers of consistent quality within a wide range of governing parameters.
Summary of the Invention

The present invention fulfills one or more of these needs in the art by providing a method for degumming (removal of structural non-cellulosic material) bast fibers comprising the soaking of a source of bast fiber in a saline or ionic solution. The source of bast fibers may be hemp.

In one embodiment, the source of bast fiber is soaked in a saline solution having a concentration ranging between about 1 part per thousand and up to about 200 parts per thousand. The ionic concentration of the saline solution may be varied while the source of bast fiber is soaking in the saline solution. This step may be conducted without electrolysis of the solution.

In one embodiment, the source of bast fiber is soaked in seawater. In another embodiment, the source of water is soaked in brackish water. The saline concentration may be varied over time; for example, either natural (tides) or man-made (alternating salt baths) may be used to fluctuate ion concentration. Because the ionic or saline concentration varies in water in estuaries as the tides ebbs and flows, immersing the source of bast fiber in an estuary for a series of tidal cycles can provide the salinity variations.

The saline solution may be amended with a gum-targeting reagent. The method may include soaking the bast fiber in a solution containing a base to degrade lignin into water-soluble forms for removal by water. A basic saline solution of a base at a pH from about 7 to about 14 may be used.

The method may include soaking the source of bast fiber in a solution including sulfur (S oxidation number < VI) to sulfonate lignin for removal from the source of bast fiber by water.

The source of bast fiber may be soaked in an oxidizing solution to scorch lignin, pectin and hemicellulose from the source of bast fiber for removal by water.

The method may include rinsing the source of bast fiber with detergent and surfactants to further remove lignin, pectin and hemicellulose from the source of bast fiber. The source of bast fiber may be mechanically agitated. For example, the source of bast fiber may be tumbled.

The present invention may also be considered a method for degumming hemp fibers from a hemp plant comprising soaking the hemp plant in a saline solution, soaking the hemp plant in a sulfur solution to sulfonate lignin for removal from hemp fiber in the hemp plant, and rinsing the hemp fiber with detergent to further remove lignin, pectin and hemicellulose from the hemp fiber.
The method may include soaking the hemp fiber in an oxidizing solution to remove lignin, pectin, and hemicellulose and their partially oxidized intermediates from the hemp fiber. For instance, the hemp fiber may be soaked in a hydrogen peroxide solution. The hydrogen peroxide and other oxidant sources may be generated in situ, e.g., via electrolysis. The hemp fiber may be soaked in the oxidizing solution at a pH between about 6 to about 14 and at a temperature below a boiling point of the oxidizing solution. This step may be conducted without electrolysis of the solution.

In one embodiment, the hemp fiber may be soaked in the sulfur solution at a pH between about 6 to about 14 and at a temperature between ambient (20-30°C) to about 95°C. In another embodiment, soaking the hemp plant in a saline solution comprises soaking the hemp plant directly into or within a vessel connected to natural, tidally-flushed coastal waters so that the ionic composition and associated alkalinity, acidity, and density of the solution approximate to the hemp plant varies with tidal fluctuations.

The resulting fiber is suitable for spinning into textile-quality yam using conventional textile methods and machinery, wherein the processing is selected from the group consisting of making a yam by spinning, braiding, felting, making nonwovens such as by needle-punching, and more than one of them. Bleaching or oxidation need not be used, eliminating the inherent production of potentially toxic by-products by this method and allowing the bast material to retain elements of its original natural green color. The fiber (fiber containing chlorophyll), thus degummed, maintains at least some of its green color and is sufficiently free of lignin, pectin, and hemicellulose, and the fiber can be processed in conventional textile machinery, wherein the processing is selected from the group consisting of making a yam by spinning, braiding, felting, making nonwovens such as by needle-punching, and more than one of them. The green color of the bast fiber is typically imparted to the bast fiber by chlorophyll. The bast fiber may be hemp.

