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(54) Title: PAPER COATING COMPOSITION CONTAINING HIGH STARCH LEVELS

(57) Abstract: Described herein is coating starch composition comprising a starch and a plasticizer, as well as a paper coating composition comprising said coating starch composition, where the paper coating composition contains at least 2% starch, a dry solids content of at least 40%, and a viscosity of less than about 1200 cPs, as well as methods of using and making such compositions, such as, for example, in paper manufacturing processes.

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PAPER COATING COMPOSITION CONTAINING HIGH STARCH LEVELS

[0001] This Application claims priority to US Provisional Patent Application Serial Number 62/809177 filed February 22, 2019 and US Provisional Patent Application Serial Number 62/855461 filed May 31, 2019, both of which are incorporated herein in their entirety.

[0002] Described herein is coating starch composition comprising a starch and a plasticizer, as well as a paper coating composition comprising said coating starch composition, where the paper coating composition contains at least 2% starch, a dry solids content of at least 40%, and a viscosity of less than about 1200 cPs, as well as methods of using and making such compositions, such as, for example, in paper manufacturing processes. The paper and board produced with one or more paper coating composition described herein meets desired strength requirements without having to add more starch before applying said one or more paper coating composition via, e.g., the coaters (*i.e.*, eliminates, e.g., the addition of starch via a wet stack calendering or size press step).

[0003] The following description is provided to assist the understanding of the reader. None of the information provided or references cited is admitted to be prior art to the compositions and methods disclosed herein.

[0004] Coated paper and paperboard require a certain level of surface strength to withstand the stresses of the ink tack in a printing process. To further increase the surface strength of paper or paperboard, the surface of the paper or paperboard is often treated with a first coating of starch applied at, e.g., a wet stack calender or size press prior to being coated with a second coating of starch via a paper coating composition. Manufacturers employing a wet stack calender in the paper-making/paperboard-making process frequently sacrifice machine speed, board density (*e.g.*, too heavy for a given caliper), quality, and uptime associated with the use of, e.g., a wet stack calender or size press. Moreover, adding starch via a first coating at, e.g., a wet stack calender or size press before coating the paper or paperboard with a second coating of starch via the paper coating composition at, e.g., a coater increases the costs associated with manufacturing the paper or paperboard. As a result, there is a need to eliminate the first coating of starch applied at, e.g., a wet stack calender or size press, before coating the paper or paperboard with a second coating of starch via a paper coating composition at, e.g., a coater without compromising the surface strength and quality of the resulting paper or paperboard.

[0005] Disclosed herein is one or more paper coating composition containing the level of starch required to produce paper or board with the required surface strength and quality while still having the desired viscosity and solids content that manufacturers demand, and which also enables the first coating of starch that was applied at, e.g., a wet calender or size press to be eliminated. More specifically, described herein is one or more paper coating composition comprising a coating starch composition comprising a starch and a plasticizer, wherein said paper coating composition contains at least about 2%, from about 2% to about 30%, from about 2% to about 25%, from about 2% to about 22%, or from about 2% to about 10% starch. Another embodiment describes one or more paper coating composition that has (i) a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cps, or about 300 to about 600cPs and a solids content of at least 40%, 45%, 50%, 55%, 60%, 65% or 70% dry solids (ds) basis, or (ii) a viscosity of about 300 to about 600 cPs and a solids content of at least 60% dry solids (ds) basis; and, optionally, wherein the viscosity is measured on a Brookfield Viscometer at 20 rpm at 18.3 °C. Still a further embodiment describes a coating starch composition comprising a starch and a plasticizer, where the coating starch composition has a starch and plasticizer solids level of at least 40% ds basis. Yet still a further embodiment describes a coating starch composition containing 1 part starch for each 1, 1.5, 2, 2.5, 3, 3.5, or 4 parts plasticizer. An even still further embodiment describes a paper coating composition containing from 2 to 20 parts of the starch and from 5 to 35 parts of the plasticizer, from 2 to 10 parts of the starch and from 5 to 25 parts of the plasticizer, or 10 parts of the starch and 25 parts of the plasticizer. A still yet further embodiment describes a paper substrate comprising, on at least one surface, one or more paper coating composition described herein.

[0006] Another embodiment disclosed herein provides a method of manufacturing a dry-finished, coated paper or paperboard product comprising applying one or more paper coating composition described herein to at least one side of a paper or paperboard, and obtaining a dry finished, coated paper or paperboard. Yet another embodiment disclosed herein provides a method of manufacturing a dry-finished, coated paper or paperboard product comprising applying one or more paper coating composition described herein to at least one side of a paper or paperboard, and obtaining a dry finished, coated paper or paperboard, with the proviso that the method does not comprise a wet stack calendering step prior to applying one or more paper coating composition described herein. Some embodiments describe one or more methods where

no starch is applied to the paper or paperboard prior to or after the application of one or more paper coating composition described herein. In some embodiments, one or more method described herein eliminates the use of a wet stack calendering step prior to the application of one or more paper coating composition described herein. In some embodiments, one or more paper coating composition described herein is applied to the paper or paperboard at a coater.

[0007] Still other embodiments describe a dry-finished, coated paper or paperboard product produced from one or more method described herein. In some embodiments, the dry-finished paper or paperboard is characterized by a surface strength equivalent to that of a wet-finished paper or paperboard product as measured by an IGT pick and blister test.

[0008] It is to be appreciated that certain aspects, modes, embodiments, variations, and features of the present technology are described below in various levels of detail in order to provide a substantial understanding of the present technology. The definitions of certain terms as used in this specification are provided below. Unless defined otherwise, all technical and scientific terms used herein generally have the same meaning as commonly understood by one of ordinary skill in the art to which this present technology belongs.

I. Definitions

[0009] The following terms are used herein, the definitions of which are provided for guidance.

[0010] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the elements (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (*e.g.*, “such as”) provided herein, is intended merely to better illuminate the embodiments and does not pose a limitation on the scope of the claims unless otherwise stated. No language in the specification should be construed as indicating any non-claimed element as essential.

[0011] As used herein, “about” will be understood by persons of ordinary skill in the art and will vary to some extent depending upon the context in which it is used. If there are uses of the term which are not clear to persons of ordinary skill in the art, given the context in which it is used, “about” will mean up to plus or minus 10% of the particular term.

[0012] As used herein, the term “DE” or “Dextrose Equivalent” refers to the degree of starch hydrolysis, specifically reducing the value of a starch hydrolysate compared to the reducing value of an equal weight of dextrose, expressed as percent, dry basis, as measured by the Lane and Eynon method described in Standard Analytical Method E-26, Corn Refiners Association, 6th Edition 1977, pp. 1-3.

[0013] As used herein, the term “DP” refers to the number of saccharide units. For example “DP1” saccharide is intended herein to refer to a monosaccharide, such as dextrose.

[0014] As used herein, “dry finish” or “dry finished” is paper or paperboard to which no starch is added at, e.g., a wet stack calender prior to, e.g., a coater.

[0015] As used herein, “low sugar syrup” means a syrup that has low mono- and disaccharide content, such as, for example, a DP1 + DP2 content less than about 65%, less than about 25%, or less than about 20%, less than about 19%, less than about 18%, less than about 17%, less than about 16%, less than about 15%, less than about 14%, less than about 13%, less than about 12%, less than about 11%, or less than about 10%. Exemplary commercial low sugar syrups include but are not limited to VERSASWEET™ 1524 low sugar glucose syrup, VERSASWEET® 1526 low sugar glucose syrup, VERSASWEET® 1526 NGM low sugar glucose syrup, VERSASWEET® 1531 low sugar glucose syrup, STABLESWEET® glucose syrup, BIOLIGIO® ML6810 glucose syrup (Ingredion Inc.), MULTIVANTAGE® syrup (Tate & Lyle), VERSYRA™ reduced sugar corn syrup, and CLEARDEX® corn syrup (Cargill).

