CLAIMS

What is claimed is:

1. A spray device, comprising:

a liquid container including a first chamber operable to retain a first liquid and a second chamber operable to retain a second liquid;

a first pump in fluid communication with the first chamber operable to aspirate and retain the first liquid;

a second pump in fluid communication with the second chamber operable to aspirate and retain the second liquid;

a plurality of mixing spaces fluidly coupled to the first pump and the second pump and operable to allow mixing of the first liquid and the second liquid; and

a nozzle fluidly coupled to the plurality of mixing spaces.

2. The spray device of claim 1, wherein the plurality of mixing spaces is substantially empty between each actuation of the pumps.

3. The spray device of claim 1, wherein the plurality of mixing spaces includes:

a first mixing space; and

a second mixing space fluidly coupled between the first mixing space and the nozzle.

4. The spray device of claim 1, further comprising a connecting plate including a first inlet, a second inlet, a central abutment, an inner perimeter wall defining at least a part of a first mixing space, and an outer perimeter wall.

5. The spray device of claim 3, wherein the first mixing space is fluidly coupled to a first outlet from the first pump and a second outlet from the second pump.

6. The spray device of claim 3, wherein the plurality of mixing spaces further includes a nozzle mixing space comprising a vortex tip of the nozzle.

7. The spray device of claim 1, further comprising a connecting plate having a recess at least partially defining the first mixing space and openings fluidly coupling the first pump and the second pump to the first mixing space.

8. The spray device of claim 1, further comprising:
a post including:
a plurality of nozzle grooves; and
a plurality of channel-forming protrusions fluidly coupling a first mixing space to a second mixing space.

9. The spray device of claim 1, further comprising a top housing including:
a nozzle opening; and
defining:
a portion of a second mixing space; and
a portion of a nozzle mixing space.

10. The spray device of claim 1, further comprising a cap operable to be coupled to a top housing.

11. The spray device of claim 1, further comprising:
a pump housing coupled between: the liquid container, and an outlet tube of the first pump and an outlet tube of the second pump;
a first pump fitting configured to retain the first pump;
a second pump fitting configured to retain the second pump;
a base operable to connect to a connecting tongue of the liquid container; and
a collar.

12. The spray device of claim 1, further comprising a gasket coupled between the liquid container and a pump housing.

13. The spray device of claim 1, wherein the liquid container further comprises:
a divider separating the first chamber and the second chamber;
an outer housing;

a bottom forming a bottom of the first chamber and the bottom of the second chamber;

a connecting tongue operable to connect to a base of a pump housing.

14. The spray device of claim 1, wherein:

the first pump comprises:

a first inlet tube in fluid communication with the first chamber, wherein the first inlet tube includes a first inlet, a first piston, a first spring, and a first ball valve; and

a first outlet tube including a first outlet fluidly coupled to the first mixing space; and

the second pump comprises:

a second inlet tube in fluid communication with the second chamber, wherein the second inlet tube includes a second inlet, a second piston, a second spring, and a second ball valve; and

a second outlet tube including a second outlet fluidly coupled to the first mixing space.

15. The spray device of claim 1, wherein:

a tip portion of the top housing is configured to spray at an angle ranging from about 0° to about 90° relative to a flow path out of the second mixing space; or

the nozzle is configured to spray a predetermined pattern of liquid including one or more of a hollow cone, a full cone, a spiral cone, a solid stream, a mist, a fog, a flat fan, or combinations thereof.

16. The spray device of claim 1, wherein a viscosity of the first liquid or the second liquid, or a combination thereof is from about 0.1 centipoise (cP) to about 10,000 cP.

17. The spray device of claim 1, wherein:

a volume of the first chamber is from about 1 ml to about 100 ml; or

a volume of the second chamber is from about 1 ml to about 100 ml.

18. The spray device of claim 1, wherein a ratio of a volume of the first chamber a volume of the second chamber is from about 1:10 to about 10:1.

19. The spray device of claim 1, wherein a volume of the first chamber and a volume of the second chamber is substantially equal.

20. The spray device of claim 1, wherein the spray device is operable to spray a liquid amount of from about 0.01 ml to about 5 ml upon each actuation of the first and second pumps.

21. The spray device of claim 1, wherein:

a ratio of a volume of the first mixing space to a volume of the second mixing space is from about 1:10 to about 10:1; or

a ratio of a volume of the first mixing space to a volume of the third mixing space is from about 1000:1 to about 10:1; or

a ratio of a volume of the second mixing space to a volume of the third mixing space is from about 1000:1 to about 10:1.

22. The spray device of claim 1, wherein:

the first pump is operable to aspirate and retain a liquid amount of from about 0.01 ml to about 5 ml; or

the second pump is operable to aspirate and retain a liquid amount of from about 0.01 ml to about 5 ml.

23. The spray device of claim 1, wherein:

a ratio of a volume of: a capacity of the first pump or the second pump, and a volume of a first mixing space or a second mixing space is from about 100:1 to about 1:1; or

a ratio of a volume of: a capacity of the first pump or the second pump, and a volume of a nozzle mixing space is from about 10000:1 to about 10:1.

24. The spray device of claim 1, wherein an exit velocity from the nozzle is from about 6.5 m/s to about 19.5 m/s.

25. A spray device, comprising:

a liquid container including a first chamber operable to retain a first liquid and a second chamber operable to retain a second liquid;

a first pump partially within the first chamber operable to aspirate and retain the first liquid;

a second pump partially within the second chamber operable to aspirate and retain the second liquid;

a mixing space fluidly coupled to the first pump and the second pump and operable to allow mixing of the first liquid and the second liquid,

wherein the mixing space is substantially empty between each actuation of the pumps; and

a nozzle.

