We claim:

1. A system having a modulatable osmotic gradient across a membrane, comprising:

a semi-permeable membrane;

a switchable water located on one side of said semi-permeable membrane, said switchable water comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the osmotic pressure of the switchable water;

means for contacting the semi-permeable membrane with a feed stream on the other side of said semi-permeable membrane; and

means for contacting the switchable water with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water and modulate the osmotic gradient across the membrane;

wherein the additive is a polymer.

2. The system of claim 1, wherein the polymer has at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger.

3. The system of claim 2, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

4. The system of claim 3, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

5. The system of claim 3, wherein the Brønsted acid is hydrochloric acid, formic acid, sulfuric acid or carbonic acid.

6. The system of any one of claims 2 – 5, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

7. The system of claim 6, wherein the pK_a is in a range from about 8 to about 10.

8. The system of any one of claims 2-5, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine (“MPEI”), an ethylated polyethyleneimine (“EPEI”), a propylated polyethyleneimine (“PPEI”), or a butylated polyethyleneimine (“BPEI”);

a functionalized polymethyl methacrylate (“PMMA”) based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid (“PAA”) polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate (“PDEAEMA”);

or any combination thereof.

9. The system of any one of claims 1 – 8 for use in removal of undesirable solutes or particles from water.

10. The system of claim 9 wherein the system is a desalination system, such as for treatment of sea water or brackish water, or a wastewater remediation system.

11. The system of any one of claims 1 – 8, for use in concentrating a dilute aqueous solution.

12. The system of claim 11, wherein the dilute aqueous solution is wastewater.

13. The system of any one of claims 1 – 12, wherein the system additionally comprises means for contacting the switchable water with non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

14. The system of claim 13, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

15. The system of claim 13 or 14, wherein the system additionally comprises means for separating the additive from the water in said switchable water.

16. The system of claim 15, wherein the means for separating the additive from the water comprises a reverse osmosis system.

17. The system of claim 15, wherein the first form of the switchable additive is immiscible in water and the system additionally comprises means for decanting the first form of the additive from the water.

18. The system of claim 15, wherein the first form of the switchable additive is insoluble in water and the system additionally comprises means for removing the insoluble first form of the additive, such as by centrifugation, filtering, skimming or nanofiltration.

19. A method for removing a solute from an aqueous solution or concentrating a dilute aqueous solution, comprising the steps of:

(a) providing a semi-permeable membrane that is selectively permeable for water and has on one side a draw solution that is a switchable water comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive;

(b) contacting the draw solution with an ionizing trigger to switch the additive to the second form before or after association with the semi-permeable membrane, thereby increasing the osmotic pressure of the draw solution;

(c) contacting the semi-permeable membrane with a feed stream of the aqueous solution to permit water to flow from the aqueous solution through the semi-permeable membrane into the increased ionic strength draw solution; and

(d) optionally, removing the additive from the resulting diluted draw solution;

wherein the additive is a polymer.

20. The method of claim 19, wherein the solute is a salt.

21. The method of claim 20, wherein the feed stream is an aqueous salt solution, such as brackish water or sea water.

22. The method of claim 19 or 21, wherein the feed stream is waste water.

23. The method of any one of claims 19 – 22, wherein step (d) comprises contacting the diluted draw solution with a non-ionizing trigger to switch the additive to its first form.

24. The method of any one of claims 19 - 23, wherein step (d) comprises a reverse osmosis.

25. The method of claim 23, wherein the first form of the switchable additive is immiscible in water and step (d) additionally comprises decanting the first form of the additive from the water.

26. The method of claim 23, wherein the first form of the switchable additive is insoluble in water and step (d) additionally comprises removing the insoluble first form of the additive from the water, such as by centrifugation, filtration or nanofiltration.

27. The method of any one of claims 19 - 26, wherein the polymer has at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of the ionizing trigger.

28. The method of claim 27, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

29. The method of claim 28, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

30. The method of claim 28, wherein the Brønsted acid is hydrochloric acid, formic acid, sulfuric acid or carbonic acid.

31. The method of any one of claims 27 to 30, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

32. The method of claim 31, wherein the pK_a is in a range from about 8 to about 10.

33. The method of any one of claims 27-30, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine (“MPEI”), an ethylated polyethyleneimine (“EPEI”), a propylated polyethyleneimine (“PPEI”), or a butylated polyethyleneimine (“BPEI”);

a functionalized polymethyl methacrylate (“PMMA”) based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid (“PAA”) polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate (“PDEAEMA”);

or any combination thereof.

34. A system for destabilization of a suspension, comprising:

a mixture of water or an aqueous solution and one or more particle solids that are substantially insoluble in water;

a switchable water comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water; and

means for contacting the switchable water with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water to stop the formation of a suspension of the one or more particle solids or destabilize a suspension of the one or more particle solids;

wherein the additive is a polymer.

