



(51) International Patent Classification:

A41D 27/12 (2006.01) A41D 13/12 (2006.01)
A41D 27/10 (2006.01)

(21) International Application Number:

PCT/IB2009/055324

(22) International Filing Date:

24 November 2009 (24.11.2009)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

12/343,624 24 December 2008 (24.12.2008) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: TREATED CUFF



FIG. 1

(57) Abstract: The present invention is generally directed to an elastic woven cuff having an alcohol repellency rating of (10) the cuff having fluoro-chemical monomer deposited onto the surface of the cuff.



TREATED CUFF

Background of the Invention

5 Sterile surgical gowns are designed to greatly reduce, if not prevent, the transmission of liquids and biological contaminants through the gown. In surgical procedure environments, such liquid sources include the gown wearer's perspiration, blood, saliva, blood plasma, alcohol, drugs and saline. Because surgical gowns require a high degree of liquid repellency to prevent strike-through of these and other liquids, disposable gowns for use under these conditions are, 10 for the most part, made primarily from liquid repellent fabrics.

Surgical gowns are generally loose fitting, with portions of the gown such as the cuffs designed to fit closely and comfortably about the wearer. Such elastic cuffs may be formed from a variety of fabrics such as cotton, knits and polyester knits. The cuff which is preferred by many medical personnel is a loosely knitted 15 cuff formed of a polyester material which provides comfort while maintaining a close fit to the wearer's wrist. These cuffs provide good freedom of movement and blood circulation in the wrist and hand, which helps to limit muscle fatigue in this area. While such cuffs may provide a comfortable form-fit about the wrist, they do not function well as a barrier to strikethrough.

20 To overcome this deficiency, the cuffs are commonly overlaid with a glove which acts as a highly effective barrier to fluids. Unfortunately, movement of the wearer creates opportunities for the glove to move away from its optimum position over the cuff, making the glove-gown interface an area that is prone to strike-through. Additionally, perspiration may be formed within the gown sleeve and 25 collect in the cuff area. As the amount of perspiration retained in the cuff increases, the liquid may migrate to the cuff/glove interface. Strike-through may occur when liquids generated during the surgical procedure contact the wearer's perspiration at the interface of the gown, glove and cuff. Liquids on the outer surface of the gown sleeve may also travel down the sleeve and contact the perspiration-laden cuff 30 before or during the removal of the glove or gown.

Due to the strong preference of medical personnel for this type of loosely-woven cuff, solutions to the glove/gown interface do not address the cuff itself. Rather, the woven elastic cuff is seen as an impediment to be overcome in the glove/gown interface and is not viewed as part of the solution.

5 As such, there remains a need for surgical gowns having cuffs which provide excellent barrier protection while maintaining the comfort levels which medical personnel have come to expect.

Summary of the Invention

10 In accordance with one embodiment of the present invention, an elastic woven cuff is treated with a fluoro-chemical monomer and has an alcohol repellency rating of 10. In some embodiments, the fluoro-chemical monomer is a perfluorodecyl acrylate (PFDEA) and may be applied to the elastic woven cuff by a
15 radio frequency plasma process.

 In another embodiment of the present invention, a polyester yarn may be treated with a fluorinated compound to achieve an alcohol repellency rating of 10, the yarn being suitable for use in an elastic woven cuff.

20 The invention also encompasses a method of forming a protective garment that includes the steps of providing a yarn and forming the yarn into a knitted cuff. The knitted cuff, or in some embodiments, the yarn which is to be formed into the knitted cuff, is subjected to a plasma process which applies a fluoro-chemical monomer to the cuff, the cuff having an alcohol repellency rating of 10. The cuff is then attached to a sleeve which is attached to a protective garment.

25 Other features and aspects of the present invention are described in more detail below.

Brief Description of the Drawings

30 A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, which makes reference to the appended figures in which:

Fig. 1 is a photograph of a cuff according to one embodiment of the present invention; and

Fig. 2 is a photograph of a cuff according to the prior art.

5

Repeat use of reference characters in the present specification and drawings is intended to represent same or analogous features or elements of the invention.

10

Detailed Description of Representative Embodiments

15

Reference now will be made in detail to various embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations may be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment, may be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations.

20

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The present invention is generally directed to an improved cuff for use in a protective garment such as a surgical gown. The present invention is a unique approach to reducing the opportunities for strike-through at the glove/gown interface by dramatically increasing the liquid repellency of the loosely-woven cuff which is preferred by many medical personnel. More specifically, this invention is directed to loosely woven elastic cuffs which have improved barrier properties to fluids as a result of grafting fluorinated moieties via a plasma process onto and through the preferred woven cuff.

