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OPEN WEAVE ENDLESS FABRIC AND METHOD FOR PRODUCING THE SAME

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This invention relates generally to the treatment of non-metallic fabrics made of synthetic resinous materials to make them stable under the particularly adverse conditions encountered in certain end uses.

More particularly, the present invention relates to a process for the treatment of non-metallic fabrics, including belt-like structures, having specific characteristics which adapt them for specialized uses, many of which could not heretofore be fulfilled by non-metallic fabrics, as well as for uses in which they achieve results which are superior to those heretofore achieved by metallic or non-metallic fabrics. Fabrics treated in accordance with the present invention may be used, for example, in papermaking and related processes as a replacement for and improvement upon the metallic screen structures heretofore used as Fourdrinier wires, or in the construction of forming cylinders, filters, dandy rolls and similar devices. Endless fabrics for use as Fourdrinier cloths are particularly important products to be treated by the process of this invention and will be emphasized in the following disclosure but by such emphasis it is not intended to limit the invention to this particular form of endless fabric.

This invention is particularly useful in connection with the treatment of a fabric woven from yarns of synthetic fibrous material in multi-filament, mono-filament, staple fiber or other suitable forms or combinations thereof. "Yarns" is employed throughout this specification and in the appended claims in this broad sense and is intended to encompass fabrics woven of multi-filament, mono-filament and staple fiber, etc., forms. By the selection of particular yarns or combinations thereof and as a result of weaving and handling techniques, the fabric will have many desirable characteristics. The process of the present invention imparts additional characteristics to the woven non-metallic fabric to provide final products of unique quality. The treatment in accordance with the process of the invention of such fabrics for use in the papermaking field opens new horizons in quality of paper and simplification of papermaking machinery.

Fabrics of one general type which may be treated in accordance with the present invention and which are capable of the uses described above are disclosed and claimed in U.S. Patent No. 2,903,021, granted September 8, 1959. It is intended to incorporate by reference the disclosure of that patent. As disclosed in that patent, it is preferred that non-metallic fabrics, useful, for example, as Fourdrinier cloths and made from the synthetic materials which are suitable and available at the present time, be woven in endless form to avoid the need for joining or splicing. Also, as disclosed in said patent, it is preferred that the yarns, whether mono-filament, multi-filament, staple fiber or other construction, that are woven as the weft or wefts in the loom, extend in helical form circumferentially of the endless belt when it is finished and ready for its intended use. However, the present invention is not limited to use in connection with such endless-woven fabrics and may be used with fabrics that have been spliced or otherwise joined to make them endless.

Fourdrinier cloths and other open-weave cloths made of synthetic resin yarns or twines possess high tensile

strength and substantial resistance to abrasion, fatigue during flexing and the like, whether wet or dry. The nylons or polyamide yarns, are particularly suitable for use in the yarns. While fabrics of synthetic resin yarns possess certain excellent properties, they suffer from certain disadvantages. Being normally smooth in surface, they have a tendency to slip or shove which is manifested by lack of dimensional stability. Thus, the wires tend to slip producing openings of uneven dimensions. The disadvantages of dimensional instability are apparent. This is particularly true in a Fourdrinier cloth where the spacing between the wires must be maintained substantially constant. Also, fabrics of the synthetic resins, while reasonably stiff, lack the stiffness required in a Fourdrinier cloth.

Said Patent No. 2,903,021 discloses the desirability of suitable treatment or other finishing steps to stabilize or otherwise condition the fabric to meet the demands which will be placed upon it. The present invention affords an improved process for improving the resistance to shoving or slipping of the yarns of endless fabrics, which at the same time improves the stiffness and abrasion-resistance of the fabric. In the process of the present invention the fabric is desirably tensioned in both directions to establish predetermined lengthwise and widthwise dimensions, with uniform yarn counts throughout each dimension, and squaring of the fabric so that every transverse yarn thereof is at right angles to the longitudinal yarns and the critical treatments and/or finishing operations are carried out while the fabric is maintained under such conditions. In the process of the invention the non-metallic fabric is subjected to a chemical treatment, preferably followed by a setting treatment to improve the qualities of the fabric. To simplify the present disclosure the treatment of Fourdrinier cloths and the stabilization thereof will be utilized as typical examples, but other open-weave fabrics can also be stabilized by the process.