35. The system of claim 34, wherein the polymer has at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger.

36. The system of claim 35, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

37. The system of claim 36, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

38. The system of claim 36, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

39. The system of any one of claims 35 – 38, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

40. The system of claim 39, wherein the pK_a is in a range from about 8 to about 10.

41. The system of any one of claims 35 - 38 wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");

a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS"), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate ("PDEAEMA");

or any combination thereof.

42. The system of any one of claims 34 – 41 for use in removal of undesirable solids from water, such as waste water or storm water.

43. The system of any one of claims 34 – 42 for separation or removal of clay particles from water.

44. A method for destabilizing a suspension or preventing formation of a suspension, comprising:

combining, in any order, to form a mixture:

water or an aqueous solution and one or more particle solids that are substantially insoluble in water;

an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive; and

an ionizing trigger to ionize the at least one functional group in the additive and thereby increase the ionic strength of the mixture to stop the formation of a suspension

of the one or more particle solids or destabilize a suspension of the one or more particle solids; and

allowing the mixture to separate into two components, a first component comprising the particle solids and a second component comprising water and an ionic form of the additive;

wherein the additive is a polymer.

45. The method of claim 44, wherein a surfactant is also combined with said mixture, said water or aqueous solution, said additive, or said ionizing trigger.

46. The method of claim 44 or 45, wherein the polymer has at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of the ionizing trigger.

47. The method of claim 46, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

48. The method of claim 47, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

49. The method of claim 47, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

50. The method of any one of claims 46 to 49, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

51. The method of claim 50, wherein the pK_a is in a range from about 8 to about 10.

52. The method of any one of claims 46 - 49, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine (“MPEI”), an ethylated polyethyleneimine (“EPEI”), a propylated polyethyleneimine (“PPEI”), or a butylated polyethyleneimine (“BPEI”);

a functionalized polymethyl methacrylate (“PMMA”) based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid (“PAA”) polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate (“PDEAEMA”);

or any combination thereof.

53. The method of any one of claims 44 – 52, further comprising the step of removing said one or more particle solids.

54. The method of claim 53, wherein said mixture of one or more particle solids and water or an aqueous solution is waste water or storm water.

55. The method of any one of claims 44 – 54, wherein said one or more particle solids are clay particles.

56. A system for modulating viscosity of a switchable water or an aqueous solution, comprising:

switchable water having a first viscosity comprising: (i) water or an aqueous solution, in combination with (ii) an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water; and

means for contacting the switchable water with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water and change the viscosity of the switchable water to a second viscosity;

wherein the first viscosity of the switchable water is different from the viscosity of the water or the aqueous solution in the absence of the first form of the additive.

57. The system of claim 56, wherein the additive is a compound having at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the additive is in the presence of an ionizing trigger.

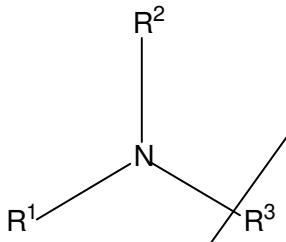
58. The system of claim 57, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

59. The system of claim 58, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

60. The system of claim 58, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

61. The system of any one of claims 56-60 wherein the switchable water comprises a polymer.

62. The system of any one of claims 57 – 61, wherein the additive is a compound of formula (1),



(1)

where R^1, R^2, and R^3 are independently:

H;

a substituted or unsubstituted C_1 to C_8 aliphatic group that is linear, branched, or cyclic, optionally wherein one or more C of the alkyl group is replaced by
{-Si(R^{10})$_2$-O-} up to and including 8 C being replaced by 8 {-Si(R^{10})$_2$-O-};

a substituted or unsubstituted C_nSi_m group where n and m are independently a number from 0 to 8 and n + m is a number from 1 to 8;

a substituted or unsubstituted C_4 to C_8 aryl group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by {-Si(R^{10})$_2$-O-};

a substituted or unsubstituted aryl group having 4 to 8 ring atoms, optionally including one or more {-Si(R^{10})$_2$-O-}, wherein aryl is optionally heteroaryl;

a –(Si(R^{10})$_2$-O)$_p$– chain in which p is from 1 to 8 which is terminated by H, or is terminated by a substituted or unsubstituted C_1 to C_8 aliphatic and/or aryl group; or
a substituted or unsubstituted (C_1 to C_8 aliphatic)-(C_4 to C_8 aryl) group wherein aryl

is optionally heteroaryl, optionally wherein one or more C is replaced by a {-Si(R^{10})$_2$-O-};

wherein R^{10} is a substituted or unsubstituted C_1 to C_8 aliphatic group, a substituted or unsubstituted C_1 to C_8 alkoxy, a substituted or unsubstituted C_4 to C_8 aryl wherein aryl is optionally heteroaryl, a substituted or unsubstituted aliphatic-alkoxy, a substituted or unsubstituted aliphatic-aryl, or a substituted or unsubstituted alkoxy-aryl group; and

wherein a substituent is independently: alkyl; alkenyl; alkynyl; aryl; aryl-halide; heteroaryl; cycloalkyl; Si(alkyl)$_3$; Si(alkoxy)$_3$; halo; alkoxyl; amino; alkylamino; alkenylamino; amide; amidine; hydroxyl; thioether; alkylcarbonyl; alkylcarbonyloxy; arylcarbonyloxy; alkoxycarbonyloxy; aryloxycarbonyloxy; carbonate; alkoxycarbonyl; aminocarbonyl; alkylthiocarbonyl; amidine, phosphate; phosphate ester; phosphonato; phosphinato; cyano; acylamino; imino; sulfhydryl; alkylthio; arylthio; thiocarboxylate; dithiocarboxylate; sulfate; sulfato; sulfonate; sulfamoyl; sulfonamide; nitro; nitrile; azido; heterocyclyl; ether; ester; silicon-containing moieties; thioester; or a combination thereof; and a substituent may be further substituted.

