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(54) **Title:** A METHOD FOR OBTAINING THERMOREACTIVE BINDERS FOR A PRODUCTION OF WOOD COMPOSITE MATERIALS FROM BIRCH OUTER BARK

(57) **Abstract:** The invention refers to a method for obtaining thermoreactive binders by isolating them from birch outer bark for use in the production of wood composite materials. The invention describes a process of obtaining a suberinic acid containing binders, which can be used for the production of particle boards and plywood, as well as a production method of the aforementioned particle boards and plywood by using the binders defined in the invention. The invention offers a zero waste method of birch outer bark processing, where the by-products of binder obtaining process may be used as mineral fertiliser, fuel or fuel filler.

WO 2021/024152 A1

A METHOD FOR OBTAINING THERMOREACTIVE BINDERS FOR A PRODUCTION OF WOOD COMPOSITE MATERIALS FROM BIRCH OUTER BARK

Technical field

[001] The invention refers to the method for obtaining thermoreactive binders by isolating them from birch outer bark for use in the production of wood composite materials.

Analysis of the prior art

[002] 85 % of wood composite materials are produced by using thermoreactive binders that usually contain phenol and formaldehyde or carbamide and formaldehyde. However, despite good technical characteristics of these binders, alternative binders that could be used to produce wood composite materials must be used due to toxic emissions of formaldehyde, as well as phenol vapour.

[003] It is known that synthetic adhesives on the basis of isocyanates that do not emit toxic vapour could be used, but they are expensive and contain other carcinogenic compounds that pose hazard during the process of production of the binder and composite materials. Several attempts to use natural binders have been made. Usually, in this case, the ways of improving moisture resistance of the boards by using synthetic additives must be sought [RU 2002486 and RU 2240334].

[004] Patent RU 2310669 offers to use suberin as a binder by obtaining it from the birch wood processing by-product (bark) and using in the form of suberinic acids and partially depolymerised, acidified suberin. Birch outer bark is ground and subjected to depolymerisation in NaOH solution, then the salt and aqueous solution that has been obtained during the reaction is immediately separated, it is acidified with HCl, obtaining sediment, which is then rinsed, separated and dried, thus obtaining the binder. The aforementioned patent has been used as a prototype for Latvian patent LV 15031, the authors of which offer the method for the production of wood particle boards, which also includes the obtaining of the binder. The binder is obtained from previously

extracted or non-extracted birch outer bark, which is depolymerised in an alkaline environment in aqueous solution. Nitric acid is then added to the obtained suberinic acid salts, which are then, in the form of suberinic acids, together with ligno-carbohydrate complex admixtures sedimented from the reaction zone by using sedimentation centrifuge and rinsed twice with water.

[005] Publication of J.Rizikovs et.al. "Isolation of Suberinic Acids from Extracted Outer Birch Bark Depending of the Application Purposes" discloses fractionation of suberinic acids by sedimentation in alkaline-alcohol solutions in order to obtain suberinic acids. Publication of A.Paze et.al. "Study of an Appropriate Suberinic Acids Binder from Manufacturing of Plywood" discloses a use of said suberinic acids in manufacturing of a plywood.

[005] The objective of the invention is to create energy and resource efficient method for the obtaining a binder from birch outer bark for the production of thermoreactive, formaldehyde-free moisture resistant wood composite materials. Moreover, the objective of the invention is to create more effective binders as adhesives in plywood and wood particle boards.

Summary of the invention

[006] Birch outer bark – extracted or non-extracted, previously obtained birch bark that has been ground to particle size of 1–5 mm.

[007] Depolymerisation – decomposition of biopolymers contained in birch outer bark to monomers, dimers and oligomers.

[008] Suspension – a mixture of solid particles (ligno-carbohydrate complex of birch outer bark or alkali insoluble outer bark) and aqueous solution (alkali – suberinate or mineral acid salt and other alkali soluble components of birch outer bark).

[009] Ligno-carbohydrate complex – solid particles containing lignocellulose, which, essentially, consist of cellulose, lignin and suberin that have not been decomposed into monomers, dimers and oligomers during depolymerisation.

[010] Mixture suspension – a suspension of a mixture of suberinic acids and ligno-carbohydrate complex in water.

[011] Suberinic acid suspension – a suspension that has been obtained by filtering particles that are smaller than 0.5 – 2 mm or first binder from mixture suspension.

[012] Fine fraction – particles sized ≤ 0.5 to 2 mm.

[013] Coarse fraction – particles of more than 0.5 to 2 mm in size.

