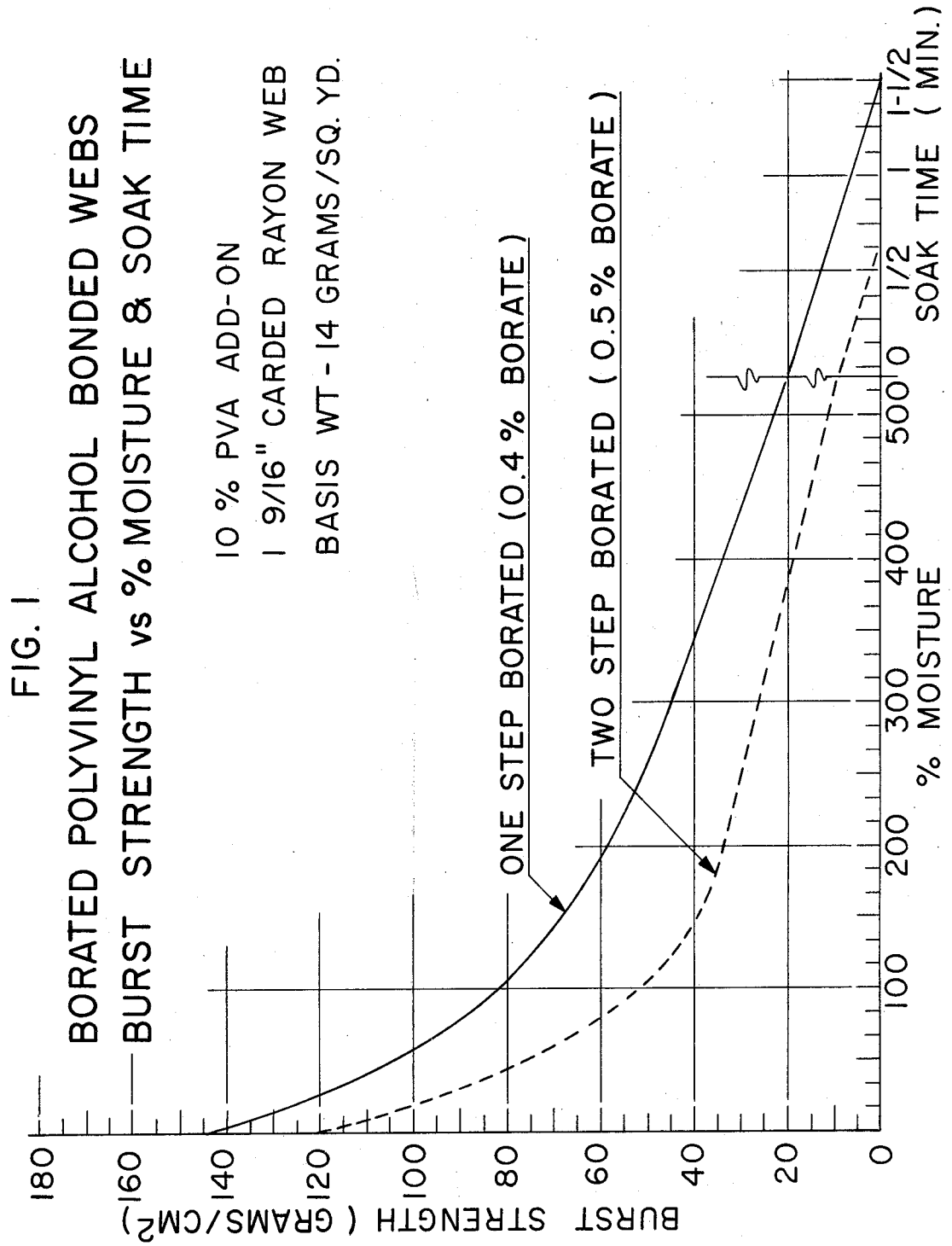
FIG. 1
BORATED POLYVINYL ALCOHOL BONDED WEBS
BURST STRENGTH vs % MOISTURE & SOAK TIME
10 % PVA ADD-ON
1 9/16" CARDED RAYON WEB
BASIS WT - 14 GRAMS/SQ. YD.
ONE STEP BORATED (0.4% BORATE)
TWO STEP BORATED (0.5% BORATE)
BURST STRENGTH (GRAMS/CM2)
180
160
140
120
100
80
60
40
20
0
100
200
300
400
500
% MOISTURE
0
1/2
1
1-1/2
SOAK TIME (MIN.)

