

(12) PATENT APPLICATION
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 200036364 A1

(54) Title
Stretched polyester foamedsheets and containers obtained therefrom

(51)⁷ International Patent Classification(s)
C08J 009/228 C08J 005/18
B65D 081/00

(21) Application No: **200036364**

(22) Application Date: **2000.05.23**

(30) Priority Data

(31) Number	(32) Date	(33) Country
MI99A001139	1999.05.24	IT
991220468	1999.11.15	EP
991259516	1999.12.27	EP

(43) Publication Date : **2000.11.30**

(43) Publication Journal Date : **2000.11.30**

(71) Applicant(s)
Sinco Recherche S.p.A.

(72) Inventor(s)
Hussein Al Ghatta; Sandro Cobror; Tonino Severini

(74) Agent/Attorney
WATERMARK PATENT and TRADEMARK ATTORNEYS,Locked Bag 5,HAWTHORN
VIC 3122

STRETCHED POLYESTER FOAMED SHEETS AND CONTAINERS OBTAINED THEREFROM

ABSTRACT

5

Polyester resin foamed sheet, mono e biaxially stretched usable for the production of containers for beverages and foods, having a density lower than 700 kg/m^3 and a crystallization rate such that, when the sheet is heated at 120°C . for 5 minutes, the crystallinity does not exceeds 15%.

- 10 The aromatic polyester resin used for preparing the foamed sheet can be mixed with an aliphatic polyester resin to impart biodegradability and/or compostability to the sheet or with 1-10% by weight of a polyamide.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

~~×~~CLAIMS

1. A mono or biaxially stretched foamed sheet from an aromatic polyester resin, suitable for the production of beverage and food containers,
5 having density lower than 700 kg/m^3 and pressed on it a design from which by folding a container can be developed, wherein the crystallization rate of the resin is such that, by heating at 120°C for 5 minutes, the crystallization does not exceed 15% .
2. The sheet according to claim 1, in which the sheet is obtained from a
10 copolyethylene terephthalate containing from 2 to 20% by moles of units deriving from isophthalic acid and/or naphthalene-dicarboxylic acids.
3. The sheet according to claims 1 and 2, in which the sheet is stretched with a ratio from 1.1 to 5:1.
4. The sheet according to claims 1 to 3 in which the polyester resin has
15 melt strength higher than 1 cN and melt viscosity higher than 1500 PAS with shear rate tending to zero (measured at 280°C).
5. The sheet according to claims 1 to 4, in which the polyester resin is mixed with 1 to 10% by weight of a polyamide.
6. The sheet according to claims 1 to 5 in which a polyester film is
20 adhered, said polyester film having an oxygen permeability rate lower than $70 \text{ ml/m}^2/24\text{h/atm}$ (measurement according to ASTM 1434).
7. The sheet according to claim 6 in which the polyester film is metallized with aluminum or coated with a layer of alumina or silicon oxide, or with potassium or lithium polysilicates.
8. The sheet according to claims 1 to 5 in which a film with gas barrier
25 properties is rendered adherent to the stretched foamed sheet by the use of glues or by heat lamination.
9. The sheet according to claims 1 to 8 in which the foamed sheet has density comprised from 60 and 500 kg/m^3 .
- 30 10. The sheet according to claim 9 in which the foamed sheet has density

from 100 and 400 kg/m³.

11. The sheet according to claims 1 to 10, having thickness from 0.5 to 3 mm.

12. The sheet according to claim 11, having a thickness of 0.7 to 1.5 mm.

5 13. The sheet according to claims 1 and 11 including an inorganic filler.

14. The sheet according to claims 1 and 13 obtained from an aromatic polyester resin mixed with 10-30% by weight of an aliphatic polyester resin.

15. The sheet according to claims 1 to 14, which is monoaxially stretched.

10 16. A beverage or food container, manufactured from the sheets of claims 1 to 15.

17. The container according to claim 16 having a closure which is realized by heat-sealing.

15 18. A container for fruit juices or for sterilized milk, manufactured by using a sheet of claims 1 to 17, to which a film is made to adhere having oxygen barrier properties corresponding to a permeation rate values lower than 70 ml/m²/24h/atm.

19. The container according to claim 18, in which the film adhered to the sheet presents an oxygen permeability rate lower than 10 ml/m²/24h/atm.

DATED this 23rd day of May 2000.

SINCO RICERCHE S.p.A.

WATERMARK PATENT & TRADEMARK ATTORNEYS
290 BURWOOD ROAD
HAWTHORN. VIC. 3122.