[014] Concentrated acid – 50 to 63 % in the case of HNO_3, 60 to 98 % in the case of H_2SO_4 and H_3PO_4, and 30 to 40 % in the case of HCl.

[015] First binder or plywood binder – particles filtered from suberinic acid suspension that are smaller than 0.5 – 2 mm, which contain suberinic acid binders and a fine fraction of a mixture of birch outer bark ligno-carbohydrate particles.

[016] Second binder or particle board binder – a mass separated from suberinic acid suspension, where the particle size is larger than 0.5 – 2 mm, which contains the mixture of the coarse fraction of suberinic acid binder and birch outer bark ligno-carbohydrate particles.

Description of the invention

[017] The objective of the invention is reached by developing binders that have been produced by the process that includes obtaining birch outer bark with the particle size of 1 to 5 mm. The size of particles is obtained by grinding birch outer bark in a mill through 4 to 6 mm sieve and sieving through a 1 mm sieve afterwards, thus separating the fine fraction. After the obtaining of the birch outer bark, the depolymerisation of the suberin biopolymer contained in the birch outer bark in 1 to 7 % potassium hydroxide or sodium hydroxide aqueous solution with the mass ratio of birch outer bark to hydroxide aqueous solution of 1:10 to 1:20 is performed, thus obtaining a birch outer

bark-alkali suspension containing suberinates and ligno-carbohydrate complex sediment with the pH of 11-14. The suspension is obtained by treating the birch outer bark for 30 to 180 minutes at the temperature of 80 to 100 °C, cooling it down to 20 to 30 °C, thus ensuring the minimum and maximum degree of depolymerisation of the suberin contained in the birch outer bark, which ensures the required adhesive properties with wood during hot pressing. Then the suspension of the obtained suberinic acid salts is acidified – by mixing at 300 to 1,000 rpm to ensure that the particles are afloat and adding a concentrated acid, selecting one of the following - HNO_3, H_2SO_4, HCl or H_3PO_4, until the pH of the suspension environment reaches 4–1 and suberinic acid mass is sedimented in the solution, by creating a suspension. The use of concentrated acid, in contrast to the use of diluted acid, serves to save water resources. The characterized feature of the process is a step of acidification before the step of filtering. The following unusual sequence of steps allows to obtain binders with better adhesion to wood. Binders obtained with the following process allows to create a plywood panel with increased shear strength. Binders obtained by the process disclosed in A.Paze et.al. "Study of an Appropriate Suberinic Acids Binder for Manufacturing of Plywood" could not reach the 3rd class (for the materials used in unprotected exterior conditions over sustained periods) of moisture resistance (European Standards EN 314-1 Plywood – Bond quality – Test methods and EN 314-2 Plywood – Bond quality – Requirements) which was possible with the binders obtained by the process of the present invention. Moreover, the shear strength of the plywood panel using the binder obtained by the process of the present inventions was in the range of 1.2 to 1.4 N/mm^2 instead of 0.9 N/mm^2 using the binder obtained according to the publication of A.Paze et.al. "Study of an Appropriate Suberinic Acids Binder for Manufacturing of Plywood". It is well known that ligno-carbohydrate complex particles swell in alkaline suspensions making a gel-like substance, which clogs the filtering pores, resulting in technological problems during the filtration process. Acidification step before filtration increase the suspension filtration ability several times. As the present invention method for obtaining binders differ from the obtaining of suberinic acids and resulting binders as disclosed in aforementioned publications, different end products with different chemical compositions are obtained. In the present invention method, a significant amount of alkali-insoluble ligno-carbohydrate complex particles <1 mm are present in total weight of the binder, but the binders disclosed in aforementioned publications do not contain such particles. Thus, the binders obtained by the present invention method

have different chemical properties, which positively influence the properties of panels after hot pressing. The best mechanical and moisture resistance properties of the panels were with the present invention method, because obtained alkali-insoluble ligno-carbohydrate complex in the binder acts as an interphase modifier, which significantly improves the adhesion to wood. Also, by acidifying the alkali suspension together with the ligno-carbohydrate complex, additional phenolic and possibly other compounds are added to the total mass, which improve the adhesion of the binder to a wood.

[018] Then the acidified suspension is filtered through a 10 to 50 micron acid resistant fabric filter, thus separating the mixture of suberinic acids and ligno-carbohydrate complex from the acid water and salt solution/suspension, which is immediately suspended in water with the mass ratio of 1:1 to 1:4, while intensively mixing and obtaining the suspension of the mixture with the pH of 3 to 5. The separated filtrate is collected and may be used as a mineral fertiliser. Since the filtering of the entire mass is performed and is efficient thanks to inhomogeneous mass, the use of energy consuming centrifugation operation for the separation of solid particles, which has been used in other patents, for instance, LV 15031, is not required. Rinsing in water is performed once – by suspending the suberinic acid and ligno-carbohydrate complex mixture – this enables easier separation of the coarsest particles. Mineral salts do not interfere with adhesion and cohesion processes, therefore it is not required to perform rinsing twice or three times, as recommended by other patents, for instance, LV 15031. As a result, economy of water resources is possible.

