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NONWOVEN FABRIC OF CRIMPED CONTINUOUS POLYETHYLENE TEREPHTHALATE FIBERS

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FIG. 1

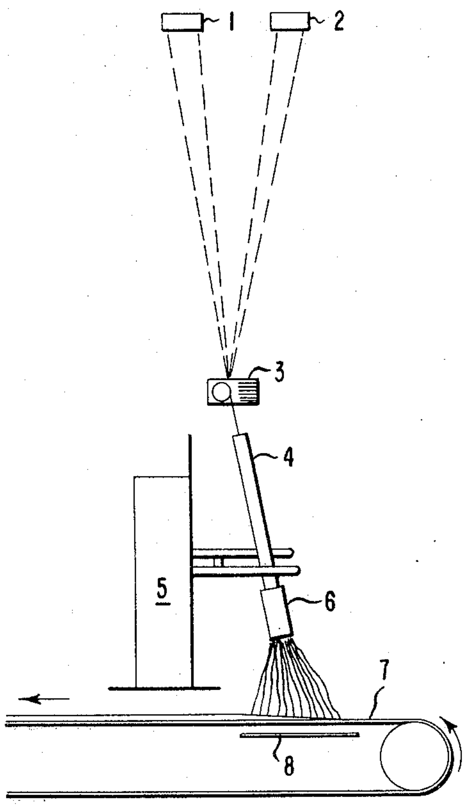


FIG. 2

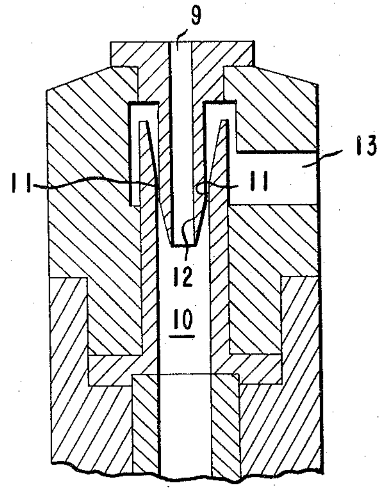
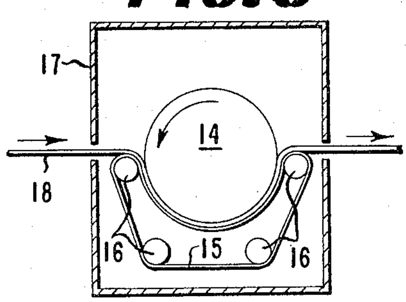


FIG. 3



INVENTOR

WILLIAM GEORGE VOSBURGH, SR.

BY Sol Schwartz

ATTORNEY

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NONWOVEN FABRIC OF CRIMPED CONTINUOUS POLYETHYLENE TEREPHTHALATE FIBERS

William George Vosburgh, Sr., West Chester, Pa., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

Nonwoven fabrics of crimped continuous synthetic organic filaments having (1) between 10 and 25% by weight of a specified synthetic organic binder distributed through the fabric and (2) at least 1500 discrete self-bond areas per square inch of fabric surface with the self-bond areas covering between about 2 and 15% of the surface area of the fabric, are useful as window shade material.

Detailed description of the invention

Nonwoven fabrics are well known and products having a broad spectrum of properties are now available in the market place. In most cases, however, the combination of properties obtainable in any one product is very limited. The requirements of window shade materials are numerous and include low edge curl, high fuzz-resistance, washability, resistance to edge tear, sufficient stiffness to give good hanging characteristics and high tensile strength. Heretofore, no single nonwoven fabric has had all of these properties to a sufficient degree to qualify it for use as a window shade material. Another requirement for any nonwoven fabric to fit in the quality window shade market is that it be competitive from the cost standpoint with the woven cotton fabrics which are now used. For the new product to have the most impact on the market place, it should, however, also offer salable property advantages over competitive materials. Particularly desired properties in a window shade material are dimensional stability, ability of both coated and uncoated shade materials to accept decorative embossing, resistance to cracking and formation of pinholes, superior edge-tear resistance and resistance to degradation by sunlight.

It is an object of this invention to provide a nonwoven fabric with a combination of properties which specially adapts it for use as a window shade material.

Another object is to provide a window shade material which exhibits good dimensional stability.

A further object is a window shade material which will accept decorative embossing.

These and other objects of this invention are obtained by providing a nonwoven fabric of continuous synthetic organic fibers having at least 5 crimps per inch (2 crimps per centimeter) of unextended length, the fabric being bonded by a combination of (1) a synthetic organic binder distributed randomly throughout the fabric as granule bonds, which binder has an initial tensile modulus (Mi) of at least 5 g.p.d. and constitutes between 10 and 25% by weight of the fabric, and (2) at least 1500 discrete self-bond areas (defined below) per square inch (230 per square centimeter) of the fabric surface, said self-bond areas covering between 2 and 15% of the surface area of the fabric.

The invention will be more readily understood by reference to the drawings in which:

FIGURE 1 is a schematic representation of an apparatus assembly which can be utilized to prepare continuous-filament nonwoven webs;

FIGURE 2 shows schematically in longitudinal section the nozzle portion of an aspirating jet which may be used with the apparatus of FIGURE 1;

FIGURE 3 is schematic representation of a bonding apparatus which is suitable for use with the nonwoven fabrics produced by the apparatus in FIGURE 1.

