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(54) **Title:** METHOD FOR GOLD RECOVERY FROM SOLUTION

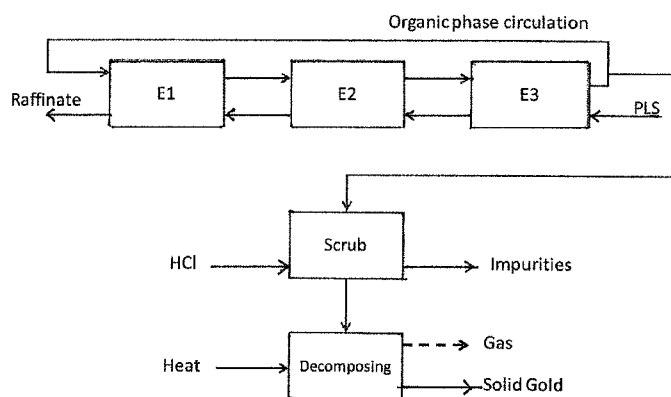


Fig. 1

(57) **Abstract:** A method is disclosed for recovering gold from a gold-containing organic solution containing soluble gold. The method comprises exposing the gold-containing organic solution to conditions that cause the organic solution to decompose, wherein gold contained in the organic solution is reduced to form solid metallic gold.

METHOD FOR GOLD RECOVERY FROM SOLUTION

TECHNICAL FIELD

The exemplary and non-limiting embodiments relate generally to recovering gold, and more particularly to a method for recovering gold from a gold-containing solution.

BACKGROUND ART

Soluble gold may be reduced on activated carbon from an acidic chloride solution. The activated carbon on which gold is adsorbed, may be burnt to obtain solid gold. However, gold thus obtained may include impurities.

A gold solvent extraction process may involve the use of a gold extraction reagent which is an efficient gold extractant having a high separation factor over metal impurities of a feed solution (i.e. pregnant leach solution, PLS). The process involves an organic phase comprised of the gold extraction reagent. The gold extraction reagent extracts gold from acidic chloride solutions. A gold-containing organic phase is obtained by the extraction. Gold extracted into the organic phase may be scrubbed to remove impurities and then stripped by an aqueous stripping solution in order to recover gold into an aqueous phase. From the aqueous phase, gold may be reduced into a solid form by using a reducing agent.

US 3 920 449 discloses a process for recovering a group VIII noble metal from an organic solvent solution containing a soluble complex of the noble metal and an organophosphorus compound.

WO 2011/154 603 A1 discloses a method for recovering gold by solvent extraction from an acidic chloride-containing aqueous solution or from slurry containing gold-bearing solids using a diester-based reagent.

DE 3 401 961 A1 discloses a process for hydrometallurgical extraction of noble metals using thiourea in an acidic medium.

SUMMARY

An object is thus to provide a method so as to alleviate the above disadvantages. The objects are achieved by a method which is characterized by what is stated in the independent claims. Preferred embodiments are disclosed in the dependent claims.

In an aspect, a method is provided for recovering gold from a gold-containing organic solution containing soluble gold, wherein the gold-

containing organic solution is exposed to conditions that cause the organic solution to decompose, wherein gold contained in the organic solution is reduced to form solid metallic gold.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In the following the solution will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 illustrates gold recovery according to an embodiment.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

10 The following embodiments are exemplary. Although the specification may refer to “an”, “one”, or “some” embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, words “comprising” and “including” should be understood
15 as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/structures that have not been specifically mentioned. All words and expressions should be interpreted broadly and they are intended to illustrate, not
20 to restrict, the embodiment.

A gold solvent extraction process may involve a gold extraction reagent containing two components, an organic diester (such as a diester of 2,2,4-trialkyl-1,3-pentanediol, e.g. 2,2,4-trimethyl-1,3-pentanediol di-isobutyrate or a derivative of it) and an organic long-chain alcohol (such as 2-ethylhexanol).
25 The gold extraction reagent may be used to extract gold from acidic chloride solutions where gold appears as a gold chloride complex $H^+AuCl_4^-$. A gold-containing organic phase is obtained by the extraction with the gold extraction reagent. The gold-containing organic phase is scrubbed with hydrochloric acid for removing impurities. The organic phase is stripped by using an aqueous stripping solution (e.g. water or an aqueous solution of NaCl). An aqueous stripping solution containing gold is obtained. The aqueous stripping solution containing gold is separated from the organic phase e.g. by phase settling. From the aqueous stripping solution gold is reduced into a solid form by using a reducing agent (e.g. sodium metabisulfite, SMBS). Solid gold is filtrated, and
35 the reducing agent is regenerated and recycled.

In an exemplary embodiment, gold is let to accumulate into the organic phase by recycling gold-containing organic solution back to a gold extraction stage where gold is extracted with the gold extraction agent. In that case the step of stripping gold off of the organic phase may be eliminated.