The source of the green color of the bast fiber may, upon extraction into a solvent, show a spectrophotometric absorption spectrum indicative of general chlorophyll pigments (Chi a, b, & c). As described in Jeffrey and Humphrey, “New Spectrophotometric Equations for Determining Chlorophylls a, b, & c in ‘Higher’ Plants, Algae and Natural Phytoplankton,” Biochem. Physiol. Pflanzen (BPP) Bd 167, 81191-194 (1975), data from 750, 664, 647 and 630 nm wavelengths can be used to calculate chlorophyll concentration directly from a suitable absorption spectrum. For example, a 500 mg sample of green-colored, degummed, hemp fiber sample produced in
accordance with an embodiment of the method was soaked in 100 mL of deionized water for 12 hours and filtered through a 0.45 µm Supor membrane. Data from an absorption spectrum per Jeffrey and Humphrey (1975) showed 1.6 mg/L total chlorophyll in the extract, equivalent to at least 0.03% chl in the fiber sample by mass.
**Brief Description of the Drawings**

The invention will be better understood by a reading of the Detailed Description of the Examples of the Invention along with a review of the drawings, in which:

5 Figure 1 is a black and white photograph of four samples.
Detailed Description of Examples of the Invention

The present invention is directed to a method for processing plants, that include bast fibers, to remove lignin, pectin, and hemicellulose (collectively referred to as "gum") and other undesirable materials. The result is a cellulose fiber partially, mostly, or wholly free from gum so that it may be used in manufacturing for conversion into marketable materials, such as textile fibers. The bast fibers may be hemp, flax or sisal. Jute and other fibers are also known as bast fibers..

The method comprises soaking a plant that is a source of bast fibers in a saline solution. The source of bast fiber may be soaked and agitated in a brine solution. The source of bast fiber may be soaked and agitated in an alkaline solution. The source of bast fiber may be soaked and agitated in solution with a pH > 6, and this is typically performed without electrolysis of the solution. In one embodiment, the solution is comprised of water and inorganic salt with a total salinity ranging from less than 1 to about 200 parts per thousand (ppt). Salinity sources can include those found naturally such as in tidally flushed estuaries, creeks, coastal and sea water.

Natural freshwater can be used, though consideration for ionic discharge into freshwater watersheds should be made. Generally, freshwater has a salinity ranging from about 0 to about 0.5 ppt, brackish waters has a salinity ranging from about 0.5 ppt to about 30 ppt, and seawater has a salinity ranging from about 30 ppt to about 50 ppt.

The submersion of the source of bast fibers into an aqueous solution leads to uptake of water and aqueous ions into interstices between cellulosic fibers and gum and into the cellulose matrix due to cellulose wetting and capillary action. This imparts a pressure on the cellulose structure causing it to swell. The presence of ions in solution within the cellulose matrix alters the wetting behavior of cellulose, alters the capillary and pore pressures, and enhances interstitial transport and swelling. Swelling imparts mechanical stress on the bast structure, helps expose the fiber body to reagent, increases substrate surface area, delivers reagent for subsequent steps, and enhances fiber separation. Conversely, reduction of ion concentration reduces the swelling behavior, enhances diffusive export of dissolved material from the cellulose matrix (effectively flushing it), and imparts stress on the fiber matrix, further enhancing separation. The process may be enhanced through additional mechanical treatment. Interstitial pressure gradients may be sustained by periodic increase and decrease in the ion concentration of the solution, through salt or brine addition or dilution, and will enhance fiber separation as well as exposure of gum to
reagent. The use of tidally-flushed estuarine water sources permits the naturally available and non-interfering use of seawater as a source of interstitial pressure. The use of tidally-flushed water in a estuary also removes gum and/or its partially oxidized intermediates from the bast fibers safely through flushing.

Exposing the source of bast fiber to the variations in ion concentration can be carried out under increased temperature and pressure to enhance diffusion and reaction rates, and increase interstitial pressures.

The method may also include exposing lignin present in the bast fiber to a degumming reagent. This may include a base to depolymerize lignin into smaller, lighter weight, soluble lignin products. A basic: saline solution of a base at a pH from about 7 to about 14 may be used.

The method may also include sulfonating the lignin present on the bast fiber to create water-soluble products that can be removed by flushing the bast fiber with water. A neutral to alkaline solution of strong base and a sulfur anion at a pH from about 7 to about 14 may be used. Sulfur in neutral to alkaline solution will react with ring structures in lignin to yield a sulfonated soluble product readily removed from the plant material through flushing. Sufficient sulfur is provided to account for the range of lignin content of the source of bast fiber (generally 5-15% lignin by mass for raw fiber, and less for retted or otherwise pre processed fiber). The source of bast fiber may be soaked in a sulfonating solution for 10 minutes to several hours at pressure ranging from ambient to 10 atmospheres. Temperatures may vary with pressure per the Clausius-Clapyeron relation.

