PROCESSES FOR DESALINATION AND PURIFICATION BY FORWARD OSMOSIS

Abstract: The present invention provides a process for producing desalinated water, the process comprising: providing a saline solution (1); providing an aqueous draw solution (2) comprising a metal bicarbonate, wherein said metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof; drawing water from the saline solution into the aqueous draw solution by forward osmosis across a selectively permeable membrane (3), such that the aqueous draw solution is diluted with desalinated water; and recovering desalinated water (7) from the diluted aqueous draw solution (4) by heating in a vessel (5). Precipitated metal carbonate (8) and a gaseous carbon dioxide containing stream (10) are passed to a vessel (9) containing water, to form an aqueous metal bicarbonate solution which is recycled as draw solution. The present invention also provides a process for the purification of gaseous streams containing carbon dioxide.
PROCESSES FOR DESALINATION AND PURIFICATION BY FORWARD OSMOSIS

Field of the Invention

5 The present invention relates to processes for the production of desalinated water, in particular potable water. The present invention also relates to processes for the purification of carbon dioxide-containing streams, such as flue gas streams.

Background to the Invention

10 Desalinated water may be produced by a process known as forward osmosis. This process involves drawing water from a saline solution across a selectively permeable membrane (also termed a semi-permeable membrane) using a draw solution which has a higher osmotic pressure than the saline solution. The membrane is selectively permeable in the sense that it is permeable to water that is present in the saline solution, but is substantially impermeable to the salt that is dissolved therein. As water is transported across the membrane, the draw solution becomes more dilute and the saline solution becomes more concentrated. The desalinated water is then recovered from the draw solution and the draw solution can be reused. Since the process is driven by an osmotic pressure differential, it does not require the input of energy.

US 2011/0100218 discloses a combined process for producing desalinated water and capturing carbon dioxide from a carbon dioxide-containing gas stream. The document teaches that by combining desalination with a carbon dioxide capture process, the efficiency of each process can be increased. The desalination process that is disclosed in this document is a forward osmosis process in which an ammonium carbonate solution is used as the draw solution. Desalinated water is obtained by heating the diluted draw solution to form ammonia and carbon dioxide, which are then separated from the water. However, the presence of ammonia and related compounds in water can present problems in terms of its high solubility, toxicity and odour, and thus the water produced by this process, though desalinated, may not be potable. Moreover, since two of the products of the process (carbon dioxide and ammonia) are obtained as gases, difficulties may be encountered in separating the products and in obtaining purified
carbon dioxide.

**Summary of the Invention**

5 According to one aspect of the present invention there is provided a process for producing desalinated water, the process comprising:
   providing a saline solution;
   providing an aqueous draw solution comprising a metal bicarbonate, wherein said metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof;
   drawing water from the saline solution into the aqueous draw solution by forward osmosis across a selectively permeable membrane, such that the aqueous draw solution is diluted with desalinated water; and
   recovering desalinated water from the diluted aqueous draw solution.

10 In a particular embodiment, the desalinated water is recovered from the diluted aqueous draw solution by:
   heating the diluted aqueous draw solution to form water, carbon dioxide and insoluble metal carbonate; and
   separating said water from said carbon dioxide.

According to another aspect of the invention, there is provided a process for purifying a gaseous stream containing carbon dioxide, the process comprising:
   contacting said gaseous stream with an aqueous medium under conditions such that an aqueous carbonic acid solution is formed;
   contacting said aqueous carbonic acid solution with a metal carbonate selected from calcium carbonate, magnesium carbonate and mixtures thereof, wherein the contacting takes place under conditions such that an aqueous metal bicarbonate solution is formed;
   drawing water from a saline solution into said aqueous metal bicarbonate solution by forward osmosis across a selectively permeable membrane, such that the aqueous metal bicarbonate solution is diluted with desalinated water; and
   recovering carbon dioxide from the diluted aqueous metal bicarbonate solution.
In a particular embodiment, the carbon dioxide is recovered from the diluted aqueous metal bicarbonate solution by:

heating the diluted aqueous metal bicarbonate solution to form water, carbon dioxide and insoluble metal carbonate; and

separating said carbon dioxide from said water and said insoluble metal carbonate.

