

wherein x = 5 wt.% - 45 wt.%;

wherein y = 55 wt.% - 95 wt.%;

wherein z = ~~1~~ 0 wt.% - 25 wt.%;

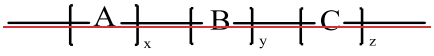
wherein A is the repeat unit obtained after the polymerization of ~~one or more anionic monomers selected from the group consisting of~~ acrylic acid~~, the salt of acrylic acid, methacrylic acid, the salt of methacrylic acid, itaconic acid, the salt of itaconic acid, maleic acid, the salt of maleic acid, 2-acrylamido-2-methylpropylsulfonic acid (AMPS), the salt of AMPS, 2-methacrylamido-2-methylpropylsulfonic acid, the salt of 2-methacrylamido-2-methylpropylsulfonic acid, styrene sulfonic acid, the salt of styrene sulfonic acid, vinylsulfonic acid, the salt of vinylsulfonic acid, ethylene glycol methacrylate phosphate, and mixtures thereof~~;

wherein B is the repeat unit obtained after the polymerization of ~~one or more polyoxoalkylene-containing monomers selected from the group consisting of polyethylene glycol methacrylate, polyethylene glycol acrylate, poly~~ethylene glycol methyl ether methacrylate~~, polyethylene glycol methyl ether acrylate, and mixtures thereof~~; and

wherein C is the repeat unit obtained after the polymerization of one or more nonionic monomers selected from the group consisting of methyl methacrylate, ethyl acrylate, hydroxy ethyl methacrylate, hydroxy propyl acrylate and cellosolve acrylate, (meth)acrylamide, N-methyl acrylamide, N,N-dimethylacrylamide, N-isopropyl acrylamide, N-t-butyl acrylamide, N,N-dimethylaminoethyl (meth)acrylate, t-butyl acrylamide, t-octyl acrylamide and dimethylacrylamide.~~methacrylates, acrylates, and acrylamides, and~~

~~wherein said polymer has a number average molecular weight between 2000 Daltons and 60000 Daltons.~~

~~[0008b] In accordance with another aspect of the disclosure, there is provided a polymer for inhibiting silica scale formation, said polymer comprising monomer A, monomer B, and monomer C, such that said polymer has the chemical formula:~~



~~wherein x = 5 wt.% - 45 wt.%;~~

~~wherein y = 55 wt.% - 95 wt.%;~~

~~wherein z = 1 wt.% - 25 wt.%;~~

~~wherein A is the repeat unit obtained after the polymerization of one or more anionic monomers selected from the group consisting of acrylic acid, the salt of acrylic acid, methacrylic acid, the salt of methacrylic acid, itaconic acid, the salt of itaconic acid, maleic acid, the salt of maleic acid, 2-acrylamido-2-methylpropylsulfonic acid (AMPS), the salt of AMPS, 2-methacrylamido-2-methylpropylsulfonic acid, the salt of 2-methacrylamido-2-methylpropylsulfonic acid, styrene sulfonic acid, the salt of styrene sulfonic acid, vinylsulfonic acid, the salt of vinylsulfonic acid, ethylene glycol methacrylate phosphate, and mixtures thereof;~~

~~wherein B is the repeat unit obtained after the polymerization of one or more polyoxoalkylene-containing monomers selected from the group consisting of polyethylene glycol methacrylate, polyethylene glycol acrylate, polyethylene glycol methyl ether methacrylate, polyethylene glycol methyl ether acrylate, and mixtures thereof; and~~

~~wherein C is the repeat unit obtained after the polymerization of one or more nonionic monomers selected from the group consisting of methacrylates, acrylates, and acrylamides, and~~

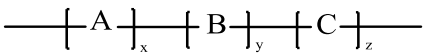
~~wherein said polymer has a number average molecular weight between 2000 Daltons and 60000 Daltons.~~

