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(54) **CELLULOSE MATERIAL PLASTICIZATION AND VISCOSITY CONTROLLED CELLULOSIC MATERIAL**

PLASTIFIZIERUNG VON CELLULOSE MATERIALIEN UND VISKOSITÄTSKONTROLLIERTES CELLULOSE MATERIAL

PLASTIFICATION DE MATIÈRE CELLULOSIQUE ET MATIÈRE CELLULOSIQUE À VISCOSITÉ CONTRÔLÉE

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Description

Technical field

[0001] This invention relates to a method and a system for manufacturing viscosity controlled cellulosic material. This invention further relates to a viscosity controlled cellulosic material.

Background

[0002] Cellulose, which is an abundant natural raw material, is a polysaccharide consisting of a linear chain of a couple of thousands to ten thousand linked D-glucose units. Cellulose can be modified, for example, to man-made fibers (MMF). At the moment, viscose filaments are the most commonly produced MMF filaments.

Summary

[0003] The present invention discloses a novel solution for manufacturing viscosity controlled cellulosic material. According to the novel method, it is possible to use a wood-based cellulosic material and treat the wood-based cellulosic material in a continuous process in order to obtain viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g, measured according to ISO 5351:2010.

[0004] Aspects of the invention are characterized by what is stated in the independent claims. Various embodiments of the invention are disclosed in the dependent claims.

[0005] A method for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process comprises the following steps:

i) forming a cellulose-water mixture comprising water and chemically treated wood-based cellulosic material comprising a bleached kraft pulp and/or a bleached sulfite pulp and/or a bleached soda pulp, the cellulose-water mixture having a dry matter content between 3% and 20%,

ii) treating the formed cellulose-water mixture in a plasticization step at a temperature between 130°C and 200°C and a pressure between 3 bar and 15 bar, preferably between 5 bar and 10 bar, at least 5 minutes and 120 minutes at the most, while

- mixing the cellulose-water mixture, and
- feeding hot water and/or water steam to the cellulose-water mixture,

thereby obtaining a treated mixture, and

iii) depressurizing the treated mixture after the plasticization step in a depressurizing step in a controlled manner without a steam explosion to maintain fiber integrity,

thereby obtaining the viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g measured according to ISO 5351:2010, and an R18 solubility between 60% and 87%, measured according to standard T 235 cm-00.

[0006] A system for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process comprises the following means:

- means for forming a cellulose-water mixture,
- a continuous reactor, such as a continuous kneader reactor, for treating the cellulose-water mixture in a plasticization step at a temperature between 130°C and 200°C,
- mixing means for mixing the cellulose-water mixture during the plasticization step,
- heating means for increasing temperature of the cellulose-water mixture in the continuous reactor, such as a feeder to feed water steam to the continuous reactor, and
- means for depressurizing the treated mixture in a controlled manner without a steam explosion after the plasticization step,

thereby obtaining the viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g.

[0007] The system can comprise means for circulating at least part of a filtrate obtained from the plasticization step to the continuous reactor. This can decrease chemical consumption of the process and speed up the plasticization step and, hence, decrease manufacturing costs. Therefore, a production efficiency can be improved.

[0008] A viscosity controlled cellulosic material has a viscosity value in a range between 150 ml/g and 500 ml/g measured according to ISO 5351:2010, and an R18 solubility between 60% and 87%, measured according to standard T 235 cm-00. Therefore, the method for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process can be a method for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g and an R18 solubility between 60 and 87% in a continuous process.

[0009] The plasticization step can be implemented by treating the formed cellulose-water mixture in a continuous reactor, such as a continuous screw reactor. The continuous screw reactor can be, for example, a horizontal screw reactor or a vertical screw reactor. Advantageously, the continuous reactor is a kneader reactor. Therefore, the material to be treated can be conveyed easily and efficiently forward. Alternatively, the plasticization step can be implemented without the screw reactor, for example, by treating the formed cellulose-water mixture in a device comprising chambers separated with

each other.

[0010] During the plasticization step, water steam can be fed continuously or substantially continuously into the continuous reactor.

[0011] Advantageously, the following combination of parameters is used in the method: The duration of the plasticization step can be at least 5 minutes or at least 6 minutes. Further, the duration of the plasticization step can be 50 minutes at the most, more preferably 25 minutes at the most, and most preferably 20 minutes at the most. Further, the temperature of the plasticization step can be at least 140°C. Further, the temperature of the plasticization step can be 180°C at the most, more preferably 170°C at the most. Further, the pressure of the plasticization step can be at least 5 bars. Further, the pressure of the plasticization step can be less than 10 bar. The technical effect on said combination of parameters is that it can improve production efficiency as well as quality of the obtained viscosity controlled cellulosic material.

[0012] In order to further improve the method, pH of the cellulose-water mixture can be at least 1, preferably at least 2. Further, pH of the cellulose-water mixture can be 6 at the most, preferably 5 at the most. Most preferably, pH of the cellulose-water mixture is between 2 and 5.

[0013] A viscosity value of the chemically treated wood-based cellulosic material, determined from the cellulose-water mixture before the plasticization step can be at least 400 ml/g, preferably at least 450 ml/g. In addition, a viscosity value of the chemically treated wood-based cellulosic material determined from the cellulose-water mixture before the plasticization step can be 1400 ml/g at the most, more preferably 1200 ml/g at the most. Said viscosity range can improve reactions during the plasticization step and, hence, decrease a reaction time. Thus, said viscosity range can improve production efficiency of the method.

[0014] The dry matter content of the cellulose-water mixture can be at least 3%, more preferably at least 5%. Further, the dry matter content of the cellulose-water mixture can be less than 20% more preferably less than 17% and most preferably less than 14%. Thanks to this quite low consistency, an effect of mixing on the plasticization step can be improved. Further, the quality of the obtained viscosity controlled cellulosic material can be improved.

[0015] ISO Brightness of the chemically treated wood-based cellulosic material, determined before the plasticization step, can be at least 70%, more preferably at least 86%. Thus, a brightness of the end product can be improved. Further, thanks to said brightness of the raw material, chemical consumption can be decreased.

[0016] A hemicellulose content of the chemically treated wood-based cellulosic material in the cellulose-water mixture can be at least 0.5%, more preferably at least 3%, for example between 3 % and 10 %, and most preferably equal or less than 33%, for example from 10% to 33%, based on a dry weight of the chemically treated wood-based cellulosic material. This kind of hemicellu-

lose content can improve a yield and a material efficiency of the manufacturing process, and the hemicelluloses can work as an internal activator causing faster reactions.

[0017] An extractive content of the chemically treated wood-based cellulosic material measured from the cellulose-water mixture before the plasticization step can be less than 0.4%, more preferably less than 0.2%, based on a dry weight of the chemically treated wood-based cellulosic material in the cellulose-water mixture. A low content of extractives can improve quality of the obtained viscosity controlled cellulosic material and a runnability of the manufacturing process.

[0018] An ash content of the chemically treated wood-based cellulosic material measured from the cellulose-water mixture can be less than 0.7%, more preferably less than 0.5%, based on a dry weight of the chemically treated wood-based cellulosic material in the cellulose-water mixture. A low ash content can improve quality of the obtained viscosity controlled cellulosic material and a runnability of the manufacturing process.

[0019] A content of fibers having length below 0.6 mm, determined from the cellulose-water mixture, can be between 10% and 30%, based on the total content of the chemically treated wood-based cellulosic material fibers.

A curliness of the wood-based cellulosic material, measured from the cellulose-water mixture before the plasticization step, can be, for example between 7% and 40%, preferably between 20% and 40%. These values can improve properties of the obtained viscosity controlled cellulosic material, such as strength properties of said product.

[0020] A sodium (Na) content of the cellulose-water mixture can be at least 200 mg/kg, preferably from 200 mg/kg to 1500 mg/kg based on the dry weight of the chemically treated wood-based cellulosic material fibers. Thanks to said sodium content, an efficiency of the manufacturing process can be improved. If the sodium content is too low, cellulose based fibers are not swollen enough and chemicals can have difficulties to access. Further, if the sodium content is too high, pH can be decreased and, hence, chemical consumption can be increased. Further, water may not penetrate to fiber walls.

[0021] The chemically treated wood-based cellulosic material, such as a kraft pulp, is preferably so called "never dried pulp". Never dried pulp can be easier to operate than a dried pulp and, further, never dried chemically treated wood-based cellulosic material can be very cost-effective raw material for the disclosed manufacturing process.

[0022] A WRV of the cellulose-water mixture can be between 1-2 g/g in order to cause an easy chemical access and, hence, decrease reaction time.

[0023] An alpha cellulose content of the chemically treated wood-based cellulosic material measured before the plasticization step can be at least 65%, more preferably at least 67%. Further, the alpha cellulose content of the chemically treated wood-based cellulosic material measured before the plasticization step can be less than

99.5%, more preferably 90% at the most. This kind of alpha cellulose content can have a technical effect by improving a yield and a material efficiency, causing fast reactions, and working as an internal activator.

[0024] A lignin content of the chemically treated wood-based cellulosic material measured before the plasticization step can be less than 3%, more preferably less than 1.0%, and most preferably less than 0.5% based on a dry weight of the chemically treated wood-based cellulosic material. Low lignin content can increase brightness of the product.

[0025] A softwood content of the chemically treated wood-based material determined before the plasticization step can be at least 70%, more preferably at least 85% and most preferably more than 95%, for example 100%, based on a dry weight of the chemically treated wood-based cellulosic material. Softwood has a lower total hemicellulose content but higher glucomannan content, hence, it can have a better solubility and faster reactions than hardwood.

[0026] A mixing efficiency during the plasticization step can be between 10 kWh/ADt and 150 kWh/ADt. More preferably from 15 kWh/ADt to 80 kWh/ADt, and most preferably from 20 kWh/ADt to 50 kWh/ADt. Technical effect of said mixing efficiency is improved, even quality, better solubility and faster reactions. During the depressurizing step, i.e., depressurizing step without a steam explosion, a pressure drop can be slower than 15 bar/s, more preferably slower than 10 bar/s, for example equal or slower than 5 bar/s, and most preferably equal or slower than 2 bar/s. Thus, a steam explosion can be avoided and, hence, integrity of fibers can be improved. Typically, the integrity of fibers improves when the speed of said pressure drop decreases.

[0027] The depressurizing step without a steam explosion, wherein the treated mixture 18 is depressurized, can take at least 1 second, more preferably at least 3 seconds, and most preferably at least 10 seconds. Furthermore, the depressurizing step without a steam explosion can take 30 minutes at the most, more preferably less than 20 minutes, for example 10 minutes at the most, and most preferably equal or less than 5 minutes. This has a technical effect of improving the method and maintaining fiber integrity.

[0028] In order to depressurize the treated mixture in a controlled manner,

- water, and/or
- a mechanical arrangement

can be used for the substantially slow depressurizing step. Thus, an uncontrollable way to depressurize the treated mixture, i.e., "a steam explosion", wherein steam can escape very fast, can be avoided. The mechanical arrangement for the depressurizing step can comprise, for example, a chamber and at least one valve, preferably at least one chamber and at least two valves.

[0029] In addition, or alternatively, the mechanical ar-

rangement can have separated chambers, each chamber having decreased pressure compared to the previous chamber. In this case, the mechanical arrangement can have, for example, at least three chambers, such as from 3 to 6 chambers. Furthermore, there is preferably at least one valve or similar solution between two adjacent chambers.

[0030] The depressurizing step can comprise the following step:

- cooling the treated mixture by adding water.

[0031] In addition, or alternatively, the depressurizing step can comprise the following step:

- reducing water vapor mechanically, for example by using
 - a screw, and/or
 - a chamber with valves, and/or
 - compartment valves.

[0032] Most preferably, the depressurizing step has the both means, the water and the mechanical solution.

[0033] The method can further comprise the following:

- dosing an activator into the cellulose-water mixture in order to plasticize the chemically treated wood-based cellulosic material in the presence of the activator during said plasticization step.

[0034] The activator can comprise a filtrate which is obtained from the plasticization step. Said filtrate can comprise hydrolysate products from the plasticization step. The amount of said filtrate can be more than 50%, more preferably more than 90%, and most preferably at least 99% from the total amount of the activator. Thanks to this filtrate, total dosage of chemicals added to the manufacturing process can be decreased, hence, manufacturing costs can be decreased, and a production efficiency can be increased. Furthermore, this can be environmentally friendly way to manufacture the viscosity controlled cellulosic material.

[0035] Alternatively, or in addition, the activator can comprise acid solutions, preferably acid filtrates, from a chemical pulp mill. The amount of said acid filtrate(s) from the chemical pulp can be at least 30%, more preferably at least 40%, and most preferably at least 50% calculated from the total amount of the activator. Hence, manufacturing costs can be decreased, and a production efficiency can be increased.

[0036] Alternatively or in addition, the activator can comprise sulfuric acid or acetic acid, the total amount of the sulfuric acid and the acetic acid being preferably less than 5%, for example 2% at the most, more preferably less than 1.5%, for example 1.0% at the most, and most preferably less than 0.5% calculated from the dry weight of the chemically treated wood-based cellulosic material.

[0037] A total usage of added chemicals of the disclosed method, excluding any circulated filtrate(s) or water(s) from the plasticization step, can be less than 5%, for example 3% at the most, more preferably less than 2%, for example 1% at the most, and most preferably less than 0.5%, for example 0.2% at the most, or exactly 0%, calculated from the dry weight of the chemically treated wood-based cellulosic material. Therefore, it can be possible to manufacture the viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a chemical free, or substantially chemical free, process. This can have a huge effect on production costs. Further, the method can be environmentally friendly way to manufacture the viscosity controlled cellulosic material.

[0038] The viscosity value of the viscosity controlled cellulosic material can be at least 170 ml/g, preferably at least 180 ml/g. Further, the viscosity value of the viscosity controlled cellulosic material can be 350 ml/g at the most, more preferably 300 ml/g at the most, and most preferably 250 ml/g at the most. This kind of viscosity values can cause improved and faster solubility of the obtained viscosity controlled cellulosic material.

[0039] The obtained viscosity controlled cellulosic material can be washed in a washing step by using water. Preferably, a temperature of said water used for the washing step is more than 50°C, for example at least 70°C and most preferably at least 85°C. Further, advantageously a temperature of said water is 100°C at the most. Washing step can be used to wash away at least part of unwanted residues from the viscosity controlled cellulosic material. Thus, quality of the product can be improved.

[0040] Advantageously, at least part of the water used for the washing step is conveyed to the cellulose-water mixture for increasing temperature of said cellulose-water mixture.

[0041] Optionally, pH of the obtained viscosity controlled cellulosic material can be adjusted in a pH adjustment step. Preferably, the target pH value in the pH adjustment step is between 4 and 9. By using water in the adjusting step, it may be possible to wash away at least a part of unwanted residues from the viscosity controlled cellulosic material while adjusting the pH value. pH adjustment may increase the effectiveness of a dissolving step of the viscosity controlled cellulosic material, which dissolving step may follow the pH adjusting step.

[0042] The obtained viscosity controlled cellulosic material can be dried to a dry matter content of at least 60%, if needed, for example, for a transportation.

[0043] Thanks to the novel process, the obtained viscosity controlled cellulosic material can have a crystallinity index of at least 74%, more preferably at least 75%, and most preferably at least 76%.

[0044] Due to the novel method, ISO Brightness of the viscosity controlled cellulosic material manufactured according to claimed method can be at least 70%, typically between 75 and 90%. Thus, optical properties of the end

product can be improved.

[0045] Further, due to the novel method, a length weighted fiber length Lc(l) of the viscosity controlled cellulosic material measured according to ISO 16065-N can be at least 0.9 mm, more preferably at least 1.0 mm, and most preferably at least 1.2 mm. Moreover, a content of fibers having length below 0.6 mm, measured from the viscosity controlled cellulosic material, can be between 10 and 30%. This kind of fiber contents and lengths can improve the easiness of the product, i.e., the product can be easier to handle and wash. Further, a yield can be improved.

[0046] An alpha cellulose content of the viscosity controlled cellulosic material can be at least 67%, preferably at least 69%. Further, the alpha cellulose content of the viscosity controlled cellulosic material is less than 99.5%, more preferably 90% at the most. This level of alpha cellulose can improve a reactivity and a yield due to improved material efficiency. Further, it can have an improved environmental impact.

