

CLAIMS

What is claimed is:

1. A method for precipitating a polymer by adding a precipitation agent into a first suspension to form a second suspension; wherein the first suspension comprises a polymer and an aqueous solvent; and wherein the polymer comprises a copolymer comprising a structural unit derived from an acid group-containing monomer and a structural unit derived from a hydrophobic group-containing monomer.
2. The method of claim 1, wherein the copolymer further comprises a hydrophilic group-containing monomer selected from the group consisting of an amide group-containing monomer, a hydroxyl group-containing monomer or combinations thereof; and wherein the hydrophobic group-containing monomer is selected from the group consisting of a nitrile group-containing monomer, an ester group-containing monomer, an epoxy group-containing monomer, a fluorine group-containing monomer or combinations thereof.
3. The method of claim 1, wherein the molar ratio of the structural unit derived from an acid group-containing monomer to the structural unit derived from a hydrophobic group-containing monomer in the copolymer is from about 0.1 to about 3; and wherein the proportion of structural unit derived from a hydrophobic group-containing monomer is from about 15% to about 85% by mole, based on the total number of moles of monomeric units in the copolymer in the polymer.
4. The method of claim 1, wherein the acid group-containing monomer is selected from the group consisting of a carboxylic acid group-containing monomer, a sulfonic acid group-containing monomer, a phosphonic acid group-containing monomer or combinations thereof; and wherein the pK_a of the acid group-containing monomer is from about 2.5 to about 7.
5. The method of claim 4, wherein the carboxylic acid group-containing monomer is selected from the group consisting of acrylic acid, methacrylic acid, crotonic acid, 2-butyl crotonic acid, cinnamic acid, maleic acid, maleic anhydride, fumaric acid, itaconic acid, itaconic anhydride, tetraconic acid, 2-ethylacrylic acid, isocrotonic acid, cis-2-pentenoic acid, trans-2-pentenoic acid, angelic acid, tiglic acid, 3,3-dimethyl acrylic acid, 3-propyl acrylic acid, trans-2-methyl-3-ethyl acrylic acid, cis-2-methyl-3-ethyl acrylic acid, 3-isopropyl acrylic acid, trans-3-methyl-3-ethyl acrylic acid, cis-3-methyl-3-ethyl acrylic acid, 2-isopropyl acrylic acid, trimethyl acrylic acid, 2-methyl-3,3-diethyl acrylic acid, 3-butyl acrylic acid, 2-butyl acrylic acid, 2-pentyl acrylic acid, 2-methyl-2-hexenoic acid, trans-3-methyl-2-hexenoic acid, 3-methyl-3-propyl acrylic acid, 2-ethyl-3-propyl acrylic acid, 2,3-diethyl acrylic acid, 3,3-diethyl acrylic acid, 3-methyl-3-hexyl acrylic acid, 3-methyl-3-tert-butyl acrylic acid, 2-methyl-3-pentyl acrylic acid, 3-methyl-3-pentyl acrylic acid, 4-methyl-2-hexenoic acid, 4-ethyl-2-hexenoic acid, 3-methyl-2-

ethyl-2-hexenoic acid, 3-tert-butyl acrylic acid, 2,3-dimethyl-3-ethyl acrylic acid, 3,3-dimethyl-2-ethyl acrylic acid, 3-methyl-3-isopropyl acrylic acid, 2-methyl-3-isopropyl acrylic acid, trans-2-octenoic acid, cis-2-octenoic acid, trans-2-decenoic acid, α -acetoxyacrylic acid, β -trans-aryloxyacrylic acid, α -chloro- β -E-methoxyacrylic acid, methyl maleic acid, dimethyl maleic acid, phenyl maleic acid, bromo maleic acid, chloromaleic acid, dichloromaleic acid, fluoromaleic acid, difluoro maleic acid, nonyl hydrogen maleate, decyl hydrogen maleate, dodecyl hydrogen maleate, octadecyl hydrogen maleate, fluoroalkyl hydrogen maleate, maleic anhydride, methyl maleic anhydride, dimethyl maleic anhydride, acrylic anhydride, methacrylic anhydride, methacrolein, methacryloyl chloride, methacryloyl fluoride, methacryloyl bromide and combinations thereof.

6. The method of claim 4, wherein the sulfonic acid group-containing monomer is selected from the group consisting of vinylsulfonic acid, methylvinylsulfonic acid, allylvinylsulfonic acid, allylsulfonic acid, methallylsulfonic acid, styrenesulfonic acid, 2-sulfoethyl methacrylic acid, 2-methylprop-2-ene-1-sulfonic acid, 2-acrylamido-2-methyl-1-propane sulfonic acid, 3-allyloxy-2-hydroxy-1-propane sulfonic acid and combinations thereof.

7. The method of claim 4, wherein the phosphonic acid group-containing monomer is selected from the group consisting of vinyl phosphonic acid, allyl phosphonic acid, vinyl benzyl phosphonic acid, acrylamide alkyl phosphonic acid, methacrylamide alkyl phosphonic acid, acrylamide alkyl diphosphonic acid, acryloylphosphonic acid, 2-methacryloyloxyethyl phosphonic acid, bis(2-methacryloyloxyethyl) phosphonic acid, ethylene 2-methacryloyloxyethyl phosphonic acid, ethyl-methacryloyloxyethyl phosphonic acid and combinations thereof.

8. The method of claim 1, wherein the proportion of structural unit derived from an acid group-containing monomer is from about 15% to about 85% by mole, based on the total number of moles of monomeric units in the copolymer in the polymer.

