DISINFECTION SYSTEMS AND METHODS

[0001]

TECHNICAL FIELD

[0002] The present disclosure is generally directed to disinfection systems and methods and more specifically to disinfection systems and methods using ozone.

BACKGROUND INFORMATION

[0003] Devices (e.g., medical devices, such as a mask, consumer devices, nebulizers etc.) are exposed to numerous environments in which pathogens (e.g., harmful bacteria and/or viruses) can come into contact with and reside on the devices. Without proper disinfection, further use of these devices after exposure can result in the spread of the pathogens. Accordingly, before reuse, devices may be disinfected in order to reduce the risk of spreading an infection to a user.

[0004] One example of a medical device is a mask, which may be coupled to one or more hoses (e.g., a continuous positive airway pressure mask and hose, a respirator mask, and/or any other type of mask). Masks are worn on a user's face and any hoses connected to the mask may come into direct contact with bodily fluids exhaled from a user's mouth and/or nose. These fluids may include pathogens. Accordingly, reuse of a mask, without proper disinfection, may increase a risk of infection.

[0005] Further, a hose coupled to the mask may include one or more crevices formed by a helical rib extending at least a substantial length of the hose and one or more pathogens may reside throughout the hose. The hose and/or the mask may include one or more regions (e.g., the crevices) which are difficult to disinfect. For example, a CPAP hose may include several crevices along the about 1.5 meter (m) to about 3 m length of the CPAP hose and/or the CPAP mask may have one or more difficult to disinfect places around the nasal passageways. The difficulty associated with

disinfecting these regions may result in a build-up of one or more pathogens that may eventually pass to a user. Additionally, in some instances, a length of the CPAP hose may increase a difficulty in getting a disinfection fluid to traverse the entire length of the CPAP hose while achieving a desired disinfection performance, which may also lead to a build-up of one or more pathogens.

SUMMARY

[0005a] According to a first aspect of the present invention, there is provided a disinfection device. The disinfection device comprises a housing; a disinfection chamber supported by the housing and configured to receive a continuous positive air pressure (CPAP) mask; an ozone generator configured to generate ozonated air; a humidifier supported by the housing and configured to generate humidity and configured to be fluidly coupled to the disinfection chamber and the ozone generator; and a controller configured to control operation of the ozone generator and the humidifier according to a disinfection cycle. The humidifier is configured to encourage a mixing of the generated ozonated air with the generated humidity to generate humidified ozonated air. The humidifier includes a humidification chamber; a liquid reservoir configured to receive water; and a liquid disperser configured to disperse water from the liquid reservoir directly into the humidification chamber to mix with the ozonated air and generate the humidified ozonated air. The humidification chamber includes a chamber ozone inlet through which the ozonated air enters the humidification chamber and a chamber outlet through which the humidified ozonated air exits the humidification chamber, the chamber outlet is configured to be selectively fluidly coupled to the disinfection chamber through a CPAP hose.

[0005b] According to a second aspect of the present invention, there is provided a disinfection device. The disinfection device comprises: a housing; a disinfection chamber supported by the housing and configured to receive a continuous positive air pressure (CPAP) mask; an ozone generator configured to generate ozonated air; a humidifier supported by the housing and configured to generate humidity and configured to be fluidly coupled to the disinfection chamber and the ozone generator; a pump fluidly coupled to the disinfection chamber at a location upstream of the disinfection chamber; a fan fluidly coupled to the disinfection chamber at a location

downstream of the disinfection chamber, wherein, for at least a portion of a disinfection cycle, the fan is operated at a fan flow rate and the pump is operated at a pump flow rate; and a controller configured to control operation of the ozone generator, the humidifier, the pump, and the fan according to the disinfection cycle. The humidifier is configured to encourage a mixing of the generated ozonated air with the generated humidity to generate humidified ozonated air. The humidifier includes: a humidification chamber; a liquid reservoir configured to receive water; and a liquid disperser configured to disperse water from the liquid reservoir into the humidification chamber to mix with the ozonated air and generate the humidified ozonated air. The humidification chamber includes a chamber ozone inlet through which the ozonated air enters the humidification chamber and a chamber outlet through which the humidified ozonated air exits the humidification chamber. The chamber outlet is configured to be selectively fluidly coupled to the disinfection chamber through a CPAP hose.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] These and other features advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0007] FIG. 1 shows a schematic block diagram of an example of a disinfection device, consistent with embodiments of the present disclosure.

[0008] FIG. 2 shows a schematic block diagram of an example of a disinfection device with humidity control, consistent with embodiments of the present disclosure.

[0009] FIG. 3 shows a schematic example of a disinfection device with humidity control configured to disinfect one or more components of a continuous positive air pressure (CPAP) machine, consistent with embodiments of the present disclosure.

[0010] FIG. 4 shows a schematic example of an operational timeline for the disinfection device of FIG. 3, consistent with embodiments of the present disclosure.

[0011] FIG. 5 shows a schematic example of an ozone generator, consistent with embodiments of the present disclosure.

[0012] FIG. 6 shows a schematic example of a humidifier, consistent with embodiments of the present disclosure.

[0013] FIG. 7 shows a perspective view of a disinfection device, consistent with embodiments of the present disclosure.

[0014] FIG. 7A shows a perspective view of the disinfection device of FIG. 7 having a CPAP hose coupled thereto, consistent with embodiments of the present disclosure.

[0015] FIG. 7B shows a cross-sectional perspective view of the disinfection device of FIG. 7A, consistent with embodiments of the present disclosure.

[0016] FIG. 8 shows a cross-sectional view of the disinfection device of FIG. 7 taken along the line VIII-VIII of FIG. 7, consistent with embodiments of the present disclosure.

