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(54) **Title:** FIBERS COMPRISING CULTIVATED MICROALGAE, METHOD FOR MANUFACTURING THE SAME, AND YARNS, FABRICS AND GARMENTS COMPRISING SUCH FIBER

(57) Abstract: The present invention is directed to fibers, yarns and fabrics comprising at least one cultivated microalgae.

FIBERS COMPRISING CULTIVATED MICROALGAE, METHOD FOR MANUFACTURING THE SAME, AND YARNS, FABRICS AND GARMENTS COMPRISING SUCH FIBER

TECHNOLOGICAL FIELD

The present invention is directed to fibers, yarns and fabrics comprising at least one cultivated microalgae.

BACKGROUND

The unique properties of algae help to protect our skin against the harmful environmental influences which we are exposed to in our daily lives. The algae are pure and rich in essential substances such as vitamins, trace elements, amino acids and minerals.

The substances found in algae help to activate cell regeneration, which in turn can help to relieve skin diseases, reduce inflammation and soothe itchiness. Its high level of antioxidants protects the skin against harmful free radicals, which damage our skin cells.

The natural moisture level of the skin enables an active exchange of those beneficial substances between the fiber and the skin, providing a noticeable sense of wellbeing.

DETAILED DESCRIPTION OF EMBODIMENTS

The present invention provides a fiber comprising at least one cultivated microalgae.

The term "***fiber***" should be understood to encompass a thread (being significantly longer than it is wide) that can be used to make a yarn, fabric, knitted, woven, nonwoven fabric, cloth, paper, having a length longer than it is width. In some embodiments, said fiber is used in the preparation of a fabric.

The term ***"microalgae"*** should be understood to encompass are unicellular photosynthesis forming species which exist individually, or in chains or groups, having a size that can range from a few micrometers (pm) to a few hundreds of micrometers. Microalgae do not have roots, stems, or leaves. Microalgae biomass is typically measured with chlorophyll concentrations.

In some embodiments, said at least one cultivated microalgae is selected from red algae, brown algae, green algae, red algae, blue algae and mixtures thereof. In other embodiments, said at least one cultivated microalgae is a red microalgae. In yet further embodiments, said at least one cultivated microalgae is selected from Porphyridium, Rhodella, Dunaliella salina, Haematococcus pluvialis, Chlorella vulgaris, Chlorella sorokinara, Spirulina platensis, Nannochloropsis gaditana, Tetraselmis sp., Chlorella vulgaris, Spirulina, Haematococcus pluvialis, Spirulina platensis and any combinations thereof.

The present invention further provides a fiber comprising at least one cultivated algae.

The natural types of microalgae are usually found in freshwater and marine systems living in both the water column and sediment, however, the microalgae used in the present invention are ***"at least one cultivated microalgae "*** thus, they are grown and cultured outside their natural marine environment, in regulated and controlled environments. Thus, in some embodiments, said at least one cultivated microalgae is grown/cultivated outside a natural marine environment (the at least one cultivated microalgae used in the present invention are not harvested from a marine or natural water source). For example, in some embodiments, said at least one cultivated microalgae is grown/cultivated in a microorganism growth apparatus. An example of a microorganism growth apparatus, including a process for growing said microalgae in the apparatus can be found in US5534417, which is herein incorporated in its entirety.

The cultivation process of growing said microalgae used in the present invention is capable of customizing the contents and thus, the properties of the fiber, yarn and fabric

of the invention. Microalgae typically contain proteins, fatty acids (palmitic, palmitoleic, stearic, oleic, linoleic, arachidonic, EPA), vitamins (C, Bl, B2, B6, E, Zeaxanthin) and minerals (Na, Ca, Se, Fe, Mg, Al, Zn, Mo, I), Astaxanthin, Phycocyanin, Oleoresin that are beneficial for human conditions, especially dermatological conditions. Thus, the cultivation process is able to provide microalgae with specific combination of proteins, fatty acids vitamins and minerals beneficial for a specific condition of the skin. The combination of fatty acids, vitamins and minerals of a cultivated microalgae can be customized to provide antioxidant, antimicrobial, antiviral and anti-irritating properties to the fiber, yarn and fabric of the invention.

In some embodiments, a fiber of the present invention comprises at least 5%wt of said at least one cultivated microalgae. In some other embodiments, said at least one cultivated microalgae comprises between about 5% to 90% of the fiber. In some other embodiments, said at least one cultivated microalgae comprises between about 5% to 95% of the fiber. In some other embodiments, said at least one cultivated microalgae comprises between about 5% to 99% of the fiber. In some other embodiments, said at least one cultivated microalgae comprises about 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100% of the fiber.

