

INDIVIDUAL VENTILATED CAGING SYSTEM

Field of the Invention

[0001] The present invention relates generally to caging systems for housing small laboratory animals and, more particularly, to a micro-safe individual ventilated caging system that provides an airtight and stable environment free from cross-contamination.

Background of the Invention

[0002] Small laboratory animals such as mice and rats are usually housed within a portable cage for the convenience of handling of animals. Conventional animal cages for maintaining animals are well known in the art. For example, U.S. Pat. 4,640,228 discloses a "shoebox" transparent cage that consists of a cage body for bedding the animals, a lid with an air filter for reducing contamination, and a wire bar lid for dispensing food and water. However, the cage is susceptible to contamination, and the filter is so large sized that it can only prevent large particles from communicating between the interior of cage and the external environment.

[0003] Construction of fully controlled animal facilities is very expensive. In order to make laboratory animals more accessible and affordable to researchers, there are provided open rack ventilated systems. For example, US 2005/0061256 A1 discloses an animal isolation and caging system within a ventilated rack. The rack includes one air exhaust plenum and canopies for ventilation of the cages. In addition, a filter top is provided for each cage, where the filter top provides a filter retainer having a filter top retainer wall designed to be in contact with the canopy forming an enclosed space so configured as to create an enclosed space from which the cage creates a zone of negative pressure. However, the cage itself does not provide a contamination-free environment when they are removed from the rack.

[0004] In many circumstances, open rack systems are disposed in less air-controlled environment; it requires each animal cage within the racks to provide the required

microenvironment for the animals housed therein. The enclosure of the animal cage should be so designed as to provide adequate air change, constant temperature, and humidity parameters that will not affect the animal normal physiological and behavior needs. The primary factors of concern in the microenvironment include air change rate, temperature and humidity conditions, carbon dioxide and ammonia levels, vibration and noise, and animal space.

[0005] The animal cage is usually employed in researches. The factors that will affect research results include bacteria per colony count, particles count, cross-contamination, and water and feed quality. In addition, researchers are exposed to the biohazards that should be minimized. The biohazards include dust and dander from animals, and ammonia.

[0006] Therefore, there is an existing need for an animal cage that satisfies all the requirements so that the animal cage can be used in a less air-controlled environment without compromise of the research results.

Summary of the Invention

[0007] Therefore, one objective of the present invention is to provide a micro-safe individual ventilation caging system that protects and ensures a safe and stable environment for research animals.

[0008] Another objective of the present invention is to provide a micro-safe individual ventilation caging system that protects the animals from cross-contamination as a result of dynamic conditions.

[0009] Another objectives of the present invention is to provide a micro-safe individual ventilation caging system that reduces the chances of allergy development in the researches and the risk of animal to human cross-contamination and vice versa.

[0010] In one aspect of the present invention, there is provided a gaseous supply and exhaust system for being used in an airtight animal cage, said gaseous supply and exhaust system comprising: a gaseous supply means that can be removably connected to an air supplier, wherein the gaseous supply means enables the desired air composition supply from the air supply to diffuse into the airtight animal cage; and a gaseous exhaust means that can be

removably connected to an exhaust vacuum, wherein the gaseous exhaust means enables the exhausted air from the airtight animal cage to be removed by diffusion; thereby the gaseous supply and exhaust system enables a user to adjust and control the air composition and pressure within the airtight animal cage. In one embodiment of the gaseous supply and exhaust system, the gaseous supply means comprises: a first filter module disposed within the airtight animal cage; wherein the first filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the first filter module facing the cage interior is closed so that the incoming air has to diffuse through the filter layer to reach the cage interior; and a first connector with two ends opposite to each other; wherein one end connects to the air supplier, and the other end integrally connects to the first filter module; and wherein the connector has an internal channel that enables the air from the air supplier to flow into the first filter module. In another embodiment of the gaseous supply and exhaust system, the inner layer and the outer layer of the first filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier to diffuse into the airtight animal cage. In yet another embodiment of the gaseous supply and exhaust system, the filter layer has a size $\leq 0.1\mu\text{m}$; thereby the first filter module will prevent any particles including bacteria with a size of larger than the filter size from entering into the cage interior. In yet still another embodiment of the gaseous supply and exhaust system, the first filter module is removable from the first connector.