Fourdrinier cloths which are treated in accordance with the process of the present invention will have dimensional stability, including weave stability or resistance to shoving, and improved stiffness and abrasion resistance. Also, they will have uniform porosity because the yarn count is made permanently uniform. The transverse yarns are permanently set precisely square with the body of the fabric and with the longitudinal yarns. For all of these reasons the finished fabric will have the ability to avoid wrinkling. All of these characteristics are exhibited in such degree as to make such fabrics preferable in many respects to the metallic Fourdrinier wires heretofore utilized in the paper industry.

It is an object of the present invention to improve the dimensional stability of non-metallic fabrics made of synthetic resinous materials.

It is also an object of the present invention to improve the dimensional stability, stiffness, abrasion-resistance and other qualities of an endless open-weave Fourdrinier cloth made of a synthetic resinous material.

It is a further object to improve an endless open-weave Fourdrinier cloth of synthetic resinous yarns by treaatment with a phenolic-aldehyde resin.

Additional objects of the present invention will be apparent from reading the present specification.

The process of the invention comprises treating an open-weave synthetic resin fabric, particularly a Fourdrinier cloth as described in said U.S. Patent No. 2,903,-021, in extended or open form with a phenolic-aldehyde resin and drying, curing and hardening the phenolic-aldehyde resin on the endless fabric while the fabric is maintained in extended form. The endless fabric may be constructed of various synthetic yarns, such as of nylon, in-

cluding nylon 6–6, nylon 6–10, nylon 11, nylon 6, etc. The yarns may be in various constructions.

The present invention resulted from an intensive research investigation in which endless synthetic resin fabrics of open weave were subjected to treatments with many synthetic resins. Although resins of many types were tested, it was found that the excellent dimensional stability, shove resistance, stiffness and abrasion resistance made possible by the present invention was obtained only by the use of phenolic-aldehyde resins. It was unexpected that resins of this type would provide results substantially superior to resins of most other types, particularly to fabrics woven of yarns of nylon. While it is not intended to be bound by any theory or mechanism by which the present invention achieves its unique results, it is believed that the phenolic-aldehyde resins have the unique property of first swelling the synthetic resins yarns of the open-weave fabric, so as to permit superior bonding of the phenolic-aldehyde resin to the fabric. This initial swelling action is an important feature of the present invention. Thereby an integral bond is formed between the phenolic-aldehyde resin and the yarns providing superior results to those obtained with other types of resin coatings.

The phenolic-aldehyde resin is applied to the endless open-weave fabric by applying to the fabric, desirably in an extended, open or ungathered condition, preferably under slight tension, a solution of a phenolic-aldehyde resin. The resin solution is desirably in the form of an aqueous or an alcoholic solution. The fabric while still maintained in extended form, is then subjected to sufficient heat to dry, cure and harden the phenolic-aldehyde resin and preferably heat set the yarns of the synthetic resin fabric. It is desirable that the solids of phenolic-aldehyde resin coating shall constitute from about 10 to 35% by weight of the fabric, with preferred results being obtained with a resin pick up of between about 15 and 30%. Best results are obtained with a coating of between about 20 and 25%. Solutions of phenolic-aldehyde resin of various concentrations of resin solids may be employed in providing that sufficient resin is picked up by the fabric from the resin solution. The amount of resin pick up will be somewhat dependent upon the closeness of the weave of the fabric, as well as the concentration of the resin solution. With smaller openings, the fabric tends to retain larger amounts of the phenolic-aldehyde resins. It is generally desirable not to exceed a resin pick up of about 35% as amounts in excess tend to plug up or fill the holes of the fabric. For many uses, such as in papermaking, a fabric, such as a Fourdrinier cloth, must remain in its open weave condition to permit free passage of liquids. A resin pick up of less than about 10% may not impart the full advantages of the present process.

In accordance with the preferred mechanical aspects of the process of the present invention, the endless fabric is placed under longitudinal tension and a portion placed simultaneously under transverse tension to establish in that portion desired widthwise and lengthwise dimensions and accuracy as to the count of yarns and squareness, and progressively advancing the endless fabric through an endless path with the result that the entire length of endless fabric is eventually moved through a zone of travel in which said desired conditions exist. In such zone the fabric is subjected to treatment, for example it may be heated to such temperature as to set the fabric, in the case of fabrics made of heat-settable material, and/or to dry, cure and harden the phenolic resin applied to the fabric as a critical part of this process. Preferably, the process also provides for maintaining the fabric under tension or in an extended position until the phenolic resin has been cured sufficiently. One such preferred treatment and apparatus for such treatment is that disclosed in the copending application of one of us, Donald R. Christie and Arthur Schieff, Serial No. 22,973, filed April 18, 1960. It is intended to incorporate by reference the disclosure of said application in its entirety.

