

(19)



(11)

EP 4 524 323 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.03.2025 Bulletin 2025/12

(21) Application number: **23197987.3**

(22) Date of filing: **18.09.2023**

(51) International Patent Classification (IPC):

D21H 11/18 ^(2006.01) **D21G 1/00** ^(2006.01)
D21H 19/34 ^(2006.01) **D21H 19/52** ^(2006.01)
D21H 19/82 ^(2006.01) **D21H 23/26** ^(2006.01)
D21H 25/06 ^(2006.01) **D21H 27/10** ^(2006.01)

(52) Cooperative Patent Classification (CPC):

D21H 27/10; D21G 1/00; D21H 11/18; D21H 19/34;
D21H 19/52; D21H 19/82; D21H 23/26; D21H 25/06

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR

Designated Extension States:

BA

Designated Validation States:

KH MA MD TN

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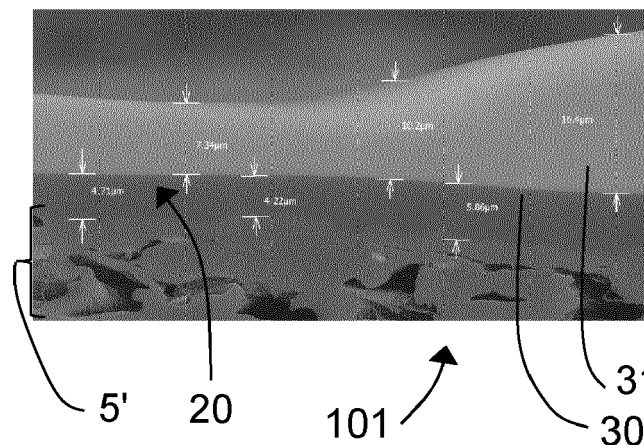
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(54) METHOD TO PRODUCE A PAPER SUBSTRATE

(57) A method to produce a coated paper substrate (5') for functional papers for packaging applications comprises the steps of forming an initial fiber-based wet substrate with solid contents between 4-20 wt.% on a wire; applying a microfibrillated cellulose (MFC) fiber suspension (20) with solid contents between 1 and 30

g/L on top of the fiber-based wet substrate on the wire at the forming table of a paper machine to form a uniform substrate layer; drying of the uniform substrate layer with a moisture content ranging from 0.5 wt.% and 12 wt.%; and inline or offline calendering of the uniform substrate layer, creating a calendered MFC coated substrate (5').

**FIG. 2B**

Description

TECHNICAL FIELD

[0001] The present invention relates to a method to produce a paper substrate for functionalized papers for packaging applications as well as a functionalized paper based on this substrate, a packaging material based on the functionalized paper and the use of this functionalized paper.

PRIOR ART

[0002] In order to protect products against the effect of substances that can damage and/or spoil such products, the products are packaged in a packaging.

[0003] Thus, the appropriate packaging needs to be selected depending on the packaged product, as well as depending on the substances that are to be kept from damaging the product. One way to achieve the desired protection is to provide the package with a barrier.

[0004] WO 2011/078770 A1 (EP 2 516 156 B1) relates to a paper or paperboard substrate having barrier properties which substrate comprises a first fiber based layer, a second layer comprising 0.1-10 g/m² (dry) microfibrillated cellulose with a length of 10-100 μm and a third layer comprising a polymer wherein said polymer is any of the following polymers: polyethylene (PE), polyethylene terephthalate (PET), polyvinyl alcohol (PVOH), polyvinyl acetate (PVA), polypropylene (PP) and/or polyamide (PA). The second layer of the substrate is preferably attached to the first layer and the third layer is preferably attached to the second layer of the paper or paperboard substrate. In this way, the paper or paperboard substrate comprises three layers and the second layer comprising microfibrillated cellulose is located in between the first fiber based layer and the third polymer layer.

[0005] WO 2016/097964 A1 (EP 3 234 260 B1) relates to a process for the production of a coated substrate comprising cellulosic fibers, the process comprising the steps of: i) providing a substrate comprising cellulosic fibers and having a dry content of less than 50% by weight; ii) applying a coating composition to the substrate in a total amount of more than 5 g/m², especially between 10 g/m² and less than 40 g/m², calculated as dry weight of the coating composition, wherein the coating composition comprises: microfibrillated cellulose (MFC), and especially a water retention agent being carboxymethyl cellulose (CMC) in an amount of at least 3% up to 8.5% by weight, calculated as dry weight and based on the dry weight of the MFC; and iii) mechanically dewatering the first substrate.

[0006] The water retention agent used in WO 2016/097964 A1 can also be selected from carboxymethyl cellulose (CMC), anionic polyacrylamide (A-PAM), sodium polyacrylates, polyacrylic acid derivatives, guar gum, alginate, MFC prepared from carboxymethylated fibers, MFC prepared from oxidized fibers, MFC prepared by CMC- functionalized fibers, and/or combinations thereof.

[0007] WO 2013/188739 A1 (EP2861800B1) is related to a release base paper and the method of its manufacture, wherein the method for producing such a release base paper comprises: i) manufacturing a release base paper with a paper-making furnish having a fiber freeness (CSF) of 180 ml or higher; ii) pressing the furnish into a web of paper; iii) drying the pressed web; and iv) calendering the web to form a release base paper, wherein the release base paper is manufactured with nano-fibrillated cellulose added to the release base paper by means of at least one of: (i) incorporation into the furnish at a loading concentration of from about 10 to about 400 lbs/ton; and (ii) coating on the web of paper at a coating rate of about 0.2 to about 12 g/m.