[0016] The terms “paper,” “paperboard,” “recycled board,” and “board,” are used interchangeably herein. Paper and paperboard are sheet materials made up from an interlaced network of cellulose fibers. The distinction between paper and paperboard is not great; however, in general, paperboard is thicker than paper and has a higher weight per unit area. Paper over 200 g/m² is defined by the International Organization for Standardization (ISO) as paperboard or board. However, some products are known as paperboard even though they are manufactured in grammages less than 200 g/m². Broad classes within paperboard include containerboard, boxboard, and all other paperboard. “Recycled paperboard” is paperboard manufactured using

recovered paper, such as newspapers, corrugated containers, and mixed papers. Recycled paperboard containers include, but are not limited to, linerboard and corrugating medium, folding boxboard used for packaging cereal and other food products, soap powders, and other dry products, and set-up boxboard. Recycled paperboard is also used for many non-packaging products, including but not limited to, gypsum wallboard facing, tubes, cans, drums, matches, tags, tickets, game boards, and puzzles.

[0017] As used herein, a “plasticizer” means any material that competes for hydrogen bonding with starch molecules and thus disrupts hydrogen bonding between the starch molecules. This increases the flexibility of a film made with starch and other components. Examples of materials that plasticize starch include glycerin/glycerol, urea, formamide, citric acid (and other carboxylic acids), ethylene glycol, sugars (e.g. sucrose), maltodextrins, dextrin, starch derived syrups (such as corn syrup), and sugar alcohols (e.g., sorbitol and maltitol). Many of the plasticizers, especially the sugars, maltodextrins, and starch derived syrups listed above are or can be derived from a carbohydrate source such as starch. Starch can be obtained from any farinaceous material including, but not limited to, for example, corn, dent corn, waxy corn, wheat, potato, tapioca, peas, sorghum, manioc, sago, and rice.

[0018] As used herein, “wet finish” or “wet finished” is paper or paperboard made by adding starch at, for example, a wet stack calender prior to also being added at, for example, a coater.

[0019] As used herein, “IGT Coating Blister” refers to a physical test that measures the surface strength of coating layers applied to paper or paper board. The test predicts the point where forces applied to the board through ink tack build in printing causes the internal layers of the board to blister and is used to predict or measure the potential printability of the board coating layers.

[0020] As used herein, “IGT Coating Pick” refers to a physical test that measures the surface strength of coating layers applied to paper or paper board. This test is used to measure the ability of a coating to resist picking as a function of increasing ink tack build with increasing velocity.

[0021] As used herein, “basis weight” refers to the weight of a paper or paperboard for a defined area.

[0022] As used herein, “caliper” means the thickness of the paper or paperboard.

[0023] As used herein, “base coat weight” refers to the weight of the coating when applied to a defined area as a base coat.

[0024] As used herein, “coated brightness” refers to an optical measurement of the coated paper or paperboard surface for the brightness or whiteness of the surface. It is a measure of the visual appearance of the paper or paperboard.

[0025] As used herein, “Appearance DMM” means the appearance according to DuPont mottle measurement, which is a quantification of the amount of surface mottle measured when a paper or paper board is scanned under a diffuse lighting scanner. It is a measure of the visual appearance of the paper or paperboard.

[0026] As used herein, “Appearance DAV2” means the appearance according to DuPont Appearance Value (version 2), which is an optical test that measures the visual appearance of a paper or paper board surface under several lighting or illumination sources. It is a measure of the visual appearance of the paper or paperboard.

[0027] As used herein, “Sheffield smoothness” is a measurement of the smoothness of a surface of a paper or paper board.

II. General

[0028] Coated paper and paperboard require a certain level of surface strength to withstand the stresses of the ink tack in a printing process. The surface of the paper or board is typically treated with a first coating of starch applied at, e.g., a wet stack calender or size press, followed by a second coating of starch applied at, e.g., a coater. In a coated paper or board manufacturing process that involve the application of a first coating of starch at, e.g., a wet stack calender, manufacturers sacrifice machine speed, board density, quality, and uptime.

[0029] In conventional coated paperboard manufacturing processes, rawstock from the paper machine is surface sized and then machine calendered prior to coating. During sizing, substances such as gelatin, rosin, starch, or other synthetic substances, are added to paper board to improve resistance of the paperboard to liquid or vapor. Calendering is a process that smooths and controls the caliper or thickness of the paperboard. In a typical wet stack calendering process, water from one or more water boxes is applied to the paperboard to enhance the calendering results and add binders like starch, but not without detrimental side effects. For example, a wet calendaring step causes the caliper of the paperboard to be reduced while also increasing its density. Accordingly, in order to achieve a certain caliper, additional rawstock will be required, resulting in additional raw materials costs. In addition, wet finishing creates

operating problems including surface mottling of the paperboard, web breaks, and corrosion on the machine.

[0030] A particular challenge associated with removing the first coating of starch applied at, e.g., a wet stack calender or size press, before the paper or board is coated with the second coating of starch via the paper coating composition subsequently applied at, e.g., a coater, is maintaining the surface strength and quality of the paper or paperboard being manufactured. A further challenge with eliminating the first coating of starch applied at, e.g., a wet stack calender or size press, is providing a paper coating composition that contains enough starch to provide the desired surface strength and quality while also having the desired viscosity and solids content manufacturers demand. Starch is often applied as a strengthening agent during the paperboard manufacturing process. To further increase the surface strength of the paperboard, it may be desirable to increase the amount of starch in the paper coating composition; however, increasing the level of starch in the paper coating composition will result in a highly-viscous, gel-like composition that is difficult to handle, pump, and/or mix with other ingredients, and therefore may negatively impact the production speed of the manufacturing equipment.

[0031] Accordingly, there is a need to develop a paper coating composition that will maintain an appropriate coating viscosity for application during paperboard manufacturing, impart the desired strength characteristics to the manufactured paperboard, have the desired solids content to limit the amount of water that has to be driven off, and that allows manufacturers to eliminate the addition of starch before or after the paper or paperboard is coated with the starch containing paper coating composition without sacrificing the strength and quality of the paperboard. One or more paper coating compositions described herein exhibit one or more of the aforementioned benefits, including eliminating the wet stack calendaring step and/or the addition of starch via the wet stack calendaring or size press steps, thereby decreasing manufacturing costs while improving manufacturing speed.

[0032] It has been shown that the addition of a plasticizer, such as, for example, corn syrup to a paper coating composition in equal amounts of solids lowers the viscosity of the paper coating composition. At higher starch levels, the addition of a plasticizer, such as, for example, corn syrup maintains the viscosity of the paper coating composition. Due to its relatively low molecular weight, one of skill in the art would not anticipate that a plasticizer, such as, for example, corn syrup would be capable of improving the strengthening properties of a paper

coating composition. However, as demonstrated by the results described below, one or more paper coating composition described herein surprisingly and unexpectedly shows that a plasticizer, such as, for example, corn syrup in combination with starch provides paper and board with excellent strength over paper coating compositions that do not contain a plasticizer, such as, for example, corn syrup. One or more paper coating composition disclosed herein enables a dry finished board (no starch added at the wet stack calender) having strength characteristics comparable to those of a wet finished board (starch added at the wet stack calender) to be manufactured after only a single application of one or more starch containing paper coating compositions described herein to the dry finished, coated paper or board (i.e., a single application of one or more paper coating compositions described herein, which enables the addition of starch at the wet stack to be eliminated). As a result, one or more paper coating composition described herein enables less total starch to be unexpectedly and surprisingly used in a paperboard manufacturing process (e.g., ~33 lbs/ton (~16.5 kg/metric ton) present method vs. ~60 lbs/ton (~30 kg/metric ton) conventional method).