[0011] In another embodiment of the gaseous supply and exhaust system, the gaseous exhaust means comprises: a second filter module disposed within the airtight animal cage; wherein the filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the second filter module facing the cage interior is closed so that the exhaust from the cage must pass through the filter layer before it is removed by the exhaust vacuum; and a second connector with two ends opposite to each other; wherein one end connects to the exhaust vacuum, and the other end integrally connects to the second filter module; and wherein the connector has an internal channel that enables the exhaust from the cage interior to flow into the exhaust vacuum. In another embodiment of the gaseous supply

and exhaust system, the second filter module is removable from the second connector. In yet another embodiment of the gaseous supply and exhaust system, the inner layer and the outer layer of the second filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier diffuse into the airtight animal cage. In a further embodiment of the gaseous supply and exhaust system, the filter layer has a size $\leq 0.1\mu\text{m}$; thereby the second filter module will prevent any particles with a size of larger than the filter size from escaping from the cage interior. In still another embodiment of the gaseous supply and exhaust system, the second filter module further comprises a dust collecting layer that is disposed distantly from the outer layer; thereby, when the cage is disturbed, any dust falling from the filter layer will be collected by the dust collecting layer. In yet still another embodiment of the gaseous supply and exhaust system, the dust collecting layer comprises a smooth surface facing the cage interior and a meshed surface facing the filter layer so that the meshed surface will collect the dust falling off the filter layer.

[0012] In another aspect of the present invention, there is provided an animal cage that comprises a cage body for flooring one or more animals; a lid disposed on the top of the cage body so as to form an enclosure with the cage body; and a gaseous supply and exhaust system disposed within the animal cage for providing controllable air conditions within the animal cage; wherein the gaseous supply and exhaust system comprises: a gaseous supply means that can be removably connected to an air supplier so as to enable a desired air composition supply to diffuse into the animal cage; and a gaseous exhaust means that can be removably connected to an exhaust vacuum so as to remove the exhausted air from the animal cage by diffusion; thereby the gaseous supply and exhaust system enables a user to adjust and control the air composition and pressure within the animal cage.

[0013] In one embodiment, the animal cage further comprises a wire mesh bar for holding water bottle and feedstuff; wherein the wire mesh bar is disposed between the cage body and the lid. In another embodiment of the animal cage, the top edge of the cage body has a vertical tip and an inner recess formed by bending outwardly of the top edge; and wherein the bottom edge of the lid has a U-shaped tip to accommodate the vertical tip of the top edge of the cage body. In another further embodiment of the animal cage, the cage body

further comprises a rubber gasket that is inserted inside the U-shaped tip to assure an airtight cage when the cage body and the lid are closed.

[0014] In another embodiment of the animal cage, the gaseous supply means comprises: a first filter module disposed within the animal cage; wherein the first filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the first filter module facing the cage interior is closed so that the incoming air has to diffuse through the filter layer to reach the cage interior; and a first connector with two ends opposite to each other; wherein one end connects to the air supplier, and the other end integrally connects to the first filter module; and wherein the connector has an internal channel that enables the air from the air supplier to flow into the first filter module. In yet another embodiment of the animal cage, the inner layer and the outer layer of the first filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier to diffuse into the animal cage. In still another embodiment of the animal cage, the filter layer has a size $\leq 0.1\mu\text{m}$; thereby the first filter module will prevent any particles including bacteria with a size of larger than the filter size from entering into the cage interior.

[0015] In another embodiment of the animal cage, the gaseous exhaust means comprises: a second filter module disposed within the animal cage; wherein the filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the second filter module facing the cage interior is closed so that the exhaust from the cage must diffuse through the filter layer before it is removed by the exhaust vacuum; and a second connector with two ends opposite to each other; wherein one end connects to the exhaust vacuum, and the other end integrally connects to the second filter module; and wherein the connector has an internal channel that enables the exhaust from the cage interior to flow into the exhaust vacuum. In yet another embodiment of the animal cage, the inner layer and the outer layer of the second filter module are made of plastics and have a plurality of through-passes allowing the exhaust air from the animal cage to diffuse into the exhaust vacuum. In yet still another embodiment of the animal cage, the filter has a size $\leq 0.1\mu\text{m}$; thereby the second filter module will prevent any particles with a size of larger than the filter size from

escaping from the cage interior. In another embodiment of the animal cage, the second filter module further comprises a dust collecting layer that is disposed distantly from the outer layer; thereby, when the cage is disturbed, any dust falling from the filter layer will be collected by the dust collecting layer. In a further embodiment of the animal cage, the dust collecting layer comprises a smooth surface facing the cage interior and a meshed surface facing the filter layer so that the meshed surface will collect the dust falling off the filter layer.