[0008] WO 2022/049484 A1 discloses a method for manufacturing a multilayer machine glazed paper comprising highly refined cellulose fibers, especially microfibrillated cellulose (MFC), the method comprising the steps of: a) forming a first wet web by applying at least one first pulp suspension comprising highly refined cellulose fibers on a first wire; b) partially dewatering the first wet web to obtain a first partially dewatered web; c) forming a second wet web by applying at least one second pulp suspension comprising highly refined cellulose fibers, especially microfibrillated cellulose (MFC), on a second wire; d) partially dewatering the second wet web to obtain a second partially dewatered web; e) joining the first and second partially dewatered web to obtain a multilayer web; f) optional dewatering the multilayer web in a dewatering unit, and g) glazing the multilayer web in at least one glazing unit, especially a Yankee cylinder, a glassine calender or an extended nip calender such as a shoe calender or belt calender, to obtain a multilayer machine glazed paper comprising highly refined cellulose fibers. The manufacturing method according to WO 2022/049484 A1 involves the separate preparation and partial dewatering of at least two webs, the two webs having a lower grammage compared to the finalized multilayer MG paper. The partially dewatered but still wet webs are joined to form a higher grammage multilayer web, which is subsequently further dewatered and dried to obtain a more dry multilayer web. The microfibrillated cellulose is laminated onto the substrate.

[0009] Furthermore, most papers currently used as substrates for functional coatings contain latex-based precoats which seal the base paper porosity in order to ensure a good coating holdout of the expensive functional barrier coatings applied on top. If the paper's porosity is too open, the areas with poor coating holdout lead to defects in the coating layer.

SUMMARY OF THE INVENTION

[0010] Based on the prior art, there is a need, and it is desirable to provide a packaging solution that is based on renewable raw materials, which allows producing a base paper at an industrial scale with a layer of MFC that seals the paper surface's porosity instead of a layer of microplastics (latex). This is to increase the sustainability and repulpability of paper constructs. Furthermore, it is an object to prepare functional paper grades which are compliant with new regulations related to sustainability such as the Single Use Plastics Directive (SUPD) in the EU, published under <https://eur-lex.europa.eu/eli/dir/2019/904/oj>.

[0011] Such a method also encompasses a method for manufacturing paper or paperboard with low Bendsten porosity and roughness to be used as a substrate to support coatings for barrier papers or other functionalities.

[0012] The above mentioned issues are solved with a method to produce a coated paper substrate for functional papers for packaging applications comprising: forming an initial fiber-based wet substrate with solid contents between 4-20 wt.% on a wire; applying a microfibrillated cellulose (MFC) fiber suspension with solid contents between 1 and 30 g/L on top of the fiber-based wet substrate on the wire at the forming table of a paper machine to form a uniform substrate layer; drying of the uniform substrate layer with a moisture content ranging from 0.5 wt.% and 12 wt.%; and inline or offline calendering of the uniform substrate layer, creating a calendered MFC coated substrate.

[0013] One of the methods to apply a layer of MFC on top of paper is by means of wet end application. Whilst this method is relatively feasible to scale-up and produce MFC precoated papers at industrial scale at economically viable machine speeds, the as-produced paper has a much higher roughness than most latex-precoated papers used as substrates for functional barrier coatings and this roughness can lead to defects when applying barrier coatings on top.

[0014] Moreover, because MFC is applied in the wet end of a paper machine and it is dewatered via filtration, some pinholes are still present in the MFC layer which act as water pathways during the dewatering process but are not desirable in substrates used for subsequent coating.

[0015] In order to solve this, MFC-precoated papers are subjected to a pressure and heat treatment (calendering) to further close the surface porosity and smoothen the paper to make it a suitable substrate for barrier or other functional coatings.

[0016] Very good results for the coated paper substrate have been achieved, when the MFC fiber suspension is prepared based on Bleached Kraft Eucalyptus pulp or sulphite beech pulp or bleached birch pulp. In general, both hardwood and softwood pulps can be used, however hardwood pulps are preferred over softwoods.

[0017] In a preferred method, a rewetting step is introduced between the drying and the calendering step. The rewetting of the paper can be performed up to 10% or 12% - 18%, before the calendering. Wet stack or multi-nip calendering is typically done with three or more rolls and two or more nips. In wet stack, water is added to the sheet surface in between one or more nips using water boxes. The added moisture and applied nip pressure develop uniform nip pressure profile and good smoothness of sheet. The rewetting can also happen during calendering, i.e. in a wet stack application,

[0018] The coated paper substrate can be used as barrier paper but can also be preferably coated with one or more specific layers of barrier coatings after the calendering step. There can be one single additional barrier coating, there can be two or more barrier coating layers.

[0019] It is a further object of the present invention to provide a packaging material comprising the barrier paper according to the first object, where the food packaging material is configured such that the barrier paper is in direct contact with the packaged material when in use. Such packaged material can be a food or non-food product.

[0020] It is another object of the present invention to provide a use of a barrier paper in a manufacturing process of a packaging material.

