SOLVENT EXTRACTION OF METALS WITH A CYCLICAL KYLENE CARBONATE

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ABSTRACT

Cyclic organic carbonates have been found, along with mixtures of some with other organic liquids that are miscible therewith, to extract the following metals in stable complex or simple salt form from a medium in which the solvent is not completely soluble. Extractable metals include gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium.

29 Claims, No Drawings
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SOLVENT EXTRACTION OF METALS WITH A CYCLIC ALKYENE CARBONATE

BACKGROUND OF THE INVENTION

Numerous techniques have heretofore been devised for the reclamation of metals from naturally occurring ores containing same. For the most part, disadvantages exist with each of these processes from the standpoint of economics of the process, purity of the metal obtained, toxicity of the materials utilized in the process, difficulty of recovery of the pure metal, and the like. A conventional process for mining gold for example is to treat the ore with sodium cyanide to dissolve the gold; add zinc powder to the leach water to form a gold-silver amalgamation if silver is present; treat the amalgam with nitric acid to dissolve the silver; recover the gold from the solution, and refine the gold. Likewise, aqua regia has been used to dissolve the gold, followed by treatment with ferrous sulfate to precipitate a spongy gold. The spongy gold is then recovered and refined in what is referred to as a problematical procedure. With other metals also, techniques are as troublesome and expensive. Moreover, the presence of certain tramp metals tremendously decrease the efficiency of the processes.

The present invention provides a solvent group that extracts metals in a greatly improved manner than those heretofore known, along with a process for using same. The problems of the prior art are avoided, thus improving mining and refining techniques for commercial mining operations.

While the prior art is replete with various and sundry techniques for improving mining and refining processes for metals, there is no known prior patented art directed to the present invention. Cyclic organic carbonates have heretofore been used for several purposes. For example, the extraction of iron three and as a tris(pentan-2,4-dione)-iron (III) from aqueous solution for the spectrophotometric determination was reported in Analyt. March 1971, Volume 96, page 230–234; extraction of the 1,10-phenanthroline, 4,7-diphenyl-1, 10-phenanthroline and 2,4,6-tripyrilid-sym-triazine complexes of iron (II) into propylene carbonate was reported in Analytical Chemistry, December 1967, page 1478–1480 and a technical bulletin on propylene and ethylene carbonate in particular was published by Jefferson Chemical Company, Houston, Texas in 1960. None of these publications teach or suggest the use of the cyclic organic carbonates as solvents for metals as discussed hereinafter.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel solvent for extraction of metals from media containing same.

A further object of the present invention is to provide a novel solvent for the extraction of gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium, from media containing same.

Still another object of the present invention is to provide a novel process for the recovery of valuable metals from naturally occurring ores containing same.

Generally speaking, the present invention is directed to the use of cyclic organic carbonates as solvents for the solvent extraction of metals selected from the class consisting of gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium.

More specifically, the cyclic organic carbonates for use in solvent extraction of metals according to the present invention are preferably propylene carbonate (4-methyl dioxolone-2) and ethylene carbonate (dioxolone). Ethylene carbonate must be used in conjunction with another organic liquid in which it is miscible since ethylene carbonate is completely soluble in water. Likewise, all of the cyclic organic carbonates may be used as mixtures with other organic liquids miscible therewith or otherwise slightly soluble in the metal-containing medium, generally water. Propylene carbonate is approximately 20 per cent soluble in water. Hence, it also may be preferably employed in conjunction with a solvent carrier to, among other things, reduce its solubility in water. In fact, the solvent mixture may be preferred due to economics and ease of concentration of the extract for recovery of the pure metals therefrom.

The process of the present invention for the solvent extraction of metal comprises the steps of contacting a medium containing the metal in extractable form with a cyclic organic carbonate, removing the extract, and separating the metal from the extract.

