

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
15 February 2007 (15.02.2007)

PCT

(10) International Publication Number
WO 2007/018368 A1(51) International Patent Classification:
D21C 5/02 (2006.01)

(21) International Application Number:

PCT/KR2006/003055

(22) International Filing Date: 3 August 2006 (03.08.2006)

(25) Filing Language: Korean

(26) Publication Language: English

(30) Priority Data:

10-2005-0071606 5 August 2005 (05.08.2005) KR

(71) Applicant (for all designated States except US): **KOREA RESEARCH INSTITUTE OF CHEMICAL TECHNOLOGY** [KR/KR]; P.O.Box No.9, Daeduk Research Complex, Jang-dong 100, Yusung-gu, Daejun, 305-343 (KR).

(72) Inventors; and

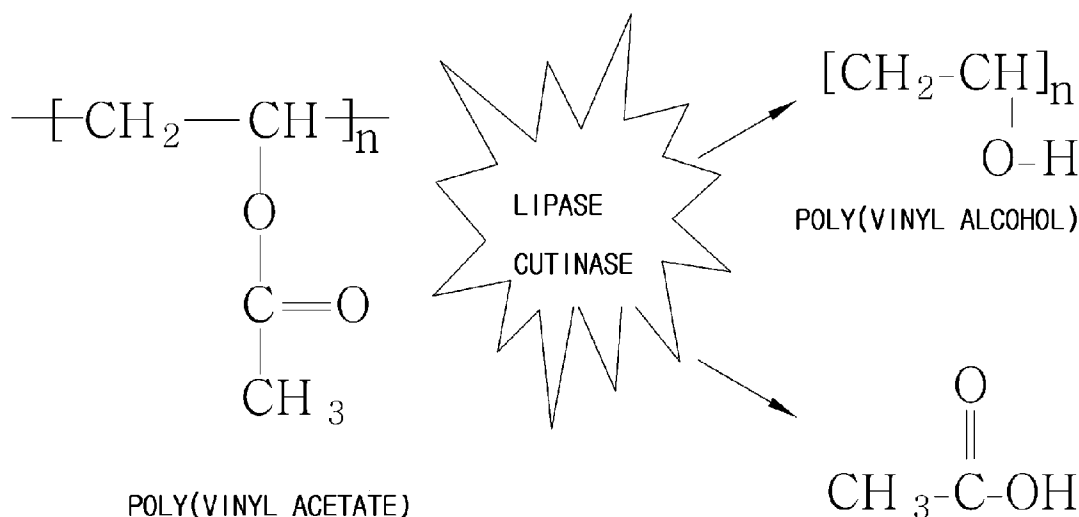
(75) Inventors/Applicants (for US only): **RYU, Jeong-Yong** [KR/KR]; Yeongudanji gongdong Apt. 8-503, Doryong-dong, Yusung-gu, Daejun, 305-340 (KR). **KIM, Yong Hwan** [KR/KR]; Gangbyeon Apt. 111-702, Mannyeon-dong, Seo-gu, Daejun, 302-741 (KR). **SONG, Jae Kwang** [KR/KR]; Jugong Apt. 202-514,Wolpyeong-dong, Seo-gu, Daejun, 302-793 (KR). **SONG, Bong Keun** [KR/KR]; Hanul Apt. 109-804, Sinseong-dong, Yusung-gu, Daejun, 305-805 (KR).(74) Agent: **SHIN, Dongjoon**; No. 402, Seocho First Bldg., 1624-2, Seocho-dong, Seocho-gu, Seoul, 137-878 (KR).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: FLOTATION-DEINKING METHOD WITH IMPROVING YIELD FOR WASTE PAPER



(57) Abstract: Disclosed herein is a method for deinking recovered paper in high yield by froth flotation. The deinking method comprises the steps of a) concentrating hydrophobic materials and b) separating and discharging the concentrated materials wherein an esterase is added to selectively modify paper components adsorbed by hydrophobic contaminants among floating materials into hydrophilic components. According to the deinking method, hydrophobic paper components are sequentially subjected to selective enzymatic hydrolysis and froth flotation without the addition of any chemical additive. As a result, froth-flotation rejects are reduced, and the brightness and the effective residual ink concentration (ERIC) of froth-flotation accepts are maintained at the same level as those of non-treated groups. Therefore, the deinking method is a new environmentally friendly method for recycling recovered paper. In addition, according to the deinking method, enzymatic treatment is performed on primary froth-flotation rejects only so that the amount of the enzyme added can be reduced.

