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(54) **Title**: A PROCESS FOR THE RECOVERY OF A METAL CHLORIDE FROM AN AQUEOUS SOLUTION THEREOF

(57) **Abstract**: The invention provides a process for the recovery of a metal chloride from an aqueous solution thereof, comprising: a. providing an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes; b. bringing said aqueous solution into contact with a substantially immiscible extractant, said extractant comprising: i. an oil soluble amine which amine is substantially water insoluble both in free and in salt form; and ii. a solvent for the amine; at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal- carrying extractant and an acidic aqueous raffinate; c. separating said acidic metal-carrying extractant from said acidic aqueous solution; d. evaporating HCl from said acidic metal-carrying extractant to form an acid-depleted extractant and gaseous HCl; and e. separating said metal chloride from said acid-depleted extractant to form said metal chloride and regenerated extractant.

# A PROCESS FOR THE RECOVERY OF A METAL CHLORIDE FROM AN AQUEOUS SOLUTION THEREOF

The present invention relates to a process for the recovery of metal chloride from an aqueous solution thereof, as well as for a process for the recovery of metal chloride and HCl from a solution comprising both.

The present invention provides a process for the recovery of a metal chloride from an aqueous solution thereof, comprising:

a) providing an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes;

b) bringing said aqueous solution into contact with a substantially immiscible extractant, said extractant comprising:

(i) an oil soluble amine which amine is substantially water insoluble both in free and in salt form; and

(ii) a solvent for the amine;

at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate;

c) separating said acidic metal-carrying extractant from said acidic aqueous solution;

d) evaporating HCl from said acidic metal-carrying extractant to form an acid-depleted extractant and gaseous HCl; and

e) separating said metal chloride from said acid-depleted extractant to form said metal chloride and regenerated extractant.

Any aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes is suitable for the purpose of the present invention. According to an embodiment of the invention, said aqueous solution is formed in a hydrometallurgical process, for example, solutions formed in leaching of metals from minerals. According to another embodiment, said aqueous solution results from incineration of waste, e.g. incineration of municipal waste. According to various embodiments, the aqueous solution comprises in addition to metal cations, chloride anions and/or anionic complexes of the metal, anions of other acids, e.g. sulfuric and phosphoric acid. For example, in a process in which phosphoric acid is produced by reacting a phosphate rock with hydrochloric acid, an acidic solution is formed comprising phosphate anions, chloride anions and cations or complexes of various metals. According to various embodiments, the provided aqueous solution

comprises a plurality of metal cations at least one of which is capable of forming anionic chloride complexes. According to another embodiment, the provided aqueous solution comprises, in addition to at least one metal cation capable of forming anionic chloride complexes, at least one metal cation incapable of forming such complexes.

Any metal capable of forming an anionic chloride complex is suitable for the process of the present invention. According to a preferred embodiment, the metal is selected from a group consisting of iron, in both ferric and ferrous forms, copper, zinc, cadmium, nickel, other transition metals and uranium.

The terms "metal", "metal ions", "metal cations" and "anionic metal chloride complex" are used herein interchangeably.

The amines of the present invention are preferably primary, secondary and tertiary amines singly or in mixtures and characterized by having at least 10, preferably at least 14, carbon atoms and at least one hydrophobic group. Such commercially available amines as Primene JM-5, and Primene JM-T (which are primary aliphatic amines in which the nitrogen atom is bonded directly to a tertiary carbon atom) sold by Rohm and Haas Chemical Co.; Amberlite LA-1 and Amberlite LA-2, which are secondary amines sold by Rohm and Haas; Alamine 336, a tertiary tricaprylyl amine (TCA) and Alamine 304, a tertiary trilaurylamine (TLA), both sold by Cognis, Inc., and tris(2-ethyl hexyl) amine can be used in the processes of the present invention, as well as other well known and available amines including, e.g., those secondary and tertiary amines listed in U.S. Patent No:3,458,282.