Among the phenolic-aldehyde resins which may be employed are resole and novolac resins, although if a novolac resin is employed it is necessary to provide additional aldehyde so as to contribute enough aldehyde to provide a molar ratio of aldehyde to phenol of at least 1 to 1 and thus impart thermo-setting characteristics to the phenolic-aldehyde resin. The resole or "A"-stage phenolic-aldehyde resins and the novolac resins are well known products, with which the resin chemist is familiar. The resole resins are produced by condensing a phenolic substance with a molecular excess of an aldehyde in the presence of an alkaline catalyst. Desirably the resole resin is produced by polymerizing at least about 1.1 moles of aldehyde for each mole of phenolic substance. In most cases it is not necessary to exceed a molar ratio of 1.5 to 1 of aldehyde to phenol. Larger ratios may be employed, but only at a loss in economy.

The phenolic component of the resin may be any mono- or poly-hydric phenol, preferably mononuclear, such as phloro-glucinol, resorcinol, orcinol, o-, m-, and p-cresols and, of course, phenol per se. The phenolic component should desirably be unsubstituted in at least one ortho or para position to a hydroxyl group, otherwise it is impossible to produce a cross-linked, thermo-setting resin upon curing. Preferably, the phenolic component shall contain an average of at least about 2.2 unsubstituted reactive sites in the nucleus, i.e., unsubstituted carbon atoms ortho and para to a hydroxyl group. Thus, ortho-creasol, which has one ortho and a para position unsubstituted, has two reactive sites. Phenol, per se, has two ortho positions and one para position unsubstituted for a total of 3 reactive sites. When ortho-cresol and phenol are employed as a mixture of phenolic components, the proportions of each are preferably calculated to provide a mixture containing an average of at least about 2.2 unsubstituted reactive sites.

The aldehyde component of the resole resin may be any aliphatic aldehyde containing up to 4 carbon atoms, such as propionaldehyde, acetaldehyde and formaldehyde. However, it is preferred to employ a lower aliphatic aldehyde containing not more than 2 carbon atoms. Formaldehyde is preferred. Formaldehyde may be employed in any of the commercial forms in which it is available. Thus, the aqueous solution, sold under the name formalin, which contains 37% by weight of formaldehyde in water with about 1 to 15% methanol added to prevent polymerization of the formaldehyde during storage, has been found to be very satisfactory for this purpose. Other aqueous solutions of formaldehyde containing various percentages of formaldehye, such as 30 to 60% by weight, may also be employed. Also, other formaldehyde donors which liberate formaldehyde may be employed, such as the well-known paraformaldehyde and hexamethylenetetramine. Also, acrylic aldehyde and glyoxal may be used.

It has been discovered that in accordance with a preferred embodiment of the process of the invention, superior results are obtained by employing a two-stage resin treatment of the endless, open-weave, synthetic resin fabric, such as a Fourdrinier cloth, with each stage employing a different type of resin treatment. In the first-stage of the preferred embodiment, the endless fabric is treated with a phenolic-aldehyde resin, desirably one having a molar ratio of aldehyde to phenol of less than 1 to 1, such as a novolac resin. After drying and only partially curing the phenolic-aldehyde resin absorbed during the first-stage, the fabric is subjected to a second-stage treatment employing an amino-aldehyde resin, such as a melamine-, urea- or substituted urea- or melamine-aldehyde resin. The amine aldehyde resin shall desirably contain a sufficient molar excess of aldehyde to compensate for any molar deficiency of aldehyde in the phenolic-aldehyde resin employed in the first stage and to thereby contribute sufficient aldehyde to provide a ratio of aldehyde to phenol in excess of 1 to 1.

When employing the preferred two-stage resin treatment of the present invention, it is desirable to provide a pickup of phenolic-aldehyde resin of about 5% to 10% by weight of the endless fabric in the first stage and about 10% to 20% by weight of amino-aldehyde resin in the second stage. Respective pickups of 5% and 15% in the first and second stages provide optimum dimensional stability, shove resistance, stiffness and abrasion resistance.

The amino-aldehyde resins are a well-known class of polymers. Among the amino-aldehyde resins which may be employed are condensation products of an aldehyde with an amine or amide such as urea, thiourea, melamine, aniline, etc., as well as substituted amines and amides of this class. The aldehyde of the resin may be any of those containing up to 4 carbon atoms employed in producing the phenolic-aldehyde resin of the first stage. However, for practical reasons, formaldehyde and formaldehyde-liberating substances are preferred.

