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(54) Title: FOOD PRODUCT CLEANING SYSTEM AND METHOD

(57) Abstract: Methods of cleaning food product are described and illustrated. Some of the methods include producing halous acid; applying the halous acid to food product to at least partially disinfect the food product with the halous acid and to generate an effluent comprising halous acid; feeding the effluent comprising halous acid into a catalytic reactor comprising a catalytic material; contacting the effluent comprising halous acid with the catalytic material to produce a halogen oxide; and applying the halogen oxide to food product to at least partially disinfect the food product with the halogen oxide. In some methods, the halous acid is applied to food product to at least partially disinfect the food product; the halous acid is catalyzed to convert the halous acid to halogen oxide; and the halogen oxide is applied to the food product to at least partially disinfect the food product.

FOOD PRODUCT CLEANING SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Priority is hereby claimed to U.S. Provisional Patent App. No. 61/011,794 filed on January 22, 2008, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0001] The generation of chlorous acid by the acidification of an aqueous chlorite salt solution or stabilized aqueous chlorine dioxide solution (stabilized chlorite salt solution) by an acid is well known by the following reaction:

$$Na^+ClO_2^- + H^+ \rightarrow H^+ClO_2^- + Na^+ \quad (1)$$

[0002] It is also well known that, chlorous acid disproportionates to chlorine dioxide by two reaction pathways represented by the following reactions:

$$5HClO_2 \rightarrow 4ClO_2 + HCl + 2H_2O \quad (2)$$

$$4HClO_2 \rightarrow 2ClO_2 + HClO3 + HCl + H_2O \quad (3)$$

[0003] Reaction (2) predominates at low pH and high chlorite concentrations.

[0004] It is also well known that chlorine dioxide can be generated from chlorous acid by reaction with an oxidizing agent, such as hypochlorite, by the following reaction:

$$2HClO_2 + OCl^- \rightarrow 2ClO_2 + Cl^- + H_2O \quad (4)$$

[0005] It is similarly known that oxidation of chlorous acid to chlorine dioxide can occur at the anode of an electrochemical cell by the following reaction:

$$HClO_2 \rightarrow ClO_2 + H^+ + e^- \quad (3)$$

[0006] It is further known that chlorous acid is generated by the acidification of chlorate salt and subsequent reaction with an oxidizable material such as methanol by the following two-step reaction:

$$Na^+ClO_3^- + H^+ \rightarrow H^+ClO_3^- + Na^+ \quad (4)$$

$$4HClO_3 + CH_3OH \rightarrow 4ClO_2 + HCOOH + 3H_2O \quad (5)$$

[0007] Other oxidizable materials may be used in place of methanol. A partial list of these other materials includes sulfur dioxide and hydrogen peroxide which react with chloric acid ($HClO_3$) according to the following reactions:

$$2ClO_3^- + SO_2 \rightarrow 2ClO_2 + SO_4^{2-} \quad (6)$$

$$2ClO_3^- + H_2O_2 + 2H^+ \rightarrow 2ClO_2 + O_2 + 2H_2O \quad (7)$$

[0008] The generation of chlorine dioxide from chlorate salt, however, is very difficult to control on a small scale, such as is required for chlorine dioxide production and use in a food and beverage processing / production / packaging facility. High concentrations of all precursors must be used to start the reactions, but when the reactions do not go to completion, undesirable byproducts or unreacted precursor materials contaminate the chlorine dioxide solutions. In addition, chloride ion plays a role in the mechanism of these reactions and must be present, either from the decomposition of chlorate or the addition of the chloride ion itself, for chlorine dioxide to be generated.

[0009] The use of chlorine dioxide in many applications has been limited due to the inability to control the reaction chemistries and the inefficiency of the reactions in solutions. Since chlorine dioxide is an unstable gas, even in solution, it must be generated on-site and used shortly after generation.

[0010] Aspects of the present invention relates generally to a process for treating objects with halous acid (e.g., chlorous acid, in some embodiments) and/or halogen oxides (e.g., chlorine dioxide in some embodiments). Modern processing operations for preparing chicken, beef, pork, veal, turkey, duck, or other meats typically include an automated system that often comprises slaughtering, bleeding, scalding, evisceration, cleaning, chilling, and/or packaging steps. Each step normally requires careful control to prevent cross-contamination, prevent spoilage, and possibly illness from subsequent consumption. Due to its very nature, the process of evisceration exposes the exterior body surfaces and inner body cavities of bird carcasses or other animal carcasses to the contents of digestive and intestinal tracts. As a result, the evisceration process can cause excrement, blood, or other pathogen-laden particulate matter to deposit and become attached to carcasses. Consequently, immediately after evisceration processes, levels of bacteria and other pathogens on surfaces of carcasses typically increase relative to pre-evisceration levels.

