

UVC Light Disinfection of X-Ray Cassettes

Field of Invention

[0001] The present invention relates to ultra-violet light disinfection of X-ray cassettes.

Background

[0002] An X-ray cassette is used many times within its life span. Before use, a cassette is disinfected by manually wiping with a paper towel or gauze that is wetted with 70% isopropyl alcohol or Johnson & Johnson™ presept. This method is time consuming and predisposes a handler to infection. For example, in hospital settings, the rate of picking up bacterial infection, such as methicillin-resistant staphylococcus aureus (MRSA) infection, ranges from about one to four per 2000 patient-days.

[0003] Ultra-violet (UV) light has been used to disinfect water and air. UV in its C-bandwidth (UVC) of 100-280 nm, in particular at two germicidal wavelengths peaks at 185 and 265 nm, is effective in disabling bacteria, viruses and molds; UVC light penetrates cell walls or cytoplasmic membranes of bacteria, viruses and molds, and causes adjacent thymine molecules of DNA to form covalent bonds; the resultant thymine dimers cannot pair normally and lead to DNA damage. If sufficient DNA damage occurs, replication of these pathogens is inhibited, rendering the pathogen harmless even though they are not killed outright.

[0004] Disinfection is often used to describe elimination of substantially all pathogens with few survivors. In contrast, sterilization describes total elimination of all pathogens.

[0005] Attempts have been made to disinfect and sterilize medical tools, such as, x-ray cassettes. For example, US patent publication no. 2006/0204398 describes a process for reducing transmission of infection between patients by x-ray cassettes. As described, the exposed surfaces of a cassette are disinfected, for example, by spraying disinfectant and allowing the surfaces to dry; covering the disinfected cassette with a fluid repelling

and radio translucent wrap; and using the disinfected cassette with the wrap or re-disinfecting a used cassette with the wrap, or repeating the entire disinfection and wrap covering process.

[0006] Despite development in disinfection of x-ray cassettes in a hospital, it can thus be seen that there exists a need for a simple device to disinfect x-ray cassettes with minimal human handling.

Summary

[0007] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[0008] The present invention provides a UVC light disinfection device for various types and sizes of x-ray cassettes with minimal human handling. The device exposes x-ray cassettes for a predetermined time and intensity of UVC light to render replication of bacteria, viruses and moulds ineffective.

[0009] In one embodiment, the present invention describes an x-ray cassette disinfection system. The system comprises: a disinfection compartment having two spaced apart side panels; a closed top panel; an end panel with an entrance and an opposite end panel with an exit; a conveyor operable in the disinfection compartment for moving an x-ray cassette from the entrance to the exit of the disinfection compartment; and an elongate UVC lamp mountable on each side panels with their longitudinal axes substantially parallel to the conveyor so that UVC light emitted from two UVC lamps are incident for an aggregate exposure of a predetermined time on all exterior surfaces of each x-ray cassette at an intensity of about 25 mW/cm² or more.

[0010] In one embodiment of the disinfection system, the panels of the system is made of black acrylic, which is UV-resistant. In another, the entrance or exit of the disinfection compartment comprises a curtain or a swing door.

[0011] In another embodiment of the disinfection system, the system comprises two rows of guide rods suspended from the top panel to contact sides of each x-ray cassette to guide its travel on the conveyor.

[0012] In another embodiment of the disinfection system, the conveyor comprises a plurality of sections. A section of the conveyor may comprise a belt and a driven pulley or may comprise a driven roller and a number of free-wheeling rollers. The driven pulleys or rollers of adjacent sections may be connected by separate transfer belts.

[0013] In yet another embodiment of the disinfection system, the system comprises an elongate UVC lamp disposed below the conveyor. A reflector may be used to reflect downward UVC light rays up through gaps between the roller conveyor to disinfect the x-ray cassettes.

Brief Description of the Drawings

[0014] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0015] FIG.1A illustrates an x-ray cassette disinfection system according to an embodiment of the present invention; and

FIG. 1B illustrates an x-ray cassette disinfection system according to another embodiment of the present invention;

[0016] FIGs. 2A and 2B illustrate schematic electrical connections of the motor, fan and UVC lamps shown in FIG. 1A or 1B;

[0017] FIG. 3 shows an x-ray image of a cassette after exposure to UVC light;

[0018] FIG. 4 shows an x-ray image of a specimen before a cassette is exposed to UVC light; and

[0019] FIG. 5 shows an x-ray image of the specimen used in FIG. 3 after a cassette is exposed to UVC light.