WO 2007/018368 A1



Published:

- with international search report
- with amended claims

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Description

FLOTATION-DEINKING METHOD WITH IMPROVING YIELD FOR WASTE PAPER

Technical Field

- [1] The present invention relates to a method for deinking recovered(waste) paper in high yield by froth flotation. More specifically, the present invention relates to a method for deinking recovered paper in high yield by froth flotation which comprises the steps of a) concentrating hydrophobic materials and b) separating and discharging the concentrated materials wherein an esterase is added to selectively modify paper components adsorbed by hydrophobic contaminants among floating materials into hydrophilic components.

[2]

Background Art

- [3] Korea is the eighth ranked country in the world in terms of the production and consumption of paper. 10,147,628 tons of paper and paperboard were produced in Korea in 2003. Korea has many paper companies, including related industrial fields, worth a total of ten trillion won in scale. Korean paper industry has recorded an export value of 1.6 billion US dollars in 2002 and extended from domestic markets to exports. Recycled paper produced through recycling processes accounts for 70% or more of the overall output of paper produced by Korean paper companies. The basic reason why the Korean paper industry has an environmentally friendly structure utilizing recovered paper as a major raw material is that pulp production is limited and industrial paper, which is easy to recycle, is produced in relatively large quantities in Korea. In order to ensure the continuous, sustainable development of paper industry and to promote the production of paper and paperboard in Korea in the future, sufficient supply of raw material, in particular recovered paper with keeping up of adequate quality is inevitably required.
- [4] However, the quality of recovered paper collected in Korea is poor when compared to that of recovered paper collected in developed countries in terms of paper industry. Every year newsprint mills of Korea import more than 600 thousand tons of old newspaper from abroad due to the deficiency of domestic supply (see, Korea Paper Manufacturers Association, Annual Report 2004). That is, Korea suffers from shortage of recovered recovered paper because a considerable quantity of recycled paper is currently exported. The recovery ratio of paper and paperboard in Korea is already very high. According to a report, Korea has recovered 72% of recovered paper in 1995, which was the highest value in top ten ranked countries in terms of paper industry

(Vital Signs 1998). Therefore, an endeavor to improve the collection yield of recovered paper becomes very important. However, since there is a limitation in improving the collection yield of recovered paper, an endeavor to increase the recycling yield of collected recovered paper to compensate for the lack of the raw material is further urgently required.

[5] On the other hand, recycling yield of recovered paper is usually influenced by two major factors, *i.e.* the amount of contaminants contained in the recovered paper and the segregation efficiency of the contaminants through cleaning treatment. Particularly, paper for printing, *e.g.*, newspaper, which is recycled from printed recovered paper through ink segregation processes, shows relatively low recycling yield when compared to other industrial paper.

[6] Deinking methods for ink removal are classified into froth flotation and washing steps. Nowadays, selective segregation of ink by froth flotation is preferred owing to less consumption of process water. The mechanism of ink separation by froth flotation is based on the fact that ink particles, which are more hydrophobic than pulp fibers, can be segregated from other paper components by attaching the ink particles to air bubbles and floating the air bubbles. The efficiency of deinking treatment by froth flotation depends upon the surface physicochemical properties and the hydraulic movement of suspended raw materials. If the ink particles are completely detached from the surfaces of regenerated fibers and become hydrophobic, it is believed that surface chemical conditions for the removal of ink by froth flotation can be fulfilled. When the ink particles detached from the fibers can have an enough chance to collide with air bubbles by effective stirring in a froth-flotation cell and the detached ink particles can be physically adsorbed to the air bubbles and floated, efficient ink removal can be achieved. For example, Korean Patent Laid-open No. 1998-25354 discloses a method for removing ink particles from recovered paper by adding cellulase or xylanase, which are secreted from *Coprinus comatus* grown in a medium at pH 9, to an alkaline aqueous solution (pH 8-10) of recovered paper. According to this method, however, the weight of the ink that must be removed by froth flotation treatment is below 2% of the total weight of the recovered paper but actual rejects from the deinking method reach 10 to 14%, indicating that the method turns out to be very inefficient. The reason why the froth-flotation rejects are actually discharged in larger quantities than ink printed on newspaper is that pulp fibers and inorganic fillers are also floated and discharged together with the ink.

[7] During froth flotation for the separation of hydrophobic ink particles, inherently hydrophilic cellulosic fibers and inorganic fillers, which are hydrophobic but turn hydrophilic by the action of a dispersant, are adsorbed to air bubbles and are lost as rejects. The reason for this loss is as follows. When printed paper is collected and

recycled after printing and various processing processes, hydrophobic contaminants, which are not intentionally added but are incorporated together with the recovered paper as a raw material, are processed into fine particles and adsorbed to the surfaces of cellulose fines and fillers having a large specific surface area. Although the cellulose fines and fillers, to which hydrophobic contaminants are adsorbed, are not contaminants, such as hydrophobic ink or sticky contaminants, to be separated by froth flotation, they are readily adsorbed to air bubbles, trapped, floated, and discharged as rejects.

