

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

(88) Date of publication of the international search report:
7 June 2012

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/45958

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C12P 7/06; C12P 7/10 (2011.01)

USPC - 435/161; 435/165

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): C12P 7/06; C12P 7/10 (2011.01)

USPC: 435/161; 435/165

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 435/252.5; 435/832; 530/859; 127/37; 127/36 127/43 162/1 162/25Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(PGPB,USPT,USOC,EPAB,JPAB); Google Patents: lignocellulosic biomass, xylose fermentation, lignocellulosic slurry, biomass heat exchange, ethanol production, particulate biomass feedstock, particulate lignocellulosic feedstock, hemicellulose hydrolysis, hydrolytic liquefaction xylose, cellulosic feedstock centrifugal pump

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7,754,457 B2 (Foody et al.) 13 July 2010 (13.07.2010) Fig 1; Col 1, ln 6; Col 6, ln 45-47; Col 9, ln 17-25, 64-65; Col 10, ln 9-12, 38-41, 50-51; Col 10, ln 9-12, 38-41, 50-51; Col 17, ln 17-18, 45-55; Col 24, ln 4-5, 9-15	1-4
Y	US 2004/0231661 A1 (Griffin et al.) 25 November 2004 (25.11.2004) para [0053], [0122]-[0123]	1-4
Y	US 2009/0215137 A1 (Hawkins et al.) 27 August 2009 (27.08.2009) para [0087], [0144], [0176], [0182]	2-4
Y	US 5,348,871 A (Scott et al.) 20 September 1994 (20.09.1994) Col 4, ln 32-55; claim 1	4

☐ 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

11 February 2012 (11.01.2012)

Date of mailing of the international search report

27 FEB 2012

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/45958

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.: 5-10, 15-20, 24-31, and 35
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:
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.

Group I: claims 1-4, drawn to a method for manufacturing ethanol from a particulate lignocellulosic biomass feedstock, comprising: subjecting a first amount of particulate lignocellulosic biomass feedstock to hydrolytic liquefaction under heated conditions to form a hot liquefied digest slurry comprising (i) dissolved biomass components representing at least 10% by weight on a dry weight basis of the biomass feedstock and comprising xylose, and (ii) undissolved lignocellulosic biomass particulates comprising lignin and cellulose; cooling the hot liquefied digest slurry by pumping the slurry through a first passage of a heat exchanger so as to transfer heat to a cooler liquid in a second passage of the heat exchanger; after said cooling, fermenting said xylose to ethanol.

***** See Supplemental Sheet to continue *****

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.:
1-4

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.

Continuation of Box No. III. Observations where unity of invention is lacking:

Group II: claims 11-14 and 32-34, drawn to a method for processing lignocellulosic biomass, by incubating a mixture comprising a first amount of a solid, particulate lignocellulosic biomass and a first amount of a liquid processing medium containing at least one dicarboxylic acid under heated conditions effective to form a biomass digest composition exhibiting a lower yield stress than the mixture and in which at least 10% by weight of the solid, particulate biomass has been converted to dissolved biomass components in the liquid medium;

passing a flowable liquid digest medium at least partially comprised of said dissolved biomass components and said undissolved lignocellulosic biomass particulate through a first passage of a heat exchanger while passing a second amount of a liquid processing medium containing at least one dicarboxylic acid through a second passage of the heat exchanger so as to transfer heat from said flowable liquid digest medium to said second amount of liquid processing medium to provide a preheated liquid processing medium.

Group III: claims 21-23, drawn to a method for recovering heat from pretreated lignocellulosic biomass, by pumping a hot aqueous liquid digest slurry comprising dissolved biomass solids and undissolved lignocellulosic biomass particulates through a first passage of a heat exchanger at a linear velocity sufficiently high to cause said particulates to enhance the generation of turbulent flow, wherein the digest slurry is comprised at least 15% by weight total biomass solids on a dry weight basis, wherein 10% to 45% of the total biomass solids are dissolved in the aqueous liquid, and recovering heat from the hot aqueous liquid digest slurry by transferring heat from the slurry to a fluid pumped through a second passage of the heat exchanger.

