FLEXIBLE NONWOVEN SHEETS FOR USE AGAINST SPLASHING LIQUIDS

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ABSTRACT

This invention relates to flash-spun linear polyolefin fibrous nonwoven sheets, the surfaces of which have been treated to provide for excellent protection against splashing liquids.

6 Claims, 2 Drawing Figures

FOREIGN PATENTS OR APPLICATIONS

1,011,888 12/1965 United Kingdom

Primary Examiner—P. E. Willis, Jr.
FIG. 1

TIME, SECONDS

% SURFACANT PICKUP

2 4 6 8 10 12 14
BACKGROUND OF THE INVENTION

The conversion of linear polyolefins such as polyethylene and polypropylene into fibrous, nonwoven sheets which are not readily permeated by water has been described in the prior art. One such product, disclosed and claimed by Steuber in U.S. Pat. No. 3,169,899, is prepared by flash-spinning the polyolefin to form continuous fibrillated strands, each comprising a three-dimensional network of film-fibrils of high surface area in the form of thin ribbons of a thickness less than 4 microns interconnected at random intervals along and across the strand. The strands are spread by means of a baffle and are then collected in multi-directional, overlapping, and intersecting arrangement on a moving belt in the form of a batt, which is then compacted and consolidated in a direction normal to its plane to an extent sufficient to produce a flexible, self-bonded, nonwoven sheet comprised of film-fibril elements having a surface area greater than 2 meter²/gm. The surfaces of the consolidated sheet are porous, and when either of the surfaces is rubbed plexifilamentary strand material is readily loosened and can then be removed in continuous lengths by pulling upon it.

After the sheet is formed it may be embossed under pressure between a resilient roll and an embossing roll, which is usually heated. Various embossing patterns may be employed, and if desired the sheet may be embossed on both sides. Embossing improves abrasion resistance, so that plexifilamentary material is no longer readily removed from a surface after it has been embossed.

Because they are relatively inexpensive, fibrous nonwoven sheets of the type described above are useful for making disposable garments, bags, dust cloths, tablecloths, drop cloths, draperies, and other textile or sheet-like materials which can be used once or only a few times and then discarded. Nonwoven sheets have been considered for use in making operating room gowns, butcher aprons, and other covering materials useful to protect against splashing liquids. As initially prepared, the nonwoven sheets are not very suitable for this purpose, since they permit passage of liquid through the sheet under slight pressure, even though the sheet is composed of hydrophobic polymer and initially is somewhat resistant to permeation by water.

The application of a waterproof coating to the nonwoven sheets prevents liquids from bleeding through the sheets. However, it has been found that even the waterproofed nonwoven sheets are not very suitable for aprons because of the tendency of liquids splashing upon the aprons to bounce off or run off the apron onto the floor or onto the shoes of the operator.

SUMMARY OF THE INVENTION

The present invention provides a linear polyolefin in the form of a flexible, nonwoven sheet comprised of film-fibril elements, said sheet being preferably embossed on at least one side; the film-fibril elements on one side of said sheet being fused together preferably in an embossed pattern of surface relief to form a continuous surface to which is adhered a continuous coating of a hydrophobic polymer effective as a liquid barrier; the other side of the sheet having areas of unfused film-fibril elements having a wetting agent adsorbed thereon. When produced in accordance with the invention and employed with the liquid barrier side of the sheet placed against the surface to be protected, the novel product provides excellent protection against splashing liquids, to a degree previously realized only with relatively heavy laminated sheet products.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fibrous nonwoven sheets useful for this invention may be prepared from any linear polyolefin, but linear (high density) polyethylene is the preferred polyolefin. Fibrous nonwoven sheets of polypropylene are also very suitable. Sheets formed from polyolefin copolymers, such as the copolymer formed from 97 weight percent ethylene and 3 weight percent octene-1, may also be employed.

