WHAT IS CLAIMED IS:

1. A method for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) introducing a sample comprising an electrolytically-active species into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

b) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage difference across the working electrode and auxiliary electrode until a change in the voltage difference is detected; and

c) generating a feedback signal based on a measured parameter of the change in the voltage difference, wherein the measured parameter of the change in the voltage difference is directly proportional to the amount of the electrolytically-active species in the sample.

2. The method of claim 1, further comprising reacting at least one reactant before step a) to produce a reaction mixture from which the sample is derived.

3. The method of claim 2, wherein the reaction mixture comprises an electrolytically-active reaction product in aqueous solution.

4. The method of claim 3, wherein the measured parameter of the change in the voltage difference is a measured duration of time of applying the constant current in step b) until the voltage difference is detected.

5. The method of claim 4, wherein the generation of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of the electrolytically-active reaction product in the sample.

6. The method of claim 5, further comprising using the feedback signal to control a rate of feeding of the at least one reactant to a process unit wherein the reacting occurs.

7. The method of claim 1, wherein the generating of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of a reactant in the sample.

8. The method of claim 1, wherein the electrolytically-active species is an oxidizing agent, and the method further comprises combining the oxidizing agent and a second reactant to produce a reaction mixture comprising at least one reaction product in aqueous solution.

9. A method for measuring and controlling the concentration of an electrolytically-active species in an aqueous solution, comprising:

a) combining at least a first reactant and a second reactant to produce a reaction mixture comprising an electrolytically-active reaction product in aqueous solution;

b) introducing a sample of the reaction mixture into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

c) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage

difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the constant current;

d) generating a feedback signal using the measured duration of time of step c), wherein the measured duration of time is directly proportional to amount of the electrolytically-active reaction product in the sample; and

e) using the feedback signal of step d) to control a rate of feeding of at least one of the first reactant and the second reactant in step a).

10. The method of claim 9, wherein the electrolytically-active reaction product is an oxidant.

11. The method of claim 9, wherein the electrolytically-active reaction product is a halo-containing oxidant, a peroxide, or a peroxide source.

12. The method of claim 9, wherein the first reactant is an oxidizing agent in aqueous solution.

13. The method of claim 9, wherein the first reactant is an alkali metal hypochlorite, the second reactant is ammonia, and the electrolytically-active reaction product oxidant is chloramine.

14. The method of claim 9, wherein the constant current is in the range of from about 10 milliampere (mA) to about 1 ampere (A).

15. The method of claim 9, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

16. The method of claim 9, wherein the selected amount of the sample is from about 1 mL to about 10 mL, wherein the measurement cell has a fixed cell volume which defines the selected amount of sample.

17. The method of claim 9, further comprising:

i) introducing a second sample composed of the first reactant into the measurement cell;

ii) applying a second constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the second sample with monitoring of voltage difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the second constant current;

iii) generating a feedback signal using the measured duration of time of step ii), wherein the measured duration of time is directly proportional to amount of the oxidizing agent in the second sample; and

iv) using the feedback signal of step iii) to control a rate of feeding of the first reactant in step a).

18. A method for measuring and controlling the concentration of an electrolytically-active

species in an aqueous solution treated with the electrolytically-active species, comprising:

a) combining at least a first reactant and a second reactant to produce an electrolytically-active reaction product which is formed in situ or before introduction in an aqueous solution to provide a treated aqueous solution;

b) introducing a sample of the treated aqueous solution in a selected amount into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

c) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the constant current;

d) generating a feedback signal using the measured duration of time of step c), wherein the measured duration of time is directly proportional to amount of the electrolytically-active reaction product in the sample; and

e) using the feedback signal of step d) to control a rate of feeding of at least one of the first reactant and the second reactant in step a).

19. The method of claim 18, wherein the aqueous solution that is treated is industrial process water, waste water, cooling water, boiler water, municipal water, food processing water, or pulp.

20. An apparatus for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) a measurement cell comprising a working electrode, an auxiliary electrode, and structure defining a cell volume for receiving a sample comprising an electrolytically-active species in an aqueous or non-aqueous solution;

b) a measurement circuit connected to the working electrode and the auxiliary electrode, wherein the measuring circuit is operable to i) provide a constant current to the measurement cell, ii) monitor and detect a change in voltage difference across the working and auxiliary electrodes, and iii) generate a feedback signal based on a measured parameter of the change in the voltage difference, wherein the measured parameter of the change in the voltage difference is directly proportional to the amount of the electrolytically-active species in the sample.

21. The apparatus of claim 20, wherein the digital processing unit comprises a clock operable for measuring the parameter as a duration of time of applying the constant current until a change in the voltage difference is detected.

22. The apparatus of claim 20, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

23. A method for measuring and/or controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution treated with the electrolytically-active species, comprising:

a) adding at least one electrolytically-active product to an aqueous solution to provide a treated aqueous or non-aqueous solution;

b) introducing a sample of the treated aqueous solution or treated non-aqueous solution into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

c) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the constant current;

d) generating a feedback signal using the measured duration of time of step c), wherein the measured duration of time is directly proportional to amount of the electrolytically-active product in the sample; and optionally,

e) using the feedback signal of step d) to control the amount of the electrolytically-active product, or a precursor thereof, or a component thereof in the aqueous solution or non-aqueous solution.

