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(54) **NOVEL METHOD OF SANITIZING FOOD PRODUCTS AND OTHER TARGET ITEMS**

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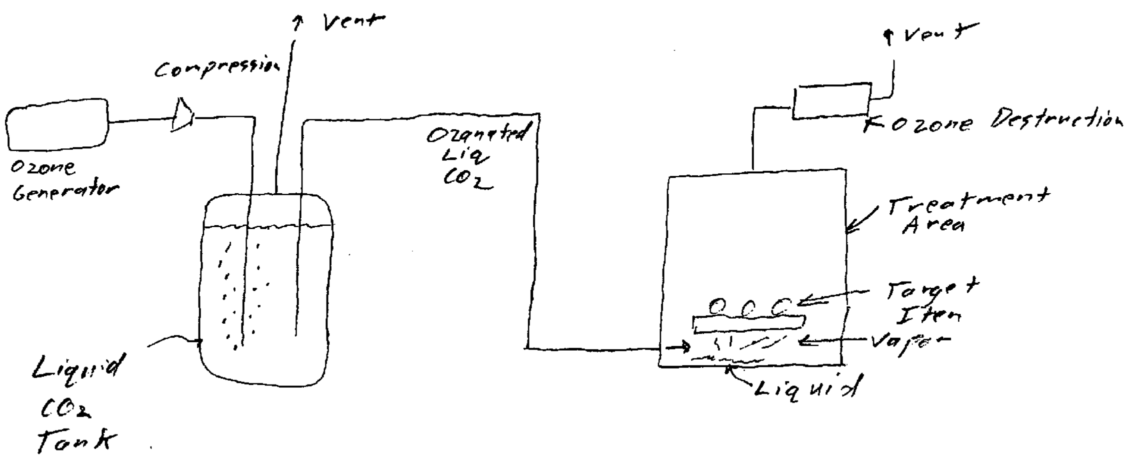
(57) **ABSTRACT**

Methods of cooling and sanitation of target items, particularly food products, food storage, and food transportation devices. A treating agent containing a sanitizing agent entrapped by or absorbed in or on a cooling agent is used when processing, transporting, displaying, or storing of target items. The treating agent can be used to chill and preserve target items, and while providing the added benefit of sanitizing the target item. This disclosure also discusses novel processes for using a treating agent to process, store, or package target items using a treating agent containing a cooling agent, such as solid carbon dioxide ("dry ice"), and a sanitizing agent, such as ozone.



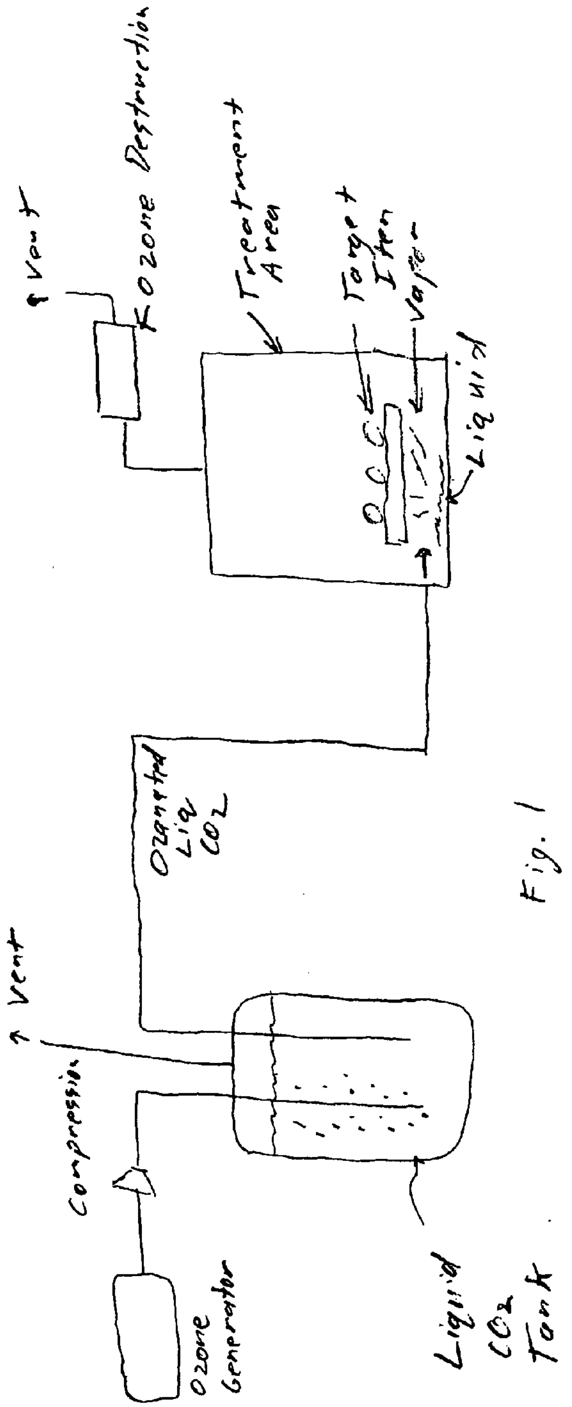

Ozone Generator
Compression
Vent
Liquid CO2 Tank
Ozanated Liq CO2
Vent
Ozone Destruction
Treatment Area
Target Item
Vapor
Liquid

