

CELLULOSE NANOFIBRIL DEHYDRATION DEVICE AND METHOD

FIELD

[0001] The subject matter relates to dehydration devices, and more particularly, to a cellulose nanofibril (CNF) dehydration device and a CNF dehydration method.

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BACKGROUND

[0002] CNFs are a kind of biomass material based on natural fibers of nanometric size. Despite the small size, the CNFs also have excellent properties such as high strength, making them suitable for reinforcing composite materials. When incorporated into a polymer matrix, the CNFs add strength and stiffness to the polymer material, making them an attractive choice for a variety of structural applications.

[0003] To facilitate storage and transportation, the CNFs are dehydrated by dehydration devices to form dried powders or subarid slurry. However, agglomeration, self-assembly, and keratinization may happen in the CNF powders or slurry due to a large amount of hydroxyl groups on the surface, making it impossible for the CNFs to retain the high dispersion ability. Even the dehydrated powders or slurry is redispersed in a liquid medium when in use, a high power or longer dispersion duration may be required to allow the CNFs to retain the dispersion ability due to the high viscosity of the CNF slurry, which increases the cost.

SUMMARY

[0004] To overcome the above shortcomings, a CNF dehydration device and method are needed.

5 **[0005]** The present application provides a CNF dehydration device for dehydrating CNFs, and includes a first supply mechanism, a second supply mechanism, a premixing mechanism, a slurry spreading mechanism, and a pressing mechanism. The first supply mechanism is configured to provide a first porous layer along a first direction. The second supply mechanism is configured to provide a second porous layer along a first
10 direction, and the second porous layer is located above and spaced from the first porous layer. The premixing mechanism is configured to mix a raw material including the CNFs with a liquid medium to obtain a first slurry. The slurry spreading mechanism is connected to the premixing mechanism, and configured to receive the first slurry from the premixing mechanism and spread the first slurry onto the first porous layer, thereby
15 causing the first slurry to be sandwiched between the first porous layer and the second porous layer to obtain a multilayer body. The pressing mechanism is located on at least one side of the multilayer body and configured to press the multilayer body, thereby removing a portion of the liquid medium from the first slurry to obtain a second slurry, such that a concentration of the CNFs in the second slurry is larger than that in the first

slurry.

[0006] The present application further provides a CNF dehydration method for dehydrating CNFs, and includes providing a first porous layer and a second porous layer located above and spaced from the first porous layer. A raw material including the CNFs is mixed with a liquid to obtain a first slurry. The first slurry is spread onto the first porous layer, thereby causing the first slurry to be sandwiched between the first porous layer and the second porous layer to obtain a multilayer body. The multilayer body is pressed, thereby removing a portion of the liquid medium from the first slurry to obtain a second slurry, such that a concentration of the CNFs in the second slurry is larger than that in the first slurry.

[0007] Compared to dehydrating the CNFs into dried powders or subarid slurry in the related arts, the present application spreads the first slurry onto the first porous layer to obtain the multilayer body, and presses the multilayer body to remove a portion of the liquid medium from the first slurry. The final multilayer material includes the first porous layer, the second porous layer, and the second slurry sandwiched between the first porous layer and the second porous layer. The second slurry of the multilayer material can have a smaller thickness and also a high concentration of CNFs. Thus, the CNFs of the multilayer material can be easily dispersed in a liquid medium to retain the dispersion ability. Thus, the power and the time duration required for dispersing the CNFs can be

reduced, thereby reducing the cost. Furthermore, it is not needed to perform surface modification on CNFs for removing the hydroxyl groups to inhibit agglomeration or keratinization. Thus, the consumption or residue of chemical agents can be reduced while preserving the original surface properties of the CNFs.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Implementations of the present technology will now be described, by way of example only, with reference to the attached figures.

[0009] FIG. 1 is a diagrammatic view of a CNF dehydration device according to an
10 embodiment of the present disclosure.

[0010] FIG. 2 is a top view of a portion of the CNF dehydration device in FIG. 1.

[0011] FIG. 3 is a diagrammatic view of a vacuum dehydration mechanism of the CNF dehydration device in FIG. 1.

[0012] FIG. 4 is a diagrammatic view of an embodiment of a vacuum dehydration
15 unit of the vacuum dehydration mechanism in FIG. 3.