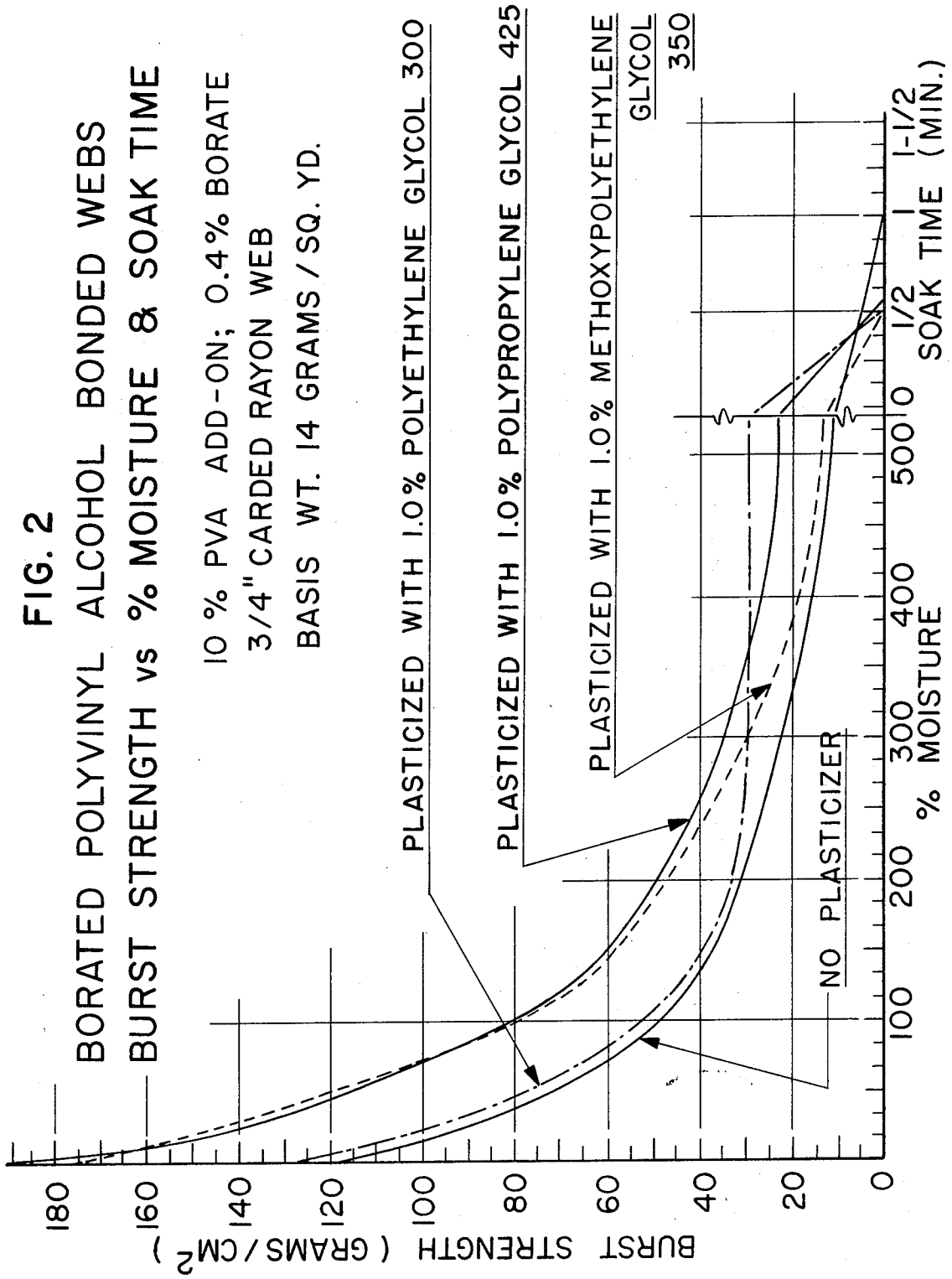
FIG. 2
BORATED POLYVINYL ALCOHOL BONDED WEBS
BURST STRENGTH vs % MOISTURE & SOAK TIME
10 % PVA ADD-ON; 0.4% BORATE
3/4" CARDED RAYON WEB
BASIS WT. 14 GRAMS / SQ. YD.
PLASTICIZED WITH 1.0% POLYETHYLENE GLYCOL 300
PLASTICIZED WITH 1.0% POLYPROPYLENE GLYCOL 425
PLASTICIZED WITH 1.0% METHOXYPOLYETHYLENE GLYCOL 350
NO PLASTICIZER
BURST STRENGTH (GRAMS / CM²)
180
160
140
120
100
80
60
40
20
0
100
200
300
400
500
0
% MOISTURE
1/2
1
1-1/2
SOAK TIME (MIN.)