[0033] Disclosed herein is a starch coating composition and a paper coating composition that enables an improved, simplified paper and paper board manufacturing process. One or more method described herein for using one or more paper coating compositions described herein provides a paperboard manufacturing process that eliminates the wet stack calendaring step, reduce manufacturing time, improves efficiency, improves water retention, improves runnability, improves yield (e.g., caliper vs. basis weight), reduces costs associated with the use of starch at the wet calendaring or size press steps, and provide greater flexibility, without compromising the strength and quality of the paperboard. Various embodiments can provide a dry finished, coated paper or board with an IGT surface strength profile that is comparable to that of a wet finished, coated paper or board, thereby eliminating the need for an additional starch application at the wet stack calendaring or size press steps. Additionally, or alternatively, in some embodiments, one or more composition described herein may eliminate vessel segment picking in mills that do not have size presses and use oak or other hard woods as part of their fiber basket.

III. Paper Coating Compositions and Coating Starch Compositions

[0034] Described herein is a coating starch composition comprising a starch and plasticizer, a starch and a non-carbohydrate derived plasticizer, a starch and a carbohydrate derived plasticizer, or a starch and a starch derived syrup. In some embodiments, one or more coating

starch composition described herein has a starch and plasticizer, a starch and a non-carbohydrate derived plasticizer, a starch and a carbohydrate derived plasticizer, or a starch and a starch derived syrup solids level of at least 40% dry solids (ds) basis. In other embodiments, one or more coating starch composition described herein contains 1 part of a starch for each 1, 1.5, 2, 2.5, 3, 3.5, or 4 parts of a plasticizer. In yet other embodiments, one or more coating starch composition described herein contains 1 part of a starch for each 2, 2.5, 3, 3.5, or 4 parts of a plasticizer. In yet other embodiments, one or more coating starch composition described herein contains 1 part of a starch for each 2.5 parts of a plasticizer. In still other embodiments, one or more coating starch composition described herein contains 1 part of a starch for each 2.5 parts of a starch derived syrup. In some embodiments, one or more coating starch composition described herein contains 1 part PEN-COTE[®] L800 (Ingredion) starch for each 2.5 parts of maltose syrup with a DE of 53, such as, for example, GLOBE[®] 55 HM Corn Syrup (Ingredion).

[0035] Also, described herein is a paper coating composition comprising one or more coating starch compositions described herein. In some embodiments, one or more paper coating composition described herein contains at least about 2%, from about 2% to about 30%, from about 2% to about 25%, from about 2% to about 22%, or from about 2% to about 10% starch. In other embodiments, one or more paper coating composition described herein has a viscosity of less than 1200 cPs. In some embodiments, one or more paper coating composition described herein has a viscosity of less than 1100 cPs, less than 1000 cPs, less than 900 cPs, less than 800 cPs, less than 700 cPs, less than 600 cPs, or less than 500 cPs, including any and all ranges and subranges therein. In other embodiments, one or more paper coating composition described herein has a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cps, or about 300 to about 600 cPs including any and all ranges and subranges therein. In further embodiments, one or more paper coating composition described herein has a viscosity of about 300 to about 600 cPs. In still other embodiments, one or more paper coating composition described herein has a viscosity of about 600 to about 700 cPs. In even yet other embodiments, one or more paper coating composition described herein has a viscosity of about 500 to about 600 cPs.

[0036] In still other embodiments, one or more paper coating composition described herein has a solids content of at least 40% dry solids (ds) basis. In some embodiments, one or more paper coating composition described herein has a solids content of at least 40% ds basis, at least

45% ds basis, at least 50% ds basis, at least 55% ds basis, at least 60% ds basis, at least 65% ds basis, or at least 70% ds basis. In some embodiments, one or more paper coating composition described herein has a solids content of at least 45% ds basis, at least 50% ds basis, or at least 60% ds basis. In yet other embodiments, one or more paper coating composition described herein has a solids content of about 40% to about 70% ds basis, about 50% to about 65% ds basis, or about 55% to about 65% ds basis. In some embodiments, one or more paper coating composition described herein has a solids content of about 60% to about 65% ds basis, about 61% ds basis, about 62% ds basis, about 63% ds basis, about 64% ds basis, or about 65% ds basis.

[0037] In yet still other embodiments, one or more paper coating composition described herein has (i) a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cps, or about 300 to about 600 cPs and a solids content of at least 40%, 45%, 50%, 55%, 60%, 65% or 70% ds basis, or (ii) a viscosity of about 300 to about 600 cPs and a solids content of at least about 60% ds basis.

[0038] In yet still an even further embodiment, one or more paper coating composition described herein contains at least about 2%, from about 2% to about 30%, from about 2% to about 25%, from about 2% to about 22%, or from about 2% to about 10% starch and has (i) a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cps, or about 300 to about 600 cPs and a solids content of at least 40%, 45%, 50%, 55%, 60%, 65% or 70% ds basis, or (ii) a viscosity of about 300 to about 600 cPs and a solids content of at least about 60% ds basis.

[0039] In still other embodiments, one or more paper coating composition described herein further comprises a pigment and/or a latex.

[0040] In some embodiments, one or more paper coating composition described herein and/or one or more coating starch composition described herein enable methods for the production of a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board.

[0041] In other embodiments, one or more coating starch compositions described herein provide a means of adding more starch to one or more paper coating compositions described herein while at the same time avoiding negative attributes such as increasing the viscosity of the paper coating composition or decreasing the solids content. In some embodiments, one or more

coating starch composition described herein allows the amount of starch added to a paper coating composition to be increased by at least 2-fold while maintaining a viscosity suitable for coating paper or paperboard as compared to a standard coating starch composition. In still other embodiments, one or more coating starch composition described herein enables methods for producing a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board while eliminating the need for a wet stack calendering step in the paper manufacturing process and/or eliminating the need to apply starch to the board at the wet stack calender and/or eliminating the need to apply starch to the board at any point prior to or after applying one or more paper coating composition containing one or more coating starch composition described herein. In yet other embodiments, one or more coating starch compositions described herein enables methods for producing a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board while reducing the overall amount of starch used in methods for manufacturing paper or board without compromising the surface strength of the paper or board. In even still other embodiments, one or more coating starch composition described herein enables methods for producing a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board while reducing the amount of starch employed in the paper-manufacturing method.

[0042] In some embodiments, one or more paper coating composition described herein comprises from 2 to 20 parts of a starch and from 5 to 35 parts of a plasticizer. In other embodiments, one or more paper coating composition described herein comprises from 2 to 10 parts of a starch and from 5 to 25 parts of a plasticizer. In yet still other embodiments, one or more paper coating composition described herein comprises 10 parts of a starch and 25 parts of a plasticizer. In even yet further embodiments, one or more paper coating composition described herein comprises from 2 to 20 parts of a starch and from 5 to 35 parts of a starch derived syrup. In yet even further embodiments, one or more paper coating composition described herein comprises from 2 to 10 parts of a starch and from 5 to 25 parts of a starch derived syrup. In even yet still other embodiments, one or more paper coating composition described herein comprises 10 parts of a starch and 25 parts of a starch derived syrup.

[0043] In further embodiments, one or more paper coating composition described herein enables methods for producing a dry finished board having improved surface strength and/or a

surface strength that is comparable to a wet finished board while eliminating the need for a wet stack calendering step in the paper manufacturing process and/or eliminating the need to apply starch to the board at the wet stack and/or eliminating the need to apply starch to the board at any point prior to or after the application of one or more paper coating composition described herein. In even still further embodiments, one or more paper coating composition described herein enables methods for producing a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board while reducing the overall amount of starch used in methods for manufacturing paper or board without compromising the surface strength of the paper or board. In yet other embodiments, one or more paper coating composition described herein enables methods for producing a dry finished board having improved surface strength and/or a surface strength that is comparable to a wet finished board while reducing the amount of starch used in the paper-manufacturing method.

