Accordingly, there is a need to overcome the limitations of existing solutions as proposed above. There is also need for enhancing a surface that becomes capable of mitigating or resisting carbon-based deposits and accumulation without suffering from these limitations.

Summary

There is provided a formulation for inhibiting carbon-based deposits on a metal substrate, the formulation comprising at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, at least one sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom.

According to a first aspect, there is provided a formulation for inhibiting carbon-based deposits on a metal substrate, the formulation comprising at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, at least one sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom, wherein the at least one etchant comprises 50 to 70 wt% of the formulation, based on the weight of the formulation, the at least one etchant being an acid selected from the group consisting of hydrochloric acid, sulfuric acid, nitric acid, trifluoromethanesulfonic acid, fluorosulfuric acid, trichloroacetic acid, trifluoroacetic acid and combination thereof.

Advantageously, the above formulation serves as an effective chemical polishing solution capable of inhibiting undesired deposition of carbon-based deposits on the surface of a metal substrate. This solution is capable of restructuring the surface of a metal substrate, thereby rendering the treated surface resistant to carbon-based deposits without corroding the metal substrate or constrained by the heating duration.

There is provided a method for inhibiting carbon-based deposits on a metal substrate, said method comprising:
contacting said metal substrate with a formulation to inhibit carbon-based deposits on said metal substrate, wherein said formulation comprises at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, a sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom.

In another aspect, there is provided a method for inhibiting carbon-based deposits on a metal substrate, said method comprising: contacting said metal substrate with a formulation to inhibit carbon-based deposits on said metal substrate, wherein said formulation comprises at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, a sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom, wherein the at least one etchant comprises 50 to 70 wt% of the formulation, based on the weight of the formulation, the at least one etchant being an acid selected from the group consisting of hydrochloric acid, sulfuric acid, nitric acid, trifluoromethanesulfonic acid, fluorosulfuric acid, trichloroacetic acid, trifluoroacetic acid and combination thereof.

This method not only produces the above advantageous formulation but also protects a solid surface, particularly a metal substrate, from undesired accumulation of carbon-based deposits. This method also provides the above advantages without suffering from the aforementioned limitations.

In another aspect, there is a metal pipe treated with the formulation as defined above. This treated metal pipe would have the abovementioned advantages.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term "inhibiting" is to be taken broadly to include removing, eliminating solid deposits, particularly carbon-based deposits, on a surface such as a metal substrate. It may also include preventing build-up of carbon-based deposits or prevent carbon-based substances from depositing on the metal substrate.

The phrase "carbon-based deposits" is taken broadly to refer to any substances having carbon. Such substances may include coke, charcoal or any hydrocarbon.

The term "ligand" is to be interpreted broadly to include any compounds, ions or molecules having a functional group that is capable of binding to a metal atom or ion to form a coordination complex. In this coordination complex, the metal atom or ion may be positioned as the central member (i.e. central atom or ion) of the coordination complex. In

Claims

1. A formulation for inhibiting carbon-based deposits on a metal substrate, the formulation comprising at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, at least one sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom, wherein the at least one etchant comprises 50 to 70 wt% of the formulation, based on the weight of the formulation, the at least one etchant being an acid selected from the group consisting of hydrochloric acid, sulfuric acid, nitric acid, trifluoromethanesulfonic acid, fluorosulfuric acid, trichloroacetic acid, trifluoroacetic acid and combination thereof.

2. The formulation according to claim 1, wherein the weight ratio of the at least one oxidizing agent to the at least one etchant is 0.2:2 to 0.2:3.

3. The formulation according to claim 1, wherein the weight ratio of the at least one etchant to the at least one sequestering agent is 5:4 to 5.5:6.

4. The formulation according to claim 1, wherein the weight ratio of the at least one sequestering agent to the at least one chelating agent is 4:0.1 to 5:0.3.

5. The formulation according to claim 1, wherein the at least one oxidizing agent comprises 10 to 15 wt% of the formulation, based on the weight of the formulation.

6. The formulation according to claim 1, wherein the at least one oxidizing agent is selected from the group consisting of peroxides, peroxyacids, peroxyesters, permanganates, mineral acids, nitrates, persulphates, perborates, perchlorates, perchlorites, chlorates, chlorites, percarbonates, derivatives thereof and combinations thereof.

7. The formulation according to claim 1, wherein the at least one sequestering agent comprises 20 to 25 wt% of the formulation, based on the weight of the formulation.

8. The formulation according to claim 1, wherein the at least one sequestering agent is an amino acid selected from the group consisting of glycine, threonine, aspartic acid, glutamic acid and serine.

9. The formulation according to claim 1, wherein the at least one sequestering agent is a hydroxycarboxylic acid selected from the group consisting of malic acid, gluconic acid, citric acid, tartaric acid, glycolic acid and lactic acid.

10. The formulation according to claim 1, wherein the at least one chelating agent comprises 0.5 to 5 wt% of the formulation, based on the weight of the formulation.

11. The formulation according to claim 1, wherein the at least one chelating agent is selected from the group consisting of ketone, phosphonic acid, sulfonic acid and an optionally substituted heterocyclic compound having at least 3 heteroatoms.

12. A method for inhibiting carbon-based deposits on a metal substrate, said method comprising:
contacting said metal substrate with a formulation to inhibit carbon-based deposits on said metal

substrate, wherein said formulation comprises at least one oxidizing agent and at least one etchant to form free metal ions from the metal substrate, a sequestering agent having a ligand selected to form a complex with the free metal ions and at least one chelating agent having a ligand selected to complex with at least one surface metal atom, wherein the at least one etchant comprises 50 to 70 wt% of the formulation, based on the weight of the formulation, the at least one etchant being an acid selected from the group consisting of hydrochloric acid, sulfuric acid, nitric acid, trifluoromethanesulfonic acid, fluorosulfuric acid, trichloroacetic acid, trifluoroacetic acid and combination thereof.

13. The method according to claim 12, wherein the weight ratio of the at least one oxidizing agent to the at least one etchant is 0.2:2 to 0.2:3.

14. The method according to claim 12, wherein the weight ratio of the at least one etchant to the at least one sequestering agent is 5:4 to 5:6.

15. The method according to claim 12, wherein the weight ratio of the at least one sequestering agent to the at least one chelating agent is 4:0.1 to 5:0.3

16. The method according to claim 12, wherein the contacting step is carried out at a pressure between 101 325 Pa to 506 625 Pa.

17. The metal according to claim 12, wherein the free metal ion is selected from the group consisting of Fe^{2+}, Fe^{3+}, Cr^{3+}, Ni^{+}, Ti^{+}, Ti^{2+}, W^{+} and W^{2+}.

18. The method according to claim 12, wherein the at least one surface metal atom is selected from the group consisting of Fe, Cr, Ni, Ti and W.

19. The method according to claim 12, wherein the surface metal atom is a surface metal ion selected from the group consisting of Fe^{2+}, Fe^{3+}, Cr^{3+}, Ni^{+}, Ti^{+}, Ti^{2+}, W^{+} and W^{2+}.

20. A metal pipe treated with the formulation according to claim 1.

21. The formulation according to claim 1, wherein the at least one etchant comprises 50 to 70 wt% of the formulation, the at least one oxidizing comprises 10 to 15 wt% of the formulation, the at least one sequestering agent comprises 20 to 25 wt% of the formulation and the at least one chelating agent comprises 0.5 to 1.5 wt% of the formulation, wherein the weight percentages add up to 100 wt% of the formulation.