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(54) Title: PROCESS FOR MANUFACTURING A FLUID TIGHT LAMINATE OF COMPOSITE MATERIAL ON AN OBJECT

(57) Abstract: A process for manufacturing a liquid tight laminate of composite material on an object; an object obtainable with the process, in particular a tank, vessel or tube; and the use of the tank, vessel or tube for storage, transport or transfer of a cryogenic fluid.



WO 2016/102624 A1

PROCESS FOR MANUFACTURING A FLUID TIGHT LAMINATE OF
COMPOSITE MATERIAL ON AN OBJECT.

Technical Field

The present invention relates to process for
manufacturing a liquid tight laminate of composite
5 material on an object; an object obtainable with the
process, in particular a tank, vessel or tube; and the
use of the tank vessel or tube for storage, transport or
transfer of a cryogenic fluid.

Background

Fluid barriers for use under cryogenic conditions
such as storage tanks and pipelines are intended to
prevent the egress of the cryogenic fluid towards
materials behind the barrier. Typically, conventional
15 fluid barriers are based on special materials having
similar properties such as nickel-steel or special fibre-
reinforced composite materials. Examples of such special
fibre-reinforced composite materials include those
composed of thermosetting plastic matrix materials (such
20 as epoxy and polyurethanes) reinforced by structural
fibres such as graphite, glass, such as S2 glass and E
glass, and Ultra High Molecular Weight polyethylene.
As an example, WO 2006/003192 A1 describes the use of a
fluid barrier in a thermally insulated container for
25 storing liquefied gas such as LNG (liquefied natural
gas), liquefied nitrogen, oxygen or carbon dioxide and
liquefied hydrogen. The fluid barrier as disclosed in WO
2006/003192 comprises a plastic material such as
polyurethane or epoxy or a combination thereof.

Tanks for storage of cryogenic liquids typically contain a fluid barrier that is made of sheets of stainless steel materials that are welded together. The application of stainless steel materials has the advantage that these materials show little shrinkage when cooled down at cryogenic temperatures. However, the stiffness of these materials leaves much room for improvement to ensure that the wall construction of the tank is not damaged as a result of for instances thermal induced stresses or sloshing during transport in tanks that are arranged inside ships such as LNG ship tanks. In addition, the building of these tanks is very expensive because the stainless steel materials used and it is most time-consuming to build such fluid barriers. The building of a large on-shore LNG tank may for instance well take up to several years to be completed.

It is an object to provide a process manufacturing a fluid barrier which deals with the above disadvantages.

Summary

A process is provided in which layers of sheets of a particular composite material are arranged and adhered together in a special manner.

Accordingly, there is provided a process for manufacturing a fluid tight laminate of composite material on an object, the process comprises the steps of:

(a) adhering to a wall of the object sheets of a composite material to form a first layer of adjacent sheets on the wall of the object;

(b) adhering to the first layer of adjacent sheets as formed in step (a) sheets of a composite material to form a second layer of sheets on the wall of the object, whereby the sheets of the second layer are arranged so as to overlap the edge interface between any two adjacent sheets of the layer of sheets formed in step (a); and wherein the composite material comprises a matrix of a thermoplastic material and an oriented thermoplastic material which is incorporated into the matrix of the thermoplastic material.

In accordance a process for manufacturing fluid tight laminate is provided which is much faster to make and for less costs when compared with known processes. In addition, the laminates so obtained display excellent stress properties under cryogenic conditions.

In the context of the present disclosure the term "fluid tight" means that the laminate will be impermeable to fluids to a very high extent. However, the skilled person will appreciate that fluids will always permeate through thermoplastic materials to some, though a very limited extent.

Detailed description

In step (a), sheets of a composite material are adhered to a wall of the object to form a first layer of adjacent sheets on the wall of the object. The wall is for instance an inner wall of a tank. In step (a), the sheets can be adhered to the wall in a variety of ways, for instance by way of an adhesive.

In step (b), sheets of a composite material are adhered to the first layer of adjacent sheets as formed in step (a) to form a second layer of sheets on the wall of the object, whereby the sheets of the second layer are

arranged so as to overlap the edge interface between any two adjacent sheets of the layer of sheets formed in step (a).