- [8] Sizing agents that are intentionally added during production of paper for printing function to impart hydrophobicity to the surface of fibers. The adsorption of sizing agents is proportional to the specific surface area of floating materials among paper components. Accordingly, sizing agents are adsorbed to cellulose fines and inorganic fillers rather than fibers, thus rendering the surfaces of the fines (cellulose fines + inorganic fillers) hydrophobic. The hydrophobic fines are further hardened after collection, storage and transportation of recovered paper. Parts of the hydrophobic fines are introduced into a froth-flotation cell without being hydrated despite alkaline pulping, and discharged as rejects.
- [9] The problem that components other than ink are floated as rejects, separated and discharged not only means simply low recycling yield of recovered paper but also has the following implications.
- [10] Froth-flotation rejects are not lost in a state in which recovered paper is collected and stored, but they are discharged after being treated in a pulper for dissociating paper, a screen for filtering contaminants and cleaning equipment (*e.g.*, a cleaner), followed by froth flotation. Accordingly, there is the meaning that costs of water and power necessary for the treatment of the recovered paper are involved. In addition, since the froth-flotation rejects must be buried and incinerated, they cause environmental contamination.
- [11] Therefore, if the selectivity of froth flotation is improved upon deinking of recovered paper such that paper components other than ink are not discharged, recycling yield of the recovered paper is improved. As a result, it is believed that the production costs of recycled paper are lowered and environmental pollution caused during recycling of the recovered paper is prevented. That is, there is a strong need to develop a novel technology for improving the recycling yield of printed paper upon deinking by froth flotation to increase the production efficiency of recycled paper and reduce the amount of wastes and for recycling the printed paper to produce high-quality paper for printing, in terms of environmentally friendly recycling of printed paper and foreign currency savings.

[12]

Disclosure of Invention

Technical Problem

- [13] Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a method for deinking recovered paper in high yield by froth flotation wherein an esterase is added to modify the surfaces of cellulose fines and fillers, which are paper components other than ink, contaminated with hydrophobic additives and contaminants into hydrophilic surfaces without a loss of the cellulose fines and fillers such that the selectivity of froth flotation is improved to increase the deinking yield without a lowering in the removal efficiency of ink, thus achieving increased production efficiency of deinked recycled paper.

[14]

Technical Solution

- [15] In accordance with an aspect of the present invention for achieving the above object, there is provided a method for deinking recovered paper in high yield by froth flotation which comprises the steps of a) concentrating hydrophobic materials and b) separating and discharging the concentrated materials wherein an esterase, acting to cleave ester bonds, is added to selectively modify paper components adsorbed by hydrophobic contaminants among floating materials into hydrophilic components.
- [16] More preferably, the esterase is selected from lipases, cutinases, and mixed those enzymes thereof. Lipases and cutinases are enzymes belonging to the esterase class. It is economically advantageous in terms of yield relative to enzyme treatment costs to add the esterase in an amount of 0.01 to 2% by weight, based on the total dry weight of recovered paper.
- [17] The enzyme is preferably added after step a) and prior to step b).
- [18] The hydrophobic contaminants are functional additives or sticky contaminants, and the paper components are cellulose fines or inorganic fillers.

Advantageous Effects

- [19] According to the deinking method of the present invention, hydrophobic paper components are sequentially subjected to selective enzymatic hydrolysis and froth flotation without the addition of any chemical additive. As a result, froth-flotation rejects are reduced, and the brightness and the effective residual ink concentration (ERIC) of froth-flotation accepts are maintained at the same level as those of non-treated groups. The deinking method of the present invention is a new environmentally friendly method for recycling recovered paper. In addition, according to the deinking method of the present invention, enzymatic treatment is performed on primary froth-flotation rejects only so that the amount of an enzyme added can be reduced. Therefore, the deinking method of the present invention is highly useful in paper

industry.

- [20] Although the preferred embodiments of the present invention have been disclosed herein, those skilled in the art will appreciate that various modifications and variations are possible, without departing from the technical spirit of the invention. Accordingly, such modifications and variations are intended to come within the scope of the appended claims.

[21]

Brief Description of the Drawings

- [22] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

- [23] Fig. 1 shows the hydrolysis reaction of poly(vinyl acetate) (PVAc) by the action of cutinase and lipase;

- [24] Fig. 2 shows the hydrolysis reaction of an AKD-cellulose ester by the action of lipase; and

- [25] Fig. 3 shows the hydrolysis reaction of an ASA-cellulose ester by the action of lipase.

