US 20060237130A1

(19) **United States**
(12) **Patent Application Publication**
Thompson

(10) **Pub. No.: US 2006/0237130 A1**
(43) **Pub. Date: Oct. 26, 2006**

(54) **ACOUSTIC WEB**

(75) Inventor: **Delton R. Thompson**, Woodbury, MN (US)

Correspondence Address:
3M INNOVATIVE PROPERTIES COMPANY
PO BOX 33427
ST. PAUL, MN 55133-3427 (US)

(73) Assignee: **3M Innovative Properties Company**

(21) Appl. No.: **11/423,985**

(22) Filed: **Jun. 14, 2006**

Related U.S. Application Data

(62) Division of application No. 10/335,752, filed on Jan. 2, 2003.

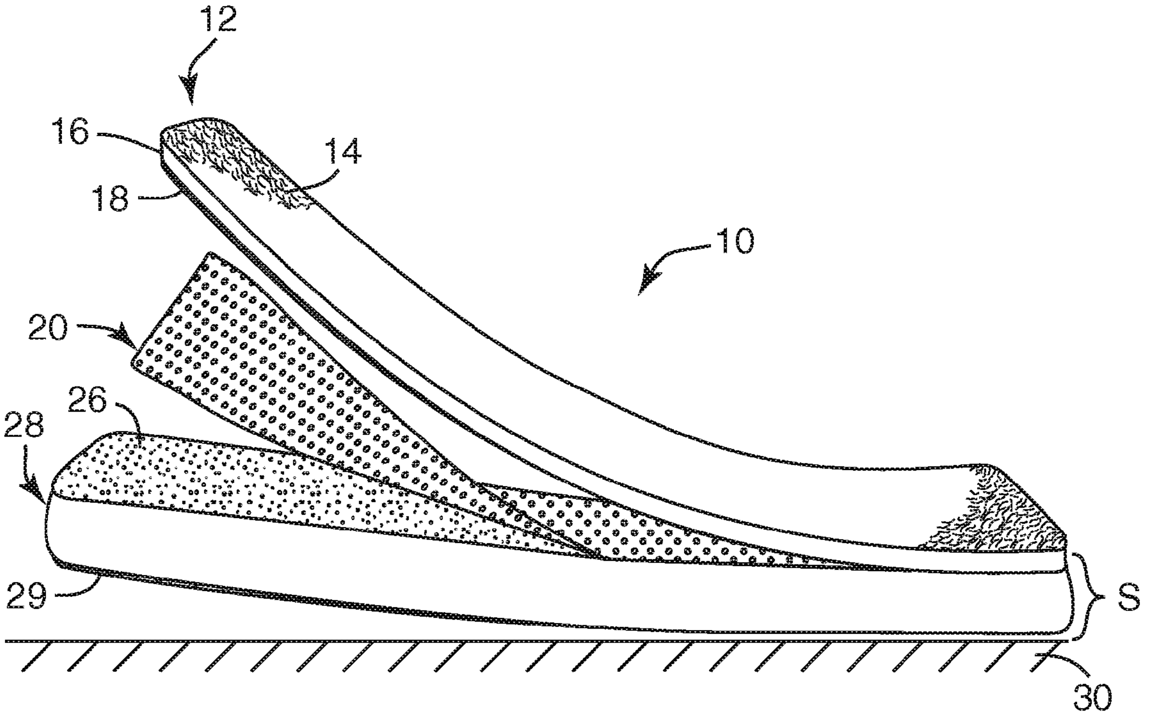
Publication Classification

(51) **Int. Cl.**
B32B 37/00 (2006.01)

(52) **U.S. Cl.** **156/273.3**

(57) **ABSTRACT**

Pore plugging is reduced when laminating an airflow resistive membrane to a thermoplastic hot melt adhesive, by treating the membrane to reduce its surface energy. This enables fabrication of acoustical laminates incorporating substantial amounts of recycled fibrous insulating mat manufacturing waste, and permits design of the laminate based primarily on one-quarter wavelength sound absorption considerations and control of the porosity and interfacial adhesion of the airflow resistant membrane.



