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GB 2496310 A **WO 2007/046806 A1**
WO 2003/090654 A1

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(54) Title of the Invention: **Antimicrobial dressing**
Abstract Title: **Wound dressing with an antimicrobial layer**

(57) A wound dressing comprising an antimicrobial layer. The antimicrobial layer is a fabric comprising a spun yarn, in which the yarn comprises a blend of gelling-, nongelling-, and silver fibres. The wound dressing may further comprise any of an absorbent material and a hydrophobic gel and may be used in a system for negative pressure wound therapy. The absorbent material may be an absorbent foam, polymeric material or superabsorbent material.

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Antimicrobial Dressing

This invention relates to antimicrobial wound dressings.

Wound dressings play an important role in wound care. Different types of wound dressings are required to meet different clinical needs and address different problems.

For example, a wound dressing can play an important part in the prevention and management of wound infection. Infection of wounds during the healing process is major concern in healthcare and, as well as being a source of pain and distress to the patient, can lead to serious complications including tissue loss, systemic infections, septic shock, and death.

One means of combating wound infection is to include an antimicrobial agent in a wound dressing. Silver is recognised as a useful antimicrobial agent and can provide a topical antimicrobial barrier, to reduce the bacteria and fungi counts on and around a wound surface. Many proposals for incorporating silver into wound dressings have been made, including providing the silver in the form of silver fibres, and a variety of means of making such would dressings have been suggested.

In one aspect, the present invention provides a wound dressing comprising an antimicrobial layer, wherein said antimicrobial layer comprises a knitted fabric in which a silver thread is knitted, optionally with a non-metallic thread.

In accordance with the above, the antimicrobial layer may be a knitted fabric consisting of silver thread, or it may be a knitted fabric in which a silver thread and a non-metallic thread are knitted together.

The antimicrobial layer may form a wound-contacting surface of the dressing, or it may be included in a composite dressing between other layers of the dressing.

The non-metallic fibre may be any flexible polymeric material, including, for example, a polyamide, polyester, polyolefin, acrylic, or polypropylene, or it may be a mixture thereof. Alternatively, the non-metallic fibre may be a natural fibre, for example cotton.

Where present, the non-metallic fibre will normally form the warp thread of the fabric. However, it may alternatively form the weft thread of the fabric.

The silver thread, if used in combination with a non-metallic fibre, will normally form the weft thread of the fabric. However, it may alternatively form the warp thread of the fabric.

The silver thread used in the present invention may comprise a thread in which metallic silver is bonded to the surface of a non-metallic base fibre; that is, the thread is a silver-coated fibre. The base fibre may be any flexible polymeric material, including, for example, a polyamide, polyester, polyolefin, acrylic, or polypropylene, or it may be a mixture thereof. The base fibre may also be a natural fibre, for example cotton. Alternatively, the silver thread is a pure silver thread, i.e., a 100% silver thread.

Preferably, in a thread in which metallic silver is bonded to the surface of a non-metallic base fibre, the metallic silver is permanently bonded to the surface of the flexible polymer to coat the entire surface of the base fibre, providing a uniform coating thereon.

When the metallic silver is bonded to the surface of a non-metallic fibre, the silver may be present in at least an amount sufficient to provide a uniform coating on the non-metallic fibre. For example, the silver may be present in a total amount of at least about 3% by weight of the total weight of the silver-coated fibre, such as from 3-15%, 3-14%, 3-13%, 3-12%, 3-11%, 3-10%, 3-9%, 3-8%, 3-7%, 3-6%, 3-5%, 3-4%, for example from 3-7%, 5-10%, or around 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14% or 15% by weight of the total weight of the silver-coated fibre. Larger amounts of silver may also be used in the coated fibre, for

example up to about 20%, or up to about 25%, by weight of the total weight of the silver-coated fibre.

Means for coating base fibres are known. Suitable silver-coated fibres include those manufactured as described in US Patent Number 4,042,737. Suitable fibres are commercially available from Noble Biomaterials, Inc., under the tradename X-STATIC®. X-STATIC® fibres comprise 99.9% pure silver. Thus, a preferred silver coated fibre for use in the present invention is a silver coated fibre wherein the silver coating comprises around 99.9% silver. Preferably the coating provides 100% coverage on the fibre.

In use, silver ions are released from the fibre in a continuous fashion. Because the metallic silver is permanently bonded to the surface of the flexible polymer, metallic silver is not released.

The silver, and if present, the non-metallic thread, may be knitted onto a non-woven sheet of a thermoplastic material.

