A glove includes an inner layer having the 3-dimensional shape of a hand and including a fibrous absorbent material, and the glove includes a fluoropolymer barrier layer thermoformed around the inner layer to have the 3-dimensional shape of the hand. The fluoropolymer barrier layer maintains the 3-dimensional shape when not in use. The glove has a breakthrough time of not greater than 1 hour when exposed to NFPA 1991 industrial chemicals and has a detectable permeation rate is not more than 0.10 micrograms/cm²/min.
GLOVE HAVING BARRIER PROPERTIES

CROSS-REFERENCE TO RELATED APPLICATION(S)


FIELD OF THE DISCLOSURE

This disclosure, in general, relates to gloves and glove liners having chemical barrier properties and methods of forming such gloves and liners.

BACKGROUND

Emergency services and first responders are increasingly becoming concerned about exposure to hazardous materials. In addition, with the fear of a terrorist attack using chemical or biological agents, government agencies are under increased pressure to plan for such attacks. As a result, there is an increasing interest in protective clothing and garments. For example, early emergency responders, such as fire and EMS personnel, desire protective covering to protect them from industrial chemicals, biological agents, chemical weapons, and extreme temperatures. Other emergency responders and military users, such as hazardous material removal personnel, are also interested in protective clothing.

However, traditional glove systems used as part of protective garment systems are cumbersome and bulky. Such gloves significantly reduce the dexterity of a user and make even simple tasks increasingly complex. As such, improved glove systems would be desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

FIG. 1 includes an illustration of an exemplary glove.

FIG. 2 includes an illustration of an exemplary cross section of an exemplary glove according to an embodiment of the invention.

FIG. 3 includes an illustration of a cross section of an exemplary glove according to an embodiment of the invention.

FIG. 4 includes an illustration of a cross section of an exemplary glove system.

FIG. 5, FIG. 6, and FIG. 7 include illustrations of exemplary intermediate products formed during a method for making a glove.

The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION

In an exemplary embodiment, a glove includes an absorbent inner layer to contact a user’s hand and a thermoformed barrier layer including a fluoropolymer and disposed on the absorbent inner layer. Optionally, the glove can include one or more outer layers, such as thermal barriers, radiative barriers, puncture or tear resistant layers, layers to enhance gripping, or any combination thereof.

In a further exemplary embodiment, a method of forming a glove includes applying an absorbent layer over a hand-shaped form, softening a fluoropolymer film, applying the softened fluoropolymer film over the absorbent layer, and thermoforming the fluoropolymer film to the absorbent layer and to bond to itself between digits of the hand-shaped form. The method can further include trimming excess fluoropolymer film after thermoforming and removing the absorbent layer and fluoropolymer barrier layer from the hand-shaped form.

In an example, a glove 100 is illustrated in FIG. 1. The glove 100 takes the form of a hand including thumbs and fingers 102. A user can slide their hand into the glove 100, the glove 100 providing protection from chemical agents. In a particular example, the glove 100 includes a thermoformed barrier layer providing a 3-dimensional structure to the glove 100.

In contrast, prior art gloves exhibit a flat profile. For example, FIG. 2 includes an illustration of a cross section of a finger formed of a top layer 202 and a bottom layer 204 and a space 206 between the top layer 202 and the bottom layer 204. A user can insert a finger into the space 206 causing the relatively flat layers 202 and 204 to flex. In traditional glove systems, such flexing causes strain at seams 208 and 210 that are formed where layers 202 and 204 meet.

In the present example, a cross section of a finger 300 illustrated in FIG. 3 taken at the cross section A-A of FIG. 1 shows thermoformed layers 302 and 304 which define a 3-dimensional space 306 that substantially maintains its shape even when a user’s finger is not within the space 306. As a result of thermoforming, less flexing is exhibited when a finger is inserted into the space 306, and as a result, less strain is placed on seams 308 and 310 formed when the layers 302 and 304 are bonded together.