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3,689,314

METHOD FOR FABRICATING IMPROVED FLUSHABLE WRAPPERS FOR ABSORBENT PADS AND PRODUCT OBTAINED THEREBY

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U.S. Cl. 117—140 A 5 Claims

ABSTRACT OF THE DISCLOSURE

A flushable wrapper for sanitary napkins and other absorbent pads. The wrapper comprises a non-woven fiber web bonded by a cold-water soluble polyvinyl alcohol adhesive which has been insolubilized in situ after the adhesive is applied to the web. The polyvinyl alcohol is applied to the web in the form of a solution containing chemical additives which do not gelate or affect the solubility of the polyvinyl alcohol until after heat is applied to dry the treated web. The heat causes the chemical additives to react and to render the polyvinyl alcohol sufficiently water resistant throughout its structure to maintain wet strength of the web at a level where it does not disintegrate in a heavily moisture laden environment. A web thus bonded has enough wet strength and abrasion resistance to perform satisfactorily at moisture levels encountered during normal use, yet disintegrates sufficiently fast after soaking in excess water to permit disposal by flushing.

CROSS REFERENCE TO RELATED APPLICATION

Copending application by David V. Duchane, Ser. No. 13,588, filed Feb. 24, 1970, and now Pat. No. 3,654,928.

BACKGROUND OF THE INVENTION

Many attempts have been made to produce sanitary napkins and other absorbent pads which for disposal purposes may be flushed away safely in conventional toilets. While the individual absorbent components of a sanitary napkin, i.e. wood fluff, absorbent cotton batts, cellulose wadding and the like, are of such construction that they easily disintegrate when agitated in water, the necessary strength requirements for the fluid-pervious wrapper enclosing such components is usually such that the wrapper will not disintegrate even after extended exposure to water. Therefore, such wrapper elements must first be removed by the user when an attempt is made to dispose of the napkin in a toilet, otherwise the absorbent components will not disintegrate because they cannot escape the confines of the wrapper. Since such napkins will retain most of their bulk form if retained in a wrapper which does not disintegrate in water, they frequently cause stoppages in the disposal ssytem when attempts at disposal are made, either accidentally or intentionally, without first removing the wrapper. The wrapper, of course, can be stripped off, but this procedure is extremely inconvenient and unsanitary, and for that reason the user usually prefers not to go to that trouble, and instead, will dispose of the used napkin in a disposal bag or other container for solid wastes.

Accordingly, there is a need to provide sanitary napkins and similar absorbent pads with a wrapper which is strong enough to perform its support and pad-enclosing functions while worn, and yet will disintegrate readily after a short time in flowing water. Non-woven fiber webs bonded by cold-water soluble adhesives such as polyvinyl alcohol, polyvinyl methylether, glycol cellulose, cellulose glycolate, methyl cellulose, and the like, have been tried as sanitary pad wrappers and found to be readily disintegratable in excesses of water. However, while the latter characteristic was easily achieved, it was also found that these water-soluble adhesives tended to soften and dissolve prematurely in the presence of body moisture generated by perspiration and discharged body fluids with the undesirable result that the wrapper often became undesirably sticky, or became weakened and ruptured prematurely while worn. Accordingly, such wrappers were considered unsatisfactory for general use.

In the copending application referenced above, there is described one form of a non-woven napkin wrapper which disintegrates in excess water after a short period, but which also exhibits sufficient wet strength to retain its integrity in use when exposed to the moist environment of the body.