24. The method of claim 23, wherein the aqueous solution that is treated is industrial process water, waste water, cooling water, boiler water, municipal water, food processing water, or pulp.

25. The method of claim 23, wherein the electrolytically-active product is a biocide.

AMENDED CLAIMS
received by the International Bureau on 27 August 2013 (27.08.2013)

WHAT IS CLAIMED IS:

1. A method for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) introducing a sample comprising an electrolytically-active species into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

b) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage difference across the working electrode and auxiliary electrode until a change in the voltage difference is detected;

c) generating a feedback signal based on a measured parameter of the change in the voltage difference, wherein the measured parameter of the change in the voltage difference is directly proportional to the amount of the electrolytically-active species in the sample; and

d) using the feedback signal of step c) to control the amount of the electrolytically-active species, or a precursor thereof, or a component thereof, or a reactant for producing the electrolytically-active species in the aqueous solution or non-aqueous solution.

2. The method of claim 1, further comprising reacting at least one reactant before step a) to produce a reaction mixture from which the sample is derived.

3. The method of claim 2, wherein the reaction mixture comprises the electrolytically-active species in aqueous solution.

4. The method of claim 3, wherein the measured parameter of the change in the voltage difference is a measured duration of time of applying the constant current in step b) until the voltage difference is detected.

5. The method of claim 4, wherein the generation of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of the electrolytically-active reaction product in the sample..

6. The method of claim 5, further comprising using the feedback signal to control a rate of feeding of the at least one reactant to a process unit wherein the reacting occurs.

7. The method of claim 1, wherein the generating of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of a reactant in the sample.

8. The method of claim 1, wherein the electrolytically-active species is an oxidizing agent, and the method further comprises combining the oxidizing agent and a second reactant to produce a reaction mixture comprising at least one reaction product in aqueous solution.

9. The method of claim of 1, further comprising combining at least a first reactant and a second reactant to produce the electrolytically-active species in aqueous solution; wherein the feedback signal is used to control a rate of feeding of at least one of the first reactant and the second reactant.

AMENDED SHEET (ARTICLE 19)

10. The method of claim 9, wherein the electrolytically-active species is an oxidant.

11. The method of claim 9, wherein the electrolytically-active species is a halo-containing oxidant, a peroxide, or a peroxide source.

12. The method of claim 9, wherein the first reactant is an oxidizing agent in aqueous solution.

13. The method of claim 9, wherein the first reactant is an alkali metal hypochlorite, the second reactant is ammonia, and the electrolytically-active species is chloramine.

14. The method of claim 9, wherein the constant current is in the range of from about 10 milliampere (mA) to about 1 ampere (A).

15. The method of claim 9, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

16. The method of claim 9, wherein the selected amount of the sample is from about 1 mL to about 10 mL, wherein the measurement cell has a fixed cell volume that defines the selected amount of sample.

17. The method of claim 12, further comprising:

i) introducing a second sample composed of the first reactant into the measurement cell;

ii) applying a second constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the second sample with monitoring of voltage difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the second constant current;

iii) generating a second feedback signal using the measured duration of time of step ii), wherein the measured duration of time is directly proportional to amount of the oxidizing agent in the second sample; and

iv) using the feedback signal of step iii) to control a rate of feeding of the first reactant in step a).

18. The method of claim 9, wherein the electrolytically-active species is formed in situ or before introduction in an aqueous solution to provide a treated aqueous solution.

19. The method of claim 18, wherein the aqueous solution that is treated is industrial process water, waste water, cooling water, boiler water, municipal water, food processing water, or pulp.

20. The method of claim 1, wherein the electrolytically-active species is a biocide.

21. The method claim 1, wherein the working electrode and the auxiliary electrodes are the only electrodes.

22. An apparatus for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) a measurement cell comprising a working electrode, an auxiliary electrode, and structure defining a cell volume for receiving a sample comprising an electrolytically-active species in an aqueous or non-aqueous solution;

b) a measurement circuit connected to the working electrode and the auxiliary electrode, wherein the measuring circuit is operable to i) provide a constant current to the measurement cell, ii) monitor and detect a change in voltage difference across the working and auxiliary electrodes, iii) generate a feedback signal based on a measured parameter of the change in the voltage difference, the measured parameter of the change in the voltage difference being directly proportional to the amount of the electrolytically-active species in the sample, and iv) use the feedback signal of step iii) to control the amount of the electrolytically-active species, or a precursor thereof, or a component thereof, or a reactant for producing the electrolytically-active species in the aqueous solution or non-aqueous solution.

23. The apparatus of claim 22, wherein the measurement circuit comprises a clock operable for measuring the parameter as a duration of time of applying the constant current until a change in the voltage difference is detected.