In step (b), the adhering of the sheets in step (b) is preferably done under the application of a laser beam to heat and adhere the sheets as used in step (b) to the first layer of sheets as formed in step (a).

Preferably, the sheets of composite material as used in step (a) and the sheets of composite material as used in step (b) have the same width and thickness.

5 Preferably, the overlap as formed in step (b) on each side of the edge interface between each two adjacent sheets of composite material in the first layer as formed in step (a) has a width of at least four times the thickness of the tape as used in step (a).

10 Preferably, the width of the overlap on each side of the edge interface between each two adjacent sheets of composite material in the first layer is of the same size.

Preferably, the edge interface between each two adjacent sheets of composite material has the same width.

15 The edge interface can have the form of a gap between two adjacent windings of tape. In that case the gap may have a width in the range of from 0.1-5 mm.

The edge interface may also be formed by the contact point between two adjacent windings of tape. In the
20 latter case there will be no gap but a line, and the width of the line is close to zero.

Suitably, steps (a) and (b) are repeated after step (b) in the same sequence to form another liquid tight laminate on the wall of the object.

25 Preferably, the sheets of composite material as used in step (a) and the sheets of composite material as used

in step (b) have a width in the range of from 5-100 mm and a thickness in the range of 0.1-2 mm.

Preferably, the composite material of which the sheets are made as used in steps (a) and (b) have a woven structure.

Suitably, both the upper surface of the sheets which form the first layer in step (a) and the bottom surface of the sheets as used in step (b) are heated by a laser beam at or near the location where the sheets as used in step (b) are adhered to the first layer formed in step (a).

Preferably, the tape of composite material as used in step (a) and the tape of composite material as used in step (b) have the same width and thickness. Preferably, the thickness of the tape as used in steps (a) and (b) is in the range of from 0.1-2 mm, more preferably in the range of from 0.5-2 mm.

Preferably, the overlap as formed in step (b) on each side of the edge interface between each two adjacent windings of tape in the tape layer as formed in step (a) has a width of at least four times the thickness of the tape as used in step (a).

The composite material to be used has suitably a tensile Young's modulus of less than 50 Gpa at ambient conditions; and a tensile strain at break of at least 5% at ambient conditions. Preferably, the tensile Young's modulus is determined according to DIN EN ISO 527 at ambient conditions, that is standard atmospheric conditions according to ISO 554, in particular the recommended atmospheric conditions i.e. at 23 °C, 50% relative humidity and at a pressure between 86 and 106 kPa.

These properties are determined in accordance with

DIN EN ISO 527, which instructs that the test specimen is extended along its major longitudinal axis at a constant speed until the specimen fractures or until the stress (load) or the strain (elongation) reaches some predetermined value. During this procedure, the load sustained by the specimen and the elongation are measured. Thus, it is within the standard that both the modulus and the strain are determined in a single direction. This doesn't exclude the possibility that the material comprises other directions wherein the Young's modulus and/or the tensile strain at break can be different. As long as there is a direction in which the tensile Young's modulus of less than 50 Gpa at ambient conditions and a tensile strain at break of at least 5% at ambient conditions present, the material falls under the above specified properties.

In case the material is a fibre-reinforced material, DIN EN ISO 527 suggests certain directions.

In case the material is an isotropic fibre-reinforced plastic composite the direction in which measurements according to DIN EN ISO 527 are performed is irrelevant, as the material is isotropic and will thus exhibit the same properties in all directions.

In case the material is an orthotropic fibre-reinforced plastic composite, DIN EN ISO 527 defines that measurements are to be done in two directions: the "1"-direction is normally defined in terms of a feature associated with the material structure or the production process, such as the length direction in continuous-sheet processes. The "2"-direction is perpendicular to the "1"-direction. In this case, the feature associated with the material structure will trigger the skilled person to choose the 1-direction to coincide with one direction of

the fibres and the 2-direction perpendicular to the 1-direction.

In case the material is an: unidirectional fibre-reinforced plastic composites, the DIN EN ISO 527 defines that measurements are to be done in two directions, i.e. direction 1 and 2: the direction parallel to the fibres is defined as the "1"-direction and the direction perpendicular to them (in the plane of the fibres) as the "2"-direction.