[0016] In yet another aspect of the present invention, there is provided a filter module for allowing air to diffuse through. The filter module comprises an inner layer; a filter layer; and an outer layer; wherein the inner layer and the outer layer hold the filter layer in place; wherein the filter has a size $\leq 0.1\mu\text{m}$; thereby the filter module will prevent any particles with a size of larger than the filter size from passing through the filter module. In one embodiment of the filter module, the inner layer and the outer layer are made of plastics and have a plurality of through-passes allowing air to pass through. In another embodiment of the filter module, the filter module is autoclavable.

[0017] The above and other objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0018] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0019] FIG 1 is an exploded view of the micro-safe individual ventilated animal cage in accordance with one embodiment of the present invention.

[0020] FIG 2 is a longitudinal cross-section view of the micro-safe individual ventilated animal cage as shown in FIG 1.

[0021] FIG 3 is a perpendicular cross-section view of the filter module in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0022] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention. However, it will be understood by those skilled in the relevant art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0023] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0024] In one aspect of the present invention, there is provided an animal cage that has many advantages over the prior art. As shown in FIG 1, the animal cage 1 comprises a cage body 10, a wire mesh bar 20, and a lid 30, where the cage body and the lid form an enclosure (cage interior) in which one or more research animals are housed.

[0025] The cage body 10 comprises a floor 11, a surrounding wall 12 that is integrally extending substantially vertically from the edges of the floor to form a space where the animals are housed, and a top edge 13 that is an integral extension of the surrounding wall 12. In one embodiment, the top edge 13 has an inner recess formed by bending the tip of the wall horizontally and outwardly, and a vertical tip; where the inner recess will provide support for the wire mesh bar 20, and the vertical tip will insert into the bottom edge of the lid.

[0026] The wire mesh bar 20 comprises a flat portion 21, a dented portion 22, and a solid edge 23. In one embodiment, the wire mesh bar 20 is made of stainless steel so that the wire mesh bar is free of animal bites and autoclavable. The flat portion 21 may provide support for the gaseous supply and exhaust system discussed hereinafter. The dented portion will hold the water bottle 24 and feedstuff. The solid edge will enable the bar to be supported by the inner recess of the cage body.

[0027] The lid 30 comprises a top surface 31, a surrounding wall 32 that is integrally extending substantially vertically from the peripheral edge of the top surface to form a space for disposing the gaseous supply and exhaust system discussed hereinafter, a bottom edge 33 that is an integral extension of the surrounding wall 32. In one embodiment, as shown in detail in FIG 2, the bottom edge 33 has a vertical U-shaped tip, and an inner recess for

accommodating the vertical tip of the top edge of the cage body. The bottom edge of the lid and the top edge of the cage body are mated each other. In one embodiment, one rubber gasket is inserted into the bottom of the inner recess of the U-shaped tip so as to make the cage airtight.

[0028] The cage body 10 and the lid 30 may be made of plastics. In one embodiment, the cage body is transparent so that the animals housed therein can be observed from outside without opening the cage. In another embodiment, the cage body and lid are autoclavable.

[0029] In one embodiment, the cage body 10 and the lid 30 further comprise a plurality of outside protrusions on their surrounding walls. When the animal cage is assembled by disposing the wire mesh bar and the lid upon the cage body, it can be clamped to for an airtight interior by the outside protrusions. Removable clamps for such purposes are well known in the art.

[0030] Now more details of the gaseous supply and exhaust system 34 are provided. In one aspect of the present invention, the gaseous supply and exhaust system 34 comprises a gaseous supply means that can be removably connected to an air supplier so as to allow a desired air composition supply to diffuse into the airtight animal cage; and a gaseous exhaust means removably connected to an exhaust vacuum so as to remove the exhausted air from the airtight animal cage by diffusion; thereby the gaseous supply and exhaust system enables a user to adjust and control the air composition and pressure within the airtight animal cage. The air supplier and exhaust vacuum are not shown in the drawings; they can be used to control the air pressures and other parameters including composition and humidity within each cage.

