encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol; an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

[0005a] In accordance with an exemplary embodiment, an aerosol delivery system comprises: an aerosol generator for producing an aerosol; a plurality of positive pressure generators, wherein at least one of the plurality of positive pressure generators is a positive pressure generator for producing a pressurized ventilation gas and at least one of the plurality of positive pressure generators is a positive pressure generator for producing a carrier gas; an aerosol transition adapter arranged to combine the aerosol produced by the aerosol generator with the carrier gas, and wherein the transition adapter divides the carrier gas into a plurality of streams of carrier gas, which are directed to at least partially encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol; an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

[0006] In accordance with an exemplary embodiment, a method of producing an entrained aerosol comprises: generating an aerosol; providing a source of carrier gas from a ventilator; and combining the aerosol and the carrier gas by dividing the carrier gas into a plurality of streams of carrier gas, which are at least partially encircling and in parallel with the aerosol to form an entrained aerosol.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure is explained below with reference to the exemplary embodiments shown in the drawings. In the drawings:

[0008] FIG. 1 is a perspective view of a transition adapter in accordance with an exemplary embodiment.

[0009] FIG. 2 is a side view of the transition adapter as shown in FIG. 1 in accordance with an exemplary embodiment.

[0010] FIG. 3 is a cross-sectional view of the transition adapter as shown in FIG. 1 along the line A-A of FIG. 2.

[0011] FIG. 4 is an end view of the transition adapter as shown in FIG. 1 in accordance with an exemplary embodiment.

[0012] FIG. 5A is a side view of the transition adapter as shown in FIG. 1.

[0013] FIG. 5B is a cross-sectional view of the transition adapter as shown in FIG. 5A along the line B-B.

[0014] FIG. 5C is a cross-sectional view of the transition adapter as shown in FIG. 5A along the line C-C.

[0015] FIG. 5D is a cross-sectional view of the transition adapter as shown in FIG. 5A along the line A-A.

[0016] FIG. 6A is an end view of the transition adapter as shown in FIG. 1 in accordance with an exemplary embodiment.

[0017] FIG. 6B is an end view of the transition adapter as shown in FIG. 1 in accordance with an exemplary embodiment.

[0018] FIG. 6C is an end view of the transition adapter as shown in FIG. 1 in accordance with an exemplary embodiment.

CLAIMS:

1. An aerosol transition adapter for delivering an aerosolized active agent to a patient, the aerosol transition adapter comprising:

a housing having a proximal end and a distal end, the proximal end having an aerosol passage for receiving an aerosol produced by a source of aerosol comprising an aerosolized active agent and the distal end having an exit port, the housing having a length between the distal end and the proximal end;

a carrier gas connection port for receiving a carrier gas from a gas source, which is in communication with a plurality of carrier gas exit ports, the plurality of carrier gas exit ports are arranged adjacent to the aerosol passage in a pattern that partially encircles the flow of aerosol;

an inner cavity, which is adapted to receive the aerosol from the aerosol passage and the carrier gas from the plurality of carrier gas exit ports and to direct streams of carrier gas to at least partially encircle and flow in parallel with a main direction of a flow of the aerosol along the length of the housing toward the exit port; and

the exit port on the distal end of the housing for delivering the aerosol to a patient in need of an aerosolized active agent.

2. The adapter of claim 1 wherein the inner cavity has a proximal portion having a conical inner wall, which expands outward towards the distal end of the housing, and a distal portion having a tapered inner diameter.

3. The adapter of claim 2 wherein the plurality of carrier gas exit ports are positioned within the proximal portion of the inner cavity at an equidistance from the aerosol passage.

4. The adapter of laim 1 wherein the housing includes a cylindrical proximal member and a cylindrical distal member, and wherein the cylindrical proximal member has a coupling for receiving a carrier gas from the gas source.

5. The adapter of claim 4 wherein an outer diameter of the cylindrical proximal member is less than an outer diameter of the cylindrical distal member.

6. The adapter of claim 1 wherein the gas connection port for receiving the carrier gas from the gas source includes at least one gas entry port for receiving the carrier gas, the at least one gas entry port directing a stream of carrier gas to one or more gas exit ports.