Upon reaction with formaldehyde, the amines or amides may form intermediate methylol derivatives of the amines or amides and these methylol derivatives may be employed in the second-stage treatment of the invention. Upon further heating the methylol derivatives may be converted to liberate excess formaldehyde and to form the amino-aldehyde polymers useful in the invention. The methylol-amine intermediates are produced at a pH of about 7, whereas at a pH of substantially lower than 7, methylene bridges form between the molecules of amine resulting in an amino-aldehyde polymer.

The amino-aldehyde resins are desirably produced in a molar ratio of aldehyde to amine in excess of about 1 to 1 and preferably of at least about 2 to 1. Sufficient aldehyde should be present not only to provide a thermosetting amine-aldehyde resin but to compensate for any deficiency in the molar ratio of aldehyde to phenol in the resin employed in the first stage. In the case of melamine-aldehyde resins, it is desirable to employ a molar ratio of aldehyde to melamine of at least about 3 to 1.

The final resin coating produced in accordance with the preferred two-stage process of the invention is probably a mixed phenolic, amino-aldehyde copolymer resin with the resin integrally linked to the yarns of the fabric by means of methylene bridges.

Treated fabrics produced in accordance with the preferred two-stage process of the invention have optimum stiffness, abrasion resistance, dimensional stability and a minimum of degradation of the yarns of the treated fabric.

Tests have indicated that reversing the order of resin treatments in the preferred two-stage process of the invention produces an inferior product. When the phenolic-aldehyde and amino-aldehyde resins are mixed together and employed in a one-stage treatment, the results are also unsatisfactory. Similarly, amino-aldehyde resins, when employed alone, do not provide results as satisfactory as a phenolic-aldehyde resin or of the preferred two-stage treatment of the invention.

In a typical method of treating a Fourdrinier cloth woven endless from nylon yarns of any desired construction in both warp and weft, having been constructed in accordance with specifications which include length, width, transverse yarn count and longitudinal yarn count, a length (circumference of the tube) of slightly less than the desired length may be employed. For example, in a particular fabric, depending on the specific yarns used in both warp and weft, the woven length may be slightly less than the desired final length. It should be pointed out that for existing papermaking machines, at least, the length is critical and it is most important that the fabric be stabilized to minimize any tendency toward an increase in length in use. The woven warp count may be slightly more than the desired transverse yarn count, the percentage of such increase being carefully calculated to correspond with the amount by which the woven length is less than the desired final length.

The fabric is then placed upon treatment apparatus so that the fabric is extended in an open, flat condition, the transverse and longitudinal yarns at true right angles to each other.

While under slight tension, a solution of phenolic-aldehyde resin is applied to the fabric and the resin dried at a moderately elevated temperature, cured at a higher temperature and the fiber in the fabric heat-set and the resin coating further cured at still a higher temperature. During these operations the tension on the fabric may progressively increase its length before curing or heat setting occurs. During the curing and heat setting the fabric is maintained under such tension as is required to hold it slightly above desired length when heat setting temperature is applied to the fabric.

During the drying of the resin or the fabric a temperature of about 100–125° C. is desirably employed. At this temperature range, as the moisture evaporates from the fabric, the temperature of the fabric will be somewhat less than 125° C. and will not exceed about 125° C. when the fabric is completely dry. Thus during the entire drying operation premature or extensive curing may be minimized.

The drying temperature of about 100–125° C. is appropriate for aqueous solutions, suspensions or the like and other temperatures may be appropriate for materials from which some other vehicle is to be evaporated.

After drying of the resin and any desired elongation of the impregnated fabric to the finished length, additional heat may be applied to cure the impregnating and coating phenolic resin. A temperature of about 175° C. is usually sufficient. At this temperature there is relatively little effect upon nylon fabric but the impregnating resin will cure to a degree which is dependent upon the time of exposure to such temperature.

After the curing of the impregnating resin has been completed, the temperature of the impregnated fabric may be raised to a point appropriate for setting of the fiber from which the fabric is woven. The nylon fabric of a typical example is capable of being heat-set at about 230° C. and such heat setting as well as further curing of the impregnating resin may be accomplished at that temperature.

As a result of the heat setting treatment, the yarns of the fabric become crimped at the crossings providing a physical deformation of the yarns which assists in improving the shove resistance and thereby the dimensional stability of the fabric.

At all times during the treatment of the fabric, the temperature should be maintained low enough not to harmfully affect the fibers from which the fabric is woven.

