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PROCESS OF PREPARING NON-WOVEN POLYMER BONDED FABRIC AND ARTICLE
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FIG. 1

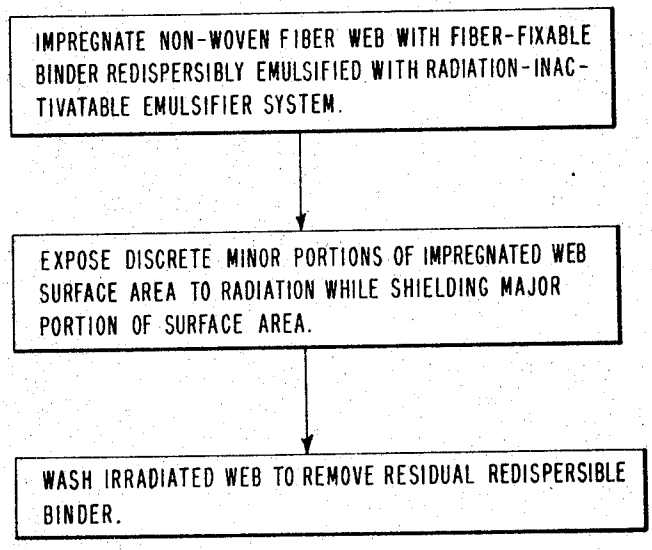
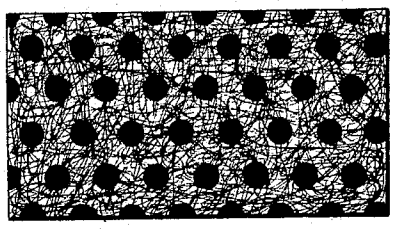


FIG. 2



● - FIBER-FIXED BINDER AREA

- BINDER-FREE AREA

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PROCESS OF PREPARING NON-WOVEN POLYMER BONDED FABRIC AND ARTICLE

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This invention relates to nonwoven fabrics and a process for the production thereof.

Techniques for producing textile-like nonwoven fabrics have received considerable attention in the textile industry. In particular, efforts have been directed to obtain a process for producing a nonwoven fabric which is equal in appearance and quality to a woven fabric. The primary incentive behind this attention is the general recognition that a fabric produced by bonding together fibers by a polymeric or resinous substance would be far less expensive then a fabric produced by the necessarily complex weaving equipment now required by fabric manufacturers.

To obtain a nonwoven fabric which is at least somewhat similar to a woven fabric in terms of softness, drape, and hand, it is known that the most satisfactory results are obtained by a particulate bonding method. Particulate bonding refers to a process whereby the fibers are bonded together in discrete areas by definite particles of a polymeric or resinous binder composition. Methods whereby the fibers are bonded together by a more or less continuous film of binder composition result in fabrics which have undesirable, stiff, and paper-like characteristics.

One method proposed heretofore for making a particulate bonded nonwoven fabric, involves preparing a random or oriented web of fibers and dispersing therein a number of small particles of a heat-fusable binder material, and thereafter heating the web under pressure to cause the binder to flow and bond to the fibers. The relative amount and size of the binder particles are primarily determinative of the characteristics or properties of the resultant fabric. If a relatively large number of closely spaced particles are used, the fabric possesses high strength, durability, and washability. However, such a fabric also is undesirably stiff and does not possess the high degree of softness and drape, characteristic of a woven fabric. Softness and drapeability may be obtained by the use of a relatively low number of particles, but at the sacrifice of strength and washability. By optimizing the size and amount of binder particles, a compromise between these properties may be obtained. However, in any case since the entire web must be subjected to heat and pressure, the resultant fabric is inherently compactant and tends to be rather stiff. Furthermore, in practical commercial operations, the preparation of satisfactory fabrics has proved to be difficult; the binder particles are not easily dispersed in the web; they tend to distribute unevenly and fall out during handling; also, control of the position and shape of the bond sites is extremely difficult.

An alternative procedure proposed for application of binder in discrete spots makes use of a printing technique. By this method the binder is applied from solution or emulsion in a predetermined pattern using equipment quite similar to a printing press. However, special care is needed during the drying process to prevent migration of the binder composition producing uneven bonding, undesirably large bonding sites, and also delamination. Furthermore, the resulting web must be heat pressed to insure adequate bonding and proper curing, producing the deleterious effects described above.