7. The adapter of claim 6 wherein the at least one gas entry port comprises at least three gas entry ports and a corresponding gas exit port for each of the at least three gas entry ports.

8. The adapter of claim 1 wherein each of the plurality of carrier gas exit ports are approximately 1 to 10 mm in diameter and located at approximately a 3 to 20 mm radius from a central axially extending aerosol passage from which the aerosol enters the housing of the transition adapter.

9. The adapter of claim 1 wherein the exit port of the transition adapter has an inner diameter of approximately 22 mm to approximately 50 mm.

10. The adapter of claim 1 comprising:
a flange, which is attached to the proximal end of the housing.

11. The adapter of claim 10 comprising:
a cavity within the flange, which is configured to receive the source of aerosol.

12. An aerosol delivery system, comprising:
an aerosol generator for producing an aerosol;
a positive pressure generator for producing a pressurized ventilation gas;
a splitter for splitting the pressurized ventilation gas into a carrier gas and a ventilation gas and a conduit from the positive pressure generator to the splitter;
an aerosol transition adapter arranged to combine the aerosol produced by the aerosol generator with the carrier gas from the splitter, and wherein the transition adapter divides the carrier gas into a plurality of streams of carrier gas, which are directed to at least partially encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol;
an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and
a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

13. The system of claim 12 further comprising a conduit for delivering the entrained aerosol and the ventilation gas from the patient-aerosol interface port to the patient interface.

14. The system of claim 12 further comprising a humidifier located between the splitter and the aerosol delivery connector for humidifying the ventilation gas before the ventilation gas enters the aerosol delivery connector.

15. The system of claim 12 wherein the aerosol transition adapter comprises:

a housing having a proximal end and a distal end, the proximal end having an aerosol passage for receiving the aerosol produced by the aerosol generator comprising an aerosolized active agent and the distal end having an exit port, the housing having a length between the distal end and the proximal end;

a carrier gas connection port for receiving the carrier gas from the positive pressure generator, which is in communication with a plurality of carrier gas entrance ports, the carrier gas entrance ports are arranged adjacent to the aerosol passage in a pattern that partially encircles the flow of aerosol;

an inner cavity, which is adapted to receive the aerosol from the aerosol passage and the carrier gas from the plurality of carrier gas exit ports and to direct the streams of carrier gas to at least partially encircle and flow in parallel with a main direction of a flow of the aerosol along the length of the housing toward the exit port; and

the exit port on the distal end of the housing for delivering the entrained aerosol to the aerosol delivery connector.

16. The system of claim 15 comprising:

a fluid trap, which is located between the aerosol transition adapter and the aerosol delivery connector, and wherein the fluid trap entraps condensed liquid or liquid from the entrained aerosol.

17. The system of claim 16 wherein the fluid trap has a capacity of at least 60 milliliters, and an airway through the fluid trap is 15 to 22 millimeters in diameter.

18. The system of claim 17 wherein the aerosol tube connecting the fluid trap to the aerosol delivery connector is a corrugated tubing having a diameter of approximately 10 to 15 mm and a length of approximately 40 to 100 cm.

19. The system of claim 12 wherein the splitter for splitting the inspiratory flow from the ventilator into the carrier and ventilation gas flows is a Wye or Tee fitting.

20. The system of claim 14 wherein ventilation flow tube connecting the splitter to the humidifier is a corrugated tubing having a diameter of approximately 10 to 12 mm in diameter with an approximately 15 mm conical end connector.

21. The system of claim 12 further comprising a source of liquid formulation containing a lung surfactant adapted for delivery as the aerosol to an infant's lungs, and wherein the source of liquid formulation is delivered to the aerosol generator.

22. The system of claim 12 wherein the ventilator supplies an inspiratory flow of gas at a flow rate of about 1 to 10 L/min (liters per minute).

23. The system of claim 12 wherein the aerosol generator is at least one of a heated capillary aerosol generator, a nebulizer, a soft mist generator, a metered dose inhaler, a liquid dose instillation device, and/or a dry powder inhaler.

24. The system of claim 12 wherein the aerosol generator comprises more than one aerosol generator.

25. The system of claim 12 wherein the port for exit of expiration gas from the patient is connected to an expiratory tube, which delivers the expiration gas to the positive pressure generator after passing through a filter.