[019] The suspension of the obtained solution is filtered through chemically and mechanically resistant sieve of hard material with the cell size of 0.5 to 2 mm. The coarsest birch outer bark particles that are undesirable in the binding process of plywood, while being ideally suitable as a filler and binder for particle boards, since they still contain suberinic acids in the amount of 15 % of the total mass of dry matter, are separated. By performing this operation at this phase, when the mass is acidified and salt solution concentrate has already been separated with 10 to 50 micron filter and it has been suspended in water, the filtering with 0.5 to 2 mm sieve occurs faster and no additional rinsing operations are required, thus saving time, and, as mentioned above, water resources. As a result, suberinic acid suspension with pH 3 to 5 and the second binder are obtained. Afterwards the suspension of suberinic acids is filtered

through 10 to 50 micron acid resistant fabric filter, obtaining the first binder and salt containing rinsing water. The salt containing rinsing water is separated as the filtrate and it is collected and can be used as mineral fertiliser. The first binder contains suberinic acids, wherein content of its dry matter is 10 to 20 wt.%, the content of ash – 3 to 5 wt.%. The first binder can be used in the production of plywood.

[020] It was offered to obtain a three-layer plywood within the framework of the invention. A specially cut 200 × 200 mm large and 1.5 mm thick dried birch veneer sheets are used. The obtained suberinic acid binder is homogeneously applied with a roller in the determined amount (consumption of oven dry binder 70 - 120 g/m2) on one surface of two veneer sheets, leaving the third layer unprocessed. All three layers are dried at 70 to 120 °C in the drying cabinet with internal air circulation until the total moisture reaches from 1 to 15 % of the total mass. The dried layers are placed one onto another with perpendicular direction of wood fibres and the plywood is pressed at the temperature of 190 to 230 °C, the pressure of 1.0 - 3.0 MPa, the pressing time is selected in accordance with the thickness of the board, – 1 minute per 1 mm of the thickness of the board. The plywood is removed from press without cooling down after pressing. The pressed material is conditioned in the climate chamber at relative air moisture of 65 % and at the temperature of 20 °C until it reaches constant mass in order to determine its physical and mechanical properties in accordance with the requirements of the standard.

[021] Meanwhile, by rinsing coarser birch outer bark particles with the rinsing water again, the yield of the binder can be increased. The remaining solid particles do not contain sufficient amount of suberinic acids to be used as a binder in the production of particle boards, however, they possess excellent granulation properties, as well as high combustion heat values to use them as a fuel or a filler and/or a binder for the obtaining granular wood particle fuel of or wood particle briquettes.

[022] If the obtained coarser particles of the mixture suspension that have remained above the said sieve with the cell size of 0.5 to 2 mm are not additionally rinsed, it can be used as the second binder that contain suberinic acids and solid particles of birch outer bark. Wherein the content of dry matter in the second binder is 22 to 30 % of the

mass, its ash content - 3 to 5 % of the mass, so it can be used in the production of wood particle boards.

[023] The pressing mass for wood particle boards is prepared by using the 0.5 to 2.0 mm large fraction of birch wood particles with the moisture of 5 to 10 %. The composition of the pressing mass by weight: 55–65 % birch wood particles and 35–45 % of coarse fraction of the binder (per oven dry mass). The mixture of the pressing mass, which is a light brown, loosely flowing mass, is prepared in spiral plate mixer at the temperatures of 20 to 30 °C. The mass is dried at 70 °C to 120 °C in the drying cabinet with internal air circulation, by regularly mixing the mass until it reaches 0.5 to 5.0 % moisture. The dry pressing mass is pressed by pressing 300 × 300 × 10 - 12 mm boards at the temperature of 190 - 230 °C under the pressure of 1.0 - 4.0 MPa, by selecting the pressing time in accordance with the thickness of the board – 1 minute per 1 mm of the thickness of the board. The boards are removed from press without cooling down after pressing. The pressed material is conditioned in the climate chamber at relative air moisture of 65 % and at the temperature of 20 ºC until it reaches constant mass in order to determine its physical and mechanical properties in accordance with the requirements of the standard.

List of figures

[024] Figure 1 provides the schematic representation of the process.

