

TITLE OF THE INVENTION
DEVICE FOR DELIVERING PARTICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to U.S. Provisional Application No. 61/945,021, filed February 26, 2014, the contents of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] The ability to deliver pharmaceuticals through skin surfaces (transdermal delivery) can provide many advantages over oral or parenteral delivery techniques. In particular, transdermal delivery can provide a safe, convenient and noninvasive alternative to traditional drug administration systems, conveniently avoiding the major problems associated with oral delivery (e.g. variable rates of absorption and metabolism, gastrointestinal irritation and/or bitter or unpleasant drug tastes) or parenteral delivery (e.g. needle pain, the risk of introducing infection to treated individuals, the risk of contamination or infection of health care workers caused by accidental needle-sticks and the disposal of used needles). In addition, transdermal delivery can afford a high degree of control over blood concentrations of administered pharmaceuticals.

[0003] Needleless syringes are known that deliver pharmaceutical particles entrained in a supersonic gas flow. Needleless syringes can be used for transdermal delivery of powdered drug compounds and compositions, for delivery of genetic material into living cells (e.g. gene therapy) and for the delivery of biopharmaceuticals to skin, muscle, blood or lymph. The needleless syringe can also be used in conjunction with surgery to deliver drugs and biologics to organ surfaces, solid tumors and/or to surgical cavities (e.g. tumor beds or cavities after tumor resection). In theory, practically any pharmaceutical agent that can be prepared in a substantially solid, particulate form can be safely and easily delivered using such devices.

[0004] Needleless syringes can have an elongate tubular converging-diverging nozzle having a rupturable membrane initially closing the passage through the nozzle and arranged substantially adjacent to the upstream end of the nozzle. Particles of a therapeutic agent to be

delivered can be disposed adjacent to the rupturable membrane, within a cassette, and can be delivered using an energizing means which applies a gaseous pressure to the upstream side of the membrane sufficient to burst the membrane and produce a supersonic gas flow (containing the therapeutic or pharmaceutical particles) through the nozzle for delivery from the downstream end thereof. The particles can thus be delivered from the needleless syringe at very high velocities which are readily obtainable upon the bursting of the rupturable membrane. The passage through the nozzle can have an upstream convergent portion, leading through a throat to a downstream, divergent portion. The converging-diverging passage is used to accelerate the gas to supersonic speed. The gas is first brought to Mach 1 in the throat and the downstream divergence accelerates it to a steady state supersonic speed.

[0005] Needleless syringes may deliver particles at a large range of velocities with potentially non-uniform spatial distribution across the target surface. A variation in particle velocity may make it difficult to deliver high-potency powdered drugs, vaccines, etc. to specific target layers within the skin. Furthermore, non-uniform spatial distribution may cause problems which would be ameliorated if a more even spatial distribution could be achieved. In addition, flow considerations inside the needleless syringes may limit the maximum size of the target area on the target tissue over which the particles may be spread, limiting the maximum particle payload size.

[0006] Additionally, the bursting of the rupturable membrane may make operation of the syringe fairly noisy, which can be a disadvantage when treating small children for example. It would be advantageous to have a needleless syringe which operates quietly and in which the particles may be spread over a larger target area, with a reasonably uniform distribution over that target area. By spreading the particles of the payload over a larger target area, with good uniformity of particle distribution over that target area, larger payloads may be delivered.

BRIEF SUMMARY OF THE INVENTION

[0007] A transdermal drug delivery system that entails the use of a needleless syringe to fire powders (i.e. solid drug containing particles) in controlled doses into and through intact skin is disclosed.

[0008] A device is disclosed for delivering particles. The device can have a pressurized gas container filled with a pressurized gas. The device can have a trigger having a user

1 interface, such as a depressible button or switch, and a gas container interface, such as a pin.
2 The device can have a disengagable safety interlock configured to impede actuation of the
3 trigger. The device can have one or more gas flow passageways. The device can have a
4 particle container comprising the particles, such as a particle cassette. The device can have a
5 delivery port. The particle container can be positioned in the gas flow passageway between
6 the gas container and the delivery port.

7 **[0009]** The device can have a cover or case. The safety interlock can be fixed to the case.
8 The case can be translatable with respect to the user interface along the longitudinal axis of the
9 case. When the case is in a first, locked, position with respect to the user interface, the safety
10 interlock can be configured to impede actuation of the trigger. When the case is in a second,
11 unlocked, position with respect to the user interface, the safety interlock can be configured to
12 allow actuation of the user interface.

13 **[0010]** When the case is in a first position with respect to the user interface, the safety
14 interlock can engagably fit into the user interface to interference fit with the user interface and
15 prevent actuation of the user interface.

16 **[0011]** The safety interlock can have or be a latch.

17 **[0012]** At least part of the safety interlock can be removably attached to the case. The
18 safety interlock can be inside at least a portion of the user interface when the safety interlock is
19 in a locked position. The user interface can be configured to break the gas container interface,
20 such as a cap on the gas cylinder, away from the gas container when the user interface is
21 activated.

22 **[0013]** The gas container interface can have a removably attached cover on the gas
23 container. The safety interlock can have a triangular impeding element.

24 **[0014]** The particles to be delivered can include a powdered form of a therapeutic agent.
25 Wherein the therapeutic agent can be an anesthetic, such as lidocaine.

26 **[0015]** A method is disclosed for delivering particles that can include disengaging a safety
27 interlock on the particle delivery device. The device can have the safety interlock, a trigger, a
28 pressurized gas, and the particles to be delivered. The method can include activating the
29 trigger. Activating the trigger can include releasing the pressurized gas. The method can
30 further include channeling the released gas toward the particles. The method can include

1 accelerating the particles. Accelerating the particles can include the released gas delivering an
2 accelerating force on the particles.

3 **[0016]** The disengaging of the safety interlock can include moving an impeding element
4 from a position impeding actuation of the user interface to a position not impeding actuation of
5 the user interface. The moving of the impeding element from a position impeding actuation
6 can include moving the case with respect to the user interface.

7 **[0017]** The impeding element can extend from the case parallel to a longitudinal axis of
8 the case. Disengaging the safety interlock can include breaking or bending the impeding
9 element. The impeding element can be contiguous with and extending from the case.

10 **[0018]** The case can be separably attached to the impeding element. The disengaging of
11 the safety interlock can include separating the impeding element from the case.

12 **[0019]** The method can further include ejecting the accelerated particles out of an exit port
13 of the device.

14 **[0020]** A device is disclosed for delivering particles. The device can have a gas supply,
15 and a particle cassette. The gas supply can be configured for supplying gas under pressure.
16 The particle cassette can be holding the particles to be delivered in a reservoir inside of the
17 particle cassette. The particle cassette can have a cassette housing, having a male cassette part
18 coupled to a female cassette part, and one or two cassette membranes, such as a first
19 membrane on a port on the male cassette part and a second membrane on a port on the female
20 cassette part. The cassette housing can be made from an Ethylene Vinyl Acetate (EVA)
21 copolymer of from about 18% to about 28% Vinyl Acetate (VA), more narrowly from about
22 18% to about 27% VA, more narrowly from about 18% to about 20% VA, for example 18%
23 VA.