More specifically, the process of the present invention involves the dissolving of the desired metal from ores or other media containing same, if necessary. In certain circumstances, the metal will then be in extractable form as a stable complex or simple salt in an aqueous solution or may be further treated to be in suitable extractable form. The cyclic organic carbonate solvent can then be brought into contact with metal containing medium and agitated. The metal complex or salt will be extracted by the solvent, generally in a large percentage of that present. Thereafter, the metal-containing extract is separated from the medium, generally an aqueous layer and the metal recovered from the extract.

Dissolution of the metal may be accomplished by known techniques. For example, aqua regia may be used to dissolve gold from gold bearing ores, whereby the gold appears as AuCl₄⁻ or perhaps HAuCl₄ in the leach water. The chloride may then be directly extracted by one of the carbonates of the present invention. Likewise, chlorine gas can be brought into contact with the gold to form the chloride for extraction. The other metals listed herein may be handled similarly to arrive at a suitable extractable form of the metal in the solution or some other media, such as a concentrate.

The cyclic organic carbonate may be used alone or in admixture with some other organic liquid that is miscible with the carbonate, but immiscible or no more than slightly soluble in the metal carrying medium. Generally any proportion from at least about 5 per cent carbonate is successful in extracting the metal. Depending upon the particular carbonate-diluent mixture, the specific gravity of the mixture may be greater or less than 1.0, whereby certain solvent compositions sink and others float, both carrying the extracted metal. Further, when utilizing a solvent carrier or diluent for the cyclic organic carbonate, it may be quite desirable to remove the diluent prior to recovery of the metal from the extract. Benzene, for example, serves as an excellent diluent due to the difference in boiling point from the carbonate and due to the lowness of the boiling point of benzene (80.1°C.). Hence a solution of 95
per cent benzene and 5 per cent propylene carbonate may be employed to extract the metal. Thereafter, the benzene may be flashed off, leaving the metal in the propylene carbonate. A highly concentrated form of extract is thus provided for reduction of the metal salt or complex to the metal form by electrowinning, or the like or precipitation of the metal salt followed by conversion of the precipitated salt to the pure metal.

A large number of metals are discussed herein as suitable for solvent extraction by a cyclic organic carbonate solvent. In general, the mere presence of these metals may be determined colorimetrically by visual observation of the extract with the metal contained therein. Gold and platinum, for example, impart a yellow color to the extract, rhodium a light red and iridium a deep red. Thus the carbonates of the present invention may also be utilized in the prospecting sense to enable one to almost immediately ascertain the presence of a particular metal being sought by a quick, but reliable analysis of an ore sample.

Insofar as the large group of metals is concerned, optimum conditions for each varies. The majority of optimization has been directed toward the recovery of gold. As such, much of the discussion herein is directed to gold recovery techniques. By routine investigation, however, optimum techniques for the metals not discussed in detail may be ascertained. Hence the best complex or salt of the metal; the pH range for extraction; the desirability of the carbonate only or a solvent mixture as the extract; and if a mixture, the best diluent and percentage thereof; and the like may be determined for each metal by routine experimentation based on the teachings set forth herein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Metals selected from the class consisting of gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium, have been found to be extractable in stable complex and/or simple salt form from a medium containing same by a cyclic organic carbonate solvent. Extraction as taught herein may be conducted in a mining process to claim the pure metal from the naturally occurring ores containing same; in a refining process where a concentrate of the metal containing medium is furnished; and in a metal reclamation process where scrap metal and/or materials are treated to reclaim valuable, reusable constituents thereof.

Preferred cyclic organic carbonates are propylene carbonate (4-methyl dioxolene-2) and ethylene carbonate (dioxolone). Further, it has been determined that organic liquids miscible with the carbonate may be used as diluents or carrier solvents if they are immiscible or no more than slightly soluble in the metal containing medium. In fact, ethylene carbonate is completely miscible in water, and for use according to the teachings of the present invention must be employed in conjunction with one of the solvent carriers. In the mixed form, the ethylene carbonate loses its miscibility with water and satisfactorily extracts the metal complex or salt without appreciable solvent loss. Immiscibility of the solvent carrier does not necessarily infer complete insolubility in water, but also refers to liquids that are no more than slightly soluble in the medium. Exemplary of suitable solvent carriers without limitation thereto are benzene, o-xylene, m-xylene, p-xylene, diethyl ether, 4-methyl-2-pentanone, 2,4-pentandione, ethyl acetate, n-heptyl alcohol, chloroform, and the like. Further, it has been found that suitable extraction is obtained in volume mixtures containing from at least about 5 per cent of the cyclic organic carbonate with the balance being solvent carrier.