[0031] Now referring to FIGs 1-3, in one embodiment, the gaseous supply and exhaust system 34 comprises two filter modules 36, where each filter module has a connector 35. The connectors 35 have two ends opposite to each other; wherein one end connects to the air supplier or the exhaust vacuum, and the other end integrally connects to the filter modules. The connectors 35 have an internal channel that enables the air to flow into/out the airtight animal cage. In one embodiment, the filter modules are removable from the connectors.

[0032] In one embodiment, the filter modules have a cylindrical configuration. Of course, other configurations may be used in making the filter modules. As shown in FIG 3 in

their cross-section view, the filter modules **36** comprise an inner layer **36a**, a filter layer **36b**, and an outer layer **36c**. The inner layer **36a** and the outer layer **36c** hold the filter layer **36b** in place. The end of the first filter module facing the cage interior is closed so that the air communication has to pass through the filter layer to reach/escape the cage interior. In one embodiment, the inner layer **36a** and the outer layer **36c** of the filter modules are made of plastics and have slits allowing the air from the air supplier diffuse into the airtight animal cage. It is to be appreciated that any air through-passes can be employed in the supporting layers to allow the air to diffuse into the cage. The filter modules are autoclavable.

[0033] As discussed above, the current filters used in animal cages have large sizes. Usually, the sizes are >5 microns. In that case, the large sized filters not only fail to capture particles including bacteria with sizes smaller than 5 microns, but also cause air disturbance within the cage interior because the air drifts through the filters too fast. In order to provide a more safe and stable microenvironment, the inventors of the present invention discovered that the filters with ≤ 1 micron size can be used to make the filter modules. The reduction of the sizes of the filters results in multiple advantages. For example, the small sized filters can prevent large particles from getting into the cage interior, resulting in less or zero bacteria counts. The small sized filters can also prevent large particles generated within the cage interior from escaping into the external environment, resulting in reduction of cross-contamination and allergy development. Furthermore, the small sized filters only allow the air to diffuse into/out of the cage interior so that the animals will have a dynamic condition without air disturbance. It would be specially advantageous when certain researches require very stable and quiet microenvironment for animals.

[0034] In one embodiment, the filter layer **36b** has a size $\leq 0.1\mu\text{m}$. The filters will prevent any particles including bacteria with a size of larger than the filter size from entering into or escaping from the cage interior.

[0035] The filter layer **36b** can be any polymer that has the suitable capacity of holding dirt and the suitable size for filtration. In one embodiment, the filter layer **36b** is made of polypropylene, polyester, or HEPA. In addition, the filter layer **36b** may be comprised of more than one layer. For example, one polymer layer may be added onto another polymer layer to form a composite filter. Furthermore, the filter layer may have

different configurations. For example, the filter layer may have waveform configuration for larger surfaces. It is to be appreciated that other synthetic and nature filters can be used in the present invention as long as the filters are not allergic to the housed animals.

[0036] In one embodiment, the filter modules **36** further comprise a dust collecting layer **36d**. When the filter modules are used for a prolonged period, many dust particles will be deposited on the surfaces of the filter layers or trapped within the filter layers; such particles will fall back into the cage interior when the cage is quickly removed or transported. Thus, when the dust collecting layer **36d** is disposed distantly from the outer layer **36c**, any dust falling from the filter layer will be collected by the dust collecting layer. The distance between the outer layer and the dust collecting layer can be as close as to a few microns that are large enough for the air to diffuse into/out of the cage interior. In one embodiment, the dust collecting layer has a smooth surface facing the cage interior and a meshed surface facing the filter layer so that the meshed surface will collect the dust falling off the filter layer.

[0037] So far, a micro-safe individual ventilated animal cage has been described using a special filtration technique that is placing individual HEPA filters of ≤ 0.1 micron on both the inlet and outlet of the cage. These high efficiency particle filters will provide clean air into the cage and filter out any contaminants before throwing the air back to the room to minimize any potential human to animal or animal to human cross-contamination issues.

[0038] In addition, with the treatment of exhaust air and trapping of dust and dander generated by the animals, it reduces risk of allergies development by the researchers in an animal laboratory.

