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BIODEGRADABLE PAPER-BASED CUP OR PACKAGE

FIELD OF INVENTION

This invention relates to biodegradable paper-based laminates.

BACKGROUND OF INVENTION

Paper cups for disposable, food service uses are typically extrusion coated with low density polyethylene (LDPE) or other similar polymer(s) in order to hold liquids for a longer period of time without leaking or becoming soft as is common with 100% paper cups. Cups for hot beverages such as coffee are generally clay coated on the outside and have a layer of LDPE on the inside for liquid resistance. Cold drink cups for soft drinks and the like are typically coated with LDPE on both sides to prevent condensation that forms on the outside of the cup from softening the paper. LDPE coat weights of 0.5 - 1.5 mils (7.2 - 21.6 lb/3msf) are common.

These types of cups are used once or a very minimal number of times then disposed. The LDPE coating is not readily degradable (and compostable), and therefore, the cup may remain in a landfill for many years without breaking down. The use of one or more biodegradable polymers in lieu of LDPE is desirable to render the used cups more "environmentally friendly".

In addition to cups, other coated paper products such as gable top cartons, folding cartons, paper pouches, sandwich wraps, paper plates and bowls, and ream wrap may also benefit from the present invention.

SUMMARY OF INVENTION

A biodegradable laminate suitable for use in containers for liquid or solid, hot or cool, food products, comprising a paper-based substrate having first and second copolyester layers coextruded onto at least one surface of the substrate, in the absence of intervening polymer layers between the substrate surface and the coextrusion deposited on the substrate surface. The coextruded copolyester layers of the present laminate exhibit a biodegradation rate in excess of the biodegradation rate of newspaper or magazine paper (as tested per ASTM D5338-93, for example) thereby rendering the laminate highly desirable as a material for use in forming food containers which are commonly used once, or a minimum number of times, before disposal thereof. Likewise, the biodegradability of the present laminate renders the laminate useful in other "one-use" paper-based products such as sandwich wrap, ream wrap, etc.

In one embodiment, the present laminate may be provided with a coextruded layer of the same or other copolyesters on the opposite flat surface of the paper-based substrate.

A biodegradable container formed from the laminate is disclosed.

A method for forming a biodegradable laminate of the present invention is also disclosed.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic representation of one embodiment of a laminate embodying various features of the present invention,

Figure 2 is a schematic representation of a second embodiment of a laminate embodying various features of the present invention,

Figure 3 is a schematic representation of a third embodiment of a laminate embodying various features of the present invention, and

Figure 4 is a diagrammatic representation of a process for the formation of a laminate of the present invention.

DETAILED DESCRIPTION OF INVENTION

Generally and with reference to Figures 1-3, the present invention provides a biodegradable laminate 10 which is paper-based, meaning that the substrate 12 of the laminate comprises paper, commonly a paper-based stock known as SBS cupstock or SUS (natural) kraft folding carton board, all of which are well known in art. The laminate of the present invention further includes first and second layers 14 and 16, respectively, of copolyesters which are coextruded onto one 18 of the flat surfaces of the paper-based substrate.

As depicted in Figure 4, formation of the laminate of the present invention includes feeding a continuous sheet 20 of SBS or other acceptable paper-based substrate from a roll 22 thereof, forwardly into a conventional coextruder 24 which is fed a first copolyester 26 and a second copolyester 28. These first and second copolyesters are coextruded onto the flat surface 18 of the paper-based substrate and thereafter collected, as by winding the completed laminate 30 onto a spindle 32, or the like. Thereafter, the laminate may be formed into a cup, pouch, gable top container, or other container for a food product. The container thus formed is useful for containing either liquid, solid or semi-solid food product, irrespective of whether the food product is cold or hot (within the normal temperature bounds of heated and cooled food products). An example of a hot food product is hot coffee at about 180° F. An example of a cool food product is iced tea at 33-40 °F.