24 **[0021]** The cassette housing can have a central channel having an inner diameter from 5
25 mm to 7 mm. The central channel diameter can be equal to one or both male or female
26 cassette part port diameters. The cassette central channel can have an inner diameter from 5.8
27 mm to 6.5 mm.

28 **[0022]** The cassette membrane can be made from polycarbonate. The cassette membrane
29 can be 100% polycarbonate. The membrane can be 10 to 30 microns thick.

30 **[0023]** A method for delivering particles is disclosed. The method can include storing the
31 particles in a cassette having a cassette housing and a cassette membrane. The method can

1 include delivering pressurized gas to the exterior of the cassette. The method can further
2 include rupturing the cassette, for example a cassette membrane, with the pressurized gas. The
3 method can further include accelerating the particles out of the cassette with the pressurized
4 gas. The pressurized gas can deliver greater than 40% of the particles in the cassette, more
5 narrowly greater than 70%. The pressurized gas can deliver 40-85% of the particles in the
6 cassette, more narrowly 40-70% of the particles, or 60-85% of the particles.

7 **[0024]** A device is disclosed for delivering particles. The device can include a pressurized
8 gas container, a gas flow passageway, a particle cassette, and a silencer. The silencer can be
9 radially outside of the gas flow passageway. The silencer can be made from a foam. The
10 foam can include porous polyurethane. The silencer can be in the gas flow passageway. The
11 pressurized gas container can include compressed gas under 25 to 60 bar of pressure.

12 **[0025]** The device can have a nozzle. At least a length of the gas flow passageway can
13 extend through the nozzle. The silencer can be radially outside of the nozzle.

14 **[0026]** The nozzle can radially expand along the longitudinal axis of the device.

15 **[0027]** The device can have a cover. The silencer can be inside of the cover. The silencer
16 can be embedded in the cover. The cover can be injection molded around the silencer (e.g., by
17 double injection molding).

18 **[0028]** The silencer can include a foam coating the interior wall of the nozzle.
19

20 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

21 **[0029]** Figure 1a illustrates a variation of the delivery device.

22 **[0030]** Figure 1b is a variation of cross-sectional view A-A of Figure 1a.

23 **[0031]** Figures 1c through 1e are a variation of close-up view B-B of Figure 1b showing
24 only some elements for illustrative purposes with the button in locked, unlocked, and
25 depressed positions, respectively.

26 **[0032]** Figure 1c' is a variation of the close-up view B-B of Figure 1c.

27 **[0033]** Figure 2a illustrates a variation of the cylinder housing.

28 **[0034]** Figure 2b is a variation of cross-sectional view C-C of Figure 2a.

29 **[0035]** Figure 2c is a perspective view of the housing of Figure 2a.

30 **[0036]** Figure 3a illustrates a variation of the pressurized gas cylinder.

31 **[0037]** Figure 3b is a variation of cross-sectional view D-D of Figure 3a.

- 1 [0038] Figure 4a illustrates a variation of the compliant ball spacer.
2 [0039] Figure 4b is a variation of cross-sectional view E-E of Figure 4a.
3 [0040] Figure 4c is a top view of the compliant ball spacer of Figure 4a.
4 [0041] Figure 5a illustrates a variation of the filter.
5 [0042] Figure 5b is a cross-sectional view of a variation of the filter.
6 [0043] Figure 6a illustrates a variation of the expansion chamber.
7 [0044] Figure 6b is a variation of cross-sectional view F-F of the expansion chamber.
8 [0045] Figure 7a illustrates a variation of the nozzle.
9 [0046] Figure 7b is a variation of cross-sectional view G-G of Figure 7a.
10 [0047] Figure 8a illustrates a variation of the retainer.
11 [0048] Figure 8b is a variation of cross-sectional view H-H of Figure 8a.
12 [0049] Figure 9a illustrates a variation of the cross-sectional view of the silencer cover.
13 [0050] Figure 9b illustrates a variation of the three-dimensional view of the silencer cover.
14 [0051] Figure 10 illustrates a variation of the silencer packing.
15 [0052] Figure 11 illustrates a variation of the spring.
16 [0053] Figure 12a illustrates a variation of the cross-sectional view of the cover.
17 [0054] Figure 12b illustrates a variation of the three-dimensional view of the cover.
18 [0055] Figure 13a illustrates a variation of the cross-sectional view of the button.
19 [0056] Figure 13b illustrates a variation of the three-dimensional view of the button.
20 [0057] Figure 13c illustrates a variation of the top view of the button.
21 [0058] Figure 14 illustrates a variation of the cassette
22 [0059] Figure 15a illustrates a variation of the male cassette part.
23 [0060] Figure 15b is a variation of cross-sectional view J-J of Figure 15a.
24 [0061] Figure 16a illustrates a variation of the female cassette part.
25 [0062] Figure 16b is a variation of cross-sectional view K-K of Figure 16a.

26

27

DETAILED DESCRIPTION OF THE INVENTION

28

29

30

31

[0063] Figure 1a illustrates that a powdered agent delivery device 1 (i.e., a needleless syringe) can deliver particles to a treatment surface, such as an organ surface, like the skin or dermis. The delivery device 1 can have a delivery device longitudinal axis 32, a delivery device lateral axis 34, and a delivery device length 36. The delivery device length 36 can be

between about 1400 mm and 1700 mm, more narrowly, between about 1600 mm and 1675 mm, for example, about 1450 mm, about 1500 mm, about 1550 mm, about 1600 mm, about 1650 mm, about 1675 mm, and about 1700 mm.

[0064] Figure 1b illustrates that the delivery device 1 can have a cylinder housing 2, a pressurized gas container, pressure vessel, or pressure cylinder 4, a compliant ball spacer (CBS) 6, a filter 8, an expansion chamber 10, a nozzle 12, a retainer 14, a silencer cover 16, a silencer packing material or packing 18, a spring 20, a case or cover 22, a user interface of button 24, a cassette 200 having a male cassette part 26 and a female cassette part 28), a delivery device opening 30, or any combination thereof.

[0065] The silencer can reduce the sound when the delivery device 1 is actuated. The silencer can have a silencer cover 16 and silencer packing 18.

[0066] The delivery device 1 can create uniformity of the particles on the surface.

[0067] Figures 1c and 1c' illustrate that the device can have a safety interlock 114. The safety interlock can be fixed to and extend from the case 22. The safety interlock 114 can be a contiguous, integrated triangular latch extending around one point or one side of the hole in the case 22 in which the button 24 is seated. The safety interlock can be on the radially inner side of the button (shown in Fig. 1c) and/or be inserted into the button seat 208 configured as a notch or groove in the button 24 (shown in Fig. 1c') impede depressing and activating the button 24, minimizing or eliminating the risk of unintentional activation of the device (i.e., release of the pressurized gas and delivery of the particles).