Knitting of the thread onto a non-woven sheet of thermoplastic material may be achieved by a stitch-bonding process, for example. Stitch-bonding is a known process, in which a flexible substrate, such as a nonwoven fabric, is pierced with a series of pointed needles positioned adjacent to each other. These needles then stitch a network of textile yarns into the substrate.

Knitting of the silver, and if present, the non-metallic threads onto a non-woven sheet of a thermoplastic material allows the antimicrobial layer to be fused onto another component of the dressing, such as to an absorbent material, to form a composite wound dressing. Said composite wound dressing comprises an antimicrobial layer and an absorbent material, wherein said antimicrobial layer comprises a knitted fabric in which a silver thread is knitted, optionally with a non-metallic thread. Fusing of the antimicrobial layer onto an absorbent base in this manner provides a dressing of high integrity which is resistant to loss of fibre due to fraying of the knitted fabric. Fusing is achieved by applying heat to an assembly

of desired components, including the antimicrobial layer and the thermoplastic material.

The composite wound dressing of the present invention can thus be described as comprising an antimicrobial layer and an absorbent material, wherein said antimicrobial layer comprises a silver thread and optionally a non-metallic thread knitted onto a non-woven sheet of a thermoplastic material, and said composite wound dressing comprises a fused assembly of said antimicrobial layer and absorbent material.

The antimicrobial layer may be fused onto multiple components of the dressing, as appropriate.

Thermoplastic materials are well known to the person skilled in the art and include, for example, polyamides, polyesters, polyolefins, acrylics, polypropylenes, and mixtures thereof.

Dressings in accordance with the present invention may comprise gelling fibres.

Accordingly, in another aspect, the present invention provides a wound dressing comprising an antimicrobial layer, wherein said antimicrobial layer comprises a yarn comprising gelling and non-gelling fibres, and silver.

Preferably, the yarn is spun from blend of gelling and non-gelling fibres, and silver fibres.

Gelling fibres are known for use in wound dressings. They have a greater capacity for absorbing liquid than standard textile fibres and, on absorbing liquid, they become moist and slippery. This prevents the dressing from adhering to the wound and therefore makes removal of the dressing easier. When gelling fibres are blended with non-gelling fibres in a yarn, a knitted fabric of high structural integrity can be produced, which fabric has the advantages of high structural

integrity and excellent capacity for absorbing wound exudate. WO 2013/064831 describes such a knitted fabric.

Methods for producing yarn from blended fibres are known in the art. The yarn for use in the present invention may be spun for example from a blend of gelling fibres, non-gelling fibres and silver fibres, by any known method.

A variety of techniques for producing a fabric from a spun yarn (for example, by knitting) are known in the art, and are suitable for use in the present invention.

The gelling fibres may be any suitable gelling fibres known in the art, including pectin fibres, alginate fibres, fibres made from alginate and another polysaccharide, chitosan fibres, hyaluronic acid fibres, fibres of other polysaccharides or derived from gums, or chemically-modified cellulosic fibres, e.g., carboxymethyl cellulose (CMC). The gelling fibres may be a combination or blend of different gelling fibres. A particularly preferred gelling fibre is CMC.

The non-gelling fibres may be any suitable non-gelling fibres known in the art, or mixtures thereof. Suitable fibres included textile fibres, and may be natural, e.g., cotton, natural fibres which have been modified, e.g., cellulosic fibres such as viscose or lyocell (e.g., sold under the trade name TENCEL®), or synthetic fibres, e.g. polyester, polypropylene, polyolefin, acrylic, or polyamide. Preferably, the non-gelling fibres are cellulosic fibres, most preferably TENCEL® fibres.

A combination of CMC fibres, TENCEL® fibres, and silver fibres is preferred.

Dressings in accordance with the present invention may comprise an absorbent material. Suitable absorbents include foam materials. Foam dressings are a common type of wound dressing and are known to be particularly useful in dressing chronic wounds that have high levels of exudate.

The foam material may be any suitable foam material known in the art. Typically, the foam is an open-celled foam. Preferably, the foam is a hydrophilic foam. More

preferably, the hydrophilic foam is a polyurethane foam. Most preferably, the foam is an open-celled polyurethane foam. The foam typically has a thickness of from 0.5mm to 10mm, for example from 1mm to 7mm, or from 2mm to 7mm, such as 2mm, 3mm, 4mm, 5mm or 6mm. "Thickness" refers to the foam in a natural, uncompressed state.

