

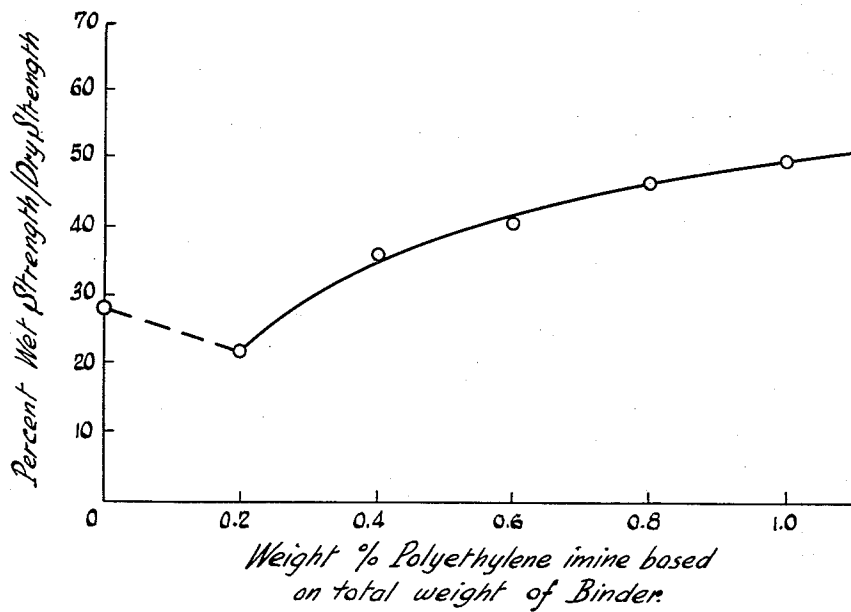
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BONDED NONWOVEN FABRICS AND METHODS OF MAKING THE SAME

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BONDED NONWOVEN FABRICS AND METHODS OF MAKING THE SAME

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19 Claims. (Cl. 117—140)

This invention relates to nonwoven fabrics produced by bonding together the fibers of a loosely assembled web of fibers.

This application is a continuation-in-part of my co-pending applications, Serial No. 860,858 and Serial No. 860,679, both filed December 21, 1959, now abandoned.

Bonded nonwoven fabrics have been formed hitherto by impregnating, printing or otherwise depositing an adhesive bonding material on a base web predominantly comprising relatively long fibers, including those of textile length of from about 1/2 inch to about 2 1/2 inches or more. Such base webs may be formed by garnetting, air deposition, carding, etc. Generally speaking, it is the aim of such processes to produce a soft fabric with as much strength as possible. Choice of bonding agent is very important in obtaining both softness and strength. Many bonding agents which have obtained importance in the art, such as polyvinyl acetate, have sufficient bonding strength when dry, but lose the greater portion of this strength when the fabric is wetted with water. This wet strength may be defined as the ability of the fabric to retain part of its dry strength after substantially complete saturation with water. This property of wet strength is very important when the fabric is to be used as a towel, in a sanitary napkin, in a disposable diaper or in any other manner where it will become moist or in contact with fluids.

The softness of nonwoven fabrics may be increased in a number of ways, such as by applying the adhesive intermittently as outlined in U.S. Patents 2,705,687 and 2,705,688, by addition of plasticizing agents to the binder as described in U.S. Patent 2,833,283 by after-treatment with cationic or non-ionic softening agents, etc. However, there is still a major problem with these fabrics, i.e., they lose considerable strength on wetting with water. This is especially true of fabrics after-treated with softening agents as it appears that the softening agents affect the resin-fiber bonds. There are bonding agents known which do not lose considerable strength when wetted, such as regenerated cellulose, derivatives of cellulose and chitin, among others. However the aforementioned agents do not have all the desirable properties of the vinyl resin polymers and copolymers.

Considerable time and effort have been expended on developing techniques for improving the wet strength of bonding agents for nonwoven fabrics consisting predominantly of cellulose fibers. One of the more important developments in this field has been the treatment of the fabrics with amino-aldehyde condensation products such as urea-formaldehyde and melamine-formaldehyde, along with heat and a catalyst to set the resin and cross-link the cellulose fibers. Such treatments, though they increase wet strength, have considerable disadvantages in that they are costly and complicated, reduce the softness of the fabric, and have a detrimental odor due to the formaldehyde release.

