

DEODORIZER WITH IONIC WIND PRODUCING MEANS

This invention relates to a deodorizer for deodorizing a gas by eliminating odor components from the gas.

5 Various odors are emitted by food stored in a refrigerator. A deodorizer is conventionally provided in the refrigerator to reduce the odors and to prevent the odors from soaking into other food in the refrigerator. The conventional deodorizer comprises an adsorbent such as activated charcoal. However, the adsorbent
10 becomes ineffective when an adsorptive power of the adsorbent has been saturated. Further, when the adsorbent is left in a saturated state, there is a possibility that odor components may be re-emitted from the adsorbent. Accordingly, the adsorbent used in the deodorizer is required to be suitably replaced with
15 a new one.

On the other hand, another deodorizer includes a catalyst of platinum disposed near a defrosting heater. Odor components are adsorbed by the catalyst and then heated to be decomposed during a defrosting operation in which the defrosting heater is
20 driven. Further another deodorizer utilizing oxidation of ozone. Japanese Patent Application No. 2000-181518 further discloses a deodorizer in which discharge light and photocatalyst are combined together. Each of these three deodorizers has an improved service life and maintains a deodorizing performance
25 for a long period of time. However, a sufficient deodorizing effect cannot be obtained when a contact efficiency between odor components and the platinum catalyst or ozone molecules is too low. As a result, cold air containing odor components needs to

18 MAY 2005

be caused to flow into the deodorizer so that the contact efficiency is improved. Accordingly, when each of the foregoing deodorizers is provided in a refrigerator of the direct expansion system in which cold air is not circulated, a blowing fan is necessitated to cause air to flow into the deodorizer, increasing the size of the deodorizer. Further, even in a case where each deodorizer is provided in a refrigerator of the type in which cold air is circulated by a blowing fan provided near an evaporator, the deodorizing efficiency is reduced when the fan is turned off.

Therefore, an object may be to provide a deodorizer which can efficiently eliminate odor components in an atmosphere in a closed space where air is not circulated.

According to a first aspect of the present invention, there is provided a deodorizer comprising; deodorizing means for eliminating an odor component from an atmosphere, the deodorizing means including a photocatalyst module including ultraviolet ray generation discharge means for generating ultraviolet rays due to high voltage discharge and a photocatalyst filter decomposing an odor component and a deleterious substance contained in the gas when the ultraviolet rays generated by the deodorizing means are irradiated onto the photocatalyst filter, the photocatalyst filter including a porous base comprising ceramic and photocatalyst grains fixed on a surface of the base, the ultraviolet ray generation discharge means including an ultraviolet ray generation discharge electrode and an ultraviolet ray generation counter electrode disposed opposite to each other with the photocatalyst filters being interposed between the ultraviolet ray generation discharge electrode and the ultraviolet ray generation counter electrode; and ionic wind producing means having a counter electrode and a discharge electrode and operable to cause high-voltage discharge thereby to produce an ionic wind when high DC voltage is applied between the counter electrode and the discharge electrode, wherein, the ultraviolet ray generation counter electrode confronts the ionic wind producing means, and wherein the ultraviolet ray generation counter electrode and the counter electrode of the ionic wind producing means are each at a ground potential.

2a

According to a second aspect of the present invention, there is provided a deodorizer comprising; a duct having therein a flow passage through which a gas flows; deodorizing means provided in the duct for eliminating an odor component from an atmosphere; and ionic wind producing means provided in the duct and comprising a discharge unit including at least two generally plate-shaped counter electrodes disposed opposite each other perpendicularly to a direction in which the gas flows and a generally wire-shaped discharge electrode disposed between the counter electrodes so as to extend in parallel with the counter electrodes and perpendicularly to the direction in which the gas flows, the ionic wind producing means causing high-voltage discharge thereby to produce an ionic wind when high DC voltage is applied between the counter electrodes and the discharge electrode, wherein each counter electrode has both ends along the direction in which the gas flows and the discharge electrode is located at either one of both sides relative to a center between the ends of each counter electrode.

In one embodiment, there is provided a deodorizer comprising deodorizing means for eliminating an odor component from an atmosphere and ionic wind producing means having a counter electrode and a discharge electrode and causing high-voltage discharge thereby to produce an ionic wind when high DC voltage is applied between the counter electrode and the discharge electrode.

According to the above-described deodorizer, the ionic wind causes the gas to flow. Consequently, the deodorizer may be disposed in a closed space where a gas does not flow. Further, the above-described deodorizer may be rendered smaller in size and reduce noise as compared with the conventional deodorizer including a fan causing a gas to flow. Additionally, ozone is produced by the high voltage discharge between the counter and discharge electrodes. Consequently, deodorization may be achieved by the oxidation of ozone.