[0047] A hemicellulose content of the viscosity controlled cellulosic material can be at least 0.5% dry wt.%, more preferably at least 3 dry wt.%, for example between 3 dry wt.% and 10 dry wt.%. This kind of hemicellulose content can improve a reactivity and, further, a yield due to improved material efficiency. Further, it can have an improved environmental impact.

[0048] Thanks to the novel method, R18 solubility of the viscosity controlled cellulosic material can be at least 60%, more preferably at least 70%. Further, R18 solubility of the viscosity controlled cellulosic material can be 87% at the most, more preferably 84% at the most, for example between 70% and 84%. R18 solubility describes a solubility of the material when measured by using 18% NaOH solution. A value of R18 solubility discloses an insoluble part of the material. Thanks to said R18 solubility of the material, the obtained viscosity controlled cellulosic material can have very good solubility. Thus, the production efficiency of the regenerated cellulose material, which can be manufactured from the viscosity controlled cellulosic material, can be improved.

[0049] A sodium (Na) content of the viscosity controlled cellulosic material can be at least 200 mg/kg, for example between 200 mg/kg and 1500 mg/kg based on the dry weight of the chemically treated wood-based cellulosic material fibers. Said sodium content has an effect, for example, on a solubility of the obtained viscosity controlled cellulosic material by improving the solubility rate of the material. Furthermore, a viscosity can be improved.

[0050] A curliness of the viscosity controlled cellulosic material can be at least 25%, more preferably at least 30%, such as at least 35%, and most preferably at least 40%. Furthermore, the curliness of the viscosity controlled cellulosic material can be 90% at the most, for example less than 85% or equal or less than 80%. The curliness has an effect on a strength of the end-product as well as water remove properties of the product.

[0051] A Water Retention Value (WRV) of the viscosity

controlled cellulosic material can be between 1 g/g and 2 g/g. This can cause an easier chemical access and, hence, a faster reaction.

[0052] A lignin content of the viscosity controlled cellulosic material can be less than 1.5%, more preferably less than 1%, and most preferably less than 0.5%. This kind of very low lignin content can increase brightness of the product, the effect on the brightness increase as the lignin content decreases.

[0053] An extractive content of the viscosity controlled cellulosic material can be less than 0.2%, more preferably less than 0.1%. This kind of low extractive content can increase quality of the product.

[0054] The chemically treated wood-based cellulosic material can comprise bleached Kraft pulp and/or bleached sulfite pulp and/or bleached soda pulp. The chemically treated wood-based cellulosic material can refer to bleached Kraft pulp and/or bleached sulfite pulp and/or bleached soda pulp. Most preferably, the chemically treated wood-based cellulosic material refers to the kraft pulp.

[0055] This invention does not relate to a viscose, which can be manufactured from dissolving pulp. The viscose is an example of a different kind of cellulosic material obtained from a different kind of raw material by using a different kind of process. Viscose manufacturing is generally an environmentally problematic and a slow process. The claimed novel method can be environmentally friendly solution to treat wood-based cellulosic material in order to obtain the viscosity controlled cellulosic material having the specific viscosity value.

[0056] Due to the claimed method, the viscosity controlled cellulosic material may be manufactured by using moderate price materials instead of expensive organic solvents and, moreover, without need of handling toxic products. Thanks to the novel solution, the product may also be used as a raw material for cosmetic or food packaging products.

[0057] A yield of a manufacturing process depends on raw materials and conditions of the process, such as a usage of chemicals, a temperature, a dry matter content, a pH level, and a duration of the plasticization step. By using the novel manufacturing process, a yield of the process may be substantially increased. For example, it can be possible to adjust hemicellulose content of the manufactured product, not simply remove substantially all hemicelluloses.

[0058] The novel process can be substantially simple. Further, the novel process can be easy to handle. The novel manufacturing process can also be environmentally friendly. With the novel process, it can be possible to consume very small quantity of chemicals. Further, it can be possible to obtain the viscosity controlled cellulosic material without further dosed chemicals e.g. after kraft pulping by using chemically treated cellulose based raw material, such as kraft pulp.

[0059] The product obtained from the claimed process, i.e., the viscosity controlled cellulosic material, is typically

cold alkali soluble. The manufactured viscosity controlled cellulosic material can be modified to produce some different kind of end products. Typically, no additional chemical treatment is needed to dissolve the viscosity controlled cellulosic material. Thus, the viscosity controlled cellulosic material may be more economical than other cellulosic materials processed with known methods.

[0060] Further, thanks to the novel process, the novel viscosity controlled cellulosic material product can be manufactured in a continuous process having a good production efficiency.

Brief description of the drawings

[0061] In the following, the invention will be illustrated by drawings in which

Figs 1-3 show schematically some example steps,
Figs 4a-c show some photos from experimental tests,
Figs 5a-c show some microscopy images from experimental tests, and
Figs 6a-11 show test results from experimental tests.

Detailed description

[0062] In the following disclosure, all percentages are by weight, if not indicated otherwise. All percentages relating to cellulosic material(s) are by dry weight, if not indicated otherwise.

[0063] All embodiments in this application are presented as illustrative examples, and they should not be considered limiting.

[0064] Unless otherwise stated, the following standards (valid on 01/2019) and measuring methods refer to methods which can be used to obtain stated values of parameters:

- R18 solubility: T 235 cm-00
- Consistency: ISO 638 (dry mater content)
- Curliness [%]: ISO 16065-N
- Ash content [%]: Mod ISO 2144
- Lignin content [%]: KCl 115 b82
- Extractive content [%]: mod. ISO 14453
- Softwood and/or hardwood can be analyzed with a microscopic method by using a microscopy.
- WRV (g/g) is measured according to ISO 23714:2014, which specifies a procedure for the determination of the water retention value (WRV) of all kinds of pulp.
- Brightness [% ISO]: ISO 2470-1
- Alfa-cellulose content [%] can be determined by using R18 solubility measurements,
- Hemicelluloses content [%] can be determined by measuring a total sugar content of a sample according to a standard SCAN-CM 71:09 and determine a hemicellulose content from the total sugar content.
- Glucose content [%] from the total sugar content can

be determined by using the standard SCAN-CM 71:09 for total sugar content and determine glucose content from said total sugar content.

- Fiber properties are measured according to standard ISO 16065-2:2014 by using Valmet Fiber Image Analyzer (Valmet FS5). A weight of a sample should be at least 0.1 g, for example between 0.1 g - 0.2 g for hardwood samples and at least 0.3 g, for example between 0.3 - 0.5 g, for softwood samples. ISO 16065-2:2014 specifies a method for determining fibre length by automated optical analysis using unpolarized light. The method is applicable to all kinds of pulp. However, fibrous particles shorter than 0.2 mm are not regarded as fibres for the purposes of ISO 16065-2:2014 and, therefore, are not included in the results.
- Sodium content of the raw material [mg/kg of dry pulp] and Sodium content of the viscosity controlled cellulosic material [mg/kg of dry material]: SFS-EN ISO 11885, by using an ICP analyzer.
- Viscosity [ml/g] is measured according to ISO 5351:2010. It relates to a determination of limiting viscosity number in cupri-ethylenediamine (CED) solution. ISO 5351:2010 specifies a method which yields a number that is an estimate of the limiting viscosity number of pulp in a dilute cupri-ethylene-diamine (CED) solution.
- Crystallinity index [%] is measured according the following method (RISE, Research of Sweden): WAXS (Wide Angle X-ray Scattering) measurements were performed on an Anton Paar SAXSpoint 2.0 system (Anton Paar, Graz, Austria) equipped with a Microsource X-ray source (Cu K α radiation, wavelength 0.15418 nm) and a Dectris 2D CMOS Eiger R 1M detector with 75 mm by 75 mm pixel size. All measurements were performed with a beam size of approximately 500 μ m diameter, at a sample stage temperature of 25°C (temperature control was employed) with a beam path pressure at about 1-2 mBar. The sample to detector distance (SDD) was 111 mm during measurements. All samples were mounted on a Multi-Solid-Sample Holder (Anton Paar, Graz, Austria). The Sampler was then mounted on a VarioStage (Anton Paar, Graz, Austria). The samples were exposed to vacuum during measurement. For each sample 6 frames each of 6 minutes duration were read from the detector, giving a total measurement time of 36 minutes per sample. For all samples the transmittance was determined and used for scaling of intensities. The software used for instrument control was SAXSdrive version 2.01.224 (Anton Paar, Graz, Austria), and post-acquisition data processing was performed using the software SAXSanalysis version 3.00.042 (Anton Paar, Graz, Austria). Crystallinity indexes (CrI) of the samples were determined according to the Segal signal height method (Segal et al. 1959), ref. Segal, L., Creely, J.J., Martin Jr., A.E. and Conrad, C.M.

(1959) An Empirical Method for Estimating the Degree of Crystallinity of Native Cellulose Using the X-Ray Diffractometer. Textile Research Journal, 29, 786-794.

- Molar Mass Distribution (MMD) is measured according to the following method:
The molar mass distributions (MMD) of the cellulose derivatives were determined by size exclusion chromatography (SEC) using tetrahydrofuran (THF) as the mobile phase. The SEC system consists of a guard column, PLgel 10 μ m Guard 50 x 7.5 mm, and three PLgel 10 μ m MIXED-B LS 300 x 7.5 mm columns connected in series. The detection was performed using a refractive index detector (Waters 410). The samples were dissolved in THF (approx. 1.5 mg/ml) and filtered (PTFE syringe filter 0.2 μ m). The samples were not completely dissolved in THF. Duplicate samples were analyzed. Calibration was performed using polystyrene standards with molecular weights from 3000 to 7 270 000. The calibration points were fitted to a linear function. MMD, peak molar weight (Mp), weight average molar weight (M_w), number average molar weight (M_n) and polydispersity (PD) index (M_w/M_n) were calculated using Cirrus GPC software version 3.1 by Polymer laboratories (Agilent).

[0065] Values, which are measured/determined from the cellulose-water mixture 15 and/or chemically treated wood-based cellulosic material 10, are values which are determined before the plasticization step 100.

[0066] Values, which are measured/determined from the viscosity controlled cellulosic material, are values which are determined after the plasticization step 100.

[0067] The following reference numbers are used in this application:

- 10 chemically treated wood-based cellulosic material,
- 15 cellulose-water mixture,
- 18 treated mixture,
- 20 viscosity controlled cellulosic material,
- 30 dissolved viscosity controlled cellulosic material,
- 40 regenerated cellulose material,
- 45 90 pretreating step comprising, for example, a pulper,
- 95 forming the cellulose-water mixture 15,
- 96 means for forming the cellulose-water mixture 15,
- 100 plasticization step,
- 50 101 continuous reactor,
- 102 filtrate obtained from the plasticization step,
- 105 depressurizing step,
- 110 washing step comprising, for example, a wash press,
- 55 120 drying step,
- 121 drying device,
- 130 dissolving step of the viscosity controlled cellulosic material, and

140 further processing of the dissolved viscosity controlled cellulosic material.

[0068] Natural cellulose is a linear compound with a simple chemical functionality having 3 hydroxyl groups for a glucose unit.

[0069] In this application, the term "chemically treated wood-based cellulosic material 10" refers to kraft pulps, sulfite pulps and soda pulps, which may contain any wood-based cellulose material, i.e., the chemically treated wood-based cellulosic material 10 can originate from any wood material(s).

[0070] Furthermore, the term "chemically treated wood-based cellulosic material 10" refers to a material that does not comprise dissolving pulp. The term "dissolving pulp" refers to so called dissolving pulp, which is a bleached pulp that has cellulose content more than 90 wt.-% and particularly low hemicellulose content. The dissolving pulp can be dissolved in a specific solvent. However, a yield and production efficiency of the manufacturing process may not be as good as with the kraft pulp, soda pulp or sulfite pulp.

[0071] Furthermore, the term "chemically treated wood-based cellulosic material 10" refers to material that does not comprise mechanical pulp. The term "mechanical pulp" refers to cellulose fibers, which are isolated from any wood-based cellulosic material by a mechanical pulping process. Preferably, the viscosity controlled cellulosic material 20 does not comprise the mechanical pulp.

[0072] The kraft pulp, soda pulp and/or sulfite pulp can be dried and/or never-dried pulp(s) and they can be pre-treated chemically, physically or enzymatically to enhance the effect of the plasticization. The never-dried pulp can be easier to operate, and the usage of the never-dried pulp can decrease manufacturing costs of the obtained viscosity controlled cellulosic material, hence, preferably the pulp(s) comprise or consist of the never-dried pulp(s).

[0073] In this application, the term "viscosity controlled cellulosic material 20" refers to a material which is obtainable from the chemically treated wood-based cellulosic material 10 by using a plasticization step and a depressurizing step. The viscosity controlled cellulosic material is typically cold alkali soluble.

[0074] The term "cold alkali soluble" refers to a cold alkali soluble, plasticized cellulose material, i.e., the viscosity controlled cellulosic material, which is dissolvable to an aqueous alkaline having NaOH content of solution between 5% and 10%, for example from 7% to 8%, at a temperature from -3°C to -12°C, for example at a temperature from -5°C to -8°C.

[0075] The term "R18 solubility" refers to a solubility without carbon sulfide treatment. R18 solubility is measured according to standard T 235 cm-00.

[0076] The term "steam explosion" refers to a method wherein a pressure is caused by over-heated water and a pressure drop is faster than 15 bar/s. This kind of fast

pressure release can cause significant fiber structure changes.

[0077] Preferably, an amount of non-wood material in the viscosity controlled cellulosic material is less than 20%, more preferably less than 10% and most preferably less than 5%, for example 2% at the most, calculated from the dry weight of the viscosity controlled cellulosic material. In an advantageous embodiment, the viscosity controlled cellulosic material does not comprise non-wood material at all. Non-wood material can be agricultural residues, grasses or other plant substances such as straw, coconut, leaves, bark, seeds, hulls, flowers, vegetables or fruits from cotton, corn, wheat, oat, rye, barley, rice, flax, hemp, manila hemp, sisal hemp, jute, ramie, kenaf, bagasse, bamboo, or reed.

[0078] The chemically treated wood-based cellulosic material can be obtained from softwood trees, such as spruce, pine, fir, larch, douglas-fir or hemlock, or hardwood trees, such as birch, aspen, poplar, alder, eucalyptus, or acacia, or a mixture of softwoods and/or hardwoods.

[0079] An effect of the plasticization step 100 typically depends on raw material(s), such as wood species used in the treatment. Thus, preferably the chemically treated wood-based cellulosic material comprises or consists of eucalyptus, birch, spruce and/or pine, the total amount of those wood species being preferably more than 70%, more preferably at least 80% and most preferably at least 90 % calculated from the total amount of the chemically treated wood-based cellulosic material. This can improve the properties of the obtained product.

[0080] A softwood content of the chemically treated wood-based material measured from the cellulose-water mixture 15 is preferably more than 30%, for example at least 50%, more preferably at least 70% and most preferably at least 90% based on a dry weight of the chemically treated wood-based cellulosic material 10. The usage of the softwood has an effect on hemicellulose content. Softwood has higher glucomannan content. Further, softwood can have a better solubility and lower reaction time. Therefore, a production efficiency can be improved.

[0081] Most advantageously, the chemically treated wood-based cellulosic material comprises at least 50%, more preferably at least 70% and most preferably at least 90% softwood kraft pulp, calculated from the dry weight of the chemically treated wood-based cellulosic material, which has

- fibers having a length over 2 mm,
- lignin content between 0 and 3%,
- hemicellulose content between 0.5 and 33%, and

wherein, advantageously, over 70 % of fibers has a fiber length more than 0.2 mm and a width between 10-50 micrometer, when measured with standard ISO 16065-2:2014 by using Valmet Fiber Image Analyzer (Valmet FS5). By using this kind of material, properties and quality of the manufactured product can be im-

proved.

[0082] An alpha cellulose content of the chemically treated wood-based cellulosic material 10 measured before the plasticization step 100 is preferably at least 65%, more preferably at least 67%. Further, the alpha cellulose content of the chemically treated wood-based cellulosic material 10 measured before the plasticization step 100 is preferably less than 99.5%, more preferably equal or less than 95% and most preferably equal or less than 90%. Thanks to said alpha cellulose content of the raw material, i.e., the chemically treated wood-based cellulosic material 10, a high yield, i.e., a high material efficiency, can be obtained. Further, the method can have a short treatment time (due to faster reactions).