Other forms of absorbent body include absorbent polymeric materials. Suitable polymeric materials include polysaccharides and polysaccharide derivatives. For example, the absorbent material may be an alginate (i.e., a salt of alginic acid) and in particular sodium alginate or calcium alginate, or a blend of the two. Other suitable absorbent materials include cellulose, a cellulose derivative such as hydroxyethyl cellulose or hydroxypropyl cellulose, and pectin or a pectin derivative such as amidated pectin.

Alternatively, the absorbent material may be of the type commonly referred to as a "superabsorber" or "superabsorbent material". Such materials are typically capable of absorbing many times their own mass of water (e.g., up to 200, 300, 400, 500 or more times their own mass of water). Preferred superabsorbent materials are polymeric superabsorbent materials and include polyacrylate (i.e., a salt of polyacrylic acid), polyacrylamide copolymers, ethylene maleic anhydride copolymer, carboxymethylcellulose, polyvinylalcohol copolymers, polyethylene oxide and starch-grafted copolymers of polyacrylonitrile.

A layered dressing may comprise more than one of absorbent material, each layer being the same or different. In this case, the antimicrobial layer may be disposed between layers of absorbent material, and/or at the wound-facing surface of the dressing.

Dressings in accordance with the present invention may include a hydrophobic gel. Means of applying a hydrophobic gel are known. Generally, a curable hydrophobic gel precursor is applied to the dressing, and caused or allowed to cure, thereby forming a layer of hydrophobic gel.

The hydrophobic gel may be disposed on the wound-contacting surface of the dressing and may coat all or part of the wound-contacting surface of the dressing. For example, the hydrophobic gel may form a border around the edge of the dressing.

Alternatively, or additionally, the hydrophobic gel may impregnate the antimicrobial layer of the dressing.

A preferred hydrophobic gel is a silicone gel, such as a soft silicone gel. Soft silicone is used in wound dressings because it adheres readily to dry skin but does not stick to the surface of a moist wound and does not cause damage on removal. It is therefore particularly useful for use in atraumatic wound dressings. There are several other intrinsic properties of soft silicone that make it particularly advantageous for use in wound dressings. These properties are well documented and include the fact that silicones are non-toxic, non-allergenic and non-sensitising, they do not shed particles or fibres into the wound, they feel soft on the skin and they are comfortable, yet robust.

Suitable silicone gels are formed by reaction between two components that are mixed immediately prior to application to the composite wound dressing. Suitable components that are intended for such reactions to form a silicone gel are readily available commercially. Typically, the two components are a vinyl-substituted silicone and a hydride-containing silicone, such as are known in the art.

Gels having different properties may be produced by varying the proportions and/or nature of the components used in the reaction. For example, the molecular weights of the various components and/or their degree of substitution by reactive groups may be different.

The hydrophobic gel may be coated onto the composite wound dressing at a wide variety of coating weights. The most appropriate coating weight will depend on the properties of the gel and its intended application. Typically, the gel may be coated onto the wound facing surface of the present dressings at a weight of from 50g/m^2

and 800g/m^2. The thickness of the gel may typically be between 5µm and 10mm, for example between 20µm and 5mm, or between 0.5mm and 5mm, or between 0.5mm and 2mm, e.g., about 1mm or about 1.5mm.

As hydrophobic gel layers do not permit the free transmission of fluids, wound dressings having a skin-contacting layer coated with hydrophobic gel generally require an opening in the gel layer to allow the transmission of wound exudate away from the wound. Advantageously, the hydrophobic gel layer may be perforated. Perforated hydrophobic gel layers are of particular advantage for use as skin-contacting layers in wound dressings that are in prolonged contact with the skin. The introduction of perforations in the hydrophobic gel layer allows the transmission of fluids, such as water vapour, improving the breathability of the gel layer and thereby improving comfort. The improved breathability of the hydrophobic gel layer allows the entire skin-contacting surface of a dressing to be coated.

Means for introducing perforations into a hydrophobic gel layer are known. For example, WO 2010/061228 describes a method for introducing perforations into a sheet of laminated material that includes a substrate and a layer of hydrophobic gel, which method involves contacting perforating elements with the sheet and subjecting the sheet, at least in the regions contacted with the perforating elements, to high frequency mechanical vibrations. The substrate may form part of a finished product in which the perforated laminate is incorporated, or it may be a processing aid used to facilitate production of the perforated laminate, which is removed prior to incorporation of the laminate into a composite product.

Perforations may be varied considerably in size and shape but are typically circular and between 0.1mm and 5mm, more commonly between 0.5mm and 2mm, in diameter, although smaller and larger perforations are possible.

