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MANUFACTURE OF NONWOVEN FABRICS

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This invention relates to non-woven fabrics of high wet strength and more particularly to porous, non-woven fabrics containing caustic alkali treated polyvinyl alcohol.

Unwoven porous fabrics usually comprise a major amount of cellulose fibers to give strength with a minimum but considerable amount of wool fibers to produce bulk and porosity. There are two main types, consisting of those from fibers that are long enough to operate on a textile carding machine and those that are too short for use in this equipment but which are adapted to operate in mechanisms that are designed to convert fibrous materials into paper. The long fiber type is usually converted into a felt by combining a number of laps of carded fibers in the dry state and felting by means of heat and pressure or by mechanical treatment in aqueous systems that promote integration of the fibers into a more or less felted condition. The short fiber type is usually converted into a felt by the wet method which consists in preparing the fibrous ingredients in a paper beater, Jordan engine or both, and then forming the felt on a wire screen, pressing out excess water and drying by passage over heated metal cylinders. Recently a type of cellulose fibers of paper making length has been developed for this wet method of felt formation by treating chemical wood pulp fibers previous to felt formation with a strong caustic alkali solution to give them a crinkle. Felts of the short fiber type have been prepared also by treating a waterleaf web of paper fibers with a strong caustic alkali solution, festooning the alkali saturated sheet in air to dry slowly and converting the caustic alkali to alkali carbonate crystals, washing and then drying. This method forms a product that is very porous, soft, water-absorbent and of moderate wet strength, but it is not strong enough in the wet state to compete with materials in its cost category. Felts have been prepared by treating waterleaf webs of paper fibers with strong alkali solutions at low or high temperatures and removing the alkali promptly by washing. The process cannot be operated economically because the sheet is too weak to wash effectively at high speed, and the product is too weak for most uses.

This invention has as an object the development of a web that has sufficient strength in strong caustic alkali treated liquor to permit high speed handling. Another object is to provide a process for the manufacture of non-woven fabrics of high wet strength. Another object is to provide a process for the manufacture of a

soft, porous, non-woven, felt-like product with sufficient wet strength so it may be handled without tearing in use. Another object is to produce a new non-woven fabric. Still another object is to provide a method for the manufacture of a soft, porous, felt-like product that does not "lint." Other objects will be apparent from the following description of the invention.

These objects are achieved by applying to a non-woven web of fibers a solution of polyvinyl alcohol, impregnating the web with a solution of at least 0.5 normal concentration of an alkali metal hydroxide or a basic reacting alkali metal salt, e. g. those salts giving an aqueous solution having a pH greater than 7, washing free from alkali and drying.

The webs may be prepared by any of the well-known methods of preparing webs from fibers of the nature covered by this invention. When webs are used that are made from fibers of carding length, they are passed between screens, and while in this condition, they are passed through a solution of polyvinyl alcohol and then passed between rolls to remove excess polyvinyl alcohol solution, dried and wound into a roll. They are then passed without any support through a bath of an aqueous sodium hydroxide solution of 0.5 normal concentration to 12.0 normal concentration at -10 to $+100^{\circ}$ C., washed free from alkali and dried by passage over steam heated cylinders or by passage through a heated chamber in a stretched condition or as festoon loops. When webs are used that are made from fibers of paper making length, the polyvinyl alcohol solution is applied by spray or roll to the sheet in the wet press system, passed over drying cylinders to attain a moisture content of 20-10 per cent, passed through a solution of sodium hydroxide of at least 0.5 normal concentration at -10 to $+100^{\circ}$ C., washed free from alkali and dried by passage over drying cylinders. The preferred temperatures of treatment are -5 to $+40^{\circ}$ C.

The fibers of carding length may be cotton, flax, ramie, jute, pineapple, musa textilis, banana or viscose staple, in the bleached or unbleached condition. The fibers of paper making length may be sulfite, sulfate, soda, rag, rope, or ground wood either in bleached or unbleached condition. The polyvinyl alcohol should be of the hot water soluble type with an intrinsic viscosity as a 4 per cent aqueous solution at 25° C. of 4 to 100 centipoises and a saponification value under 100. Polyvinyl alcohols with intrinsic viscosities of 10 to 80 and with saponification values below 20 are preferred. The caustic alkali may be sodium,

potassium or lithium hydroxides. Alkali metal salts which are basic reacting in aqueous solutions, e. g., which form aqueous solutions having a pH greater than seven, are also useful and include sodium, potassium or lithium carbonates, trisodium phosphate, sodium silicate, and the like. The sodium, potassium or lithium alkalis may contain, besides the hydroxides, considerable amounts of carbonates or chlorides.