[0011] Several methods have been developed to reduce the overall contamination rate after evisceration. Among these methods are co-current and counter-current chill tank systems, and the addition of various processing aids to tanks in such systems. Sonification may also be employed in chill tanks at sonic or ultrasonic frequencies.

[0012] Other methods include mechanically spraying carcasses with water and/or a treatment solution, possibly including the use of such fluids under high pressure. Additional methods include contacting eviscerated carcasses with a treatment solution in a rotating drum or immersion in a drag-through dip tank.

[0013] The use of chlorine in various forms, and the use of chlorine dioxide gas in particular as a sterilizing or sanitizing agent have long been known. One reason that chlorine dioxide based solutions are not widely used in sterilization and sanitation systems is the problem of outgassing of hazardous chemicals from chlorine dioxide solutions. For example, current OSHA regulations permit a maximum exposure level to chlorine dioxide of under 0.1 ppm.

[0014] Based at least in part upon the above-described challenges of using halous acid and halogen oxides in carcass cleaning systems, new systems employing halous acid and halogen oxides have significant design limitations. Accordingly, carcass cleaning systems adapted to clean carcasses in an efficient and effective manner while meeting government guidelines and standards are welcome additions to the art.

SUMMARY

[0015] Some embodiments of the present invention provide a method of cleaning food product, comprising: producing halous acid from an ion exchange column containing an ion exchange material; applying the halous acid to food product to at least partially disinfect the food product with the halous acid and to generate an effluent comprising halous acid; feeding the effluent comprising halous acid into a catalytic reactor comprising a catalytic material; contacting the effluent comprising halous acid with the catalytic material to produce a halogen oxide; and applying the halogen oxide to food product to at least partially disinfect the food product with the halogen oxide.

[0016] In some embodiments, a method of cleaning food product is provided, and comprises: applying halous acid to food product to at least partially disinfect the food

product; catalyzing the halous acid to convert the halous acid to halogen oxide; and applying the halogen oxide to the food product to at least partially disinfect the food product.

[0017] Some embodiments of the present invention provide a method of cleaning food product, comprising: introducing halous acid into a vessel; moving the halous acid from the vessel through a filter; moving at least a first portion of the filtered halous acid to a spray area; moving at least a second portion of the filtered halous acid to at least one catalyst; catalyzing the second portion of the filtered halous acid to produce halogen oxide; moving the halogen oxide to at least one of a pre-chiller and a spin chiller; spraying food product with the halous acid moved to the spray area; moving the food product through at least one of the pre-chiller and spin chiller; applying the halogen oxide moved to the at least one of the pre-chiller and spin chiller to the food product; and submerging the food product in the halous acid introduced into the vessel.

BRIEF DESCRIPTION OF THE DRAWING

[0018] The accompanying figure shows an embodiment of a process for producing and using halous acid and halogen oxide.

DETAILED DESCRIPTION

[0019] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0020] Also, it is to be understood that phraseology and terminology used herein with reference to device or element orientation (such as, for example, terms like "central," "upper," "lower," "front," "rear," and the like) are only used to simplify description of the present invention, and do not alone indicate or imply that the device or element referred to must have a particular orientation. In addition, unless otherwise specified, terms such as "first," "second," and "third" are used herein for purposes of description and are not intended to indicate or imply relative importance or significance.

[0021] It also is understood that any numerical range recited herein includes all values from the lower value to the upper value. For example, if a concentration range is stated as 1% to 50%, it is intended that values such as 2% to 40%, 10% to 30%, or 1% to 3%, etc., are expressly enumerated in this specification. These are only examples of what is specifically intended, and all possible combinations of numerical values between and including the lowest value and the highest value enumerated are to be considered to be expressly stated in this application.

[0022] Disclosed herein is a process for producing halogen oxide, wherein the process comprises feeding a dilute aqueous alkali metal halite solution into an ion exchange column, wherein the ion exchange column contains an ion exchange material; contacting the dilute aqueous alkali metal halite solution with the ion exchange material to produce an effluent containing halous acid that can be used to clean animal carcasses, such as in a dip tank or other vessel into which the carcasses are received; feeding the effluent containing halous acid into a catalytic reactor containing a catalytic material; and contacting the halous acid containing effluent with the catalytic material to produce a halogen oxide that can be used to further clean animal carcasses, such as within a spray enclosure through which the carcasses pass.