[0021] Further embodiments of the invention are laid down in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

- Fig. 1A shows a cross-section SEM image of an uncalendered MFC-precoated substrate with two barrier coatings on top at a first magnification,;
- Fig. 1B shows a cross-section SEM image of a calendered (at 100 kN/m) MFC-precoated substrate with two barrier coatings on top at a first magnification;
- Fig. 1C shows a cross-section SEM image of a calendered (at 280 kN/m) MFC-precoated substrate with two barrier coatings on top at a first magnification;
- Fig. 1D shows a comparative example of a cross-section SEM image of a calendered (at 280 kN/m) substrate without MFC-precoating with two barrier coatings on top at a first magnification;

Fig. 2A shows a cross-section SEM image of the substrate of Fig. 1A at a second (10 times higher) magnification;
 Fig. 2B shows a cross-section SEM image of the substrate of Fig. 1B at a second (10 times higher) magnification;
 Fig. 2C shows a cross-section SEM image of the substrate of Fig. 1C at a second (10 times higher) magnification;
 Fig. 2D shows a cross-section SEM image of the substrate of Fig. 1D at a second (10 times higher) magnification;
 5 Fig. 3A shows a view from above on the substrate of Fig. 1A on which, subsequently, a blue dye was applied for 10 min to identify coating defects;
 Fig. 3B shows a view from above on the substrate of Fig. 1B on which, subsequently, a blue dye was applied for 10 min to identify coating defects;
 Fig. 3C shows a view from above on the substrate of Fig. 1C on which, subsequently, a blue dye was applied for 10 min to identify coating defects; and
 10 Fig. 3D shows a view from above on the substrate of Fig. 1D on which, subsequently, a blue dye was applied for 10 min to identify coating defects.

DESCRIPTION OF PREFERRED EMBODIMENTS

15 **[0023]** Fig. 1A shows a cross-section SEM image of a calendered (at 100 kN/m) MFC-precoated substrate 5 with two barrier coatings 30, 31 on top at a first magnification. The MFC-precoated substrate 5 comprises a base paper substrate 10 and a MFC layer 20 which is difficult to spot as it has the same composition as the fibers forming the base paper substrate 10. The fibers of the MFC layer 20 might penetrate into the base paper and not stay completely on the surface. Reference
 20 numeral 80 indicates the area of Fig. 1A which is shown in Fig. 2A which is a cross-section SEM image of the substrate of Fig. 1A at a second magnification which is 10 times higher.

[0024] A method to produce a coated paper substrate for functional papers for packaging applications comprises: forming an initial fiber-based wet substrate with solid contents between 4-20 wt.% on a wire;

- 25 - applying a microfibrillated cellulose (MFC) fiber suspension with solid contents between 1 and 30 g/L on top of the fiber-based wet substrate on the wire at the forming table of a paper machine to form a uniform substrate layer 5;
- drying of the uniform substrate layer 5 with a moisture content ranging from 0.5 wt.% and 12 wt.%; and
- inline or offline calendering of the uniform substrate layer 5, creating a calendered MFC coated substrate 5'.

30 **[0025]** The coated substrate 5' is also named precoated substrate since it can be treated in additional further steps.

[0026] The SEM images of Fig. 1A and 2A show a first barrier coating 30 and a second barrier coating 31 applied on top of the uniform substrate layer 5. It can be seen that, when the uncalendered substrate layer 5 is used as basis to apply the barrier coatings 30 and 31, the entire paper substrate is rough and the thin MFC fiber coating 20 follows the roughness of this paper substrate whereas the calendered MFC precoated substrate 5' allows the barrier coating 30 to be applied on a
 35 far smoother surface. In fact, when the MFC is applied with the wet end applicator it contours the original roughness of the substrate on which it is applied. Therefore, based on a paper substrate with a high roughness, the MFC coating layer 20 will follow this roughness too until the calendering step.

[0027] The coat weight of the MFC layer 20 can range from 1 to 20 gsm, the example/embodiments shown in Fig. 1 uses a coat weight of 8 gsm.

40 **[0028]** Fig. 1B shows a cross-section SEM image of a calendered (at 100 kN/m) MFC-precoated substrate with two barrier coatings 30, 31 on top at a first magnification.

[0029] The calendering uses a, or a multi-nip calender, or a soft-nip calender, or a belt calender. The temperature applied is preferably above 100°C, preferably between 110-190°C. It is optional and may even be preferred that before calendering, the MFC pre-coated paper substrate is rewetted to increase its moisture content and make it more malleable
 45 during the calendaring process. The MFC side of the uniform substrate layer will be in direct contact with the calender. The pressure applied can be between 10 kN/m and 400 kN/m, especially from 80kN/m to 300kN/m.

[0030] It will be apparent to the person skilled in the art of papermaking or paperboardmaking processes that multiple technical solutions may be levied in order to prevent the drying shrinkage of the base paper layer in the drying section of the paper machine. An exemplary solution is the use of Yankee dryers in the drying section of the paper machine or
 50 paperboarding machine, because Yankee dryers restrain the paper or paperboard during drying so that drying shrinkage is countered. Thus, in a preferred embodiment of the functionalized paper, the base paper layer of the barrier paper is obtained from a paper machine or paperboard machine having a drying section equipped with Yankee dryers.

[0031] It is possible to calender one or both sides of the uniform substrate layer. The treatment in the calender can be done inline. The calendering step can be a supercalendering step.

55 **[0032]** The calendering process is related to smoothening the surface of the uniform substrate layer to provide it with low surface roughness values. Different parameters as well as calendering techniques can be used to achieve this: rewetting of the uniform substrate layer prior to calendering to increase the moisture content and aid the smoothening of the uniform substrate layer before calendering, increased temperature during the calendering process, increased dwell time during

the calendering process. Furthermore, there can be used as a calender unit: a calender with a higher amount of nips, or a belt calender with a longer nip, or different nip materials in contact with the paper.

[0033] It is preferred, when a rewetting step is introduced between the drying and the calendering step. The rewetting can especially comprise the feature of increasing moisture from 2-7% to 10-18%. This can be achieved by water spraying or water vapour, on one side of the paper or on both sides. This can be performed at a speed from 200 to 1500m/min. A residence time before calendering can be chosen to be between from 1 to 24h.

[0034] It is also preferred to apply, additionally or as an alternative to the rewetting step, one or more coating layer 30, 31 before calendering, especially an additional coating with a barrier layer. Such layers can be starch or PVOH with coat weights between 0.2 and 3.0 gsm. Such coatings can be applied with speed sizer, film press and other means.

