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- (71) **Applicant:** NOVOMER, INC [US/US]; 200 West St, Floor 4E, Waltham, New York 02451 (US).
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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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, 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, SA, 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.

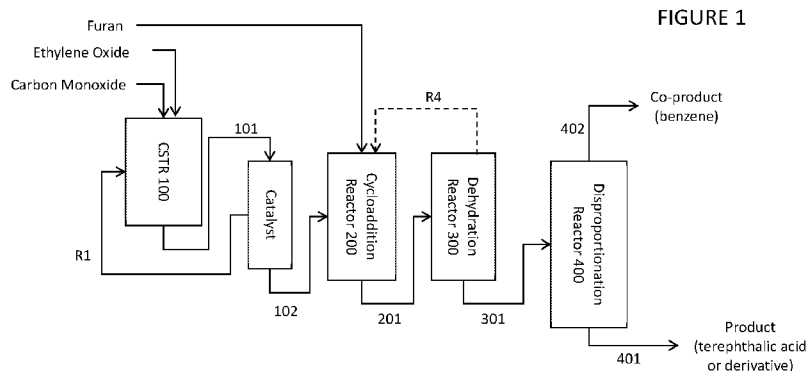
- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, 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:**
23 February 2017

(54) **Title:** METHODS FOR COPRODUCTION OF TEREPHTHALIC ACID AND STYRENE FROM ETHYLENE OXIDE



(57) **Abstract:** The present invention provides methods for the production of terephthalic acid and derivatives thereof using ethylene oxide, carbon monoxide and furan as feedstocks. The process is characterized by high yields and high carbon efficiency. The process can utilize 100% biobased feedstocks (EO via ethanol, CO via biomass gasification, and furan via known processes from cellulosic feedstocks). In one aspect, processes of the invention coproduce biobased terephthalic acid and biobased styrene.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/040534

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.: 7,8
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:

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 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.:

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.

A. CLASSIFICATION OF SUBJECT MATTER**C07C 51/31(2006.01)i, C07C 63/26(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)

C07C 51/31; C07C 51/347; B32B 1/02; C07C 51/353; B32B 27/00; C07C 63/26

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), STN(Registry, CAplus), Google & Keywords: terephthalic acid, furan, ethylene oxide, carbon monoxide, beta propiolactone, acrylic acid, biomass**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4230885 A (WU, YULIN) 28 October 1980 See column 1, lines 57-61.	1-6, 11
Y	SLOWIK, MIKE et al., "Catalytic conversion of waste carbon monoxide to valuable chemicals & materials." Clean Technology, 2010, pages 283-286 See page 283; and figure 1, 2.	1-6, 9-18
Y	MAHMOUD, EYAS et al., "Production of benzoic acid from biomass-derived furan and methyl acrylate using Lewis-acidic zeolites." In Catalysis at the Confluence of Science and Technology, NAM24 PITTSBURGH, PA, 15 June 2015, pages 1-2 See page 1; and scheme 1.	1-6, 9-18
Y	US 2009-0246430 A1 (KRIEGER, ROBERT M. et al.) 1 October 2009 See abstract; and claim 23.	9-18
A	TACHIBANA, YUYA et al., "Synthesis and verification of biobased terephthalic acid from furfural." Scientific Reports, 4 February 2015, vol. 5, no. 8249, pages 1-5 See figure 1.	1-6, 9-18



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 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

16 January 2017 (16.01.2017)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/040534

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4230885 A	28/10/1980	None	
US 2009-0246430 A1	01/10/2009	AU 2009-229151 A1	01/10/2009
		AU 2010-221723 A1	10/09/2010
		BR PI0910239 A2	29/09/2015
		BR PI1007844 A2	23/02/2016
		CA 2718279 A1	01/10/2009
		CA 2754220 A1	10/09/2010
		CN 101970530 A	09/02/2011
		CN 102341432 A	01/02/2012
		CN 103483566 A	01/01/2014
		CN 103497317 A	08/01/2014
		CN 105254858 A	20/01/2016
		CN 105254859 A	20/01/2016
		EP 2265659 A2	29/12/2010
		EP 2265659 A4	04/06/2014
		EP 2403894 A2	11/01/2012
		EP 2403894 A4	07/11/2012
		EP 2403894 B1	01/06/2016
		JP 2011-527348 A	27/10/2011
		JP 2012-519748 A	30/08/2012
		JP 2014-040591 A	06/03/2014
		JP 2015-206055 A	19/11/2015
		JP 2016-020503 A	04/02/2016
		JP 5784510 B2	24/09/2015
		MX 2010009905 A	30/09/2010
		MX 2011009199 A	28/09/2011
		MX 337582 B	11/03/2016
		RU 2010142201 A	10/05/2012
		RU 2011137326 A	10/04/2013
		RU 2013147310 A	27/04/2015
		RU 2513520 C2	20/04/2014
		RU 2569371 C2	27/11/2015
		TW 201002756 A	16/01/2010
		TW 201127870 A	16/08/2011
		TW I504632 B	21/10/2015
		US 2010-0028512 A1	04/02/2010
		US 2011-0262669 A1	27/10/2011
		WO 2009-120457 A2	01/10/2009
		WO 2009-120457 A3	26/11/2009
		WO 2010-101698 A2	10/09/2010
		WO 2010-101698 A3	24/02/2011