In some embodiments, said fiber of the invention is a cellulose base fiber. Such fibers are prepared from ethers or esters of cellulose, which can be obtained from the bark, wood or leaves of plants, or from other plant-based material. In addition to cellulose, the fibers may also contain hemicellulose and lignin, with different percentages of these components altering the mechanical properties of the fibers. The preparation and properties of cellulose based fibers are disclosed in the following publications which are herein incorporated by reference: (i) Z. *A. Rogowin, Chemiefasern: Chemie - Technologie 1982, Thieme Verlag, Stuttgart - New York, Page 121;* (ii) *http://www.madehow.com/Volume-5/Lyocell.html* Access date: 02.07.2018; (iii) http://textilelibrary.weeblv.com/cuprammonium-ravOn-mfg-process.html Access date: 02.07.2018; (iv) http://mrtx.co.jp/en/sozai/acetate.html Access date: 02.07.2018.

In some embodiments, said cellulose based fiber is selected from viscose, lyocell, cupro, acetate, modal, nitrocellulose and any combinations thereof.

In some embodiments, said fiber of the invention is a protein based fiber. Such protein based fibers comprise fibrous proteins or protein filaments which include, among others collagen family of proteins, Polylactic acid (PLA), tendon, actin, cell proteins like microtubules and others, spider silk, sinew and hair etc.

In other embodiments, a fiber of the invention is a petroleum based fiber.

Common petroleum based fibers include, but are not limited to: Nylon, Modacrylic, Olefin, Acrylic, Polyester, Rayon (artificial silk), Vinyon, Saran, Spandex, Vinalon , Aramids (Nomex), Kevlar, Twaron, Dyneema/Spectra, PBI (Polybenzimidazole fiber), Sulfar, M-5 (PIPD fiber), Orlon, Zylon (PBO fiber), Vectran (TLCP fiber) made from Vectra LCP polymer, Derclon, Acrylonitrile rubber and any combinations thereof.

In some embodiments a fiber of the invention is being formed by melt spinning. The process of melt spinning is known in the art, for example from *D. R. Salem, Structure Formation in Polymeric Fibers 2001, Hanser, Munchen,* which is herein incorporated by reference.

In some other embodiments, a fiber of the invention is being formed by dry spinning. The process of dry spinning is known in the art, for example from A. *Ziabicki, Fundamentals of Fibre Formation - The Science of Fibre Spinning and Drawing 1976, Wiley-Interscience, London,* which is herein incorporated by reference.

In other embodiments, a fiber of the invention is being formed by wet spinning (in some embodiments by jet air wet spinning). The process of wet spinning is known in the art, for example from Z. *K. Walczak, Processes of Fiber Formation 2002, Elsevier, Amsterdam, Page 268,* whichis herein incorporated by reference.

In some embodiments, a fiber of the present invention further comprises at least one of cellulose, saccharide, protein, amino acid, vitamin, metal ion or any combinations thereof.

In some embodiments, vitamin is selected from the group consisting of ascorbic acid, tocopherol, carotene, vitamin B3, vitamin K, riboflavin, thiamin, folic acid, folinic acid, biotin, vitamin A, vitamin B6, vitamin B12 and any combinations thereof.

In further embodiments, said metal ion is selected from the group consisting of aluminum, antimony, barium, boron, calcium, chromium, iron, germanium, gold, potassium, cobalt, copper, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, rubidium, selenium, silicon, titan, vanadium, tungsten, zinc, tin and any combinations thereof.

In other embodiments, said saccharide is selected from the group consisting of monosaccharides, oligosaccharides, polysaccharides and any combinations thereof.

In other embodiments, said saccharide is selected from alginic acid, laminarin, mannitol, methylpentosanes and any combination thereof.

In further embodiments, the protein is selected from contain alanine, arginine, asparagic acid, glutamic acid, glycin, leucine, lysine, serine, threonine, tyrosine, valine, methionine and any combinations thereof.

A fiber of the invention is measured in terms of linear mass density, the weight of a given length of fiber. Various other units used to refer to the measurement of a fiber of the invention include: the denier and tex (linear mass density of fibers), worsted count, Number metric (Nm) and yield (the reciprocal of denier and tex).

The invention further provides a yarn comprising at least one fiber of the invention comprising cultivated microalgae. A yarn of the invention is defined as a long continuous length of interlocked fibers of the invention, suitable for use in the production

of textiles, sewing, crocheting, knitting, weaving, embroidery or ropemaking. The term yarn also includes a thread that is a type of yarn intended for sewing by hand or machine.

The invention further provides a woven, non-woven or knitted fabric comprising fibers of the invention. The invention further provides a nonwoven fabric comprising fibers of the invention. In some embodiments said fabric is used for preparation of a garment. In other embodiments said fabric is used in the preparation of a medical fabric. In other embodiments said fabric is used in the preparation of a cosmeceutical fabric. In other embodiments said fabric is used in the preparation of a hygienic fabric.

