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(54) Linerboard and process for making the same.

(57) Linerboard is impregnated with a cured resin so as to remain sufficiently flexible to be formed into standard rolls for storage and has high strength and better water resistance than comparable untreated linerboard. The impregnated linerboard is convertible to corrugated paperboard by standard techniques. Impregnation of the linerboard with thermosetting resin and substantial cure of said resin occurs prior to introduction of the linerboard into a corrugation process. The corrugated paperboard so produced retains the enhanced water resistant properties of the linerboard.

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LINERBOARD AND PROCESS FOR MAKING THE SAME

FIELD OF THE INVENTION

This invention relates to linerboard and to a process for preparation of linerboard having improved humidity resistance, wet rigidity and substantial dry flexibility.

A problem with present packages formed from standard commercial corrugated paperboard is the lack of water and humidity resistance. The numerous publications referred to below attest to this problem and to the numerous attempts to remedy this problem. Almost invariably these attempts have required use of expensive coatings, modification of the papermaking process, modification of the corrugator, reduced speed of operation of the corrugator, substantial modification of post corrugator processing of the board, and the like. Needless to say the above requirements all add a cost factor to the finished product. In a highly competitive field, such as, corrugated packaging the game is usually won by the lowest cost solution, all else being equal.

The present invention provides a linerboard which makes possible the fabrication of corrugated packages having enhanced moisture and high humidity level performance, increased strength for a given basis weight of board employed with no modification required of the papermaking process, the corrugating machinery and process, or the post corrugator processing of the board.

BACKGROUND ART

The following patents represent background prior art.

U.S. Patent 2,708,645. This patent teaches the surface coating of produced paper articles such as two piece substantially cylindrical cups, with urea formaldehyde resin. Precoating and cure prior to formation of the object and impregnation other than on the immediate surface are not suggested.

thereon which is produced by coating a paper substrate with an aqueous emulsion containing a synthetic rubber latex and a wax emulsion and then drying the coated paper at a temperature the same as or higher than the melting point of the wax. The resultant paper is said to be highly capable of repulping.

U.S. Patent 3,196,021. This patent teaches a corrugated board having good wet strength wherein the paperboard is treated with wet strength resins and the paperboard (liner and medium) is impregnated with a molten blend of wax and thermoplastic resins prior to assembly on the corrugator.

Other patents of which applicants are aware, which, while bearing on the art, are deemed cumulative and thus even more remote are U.S. Patents 3,357,877; 3,485,575; 3,644,167; 3,682,762; 3,920,496; 3,936,339; and 3,984,275. Copies of all the cited patents are provided for the Examiner's convenience.

The present invention is concerned with the unexpected finding that linerboard may be impregnated with thermosetting resin, the resin may then be substantially cured and the impregnated linerboard will remain flexible enough to be rolled in standard rolls for shipping and storage. The treated linerboard may then be fabricated in a standard corrugator at high speed employing standard medium, either untreated or similarly treated, to provide corrugated board having excellent wet crush resistance and enhanced overall wet and dry strength properties. No wax or other water resistant coating is required to obtain the substantial improvement in water resistant peroperties.

SUMMARY OF THE INVENTION

In accordance with the invention, we provide linerboard having improved humidity resistance, wet rigidity and substantial dry flexibility, characterized by containing up to about 15% by weight of a substantially

cured thermosetting resin.

We also provide a process for making linerboard, characterized by impregnating the linerboard with an aqueous emulsion of a thermosetting resin for deep penetration of said resin into the linerboard, said aqueous emulsion being applied in an amount sufficient to provide up to about 15% by weight resin solids in said linerboard; drying the resin impregnated linerboard and substantially curing said resin.

The linerboard thus treated are sufficiently flexible to be formable into conventional rolls for subsequent processing or storage, of having enhanced wet strength, and of being formable into corrugated paperboard having enhanced wet strength. The board may be fabricated on conventional corrugating machinery employing conventional techniques of fabrication and conventional commercial speeds. Subsequent formation of carton blanks and cartons may also be accomplished employing standard machinery and techniques. The usefulness of the tangible embodiments in the fabrication of packages is, thus evidenced.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In describing the process of the invention, for convenience of disclosure, reference will be made to a kraft linerboard impregnated with urea formaldehyde resin.

