CLAIMS

What is claimed is the following:

1. A method comprising:

providing a graphite source;

providing a solution comprising at least one oxidant and at least one protecting agent;

mixing the graphite source with the solution; and

oxidizing the graphite source with the at least one oxidant in the presence of the at least one protecting agent to form graphene oxide.

2. The method of claim 1, wherein the at least one oxidant is selected from the group consisting of permanganate, ferrate, osmate, ruthenate, chlorate, chlorite, nitrate, osmium tetroxide, ruthenium tetroxide, lead dioxide, and combinations thereof.

3. The method of claim 1, wherein the at least one oxidant comprises potassium permanganate.

4. The method of claim 1, wherein the solution further comprises at least one acid solvent.

5. The method of claim 4, wherein the at least one acid solvent is selected from the group consisting of oleum, sulfuric acid, chlorosulfonic acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and combinations thereof.

6. The method of claim 4, wherein the at least one acid solvent comprises sulfuric acid.

7. The method of claim 4, wherein the at least one protecting agent is operable for protecting vicinal diols in the presence of the at least one acid solvent.

8. The method of claim 1, wherein the at least one protecting agent is operable for protecting vicinal diols.

9. The method of claim 8, wherein the at least one protecting agent chelates the vicinal diols.

10. The method of claim 8, wherein the at least one protecting agent protects each alcohol of the vicinal diols individually.

11. The method of claim 1, wherein the at least one protecting agent is selected from the group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; trifluroacetic anhydride; phosphoric anhydride; orthophosphoric anhydride; metaphosphoric anhydride; polyphosphoric anhydride; boric anhydride; mixed anhydrides of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and combinations thereof.

12. The method of claim 1, wherein the at least one protecting agent is selected from the group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and combinations thereof.

13. A method comprising:

providing a graphite source;

providing a solution comprising at least one acid solvent, at least one oxidant and at least one protecting agent;

wherein the at least one protecting agent is operable for protecting vicinal diols;

mixing the graphite source with the solution; and

oxidizing the graphite source with the at least one oxidant in the presence of the at least one protecting agent to form graphene oxide.

14. The method of claim 13, wherein the graphene oxide is more oxidized than graphene oxide prepared in the absence of the at least one protecting agent.

15. The method of claim 13, wherein the at least one acid solvent is selected from the group consisting of oleum, sulfuric acid, chlorosulfonic acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and combinations thereof.

16. The method of claim 13, wherein the at least one acid solvent comprises sulfuric acid.

17. The method of claim 13, wherein the at least one protecting agent is selected from the group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; trifluroacetic anhydride; phosphoric anhydride; orthophosphoric anhydride; metaphosphoric anhydride; polyphosphoric anhydride; boric anhydride; mixed anhydrides of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and combinations thereof.

18. The method of claim 13, wherein the at least one protecting agent is selected from the group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and combinations thereof.

19. The method of claim 13, wherein the at least one oxidant comprises potassium permanganate.

20. The method of claim 13, wherein oxidizing the graphite source takes place at a temperature between about 30°C and about 85°C.

21. The method of claim 13, further comprising:

isolating the graphene oxide.

22. The method of claim 21, further comprising:

reacting the graphene oxide with a derivatizing agent to form a functionalized graphene oxide.

23. The method of claim 21, further comprising:

esterifying the graphene oxide to form an esterified graphene oxide.

24. The method of claim 21, further comprising:

reducing the graphene oxide with at least one reducing agent to form chemically converted graphene.

25. The method of claim 24, wherein the at least one reducing agent is selected from the group consisting of hydrazines, iodides, phosphines, phosphites, sulfides, sulfites, hydrosulfites, borohydrides, cyanoborohydrides, aluminum hydrides, boranes, hydroxylamine, diimine, dissolving metal reductions, hydrogen, and combinations thereof.

26. The method of claim 24, wherein the at least one reducing agent comprises hydrazine.

27. The method of claim 24, wherein the at least one reducing agent comprises hydrogen.

28. The method of claim 24, further comprising:

esterifying the chemically converted graphene to form an esterified, chemically converted graphene.