[0009] The disclosure covers the use of novel bottle brush copolymers of one or more anionic monomers in combination with one or more polyoxoalkylene-containing monomers of varying molecular weight, or bottle brush copolymers of a polyoxoalkylene-containing monomer and either two or more anionic monomers, or an anionic monomer and nonanionic monomer. Preferred anionic monomers include, but are not limited to carboxylic acids,

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 polymer comprising monomer A, monomer B, and monomer C, such that said polymer has the chemical formula:



wherein x = 5 wt.% - 45 wt.%;

wherein y = 55 wt.% - 95 wt.%;

wherein z = ~~1~~ 0 wt.% - 25 wt.%;

wherein A is the repeat unit obtained after the polymerization of ~~one or more anionic monomers selected from the group consisting of~~ acrylic acid~~, the salt of acrylic acid, methacrylic acid, the salt of methacrylic acid, itaconic acid, the salt of itaconic acid, maleic acid, the salt of maleic acid, 2-acrylamido-2-methylpropylsulfonic acid (AMPS), the salt of AMPS, 2-methacrylamido-2-methylpropylsulfonic acid, the salt of 2-methacrylamido-2-methylpropylsulfonic acid, styrene sulfonic acid, the salt of styrene sulfonic acid, vinylsulfonic acid, the salt of vinylsulfonic acid, ethylene glycol methacrylate phosphate, and mixtures thereof~~;

wherein B is the repeat unit obtained after the polymerization of ~~one or more polyoxoalkylene-containing monomers selected from the group consisting of polyethylene glycol methacrylate, polyethylene glycol acrylate, poly~~ethylene glycol methyl ether methacrylate~~, polyethylene glycol methyl ether acrylate, and mixtures thereof~~; and

wherein C is the repeat unit obtained after the polymerization of one or more nonionic monomers selected from the group consisting of methyl methacrylate, ethyl acrylate, hydroxy ethyl methacrylate, hydroxy propyl acrylate and cellosolve acrylate, (meth)acrylamide, N-methyl acrylamide, N,N-dimethylacrylamide, N-isopropyl acrylamide, N-t-butyl acrylamide, N,N-dimethylaminoethyl (meth)acrylate, t-butyl acrylamide, t-octyl acrylamide and dimethylacrylamide~~methacrylates, acrylates, and acrylamides., and~~

~~wherein said polymer has a number average molecular weight between 2000 Daltons and 60000 Daltons.~~

~~2. The method of claim 1, wherein C is selected from the group consisting of methyl methacrylate, ethyl acrylate, hydroxy ethyl methacrylate hydroxy propyl acrylate and cellosolve acrylate, (meth)acrylamide, N-methyl acrylamide, N,N-dimethylacrylamide, N-isopropyl acrylamide, N-t-butyl acrylamide, N,N-dimethylaminoethyl (meth)acrylate, t-butyl acrylamide, t-octyl acrylamide and dimethylacrylamide.~~

~~3. The method of claim 1, wherein A is acrylic acid;~~
~~wherein B is polyethylene glycol methyl ether methacrylate;~~
~~wherein x= approximately 20 wt. %; and~~
~~wherein y = approximately 80 wt. %.~~

~~4.~~2. The method of claim ~~3~~1, wherein said ~~polyethylene glycol methyl ether methacrylate~~ polymer has a number average molecular weight between ~~of approximately~~ 2000 Daltons and 60000 Daltons.

~~5. The method of claim 1, wherein said effective amount of said polymer is between 0.5 ppm and 1000 ppm.~~

~~6. The method of claim 1, wherein said aqueous system has a pH of from 6.0 to 10.0.~~

~~7. The method of claim 6, wherein said aqueous system has a temperature between 20°C and 250°C.~~

~~8.~~3. The method of claim 1, wherein x = approximately 20 wt. %; and wherein y = approximately 80 wt. %.~~5 wt.% - 30 wt.%; and~~
~~wherein y = 70 wt.% - 95 wt.%.~~

4. The method of claim 1, wherein said polyethylene glycol methyl ether methacrylate has a number average molecular weight of approximately 2000 Daltons.

