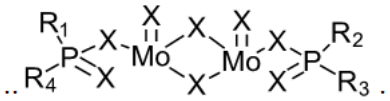
What is claimed is:

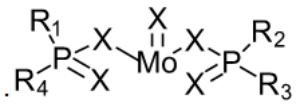
1. A method of inhibiting deposition of a foulant comprising:

introducing into a process equipment subject to fouling or a fluid in contact with the process equipment subject to fouling a foulant inhibiting composition effective to inhibit deposition of a foulant onto the process equipment, said foulant inhibiting composition comprising a molybdenum-containing complex comprising:

at least one molybdenum-containing complex having the formula selected from Formula I, II, III, or IV,~~.~~

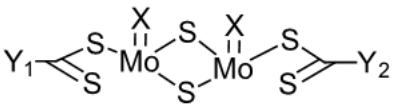


Formula I

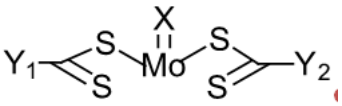


Formula II

wherein R_1, R_2, R_3, and R_4, are each a hydrocarbon group and wherein R_1, R_2, R_3, and R_4 can be the same or different; and X is oxygen or sulfur and X can be the same or different,~~.~~



Formula III



Formula IV

wherein Y_1 and Y_2 are each oxygen, nitrogen or carbon-containing ligands and Y^1 and Y^2 can be the same or different, and X is each oxygen or sulfur, and X can be the same of different from each other.

~~2. The method of claim 1, wherein the introducing is by injecting, spraying, or dripping the molybdenum-containing complex.~~

~~3.~~2. The method as in ~~any one of~~ claim~~s~~ 1~~-2~~, wherein the introducing is carried out after or during a decoking or cleaning or during a warm up process in the process equipment.

~~4.~~3. The method as in any one of claims 1-~~3~~2, wherein the introducing is carried out during a hydrocarbon processing in the process equipment.

~~5.~~4. The method as in any one of claims 1-~~4~~3, wherein the introducing is carried out intermittently.

~~6.~~5. The method as in any one of claims 1-~~4~~3, wherein the introducing is carried out continuously.

~~7.~~6. The method as in any one of claims 1-~~6~~5, wherein the process equipment comprises a coil~~s~~, a heat exchanger~~s~~, a transfer line exchanger~~s~~, a quench cooler~~s~~, a furnace~~s~~, a separation column~~s~~ or a fractionator~~s~~.

~~8.~~7. The method as in any one of claims 1-~~7~~6, wherein the process equipment comprises iron or an iron alloy~~s~~.

~~9.~~8. The method as in any one of claims 1-~~8~~7, wherein the iron alloy~~s~~ comprise~~s~~ carbon steel, stainless steel, or a nickel-chromium-iron alloy~~s~~.

~~10.~~9. The method as in any one of claims 1-~~9~~8, wherein the foulant comprises one or more of coke, sludge, a corrosion product~~s~~, a polymer~~s~~, and catalyst fines.

~~11.~~10. The method as in one of claims 1-~~10~~9, wherein the fluid comprises at least a liquid hydrocarbon material.

~~12.~~11. The method as in one of claims 1-~~11~~10, wherein the molybdenum-containing complex is added to the fluid in an amount from 1 ppm to 3000 ppm of the fluid volume.

~~13.~~12. The method as in one of claims 1-~~12~~11, wherein the fluid ~~molybdenum-containing complex~~ further comprises one or more~~,~~ asphaltene inhibitors, paraffin inhibitors, scale inhibitors, emulsifiers, water clarifiers, dispersants, emulsion breakers, or any combination thereof.

~~14.~~13. The method as in one of claims 1-~~13~~12, wherein the R_1, R_2, R_3, and R_4 of formulae I and II comprise thiophosphates, phosphates and polymers thereof.

~~15.~~14. The method as in one of claims 1-~~13~~12, wherein the Y^1 and Y^2 of formulae III and IV comprise thiocarbamates and polymers thereof.

~~16.~~15. The method as in one of claims 1-~~15~~14, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiocarbamate, dithiophosphate, polymers thereof and combinations thereof.

~~17.~~16. The method of claim ~~16~~1, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiocarbamate and wherein the molybdenum dithiocarbamate comprises an alkyldithiocarbamate.

~~18.~~17. The method of claim ~~17~~16, wherein the alkyldithiocarbamate comprises an ethyl hexyl dithiocarbamate~~, straight chain C6-C10 alcohols or mixtures thereof~~.

~~19.~~18. The method of claim ~~16~~1, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiophosphate and wherein the molybdenum dithiophosphate comprises an alkyldithiophosphate.