29. The method of claim 24, further comprising:

reacting the chemically converted graphene with a derivatizing agent to form a functionalized, chemically converted graphene.

30. The method of claim 29, wherein the derivatizing agent comprises an aryl diazonium species.

31. The method of claim 29, further comprising:

esterifying the functionalized, chemically converted graphene to form an esterified, functionalized, chemically converted graphene.

32. A method comprising:

providing a graphite source;

providing a solution comprising at least one acid solvent, potassium permanganate and at least one protecting agent;

wherein the at least one acid solvent is selected from the group consisting of oleum, sulfuric acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and combinations thereof; and

wherein the at least one protecting agent is selected from the group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; trifluroacetic anhydride; phosphoric anhydride; orthophosphoric anhydride; metaphosphoric anhydride; polyphosphoric anhydride; boric anhydride; mixed anhydrides of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and combinations thereof;

mixing the graphite source with the solution; and

oxidizing the graphite source with the potassium permanganate in the presence of the at least one protecting agent to form graphene oxide.

33. The method of claim 32, wherein the at least one protecting agent is selected from the group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and combinations thereof.

34. The method of claim 32, wherein the at least one acid solvent comprises sulfuric acid.

35. The method of claim 32, wherein oxidizing the graphite source takes place at a temperature between about 30°C and about 85°C.

36. The method of claim 32, wherein the graphene oxide is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

37. Graphene oxide prepared by the method of claim 13.

38. The graphene oxide of claim 37, wherein the graphene oxide is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

39. Functionalized graphene oxide prepared by the method of claim 22.

40. The functionalized graphene oxide of claim 39, wherein the functionalized graphene oxide is soluble in a substantially non-aqueous liquid medium.

41. The functionalized graphene oxide of claim 40, wherein the substantially non-aqueous liquid medium comprises oil.

42. The functionalized graphene oxide of claim 40, wherein the functionalized graphene oxide is operable to slow the filtration rate of a substantially non-aqueous liquid mixture.

43. Chemically converted graphene prepared by the method of claim 24.

44. Functionalized, chemically converted graphene prepared by the method of claim 30.

45. A mixture comprising graphene oxide prepared by the method of claim 13, wherein the graphene oxide is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

46. The mixture of claim 45, wherein the mixture comprising graphene oxide comprises at least two different particle size ranges of graphene oxide.

47. A mixture comprising functionalized graphene oxide prepared by the method of claim 22, wherein the functionalized graphene oxide is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

48. The mixture comprising functionalized graphene oxide of claim 47, wherein the functionalized graphene oxide is operable to slow the filtration rate of a substantially non-aqueous liquid mixture.

49. The mixture comprising functionalized graphene oxide of claim 47, wherein the mixture comprising functionalized graphene oxide comprises at least two different particle size ranges of functionalized graphene oxide

50. A mixture comprising chemically converted graphene prepared by the method of claim 24, wherein the chemically converted graphene is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

51. The mixture comprising chemically converted graphene of claim 50, wherein the mixture comprising chemically converted graphene comprises at least two different particle size ranges of chemically converted graphene.

52. A mixture comprising functionalized, chemically converted graphene prepared by the method of claim 30, wherein the functionalized, chemically converted graphene is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

53. The mixture comprising functionalized, chemically converted graphene of claim 52, wherein the mixture comprising functionalized, chemically converted graphene comprises at least two different particle size ranges of functionalized, chemically converted graphene.

54. A mixture comprising more than one graphene type selected from the group consisting of graphene oxide, functionalized graphene oxide, chemically converted graphene, and functionalized, chemically converted graphene, wherein the mixture comprising more than one type graphene type is operable to slow the filtration rate of a liquid mixture selected from the group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and combinations thereof.

CLAIMS

1. A method, comprising:

providing a graphite source;

providing a solution including at least one type of oxidant and at least one type of protectant;

mixing the graphite source and the solution; and

oxidizing the graphite source with the at least one type of oxidant under a presence of the at least one type of protectant to form a graphene oxide.

2. The method according to claim 1, wherein the at least one type of oxidant is selected from a group consisting of a permanganate, a ferrate, an osmate, a ruthenate, a chlorate, a chlorite, a nitrate, osmium tetroxide, ruthenium tetroxide, lead dioxide, and a combination thereof.