The present invention is also directed to the use of an aqueous metal bicarbonate solution as a draw solution in a process for producing desalinated water by forward osmosis, wherein said metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof.

The processes of the present invention involve the use of a draw solution comprising a metal bicarbonate selected from calcium bicarbonate, magnesium bicarbonate, and mixtures thereof. Since these metal bicarbonates and their carbonates are not considered to be toxic, the desalinated water obtained by the present processes may be potable. Moreover, where the desalinated water is recovered by heating, the process yields a solid (insoluble metal carbonate), a liquid (water) and a gas (carbon dioxide), and thus the products can be readily separated.

By way of illustration, the present processes may be used to desalinate sea water and other saline sources, and/or to produce purified carbon dioxide from e.g. flue gas streams. Thus, for instance, the present processes may be used alongside power plants to meet targets relating to carbon dioxide emissions.

A process of the present invention may be performed in a simultaneous manner, a step-wise manner, or a combination thereof. It is also envisaged that the process for producing desalinated water and the process for purifying a carbon dioxide-containing gaseous stream may be looped and performed in a simultaneous manner, a step-wise manner, or a combination thereof.
Brief Description of the Drawings

Figures 1 and 2 are schematic diagrams illustrating processes of the present invention.

Description of Various Embodiments

In one aspect, the present invention provides a process for the desalination of water by forward osmosis. The process involves drawing water from a saline solution across a selectively permeable membrane using an aqueous draw solution comprising a metal bicarbonate, wherein the metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof. Desalinated water can then be recovered from the diluted aqueous draw solution. In particular, desalinated water may be recovered by heating the diluted draw solution to form water, carbon dioxide and insoluble metal carbonate, and then separating the water from the carbon dioxide.

The saline solution that is employed in the processes of the present invention may be obtained from any suitable source. For instance, the saline solution may be sourced naturally, e.g. from sea water or brackish water, or it may be obtained from other sources, e.g. from underground water or cooling tower blowdown. In a particular embodiment, the saline solution is obtained from a saline aquifer.

The saline solution will typically comprise sodium ions and chloride ions and, optionally, one or more other ions. In an embodiment, the osmotic pressure of the saline solution is from about 1 MPa to about 10 MPa, e.g. from about 1 MPa to about 3 MPa or from about 6 MPa to about 8 MPa.

The processes of the present invention involve the desalination of water by forward osmosis. This process involves drawing water across a selectively permeable membrane (also known as a semi-permeable membrane). The membrane is selectively permeable in the sense that it is permeable to the water that is present in the saline solution, but is substantially impermeable to the sodium ions and/or the chloride ions that are dissolved therein. The forward osmosis process may be performed using techniques and apparatus known in the art. Preferably, the forward osmosis process is performed
under ambient conditions, *e.g.* a temperature of from about 10 °C to about 30 °C and a pressure of about 1 Bar.

Membranes for use in the forward osmosis processes are known in the art. By way of illustration, and without limitation, the forward osmosis membrane may comprise an asymmetric membrane comprising a dense reject layer and a porous support substrate. The forward osmosis membrane may be a flat-sheet membrane, used in spiral wound modules. Preferred flat-sheet membranes are those comprising coated cellulose triacetate embedded onto a polyester screen mesh with a thickness of about 50 nm and suitable for solutions with pH ranging from 3 to 8, such as those fabricated by Hydration Technologies Innovations (HTI, Albany, USA). Alternatively, the forward osmosis membrane may be a hollow fibre membrane. Hollow fibre membranes may comprise a thin film composite with a polyamide-based, reverse osmosis-like skin layer on either the inner or outer surface of a porous hollow fibre substrate, the substrate typically having thickness varying from about 300 nm to about 600 nm. Hollow fibre membranes may be particularly preferred for forward osmosis processes because they are self-supported, may possess a desirable flow pattern and may have less propensity to foul.

