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[Continued on next page]

(54) Title: METHODS FOR TREATING LIGNOCELLULOSIC MATERIALS

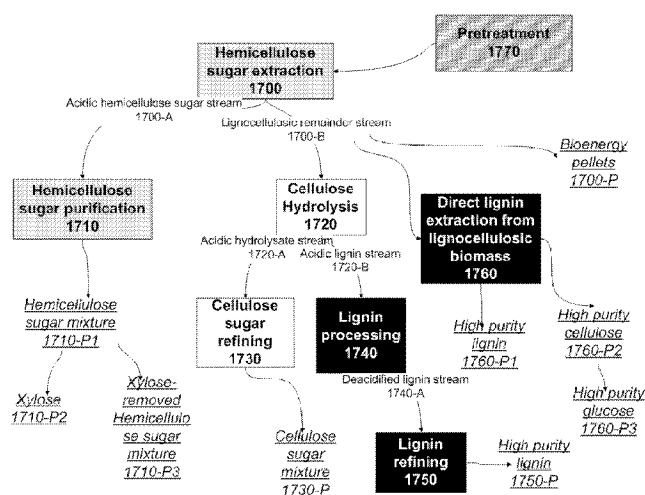


Fig. 17

(57) Abstract: The present invention relates to methods of processing lignocellulosic material to obtain hemicellulose sugars, cellulose sugars, lignin, cellulose and other high-value products. Also provided are hemicellulose sugars, cellulose sugars, lignin, cellulose, and other high-value products.



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

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/039585

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C07H 1/08 (2013.01)

USPC - 127/37

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)

IPC(8) - B01D 11/00, 11/04; C07G 1/00; C07H 1/00, 1/06, 1/08, 3/02; C13K 1/00, 1/02, 1/04 (2013.01)

USPC - 127/34, 36, 37, 42, 46.1, 46.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - B01D 11/00, 11/04; C07G 1/00; C07H 1/00, 1/06, 1/08, 3/02; C13K 1/00, 1/02, 1/04 (2013.01)

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

Orbit, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012/0058526 A1 (JANSEN et al) 08 March 2012 (08.03.2012) entire document	1-22, 25-28, 30-60, 71-76, 196-207
Y	US 6,087,532 A (BANIEL et al) 11 July 2000 (11.07.2000) entire document	1-22, 25-28, 30-60, 71-76
Y	WO 2012/018740 A1 (JANSEN et al) 09 February 2012 (09.02.2012) entire document	3, 4, 7, 32-36, 40, 41, 44, 72-76, 201
Y	US 2010/0043784 A1 (JENSEN) 25 February 2010 (25.02.2010) entire document	8, 21, 59
Y	US 6,207,824 B1 (HENKES et al) 27 March 2001 (27.03.2001) entire document	20-22, 58-60
Y	WO 00/61276 A1 (TORGET) 19 October 2000 (19.10.2000) entire document	26-28, 198-200
Y	US 6,391,204 B1 (RUSSO JR) 21 May 2002 (21.05.2002) entire document	30-36, 71-75, 202
Y	WO 84/03304 A1 (PASZNER) 30 August 1984 (30.08.1984) entire document	54, 55, 203-207
Y	WO 2011/017797 A1 (JEMAA et al) 17 February 2011 (17.02.2011) entire document	196-207
A	WO 2010/045576 A2 (WENGER et al) 22 April 2010 (22.04.2010) entire document	1-22, 25-28, 30-60, 71-76, 196-207

☐ Further documents are listed in the continuation of Box C.

* 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 another 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

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Date of mailing of the international search report

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Name and mailing address of the ISA/US

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 23, 24, 29, 61-70, 179-181, 284, 285, 292-313, 316
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Extra Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-22, 25-28, 30-60, 71-76, 196-207

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I: Claims 1-22, 25-28, 30-60, 71-76, and 196-207 are drawn to a method of refining and processing a sugar stream

Group II: Claims 77-83 are drawn to a method for fractionating a liquid sample

Group III: Claims 84-138 and 208-223 are drawn to sugar compositions

Group IV: Claims 139-178, 182-195, 224-247, 257-283, and 286-291 are drawn to a process of producing a high purity lignin

Group V: Claims 248-256, 314, 315, and 317-329 are drawn to a lignin composition with a low ash content

The inventions listed as Groups I through V do not relate to a single general inventive concept under PCT Rule 13.1 because under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of the Group I, *a method of refining and processing a sugar stream* are not found in Groups II through V; the special technical features of Group II, *a method for fractionating a liquid stream* are not found in Groups I and II through V; the special technical features of Group III, *a sugar composition* are not found in Groups I, II, IV and V; the special technical features of Group IV, *a process of producing high purity lignin* are not found in Groups I through III and V; and the special technical features of Group V, *a lignin composition with low ash* are not found in Groups I through IV.

Groups I through V share the technical features of sugar compositions comprising xylose in the range of less than 0.2 weight/weight to greater than 0.5 weight/weight, fractionating a liquid stream and also a lignin composition containing ash content in an amount up to 0.1% weight/weight, and contacting an acidic hydrolysate stream in a reaction. However, these technical features do not represent a contribution over the prior art.

Specifically, US 2012/0058526 A1 to Jansen et al. teaches sugar composition comprising xylose in the range of about 0.18 weight/weight to about 0.5 weight/weight (Para. [0153] ...a sugar composition; Para. [0154] (a) at least 25% xylose by weight...; Para. [0165], ...a sugar composition including (by weight...; see also Paras. [0166] and Para. [0187] ...a sugar composition including: ... (b) 0.01%-20% xylose by weight...) and contacting an acidic hydrolysate stream in a reaction (Para. [0069], reacting the mixture...; Paras. [0082]-[0085], preparing the mixture...hydrolyzing the lignocellulosic material feed to form a hydrolyzate including at least one first sugar and at least one of at least one second sugar and at least one second sugar precursor; Para. [0034], ...hydrolysis employs a strong acid...; Para. [0086], de-acidifying the hydrolyzate).

Further, US 6,391,204 B1 to Russo, Jr. teaches a method of fractionating a liquid stream (Col. 2, Lines 9-12, separating acid and sugars obtained from liquids resulting from the acid hydrolysis of at least one cellulosic and hemicellulosic materials...; Col. 3, Lines 22-50, ...adding the sugar/acid solution...to a simulated moving bed separation unit comprising a bed of anionic exchange or exclusion chromatographic material whereby the acid is adsorbed onto the chromatographic material, thereby producing a series of first fractions comprising sugar solution and a later series of fractions comprising acid...; Col. 7, Lines 26-62, ...anionic exchange or exclusion chromatographic material can include...amines...).

In addition, WO 2010/045576 A2 to Wenger et al. discloses a lignin composition containing ash content in an amount up to 0.1% weight/weight (Para. [0029] The substantially pure lignin produced by the present invention refers to lignin that is...at least 95% pure lignin. Trace impurities such as ash, carbohydrate, and sulfur are minimized and comprise only a minority of the substantially pure lignin. In some embodiments, carbohydrates comprise less than ... less than 1% of the final substantially pure lignin product. In some embodiments, ash comprises ... less than 0.05% of the final substantially pure lignin product....).

The inventions listed in Groups I through V therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.