However, according to the present disclosure, as long as the above mentioned parameters are found in one direction within the material, the material falls within the mentioned parameters. So, a material having at least one direction with the above parameters fits the concept underlying the present disclosure. By proposing a composite material having a low stiffness and a high elongation at break, this material is allowed to deform such as to prevent the generation of high stress whereby the very strong fibres (such as carbon) can be avoided.

Preferably, the tensile strain at break at ambient conditions is above 8%, more preferably above 10%, and even more preferably above 15%. Typically, the tensile strain at break at ambient conditions is not more than 75%.

The tensile strain at break is determined according to DIN EN ISO 527 at ambient conditions.

The stress of a material is related to its tensile Young's modulus and its coefficient of thermal expansion, and for cryogenic materials, it has hitherto been considered that low stress materials could not be used with cryogenic fluids due to the significant changes in temperatures experienced in use. However, it has been found that the use of a composite material having a

relatively low tensile Young's modulus is useable with cryogenic fluids. The use of such composite materials reduces the thermally induced stresses on the fluid barrier material as well as on any supporting structure, thereby enabling a wider range of materials to be selected for this supporting structure.

According to the present disclosure, a "composite material" is an engineered material made from two or more constituent materials with different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. The tensile Young's modulus value of the composite material may depend on the relative amounts of the materials used. The person skilled in the art will readily understand how to vary the volume fractions of the various components of the composite material to tailor the desired properties.

In one embodiment, the composite material is a mono-material composite, i.e. a composite material formed from two layers comprising the same material, for example two layers of oriented thermoplastic material that are fused together at elevated temperature and pressure, thus forming thermoplastic matrix material interdispersed between and in the layers of oriented thermoplastic material. As is known by those skilled in the art, elevated pressure, in particular hydrostatic pressure, is important to control the melting temperature of the oriented thermoplastic material. Furthermore, in the mono-material composite material one or more additives may also be incorporated being chemically different. The composite material is a thermoplastic matrix material reinforced by a reinforcer, preferably where the reinforcer is at least partially incorporated into the thermoplastic matrix material. The thermoplastic matrix

material may thus function as a continuous solid phase in which the reinforcer is embedded. There are no specific limitations with respect to the ratio of thermoplastic matrix material and reinforcer. The reinforcer may be in the form of chopped or continuous fibres, flakes or particles, but is preferably transformed into a material having a textile-like structure, such as felt, woven, roving, fabric, knit or stitched structure. Further it is preferred that the reinforcer is selected from the group consisting of natural and thermoplastic materials or a combination thereof. The natural material may comprise fibres including vegetable fibres such as coir, cotton, linen, jute, flax, ramie, sisal and hemp; and animal fibres such as sheep wool, horse hair, and silk.

Preferably the reinforcer comprises a thermoplastic material. Preferably the thermoplastic material for the reinforcer comprises a polyolefin selected from the group consisting of polyethylene, polypropylene, polybutylene, polymethylpentene, polyisobutene or a copolymer or terpolymer thereof, preferably polypropylene.

The reinforcer can also be selected from a broad range of materials including carbon fibres, glass fibres, and polymeric fibres as long as the resulting composite material has a tensile Young's modulus of less than 50 Gpa and a tensile strain at break of at least 5%.

Preferably, the reinforcer has a tensile strain at break of at least 5% as determined according to DIN EN ISO 527 at ambient conditions, more preferably the tensile strain at break at ambient conditions is above 8%, even more preferably above 10%, and most preferably above 15%. Typically, the tensile strain at break at ambient conditions is not more than 75%.

The thermoplastic matrix material to be used can be

selected from a broad range of materials such as polymer materials including polyester, polycarbonate, vinyl ester, epoxy, phenolic, polyimide, polyamide and others, as long as the resulting composite material has a tensile Young's modulus of less than 50 GPa. However, it is preferred that the plastic matrix material has a tensile Young's modulus of 0.1-5.0 GPa as determined according to DIN EN ISO 527 at ambient conditions.