It is the purpose of this invention to provide a new method for improving the wet strength of nonwoven fabrics formed predominantly from cellulose textile-length fibers, bonded with vinyl polymers and copolymers, without harming the softness of such a fabric.

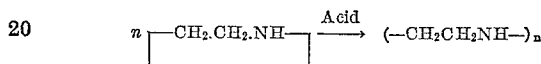
In accordance with this invention, vinyl resin-bonded nonwoven fabrics of cellulose, textile-length fibers are ob-

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tained which retain a greater portion of their dry strength after substantially complete saturation with water. Furthermore, if desired, the nonwoven fabrics of the present invention may be after-treated with softening agents without detrimental effects on the fabric strength.

The wet strength of the vinyl resin-bonded nonwoven fabrics is increased by adding to the resin, prior to applying the resin to the fibrous web, a small quantity of a water-soluble polyalkylene imine. Although the inventive concept will be described with particular reference to a specific polyalkylene imine, for example, polyethylene imine, such is merely for illustrative purposes and is not to be construed as limitative of the broader aspects involved.

Polyethylene imine is essentially a linear poly secondary amine. It is prepared by the acid catalyzed polymerization of ethylene imine according to the following reaction:



Polymerization is spontaneous and if uncontrolled, will lead to water-insoluble products which are difficult to apply to textile fabrics. If the polymerization is stopped before water-insolubility occurs, the application of the polymerized ethylene imine to the fabric is greatly simplified, and it is such a degree of polymerization which is preferred in accordance with the method for applying polyethylene imine to fibrous webs.

Polyethylene imine is available in a 50% aqueous solution. It is a highly viscous liquid with a slight amine-like odor.

The term "vinyl resins" is meant to include all thermoplastic polymers, copolymers, and mixtures thereof of vinyl monomers such as vinyl chloride, vinyl acetate, styrene, alkyl acrylates, etc.

The vinyl resins generally used in accordance with this invention are available as water-dispersed resins or latices of finely divided resin particles ranging from 0.1 to 20 microns in diameter suspended in water to about 45% to 55% total solids. The resin dispersions may also contain certain additives such as plasticizers, protective colloids, dyes, emulsifiers, flameproofing agents, mildew-proofing agents, stabilizers, etc.

Of particular interest are those dispersions of polyvinyl acetate containing polyvinyl alcohol as the protective colloid. These dispersions are of excellent mechanical stability and printability, but normally confer water sensitivity to fiber assemblies.

The starting layer may be formed by any one of the conventional techniques for depositing or arranging fibers in a web or layer. These techniques include carding, garnetting, air-laying and the like. Individual webs or thin layers formed by one or more of these techniques may be laminated to provide a thicker layer for conversion into a fabric. In general, the fibers extend in a plurality of diverse directions in general alignment with the major plane of the fabric, overlapping, intersecting and supporting one another to form an open, porous structure.

When speaking of cellulose fibers, it is meant those fibers containing predominantly C₆H₁₀O₅ groupings. Exemplary of the fibers to be used in the starting layer are the natural cellulose fibers such as cotton and hemp and the synthetic cellulose fibers, notably rayon, and regenerated cellulose. The fibrous starting layer should contain at least 50% cellulose fibers whether they be natural or synthetic or a combination thereof. The remaining fibers in the starting layer may comprise natural fibers such as wool, or jute; artificial fibers such as cellulose acetate; synthetic fibers such as polyamides, i.e.,

nylon, polyesters, i.e., "Dacron," acrylics, i.e., "Dynel," "Acrilan," "Orlon," polyolefins, i.e., polyethylene, polyvinyl chloride, polyurethane, etc., alone or in combination with one another.

The fibrous starting layer weighs from about 100 grains to about 2,000 grains per square yard and preferably weighs about 200 grains to about 800 grains per square yard.