Continuous synthetic organic fibers are used in the nonwoven fabrics of this invention. The fabrics can be made economically in a process which integrates spinning, orientation of the fibers, and laydown of the filaments in the form of a random nonwoven web which is essentially free from filament aggregates. Such a process, which involves electrostatic charging of the filaments and then permitting the filaments to separate due to the applied electrostatic charge, is described in British Patent 932,482 and illustrated schematically in FIGURE 1. This process when used to produce a nonwoven fabric of poly(hexamethylene adipamide) or other polyamide filaments can be so operated that it inherently gives fibers with the level of crimp required for the fabric to have minimum edge curl when used as a window shade material. In the case of poly(ethylene terephthalate) filaments, a heat-relaxation step according to Kitson and Reese, U.S. Patent 2,952,879 can be effected during or subsequent to the web-laydown process to provide fibers which are spontaneously elongatable. Subsequent heating of the filaments, for example, during the bonding operation, causes the fibers to elongate and form crimps.

The concept of filament crimp is well understood in the art. Crimps can be measured by direct observation using a microscope with a scaled eyepiece, or by projection. A procedure which can be utilized with the bonded nonwoven fabrics of this invention involves making a photomicrograph of the fabric surface. A magnification of about 65× will usually be suitable. An overlay of a transparent sheet material, e.g., cellophane, is then placed over the photomicrograph. Several filaments (e.g., 10) are then traced on the transparent sheet. The total length of the traced filaments is then determined with a map measure. In this measurement, the general contour of each filament is followed and the deviations from this contour are ignored. The total number of crimps in the sketched filaments is counted and then the number of crimps per inch of unextended length (c.p.i.) is calculated as follows:

$$\text{c.p.i.} = \frac{N \times M}{L}$$

where:

N=total number of crimps
M=magnification of photomicrograph
L=total length of traced filaments

In this invention a filament crimp is one in which the amplitude of the departure from the filament contour line is less than 3 times the radius of curvature of the crimp, the latter always being less than 0.5 inch (1.3 cm.).

Since, as indicated above, poly(hexamethylene adipamide) and poly(ethylene terephthalate) filaments can be readily formed into a web with crimped fibers, and moreover, because these synthetic fibers yield nonwoven fabrics which can be readily given a decorative embossing pattern, they are preferred for use in this invention. The most preferred species is poly(ethylene terephthalate) particularly because of its resistance to degradation from sunlight. Other continuous synthetic filaments which can be formed into nonwoven webs having crimped fibers can also be used, however; and this invention is not limited to either the specific polymers above or to products made by the above-described web-laydown process. For example, crimp in continuous filaments can also be obtained by the use of two-component fibers as disclosed in Breen, U.S. Patent 2,931,091; and such side-by-side spun fibers as poly(ethylene terephthalate)/poly(propylene terephthalate) and poly(ethylene terephthalate)/poly(hexamethylene adipamide) can be used in the nonwoven fabrics of this invention. Crimped filaments can also be prepared by the process of Kilian U.S. Patent 3,118,012.

A convenient and effective way to distribute the binder uniformly throughout the nonwoven fabrics is by cospinning it with the matrix fiber of the fabric. In order to be readily melt-spinnable, the initial tensile modulus of the binder should be 5 g.p.d. or higher. With this limitation on the modulus of the binder, it is necessary, in order to avoid excessive stiffness in the nonwoven fabric and the development of a papery feel and rattle, not to use more than about 25% binder in the fabric. The minimum level of binder is 10%, which is the amount necessary to obtain the strength required in window shade materials particularly when the fabric is used in the uncoated form.

The nonpapery character required and exhibited in the fabrics of this invention and referred to hereinabove is evidence by the lack of, or low level of noise generation in the frequency range of 2,000 cycles per second and above when the fabric is flexed or scrubbed against itself at a constant moderate speed. The level and frequency of sound developed under such conditions can be measured with a sound level meter. Nonpapery character is also demonstrated by the ability of a fabric to conform to a curved, three-dimensional surface such as a sphere when stretched thereover, without the formation of sharp bends and breaks. It is characteristic of all stiff papers that, when they are forced to conform to a curved surface, a bend in one portion will intersect a bend in another portion with the occurrence of sharp breaks, abrupt changes in slope and sharp edges.

Another structural requirement in the nonwoven fabrics of this invention is the presence of at least 1500 discrete self-bond areas per square inch (230 per square centimeter) of the fabric surface. These self-bond areas cover between 2 and 15% of the total surface area of the fabric. If the number and area covered are below these limits, the fabric is deficient from the standpoints of both fuzz- and scrub-resistance. If the self-bond areas are not discrete or if an excessive area of the fabric is covered, the fabric becomes paperlike and is deficient as a window shade material. The upper limit on the number of discrete self-bond areas is determined not by property considerations but by mechanical limitations of the apparatus used to form the self-bond areas.

The self-bond areas can be formed by passing the nonwoven fabric between heated embossing rolls under pressure. Under these conditions the fibers in sections of fabric compressed between raised portions of the rolls are consolidated as discrete columns extending through the thickness of the fabric in a direction generally perpendicular to the plane of the fabric. The columns, which are arranged in a predetermined pattern, comprise matrix filaments that are adhered to each other and may additionally contain binder particles of the type randomly dispersed through the remainder of the bonded fabric of the invention. The terminals of the columns at the faces of the fabric constitute the self-bond areas.