24. The apparatus of claim 22, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

25. The apparatus of claim 22, wherein the working electrode and the auxiliary electrodes are the only electrodes.

AMENDED SHEET (ARTICLE 19)

WHAT IS CLAIMED IS:

1. A method for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) introducing a sample comprising an electrolytically-active species into a measurement cell, wherein the measurement cell comprises a working electrode and an auxiliary electrode;

b) applying a constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the sample with monitoring of voltage difference across the working electrode and auxiliary electrode until a change in the voltage difference is detected;

c) generating a feedback signal based on a measured parameter of the change in the voltage difference, wherein the measured parameter of the change in the voltage difference is directly proportional to the amount of the electrolytically-active species in the sample; and

d) using the feedback signal of step c) to control the amount of the electrolytically-active species, or a precursor thereof, or a component thereof, or a reactant for producing the electrolytically-active species in the aqueous solution or non-aqueous solution.

2. The method of claim 1, further comprising reacting at least one reactant before step a) to produce a reaction mixture from which the sample is derived.

3. The method of claim 2, wherein the reaction mixture comprises the electrolytically-active species in aqueous solution.

4. The method of claim 3, wherein the measured parameter of the change in the voltage difference is a measured duration of time of applying the constant current in step b) until the voltage difference is detected.

5. The method of claim 4, wherein the generation of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of the electrolytically-active reaction product in the sample.

6. The method of claim 5, further comprising using the feedback signal to control a rate of feeding of the at least one reactant to a process unit wherein the reacting occurs.

7. The method of claim 1, wherein the generating of the feedback signal comprises generating a feedback signal using the measured duration of time, wherein the measured duration of time is directly proportional to an amount of a reactant in the sample.

8. The method of claim 1, wherein the electrolytically-active species is an oxidizing agent, and the method further comprises combining the oxidizing agent and a second reactant to produce a reaction mixture comprising at least one reaction product in aqueous solution.

9. The method of claim 1, further comprising combining at least a first reactant and a second reactant to produce the electrolytically-active species in aqueous solution; wherein the feedback signal is used to control a rate of feeding of at least one of the first reactant and the second reactant.

10. The method of claim 9, wherein the electrolytically-active species is an oxidant.

11. The method of claim 9, wherein the electrolytically-active species is a halo-containing oxidant, a peroxide, or a peroxide source.

12. The method of claim 9, wherein the first reactant is an oxidizing agent in aqueous solution.

13. The method of claim 9, wherein the first reactant is an alkali metal hypochlorite, the second reactant is ammonia, and the electrolytically-active species is chloramine.

14. The method of claim 9, wherein the constant current is in the range of from about 10 milliampere (mA) to about 1 ampere (A).

15. The method of claim 9, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

16. The method of claim 9, wherein the selected amount of the sample is from about 1 mL to about 10 mL, wherein the measurement cell has a fixed cell volume that defines the selected amount of sample.

17. The method of claim 12, further comprising:

i) introducing a second sample composed of the first reactant into the measurement cell;

ii) applying a second constant current to the measurement cell while the working electrode and auxiliary electrode are in contact with the second sample with

monitoring of voltage difference across the working electrode and auxiliary electrode until detecting of a change in the voltage difference at a measured duration of time of applying the second constant current;

iii) generating a second feedback signal using the measured duration of time of step ii), wherein the measured duration of time is directly proportional to amount of the oxidizing agent in the second sample; and

iv) using the feedback signal of step iii) to control a rate of feeding of the first reactant in step a).

18. The method of claim 9, wherein the electrolytically-active species is formed in situ or before introduction in an aqueous solution to provide a treated aqueous solution.

19. The method of claim 18, wherein the aqueous solution that is treated is industrial process water, waste water, cooling water, boiler water, municipal water, food processing water, or pulp.

20. The method of claim 1, wherein the electrolytically-active species is a biocide.

21. The method of claim 1, wherein the working electrode and the auxiliary electrodes are the only electrodes.

22. An apparatus for measuring and controlling the concentration of an electrolytically-active species in an aqueous or non-aqueous solution, comprising:

a) a measurement cell comprising a working electrode, an auxiliary electrode, and structure defining a cell volume for receiving a sample comprising an electrolytically-active species in an aqueous or non-aqueous solution;

b) a measurement circuit connected to the working electrode and the auxiliary electrode, wherein the measuring circuit is operable to i) provide a constant current to the measurement cell, ii) monitor and detect a change in voltage difference across the working and auxiliary electrodes, iii) generate a feedback signal based on a measured parameter of the change in the voltage difference, the measured parameter of the change in the voltage difference being directly proportional to the amount of the electrolytically-active species in the sample, and iv) use the feedback signal of step iii) to control the amount of the electrolytically-active species, or a precursor thereof, or a component thereof, or a reactant for producing the electrolytically-active species in the aqueous solution or non-aqueous solution.

23. The apparatus of claim 22, wherein the measurement circuit comprises a clock operable for measuring the parameter as a duration of time of applying the constant current until a change in the voltage difference is detected.

24. The apparatus of claim 22, wherein the working electrode and the auxiliary electrode independently comprise graphite, glassy carbon, or any combinations thereof.

25. The apparatus of claim 22, wherein the working electrode and the auxiliary electrodes are the only electrodes.