

Claims

1. An auto injector apparatus comprising:
 - a syringe comprising:
 - a barrel comprising an inner surface and a lubricant on the inner surface;
 - a therapeutic fluid held within the barrel, the therapeutic fluid comprising an anti-calcitonin gene-related peptide (anti-CGRP) antibody; and
 - a stopper disposed within the barrel, the stopper being configured to move axially within the barrel between an initial position and a final position to expel a full dose of the therapeutic fluid from the barrel; and
 - an auto injector that holds the syringe, the auto injector comprising:
 - a rod configured to move the stopper; and
 - an injection spring configured drive the rod to move the stopper from the initial position to the final position, wherein:
 - the injection spring is configured to move the stopper from the initial position to the final position within a period of 5 seconds to 25 seconds,
 - the injection spring, when the stopper is in the initial position, is configured to provide an initial dispensing force of between 20 N and 30 N, and
 - the injection spring, when the stopper is in the final position, is configured to provide a final dispensing force that is at least 50% of the initial dispensing force.
2. The auto injector apparatus of claim 1, wherein the anti-CGRP antibody comprises a heavy chain variable region that is at least 90% identical in amino acid sequence to SEQ ID NO: 1 and a light chain variable region that is at least 90% identical in amino acid sequence to SEQ ID NO: 2.
3. The auto injector apparatus of claim 2, wherein the heavy chain variable region is at least 95% identical in amino acid sequence to SEQ ID NO: 1 and the light chain variable region is at least 95% identical in amino acid sequence to SEQ ID NO: 2.
4. The auto injector apparatus of claim 3, wherein the heavy chain variable region is

100% identical in amino acid sequence to SEQ ID NO: 1 and the light chain variable region is 100% identical in amino acid sequence to SEQ ID NO: 2.

5. The auto injector apparatus of claim 2, wherein the anti-CGRP antibody is formulated at 150 mg/mL nominal concentration in 16 mM histidine; 6.6% sucrose; 0.136 mg/mL disodium ethylenediaminetetraacetic acid dihydrate (EDTA); and 1.2 mg/mL polysorbate-80, having a pH of 5.5.

6. The auto injector apparatus of claim 1, wherein the therapeutic fluid comprises a liquid pharmaceutical composition, the liquid pharmaceutical composition comprising:

about 225 mg of the anti-CGRP antibody, the anti-CGRP antibody comprising a heavy chain variable region that is 100% identical in amino acid sequence to SEQ ID NO: 1 and a light chain variable region that is 100% identical in amino acid sequence to SEQ ID NO: 2;

about 0.204 mg disodium ethylenediaminetetraacetic acid dihydrate (EDTA);

about 0.815 mg L-histidine;

about 3.93 mg L-histidine hydrochloride monohydrate;

about 0.3 mg polysorbate-80;

about 99 mg sucrose; and

water,

wherein liquid pharmaceutical composition for injection has a pH of 5.5.

7. The auto injector apparatus of claim 1, wherein the injection spring, before the auto injector is actuated, has a stored energy of between 0.9 J and 2 J.

8. The auto injector apparatus of claim 1, wherein the injection spring, before the auto injector is actuated, has a spring constant of between 0.2 N/mm and 0.4 N/mm and a compressed length of between 50 mm and 100 mm.

9. The auto injector apparatus of claim 8, wherein the spring constant is between 0.28 N/mm and 0.32 N/mm and the compressed length is between 75 mm and 95 mm.

10. The auto injector apparatus of claim 1, wherein the injection spring is configured to move the stopper, via the rod, from the initial position to the final position within a period of 19 seconds or less.

11. The auto injector apparatus of claim 1, wherein the injection spring is configured to move the stopper, via the rod, from the initial position to the final position in a period of between 5 seconds and 19 seconds.

12. The auto injector apparatus of claim 1, wherein:
the syringe is unaged, and
an actual stored spring energy of the injection spring, when the stopper is at the initial position, is at least 25% greater than a minimum stored spring energy required to move the stopper from the initial position to the final position without stalling the syringe.

13. The auto injector apparatus of claim 1, wherein:
the syringe is unaged,
the barrel comprises an inner surface comprising glass, and
the syringe comprises oil on the inner surface.