The nonwoven fabrics produced heretofore have met

with some degree of commercial acceptance, being used primarily to make items such as towels, napkins, tablecloths, draperies, and curtains suitable for hotel or restaurant use, handkerchiefs, sanitary napkins, surgical dressings, and reusable industrial fabrics. However, these nonwoven fabrics do not sufficiently resemble types of woven fabrics commonly used to make outer garments and therefore are not satisfactory for making garments such as shirts, trousers, blouses, dresses, and the like, which must have a comfortable feel and also be aesthetically pleasing to the discerning eye.

An object of this invention is to provide an improved nonwoven fabric and a process for the production thereof. Another object is to provide an improved method for the particulate bonding of a web of fibers to produce a textile-like nonwoven fabric. A further object is to provide a web of fibers impregnated with a unique binder composition which may be conveniently converted into an improved, textile-like nonwoven fabric.

These and other objects are attained by the process for preparing a nonwoven fabric comprising preparing a web of fibers impregnated with a composition which is characterized by being fiber-fixable upon exposure to electromagnetic radiation and exposing said web to said radiation at predetermined areas while shielding the remaining area from said radiation, the total surface area exposed being substantially less than the total surface area of said web, and thereafter removing from said web the composition shielded from said radiation. FIGURE 1 is a flow sheet drawing of a process of the present invention. FIGURE 2 is a plan view of a nonwoven fiber fabric product of the present invention.

The term "electromagnetic radiation" refers to the entire spectrum of light waves, being all forms of such radiation by which a chemical reaction may be initiated, and includes, ultraviolet light (U.V.) infrared light, visible or white light, X-rays, and the like.

As used herein, the term "fiber-fixable composition" refers to a composition which will become fixed or adhered onto a fiber and which will thus bond together two or more fibers, but which after being so fixed, will not be removed during the process step whereby the nonfixed binder composition is removed from the web. Any of the compositions known in the art as being fiber-fixable and hence, useful as a binder in the manufacture of nonwoven fabrics, may be used in this invention, for example, the binders disclosed and described in U.S.P. 2,039,312, U.S.P. 2,277,049, U.S.P. 2,647,128, U.S.P. 2,774,687, U.S.P. 2,794,010, U.S.P. 2,823,142, U.S.P. 2,915,418, U.S.P. 2,923,653, U.S.P. 2,931,749, and U.S.P. 3,081,197. Particularly desirable fiber-fixable compositions are those which comprise polyvinyl acetate or a copolymer comprising at least one alkyl ester of an acid selected from the group consisting of acrylic acid and methacrylic acid, and a copolymerizable monomer having at least one functional group selected from the class consisting of carboxyl, epoxide, hydroxyl, isocyanate, amine, amide, and methylolamide groups.

Any composition which is fiber-fixable upon exposure to electromagnetic radiation may be used in this invention. For example, a photopolymerizable monomer may be used which will polymerize in situ on the fiber upon exposure to U.V. Also, a preformed polymer which will crosslink by photoinitiation is useful in this technique. Another example is an emulsion of a binder composition wherein the emulsifying agent is radiation sensitive, thereby making the composition nonredispersible upon radiation exposure. A solution of a binder composition which coagulates to form a nonredispersible bonding site upon radiation exposure may also be used. Other alternatives will be obvious to those skilled in the art. A few

photoinitiated techniques are discussed in Bovey et al., Emulsion Polymerization, Interscience Publishers, Inc., New York (1955), p. 30; Davidson, ed., Water-Soluble Resins, Reinhold Publishing Corp., New York (1962), p. 104; and Schildnecht, Vinyl and Related Polymers, John Wiley and Sons Inc., New York (1952), pp. 207 to 8; and also U.S.P. 2,716,633, U.S.P. 2,722,512, U.S.P. 2,892,716, U.S.P. 2,893,868, U.S.P. 2,902,365, U.S.P. 2,923,673, U.S.P. 2,927,022, U.S.P. 2,929,710, U.S.P. 2948,611, U.S.P. 2,951,758, U.S.P. 3,012,952, and U.S.P. 3,016,297.