[26]

Best Mode for Carrying Out the Invention

- [27] The present invention will now be described in greater detail.

- [28] The present invention provides a method for deinking recovered paper in high yield by froth flotation which comprises the steps of a) concentrating hydrophobic materials and b) separating and discharging the concentrated materials wherein an esterase is added to selectively modify paper components adsorbed by hydrophobic contaminants among floating materials into hydrophilic components.

- [29] Any deinking method by froth flotation can be applied so long as it can be used to recycle recovered paper. It is preferred in terms of yield that the deinking method of the present invention is applied to a method for deinking recovered paper by froth flotation which comprises the steps of a) concentrating hydrophobic materials and b) separating and discharging the concentrated materials.

- [30] The esterase used in the deinking method of the present invention is an enzyme acting to cleave ester bonds. More preferably, the esterase is selected from lipases, cutinases, and mixed those enzymes thereof. Lipases and cutinases are enzymes belonging to the esterase class. The hydrophobic contaminants are functional additives or sticky contaminants, and the paper components are cellulose fines or inorganic fillers.

- [31] Conventional methods for deinking recovered paper, such as newspaper, are carried

out under alkaline conditions. According to conventional deinking methods, since fibers are swollen and ink is hydrolyzed in alkali process water, the detachment of the ink and the surface hydration of the fibers are promoted, thereby avoiding discharge of the fibers as froth-flotation rejects. Attempts to perform deinking under neutral conditions and to lower the level of alkali added have been made to avoid unnecessary contamination of process water for deinking and lower the treatment costs due to the addition of an excess of alkali. However, these attempts cause relatively insufficient surface hydration of fibers. Under these circumstances, for better selectivity of froth flotation, an increase in the amount of alkali added may be taken into consideration in order to modify the surfaces of cellulose fines and fillers contaminated with hydrophobic additives and contaminants into hydrophilic surfaces. However, benefits of using increased amount of alkali are negligible over the aforementioned disadvantages, including contamination of process water. In contrast, the deinking method of the present invention is not a chemical method using an inorganic salt, but a novel biochemical method using lipase as a hydrolytic enzyme to cleave ester bonds of hydrophobic additives and contaminants.

- [32] Cellulases and hemicellulases are currently used in the beating of pulp fibers and deinking of printed paper. Further, lipases are treated to control sticky contaminants and pitches. For the purpose of increasing the froth flotation yield, an esterase is added to modify hydrophobic paper components in the deinking method of the present invention.
- [33] Since esterases, such as lipases and cutinases, hydrolyze ester bonds of the surface of hydrophobic floating materials, *i.e.* functional additives (*e.g.*, sizing agents accumulated during deinking recycling) and contaminants, they are suitable for the modification of the hydrophobic floating materials into hydrophilic materials. Based on these findings, the deinking method of the present invention uses lipase from *Thermomyces Lanuginosus* or cutinase from *Magnaporthe grisea*, which is a representative breakdown enzyme of the cuticle layer (Figs. 1 to 3).
- [34] Fig. 1 shows the mechanism of deacetylation reaction of polyvinyl acetate (PVAc), which is a sticky contaminant and a major material for a pressure-sensitive adhesive, by the action of an enzyme; and Figs. 2 and 3 show the hydrolytic mechanisms of an alkyl ketene dimer (AKD) and an alkenyl succinic anhydride as neutral sizing agents by the action of enzymes, respectively. In addition to these sizing agents, a rosin-alum sizing agent can be treated by lipases. As is apparent from the foregoing, the three sizing agents that are most generally used in the papermaking processes are hydrolyzed by lipases.
- [35] The present invention has been accomplished based on the following findings. Firstly, lipases and cutinases belonging to the esterase class are effective for the mod-

ification of functional additives and hydrophobic contaminants in the recycling of recovered paper. Secondly, hydrophobic paper components (cellulose fines + fillers), which are removed by froth flotation to cause low recycling yield, are concentrated as primary rejects, separated and introduced into a secondary step. The concentrated hydrophobic fines as primary rejects are subjected to effective enzymatic hydrolysis in the deinking method of the present invention, unlike in conventional deinking methods in which all paper components are enzymatically treated, to effectively modify the surface of the hydrophobic paper components into hydrophilic surface without using any chemical additive. In addition, since lipases and cutinases do not react with ink particles containing no ester bond, they can selectively modify the hydrophobic paper components only.