Turning to FIG. 4, a portion of a glove 400 includes an inner layer 404 to surround at least a portion a user’s hand 402. A barrier layer 406 is disposed over the inner layer 404 relative to the intended location of the hand 402. In an example, the inner layer 404 and the barrier layer 406 form a stand-alone glove. In another example, one or more outer layers 410 can be disposed over the barrier layer 406. The outer layer 410 can directly contact the barrier layer 406, such as without intervening layers. Alternatively, a space 408 can be formed between the outer layer 410 and the barrier layer 406.

In an example, the outer layer 410 forms a separate glove into which a glove formed of the inner layer 404 and the barrier layer 406 is inserted. In another example, the outer layer 410 can be formed as part of an integral glove that includes the barrier layer 406 and the inner layer 404.

In an example, the inner layer 404 is formed of fabric, foam or random fibrous material. The fabric can be a woven or knitted material or cloth. For example, the inner layer 404 can be a woven fabric. In another example, the inner layer 404 includes a quilted random fibrous material. In a further example, the inner layer 404 includes polymeric foam. The inner layer 404 can be formed using synthetic fibers, such as aramids, such as meta- and para-aramids, such as Nomex®, and Kevlar®, respectively, polyester, polybenzimidazole (PBI), monacrylic, modacrylic, polycyimide, polyolefin, polyetherimide, polyethersulfone, acrylic, a liquid crystal polymer, acetal polymer, derivatives, modifications,
ionomers thereof, copolymers thereof, or any combination thereof. The inner layer 404 can alternatively be formed of natural fibers including cotton and wool. Further exemplary substrate materials include Panomex®, Lenzing, Technora®, Opan, Basofil, fiberglass, basalt, ceramic fibers, carbon fibers, or any combination thereof. The inner layer 404 can also include phase change materials that absorb energy when changing phase so as to cool a wearer of the glove. In another example, the inner layer 404 includes catalytic/oxidizing materials that provide additional protection against chemical and biological agents. In an example, the inner layer 404 includes a woven aramid material, such as a Nomex® or Kevlar® material. In another example, the inner layer 404 includes a woven material formed of natural fibers, such as cotton or wool. In a further example, the woven material can be impregnated with absorbent or hygroscopic material.

The inner layer 404 is to contact the skin of a user. As such, the inner layer 404 can be selected to provide comfort to a wearer, such as through moisture wicking, moisture absorptivity and heat protection. In an example, the material of the inner layer 404 has a moisture absorptivity of at least about 3% by weight, such as about 4% to about 6%, or at least about 6% by weight. In particular, the inner layer 404 can be formed of a knitted yarn or thread having absorbent properties, such as yarns or threads of cotton, wool, polyamide, polyester, polyaramid, or any combination thereof. For example, the inner layer 404 can be formed of a woven or knit cotton glove.

In an example, the barrier layer 406 can be formed of a fluoropolymer sheet that is thermoformed over the absorbent layer 404. An exemplary fluoropolymer includes a homopolymer, copolymer, terpolymer, or polymer blend formed from a monomer, such as tetrafluoroethylene, hexafluoropropylene, chlorotrifluoroethylene, trifluoroethylene, vinylidene fluoride, vinyl fluoride, perfluoropropyl vinyl ether, perfluoromethyl vinyl ether, or any combination thereof. For example, the fluoropolymer can include polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), polytetrafluoroethylene (PTFE), ethylene tetrafluoroethylene copolymer (ETFE), polyvinylidene fluoride copolymer (PVDF), ethylene chlorotrifluoroethylene copolymer (ECTFE), fluorinated ethylene propylene copolymer (FEP), a copolymer of ethylene and fluorinated ethylene propylene (FEP), a terpolymer of tetrafluoroethylene, hexafluoropropylene, and vinylidene fluoride (THF), a terpolymer of tetrafluoroethylene, hexafluoropropylene, and ethylene (HTE), a copolymer of tetrafluoroethylene and perfluoromethyl vinyl ether (PFA or MFA), or any combination thereof. In an example, the fluoropolymer includes ETFE, FEP, PFA, THF, PTFE, or any combination thereof. Exemplary fluoropolymers films can be cast, skived, or extruded. For example, the fluoropolymer film can be a cast film. In particular, the fluoropolymer can have the ability to be thermoformed and bonded to itself. An exemplary fluoropolymer includes FEP. In another example, the fluoropolymer includes PFA, and in a further example, the fluoropolymer includes a modified PTFE. In an additional example, the fluoropolymer includes ETFE.

