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(54) A 100% POLYPROPYLENE FABRIC

(57) The present invention relates to a textile fiber and a pure polypropylene fabric and its applications in the clothing and linen production sector.

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Description

[0001] According to the Intergovernmental Panel on Climate Change (IPCC), the fashion industry produces 10% of global carbon dioxide emissions each year and is estimated to use around 1.5 trillion liters of water annually.

[0002] Textile waste represents a significant problem; the World Economic Forum reported in 2020 that an estimated 18.6 million tons of clothing would end up in landfills.

[0003] The European Commission, with the EU Directive 2018/851, has mandated that Member States organize to collect post-consumer textile waste separately starting from January 1, 2025.

[0004] Another major issue is the pollution resulting from textile dyeing. Between 7-20% of acid dyes, 5-20% of direct dyes, and 20-50% of reactive dyes are lost in effluents in Europe. A large percentage of pollution generated by the textile industry is attributable to salts, binders, preparations, detergents, and organic acids. For example, dyeing 1 kg of cotton requires about 150 L of water, 0.6-0.8 kg of NaCl, and about 40 g of reactive dye. The total amount of pollution generated can easily be imagined. (Environment and Ecology 35 (3C): 2349-2353, July-September 2017).

[0005] The eight most significant impact categories for laundry detergents in Europe are freshwater eutrophication, human toxicity, freshwater ecotoxicity, marine ecotoxicity, and natural soil transformation. Additionally, concerns about microplastic pollution are increasing. (European Ecolabel criteria for laundry detergent).

[0006] Textile dyeing is one of the major pollutants of aquatic environments. High concentrations in water bodies disrupt their reoxygenation capacity and prevent sunlight penetration, disrupting aquatic life and photosynthesis.

[0007] Figure 2 shows the percentage of unfixed dye.

[0008] Additionally, other textile processing procedures, some of which are described below, are responsible for pollution.

TRADITIONAL TEXTILE FINISHING OR TREATMENT

[0009] The term "finishing" refers to the set of processing operations applied to fabrics to improve their appearance, handle, properties, and possible applications. Finishing operations can be performed through mechanical action, the use of chemicals, or the application of resins or silicones in the form of microfilm, all aimed at providing various textile materials with qualities and characteristics that ensure optimal performance in manufacturing and during use.

ANTIBACTERIAL FINISHING

[0010] Increasing literature describes the microbial colonization of traditional textiles and the resulting health risks. As reported by Al-Balakocy N.G. & Shalaby S.E. ("Imparting antimicrobial properties to polyester and polyamide fibers-state of art". Journal of the TEXTILE Association, p. 179-201 September-October 2017), biocides used for cotton, polyester, and nylon include:

- Oxidizing agents,
- Coagulants,
- Triclosan,
- Quaternary ammonium compounds,
- Metals and metal salts.

ANTIMICROBIAL FINISHING TECHNOLOGIES

[0011]

(1) Impregnation of the fibrous material with a solution, suspension, or emulsion of the bactericidal (fungicidal) product;
(2) Padding of an antimicrobial product, converting it from its soluble state to an insoluble state on the fibrous material.
(3) Binding of an antimicrobial product to the fiber via a chemical product with ionic, coordinative, or covalent bonds;
(4) Immersion of a bactericidal product either in the spinning solution or melt during the preparation of the chemical fiber substance.

[0012] Antimicrobial fabrics have gained significant attention in recent years due to their potential to provide protection against harmful microorganisms.

STAIN RESISTANCE

[0013] Application of stain-repellent substances. For water-soluble stains (tea, ink, fruit juice), products based on silicones are predominantly used, while for greasy stains, synthetic resin-based products are used. Stain-resistant finishing has a water-repellent and oil-repellent effect. It is mainly applied to fabrics for clothing and table linens.

ANTI-PILLING

[0014] For wool, a fiber particularly affected by this phenomenon, all finishes that reduce scales, such as chlorination or chlorination with resins, are appropriate. For synthetic fibers, resin film application is relied upon.

ANTI-SOI L

[0015] Hydrophilic, uncoated fibers are considered materials that are easily cleaned by washing. Conversely, some synthetic fibers (polyester) as well as cellulosic fibers that have not undergone chemical finishing are not easily cleaned due to their particularly hydrophobic surfaces, resulting in the accumulation of electrostatic charges, absorption, and retention of dirt. If, through a chemical finish, the surface irregularities of the fiber are saturated with white and translucent particles, dirt can no longer adhere to the irregularities of the fiber surfaces and can therefore be removed using normal cleaning methods.

Polypropylene

[0016] Polypropylene is the product of the polymerization of propylene. Depending on the conditions adopted for polymerization, the units of the monomer can assume different spatial configurations. In which the individual molecules are all oriented in the same way (isotactic polymer) or in a random and disordered manner.

[0017] The p. isotactic is the most interesting from a practical standpoint; the regularity of the configuration allows for a high degree of crystallinity, which corresponds to improved chemical, physical, and mechanical properties of the polymer.

[0018] It is prepared through stereospecific polymerization, starting from propylene (obtained from petroleum cracking, natural gas, etc.) using heterogeneous catalysis processes with special catalysts.

PP TEXTILE FIBER

[0019] The first textile fiber based on PP is Meraklon, introduced in 1959 by Montekatini (Polymer Chemische SpA), Italy. Subsequently, PP fibers were produced under various trade names: Herculon (USA), Ulstreng (Great Britain), Found (Japan), etc.

[0020] The first application of this fiber in the textile field was in carpeting or rugs, due to its high abrasion resistance, non-absorption of dirt, liquids, and stains, ease of washing, and colorfastness.

[0021] Initially, PP fiber was excluded from the clothing industry due to its inability to be dyed and other technological shortcomings and difficulties. It took years to overcome many shortcomings and develop superior PP textile fibers for clothing and sportswear. In 1986, Engineer Fernando Scotti presented at the International Textile Fiber Congress held in Dorbin (Austria) "THIN FILAMENT POLYPROPYLENE YARNS, PASTE DYED AND TEXTURIZED," dedicated to the production of continuous filament yarns made of 100% polypropylene.

