REINFORCED CARBON FABRICS

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Related U.S. Application Data


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Field of Search ....... 55/514, 527; 156/290, 295, 156/309; 117/46 CC; 161/85, 88, 92, 146, 156; 264/29

References Cited

UNITED STATES PATENTS

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ABSTRACT

Activated carbon fabrics, having poor textile properties in terms of tensile strength, abrasion resistance and flex performance, are substantially upgraded by laminating the carbon fabric to at least one other fabric having significantly better textile properties. Lamination is effected without substantial loss of fabric air permeability or excessive increase in weight by using a hot-melt adhesive fabric or netting as the binding medium.

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to us of any royalty thereon.

3 Claims, No Drawings
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REINFORCED CARBON FABRICS

This is a continuation of application Ser. No. 191,557 filed Oct. 21, 1971 and now abandoned.

BACKGROUND OF THE INVENTION

Activated carbon is a material that finds widespread use because of its unusual ability to adsorb significant quantities of gaseous or liquid matter. This property is attributable to the extensive surface area and developed pore structure of the carbon material. Activated carbon in the form of powder or granules is widely used for the removal of odors, selected gases and vapors, especially toxic gases and vapors from the atmosphere, for decoloring liquids and for solvent recovery. Recent developments have made it possible to obtain activated carbon as fibers in fabric form. As fabrics, activated carbon can be used for applications not possible with powder or granules, e.g., as clothing to protect against toxic liquid, vapor or gaseous agents, as filters or screens in air systems to eliminate odors and pollution without restricting the flow of air, etc. A serious drawback, however, exists in connection with the use of such carbon fabrics, in that such fabrics have extremely poor textile properties, notably, low tensile strength, poor abrasion resistance and poor flex performance. Improvement in the foregoing properties without any substantial impairment of the sorption or air permeability properties of the carbon fabric would greatly enhance the suitability of such fabrics for any of the described uses.

SUMMARY OF THE INVENTION

This invention relates to a reinforced, activated-carbon, fabric constructed by laminating an activated-carbon fabric having poor textile properties to at least one other fabric having good textile properties and bonding said fabrics together by means of a hot-melt adhesive fabric or netting. The resulting laminate composite has textile properties that far exceeds those of the carbon fabric alone and is suitable for most textile applications. The use of hot-melt adhesive fabric or netting rather than conventional adhesive coatings to effect bonding results in an inherently more air permeable fabric composite than would otherwise be obtained, does not excessively increase the weight or stiffness of the fabric composite, and does not significantly reduce the sorptive properties of the activated carbon by solvent poisoning.

DETAILED DESCRIPTION

The objective of this invention, to prepare an activated-carbon fabric having textile properties suitable for typical textile applications, is achieved by laminating of an activated-carbon fabric to one or more non-carbon fabrics having significantly better textile properties. Such laminate composite is formed in a manner which does not result in any substantial loss of air permeability characteristics or sorptive capacity. Conventional adhesives require solvents and solvents will poison the activated carbon material.

Carbon fabrics are known and commercially available and may vary from weakly activated to highly activated. The activity of carbon is a function of the surface area and pore development of the carbon material. The more highly active carbon materials adsorb greater quantities of materials and depending on pore size and development can selectively adsorb certain gases, vapors or liquids. For purposes of this invention, it is necessary that the activated carbon have a surface area of at least 100m²/g and have micropores with an effective diameter of less than 30 Å for gas and vapor sorption and preferably a transitional pore structure with an effective diameter ranging from 30 Å up to 2,000–4,000 Å, for liquid sorption. While activated carbon materials are produced by techniques well known in the art and constitute no part of this invention, U.S. Pat. Nos. 3,253,322 and 3,484,183 may be referred to as illustrating or describing techniques for the fabrication of certain carbon fabrics.

Activated carbon fabrics are known to have relatively poor textile properties which properties further decline with increase in activation. The poor or weak textile properties of activated carbon fabrics are typified by low breaking (tensile) strength, poor abrasion resistance, and poor flexing properties. Carbon yarns, for example, normally have a breaking strength of less than 1 gm/denier. The expression "carbon fabric," as used herein, refers to fabrics whose yarns are composed of fibers having a carbon content of from 50% up to 99+. Carbon fabrics can be produced by pyrolysis of any fabric made from non-melting organic fibers. Activation is usually accomplished with a heated oxidizing gas, e.g., CO₂, H₂O, or O₂. Because of the weakness of the carbon yarns, it is usual and preferred that the finished fabric be pyrolyzed to the carbon derivative and then activated, although it is possible to form fabrics from activated carbon yarns. The expression "fabric," as used herein, refers to woven, knitted or felt materials.