[0013] FIG. 5 is a diagrammatic view of another embodiment of a vacuum dehydration unit of the vacuum dehydration mechanism in FIG. 3.

[0014] FIG. 6 is a diagrammatic view of an embodiment of a pressing roller of the CNF dehydration device in FIG. 1.

[0015] FIG. 7 is a diagrammatic view of another embodiment of a pressing roller of the CNF dehydration device in FIG. 1.

5 **[0016]** FIG. 8 is a diagrammatic view showing a portion of the CNF dehydration device in FIG. 2.

[0017] FIG. 9 is a diagrammatic view showing a movable plate of the CNF dehydration device in FIG. 2 being moved.

[0018] FIG. 10 is a flowchart of a CNF dehydration method according to an
10 embodiment of the present application.

DETAILED DESCRIPTION

[0019] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to
15 indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the

embodiments described herein can be practiced without these specific details. In other instances, methods, procedures, and members have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings
5 are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

[0020] The term “comprising,” when utilized, means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

10 **[0021]** Referring to FIG. 1, a CNF dehydration device 1 is provided according to an embodiment of the present application. The device 1 is used for dehydrating CNFs. The device 1 includes a first supply mechanism 10, a second supply mechanism 20, a premixing mechanism 30, a slurry spreading mechanism 40, and a pressing mechanism 50.

15 **[0022]** The first supply mechanism 10 provides a first porous layer 101, and may guide the first porous layer 101 along a first direction X. The second supply mechanism 20 provides a second porous layer 102, and may guide the second porous layer 102 substantially along the first direction X. The second porous layer 102 is located above and spaced from the first porous layer 101. The first porous layer 101 and the second

porous layer 102 may be polyamide layers or mesh fabric layers. In the present application, the first porous layer 101 has a length direction and a width direction, and the second porous layer 102 also has a length direction and a width direction. The length direction of the first porous layer 101 or the second porous layer 102 is parallel to the first direction X. The width direction of the first porous layer 101 or the second porous layer 102 is parallel to a second direction Y. The second direction Y is perpendicular to the first direction X.

[0023] The premixing mechanism 30 mixes a raw material including the CNFs with a liquid medium to obtain a first slurry 103. In at least one embodiment, the raw material may be a primary slurry including the CNFs, and may also be CNFs powders; the liquid medium may be water or other solvents suitable for mixing with the CNFs. In at least one embodiment, the premixing mechanism 30 includes a premixing chamber 31 for mixing the CNFs with the liquid medium. The premixing mechanism 30 may further include a first stirring unit 32 mounted in the premixing chamber 31. The first stirring unit 32 can stir the CNFs and the liquid medium in the premixing chamber 31, thereby enabling the CNFs to be fully mixed with the liquid medium. The first stirring unit 32 may include a rectifier roller, a stirring rod, or a stirring paddle. In at least one embodiment, the first slurry may further include an additive, and the additive includes at least one of a preserving agent, a stabilizing agent, and a modifying agent. The specific

type of the additive may be selected according to actual needs, thereby achieving the functions of preserving, stabilizing, and surface modifying.

[0024] The slurry spreading mechanism 40 is connected to the premixing mechanism

30. Referring to FIGS. 1 and 2, the slurry spreading mechanism 40 can receive the first
5 slurry 103 from the premixing mechanism 30 and spread the first slurry 103 onto the first porous layer 101, thereby causing the first slurry 103 to be sandwiched between the first porous layer 101 and the second porous layer 102 to obtain a multilayer body 100. In at least one embodiment, the slurry spreading mechanism 40 includes a spreading chamber 41. The spreading chamber 41 has a slurry inlet 411 and a slurry outlet 412. The
10 premixing chamber 31 is connected to the slurry inlet 411 through a valve 33, and the valve 33 can be opened to feed the first slurry 103 into the spreading chamber 41 through the slurry inlet 411. The first slurry 103 is then spread onto the first porous layer 101 through the slurry outlet 412 such as by a positive pressure generated in the spreading chamber 41 or by a gravity of the first slurry 103 for example. The slurry outlet 412
15 may extend along the second direction Y, thereby enabling the first slurry 103 to be fully spread onto the entire width of the first porous layer 101. When the spreading chamber 41 spreads the first slurry 103 onto the first porous layer 101, the premixing mechanism 30 can prepare a new first slurry 103 at the same time, thereby improving the efficiency of the device 1.