Detailed description of examples of the implementation of the invention

[025] Prior to the detailed description of the versions of the present invention, we would like to point out that the invention is not limited by type of use and technical implementation, as indicated further in the description, since the invention can be implemented in other ways, without going beyond the scope of the protection of the invention. The terminology used is intended for the description and understanding of the invention, it dies not aim at limiting of the invention.

[026] The invention includes the performance of depolymerisation of the suberin biopolymer present in the birch outer bark, by pouring 313.5 grams (moisture 4.29 %)

of ground birch outer bark particles (fraction 1 to 3 mm) extracted by means of ethanol into a 4 litre glass reaction vessel, pouring over with 3 litres of 3 % aqueous solution of potassium hydroxide (density 1.024 kg/m3), closing it with a three-neck lid and starting to mix with the electric mixer with the speed of 800 rpm, while heating the reaction vessel in water bath. When the suspension temperature in the reactor reaches 90 °C, the time count is connected and the processing is continued for 1 hour. After the processing, the suspension that has been cooled down to 20 - 30 °C, is stirred at 800 rpm, while 160 grams of 60 % nitric acid are added in small portions (density 1.360 kg/m3), until the pH of the environment of the suspension reaches 2 and brown mass of suberinic acids is sedimented in the solution. Then the acidified suspension is filtered through a 25 micron fabric filter to separate the mixture of suberinic acids and ligno-carbohydrate complex from acid water and potassium nitrate salt solution. 1.770 grams of filtrate with the content of dry matter amounting to 5.69 % are separated, which essentially consist of potassium nitrate salts. The resulting paste consisting of the mixture of suberinic acids, ligno-carbohydrate complex and potassium nitrate aqueous solution (the yield of 1.650 grams), is suspended in 4 litres of water by mixing at 400 rpm. The obtained suspension is filtered through a 1 mm cell size metal sieve to separate coarser particles from the basic suberinic acid binder (the yield amounts to 35.1 % of the mass of oven dry raw material or 620 grams with 17.1 % of dry matter). The obtained binder water suspension is further filtered through a 25 micron fabric filter to separate the paste containing a mixture of suberinic acid binder suitable for plywood and fine birch outer bark ligno-carbohydrate particles (≤ 1 mm) from the potassium nitrate salt containing rinsing water. 3,714 grams of filtrate with the content of dry matter amounting to 1.11 % of the mass are separated, which essentially consist of potassium nitrate salts. The yield of plywood binder is 929.6 grams with 14.2 % of dry matter (ash content 4.4 % of the oven dry matter mass) or 43.8 % of oven dry raw material mass.

[027] The obtained suberinic acid binder fraction that was smaller or equal with 1 mm, was further used to produce plywood. For the production of three-layer plywood a specially cut 200 × 200 mm large and 1.5 mm thick dried birch veneer sheets were used. The joint suberinic acid binder with 19.6 % of dry matter, which was obtained during the previous experiment, was homogeneously applied with a roller in the determined amount (consumption of oven dry binder - 90 g/m2) on one surface of two veneer sheets, leaving the third layer unprocessed. All three layers were dried at 70 to 80 °C in the

drying cabinet with internal air circulation until the total moisture reached on average 10 % of the total mass. The dried layers were placed one above the other with veneer layer fibres perpendicular to each other and *Type LAP-40* press of laboratory, manufactured by the company *Gottfried Joos Maschinenfabrik GmbH und CO KG,* was used to press the plywood at the temperature of 215 ºC, under the pressure of 2.0 MPa, by selecting the time of pressing in accordance with the thickness of the board, – 1 minute per 1 mm of the board thickness (in this case - 4 min). The plywood was removed from press without cooling down after pressing. The pressed material was conditioned in the climate chamber at the air moisture of 65 % and temperature of 20 ºC until constant mass. The edges of the conditioned plywood boards were cut and samples were cut out in accordance with the requirements of international standard EN-310 and EN-314-1. The samples were tested in the testing machine by the company *„Zwick/Roell"*, which demonstrated that the average bending strength value of the samples was 155 N/mm2 (class F 80) and the average value of glued strength after 3 cycles of sample treatment (boiling in water for 4 hours, drying for 20 hours at the temperature of 60 °C and boiling in water for 4 hours) was 1.33 N/mm2, which conforms to 3rd moisture resistance class, which is the highest moisture resistance class for the materials used in unprotected exterior conditions over sustained periods.

