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**US-A-2 309 089
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Description

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

- 5 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.

- 15 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.

- 20 US—A—2,309,089 teaches to introduce uncured resin into a sheet while processed in the paper machine and before final drying on the paper machine. Further, the known process requires that cure catalyst is introduced subsequently to drying for retention of the desired flexibility. Thus, this known method requires a substantial modification of the ordinary paper making process which is a considerable draw-back of this known method.

- 25 US—A—2,708,645 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.

- US—A—3,431,162 teaches surface coating linerboard with thermoset resins. Phenolformaldehyde resins are preferred. However, the thermoset resins are applied to the surfaces of the webs forming the linerboard at the entrance of a sizing press, and the pulp forming the webs has been prepared to retard penetration of the resin. Thus, coating rather than impregnation is the objective, and the process takes place again during the paper making process.

US—A—3,519,478 teaches the use of surfactants to assist penetration of a blocked polyurethane emulsion into paper and paperboard.

- 35 US—A—3,687,767 teaches the fabrication of corrugated board wherein wet strength is enhanced by thermoset resin, preferably phenol, with which the linerboard and medium are impregnated. Cure of the resins is avoided until after formation of the corrugated board and cutting, scoring, folding and the like are performed on the otherwise finished corrugated board.

- 40 US—A—3,697,365 is similar to US—A—3,687,767 in that linerboard and medium are both impregnated with wet strength resin. The incorporation of a silyl compound permits cure after formation of corrugated board and before formation of carbon blanks, if desired.

US—A—4,046,930 is directed to the use of anionic sulfonate emulsifiers to form stable aqueous emulsions of epoxy silicones. These emulsions are useful in waterproofing textiles and paper and cure without curing catalysts.

- 45 US—A—4,051,277 deals with rigid-when-wet, but foldable, corrugated paperboard and a process of making the same by applying phenolic resin to contiguous surfaces of the outer liner, the medium and the inner liner without substantially altering the hygroscopicity of the exposed faces of the liners, and adhering the three components together before the resin is cured.

- 50 US—A—4,117,199 teaches a coated paper having a moisture and waterproof coating 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.

- 55 US—A—3,196,021 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.

- 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 properties.

Summary of the invention

- 65 In accordance with the invention, the process for making linerboard comprises impregnating, in the

absence of a wax constituent, preformed and dried linerboard as provided from a paper machine, with an aqueous emulsion of a thermosetting resin for deep penetration of said resin into said linerboard, said preform linerboard being impregnated with an amount of said emulsion sufficient to provide up to 15% by weight resin solids in said linerboard; and thereafter drying the resin impregnated linerboard and substantially curing said resin.

The linerboard thus treated is 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 a 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 containing 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 US—A—3,984,275 may be used as well as known basic starch vinyl emulsion 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 construction 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.

5 For linerboard having a basis weight of about 200 g/m² (42 pounds per one thousand square feet), a final cured resin concentration of from 10 to 30 g/m² (two pounds to about six pounds per one thousand square feet) may be employed with about 20 g/m² (4.0 pounds per one thousand square feet) being preferred.

10 For corrugating medium having a basis weight of about 130 g/m² (26 pounds per one thousand square feet), a final cured resin concentration of from about 5 to 15 g/m² (one pound to about three pounds per one thousand square feet) may be employed with about 10 g/m² (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.

15 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 200 g/m² (42 pounds basis weight) kraft linerboard and the corrugating medium is standard 130 g/m² (26 pounds) basis weight corrugating medium.

25 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
30 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.

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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 (g/m ²)	229	249	235	234	228	227	229	206
Mullen (kg)	35,4	25,9	36,7	27,2	43,5	39,9	27,2	49,0
Caliper (mm)	0,356	0,351	0,366	0,368	0,351	0,351	0,335	0,318
Tensile N/cm ²)								
**MD, Dry	62,7	60,7	49,0	42,1	61,4	57,9	69,6	62,7
***CD, Dry	25,5	24,1	26,9	23,4	27,6	29,6	24,1	23,4
MD, Wet	15,2	26,9	7,6	5,5	8,3	7,6	26,9	7,4
CD, Wet	6,9	9,7	4,1	4,8	3,4	4,1	9,7	0,7
Ring Crush (N/cm ²)								
MD, Dry	82,7	94,5	64,8	66,2	86,2	88,9	102,7	72,4
CD, Dry	71,0	117,9	60,7	61,4	68,9	71,7	84,8	48,3
MD, Wet	—	—	11,0	9,0	11,0	9,7	19,3	6,9
CD, Wet	9,6	16,5	9,0	8,3	8,3	8,3	15,2	4,8
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

50 *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

55 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.