[0025] In at least one embodiment, the spreading chamber 41 is sealed, thereby reducing or avoiding the changes in the concentration of the CNFs in the first slurry 103 caused by moisture loss. The slurry spreading mechanism 40 may further include a second stirring unit 42 mounted in the spreading chamber 41. The second stirring unit
5 42 can stir the first slurry 103 in the spreading chamber 41, thereby enabling the CNFs to be uniformly dispersed in the liquid medium. In at least one embodiment, the second stirring unit 42 may include a rectifier roller, a stirring rod, or a stirring paddle.

[0026] The pressing mechanism 50 is located on at least one side of the multilayer body 100. The pressing mechanism 50 can press the multilayer body 100, thereby
10 removing a portion of the liquid medium from the first slurry 103 to increase the concentration of the CNFs in the first slurry 103. After the pressing mechanism 50 presses the multilayer body 100, the first slurry 103 is transformed to a second slurry 104. That is, a concentration of the CNFs in the second slurry 104 is larger than that in the first slurry 103. The second slurry 104 is sandwiched between the first porous layer 101 and
15 the second porous layer 102 to form the final multilayer material 100a. The multilayer material 100a can further be immersed in a liquid, which may be the same or different from the above liquid medium, for storage and transportation purposes. In at least one embodiment, the concentration of the CNFs in the second slurry 104 may be larger than or equal to 20%. For example, the concentration of the CNFs in the second slurry 104

may be in a range of 20% to 40%. In the embodiment, the concentration of the CNFs in the second slurry 104 may be in a range of 30% to 40%.

[0027] According to the device 1 of the present application, compared to dehydrating the CNFs into dried powders or subarid slurry in the related arts, the slurry spreading mechanism 40 spreads the first slurry 103 onto the first porous layer 101 to obtain the multilayer body 100, and the pressing mechanism 50 presses the multilayer body 100 to remove a portion of the liquid medium from the first slurry 103. The final multilayer material 100a includes the first porous layer 101, the second porous layer 102, and the second slurry 104 sandwiched between the first porous layer 101 and the second porous layer 102. The second slurry 104 of the multilayer material 100a can have a smaller thickness and also a high concentration of CNFs. Thus, the CNFs of the multilayer material 100a can be easily dispersed in a liquid to retain the dispersion ability, and the cost for storage and transportation can also be reduced due to the high concentration of CNFs. Thus, the power and the time duration required for dispersing the CNFs can be reduced, thereby reducing the cost. Furthermore, it is not needed to perform surface modification on CNFs for removing the hydroxyl groups to inhibit agglomeration or keratinization. Thus, the consumption or residue of chemical agents can be reduced while preserving the original surface properties of the CNFs.

[0028] Referring to FIG. 1, in at least one embodiment, the first supply mechanism

10 includes a first roller 11 and a second roller 12. The first roller 11 can store the first porous layer 101 coiled thereon. The first porous layer 101 from the first roller 11 is further coiled on the second roller 12. The second roller 12 can position the first porous layer 101 at a desired position. The second roller 12 can further convey the first porous layer 101 from the first roller 11 along the first direction X. The conveying speed of the first porous layer 101 along the first direction X may be in a range of 1 meter to 10 meters per minute.

[0029] Furthermore, the second supply mechanism 20 includes a third roller 21 and a fourth roller 22. The third roller 21 can store the second porous layer 102 coiled thereon. The second porous layer 102 from the third roller 21 is further coiled on the fourth roller 22. The fourth roller 22 can position the second porous layer 102 at a desired position. The fourth roller 22 can further convey the second porous layer 102 from the third roller 21 along the first direction X. The conveying speed of the second porous layer 102 along the first direction X may be in a range of 1 meter to 10 meters per minute.

[0030] The second roller 12 may be located between the first roller 11 and the fourth roller 22 along a third direction Z, and the third direction Z is perpendicular to the first direction X and the second direction Y. The fourth roller 22 may be located between the second roller 12 and the third roller 21 along the third direction Z. Furthermore, the first roller 11, the second roller 12, the third roller 21, and the fourth roller 22 may be

successively arranged along the first direction X. Thus, the second porous layer 102 from the fourth roller 22 may not cover the head portion of the first porous layer 101 from the second roller 12. That is, the second porous layer 102 is not located above the head portion of the first porous layer 101. In this case, the slurry spreading mechanism 40 may spread the first slurry 103 onto the head portion of the first porous layer 101.