Fig. 1

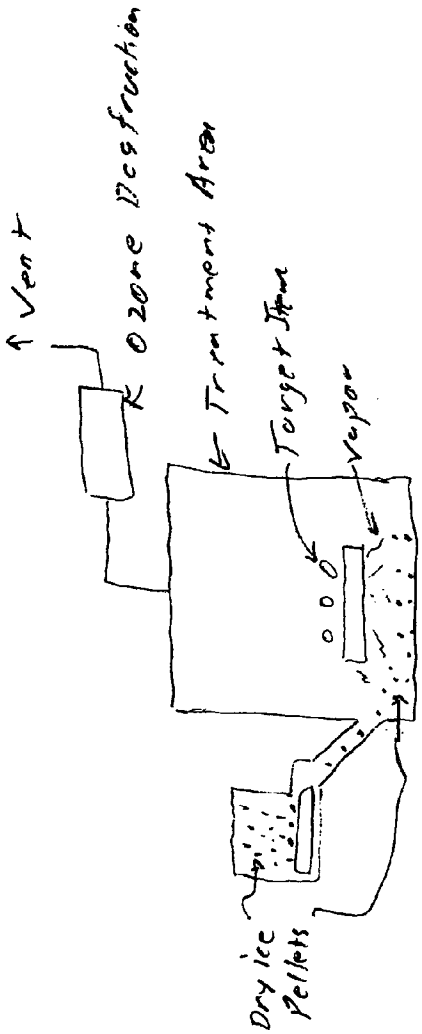

Vent
Ozone Destruction
Treatment Area
Target Item
Vapor
Dry ice Pellets

Fig. 2

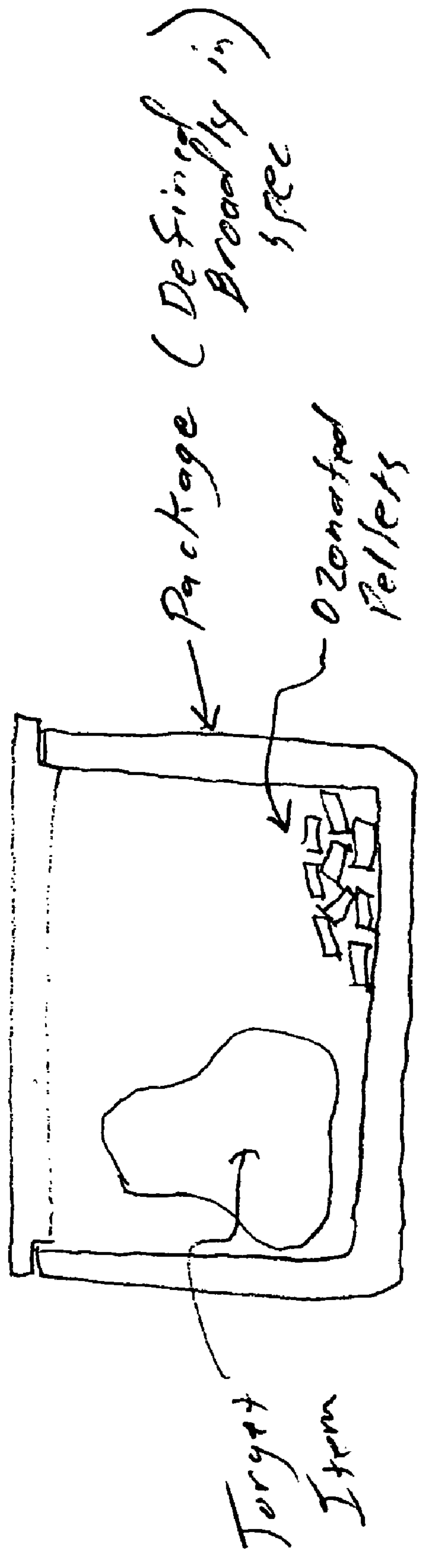

Package (Defined Broadly in spec)
Ozonated Pellets
Target Item

Fig. 3

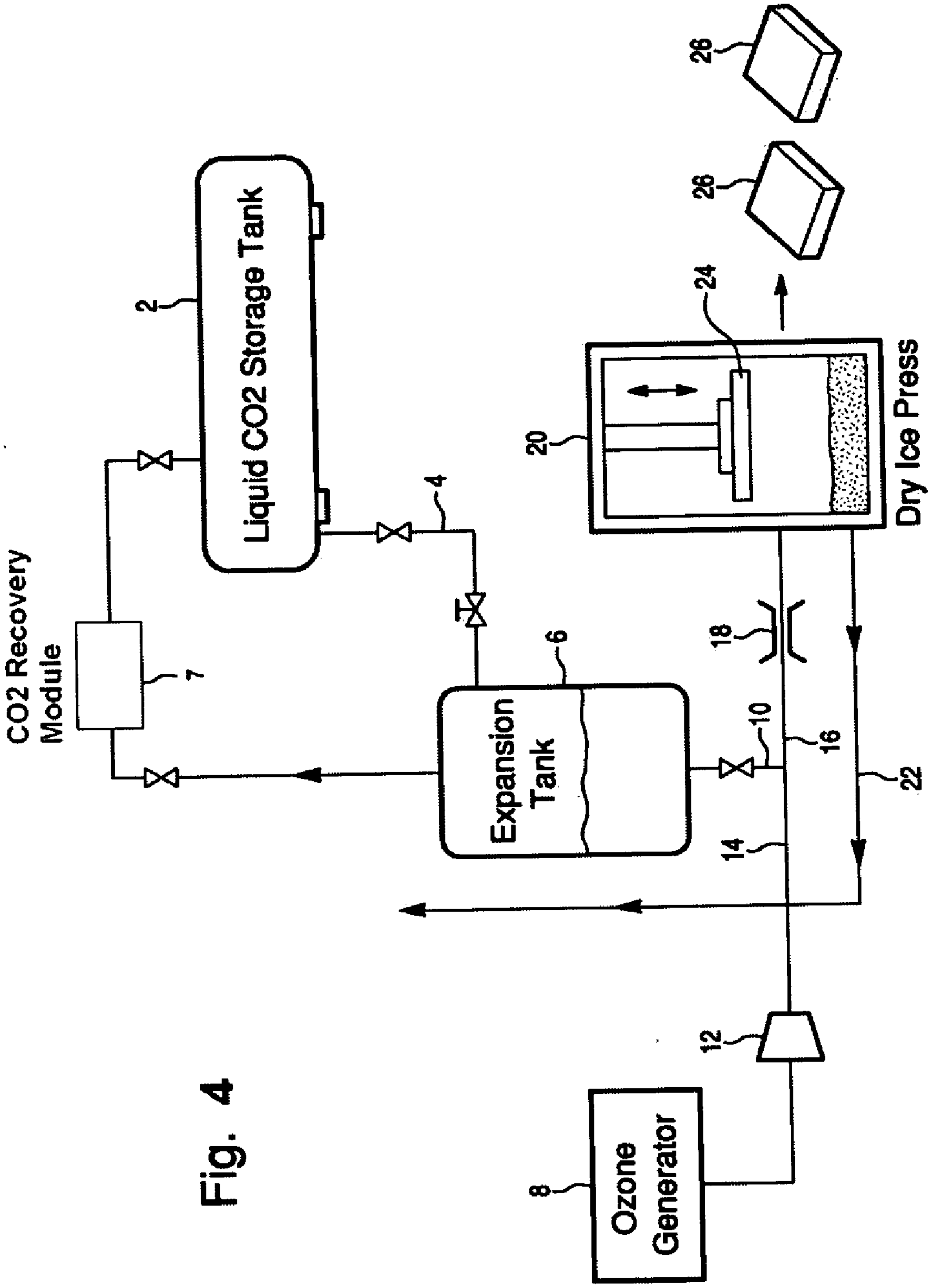

Liquid CO2 Storage Tank
2
4
CO2 Recovery Module
7
6
Expansion Tank
10
16
14
18
22
20
24
Dry Ice Press
26
26
12
8
Ozone Generator