The resulting fibrous starting layer, regardless of its method of production, is then subjected to at least one of the several types of bonding operations to anchor the individual fibers together to form a self-sustaining web. Some of the better-known methods of bonding are overall impregnation, and printing the web with intermittent or continuous straight or wavy lines or areas of binder extending generally transversely or diagonally across the web and additionally, if desired, along the web.

The desired amount of binder, calculated on a dry add-on basis, to be applied to the fibrous starting layer, may range from about 1% to about 100% by weight of the starting web and preferably from about 10% to about 35% by weight of the starting web.

The amount of polyalkylene imine to be added to the resin dispersion may vary from about ¼% to about 2½% by weight of the resin. The preferred amount of polyalkylene imine to be added is from about ½% to about 1½% by weight of the resin. If less than ¼% is used, the wet-strength contribution of the polyalkylene imine is substantially negligible. While more than 2½% polyalkylene imine may be used, the resultant increase in wet strength from the additional polyalkylene imine is also substantially negligible, and such greater amounts may in fact start to decrease the wet strength again. Using more than 1½% polyalkylene imine is not economically feasible at the present time.

The effect of increasing the proportions of polyethylene imine in a polyvinyl-acetate resin binder is illustrated in the drawing wherein the figure is a graph of the ratio of wet strength to dry strength of a fabric weighing approximately 240 gr./yd.² and containing about 40 gr./yd.² of binder plotted against the weight percent of polyethylene imine based on the total weight of binder.

The polyethylene imine used is usually a 50% aqueous solution in order to simplify handling and processing techniques. The binder dispersions used are usually dispersions containing 45% to 55% solids with the remainder of the dispersion being water.

The softness of nonwoven fabrics made as described above may be improved by impregnating the fabric with an aqueous solution of a cationic or non-ionic surface-acting softening agent.

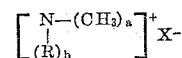
Normally such softening agents are harmful to the bond between the cellulose fiber and the vinyl resin and reduce fabric strength. However, when such softening agents are used in the presence of polyalkylene imine fabric strength is not harmed. It appears as though the polyalkylene imine orients itself on the outer surfaces of the vinyl resin particles thus forming a protective barrier about the vinyl resin and preventing attack by the cationic or nonionic surface-acting agents on the vinyl resin to cellulose fiber bond.

Illustrative of the cationic softeners are the long-chain quaternary ammonium salt compounds containing one or two alkyl groups, said alkyl groups containing from 8 to 18 carbon atoms. Such compounds are sold by the Armour Chemical Company under the trade name "Arquad." Other quaternary compounds which may be used are the quaternary ammonium salts of amino amides such as the quaternized guanidinium salts containing long straight aliphatic chains, said chains containing from 8 to 18 carbon atoms. Such compounds are sold by the Ciba Company under the trade name "Sapamine." Some non-quaternary cationic softeners which may be used in accordance with this invention are the long-chain compounds containing primary, secondary or tertiary amino

groups. Illustrative of this group of compounds are the condensates of polyamides such as diethyltriamine and its analogs with less than 1 equivalent of a fatty acid such as stearic acid. These compounds are also sold by the Ciba Company under the trade name "Sapamine." Other cationic compounds which may be used are the long-chain compounds containing thiourea groups instead of the amino or quaternary groups previously mentioned. Illustrative of the nonionic softening agents are the amides of the aliphatic diamines and polyamines, the polyethenoxy derivatives of higher fatty alkylolamides and higher fatty acids and the glycerides of fatty acids.

Probably the most important softening agents of the above-described group are the monoalkyl trimethyl ammonium chlorides and the dialkyl dimethyl ammonium chlorides. These compounds not only soften the fabric but have a considerable degree of bacteriostatic action which is considerably important for sanitary and surgical nonwoven-fabric products.

Such compounds may be represented by the following formula:



where R is an alkyl group containing 8 to 18 carbon atoms; *a* is selected from integers 2 and 3; *b* is selected from the integers 1 and 2; and X is a halogen.