AUSTRALIA

Patents Act 1990

**ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT**

Application Number:

Lodged:

Invention Title:

STRETCHED POLYESTER FOAMED SHEETS AND CONTAINERS
OBTAINED THEREFROM

The following statement is a full description of this invention, including the best method of performing it known to us :-

STRETCHED POLYESTER FOAMED SHEETS AND CONTAINERS OBTAINED THEREFROM

The present invention regards stretched polyester resin foamed sheets, which are heat-sealable, and suitable for the production of beverage and food containers, on which a design from which the shape of the container can be developed by folding can be stamped by pressing.

The invention includes the containers obtained from such sheet. It regards in particular stretched sheets having gas barrier properties suitable for the production of containers for beverages such as fruit juices, medium shelf-life milk, tea and similar.

The materials employed till now for the production of beverage and food containers such as containers for fruit juices, milk or other, include substantially a functional layer of cardboard which gives to the container mechanical properties, in particular rigidity, and, adhered to the cardboard, in some cases, a layer of thin sheet of aluminum coated, on the side which comes into contact with the beverage or food, by a polyethylene film or similar polymeric material.

Containers produced with such multi-layer materials are difficult to recycle due to the different chemical nature of the various layers.

The recyclability of the material forming a food or beverage container is a most important requisite both from the point of view of savings that recycling allows to be obtained and from an ecological aspect.

The possibility of having a recyclable material is a very important topic in the sector.

Containers for beverages and liquids produced of polymeric materials exist but do not offer characteristics of rigidity comparable to those of cardboard and for this reason they do not result in being suitable to produce rigid containers. The containers obtained with such materials are comprised into the category of small sacks (pouches).

The attempt to obtain containers with the necessary rigidity by using

polymeric materials has failed until now.

The rigidity in the containers is in function of the thickness of the wall and more precisely varies with the cube of the wall thickness.

The use of polymeric material such as polyolefins for the production of
5 containers having sufficient rigidity would imply a thickness which is not economical and, furthermore, is not processable due to the difficulty in folding that one encounters in the container closing phase.

Another material such as foamed polystyrene is not employable due to its fragility when it is conformed into thin layers.

10 Known from the patent literature (USP 5,000,991) are rigid laminates, which are used for the preparation of thermoformed containers for victuals, formed of a sheet of foamed polyester material and of a film of the same nature as the sheet, or of other polymeric material. Known from EP-A-836937 are semi-rigid laminates having a thickness of 0,5 to 1.5 mm
15 comprising a layer of polyester resin foam having a density of 0.7 to 1 g/cm³ on which a layer having gas barrier properties, made of a polymeric material different from that of the layer in polyester foam, is adhered.

The laminates are used for the preparation by thermoformation of articles for packaging.

20 Materials comprising a layer in polyester foam capable of being creased to form, by folding according to the design pressed on the material, the shape of the container, are not known in patent literature.

The capability of a mono-layer or multi-layer polymeric foamed material, to be creased with a design set to develop by folding the shape of a
25 container, and the foldability of the material according to such a design, constitute indispensable requirements for the production of beverage and food containers when using the creasing and folding technique.

A material is suitable for creasing if the design pressed on it remains stable over time and if when stamping such design, breakage which could
30 impair the possibility of folding the material does not occur.

Moreover the material must be heat-sealable so as to make possible the closure of the container.

It has now unexpectedly been found aromatic polyester resin foamed sheets, which are suitable for the production of beverage and food
5 containers, satisfying the above mentioned creasing requirements, and which present rigidity sufficient to substitute cardboard and having high impact resistance.

The sheets of the present invention are monoaxially or biaxially stretched foamed sheets, have crystallization rate of the resin such that by heating at
10 120°C for 5 minutes the crystallinity does not exceed 15% and have pressed a design from which by folding a container can be developed.

The polyester resin preferably used for the preparation of the stretched foamed sheets is a copolyethylene terephthalate in which from 2 to 20% in moles of units of terephthalic acid are substituted by units deriving from
15 isophthalic and/or naphthalene-dicarboxylic acids.

Preferably, the copolyethylene terephthalate comprises from 4 to 10% of units deriving from isophthalic acid.

The intrinsic viscosity of the resin is higher than 0.8 dl/g (measured in solution 60/40 by weight of phenol and tetrachloroethone at 25°C according
20 to ASTM D 4603-86).

The melt strength is higher than 2 centi Newton at 280 ° C preferably is from 10 to 100 centi Newton and the melt viscosity is of at least 1200 PAS at 280° C and shear rate tending to zero, preferably 2000-20.000 PAS.