The temperature and pressure required to produce self-bond areas through use of embossing rolls will depend on the nature of the matrix fibers in the nonwoven fabric. For instance, with fibers of poly(ethylene terephthalate) a pressure of 50 p.s.i. (3.5 kg./cm.^{2}) and a temperature of 150° C. or greater are suitable. The embossing rolls which are used may have matching surface patterns with land areas corresponding to the desired number and size of the self-bond areas. It is, however, difficult with paired rolls of this type to obtain the exact and complete registry which is required to form distinct self-bond areas. It is especially difficult because of the large number and small size of the self-bond areas. Thus the land areas on the embossing rolls must number at least 1500 per square inch (230 per square centimeter) and will have a size of

0.0001 square inch (0.00065 sq. cm.) or less. While it is possible to use the foregoing type of embossing rolls, it is preferred to use grooved rolls, one roll having parallel grooves running circumferentially around the roll and the other having parallel grooves running axially along the surface of the roll. As the fabric passes between these two rolls, it receives the maximum pressure between the rolls only at the locations where the land areas between the grooves on the two rolls cross, thus only at these locations will self-bond areas be formed. Typical rolls for use in making the non-woven fabrics of this invention will have 48 grooves per inch (19 per centimeter) with the lands between grooves being 0.004 inch (0.10 cm.) wide. Use of two such rolls gives 2,304 self-bond areas per square inch (360 per square centimeter) and the self-bond areas cover about 4% of the surface of the fabric.

The filament denier of the matrix fibers of the nonwoven fabric affects the maximum opacity which can be obtained by complete and random separation of the individual filaments in the fabric. Since opacity increases as filament denier decreases, it is generally preferred that the filaments in the nonwoven fabric have a denier of 9 or less. The binder fibers are normally spun at about the same denier as the matrix fibers to aid in obtaining uniform distribution throughout the nonwoven fabric. Opacity and covering power of the fabrics of this invention are also improved by the use of trilobal cross section fibers.

As indicated previously, the binders used in this invention are high-modulus materials. The binder should be chosen so that its melting point is at least 10° C., and preferably at least 25° C., below the melting point of the matrix fiber. Preferred binders for use with poly(hexamethylene adipamide) include polycaproamide or copolymers thereof with poly(hexamethylene adipamide). Preferred binders for use with poly(ethylene terephthalate) include poly(ethylene terephthalate)/poly(ethylene isophthalate), poly(ethylene terephthalate)/poly(ethylene sebacate), and similar copolyesters. The heating operation in which the binder fibers are activated to form the granule bonds is usually carried out after the embossing operation which forms the self-bond areas. The temperature used is, of course, dependent on the nature of the binder. Typical temperatures used when an 80/20 copolymer of poly(ethylene terephthalate)/poly(ethylene isophthalate) is used as binder are in the range of 190 to 230° C. Higher temperatures favor improved fuzz resistance but reduce tear strength.

The nonwoven fabrics of this invention can be used as both coated and uncoated window shade materials. A substrate having a fabric weight of about 3 oz./yd.^{2} is suitable for vinyl-coated translucent shade cloth and offers the advantage over woven cottons that it does not have to be filled before top-coating. This reduces the number of coating passes required from 4–6 for cotton to 1–2 for the fabrics of this invention. The coated product also has greater flex resistance than cotton shade cloth.

Both coated and uncoated window shade materials of this invention are superior to cotton in edge durability, that is, in resistance to tearing and ravelling. Because of the thermoplastic nature of the synthetic organic filaments, both products are readily embossed with deep decorative patterns. Translucent shades prepared with the fabrics of this invention are apparently unique in that they are the only shades known which have a look-through textured appearance as well as good durability. Translucent cotton shade cloth cannot be embossed at all and opaque cotton shade cloth can only be embossed with shallow patterns and only when coated with a thick, and therefore, expensive coating. Inexpensive paper and vinyl film translucent shades are embossed but they are inferior to the fabrics of this invention in tear strength and dimensional stability.

The window shade materials of this invention also have excellent washability as evidenced by resistance to fuzzing when scrubbed with water and a detergent, exhibit the low edge curl required for good appearance when the shade is in the "down" position, and are resistant to cracking, formation of pinholes and fuzzing during use.

The invention will be further illustrated by the following examples. The procedures used to evaluate the nonwoven fabrics in the examples for fuzz resistance, edge curl, flex resistance, tear resistance and pinholes are described below.

Fuzz resistance.—A rubber-covered box (4 in. x 4 in.) (10 cm. x 10 cm.) weighing 1000, 1500 or 2000 grams is moved back and forth once across the fabric. The degree of fuzz is then visually inspected and rated 1 to 5 with 1 representing severe fuzzing and 5, no fuzzing. Both sides of the fabric are tested and the fuzz ratings are averaged.

Edge curl.—Window shades (3 ft. x 6 ft.) (0.914 m. x 1.83 m.) are rolled up overnight, then pulled down 3 feet (0.914 m.) and allowed to hang at least 30 minutes. The amount that the edge curls away and stands out from the plane of the shade halfway down the unrolled portion is then measured as follows: a light-weight but rigid 6-inch (15 cm.) ruler is attached to the back of shade at 4 to 5 inches (10 to 13 cm.) from the edge, with the long dimension of the rule being perpendicular to the edge of the shade. A convenient way to attach the ruler is by means of two-sided, pressure-sensitive tape placed near one end of the ruler. The perpendicular distance from the ruler (the plane of the shade) to the edge of the shade is then measured. The measurement is repeated at the other edge of the shade and the two values are averaged.

