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(54) Title: NOVEL YARN AND FABRIC

(57) **Abrégé/Abstract:**

The present invention aims to provide a fabric useful in production of clothes and other textile articles, in particular for use in a healthcare environment such as hospitals, long term care facilities, etc. The invention relates to a yarn consisting essentially of cotton fibres, hemp fibres, and fibres comprising porous particles, and to threads and fabrics comprising such yarns, as well as to the use of such clothing as healthcare staff uniforms. The yarn and fabric may further include at least one metal wire usable as a temperature sensor.

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(54) Title: Novel yarn and fabric

(57) **Abstract:** The present invention aims to provide a fabric useful in production of clothes and other textile articles, in particular for use in a healthcare environment such as hospitals, long term care facilities, etc. The invention relates to a yarn consisting essentially of cotton fibres, hemp fibres, and fibres comprising porous particles, and to threads and fabrics comprising such yarns, as well as to the use of such clothing as healthcare staff uniforms. The yarn and fabric may further include at least one metal wire usable as a temperature sensor.

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Novel yarn and fabric

Field of the invention

The present invention relates to the field of textiles and garments, and in particular to new combinations of fibres in production of yarns and fabric made from such yarns.

Background

Healthcare-associated infections (HAI) are a major problem worldwide. It has been reported that about 6% of in-patients in Europe present with one or more healthcare associated infections during the hospital stay. In long-term care facilities, the prevalence of HAI has been estimated to 3.4% (European Centre for Disease Prevention and Control; Technical report: Assessment of infection control, hospital hygiene capacity and training needs in the European Union, 2014). The cost for hospital acquired infections in Sweden is estimated to 6.5 *10⁹ SEK per year.

The ability of bacteria to survive on various surfaces in a hospital is a key aspect in transfer of bacteria in a hospital setting and textiles are recognized as the second largest cause of HAI. It has been found that various Enterococci and Staphylococci survive for at least four days on hospital textiles made of pure cotton and for at least one day on cotton/polyester blends. In some instances, the bacteria survived for more than 90 days. (Neely and Maley, J Clin Microbiol, Feb 200, 724-726).

Hospital guidelines generally require that clothes used by healthcare staff are changed at least once per day and always after contamination. Washing and drying of staff uniforms thus require a significant amount of energy. Frequent washing and drying also wear at the fabric and reduces the lifetime of the clothes. Using stronger or thicker and thus more wear-resistant fabric often necessitates a trade-off between wear-resistance and comfortability of the clothes.

It has been suggested to treat textiles with silver ions (Ag⁺) or nanosized silver colloids to achieve an antimicrobial effect (Lee et al. Journal of Materials Science (2003) 38: 2199). However, such textiles may be prone to leaking silver ions into the environment, in particular in connection with washing, and thus have a significant detrimental effect on the environment.

It is also known in the art to provide temperature sensors in healthcare garments in order to monitor the usage cycle of the garment, and in particular that the garment is washed at an adequate wash temperature after being worn, see e.g. WO2017/099658. Fabrics including metal wires usable as temperature sensors are known through e.g. WO2005083164.

Summary of the invention

The present invention recognizes the above problems and aims to provide a fabric useful in production of textile articles, and in particular production of textile articles such as staff uniforms, labcoats, patients' clothing, towels, bedsheets, drapes etc., for use in a healthcare environment such as hospitals, long term care facilities, etc. Such textile articles are in particular useful in facilities where sensitive patients are treated, such as infants, in particular prematurely born infants, immunocompromised patients, and generally fragile patients such as patients in intensive care units and elderly patients, who can be seriously affected even by otherwise harmless infections.

The fabric has antimicrobial properties, i.e. microorganisms contaminating the fabric do not grow or replicate to any significant degree thereby reducing the risk of transmitting the bacteria to other patients, staff members, visitors or other persons. The fabric is also wear-resistant, comfortable to wear, requires less energy to dry as compared to standard healthcare uniforms made of cotton and/or polyester, has a high tensile strength and good dimensional stability, and does not leak antimicrobial substances to the environment.

The yarn may also incorporate at least one metal wire that can be used as a temperature sensor.

