

**Nonwoven fabric for producing cleanroom protective
clothing**

Description of the field of the invention

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Protective clothing for cleanrooms shall protect the articles which are produced or processed in these rooms, for example microelectronic parts, pharmaceuticals or optical glass fibers, from human beings as a source for
10 the emission of troublesome particles, e.g., dust or skin particles, bacteria.

The most important requirement of a material for producing such protective clothing is therefore the
15 barrier effect. The protective clothing material has to retain not only the particles permanently emitted by the human body (skin flakes, hair fragments, bacteria, etc.) but also the fiber fragments detached from any textile clothing underneath in order that contamination
20 of the cleanroom air and hence of the article of manufacture may be avoided. Nor, of course, must the material itself emit any fiber parts or other constituents into the cleanroom air.

25 As well as the requisite barrier effect, the protective clothing material must possess high mechanical strength, especially a high tear and abrasion resistance, in order that the risk of the formation of tears or holes due to outside influence or normal wear may be
30 minimized. In order that the protective clothing may be repeatedly reusable as well, moreover, the material must survive the industry-customary washing or cleaning operations (for example sterilization in an autoclave) as intact as possible, i.e., be resistant to wet
35 mechanical abrasion and pilling and also sufficiently dimensionally stable.

In addition to the barrier effect and (wet) mechanical resistance, the protective clothing material must -

especially for use in cleanrooms of the microelectronics industry - possess an antistatic effect, i.e., the material should not become excessively electrostatically charged as a result of the inevitable friction during wearing and should be able to rapidly dissipate and conduct away any charges. This is necessary in order that, first, sensitive microelectronic parts are not damaged by point discharges and, secondly, no dust particles may be attracted from the ambient air onto the surface of the material from where they might be reemitted later.

In addition, the protective clothing material should also possess a sufficiently high wear comfort, i.e., an ideally textile character with regard to drape, hand and appearance and be breathable and where appropriate also thermally insulating in order that excessive sweating or freezing on the part of the user may be avoided.

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Background art

It is known to use very low denier synthetic fibers or filaments for producing cleanroom protective clothing material. "Very low denier" here refers to fibers having a linear density of less than 1 dtex, which are also known as "microfibers". Microfibers having a linear density of less than 0.3 dtex are also commonly known as "supermicrofibers".

30 Customary protective clothing material based on woven or loop-formingly knitted microfiber or microfilament fabrics is produced in several steps. First, polymeric raw materials are spun into microfibers or microfilaments. These are then further processed into yarns which may additionally undergo a subsequent texturing operation. The textured microfiber or microfilament yarns are finally woven up to the actual protective clothing material. Conductive yarns may be additionally woven into the fabric in the form of a

regular pattern, for example in a stripe or check arrangement, in order that the required antistatic effect may be provided. The conductive yarns contain for example core-sheath filaments where the core or
5 sheath contains carbon black or graphite or else for example metal fibers or metalized filaments. The requisite barrier function and the high (wet) mechanical strength is obtained through extremely close and regular weaving of the microfiber yarns. This high
10 closeness of weave and the predominantly surface-parallel filament orientation, however, is unfavorable for the breathability of the material. There are only a few micropores or microchannels through which water vapor might be transported through the fabric.

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The problematic combination of barrier effect and breathability is achievable for the protective clothing material through the use of membranes that are impervious to particles yet pervious to water vapor.
20 Such "microporous" layers can be applied to normally (im)pervious textile materials, for example by lamination or direct extrusion, to obtain a material having a textile character.

25 The operation to produce closely woven microfilament fabrics and laminates formed from a breathable barrier membrane and a textile involves multiple stages and hence is relatively time consuming. Nonwoven fabrics are one alternative that is simple to produce.

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Flat calendered microfilament spunbondeds based on polyethylene are capable of meeting the barrier requirements and are also very economical to produce. However, such materials are virtually impervious to air
35 and water vapor and possess a foillike character, i.e., their wear comfort is low. Moreover, they are insufficiently stable to washing and cleaning, so that their utility is limited to single use or disposable protective clothing.

Nonwoven fabrics produced from multisegment or multicore staple fibers which are split into individual microfibers by means of a solvent or water jets after web laydown and possible preconsolidation should offer a good barrier effect coupled with an appreciably superior wear comfort than the abovementioned highly calendered microfilament spunbondeds.