[0031] In at least one embodiment, the pressing mechanism 50 includes at least two pairs of pressing rollers 51 arranged along the first direction X. As shown in FIG. 1, the pressing mechanism 50 includes three pairs of pressing rollers 51 arranged along the first direction X. Each pair of pressing rollers 51 includes two pressing rollers 51 located at opposite sides of the multilayer body 100. A distance between the two pressing rollers 51 of the at least two pairs of pressing rollers 51 decreases along the first direction X. That is, the two pressing rollers 51 closest to the slurry spreading mechanism 40 in the first direction X has a maximum distance. The two pressing rollers 51 farthest from the slurry spreading mechanism 40 in the first direction X has a minimum distance. Thus, the different pairs of pressing rollers 51 realize a multi-section compression. By gradually decreasing the distance between the two pressing rollers 51 of the different pairs of pressing rollers 51 along the first direction X, the concentration of the CNFs in the first slurry 103 is gradually increased.

[0032] Furthermore, the distance between the two pressing rollers 51 of each pair of

pressing rollers 51 may be adjustable. For example, at least one of the two pressing rollers 51 of each pair of pressing rollers 51 may move along the third direction Z to adjust the distance between the two pressing rollers 51. The device 1 may further include a first sensor 60 located at one side of the pressing mechanism 50 away from the second roller 12 or the fourth roller 22 along the first direction X. The first sensor 60 senses a content of the liquid medium in the second slurry 104, and the sensed content is configured to indicate whether the concentration of the CNFs in the second slurry 104 matches a desired concentration. When the content of the liquid medium in the second slurry 104 is too large, the distance between the two pressing rollers 51 of each pair of pressing rollers 51 may be reduced, thereby allowing the second slurry 104 to have a desired concentration. Referring to FIG. 6, in at least one embodiment, the pressing rollers 51 may include a pressing roller body 511 made of hard and corrosion-resistant materials, such as stainless steel or granite. The pressing rollers 51 may also include a resin layer 512 (such as a rubber layer) on the pressing roller body 511. The resin layer 512 can increase the friction between the pressing rollers 51 and the multilayer body 100, thereby improving the pressing effect.

[0033] Referring to FIG. 1, in at least one embodiment, the device 1 further includes a vibration mechanism 70 located between the second roller 12 and the pressing mechanism 50 along the first direction X. The vibration mechanism 70 applies

vibrations on the first porous layer 101 and the first slurry 103 spread thereon, thereby enabling the first slurry 103 to be uniformly located on the first porous layer 101. In at least one embodiment, the vibration mechanism 70 may include an ultrasonic device, a mechanical vibration device, or a liquid injection device, which is in contact with or
5 spaced from the head portion of the first porous layer 101. The vibration mechanism 70 may apply ultrasonic waves, mechanical vibration, or liquid injection onto the head portion of the first porous layer 101, thereby enabling the first slurry 103 to be uniformly located on the first porous layer 101.

[0034] Referring to FIG. 1, the device 1 may further include a vacuum dehydration
10 mechanism 80 located at one side of the pressing mechanism 50 away from the slurry spreading mechanism 40 along the first direction X. After the pressing mechanism 50 presses the multilayer body 100, the multilayer body 100 moves toward the vacuum dehydration mechanism 80. The vacuum dehydration mechanism 80 dehydrates the CNFs in the first slurry 103 of the multilayer body 100, thereby removing another portion
15 of the liquid medium from the first slurry 103 to further increase the concentration of the CNFs in the first slurry 103. Referring to FIGS 3 and 4, in at least one embodiment, the vacuum dehydration mechanism 80 may include at least one vacuum dehydration unit 81. When the vacuum dehydration mechanism 80 includes a plurality of vacuum dehydration units 81, the vacuum dehydration units 81 are arranged along the first direction X. Each