[0083] The chemically treated wood-based cellulosic material 10 contains cellulose material which can contain hemicelluloses. Typically, lignin and wood extractives have been removed at least mostly.

[0084] The chemically treated wood-based cellulosic material 10 can comprise cellulose fibers, which are isolated from cellulose material by a chemical pulping process. Therefore, lignin is at least mostly removed from the material. The chemically treated wood-based cellulosic material 10 can be unbleached or bleached. Preferably, the chemically treated wood-based cellulosic material 10 is bleached.

[0085] Natural pulp fibers can be very difficult to process with chemicals due to high crystallinity of preventing the chemicals from penetrating fiber surfaces. Thanks to the novel method disclosed in this application, it can be possible to produce cellulose based products with improved safety of workers. For example, highly toxic carbon disulphide that is used in the production of viscose, can be replaced with more safety raw material.

[0086] The chemically treated wood-based cellulosic material 10 is preferably kraft pulp, and/or sulphite pulp, and/or soda pulp in order to obtain viscosity controlled cellulosic material 20 having good properties. Further, by using these materials, the viscosity controlled cellulosic material can be manufactured in an environmentally friendly way. Thus, chemically treated wood-based cellulosic material 10 can comprise at least 70 wt.-% or at least 80% wt.-%, more preferably at least 90 wt.-% or at least 95 wt.-%, and most preferably at least 98 wt.-% or exactly 100 wt.-% bleached kraft pulp, and/or sulfite pulp and/or soda pulp, based on the dry weight of the chemically treated wood-based cellulosic material 10. These raw materials can have the following advantages:

- high yield, and
- accelerated reactions during the plasticization step 100 into wanted area of viscosity due to hemicelluloses which tends to degrade into acid.

[0087] Most advantageously, the chemically treated wood-based cellulosic material 10 comprises kraft pulp, preferably bleached kraft pulp. The amount of bleached kraft pulp is preferably at least 50 w-%, more preferably

at least 80 w-% and most preferably at least 90 wt.-%, such as 100 wt.-%, calculated from the total dry weight of the chemically treated wood-based cellulosic material 10. The bleached kraft pulp is an economical raw material with suitable properties for this novel method. Further, the usage of the kraft pulp can improve the properties of the obtained viscosity controlled cellulosic material. Furthermore, the kraft pulp can be environmentally friendly raw material. Therefore, a yield and quality of the obtained product as well as production efficiency of the manufacturing process can be increased.

[0088] A lignin content of the chemically treated wood-based cellulosic material 10 is preferably less than 3%, more preferably less than 1.0%, and most preferably less than 0.5% based on the dry weight of the chemically treated wood-based cellulosic material. Therefore, the lignin, which could be harmful for the process, is not decreasing the efficiency of the method. Further, a very low lignin content can increase a brightness value of the obtained product.

[0089] The chemically treated wood-based cellulosic material 10 can be pretreated for better manufacturing efficiency. Thus, the chemically treated wood-based cellulosic material 10 can have at least one pretreating step 90 in order to pretreat the chemically treated wood-based cellulosic material 10 before the plasticization step 100.

[0090] The pretreatment step 90 can comprise, for example, a refining step. The refining step of the chemically treated wood-based cellulosic material 10 can be carried out with a device capable of separating and/or making the cellulose fibers shorter. The prerefiner device can be a refiner, such as a hammer mill, a fluffing machine, a rotary cutter, a conical refiner, or a disk refiner.

[0091] In an embodiment, due to the increased costs and, further, an effect of the refining for the properties of the manufactured product, the chemically treated wood-based cellulosic material 10 is preferably an unrefined pulp.

[0092] The amount of mechanical energy used in refining correlates with the water drainage resistance, which may be measured by the Schopper Riegler (SR) Freeness test. The Schopper Riegler (SR) Freeness test provides an empirical measurement value of the drainage resistance of a pulp slurry. The Schopper Riegler (SR) Freeness value may be determined using a SCAN-C 19:65 test method. The chemically treated wood-based cellulosic material 10, such as Kraft pulp, preferably has Schopper Riegler (SR) Freeness 35 at the most, more preferably 30 at the most, for example between 12 and 20, measured before the plasticization step.

[0093] The pretreatment step 90 can comprise a dosage of a chemical, such as an acid. The pretreatment step can comprise, for example, a dosage of acetic acid. The pretreatment step comprising the dosage of an acid can decrease a time needed for the plasticization step 100. However, the addition of the chemical, such as the acid, can increase the manufacturing costs of the manufactured product. However, due to the decreased dura-

tion of the plasticization step 100, the production efficiency can be improved despite of the increased chemical costs.

[0094] Due to the novel process, properties of the obtained viscosity controlled cellulosic material can be improved. Thus, properties of a regenerated cellulose material 40 which may be obtained from the viscosity controlled cellulosic material 20, can also be improved. Further, because no dissolving pulp is needed as raw material, raw material costs may be decreased.

[0095] Hemicellulose content of the chemically treated wood-based cellulosic material 10 can be between 0 and 33 wt.-%. Hemicellulose content of the chemically treated wood-based cellulosic material 10 is preferably at least 0.5 wt.-%, more preferably at least 3 wt.-%, or at least 5 wt.-%, and most preferably at least 10 wt.-%. Further, hemicellulose content of the chemically treated wood-based cellulosic material 10 is preferably 33 wt.-% at the most, more preferably 20 wt.-% at the most, and most preferably 15 wt.-% at the most. Higher hemicellulose content can be used to increase yield and to achieve higher material efficiency. Further, hemicellulose can be used as internal activator, improving reactions and decreasing a dosage of other chemicals.

[0096] The chemically treated wood-based cellulosic material 10 can be treated in a continuous process to form the viscosity controlled cellulosic material 20. Thanks to the novel continuous process, a production capacity can be increased, and production costs decreased and, hence, a production efficiency can be improved. Surprisingly, also brightness of the continuously manufactured product was improved comparing to a product obtained from a batch process.

[0097] The method for manufacturing viscosity controlled cellulosic material 20 having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process can comprise the following steps:

i) forming a cellulose-water mixture 15 comprising the chemically treated wood-based cellulosic material, the cellulose-water mixture having a dry matter content between 3% and 20%,

ii) treating the formed cellulose-water mixture 15 in a plasticization step 100 at a temperature between 130°C and 200°C and preferably at a pressure between 3 and 15 bar, more preferably between 5 and 10 bar, at least 5 minutes and 120 minutes at the most, while mixing the cellulose-water mixture 15, and feeding hot water and/or water steam to the cellulose-water mixture, thereby obtaining a treated mixture 18, and

iii) depressurizing the treated mixture 18 after the plasticization step 100 in a depressurizing step 105 in a controlled manner without a steam explosion, to maintain fiber integrity, thereby obtaining the viscosity controlled cellulosic material.

[0098] The step ii) wherein the cellulose-water mixture is treated in the plasticization step 100 in the presence of hot water and/or water steam can activate fibres.

[0099] A polydispersity of the obtained viscosity controlled cellulosic material can be less than 10, for example 8 at the most, more preferably less than 7, and most preferably less than 6, for example 5 at the most. Further, the polydispersity can be at least 1. Thanks to the novel, continuous process, the polydispersity of the viscosity controlled cellulosic material 20 can be improved, i.e. the polydispersity value can be smaller than conventionally. Therefore, properties and a solubility of the viscosity controlled cellulosic material 20 can also be improved.

[0100] A system for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process can comprise the following:

- means for forming a cellulose-water mixture and/or feeding the cellulose-water mixture to a continuous reactor,
- a continuous reactor, such as a continuous kneader reactor, for treating the cellulose-water mixture in a plasticization step 100 at a pressure between 5 bars and 10 bars,
- mixing means, such as a mixing device, for mixing the cellulose-water mixture during the plasticization step,
- heating means for increasing temperature of the cellulose-water mixture in the continuous reactor, such as a feeder to feed water steam to the continuous reactor, and
- means for depressurizing the treated mixture 18 in a controlled manner without a steam explosion after the plasticization step 100, such as a feeder to feed water to the treated mixture.

[0101] Further, the system for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process can also comprise the following means:

- washing device, such as a wash press, for washing the obtained viscosity controlled cellulosic material, and/or
- pH adjusting means, such as means for adding water and/or dosing chemical(s) and/or
- a dryer for drying the obtained viscosity controlled cellulosic material.

[0102] The chemically treated wood-based cellulosic material can have a viscosity value between 400 ml/g and 1200 ml/g, determined from the cellulose-water mixture 15 before the plasticization step. The viscosity value of the chemically treated wood-based cellulosic material is preferably at least 400 ml/g, more preferably at least 450 ml/g, and most preferably at least 500 ml/g, determined from the cellulose-water mixture 15 before the

plasticization step. Further, the viscosity value of the chemically treated wood-based cellulosic material is preferably 1200 ml/g at the most, more preferably 1000 ml/g at the most, and most preferably 900 ml/g at the most, determined from the cellulose-water mixture 15 before the plasticization step. The technical effect of said viscosity value is that the reaction can be improved, i.e., the reaction time during the plasticization step can be decreased. Further, typically, the alkali solubility of the viscosity controlled cellulosic material improves when the viscosity decreases. However, too low viscosity can cause several problems to the end product, for example an average fibre length and a brightness of the end product can be decreased and, moreover, a yield can also be decreased.

[0103] ISO Brightness of the chemically treated wood-based cellulosic material 15, determined before the plasticization step, is preferably at least 70%, more preferably at least 86%. Thus, the obtained viscosity controlled cellulosic material can have desired optical properties. Further, chemical consumption of the process may be decreased if brightness of the raw material is high enough. Thus, the chemically treated wood-based cellulosic material preferably consists of bleached pulp(s).

[0104] Further, an extractive content of the chemically treated wood-based cellulosic material 15, determined before the plasticization step, is preferably less than 0.4% and more preferably less than 0.2%, based on a dry weight of the chemically treated wood-based cellulosic material. The quality of the obtained viscosity controlled cellulosic material can be improved and runnability of the end-product can be increased if the extractive content is small enough.

[0105] An ash content of the chemically treated wood-based cellulosic material 10 measured from the cellulose-water mixture is preferably less than 0.7%, more preferably less than 0.5%, based on a dry weight of the chemically treated wood-based cellulosic material. The technical effect of the low ash content is that a quality of the viscosity controlled cellulosic material and runnability of the process can be improved.

[0106] A content of fibers having length below 0.6 mm, determined from the fibers of the cellulose-water mixture 15, is preferably between 10% and 30%, based on the total content of the chemically treated wood-based cellulosic material fibers.

[0107] A curliness of the chemically treated wood-based cellulosic material 10 determined from the cellulose-water mixture 15 before the plasticization step is preferably between 7% and 40%, more preferably between 20% and 40%. This has a technical effect of improving strength properties of the obtained product.

[0108] A sodium (Na) content of the cellulose-water mixture 15 is preferably at least 200 mg/kg, for example from 200 mg/kg to 1500 mg/kg based on the dry weight of the chemically treated wood-based cellulosic material fibers. If the sodium content is too low, fibers may not be swollen enough, hence, chemicals may have difficulties

to access to the fibers. Further, if the sodium content is too high, consumption of chemicals may be increased, and water may not penetrate fiber walls as efficiently as with the optimum sodium content.

[0109] The chemically treated wood-based cellulosic material 10 can have a crystallinity index between 50% and 70%. Said crystallinity index can improve chemical access into fibres of the chemically treated wood-based cellulosic material.

[0110] A WRV of the cellulose-water mixture 15 is preferably between 1 g/g and 2 g/g. This WRV rate can improve chemical access and, hence, decrease the reaction time.

[0111] At least one acid is preferably used as an activator to accelerate a viscosity adjustment during the plasticization step 100. The activator can be dosed before the plasticization step 100 and/or in the beginning of the plasticization step. Thus, the method can comprise the following step:

- dosing an activator into the cellulose-water mixture 15 in order to hydrolyse the chemically treated wood-based cellulosic material 10 in the presence of the activator during the plasticization step 100.

[0112] Advantageously, the activator comprises a filtrate 102 from the plasticization step 100. The acids from wood can release protons during plasticization step 100, thus, mild acidic conditions may be created without chemicals. However, this is typically not enough for the needed acidic conditions. Thanks to the novel method, part of this acid solution can be separated and conveyed as filtrate(s) 102 and used again in the plasticization step 100, hence, improved acidic conditions can be obtained without any addition of chemicals (see Fig. 1b).

[0113] Therefore, the activator can comprise filtrate(s) 102, which are obtained from the plasticization step 100. The filtrate(s) 102 are typically reaction filtrate(s) which comprise hydrolysate products from the plasticization step 100. Said filtrate(s) 102 typically contains carboxylic acid, hence, they can be used to improve the reaction efficiency during the plasticization step 100. Therefore, the activator comprising the filtrate(s) 102 can be used to obtain the suitable acidic conditions to obtain the pre-determined viscosity adjustment during the plasticization step 100.

[0114] The total amount of said filtrate(s) 102, obtained from the plasticization step 100, can be more than 50%, such as at least 80%, more preferably more than 90%, such as at least 95%, and most preferably at least 99% or exactly 100% calculated from the total amount of the activator. This can be very cost-effective solution for the activator. Therefore, a production efficiency of the novel method can be increased. Further, said filtrate 102 separated from the plasticization step 100 and circulated to the plasticization step 100, e.g. to the continuous reactor 101, can be very environmentally friendly solution.

[0115] In addition, or alternatively, the activator may

comprise acid solutions, preferably acid filtrates, such as acid bleaching filtrates from a chemical pulp mill.

[0116] If the activator comprises added chemicals, such as added acid(s), and not only said filtrates, the added acid(s) preferably comprise acetic acid and/or sulfuric acid. In this case, the added chemicals preferably comprise at least 80 wt.-%, more preferably at least 90 wt.-%, and most preferably at least 97 wt.-% acetic acid and/or sulfuric acid. Advantageously, the added chemicals comprise or consist of acetic acid. The amount of acetic acid can be at least 80 wt.-%, more preferably at least 90 wt.-%, and most preferably at least 97 wt.-% calculated from the total weight of the added chemicals for the plasticization process. Acetic acid has good properties for the activator, and it is quite cost-effective chemical, hence, it is possible to reduce manufacturing costs and increase production efficiency by using the acetic acid for the viscosity adjustment.

[0117] If the activator comprises sulfuric acid and/or acetic acid, the total amount of the sulfuric acid and the acetic acid can be less than 5%, for example 3% at the most, more preferably less than 2%, for example 1.5% at the most, and most preferably less than 1%, for example 0.5% at the most, calculated from the dry weight of the chemically treated wood-based cellulosic material. Thus, thanks to the novel environmentally friendly solution, only small quantity of acid, if any, can be used.

[0118] Acids from the filtrate(s) 102 can be separated by e.g. distillation and/or at least part of the filtrate(s) 102 is circulated into the plasticization step 100 without the separation stage. Advantageously, to obtain improved production efficiency, the filtrate(s) 102 or at least a part of the filtrate(s) 102 is circulated into the plasticization step 100 as such. Typically, these filtrate(s) 102 obtained from the plasticization step, contains carboxylic acids formed from the wood-based cellulosic material during the plasticization step 100.

[0119] The only chemical used in the method can be the filtrate 102 obtained from the plasticization step 100. Therefore, thanks to the novel method, the viscosity controlled cellulosic material can be manufactured from the chemically treated wood-based cellulosic material 10 without chemicals. Therefore, this novel method can be chemical free.

[0120] Advantageously, total dosage of chemicals added to the system during the following steps:

- i) forming a cellulose-water mixture,
- ii) treating the formed cellulose-water mixture 15 in a plasticization step, and
- ii) depressurizing the treated mixture 18 after the plasticization step 100 in a depressurizing step 105, is less than 5%, for example 3 % at the most, more preferably less than 2%, for example 1%, and most preferably less than 0.5%, such as exactly 0%, calculated from the dry weight of the chemically treated wood-based cellulosic material 10.

[0121] Therefore, thanks to this novel method, the viscosity controlled cellulosic material 20 can be manufactured in an environmentally friendly way, and still have a high yield and an improved production efficiency.

[0122] Preferably, the plasticization step 100 does not contain enzymes due to their expensiveness and difficulty in use. Furthermore, the enzymes may not work within conditions of the plasticization step 100. Thus, if any enzymes are used, they are preferably dosed before the plasticization step 100, hence, the enzyme(s) will be destroyed during the plasticization step. Thus, any allergy reactions of end users, as well as other problems caused by the enzymes, can be avoided. A total dosage of the enzyme(s) is preferably less than 0.5%, more preferably less than 0.1%, and most preferably exactly 0%, calculated from the dry weight of the chemically treated wood-based cellulosic material 10.

