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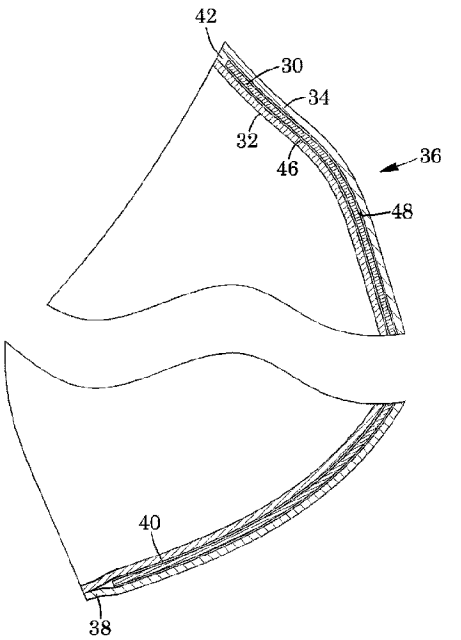
(54) Titre : MASQUE FONCTIONNALISE A L'AIDE DE NANOPARTICULES D'ARGENT ET PIECE RAPPORTEE POUR UN MASQUE

(54) Title: SILVER NANOPARTICLE FUNCTIONALIZED FACE MASK AND INSERT FOR A FACE MASK



(57) Abrégé/Abstract:
A face mask is provided. The face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer. A functionalized graphene mask insert is also provided.

ABSTRACT

A face mask is provided. The face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer. A functionalized graphene mask insert is also provided.

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SILVER NANOPARTICLE FUNCTIONALIZED FACE MASK AND INSERT FOR A FACE MASK

FIELD

The present technology is directed to a face mask or mask insert for a mask that can be worn by a user to protect them from airborne microbes, including bacteria, fungus and viruses. More specifically, it is a face mask or mask insert that traps the microbes and kills a substantial percentage of them on contact.

BACKGROUND

It is well known that filters need to have a 0.2 micrometer (micron) pore size or smaller to sterilize liquids and gases. Despite this, disposable masks for protecting against disease have much larger pore sizes. For example, the N95 mask, which is promoted as the mask of choice for the general public to wear, has a pore diameter of 0.3 microns. As the name suggests, the mask is supposed to remove 95% of particulate matter that is 0.3 microns or larger in diameter. Unfortunately, many bacteria are smaller than 0.3 microns. For example, Haemophilus influenzae ranges in diameter from about 0.2 microns to about 0.3 microns. Viruses are generally smaller than bacteria and may range is diameter from 30 nanometers (0.03 microns) for the polio virus to 120-150 nanometers (0.120-0.150 microns) for the HIV-1 virus. The COVID-19 virus is reported to range in diameter between about 0.06 microns to about 0.14 microns. Based on the foregoing, it is apparent that the N95 mask is insufficient to protect a user from some bacteria and most viruses, both of which are the most common pathogens.

Another problem with the disposable masks is contamination. Even if the mask can reduce the passage of pathogens from the ambient to the user, the mask is then contaminated. If the mask is not properly disposed of or is reused, it then becomes a source of infection.

Yet another problem with disposable masks is air flow. As the pore size restricts air flow, these masks are not suitable for users with breathing issues, such as decreased lung capacity and shortness of breath. In one study, breathing through N95 mask materials have been shown to impede gaseous exchange and impose an additional workload on

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the metabolic system. Specifically, N95-mask materials reduced mean tidal volume by 23.0 % (95 % CI −33.5 % to −10.5 %, $p < 0.001$) and lowered minute ventilation by 25.8 % (95 % CI −34.2 % to −15.8 %, $p < 0.001$), with no significant change in breathing frequency compared to breathing ambient air. Volumes of oxygen consumption (VO_2) and carbon dioxide expired (VCO_2) were also significantly reduced; VO_2 by 13.8 % (95 % CI −24.2 % to −3 %, $p = 0.013$) and VCO_2 by 17.7 %, (95 % CI −28.1 % to −8.6 %, $p = 0.001$).

As disclosed in US Patent No. 8,815,131 "Although a hybrid nanostructure in which a silver nanoparticle is bound to a carbon nanotube is disclosed in the prior art (Korean Patent Publication No. 2011-78136), since the silver nanoparticle is not dissolved in a solvent, the binding efficiency of the silver nanoparticle to the carbon nanotube is very poor when a hybrid nanostructure is formed by dispersing the silver nanoparticle and the carbon nanotube in a solvent according to the method of the present disclosure."