[0044] In some embodiments, one or more coating starch composition described herein or one or more paper coating composition described herein allows the amount of starch employed in the overall paper-manufacturing method to be reduced from approximately 60 lbs starch per ton (~30 kg/metric ton) of paperboard to approximately 33 lbs of starch per ton (~16.5 kg/metric ton) of paperboard. In some embodiments, one or more paper coating composition described herein or one or more coating starch composition described herein enables the amount of starch employed in the paper-manufacturing method to be reduced by at least 5%, at least 10%, at least 15%, at least 20%, at least 25%, at least 30%, at least 35%, at least 40%, at least 45%, at least 50%, at least 55%, or at least 60%, including any and all ranges and subranges therein. In some embodiments, one or more paper coating composition described herein or one or more coating starch composition described herein enables the amount of starch used in the paper-manufacturing method to be reduced by from about 10% to about 60%, from about 15% to about 55%, from about 20% to about 50%, from about 25% to about 50%, from about 30% to about 50%, or from about 40% to about 50%. In some embodiments, one or more paper coating composition described herein or one or more coating starch composition described herein enables the amount of starch used in the paper-manufacturing method to be reduced by from about 40% to about 45%. In some embodiments, one or more paper coating composition described herein or one or more coating starch composition described herein enables the amount

of starch used in the paper-manufacturing method to be reduced by from about 45% to about 50%.

A. Plasticizer

[0045] In one embodiment, the plasticizer is a non-carbohydrate derived plasticizer, a carbohydrate derived plasticizer, or a mixture thereof. In another embodiment, the non-carbohydrate derived plasticizer is selected from urea, glycerin/glycerol, ethylene glycol, formamide, citric acid or other carboxylic acids, and a mixture of any two or more of the foregoing. In another embodiment, the carbohydrate derived plasticizer is a sugar. In still another embodiment, the sugar is selected from a sucrose, a starch derived syrup, a maltodextrin, a dextrin, a sugar alcohol, or a mixture of any two or more of the foregoing. In yet still another embodiment, the carbohydrate derived plasticizer is a starch derived syrup. In still another embodiment, the sugar alcohol is a sorbitol.

[0046] The starch derived syrup may be any type of starch derived syrup suitable for use in paper coating formulations. In some embodiments, the starch derived syrup is selected from a corn syrup, a low sugar syrup, dextrose, or a mixture of any two or more of the foregoing. In some embodiments, the starch derived syrup is a corn syrup. In further embodiments, the starch derived syrup is a low sugar syrup. In further embodiments, the corn syrup is a maltose corn syrup or high fructose corn syrup. In some embodiments, the corn syrup is a maltose corn syrup. In some embodiments, the corn syrup is a high fructose corn syrup. In some embodiments, the corn syrup is a maltose corn syrup with a DE of 53, such as GLOBE[®] 55 HM Corn Syrup (Ingredient). In some embodiments, the corn syrup is a high fructose corn syrup.

[0047] In some embodiments, the starch derived syrup has a DE of about 20 to about 100. In some embodiments, the starch derived syrup has a DE of about 30 to about 100, about 35 to about 100, about 40 to about 100, about 45 to about 100, about 50 to about 100, about 55 to about 100, about 60 to about 100, about 65 to about 100, about 70 to about 100, about 75 to about 100, about 80 to about 100, about 85 to about 100, about 90 to about 100, or about 95 to about 100, including any and all ranges and subranges therein. In other embodiments, the starch derived syrup has a DE of about 20 to about 90, about 30 to about 90, about 35 to about 90, about 40 to about 90, about 45 to about 90, about 50 to about 90, about 55 to about 90, about 60 to about 90, about 65 to about 90, about 70 to about 90, about 75 to about 90, about 80 to about 90, or about 85 to about 90, including any and all ranges and subranges therein. In other

embodiments, the starch derived syrup has a DE of about 20 to about 90, about 20 to about 100, about 40 to about 75, about 40 to about 70, about 40 to about 44, about 49 to about 55, about 53 or 53. In some embodiments, the starch derived syrup includes any starch derived syrup having a DE of about 40 to about 75. In some embodiments, the starch derived syrup has a DE of about 40 to about 70, about 40 to about 44, about 50 to about 55, about 53 or 53.

B. Starch

[0048] In one embodiment, the starch is obtained or derived from one or a combination of farinaceous materials. Any farinaceous material can be used as the source of the starch including corn, dent corn, waxy corn, wheat, potato, tapioca, pea, sorghum, manioc, sago, and rice, among others. Accordingly, the starch can be comprised of one or more unmodified starch, blends of different types of unmodified starches, one or more modified starch, blends of different types of modified starches, and/or blends of modified and unmodified starches. In some embodiments, the starch is selected from corn starch, dent corn starch, waxy corn starch, wheat starch, potato starch, tapioca starch, pea starch, sorghum starch, manioc starch, sago starch, rice starch, and a mixture of any two or more of the foregoing. In other embodiments, that starch is selected from one or more of unmodified or modified corn starch, unmodified or modified dent corn starch, unmodified or modified waxy corn starch, unmodified or modified wheat starch, unmodified or modified potato starch, unmodified or modified tapioca starch, unmodified or modified pea starch, unmodified or modified sorghum starch, unmodified or modified manioc starch, unmodified or modified sago starch, unmodified or modified rice starch, and blends of two or more of any of the foregoing.

[0049] In some embodiments, the starch may be modified in any manner known in the art. In some embodiments, the starch is a thinned starch. Exemplary commercial thinned starches, include but are not limited to PENFORD[®] GUM 230, PENFORD[®] GUM 240, PENFORD[®] GUM 250, PENFORD[®] GUM 260, PENFORD[®] GUM 270, PENFORD[®] GUM 280, PEN-COTE[®], FILMKOTE[®] 340, FILMKOTE[®] 355, FILMKOTE[®] 370, FILMKOTE[®] 54, FILMKOTE[®] 550, FILMKOTE[®] 70, PENFILM[™] 2230, PENFILM[™] 2240, StacKote[®] 4, StacKote[®] 6, or StacKote[®] 8 (Ingredion Inc.). In some embodiments, the thinned starch is a stable liquid coating starch. Exemplary stable liquid coating starches include but are not limited to PEN-COTE[®] L800, PEN-COTE[®] L1000, RediFILM[™] 5400, RediFILM[™] 5800, or RediBOND[™] HM12 (Ingredion Inc.). In some embodiments, the starch is a modified starch. In

other embodiments, the modified starch is selected from a nonionic starch, an anionic starch, an amphoteric starch, an etherified starch, an acetylated starch, a sulfonated starch, and a mixture of any two or more of the foregoing.

C. Additives/Other Components

[0050] In some embodiments, one or more paper coating composition described herein further comprises a pigment and/or a latex. Exemplary pigments include but are not limited to clay, calcium carbonate, TiO₂, or any combination thereof. Exemplary latexes include but are not limited to vinyl acrylic, polyvinyl acetate (PVAC), styrene butadiene, styrene acrylate, or any combination thereof. In some embodiments, one or more paper coating composition described herein further comprises about 100 parts pigment and about 10 to about 25 parts latex.

D. Coating Applications and Surfaces

[0051] One or more paper coating composition described herein and/or one or more coating starch composition described herein may be adapted for use in a number of applications, including in compositions used in the paper-making processes. In particular, one or more paper coating composition described herein and/or one or more coating starch composition described herein are adaptable for use in coatings used to make dry finished paper and paperboard. In addition to paper and paperboard, one or more paper coating composition described herein and/or one or more coating starch composition described herein can be applied to parchment, cellophane, metals, textiles, or like surfaces that are wettable by water. One or more paper coating composition described herein and/or one or more coating starch composition described herein are useful, for example, in applications where contact with an aqueous solution is possible, such as, e.g., in offset printing.

[0052] One or more paper coating composition described herein, such as, e.g., coatings on paper and paperboard, are desirable for subsequent operations, such as, e.g., printing, and the like. As the Examples set forth herein demonstrate, dry finished paperboard coated with one or more paper coating composition described herein resists picking and blistering during offset printing to an extent that is comparable to that of a wet finished paperboard coated with a standard first starch coating applied, for example, via a wet stack calendar or size press, followed by a second standard coating applied, for example via a coater (hereinafter “conventional paper coating process”).