Standard kraft linerboard may be treated in standard application apparatus, for example, a three roll coater, with an aqueous emulsion of a urea formaldehyde resin, for example, an approximately 65% solids content emulsion sold under the designation PR-274 by the Borden Company. In addition to the three roll coater, other standard applicator devices such as size presses, may be employed at the convenience of the operator.

The configuration of the applicator roll, if a three roll coater is employed, is not critical but it

has been found convenient to use a gravure roll rather than a smooth roll. The gravure roll provides more uniform pickup and application of the emulsion to the board thus permitting easier control of resin application. It has also been found that a reverse three-roll coater with smooth rolls provides emulsion application equivalent to that obtained employing a three-roll direct coater with gravure rolls. The use of a reverse three-roll coater so equipped is also preferred.

The board containing the resin emulsion may then be heated in conventional fashion, conveniently in a drying oven or with heated rolls or a combination thereof, to remove moisture and to substantially cure the resin. The board containing the substantially cured resin may then be stored in conventional fashion, conveniently in the form of rolls for use when required in conventional fashion in a conventional corrugator. In the alternative, it may be passed directly to the corrugator without intermediate storage, although, this would not be preferred.

Corrugated board may be formed from the linerboard containing the substantially cured resin in conventional fashion employing conventional corrugators to adhere at least one corrugated corrugating medium to at least one substantially cured resin contaning board. One skilled in the art will recognize however that, in addition to kraft linerboard, any paperboard normally considered as suitable for use as linerboard in the manufacture of corrugated paperboard may be employed. One may employ any desired, suitable corrugating medium in combination with the cured resin impregnating linerboard of the invention.

Adherence of the corrugating medium and linerboard may be accomplished by conventional methods long known in the art. Conventional starch based, acid catalyzed adhesives containing vinyl emulsions to enhance water resistance such as those of U.S. Patent 3,984,275

may be used as well as known basic starch vinylemulsion adhesives.

It will also be obvious that the process of the invention is applicable to the manufacture of modified versions; i.e. any desired weight basis of linerboard and medium, single faced, single, double, or triple wall contruction etc., at the option of the artisan employing said process.

After formation of the corrugated board it may be cut to any desired shape, slotted and scored for forming into containers in standard fashion.

In addition to the urea formaldehyde resin emulsion, PR-274, specifically referred to above, other equivalent urea formaldehyde resin emulsions including Pacific 2027 supplied by Pacific resin and chemicals may be used. In fact, any thermosetting resin emulsion known to those in the art may be employed. Illustrative of these are emulsions of phenolformaldehyde and melamin formaldehyde.

The resin emulsions may also, if desired, contain other conventional additives, such as cure catalysts.

It has also been found that, while not critical, the presence of a surfactant in the emulsion as a penetration aid assists in obtaining more uniform distribution of the resin emulsion and consequently the cured resin within the paperboard sheet. A non-ionic wetting agent has been found advantageous for use with urea formaldehyde emulsions.

In addition to treatment of linerboard with thermosetting resin as disclosed, it will readily be apparent to those skilled in the art that corrugating medium may similarly be impregnated for it to remain sufficiently flexible after resin cure to be stored in roll form and to be fluted on the corrugator. The use of such impregnated corrugating medium is comprehended in the terms "corrugating medium" and "standard corrugating medium" herein and in the appended claims, unless the context specifically requires otherwise.

One skilled in the art will recognize that subsequent to formation of the corrugated paperboard of this invention, it may, as part of its subsequent processing be further treated with additional water resistance supplying or waterproofing materials. Coating of carton blanks with wax is an example of such a process.

The amount of resin emulsion applied to the paperboard so as to provide a desired final concentration of cured resin and the final concentration of cured resin in the paperboard may vary within wide limits and is not critical.

