

PROCESS FOR THE RECOVERY OF GOLD

The present invention is concerned with the recovery of gold and more particularly to a process for recovering gold from a gold-containing solution by using an electrically conducting polymer.

Gold-containing solutions may result from the extraction of gold from natural sources such as quartz or as a consequence of the activities of the electroplating and electronics industries and jewellery manufacturers. Typically gold exists in such solutions in the form of complex anions, for example, $\text{Au}(\text{CN})_2^-$, AuCl_4^- and $\text{Au}(\text{SO}_3)_2^-$.

Recovery of gold from such solutions has typically been carried out by carbon adsorption, conventional ion exchange techniques and electro-extraction. All of the above methods can be employed to recover gold from solution at concentrations as low as 1 part per million (ppm).

Such conventional methods suffer from a number of drawbacks. For example, current adsorption and ion exchange processes typically have only a low capacity and are generally time consuming. Therefore, there exists a need to develop processes which exhibit improved uptake capacity and reduced processing time. Furthermore, processes which simplify the regeneration

procedure and enhance separation selectivity would also be advantageous.

5 The present invention seeks to provide a process for the recovery of gold from a gold-containing solution which overcomes the above disadvantages and which further uses materials which are chemically and physically stable under ambient conditions.

10 Accordingly, the present invention provides a process for the recovery of gold from solution, the process comprising the steps of

(a) adsorbing the gold from the solution onto an electrically conducting polymer;

(b) separating the gold-adsorbed polymer from the solution; and

15 (c) desorbing the gold from the polymer.

20 The resultant gold-containing solution is significantly concentrated and thereafter, if desired, other conventional techniques, for example, electro-extraction may be employed to recover gold therefrom. Thus the process according to the present invention can be used as a pre-concentration step to enhance the efficiency of subsequent recovery techniques which may then be employed.

25 Preferred polymers are homopolymers of pyrrole and aniline and derivatives thereof. More preferably the polymer is polypyrrole. Polypyrrole has the

advantage of being readily synthesised and relatively stable. Furthermore, polypyrrole is easily regenerated and can therefore be utilised in subsequent process cycles.

5 Methods for synthesising conductive polymers in general can be found in Handbook of Conducting Polymers, Vol. 1, Marcel Dekker, New York, 1986 and Conducting Polymers/Molecular Recognition, Springer-Verlag, Berlin, 1989. Methods for the synthesis of
10 polypyrrole and polyaniline specifically can be found in, for example, Synthetic Metals, 20 (1987) 365-371 and Polymer, (1988) Vol 30, December 2305-2311 respectively. The preferred method of synthesising polypyrrole is by oxidative polymerisation of pyrrole
15 by FeCl_3 .

The process according to the present invention can be carried out in a variety of ways, for example, using polypyrrole in pulp form or on a column.

Polypyrrole in particulate form can be used in
20 the process of the present invention and can be synthesised as per the method set out in Polymer, 1989, Vol. 30, December 2305 to 2311. The pulp method involves adding a gold- containing solution to the particulate conducting polymer under constant
25 stirring. The gold is adsorbed onto the polymer from solution. The gold-bound polymer can then be separated

from the effluent by, for example, filtration or centrifugation and the effluent treated further. The filter size and centrifugation speed employed is necessarily determined by the size and mass of the polymer particles. Desorption of gold from the conducting polymer can be achieved by elution with an appropriate solution, for example, one having a different pH, ionic strength or containing an ion for which the polymer material demonstrates a much greater affinity. The preferred method of desorption is to use a salt solution and the preferred salts are hydroxides and cyanides of alkali metals.

Adsorption and desorption of gold from the polymer is typically carried out at room temperature. Adsorption is usually carried out at pH values of less than pH 7 and desorption at pH values in excess of pH 7. Polymers can be used in matrix form or coated onto a substrate, for example, a textile. Methods of preparing polypyrrole in such forms are well known in the art, for example, see Handbook of Conducting Polymers, page 507 and Synthetic Metals, 28 (1989) see 823 - see 835. The concentration of salt solution used in the desorption step is typically 0.1 to 3 mole per litre and the pH typically greater than pH 9.

