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(71) **Applicant** *(for all designated States except US)*: **ORBITE ALUMINAE INC.** [CA/CA]; 6505 route Transcanadienne, Bureau 610, Saint-Laurent, Québec H4T 1S3 (CA).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **BOUDREAULT, Richard** [CA/CA]; 2723 Luce-Guilbeault, St-Laurent, Québec H4R 2T3 (CA). **FOURNIER, Joel** [CA/CA]; 1761 des Amarantes, Carignan, Québec J3L 4Z8 (CA). **GAUTHIER, Laury** [CA/CA]; 75 rue des Pins, Apt. 4, Saint-Apollinaire, Québec GOS (CA).

(74) **Agent**: **BERESKIN & PARR LLP / S.E.N.C.R.L., S.R.L.**; 40 King Street West, 40th Floor, Toronto, Ontario M5H 3Y2 (CA).

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(54) **Title**: METHODS FOR PREPARING HEMATITE

(57) **Abstract**: There are provided methods for preparing hematite. For example, the method can comprise reacting a basic aqueous composition comprising the iron and the aluminum with hematite under conditions suitable for at least partially converting the iron into hematite under the form of a precipitate, thereby obtaining a liquid phase and a solid phase; and separating the liquid phase from the solid phase.

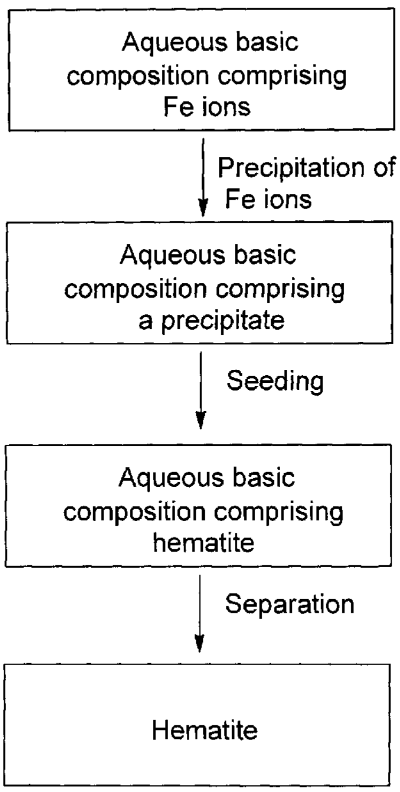

FIG. 1

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METHODS FOR PREPARING HEMATITE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority on US 61/493,018 filed on June 3, 2011, that is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to improvements in the field of chemistry applied to the synthesis of iron-based products. For example, such methods are useful for the preparation of hematite.

BACKGROUND OF THE DISCLOSURE

[0003] Hematite has been used as a colorant for centuries. It is the most common type of naturally occurring iron oxide mineral. Examples of hematites include hematites, pyrites, and magnetites, which are respectively red-colored, yellow-colored, and black-colored. Hematites are mostly prepared as synthetic products, and thus are used in various fields as pigments having clear color tones and excellent durability, being inexpensive and having low toxicity and high stability. In particular, well-known synthetic hematite pigments include red or red brown-colored hematite particle powder (α-Fe_2O_3 or micaceous iron oxide (MIO)), yellow or deep brown-colored maghemite (γ-Fe_2O_3) particle powder, and black-colored magnetite ($FeOx$-Fe_2O_3 where $0<x<=l$). Many of the processes proposed so far for preparing such products comprise at least one drawbacks such as being not cost effective, not being environmental friendly or being complicated.

[0004] There is thus a need for at least providing an alternative to the existing solutions for preparing hematites. Moreover, there would be a need for valorizing certain waste materials and at least partially convert them into hematite.

SUMMARY OF THE DISCLOSURE

[0005] According to one aspect, there is provided a method for preparing hematite. The method comprises obtaining the hematite from a basic aqueous composition comprising at least one precipitated iron ion, having a pH of about 10.5 to about 12 and being at a temperature of about 70 °C to about 120 °C, by reacting the composition with a predetermined quantity of hematite, thereby promoting, catalyzing and/or enhancing formation of the hematite.

[0006] According to another aspect, there is provided a method for preparing hematite. The method comprises obtaining the hematite from a basic aqueous composition comprising at least one precipitated iron ion, having a pH of about 10.5 to about 13 and being at a temperature of about 50 °C to about 150 °C, by reacting the composition with hematite, thereby promoting, catalyzing and/or enhancing formation of the hematite.

[0007] According to one aspect, there is provided a method for preparing hematite. The method comprises obtaining the hematite from a basic aqueous composition comprising at least one precipitated iron ion, having a pH of about 10.5 to about 12 and being at a temperature of about 70 °C to about 120 °C, by reacting the composition with a predetermined quantity of hematite, thereby promoting, catalyzing and/or enhancing formation of the hematite.

[0008] According to another aspect, there is provided a method for separating iron ions from aluminum ions contained in a basic aqueous composition, the method comprising :

obtaining a basic aqueous composition comprising iron ions and aluminum ions and having a pH of about 10.5 to about 12 and a temperature of about 70 °C to about 120 °C;

reacting the composition with a predetermined quantity of hematite so as to promote, catalyze and/or enhance formation of hematite and to obtain a liquid phase comprising the aluminum ions and a solid phase comprising the so-formed hematite; and

separating the liquid phase from the solid phase.

[0009] According to another aspect, there is provided a method for separating iron ions from aluminum ions contained in a basic aqueous composition, the method comprising :

obtaining a basic aqueous composition comprising the iron ions and the aluminum ions and having a pH of about 10.5 to about 13 and a temperature of about 50 °C to about 150 °C;

reacting the composition with hematite so as to promote, catalyze and/or enhance formation of hematite and to obtain a liquid phase comprising the aluminum ions and a solid phase comprising the so-formed hematite; and

separating the liquid phase from the solid phase.

[0010] According to another aspect, there is provided a method for separating iron ions from aluminum ions contained in a basic aqueous composition, the method comprising :

obtaining the basic aqueous composition comprising the iron ions and the aluminum ions and having a pH of about 10.5 to about 13 and a temperature of about 50 °C to about 150 °C;

reacting the basic aqueous composition with hematite so as to promote, catalyze and/or enhance formation of hematite and to obtain a liquid phase comprising the aluminum ions and a solid phase comprising the so-formed hematite generated with at least a portion of the iron ions; and

separating the liquid phase from the solid phase.

[0011] According to another aspect, there is provided a method for separating iron ions from aluminum ions contained in a basic aqueous composition, the method comprising :

reacting the basic aqueous composition comprising the iron ions and the aluminum ions with a seeding agent under conditions suitable for promoting, catalyzing and/or enhancing formation of hematite under the form of a precipitate, thereby obtaining a liquid phase and a solid phase; and

separating the liquid phase from the solid phase.

[0012] According to another aspect, there is provided a method for separating iron ions from aluminum ions contained in a basic aqueous composition, the method comprising :

reacting the basic aqueous composition comprising the iron ions and the aluminum ions with a seeding agent under conditions suitable for at least partially converting the iron ions into hematite under the form of a precipitate, thereby obtaining a liquid phase and a solid phase; and

separating the liquid phase from the solid phase.

[0013] According to another aspect, there is provided a method for separating iron from aluminum contained in a basic aqueous composition, the method comprising :

reacting the basic aqueous composition comprising the iron and the aluminum with hematite under conditions suitable for at least partially converting the iron into hematite under the form of a precipitate, thereby obtaining a liquid phase and a solid phase; and

separating the liquid phase from the solid phase.

DETAILLED DESCRIPTION OF VARIOUS EMBODIMENTS

[0014] Further features and advantages will become more readily apparent from the following description of various embodiments as illustrated by way of examples only and in a non-limitative manner.

[0015] The term "hematite" as used herein refers, for example, to a compound comprising α-Fe_2O_3, γ-Fe_2O_3, β-FeO.OH or mixtures thereof.

