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PROCESS FOR PREPARING A COHESIVE WEB FROM NON-FIBRILLATABLE RAYON FIBERS

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The present invention relates broadly to methods and techniques which develop tensile strength and stretch in paper webs. More particularly, the invention disclosed herein is concerned with a process for developing improved wet and dry tensile strength, as measured by breaking length, and stretch in paper webs by treating the paper webs with selected nitrogen-chemicals. Practice of the disclosed process results in paper webs exhibiting improved breaking length and stretch without requiring the incorporation of resins, latices or other binder materials therein. The present process also minimizes, and in the instance of paper webs composed entirely of rayon fibers negates, the requirement of fibrillatable fibers for the development of cohesiveness in paper webs devoid of binder materials.

Specifically the present invention provides for a process wherein the breaking length and stretch of a paper web containing a substantial proportion of cellulosic fibers is enhanced by first forming and drying a paper web and thereafter treating the paper web with an aqueous solution containing about 80% to about 100% by volume of a nitrogen-chemical selected from the group consisting of ammonia, methylamine, dimethylamine, ethylenediaine, hydrazine and ethylamine. In the instant application the term cellulosic fibers includes cellulose fibers prepared from wood, cotton and other natural sources as well as rayon and other regenerated cellulose fibers.

It is known that the breaking length of paper webs can be improved by the addition of various resins, latices and gums to the furnishes from which the paper webs are formed. U.S. 2,563,897, issued to Lucius H. Wilson, Chester G. Landes and Charles S. Maxwell on Aug. 14, 1951, for example, discloses a method of adding combinations of resins and latices to moulded or sheeted cellulosic fiber products and discusses a variety of additives useful in paper webs. Although these additives, used in effective amounts under the proper conditions to induce bonding between the individual fibers of a paper web, do develop the strength characteristics of paper webs, they do so at the expense of adding extraneous materials to the basic cellulosic structure.

The wet strength resins, for example, make paper so difficult to repulp for reworking or reclamation that special processes have been developed to handle wet-strength broke. U.S. 2,872,313, issued to Ronald R. House and Yun Jen on Feb. 3, 1959, for example, discloses a process for the pulping of paper containing a wet-strength resin.

In another area of interest, the use or introduction of various resins, latices and gums to develop the strength of a paper web may give rise to toxicity problems in a paper web which is intended for wrapping or otherwise contacting food.

The development of improved stretch and strength in paper webs without the addition of resins, latices and gums also has significant advantage in the production of paper webs for use in diapers, towels, and expendable medical dressings. In these products wet strength, dry strength and stretch are desirable in paper webs, but the additional loading and obstruction of the paper pores caused by the addition of resins, latices and gums is an undesirable feature.

Practice of the inventive process in connection with paper webs containing rayon and other cellulosic fibers in admixture results in paper webs exhibiting greatly improved stretch characteristics. Applicant has also found that practice of the inventive process enables the formation of strong paper webs composed solely of unfibrillated rayon fibers, which heretofore have not formed cohesive paper webs in the absence of fiber binders.

The effect of treating various cellulosic fibers with ammonia and amines is known to alter the fibers. For example, Messrs. Leopold Loeb and Leon Segal reported in the "Textile Research Journal," June 1955, pages 516–519, the results of treating cotton cellulose fibers with aqueous solutions of ethylamine containing from 70% to 100% by weight of the amine. These investigators found that the treatment of cotton fibers with aqueous solutions containing 70% of ethylamine had little effect in reducing the degree of crystallinity of the cotton fibers. Aqueous solutions containing a slightly higher concentration of the amine than 70%, however, were found to strongly reduce both the crystallinity and the leveling off degree of polymerization of the cotton fibers. Paper webs formed from the pre-treated fibers, however, do not exhibit increased strength and stretch.