[0053] Paper and paperboard coated with one or more paper coating composition described herein may have any surface strength. In some embodiments, a dry finished paperboard coated with one or more paper coating composition described herein has a surface strength that is comparable or increased relative to a wet finished paperboard coated with standard paper coating compositions via a conventional paper coating process. Examples of physical tests of a substrate's (*e.g.*, paper, board, *etc.*) surface strength that correlate well with a substrate's print performance are the IGT pick and blister tests and wax pick tests. In addition, both tests correlate well with strong surface strength of paper substrates. While either of these tests may be utilized, the IGT pick test is preferred. In some embodiments, a dry-finished coated paper or paperboard product coated with one or more paper coating composition described herein is characterized by an IGT average increase of at least 50%, 55%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, or 70% as compared to a dry-finished paper or paperboard product coated with standard paper coating compositions via a conventional paper coating process.

[0054] The IGT tests predict the ability of coated or uncoated paper or paperboard to resist picking or blistering during offset printing. The test device operates by applying a known film thickness of polybutyne oil of a given viscosity to an aluminum printing disk. The oil is applied to the disk with a standard IGT inking unity. The oil is transferred to the sample surface while under acceleration. The oil creates a pulling action on the paper surface, similar to offset ink, resulting in picking, blistering, or both. The point at which the picking and blistering starts is the end point of the test. The reported units for both pick and blister are Kilopoise-Centimeters per second (KPCMS). At a known oil viscosity, this value relates to the velocity or press speed that can be achieved before the sheet is damaged.

[0055] One or more dry finished paper or board described herein may have at least one surface having a surface strength as measured by the IGT pick and blister test of at least 35 KPCMS, at least 40 KPCMS, at least 45 KPCMS, at least 50 KPCMS, at least 55 KPCMS, at least 60 KPCMS, at least 65 KPCMS, at least 66 KPCMS, at least 67 KPCMS, at least 68 KPCMS, at least 69 KPCMS, at least 70 KPCMS, at least 71 KPCMS, at least 72 KPCMS, at least 73 KPCMS, at least 74 KPCMS, at least 75 KPCMS, at least 76 KPCMS, at least 78 KPCMS, at least 79 KPCMS, or at least 80 KPCMS, including any and all values therein.

[0056] Paper coating compositions described herein can be applied to one or both sides of the paper or paperboard by any means known in the art. Coating methods include, but are not

limited to, roll applicator and metering with roll, rod, blade, bar, or air knife; pond application and metering with roll, rod, blade, or bar, or air knife; premetered films or patterns; foam application; curtain coaters; and combinations of any of the foregoing.

[0057] Subject matter contemplated by the present disclosure is set out in the following numbered embodiments:

1. A coating starch composition comprising a starch and a plasticizer, wherein said composition has a starch and plasticizer solids level of at least 40% dry solids (ds) basis.
2. The coating starch composition of embodiment 1, wherein said composition contains 1 part of a starch for each 1, 1.5, 2, 2.5, 3, 3.5, or 4 parts of a plasticizer.
3. The coating composition of embodiment 1 or 2, where said plasticizer is a non-carbohydrate derived plasticizer, a carbohydrate derived plasticizer, or a mixture thereof.
4. The coating composition of embodiment 3, where said non-carbohydrate derived plasticizer is selected from urea, glycerin/glycerol, formamide, citric acid or other carboxylic acids, ethylene glycol, and a mixture of any two or more of the foregoing.
5. The coating composition of embodiment 3, where said carbohydrate derived plasticizer is (i) a sugar; (ii) a sucrose, a starch derived syrup, a maltodextrin, a dextrin, a sugar alcohol, or a mixture of any two or more of the foregoing; (iii) a starch derived syrup selected from a corn syrup, a low sugar syrup, dextrose, or a mixture of any two or more of the foregoing; (iv) a maltose corn syrup or a high fructose corn syrup; or (v) a sorbitol.
6. The coating composition of embodiment 5, wherein said starch derived syrup has a dextrose equivalency (DE) of about 20 to about 90, about 20 to about 100, about 40 to about 75, about 40 to about 70, about 40 to about 44, about 49 to about 55, about 53 or 53.
7. The coating starch composition of any preceding embodiment, wherein said plasticizer is a corn syrup selected from maltose corn syrup, high fructose corn syrup, and a mixture thereof.
8. The coating starch composition of any preceding embodiment, wherein the starch is a modified starch selected from a nonionic starch, an anionic starch, an amphoteric starch, an etherified starch, an acetylated starch, a sulfonated starch, and a mixture of any two or more of the foregoing.
9. The coating starch composition of any preceding embodiment, wherein the starch is selected from corn starch, dent corn starch, waxy corn starch, wheat starch, potato starch, tapioca

starch, pea starch, sorghum starch, manioc starch, sago starch, rice starch, and a mixture of any two or more of the foregoing.

10. A paper coating composition comprising the coating starch composition of any preceding embodiment, wherein said composition contains at least about 2%, from about 2% to about 30%, from about 2% to about 25%, from about 2% to about 22%, or from about 2% to about 10% starch.

11. The paper coating composition of embodiment 10, wherein the composition has (i) a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cps, or about 300 to about 600cPs and a solids content of at least 40%, 45%, 50%, 55%, 60%, 65% or 70% dry solids (ds) basis, or (ii) a viscosity of about 300 to about 600 cPs and a solids content of at least 60% dry solids (ds) basis; and, optionally, wherein the viscosity is measured on a Brookfield Viscometer at 20 rpm at 18.3 °C.

12. The paper coating composition of embodiment 10 or 11, wherein said composition contains from 2 to 20 parts of the starch and from 5 to 35 parts of the plasticizer, from 2 to 10 parts of the starch and from 5 to 25 parts of the plasticizer, or 10 parts of the starch and 25 parts of the plasticizer.

13. The paper coating composition of any one of embodiments 10-12, wherein said composition further comprises (i) a pigment, a latex, or a mixture thereof; or (ii) about 100 parts pigment and about 10 to about 25 parts latex.

14. A method of manufacturing a dry-finished, coated paper or paperboard product comprising applying the paper coating composition of any one of embodiments 10-13 to at least one side of a paper or paperboard; and obtaining a dry finished, coated paper or paperboard.

15. The method of embodiment 14, wherein no starch is applied to the paper or paperboard prior to or after the application of the paper coating composition.

16. The method of embodiment 14 or 15, with the proviso that the method does not comprise a wet stack calendering step prior to applying the paper coating composition of any one of embodiments 10-13.

17. The method of any one of embodiments 14-16, wherein the coating composition is applied to the paper or paperboard at a coater.

18. A dry-finished, coated paper or paperboard product produced from the method of any one of embodiments 14-17.

19. The dry-finished, coated paper or paperboard product of embodiment 18, wherein the dry-finished paper or paperboard is characterized by a surface strength equivalent to that of a wet-finished paper or paperboard product as measured by an IGT pick and blister test.

20. The dry-finished, coated paper or paperboard product of embodiment 19, wherein the dry-finished paper or paperboard is characterized by an IGT average increase of at least 50%, 55%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, or 70% as compared to a dry-finished paper or paperboard product coated with a standard coating.

21. A paper substrate comprising, on at least one surface, the paper coating composition of any one of embodiments 10-13.

Examples

[0058] The following examples are provided by way of illustration only and not by way of limitation. Those of skill in the art will readily recognize a variety of non-critical parameters that could be changed or modified to yield essentially the same or similar results. The examples should in no way be construed as limiting the scope of the present technology, as defined by the appended claims

Materials and Methods

[0059] *Coating Starch.* PEN-COTE[®] L800 coating starch was obtained from Ingredion. PEN-COTE[®] D LV coating binder was also obtained from Ingredion. PEN-COTE[®] L800 coating starch is a stable liquid waxy starch (Ingredion, Inc.). PEN-COTE[®] D LV coating binder is a thinned starch that can be added to a coating in a dry form or, alternatively, rehydrated and then added to a coating (Ingredion, Inc.). A viscosity reduced hydroxypropyl modified waxy corn starch that has been fully cooked through a jet cooker (hereinafter “Liquid Starch Composition A”) (Ingredion, Inc.). A viscosity reduced ethylated dent corn starch that has been fully cooked through a jet cooker (hereinafter “Liquid Starch Composition B”) (Ingredion, Inc.). A viscosity reduced OSA modified waxy corn starch that has been fully cooked through a jet cooker (hereinafter “Liquid Starch Composition C”) (Ingredion).