In another embodiment deodorizer preferably further comprises a duct having therein a flow passage through which a gas flows and accommodating the deodorizing means and the ionic wind producing means. In this construction, the counter electrode has a centerline passing a center thereof with respect to a direction in which the gas flows and the discharge electrode is located at either one of both sides of the centerline. The ionic wind is produced when a high voltage is applied to the ionic wind producing means. The ionic wind causes the gas to flow through the duct. Consequently, since the deodorizing means is efficiently brought into contact with the gas, odor components contained in the gas may efficiently be eliminated.

The ionic wind producing means may preferably comprise a discharge unit including a pair of generally plate-shaped counter electrodes disposed opposite each other perpendicularly to a direction in which the gas flows and a generally wire-shaped discharge electrode disposed between the counter electrodes so as to extend in parallel with the counter electrodes and perpendicularly to the direction in which the gas flows. Consequently, this construction may produce a larger amount of ionic wind than the construction in which the counter electrode is provided only in one side of the discharge electrode. Further, the gas may be prevented from flowing in the duct by the counter and discharge electrodes.

The deodorizing means may preferably include a photocatalyst module including ultraviolet ray generation discharge means for generating ultraviolet rays due to high voltage discharge and

a photocatalyst filter decomposing an odor component and a deleterious substance contained in the gas when the ultraviolet rays generated by the deodorizing means are irradiated onto the photocatalyst filter. Consequently, various odor components may be eliminated from the gas by oxidation and decomposition of ozone produced by the ionic wind producing means and photocatalytic action of the photocatalyst module.

The photocatalyst filter may preferably include a porous base comprising ceramic and photocatalyst grains fixed on a surface of the base. Furthermore, the ultraviolet ray generation discharge means may preferably include an ultraviolet ray generation discharge electrode and an ultraviolet ray generation counter electrode disposed opposite to each other with the photocatalyst filters being interposed between the ultraviolet ray generation discharge electrode and the ultraviolet ray generation counter electrode. Additionally, the ultraviolet ray generation counter electrode may preferably confront the ionic wind producing means. The ultraviolet ray generation counter electrode and the counter electrode of the ionic wind producing means are grounded. Non-directional ultraviolet rays may be produced by high voltage discharge between the counter and discharge electrodes of the photocatalyst module. The photocatalytic action may be efficiently carried out since the non-directional ultraviolet rays may be irradiated onto the photocatalyst filter. Furthermore, discharge may be prevented between the ionic wind producing means and the photocatalyst module.

The deodorizing means preferably includes ozone producing

discharge means for producing ozone by high voltage discharge and an ozone decomposing catalyst filter decomposing the ozone produced by the discharge means, or an active charcoal filter adsorbing an odor component and a deleterious substance
5 contained in the gas.

The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic longitudinal section of a deodorizer of a first embodiment in accordance with the present invention;

10 FIG. 2 is a schematic perspective view of the inner structure of the deodorizer;

FIG. 3 is a longitudinally sectional side view of a refrigerator of the direct expansion system provided with the deodorizer of the first embodiment;

15 FIG. 4 is a block diagram showing an electrical arrangement of the refrigerator;

FIG. 5 typically illustrates a refrigerating unit;

FIG. 6 is a view similar to FIG. 1, showing a deodorizer of a second embodiment in accordance with the invention;

20 FIG. 7 is a view similar to FIG. 1, showing a deodorizer of a third embodiment in accordance with the invention;

FIG. 8 is a view similar to FIG. 1, showing a deodorizer of a fourth embodiment in accordance with the invention;

FIG. 9 is a view similar to FIG. 1, showing a deodorizer
25 of a fifth embodiment in accordance with the invention;

FIG. 10 is a view similar to FIG. 1, showing a deodorizer of a sixth embodiment in accordance with the invention;

FIG. 11 is a view similar to FIG. 1, showing a deodorizer

of a seventh embodiment in accordance with the invention; and FIG. 12 is a longitudinally sectional side view of a freezer-refrigerator of circulation type provided with a deodorizer of an eighth embodiment in accordance with the invention.