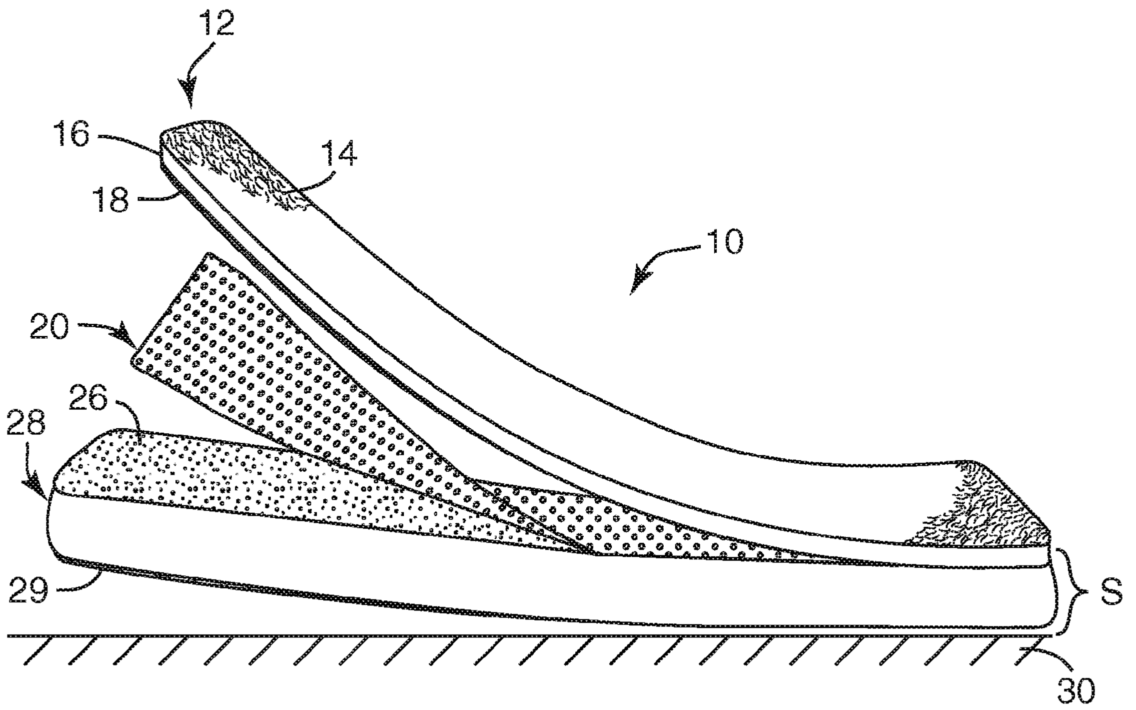


FIG. 1

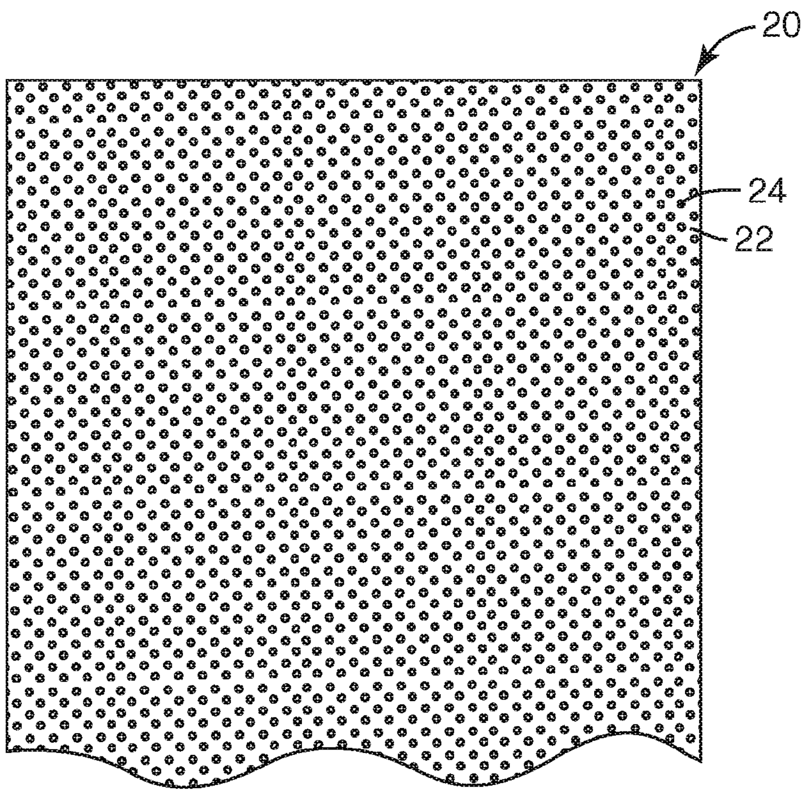


FIG. 2

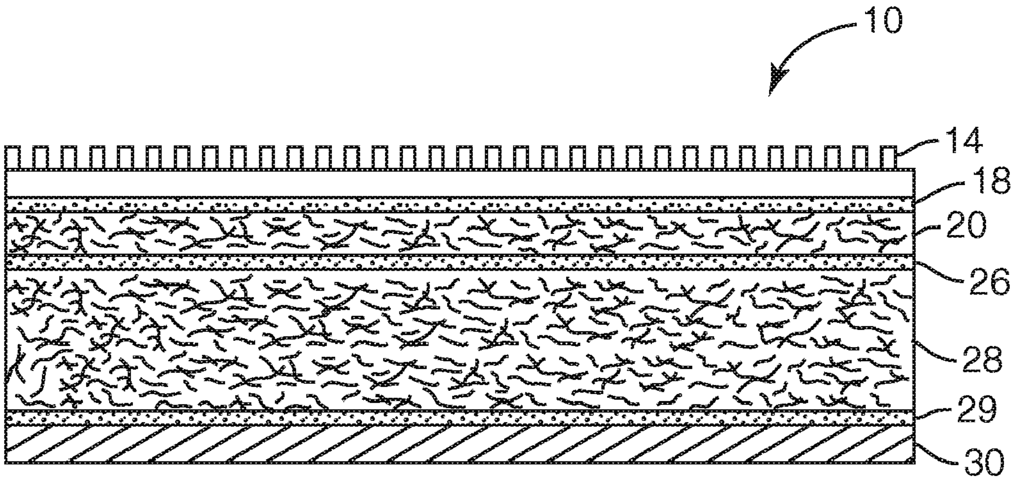


FIG. 3

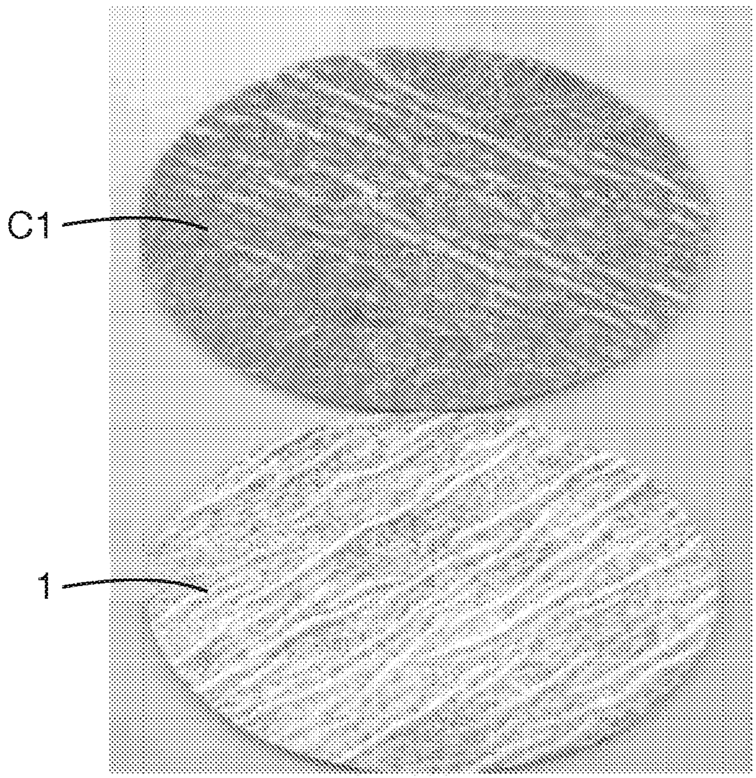


FIG. 4

ACOUSTIC WEB

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This is a divisional of U.S. patent application Ser. No. 10/335,752, filed Jan. 2, 2003, the entire disclosure of which is incorporated herein by reference.

FIELD

[0002] This invention relates to sound absorptive articles and methods for their preparation.

BACKGROUND

[0003] Typical insulating mat substrates may employ air laid nonwoven polyester fibers bound with adhesive bicomponent fibers, open- or closed-cell foam sheets, or resinated shoddy mats. If made in a porous structure and with a suitable thickness, these substrates can absorb sound and thereby reduce noise levels in nearby spaces. For example, porous insulating mat substrates can be laminated to carpeting, headliners, trunk liners, hood liners, interior panels, and other porous decorative or functional facings such as those employed in vehicles, in order to provide enhanced noise reduction compared to use of the facing by itself.