[0068] The safety interlock 114 can have a tab or safety cover over the radially outer face of the button 24. The tab or safety cover can be bent out of the way of the button 24 or broken off of the remainder of the safety interlock 114 before unlocking the device 1.

[0069] The safety interlock 114 can be biased to remain in or pressed against the button seat 208 or otherwise in a position to impair or interfere with depression of the button 24.

[0070] The spring 20 can deliver a force parallel with the device longitudinal axis toward the distal end of the device 1, as shown by arrow, pressing the cylinder housing 2 distally. The cylinder housing 2 can be longitudinally fixed to the button pin 48 and the button 24. The spring force can be transferred through the cylinder housing 2 to the button 24, maintaining the locked position of the button 24 against the safety interlock 114 in the absence of large enough outside forces counter to the spring force.

[0071] Figure 1d illustrates that the button 24 (and other elements fixed to the button, such as the rest of the trigger) can overcome the spring force and be slidably translated, as shown by arrow 204, with respect to the case 22 parallel with the device longitudinal axis 32 (and/or the case longitudinal axis). The button 24 and/or case 22 can be translated with respect to each other, the latter shown by arrow 206, to disengage the interference fit of the safety interlock 114 from the button 24. A radially outer surface of a stepped-down portion 116a of the button 24 can slide against the inside of the case 22. After the safety interlock 114 has been disengaged from the button 24, the button 24 can be depressed (i.e., translated radially or laterally toward the center of the device) unimpeded by the safety interlock 114.

[0072] When the distal end of the delivery device 1 is pressed against a surface (e.g., against the user's palm, the backside of their hand, or the skin onto which the particles are to be delivered), such as by pressing on the distal end of the silencer cover 16, the cylinder housing 2 can translate proximally with respect to the case 22, as shown by arrow 205. The cylinder housing 2 can translate the button 24 proximally with respect to the case 22, as shown by arrow 204. The button 24 can then be disengaged, unimpeded, and unlocked from the safety interlock 114.

[0073] Figure 1e illustrates that after the safety interlock 114 is disengaged, the button 24 can be pressed and/or actuated, as shown by arrow, on the contact portion 116b. When the button 24 is be pressed and/or actuated, the cylinder 4 holding a pressurized gas (e.g., helium) can be breached. When the cylinder 4 is breached, the pressurized gas can escape from the cylinder 4. The gas can go through a gas flow path from any portion of the cylinder (e.g., top portion, middle portion, or bottom portion) through the CBS 6. The gas can go through the filter 8. The gas can enter the expansion chamber 10. When pressure builds up in the expansion chamber 10, the gas can enter the cassette 200. The gas can enter the cassette by breaking through a film. The gas can take particles (e.g., drug particles, therapeutic agents, solids, drug substances, or any combination thereof) located in the cassette 200 and shoot them through the nozzle 12. The nozzle 12 can accelerate the velocity of the gas and/or particles. The gas and/or the particles can exit through the delivery device opening 30.

[0074] The button 24 can have a hammer or button pin 48 extending radially toward the center of the device. When the button 24 is depressed, the button pin 48 can push or break open the cylinder 4, or push a secondary (e.g., cylinder housing) pin, releasing the pressurized

1 gas stored in the cylinder 4, for example, by breaking open or pushing off a cap at the end of
2 the cylinder 4. The button 24, button pin 48 and possibly secondary pins and/or the cap at the
3 end of the cylinder 4 can be part or all of a trigger to release the pressurized gas and activate
4 the device to deliver the particles.

5 **[0075]** Figures 2a through 2c illustrate the cylinder housing 2 that can hold the cylinder 4
6 (e.g., filled with pressurized helium, oxygen, carbon dioxide, or combinations thereof). The
7 cylinder housing 2 can have a housing length 44, a housing opening 38, a housing port 40, a
8 housing bracket 42, a housing tip 52, or any combination thereof. The cylinder housing 2 can
9 be made of polycarbonate or any other material fit for the cylinder housing 2. The housing
10 length 44 can be between about 90 mm and 120 mm, more narrowly, between about 100 mm
11 and 115mm, for example, about 105 mm, about 108 mm, about 108.5 mm, about 110 mm, and
12 about 115 mm.

13 **[0076]** The housing opening 38 is on the distal end of the cylinder housing 2. The housing
14 opening 38 can allow the cylinder 4 to be inserted into the cylinder housing 2. Gas can exit the
15 housing opening 38 when the trigger is actuated.

16 **[0077]** The housing port 40 can be located on the proximal or distal end of the cylinder
17 housing 2. The housing port 40 can be located on the lateral side of the cylinder housing 2.
18 The housing port 40 can be perpendicular to the longitudinal axis of the cylinder housing 2.
19 The housing port 40 can be coupled to the button 24. The housing port 40 can allow a pin 48 to
20 enter when the delivery device 1 is actuated by the button 24. The pin 48 can breach a top
21 portion of the cylinder 50.

22 **[0078]** The housing bracket 42 can stabilize the cylinder housing 2 within the cover 22.
23 The housing bracket 42 can be a circular latch. The housing bracket 42 can extend radially
24 outward from the longitudinal axis of the cylinder housing 2. The housing tip 52 can be on the
25 proximal end of the cylinder housing 2 and/or the delivery device 1. The housing tip 52 can be
26 coupled to the spring 20.

27 **[0079]** The cylinder housing 2 can have an electronic or mechanical sensor. The electronic
28 or mechanical sensor can alert the user to ensure that the cylinder 4 is secured in the cylinder
29 housing 2. The cylinder housing 2 can have a sensor to determine when the cylinder 4 is full
30 and/or empty. The cylinder housing 2 can have an ejection mechanism. The ejection

mechanism can be on the cylinder housing 2 and/or on the remainder of the delivery device 1. The ejection mechanism can eject the cylinder 4 from the cylinder housing 2.

[0080] Figures 3a and 3b illustrate the cylinder 4 that can hold the pressurized gas. The cylinder 4 can have a cylinder length 54, a cylinder compartment 56, a cylinder bevel 58, the cylinder top portion 50, or any combination thereof. The cylinder 4 can be made of aluminum, steel, polycarbonate, or any combination thereof. The cylinder length 54 can be between about 65 mm and 75 mm, more narrowly, between about 69 mm and 73 mm, for example, about 70 mm, about 70.8 mm, about 71 mm, about 71.3 mm, and about 72 mm.

[0081] The cylinder compartment 56 can hold the pressurized gas. The cylinder compartment 56 can have an inner wall and an outer wall. The pressurized gas can be charged greater than about 10 bar or, more narrowly, greater than about 100 bar. The pressurized gas can be charged from about 25 to about 60 bar. When the delivery device 1 is actuated (e.g., by pressing the button), the pressurized gas in high velocity can carry the particles to the intended target site.

