

CLAIMS

What is claimed is:

1. A method for sequestering cations that can precipitate from an aqueous composition, the method comprising:
 - adding a multi-dentate ligand to an aqueous composition that includes monovalent ions and at least one type of dissolved divalent cation that can precipitate from the aqueous composition to produce scaling; then
 - enabling the multi-dentate ligand to bond with the dissolved divalent cation to form a an aqueous non-scaling ionic complex; then
 - ~~using at least a portion of the aqueous solution in a process involving production of substantially pure water from~~ filtering the aqueous non-ionic scaling complex from the aqueous composition with a membrane that retains the aqueous non-scaling ionic complex in a brine and that passes a remnant of the aqueous composition comprising water and monovalent ions ~~where the cation, absent formation of the ionic complex, is subject to scaling;~~
 - reducing the pH of the ~~aqueous composition or of a filtered brine including components of the aqueous composition~~ to release the divalent cation from the multi-dentate ligand; and
 - ~~reintroducing the multi-dentate ligand~~ after the cation is released, reintroducing the multi-dentate ligand into additional aqueous composition to form additional non-scaling ionic complex in a predominantly closed loop.
2. The method of claim 1, wherein the dissolved divalent cation includes at least one of the following: calcium, barium, strontium and magnesium.
3. The method of claim 1, wherein the aqueous composition includes flowback water or produced water from oil or gas extraction.
4. The method of claim 1, wherein the aqueous composition includes at least one of sea water and brackish water.
5. The method of claim 1, wherein the aqueous composition includes waste water.
6. The method of claim 1, wherein the pH of the ~~aqueous composition or~~ filtered brine is reduced via addition of an acid to release the scaling component from the multi-dentate ligand.

7. The method of claim 1, further comprising separating purified water from the brine with the non-scaling ionic complex included in the brine.
8. The method of claim 1, ~~further comprising separating purified water from other components of the aqueous composition via~~ wherein the separation of the purified water from the monovalent ions of the remnant of the aqueous composition is performed via a desalination process selected from at least one of the following: reverse osmosis, multi-stage flash distillation, multiple-effect distillation, mechanical vapor recompression, electrodialysis, membrane distillation, directional solvent extraction and humidification-dehumidification.
9. The method of claim 1, further comprising ~~separating purified water from other components of the aqueous composition in a process that heats~~ heating the remnant of the aqueous composition up to a temperature at which the dissolved divalent cation would precipitate from the aqueous composition absent bonding of the scaling component in the non-scaling ionic complex if the dissolved divalent cation remained in the remnant of the aqueous composition in unbounded form.
10. The method of claim 1, ~~further comprising separating purified water from other components wherein the remnant of the aqueous composition in a process that heats the aqueous composition is heated~~ up to a temperature of at least 50°C.
11. The method of claim 1, wherein the ~~aqueous composition includes~~ monovalent ions include at least one dissolved component of a compound selected from NaCl, KCl, Na₂SO₄, and Na₂CO₃.
12. The method of claim 1, wherein the pH of the ~~aqueous composition or a brine including components of the aqueous composition~~ the ionic complex is reduced by adding an acid to the ~~aqueous composition or brine~~, the method further comprising adding a base to the ~~aqueous composition or brine~~ after the multi-dentate ligand is released and removed, wherein the base neutralizes the acid.
13. ~~The method of claim 1, further comprising filtering the non-scaling ionic complex from the aqueous composition to produce the brine, wherein the filtered brine includes the non-scaling ionic complex, and wherein the pH of the filtered brine is reduced to release the multi-dentate ligand.~~
14. ~~The method of claim 13, further comprising separating purified water from a portion of the aqueous composition that remains after the coordination complex containing brine is filtered out.~~

- ~~1513.~~ The method of claim 1, wherein the ~~solution containing~~ brine including the ionic complex is cooled to less than 20°C after the pH is reduced to increase the amount of multi-dentate ligand released from the cation.
- ~~1614.~~ The method of claim 1, wherein the multi-dentate ligand comprises an ethylenediamine tetra-acetate ion.
- ~~1715.~~ An apparatus for scaling-preventive desalination, the apparatus comprising:
a source of an aqueous composition including monovalent ions and at least one type of dissolved divalent cation that can precipitate from the aqueous composition to produce scaling;
a desalination system;
a first conduit configured to feed the aqueous composition from the aqueous-composition source to the desalination system;
a source of a multi-dentate ligand;
a second conduit configured to feed the multi-dentate ligand from the multi-dentate-ligand source into the first conduit to bond the multi-dentate ligand with divalent cations in the aqueous composition to form a non-scaling ionic complex;
a filtration unit coupled with the first conduit and configured to receive the aqueous composition with the non-ionic scaling complex, wherein the filtration unit includes a membrane having pores sized to pass the remnant of the aqueous composition before the aqueous composition is fed to the desalination system;
a pH-reduction apparatus coupled with a source of a pH-reducing agent and configured to separate the divalent cations from the multi-dentate ligand; and
a third conduit configured to feed the non-scaling ionic complex ~~in the aqueous composition or in a brine produced from the aqueous composition~~ from the filtration unit to the pH-reduction apparatus.
- ~~1816.~~ The apparatus of claim ~~1715~~, wherein the second conduit is configured to feed the multi-dentate ligand from the pH-reduction apparatus into the first conduit.
- ~~1917.~~ The apparatus of claim ~~1816~~, ~~further comprising an~~ wherein the ultra-filtration unit is coupled with the first conduit and configured to separate the non-scaling complex from the remnant of the aqueous composition before the aqueous composition is fed to the desalination system.