Detailed Description

[0020] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0021] Low pressure mercury vapour lamps emit about 85% of their light at about 254 nm, which is in the UVC band and is effective in disabling bacteria, viruses and moulds from replicating. The present invention provides a UVC light disinfection device for various types and sizes of x-ray cassettes with minimal human handling. The device exposes x-ray cassettes for a predetermined duration and predetermined intensity of UVC light to render replication of bacteria, viruses and moulds ineffective.

[0022] FIG. 1A shows a system 10 for disinfecting x-ray cassettes 11 according to an embodiment of the present invention. As shown in FIG. 1A, the system 10 includes a conveyor 20 and a disinfection compartment 30. An input end of the conveyor 20 defines a cassette input section 12 whilst the opposite end defines a cassette output section 14, with the disinfection compartment 30 located between the cassette input and output sections 12, 14.

[0023] As shown in FIG. 1A, the conveyor 20 is made up of a plurality of sections, each section is made up of a belt 24, a driven roller 22a and some free-wheeling rollers

22b. The conveyor 20 is driven by a motor 26 through a drive pulley 23 and drive belt 25. Another drive belt 25 is connected to a driven rollers 22a of an adjacent section of the conveyor 20. Remote from the motor 26, the free-wheeling rollers 22b at the ends of adjacent sections of the conveyor 20 are linked by a separate transfer belt 25a. The motor 26 is an electric motor and is located in a service compartment 16, which is below the conveyor 20. All the rollers 22a,22b, belts 24,25,25a and pulleys are made of UV resistant thermoplastics. Given that a typical x-ray cassette is about 24 cm long when placed in an erect and longitudinal position on the conveyor 20, the length of each section of the conveyor is less than 24 cm. In one embodiment, the motor 26, drive pulley 23 and rollers 22a,22b are selected so that the linear conveying speed of the conveyor 20 is about 70 cm/min and gives a cassette 11 a travel time of about one minute in the disinfection compartment 30.

[0024] The disinfection compartment 30 is defined by two spaced apart side panels 32, a closed top panel 34, an entry panel 36 and an exit panel 38. Suspended from the top panel 34 are two rows of vertical guides 40. The vertical guides 40 are located so that lower ends 40a of the guides 40 contact the top side edges of each x-ray cassette 11 such that the vertical guides 40 guide travel of an x-ray cassette 11 through the disinfection compartment 30.

[0025] Mounted on an interior face of one side panel 32 is an elongate UVC lamp 50 such that a longitudinal axis of the elongate UVC lamp 50 is substantially parallel to the direction of travel of the x-ray cassette 11 on the conveyor 20 and UVC light from the lamp irradiates both top and near side of the x-ray cassette 11. As seen in FIG. 1B, on the opposite side panel 32, another elongate UVC lamp 50 is mounted parallel to the conveyor 20 so that UVC light from the another elongate UVC lamp 50 irradiates both top and far side of the x-ray cassette 11. By over-turning an x-ray cassette 11 and passing the cassette through the disinfection compartment 30 a second time, all the external surfaces, including the end faces, of the x-ray cassette 11 are exposed to UVC light for an aggregate of about one minute or more.

[0026] Each UVC lamp 50 is a low-pressure mercury lamp with external dimensions of a typical fluorescent lamp except that the tube is made of fused quartz and is not

internally coated with phosphor. Each UVC lamp 50 has an input power of 25 W and gives an output intensity of about 25mW/cm^2 at a radial distance of about 20 mm. Ballasts 52 required to regulate current to the UVC lamps 50 are located in the service compartment 16. In addition, a starter 54 for starting illumination of each UVC lamp 50 is connected across the ends of each UVC lamp 50.

[0027] In another embodiment (not shown in the figures) of the disinfection system 10a, an elongate UVC lamp 50a, which is similar to the above UVC lamp 50, is mounted on the near side panel 32 between the UVC lamp 50 and the conveyor 20 and another elongate UVC lamp 50a on the opposite side panel 32 at the same elevation as that on the near side panel 32. These elongate UVC lamp 50a are also mounted substantially parallel to the UVC lamp 50 or conveyor 20 such that the UVC light is incident on respective side faces and end faces of an x-ray cassette 11.

[0028] The walls of the disinfection compartment 30, including the side panels 32, top panel 34, entry panel 36 and exit panel 38, and those of the entire disinfection system 10 are made of 5 mm thick black acrylic. The entry panel 36 has an entry aperture 36a whilst the exit panel 38 has an exit aperture 38a. Each entry aperture 36a and exit aperture 38a is covered by a curtain 37. The curtain 37 is flexible and is cut into strips to make it more flexible so as to reduce leakage of UVC light from the disinfection system 10. Preferably, the curtain 37 is made of UV resistant thermoplastics. In another embodiment, the entry aperture 36a or exit aperture 38a is covered by a swing door 37.