[0022] The first use of these yarns in the medical field was in 1958 when Usher and Wallace introduced polypropylene mesh for hernia repair, due to its compatibility with human tissues.

YARN PRODUCTION BY EXTRUSION

[0023] Polypropylene polymerization can occur through three different mechanisms.

- Atactic: The polymer chains are oriented in a disordered manner with the methyl group (Fig. 1A).
- Syndiotactic: The chains are partly crystalline and ordered, with the methyl groups arranged alternately on either side (Fig. 1B).
- Isotactic: The methyl groups are all arranged on one side of the polymer chain axis (Fig. 1C). Melt spinning is the most commonly used method for the production of polymer fibers on an industrial scale. Melt spinning uses heat to melt the polymer to a suitable viscosity for extrusion through the spinneret. The polymer in the form of pellets or granules is melted and then pumped through capillary orifices of the chosen shape to produce the desired filament cross-section.

[0024] The known cross-sectional shapes in the art can include circular, non-circular, triangular, hollow, and diabolo

shapes.

[0025] Regarding the fiber sections, the surface characteristics affect the tactile sensitivity (circular section) and the way the fabric reflects light (triangular section). The round section appears opaque, while the triangular section appears shinier. The triangular fiber increases the amount of trapped air and enhances thermal insulation.

[0026] PP is the lightest textile fiber compared to those available on the market:

Fiber	Specific Weight g/cm^3
Polypropylene	0.91
Wool	1.32
Polyester	1.35
Cotton	1.54

Summary of the invention:

[0027] Polypropylene is therefore a suitable material for textile applications. The inventors of this patent application have developed a processing procedure for polypropylene that allows obtaining a textile material with satisfactory characteristics.

[0028] Such material possesses excellent properties, including outstanding elasticity, achieved without the use of any elastomer.

Object of the Invention

[0029] In a first aspect, this patent application describes a 100% polypropylene textile fiber.

[0030] In a second aspect, this patent application describes a 100% polypropylene fabric made with the fiber of the invention.

[0031] In further aspects, this patent application describes products made with the fabric of the invention. According to preferred embodiments of the invention, garments, workwear, and bed sheets made with the fabric of the invention are described.

[0032] In an additional aspect of the invention, a laminated fabric comprising the spun fabric of the invention and a polypropylene film is described.

Brief Description of the Figures

[0033]

Figure 1 represents the different orientation forms of polypropylene.
Figure 2 shows the data of dye that is not fixed with coloring according to the different fabrics.
Figure 3 represents a first embodiment of the invention represented by a bed sheet.
Figure 4 represents a second embodiment of the invention represented by a t-shirt.
Figure 5 shows the results of the antiviral test.

Detailed Description of the Invention

Fabrics

ORTHOGONAL FABRICS

[0034] Weaving is the technique used to manufacture a cloth or fabric. This operation involves interlacing perpendicular threads using a machine called a loom. On the loom, threads are stretched in the longitudinal direction of the fabric, constituting the warp of the fabric, and then thanks to the mechanical movements of the loom, a thread is transported and interwoven with the warp in the longitudinal direction, forming the weft of the fabric.

[0035] The system by which the warp and weft are interwoven is called the weave structure. This can vary from one fabric to another. Before starting production, a graphical representation of the weave structure is made through a process called put on paper, which is carried out on a special grid paper. In this representation, the vertical columns represent the warp threads, while the horizontal rows represent the weft.

[0036] The main components of the loom are the warp beam, located at the back of the loom and consisting of a large cylinder on which the warp threads are wound; the heddles, which contain the eyelet holes through which the warp threads pass and which serve to open the shed, i.e., to space the warp threads apart to allow the shuttle to pass through; the shuttle, which contains the weft thread that is inserted into the warp in an alternating motion; the reed, mounted on the beater, which compresses the weft threads against each other with each pass of the shuttle to compact the forming fabric; and the cloth beam, which winds the produced fabric.

KNITTING

[0037] Knitted fabric is created by the interlacing of yarn transversely (courses) and longitudinally (wales). The distance between the needles determines the "gauge," which expresses the number of needles in a given area.
[0038] Knitted fabrics can have two types of interlacing:

- Weft knitting: a single yarn forms a transverse row, or course, which interlaces with the subsequent courses.
- Warp knitting: occurs in the longitudinal direction, with as many yarns as there are wales interlacing to form the knit.

[0039] Knitting machines are distinguished by the arrangement of the needles, which can be set in straight or circular metal bars. The assembly of the bars and needles is called the needle bed, and knitting machines can have one or two needle beds.

STRAIGHT LOOMS

[0040] Straight looms are capable of producing complex stitches (inlays, two-color or multicolor jacquard). In weft looms, the thread works along the ranks and on circular supports the needles move individually, while on looms with straight line supports, the needles move together with a bar.

CIRCULAR LOOMS

[0041] Circular looms have needles arranged in a circular needle bed as well as the movement of the knitting formation mechanism. The resulting fabric is tubular in shape. The thread is wound on the beams and works along the "rows" and the number of needles corresponds to the number of threads. The essential characteristic of the chain loom is that the thread is knotted on itself, thus making the fabric perfectly non-laddering, which is why they are also called "RUN-RESISTANT". They are almost completely locked in the warp direction, thus becoming the ideal item for all uses as industrial support, where fabric stability is an indispensable characteristic.
[0042] The main types of knit are:

- Plain knit, which is one of the fundamental weaves of weft knitting.
- Rib knit, obtained with double needle bed machines and features columns of different sizes.
- Patterned knit, which includes various aspects such as lace, cables, and reliefs.

TEXTURIZING

[0043] Texturizing is a thermo-mechanical process, in which fibers, due to their thermoplasticity, undergo a permanent deformation of the individual filaments. It improves the hand, giving bulkiness, maintains the elasticity of the PP yarn, and provides greater wear resistance.