The bast fibers may also be soaked in an oxidizing solution to bleach the fibers and scour remaining gum. The oxidant may be added to the solution directly or generated in situ (e.g., by electrolysis). The addition of oxidant stabilizers may be included in some embodiments. The needed water temperature and soak time are dependent on the oxidant used. A water solution with a pH ranging from about 8 to about 12 is made with a combination of a strong base and a buffer. As a non-limiting example of the proportions, 50 mL of 3% \( \frac{3}{4} \) is added to a solution of 2 g/L NaOH and 1 g/L NaHCO\(_3\). The hemp fiber is soaked from about 0.1 to about 1 hour at a temperature below the boiling point of the solution. Since some naturally occurring heavy metals (Fe, Mg) interfere with \( \frac{3}{4} \) oxidation of gum (e.g., Fenton's Reagent), the addition of chelators may be used to prohibit or minimize their interference.
Additional steps may also be added to further degum the bast fibers. For example, detergent may be used to rinse and remove any remaining soluble, partially soluble, or insoluble (but mobile) gum in the bast fiber. Pectinase or other natural enzymes (either directly added or through in situ biological production) may be used as a non-essential component to assist in the removal of gum from the bast fibers. The steps may include mechanical agitation. Mechanical agitation may be tumbling, stirring or other agitation.

The steps for degumming the bast fibers may vary depending upon the chemical and physical conditions of the water source. Potential sources of water for soaking the bast fibers include most natural waters as well as municipal and purified water. Since the method utilizes saline solutions, sources of naturally saline water may be used to advantage.

Raw water (non-municipal or otherwise untreated, saline, brackish or fresh) may be used in one or more steps. Some natural sources of water contain components that may be utilized as reagents for one or more of the steps described above. For instance, waters available from wetlands contain naturally abundant sulfur (i.e., having an oxidation number less than or equal to VI) that can be used for sulfonating lignin. The presence of naturally available reactants or reagent components within the water source may be accounted for when formulating the desired reagent composition. For example, naturally available chelators may be used in place of manually added ones. The natural salinity of the water source may be accounted for in all steps, and its natural salinity variability (due to tides or other factors) may be used as a source of enthalpy for physical and chemical processing. Naturally available alkaline water sources may also be useful for certain processes wherein the pH of the solution is within a range from about 8 to about 12.

Moreover, certain steps of the method may vary for several reasons. For example, the bast fibers may be pretreated or decorticated, thus requiring a less aggressive treatment. Certain steps may be repeated (with or without a more aggressive reagent) if it is determined by an operator that the results of one or more steps are deemed insufficient. In some examples, the plant stalks may still be intact (i.e., the bast is not separated from the whole plant), requiring additional steps/repetitions to remove additional gum. On the other hand, some sources of bast fibers may already be partially processed ("retted") and require a less aggressive treatment, permitting omission of one or more steps. Material of a specified quality due to variable control available to the method may also be desired.
The effluent from the degumming process may be a solution and mixture of gum, its partially oxidized intermediates, and its oxidation byproducts, residual cellulose, fiber lost due to agitation, as well as inorganic salts, residual reagent, detergent, and chelators. Post-treatment of effluent includes additional oxidation (through addition of oxidants and/or in situ generation) or biological activity, per standard municipal water-treatment protocols. Residual fiber, lignin and sulfonated lignin may be recovered from the effluent as marketable material. Suitable detoxified effluent may be used as a nutrient additive to soils for agriculture. Inorganic ions may be added to the effluent to adjust ion ratios and salinity to match that of surface waters into which effluent will be discharged. Effluent alkalinity or acidity may be neutralized through titration with a suitable acid or base.

The fiber obtained by the process outlined above is a high-quality, separated, soft, spinnable fiber. The bast fiber is sufficiently free of lignin, pectin and hemicellulose that the fiber can be processed in conventional textile machinery. Such processing can include making a yam by spinning, braiding, felting, and making nonwovens such as by needle-punching.