The solvents can be chosen from a wide range of organic liquids known to persons skilled in the art which can serve as solvents for said amine (and oil-soluble acid, where present) and which provide for greater ease in handling and extracting control. Said solvents can be unsubstituted or substituted hydrocarbons in which the organic acid and amine are known to be soluble and which are substantially water-insoluble, e.g., kerosene, mineral spirits, naphtha, benzene, xylene, toluene, nitrobenzene, carbon tetrachloride, chloroform, trichloroethylene, etc. Also higher oxygenated compounds such as alcohols, ketones, esters, ethers, etc., that may confer better homogeneity and fluidity and others that are not acids or amines, but which may confer an operationally useful characteristic, can also be included. According to a preferred embodiment, the solvent is a hydrocarbon.

To avoid any misunderstanding, it is to be noted that the term "solvent," as used herein, relates to the second component of the extractant.

According to a preferred embodiment, the extractant further comprises an oil soluble organic acid. Any organic acid that is substantially water insoluble both in free and in salt form and is soluble in the solvent of the present invention is suitable. According to a preferred embodiment, the organic acid is selected from a group consisting of carboxylic or fatty acids, sulfuric acid or phosphoric acid substituted with alkyl group, aryl group or both and esters of those acids with fatty alcohols. Various examples of those are alpha-, beta- and gamma-chloro and bromo-substituted carboxylic acids; hexadecylsulfonic acid; didodecylnaphthalene disulfonic acid; alpha-bromo lauric acid; beta, beta-dichloro decanoic acid; beta, gamma dibromo octanoic acid; naphtalenesulfonic acid and carboxylic acids with between 4 and 20 carbon atoms, preferably between 6 and 12 carbon atoms. According to various embodiments, the carbon chain(s) on the organic acid are linear, branched or a combination of those.

According to a preferred embodiment, the molar ratio between the oil-soluble amine and the oil-soluble acid lies between 0.5 to 2 and 2 to 0.5, and preferably between about 0.5 to 1 and 1 to 0.5.

An extractant comprising said oil soluble amine, oil soluble organic acid and solvent according to the present invention is referred to as "acid-base couple extractant" or as "ABC extractant"

According to the process of the present invention, the provided aqueous solution is brought into contact with said extractant at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate.

Any form of bringing said solution in contact with said extractant is suitable for the present invention, e.g. using commercially available contactors of types such as mixer settlers, columns, centrifugal contactors, etc. Selection could be done by a person versed in the art, e.g. based on considerations such as the volumes involved, the viscosity of the aqueous solution and presence there of other components, e.g. ones with some tendency of slowing phase mixing and/or phase separation.

The term acidic conditions, as used herein, means conditions in which the amine of the present invention can protonate, at least partially. The amines of the present invention – $R^1R^2R^3N$– are primary amines ($R^1$ is an alkyl or aryl group and $R^2$ and $R^3$ are hydrogen atoms), secondary amines ($R^1$ and $R^2$ are alkyl groups, aryl

groups or a combination of those and $R^3$ is hydrogen atoms), or tertiary amines ($R^1$, $R^2$ and $R^3$are alkyl groups, aryl groups or a combination of those). In acidic conditions, those amines protonate, i.e. bind a proton via the non-bonding electrons of the nitrogen atom to form $R^1R^2R^3NH^+$, which is the cationic form of the amine. The acidity required for the protonation depends on the basicity of the amine, the weaker the basicity, the higher is the required acidity. The basicity of amines is typically presented as their pKa. For water soluble amines, at pH equal to their pKa, one half of the amine is protonated (90% protonated at pH equal pKa -1 and 10% protonated at pH equal pKa +1).

For water immiscible amines, such as the ones of the present invention, direct measurement of pKa is complicated and pH half neutralization is used instead. The term "pH half neutralization (pHhn)," as used herein refers to the pH of an aqueous solution, which is in equilibrium with an amine-containing extractant carrying HCl at an HCl-to-amine molar/molar ratio of 1:2. Basicity determination by pH half neutralization applies for any extractant comprising a water-immiscible amine, including ones comprising also the organic acid of the preferred embodiment, i.e. for the ABC extractants. Thus, on contacting an extractant comprising a water-immiscible amine with an aqueous solution having pH equal to their pHhn, one half of the amine is protonated (90% protonated at pH equal pHhn -1 and 10% protonated at pH equal pHhn +1). According to an embodiment of the invention, the extractant is characterized by a pHhn of less than 3.