[0023] In some embodiments, a process for producing chlorine dioxide from an alkali metal chlorite solution comprises contacting a diluted alkali metal chlorite or chlorate with an ion exchange material to produce a halous acid-enriched solution; and contacting the halous acid-enriched solution with a catalyst to produce a halogen oxide. In some embodiments, the diluted alkali metal chlorite or chlorate contacts an ion exchange material in an ion exchange material column.

[0024] The halous acid may be generated separately in a first step, and subsequently catalyzed to form the halogen oxide in a second step, or the halous acid and the halogen oxide may be generated simultaneously in the same reaction environment in the presence of the requisite catalyst. In addition, the halous acid may be used in various processes before being converted to a halogen oxide. The process may be performed in either a continuous or a batch manner, with the reaction carried out in an aqueous solution or otherwise aqueous moist environment, i.e., in the presence of water or water vapor.

[0025] In addition, additional precursors may be used with the aqueous alkali metal halite solution to enhance the catalysis of halous acid in a moist environment to form halogen oxide either subsequently or simultaneously. Such precursors include, but are not limited to, permanganate ion, halide ion, chloride ion, sodium acid sulfite, peroxide and alcohol.

[0026] Still further, anion exchange materials may be a source of alkali metal halite ion, exchanged with a counter anion in a moist acidic environment to form halous acid, and further catalyzed in the moist environment to form halogen oxide either subsequently or simultaneously. By the ion exchange, a solution of halous acid can be generated from aqueous alkali metal halite solution by the salt cation/hydrogen ion exchange.

[0027] Additionally, ionic contaminants otherwise contained in the halous acid and/or halogen oxide solution can be removed with ion exchange, and ionic stabilizers may be added to the halous acid and/or the halogen oxide solutions via ion exchange. Still further, the pH of the halous acid and/or halogen oxide solutions may be adjusted by the use of ion exchange.

[0028] In some embodiments, a dilute alkali metal halite solution is introduced into the inlet of an ion exchange column. The alkali metal ions are adsorbed and exchanged with hydrogen ions by the ion exchange material to produce a halous acid effluent from the outlet. The halous acid effluent is then fed to the inlet of one or more catalytic reactors, wherein the halous acid is catalytically oxidized to produce a halogen oxide effluent.

[0029] As used herein, the term "solution" means a mixture formed by a process by which a solid, liquid, or gaseous substance is mixed with a liquid, whether that liquid is a droplet, aerosol, vapor, or mist. Also, as used herein, the term "moist environment" means that the environment in which the reaction occurs contains water moisture, ranging from a slightly humid environment to fully wet. Also, as used herein, the term "precursor" means any solution and/or combination of solutions used to generate halous acid and/or halogen oxide.

[0030] In some embodiments of the present invention, chlorous acid is generated by a salt cation/hydrogen ion exchange of chlorite salt or chlorate salt, or a combination of both, and, either subsequently or simultaneously, the chlorous acid is exposed to a catalyst in a moist environment to form chlorine dioxide. Further, chlorous acid, generated by the chemical acidification of chlorite salt or chlorate salt or both can also be exposed to a catalyst in a moist environment to form chlorine dioxide either subsequently or simultaneously. Processes for producing chlorine dioxide from an alkali metal chlorite or chlorate solution are disclosed in U.S. Patent No. 7,087,208, which is incorporated herein by reference in its entirety.

[0031] It is well known to those knowledgeable of the manufacture of chlorine dioxide that chlorous acid is formed by the acidification of chlorite salt and/or chlorate salt. In these reactions, hydrogen ion is placed in solution where it partially acidifies the chlorite salt and/or chlorate salt. The equilibrium conditions of the solution prevent the total acidification of the chlorite and/or chlorate salts. It has now been found that if the sodium ion is replaced by a hydrogen ion by means of a cation exchange material, the equilibrium conditions of the solution change, and essentially complete or at least enhancement of acidification of the chlorite salt and/or chlorate salt is possible, thereby making a substantially pure or purified chlorous acid solution.

[0032] Chlorous acid and aqueous solutions containing chlorous acid are particularly useful in applications where low-level disinfection over a long period of time is desirable. Some of these applications include disinfection of skin, the mouth, and cow teats. In addition, chlorous acid has a relatively low volatility level, making it applicable for surface disinfection in environments where off-gassing could be harmful. However, due to relatively high levels of residual chlorite in chlorous acid solutions and their inability to rapidly disinfect, chlorine dioxide is preferred in applications such as the disinfection of drinking water, cooling towers, food, and surfaces. In addition, chlorine dioxide is desirable for oxidizing organic contaminants and reducing iron and manganese levels in drinking water.