vacuum dehydration unit 81 includes a vacuum chamber 810. The vacuum chamber 810 includes at least one vacuum adsorption hole 811 facing the first porous layer 101 and arranged in the second direction Y. For example, as shown in FIG. 4, the vacuum chamber 810 may include a single vacuum adsorption hole 811 extending in the second direction Y. As shown in FIG. 5, the vacuum chamber 810 may also include a plurality of vacuum adsorption holes 811 separated from each other in the second direction Y. When a vacuum pressure is generated inside the vacuum chamber 810, a portion of the liquid medium can be extracted from the first slurry 103 and enter the vacuum chamber 810 through the first porous layer 101 and the vacuum adsorption hole 811. That is, the vacuum adsorption hole 811 can adsorb the liquid medium in the first slurry 103 of the multilayer body 100. It is notable that the liquid medium extracted from the first slurry 103 may include a small amount of CNFs, which can be recycled and reused. In at least one embodiment, the vacuum dehydration unit 81 may be strip-shaped and have a length larger than or equal to the width of the first porous layer 101. The vacuum adsorption hole 811 may also have a length larger than or equal to the width of the first porous layer 101, thereby enabling the vacuum dehydration unit 81 to fully remove the liquid water of the entire first slurry 103.

[0035] Referring to FIG. 7, in at least one embodiment, the pressing rollers 51 of the pressing mechanism 50 may also include a vacuum dehydration function, which can

further improve the dehydration effect of the first slurry 103. For example, the pressing roller body 511 of the pressing roller 51 may also include a vacuum chamber (not shown), and the vacuum chamber includes a vacuum adsorption hole 513 facing the first porous layer 101. When a vacuum pressure is generated inside the vacuum chamber, a portion
5 of the liquid medium can be extracted from the first slurry 103 and enter the vacuum chamber of the pressing roller 51.

[0036] Referring to FIGS. 1 and 2, the device 1 may further include a cutting mechanism 90 located between the fourth roller 22 and the second roller 12 along the first direction X. The cutting mechanism 90 cuts off an edge of the first slurry 103
10 spread on the first porous layer 101 by high velocity flow. The above edge is the edge of the first slurry 103 along the width direction. Thus, the cutting mechanism 90 can remove the edge of the first slurry 103 that may be thinner than the remaining portion of the first slurry 103, thereby enabling the final multilayer material 100a to have a desired thickness. In at least one embodiment, the cutting mechanism 90 may include two edge
15 cutter needles 91. One of the edge cutter needles 91 cuts off an edge of the first slurry 103. The other one of the edge cutter needles 91 cuts off another edge of the first slurry 103.

[0037] Referring to FIG. 1, in at least one embodiment, at least one of the premixing mechanism 30 and the slurry spreading mechanism 40 may further include a second

sensor 34, 43, respectively, for sensing characteristic data of the first slurry 103. In the embodiment, the slurry spreading mechanism 40 includes a second sensor 43 located in the spreading chamber 41. The second sensor 43 is at least partially immersed in the first slurry 103 located in the spreading chamber 41. The second sensor 43 can sense
5 characteristic data which includes at least of a temperature, a pH value, and a viscosity of the first slurry 103 in the spreading chamber 41. The characteristic data can be compared with preset data, and the comparison result is for indicating that whether the first slurry 103 in the spreading chamber 41 meets requirements.

[0038] Referring to FIGS. 1, 2 and 8, the slurry spreading mechanism 40 may further
10 include a movable plate 44. The movable plate 44 is movably connected to the slurry outlet 412 of the spreading chamber 41. For example, the movable plate 44 may be rotate relative to the slurry outlet 412. The movable plate 44 can adjust an amount of the first slurry 103 from the slurry outlet 412. For example, referring to FIG. 8, when the amount of the first slurry 103 from the slurry outlet 412 is too large, the movable
15 plate 44 moves relative to the slurry outlet 412 to block a portion of the slurry outlet 412, thereby reducing the amount of the first slurry 103 from the slurry outlet 412. Referring to FIG. 9, when the amount of the first slurry 103 from the slurry outlet 412 is too small, the movable plate 44 moves relative to the slurry outlet 412 to expose a portion of the slurry outlet 412, thereby increasing the amount of the first slurry 103 from the slurry

outlet 412.

[0039] Furthermore, Referring to FIGS. 2, 8 and 9, the movable plate 44 may include a plurality of movable portions 440. The movable portions 440 may independently move relative to the slurry outlet 412. Thus, the movable portions 440 can independently adjust the amount of the first slurry 103 from different positions of the slurry outlet 412, thereby improving the quality and the stability of the final multilayer material 100a.

