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(54) PROCESS FOR PRODUCING PULP.

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ABSTRACT BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, vol. 53, no. 11, May 1983, APPLETON US page 1238 GOLOVLEVA, L.A. et al. "Lingnin decomposition by fungal cultures"

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Description

Field of the Invention

This invention relates to methods for producing pulp, comprising microbial treatment, in either or both of pulping process and bleaching process, using a microorganism which grows well in a culture medium containing lignin as a single carbon source.

The present invention relates to methods for producing pulp, comprising microbial treatment substantially without adding nutrients and without adding inhibitors of cellulose degradation at any one stage of the process of producing pulp.

The present invention enables to produce pulp in good quality, by microbial treatment using a microorganism which grows well in a culture medium containing lignin as a single carbon source at a process for producing pulp, thereby suppressing cellulose degradation to the minimum.

The present invention enables pulping or bleaching, substantially without adding nutrients and without adding inhibitors of cellulose degradation, for example glucose, at a process of producing pulp, by using a microorganism with excellent lignin-degrading activity and a high selectivity, whereby the present invention can provide economical and industrial methods for producing pulp in remarkably energy-saving manner.

Prior Art and Problems

Since considerably early days, a great number of research efforts have been carried out on pulping or bleaching for the process of producing paper and pulp by using microorganisms.

The JP-A 46903/1975 proposes a method for producing cellulose pulp, comprising degradation of lignin under the condition to substantially degrade lignin, by using a microorganism having a production potential of a lignin-degrading enzyme.

However, the method has never been put to industrial use, because the degree of lignin degradation is so low due to the extremely low lignin-degrading activity of the microorganism used, and because the addition of sugars and nitrogen compounds is required added due to the suppression of cellulose assimilation by the microorganism.

The bleaching of pulp with Phanerochaete chrysosporium has been also reported (Biotechnol Lett., 1, 347-353(1979)), but it has neither been practiced industrially because of the low lignin-degrading activity and the use of the large amount of an inhibitor of cellulose degradation.

Means to Solve the Problems

The present inventors have investigated intensively in order to develop a method for pulping or bleaching with microbial treatment, without causing cellulose degradation and adding a nutrient and inhibitor of cellulose degradation. Consequently, they have achieved the object in accordance with the present invention.

That is, in accordance with the present invention, it is the use of a microorganism which grows well in a culture medium containing lignin as a single carbon source that realizes pulping and bleaching of wood chips, pulp after refining and unbleached pulp, substantially without adding nutrients and without adding inhibitors of cellulose degradation, in the economical and tremendously energy-saving manner.

Brief Description of the Drawings

Fig. 1 shows the increase in brightness (%) after the microbial treatment for 1 to 5 days in Example 5.

The microorganism to be used in the present invention is from a microbial strain, well grown by inoculation and culture in a culture medium containing lignin as a single carbon source.

As the culture medium, there may be prepared an agar medium to which is added as a single carbon source, about 1 to 10% of lignin, preferably 2 to 4% of lignin.

An isolating source collected from a natural source is dispersed at an appropriate concentration in the culture medium, and cultured at 25 to 35 °C, to collect a colony exhibiting a good growth, which is to be an effective microorganism to be used in the present invention.

The present inventors have previously isolated the strains NK-1148 (FERM BP-1859) and NK-729W (FERM BP-1860), which are among the microorganisms very effective for the present invention. EP-A-0 295 063 discloses that these strains are excellent in lignin-degrading activity and high degrading selectivity.

The mycological characteristics of NK-1148 strain (FERM BP-1859) are shown as follows.