While Messrs. Loeb and Segal determined the effect of treating cotton fibers themselves with ethylamine solutions, applicant made the discovery that, if formed and dried paper webs containing a substantial proportion of cellulosic fibers were treated by dipping, spraying or otherwise wetting them with aqueous solutions containing about 80% to about 100% by volume of ammonia, or another of the nitrogen-chemicals disclosed herein, and thereafter dried, either directly or after completely or incompletely washing the nitrogen-chemical from the treated paper web with water, the treated paper webs would exhibit an improved combination of strength and stretch properties.

Applicant found that, surprisingly, the web and dry strength and stretch improvements are only noted when the paper webs are formed, dried and thereafter treated with the disclosed nitrogen-chemical solutions prior to redrying. Similar treatments applied to formed, but not dried paper webs or to cellulosic fibers prior to incorporating them into paper webs are not effective.

The present invention is particularly notable in that it provides a method of forming a cohesive paper web composed entirely of non-fibrillatable rayon fibers as opposed to paper webs composed of the hollow-core, fibrillatable rayon fibers, commonly referred to as papermaking rayon fibers. Formation of cohesive paper webs from non-fibrillatable rayon fibers has been impossible heretofore without the use of binders or adhesives.

Accordingly, it is an object of this invention to provide a novel process for the manufacture of paper webs which exhibit improved combinations of wet and dry braking length and stretch characteristics and are comprised of a substantial proportion of cellulosic fibers.

Another object of this invention is to provide a process whereby the wet breaking length, dry breaking length, stretch profile of a paper web containing cellulosic fibers can be greatly enhanced without the addition of resins, latices or other binder additives used to promote strength in paper webs.

A further object of this invention is to provide a process whereby paper webs exhibiting a high degree of stretch can be prepared from rayon and other cellulosic fibers in admixture.

It is a still further object of this invention to provide a process whereby a cohesive paper web can be formed from non-fibrillatable rayon fibers without the addition of binders or adhesives.

These objects are achieved by the present invention which is directed to a process which broadly speaking comprises the treatment of pre-formed and dried paper webs composed of cellulosic fibers with aqueous solutions containing about 80% to about 100% by volume of a nitrogen-chemical selected from the group consisting of ammonia, methylamine, dimethylamine, ethylenediamine, hydrazine and ethylamine. It will be understood that the volumes of all nitrogen-chemicals referred to in the present specification and claims refer to nitrogen-chemicals in their liquid state at a pressure of one atmosphere.

The process comprises the steps of initially forming a paper web containing all or a substantial proportion of cellulosic fibers. The paper web is then dried.

The cellulosic fibers incorporated into the paper web can be any of the cellulosic fibers normally incorporated in paper webs, including, for example, wood fibers, cotton linter fibers, fibrillatable papermaking rayon fibers, and non-fibrillatable textile rayon fibers.

With the exception of paper webs containing all non-fibrillatable rayon fibers, which require mechanical support, the paper webs can be pre-formed and dried by any of the conventional methods and can contain papermaking fibers in any proportion. The practice of the present invention to form, dry and treat a paper web composed entirely of nonfibrillatable rayon fibers requires that the initial paper web be formed, dried and thereafter supported between foraminous supports, for example, between two screens until the treatment of the present invention is completed. The foregoing requirement of support is imposed by the lack of initial cohesion between the non-fibrillatable rayon fibers, and any means of support which will maintain the integrity of the rayon web during treatment and final drying can be employed.

The pre-formed and dried paper webs are then treated by wetting them with aqueous solutions containing about 80% to 100% by volume of the disclosed nitrogen-chemicals. In practising the process of this invention with paper webs containing fibrillatable fibers in substantial proportion applicant has found it preferable to use solutions which contain about 90% to about 98% by volume of the nitrogen-chemicals. Also in the instance of a paper web composed completely, or so nearly completely of non-fibrillatable rayon fibers, that there is little if any cohesion in the pre-formed and dried paper web, applicant has found it desirable in achieving strength improvement to use solutions containing about 90% to about 98% of the selected nitrogen-chemical in treating the paper web. In treating pre-formed and dried paper webs containing about 20% to about 80% by weight of rayon fibers in admixture with other papermaking fibers, for example wood fibers, applicant has found that high stretch is developed by the use of anhydrous nitrogen-chemicals in treating.