Thus, in a first aspect the present invention relates to yarn consisting essentially of cotton or rayon fibres, hemp fibres, and fibres comprising porous particles, and a yarn consisting essentially of cotton or rayon fibres, hemp fibres, fibres comprising porous particles, and furthermore polyester and/or a metal wire.

In a further aspect, the invention relates to a thread comprising at least two yarns according to the invention.

In a further aspect, the invention relates to a fabric comprising at least one yarn according to the invention, and/or at least one thread according to the invention.

The thread and/or fabric of the invention may further include at least one metal wire usable as a temperature sensor.

In a further aspect, the invention relates to the use of clothing made of a fabric according to the invention as healthcare staff uniforms.

Preferred embodiments are disclosed in the dependent claims.

Definitions

All words and terms used in the present specification are intended to have the meaning given to them by the person of ordinary skill in the art. For the sake of clarity, a few terms are however specifically defined below.

A “fibre” is a single filament of a material that can be natural (i.a. cotton, linen, wool, hemp) or artificial (i.a. polyester, metal, nylon, carbon fibre, glass).

A “particle” is a body having substantial extension in three dimensions, i.e. having a breadth, width and height. The outer surface of a particle defines a volume of the particle. Porous particles have one or more pores extending from the surface into the interior of the particle. A particle may be generally spherical, cubic, or irregular.

A “yarn” is a spun agglomeration of fibres.

A “thread” comprises multiple yarns plied together.

All percentages are given as percentages of weight, unless otherwise indicated.

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Detailed description

The present invention relates in a first aspect to a yarn comprising cotton or rayon fibres, hemp fibres, and fibres comprising porous particles and consisting essentially of these three types of fibre and optionally also polyester and/or a metal wire.

15 In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of cotton fibres, hemp fibres, and fibres comprising porous particles.

In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of rayon fibres, hemp fibres, and fibres comprising porous particles.

20 In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of cotton or rayon fibres, hemp fibres, fibres comprising porous particles, and metal wire(s).

In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of cotton fibres, polyester fibres, hemp fibres, and fibres comprising porous particles.

25 In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of rayon fibres, polyester fibres, hemp fibres, and fibres comprising porous particles.

In one embodiment, the yarn consist at least to 95%, such as 96%, 97%, 98%, 99% or 100%, of a mix of cotton or rayon fibres, polyester fibres, hemp fibres, fibres comprising porous particles, and metal wire(s).

30 Cotton fibres, rayon fibres, polyester and hemp fibres are well-known commodities in the art of yarn and textile manufacture and commercially available from a multitude of suppliers.

Hemp (*Cannabis sativa* L.) is a fast-growing plant that quickly covers the ground and suppresses growth of weeds and some soil-borne pathogens, substantially reducing or even totally removing the need for herbicides, pesticides, fungicides and fertilizer and making it an environmentally friendly alternative to other fibre producing plants ("Natural Fibers, Biopolymers, and Biocomposites", Mohanty et al. (eds) CRC Press, Boca Raton, FL, USA, 2005). Hemp has natural antibacterial properties (Khan et al., BioResources 9(2), 3642-3659). Hemp has been cultivated for a variety of uses, including textiles and clothing, for thousands of years.

Rayon is a fibre manufactured from cellulose and can be manufactured in a number of varieties, types and grades, all of which may be included in the present invention. Rayon was first developed in the early 20th century and used primarily for industrial purposes. Further development and refinement of the manufacturing technique have created a whole range of fibres with improved properties. Lyocell, sold under the trade name Tencel®, was developed in the 1990s (D J Cole, 'A new cellulosic fibre – Tencel', Advances in Fibre Science, The Textile Institute, 1992). Viscose and lyocell are preferred embodiments of rayon in the present invention. Lyocell is available e.g. from Lenzing AG, Austria.

The metal wire or metal wires that may optionally be included in the yarn, thread or fabric according to the invention is preferably useful as a sensor, such as a temperature sensor. It is known that the electrical resistance of a metal wire may vary with temperature and that this may be used in temperature sensors. Metal wires may be made from a single metal or alloys, including but not limited to FeCrAl, NiCr, NiFe, CuNi, and CuMn. Such metal alloy wires are available from under the trade name Kanthal® from Sandvik AB (Sandviken, Sweden). Metal wires may also be used in a thermocouple, two wires of dissimilar metals joined at one or two points, to measure temperature. Suitable metal wires are available e.g. under the trade name EXERA™ from Sandvik AB (Sandviken, Sweden). The metal wire(s) are preferably coated with an insulating material, such as a polymer, prior to inclusion in the yarn or fabric.