63. The system of any one of claims 57 – 62, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

64. The system of claim 63, wherein the pK_a is in a range from about 8 to about 10.

65. The system of claim 62, wherein the additive is:
MDEA (N-methyl diethanol-amine);
TMDAB (N, N, N', N'-tetramethyl-1, 4-diaminobutane);
TEDAB (N,N,N',N'-tetraethyl-1,4-diaminobutane);
EPDAB (N,N'-diethyl-N,N'-dipropyl-1,4-diaminobutane);
THEED (N, N, N', N'-tetrakis(2-hydroxyethyl) ethylenediamine);
DMAPAP (1-[bis[3-(dimethylamino)]propyl]amino-2-propanol);
HMTETA (1,1,4,7,10,10-hexamethyl triethylenetetramine);
MeSpe (N^1,$N^{1'}$-(butane-1,4-diyl)bis(N^1,N^3,N^3-trimethylpropane-1,3-diamine);
CHTDMA (1,1',1''-(cyclohexane-1,3,5-triyl)tris(N,N-dimethylmethanamine); or
DMCA (N,N-dimethylcyclohexylamine).

66. The system of claim 62, wherein the additive is a polyamine.

67. The system of any one of claims 57 - 61, wherein the additive is a polymer.

68. The system of claim 67, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");

a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS"), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate ("PDEAEMA");

or any combination thereof.

69. The system of any one of claims 56 – 68, wherein the system additionally comprises means for contacting the combination with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

70. The system of claim 69, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

71. A method for modulating viscosity of a switchable water having a first viscosity, comprising:

(a) providing said switchable water, wherein said switchable water comprises water or an aqueous solution and an additive that is switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water; and

(b) contacting the switchable water provided by step (a) with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic

strength of the switchable water and change the viscosity of the switchable water to a second viscosity;

wherein the first viscosity of the switchable water is different from the viscosity of the water or the aqueous solution in the absence of the first form of the additive.

72. The method of claim 71, wherein the additive is a compound having at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the additive is in the presence of the ionizing trigger.

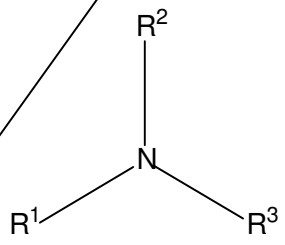
73. The method of claim 72, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

74. The method of claim 73, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

75. The method of claim 73, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

76. The method of any one of claims 71-75, wherein the switchable water comprises a polymer.

77. The method of any one of claims 72 – 75, wherein the additive is a compound of formula (1),



(1)

where R^1, R^2, and R^3 are independently:

H;

a substituted or unsubstituted C_1 to C_8 aliphatic group that is linear, branched, or cyclic, optionally wherein one or more C of the alkyl group is replaced by $\{-Si(R^{10})_2-O-\}$ up to and including 8 C being replaced by 8 $\{-Si(R^{10})_2-O-\}$;

a substituted or unsubstituted C_nSi_m group where n and m are independently a number from 0 to 8 and n + m is a number from 1 to 8;

a substituted or unsubstituted C_4 to C_8 aryl group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by {-Si(R^{10})$_2$-O-};

a substituted or unsubstituted aryl group having 4 to 8 ring atoms, optionally including one or more {-Si(R^{10})$_2$-O-}, wherein aryl is optionally heteroaryl;

a –(Si(R^{10})$_2$-O)$_p$– chain in which p is from 1 to 8 which is terminated by H, or is terminated by a substituted or unsubstituted C_1 to C_8 aliphatic and/or aryl group; or

a substituted or unsubstituted (C_1 to C_8 aliphatic)-(C_4 to C_8 aryl) group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by a {-Si(R^{10})$_2$-O-};

wherein R^{10} is a substituted or unsubstituted C_1 to C_8 aliphatic group, a substituted or unsubstituted C_1 to C_8 alkoxy, a substituted or unsubstituted C_4 to C_8 aryl wherein aryl is optionally heteroaryl, a substituted or unsubstituted aliphatic-alkoxy, a substituted or unsubstituted aliphatic-aryl, or a substituted or unsubstituted alkoxy-aryl group; and