A further important feature of extractability with the cyclic organic carbonates is the particular means of removing the extract containing the metal from the original medium, where the medium is water. Propylene carbonate, which is the preferred cyclic organic carbonate has a specific gravity of 1.283 at 20/20°C. The metal containing extract will therefore pass through the water and become a bottom layer of a two layer solution. Propylene carbonate is, however, about 20 per cent soluble in water. As such, approximately 20 per cent of the solvent is lost, though it may be recovered by the later addition of benzene or one of the aforementioned solvent carriers. The procedure may be reversed, however, by mixture of one of the diluents with the propylene carbonate. Benzene, for example, mixed with the propylene carbonate also extracts the metal.

The specific gravity of the propylene carbonate-benzene mixture may be less than 1.0, depending upon the ratio of the constituents, whereby the extract containing the metal forms the top phase of the two phase system. Hence, depending upon the needs of the particular process, the metal to be extracted may be carried to the bottom or the top of the water medium for removal. Thereafter, the metal-pregnant extract may be separated from the water or other liquid medium by conventional separation techniques, dependent upon the position of the extract phase.

The particular metal or metals to be recovered should be in a stable form to be removed by the solvent. For example, gold, platinum, palladium, iridium, rhodium, and uranium may be suitably removed as halides, thiocyanates and the like over a wide pH range. On the other hand, copper, cobalt, vanadium, bismuth, cadmium, mercury and cerium, will not extract as halides unless the pH of the medium is very acid, generally zero or less. For instance, at a pH of 0, cobalt as a chloride will extract in quantity, with the extractability decreasing rapidly at increased pH levels. At a pH of 1.0 for example, virtually no cobalt comes across, while gold, is rapidly extracted at a pH of 1.0 with slight agitation.

Conversion of the metal to the complex or salt may be accomplished as desired. For example, treatment of gold bearing ore with aqua regia will dissolve the gold as AuCl₃ and HAuCl₄, thus providing the gold in a form that may be directly extracted after dissolution. Likewise, platinum may be converted to the chloride by treatment of platinum containing mud with aqua regia from direct extraction. Sea water, on the other hand, contains gold in solution as a chloride and requires no further treatment prior to the solvent extraction with the possible exception of pH adjustment. It may be preferred, however, to concentrate sea water, even to a dry residue prior to the extraction. The solvent may then be slurried with a pass through the residue to extract the gold therefrom. Further recovery may be made from scrap items. Scrap may be dissolved in aqua regia for gold, platinum, and the like, followed by direct extraction. In certain situations, several precious metals may be extracted simultaneously from the scrap. In these cases, numerous conventional techniques may be employed for separating the extracted metals. If, for
example, gold and platinum are simultaneously extracted from dissolved scrap, the gold may be precipitated from the extract with hydroquinone and the platinum remaining may be electrowon from the extract, or the like.

Insofar as the particular complex or salt is concerned, obviously other systems may be employed such as the remaining halides and the like.

The particular medium containing the metal in extractable form, as set forth above may be liquid or solid. Economics of the operation may determine the proper form to be used. For example, sea water is currently being commercially evaporated by solar energy for the recovery of sodium chloride. Treatment of the residue after evaporation will recover the gold contained therein without any extraction or dissolution of the sodium chloride. In mining operations, on the other hand, leach water after dissolution of the desired metal may be brought into contact with the carbonate solvent according to the present invention, agitated slightly and the metal quickly extracted therefrom with only slight, if any, loss of solvent.

