CLAIMS

What is claimed is:

1. A method of reducing corrosion of a metal surface in an aqueous system, comprising:

adding a benzimidazole to an aqueous system comprising a metal surface; and

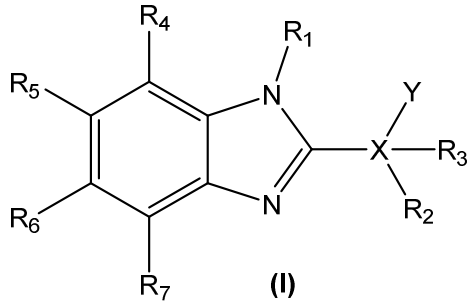
adding an oxidizing halogen selected from bromine, iodine, and any combination thereof to the aqueous system,

wherein:

a dosage of the benzimidazole ranges from 0.01 ppm to 500 ppm; and

a dosage of the oxidizing halogen ranges from 2 ppm to 500 ppm.

2. The method of claim 1, wherein the benzimidazole is a compound of formula (I) or salt thereof,



(I)

where

R^1 is halo, hydrogen, deuterium, hydroxyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_4-C_6 heteroaryl, or substituted or unsubstituted C_3-C_8 cycloalkyl;

X is absent, C, or N;

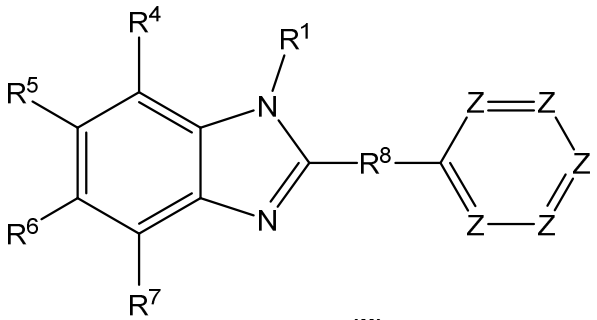
Y is hydroxyl, halo, substituted or unsubstituted C_1-C_{16} alkoxy, thiol, alkylthio, amino, hydrogen, or aminoalkyl;

R^2 and R^3 are each independently selected from the group consisting of: hydrogen, halo, hydroxyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_4-C_6 heteroaryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_3-C_8 cycloalkyl, and substituted or unsubstituted C_1-C_{16} alkyl; and

R^4, R^5, R^6, and R^7 are each independently selected from the group consisting of: hydrogen, halo, amino, cyano, substituted or unsubstituted C_1-C_{16} alkoxy, hydroxyl, thiol, nitro, phosphoryl, phosphonyl, sulfonyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_4-C_6 heteroaryl, and substituted or unsubstituted C_3-C_8 cycloalkyl,

provided that at least one of R^4, R^5, R^6, and R^7 is hydrogen.

3. The method of claim 1, wherein the benzimidazole is a compound of formula (II) or salt thereof,



(II)

where

R^1 is hydrogen, a substituted or unsubstituted C_1-C_{16} alkyl group, or a substituted or unsubstituted C_6 aryl group;

R^4, R^5, R^6, and R^7 are each independently selected from the group consisting of: hydrogen, halo, amino, cyano, substituted or unsubstituted C_1-C_{16} alkoxy, hydroxyl, thiol, nitro, phosphoryl, phosphonyl, sulfonyl, substituted

or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_4-C_6 heteroaryl, and substituted or unsubstituted C_3-C_8 cycloalkyl, provided that at least one of R^4, R^5, R^6, and R^7 is hydrogen;

R^8 is a bond or CHR^9;

R^9 is hydrogen, halo, $NR^{10}R^{11}$, or OR^{10};

wherein R^{10} and R^{11} are each independently selected from the group consisting of: hydrogen, a substituted or unsubstituted C_1-C_{12} alkyl group, and a substituted or unsubstituted C_6 aryl group; and

Z is independently nitrogen, CR^4, or N^+-R^{10}.

4. The method of any one of claims 1-3, wherein the oxidizing halogen is prepared from a bromine precursor, an iodine precursor, or any combination thereof.

5. The method of any one of claims 3-4, wherein Z is CR^4 and R^4 is hydrogen.

6. The method of any one of claims 1-4, further comprising adding a halogen stabilizer that is an isocyanate, a hydantoin, sulfamic acid, ammonia, urea, an amine, or any combination thereof.

7. The method of any one of claims 1-6, further comprising measuring a corrosion rate of a metal surface in the aqueous system.

8. The method of claim 7, wherein the metal surface is copper or a copper alloy.

9. The method of any one of claims 1-8, further comprising adjusting a dosage of the benzimidazole or salt thereof to achieve a predetermined corrosion rate.

10. The method of any one of claims 1-9, further comprising adjusting a dosage of the halogen to achieve a predetermined corrosion rate.

11. The method of any one of claims 1-10, wherein a dosage of the benzimidazole ranges from 0.01 ppm to 100 ppm.

12. The method of any one of claims 1-11, wherein a dosage of the halogen ranges from 2 ppm to 100 ppm.

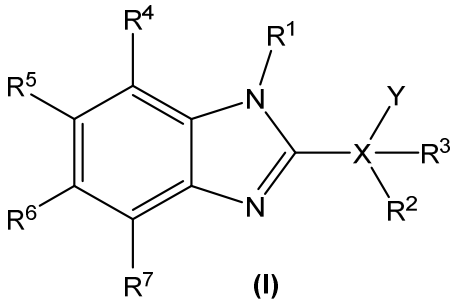
13. The method of any one of claims 1-12, wherein the aqueous system comprises a biocide.