Flex resistance.—A mechanical scrub test as described in Industrial and Engineering Chemistry 27, 1400–1403 (1935) is used. In this test, a 2 in. x 4 in. (5.1 cm. x 10.2 cm.) sample is cut with the long dimension in the machine direction of the fabric, and is then clamped between a pair of jaws which move in opposite but parallel directions. The sample is inserted with the jaws placed directly opposite each other. At the extremity of movement of the jaws, corresponding to a distance of 0.75 in. (1.9 cm.) from the position where the jaws are directly facing each other, a sample elongation of 23% is achieved along a diagonal. In operation, the jaws of the scrub machine move back and forth past each other at a rate of 178 cycles/min., a cycle being movement of the jaws to both extreme positions and return to the starting position. A hinged rider bearing a weight rests on top of the sample as it is scrubbed. Samples are inspected for breaks, flaking and pinholes after varying numbers of flex cycles.

Tear ressitance.—The Elmendorf tear test (ASTM D 1424–59) is used. Tear strength in both the machine direction (MD) and cross-machine direction (XD) is determined. The latter is the more important in window shade materials.

Pinholes.—The window shade material is illuminated from behind with a 100 watt light bulb and is examined for pinholes from a distance of 3 feet (0.914 m.).

Noise generation.—Window shades (3 ft. x 6 ft.) (0.914 m. x 1.83 m.) are pulled down 3 feet (0.914 m.) and then rattled by shaking the bottom of the shade back and forth at a rate of about 180 cycles per minute. The noise generated is picked up by a sound level meter (General Radio Co., Type 1551B) which is connected to a sound and vibration analyzer (General Radio Type 1554A). The analyzer is set at the frequency range desired, and the level of sound in decibels generated at that frequency is read directly from the analyzer.

The nonwoven fabrics of this invention have the following combination of properties which especially adapts them for use as uncoated and coated window shade materials: An average tear strength of at least 200 g./oz./yd.^{2} (5.9 g./g./m.^{2}) an edge curl of 0.5 inch (1.3 cm.) or or less, and a minimum fuzz rating of $\frac{3}{2000}$ g. for substrates to be used as uncoated window shade materials, and $\frac{2}{1000}$ g. for substrates to be coated. In addition, the fabrics exhibit a low level of sound generation when flexed, good washability and superior flex resistance.

EXAMPLE 1

This example illustrates a method for the preparation of bonded nonwoven products of this invention which are useful as window shade materials. The apparatus assembly used in this example is shown schematically in FIGURE 1, wherein the filaments pass directly, as indicated by the dotted lines, from the spinnerets **1** and **2** to the target bar of corona discharge device **3**. Poly(ethylene terephthalate) (27 relative viscosity) is spun through spinneret **1** having 17 holes (0.009 in. diameter x 0.012 in. long) (0.023 cm. x 0.031 cm.) at a total throughput of 20.0 g./min. while an 80/20 copolymer of poly(ethylene terephthalate)/polyethylene isophthalate) (29 relative viscosity) is spun through spinneret **2** having 10 holes (0.009 in. diameter x 0.012 in. long) (0.023 cm. x 0.031 cm.) at a total throughput of 9.0 g./min. The spinneret temperatures are 285° C. and 258° C., respectively. Three of the copolyester filaments are used and the other 7 are spun to waste. The filaments are quenched in the ambient air at 27° C. before entrance into a draw jet **4** located about 65 inches (165 cm.) below the spinnerets. The 20 filaments from the two spinnerets are combined into a filament bundle at the target bar of corona discharge device **3** which is located about 6 inches (15 cm.) from the jet inlet.

The corona discharge device consists of a 4-point electrode positioned 0.63 inch (1.6 cm.) from a grounded, 1.25-inch (3.2 cm.) diameter, chrome-plated target bar rotating at 10 r.p.m. A negative voltage of 35 kv. (200 microamperes) is applied to the corona points. The filament bundle passes between the target bar and electrode and makes light contact with the target bar.

The yarn is drawn and forwarded toward the laydown belt **7** by aspirating jet **4** having a nozzle section as shown in FIGURE 2 and having the following dimensions:

Over-all jet length	24 in. (61 cm.).
Filament inlet diameter (9)	0.062 in. (0.158 cm.).
Filament passageway diameter (10)	0.100 in. (0.254 cm.).
Metering annulus (11):	
Inner diameter	0.0750 in. (0.190 cm.).
Outer diameter	0.0930 in. (0.236 cm.).
Length	0.020 in. (0.051 cm.).
Filament inlet length (12)	0.55 in. (1.40 cm.).