[0035] In case of applying a further coating layer and introducing the rewetting step, the rewetting can take place before the further coating. It is also possible that a first layer coating 30 could be applied before the calendering step by using an inline coater such as a speed sizer. The optional second coating layer can be applied after calendering

[0036] Fig. 1C shows a cross-section SEM image of a calendered MFC-precoated substrate 5' with two barrier coatings 30, 31 on top at a first magnification, just calendered at 280 kN/m. Therefore, identical reference numerals are used in Fig. 1C and the ten times higher magnification image 2C.

[0037] On the other side, Fig. 1D shows a comparative example of a cross-section SEM image of a calendered (at 280 kN/m) substrate without MFC-precoating with two barrier coatings 30, 31 on top at a first magnification and Fig. 2D the detail view of Fig. 1D at a higher magnification

[0038] The properties of the MFC precoated calendered paper before an optional further coating step with a barrier layer are evaluated based on:

1- Bendtsen permeability: preferably < 50 mL/min

2- Bendtsen roughness at the side of the uniform substrate layer, where MFC is applied: preferably < 100 mL/min.

Table 1

Coat weight and type MFC	Calendering pressure (kN/m)	Bendtsen Roughness FS (mL/min)	Bendtsen porosity (mL/min)	Pinholes	WVTR 90% RH, 38C (g/m ² .d)	OTR 50% RH, 23C (cc/(m ² .day))
8 gsm MFC type 1	280	25.8	1.9	0.0	3.05	1.78
5 gsm MFC type 1	280	30.2	4.7	0.0	3.90	1.47
8 gsm MFC type 1	100	60.2	5.1	0.0	6.00	4.10
5 gsm MFC type 1	100	74.3	21.9	2.5	11.84	Faulty result out of range
12 gsm MFC type 2	280	51.2	10.5	0.3	4.45	203
8 gsm type 2	280	85.4	22.5	0.0	4.50	2.75
8 gsm type 2	150	280.4	70.5	2.7	5.41	>7
8 gsm type 2	0	954.7	13.9	>10	Faulty result out of range	Faulty result out of range
0 gsm MFC	280	102.8	181.8	2.5	4.64	Faulty result out of range

[0039] Type 1 is MFC from Kraft eucalyptus, type 2 is MFC from beech sulphite. The prepared examples and comparative examples show:

- the influence of MFC type, since type 1 is more efficient than type 2 at sealing the paper porosity and therefore achieving better results when barrier coating is applied.
- the influence of calendering and that, in general, the higher the calender pressure the smoother the paper. This also helps to get better barrier results when coating the substrate.

- importance of presence of MFC layer 20. The last row shows the results when coating a supercalendered base paper without any MFC layer. This paper has pinholes and has a worse barrier performance.

[0040] The method can furthermore comprise a further coating step:

- application of a very thin layer of a polymer such as PVOH on top of the MFC coated/precoated substrate via speed sizing before calendering but after drying. This improves the coating holdout and can reduce the need for a very harsh calendaring and online calendaring can be sufficient. The coat weight can be chosen from 0.1 to 3gsm.

[0041] Following the preparation of the calendered substrate, a further optional, i.e. second coating step can follow:

- application of one or more layers of barrier coating 30, 31 on top of the calendered MFC precoated substrate 5'.

[0042] The presence of the MFC layer 20 within the uniform substrate layer 5' has the function to densify and seal the base paper surface porosity to ensure a good holdout of the functional layers applied on top of the uniform substrate layer. However, since MFC is applied in a pre-metered manner, the MFC layer contours the surface roughness of the fiber-web substrate onto which it is being applied and therefore it does not have a major impact in reducing its roughness. When, later on, functional coatings such as barrier coatings are applied on top of a substrate, smoothness is an important parameter. If a thin layer is applied and a substrate is rougher, it will be more difficult to obtain a perfect coverage than if the substrate is smoother. Rougher substrates can lead to uncoated areas or areas in which the coating thickness is not uniform. This can cause defects (pinholes) or irregular barrier properties with high standard deviations due to the unevenness of the barrier coating thickness applied. In order to address this issue, it is important to ensure the right level of pressing (calendaring) to the MFC-precoated substrate in order to smoothen it enough to make it suitable for thin layer barrier coating application. The calendaring can use a pressure of between 10 kN/m and 400 kN/m, especially between 80 kN/m and 300 kN/m. The temperature applied can be in the range between 80 and 150 degree Celsius.

[0043] When two coating layers are applied, e.g. one with 2 and one with 10 gsm, they have a higher grammage and counter MFC's hydrophilicity. Additionally, when added in two layers, the first barrier coating is 'sizing' the MFC surface to make it less susceptible to water when the second layer is applied.

Example

[0044] As mentioned above, Fig. 1B and 1C, as well as Fig. 2B and Fig. 2C show cross-section SEM images 101, 102 showing different MFC-precoated substrates 5' with barrier coatings 30, 31 on top.

[0045] The SEM image 100 in Fig. 1A and 2A shows a paper, not according to the invention, where the barrier coatings 30, 31 have been applied to an uncalendered substrate 5 comprising the fiber base layer 10 and the MFC layer 20.

[0046] The SEM image 103 in Fig. 1D shows a paper, not according to the invention, where the barrier coatings 30, 31 have been applied to a base paper substrate without a MFC precoating.

[0047] These images of Fig 1B and 1C are specifically the cross-sections of the MFC precoated samples with the following coatings applied on top: layer 30 has 2.5 gsm of a first coating, layer 31 has 9.5 gsm of a second coating. The results shown in Table 2 correspond to the samples shown in Fig. 1A to 1D.