wherein a substituent is independently: alkyl; alkenyl; alkynyl; aryl; aryl-halide; heteroaryl; cycloalkyl; Si(alkyl)$_3$; Si(alkoxy)$_3$; halo; alkoxyl; amino; alkylamino; alkenylamino; amide; amidine; hydroxyl; thioether; alkylcarbonyl; alkylcarbonyloxy; arylcarbonyloxy; alkoxycarbonyloxy; aryloxycarbonyloxy; carbonate; alkoxycarbonyl; aminocarbonyl; alkylthiocarbonyl; amidine, phosphate; phosphate ester; phosphonato; phosphinato; cyano; acylamino; imino; sulfhydryl; alkylthio; arylthio; thiocarboxylate; dithiocarboxylate; sulfate; sulfato; sulfonate; sulfamoyl; sulfonamide; nitro; nitrile; azido; heterocyclyl; ether; ester; silicon-containing moieties; thioester; or a combination thereof; and a substituent may be further substituted.

78. The method of any one of claims 72 to 77, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

79. The method of claim 78, wherein the pK_a is in a range from about 8 to about 10.

80. The method of claim 77, wherein the additive is:

MDEA (N-methyl diethanol-amine);

TMDAB (N, N, N', N'-tetramethyl-1, 4-diaminobutane);

TEDAB (N,N,N',N'-tetraethyl-1,4-diaminobutane);

EPDAB (N,N'-diethyl-N,N'-dipropyl-1,4-diaminobutane);

THEED (N, N, N', N'-tetrakis(2-hydroxyethyl) ethylenediamine);

DMAPAP (1-[bis[3-(dimethylamino)]propyl]amino-2-propanol);

HMTETA (1,1,4,7,10,10-hexamethyl triethylenetetramine);

MeSpe (N^1,$N^{1'}$-(butane-1,4-diyl)bis(N^1,N^3,N^3-trimethylpropane-1,3-diamine);

CHTDMA (1,1',1''-(cyclohexane-1,3,5-triyl)tris(N,N-dimethylmethanamine); or

DMCA (N,N-dimethylcyclohexylamine).

81. The method of claim 77, wherein the additive is a polyamine.

82. The method of any one of claims 72 - 76, wherein the additive is a polymer.

83. The method of claim 82, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");

a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS"), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate ("PDEAEMA");

or any combination thereof.

84. The method of any one of claims 71 – 83, additionally comprising:

(c) subjecting the switchable water having the second viscosity to a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form and reform the switchable water having the first viscosity.

85. The method of claim 84, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

86. A system for homogeneous catalysis, comprising:

a hydrophilic catalyst;

an organic solvent;

a switchable water comprising water in combination with an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water; and

means for contacting the switchable water with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water;

wherein the organic solvent is miscible with the switchable water when the additive is in the first form and immiscible or poorly miscible with the switchable water when the ionic strength is increased by switching the additive to the second form.

87. The system of claim 86, which additionally comprises reactants for a homogeneous catalysis reaction.

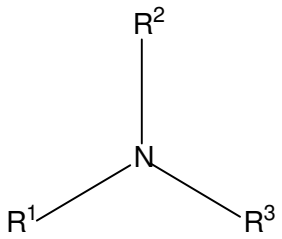
88. The system of any one of claims 86 – 87, wherein the additive is a compound having at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the additive is in the presence of an ionizing trigger.

89. The system of claim 88, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

90. The system of claim 89, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

91. The system of claim 89, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

92. The system of any one of claims 88 – 91, wherein the additive is a compound of formula (1),



(1)

where R^1, R^2, and R^3 are independently:

H;

a substituted or unsubstituted C_1 to C_8 aliphatic group that is linear, branched, or cyclic, optionally wherein one or more C of the alkyl group is replaced by $\{-Si(R^{10})_2-O-\}$ up to and including 8 C being replaced by 8 $\{-Si(R^{10})_2-O-\}$;

a substituted or unsubstituted C_nSi_m group where n and m are independently a number from 0 to 8 and n + m is a number from 1 to 8;

a substituted or unsubstituted C_4 to C_8 aryl group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by $\{-Si(R^{10})_2-O-\}$;

a substituted or unsubstituted aryl group having 4 to 8 ring atoms, optionally including one or more $\{-Si(R^{10})_2-O-\}$, wherein aryl is optionally heteroaryl;

a $-(Si(R^{10})_2-O)_p-$ chain in which p is from 1 to 8 which is terminated by H, or is terminated by a substituted or unsubstituted C_1 to C_8 aliphatic and/or aryl group; or a substituted or unsubstituted (C_1 to C_8 aliphatic)-(C_4 to C_8 aryl) group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by a $\{-Si(R^{10})_2-O-\}$;

wherein R^{10} is a substituted or unsubstituted C_1 to C_8 aliphatic group, a substituted or unsubstituted C_1 to C_8 alkoxy, a substituted or unsubstituted C_4 to C_8 aryl wherein aryl is optionally heteroaryl, a substituted or unsubstituted aliphatic-alkoxy, a substituted or unsubstituted aliphatic-aryl, or a substituted or unsubstituted alkoxy-aryl group; and