Preferably the resin is obtained by upgrading the resin having I.V. of less
25 than about 0.7-0.75 dl/g at temperature from 160°C to 210°C operating in the presence of a dianhydride of an aromatic tetracarboxylic acid, preferably pyromellitic dianhydride used in amount of from 0.04 to 2% by weight. The preparation of the foamed sheets is carried out according to known methods.

A preferred method is disclosed in USP 5.362.763, the description of
30 which is herewith incorporated by reference.

The melt strength and the melt viscosity are measured according to the methods hereinafter specified.

The melt strength of the resin forming the sheet shows values lower than those of the resin used for preparing the sheet.

5 The stretched foamed sheets of the present invention are obtained by stretching according to known methods foamed sheets having bulk density from 50 to 700 kg/m³, preferably 200 to 400 kg/m³, thickness from 0.5 to 5.

The thickness of the stretched sheets is reduced in function of the stretching ratio applied and is generally comprised from 0.2 to 3 mm, 10 preferably from 0.6 e 1.2 mm.

The density of the biaxially oriented sheets in general is higher than that of the sheets prior stretching.

When the used foaming agent is a liquid hydrocarbon the density decreases.

15 The monoaxially stretched sheets have a density lower than that of prior stretching (the lower density is due to the different apparatus used for the monoaxially stretching which is different from that used in the biaxially stretching).

The stretching ratio applicable either in monoaxially and biaxially 20 stretching is from 1.1:1 to 5:1.

Stretching ratio of 1.2:1 are sufficient in the case of the monoxially stretched sheets to impart the desired mechanical properties, in particular the increased impact resistance.

The high impact properties combined with the low density renders the 25 monoaxially stretched sheets particularly suitable for the manufacture of containers for beverages and food.

The biaxially stretching (in direction of the machine and transversally) can be carried out contemporaneously or sequentially.

The stretching temperature is generally comprised from 80°C to 120°C.

30 The residence time is of few seconds to 60 or more seconds.

The monoaxially stretching can be conducted on a series of rolls heated at 95°C-110°C and rotating with different peripheral speed.

The monoaxially stretching can be conducted in the direction of the machine or transversally.

5 In many cases it is convenient to subject the stretched sheets to heat-setting at temperatures in general comprised from 160°C to 220°C.

The heat setting has the effect of dimensionally stabilizing the sheets (the shrinkage is remarkably reduced) and to increase the mechanical properties.

With the aim of improving the gas barrier properties of the foamed sheet,
10 the same can be coated with a polyester resin film or other material having gas barrier properties.

In the case in which the sheet is covered with a polyester film, the barrier properties of the latter are conferred by subjecting the film to surface treatment giving it barrier properties or by the application of materials with
15 barrier properties such as aluminum and oxides of aluminum and silicon (Al_2O_3 and SiO_x).

A representative surface treatment is the lacquering of the film with a layer of lithium or potassium polysilicate. The treatment allows the realization of very slow oxygen permeation rates, which can be 0.3
20 $\text{ml/m}^2/24\text{h/atm}$ or less.

The application of layers of aluminum and oxides of Al and/or Si is carried out according to known methods.

The surface treatments and the deposition of barrier materials are selected and carried out in a way such as to confer to the polyester film
25 oxygen permeability properties generally lower than 70 $\text{ml/m}^2/24\text{h/atm}$ (ASTM 1434). In the case of a film metallized with Al or coated with oxides of Al and/or Si, the rate of oxygen permeability can be reduced to values lower than 0.3 $\text{ml/m}^2/24\text{h/atm}$. Values lower than 10 $\text{ml/m}^2/24\text{h/atm}$ are preferred.

30 Polyester films metallized with aluminum are commercially obtainable

under the name of Nu Roll of Nurol S.p.A. (Nu Roll is a registered trade mark of Nurol S.p.A.).

In the case where a film with barrier properties is adhered on the sheet, the untreated side of this film is the one which comes into contact with the beverage or food inside the container.

It is also possible, and this is in function of the various requirements, such as for example printing with inks or other, to use a film corresponding to the above requirements as external layer having the foamed sheet onto which the film is adhered as the internal layer.

The adhesion of the film with barrier properties or other film on the foamed sheet, can be realized according to known methods by gluing or heat-lamination or by coextrusion.

It is also possible to cover the foamed polyester sheet with a layer of a heat-sealable polymer different from the polyester resin.

The rigidity of the stretched foam sheets is in function of the thickness of the same: it increases (not proportionally) with the thickness. The use of inorganic fillers (usable up to about 20% by weight) allows an increase of the sheet rigidity. Examples of fillers are silica, alumina, titanium dioxide, calcium carbonate and similar.