[36] On the other hand, the amount of the enzyme used in the deinking method of the present invention is substantially the same as that of an enzyme used in a general deinking method by froth flotation. Preferably, the enzyme is added in an amount of 0.01 to 2% by weight, based on the total dry weight of recovered paper. If the enzyme is added in an amount of less than 0.01% by weight, selective surface modification of the hydrophobic paper components is negligible. Meanwhile, if the enzyme is added in an amount exceeding 2% by weight, floating of the hydrophobic components (cellulose fines + inorganic fillers) is excessively inhibited. This inhibited floating causes poor stability of bubbles upon deinking, resulting in a lowering in the brightness of ink-free paper components and an increase in ERIC value. Moreover, the increased amount of the enzyme leads to an increase in production costs.

[37] The enzyme is preferably added after step a) of concentrating hydrophobic materials and prior to step b) separating and discharging the concentrated materials. Generally, primary froth-flotation rejects are ink and paper components adsorbed by contaminants. Since appreciable amounts of the primary rejects are discharged as secondary froth-flotation rejects, enzymes, such as cellulases, hemicellulases and lipases, which are used in conventional deinking methods, cannot be applied to treat the primary rejects. That is, other enzymes, except lipases and cutinases applied to improve the froth flotation yield, are added to treat the entire paper components.

[38] In contrast, in the deinking method of the present invention, the primary froth-flotation rejects remaining in a concentrated state are treated with an esterase (lipase or cutinase) to make the rejects hydrophilic, followed by subsequent secondary processing to reduce the amount of the final rejects. Since the deinking method of the present invention requires a reduced amount of the enzyme as compared to conventional deinking methods in which an enzyme is added in the initial stage, it is economically advantageous over the conventional deinking methods in terms of enzyme treatment costs.

[39]

Mode for the Invention

[40] Hereinafter, the present invention will be explained in more detail with reference to the following examples. However, these examples are given for the purpose of illustration and are not intended to limit the present invention.

[41]

[42] Example 1

[43] 303.6g of primary froth-flotation rejects on a dry weight basis was collected from a froth-flotation cell in a paper maker for newspaper printing (P company, Korea). The primary froth-flotation rejects thus collected corresponded to about 30% of the paper components treated by froth flotation. The primary froth-flotation rejects were composed of about 66% of ash (inorganic fillers), about 30% of cellulose fines and small quantities of fibers, as indicated in Table 1.

[44] A lipase (Resinas, Novozymes) from *Thermomyces Lanuginosus* was added in an amount of 0.025% by weight, based on the total dry weight of recovered paper to degrade hydrophobic additives and contaminants adsorbed to the fines, and the mixture was aged in a delta type froth-flotation cell (Voith, Germany) at 45 C with stirring at 1,850 rpm for 15 minutes.

[45] The fines hydrolyzed by the lipase were subjected to froth flotation using a delta type froth-flotation cell (Voith, Germany) to separate rejects. At this time, the froth flotation was carried out under the following conditions: Concentration: 1.3%, temperature: 45 C, rotational speed of rotor: 1,500 rpm, flow rate of air: 7 L/min., time: 2 min.

[46]

[47] Example 2

[48] The procedure of Example 1 was repeated, except that a cutinase (Optimize, Buckman Laboratories), which is an enzyme causing breakdown of the cuticle layer, from *Magnaporthe grisea*, was used in an amount of 0.2% by weight with respect to the total dry weight of recovered paper, instead of the lipase.

[49]

[50] Comparative Example 1

[51] The procedure of Example 1 was repeated, except that no enzyme was added.

[52]

[53] Experimental Example 1

[54] The secondary froth-flotation rejects and accepts separated in Examples 1 and 2 and Comparative Example 1 were measured for froth flotation yield and ash content in a muffle furnace at 400 C. Pursuant to ISO 2470:1977, the flotation accepts and rejects

were molded into pads having a basis weight of 200 g/m², and the brightness and ERIC values of the pads were measured. The obtained results are shown in Table 1.

[55]

[56] 1. Measurement of effective residual ink concentration (ERIC)

[57] In accordance with the TAPPI standard method T567 pm-97, the flotation accepts and rejects were molded into pads having a basis weight of 200 g/m², and the ERIC values of the pads were analyzed by measuring the reflectance of light at a wavelength of 950 nm using a spectrometer (Color Touch 2, Technidyne, U.S.A.). Since factors, *e.g.*, yellowing of high-yield pulp that deteriorates the brightness, other than ink contained in the pads had no influence on the ERIC values, the residual amount of the ink could be accurately analyzed.

[58]

[59] 2. Measurement of brightness

[60] In accordance with ISO 3688:1977, the flotation accepts and rejects were molded into pads having a basis weight of 200 g/m², and the ISO brightness of the pads was analyzed by measuring the reflectance of light at a wavelength of 457 nm using a spectrometer (Color Touch 2, Technidyne, U.S.A.). Taking into consideration factors, *e.g.*, yellowing of high-yield pulp that deteriorates the brightness, other than ink contained in the pads, the brightness of the pads was analyzed by visual observation.

