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(54) Title: RECYCLABLE, BIODEGRADABLE, AND INDUSTRIALLY COMPOSTABLE FOAMS, AND METHODS OF MANUFACTURING THE SAME

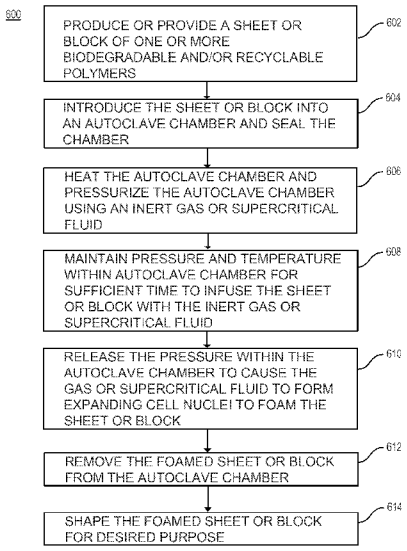


FIG. 6

(57) Abstract: A process for producing a flexible foam includes introducing a polymer into an autoclave chamber or mold cavity, pressurizing the autoclave chamber or mold cavity to an elevated pressure using a supercritical fluid, maintaining the elevated pressure within the autoclave chamber or mold cavity for a sufficient time to infuse the supercritical fluid into the polymer, reducing the pressure within the autoclave chamber or mold cavity to cause the infused supercritical fluid to form cell nuclei throughout the polymer, and allowing the cell nuclei to expand to form a foam from the polymer within the autoclave chamber or mold cavity. The polymer is composed of one or more non-cross-linked thermoplastic polymers that are recyclable and/or biodegradable. The polymer may be introduced into the autoclave chamber of mold cavity as a solid sheet or block, or the polymer may be dissolved in a solvent.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B29C 44/34, C08J 9/12 (2024.01)
ADD. C08J 9/18, C08J 9/228 (2024.01)

CPC - INV. B29C 44/3453, B29C 44/348, C08J 9/122
ADD. C08J 9/18, C08J 9/228, Y10S 264/13, C08J 2203/06, C08J 2203/08

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)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

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 5,158,986 A (Cha et al.) 27 October 1992 (27.10.1992); col 1, ln 5-15, col 4, ln 10-20, col 6, ln 5-6, col 7, ln 29-40, col 9, ln 40-70, col 10, ln 24-26, col, 12, ln 1-10, Fig. 14, 17	1-8, 11-20 ---------- 9-10, 21
Y	US 2019/0351592 A1 (Falken) 21 November 2019 (21.11.2019); abstract, Fig. 1, para [0041], [0150]	9-10, 21
A	US 6,328,916 B1 (Nishikawa et al.) 11 December 2001 (11.12.2001); entire document	1-21
A	Santiago et al. "Supercritical CO2 Foaming of Thermoplastic Materials Derived from Maize: Proof-of Concept Use in Mammalian Cell Culture Applications" PLOS one. 10 April 2015 (10.04.2015) pg. 1-22; entire document	1-21
A	WO 2019/178154 A1 (NIKE INNOVATE C.V.) 19 September 2019 (19.09.2019); entire document	1-21

☐ 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
"D" document cited by the applicant in the international application
"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
06 June 2024	JUL 15 2024
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. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 24/16793

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.: 22-34
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 supplemental page)

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.:

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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--continued from Box No. III--

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 searched, the appropriate additional search fees must be paid.

Group I: Claims 1-12 and (20-21)/(1-12), directed to a method for producing a foam comprising introducing a polymer sheet or block into an autoclave chamber, pressurizing the autoclave chamber to an elevated pressure using a supercritical fluid and reducing the pressure within the autoclave chamber to cause the infused supercritical fluid to form cell nuclei throughout the polymer sheet or block.

Group II: Claims 13-19 and (20-21)/(13-19), directed to a method for producing a foam comprising placing a polymer sheet or block into a mold cavity, closing and sealing the mold cavity; heating the mold cavity to a predetermined temperature; and allowing the supercritical fluid to diffuse into the polymer sheet or block for a predetermined amount of time.

The group of inventions listed above 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:

Special Technical Features:

Group I includes the technical feature of a method for producing a foam comprising introducing a polymer sheet or block into an autoclave chamber, pressurizing the autoclave chamber to an elevated pressure using a supercritical fluid and reducing the pressure within the autoclave chamber to cause the infused supercritical fluid to form cell nuclei throughout the polymer sheet or block, which is not required by any other invention of Group II.

Group II includes the technical feature of a method for producing a foam comprising placing a polymer sheet or block into a mold cavity, closing and sealing the mold cavity; heating the mold cavity to a predetermined temperature; and allowing the supercritical fluid to diffuse into the polymer sheet or block for a predetermined amount of time, which is not required by any other invention of Group I.

Common Technical Features:

The inventions of Groups I and II share the technical feature of a method for producing a foam comprising a polymer sheet or block comprising one or more non-cross-linked thermoplastic polymers that are recyclable and/or biodegradable and an elevated pressure using a supercritical fluid wherein the supercritical fluid expands into the polymer sheet or block.

These shared technical features, however, do not provide a contribution over the prior art, as being anticipated by a document entitled "Supercritical CO2 Foaming of Thermoplastic Materials Derived from Maize: Proof-of Concept Use in Mammalian Cell Culture Applications" to Santiago et al. (hereinafter Santiago). Santiago discloses a method for producing a foam (pg. 1, para 2: We used supercritical CO2 to produce foams from thermoplasticized maize derived materials) comprising a polymer sheet or block (pg. 4, para 2: thermoplastic slabs) comprising one or more non-cross-linked thermoplastic polymers that are recyclable and/or biodegradable (pg. 6, Table 1: TPS - thermoplasticized starch) and an elevated pressure using a supercritical fluid (pg. 4, para 4; pg. 6, top para: pressurized with CO2 until a set point of 15 MPa and 70°C was reached) wherein the supercritical fluid expands into the polymer sheet or block (pg. 7, Fig 2C-D).

As said compound was known in the art, these cannot be considered special technical features that would otherwise unify the inventions of Groups I and II. The inventions of Group I or II thus lack unity under PCT Rule 13.

Note: Claims 22-34 have been found to be unsearchable because they are not drafted in accordance with the second and third sentences of Rule 6.4(a).