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(54) Title: A NONWOVEN WEB DESIGNED FOR USE IN A CLEAN ROOM WIPE

(57) Abstract: This invention describes a nonwoven material suitable for use as a clean room wipe, containing at least a first cellulosic nonwoven web which (a) has low linting, low residual ions and low extractables (water and solvents) (b) has good dimensional stability (wet and dry), (c) is absorbent, (d) provides excellent surface cleaning, (e) is able to absorb and recover spent or contaminated cleaning liquids from a surface, and (f) is biodegradable, compostable and based on renewable resources. The nonwoven material is characterized in that the cellulosic nonwoven web is made from essentially pure cellulose formed of essentially continuous filaments and multibonded by merged filaments, hydrogen bonding and physical intermingling of the filaments.

A nonwoven web designed for use in a clean room wipe

This invention relates to a nonwoven web suitable to be used as the base sheet for a clean room wipe and, more particularly, to an essentially pure cellulose nonwoven web formed from essentially continuous filaments and multibonded by merged filaments, hydrogen bonding and physical intermingling of the filaments, providing good surface cleaning, low linting, low residual ion content, low extractables in water and other solvents, absorbency and ability to adsorb and hold fine particulates. Additionally, this inventive nonwoven web provides biodegradability and sustainability. This invention further relates to additional bonding of this web alone, or to other webs or materials through hydroentangling to enhance these key performance properties needed in a clean room wipe.

The term "essentially pure cellulose" shall address the fact that cellulosic moulded bodies, e.g. made according to the lyocell process, always contain a small amount of polymers other than cellulose, namely hemicellulose. This does not influence in any way the suitability for the use according to this invention.

Prior Art

There are many substrates used for clean room wipes, including paper, nonwovens and textiles. There are several types of nonwovens known for use as clean room wipes. U.S. 3,978,185 describes a meltbown thermoplastic nonwoven suitable for clean room wipers. Canadian 1,186,193 describes polyolefin based nonwovens treated to impart hydrophilicity to a hydrophobic web. U.S. 3,811,957 describes a hydrophobic meltblown polyolefin nonwoven with low linting, good cleaning, which is also treated to add hydrophilicity. U.S. 6,117,515 describes an absorbent nonwoven laminated between apertured films to provide both surface cleaning and absorbency, U.S. 7,968,480 describes a 100% multi-lobal polyolefinic spunlaid nonwoven, JP 2008060666 describes a low linting nonwoven based on covering both surfaces of the wipe with electro- or melt-spun thermoplastic nanofibers to not only minimize dust but also to capture fine particles on the surface to be cleaned. JP 2008078524 describes a low linting, absorbent

nonwoven for clean room wiping applications composed of a meltblown multilayer structure where one layer is a meltspun hydrophilic thermoplastic copolymer of polyethylene glycol and polytetramethylene terephthalate polyester. JP 2005160721 describes a meltspun regenerated cellulose nonwoven with low linting and excellent absorbency for use as a clean room wiper.

There has been significant research in nonwovens for clean room wipes but the current technology is not yet optimal. The requirement for low linting, low residual ions, low extractables in both water and other solvents are in addition to the need for dimensional stability and strength (wet and dry), surface cleaning ability and absorbency required by the wipe to perform its required duty in the clean room. Polyolefin thermoplastic-based nonwovens, especially meltspun nonwovens, contribute low linting, dimensional stability and strength, and acceptable extractables in water and some solvents as well as acceptable residual ion content. Surface cleaning is still less than ideal, as is absorbency. Staple fiber cellulose based nonwovens provide superior absorbency and surface cleaning, along with low extractables, but linting and dimensional stability are issues. The optimal product would combine properties of both meltspun polyolefins and staple fiber cellulosic nonwovens.

Previous technology has targeted this optimal solution, though with limited success. CA 1,186,193 and U.S. 3,811,957 attempt to add the hydrophilicity and absorbency of cellulose based nonwovens to a meltspun thermoplastic nonwoven by treating the surface with wetting agents. Unfortunately, these wetting agents add potential residual ions and extractables, and do not address surface cleaning effectiveness, while increasing cost and complexity. U.S. 7,968,480 and JP 2008060666 describe improvements to the cleaning ability of thermoplastic based nonwovens, modifying the cross sectional fiber profile or using nanofiber structures. U.S. 6,117,515 suggests a laminate of a center cellulosic layer with meltspun thermoplastic outer layers; this does add absorbency and dimensional stability, but otherwise the negative properties of each layer are still apparent; surface cleaning and extractables in certain solvents are still an issue with the outer layers, while linting (though reduced)