[0033] Further, it has been discovered that a chlorous acid solution can be readily catalyzed to form chlorine dioxide. The source of the chlorous acid solution can be either that generated by ion exchange or by conventional acidification. If the latter, the catalytic conversion of the chlorous acid to chlorine dioxide drives the acidification reaction to completion or substantial completion.

[0034] By definition, catalysts work by changing the activation energy for a reaction, i.e. the minimum energy needed for the reaction to occur. This is accomplished by providing a new mechanism or reaction path through which the reaction can proceed. When the new reaction path has a lower activation energy, the reaction rate is increased, and the reaction is said to be catalyzed. When catalysis is used to generate halogen oxide from halous acid in the present invention, it was found that neither high concentrations of precursor solutions nor high concentrations of halous acid were required to initiate the reactions. Further, it was discovered that the reactions proceeded toward completion rapidly, thus decreasing the opportunity for undesirable byproducts or unreacted precursor materials to contaminate the halogen oxide solutions.

[0035] There are many catalysts that can be used within the scope of the present invention. As used herein, the term "catalyst material" refers to a support and a catalyst. In some embodiments, the catalyst may be carbon or an ion exchange material. In another embodiment, the catalyst is a noble metal. Suitable active metal catalysts include, but are not limited to, ruthenium, platinum, palladium, osmium, iridium, rhodium, titanium, manganese, lead, zirconium, niobium, tantalum, tungsten, tin, and composites or mixtures or alloys or oxides of at least one of the foregoing metal catalysts. In some embodiments, the active metal catalyst is a combination of an oxide of ruthenium, platinum, palladium, osmium, iridium, rhodium, or mixtures or alloys of at least one of the foregoing metals and a less active oxide of a metal including titanium, lead, manganese, zirconium, niobium, tantalum, tungsten, tin, or mixtures, or alloys of at least one of the foregoing metals.

[0036] Further, it is well known that depositing such catalysts on various substrates, such as zeolites, aids in the catalysis by increasing surface area. Such catalysts are commercially available, and it is within the scope of those skilled in the art to choose an appropriate catalytic material and/or substrate to catalyze halous acid to halogen oxide. Suitable supports for the catalyst material include, without limitation, metals, zeolites, anthracite, glauconite, faujasite, mordenite, clinoptilolite, aluminas, silicas, clays, ceramics, carbon, and the like.

[0037] Further, it has been discovered that an anion exchange material can be used to contribute a controlled amount of anions to the precursor, halous acid solution, and/or halogen oxide solution.

[0038] Ion exchange material can also be used to remove unwanted ions from the precursor, halous acid, and/or halogen oxide solution. For example, if the reaction to halogen oxide does not go to completion, unreacted halite and/or halate anion will be present in the halogen oxide solution. Anion exchange material can be used to remove the halite and/or halate ion. Further, if the precursor solution is acidified chemically, excess alkali metal ion will be present in the halogen oxide solution. Cation exchange material can be used to remove the alkali metal ion.

[0039] Ion exchange materials, such as inorganic and organic resins, membranes, powders, gels, and solutions are well known to those skilled in the art, and the type of ion exchange material used does not limit the invention. Examples of ion exchange materials are weak acid cation resins and powders, strong acid cation resins and powders, weak base anion resins and powders, strong base anion resins and powders, sulfonated polystyrene solutions, cation and anion selective membranes. One example of an exchange material is one that has portions of its active sites occupied with hydrogen, i.e., exchange material in the hydrogen form. Further examples of suitable ion exchange materials include, but are not limited to, polystyrene divinylbenzene cross-linked cation exchangers (e.g., strong acid types, weak acid types, iminodiacetic acid types, chelating selective cation exchangers and the like); strong acid perfluorosulfonated cation exchangers, e.g., NR40 and NR50 commercially available from E.I. DuPont de Nemours, Wilmington, Del.; naturally occurring cation exchangers, such as manganese greensand and hydrotalcite; high surface area macro-reticular or microporous type ion exchange resins having sufficient ion conductivity, and the like. Suitable ion exchange resins for the ion exchange column include Relite EXC04 (Mitsubishi Chemical Corporation), Diaion HPK25 (Mitsubishi Chemical Corporation), Diaion PK228 (Mitsubishi Chemical Corporation), Diaion SK116 (Mitsubishi Chemical Corporation), Resintech CG-8 (ResinTech Corporation), Resintech SIR-600 (ResinTech Corporation), Lewatit K7333 (Bayer Corporation), and Resintech WBMP (ResinTech Corporation). In some embodiments, ion exchange materials and catalysts such as those described in U.S. Patent Nos. 6,913,741 and 7,087,208 can be used. U.S. Patent No. 6,913,741 is incorporated herein by reference in its entirety. Selection of a particular ion exchange material is considered within the skill of those knowledgeable in the field.