5. The method of claim 1, wherein said effective amount of said polymer is between approximately 0.5 ppm and approximately 1000 ppm.

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

7. The method of claim 1, wherein x = approximately 5 wt.% - approximately 30 wt.%; and wherein y = approximately 70 wt.% - approximately 95 wt.%.

~~9.~~8. 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, geothermal energy systems, SAGD systems, and silica brine.

~~10.~~9. The method of claim 1, wherein said aqueous system is said silica brine; and

wherein said ~~bottle-brush~~ polymer inhibits the formation of colloidal silica without the formation of insoluble precipitates.

10. The method of claim 1, wherein n is greater than 40 and less than or equal to 100.

11. The method of claim 1, wherein n is greater than 80 and less than or equal to 100

~~11.~~12. The method of claim 1, ~~wherein A is methacrylic acid;~~

~~wherein B is polyethylene glycol methyl ether methacrylate;~~

wherein C is methyl methacrylate;

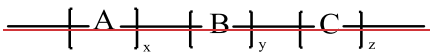
wherein x is approximately 7 wt.%;

wherein y is approximately 72 wt.%; and

wherein z is approximately 21 wt.%.

~~12. The method of claim 11, wherein said polyethylene glycol methyl ether methacrylate has a number average molecular weight of approximately 550 Daltons.~~

~~13. A polymer for inhibiting silica scale formation, said polymer comprising monomer A, monomer B, and monomer C, such that said polymer has the chemical formula:~~



~~wherein x = 5 wt.% - 45 wt.%;~~

~~wherein y = 55 wt.% - 95 wt.%;~~

~~wherein z = 1 wt.% - 25 wt.%;~~

~~wherein A is the repeat unit obtained after the polymerization of one or more anionic monomers selected from the group consisting of acrylic acid, the salt of acrylic acid, methacrylic acid, the salt of methacrylic acid, itaconic acid, the salt of itaconic acid, maleic acid, the salt of maleic acid, 2-acrylamido-2-methylpropylsulfonic acid (AMPS), the salt of AMPS, 2-methacrylamido-2-methylpropylsulfonic acid, the salt of 2-methacrylamido-2-methylpropylsulfonic acid, styrene sulfonic acid, the salt of styrene sulfonic acid, vinylsulfonic acid, the salt of vinylsulfonic acid, ethylene glycol methacrylate phosphate, and mixtures thereof;~~

~~wherein B is the repeat unit obtained after the polymerization of one or more polyoxoalkylene-containing monomers selected from the group consisting of polyethylene glycol methacrylate, polyethylene glycol acrylate, polyethylene glycol methyl ether methacrylate, polyethylene glycol methyl ether acrylate, and mixtures thereof; and~~

~~wherein C is the repeat unit obtained after the polymerization of one or more nonionic monomers selected from the group consisting of methacrylates, acrylates, and acrylamides, and~~

~~wherein said polymer has a number average molecular weight between 2000 Daltons and 60000 Daltons.~~

~~14. The polymer of claim 13, wherein A is acrylic acid;~~
~~wherein B is polyethylene glycol methyl ether methacrylate;~~
~~wherein x= approximately 20 wt. %; and~~
~~wherein y = approximately 80 wt. %.~~

~~15. The polymer of claim 14, wherein said polyethylene glycol methyl ether methacrylate has a number average molecular weight of approximately 2000 Daltons.~~

~~16. The polymer of claim 13, wherein A is methacrylic acid;~~
~~wherein B is polyethylene glycol methyl ether methacrylate;~~
~~wherein C is methyl methacrylate;~~
~~wherein x is approximately 7 wt.%;~~
~~wherein y is approximately 72 wt.%; and~~
~~wherein z is approximately 21 wt.%.~~

~~17. The method of claim 16, wherein said polyethylene glycol methyl ether methacrylate has a number average molecular weight of approximately 550 Daltons.~~