The treatment of the pre-formed and dried paper webs is carried out by spraying, dipping, soaking or otherwise infusing the nitrogen-chemical solution on and into the paper web. An amount of nitrogen-chemical solution sufficient to wet the paper web is required for effective treatment.

Treatment of the paper webs by dipping is preferred because of the even wetting of the paper web fibers obtainable by using this procedure with an excessive of nitrogen-chemical solution.

Applicant has found that the nitrogen-chemical treatment is effective when the paper webs are in contact with the nitrogen-chemical solutions for only a short time. Treatment times include the entire period during which the paper web fibers are in the presence of a nitrogen-chemical. Effective treatment times range from about 10 seconds to about 30 minutes. The breaking length and stretch improvements are rapidly engendered in the paper webs, so that treatment times of about 10 seconds to about 10 minutes are preferred, although treatment times up to 30 minutes have not been found detrimental.

Continuity has been found to be important in the treatment of the pre-dried paper webs with respect to the final breaking length and stretch improvements achieved. Any method of treatment which is discontinuous or any interruption in the treatment of the paper web tends to result in a weakened area along the wet-dry line of the paper web at the time of treatment interruption. Applicant has found it preferable to dip the pre-dried paper web without interruption at a rate which exceeds the wicking rate for the paper web and nitrogen-chemical solution combination employed.

Applicant has found it preferable to cool the nitrogen-chemical treating solutions slightly below their boiling points where the solution boiling point is below room temperature because boiling of the nitrogen-chemical solution during treatment tends to disrupt the fibrous formation of the pre-formed and dried paper web. Where the boiling point of the nitrogen-chemical treating solution is higher than 24° C., i.e. room temperature, 24° C. has been found satisfactory for carrying out the nitrogen-chemical treatment of this invention.

Subsequent to the treatment with a nitrogen-chemical solution, the paper web is drained and dried directly from the nitrogen-chemical solution by any conventional means suitable for drying a paper web. Alternatively the treated paper web can be washed with water and then dried. Washing the treated paper web prior to drying is preferable where higher boiling nitrogen-chemicals are used in the treating solutions, because these nitrogen-chemicals are not readily evaporated from the paper webs during drying. Drying means include, for example, steam cans, ovens, Yankee driers and festoon drying. As mentioned in the treating procedure, above, it is preferable that the drying procedure be carried out in a continuous fashion with the treated paper web in a horizontal, or nearly horizontal, plane. If the drying procedure is discontinuous, treating solution composition and quantity changes along interface lines in the paper web during drying may cause variations in tensile strength or weak spots in the dried paper web. In an oven drying operation, for example, the foregoing considerations indicate the preferability of placing the treated and drained paper webs in a horizontal plane during drying.

The development of stronger fiber bonds in the initially formed paper webs by wet pressing, prior to drying and subsequent treatment with nitrogen-chemical solutions has been found to increase the breaking length values obtained by nitrogen-chemical treatment. Pressing the paper webs subsequent to treatment with a nitrogen-chemical solution, while the paper web is still wet with nitrogen-chemical solution and prior to drying, has also been found beneficial in increasing the breaking length of paper webs accorded the treatments of this invention.

Treating paper webs by the process disclosed herein results in very little detectable chemical difference between the treated and untreated paper webs. For example, chemical analysis of one treated paper web composed of sulfate spruce fibers revealed that there was a decrease in soluble wood constituents in the paper web, after treatment with an aqueous solution containing 90% ammonia, of only 0.4% and an increase in nitrogen content of less than 0.1%.

A tendency toward an increased equilibrium moisture content has been noted in the treated and dried paper webs. When treating paper webs having a thickness in excess of .050 inch, a noticeable tendency for the tensile strength improvement to be concentrated adjacent to the sheet surfaces has been detected.