The bast fiber may retain a green color. The color can be ascertained by extraction of the bast fiber into a solvent, showing a photometric absorption spectrum indicative of general chlorophyll pigments (Chl a, b & c). As described in Jeffrey and Humphrey, "New Spectrophotometric Equations for Determining Chlorophylls a, b, c, c2 in Higher Plants, Algae and Natural Phytoplankton," Biochem. Physiol. Pflanzen (BPP) Bd 167, S, 191-194 (1975), data from 750, 664, 647 and 630 nm wavelengths can be used to calculate chlorophyll concentration directly from a suitable absorption spectrum. For example, a 500 mg sample of green-colored, degummed, spinnable hemp fiber sample produced in accordance with an embodiment of the method was soaked in 100 mL of deionized water for 12 hours and filtered through a 0.45 pm Supor membrane. Data from an absorption spectrum per Jeffrey and Humphrey (1975) showed 1.6 mg/L total chlorophyll in the extract, equivalent to at least 0.03% chl in the fiber sample by mass. Evaluations using the methodology of Jeffrey and Humphrey (1975) yields this result:

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<th>Wavelength (nm)</th>
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<td>Absorption</td>
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When the processing of the source of the bast fiber is performed without bleaching or oxidation, production of potentially toxic by-products is virtually eliminated and the green color may be retained.
Figure 1 is a black and white photograph of four samples. From left to right, these samples are:

- raw green hemp (not degummed)
- degummed hemp fiber that shows the remaining slightly green color (the actual sample used to extract chlorophyll for the UV-VIS scans)
- degummed fiber (different variety — original fiber was green), slightly darker green
- degummed fiber — no green (the original fiber was not green)

Certain modifications and improvements will occur to those skilled in the art upon reading the foregoing description. By way of example, the method disclosed herein is not limited to the order described above. In certain embodiments, the above steps may be omitted, repeated, combined, or carried out in a different order. For example, limited resources may require combining steps, or reusing effluent from one step in another. The step order, parameters, and iterations may be modified in some embodiments to enhance or diminish specific fiber properties or composition, or to unify the properties of the end product relative to those of the unprocessed bast. It should be understood that all such modifications and improvements have been omitted for the sake of conciseness and readability, but are properly within the scope of the following claims.
What is claimed is:

1. A method for degumming bast fibers comprising immersing a source of bast fibers in an aqueous solution and varying the ionic concentration of the aqueous solution in which the source of bast fibers is immersed so that the varying ionic concentration of the solution imposes varying interstitial pressure within the source of bast fibers to aid in release of gum from cellulose fibers in the source of bast fibers,

2. The method as claimed in claim 1 wherein varying the ionic concentration of the solution has an effect selected from the group consisting of delivering reagent to the source of bast fibers, flushing gum and reacted byproducts from the bast fibers, imparting structural stress on the source of bast fibers, increasing surface area of gum as a reactive substrate, separating the bast fibers freed of gum, and more than one of them.

3. The method as claimed in claim 1 wherein the source of bast fibers soaks in an ionic solution without electrolysis of the ionic solution.

4. The method of claim 1, wherein the ionic solution is a saline solution having a concentration ranging from less than 1 part per thousand to about 200 parts per thousand.

5. The method of claim 4 including varying the ion concentration of the aqueous soaking solution in which the source of bast fiber is immersed.

6. The method of claim 1, wherein immersing a source of bast fiber comprises soaking the source of bast fiber in seawater.

7. The method of claim 1, wherein immersing a source of bast fiber comprises soaking the source of bast fiber in brackish water.

8. The method of claim 5, wherein varying the concentration of the aqueous solution comprises exposing the source of bast fiber to water with salinity that varies with time.
9. The method of claim 1 including soaking the source of bast fiber in a sulfur solution to sulfonate lignin for removal from bast fiber in the source of bast fiber.

10. The method of claim 1 including soaking the source of bast fiber in an oxidizing solution to remove lignin, pectin and hemicellulose from bast fiber in the source of bast fiber.

11. The method of claim 1 including rinsing the source of bast fiber with water to further remove lignin, pectin and hemicellulose from the bast fiber in the source of bast fiber.

12. The method of claim 1 including rinsing the source of bast fiber with detergent and water to further remove lignin, pectin and hemicellulose from the bast fiber in the source of bast fiber.

13. The method of claim 1 wherein the source of bast fiber is hemp.

14. A method for removing lignin, pectin and hemicellulose from cellulosic fibers in a hemp plant comprising:
   - soaking the hemp plant in a saline solution;
   - soaking the hemp plant in a sulfur solution to sulfonate lignin for removal from the hemp plant; and
   - rinsing the hemp plant with aqueous solution to further remove lignin, pectin and hemicellulose and their partially oxidized intermediates from the cellulosic fibers in the hemp plant.

15. The method of claim 14 including soaking the hemp plant in an oxidizing solution to remove lignin, pectin and hemicellulose from the cellulosic fiber.