Several embodiments of the present invention will be described with reference to the accompanying drawings. FIGS. 1 to 5 illustrate a first embodiment in which a deodorizer of the invention is applied to a refrigerator of the direct expansion system. Referring first to FIG. 3, the refrigerator comprises a body 1 including a heat-insulated casing. An interior of the body 1 is partitioned into an upper cold storage compartment 3 and a lower freezing compartment 4 by a heat-insulating partition wall 2. A vegetable compartment 6 is defined below the cold storage compartment 3 by a partition plate 5. A lower case 7 and an upper case 8 mounted on an upper portion of the lower case 7 are provided in the vegetable compartment 6. A deodorizer 9 in accordance with the invention is provided on a rear part of the partition plate 5 in the cold storage compartment 3. The deodorizer 9 will be described in detail later. A chilling case 10 is provided over the partition plate 5 in the cold storage compartment 3. A first evaporator 11 for the cold storage compartment is provided on a rear wall of the cold storage compartment 3. The first evaporator 11 comprises a cooling pipe.

The freezing compartment 4 is partitioned into two interiors by a partition plate 12. A case 13 is provided in the upper interior, whereas an upper case 14 and a lower case 15 are provided in the lower interior of the freezing compartment 4. A second

evaporator 17 is mounted on a mounting plate 16 provided in the rear of the partition plate 12 in the freezing compartment 4. A machine compartment 18 is defined in the lower rear of the refrigerator body 1. A compressor 19 for the cooling unit is
5 provided in the machine compartment 18. The compressor 19 is of the reciprocating type and includes a compressor motor 20 serving as a driving source.

Referring to FIG. 5, a refrigerating machine for the refrigerator is shown. The compressor 19 has a discharge opening
10 connected via a condenser 21 to an input port of a flow passage valve 22. The flow passage valve 22 has an RF output port and F output port and selectively opens either one of the ports. A valve motor 23 is provided for switching between the output ports of the valve 22. The RF output port of the valve 22 is connected
15 via an RF capillary tube 24 to an entrance of the first evaporator 11. The first evaporator 11 has an exit connected to an entrance of the second evaporator 17. The second evaporator 17 has an exit connected to a suction port of the compressor 19. Accordingly, when the RF output port is opened, a refrigerant
20 discharged from the compressor 19 is supplied to both first and second evaporators 11 and 17. On the other hand, the F output port of the valve 22 is connected via an F capillary tube 25 between the exit of the first evaporator 11 and the entrance of the second evaporator 17. Thus, when the F output port of the
25 valve 22 is opened, the refrigerant discharged from the compressor 19 is supplied only to the second evaporator 17.

Referring now to FIGS. 1 and 2, the construction of the deodorizer 9 will be described. The deodorizer 9 comprises a

generally rectangular cylindrical duct 26. A DC discharge mechanism 27, a photocatalyst module 28 and an ozone decomposing catalyst filter 29 are disposed in the duct 26 in this order as viewed in FIG. 1. The duct 26 has right-hand and left-hand end openings 26a and 26b through which cold air is caused to flow into the duct 26. The DC discharge mechanism 27 constitutes ionic wind producing means and comprises a generally wire-shaped discharge electrode 30 made from, for example, tungsten and a pair of generally flat plate-shaped counter electrodes 31 disposed opposite each other. The counter electrodes 31 are disposed so as to extend along a direction in which cold air flows in the duct 26 as shown in FIG. 2. The discharge electrode 30 is disposed in parallel with the counter electrodes 31 so as to be located centrally between the counter electrodes. The counter electrodes 31 have a centerline A passing centers thereof with respect to the direction in which cold air flows. The discharge electrode 30 is located at either one of both sides of the centerline, or on the left of the centerline A in the embodiment.

The counter electrodes 31 are at the ground potential, and a negative DC high potential or a DC high potential of -4.5 kV is applied to the discharge electrode 30. As a result, a corona discharge occurs between the discharge electrode 30 and the counter electrodes 31 such that a negative ion is produced near the discharge electrode 30. The negative ion proceeds toward the counter electrodes by the action of an electric field and also collides with neutral molecules in the gas (mainly, oxygen molecules) thereby to give kinetic energy to the neutral

molecules, proceeding toward the counter electrodes 31 with the neutral molecules. This transfer of the negative ion and neutral molecules toward the counter electrodes 31 is referred to as "ionic wind." Since the discharge electrode 30 is located on the left of the centerline A in the embodiment, the ionic wind flows from the discharge electrode 30 toward each counter electrode 31 in a direction inclined rightward as viewed in FIG. 1. The ionic wind establishes a flow of air as shown by arrow B in FIG. 1 in the duct 26. As a result, cold air in the cold storage compartment 3 flows through the left opening 26a into the duct 26. The cold air flows in the direction of arrow B, thereafter exiting the duct 26 through the right opening 26b. The openings 26a and 26b will be referred to as an "entrance" and an "exit" respectively. The location of the discharge electrode 30 relative to the counter electrodes 31 is set so that a flow of air ranging between 0.1 and 0.2 m/sec is caused in the duct 26 when the DC high potential of -4.5 kV is applied between the discharge electrode 30 and the counter electrodes 31.

