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(54) PROCESS FOR EXTRACTION OF METALS FROM ORES OR INDUSTRIAL MATERIALS

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(57) **ABSTRACT**

Process for extracting and recovering metals, including precious metals, such as platinum group metals and gold, from natural ores, ore concentrates or industrial materials, including contacting the natural ores, ore concentrates or industrial materials with a hydroxide-containing compound at an elevated temperature; dissolving the material in a solution, and recovering the metals from the solution.

PROCESS FOR EXTRACTION OF METALS FROM ORES OR INDUSTRIAL MATERIALS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This patent application is a continuation-in-part of International Application PCT/US2005/011572, filed on Apr. 4, 2005, which claims priority to U.S. provisional application Ser. No. 60/559,868, filed on Apr. 5, 2004. The foregoing patent applications are incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to the extraction and recovery of metals, including precious metals such as platinum group metals, and gold, from natural ores, ore concentrates or industrial materials, and more particularly to the extraction of metals which are not complexed with sulfur in the natural ores and ore concentrates.

[0004] 2. Brief Description of the Related Art

[0005] Currently, acid or cyanide leaches, either pressurized or at atmospheric pressure, or other means such as smelting, are generally utilized to extract metals such as platinum group metals, gold, nickel and/or copper from natural ores, ore concentrates or industrial materials.

[0006] One disadvantage of the cyanide chemical extraction leach is the toxicity and potential environmental impact of an accidental discharge which can result in devastating environmental damage. On numerous occasions, there have been accidental releases of cyanide leach solutions into surrounding watersheds.

[0007] One disadvantage of the acid leaches is that this process is so costly that it can only be used economically on very concentrated ore (i.e., where the percentage of precious metals has been increased) or industrial materials.

[0008] A further disadvantage with the acid leach process is that a significant amount of iron and other base metals may be leached from natural ores, ore concentrates or industrial materials. This resulting presence of iron and other base metals severely complicates the refining of the recovered platinum group metals and gold, and may have an adverse effect on the amount of refined platinum, palladium, rhodium, iridium, ruthenium, osmium or gold that can be ultimately recovered.

[0009] A need exists for an improved process for economically extracting platinum group metals and gold from natural ores, ore concentrates and industrial materials.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The invention provides a process for extracting metals, including platinum group metals and gold, from natural ores, ore concentrates or industrial materials. The most effective recovery of metals from natural ores and ore concentrates is achieved for natural ores and ore concentrates where the metals to be recovered are not bound in a sulfide complex. The process of the invention is carried out in order to convert metals, such as, for example, precious metals (e.g., platinum group metals and gold), as well as copper, silver and nickel, contained in the target material (natural ores, ore concentrates or industrial materials) from their original forms to hydroxide forms.

[0011] In one embodiment, the process according to the invention is accomplished by effecting contact between the target material and a hydroxide-containing chemical or material (that is any chemical or compound which includes the characters "O" and "H" written as the linked symbol "OH", also known as the OH radical, in its chemical formula or described as a hydroxide or containing a hydroxide) of a minimum of 1% hydroxide content by weight at elevated temperatures, for example, which may be temperatures generally higher than the standard average room temperature of about 68° F. The hydroxide-containing chemical or material is put in contact with the natural ores, ore concentrates or industrial materials. This contacting step can be effected by either gaseous, liquid or solid means, or a combination thereof, whereby a hydroxide-containing chemical or material, or mixtures of one or more of these compounds, may be heated separately or in conjunction with the natural ores, ore concentrates or industrial materials being processed. According to embodiments of the invention, the contacting of the hydroxide-containing chemical with the target material may occur at temperatures ranging from about 50° C. to about the melting point of the target material. Heating of the hydroxide-containing chemical and target material may be accomplished in a number of ways. One example is with an electric heating device, such as an electric furnace.

[0012] According to embodiments of the invention, heating is carried out to drive the reaction of the metals that are recoverable from the target material, so that the metal bonds are converted to their hydroxide forms. Suitable heating may involve bringing the target material and hydroxide to an elevated temperature, or alternately, or in addition thereto, may involve maintaining these materials at an elevated temperature for from about a few to several minutes. In one embodiment, the target material and hydroxide are heated to effectuate drying of the target material at a temperature greater than the room temperature, and the material is eventually heated to a higher temperature, such as, for example, to about 600° C.

[0013] After the target material and hydroxide chemical have been heated for a suitable duration, the material is then cooled. Cooling may be effected by removing the target material from the heat source and allowing it to cool in the ambient temperature, or the cooling may be facilitated through the use of cooling means, such as, for example, quenching, which may be carried out by immersing the treated target material in water, or another suitable cooling liquid.