Chinese Patent Application No. 111617563 discloses a degerming antibacterial graphene filter element for a vehicle-mounted air conditioner, which belongs to the field of air filtration and is characterized by comprising a supporting seat, a fixing layer and a plurality of sleeve pipe assemblies, wherein the supporting seat comprises a first support and a second support; the sleeve assembly comprises a first filtering sleeve, a second filtering sleeve and a third filtering sleeve, wherein the first filtering sleeve is composed of a first non-woven fabric layer, an activated carbon filtering layer and a first non-woven fabric layer which are sequentially arranged, the activated carbon layer is clamped between the two first non-woven fabric layers, the second filtering sleeve is sleeved outside the first filtering pipe and is composed of a second non-woven fabric layer, a graphene silver nanoparticle filtering layer and a second non-woven fabric layer which are sequentially arranged, and the graphene silver nanoparticle filtering layer is clamped between the two second non-woven fabric layers; aims to solve the problems that the filter element of the vehicle-mounted air conditioner filter has short service life, needs to be replaced frequently, is inconvenient to replace and operate and the like.

Chinese Patent No. 103738944 discloses a method to prepare nanoparticle doped three-dimensional graphene. Technical solution of the present invention includes: make

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graphene oxide lamella using graphite as stock, by nanoparticle appendix on graphene oxide lamella, and by being self-assembly of three-dimensional graphene between the rare lamella of graphite. By regulating reaction temperature and graphene oxide solution concentration, the three-dimensional graphene of perforate, closed pore (different densities) is provided. The three-dimensional graphene prepared by the present invention can be widely used in the fields such as ultracapacitor, oil suction, desalinization.

United States Patent Application Publication No. 20200376305 discloses personal protection systems against COVID-19 including face masks and methods, systems or devices of managing, regulating and/or filtering airflow during travel on an aircraft, train, or bus. A mesh of nonwoven polypropylene fabric with silver nanoparticles is disclosed.

United States Patent Application Publication No. 20160113336 discloses a mask has a mask body and a pair of ear straps. The mask body includes an outer layer sheet and an intermediate layer sheet. The outer layer sheet is formed of hydrophobic fibers. The intermediate layer sheet is laid on the outer layer sheet so as to be located on a wearer's side of the outer layer sheet when the mask is worn. The intermediate layer sheet includes a first fiber layer which is formed of polyolefin fibers, which may be non-woven polypropylene, containing an inorganic antimicrobial agent, which may be silver ions and a second fiber layer which is formed of polyolefin fibers and has a larger fiber diameter than the first fiber layer. The fiber diameter of the first fiber layer is within a range of 0.5 to 2.8 μ and the ratio of a particle diameter of the inorganic antimicrobial agent with respect to the fiber diameter is within the range of 0.1 to 6.0.

What is needed is a face mask or mask insert that kills a substantial percentage of airborne microbes on contact and additionally traps the microbes, while minimally restricting air flow to the user. It would be preferable if it was inexpensive to manufacture. It would be further preferable if the face mask was form-fitting to a user's face, covering the chin, mouth and nostrils. It would be further preferable if the mask insert could be removed and replaced.

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SUMMARY

The present technology is a face mask or mask insert that kills a substantial percentage of airborne microbes on contact and additionally traps the microbes, while minimally restricting air flow to the user. It is inexpensive to manufacture. The face mask is form-fitting to a user's face, covering the chin, mouth and nostrils. The mask insert can be removed and replaced.

In one embodiment, a face mask is provided comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer.

The face mask may further comprise an outer layer, which is breathable material with interstitial spaces and which has an inner surface and an outer surface, the inner surface abutting the functionalized graphene layer.

In the face mask, the breathable material may be non-woven polypropylene.

In the face mask, the breathable material may be a woven fabric.

In the face mask, the inner layer and the outer layer may define a pocket in which the functionalized graphene layer is releasably retained.

In another embodiment, an insert for a face mask is provided, the insert comprising a graphene layer which is functionalized with silver nanoparticles, the insert shaped to be inserted into a face mask.

In another embodiment, a method of reducing pathogens in air inhaled and exhaled by a user is provided, the method comprising providing a face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized

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with a plurality of silver nanoparticles, to provide a functionalized graphene layer; the user locating the face mask on their face such that their mouth and nostrils are covered; and the user breathing through the face mask.

In another embodiment, a method of reducing pathogens in air inhaled and exhaled by a user is provided, the method comprising providing a face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer; and an outer layer, which is breathable material with interstitial spaces and which has an inner surface and an outer surface, the inner surface abutting the functionalized graphene layer; the user locating the face mask on their face such that their mouth and nostrils are covered; and the user breathing through the face mask.