[0082] The cylinder top portion 50 can be located on the proximal or distal end of the device 1. The cylinder top portion 50 can have a tapered neck leading to the cylinder compartment 56. When there is a breach in the cylinder top portion 50, the pressurized gas can escape. The breach can occur when the trigger is actuated. For example, the breach of the cylinder top portion 50 can occur by the action of the pin 48 which can be controlled and/or coupled to the button 24. The pin 48 can snap off a portion of the cylinder top portion 50.

[0083] The cylinder top portion 50 can have a screen to prevent gas from leaking before the delivery device 1 is actuated. When the device 1 is actuated, the screen can be pierced to allow the gas to escape from the cylinder 4.

[0084] The cylinder bevel 58 can be located on the distal or proximal end of the cylinder 4. The cylinder bevel 58 can have a depression. The cylinder bevel 58 can be curved inward towards the cylinder compartment 56. The cylinder bevel 58 can be coupled to the CBS 6. The cylinder bevel 58 can have a screen to prevent gas from leaking. The screen can be broken by the pressurized gas when the delivery device 1 is actuated.

[0085] Figures 4a through 4c illustrate that the compliant spacer ball (CBS) 6 can be a gasket. The CBS 6 can have at least one, two, three, four or more hollow portions 60, a CBS base 61, a CBS tip 62, a CBS height 64, a CBS diameter 66, or any combination thereof. The

CBS 6 can be made of Santoprene, high impact polystyrene (HIPS), or any combination thereof. For example, the CBS tip 62 can be made of santoprene and the CBS base 61 can be made of HIPS. The CBS diameter 66 can be between about 15 mm and 20 mm, more narrowly, between about 18 mm and 19 mm, for example, about 18 mm, about 18.8 mm, and about 19 mm. The CBS height can be between about 8 mm and 10 mm, for example, about 8.8 mm, about 9 mm, and about 9.2 mm. The CBS 6 can be circular, square, triangular, or any combination thereof. The CBS 6 can be coupled to the cylinder 4, the filter 8, the nozzle 12, the cassette 200 (i.e., the male cassette part 26, the female cassette part 28), the expansion chamber 10, or any combination thereof. For example, the CBS tip 62 can be coupled to and/or facing the cylinder 4. The CBS base 61 can be coupled to the filter 8. The CBS 6 can prevent/reduce the leakage of gas.

[0086] The hollow portion 60 can allow gas to enter the cassette 200. The hollow portion 60 can have a first opening 60a at the CBS tip. The hollow portion 60 can have a second opening 60b at the CBS base. Gas can flow from the first opening 60a through the second opening 60b. The first opening 60a can be equal, smaller, or greater in diameter than the second opening 60b. The hollow portion 60 can be circular, oval, square, triangular, or any combination thereof.

[0087] Figure 5a illustrates the at least one, two or more filters 8 that can filter any extraneous matters in the gas. The filter 8 can be made of stainless steel (e.g., 316L stainless steel), plastics (e.g., polypropylene), or any combination thereof. The filter 8 can be circular, oval, triangular, rectangular, square, or any combination thereof. The filter 8 can be porous, mesh, or any other material that can allow gas to flow through it. The filter 8 can have pores. The pores can be triangular, square, rectangular, oval, circular, or any combination thereof.

[0088] The filter 8 can be coupled to an end (e.g., the second opening 60b) of the CBS 6, the expansion chamber 10, the nozzle 12, the cylinder 4, or any combination thereof. The filter 8 can be sized to fit within the delivery device 1. For example, the filter 8 can be sized to fit between the CBS 6 and the expansion chamber 10.

[0089] The filter can have a filter diameter 67. The filter diameter 67 can be between about 17 mm and 20 mm, more narrowly, between about 18 mm and 19 mm, for example, about 18 mm, about 18.5 mm, and about 19 mm.

1 [0090] Figure 5b illustrates the filter 8 that can have a filter thickness 68. The filter
2 thickness 68 can be between about .1 mm and about .25 mm, more narrowly, between about .1
3 mm and .2 mm, for example, about .1 mm, about .15 mm, and .2 mm.

4 [0091] Figures 6a and 6b illustrate the expansion chamber 10 that can hold the cassette
5 200 in place. The expansion chamber 10 can hold the filled, partially filled, or empty cassette
6 200 in place. The expansion chamber 10 can allow the gas pressure from the cylinder 4 to
7 build up. The expansion chamber 10 can build pressure to accelerate the gas. The expansion
8 chamber 10 can be made of high impact polystyrene. The expansion chamber 10 can be
9 coupled to the filter 8, the CBS 6, the cassette 200, the nozzle 12, or any combination thereof.

10 [0092] The expansion chamber 10 can have a first expansion chamber opening 70a, a
11 second expansion chamber opening 70b, a middle portion 72, an inner wall, and an outer wall.
12 The first expansion chamber opening 70a can have a first tapered portion 74a at the end (i.e., at
13 the edge) of the first expansion chamber opening 70a. The first tapered portion 74a can taper
14 inward relative to the expansion chamber 10. The first expansion chamber opening 70a can
15 have a straight portion. The straight portion can be connected to the first tapered portion 74a.
16 The first expansion chamber opening 70a can have a larger, smaller, or equal diameter than the
17 second expansion chamber opening 70b. The second expansion chamber 70b can have a
18 second tapered portion 74b at the end of the second expansion chamber 70b. The second
19 tapered portion 74b can taper inward relative to the expansion chamber 10. The second
20 expansion chamber opening 70b can have a curved portion. The curved portion can be
21 connected to the second tapered portion 74b. The middle portion 72 can have a portion that
22 can be narrower (or can have a smaller diameter) than the first expansion chamber opening 70a
23 and/or the second expansion chamber opening 70b. The middle portion 72 can be curved,
24 straight, or any combination thereof.

25 [0093] Figures 7a and 7b illustrate the nozzle 12 that can enable the emitted gas to
26 accelerate. The nozzle 12 can be made of high impact polystyrene. The nozzle 12 can be
27 coupled to the expansion chamber 10, the filter 8, the cassette 200, the cylinder 4, or any
28 combination thereof. The nozzle 12 can be an elongate, tubular duct. The nozzle 12 can handle
29 a pressure of greater than or equal to 20 bar. The nozzle 12 can have a nozzle length 76
30 between about 50 mm and 75 mm, more narrowly, between about 55 mm and 65 mm, for
31 example, about 60 mm.

1 [0094] The nozzle 12 can have at least one, two, three, four, or more fins 78. The fins 12
2 can be coupled to a conical tube 79, the cover 22, the housing 2, or any combination thereof.
3 The fins can be radially located on the conical tube 79. The fins 78 can extend outward relative
4 to the longitudinal axis of the nozzle 12. The fins 78 can provide structural rigidity.

5 [0095] The nozzle 12 can have an upper convergent section 80, a lower divergent section
6 82, and a throat section 84 connecting the upper convergent section 80 and the lower divergent
7 section 82. The converging-diverging sections can be used to accelerate the gas to supersonic
8 speed or any other desired speed. The gas can be first brought to Mach 1 or any other desired
9 speed in the throat section. The downstream divergence can accelerate the gas to a steady state
10 supersonic speed or any other desired speed. The nozzle 12 can have a hollow cavity at the
11 proximal end for the expansion chamber 10.