[0048] Table 2 shows the properties of MFC-precoated paper substrate (Bendtsen permeability and roughness) as well as barrier properties (WVTR = water vapor transmission rate, OTR = oxygen transmission rate) of MFC-precoated substrate with barrier coatings on top as shown in Fig. 1. The four entries in Table 2 correspond to the four examples/comparative samples of Fig. 1A to Fig. 1D.

Table 2

MFC coat weight (gsm)	Calendering pressure	Bendtsen permeability (mL/min)	Bendtsen roughness (mL/min)	WVTR 90% RH, 38C (g/m ² .d)	OTR 50% RH, 23C cc/(m ² .d)
8	Uncalendered	14	955	Coating pinhole defects	Coating pinhole defects
8	100 kN/m	7	67	7.6 ± 2	> 50
8	280 kN/m	2	26	2.9 ± 0.3	1.55 ± 0.01
0	280 kN/m	182	103	4.6 ± 0.5	Faulty result out of range

[0049] In short, Table 2 and Fig. 1A to 1D illustrate the effect of calendering through the substrate properties such as smoothness on the performance of the MFC-precoated substrates as a support for barrier polymers. The construct of the functional papers described here are: Base paper + 8 gsm MFC + two barrier polymer layers applied on top (2.5 gsm first coating + 9.5 gsm second coating).

[0050] Fig. 3A to Fig. 3D show the amount of defects (pinholes) 210 for four papers 200, 201, 202 and 203, respectively which are based on the four examples 100, 101, 102, 103 of Fig. 1A to Fig. 1D, respectively. Fig. 3A to Fig. 3D show each a view from above on a paper based for Fig. 3A to Fig. 3C on MFC-precoated substrates with barrier coatings on top and Fig. 3D on a paper without MFC with barrier coatings on top, wherein, subsequently, a blue dye was applied for 10 min to identify coating defects 210. The application of a blue dye allows to identify coating defects 210.

[0051] In short, the uncalendered paper sample 200 is too rough to even obtain grease barrier performance and shows too many coating defects 210. The calendered paper sample 201 is smooth enough to obtain grease barrier performance, medium WVTR performance but too rough to get oxygen barrier (OTR). The supercalendered paper sample 202 does not show any coating defects. The supercalendered paper is smooth enough to have all barrier properties on target (oxygen, water vapor and grease). The calendered paper without MFC 203 shows pinhole defects 210.

[0052] Of course, the barrier layer construct which is characterized on parameters relating to the number of layers, different types of coatings, different barrier layer thickness, coat weights, viscosity barrier coating, etc. will achieve different results but the baseline teaching of the samples 200, 201, 202 and 203 is that a (super)calendered MFC coated fiber substrate provide in any case sufficient performance relating to defects as pinholes, independent from any barrier coating applied later on.

[0053] In conclusion, the more uniform the MFC layer 20 within the precoated substrate 5', the lower the Bendtsen permeability and roughness, the better will be a latter applied barrier coating holdout without coating defects.

[0054] Calendered samples as shown with samples 201 and 202 in Fig. 3B and 3C were prepared with the following properties:

- use of MFC with fines content (fibers with length < 200 microns) above 50 wt.% and Schopper-Riegler (SR) values above 85
- use of MFC produced from Bleached Kraft Eucalyptus pulp
- MFC layer coat weight ideally above 4 gsm, above 2 gsm is a minimum,

wherein the substrate has the following properties:

- Bendtsen permeability ideally below 20 mL/min
- Bendtsen roughness ideally below 80 mL/min

and the uniform substrate layer can receive a further coating:

- applying the barrier coating in two layers.

[0055] The Bleached Kraft Eucalyptus pulp can be prepared as described in https://www.eucalyptus.com.br/icep02/jorge_colodette.pdf.

[0056] Fines are defined as the fine cellulosic particles, which are able to pass through a 200 mesh screen (according to ARTM being equivalent to a hole diameter of 76 μ m (micrometer)) of a conventional laboratory fractionation device.

[0057] When the barrier coating is applied in only one step the MFC-precoated substrate is more open, absorbs the water-based coating faster and this might lead to creation of coating defects but which are acceptable for functionalized papers. The barrier coating 30 was applied in two steps with a 2.5 gsm first barrier coating and a 9.5 gsm second barrier coating layer. In samples with one single barrier coating, the resulting paper was rougher but still provided a decent performance as functionalized paper.

[0058] The MFC layer can also be a mix of MFC fibers and additives such as CMC, starch, etc.. Specifically, adding a sizing agent such as AKD to the MFC makes the MFC layer more hydrophobic.

[0059] The base paper layer 10 may be a paper or paper-board layer, which may be formed from a mixture of paper pulp and mineral particles such as fillers, pigments or sizing materials.

[0060] Suitable paper pulp may be sourced from either virgin or recycled pulp sources. An example of a recycled pulp source is deinked pulp. Virgin pulp sources are plant materials such as wood, rice straw, bagasse, bamboo, sisal, and others. In a preferred embodiment, the paper pulp forming the base paper layer is chemical wood pulp such as Kraft or sulfite wood pulp, and is more preferably a bleached chemical wood pulp. Suitable bleached chemical wood pulps are northern bleached softwood kraft (NBSK), southern bleached softwood kraft (SBSK) or dissolving pulp. The mineral particles in the base paper layer are formed of minerals chosen from calcium carbonate, talcum, gypsum or titanium dioxide, aluminum phyllosilicate clays such as kaolin clay.