It is desirable that the fabric being treated is maintained under control with respect to length and width during the resin coating treatment. Where the fabric is to be used as a Fourdrinier cloth, it is desired to maintain the undulations in the warp yarns and to make the longitudinally extending weft yarns as straight as possible. To accomplish this, the fabric is brought out to final width, to produce the desired weft count, at a time when the longitudinal tension is somewhat less than that required to pull the fabric out to final length. At such time, the relatively less-tensioned weft yarns will be free to flex somewhat as the warp yarns are progressively tensioned with the result that the weft count will be uniformly reduced throughout the width of the fabric to the count in which it is desired to set the fabric. Thereafter the fabric is placed under increased longitudinal tension to pull all of the weft yarns into substantially straight condition. As the weft yarns progressively straighten, the tension on the warp yarns will be increased in uniform increments throughout the width of the fabric, thus emphasizing the undulations thereof without danger of producing local irregularities in either weft or warp count.

In order more clearly to disclose the nature of the present invention, the following examples illustrating the invention are disclosed. It should be understood, however, that this is done solely by way of example and is intended neither to delineate the scope of the invention nor limit the ambit of the appended claims. In the examples which follow, and throughout the specification, the quantities of materials are expressed in terms of parts by weight, unless otherwise specified.

Example I

A resorcinol-formaldehyde resin syrup was prepared by mixing 2500 parts of resorcinol and 500 parts of a 37% aqueous solution of formaldehyde and heating the mixture to 100° C. After the reaction mixture became homogeneous, an additional 750 parts of a 37% aqueous solution of formaldehyde were added slowly at such a rate as to maintain gentle refluxing. Vigorous stirring was maintained throughout the reaction to prevent local formation of gelled particles. When the addition of the formaldehyde solution was completed, 15 parts of oxalic acid were added and the reaction mixture was refluxed for an additional 5 minutes. A fabric-treatment solution of the resorcinol-formaldehyde resin syrup was prepared by dissolving the resorcinol-formaldehyde resin concentrate produced above in water until the solids content was about 5%. The pH of the resulting treatment solution was adjusted to between about 5.5 and 6.0 by the addition of sodium hydroxide.

First step.—A Fourdrinier cloth, woven endless, and made of yarns of nylon 6–6, in accordance with United States Patent No. 2,903,021, granted September 8, 1959, with the yarns making up the warps being multifilament yarns of approximately 630 denier and made up of 102 filaments while the wefts were made of multifilament nylon yarns of approximately 420 denier and made up of 68 filaments, the Fourdrinier cloth being 150 inches wide and 1200 inches in periphery, was passed into the above described resorcinol-formaldehyde resin treatment solution while in an open, extended form, under slight tension, so that about 100% by weight of treatment solution was picked up by the Fourdrinier cloth. The Fourdrinier cloth was restrained and slightly tensioned on a moving frame to prevent dimensional change, and air-dried at a temperature of between about 100 and 125° C. by passing through a heated zone.

Second step.—A melamine-formaldehyde resin treatment solution was prepared by charging a reactor with 267 parts of 37% aqueous formaldehyde, adjusting the pH to about 8 with an aqueous solution of sodium hydroxide, and adding 126 parts of melamine with stirring. The reaction mixture was heated to about 80° C. to dissolve all the melamine. A thick syrup resulted which solidified upon cooling. The resulting melamine-formaldehyde resin was diluted with sufficient water to provide a treatment solution containing 15% resin solids. 5% by weight of urea and 1% by weight of hydrochloric acid were added. The nylon Fourdrinier cloth after drying in Step 1 was passed continuously through the resulting melamine-formaldehyde treatment solution while still under slight tensioning so that about 100% by weight of treatment solution was picked up by the cloth. The treated Fourdrinier cloth, while still remaining under slight tension, was air-dried at 100–125° C., by passing through a heated zone, followed by a curing treatment at 175° C. for 30 seconds. The cloth was then heat-set and the curing of the resin coating continued at a temperature of about 230° C.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance. The dimensional stability was demonstrated by excellent shove stability of the individual yarns.

Example II

First step.—The first step of this example was the same as that of Example I except that an aqueous resorcinol-formaldehyde novolac resin solution sold by Koppers Company under the designation R–2170 was employed directly at a resin solids concentration of 5%.

Second step.—This step was carried out in the same manner as in the second step of Example I except that a melamine-formaldehyde resin sold by American Cyanamid Company under the trademark "Aerotex M–3" was employed in the same solids concentration of 15%. An acid-liberating catalyst, sold by the Monsanto Chemical Company under the designation "AC" was employed at a concentration of 0.75%.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example III

First step.—The first step of this example was the same as that of Example II.