What is claimed is:

1. A disinfection device comprising:

a housing;

a disinfection chamber supported by the housing and configured to receive a continuous positive air pressure (CPAP) mask;

an ozone generator configured to generate ozonated air;

a humidifier supported by the housing and configured to generate humidity and configured to be fluidly coupled to the disinfection chamber and the ozone generator, the humidifier being configured to encourage a mixing of the generated ozonated air with the generated humidity to generate humidified ozonated air, the humidifier including:

a humidification chamber, the humidification chamber including a chamber ozone inlet through which the ozonated air enters the humidification chamber and a chamber outlet through which the humidified ozonated air exits the humidification chamber, the chamber outlet being configured to be selectively fluidly coupled to the disinfection chamber through a CPAP hose;

a liquid reservoir configured to receive water; and

a liquid disperser configured to disperse water from the liquid reservoir directly into the humidification chamber to mix with the ozonated air and generate the humidified ozonated air; and

a controller configured to control operation of the ozone generator and the humidifier according to a disinfection cycle.

2. The disinfection device of claim 1 further comprising the CPAP hose fluidly coupling the chamber outlet to the disinfection chamber, the CPAP hose having a hose inlet and a hose outlet, wherein the liquid disperser is configured to disperse water according to a droplet size distribution, the droplet size distribution having a most prevalent droplet size range, wherein a quantity of droplets within the most prevalent droplet size range is substantially the same at both the hose inlet and the hose outlet.

3. The disinfection device of claim 1, wherein the liquid disperser is configured to generate droplets having a droplet size in a range of about 1 micron to about 5 microns.

4. The disinfection device of claim 1, wherein the chamber ozone inlet is configured to introduce a turbulent flow to the ozonated air passing therethrough.

5. The disinfection device of claim 1, wherein generation of the humidified ozonated air causes ozone to become entrained within the dispersed water.

6. The disinfection device of claim 1, wherein the disinfection cycle includes an initialization period, an operation period, and a purge period, wherein, during the initialization period, the controller causes both the ozone generator and the humidifier to operate concurrently.

7. The disinfection device of claim 6, wherein the humidifier is disabled during the operation period.

8. The disinfection device of claim 7, wherein, during the operation period, the controller selectively enables and disables the ozone generator, causing the ozone generator to generate ozone pulses.

9. The disinfection device of claim 8, wherein the humidifier and the ozone generator are disabled during the purge period.

10. The disinfection device of claim 8, wherein, to generate the ozone pulses, the controller alternates between enabling the ozone generator for about 10 seconds and disabling the ozone generator for about 65 seconds.

11. The disinfection device of claim 8, wherein the controller is configured to cause the ozone generator to generate the ozone pulses at a pulse rate, wherein the pulse rate is configured such that a quantity of ozone within the disinfection chamber is in a range of about 80 parts-per-million (ppm) to 150 ppm during at least a portion of the disinfection cycle.

12. The disinfection device of claim 6, wherein, during the initialization period, the controller operates the humidifier such that a relative humidity within the disinfection chamber is in a range of about 65% to about 99%.

13. A disinfection device comprising:

a housing;

a disinfection chamber supported by the housing and configured to receive a continuous positive air pressure (CPAP) mask;

an ozone generator configured to generate ozonated air;

a humidifier supported by the housing and configured to generate humidity and configured to be fluidly coupled to the disinfection chamber and the ozone generator, the humidifier being configured to encourage a mixing of the generated ozonated air with the generated humidity to generate humidified ozonated air the humidifier including:

a humidification chamber, the humidification chamber including a chamber ozone inlet through which the ozonated air enters the humidification chamber and a chamber outlet through which the humidified ozonated air exits the humidification chamber, the chamber outlet being configured to be selectively fluidly coupled to the disinfection chamber through a CPAP hose;

a liquid reservoir configured to receive water; and

a liquid disperser configured to disperse water from the liquid reservoir into the humidification chamber to mix with the ozonated air and generate the humidified ozonated air;

a pump fluidly coupled to the disinfection chamber at a location upstream of the disinfection chamber;

a fan fluidly coupled to the disinfection chamber at a location downstream of the disinfection chamber, wherein, for at least a portion of a disinfection cycle, the fan is operated at a fan flow rate and the pump is operated at a pump flow rate; and

a controller configured to control operation of the ozone generator, the humidifier, the pump, and the fan according to the disinfection cycle.

14. The disinfection device of claim 13, wherein the liquid disperser is configured to generate droplets having a droplet size in a range of about 1 micron to about 5 microns.

15. The disinfection device of claim 13, wherein the ozone generator is configured to generate a quantity of ozone in a range of about 200 parts-per-million (ppm) to about 300 ppm.

16. The disinfection device of claim 13, wherein the chamber ozone inlet is configured to introduce a turbulent flow to the ozonated air passing therethrough.

17. The disinfection device of claim 13 further comprising a hose sensor configured to detect when the CPAP hose is fluidly coupled to the chamber outlet, wherein generation of ozonated air is prevented when the hose sensor indicates that the CPAP hose is not fluidly coupled with the chamber outlet.

18. The disinfection device of claim 13, wherein the CPAP hose is configured to be fluidly coupled with the chamber outlet using a CPAP hose adapter.

19. The disinfection device of claim 13, wherein the disinfection chamber includes a hose passthrough configured such that the CPAP hose can pass therethrough and a hose sensor configured to detect a presence of the CPAP hose within the hose passthrough.

20. The disinfection device of claim 13, wherein the liquid disperser is a piezo-electric atomizer and is user replaceable.