[0040] The ion exchange material and/or the catalytic material are not intended to be limited to any particular shape. Suitable shapes include rods, extrudates, tablets, pills, irregular shaped particles, spheres, spheroids, capsules, discs, pellets and the like.

[0041] In some embodiments of the present invention, cation exchange material is used to exchange the salt cation in a halite precursor with hydrogen ion to form halous acid. The resulting halous acid is then placed in contact with a catalytic material for a time sufficient to form halogen oxide.

[0042] In some embodiments of the present invention, acid is added to the halite precursor to form halous acid with the salt cation still present in solution. The halous acid is then placed in contact with a catalytic material for a time sufficient to form halogen oxide. The choice of which acid to use depends upon the application. For example, if halous acid and/or halogen oxide solution are to be used in a food processing application, an acid such as acetic acid may be preferred. If halous acid and/or halogen oxide solution are to be used in a high purity industrial application, electrochemically-generated acid may be used. The choice of acid is well within the scope of knowledge of those skilled in the art.

[0043] In some embodiments of the present invention, an acidic reducing agent precursor is added to the halate precursor as the halate precursor is placed in contact with a catalytic material for a time sufficient to cause the generation of halous acid and halogen oxide simultaneously.

[0044] Also, in some embodiments of the present invention, an acid precursor and a reducing agent precursor are added to the halate precursor as the halate precursor is placed in contact with a catalytic material for a time sufficient to cause the generation of halous acid and halogen oxide simultaneously.

[0045] In some embodiments of the present invention, a halate precursor is placed in contact with a cation exchange material mixed with a catalytic material. The salt cation in the halate precursor is exchanged with hydrogen ion as the halate precursor contacts both the cation exchange material and the catalytic material for a time sufficient to cause the generation of halous acid and halogen oxide simultaneously. If necessary, other precursors, such as an alkali metal halide, may be used along with the halate precursor to aid in the reaction.

[0046] In some embodiments of the present invention, a reducing agent is placed in contact with the halate precursor either prior to the precursor being placed in contact with the catalytic material or as the precursor is placed in contact with the catalytic material for a time sufficient to form halogen oxide. In one example of this embodiment, the catalytic material aids in reactions (5), (6), and (7).

[0047] A mixed halite and halate precursor can be acidified as it is placed into contact with a catalytic material for time sufficient to form halogen oxide.

[0048] With reference now to the accompanying figure of the present patent application, a process for treating food products with a cleaning substance is illustrated schematically. In particular, the accompanying figure illustrates a process generally designed by reference number 10, wherein the process 10 defines one or more stations incorporated into an automated food processing system. The process 10 can be used on an existing or new automated processing line, or in other applications that need not necessarily be used in conjunction with an automated processing line. By way of example only, the following process will be described as it relates to processing eviscerated poultry (e.g., chickens, ducks, geese, turkeys, and the like). However, it is noted that the process can also be employed as one or more stations for automated processing of such food in other stages of a food processing system (e.g., prior to evisceration), and for other animal carcasses, fish, and other foods, such as vegetables and fruit, as would be apparent to those skilled in the art in view of this disclosure. In any case, the process 10 can be used for treating various types of food with an anti-microbial agent to remove pathogens and/or retard spoilage caused by microbes.

[0049] The process 10 shown in the accompanying figure includes an on-line reprocessing unit 12 for the production of halous acid (described above). In some embodiments, by way of example only, the halous acid is chlorous acid. The on-line reprocessing unit 12 can include, for example, two or four ion exchange resin bottles. Once a first ion exchange resin bottle is exhausted, it can be automatically regenerated using hydrochloric acid while a second ion exchange resin bottle takes the first bottle's place. In other embodiments, other numbers of such bottles can be used as desired. In some embodiments, (not shown), chlorous acid from the on-line reprocessing unit 12 may contain some chlorine dioxide, which chlorine dioxide may be extracted, without limitation, by a fume hood.

[0050] In some embodiments, a water stream 14 is combined with the chlorous acid from the online reprocessing unit 12 to produce a diluted chlorous acid stream 16. In some embodiments, the ratio of water to chlorous acid is 60/40, although other ratios of water to chlorous acid are possible. Also, in some embodiments, the diluted chlorous acid stream 16 can be at a concentration of about 500 ppm to about 900 ppm.