Applicant has also noted fiber fusion at points of fiber crossover when paper webs composed of non-fibrillatable, textile rayon fibers of less than about four denier were treated with aqueous solutions containing about 90% to about 98% ammonia for a period of at least 10 seconds,

drained and dried directly from the treating solution. By fiber fusion, applicant means that microscopic examination of the dried paper web showed that the rayon fibers had adhered to one another with an apparent thickened weld at the points of fiber crossover.

Tensile strength and stretch data in terms of breaking length and percentage stretch, respectively, are set forth in the examples below for untreated paper webs and for paper webs treated with nitrogen-chemicals according to the process of this invention.

The breaking lengths were calculated from tensile strength data obtained from testing paper web samples by conventional procedures on a Schopper tensile tester. The tensile strength data were thereafter converted to breaking lengths by calculating, in the manner stated on page 1318, "Pulp And Paper," Casey, vol. III, second edition, the length of a strip of the sample paper web which would break under its own weight. Breaking length data are considered as useful comparative measurements, since they relate tensile strength and basis weight.

The stretch data were determined by rupturing paper web samples on an Instron tester using a three inch span between the Instron tester jaws. The stretch was taken as the movement of the Instron tester jaws from the position of first load to the rupture of the paper web under test. The stretch data were thereafter converted to percentage stretch based on the three inch sample length.

The following examples illustrate specific embodiments of the invention together with illustrations showing the effect of operating outside the disclosed ranges of the invention. The examples are intended to illustrate the invention, but it will be apparent to those skilled in the art that many changes and modifications can be made in the procedural methods without departing from the spirit of the invention. It will be understood, therefore, that the examples cited and the procedures set forth are intended to be illustrative only and are not intended to limit the invention any more than is required by the scope of the appended claims.

Example I

A paper web was formed from an aqueous slurry of unbeaten, bleached sulfate fibers prepared from Northern spruce wood. The paper web was wet pressed and then oven-dried to air dry moisture content. The paper web had an air dried basis weight of 16.6 lbs. per 3000 sq. ft. The dried paper web was carried between screens and treated by being dipped at the rate of 5 inches per second into a stainless steel tank holding an aqueous solution containing 90% ammonia by volume. The aqueous ammonia solution in the stainless steel tank was maintained at a temperature of about —40° C., or slightly below the boiling temperature of the aqueous ammonia solution.

The paper, remaining between the screens for transport purposes, was carried through and out of the aqueous ammonia solution so that each increment of the paper web was in contact with the aqueous ammonia solution during a period of one minute. After the paper web was carried from the ammonia solution by the screens, it was drained free of excess ammonia solution and air dried at room temperature in a horizontal position. The paper web was under no restraint during drying so that it was free to shrink.

Additional paper webs formed from spruce wood fibers and dried in the manner of Example I were treated with solutions containing various percentages of ammonia and other nitrogen-chemicals by volume. Wet and dry breaking length and percentage stretch data for the paper webs after draining and drying in the manner of Example I are reported in Table I below as Examples II–XV together with like data for Example I. In the case of Examples II, VII, X, XI, XIII, XIV and XV, the paper webs were washed free of the nitrogen-chemical treating solution with water after treatment. The paper web of Example II was clamped in a frame during drying so that it was dried under tension; the paper webs of the remainder of the examples of Table I were free to shrink during drying.

Blank I reports the physical characteristics of the paper web first formed and dried in the manner of Example I. Blank I, therefore, gives the physical characteristics of the paper web of Examples I–XV prior to treatment with nitrogen-chemical solution.

Blank II reports the physical characteristics of the Blank I paper web after wetting it with water and allowing it to dry at room temperature under conditions of free shrinkage.