is still possible from the center layer. JP 2008078524 describes a low linting, absorbent nonwoven for clean room wiping applications composed of a meltblown multilayer structure where one layer is a meltspun hydrophilic thermoplastic copolymer of polyethylene glycol and polytetramethylene terephthalate polyester. JP 2008078524 attempts to address the hydrophilicity and absorbency deficiencies of meltspun thermoplastic nonwovens by using novel hydrophilic thermoplastic polymers instead of conventional polyolefins. This still does not solve the surface cleaning issues, and these novel polymers add significant cost and, like most thermoplastic polymers, are not sustainable products.

The present invention relates to the use of specially designed nonwoven substrates produced using novel variants of the spunlaid nonwoven process, comprising 100% cellulose polymers. There are known methods and products using spunlaid cellulose webs. U.S. 6,358,461, U.S. 7,067,444, U.S. 8,012,565, U.S. 8,191,214, U.S. 8,263,506 and U.S. 8,318,318 all teach methods for producing and using spunlaid cellulose webs. None of these teaches either production methods for or products addressing the specific substrate requirements for clean room wipes.

Problem

Clean room wipes can be based on paper, nonwoven, textile, sponge, or even foam substrates. Nonwovens have proven to be especially successful in meeting the stringent and varied needs of this product. A clean room wipe must be low linting or fiber shedding, must have low residual ion content, must have low extractables in both water and various solvents, must be capable of surface cleaning, dry and wet, must be dimensionally stable, dry and wet, must be able to absorb and remove cleaned particulates and contaminants.

The problem with current clean room wipe technology is that none addresses all of the needs. The meltspun polyolefin nonwovens address half of the requirements, while the cellulosic-based nonwovens address a different range of needs. An optimal solution is not available.

There is distinct need for a sustainable, low linting, low residual ion, low extractables nonwoven with good cleaning and absorbency capabilities including the ability to remove small particulates at high efficiency.

Description

It is the object of the present invention to provide a nonwoven material suitable for use as a clean room wipe, containing at least a first cellulosic nonwoven web which (a) has low linting, low residual ions and low extractables (water and solvents) (b) has good dimensional stability (wet and dry), (c) is absorbent, (d) provides excellent surface cleaning, (e) is able to absorb and recover spent or contaminated cleaning liquids from a surface, and (f) is biodegradable, compostable and based on renewable resources. The nonwoven material is characterized in that the cellulosic nonwoven web is made from essentially pure cellulose formed of essentially continuous filaments and multibonded by merged filaments, hydrogen bonding and physical intermingling of the filaments.

This material is suitable for use in critical cleaning applications such as aerospace manufacturing, paint preparation, window installation & cleaning and metal polishing.

This material which is essentially pure cellulose formed from essentially continuous filaments will provide the low linting, dimensional stability, low extractables and low residual ions of a meltspun polyolefin with the absorbency and cleaning ability of a cellulosic nonwoven, and as a cost effective, biodegradable and sustainable product. Low residual ions and low extractables are critical factors in critical cleaning wipes. In many critical cleaning applications, you are preparing a critical surface for a treatment such as painting, or application of an adhesive layer, in these cases any residual chemicals left behind by the wipe can influence the quality of the treatment or application.

The nonwoven material according to the invention is used in a clean room wipe that is designed to be a biodegradable, compostable and sustainable

nonwoven with excellent cleanability, high strength, high abrasion resistance, high absorbency, and 100% biodegradability. The nonwoven web, which is a 100% continuous filament cellulose nonwoven will provide both high strength/abrasion resistance and high absorbency, and as a sustainable product, produced using an environmentally sound process.

Compared to nonwoven substrates based on meltblown polyolefins, the present invention is more absorbent and biodegradable and sustainably produced.

Compared to nonwoven substrates based on cellulosic fibers, the present invention has superior strength and abrasion resistance, with comparable absorbency, biodegradability and sustainability.

Compared to composites, including those of hydroentangled combinations of meltblown polyolefins with cellulose materials, the present invention has equivalent strength, superior cleanability, liquid take up rate, and overall absorbency.

The degree of merged filament bonding also results in a range of filament diameters and cross-sections being present. This characteristic enables additional cleanability versus nonwoven webs with a tight range of fiber and/or filament diameters and standard cross sections.

