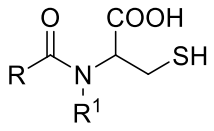
drinking water.

A range of technologies have been developed for the removal of high concentrations of arsenic or other heavy metals from drinking water, including oxidation, coagulation, precipitation, adsorption, adsorbing floc flotation, ion-exchange and membrane techniques. Many of these techniques are costly and/or energy-intensive. Other approaches for the removal of high concentrations of arsenic from drinking water include phytoremediation or the use of bacteria, which can play an important role in facilitating biological arsenic removal processes.

It would be advantageous to provide an alternative method for removing dissolved heavy metals from drinking water and other aqueous solutions. It would also be advantageous to provide such a method which can be used to remove dissolved heavy metals from dilute aqueous solutions comprising less than 10 ppm of the dissolved heavy metal.

SUMMARY OF THE INVENTION

In a first aspect, the present invention provides a method for removing a dissolved heavy metal ion from an aqueous solution, the method comprising dissolving in the aqueous solution a cysteine-surfactant foaming agent of formula (I):



(I)

or a salt thereof,

wherein R represents a linear or branched C_5-C_{10} alkyl;

R^1 represents a hydrogen or methyl group; and

wherein the method further comprises passing a gas through the aqueous solution to form a foam, and separating the foam from the aqueous solution and removing said dissolved heavy metal ion from the aqueous solution.

In one embodiment, R represents a linear or branched C_7-C_9 alkyl.

In one embodiment, R represents -$(CH_2)_6CH_3$ and R_1 represents H.

In one embodiment, the cysteine-surfactant foaming agent of formula (I) or salt thereof has a solubility of greater than 0.0001 M in water.

In one embodiment, the CMC of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is greater than 0.0001 M.

In one embodiment, the cysteine-surfactant foaming agent is in the form of a salt.

In one embodiment, the salt is a Na, K, Li or Cs salt.

In one embodiment, the concentration of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is from about 0.01 mM to about 0.02 M.

In one embodiment, the concentration of the foaming agent of formula (I) or salt thereof in the aqueous solution is from about 0.0001 M to about 0.02 M.

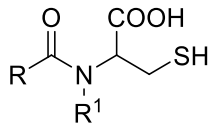
In one embodiment, the pH of the aqueous solution is in the range of from about 8 to about 9.

In one embodiment, the heavy metal ion is selected from the group consisting of As, Hg, Pb, Cd, Ni, Co, Cr, Zn and Cu. In some embodiments, the heavy metal is present in the solution as the metal cation. In some embodiments, the heavy metal ion is present in the solution as an oxyanion of the heavy metal (e.g. an oxyanion of As(V)).

In one embodiment, the gas is selected from the group consisting of dry air, humidified air, carbon dioxide, nitrogen, helium, argon and oxygen.

In a second aspect, the present invention provides a use of a compound of a cysteine-

surfactant foaming agent of formula (I):



(I)

or a salt thereof,

wherein R represents a linear or branched C_5-C_{10} alkyl; and

R^1 represents a hydrogen or methyl group;

for removing a dissolved heavy metal ion from an aqueous solution.

In one embodiment, the cysteine-surfactant foaming agent of formula (I) or salt thereof is used in an ion flotation process to remove the dissolved heavy metal ion from the aqueous solution.

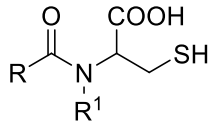
In one embodiment R represents a linear or branched C_7-C_9 alkyl.

In one embodiment the cysteine-surfactant foaming agent of formula (I) or salt thereof has a solubility of greater than 0.0001 M in water.

In one embodiment the CMC of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is greater than 0.0001 M.

CLAIMS

1. A method for removing a dissolved heavy metal ion from an aqueous solution, the method comprising dissolving in the aqueous solution a cysteine-surfactant foaming agent of formula (I):



(I)

or a salt thereof,

wherein R represents a linear or branched C_5-C_{10} alkyl;

R^1 represents a hydrogen or methyl group; and

wherein the method further comprises passing a gas through the aqueous solution to form a foam, and separating the foam from the aqueous solution and removing said dissolved heavy metal ion from the aqueous solution.

2. The method according to claim 1, wherein R represents a linear or branched C_7-C_9 alkyl.

3. The method according to claim 2, wherein R represents -$(CH_2)_6CH_3$ and R^1 represents H.

4. The method according to any one of claims 1 to 3, wherein the cysteine-surfactant foaming agent of formula (I) or salt thereof has a solubility of greater than 0.0001 M in water.

5. The method according to any one of claims 1 to 4, wherein the CMC of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is greater than 0.0001 M.

6. The method according to any one of claims 1 to 5, wherein the cysteine-surfactant foaming agent is in the form of a salt.

7. The method according to claim 6, wherein the salt is a Na, K, Li or Cs salt.

8. The method according to any one of claims 1 to 7, wherein the concentration of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is from about 0.01 mM to about 0.02 M.

9. The method according to claim 8, wherein the concentration is about 0.0001 M to about 0.02 M.

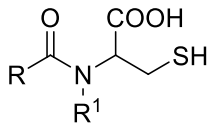
10. The method according to any one of claims 1 to 9, wherein the pH of the aqueous solution is in the range of from about 8 to about 9.

11. The method according to any one of claims 1 to 10, wherein the heavy metal ion is selected from the group consisting of As, Hg, Pb, Cd, Ni, Co, Cr, Zn and Cu.

12. The method according to any one of claims 1 to 11, wherein the dissolved heavy metal ion is arsenic (V), mercury (II) or lead (II).

13. The method according to any one of claims 1 to 12, wherein the gas is selected from the group consisting of dry air, humidified air, carbon dioxide, nitrogen, helium, argon and oxygen.

14. Use of a compound of a cysteine-surfactant foaming agent of formula (I):



(I)

or a salt thereof,

wherein R represents a linear or branched C_5-C_{10} alkyl; and

R^1 represents a hydrogen or methyl group;

for removing a dissolved heavy metal ion from an aqueous solution.

15. Use according to claim 14, wherein the cysteine-surfactant foaming agent of formula (I) or salt thereof is used in an ion flotation process to remove the dissolved heavy metal ion from the aqueous solution.

16. Use according to claim 14 or 15, wherein R represents a linear or branched C_7-C_9 alkyl.

17. Use according to any one of claims 14 to 16, wherein the cysteine-surfactant foaming agent of formula (I) or salt thereof has a solubility of greater than 0.0001 M in water.

18. Use according to any one of claims 14 to 17, wherein the CMC of the cysteine-surfactant foaming agent of formula (I) or salt thereof in the aqueous solution is greater than 0.0001 M.