The sheets employed in the invention are formed from continuous fibrillated strands of film-fibril elements of the linear polyolefin. These strands are described by Blades and White in U.S. Pat. No. 3,081,519 and referred to by them as plexifilaments. The flash-spinning process for preparing the continuous fibrillated strands involves extruding at high velocity into a low pressure zone a solution of the polyolefin under high pressure and at a temperature above the boiling point characteristic of the solvent in the low pressure zone. Steuber, in his U.S. Pat. No. 3,169,899, further describes the flash-spinning of a plurality of the continuous fibrillated strands, spreading the strands by means of a baffle, and collecting them in a multi-directional, overlapping, and intersecting arrangement in the form of a batt on a moving belt. The batt is then cold consolidated as described in said U.S. Pat. No. 3,169,899 to form a nonwoven sheet. The product comprises a coherent, flexible, nonwoven fibrous sheet of film-fibril elements having a surface area greater than 2 meter²/gm. For purposes of this invention sheets weighing preferably between about 0.75 and 4 oz./yd.² are used.

Before treating the sheet in accordance with the present invention, the cold consolidated fibrous non-woven sheet is embossed on one side by passing it to heat and pressure between a pair of rolls, one of the rolls having a heat-conductive surface of bosses in a designated configuration and the other roll having a resilient surface. The embossing process is described in more detail by Dempsey et al. in U.S. Pat. No. 3,478,141. To provide a sheet suitable for use in the present invention, the embossing step is carried out in a known manner so that the film-fibril elements on one side of the sheet are fused together in an embossed pattern of surface relief to form a continuous surface. An embossed pattern simulating a fabric surface is suitable for this side of the sheet.

The other (or second) side of the sheet may be left in its original consolidated condition. In this form the surface is porous and comprises film-fibril elements having a surface area greater than 2 meter²/gm. It is preferred that the second side of the sheet also be embossed, but under less severe conditions than the first side of the sheet. The second side of the sheet should retain a considerable degree of porous character. The embossed areas on the second side of the sheet should preferably be only lightly bonded, but in any case should be surrounded by intervening areas wherein the film-fibril elements are not fused together, so that the surface exhibits porosity. When the surface of this side
of the sheet is rubbed lightly, as with the tip of an eraser on the end of a pencil, movement of the film-fibril elements relative to one another is readily effected.

In accordance with the invention, a continuous coating of hydrophobic polymer is applied to the side of the sheet having the continuous surface comprised of film-fibril elements fused together in an embossed pattern of surface relief. At least about 0.5 oz. per square yard (dry basis) of the hydrophobic polymer should be used. A highly suitable hydrophobic polymer which may be used as the liquid barrier coating upon application to the continuous side of the fibrous nonwoven polyolefin sheet of the present invention is a copolymer of butadiene and styrene, particularly a carboxylated butadiene/styrene copolymer. This resinous material, applied as an aqueous latex and dried, provides a coating which is resistant to the passage of water even under some pressure. The sheet remains resistant to the passage of water even after mechanical working and considerable flexing of the sheet. Clay and titanium dioxide or silica may be mixed with the resinous latex to prevent tackiness of the coated sheet.

Other suitable hydrophobic polymers may be used in place of the carboxylated butadiene/styrene copolymer. A latex of polyvinyl chloride plasticized with a phosphate ester or diocyl phthalate may be employed when a stiff sheet is desired as the final product; however, mechanical working or an undue degree of flexing of the sheet should be avoided when the polyvinyl chloride coating is used, since this coating material may leak after it is mechanically worked.

A highly suitable material for use as a wetting agent to be applied to the surface of the sheet having a relatively large proportion of nonfused surface areas is an alkyl aryl polyether alcohol. A small amount of a thickener, such as a polysaccharide thickener, is desiredly added to the wetting agent to increase the viscosity of the aqueous emulsion to the desired level. Another suitable wetting agent is an ethylene oxide condensate of a fatty alcohol, and other equivalent wetting agents or surfactants may be used. To provide good adsorption, the sheet should contain a minimum of 5% by weight of the wetting agent, based on the weight of the fibrous, nonwoven sheet. Up to 25% or even more may be employed, if desired. However, about 10–15% is usually found to be optimum.

When the hydrophobic polymer and the wetting agent are applied to the fibrous nonwoven sheet in separate steps, the hydrophobic polymer should be applied first and the sheet should be subsequently dried before the wetting agent is applied to the other side. The hydrophobic polymer and the wetting agent may be applied simultaneously, but if this is done the process should be carried out in such a manner that the hydrophobic polymer can be applied and dried very quickly, before the wetting agent penetrates through the sheet to reach the more highly embossed surface upon which the hydrophobic polymer has been applied.