[0123] The step i), i.e., forming the cellulose-water mixture 15, can be implemented by any means known to a man skilled in the art.

[0124] The plasticization step 100 can be carried out in a continuous reactor 101. Thus, the plasticization step 100 preferably comprises the following steps:

- feeding the cellulose-water mixture 15 to the continuous reactor 101, and
- treating the formed cellulose-water mixture 15 continuously in the reactor 101, thereby obtaining a treated mixture 18.

[0125] Thus, the means for treating the cellulose-water mixture 15 during the plasticization step preferably comprises the continuous reactor 101.

[0126] Advantageously, the raw material is conveyed horizontally, or at least substantially horizontally, during the plasticization step 100. This can improve an effect of mixing and, hence, increase a reaction efficiency. Thus, a production efficiency can be improved. Preferably, an angle between a horizontal line and a length direction of the continuous reactor 101 can be less than 20°.

[0127] The heating means in a plasticization step 100 can comprise a feeding device for feeding water steam and/or hot water to the continuous reactor 101 in order to increase temperature of the reactor 101.

[0128] The mixing means for mixing the cellulose-water mixture 15 during the plasticization step can comprise, for example, a mixing device. The mixing means can comprise, for example, an extruder. Advantageously, the mixing means for mixing the cellulose-water mixture 15 can comprise, for example, a continuous kneader reactor (i.e., a kneader type of a reactor), or another kind of continuous screw reactor, which is configured to mix the cellulose-water mixture during the plasticization step 100. Thanks to the mixing during the plasticization step 100, a reaction efficiency during the plasticization step can be hugely improved, hence, production time and energy needed for the plasticization step can be decreased. Furthermore, properties of the manufactured product, such

as a polydispersity and a brightness of the viscosity controlled cellulosic material 20, can be improved.

[0129] Preferably, a mixing efficiency during the plasticization step is between 10 kWh/ADt and 150 kWh/ADt. More preferably, the mixing efficiency during the plasticization step is at least 15 kWh/ADt, and most preferably at least 20 kWh/ADt. Furthermore, the mixing efficiency during the plasticization step is more preferably equal or less than 80 kWh/ADt, and most preferably equal or less than 50 kWh/ADt. Technical effect of said mixing efficiency is even quality, better solubility and faster reactions. Thus, reaction time can be decreased, hence, production efficiency can be improved.

[0130] The continuous reactor can have several segments, wherein each segment forms a chamber, hence, there may not be too much of exchange of materials between neighboring chambers over the length of the continuous reactor.

[0131] Advantageously, the plasticization step 100 is implemented by treating the formed cellulose-water mixture 15 in a continuous horizontal reactor. The cellulose-water mixture 15 can be efficiently conveyed over the length of the continuous horizontal reactor, such as a continuous horizontal screw reactor. Most preferably, the continuous horizontal reactor is a kneader reactor. Therefore, there may not be any or almost any exchange of material between neighboring parts over the length of the continuous horizontal reactor. Thus, the manufacturing process can be easily controlled. Therefore, it is possible to have a mild treatment, which may improve properties of the manufactured product.

[0132] The continuous reactor 101, such as a screw reactor, can have valves, wherein the valves are opened at different times to prevent the material in different chambers to be mixed and, hence, the valves can be used to control the conveying process of the material during the plasticization step 100.

[0133] In an embodiment, a screw reactor, if used, does not have very high pressing effect on the wood-based cellulosic material during the plasticization step 100 in order to avoid many fibre bundles affecting the properties of the manufactured product.

[0134] The system can further comprise means for dosing the activator to the cellulose-water mixture 15 in order to treat the cellulose-water mixture in the presence of the activator in the plasticization step 100.

[0135] At least part of the filtrate 102 obtained from the plasticization step 100 can be conveyed from at least one of the chambers of the continuous reactor 101 and/or after the continuous reactor 101 to another chamber of said continuous reactor 101 and/or before the first chamber of the continuous reactor 101. Hence, at least part of the acid filtrate 102 can be separated and conveyed as acid filtrate and used again in the plasticization step 100. Therefore, improved acidic conditions can be obtained without any addition of chemicals when, for example, the continuous reactor 101 has chambers.

[0136] The means for dosing the activator to the cel-

lulose-water mixture can comprise means for conveying filtrate 102 obtained from the second part 100b of the continuous reactor 101 and/or after the continuous reactor 101 to the first part 100a of the continuous reactor 101 and/or before the continuous reactor 101. The second part 100b of the continuous reactor 101 is located forward from the first part 100a of the continuous reactor 101. This is illustrated in Fig 1b.

[0137] Temperature of the plasticization step 100 can be increased and/or controlled with

- water steam,
- hot water,
- electricity (with electrical resistance),
- gas, and/or
- fuel oil.

[0138] Preferably, the temperature of the plasticization step 100 is increased and/or controlled by using hot water and/or water steam. Thus, the chemically treated wood-based cellulosic material 10 is preferably treated with hot water and/or water steam during the plasticization step 100. Thus, the plasticization step 100 can further comprise:

- feeding water steam and/or hot water to a continuous reactor 101 in order to increase temperature of the continuous reactor 101.

[0139] Thanks to the water steam and/or the hot water, the viscosity controlled cellulosic material 20 can be manufactured efficiently and environmentally friendly. Furthermore, the hot water and/or water steam plasticization can be economically viable. Most preferably, water steam is used to increase temperature of the continuous reactor 101, because water steam can efficiently spread into the chemically treated wood-based cellulosic material 10, and penetrate to fiber walls of the chemically treated wood-based cellulosic material 10.

[0140] The duration of the plasticization step 100 is preferably less than 60 minutes, for example 50 minutes at the most, more preferably less than 30 minutes, for example 25 minutes at the most, and most preferably less than 20 minutes, for example 15 minutes at the most. Further, the duration of the plasticization step 100 is preferably at least 4 minutes, more preferably at least 5 minutes. Most advantageously, the duration of the plasticization step is between 5 and 20 minutes. Thanks to the present invention having continuous process, wherein the treated mixture is mixed during the plasticization step, it is possible to obtain viscosity controlled cellulosic material 20 having good properties by using a short treatment time while avoiding steam explosion. Therefore, due to quite fast viscosity adjustment and lower energy consumption during the plasticization step 100, manufacturing costs can be remarkably decreased. Further, said shorter reaction time increases the production capacity. Thus, viscosity controlled cellulosic material can

be manufactured with improved production efficiency. Furthermore, properties of the viscosity controlled cellulosic material, such as a brightness and/or a polydispersity, can be improved.

[0141] The plasticization step 100 can be carried out at a temperature of at least 130°C, more preferably at least 140°C and most preferably at least 150°C. Further, temperature of the plasticization step 100 can be 200°C at the most, more preferably 180°C at the most, and most preferably 170°C or 160°C at the most. This quite low temperature, especially when used together with quite low duration of the plasticization step 100, can cause remarkable manufacturing cost savings due to lower energy consumption. Moreover, this kind of temperature range, particularly if the temperature is 170°C at the most, or 160°C at the most, can improve brightness of the obtained product. The brightness value of the obtained product typically increases (i.e., improves) when the temperature of the process decreases.

[0142] A pressure during the plasticization step 100 can be at least 3 bar, more preferably at least 4 bar, and most preferably at least 5 bar. Further, pressure of the steam treatment can be 15 bar at the most, more preferably 10 bar at the most, and most preferably 8 bar at the most. This quite low pressure, especially when used together with the above-mentioned duration of the plasticization step 100, can cause remarkable manufacturing cost savings together with improved properties for the manufactured viscosity controlled cellulosic material. Moreover, this can improve the brightness of the obtained product.

[0143] pH of the plasticization step 100 can be at least 1, more preferably at least 2, and most preferably at least 3. In addition, pH of the plasticization step 100 can be 6 at the most, more preferably 5 at the most, and most preferably 4 at the most, for example between 2 and 5. By using said pH ranges, it is possible to obtain efficient manufacturing process for the viscosity controlled cellulosic material, said effect of pH improves when used together with the above-mentioned pressure and duration of the plasticization step.

[0144] The cellulose-water mixture 15 can have a dry matter content (consistency) between 3% and 20% during the plasticization step 100. The dry matter content during the plasticization step 100 can be at least 5%, more preferably at least 7%, and most preferably at least 10%. Further, the dry matter content during the plasticization step 100 can be 18% at the most, more preferably 15% at the most, and most preferably 13% at the most. This consistency range, particularly consistency between 5% and 15% or between 5% and 13%, can improve the properties of the manufactured viscosity controlled cellulosic material.

[0145] During the plasticization step 100, a degree of polymerization can be decreased at least 50%, more preferably at least 70%, and most preferably at least 80%. This can improve an R18 solubility of the obtained product.

[0146] The depressurizing of the treated mixture 18 in the depressurizing step 105 after the plasticization step 100 can be done in a controlled manner to avoid steam explosion. Thus, the treated mixture 18 can be non-explosively depressurized to the atmospheric pressure after the plasticization step 100. Thus, the depressurizing step 105 is preferably substantially slow and controlled i.e., implemented without a steam explosion. Therefore, the depressurizing step 105 is not advantageously simply implemented, for example, by opening a valve of the continuous reactor 101 and, hence, blowing off the water steam from the continuous reactor 101. Thus, thanks to the novel method, it is possible to maintain fiber integrity.

[0147] Suitable depressurization time depends, for example, on the pressure under which the plasticization step 100 is carried out.

[0148] The depressurizing step 105 may be implemented, for example, by adding water to the treated mixture 18. The addition of water during the depressurizing step can be implemented, for example, by using a chamber method, wherein water is added into an intermediate chamber in order to decrease a temperature and a pressure of the treated mixture 18. The intermediate chamber can comprise at least one valve for letting the wood-based cellulosic material into the chamber, and at least one another valve for letting the wood-based cellulosic material out from the intermediate chamber after said depressurizing.

[0149] Further, the intermediate chamber can comprise at least one valve, for example exactly one valve, for letting some water steam go out from the chamber while adding the cold water.

[0150] Alternatively, or in addition, the addition of the water can be implemented, for example, by using compartment valves.

[0151] Furthermore, the addition of the water can be implemented, for example, by using a continuous screw reactor, wherein cold water is added into the continuous screw reactor, such as to a last chamber of the screw reactor, in order to decrease a temperature and a pressure of the treated mixture 18.

[0152] Therefore, the depressurizing step 105 can comprise the following step:

- cooling the treated mixture 18 by adding water.

[0153] The water used for the cooling has preferably a temperature less than 40°C, for example between 5°C and 30°C. Temperature of the obtained viscosity controlled cellulosic material after the depressurizing step is preferably about 100°C, for example between 90°C and 110°C. Thus, effectiveness of the possible following treatment(s) can be increased.

[0154] This kind of the gentle depressurizing step 105 can be used to maintain integrity of the fibers.

[0155] Thus, the means for depressurizing the treated mixture 18 in the depressurizing step can comprise means for adding water, preferably cold water, to the

treated mixture 18. Further, the means for depressurizing the treated mixture 18 can comprise an openable valve. Further, the means for depressurizing the mixture can comprise an intermediate chest. In this case, the cold water is preferably added to the intermediate chest.

[0156] During the depressurizing step 105, the pressure can be decreased from the pressure of the plasticization step to the standard atmosphere (i.e. standard pressure, 1 atm), or to a pressure having below 1 bar difference to the atmospheric pressure, preferably below 0.5 bar difference to the atmospheric pressure. Thanks to the non-explosive depressurizing step 105, properties of the manufactured viscosity controlled cellulosic material 20 may be substantially improved. Especially, strength properties may be substantially improved.

[0157] After the depressurizing step 105, the obtained viscosity controlled cellulosic material 20 can be further treated, for example, as follows:

- washing the cellulosic material 20 in a washing step 110 and/or
- adjusting pH of the obtained viscosity controlled cellulosic material 20 in a pH adjusting step.

[0158] The washing step 110 can comprise the following step:

- washing the obtained viscosity controlled cellulosic material 20 with water to remove excess acid.

[0159] Furthermore, the washing step 110 can comprise the following step:

- conveying at least part of the water used in the washing step to the cellulose-water mixture 15.

[0160] Thus, in this embodiment, at least part of the water used for washing step 110 of the viscosity controlled cellulosic material 20 can be used for diluting the cellulose-water mixture 15 before the plasticization step. Thus, said water can increase a temperature of the cellulose-water mixture 15 before the plasticization step. Furthermore, at least some of excess acid removed during the washing step 110 can be circulated to the plasticization step and reused therein.

[0161] Furthermore, the washing step 110 can comprise the following step:

- dewatering the washed viscosity controlled cellulosic material, for example, by pressing the viscosity controlled cellulosic material 20 to reach a dry matter content between 10% and 50%, preferably at least 15%, more preferably at least 20%, and preferably 45% at the most, more preferably 40% at the most.

[0162] The washing step 110 can be carried out, for example, by using a wash press.

[0163] In an embodiment, pH of the viscosity controlled

cellulosic material can be adjusted, for example, by diluting the material with water, wherein the viscosity controlled cellulosic material 20 is diluted to a predetermined pH. Alternatively, or in addition, suitable chemical(s) known by a person skilled in the art, can be used for said pH adjustment. The predetermined pH can be, for example, between 4 and 7, more preferably between 4 and 6.

[0164] Further, the method can comprise the following step, preferably following the washing step 110 and/or the pH adjusting step:

- drying the obtained viscosity controlled cellulosic material 20 in a drying step 120 to reach a dry matter content of at least 50%.

[0165] Dry matter content of the viscosity controlled cellulosic material 20 after the drying step 120 can be between 50 and 100%, preferably between 80 and 90%.

[0166] The drying step 120 is typically needed, for example, for a transportation.

[0167] The drying step 120 may be implemented in a flash drying step using a flash dryer. However, the flash dryer is not necessarily an economical device. Thus, more advantageously, the drying step is implemented, for example, by using a drying machine of a pulp mill. Therefore, the drying step 120 may be implemented without a large investment.

[0168] If the manufacturing process is an integrated process, for example, in a pulp mill, there may not be any need for the drying step 120 of the obtained viscosity controlled cellulosic material before, for example, a regenerated cellulose material is formed from the viscosity controlled cellulosic material 20.

[0169] Thanks to the novel method, the obtained viscosity controlled cellulosic material 20 can have a viscosity value in a range between 150 ml/g and 500 ml/g. Preferably, the viscosity value of the viscosity controlled cellulosic material is at least 160 ml/g, more preferably at least 170 ml/g, and most preferably at least 180 ml/g. Further, preferably the viscosity value of the viscosity controlled cellulosic material is 350 ml/g at the most, more preferably 300 ml/g at the most, and most preferably 250 ml/g at the most.

[0170] The viscosity controlled cellulosic material 20 can have a special hemicellulose content due to the novel method. Hemicellulose content of the obtained viscosity controlled cellulosic material 20 can be between 0.5 wt.-% and 30 wt.-%. Hemicellulose content of the viscosity controlled cellulosic material 20 is preferably at least 1 wt.-%, more preferably at least 3 wt.-%, and most preferably at least 5 wt.-%. Further, the hemicellulose content of the viscosity controlled cellulosic material 20 is preferably 30 wt.-% at the most, more preferably 25 wt.-% at the most. The technical effect of said hemicellulose content includes an improved yield and a material efficiency, an improved environmental impact as well as an improved reactivity.

[0171] The viscosity controlled cellulosic material 20

can have a special glucose content due to the novel method. Said glucose content the obtained viscosity controlled cellulosic material 20 can be between 76 wt.-% and 99.6 wt.-% calculated from the total sugar content of the viscosity controlled cellulosic material. Said glucose content of the viscosity controlled cellulosic material 20 is preferably at least 80 wt.-%, more preferably at least 85 wt.-%, and most preferably at least 90 wt.-% calculated from the total sugar content of the viscosity controlled cellulosic material. In addition, said glucose content of the viscosity controlled cellulosic material 20 is preferably 99 wt.-% at the most, and more preferably 95 wt.-% at the most, calculated from the total sugar content of the viscosity controlled cellulosic material. The technical effect of said glucose content includes an improved material efficiency.