Fig. 4

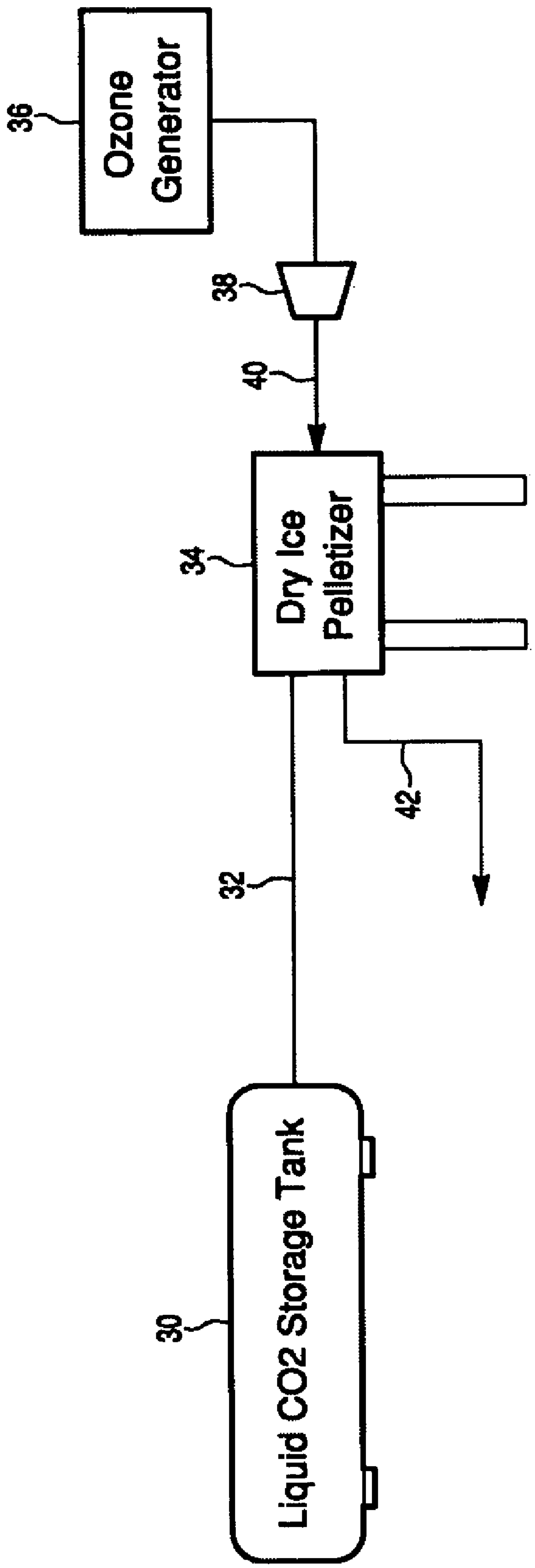

36
Ozone Generator
38
40
34
Dry Ice Pelletizer
42
32
30
Liquid CO2 Storage Tank

Fig. 5

S 6629

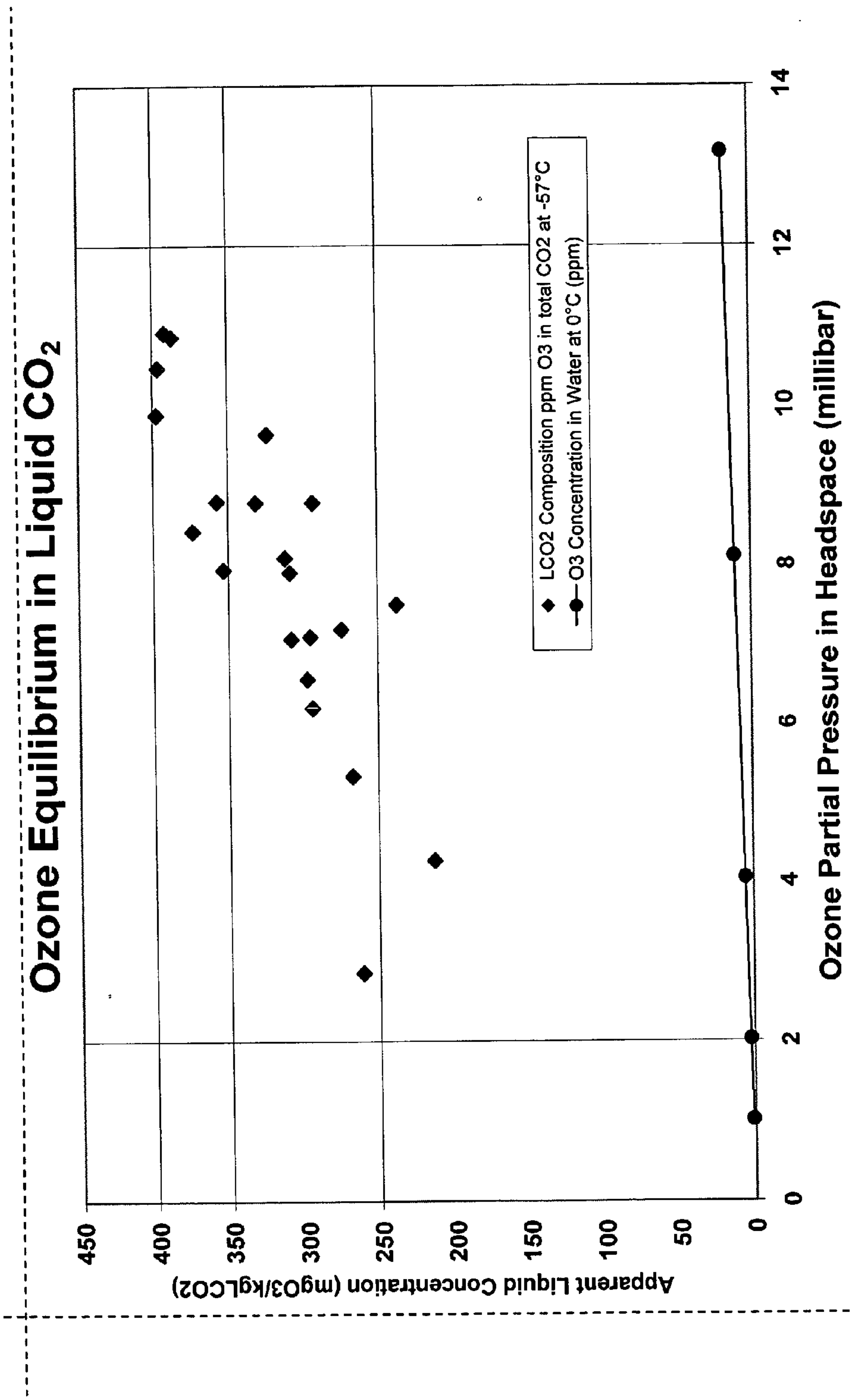


Figure 6

NOVEL METHOD OF SANITIZING FOOD PRODUCTS AND OTHER TARGET ITEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation in part of and claims priority to U.S. application Ser. No. 10/632,232, filed Jul. 31, 2003, which is a non-provisional application claiming priority of U.S. Provisional application 60/404,635, filed Aug. 20, 2002, and U.S. Provisional application 60/459,398, filed Apr. 1, 2003. The entire contents of these applications are herby incorporated by these references.

BACKGROUND

[0002] The protection of food from damage caused by microbes, spores, insects, and other similar sources, is a major concern. Each year, economic loss of food and labor, due to damage from such sources, is more than $100 billion. Currently, food items are preserved using a variety of methods, including refrigeration, fumigation with toxic chemicals, irradiation, biological control, heat exposure, and controlled atmosphere storage (a fruit industry technique that involves modifying the concentration of gases naturally present in the air).

[0003] The primary problem regarding food spoilage in public health is microbial growth. If pathogenic microorganisms are present,, then growth can potentially lead to food-borne outbreaks, and significant economic losses. Food safety concerns have been brought to the consumers' attention since the early part of the 20th century, and those concerns have become even stronger today. Outbreaks from *Salmonella* and *E. coli* have increased the focus on food safety, including from a regulatory perspective.

[0004] A study completed by the Centers for Disease Control and Prevention (CDC) estimated that food-borne diseases cause approximately 76 million illnesses, 325,000 hospitalizations and 5,000 deaths annually in the U.S. those numbers reveal the dramatic need for effective means of handling food products in order to ensure food safety.

[0005] Effective sanitation depends on the combination of what is to be sanitized and the sanitation process type. Not all of the currently available technologies can deliver an effective reduction of microorganisms, and at the same time, prevent product, or environmental degradation. It is well known in the art to cool products, such as foods, during processing with some type of refrigerant to slow down the growth of unwanted microbes and enzymatic reactions in foods. For instance, the shelf life and quality of food products are improved by processing, transporting, and storing under refrigerated conditions.