16. The method of claim 15, wherein soaking the hemp plant in an oxidizing solution comprises soaking the hemp plant in a hydrogen peroxide solution.
17. The method of claim 16, including generating hydrogen peroxide as the oxidizing solution with electrolysis.

18. The method of claim 15, wherein soaking hemp plant in an oxidizing solution comprises soaking the hemp plant in the oxidizing solution at a pH between about 6 to about 12 and at a temperature below a boiling point of the oxidizing solution.

19. The method of claim 14, wherein soaking the hemp plant in a sulfur solution comprises soaking the hemp plant in the sulfate solution at a pH between about 6 to about 12 and at a temperature between about 20°C to about 90°C.

20. The method of claim 14, wherein soaking the hemp plant in a saline solution comprises soaking the hemp plant in tidally flushed water so that the salinity of the solution proximate to the hemp plant varies with tidal fluctuations.

21. A bast fiber having a green color, the bast fiber being sufficiently free of lignin, pectin and hemicellulose that the fiber can be processed in conventional textile machinery.

22. A bast fiber as claimed in claim 21 wherein the bast fiber has a green color imparted to the bast fiber by chlorophyll.

23. A bast fiber as claimed in claim 21 wherein processing in conventional textile machinery is selected from the group consisting of spinning, braiding, felting, making nonwovens such as by needle-punching, and more than one of them.

24. A bast fiber as claimed in claim 21 wherein the bast fiber is hemp.

25. A bast fiber as claimed in claim 21 wherein the green color of the bast fiber is extractable and has an absorption spectrum indicating the presence of chlorophyll in the extract.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8)- C12S 3/06; D01C 1/02 (2019.01)
CPC - D01C 1/02; D06N 2201/045

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>A</td>
<td>CN 101768785 B (Yingchao et al.) 27 February 2013 (27.02.2013); entire document</td>
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Date of the actual completion of the international search
17 June 2019

Date of mailing of the international search report
30 AUG 2019

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-8300

Authorized officer
Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OGP: 571-272-7774

Form PCT/ISA(21)(second sheet)(January 2015)
### INTERNATIONAL SEARCH REPORT

**Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

---See Supplemental Sheet---

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<td>4.</td>
<td>☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: Claims 1-13</td>
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**Remark on Protest**

☐ The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.
Lack of Unity Invention

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-13 directed to a method for degumming bast fibers.

Group II: Claims 14-20 directed to a method for removing lignin, pectin and hemicellulose from cellulosic fibers in a hemp plant.

Group III: Claims 21-25 directed to bast fiber having a green color.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical feature of a method for degumming bast fibers comprising: immersing a source of bast fibers in an aqueous solution and varying the ionic concentration of the aqueous solution in which the source of bast fibers is immersed so that the varying ionic concentration of the solution imposes varying interstitial pressure within the source of bast fibers to aid in release of gum from cellulose fibers in the source of bast fibers, not required by the claims of Groups II.

The invention of Group II includes the special technical feature of method for removing lignin, pectin and hemicellulose from cellulosic fibers in a hemp plant comprising: soaking the hemp plant in a saline solution; soaking the hemp plant in a sulfur solution to sulfonate lignin for removal from the hemp plant; and rinsing the hemp plant with aqueous solution to further remove lignin, pectin and hemicellulose and their partially oxidized intermediates from the cellulosic fibers in the hemp plant, not required by the claims of Groups I or III.

The invention of Group III includes the special technical feature of a bast fiber having a green color, the bast fiber being sufficiently free of lignin, pectin and hemicellulose that the fiber can be processed in conventional textile machinery, not required by the claims of Groups II-III.

COMMON TECHNICAL FEATURES

Groups I-III share the common technical feature of degummed bast fibers (see instant specification page 1 lines 6-8: "Cellulosic bast fibers harvested from plants like hemp... are composed of large proportions of undesired material other than cellulose, including lignin, pectin and hemicellulose, known collectively as gum"). However, this shared technical feature does not represent a contribution over prior art as being anticipated by CN 101765785 B to Yinghao et al., which discloses a method of degumming bast fibers, such as hemp, which removes pectin, lignin, and hemicellulose from the bast fiber (para [0007]: "The technical problem to be solved by the present invention is to provide a progressive hemp fiber degumming method..."); para [0016]: "The degumming action removes pectin, lignin, hemicellulose, etc. from the fiber, and the quality of the hemp fiber processed by the present invention is remarkably improved").

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

Therefore, Groups I-III lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.