In accordance with that invention, a flushable non-woven fabric, suitable for use as a wrapper for sanitary napkins and other absorbent pads, is provided by first applying to a web of fibers a cold water soluble polyvinyl alcohol binder, such as by spraying, impregnating, printing and the like. Before this polyvinyl alcohol treated web is dried, it is oversprayed with a solution of insolubilizing agent, such as borax. This agent, when applied to the polyvinyl alcohol treated web before the polymer has set to a film, crosslinks at least the exposed surface areas of the polymer sufficiently to render the polymer somewhat water resistant after the web is dried. Webs treated in this manner are found to have much greater strengths at the intermediate moisture levels normally encountered during use, than webs bonded by untreated or unmodified polyvinyl alcohol. Yet in a large excess of water, as is encountered when dropped in a toilet bowl, the insoluble nature of the treated binder is nullified, and the web bonded with borax treated binder disintegrates almost as fast as a web bonded with untreated polyvinyl alcohol. The large excess of water is instrumental in leaching out the borax to destroy enough of the crosslinks in the polymer to reduce water-resistance to a non-effective level.

While applying borax in the above manner to the polyvinyl alcohol with which a non-woven web has been freshly treated improves the functional strength properties as indicated above, it was found to have some disadvantages. First, the process itself requires a two-step operation, i.e., an initial application of polyvinyl alcohol binder to the web followed by an application of borax. Second, borax treatment, the described second step, tends to produce a somewhat non-uniform product, probably because the borax coats the polyvinyl alcohol indiscriminately, and also because the polyvinyl alcohol surface first contacted by the borax forms a gel which prevents further penetration by the salt and results in crosslinking primarily in surface areas when heat is later applied. In an effort to alleviate these shortcomings an improved process for bonding a non-woven web with a uniformly borated polyvinyl alcohol has been devised. Several advantages are obtained. The process is accomplished in one step; the cross-linking which makes the polyvinyl alcohol insoluble is more uniform and results in a stronger web; and less binder is required to obtain equivalent strengths. The present invention describes this improved process and product.

SUMMARY OF THE INVENTION

In an effort to provide a more suitable product attempts were made to add borax directly to the polyvinyl alcohol solution before applying the binder solution to non-woven webs. However, this proved unsuccessful because the borax caused gelation of the polymer at relatively low concentrations making it virtually impossible to apply the polyvinyl alcohol to the web in useful quantities by known methods. For example, it was found that a 2% solution of

polyvinyl alcohol gels quickly in the presence of 4% sodium borate (borax) on the basis of the polymer.

It was then discovered that this difficulty could be overcome if there is added to the polyvinyl alcohol solution certain chemicals which are non-reactive in room temperature solutions but which react to form borax upon heating. Under these conditions, the polyvinyl alcohol does not gel prematurely or become too viscous to handle, and can be applied in quantities sufficient to provide useful strength. For example, a 4% solution of the same type of polyvinyl alcohol containing 5% boric acid and 3.5% sodium bicarbonate based on the polymer will have a viscosity of only about 1000 cps. Upon heating this solution these two salts react to yield 4% sodium borate on the basis of the polyvinyl alcohol. The newly formed borax causes the polyvinyl alcohol solution to gel and at the same time forms cross-links therewith. The gelation of the polyvinyl alcohol by the boric acid-sodium bicarbonate system appears to be at least in part, a function of pH. A solution of 0.2% boric acid and 0.14% sodium bicarbonate, i.e. the 4% solution mentioned above, has a pH of 7.6 and will not gel an equal volume of a solution of 4% polyvinyl alcohol. When this mixed salt solution is heated, however, carbon dioxide is released and the pH rises to about 8.0. The salt solution then becomes a gelling agent for the above mentioned polyvinyl alcohol solution. With this discovery, it is now possible to impregnate or otherwise treat a web with controlled amounts of polyvinyl alcohol and subsequently crosslink the resin in situ. The chemicals are first added to the polyvinyl alcohol solution, and the solution containing the chemicals is then applied to the web as before. The treated web is then heated to form the borax in situ, which gels the polyvinyl alcohol while simultaneously forming crosslinks therewith to render it substantially water-insoluble. This insolubility is of a temporary nature, being effective under very high moisture conditions while being destroyed after a short soaking in excess water.

Accordingly, it is an object of the present invention to provide an improved flushable wrapper for sanitary napkins and other absorbent pads, which wrapper is bonded with a uniformly crosslinked polyvinyl alcohol giving the web sufficient wet strength to retain its integrity during normal use in the presence of body moisture, but disintegrating readily after a short time when deposited in water such as in a toilet bowl, and when further agitated as by passing through a sewer line.

Another object is to provide a process for obtaining the improved wrapper.