(1) State of Growth in Culture Media

Type of Medium	State of Growth
Malt extract agar medium	+ + +
Potato-glucose agar medium	+ + +
Czapek's agar medium	+
Sabouraud's agar medium	+ +
Synthesized mucor agar medium	+ +
YpSs agar medium	+ + +
Glucose-dried yeast agar medium	+ + +

Note-1 pH of the medium: 5.0 (before sterilization in autoclave)
Note-2 Culture conditions: 28 °C x 7 days
Note-3 State of growth
weak : +
medium : + +
abundant : + + +

(2) Physiological and Morphological Properties

① pH range for the growth (Cultivation in a potato-glucose agar medium at 28 °C for 4 days) Grows at pH near 3 - 9, but never grows at pH 2 or pH 10. The optimum pH is near 4 to 6.
② Temperature range for the growth (Cultivation in a potato-glucose agar medium at pH 5 for 4 days) Grows at temperatures near 10 - 45 °C, but never grows at 50 °C. The optimum temperature range is near 28 - 37 °C.
③ Phenol oxidase reaction (Cultivation at 28 °C for 4 days)
Shows weak or negative response.
④ Morphology of colony (Cultivation in a potato-glucose agar medium at pH 5 at 28 °C for 4 days) White and felt-like.
The mycological characteristics of NK-729W strain (FERM BP-1860) are shown as follows.

(1) State of Growth in Culture Media

Type of Medium	State of Growth
Malt extract agar medium	+ + +
Potato-glucose agar medium	+ + +
Czapek's agar medium	+
Sabouraud's agar medium	+ +
Synthesized mucor agar medium	+ +
YpSs agar medium	+ + +
Glucose-dried yeast agar medium	+ + +

Note-1 pH of the medium: 5.0 (before sterilization in autoclave)
Note-2 Culture conditions: 28 °C x 7 days
Note-3 State of growth
weak : +
medium : + +
abundant : + + +

(2) Physiological and Morphological properties

① pH range for the growth (Cultivation in a potato-glucose agar medium at 28 °C for 4 days) Grows at pH near 3 - 7, but never grows at pH 2 or pH 8. The optimum pH is near 4 to 5.

② Temperature range for the growth (Cultivation in a potato-glucose agar medium at pH 5 for 4 days) Grows at temperatures near 10 - 32 °C, but never grows at 37 °C. The optimum temperature range is near 20 - 30 °C.

③ Phenol oxidase reaction (Cultivation at 28 °C for 4 days)
Shows positive response.

④ Morphology of colony (Cultivation in a potato-glucose agar medium at pH 5 at 28 °C for 4 days)
White and hairy.

⑤ Morphology of fruit body

Size :	2 - 5 mm diameter
Shape :	Inverted cup shape (nose shape)
Edge or surface :	Edge turned inwardly, surface color of yellow black, having brown fleece or hair over the entire surface
Surface of tubular pore :	Pale white gray, recessed in an upturned dish shape, with small pore
Texture :	Soft leather-like texture, substantially white

⑥ Spore shape
About 3 - 4 x 1μm, sausage-like shape, colorless and smooth.

The microorganism to be used in the present invention may be NK-1148 strain or NK-729W strain isolated by the present inventors, and there may be used a selectively isolated strain growing well using lignin as a single carbon source, obtained with or without mutation of these two strains, or a strain growing well using lignin as a single carbon source and having been isolated from nature.

In accordance with the present invention, the microorganism growing well using lignin as a single carbon source, represents, for example, a microorganism capable of bleaching an unbleached kraft pulp up to a brightness of 45 % or more, preferably 50 % or more, more preferably 60 % or more, with no reduction in the strength of the pulp.

The microorganism to be used in the present invention can be cultured in any one of a culture medium containing lignin as a single carbon source, a general culture medium for basidiomycetes and fungi without containing lignin, and a culture medium containing wood powder, wood chips and pulp.

The type of pulp is generally classified in the following three.

① Mechanical pulp fiberized by mechanical treatment of wood.

② Semichemical pulp obtained by chemical and mechanical treatments in combination.

③ Chemical pulp with most of lignin removed through chemical treatment.

The present invention is to produce individual pulp corresponding mechanical pulp (the degree of lignin degradation below 35 %), semichemical pulp (the degree of lignin degradation of not less than 35% to less than 75 %), and chemical pulp (the degree of lignin degradation of riot less than 75%), by replacing a part or the entire part of the chemical treatment or mechanical treatment in the processes of producing pulp i.e., ① to ③ , with the microbial treatment of the present invention.