The method may further comprise the user removing the functionalized graphene layer and laundering a remainder of the face mask to provide a laundered remainder of the face mask.

The method may further comprise the user inserting a new functionalized graphene layer into the laundered remainder of the face mask.

The method may further comprise the user reinserting the functionalized graphene layer into the laundered remainder of the face mask.

FIGURES

Figure 1 is a face view of the mask of the present technology.

Figure 2 is a sectional view along lines A-A of Figure 1.

Figure 3 is a sectional view of an alternative embodiment.

Figure 4A is a sectional view of a mask with a mask insert; Figure 4B is a face view of the mask of Figure 4A.

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Figure 5 is microscopic view of the functionalized graphene layer of the mask and the mask insert of the present technology.

DESCRIPTION

Except as otherwise expressly provided, the following rules of interpretation apply to this specification (written description and claims): (a) all words used herein shall be construed to be of such gender or number (singular or plural) as the circumstances require; (b) the singular terms "a", "an", and "the", as used in the specification and the appended claims include plural references unless the context clearly dictates otherwise; (c) the antecedent term "about" applied to a recited range or value denotes an approximation within the deviation in the range or value known or expected in the art from the measurements method; (d) the words "herein", "hereby", "hereof", "hereto", "hereinbefore", and "hereinafter", and words of similar import, refer to this specification in its entirety and not to any particular paragraph, claim or other subdivision, unless otherwise specified; (e) descriptive headings are for convenience only and shall not control or affect the meaning or construction of any part of the specification; and (f) "or" and "any" are not exclusive and "include" and "including" are not limiting. Further, the terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted.

Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. Where a specific range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is included therein. All smaller sub ranges are also included. The upper and lower limits of these smaller ranges are also included therein, subject to any specifically excluded limit in the stated range.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the relevant art. Although

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any methods and materials similar or equivalent to those described herein can also be used, the acceptable methods and materials are now described.

Definitions:

Pathogen – in the context of the present technology, a pathogen is a living microbe that causes disease. Pathogens include but are not limited to a bacterium, a fungus or a virus.

Aerosol – in the context of the present technology an aerosol is a suspension of solid and/liquid particles in a gas.

Fluid – in the context of the present technology, a fluid is a gas, a liquid or both.

Airborne – in the context of the present technology, airborne includes aerosols and particles in the air.

Silver nanoparticle – in the context of the present technology, silver nanoparticles are particles that range in size from 1 nanometer to 100 nanometers in diameter. The nanoparticles include elemental silver and silver oxide.

Graphene – in the context of the present technology, graphene is an allotrope of carbon consisting of a single layer of atoms arranged in a two-dimensional honeycomb lattice.

Functionalized graphene – in the context of the present technology, functionalized graphene is graphene with silver nanoparticles on at least a portion of the surface of the lattice.

Detailed Description:

A disposable face mask, generally referred to as 2 is shown in Figure 1. The mask 2 has a mask body 4, a margin 6, a nose piece 8 and two straps 10. The nose piece 8 is formable and is preferably aluminum or a pliable plastic, which when molded on a user's nose retains its shape. The straps 10 are preferably elastomeric and are retained on the mask body 4 or margin 6. The mask body 4 is sufficiently resilient to maintain its shape when in use. It may be, as shown, cup-shaped.

As shown in Figure 2, the mask body 4 consists of two layers, an inner non-woven polypropylene layer 12 and an outer functionalized graphene layer 14. The inner non-

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woven polypropylene layer 12 has interstitial spaces that allow for air flow through the mask body 4, hence it is breathable. An adhesive layer 16 is on the margin 6 to hold the inner non-woven polypropylene layer 12 and the outer functionalized graphene layer 14 in place, with the outer functionalized graphene layer abutting the outer surface 15 of the inner non-woven polypropylene layer 12.

In an alternative embodiment shown in Figure 3, the mask body 4 consists of three layers, an inner non-woven polypropylene layer 12, a middle, functionalized graphene layer 14 and an outer non-woven polypropylene layer 18. Both the inner non-woven polypropylene layer 12 and the outer non-woven polypropylene layer 18 have interstitial spaces that allow for air flow through the mask body 10, hence they are breathable. The inner surface 20 of the outer non-woven polypropylene layer 18 abuts the functionalized graphene layer 14.