Still another object is to provide sanitary napkins and the like in which the entire structure is flushable.

These and other objects will become apparent by reference to the following specification and drawings wherein there are described various selected embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a chart comparing the burst strengths of a one-step borated polyvinyl alcohol bonded web made in accordance with this invention with the burst strengths of a two-step borated polyvinyl alcohol bonded web.

FIG. 2 is a chart comparing the burst strengths of webs bonded by a one-step borated polyvinyl alcohol modified by various plasticizers with a non-plasticized one-step borated web, and with each other, and illustrating another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In one embodiment of the invention, a cold water solution of 3% polyvinyl alcohol containing 0.15% boric acid, 0.10% sodium bicarbonate was sprayed onto a carded web, weighing approximately 14 grams per square yard and comprised of 1.5 denier 1⅜" staple length rayon fibers, to give a 10% add-on of polyvinyl alcohol. The

treated web was then dried at a temperature sufficient to cause the chemicals to react, i.e. 20 minutes at 90°–100° C. Under these conditions, it is calculated that for the amount of boric acid and sodium bicarbonate used the amount of borax formed and crosslinked with the polyvinyl alcohol was above 4% on the weight of the polyvinyl alcohol or 0.4% of the weight of the fibers.

For comparison, a second base web of the type described above was sprayed with a 3% solution of cold water soluble polyvinyl alcohol to provide a solids pickup of about 10% based on the web weight and then oversprayed with a 2% solution of borax to provide 5% salt pickup on the weight of the polyvinyl alcohol or about 0.5 percent salt pickup based on the web weight. This web was also dried in the same manner to crosslink the borax to polyvinyl alcohol.

Both webs were then subjected to burst strength measurements, first while dry, and then while containing various amounts of moisture, and after soaking for various time periods. It was found that the first web had greater dry strength, as well as greater burst strength under all moisture conditions than the second web bonded by the two-step process.

The chart of FIG. 1 graphically illustrated these differences.

Note that the one-step borated PVA starts with a dry burst strength of over 140; has a wet burst of about 81 at 100% moisture; and about 23 at 500% moisture; yet falls off to 0.0% burst after 1½ min. soaking.

Note that the two-step borated PVA with 20% additional borax starts out with a dry burst strength of over 120; has a wet burst of about 52 at 100% moisture, and about 11 at 500% moisture. It loses all strength at a faster rate upon soaking, as might be expected.

The improved strengths of the one-step borated PVA as indicated by this chart, shows that it has a marked functional advantage over the older style web. The figures also indicate that less borax is needed to obtain equivalent or greater strengths.

It was also discovered that a plasticized, one-step borated polyvinyl alcohol adhesive is often stronger under extreme moisture conditions than the borated polyvinyl alcohol adhesive alone, and that the use of a properly selected plasticizer can improve the function of the borated polyvinyl alcohol without interfering with disposability of a web bonded therewith, and in fact speeding up its dispersability in excess water. Not all plasticizers provide the necessary wet strength characteristics. Some make the web too strong so that it will not disintegrate in water. Others tend to weaken the original bonding power or dry strength. It is evident that the choice of plasticizer used in the adhesive has a significant effect on the bonding strength of the formulation under various conditions of moisture.

Glycerine and polyglycol compounds are the most frequently used plasticizers for polyvinyl alcohol. It was found that glycerine was detrimental to dry strength of the polyvinyl alcohol and yet would not disintegrate readily in water as desired, while certain polyglycol compounds improved dry strength of the polyvinyl alcohol and surprisingly would disintegrate more rapidly in water than unplasticized polyvinyl alcohol.

It is believed that these latter polyhydroxy plasticizers react with the borate ion in a manner similar to the polyvinyl alcohol. These compounds thus tend to bridge the polyvinyl alcohol chains with the borate ion acting as a crosslinking agent.

It was found that when a series of polyglycols of different molecular weights are used as plasticizers there is considerable variance in wet burst strengths at various moisture levels and after soaking. In most instances the burst strengths after soaking start high with the low molecular weight plasticizers, decrease as these weights increase, then rise again as weights increase still more. Table 1 illustrates this effect.