[0051] Chlorous acid may provide antimicrobial protection when used in accordance with 21 C.F.R. § 173.325 (500 to 1200 ppm measured as sodium chlorite). In some embodiments, the chlorous acid stream 16 is fed to a post chill dip tank 18. The post chill dip tank 18 is designed to fully immerse carcasses in a solution of chlorous acid. The chlorous acid concentration can range, in some embodiments, from about 500 ppm to about 1200 ppm. In some embodiments, the post chill dip tank 18 includes a pump 21. The pump 21 pumps air into the bottom of the post chill dip tank 18. This may contribute to driving off chlorine dioxide build-up in the chlorous acid solution. The post chill dip tank 18 can also include a bypass outlet to prevent production stoppage in the event of a backup or equipment shutdown. The post chill dip tank 18 can be sized according to anticipated required flow rates to keep the solution fresh while optimizing consumption for economic gain. Also, the carcass conveyor or other apparatus used to move carcasses into and out of the post chill dip tank 18 can include variable drive speeds. The post chill dip tank 18 can further include a full hooded ventilation system to extract chemical vapors.

[0052] In some embodiments, the chlorous acid stream 16 is fed directly (not shown) to a spray cabinet 34 or other area. However, in the illustrated embodiment, the chlorous acid stream 16 is first fed to the post chill dip tank 18. Used chlorous acid 20 can then be filtered through a filter 22. The filtered chlorous acid 24 can then be fed to one or more catalysts 26 and/or spray cabinets 34. Carcasses can be treated with chlorous acid in the spray cabinet 34. A number of different spray cabinets can be used. As illustrated, waste chlorous acid 36 from the spray cabinet 34 is fed to a drain 38. However, in some applications, the chlorous acid 36 from the spray cabinet 34 can be filtered and reused, if desired. Filtration may remove animal fat and/or other impurities from the chlorous acid. Examples of filtration techniques include, without limitation, mechanical filtration, ultrafiltration, centrifugal filtration, and combinations thereof. Other examples of cleaning techniques include, without limitation, chemical treatments (e.g., changing the pH to saponify fat) or chilling treatments (e.g., drop the temperature to assist in the filtration of fat). Still other examples of cleaning techniques

include, without limitation, adjusting the catalyst to make it foul-resistant or adjusting the pore size of the catalyst so that there is enough contact of the chemicals while still avoiding fouling of the catalyst with fat. In some embodiments, mechanical filtration is used prior to the use of other filtration or cleaning techniques.

[0053] In some embodiments, such as the illustrated embodiment, the chlorous acid stream 16 or the filtered chlorous acid 24 can be fed to a catalyst 26. The catalyst 26 can be a catalyst as described above. By passing through the catalyst 26, the chlorous acid stream 16 or the filtered chlorous acid 24 can be converted to an aqueous solution of chlorine dioxide 30. The conversion of chlorous acid to chlorine dioxide has been described above. Chlorine dioxide can be an effective chiller treatment providing microbial control of carcasses. Chlorine dioxide is a gas which can be effective at low concentrations (21 C.F.R. § 173.300 limits residual chlorine dioxide on carcasses upon exit of a spin chiller 28 or pre-chiller 32 (see accompanying figure) to be no more than 3 ppm). By passing chlorous acid through the catalyst(s) 26, chlorine dioxide can be produced at acceptable concentrations for the spin chiller 28 and the pre-chiller 32.

[0054] In some embodiments, a chlorine dioxide stream 30 is fed to a spin chiller 28 and/or to a pre-chiller 32. If the spin chiller 28 is used alone to treat carcasses, the carcasses can be treated up to 3 ppm residual. The initial concentration of chlorine dioxide can be from about 7 ppm to about 15 ppm. In some embodiments, the chlorine dioxide stream 30 is injected at or near the carcasses output end of the spin chiller 28. The residual concentration of chlorine dioxide can be measured anywhere in the system (e.g., downstream of the spin chiller 28, between the spin chiller 28 and pre-chiller 32, between the pre-chiller 32 and spray cabinet 34, and/or downstream of the spray cabinet 34). Such measurements can be used in an automated or semi-automated system to control the feed rate of carcasses moving any part or all of the process 10. If desired, the concentrated chlorine dioxide can be diluted.