[0006] Cooling agents, such as dry ice or nitrogen, are liquid or solid agents that can be used as an expendable refrigerant. Water ice is a traditional expendable refrigerant, but has the disadvantage of converting to water after the ice melts. Some solid cooling agents convert from a solid directly to a gas in the process known as sublimation. For example, dry ice sublimes by going directly from a solid to a gas without passing through the liquid stage. The cold temperature of dry ice and the fact that it leaves no residue like water ice makes it an excellent refrigerant in some applications. For example, when transporting food products that must remain frozen during transportation, the food can be packed with dry ice. The contents will be frozen when they reach their destination and there will be no messy liquid left over like traditional water ice. In food processing applications, liquids, such as nitrogen, are used to cool and inert the atmosphere during food processing or storage.

[0007] While refrigeration can retard microbial growth, such treatment does not necessarily kill bacteria. Accordingly, microorganisms can still survive through refrigeration, and worse, some microorganisms can still grow and produce harmful substances during refrigerated storage.

[0008] Biocidal agents are used to sanitize equipment, provide antiseptic environments, and process foods while reducing spoilage and sanitizing the food. The reaction of biocidal agents with microbial cell structures is often irreversible; therefore the cells either become attenuated or die.

[0009] It is desirable to sanitize equipment or devices and process foods using a combination of the cooling properties of cooling agents with the pathogen destruction capability of sanitizing agents. It is further desirable that the cooling agent and the sanitizing agents be exposed to the equipment or food product substantially simultaneously.

SUMMARY OF THE INVENTION

[0010] This invention addresses the need to cool and sanitize equipment, devices, and food or food products. The process uses a treating agent that contains a cooling agent for cooling and a sanitizing agent to reduce microbial growth. By combining the effects of cooling and sanitizing provides maximum biocidal efficiency to ensure pathogenic safety.

[0011] The current invention provides a method of cooling and sanitizing an item or piece of equipment by exposing the item or equipment to a treating agent, wherein the treating agent contains a sanitizing agent and a cooling agent. The treating agent is in a solid form when initially exposed to the item or equipment, and the sanitizing agent is present in the treating agent while the treating agent is in a solid form. As the treating agent melts or sublimes, the sanitizing agent is released and contacts the item or equipment.