TABLE 1

Bonding strength of plasticized, borated polyvinyl alcohol adhesives

Plasticizer	Burst strength (g./cm.²)							
	Moisture—						Soak time of—	
	Dry	100%	200%	300%	400%	500%	30 sec.	1 min.
None	127	58.3	35.5	24.7	17.5	15.5	3.9	1.8
Polyethylene glycol—(2, 2' oxydiethanol):								
106	143	60.2	50.9	38.1	41.5	26.3	10.2	3.9
200	118	49.0	48.3	41.9	34.5	36.9	3.1	0.0
300	128	51.2	36.4	30.5	30.8	30.0	0.0	
400	101	62.7	32.2	36.5	34.6	25.6	8.1	0.0
600	146	40.1	22.3	21.6	16.0	16.8	7.5	4.2
1,000	96	25.3	21.4	18.6	22.3	20.8	18.0	13.0
Methoxypolyethylene glycol:								
350	176	70.0	43.6	33.8	18.0	15.5	0.0	
750	165	42.5	41.1	40.7	38.5	36.9	5.3	2.6
Polypropylene glycol—(1, 2-propanediol):								
76	155	79.4	64.3	41.4	43.7	32.1	19.9	4.2
150	168	112.8	85.8	80.6	56.2	42.8	8.7	3.0
425	192	77.4	46.6	40.0	26.8	25.6	1.6	0.0
Glycerine	87	63.9	45.6	45.3	40.9	17.7	3.3	1.0
1, 5-pentanediol	132	51.2	55.1	44.9	40.6	20.6	15.0	6.9
1, 2, 6-hexanetriol	138	59.5	58.8	49.3	41.3	35.1	19.8	8.9

NOTE.—¾" rayon fiber carded web substrate; Basis weight 14 grams/sq. yd., 10% polyvinyl alcohol add-on. 0.4% borate, 1% plasticizer.

The table shows that, in general, the soak strengths of the bonded webs are fairly high when plasticized with the lower molecular weight compounds. For example, when using the polyethylene glycol of 106 molecular weight, soak strength after 30 seconds of soaking is high. At 200 molecular weight, soak strength declines to about 3.1, and at 300 molecular weight, the soak strength declines to zero. Then as the molecular weight of the polyethylene glycol is further increased, the soak strength increases markedly again.

While for the methoxypolyethylene glycol only two molecular weights were tested, it is evident that the trend is similar to the polyethylene glycol. The 350 molecular weight material has zero soak strength, and the heavier 750 weight material has a 5.3 soak strength value. Tests with polypropylene glycols further confirm this. For a molecular weight of 76 the latter showed a soak strength of 19.9 decreasing to 1.6 at a molecular weight of 425. Higher molecular weights for both methoxypolyethylene glycol and polypropylene glycol would most likely show increasing burst values.

Apparently at least two competing factors are responsible for the crosslinking strength of the polyglycols. These are believed to be polymer solubility and molecular size. For the purposes of this invention the polyethylene glycol of 300 molecular weight appears to have the proper balance of the solubility and molecular size to give a rapid breakdown of the complex in excess water. Below a molecular weight of about 300, a polyethylene glycol may form such strong crosslinks to polyvinyl alcohol through the borate ion that excess water cannot easily break the complex down. Above a molecular weight of 300, the polyethylene glycol may be forming increasingly weaker crosslinks due to steric hindrance but it is also becoming less soluble and thus less prone to attack by excess water.

As indicated previously, when methoxypolyethylene glycol was used as the plasticizer, the 350 molecular weight material had zero burst strength after a 30 second soaking while the 750 molecular weight material had a higher burst strength of 5.3 after soaking. The 350 molecular weight is therefore preferred for this particular plasticizer.

When polypropylene glycol was used as the plasticizer the low molecular weight material of 76 had a high burst strength of 19.9 after soaking for 30 seconds. This value fell off to 8.7 for the 150 molecular weight material, and fell off further to a value of 1.6 for the 425 molecular weight material which is therefore the preferred weight for the latter plasticizer.

In general the indication is that polyglycol plasticizers of intermediate weight are preferred, particularly those falling in the range of slightly below 200 to about 500.