[0055] In some embodiments, carcasses enter the spray cabinet 34, enter the pre-chiller 32, then enter the spin chiller 28, and finally are dipped in the post chill dip tank 18. In other embodiments, carcasses are treated using only one of the spray cabinet 34, pre-chiller 32, spin chiller 28, and post chill dip tank 18, or using any combination of the spray cabinet 34, pre-chiller 32, spin chiller 28, and post chill dip tank 18. In some embodiments, carcasses are treated with chlorous acid in the post chill dip tank 18 or the spray cabinet 34 before entering the spin chiller 28 or the pre-chiller 32. Also, in some embodiments, carcasses are

treated with chlorous acid in the post chill dip tank 18 or the spray cabinet 34 after entering the spin chiller 28 or the pre-chiller 32. Any combination of the steps in the process 10 illustrated in the accompanying figure can be used for a total program approach. The steps in the process 10 can also be separated for a spot treatment approach.

[0056] Additionally, the present invention can incorporate other treatment processes along with those disclosed herein, including the use of brushes or other cleaning devices that can mechanically assist in the cleaning process. Furthermore, although chlorine dioxide solution and/or chlorous acid solution is the cleaning substance used in each step of the illustrated embodiments described above, in other embodiments, different substances can be used in one or more of the steps.

[0057] Other modifications, changes, and substitutions are intended in the foregoing description and in the accompanying drawing, and in some instances, some features of the invention will be employed without a corresponding use of other features. For example, in some embodiments, the spray cabinet need not necessarily be used. Or, in other embodiments, the post chill dip tank, or spin chiller, or pre-chiller need not necessarily be used. Any combination of the elements shown in the process 10 may be used.

[0058] In any of the embodiments described herein, chlorous acid can be re-used prior to being filtered and converted to chlorine dioxide. In some embodiments, waste chlorous acid 36 from the spray cabinet 34 is filtered and re-used and/or converted to chlorine dioxide.

[0059] The embodiments described above and illustrated in the accompanying figure are presented by way of example only, and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A method of cleaning food product, comprising:

producing halous acid from an ion exchange column containing an ion exchange material;

applying the halous acid to food product to at least partially disinfect the food product with the halous acid and to generate an effluent comprising halous acid;

feeding the effluent comprising halous acid into a catalytic reactor comprising a catalytic material;

contacting the effluent comprising halous acid with the catalytic material to produce a halogen oxide; and

applying the halogen oxide to food product to at least partially disinfect the food product with the halogen oxide.

2. The method of claim 1, wherein the food product comprises animal carcasses.

3. The method of claim 2, wherein the halous acid is applied to the same food product as the halogen oxide.

4. The method of claim 1, wherein at least partially disinfecting the food product comprises at least partially submerging the food product in a vessel comprising at least one of halous acid, halogen oxide, and a combination thereof.

5. The method of claim 1, wherein at least partially disinfecting the food product comprises spraying the food product with at least one of halous acid, halogen oxide, and a combination thereof.

6. The method of claim 5, further comprising moving the food product through a spray enclosure while spraying the food product with at least one of halous acid, halogen oxide and combinations thereof.

7. The method of claim 1, further comprising filtering the effluent comprising halous acid prior to contacting the effluent comprising halous acid with the catalytic material to produce a halogen oxide.

8. The method of claim 1, wherein the halous acid is applied to food product to at least partially disinfect the food product with the halous acid prior to contacting the effluent comprising halous acid with the catalytic material to produce halogen oxide.

9. The method of claim 7, further comprising applying the halogen oxide to food product passing through at least one of a pre-chiller, a spin chiller, and a combinations thereof.

10. The method of claim 1, wherein the halous acid comprises chlorous acid and the halogen oxide comprises chlorine dioxide.

11. A method of cleaning food product, comprising:
applying halous acid to food product to at least partially disinfect the food product;
catalyzing the halous acid to convert the halous acid to halogen oxide; and
applying the halogen oxide to the food product to at least partially disinfect the food product.

12. The method of claim 11, further comprising producing the halous acid in an on-line reprocessing unit.

13. The method of claim 11, further comprising filtering the halous acid prior to catalyzing the halous acid.

14. The method of claim 11, further comprising recycling at least a portion of the halous acid for re-application to food product.

15. The method of claim 14, further comprising filtering the recycled halous acid prior to re-application to food product.

16. The method of claim 11, wherein applying halous acid to the food product comprises at least one of spraying the food product with the halous acid, at least partially submerging the food product in the halous acid, and a combinations thereof.

17. The method of claim 11, wherein the halogen oxide is applied to the food product in at least one of a pre-chiller, a spin chiller, and a combination thereof.

18. The method of claim 11, wherein the halous acid comprises chlorous acid and the halogen oxide comprises chlorine dioxide.

19. The method of claim 11, further comprising diluting the halous acid with water prior to applying the halous acid to the food product.