On the other hand, the photocatalyst module 28 comprises a plurality of generally wire-shaped discharge electrodes 32 made from tungsten, two grid counter electrodes 33 and two generally plate-shaped photocatalyst filters 34. The discharge electrodes 32, counter electrodes 33 and photocatalyst filters 34 all extend across the direction in which the cold air flows. The discharge electrodes 32 are arranged in a row, and the counter electrodes 33 sandwich the discharge electrodes 32 so as to be located at an upstream side with respect to the cold air or entrance 26a side and a downstream side or exit 26b side

respectively. The photocatalyst filters 34 are disposed between discharge electrodes 32 and the counter electrodes 33. Each photocatalyst filter 34 includes a porous base made of ceramic (alumina or silica, for example) and is formed by applying a photocatalyst material such as titanium oxide to a surface of the base. The photocatalyst material is then dried or fired to be fixed to the surface of the base. The upstream counter electrode 33 confronts the DC discharge mechanism 27.

The counter electrodes 33 are at the ground potential, and, for example, a positive pulsed DC high voltage of +10 kV is applied to the discharge electrodes 32. As a result, an electric discharge occurs between the discharge electrodes 32 and the counter electrodes 33 such that ultraviolet rays having a wavelength not more than 380 nm are produced. Accordingly, the discharge electrodes 32 serve as ultraviolet ray producing discharge means. The ozone decomposing catalyst filter 29 comprises a core which may be a ceramic honeycomb containing manganese oxide as a base or may be made by forming a metallic honeycomb into the shape of a generally rectangular plate, and a catalyst fixed to the core.

Ozone is produced together with ion when the DC potential of -4.5 kV is applied to the discharge electrode 30 of the DC discharge mechanism 27 so that electric discharge is caused. Further, ozone is also produced together with ion when the DC voltage of +10 kV is applied to the discharge electrodes 32 of the photocatalyst module 28. Accordingly, the DC discharge mechanism 27, photocatalyst module 28 and ozone decomposing catalyst filter 29 constitute deodorizing means, and the DC

discharge mechanism 27 and the discharge electrodes 32 and counter electrodes 33 of the photocatalyst module 28 constitute ozone producing discharge means in the embodiment.

FIG. 4 shows an electrical arrangement of the refrigerator.

5 A control device 35 comprises a microcomputer (not shown). A first temperature sensor 36 is provided for detecting a temperature in the cold storage compartment 3. A second temperature sensor 37 is provided for detecting a temperature in the freezing compartment 4. A first evaporator temperature
10 sensor 38 is provided for detecting a surface temperature of the first evaporator 11. A second evaporator temperature sensor 39 is provided for detecting a surface temperature of the second evaporator 17. A first door switch 40 is provided for detecting an open or closed state of the door 3a of the cold storage
15 compartment 3. A second door switch 41 is provided for detecting an open or closed state of the door 6a of the vegetable compartment 6. All of these sensors and switches 36 to 41 are connected to the control device 35. Each temperature sensor 36 to 39 comprises a thermistor delivering a signal which is converted
20 to a voltage signal by the control device 35 to be supplied into the microcomputer.

The control device 35 includes a ROM storing an operation control program for the refrigerator and controls a drive circuit 42 further controlling the compressor motor 20 and valve motor
25 23 on the basis of the signals delivered by the temperature sensors 36 to 39 according to the control program. The control device 35 further controls a first high voltage applying section 43 to apply the negative DC voltage to the discharge electrode

30 of the DC discharge mechanism 27. The control device 35 still further controls a second high voltage applying section 44 to apply the positive pulsed DC voltage to the discharge electrodes 32 of the photocatalyst module 28.

5 The operation of the deodorizer 9 will now be described. When the high voltage is applied to the discharge electrode 30 of the discharge mechanism 27 and the discharge electrodes 32 of the photocatalyst module 28, a high voltage discharge is caused between the discharge electrode 30 and the counter electrodes
10 31, whereupon an ionic wind is caused and ozone is produced. As a result, a flow of air in the arrow B is established in the duct 26, cold air containing odor components is caused to flow from the cold storage compartment 3 through the entrance 26a into the duct 26, reaching the DC discharge mechanism 27. The cold air
15 having reached the DC discharge mechanism 27 is mixed with the ozone produced by the high voltage discharge, flowing to the photocatalyst module 28.