TWISTING (KNITWEAR, ORTHOGONAL)

[0044] Twisting gives a bundle of fibers the necessary cohesion to achieve the required strength values for textile processing. This is achieved by rotating a bundle of parallel fibers around its own axis. In this way, the outermost fibers assume a helical arrangement.
[0045] Twists are either S or Z and can increase or decrease based on whether the fabric is knitted or woven. We have calibrated the number of twists to maintain the intrinsic elasticity of the PP as much as possible, which is one of the qualities required for knitted fabrics, and to give the fabric more strength.

WEAVING

POSSIBLE WAXING

[0046] Basting is a temporary operation performed on yarns (usually the warp) to make them more resistant and lubricated, thus better supporting the weaving operations. For this purpose, steam is used to dry the yarn.

YARN TENSION

[0047] In weaving, particularly with this yarn, the tension of the yarn tends to change; therefore, tensions must be constantly monitored and controlled with the tensioner, sensor, and processor, which are the elements that detect real-time tension values on individual yarns. The tensioner setting must be calibrated for PP, which behaves like an elastomer in FT, respecting the length of the silo in the absence of tension.

FINISHING

[0048] Washing the fabric with water, in case of sizing, aims to remove the substances used to facilitate weaving and to stabilize the fabric.

[0049] For FT yarns, washing is done with cold water if we want to maintain the characteristics of the raw fabric. It is done at 90°C to obtain greater elasticity in knitted fabrics and to achieve elasticity in woven fabrics.

[0050] For FTF yarns, the water temperature is indifferent.

[0051] Passing the fabric through a centrifuge, suction, or squeezing.

RAMEUSE

[0052] The residual moisture is extracted by subjecting the fabric to a thermal treatment (rameuse) at low temperatures and calibrated speed to avoid plastification of the fabric.

[0053] This step also aims to stabilize the fibers, reducing the risk of shrinkage (dimensional stability).

Selvages

[0054] On the sides of the knitted fabric, to delimit the height of the piece, the two selvages are formed with bonding at temperatures below 90°C.

ULTRASONIC WELDING

[0055] Most polyolefins (polypropylene and polyethylene) exhibit excellent welding characteristics. Ultrasonic welding of polypropylene fabric is a process that allows two pieces of polypropylene fabric to be joined using high-frequency sound waves. This method is commonly used in various sectors, including textile manufacturing and the production of bags, automotive fabrics, and medical textiles. The ultrasonic welding process for polypropylene fabric involves the following steps:

- Preparation: The two pieces of polypropylene fabric to be welded are overlapped with the edges aligned.
- Clamping: The fabric layers are secured together using a specialized welding device or tool to ensure they remain in place during the welding process.
- Ultrasonic Application: An ultrasonic welder is used to apply high-frequency sound waves to the fabric layers. The machine consists of a generator and a sonotrode (also known as a horn). The sonotrode is brought into contact with the fabric at the welding point.
- Transfer of Vibrational Energy: The sonotrode generates mechanical vibrations at ultrasonic frequencies, typically between 20 kHz and 40 kHz. These vibrations create localized friction and heat at the points of contact between the fabric layers.
- Fusion and Bonding: The heat generated by the vibrations causes the polypropylene fabric to melt at the weld interface. As the fabric cools, the molten polymer solidifies, creating a strong bond between the two pieces.
- Cooling and Solidification: After the ultrasonic energy is removed, the molten fabric cools and solidifies quickly, resulting in a permanent weld.

Infections

[0056] Bacterial Infections: *Staphylococcus aureus* and *Streptococcus pyogenes* are two common bacteria that can cause skin infections. These infections can range from mild impetigo (a superficial infection) to more severe cellulitis or abscesses.

[0057] Fungal Infections: Species of Candida and dermatophytes (such as *Trichophyton* and *Microsporum*) are common fungi that can cause skin infections. These infections can lead to conditions like candidiasis (yeast infection), tinea (ringworm), or fungal nail infections.

[0058] Viral Infections: The herpes simplex virus (HSV) and the varicella-zoster virus (VZV) can cause skin infections in immunocompromised individuals. These infections can manifest as painful cold sores (HSV) or shingles (VZV), which can be more severe and widespread in immunodeficient individuals.

[0059] Parasitic Infections: Certain parasitic infections, such as scabies or lice infestations, can affect the skin and cause itching, rashes, or sores. These infections can be more challenging to control in individuals with a compromised immune system.

[0060] Opportunistic Infections: Immunodeficiency increases the risk of opportunistic infections, which are caused by organisms that typically do not cause disease in individuals with a healthy immune system. Examples include infections by *Pneumocystis jirovecii* (which causes *Pneumocystis* pneumonia) or various types of mycobacteria.

[0061] It is important to keep the affected area clean and dry and to maintain good hygiene practices. It is crucial for individuals with immunodeficiency to pay attention to any signs of skin infection, as these infections can progress more rapidly and become severe in this population.

[0062] In a first aspect, the present patent application describes a 100% polypropylene textile fiber.

[0063] In one aspect of the present invention, the polypropylene is virgin, i.e., not obtained from recycled polypropylene.

[0064] In another aspect, a 100% pure PP yarn comprising the textile fiber of the invention is described. For the purposes of the present invention, the yarn of the invention does not include elastomers. For the purposes of the present invention, the following can be employed:

- single thread from 0.5 to 7 dtex,
- yarn from 5 to 300 dtex.

[0065] The polymer in the form of *pellets* or granules is melted and then pumped through capillary orifices of the chosen shape to produce filaments with the desired cross-section.

[0066] Regarding the fiber cross-sections, a circular or triangular section can be used. The circular section is preferable for the production of technical work garments, as it improves *comfort.*

[0067] The yarn of the present invention does not include nodes.

[0068] For the purposes of the present invention, the number of filaments is preferably ≥10% of the yarn count (e.g., 70 Dtex = 80 filaments).