[61]

[62] Table 1

		Conc. (%)	Total dryweight (g)	Fraction (%)	ERIC(pp m)	Brightness (%)	Ash content(%)
Primary froth-flotation rejects		1.32	303.6	-	5702	21.22	66.21
Example 1	Accepts	0.8	210.1	69.8	4001.3	25.12	63.12
	Rejects	3.77	93.5	30.8	12863.2	9.74	73.13
Example 2	Accepts	0.81	209.1	68.9	4011.3	25.72	64.12
	Rejects	3.76	94.5	31.1	12803.2	9.97	72.13
Comparative Example 1	Accepts	0.79	186	61.3	4030.9	25.34	63.81
	Rejects	4.02	117.6	38.7	10781	13.23	72.17

[63]

[64] As can be seen from the data shown in Table 1, when the hydrophobic fines

separated as the primary froth-flotation rejects were subjected to selective enzymatic hydrolysis, followed by secondary froth flotation, the ratios of the final froth-flotation rejects were reduced by at least 8%. In addition, the brightness and ERIC values of the froth-flotation accepts were maintained at the same level as those obtained when no enzyme was added.

[65] These results indicate that the hydrophobic additives and other contaminants, which were accumulated in the primary froth-flotation rejects and adsorbed on the surface of the cellulose fines and fillers other than ink to promote the floating of the useful fines, were modified into hydrophilic components by the enzymes, and as a result, they were not floated any further. If the hydrophobic fines will not be subjected to selective enzymatic hydrolysis, the removal rate of ink will be decreased as the froth-flotation rejects will be reduced, resulting in a decrease in brightness and ERIC value. Ink is hydrophobic like the hydrophobic contaminants. However, since ink is prepared by dispersing carbon black as a pigment in a mixture of an unsaturated oil, *e.g.*, flaxseed oil, and a synthetic resin for crosslinking, it has no ester group on its surface, which can be modified by the enzymes. Accordingly, although the enzymes are added to cleave the ester groups present on the surfaces of the hydrophobic contaminants and to modify the contaminants into hydrophilic components, there was no influence on the ink surface and no change in the separation efficiency of the ink by froth flotation. For these reasons, the brightness of the secondary froth-flotation rejects separated in Example 1 was by 3.5% lower than that of the rejects separated in Comparative Example 1, and the ERIC value of the secondary froth-flotation rejects separated in Example 1 was by 2,000 ppm or more higher than that of the rejects separated in Comparative Example 1.

[66] Comparing the results of the selective enzymatic hydrolysis performed in Example 1 with the results obtained when no enzyme was used in Comparative Example 1, the secondary froth-flotation yield was improved and insignificant changes in the ash content of the froth-flotation rejects were observed. These results indicate that the cellulose fines and the fillers, whose surfaces were modified into hydrophilic surfaces by the selective enzymatic hydrolysis so as not to float any further, were present in the same ratio.

[67]

Industrial Applicability

[68] As apparent from the above description, according to the deinking method of the present invention, the selectivity of froth flotation is improved upon deinking of recovered paper such that paper components other than ink are not discharged. As a result, recycling yield of the recovered paper can be improved, thus contributing to a

reduction in the production costs of recycled paper. In addition, environmental pollution caused during recycling of the recovered paper can be prevented. Therefore, the deinking method of the present invention is very useful in the recycling of recovered paper.

Claims

- [1] A method for deinking recovered paper in high yield by froth flotation, the method comprising the steps of a) floating and concentrating hydrophobic materials and b) separating and discharging the concentrated froth-flotation rejects wherein an esterase is added to selectively modify paper components adsorbed by hydrophobic contaminants among the floating materials into hydrophilic components.
- [2] The method according to claim 1, wherein the esterase is selected from lipases, cutinases, and mixed those enzymes thereof.
- [3] The method according to claim 1 or 2, wherein the enzyme is added in an amount of 0.01 to 2% by weight, based on the total dry weight of recovered paper.
- [4] The method according to claim 1, wherein the enzyme is added after step a) and prior to step b).
- [5] The method according to claim 1 or 2, wherein the hydrophobic contaminants are functional additives or sticky contaminants.
- [6] The method according to claim 1 or 2, wherein the paper components are cellulose fines or inorganic fillers.

AMENDED CLAIMS

[received by the International Bureau on 16 January 2007 (16.01.2007)]

【Claim 1】 (amended)

A method for deinking recovered paper in high yield by froth flotation, the method comprising the steps of a) floating and concentrating hydrophobic materials and b) separating and discharging the concentrated froth-flotation rejects wherein an esterase is added after step a) and prior to step b) to selectively modify paper components adsorbed by hydrophobic contaminants among the floating materials into hydrophilic components.