[0012] The current invention also provides a method of packaging an item, such as a food product, by placing the item into a container and adding a treating agent as described above to the container.

[0013] The current invention further provides for a product that is a treating agent containing a cooling agent and a sanitizing agent, wherein the cooling agent is in a solid form, and the sanitizing agent is present in the cooling agent while the cooling agent is in the solid form.

BRIEF DESCRIPTION OF DRAWINGS

[0014] For a further understanding of the nature and objects of the present invention, reference should be made to the following detailed description, taken in conjunction with the accompanying drawing, in which like elements are given the same or analogous reference numbers and wherein:

[0015] **FIG. 1** is a schematic of one embodiment of the invention for incorporating ozone into dry ice and forming pressed blocks of ozonated dry ice.

[0016] **FIG. 2** is a schematic of another embodiment for forming extruded pellets of ozonated dry ice.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0017] The current invention provides a process and product for cooling and sanitizing a target item by using a treating agent that contains a cooling agent for cooling the target item, and a sanitizing agent to reduce microbial growth on and in the target item. The current invention is particularly useful for processing, transporting, or storing a food product.

[0018] As used herein, the phrase "target item" refers to equipment, devices, food products, pharmaceutical products, or other items that are in need of sanitation, preserving, or otherwise protecting from or treated for pathogenic microorganisms.

[0019] As used herein, the phrase "food or food product" generally refers to all types of foods, including, but not limited to, meats, including ground meats, poultry, seafood, produce including vegetables and fruit, dry pasta, meats, poultry, seafood, produce including vegetables and fruit, dry pasta, breads and cereals, and fried, baked or other snack foods. The food may be in solid or liquid form, such as beverages or juices. The current inventive method may be used in conjunction with any food that is able to support microbial, i.e. fungal, bacterial or viral growth, including unprocessed or processed foods.

[0020] As used herein, the term "biocidal agent" or "sanitizing agent" generally refers to a substance that when contacted with the target item reduces the number of pathogenic microorganisms on or in the target item, or reduces the growth rate of the pathogenic microorganisms on or in the same.

[0021] The terms "sanitize" and "disinfect", as well as variations thereof, generally mean the reduction of the microbial and/or spore content. The terms "substantially sanitize" and "substantially disinfect" refer to the attainment of a level of microorganisms and/or spores such that the target item is safe to use, or safe for consumption by a mammal, particularly by humans. Generally, as used herein, these terms refer to the elimination of at least about 90.0 to 99.9% of all microorganisms and/or spores, including pathogenic microorganisms, in or on target items. Preferably, at least about 90.0 to 99.99%, and more preferably at least about 90.0 to 99.999% of such microorganisms and/or spores, are eliminated.

[0022] One embodiment of the current invention provides a method of processing a target item that exposes the target item to a treating agent that contains a sanitizing agent and a cooling agent. The treating agent is preferably in a solid form. The sanitizing agent remains present in the treating agent while the treating agent is in its solid form. As heat is absorbed by the treating agent, the treating agent converts to a gas by sublimation, or melts into a liquid, and the sanitizing agent is released from the treating agent. Once released, the sanitizing agent contacts the target item, thus providing a sanitizing action. Alternately, after the solid melts into a liquid, the liquid then evaporates, releasing the sanitizing agent. In another alternative, the solid melts into a liquid that contains the sanitizing agent, and the mixture of the liquid and the sanitizing agent contact the target item. Preferred treating agents contain at least 90% by weight cooling agent. Preferred treating agents also contain at least 0.1% by weight sanitizing agent, preferably more than 1% by weight sanitizing agent, and more preferably at least 5% by weight sanitizing agent.

[0023] The sanitizing agent of the current invention can be any biocidal agent known to one skilled in the art that can be combined with a cooling agent. Preferred sanitizing agents include, but are not limited to, ozone, chlorine dioxide, hydrogen peroxide, chlorine, and mixtures thereof.

[0024] The cooling agent of the current invention can be any cooling agent known to one in the art that is suitable for use in or on target items, target item processing systems, or food storage systems. Preferred cooling agents include cryogenic materials such as carbon dioxide (CO_2), nitrogen (N_2), or other cryogenic substances known to one of ordinary skill in the art. The cooling agent may also be other non-cryogenic material, such as water ice. However, in one preferred embodiment, the cooling agent is substantially absent any water.

[0025] In some preferred embodiments, the treating agent does not contact said target item while in said solid form. The treating agent may be placed into a target item treatment area, package, or storage container adjacent to or in an adjoining compartment with the target item. The treating agent absorbs the heat from the target item, thus cooling the target item.

[0026] Alternately, the treating agent absorbs heat coming into the treatment area, package, or storage container, thus keeping the target item at desired temperature.

[0027] Preferred methods of processing a target item according to the current invention may also expose the target item to a UV device. Exposing the target item to a UV device during or after the target item is exposed to the sanitizing agent will improve effectiveness of the sanitizing method.

[0028] Preferred methods of processing a target item can be used to treat the target item while in any type of treatment device known to one of ordinary skill in the art. Examples for processing food products include a tunnel, tumbler, blender, plate, chamber, vessel, and combinations of these devices. Some preferred embodiments capture and recycle the cooling agent.

[0029] In one aspect of the current invention, a method of packaging a target item is provided. The method places a target item into a container and adds a treating agent that contains a sanitizing agent and a cooling agent as described above to the container. The treating agent melts or sublimes to keep the interior of the container, and thus the target item, at a desired temperature while also contacting the contained target item with the sanitizing agent. The container is typically, but not necessarily, a food storage container, or a food transportation container. In one embodiment, the food is packaged for sale or distribution with the treating agent placed in the package. The treating agent may be in direct contact with the target item, or may be separated from the food by packaging material, or in a separate compartment of the container.