The following examples will serve to illustrate this invention without limiting it thereby:

Example I

A sheet of waterleaf porous paper in the dry condition is sprayed on one side with a 5 per cent solution of polyvinyl alcohol in sufficient amount to give a 2% polyvinyl alcohol based on the fibers, dried 90 seconds by pressing against a cylinder heated with 10 pounds steam pressure, passed through a 10% aqueous solution of sodium hydroxide at 5° C., washed in water at 25° C. until free from alkali and dried by passing over a steam heated cylinder. The waterleaf sheet before treatment is of 100 pounds ream weight, 0.037" thick and consists of bleached sulfite high alpha cellulose from wood. The polyvinyl alcohol has a specific viscosity of 23 centipoises and a saponification value of 8. The sheet is then passed over a knife edge under tension to increase the pliability. It is soft, rapidly wetted by water, tough when dry or wet, and it does not "lint" when rubbed on a wet smooth glass plate. Its wet strength is 1.75 pounds for a strip 0.5" wide. A control sheet that is sprayed with water only and dried before treatment disintegrates completely on passing through the sodium hydroxide solution. The sheet containing polyvinyl alcohol becomes tough and rubber-like at the instant that it is impregnated with the sodium hydroxide solution, and it retains this strength throughout the washing and drying treatments.

Example II

To a web of kraft fibers a 5 per cent solution of polyvinyl alcohol is applied in the stage just ahead of the drier system in sufficient amount to give 3 per cent polyvinyl alcohol, based on the fibers. The sheet is passed over the steam heated drier system, passed through a 20% aqueous solution of sodium hydroxide at 25° C., washed free from alkali, passed over a drier system and then over a knife edge to soften. The sheet is much softer than ordinary waterleaf kraft, feels like a chamois skin when wet, but is considerably denser than the product of Example I. Its wet strength from a strip 0.5" wide is 2.62 pounds in contrast to wet strength of 0.04 pound for a sample of the same paper that is given the same treatment with aqueous sodium hydroxide solution but with the omission of the polyvinyl alcohol application step. Basis weight of sheet is 50 pounds per ream. The polyvinyl alcohol used has an intrinsic viscosity as a 4% solution at 25° C. of 78 centipoises and a saponification value of 14.

Example III

A web is prepared by carding a good ordinary grade of 1" staple cotton fibers and combining six of these carded webs into a continuous web with the fibers of alternate layers aligned in diagonal directions to the main direction of the web. After compressing and passing between metal screens, the web is impregnated with an 8% solution of polyvinyl alcohol having an intrinsic viscosity of 54 centipoises and a saponifi-

cation value of 6. The web is compressed sufficiently to leave enough polyvinyl alcohol solution to make 10%, based on the fibers, and dried. The dry web is then passed without support through a 24% aqueous solution of potassium hydroxide at 30° C., washed free from alkali, sprayed with a solution of glycerol in sufficient amount to make 0.5% based on the fibers, dried and passed over a knife edge to increase the pliability. Its wet strength from a strip 0.5" wide is 11.8 lbs. in contrast to a wet strength of 1.1 lbs. for a sample of the same material that is given the same treatment with aqueous potassium hydroxide solution with omission of the polyvinyl alcohol treatment.

Example IV

Viscose rayon staple of 2" length is carded into a continuous web, and four of these webs are combined into a mat and treated with polyvinyl alcohol as in Example III except that it is squeezed to leave 15% polyvinyl alcohol based on fibers. The dried web containing polyvinyl alcohol is passed through a 20% solution of trisodium phosphate at 60° C., washed free from sodium phosphate and dried. The product is a porous, soft felt with a wet strength of 12.3 lbs. for a strip 0.5" wide in contrast to a wet strength of 0.1 lb. for a sample of the same material that is given the same treatment with aqueous trisodium phosphate solution and with omission of the polyvinyl alcohol treatment.

Example V

Thirty parts of a middling grade of cotton fibers are blended with 70 parts of fiber glass of about the same diameter and length by picking and carding into laps, and these are combined into a mat as in Example III. This mat is supported between wire screens and passed through a 5% aqueous solution of polyvinyl alcohol, having an intrinsic viscosity as a 4% solution at 25° C. of 42 centipoises and a saponification value of 24, passed between rolls to squeeze out excess solution and leave enough to make 5% polyvinyl alcohol based on the dry fiber weight, dried and wound into a roll. This dried mat is then passed, without support, into a solution at 25° C. containing sodium hydroxide 15 parts, sodium chloride 15 parts and water 70 parts, washed free from alkali and dried. The product is porous, of high dielectric value, and has a wet strength for a strip 0.5" wide of 5.2 lbs. in contrast to a wet strength of 0.7 lb. for a sample of the same material that is given the same treatment with aqueous sodium hydroxide and sodium chloride solution with omission of the polyvinyl alcohol treatment.