30

While a variety of woven cuffs may be utilized in the present invention, woven elastic cuffs which are preferably used in medical garments are available from Straus Knitting Mills, Inc. (St. Croix Falls, WI). The term "elastic", as used herein, refers to a material that, upon application of a stretching force, is stretchable in a direction, and which upon release of the stretching force, returns to

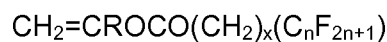
approximately its original dimension. For example, a stretched material may have a stretched length that is at least 50% greater than its relaxed unstretched length, and which will recover to within at least 50% of its stretched length upon release of the stretching force. A hypothetical example would be a 2.54-cm sample of a material that is stretchable to at least 3.81 centimeters and which, upon release of the stretching force, will recover to a length of not more than 3.175 centimeters. Desirably, the material contracts or recovers at least 50%, and even more desirably, at least 80% of the stretched length. In a preferred embodiment, polyester staple fiber is woven into a four ply tubular knit cuff having a relatively open knitted structure. These elastic cuffs function to secure the gown sleeve onto a user's wrist without applying such a significant retracting force to the wearer's wrist.

Various references are available which describe, in detail, plasma fluorination processes. For example, US 20030134515 and EP 1 557 489 disclose plasma fluorination processes. RF plasma fluorination processes have been primarily investigated for filtration needs and for oil and water repellency. Materials which have previously been evaluated are unlike the loosely woven elastic cuff of the present invention, in that the woven elastic cuff is entirely unsuitable for most filtration and repellency applications.

The plasma fluorination process to treat the polyester cuffs for repellency to fluids encountered in medical applications involves generating radio frequency (RF) plasma in a vacuum chamber that is filled with a gas that can be sustained in a plasma state, such as helium or argon. A fluorinated gas, such as a fluoro-acrylic monomer, is flash-evaporated into the chamber, and the plasma initiates the graft polymerization of the fluoro-acrylic monomer onto the surfaces of the cuff, including pores, seams and stitching holes, that can be reached by the activated fluoro-chemistry.

A variety of monomer compounds may be used in the present invention, including, for example, fluorinated compounds. Exemplary fluorinated monomers include 2-propenoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluorooctyl ester; 2-propenoic acid, 2-methyl-2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluorooctol ester; 2-propenoic acid, pentafluoroethyl ester; 2-propenoic acid, 2-methyl-pentafluorophenyl ester; 2,3,4,5,6-Pentafluorostyrene; 2-Propenoic acid, 2,2,2-

trifluoroethyl ester; and 2-propenoic acid, 2-methyl-2,2,2-trifluoroethyl ester. Other suitable monomers include those fluoroacrylate monomers having the general structure of:



5 wherein n is an integer ranging from 1 to 12, x is an integer ranging from 1 to 8, and R is H or an alkyl group with a chain length varying from 1 to 16 carbons. Specifically, perfluorodecyl acrylate, 1H,1H,2H,2H-heptadecafluorodecyl acrylate and 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluorodecyl methacrylate are also suitable for use in the present invention. In many instances, the fluoroacrylate
10 monomer may be comprised of a mixture of homologues corresponding to different values of n. Monomers of this type may be readily synthesized by one of skill in the chemical arts by applying well-known techniques. Additionally, many of these materials are commercially available. Specifically, suitable fluoro-acrylic monomers include TG-10, TG-20 or TG-30, which are available from Daikin Americas, Inc.
15 (Decatur, AL). If desired, perfluorodecyl acrylate may be utilized and is available from Apollo Chemical Company, LLC (Burlington, NC).

In selected embodiments, the formed cuff, or if desired, the material that will be formed into a cuff (such as yarn or thread), may be subjected to a high-energy pre-treatment such as a glow discharge from a corona or plasma treatment
20 system. The high energy treatment may function to "clean" the cuff or cuff forming material from "loose" or weak boundary layers made of contaminants and short chain oligomers. The high energy treatment can also generate radicals on the surface of the cuff or cuff forming material, which can subsequently enhance surface attachment and uniformity of the fluorinated monomer.

25 The strength of the high energy treatment may be varied in a controlled manner by known means across at least one dimension of the fibrous web. For example, a corona apparatus having a segmented electrode may be employed, in which the distance of each segment from the sample to be treated may be varied independently. As another example, a corona apparatus having a gap-gradient
30 electrode system may be utilized; in this case, one electrode may be rotated about an axis which is normal to the length of the electrode. Other methods also may be employed; see, for example, "Fabrication of a Continuous Wettability Gradient by Radio Frequency Plasma Discharge", W. G. Pitt, J. Colloid Interface Sci., 133, No.

