CLAIMS

What is claimed is the following:

1. A process comprising:

reacting an insoluble complex of a metal salt with a reducing agent in a reaction mixture comprising a first surfactant, a second surfactant, and a third surfactant so as to form metal nanoparticles;

wherein the first surfactant comprises a primary amine, the second surfactant comprises a secondary amine, and the third surfactant comprises a chelating agent comprising an N,N'-dialkylethylenediamine.

2. The process of claim 1, wherein the metal nanoparticles comprise copper nanoparticles.

3. The process of claim 1, wherein the insoluble complex comprises a coordination compound of the metal salt with at least one of the first surfactant, the second surfactant, and the third surfactant.

4. The process of claim 1, wherein the reaction mixture is substantially oxygen free.

5. The process of claim 1, further comprising:

after forming the metal nanoparticles, quenching the reducing agent with a terminating agent that is reactive therewith.

6. The process of claim 5, wherein the terminating agent is selected from the group consisting of an aldehyde, a nitrile, an organic acid, water, and combinations thereof.

7. The process of claim 1, further comprising:

arresting the formation of the metal nanoparticles by performing an action selected from the group consisting of adding a terminating agent to the reaction mixture, cooling the reaction mixture to about -10°C or below, centrifuging the reaction mixture, and combinations thereof.

8. The process of claim 1, further comprising:

isolating the metal nanoparticles from the reaction mixture.

9. The process of claim 1, wherein the reaction mixture further comprises an organic solvent.

10. The process of claim 9, wherein the organic solvent comprises diglyme or triglyme.

11. The process of claim 1, wherein reacting takes place at a temperature ranging between about 0°C and about 50°C.

12. The process of claim 1, wherein the insoluble complex is formed at a temperature of at most about 85°C.

13. The process of claim 1, wherein the reducing agent comprises $NaBH_4$.

14. The process of claim 1, wherein the metal nanoparticles range from about 3 nm to about 6 nm in size.

15. The process of claim 1, wherein the reaction mixture comprises about 1 part of the first surfactant, about 2 parts of the second surfactant, and about 1 part of the third surfactant.

16. A process comprising:

forming a first solution comprising a copper salt, a first surfactant, a second surfactant, and third surfactant;

wherein the first surfactant comprises a primary amine, the second surfactant comprises a secondary amine, and the third surfactant comprises a chelating agent comprising an N,N'-dialkylethylenediamine;

allowing an insoluble complex of the copper salt to form from the first solution;

combining a second solution comprising a reducing agent with the insoluble complex, thereby forming a reaction mixture; and

forming copper nanoparticles from the insoluble complex.

17. The process of claim 16, wherein the insoluble complex comprises a coordination compound of the copper salt and at least one of the first surfactant, the second surfactant, and the third surfactant.

18. The process of claim 16, wherein the copper salt is selected from the group consisting of a copper halide, copper nitrate, copper acetate, copper sulfate, copper formate, copper oxide, and combinations thereof.

19. The process of claim 16, wherein the first solution and the second solution are substantially oxygen free.

20. The process of claim 16, further comprising:

isolating the insoluble complex from the first solution.

21. The process of claim 16, wherein the primary amine comprises a C4 to C18 primary alkylamine.

22. The process of claim 21, wherein the primary alkylamine comprises a branched alkyl group bound to its nitrogen atom.

23. The process of claim 22, wherein the branching occurs on the carbon atom bound to the nitrogen atom.

24. The process of claim 16, wherein the secondary amine comprises branched or cyclic C4 to C12 alkyl groups bound to its nitrogen atom.

25. The process of claim 24, wherein the branching occurs on the carbon atom bound to the nitrogen atom.

26. The process of claim 16, wherein the diamine comprises a secondary diamine or a tertiary diamine comprising C1 to C6 alkyl groups bound to its nitrogen atoms.

27. The process of claim 26, wherein the secondary diamine or the tertiary diamine comprises branched or cyclic C3 to C6 alkyl groups bound to its nitrogen atoms.