[028] Meanwhile the separated fraction that remains above the 1 mm sieve was later used to produce wood particle boards. The pressing mass is prepared by using the 0.5 to 2.0 mm large fraction of birch wood particles with the moisture of 7.6 %. The composition of the pressing mass by weight: 60 % birch wood particles and 40 % of coarse fraction of the binder (per oven dry mass). 813.2 g of pressing mass mixture with the moisture content of 60.2 %, which is a light brown, loosely flowing mass, were prepared in spiral plate mixer at the temperature of 20 to 30 °C. The mass is dried at 70 °C to 80 °C in the drying cabinet with internal air circulation, by regularly mixing the mass until it reaches 0.5 to 1.0 % of moisture. The dry pressing mass is pressed by using the *Type LAP-40* press of laboratory, manufactured by the company *Gottfried Joos. Maschinenfabrik GmbH und CO KG,* by pressing 300×300×10–12 mm boards at the temperature of 225 °C and the pressure of 3.0 MPa, by selecting the pressing time in accordance with the thickness of the sheet – 1 minute per 1 mm of the thickness of the board. The boards were removed from press without cooling down after pressing. The pressed material was conditioned in the climate chamber at the air moisture of 65 %

and temperature of 20 °C until constant mass. The samples with the density of 833 kg/m3 were tested in the testing machine by the company *„Zwick/Roell"*, which demonstrated that the average bending resistance values were 16.3 N/mm2, thickness swelling after 24 hours of soaking in water – 14 % and strength of internal bonds 1.75 N/mm2, which falls within the P3 values of EN 312 standard for boards, which are intended for use in moist conditions.

[029] One of the options of the implementation of the invention must be implemented as follows: by performing the depolymerisation of the suberin biopolymer present in the birch outer bark, by pouring 628.7 grams (moisture 4.56 %) of ground birch outer bark particles (fraction 1 to 3 mm) extracted by means of ethanol into a 7 litre glass reaction vessel, pouring over with 6 litres of 3 % aqueous solution of potassium hydroxide (density 1.024 kg/m3), closing it with a three-neck lid and starting to mix with the electric mixer with the speed of 800 rpm, while heating the reaction vessel in water bath. When the suspension temperature in the reactor reaches 90 °C, the time count is connected and the processing is continued for 1 hour. After the processing, the suspension that has been cooled down to 20 - 30 °C, is stirred at 800 rpm, while 329 grams of 61 % nitric acid are added in small portions (density 1.370 kg/m3), until the pH of the environment of the suspension reaches 2 and brown mass of suberinic acids is sedimented in the solution. Then the acidified suspension is filtered through a 25 micron fabric filter to separate the mixture of suberinic acids and ligno-carbohydrate complex from acid water and potassium nitrate salt solution. 3,440 grams of filtrate with the content of dry matter amounting to 6.44 % of the mass are separated, which essentially consist of potassium nitrate salts. The resulting paste consisting of the mixture of suberinic acids, ligno-carbohydrate complex and potassium nitrate aqueous solution (yield of 3,450 grams), is suspended in 4 litres of water by mixing at 400 rpm. The obtained suspension is filtered through a 1 mm cell size metal sieve to separate coarser particles of birch outer bark from the basic suberinic acid binder, which still contain suberinic acids amounting to approximately 15 % of the mass of total dry matter. The obtained binder water suspension is further filtered through a 25 micron fabric filter to separate the paste containing a mixture of suberinic acid binder suitable for plywood and fine birch outer bark ligno-carbohydrate particles (≤ 1.0 mm) from the potassium nitrate salt containing rinsing water. 3,780 grams of filtrate with the content of dry matter amounting to 2.47 % of the mass are separated, which essentially consist

of potassium nitrate salts. The yield of plywood binder is 1,431 grams with 19.2 % of dry matter or 45.8 % of absolute dry raw material mass.

[030] To obtain higher yield of plywood binder, the separated coarser particles of birch outer bark are placed in the bucket, the last rinsing water filtrate is poured over them and suspended, while stirring at 400 rpm. Then the obtained suspension is filtered through 1 mm cell size metal sieve as earlier and the binder and water suspension is filtered through a 25 micron fabric filter to separate the additional amount of suberinic acid binder suitable for the binding of plywood. As a result, 407 grams of plywood binder were obtained, containing 18.9 % of dry matter or 12.8 % of oven dry raw material mass, which, together with the binder obtained during the first time, amounts to 58.6 % of the mass of the oven dry raw material (the content of dry matter in the collected binder after first and second filtering amounted to 19.6 % and its ash content to 4.1 % of the dry matter mass). 3,389 grams of filtrate with 2.28 % of dry matter and 917 grams of moist ligno-carbohydrate complex with 25% % of dry mass or 38.3 % of oven dry raw material mass are obtained as by products, which can be used either as fuel or fuel additive/binder due to their excellent granulation properties.

