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Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

United States Patent

Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, or importing into the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

David J. Kayros

Director of the United States Patent and Trademark Office



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(12) **United States Patent**
Frankel et al.

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- (54) **MULTIPLE LAYERED MEMBRANE WITH THIN FLUORINE CONTAINING POLYMER LAYER**
- (76) Inventors: **Thomas E Frankel**, 4 Tucker Dr., Poughkeepsie, NY (US) 12603; **Seungil Kang**, 4 Tucker Dr., Poughkeepsie, NY (US) 12603; **Todd D Ritter**, 4 Tucker Dr., Poughkeepsie, NY (US) 12603; **Hong-suk Kim**, 106-501 Dongwan Apt., Jung-Wang Dong, Shihung City (KR)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 741 days.

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B01F 3/04 (2006.01)
F16L 11/04 (2006.01)
B32B 27/08 (2006.01)

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(58) **Field of Classification Search** 428/195.1, 428/36.8, 36.91, 131, 136, 137, 422, 476.3, 428/519; 261/121.1, 122.2, 124, DIG. 70
See application file for complete search history.

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Primary Examiner—Mark Ruthkosky
Assistant Examiner—Gerard T Higgins
(74) *Attorney, Agent, or Firm*—Law Offices of Michael L. Wise, LLC

(57) **ABSTRACT**

A multi-layer membrane includes a fluorine containing layer and a substrate which are joined through spray coating and heat treatment in a multi-step technique.