In an example, fillers or additives such as pigments, plasticizers, stabilizers, softeners, extenders, and the like, can be present in the fluoropolymer film. For example, the fluoropolymer film can include graphite, carbon black, titanium dioxide, alumina, alumina trihydrate, glass fibers, beads or microballoons, carbon fibers, magnesium, silica, wallastonite, mica, or any combination thereof.

The fluoropolymer film is generally less than about 5 mils thick, resulting in composites of sufficiently flexibility for use in garments. Such films can be about 0.25 mils to 4 mils thick, such as about 1 mil to 2 mils thick.

In an example, an outer layer 410 can optionally be disposed over the barrier layer 406. The outer layer 410 can provide additional properties such as flame resistance, heat resistance, radiation resistance, tear resistance, puncture resistance, or additional support for gripping, or any combination thereof. In an example, the outer layer includes flame resistant materials such as woven or knitted flame resistant fabrics. Such fabrics can be formed of yarns or threads of polyamides, such as Nomex® or Kevlar®, fiberglass, or any combination thereof.

In another example, the outer layer 410 can include reflective materials acting as a shield against radiative heat. For example, such reflective materials can include metal foils or metal coatings on other substrates.

In a further example, the outer layer 410 can be formed of flexible elastomeric materials that provide additional grip to the glove. For example, the outer layer can be a latex glove. In another example, the outer layer 410 can include a coated fabric material. For example, the fabric can be formed of knitted or woven fibers coated with an elastomeric material. In particular, the knitted or woven fibers can impart tear resistance or puncture resistance to the glove system. For example, the fabric can be formed of polyaramid fibers, such as Nomex® or Kevlar®, fiberglass, liquid crystal polymers, polybenzimidazole, or any combination thereof. In another example, the fabric can be formed of a cotton, wool, other natural fiber, polyester, polyamide, polylefin, or any combination thereof. The elastomeric material can include butyl rubber, acrylonitrile rubber, ethylene propylene rubber (EPR), ethylene propylene diene elastomer (EPDM), fluororubber, polyvinylchloride, acrylic polymer, or any combination thereof.

In each of the examples, the inner layer 404 and the thermoformed barrier layer 406 provide a glove having desirable chemical resistance. In an example, the glove provides vapor protection and chemical permeation resistance to industrial chemicals, such as acetone, acetonitrile, anhydrous ammonia (gas), 1,3-butadiene (gas), carbon disulfide, chlorine (gas), dichloromethane, diethyl amine, dimethyl formamide, ethyl acetate, ethylene oxide (gas), hexane, hydrogen chloride (gas), methanol, methyl chloride (gas), nitrobenzene, sodium hydroxide, sulfuric acid, tetrachloroethylene, tetrahydrofuran, or toluene. In a further exemplary embodiment, the glove exhibits chemical permeation resistance to cyanogen chloride (CK). Following a permeation resistance test in accordance with ASTM F 739 at 27°C ±2°C for a test duration of at least 3 hours, the glove exhibits a breakthrough detection time of at least 1 hour. For example, the glove can exhibit a breakthrough detection time of at least about 1.1 hours, such as at least about 1.5 hours or at least about 2 hours. In particular, the glove exhibits a breakthrough detection time of at least 1 hour when tested with NFPA 1991 industrial chemicals. The minimal detectable permeation rate is not more than 0.10 micrograms/cm²/min. In another example, the glove can be permeation resistant to chemical warfare agents such as lewisite (L), distilled mustard (HD), sarin (GB), and V-Agent (VX). For example, when tested with lewisite (L) and distilled mustard (HD), the glove exhibits an average cumulative permeation in 1 hour that is less than about 0.4 micrograms/cm². In another example, the
glove exhibits an average cumulative permeation over 1 hour that is less than 1.25 micrograms/cm² when exposed to chemical warfare agents, such as sarin (GB) and V-Agent (VX). In a further example, the glove exhibits chemical penetration resistance and exhibits no penetration for at least 1 hour for chemicals, such as acetone, acetonitrile, ethyl acetate, hexane, 50 weight percent sodium hydroxide solutions, 93.1 weight percent sulfuric acid solutions, or tetrahydrofuran. For example, penetration resistance can be measured in accordance with ASTM F 903 at 29°C ±3°C and 65% plus or minus 5% relative humidity.