Preferably, the inventive nonwoven material is further processed by hydroentanglement. It surprisingly still has acceptable consumer acceptable drape and softness while it still can be loaded with a solution, has high wet strength and abrasion resistance, is absorbent and dispenses absorbed liquids uniformly, and is compostable and based on renewable resources.

The first cellulosic nonwoven web is preferably made according to a lyocell process.

Cellulosic fibres can be produced by various processes. In one embodiment a lyocell fibre is spun from cellulose dissolved in N-methyl morpholine N-oxide (NMMO) by a meltblown process, in principle known from e.g. EP 1093536

B1, EP 2013390 B1 and EP 2212456 B1. Where the term meltblown is used it will be understood that it refers to a process that is similar or analogous to the process used for the production of synthetic thermoplastic fibres (filaments are extruded under pressure through nozzles and stretched to required degree by high velocity/high temperature extension air flowing substantially parallel to the filament direction), even though the cellulose is dissolved in solution (i.e. not a molten thermoplastic) and the spinning & air temperatures are only moderately elevated. Therefore the term "solution blown" may be even more appropriate here instead of the term "meltblown" which has already become somewhat common for these kinds of technologies. For the purposes of the present invention both terms can be used synonymously. In another embodiment the web is formed by a spun bonding process, where filaments are stretched via lower temperature air. In general, spunbonded synthetic fibres are longer than meltblown synthetic fibres which usually come in discrete shorter lengths. Fibres formed by the solution blown lyocell process can be continuous or discontinuous depending on process conditions such as extension air velocity, air pressure, air temperature, viscosity of the solution, cellulose molecular weight and distribution and combinations thereof.

In one embodiment for making a nonwoven web the fibres are contacted with a non-solvent such as water (or water/NMMO mixture) by spraying, after extrusion but before web formation. The fibres are subsequently taken up on a moving foraminous support to form a nonwoven web, washed and dried.

Freshly-extruded lyocell solution ('solvent spun', which will contain only, for example, 5-15% cellulose) behaves in a similar way to 'sticky' and deformable thermoplastic filaments. Causing the freshly-spun filaments to contact each other while still swollen with solvent and with a 'sticky' surface under even low pressure will cause merged filament bonding, where molecules from one filament mix irreversibly with molecules from a different filament. Once the solvent is removed and coagulation of filaments completed, this type of bonding is impossible.

It is another object of the present invention to provide a process for the manufacture of a nonwoven material consisting of essentially continuous cellulosic filaments by:

a. Preparation of a cellulose-containing spinning solution

b. Extrusion of the spinning solution through at least one spinneret containing closely-spaced meltblown jet nozzles

c. Attenuation of the extruded spinning solution using high velocity air streams,

d. Forming of the web onto a moving surface [e.g. a perforated belt or drum],

e. Washing of the formed web

f. Drying of the washed web

wherein in step c. and/or d. coagulation liquor, i.e. a liquid which is able to cause coagulation of the dissolved cellulose; in a lyocell process this preferably is water or a diluted solution of NMMO in water, is applied to control the merged filament bonding. The amount of merged filament bonding is directly dependent on the stage of coagulation of the filaments when the filaments come into contact. The earlier in the coagulation process that the filaments come into contact, the greater the degree of filament merging that is possible. Both placement of the coagulation liquor application and the speed at which the application liquor is applied can either increase, or decrease, the rate of coagulation. Which results in control of the degree (or amount) of merged filament bonding that occurs in the material.

Preferably the merged filament bonding is further controlled by filament spinning nozzle design and arrangement and the configuration and temperature of filament extension air. The degree of molecular alignment that is present as the solution exits the spinning nozzle has an impact on the coagulation rate. The more aligned the molecules are, the faster the coagulation rate, and conversely, the less aligned the molecules are, the slower the coagulation rate. The spinning nozzle design and arrangement, along with the molecular weight of the cellulosic raw material used will determine the starting coagulation rate at the exit of the spinning nozzle. Additionally, the rate of cooling (temperature decrease) of the solution upon spinning nozzle exit will impact the coagulation rate as well. The slower the

cooling rate, the slower the coagulation rate, and conversely, the faster the cooling rate, the faster the coagulation rate. Therefore, configuration of the filament extension air can directing impact the cooling rate and therefore, impact the coagulation rate, which impacts the achievable amount of merged filament bonding that is possible.