Depending upon the metal being extracted as well as the particular form thereof, and the presence of other metals in the medium, it may or may not be desirable to adjust the pH of the medium. As mentioned above, gold as a chloride may be extracted over a wide pH range, while cobalt, copper, and the like will not be extracted as chlorides unless the pH of the medium is approximately zero or less. Hence pH adjustment of the medium may enable selective extraction of one metal from a group of metals that are present in the medium. At a pH of 1.0, for example, gold is very successfully extracted in approximately the 98 plus per centile while only trace quantities of iron, copper or the like are extracted. At a pH of 3.0, virtually no iron, copper or the like are extracted and the gold is extracted in approximately the 98 per centile by multiple solvent passes or extractions.

Once the metal has been solvent extracted and is present in the extract, it may be recovered by reducing the complex or salt to the pure metal form. Likewise, insoluble salts may be precipitated followed by further purifications. Electro-winning is a convenient method for reduction of the metal, directly from the extract. In this regard, while electrowinning in certain circumstances is a slow and not particularly efficient process, certain measures may be taken to vastly improve both time and efficiency. Electrowinning, in fact, is an extremely good recovery technique when the metal to be recovered is present in propylene carbonate. Propylene carbonate has a dielectric constant of 69.0 esu at 23°C. and thus is quite suitable for the electrowinning of metal therefrom. Further as mentioned herein the extract may be easily concentrated prior to recovery of the metal which also fosters the efficiency of the electrowinning process. Any other technique may also be employed which will precipitate or otherwise remove the metal from the extract. Electrowinning may, however, be more feasible since the solvent is virtually unaffected thereby. Electrowinning of gold, for instance, destroys a like amount of propylene carbonate as there is gold won therefrom. In fact the operating efficiency for the carbonates of the present invention is in the neighborhood of 98 per cent for a carbonate-carrier mixture and 80 per cent for propylene carbonate per se, though as mentioned earlier the dissolved propylene carbonate may be recovered. The carbonate solvent may thus be recycled for further extraction. Originally if a diluent is utilized and flashed from the metal-pregnant extract, the volatilized diluent may be condensed and reclaimed for further use. There is thus little solvent that is completely lost during recovery of metals according to the present invention.

While propylene carbonate is approximately 20 per cent soluble in water, the addition of one of the diluents thereto reduces the solubility of the propylene carbonate. Also a saturated salt solution may be added to the metal-containing medium which will tend to “salt out” the propylene carbonate which again reduces the solubility of the propylene carbonate.

A mining process for gold will better illustrate the process of the present invention. Certainly the particular process for mining of other of the metals may differ substantially from the gold process. The gold process is only exemplary, however, of the various processes.

Gold bearing ore is crushed or otherwise treated preparatory to dissolution of the gold. The ore is then subjected to aqua regia, a mixture of hydrochloric and nitric acids. The gold then dissolves and exists in the leach solution as AuCl₄⁻ or AuH₂Cl₄. Leach solution is then adjusted to a pH of 0 to 3 by the addition of sodium hydroxide. Approximately 1 part of a propylene carbonate-benzene mixture ranging from about 5 to about 40 percent propylene carbonate is poured into the leach solution for each 100 parts of leach solution. The solvent and leach solution are then stirred slightly. Stirring is then stopped and the propylene carbonate-benzene allowed to rise to the top of the vat. The extract is then removed from the top of the vat, the benzene is flashed from the extract and the gold-pregnant carbonate is transferred to a further vessel for electrowinning the metal in the form. The gold is then electrodiposited onto a suitable electrode. Both the benzene and the propylene carbonates may then be recycled into the system for further extraction. Likewise, depending upon the amount of solvent added to the leach solution and the ratio of propylene carbonate to benzene, more than one extraction may be desirable to recover the gold present in the leach solution.

A still better understanding of the present invention may be had by reference to the following specific examples.

