(57) Abstract: A two-stage pyrolysis process is used to produce a low oxygenate bio-oil. In the first stage, biomass feedstock is subjected to a slow pyrolysis to convert the biomass feedstock into a low-oxygen content biomass feedstock having an oxygen removal degree of at least 0.5 at minimal carbon loss, while the low-oxygen content biomass feedstock is subjected to flash pyrolysis in the second stage. So produced bio-oil has low oxygenate content and therefore significantly improved storage and stability properties.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

CIOG 3/00(2006.01)i, CIOB 53/02(2006.01)i, CIOL 3/00(2006.01)i, CIOL 1/02(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)
CIOG 3/00; CIOL 1/16; C07C 4/00; C07C 1/00; CIOG 1/00; CIOL 1/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: oxygen, pyroly*, biomass

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>A</td>
<td>See abstract , Figure 1, Table 2 and pages 122, 123, 126, 127.</td>
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<td>See abstract and pages 142, 143, 145.</td>
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<td>US 4678860 A (KUESTER, JAMES L.) 07 July 1987</td>
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<td>See abstract , TABLE B and claims 1-3.</td>
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<td>US 4891459 A (KNIGHT; JAMES A. et al.) 02 January 1990</td>
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<td>See abstract and column 2 lines 49-58.</td>
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<td>wo 2009-050249 A2 (BIOECON INTERNATIONAL HOLDING N.V. et al.) 23 April 2009</td>
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<td>See abstract , paragraphs 0014, 0017 and claims 10-13.</td>
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☐ 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

28 FEBRUARY 2012 (28.02.2012)

Date of mailing of the international search report

29 FEBRUARY 2012 (29.02.2012)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 189 Cheoungsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM Dae Young

Telephone No. 82-42-481-8651

Form PCT/ISA/210 (second sheet) (July 2009)
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).

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 an additional fee, this Authority did not invite payment of any additional fee.

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.

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.
I. Claims 1-6 are directed to a method of producing low-oxygenate bio-oil, comprising, subjecting a biomass feedstock to a slow pyrolysis to produce a plurality of gaseous oxygen-containing compounds and a low-oxygen biomass feedstock having an oxygen removal degree of at least 0.5, removing the plurality of gaseous oxygen-containing compounds from the low-oxygen biomass feedstock, and subjecting the low-oxygen biomass feedstock to a flash pyrolysis to produce, at a conversion rate of at least 70 wt%, a bio-oil having an oxygen content of less than 25 wt%.

II. Claims 7-11 is directed to a low-oxygenate bio-oil production plant comprising a slow pyrolysis reactor, a flash pyrolysis reactor, and a control device having a digital storage medium.

III. Claims 12-14 is directed to a slow-pyrolysed low-oxygen biomass having an oxygen removal degree of at least 0.5 as compared to the same biomass prior to slow-pyrolysis.

IV. Claims 15-17 is directed to a method of producing low-oxygenate bio-oil, comprising subjecting a low-oxygen biomass feedstock to a flash-pyrolysis to produce, at a conversion rate of at least 70 wt%, a bio-oil having an oxygenate content of less than 25 wt%.

V. Claims 18-20 is directed to a method of treating a biomass feedstock comprising subjecting the biomass feedstock to a slow pyrolysis to produce a solid phase low-oxygen biomass feedstock and a gas phase comprising a plurality of gaseous oxygen-containing compounds wherein the low-oxygen biomass feedstock has an oxygen removal degree of at least 0.5, and wherein a carbon loss from the low-oxygen biomass feedstock through the gas phase is less than 20 mole %.

Form PCT/ISA/210 (extra sheet) (July 2009)
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<td>25.03.1992</td>
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<tr>
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<td></td>
<td>JP 62- 169887 A</td>
<td>27.07.1987</td>
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<td>02.01.1990</td>
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Form PCT/ISA/210 (patent family annex) (July 2009)