[0030] A further aspect of the current invention provides a product that is a treating agent comprising a cooling agent and a sanitizing agent. In one preferred embodiment, the cooling agent is in solid form. The sanitizing agent is present in or to the cooling agent until the cooling agent melts, or sublimes, then releasing the sanitizing agent. Melting or sublimation of the treating agent occurs as the treating agent absorbs heat from the target item or the surrounding environment. The treating agent preferably contains at least about 0.1 ppm by weight sanitizing agent, and more preferably about 1 to 100 ppm by weight sanitizing agent. The sanitizing agent can be any biocidal agent known to one of ordinary skill in the art that provides the sanitizing effect desired and can be combined with a cooling agent. Preferred sanitizing agents include ozone, chlorine dioxide, hydrogen peroxide, chlorine, or mixtures of these biocidal agents. The cooling agent can be any suitable material for cooling target items. Preferred cooling agents include N_2, CO_2, and mixtures of N_2 and CO_2. The sanitizing agent can be any biocidal agent.

[0031] The current invention will now be further described in terms of one embodiment of the current invention that uses solid CO_2 ("dry ice") as the cooling agent and ozone as the sanitizing agent. The dry ice product can be manufactured in the form of blocks, pellets, flakes, powders, and other possible forms containing carbon dioxide and ozone. The dry ice product is essentially free of, or absent water. What is meant by "essentially free of" or "absent" water is that the dry ice product, if it contains water, will comprise less than 5% by weight (wt. %) water. Typically, the water content will be less than 1 wt. %. Moisture levels of up to 5,000 ppm may be helpful in maintaining the desired shape of the product. The major constituent of the dry ice based treating agent is carbon dioxide. The ozone concentration in the treating agent can vary widely and can depend upon the end use of the product and, in particular, the product being treated and the environment surrounding the treated product. Only minute amounts of ozone are required to contact the target item to provide an antimicrobial effect. Furthermore, OSHA limits the exposure levels of ozone to humans at 0.1 ppm to 0.3 ppm in 8 hour and 15 minute shifts, respectively. Accordingly, the amounts of ozone dispersed into an area must be kept at a minimum and to a level safe for persons handling the treated product. A non-limiting level of ozone in the dry ice product can range from 0.1 ppm and above. More typically, the ozone content of the dry ice product will range from about 1 to 100 ppm. Ozone levels in the environment in contact with the target item of 1 to 10 ppm by weight are believed to be effective for killing bacteria.

[0032] The treating agent of ozonated dry ice embodiment provides an expendable form of refrigeration while simultaneously providing a method of biological treatment that does not expose humans coming in contact with the target item to excessive levels of ozone. Ozone gas is generally considered to be an unstable molecule that has a short shelf life. It is known that at lower temperatures ozone is more stable and has a reduced tendency to decompose to oxygen prior to providing any biological effect. Dry ice at atmospheric pressure is at a temperature of −109.9° F. The liquefaction temperature of ozone is −168° F. This means that the ozone contained in the dry ice product is close to the liquefaction point, but still well into the gas phase. Accordingly, the ozone mixed with dry ice as in the product of this invention can be trapped in the structural lattices of the dry ice and/or by physical absorption onto the surface of the dry ice. The ozone in the dry ice is added for biological treatment. The most effective biocidal treatment occurs when the ozone is released in proportion with the dry ice sublimation.

[0033] The exact form of the treating agent can vary and, accordingly, a wide variety of forms can be manufactured and used depending upon the target item to be treated and the purpose of such treatment such as, for example, storage, transport, or commercial sale display of food products. Thus, if the target item is stored in large rooms, for example, blocks of dry ice ranging from 5 to 50 lbs. can be used. Likewise, if the target item to be stored, transported, or displayed for sale requires direct contact of the dry ice product, smaller manufactured shapes can be provided. Thus, for example, pellets in the range of 1/16 to 1 inch can be formed, or even powders such as snow, flakes, or chips can be formed by methods known in the art.

[0034] In the ozonated dry ice embodiment, it has been found to be particularly useful to incorporate the ozone into the carbon dioxide during the dry ice manufacturing process. The traditional first step in making dry ice is to manufacture carbon dioxide liquid. This is done by compressing CO_2 gas and removing any excess heat. The CO_2 is typically liquefied at pressures ranging from 200-300 pounds per square inch and at a temperature of −20° F. to 0° F. respectively. It is typically stored in a pressure vessel at lower than ambient temperature. The liquid pressure is then reduced below the triple point pressure of 69.9 psig by sending it through an expansion valve. This can be done in a single step or, in many cases, by reducing the liquid pressure to 100 psig at a temperature of −50° F. as a first step to allow easy recovery of the flash gases. The liquid CO_2 is expanded inside a dry ice manufacturing press to form a mixture of dry ice solid and cold gas. The cold gas is vented or recycled and the remaining dry ice snow is then compacted to form blocks. Dry ice is typically compacted to a density of approximately 90 lb/ft^3.

[0035] The ozonated dry ice embodiment of the present invention directly contacts compressed ozone with carbon dioxide. In comparison, existing prior art as discussed previously dwells in using indirect methods to combine ozone with dry ice after the dry ice is manufactured. Such products include substantial amounts of water ice and, accordingly, inherit the problems associated with melting.

[0036] In general, to manufacture the treating agent of ozonated dry ice, compressed ozone at a pressure of at least 90 psig is combined with liquid carbon dioxide at a pressure above the triple point of CO_2 (70 psig), allowing the ozone to fully dissolve in the liquid CO_2. The feed gas for ozone injection can include O_2, air, a mixture of O_2 and air or mixture of O_2, air, and an inert gas, e.g. N_2, CO_2, Ar, Kr, Xe, or Ne.

[0037] Inert gas, if included with the ozone during contact with the CO_2, may comprise 10-99% total concentration of injected gas in the process. The inert gases may be mixed with ozone or added separately during the process. The temperature of the ozone treatment is maintained at ambient or below. CO_2 pressures ranging from 70 psig to 100 psig can be used during the mixing process. The ozone compression pressure will typically range from about 100 to 150 psig. Higher ozone pressures can also be used when available. The liquid carbon dioxide/ozone mixture is then expanded to generate dry ice, "snow", containing ozone, oxygen, and dry ice—"ozonated dry ice." This modified dry ice can then be collected or shaped such as by pressing or extrusion. This scheme can be successfully adapted to existing dry ice plants.