[0060] *Plasticizers.* Plasticizers used in the Examples include carbohydrate derived plasticizers such as: ENZOSE[®] Brewers’ Corn Syrup 55 DE or GLOBE[®] 55 HM Corn Syrup having a DE of 53 (“53 DE High Maltose Corn Syrup”) (Ingredion, Inc.); GLOBE[®] 63 DE Corn Syrup having a DE of 60-67 (Ingredion, Inc.); GLOBE[®] Plus 18 DE maltodextrin having a DE of 17-20 (Ingredion, Inc.); VERSASWEET[™] 1526 28 DE Glucose Syrup having a DE of 26-30

(Ingredion, Inc.); INVERTOSE[®] HFCS 55 (Ingredion, Inc.) and INVERTOSE[®] HFCS 42 (Ingredion, Inc.), which are high fructose corn syrups; Sucrose (Evaporated Cane Juice from Trader Joe's); and sorbitol (Ingredion, Inc.). Plasticizers used in the Examples also include non-carbohydrate derived plasticizer such as: glycerin (Fisher Scientific), sorbitol (Ingredion, Inc.), and urea (Alpha Aesar).

[0061] *Other Components.* A clay pigment and vinyl acrylic latex were also added to the coating compositions, either alone or in combination.

[0062] *Paperboard Milling.*

[0063] Procedure 1: The paperboard was produced on a multi-ply machine, with a press section and steam heated dryer cans. The dried paperboard was then calendered and coated with a rod coater to which a paper coating composition described herein was added. The paperboard was then coated with an airknife coater, dried, calendered again and wound up on a reel.

[0064] Procedure 2: The paperboard was produced on a multi-ply machine, with a press section and steam heated dryer cans. The dried paperboard was then calendered and coated with a rod coater to which a paper coating composition described herein was added.

[0065] *IGT Pick and Blister Test.* The Tappi Classical Test Method T 514 cm-92 was used to assess surface strength.

EXAMPLE 1

Preparing Paper Coating Compositions

[0066] Four paper coating compositions were prepared with the ingredients as shown in **Table 1**. Coating **1**, the control coating, is a standard paper coating composition routinely used as a coated recycled paperboard basecoat application. The control paper coating composition comprises 100 parts Clay, 16 parts latex, and 5 parts PEN-COTE[®] L800 coating starch, with a viscosity of 680 cPs at 18.3 °C. Coating **2** comprises 100 parts Clay, 16 parts latex, 5 parts PEN-COTE[®] L800 coating starch, and 30 parts 53 DE High Maltose Corn Syrup, with a viscosity of 160 cPs at 18.3 °C. Coating **3** comprises 100 parts Clay, 16 parts latex, 35 parts PEN-COTE[®] D LV coating binder (a thinned coating starch), with a viscosity of 1480 cPs at 18.3 °C. Coating **4**, the “high starch coating,” comprises 100 parts Clay, 16 parts latex, 10 parts PEN-COTE[®] L800 starch, and 25 parts 53 DE High Maltose Corn Syrup, with a viscosity of 560 cPs at 18.3 °C. All coating parts were added based on dry solids weight (parts is the standard convention for paperboard coatings where the pigment portion makes up 100 parts and all the other materials

are additive). Viscosity was measured using the Brookfield viscosity test. The test allows for a variety of RPMs to be employed. Viscosity measurements were performed at 20 RPMs.

Table 1: Paper Coating Compositions				
Coating	Components	Coating Solids (%)	Temp (°C)	Viscosity (cPs)
1 Control	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex	62.0	18.3	680
2	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 30 parts 53 DE High-Maltose Corn Syrup	60.7	18.3	160
3	35 parts PEN-COTE [®] D LV coating binder 100 parts Clay 16 parts Latex	62.0	18.3	1480
4 High Starch Coating	10 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 25 parts 53 DE High-Maltose Corn Syrup	63.2	18.3	560

[0067] The data presented in Table 1 shows that the addition of 30 parts of 53 DE High-Maltose Corn Syrup decreases the viscosity of the standard (“Control”) starch coating by more than 75% (coating 2). Increasing the starch content of coating 3 to achieve a similar coating solids content as for coatings 1, 2, and 4, results in the composition becoming too viscous. The data also shows that, with the addition of 25 parts of 53 DE High-Maltose Corn Syrup, the amount of PEN-COTE[®] L800 coating starch in the composition can be doubled from 5 parts to 10 parts (coating 4), while still producing a coating with an acceptable viscosity.

EXAMPLE 2

The High Starch Paper Coating Composition of the Present Technology Enables Production of a Dry Finish Board with Strength Characteristics Similar to Those of a Wet Finish Board

[0068] A trial was run on a pilot coater in accordance with the Paper Board Milling, Procedure 1 set forth hereinabove. Wet finished uncoated board and dry finished uncoated board were used as the substrates. A wet finished uncoated board was rod coated with Coating 1 set forth in Table 1. The wet finish board was produced by adding starch to the wet stack calender prior to the coaters. A first dry finished board was rod coated with Coating 1 set forth in Table 1.

A second dry finished board was rod coated with the high starch containing coating of Coating 4 set forth in Table 1. The dry finish board was produced without adding starch to the wet stack calender prior to the coaters. All 3 boards were subsequently top coated with a control airknife topcoat. The boards were calendered after coatings applied and then tested. Coatings 1 and 4 from Table 1 were applied on a 2.5 lbs/msf (12.21 grams/m²) base sheet for each test group.

[0069] As shown in Table 2, the high starch coating (coating 4) had an IGT average increase of 63%, as compared to the standard coating (coating 1) on the dry finished board. In addition, the dry finished boards coated with the high starch coating (coating 4) exhibited on average a slightly higher blister IGT than the standard coating (coating 1) on a wet finished paperboard.

Table 2: IGT Results For Wet Finish And Dry Finish Boards Using Standard And High Starch Coatings					
Wet Finish-Standard Coating (Coating 1, Table 1)		Dry Finish-Standard Coating (Coating 1, Table 1)		Dry Finish-High Starch Coating (Coating 4, Table 1)	
IGT		IGT		IGT	
Pick (KPCMS)	Blister (KPCMS)	Pick (KPCMS)	Blister (KPCMS)	Pick (KPCMS)	Blister (KPCMS)
71	56	39	38	74	78
73	76	43	46	68	70
76	66	46	45	66	76
Avg. = 73.3	Avg. = 66	Avg. = 43	Avg. = 43	Avg. = 69	Avg. = 75

[0070] These results demonstrate that the paper coating compositions described herein provide an improved method for manufacturing paperboard. As demonstrated herein, the use of a high starch coating compositions described herein in a dry finished board coating process confers strength and quality characteristics comparable to those resulting from the use of a standard starch coating composition in a wet finished board coating process. Surprisingly, the addition of maltose corn syrup to a paper coating composition (coating 4) reduced the viscosity of the coating and allowed more starch to be added to the paper coating composition, thereby enabling the production of a paper coating composition with a higher starch solids content. The higher starch solids content of the paper coating composition enabled the wet stack calender to be eliminated from the paper coating process, thereby decreasing manufacturing time and costs associated therewith. As illustrated in Table 1, the starch content can be doubled (from 5 parts to 10 parts) while producing a coating that has a lower viscosity than a standard coating (coating 1).