[0172] An alpha cellulose content of the viscosity controlled cellulosic material is preferably at least 67%, more preferably at least 69%. Further, the alpha cellulose content of the viscosity controlled cellulosic material is preferably less than 99.5%, more preferably less than 95%, and most preferably 90% at the most. The technical effect is an improved yield, an improved reactivity and a material efficiency, as well as better environmental impact.

[0173] The obtained viscosity controlled cellulosic material 20 can have a degree of polymerization between 200 and 700. The degree of polymerization is preferably at least 220, more preferably at least 250, and most preferably at least 300. Further, the degree of polymerization is preferably 650 at the most, more preferably 620 at the most, and most preferably 600 at the most.

[0174] The viscosity controlled cellulosic material 20 can have a special fiber length due to the novel method. Advantageously, a content of fibers having length below 0.6 mm, measured from the viscosity controlled cellulosic material, is between 10% and 30%. The technical effect is that this kind of viscosity controlled material can be very easy to handle and wash and, further, yield loss can be decreased.

[0175] Moreover, thanks to the novel method, the length weighted fiber length $L_c(l)$ of the viscosity controlled cellulosic material measured according to ISO 16065-N can be more than 0.5 mm, for example at least 0.7 mm, more preferably at least 0.9 mm or at least 1.0 mm, and most preferably at least 1.2 mm. Further, the average fiber length of the viscosity controlled cellulosic material 20 can be 3.0 mm at the most. The fiber length of the viscosity controlled cellulosic material depends on the fiber length of the raw material, which is affected, for example, by the amount of softwood and/or hardwood raw materials. Said length weighted fiber length of the viscosity controlled cellulosic material can improve strength properties of the product. Especially bursting strength of an end product can be improved.

[0176] Good optical properties may be important for the viscosity controlled cellulosic material 20. With the novel method, ISO Brightness of the viscosity controlled cellulosic material can be at least 70%, for example be-

tween 75% and 90%. Thus, a quality of the end-product can be increased.

[0177] A curliness of the viscosity controlled cellulosic material can be between 20% and 90%, more preferably between 25% and 85%, and most preferably between 30% and 65%. This may improve strength properties of the end-product. Further, said curliness can improve water removing properties of the product.

[0178] Further, a WRV of the viscosity controlled cellulosic material 20 is preferably between 1 g/g and 2 g/g. The technical effect is an improved chemical access together with an improved reaction efficiency, i.e. decreased reaction time.

[0179] To achieve good properties for the viscosity controlled cellulosic material, the lignin content of the viscosity controlled cellulosic material can be less than 1.5%, more preferably less than 1%, and most preferably less than 0.5%. Further, an extractive content of the viscosity controlled cellulosic material is preferably less than 0.2%, more preferably less than 0.1%. Decreased lignin and extractive contents of the product improves a brightness and a quality of the product.

[0180] The viscosity controlled cellulosic material 20 can have a special crystallinity index Crl due to the novel method. The obtained viscosity controlled cellulosic material 20 can have a crystallinity index of at least 74%, more preferably at least 75%, and most preferably at least 76%. In addition, crystallinity index of the obtained viscosity controlled cellulosic material can be less than 85%, for example 80% at the most. Thanks to the novel method, it is possible to obtain said improved crystallinity index which can improve properties, such as strength properties, of the product.

[0181] A sodium (Na) content of the viscosity controlled cellulosic material can be at least 200 mg/kg, preferably 200 - 1500 mg/kg based on the dry weight of the chemically treated wood-based cellulosic material fibers. Sodium content has an effect on a viscosity value of the obtained product. Too high sodium content of the viscosity controlled cellulosic material may cause too high viscosity value for the product.

[0182] Thanks to the novel method, the novel viscosity controlled cellulosic material can have a special R18 solubility of the viscosity controlled cellulosic material 20. R18 solubility of the viscosity controlled cellulosic material can be at least 60%, more preferably at least 65% and most preferably at least 70%. In addition, R18 solubility of the viscosity controlled cellulosic material is preferably 87% at the most, most preferably 84% at the most. Thanks to this novel R18 solubility of the viscosity controlled cellulosic material, an environmentally friendly product can be obtained. Moreover, a yield as well as a production efficiency can be improved.

[0183] The viscosity controlled cellulosic material 20 can be dissolvable in an aqueous solution of alkali metal hydroxide at a temperature between -5°C and 0°C, typically at a temperature between -10°C and 5°C in order to form homogenous cellulose solution. Most preferably,

the viscosity controlled cellulosic material 20 is dissolvable at least to a cold NaOH having a temperature within the above-mentioned temperature range. NaOH can help to obtain relatively inexpensive and environmentally friendly aqueous alkali-based solution.

[0184] The viscosity controlled cellulosic material 20 can be dissolved in aqueous alkaline solutions to form a dissolved viscosity controlled cellulosic material 30. Further, a regenerated cellulose material 40 can be obtained from the dissolved viscosity controlled cellulosic material 30. Thanks to an activation of fibres in the plasticization step 100, reactivity of the fibres can be increased and, hence, the viscosity controlled cellulosic material can be easily modified into the regenerated cellulose material 40. Furthermore, the water steam, if used during the plasticization step, can decrease crystallinity of the viscosity controlled cellulosic material.

[0185] The dissolved viscosity controlled cellulosic material 30, which can also be called as "a dope", may be raw material for other products, such as fibers. The dissolved viscosity controlled cellulosic material 30 i.e., the dope, can be used, for example, for filaments, staple fibers, cellulose beads, and/or films.

[0186] A method for processing the obtained viscosity controlled cellulosic material 20 to form the regenerated cellulose material 40 can comprise the following steps:

- dissolving the viscosity controlled cellulosic material 20 in a dissolving step 130 by using an aqueous alkaline, thereby forming a dissolved viscosity controlled cellulosic material 30, and
- forming the regenerated cellulose material 40 from the dissolved viscosity controlled cellulosic material 30.

[0187] The concentration of the viscosity controlled cellulosic material in a dissolving step 130 is preferably between 5 and 10%.

[0188] The aqueous alkaline can comprise

- NaOH,
- LiOH, and/or
- KOH,

and/or a mixture of any of the above mentioned with zinc compounds

[0189] Advantageous, at least NaOH is used for the dissolving step 130, because NaOH is substantially cost-effective chemical which may be easy to use in the process.

[0190] The addition of the zinc compounds to the alkali hydroxide solution can, for example, increase the stability of the solution. A stability time of the dissolved viscosity controlled cellulosic material 30 can be, for example, 30 d at a room temperature, 180 days in fridge.

[0191] Optionally, additives such as colorants, surface active agents, ultra-violet degradation inhibitors, anti-fungal components, anti-microbial components, inor-

ganic fillers or other components may be blended into the dissolved viscosity controlled cellulosic material 30.

[0192] The novel process can be technologically simple and ecologically safe process without a need of toxic substances. Further, the novel process can be inexpensive due to small chemical consumption and substantially simple technology.

Experimental tests, Example 1

[0193] Three similar samples were treated by using different kind of manufacturing methods. The results can be seen in Figures 4a - 4c. The treatments were as follows:

- Sample 1A: viscosity controlled cellulosic material manufactured with a steam explosion by using a batch process (Fig. 4a),
- Sample 2A: viscosity controlled cellulosic material manufactured without a steam explosion by using a batch process (Fig. 4b), and
- Sample 3A: viscosity controlled cellulosic material manufactured without a steam explosion by using a continuous process (Fig. 4c).

[0194] As can be seen from the photos, the sample 3, which was manufactured without the steam explosion by using the continuous process, has improved optical properties, such as an improved brightness value comparing to the sample 1. Further, fibers of the sample 1 were much more damaged than fibers of the sample 3.

Example 2

[0195] Three different samples were analyzed under a light microscope. The results can be seen in Figures 5a - 5c. Said samples were stained with Graff-C.

[0196] Sample 1B (Figure 5a) was a kraft pulp, which was used as a raw material, Sample 2B (Figure 5b) was a viscosity controlled cellulosic material, and Sample 3B (Figure 5c) was a steam exploded cellulosic material.

[0197] Fibers of the sample 1 were straight and intact with clearly visible typical pores. Some of the Kraft fibers had loose outer fibril layer and kinks typical for kraft fibers.

[0198] Fibers of the sample 2 were clearly more fibrillated on the surface and they had gained a loose structure. The fibers were quite curly. The fiber structure is probably absorbing and easy to disintegrate.

[0199] The sample 3 consists of crystalline material and some slender fibers.

[0200] As can be seen from the Figures 5b and 5c, the continuous process without the steam explosion has maintained the fiber integrity, but the steam explosion process has almost destroyed the fibers.

Example 3

[0201] During the experimental tests, several pulp samples were treated in a plasticization step and properties of the treated pulps were measured. These results are shown in Figures 6-11.

[0202] Sample A was a never dried conifer pulp which was treated without a steam explosion by using a batch type of reactor having the following parameters:

Temperature: 170°C,
Pressure: 7 bar,
Time: 120 min, and
pH: 3.3.

[0203] Sample B was a never dried conifer pulp which was treated without a steam explosion by using a continuous reactor having the following parameters:

Temperature: 170°C,
Pressure: 7 bar,
Time: 20 min, and
pH: 3.3.

[0204] Sample C was a never dried conifer pulp which was treated without a steam explosion by using a continuous reactor having the following parameters:

Temperature: 170°C,
Pressure: 7 bar,
Time: 50 min, and
pH: 3.3.

[0205] Sample D was a never dried conifer pulp which was treated without a steam explosion by using a semi-continuous reactor having the following parameters:

Temperature: 160°C,
Pressure: 6 bar,
Time: 25 min, and
pH: 3.3.

[0206] Sample E was a never dried conifer pulp which was treated without a steam explosion by using a semi-continuous reactor having the following parameters:

Temperature: 160°C,
Pressure: 6 bar,
Time: 10 min, and
pH: 3.3.

[0207] Sample F was a dried conifer pulp which was treated without a steam explosion by using a semi-continuous reactor having the following parameters:

Temperature: 160°C,
Pressure: 6 bar, and
Time: 25 min.

[0208] Sample G was a dried conifer pulp which was treated without a steam explosion by using a batch type of reactor having the following parameters:

5 Temperature: 170°C,
 Pressure: 7 bar,
 Time: 120 min, and
 pH: 4.0.

10 **[0209]** Sample H was a dried conifer pulp which was treated with a steam explosion method by using a continuous reactor having the following parameters:

15 Temperature: 190°C,
 Pressure: 10 bar,
 Time: 5 min, and
 pH: 4.0.

20 **[0210]** Samples I and J were never dried birch pulps which were treated by using a continuous reactor having the following parameters:

25 Temperature: 170°C,
 Pressure: 7 bar,
 Time: 50 min, and
 pH: 3.3.

30 **[0211]** Samples K and L were never dried conifer pulps which were treated by using a continuous reactor having the following parameters:

35 Temperature: 170°C,
 Pressure: 7 bar,
 Time: 50 min, and
 pH: 10.3.

[0212] Reference samples Ref1 and Ref2 were (untreated) never dried conifer pulps.

40 **[0213]** Molar mass distribution by tricabanilate (RI detection), Mw [g/mol], of all samples is illustrated in Figures 6a and 6b. As can be seen, the samples obtained by using continuous and semi-continuous processes (Samples B, C, D, E, F) had improved properties comparing to the samples obtained by using a batch process (Sample A and G).

45 **[0214]** Viscosity values of the samples are illustrated in Figure 7. As can be seen, pH had an effect on the viscosity values of the manufacture product. High pH (Samples K and L) increased the viscosity value of the manufactured product. Further, surprisingly, a batch process (Samples A and G) was very ineffective way to manufacture the viscosity controlled cellulosic material. The samples A and G obtained from the batch processes had higher viscosity values than the samples obtained from the continuous processes. On the contrary, the continuous process seemed to be very efficient. The viscosity values were lower in the samples B-F and H obtained from the continuous process (having a reaction time be-

tween 10 and 50 min) than in the samples A and G obtained from the batch process (having a reaction time around 120 min).

[0215] The viscosity values of the samples decreased along with the increased reaction temperature and/or reaction time. As can be seen, it is possible to obtain the viscosity controlled cellulosic material in an effective way by using the claimed method. Hence, thanks to the novel method, the production efficiency can be increased significantly. Further, due to the decreased reaction time and/or the decreased reaction temperature, the properties of the obtained viscosity controlled cellulosic material, such as a brightness value of the obtained product, can be significantly increased.

[0216] Length weighted fiber lengths of the samples are shown in Figure 8a. As can be seen, the sample H, manufactured by using a steam explosion process, had the shorter fibers. Fibers of said sample H (manufactured by using the steam explosion method) seemed to be so broken that a length weighted fiber length of the sample H had been reduced to the same level with the samples I and J having a birch pulp as a raw material. The length weighted fiber lengths of the samples A-G and K-L, manufactured without the steam explosion, were at a very good level.

[0217] Further, the continuous process seemed to be very efficient. Fiber lengths of those samples, which were manufactured by using a continuous process, had already decreased when the treatment time was 50 minutes. Thus, with the continuous process also a very short time, such as around 10 minutes, can be sufficient for the process. A longer treatment time was needed for the batch processes than for the continuous processes. Therefore, with the continuous process, the production efficiency can be improved, and a quality of the product can be better than a quality of the product manufactured by using the steam explosion method.

[0218] A fiber curl [%] is illustrated in Figure 8b. As can be seen, the fiber curliness was very small in Sample H due to the steam explosion process. Further, the samples A and G, which were obtained from the batch processes, as well as the sample C, which was obtained from the continuous process having a quite long treatment time together with a quite high temperature, had decreased curliness values. Furthermore, high pH (Samples K and L) and a birch pulp as a raw material (Samples I and J) seemed to decrease the curliness of fiber. The samples B, D, E and F, which were obtained from the continuous processes having a treatment time between 10 and 25 min, had the most promising results.

[0219] A Kink value [1/m] is illustrated in Figure 9a. As can be seen, the kink value was the smallest in the samples A and G (batch processes). In addition, the kink value was a little bit low in the sample H (steam explosion process). The kink value was the highest with the samples which were manufactured without a steam explosion by using a continuous process.

[0220] Fibrillation is illustrated in Figure 9b. As can be

seen, the samples manufactured without a steam explosion by using the continuous processes had slightly higher fibrillation level than the samples manufactured by using the batch processes. The steam explosion process (sample H) can destroy a structure of fibres, thereby causing a very high fibrillation level.

[0221] A polydispersity is illustrated in Figure 10. The polydispersity value of the samples manufactured by using the continuous process was improved. The continuous processes seemed to be very efficient. The sample E obtained from the continuous process having a very short treatment time (10 min) had the same polydispersity level as the samples A and G obtained from batch processes having a long treatment time (120 min). Therefore, by using the continuous process, it is possible to improve the production efficiency.

[0222] Crystallinity index by XRD [%] is illustrated in Fig. 11. Crystallinity index typically increases due to the plasticization process.