[0061] A paper machine or a paperboard machine includes several section, starting with a wet section, or wet end, where a web of wet paper precursor is formed by discharging a paper furnish onto a formation table, where the furnish is drained of some water mainly by suction. After the wet section, in the press section, the paper precursor is passed through dewatering devices which remove water via mechanical action, such as for example rolls that squeeze the paper precursor to dewater the paper precursor. At this point, the "dewatered" paper precursor, which is still moist, transits into the dryer section, where drying devices such as heated rolls, infrared heaters, and hot air heaters remove the remaining moisture from the dewatered paper precursor.

[0062] When dried in the dryer section, the dewatered paper precursor tends to shrink, in both machine direction as well as in cross direction, unless the drying shrinkage is prevented in some way. In the drying section of the paper or paperboard machine equipped with a drying device, the dewatered paper base layer is dried to form the paper base layer using said drying device, which drying device is configured to prevent drying shrinkage.

LIST OF REFERENCE SIGNS

5	uniform substrate layer		calender pressure)
15	5' calendered MFC precoated substrate	103	calendered paper (without MFC)
	10 fiber based substrate	200	uncalendered sample
	20 MFC fiber coating	201	calendered sample (lower calender pressure)
	30 first barrier coating		
20	31 second barrier coating	202	calendered sample (higher calender pressure)
	80 detail view area of Fig. 2A		
	100 uncalendered paper	203	calendered sample (without MFC)
	101 calendered paper (lower calender pressure)	210	coating defects
25	102 calendered paper (higher		

Claims

1. A method to produce a coated paper substrate (5') for functionalized papers suitable for packaging applications comprises:
 - forming an initial fiber-based wet substrate with solid contents between 4-20 wt.% on a wire;
 - applying a microfibrillated cellulose (MFC) fiber suspension with solid contents between 1 and 30 g/L on top of the fiber-based wet substrate on the wire at the forming table of a paper machine to form a uniform substrate layer (5);
 - drying of the uniform substrate layer (5) with a moisture content ranging from 0.5 wt.% and 12 wt.%, especially from 2 wt.% to 7 wt.%; and
 - inline or offline calendering of the uniform substrate layer (5), creating a calendered MFC coated substrate (5').
2. The method according to claim 1, wherein a rewetting step is introduced between the drying and the calendering step or a rewetting step is provided during the calendering.
3. The method according to claim 2, wherein the rewetting step comprises raising the moisture content to 10 wt.% to 18 wt.%, especially between 12 wt.% and 18 wt.%.
4. The method according to any one of claims 1 to 3, wherein the microfibrillated cellulose (MFC) fiber suspension creates a MFC layer (20) having a coat weight from 1 to 20 gsm, especially between 5 and 10 gsm, preferably a coat weight between 6 and 8 gsm.
5. The method according to any one of claims 1 to 4, wherein the calendering uses a a multi-nip calender, or a soft-nip calender, or a belt calender or a wet stack calender.
6. The method according to any one of claims 1 to 5, wherein the calendering is applied on one or both sides of the uniform substrate layer (5).
7. The method according to any one of claims 1 to 6, wherein calendering is performed with a pressure of between 10 kN/m and 400 kN/m, especially between 80 kN/m and 300 kN/m.

8. The method according to any one of claims 1 to 7, wherein the MFC fiber suspension has a fines content with fibers with length of less than 200 microns above 50 wt.% and Schopper-Riegler values above 85.
- 5 9. The method according to any one of claims 1 to 8, wherein the MFC fiber suspension is prepared based on a hardwood pulp, especially taken from the group of Bleached Kraft Eucalyptus pulp, bleached birch pulp or sulphite beech pulp.
10. The method according to any one of claims 1 to 9, wherein, before the calendering and after the drying, the uniform substrate layer (5) is coated, on the side where the MFC layer (20) is applied, with a first barrier coating (30).
- 10 11. The method according to claim 10, wherein a second barrier coating (31) is applied on top of the first coating (30).
12. The method according to claim 10 or 11, wherein at least one barrier coating (30, 31) comprises a polymer, preferably PVOH.
- 15 13. A barrier paper for packaging applications produced based on the coated paper substrate (5') for functional papers produced according to any one of claims 1 to 12.
14. A packaging material comprising the barrier paper of claim 13, where the packaging material is configured such that the barrier paper is in direct contact with a product, being a food or a non-food product.
- 20 15. Use of a barrier paper according to claim 13, in a manufacturing process of a packaging material according to claim 14.

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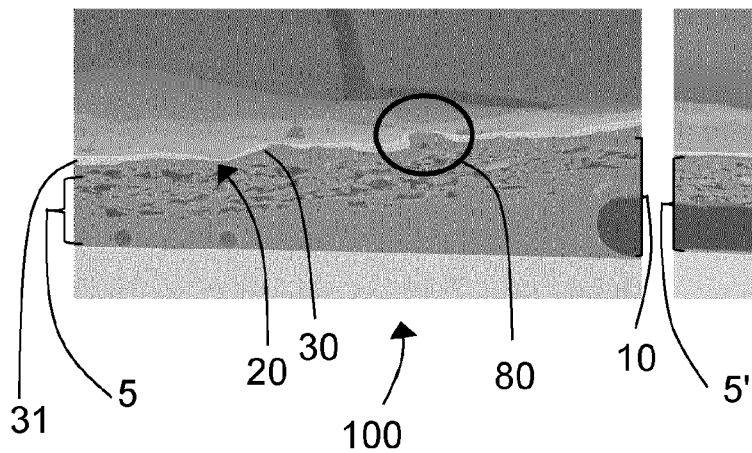