Any form of reaching the acidic condition is suitable for the purpose of the present invention. Thus, according to one embodiment, the extractant of the present invention comprises an oil-soluble acid (the extractant is an ABC extractant) and that acid is strong enough to protonate the amine. Thus, in an ABC extractant made by mixing an amine $R^1R^2R^3N$ and an organic acid HA, if the acid is strong enough, such protonation forms $R^1R^2R^3NH^+ A^-$. According to another embodiment, the provided aqueous solution is acidic enough to protonate the amine, e.g. having pH lower than pHhn + 1.5. According to still another embodiment, the extractant to be contacted with the provided aqueous solution comprises an acid, e.g. HCl, possibly forming there $R^1R^2R^3NH^+ Cl^-$.

On such contacting the extractant with the provided solution at acidic conditions, an anionic chloride complex transfers to said extractant to form an acidic metal-carrying extractant. Many metal ions form anionic complexes with chloride

anions. A metal cation (M) with valancey of m ($M^{m+}$) complexes with m+n anions (X) to form the anionic complex $[MX_{m+n}]^{n-}$. In this example, the anion is mono-valent, but multivalent anions also form anionic complexes. In such complex, X presents both the case where all the anions in the complex are of the same type and the case where anions of different types participate in the same complex. As used here, anionic chloride complex means that part or all of the anions are chloride anions, e.g. as in $[FeCl_4]^{-1}$ or $[FeCl_pX_{4-p}]^{-1}$.

According to some solvent extraction literature, on extraction with extractant comprising water-immiscible amines, a protonated amine binds the anionic complex from the aqueous solution, forming in the organic phase $(R^1R^2R^3NH^+)_n[MX_{m+n}]$. For the case of an ABC extractant with an acid HA, one may suggest, without wishing to be limited by theory, that that acid doesn't participate in the interaction or that the anion of the acid forms part of the anions in the complex, e.g. in case both X and A are monovalent, the formation of $(R^1R^2R^3NH^+)_n[MX_qA_r]$. As used here, "an acidic metal-carrying extractant" means an extractant comprising metal ion in the form of an anionic complex.

In the process of the present invention, the anionic chloride complex of the metal transfers to said extractant selectively, i.e. preferentially over other solutes in the provided aqueous solution. Such solution may contain solutes that are too hydrophilic to transfer into the hydrophobic extractant. It may, however, contain HCl or another acid which tend to extract into the extractant. Yet, the inventors have found that the extractant has high preference to many anionic complexes over such acids. Cations in the provided aqueous solution that are not capable of forming an anionic complex are not extracted.

According to the present invention it has now been found that the extraction of such metal complexes is dependent on chloride concentration in the aqueous solution. According to an embodiment of the invention, the provided aqueous solution comprises two or more metal cations capable of forming anionic chloride complexes and contacting extracts one of those complexes preferably to the other(s). For example, the solution comprises two metal ions capable of forming chloride complexes ($M^1$ and $M^2$) and $M^2$ requires higher chloride concentration to form the anionic complex compared with $M^1$. According to an embodiment of the invention, the chloride concentration in the aqueous solution in a first step is low and $M^1$ is selectively extracted. In a second step, the chloride concentration is increases

and $M^2$ is extracted selectively over other solutes in the solution, e.g. HCl. Increasing the chloride concentration could be done by various methods, including the addition of HCl and of a chloride salt of a metal that is not capable of forming anionic complexes.

That contacting of the provided aqueous solution with the extractant forms an acidic metal-carrying extractant and an acidic aqueous raffinate. In case of extraction of a specific metal, the raffinate is the metal-depleted aqueous solution. The acidity of the raffinate depends on the basicity of the extractant. According to a preferred embodiment, the pH of said acidic raffinate is at most 5.

According to an embodiment of the present invention, said aqueous solution further comprises at least one of hydrochloric acid and a chloride of a metal incapable of forming anionic chloride complexes. According to a related embodiment, the extractant of the present invention extracts both an anionic complex of the metal and HCl. According to another related embodiment, the extractant selectively extracts the anionic complex of the metal to form the acidic, metal-depleted raffinate and the hydrochloric acid is then extracted from said raffinate, optionally with the regenerated extractant.