In an alternative embodiment shown in Figure 4A, a mask insert 30 is provided. As shown in Figure 4A, the mask insert 30 is retained between two layers of fabric, an inner layer 32 and an outer layer 34, to form a reusable mask 36. Both layers are woven fabric, for example, cotton and have interstitial spaces that allow for air flow, hence they are breathable. The inner layer 32 and the outer layer 34 are stitched or glued or otherwise adhered to one another along most of an outer margin 38 to form a pocket 40 which has an opening 42 to the ambient environment to allow for inserting and removing the mask insert 30. As shown in Figure 4B, the mask 36 is shaped to fit over the mouth, chin and at least the nostrils of the user's nose and is held in place with two straps 44 which may fit over the user's ears. The mask insert 30 is a functionalized graphene layer 14. Returning to Figure 4A, the mask insert 30 abuts the outer surface 46 of the inner layer 32 and an inner surface 48 of the outer layer 32 in the pocket 40.

As shown in Figure 5, the functionalized graphene layer 14 is one molecular layer thick and has hexagonal pores 24 created by a honeycomb lattice 26. Silver nanoparticles 28 adhere to or are bound to or are associated with the surfaces of the lattice 26 and pores 24. The pores 24 allow for air flow.

The mask or mask insert is manufactured by dipping, spraying or otherwise applying an aqueous mixture of silver nanoparticles in water on the graphene layer which has been

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cut to shape prior to wetting. The aqueous mixture is 10 ppm silver nanoparticles. The functionalized graphene layer is then allowed to dry and is pressed onto the margins 6 of the mask body 4 or is inserted into the pocket 40 of the reusable mask 36. When the reusable mask 36 is laundered, the mask insert 30 is removed and either replaced with a new mask insert 30 or the existing mask insert 30 is returned to the pocket 40.

While example embodiments have been described in connection with what is presently considered to be an example of a possible most practical and/or suitable embodiment, it is to be understood that the descriptions are not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the example embodiment. Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation, many equivalents to the specific example embodiments specifically described herein.

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CLAIMS

1. A face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer.
2. The face mask of claim 1, further comprising an outer layer, which is breathable material with interstitial spaces and which has an inner surface and an outer surface, the inner surface abutting the functionalized graphene layer.
3. The face mask of claim 1 or 2, wherein the breathable material is non-woven polypropylene.
4. The face mask of claim 2, wherein the breathable material is a woven fabric.
5. The face mask of claim 2 or 4, wherein the inner layer and the outer layer define a pocket in which the functionalized graphene layer is releasably retained.
6. An insert for a face mask, the insert comprising a graphene layer which is functionalized with silver nanoparticles.
7. A method of reducing pathogens in air inhaled and exhaled by a user, the method comprising providing a face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface and an outer surface; and a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer; the user locating the face mask on their face such that their mouth and nostrils are covered; and the user breathing through the face mask.
8. A method of reducing pathogens in air inhaled and exhaled by a user, the method comprising providing a face mask comprising a mask body, which includes a margin, and straps attached to the mask body proximate the margin for releasably retaining the mask on a user's face, the mask body including: an inner layer, which is a breathable material with interstitial spaces, and which has an inner surface

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and an outer surface; a graphene layer which abuts the outer surface and is functionalized with a plurality of silver nanoparticles, to provide a functionalized graphene layer; and an outer layer, which is breathable material with interstitial spaces and which has an inner surface and an outer surface, the inner surface abutting the functionalized graphene layer; the user locating the face mask on their face such that their mouth and nostrils are covered; and the user breathing through the face mask.

9. The method of claim 8, further comprising the user removing the functionalized graphene layer and laundering a remainder of the face mask to provide a laundered remainder of the face mask.
10. The method of claim 9, further comprising the user inserting a new functionalized graphene layer into the laundered remainder of the face mask.
11. The method of claim 9 further comprising the user reinserting the functionalized graphene layer into the laundered remainder of the face mask.