TABLE I

Example	Nitrogen-Chemical Composition	Treatment Time	Water Wash After Nitrogen-Chemical Treatment	Breaking Length-Meters		Percentage Stretch
				Dry	Wet	
I	90% NH_3	1 min	No	5,060	700	5.8
II	90% NH_3	1 min	Yes	4,870	740	2.6
III	80% NH_3	10 sec	No	3,460	140	
IV	95% NH_3	10 sec	No	4,960		
V	98% NH_3	10 sec	No	3,160		
VI	99% NH_3	10 sec	No	2,740		
VII	100% NH_3	10 sec	Yes	1,650	130	
VIII	95% Methylamine	10 sec	No	4,140		
IX	90% Ethylamine	10 sec	No	2,450		2.0
X	do	1 min	Yes	2,780		
XI	100% Ethylamine	1 min	Yes	3,200	90	
XII	95% Dimethylamine	10 sec	No	1,550		3.3
XIII	97% Hydrazine (room temperature)	1 min	Yes	3,500	230	
XIV	90% Ethylenediamine (room temperature).	30 min	Yes	2,900		
XV	100% Ethylenediamine (room temperature).	30 min	Yes	3,100		
Blank I	None			1,700	100	1.5
Blank II	do		Yes	1,290	30	1.9

The data reported in Table I above clearly show the effect of the various nitrogen-chemical treatments of Examples I–XV in improving the physical characteristics of the untreated paper web of Example I.

The paper webs of Example I and Examples II–XV are especially suited for use as protective wrappings and as filter pads.

Example XVI

A paper web was formed from an aqueous slurry of 3.75 denier, non-fibrillatable rayon fibers of a medium tensile strength type used in textiles. The rayon fibers were cut to a length of 3 millimeters. The paper web was formed and air dried on a screen because the paper web formed of non-fibrillatable rayon fibers did not possess sufficient strength to allow unsupported handling. The air-dried rayon fiber paper web had a basis weight of 16.5 pounds per 3000 square feet. A second screen was then placed on top of the dried rayon fiber web, and the dried rayon fiber web was held in restraint between the two screens. The rayon fiber web was then treated by pouring an aqueous solution containing 90% by volume of ammonia onto the rayon fiber web through the top screen. The rayon fiber web was wetted with the 90%

ammonia solution and then the top screen was removed. The rayon fiber web was then air dried while supported on the forming screen. The wet and dry breaking lengths of the air dried rayon web of this Example XVI are reported in Table II below. Additional paper webs having the same basis weight were prepared from 1.0 denier non-fibrillatable rayon fibers of the high tensile strength type used in textiles and cordage cut to a length of 4 millimeters and from 1.5 denier, hollow-filament, fibrillatable rayon fibers of the type known as papermaking rayon cut to a length of 6.35 millimeters and treated in the manner of Example XVI. The wet and dry breaking lengths of these paper webs are reported as Examples XVII and XVIII in Table II below. No breaking lengths for the untreated non-fibrillatable rayon webs are reported in Table II because as stated in the procedure of Example XVI above, these rayon webs were so weak as to require physical support prior to nitrogen-chemical treatment. The untreated paper web composed of 1.5 denier, hollow-filament, fibrillatable rayon fibers had a dry breaking length of 2900 meters and a wet breaking length of 120 meters. The rayon fiber paper web of Example XVIII was washed with water after treatment with the 90% ammonia solution and prior to removing the top screen for drying.

TABLE II

Example	Rayon Fiber			Breaking Length	
	Denier	Type	Length (mm.)	Dry	Wet
XVI	3.75	Medium tensile strength-textile.	3	2,710	700
XVII	1.0	High tensile strength-textile.	4	5,200	2,280
XVIII	1.5	Papermaking	6.35	3,840	1,350

The data tabulated in Table II above clearly show the effect of the nitrogen-chemical treatment of Examples XVI–XVIII in preparing rayon fiber paper webs having breaking lengths comparable to paper webs prepared from fibrillated fibers. The untreated rayon fiber paper webs did not, with the exception of the paper web of Example XVIII, possess sufficient untreated strength for unsupported handling. The paper webs of Examples XVI–XVIII are especially suited for use as rayon fiber filters.