The ratio of conducting polymer to gold-containing solution is from 0.01% to 1% w/v depending

upon the initial concentration of gold in solution, cell design and desired absorption rate.

The ratio of gold-bound polymer to desorption solution is from 0.3% to 10% w/v.

5 Typically the process of the present invention can effectively provide a 1000 fold increase in gold concentration following desorption and can be used to recover gold from solutions where the initial gold concentration is 1 to 50 ppm. Furthermore,
10 optimisation of process conditions can ensure that the concentration of gold remaining in solution following adsorption is negligible thereby avoiding the need for repeated treatment of the same sample.

 The process according to the present invention
15 will now be described by way of example only with reference to the accompanying Figures in which:

 Figure 1 shows schematically adsorption/desorption from polypyrrole using the pulp method;

20 Figure 2 shows schematically the process carried out by a column method;

 Figure 3 shows the adsorption kinetics of gold onto polypyrrole; and

 Figure 4 shows desorption kinetics of gold from
25 polypyrrole.

 Referring first to Figure 1, a solution of

Au(SO₃)₂⁻ (aq) at a concentration of 10 ppm was first cleaned by filtration to remove any particulate material present. The pH of the gold solution was then adjusted to a pH of less than pH 7 and was added to polypyrrole in particulate form under constant stirring at room temperature (25°C approximately) for 10 minutes. The ratio of polymer to gold-containing solution was 0.2 g per 200 ml solution. The gold-bound polymer was then separated from the solution by filtration at 2 μm and the effluent discharged. Gold can then be recovered from the polypyrrole by adding 1M KCN (pH11) at a temperature of 25°C under constant stirring. The ratio of gold-polypyrrole to KCN (aq) was 0.2 g per 50 ml KCN. Thus the concentration of gold in solution following desorption is at least four times that of the original sample.

Referring now to Figure 2, a method similar to that described above can be carried out in a column packed with polypyrrole in particulate form. Au(SO₃)₂⁻ (aq) 10ppm was cleaned and the pH adjusted as before. The resultant solution was then passed through the polypyrrole column at a velocity of 0.1 to 1 cm/second. The effluent received from the column was discharged. The gold was then eluted from the column as above and the gold-enriched eluent was collected. The column was then washed with water to remove

residual eluent and regenerated by acid such as 0.1 to 3 M HCl.

Figures 3 and 4 show adsorption and desorption kinetics respectively of gold from different gold-containing solutions on polypyrrole. 1 denotes $\text{Au}(\text{SO}_3)_2^-$, 2 denotes $\text{Au}(\text{CN})_2^-$ and 3 denotes AuCl_4^- in both figures. The ratio of polypyrrole to gold-containing solution is 0.2 g per 200 ml and the initial concentration of gold is 10 ppm. Kinetics was studied at 25°C. Figure 3 shows that 100% of gold in the form of $\text{Au}(\text{SO}_3)_2^-$ and $\text{Au}(\text{CN})_2^-$ was adsorbed by polypyrrole very rapidly i.e. within 10 minutes whereas AuCl_4^- was fully adsorbed after 60 minutes.

In contrast, desorption of AuCl_4^- from polypyrrole was most rapid. Desorption was achieved by 1M KCN (aq) pH 11 at a ratio of polypyrrole to KCN of 0.2 g per 50 ml.

CLAIMS:

1. Process for recovering gold from a gold-containing solution comprising

(a) adsorbing the gold from the solution onto an electrically conducting polymer;

(b) separating the gold-adsorbed polymer from the solution; and

(c) desorbing the gold from that polymer.

2. Process according to claim 1, wherein the conducting polymer is polypyrrole or polyaniline or derivatives thereof.

3. Process according to claim 1 or claim 2, wherein the gold in the solution is in the form of $\text{Au}(\text{CN})_2$, AuCl_4 or $\text{Au}(\text{SO}_3)_2$.

4. Process according to any preceding claim, wherein the pH of the gold-containing solution is controlled.

5. Process according to any preceding claim, wherein separation is achieved by filtration or centrifugation.



6. Process according to any preceding claim, wherein desorption from the polymer is achieved by elution with hydroxides and cyanides of alkali metals.

5 7. Process for recovering gold from a gold-containing solution substantially as hereinbefore described with reference to Figures 1 and 2.



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