That is, the following processes are fundamentally included in the present invention.

A: Wood chips are directly treated with the microorganism of the present invention, to degrade the lignin component in the wood chips to produce unbleached pulp.

B: Pulp from the wood chips refined at a light degree is treated with the microorganism of the present invention, to degrade the lignin component in the pulp to produce unbleached pulp.

C: The wood chips after chemical treatment at a light degree are treated with the microorganism of the present invention, to degrade the lignin component in the pulp described above to produce unbleached pulp.

D: The pulp obtained by lightly refining wood chips is chemically treated lightly, and then are treated with the microorganism of the present invention, to degrade the lignin component in the pulp to produce unbleached pulp.

E: The pulp obtained by chemically treating wood chips lightly and refining the wood chips lightly is treated with the microorganism of the present invention, to degrade the lignin component in the pulp to produce unbleached pulp.

F: The unbleached pulp obtained in any one of A to E is further treated by a light chemical treatment and/or light refining to produce unbleached pulp.

In the microbial treatment in the processes A to F, there may be used the microorganism growing well in the culture medium containing lignin as a single carbon source. The microorganism can selectively

degrade the lignin component in wood and uses the wood lignin as a nutrient. It is therefore possible to carry out the aforementioned microbial treatment without adding an inhibitor of cellulose degradation.

The degree of the chemical treatment to a light degree and the refining treatment to a light degree in the processes A to F is appropriately determined by a predetermined lignin content, depending on the type of the unbleached pulp including mechanical pulp, semichemical pulp and chemical pulp, or in any type of the pulp.

The microorganism to be used in the present invention has a far greater lignin-degrading activity than the lignin-degrading microorganisms conventionally known. Hence, the present invention enables the substitution of all stages of the chemical treatment and the refining in the conventional processes of producing mechanical pulp, semichemical pulp and chemical pulp, with the microbial treatment, along with the marked decrease in the degree of the chemical treatment and the refining. In other words, the process of producing pulp in accordance with the present invention can decrease the amount of chemicals, and is appropriate for production of high-quality pulp in energy-saving manner.

As the fundamental processes in the process of producing pulp according to the present invention, there have been described herein A to F. But they are just representative, so it is possible to appropriately combine the microbial treatment with the microorganism of the present invention, with other treatments.

Intensely colored lignin generally remains in unbleached chemical pulp and unbleached semichemical pulp. In case of using these unbleached pulp for papers for the use requiring a higher brightness, therefore, the pulp is transferred to the bleaching process to remove the remaining lignin, to increase the brightness.

In such case, in accordance with the present invention, unbleached pulp is treated with the microorganism growing well in a culture medium containing lignin as a single carbon source, to degrade and remove the remaining lignin in the unbleached pulp, for the bleaching of the unbleached pulp.

The unbleached pulp may be any one of the unbleached chemical pulp and unbleached semichemical pulp by conventional methods, and the unbleached pulp corresponding to chemical pulp and those corresponding to semichemical pulp, produced with the microbial treatment of the present invention. The bleaching of the present invention may be applied to the unbleached mechanical pulp by the conventional methods, and the unbleached pulp corresponding to mechanical pulp produced through the microbial treatment of the present invention. However, since a great amount of chlorine-based bleaching agents is used for bleaching of unbleached chemical and semichemical pulp, the present bleaching is effectively applied to the unbleached pulp corresponding to unbleached chemical and semichemical pulp, from the standpoint of pollution control.

In accordance with the present invention, the bleaching process may be carried out entirely as the bleaching with the use of the microorganism, but a combination of the present bleaching with other bleaching methods may be also possible. The bleaching of the present invention can achieve a high standard of safety due to its microbial treatment.