28. The process of claim 16, wherein at least one of the first solution or the second solution comprises an organic solvent comprising diglyme or triglyme.

29. The process of claim 16, wherein formation of the insoluble complex takes place at a temperature of at most about 85°C.

30. The process of claim 16, wherein forming the copper nanoparticles takes place at a temperature between about 0°C and about 50°C.

31. The process of claim 16, further comprising:

heating the second solution prior to combining with the insoluble complex.

32. The process of claim 16, further comprising:

after forming the copper nanoparticles, quenching the reducing agent with a terminating agent that is reactive therewith.

33. The process of claim 32, wherein the terminating agent is selected from the group consisting of an aldehyde, a nitrile, an organic acid, water, and combinations thereof.

34. The process of claim 16, further comprising:

arresting the formation of the copper nanoparticles by performing an action selected from the group consisting of adding a terminating agent to the reaction mixture, cooling the reaction mixture to about -10°C or below, centrifuging the reaction mixture, and combinations thereof.

35. The process of claim 16, further comprising:

isolating the copper nanoparticles.

36. The process of claim 16, wherein the reducing agent comprises $NaBH_4$.

37. The process of claim 16, wherein the copper nanoparticles range from about 3 nm to about 6 nm in size.

38. The process of claim 16, wherein the first solution comprises about 1 part of the first surfactant, about 2 parts of the second surfactant, and about 1 part of the third surfactant.

39. The process of claim 16, wherein the insoluble complex is uniformly distributed in the reaction mixture.

40. The process of claim 16, wherein the reaction mixture has a water content of about 200 ppm or lower.

41. Copper nanoparticles prepared by the process of claim 16 and having a fusion temperature of about 200°C or lower, wherein the copper nanoparticles comprise at least some of the first surfactant, the second surfactant, and the third surfactant.

42. The copper nanoparticles of claim 41, wherein the first surfactant and the second surfactant can be dissociated from the copper nanoparticles by heating.

43. The copper nanoparticles of claim 41, wherein the copper nanoparticles range from about 3 nm to about 6 nm in size.

CLAIMS

What is claimed is the following:

1. A process comprising:

reacting an insoluble complex of a metal salt with a reducing agent in a reaction mixture comprising a solvent, a first surfactant, a second surfactant, and a third surfactant so as to form metal nanoparticles;

wherein the first surfactant comprises a primary amine, the second surfactant comprises a secondary amine, and the third surfactant comprises a chelating agent comprising an N,N'-dialkylethylenediamine, wherein the insoluble complex comprises a coordination compound of the metal salt with at least one of the first surfactant, the second surfactant, and the third surfactant.

2. The process of claim 1, wherein the metal nanoparticles comprise copper nanoparticles.

3. The process of claim 1, wherein the reaction mixture is substantially oxygen free.

4. The process of claim 1, further comprising:

after forming the metal nanoparticles, quenching the reducing agent with a terminating agent that is reactive therewith.

5. The process of claim 4, wherein the terminating agent is selected from the group consisting of an aldehyde, a nitrile, an organic acid, water, and combinations thereof.

6. The process of claim 1, further comprising:

arresting the formation of the metal nanoparticles by performing an action selected from the group consisting of adding a terminating agent to the reaction mixture, cooling the reaction mixture to about -10°C or below, centrifuging the reaction mixture, and combinations thereof.

7. The process of claim 1, further comprising:

isolating the metal nanoparticles from the reaction mixture.

8. The process of claim 1, wherein the reaction mixture further comprises an organic solvent.

9. The process of claim 8, wherein the organic solvent comprises diglyme or triglyme.

10. The process of claim 1, wherein reacting takes place at a temperature ranging between about 0°C and about 50°C.

11. The process of claim 1, wherein the insoluble complex is formed at a temperature of at most about 85°C.

12. The process of claim 1, wherein the reducing agent comprises $NaBH_4$.

13. The process of claim 1, wherein the metal nanoparticles range from about 3 nm to about 6 nm in size.

14. The process of claim 1, wherein the reaction mixture comprises about 1 part of the first surfactant, about 2 parts of the second surfactant, and about 1 part of the third surfactant.