[0014] After cooling, the treated target material, if not already in solution, is placed into a solution for the purpose of recovering the desired end products, i.e., metals, including precious metals such as platinum group metals and gold. For example, the target material may be placed in an acidic solution of hydrochloric or citric acid. To facilitate such a recovery, the solution should be maintained at a pH level of 3.3 or lower, and contact between the target material and the acidic solution should be maximized.

[0015] The metals are then recovered from the solution. This recovery step involves converting the metals to a solid form and removing them from the solution using one or more suitable known techniques for recovering metals from solution, such as, for example, one or more of the following: electrowinning, electrolytic precipitation, or precipitating with metal chelating chemicals.

[0016] There are many possible implementations of the invention, but excellent results have been achieved in one embodiment, where the step of contacting the target material with a hydroxide-containing chemical is effected by immersing the target material in a solution of commercially available liquid sodium hydroxide solution. The target material was in the form of an ore concentrate, in particular, the ore concentrate comprised an ore containing metal oxides. The target material is immersed for about 1 hour in a solution consisting of 51 percent water and 49 percent sodium hydroxide, by weight. The target material is agitated during its immersion. The target material is removed from the solution, allowing the excess solution to drain from the material for one hour. The treated material is heated with a suitable heating means, such as, for example, an electric furnace. The material is heated to a temperature of about 600° C., and is maintained at that temperature for less than ten minutes. (Alternately, heating with a suitable heating means may be accomplished by heating either the hydroxide-containing material or the target material, or both, prior to their contact with each other.) The existing bonds of the metals, which included platinum group metals and gold, will be partially or completely converted to hydroxide forms during the period that the target material is in the electric furnace.

[0017] After the application of heat, the material is cooled. According to this embodiment, once the material has been taken from the furnace and cooled, to facilitate yields of the desired end product, i.e., metals such as precious metals, including, for example, platinum group metals, and gold, the material is then introduced into a solution. One example of introducing the material to a solution is placing the material in a tank containing a solution of water and either hydrochloric or citric acid. The solution should be maintained at a pH of about 2.5 to 3.0 for about 24 hours with continuous agitation or circulation of the tank solution. This treatment results in the reaction of any remaining sodium hydroxide in the material with the selected acids to produce either water plus sodium chloride or water plus sodium citrate (depending on the acid used), allowing for separation of said material from the solution with a minimum of effort by mechanical means, such as, for example, filter presses or centrifuges, or other known techniques for separating solids from liquids.

[0018] The above process was performed using all forms of the target material: natural ore, ore concentrate and industrial material. In the instances, the natural ore and ore concentrate were essentially free of sulfide compounds. The industrial material included metals in the form of plated metals.

[0019] One advantage of the invention is that unlike acid leach chemistry, under this process virtually no iron is leached into solution from the material. However, because of the heat treatment with hydroxides, some of the metals in the material, including, but not limited to, for example, nickel, platinum, palladium and rhodium will be converted to water soluble hydroxides. These metal hydroxides in solution can be readily converted to solid form and removed from solution by using either electrowinning, electrolytic precipitation, precipitating with metal chelating chemicals or other known techniques.

[0020] The process according to the invention has been found to be simple, extremely economical and is highly effective in destroying the original bond between the material and the precious metals (platinum group metals and gold), thereby converting the metals into hydroxides in various types of natural ores, ore concentrates or industrial materials. This breaking of the original bond and the reforming of metals as hydroxides allows for easy removal of the valuable platinum group metals, gold and some other metals contained in the material. In addition, the invention has significant cost and environmental advantages in that there is neither any release of heavy metals in any form nor any use of toxic chemicals. Instead, inexpensive sodium hydroxide (also known as caustic soda or lye) can be used as the principal process chemical. The resulting process byproducts, depending on the specific implementation of the invention, for example, where sodium hydroxide is used, consist of essentially lye (sodium hydroxide), which can be reused, salt (sodium chloride), which can be easily and safely disposed of, or biodegradable sodium citrate.

[0021] While the invention has been described with reference to specific embodiments, the description is illustrative and is not to be construed as limiting the scope of the invention. For example, though immersion is discussed as a preferred mechanism for contacting the target material with the hydroxide-containing chemical, other means of effectuating contact may be utilized, including, for example, a continued or recycled spraying of the target material. In addition, the natural ores, ore concentrates, and industrial materials may, optionally, be supplied in, or converted to, a ground form prior to processing. In order to maximize yields of the metals from the target material, the process may be repeated. Various modifications and changes may occur to those skilled in the art without departing from the spirit and scope of the invention described herein and as defined by the appended claims.