Air at a pressure of 49.5 p.s.i.g. (3.5 kg./cm.^{2}) is supplied to the jet through inlet **13**. The jet under these conditions applies about 13.5 grams total tension to the filament bundle. Attached to the bottom of the jet is a relaxing chamber **6** (9.5 in. long; 0.375 in. inside diameter) (24 cm.; 0.95 cm.) which is provided with an annular nozzle for supplying additional air to the relaxing chamber. Hot air (about 300° C.) is supplied to the relaxing chamber at a rate of 4.5 standard cu. ft./min. (127 liters/min.), or sufficient to give an air temperature of 225° C. at the exit of the relaxing chamber. This raises the filament temperature to an estimated 125° C. at the exit. Filaments spun without hot air in the relaxing chamber will have a linear shrinkage of 25% when treated in 75° C. water. Filaments processed with hot air in the relaxing chamber will show a linear shrinkage of less than 2% in 75° C. water, and will show spontaneous elongation (S.E.) as exhibited by a linear elongation of about 15% when heated relaxed in dry air at 200° C.

The jet-relaxing chamber unit is positioned at an angle of 82° with the plane of laydown belt and is moved by a traversing mechanism **5** so that it generates a portion of the surface of a cone, while the output from the relaxing chamber forms an arc on the laydown belt **7** having a chord length of 36 inches (91 cm.). The traverse speed is 20 passes (10 cycles) per minute. The distance from the exit of the relaxing chamber to the laydown belt is approximately 30 inches (76 cm.). The laydown belt moves at a speed of 7.8 inches (20 cm.) per minute. Plate

8 located beneath the belt is charged at +35 kv. to pin the filaments to the laydown belt.

A typical unbonded web prepared by this procedure will have the following properties: unit weight 3.5 oz./yd.^{2} (119 g./m.^{2}); homopolymer, 3.8 d.p.f.; copolymer binder fiber, 3.7 d.p.f.; amount of copolymer binder fiber, 12% by weight.

A web prepared by the above process is next embossed in a hot-calendering operation. Embossing is carried out with a conventional calender stack equipped with two steel rolls each 16 in. (41 cm.) in diameter. The top roll of the pair is patterned with lands and grooves machined parallel to the axis of the roll, at a frequency of 48 lands/in. (approximately 19/cm.). Each land is .003 to .004 in. (0.0076–0.0102 cm.) wide. The bottom roll has lands and grooves of the same size and frequency set perpendicular to the axis of the rolls. Web embossing is carried out at 4 yd./min. (3.7 m./min.) with both rolls heated to a temperature of 180° C., and under a pressure of 50 lbs./linear in. (9 kg./cm.). The heating and compression of the web in the areas that the lands of the calender rolls cross results in self-bond sections. The self-bond areas so formed cover about 3% of the surface of the web.

Bonding of the embossed web at a temperature sufficient to melt the binder fibers throughout the web is accomplished by restraining the web between a belt and a metal drum while heating the web to the desired temperature. The bonding unit is shown schematically in FIGURE 3. This consists of a 20-in. (51 cm.) diameter steel drum **14** wrapped tightly with a woven wire screen having 30 x 28 wires per inch (11 x 12 per cm.). This drum is motor-driven and has provision for internal oil heating. An endless flexible wire screen **15** is held in contact with the drum by guiding over suitable rollers **16**, to provide a drum-to-belt contact 31.4 in. (80 cm.), and tensioned suffciently to provide a unit pressure of about 0.4–0.5 lb./sq. in. (0.03–0.04 kg./cm.^{2}) against the drum. The entire assembly is enclosed in an insulated box **17** which can be heated with hot air and is provided with entrance and exit slots for the web **18**. The embossed web from above is bonded by a passing through this unit at 4 yd./min. (3.7 m./min.) with both the drum and air temperature inside the box being held at 200° C. Residence time in the box is about 28 seconds and residence time under restraint is about 13 seconds.

Typical properties of a sheet prepared by the above described process are as follows:

Strip tensile strength—6 lb./in.//oz. yd.^{2} (32 g./cm.//g.m.^{2})
Tongue tear—1.3 lb.//oz./yd.^{2} (17 g.//g./m.^{2})
Elmendorf tear—260–400 g.//oz./yd.^{2} (7.7–11.8 g.//g./m.^{2})

The nonwoven webs used in the Examples 2–9 are prepared by web laydown procedures either the same or closely related to that described in Example 1. The embossing and bonding conditions used in these remaining examples are given in each instance. For convenience, poly(ethylene terephthalate) and the copolyester of poly(ethylene terephthalate)/poly(ethylene isophthalate) will hereinafter be referred to as 2GT and *2GT/2GI*, respectively.

EXAMPLE 2

Continuous-filament nonwoven webs A and B (1.8 and 2.2 oz./yd.^{2}) (61 and 75 g./m.^{2}) containing 85% of round, 3.2 d.p.f., 6.6% S.E. fibers of 2GT and 15% of an 80/20 *2GT/2GI* copolyester as binder are embossed on a 66 in. (170 cm.) calender using rolls with 48 grooves per inch (19 per cm.) as in Example 1. The temperature and speed of embossing are 170° C. and 4 yd./min. (3.7 m./min.). The webs are then bonded on a rotary bonder with hot air being passed through the web. The temperature and speed of bonding are 200° C. and 5 yd./min. (4.6 m./min.). These nonwoven fabrics have 0 to 0.25 in. (0 to 0.6 cm.) edge curl compared with 1 to 1.25 in. (2.5 to 3.2 cm.) for nonwoven fabric having uncrimped fibers (no SE) but otherwise similarly prepared, embossed and bonded.

The above substrates are then coated with a typical vinyl coating formulation such as shown below.