Pulping and/or bleaching can be carried out through by adding the cultured microorganism to about 1/10000 to 10/100 of wood chips or pulp, and culturing the mixture at about 20 to 35 °C for 3 to 90 days, without adding any nutrient or inhibitor of cellulose degradation to wood chips or various pulp.

Example 1

The culture medium containing 1.0 g of beech wood powder 0.250mm-0.177mm (60 - 80 mesh) and 2.5 mℓ of water, placed in a 50 mℓ flask, is heated and sterilized at 120 °C for 15 minutes, into which is inoculated NK-1148 strain (FERM BP-1859) and cultured at 28 °C for a week. The resulting mycelia are suspended in water.

Alternatively, the culture medium containing 2.0 % of milled wood lignin from white birch, 0.2 % of $NH_4H_2PO_4$ and 1.6 % of agar is heated and sterilized at 120 °C for 15 minutes, which is then aseptically divided by 20 mℓ each into petri dishes (90 mℓ in diameter).

The mycelia in suspension were added to the culture medium and cultured at 28 °C for two weeks, to isolate a strain exhibiting good growth, which was defined an isolated strain A. The isolated strain A was designated as NK-1148-3 strain and has been deposited in Fermentation Research Institure, Agency of Industrial Science and Technology, under the accession number of FERM BP-3220.

Example 2

The isolated strain NK-1148-3 obtained in Example 1 was inoculated into the culture medium containing 1.2 % of potato-dextrose broth commercially available (DIFCO Co., Ltd.) after sterilization at 120 °C for 15 minutes, and cultured at 28 °C for a week, which was used as a seed culture.

Example 3

In the process of producing mechanical pulp, 10 kg of pulp obtained through a first refining of beech wood chips at a light degree was mixed with 24.5 ℓ of water, and sterilized at 120 °C for 15 minutes, to which was added 0.5 kg of the seed culture obtained in Example 2 and cultured under aeration at 28 °C for a week. Subsequently after a second refining, a mechanical pulp with a high strength could be obtained in an extremely energy-saving manner. The properties of the obtained biomechanical pulp are shown in the following Table 1.

Table 1

Properties of biomechanical pulp				
	Refining energy (KWH/pulp (t))	Quality of bleached pulp		
		kPa•m^2/g Burst index	N•m/g Tensile index	mN•m^2/g Tear index
Mechanical pulp	2000	0.52	9.6	1.21
Biomechanical pulp	710	1.15	20.3	2.53

Example 4

NK-1148 strain and the isolated strain NK-1148-3, obtained in Example 1, were separately inoculated into each culture medium mixed with 10 kg of an unbleached pulp (eucalyptus) and 25 ℓ of water, which medium had been treated and sterilized in advance at 120 °C for 15 minutes, and
cultured under aeration at 28 °C for two weeks. The resulting cultures were individually used as a seed culture.

Example 5

For bleaching of chemical pulp, 10 kg of a unbleached kraft pulp (eucalyptus) was mixed with 25 ℓ of water and sterilized at 120 °C for 15 minutes, to which were separately added 1 kg of each of the seed cultures obtained in Example 4, together with 0.5 kg of glucose, and mixed for culture under, and cultured under aeration at 28 °C for 1 to 5 days, leading to the production of a bleached kraft pulp. The enhancement of the brightness during the microbial treatment period for 1 to 5 days is shown in Fig. 1. Reference on the microorganisms under deposition, according to the Regulation, Provision 13.2.

1. NK-1148

a Name and address of the depository institute in which the microorganism has been deposited
Name: FERMENTATION RESEARCH INSTITUTE, AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY, MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY
Address: 1-3, Higashi 1 chome, Tsukuba-shi, Ibaraki-ken 305, Japan
b Date of deposition to the depository institute May 23, 1987
c Accession number assigned by the depository institute
FERM BP-1859

2. Porodisculus pendulus NK-729W

a Name and address of the depository institute in which the microorganism has been deposited
Name: FERMENTATION RESEARCH INSTITUTE, AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY, MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY
Address: 1-3, Higashi 1 chome, Tsukuba-shi, Ibaraki-ken 305, Japan
b Date of deposition to the depository institute May 23, 1987
c Accession number assigned by the depository institute
FERM BP-1860