EXAMPLE 1

A 100-millilter aliquota of an aqueous solution containing 130 to 230 mg of gold as gold (III) chloride was transferred to a separatory funnel. Five milliliters of saturated sodium chloride solution were added, the pH was adjusted to approximately 1.0 with sodium hydroxide and enough propylene carbonate added to give a 5-ml extract. The funnel was shaken for about 15 seconds and the phases allowed to separate. The propylene carbonate layer (lower) exhibited a yellow color indicating the presence of gold and was then drained into a beaker. The extraction step was repeated and the combined extracts dissolved in an excess of water. Analysis by an iodine-thiosulfate method showed that at least 98 per cent of the gold was extracted. Gold was also extracted with at least the same efficiency from additional solutions whose pH ranged from about -0.6 to about 3.0.
EXAMPLES 2–10
The procedure of Example 1 was repeated to ascertain the extractability of other metals as chlorides. These metals, the color of the extract and the pH range of the extractions are set forth in Table I below.

<table>
<thead>
<tr>
<th>Example No.</th>
<th>Metal</th>
<th>Extract Color</th>
<th>pH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Platinum</td>
<td>Yellow</td>
<td>−0.6 to 2.5</td>
</tr>
<tr>
<td>3</td>
<td>Iridium</td>
<td>Red</td>
<td>−0.6 to 2.5</td>
</tr>
<tr>
<td>4</td>
<td>Rhodium</td>
<td>Lt. Red</td>
<td>−0.6 to 0</td>
</tr>
<tr>
<td>5</td>
<td>Palladium</td>
<td>Yellow</td>
<td>−0.6 to 2.5</td>
</tr>
<tr>
<td>6</td>
<td>Uranium</td>
<td>Yellow</td>
<td>−0.6 to 2.5</td>
</tr>
<tr>
<td>7</td>
<td>Gold</td>
<td>Yellow</td>
<td>−0.6 to 3.0</td>
</tr>
<tr>
<td>8</td>
<td>Cobalt</td>
<td>Blue</td>
<td>−0.6 to 0</td>
</tr>
<tr>
<td>9</td>
<td>Mercury</td>
<td>Colorless</td>
<td>−0.6 to 0</td>
</tr>
<tr>
<td>10</td>
<td>Vanadium</td>
<td>Yellow</td>
<td>−0.6 to 0</td>
</tr>
</tbody>
</table>

Examples 2–10 thus illustrate how platinum could be extracted selectively from a solution containing platinum and cobalt by adjusting the pH of the solution above 0.

EXAMPLE 11
A 100-milliliter aliquot of an aqueous solution containing 20 mg each of cobalt, nickel, copper, zinc, iron, and mercury as chlorides and 130 to 230 milligrams of gold as its chloride was transferred to a separatory funnel. Extractions and analyses were performed as in Example 1. At least 98 percent of the gold was extracted into the propylene carbonate layer, thus indicating that the other metals in solution with the gold did not interfere with the extraction.

EXAMPLES 12–22
One-hundred-milliliter solutions were made up containing 150 milligrams of one of the metals listed in Table II. Extraction for each of the metals was conducted as set forth in Example 1 followed by conventional analytical techniques for the particular metal, to determine its presence in the extract. pH of the solutions in each case was adjusted to 1.0.

<table>
<thead>
<tr>
<th>Ex. No.</th>
<th>Metal</th>
<th>Detected In</th>
<th>pH 1.0</th>
<th>Decolorized</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Manganese</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Iron</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Cobalt</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Nickel</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Gold</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Copper</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Zinc</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Mercury</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Aluminum</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Alkali Metals</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Alkaline Earth Metals</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

EXAMPLE 23
A 10-milliliter aliquot of aqueous solution containing 25 mg of gold as gold (III) chloride was transferred to a separatory funnel. Two milliliters of saturated sodium chloride solution were added to the solution and the pH of the solution was adjusted to 1.0. 5 milliliters of a mixture containing 5 volume percent propylene carbonate and 95 volume percent benzene was added to the solution and the funnel was shaken for about 15 seconds. Gold extracted into the propylene carbonate-benzene upper phase. The extract was separated from the aqueous phase and the benzene volatilized. The gold remained in the unvolatilized propylene carbonate.