Ingredients:	Parts by weight
Copolymer of vinyl chloride/vinyl acetate	15
Plasticizer (e.g., tricresyl phosphate)	3
Methyl isobutyl ketone	30
Toluene	30
Propylene oxide	0.2
TiO_2 or TiO_2/Sb_2O_3 (9/1)	10

The coating is applied in two passes (one per side) to a total coating weight of 1.7 oz./yd.^{2} (58 g./m.^{2}) and is then calendered to smooth the surfaces. Window shades fabricated from these materials are compared with vinyl-coated cotton in Table I.

TABLE I

Type	Uncoated Weight		Coating	Coated Weight		Edge Curl		Tear Strength (g.)	
	Oz./yd.^{2}	G./m.^{2}	Passes	Oz./yd.^{2}	G./m.^{2}	In.	Cm.	MD	XD
Nonwoven fabric	1.8	61	2	3.5	119	0.13	0.32	260	375
Do	2.2	75	2	3.9	132	0.25	0.64	360	455
Woven cotton	2.6	88	4	5.1	173	0.94	2.4	350	255

The data in Table I show that the nonwoven fabrics of this invention are superior to woven cotton as substrates for window shades in edge curl and also in tear strength, especially in the important cross-machine (filling) direction.

EXAMPLE 3

A nonwoven fabric with a unit weight of 3 oz./yd.^{2} (102 g./m.^{2}) and containing (1) trilobal 2GT fibers (2.4 d.p.f.; MR 2.0) (modification ratio, MR, of trilobal fibers is the ratio of the radius of the circumscribed circle to the radius of the inscribed circle) having 4.8% SE and (2) 15% copolyester binded 80/20 (*2GT/2GI*) is embossed and bonded by the procedures described in Example 2. The fuzz-resistance rating of this material is 3 at 1000 g. and the edge curl is 0.5 in. (1.3 cm.). When this fabric is coated by dipping in a vinyl solution, removing the excess solution by passing the coated material between non-rotating round bars, and then air-drying at room temperature, a material free from pinholes is obtained with a dry coating weight of only 1 oz./yd.^{2} (34 g./m.^{2}).

EXAMPLE 4

This example demonstrates the effect of crimp level (percent SE) and embossing and bonding conditions on fuzz resistance of the nonwoven fabrics of this invention. The webs weigh 3 oz./yd.^{2} (102 g./m.^{2}) and contain trilobal 2GT fibers (3.1–3.4 d.p.f.; MR 3.2) and 15% cospun binder fibers 80/20 (*2GT/2GI*). The webs are embossed with calender rolls having 48 lines/inch (19/cm.) as in Example 1, and then bonded with a flow-through bonder as in Example 2. The results are summarized in Table II below. All of the materials listed in the table exhibit an edge curl of 0 to 0.25 inch (0 to 0.64 cm.). Although tear strength decreases with increasing embossing and bonding temperatures, all of the materials have a tear strength of greater than 700 g. in the cross-machine direction.

TABLE II

Emboss Temp. (° C.)	Bond Temp. (° C.)	Percent SE	Crimp level per—		Fuzz Rating/ load (g.)
			Inch	Cm.	
170	190	5	---------	---------	1/1,000
		10	---------	---------	3/1,500
		15	---------	---------	3/1,500
170	200	5	6.4	2.5	2/1,000
		10	14.7	5.8	3/1,500
		15	24	9.5	4/2,000
170	210	5	---------	---------	3/1,000
		10	---------	---------	3/1,500
		15	---------	---------	5/2,000
185	210	5	7.5	3.0	2/1,500
		10	9.6	3.8	4.5/2,000
		15	21	8.3	4.5/2,000
185	220	5	---------	---------	1/2,000
		10	---------	---------	4.5/2,000
		15	---------	---------	4.5/2,000
185	230	5	---------	---------	2/2,000
		10	---------	---------	4.5/2,000
		15	---------	---------	4.5/2,000

The data in Table II show that fuzz resistance generally is raised by increasing the percent of SE, the embossing temperature or the bonding temperature. Preferred fabrics, for example, the material with 15% SE embossed at 185° C. and bonded at 210° C., are observed to have a crimp level of greater than 20 per inch (7.9 per cm.) and exhibit zero edge curl.

An 8 in. x 18 in. (20 cm. x 46 cm.) sample of the fabric with 15% SE, embossed at 185° C. and bonded at 210° C., is coated with a commercial vinyl-coating solution by the procedure in Example 3. Drying at 135° C. for 3 minutes and then at 175° C. for one minute produces a product with the best flex resistance. This product, Sample A, is superior to a cotton shade cloth material coated with the same formulation in both tear strength and flex resistance. The results are summarized below:

Substrate Material	Flex Resistance, Cycles to pinhole	Tear Strength (g.)	
		MD	XD
Sample A	2,000	480	830
Cotton	75	285	350

EXAMPLE 5

This example demonstrates further the effect of fiber crimp level (percent SE) and bonding temperature on fuzz resistance, edge curl and tear strength. Light-weight nonwoven fabrics (1.8 oz./yd.²) (61 g./m.²) are prepared with (1) round 2GT fibers (4 d.p.f.) having varying levels of SE and (2) 12% binder fibers 80/20 (*2GT/2GI*).The fabrics are embossed at 170° C. with calender rolls having 58 lines/inch (19/cm.) as in Example 1 and then bonded with a flow-through bonder as in Example 2. The results are summarized in Table III.