[031] The obtained suberinic acid binder fraction that was smaller or equal with 1 mm, was further on used to produce plywood. For the production of three-layer plywood a specially cut 200 × 200 mm large and 1.5 mm thick dried birch veneer sheets were used. The joint suberinic acid binder with 19.6 % of dry matter, which was obtained during the previous experiment, was homogeneously applied with a roller in the determined amount (consumption of oven dry binder - 90 g/m2) on one surface of two veneer sheets, leaving the third layer unprocessed. All three layers were dried at 70 to 80 °C in the drying cabinet with internal air circulation until the total moisture reached on average 10 % of the total mass. The dried layers were placed one above the other with veneer layer fibres perpendicular to each other and *Type LAP-40* press of laboratory, manufactured by the company *Gottfried Joos Maschinenfabrik GmbH und CO KG,* was used to press the plywood at the temperature of 215 °C, under the pressure of 2.0 MPa, by selecting the time of pressing in accordance with the thickness of the board, – 1 minute per 1 mm of the board thickness (in this case - 4 min). The plywood was removed from press without cooling down after pressing. The pressed material was conditioned in the climate chamber at the air moisture of 65 % and temperature of 20

°C until constant mass. The edges of the conditioned plywood boards were cut and samples were cut out in accordance with the requirements of international standard EN-310 and EN-314-1. The samples were tested in the testing machine by the company *„Zwick/Roell"*, which demonstrated that the average bending strength value of the samples was 155 N/mm2 (class F 80) and the average value of shear strength after 3 cycles of sample treatment (boiling in water for 4 hours, drying for 20 hours at the temperature of 60 °C and boiling in water for 4 hours) was 1.33 N/mm2, which conforms to 3rd moisture resistance class, which is the highest moisture resistance class for the materials used in unprotected exterior conditions over sustained periods.

[032] The invention is described with references to various specific and illustrative implementation versions and methods. However, the specialist in the area will recognise that multiple and diverse variations and modifications are possible without going beyond the scope of the protection of the invention, which has been indicated in the claims.

CLAIMS

1. The process for obtaining thermoreactive binders that includes the following steps:

a1) providing a birch outer bark,

a) depolymerisation of a suberin biopolymer of said birch bark in 1 to 7 % potassium hydroxide or sodium hydroxide aqueous solution, wherein a weight ratio of birch outer bark to the hydroxide aqueous solution is 1:10 to 1:20, obtaining a birch outer bark-alkali suspension containing suberinates and ligno-carbohydrate complex with pH of 11–14, wherein the suspension is treated for 30 to 180 minutes at the temperature of 80 to 100 °C,

b1) cooling the suspension obtained and treated in step (a) to the temperature of 20–30 °C and b2) acidification thereof by adding concentrated acid, selected from HNO_3, H_2SO_4, HCl, H_3PO_4, while stirring until the environment pH of the suspension reaches 4–1 and a mass of suberinic acids and ligno-carbohydrate complex is sedimented in the suspension,

c) filtering the suspension obtained in the step (b1 and b2) through a 10 to 50 micron acid resistant fabric filter, separating a mixture of suberinic acids and ligno-carbohydrate complex from the suspension,

d) suspending the mixture of suberinic acids and ligno-carbohydrate complex in water at weight ratio of 1:1 to 1:4, obtaining a mixture suspension of pH 3 to 5 by stirring,

e) filtering the mixture suspension of step (d) through a chemically and mechanically durable solid material sieve with the cell size of 0.5 to 2 mm, obtaining a suberinic acid suspension of pH 3 to 5 and a second binder, wherein the second binder contains the suberinic acids and a coarse fraction of the ligno-carbohydrate complex with particle size larger than 0.5–2 mm, wherein a dry matter content of the second binder is 22 to 30 wt.%, ash content – 3 to 5 wt.%,

f) filtering the suberinic acid suspension of step (e) through a 10 to 50 micron acid resistant fabric filter, obtaining a rinsing water and a first binder, wherein the first binder contains the suberinic acids and a fine fraction of the ligno-

carbohydrate complex with particle size smaller than 0.5–2 mm, wherein a dry matter content of the first binder is 10 to 20 wt.%, ash content – 3 to 5 wt.%.

2. The process according to Claim 1, wherein it optionally prior to step (a) further comprises an extraction of birch outer bark.

3. The process according to Claim 1, wherein the size of the birch outer bark particles is 1 to 5 mm.

4. The process according to Claim 1, characterised in that mixing is performed at 20 to 1,000 rpm, preferably at 300 to 1,000 rpm.