An advantage of the thermoplastic material to be used is that it can be easily shaped. Preferably, the thermoplastic material comprises a polyolefin selected from the group consisting of polyethylene, polypropylene, polybutylene, polymethylpentene, polyisobutene or a copolymer or terpolymer thereof, such as EPDM, preferably polypropylene.

The thermoplastic matrix material is preferably a thermoplastic material, in which both an oriented thermoplastic material, such as a reinforcing fibrous phase, and a matrix between the oriented thermoplastic material, comprises, preferably consists essentially of, more preferably consists of, the same thermoplastic polymer. Bonding is achieved due to controlled surface melting of the oriented thermoplastic material. The physical properties of the thermoplastic matrix material, such as tensile Young's modulus and coefficient of thermal expansion (CTE), can be controlled by the extent of melting affected in the process, which determines the oriented/not oriented thermoplastic material volumetric ratio, also referred to as the fibre/matrix ratio. The way to manufacture these mono-material composites is known in the art and has for example been disclosed in US patent application publication No. 2005/0064163; B. Alcock et al. (2007), Journal of Applied Polymer Science,

Vol. 104, 118-129; and B. Alcock et al . (2007),
Composites: Part A (applied science and manufacturing),
Vol. 38, 147-161, incorporated herein by reference.

The manufacturing process typically utilizes oriented
5 thermoplastic polymer fibres in various forms:
unidirectional lay-up, woven fabric or chopped
fibres/non-woven felt. As is known in the art, it is
important to control the fibres' melting temperature by
hydrostatic pressure. The fibres are heated under
10 elevated pressure to a temperature that is below their
melting point at the elevated pressure but above the
melting temperature at a lower pressure. Reduction of
pressure for controlled time results in melting of the
fibres, which starts at the fibre surface. This surface
15 melting under controlled pressure followed by
crystallization produces the consolidated structure. An
alternative known process involves the use of a special
co extrusion of matrix material around oriented
thermoplastic material strands, such as fibres. This
20 process of co-extrusion and tape welding has advantages
over the conventional sealing processes because of the
large sealing window (130-180 °C) without loss of
material properties.

Preferably, the thermoplastic material comprises,
25 more preferably consists essentially of, even more
preferably consists of, a polyolefin selected from the
group consisting of polyethylene, polypropylene,
polybutylene, polymethylpentene, polyisobutene or a
copolymer or terpolymer thereof, such as EPDM, more
30 preferably polypropylene.

The composite material is to be used as a fluid
barrier under cryogenic conditions, which means below -30
°C, more preferably at temperatures below -100 °C, or

even below -150 °C. Such a temperature (below -100 °C, preferably below -150 °C, typically, -160 °C) is suitable for liquefied natural gas (LNG).

Preferably, the composite material has a tensile strain at break of at least 3% as determined according to DIN EN ISO 527 at -196 °C (in liquid nitrogen), more preferably at least 5%, even more preferably at least 6%, even more preferably above 8%, even more preferably above 10%. The composite material preferably has a coefficient of thermal expansion less than 250×10^{-6} m/m/°C at 40 °C. More preferably, the composite material is oriented and the composite material has a coefficient of thermal expansion less than 250×10^{-6} m/m/°C at 40 °C in the direction of the orientation of the composite material.

Further, preferably, the composite material has a coefficient of thermal expansion less than 100×10^{-6} m/m/°C at -60 °C. More preferably, the composite material is oriented and the composite material has a coefficient of thermal expansion less than 100×10^{-6} m/m/°C at -60 °C in the direction of the orientation of the composite material.

The coefficient of thermal expansion can suitably be determined according to ISO11359-2 in the temperature range between -60 and +70 °C by thermal mechanical analysis (TMA).

Preferably, both the upper surface of the first layer of adjacent sheets as formed in step (a) and the bottom surface of the sheets to be used in step (b) are heated by a laser beam at or near the location where the sheets as used in step (b) is adhered to the first layer of sheets formed in step (a).

Preferably, the composite material as used in step (a) is the same as the composite material as used in step

(b) .

In a particularly attractive embodiment, the sheets of composite material as used in step (a) and the sheets of composite material as used in step (b) comprise a non-coloured core and two coloured outer layers. This
5 embodiment has the advantage that less heat is required to adhere the sheets on each other, as a result of which the original properties of the composite material are better retained.