[0016] The expression "iron ions" as used herein refers, for example to ions comprising to at least one type of iron ion chosen from all possible forms of Fe ions. For example, the at least one type of iron ion can be Fe^{2+}, Fe^{3+}, or a mixture thereof.

[0017] The expression "aluminum ions" as used herein refers, for example to ions comprising to at least one type of aluminum ion chosen from all possible forms of Al ions. For example, the at least one type of aluminum ion can be Al^{3+}.

[0018] The expression "at least one aluminum ion", as used herein refers, for example, to at least one type of aluminum ion chosen from all possible forms of Al ions. For example, the at least one aluminum ion can be Al^{3+}.

[0019] The expression "at least one iron ion", as used herein refers, for example, to at least one type of iron ion chosen from all possible forms of Fe ions. For example, the at least one iron ion can be Fe^{2+}, Fe^{3+}, or a mixture thereof.

[0020] The expression "at least one precipitated iron ion", as used herein refers, for example, to at least one type of iron ion chosen from all possible forms of Fe ions that was precipitated in a solid form. For example, the at least one iron ion present in such a precipitate can be Fe^{2+}, Fe^{3+}, or a mixture thereof.

[0021] The term "suitable" as used herein means that the selection of the particular conditions would depend on the specific manipulation to be performed, but the selection would be well within the skill of a person trained in the art. All process/method elements described herein are to be conducted under conditions sufficient to provide the desired product. A person skilled in the art would understand that all reaction conditions, including, for example, reaction solvent, reaction time, reaction temperature, reaction pressure, reactant ratio, etc, can be varied to optimize the yield of the desired product and it is within their skill to do so.

[0022] Terms of degree such as "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. These terms of degree should be construed as including a deviation of at least ±5% or at least ±10% of the modified term if this deviation would not negate the meaning of the word it modifies.

[0023] The expression "at least substantially maintained" as used herein when referring to a value of a pH or a pH range that is maintained when reacting the basic aqueous composition with hematite refers to maintaining the value of the pH or the pH range at least 75, 80, 85, 90, 95, 96, 97, 98 or 99 % of the time during such a reaction.

[0024] The expression "at least substantially maintaining" as used herein when referring to a value of a pH or a pH range that is maintained when reacting the basic aqueous composition with hematite refers to maintaining the value of the pH or the pH range at least 75, 80, 85, 90, 95, 96, 97, 98 or 99 % of the time during such a reaction.

[0025] The expression "at least substantially maintaining" as used herein when referring to a value of a temperature or a temperature range that is maintained when reacting the basic aqueous composition with hematite refers to maintaining the value of the temperature or the temperature range at least 75, 80, 85, 90, 95, 96, 97, 98 or 99 % of the time during the process or the portion thereof.

[0026] The expression "at least substantially maintained" as used herein when referring to a value of a temperature or a temperature range that is maintained when reacting the basic aqueous composition with hematite refers to maintaining the value of the temperature or the temperature range at least

75, 80, 85, 90, 95, 96, 97, 98 or 99 % of the time during the process or the portion thereof.

[0027] For example, the methods can further comprise precipitating the aluminum ions from the liquid phase by adjusting pH of the liquid phase at a value of about 7 to about 11, about 8 to about 10.5, about 9 to about 10, about 9.2 to about 9.8, or about 9.5.

[0028] For example, aluminum ions can be precipitated from the liquid phase by reacting it with an acid. The acid used can be HCl, H_2SO_4, HNO_3 or mixtures thereof.

[0029] For example, precipitating the aluminum ions can be carried out at a temperature of about 40 °C to about 80 °C, about 50 °C to about 70 °C or about 60 °C to about 70 °C. For example, precipitating the aluminum ions can be carried out at by at least substantially maintaining the temperature.

[0030] For example, the methods can further comprise adding a precipitating agent effective for facilitating precipitation of the aluminum ions. For example, the precipitating agent is a polymer such as an acrylamide polymer.

[0031] For example, the basic aqueous composition, before being reacted with the hematite, can comprises at least one precipitate that comprises iron under the form of Fe^{3+}, Fe^{2+}, or a mixture thereof.

[0032] For example, the basic aqueous composition, before being reacted with the hematite, can comprise at least one precipitate that comprises $Fe(OH)_3$, $Fe(OH)_2$, or a mixture thereof.

[0033] For example, the basic aqueous composition, before being reacted with the hematite, comprises iron ions under the form of Fe^{3+}, Fe^{2+}, or a mixture thereof.

[0034] For example, the hematite can be reacted with the basic aqueous composition under agitation.

[0035] For example, the basic aqueous composition can have a temperature of about 50 °C to about 70 °C, about 65 °C to about 75 °C, about 70 °C to about 80 °C, about 70 °C to about 100 °C, about 75 °C to about 110 °C, about 80 °C to about 100 °C, about 85 °C to about 95 °C, about 87 °C to about 93 °C, about 70 °C to about 120 °C, about 90 °C to about 100 °C, about 70 °C, about 75 °C, about 80 °C, about 85 °C, about 90 °C, or about 95 °C.

[0036] For example, the basic aqueous composition can be reacted with the hematite by at least substantially maintaining the basic aqueous composition at the temperature.

[0037] For example, the reaction between the basic aqueous composition and hematite can be carried out by at least substantially maintaining a temperature of about 50 °C to about 150 °C, about 50 °C to about 70 °C, about 65 °C to about 75 °C, about 70 °C to about 80 °C, about 70 °C to about 100 °C, about 75 °C to about 110 °C, about 80 °C to about 100 °C, about 85 °C to about 95 °C, about 87 °C to about 93 °C, about 70 °C to about 120 °C, about 90 °C to about 100 °C, about 70 °C, about 75 °C, about 80 °C, about 85 °C, about 90 °C, or about 95 °C.

[0038] For example, the basic aqueous composition can have a pH of about 10.8 to about 11.8, about 11 to about 12, about 11.5 to about 12.5, about 11.0 to about 11.6, about 11.2 to about 11.5, about 10.5 to about 12, about 11.5 to about 12.5, or about 11.8 to about 12.2, about 11.0, about 11.1, about 11.2, about 11.3, about 11.4, about 11.5, about 11.6, about 11.7, about 11.8, about 11.9, or about 12.0.

[0039] For example, the reaction between the basic aqueous composition and hematite can be carried out by at least substantially maintaining the pH.

[0040] For example, the reaction between the basic aqueous composition and hematite can be carried out by at least substantially maintaining a pH of about 10.5 to about 13, about 10.8 to about 11.8, about

11 to about 12, about 11.5 to about 12.5, about 11.0 to about 11.6, about 11.2 to about 11.5, about 10.5 to about 12, about 11.5 to about 12.5, about 11.8 to about 12.2, about 11.0, about 11.1, about 11.2, about 11.3, about 11.4, about 11.5, about 11.6, about 11.7, about 11.8, about 11.9, or about 12.0.

[0041] For example, about 0.25 to about 25 g, about 1 to about 20 g, about 1 to about 10 g, about 1.5 to about 5.5 g, or about 2 to about 15 g of hematite can be used per liter of the basic aqueous composition.

[0042] For example, the basic aqueous composition can have a concentration of Fe of about 0.5 to about 10 g/L, about 1 to about 7 g/L, or about 1.5 to about 5.5 g/L.

[0043] For example, hematite can be into the basic aqueous composition. For example, hematite can be added at a molar ratio hematite / total amount of iron contained in the basic aqueous composition of about 0.005 to about 0.5 or about 0.01 to about 0.1.

[0044] For example, the basic aqueous composition can be obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising the iron ions and the aluminum ions and a solid residue;

separating the leachate from the solid residue; and

reacting the leachate with a base.

[0045] For example, the basic aqueous composition can be obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising the iron ions and the aluminum ions and a solid residue;

optionally removing at least a portion of the iron ions from the leachate;

separating the leachate from the solid residue; and

reacting the leachate with a base.