5. The first binder obtainable by the method of any one of claims 1 to 4.

6. Use of the first binder according to Claim 5 in the production of plywood panel.

7. The second binder obtainable by the method of any one of claims 1 to 4

8. Use of the second binder according to Claim 7 in the production of wood particle boards.

9. Use of the rinsing water according to Claim 1 as a mineral fertiliser.

10. Use of the residue of solid particles according to Claim 1 for use as a fuel or filler and/or binder for fuel wood pellets or briquettes.

11. A plywood panel comprising at least two veneer layers and the first binder obtained by the process according to Claim 1, wherein a shear strength of the plywood panel is in the range of 1.2 to 1.4 N/mm2, preferably about 1.3 N/mm2.

12. A wood particle board comprising wood particles and the second binder obtained by the process according to Claim 1.

13. A method for production of the plywood panel according to Claim 11, wherein the method comprises the following steps:

a) providing three dried birch veneer sheets of size 200×200 mm and thickness of 1.5 mm,

b) homogeneous application of the first binder of Claim 5 or 6 in the amount of 70 to 120 g/m2 on one side of two veneer sheets, leaving the third sheet untreated,

c) drying all three layers at the temperature of 70 to 120 ºC in a drying cabinet with internal air circulation until the total moisture reaches 1 to 15 wt.% of the total weight.

d) placing the dried layers one above another with fibre direction of each layer perpendicular to the previous layer,

e) pressing the plywood at the temperature of 190 to 230 ºC and pressure of 1.0 to 3.0 MPa.

14. A method for production of the wood particle board according to Claim12, wherein the method comprises the following steps:

a1) providing birch wood particles sized 0.5 to 2.0 mm and having moisture content of 5 to 10 %,

a) obtaining particle board pressing mass that consists of the said fraction of birch wood particles and the binder of Claim 7 or 8 in a spiral plate mixer at the temperature of 20 to 30 °C,

b) drying the mass at temperature of 70 to 120 °C in a drying cabinet with internal air circulation, by regularly mixing the mass until it reaches 0.5 to 5.0 % of moisture,

c) pressing the mass of step (b), by pressing the 300×300×10–12 mm sheets at temperature of 190 to 230 ºC and pressure of 1.0 to 4.0 MPa,

15. The method according to Claim 14, wherein said pressing mass contains 55 to 65% of birch wood particles and 35 to 45% of the coarse fraction of the binder, calculating per oven dry mass.

