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HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
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[Continued on next page]

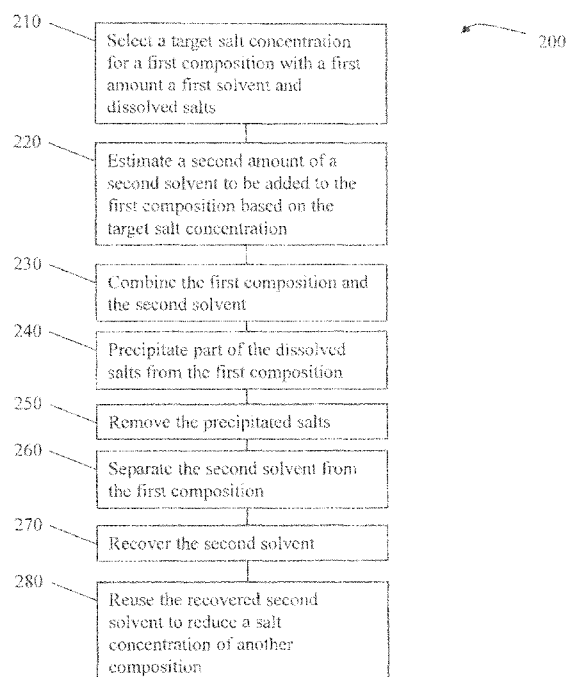
(54) **Title:** REMOVAL OF DISSOLVED SALTS USING A SOLVENT

FIG. 2

(57) **Abstract:** A method and apparatus for reducing a salt concentration in a liquid composition use a solvent. The method includes combining the liquid composition and the solvent, where the solvent has lower carrying capacity for at least one salt in solution with the liquid composition. The liquid composition may be miscible with the solvent. The solvent may also have a lower boiling point than the liquid composition. The method includes precipitating some of the salt out of the liquid and removing the precipitate. The solvent may then be separated, leaving the liquid composition with a reduced salt concentration. The solvent may be reused if recovered after separation. The apparatus includes elements for implementing the method.



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41413

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - B01D 11/04, C02F 1/26, G01N 31/02 (2014.01) CPC - B01D 11/0492, C02F 1/26, G01N 31/02 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) CPC (B01D11/0492; C02F1/26; G01N31/02; Y10S159/20; C01D3/06; C02F1/54; C02F1/265; C02F2303/18; C02F2103/08; C02F2103/365; C02F1/26; C07C41/34; B01D53/1425; C02F1/048; B01D3/06; B01D1/305; B01D3/42; B01D1/0094; C02F1/42)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC (210/511; 210/634; 210/642; 702/22; 702/23; 702/30; 23/300; 23/303; 159/DIG.200; 210/729; 423/158; 210/787; 423/11; 210/695; 210/712; 210/177; 210/709; 568/699; 203/10; 202/160; 202/197; 202/200; 159/44; 159/2.1; 203/DIG.18; 210/295; 203/11; 203/88; 202/18)		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Free Patents Online; search terms: remove extract salt brine precipitate crystallize solubility solvent carrying capacity reuse algorithm particulates microorganism layer skim acetone ethanol methanol sodium chloride...		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,548,614 A (IRELAND) 22 October 1985 (22.10.1985), Fig. 1-3; Table; col 1, ln 33-67; col 2, ln 1-6 and 41-51; col 3, ln 6-12; col 4, ln 37-67; col 5, ln 1-10 and 30-67; col 6, ln 1-10; Clm 1, 5, 7	1, 3-7, 11-12, 15 ----- 2, 8-10, 13-14, 16
X	US 2010/0063783 A1 (CHEN et al.) 11 March 2010 (11.03.2010), para [0010], [0035], [0059]-[0064]; figure 4	32-34
X -- Y	US 2010/0219372 A1 (HOOK et al.) 02 September 2010 (02.09.2010), para [0275], [0276], [0404], [0487]	32 ----- 35
Y	WO 2013/028938 A1 (LAROCHE) 28 February 2013 (28.02.2013), pg 4, ln 6-30	2, 35
Y	US 2002/0088703 A1 (WALKER) 11 July 2002 (11.07.2002), para [0005], [0025]; Clm 9	8
Y	US 2006/0157415 A1 (KOEFOOD) 20 July 2006 (20.07.2006), para [0005], [0009], [0019]; Clm 7	9
Y	WO 2004/089830 A2 (SCHAFFER et al.) 21 October 2004 (21.10.2004), pg 4, ln 6-10	10
Y	US 5,468,394 A (BADER) 21 November 1995 (21.11.1995), col 2, ln 26-31 and 63-67; col 3, ln 1-18	13, 14
Y	US 2013/0082003 A1 (BAJPAYEE et al.) 04 April 2013 (04.04.2013), para [0008], [0038]	16
☐ Further documents are listed in the continuation of Box C. ☐		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 31 October 2014 (31.10.2014)		Date of mailing of the international search report 13 NOV 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41413