In the photocatalyst module 28, ultraviolet rays produced by the high voltage discharge are irradiated onto the
20 photocatalyst filter 34 so that titanium oxide is activated for progress of the photocatalytic reaction. Consequently, the odor components, such as ammonia, contained in the cold air is oxidized thereby to be decomposed. Furthermore, the high voltage discharge produces ozone as well as the ultraviolet rays in the
25 photocatalyst module 28. Accordingly, the cold air mixed with the ozone in the DC discharge mechanism 27 is further mixed with the ozone when passing through the photocatalytic module 28, thereafter reaching the ozone decomposing catalyst filter 29.

In the ozone decomposing catalyst filter 29, the ozone is decomposed and active oxygen is produced. The odor components and the like are decomposed by the oxidation of the active oxygen. The cold air deodorized by the deodorizer 9 is caused to flow
5 through the exit 26b of the duct 26 into the cold storage compartment 3.

As described above, the deodorizer 9 of the embodiment includes the DC discharge mechanism 27 producing the ionic wind by the high voltage discharge. The ionic wind causes the cold
10 air in the cold storage compartment 3 to positively flow through the duct 26. As a result, the odor components can efficiently be eliminated from the cold air even in the refrigerator of the direct expansion system in which the cold air is not circulated through the cold storage compartment 3. Further, the DC
15 discharge mechanism 27 includes the discharge electrode 30 and the counter electrodes 31. The discharge electrode 30 is located at either one of both sides of the centerline A between the counter electrodes 31. Thus, since the DC discharge mechanism 27 has a simple arrangement, the size and an amount of noise produced
20 can be reduced in the deodorizer 9 as compared with the conventional construction in which a fan is provided for causing cold air to flow into the duct 26.

The DC discharge mechanism 27 is disposed upstream relative to the photocatalyst module 28, and the discharge electrode 30
25 is disposed upstream relative to the centerline A between the counter electrodes 31. Accordingly, since the counter electrodes 31 is located away from the photocatalyst module 28, electric discharge can be prevented from being caused between

the counter electrodes 31 of the DC discharge mechanism 27 and the discharge electrodes 32 and counter electrodes 33 of the photocatalyst module 28. Additionally, the counter electrodes 31 of the DC discharge mechanism 27 and the counter electrodes 33 of the photocatalyst module 28 are at the ground potential. Consequently, electric discharge can be prevented from being caused between the counter electrodes 31 and 33.

The ozone and ultraviolet rays are produced when the high voltage is applied to the discharge electrodes 30 and 32 of the DC discharge mechanism 27 and photocatalyst module 28. As a result, various odor components are decomposed and eliminated such that a high deodorizing effect can be achieved. Furthermore, differing from the conventional deodorizer using the adsorbent such as activated charcoal, the deodorizer 9 does not require a tiresome replacement of adsorbent and chemical replenishment, providing convenience. Additionally, the ozone produced both by the DC discharge mechanism 27 and by the photocatalyst module 28 is decomposed by the ozone decomposing catalyst filter 29. This can prevent an excessive increase in the density of ozone in the cold storage compartment 3.

The DC discharge mechanism 27 comprises the wire-shaped discharge electrode 30 and the plate-shaped counter electrodes 31. This arrangement provides a larger space for the deodorizing process in the duct 26 as compared with conventional deodorizers of the surface discharge type in which electric discharge is caused via an insulator. Further, the two electrodes 31 are disposed at the opposite sides of the discharge electrode 30. Accordingly, the deodorizing efficiency can be improved since

the deodorizer 9 can produce a larger amount of ionic wind as compared with the arrangement in which a counter electrode is disposed at one side of the discharge electrode. Furthermore, the photocatalyst filter 34 of the photocatalyst module 28 is
5 disposed between the discharge electrodes 32 and the counter electrodes 33. As a result, the non-directional ultraviolet rays produced by the high voltage discharge between the discharge electrodes 32 and counter electrodes 33 can efficiently be irradiated onto the photocatalyst filter 34, whereby the
10 photocatalytic reaction can efficiently be performed. Additionally, the photocatalyst filter 34 comprises the porous ceramic base with the surface on which titanium oxide is fixed. Consequently, the flow of cold air can be prevented from being blocked by the photocatalyst filter 34 even though the filter
15 is disposed in the flow passage of the cold air.