[0046] For example, the base can be KOH, NaOH, $Ca(OH)_2$, CaO, MgO, $Mg(OH)_2$, $CaCO_3$, Na_2CO_3, $NaHCO_3$, or mixtures thereof.

[0047] For example, the base can have a concentration of about 2 to about 20 M, about 2.5 M to about 10 M or about 3 to about 4 M.

[0048] For example, the base can have a concentration of about 30 to about 60 weight %, about 35 to about 55 weight %.

[0049] For example, the leachate and a first portion of the base can be added simultaneously into a reactor comprising a second portion of the base. For example, the basic aqueous composition can be reacted with the hematite by at least substantially maintaining the basic aqueous composition at the pH. For example, the basic aqueous composition can be at least substantially maintained at the pH by reacting it with a further amount of the base.

[0050] For example, reacting the leachate with the base can generate precipitation of at least a portion of the iron ions into $Fe(OH)_3$, $Fe(OH)_2$, or a mixture thereof.

[0051] For example, upon reacting hematite with the basic aqueous composition, at least a portion of the $Fe(OH)_3$, $Fe(OH)_2$, or the mixture thereof can be converted into hematite.

[0052] For example, iron can be present in the basic aqueous composition, before reacting it with the hematite, under the form of solubilized ions, a precipitate or a mixture thereof.

[0053] For example, the basic aqueous composition can comprise, before reacting it with the hematite, solubilized Fe^{3+} ions, solubilized Fe^{2+} ions or a mixture thereof.

[0054] For example, the basic aqueous composition can comprise, before reacting it with the hematite, precipitated iron under the form of $Fe(OH)_3$, $Fe(OH)_2$ or a mixture thereof.

[0055] For example, the conditions suitable for at least partially converting the iron into hematite under the form of a precipitate can comprise reacting the basic aqueous composition with hematite at a temperature of about 50 °C to about 150 °C, about 50 °C to about 70 °C, about 65 °C to about 75 °C, about 70 °C to about 80 °C, about 70 °C to about 100 °C, about 75 °C to about 110 °C, about 80 °C to about 100 °C, about 85 °C to about 95 °C, about 87 °C to about 93 °C, about 70 °C to about 120 °C, about 90 °C to about 100 °C, about 70 °C, about 75 °C, about 80 °C, about 85 °C, about 90 °C, or about 95 °C.

[0056] For example, the conditions suitable for at least partially converting the iron into hematite under the form of a precipitate can comprise at least substantially maintaining the temperature while reacting the basic aqueous composition with hematite.

[0057] For example, the conditions suitable for at least partially converting the iron into hematite under the form of a precipitate can comprise reacting the basic aqueous composition with hematite at a pH of about 10.5 to about 13, about 10.8 to about 11.8, about 11 to about 12, about 11.5 to about 12.5, about 11.0 to about 11.6, about 11.2 to about 11.5, about 10.5 to about 12, about 11.5 to about 12.5, about 11.8 to about 12.2, about 11.0, about 11.1, about 11.2, about 11.3, about 11.4, about 11.5, about 11.6, about 11.7, about 11.8, about 11.9, or about 12.0.

[0058] For example, the conditions suitable for at least partially converting the iron into hematite under the form of a precipitate can comprise at least substantially maintaining the pH while reacting the basic aqueous composition with hematite.

[0059] For example, the conditions suitable for at least partially converting the iron into hematite under the form of a precipitate can comprise reacting about 0.25 to about 25 g of, about 0.5 to about 25 g, about 1 to about 20 g, about 1 to about 10 g, about 1.5 to about 5.5 g, or about 2 to about 15 g of hematite per liter of the basic aqueous composition.

[0060] For example, the precipitated aluminum ions can be under the form of $Al(OH)_3$.

[0061] For example, the methods can further comprise converting $Al(OH)_3$ into Al_2O_3. Such a conversion can be done, for example, in various manner including by those as described in WO 2008/141423.

[0062] For example, the methods can further comprise converting $Al(OH)_3$ into $AlCl_3$. Such a conversion can be done, for example, by reacting $Al(OH)_3$ with HCl.

[0063] For example, the methods can further comprise converting $AlCl_3$ into Al_2O_3. Such a conversion can be done, for example, in various manner including by thermal decomposition and calcination. For example, the decomposition/calcination can be done in a rotary furnace. For example, it can be done at variable speed where the temperature gradually rises from 300° C at the entry to reach around 1250° C at its maximum.

[0064] For example, the at least one precipitated iron ion can be chosen from Fe^{3+}, Fe^{2+}, and a mixture thereof.

[0065] For example, the at least one precipitated iron ion can be under the form of $Fe(OH)_2$, $Fe(OH)_3$), or a mixture thereof.

[0066] For example, the predetermined quantity of hematite can be added to the basic aqueous composition, over a predetermined period of time, optionally under agitation.

[0067] For example, the predetermined quantity of hematite can be added at a molar ratio hematite / the at least one iron ion of about 0.005 to about 0.5 or about 0.01 to about 0.1.

[0068] For example, the basic aqueous composition can be obtained by :

leaching an aluminum-containing ore comprising the at least one iron ion (or comprising iron) with an acid so as to obtain a leachate and a solid residue;

separating the leachate from the solid residue; and

reacting the leachate with a base.

[0069] For example, the basic aqueous composition can be obtained by :

leaching an aluminum-containing ore comprising the at least one iron ion (or comprising iron) with an acid so as to obtain a leachate and a solid residue;

optionally removing at least a portion of the iron ions from the leachate;

separating the leachate from the solid residue; and

reacting the leachate with a base.

[0070] For example, the acid used for leaching can be HCl, H_2SO_4, HNO_3 or mixtures thereof.

[0071] The iron-containing material can be an aluminum-containing material, The aluminum-containing material can be an aluminum-containing ore. For example, clays, argillite, mudstone, beryl, cryolite, garnet, spinel, bauxite, or mixtures thereof can be used as starting material. The aluminum-containing material can also be a recycled industrial aluminum-containing material such as slag. The aluminum-containing material can also be red mud or fly ashes.

[0072] The acid used for leaching aluminum-containing ore can be HCl, H_2SO_4, HNO_3 or mixtures thereof. More than one acid can be used as a mixture or separately. Solutions made with these acids can be used at various concentration. For example, concentrated solutions can be used. For example, 6 M or 12 M HCl can be used. For example, up to 100 % wt H_2SO_4 can be used.

[0073] The leaching can be carried out under pressure. For example, the pressure can be about 10 to about 300 psig, about 25 to about 250 psig, about 50 to about 200 psig or about 50 to about 150 psig. The leaching can be carried out for about 30 minutes to about 5 hours. It can be carried out at a temperature of about 60 to about 300 °C, about 75 to about 275 °C or about 100 to about 250 °C.

[0074] After the leaching, various bases can be used for raising up the pH such as KOH, NaOH, $Ca(OH)_2$, CaO, MgO, $Mg(OH)_2$, $CaCO_3$, Na_2CO_3, $NaHCO_3$, or mixtures thereof.

[0075] For example, iron ions can be precipitated. When precipitating iron ions, the iron ions can be precipitated by means of an ionic precipitation and they can precipitate in the form of various salts, hydroxides or hydrates thereof. For example, the iron ions can be precipitated as $Fe(OH)_3$, $Fe(OH)_2$, hematite, geotite, jarosite or hydrates thereof.

[0076] For example, aluminum ions can be precipitated. When precipitating aluminum ions, the aluminum ions can be precipitated by means of an ionic precipitation and they can precipitate in the form of various salts, (such as chlorides, sulfates) or hydroxides or hydrates thereof. For example, the aluminum ions can be precipitated as $Al(OH)_3$, $AlCl_3$, $Al_2(SO_4)_3$, or hydrates thereof.