- 5 When the organic phase has reached a desired (e.g. maximum) concentration of soluble gold, the organic phase is decomposed by burning it. The gold concentration in the gold-containing organic solution (i.e. the organic phase) may be 0.1 g/l to 100 g/l, preferably 3 g/l to 10 g/l.

- 10 In an exemplary embodiment, the acidic chloride solution containing gold (e.g. pregnant leach solution (PLS)) or solution from anodic slime treatment is extracted with the organic gold extraction reagent, and the obtained organic phase, even with a maximum gold concentration (i.e. about 100 g/l for the anodic slime treatment), still remains as an upper phase and the aqueous phase is the lower phase in the extraction system.

- 15 In an exemplary embodiment, the organic phase containing gold may be scrubbed with HCl before the organic phase is decomposed (burnt). The decomposing of the organic phase containing gold produces solid gold, carbon dioxide, and chlorides obtainable from the $H^+AuCl_4^-$ complexes.

- 20 Figure 1 illustrates gold recovery according to an embodiment. A gold-bearing acidic chloride-based aqueous solution PLS (or slurry) exiting acid leaching, is routed to an extraction stage. Besides chloride the aqueous solution PLS may also contain small amounts of bromide and/or iodide. The extraction stage may take place in one or more steps E1, E2, E3, but it has been found that even with an extraction stage of only one step good results
25 may be achieved. The extraction stage involves extracting gold from PLS into an organic phase containing the gold extraction reagent. The extraction stage may involve circulation of the organic phase (e.g. by using counter current extraction).

- After the extraction stage, the organic phase containing gold may be
30 routed to an optional scrubbing stage, in which the organic phase is scrubbed with an acidic aqueous solution (e.g. hydrochloric acid) in order to remove metals other than gold and impurities out of the organic phase containing gold. Other metals may be, for instance, precious metals other than gold, as well as platinum, copper, iron, antimony, arsenic, selenium, tellurium and/or bismuth.
35 Some of these may be extracted into the organic phase in small amounts as impurities. The gold-depleted aqueous solution or raffinate may be fed, for ex-

ample, back to a gold leaching stage (not shown in Figure 1). An aqueous solution of hydrochloric acid may be used as the scrubbing liquid for the gold-containing organic solution, since it may be recycled after scrubbing to the gold leaching stages. The concentration of the hydrochloric acid in scrubbing is 1.5
5 – 8 mol/l, preferably 2 – 6 mol/l, so that the gold is not scrubbed out along with the impurities. The scrubbing may be performed in at least two steps. In the first scrubbing step the HCl concentration is preferably greater than 2.0 mol/l. In the second scrubbing step the hydrochloric acid concentration may be the same or different, for instance lower, than in the first step. The hydrochloric
10 acid concentration chosen depends on the quality and quantity of the impurity metals extracted into the organic extraction solution.

The organic phase containing gold is routed from the final scrubbing step (or, if no scrubbing is performed, directly from the extraction stage) to the decomposing stage.

15 In the decomposing stage, the organic phase (i.e. the gold-containing organic solution) is exposed to heat to inflame the organic extraction reagent, wherein the organic solution burns and gold is reduced as solid gold. Carbon dioxide, water and chlorides are formed. Gas (CO₂) and water are removed as they evaporate, and solids (including gold) may be separated
20 by filtering. Impurities (e.g. ash, metals other than gold) may be removed from gold by exposing the filtered solids to a suitable solvent (e.g. mineral acid) that dissolves the impurities (but not gold). Gold may then be separated from the solvent (containing the dissolved impurities) by filtering. Alternatively, solvent is added to water (containing solid gold) to dissolve the impurities, after which
25 gold is recovered by filtering.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A method for recovering gold from a gold-containing organic solution containing soluble gold, wherein the method comprises

5 exposing the gold-containing organic solution to conditions that cause the organic solution to decompose, wherein gold contained in the organic solution is reduced to form solid metallic gold; and

contacting a pregnant leach solution containing gold with a gold extraction reagent, in order to obtain the gold-containing organic solution.

2. A method according to claim 1, wherein the method comprises
10 exposing the gold-containing organic solution to heat causing the organic solution to inflame.

3. A method according to claim 1 or 2, wherein the method comprises burning the gold-containing organic solution, wherein gold contained in the organic solution is reduced to form solid metallic gold.

4. A method according to claim 1, 2 or 3, wherein the organic solution contains an organic extraction reagent containing a diester of 2,2,4-trialkyl-1,3-pentanediol, such as a diester of 2,2,4-trimethyl-1,3-pentanediol diisobutyrate or a derivative of it.
15

5. A method according to claim 4, wherein the organic extraction reagent contains a branched long-chain alcohol, such as 2-ethylhexanol.
20

6. A method as claimed in any one of the preceding claims, wherein the pregnant leach solution is an acidic chloride solution where gold appears as a gold chloride complex $H^+AuCl_4^-$.