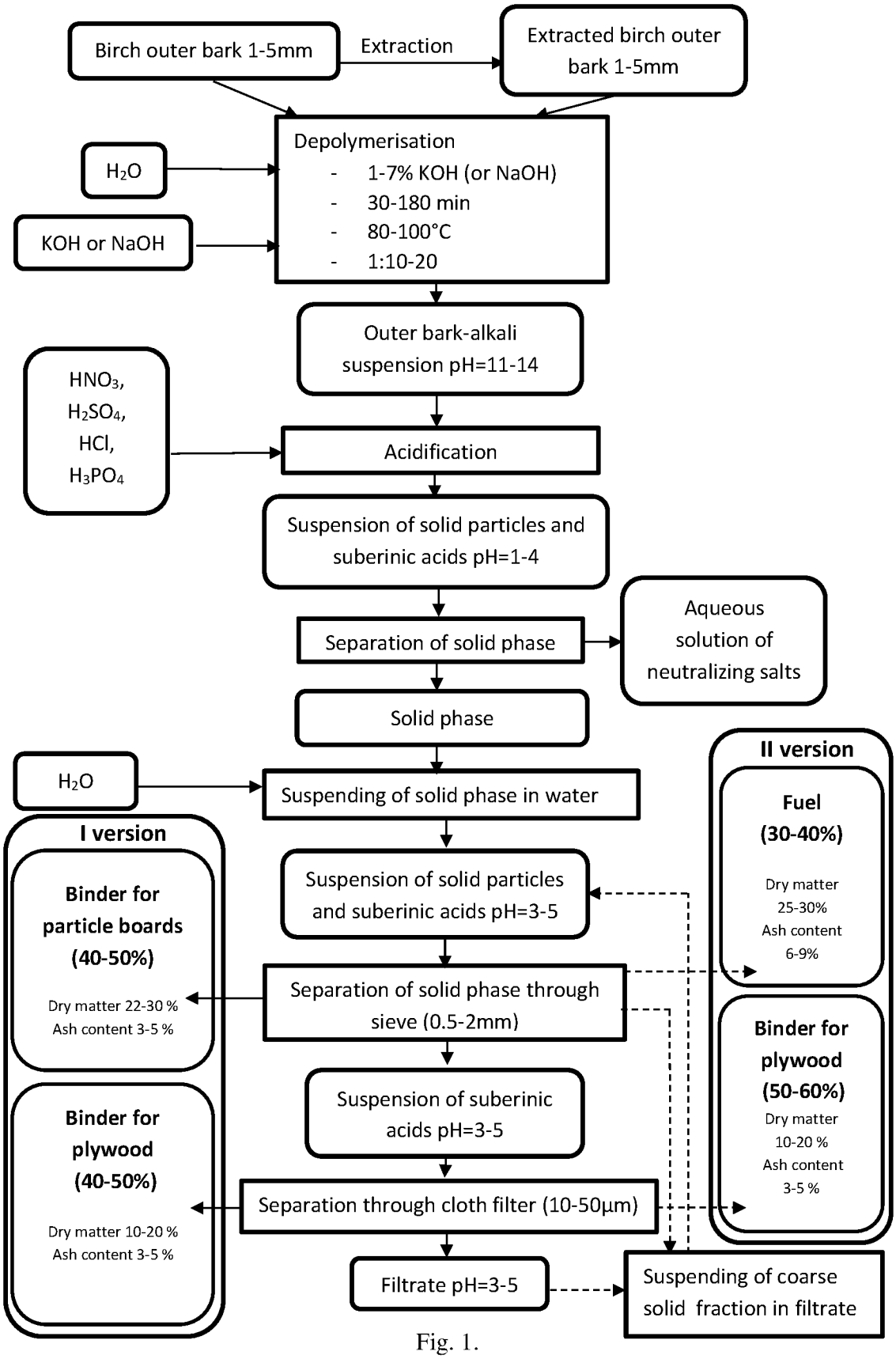
Birch outer bark 1-5mm
Extraction
Extracted birch outer bark 1-5mm
Depolymerisation
- 1-7% KOH (or NaOH)
- 30-180 min
- 80-100°C
- 1:10-20
H2O
KOH or NaOH
Outer bark-alkali suspension pH=11-14
HNO3, H2SO4, HCl, H3PO4
Acidification
Suspension of solid particles and suberinic acids pH=1-4
Separation of solid phase
Aqueous solution of neutralizing salts
Solid phase
H2O
Suspending of solid phase in water
I version
Binder for particle boards (40-50%)
Dry matter 22-30 %
Ash content 3-5 %
Binder for plywood (40-50%)
Dry matter 10-20 %
Ash content 3-5 %
Suspension of solid particles and suberinic acids pH=3-5
Separation of solid phase through sieve (0.5-2mm)
Suspension of suberinic acids pH=3-5
Separation through cloth filter (10-50µm)
Filtrate pH=3-5
II version
Fuel (30-40%)
Dry matter 25-30%
Ash content 6-9%
Binder for plywood (50-60%)
Dry matter 10-20 %
Ash content 3-5 %
Suspending of coarse solid fraction in filtrate

Fig. 1.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/057311

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08H8/00 C08H99/00 C08L97/02 C08L99/00 C09J199/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B27N B32B C08H C08L C09J

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Jânis Ri ikovs ET AL: "Isolation of Suberinic Acids from Extracted Outer Birch Bark Depending on the Application Purposes", Baltic Forestry, 1 January 2014 (2014-01-01), pages 98-105, XP055697979, Retrieved from the Internet: URL:https://www.balticforestry.mi.lt/bf/PDF_Articles/2014-201!/Isolation%20of%20Suberinic%20Acids%20from%20extracted%20Outer%20Birch.pdf	5,9,10
Y	abstract Materials and Methods Feedstock Depolymerisation in alkaline-water solution; page 100 Particle board's preparation and -/--	1-4,6-8, 12

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 2020	09/11/2020

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	"Results", four first lines; page 101 Right column, second paragraph; page 102 page 103; figure 4 From page 103, table 4 to page 104, line 4 "Conclusions", points 2 and 4; page 104 -----	
X	AIGARS PAZE ET AL: "Study of an Appropriate Suberinic Acids Binder for Manufacturing of Plywood", KEY ENGINEERING MATERIALS, vol. 800, 1 April 2019 (2019-04-01), pages 251-255, XP055699037, DOI: 10.4028/www.scientific.net/KEM.800.251	1-15
Y	abstract Materials and Methods Preparation of Feedstock Obtaining of SA; page 252 - page 253 Results and Discussion; page 253 -----	1-4,6-8, 12