[0077] The methods of the present disclosure can be effective for treating various aluminum-containing ores. For example, clays, argillite, mudstone, beryl, cryolite, garnet, spinel, bauxite, or mixtures thereof can be used as starting material.

[0078] The leaching can be carried out at a pH of about 0.5 to about 2.5., about 0.5 to about 1.5, or about 1; then iron can be precipitated at a pH of at least about 9.5, 10, 10.5, 11, 11.5; then aluminum can be precipitated at a pH of about 7 to about 11, about 7.5 to about 10.5, or about 8 to about 9.

[0079] The leaching can be carried out under pressure into an autoclave. For example, it can be carried out at a pressure of 5 KPa to about 850 KPa, 50 KPa to about 800 KPa, 100 KPa to about 750 KPa, 150 KPa to about 700 KPa, 200 KPa to about 600 KPa, or 250 KPa to about 500 KPa. The leaching can be carried out at a temperature of at least 80 °C, at least 90 °C, or about 100 °C to about 110 °C. In certain cases it can be done at higher temperatures so as to increase extraction yields in certain ores.

[0080] For example, the methods can further comprise precipitating the aluminum ions from the liquid phase by adjusting the pH at a value of about 7 to about 11 or about 8 to about 10.5. The methods can further comprise adding a precipitating agent effective for facilitating precipitation of the aluminum ions. For example, the precipitating agent can be a polymer. For example, the precipitating agent can be an acrylamide polymer.

[0081] For example, the seeding agent can be hematite.

Example 1

Preparation of hematite

[0082] Hematite (0.5 g) was added to a basic aqueous composition (300 mL) having a temperature of about 90 °C. The basic aqueous composition contained about 17 to about 20 wt% of iron precipitate under the form of $Fe(OH)_2$ and $Fe(OH)_3$. The basic aqueous composition was heated over a period of time of about 5 minutes to about 20 hours under agitation at atmospheric pressure. Hematite was added over a period of time of about 5 minutes to about 20 hours at atmospheric pressure. After about 1 hour, a change of color of the precipitate is observed (from brown to red brick). The red color was intensified until a red intense color having the same color than hematite was obtained.

[0083] The above-mentioned example was carried out as a proof of concept. Then further examples have been carried out so as to carry out the precipitation of hematite from a basic aqueous that was derived from an acid leaching solution. The acid leaching solution was obtained by leaching an aluminum-containing ore (for example argillite) with HCl.

Example 2

Preparation of hematite from an aluminum-containing ore sample

[0084] The aluminum-containing ore (for example argillite) can be activated mechanically by grinding. Mineral activation leads to a positive influence on the leaching reaction kinetics. For example, a ball mill can be used in air atmosphere for about 2 to 4 hours. Argillite can be also calcinated. This stage of pretreatment can be accomplished at a calcinating temperature between about 400 to about 700°C for a period about 1 to about 2 hours. These two operations, for example, increase the quantity of extracted aluminum by about 25 to 40%.

Acid leaching

[0085] Acid leaching can be made by mixing activated argillite with an acid solution (for example HCl) at elevated temperature and under pressure during a given period of time. For example, the argillite / acid ratio can be of about of 1:3 (weight / volume), the concentration of about 6M, the pressure can be of about 70 to about 80 psi, the temperature can be of about 150 to about 170°C, and the reaction time can be about 1 hour to about 7 hours. Under these conditions, over 90% of aluminum and 100% of the iron can be extracted besides the impurities.

[0086] At the end of extraction, the solid (not dissolved portion) can be separated from the liquid rich aluminum and iron by decantation or by filtration, after which is washed. This solid represent about 50 to about 60% of the initial mass of argillite. It can be valorized and be used as constituent alloy.

Removal of iron

[0087] The iron contained in the solution can be removed by selectively precipitating it at certain pH values. For example, iron removal can be carried out by precipitation in basic medium at a pH greater than about 11.2. This stage can be made by adding the solution containing aluminum and iron in a basic aqueous composition, for example NaOH at a concentration of 6M. Other bases such as KOH can also be used. Iron can thus be precipitated under the form of compounds such as $Fe(OH)_2$ and/or $Fe(OH)_3$.

[0088] During the second half of such a treatment, hematite can be added (can be called seeding hematite). Hematite seed addition can enhance hematite precipitation reaction (for example transformation of $Fe(OH)_2$ and/or $Fe(OH)_3$) into hematite). For example, 10 g of hematite can be added to 1L of basic aqueous composition optionally under agitation. The concentration of Fe in the solution was about 2.5 to about 3.0 g/L. The reaction temperature can be of about 80°C to about 140°C (for example, the basic aqueous composition can be at such a temperature), and the reaction time can be of about 3 hours to about 72 hours. Under such conditions, about 98% to about 100% of iron can be precipitated and about 70% to 100% of this iron can be precipitated as hematite. Optionally, it is possible to recover iron by using a refining step by liquid-liquid extraction through a hollow fiber membrane.

[0089] It is possible to separate the solid portion from the liquid portion by filtration, decantation or centrifugation and to rinse the solid by means of a diluted base, such as a solution of NaOH (for example NaOH at a concentration of 1M to 2M). At the end of this step, the solid can be washed with water.

Aluminum recovery

[0090] This step can also be carried in various ways. Aluminum ions can be precipitated under the form of aluminum hydroxide. For example, an hydrated form of $Al(OH)_3$ can be obtained by addition of a liquid acid, at a pH of about 7 to about 10.5 or about 7.5 to about 10 or about 9, the temperature can be of about 50°C to about 80°C, and the reaction time can be of about 3 hours to about 24 hours. This step can be made by adding a solution of HCl, for example at a concentration of 6M. Other acid can also be used. From the previous step, for example 90 to 100% aluminum hydroxide can be precipitated.

[0091] Alternatively, aluminum ions can be precipitated by addition of an acid gas. For example, an hydrated form of $Al(OH)_3$ sprayed by CO_2, at a pH of about 7 to about 10.5, the temperature can be of 50°C to 80°C, and the reaction time can be of about 3 hours to about 24 hours. From the previous step, for example 90 to 100% aluminum hydroxide can be precipitated.

[0092] Another way of precipitating aluminum ions can be carried out by addition of flocculating agent. Various flocculating agents can help to the formation of voluminous flakes which settles by sedimentation. For example, an acrylamide polymer can be used, at a concentration of about 0.1% to about 0.3%. The ratio flocculating agent / solution of hydroxide aluminum can be about 1:300 (volume / volume). The temperature can be below 30°C and the reaction time can be of about 5 minutes to about 20 minutes. Under such conditions, more about 97% of the aluminum can be precipitated.

Example 3

Preparation of hematite from an aluminum-containing ore sample

Argillite

[0093] The argillite was ground up in the wet phase in a ball grinder. The mixture of water and roughly crushed argillite coming from the mine was fed into the grinder, where the mineral is reduced to less than 100 microns. The mud went down by gravity into a mixer outfitted with two impellers, which ensures a good homogeneity. When the mixture reaches the desired density, the contents of the mixer are pumped to an accumulation bunker, which will serve to feed the mud to an autoclave.

Acid

[0094] The acid fed to the leaching came from two sources. The major portion was recycled spent acid. This recycled acid contained about 20 to about 22 wt. % of hydrochloric acid (HCl) and about 10 to about 11% of $AlCl_3$. For example, if excess acid is required, a small quantity of fresh 36 % acid can be used.

Leaching

[0095] The mud of argillite and acid were fed to the autoclave of 32 m^3 in stoichiometric proportion. The autoclave was then hermetically sealed, mixed well and heated by indirect contact with the steam-fed jacket. As the temperature was rising, the steam pressure increased such that the reaction reached a temperature of about 175 °C and a pressure of about 7.5 barg. At the end of the leaching cycle, the metals contained in the argillite were converted into chlorides. The mixture was then cooled by indirect contact with the cooling water in the reactor jacket. When the mixture was at about 70 to about 80 °C, the leached mud was transferred by air pressure to two buffer reservoirs maintained in communicating vessels for further treatment and disposal and the leachate was thus ready for further treatments.