7. A method as claimed in any one of the preceding claims 1 to 5, wherein the method comprises contacting anodic slime containing gold with a gold extraction reagent, in order to obtain the gold-containing organic solution.
25

8. A method as claimed in any one of the preceding claims, wherein the method comprises scrubbing the gold-containing organic solution before reducing gold from the gold-containing organic solution.

9. A method as claimed in any one of the preceding claims, wherein the method comprises contacting the solid metallic gold with a solvent to remove impurities by dissolving.
30

10. A method as claimed in claim 9, wherein the method comprises filtrating the solid metallic gold to remove impurities after the dissolving.

11. A method as claimed in any one of the preceding claims, wherein the gold-containing organic solution contains gold in a concentration of 0.1 g/l to 100 g/l, preferably 3 g/l to 10 g/l.

12. A method as claimed in any one of the preceding claims, wherein the contacting of the pregnant leach solution containing gold with the gold extraction reagent is performed as a counter current extraction.

13. A method as claimed in claim 7, wherein the contacting of the anode slime containing gold with the gold extraction reagent is performed as a counter current extraction.

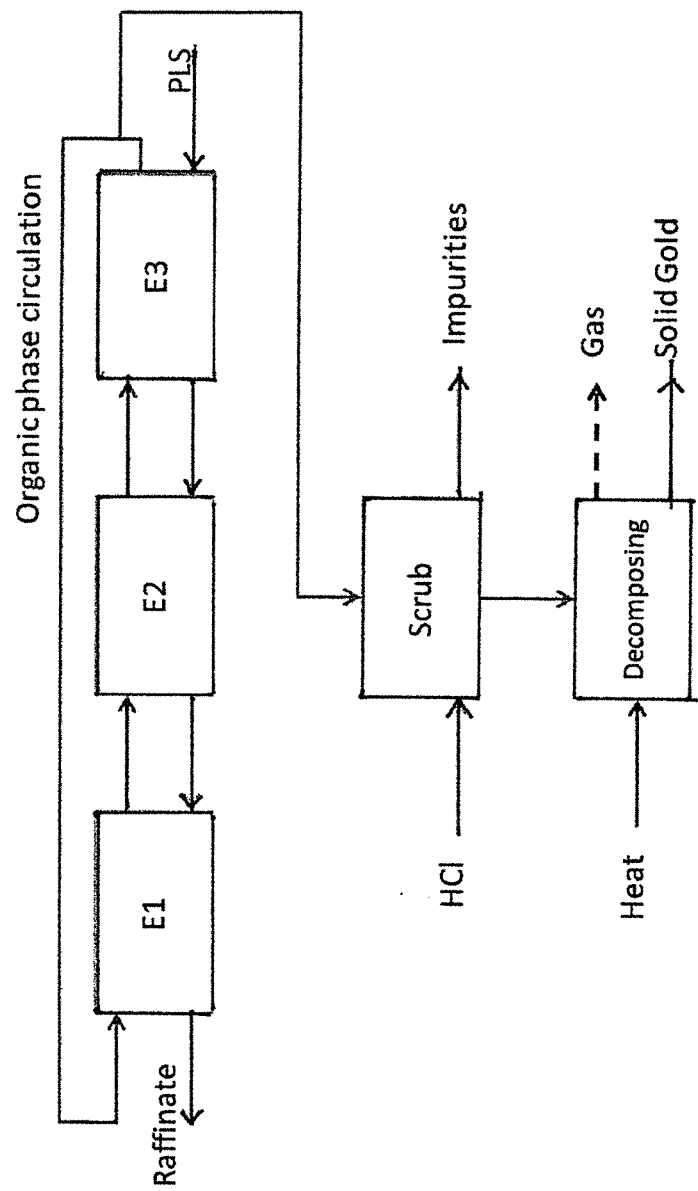


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. C22B3/26 C22B3/00
ADD.

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)
C22B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 4 936 910 A (DADGAR AHMAD [US] ET AL) 26 June 1990 (1990-06-26) the whole document	1-13
X	----- TASDELEN C ET AL: "Gold recovery from dilute gold solutions using DEAE-cellulose", HYDROMETALLURGY, ELSEVIER SCIENTIFIC PUBLISHING CY. AMSTERDAM, NL, vol. 96, no. 3, 1 April 2009 (2009-04-01), pages 253-257, XP025940048, ISSN: 0304-386X, DOI: 10.1016/J.HYDROMET.2008.10.006 [retrieved on 2008-11-03] the whole document ----- -/-	1-13



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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