[0004] Typical vehicular carpet laminates have a fibrous face of nylon or other synthetic tufted into a high basis weight supporting layer made of nylon or other compatible synthetic. The supporting layer backside is typically extrusion coated with a molten hot melt adhesive or calcium carbonate-loaded latex to fix the fiber tufts. Optionally, a hot melt adhesive may be applied as a thin primary backcoat followed by a heavy latex secondary backcoat. The resulting backed carpet can be applied over an insulating mat. To form a vehicular carpet laminate, the backed carpet and the insulating mat typically are preheated followed by compression molding. The backcoat adhesively bonds the carpet to the mat. The resulting laminate is subsequently air quenched and water jet cut to yield the final vehicular part.

[0005] For applications involving noise reduction, latex carpet backings typically are omitted in favor of hot melt adhesive primary backings. Calcium carbonate-loaded lattices typically are sufficiently thick and impermeable to prevent the passage of sound waves through the backing and into the insulating mat, thus limiting the available noise reduction. Hot melt adhesive backings typically may be continuous and impervious when applied, but become porous during lamination of the backing to the insulating mat due to capillary flow of the adhesive into the carpet or into the mat. Polyolefins such as low density polyethylene ("LDPE") are often used as the hot melt adhesive.

[0006] When an airflow resistive membrane is positioned between a carpet and an insulating mat, improved sound insulating performance can be obtained, see e.g., M. Schwartz and E. J. Gohmann, Jr., "Influence of Surface Coatings on Impedance and Absorption of Urethane Foams, J. Acoust. Soc. Am., 34 (4): 502-513 (April, 1962), M. Schwartz and W. L. Buehner, "Effects of Light Coatings on Impedance and Absorption of Open-Celled Foams, J, Acoust. Soc. Am., 35 (10): 1507-1510 (October, 1963), U.S.

No. US 2001/0036788 A1 and PCT Published Application Nos. WO 99/44817 A1, WO 00/27671 A1, WO 01/64991 A2 and WO 02/20307 A1.