3. The method according to claim 1, wherein the at least one type of oxidant includes potassium permanganate.

4. The method according to claim 1, wherein the solution further includes at least one type of acid solvent.

5. The method according to claim 4, wherein the at least one type of acid solvent is selected from a group consisting of oleum, sulfuric acid, chlorosulfonic acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and a combination thereof.

6. The method according to claim 4, wherein the at least one type of acid solvent includes sulfuric acid.

7. The method according to claim 4, wherein the at least one type of protectant can be used to protect vicinal diols under a presence of the at least one type of acid solvent.

8. The method according to claim 1, wherein the at least one type of protectant can be used to protect vicinal diols.

9. The method according to claim 8, wherein the at least one type of protectant chelates the vicinal diols.

10. The method according to claim 8, wherein the at least one type of protectant individually protects each alcohol of the vicinal diols.

11. The method according to claim 1, wherein the at least one type of protectant is selected from a group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; anhydrous trifluoroacetic acid; anhydrous phosphoric acid; anhydrous orthophosphoric acid; anhydrous metaphosphoric acid; anhydrous polyphosphoric acid; anhydrous boric acid; a mixed anhydride of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and a combination thereof.

12. The method according to claim 1, wherein the at least one type of protectant is selected from a group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and a combination thereof.

13. A method, comprising:

providing a graphite source;

providing a solution including at least one type of acid solvent, at least one type of oxidant, and at least one type of protectant;

mixing the graphite source and the solution; and

oxidizing the graphite source with the at least one type of oxidant under a presence of the at least one type of protectant to form a graphene oxide.

14. The method according to claim 13, wherein the at least one type of protectant is used to protect vicinal diols.

15. The method according to claim 13 or 14, wherein the graphene oxide is more oxidized than a graphene oxide manufactured under a non-presence of the at least one type of protectant.

16. The method according to any of claims 13 to 15, wherein the at least one type of acid solvent is selected from a group consisting of oleum, sulfuric acid,

chlorosulfonic acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and a combination thereof.

17. The method according to any of claims 13 to 16, wherein the at least one type of acid solvent includes sulfuric acid.

18. The method according to any of claims 13 to 17, wherein the at least one type of protectant is selected from a group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; anhydrous trifluoroacetic acid; anhydrous phosphoric acid; anhydrous orthophosphoric acid; anhydrous metaphosphoric acid; anhydrous polyphosphoric acid; anhydrous boric acid; a mixed anhydride of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and a combination thereof.

19. The method according to any of claims 13 to 18, wherein the at least one type of protectant is selected from a group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and a combination thereof.

20. The method according to any of claims 13 to 19, wherein the at least one type of oxidant includes potassium permanganate.

21. The method according to any of claims 13 to 20, wherein oxidation of the graphite source is performed at a temperature of 30°C to 85°C.

22. The method according to any of claims 13 to 21, further comprising: isolating the graphene oxide.

23. The method according to claim 22, further comprising: reacting the graphene oxide with a derivatizing agent to form a functionalized graphene oxide.

24. The method according to claim 22, further comprising: esterifying the graphene oxide to form an esterified graphene oxide.

25. The method according to claim 22, further comprising: reducing the graphene oxide with at least one type of reducing agent to form a chemically converted graphene.

26. The method according to claim 25, wherein the at least one type of reducing agent is selected from a group consisting of hydrazine, an iodide, phosphine, a phosphite, a sulfide, a sulfite, a hydrosulfite, borohydride, a cyanoborohydride, aluminum hydride, borane, hydroxylamine, diimine, a dissolving metal reduction, hydrogen, and a combination thereof.

27. The method according to claim 25, wherein the at least one type of reducing agent includes hydrazine.

28. The method according to claim 25, wherein the at least one type of reducing agent includes hydrogen.

29. The method according to claim 25, further comprising: esterifying the chemically converted graphene to form an esterified chemically converted graphene.

30. The method according to claim 25, further comprising: reacting the chemically converted graphene with a derivatizing agent to form a functionalized chemically converted graphene.