Claims

1. A viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g measured according to standard ISO 5351:2010, and an R18 solubility between 60% and 87% measured according to standard T 235 cm-00, wherein the viscosity controlled cellulosic material comprises wood-based cellulosic material.
2. The viscosity controlled cellulosic material according to claim 1, wherein
 - the material is cold alkali soluble, and
 - optionally, the material is dissolvable to an aqueous alkaline having NaOH content of solution between 5% and 10% at a temperature from -10°C to +5°C.
3. The viscosity controlled cellulosic material according to claim 1 or 2 wherein
 - the viscosity controlled cellulosic material is manufactured from chemically treated wood-based cellulosic material comprising bleached kraft pulp and/or bleached sulfite pulp and/or bleached soda pulp, and/or
 - a length weighted fiber length Lc(l) of the viscosity controlled cellulosic material measured according to standard ISO 16065-N is at least 0.9 mm, more preferably at least 1.0 mm, and most preferably at least 1.2 mm.
4. The viscosity controlled cellulosic material according to any of the preceding claims, wherein ISO Brightness of the viscosity controlled cellulosic material is at least 70%, preferably in a range between 75% and

- 90%.
5. The viscosity controlled cellulosic material according to any of the preceding claims, wherein the viscosity value of the viscosity controlled cellulosic material is between 170 ml/g and 350 ml/g, preferably 250 ml/g at the most. 5
 6. The viscosity controlled cellulosic material according to any of the preceding claims, wherein a crystallinity index of the viscosity controlled cellulosic material is at least 74%, preferably at least 76%. 10
 7. The viscosity controlled cellulosic material according to any of the preceding claims, wherein a content of fibers having length below 0.6 mm, measured from the viscosity controlled cellulosic material, is between 10% and 30%. 15
 8. The viscosity controlled cellulosic material according to any of the preceding claims, wherein alpha cellulose content of the viscosity controlled cellulosic material is between 67% and 99.5%, preferably at least 69% and 90% at the most. 20
 9. The viscosity controlled cellulosic material according to any of the preceding claims, wherein hemicellulose content of the viscosity controlled cellulosic material is between 0.5 dry wt.% and 30 dry wt.%, preferably at least 5 dry wt.%, and most preferably in a range between 10 dry wt.% and 30 dry wt.%. 25 30
 10. The viscosity controlled cellulosic material according to any of the preceding claims, wherein the R18 solubility value of the viscosity controlled cellulosic material is at least 70% and 87% at the most, preferably 84% at the most. 35
 11. The viscosity controlled cellulosic material according to any of the preceding claims, wherein a sodium (Na) content of the viscosity controlled cellulosic material is in a range between 200 mg/kg and 1500 mg/kg based on the dry weight of the chemically treated wood-based cellulosic material fibers. 40
 12. The viscosity controlled cellulosic material according to any of the preceding claims, wherein a curliness of the viscosity controlled cellulosic material is between 25% and 90%, preferably in a range between 30% and 85%. 45 50
 13. The viscosity controlled cellulosic material according to any of the preceding claims, wherein a water retention value (WRV) of the viscosity controlled cellulosic material is between 1 g/g and 2 g/g. 55
 14. The viscosity controlled cellulosic material according to any of the preceding claims, wherein
 - a lignin content of the viscosity controlled cellulosic material is less than 1.5%, preferably less than 1%, and most preferably less than 0.5%, and/or
 - an extractive content of the viscosity controlled cellulosic material is less than 0.2%, more preferably less than 0.1%.
 15. A method for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g in a continuous process, the method comprising the following steps:
 - i) forming a cellulose-water mixture (15) comprising
 - water and
 - chemically treated wood-based cellulosic material comprising bleached kraft pulp, bleached sulfite pulp and/or bleached soda pulp, the cellulose-water mixture (15) having a dry matter content between 3% and 20%,
 - ii) treating the formed cellulose-water mixture (15) in a plasticization step (100) at
 - a temperature between 130°C and 200°C, and
 - a pressure between 3 bars and 15 bars, at least 5 minutes and 120 minutes at the most,
 - while
 - mixing the cellulose-water mixture (15), and
 - feeding hot water and/or water steam to the cellulose-water mixture,
 - thereby obtaining a treated mixture (18), and
 - iii) depressurizing the treated mixture (18) after the plasticization step (100) in a depressurizing step (105) in a controlled manner without a steam explosion to maintain fiber integrity,
 - thereby obtaining the viscosity controlled cellulosic material (20), the viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g measured according to standard ISO 5351:2010, and an R18 solubility between 60% and 87%, measured according to standard T 235 cm-00.
 16. A system for producing viscosity controlled cellulosic material having a viscosity value in a range between 150 ml/g and 500 ml/g, measured according to ISO

5351:2010, in a continuous process, the system comprising:

- means for forming a cellulose-water mixture (15),
- a continuous reactor (101) for treating the cellulose-water mixture in a plasticization step (100) at a temperature between 130°C and 200°C,
- mixing means for mixing the cellulose-water mixture during the plasticization step,
- heating means for increasing temperature of the cellulose-water mixture in the continuous reactor, such as a feeder to feed water steam to the continuous reactor,
- means for depressurizing the treated mixture (18) in a controlled manner without a steam explosion after the plasticization step (100), and
- optionally, means for conveying at least part of a filtrate (102) obtained from the plasticization step to the continuous reactor (101).

Patentansprüche

1. Viskositätskontrolliertes Zellulosematerial mit einem Viskositätswert in einem Bereich zwischen 150 ml/g und 500 ml/g, gemessen nach der ISO-Norm 5351:2010, und einer R18-Löslichkeit zwischen 60 % und 87 %, gemessen gemäß der Norm T 235 cm-00, wobei das viskositätskontrollierte Zellulosematerial ein Zellulosematerial auf Holzbasis umfasst.
2. Viskositätskontrolliertes Zellulosematerial nach Anspruch 1, wobei
 - das Material kalt-alkalilöslich ist, und
 - gegebenenfalls das Material in einer wässrigen Lauge mit einem NaOH-Gehalt der Lösung zwischen 5 % und 10 % bei einer Temperatur von -10°C bis +5°C löslich ist.
3. Viskositätskontrolliertes Zellulosematerial nach Anspruch 1 oder 2, wobei
 - das viskositätskontrollierte Zellulosematerial aus chemisch behandeltem Zellulosematerial auf Holzbasis hergestellt ist, das gebleichten Kraftzellstoff und/oder gebleichten Sulfitzellstoff und/oder gebleichten Natronzellstoff umfasst, und/oder
 - eine längengewichtete Faserlänge Lc(l) des viskositätskontrollierten Zellulosematerials, gemessen nach der ISO-Norm 16065-N, mindestens 0,9 mm, bevorzugter mindestens 1,0 mm und am meisten bevorzugt mindestens 1,2 mm beträgt.

4. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei die ISO-Helligkeit des viskositätskontrollierten Zellulosematerials mindestens 70 % beträgt und vorzugsweise in einem Bereich zwischen 75 % und 90 % liegt.
5. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Viskositätswert des viskositätskontrollierten Zellulosematerials zwischen 170 ml/g und 350 ml/g liegt und vorzugsweise höchstens 250 ml/g beträgt.
6. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Kristallinitätsindex des viskositätskontrollierten Zellulosematerials mindestens 74 %, vorzugsweise mindestens 76 %, beträgt.
7. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Gehalt an Fasern mit einer Länge unter 0,6 mm, gemessen an dem viskositätskontrollierten Zellulosematerial, zwischen 10 % und 30 % liegt.
8. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Alpha-Zellulosegehalt des viskositätskontrollierten Zellulosematerials zwischen 67 % und 99,5 % liegt, vorzugsweise mindestens 69 % und höchstens 90 % beträgt.
9. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Hemizellulosegehalt des viskositätskontrollierten Zellulosematerials zwischen 0,5 Trockengew.-% und 30 Trockengew.-% liegt, vorzugsweise mindestens 5 Trockengew.-% beträgt und am meisten bevorzugt in einer Größenordnung zwischen 10 Trockengew.-% und 30 Trockengew.-% liegt.
10. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der R18-Löslichkeitswert des viskositätskontrollierten Zellulosematerials mindestens 70 % und höchstens 87 %, vorzugsweise höchstens 84 % beträgt.
11. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei ein Natrium-(Na)-Gehalt des viskositätskontrollierten Zellulosematerials in einen Bereich zwischen 200 mg/kg und 1500 mg/kg liegt, basierend auf dem Trockengewicht der Fasern des chemisch behandelten Zellulosematerials auf Holzbasis.
12. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei eine Welligkeit des viskositätskontrollierten Zellulosema-

terials zwischen 25 % und 90 %, vorzugsweise in einem Bereich zwischen 30 % und 85 % liegt.

13. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei der Wasserretentionswert (WRV) des viskositätskontrollierten Zellulosematerials zwischen 1 g/g und 2 g/g liegt. 5
14. Viskositätskontrolliertes Zellulosematerial nach einem der vorhergehenden Ansprüche, wobei 10
- ein Ligningehalt des viskositätskontrollierten Zellulosematerials weniger als 1,5 %, vorzugsweise weniger als 1 % und am meisten bevorzugt weniger als 0,5 % beträgt und/oder
 - ein Extraktgehalt des viskositätskontrollierten Zellulosematerials weniger als 0,2 %, besonders bevorzugt weniger als 0,1 % beträgt. 20
15. Verfahren zur Herstellung von viskositätskontrolliertem Zellulosematerial mit einem Viskositätswert in einem Bereich zwischen 150 ml/g und 500 ml/g in einem kontinuierlichen Prozess, wobei das Verfahren die folgenden Schritte umfasst: 25
- i) Bilden eines Cellulose-Wasser-Gemisches (15), das umfasst:
 - Wasser und 30
 - chemisch behandeltes Zellulosematerial auf Holzbasis, das gebleichten Kraftzellstoff, gebleichten Sulfitzellstoff und/oder gebleichten Natronzellstoff umfasst, wobei das Zellulose-Wasser-Gemisch (15) einen Trockensubstanzgehalt zwischen 3 % und 20 % aufweist, 35
 - ii) Behandeln des gebildeten Zellulose-Wasser-Gemisches (15) in einem Plastifizierungsschritt (100) bei 40
 - einer Temperatur zwischen 130 °C und 200 °C und
 - einem Druck zwischen 3 bar und 15 bar, mindestens 5 Minuten und höchstens 120 Minuten lang, während
 - Mischen des Zellulose-Wasser-Gemisches (15), und
 - Zuführen von heißem Wasser und/oder Wasserdampf zu dem Zellulose-Wasser-Gemisch, 50
- wodurch ein behandeltes Gemisch (18) erhalten wird, 55
- und
- iii) Druckentlastung des behandelten Gemisches (18) nach dem Plastifizierungsschritt

(100) in einem Druckentlastungsschritt (105) auf kontrollierte Weise ohne eine Dampfexplosion, um die Faserintegrität zu erhalten,

wodurch das viskositätskontrollierte Zellulosematerial (20) erhalten wird, wobei das viskositätskontrollierte Zellulosematerial einen Viskositätswert in einem Bereich zwischen 150 ml/g und 500 ml/g, gemessen gemäß der ISO-Norm 5351:2010, und eine R18-Löslichkeit zwischen 60 % und 87 %, gemessen gemäß der Norm T 235 cm-00, aufweist.

16. System zur Herstellung von viskositätskontrolliertem Zellulosematerial mit einem Viskositätswert in einem Bereich zwischen 150 ml/g und 500 ml/g, gemessen nach ISO 5351:2010, in einem kontinuierlichen Prozess, wobei das System umfasst:

- Mittel zur Bildung eines Zellulose-Wasser-Gemisches (15),
- einen kontinuierlichen Reaktor (101) zur Behandlung des Zellulose-Wasser-Gemisches in einem Plastifizierungsschritt (100) bei einer Temperatur zwischen 130 °C und 200 °C,
- Mischmittel zum Mischen des Zellulose-Wasser-Gemisches während des Plastifizierungsschrittes,
- Heizmittel zum Erhöhen der Temperatur des Zellulose-Wasser-Gemisches in dem kontinuierlichen Reaktor, wie z. B. eine Zuführeinrichtung zum Zuführen von Wasserdampf zu dem kontinuierlichen Reaktor,
- Mittel zur Druckentlastung des behandelten Gemisches (18) auf kontrollierte Art und Weise ohne Dampfexplosion nach dem Plastifizierungsschritt (100), und
- gegebenenfalls Mittel, um zumindest einen Teil eines aus dem Plastifizierungsschritt erhaltenen Filtrats (102) zu dem kontinuierlichen Reaktor (101) zu befördern.

Revendications

1. Matière cellulosique à viscosité contrôlée ayant une valeur de viscosité dans une plage entre 150 ml/g et 500 ml/g mesurée selon la norme ISO 5351:2010, et une solubilité R18 entre 60 % et 87 % mesurée selon la norme T 235 cm-00, dans laquelle la matière cellulosique à viscosité contrôlée comprend de la matière cellulosique à base de bois.
2. Matière cellulosique à viscosité contrôlée selon la revendication 1, dans laquelle
 - la matière est soluble à froid dans les alcalis, et
 - facultativement, la matière est apte à être dissoute dans une solution aqueuse alcaline ayant

- une teneur de solution en NaOH entre 5 % et 10 % à une température de -10 °C à +5 °C.
3. Matière cellulosique à viscosité contrôlée selon la revendication 1 ou 2 dans laquelle
 - la matière cellulosique à viscosité contrôlée est fabriquée à partir de matière cellulosique à base de bois traitée chimiquement comprenant de la pâte kraft blanchie et/ou de la pâte au bisulfite blanchie et/ou de la pâte à la soude blanchie, et/ou
 - une longueur de fibre pondérée en longueur Lc(l) de la matière cellulosique à viscosité contrôlée mesurée selon la norme ISO 16065-N est d'au moins 0,9 mm, plus préférentiellement d'au moins 1,0 mm, et de manière préférée entre toutes d'au moins 1,2 mm.
 4. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle la blancheur ISO de la matière cellulosique à viscosité contrôlée est d'au moins 70 %, de préférence dans une plage entre 75 % et 90 %.
 5. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle la valeur de viscosité de la matière cellulosique à viscosité contrôlée est entre 170 ml/g et 350 ml/g, de préférence de 250 ml/g au plus.
 6. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle un indice de cristallinité de la matière cellulosique à viscosité contrôlée est d'au moins 74 %, de préférence d'au moins 76 %.
 7. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle une teneur en fibres ayant une longueur inférieure à 0,6 mm, mesurée sur la matière cellulosique à viscosité contrôlée, est entre 10 % et 30 %.
 8. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle la teneur en alpha-cellulose de la matière cellulosique à viscosité contrôlée est entre 67 % et 99,5 %, de préférence d'au moins 69 % et de 90 % au plus.
 9. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle la teneur en hémicellulose de la matière cellulosique à viscosité contrôlée est entre 0,5 % en poids sec et 30 % en poids sec, de préférence d'au moins 5 % en poids sec, et de manière préférée entre toutes dans une plage entre 10 % en poids sec et 30 % en poids sec.
 10. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle la valeur de solubilité R18 de la matière cellulosique à viscosité contrôlée est d'au moins 70 % et de 87 % au plus, de préférence de 84 % au plus.
 11. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle une teneur en sodium (Na) de la matière cellulosique à viscosité contrôlée est dans une plage entre 200 mg/kg et 1 500 mg/kg sur la base du poids sec des fibres de matière cellulosique à base de bois traitée chimiquement.
 12. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle une frisure de la matière cellulosique à viscosité contrôlée est entre 25 % et 90 %, de préférence dans une plage entre 30 % et 85 %.
 13. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle une valeur de rétention d'eau (WRV) de la matière cellulosique à viscosité contrôlée est entre 1 g/g et 2 g/g.
 14. Matière cellulosique à viscosité contrôlée selon l'une quelconque des revendications précédentes, dans laquelle
 - une teneur en lignine de la matière cellulosique à viscosité contrôlée est de moins de 1,5 %, de préférence de moins de 1 %, et de manière préférée entre toutes de moins de 0,5 %, et/ou
 - une teneur en produits d'extraction de la matière cellulosique à viscosité contrôlée est de moins de 0,2 %, plus préférentiellement de moins de 0,1 %.
 15. Procédé pour la production de matière cellulosique à viscosité contrôlée ayant une valeur de viscosité dans une plage entre 150 ml/g et 500 ml/g dans un processus continu, le procédé comprenant les étapes suivantes :
 - i) la formation d'un mélange cellulose-eau (15) comprenant
 - de l'eau et
 - de la matière cellulosique à base de bois traitée chimiquement comprenant de la pâte kraft blanchie, de la pâte au bisulfite blanchie et/ou de la pâte à la soude blanchie, le mélange cellulose-eau (15) ayant une teneur en matière sèche entre 3 % et 20 %,
 - ii) le traitement du mélange cellulose-eau (15) formé dans une étape de plastification (100) à

- une température entre 130 °C et 200 °C, et
- une pression entre 3 bars et 15 bars, au moins 5 minutes et 120 minutes au plus, tout en
- mélangeant le mélange cellulose-eau (15), et
- apportant de l'eau chaude et/ou de la vapeur d'eau au mélange cellulose-eau, ce qui permet d'obtenir un mélange traité (18), et

iii) la dépressurisation du mélange traité (18) après l'étape de plastification (100) dans une étape de dépressurisation (105) d'une manière contrôlée sans vapocraquage pour conserver l'intégrité des fibres,

ce qui permet d'obtenir la matière cellulosique à viscosité contrôlée (20), la matière cellulosique à viscosité contrôlée ayant une valeur de viscosité dans une plage entre 150 ml/g et 500 ml/g mesurée selon la norme ISO 5351 :2010, et une solubilité R18 entre 60 % et 87 %, mesurée selon la norme T 235 cm-00.

