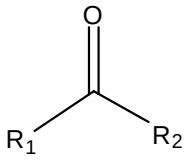
CLAIMS

1. A thermo-responsive osmotic solution having a lower critical solution temperature in a solvent suitable for use in osmosis comprising:

a) at least one tertiary amine containing compound; and

b) at least one enolisable carbonyl of Formula I,



Formula I

wherein

c) R_1 and R_2 are independently selected from a -C_1-C_7 alkyl or a -C_3-C_7 monocyclic or a -phenyl; or

d) one of R_1 or R_2 is selected from a -O-(C_1-C_7 alkyl) and the other is selected from a -C_1-C_7 alkyl, or

e) R_1 and R_2 together, with the carbonyl of Formula I, form

a. a 3-15 membered monocyclic ketone or

b. a 3-15 membered monocyclic heterocyclic ketone;

and

wherein in use at least one of the tertiary amine containing compound or the at least one enolisable carbonyl is immiscible with the solvent at or above 20 degrees Celsius and at 1 atmosphere; wherein the solvent is water.

2. The solution as claimed in claim 1, wherein the solution includes a combination of more than one enolisable carbonyl of Formula I.

3. The solution as claimed in claim 1 or claim 2, wherein the solution includes a combination of more than one tertiary amine containing compound.

4. The solution as claimed in any one of claims 1 to 3, wherein the at least one tertiary amine containing compound is a Lewis base.

5. The solution as claimed in any one of claims 1 to 4, wherein the at least one tertiary amine containing compound is immiscible with the solvent at or above 20 degrees Celsius and at 1 atmosphere.

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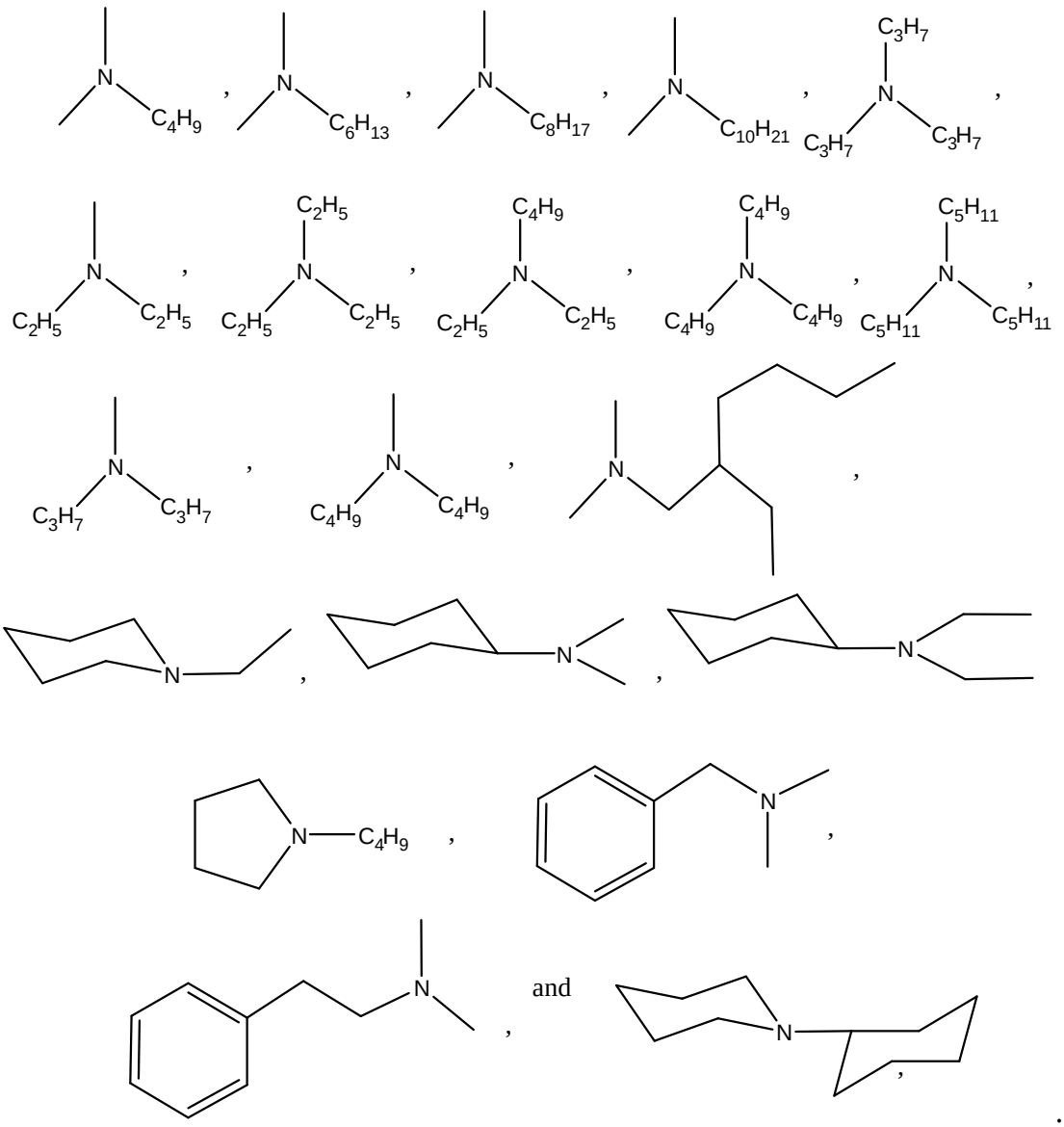
6. The solution as claimed in any one of claims 1 to 5, wherein the at least one tertiary amine containing compound is selected from a conjugated, aliphatic, asymmetric or cyclic tertiary amine.