[0029] The cassette input section 12 is located in front of the entry aperture 36a and associated curtain/door 37. Side panels 12a at the cassette input section 12 are provided so that they are spaced apart according to a function of thickness of the x-ray cassettes 11 and guide entry of the cassettes into the disinfection compartment 30. The upper edges of the side panel 12a are, preferably, bent outward to form a Y-shaped guide for ease of inserting a cassette 11 into the input section 12. Preferably, the side panels 12a are substantially in line with the vertical guides 40 in the disinfection compartment 30 so that an x-ray cassette 11 is operable to move on the conveyor 20 from the input section 12, through the disinfection compartment 30 and out through the output section 14.

[0030] The cassette output section 14 is located outside the exit aperture 38a and associated curtain/door 37. The conveyor 20 extends into the output section 14 and may comprise an overhung section 21. Preferably, below the conveyor overhung section 21, is a collection bin 60 for receiving the newly disinfected x-ray cassettes 11.

[0031] In one embodiment of the disinfection system 10, the input section 12 has an input cassette sensor 72 whilst the output section 14 has an output cassette sensor 74. In use, the input and output sensors 72,74 are interlocked by a timer 76 so that when cassette 11 is detected in the input section 12 or output section 14, a red indicator light 77 is turned; when no cassette 11 is inserted into the input section 12 and no cassette 11 is detected at the output section 14 after a time delay, the disinfection system 10 may turn off the UVC lamps 50 and the green indication light 77 may be turned on whilst the red indicator light 77 is turned off.

[0032] As shown in FIG. 1A, a fan 80 and associated filter 82 is installed on a side wall of the disinfection system 10. The fan 80 and associated filter 82 is located below the conveyor 20, for example, in the service compartment 16. In one embodiment, the filter 82 is on the outside in relation to the fan 80, so that the fan 80 blows filtered air into the disinfection system 10 and provides cooling to the UVC lamps 50,50a and associated ballasts 52. In another embodiment, the fan 80 is on the inside in relation to the filter 82, so that the fan 80 sucks air from inside the disinfection system 10 and blows air to the exterior through the filter 82. The filter 82 may be a high-efficiency particulate (HEPA) filter.

[0033] FIG. 1B shows a disinfection system 10a according to another embodiment of the present invention. As shown in FIG. 1B, the disinfection system 10a is similar to the earlier embodiment 10 except that the conveyor 20 does not have belt 24 but is made up of sections of rollers. Each section of rollers includes a plurality of driven roller 22. The driven rollers 22 are linked by transfer belts 25b and are powered by a motor 26. The rollers 22 are spaced apart so that there is a gap between adjacent rollers. Some of the rollers 22 have flanges at both ends for guiding travel of the x-ray cassettes

11 on the conveyor 20. In one embodiment, the flanges have step edges; in another, the flanges have inclined edges.

[0034] The disinfection system 10a is also different from the earlier system 10 in that there is an additional elongate UVC lamp 50b on each interior face of the two side panels 32. The additional UVC lamps 50b are disposed below the rollers 22 so that during a pass of the cassette 11 on the conveyor 20, an aggregate exposure time on the bottom surface of the cassette 11 is about 1 minute. In one embodiment, the additional UVC lamps 50b have higher input and output power than the UVC lamps 50,50a disposed above the conveyor 20. In another embodiment, a reflector 28 is used to reflect the downward UVC rays back up the gaps between the rollers 22 to disinfect bottom faces of each cassette 11.

[0035] FIG. 2A and 2B show schematics of the electrical connections of the motor 26, fans 80 and UVC lamps 50,50b,50c.

[0036] A prototype was built and tests were carried out in a hospital environment. Bacteria swaps were taken on x-ray cassettes 11 before and after disinfection with the disinfection system 10,10a. Table 1 shows the results of bacteria cultures. According to the present invention, bacteria cultures showed that one minute of aggregate exposure of the x-ray cassettes 11 to UVC light intensity at substantially about 25 mW/cm^2 was sufficient to disable replication of pathogens found in hospitals. With the present invention, cross infections due to sharing to x-ray cassettes 11 and transmission of infections among people in a hospital would be significantly reduced.

