synchronous with the increasing regulations put up worldwide that mandates the recycling of electronic wastes, which accounts for the bulk of secondary sources of silver. The existing hydrometallurgy methods used in the industry currently are strong acid-based or cyanide-based techniques that are hazardous and highly toxic. Though several alternative non-cyanide systems utilising thiourea, thiosulfate and halogen/halides have been examined and shown to perform well, there is limited demonstration of their large-scale application.

In view of the limitations of current methods for extraction of silver from solid wastes comprising silver, there is a need for development of a lixiviant that is non-toxic, user and environmentally friendly, economical, and capable of achieving selective extraction with high efficiencies, to overcome or at least ameliorate, one or more of the disadvantages described above.

Summary

In an example, there is provided a composition comprising:

i) a first weak acid;

ii) an oxidant; and

iii) a metal complexing agent,

wherein the composition has a pH in the range of 2 to 4.

In one aspect, the present disclosure refers to a composition comprising:

i) a first weak acid comprising a mixture of acetic acid and monochloroacetic acid;

ii) an oxidant that is a peroxide; and

iii) a metal complexing agent comprising an amine group,

wherein the metal complexing agent has a concentration in a range of 0.05% w/v to 2.0% w/v, based on the total volume of the composition and wherein the composition has a pH in the range of 2 to 4.

Advantageously, the disclosed composition is significantly less toxic and hazardous compared to conventional lixiviants since there is no highly corrosive or highly toxic reagents used. In particular, the composition does not comprise any cyanide, eliminating the safety, health and environmental problems associated with the use and post-treatment of cyanide-based solutions. The composition further advantageously does not use any other highly toxic reagents, including strong corrosive acids. Therefore, the waste streams generated using these reagents would advantageously not require any specialised and costly treatment before discharging into the environment.

Advantageously, the composition may further comprise a catalyst. The catalyst may further enhance the rate of extraction of silver without compromising the other advantageous properties of the composition.

In another example, there is provided a method of preparing the composition according any one of the preceding claims, comprising the step of mixing:

i) a first weak acid;

ii) an oxidant; and

iii) an metal complexing agent,

wherein the composition has a pH in the range of 2 to 4.

In another aspect, the present disclosure refers to a method of preparing the composition as defined above, comprising the step of mixing:

i) a first weak acid comprising a mixture of acetic acid and monochloroacetic acid;

ii) an oxidant that is a peroxide; and

iii) a metal complexing agent comprising an amine group,

wherein the metal complexing agent has a concentration in a range of 0.05% w/v to 2.0% w/v, based on the total volume of the composition and wherein the composition has a pH in the range of 2 to 4.

Claims

1. A composition comprising:

   i) a first weak acid comprising a mixture of acetic acid and monochloroacetic acid;

   ii) an oxidant that is a peroxide; and

   iii) a metal complexing agent comprising an amine group,

   wherein the metal complexing agent has a concentration in a range of 0.05% w/v to 2.0% w/v, based on the total volume of the composition and wherein the composition has a pH in the range of 2 to 4.

2. The composition according to claim 1, wherein the first weak acid has a concentration in a range of 0.3% w/v to 2.0% w/v, based on the total volume of the composition.

3. The composition according to any one of the preceding claims, wherein the oxidant has a concentration in a range of 3% w/v to 15 % w/v, based on the total volume of the composition.

4. The composition according to any one of the preceding claims, further comprising a catalyst.

5. The composition according to claim 4, wherein the catalyst has a concentration in a range of 0.01% w/v to 0.3% w/v, based on the total volume of the composition.

6. The composition according to any one of the preceding claims, further comprising a surfactant.

7. The composition according to claim 6, wherein the surfactant has a concentration in a range of 0.05% w/v to 0.3% w/v, based on the total volume of the composition.

8. The composition according to any one of the preceding claims, further comprising an oxidant stabilising agent.

9. The composition according to claim 8, wherein the oxidant stabilising agent has a concentration in a range of 0.15 w/v to 0.35% w/v, based on the total volume of the composition.

10. The composition according to any one of the preceding claims, further comprising a second weak acid.

11. The composition according to claim 10, wherein the second weak acid has a concentration in a range of 0.05% w/v to 1.5% w/v, based on the total volume of the composition.

12. A method of preparing the composition according any one of the preceding claims, comprising the step of mixing:

i) a first weak acid comprising a mixture of acetic acid and monochloroacetic acid;

ii) an oxidant that is a peroxide; and

iii) a metal complexing agent comprising an amine group,

wherein the metal complexing agent has a concentration in a range of 0.05% w/v to 2.0% w/v, based on the total volume of the composition and wherein the composition has a pH in the range of 2 to 4.

13. The method according to claim 12, further comprising the step of adding a catalyst, a surfactant, an oxidant stabiliser and/or a second weak acid to the composition.

14. A method of extracting silver from a solid mixture comprising a plurality of metals comprising silver, the method comprising the step of contacting the composition according to any one of claims 1 to 11 with the solid mixture to form a leachate solution.

15. The method according to claim 14, wherein the solid mixture further comprises silica, silicates, an organic compound or any mixture thereof.

16. The method according to claim 14 or 15, wherein the contacting step is performed at a temperature at or less than 50°C or for a duration of less than 6 hours.

17. The method according to any one of claims 14 to 16, further comprising a pre-treatment step, wherein the solid mixture is rinsed with an organic solvent and/or a strong acid before contacting with the composition.

18. The method according to any one of claims 14 to 17, further comprising the step of contacting the leachate solution with an anion to precipitate the silver as a silver salt.

19. The use of the composition according to any one of claims 1 to 11, to recover silver from a solid mixture comprising a plurality of metals comprising silver.