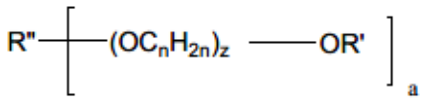
wherein each R' is independently either a hydrogen atom, hydrogen radicals, or acyl radicals; R" is independently either a hydrogen atom, hydrogen radicals, amine-containing radicals, or acyl radicals; each "n" has, independently, a value of from 2 to 4; each "Z" has, independently, a value of from 4 to about 1800; and "a" has a value of from 1 to 4. In a preferred example, "n" = 2 or 3; "a" has a value of 1; and each R' or R" is independently either a hydrogen atom, hydrogen radicals, or acyl radicals, resulting respectively in either an ethylene oxide ("EO") or propylene oxide ("PO") polymer. The base polymer preferably has a molecular weight of between about 200 Daltons and 80,000 Daltons.

[0009a] In accordance with one aspect of the disclosure, there is provided a method of inhibiting silica scale formation, said method comprising the steps of: treating an aqueous system comprising silica with an effective amount of a polymerizable-acid graft polymer ~~comprising~~ consisting of from 3.0% to 35% by weight of an unsaturated grafting acid and an alkylene oxide polymer backbone, said alkylene oxide polymer backbone having the following formula:



wherein each R' is independently selected from the group consisting of a hydrogen atom, ~~hydrogen radicals,~~ and acyl radicals;

wherein R" is independently selected from the group consisting of a hydrogen atom, ~~hydrogen radicals,~~ amine-containing radicals, and acyl radicals;

wherein each "n" ~~=~~ ~~has, independently, a value of from~~ 2 ~~to 4~~or 3;

wherein each "Z" has, independently, a value of from 4 to 1800; and

wherein "a" has a value of from 1 to 4; ~~and~~

wherein said alkylene oxide polymer backbone is a copolymer of oxyethylene ("EO") and oxypropylene ("PO") polymers having a weight ratio of from 75:25 to 25:75 of EO:PO, and

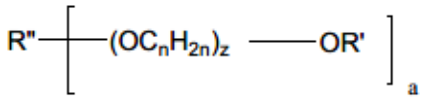
wherein said grafting acid is selected from acrylic acid, methacrylic acid and mixtures thereof~~wherein said aqueous system has a pH of from 6.5 to 8.5~~.

[0010] The disclosure covers the novel use of an acrylic acid grafted ethylene oxide–propylene oxide (EO-PO) copolymer as a colloidal silica scale inhibitor that can be used in reverse osmosis (RO), cooling tower, boiler, geothermal, and SAGD applications. In a preferred example, the copolymer for use in the disclosed disclosure is a copolymer of EO and PO with a molecular weight of approximately 5000 Daltons, with approximately 10% by weight of acrylic acid grafted to the alkylene oxide polymer backbone.

CLAIMS

What is claimed is:

1. A method of inhibiting silica scale formation, said method comprising the steps of: treating an aqueous system comprising silica with an effective amount of a polymerizable-acid graft polymer ~~comprising~~ consisting of from 3.0% to 35% by weight of an unsaturated grafting acid and an alkylene oxide polymer backbone, said alkylene oxide polymer backbone having the following formula:



wherein each R' is independently selected from the group consisting of a hydrogen atom, ~~hydrogen radicals,~~ and acyl radicals;

wherein R" is independently selected from the group consisting of a hydrogen atom, ~~hydrogen radicals,~~ amine-containing radicals, and acyl radicals;

wherein each "n" ~~has, independently, a value of from~~ = 2 ~~to 4~~or 3;

wherein each "Z" has, independently, a value of from 4 to 1800; and

wherein "a" has a value of from 1 to 4; ~~and~~

~~wherein said aqueous system has a pH of from 6.5 to 8.5~~

wherein said alkylene oxide polymer backbone is a copolymer of oxyethylene ("EO") and oxypropylene ("PO") polymers having a weight ratio of from 75:25 to 25:75 of EO:PO, and

wherein said grafting acid is selected from acrylic acid, methacrylic acid and mixtures thereof.