I claim:

1. A process for extracting one or more metals from a target material, the method comprising the steps of:

a) contacting the target material with a liquid hydroxide solution;

b) heating the target material of step a) with heating means;

c) removing the target material from the heating means;

d) cooling the target material;

e) placing the target material in a solution;

f) recovering one or more metals from the solution.

2. The process of claim 1, wherein recovering one or more metals from solution is carried out by one or more of the following recovery techniques: chemical, electrowinning, and electrolytic precipitation.

3. The process of claim 1, wherein the one or more metals includes at least one precious metal.

4. The process of claim 2, wherein at least one of the metals includes a metal selected from the group consisting of platinum group metals, gold, silver, nickel and copper.

5. The process of claim 1, wherein the target material is one or more of natural ores, ore concentrates, and industrial materials.

6. The process of claim 4, wherein the target material is one or more of natural ores, ore concentrates, and industrial materials.

7. The process of claim 1, wherein the liquid hydroxide solution has a concentration of at least about 1% hydroxide content by weight.

8. The process of claim 1, wherein the liquid hydroxide solution is a sodium hydroxide solution.

9. The process of claim 1, wherein the step of cooling comprises quenching the target material with a solution.

10. The process of claim 1, wherein the heating means comprises a furnace, and wherein the step of heating the target material with heating means comprises placing the target material into the furnace.

11. The process of claim 1, wherein the step of heating comprises heating the target material of step a) at temperatures ranging from about between 50° C. and the melting point of the target material, for a duration of time sufficient to convert all or substantially all of the bonds of metals to be recovered to their hydroxide forms.

12. The process of claim 1, wherein the step of heating comprises heating the target material of step a) at a temperature of about 600° C. for ten minutes or less.

13. The process of claim 1, wherein during the step of contacting the target material with a liquid hydroxide solution, one or the other or both the target material and liquid solution is agitated.

14. A process for extracting one or more metals from a target material, the method comprising the steps of,:

a) contacting the target material with a hydroxide-containing chemical or material;

b) heating the target material of step a) with a heating means to convert metal bonds of the target material to their metal hydroxide forms;

c) cooling the target material of step b);

e) placing the target material in a solution;

f) recovering one or more metals from the solution.

15. The process of claim 14, wherein the step of recovering one or more metals from the solution is accomplished by using one or more of the following recovery techniques: chemical, electrowinning, and electrolytic precipitation.

16. The process of claim 14, wherein the hydroxide-containing chemical or material is supplied in a gaseous phase.

17. The process of claim 14, wherein the hydroxide-containing chemical or material is supplied in a liquid phase.

18. The process of claim 14, wherein the hydroxide-containing chemical or material is supplied in a solid phase.

19. The process of claim 14, wherein the hydroxide-containing chemical or material comprises any chemical or compound which includes the characters "O" and "H" written as the linked symbol "OH", also known as the OH radical, in its chemical formula or described as a hydroxide or containing a hydroxide.

20. The process of claim 14, wherein the hydroxide containing chemical or material is provided in a concentration of at least about 1% hydroxide content by weight.

21. The process of claim 14, wherein in step b) the target material is heated to a range of from or about 50° C. to about the melting point temperature of the target material.

22. The process of claim 14, wherein the one or more metals are selected from the group consisting of platinum group metals, gold, silver, nickel and copper.

23. The process of claim 14, wherein the target material is one or more of natural ores, ore concentrates, and industrial materials.

24. The process of claim 14, wherein the hydroxide-containing chemical or material contains sodium hydroxide.

25. The process of claim 14, wherein the solution in step e) is acidic.

26. A process for recovering one or more metals, including one or more precious metals which may include platinum group metals, gold, silver, nickel and copper, from a target material comprised of natural ores, ore concentrates or industrial materials, the process comprising the steps of:

a) effectuating contact of the target material with a hydroxide-containing material at a temperature of about or greater than 50° C. to convert existing metal bonds to metal hydroxides;

b) reducing the temperature of the target material after step a);

c) immersing the target material in a solution;

d) recovering from the solution in step c) one or more metals.

27. The process of claim 26, wherein the step of effectuating contact of the target material at a temperature of about or greater than 50° C. comprises introducing preheated hydroxide-containing material to the target material.

28. The process of claim 26, wherein the target material is subjected to a pre-treatment step of grinding the target material to a finely divided form.

29. The process of claim 1, including repeating one or more times the steps a) through f) of claim 1 in order to recover additional metals from the target material.

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