Second step.—A urea-formaldehyde resin syrup was prepared by condensing 60 parts of urea with 162 parts of a 37% aqueous solution of formaldehyde at a pH of 7 under reflux conditions for 10 minutes. The reaction mixture was then further refluxed for 2.5 hours. A moderately viscous solution resulted. A treatment solution was prepared by dissolving the resulting urea-formaldehyde resin syrup in sufficient water to provide a concentration of 15% resin solids. The pH of the treatment solution was adjusted to 4.5 with aqueous hydrochloric acid. The nylon Fourdrinier cloth was then passed through the treatment solution, while under slight tension, so that about 100% by weight of treatment solution was picked up by the cloth. The treated Fourdrinier cloth was air-dried at 100° C. while still under slight tension and the resin coating cured at 125° C. for about one minute and the cloth and resin coating heat-set at 230° C.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example IV

First step.—A phenol-formaldehyde resin condensate was produced by mixing 188 parts of phenol, 243 parts of a 37% aqueous solution of formaldehyde, 57 parts of water and 18.8 parts of barium hydroxide and heating the resulting mixture, with stirring, at 70° C. for 5 hours. The reaction mixture was then concentrated by heating at reduced pressure until it contained 69% solids. It was then heated at 70° C. for another 4 hours after which a thick resinous syrup was obtained. The thick resinous syrup was dissolved in 20% aqueous ethanol until the resulting solution contained 5% by weight of resin solids. A nylon Fourdrinier cloth as employed in Example I was passed through the resulting ethanolic phenol-formaldehyde resin solution, while under slight tension, so that it had picked up about 100% by weight of solution. The cloth was air-dried as in Example I.

Second step.—The treated Fourdrinier cloth of Step 1 was treated as in the second step of Example I above.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example V

First step.—A meta-cresol novolac resin solution was produced by heating together at reflux temperature for one hour, 149 parts of meta-cresol, 93 parts of a 37% solution of formaldehyde, 35 parts of water and 0.7 part of oxalic acid. Then 3.5 parts of a 15% aqueous solution of hydrochloric acid were added and the solution heated at reflux temperature for an additional 35 minutes and thereafter to it were added 40 parts of water. The reaction mixture was cooled to 70° C. and allowed to stand for 30 minutes. The supernatent layer of liquid was poured off and the remaining semi-solid layer was treated with 0.75 part of sodium hydroxide and dissolved

in 146 parts of ethanol. This resulting resin solution was further diluted with ethanol until it contained 5% solids. A Fourdrinier cloth as employed in Example I, first step, was treated as described in that example, except that the ethanolic solution of the meta-cresol novolac resin was employed.

Second step.—This step employed the same treatment as in Example I, second step.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example VI

First step.—A cresol-formaldehyde resin solution was prepared by heating together at reflux for one hour 149 parts of para-cresol, 35 parts of water, 93 parts of a 37% aqueous solution of formaldehyde and 0.7 part of oxalic acid. Then 3.5 parts of a 15% aqueous hydrochloric acid solution were added and the solution heated for an additional 35 minutes at reflux and then treated with 40 parts of water. The reaction mixture was cooled to 70° C. and allowed to stand for 30 minutes. The supernatent liquid layer was removed and the semi-solid liquid layer which remained was treated with 0.75 part of sodium hydroxide and dissolved in 146 parts of ethanol. The resulting ethanolic solution was diluted with sufficient additional ethanol to provide a solution containing 5% solids. A Fourdrinier cloth as employed in Example I was treated with the resulting resin solution as in Example I, first part.

Second step.—This step was carried out in the same manner as in Example I, second step.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example VII

First step.—A nylon Fourdrinier cloth as employed in Example I was immersed in an extended, open condition in an aqueous resin solution which was 0.1 molar with respect to both resorcinol and formaldehyde. The solution was buffered at pH 7.0 with a buffering agent and the temperature was increased to 70° C. The fabric was removed from the bath and placed on a tenter frame and air-dried at 100–125° C.

Second Step.—This step was carried out in the same manner as in Example I, second step.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example VIII

First step.—A nylon Fourdrinier cloth as described in Example I was immersed for 5 minutes in an aqueous solution which contained 5% of resorcinol and 1.5% of formaldehyde. The nylon Fourdrinier cloth absorbed 100% by weight of the aqueous solution. The Fourdrinier cloth was dried on a tenter frame at 100–125° C.

Second step.—This step was carried out in the same manner as in Example I, second step.