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Group I: Claims 1-16, drawn to a method of removing at least part of at least one dissolved salt from a liquid composition, the method comprising the steps of: combining a first quantity of the liquid composition and a quantity of a second solvent, the liquid composition comprising: a first solvent, and the at least one dissolved salt; precipitating an amount of the at least one dissolved salt out of the liquid composition, wherein the first solvent has a carrying capacity for the at least one dissolved salt that is greater than the carrying capacity of the second solvent for the at least one dissolved salt; removing the at least part of the at least one dissolved salt from contact with the first quantity of the liquid composition and second solvent; and separating the second solvent from the first quantity of the liquid composition.

** Please see the continuation on the extra sheets after the references **

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
claims 1-16 and 32-35
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41413

Box No. III, Observations where unity of invention is lacking:

Group II: Claims 17-27, drawn to an apparatus for removing dissolved salts from a liquid composition, the system comprising: a container configured to store a quantity of the liquid composition, the liquid composition comprising a first solvent and at least one dissolved salt; a controller configured to add a predetermined quantity of a second solvent to the container; a controller configured to estimate the predetermined quantity of the second solvent based on a selected output salt concentration; a salt removal means configured to remove a precipitated salt from the container; a heater in thermal communication with the second solvent and configured to separate the second solvent from the liquid composition after the precipitated salt has been removed; and a recovery container configured to store the separated second solvent.

Group III: Claims 28-31, drawn to a method of reducing a salt concentration in a liquid composition, the method comprising: estimating a quantity of a second solvent required to be combined with a quantity of the liquid composition to reduce the salt concentration of the liquid composition to a selected level after the second solvent has been separated from the liquid composition.

Group IV: Claims 32-35, drawn to a non-transitory computer-readable medium product, the medium comprising instructions thereon that, when executed by a processor, perform a method, the method comprising: estimating a quantity of a second solvent required to be combined with a quantity of the liquid composition to reduce the salt concentration of the liquid composition to a selected level after the second solvent has been separated from the liquid composition.

The inventions listed as Groups I through IV do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Groups II, III, and IV do not require wherein the first solvent has a carrying capacity for the at least one dissolved salt that is greater than the carrying capacity of the second solvent for the at least one dissolved salt, as required by Group I.

Groups I, III, and IV do not require a container configured to store; a controller configured to add a predetermined quantity of a second solvent to the container; a salt removal means configured to remove a precipitated salt from the container; a controller configured to estimate the predetermined quantity of the second solvent based on a selected output salt concentration; a heater in thermal communication with the second solvent and configured to separate the second solvent from the liquid composition after the precipitated salt has been removed; or a recovery container, as required by Group II.

Groups I and II do not require a method of estimating a quantity of a second solvent required to be combined with a quantity of the liquid composition to reduce the salt concentration of the liquid composition to a selected level after the second solvent has been separated from the liquid composition, as required by Groups III and IV.