In preferred embodiments of the present invention said extractant further comprises

(iii) an oil soluble organic acid which acid is substantially water insoluble both in free and in salt form

Preferably said process further comprises the step of

f) absorbing the gaseous HCl produced in step d in at least one of water, an aqueous solution and an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes.

In preferred embodiments of the present invention said extractant is characterized by a pHhn of less than 3.

A previous invention of the present inventors provided a process for the recovery of gaseous HCl from a dilute solution thereof, comprising: (a) bringing a dilute aqueous HCl solution into contact with a substantially immiscible extractant, said extractant comprising: (i) an oil soluble amine, which amine is substantially water insoluble both in free and in salt form; (ii) an oil soluble weak organic acid having a pKa above 3, which acid is substantially water insoluble both in free

and in salt form; and (iii) a solvent for the amine and organic acid; whereupon HCl selectively transfers to said extractant to form an HCl-carrying extractant; and (b) treating said HCl-carrying extractant to obtain gaseous HCl

According to the present invention it has now been found that in contacting with a provided solution comprising both HCl and a chloride of a metal capable of forming anionic chloride complexes, the chloride metal anion is extracted selectively. Thus, according to an embodiment of the invention, such solution is contacted in a first step with the extractant to form an acidic metal-carrying extractant and a metal-depleted aqueous solution. The amount of extractant in said first step can be selected so that the substantially all the metal is extracted, but very little of the HCl. In a second step, HCl is extracted with another portion of the same extractant or with another extractant.

As indicated, in the process of the present invention, upon contacting the provided solution with the extractant, an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate. In a following step, the two phases are separated. The acidic metal-carrying extractant is further treated to effect evaporation of HCl from it.

It has thus been found that such evaporation takes place on various treatments, such as heating, maintaining under a sub-atmospheric pressure, exposure to a carrier gas and various combinations of those.

According to a preferred embodiment, evaporation of HCl comprises heating of the acidic metal-carrying extractant to a temperature of up to 250 °C, preferably a temperature of up to 200 °C. According to another embodiment, evaporating comprises introducing a stream of an inert gas for conveying the HCl from said extractant phase. Preferably, evaporating comprises a combination of heating and introducing a stream of an inert gas. According to an embodiment of the invention, said inert gas is selected from superheated steam and vapors of a hydrocarbon.

According to a preferred embodiment, the inert gas is the vapors of a hydrocarbon and said solvent for the amine of said extractant comprises said hydrocarbon. Such preferred embodiment is disclosed in a previous patent application of the same inventors, the teaching of which is incorporated here by reference. That patent application explains the evaporation of HCl with respect to two classes of possible stripping-carriers (1) inert gas, typically $N_2$; and (2) steam.

As is known, inert gases such as nitrogen and carbon dioxide are effective for stripping – they represent conventional technology and are effective for stripping HCl from HCL-carrying extractant. However, the demands in equipment and operational costs of absorbing the HCl out of a carrier such as $N_2$ (or $CO_2$) and recycling the inert carrier present a drawback of this mode of stripping. Furthermore, while water and, generally, aqueous systems are very effective in absorbing the HCl, the $N_2$ that is thus separated will necessarily carry in it water vapor. The water that is thus recycled decreases the effectiveness where dry HCl is desired.

The use of steam as an inert stripping gas does away with costly recycle since steam condenses to form a liquid water phase and an HCl gas phase. However the liquid phase retains some of the stripped HCl thereby decreasing overall process efficiency.

According to the present invention it has now been surprisingly found that the advantages of (1) and of (2) above can be retained with none of their disadvantages by using a hydrocarbon in vapor phase as an inert stripping gas. On cooling the hydrocarbon vapor, it condenses to form a liquid hydrocarbon phase that does not retain any HCl. The HCl is thus recovered fully as a nearly dry HCl phase.

Thus, in preferred embodiments of the present invention, said evaporating comprises introducing a stream of an inert gas for conveying the HCl from said extractant phase.

