CLAIMS

What is claimed is:

1. A method of determining corrosion inhibitor concentration in water, comprising:

withdrawing a sample of water from an aqueous system, the sample of water comprising a benzimidazole-based compound;

adding an acid to the sample of water;

exposing the sample of water to light energy of a selected excitation wavelength;

measuring an intensity of emitted light about a selected fluorescence emission wavelength;

comparing the intensity of the emitted light to a standard curve, the standard curve comprising a plot of fluorescence emission intensity of the benzimidazole-based compound versus concentration of the benzimidazole-based compound; and

determining the concentration of the benzimidazole-based compound in the sample of water from the standard curve.

2. The method of claim 1, further comprising diluting the sample of water by adding water to the sample of water.

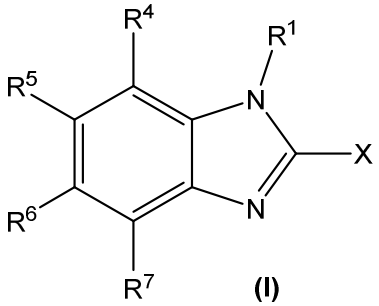
3. The method of claim 2, wherein the sample of water is diluted by 10 times.

4. The method of any one of claims 1-3, wherein the aqueous system is a cooling water system and the sample of water is a sample of cooling tower water.

5. The method of any one of claims 1-4, wherein the sample of water comprises hard water.

6. The method of any one of claims 1-5, wherein the sample of water comprises 25 ppm to 400 ppm of calcium and 25 ppm to 400 ppm of magnesium.

7. The method of any one of claims 1-6, wherein the benzimidazole-based compound is of formula (I) or salt thereof,



(I)

where

R^1 is halo, hydrogen, deuterium, hydroxyl, carbonyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_4-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;

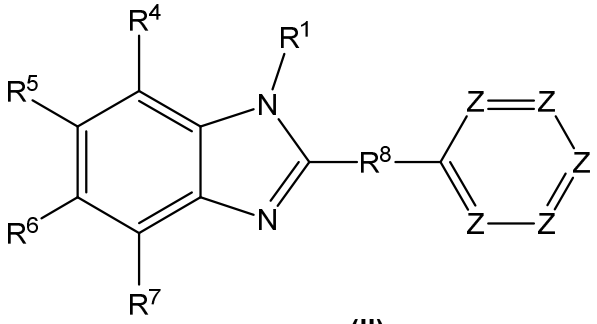
X is hydrogen, or CR^2R^3Y~~, or NR^2R^3Y~~;

Y is hydroxyl, halo, oxo, 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_4-C_6 aryl, substituted or unsubstituted C_4-C_6 heteroaryl, carbonyl, 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, carbonyl, nitro, phosphoryl, phosphonyl, sulfonyl, substituted or unsubstituted C_1-C_{16} alkyl, substituted or unsubstituted C_4-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.

8. The method of any one of claims 1-7, wherein the benzimidazole-based compound is 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_4-C_6 aryl group;

R^8 is a bond or CHR^9;

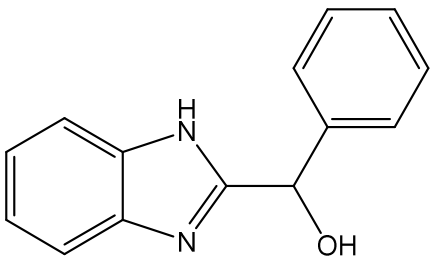
R^9 is hydrogen, halo, $NR^{10}R^{11}$, or OR^{10};

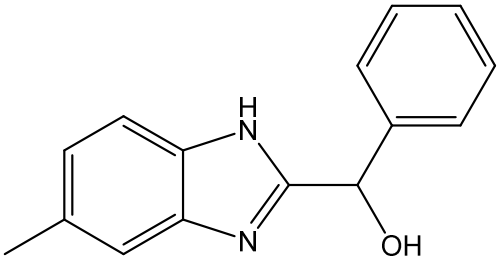
wherein R^{10} and R^{11} are each independently selected from the group consisting of: hydrogen, a substituted or unsubstituted C_1-C_{12} alkyl group, and a substituted or unsubstituted C_4-C_6 aryl group; and

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

9. The method of claim 8, wherein Z is CR^4 and R^4 is hydrogen.

10. The method of any one of claims 1-9, wherein the benzimidazole-based compound is selected from the group consisting of:



and


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11. The method of any one of claims 1-10, wherein the acid is a mineral acid, an organic acid, or any combination thereof.

12. The method of any one of claims 1-11, wherein the acid is hydrochloric acid, formic acid, phosphoric acid, nitric acid, sulfuric acid, acetic acid, propionic acid, oxalic acid, lactic acid, citric acid or any combination thereof.

13. The method of any one of claims 1-12, wherein the selected excitation wavelength is from 200 nm to 400 nm.

14. The method of any one of claims 1-13, wherein the selected fluorescence emission wavelength is from 300 nm to 500 nm.

15. The method of any one of claims 1-14, further comprising protonating the benzimidazole-based compound after adding the acid.

16. The method of any one of claims 1-15, wherein the sample of water has a pH of 1 to 5 after adding the acid.

17. The method of any one of claims 1-16, wherein the acid is added to the sample of water in an amount of 0.001% by weight to 10% by weight.

18. The method of any one of claims 1-17, wherein the addition of the acid decreases a fluorescence intensity of an emission band at 300 nm and increases a fluorescence intensity of an emission band at 370 nm for the benzimidazole-based compound.

19. A method of controlling the concentration of a corrosion inhibitor in an aqueous system, comprising:

determining the concentration of the benzimidazole-based compound in the sample of water according to any one of claims 1-18; and

adding the benzimidazole-based compound to the aqueous system if the concentration of the benzimidazole-based compound in the sample of water is below a predetermined level.

20. The method of claim 19, wherein the predetermined level is from 0.05 ppm to 20 ppm.

21. The method of any one of claims 19-20, wherein the aqueous system comprises an oxidizing biocide.