2. The method of claim 1, wherein said R' is acyl radicals free of aliphatic unsaturation.

3. The method of claim 1, wherein R' and R" are not both a hydrogen atom.

~~4. The method of claim 1, wherein said grafting acid is selected from the group consisting of acrylic acid, methacrylic acid, itaconic acid, maleic acid, 2-acrylamido-2-methylpropylsulfonic acid (AMPS), 2-methacrylamido-2-methylpropylsulfonic acid, styrene sulfonic acid, vinylsulfonic acid, ethylene glycol methacrylate phosphate, vinyl phosphonic acid and mixtures thereof.~~

~~5. The method of claim 1, wherein "n" = 2 or 3;~~

~~wherein "a" has a value of 1;~~

~~wherein each R' or R" independently selected from the group consisting of a hydrogen atom, hydrogen radicals, and acyl radicals; and~~

~~wherein said alkylene oxide polymer backbone is either an ethylene oxide ("EO") or propylene oxide ("PO") polymer.~~

~~6. The method of claim 1, wherein said alkylene oxide polymer backbone is selected from the group consisting of oxyethylene ("EO") and oxypropylene ("PO").~~

~~7. The method of claim 1, wherein said alkylene oxide polymer backbone is a copolymer of EO and PO polymers having a weight ratio of from 0:100 to 100:0 of EO:PO.~~

~~8. The method of claim 1, wherein said alkylene oxide polymer backbone is a copolymer of EO and PO polymers having a weight ratio of from 90:10 to 10:90 of EO:PO.~~

~~9. The method of claim 1, wherein said alkylene oxide polymer backbone is a copolymer of EO and PO polymers having a weight ratio of from 75:25 to 25:75 of EO:PO.~~

~~10.~~4. The method of claim 1 wherein said polymerizable-acid graft polymer has a weight average molecular weight between 1500 Daltons and 80000 Daltons.

~~11.~~5. The method of claim 1, wherein the polymerizable-acid graft polymer consists of ~~said grafting acid is~~ 10% by weight of acrylic acid and the alkylene oxide polymer backbone, and said alkylene oxide polymer backbone is poly~~(~~oxyethylene-oxypropylene~~)~~ having a weight ratio of ~~oxyethylene ("~~EO~~")~~ to ~~oxypropylene ("~~PO~~")~~ of 50:50.

~~12.~~6. The method of claim ~~10~~4, wherein said poly~~(~~oxyethylene-oxypropylene~~)~~ has a molecular weight of approximately 5000 Daltons.

~~13.~~7. The method of claim 1, wherein said effective amount of said graft polymer is between 0.5 ppm and 1000 ppm.

8. The method of claim 1, wherein said aqueous system has a pH of from 6.0 to 10.0.

~~14.~~9. The method of claim 1, wherein said aqueous system has a temperature between 20°C and 250°C.

~~15.~~10. The method of claim 1, wherein said aqueous system is selected from the group consisting of cooling water, desalination, filtration, reverse osmosis, sugar evaporators, paper processing, mining circuits, and geothermal energy systems~~, SAGD systems, and silica brine~~.

11. The method of claim 1, wherein said aqueous system is a SAGD system.

12. The method of claim 1, wherein said aqueous system is silica brine.

~~16.~~13. The method of claim ~~10~~4, wherein said aqueous system is said silica brine; wherein said graft polymer inhibits silica scale formation with minimal formation of precipitates.

~~17.~~14. The method of claim 1, wherein the effective amount of said aqueous system is between 5 ppm and 15 ppm;

wherein said aqueous system has a percent inhibition of silica scale of greater than 50% after 24 hours of treatment with said graft polymer; and

wherein said aqueous system has a turbidity of less than 10 NTU after 24 hours of treatment with said graft polymer.