【Claim 2】

The method according to claim 1, wherein the esterase is selected from lipases, cutinases, and mixed those enzymes thereof.

【Claim 3】

The method according to claim 1 or 2, wherein the enzyme is added in an amount of 0.01 to 2% by weight, based on the total dry weight of recovered paper.

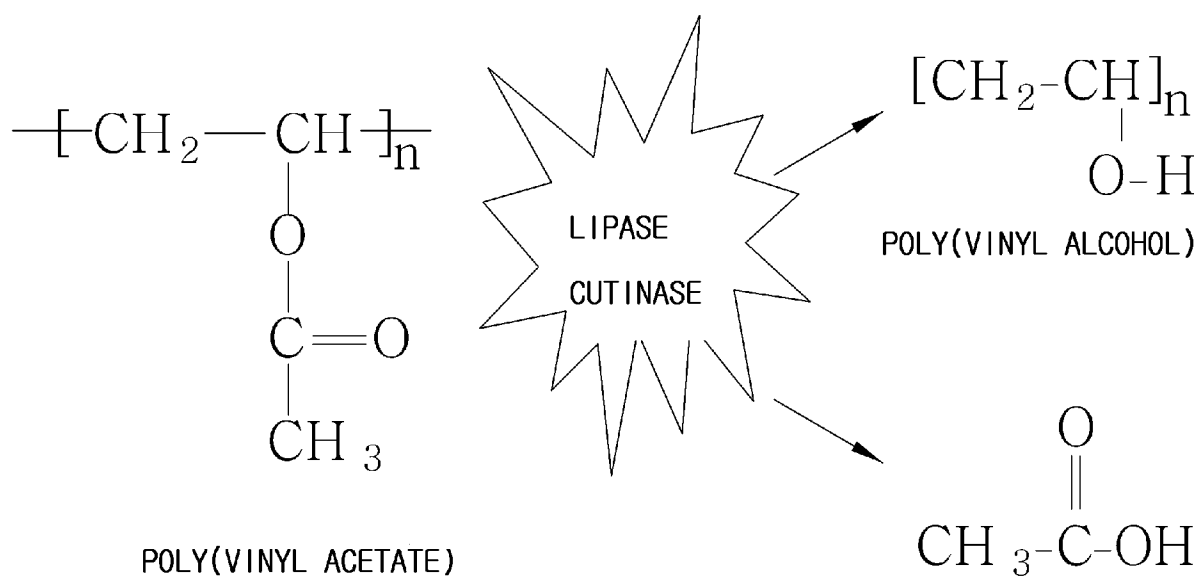
【Claim 4】 (DELETED)**【Claim 5】**

The method according to claim 1 or 2, wherein the hydrophobic contaminants are functional additives or sticky contaminants.