Three formulations of plasticized, borated polyvinyl alcohol were found to have particularly good strength characteristics. These were the adhesives incorporating (1) polyethylene glycol 300, (2) methoxypolyethylene glycol 350, and (3) polypropylene glycol 425 as plasticizers. Each of these adhesive formulations imparted good dry strength to the web, retained significant strength at intermediate moisture levels, and yet broke down quickly in excess water. FIG. 2 illustrates the strength properties of webs produced with these formulations. Note that strengths of these webs tend to hold up better under high moisture conditions yet fall off sharply in strength when subjected to soaking. Note also that the fibers used in these webs averaged about ¾" in length, yet the webs had a strength comparable to webs using 1 9/16" length fibers and bonded with non-plasticized borated polyvinyl alcohol. It is evident that the added strength provided by the plasticized and borated binder permits the use of shorter fibers while providing equivalent strengths.

The polyvinyl alcohol employed in the above-described examples was of a type which was about 79–82% hydrolyzed, had a viscosity of about 22 cps. (4% solution at 20° C.), and was readily soluble in cold water. Other polyvinyl alcohols were also found to perform well as long as they were cold-water soluble. For example, polyvinyl alcohols having a percent hydrolysis in the range of 74 to about 98 are generally cold-water soluble and are suitable for the described use.

When using cold-water soluble polyvinyl alcohols with the degree of hydrolysis indicated above, the borax treatment was found to give the bonded web a better burst strength at high moistures than webs bonded with untreated polyvinyl alcohol binder of the same degree of hydrolysis, while not substantially inhibiting ultimate solution of the binder in excess water.

It is possible to prepare functional wrappers using from 5% to 15% polyvinyl alcohol by weight of fibers, and from about 2% to about 8% borax based on the weight of the PVA (i.e. 0.1% to 1.5% borax on the weight of the fibers). Below 2% borax there is not sufficient crosslinking to effect the wet strength. Above 8% the resulting amount of crosslinking provided too much wet strength.

With regard to the amount of polyvinyl alcohol used to bind the web, the following was noted; when the amount was below 5% the web was too weak, and when the amount was above 15% the web tended to become too sticky when moist to be of practical use.

In addition to the rayon fibers of textile length described in the specific examples, other synthetic textile fibers, especially other types of regenerated cellulose may be suitably used in the non-woven wrapper, as well as natural cellulose fibers, and various mixtures of synthetic and natural fibers.

The polyvinyl alcohol may be applied by spraying, impregnation, printing or the like. However, a printing application can be better controlled and usually gives better strengths for equivalent amounts while also providing better softness and drying qualities.

Any suitable absorbent core which is disintegratable in water may be used for the pad filler in the sanitary napkin structure. Soluble or insoluble baffle members as found in various sanitary napkin structures may be used. While insoluble baffles such as thin sheets of polyethylene film will not disintegrate in water, such baffles are usually so thin, flexible and small that they will not cause stoppages in sewerage systems having standard diameter pipelines.

While the above described preferred embodiments relate particularly to sanitary napkins, it will readily be seen that the wrapper is equally applicable to other absorbent pads such as diapers, hospital pads, absorbent bandages and the like.

What is claimed is:

1. A method for fabricating an improved flushable wrapper designed especially for sanitary napkins and similar pads, said method comprising the steps of first providing an aqueous solution of normally cold-water soluble polyvinyl alcohol, preparing a mixture of boric acid and sodium bicarbonate in water and adding said mixture to said polyvinyl alcohol solution, said boric acid and said sodium bicarbonate being present in amounts such that when heated to cause the boric acid and sodium bicarbonate to interact, an amount of borax is generated which is equal to about 2% to about 8% by weight of the polyvinyl alcohol, treating a non-woven web of textile length fibers with said solution in an amount to deposit on said web from 5% to about 15% polyvinyl alcohol by weight of said fibers, heating said treated web to a temperature sufficient to cause the boric acid and sodium bicarbonate to react and form borax, and continuing to heat said web to dry it whereby substantially all of said borax crosslinks with said polyvinyl alcohol uniformly throughout the polyvinyl alcohol structure and thereby renders said polyvinyl alcohol temporarily water-insoluble.

2. The method of claim 1 wherein said solution is a 4% solution of polyvinyl alcohol, said boric acid is present in the amount of 5% based on the weight of the polyvinyl alcohol, said sodium bicarbonate is present in the amount of 3.5% on the same basis and the amount of borax generated is about 4% based on said polyvinyl alcohol.

3. The method of claim 1 in which said solution also contains a plasticizer.

4. The method of claim 3 in which said plasticizer is a polyglycol of intermediate molecular weight.

5. The improved flushable wrapper obtained by the method set forth in claim 1.

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