The aqueous draw solution that is employed in the present processes comprises a metal bicarbonate selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof. The use of calcium bicarbonate or magnesium bicarbonate is advantageous in that the residual calcium or magnesium ions are non-toxic, and thus desalinated water produced by the process may be potable. In a preferred embodiment, the aqueous draw solution comprises calcium bicarbonate. The aqueous draw solution has a higher osmotic pressure than the saline solution, such that water is transported across the membrane by an osmotic pressure differential.

The aqueous draw solution may comprise one or more other species, *e.g.* one or more other solutes, in addition to the metal bicarbonate. For example, the aqueous draw solution may contain one or more species selected from calcium ions, magnesium ions and dissolved carbonate species. Preferably, the aqueous draw solution is substantially pure in the sense that any other species which may be present (*i.e.* in addition to the metal bicarbonate and related species) are only present in trace quantities. Preferably,
the draw solution is substantially free of sodium chloride.

As water is drawn from the saline solution into the draw solution, the draw solution becomes diluted with desalinated water and the sodium chloride concentration of the saline solution increases. Desalinated water may then be recovered from the diluted aqueous draw solution. The concentrated saline solution may be subjected to further processing if desired, e.g. it may be passed to a saline aquifer.

In a preferred embodiment, desalinated water is recovered from the diluted aqueous draw solution by heating the diluted draw solution under conditions such that the metal bicarbonate decomposes to form water, carbon dioxide and insoluble metal carbonate. The water may then be separated from the carbon dioxide and, optionally, the insoluble metal carbonate. Heating of the diluted draw solution results in the formation of water, carbon dioxide and insoluble metal carbonate. Thus, since the products of the heating step are a liquid (water), a gas (carbon dioxide) and a solid (metal carbonate), they can be readily separated from one another.

The step of heating the diluted draw solution may be performed under conditions known in the art. In an embodiment, the step of heating is performed at a temperature of from about 50 °C to about 90 °C, e.g. from about 60 °C to about 80°C. In an embodiment, the step of heating is performed at a pressure of about 1 Bar.

In a particular embodiment, the diluted draw solution is heated using waste heat. Waste heat (also known as low-grade heat) is heat that is produced e.g. as a by-product of industrial processes or during the operation of machinery or electrical equipment. In the processes of the present invention, the step of heating is preferably performed using waste heat from an industrial process, e.g. waste heat produced from the cooling cycle of a power plant. Thus, the process may utilise waste heat generated by a coal-fired, natural gas-fired or other fossil fuel-fired power plant.

The water that is recovered from the diluted aqueous draw solution is desalinated as compared to the saline solution. That is, the concentration of sodium chloride in the product water is less than that of the saline solution.
As mentioned *supra*, the use of calcium bicarbonate and/or magnesium bicarbonate in the draw solution is advantageous because the residual calcium or magnesium ions are non-toxic, and thus desalinated water produced by the process may be potable. The term “potable water” as used herein refers to water that is considered safe for humans to drink. Guidelines for the composition of potable water are set by *e.g.* the World Health Organisation and contain limitations on the amount of contaminants such as chemicals, pesticides, metals and microorganisms. In an embodiment, the desalinated water that is obtained by the process has a total dissolved solids content of less than 500 ppm. In an embodiment, the product water has a total dissolved solids content of less than 300 ppm.

Since the insoluble metal carbonate that is generated by heating the diluted draw solution is not toxic, separation of the metal carbonate from the product water may not be necessary for the purpose of providing potable water. It may nonetheless be preferable to remove at least the insoluble metal carbonate species from the water, particularly for the purpose of improving the appearance of the water. Thus, in an embodiment, the processes of the present invention further comprise separating the desalinated product water from the insoluble metal carbonate. Separation may be performed by any suitable separation means, *e.g.* by filtration.

Heating of the diluted aqueous draw solution also results in the formation of gaseous carbon dioxide. Advantageously, the carbon dioxide produced by the step of heating may be obtained in a substantially pure form and, since it is produced as a gas, it can be readily separated from the desalinated water and the insoluble metal carbonate. Any suitable means known in the art may be used to separate the carbon dioxide from the other products of the heating step. For instance, a vapour-liquid separator may be used. The carbon dioxide may be captured and subjected to further processing, *e.g.* it may be subjected to compression and/or sequestration. For instance, carbon dioxide may be sequestered in a saline aquifer. In a particular embodiment, the saline solution is drawn from a saline aquifer and the carbon dioxide produced by the process is passed to said aquifer.