SUMMARY OF THE INVENTION

[0007] Airflow resistive membranes can experience partial or even substantially complete pore plugging when molded or laminated against a carpet or other decorative or functional object backed with a hot melt adhesive. Pore plugging can be exacerbated when the hot melt adhesive has a lower surface energy than the surface energy of the membrane. Meltblown webs made of polyamide (e.g., Nylon 6) or polyester (e.g., polybutylene terephthalate) are especially useful airflow resistive membrane materials, but are susceptible to plugging by molten polyolefin. The low surface energy molten polyolefin readily wets the higher surface energy polyamide or polyester membrane material, can flow into pores or other interstices in the membrane, and may fill the pores and saturate the membrane when cooled. This can undesirably reduce porosity and sound absorption performance, although it may also increase interfacial adhesion.

[0008] The above-mentioned PCT Published Application No. WO 00/2767 A1 describes a vehicle roof lining that includes a porous barrier layer said to be made of a material that prevents the migration of adhesive components. This Application states that the barrier layer's surface areas can be treated to promote wettability of adhesives coming into contact with the surface, while the barrier layer's core could repel adhesives. Such a treatment presumably would involve increasing the surface energy at the barrier's surface to promote such wettability.

[0009] The present invention provides, in one aspect, a method for laminating an adhesive layer to a semipermeable airflow resistive membrane, comprising treating the airflow resistive membrane to reduce its surface energy before laminating the adhesive layer to the membrane.

[0010] The invention also provides a method for making a sound-modifying structure comprising:

[0011] a) providing a stack of layers comprising a decorative facing layer, a thermoplastic adhesive layer, a porous membrane that has been treated to render the membrane substantially impenetrable by molten polyethylene, and a layer of fibrous material, and

[0012] b) laminating the stack of layers together under sufficient heat and pressure to form a unitary porous sound-modifying, structure.

[0013] The invention also provides a method for attenuating sound waves passing from a source area to a receiving area of a vehicle, comprising:

[0014] a) providing an acoustical laminate comprising a fibrous or open cell foam underlayment, a hot melt adhesive layer, a porous membrane that has been treated to render the membrane substantially impenetrable by molten polyethylene a hot melt adhesive layer, and a decorative layer; and

[0015] b) positioning the laminate between the source area and the receiving area such that a major face of the

[0016] The invention also provides a porous laminate comprising a discontinuous hot melt adhesive layer adhered to a semipermeable low surface energy airflow resistive porous layer whose pores are substantially impenetrable by the adhesive.

[0017] The invention also provides a porous laminate comprising a thermoplastic adhesive layer adjacent to a semipermeable fluorochemically-treated airflow resistive membrane.

[0018] The invention further provides a sound-absorbing laminate having a porous sound-absorbing spacing layer adjacent to a semipermeable airflow resistive membrane that is substantially impenetrable by molten polyethylene.

[0019] In a further embodiment, the invention provides a sound-modifying structure comprising a sound-reflecting surface spaced from a semipermeable sound modifying laminate comprising a facing layer and a porous membrane that is substantially impenetrable by molten polyethylene.

[0020] In another embodiment, the invention provides a vehicular sound-absorbing, structure comprising a decorative layer backcoated with a discontinuous hot melt adhesive layer adhered to a fluorochemically-treated nonwoven airflow resistive membrane having an airflow resistance between 50 and 5000 mks Rayls.

[0021] In yet another embodiment, the invention provides a carpet comprising fibers tufted into a backing backcoated with a discontinuous hot melt adhesive layer adhered to a fluorochemically-treated nonwoven airflow resistive membrane having an airflow resistance between 50 and 5000 mks Rayls.

[0022] In another embodiment, the invention provides an acoustical laminate comprising:

[0023] a) a fibrous or open cell foam underlayment,

[0024] b) a hot melt adhesive layer,

[0025] c) a fluorochemically-treated nonwoven airflow resistive membrane having an airflow resistance between 50 and 5000 mks Rayls,

[0026] d) a hot melt adhesive layer, and

[0027] e) a decorative layer.