20. A method of cleaning food product, comprising:

introducing halous acid into a vessel;

moving the halous acid from the vessel through a filter;

moving at least a first portion of the filtered halous acid to a spray area;

moving at least a second portion of the filtered halous acid to at least one catalyst;

catalyzing the second portion of the filtered halous acid to produce halogen oxide;

moving the halogen oxide to at least one of a pre-chiller and a spin chiller;

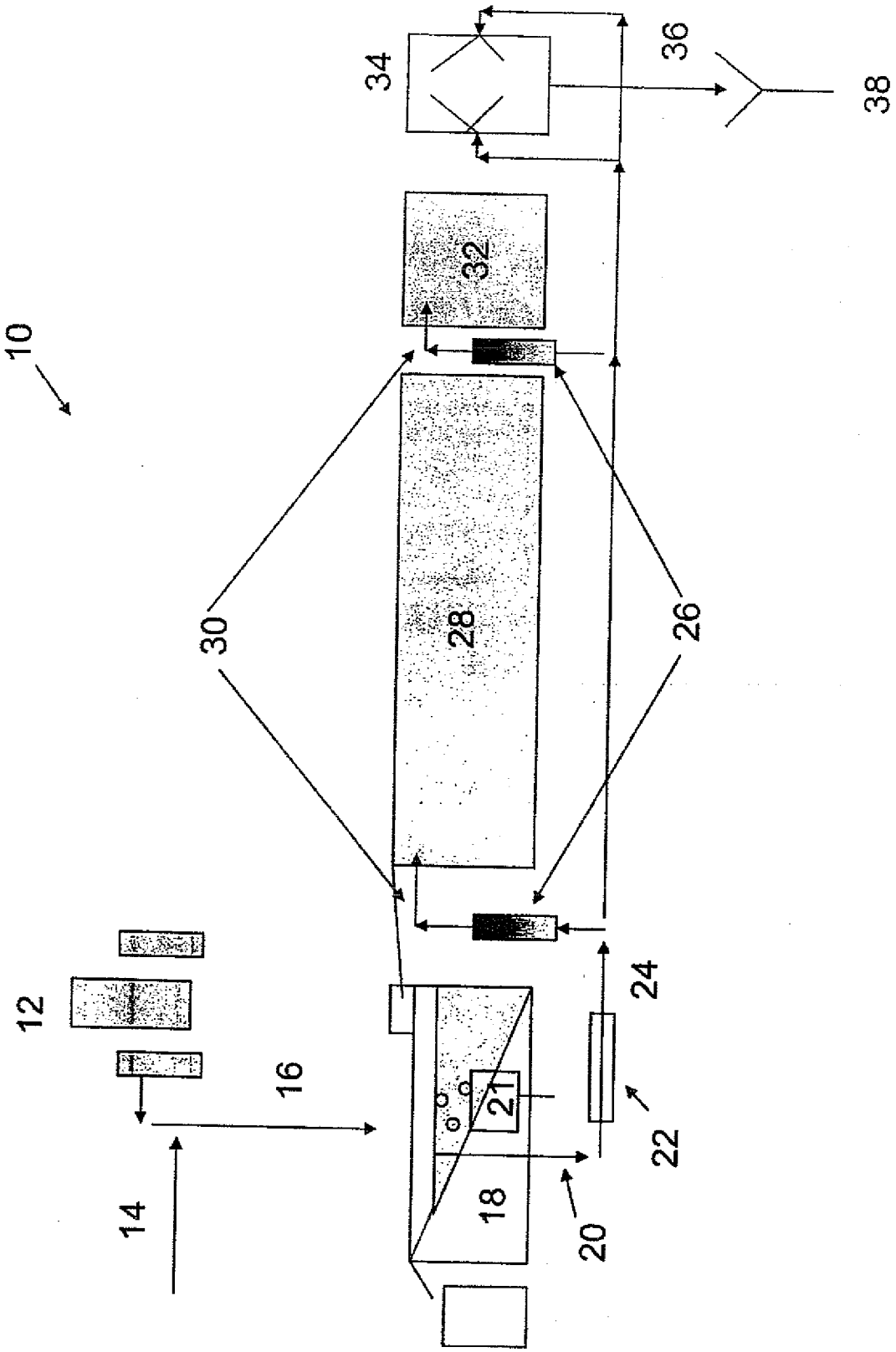
spraying food product with the halous acid moved to the spray area;

moving the food product through at least one of the pre-chiller and spin chiller;

applying the halogen oxide moved to the at least one of the pre-chiller and spin chiller to the food product; and

submerging the food product in the halous acid introduced into the vessel.

21. The method of claim 20, wherein the halous acid comprises chlorous acid and the halogen oxide comprises chlorine dioxide.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