The fabrics which are laminated to the activated-carbon fabrics to improve the textile properties of the latter are light in weight and woven or knitted from common, commercial, yarns (containing man-made or natural fibers) having a breaking strength in the range of 2 to 5 gm/denier. These fabrics, which may be referred to as "non-carbon fabrics," i.e., they are composed of yarns containing less than 50% carbon, include such materials as wool, silk, cotton, viscose, acetate, acrylic, modacrylic, nylon, Nomex, a product of E. I. duPont de Nemours and Co., and other special polyamides, polyester and blends of the same. Nylon tricot, nylon-cotton (50/50), poplin or sateen, Nomex muslin, Nomex twill and acetate taffeta are but some examples of suitable lightweight fabrics.

Lamination of the activated carbon fabric to the non-carbon fabric is accomplished by use of a hot-melt adhesive fabric or netting as the bonding agent. Such hot-melt adhesives are well-known and include thermoplastic materials, such as polyamides, polyesters and polyolefins that melt at temperatures that range from 300°F. to 400°F. The adhesive fabric or netting is an open type structure and weighs from 0.1 oz/yd² to 3.0 oz/yd². Unlike conventional adhesives, hot-melt adhesives do not require solvents to effect bonding. The temperature applied to the fabric layers for the lamination step to activate the adhesive will vary with the adhesive material employed but will ordinarily range from 325°F. to 375°F. Pressures applied will ordinarily range from 2 to 20 p.s.i. and the dwell time is such as to permit the adhesive to fuse and wet the fabric layers. The open fabric or net nature of the adhesive means that more of the surface area of the laminated composite will be free of adhesive material. As a consequence,
the air permeability of the fabric assembly is not affected to any significant degree.

EXAMPLE I

A weakly activated carbon fabric, Pluron B-1, 6 oz/yd², a product of 3M Co., having a saturated carbon tetrachloride vapor sorption capacity of 15% by weight, a surface area of 250m²/g, and a yarn breaking strength in the warp direction of approximately 0.4 gm/denier and in the filling direction of approximately 0.2 gm/denier is reinforced with nylon and acetate fabrics. Nine inch squares of the different textile fabrics are cut and assembled in the following laminate sequence: Acetate taffeta fabric (2.56 oz/yd²)/adhesive fabric/carbon fabric/adhesive fabric/nylon tricot fabric (0.9 oz/yd²). The adhesive fabric is Thermogrip 5030A, polyester-type adhesive, having a weight of 1.23 oz/yd², a product of USM Chemical Company. The fabric assembly is laminated at 370°F., at 4 p.s.i. for 20 seconds in a commercial press. Upon removal from the press, the laminate is allowed to cool. The laminate has good air permeability values ranging from 26 to 41 cubic feet per minute per sq. ft. when tested under Method 5450 of Federal Test Method Standard 191. The laminate also had good flexible properties and suffers no weight loss or significant visible damage when flex tested 1,260 cycles as specified in Federal Test Method Standard 191, Method 5320. The laminate layers are securely bonded together and the outer fabric layers provide the inner carbon layer from abrasive influences.

EXAMPLE II

The carbon fabric of Example I is laminated between a nylon-cotton poplin (50-50) fabric (5 oz/yd²), and a nylon tricot (2.0 oz/yd²). The adhesive fabric or netting employed between the fabric layers is selected from one of the following:
1. A polyester type, Thermogrip 5030A, a product of USM Corp., weighing 1.23 oz/yd².
2. A polyamide type, Thermogrip LM 5230A, a product of USM Corp., weighing 1.15 oz/yd².
3. A polyolefin type, Delnet X230, a product of Hercules, Inc., weighing 0.53 oz/yd².