In a preferred embodiment of the process according to the invention at least two spinnerets (also known as jets), preferably between two and ten, and further preferred between 2 and 6, each one arranged to form a layer of nonwoven web, are used to obtain a multilayer nonwoven material. By applying different process conditions at the individual spinnerets it is even possible to obtain a multilayer nonwoven material wherein the individual layers have different properties. This may be useful to optimize the nonwoven material according to the invention for different applications. In one embodiment this could provide a gradient of filament diameters from one side of the material to the other side by having each individual web having a standard filament diameter that is less than the web on top, it is possible to create a material suitable for use as an air filter media that will provide a gradient of pore size (particle size capture). This will provide an efficient filtration process and result in a lower pressure drop across the filter media compared to a single web with similar characteristics at the same basis weight and pore size distribution.

Preferably the filaments are spun using a solution of cellulose in an aqueous amine oxide and the coagulation liquor is water, preferably with a content of amine oxide not being able to dissolve cellulose, also referred to as a lyocell process; the manufacture of such a solution is in principle known, e.g. from U.S. 6,358,461, U.S. 7,067,444, U.S. 8,012,565, U.S. 8,191,214, U.S. 8,263,506 and U.S. 8,318,318; preferably the amine oxide is NMMO.

The present invention describes a cellulosic nonwoven web produced via a meltblown or spunbond-type process. The filaments produced are subjected to touching and/or compaction and/or intermingling at various points in the process, particularly before and during initial web formation. Contact between filaments where a high proportion of solvent is still present and the filaments

are still swollen with said solvent causes merged filament bonding to occur. The amount of solvent present as well as temperature and contact pressure (for example resulting from extension air) controls the amount of this bonding.

In particular the amount of filament intermingling and hydrogen bonding can be limited by the degree of merged filament bonding. This is the result of a decrease in filament surface area and a decrease in the degree of flexibility of the filaments. For instance, as the degree of merged filament bonding increase, the amount of overall surface area is decreased, and the ability of cellulose to form hydrogen bonds is directly dependent on the amount of hydroxyl groups present on the cellulosic surface. Additionally, filament intermingling happens as the filaments contact the forming belt. The filaments are traveling at a faster rate of speed than the forming belt. Therefore, as the filament contacts the belt, it will buckle and sway side to side, and back and forth, just above the forming belt. During this buckling and swaying, the filaments will intermingle with neighboring filaments. If the filaments touch and merge prior to the forming belt, this limits the number of neighboring filaments by which it can intermingle with. Additionally, filaments that merge prior to contacting the forming belt with not have the same degree of flexibility as a single filament and this will limit the total area over which the filament will buckle and sway.

Surprisingly, it has been found that high levels of control of filament merging can be achieved by modifying key process variables. In addition, physical intermingling of at least partially coagulated cellulose filaments can occur after initial contact with non-solvent, particularly at initial filament laydown to form the web. It arises from the potential of the essentially continuous filaments to move laterally during initial filament formation and initial laydown. Degree of physical intermingling is influenced by process conditions such as residual extension air velocity at the foraminous support (forming belt). It is completely different from the intermingling used in production of webs derived from cellulose staple fibers. For staple fibers, an additional process step such as calendaring is applied after the web has been formed. Filaments which still contain some residual solvent are weak, tender and prone to damage.

Therefore, in combination with controlling degree and type of bonding at this stage, it is essential that process conditions are not of a type which could cause filament and web damage. Initial drying of the washed but never-dried nonwoven, together with optionally compacting, will cause additional hydrogen bonding between filaments to develop. Modifying temperature, compacting pressure or moisture levels can control the degree of this hydrogen bonding. Such treatment has no effect on intermingling or the merged filament bonding.

In a preferred embodiment of the invention the nonwoven material is dried prior to subsequent bonding/treatment.

In a preferred embodiment of the invention the percentage of each type of bonding is controlled using a process with up to two compaction steps, where one of these compaction steps is done after step d. of the inventive process where the spun filaments are still swollen with a solvent, and one of these compaction steps is done before or in step e. of the inventive process where all or most of the solvent has been removed and the web has been wet with water. As previously discussed, control of the coagulation of the spun solution is a factor in controlling the degree of merged filament bonding. This preferred embodiment concerns decreasing the coagulation rate to a state where additional compaction steps can be used after filament laydown to further increase the actual amount of merged filament boding that is achievable. It might be helpful to view the maximum achievable filament bonding as the state where we have merged all filaments into an essentially film-like structure.