12 [0096] Figures 8a and 8b illustrate at least one, two, or more retainers 14 that can hold the
13 nozzle-housing assembly in place. A first and a second retainer 14a, 14b can be located on
14 lateral sides of the of the delivery device 1. The retainer 14 can be made of polycarbonate. The
15 retainer 14 can have a retainer opening 85. The retainer opening 85 can be at the top of the
16 retainer 14. The retainer opening 85 can aid in installation. The retainer 14 can have a retainer
17 space 87. The retainer space 87 can lock the nozzle 12 in place.

18 [0097] Figures 9a and 9b illustrate a silencer cover 16 that can hold the silencer packing
19 18. The silencer cover 16 can be made of high impact polystyrene, polyurethane, or any
20 combination thereof. The silencer cover 16 can have a cylinder shape. The silencer cover 16
21 can be coupled to the silencer packing 18, the nozzle 12, the filter 8, the cover 22, the housing
22 2, the retainer 14, or any combination thereof. The silencer cover 16 can encompass and/or
23 surround all or a portion of the nozzle 12. The silencer cover 16 can be sized to fit within the
24 cover 22 such that a portion of the silencer cover 16 (e.g., the distal end of the silencer cover
25 16) is not covered or surrounded by the cover 22. A portion of the silencer cover 16 can extend
26 from the cover 22. The silencer cover 16 can have a silencer cover outer diameter 88, a
27 silencer cover inner diameter 90, a silencer cover length 92, at least one, two, three, four, five,
28 six, or more gaps 94, a silencer gap width 96, a silencer gap length 98, a silencer cover
29 longitudinal axis 100, or any combination thereof.

30 [0098] The silencer cover outer diameter 88 can be between about 25 mm and 35 mm,
31 more narrowly, between about 25 mm and 30 mm, for example, about 29 mm and about 30

mm. The silencer cover inner diameter 90 can be between about 15 mm and 20 mm, more narrowly, between about 16 mm and 18 mm, for example, about 17 mm. The silencer cover length 92 can be between about 50 mm and 100 mm, more narrowly, between about 60 mm and 70 mm, for example, about 64 mm, about 64.6 mm, and about 65 mm. The silencer gap width 96 can be between about 5 mm and 10 mm, more narrowly, between about 6 mm and 9 mm, for example, about 7 mm and about 8 mm. The silencer gap length 98 can be between about 5 mm and 15 mm, more narrowly, between about 8 mm and 12 mm, for example, about 10 mm, about 11 mm, and about 12 mm.

[0099] The gaps 94 can be located on the silencer cover 16. The gaps can allow gas to escape. The gaps 94 can be circular, triangular, square, rectangular, diamond, or any combination thereof. At least the first gap 94a, the second gap 94b, and/or the third gap 94c can be in a first row. At least the fourth gap 94d, the fifth gap 94e, and/or the sixth gap 94f can be in a second row. The first row and the second row can be on the same side of the silencer cover 16. The first row can be directly above the second row. The first row and the second row can be on opposing sides of the silencer cover 16. The first gap 94a and the second gap 94b can be adjacent to one another. The first gap 94a can have a first side and the second gap 94b can have a first side. The first side of the first gap 94a and the first side of the second gap 94b can be parallel to one another or perpendicular to one another.

[0100] Figure 10 illustrates a silencer packing 18 that can dampen the noise created when the delivery device 1 is actuated. The silencer packing 18 can be one piece. The silencer packing 18 can have a first portion and a second portion. The silencer packing 18 can be made from a dampening or silencing foam. The silencer foam can be injected as a liquid into the silencer cavity and cure and solidify. The silencer foam can be spray coated onto the insider surfaces of the silencer cavity, cured and solidify. The curing can be performed by UV exposure and/or exposure to air and/or time elapsing.

[0101] The silencer foam can be a solid piece of flexible or rigid foam die-cut from a larger piece of solid foam. The silencer packing 18 can be made of urethane (e.g., porous polyurethane).

[0102] The silencer packing 18 can be inserted inside the silencer cover 16. The case 22 can have a silencer cavity 220 configured to hold the silencer packing 18. The silencer cavity 220 can be defined by part or all of the interior surface of the silencer cover 16. The solid

foam can be slidably inserted into the silencer cavity 220. The silencer foam can have a cylindrical shape before insertion into the silencer cavity or can be shaped as shown in Figure 10 and flexibly deformed when inserted into the silencer cavity. The silencer cavity can, for example, be closed on all sides except for an intake port to receive a liquid silencer packing 18 (e.g., before curing) and an outlet port to vent pressure when injecting liquid silencer packing 18.

[0103] The silencer packing 18 can attach to the inner circumference of the silencer cover 16. The silencer packing 18 can cover the inner circumference of the silencer cover 16. The silencer packing 18 can surround the outer circumference of the silencer cover 16. The silencer packing 18 can surround/encompass the entire nozzle 12 or a portion of the nozzle 12. The silencer packing 18 can be produced by double injection molding. The silencer packing 18 can be molded inside the silencer cover 16. The silencer packing 18 can be square, rectangular, circular, oval, or any combination thereof.

[0104] The silencer packing 18 can have a silencer packing length 102 of between about 60 mm and 70 mm, for example, about 66 mm. The silencer packing 18 can have a silencer packing height 104 of between about 40 mm and 55 mm, for example, about 49 mm. The silencer packing 18 can have a silencer packing width (i.e., thickness) 106 of between about .01 mm and 2 mm, for example, about 1.8 mm.

[0105] The silencer packing 18 can be coated onto the inside surface of the nozzle 12 in contact with the gas passageway.

[0106] The silencer, including the silencer packing 18, can act as a vibration dampener and sound barrier of the device 1. The silencer packing 18 can minimize the noise produced when the delivery device 1 is actuated. The porous property of the polyurethane can allow gas to escape after the device 1 is actuated. The escape of the gas through the pores can prevent or reduce gas in the nozzle 12 area. The build-up of gas can create a back pressure which can affect the amount of drug substance emitted, the uniformity of the drug substance, and/or the force of the emission. For example, the sound level with the silencer packing 18 can be about less than 85 dB during use without the build-up of gas. The pores in the silencer packing 18 can be circular, square, rectangle, diamond, oval, triangular, or any combination thereof.