BRIEF DESCRIPTION OF THE DRAWING

[0028] **FIG. 1** is a perspective view of a carpet bonded to an airflow resistive membrane and insulating mat, with the carpet and membrane being partly peeled away to better illustrate individual layers.

[0029] **FIG. 2** is an enlarged top view of the airflow resistive membrane of **FIG. 1**.

[0030] **FIG. 3** is a schematic side view of a carpet bonded to an airflow resistive membrane and insulating mat.

[0031] **FIG. 4** is a photograph comparing fluorochemically-treated and nonfluorochemically-treated membranes in automotive carpet laminates that have been pulled apart to expose the membrane-carpet interface.

DETAILED DESCRIPTION

airflow resistance between about 50 and about 5000 mks Rayls when evaluated using ASTM C522. The phrase "low surface energy" refers to a surface whose surface energy is less than about 34 dynes/cm^2. The phrase "hot melt adhesive" refers to a thermoplastic material having a melting point and adhesive strength over a range of temperatures suitable for use in assembling acoustic laminates for vehicular applications.

[0033] **FIG. 1** is a perspective view of an acoustical laminate **10**. Laminate **10** includes carpet **12** made from nylon fibers **14** tufted into nylon spunbond fabric **16** and backcoated with LDPE hot melt adhesive layer **18**. Layer **18** bonds carpet **12** to airflow resistive nylon meltblown fiber membrane **20**. Membrane **20** is shown in an enlarged top view in **FIG. 2**, and includes a porous nonwoven portion **22** interspersed with generally nonporous embossed regions **24**. Embossed regions **24** can improve the tensile strength of membrane **24**. Referring again to **FIG. 1**, membrane **20** is bonded by discontinuous LDPE hot melt adhesive layer **26** to a nonwoven insulating mat **28** whose thickness provides a space S between carpet **12** and sound-reflecting surface **30**. Mat **28** is bonded to surface **30** via a suitable adhesive layer **29**. Mat **28** preferably is compressible and lightweight but sufficiently resilient so that mat **28** will move back into place if a force is applied to and then removed from carpet **12**. As shown in **FIG. 1**, carpet **12**, membrane **20** and mat **28** have been partly peeled away from surface **30** to better illustrate the various layers in acoustical laminate **10**.

[0034] A variety of airflow resistive membranes can be used in the invention. The membrane is semipermeable and thus as indicated above has an acoustical airflow resistance between about 50 and about 5000 mks Rayls. Preferred membranes have an acoustical airflow resistance of at least about 200 mks Rayls. Preferred membranes also have an acoustical airflow resistance less than about 3300 mks Rayls. More preferably, the membrane has an acoustical airflow resistance of at least about 600 mks Rayls. Most preferably, the membrane also has an acoustical airflow resistance less than about 1100 mks Rayls. The airflow resistive membrane is treated so that it has a low surface energy, viz, less than that of the hot melt adhesive, and preferably less than about 34 dynes/cm^2, more preferably less than about 30 dynes/cm^2, and most preferably less than about 28 dynes/cm^2. Preferably the airflow resistive membrane has an elongation to break sufficient to enable the membrane to survive deep cavity molding (e.g., at least about 20%), and a thermal resistance sufficient to withstand the rigors of high temperature molding processes (e.g., at least about 210° C.). Lightweight meltblown nonwoven membranes having basis weights less than 300 g/m^2 are especially preferred, more preferably less than about 100 g/m^2 and most preferably less than about 70 g/m^2. Stiff or flexible membranes can be employed, with flexible membranes being especially preferred for carpet applications. For example, the membrane can have a bending stiffness B as low as 0.005 Nm or less when measured according to ASTM D1388 using Option A. The selection and processing of suitable membrane materials will be familiar to those skilled in the art. Preferred membrane materials include polyamides, polyesters, polyolefins and the materials disclosed in U.S. Pat. Nos. 5,459,291, 5,824,973, 6,145,617 and 6,296,

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