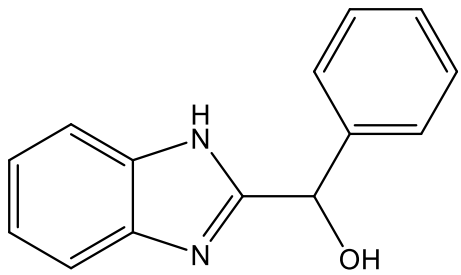
CLAIMS

What is claimed is:

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

adding a benzimidazole selected from the group consisting of



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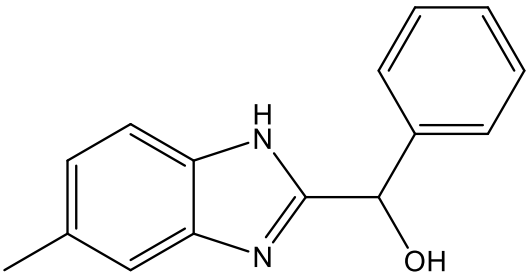


to an aqueous system comprising a metal surface; and

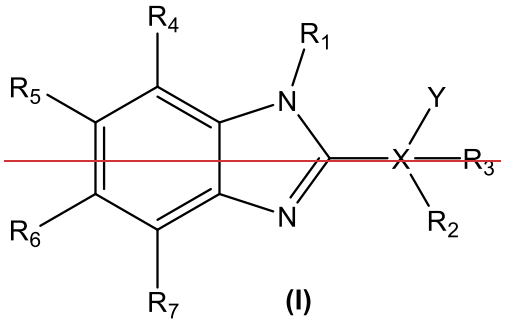
adding an oxidizing halogen comprising bromine~~, iodine, and any combination thereof to the aqueous system~~,

wherein:

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

a dosage of the oxidizing halogen ranges from ~~2~~ 0.6 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;~~

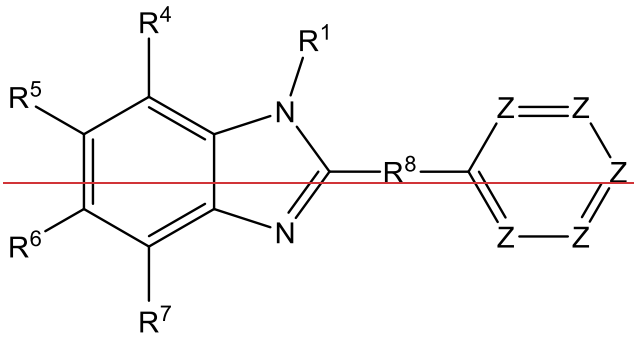
~~Y is hydroxyl, halo, substituted or unsubstituted C_1-C_{16} alkoxy, thiol, alkylthio, amino, hydrogen, or aminoalkyl;~~

~~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~~2. The method of ~~any one of~~ claim~~s~~ 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~~3. The method of ~~any one of~~ claim~~s~~ 1 or 2~~-4~~, further comprising adding a halogen stabilizer that is an isocyanate, a hydantoin, sulfamic acid, ammonia, urea, an amine, or any combination thereof.

~~7~~4. The method of any one of claims 1-~~6~~3, further comprising measuring a corrosion rate of a metal surface in the aqueous system.

~~8~~5. The method of claim ~~7~~4, wherein the metal surface is copper or a copper alloy.

~~9~~6. The method of any one of claims 1-~~8~~5, further comprising adjusting a dosage of the benzimidazole or salt thereof to achieve a predetermined corrosion rate.

~~10~~7. The method of any one of claims 1-~~9~~6, further comprising adjusting a dosage of the oxidizing halogen to achieve a predetermined corrosion rate.

~~11~~8. The method of any one of claims 1-~~10~~7, wherein a dosage of the benzimidazole ranges from 0.01 ppm to 100 ppm.

~~12~~9. The method of any one of claims 1-~~11~~8, wherein a dosage of the oxidizing halogen ranges from ~~2~~ 0.6 ppm to ~~-~~100 ppm.

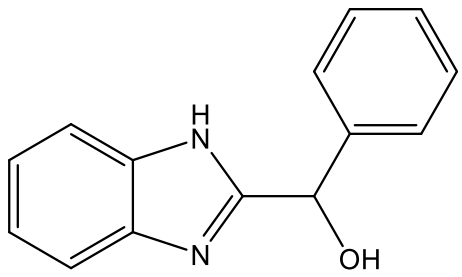
10~~13~~. The method of any one of claims 1-9~~12~~, wherein the aqueous system comprises a biocide.

~~14~~11. The method of any one of claims 1-~~13~~10, wherein the aqueous system is chlorinated.