Preparation of hematite

[0096] The mother liquor from leaching (leachate) was pumped at constant rate across cartridge filters to the first iron precipitation reactor. This reservoir was well mixed and the temperature was controlled to about 65 to 70 ° C by means of a heating coil. The pH was continuously metered and the solution was maintained at a pH of about 12 by addition of 50 wt % caustic soda with the help of a dispensing pump. The precipitation reaction converted the iron chloride and the other metal chlorides into hydroxides, which were leading to a gradual precipitation and agglomeration of the solid crystals. The leachate was then fed consecutively to two other precipitation reactors when the pH was also controlled by the addition of caustic soda and the temperature maintained by a heating coil. At the exit from the last reactor, the liquor was fed to a gravity decanter.

Decanting and seeding

[0097] The purpose of the gravity decanter was to produce a thickened mud of the largest crystals of hematite. These crystals served for the seeding in the first precipitation reactor. It was observed that such a technique was useful to promote the creation of precipitates (hematite) that are larger and more easy to filter. A quantity of about 1.5 to about 5.5 g of hematite per liter of the solution was used for seeding. The concentration of Fe in the solution was about 2.5 to about 3.0 g/L.

Filtration of hematite

[0098] The filtration of the hematite was carried out with the help of two automated filter presses. The mother liquor was then sent to a buffer reservoir to be pumped to the aluminum precipitation reactor.

Neutralization of hematite

[0099] The washed hematite was sent to a blade mixer where the pH of the solid is metered. A pH less than about 8 was maintained by the addition of hydrochloric acid (HCl) with the help of a dispensing pump..

Precipitation of aluminum

[00100] For the precipitation of the aluminum, the pH of the mother liquor was adjusted to about 9.5 by reacting it with HCl. Since the mother liquor has been purified of all other metals, the obtained precipitate was white and with purity of at least 98.5%.

[00101] The mother liquor was pumped at constant rate across guard filters to the first main reactor for precipitation of aluminum hydroxide. This reservoir was maintained in suspension by an impeller and the temperature was controlled at 65° C with the help of a heating coil. The pH was metered continuously and the solution was maintained at pH of about 9.5 by addition of HCl using a dispensing pump. The precipitation reaction was effective for converting the aluminum chloride into aluminum hydroxide, which resulted in a gradual precipitation and agglomeration of solid crystals. The liquor was then sent consecutively to two other precipitation reactors where the pH was also controlled by the adding of acid and the temperature maintained by a coil. At the exit from the last reactor, the liquor is fed to a gravity decanter.

Decanting and seeding

[00102] A gravity decanter was also used to produce a thickened $Al(OH)_3$ mud of the largest crystals. These crystals were pumped from the bottom of the decanter to the first precipitation reactor to seed the crystallization.

[00103] The rest of the $Al(OH)_3$ mud and the supernatant fluid of the decanter were sent to a repulping tank from which the mixture was pumped to a centrifuge type separator/washer. After the treatment with the separator, the $Al(OH)_3$ was then dried.

[00104] While a description was made with particular reference to the specific embodiments, it will be understood that numerous modifications thereto will appear to those skilled in the art. Accordingly, the above description and accompanying drawings should be taken as specific examples and not in a limiting sense.

WHAT IS CLAIMED IS:

1. A method for separating iron ions from aluminum ions contained in a basic aqueous composition, said method comprising :

obtaining said basic aqueous composition comprising said iron ions and said aluminum ions and having a pH of about 10.5 to about 13 and a temperature of about 50 °C to about 150 °C;

reacting said basic aqueous composition with hematite so as to promote, catalyze and/or enhance formation of hematite and to obtain a liquid phase comprising said aluminum ions and a solid phase comprising said so-formed hematite generated with said iron ions; and

separating said liquid phase from said solid phase.

2. The method of claim 1, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 7 to about 11.

3. The method of claim 1, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting the pH of said liquid phase at a value of about 8 to about 10.5.

4. The method of claim 1, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9 to about 10.

5. The method of claim 1, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9.2 to about 9.8.

6. The method of claim 1, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9.5.

7. The method of any one of claims 2 to 6, wherein said method further comprises adding a precipitating agent effective for facilitating precipitation of said aluminum ions.

8. The method of claim 7, wherein said precipitating agent is a polymer.

9. The method of claim 7, wherein said precipitating agent is an acrylamide polymer.

10. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises iron under the form of Fe^{3+}.

11. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises iron under the form of Fe^{2+}.

12. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises iron under the form of Fe^{3+}, Fe^{2+}, or a mixture thereof.

13. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises $Fe(OH)_2$.

14. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises $Fe(OH)_3$.

15. The method of any one of claims 1 to 9, wherein said basic aqueous composition, before being reacted with said hematite, comprises at least one precipitate that comprises $Fe(OH)_3$, $Fe(OH)_2$, or a mixture thereof.

16. The method of any one of claims 1 to 15, wherein said basic aqueous composition, before being reacted with said hematite, comprises iron ions under the form of Fe^{2+}.

17. The method of any one of claims 1 to 15, wherein said basic aqueous composition, before being reacted with said hematite, comprises iron ions under the form of Fe^{3+}.

18. The method of any one of claims 1 to 15, wherein said basic aqueous composition, before being reacted with said hematite, comprises iron ions under the form of Fe^{3+}, Fe^{2+}, or a mixture thereof.

19. The method of any one of claims 1 to 18, wherein said hematite is reacted with said basic aqueous composition under agitation.

20. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 50 °C to about 70 °C.

21. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 65 °C to about 75 °C.

22. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 70 °C to about 80 °C.

23. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 70 °C to about 100 °C.

24. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 75 °C to about 110 °C.

25. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 80 °C to about 100 °C.

26. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 85 °C to about 95 °C.

27. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 87 °C to about 93 °C.

28. The method of any one of claims 1 to 19, wherein said basic aqueous composition has a temperature of about 70 °C to about 120 °C.

29. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 10.8 to about 11.8.

30. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 11.0 to about 11.6.

31. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 11.2 to about 11.5.

32. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 10.5 to about 12.

33. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 11.5 to about 12.5.

34. The method of any one of claims 1 to 28, wherein said basic aqueous composition has a pH of about 11.8 to about 12.2.

35. The method of any one of claims 1 to 34, wherein about 0.5 to about 25 g hematite are reacted per liter of said basic aqueous composition.

36. The method of any one of claims 1 to 34, wherein about 1 to about 20 g hematite are reacted per liter of said basic aqueous composition.

37. The method of any one of claims 1 to 34, wherein about 1 to about 10 g hematite are reacted per liter of said basic aqueous composition.

38. The method of any one of claims 1 to 34, wherein about 1.5 to about 5.5 g hematite are reacted per liter of said basic aqueous composition.

39. The method of any one of claims 1 to 34, wherein about 2 to about 15 g hematite are used per liter of said basic aqueous composition.

40. The method of any one of claims 1 to 39, wherein said basic aqueous composition has a concentration of Fe of about 0.5 to about 10 g/L.

41. The method of any one of claims 1 to 39, wherein said basic aqueous composition has a concentration of Fe of about 1 to about 7 g/L.

42. The method of any one of claims 1 to 39, wherein said basic aqueous composition has a concentration of Fe of about 1.5 to about 5.5 g/L.

43. The method of any one of claims 1 to 34, wherein hematite is added at a molar ratio hematite / total amount of iron contained in the basic aqueous composition of about 0.005 to about 0.5.

44. The method of any one of claims 1 to 34, wherein hematite is added at a molar ratio hematite / total amount of iron contained in the basic aqueous composition of about 0.01 to about 0.1.

45. The method of any one of claims 1 to 44, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising said iron ions and said aluminum ions and a solid residue;

separating said leachate from said solid residue; and

reacting said leachate with a base.