EP patent specification 0 624 676 describes for example a method of water jet splitting to produce a nonwoven fabric possessing an extremely high bulkiness and hence also a good barrier effect. But this fabric lacks softness and thermal insulation properties. Consequently, water jet consolidated nonwovens are believed to be of limited usefulness for the (protective) clothing sector. The cited patent specification therefore proposes a different method which does not employ the water jet technique.

PCT application WO 98 / 23 804 departs from the abovementioned patent specification in proposing that the fabric first be subjected to thermal point bonding prior to the water jet splitting. The idea is to prevent the hydroentangled web from becoming tangled with the screen of the hydroentangling apparatus and being damaged or even destroyed on being removed therefrom. Secondly, a higher degree of fiber separation is said to be achieved as a result, which is said to provide improved barrier and tactile characteristics.

Extending the range of applications of nonwoven fabrics is also desired in EP patent specification 97 108 364. It describes the production of a nonwoven fabric from very fine filaments that is said to have comparable properties to woven or loop-formingly knitted textiles. The very fine filaments with a linear density of 0.005 to 2 dtex are produced by water jet splitting from

melt-spun, crimped or uncrimped multicomponent multisegment filaments having linear densities of 0.3 dtex to 10 dtex. The nonwoven fabric thus obtained can additionally be aftertreated in various ways, for example by means of heat setting, point calendering, etc., to obtain specific performance characteristics. The spunbondeds produced by this process are said to be very useful for producing garments and other textile articles of manufacture.

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Summary of the invention

Subsequent studies have shown that, surprisingly, nonwoven fabrics produced according to the abovementioned EP patent specification 97 108 364 are very useful for producing cleanroom protective clothing when they consist of supermicrofilaments having linear densities of less than 0.2 dtex and are also emboss calendered. The supermicrofilaments themselves are produced by water jet splitting of multicomponent filaments having a linear density of less than 2 dtex, that were formed by melt spinning, aerodynamically stretched and prebonded by means of water jets.

The present invention consequently describes a novel nonwoven fabric material and also the steps for producing it. The nonwoven fabric meets all requirements of a repeatedly reusable cleanroom protective clothing material. It has a high barrier effect, a high mechanical strength and dimensional stability, an efficient antistatic action and a high wear comfort (breathability and textile character). These favorable properties are sufficiently preserved even following repeated industry-customary washing and cleaning operations (up to 30 cycles). The sum total of these properties was hitherto deemed unattainable with a nonwoven fabric comprising split ultrafine filaments.

The nonwoven fabric consists of supermicrofilaments having linear densities of less than 0.2 dtex, which

are produced from uncrimped primary filaments having a linear density of 1.5 to 2 dtex. The primary filaments used are preferably bicomponent multisegment filaments of two incompatible polymers, especially of polyester and polyamide. This combination is known, and EP 97 108 364 is incorporated herein by reference to that extent. The polyester fraction is chosen to be higher than the polyamide fraction, preferably between 60 to 70% by weight. To obtain the requisite antistatic effect, either or both of the polymers are provided with corresponding additives that have a permanent effect, i.e., cannot be washed off or out. The antistatic effect can be obtained for example by mixing in carbon black or graphite or by admixture of polymers having a strongly hydrophilic character or of polymers having (semi)conductive properties, possibly with addition of compatibilizers. The primary bicomponent filaments possess a cross section having an orangelike multisegment "pie" structure in which segments each containing one of the two incompatible, additized polymers alternate. This well known filament cross section has proven useful for the hereinbelow described production of the supermicrofilaments. To obtain the desired high abrasion resistance and low pilling tendency for the nonwoven fabric, the primary filaments, having been subjected to the customary aerodynamic stretching, are thereafter subjected to a further stretching and synchronous annealing operation ("Hot Channel Stretching").

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The primary filaments thus produced are laid down on a moving belt in a random arrangement by means of specific assemblies and are subsequently preconsolidated by means of conventional water jet technology, i.e., mechanically entwined. The preconsolidated primary filament web is then repeatedly subjected to high pressure water jets from both sides on perforated drums, and the primary filaments disintegrate virtually completely into their

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constituents, i.e., into the individual supermicrofilaments, and these are at the same time entangled with each other to an extremely homogeneous degree. This process step produces a microfiber web which, owing to its extremely random and entangled fiber structure, not only has the requisite high barrier effect but also is still sufficiently pervious to water vapor.