3. NK-1148-3

a Name and address of the depository institute in which the microorganism has been deposited
Name: FERMENTATION RESEARCH INSTITUTE, AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY, MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY
Address: 1-3, Higashi 1 chome, Tsukuba-shi, Ibaraki-ken 305, Japan
b Date of deposition to the depository Institute January 10, 1990
c Accession number assigned by the depository institute
FERM BP-3220

Claims

1. A method for producing pulp from wood by using a microorganism, comprising microbial treatment, in either a pulping process or a bleaching process following a pulping process or both, using a microorganism which grows well in a culture medium containing lignin as a single carbon source, characterised in that an inhibitor of cellulose degradation is not added and a nutrient is either not added or only added in small amounts.

2. A method according to claim 1, for producing unbleached pulp, comprising degrading at least partially lignin present in wood chips by using the microorganism.

3. A method according to claim 1, for producing unbleached pulp, comprising refining wood chips to a light degree to produce pulp and degrading at least partially the lignin present in the obtained pulp by using the microorganism.

4. A method according to claim 1, for producing unbleached pulp, comprising treating wood chips with a chemical to a light degree and degrading at least partially the lignin present in the resulting wood chips by using the microorganism.

5. A method according to claim 1, for producing unbleached pulp, comprising refining wood chips to a light degree to produce pulp, treating the obtained pulp with a chemical to a light degree, and degrading at least partially the lignin present in the resulting pulp by using the microorganism.

6. A method according to claim 1, for producing unbleached pulp, comprising treating wood chips with a chemical to a light degree, refining the resulting wood chips to produce pulp, and degrading at least partially the lignin present in the obtained pulp by using the microorganism.

7. A method according to any of claims 2 to 6, wherein the unbleached pulp is further treated with a chemical and/or refined after the microbial treatment.

8. A method according to claim 1, for producing bleached pulp, comprising carrying out at least a part of bleaching treatment of unbleached pulp in a bleaching process, using the microorganism.

9. A method according to any of claims 1 to 8, in which the microorganism is NK-1148 or NK-729W or a mutant thereof.

Patentansprüche

1. Ein Verfahren zur Herstellung von Zellstoff aus Holz durch Verwendung eines Mikroorganismus, das sich auf mikrobielle Behandlung in einem Zellstoffgewinnungsprozeß oder einem auf einen Zellstoffgewinnungsprozeß folgenden Bleichprozeß oder beiden erstreckt, wobei ein Mikroorganismus zur Verwendung gelangt, der in einem als einzige Kohlenstoffquelle Lignin enthaltenden Kulturmedium gut gedeiht, dadurch gekennzeichnet, daß kein Celluloseabbauhemmstoff zugesetzt wird und entweder kein Nährstoff oder nur kleine Mengen von Nährstoff zugesetzt werden.

2. Ein Verfahren nach Anspruch 1 zur Herstellung von ungebleichtem Zellstoff, das sich auf mindestens teilweisen Abbau des in Holzspänen vorhandenen Lignins durch Verwendung des Mikroorganismus erstreckt.

3. Ein Verfahren nach Anspruch 1 zur Herstellung von ungebleichtem Zellstoff, das sich auf die Veredelung in geringem Maße von Holzspänen zwecks Erzeugung von Zellstoff und auf mindestens teilweisen Abbau des in dem gewonnenen Zellstoff vorhandenen Lignins durch Verwendung des Mikroorganismus erstreckt.

4. Ein Verfahren nach Anspruch 1 zur Herstellung von ungebleichtem Zellstoff, das sich auf die Behandlung in geringem Maße von Holzspänen mit einer chemischen Verbindung und mindestens teilweisen Abbau des in den anfallenden Holzspänen vorhandenen Lignins durch Verwendung des Mikroorganismus erstreckt.