After both the hydrophobic polymer and the wetting agent have been applied to the fibrous nonwoven sheet, it is desirable to soften the coated sheet. The softening process described in "Product Licensing Index," No. 84, April, 1971, page 74, may be used. In this process, the coated sheet is passed through the nip of parallel rolls whose surfaces are studded with numerous closely spaced small peg-like projections. Perforation of the coated sheet should be avoided. In this process, the sheet is subjected to mechanical working to loosen and mobilize the plexifilamentary material in the interior of the sheet between the point-bonded regions imposed by the embossing step. After subjecting the sheet to this process, it is much more supple and flexible, a desired characteristic of the sheet for many end uses.

**DESCRIPTION OF TESTS**

The following tests are employed in determining the absorbency and leakage resistance of the nonwoven sheet products of the invention.

**Absorbency Test**

A sample approximately 11 inches in length of the sheet to be tested is mounted in a position inclined 15° from the vertical, with the porous side of the sheet uppermost (the side coated with wetting agent, if the sample has been given this treatment). A dilute aqueous solution of a dye is prepared, and droplets of the colored water are placed on the sheet by means of a medicine dropper, without allowing the dropper to touch the sheet. The droplets which are released on the sheet are observed to see whether they become absorbed by the sheet. If the droplets are absorbed quickly by the sheet (less than about 10 seconds), it is reported as a test result that the sheet is absorbent. If the droplets retain their identity as discreet droplets, pool together without becoming absorbed into the sheet, or move down the entire length of the sheet and drip off the sheet, it is reported as a test result that the sheet is nonabsorbent.

**The Finger Tap Test**

A piece of Kraft paper toweling is placed under the sheet to be tested. A drop of water containing a red dye is placed on the surface of the sheet, and the droplet is tapped 40 times with the forefinger, requiring 10–15 seconds. The piece of paper toweling underneath the sheet being tested is then examined for presence or absence of the red dye. The test is carried out at least 7 times (more if desired). The following system of ratings is employed to report the results:

<table>
<thead>
<tr>
<th>Observation</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dye observed on paper toweling</td>
<td>Excellent (or &quot;No Leak&quot;)</td>
</tr>
</tbody>
</table>
| Scattered pin-point leaks
  (1 to 2 pin-point leaks per test droplet) | Good |
| Numerous pin-point leaks
  (3 to 6 pin-point leaks per test droplet) | Satisfactory |
| Dye solution readily oozes through sheet, much dye observed on paper | Unsatisfactory |

**Vented Mason Jar Test**

A small hole (approximately one-sixteenth-inch in diameter) is drilled in the bottom of a Mason jar. While the jar is held in such a way that the vent hole is covered by a finger, approximately 600 ml. of saline solution (0.9% sodium chloride) is poured into the jar to provide a 4.5-inch head of liquid in the jar. A 4.5-inch square sample of the fabric to be tested is placed on the jar, after which a gasket and ring assembly are mounted onto the jar to secure the fabric sample over the top of the jar. The jar is then inverted onto a glass plate, which
is mounted 6-8 inches above a mirror, being sure that the fabric touches the glass. The glass plate in contact with the fabric is then observed with the aid of the mirror. Wetting of the glass surface through the fabric in 3 minutes or less is recorded as a pinhole failure. If no pinhole failure occurs, observation is continued for up to 1 hour and the first appearance of wetting of the glass surface is recorded as repellency time. A set of 5 samples is tested in this way. One pinhole failure per set of 5 is considered acceptable, and samples meeting this standard are reported as having no leaks. Two pinhole failures per set of 5 require a retest, and the sample is considered a failure if 2 or more pinhole failures occur on the second trial. Three pinhole failures per set of 5 or more are considered a failure, and it is reported as a test result that the sample leaks.

Of the two leakage tests described above, the Finger Tap Test is the more severe, and when only one leakage test is employed the Finger Tap Test is the procedure which is selected to test the sample.

The following examples are intended to illustrate the scope of the invention without being considered as limitative. All percentages are by weight unless otherwise specified.