7. The solution as claimed in claim 6, wherein the tertiary amine is selected from one or more of the following:



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8. The solution as claimed in claim 6, wherein the at least one tertiary amine containing compound is selected from a -N(C_1-C_7 alkyl)$_3$.

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9. The solution as claimed in claim 8, wherein the at least one tertiary amine containing compound is selected from a -N(C_1-C_4 alkyl)$_3$.

10. The solution as claimed in claim 9, wherein the at least one tertiary amine containing compound is -N(C_2 alkyl)$_3$ (triethylamine).

11. The solution as claimed in a claim 4 or any one of claims 5 to 10 when dependent upon claim 4, wherein the lewis base forms a lewis adduct with the enolisable carbonyl.

12. The solution as claimed in any one of claims 1 to 11, wherein R_1 and R_2 of Formula I are independently selected from a -C_1-C_7 alkyl.

13. The solution as claimed in claim 12, wherein R_1 and R_2 are independently selected from methyl and ethyl.

14. The solution as claimed in any one of claims 1 to 10, wherein R_1 and R_2 together with the carbonyl of Formula I, form a cyclic system selected from a 4-8 membered monocyclic ketone or a monocyclic ester.

15. The solution as claimed in claim 1 or claim 2, wherein the one or more enolisable carbonyls of Formula I is selected from acetone, acetophenone, methylethylketone (2-butanone), cyclohexanone, cyclopentanone, 2-propanone, 2-pentanone, 3-pentanone, 4-methyl-2-pentanone, 2-octanone and 3-methyl-2-butanone.

16. The solution as claimed in any one of claims 1 to 12 and 14, wherein each R_1 and R_2 are further substituted with one or more substituents selected from -halo, -OH, -CN, -NO_2, -CΞCH, -SH, -C_1-C_7 alkyl, -(C_1-C_7 alkyl)-OH, -NH_2, -NH(C_1-C_7 alkyl),-N(C_1-C_7 alkyl)$_2$, -O (C_1-C_7 alkyl), -C(O)-O(-C_1-C_7 alkyl), -C(O)OH; -C(O)-H, or -C(O)-(C_1-C_7 alkyl).