The present invention describes a process and product where merged filament bonding, physical intermingling and hydrogen bonding can be controlled independently. However, the degree of merged filament bonding can limit the degree of physical intermingling and hydrogen bonding that can occur. In addition, for the production of multi-layer web products, process conditions can be adjusted to optimise these bonding mechanisms between layers. This can include modifying ease of delamination of layers, if required.

In addition to merged filament, intermingling and hydrogen bonding being independently set as described above, additional bonding/treatment steps may optionally be added. These bonding/treatment steps may occur while the web is still wet with water, or dried (either fully or partially). These bonding/treatment steps may add additional bonding and/or other web property modification. These other bonding/treatment steps include hydroentangling or spunlacing, needling or needlepunching, adhesive or chemically bonding. As will be familiar to those skilled in the art, various post-treatments to the web may also be applied to achieve specific product performance. By contrast, when post-treatments are not required, it is possible to apply finishes and other chemical treatments directly to the web of this invention during production which will not then be removed, as occurs with, for example, a post-treatment hydroentanglement step.

Varying the degree of merged filament bonding provides unique property characteristics for nonwoven cellulose webs with regards to softness, stiffness, dimensional stability and various other properties. Properties may also be modified by altering the degree of physical intermingling before and during initial web formation. It is also possible to influence hydrogen bonding, but the desired effect of this on web properties is minor. Additionally, properties can be adjusted further by including an additional bonding/treatment step such as hydroentangling, needlepunching, adhesive bonding and/or chemical bonding. Each type of bonding/treatment provides benefits to the nonwoven web. For example, hydroentangling can add some strength and soften the web as well as potentially modifying bulk density; needling is typically employed for higher basis weights and used to provide additional strength; adhesive and chemical bonding can add both strength and surface treatments, like abrasive material, tackifiers, or even surface lubricants.

The present invention allows independent control of the key web bonding features: merged filaments, intermingling at web formation, hydrogen bonding and optional additional downstream processing. Manipulation of merged

filament bonding can be varied to predominantly dictate the properties of the nonwoven web.

In a further preferred embodiment of the invention the nonwoven material contains a second layer, consisting of a cellulosic nonwoven web, which is formed of essentially continuous filaments, pulp fiber or staple fiber, which is formed on top of the first cellulosic nonwoven web, and subsequently both layers are hydroentangled together. One useful advantage of two layers is that one layer can be higher density, and have a more abrasive surface and clean a surface better ("scrubby layer") while the other is lower density, and more absorbent ("absorbent layer"). Another useful advantage of a dual-layer structure is that one layer can be designed to provide the tensile strength, while another layer can be designed to provide the absorbency, cleanability, or other desired attribute.

In a further preferred embodiment of the invention the nonwoven material contains a third layer, consisting of a cellulosic nonwoven, which is formed of essentially continuous filaments, pulp fiber or staple fiber, which is formed on top, and subsequently all three layers are hydroentangled together Here, another useful advantage is to have one outer layer as high density for cleaning a surface ("scrubby layers"), another outer layer to have a high surface area for excellent lotion distribution with the center layer designed to have a high absorbent capacity.

In especially preferred embodiments of the invention one or more of the cellulosic nonwoven layers within the nonwoven material, if formed of essentially continuous filaments, are made according to a lyocell process. As known to an expert in the art, the lyocell process allows for use of a sustainable raw material (pulp) and provides a final filament with high purity (very low residual chemicals).

In particularly preferred embodiments of a two-layer material according to the invention either both layers consist of continuous filaments, made according to

a lyocell process, or one layer consist of continuous filaments, made according to a lyocell process, and the second layer consist of pulp fiber.

In particularly preferred embodiments of a three-layer material according to the invention either all three layers consist of continuous filaments, made according to a lyocell process, or the two outer layers consist of continuous filaments, made according to a lyocell process, and the middle layer consist of pulp fiber.

The invention will now be illustrated by examples. These examples are not limiting the scope of the invention in any way. The invention includes also any other embodiments which are based on the same inventive concept.

Examples

All samples for testing were conditioned at 23°C ±2°C rel. humidity 50% ±5% for 24 hours.

Example 1

A 66-gsm fabric product of the invention was compared with a commercial product of the same basis weight comprised of 50 % lyocell and 50 % polyester for water uptake using test method DIN 53923. The product of invention showed a 1.3 times higher water uptake compared to the commercial sample.