14. The auto injector apparatus of claim 13, wherein:
between 0.4 mg and 1.1 mg of the oil is on the inner surface, and
the oil comprises silicone oil having a viscosity of about 1000 cSt at 25° C.

15. The auto injector apparatus of claim 1, wherein the therapeutic fluid has a volume of between 1.51 mL and 1.66 mL and a viscosity of 10 cP or less at 22° C.

16. The auto injector apparatus of claim 1, wherein the syringe has an accelerated age of at least 24 months.

17. The auto injector apparatus of claim 1, wherein the barrel has an inner diameter of about 8.65 mm.

18. The auto injector apparatus of claim 1, wherein:

the syringe further comprises a needle at a distal end of the barrel, and

the needle has an inner diameter of about 0.27 mm and a length of 19.5 mm or less.

19. The auto injector apparatus of claim 1, wherein:

the stopper is coated with a first coating comprising ethylene tetrafluoroethylene and a second coating comprising silicone, and

the first coating coats a first portion of the stopper and the second coating coats a second portion of the stopper that is different from the first portion of the stopper.

20. The auto injector apparatus of claim 1, wherein the stopper has a length of between 7.3 mm and 8.1 mm.

21. The auto injector apparatus of claim 1, wherein:

the stopper is configured to compress to a compressed state and relax to an uncompressed state, and

the stopper comprises:

a main body that is substantially cylindrical and that has a diameter in the uncompressed state of between 8.85 mm and 9.05 mm; and

an annular rib extending radially from the main body, the annular rib having an outer diameter in the uncompressed state of between 9.25 mm and 9.45 mm.

22. The auto injector apparatus of claim 1, wherein a distance between the initial position and the final position is between 25.7 mm and 30 mm.

23. The auto injector apparatus of claim 1, wherein the anti-CGRP antibody is fremanezumab.

24. The auto injector apparatus of claim 1, wherein:

the syringe comprises a needle disposed at a distal end of the barrel,

the anti-CGRP antibody is fremanezumab, and
the initial dispensing force is greater than the final dispensing force.

25. The auto injector apparatus of claim 1, wherein:

the syringe further comprises a needle at a distal end of the barrel, the needle having an inner diameter that is less than an inner diameter of the barrel and that is between 0.25 mm and 0.29 mm, and the needle has a length of 19.5 mm or less,

the anti-CGRP antibody comprises a heavy chain variable region that is at least 90% identical in amino acid sequence to SEQ ID NO: 1 and a light chain variable region that is at least 90% identical in amino acid sequence to SEQ ID NO: 2,

the therapeutic fluid has a volume between 1.51 mL and 1.66 mL,

the therapeutic fluid has a viscosity of 10 cP or less at 22° C,

the injection spring is configured to drive the rod to move the stopper from the initial position to the final position when the syringe is unaged, and

the injection spring is configured to drive the rod to move the stopper from the initial position to the final position when the syringe has been aged artificially to a simulated age of at least 24 months by heating the syringe to a temperature of between 20°C to 60°C for a period of time associated with at least 24 months of natural aging.

26. The auto injector apparatus of claim 1, wherein the injection spring, when the stopper is in the final position, is at least partially within the barrel.

27. The auto injector apparatus of claim 1, wherein a distal end of the injection spring is adjacent to the stopper during movement of the stopper from the initial position to the final position.

28. The auto injector apparatus of claim 1, wherein:

the injection spring is a first spring of the auto injector,

the auto injector comprises a second spring, and

an uncompressed length of the first spring is greater than an uncompressed length of the second spring.

29. The auto injector apparatus of claim 1, wherein:
the injection spring comprises a first end and a second end, and
the injection spring extends between the first end and the second end along a longitudinal axis of the barrel.

30. The auto injector apparatus of claim 1, wherein:
the rod moves axially along a longitudinal axis of the barrel when the rod drives the stopper axially within the barrel, and
the injection spring decompresses along the longitudinal axis of the barrel when the injection spring drives the rod and the stopper axially within the barrel.

31. The auto injector apparatus of claim 1, wherein:
the stopper, when the syringe is unaged, experiences a maximum resistance force of as the stopper moves from the initial position to the final position, and
the final dispensing force is at least 25% greater than the maximum resistance force.