In another example, the glove and the seams of the glove are resistant to liquid or blood borne pathogens. For example, when tested in accordance with ASTM F 1671, the glove demonstrates no penetration of the phi-x-174 bacterial phage for at least one hour. In another example, the seams are liquid tight. In a further example, the glove can be decontaminated with decontamination methods, such as autoclave.

The exemplary glove can also exhibit dexterity as measured in accordance with the pegboard procedure listed in standard NFPA 1991. For example, the glove can exhibit a dexterity performance, such as an average percent increase of bare hand control of less than 200%. For example, the dexterity performance can be no greater than about 180%, not greater than about 165%, not greater than about 150%, or not greater than about 120%. In particular, when tested relative to the Saint-Gobain Performance Plastics ONEGlove® system (product code 22411M), a glove including a similar outer layer provides a performance improvement (herein referred to as a dexterity index, defined as the ratio of the dexterity of the exemplary glove relative to the dexterity of the ONEGlove® system, expressed as a percentage) of not greater than 95%, such as not greater than 90%, not greater than 85%, or even not greater than 80%. For example, the dexterity index can be not greater than 75%.

Gloves that further include a flame resistant outer layer exhibit flammability resistance. For example, when tested in accordance with ASTM F 1359, the integrated glove does not ignite during an initial 3-second exposure period and does not burn a distance greater than 100 mm, does not sustain burning for more than 10 seconds, and does not melt as evidenced by flow or dripping during a subsequent 12-second exposure period.

In an additional example, a glove that further includes a cut resistant outer layer exhibits cut and penetration resistance. For example, the glove when measured in accordance with ASTM F 1790 exhibits a cut resistance performance not more than 25 mm, such as not more than about 21 mm or not more than about 19 mm. In a further example, the glove exhibits puncture resistance. For example, when tested in accordance with ASTM F 1342, the glove exhibits a puncture resistance performance not less than 2.3 kg (5 lbs).

In a further example, the glove exhibits a cold temperature performance. For example, when tested in accordance with ASTM D 747, the glove exhibits a bending moment of 0.057 N-meters at an angular deflection of 60° at -25°C.

When used in conjunction with a flame retardant and puncture resistant outer layer 410, the glove system 400 can comply with various NFPA standards. For example, embodiments of the glove system conform to standards, such as NFPA 1991, NFPA 1992, and NFPA 1994.

To form the barrier layer glove, a barrier layer is thermoformed over a three-dimensional hand-shaped form. Optionally, an inner layer can be applied over the hand-shaped form. For example, a woven or knitted glove, such as a cotton glove or a polyamide glove, can be applied over the hand-shaped form to form an absorbent inner layer. Alternatively, absorbent foam materials cut into the shape of a 2-dimensional hand can be applied on either side of the hand-shaped form.

In an example, a fluoropolymer film is softened. For example, the fluoropolymer film can be heated to a temperature of at least the glass transition temperature, but not greater than a melting temperature. As illustrated in FIG. 5, the softened fluoropolymer film 504 can be applied over the hand-shaped form. Alternatively, the softened film can be wrapped around the hand-shaped form, drawn from under the hand-shaped form and wrapped around the top, or applied at the end of the fingers and wrapped towards the wrist. In a further alternative, two softened separate fluoropolymer films can be placed, one on either side of the hand-shaped form.