The amount of softening agent used will, of course, depend on the softness desired in the end product and the exact type softener used. Generally speaking, the amount of softening agent used in accordance with this invention may be as low as about ½% or as much as about 5% based on the weight of the bonded fabric. We prefer to keep the amount of softening agent applied between about ½% to about 1½%, based on the weight of the bonded fabric. If less than ½% is used, the increase in fabric softness is substantially negligible. While more than 5% of the softening agent may be used, it is not economically feasible at the present time as the increased benefits do not warrant the consequent increased cost. The softener is generally applied by forming an emulsion of the softener in water and then impregnating the web with the emulsion to give the desired pickup so that when the fabric is dried, it contains the desired percentage of softening agent required for the end-use product.

The invention will be further illustrated in greater detail by the following specific examples. It should be understood, however, that although these examples may describe in particular detail some of the more specific features of the invention, they are given primarily for purposes of illustration, and the invention, in its broader aspects, is not to be construed as limited thereto.

Example I

A polyvinyl-acetate binder is prepared as follows: 295 grams of a plasticizer, dibutoxyethyl phthalate, is added to 3,175 grams of a homopolymer polyvinyl-acetate resin dispersion of 55% solids. Ammonia is then added to raise the pH of the dispersion to approximately 7, and at this point, a small amount of antifoaming agent sold as Anti Foam A, by the Dow-Corning Co., is added to aid in processing. This dispersion is then diluted with 30 grams of water. No polyalkylene imine is included.

This binder dispersion is printed on a 200-gr./yd.², 100%-rayon, of 1½ denier, 2-inch fiber length, carded web in an intermittent pattern consisting of 4 horizontal wavy lines per inch. The print lines run the width of the web and cover less than 50% of the total surface area of the web. The total amount of binder picked up by the web on a dry-add-on basis, is between 35 to 40 gr./yd.². The fabric is then dried at approximately 240° F.

The dry strength and the wet strength of this fabric is then tested. This is done by randomly cutting 12 samples

the web and cover less than 30% of the total surface area of the web. The total amount of binder picked up by the web is about 43 gr./yd.². The fabric is then dried at approximately 240° F.

This fabric is then impregnated with an aqueous solution containing about 2/3% of a dialkyl dimethyl-ammonium chloride sold by the Armour Chemical Co. under the trade name "Arquad 2HT-75," to a moisture pickup of 150% of the weight of the fabric. The alkyl groupings in "Arquad 2HT-75" are approximately 25% hexadecyl groups and 75% octadecyl groups. This fabric is then dried at approximately 240° F. so that the final fabric contains approximately 1% of the softening agent, based on the final weight of the fabric.

This fabric is then tested for its strength when dry and when saturated with water. The fabric is then also tested for softness or flexural rigidity. The strength of the fabric is determined as described in Example I. The average dry strength of the fabric is 50. The average wet strength is determined as about 22.6. The ratio of wet strength to dry strength is approximately 45%.

The softness of the fabric is also determined. The softness or flexural rigidity of a fabric is determined by cutting four 8 1/2-inch-square samples randomly from the fabric. Each sample is then tested on a Thwing-Albert Handle-O-Meter, an instrument designed and manufactured by the Thwing-Albert Instrument Co. of Philadelphia, Pa., for testing the softness of flexural resistance of fabrics. A metal bar bends the fabric, and the resistance to flex is determined in milliamperes, which is converted to a softness figure. The average softness of this fabric, as determined by this machine, is about 88.

Example XII

A binder dispersion is prepared as described in Example XI. No polyalkylene imine is added to the dispersion, but it is applied directly to the base web. This fabric is not aftertreated with a chemical-softening agent, but is tested for dry strength and wet strength and also for softness as outlined in Example XI. The dry strength of the fabric is 54.0, and the wet strength is only 16.4, giving a ratio of wet to dry strength of only 30%. The softness of this fabric is poor, giving a reading of only 79 on the Thwing-Albert Handle-O-Meter.

Example XIII

A portion of the fabric made as described in Example II is aftertreated with 2/3% aqueous solution of a dialkyl dimethyl ammonium chloride sold by the Armour Chemical Co. under the trade name of "Arquad 2HT-75". The fabric is treated so as to pick up 1% of the softening agent based on the dry weight of the fabric. This fabric is also tested for dry and wet strength, and softness as described in Example XI. The softness of the fabric is excellent, giving a reading on the Thwing-Albert Handle-O-Meter of 88; but the dry strength is only 42.0, and the wet strength is just as poor being only 15.0. The ratio of wet strength to dry strength of the fabric is about 35%.