The inventions listed as Groups I-III 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 inventions of Groups I and III do not include the inventive concept of a first and second amount of a liquid processing medium containing at least one dicarboxylic acid, as required by Group II.

The invention of Groups I-II do not include the inventive concept of pumping a hot aqueous liquid digest slurry through a first passage of a heat exchanger at a linear velocity sufficiently high to cause said particulates to enhance the generation of turbulent flow, as required by Group III.

In addition, claim 1 is obvious over US 7,754,457 B2 Foody et al. (13 July 2010) (hereinafter 'Foody'), in view of US 2004/0231661 A1 to Griffin et al. (hereinafter 'Griffin') as follows:

Foody discloses methods for manufacturing ethanol from particulate lignocellulosic biomass feedstock (Col 1, In 6, "... a method for continuous processing of lignocellulosic feedstocks"; Col 9, In 17-19, "The feedstock for the process is a lignocellulosic material. By the term "lignocellulosic feedstock", it is meant any type of plant biomass..."; In 23-25, "The production of fuel ethanol from cellulosic feedstocks provides an ... alternative to... feedstocks used to date"; Col 9, In 64-65, "Feedstock may be reduced to particles having a length of about 1/16 to about 1 in...").

Foody further discloses subjecting the particulate feedstock to hydrolysis under heated conditions to form a hot aqueous digest slurry comprising dissolved biomass components and xylose and undissolved lignocellulosic biomass particulates comprising lignin and cellulose (Col 10, In 38-41, "the feedstock is slurried in liquid prior to pretreatment, ... such as water"; Col 10, In 50-51, "The feedstock may be slurried at a temperature of between about 40C. and about 100C. ..."; Col 11, In 15-16 "the pretreatment temperature is generally between about 160C. and about 280C. ..."; Col 10, In 9-12, "...the pretreatment may be carried out to hydrolyze the hemicellulose ... in the lignocellulosic feedstock to monomeric sugars, for example xylose"; Col 17, In 45-55, "... hydrolysis continues for about 24 hours to about 250 hours, The resulting slurry is an aqueous solution of glucose and xylose with lignin and other unconverted, suspended solids"; Col 24, In 9-15, "... pretreated slurry...consisted of 4.5% undissolved solids, and the undissolved solids consisted of 55% cellulose").

Foody further discloses cooling the hot hydrolyzed digest slurry by pumping the slurry through a first passage of a heat exchanger so as to transfer heat to a cooler liquid in a second passage of the heat exchanger (Col 24, In 4-5, "The final cooling of the slurry was carried out by heat exchange with a heat exchanger with cooling water").

Foody does not expressly disclose the term "hydrolytic liquefaction". However, "hydrolytic liquefaction" is understood in the art as equivalent to aqueous hydrolysis of polysaccharides such as hemicellulose to produce dissolved sugars such as xylose, and as such is disclosed by Foody as set forth immediately above.

Foody does not expressly disclose a digest slurry comprising dissolved biomass components representing at least 10% by weight on a dry weight basis of the biomass feedstock and comprising xylose wherein said xylose is fermented to ethanol.

Griffin discloses a method of producing a slurry under heated conditions containing said amounts of dissolved xylose for ethanol production (abstract, "...a method of producing xylose from lignocellulosic feedstock"; para [0123], "A cellulase enzyme treatment may be performed by mixing the pretreated feedstock ... to achieve a slurry of 5% to 10% by weight cellulose. C... the hydrolysis is run for about 24 to about 200 hours at about 50.degree. C"; para [0122], "...as a result of the methods as described herein, the composition comprises between about 150 to about 260 mg of xylose per gram (15-26%) of dry lignocellulosic feedstock"; para [0053], "treating the composition with a microorganism under conditions which permit fermentation of the xylose in the composition to ethanol").

It would have been obvious to one of ordinary skill in the art to combine the methods of Foody and Griffin to create a method in which abundant xylose (in addition to glucose) is produced and fermented to ethanol from inexpensive lignocellulosic biomass using economical steps such as the heat exchange (energy conservation) of Foody and the xylose-fermenting organism of Griffin.

Groups I-III therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.