In a preferred embodiment, the paper-based substrate of the laminate of the present invention comprises either SBS (solid bleached sulfate) cupstock or SUS (solid unbleached sulfate) (natural kraft) folding carton board. The preferred range of board thickness ranges between about 100-300 lb/3000ft^2. Other examples of acceptable basestock (substrate) include, liquid packaging board, SBS folding carton board, natural Kraft cupstock, light weight Kraft or SBS papers, and board or paper with post-consumer waste ("recycled") content. The light weight papers are defined as less than 100 lb/3000ft· The liquid packaging board may be used for gable top cartons for products such as dairy, for example. Uses of the light weight papers include pouches for powders or other dry products like oatmeal, sandwich wraps for quick serve restaurants, and ream wrap for copy paper.

In accordance with one aspect of the present invention, there is applied to at least one flat surface of the paper-based substrate a coextruded combination of a copolyester, namely, either a copolyester produced from the copolymerization of 1,4-benzenedicarboxylic acid (terephthalic acid), 1,4-butanediol, and adipic acid as well as a chain extender or branching agent)(available from BASF under the name ECOFLEX® having a melting point (MP) range of 212-248° F), a copolyester produced from the copolymerization of 1,4 benzene dicarboxylic acid (terephthalic acid, 1,4- butanediol and adipic acid (the resulting copolyester being poly(tetramethylene adipate-co-terephthalate)(available from Eastman Chemical under the name Eastar Bio® having a MP of 226° F, or a copolyester produced by the condensation reaction of 1,4-benzenecarboxylic acid, ethylene glycol, and 1,4:3,6-dianhydro-D-sorbitol (available from DuPont under the name Biomax® having a MP of 383° F).

As depicted in Figure 2, in a preferred embodiment for use with containers for hot food products, a paper-based substrate is provided on one flat surface thereof with a coextruded layer of Ecoflex and Biomax. In this laminate, in a compost environment, about 90% of the Ecoflex biodegrades within about 80 days; about 95% of the Biomax biodegrades within about 63 days, both rates being faster than the biodegradation rates of the paper-based substrate of the present laminate.

In this preferred embodiment for hot food containers, a total coextrusion coat weight of between about 10 and about 40, lb/3000ft^2, in any combination of between about 80/20 to 20/80 Ecoflex to Biomax, by wt., may be employed. A total coat weight of about 25 lb/3000ft^2 is preferred, for both processability and end use performance. Preferably, the Biomax is applied at between about 10 and about 25 lb/3000ft^2, the remainder of the total coat weight being Ecoflex. For a hot beverage cup, for example, the coextrustion is applied to the non-clay coated side of the paper-based substrate. Flame and/or corona pre-treatment of the substrate surface may be employed to enhance adhesion, as desired or needed. Lighter total coat weights may be employed, but at the possible loss of heat seal quality in subsequent finished packages (cups, gable top containers, etc.). Heavier total coat weights may also be used but material costs may outweigh any incremental performance advantages of such heavier total coat weights, and/or may slow down the overall degradation rate of the container.

Further, it has been found that use of either of the copolyesters as a monolayer in a laminate for biodegradation purposes typically requires slip/antiblock additive packages to prevent chill roll sticking and blocking in the roll of finished laminate. Further, considerable neck-in is experienced with one or more of the copolyesters when it is applied as a monolayer, resulting in excessive trim and waste. Biomax, in particular, when applied as a monolayer does not satisfactorily adhere to the paper-based substrate. Employing a coextrusion of the noted copolyesters has been found effective in overcoming the shortcomings of the copolyesters when applied as a monolayer.