16. Système pour la production de matière cellulosique à viscosité contrôlée ayant une valeur de viscosité dans une plage entre 150 ml/g et 500 ml/g, mesurée selon ISO 5351:2010, en un processus continu, le système comprenant :

- un moyen de formation d'un mélange cellulose-eau (15),
- un réacteur continu (101) pour le traitement du mélange cellulose-eau dans une étape de plastification (100) à une température entre 130 °C et 200 °C,
- un moyen de mélange pour mélanger le mélange cellulose-eau pendant l'étape de plastification,
- un moyen de chauffage pour augmenter la température du mélange cellulose-eau dans le réacteur continu, tel qu'un dispositif d'apport pour apporter de la vapeur d'eau au réacteur continu,
- un moyen de dépressurisation du mélange traité (18) d'une manière contrôlée sans vapocraquage après l'étape de plastification (100), et
- facultativement, un moyen de transport d'au moins une partie d'un filtrat (102) obtenu à partir de l'étape de plastification jusqu'au réacteur continu (101).

55

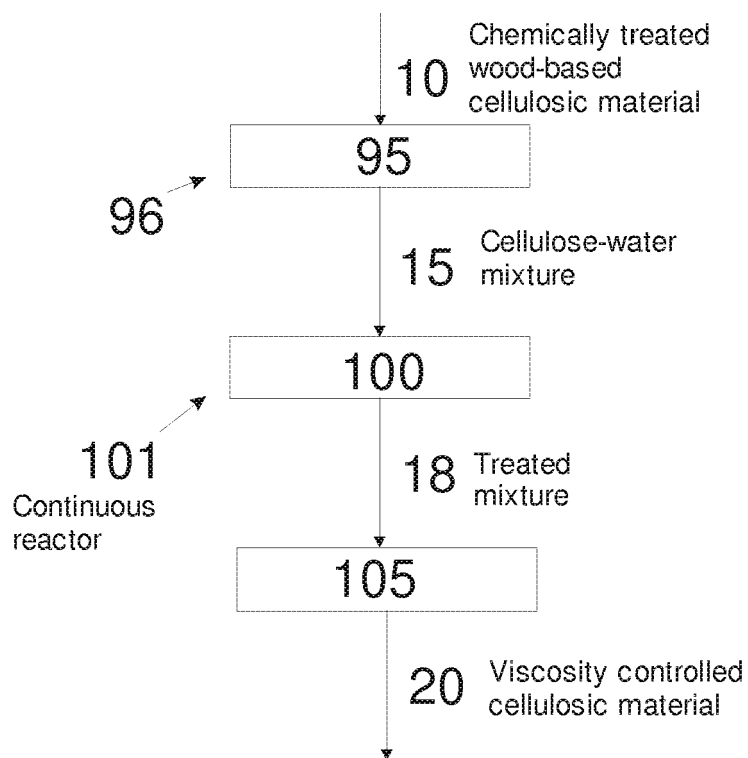


Fig.1a

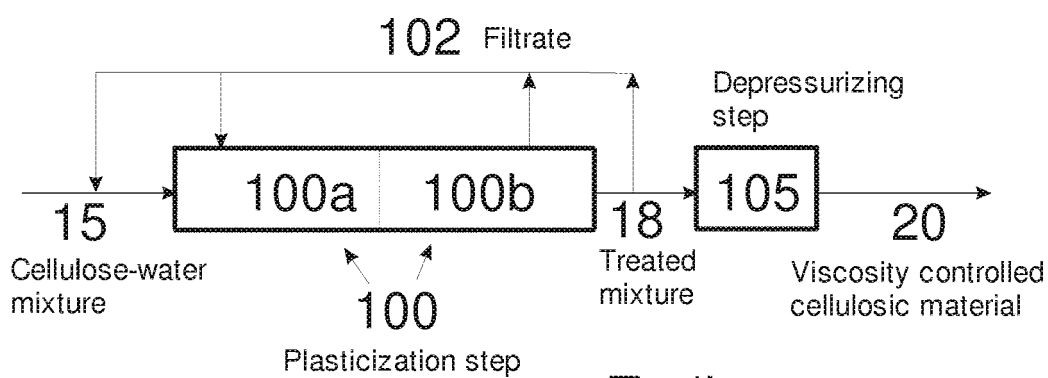


Fig.1b

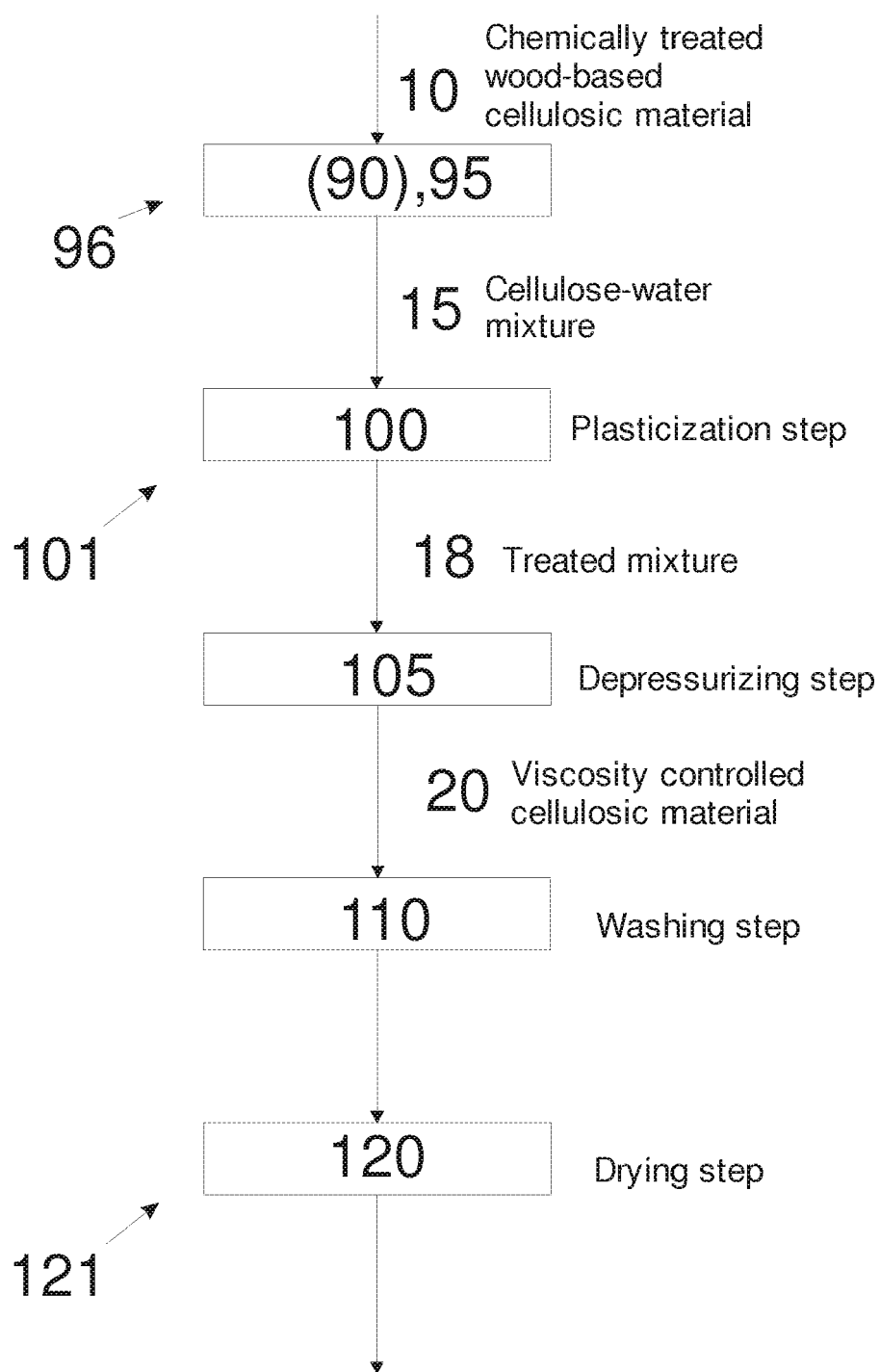


Fig.2

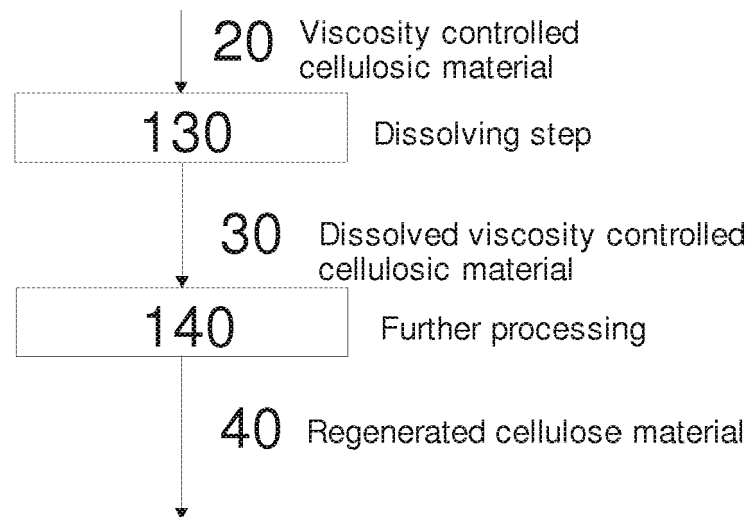
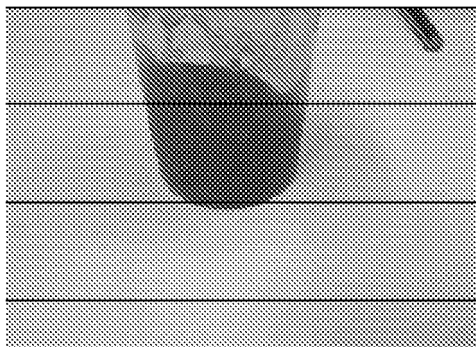


Fig. 3

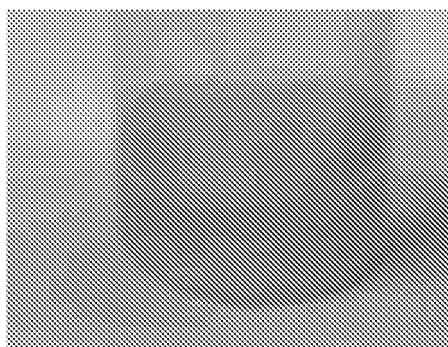
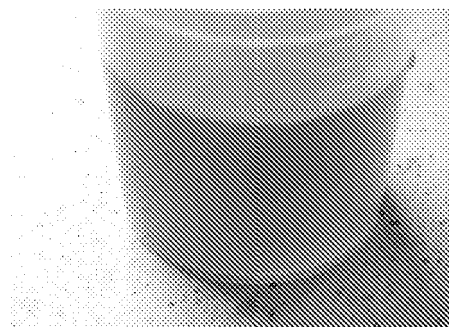


batch process
with
steam explosion

Fig. 4a

batch process
without
steam explosion

Fig. 4b



continuous process
without
steam explosion
(sample at 5°C)