[0039] The critical advantage of the micro-safe system is that the system considers dynamic conditions. A dynamic condition refers to situation where cage is removed from the racks. In addition, the air regulation/control system can alter the air pressures within each cage according to research requirements. For example, the cage can be set to atmosphere pressures in most of the situations. When a SPF grade animal is housed, the cage may require a positive pressure. When a research involves some transmittable virus, the cage can be set to a negative pressure.

[0040] The high efficiency particle filter that is fitted into an airtight cage will remove of particles ≥ 0.1 micron in size thus reducing the bacteria level within the

microenvironment. The airtight enclosure will prevent any outside contaminants from coming in contact with the research animal. The benefits are summarized as follows:

[0041] 1) With a 0.1 μm filter on both supply and exhaust of the cage, the animal microenvironment can achieve a 0 count for particle above 0.1 μm , resulting in zero count of bacteria;

[0042] 2) The filter holding is specially designed to achieve a flow velocity of less than 0.04m/s. This will provide a stable condition that will not disturb and affect the research animal normal physiological and behavior;

[0043] 3) The filters as acts as a sound attenuation that will create a less than 55 db(A) sound level;

[0044] 4) The 0.1 μm and filters between the supply and exhaust in conjunction with an airtight enclosure, will allow a germ free grade type of animal to be able to use the rack as holding equipment;

[0045] 5) There is no need for any special transportation treatment as the cages has internal filters;

[0046] 6) The HEPA filter eliminates cross-contamination issue resulting from dynamic conditions and even backflow if it occurs;

[0047] 7) Different species of animal of different grade can be placed into one single rack because of elimination of cross-contamination.

[0048] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

Claims

What is claimed is:

1. A gaseous supply and exhaust system for being used in an airtight animal cage, said gaseous supply and exhaust system comprising:

a gaseous supply means that can be removably connected to an air supplier, wherein the gaseous supply means enables the desired air composition supply from the air supply to diffuse into the airtight animal cage; and

a gaseous exhaust means that can be removably connected to an exhaust vacuum, wherein the gaseous exhaust means enables the exhausted air from the airtight animal cage to be removed by diffusion;

thereby the gaseous supply and exhaust system enables a user to adjust and control the air composition and pressure within the airtight animal cage.

2. The gaseous supply and exhaust system of claim 1, wherein the gaseous supply means comprises:

a first filter module disposed within the airtight animal cage; wherein the first filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the first filter module facing the cage interior is closed so that the incoming air has to diffuse through the filter layer to reach the cage interior; and

a first connector with two ends opposite to each other; wherein one end connects to the air supplier, and the other end integrally connects to the first filter module; and wherein the connector has an internal channel that enables the air from the air supplier to flow into the first filter module.

3. The gaseous supply and exhaust system of claim 2, wherein the inner layer and the outer layer of the first filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier to diffuse into the airtight animal cage.
4. The gaseous supply and exhaust system of claim 2, wherein the filter layer has a size $\leq 0.1\mu\text{m}$; thereby the first filter module will prevent any particles including bacteria with a size of larger than the filter size from entering into the cage interior.
5. The gaseous supply and exhaust system of claim 2, wherein the first filter module is removable from the first connector.
6. The gaseous supply and exhaust system of claim 1, wherein the gaseous exhaust means comprises:
 - a second filter module disposed within the airtight animal cage; wherein the filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the second filter module facing the cage interior is closed so that the exhaust from the cage must pass through the filter layer before it is removed by the exhaust vacuum; and
 - a second connector with two ends opposite to each other; wherein one end connects to the exhaust vacuum, and the other end integrally connects to the second filter module; and wherein the connector has an internal channel that enables the exhaust from the cage interior to flow into the exhaust vacuum.
7. The gaseous supply and exhaust system of claim 6, wherein the second filter module is removable from the second connector.
8. The gaseous supply and exhaust system of claim 6, wherein the inner layer and the outer layer of the second filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier diffuse into the airtight animal cage.