Fibres comprising porous particles as used in the present invention are also known in the art and can be produced in a multitude of ways. For instance, it is known in the art (i.a. from WO9842909) to introduce UV-blocking particles into a fabric. Methods for permanently binding particles such as zeolites to cellulosic and synthetic fibres are disclosed in US5538783. Other methods are disclosed in WO03/000979 and WO03/105996.

Preferably, the porous particles have the capacity to adsorb and/or absorb water. The pore structure of the particles increases the surface area of the textile, facilitating rapid evaporation of water.

In one embodiment, the porous particles have a breadth and/or width and/or height of 1-1000 µm, such as 10-500 µm or 50-250 µm. In one embodiment, the breadth, width and height of the particles are within one or two orders of magnitude of each other.

In one embodiment, the porous particles have a specific surface area of 500 m²/g, 750 m²/g, 1000 m²/g, or more.

In an embodiment, the porous particles include charcoal or activated carbon particles. Activated carbon is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions.

In one embodiment, the porous particles include zeolites. Zeolites are aluminosilicate minerals composed mainly of aluminium, silicon, and oxygen. Zeolites are formed in nature in certain geological environments and can be obtained from e.g. some volcanic rocks. Zeolites may also be produced synthetically, with natural and synthetic zeolites being commercially available from a range of suppliers.

In other embodiments, the porous particles include silica gel, graphite, and/or aluminium oxide.

In one embodiment, the fibres comprising porous particles are polyester fibres, cotton fibres, rayon fibres, or nylon fibres.

In one embodiment, the yarn according to the invention consists essentially of 20% cotton, 55% hemp, and 25% fibres comprising porous particles.

In one embodiment, the yarn according to the invention consists essentially of 20% cotton, 35% hemp, 25% fibres comprising porous particles, and 20% polyester.

In a further aspect, the invention relates to a thread comprising at least two yarns according to the invention, and optionally at least one metal wire.

In a further aspect, the invention relates to a fabric comprising at least one yarn or thread according to the invention.

In one embodiment, the fabric according to the invention comprises a first yarn or thread according to the invention as warp and a second yarn or thread according to the invention as weft.

In one embodiment, the fabric has a warp and/or weft tensile strength of at least 700 N. This can be measured using the international standard ISO 13934-1.

In one embodiment, the fabric has a warp and/or weft tear strength of at least 30 N. This can be measured using the international standard ISO 13937-1.

In one embodiment, the fabric has a dimensional stability of $\pm 1\%$. This can be measured using the international standard BS EN ISO 26330-1A.

In one embodiment, the fabric has an improved drying time as compared to fabrics made of pure cotton, pure polyester, or polyester/cotton mixes. This can be measured using e.g. the

AATCC standard 199-2013. In one embodiment, the fabric has a drying time of less than 25 minutes as measured using the AATCC standard 199-2013. . In one embodiment, the fabric has a drying time of less than 24, 23, or 22 minutes as measured using the AATCC standard 199-2013. In one embodiment, the fabric has a drying time of about 21 minutes as measured
5 using the AATCC standard 199-2013.

In a further aspect, the invention relates to use of the fabric according to the invention in the manufacture of textile articles for use in a healthcare environment. Such articles include staff uniforms, laboratory coats, patients' clothing, towels, bedsheets, and drapes. Healthcare environments include hospitals, long-term care facilities, neonatal care units, and
10 intensive care units.

In a preferred embodiment, the yarns, threads, and fabrics according to the invention do not comprise any additional compound, agent, or material having antimicrobial activity. Such additional substances may leak from the products according to the invention and cause environmental harm. In particular, the yarns, threads and fabrics according to the invention
15 do not comprise silver, copper, or zinc, in metallic form or in salt form.

The present invention is further illustrated by means of the following examples. The examples only serve to illustrate the invention and should not be construed as limiting the scope of the invention, which is that of the appended claims. All documents cited herein as prior art are expressly incorporated by reference herein in their entirety.