26. The system of claim 12 wherein the port for exit of expiration gas from the patient is connected to a source of back pressure.

27. The system of claim 26 wherein the source of back pressure is a water bath or reservoir.

28. The system of claim 12 wherein the splitter and the aerosol delivery connector each have a closure, which allows the system to deliver the ventilation gas to the patient without the aerosol.

29. An aerosol delivery system, comprising:

an aerosol generator for producing an aerosol;

a plurality of positive pressure generators, wherein at least one of the plurality of positive pressure generators is a positive pressure generator for producing a pressurized ventilation gas and at least one of the plurality of positive pressure generators is a positive pressure generator for producing a carrier gas;

an aerosol transition adapter arranged to combine the aerosol produced by the aerosol generator with the carrier gas, and wherein the transition adapter divides the carrier gas into a plurality of streams of carrier gas, which are directed to at least partially encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol;

an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and

a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

30. A method of producing an entrained aerosol comprising:

generating an aerosol;

providing a source of carrier gas from a ventilator; and

combining the aerosol and the carrier gas by dividing the carrier gas into a plurality of streams of carrier gas, which are at least partially encircling and in parallel with the aerosol to form an entrained aerosol.

31. The method of claim 30 comprising:

splitting an inspiratory flow of gas from the ventilator into a carrier gas flow and a ventilation gas flow, wherein the carrier gas is combined with the aerosol in a transition adapter to form the entrained aerosol and the ventilation gas is delivered to an aerosol delivery connector, which receives the entrained aerosol and combines the entrained aerosol and the ventilation gas for delivery to a patient.

32. The method of claim 31 further comprising delivering the entrained aerosol and the ventilation gas to the patient via a patient interface.

33. The method of claim 32, wherein for a neonatal application providing the inspiratory flow from the ventilator at a rate of approximately six liters per minute, and splitting the inspiratory flow rate from the ventilator into approximately three liters per minute into a carrier gas conduit and approximately three liters per minute into a ventilation gas conduit.

34. The method of claim 33, wherein the entrained aerosol enters the aerosol delivery connector and the patient interface at approximately 35 °C to 39 °C.

35. The method of claim 31, wherein the humidified ventilation gas enters the aerosol delivery connector at approximately 35 °C to 39 °C.

36. The method of claim 31, comprising:

directing an exhaled gas from a patient to the ventilator such that a volume of an inspiratory gas originating from the ventilator is approximately equal to a volume of the exhaled gas directed to the ventilator.

37. The method of claim 31, wherein the step of generating the aerosol includes generating the aerosol with a heated capillary.

38. The method of claim 31, wherein the step of generating the aerosol includes generating the aerosol with a nebulizer, a soft mist generator, a metered dose inhaler, a liquid dose instillation device, or a dry powder inhaler.

CLAIMS:

1. An aerosol transition adapter for delivering an aerosolized active agent to a patient, the aerosol transition adapter comprising:

a housing having a proximal end and a distal end, the proximal end having an aerosol passage for receiving an aerosol produced by a source of aerosol comprising an aerosolized active agent and the distal end having an exit port, the housing having a length between the distal end and the proximal end;

a carrier gas connection port for receiving a carrier gas from a gas source, which is in communication with a plurality of carrier gas exit ports, the plurality of carrier gas exit ports are arranged adjacent to the aerosol passage in a pattern that partially encircles the flow of aerosol;

an inner cavity, which is adapted to receive the aerosol from the aerosol passage and the carrier gas from the plurality of carrier gas exit ports and to direct streams of carrier gas to at least partially encircle and flow in parallel with a main direction of a flow of the aerosol along the length of the housing toward the exit port; and

the exit port on the distal end of the housing for delivering the aerosol to a patient in need of an aerosolized active agent.

2. The adapter of claim 1 wherein the inner cavity has a proximal portion having a conical inner wall, which expands outward towards the distal end of the housing, and a distal portion having a tapered inner diameter.

3. The adapter of claim 2 wherein the plurality of carrier gas exit ports are positioned within the proximal portion of the inner cavity at an equidistance from the aerosol passage.

4. The adapter of claim 1 wherein the housing includes a cylindrical proximal member and a cylindrical distal member, and wherein the cylindrical proximal member has a coupling for receiving a carrier gas from the gas source.