wherein a substituent is independently: alkyl; alkenyl; alkynyl; aryl; aryl-halide; heteroaryl; cycloalkyl; $Si(alkyl)_3$; $Si(alkoxy)_3$; halo; alkoxyl; amino; alkylamino; alkenylamino; amide; amidine; hydroxyl; thioether; alkylcarbonyl; alkylcarbonyloxy; arylcarbonyloxy; alkoxycarbonyloxy; aryloxycarbonyloxy; carbonate; alkoxycarbonyl; aminocarbonyl; alkylthiocarbonyl; amidine, phosphate; phosphate ester; phosphonato; phosphinato; cyano; acylamino; imino; sulfhydryl; alkylthio; arylthio; thiocarboxylate; dithiocarboxylate; sulfate; sulfato; sulfonate; sulfamoyl; sulfonamide; nitro; nitrile; azido; heterocyclyl; ether; ester; silicon-

containing moieties; thioester; or a combination thereof; and a substituent may be further substituted.

93. The system of any one of claims 88 – 92, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

94. The system of claim 93, wherein the pK_a is in a range from about 8 to about 10.

95. The system of claim 92, wherein the additive is:
MDEA (N-methyl diethanol-amine);
TMDAB (N, N, N', N'-tetramethyl-1, 4-diaminobutane);
TEDAB (N,N,N',N'-tetraethyl-1,4-diaminobutane);
EPDAB (N,N'-diethyl-N,N'-dipropyl-1,4-diaminobutane);
THEED (N, N, N', N'-tetrakis(2-hydroxyethyl) ethylenediamine);
DMAPAP (1-[bis[3-(dimethylamino)]propyl]amino-2-propanol);
HMTETA (1,1,4,7,10,10-hexamethyl triethylenetetramine);
MeSpe (N^1,$N^{1'}$-(butane-1,4-diyl)bis(N^1,N^3,N^3-trimethylpropane-1,3-diamine);
CHTDMA (1,1',1''-(cyclohexane-1,3,5-triyl)tris(N,N-dimethylmethanamine); or
DMCA (N,N-dimethylcyclohexylamine).

96. The system of claim 92, wherein the additive is a polyamine.

97. The system of any one of claims 88 - 91, wherein the additive is a polymer.

98. The system of claim 97, wherein the polymer is:
a biopolymer or a derivative thereof;
a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");
a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;
a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;
an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate (“PDEAEMA”);

or any combination thereof.

99. The system of any one of claims 86 – 98, wherein the system additionally comprises means for contacting the combination with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

100. The system of claim 99, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

101. A method for homogeneous catalysis, comprising:

(a) forming a homogeneous reaction mixture by combining, in any order: a hydrophilic catalyst; one or more reactants; an organic solvent; water or an aqueous solution; and an additive in a first form, wherein the additive is switchable from the first form to a second form that includes at least one ionized functional group that is neutral in said first form of the additive;

(b) allowing the reactants to react to form one or more products; and

(c) subsequently contacting the homogeneous mixture with an ionizing trigger to switch the additive to its second form by ionizing at least one functional group in the additive, and increase the ionic strength of the mixture to salt out the organic solvent and the one or more products;

wherein the organic solvent is miscible with water when the additive is in the first form and immiscible or poorly miscible with water when the ionic strength is increased by switching the additive to the second form.

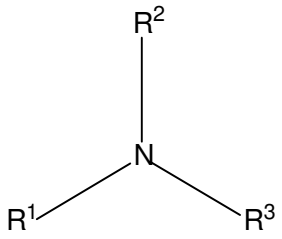
102. The method of claim 101, wherein the additive is a compound having at least one nitrogen-containing functional group that is sufficiently basic to be protonated when the additive is in the presence the ionizing trigger.

103. The method of claim 102, wherein the ionizing trigger is a Brønsted acid, or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

104. The method of claim 103, wherein the ionizing trigger is CO_2, NO_2, SO_2, SO_3, CS_2, or COS.

105. The method of claim 103, wherein the Brønsted acid is HCl, formic acid, sulfuric acid or carbonic acid.

106. The method of any one of claims 102 – 105, wherein the additive is a compound of formula (1),



(1)

where R^1, R^2, and R^3 are independently:

H;

a substituted or unsubstituted C_1 to C_8 aliphatic group that is linear, branched, or cyclic, optionally wherein one or more C of the alkyl group is replaced by $\{-Si(R^{10})_2-O-\}$ up to and including 8 C being replaced by 8 $\{-Si(R^{10})_2-O-\}$;

a substituted or unsubstituted C_nSi_m group where n and m are independently a number from 0 to 8 and n + m is a number from 1 to 8;

a substituted or unsubstituted C_4 to C_8 aryl group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by $\{-Si(R^{10})_2-O-\}$;

a substituted or unsubstituted aryl group having 4 to 8 ring atoms, optionally including one or more $\{-Si(R^{10})_2-O-\}$, wherein aryl is optionally heteroaryl;