20 **Example**

Yarns and threads were produced according to the invention and used as warp and weft in the production of a woven fabric according to the invention. The warp comprised 35% hemp, 20% polyester, 20% cotton, and 25% fibre comprising porous particles. The weft comprised 55% hemp, 20% cotton, and 25% fibre comprising porous particles.

25 The properties of the fabric were tested for requirements under the Swedish standard for textiles for healthcare and social services facilities (SIS-CEN/TS 14237:2016), which in turn reference standards set by the International Organization for Standardization (ISO).

Dimensional change was tested in accordance with BS EN ISO 26330-1A and was found to be -0.5% to -1.0%, which is within the tolerance of $\pm 3.0\%$ according to Swedish standards.

30 Tensile strength was tested in accordance with ISO 13934-1 and was found to be ~ 700 N (warp) and ~ 425 N (weft), which is well above the requirements of 400 N set by Swedish standards.

Tear strength was tested in accordance with ISO 13937-1 and was found to be >30 N (warp) and >20 N (weft).

The antibacterial properties of the fabric was tested using the American Association of Textile Chemists and Colorists (AATCC) standard 100-2012 for assessment of antibacterial finishes on textile materials, using the test organism *Staphylococcus aureus* (ATCC 6538). A control sample consisting of 100% cotton was used.

- 5 1 mL of inoculum comprising $\sim 1.1 \times 10^5$ cfu/mL *S. aureus* was applied to eight pieces of the fabric sample and the control sample, respectively. After 24 hours, the number of cfu per sample was counted and found to be on average <100 for the fabric sample and 4.4×10^6 for the control sample. The fabric thus shows excellent antibacterial properties.

- 10 The drying time reflects the energy required to dry the fabric and was measured using the AATCC standard 199-2013. Water absorbency times were measured using the AATCC standard 79. Two fabrics according to the invention were tested and showed water absorbency times of 6-8 seconds, a moisture retention of 96-99 % and an average drying time of 21 minutes (21.2 and 21.4, respectively). The fabric thus has an improved drying time as compared to fabrics made of pure cotton, pure polyester, or polyester/cotton blends.

- 15 The comfortability of clothes made from the fabric can be assessed by providing users of the clothes with a survey of questions relating to the comfortability of the clothes relative existing clothing. The survey results show that clothes made from fabric according to the invention are as comfortable, more comfortable, or significantly more comfortable to wear as compared to existing clothing.

Claims

1. A yarn consisting essentially of cotton or rayon fibres; hemp fibres; and fibres comprising porous particles.
- 5 2. A yarn consisting essentially of cotton or rayon fibres; hemp fibres; fibres comprising porous particles; and polyester and/or at least one metal wire.
3. The yarn according to claim 1 or 2, wherein the fibres comprising porous particles are made from polyester, cotton, rayon, or nylon.
- 10 4. The yarn according to any one of claims 1-3, wherein the porous particles are capable of adsorbing water.
- 15 5. The yarn according to any one of claims 1-4, wherein the porous particles are selected from the group consisting of charcoal, activated carbon, zeolites, silica gel, graphite, and aluminium oxide.
- 20 6. The yarn according to any one of claims 1, 3-5, consisting essentially of 20% cotton or rayon, 55% hemp, and 25% fibres comprising porous particles.
- 25 7. The yarn according to any one of claims 2-5, consisting essentially of 20% cotton or rayon, 35% hemp, 25% fibres comprising porous particles, and 20% polyester.
8. A thread comprising at least two yarns according to any one of claims 1-7, and optionally at least one metal wire.
9. A fabric comprising at least one yarn according to any one of claims 1-7, and/or at least one thread according to claim 8.
- 30 10. The fabric according to claim 8, comprising a first yarn or thread according to any one of claims 1-8 as warp and a second yarn or thread according to any one of claims 1-8 as weft.
- 35 11. The fabric according to any one of claims 9 or 10, wherein the warp and/or weft tensile strength is at least 700 N.
12. The fabric according to any one of claims 9-11 wherein the warp and/or weft tear strength is at least 30 N.

13. The fabric according to any one of claims 9-12, having a dimensional stability of $\pm 1\%$.

14. The fabric according to any one of claims 9-13, having a drying time of less than 25 minutes as measured using the AATCC standard 199-2013.

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15. Use of a fabric according to any one of claims 9-14 in the manufacture of textile articles for use in a healthcare environment.