Example VI

To a web of unbleached sulfite fibers a 5% solution of polyvinyl alcohol identical with that recorded in Example I is applied in the stage just ahead of the drier system in sufficient amount to give 4% based on the fibers. The sheet is passed over steam heated cylinders to dry, passed through a solution of sodium carbonate (25% Na_2CO_3), and it is then festooned at a temperature below 25° C. and at a relative humidity corresponding to at least 65% at 25° C. until the sheet is dry. The sheet is then washed free from alkali and dried. It is soft, bulkier than the product of Example II and lint free when used to wipe a wet glass surface.

The webs which have been treated with a poly-

vinyl alcohol solution may be treated with alkali solutions of suitable concentration before they are dried, when the treating solutions are below 10° C. or at higher temperatures when they contain a small amount of borax. Methods of treating the webs with alkali solutions are not restricted to spraying or dipping. Just enough alkali solution may be applied to the web to wet it entirely, or an excess of alkali solution may be added, and then the excess may be removed by squeezing, etc. Treatment with alkali solutions at temperatures below 10° C. produces the greatest sheet porosity and wet strength. Treatments at room temperature are in many cases most economical, and treatments at temperatures up to 100° C. are effective when the time is limited sufficiently to avoid degradation. The sheets develop the maximum strength effect just as soon as the alkali solution penetrates them throughout, and this time of penetration varies from less than one second to several minutes, depending on the density of the original webs, temperature and concentration of the alkali solution, ratio of the polyvinyl alcohol to fibers, and wetting agents employed. The webs may be washed countercurrently in cold dilute solutions of the same material as that used for treating or in water at room or higher temperatures, although room temperature is preferred. Washing rate is increased by passing the web between squeeze rolls after each addition of wash liquors.

The caustic alkali solution can be made from commercial grades of lithium, sodium, or potassium hydroxides which may contain considerable amounts of the chlorides or carbonates and smaller amounts of other common impurities. In the case of the basic reacting salts the sodium silicate solutions may vary in ratio of the sodium to SiO_2 , but those of the high sodium ratio are most effective. Trisodium phosphate of all commercial grades is useful. Borax in small amounts may be added to any of the alkali solutions to increase the speed of "setting" of the polyvinyl alcohol in the fabric. The strength of the alkali solution may vary according to the results desired. Solutions of from 0.5 normal concentration up to the upper limit of solubility at the temperature used of the alkali hydroxide or basic reacting salt may be employed. A 0.5 normal solution of NaOH is a 2% solution by weight. Twelve normal, or 48% concentration by weight, is about the upper limit of operability for NaOH since compositions containing higher percentages of NaOH are no longer sufficiently fluid at the lower temperatures of treatment.

The fibers may be of any length that is operable on a carding machine or of any length that is operable in paper making machines. They may be fibers of animal origin, natural cellulose fibers or synthetic fibers such as staple from viscose, cellulose ethers or polymeric resins. Fibers of animal origin may be used with the alkali solutions only at low temperatures and only for brief periods of treatment. Mixtures of the various fibers may be used to obtain certain desired effects.

The polyvinyl alcohols that are useful are tough, water-white resin-like materials which are usually obtained by the hydrolysis of polyvinyl esters, such as polyvinyl acetate. They are difficultly soluble to insoluble in cold water, but all of them are soluble in hot water and remain dissolved when the solution is cooled. Although polyvinyl alcohol may be made in a number of modifications of various degrees of polymeriza-

tion, those only are useful that have an intrinsic viscosity as a 4% aqueous solution at 25° C. of 4 to 100 centipoises and saponification values below 100. The term "polyvinyl alcohol" is used herein and in appended claims to designate generically pure polyvinyl alcohol and also such partial derivatives thereof that contain a sufficient number of free hydroxyl groups to render the composition soluble in hot water.

Various softeners may be applied to the sheet after it is washed free from alkali and before or after drying. Useful softeners are formamide, ethanol formamide, ethanol acetamide, glycerol, invert sugars, certain hygroscopic salts, such as sodium lactate, and the higher fat alcohol sulfates. The ratio of softeners to polyvinyl alcohol may vary in a wide range, but 2 to 20%, based on polyvinyl alcohol, represents the preferred range.