The resulting Fourdrinier cloth was found to possess excellent dimensional stability, stiffness and abrasion-resistance.

Example IX

This example describes a one-step treatment with a phenolic-aldehyde resin.

A Fourdrinier cloth, woven endless, as employed in Example I, while in extended condition, under slight tension, was passed through an aqueous solution containing 20% of a phenol-formaldehyde resole resin sold by the Schenectady Varnish Company under the designation SP 2740. The fabric, while still under tension, was air-dried at 100–125° C. and the resin then cured at 175° C. The resulting treated Fourdrinier cloth was found to possess excellent dimensional stability, abrasion-resistance and stiffness.

Example X

This example describes a one-step treatment with a phenolic-aldehyde resin.

A Fourdrinier cloth as in Example I was soaked for 5 minutes, in an open, extended condition, in an alcoholic solution which contained 20% with respect to phenol-formaldehyde novolac resin solids sold by the Schenectady Varnish Company as SP 7459 and to which was added sufficient hexamethylenetetramine to constitute 2% of the solution or provide a molar excess of formaldehyde. The fabric was placed on a tenter frame, dried at 100–125° C. and the resin coating cured at 175° C. The resulting treated Fourdrinier cloth was found to possess excellent dimensional stability, abrasion-resistance and stiffness.

In the foregoing examples, the nylon Fourdrinier cloth may be replaced by woven open-weave fabrics of other synthetic resinous materials. Thus, in addition to nylon 6–6, other nylons, such as nylon 6–10, nylon 11, nylon 12, etc., may be employed.

In place of the phenolic-aldehyde resins employed in the foregoing examples, aldehyde resins of various mono-, di- or tri-hydroxy phenolic materials may be employed, such as phloroglucinol, pyrogallol, resorcinol, catechol, phenol and the various cresols. Aldehydes containing up to 4 carbon atoms, such as formaldehyde, acetaldehyde, propionaldehyde and butyraldehyde may be employed in producing the phenolic resins. The formaldehyde may be employed as a 37% aqueous solution or it may be employed in the form of a formaldehyde-deformer, such as hexamethylenetetramine, paraformaldehyde, etc. The phenolic-aldehyde resin may be employed in the form of a novolac or resol resin. The resorcinol-aldehyde resins do not form a stable resol resin and must be employed as a novolac, i.e., an aldehyde-starved resin (less than one mole of aldehyde for each mole of phenolic substance). Where a novolac resin is employed it is necessary to provide sufficient additional aldehyde to provide a molar ratio of aldehyde to phenolic substance of at least 1 to 1. Preferably the molar ratio is at least 1.1 to 1. There is no upper limit to the molar ratio of aldehyde to phenolic material except that large excesses of aldehyde are wasteful.

Many of the phenolic-aldehyde resins suitable for use in the process of the invention are commercially available. Among the phenol-formaldehyde resin condensates commercially available are SP 7459, a novolac resin marketed by the Schenectady Varnish Company, S 1802 and S 1801 which are resol and novolac resins, respectively, marketed by General Electric Company, and resin 13,999, a novolac resin marketed by Durez Plastics Company. Resin R–2170 is a novolac resorcinol-formaldehyde resin marketed by Koppers Company.

Various amino-aldehyde resins may be employed in the second stage where the preferred two-stage process of the invention is used. Melamine- and urea-formaldehyde resins are considered to be the most satisfactory, although methylated melamine-formaldehyde, methylated urea-formaldehyde and ethylene urea-formaldehyde resins are also suitable. Melamine-formaldehyde type resins are preferred over urea-formaldehyde type resins. The following are some of the commercially available amine-formaldehyde resins which are suitable:

Resin Product	Producer	Type Resin
Lanaset	American Cyanamid Co.	Methylated melamine-formaldehyde.
Resipon	Arkansas Co	Methylated urea-formaldehyde.
Rhonite R–2	Rohm & Haas Co	Urea-formaldehyde.
Aerotex EU	American Cyanamid Co.	Ethylene urea-formaldehyde.
Aerotex M–3	do	Methylated melamine-formaldehyde.

With the urea and ethylene urea-aldehyde type of resin

it is desirable to employ aldehyde in excess of two moles for each mole of urea and ethylene urea. With a melamine-aldehyde resin it is desirable to employ at least about three moles of aldehyde for each mole of melamine.

While amino-aldehyde resins provide excellent results when used as a second-stage treatment in conjunction with an initial treatment of the fabric with a phenolic-aldehyde resin, when used alone, or as a first-stage treatment followed by a second-stage phenolic-aldehyde resin treatment, the results obtained are far less satisfactory.