[0107] Figure 11 illustrates the spring 20 that can aid in the delivery device 1 safety interlock function. The spring 20 can engage and disengage the delivery device 1 interlock

function (i.e., the triangular latch or safety interlock 114). The spring 20 can be made of nickel coated stainless steel (e.g., stainless steel 302). The spring 20 can be located at the proximal end of the device 1. The spring 20 can be compressed when the delivery device 1 is pressed against a surface. The spring 20 can be coupled to the housing tip 52. The spring 20 can bias (i.e., push) some components of the device 1, for example including the trigger (e.g., the button 24 and pin 48) toward the distal end of the case 22, which respect to the case 22, when no force is being applied otherwise. For example, the spring 20 can force the button 24 into a locked position against the safety interlock 114 when an external force is not applied to translate the button 24 with respect to the case 22 to unlock the button 24

[0108] Figure 12a and 12b illustrate the cover 22 that can be the external shell of the delivery device 1. The cover can allow a user to actuate the delivery device 1 with one hand. The cover 22 can be made of high impact polystyrene. The cover 22 can be ergonomic for the user. The exterior of the cover 22 can be smooth. The exterior of the cover 22 can be rounded. The exterior of the cover 22 can be free of edges. The cover 22 can have a tapered shape. The cover 22 can have a pen-like shape. The cover 22 can be combined with the cylinder housing 2 to form one piece. The cover 22 and/or cylinder housing 2 can enclose any combination of components listed in the application.

[0109] The cover 22 can have an opening for the button 24. The cover 22 can have a cover opening 108. The cover opening 108 can allow a portion of the silencer cover 16 to extend out. The cover 22 can have a cover side opening 110. The cover side opening 110 can be a latch opening for the cylinder housing 2. The cover 22 can have a V-shaped ridge 112 surrounding a portion of the button 24. The ridge 112 can protect the button 24. The cover 22 can have a positioning fin for the cylinder housing 2.

[0110] Figures 13a through 13c illustrate that the button 24 can be made of polycarbonate. The button 24 can be triangular, circular, oval, square, or any combination thereof. The button 24 can have a button surface 116.

[0111] The button surface 116 can be tilted or slanted with respect to the device longitudinal axis. The button surface 116 can have a stepped-down portion 116a lower than a contact portion 116b. A part of the contact portion 116b can be at the same level as the ridge 112.

1 [0112] The button can have one or more catches 119 extending toward the center of the
2 device 1. The catches 119 can couple to the housing 2. The catches 119 can engage internal
3 lips in the device 1 to prevent the button from radially separating from the remainder of the
4 device 1.

5 [0113] The button 24 can have a safety interlock engagement interface, such as a groove,
6 slot, notch, or button seat 208. (The safety interlock engagement interface shown herein is
7 female and the safety interlock is male, but the safety interlock engagement interface can be
8 male, e.g., a tab, latch, brad, prong, or combinations thereof, and the safety interlock can be
9 female, e.g., a groove, slot, notch, seat, or combinations thereof.)

10 [0114] The interaction between the safety interlock engagement interface and the safety
11 interlock can prevent the button 24 from being actuated in free stand by the small triangular
12 latch 114 on the cover 22 and/or button 24. The triangular latch 114 can be on the proximal or
13 distal end of the device 1. The triangular latch 114 can be on the proximal or distal end of the
14 button 24.

15 [0115] When the end of the silencer cover 16 of the delivery device 1 is pressed onto or
16 against a surface, the button 24 can be lifted away from the triangular latch 114. For example,
17 the button 24 can be lifted away from the triangular latch 114 by the triangular latch 114
18 moving proximally or distally relative to the button 24. When the button 24 is lifted away from
19 the triangular latch 114, the button 24 can be pressed. The button 24 can cause the gas cylinder
20 4 to open (e.g., by rupturing the top portion of the cylinder 50 by the pin 48) releasing the gas
21 and creating a gas flow in the device 1 to deliver the particles in the cassette 200. After the
22 delivery device 1 is actuated, the button 24 can remain pressed. The button 24 may not return
23 to its original position after the delivery device 1 is actuated.

24 [0116] Figure 14 illustrates that the cassette 200 can have a cassette housing 204, housing
25 ports (e.g., one on the top and one on the bottom, out of view), and one or two cassette
26 membranes particle compartment. The cassette 200 can have a cassette reservoir inside of the
27 cassette 200. The cassette housing 204 can be made of a single portion or two portions, a male
28 cassette part 26 and a female cassette part 28, which can be coupled to enclose the particles.
29 The cassette reservoir can contain a dosage of particles, such as therapeutic (e.g., anesthetic
30 such as lidocaine, insulin, epinephrine/adrenaline) or diagnostic particles.

[0117] The cassette 200 can have an open cassette port 208 on one or both sides of the housing. The cassette ports 208 can be in fluid communication (i.e., access) the cassette channel or reservoir, for example including the particles (i.e., powder). The open cassette ports 208 can be covered by cassette membranes 210. The cassette membranes 210 can be made from polycarbonate, for example 100% polycarbonate. The cassette membranes 210 can be heat sealed to the cassette housing 204.

[0118] The cassette housing 204 can have a cassette housing height 214 from about 2 mm to about 5 mm, more narrowly from about 3.5 mm to about 4 mm, for example about 3.79 mm, or about 4 mm. The cassette housing 204 can have a cassette housing diameter 212 from about 5 mm to about 15 mm, more narrowly from about 10 mm to about 15 mm, for example, about 11 mm or about 11.1 mm.

[0119] The cassette housing 204 can be made of polymers, for example, ethylene vinyl acetate (EVA). EVA is a copolymer of ethylene and vinyl acetate (VA): EVA can be VA with the remainder being Ethylene Copolymer. The two key parameters that determine their properties are weight percent vinyl acetate in the copolymer and melt index (MI). As more vinyl acetate is added to the polymer, it can disrupt the polyethylene crystallinity, which can lower the melting point, modulus, and hardness. The VA can make the polymer more polar, which can improve adhesion to polar substrates (film) and aid in solubility.

[0120] The below table lists thermal properties of a variation of EVA copolymer. The EVA can be 40% VA. Ring and ball softening point can predict high temperature properties. The ring and ball value for EVA resin is a reflection of the DSC melt point and the polymer viscosity. It is possible to have a low melting polymer as measured by DSC, which has a high ring and ball number. For example, the EVA resin can be 28% VA and melt at 74°C, but due to its high melt strength, it can have a ring and ball of 171°C. Changing the melt index does not change the melting point. The EVA resin can be 28% VA and the MI can vary from about 3 to about 43 and the melting point can drop by 1°C.

[0121] Table 1 Thermal Properties of EVA copolymer

% Vinyl Acetate	Melt Index	Melt Point (°C)	Ring and Ball (°C)
40	57	47	104
32	43	63	110

28	3	75	171
28	43	74	110
18	2.5	67	188
12	2.5	74	199
9	2	81	193

[0122] Table 2 shows the DSC results for high MI (low viscosity) polymers. For the same VA level, there was a drop-off in melting point versus the low MI (high viscosity) counterpart.

[0123] Table 2 High Melt Index

% Vinyl Acetate	Melt Index	Melt Point (°C)	Freeze Pt. (°C)	Ring and Ball (°C)
28	400	60	39	82
18	500	73	53	88

[0124] The melting point of the polymer reflects the upper end use temperature for an adhesive. Above the melting point, the polymer is a viscous liquid and can creep or fail. The freezing point of the polymer can affect the set speed. The polymers can freeze, for example, at 80°C or 40°C, and the polymer with high freeze point will set faster.