[0069] Dtex is a commonly used unit of measurement to describe the fineness of yarns. It represents the weight in grams of 10,000 meters of yarn. A yarn with a designation of 70 Dtex means that 10,000 meters of that yarn weigh 70 grams. If using the Denier unit, then 70 Denier corresponds to 78Dtex. For the preparation of heavier fabrics, such as a sweatshirt, the threads can be paired (or twined) into 2, 3, or more.

[0070] For the purposes of the present invention, FT (textured yarn) is used for knitting and for orthogonal fabrics to which elasticity is to be imparted, while FTF (textured and fixed yarn) is used for the production of stable orthogonal fabrics.

[0071] For the purposes of the present invention, texturizing is carried out using steam.

[0072] Specifically, fabrics obtained with FT yarns are treated in pieces with a wash at a temperature up to 90°C, which produces substantial shrinkage of the material, imparting elasticity to the fabric.

[0073] For the purposes of the present invention, twisting can be either S or Z, as needed.

[0074] For the purposes of the present invention, sizing can be carried out using cold air jets.

[0075] In another aspect, this patent application describes a fabric made from 100% polypropylene textile fiber as disclosed in the present invention.

[0076] The fabric that can be prepared according to the present invention can be either a woven or a knitted fabric.

[0077] In further aspects, this patent application describes products made with the fabric of the invention. Non-limiting examples of such products include:

- Clothing items, such as: sweaters, shirts, t-shirts, undershirts, sweatshirts, cardigans, skirts, pants, underwear, socks;
- Technical or work clothing: lab coats, uniforms, type 2 (non-underwear) or type 3 technical work clothing;
- Sportswear;
- Bed linen: sheets, pillowcases, mattress covers, pillow protectors;
- Bath linen: towels, bathrobes;

- Kitchen or table linen: tablecloths, napkins, banners, dish towels.

[0078] According to another aspect of the invention, a laminated fabric is described, comprising the fabric of the invention laminated to a 100% polypropylene film. For the purposes of the present invention, the polypropylene film has a thickness between 25 μm and 50 μm.

[0079] In a preferred embodiment, said fabric according to the present invention is a knitted or woven fabric. In a particularly preferred embodiment, the coupled fabric is preferably jersey.

[0080] Advantageously, such coupled fabric is waterproof, chemically resistant, and fully recyclable.

[0081] The preparation of such coupled fabric is conducted using appropriate heated cylinders at a temperature of 100-120°C and coated with Teflon.

[0082] According to a first preferred embodiment, the fabric of the present invention can be used for the production of a garment represented by a T-shirt.

[0083] Preferred applications include T-shirts for immunocompromised individuals.

[0084] An example of a T-shirt made according to the present invention is shown in Figs. 4A and 4B.

[0085] A T-shirt according to one embodiment of the present invention is shown in Fig. 4A.

[0086] This T-shirt 200 is made from a single piece 30 of 100% polypropylene fabric made according to the present invention.

[0087] This piece 30 comprises the front portion 30a and a rear portion 30b separated by a shoulder line42. The front portion 30a is bounded by a lower front edge 31, a right side front edge 32, a left side front edge 33, a right sleeve front edge 34, and a left sleeve front edge 35.

[0088] The rear portion 30b is bounded by a lower rear edge 40, a right side rear edge 38, a left side rear edge 39, a right sleeve rear edge 36, and a left sleeve rear edge 37.

[0089] An opening 41 is made on the front portion 30a.

[0090] T-shirt manufacturing 200 of the invention is obtained by folding the two portions along the shoulder line 42 and sewing together the edges of the right side, and sewing together the edges of the left side.

[0091] Advantageously, such seams can be replaced by suitable welds as described above.

[0092] According to a preferred aspect of the present invention, a T-shirt can be prepared with a jersey fabric using a 70X2 thread with 150 FT twists.

[0093] The resulting fabric is elastic in both directions.

[0094] Preferably, the seam is obtained with overlapping selvedges.

[0095] The T-shirt thus obtained offers excellent wearability due to a minimum number of possible seams and, since the fabric is run-resistant, does not require trimming.

[0096] In accordance with a second preferred embodiment of the present invention, the described fabric can be used for the preparation of bed sheets.

[0097] In particular, bed sheets can be produced for domestic use or within communities, hospitals, nursing homes, and more generally, in all situations that require particular attention to hygienic and practical aspects.

[0098] For the purposes of the present invention, the term "bed sheets" refers to the entire set of bed linen: bottom sheet (which covers the mattress), top sheet, and pillowcase.

[0099] As an alternative to the top sheet, it is possible to produce the so-called "duvet cover," represented by a sort of sack within which the duvet or blanket is placed.

[0100] For the purposes of the present invention, the fabric is prepared using a 100% pure polypropylene yarn having the following characteristics:

Description	Value
FT	140 dtex
Filaments	160 + 10% dtex
Section	Round
Twists per meter	100-250

For the purposes of the present invention, the fabric has a jersey knit structure.

[0101] The material weight is approximately 100-120 g/m^2 (±5%).

[0102] The fabric production can be achieved with the following parameters:

Type of machine: Circular	diameter between 30 and 38 inches

(continued)

Type of rolling	Tubolar
Washing	In open
Water temperature	40°C
Squeezing	Between Rollers
Drying	Free 60° C Treal

[0103] The welding of the parts can be carried out by means of ultrasound under the following conditions:

FREQUENCY	Hertz [Hz]	20-40
AMPLITUDE	micron [μ]	38-28

[0104] According to a preferred embodiment of the invention, the bottom sheet, which covers the mattress, has the shape shown in fig. 3.

[0105] This sheet 100 has a substantially rectangular shape with two longer sides L, L', two shorter sides I, I', defining four corners 7, 8, 9, 10.

[0106] In particular, the sheet 100 has a surface 1, which comprises an area 2 that covers the surface of a mattress, which is substantially rectangular in shape, with two longer sides M, M' and two shorter sides m, m', defining four corners 7', 8', 9', 10'.