5. The adapter of claim 4 wherein an outer diameter of the cylindrical proximal member is less than an outer diameter of the cylindrical distal member.

6. The adapter of claim 1 wherein the gas connection port for receiving the carrier gas from the gas source includes at least one gas entry port for receiving the carrier gas, the at least one gas entry port directing a stream of carrier gas to one or more gas exit ports.

7. The adapter of claim 6 wherein the at least one gas entry port comprises at least three gas entry ports and a corresponding gas exit port for each of the at least three gas entry ports.

8. An aerosol delivery system, comprising:

an aerosol generator for producing an aerosol;

a positive pressure generator for producing a pressurized ventilation gas;

a splitter for splitting the pressurized ventilation gas into a carrier gas and a ventilation gas and a conduit from the positive pressure generator to the splitter;

an aerosol transition adapter arranged to combine the aerosol produced by the aerosol generator with the carrier gas from the splitter, and wherein the transition adapter divides the carrier gas into a plurality of streams of carrier gas, which are directed to at least partially encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol;

an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and

a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

9. The system of claim 8 further comprising a humidifier located between the splitter and the aerosol delivery connector for humidifying the ventilation gas before the ventilation gas enters the aerosol delivery connector.

10. The system of claim 8 wherein the aerosol transition adapter comprises:

a housing having a proximal end and a distal end, the proximal end having an aerosol passage for receiving the aerosol produced by the aerosol generator comprising an aerosolized active agent and the distal end having an exit port, the housing having a length between the distal end and the proximal end;

a carrier gas connection port for receiving the carrier gas from the positive pressure generator, which is in communication with a plurality of carrier gas entrance ports, the carrier gas entrance ports are arranged adjacent to the aerosol passage in a pattern that partially encircles the flow of aerosol;

an inner cavity, which is adapted to receive the aerosol from the aerosol passage and the carrier gas from the plurality of carrier gas exit ports and to direct the streams of carrier gas to at least partially encircle and flow in parallel with a main direction of a flow of the aerosol along the length of the housing toward the exit port; and

the exit port on the distal end of the housing for delivering the entrained aerosol to the aerosol delivery connector.

11. The system of claim 10 comprising:

a fluid trap, which is located between the aerosol transition adapter and the aerosol delivery connector, and wherein the fluid trap entraps condensed liquid or liquid from the entrained aerosol.

12. The system of claim 8 wherein the port for exit of expiration gas from the patient is connected to an expiratory tube, which delivers the expiration gas to the positive pressure generator after passing through a filter.

13. The system of claim 8 wherein the port for exit of expiration gas from the patient is connected to a source of back pressure.

14. The system of claim 13 wherein the source of back pressure is a water bath or reservoir.

15. The system of claim 8 wherein the splitter and the aerosol delivery connector each have a closure, which allows the system to deliver the ventilation gas to the patient without the aerosol.

16. An aerosol delivery system, comprising:

an aerosol generator for producing an aerosol;

a plurality of positive pressure generators, wherein at least one of the plurality of positive pressure generators is a positive pressure generator for producing a pressurized ventilation gas and at least one of the plurality of positive pressure generators is a positive pressure generator for producing a carrier gas;

an aerosol transition adapter arranged to combine the aerosol produced by the aerosol generator with the carrier gas, and wherein the transition adapter divides the carrier gas into a plurality of streams of carrier gas, which are directed to at least partially encircle and to flow in parallel with the aerosol entering the transition adapter, and which forms an entrained aerosol;

an aerosol delivery connector having a port for receiving the entrained aerosol, a port for entry of the ventilation gas, a patient-aerosol interface port for delivering the entrained aerosol from the aerosol transition adapter and the ventilation gas from the splitter to a patient, and a port for exit of expiration gas from the patient; and

a patient interface for receiving the entrained aerosol and the ventilation gas from the aerosol delivery connector.

17. A method of producing an entrained aerosol comprising:

generating an aerosol;

providing a source of carrier gas from a ventilator; and

combining the aerosol and the carrier gas by dividing the carrier gas into a plurality of streams of carrier gas, which are at least partially encircling and in parallel with the aerosol to form an entrained aerosol.