[0040] In at least one embodiment, the device 1 may further include a processor (not shown). The processor can control different components of the device 1, including but not limited to the pressing mechanism 50, the first stirring unit 32, the second stirring unit 42, the first sensor 60, the second sensor 43, to operate. The processor may be a central processing unit (CPU), a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or other programmable logic devices, discrete gates, or transistor logic devices.

[0041] The device 1 may further include a user interface (not shown) for a user to input a desired concentration of the CNFs in the second slurry 104. The processor may control the different components of the device 1 to operate according to the desired concentration input by the user, thereby enabling the second slurry 104 to have the desired concentration of the CNFs.

[0042] FIG. 10 illustrates a flowchart of a CNF dehydration method for dehydrating CNFs in accordance with an embodiment. The method is provided by way of embodiments, as there are a variety of ways to carry out the method. Each step shown in FIG. 10 represents one or more processes, methods, or subroutines carried out in the method. Furthermore, the illustrated order of steps may be changed. Additional steps may be added or fewer steps may be utilized, without departing from this disclosure. The method begins at step S1.

[0043] At step S1, a first porous layer 101 and a second porous layer 102 are provided and conveyed along a first direction X. The second porous layer 102 is located above and spaced from the first porous layer 101.

[0044] In at least one embodiment, providing and conveying the first porous layer 101 along the first direction X may be carried out by coiling the first porous layer 101 around a first roller 11 and connecting the first porous layer 101 from the first roller 11 to a second roller 12. Then, the first roller 11 and the second roller 12 are rotated to convey the first porous layer 101 along the first direction X. Providing and conveying the second porous layer 102 along the first direction X may further be carried out by coiling the second porous layer 102 around a third roller 21 and connecting the second porous layer 102 from the third roller 21 to a fourth roller 22. Then, the third roller 21 and the fourth roller 22 are rotated to convey the second porous layer 102 along the first

direction X.

[0045] At step S2, a raw material including the CNFs is mixed with a liquid medium to obtain a first slurry 103.

[0046] In at least one embodiment, the liquid medium may be water or other solvents
5 suitable for mixing with the CNFs.

[0047] At step S3, the first slurry 103 is spread onto the first porous layer 101, thereby causing the first slurry 103 to be sandwiched between the first porous layer 101 and the second porous layer 102 to obtain a multilayer body 100.

[0048] In at least one embodiment, spreading the first slurry 103 onto the first porous
10 layer 101 may be carried out by adding the first slurry 103 into a slurry spreading mechanism 40, wherein the slurry spreading mechanism 40 includes a spreading chamber 41 having a slurry outlet 412 and a movable plate 44 movably connected to the slurry outlet 412. Then, the movable plate 44 is opened relative to the slurry outlet 412 for spreading the first slurry 103 onto the first porous layer 101. The first slurry 103 is
15 spread onto the first porous layer 101 by a positive pressure generated in the spreading chamber 41 or by a gravity of the first slurry 103.

[0049] In at least one embodiment, after spreading the first slurry 103 onto the first porous layer 101, the method may further include applying vibrations on the first porous layer 101 between the second roller 12 and the pressing mechanism 50, thereby enabling

the first slurry 103 to be uniformly located on the first porous layer 101. The vibrations may be generated by applying ultrasonic waves, mechanical vibration, or liquid injection onto the first porous layer 101.

5 **[0050]** After spreading the first slurry 103 onto the first porous layer 101, the method may further include cutting off an edge of the first slurry 103 spread on the first porous layer 101. Thus, the final multilayer material 100a can have a uniform and desired thickness.

10 **[0051]** At step S4, the multilayer body 100 is pressed, thereby removing a portion of the liquid medium from the first slurry 103 to obtain a second slurry 104, such that a concentration of the CNFs in the second slurry 104 is larger than that in the first slurry 103. Then, the multilayer material 100a is obtained.

[0052] The multilayer material 100a can further be immersed in a liquid, which may be the same or different from the above liquid medium, for storage and transportation purposes.

15 **[0053]** In at least one embodiment, pressing the multilayer body 100 may be carried out by disposing a pressing mechanism 50 on at least one side of the multilayer body 100, wherein the pressing mechanism 50 includes at least two pairs of pressing rollers 51 arranged along the first direction X, each pair of pressing rollers 51 includes two pressing rollers 51 located at opposite sides of the multilayer body 100, and a distance between the

two pressing rollers 51 of the at least two pairs of pressing rollers 51 decreases along the first direction X. Then, each pair of pressing rollers 51 is controlled to press the multilayer body 100. By gradually decreasing the distance between the two pressing rollers 51 of the different pairs of pressing rollers 51 along the first direction X, the concentration of the CNFs in the first slurry 103 is gradually increased.