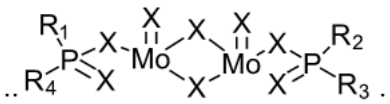
~~20. The method of claim 19, wherein the alkyldithiophosphate comprises an ethyl hexyl, straight chain C6-C10 alcohols or mixtures thereof.~~

~~21. The method as in one of claims 1-20 wherein the molybdenum-containing complex provides at least 70% inhibition of foulant deposition.~~

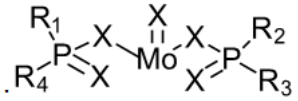
~~22. The method as in one of claims 1-21, wherein the molybdenum-containing complex provides at least 70% inhibition of foulant deposition in a SS304 mesh test.~~

~~23.~~19. The method as in one of claims 1-~~22~~18, wherein the introducing the molybdenum-containing complex inhibits foulant deposition ~~of a~~ onto the process equipment compared to ~~a~~ operating the process equipment under the same conditions without the introduction of the molybdenum-containing complex.

~~24.~~20. A composition comprising at least one molybdenum-containing complex to inhibit deposition of a foulant in contact with process equipment subject to fouling, the at least one molybdenum-containing complex comprising the formula selected from Formula I, II, II or IV:

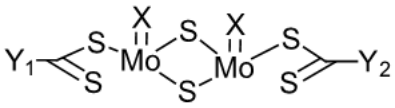


Formula I

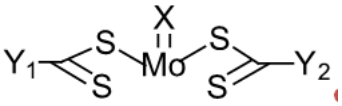


Formula II

wherein R_1, R_2, R_3, and R_4, are each a hydrocarbon group and wherein R_1, R_2, R_3, and R_4 can be the same or different; and X is oxygen or sulfur and X can be the same or different.



Formula III



Formula IV

wherein Y_1 and Y_2 are each oxygen, nitrogen or carbon-containing ligands and Y^1 and Y^2 can be the same or different, and X is each oxygen or sulfur, and X can be the same of different from each other.

~~25.~~21. The composition of claim ~~24~~20, wherein the composition further comprises one or more~~,~~ asphaltene inhibitors, paraffin inhibitors, scale inhibitors, emulsifiers, water clarifiers, dispersants, emulsion breakers, or any combination thereof.

~~26.~~22. The composition as in one of claims ~~24~~20-2~~15~~, wherein the R_1, R_2, R_3, and R_4 of formulae I and II comprise thiophosphates, phosphates and polymers thereof.

~~27.~~23. The composition as in one of claims ~~24~~20-~~26~~22, wherein the Y^1 and Y^2 of formulae III and IV comprise thiocarbamates and polymers thereof.

~~28.~~24. The composition as in one of claims ~~24~~20-~~27~~23, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiocarbamate, dithiophosphate, polymers thereof and combinations thereof.

~~29.~~25. The composition of claim ~~28~~20, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiocarbamate and wherein the molybdenum dithiocarbamate comprises an alkyldithiocarbamate.

~~30.~~26. The composition of claim ~~29~~25, wherein the alkyldithiocarbamate comprises an ethyl hexyl dithiocarbamate~~, straight chain C6-C10 alcohols or mixtures thereof~~.

~~31.~~27. The composition of claim ~~28~~20, wherein the at least one molybdenum-containing complex comprises a molybdenum dithiophosphate and wherein the molybdenum dithiophosphate comprises an alkyldithiophosphate.

~~32. The method of claim 31, wherein the alkyldithiophosphate comprises an ethyl hexyl, straight chain C6-C10 alcohols or mixtures thereof.~~

~~33.~~28. The composition as in one of claims ~~24~~20-~~32~~27, wherein the molybdenum-containing complex is ~~about~~ 1 ppm to 3000 ppm of the composition.

~~34. A composition comprising:~~

~~a fluid; and~~

~~the at least one molybdenum-containing complex as in one of claims 24-33.~~

~~35. The composition as in one of claims 22-34, wherein the fluid is in contact in with coils, heat exchangers, transfer line exchangers quench coolers, furnaces, separation columns or fractionators.~~

~~36. The composition as in one of claims 24-35, wherein the fluid comprises at least a liquid hydrocarbon fraction.~~

~~37. The composition as in one of claims 24-36, wherein the hydrocarbon fraction is a distillate.~~

~~38. The composition as in one of claims 24-37, wherein the fluid temperature is 200°C to 1500°C.~~

~~39. A treated process equipment comprising:~~

~~a process equipment comprising a metal surface; and~~

~~the fluid source comprising the molybdenum-containing complex as in one of claims 24-38, wherein at least a portion of the metal surface is contacted by the fluid source.~~

~~40. The treated process equipment of claim 39, wherein the process equipment comprises iron or iron alloys.~~

~~41. The treated process equipment of claim 40, wherein the iron alloys comprise carbon steel, stainless steel, nickel-chromium-iron alloys, or other alloys.~~

~~42. The treated process equipment as in one of claims 39-41, wherein the metal containment comprises coils, heat exchangers, transfer line exchangers quench coolers, furnaces, separation columns or fractionators.~~

~~43. The treated process equipment as in one of claims 39-42, wherein the fluid comprises, at least liquid hydrocarbon fraction.~~

~~44. Use of the molybdenum-containing complex as in one of claims 1-43 to inhibit foulant deposition.~~