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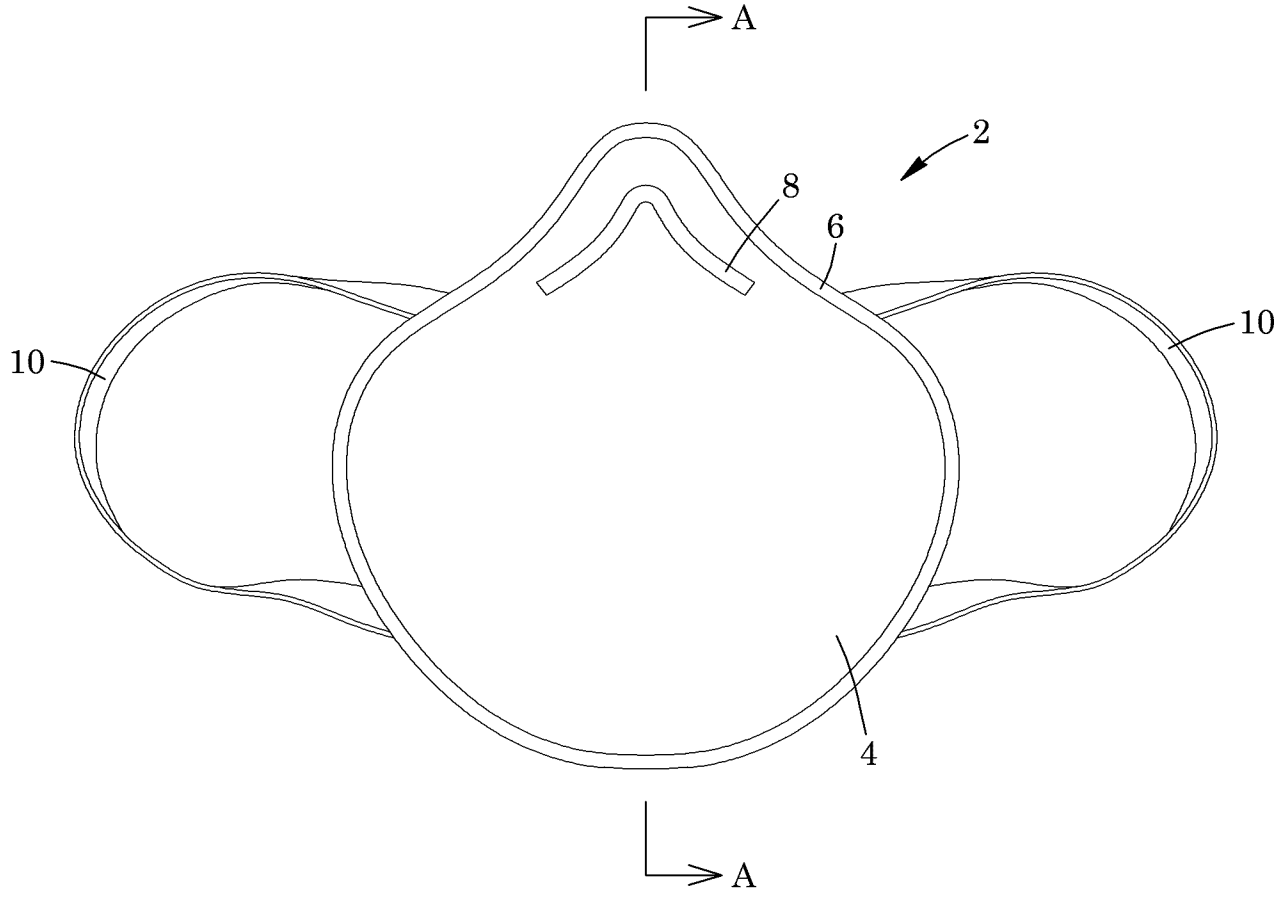

FIG. 1

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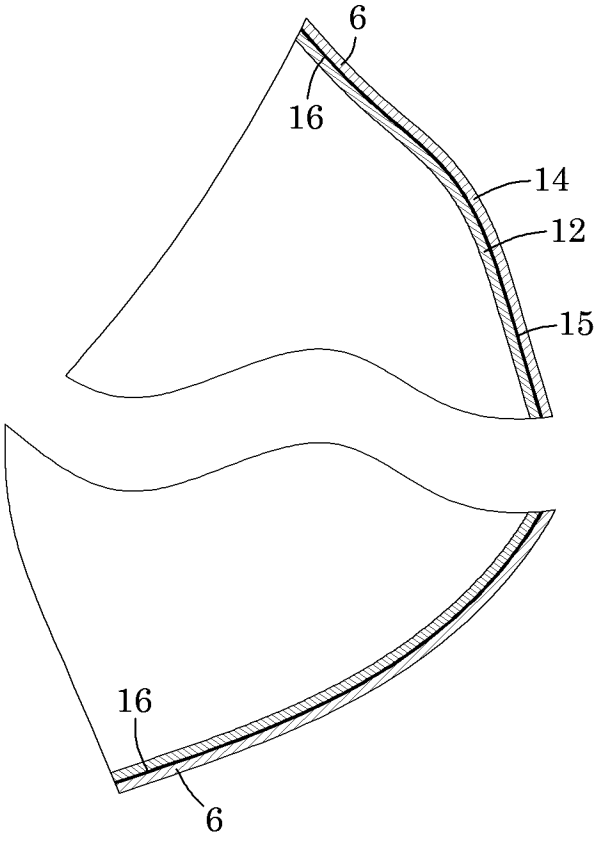