17. The solution as claimed in any one of claims 1 to 16, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:99 or 99:1.

18. The solution as claimed in claim 17, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:50 or 50:1.

19. The solution as claimed in claim 17 or claim 18, wherein the molar ratio of the at least one base to the enolisable carbonyl of Formula I are present in a ratio of 1:10 or 10:1.

20. The solution as claimed in any one of claims 17 to 19, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:5 or 5:1.

21. The solution as claimed in any one of claims 17 to 20, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:3 or 3:1.

22. The solution as claimed in any one of claims 17 to 21, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:2 or 2:1.

23. The solution as claimed in any one of claims 17 to 22, wherein the molar ratio of the at least one base to the one or more enolisable carbonyls of Formula I are present in a ratio of 1:1.

24. A method for separating a first solution including one or more solvents, using a thermo-responsive solution as defined in any one of claims 1 to 23, the method comprising:

1) bringing the first solution into contact with a semi-permeable membrane;
2) allowing one or more solvents in the first solution to flow through the semi-permeable membrane from the first solution into the thermo-responsive solution by osmosis to form a second solution, wherein the thermo-responsive solution is at a higher osmotic concentration than the first solution;

3) raising the temperature of the second solution to or above the lower critical solution temperature of the thermo-responsive solution to cause the thermo-responsive solution to become immiscible with the one or more solvents from the first solution that have passed through the semi-permeable membrane; and
4) separating the one or more solvents that have passed through the semipermeable membrane from the immiscible thermo-responsive solution.

25. The method as claimed in claim 24, wherein the first solution further includes one or more dissolved solutes.

26. The method as claimed in claim 24 or claim 25, wherein the first solution includes water as a solvent.

27. The method as claimed in any one of claims 24 to 26, wherein the first solution is selected from seawater, brackish water, industrial water waste streams, compromised water sources, sewage, wastewater liquors, digestates, food & beverage processing effluents, grey water, fruit juices, vegetable juices, milk, produced waters, leachates, flue gas scrubber discharge or the like.

28. A method for separating a first solution including one or more solvents, using a thermo-responsive solution as defined in any one of claims 1 to 23, the method comprising:

1) bringing the first solution into contact with a semi-permeable membrane;
2) allowing one or more solvents in the first solution to flow through the semi-permeable membrane from the first solution into the thermo-responsive solution by osmosis to form a second solution, wherein the thermo-responsive solution is at a higher osmotic concentration than the first solution;
3) adjusting the lower critical solution temperature of the thermo-responsive solution to cause the thermo-responsive solution to become immiscible with the one or more solvents from the first solution that have passed through the semi-permeable membrane; and
4) separating the one or more solvents that have passed through the semipermeable membrane from the immiscible thermo-responsive solution.

29. The method as claimed in claim 28, wherein the lower critical solution temperature of the thermo-responsive solution is adjusted by adding one or more tertiary amine containing compounds as defined in any one of claims 1 to 23.

30. The method as claimed in claim 28 or claim 29, wherein the lower critical solution temperature of the thermo-responsive solution is adjusted by adding or more enolisable carbonyls as defined in any one of claims 1 to 23.

31. The method as claimed in any one of claims 28 to 30, wherein the lower critical solution temperature of the thermo-responsive solution is adjusted by adding one or more tertiary amine containing compounds as defined in any one of claims 1 to 23 and by adding or more enolisable carbonyls as defined in any one of claims 1 to 23 or combinations thereof.

32. The method as claimed in any one of claims 28 to 31, wherein the first solution further includes one or more dissolved solutes.

33. The method as claimed in any one of claims 28 to 32, wherein the first solution includes water as a solvent.

34. The method as claimed in any one of claims 28 to 33, wherein the first solution is selected from seawater, brackish water, industrial water waste streams, compromised water sources, sewage, wastewater liquors, digestates, food & beverage processing effluents, grey water, fruit juices, vegetable juices, milk, produced waters, leachates, flue gas scrubber discharge or the like.