Following application over the hand-shaped form, the fluoropolymer film 504 is thermoformed around the hand-shaped form 502. For example, a vacuum can be drawn between the fluoropolymer film 504 and the hand-shaped form 502, drawing the fluoropolymer film 504 in towards the hand and in contact with itself between fingers and around the hand-shaped form 502. As illustrated in FIG. 6, the fluoropolymer barrier layer bonds to itself in a region 504 away from the fingers and the hand-shaped form and thermoforms to adopt the 3-dimensional shape of the hand-shaped form.

Following thermoforming, the excess fluoropolymer can be trimmed forming seams 704 around a 3-dimensional thermoformed shape 702 adopting the shape of the hand-shaped form. An opening 706 is formed at a wrist of the glove, as illustrated in FIG. 7.

The hand-shaped form can be removed from the form. Following removal, the thermoformed barrier layer maintains a three-dimensional hand-shape even when not in use (i.e., when a form or a hand is not disposed inside the glove).

The thermoformed barrier layer can be used as a separate glove or can be integrally formed with an outer layer to provide additional properties to the glove system. As such, an outer layer can be applied over the barrier layer. In a particular example, the outer layer can be attached to the barrier layer and optionally the absorbent layer at a wrist of the glove. In another example, the outer layer can be attached to tabs (not illustrated) formed of the thermoformed barrier layer at the end of the fingers.

EXAMPLES

Example 1

A 3-mil film formed of fluorinated ethylene propylene (FEP) copolymer is applied over a three-dimensional hand-shaped form. The FEP film is softened and draped over the hand-shaped form. The edges of the film at a front and back of the form are held together and a vacuum is applied inside the thus formed enclosed space. As a result, the film takes the shape of the form and bonds to itself in regions not occupied by the form.

The film is cooled and the form removed to leave a fluoropolymer barrier layer that maintains the three-dimensional shape of the form.

Example 2

A knitted cotton glove is applied over a three-dimensional hand-shaped form. A 2-mil PFA film is softened
and draped over the knitted cotton glove. The edges of the film at a front and back of the form are held together and a vacuum is applied inside the thus formed enclosed space. As a result, the film takes the shape of the form and bonds to itself in regions not occupied by the form.

[0043] The film is cooled and the form removed to leave a glove including an absorbent inner layer and a barrier layer that maintains the three-dimensional shape of the form.

[0044] In an exemplary embodiment, a glove includes an inner layer having a three-dimensional shape of a hand and includes a fibrous absorbent material, and the glove includes a fluoropolymer barrier layer thermoformed around the inner layer to have the three-dimensional shape of the hand. The fluoropolymer barrier layer maintains the three-dimensional shape when not in use. The glove has a breakthrough time of not greater than 1 hour when exposed to NFPA 1991 industrial chemicals and has a detectable permeation rate is not more than 0.10 micrograms/cm²/min.

[0045] In an example of the first embodiment, the fluoropolymer barrier layer includes ethylene-tetrafluoroethylene copolymer (ETFE), fluorinated ethylene propylene copolymer (FEP), perfluoroalkoxy (PFA), THV, polytetrafluoroethylene (PTFE), or any combination thereof. For example, the fluoropolymer barrier layer can include FEP. In another example, the fluoropolymer barrier layer can include PFA. In a further example, the fluoropolymer barrier layer can include ETFE.

[0046] In an example of the first embodiment, the fibrous absorbent material includes a woven or knitted fabric. In another example, the fibrous absorbent material includes cotton or wool.

[0047] In a further example of the first embodiment, the glove further includes a flame resistant outer layer disposed over the fluoropolymer barrier layer. In another example, the glove further includes a tear resistant outer layer disposed over the fluoropolymer barrier layer. In an additional example, the glove further includes an outer layer that provides improved grip and is disposed over the fluoropolymer barrier layer. In a particular example, the glove further includes an outer layer formed of a polyaramid material disposed over the fluoropolymer barrier layer.

[0048] In an example of the first embodiment, the fluoropolymer barrier layer has a thickness of not greater than 5 mils. In another example, the thickness can be in a range of 0.25 mils to 4 mils.

[0049] In an example of the first embodiment, the glove exhibits a dexterity performance of not greater than 200%, such as not greater than 180%. In another example, the glove exhibits a dexterity index of not greater than 95%, such as not greater than 90%.