Groups III and IV do not require a method of removing at least part of at least one dissolved salt from a liquid composition, the method comprising the steps of: combining a first quantity of the liquid composition and a quantity of a second solvent, the liquid composition comprising: a first solvent, and the at least one dissolved salt; precipitating an amount of the at least one dissolved salt out of the liquid composition, wherein the first solvent has a carrying capacity for the at least one dissolved salt that is greater than the carrying capacity of the second solvent for the at least one dissolved salt; removing the at least part of the at least one dissolved salt from contact with the first quantity of the liquid composition and second solvent; and separating the second solvent from the first quantity of the liquid composition, as required by Group I.

Group III and IV do not require an apparatus dissolved salts from a liquid composition, the system comprising: a container configured to store a quantity of the liquid composition, the liquid composition comprising a first solvent and at least one dissolved salt; a controller configured to add a predetermined quantity of a second solvent to the container; a controller configured to estimate the predetermined quantity of the second solvent based on a selected output salt concentration; a salt removal means configured to remove a precipitated salt from the container; a heater in thermal communication with the second solvent and configured to separate the second solvent from the liquid composition after the precipitated salt has been removed; and a recovery container configured to store the separated second solvent, as required by Group II.

Groups I, II, and III do not require a non-transitory computer-readable medium product, the medium comprising instructions thereon that, when executed by a processor, perform a method, as required by Group IV.

Shared Technical Features

The only feature shared by Groups I through IV that would otherwise unify the groups is reducing a salt concentration in a liquid composition. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by US 4,548,614 A (Ireland). Ireland discloses reducing a salt concentration in a liquid composition (col 1, ln 38-48, organic solvent added to brine to reduce the solubility of salt in the brine and precipitate the salt therefrom.).

The only feature shared by Groups I and II that would otherwise unify the groups is removing dissolved salts from a liquid composition, comprising precipitating an amount of at least one dissolved salt out of a liquid composition; the liquid composition comprising a first solvent and at least one dissolved salt; combining/adding a quantity of a second solvent to the liquid composition; and removing a precipitated salt. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Ireland.

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INTERNATIONAL SEARCH REPORT

International application No.

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Box No. III, Observations where unity of invention is lacking:

Ireland discloses removing dissolved salts from a liquid composition (col 1, ln 38-48, organic solvent added to brine to reduce the solubility of salt in the brine and precipitate the salt therefrom.), comprising precipitating an amount of at least one dissolved salt out of a liquid composition (col 1, ln 37-47, precipitating salt from the brine after addition of the organic solvent); the liquid composition comprising a first solvent and at least one dissolved salt (col 1, ln 37-47; col 1, ln 63 to col 2, ln 19, a brine solution comprising water and sodium chloride.); combining/adding a quantity of a second solvent to the liquid composition (col 2, ln 9-40, adding organic solvent to precipitate salt from the brine.); and removing a precipitated salt (col 1, ln 38-48; col 4, ln 60 to col 5, ln 2; col 5, ln 51 to col 6, ln 2, filtered precipitated salt using filter unit.).

The only feature shared by Groups II, III, and IV that would otherwise unify the groups is the estimating a quantity of a second solvent. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated obvious by Ireland. Ireland discloses estimating a quantity of a second solvent (Fig. 1; col 4, ln 37-44; col 5, ln 32-50, graph showing abscissa the number of grams of ethylamine organic solvent added to saturated brine solution, and on the ordinate, the total grams of salt precipitated from brine... for use with Example for salt precipitation.).

The only feature shared by Groups III and IV that would otherwise unify the groups is the method for estimating a quantity of a second solvent required to be combined with a quantity of the liquid composition to reduce the salt concentration of the liquid composition to a selected level after the second solvent has been separated from the liquid composition. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated obvious by Ireland. Ireland discloses estimating a quantity of a second solvent required to be combined with a quantity of the liquid composition to reduce the salt concentration of the liquid composition to a selected level after the second solvent has been separated from the liquid composition (Fig. 1; col 4, ln 37-44; col 5, ln 32-64, graph showing abscissa the number of grams of ethylamine organic solvent added to saturated brine solution, and on the ordinate, the total grams of salt precipitated from brine... for use with Example for salt precipitation... filtering to recover the precipitated salt... to obtain about 52 percent of the salt recovered or about 48 percent of salt in solution.).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups. Groups I through IV therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.