In embodiments in which the insoluble metal carbonate is recovered from the product water, the process may further comprise contacting the recovered metal carbonate with
an aqueous carbonic acid solution under conditions such that an aqueous metal bicarbonate solution is formed. Preferably, the aqueous metal bicarbonate solution is then recycled to the process as the aqueous draw solution.

In an embodiment, the step of contacting the metal carbonate with the aqueous carbonic acid solution is performed in the presence of a catalyst or enzyme which catalyses the reaction of the metal carbonate and the carbonic acid. For example, an enzyme such as carbonic anhydrase may be used.

In an embodiment, the aqueous carbonic acid solution is formed by contacting an aqueous medium, e.g. water, with a gaseous stream containing carbon dioxide. In an embodiment, the gaseous stream is a flue gas stream, e.g. a flue gas stream from a power plant, and thus, in embodiments, may comprise one or more other gases (e.g. oxygen and/or nitrogen) in addition to carbon dioxide. Where other gases are present in the gaseous stream, these gases may pass through the aqueous medium substantially undissolved. In an embodiment, the gaseous stream is a flue gas stream containing from about 5% to about 15% by volume of carbon dioxide, e.g. about 10% by volume of carbon dioxide. In an embodiment, the flue gas stream is obtained from a power plant, e.g. a coal-fired, natural gas-fired or other fossil fuel-fired power plant.

In a particular embodiment, the process comprises feeding the insoluble metal carbonate and the gaseous carbon dioxide-containing stream into a reaction vessel containing water or another aqueous medium, such that the carbonic acid, and hence the metal bicarbonate, are generated in situ. By way of illustration, such a process may be performed by passing the gaseous stream and the insoluble metal carbonate to a scrubber.

In embodiments, the step of generating an aqueous carbonic acid solution and/or the step of forming the metal bicarbonate are performed using waste heat, e.g. waste heat produced from the cooling cycle of a power plant. Thus, once again, the process may utilise waste heat generated by a coal-fired, natural gas-fired or other fossil fuel-fired power plant.
In a related aspect, the present invention provides a process for purifying a gaseous stream containing carbon dioxide. The process comprises contacting the gaseous stream with an aqueous medium under conditions such that an aqueous carbonic acid solution is formed. The aqueous carbonic acid solution is then contacted with a metal carbonate selected from calcium carbonate, magnesium carbonate and mixtures thereof, wherein the contacting takes place under conditions such that an aqueous metal bicarbonate solution is formed. Water is then drawn from a saline solution into the aqueous metal bicarbonate solution by forward osmosis across a selectively permeable membrane, thereby diluting the aqueous metal bicarbonate solution with desalinated water. Carbon dioxide is then recovered from the diluted aqueous metal bicarbonate solution.

In an embodiment, the step of contacting the aqueous carbonic acid solution with a metal carbonate is performed in the presence of a catalyst or enzyme which catalyses the reaction of the carbonic acid and the metal carbonate. For example, an enzyme such as carbonic anhydrase may be used.

In an embodiment, the step of contacting the gaseous stream with the aqueous medium to form the aqueous carbonic acid solution and the step of contacting the aqueous carbonic acid solution with the metal carbonate are performed simultaneously.

The carbon dioxide produced by the process may be compressed and/or sequestered. In a particular embodiment, the carbon dioxide is sequestered in a saline aquifer. The process also yields desalinated water. Preferably, said water is potable.

In a particular embodiment, carbon dioxide is recovered from the diluted aqueous metal bicarbonate solution by heating the diluted aqueous metal bicarbonate solution to form water, carbon dioxide and insoluble metal carbonate. The resulting carbon dioxide can then be separated from the water and insoluble metal carbonate. In an embodiment, the step of heating is performed using waste heat, e.g. waste heat from a power plant. In an embodiment, the gaseous stream contains oxygen and/or nitrogen. In a particular embodiment, the gaseous stream is a flue gas stream, e.g. a flue gas stream from a power plant.
The present invention will now be described with reference to the accompanying drawings. It will be understood that the processes described in the drawings are merely provided for the purpose of illustration, and should not be construed as limiting.

