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(54) **Title**: NATURAL FIBER OR FIBROUS MATERIAL BASED COMPLETELY BIODEGRADABLE FOOD CONTAINERS

(57) **Abstract**: Completely biodegradable disposable food containers or boxes made from natural fibers or fibrous materials, where the natural fibers include, but are not limited to: jute, coir, banana, and/or bagasse that have considerably different properties and structure than cardboard. The fibers can be used alone or in combination with other fibers or polymers, and can be combined with a binder and/or filler to form a composite for making any shape, size or configuration biofiber food container. The biodegradable containers made are not restricted to food applications, but could also be used for packaging commodity products such as electronics, textiles, metallic products etc.

Natural Fiber or Fibrous Material based Completely Biodegradable Food Containers

Description

Food packaging is one of the largest industries in the world and consumes considerable amount of materials. Currently, a majority of the foods are packaged using synthetic polymers such as polyethylene, polypropylene and the like, or aluminum foils. Although these materials are widely used since they have excellent properties and low cost, they are non-biodegradable and pose a large risk to the environment when disposed in the environment. In addition to plastics and aluminum, considerable amount of food are also packaged in paper boxes. Although paper is biodegradable, paper is derived from non-renewable sources such as wood and is also expensive. Our invention pertains to replacing the current food packaging with those made from fibrous materials. The packaging materials used in our invention are made from completely renewable resources and the packages themselves degrade completely in the environment.

Our invention also pertains to using agricultural residue or byproduct based fibrous materials instead of the traditional natural fibers such as jute, cotton, wool, silk etc. The packaging materials are intended for packaging processed, unprocessed, ready-to-eat, carry out and other types of food. The packaging materials can also be used to pack carry-out items such as pizzas, bakery products, confectionary and other items. Other materials that can be packed include cereals, grains, dairy products, fruits, nuts etc.

The form of the packaging materials can be in rectangular, cylindrical, square or any other form depending on the application. In addition to food packaging the materials developed could also be used to wrap or pack non-food items including clothes, electronics, toys, construction and building materials, medicine and pharmaceuticals, chemicals etc.

The packaging materials can be made from a single layer or a multiple layer of fibers. Some of the fibers that are considered for making the completely biodegradable packaging materials include but not limited to coir, banana, corn stalk, cornhusk, rice straw, wheat straw and other agricultural residues. The packaging boxes can be directly made using these fibrous materials or using the fibers extracted from the agricultural residues. In addition to these, other agricultural residues such as coconut shells, sugarcane bagasse, rice husk and similar materials made used in 100% form or as blends with other materials. These agricultural materials can be used in their native form or chemically and/or physically processed depending

on the requirement. Physical modifications including cutting, shearing or powdering and separating into individual or bundles of fibers. Chemical modifications including acetylation, etherification, grafting etc.

Preferably, the packaging material consists of a fibrous material as the reinforcement and a matrix (binder). The binder will be chosen from agricultural product or byproduct that is completely biodegradable. Examples of the binders (matrix) to be considered include but not limited to protein based resins (soy resin, gluten resin), proteins in their native form, proteins extracted from non-edible and edible oil meals. In addition, the matrix can be a carbohydrate such as alginate or cellulose or hemicellulose. Further, the matrix can also be a completely biodegradable synthetic polymer such as poly(lactic acid).

Method of preparing the packaging material could be injection, compression, resin transfer molding or any other suitable method. Fiber and resin can be mixed before or during the molding process. Ratio of the fiber and resin can be from 3 to 99% and vice versa. In addition to the reinforcement and matrix, other chemicals such as plasticizers, preservatives, colorants, bleaching agents, brighteners could be included in the packaging material. The packaging material developed could be further subject to processing including molding to desired shape, painting, printing etc. Another approach to make the packaging material is the pulping method similar to that used in the paper industry.

Examples

Example 1: A specific example of the embodiment is a coir fiber -wheat protein composite containing about 50% fibers and 50% proteins. The two materials are mixed together and compression molded to form a composite. Density of the composite varies from 500 to 2500 g/cm^3 with thickness from 0.2 to 5 mm. Coir fibers were used in their native form and had diameters ranging from 250 to 700 µm. Composites developed had tensile strength of 7-12 MPa, elongation from 2 to 20% depending on the thickness, density and ratio of the fiber and binder. These packaging materials were particularly considered to be suitable for packaging pizzas and bakery products.