[0071] Accordingly, these results demonstrate that the paper coating compositions described herein permit for elimination of a wet stack calender step in the paper manufacturing process. Ordinarily, if the wet stack calender step is removed from the process, the amount of starch applied to the paperboard at the rod coater must be increased. However, for practical purposes, the additional starch that must be added at the coater when the wet stack calender is removed cannot increase the viscosity of the coating. As shown herein, the compositions of the present technology enable additional starch to be added to the paper coating compositions applied via the rod coaters without increasing the viscosity, thereby permitting the elimination of the wet stack calendering step without compromising the strength and quality of the finished paperboard product.

EXAMPLE 3

Preparing Paper Coating Compositions Containing a Variety of Starch Derived Syrups and Testing Strength Characteristics

[0072] Additional paper coating compositions were prepared with the ingredients as shown in Table 3. The coating 5 control composition is a standard paper coating composition routinely used as a basecoat to coat recycled paperboard. The coating 5-22 compositions are coatings compositions prepared in accordance with the present invention with a variety of starch derived syrups. All coating parts were added based on dry solids weight (parts is the standard convention for paperboard coatings where the pigment portion makes up 100 parts and all the other materials are additive) using an overhead mixer. Viscosity was measured using the Brookfield viscosity test. The test allows for a variety of RPMs to be employed. Viscosity measurements were performed at a temperature of 23.9 °C using spindle 4 at 20 RPMs. The solids content of the coating 5-16 and 19-22 compositions was measured using a moisture balance (available from Mettler-Toledo Ltd., Beaumont Ley, Leicester, UK). The solids content of the coating 17-18 compositions was calculated based on the solids content of the ingredients used as measured or provided by the manufacturer.

[0073] Each coating 5-22 composition was coated on a dry finished board in accordance with the Paper Board Milling, Procedure 2 set forth hereinabove using a hand drawdown process using a rod. None of the boards were subsequently top coated.

[0074] Each of the Table 3 coating 6-22 compositions exhibited a lower viscosity in combination with improved strength characteristics than the coating 5 control composition.

Table 3: Additional Paper Coating Compositions & Associated Strength Characteristics						
Coating	Components	Coating Solids (%)	Temp (°C)	Viscosity (cPs)	IGT	
					Pick Avg (n=2) (KPCMS)	Blister Avg (n=2) (KPCMS)
5 Control	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex	62.1	23.9	1420	22	19
6	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts GLOBE [®] Plus 18 DE Maltodextrin	61.6	23.9	1040	28	24
7	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts GLOBE [®] Plus 18 DE Maltodextrin	62.0	23.9	650	24	19
8	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts VERSASWEET [™] 1526 28 DE Glucose Syrup	61.7	23.9	1000	35	22
9	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts ENZOSE [®] Brewers' Corn Syrup 55DE	61.5	23.9	620	24	20
10	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.0	23.9	550	30	24
11	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts INVERTOSE [®] HFCS 55	61.7	23.9	720	31	22
12	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts INVERTOSE [®] HFCS 55	61.7	23.9	390	29	22
13	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts INVERTOSE [®] HFCS 42	61.8	23.9	660	27	21

Table 3: Additional Paper Coating Compositions & Associated Strength Characteristics						
Coating	Components	Coating Solids (%)	Temp (°C)	Viscosity (cPs)	IGT	
					Pick Avg (n=2) (KPCMS)	Blister Avg (n=2) (KPCMS)
14	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts INVERTOSE [®] HFCS 42	61.9	23.9	520	27	26
15	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts GLOBE [®] 63 DE Corn Syrup	61.6	23.9	840	27	23
16	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts GLOBE [®] 63 DE Corn Syrup	61.9	23.9	700	31	27
17	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts Glycerin	62	23.9	600	27	34
18	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts Glycerin	62	23.9	450	27	23
19	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts sucrose	62.0	23.9	670	27	21
20	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts sucrose	62.0	23.9	490	26	19
21	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 10 parts sorbitol	61.6	23.9	720	32	28
22	3 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex 12 parts sorbitol	61.9	23.9	520	28	28

EXAMPLE 4**PREPARING PAPER COATING COMPOSITIONS CONTAINING A VARIETY OF STARCHES AND TESTING STRENGTH CHARACTERISTICS**

[0075] Additional paper coating compositions were prepared with the ingredients as shown in Table 4. The coating 23 control composition is a standard paper coating composition routinely used as a basecoat to coat recycled paperboard. The coating 24-31 compositions are coating compositions prepared in accordance with the present invention with a variety of starches. All coating parts were added based on dry solids weight (parts is the standard convention for paperboard coatings where the pigment portion makes up 100 parts and all the other materials are additive) using an overhead mixer. Viscosity was measured using the Brookfield viscosity test. The test allows for a variety of RPMs to be employed. Viscosity measurements were performed at a temperature of 23.9 °C using spindle 4 at 20 RPMs. The solids content of the coating 23-31 compositions was measured using a moisture balance (available from Mettler-Toledo Ltd., Beaumont Ley, Leicester, UK).

[0076] Each coating 23-31 composition was coated on a dry finished board in accordance with the Paper Board Milling, Procedure 2 set forth hereinabove using a hand drawdown process using a rod. None of the boards were subsequently top coated.

[0077] Each of the Table 4 coating compositions 24-31 exhibited a lower viscosity in combination with improved strength characteristics than the coating 23 control composition.

Table 4: Additional Paper Coating Compositions & Associated Strength Characteristics						
Coating	Components	Coating Solids (%)	Temp (°C)	Viscosity (cPs)	IGT	
					Pick Avg (n=2) (KPCMS)	Blister Avg (n=2) (KPCMS)
23 Control	5 parts PEN-COTE [®] L800 coating starch 100 parts Clay 16 parts Latex	62.1	23.9	1420	22	19
24	5 parts Liquid Starch Composition A 100 parts Clay 16 parts Latex 10 parts urea	61.3	23.9	880	29	26
25	3 parts Liquid Starch Composition A 100 parts Clay 16 parts Latex 12 parts urea	61.4	23.9	520	26	22
26	5 parts Liquid Starch Composition A 100 parts Clay 16 parts Latex 10 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.1	23.9	1180	28	25
27	3 parts Liquid Starch Composition A 100 parts Clay 16 parts Latex 12 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.0	23.9	830	30	29
28	5 parts Liquid Starch Composition B 100 parts Clay 16 parts Latex 10 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.0	23.9	1080	30	30
29	3 parts Liquid Starch Composition B 100 parts Clay 16 parts Latex 12 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.2	23.9	640	31	28
30	5 parts Liquid Starch Composition C 100 parts Clay 16 parts Latex 10 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.8	23.9	1350	31	26
31	3 parts Liquid Starch Composition C 100 parts Clay 16 parts Latex 12 parts ENZOSE [®] Brewers' Corn Syrup 55DE	62.2	23.9	750	33	26

EXAMPLE 5**PAPER COATING COMPOSITION HAS IMPROVED SURFACE STRENGTH CHARACTERISTICS WITHOUT SACRIFICING OTHER PHYSICAL CHARACTERISTICS**

[0078] Paper coating compositions were prepared with the ingredients as shown in Table 5. The coating 32 control composition is a standard paper coating composition routinely used as a basecoat to coat recycled paperboard. The coating 33 composition was prepared in accordance with the present invention. All coating parts were added based on dry solids weight (parts is the standard convention for paperboard coatings where the clay portion makes up 100 parts and all the other materials are additive) using an overhead mixer.

[0079] Each coating 32-33 composition was coated on a dry finished board in accordance with the Paper Board Milling, Procedure 2 set forth hereinabove using a hand drawdown process using a rod. None of the boards were subsequently top coated. For Tables 5 and 6, the surface and physical characteristics of the coated paper boards were measured at least three times and reported as an average (“Avg”) measurement.