The laminates are inserted in a commercial press and bonded at 4 p.s.i. for 16 seconds at temperatures which range from 325°F. to 375°F. and are allowed to cool before testing. The laminates are tested as follows:
2. Stiffness in accordance with Method 5205 of Federal Test Method Standard 191 using the standard 60° angle of bend, and with the reading in lbs.
3. Peel test of each fabric laminated to the carbon fabric using 1 inch wide by 4 inch long samples of an Instron Tensile Tester, with reading in lbs., using 5 lbs. full scale and a separation rate of 5 in./min.

The results of the foregoing tests for each of the laminate samples are set forth in TABLE I.

| TABLE I |
|------------------|------------------|------------------|
| Adhesive —       | Thermogrip       |
| Fabric or Netting| 5030A            |
| Air Permeability | 25.3—31.5        |
| (ft²/min./ft²)   | 23.4—29.0        |
| Stiffness (lbs)  | 26.0—32.0        |
| Warp             | 0.072—0.81       |
| Fill             | 0.068—0.126      |
| Peel (lbs)       | 0.052—0.067      |
| Nylon tricot     | 1.40—2.1         |
| Warp             | 1.47—2.56        |
| Fill             | 0.60—1.1         |
| Nylon-Cotton Poplin | 0.78—1.82    |
| Warp             | 2.3—2.9         |
| Fill             | 1.48—2.8        |

EXAMPLE III

A moderately activated carbon fabric, Pluron H-1, 4 oz/yd², a product of 3M Company, having a saturated carbon tetrachloride vapor sorption capacity of 30% by weight, a surface area of 450 m²/g is reinforced with nylon and a selection of three other fabrics. 24 inch by 20 inch rectangles of different textile fabrics are cut and assembled in the following laminate sequence: Any one of three fabrics, (1) nylon-cotton (50/50) twill, (5 oz/yd²), (2) Nomex muslin, (3.1 oz/yd²) or (3) Nomex twill, (4.5 oz/yd²)/ together with adhesive fabric/carbon fabric/adhesive fabric/nylon tricot fabric (2 oz/yd²). The adhesive fabric is Thermogrip 5030A as in EXAMPLE I. The fabric assembly is laminated at 350°F. at 4½ p.s.i. for 20 seconds on a commercial press and allowed to cool. The laminates have the following air permeabilities when tested in accordance with Method 5450 of Federal Test Method Standard 191:

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Air Permeability (cu ft/min./ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon-cotton (50/50) twill, 5 oz/yd²</td>
<td>31.6</td>
</tr>
<tr>
<td>Nomex muslin, 3.1 oz/yd²</td>
<td>55.5</td>
</tr>
<tr>
<td>Nomex twill, 4.5 oz/yd²</td>
<td>66.9</td>
</tr>
</tbody>
</table>

The technique described herein using a hot-melt adhesive fabric or netting to laminate lightweight, strong fabrics to weak carbon fabrics makes the use of such carbon fabrics possible for conventional textile applications. Adhesion of the reinforcing fabric to the carbon fabric is accomplished without impairment of the activated carbon system and without any significant reduction in the air permeability of the laminate system. The invention described in detail in the foregoing specification is susceptible to changes and modifica-
tions as may occur to persons skilled in the art without departing from the principle and spirit thereof. The terminology used is for purpose of description and not limitation, the scope of the invention being defined in the claims.

We claim:

1. A reinforced activated-carbon fabric formed by laminating an activated-carbon fabric constructed of activated-carbon yarns having a breaking strength of less than 1 gm/denier to at least one other non-carbon fabric in such a manner as not to poison the activated-carbon and so as not to substantially reduce the permeability of the fabric layers wherein the lamination is accomplished by:
   a. placing a layer of hot-melt adhesive fabric or netting between said activated-carbon fabric layer and said non-carbon fabric layer,
   b. subjecting said combined layers to sufficient heat and pressure for such time as to cause said hot-melt adhesive to fuse and flow, and
   c. removing said source of heat and pressure whereby said fused adhesive solidifies bonding said fabric layers together to produce a laminated fabric having substantially the same air permeability as the original fabric layers.

2. A reinforced activated-carbon fabric wherein said hot-melt adhesive fabric or netting has a weight of from 0.1 to 3.0 oz/yd².

3. A reinforced activated-carbon fabric wherein said bonded fabric layers have an air permeability of at least 25 ft³/min/ft².