**EXAMPLE 1**

A nonwoven sheet comprising film-fibril elements of linear polyethylene is prepared by the process of U.S. Pat. No. 3,169,899. The film-fibril elements are collected on an endless wire-woven screen belt by depositing them in the form of a web-like sheet structure and lightly consolidating the structure by passing the screen belt carrying the web-like sheet over a steel guide roll and simultaneously under a rubber consolidation roll (70 Shore A durometer), which exerts a pressure on the sheet of about 40 pounds per inch of roll length. From this point, the sheet leaves the screen and is wound up as a roll.

The cold consolidated sheet is then passed through the nip of a pair of rolls to develop a linear pattern on one side of the sheet only. One of the rolls is a smooth, hard rubber backup roll 12 inches in diameter, while the other roll is 9.5 inches in diameter and has a steel surface shaped to provide an embossing pattern simulating a linen fabric (embossing roll manufactured by Holyoke Machine Company, pattern no. 60-61). The temperature of the embossing roll is 205°C., and the sheet is passed through the nip of the pair of rolls at a speed of 175 yards per minute and with a pressure of 30-40 pounds per linear inch. The film-fibril elements comprising the side of the sheet embossed with the linen pattern are fused into a continuous surface as a result of this step.

After the linen pattern is embossed on one side of the sheet, the sheet is passed through a second pair of rolls to emboss the other side of the sheet in a ribbed pattern. The embossing pattern on the second steel roll consists of tiny raised ridges which follow the circumference of the roll, the ridges being disposed every 0.0625 inch across the axial length of the roll and comprising 28 individual points per inch within each ridge, the points being raised to a height of 0.020 inch relative to the roll surface. The upper surface of the raised portions in the embossing pattern has an area of about 5% of the surface of the steel roll. In the second embossing step, the temperature of the steel embossing roll is maintained at 175°C. and the sheet is passed through

the nip of the rolls at a speed of 175 yards per minute and with a pressure of 1,000 pounds per inch being maintained between the rolls. The side of the sheet embossed with the ribbed pattern has fused areas corresponding to the raised ridges of points, but also has areas in which the film-fibril elements are not fused together, so that the surface provided on this side of the sheet is somewhat porous rather than continuous. The resulting nonwoven polyethylene sheet (referred to below as the "uncoated sheet") has a weight of approximately 1.15 ounces per square yard.

A hydrophobic polymer is then applied as a water-repellent coating to the liner side (fused continuous surface) of the uncoated sheet by passing the sheet through a pair of rolls, the upper roll being a rubber nip roll and the liner side of the sheet contacting the lower roll, which is a gravure coater roll rotating in a bath consisting of an aqueous emulsion of 16.5% carboxylated butadiene/styrene (53%/47%) copolymer (identified as Tylac 5025, a product of Standard Brands Chemical Co.), 33.5% clay, 5% TiO₂, 0.4% sodium polycrylate thickener (identified as Good-rite K-718, a product of the B. F. Goodrich Chemical Co.), and 44.6% water. A knife in close proximity to the coater roll is employed to regulate the amount of coating applied, and a wire-wound metering bar comprising a 1-inch diameter rod wound with fine wire is rotated in a direction opposite to the sheet direction at a speed of about 30% of that of the sheet speed to make the coating more uniform. After the hydrophobic polymer coating is applied, the sheet is passed under a guide roll and through a pin tenter to dry the coating on the sheet. A sample of the sheet coated with hydrophobic polymer is saved for testing.

The coated sheet is then turned over and passed through the same apparatus a second time, applying on this second pass a wetting agent to the ribbed side of the sheet. The wetting agent is an aqueous emulsion of 10% of an alkyl aryl polyether alcohol (identified as "Triton X-100", produced by Rohm & Haas Co.) and 0.7% of a polysaccharide thickener (identified as "705DA", a product of Stein, Hall & Co., Inc.). The pickup of the wetting agent is 5.2% and the pickup of the water-repellent coating is 65% based on the weight of the sheet.

The nonwoven polyethylene sheet coated with hydrophobic polymer on the liner side and wetting agent on the ribbed side as described above is found to be absorbent when tested by the Absorbency Test, and is found to be free from leaks when tested by the Finger Tap Test and the Vented Mason Jar Test. In each of the tests, the water is applied to the ribbed side of the sheet coated with the wetting agent. For comparison, results obtained with the uncoated sheet, and with the sheet coated with the hydrophobic polymer on the liner side only (not treated with wetting agent) are tested. These results are summarized in the following table.