26. The spray device of claim 25, further comprising an additional mixing spaces fluidly coupled to the first pump and the second pump and operable to allow mixing of the first liquid and the second liquid.

27. The spray device of claim 26, further comprising a nozzle mixing space comprising a vortex tip of the nozzle.

28. The spray device of claim 25, wherein the mixing space is fluidly coupled to a first outlet from the first pump and a second outlet from the second pump.

29. A spray device, comprising:

a liquid container including a plurality of chambers operable to retain a plurality of separate liquids;

a first pump partially within a first chamber operable to aspirate and retain a first liquid;

a second pump partially within a second chamber operable to aspirate and retain a second liquid; and

a plurality of mixing spaces fluidly coupled to the first pump and the second pump and operable to allow mixing of the first liquid and the second liquid; and

a nozzle.

30. The spray device of claim 29, wherein the plurality of mixing spaces is substantially empty between each actuation of the pumps.

31. The spray device of claim 29, wherein the plurality of mixing spaces includes:

a first mixing space;

a second mixing space fluidly coupled between the first mixing space and the nozzle; and

a nozzle mixing space fluidly coupled between the second mixing space and a nozzle opening.

32. A method of dispensing a solution, comprising:

providing an active pharmaceutical ingredient (API) precursor in a first chamber of a liquid container and an activator in a second chamber of a liquid container of a spray device;

activating the API precursor by mixing the API precursor and the activator a plurality of times in the spray device; and

dispensing the solution from the spray device.

33. The method of claim 32, further comprising:

mixing the API precursor and the activator upon an act of dispensing the solution from the spray device.

34. The method of claim 32, further comprising:

mixing the API precursor and the activator less than 50 milliseconds before dispensing the solution from the spray device.

35. The method of claim 32, further comprising:

mixing the API precursor and the activator for a first time when the API precursor exits a first pump and the activator exits a second pump.

36. The method of claim 35, further comprising:

mixing the API precursor and the activator for a second time when a combination of the API precursor and the activator exits a first mixing space and enters a second mixing space of the spray device.

37. The method of claim 36, further comprising:

mixing the API precursor and the activator for a third time when the combination of the API precursor and the activator enters a nozzle tip of the spray device.

38. The method of claim 32, further comprising:

mixing a ratio of a volume of the first chamber and a volume of the second chamber from about 1:10 to about 10:1.

39. The method of claim 32, further comprising:

pressurizing the combination of the API precursor and the activator when dispensing the solution from the spray device.

40. The method of claim 32, further comprising:

spraying the solution in an amount of from about 0.01 ml to about 5 ml per dispensing event.

41. The method of claim 32, further comprising:

spraying the solution at an exit velocity from the spray device from about 6.5 m/s to about 19.5 m/s.

42. The method of claim 32, wherein a viscosity of the first liquid, or the second liquid, or a combination thereof is from about 0.1 centipoise (cP) to about 10,000 cP.

43. A method of activating a solution, comprising:

providing an active pharmaceutical ingredient (API) precursor-containing solution in a first chamber of a liquid container and an activator-containing solution in a second chamber of the liquid container of a spray device; and

activating the API precursor by mixing the API precursor-containing solution and the activator-containing solution upon an act of dispensing the mixed solution from the spray device.

44. The method of claim 43, further comprising:

mixing the API precursor-containing solution and the activator-containing solution less than 50 milliseconds before dispensing the mixed solution from the spray device.

45. The method of claim 43, further comprising:

mixing the API precursor-containing solution and the activator-containing solution for a first time when the API precursor-containing solution exits a first pump and the activator-containing solution exits a second pump.

46. The method of claim 45, further comprising:

mixing the API precursor-containing solution and the activator-containing solution for a second time when a combination of the API precursor-containing solution and the activator-containing solution exits a first mixing space and enters a second mixing space of the spray device.

47. The method of claim 46, further comprising:

mixing the API precursor-containing solution and the activator-containing solution for a third time when the combination of the API precursor-containing solution and the activator-containing solution enters a nozzle tip of the spray device.

48. A method of manufacturing a product suitable for administering nitric oxide releasing solution (NORS) after an extended storage period, comprising:

providing a nitric oxide (NO) donor-containing solution in a first chamber of a liquid container of a spray device;

providing an activator-containing solution in a second chamber of the liquid container of the spray device; and

activating the NORS by mixing the NO donor-containing solution and the activator-containing solution upon an act of dispensing the mixed solution from the spray device.

49. The method of claim 48, further comprising:

mixing the NO donor-containing solution and the activator-containing solution a plurality of times in the spray device upon the act of dispensing the mixed solution from the spray device.

50. The method of claim 48, wherein the extended storage period is greater than at least one of: 5 days, 15 days, 30 days, 45 days, 90 days, 120 days, 180 days, one year, two years, or five years.

51. The method of claim 48, wherein an activated NORS potency after the extended storage period relative to the activated NORS potency before the extended storage period is greater than one or more of: 70%, 80%, 90%, 95%, 99%, or 99.9%.

52. The method of claim 51, wherein the NO donor-containing solution and the activator-containing solution is mixed less than a selected period of time before dispensing the mixed solution from the spray device.

53. The method of claim 52, wherein the selected period of time is less than one or more of 15 seconds, 5 seconds, 1 second, 100 milliseconds (ms), 50 ms, or 10 ms.