[0038] Methods of producing ozone are well known in the art. Ozone is generated using oxygen or air. There are two primary methods of creating ozone from air: by an ultraviolet light generator light system or by an electrical discharge system. An ultraviolet light ozone generator typically consists of multiple ultraviolet light tubes within an aluminum housing. In a multiple tube apparatus, air enters the generator cavity and is subjected to the ultraviolet light and the ultraviolet light causes a disassociation of the oxygen molecules, which exists as O_2, to two oxygen atoms. Some of these oxygen atoms attach themselves to oxygen molecules to form ozone (O_3). The resulting ozone and sterile air mixture comprises approximately 0.2 percent of ozone by weight/weight of air. In the preferred mode, the ozone gas is generated from oxygen or oxygen-enriched air by a corona discharge device that produces concentrations ranging between about 1% to about 15% by weight of ozone. Based on technologies available today, it is possible to generate ozone concentrations up to a maximum of 13.5% with the remainder being oxygen and a small fraction of other gases. It is possible to use higher ozone concentrations for this application if the generator technology becomes available. Higher concentrations of ozone are preferred. It is preferred to use oxygen compared to air due to the possibility of producing higher concentrations of ozone. It is industrially proven that ozone can be compressed to 150 psig using water ring compressors. It is feasible to safely compress an ozone/oxygen mixture containing 10% by weight of ozone to 70 atmospheres pressure. Several others have tried ozone liquefaction by using higher pressures without much success.

[0039] **FIGS. 1 and 2** depict representative methods of forming a treating agent of ozonated dry ice. Each figure represents a typical dry ice manufacturing process in which **FIG. 1** is a process used to form blocks of dry ice, while **FIG. 2** depicts a process used to form dry ice pellets. These processes can be modified to incorporate ozone into the dry ice product. First, with respect to **FIG. 1**, liquid carbon dioxide is stored in tank **2**, typically at pressures of 200 to 300 psig. The liquid carbon dioxide from storage tank **2** is then passed via line **4** to a low-pressure expansion tank **6** wherein the liquid CO_2 is expanded to a pressure above the triple point of carbon dioxide (69.9 psig). Typically, the liquid CO_2 is expanded to pressures of from about 70 to 100 psig in expansion tank **6**. What results is a mixture of gas and a dense, viscous carbon dioxide liquid. It is important that the liquid CO_2 is not formed into solid dry ice at this point in as much as the solid in the piping would disadvantageously reduce transport of the liquid. Ozone from an ozone generator **8** is then injected into the liquid carbon dioxide. Injection of the ozone can be done in the low-pressure expansion tank although, as shown in **FIG. 1**, the ozone is mixed with the liquid CO_2 after the liquid CO_2 leaves expansion tank **6** via line **10**. Ozone from the ozone generator **8** is compressed to pressures of from about 100 to 150 psig in compressor **12** and then fed via line **14** to mix with the liquid CO_2 from line **10**. The mixture of ozone and liquid CO_2 is passed via line **16** through an expansion orifice **18** into the dry ice press **20**. Alternatively, although not shown, the mixture of ozone and liquid CO_2 can be passed to a separate refrigeration unit, wherein the liquid CO_2 is frozen into a solid containing the entrapped ozone.

[0040] As further shown in **FIG. 1**, the mixture of liquid CO_2 and ozone is allowed to expand inside the dry ice press **20**. During expansion, the liquid CO_2 is converted to a solid form and the ozone is trapped in the structural lattices of dry ice and/or by physical absorption during dry ice formation. The major portion of the ozone will remain attached to the cold dry ice particles and only a small portion will exit dry ice press **20** with the flash gases via line **22**. Once the dry ice solid is formed, the solid particles can be compressed via platen **24** in press **20** into ozonated dry ice blocks **26**.

[0041] The sanitizing agent in the treating agent necessary for biological treatment is slowly released as the treating agent sublimes or melts during use. Higher concentrations and pressures of sanitizing agent are preferred to achieve higher concentrations of sanitizing agent in the treating agent. The preferred concentration of sanitizing agent can vary depending upon the use of the treating agent and the target item treated. By applying the above method to the ozonated dry ice example product, it is possible to achieve higher concentrations of ozone compared to the prior art methods, which have involved a mixture of ozonated water ice and dry ice.

[0042] Referring now to **FIG. 2**, which depicts a process used to form dry ice pellets, such process is similar to that shown in **FIG. 1**. With respect to **FIG. 2**, liquid carbon dioxide is stored in tank **30**, again, typically at pressures of 200 to 300 psig. The liquid carbon dioxide from storage tank **30** is then passed via line **32** directly to a dry ice pelletizer **34**. Dry ice pelletizers are well known in the art. It is believed any dry ice pelletizer is capable of use with this invention. In the pelletizer, the liquid CO_2 is expanded to a pressure below 70 psig. What results is a mixture of gas and carbon dioxide solid particles. Ozone from the ozone generator **34** is compressed to pressures of at least about 100 psig in compressor **38** and then fed via line **40** to mix with the CO_2 in the dry ice pelletizer **34**. Ozone injection can be done prior to extrusion of the dry ice particles into pellets or the ozone can be mixed with the CO_2 pellets after extrusion.

[0043] The liquid CO_2 is allowed to expand inside the dry ice pelletizer **34** and is converted to a solid form. While not wanting to be bound by any theory of operation, if the ozone is added during expansion, the ozone is believed to be trapped in the structural lattices of dry ice. If the CO_2 is solid, either as particles or as extruded pellets during injection of the ozone, the ozone is believed to be contained in the dry ice by physical absorption. It is believed a major portion of the ozone will remain attached to the cold dry ice particles and only a small portion will exit with the flash gases from pelletizer **34** via line **42**. The solid CO_2 particles are extruded into pellets, typically ranging from 1/16 to 1 in. As in the block dry ice, the ozone in dry ice pellets necessary for biological treatment is slowly released as the carbon dioxide sublimes during use.