In some preferred embodiments of the present invention, said evaporating comprises a combination of heating and introducing a stream of an inert gas.

Preferably said inert gas is a superheated steam.

In other preferred embodiments of the present invention, said inert gas is hydrocarbon vapors.

In said other preferred embodiments, preferably said solvent for the amine of said extractant comprises said hydrocarbon.

Thus, according to a preferred embodiment, the present invention provides a process for the recovery of metal chloride from an aqueous solution thereof, comprising:

a) providing an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes;

b) bringing said aqueous solution into contact with a substantially immiscible extractant, said extractant comprising:

i. an oil soluble amine which amine is substantially water insoluble both in free and in salt form;

ii. an oil soluble organic acid which acid is substantially water insoluble both in free and in salt form and

iii. a solvent for the amine;

at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate;

c) separating said acidic metal-carrying extractant from said acidic aqueous solution;

d) introducing a stream of an inert stripping gas comprising a hydrocarbon in vapor phase into said HCl-carrying extractant for conveying HCl vapors from said extractant phase and for obtaining gaseous HCl, and an acid depleted extractant; and

e) separating said metal chloride from said acid-depleted extractant to form said metal chloride and regenerated extractant.

In preferred embodiments of the present invention, said hydrocarbon is selected from the group consisting of aliphatic and aromatic unsubstituted hydrocarbons.

In especially preferred embodiments the hydrocarbon is selected for having, at atmospheric pressure, a boiling point at which it is desired to effect the stripping.

In a further embodiment of the present invention, it is envisioned to generate the hydrocarbon in vapor phase by boiling off some of the solvent of the extractant, provided that said hydrocarbon is one that boils at 120 °C or higher at atmospheric pressure.

Evaporating HCl from said acidic metal-carrying extractant forms an acid-depleted extractant. In the following step of the process of the present invention, the metal chloride is recovered from said acid-depleted extractant. It has been surprisingly found that the extractant extracts the anionic metal complex very efficiently at the condition of the extraction, but liberates it easily after HCl evaporation. Separating may use various methods. According to one embodiment, the acid-depleted extractant is contacted with a small amount of water, whereby two liquid phases are formed, a regenerated extractant and an aqueous solution of the metal chloride. According to another embodiment, the metal chloride crystallizes out

of the extractant. According to still another embodiment, separation of the metal complex is facilitated by the addition of a hydrophobic organic solvent, e.g. the solvent comprised in the extractant.

While the invention will now be described in connection with certain preferred embodiments in the following examples so that aspects thereof may be more fully understood and appreciated, it is not intended to limit the invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined by the appended claims. Thus, the following examples which include preferred embodiments will serve to illustrate the practice of this invention, it being understood that the particulars shown are by way of example and for purposes of illustrative discussion of preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of formulation procedures as well as of the principles and conceptual aspects of the invention.

**Examples**

Acidic aqueous solutions of metal chlorides were prepared by mixing metal chloride with aqueous solution of HCl. Those aqueous solutions were brought in contact with an extractant composed of an amine and at least one organic acid at various molar ratios dissolved in dodecane. Metal anionic complex transferred into the organic phases, as indicated by the coloring of those phases. The organic phases were separated from the aqueous ones and treated for HCl evaporation at 165 °C and under steady nitrogen flow, whereby gaseous HCl evaporated. The organic phases were than cooled and contacted with water, whereby chlorides of the metal transferred into the aqueous solution. The experiments are summarized in the following table:

| # | Amine | 1st org. acid | 2nd org. acid | Amine/1st acid/ 2nd acid molar ratio | Selected metal | Metal ion conc. (Mol/Kg) | Total chloride conc. (Mol/Kg) |
|---|---|---|---|---|---|---|---|
| 1 | TEHA | Lauric | Capric | 1/0.25/0.25 | Co | 0.99 | 5.1 |
| 2 | MTCA | DNNSA | | 1/1 | Co | 0.99 | 5.1 |
| 3 | MTCA | LABS | | 1/1 | Co | 0.85 | 5.3 |
| 4 | TEHA | Lauric | Capric | 1/0.17/0.17 | Fe (2+) | 0.43 | 5.3 |
| 5 | MTCA | DNNSA | | 1/1 | Fe (2+) | 0.75 | 5.5 |
| 6 | TEHA | Lauric | Capric | 1/0.17/0.17 | Co(*) | 0.60 | 3.7 |