Containers for cool food products, preferably are formed from a laminate as depicted in Figure 3. This depicted laminate includes a paper-based substrate having a first layer of coextruded Eastar Bio or Ecoflex (preferably Ecoflex) with Biomax provided on one flat surface of the substrate, the Biomax being disposed outermost from the substrate. Further a second layer of coextruded Eastar Bio or Ecoflex (preferably Ecoflex) with Biomax is provided on the opposite flat surface of the substrate, the Biomax again being disposed outermost from the substrate. In this embodiment for cool food containers, the coextruded layer of copolyester (irrespective of which side of the substrate the layer is disposed) is of a total coat weight of between about 10 and about 40, $lb/3000ft^2$, in any combination of between about 80/20 to 20/80 Ecoflex to Biomax, by wt. A total coat weight of about 25 $lb/3000ft^2$ is preferred. As in a laminate intended for use with hot food product, in this laminate intended for use with a cool food product, the Biomax is applied at a coat weight of between about 10 and 25 $lb/3000ft^2$, the remainder of the total coat weight being either Ecoflex or Eastar Bio.

In a further embodiment, as depicted in Figure 1, the paper-based substrate may be provided with a coextruded layer of Eastar Bio and Biomax on one of the flat surfaces of the substrate. In this embodiment, a total coat weight of between about 10 and about 40, $lb/3000ft^2$, in any combination of between about 80/20 to 20/80 Eastar Bio to Biomax, by wt. may be employed. A total coat weight of about 25 $lb/3000ft^2$ is preferred. The Biomax is applied at a coat weight of between about 10 and 25 $lb/3000ft^2$, the remainder of the total coat weight being Eastar Bio.

As desired, calcium carbonate may be added to any or all of the copolyester extrusions as a cost savings measure and to provide increase in the degradation rate by displacement of some of the biodegradable resin material. Other possible organic and inorganic fillers may be employed with, or in lieu of, calcium carbonate, including starch, clay, kaolin, talc, cellulose fibers, and diatomaceous earth.

A two-layer coextrusion coating consisting of BASF Ecoflex and DuPont Biomax was applied to SBS cupstock and natural Kraft folding carton paperboards. Basis weights of the SBS and kraft were in the range of 180-210 lb/3000ft2. Melt processing temperatures of the two resins were 450° F and 485° F, respectively.

Coat weights applied were 12.5 lb/3000ft^2 Ecoflex and 12.5 lb/3000ft^2 Biomax. Total coat weights of at least 10 lb/3000ft^2 provided good melt strength and minimal edge weave of the coextrusion curtain.

The materials produced as set forth above were converted into cups on a PMC 1000 cup forming machine at a rate of 140 cups per minute. All cups passed testing for holding coffee (at 180° F) for at least 25 minutes.

Heat seal testing was conducted on standard low density polyethylene (LDPE) coated cupstock and the coated Kraft folding carton materials onto which the Ecoflex and Biomax were coextruded. For each substrate, samples were placed coated side to uncoated side in a Barber-Coleman sealing unit. Sealing pressure was held constant at 80 psi and dwell time was held at

5 second. Temperatures were varied to determine the minimum temperature at which 100% fiber tear was obtained. Following the sealing step, the samples were allowed to cool for 30 second before manually pulling the layers apart and visually evaluating the extent of fiber tear. For the standard LDPE coated cupstock, the optimum sealing temperature was 415°. The Kraft board coated with Ecoflex and Biomax sealed at a lower optimum temperature of 210°F.

In accordance with one aspect of the present invention, it is noted that the coextrusion of two copolyesters provides multiple benefits. For example, Eastar Bio and Ecoflex adhere well to paper, resulting in 100% fiber tear. On the other hand, the level of adhesion between Biomax and the paper is far less, resulting in very little fiber tear. Thus, in the present invention, the Eastar Bio or Ecoflex layer of the coextrusion is disposed directly adjacent to the paperboard substrate to gain good adhesion, while the Biomax layer of the coextrusion is disposed outermost of the layers of the laminate.

Further, Biomax has a significantly higher melting point than either Eastar Bio or Ecoflex (T_m = 383° F for Biomax vs. 226° F for Eastar Bio and 212-248° F for Ecoflex), so that the positioning of the Biomax as the outermost layer of the laminate in contact with the hot food product allows a container formed from the laminate to better withstand deterioration and softening of the coating by the hot food product.