Example XIV

The procedure of Example XI is followed except that in the first instance the aftertreatment of the bonded web with the chemical-softening agent is conducted so as to allow for only 75% moisture pickup based on the weight of the final weight of the fabric. In the second instance the moisture pickup is controlled at 225% so that the final fabric contains 1 1/2% of the softening agent. In both cases results comparable to those obtained in Example XI are obtained.

Example XV

The procedure of Example XI is followed, except that a cationic softener, of the high-molecular-weight amine-acetate type sold by the Refined Products Co., under the trade name "Perma-Par RG," is substituted for the di-

alkyl dimethylammonium chloride. Similar results are obtained. The same procedure is again followed, but this time a long-chain compound containing secondary and tertiary amino groups in its structure, sold under the trade name "Sapamine" by the Ciba Co., Inc., is substituted for the dialkyl dimethyl ammonium chloride, and again similar results are obtained.

Example XVI

The procedure of Example XI is followed, except that the binder dispersion is polyvinyl chloride rather than polyvinyl acetate. Similar results are obtained.

Since many variations and modifications may be made in practicing this invention without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description shall be interpreted as descriptive and not in a limiting sense.

It is also to be understood that the inventive concept is not to be limited except by the scope of the appended claims.

What is claimed is:

1. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about 1/4% to about 2 1/2% by weight, based on the weight of said vinyl acetate resin polymer.

2. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improve therefor, a polyalkylene imine in an amount of from about 1/4% to about 2 1/2% by weight, based on the weight of said vinyl acetate resin polymer.

3. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein; said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about 1/4% to about 2 1/2% by weight, based on the weight of said vinyl acetate resin polymer.

4. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about 1/4% to about 2 1/2% by weight, based on the weight of said vinyl acetate resin polymer.

5. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and from about 1% to about 100% by weight of the web of a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl

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from the fabrics. The samples are 1" x 6" in size with the 6" dimension being the machine direction. The dry strength of the fabric is determined by placing the 4 samples in the jaws of a Scott-IP-4 Tester, an instrument designed and manufactured specifically for determining the strength of a fabric by Scott Testers, Inc. of Providence, R.I. A force is applied to each end of the sample until it breaks. When determining the wet strength of the fabric, a similar procedure is followed with the exception that before placing the fabric samples in the jaws of the Scott-IP-4 Tester, each sample is saturated with 3 cc. of water and allowed to dry for 30 seconds on a piece of kraft paper. This procedure is followed with 3 groups of 4 samples each in order to obtain an average result for the strength of the fabric. The wet strength of this fabric is only 28% of its dry strength.

Example II

A binder dispersion is prepared as described in Example I. To this binder dispersion approximately 14 grams of 50% aqueous polyethylene imine is added. The polyethylene imine has a molecular weight ranging from 30,000 to 40,000. This binder dispersion is applied in a similar manner and to a similar web as that described in Example I. This fabric is then tested for dry strength and wet strength as described in Example I. The wet strength of this fabric is increased to 37.8% of the dry strength. This degree of wet strength in a fabric is acceptable for many products, though there are certain uses for a nonwoven fabric where it is desired to attain a higher value for the wet strength such as in the cover for an absorbent medium.

Example III

A binder dispersion is prepared as described in Example I. To this binder dispersion approximately 35 grams of 50% aqueous polyethylene imine is added. The binder dispersion is then applied to a base web in the manner as described in Example I. This fabric is then tested for dry strength and wet strength as described in Example I. The wet strength of the fabric is 47.6% of the dry strength.

Example IV

A polyvinyl-acetate binder is prepared as follows: 39 pounds of a plasticizer, dibutoxyethyl phthalate, is added to 420 pounds of a homopolymer polyvinyl acetate-resin dispersion of 55% solids. Three pounds of ammonium hydroxide is then added to the dispersion and a small amount of an antifoaming agent, as well as other conventional agents to aid in processing. This dispersion is then diluted with 4 pounds of water. No polyethylene imine is included.