[0054] In at least one embodiment, after pressing the multilayer body 100, the method may further include dehydrating the CNFs in the first slurry 103 of the multilayer body 100, thereby removing another portion of the liquid medium from the first slurry 103 to further increase the concentration of the CNFs in the first slurry 103.

10 **[0055]** After pressing the multilayer body 100, the method may further include sensing a content of the liquid medium in the second slurry 104, and the sensed content configured to indicate whether the concentration of the CNFs in the second slurry 104 matches a desired concentration. Then, the distance between the two pressing rollers 51 of the at least two pairs of pressing rollers 51 is adjusted according to the sensed content.

15 For example, when the content of the liquid medium in the second slurry 104 is too large, the distance between the two pressing rollers 51 of each pair of pressing rollers 51 may be reduced, thereby allowing the second slurry 104 to have a desired concentration. When the content of the liquid medium in the second slurry 104 is too small, the distance between the two pressing rollers 51 of each pair of pressing rollers 51 may be increased,

thereby allowing the second slurry 104 to have a desired concentration.

[0056] The method may also adjust a position of the movable plate 44 relative to the slurry outlet 412, thereby adjusting the amount of the first slurry 103 from the slurry outlet 412 according to the sensed content. For example, when the amount of the first
5 slurry 103 from the slurry outlet 412 is too large, the movable plate 44 moves relative to the slurry outlet 412 to block a portion of the slurry outlet 412, thereby reducing the amount of the first slurry 103 from the slurry outlet 412. When the amount of the first slurry 103 from the slurry outlet 412 is too small, the movable plate 44 moves relative to the slurry outlet 412 to expose a portion of the slurry outlet 412, thereby increasing the
10 amount of the first slurry 103 from the slurry outlet 412.

[0057] Even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only. Changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the
15 principles of the present exemplary embodiments, to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

CLAIMS

What is claimed is:

1. A cellulose nanofibril (CNF) dehydration device for dehydrating CNFs and comprising:

5 a first supply mechanism configured to provide a first porous layer along a first direction;

 a second supply mechanism configured to provide a second porous layer along the first direction, the second porous layer located above and spaced from the first porous layer;

10 a premixing mechanism configured to mix a raw material comprising the CNFs with a liquid medium to obtain a first slurry;

 a slurry spreading mechanism connected to the premixing mechanism, and configured to receive the first slurry from the premixing mechanism and spread the first slurry onto the first porous layer, thereby causing the first slurry to be sandwiched

15 between the first porous layer and the second porous layer to obtain a multilayer body; and

 a pressing mechanism located on at least one side of the multilayer body and configured to press the multilayer body, thereby removing a portion of the liquid medium

from the first slurry to obtain a second slurry, such that a concentration of the CNFs in the second slurry is larger than that in the first slurry.

2. The CNF dehydration device according to claim 1, wherein the first supply mechanism comprises a first roller for storing the first porous layer coiled thereon and a second roller, the second roller is configured to move the first porous layer from the first roller along the first direction;

the second supply mechanism comprises a third roller for storing the second porous layer coiled thereon and a fourth roller, the fourth roller is configured to move the second porous layer from the third roller along the first direction.

3. The CNF dehydration device according to claim 2, wherein the pressing mechanism comprises at least two pairs of pressing rollers arranged along the first direction, each pair of pressing rollers comprises two pressing rollers located at opposite sides of the multilayer body, and a distance between the two pressing rollers of the at least two pairs of pressing rollers decreases along the first direction.

4. The CNF dehydration device according to claim 2, further comprising:

a vibration mechanism located between the second roller and the pressing mechanism along the first direction and configured to apply vibrations on the first porous layer.

5. The CNF dehydration device according to claim 2, further comprising:

a cutting mechanism located between the fourth roller and the second roller along the first direction, and configured to cut off an edge of the first slurry spread on the first porous layer.

6. The CNF dehydration device according to claim 3, wherein at least one of the two pressing rollers is a vacuum dehydration roller, and the vacuum dehydration roller is configured to dehydrate the CNFs in the first slurry of the multilayer body.