The results in Table III indicate that increasing the SE level increases fuzz resistance, decreases edge curl, but, in general, does not have a significant effect on tear strength. Fuzz resistance increases and the tear strength decreases as the bonding temperature is raised.

Application of a vinyl coating to a sample of the lightweight nonwoven fabric in Table III (having an SE level of 15% and bonded at 210° C.) by the procedure described in Example 4 provides a material, Sample B, which is superior to vinyl-coated cotton in both flex resistance and tear strength and which is decidedly superior to low-cost, machine-oil grade cotton shade cloth. The results are summarized below:

Shade Cloth	Flex Resistance Cycles to pinhole	Tear Strength (g.) XD
Sample B	200	395
Vinyl-coated cotton	75	350
Machine-oil cotton	1	325

Although the tear strength of the nonwoven fabric of this invention decreases when a vinyl coating is applied (from 955 to 395 g.), the coated product is superior to a similarly coated cotton substrate.

EXAMPLE 6

Two webs for use as uncoated shade cloth (4.2 and 5.1 oz./yd.²) (142 g. and 173 g./m.²) are prepared with trilobal (MR 2.0) 2GT fibers (14% SE; 3–3.3 d.p.f.) and 15% copolyester binder fibers 80/20 (*2GT/2GI*). The webs are embossed at 185° C. with 48 x 48 l.p.i. (lines per inch) (19 x 19 lines per cm.) rolls and then bonded at 200° C. with a rotary flow-through bonder as in Example 2. The properties of these bonded webs are as follows:

Bonded Web	Weight (oz./yd.²)	Fuzz Rating at 2,000 g.	Tear Strength (g.)	
			MD	XD
A	4.2	4	700	1,272
B	5.1	4.5	1,210	1,660

These materials are washable using a solution of a typical laundry detergent and either a sponge or cloth. The materials have the advantage of being embossable due to their inherent thermoplastic nature. Thus they are readily embossed with deep decorative patterns using commercial fabric embossing equipment having heated rolls.

EXAMPLE 7

A web weighing 5 oz./yd.² (170 g./m.²) is prepared with trilobal 2GT fibers (3.7 d.p.f.; MR 3.2; 15% SE) and 15% copolyester binder fibers 80/20 (*2GT/2GI*). It is embossed with 48 x 48 l.p.i. (19 x 19 lines per cm.) rolls at 185° C. and then bonded with a rotary, flow-through bonder at 200° C. This material has a fuzz rating of 4.5 at 2000 g., tear strength of 870 (MD) 1490 (XD), low edge curl (<0.5 in.; 1.3 cm.) low light transmission and good visual uniformity. It does not show any pinholes when viewed with a light behind it. This is a preferred window shade material.

TABLE III

Bond Temp. (° C.)	Percent SE	Crimp Level per—		Fuzz Rating at 2,000 g.	Tear Strength (g.)		Edge Curl	
		Inch	Cm.		MD	XD	In.	Cm.
190	5	---------	---------	1	1,380	1,675	0.4	1.0
	10	---------	---------	4	1,045	1,470	0.2	0.5
	15	---------	---------	5	1,035	1,660	0	0
200	5	---------	---------	4.5	605	980	0.4	1.0
	10	---------	---------	4	955	1,215	0	0
	15	---------	---------	5	590	1,210	0	0
210	5	21	8.3	5	895	1,345	0	0
	10	29	11.4	5	565	935	0	0
	15	33	13.0	5	560	935	0	0

EXAMPLE 8

This example demonstrates the effect of number of self-bond areas on fuzz resistance of the nonwoven fabrics of this invention. A web (3.3 oz./yd.^{2}; 112 g./m.^{2}) containing round 2GT fibers (11.4% SE) and 10% copolyester binder fibers 80/20 (*2GT/2GI*) is embossed and bonded in a single operation by being held within a heated chamber between lined plates (lines in top plate perpendicular to lines in bottom plate) at 210° C. and a plate pressure 78 lb./in.^{2} (5.5 kg./cm.^{2}) for 1 minute. A series of plates with different number of lines is used. The resulting embossed and bonded webs are evaluated for fuzz resistance with the following results:

Lined Plates				Self-bond Areas			
Lines/in.	Lines/cm.	Land Width In.	Land Width Cm.	No./in.^{2}	No./cm.^{2}	Percent of Fabric covered	Fuzz Rating at 2,000 g.
24	9.45	0.00834	0.0212	576	89	4.0	2.5
30	11.80	0.00500	0.0127	900	139	2.25	2.6
44	17.3	0.00500	0.0127	1,936	300	4.84	3.1

These results indicate that fuzz resistance increases as the number of self-bond areas increases. At more than 1500 self-bond areas per square inch (230 per square centimeter), the nonwoven fabric has a fuzz resistance above the desired 3 level. This minimum number of self-bond areas is also preferred in order to obtain good coating uniformity as judged by translucent appearance, and to obtain adequate stiffness for good hanging characteristics.