This binder dispersion is then printed on a 200-gr./yd.², 100%-rayon, of 1½ denier and 2-inch fiber length, carded web in an intermittent pattern of ring-like areas as described in U.S. Patent 2,705,688. The total amount of binder picked up by the web is approximately 35 to 40 gr./yd.². The fabric is then dried at approximately 240° F.

A water solution containing 1% of a 50% aqueous polyethylene imine is then separately padded on the aforementioned fabric to saturate the fabric, approximately 100% pick-up. The fabric is then air-dried and tested to determine its wet strength and dry strength.

The strength of the fabric is tested by randomly taking 5 samples from the fabric. The samples are 1" x 6" in size, with the 6" dimension being the machine direction of the fabric. The dry strength of the fabric is determined by placing each of the samples in the jaws of an Insko Tensile Tester, an instrument manufactured by the Insko Co. of Natick, Mass., specifically for testing tensile strengths of fabrics. A force is applied to the fabric until it breaks. When determining the wet strength of the fabric, a similar procedure is followed

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except immediately prior to placing the samples in the Insko Tensile Tester, they are saturated with 3 cc. of water and allowed to dry for 30 seconds on kraft paper. This procedure is followed with each individual sample in order to obtain an average result for the fabric tested. The wet strength of this fabric is only 10% of its dry strength.

Samples of this same basic fabric without the polyethylene imine aftertreatment are tested in the same manner in order to determine the wet strength and dry strength of the fabric. The wet strength of the fabric without the polyethylene imine aftertreatment is only 10% of its dry strength.

Example V

A binder dispersion is formulated as described in Example IV. To this dispersion approximately 4.7 pounds of 50% aqueous polyethylene imine is added. This dispersion is then printed on a similar base web and in a similar manner as that outlined in Example IV. In this experiment there is no polyethylene imine aftertreatment.

The wet strength and dry strength of the fabric produced in accordance with the above procedure is determined in the same manner as described in Example IV. The wet strength of the fabric is 40% of the dry strength of the fabric.

Example VI

A binder dispersion is prepared as described in Example I. To this binder dispersion approximately 55 grams of 50% aqueous polyethylene imine is added. This binder dispersion is applied in a similar manner and to a similar web as that described in Example I. Comparative results are obtained.

Example VII

The procedure of Example III is followed except that approximately 35 grams of 50% aqueous polymethylene imine is added to the binder dispersion rather than polyethylene imine. Similar results to those obtained in Example III are obtained.

Example VIII

The procedure of Example III is followed except that polypropylene imine is added to the binder dispersion instead of polyethylene imine. Similar results are obtained.

Example IX

The procedure of Example I is followed except that the binder dispersion is a copolymer of polyvinyl acetate and polyvinyl chloride rather than the homopolymer vinyl acetate. Similar results are obtained.

Example X

The procedure of Example I is followed except that the fibrous starting layer contains 50% rayon and 50% nylon. Similar results are obtained.

Example XI

A polyvinyl-acetate binder is prepared as follows: 15 grams of a plasticizer, dibutoxyethyl phthalate, is added to 160 grams of a homopolymer polyvinyl-acetate resin dispersion sold by E. I. du Pont de Nemours & Co. Inc. under the trade name of "Elvacet 81-900." The pH of the dispersion is raised to 7, and a small amount of antifoaming agent sold as Anti-Foam A by the Dow-Corning Co., as well as other conventional agents, are added to aid in processing. To this binder dispersion is added 1.5 grams of 50% aqueous polyethylene imine. The polyethylene imine has a molecular weight ranging from 30,000 to 40,000.

This binder dispersion is printed on a 200 gr./yd.², 100% rayon, of 1½ denier, 2-inch fiber length, carded web in an intermittent pattern consisting of 4 horizontal wavy lines per inch. The print lines run the width of

acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

6. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and from about 5% to about 35% by weight of the web of a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

7. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are cellulose fibers, and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein; said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about ½ % to about 1½ % by weight, based on the weight of said vinyl acetate resin polymer.

8. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are natural vegetable fibers, and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

9. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are regenerated cellulose fibers, and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

10. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are cotton fibers, and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

11. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are viscose rayon fibers and a binder material distributed throughout said web in adhesive bonding contact with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of said vinyl acetate resin polymer.