The production of the containers is realized according to known methods by folding from a design pressed on the sheet by creasing, set to develop the shape of the container.

The containers can have different shape and volume according to their end use. Cubic, oblong or pyramid shapes can be used. Generally the volume of the containers for beverages and fruit juices is between 0.2 and 2 litres.

The surface characteristics of the stretched foamed sheets renders the same suitable for being easily inkable.

The high impact resistance of the stretched sheets renders the containers suitable for being used under conditions wherein the impact resistance is a

required property.

The polyester resin used for the preparation of stretched foamed sheets of the invention and having the characteristics herein above set forth is obtainable by polycondensation of an aromatic bicarboxylic acid, preferably
 5 terephthalic acid, with a diol of 2-12 carbon atoms such as ethylene glycol, 1,4-buthane-diol, or by transesterification of a dimethylester of the aromatic bicarboxylic acid with a diol and polycondensation of the hydroxi ester.

Preferably the resin is selected from the polyethylene terephthalate copolymers in which up to 20% by moles of unit deriving from terephthalic
 10 acid are substituted by units deriving from isophthalic acid and/or a naphthalene-dicarboxylic acid.

To impart biodegradability and/or compostability to the foamed sheets, the polyester resin used to prepare the sheets is mixed with 10-35% by weight of a biodegradable aliphatic polyester resin, and the mixture is
 15 subjected to a reaction of polyaddition in the solid state in the presence of a dianhydride of a tetracarboxylic acid, preferably aromatic.

Pyromellitic anhydride is the preferred dianhydride and is employed in a quantity from 0.05% to 2% by weight of the total quantity of resin.

The reaction of polyaddition in the solid state is carried out at a
 20 temperature from about 150 to 220°C, for periods of time and with dianhydride concentration sufficient to obtain resin intrinsic viscosity values higher than 0.7 dl/g (viscosity measured at 25°C. in a mixture 60/40 by weight of phenol and tetrachloroethane) and values of melt strength sufficiently high to allow foaming of the resin.

25 The intrinsic viscosity is generally comprised between 0.8 and 1.2 dl/g.

Suitable melt strength values are higher than 8 centinewton, and preferably higher than 20 centinewton.

The aliphatic polyester resin is obtained by polycondensation of a hydroxy-acid with 2-22 atoms of carbon or its lactone or lactide, or by
 30 polycondensation of an aliphatic bicarboxylic acid with 2-22 carbon atoms

with an aliphatic or aromatic diol with 2-22 carbon atoms. Polycaprolactone is the preferred polyester. The above polyesters have the characteristic of being biodegradable.

5 MEASUREMENT METHODS

The rheological measurements are made according to ASTM D 3835 using a Goeffert rheometer at 280°C.

The melt strength is determined measuring the force in cN necessary to stretch the material extruded from the capillary of Goeffert Rheometer 2002.

10 For the determination, a Rheotens apparatus is applied to the exit of a capillary of Goeffert Rheometer 2002.

The extrusion conditions are as follows:

	speed of the pistons	0.2 mm/sec
	die diameter	2 mm
15	length of the capillary	30 mm
	temperature of test	280°C
	acceleration used	2.4 cm/sec ²

Every test is twice repeated and the average of the two results is the reported value.

20 The crystallinity is measured according to the ATR method (Alternated Total Reflectance) from the ratio between the trans and gauche configuration. The ATR instrument was fitted to a Perkin model 2000 FT-IR. Absorption at 1410 cm⁻¹ was used as reference band.

25 The following examples are provided to illustrate but not to limit the invention.

EXAMPLE 1

A monoaxially stretched (stretch ratio of 1.1:1) sheet of foamed COPET (copolyethylene terephthalate containing 4% by weight of isophthalic acid)
30 having a crystallization rate such that when heated at 120°C for 5 minutes

the cristallinity does not exceed 15%, a thickness of 0.7 mm and a density of 375 Kg/m³ is creased with a design suitable to develop after folding a container having a parallelepipedon shape.

The stretched sheet was obtained from a foamed sheet having density of 450 Kg/m³, thickness of 1.1 mm and average diameter of the cells of 300 micron and cristallinity content of 8%.

The total impact energy determined using a Franctovis Ceast impact apparatus was of 0.41 J; the energy after stretching (stretching ratio 1.2:1) was 0.59J.

The foamed sheets was obtained from COPET having melt strength of 150 cN at 280°C, melt viscosity of 1800 PAS at 300° C and 10 rad/second and intrinsic viscosity of 1.24 dl/g, prepared by upgrading the COPET with I.V of 0.7 dl/g at 210°C in presence of 0.4% by weight of pyromellic dianhydride.