FIG. 2

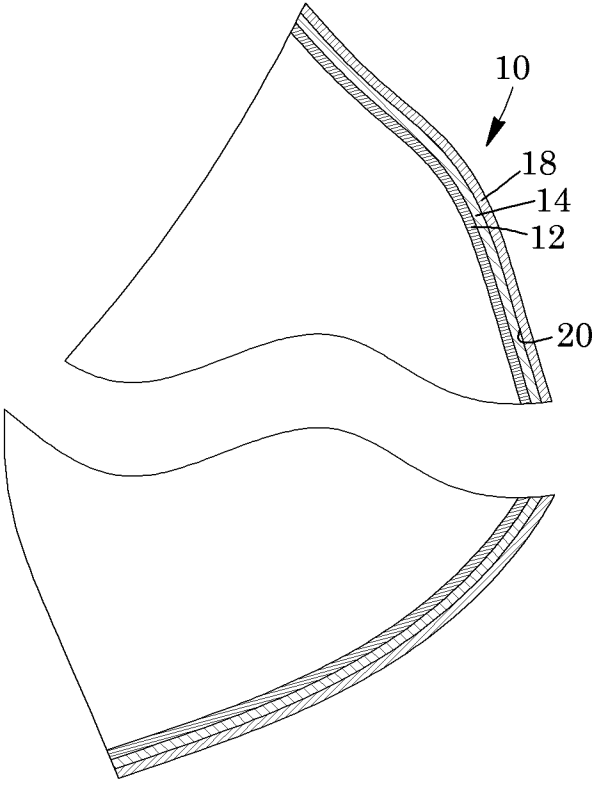

FIG. 3

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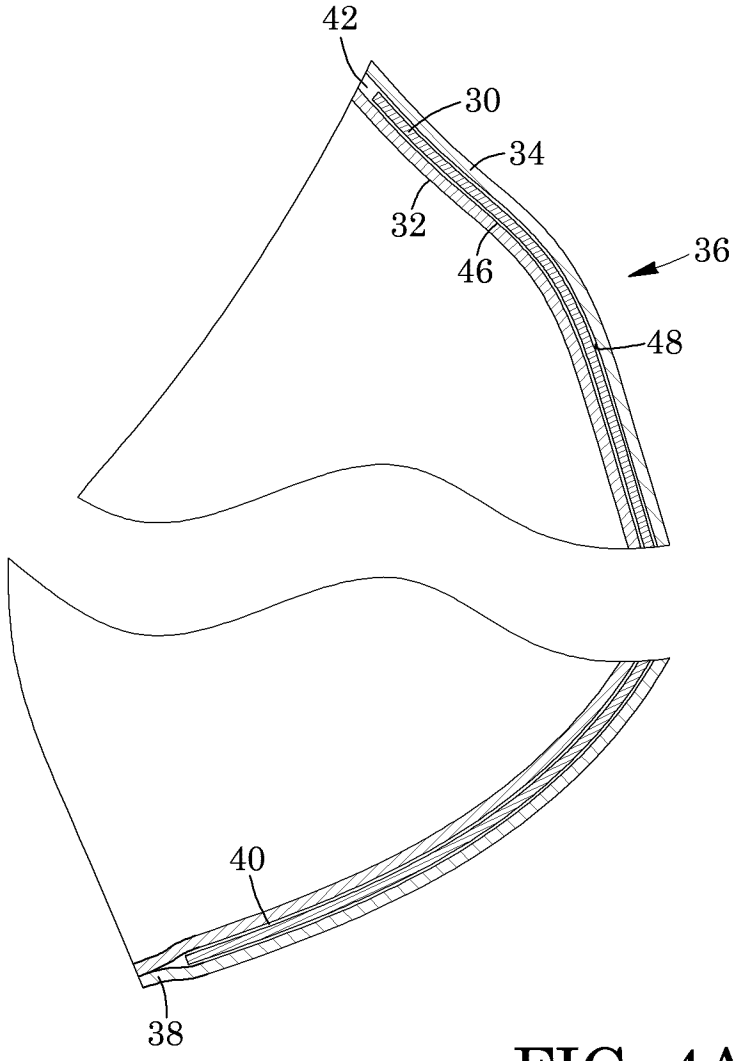