[0107] The surface of the sheet also includes a left lateral covering area 3 of the mattress, a right lateral covering area 4 of the mattress, a front covering area 5 of the mattress, and a rear covering area 6 of the mattress.

[0108] At the four corners 7, 8, 9, 10 of the sheet, there are four corner areas 7", 8", 9", 10".

[0109] In particular, the front left corner area 7" is bounded by a left front edge 11 and a left front lateral edge 15, the front right corner area 8" is bounded by a right front edge 12 and a right front side edge 16, the right rear corner area 9' is bounded by a right rear side edge 17 and a right rear edge 13, and the left rear corner area 10 is bounded by a left rear edge 14 and a left rear side edge 18. According to a preferred aspect of the invention, the sheet 1 is manufactured by sewing the edges that define the corner areas.

[0110] Therefore, the following edges are sewn together:

- the left front edge 11 and the left front side edge 15
- the right front edge 12 and the right front side edge 16
- the right rear side edge 17 and the right rear edge 13
- the left rear edge 14 and the left rear side edge 18.

[0111] Advantageously, such seams can be made without the use of elastomers.

[0112] Alternatively, welding may be performed instead of sewing.

[0113] For the purposes of the present invention, the seams create folds along the diagonals d1, d2, d3, and d4, as shown, for example, in Figures 3B and 3C.

[0114] Each fold forms a gripping end 7'", 8'", 9‴, 10‴ that helps with gripping and placing the sheet 1 over the mattress 2.

Antiviral and antibacterial activity

[0115] To evaluate the antiviral activity of the textile material of the invention, the guidelines of ISO 18184 "Textile-Determination of antiviral activity of textile products" 2014-09-01 were followed. The reference strain SARS-CoV-2 PV10734 was used.

[0116] Figure 5 shows the results of the assay conducted; specifically, the graph shows the average absorbance values of the 5 experiments conducted for each dilution of each fabric for virus control. The results clearly indicate a reduction in viral load for cotton (COT), while the viral load found in the fabric of the invention (PP) is comparable to the virus control (VC).

[0117] This data suggests a lack of virus absorption by the PP fabric compared to traditional cotton, which retains viral particles. In conclusion, the PP fabric has proven to be resistant to retaining viral particles.

[0118] The advantages offered by the present invention will be immediately evident from the description provided above.

[0119] The fabric of the present invention is capable of inhibiting microbial colonization.

[0120] It is increasingly evident that clothing is a significant source of daily exposure to various chemical substances,

abiotic particles, and biotic particles, including microbes and allergens.

[0121] The first approach to designing antibacterial surfaces focuses on leaching biocides (e.g., cytotoxic compounds from the surface) and inducing the death of both adhered and nearby bacteria. However, there is growing concern that the increased use of biocides may lead to greater bacterial resistance and adverse effects (toxic, allergic, and carcinogenic) on the wearer and the environment. Another approach includes nanoparticle-based finishes; however, nanocomposites, such as polymer/nanocarbon nanocomposites (based on fullerene, nanodiamond, graphene, carbon nanotubes, carbon black, etc.), have low wash resistance.

[0122] Polypropylene, on the other hand, due to its super-hydrophobic characteristic, absorbs 0.01-0.3% (by weight) of water after 24 hours immersed in water and avoids any type of chemical treatment. Such a low liquid absorption coefficient value reduces the amount of liquid in contact with the skin compared to other fabrics.

[0123] The super-hydrophobicity decreases the adhesion of viruses such as COVID-19 (see the above results of the ISO 18184 test conducted at the San Matteo Polyclinic Hospital in Pavia).

[0124] The fabric developed by the present invention does not allow microbial colonization, does not actively interact with bacteria and fungi; therefore, it does not generate microbial resistance.

[0125] Other advantages of the polypropylene fabric of the present invention include

- Extremely high wear resistance. Thus, the fabric of the invention does not release fibers and dust.
- High impact resistance.
- High tensile strength.
- Excellent biocompatibility (biostable and non-cytotoxic).
- Low coefficient of friction (useful for joint prosthesis wearers).
- High chemical stability to bases and acids (therefore, it does not require additives and stabilizers and does not deteriorate upon contact with chemicals).
- Processability: the fabric can be cold-printed with lithographic inks that set at temperatures below 100°C.
- Direct compression (components) - Extrusion.

[0126] Breathability: The yarns are composed of dozens of threads thinner than a hair. The finer the fibers, the better the properties of softness and breathability.

[0127] Breathability is influenced by the weave and weight of the fabric. The breathability of the 120 g/m^2 jersey has been measured at (Ret), m^{2}Pa/W 2.790 $\pm$ 0.020 (R.E.T. is an index, and a value <6 is considered very good).

[0128] The fabric of the present invention is elastic despite not including any elastomeric material.

[0129] The thermal conductivity coefficient, i.e., the heat dissipation capacity, is 6 for the fiber of the invention, compared to 7 for polyester, 7.3 for wool, 11 for nylon, and 17.5 for cotton.

[0130] The fabric obtained according to the present invention is distinguished by a high capacity to retain heat, thus contributing to maintaining body temperature at comfortable levels.

[0131] The fabric of the invention has a pH of 4.0-7.5 (OEKO TEX 100 class I certified), which is well-suited for skin contact, avoiding even very significant reactive phenomena.

[0132] The pigments used meet all the new European Union requirements according to the REACH (EU) regulation.

[0133] The abrasion resistance of the fabrics produced according to the present invention is excellent, similar to that of nylon, superior to all other fibers, and remains unchanged when wet.

[0134] The high standard of mechanical performance and abrasion resistance prevents *pilling.*

[0135] Due to its very low water absorption, as mentioned above, dirt remains on the surface and does not penetrate inside the fiber; therefore, garments are easily washed by hand and in the washing machine with reduced detergent and energy consumption, as excellent results are achieved even at low temperatures.

[0136] Furthermore, the hydrophobic fiber of the present invention does not absorb water, and thus, fabrics prepared with it dry more quickly.

[0137] It should also be noted that due to the characteristics of mass dyeing, colored garments can be washed together with articles made of other fibers without the risk of color bleeding.