The container is closed by heat-sealing. The closure is hermetically sealed, and is easily openable by tearing, or by cutting or by other methods.

EXAMPLE 2

A monoaxially foamed sheet with the characteristics reported in Example 1, is adhered with the use of a glue compatible with recyclability of the container, to a Nu Roll metallized film of Nurol S.p.A. with a thickness of 15 micron.

The sheet is utilized for the production of containers for liquids.

EXAMPLE 3

A biaxially stretched foamed sheet (stretching ratio of 3:1 in both directions) obtained from foamed sheet prepared from copolyethylene terephthalate containing 4% of units of isophthalic acid, mixed with 10% by weight of polycaprolactone UC PCL 787 from Union Carbide, and then subjected to polyaddition in the solid state at 180°C. until inherent viscosity

of 0.85 dl/g is obtained, having a thickness of 1.2 mm, a density of 180 kg/m³ and crystallization rate of the resin such that, when heated at 120°C for 5 minutes, the crystallinity does not reach values higher than 15%, is pressed according to a design intended to develop by creasing a container of parallelepipedon shape.

The creased sheet is used for the preparation of containers for medium shelf-life milk and for fruit juices.

The containers are closed by heat-sealing. The closure is maintained hermetical and is easily openable by tearing, by cutting or by other methods. The containers subjected to composting under normal operational conditions used in composting processes, result compostable.

EXAMPLE 4

A foamed PET sheet having the characteristics of Example 3, is adhered by gluing with glue which is compatible with the recyclability of the container, to a Nu Roll metallized film of thickness 15 micron of Nurol S.p.A.

The sheet is utilized for the production of containers for liquids, having barrier properties.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

~~×~~ CLAIMS

1. A mono or biaxially stretched foamed sheet from an aromatic polyester resin, suitable for the production of beverage and food containers, having density lower than 700 kg/m^3 and pressed on it a design from which by folding a container can be developed, wherein the crystallization rate of the resin is such that, by heating at 120°C for 5 minutes, the crystallization does not exceed 15% .
2. The sheet according to claim 1, in which the sheet is obtained from a copolyethylene terephthalate containing from 2 to 20% by moles of units deriving from isophthalic acid and/or naphthalene-dicarboxylic acids.
3. The sheet according to claims 1 and 2, in which the sheet is stretched with a ratio from 1.1 to 5:1.
4. The sheet according to claims 1 to 3 in which the polyester resin has melt strength higher than 1 cN and melt viscosity higher than 1500 PAS with shear rate tending to zero (measured at 280°C).
5. The sheet according to claims 1 to 4, in which the polyester resin is mixed with 1 to 10% by weight of a polyamide.
6. The sheet according to claims 1 to 5 in which a polyester film is adhered, said polyester film having an oxygen permeability rate lower than $70 \text{ ml/m}^2/24\text{h/atm}$ (measurement according to ASTM 1434).
7. The sheet according to claim 6 in which the polyester film is metallized with aluminum or coated with a layer of alumina or silicon oxide, or with potassium or lithium polysilicates.
8. The sheet according to claims 1 to 5 in which a film with gas barrier properties is rendered adherent to the stretched foamed sheet by the use of glues or by heat lamination.
9. The sheet according to claims 1 to 8 in which the foamed sheet has density comprised from 60 and 500 kg/m^3 .
10. The sheet according to claim 9 in which the foamed sheet has density

from 100 and 400 kg/m³.

11. The sheet according to claims 1 to 10, having thickness from 0.5 to 3 mm.

12. The sheet according to claim 11, having a thickness of 0.7 to 1.5 mm.

5 13. The sheet according to claims 1 and 11 including an inorganic filler.

14. The sheet according to claims 1 and 13 obtained from an aromatic polyester resin mixed with 10-30% by weight of an aliphatic polyester resin.

15. The sheet according to claims 1 to 14, which is monoaxially stretched.

10 16. A beverage or food container, manufactured from the sheets of claims 1 to 15.

17. The container according to claim 16 having a closure which is realized by heat-sealing.

15 18. A container for fruit juices or for sterilized milk, manufactured by using a sheet of claims 1 to 17, to which a film is made to adhere having oxygen barrier properties corresponding to a permeation rate values lower than 70 ml/m²/24h/atm.

19. The container according to claim 18, in which the film adhered to the sheet presents an oxygen permeability rate lower than 10 ml/m²/24h/atm.

DATED this 23rd day of May 2000.

SINCO RICERCHE S.p.A.

WATERMARK PATENT & TRADEMARK ATTORNEYS
290 BURWOOD ROAD
HAWTHORN. VIC. 3122.