[0125] The cassettes can be made from EVA or from about 18% to about 28% VA, for example. The softening temperature can be below 150°C and the freeze point can be from about 40°C to about 50°C. The softening temperature of 150°C can allow the EVA cassette housing 204 to melt and affix to the cassette membrane 210 (e.g., polycarbonate film). During cooling, the cassette membrane 210 can adhere to the cassette housing 204 and form a permanent bond.

[0126] All or part of the cassette housing 204 can be made from EVA copolymer that can be from about 18 to about 28% VA (i.e., having from about 18% to about 28% VA with the remainder being Ethylene Copolymer), more narrowly from about 18% to about 27% VA, yet more narrowly from about 18% to about 20% VA, for example about 18% VA. The composition of EVA copolymer can be suitable for use in the formation of the cassette housing 204 as the low melting property of EVA can enable EVA to form a permanent firm seal with a polycarbonate film (for example, used as the cassette membrane 210) when applied with heat.

[0127] Figures 15a and 15b illustrate that the male cassette part 26 can have a male first portion 118a with a male cassette outer diameter 120 and a male second portion 118b with a male cassette inner diameter 122. The male cassette outer diameter 120 can be greater than the male cassette inner diameter 122. The male cassette outer diameter 120 can be between about 5 mm and 15 mm, more narrowly between 10 mm and 15 mm, for example, about 11 mm and about 11.2 mm. The male cassette inner diameter 122 can be between about 4 mm and 10 mm, more narrowly, between about 5 mm and 7 mm, for example, about 6 mm and about 6.1 mm.

[0128] Figures 16a and 16b illustrate that the female cassette part 28 can be made from the same material as the male cassette part 26.

[0129] The female cassette part 28 can have a female first portion 124a with a female cassette outer diameter 126 and a female second portion 124b with a female cassette inner diameter 128. The female cassette outer diameter 126 can be greater than the male cassette inner diameter 128. The female cassette outer diameter 126 can be between about 5 mm and 15 mm, more narrowly between 10 mm and 15 mm, for example, about 11 mm and about 11.1 mm. The female cassette inner diameter 128 can be between about 4 mm and 10 mm, more narrowly, between about 5 mm and 7 mm, for example, about 6 mm and about 6.1 mm.

[0130] The male second portion 118b can be sized to fit or couple to the female first portion 124a. The male cassette and the female cassette can form a tight seal such that particles cannot escape prior to the actuation of the device 1.

[0131] The cassette membrane 210 or film can be made of PET (polyethylene terephthalate), PEEK (polyether ether ketone), polycarbonate, or any combination thereof. For example, the cassette membrane can be 100% PET; 100% PEEK; 100% polycarbonate; 33.3% PET, 33.3% PEEK, and 33.3% polycarbonate; or 50% PET or PEEK, and 50% polycarbonate. The cassette 200 can be heat sealed on one or more sides with the cassette membrane 210. The cassette membrane 210 can be from about 10 microns to about 30 microns in thickness, more narrowly, between about 15 microns to 24 microns, for example, about 12 microns, about 15 microns, about 20 microns, and about 25 microns. The membrane 210 can be a barrier or closure to hold the drug substance, powder, or particles within the reservoir of the cassette 200. When an energy source (e.g., a compressed gas of 10-40 bar) is applied, the energy source can burst the upstream membrane 210 first and then the downstream membrane 210, also accelerating the particles out of the reservoir and down the gas flow passageway

1 (e.g., at that point, for example, the nozzle length of the passageway or path), and then
2 emitting and delivering the particles (e.g., drug substance) in the cassette 200 to the target
3 (e.g., skin surface).

4 **[0132]** The cassette membranes 210 can have burst pressures from about 10 bar to about
5 40 bar. When the cassette membranes 210 burst, the compressed gas can pass through the
6 cassette.

7 **[0133]** In this disclosure “coupled” can mean, but is not limited to, screwed on,
8 interlocked, twisted, heat sealed, sealed, welded, sized to fit, clipped on, resting on or between,
9 snap fit, any other known coupling to one skilled in the art, or any combinations thereof.

10 **[0134]** It is apparent to one skilled in the art that various changes and modifications can be
11 made to this disclosure, and equivalents employed, without departing from the spirit and scope
12 of the invention. Elements of systems, devices and methods shown with any variation are
13 exemplary for the specific embodiment and can be used in combination or otherwise on other
14 embodiments within this disclosure.

15

CLAIMS

We claim:

1. A device for delivering particles comprising:
 - a gas supply configured for supplying gas under pressure;
 - a particle cassette comprising the particles, a cassette housing, and a cassette membrane, wherein the cassette housing comprises an Ethylene Vinyl Acetate (EVA) copolymer of 18% to 27% Vinyl Acetate (VA).
2. The device of claim 1, wherein the cassette housing has a central channel having an inner diameter from 5 mm to 7 mm.
3. The device of claim 1, wherein the cassette housing has a central channel having an inner diameter from 5.8 mm to 6.5 mm.
4. The device of claim 1, wherein the membrane comprises polycarbonate.
5. The device of claim 4, wherein the membrane is 10 to 30 microns thick.
6. The device of claim 1, wherein the cassette housing comprises an EVA copolymer of 18% to 20% VA.
7. The device of claim 6, wherein the membrane comprises polycarbonate.
8. The device of claim 7, wherein the membrane is 10 to 30 microns thick.
9. The device of claim 1, wherein the cassette housing comprises an EVA copolymer of 18% VA.
10. The device of claim 9, wherein the membrane comprises polycarbonate.
11. The device of claim 10, wherein the membrane is 10 to 30 microns thick.

1
2 12. A device for delivering particles comprising:

3 a gas supply configured for supplying gas under pressure;

4 a particle cassette comprising the particles, a cassette housing, and a cassette
5 membrane, wherein the membrane comprising polycarbonate.
6

7 13. The device of claim 12, wherein the membrane is 10 to 30 microns thick.
8

9 14. The device of claim 12 wherein the membrane is 100% polycarbonate.
10

11 15. A method for delivering particles comprising:

12 storing the particles in a cassette having a cassette housing and a cassette membrane,

13 delivering pressurized gas to the exterior of the cassette;

14 rupturing the cassette with the pressurized gas; and

15 accelerating the particles out of the cassette with the pressurized gas, wherein greater
16 than 40% of the particles are delivered by the pressurized gas.
17

18 16. The method of claim 15, wherein greater than 70% of the particles are delivered by the
19 pressurized gas.
20

21 17. The method of claim 15, wherein 40-85% of the particles are delivered by the pressurized
22 gas.
23

24 18. The method of claim 15, wherein 40-70% of the particles are delivered by the pressurized
25 gas.
26

27 19. The method of claim 15, wherein 60-85% of the particles are delivered by the pressurized
28 gas.
29

30 20. The method of claim 15, wherein the cassette housing comprises a copolymer of 18% to
31 28% EVA.