In the practice of this invention, the fibers are impregnated with the fiber-fixable radiation sensitive binder composition This impregnation may be accomplished either by impregnating the individual fibers before the web of fibers is formed, or alternatively, the web of fibers may be formed first and then the entire web may be impregnated. The fibers may be of any material desired, such as wool, glass, cellulosic including cotton, rayon, and wood pulp, and also the synthetic fibers produced from fiber-forming polymers including polyamides, polyacrylontrile, polyesters, polyurethanes, polypropylene, polyvinylidene chloride and the like. It is generally preferred to prepare the web either by use of the continuous fiber technique as shown in Belgian Patent No. 608,646, or by use of short lengths of fibers, that is, fibers having an average length of about 1/16 to 2 inches or preferably about 1/8 to 3/8 inch. Thereafter, the impregnated web is exposed to suitable eletromagnetic radiation at predetermined discrete areas or spots while shielding the remaining area of the web from the radiation, to permanently bond the fibers together at these spots. Then the unexposed composition is removed in any convenient manner, for example, it may be washed out with a solvent or dispersing medium, or if the unexposed composition is relatively volatile, it may be removed by vaporization techniques. The fabric thickness is controlled by two factors: the thickness of the impregnated web and by the treatment to which the exposed web is subjected after the enumerated steps. By using a very thick web, on the order of about 2 or 3 inches thick, and by not compressing the web during the various process step, extremely bulky fabrics can be prepared which are useful as insulation batts. Relatively thinner webs may be used to create other special fabrics. If desired, after the web has been exposed to electromagnetic radiation and the unexposed fiber-fixable composition has been removed, the web may be subjected to hot pressing to compress the fibers and reduce the fabric bulk.

A very convenient method to practice this invention is to first form a random or oriented web of fibers by any of the methods commonly used in the art. This web is then impregnated with a solution or dispersion of a fiber-fixable composition which will upon drying, but before exposure to the electromagnetic radiation, coalesce to a more or less continuous, but redispersible or solvent-soluble film, to thereby temporarily bond together the entire web as a sheet structure. This temporarily bonded web or sheet structure may be easily handled during subsequent process steps. This impregnated web may be stored for any length of time or shipped about, so long as the web is shielded from the particular type of electromagnetic radiation to which the fiber-fixable composition is sensitive. This web may then be later exposed to the radiation when convenient and further treated to produce a nonwoven fabric.

This technique provides the textile industry with an intermediate product and a process for producing nonwoven fabrics and garments manufactured therefrom which heretofore has been unavailable. Since the above-described sheet structure may be easily handled, it is now possible for a supplier to produce a general line of webs of fibers impregnated with an electromagnetic-sensitive, fiber-fixable binder composition, in the form of the aforedescribed sheet structure. Such a web may be then distributed to the garment or other manufacturers who may then cut the web to any desired shape either before or after radiation exposure, dye the web as desired, and subject the web to post treatment such as hot pressing to control bulk, and so forth. Thus, the initial supplier needs to produce fewer different types of materials to meet the many diverse demands of its customers, and the garment manufacturer can treat the web in many different ways to obtain specialty fabrics adapted to his own particular requirements.

The pattern and area of exposure and thus the location and size of the binder sites may be controlled in any convenient manner. Practitioners of the art are knowledgeable of the requirements of binder particle size, shape, and pattern or placement in order to obtain nonwoven fabrics which are serviceable in specific end uses, as shown, for example, in U.S.P. 2,705,686, U.S.P. 2,705,687, U.S.P. 2,705,688, U.S.P. 2,782,130, U.S.P. 2,880,111, U.S.P. 2,880,112, and U.S.P. 2,880,113. In every instance it is necessary that the total surface area of the binder be substantially less than the total surface of the web. The most practical method is to interpose between the web and source of radiation a suitable mask containing a plurality of holes corresponding to the pattern and area of exposure desired. The mask may be constructed of any suitable material so long as the material is impervious to the type of radiation employed. Thus, a foraminous metal plate is convenient to use in conjunction with ultraviolet light radiation.