FIG. 4A

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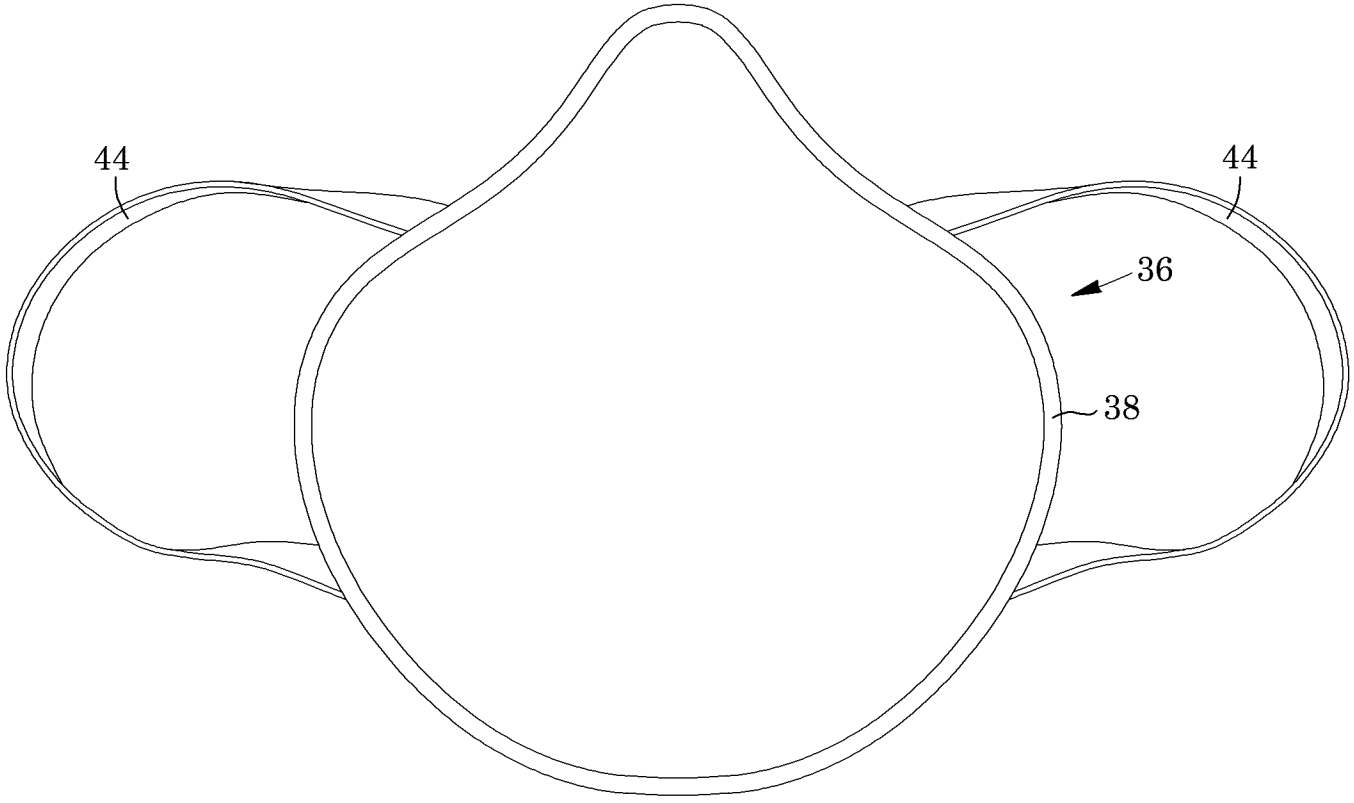

FIG. 4B

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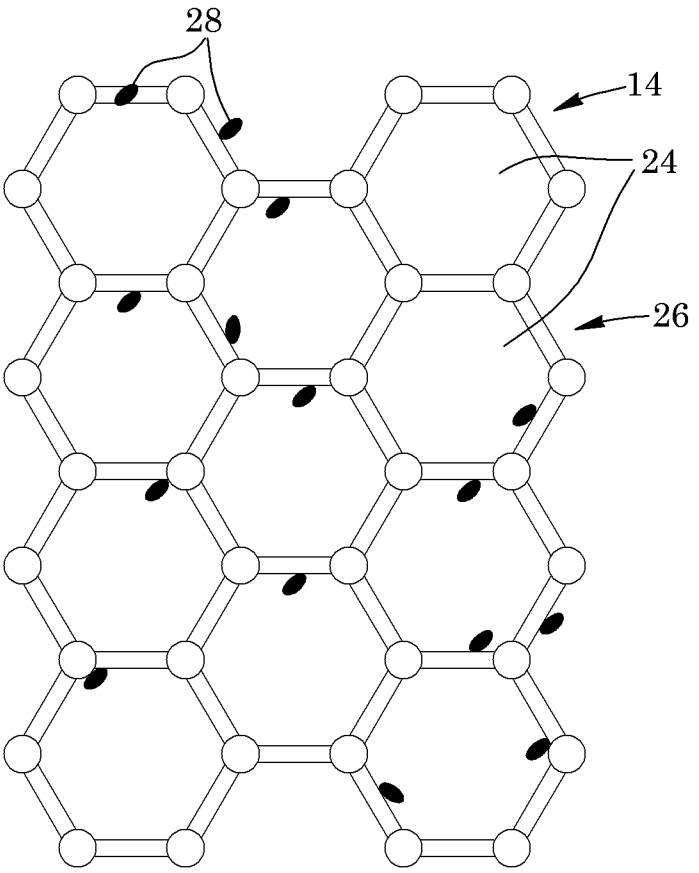