Example XIX

In order to illustrate the advantage of the process of this invention in connection with the treatment of paper webs containing rayon fibers in admixture with other cellulosic fibers, a paper web was formed from an aqueous slurry of hollow-filament papermaking rayon fibers and bleached sulfite poplar fibers. The fibers in the aqueous slurry consisted of 40% by weight of the hollow-filament papermaking rayon fibers and 60% by weight of the bleached sulfite poplar fibers. The paper web was oven-dried to an air dried basis weight of 16.5 pounds per 3000 sq. ft. The dried paper web was then dipped into an insulated stainless steel container holding an aqueous solution containing 90% ammonium by volume. The ammonia solution was maintained at −40° C. After 10 seconds of immersion the paper web was removed from the stainless steel tank, drained and dried at room temperature in a horizontal plane under conditions of free shrinkage.

The breaking length and percentage stretch of the paper web resulting from the process of Example XIX is reported in Table III below. The breaking length and percentage stretch of the untreated paper web of Example XIX, dipped in water and dried at room temperature under conditions of free shrinkage is reported in Table III below as a blank sample for comparison.

An additional paper web containing 60% hollow-filament, papermaking rayon fibers and 40% bleached sulfite poplar fibers by weight and treated in the manner of Example XIX, with the exception that the treating liquid was anhydrous ammonia, is reported in Table III below as Example XX.

TABLE III

Example	Dry Breaking Length (meters)	Percentage Stretch
XIX	2,750	17.0
XX	940	12.0
Blank	2,340	1.5

The data in Table III above clearly show the surprising improvement in percentage stretch which occurs when paper webs containing rayon in admixture with natural cellulosic fibers are given a nitrogen-chemical treatment.

A paper web prepared and treated according to the process of Example XIX, but containing 20% hollow-filament papermaking rayon fibers and 80% bleached sulfite poplar fibers by weight will exhibit a comparably increased percentage stretch. Another paper web prepared and treated according to the process of Example XIX, but containing 80% hollow-filament, papermaking rayon fibers and 20% bleached sulfite poplar fibers by weight will also exhibit and increased percentage stretch.

The paper web products of Examples XIX and XX exhibit a soft subjective feel and are especially useful as facial tissues.

Example XXI

In order to illustrate that the improvement in physical properties of paper webs is not limited to paper webs containing sulfate wood fibers, a paper web was prepared from bleached sulfite spruce fibers. The paper web was drum dried to air dry moisture content. The paper web had an air dried basis weight of 16.5 lbs. per 3000 sq. ft. The paper web was treated with an aqueous solution of ammonia containing 90% ammonia by volume, drained and dried according to the procedure of Example I.

An additional paper web was formed from bleached sulfite spruce fibers and two paper webs were formed from beaten cotton linter fibers as Examples XXII, XXIII and XXIV, respectively.

The paper webs of Examples XXI and XXIII were treated with an aqueous solution of ammonia containing 90% ammonia by volume, drained and dried according to the procedure of Example I.

The paper webs of Examples XXII and XXIV were treated according to the procedure of Example I with the exception that they were washed free of the nitrogen-chemical treating solution with water after treament and prior to drying.

The dry breaking lengths of the paper webs of Examples XXI–XXIV are reported in Table IV below together with the dry breaking lengths of the drum-dried paper webs of each example prior to treatment.

TABLE IV

Example	Dry Breaking Length (meters)		
	Paper web prior to treatment	Dried from 90% ammonia	Washed with water prior to drying
XXI	2,160	2,930	----------
XXII	1,960	----------	2,680
XXIII	2,840	3,100	----------
XXIV	2,120	----------	3,010

The data reported in Table IV above illustrate the improvement in the breaking lengths of paper webs first formed from either sulfite wood fibers or cotton linter fibers, dried, treated with a solution containing 90% of ammonia by volume and then finally dried. The improvement in breaking length is evident when the paper webs are dried directly from the treating solution or when they are washed with water prior to drying.

A paper web formed from equal parts by weight of bleached sulfite spruce fibers, rayon fibers and cotton linter fibers will exhibit increased breaking length when treated according to the process of Example XXI.

The paper webs of Examples XXI and XXII are especially useful as wrapping papers, while the paper webs of Examples XXIII and XXIV are useful as paper handkerchiefs.