**TABLE**

<table>
<thead>
<tr>
<th>PERFORMANCE OF FIBROUS NONWOVEN SHEETS</th>
<th>WHEN TESTED WITH WATER</th>
<th>Absorbent</th>
<th>Leakage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Sheet</strong></td>
<td><strong>Performance</strong></td>
<td><strong>Absorbent</strong></td>
<td><strong>Leakage</strong></td>
</tr>
<tr>
<td>1. Uncoated</td>
<td>No</td>
<td>Unsatisfactory</td>
<td></td>
</tr>
<tr>
<td>2. Coated with Hydrophobic Polymer only</td>
<td>No</td>
<td>No Leak</td>
<td></td>
</tr>
<tr>
<td>3. Coated with Wetting Agent and Hydrophobic</td>
<td>Yes</td>
<td>No Leak</td>
<td></td>
</tr>
</tbody>
</table>
TABLE-Continued

<table>
<thead>
<tr>
<th>Type of Sheet</th>
<th>Performance</th>
<th>Absorbent</th>
<th>Leakage</th>
</tr>
</thead>
</table>

**EXAMPLE 2**

A nonwoven polyethylene sheet coated with hydrophobic polymer on the linen side and wetting agent on the ribbed side is prepared as described in Example 1. After the coating operation, the sheet is passed through the nip of a rotary pin softener apparatus comprising two rolls, each bearing a multiplicity of pins in the form of round-ended pegs in spaced array. As the coated sheet is passed through the nip of the two rolls, the pins interpenetrate in the nip, displacing small portions of the sheet out of the initial planar configuration. Pin penetration during softening is 40 mils. The resulting sheet is soft, supple, and has good hand and good drape. The sheet is absorbent when tested by the Absorbency Test, and it has excellent leakage resistance when tested by the Finger Tap Test and the Vented Mason Jar Test.

**EXAMPLE 3**

A nonwoven polyethylene sheet is prepared as described in Example 1, except that the hydrophobic polymer composition which is applied to the linen side consists of an aqueous emulsion of 15% carboxylated butadiene/styrene (53%/47%) copolymer, 30% clay, 5% TiO₂, and 50% water; while the wetting agent composition applied to the ribbed side of the sheet consists of an aqueous emulsion of 15% of the same alkyl aryl polyether alcohol used in Example 1 together with 0.5% of the polysaccharide thickener and 84.5% water. In this instance, each of the coatings is applied to the sheet by pouring the respective mixtures onto the surface of an 8-inch X 12-inch sample of the sheet and hand drawing the wire-wound metering bar over the surface to spread the coating. The hydrophobic polymer coating is applied first and the wet sheet is then placed in an oven at 100°C for 2 minutes to dry the sheet; after which the wetting agent composition is applied and the sheet is then again dried. The coated sheet has a weight of 1.74 ounces per square yard. The hydrophobic polymer pickup is 42.2% and the wetting agent pickup is 9.5%. The sheet has excellent absorptive properties and excellent leakage resistance.

**EXAMPLE 4**

A nonwoven sheet composed of film-fibril elements of linear polypropylene is embossed on one side with a linen pattern as in Example 1, except that the temperature of the linen embossing roll is 150°C. The sheet is then embossed on the other side in a ribbed pattern as in Example 1, except that the temperature of the rib pattern roll is 186°C. In each of the embossing operations the sheet is passed through the rolls at the rate of 75 yards per minute. The embossed sheet has a weight of approximately 1.10 ounces per square yard. It is coated on the linen side with a hydrophobic polymer composition and on the ribbed side with a wetting agent composition, using the same compositions as those employed in Example 1 but employing the coating procedures of Example 3. After coating, the weight of the sheet is 2.66 ounces per square yard. The pickup of the hydrophobic polymer on the sheet is 125% and the pickup of the wetting agent is 16.4%. The sheet has excellent absorptive properties, and its resistance to leakage is excellent.