In order to provide satisfactory results, it is desirable to provide a resin coating over the open weave synthetic filament cloth which weighs between about 10% and 35% by weight of resin solids based on the weight of the cloth. Best results are obtained with a pickup of about 20–25% by weight of resin solids.

The terms and expressions which have been employed are used as terms of description and not of limitation, and it is not intended, in the use of such terms and expressions, to exclude any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A process for treating an open-weave fabric of yarns of a synthetic resin to improve the dimensional stability, abrasion-resistance and stiffness which comprises applying to the fabric a phenolic-aldehyde resin, partially curing said phenolic-aldehyde resin and then applying an amino-aldehyde resin and finally curing the resin coating while the fabric is in an extended condition.

2. A process as defined by claim 1 wherein the phenolic-aldehyde resin is a phenol-formaldehyde resin and the amino-aldehyde resin is a melamine-formaldehyde resin.

3. A process as defined by claim 1 wherein the phenolic-aldehyde resin is applied in amounts of between about 5% and 10% of the weight of the fabric and the amino-aldehyde resin is applied in an amount of between about 10% and 20% by weight of the fabric.

4. A process as defined by claim 1 wherein the open-weave fabric is constructed of yarns of nylon.

5. A process as defined by claim 1 wherein the molar ratio to total aldehyde to phenolic component is at least 1 to 1.

6. A process as defined by claim 1 wherein the total amount of resin applied to the fabric constitutes from about 10% to 35% by weight of the fabric.

7. A process as defined by claim 1 wherein the total amount of resin applied to the fabric constitutes from about 15% to 30% by weight of the fabric.

8. A process as defined by claim 1 wherein the final curing takes place at a temperature of at least about 175° C.

9. A process as defined by claim 2 wherein the phenol-formaldehyde resin is applied in an amount of about 5% of the weight of the fabric and the melamine-formaldehyde is applied in an amount of about 15% of the weight of the fabric.

10. A process for treating a Fourdrinier cloth of yarns of a synthetic resin to improve the dimensional stability, abrasion-resistance and stiffness which comprises applying to the cloth a phenolic-aldehyde resin, partially curing said phenolic-aldehyde resin and then applying an amino-aldehyde resin and finally curing the resin coating while the cloth is under tension.

11. A process as defined by claim 10 wherein the phenolic-aldehyde resin is a phenol-formaldehyde resin and the amino-aldehyde resin is a melamine-formaldehyde resin.

12. A process as defined by claim 10 wherein the phenolic-aldehyde resin is applied in an amount of between about 5% and 10% of the weight of the fabric and the amino-aldehyde resin is applied in an amount of between about 10% and 20% by weight of the fabric.

13. A process as defined by claim 11 wherein the phenol-formaldehyde resin is applied in an amount of about 5% of the weight of the cloth and the melamine-formaldehyde is applied in an amount of about 15% of the weight of the cloth.

14. A Fourdrinier cloth of yarns of a synthetic resin having improved dimensional stability, abrasion-resistance and stiffness, said cloth having a cured coating of between about 5 and 10% of a phenolic-aldehyde resin and between about 10 and 20% of an amino-aldehyde resin.

15. A Fourdrinier cloth, as defined by claim 14 wherein the yarns are of nylon.

16. A process for treating a Fourdrinier cloth of yarns of a synthetic resin to improve the dimensional stability, abrasion-resistance and stiffness which comprises applying to the cloth a phenolic-aldehyde resin, partially curing said phenolic-aldehyde resin and then applying an amino-aldehyde resin and finally curing the resin coating while the cloth is in an extended condition.

17. A process as defined by claim 16 wherein the Fourdrinier cloth is constructed of yarns of nylon.

18. An open weave, endless fabric of yarns of a synthetic resin having improved dimensional stability, abrasion-resistance and stiffness, said fabric having a cured coating of the reaction product of a partially cured phenolic-aldehyde resin and an amino-aldehyde resin.

19. An open weave, endless fabric as defined by claim 18 wherein the total amount of resin coating constitutes from about 10% to 35% by weight of the fabric.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,032,441

May 1, 1962

Ralph H. Beaumont et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, lines 60 and 61, for "treaatment" read -- treatment --; column 3, line 17, for "resins" read -- resin --; column 10, line 31, for "formaldehyde-deformer" read -- formaldehyde-former --.

Signed and sealed this 28th day of August 1962.

(SEAL)
Attest:

ESTON G. JOHNSON

Attesting Officer

DAVID L. LADD

Commissioner of Patents