~~15~~12. A composition, comprising:

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

a compound ~~of formula (I)~~ or salt thereof, selected from the group consisting of:



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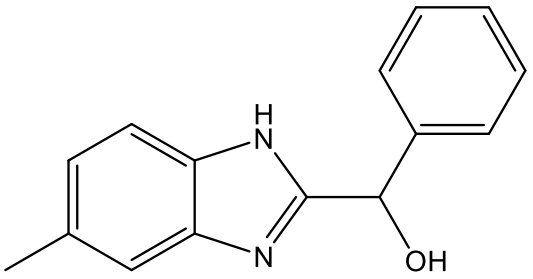
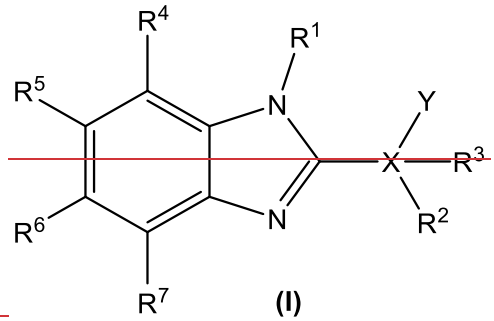




(I)

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

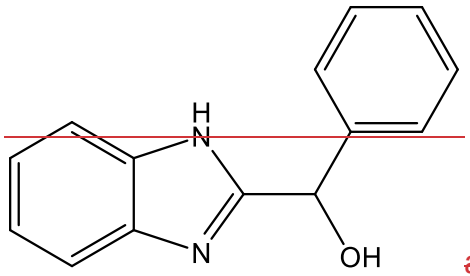
the composition comprises the oxidizing halogen at a concentration of ~~2~~ 0.6 ppm to 500 ppm.

~~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~~13. A method of reducing corrosion of a metal surface in an aqueous system comprising adding the composition of ~~any one of claims 15-16~~claim 12.

~~18~~14. Use of the composition of ~~any one of~~ claim~~s 15-16~~12 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:~~



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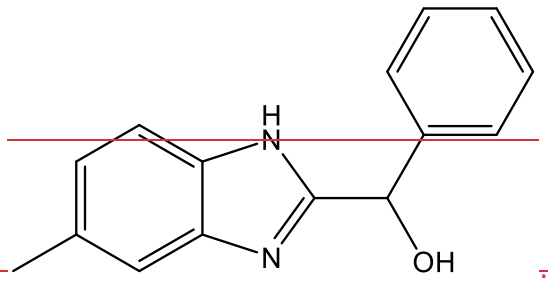

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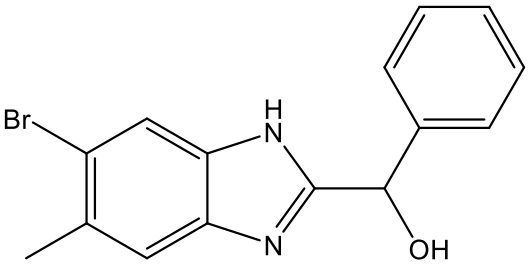
~~20~~15. The composition of ~~any one of~~ claim~~s 15-16~~12, ~~wherein the compound of formula (I) or salt thereof is~~further comprising a compound selected from the group consisting of:



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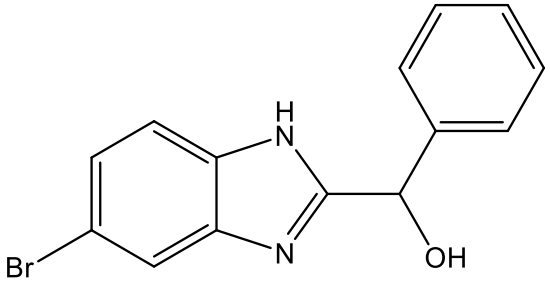

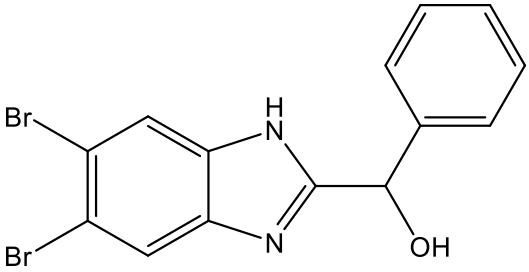

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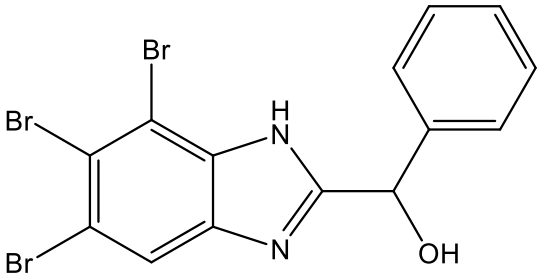

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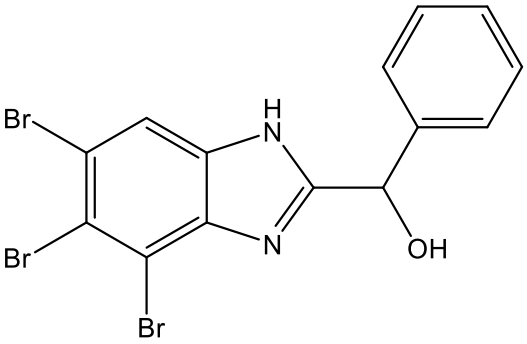

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