14. The method of any one of claims 1-13, wherein the aqueous system is chlorinated.

15. A composition, comprising:

An oxidizing halogen selected from bromine, iodine, and any combination thereof; and

a compound of formula (I) or salt thereof,



(I)

where

R^1 is halo, hydrogen, deuterium, hydroxyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_4-C_6 heteroaryl, or substituted or unsubstituted C_3-C_8 cycloalkyl;

X is absent, C or N;

Y is hydroxyl, halo, substituted or unsubstituted C_1-C_{16} alkoxy, thiol, alkylthio, amino, hydrogen, or aminoalkyl;

R^2 and R^3 are each independently selected from the group consisting of: hydrogen, halo, hydroxyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_4-C_6 heteroaryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_3-C_6 cycloalkyl, and substituted or unsubstituted C_1-C_{16} alkyl; and

R^4, R^5, R^6, and R^7 are each independently selected from the group consisting of: hydrogen, halo, amino, aminoalkyl, cyano, substituted or unsubstituted C_1-C_{16} alkoxy, hydroxyl, thiol, nitro, phosphoryl, phosphonyl, sulfonyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_6 aryl, substituted or unsubstituted C_2-C_{16} alkenyl, substituted or unsubstituted C_2-C_{16} alkynyl, substituted or unsubstituted C_4-C_6 heteroaryl, and substituted or unsubstituted C_3-C_8 cycloalkyl,

provided that at least one of R^4, R^5, R^6, and R^7 is hydrogen,

wherein:

the composition comprises the compound of formula (I) or salt thereof at a concentration of 0.01 ppm to 500 ppm; and

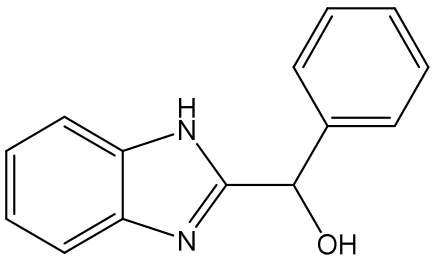
the composition comprises the oxidizing halogen at a concentration of 2 ppm to 500 ppm.

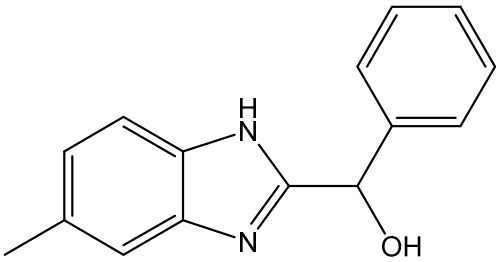
16. The composition of claim 15, wherein X is C; Y is hydroxyl; and R^2 is a substituted or unsubstituted C_6 aryl.

17. A method of reducing corrosion of a metal surface in an aqueous system comprising adding the composition of any one of claims 15-16.

18. Use of the composition of any one of claims 15-16 for reducing corrosion of a metal surface in an aqueous system.

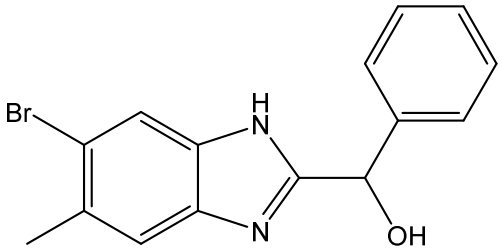
19. The method of any one of claims 1-14, wherein the compound of formula (I) or salt thereof is selected from the group consisting of:

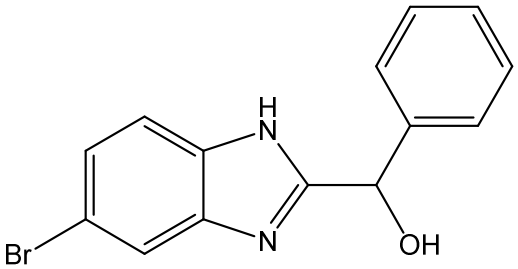


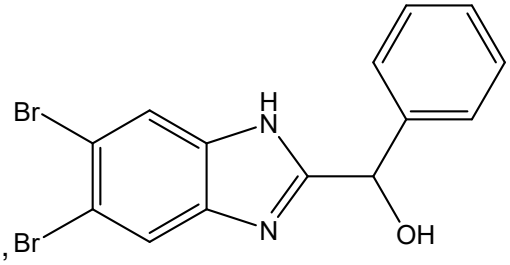
and


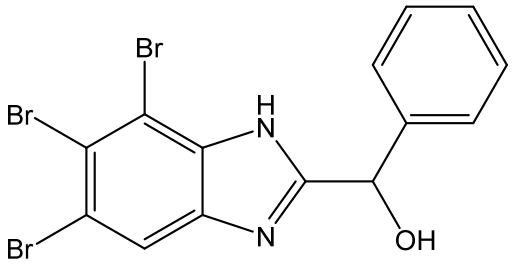
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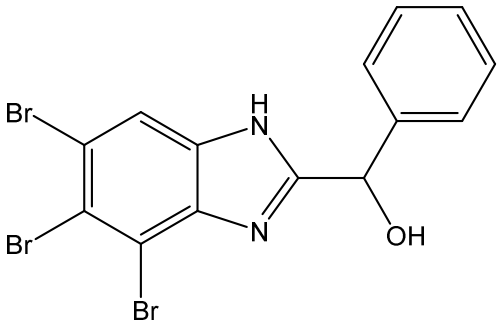
20. The composition of any one of claims 15-16, wherein the compound of formula (I) or salt thereof is selected from the group consisting of:



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