46. The method of any one of claims 1 to 28, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising said iron ions and said aluminum ions and a solid residue;

optionally removing at least a portion of said iron ions from said leachate;

separating said leachate from said solid residue; and

reacting said leachate with a base.

47. The method of claim 45 or 46, wherein said iron-containing material is chosen from argillite, red mud, fly ashes and mixtures thereof.

48. The method of claim 45 or 46, wherein said iron-containing material is an aluminum-containing material.

49. The method of claim 45 or 46, wherein said iron-containing material is argillite.

50. The method of any one of claims 45 to 49, wherein said base is NaOH.

51. The method of any one of claims 45 to 49, wherein said base is KOH.

52. The method of any one of claims 45 to 51, wherein said base has a concentration of about 2 to about 20 M.

53. The method of any one of claims 45 to 51, wherein said base has a concentration of about 3 to about 4 M.

54. The method of any one of claims 45 to 51, wherein said base has a concentration of about 30 to about 60 weight %.

55. The method of any one of claims 45 to 51, wherein said base has a concentration of about 35 to about 55 weight %.

56. The method of any one of claims 45 to 55, wherein said leachate and a first portion of said base are added simultaneously into a reactor comprising a second portion of said base.

57. The method of any one of claims 1 to 56, wherein said basic aqueous composition is reacted with said hematite by at least substantially maintaining said basic aqueous composition at said pH.

58. The method of claim 57, wherein said basic aqueous composition is at least substantially maintained at said pH by reacting it with a further amount of said base.

59. The method of claim 57 or 58, wherein reacting said leachate with said base generates precipitation of at least a portion of said iron ions into $Fe(OH)_3$, $Fe(OH)_2$, or a mixture thereof.

60. The method of claim 59, wherein upon reacting hematite with said basic aqueous composition, at least a portion of said $Fe(OH)_3$, $Fe(OH)_2$, or said mixture thereof is converted into hematite.

61. The method of any one of claims 1 to 60, wherein said basic aqueous composition is reacted with said hematite by at least substantially maintaining said basic aqueous composition at said temperature.

62. A method for separating iron from aluminum contained in a basic aqueous composition, said method comprising :

reacting said basic aqueous composition comprising said iron and said aluminum with hematite under conditions suitable for at least partially converting said iron into hematite under the form of a precipitate, thereby obtaining a liquid phase and a solid phase; and

separating said liquid phase from said solid phase.

63. The method of claim 62, wherein said iron is present in said basic aqueous composition, before reacting it with said hematite, under the form of solubilized ions, a precipitate or a mixture thereof.

64. The method of claim 63, wherein said basic aqueous composition comprises, before reacting it with said hematite, solubilized Fe^{3+} ions.

65. The method of claim 63, wherein said basic aqueous composition comprises, before reacting it with said hematite, solubilized Fe^{2+} ions.

66. The method of claim 63, wherein said basic aqueous composition comprises, before reacting it with said hematite, solubilized Fe^{3+} ions, solubilized Fe^{2+} ions or a mixture thereof.

67. The method of any one of claims 62 to 66, wherein said basic aqueous composition comprises, before reacting it with said hematite, precipitated iron under the form of $Fe(OH)_3$.

68. The method of any one of claims 62 to 66, wherein said basic aqueous composition comprises, before reacting it with said hematite, precipitated iron under the form of $Fe(OH)_2$.

69. The method of any one of claims 62 to 66, wherein said basic aqueous composition comprises, before reacting it with said hematite, precipitated iron under the form of $Fe(OH)_3$, $Fe(OH)_2$ or a mixture thereof.

70. The method of any one of claims 62 to 69, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 7 to about 11.

71. The method of any one of claims 62 to 69, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting the pH of said liquid phase at a value of about 8 to about 10.5.

72. The method of any one of claims 62 to 69, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9 to about 10.

73. The method of any one of claims 62 to 69, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9.2 to about 9.8.

74. The method of any one of claims 62 to 69, wherein said method further comprises precipitating said aluminum ions from said liquid phase by adjusting pH of said liquid phase at a value of about 9.5.

75. The method of any one of claims 70 to 74, wherein said method further comprises adding a precipitating agent effective for facilitating precipitation of said aluminum ions.

76. The method of claim 75, wherein said precipitating agent is a polymer.

77. The method of claim 75, wherein said precipitating agent is an acrylamide polymer.

78. The method of any one of claims 62 to 77, wherein said hematite is reacted with said basic aqueous composition under agitation.

79. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 50 °C to about 150 °C.

80. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 50 °C to about 70 °C.

81. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 65 °C to about 75 °C.

82. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous

composition with hematite at a temperature of about 70 °C to about 80 °C.

83. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 70 °C to about 100 °C.

84. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 75 °C to about 110 °C.

85. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 80 °C to about 100 °C.

86. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 85 °C to about 95 °C.

87. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 87 °C to about 93 °C.

88. The method of any one of claim 62 to 78, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a temperature of about 70 °C to about 120 °C.

89. The method of any one of claim 79 to 88, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises at least substantially maintaining said temperature while reacting said basic aqueous composition with hematite.

90. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 10.5 to about 13.

91. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 10.8 to about 11.8.

92. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 11.0 to about 11.6.

93. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 11.2 to about 11.5.

94. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 10.5 to about 12.

95. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 11.5 to about 12.5.

96. The method of any one of claim 62 to 89, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting said basic aqueous composition with hematite at a pH of about 11.8 to about 12.2.

97. The method of any one of claim 90 to 96, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises at least substantially maintaining said pH while reacting said basic aqueous composition with hematite.

98. The method of any one of claim 62 to 97, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting about 0.25 to about 25 g of hematite per liter of said basic aqueous composition.

99. The method of any one of claim 62 to 97, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting about 1 about 20 g of hematite per liter of said basic aqueous composition.

100. The method of any one of claim 62 to 97, wherein said conditions suitable for at least partially converting said iron into hematite under

the form of a precipitate comprises reacting about 1 about 10 g of hematite per liter of said basic aqueous composition.

101. The method of any one of claim 62 to 97, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting about 1.5 about 5.5 g of hematite per liter of said basic aqueous composition.

102. The method of any one of claim 62 to 97, wherein said conditions suitable for at least partially converting said iron into hematite under the form of a precipitate comprises reacting about 2 about 15 g of hematite per liter of said basic aqueous composition.

103. The method of any one of claims 62 to 102, wherein said basic aqueous composition has a concentration of Fe of about 0.5 to about 10 g/L.

104. The method of any one of claims 62 to 102, wherein said basic aqueous composition has a concentration of Fe of about 1 to about 7 g/L.

105. The method of any one of claims 62 to 102, wherein said basic aqueous composition has a concentration of Fe of about 1.5 to about 5.5 g/L.

106. The method of any one of claims 62 to 97, wherein hematite is added at a molar ratio hematite / total amount of iron contained in the basic aqueous composition of about 0.005 to about 0.5.

107. The method of any one of claims 62 to 97, wherein hematite is added at a molar ratio hematite / total amount of iron contained in the basic aqueous composition of about 0.01 to about 0.1.

108. The method of any one of claims 62 to 107, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising iron ions and aluminum ions and a solid residue;

separating said leachate from said solid residue; and

reacting said leachate with a base.

109. The method of any one of claims 62 to 107, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising iron and aluminum with an acid so as to obtain a leachate comprising iron ions and aluminum ions and a solid residue;

optionally removing at least a portion of said iron ions from said leachate;

separating said leachate from said solid residue; and

reacting said leachate with a base.

110. The method of claim 108 or 109, wherein said iron-containing material is chosen from argillite, red mud, fly ashes and mixtures thereof.