a $-(Si(R^{10})_2-O)_p-$ chain in which p is from 1 to 8 which is terminated by H, or is terminated by a substituted or unsubstituted C_1 to C_8 aliphatic and/or aryl group; or a substituted or unsubstituted (C_1 to C_8 aliphatic)-(C_4 to C_8 aryl) group wherein aryl is optionally heteroaryl, optionally wherein one or more C is replaced by a $\{-Si(R^{10})_2-O-\}$;

wherein R^{10} is a substituted or unsubstituted C_1 to C_8 aliphatic group, a substituted or unsubstituted C_1 to C_8 alkoxy, a substituted or unsubstituted C_4 to C_8 aryl wherein aryl is optionally heteroaryl, a substituted or unsubstituted aliphatic-alkoxy, a substituted or unsubstituted aliphatic-aryl, or a substituted or unsubstituted alkoxy-aryl group; and

wherein a substituent is independently: alkyl; alkenyl; alkynyl; aryl; aryl-halide; heteroaryl; cycloalkyl; $Si(alkyl)_3$; $Si(alkoxy)_3$; halo; alkoxyl; amino; alkylamino; alkenylamino; amide; amidine; hydroxyl; thioether; alkylcarbonyl; alkylcarbonyloxy; arylcarbonyloxy; alkoxycarbonyloxy; aryloxycarbonyloxy; carbonate; alkoxycarbonyl; aminocarbonyl; alkylthiocarbonyl; amidine, phosphate; phosphate ester; phosphonato; phosphinato; cyano; acylamino; imino; sulfhydryl; alkylthio; arylthio; thiocarboxylate; dithiocarboxylate; sulfate; sulfato; sulfonate; sulfamoyl; sulfonamide; nitro; nitrile; azido; heterocyclyl; ether; ester; silicon-containing moieties; thioester; or a combination thereof; and a substituent may be further substituted.

107. The method of any one of claims 102 to 106, wherein the at least one nitrogen being sufficiently basic to be protonated by the ionizing trigger has a conjugate acid with a pK_a in a range from about 6 to about 14.

108. The method of claim 107, wherein the pK_a is in a range from about 8 to about 10.

109. The method of claim 106, wherein the additive is:
MDEA (N-methyl diethanol-amine);
TMDAB (N, N, N', N'-tetramethyl-1, 4-diaminobutane);
TEDAB (N,N,N',N'-tetraethyl-1,4-diaminobutane);
EPDAB (N,N'-diethyl-N,N'-dipropyl-1,4-diaminobutane);
THEED (N, N, N', N'-tetrakis(2-hydroxyethyl) ethylenediamine);
DMAPAP (1-[bis[3-(dimethylamino)]propyl]amino-2-propanol);
HMTETA (1,1,4,7,10,10-hexamethyl triethylenetetramine);
MeSpe (N^1,$N^{1'}$-(butane-1,4-diyl)bis(N^1,N^3,N^3-trimethylpropane-1,3-diamine);
CHTDMA (1,1',1''-(cyclohexane-1,3,5-triyl)tris(N,N-dimethylmethanamine); or
DMCA (N,N-dimethylcyclohexylamine).

110. The method of claim 106, wherein the additive is a polyamine.

111. The method of any one of claims 102 - 105, wherein the additive is a polymer.

112. The method of claim 111, wherein the polymer is:
a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine (“MPEI”), an ethylated polyethyleneimine (“EPEI”), a propylated polyethyleneimine (“PPEI”), or a butylated polyethyleneimine (“BPEI”);

a functionalized polymethyl methacrylate (“PMMA”) based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid (“PAA”) polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate (“PDEAEMA”);

or any combination thereof.

113. The method of any one of claims 101 – 112, additionally comprising:

(d) separating an organic phase comprising the one or more products from the switchable water comprising the catalyst and the additive in the second form; and

(e) subjecting the reaction mixture comprising the catalyst and the additive in the second form to a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

114. The method of claim 113, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

115. A system for modulating ionic strength of an aqueous solution comprising:

a switchable water comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water; and

means for contacting the switchable water with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water;

wherein the additive is a polymer.

116. The system of claim 115, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");

a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS"), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate ("PDEAEMA");

or any combination thereof.

117. The system of claim 115 or 116, wherein the polymer is insoluble in water when in the first form.

118. The system of claim 115 or 116, wherein the polymer is at least partially soluble in water when in the first form.

119. The system of any one of claims 115 – 118, wherein the system additionally comprises means for contacting the switchable water with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

120. The system of claim 119, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

121. A method for modulating the ionic strength of an aqueous solution, comprising:

contacting a switchable water comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water, with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water;

wherein the additive is a polymer.

122. The method of claim 121, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine, such as a methylated polyethyleneimine ("MPEI"), an ethylated polyethyleneimine ("EPEI"), a propylated polyethyleneimine ("PPEI"), or a butylated polyethyleneimine ("BPEI");

a functionalized polymethyl methacrylate ("PMMA") based polymer, such as 3-(dimethylamino)-1-propylamine functionalized PMMA;

a functionalized polyacrylic acid ("PAA") polymer, such as 3-(dimethylamino)-1-propylamine functionalized PAA;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS"), such as a 3-(dimethylamino)-1-propylamine functionalized PMMA/PS;

a polymer synthesized from amine-containing monomers, such as a polydiethylaminoethylmethacrylate ("PDEAEMA");

or any combination thereof.