[0037] Additional accelerated tests were also carried out to determine degradation of coatings on x-ray cassettes and effects on x-ray plates. No degradation of coatings on the cassettes or any significant optical density change of the x-ray plates was noticeable. FIG. 3 shows an x-ray image of a cassette exposed to 1 minute of UVC light. As shown in FIG. 3, there is no effect on the x-ray image after a cassette is exposed to UVC light. FIG. 4 shows the x-ray image of a hand specimen before UVC light exposure while FIG. 5 shows the x-ray image of the hand specimen after 1 minute of exposure to UVC light. Table 2 shows the results of optical density tests on the x-ray

plates before and after exposure to UVC light that UVC light does not affect the x-ray cassettes and x-ray plates.

[0038] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For example, the disinfection system 10,10a may be modified for disinfecting x-ray cassettes for use in dental or veterinary clinics or for use with portable x-ray equipment in hospitals' accident and emergency rooms.

What is claimed is:

1. A device for disinfecting a product using C-bandwidth Ultra-Violet (UVC) light comprising:
 - a disinfection compartment having a top side panel;
 - an UVC lamp structure inside said disinfection compartment for irradiating a portion of said product;
 - a plurality of guide posts suspended from an interior of said top side panel to contact said product on said conveyor system to hold said product in position to expose said portion of said product to said UVC light; and
 - a conveyor system inside said disinfection compartment for moving said product through said disinfection compartment to expose said portion of said product to UVC light from said UVC lamp structure at a predetermined intensity for a predetermined amount of time.
2. The device of claim 1 wherein said product comprises:
 - an x-ray cassette.
3. The device of claim 1 wherein said device is connected to an image processor.
4. The device of claim 1 wherein said predetermined intensity is substantially 25 mW/cm^2 .
5. The device of claim 1 wherein said predetermined time is approximately 1 minute.
6. The device of claim 1 wherein said disinfection compartment comprises:
 - a front end panel;
 - a back end panel;
 - a first side panel; and
 - a second side panel.

7. The device of claim 1 wherein said disinfection compartment further comprises:

an input opening through said front end panel; and

an output opening through said back end panel wherein said conveyor system receives said product proximate said input opening and deposits said product proximate said output opening.

8. The device of claim 7 wherein said disinfection compartment further comprises:

a swing door over said input opening.

9. The device of claim 7 wherein said disinfection compartment further comprises:

a swing door over said output opening.

10. The device of claim 7 wherein said disinfection compartment further comprises:

a curtain over said input opening; and

a slit in said curtain to make said curtain more flexible.

11. The device of claim 7 further comprising:

an input section proximate said input opening that is configured to receive said product and transferring said product into said disinfection compartment.

12. The device of claim 7 wherein said disinfection compartment further comprises:

a curtain over said output opening; and

a slit in said curtain to make said curtain more flexible.

13. The device of claim 7 further comprising:

an output section proximate said output opening that is configured to receive said product from said output opening and transferring said product away from said disinfection compartment.

14. The device of claim 6 wherein said UVC lamp structure comprises:
a first elongate lamp mounted on an interior of said first side panel substantially parallel to said conveyor system.
15. The device of claim 14 wherein said UVC lamp structure further comprises:
a second elongate lamp mounted on said interior of said first panel substantially parallel to said conveyor and said first elongate lamp.
16. The device of claim 14 wherein said UVC lamp structure comprises:
a second elongate lamp mounted on an interior of said second side panel in a manner that light emitted from said first elongate lamp and said second elongate lamp are incident for an aggregate exposure on said portion of said product.
17. The device of claim 16 wherein said UVC lamp structure comprises:
a third elongate lamp mounted on said interior of said second side panel substantially parallel to said second elongate lamp.
18. The device of claim 14 wherein said UVC lamp structure further comprises:
a second elongate lamp mounted under said conveyor system in a manner to expose a bottom side of said product to emitted UVC light.
19. The device of claim 14 wherein said UVC lamp structure further comprises:
a reflector configured to reflect emitted light from said UVC lamp structure onto a bottom side of said product.
20. The device of claim 1 further comprising:
a fan in an opening defined in said disinfection compartment to force air into said disinfection compartment.
21. The device of claim 20 further comprising:
a filter in an opening through said disinfection compartment to allow air to escape from said disinfection compartment.

22. The device of claim 1 wherein an interior of said disinfection compartment is comprises of black acrylic that is UV-resistant.
23. A method for disinfecting a product comprising:
placing said product on a conveyor;
moving said product through a disinfection compartment along said conveyor;
and
emitting light from a UVC lamp structure to expose a portion of said product to UVC light of an intensity of substantially 25 mW/cm^2 for approximately 1 minute.
24. The method of claim 23 wherein said product is an x-ray cassette.
25. The method of claim 23 further comprising:
outputting said product to an image processor.