111. The method of claim 108 or 109, wherein said iron-containing material is an aluminum-containing material.

112. The method of claim 108 or 109, wherein said iron-containing material is argillite.

113. The method of any one of claims 108 to 112, wherein said base is NaOH.

114. The method of any one of claims 108 to 112, wherein said base is KOH.

115. The method of any one of claims 108 to 114, wherein said base has a concentration of about 2 to about 20 M.

116. The method of any one of claims 108 to 114, wherein said base has a concentration of about 3 to about 4 M.

117. The method of any one of claims 108 to 114, wherein said base has a concentration of about 30 to about 60 weight %.

118. The method of any one of claims 108 to 114, wherein said base has a concentration of about 35 to about 55 weight %.

119. The method of any one of claims 108 to 118, wherein said leachate and a first portion of said base are added simultaneously into a reactor comprising a second portion of said base.

120. The method of any one of claims 108 to 119, wherein reacting said leachate with said base generates precipitation of at least a portion of said iron ions into $Fe(OH)_3$, $Fe(OH)_2$, or a mixture thereof.

121. The method of any one of claims 108 to 120, wherein upon reacting hematite with said basic aqueous composition, at least a portion of said $Fe(OH)_3$, $Fe(OH)_2$, or said mixture thereof is converted into hematite.

122. The method of claim 97, wherein said basic aqueous composition is at least substantially maintained at said pH by reacting it with a further amount of said base.

123. The method of any one of claims 2 to 7 and 70 to 75, wherein said precipitated aluminum ions are under the form of $Al(OH)_3$.

124. The method of claim 123, further comprising converting $Al(OH)_3$ into Al_2O_3.

125. The method of claim 123, further comprising converting $Al(OH)_3$ into $AlCl_3$.

126. The method of claim 123, further comprising converting $AlCl_3$ into Al_2O_3.

127. A method for preparing hematite, said method comprising obtaining said hematite from a basic aqueous composition comprising at least one precipitated iron ion, having a pH of about 10.5 to about 13 and being at temperature of about 50 °C to about 150 °C, by reacting said composition with a predetermined quantity of hematite, thereby promoting, catalyzing and/or enhancing formation of said hematite.

128. The method of claim 127, wherein said at least one precipitated iron ion is Fe^{3+}.

129. The method of claim 127, wherein said at least one precipitated iron ion is Fe^{2+}.

130. The method of claim 127, wherein said at least one precipitated iron ion is chosen from Fe^{3+}, Fe^{2+}, and a mixture thereof.

131. The method of claim 127, wherein said at least one precipitated iron ion is under the form of $Fe(OH)_3$.

132. The method of claim 127, wherein said at least one precipitated iron ion is under the form of $Fe(OH)_2$.

133. The method of claim 127, wherein said at least one precipitated iron ion is under the form of $Fe(OH)_2$, $Fe(OH)_3$), or a mixture thereof.

134. The method of any one of claims 127 to 133, wherein said predetermined quantity of hematite is added to said composition, over a predetermined period of time, under agitation.

135. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 50 °C to about 70 °C.

136. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 75 °C to about 110 °C.

137. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 80 °C to about 100 °C.

138. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 85 °C to about 95 °C.

139. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 87 °C to about 93 °C.

140. The method of any one of claims 127 to 134, wherein said basic aqueous composition has a temperature of about 70 °C to about 120 °C.

141. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 10.8 to about 11.8.

142. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 11.0 to about 11.6.

143. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 11.2 to about 11.5.

144. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 10.5 to about 12.

145. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 11.5 to about 12.5.

146. The method of any one of claims 127 to 140, wherein said basic aqueous composition has a pH of about 11.8 to about 12.2.

147. The method of any one of claims 127 to 146, wherein said basic aqueous composition is at least substantially maintained at said pH when being reacted with said hematite.

148. The method of any one of claims 127 to 147, wherein said basic aqueous composition is at least substantially maintained at said temperature when being reacted with said hematite.

149. The method of any one of claims 127 to 148, wherein said predetermined quantity of hematite is added at a molar ratio hematite / said at least one iron ion of about 0.005 to about 0.5.

150. The method of any one of claims 127 to 149, wherein said predetermined quantity of hematite is added at a molar ratio hematite / said at least one iron ion of about 0.01 to about 0.1.

151. The method of any one of claims 127 to 150, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising said at least one iron ion with an acid so as to obtain a leachate and a solid residue;

separating said leachate from said solid residue; and

reacting said leachate with a base.

152. The method of any one of claims 127 to 150, wherein said basic aqueous composition is obtained by :

leaching an iron-containing material comprising said at least one iron ion with an acid so as to obtain a leachate and a solid residue;

optionally removing at least a portion of said at least one iron ion from said leachate;

separating said leachate from said solid residue; and

reacting said leachate with a base.

153. The method of claim 151 or 152, wherein said iron-containing material is chosen from argillite, red mud, fly ashes and mixtures thereof.

154. The method of claim 151 or 52, wherein said iron-containing material is an aluminum-containing material.

155. The method of claim 151 or 152, wherein said iron-containing material is argillite.

156. The method of any one of claims 151 to 155, wherein said base is NaOH.

157. The method of any one of claims 151 to 155, wherein said base is KOH.

158. The method of any one of claims 151 to 157, wherein said base has a concentration of about 2 to about 20 M.

159. The method of any one of claims 151 to 157, wherein said base has a concentration of about 3 to about 4 M.

160. The method of any one of claims 151 to 157, wherein said base has a concentration of about 30 to about 60 weight %.

161. The method of any one of claims 151 to 157, wherein said base has a concentration of about 35 to about 55 weight %.

162. The method of any one of claims 151 to 157, wherein said leachate and a first portion of said base are added simultaneously into a reactor comprising a second portion of said base.

163. The method of any one of claims 151 to 162, wherein reacting said leachate with said base generates said at least one precipitated iron ion.

164. The method of claims 127 to 163, wherein upon reacting hematite with said basic aqueous composition, at least a portion of said at least one precipitated iron ion is converted into hematite.

165. The method of any one of claims 2 to 6 and 70 to 74, wherein said aluminum ions are precipitated from said liquid phase by reacting it with an acid.

166. The method of claim 165, wherein said acid is HCl.

167. The method of claim 165 or 166, wherein precipitating said aluminum ions is carried out at a temperature of about 40 °C to about 80 °C.

168. The method of claim 165 or 166, wherein precipitating said aluminum ions is carried out at a temperature of about 50 °C to about 70 °C.

169. The method of claim 165 or 166, wherein precipitating said aluminum ions is carried out at a temperature of about 60 °C to about 70 °C..

170. The method of any one of claims 167 to 169, wherein precipitating said aluminum ions is carried out at by at least substantially maintaining said temperature.