12. A soft, strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least about 50% by weight are viscose rayon fibers, and a binder material distributed throughout said

web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, said binder material possessing wet strength and comprising a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about ½ % to about 1½ % by weight, based on the weight of said vinyl acetate resin polymer.

13. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least 50% by weight are cellulose fibers, a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, the binder material possessing wet strength and comprising a vinyl resin polymer, and dispersed in said vinyl resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of the vinyl resin polymer, and from about ½ % to about 5% based on the weight of the fabric of a chemical softening agent selected from the group consisting of cationic surface-active agents and nonionic surface-active agents distributed substantially uniformly throughout the bonded fibrous web.

14. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least 50% by weight are cellulose fibers, a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, the binder material possessing wet strength and comprising a vinyl acetate resin polymer, and dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of the vinyl acetate resin polymer, and from about ½ % to about 5% based on the weight of the fabric of a chemical softening agent selected from the group consisting of cationic surface-active agents and nonionic surface-active agents distributed substantially uniformly throughout the bonded fibrous web.

15. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least 50% by weight are cellulose fibers, a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, the binder material possessing wet strength and comprising a vinyl resin polymer, and dispersed in said vinyl resin polymer as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of the vinyl resin polymer, and from about ½ % to about 5% based on the weight of the fabric of a dialkyl dimethyl ammonium chloride, said alkyl groups containing 8 to 18 carbon atoms, distributed substantially uniformly throughout the bonded fibrous web.

16. A soft and strong nonwoven fabric comprising a loosely assembled web of overlapping, intersecting fibers, of which at least 50% by weight are cellulose fibers, a binder material distributed throughout said web in spaced areas covering less than about 35% of the surface of the web and in adhesive bonding relationship with the fibers therein, the binder material possessing wet strength and comprising a vinyl acetate resin polymer, and dispersed in said vinyl acetate resin polymer as a wet strength improver therefor, a polyethylene imine in an amount of from about ¼ % to about 2½ % by weight, based on the weight of the vinyl acetate resin polymer, and from about ½ % to about 5% based on the weight of the fabric of dialkyl dimethyl ammonium chloride, said alkyl groups containing 8 to 18 carbon atoms, distributed substantially uniformly throughout the bonded fibrous web.

17. A method of forming a soft and strong nonwoven

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11 fabric having improved wet strength which comprises bonding a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are cellulose fibers with a binder material comprising a dispersion of a vinyl acetate resin polymer, and, dispersed in said vinyl acetate resin polymer dispersion as a wet strength improver therefor, a polyalkylene imine in an amount of from about ¼% to about 2½% by weight, based on the weight of the vinyl acetate resin polymer, said polyalkylene imine being dispersed in said vinyl acetate resin polymer dispersion prior to its application to said web.

18. A method of forming a soft and strong nonwoven fabric having improved wet strength which comprises bonding a loosely assembled web of overlapping, intersecting fibers of which at least about 50% by weight are cellulose fibers with a binder material comprising a dispersion of a vinyl acetate resin polymer and, dispersed in said vinyl acetate resin polymer dispersion as a wet strength improver therefor, a polyethylene imine in an amount of from about ¼% to about 2½% by weight, based on the weight of the vinyl acetate resin polymer, said polyethylene imine being dispersed in said vinyl acetate resin polymer dispersion prior to its application to said web.

19. A method of forming a soft and strong nonwoven fabric having improved wet strength and softness which

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comprises bonding a loosely assembled web of overlapping and intersecting fibers, of which at least 50% by weight are cellulose fibers, in a pattern of spaced binder areas covering less than about 35% of the surface of said web, with a binder material comprising a dispersion of a vinyl resin polymer and dispersed in said vinyl resin polymer as a wet strength improver therefor, a polyalkylene imine in the amount of from about ¼% to about 2½% by weight, based on the weight of the vinyl resin polymer, said polyalkylene imine being dispersed in said vinyl resin polymer dispersion prior to the application of said dispersion to the web, and applying to said bonded fibrous web from about ½% to about 5% of a chemical softening agent selected from the group consisting of cationic surface-active agents and nonionic surface-active agents and drying the same.

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