Due to the ability of customizing the properties of the cultivated microalgae used in the preparation of a fiber, yarn and fabric of the invention, its is possible to provide customized fabrics for different conditions, indications and needs.

Medical fabrics are defined as comfortable, safe and effective for use in healthcare facilities. Such fabrics are strong, durable, antimicrobial, antistatic, flame resistant, stain, odor, fluid resistant, and resistant to popular disinfectants when used as directed. In some embodiments, said medical fabrics further comprise additional medical agents such as antimicrobial agents, antifungal agent, anticoagulating agents and so forth. Medical fabrics may be used to cover wounds, burns, pressure ulcers, cast into plaster fixations, may be used in operation room procedures and so forth. Hygienic fabrics include hygienic pads, tampons, diapers, fabrics in contact with intimate body parts, such as underwear, means used for delivering agents or devices into the body, hygienic wet wipes, hygienic skin masks and so forth. Cosmeceutical fabrics include cosmetic and dermatological masks, fabrics used in direct contact with the skin of a subject capable of delivering nutritional elements and moisture to the skin, wet wipes, cosmetic applicators, cosmetic pads.

In a further aspect, the invention provides a method of manufacturing a fiber comprising the steps of: (a) preparing a base material comprising at least 5% of at least one at least one cultivated microalgae; (b) forming the fiber from said base material through spinneret; (c) fixating the formed fiber; (d) post-treating the fixated fiber.

In some other embodiments, said base material comprises between about 5% to 90% of at least one at least one cultivated microalgae. In some other embodiments, said base material comprises between about 5% to 95% of at least one at least one cultivated microalgae . In some other embodiments, said base material comprises between abou 5% to 99% of at least one at least one cultivated microalgae. In some other embodiments, said base material comprises about 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100% of at least one at least one cultivated microalgae.

In some embodiments of a method of the invention said base material comprises at least one protein base polymer (in some embodiments PLA) and/or petroleum based polymer (in some embodiments polyester, polyamide, olefin, polyurethane and any combinations thereof). In some embodiments, said base material is melted at step (a). In further embodiments, fiber fixation of step (c) is performed by airflow cooling. In further embodiments, fiber post-treatment of step (d) is performed by drawing.

In other embodiments of a method of the invention, said base material comprises at least one cellulose based material (in some embodiments, wood pulp, cotton linters and so forth). In some embodiments, said base material is dissolved in at least one solvent. In some embodiments said fiber fixation of step (c) is performed by evaporation of at least one solvent or precipitation of said at least one solvent. Said at least one solvent is added to the base material so as to form a solution of the cellulose based material and at least one at least one cultivated microalgae. Solvents used in such processes may be selected from NaOH solution, CS_2 solution, acetone, organic solvents, acetic anhydride, amine oxide, cuprammonium liquor, tetraaminecopper dihydroxide, N-methylmorphine N-oxide (NMMO) solution, acetic acid and combinations thereof. In some embodiments, said fiber post-treatment of step (d) is performed by drawing, washing, drying and any combinations thereof.

Example - Preparation of acetate fiber of the invention

Acetate fiber is produced by reacting high purity wood pulp and 5% crude cultivated red microalgae with acetic anhydride. The acetate flakes that are produced

through this chemical reaction are dissolved in a solvent, filtered, and adjusted to obtain spinning stock solution. The spinning stock solution is extruded through controlled nozzles with extremely small pore diameters ranging from 30 to 50μm. The solvent is then evaporated, and the yarns are formed. This process for producing acetate fiber is known as the dry spinning method. The cross-section of acetate fiber is called a "chrysanthemum," and is shaped uniquely with many lobes. After the spinning stock has been extruded through the pores, it takes on a round-shaped cross-section. However, rapid evaporation of the solvent from the surface results in the formation of a skin layer on the surface of the fiber. After that, evaporation of the solvent from the inside of the fiber causes the skin layer to cave in toward the fiber cross-section, giving rise to the final multi-lobal cross-section.

CLAIMS:

1. A fiber comprising at least one at least one cultivated microalgae .

2. A fiber according to claim 1, wherein said at least one at least one cultivated microalgae is selected from red algae, brown algae, green algae, red algae, blue algae and mixtures thereof.

3. A fiber according to claims 1 or 2, wherein said at least one at least one cultivated microalgae is a red microalgae.

4. A fiber according to claim 3, wherein said at least one cultivated microalgae is selected from Porphyridium, Rhodella, Dunaliella salina, Haematococcus pluvialis, Chorella vulgaris, Chlorella sorokinara, Spirulina platensis, Nannochloropsis gaditana, Tetraselmis sp., Chlorella vulgaris, Spirulina, Haematococcus pluvialis, Spirulina platensis and any combinations thereof.