[0138] Ultrasonic welding for polypropylene fabric offers several advantages; for example, it provides a strong bond without the need for additional adhesives or sewing threads. The process is also relatively quick and precise and produces aesthetically pleasing, flat, and seamless welds.

[0139] Polypropylene has the highest resistance to the action of chemical agents compared to common fibers. Additionally, it is fully recyclable, and its disposal is not burdensome because, being 100% PP, it is not waste but a recyclable good (DM 05/02/1998, CER 04 02 22).

[0140] Moreover, by-products derived from production are reused in compliance with the DM 264/2016 of the circular economy.

[0141] There are various recycling methods for polypropylene (with and without the extrusion and regranulation operation), and the damage caused by plastic recycling operations is two orders of magnitude lower than that avoided

by producing virgin polymer.

[0142] Furthermore, fractions that cannot be sustainably recycled represent a valuable source of alternative energy; the advantage of incineration lies in the energy produced.

[0143] Polypropylene is the plastic with the highest calorific value, making incineration potentially more advantageous than recycling.

[0144] Polypropylene yarns are the most sustainable compared to all other natural and man-made fibers based on the impact measured by the HIGG INDEX developed by the "Sustainable Apparel Coalition" for the apparel, footwear, and textile industries:

Polypropylene	37
Polyester	44
Wool	82
Cotton	98
Silk	681

Claims

1. A 100% polypropylene textile fiber.

2. A yarn comprising the textile fiber according to the preceding claim.

3. The yarn according to the preceding claim comprising a single, double, or triple thread with a count from 5 to 300 dtex.

4. The yarn according to claim 2 or 3 comprising a number of filaments ≥10% relative to its dtex count.

5. The yarn according to the preceding claim that is textured or textured and set.

6. The textured yarn according to the preceding claim, which is elastic and does not comprise elastomer.

7. The yarn according to any one of claims 2 to 6, wherein said polypropylene is virgin.

8. A method for producing a yarn comprising a 100% polypropylene textile fiber according to any one of claims 2 to 7, which comprises the step of subjecting said textile fiber to a steam texturing process.

9. A fabric made with the yarn comprising a 100% polypropylene textile fiber according to any one of claims 1 to 7.

10. The fabric according to the preceding claim, which is an orthogonal or knitted fabric.

11. A method for the preparation of a fabric made from yarn according to any of the claims 2 to 7, including a phase of subjecting that fabric to a phase of washing with water at a temperature of up to 90 °C.

12. A product made from fabric according to claim 10.

13. The product according to the preceding claim, wherein the product is chosen from:

    - shirts, t-shirts, vests, sweatshirts, sweaters, skirts, trousers, underwear, stockings,
    - shirts, uniforms, technical clothing for sport and work;
    - bed linen: sheets, pillow cases, mattress covers, pillow covers;
    - bath linen: towels, bathrobes,
    - kitchen or table linen: tablecloths, napkins, banners, tea towels.

14. A fabric comprising the fabric according to claim 10 coupled to a 100% polypropylene film.

15. The fabric according to the preceding claim, wherein said polypropylene film has a thickness from 25 μm to 50 μm.

16. The fabric according to claim 14 or 15, wherein said coupled fabric is a jersey.

Fig. 1C

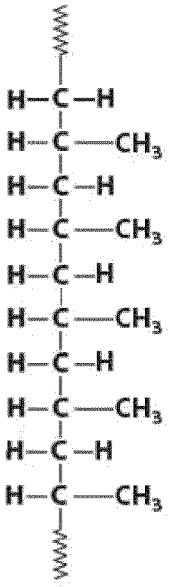


Fig. 1B

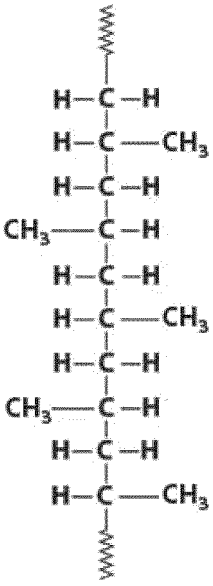


Fig. 1A

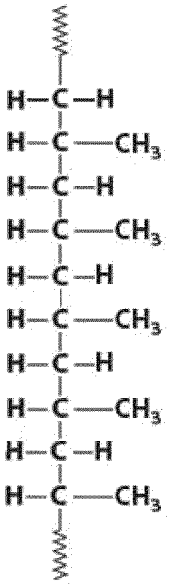


Fig. 2

Fiber	Dye Type	Unfixed Dye %
Wool and Nylon	Acid dyes/reactive dyes for wool Pre-metallized dyes	7-20 2-7
Cotton and viscose	Azotic dyes Reactive dyes Direct dyes Pigment Vat dyes Sulfur Dyes	5-10 20-50 5-20 1 5-20 30-40
Polyester	Disperse	8-20
Acrylic	Modified basic	2-3

(Gita Samchetshabam, 2017)