123. The method of claim 121 or 122, wherein the polymer is insoluble in water when in the first form.

124. The method of claim 121 or 122, wherein the polymer is at least partially soluble in water when in the first form.

125. The method of any one of claims 121 – 124, additionally comprising the step of contacting the switchable water with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form.

126. The method of claim 125, wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

We claim:

1. A switchable water composition for modulating ionic strength comprising:

water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water composition;

wherein contacting the switchable water composition with an ionizing trigger to ionize at least one functional group in the additive increases the ionic strength of the switchable water composition and removal of the ionizing trigger from the switchable water composition reduces the ionic strength of the switchable water composition; and

wherein the additive is a polymer, and the the polymer has at least one amine nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger, and has a conjugate acid with a pK_a in a range from 6 to 14, or from 8 to 10,

wherein the polymer is optionally a polyamine.

2. The switchable water composition of claim 1 for modulating an osmotic gradient across a membrane in a system, said system comprising:

a semi-permeable membrane;

the switchable water composition located on one side of said semi-permeable membrane;

means for contacting the semi-permeable membrane with a feed stream on the other side of said semi-permeable membrane; and

means for modulating the osmotic gradient across the membrane by addition and removal of the ionizing trigger to and from the switchable water composition, respectively.

3. The switchable water composition of claim 1 or 2 for use in:

(i) removal of undesirable solutes or particles from water, wherein the system is a desalination system, or a wastewater remediation system; or

(ii) concentrating a dilute aqueous solution, wherein the dilute aqueous solution can be wastewater.

4. The switchable water composition of any one of claims 1 - 3, wherein said ionizing trigger can be removed from the switchable water composition with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form; wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

5. The switchable water composition of any one of claims 1 - 4, wherein the ionizing trigger is a Brønsted acid; or a gas that when dissolved in water reacts with water to liberate hydrogen ions.

6. The switchable water composition of claim 5, wherein the ionizing trigger is CO_2.

7. The switchable water composition of any one of claims 1 - 6, wherein the polymer is insoluble in water when in the first form; or is at least partially soluble in water when in the first form.

8. The switchable water composition of any one of claims 1 - 6, wherein the polymer is:

a biopolymer or a derivative thereof;
a functionalized branched or linear polyethyleneimine;
a functionalized polymethyl methacrylate (“PMMA”) based polymer;
a functionalized polyacrylic acid (“PAA”) polymer;
an amine-containing polyacrylic acid salt;
a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”);
a polymer synthesized from amine-containing monomers;
or any combination thereof.

9. The switchable water composition of any one of claims 1 - 8, for use in a system comprising means for separating the additive from the water in said switchable water composition; wherein:

the means for separating the additive from the water comprises a reverse osmosis system;

the first form of the switchable additive is immiscible in water and the system additionally comprises means for decanting the first form of the additive from the water; or

the first form of the switchable additive is insoluble in water and the system additionally comprises means for removing the insoluble first form of the additive.

10. A method for modulating the ionic strength of an aqueous solution, comprising:

(a) contacting a switchable water composition comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water composition, with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water composition;

wherein the additive is a polymer, and the the polymer has at least one amine nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger, and has a conjugate acid with a pK_a in a range from 6 to 14, or from 8 to 10;

wherein the polymer is optionally a polyamine.

11. The method of claim 10 for removing a solute from an aqueous solution or for concentrating a dilute aqueous solution, wherein the method additionally comprises the steps of:

(b) providing a semi-permeable membrane that is selectively permeable for water and has on one side a draw solution that comprises said switchable water composition, wherein the step of contacting the switchable water composition with the ionizing trigger to switch the additive to the second form is performed before or

after association of the switchable water composition with the semi-permeable membrane to increase the osmotic pressure of the draw solution; and

(c) contacting the semi-permeable membrane with a feed stream of the aqueous solution to permit water to flow from the aqueous solution through the semi-permeable membrane into the increased ionic strength draw solution.

12. The method of claim 11, wherein the solute is a salt and the feed stream is an aqueous salt solution.

13. The method of claim 11 or 12, additionally comprising:

(d) removing the additive from the resulting diluted draw solution,

wherein step (d) comprises:

contacting the diluted draw solution with a non-ionizing trigger to switch the additive to its first form;

reverse osmosis;

decanting the first form of the additive from the water, wherein the first form of the switchable additive is immiscible in water; or

removing the insoluble first form of the additive from the water, wherein the first form of the switchable additive is insoluble in water.

14. The method of any one of claims 10 - 13, wherein the ionizing trigger is:

a Brønsted acid; or

a gas that when dissolved in water reacts with water to liberate hydrogen ions.