EXAMPLES 24–37
Example 23 was repeated with the exception that the ratio of propylene carbonate to benzene or the diluent was changed, as indicated in Table III. In each case the gold extracted into the solvent mixture as determined by visual observation of the color of the extract.

TABLE III

<table>
<thead>
<tr>
<th>Extractant</th>
<th>% Propylene Carbonate—Diluent Solvent</th>
<th>Diluent</th>
<th>Extract Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>benzene</td>
<td>10</td>
<td>Yellow</td>
</tr>
<tr>
<td>25</td>
<td>to</td>
<td>20</td>
<td>do</td>
</tr>
<tr>
<td>26</td>
<td>do</td>
<td>30</td>
<td>do</td>
</tr>
<tr>
<td>27</td>
<td>to</td>
<td>40</td>
<td>do</td>
</tr>
<tr>
<td>28</td>
<td>toluene</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>29</td>
<td>o-xylene</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>30</td>
<td>m-xylene</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>31</td>
<td>p-xylene</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>32</td>
<td>diethyl ether</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>33</td>
<td>2,4-dimethyl-2-pentanone</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>34</td>
<td>2,4-pentandione</td>
<td>50</td>
<td>do</td>
</tr>
<tr>
<td>35</td>
<td>ethyl acetate</td>
<td>do</td>
<td>do</td>
</tr>
<tr>
<td>36</td>
<td>n-heptyl alcohol</td>
<td>do</td>
<td>do</td>
</tr>
<tr>
<td>37</td>
<td>chloroform</td>
<td>do</td>
<td>do</td>
</tr>
</tbody>
</table>

EXAMPLES 38–46
One-hundred-milliliter aliquots of aqueous solutions containing 100 mg of one of copper (II), copper (I), vanadium (V), gold (III), platinum (IV), uranium (VI), bismuth (III), cobalt (II), and cadmium (II) respectively as simple salts were transferred to separatory funnels. One gram of potassium thiocyanate was added to each and the pH of the solution adjusted to values of 0, 2, 3, 4, 6 and 8. Enough propylene carbonate was added to each solution to give a 5-mL extraction. Extraction was performed as in Example 1 above. It was determined by colorimetry and conventional analytical methods that all the metal thiocyanate except bismuth were extracted almost completely from aqueous solution whose pH's were 0 to 3. Approximately 50 percent of the bismuth was extracted in this pH range. Cobalt was the only metal completely extracted at high pH values (greater than 6.0).

EXAMPLE 47
Example 1 was repeated with the exception that a solvent mixture of 40 per cent ethylene carbonate-60 per cent benzene was employed in lieu of the propylene carbonate solvent. The extract showed the presence of gold, though extraction efficiency was less than with the propylene carbonate.

Having described the present invention in detail, it is obvious that one skilled in the art will be able to make variations and modifications thereto without departing from the scope of the invention. Accordingly, the scope of the present invention should be determined only by the claims appended hereto.
What is claimed is:

1. A process for the solvent extraction of metal values selected from the group consisting of salts and complexes of gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium, comprising the steps of providing an aqueous medium containing at least one of the said metal values, said medium having an acid pH, and contacting said medium with a composition comprising a cyclic alkylene carbonate, said carbonate composition being at least partially insoluble in said medium.

2. A process as defined in claim 1 wherein the salt is a halide.

3. A process as defined in claim 2 wherein the halide is a chloride.

4. A process as defined in claim 1 wherein the cyclic alkylene carbonate is propylene carbonate.

5. A process as defined in claim 1 wherein the cyclic alkylene carbonate is ethylene carbonate.

6. A process as defined in claim 1 wherein the cyclic alkylene carbonate composition includes an organic liquid that is miscible with the carbonate and is from only slightly soluble to insoluble in the medium.

7. A process as defined in claim 6 wherein the organic liquid is selected from the group consisting of benzene, o-xylene, m-xylene, p-xylene, diethyl ether, 4-methyl-2-pentanone, 2,4-pentandione, ethyl acetate, n-heptyl alcohol, and chloroform.