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TABLE II

	Sample designation	M-1	M-2	M-3*	Control medium
5	Days Between Treatment and Testing	12	8	2	
	Basis Weight (g/m ²)	137	139	144	129
10	Caliper (mm)	0,216	0,216	0,227	0,269
	Tensile (N/cm ²)				
	MD, Dry	37,9	34,5	50,3	32,4
15	CD, Dry	15,2	13,1	17,2	13,1
	MD, Wet	1,4	3,4	22,8	1,4
	CD, Wet	0,7	1,4	9,0	0,7
20	Ring Crush (N/cm ²)				
	MD	36,5	39,3	46,9	—
	CD	22,8	31,7	34,5	29,6
25	Tear (g)				
	MD	104	136	—	116
	CD	150	188	—	138
30	Water Drop (s)				
	Felt	102	87	—	44
	Wire	273	300+	—	—
35	Concora Crush (N/cm ²)	49,0	50,3	82,0	37,2

*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 200 g/m² (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.

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TABLE III

	Mode of resin treatment	Off-line	Off-line	Off-line	In-line	None
5	Liner Code	L-1	L-5	L-7	Control	Control
	Basis Weight (g/m ²)	686	667	689	701	628
	Caliper (mm)	4,166	4,064	4,064	4,097	4,059
10	Column Crush (N/cm ²) 22,8°C/50% RH*	50,3	50,3	65,5	60,7	47,6
	Wet, 24 hr	4,8	5,5	6,9	7,6	3,4
15	Flat Crush (N/cm ²)	25,5	26,2	27,6	22,8	23,4
	Ply Adhesion (N/cm) 22,8°C/50% RH	12,4	13,7	12,1	12,1	11,2
20	Wet, 2 hr	1,6	2,3	1,5	1,9	0
	Box Compression T/B** (N) 22,8°C/50% RH	6201	6450	5916	5480	3977
25	32,2°C/90% RH	3265	—	3265	3043	2313

*Relative Humidity.

**Top to bottom.

30 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 60, 90 and 120 m/min (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

40	Corrugator Speed, m/min	60	90	120	60	90	120
	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
45	Basis Weight (g/m ²)	686	695	695	697	695	697
	Caliper (mm)	4,166	4,105	4,023	4,089	4,089	3,912
50	Column Crush (N/cm ²) 22,8°C/50% RH	50,3	80,7	44,1	52,4	56,5	55,2
	Wet, 24 hr	4,8	9,0	9,0	4,8	4,8	6,2
55	Flat Crush (N/cm ²)	25,5	23,4	23,4	29,0	31,7	29,6
	Pin Adhesion (N/cm) 22,8°C/50% RH	12,0	13,9	13,1	14,0	14,7	15,0
60	Wet, 24 hr	1,5	2,0	2,3	3,5	3,2	3,1
	Box Compression T/B, (N) 22,8°C/50% RH	6201	6779	6165	6539	6895	6450
65	32,2°C/90% RH	3265	3745	3630	—	—	—

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, particular under wet conditions for the corrugated having treated liner and both treated and untreated medium.

TABLE V

10	Corrugator Speed, m/min	60	60	60
15	Liner Code	L-5	L-5	Control
	Medium Code	M-2	Control	Control
	Basis Weight (g/m ²)	697	668	626
20	Caliper (mm)	4,089	4,064	4,064
	Column Crush (N/cm ²) 22,8°C/50% RH	52,4	50,3	31,7
25	Wet, 24 hr	4,8	4,8	1,4
	Flat Crush (N/cm ²) 22,8°C/50% RH	29,0	26,2	18,6
30	Wet, 24 hr	2,1	2,1	0,7
	Pin Adhesion (N/cm) 22,8°C/50% RH	14,0	13,6	12,8
35	Wet, 24 hr	3,5	2,3	0
	Box Compression T/B (N) 22,8°C/50% RH	6539	6450	4248
40	32,2°C/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, m/min	60	60
5	Liner Code	L-5	L-4
	Time Period, days (Coating-Converting)	65	15
10	Medium Code	Control	Control
	Basis Weight (g/m ²)	691	668
	Caliper (mm)	4,039	4,064
15	Column Crush (N/cm ²) 22,8°C/50% RH	50,3	50,3
	Wet, 24 hr	4,1	4,8
20	Flat Crush (N/cm ²)	24,8	26,2
	Pin Adhesion (N/cm) 22,8°C/50% RH	11,1	13,6
25	Wet, 24 hr	2,3	2,3
	Box Compression T/B (N) 22,8°C/50% RH	6050	6450

30 Example 7

35 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.