The particular type of fiber, type of web, type of binder, binder size, amount and location in the web, etc. are several variables which affect the physical characteristics of the nonwoven fabric. By proper selection and control of these variables, it is possible to produce many different types of nonwoven fabrics suitable for many different end uses. Selection of these variables to produce any one particular type of nonwoven fabric is a part of the prior art and is well known to those skilled in the art. The contribution to the art provided by the present invention is a unique method for the controlled bonding together of fibers in a web at discrete binder sites, to obtain a nonwoven fabric which is remarkably similar to a woven fabric. By use of this invention in the manner described above, nonwoven fabrics are obtained which are free from objectionable stiffness, but which have woven-like bulkiness and which are strong and durable. This invention gives practitioners of the art a process whereby nonwoven fabrics may be made which are entirely satisfactory for use in making outergarments such as shirts, blouses, trousers, dresses, and the like.

The following examples are intended for illustrative purposes only and not to impose limitations upon the scope of this invention. In these examples all stated proportions, parts, and percentages are proportions, parts, and percentages by weight, except where otherwise noted.

EXAMPLE 1

A U.V. sensitive fiber-fixable composition is formulated in the dark by using a commercially available redispersible polyvinyl acetate emulsion having a solids content of approximately 55%, a viscosity within the range of 850 to 1,000 centipoises, a pH within the range of 4 to 6, and a predominant particle size of 1 to 3 microns, and adding thereto, with stirring, the following components, based on the solids content of the emulsion: 0.8% N,N'-m-phenylenedimaleimide (as a 20% solution in dimethylformamide), 0.8% benzoin methyl ether (as a 20% solution in ethanol), and 0.6% sodium dichromate. The resulting formulated dispersion is diluted with water to 10% solids while still shielded from light exposure. A random web of crimped polyethylene terphthalate fibers (4.75 denier, 1 inch staple, 8 crimps per inch), obtained by air deposition, weighing about 2.7 oz./sq. yd., is impregnated with this dispersion and dried while shielded from light exposure. The fibers of this impregnated web are sufficiently

bound together to form a sheet structure which may be easily handled without causing any damage thereto. The dried web is placed between foraminous steel plates having holes 3/32 inch in diameter spaced 3/16 inch apart in rows which are in turn spaced 9/16 inch apart and having 1/4 inch diameter holes placed equidistant from each 4 adjacent holes which form a rectangle. The web is then exposed for 5 minutes to radiation from two 250 watt ultraviolet lights each placed on opposite sides of the plates at a distance of 7 inches therefrom. The sheet is then washed with water to remove all unexposed polymer. This gives a nonwoven fabric bonded with polyvinyl acetate dots in locations corresponding to the holes in the steel plate. The pattern is well defined on both sides of the nonwoven fabric.

EXAMPLE 2

A random web of crimped polyethylene terphthalate fibers is prepared and saturated with the formulated dispersion as shown in Example 1. The wet web is placed between the foraminous steel plates and exposed to ultraviolet radiation from both sides. After exposure the still wet web is washed with water. This gives a nonwoven fabric bonded with polyvinyl acetate dots similar to that obtained in Example 1.

EXAMPLE 3

A U.V. sensitive fiber-fixable composition is formulated in the dark by using a commercially available redispersible polyvinyl acetate emulsion as shown in Example 1, and adding thereto, with stirring, the following components, based on the solids content of the emulsion: 10% triethylene glycol dimethacrylate, 0.8% benzoin methyl ether (as a 30% solution in ethanol) and 0.6% sodium dichromate. This formulated dispersion is diluted with water to 10% solids while still shielded from light exposure. A random web of 6,6-nylon fibers (3 denier, 1½ inches staple) obtained by air deposition and weighing about 2.8 oz./sq. yd. is impregnated with this formulated dispersion, and then passed through a rubber-roller wringer applying a total of 10 pounds force to remove excess dispersion. Then the web is dried in the dark. The dried web is placed between the foraminous steel plates used in Example 1 and exposed for 10 minutes to radiation from two 275 watt ultraviolet lamps placed on opposite sides of the web-foraminous plate assembly 7 inches from the assembly, with ¼ inch glass plates interposed between the lamps and the assembly. The sheet is then washed in water to remove the unexposed dispersion. A nonwoven fabric is obtained which is bonded with polyvinyl acetate in discrete areas corresponding to the holes in the steel plates. This nonwoven fabric is suitable for use in clothing manufacture.