FIG. 6 illustrates a second embodiment of the invention. In the second embodiment, the deodorizer 9 includes a plurality of, for example, two DC discharge mechanisms 27 disposed in the duct 26. The DC discharge mechanism 27 serves as a discharge
20 unit and is disposed along the direction in which the cold air flows. According to the second embodiment, an amount of ionic wind produced is increased and accordingly, an amount of cold air flowing into the duct 26 is increased. Consequently, the deodorizing performance of the deodorizer can further be
25 improved. The other construction of the deodorizer in the second embodiment is substantially the same as that of the deodorizer in the first embodiment. Accordingly, the same effect can be achieved from the second embodiment as from the first embodiment.

FIG. 7 illustrates a third embodiment of the invention. In the third embodiment, the DC discharge mechanism 27 includes a plurality of, for example, four counter electrodes 31 juxtaposed perpendicularly to the direction in which the cold air flows and discharge electrodes 30 disposed between the opposed counter electrodes 31. The discharge electrodes 30 are located on the left of the centerline A between the counter electrodes 31. According to the third embodiment, an amount of ionic wind produced is increased and accordingly, an amount of cold air flowing into the duct 26 is increased. Consequently, the deodorizing performance of the deodorizer can further be improved. Moreover, the third embodiment differs from the second embodiment in that an increase in the size of the deodorizer can be prevented. The other construction of the deodorizer in the third embodiment is substantially the same as that of the deodorizer in the first embodiment. Accordingly, the same effect can be achieved from the third embodiment as from the first embodiment.

FIG. 8 illustrates a fourth embodiment of the invention. In the fourth embodiment, the DC voltage applied to the discharge electrode 30 is variable. More specifically, the control device 35 controls the high voltage applying section 43 to apply the DC high voltage ranging between -4 and -6 kV to the discharge electrode 30. Thus, the control device 35 and the high voltage applying section 43 constitute voltage changing means. In this case, a sensor may be provided for detecting a density of odor component such as ammonia in the cold storage compartment 3, and the control device 35 may change the applied voltage according

to the result of detection by the sensor. Consequently, since the deodorizing performance can be changed according to an amount of odor component in the cold storage compartment 3, the odor component in the cold air can efficiently be eliminated. The other construction of the deodorizer in the fourth embodiment is substantially the same as that of the deodorizer in the first embodiment. Accordingly, the same effect can be achieved from the fourth embodiment as from the first embodiment.

FIG. 9 illustrates a fifth embodiment of the invention. In the fifth embodiment, the deodorizer 9 is not provided with the photocatalyst module 28 and uses only ozone to decompose and eliminate the odor component. Consequently, the deodorizer 9 can be rendered smaller in size in the fifth embodiment although the deodorizing performance thereof is lower than that in the first embodiment.

FIG. 10 illustrates a sixth embodiment of the invention. In the sixth embodiment, the deodorizer 9 includes the DC discharge mechanism 51 serving as the ionic wind producing means and an active charcoal filter 52 serving as deodorizing means, both of which are provided in the duct 26. The DC discharge mechanism 51 includes the discharge electrode 30 and the counter electrodes as the DC discharge mechanism 27 in the first embodiment. However, a positive DC voltage of, for example, +4.5 kV is applied to the discharge electrode 30 in the sixth embodiment. Upon application of the DC voltage to the discharge electrode 30, the ionic wind is produced such that air flows in the direction of arrow B in the duct 26. As a result, the cold air in the cold storage compartment 3 flows through the entrance

26a into the duct 26. The cold air reaches the activated charcoal filter 52 after having passed through the DC discharge mechanism 51. When passing through the activated charcoal filter 52, the odor component in the cold air is adsorbed by the activated charcoal filter 52, and the deodorized cold air is discharged through the exit 26b.

In the sixth embodiment, the activated charcoal filter 52 needs to be replaced by a new one when adsorbing performance is saturated. However, the deodorizing performance can be improved in the deodorizer of the sixth embodiment as compared with the conventional deodorizer provided only with the activated charcoal since the cold air is positively caused to flow into the duct 26. Furthermore, the density of ozone produced by the DC discharge mechanism 51 upon application of +4.5 kV to the discharge electrode 30 is reduced to about one fifth of the density of ozone produced by the DC discharge mechanism 27 in the first embodiment. Accordingly, the density of ozone in the cold storage compartment 3 can be prevented from being excessively increased without provision of the ozone decomposing catalyst.