9. The gaseous supply and exhaust system of claim 7, wherein the filter layer has a size $\leq 0.1\mu\text{m}$; thereby the second filter module will prevent any particles with a size of larger than the filter size from escaping from the cage interior.
10. The gaseous supply and exhaust system of claim 7, wherein the second filter module further comprises a dust collecting layer that is disposed distantly from the outer layer; thereby, when the cage is disturbed, any dust falling from the filter layer will be collected by the dust collecting layer.
11. The gaseous supply and exhaust system of claim 10, wherein the dust collecting layer comprises a smooth surface facing the cage interior and a meshed surface facing the filter layer so that the meshed surface will collect the dust falling off the filter layer.
12. An animal cage comprising:
a cage body for flooring one or more animals;
a lid disposed on the top of the cage body so as to form an enclosure with the cage body; and
a gaseous supply and exhaust system disposed within the animal cage for providing controllable air conditions within the animal cage; wherein the gaseous supply and exhaust system comprises:
a gaseous supply means that can be removably connected to an air supplier so as to enable a desired air composition supply to diffuse into the animal cage; and
a gaseous exhaust means that can be removably connected to an exhaust vacuum so as to remove the exhausted air from the animal cage by diffusion;
thereby the gaseous supply and exhaust system enables a user to adjust and control the air composition and pressure within the animal cage.
13. The animal cage of claim 12, further comprises a wire mesh bar for holding water bottle and feedstuff; wherein the wire mesh bar is disposed between the cage body and the lid.

14. The animal cage of claim 12, wherein the top edge of the cage body has a vertical tip and an inner recess formed by bending outwardly of the top edge; and wherein the bottom edge of the lid has a U-shaped tip to accommodate the vertical tip of the top edge of the cage body.

15. The animal cage of claim 14, wherein the cage body further comprises a rubber gasket that is inserted inside the U-shaped tip to assure an airtight cage when the cage body and the lid are closed.

16. The animal cage of claim 12, wherein the gaseous supply means comprises:

a first filter module disposed within the animal cage; wherein the first filter module having a cylindrical configuration comprises an inner layer, a filter layer, and an outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the first filter module facing the cage interior is closed so that the incoming air has to diffuse through the filter layer to reach the cage interior; and

a first connector with two ends opposite to each other; wherein one end connects to the air supplier, and the other end integrally connects to the first filter module; and wherein the connector has an internal channel that enables the air from the air supplier to flow into the first filter module.

17. The animal cage of claim 16, wherein the inner layer and the outer layer of the first filter module are made of plastics and have a plurality of through-passes allowing the air from the air supplier to diffuse into the animal cage.

18. The animal cage of claim 16, wherein the filter layer has a size $\leq 0.1 \mu\text{m}$; thereby the first filter module will prevent any particles including bacteria with a size of larger than the filter size from entering into the cage interior.

19. The animal cage of claim 12, wherein the gaseous exhaust means comprises:

a second filter module disposed within the animal cage; wherein the filter module having a cylindrical configuration comprises an inner layer, a filter layer, and a outer layer; wherein the inner layer and the outer layer hold the filter layer in place; and wherein the end of the second filter module facing the cage interior is closed so that the exhaust from the cage must diffuse through the filter layer before it is removed by the exhaust vacuum; and

a second connector with two ends opposite to each other; wherein one end connects to the exhaust vacuum, and the other end integrally connects to the second filter module; and wherein the connector has an internal channel that enables the exhaust from the cage interior to flow into the exhaust vacuum.

20. The animal cage of claim 19, wherein the inner layer and the outer layer of the second filter module are made of plastics and have a plurality of through-passes allowing the exhaust air from the animal cage to diffuse into the exhaust vacuum.

21. The animal cage of claim 19, wherein the filter has a size $\leq 0.1\mu\text{m}$; thereby the second filter module will prevent any particles with a size of larger than the filter size from escaping from the cage interior.

22. The animal cage of claim 19, wherein the second filter module further comprises a dust collecting layer that is disposed distantly from the outer layer; thereby, when the cage is disturbed, any dust falling from the filter layer will be collected by the dust collecting layer.

23. The animal cage of claim 21, wherein the dust collecting layer comprises a smooth surface facing the cage interior and a meshed surface facing the filter layer so that the meshed surface will collect the dust falling off the filter layer.

24. A filter module for allowing air to diffuse through, said filter module comprises:
an inner layer;
a filter layer; and
a outer layer; wherein the inner layer and the outer layer hold the filter layer in place;

wherein the filter has a size $\leq 0.1\mu\text{m}$; thereby the filter module will prevent any particles with a size of larger than the filter size from passing through the filter module.

25. The filter module of claim 24, wherein the inner layer and the outer layer are made of plastics and have a plurality of through-passes allowing air to pass through.

26. The filter module of claim 24, wherein the filter module is autoclavable.