EXAMPLE 4

Example 3 is repeated except that 5% of phthalocyanine green paste, based on the solids content of the formulated dispersion, is mixed into the dispersion. The resultant non-woven fabric appears white with a decorative green dot pattern corresponding to the holes in the foraminous steel plate.

EXAMPLE 5

Example 3 is repeated except that 10% of dibutyl phthalate, based on the solids content of the formulated dispersion, is mixed into the dispersion to plasticize the polyvinyl acetate. The resultant nonwoven fabric is more drapeable than the nonwoven fabric obtained in Example 3.

EXAMPLE 6

Twenty grams of a commercially available polyvinyl alcohol (polyvinyl acetate having 70% of the acetate groups hydrolyzed; molecular weight of about 100,000) is dissolved in 80 grams of water. While shielding this solution from light, 4 grams of potassium bichromate (in 96 grams of water) are added to the solution. A random web of cotton fibers (bleached Egyptian filter cotton, grade AA having lengths varying from ½ to 1 inch) weighing about 2.5 oz./sq. yd. is impregnated with this solution and then dried in the dark. A foraminous steel plate used in Example 1 is placed over this dried web. The web is then exposed for 5 minutes to radiation from a 35 ampere, 1,500 candle power arc lamp placed 30 inches from the web. The web is then immersed for 2 minutes in water at about 50° C., is then shaken in cold water in a tumbling machine, to dissolve the unexposed polyvinyl alcohol, and then dried. A strong, drapeable nonwoven fabric is obtained having discrete bonded spots corresponding to the holes in the foraminous plate.

EXAMPLE 7

Standard craft grade wood pulp fibers are slurried in water and collected on a fine mesh wire filter, to form a web. This web is then impregnated with a polyvinyl alcohol-potassium bichromate solution prepared as shown in Example 6. A foraminous steel plate having uniform holes 1/16 inch in diameter situated ⅛ inch apart is placed over this impregnated web. The web is exposed to radiation, washed and dried as shown in Example 6. This procedure gives a nonwoven fabric suitable for use as a disposable material such as is useful for tablecloths, napkins, surgical gowns, industrial drape cloths and the like.

EXAMPLE 8

A photopolymerizable composition is prepared by mixing the following ingredients:

	Grams
Water	100
Ethylene dimethacrylate	100
Polyoxyethylene sorbitan tristearate	2
Ethylene oxide condensation product with alkyl phenol	3

These components are stirred in a high shear mixer to give an emulsion. To this emulsion is added 100 ml. of a commercial dispersion (45% solids), of a terpolymer containing 92% ethyl acrylate, 6% methyl acrylate, and 2% acrylic acid, having a molecular weight of over 200,000 and also ½ g. anthraquinone. This emulsion is diluted with water to 5% solids. A random web of crimped polyethylene terphthalate fibers is prepared as shown in Example 1 and is impregnated with this emulsion and placed between the foraminous steel plates used in Example 1 while still wet. The web is exposed on both sides to radiation from two 250 watt ultraviolet lamps placed on opposite sides of the plates, both at a distance of 7 inches from the plates for an exposure time of 4 minutes. The unexposed emulsion is then removed by washing with water. This gives a nonwoven fabric bonded with discrete dots of binder at locations corresponding to the holes in the steel plates showing excellent definition, and exhibiting a high degree of conformability and possessing a pleasing hand or drape, which would be suitable for use in the preparation of outer garments.

EXAMPLE 9

Example 8 is repeated except that the random web is prepared from crimped, dull, rayon fibers, 1 9/16 inches long before crimping, and weighs about 3.1 oz./sq. yd. The resultant nonwoven fabric is strong and has a comfortable feel.