Typically, perforations in any given product will all be of similar form, although it is possible for a variety of sizes and shapes of perforation to be present in a single product.

The perforations are preferably arranged in a regular array, the perforations typically being separated by 0.2 to 10mm. Most commonly, the number of perforations per unit area is between 1 and 100, more commonly between 1 and 50, or between 1 and 20, perforations/cm^2. The perforations typically account for more than 5%, and up to 75%, or up to 50%, or up to 25%, of the area of the hydrophobic gel layer.

Wound dressings in accordance with the present invention may be provided in a number of different forms. Wound dressings may consist of, or include, the antimicrobial layer described herein.

For example, dressings in accordance with the present invention may be provided as simple dressings which may be in ribbon or tape form, or may be square, rectangular, circular, ovoid, or may have any other suitable shape, for example to conform to the shape of a specific part of the body, such as the sacrum or the heel. They may also take the form a jointed dressing, that is, a dressing adapted for application to a jointed limb.

Dressings in accordance with the present invention may be provided with a backing layer on the non-wound-facing surface of the dressing. Any suitable material known in the art may be used for the backing layer. For example, the backing layer may be a plastics film such as a polyurethane foam. The backing layer may be attached to the composite wound dressing by means of an adhesive provided on the dressing-facing surface of the backing layer or on the backing layer-facing surface of the dressing.

The backing layer may be oversized, extending beyond the edges of the rest of the wound dressing, for example on all sides to provide a border therearound. In this case, the adhesive may extend over the full surface of the backing layer and may serve to adhere the wound dressings to a patient's skin, around the wound. Suitable skin contact adhesives are known. For example, the skin contact

adhesive may be a hydrophobic gel such as a silicone gel, as described above, or an acrylic adhesive, or a combination of the two.

Dressings in accordance with the present invention may be provided on the wound-facing surface with a release liner that is removed to expose the wound-facing surface of the dressing immediately prior to use. Preferably, the release liner is formed in such a way as to be readily grasped and removed, for example by having one or more projecting tabs.

The release line may be formed from any suitable material, for example, form high density polyethylene.

The release liner may be oversized, for example in correspondence with the backing layer.

Dressings in accordance with the present invention may be included in a system for negative pressure wound therapy.

Negative pressure wound therapy (NPWT) involves the application of a pressure that is reduce relative to that of the surroundings (commonly referred to as "negative pressure") to a wound, which causes mechanical contraction of the wound and removal of wound fluid, thus promoting formation of granulation tissue and accelerating wound closure. This technique is particularly effective in the treatment of slow healing wounds such as chronic leg ulcers and large open wounds. A dressing comprising an occlusive drape, traversed by a drainage tube, is applied to the wound opening, forming a seal under which a negative pressure can be established. The drainage tube is connected to a negative pressure source allowing the wound fluid to be drawn away.

EXAMPLE

Dressings in accordance with the present invention, including an antimicrobial layer fused to an absorbent foam, were tested for capability to kill organisms upon contact.

The inhibitory activity of the material was tested against *Staphylococcus aureus* (ATCC 6538) and *Pseudomonas aeruginosa* (ATCC 9027).

Procedure

Tryptone Soya Agar (TSA) plates were seeded with approximately 10^4 cfu/ml of the bacteria.

Small pieces of the dressing were added to each TSA plate. In addition, control samples were prepared using small pieces of non-antimicrobial based dressings. These were added to each type of seeded agar plate.

At intervals of 1, 4 and 24 hours, the inhibitory material was removed from the surface of the appropriate seeded plate. The plates were incubated at 30°C (+/- 2°C) for a minimum period of 24 hours. This was used to establish whether dressing contact time had any effect on the inhibitory capability of the material. Any leaching of the inhibitory substance from the dressing into the agar, causing inhibition away from the dressing, was also assessed.

Results

At each time interval, almost complete inhibition was observed for both organisms.

Leaching was observed for *Staphylococcus aureus* at 1 and 4 hours, with extensive leaching at 24 hours.

No leaching was observed for *Pseudomonas aeruginosa*.

Conclusion

Anti-microbial effect was observed against both organisms in comparison to control samples, particularly after 24 hours. The material was found to be very effective at inhibiting organisms. Extensive leaching of the anti-microbial substance was also seen with *Staphylococcus aureus*.

CLAIMS

1. A wound dressing comprising an antimicrobial layer, wherein said antimicrobial layer is a fabric comprising a spun yarn, which yarn comprises a blend of gelling-, non-gelling-, and silver fibres.