FIG. 1A

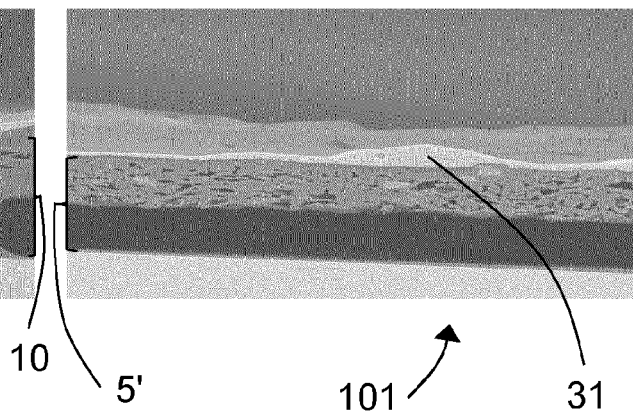


FIG. 1B

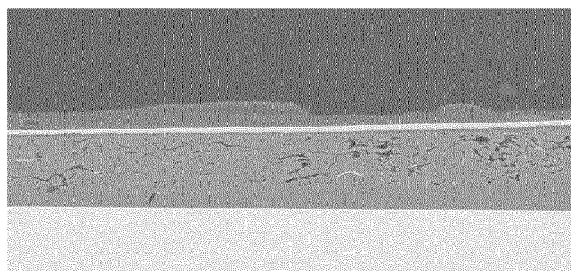


FIG. 1C

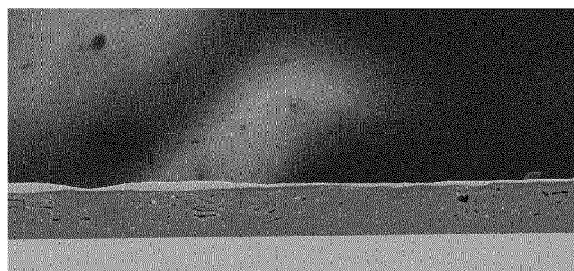
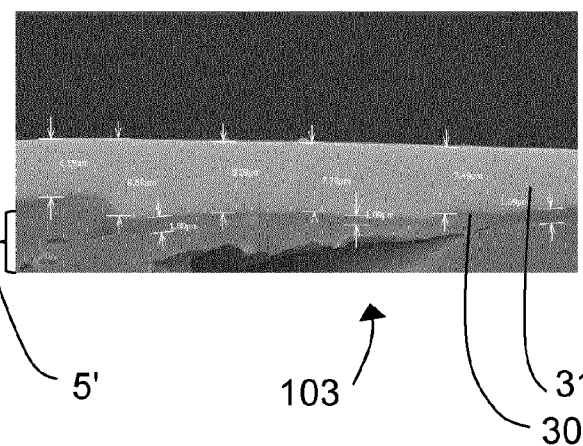
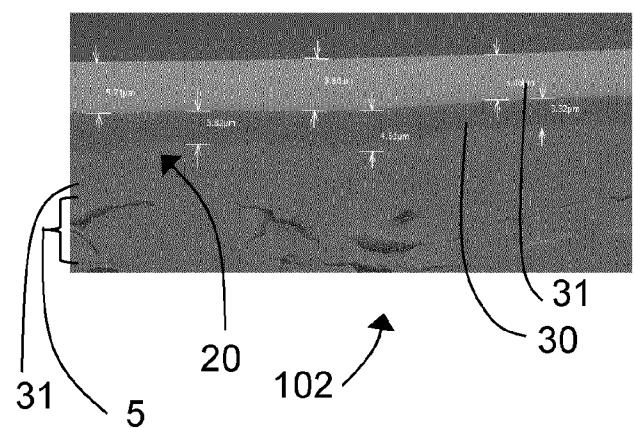
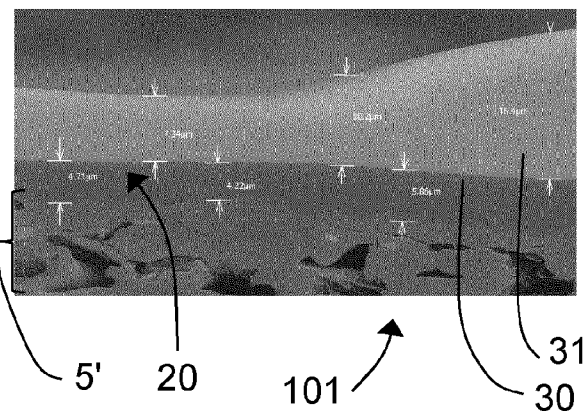
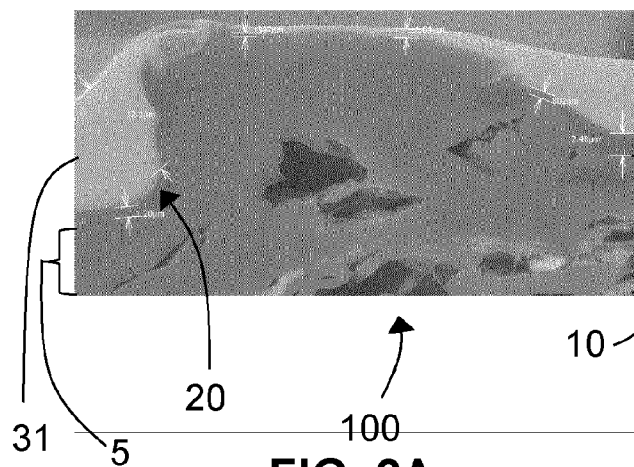