[0044] Small amounts of adjuvants may be added into the treating agent to improve the stability of the sanitizing agent in the treating agent. Non-limiting useful adjuvants are as follows:

[0045] a) Water (not to exceed 5 wt. % of dry ice);

[0046] b) GRAS (generally recognized as safe) grade acidulants such as citric acid, acetic acid, lactic acid;

[0047] c) GRAS grade surfactants such as polysorbate 60/65/80

[0048] d) GRAS grade food preservatives such as EDTA (in any forms), BHA, BHT, sodium nitrate (in any forms);

[0049] e) GRAS gums such as carrageenan (in any forms), xanthan gum, furcelleran (in any forms), arabinogalactan; and

[0050] f) Any other GRAS grade food additives such as polyethylene glycol, sucrose fatty acid esters, fatty acids (in any forms).

[0051] The chilling product of this invention improves the biocidal efficacy of cooling agents, such as dry ice, to better ensure safe target items, such as safe food products. The sanitizing agent is effectively delivered into the cooling agent, such as dry ice, at a desired concentration such that during sublimation or melting of the cooling agent, the sanitizing agent contacts the target item and exerts the desired biocidal effect for disinfection and/or sanitation purposes. The sanitizing agent is released to disinfect target items, and to ensure significant reductions of pathogenic microorganisms. Because sanitizing agents are often more stable under cold environments, the process provides the favorable conditions for sanitizing agents to work at maximum reactivity. Since the release of the sanitizing agent from the cooling agent is well regulated, target items receive sanitizing agent slowly and constantly during the entire storage thereof, and accordingly, shelf life and quality of the target item is enhanced. Moreover, the cooling agent chills the target items efficiently, further providing benefits to target item. The cooling agent slows down the growth of pathogenic microorganisms, particularly pathogenic microorganisms that lead to spoilage in food, allowing food products to last longer and be safer. The cooling agent also slows down the enzymatic reactions in food, allowing the quality of food to be extended during storage. A cooling agent using dry ice sublimation also allows carbon dioxide to penetrate into microbial cells, lowering the intracellular pH of microbial cells, and causing those microbial cells to be more sensitive to the sanitizing agent. Accordingly, a synergistic effect on biocidal efficacy can be achieved by combining a cooling agent, such as dry ice, and a sanitizing agent, such as ozone.

[0052] Preferred processes and apparatus for practicing the present invention have been described. It will be understood and readily apparent to the skilled artisan that many changes and modifications may be made to the above-described embodiments without departing from the spirit and the scope of the present invention. The foregoing is illustrative only and that other embodiments of the integrated processes and apparatus may be employed without departing from the true scope of the invention defined in the following claims.

What is claimed is:

1. A method of processing a target item comprising the steps of:

a) exposing a target item to a treating agent, wherein:

i) said treating agent comprises a sanitizing agent and a cooling agent;

ii) said treating agent is in a solid form when initially exposed to said target item; and

iii) said sanitizing agent is present in said treating agent while said treating agent is in said solid form; and

b) contacting said target item with said sanitizing agent.

2. The method of claim 1, wherein said treating agent converts to a gaseous form thereby allowing said sanitizing agent to contact said target item.

3. The method of claim 2, wherein said treating agent does not contact said target item while in said solid form.

4. The method of claim 1, wherein said treating agent comprises at least 90% by weight said cooling agent.

5. The method of claim 1, wherein said cooling agent is substantially absent water.

6. The method of claim 1, wherein said sanitizing agent is selected from the group consisting of:

a) ozone;

b) chlorine dioxide;

c) hydrogen peroxide;

d) chlorine; and

e) mixtures thereof.

7. The method of claim 6, wherein said cooling agent is selected from the group consisting of N_2, CO_2, and mixtures thereof.

8. The method of claim 1, wherein said cooling agent is CO_2.

9. The method of claim 8, wherein said sanitizing agent is selected from the group consisting of:

a) ozone;

b) chlorine dioxide;

c) hydrogen peroxide;

d) chlorine; and

e) mixtures thereof.

10. The method of claim 1, wherein said target item, during said exposure step, is in a treatment area selected from the group consisting of:

a) a tunnel;

b) a tumbler;

c) a blender;

d) a plate;

e) a chamber;

f) a vessel;

g) packages;

h) transportation containers; and

i) combinations thereof.

11. The method of claim 1, wherein said cooling agent is recycled.

12. A method of packaging a target item comprising the steps of:

a) placing a target item into a container;

b) adding a treating agent to said container, wherein:

i) said treating agent comprises a cooling agent and a sanitizing agent;

ii) said treating agent is in a solid form when introduced into said container; and

iii) said sanitizing agent if present in said treating agent while said treating agent is in said solid form; and

c) contacting said target item with said sanitizing agent.

13. The method of claim 12, wherein said treating agent comprises at least 90% by weight said cooling agent.

14. The method of claim 12, wherein said container is selected from the group consisting of:

a) a target item package;

b) a food package;

c) a food storage container; and

d) a food transport container.

15. The method of claim 12, wherein said cooling agent is CO_2.

16. The method of claim 12, wherein said sanitizing agent is selected from the group consisting of:

a) ozone;

b) chlorine dioxide;

c) hydrogen peroxide;

d) chlorine; and

e) mixtures thereof.

17. A treating agent comprising a cooling agent and a sanitizing agent, wherein:

a) said cooling agent is in a solid form; and

b) said sanitizing agent is present in said cooling agent while said cooling agent is in said solid form.

18. The treating agent of claim 17, wherein said sanitizing agent is released when said cooling agent converts to a liquid or gaseous form.

19. The treating agent of claim 18, wherein said cooling agent converts to a gaseous form as heat is absorbed by said cooling agent.

20. The treating agent of claim 17, wherein said sanitizing agent is present in amounts of about 1 to 100 ppm.

21. The treating agent of claim 17, wherein said sanitizing agent is selected from the group consisting of:

a) ozone;

b) chlorine dioxide;

c) hydrogen peroxide;

d) chlorine; and

e) mixtures thereof.

22. The treating agent of claim 17, wherein said cooling agent is selected from the group consisting of N_2, CO_2, and mixtures thereof.

23. The treating agent of claim 17, wherein:

a) said cooling agent is CO_2; and

b) said sanitizing agent is selected from the group consisting of:

i) ozone;

ii) chlorine dioxide;

iii) hydrogen peroxide;

iv) chlorine; and

v) mixtures thereof.

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