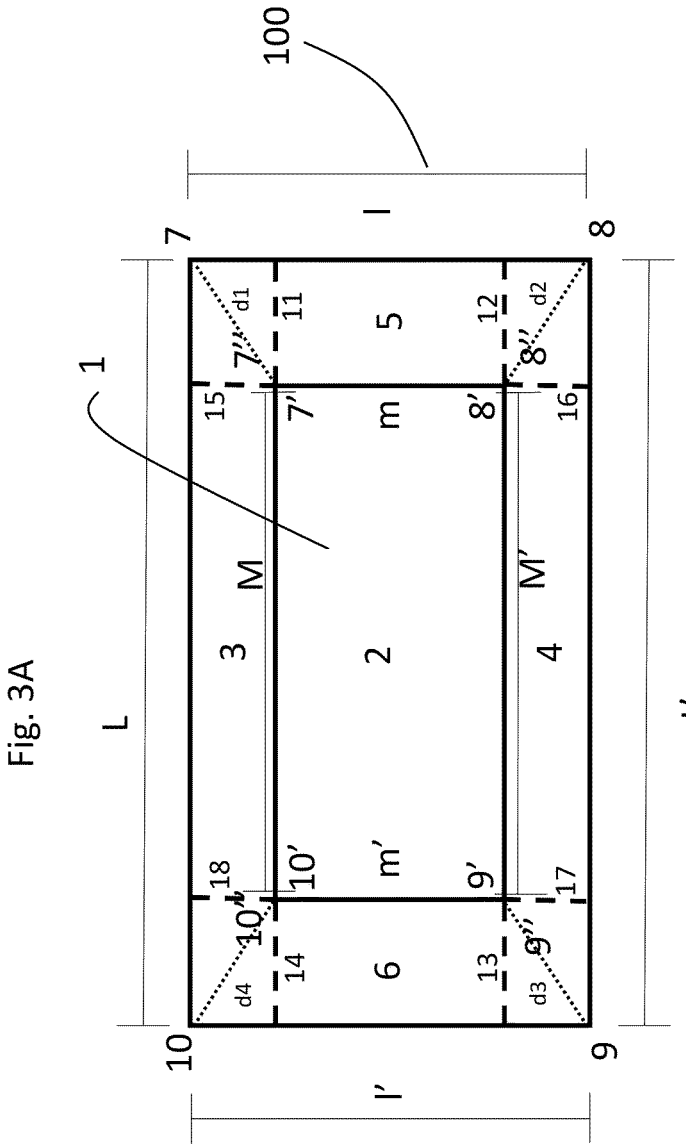


Fig. 3A
1
100
L
L'
l
l'
M
M'
m
m'
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
d1
d2
d3
d4