EXAMPLE 10

A random web is prepared as shown in Example 1 and is impregnated with a photopolymerizable composition prepared as shown in Example 8. This impregnated web is passed through a rubber-roller wringer which applies a total force of 10 pounds. The web is then dried and stored in complete darkness for six months. Thereafter, the web is exposed as shown in Example 8. The unexposed photopolymerizable composition is removed by

washing with tetrahydrofuran. A nonwoven fabric is obtained which is identical to that obtained in Example 8.

EXAMPLE 11

A photopolymerizable composition is prepared by mixing the following ingredients:

	Grams
Water	100
Tetraethylene glycol dimethacrylate	100
Polyoxyethylene sorbitan tristearate	2
Ethylene oxide condensation product with alkyl phenol	3

These components are stirred in a high shear mixture to give an emulsion. To this emulsion is added 100 ml. of the commercial dispersion of the terpolymer used in Example 8 and in addition 0.5 gram of anthraquinone. This dispersion is then diluted with water to 5% solids content. A random web of fibers prepared as shown in Example 1 is impregnated with this emulsion, and placed between the foraminous steel plates used in Example 1 while still wet. This web is exposed to radiation as shown in Example 8 and then the unexposed photopolymerizable composition is removed by washing with water. The resultant nonwoven fabric is similar to that obtained in Example 8.

EXAMPLE 12

A random web of fibers is prepared and impregnated with a photopolymerizable composition as shown in Example 8. This wet web of fibers is placed between two foraminous steel plates ¼ inch thick having uniform holes 3/32 inch in diameter and spaced 3/16 inch apart. The web is exposed to radiation from a Van de Graff election accelerator operated to deliver 2 m.e.v. radiation at 125 milliamperes current covering a rectangular area measuring 2 cm. by 20 cm. at a distance of 10 cm. from the generator. The web-foraminous plate assembly is passed through the beam area at a rate of 2 cm./sec. in a direction perpendicular to the long dimension of the beam area, passing through the beam area six times. The web is then washed with water to remove the unexposed photopolymerizable composition. This procedure produces a nonwoven fabric similar to the nonwoven fabric obtained in Example 8.

This invention has been described in considerable detail. However, since there are obviously many variations which can be made in these details without departing from the spirit and scope of this invention, this invention is not intended to be limited except as defined by the appended claims.

I claim:

1. Process of preparing non-woven fabric comprising contacting non-woven fiber with water-dispersible polymer particles intimately associated with minor amounts, by weight of said particles, of emulsifier rendering said particles water-redispersible and material reactive with said emulsifier on exposure to electromagnetic radiation to render said particles non-water-redispersible, exposing said fibers in web form in contact with said particles to said radiation at discrete web surface areas while shielding the remaining web surface area, the total web surface area thus exposed being substantially less than the total web surface area, and washing the resulting web with water to remove residual water-redispersible polymer particles.

2. Process of claim 1, wherein said polymer is a vinyl acetate polymer.

3. Process of claim 2, wherein said emulsifier is a vinyl alcohol polymer.

4. Process of claim 3, wherein said material is a chromate or dichromate salt.

5. Process of claim 4, wheren said radiation is ultraviolet light.

6. Process of claim 5, wherein said polymer is polyvinyl acetate.

7. Process of claim 6, wherein said polyvinyl acetate is further intimately associated with a minor amount, by weight of said particles, of photopolymerizable polyfunctional monomer, and a photoinitiator therefor.

8. Process of claim 6, wherein said polyvinyl acetate is further intimately associated with a minor amount, by weight of said particles, of a plasticizer therefor.

9. A sheet structure comprising a non-woven fiber web impregnated with water-dispersible polymer particles intimately associated with minor amounts, by weight of said particles, of emulsifier rendering said particles water-redispersible and material reactive with said emulsifier on exposure to electromagnetic radiation to render said particles non-redispersible.

10. A sheet structure comprising a non-woven fiber web impregnated with water-dispersible vinyl acetate polymer particles intimately associated with minor amounts, by weight of said particles, of vinyl alcohol polymer emulsifier rendering said particles water-redispersible and chromate or dichromate salt reactive with said emulsifier on exposure to electromagnetic radiation to render said particles non-redispersible.

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MURRAY KATZ, *Primary Examiner.*