10 Preferably, the two coloured outer layers have a thickness in the range of from 0.015-0.1 mm, more preferably in the range of from 0.035-0.075 mm.

15 Preferably, the laser beam emits electromagnetic radiation at a wavelength of between 360 and 480 nanometres.

Suitably, in the process use is made of an apparatus for providing the sheets to be used in steps (a) and (b). Suitably, use will be made of an apparatus for providing the tape that comprises a sheet placement device, a
20 pressure device and a laser beam device. Suitably, the sheet, preferably in the form of a tape, is provided by means of a sheet (tape) placement device which is provided with a pressure devices and a laser beam device to ensures that sheet (tape) applies and adheres to the
25 outer surface of the mandrel or tube part or each tape layer formed under radial pressing force.

The apparatus for providing the sheet (tape) comprise two or more sheet (tape) placement devices which each may be provided with a pressure device and a laser beam
30 device. In this way, two or more sheets (tapes) can at the same time be adhered to the wall or earlier layer pf sheets in parallel.

A major advantage of the present process is that the

layer of sheets will only be heated where the sheets are to be adhered to the first layer of sheets or any subsequent layer of sheets.

The apparatus for providing the sheets will be moved
5 along the surface of the wall of the object. Preferably, vertically or horizontally.

Suitably, the wall of the object is the inside wall of a tank, vessel or tube.

Further provided is an object obtainable with a
10 process according to the above. Suitably, such an object is a tank, vessel or tube.

Further provided is the use of such a tank, vessel or tube for storage, transport or transfer of a cryogenic fluid.

15 Suitable tanks include tanks (i.e. bulk storage) at export and import terminals, shipping, and transfer elements such as pipes and hoses; onshore and offshore tanks of any geometric shape including (vertical) cylindrical tanks, prismatic tanks, ellipsoidal tanks,
20 and spherical tanks; portable tanks and cargo tanks; pressurized or non-pressurized vessels for the temporary or permanent storage of cryogenic fluids; pressurized or non-pressurized vessels for the transport (on land, by sea or air by any means) of cryogenic fluids of any
25 geometric shape including but not limited to (vertical) cylindrical, prismatic, ellipsoidal, spherical shapes); flexible or rigid tubes including onshore and offshore, above water, in water or underwater, including pipes, pipe sections, pipelines, piping systems, hoses, risers
30 and associated equipment and detailing.

C L A I M S

1. Process for manufacturing a fluid tight laminate of composite material on an object, the process comprises the steps of:

5 (a) adhering to a wall of the object sheets of a composite material to form a first layer of adjacent sheets on the wall of the object;

(b) adhering to the first layer of adjacent sheets as formed in step (a) sheets of a composite material to form
10 a second layer of sheets on the wall of the object, whereby the sheets of the second layer are arranged so as to overlap the edge interface between any two adjacent sheets of the layer of sheets formed in step (a); and wherein the composite material comprises a matrix of a
15 thermoplastic material and an oriented thermoplastic material which is incorporated into the matrix of the thermoplastic material.

2. Process according to claim 1, wherein the adhering of
20 the sheets in step (b) is done under the application of a laser beam to heat and adhere the sheets as used in step (b) to the first layer of sheets as formed in step (a).

3. Process according to claim 1 or 2, wherein the sheets
25 of composite material as used in step (a) and the sheets of composite material as used in step (b) have the same width and thickness.

4. Process according to any one of claims 1-3, wherein
30 the overlap as formed in step (b) on each side of the edge interface between each two adjacent sheets of composite material in the first layer as formed in step

(a) has a width of at least four times the thickness of the tape as used in step (a).

5 5. Process according to claim 4, wherein the width of the overlap on each side of the edge interface between each two adjacent sheets of composite material in the first layer is of the same size.

10 6. Process according to any one of claims 1-5, wherein the edge interface between each two adjacent sheets of composite material has the same width.

15 7. Process according to any one of claims 1-6, wherein steps (a) and (b) are repeated after step (b) in the same sequence to form another liquid tight laminate on the wall of the object.