TEHA – tri-2-ethylhexyl amine; MTCA – methyl-tricaprylyl amine; DNNSA – dinonyl-naphthalene sulfonic acid; LABS – linear alkyl benzene sulfonic acid

(*) The aqueous solution contained also sodium chloride.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative examples and that the present invention may be embodied in other specific forms without departing from the essential attributes thereof, and it is therefore desired that the present embodiments and examples be considered in all respects as illustrative and not restrictive, reference being made to the appended claims, rather than to the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

**WHAT IS CLAIMED IS:**

1. A process for the recovery of a metal chloride from an aqueous solution thereof, comprising:
   a. providing an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes;
   b. bringing said aqueous solution into contact with a substantially immiscible extractant, said extractant comprising:
      i. an oil soluble amine which amine is substantially water insoluble both in free and in salt form; and
      ii. a solvent for the amine;
      at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate;
   c. separating said acidic metal-carrying extractant from said acidic aqueous solution;
   d. evaporating HCl from said acidic metal-carrying extractant to form an acid-depleted extractant and gaseous HCl; and
   e. separating said metal chloride from said acid-depleted extractant to form said metal chloride and regenerated extractant.
2. A process according to claim 1, wherein said extractant further comprises
   iii) an oil soluble organic acid which acid is substantially water insoluble both in free and in salt form
3. A process according to claim 1, wherein said aqueous solution further comprises at least one of hydrochloric acid and a chloride of a metal incapable of forming anionic chloride complexes.
4. A process according to claim 3, further comprising
   f) absorbing the gaseous HCl produced in step d in at least one of water, an aqueous solution and aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes.
5. A process according to claim 1, wherein said extractant is characterized by a pHhn of less than 3.
6. A process according to claim 1, wherein the pH of said acidic raffinate is 5 at most.

7. A process according to claim 1, wherein said provided aqueous solution is a product of waste incineration.
8. A process according to claim 1, wherein said metal is selected from a group consisting of iron, in both ferric and ferrous forms, copper, zinc, cadmium, nickel, other transition metals and uranium.
9. A process according to claim 1, wherein said evaporating is at a temperature of up to 250 °C.
10. A process according to claim 1, wherein said evaporating is at a temperature of up to 200 °C.
11. A process according to claim 1, wherein said evaporating comprises introducing a stream of an inert gas for conveying the HCl from said extractant phase.
12. A process according to claim 1, wherein said evaporating comprises a combination of heating and introducing a stream of an inert gas.
13. A process according to claims 11 and 12, wherein said inert gas is a superheated steam.
14. A process according to claims 11 and 12, wherein said inert gas is hydrocarbon vapors.
15. A process according to claim 14 wherein said solvent for the amine of said extractant comprises said hydrocarbon.
16. A process for the recovery of metal chloride from an aqueous solution thereof, comprising:
    a) providing an aqueous solution comprising a chloride of a metal capable of forming anionic chloride complexes;
    b) bringing said aqueous solution into contact with a substantially immiscible extractant, said extractant comprising:
        i. an oil soluble amine which amine is substantially water insoluble both in free and in salt form;
        ii. an oil soluble organic acid which acid is substantially water insoluble both in free and in salt form and
        iii. a solvent for the amine;

    at acidic conditions, whereupon an anionic chloride complex of said metal selectively transfers to said extractant to form an acidic metal-carrying extractant and an acidic aqueous raffinate;

c) separating said acidic metal-carrying extractant from said acidic aqueous solution;

d) introducing a stream of an inert stripping gas comprising a hydrocarbon in vapor phase into said HCl-carrying extractant for conveying HCl vapors from said extractant phase and for obtaining gaseous HCl, and an acid depleted extractant; and

e) separating said metal chloride from said acid-depleted extractant to form said metal chloride and regenerated extractant.