Example 2

A 50-gsm fabric product of the invention was compared with a commercial product of the same basis weight comprised of 100 % lyocell for dimensional stability as indicated by stiffness. Fabric stiffness was measured using a 'Handle-o-meter' according to standard method WSP 90.3, with ¼ inch slot width, stainless steel surface and 1000 g beam. Sample size was 10cm x 10cm.

The product of invention showed a 2.7 higher overall stiffness compared to the commercial sample.

Example 3

The product of invention of example 1 was tested for wet lint performance

Equipment detail:
Cleanability tester for wipes, „Wischtester Fasertücher 2013“, Type S03003-001, Mach.-Nr.: 001, Art.Nr.: 84311, Year built: 12/2013
from SOMA Sondermaschinen u. Werkzeugbau GmbH
Software: SMATECH Sondermaschinen & Automatisierungstechnik

The product of invention was wetted with water 3 fold (equilibrium time 2 hours). Then it was used in MD for a wiping test, wiping over a glass plate, which was free of visible particles prior to test. The wiping equipment simulates a real wiping movement with 550 g wiping pressure.

The product of invention showed no visible wet lint from this test.

Claims

1. A nonwoven material suitable for use as a clean room wipe, containing at least a first cellulosic nonwoven web, characterized in that the cellulosic nonwoven web is made from essentially pure cellulose formed of essentially continuous filaments and multibonded by merged filaments, hydrogen bonding and physical intermingling of the filaments.
2. The nonwoven material of Claim 1 that is further bonded or treated by a hydroentanglement, needlepunch or chemical bonding process to modify the physical properties.
3. The nonwoven material of Claim 1 where the first cellulosic nonwoven web is made according to a lyocell process.
4. The nonwoven material of Claim 1 where a second cellulosic nonwoven web, which is essentially formed of continuous filaments, pulp fiber or staple fiber, is formed on top of the first cellulosic nonwoven web, and subsequently both layers are hydroentangled together.
5. A nonwoven material according to claim 1, wherein the number of layers is at least two, preferably between two and ten, with a further preferred range from 2 to 6.
6. The nonwoven material of Claim 5, where the layers are formed of essentially continuous filaments, pulp fiber or staple fiber, and subsequently all layers are bonded together using merged filament bonding, hydrogen bonding and filament intermingling.
7. The nonwoven material of Claim 5, where the layers are formed of essentially continuous filaments, pulp fiber or staple fiber, and subsequently all layers are hydroentangled together.
8. The nonwoven material of Claim 4 or 6, where one or more of the cellulosic nonwoven layers within the nonwoven material, if formed of essentially continuous filaments, are made according to a lyocell process.
9. Use of the nonwoven material of claim 1 as a base sheet for the manufacture of a compostable clean room wipe, such wipe being loaded with a cleaning solution, or produced and used dry..

10. Use of the nonwoven material of claim 1 for the manufacture of a product where the material of claim 1 is combined with another nonwoven material to produce a nonwoven composite clean room wipe.
11. Use according to claim 8 where the material of claim 1 is combined with the other nonwoven material through hydroentanglement.

INTERNATIONAL SEARCH REPORT

International application No
PCT/AT2017/000024

A. CLASSIFICATION OF SUBJECT MATTER
INV. D04H1/4258 A45D44/00 A61Q19/00 A61K8/02 D04H3/013
D04H3/11 D01D5/098 B32B5/26 D04H1/4374
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)
D04H A45D A61Q A61K D01D B32B D01F A47L H01L

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/056956 A1 (ZHAO RONGGUO [US] ET AL) 17 March 2005 (2005-03-17)	1-3
Y	paragraph [0012] - paragraph [0016]	4-8
A	paragraph [0027] - paragraph [0028]; claims 1, 12; figures 3-6; example 1	9-11

X	WO 98/26122 A1 (COURTAULDS FIBRES HOLDINGS LTD [GB]; LAW STEPHEN JOHN [GB]; STREET HEA) 18 June 1998 (1998-06-18)	1-4,8
Y	page 3, line 6 - line 11	5-7
A	page 7, line 13 - page 8, line 29; figure 1; table 3	9-11

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[X] Further documents are listed in the continuation of Box C.

[X] 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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Date of the actual completion of the international search	Date of mailing of the international search report
10 October 2017	19/10/2017

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