[0050] In a further example of the first embodiment, the glove exhibits an average cumulative permeation in 1 hour that of less than about 4.0 micrograms/cm² for lewisite (L) and distilled mustard (HD). In an additional example of the first embodiment, the glove exhibits an average cumulative permeation over 1 hour that is less than 1.25 micrograms/cm² when exposed to sarin (GB) or V-Agent (VX).

[0051] In a second exemplary embodiment, the glove includes an inner layer including a moisture wicking material and a fluoropolymer barrier layer thermoformed around the inner layer to have a three-dimensional shape of a hand. The fluoropolymer barrier layer maintains the three-dimensional shape when not in use. The glove has a dexterity index of not greater than 95%.

[0052] In an example of the second embodiment, the fluoropolymer barrier layer includes ethylene-tetrafluoroethylene copolymer (ETFE), fluorinated ethylene propylene copolymer (FEP), perfluoroalkoxy (PFA), THV, polytetrafluoroethylene (PTFE), or any combination thereof. For example, the fluoropolymer barrier layer can include FEP. In another example, the fluoropolymer barrier layer can include PFA. In a further example, the fluoropolymer barrier layer can include ETFE.

[0053] In a further example of the second embodiment, the wicking material includes a woven or knitted fabric. In an additional example, the wicking material can include cotton or wool.

[0054] In an example of the second embodiment, the glove further includes a flame resistant outer layer disposed over the fluoropolymer barrier layer. In an additional example, the glove further includes a tear resistant outer layer disposed over the fluoropolymer barrier layer. In a further example, the glove further includes an outer layer that provides improved grip and is disposed over the fluoropolymer barrier layer. In a particular example, the glove includes an outer layer formed of a polyaramid material disposed over the fluoropolymer barrier layer.

[0055] In an additional example of the second embodiment, the fluoropolymer barrier layer has a thickness of not greater than 5 mils. In an example, the thickness can be in a range of 0.25 mils to 4 mils.

[0056] In a further example of the second embodiment, the glove exhibits a dexterity performance of not greater than 200%, such as not greater than 280%. Further, the dexterity index can be not greater than 90%.

[0057] In another example of the second embodiment, the glove exhibits an average cumulative permeation in 1 hour that of less than about 4.0 micrograms/cm² for lewisite (L) and distilled mustard (HD). In a further example, the glove exhibits an average cumulative permeation over 1 hour that is less than 1.25 micrograms/cm² when exposed to sarin (GB) or V-Agent (VX).

[0058] In a third exemplary embodiment, a method of forming a glove includes applying an inner layer over a three-dimensional hand-shaped form, softening a fluoropolymer film, and thermoforming the softened fluoropolymer film over the inner layer, whereby a glove is formed that maintains the three-dimensional hand-shape after the form is removed.

[0059] In an example of the third embodiment, softening the fluoropolymer film including softening a fluoropolymer film comprising ethylene-tetrafluoroethylene copolymer (ETFE), fluorinated ethylene propylene copolymer (FEP), perfluoroalkoxy (PFA), THV, polytetrafluoroethylene (PTFE), or any combination thereof. For example, the fluoropolymer film can include FEP. In another example, the fluoropolymer film can include ETFE. In an additional example, the fluoropolymer film can include PFA.

[0060] In a further example of the third embodiment, the method further includes removing the three-dimensional hand-shaped form from the glove.

[0061] In another example of the third embodiment, the method further includes applying an outer layer over the thermoformed fluoropolymer film. For example, applying the outer layer includes applying a flame resistant outer layer over the thermoformed fluoropolymer film. In a further example, applying the outer layer includes applying a tear resistant outer layer over the thermoformed fluoropolymer film. In an additional example, applying the outer layer
includes attaching the outer layer to a barrier layer formed of the thermoformed fluoropolymer film at a wrist of the glove.

[0062] In an example of the third embodiment, applying an inner layer includes applying a woven or knitted glove over the three-dimensional hand-shaped form.