5. Ein Verfahren nach Anspruch 1 zur Herstellung von ungebleichtem Zellstoff, das sich auf die Veredelung in geringem Maße von Holzspänen zwecks Herstellung von Zellstoff, Behandlung in geringem Maße des gewonnenen Zellstoffs mit einer chemischen Verbindung und mindestens teilweisen Abbau des in dem anfallenden Zellstoff vorhandenen Lignins durch Verwendung des Mikroorganismus erstreckt.

6. Ein Verfahren nach Anspruch 1 zur Herstellung von ungebleichtem Zellstoff, das sich auf die Behandlung in geringem Maße von Holzspänen mit einer chemischen Verbindung, Veredelung der anfallenden Holzspäne zwecks Herstellung von Zellstoff und mindestens teilweisen Abbau des in dem gewonnenen Zellstoff vorhandenen Lignins durch Verwendung des Mikroorganismus erstreckt.

7. Ein Verfahren nach einem der Ansprüche 2 bis 6, bei dem der ungebleichte Zellstoff nach der mikrobiellen Behandlung weiterhin mit einer chemischen Verbindung behandelt und/oder veredelt wird.

8. Ein Verfahren nach Anspruch 1 zur Herstellung von gebleichtem Zellstoff, das sich auf mindestens teilweise Durchführung der Bleichbehandlung von ungebleichtem Zellstoff in einem Bleichprozeß unter Verwendung des Mikroorganismus erstreckt.

9. Ein Verfahren nach einem der Ansprüche 1 bis 8, bei dem der Mikroorganismus NK-1148 oder NK-729W oder eine Mutante davon ist.

Revendications

1. Procédé de production de pâte à partir de bois, avec un microorganisme, comprenant un traitement microbien, que ce soit dans un procédé de trituration ou dans un procédé de blanchiment suivant un procédé de trituration, ou dans les deux, à l'aide d'un microorganisme qui se développe bien dans un milieu de culture contenant de la lignine comme source de carbone unique, caractérisé en ce que l'on n'ajoute pas d'inhibiteur de décomposition de la cellulose et que l'on n'ajoute pas non plus de nutriment, ou que l'on n'en ajoute qu'en petites quantités.

2. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant la décomposition d'au moins une partie de la lignine présente dans les copeaux de bois à l'aide du microorganisme.

3. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant le raffinage léger de copeaux de bois pour produire une pâte et la décomposition d'au moins une partie de la lignine présente dans la pâte obtenue à l'aide du microorganisme.

4. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant le traitement léger de copeaux de bois avec un produit chimique et la décomposition d'au moins une partie de la lignine présente dans les copeaux de bois résultants à l'aide du microorganisme.

5. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant le raffinage léger de copeaux de bois pour produire une pâte, le traitement léger de la pâte obtenue avec un produit chimique, et la décomposition d'au moins une partie de la lignine présente dans la pâte résultante à l'aide du microorganisme.