171. The method of any one of claims 1 to 170, wherein said hematite is recovered by means of a gravity decanter.

172. The method of any one of claims 1 to 171, wherein said hematite is α-Fe_2O_3.

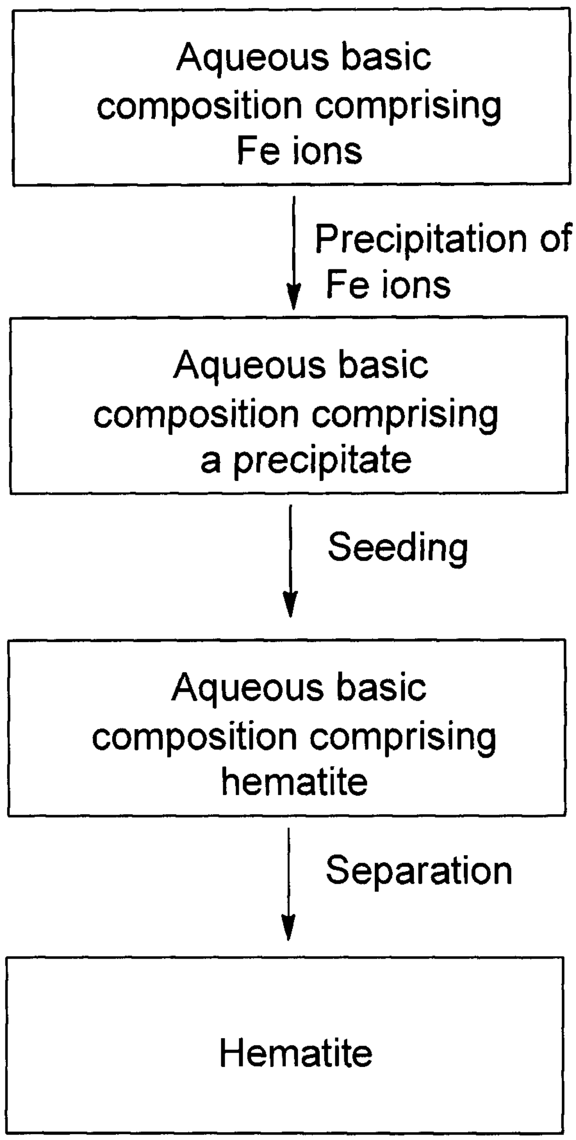
Aqueous basic composition comprising Fe ions
Precipitation of Fe ions
Aqueous basic composition comprising a precipitate
Seeding
Aqueous basic composition comprising hematite
Separation
Hematite

FIG. 1

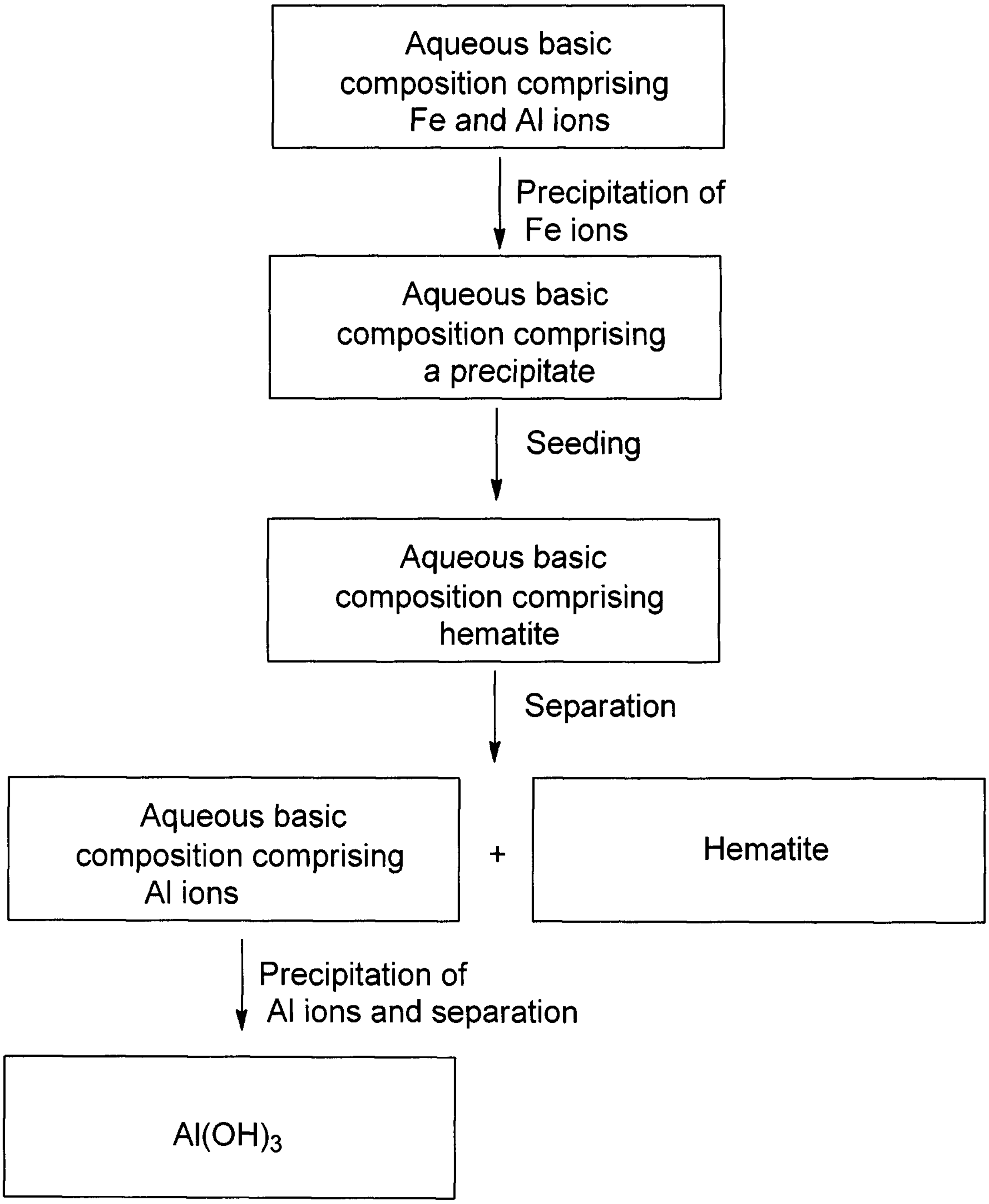
Aqueous basic composition comprising Fe and Al ions
Precipitation of Fe ions
Aqueous basic composition comprising a precipitate
Seeding
Aqueous basic composition comprising hematite
Separation
Aqueous basic composition comprising Al ions
+
Hematite
Precipitation of Al ions and separation
Al(OH)3

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/000541

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***C01G 49/00*** (2006.01) , ***C01G 49/06*** (2006.01) , ***C22B 3/06*** (2006.01) , ***C22B 3/24*** (2006.01) , ***C22B 3/46*** (2006.01)
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)
IPC: C01G*, C01B*

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases: CPD, EPODOC, TotalPatent, Scopus, Google.
Keywords: h?ematite OR ((ferric OR iron) w/2 oxide) OR fe2O3, seed OR nucle!, (high w/2 ph) or alkali! or hydroxide or basic or base

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, Y	CN 101792185 A (CENTRAL SOUTH UNIVERSITY) 4 August 2010 (04-08-2010) *abstract; claim 1; Examples; paragraph following heading "Background Art"*	1-172
X, Y	WO 2007/079532 A1 (RODRIGUEZ et al.) 19 July 2007 (19-07-2007) *abstract; page 1, lines 1-8; page 3, line 4-page 4, line 13; page 6, lines 5-7; Figure 1*	1-172
X Y	US 4,414,196 A (MATSUMOTO et al.) 8 November 1983 (08-11-1993) *abstract; Examples 1, 2, 8, 9, 11, 13, 15, 16, 20 and 21; Table 2; col. 5, lines 6-16; col. 5, lines 17-34*	127-150, 164, 171 and 172 1-172
X Y	JP 06-056429 A (TODA KOGYO CORP) 1 March 1994 (01-03-1994) *abstract; claim 1; [0014], [0019]-[0020], [0036]-[0037]*	127-150, 164, 171 and 172 1-172

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
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"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	Date of mailing of the international search report
04 September 2012 (04-09-2012)	21 September 2012 (21-09-2012)

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Authorized officer
Heather Hurley (819) 994-0472

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,676,838 A (FRANZ et al.) 30 June 1987 (30-06-1987) *abstract; claims 3-7; Examples 1, 4; col. 3, line 6-46; col. 4, lines 7-14*	127-150, 164, 171 and 172
A	CA 2 684 696 A1 (BOUDREAULT et al.) 27 November 2008 (27-11-2008) *whole document*	1-172
A	CA 2 711 013 A1 (BOUDREAULT et al.) 27 November 2008 (27-11-2008) *whole document*	1-172

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		US20110044869A1	24 February 2011 (24-02-2011)
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		US8241594B2	14 August 2012 (14-08-2012)
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		CA2711013C	13 December 2011 (13-12-2011)
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		US7837961B2	23 November 2010 (23-11-2010)
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		WO2008141423	27 November 2008 (27-11-2008)