The ratio of polyvinyl alcohol to fibrous ingredients may vary from 0.1 to 100% based on dry fiber weight. The preferred range is 0.5 to 15.0%.

The penetration of the caustic alkali solution into the fabric may be assisted by addition of small amounts of surface active substances of the type of mercerizing assistants and wetting agents for mercerizing solutions. Compounds of this type are described in U. S. No. 2,033,125 and in U. S. No. 2,033,819.

The products are useful as bases for coating with pyroxylin, rubber, drying oils and resin compositions such as in the manufacture of synthetic leather. They are useful also for purposes where natural chamois are employed, for certain items of clothing, pillow slips, towels and other purposes where high degree of water absorption, softness, high wet strength and low cost are desirable.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended patent claims.

I claim:

1. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength which comprises applying to the said low wet strength non-woven web of fibers polyvinyl alcohol having an intrinsic viscosity of 4 to 100 centipoises as a 4% aqueous solution at 25° C. and having a saponification value below 100, and then impregnating the web with an aqueous solution of at least 0.5 normal concentration of a compound of the class consisting of alkali metal hydroxides and basic reacting alkali metal salts.

2. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength which comprises applying to the said low wet strength non-woven web of fibers polyvinyl alcohol having an intrinsic viscosity of 4 to 100 centipoises as a 4% aqueous solution at 25° C. and having a saponification value below 100, and then impregnating the web with an aqueous solution of at least 0.5 normal concentration of sodium hydroxide.

3. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength

which comprises applying to the said low wet strength non-woven web of fibers a polyvinyl alcohol solution, then impregnating said web with an aqueous caustic alkali solution of from 0.5 to 12.0 normal concentration, washing same free from alkali and drying.

4. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength which comprises applying to the said low wet strength non-woven web of fibers a polyvinyl alcohol solution, said polyvinyl alcohol having an intrinsic viscosity of from 4 to 100 centipoises when in a 4% solution in water at 25° C. and having a saponification value below 100, then passing said web through an aqueous solution of at least 0.5 normal concentration of a compound of a class consisting of alkali metal hydroxides and basic reacting alkali metal salts at a temperature between -10° C. and +100° C., washing said treated web free from alkali and drying same.

5. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength which comprises applying to the said low wet strength non-woven web of fibers of paper making length an aqueous solution of polyvinyl alcohol having an intrinsic viscosity of from 4 to 100 centipoises when in a 4% solution in water at 25° C. and having a saponification value below 100, while the said web is in the wet press system, then drying same so as to obtain a moisture content of from 10 to 20% and passing said dried web through a solution of sodium hydroxide of at least 0.5 normal concentration at a temperature between -10° C. and +100° C., washing the web free from alkali and drying same.

6. As a new article of commerce a soft, porous,

felt-like, non-woven web of fibers having a high wet strength containing polyvinyl alcohol and obtainable by applying to an untreated soft, porous, felt-like, non-woven web of fibers having a low wet strength polyvinyl alcohol having an intrinsic viscosity of 4 to 100 centipoises as a 4% aqueous solution at 25° C. and having a saponification value below 100, and then impregnating this web with an aqueous solution of at least 0.5 normal concentration of a compound of the class consisting of alkali metal hydroxides and basic reacting alkali metal salts.

7. As a new article of commerce a soft, porous, felt-like non-woven web of fibers having a high wet strength containing polyvinyl alcohol and obtainable by applying to an untreated soft, porous, felt-like non-woven web of fibers having a low wet strength polyvinyl alcohol having an intrinsic viscosity of 4 to 100 centipoises as a 4% aqueous solution at 25° C. and having a saponification value below 100, and then impregnating this web with an aqueous solution of at least 0.5 normal concentration of sodium hydroxide at between -10 and +100° C. and then washing the web free from alkali.

8. The process for the preparation of a soft, porous, felt-like, non-woven web of fibers having a high wet strength from a soft, porous, felt-like, non-woven web of fibers of low wet strength which comprises applying to the said low wet strength non-woven web of fibers polyvinyl alcohol having an intrinsic viscosity of 10 to 80 centipoises as a 4% aqueous solution at 25° C. and having a saponification value below 20, then drying the web so as to obtain a moisture content of from about 10 to about 20%, then impregnating the web with an aqueous caustic alkali solution of from 0.5 to 12.0 normal concentration at a temperature of from about -5° C. and about +40° C. and then washing said web free from alkali and drying.

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