In more detail, Figure 1 illustrates a process in accordance with the present invention. Saline solution 1 and aqueous draw solution 2 are fed as separate streams into forward osmosis unit 3. The aqueous draw solution 2 comprises a metal bicarbonate selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof. In forward osmosis unit 3, water is drawn from the saline solution across a selectively permeable membrane (not shown) into the aqueous draw solution by forward osmosis, causing the draw solution to become diluted with desalinated water. The diluted draw solution 4 is then passed to vessel 5, where it is heated to form carbon dioxide, water and insoluble metal carbonate. A gaseous carbon dioxide stream 6, desalinated water stream 7 and insoluble metal carbonate 8 are recovered. The desalinated water may be used directly as potable water, or it may be subjected to further processing, e.g. further purification.

Figure 2 illustrates a process similar to that depicted in Figure 1. In the process of Figure 2, the insoluble metal carbonate 8 and a gaseous carbon dioxide-containing stream 10 are passed to vessel 9 containing an aqueous medium such as water. The carbon dioxide dissolves in the aqueous medium to form carbonic acid, which then reacts with the insoluble metal carbonate to form an aqueous metal bicarbonate solution. The resulting aqueous metal bicarbonate solution is then recycled to the vessel 3 as the aqueous draw solution 2. In an alternative embodiment, the carbonic acid is generated in a separate vessel (not shown) before being passed to vessel 9 where it is contacted with the insoluble metal carbonate 8.

The process illustrated in Figure 2 effectively comprises two looped processes: a process for the desalination of water and a process for the purification of a carbon dioxide-containing stream. It is envisaged that these looped processes may be performed in a simultaneous manner, a step-wise manner, or a combination thereof. Preferably, the processes are performed simultaneously.
It will be understood that the present invention has been described above purely by way of example, and modification of detail can be made within the scope of the invention. Each feature disclosed in the description, and where appropriate the claims and drawings, may be provided independently or in any appropriate combination.
CLAIMS

1. A process for producing desalinated water, the process comprising:
   providing a saline solution;
   providing an aqueous draw solution comprising a metal bicarbonate, wherein said
   metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and
   mixtures thereof;
   drawing water from the saline solution into the aqueous draw solution by forward
   osmosis across a selectively permeable membrane, such that the aqueous draw solution
   is diluted with desalinated water; and
   recovering desalinated water from the diluted aqueous draw solution.

2. A process according to claim 1, wherein desalinated water is recovered from the
   diluted aqueous draw solution by:
   heating the diluted aqueous draw solution to form water, carbon dioxide and
   insoluble metal carbonate; and
   separating said water from said carbon dioxide.

3. A process according to claim 2, the process further comprising:
   separating said water from said insoluble metal carbonate.

4. A process according to claim 3, wherein said water is separated from said
   insoluble metal carbonate by filtration.

5. A process according to claim 3 or claim 4, the process further comprising:
   contacting the separated metal carbonate with an aqueous carbonic acid solution
   under conditions such that an aqueous metal bicarbonate solution is formed; and
   recycling said aqueous metal bicarbonate solution to the process as said
   aqueous draw solution.

6. A process according to claim 5, wherein the process further comprises:
   forming said aqueous carbonic acid solution by contacting an aqueous medium
   with a gaseous stream containing carbon dioxide.
7. A process according to claim 6, wherein said gaseous stream is a flue gas stream, *e.g.* a flue gas stream from a power plant.

8. A process according to claim 6 or claim 7, wherein the process comprises contacting the separated metal bicarbonate and the gaseous stream with said aqueous medium such that the carbonic acid is generated *in situ*.

9. A process according to any one of claims 2 to 8, wherein the step of heating is performed at a temperature of from about 50 °C to about 90 °C, *e.g.* from about 60 °C to about 80 °C.

10. A process according to any one of claims 2 to 9, wherein the step of heating is performed using waste heat, *e.g.* waste heat from a power plant.

11. A process according to any one of claims 2 to 10, wherein the process further comprises compressing and/or sequestering the carbon dioxide produced by the step of heating.