[0063] Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the orders in which activities are listed are not necessarily the order in which they are performed.

[0064] In the foregoing specification, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of invention.

[0065] As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0066] Also, the use of “a” or “an” is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

[0067] Benefits, advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

[0068] After reading the specification, skilled artisans will appreciate that certain features are, for clarity, described herein in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, references to values stated in ranges include each and every value within that range.

1. A glove comprising:
   an inner layer having the 3-dimensional shape of a hand and including a fibrous absorbent material; and
   a fluoropolymer barrier layer thermoformed around the inner layer to have the 3-dimensional shape of the hand, the fluoropolymer barrier layer maintaining the 3-dimensional shape when not in use;
   wherein the glove has a breakthrough time of not greater than 1 hour when exposed to NFPA 1991 industrial chemicals and has a detectable permeation rate is not more than 0.10 micrograms/cm²/min.

2. The glove of claim 1, wherein the fluoropolymer barrier layer includes ethylene-tetrafluoroethylene copolymer (ETFE), fluorinated ethylene propylene copolymer (FEP), perfluoroalkoxy (PFA), THV, polytetrafluoroethylene (PTFE), or any combination thereof.

3-5. (canceled)

6. The glove of claim 1, wherein the fibrous absorbent material includes a woven or knitted fabric.

7. The glove of claim 1, wherein the fibrous absorbent material includes cotton or wool.

8. The glove of claim 1, further comprising a flame resistant outer layer disposed over the fluoropolymer barrier layer.

9. The glove of claim 1, further comprising a tear resistant outer layer disposed over the fluoropolymer barrier layer.

10. (canceled)

11. The glove of claim 1, further comprising an outer layer formed of a polyaramid material disposed over the fluoropolymer barrier layer.

12. The glove of claim 1, wherein the fluoropolymer barrier layer has a thickness of not greater than 5 mils.

13. (canceled)

14. The glove of claim 1, wherein the glove exhibits a dexterity performance of not greater than 200%.

15. (canceled)

16. The glove of claim 1, wherein the glove exhibits a dexterity index of not greater than 95%.

17. (canceled)

18. The glove of claim 1, wherein the glove exhibits an average cumulative permeation over 1 hour that is less than about 4.0 micrograms/cm² for lewisite (L) and distilled mustard (HD).

19. The glove of claim 1, wherein the glove exhibits an average cumulative permeation over 1 hour that is less than 1.25 micrograms/cm² when exposed to sarin (GB) or V-Agent (VX).

20. A glove comprising:
   an inner layer including a moisture wicking material; and
   a fluoropolymer barrier layer thermoformed around the inner layer to have a 3-dimensional shape of a hand, the fluoropolymer barrier layer maintaining the 3-dimensional shape when not in use;
   wherein the glove has a dexterity index of not greater than 95%.

21. The glove of claim 20, wherein the fluoropolymer barrier layer includes ethylene-tetrafluoroethylene copolymer (ETFE), fluorinated ethylene propylene copolymer (FEP), perfluoroalkoxy (PFA), THV, polytetrafluoroethylene (PTFE), or any combination thereof.

22-34. (canceled)

35. The glove of claim 20, wherein the dexterity index is not greater than 90%.

36-37. (canceled)

38. A method of forming a glove comprising:
   applying an inner layer over a three-dimensional hand-shaped form;
   softening a fluoropolymer film; and
   thermoforming the softened fluoropolymer film over the inner layer,
   whereby a glove is formed that maintains the three-dimensional hand-shape after the form is removed.

39-43. (canceled)
44. The method of claim 38, further comprising applying an outer layer over the thermoformed fluoropolymer film.

45. The method of claim 44, wherein applying the outer layer includes applying a flame resistant outer layer over the thermoformed fluoropolymer film.

46. The method of claim 44, wherein applying the outer layer includes applying a tear resistant outer layer over the thermoformed fluoropolymer film.

47. The method of claim 44, wherein applying the outer layer includes attaching the outer layer to a barrier layer formed of the thermoformed fluoropolymer film at a wrist of the glove.

48. (canceled)