1, 223 (1989); and "Wettability Gradient Surfaces Prepared by Corona Discharge Treatment", J. H. Lee, et al., Transactions of the 17th Annual Meeting of the Society for Biomaterials, May 1-5, 1991, page 133, Scottsdale, Ariz.

In a particular embodiment, the plasma fluorination process to treat the loosely woven polyester cuffs for repellency to fluids involves generating plasma in a chamber using radio frequency (RF). Initially, a vacuum is used to evacuate the chamber to about 10^{-2} torr. The chamber, which includes a powered electrode, is then filled with the desired amount of a gas that can sustain plasma, such as, for example, argon. Upon application of an RF field to the powered electrode, a plasma is established which acts as a charge carrier between the electrodes. The plasma is typically visible as a colored cloud. A fluoro-acrylic monomer is flash-evaporated into the chamber.

The plasma initiates the graft polymerization of the fluoro-acrylic monomer onto the surfaces of the cuffs, including pores that are easily reached by the activated fluoro-chemistry. The reaction can vary from about 10 seconds to about 30 minutes or longer if necessary, depending on the size of the reactor and the number of cuffs loaded inside the plasma reactor. Alternatively, other fluorinated gases and fluorine precursors can be used in the plasma treatment process.

The level of liquid repellency achieved by plasma fluorination the cuff will depend upon the amount of acrylic monomer (e.g. perfluorodecyl acrylate) that has been deposited and graft copolymerized on the surface of the woven cuff. As shown in Figure 1, a droplet of synthetic blood has been placed on a treated cuff to demonstrate the liquid repellency of the treated cuff. The synthetic blood shown in Figure 1 was the synthetic blood which is required for use in ASTM F-1670-98, Standard Test Method for Resistance of Material Used in Protective Clothing to Penetration by Synthetic Blood. The droplet has maintained a rounded shape and has not 'flattened out', indicating resistance to penetration into the cuff material. In Figure 2, which shows a cuff that has not been treated according to the present invention, the droplet of synthetic blood has penetrated the un-treated cuff, as shown by the flattened profile of the droplet.

To produce a plasma fluorinated cuff similar to that shown in Figure 1, 30 sccm (standard cubic centimeters per minute) of argon gas and 15 ml/hr of the fluorinated acrylic monomer perfluorodecyl acrylate were simultaneously

introduced into a plasma chamber to a pressure of about 5 mtorr. A pulsed glow discharge plasma was generated at 100 Watts and at 100 Hz for a reaction time of 10 minutes. After the reaction was completed, the vacuum chamber was purged with 500 sccm of argon for two minutes until atmospheric pressure was reached.

5 The samples were removed from the plasma chamber and tested for liquid repellency.

To determine the appropriate repellency of the cuff, the Worldwide Strategic Partners standard test number WSP 80.8 (05) entitled "Standard Test Method for Alcohol Repellency of Nonwoven Fabrics" should be used. The term "nonwoven web" generally refers to a web having a structure of individual fibers or threads which are interlaid, but not in an identifiable manner as in a knitted fabric.

10 Although the cuff is a woven fabric rather than a nonwoven fabric, this test may still be used effectively to determine the fluid repellency of the cuff. The terms "woven" and "knitted" are used interchangeably with respect to the present invention, and are intended to include materials which have an identifiable interlaid pattern of fibers or threads.

15 The test method is used to measure the resistance of nonwoven fabrics to wetting and penetration by alcohol and alcohol/water solutions. Drops of standard test liquids, consisting of a selected series of water/alcohol solutions, are placed on the test material and observed for penetration or wetting. The alcohol repellency rating is the highest numbered test liquid which does not penetrate the fabric.

If there is a conflict between the test as discussed in this document and the test specification, the test specification is to be followed.

25 Alcohol solutions having decreasing surface tensions with increasing alcohol concentrations are utilized in the test, and are listed below in Table 1. The alcohol repellency rating determined in WSP 80.8 (05) serves as a rough estimate of the overall surface repellency of the test material.

Alcohol Repellency Rating No.	Composition by Weight	
	Percent Alcohol	Percent Water
0	0	100
1	10	90
2	20	80
3	30	70
4	40	60
5	50	50
6	60	40
7	70	30
8	80	20
9	90	10
10	100	0

Table 1. Standard Test Solutions

The alcohol repellency rating of the fabric is the highest numbered test liquid which will not penetrate the fabric within a period of five minutes. The cuff will show complete resistance to penetration by a given test liquid, which is indicated by a spherical drop which shows no tendency to penetrate the cuff, such as is shown in Figure 1.