15. The method of claim 14, wherein the ionizing trigger is CO_2.

16. The method of any one of claims 11 - 15, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine;

a functionalized polymethyl methacrylate (“PMMA”) based polymer;

a functionalized polyacrylic acid (“PAA”) polymer;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”);

a polymer synthesized from amine-containing monomers;

or any combination thereof.

17. The method of any one of claims 10 - 15, wherein the polymer is insoluble in water when in the first form; or is at least partially soluble in water when in the first form.

18. The method of any one of claims 10 - 17, additionally comprising the step of contacting the switchable water composition with a non-ionizing trigger to neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form; wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

19. A switchable water composition comprising:

water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water composition;

wherein contacting the switchable water composition with an ionizing trigger to ionize at least one functional group in the additive increases the ionic strength of the switchable water composition and removal of the ionizing trigger from the switchable water composition reduces the ionic strength of the switchable water composition,

wherein the additive is a polymer, and the the polymer has at least one amine nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger, and has a conjugate acid with a pK_a in a range from 6 to 14, or from 8 to 10,

wherein the polymer is optionally a polyamine; and

wherein the switchable water composition is for:

destabilizing a suspension in a system, wherein the system comprises:

the switchable water composition;

a mixture of water or an aqueous solution and one or more particle solids that are substantially insoluble in water;

and means to stop the formation of a suspension of the one or more particle solids or destabilize a suspension of the one or more particle solids by addition of the ionizing trigger to the switchable water composition.

20. The switchable water composition of claim 19, wherein the polymer is:

a biopolymer or a derivative thereof;

a functionalized branched or linear polyethyleneimine;

a functionalized polymethyl methacrylate ("PMMA") based polymer;

a functionalized polyacrylic acid ("PAA") polymer;

an amine-containing polyacrylic acid salt;

a functionalized poly(methyl methacrylate-co-styrene) ("PMMA/PS");

a polymer synthesized from amine-containing monomers;

or any combination thereof.

21. The switchable water composition of claim 19 or 20, wherein the ionizing trigger is:

a Brønsted acid; or

a gas that when dissolved in water reacts with water to liberate hydrogen ions.

22. The switchable water composition of claim 21, wherein the ionizing trigger is CO_2.

23. The switchable water composition of any one of claims 19 - 22 for destabilizing a suspension, wherein the switchable water composition is for use in removal of undesirable solids from water; or for separation or removal of clay particles from water.

24. The switchable water composition of any one of claims 19 - 23, wherein contacting the switchable water composition with a non-ionizing trigger will neutralize the at least one functional group ionized by the ionizing trigger and thereby switch the additive from the second form to the first form;

wherein the non-ionizing trigger is (i) heat, (ii) a flushing gas, (iii) a vacuum or partial vacuum, (iv) agitation, (v) a strong base, or (vi) any combination thereof.

25. A method for modulating the ionic strength of an aqueous solution, comprising:

contacting a switchable water composition comprising water and an additive switchable between a first form and a second form, wherein said second form of the additive includes at least one ionized functional group that is neutral in said first form of the additive, such that switching the additive from the first form to the second form increases the ionic strength of the switchable water composition, with an ionizing trigger to ionize at least one functional group in the additive and thereby increase the ionic strength of the switchable water composition,

wherein the additive is a polymer, and the polymer has at least one amine nitrogen-containing functional group that is sufficiently basic to be protonated when the polymer is in the presence of an ionizing trigger, and has a conjugate acid with a pK_a in a range from 6 to 14, or from 8 to 10,

wherein the polymer is optionally a polyamine; and

wherein the method is for destabilizing a suspension or preventing formation of a suspension, additionally comprising:

combining, in any order, to form a mixture:

water or an aqueous solution and one or more particle solids that are substantially insoluble in water;

and allowing the mixture to separate into two components, a first component comprising the particle solids and a second component comprising water and an ionic form of the additive.

26. The method of claim 25, wherein a surfactant is also combined with said mixture, said water or aqueous solution, said additive, or said ionizing trigger.

27. The method of claim 25 or 26, wherein the polymer is:
a biopolymer or a derivative thereof;
a functionalized branched or linear polyethyleneimine;
a functionalized polymethyl methacrylate (“PMMA”) based polymer;
a functionalized polyacrylic acid (“PAA”) polymer;
an amine-containing polyacrylic acid salt;
a functionalized poly(methyl methacrylate-co-styrene) (“PMMA/PS”);
a polymer synthesized from amine-containing monomers;
or any combination thereof.

28. The method of any one of claims 25 - 27, wherein the ionizing trigger is:
a Brønsted acid; or
a gas that when dissolved in water reacts with water to liberate hydrogen ions.

29. The method of claim 28, wherein the ionizing trigger is CO_2.

30. The method of any one of claims 25 - 29, for:
destabilizing a suspension or preventing formation of a suspension, wherein the method further comprises the step of removing said one or more particle solids;
wherein said one or more particle solids can be clay particles, or
wherein the mixture of said one or more particle solids and water or an aqueous solution can be wastewater or storm water.