To improve the dimensional stability to washing and cleaning operations, the microfiber fabric after water jet splitting and subsequent drying is subjected to a hot air heat setting operation under tension. The fabric is subsequently emboss calendered in a calender having a specific engraved roll in order that the dimensional stability and abrasion resistance may be further enhanced. The finished nonwoven fabric has a basis weight of 80 to 150 g/m², preferably of 95 to 115 g/m².

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Example

The first step is to produce a nonwoven fabric having a basis weight of 95 g/m² coupled with uniform thickness from bicomponent filaments consisting of 70% of polyethylene terephthalate and 30% of polyhexamethylenedipamide. The primary filaments have a linear density of 1.6 dtex and contain 16 segments which are alternately constructed of the polyester or of the polyamide. The melt-spun filaments are aerodynamically stretched, randomly laid down on a belt and fed to a water jet treatment in which a first preconsolidation of the filaments takes place. The preconsolidated web is subsequently treated with high pressure water jets, which causes the primary filaments to split into the individual segments and these to be further clewed. The water jet splitting is repeatedly carried out from both sides of the nonwoven fabric. The resultant supermicrofilaments have an average linear density of 0.1 dtex and are uncrimped. The web is

subsequently dried and emboss calendered. The nonwoven fabric thus produced has a filter efficiency of about 60% for particles $\geq 0.5 \mu\text{m}$ and of about 98% for particles $\geq 1 \mu\text{m}$. After a 30-fold wash treatment with a
5 standard laundry detergent at 40°C the filter efficiency decreases only insignificantly to about 55% for particles $\geq 0.5 \mu\text{m}$ and to about 95% for particles $\geq 1 \mu\text{m}$.



Claims

1. Nonwoven fabric for producing repeatedly reusable cleanroom protective clothing, consisting of supermicrofilaments having a linear density of less than 0.2 dtex, which in turn are generated by water jet splitting of multicomponent filaments (hereinafter "primary filaments") having a linear density of less than 2 dtex, the primary filaments being spun from the melt, aerodynamically stretched, directly laid down to form a web and subjected to water jet preconsolidation prior to splitting.
2. Nonwoven fabric as claimed in claim 1, characterized in that the primary filaments after the aerodynamic stretching are subjected to an additional stretching and annealing operation.
3. Nonwoven fabric as claimed in claim 1 or 2, characterized in that the primary filaments represent bicomponent filaments of two incompatible polymers, especially of a polyester and a polyamide.
4. Nonwoven fabric as claimed in claim 3, characterized in that the polyester fraction is higher than the polyamide fraction.
5. Nonwoven fabric as claimed in claim 4, characterized in that the polyester fraction is between 60 and 70% by weight, based on the total weight of nonwoven fabric.
6. Nonwoven fabric as claimed in any of claims 1 to 5, characterized in that the basis weight of the nonwoven fabric is between 80 and 150 g/m², preferably between 95 and 115 g/m².
7. Nonwoven fabric as claimed in any of claims 1 to 6,



characterized in that the primary filaments have a cross section having an orangelike multisegment structure in which segments each containing one of the two incompatible polymers alternate.

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8. Nonwoven fabric as claimed in any of claims 1 to 7, characterized in that the water jet splitting of the primary filaments is effected by subjecting the preconsolidated fabric repeatedly to high pressure water jets alternately from both sides.

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9. Nonwoven fabric as claimed in claim 8, characterized in that the water jet splitting is carried out on an assembly having rotating sieve drums.

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10. Nonwoven fabric as claimed in any of claims 1 to 9, characterized in that the fabric after the water jet splitting and subsequent drying is emboss calendered.

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11. Nonwoven fabric as claimed in any of claims 1 to 10, characterized in that the fabric after the water jet splitting is additionally subjected to a heat setting step and subsequently to a thermosetting step.

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12. Nonwoven fabric as claimed in any of claims 1 to 11, characterized in that either or both of the incompatible polymers contain a permanently antistatic additive, for example carbon black or graphite, a polymer having a markedly hydrophilic character (for example a poly(amide-block-ether) copolymer or a polymer having (semi)conductive properties (for example a polyaniline or polyacetylene derivative).

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13. Nonwoven fabric as claimed in any of claims 1 to 12, characterized in that the supermicrofilaments

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are uncrimped.