Table 5: Additional Paper Coating Compositions & Associated Strength Characteristics						
Coating	Components	Coating Solids (%)	Temp (°C)	Viscosity (cPs)	IGT	
					Pick Avg (n≥3) (KPCMS)	Blister Avg (n≥3) (KPCMS)
32 Control	100 parts Clay 21 parts Latex	54.0	25	125	38.2	24.2
33 High Starch	9 parts PEN-COTE [®] L800 coating starch 9 parts ENZOSE [®] brewers corn syrup 55DE 100 parts Clay 18 parts Latex	54.0	25	157	59.67	24

[0080] The data shown in Tables 5 and 6 show that adding the coating starch and plasticizer and decreasing the ratio of starch to pigment from 4.8:1 in Coating 32 (“Control”) to a ratio of 2.9:1 while leaving the coating solids percentage unchanged (Coating 33), resulted in a slight increase in the viscosity that was coupled to a surprising improvement in surface strength characteristics. The average IGT Pick value increased by more than 56%, while the average IGT Blister value increased by more than 97%. The data in Table 6 further shows that the high starch

33 composition displayed a significant improvement in surface strength characteristics without suffering a loss in the quality of the basis weight, caliper, base coat weight, coated brightness, Appearance DAV2, Appearance DMM, or Sheffield smoothness. The physical characteristics related to the weight, thickness, and appearance of the coated paper surface remained unchanged or substantially unchanged, when comparing the coating 32 control composition and high starch 33 composition applied to paper boards.

Table 6: Physical Characteristics of Additional Paper Coating Compositions										
Coating	Basis Weight Avg (g/m²)	Caliper Avg (.0001 in)	Base Coat Weight Avg (g/m²)	Coated Brightness Avg (points)	Appearance DAV2 Avg	Appearance DMM Avg	Sheffield Smoothness Avg (sec)	Viscosity (cPs)	IGT	
									Pick Avg (KPCMS)	Blister Avg (KPCMS)
32 Control	65.8	18.1	1.4	79.8	58.1	27.9	153.2	125	38.2	24.2
33 High Starch	65.8	18.1	1.5	79.0	58.3	27.8	156.7	157	59.7	37.6

[0081] The present technology is not to be limited in terms of the particular embodiments described in this application, which are intended as single illustrations of individual aspects of the present technology. Many modifications and variations of this present technology can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the present technology, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present technology is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this present technology is not limited to particular methods, reagents, compounds compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

[0082] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0083] As will be understood by one skilled in the art, for any and all purposes, particularly in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, *etc.* As a nonlimiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, *etc.* As will also be understood by one skilled in the art all language such as “up to,” “at least,” “greater than,” “less than,” and the like, include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0084] All patents, patent applications, provisional applications, and publications referred to or cited herein are incorporated by reference in their entirety, including all figures and tables, to the extent they are not inconsistent with the explicit teachings of this specification. Other embodiments are set forth within the following claims.

WHAT IS CLAIMED IS:

1. A coating starch composition comprising a starch and a plasticizer, wherein said composition has a starch and plasticizer solids level of at least 40% dry solids (ds) basis.
2. The coating starch composition of claim 1, wherein said composition contains 1 part of a starch for each 1, 1.5, 2, 2.5, 3, 3.5, or 4 parts of a plasticizer.
3. The coating composition of claim 1 or 2, where said plasticizer is a non-carbohydrate derived plasticizer, a carbohydrate derived plasticizer, or a mixture thereof.
4. The coating composition of claim 3, where said non-carbohydrate derived plasticizer is selected from urea, glycerin/glycerol, formamide, citric acid or other carboxylic acids, ethylene glycol, and a mixture of any two or more of the foregoing.
5. The coating composition of claim 3, where said carbohydrate derived plasticizer is (i) a sugar; (ii) a sucrose, a starch derived syrup, a maltodextrin, a dextrin, a sugar alcohol, or a mixture of any two or more of the foregoing; (iii) a starch derived syrup selected from a corn syrup, a low sugar syrup, dextrose, or a mixture of any two or more of the foregoing; (iv) a maltose corn syrup or a high fructose corn syrup; or (v) a sorbitol.
6. The coating composition of claim 5, wherein said starch derived syrup has a dextrose equivalency (DE) of about 20 to about 90, about 20 to about 100, about 40 to about 75, about 40 to about 70, about 40 to about 44, about 49 to about 55, about 53 or 53.
7. The coating starch composition of any preceding claim, wherein said plasticizer is a corn syrup selected from maltose corn syrup, high fructose corn syrup, and a mixture thereof.
8. The coating starch composition of any preceding claim, wherein the starch is a modified starch selected from a nonionic starch, an anionic starch, an amphoteric starch, an etherified starch, an acetylated starch, a sulfonated starch, and a mixture of any two or more of the foregoing.
9. The coating starch composition of any preceding claim, wherein the starch is selected from corn starch, dent corn starch, waxy corn starch, wheat starch, potato starch, tapioca

starch, pea starch, sorghum starch, manioc starch, sago starch, rice starch, and a mixture of any two or more of the foregoing.

10. A paper coating composition comprising the coating starch composition of any preceding claim, wherein said composition contains at least about 2%, from about 2% to about 30%, from about 2% to about 25%, from about 2% to about 22%, or from about 2% to about 10% starch.
11. The paper coating composition of claim 10, wherein the composition has (i) a viscosity of less than 1200 cPs, about 100 to about 1200 cPs, about 200 to about 1200 cPs, or about 300 to about 600 cPs and a solids content of at least 40%, 45%, 50%, 55%, 60%, 65% or 70% dry solids (ds) basis, or (ii) a viscosity of about 300 to about 600 cPs and a solids content of at least 60% dry solids (ds) basis; and, optionally, wherein the viscosity is measured on a Brookfield Viscometer at 20 rpm at 18.3 °C.
12. The paper coating composition of claim 10 or 11, wherein said composition contains from 2 to 20 parts of the starch and from 5 to 35 parts of the plasticizer, from 2 to 10 parts of the starch and from 5 to 25 parts of the plasticizer, or 10 parts of the starch and 25 parts of the plasticizer.
13. The paper coating composition of any one of claims 10-12, wherein said composition further comprises (i) a pigment, a latex, or a mixture thereof; or (ii) about 100 parts pigment and about 10 to about 25 parts latex.
14. A method of manufacturing a dry-finished, coated paper or paperboard product comprising applying the paper coating composition of any one of claims 10-13 to at least one side of a paper or paperboard; and obtaining a dry finished, coated paper or paperboard.
15. The method of claim 14, wherein no starch is applied to the paper or paperboard prior to or after the application of the paper coating composition.

16. The method of claim 14 or 15, with the proviso that the method does not comprise a wet stack calendering step prior to applying the paper coating composition of any one of claims 10-13.
17. The method of any one of claims 14-16, wherein the coating composition is applied to the paper or paperboard at a coater.
18. A dry-finished, coated paper or paperboard product produced from the method of any one of claims 14-17.
19. The dry-finished, coated paper or paperboard product of claim 18, wherein the dry-finished paper or paperboard is characterized by a surface strength equivalent to that of a wet-finished paper or paperboard product as measured by an IGT pick and blister test.
20. The dry-finished, coated paper or paperboard product of claim 19, wherein the dry-finished paper or paperboard is characterized by an IGT average increase of at least 50%, 55%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, or 70% as compared to a dry-finished paper or paperboard product coated with a standard coating.
21. A paper substrate comprising, on at least one surface, the paper coating composition of any one of claims 10-13.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/019027

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	D21H19/54 D21H17/54	D21H21/18 D21H17/57
	D21H17/14	D21H17/24 D21H17/28
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) D21H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 4 289 808 A (HUANG DENIS K) 15 September 1981 (1981-09-15) claim 1; examples 1-2	1-21
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 8 June 2020		Date of mailing of the international search report 17/06/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Karlsson, Lennart

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 2008/193784 A1 (TIPPIT PATRICIA S [US]) 14 August 2008 (2008-08-14) the whole document -----	1-21
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