1
2 21. The method of claim 15, wherein the cassette housing comprises a copolymer of 18%
3 EVA.

4
5 22. The method of claim 15, wherein the cassette membrane comprises a polycarbonate.

6
7 23. The method of claim 15, wherein the membrane is 10 to 30 microns thick.

8
9 24. A device for delivering particles comprising:

10 a pressurized gas container comprising a pressurized gas;
11 a trigger comprising a user interface and a gas container interface;
12 a disengagable safety interlock configured to impede actuation of the trigger;
13 a gas flow passageway;
14 a particle container comprising the particles; and
15 a delivery port, wherein the particle container is positioned in the gas flow passageway
16 between the gas container and the delivery port.

17
18 25. The device of claim 24, further comprising a case, and wherein the safety interlock is
19 fixed to the case.

20
21 26. The device of claim 25, wherein the case is translatable with respect to the user interface.

22
23 27. The device of claim 26, wherein when the case is in a first position with respect to the user
24 interface, the safety interlock is configured to impede actuation of the trigger.

25
26 28. The device of claim 26, wherein when the case is in a first position with respect to the user
27 interface, the safety interlock is configured to impede actuation of the user interface.

28
29 29. The device of claim 28, wherein when the case is in a first position with respect to the user
30 interface, the safety interlock engagably fits into the user interface to prevent actuation of the
31 user interface.

1
2 30. The device of claim 28, wherein when the case is in a second position with respect to the
3 user interface, the safety interlock is configured to allow actuation of the user interface.
4

5 31. The device of claim 24, wherein the user interface is translatable with respect to the safety
6 interlock, and wherein the trigger has a first position with respect to the safety interlock and a
7 second position with respect to the safety interlock.
8

9 32. The device of claim 24, wherein the safety interlock comprises a latch
10

11 33. The device of claim 24, further comprising a case, wherein at least part of the safety
12 interlock is removably attached to the case.
13

14 34. The device of claim 24, wherein the safety interlock is inside at least a portion of the user
15 interface when the safety interlock is in a locked position.
16

17 35. The device of claim 24, wherein the user interface is configured to break the gas container
18 interface away from the gas container when the user interface is activated.
19

20 36. The device of claim 24, wherein the user interface comprises a depressible button.
21

22 37. The device of claim 24, wherein the gas container interface comprises a removably
23 attached cover on the gas container.
24

25 38. The device of claim 24, wherein the safety interlock comprises a triangular impeding
26 element.
27

28 39. The device of claim 24, wherein the particles comprise a powdered form of a therapeutic
29 agent.
30

31 40. The device of claim 39, wherein the therapeutic agent comprises an anesthetic.

1
2 41. A device for delivering particles comprising:

3 a pressurized gas container comprising a pressurized gas;

4 a trigger comprising a user interface and a gas container interface;

5 a case comprising a disengagable safety interlock configured to impede actuation of the
6 trigger;

7 a gas flow passageway;

8 a particle container comprising the particles; and

9 a delivery port.
10

11 42. The device of claim 41, wherein the particle container is positioned in the gas flow
12 passageway between the gas container and the delivery port.
13

14 43. A method for delivering particles comprising:

15 disengaging a safety interlock on a particle delivery device comprising the safety
16 interlock, a trigger, a pressurized gas, and the particles;

17 activating the trigger, wherein activating the trigger comprises releasing the pressurized
18 gas;

19 channeling the released gas toward the particles;

20 accelerating the particles, wherein accelerating the particles comprises the released gas
21 delivering an accelerating force on the particles.
22

23 44. The method of claim 43, wherein the trigger comprises a user interface, and wherein the
24 disengaging of the safety interlock comprises moving an impeding element from a position
25 impeding actuation of the user interface to a position not impeding actuation of the user
26 interface.
27

28 45. The method of claim 43, wherein the device further comprises a case, and wherein the
29 safety interlock is fixed to the case, and wherein the moving of the impeding element from a
30 position impeding actuation comprises moving the case with respect to the user interface.
31

1 46. The method of claim 45, wherein the impeding element extends from the case parallel to a
2 longitudinal axis of the case.

3
4 47. The method of claim 43, wherein disengaging the safety interlock comprises breaking an
5 impeding element.

6
7 48. The method of claim 43, wherein the device comprises a case, and wherein the impeding
8 element is contiguous with and extends from the case.

9
10 49. The method of claim 43, wherein the device comprises a case and wherein the case is
11 separably attached to an impeding element, and wherein the disengaging of the safety interlock
12 comprises separating the impeding element from the case.

13
14 50. The method of claim 43, wherein the device further comprises a cassette comprising the
15 particles and a membrane, and wherein the method.

16
17 51. The method of claim 43, further comprising ejecting the accelerated particles out of an
18 exit port of the device.

19
20 52. A device for delivering particles comprising:

- 21 a pressurized gas container;
22 a gas flow passageway;
23 a particle cassette; and
24 a silencer.

25
26 53. The device of claim 52, wherein the silencer is radially outside of the gas flow
27 passageway.

28
29 54. The device of claim 53, wherein the silencer comprises a foam.

30
31 55. The device of claim 52, wherein the silencer is in the gas flow passageway.

1
2 56. The device of claim 55, wherein the silencer comprises a foam.

3
4 57. The device of claim 52, wherein the pressurized gas container comprises a compressed gas
5 under 25 to 60 bar of pressure.

6
7 58. The device of claim 52, further comprising a nozzle, and wherein at least a length of the
8 gas flow passageway extends through the nozzle, and wherein the silencer is radially outside
9 of the nozzle.

10
11 59. The device of claim 52, wherein at least a length of the nozzle radially expands relative to
12 a longitudinal axis of the device.

13
14 60. The device of claim 52, wherein the silencer comprises a foam.

15
16 61. The device of claim 60, wherein the foam comprises porous polyurethane.

17
18 62. The device of claim 52, wherein the silencer comprises a coating on the radially inner
19 surface of the gas flow passageway.

20
21 63. The device of claim 62, wherein the coating comprises polyurethane.

22
23 64. The device of claim 62, wherein the coating comprises a foam.

24
25 65. A device for delivering particles comprising:

26 a cover;

27 a silencer inside of the cover;

28 a pressurized gas container;

29 a gas flow passageway; and

30 particles configured to be delivered by pressurized gas.

31

1 66. The device of claim 65, wherein the silencer is embedded in the cover.

2

3 67. The device of claim 65, wherein the silencer comprises a foam.

4

5 68. The device of claim 67, wherein the foam comprises porous polyurethane.

6

7 69. The device of claim 65, wherein the cover surrounds the silencer.

8

9 70. A device for delivering particles comprising:

10 a case;

11 a pressurized gas container;

12 a gas flow passageway;

13 a particle cassette; and

14 a silencer, wherein the silencer is double-injection molded inside cover

15 coating.

16

17 71. The device of claim 70, wherein the silencer comprises a foam.

18

19 72. The device of claim 71, wherein the foam comprises porous polyurethane.

20

21