2. A wound dressing as claimed in claim 1, further comprising an absorbent material.

3. A wound dressing as claimed in claim 2, wherein the absorbent material is an absorbent foam.

4. A wound dressing as claimed in claim 2, wherein the absorbent material is an absorbent polymeric material.

5. A wound dressing as claimed in claim 2, wherein the absorbent material is a superabsorbent material.

6. A wound dressing as claimed in any one of the preceding claims, further comprising a hydrophobic gel.

7. A wound dressing as claimed in claim 6, wherein the hydrophobic gel is a soft silicone gel.

8. A wound dressing as claimed in claim 6 or claim 7, wherein the hydrophobic gel is perforated.

9. A wound dressing as claimed in any one of claims 6-8, wherein the hydrophobic gel is provided as a coating on a wound-contacting surface of the dressing.

10. A wound dressing as claimed in any one of claims 6-9, wherein the hydrophobic gel impregnates the antimicrobial layer of the dressing.

11. A wound dressing as claimed in any one of the preceding claims, further comprising a backing layer secured to the non-wound-contacting surface of the dressing.

12. A wound dressing as claimed in claim 11, wherein the backing layer extends beyond the antimicrobial layer or the antimicrobial layer and absorber on all sides, to form a border around the wound dressing.

13. A wound dressing as claimed in claim 12, wherein the backing layer is provided with an adhesive for securing the dressing to a patient.

14. A wound dressing as claimed in any one of the preceding claims, further comprising a release liner on the wound-facing surface of the dressing.

15. A system for negative pressure wound therapy, including a wound dressing according to any one of claims 1-10.

Amendments to the claims are filed as follows:

CLAIMS

1. A wound dressing comprising an antimicrobial layer, wherein said antimicrobial layer is a fabric comprising a spun yarn, which yarn comprises a blend of
(i) gelling-fibres,
(ii) non-gelling-fibres, and
(iii) silver fibres comprising metallic silver bonded to the surface of a non-metallic fibre.

2. A wound dressing as claimed in claim 1, further comprising a layer of hydrophobic gel.

3. A wound dressing as claimed in claim 2, wherein the hydrophobic gel is disposed on the wound-contacting surface of the dressing and coats all or part of said surface.

4. A wound dressing as claimed in claim 2 or claim 3, wherein the hydrophobic gel impregnates the antimicrobial layer of the dressing.

5. A wound dressing as claimed in any preceding claim, further comprising an absorbent material.

6. A wound dressing as claimed in claim 5, wherein the absorbent material is an absorbent foam.

7. A wound dressing as claimed in claim 5, wherein the absorbent material is an absorbent polymeric material.

8. A wound dressing as claimed in claim 5, wherein the absorbent material is a superabsorbent material.

9. A wound dressing as claimed in any one of claims 2-8, wherein the hydrophobic gel is a soft silicone gel.

10. A wound dressing as claimed in any one of claims 2-10, wherein the hydrophobic gel is perforated.

11. A wound dressing as claimed in any one of the preceding claims, further comprising a backing layer secured to the non-wound-contacting surface of the dressing.

12. A wound dressing as claimed in claim 11, wherein the backing layer extends beyond the antimicrobial layer or the antimicrobial layer and absorber on all sides, to form a border around the wound dressing.

13. A wound dressing as claimed in claim 12, wherein the backing layer is provided with an adhesive for securing the dressing to a patient.

14. A wound dressing as claimed in any one of the preceding claims, further comprising a release liner on the wound-facing surface of the dressing.

15. A system for negative pressure wound therapy, including a wound dressing according to any one of claims 1-10.

Intellectual Property Office

Application No:	GB2207279.7	**Examiner:**	Mr Tony Judge
Claims searched:	1-15	**Date of search:**	15 June 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-15	GB2496310 A (BRIGHTWAKE LTD) Please see figures and page 14, lines 9-15, page 21, lines 16-17 and page 24, lines 4-21.
X	1-4 and 11-15	WO 03/090654 A1 (ARGENTUM RES INC) Please see figures and page 6, lines 24-32, page 11, lines 3-14 and page 13, lines 12-22.
X	1-4, 11-13 and 15	WO 2007/046806 A1 (ARGENTUM MEDICAL LLC) Please see figures and page 13, lines 14-15, page 14, line 17-page 15, line 3 and page 20, lines 14-24.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A61F

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
A61F	0013/00	01/01/2006
A61F	0013/15	01/01/2006
A61F	0013/51	01/01/2006