12. A process according to any one of the preceding claims, the process comprising:

   providing a saline solution;

   providing an aqueous draw solution comprising a metal bicarbonate, wherein said metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof;

   drawing water from the saline solution into the aqueous draw solution by forward osmosis across a selectively permeable membrane, such that the aqueous draw solution is diluted with desalinated water;

   heating the diluted draw solution to form water, carbon dioxide and insoluble metal carbonate, wherein said step of heating is optionally performed using waste heat from a power plant;

   separating said water, said insoluble metal carbonate and said carbon dioxide;

   forming an aqueous carbonic acid solution by contacting a gaseous stream containing carbon dioxide with an aqueous medium, wherein said gaseous stream is optionally a flue gas stream from a power plant;
contacting the separated metal carbonate with said aqueous carbonic acid solution under conditions such that an aqueous metal bicarbonate solution is formed; and
recycling said aqueous metal bicarbonate solution to the process as said aqueous draw solution.

13. A process according to any one of the preceding claims, wherein the metal bicarbonate is calcium bicarbonate.

14. A process according to any one of the preceding claims, wherein the desalinated water is potable.

15. A process for purifying a gaseous stream containing carbon dioxide, the process comprising:
contacting said gaseous stream with an aqueous medium under conditions such that an aqueous carbonic acid solution is formed;
contacting said aqueous carbonic acid solution with a metal carbonate selected from calcium carbonate, magnesium carbonate and mixtures thereof, wherein the contacting takes place under conditions such that an aqueous metal bicarbonate solution is formed;
drawing water from a saline solution into said aqueous metal bicarbonate solution by forward osmosis across a selectively permeable membrane, such that the aqueous metal bicarbonate solution is diluted with desalinated water; and
recovering carbon dioxide from the diluted aqueous metal bicarbonate solution.

16. A process according to claim 15, wherein carbon dioxide is recovered from the diluted aqueous metal bicarbonate solution by:
heating the diluted aqueous metal bicarbonate solution to form water, carbon dioxide and insoluble metal carbonate; and
separating said carbon dioxide from said water and said insoluble metal carbonate.
17. A process according to claim 16, wherein the step of heating is performed at a temperature of from about 50 °C to about 90 °C, e.g. from about 60 °C to about 80 °C.

18. A process according to claim 16 or claim 17, wherein the step of heating is performed using waste heat, e.g. waste heat from a power plant.

19. A process according to any one of claims 15 to 18, wherein said gaseous stream includes oxygen and/or nitrogen.

20. A process according to any one of claims 15 to 19, wherein said gaseous stream is a flue gas stream, e.g. a flue gas stream from a power plant.

21. A process according to any one of claims 15 to 20, wherein the process further comprises compression and/or sequestration of the recovered carbon dioxide.

22. A process according to any one of claims 15 to 21, wherein the metal carbonate is calcium carbonate.

23. A process according to any one of claims 15 to 22, wherein the process further comprises recovering desalinated water from the diluted aqueous metal bicarbonate solution.

24. A process according to claim 23, wherein said desalinated water is potable water.

25. Use of an aqueous metal bicarbonate solution as a draw solution in a process for producing desalinated water by forward osmosis, wherein said metal bicarbonate is selected from calcium bicarbonate, magnesium bicarbonate and mixtures thereof.

26. The use according to claim 25, wherein said metal bicarbonate is calcium bicarbonate.
Fig. 2
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   INV. C02F1/44
   ADD. C02F103/08 C02F103/18

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)
   C02F B01D

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, INSPEC, COMPENDEX, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>BE 705 135 A (RAY A. NEFF) 1 March 1968 (1968-03-01) page 4, last paragraph - page 7, paragraph 3 paragraph 10, last paragraph - page 11, paragraph 1; example 1</td>
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<td>Y</td>
<td>EP 2 354 098 A1 (BIOMIM GREENLOOP [BE]) 10 August 2011 (2011-08-10) paragraph [0019]; claims 1,2</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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Data of the actual completion of the international search | Date of mailing of the international search report
5 June 2014 | 18/06/2014

Name and mailing address of the ISA/
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Authorized officer
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