(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 January 2014 (03.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/004966 A3

(51) International Patent Classification:
C07C 29/80 (2006.01)

(21) International Application Number:
PCT/US2013/048460

(22) International Filing Date:
28 June 2013 (28.06.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/666,648 29 June 2012 (29.06.2012) US

(71) Applicant: **GEVO, INC.** [US/US]; 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US).

(72) Inventors: **WOOLEY, Robert**; c/o GEVO, INC., 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US). **LYTHGOE, Steven**; c/o GEVO, INC., 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US). **GUIMARAES, Jose**; c/o GEVO, INC., 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US). **MEINTYRE, Michael**; c/o GEVO, INC., 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US). **ROBBINS, Lanny**; c/o GEVO, INC., 345 Inverness Drive South, Building C, Suite 310, Englewood, Colorado 80112 (US).

(74) Agents: **BLINKA, Thomas** et al.; Cooley Llp, 1299 Pennsylvania Avenue, N.W., Suite 700, Washington, District of Columbia 20004-2400 (US).

[Continued on next page]

(54) Title: METHOD FOR PURIFICATION OF ALCOHOLS

(57) Abstract: This invention is directed to methods for recovery of C3-C6 alcohols. The recovery process advantageously utilizes the immiscible properties of a first phase liquid and a second phase liquid to separate the liquids prior to processing C3-C6 alcohols to recovery. The invention is also directed to C3-C6 alcohol-containing compositions.

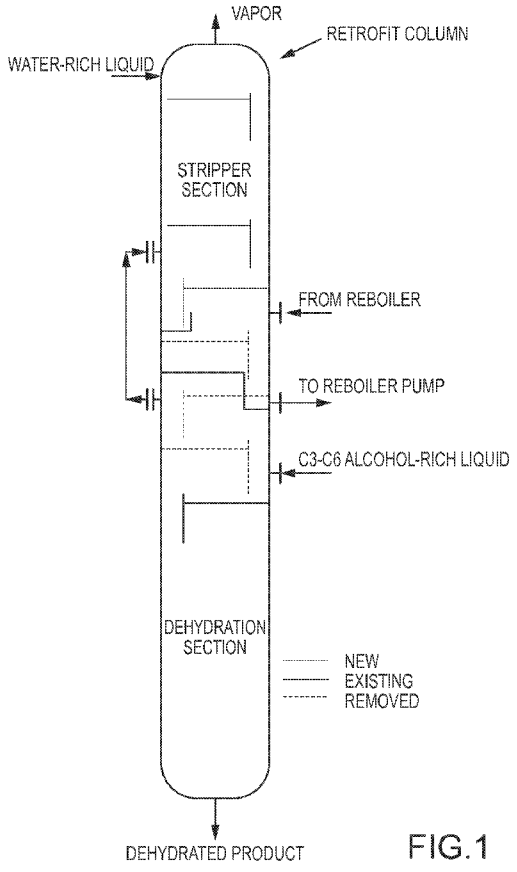


FIG.1

WO 2014/004966 A3

(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, 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.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) **Date of publication of the international search report**:
10 April 2014

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/048460

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C07C 29/80 (2014.01)
USPC - 203/18
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) - C07C 29/80; C12P 7/02, 7/06, 7/16 (2014.01)
USPC - 203/18, 19; 435/160; 568/913

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - C07C 29/80; C12P 7/02, 7/06, 7/16 (2013.01)

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2011/0124068 A1 (EVANKO et al) 26 May 2011 (26.05.2011) entire document	28-44, 64 --- 1-27, 65, 66
X --- Y	CN 101367710 A (LANYI et al) 18 February 2009 (18.02.2009), see machine translation	67, 68 --- 11-15, 65, 66
Y	US 2007/0144886 A1 (SYLVESTER et al) 28 June 2007 (28.06.2007) entire document	1-27
A	US 5,417,813 A (BERG) 23 May 1995 (23.05.1995) entire document	1-44, 64-68
A	US 2011/0303526 A1 (LEE et al) 15 December 2011 (15.12.2011) entire document	1-44, 64-68
A	US 2011/0087000 A1 (PETERS et al) 14 April 2011 (14.04.2011) entire document	1-44, 64-68

☐ 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	Date of mailing of the international search report
29 January 2014	14 FEB 2014
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: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/048460

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.:
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.:
1-44, 64-68

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.

<Continued from Box III: Observations where unity of invention is lacking>

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 1-44, 64-68 are drawn to a method to recover a C3-C6 alcohol from a stream.

Group II: Claims 45-63 are drawn to a composition comprising butanol and other C3-C6 alcohols.

Group III: Claims 69-72 are drawn to a composition containing isobutanol, water, and impurities.

The inventions listed as Groups I through 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 special technical features of Group I, a method to recover a C3-C6 alcohol from stream comprising dehydration, are not found in Groups II and III; the special technical features of Group II, a composition comprising butanol and other C3-C6 alcohols, are not found in Groups I and III; and the special technical features of Group III, a composition comprising isobutanol, water and impurities, are not found in Groups I and II.

Groups I through III share the technical features of a composition comprising greater than 96 wt% C3-C6 alcohol, water and impurities or ethanol. However, these technical features do not represent a contribution over the prior art.

Specifically, US 2011/0124068 A1 to Evanko et al. teach of a composition comprising greater than 96 wt% C3-C6 alcohol, water and ethanol (Para. [0231], ...the substantially pure C3-C6 alcohol can have a water content of less than about 5 wt%, less than about 1 wt% or less than about 0.5%; Para. [0029], ...impurity can include ethanol...).

Further, US 2011/0087000 A1 to Peters et al. teach a composition comprising greater than 96 wt% C3-C6 alcohol, water and ethanol (Para. [0061], ...aqueous isobutanol containing about 0-15% water (e.g. about 85-100% isobutanol, and about 0-15% water), and trace levels of impurities (for example less than about 5% impurities, e.g., less than about 4%, less than about 3%, less than about 2%, or less than about 1% impurities; Para. [0113], ...GC-MS analysis was performed for oxygen, isobutanol, ethanol...; Para. [0050], ...alcohols such as isobutanol are produced by yeasts during fermentation of sugars into ethanol....).

Further, US 5,417,813 A to Berg teaches a composition comprising greater than 96 wt% butanol and 2-pentanol (Col. 4, Lines 7-9, ... composition was 96.7% 1-butanol and 3.3% 2-pentanol).

Additionally, US 2011/0303526 A1 to Lee et al. teach a composition comprising greater than 96 wt% C3-C6 alcohol, water and impurities or ethanol (Table 3, Examples 1 and 5-7 show n-BuOH have concentrations greater than 97.3 wt% and low concentrations of water and light components).

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

<End Box III: Observations where unity of invention is lacking>