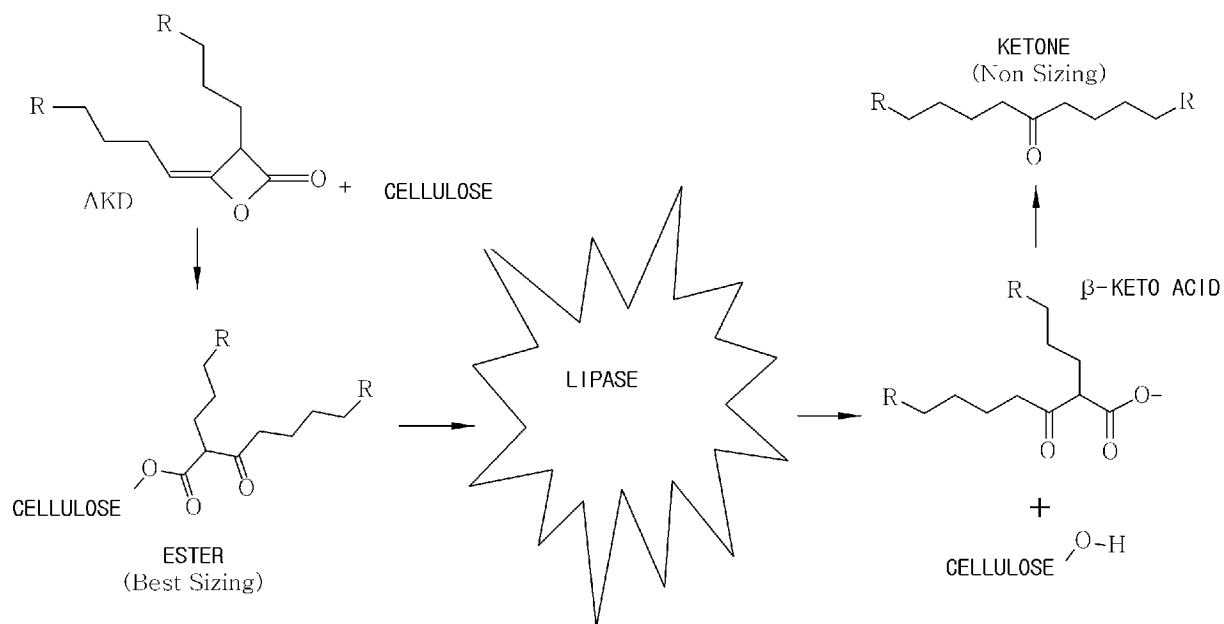
【Claim 6】

The method according to claim 1 or 2, wherein the paper components are cellulose fines or inorganic fillers.

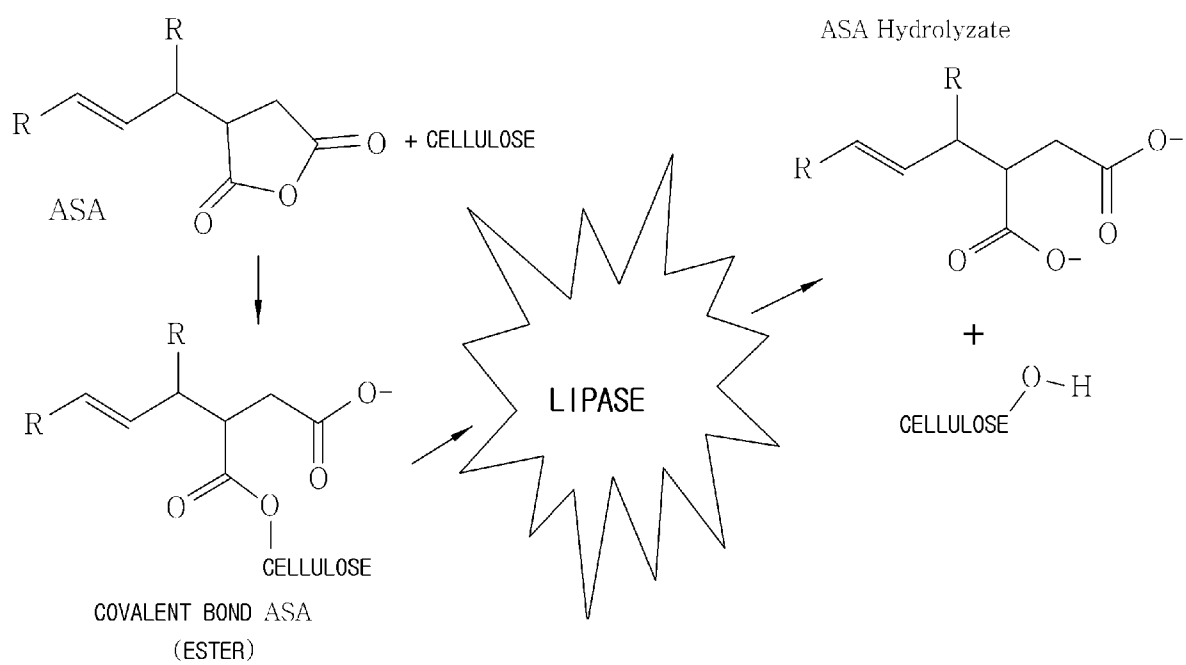
[Fig. 1]



[Fig. 2]



[Fig. 3]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/003055**A. CLASSIFICATION OF SUBJECT MATTER***D21C 5/02(2006.01)i*

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)

IPC8 D21C 5/02

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)

eKIPASS, INSPECT "waste paper", "deink", "lipase", "esterase"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2000-0003300 A (Jan 15, 2000) -- See the abstract, embodiment 1 and 2 in page 3.	1 ~ 2
Y	US 2002/0059998 A1(Daniel E. Glover et al. May 23, 2002) -- See the abstract and claims 1 to 29.	1 ~ 2
A	JP 02/160984 A (Jun 20, 1990) -- See the whole document.	1 ~ 6



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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

20 NOVEMBER 2006 (20.11.2006)

Date of mailing of the international search report

20 NOVEMBER 2006 (20.11.2006)

Name and mailing address of the ISA/KR

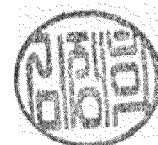
Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, JUNG HEE

Telephone No. 82-42-481-8191



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2006/003055

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 10-2000-0003300 A	2000.01.15	NONE	
US 2002/0059998 A1	2002.05.23	NONE	
JP 02/160984 A	1990.06.20	NONE	