7. The CNF dehydration device according to claim 2, further comprising:

a vacuum dehydration mechanism located at one side of the pressing mechanism away from the slurry spreading mechanism along the first direction, and configured to dehydrate the CNFs in the first slurry of the multilayer body.

8. The CNF dehydration device according to claim 7, wherein the vacuum dehydration mechanism comprises a vacuum adsorption hole arranged in a second direction perpendicular to the first direction, and the vacuum adsorption hole is configured to adsorb the liquid medium in the first slurry of the multilayer body.

9. The CNF dehydration device according to claim 2, further comprising:

a sensor located at one side of the pressing mechanism away from the second roller or the fourth roller along the first direction, and configured to sense a content of the liquid medium in the second slurry, and the sensed content configured to indicate whether the concentration of the CNFs in the second slurry matches a desired concentration.

10. The CNF dehydration device according to claim 1, wherein the slurry spreading mechanism comprises:

a spreading chamber having a slurry outlet for spreading the first slurry onto the first porous layer; and

5 a movable plate movably connected to the slurry outlet and configured to adjust an amount of the first slurry from the slurry outlet.

11. The CNF dehydration device according to claim 10, wherein the movable plate comprises a plurality of movable portions configured to independently adjust the amount of the first slurry from different positions of the slurry outlet.

10 12. A cellulose nanofibril (CNF) dehydration method for dehydrating CNFs and comprising:

providing a first porous layer and a second porous layer each along a first direction, and the second porous layer located above and spaced from the first porous layer;

15 mixing a raw material comprising the CNFs with a liquid medium to obtain a first slurry;

spreading the first slurry onto the first porous layer, thereby causing the first slurry to be sandwiched between the first porous layer and the second porous layer to obtain a multilayer body; and

pressing the multilayer body and removing a portion of the liquid medium from the

first slurry to obtain a second slurry.

13. The CNF dehydration method according to claim 12, wherein providing the first porous layer and the second porous layer each along a first direction comprises:

coiling the first porous layer around a first roller and connecting the first porous
5 layer from the first roller to a second roller;

rotating the first roller and the second roller to convey the first porous layer along the first direction;

coiling the second porous layer around a third roller and connecting the second porous layer from the third roller to a fourth roller; and

10 rotating the third roller and the fourth roller to convey the second porous layer along the first direction.

14. The CNF dehydration method according to claim 13, wherein after spreading the first slurry onto the first porous layer, the method further comprises:

applying vibrations on the first porous layer between the second roller and the
15 pressing mechanism.

15. The CNF dehydration method according to claim 13, wherein after spreading the first slurry onto the first porous layer, the method further comprises:

cutting off an edge of the first slurry spread on the first porous layer.

16. The CNF dehydration method according to claim 13, wherein after pressing the

multilayer body, the method further comprises:

dehydrating the CNFs in the first slurry of the multilayer body.

17. The CNF dehydration method according to claim 13, wherein pressing the multilayer body comprises:

- 5 disposing a pressing mechanism on at least one side of the multilayer body, the pressing mechanism comprising at least two pairs of pressing rollers arranged along the first direction, each pair of pressing rollers comprising two pressing rollers located at opposite sides of the multilayer body, and a distance between the two pressing rollers of the at least two pairs of pressing rollers decreases along the first direction; and
- 10 controlling each pair of pressing rollers to press the multilayer body.

18. The CNF dehydration method according to claim 17, wherein after pressing the multilayer body, the method further comprises:

sensing a content of the liquid medium in the second slurry; and

- adjusting the distance between the two pressing rollers of the at least two pairs of
- 15 pressing rollers according to the sensed content.

19. The CNF dehydration method according to claim 13, wherein spreading the first slurry onto the first porous layer comprises:

adding the first slurry into a slurry spreading mechanism, the slurry spreading mechanism comprising a spreading chamber having a slurry outlet and a movable plate

movably connected to the slurry outlet; and

opening the movable plate relative to the slurry outlet for spreading the first slurry onto the first porous layer.

20. The CNF dehydration method according to claim 19, wherein after pressing the
5 multilayer body, the method further comprises:

sensing a content of the liquid medium in the second slurry; and

adjusting a position of the movable plate relative to the slurry outlet to adjust the amount of the first slurry from the slurry outlet according to the sensed content.