FIG. 11 illustrates a seventh embodiment of the invention. The seventh embodiment differs from the sixth embodiment in that the photocatalyst module 28 is disposed down the DC discharge mechanism 51, instead of the activated charcoal filter 52. An amount of ozone produced is small when the positive pulsed DC voltage is applied between the discharge electrodes 32 and counter electrodes 33 of the photocatalyst module 28. Accordingly, the density of ozone in the cold storage compartment

3 can be prevented from being excessively increased without provision of the ozone decomposing catalyst. Further, the odor component contained in the cold air having flown into the duct 26 is oxidized by the photocatalytic action to be decomposed when
5 passing through the photocatalyst module 28.

FIG. 12 illustrates an eighth embodiment of the invention. In the eighth embodiment, the deodorizer of the invention is applied to a freezer-refrigerator of the type in which cold air is circulated in the cold storage compartment 3. More
10 specifically, an atmosphere in each of the cold storage and vegetable compartments 3 and 6 is refrigerated by the first evaporator 61. A first evaporator chamber 63 is defined by a partition wall 62 in the rear of the vegetable compartment 6. A first fan 64 is provided in an upper interior of the chamber
15 63. A cylindrical cold air discharge section 62a is provided on an upper portion of the partition wall 62 so as to correspond to the fan 64. The cold air discharge section 62a has a distal end opening located in the upper case 8 disposed in the vegetable compartment 6. The upper case 8 has a top to which a cover 8b
20 with a cold air discharge hole 8a is attached so as to be opened and closed.

The first evaporator 61 is disposed in a lower interior of the chamber 63. The partition wall 62 has a louver-like cold air suction opening 65 formed in the lower front thereof. A
25 generally L-shaped duct cover 66 forms a cold air duct 67 on the rear and upper interiors of the cold storage compartment 3. The duct cover 63 is formed with a plurality of cold air discharge holes 66a.

In the above-described construction, the fan 64 is driven when the compressor 19 is driven so that the refrigerating operation for the cold storage compartment 3 is executed. Part of the cold air in the evaporator chamber 63 is discharged through the cold air discharge opening 62a into the upper case 8 as shown by arrow in FIG. 12. The cold air discharged into the upper case 8 flows through the cold air discharge hole 8a into a space between the upper case 8 and the partition plate 5. Thereafter, part of the cold air flows into the lower case 7, whereas the other part of the cold air flows along the front and the underside of the lower case 7 and thereafter, is returned in to the evaporator chamber 63 through the cold air suction opening 65.

On the other hand, the remainder of cold air in the evaporator chamber 63 flows upward through the cold air duct 67 as shown by arrow in FIG. 12, being discharged through the cold air discharge holes 66a and an upper end of the duct 67 into the cold storage compartment 3. After flowing between the chilling case 10 and the partition plate 5, the cold air further flows through the entrance 26a into the duct 26 of the deodorizer 9. Thus, the deodorizer 9 is disposed in a cold air circulation passage so that the cold air can efficiently be supplied into the duct 26 by use of the flow of cold air circulated in the cold storage compartment 3 in addition to the ionic wind produced in the DC discharge mechanism 27. Furthermore, even when the fan 64 is turned off such that the cold air is not circulated in the cold storage compartment 3, the cold air in the cold storage compartment 3 can positively be caused to flow into the duct 26 by the ionic wind produced by the DC discharge mechanism 27.

In a modified form, either one of the counter electrodes 31 may be provided. When each counter electrode 31 is formed into such a shape as not to block the flow of air, such as the shape of a grid or wire, each counter electrode 31 may be disposed
5 up or down the discharge electrode 30 across the direction in which cold air flows. Further, the counter electrodes 31 may be at a minus potential. In this case, a reactive force acts between ion produced by the discharge electrode and the counter electrodes 31, the produced ionic wind flows in the direction
10 opposite arrow B. Accordingly, the ozone decomposing catalyst filter 29, photocatalyst module 28 and DC discharge mechanism 26 are preferably disposed in this order as viewed in FIG. 1.

In each of the sixth and seventh embodiments, the DC discharge mechanism 51 may be disposed down the deodorizing means
15 (the activated charcoal filter 52, photocatalyst module 28). Since the DC discharge mechanism 51 serves as the blowing means, the same effect can be achieved even when the DC discharge mechanism is disposed up or down the deodorizing means. Further, negative voltage may be applied to the discharge electrodes 32
20 of the photocatalyst module 28. In this case, the deodorizing efficiency of ozone can be improved since an amount of ozone produced is increased. Additionally, the deodorizer may be applied to a closed space other than the refrigerator, for example, a shoe box, closet, toilet, locker room, etc.