In yet another embodiment of the invention, a method of forming a protective garment includes the steps of providing a yarn and forming the yarn into a knitted cuff. The knitted cuff, or in some embodiments, the yarn which is to be formed into the knitted cuff, is subjected to a plasma process which applies a fluoro-chemical monomer to the cuff, the cuff having an alcohol repellency rating of 10. The yarn from which the cuff is made can be treated as a single filament within a continuous RF plasma process, if desired. The cuff is then attached to a sleeve which is attached to a protective garment.

While the invention has been described in detail with respect to the specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to,

variations of, and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto.

WHAT IS CLAIMED IS:

1. A protective garment comprising:

a sleeve having attached thereto a woven cuff;

the woven cuff having an alcohol repellency rating of 10, the cuff having
fluoro-chemical monomer graft polymerized onto at least a portion of the woven
cuff.

2. The protective garment of claim 1, the fluoro-chemical monomer graft
polymerized onto the cuff being perfluorodecyl acrylate.

3. The protective garment of claim 2, the fluoro-chemical monomer being graft
polymerized onto the cuff by an RF plasma process.

4. The protective garment of claim 1, the protective garment comprising a surgical
gown.

5. The protective garment of claim 1, the woven cuff being elastic.

6. An elastic woven cuff having an alcohol repellency rating of 10, the cuff having
fluoro-chemical monomer graft polymerized onto the cuff.

7. The cuff of claim 6, the cuff comprising polyester fiber.

8. The cuff of claim 6, the fluoro-chemical monomer graft polymerized onto the cuff
being perfluorodecyl acrylate.

9. The cuff of claim 6, the fluoro-chemical monomer being graft polymerized onto
the cuff by an RF plasma process.

10. A method for forming a protective garment comprising the steps of:

providing a yarn;

subjecting the yarn to a plasma process which graft polymerized a fluoro-

chemical monomer to the yarn;

forming the yarn into a knitted cuff;

attaching the knitted cuff to a sleeve, the cuff having an alcohol repellency rating of 10;

5 attaching the sleeve to a body of a garment.

11. The method of claim 10, the step of subjecting the yarn to a plasma process includes the step of subjecting the yarn to an RF plasma process.

10 12. The method of claim 10, the fluoro-chemical monomer graft polymerized to the cuff being perfluorodecyl acrylate.

13. The method of claim 10, including the step of forming the yarn into an elastic woven cuff.

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14. A method for forming a protective garment comprising the steps of:

providing a yarn;

forming the yarn into a knitted cuff;

20 subjecting the knitted cuff to a plasma process which graft polymerizes a fluoro-chemical monomer to the cuff, the cuff having an alcohol repellency rating of 10;

attaching the knitted cuff to a sleeve;

attaching the sleeve to a body of a garment.

25 15. The method of claim 14, the step of subjecting the yarn to a plasma process includes the step of subjecting the yarn to an RF plasma process.

16. The method of claim 14, the fluoro-chemical monomer graft polymerized to the cuff being perfluorodecyl acrylate.

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17. The method of claim 14, including the step of forming the yarn into an elastic woven cuff.



FIG. 1

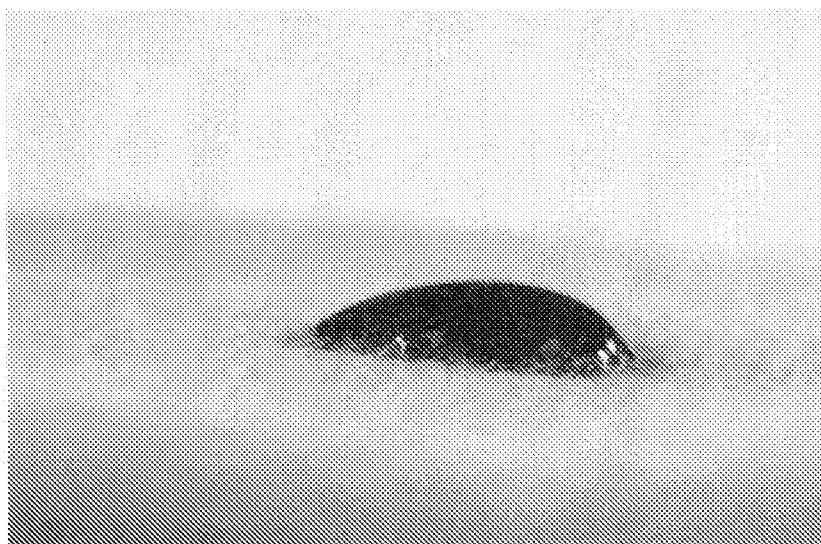


FIG. 2