For linerboard having a basis weight of about 42 pounds per one thousand square feet, a final cured resin concentration of from two pounds to about six pounds per one thousand square feet may be employed with about 4.0 pounds per one thousand square feet being preferred.

For corrugating medium having a basis weight of about 26 pounds per one thousand square feet, a final cured resin concentration of from about one pound to about three pounds per one thousand square feet may be employed with about 2.0 pounds per thousand square feet being preferred.

As used herein and in the appended claims, the term "deep penetration" means penetration of a particular paperboard approaching and/or including the midpoint of the thickness of the paperboard as contrasted to a shallow or a surface coating which penetrates only a slight degree.

The following examples further illustrate the best mode contemplated by the inventors for the practice of their invention.

In the following examples, the resin employed is a urea formaldehyde resin emulsion sold by the Borden Company under the designation PR-274. This material has approximately 65% solids content and for convenience in application it is diluted with water to about a 55% solids

content immediately before application. When a cure catalyst is added, it is a 25% aqueous solution of ammonium sulfate and is added in an amount 2% by weight of the resin solids. The paperboard employed is standard 42 pounds basis weight kraft linerboard and the corrugating medium is standard 26 pounds basis weight corrugating medium.

Testing procedures employed to obtain the physical data are all well known in the industry.

Example 1

Linerboard samples are treated with urea formaldehyde resin emulsion, dried, and simultaneously cured, to about six to eight percent moisture content. The physical properties of treated samples and of an untreated control linerboard are tabulated in Table I which illustrates the improved wet tensile and ring crush properties for linerboard treated with resin compared with untreated linerboard and illustrates generally the effect of resin treatment on the physical properties of linerboard in comparison with untreated linerboard.

TABLE I

Sample Designation	L-1	L-2*	L-3	L-4	L-5	L-6	L-7*	Control Liner
Days Between Treatment and Testing	2	2	21	21	8	8	12	-
Basis Weight, lb/MSF#	46.9	51.1	48.1	48.0	46.7	46.5	46.9	42.3
Mullen (lb)	78	57	81	60	96	88	60	108
Caliper (0.001 in.)	14.0	13.8	14.4	14.5	13.8	13.8	13.2	12.5
Tensile (lb)								
**MD, Dry	91	88	71	61	89	84	101	91
***CD, Dry	37	35	39	34	40	43	35	34
MD, Wet	22	39	11	8	12	11	39	2
CD, Wet	10	14	6	7	5	6	14	1
Ring Crush (lb)								
MD, Dry	120	137	94	96	125	129	149	105
CD, Dry	103	171	88	89	100	104	123	70
MD, Wet	-	-	16	13	16	14	28	10
CD, Wet	14	24	13	12	12	12	22	7
Cobb Size, (g/m^2/2 min)								
Felt Side	33	29	20	23	35	34	35	39
Wire Side	13	7	26	25	27	25	12	48
MIT Fold ##								
MD	-	-	232	137	244	234	327	576
CD	-	-	118	64	127	175	119	278
Tear (g)								
MD	-	-	240	-	220	192	200	340
CD	-	-	282	-	272	300	240	385

#MSF-1000 square feet
*Resin - Precatalyzed
**MD - Machine Direction
***CD - Cross Machine Direction
MIT Fold - Standard fold test described in TAPPI- 511 su-69 published 1967 and available from TAPPI, 360 Lexington Avenue, New York, N.Y. 10017

Example 2

Sample media are treated with urea formaldehyde resin emulsion, dried, and simultaneously cured, to about six to eight percent moisture content. The physical properties of treated samples and of an untreated control medium are tabulated in Table II which illustrates the effect of resin treatment on physical properties of corrugating medium in comparison with untreated medium.

TABLE II

Sample Designation	M-1	M-2	M-3*	Control Medium
Days Between Treatment and Testing	12	8	2	
Basis Weight (lb/MSF)	28.0	28.5	29.5	26.4
Caliper (0.001 in.)	8.5	8.5	9.0	10.6
Tensile (lb)				
MD, Dry	55	50	73	47
CD, Dry	22	19	25	19
MD, Wet	2	5	33	2
CD, Wet	1	2	13	1
Ring Crush (lb)				
MD	53	57	68	-
CD	33	46	50	43
Tear (g)				
MD	104	136	-	116
CD	150	188	-	138
Water Drop (s)				
Felt	102	87	-	44
Wire	273	300+	-	-
Concora Crush (lb)	71	73	119	54

*Had difficulty in fluting during conversion trial.