31. The method according to claim 30, wherein the derivatizing agent includes an aryldiazonium species.

32. The method according to claim 30, further comprising: esterifying the functionalized chemically converted graphene to form an esterified functionalized chemically converted graphene.

33. A method, comprising:

providing a graphite source;

providing a solution including at least one type of acid solvent, potassium permanganate, and at least one type of protectant (here, the at least one type of acid solution is selected from a group consisting of oleum, sulfuric acid, fluorosulfonic acid, trifluoromethanesulfonic acid, and a combination thereof, and the at least one type of

protectant is selected from a group consisting of trifluoroacetic acid; phosphoric acid; orthophosphoric acid; metaphosphoric acid; polyphosphoric acid; boric acid; anhydrous trifluoroacetic acid; anhydrous phosphoric acid; anhydrous orthophosphoric acid; anhydrous metaphosphoric acid; anhydrous polyphosphoric acid; anhydrous boric acid; a mixed anhydride of trifluoroacetic acid, phosphoric acid, orthophosphoric acid, metaphosphoric acid, polyphosphoric acid, and boric acid; and a combination thereof);

mixing the graphite source and the solution; and

oxidizing the graphite source with potassium permanganate under a presence of the at least one type of protectant to form a graphene oxide.

34. The method according to claim 33, wherein the at least one type of protectant is selected from a group consisting of phosphoric acid, boric acid, trifluoroacetic acid, and a combination thereof.

35. The method according to claim 33, wherein the at least one type of acid solvent includes sulfuric acid.

36. The method according to claim 33, wherein oxidation of the graphite source is performed at a temperature of 30°C to 85°C.

37. The method according to claim 33, wherein the graphene oxide can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

38. A graphene oxide manufactured by the method according to claim 13 or 14.

39. The graphene oxide according to claim 38, wherein the graphene oxide can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

40. A functionalized graphene oxide manufactured by the method according to claim 23.

41. The functionalized graphene oxide according to claim 40, wherein the functionalized graphene oxide is soluble in a non-aqueous liquid medium.

42. The functionalized graphene oxide according to claim 41, wherein the non-aqueous liquid medium includes an oil.

43. The functionalized graphene oxide according to claim 41, wherein the functionalized graphene oxide can be used to reduce a filtration speed of a non-aqueous liquid mixture.

44. A chemically converted graphene manufactured by the method according to claim 25.

45. A functionalized chemically converted graphene manufactured by the method according to claim 31.

46. A mixture including the graphene oxide manufactured by the method according to claim 13 or 14, wherein the graphene oxide can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

47. The mixture according to claim 46, wherein the mixture including the graphene oxide includes at least two types of graphene oxide with different size ranges.

48. A mixture including the functionalized graphene oxide manufactured by the method according to claim 23 wherein the functionalized graphene oxide can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

49. A mixture including the functionalized graphene oxide according to claim 48, wherein the functionalized graphene oxide can be used to reduce a filtration speed of a non-aqueous liquid mixture.

50. A mixture including the functionalized graphene oxide according to claim 48, wherein the mixture including the functionalized graphene oxide includes at least two types of functionalized graphene oxide with different size ranges.

51. A mixture including the chemically converted graphene manufactured by the method according to claim 25, wherein the chemically converted graphene can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

52. A mixture including the chemically converted graphene according to claim 51, wherein the mixture including the chemically converted graphene includes at least two types of chemically converted graphene of different size ranges.

53. A mixture including the functionalized chemically converted graphene manufactured by the method according to claim 31, wherein the functionalized chemically converted graphene can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.

54. A mixture including the functionalized chemically converted graphene according to claim 53, wherein the mixture including the functionalized chemically converted graphene includes at least two types of functionalized chemically converted graphene of different size ranges.

55. A mixture including more than one type of graphene selected from a group consisting of a graphene oxide, a functionalized graphene oxide, a chemically converted graphene, and a functionalized chemically converted graphene, wherein the mixture including more than one type of graphene can be used to reduce a filtration speed of a liquid mixture selected from a group consisting of an aqueous liquid mixture, a non-aqueous liquid mixture, and a combination thereof.