Example 2: Banana fibers (extracted from the pseudo stem) were combined with neem or pongamia oil cake and compression molded to form the packaging material. Instead of using the raw meal, proteins were extracted from the meal and combined with the fibers to form the composites. These materials had moisture absorption ranging from 3 to 10%.

Example 3: Coir fibers, powdered coconut shell powders were mixed with soyprotein and compression molded into composites. Addition of coconut shell powder decreased moisture absorption and increased strength. These packaging materials were considered to be particularly suitable for packaging cereals, medicines and other materials with low hydrophilicity.

Example 4: Rice husk was combined with protein powder and made into a slurry. The slurry was allowed to stay overnight and later poured onto a belt or a plate and allowed to dry. The dried material was considered to be suitable for packaging cookies and other products.

Example 5: Materials mentioned in examples 1 to 4 but the binder being commercially available alginate. The alginate was dissolved in water and added into the reinforcing materials. The mixture was poured onto plates or on a belt and made in to packaging material as described in example 4.

Example 6: Fibers extracted from the stem of castor oil plant were mixed with poly(vinyl alcohol) and cast into composites. The composite was dried and compressed under heat into a box.

Example 7: The materials described in examples 1 to 5 which were further compressed into desired shape, painted, embossed or labelled to denote a particular product(s).

The above descriptions are examples of the materials, processes and intended application of the packaging materials. Considerable variations and deviations are expected as and when new materials and processed are followed.

Natural Fiber or Fibrous Material based Completely Biodegradable Food Containers

Claims

We claim,

1. Completely biodegradable food containers made using fibers or fibrous materials as reinforcement and an biopolymer based matrix
2. Where in the fiber is described as a bundle of single cells (fibers) and unlike those in pulp used to prepare the cardboards and corrugated boxes
3. The biodegradable food containers containing fibers alone or in combination with other natural fibers, binders, fillers or materials resulting in a composite
4. Biodegradable food containers made using natural fibers including but not limited to cotton, linen, jute, banana, coir and the like where the fibers are composed of about 30-50% cellulose, 30-50% hemicellulose and 5-30% lignin. Fibers can also be derived (extracted) from agricultural wastes such as stems, leaves and husks of plants or fruits or agricultural byproducts such as sugarcane bagasse that are used in their natural form or treated using chemical and/or physical approaches.
5. Fibrous food containers wherein the fibers act as reinforcement and contain a natural polymer as binder. The binder could be a protein such as soyprotein, wheat gluten, collagen, a polysaccharide such as starch, cellulose and alginate. Proteins can be also exracted from agricultural byproducts such as oil meals. The food containers may have an additional protective layer also made using biopolymers.
6. The food containers wherein the matrix or binder is the oil meal or a chemically modified (for example etherification, esterification, grafting etc) oil meal or one or several components in the oil meals that have been derived or extracted from oil meals with chemical and/or physical modifications.
7. A biodegradable fiber based food containers in any size, shape and in single or multiple layers that is intended for single use or multiple uses.
8. The food containers in which the fiber or any other component can be extracted and reused to form the food containers or other material.
9. Fibers used in the food containers in the form of natural fibers or the fibers being processed into particles, yarns, fabrics, non-wovens, knitted structures or any other form excepting pulp. The fibers, yarns of fabrics can also be obtained from used or discarded textiles or commodity products.
10. Biodegradable food containers containing chemicals or additives that assist in improving the performance and/or degradability of the containers where in such additives are less than 40% by weight of the food containers.
11. The containers developed in this invention also usable for non-food applications including but not limited to packaging commodity products, electronics, textiles, metallic parts and other goods.

AMENDED CLAIMS
received by the International Bureau on 12 October 2016 (12.10.2016)

[Claim 1] A completely biodegradable food container comprising a composition comprising a biopolymer based matrix and fibers or fibrous materials as reinforcement.]

[Claim 2] [The food container of claim 1, wherein the fiber is a bundle of single fibers and does not comprise pulp.]

[Claim 3] [The food container of claim 1, wherein the composition further comprises natural fibers, binders, or fillers].

[Claim 4] [The food container of claim 1, wherein the fibers or fibrous materials comprise cotton, linen, jute, banana, coir or the like, wherein the fibers or fibrous materials comprise about 30-50% cellulose, 30-50% hemicellulose and 5-30% lignin, wherein the fibers or fibrous materials optionally further comprise fibers extracted from agricultural wastes, stems, leaves or husks of plants or fruits, agricultural byproducts, sugarcane bagasse in their natural form, or sugarcane bagasse treated with chemical and/or physical treatment].