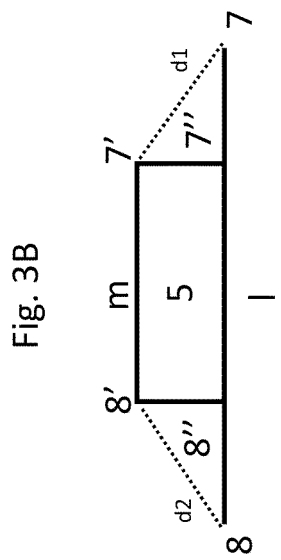


Fig. 3B
7
7'
7''
8'
8''
8
m
5
l
d1
d2

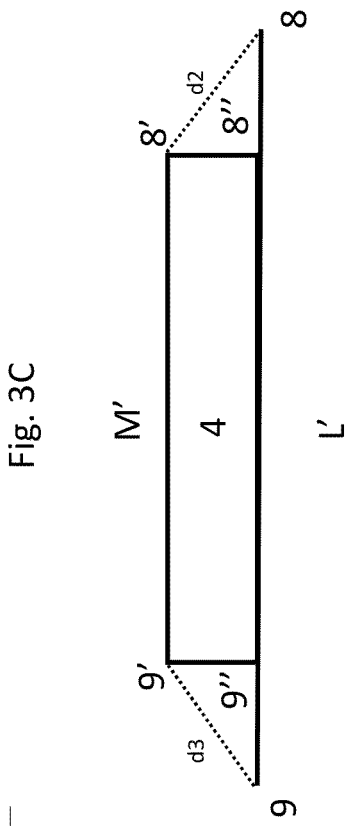


Fig. 3C
8
8'
8''
9'
9''
9
M'
4
L'
d2
d3

Fig. 3E

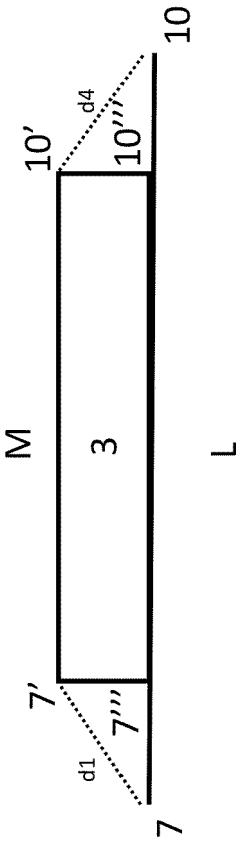


Fig. 3D

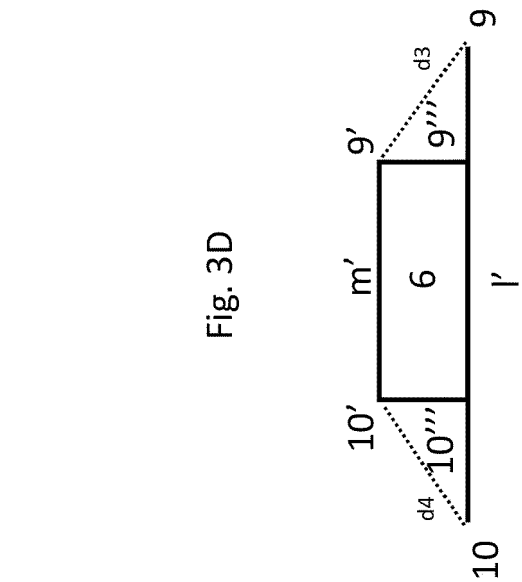


Fig. 4B

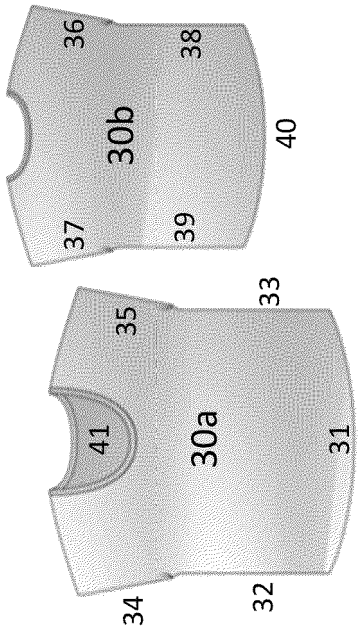

36
38
30b
40
37
39
35
33
41
30a
31
34
32

Fig. 4A

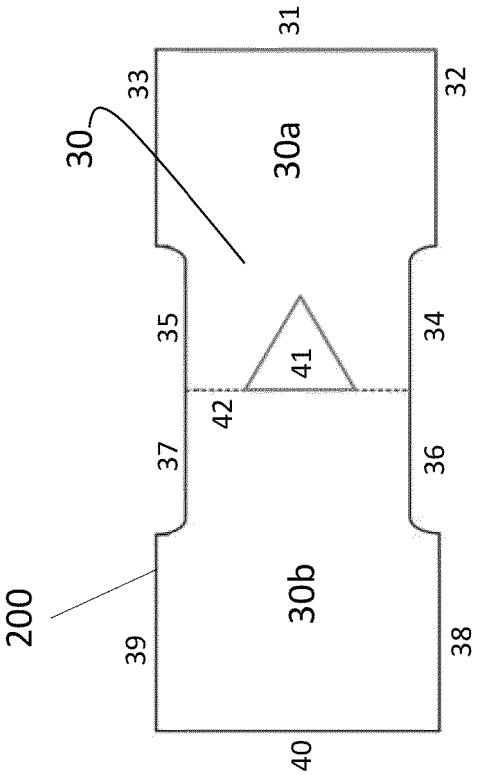
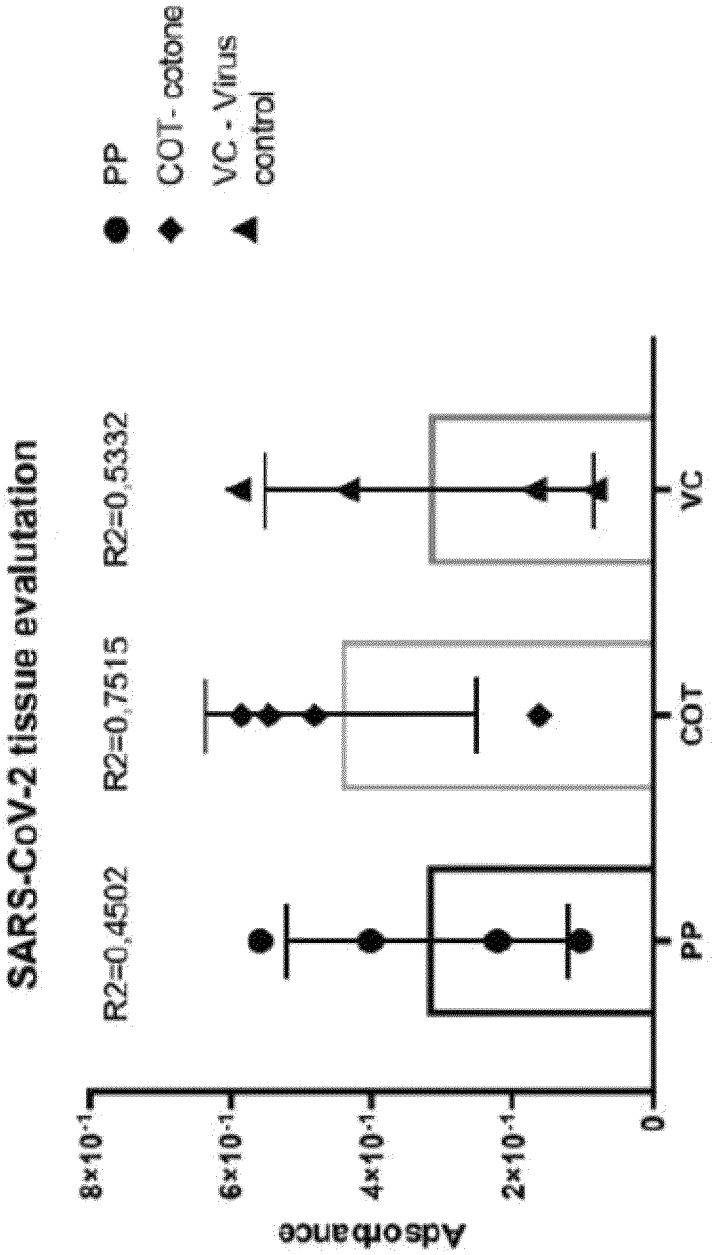

31
33
32
30
30a
35
34
41
42
37
36
200
30b
39
38
40

Fig. 5


SARS-CoV-2 tissue evalutation
PP
COT- cotone
VC - Virus control
R2=0,4502
R2=0,7515
R2=0,5332
Absorbance
8×10⁻¹
6×10⁻¹
4×10⁻¹
2×10⁻¹
0
PP
COT
VC

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 9769

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X	GB 1 239 331 A (MITSUBISHI RAYON COMPANY LTD) 14 July 1971 (1971-07-14) * page 1, line 10 - line 39 * * page 2, line 5 - line 30; examples 1,4,6 *	1-3, 5-10,12, 13	
X	US 7 926 307 B1 (WILLIAMS JOHN M [US]) 19 April 2011 (2011-04-19) * column 1, line 6 - line 11 * * column 1, line 43 - column 2, line 2 * * column 3, line 65 - column 4, line 19 *	1-3,7	TECHNICAL FIELDS SEARCHED (IPC) D02G D01F
X	UA 62 498 A (CLOSE JOINT STOCK COMPANY FACT [UA]) 15 December 2003 (2003-12-15) * abstract *	1,2,5-7, 9-12	
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-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 August 2024	Pollet, Didier

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 9769

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X	CN 111 364 135 A (WEIQIAO TEXTILE CO LTD) 3 July 2020 (2020-07-03) * paragraph [0005] - paragraph [0009] * * paragraph [0038] *	1-3,7,9, 10	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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- *Environment and Ecology*, July 2017, vol. 35 (3C), 2349-2353 **[0004]**
- **AL-BALAKOCY N.G.** ; **SHALABY S.E.** Imparting antimicrobial properties to polyester and polyamide fibers-state of art. *Journal of the TEXTILE Association*, September 2017, 179-201 **[0010]**