FIG. 1D



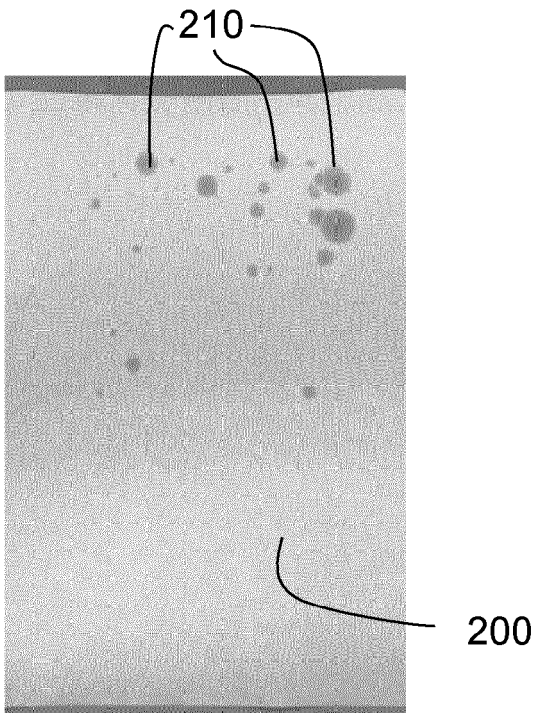


FIG. 3A

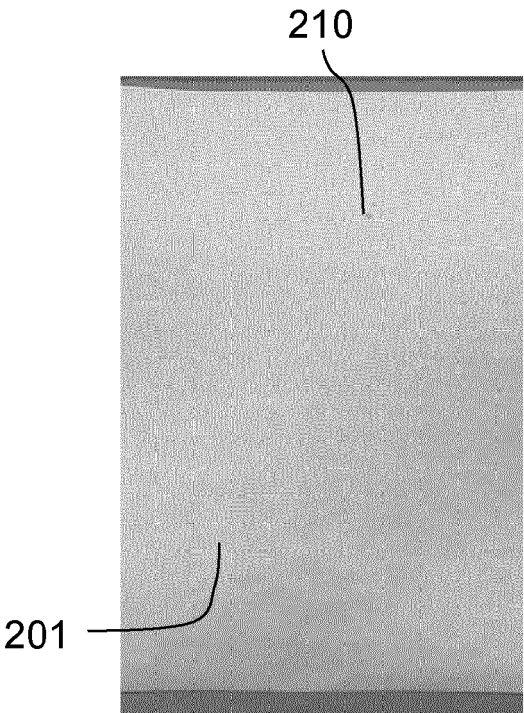


FIG. 3B

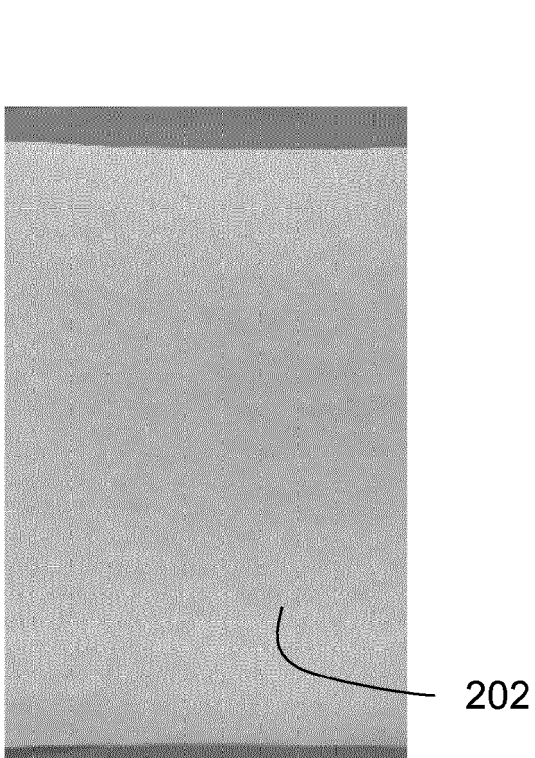


FIG. 3C

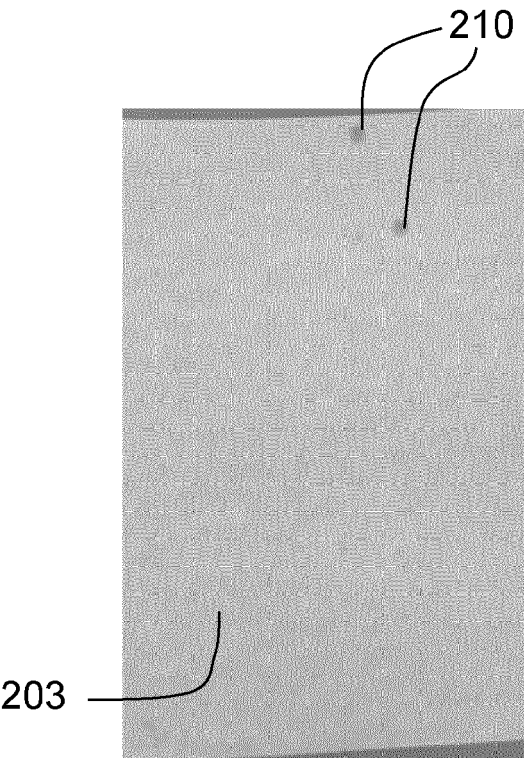


FIG. 3D



EUROPEAN SEARCH REPORT

Application Number

EP 23 19 7987

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Y	* claims 1-23; examples 5, 6 * * page 14, line 15 - line 20 * * page 17, line 15 - page 20, line 11 * * page 5, line 32 - line 33 * * page 16, line 5 - line 19 * * page 8, line 26 - line 34 * -----	2, 3, 5-7, 10-12	D21G1/00 D21H19/34 D21H19/52 D21H19/82 D21H23/26 D21H25/06 D21H27/10
X	JP 2019 023360 A (DAIO SEISHI KK) 14 February 2019 (2019-02-14)	1, 13	
Y	* claims 1-2 * * paragraph [0016] - paragraph [0023] * * paragraph [0032] - paragraph [0046] * -----	2, 3, 5-7, 10-12	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 February 2024	Examiner Billet, Aina
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