[Claim 5] [The food container of claim 1, wherein the biopolymer based matrix is a binder comprising a protein, soy protein, wheat gluten, collagen, a polysaccharide, starch, cellulose, alginate, protein extracted from agricultural byproducts, or oil meals, wherein the food container optionally comprises a protective layer comprising biopolymers].

[Claim 6] [The food container of claim 1, wherein the biopolymer based matrix comprises oil meal, an oil meal chemically modified optionally by etherification, esterification, or grafting, or at least one component derived or extracted from oil meal].

[Claim 7] [The food container of claim 1, wherein the food container has any size and shape, wherein the food container comprises single or multiple layers, and wherein the food container is capable of carrying food.]

[Claim 8] [The food container of claim 1, wherein the fibers or fibrous materials or the biopolymer based matrix are capable of being extracted and reused to make another food container or other article].

[Claim 9] [The food container of claim 1, wherein the fibers or fibrous materials comprise: natural fibers; fibers processed into particles, yarns, fabrics, non-wovens, knitted structures or any other form that is not pulp; or fibers, yarns, or fabrics obtained from used or discarded textiles or commodity products].

[Claim 10] [The food container of claim 1, wherein the composition further

comprises chemicals or additives that assist in improving the performance and/or degradability of the food container, wherein the chemicals or additives are less than 40% by weight of the food container.]

[Claim 11] [The food container of claim 1, wherein the food container is suitable for non-food applications, packaging commodity products, electronics, textiles, metallic parts, and other goods.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C08L 3/02, 97/02; D02G 3/02, 3/40 (2016.01)
CPC - C08L 3/02, 97/02; D02G 3/02, 3/042, 3/404
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): A01N 65/00; C08L 3/02, 97/02; D02G 3/02, 3/36, 3/40 (2016.01) CPC: A01N 65/00; C08L 3/02, 97/02; D02G 3/02, 3/042, 3/36, 3/404; Y10T 428/1352; USPC: 162/91, 95-99; 426/89, 138; 428/35.6, 35.7

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, RU, AT, CH, TH, BR, PH, INPADOC Data); Google Scholar; Google; EBSCO; biodegradable, decomposable, eco-friendly, ecological, green, recycle, environmentally friendly, renewable, comestible, food, container, box, carton, package, fibers, fibrous, cotton, linen, jute, banana, coir, coconut, sugarcane bagasse, biopolymer, natural

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 5,922,379 A (WANG, SH) 13 July 1999; column 1, lines 7-11; column 2, lines 35-45, 56-65; column 3, lines 36-60; column 6, lines 28-43; column 8, lines 41-42; column 12, lines 27-29; column 11, sample 1 in table 3; claims 7, 25	1, 3-4 --- 2, 5-6, 10, 11/1
X --- Y	DE 10 2005 031 250 A1 (CROPP, DR., RSA et al.) 18 January 2007; see translation; paragraphs [0003], [0008], [0010]-[0016]	7-9 --- 6, 10, 11/7
Y	US 2007/0199669 A1 (YANG, Y et al.) 30 August 2007; paragraphs [0006], [0011], [0014], [0028]	2
Y	US 2007/0292643 A1 (RENN, DW) 20 December 2007; abstract; paragraphs [0002], [0010], [0018], [0020]	5, 11/1, 11/7
A	(CENGIZ, M et al.) Fractional extraction and structural characterization of opium poppy and cotton stalks hemicelluloses. Pharmacognosy Magazine. 2010. vol. 6. issue 24; page 316, third paragraph; table 1	4
A	US 2012/0135170 A1 (MELDAL, M et al.) 31 May 2012; entire document	1-10, 11/1, 11/7
A	US 2010/0086714 A1 (SATO, S) 08 April 2010; entire document	1-10, 11/1, 11/7
A	(VIGNESWARAN, C et al.) Banana Fiber: Scope and Value Added Product Development. Journal of Textile and Apparel, Technolgy and Management. 2015. vol. 9. issue 2; entire document	1-10, 11/1, 11/7

☐ 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
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"O" document referring to an oral disclosure, use, exhibition or other means
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"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
15 July 2016 (15.07.2016)	12 AUG 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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