FIG. 5

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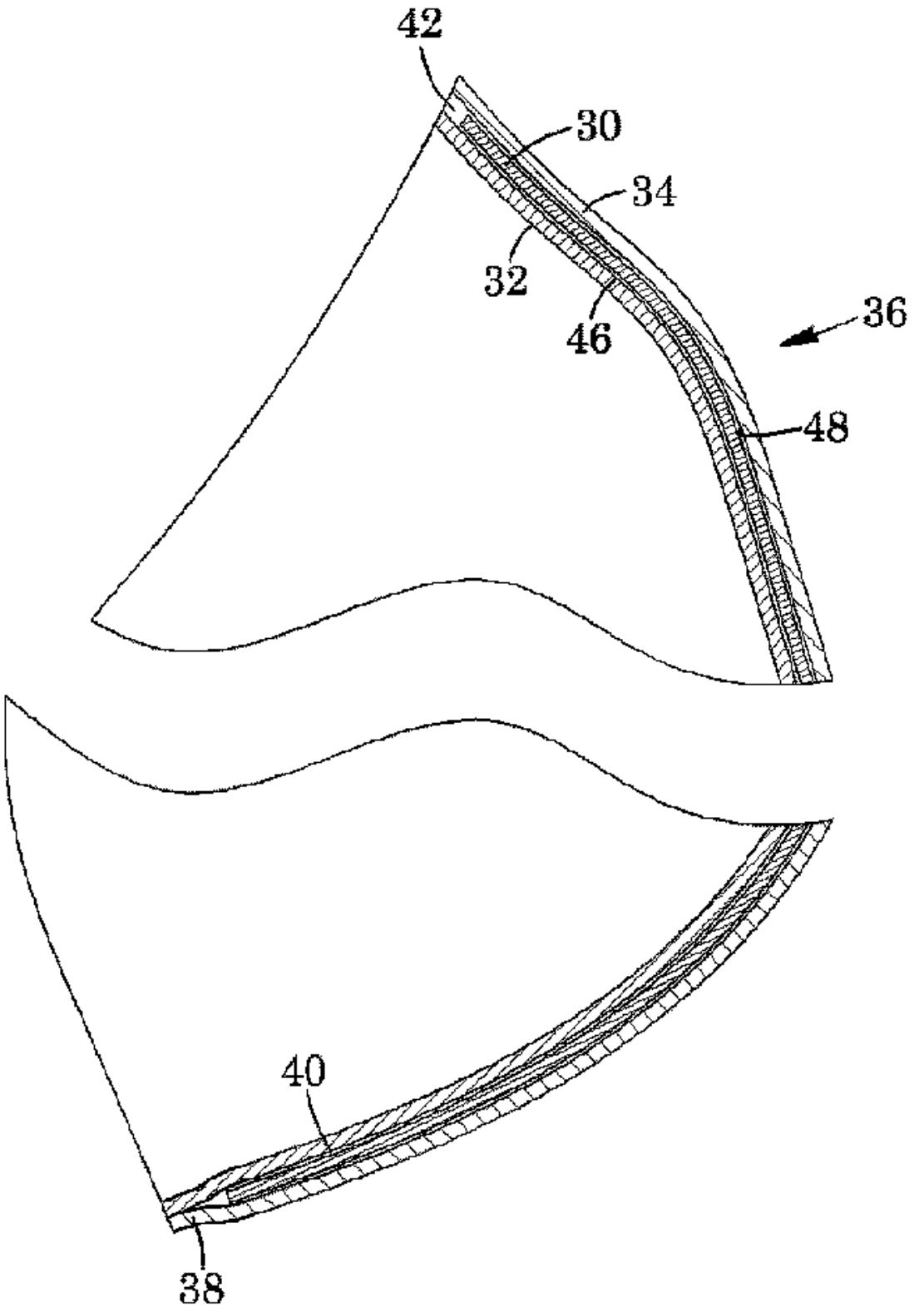
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