20 8. Process according to any one of claims 1-7, wherein the sheets of composite material as used in step (a) and the sheets of composite material as used in step (b) have a width in the range of from 5-100mm and a thickness in the range of 0.1-2 mm.

25 9. Process according to any one of claims 1-8, wherein the composite material of which the sheets are made as used in steps (a) and (b) have a woven structure.

30 10. Process according to any one of claims 2-9, wherein both the upper surface of the sheets which form the first layer in step (a) and the bottom surface of the sheets as used in step (b) are heated by the laser beam at or near the location where the sheets as used in step (b) are adhered to the first layer formed in step (a).

11. Process according to any one of claims 1-10,
wherein the thermoplastic material comprises an
polyolefin selected from the group consisting of
polyethylene, polypropylene, polybutylene,
polymethylpentene, polyisobutene or a copolymer or
terpolymer thereof, and polyester.

12. Process according to any one of claims 1-11,
wherein the matrix of a thermoplastic material and the
oriented thermoplastic material which is incorporated
into the matrix of the thermoplastic material are made of
the same thermoplastic material.

13. Process according to any one of claims 1-12,
wherein the sheets of composite material as used in step
(a) and the sheets of composite material as used in step
(b) comprise a non-coloured core and two coloured outer
layers.

14. Process according to claim 13, wherein the two
coloured outer layers have a thickness in the range of
from 0.015-0.1 mm.

15. Process according to any one of claims 1-14, wherein
the laser beam emits electromagnetic radiation at
a wavelength of between 360 and 480 nanometres.

16. Process according to any one of claims 1-15, wherein
the wall is the inside wall of a tank, vessel or tube.

17. An object obtainable with a process according to any
one of claims 1-15.

18. An object according to claim 17 which is a tank, vessel or tube.

5 19. Use of the tank, vessel or tube according to claim 18 for storage, transport or transfer of a cryogenic fluid.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/081086

A. CLASSIFICATION OF SUBJECT MATTER

INV. B29C70/86 B29C70/30 B32B1/08 F17C1/06 F16L9/12
B29C63/26

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)

F17C B29C B29D B21D F16L B32B B29L

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.
X	WO 2013/179442 A1 (SEKISUI CHEMICAL CO LTD [JP]; OKAMOTO TADASHI [JP]; OKUMURA MASAHICO []) 5 December 2013 (2013-12-05)	1,3,4, 7-9,11, 12,16-18
Y	figures 2, 5, 6, 10 page 11, paragraph [0054] page 9, paragraph [0046] page 17, paragraph [0075]	2,5,6, 10,13-15
X	WO 2008/068303 A1 (SHELL INT RESEARCH [NL]; SHELL CANADA LTD [CA]; JANSSEN FRANCISCUS ANT) 12 June 2008 (2008-06-12) page 1, lines 1-8	17-19
Y	EP 1 818 596 A1 (GRAEFENTHALER KUNSTSTOFFTECHNI [DE]) 15 August 2007 (2007-08-15) page 5, lines 28-33 page 9, paragraph [0085]	2,10, 13-15
	----- -/-	



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

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"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

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Date of the actual completion of the international search

25 February 2016

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04/03/2016

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/081086

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 879 498 A (LEMONS CARL R [US]) 9 March 1999 (1999-03-09) figure 6 -----	5,6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/081086

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013179442	A1	05-12-2013	NONE
WO 2008068303	A1	12-06-2008	AT 462922 T 15-04-2010
		AU 2007328923 A1 12-06-2008	
		BR PI0719424 A2 25-02-2014	
		CA 2670920 A1 12-06-2008	
		CN 101548129 A 30-09-2009	
		DK 2100073 T3 31-05-2010	
		EP 2100073 A1 16-09-2009	
		JP 5312344 B2 09-10-2013	
		JP 2010511845 A 15-04-2010	
		KR 20090096433 A 10-09-2009	
		US 2010078439 A1 01-04-2010	
		WO 2008068303 A1 12-06-2008	
EP 1818596	A1	15-08-2007	AT 428888 T 15-05-2009
		DE 102006006902 A1 16-08-2007	
		EP 1818596 A1 15-08-2007	
US 5879498	A	09-03-1999	NONE