5. A fiber according to any one of the preceding claims, wherein said at least one cultivated microalgae is grown/cultivated in a microorganism growth apparatus.

6. A fiber according to any one of the preceding claims, wherein said at least one cultivated microalgae is grown/cultivated outside a marine environment.

7. A fiber according to any one of the preceding claims wherein said at least one cultivated microalgae comprises at least 5% of the fiber.

8. A fiber according to any one of claims 1 to 7, being a cellulose base fiber.

9. A fiber according to claim 8, wherein said fiber is selected from viscose, lyocell, cupro, acetate, modal, nitrocellulose and any combinations thereof.

10. A fiber according to any one of claims 1 to 7, being a protein based fiber.

11. A fiber according to any one of claims 1 to 7, being a petroleum based fiber.

12. A fiber according to any one of claims 1 to 7, being formed by melt spinning.

13. A fiber according to any one of claims 1 to 7, being formed by dry spinning.

14. A fiber according to any one of claims 1 to 7, being formed by wet spinning.

15. A fiber according to any one of the preceding claims, further comprising at least one of cellulose, saccharide, protein, amino acid, vitamin, metal ion, fiber, unsaturated fatty acid, anti-irritating agent, anti-inflammatory agent, anti-oxidant, anti-viral agent or zeaxanthine, fluridoside any combinations thereof.

16. A fiber according to claim 15, wherein said vitamin is selected from the group consisting of ascorbic acid, tocopherol, carotene, vitamin B3, vitamin K, riboflavin,

thiamin, folic acid, folinic acid, biotin, vitamin A, vitamin B6, vitamin B12 and any combinations thereof.

17. A fiber according to claim 15, wherein said metal ion is selected from the group consisting of aluminum, antimony, barium, boron, calcium, chromium, iron, germanium, gold, potassium, cobalt, copper, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, rubidium, selenium, silicon, titan, vanadium, tungsten, zinc, tin and any combinations thereof.

18. The fibers according to claim 15, wherein said saccharide is selected from the group consisting of monosaccharides, oligosaccharides, polysaccharides and any combinations thereof.

19. The fibers according to claim 15, wherein said saccharide is selected from alginic acid, laminarin, mannitol, methylpentosanes and any combination thereof.

20. The fibers according to claim 15, wherein the protein is selected from contain alanine, arginine, asparagic acid, glutamic acid, glycin, leucine, lysine, serine, threonine, tyrosine, valine, methionine and any combinations thereof.

21. A yarn comprising fibers according to any one of claims 1 to 20.

22. A fabric comprising fibers according to any one of claims 1 to 20.

23. A fabric according to claim 22, being selected from a woven fabric, a non-woven fabric, knitted fabric, and any combinations thereof.

24. A garment comprising a fiber according to claims 1 or 20.

25. A method of manufacturing a fiber comprising the steps of: (a) preparing a base material comprising at least 5% of at least one cultivated microalgae ; (b) forming the fiber from said base material through spinneret; (c) fixating the formed fiber; (d) post-treating the fixated fiber.

26. A method according to claim 25, wherein said base material comprises at least one protein base polymer and/or petroleum based polymer.

27. A method according to claim 26, wherein said base material is melted at step (a).

28. A method according to any one of claims 25 to 27, wherein fiber fixation of step (c) is performed by airflow cooling.

29. A method according to any one of claims 25 to 27, wherein fiber post-treatment of step (d) is performed by drawing.

30. A method according to claim 25, wherein said base material comprises at least one cellulose based material.

31. A method according to claim 30, wherein said base material is dissolved in at least one solvent.

32. A method according to claims 25 or 31, wherein fiber fixation of step (c) is performed by evaporation of at least one solvent or precipitation of said at least one solvent.

33. A method according to any one of claims 25, 30 to 32, wherein fiber post-treatment of step (d) is performed by drawing, washing, drying and any combinations thereof.

INTERNATIONAL SEARCH REPORT

International application No
PCT/I L2018/051236

A. CLASSIFICATION OF SUBJECT MATTER
INV. D01FI/ 10
ADD.

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)
D01F D01D

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)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105 483 862 B (QINGDAO MINGYUE BIOMEDICAL MAT CO LTD) 27 October 2017 (2017-10-27) abstract examples 1-9 claims 1-3	1-33
X	KR 2014 0022575 A (INHA IND PARTNERSHIP INST [KR]) 25 February 2014 (2014-02-25) claims 1-8 example 1	1-33
X	US 2011/307976 A1 (PLOECHINGER HEINZ [AT]) 15 December 2011 (2011-12-15) claims 1,2,34-49 paragraphs [0067] - [0070] figures 1-6	1,2,4-7, 21-24

☐ 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

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"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

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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
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/I L2018/051236

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 105483862 B	27-10-2017	NONE	
KR 20140022575 A	25-02-2014	NONE	
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