9. The method of claim 2, wherein the nitrile group-containing monomer is selected from the group consisting of acrylonitrile, α -halogenoacrylonitrile, α -alkylacrylonitrile, α -chloroacrylonitrile, α -bromoacrylonitrile, α -fluoroacrylonitrile, methacrylonitrile, α -ethylacrylonitrile, α -isopropylacrylonitrile, α -n-hexylacrylonitrile, α -methoxyacrylonitrile, 3-methoxyacrylonitrile, 3-ethoxyacrylonitrile, α -acetoxyacrylonitrile, α -phenylacrylonitrile, α -tolylacrylonitrile, α -(methoxyphenyl)acrylonitrile, α -(chlorophenyl)acrylonitrile, α -(cyanophenyl)acrylonitrile, vinylidene cyanide and combinations thereof; and wherein the proportion of structural unit derived from a nitrile group-containing monomer is from about 15% to about 85% by mole, based on the total number of moles of monomeric units in the copolymer in the polymer.

10. The method of claim 2, wherein the amide group-containing monomer is selected from the group consisting of acrylamide, methacrylamide, N-methyl methacrylamide, N-ethyl methacrylamide, N-n-propyl methacrylamide, N-isopropyl methacrylamide, isopropyl

acrylamide, N-n-butyl methacrylamide, N-isobutyl methacrylamide, N,N-dimethyl acrylamide, N,N-dimethyl methacrylamide, N,N-diethyl acrylamide, N,N-diethyl methacrylamide, N-methylol methacrylamide, N-(methoxymethyl)methacrylamide, N-(ethoxymethyl)methacrylamide, N-(propoxymethyl)methacrylamide, N-(butoxymethyl)methacrylamide, N,N-dimethyl methacrylamide, N,N-dimethylaminopropyl methacrylamide, N,N-dimethylaminoethyl methacrylamide, N,N-dimethylol methacrylamide, diacetone methacrylamide, diacetone acrylamide, methacryloyl morpholine, N-hydroxyl methacrylamide, N-methoxymethyl acrylamide, N-methoxymethyl methacrylamide, N,N'-methylene-bis-acrylamide (MBA), N-hydroxymethyl acrylamide and combinations thereof; and wherein the proportion of structural unit derived from an amide group-containing monomer is from about 0% to about 35% by mole, based on the total number of moles of monomeric units in the copolymer in the polymer.

11. The method of claim 1, wherein the aqueous solvent is water or a solution containing water as the major component and a minor component.

12. The method of claim 11, wherein the proportion of water in the aqueous solvent is from about 51% to about 100% by weight; and wherein the minor component is selected from the group consisting of methanol, ethanol, isopropanol, n-propanol, tert-butanol, n-butanol, acetone, dimethyl ketone, methyl ethyl ketone, ethyl acetate, isopropyl acetate, propyl acetate, butyl acetate and combinations thereof.

13. The method of claim 1, wherein the precipitation agent is a strong acid, a weak acid or a combination thereof.

14. The method of claim 13, wherein the strong acid is selected from the group consisting of nitric acid, sulphuric acid, hydrochloric acid, perchloric acid, hydrobromic acid, hydroiodic acid, chloric acid, bromic acid, iodic acid, dithionic acid, dithionous acid, sulfamic acid, trithionic acid, tetrathionic acid, methane sulphonic acid, p-toluenesulfonic acid, benzene sulfonic acid, trichloroacetic acid, trifluoroacetic acid, oxalic acid, propiolic acid, mesoxalic acid, mellitic acid or combinations thereof; and wherein the pK_a of the strong acid is from about -10 to about 2.

15. The method of claim 13, wherein the weak acid is selected from the group consisting of formic acid, acetic acid, glycolic acid, glyoxylic acid, oxalic acid, propionic acid, acrylic acid, propiolic acid, lactic acid, 3-hydroxypropionic acid, glyceric acid, pyruvic acid, 3-oxopropionic acid, 2,3-dioxopropionic acid, malonic acid, tartronic acid, dihydroxymalonic acid, mesoxalic acid, glycidic acid, butyric acid, isobutyric acid, crotonic acid, isocrotonic acid, methacrylic acid, vinylacetic acid, tetrolic acid, 2-hydroxybutyric acid, 3-hydroxybutyric acid, 4-hydroxybutyric acid, 2-oxobutanoic acid, acetoacetic acid, 4-oxobutanoic acid, butanedioic acid, methylmalonic acid, fumaric acid, maleic acid, 2-hydroxybutanedioic acid, tartaric acid, oxaloacetic acid, dioxosuccinic acid, valeric acid, isovaleric acid, 2-methylbutyric acid, pivalic acid, 3-

hydroxyvaleric acid, 4-hydroxypentanoic acid, 3-hydroxyisovaleric acid, glutaric acid, 2-oxoglutaric acid, 3-oxoglutaric acid, 2-furoic acid, tetrahydrofuroic acid, hexanoic acid, hexanedioic acid, citric acid, aconitic acid, isocitric acid, sorbic acid, pimelic acid, benzoic acid, salicylic acid, 4-carboxybenzoic acid, trimesic acid, mellitic acid, malic acid, dithionous acid, phosphoric acid, nitrous acid, orthosilicic acid or combinations thereof; and wherein the pK_a of the weak acid is from about 2 to about 7.

16. The method of claim 1, wherein the pH of the second suspension is from about 0.2 to about 4.5.

17. The method of claim 1, wherein the pH of the second suspension is at least 0.2 pH unit below the pK_a of the acid group-containing monomer.

18. The method of claim 1, wherein the second suspension is stirred for a time period of from about 1 minute to 180 minutes; and wherein the precipitation agent is added into the first suspension at a temperature of from about 20 °C to about 95 °C.