**EXAMPLE 5**

A nonwoven polyethylene sheet is formed, lightly consolidated, and embossed on one side with a linen pattern as in Example 1; however, the other side of the nonwoven sheet is not embossed and remains porous throughout the entire surface of the unembossed side of the sheet. The hydrophobic polymer composition of Example procedure 1 is then coated on the linen side of the sheet, using the same coating composition as that of Example 1 but employing a hand coating procedure as in Example 3. The sheet is then dried, and the wetting agent composition of Example 1 is then coated on the porous (unembossed) side of the sheet, again using the hand coating procedure of Example 3. After the sheet is dried, it is found that the pickup of the hydrophobic polymer is 65% and the pickup of the wetting agent is 5.4%. The sheet has excellent absorptive properties and is rated “satisfactory” in the Finger Tap Test.

**EXAMPLE 6**

A nonwoven polyethylene sheet is prepared as described in Example 1, except that the hydrophobic polymer composition of Example 1 is coated on the linen side of the sheet using the hand coating procedure of Example 3, and the wetting agent composition comprises 10% of the diethycyclohexylamine salt of lauryl sulfate monooester, 0.7% of a polysaccharide thickener, and 89.3% water, also applied by a hand coating procedure. The pickup of the hydrophobic polymer is 81% and the pickup of the wetting agent is 10.4%. The sheet has excellent absorptive properties and is rated “no leak” when subjected to the Finger Tap Test.

**EXAMPLE 7**

A nonwoven polyethylene sheet is prepared as described in Example 1, except that the hydrophobic polymer composition of Example 1 is coated on the linen side of the sheet using the hand coating procedure of Example 3, and the wetting agent composition comprises 10% of a quaternized alkylalkylamine ester (a cationic wetting agent), 0.7% of a polysaccharide thickener, and 89.3% water, also applied by a hand coating procedure. The pickup of the hydrophobic polymer is 85% and the pickup of the wetting agent is 12.2%. When subjected to the Finger Tap Test, the sheet is rated “no leak.” When subjected to the Absorbency Test, the sheet is rated as excellent, although it is observed that it absorbs water at a slower rate than the coated sheet of Example 1. It is also observed that the coating mix containing the wetting agent penetrates the sheet at a slower rate during application than do the nonionic and anionic wetting agents of previous examples. The slow penetration rate during manufacture of the sheet is advantageous when facilities for rapid drying of the sheet in manufacture are not available.

**EXAMPLE 8**

A series of nonwoven polyethylene sheets is prepared, following the procedure described in Example 1 but adjusting the concentration of the alkyl aryl poly-
ether alcohol in the bath in order to produce sheets containing varying amounts of wetting agent. Six sheets are prepared, the pickup of wetting agent ranging from 1.8–13%. The ribbed side of each sheet is then subjected to the Absorbency Test, timing the test for each sheet to determine the time in seconds for complete absorption. The distance traveled by the droplets before they are absorbed is also measured for each sheet. The results are shown in FIGS. 1 and 2. As shown in FIG. 1, absorption time decreases rapidly with increasing levels of wetting agent and reaches a constant minimum level at about 5.5% by weight of the wetting agent on the sheet. FIG. 2 illustrates that the distance traveled by the droplets reaches a minimum level at about 10% by weight of the wetting agent on the sheet.

What is claimed is:

1. A flexible nonwoven sheet for use against splashing liquids comprised of film-fibril elements of linear polyolefin, the film-fibril elements on one side of said sheet being fused together to form a continuous surface and having adhered thereto a continuous coating of a hydrophobic polymer effective as a liquid barrier, the other side of the sheet having areas of unfused film-fibril elements and having a wetting agent adsorbed thereon.

2. The sheet of claim 1 having at least about 5% by weight of wetting agent and at least about 0.5 oz./yard² of hydrophobic polymer.

3. The sheet of claim 2 wherein the hydrophobic polymer is a copolymer of butadiene and styrene.

4. The sheet of claim 2 wherein the hydrophobic polymer is a plasticized polyvinyl chloride.

5. The sheet of claim 2 wherein the wetting agent is an alkyl aryl polyether alcohol.

6. The sheet of claim 5 wherein the wetting agent is present in an amount from about 10–15% by weight of the sheet.

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