25 The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill

18 MAY 2005

22

in the art. All such changes and modifications are seen to fall within the scope of the invention as defined by the appended claims.

CLAIMS**1. A deodorizer comprising:**

deodorizing means for eliminating an odor component from an atmosphere, the deodorizing means including a photocatalyst module including ultraviolet ray generation discharge means for generating ultraviolet rays due to high voltage discharge and a photocatalyst filter decomposing an odor component and a deleterious substance contained in the gas when the ultraviolet rays generated by the deodorizing means are irradiated onto the photocatalyst filter, the photocatalyst filter including a porous base comprising ceramic and photocatalyst grains fixed on a surface of the base, the ultraviolet ray generation discharge means including an ultraviolet ray generation discharge electrode and an ultraviolet ray generation counter electrode disposed opposite to each other with the photocatalyst filters being interposed between the ultraviolet ray generation discharge electrode and the ultraviolet ray generation counter electrode; and

ionic wind producing means having a counter electrode and a discharge electrode and operable to cause high-voltage discharge thereby to produce an ionic wind when high DC voltage is applied between the counter electrode and the discharge electrode,

wherein, the ultraviolet ray generation counter electrode confronts the ionic wind producing means, and

wherein the ultraviolet ray generation counter electrode and the counter electrode of the ionic wind producing means are each at a ground potential.

2. A deodorizer comprising;

a duct having therein a flow passage through which a gas flows;
deodorizing means provided in the duct for eliminating an odor component from an atmosphere; and

ionic wind producing means provided in the duct and comprising a discharge unit including at least two generally plate-shaped counter electrodes disposed opposite each other perpendicularly to a direction in which the gas flows and a generally wire-shaped discharge electrode disposed between the counter electrodes so as to extend in parallel with the counter electrodes and perpendicularly to the direction in which the gas flows, the ionic wind producing means causing high-voltage discharge thereby to produce an ionic wind when high DC voltage is applied between the counter electrodes and the discharge electrode,

wherein each counter electrode has both ends along the direction in which the gas flows and the discharge electrode is located at either one of both sides relative to a center between the ends of each counter electrode.

3. A deodorizer according to claim 2, wherein the deodorizing means includes a photocatalyst module including ultraviolet ray generation discharge means for generating ultraviolet rays due to high voltage discharge and a photocatalyst filter decomposing an odor component and a deleterious substance contained in the gas when the ultraviolet rays generated by the deodorizing means are irradiated onto the photocatalyst filter.

4. A deodorizer according to claim 3, wherein the photocatalyst filter includes a porous base comprising ceramic and photocatalyst grains fixed on a surface of the base, wherein the ultraviolet ray generation discharge means includes an ultraviolet ray generation discharge electrode and an ultraviolet ray generation counter electrode disposed opposite to each other with the photocatalyst filters being interposed between the ultraviolet ray generation discharge electrode and the ultraviolet ray generation counter electrode, wherein the ultraviolet ray generation counter electrode confronts the ionic wind producing means, and wherein the ultraviolet ray generation counter electrode and the counter electrode of the ionic wind producing means are each at a ground potential.
5. A deodorizer according to claim 1, further comprising a duct having therein a flow passage through which a gas flows and accommodating the deodorizing means and the ionic wind producing means, wherein the counter electrode has a centerline passing a center thereof with respect to a direction in which the gas flows and the discharge electrode is located at either one of both sides of the centerline.
6. A deodorizer according to claim 5, wherein the ionic wind producing means comprises a discharge unit including a pair of generally plate-shaped counter electrodes disposed opposite each other perpendicularly to a direction in which the gas flows and a generally wire-shaped discharge electrode disposed between the counter electrodes so as to extend in parallel with the counter electrodes and perpendicularly to the direction in which the gas flows.
7. A deodorizer according to claim 5 or 6 wherein the ionic wind producing means includes three or more generally plate-shaped counter electrodes disposed in parallel with one another perpendicularly to the direction in which the gas flows and a

18 MAY 2005

26

plurality of generally wire-shaped discharge electrodes between the two counter electrodes opposed to each other so as to extend in parallel with the counter electrodes perpendicularly to the direction in which the gas flows.

8. A deodoriser according to any one of the preceding claims, wherein the ionic wind producing means includes a plurality of the discharge units serially disposed in the direction of the gas flow.

9. A deodorizer substantially as herein described with reference to the accompanying drawings.

10. A refrigerator substantially as herein described with reference to the accompanying drawings.