8. A process as defined in claim 7 wherein the cyclic alkylene carbonate is propylene carbonate.

9. A process as defined in claim 7 wherein the cyclic alkylene carbonate is ethylene carbonate.

10. A process for the solvent extraction of a metal selected from the group consisting of gold, platinum, palladium, rhodium, iridium and uranium comprising the steps of:
   a. providing a halide of the metal to be extracted in a suitable aqueous medium therefor;
   b. adjusting the pH of the medium to a range of about 0.6 to about 3.0;
   c. contacting the medium with a composition comprising an organic alkylene carbonate, said composition being at least partially insoluble in said medium; whereby a phase separation occurs, the metal being located in the carbonate phase;
   d. separating the carbonate phase from the remainder of the medium; and
   e. recovering the metal from the carbonate phase.

11. The process as defined in claim 10 wherein the metal is recovered from the carbonate phase by an electrowinning process.

12. A process as defined in claim 10 wherein the carbonate is propylene carbonate.

13. A process as defined in claim 10 wherein the carbonate is ethylene carbonate.

14. A process as defined in claim 10 wherein the carbonate composition includes an organic liquid that is miscible with the carbonate and from only slightly soluble to insoluble in the medium.

15. A process as defined in claim 14 wherein the organic liquid is selected from the group consisting of benzene, o-xylene, m-xylene, p-xylene, diethyl ether, 4-methyl-2-pentanone, 2,4-pentandione, ethyl acetate, n-heptyl alcohol, and chloroform.

16. A process as defined in claim 14 wherein the carbonate phase is separated from the medium, the organic liquid is volatilized from the carbonate prior to recovery of the metal therefrom.

17. A process as defined in claim 15 wherein the carbonate is propylene carbonate which is present in the composition in a range of from about 5 to about 40 per cent and the organic liquid is benzene which is present in the range of from about 95 to about 60 per cent.

18. A process as defined in claim 17 wherein the metal is recovered from the carbonate phase by electrowinning.

19. A process for the solvent extraction of a metal selected from the group consisting of gold, platinum, palladium, rhodium, iridium, cobalt, copper, vanadium, uranium, bismuth, cadmium, mercury, and cerium, comprising the steps of:
   a. providing an aqueous medium of a thiocyanate of at least one of said metals;
   b. adjusting the pH of the medium into the acid range;
   c. contacting the aqueous medium with a composition comprising an organic alkylene carbonate, said composition being at least partially insoluble in said medium whereby a phase separation occurs, the metal being located in the carbonate phase;
   d. separating the carbonate phase from the remainder of the medium; and
   e. recovering the metal from the carbonate phase.

20. A process as defined in claim 19 wherein the metal is electrowon from the carbonate phase.

21. A process as defined in claim 19 wherein the carbonate is propylene carbonate.

22. A process as defined in claim 19 wherein the carbonate is ethylene carbonate.

23. A process as defined in claim 19 wherein the carbonate composition also includes an organic liquid in admixture therewith, said liquid being miscible with the carbonate and from only slightly soluble to completely insoluble in the aqueous medium.

24. A process as defined in claim 23 wherein the organic liquid is selected from a member of the group consisting of benzene, o-xylene, m-xylene, p-xylene, diethyl ether, 4-methyl-2-pentanone, 2,4-pentandione, ethyl acetate, n-heptyl alcohol, and chloroform.

25. A process as defined in claim 24 wherein the carbonate is propylene carbonate.

26. A process as defined in claim 24 wherein the carbonate is ethylene carbonate.

27. A process as defined in claim 23 wherein prior to recovery of the metal from the carbonate phase, the organic liquid is volatilized from the carbonate composition.

28. A process as defined in claim 23 wherein the carbonate composition comprises from about 5 to about 40 per cent propylene carbonate and from about 95 to about 60 per cent benzene and the organic liquid.

29. A process as defined in claim 28 wherein the metal is removed from the carbonate phase by an electrowinning process.

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