9 Claims, 2 Drawing Sheets

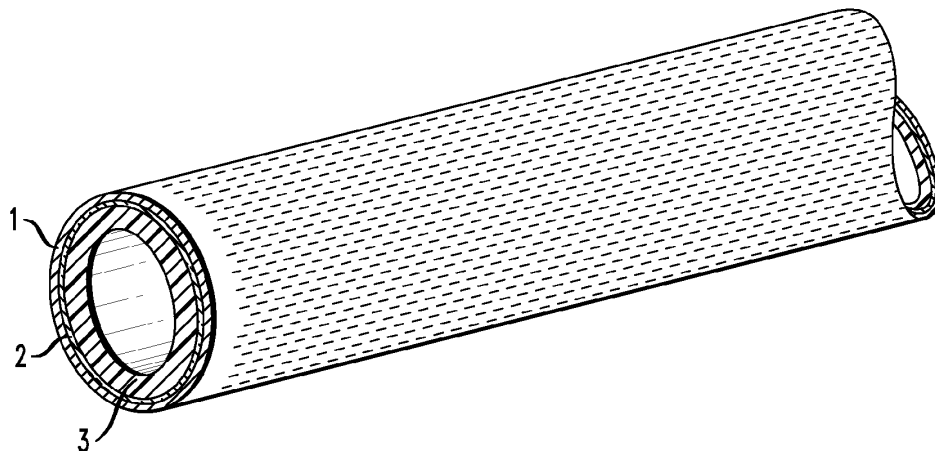


FIG. 1

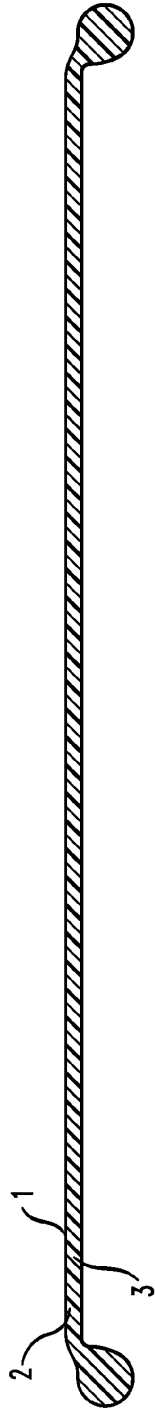


FIG. 2

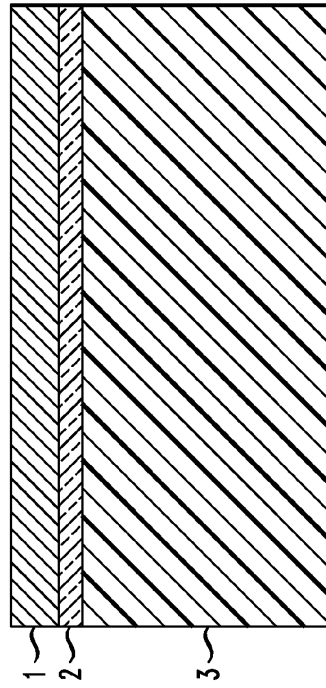
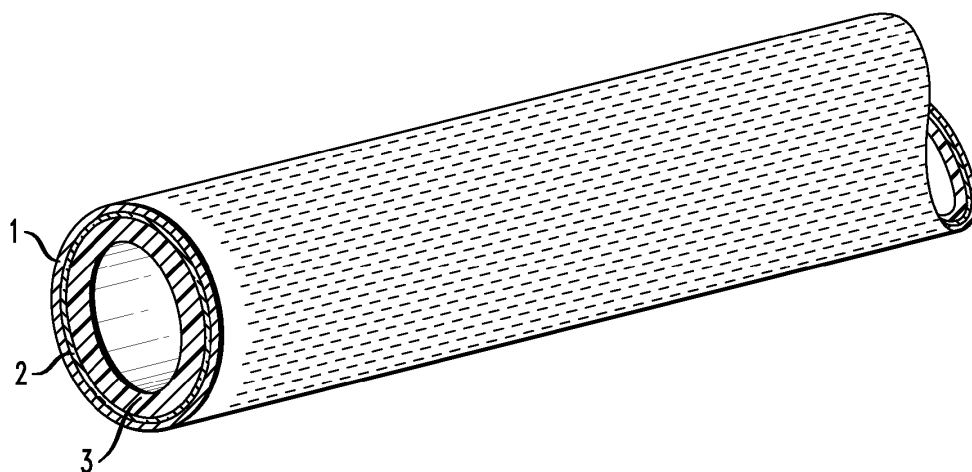


FIG. 3



1

**MULTIPLE LAYERED MEMBRANE WITH
THIN FLUORINE CONTAINING POLYMER
LAYER**

FIELD OF THE INVENTION

This patent applies to an improvement in the invention filed under U.S. Pat. No. 7,396,499, in which a thin-film fluorine containing layer of 0.3 mm or less was bonded through cross linking in a mold to substrate such as ethylene propylene diene monomer (EPDM) or nitrile rubber to improve upon the substrate's physical and chemical resistance properties. The improvements in the invention are that the surface of the fluorine containing layer can be made smoother through the application of a spray-coated fluorine containing layer rather than through the previous molding method, and that the fluorine containing layer has been specifically formulated to optimize the efficiency of the product. The previous method did not offer such flexibility in formulation.

BACKGROUND OF THE INVENTION

Spray coating methods of applying fluorine containing dispersions onto substrates such as EPDM and nitrile rubber already exist. They are typically combined with primers such as but not limited to polyamide-imide, polyether sulfones and sprayed onto a substrate that may have been pretreated with methyl-ethyl ketone, N-methyl pyrrolidone, plasma or corona treatment to improve adhesion of the primer to the substrate. Following surface preparation and priming, they are coated with a fluorine containing dispersion coating, and are then cured on-line or off-line in an oven. However such methods have not previously been applied to a diffuser membrane for use in water treatment plants, which is a difficult application.

This improvement is of particular importance in application of such a coating to a diffuser membrane used in the sewage and industrial wastewater treatment industries. Diffuser membranes are typically made from perforated non-fluorinated elastomers or polymers, which are perforated with small slits and, when inflated, produce a plume of bubbles which are released into wastewater. The efficacy of such diffusers is measured primarily in their ability to produce small bubbles in great quantity, such that the combined surface area of the bubbles is large. A large quantity of small bubbles transfers much more oxygen to the process than do a smaller quantity of large bubbles and oxygen mass transfer is desirable. Manufacturers of diffusers typically spend a great deal of time and energy formulating elastomeric compounds that produce small bubbles. The slightest compound formulation change may result in a vastly different bubble size. Furthermore, where diffuser membranes are submerged in dirty water, surface contamination from foulants such as bio-film, calcium and gypsum can cause an increase in bubble size over time, just as fats, oils, greases and solvents can penetrate traditional membranes causing chemical oxidation of the rubber. This can result in either a failed part or increased bubble size. The coating of a non fluorine containing membrane with a smooth fluorinated layer that is specifically designed to produce small bubbles, and to withstand thousands of perforations and a constant state of flux while submerged in waste-

2

water is a novel invention and provides a universal solution to both fouling and efficiency issues.