Example 3

Corrugated paperboard is formed from linerboard samples described in Example 1 and from untreated medium. As an additional comparison, a board is formed wherein the previously untreated 42 pounds linerboard is treated with the urea formaldehyde resin and subjected to a brief period at drying and curing temperature in line during corrugation. The treatment and heating occur immediately before gluing to the medium and during the glue drying and setting process. The properties obtained are tabulated in Table III which illustrates the physical properties of corrugated board formed with resin treated linerboard wherein the resin is applied off-line as contemplated by the instant invention or in the corrugator line as in current industrial practice in comparison with standard untreated corrugated board. It particularly illustrates the improved properties under wet or high humidity conditions and the greater crush resistance of boxes formed from treated board. It also shows that the properties obtained from off-line treatment are substantially similar to those obtained through the known in-line process.

TABLE III

MODE OF RESIN TREATMENT	OFF-LINE	OFF-LINE	OFF-LINE	IN-LINE	NONE
Liner Code	L-1	L-5	L-7	Control	Control
Basis Weight (lb/MSF)	140.6	136.8	141.2	143.6	128.7
Caliper, (0.0001 in.)	164.0	160.0	160.0	161.3	159.8
Column Crush, (lb)					
73°F/50% RH*	73	73	95	88	69
Wet, 24 hr	7	8	10	11	5
Flat Crush (psi)	37	38	40	33	34
Ply Adhesion (p5si)					
73°F/50% RH	85	94	83	83	77
Wet, 2 hr	11	16	10	13	0
Box Compression T/B**(lb)					
73°F/50% RH	1394	1450	1330	1232	894
90°F/90% RH	734	-	734	684	520

*Relative Humidity
**Top to bottom.

Example 4

Corrugated paperboard is prepared from linerboard samples prepared in Example 1 and from untreated medium, as well as, medium prepared in Example 2. The corrugated is run at speeds of 200, 300 and 400 feet per minute. Properties of the boards so prepared are tabulated in Table IV which illustrates the physical properties of corrugated board prepared with resin treated liner and untreated medium compared with those of corrugated board prepared from resin treated liner and resin treated medium.

TABLE IV

Corrugator Speed, ft/min	200	300	400	200	300	400
Liner Code	L-1	L-1	L-1	L-5	L-5	L-5
Medium Code	Control	Control	Control	M-2	M-2	M-2
Basis Weight (lb/MSF)	140.6	142.5	142.5	142.8	142.5	142.9
Caliper (0.001 in.)	164.0	161.6	158.4	161	161	154
Column Crush (lb)						
73°F/50% RH	73	117	64	76	82	80
Wet, 24 hr	7	13	13	7	7	9
Flat Crush (psi)	37	34	34	42	46	43
Pin Adhesion (p5si)						
73°F/50% RH	82	95	90	96	101	103
Wet, 24 hr	10	14	16	24	22	21
Box Compression T/B, (lb)						
73°F/50% RH	1394	1524	1386	1470	1550	1450
90°F/90% RH	734	842	816	-	-	-

Example 5

Corrugated paperboard is prepared from samples of linerboard prepared in Example 1, from an untreated control linerboard, from medium prepared in Example 2 and untreated control medium. The properties of the boards are tabulated in Table V which illustrates the physical properties of corrugated board prepared from resin treated liner and treated and untreated medium compared with board prepared from untreated liner and medium. It particularly shows the similarity of and improvement of properties, particularly under wet conditions for the corrugated having treated liner and both treated and untreated medium.

