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(54) Title: PROCESS AND SYSTEM FOR BUTANOL PRODUCTION

(57) Abstract: An apparatus and method for converting acetic, butyric acids and other short chain carboxylic acids from the acetone-butanol-ethanol (ABE) fermentation process into their corresponding alkyl esters, which have a pleasant odor. Preferably, a strong acid and/or an immobilized lipase is used as a catalyst in a packed bed reactor. The produced esters remain in the butanol fuel as oxygenate agents or additives. A simplified separation and purification process for butanol fuel production results.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US07/06645

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **C12Q** 3/00(2006 01)

USPC- 435/3, 135
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)
U S . . 435/3,135

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	6,242,015 A (EGI et al) 05 June 2001 (05 06.2001), see entire disclosure.	1-1 1
A	U S A (HOROWITZ et al) (09 April 2002) 09.04.2004, see entire disclosure.	1-1 1

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents	"T"
"A" document defining the general state of the art which is not considered to be of particular relevance	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
"E" earlier application or patent published on or after the international filing date	"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
"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)	"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
"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	"&" document member of the same patent family

Date of the actual completion of the international search: 25 August 2008 (25.08.2008)
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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
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INTERNATIONAL SEARCH REPORT

International application No.

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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.:
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:
Please See Continuation 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 any 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.: 1-1 1
- 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.

INTERNATIONAL SEARCH REPORT

International application No.

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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 must be paid.

Group I, claim(s) 1-11, drawn to a process for producing carboxylic acid alkyl esters for de-odorizing an acetone-butanol-ethanol fermentation product mixture and oxygenating a butanol fuel derived from the acetone-butanol-ethanol fermentation product mixture, said process comprising:

introducing the acetone-butanol-ethanol fermentation product mixture to a solvent extraction reactor containing an organic solvent to produce an organic solvent phase comprising butanol, ethanol and a plurality of short-chain organic acids; introducing said organic solvent phase to an esterification reactor at a controlled rate to produce an esterified product mixture containing a deodorizing agent, and monitoring the organic acid content of said esterified product mixture and controlling said controlled rate to be the rate at which the weight of an unreacted portion of said plurality of short-chain acids does not exceed about 0.005 percent of the weight of said esterified product mixture

Group II, claim(s) 12 and 13, drawn to a system drawn to means to produce a butanol fuel.

Group III, claim(s) 14 and 15, drawn to a product comprising butanol and a deodorizing agent.

Group IV, claim(s) 16-23, drawn to a process for eliminating unpleasant odors associated with butanol production, the process comprising:

mixing and sterilizing a carbohydrate feed and/or a sugar feed to produce a mixed and sterilized feedstock; performing acidogenesis fermentation on said mixed and sterilized feedstock to produce an first intermediate product that comprises at least one organic acid; performing solventogenesis fermentation on said intermediate product to produce a second intermediate product comprising said at least one organic acid, at least one alcohol, at least one ketone and water; using solvent extraction to extract at least some of said water from said second intermediate product to produce a solvent phase that comprises said at least one organic acid, said at least one alcohol and said at least one ketone; exposing said solvent phase to a solid acid and/or an immobilized lipase enzyme to catalyze an esterification reaction between said at least one organic acid and said at least one alcohol to produce a reaction product that comprises at least one ester and reaction water; exposing said reaction product to a molecular sieve to remove a first portion of said reaction water to produce an organic mixture; and distilling said organic mixture to remove said at least one ketone and a second portion of said reaction water to produce a butanol-ester mixture.

Group V, claim(s) 24-26, drawn to producing butanol involving a fermentation of feedstock and removing water to form a dehydrated mixture and removing some of the water from reaction product.

Group VI, claim(s) 27, drawn to a system comprising means for removing water from an aqueous solution.

INTERNATIONAL SEARCH REPORT

International application No.

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The inventions listed as Groups I-VI 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:
Invention I is drawn to a process for producing carboxylic acid esters whereas Invention II is drawn to a means for producing butanol fuel. Invention III is drawn to a butanol fuel which does not require the specifics of Inventions I or II. Invention IV is drawn to a different invention involving the elimination of unpleasant odors involving sterilizing carbohydrate feed. Invention V is drawn to a process of producing butanol which process involves only the production of a plurality of alcohols and removing water. Invention VI system does not require the specifics of Invention II system which means are not the same.