SUMMARY OF THE INVENTION

The present invention applies to flexible diffuser membranes which are used in the aeration of wastewater and which is spray coated with a fluorine containing surface layer.

A diffuser membrane is produced from blended EPDM rubber, nitrile rubber, or neoprene rubber, the surface is roughened through a corona, a plasma, or methyl-ethyl ketone, and primer and fluorine containing surface layers are applied through spray coating. Alternatively, a blended primer and fluorine containing surface layer is applied through spray coating.

When treated in this way, the membrane becomes significantly more resistant to surface fouling, chemical oxidation, and its oxygen transfer efficiency is acceptably high by industry standards.

DESCRIPTION OF DRAWINGS

FIG. 1 is a cross-sectional view of a multi layered disc membrane.

FIG. 2 is a cross-sectional view of a membrane onto which layers have been applied.

FIG. 3 is a cutaway view of a multi layered tube membrane.

DETAILED DESCRIPTION

Adhesion between a spray coated fluorine containing layer and a substrate is accomplished through substrate surface treatment, priming, coating, and curing.

Firstly, a substrate layer such as membrane 3 is molded.

Secondly, a roughening agent such as a corona, a plasma, methyl-ethyl ketone or N-methyl pyrrolidone is applied to the surface to be coated as needed depending on the quality of the substrate.

Thirdly, a primer layer 2 of less than 10 microns is sprayed onto the substrate surface. This primer is then heat treated at >100 degrees C. for >15 minutes. The primer layer may contain polyamide-imide or polyether sulfone. Alternatively, the primer is blended with a fluorine containing dispersion layer and this layer is sprayed onto the substrate surface, then heat treated.

Fourthly, if using separate primer and fluorine containing dispersion layers, the fluorine containing dispersion layer 1 of less than 20 microns is sprayed over the cured primer, and is heat treated at >120 degrees C. for >20 minutes. The fluorine containing dispersion layer may contain fluoride acryl resin, xylene, toluene, bentonite, titanium dioxide, carbon black, 2-isocyanatoethyl 2,6-diisocyanatohexanoate, 2,6-diisocyanatohexanoic acid 2-isocyanato ethyl ester and/or ethyl acetate.

From the foregoing it will be seen that this invention is one well adapted to attain all ends and objectives hereinabove set forth together with the other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

Since many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative, and not in a limiting sense.

3

4

What is claimed is:

1. A multi-layer flexible perforated diffuser membrane comprising:

a substrate layer, wherein said substrate layer comprises ethylene propylene diene monomer (EPDM);
a primer layer disposed on said substrate layer; and
a dispersion layer disposed on said primer layer, wherein said dispersion layer comprises polytetrafluoroethylene (PTFE);

wherein said substrate layer, said primer layer and said dispersion layer are perforated to form said multi-layer flexible perforated diffuser membrane.

2. The diffuser membrane of claim 1, wherein said primer layer is less than 10 microns thick.

3. The diffuser membrane of claim 1, wherein said diffuser membrane is selected from the group consisting of a tubular shaped membrane, a disc shaped membrane and a panel shaped membrane.

4. The diffuser membrane of claim 1, wherein said primer layer comprises a material selected from the group consisting of polyamide-imide and polyether sulfone.

5. The diffuser membrane of claim 1, wherein said dispersion layer is less than 20 microns thick.

6. The diffuser membrane of claim 1, wherein said dispersion layer is less than 20 microns thick and said dispersion layer is heat treated at a temperature of greater than 120 degrees C. prior to the use of the diffuser membrane.

7. The diffuser membrane of claim 1, wherein said dispersion layer further comprises a material selected from the group consisting of fluoride acryl resin, xylene, toluene, bentonite, titanium dioxide, carbon black, 2-isocyanatoethyl 2,6-diisocyanatohexanoate, 2,6-diisocyanatohexanoic acid 2-isocyanatoethyl ester and ethyl acetate.

8. The diffuser membrane of claim 1, wherein said dispersion layer is deposited through a spray.

9. The diffuser membrane of claim 1, wherein a plasma discharge, a corona discharge, N-methyl pyrrolidone or methyl-ethyl ketone is applied to said substrate layer prior to deposition of said primer layer.

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