15. A process comprising:

forming a first solution comprising a copper salt, a first surfactant, a second surfactant, and third surfactant;

wherein the first surfactant comprises a primary amine, the second surfactant comprises a secondary amine, and the third surfactant comprises a chelating agent comprising an N,N'-dialkylethylenediamine;

allowing an insoluble complex of the copper salt to form from the first solution;

combining a second solution comprising a reducing agent with the insoluble complex, thereby forming a reaction mixture; and

forming copper nanoparticles from the insoluble complex;

wherein the insoluble complex comprises a coordination compound of the copper salt and at least one of the first surfactant, the second surfactant, and the third surfactant.

16. The process of claim 15, wherein the copper salt is selected from the group consisting of a copper halide, copper nitrate, copper acetate, copper sulfate, copper formate, copper oxide, and combinations thereof.

17. The process of claim 15, wherein the first solution and the second solution are substantially oxygen free.

18. The process of claim 15, further comprising:

isolating the insoluble complex from the first solution.

19. The process of claim 15, wherein the primary amine comprises a C4 to C18 primary alkylamine.

20. The process of claim 19, wherein the primary alkylamine comprises a branched alkyl group bound to its nitrogen atom.

21. The process of claim 20, wherein the branching occurs on the carbon atom bound to the nitrogen atom.

22. The process of claim 15, wherein the secondary amine comprises branched or cyclic C4 to C12 alkyl groups bound to its nitrogen atom.

23. The process of claim 22, wherein the branching occurs on the carbon atom bound to the nitrogen atom.

24. The process of claim 15, wherein the diamine comprises a secondary diamine or a tertiary diamine comprising C1 to C6 alkyl groups bound to its nitrogen atoms.

25. The process of claim 24, wherein the secondary diamine or the tertiary diamine comprises branched or cyclic C3 to C6 alkyl groups bound to its nitrogen atoms.

26. The process of claim 15, wherein at least one of the first solution or the second solution comprises an organic solvent comprising diglyme or triglyme.

27. The process of claim 15, wherein formation of the insoluble complex takes place at a temperature of at most about 85°C.

28. The process of claim 15, wherein forming the copper nanoparticles takes place at a temperature between about 0°C and about 50°C.

29. The process of claim 15, further comprising:

heating the second solution prior to combining with the insoluble complex.

30. The process of claim 15, further comprising:

after forming the copper nanoparticles, quenching the reducing agent with a terminating agent that is reactive therewith.

31. The process of claim 30, wherein the terminating agent is selected from the group consisting of an aldehyde, a nitrile, an organic acid, water, and combinations thereof.

32. The process of claim 15, further comprising:

arresting the formation of the copper nanoparticles by performing an action selected from the group consisting of adding a terminating agent to the reaction mixture, cooling the reaction mixture to about -10°C or below, centrifuging the reaction mixture, and combinations thereof.

33. The process of claim 15, further comprising:

isolating the copper nanoparticles.

34. The process of claim 15, wherein the reducing agent comprises $NaBH_4$.

35. The process of claim 15, wherein the copper nanoparticles range from about 3 nm to about 6 nm in size.

36. The process of claim 15, wherein the first solution comprises about 1 part of the first surfactant, about 2 parts of the second surfactant, and about 1 part of the third surfactant.

37. The process of claim 15, wherein the insoluble complex is uniformly distributed in the reaction mixture.

38. The process of claim 15, wherein the reaction mixture has a water content of about 200 ppm or lower.

39. Copper nanoparticles prepared by the process of claim 15 and having a fusion temperature of about 200°C or lower, wherein the copper nanoparticles comprise at least some of the first surfactant, the second surfactant, and the third surfactant.

40. The copper nanoparticles of claim 39, wherein the first surfactant and the second surfactant can be dissociated from the copper nanoparticles by heating.

41. The copper nanoparticles of claim 39, wherein the copper nanoparticles range from about 3 nm to about 6 nm in size.