EXAMPLE 9

A nonwoven fabric with a unit weight of 3 oz./yd.^{2} (102 g./m.^{2}) and containing (1) trilobal 2GT fibers (3 d.p.f.; MR 2) having 13.6% SE and (2) 15% copolyester binder 80/20 (*2GT/2GI*) is embossed at 185° C. and 5 yd./min. (4.6 m./min.) and then bonded at 200° C. and 5 yd./min. (4.6 m./min.) with the embossing and bonding apparatus described in Example 1. The fabric is then coated with a typical vinyl latex coating formulation, such as shown below, to make a translucent shade cloth material.

Ingredients:	Parts by weight (solids basis)
Vinyl chloride/vinyl acetate copolymer latex	100
Plasticizer:	
Dioctyl phthalate	20
Dioctyl adipate	15
Polymeric plasticizer	15
TiO_2	30
Whiting	15
Aqueous thickener solution (as required for proper flow properties).	

The coated fabric is compared with a translucent vinyl-coated cotton shade cloth in the following table:

	Coated Fabric of this invention	Woven Cotton Shade Cloth
Coating passes, number	2	4
Total weight:		
Oz./yd.^{2}	5.6	5.1
G./m.^{2}	190	173
Tear Strength, g. (XD)	550	215
Flex resistance, cycles to pinhole	100	15
Edge Curl, inch	0.5	1
Edge Curl, cm	1.3	2.5
Washability	(1)	(1)

[1] Scrubbable.

The coated fabric is next compared with a commercial, vinyl-coated, cotton window shade and a commercial, uncoated paper window shade for noise generation. The results are summarized below:

Sound Frequency (cycles/sec.)	Sound Intensity (decibels) Commercial vinyl-coated cotton	Commercial uncoated paper	Vinyl-coated fabric of this invention
250	15	15	11
500	34	30	23
1,000	44	44	27
3,150	38	48	18
5,000	33	47	17
10,000	20	38	5
16,000	9	34	0
25,000	5	21	0

These results illustrate the nonpapery character of the nonwoven fabrics of this invention, as evidenced by the relatively low level of noise generation, particularly at the higher frequency levels, when the material is flexed. It is significant that the nonwoven fabric of this invention evaluated above not only is far superior to a typical paper material in noise generation, but is actually superior in this respect to a woven cotton material, which type of material is considered to have acceptable nonpapery character.

Calendering and/or embossing of nonwoven webs containing crimped fibers or fibers with residual spontaneous elongatability tend to produce cockles, longitudinal wrinkles or puckers when carried out between heated rolls. This effect can be eliminated by preheating the web to calendering or embossing temperature and then passing it between cold rolls. Prevention of cockles is important not only in uncoated window shades made with the fabrics of this invention, but is also desirable in substrates which are to be coated in order to obtain a uniform coating. With both types of fabrics, the ability to be post-embossed with deep decorative patterns is an important styling advantage obtained through the use of the fabrics of this invention; but it is necessary, in order to obtain the full benefit of this advantage, that the embossing operation can be carried out without formation of cockles. The preheating-cold roll technique ensures that the embossing can be effected to obtain this desired result. Example 10 below illustrates this technique as applied to a nonwoven fabric of this invention.

EXAMPLE 10

A nonwoven fabric of this invention, prepared in accordance with Example 1 and having a unit weight of 5 oz./yd.^{2} (170 g./m.^{2}), is preheated by passing over an infrared heating panel (12 in. x 50 in.) (30 cm. x 127 cm.) at 200° C. The fabric is then embossed on a cold 14 in. (36 cm.) calender between a smooth elastomer-covered roll and a steel roll engraved with a burlap pattern. The calender nip is about 2 inches (5 cm.) from the heating panel. A distinct burlap pattern is obtained without cockling with a calender pressure of 476 pounds/linear inch (85 kg./cm.) and a speed of 3 to 5 yards/min. (2.7 to 4.6 meters/min.). Post-embossing with hot rolls (100° C. or higher) will often produce cockling. By cold-calendering with a smooth steel roll in place of the patterned roll the side of the fabric contacting the steel roll is given a smooth surface which is especially suitable for coating. With this arrangement, two passes are required to smooth both sides. Alternatively, two smooth steel rolls can be used to smooth both sides of the fabric in a single pass. Smooth calendering with hot rolls (75° C. or higher) will often produce cockles.

Cockles and wrinkles are sometimes observed after embossing the nonwoven fabrics to produce the discrete self-bond areas required in the products of this invention.

These wrinkles can be avoided by developing some of the potential spontaneous elongation in the nonwoven web prior to the embossing step. A convenient way to accomplish this is to consolidate the nonwoven web between heated rolls at 100–175° C. prior to the embossing operation.

What is claimed is:

1. A nonwoven fabric suitable for use as a window shade material comprising continuous poly(ethylene terephthalate) fibers having at least 5 crimps per inch of unextended length, said fabric having randomly distributed therethrough as granule bonds, a synthetic organic binder which binder has an initial tensile modulus of at least 5 grams per denier and constitutes between about 10 and

25% by weight of the fabric and at least 1500 discrete self-bond areas per square inch of the fabric surface, said self-bond areas covering between about 2 and 15% of the surface area of the fabric.

2. The fabric of claim 1 wherein the synthetic fibers have at least 20 crimps per inch of unextended length.

3. The fabric of claim 1 wherein the synthetic organic binder is a copolymer of poly(ethylene terephthalate) and poly(ethylene isophthalate).

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MORRIS SUSSMAN, *Primary Examiner.*