TABLE V

Corrugator Speed, ft/min	200	200	200
Liner Code	L-5	L-5	Control
Medium Code	M-2	Control	Control
Basis Weight (lb/MSF)	142.8	136.8	128.2
Caliper (0.001 in.)	161	160	160
Column Crush (lb)			
73°F/50% RH	76	73	46
Wet, 24 hr	7	7	2
Flat Crush (psi)			
73°F/50% RH	42	38	27
Wet, 24 hr	3	3	1
Pin Adhesion (p5si)			
73°F/50% RH	96	93	88
Wet, 24 hr	24	16	0
Box Compression T/B (lb)			
73°F/50% RH	1470	1450	955
90°F/90% RH	-	-	-

Example 6

Corrugated paperboard is prepared from linerboard prepared in Example 1 at various times after treatment. The properties of the boards are tabulated in Table VI which illustrates that storage of linerboard prepared as contemplated by the invention for an extended period does not result in substantial variation in properties in corrugated board made from it when compared to properties of corrugated board prepared from the same liner a relatively short time after treatment.

TABLE VI

Corrugator Speed, ft/min	200	200
Liner Code	L-5	L-4
Time Period, days (Coating-Converting)	65	15
Medium Code	Control	Control
Basis Weight (lb/MSF)	141.5	136.8
Caliper (0.001 in)	159	160
Column Crush (lb)		
73°F/50% RH	73	73
Wet, 24 hr	6	7
Flat Crush (psi)	36	38
Pin Adhesion (p5si)		
73°F/50% RH	76	93
Wet, 24 hr	16	16
Box Compression T/B (lb)		
73°F/50% RH	1360	1450

Example 7

A sample of linerboard prepared in Example 1 is tested at various times after preparation. The properties of the treated linerboard and of an untreated control are tabulated in Table VII which illustrates that storage of resin treated linerboard prepared as contemplated by the invention has substantially little effect on properties. Properties of an untreated control sample are included for reference and further illustration of the superior properties under wet conditions provided by resin treatment.

TABLE VII

Liner Code	L-4	L-4	L-4	Control
Age, days before test	20	35	77	-
Basis Weight (lb/MSF)	48.1	48.0	48.2	42.3
Mullen (lb)	81	72	88	108
Caliper (0.001 in.)	14.4	14.3	14.2	12.5
Tensile (psi)				
73°F/50% RH				
MD	71	70	69	91
CD	39	45	39	34
Wet, 24 hr				
MD	11	13	9	2
CD	6	9	6	1
Ring Crush (psi)				
73°F/50% RH				
MD	94	110	92	105
CD	88	100	84	70
Wet, 24 hr				
MD	16	15	14	-
CD	13	13	11	9
MIT Fold				
MD	232	247	251	576
CD	118	207	280	278

C L A I M S

1. Linerboard having improved humidity resistance, wetrigidity and substantial dry flexibility, characterized by containing up to about 15% by weight of a substantially cured thermosetting resin.

2. Linerboard according to claim 1, characterized in that the thermosetting resin is ureaformaldehyde resin.

3. Linerboard according to claim 1 or 2, characterized by a corrugating medium adhered to the cured linerboard.

4. A process for making linerboard according to claim 1 or 2, characterized by impregnating the linerboard with an aqueous emulsion of a thermosetting resin for deep penetration of said resin into the linerboard, said aqueous emulsion being applied in an amount sufficient to provide up to about 15% by weight resin solids in said linerboard; drying the resin impregnated linerboard and substantially curing said resin.

5. A process for making the linerboard of claim 3, characterized by adhering at least one corrugating medium to the linerboard before curing thereof.

6. A process according to claim 4 or 5, characterized in that the aqueous emulstion of a thermosetting resin is a urea formaldehyde aqueous emulsion.

European Patent Office

EUROPEAN SEARCH REPORT

0071871
Application number

EP 82 10 6770

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	US-A-2 309 089 (J.V. BAUER et al.) * Whole document *	1-4	D 21 H 3/54 B 31 F 1/20
A	US-A-3 858 273 (H.B. GOLDSTEIN)		
D,A	US-A-3 431 162 (R.M. MORRIS)		

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

B 31 F
D 21 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-11-1982	NESTBY K.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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& : member of the same patent family, corresponding document

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