Example XXV

In order to illustrate the effect of various conventional papermaking procedures used in forming the initial dry paper web for treatment according to the procedures of this invention, a paper web was formed in the manner of Example I, but without wet pressing the paper web, prior to initial drying. The dry breaking length of this paper web is reported in Table V below together with the dry and wet breaking lengths of the same paper treated with an aqueous ammonia solution containing 90% ammonia by volume according to the procedure of Example I.

Similar data for an initial paper web like that of Example XXV but which was given a wet press prior to initial drying and nitrogen-chemical treatment by the process of Example I is reported in Table V as Example XXVI.

The paper web of Example XXVII was formed and treated as in Example I, with the exception that the bleached sulfate fibers were beaten prior to formation of the paper web, and the formed paper web was wet pressed prior to initial drying and nitrogen-chemical treatment.

TABLE V

Example	Preparation Of Initial Web	Breaking Length (meters)		
		Paper Web prior to treatment	Dried from 90% ammonia	
		Dry	Dry	Wet
XXV	Unbeaten fiber, no wet press.	1,030	3,600	560
XXVI	Unbeaten fiber, wet press.	2,000	5,060	700
XXVII	Beaten fiber, wet press	5,030	9,150	930

The data reported in Table V above illustrate the desirability of forming a well-bonded dry paper web for treatment wtih nitrogen-chemicals according to the procedures of this invention.

The paper webs of Example XXV–XXVII have use as protective wrappings or filter pads.

Example XXVIII

In order to illustrate the effect on breaking length of applying high pressure to the paper web of Example I while wet with aqueous solution containing 90% ammonia by volume, a paper web, Example XXVIII, was prepared and treated according to the procedure of Example I.

The paper web of Example XXIX was prepared according to the procedure of Example I with the exception that it was pressed between flat plates at 3760 p.s.i. for 30 minutes at room temperature while wet with the 90% ammonia solution and prior to final drying.

The paper web of Example XXX was prepared and treated according to the procedure of Example I and then washed with water prior to the pressure treatment of Example XXIX.

The paper web of Example XXXI was prepared and treated according to the procedure of Example XXIX with the exception that the paper web, wet with 90% ammonia solution, was placed on a 7/32 inch sheet of fiber board and pressed at 3760 p.s.i. for one hour with the lower plate of the press heated to a temperature of 110° C.

The breaking lengths of the paper webs of Examples XXVIII–XXXI are reported in Table VI below.

TABLE VI

Example	Breaking Length (meters)	
	Dry	Wet
XXVIII	3,000	----------
XXIX	7,700	----------
XXX	4,200	----------
XXXI	8,000	850

The data reported in Table VI above illustrate that pressure applied to a paper web after a nitrogen-chemical treatment of this invention increases the effect of the nitrogen-chemical treatment in improving the breaking length.

The paper webs of Examples XXVIII–XXXI are all useful as high strength paper wrappings.

Having thus described the invention, what is claimed is:

1. The process of preparing a paper web consisting essentially of non-fibrillatable rayon fibers which comprises the steps of (1) forming and drying a non-cohesive web from said rayon fibers, (2) supporting the non-cohesive web between foraminous supports, (3) wetting the supported non-cohesive web with an aqueous solution containing about 80% to about 100% by volume of a nitrogen-chemical selected from the group consisting of ammonia, methylamine, dimethylamine, ethylenediamine, hydrazine and ethylamine for a period of about 10 seconds to about 30 minutes and (4) drying the so formed non-cohesive web to form a paper web.

2. The process of preparing a paper web consisting essentially of non-fibrillatable rayon fibers which comprises the steps of (1) forming and drying a non-cohesive web from said rayon fibers, (2) supporting the non-cohesive web between foraminous supports, (3) wetting the supported non-cohesive web with an aqueous solution containing about 90% to about 98% by volume of a nitrogen-chemical selected from the group consisting of ammonia, methylamine, dimethylamine, ethylenediamine, hydrazine and ethylamine for a period of about 10 seconds to about 10 minutes and (4) drying the so formed non-cohesive web to form a paper web.

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