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TABLE VII

	Liner Code	L-4	L-4	L-4	Control
5	Age, days before test	20	35	77	—
	Basis Weight (g/m ²)	235	234	235	206
10	Mullen (kg)	36,7	32,7	40,0	49,0
	Caliper (mm)	0,366	0,363	0,361	0,318
15	Tensile (N/cm ²) 22,8°C/50% RH MD	49,0	48,3	47,6	62,7
	CD	26,9	31,0	26,9	23,4
20	Wet, 24 hr MD	7,6	9,0	6,2	1,4
	CD	4,1	6,2	4,1	0,7
25	Ring Crush (N/cm ²) 22,8°C/50% RH MD	64,8	75,8	63,4	72,4
	CD	60,7	68,9	57,9	48,3
30	Wet, 24 hr MD	11,0	10,3	9,7	—
	CD	9,0	9,0	7,6	6,2
35	MIT Fold MD	232	247	251	576
	CD	118	207	280	278

40 **Claims**

1. A process for making linerboard having improved humidity resistance, wet rigidity and substantial dry flexibility, which comprises impregnating, in the absence of a wax constituent, preformed and dried linerboard, as provided from a paper machine, with an aqueous emulsion of a thermosetting resin for deep penetration of said resin into said linerboard, said preform linerboard being impregnated with an amount of said emulsion sufficient to provide up to 15% by weight resin solids in said linerboard; and thereafter drying the resin impregnated linerboard and substantially curing said resin.

2. A process for making the linerboard of claim 1, characterized by adhering at least one corrugating medium to the linerboard after curing thereof.

3. A process according to claim 1 or 2, characterized in that the aqueous emulsion of a thermosetting resin is a urea formaldehyde aqueous emulsion.

Patentansprüche

1. Verfahren zur Herstellung von Deckpappe mit verbesserter Feuchtigkeitsbeständigkeit, Festigkeit in Naßzustand und Flexibilität im Trockenzustand, bei dem vorgeformte und getrocknete Deckpappe, wie sie von der Papiermaschine geliefert wird, bei Fehlen einer Wachskomponente mit einer wässrigen Emulsion eines in der Wärme aushärtenden Harzes in der Weise imprägniert wird, daß das Harz tief in die Deckpappe eindringt, wobei die Imprägnierung mit einer Menge der Emulsion erfolgt, die ausreicht, um in die Deckpappe bis zu 15 Gew.% an Feststoffen des Harzes einzulagern, und daß danach die imprägnierte Deckpappe getrocknet und das Harz im wesentlichen ausgehärtet wird.

2. Verfahren zur Herstellung von Deckpappe nach Anspruch 1, dadurch gekennzeichnet, daß an der Deckpappe nach dem Aushärten wenigstens eine Wellenbahn zum Haften gebracht wird.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die wässrige Emulsion des hitzehärtbaren Harzes eine wässrige Harnstoff-Formaldehyd-Emulsion ist.

Revendications

1. Procédé de fabrication d'une feuille de recouvrement en carton ayant une résistance à l'humidité améliorée, une rigidité à l'état mouillé et une bonne flexibilité à sec, caractérisé en ce que l'on imprègne, sans constituant à base de cire, une feuille de recouvrement en carton préformé et séché, telle qu'elle sort d'une machine à papier, avec une émulsion aqueuse d'une résine thermodurcissable afin de faire pénétrer profondément la résine dans la feuille de recouvrement en carton, la feuille de recouvrement en carton préformée étant imprégnée avec une quantité d'émulsion suffisante pour constituer jusqu'à 15% en poids de matières solides de résine dans la feuille de recouvrement en carton; et ensuite on sèche la feuille de recouvrement en carton imprégnée de résine et l'on durcit la résine.

2. Procédé de fabrication d'une feuille de recouvrement en carton selon la revendication 1, caractérisé en ce que l'on fait adhérer au moins un élément ondulé sur la feuille de recouvrement en carton après son durcissement.

3. Procédé selon la revendication 1 ou 2, caractérisé en ce que l'émulsion aqueuse de la résine thermodurcissable est une émulsion aqueuse urée formaldéhyde.

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