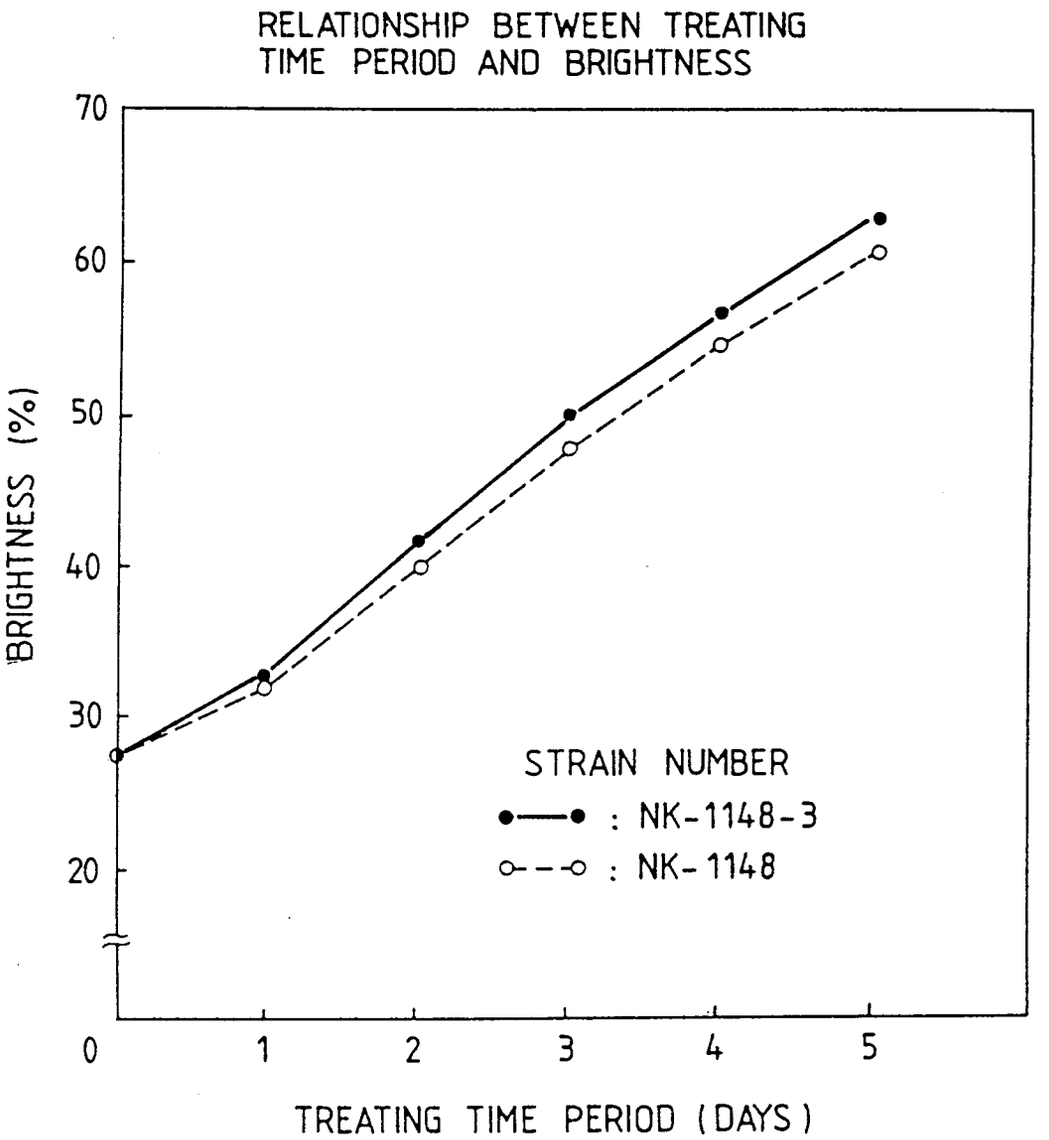
6. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant le traitement léger de copeaux de bois avec un produit chimique, le raffinage des copeaux de bois résultants pour produire une pâte et la décomposition d'au moins une partie de la lignine présente dans la pâte résultante à l'aide du microorganisme.

7. Procédé selon l'une quelconque des revendications 2 à 6, dans lequel la pâte non blanchie est aussi traitée avec un produit chimique et/ou raffinée après le traitement microbien.

8. Procédé selon la revendication 1, permettant de produire une pâte non blanchie, comprenant la réalisation d'au moins une partie du traitement de blanchiment de la pâte non blanchie dans un procédé de blanchiment, à l'aide du microorganisme.

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel le microorganisme est NK-1148 ou NK-729W, ou un mutant de ces derniers.

FIG. 1


RELATIONSHIP BETWEEN TREATING TIME PERIOD AND BRIGHTNESS
BRIGHTNESS (%)
70
60
50
40
30
20
0
1
2
3
4
5
TREATING TIME PERIOD (DAYS)
STRAIN NUMBER
: NK-1148-3
: NK-1148