Fig. 4c

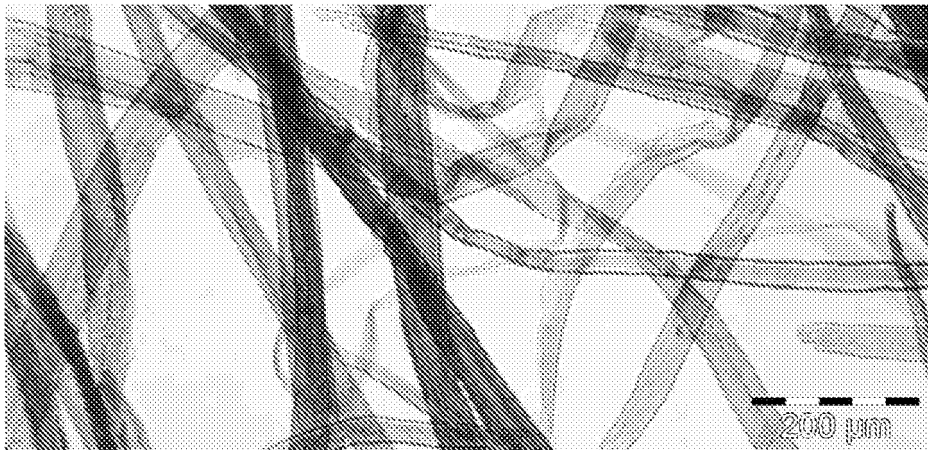


Fig. 5a



Fig. 5b

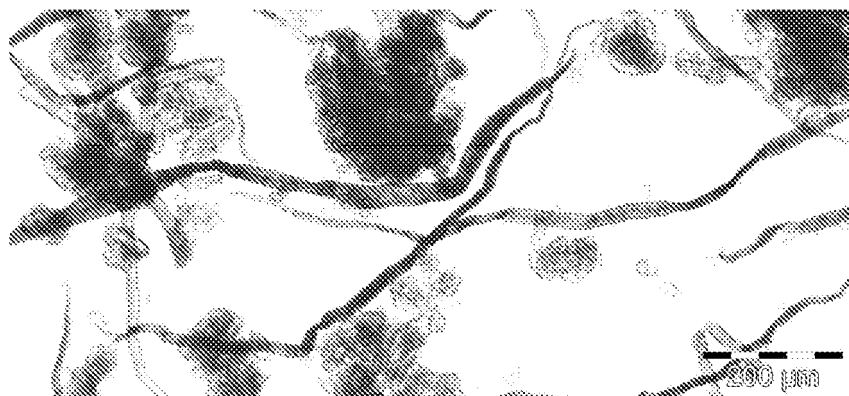


Fig. 5c

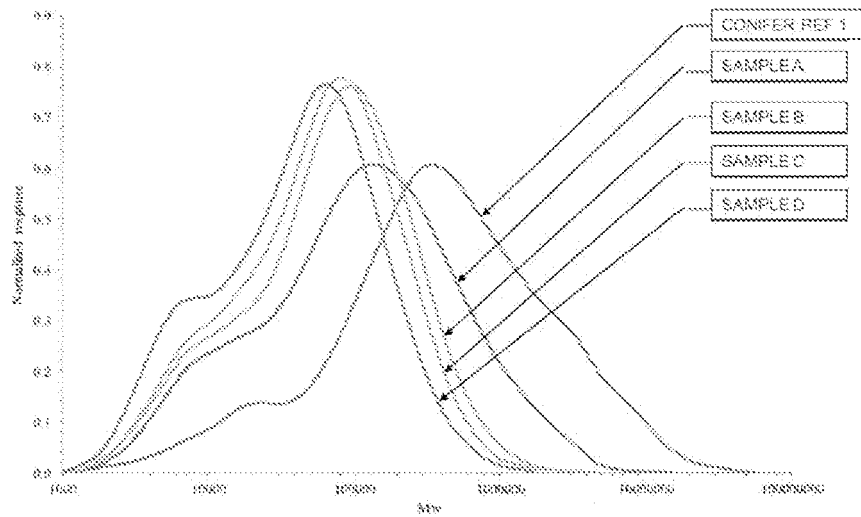


Fig. 6a

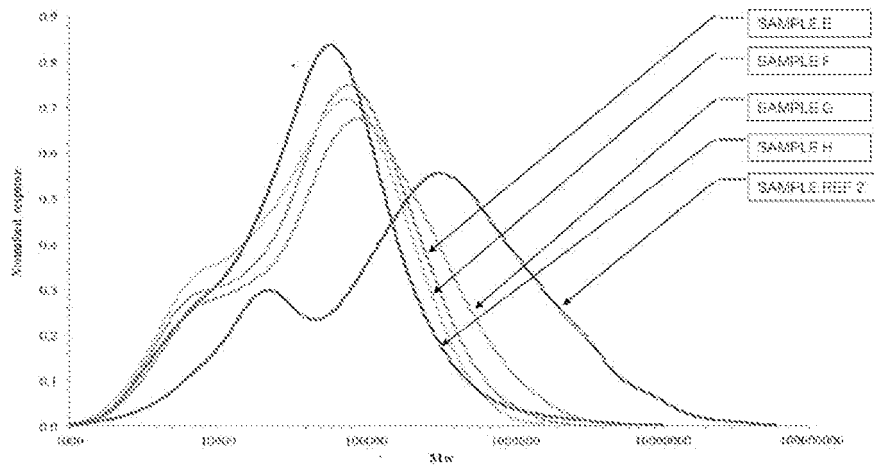


Fig. 6b

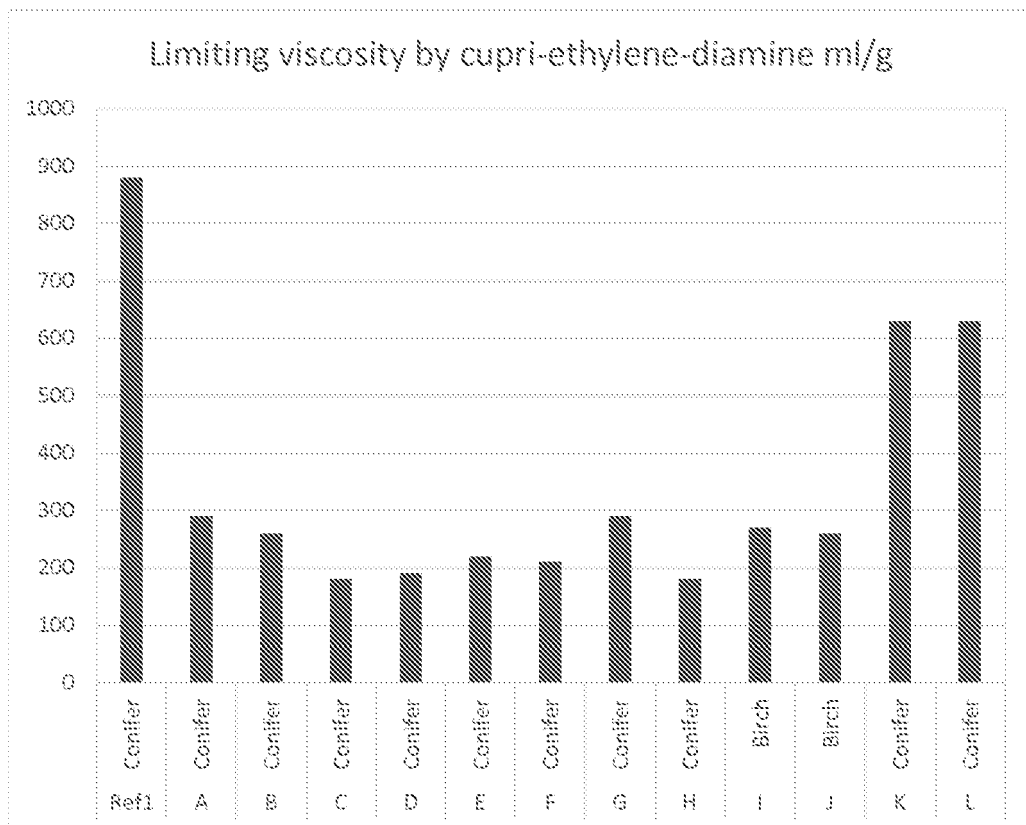


Fig. 7

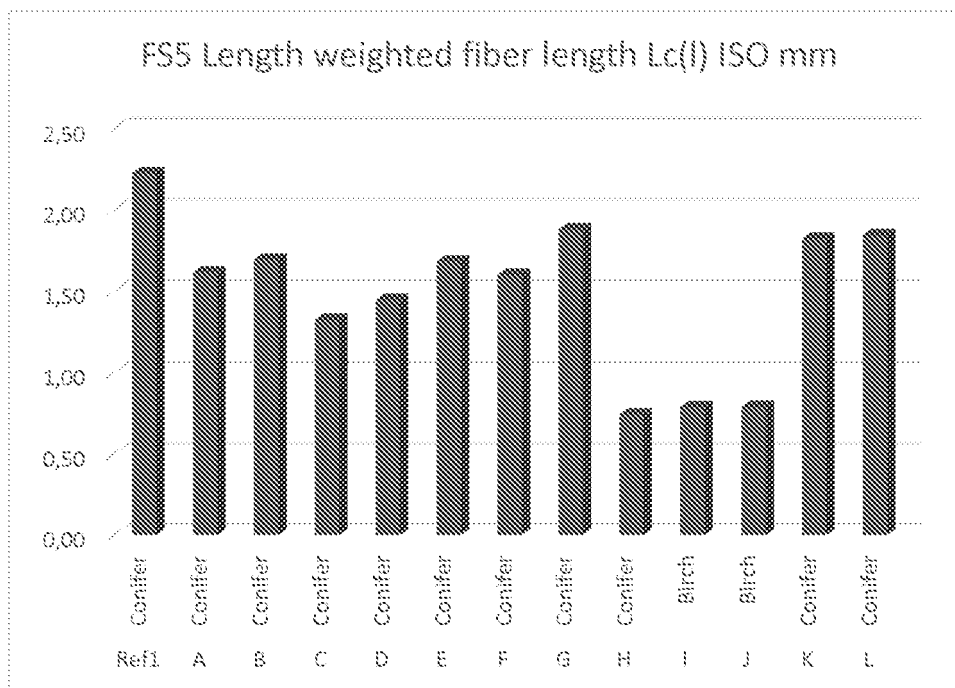


Fig. 8a

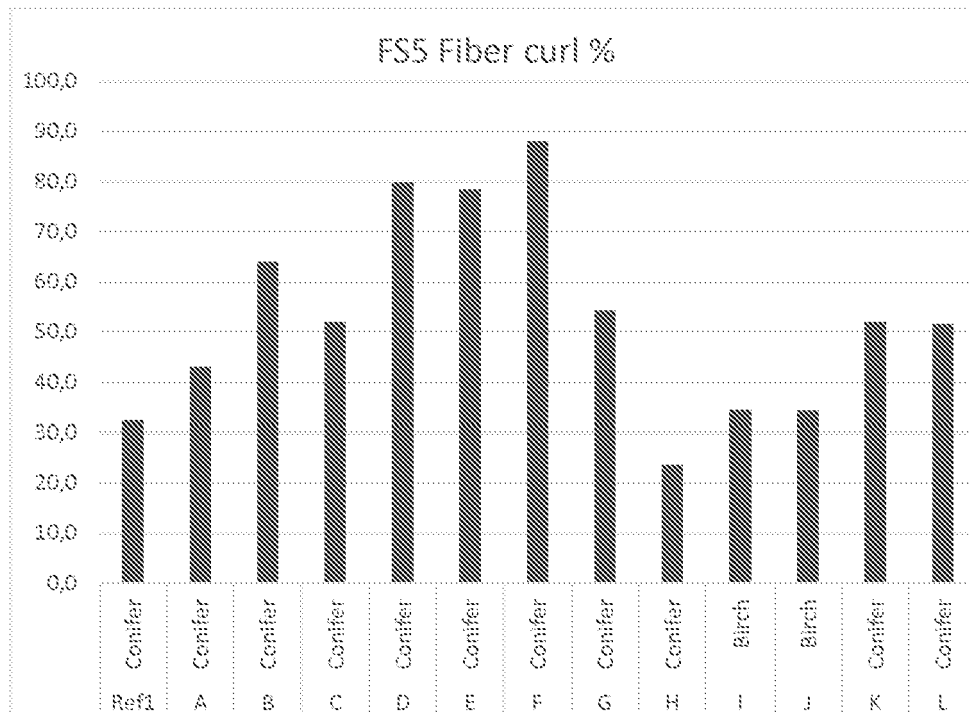


Fig. 8b

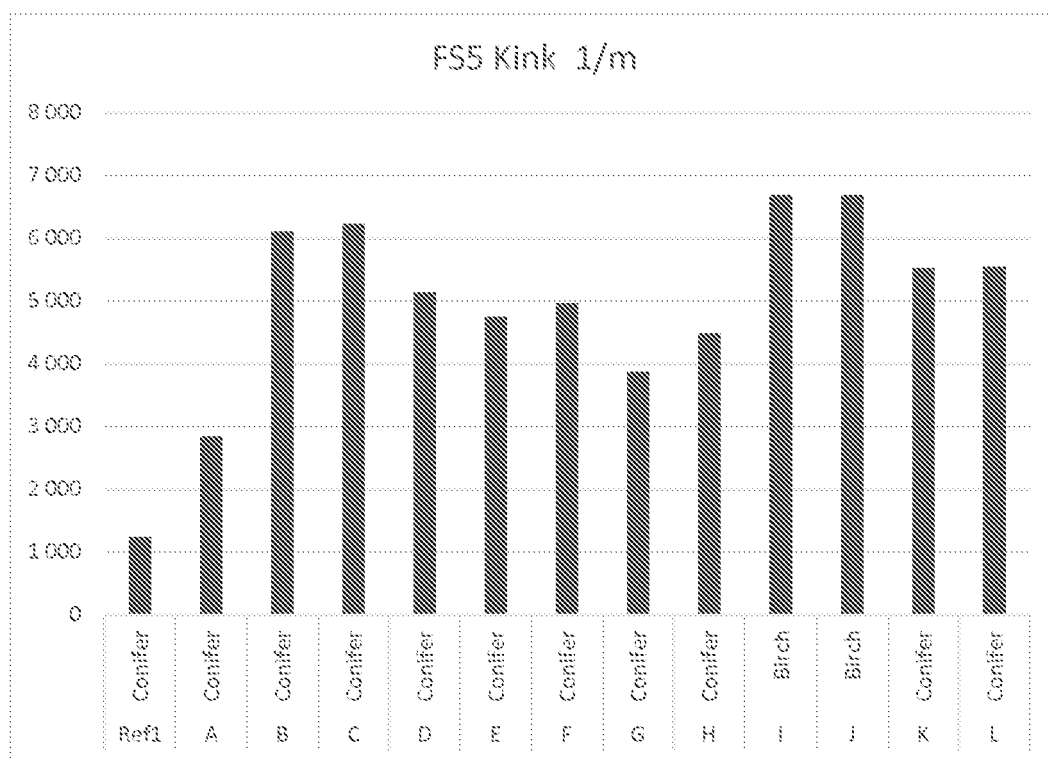


Fig. 9a

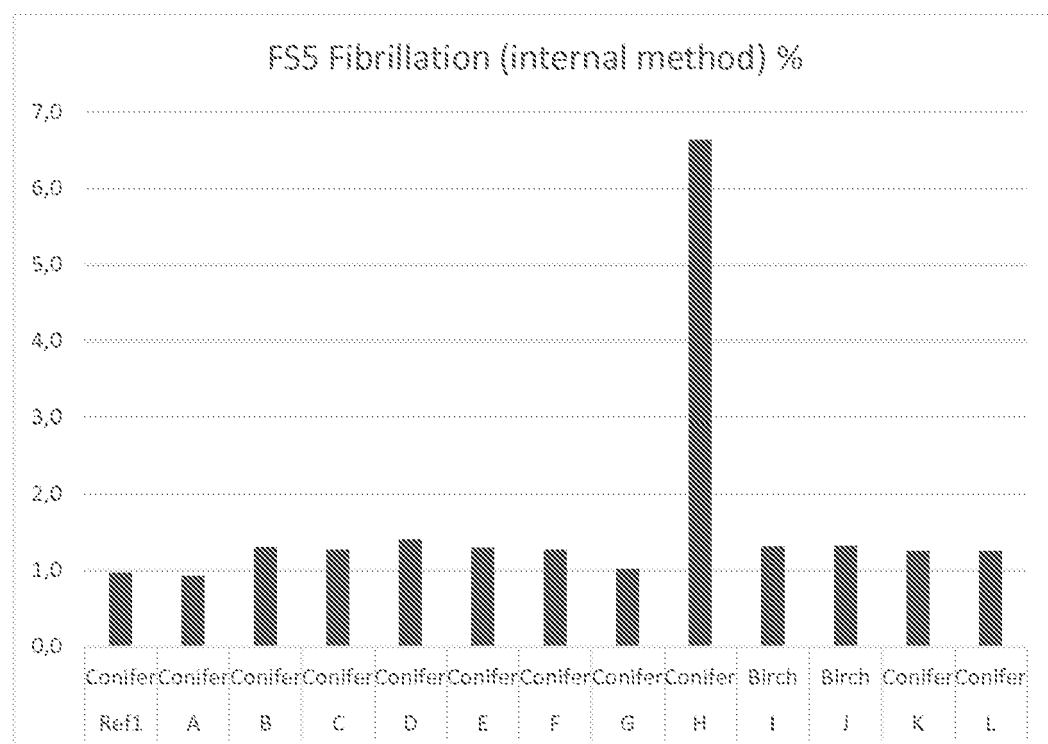


Fig. 9b

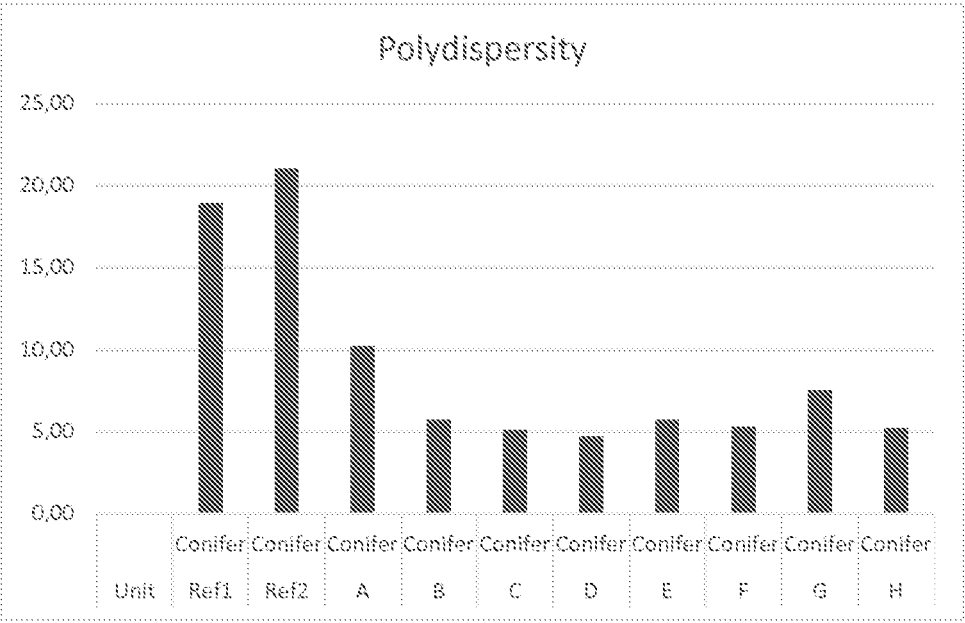


Fig. 10

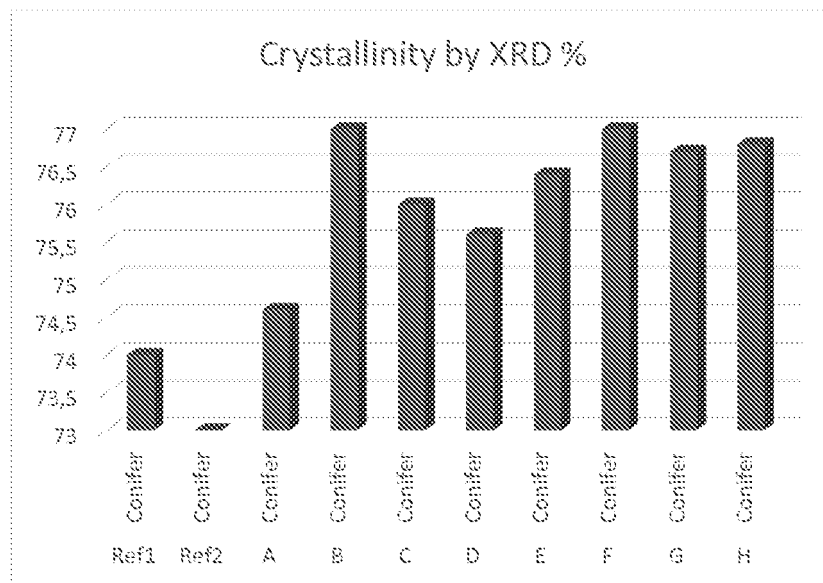


Fig. 11

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **CREELY, J.J. ; MARTIN JR., A.E. ; CONDRAD, C.M.** An Empirical Method for Estimating the Degree of Crystallinity of Native Cellulose Using the X-Ray Diffractometer. *Textile Research Journal*, 1959, vol. 29, 786-794 **[0064]**