PLUNGERS FOR DRUG DELIVERY DEVICES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The priority benefit of U.S. Provisional Patent Application No. 62/584,335, filed November 10, 2017, is claimed, and the entire contents thereof are expressly incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure generally relates to plungers and, more particularly, to plungers for drug delivery products.

BACKGROUND

[0003] Highly viscous products are being increasingly used in automatic delivery devices, such as autoinjectors and on-body injectors. Automatic delivery devices typically have requirements related to drug delivery time. When using high viscous products, however, the automatic delivery devices require large driving forces to attain required drug delivery times. Additionally, automatic delivery devices can have drive mechanisms that are spaced from plungers within the devices and that deliver up to five times the sustained injection force during initial impact and through drug delivery.

[0004] Some conventional plungers have a cylindrical side surface that slides along and seals with the syringe or reservoir of the delivery device. Large driving forces apply a large axial compressive force on the conventional plunger and this can cause the conventional plunger to deform radially outward during extrusion. Such radial deformation can increase the contact area between the plunger and the syringe or reservoir, resulting in greater friction and unpredictability in the extrusion process.

SUMMARY

[0005] The present disclosure sets forth plungers, drug delivery assemblies, drug delivery devices, and related methods embodying advantageous alternatives to conventional plungers and methods, and that may address one or more of the challenges or needs mentioned herein, as well as provide other benefits and advantages.

[0005a] According to a first aspect of the present invention, there is provided a plunger for use in a drug delivery device, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein;

a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration;

wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal.

[0005b] According to a second aspect of the present invention, there is provided a drug delivery assembly comprising: a plunger including:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and

a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial

dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal;

a chamber with an annular sidewall extending between a first, open end and a second end having a dispensing opening, the plunger received within the chamber so that the ribs thereof seal against an interior surface of the sidewall; and

a drive member configured to drive the plunger through the chamber to the second end thereof.

[0005c] According to a third aspect of the present invention, there is provided an autoinjector device comprising:

a housing;

a syringe assembly at least partially received within the housing and including a syringe barrel with an annular sidewall extending between a first, open end and a second end having a dispensing opening;

an actuating mechanism at least partially received within the housing and including a plunger received within the syringe barrel, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another by recessed side surfaces, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration and sized so that the ribs seal against an interior surface of the sidewall of the syringe barrel, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal;

a drive mechanism; and

a drive member configured to be driven by the drive mechanism to push the plunger through the syringe barrel to the second end thereof to thereby force a medicament within the syringe barrel through the dispensing opening.

[0005d] According to a fourth aspect of the present invention, there is provided an on-body injector device comprising:

a housing having an interior and a bottom wall within an opening extending therethrough, the housing configured to be secured to the tissue of a user;

a reservoir with an annular sidewall extending between a first, open end and a second end having a dispensing opening;

a drive mechanism including a plunger received within the reservoir, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another by recessed side surfaces, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration and being sized so that the ribs seal against an interior surface of the sidewall of the reservoir, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial

dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal; and

a drive member configured to drive the plunger through the reservoir to the second end thereof;

an insertion mechanism including a delivery member configured to shift from a retracted position within the housing to a deployed position extending outside of the housing through the opening thereof;

a fluid pathway assembly configured to fluidly couple the reservoir to the insertion mechanism; and

an actuator configured to cause the drive mechanism to drive the plunger through the reservoir to the second end thereof in response to an actuation thereof to thereby dispense medicament within the reservoir through the insertion mechanism.

[0006] In some embodiments, a plunger for use in a drug delivery device is described herein that includes a body portion having a generally cylindrical sidewall, a leading surface, and a trailing surface. The plunger further includes a plurality of ribs that project radially outwardly from the sidewall of the body portion and are spaced axially apart from one another by recessed side surfaces. The plurality of ribs include at least a trailing rib, a leading rib, and an intermediate rib, where each of the ribs have an annular configuration. The body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, where the first and second configurations have a substantially equal radial dimension and the second configuration has an axial dimension that is less than an axial dimension of the first configuration.

[0007] The plunger can further include one or more of the following: a trim edge of the body portion can be adjacent to the trailing surface thereof, where the trim edge can further have an outer diameter less than outer diameters of the ribs; the leading surface of the plunger can include a roughened portion and/or have a generally cone-shaped configuration; one or both of the trailing rib and the intermediate rib can be axially smaller than the leading rib; at least one of the ribs can have a curved profile; at least one of the ribs can include a cylindrical portion extending between curved, axial end portions thereof; radial surfaces of the sidewall extending between the ribs can have curved configurations; radial surfaces of the body portion extending between the ribs can have flat configurations; or the plunger can further include a plurality of protrusions extending away from the trailing surface of the body portion.

[0008] In several embodiments, a drug delivery assembly is described herein that includes the plunger configured as recited in any combination of the above paragraphs, where the drug delivery assembly includes: a chamber with an annular sidewall extending between a first, open end and a second end having a dispensing opening, the plunger received within the chamber so that the ribs thereof seal against an interior surface of the sidewall; and a drive member configured to drive the plunger through the chamber to the second end thereof.

[0009] The drug delivery assembly can further include one or more of the following: a contact area of the ribs on the sidewall interior remains substantially constant while the plunger is driven through the chamber; a trim edge of the plunger is spaced from

What is Claimed is:

1. A plunger for use in a drug delivery device, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein;

a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration;

wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal.

2. The plunger of claim 1, wherein radial surfaces of the sidewall extending between the ribs have curved configurations.

3. The plunger of claim 2, wherein the radial surfaces of the sidewall extending between the ribs are concavely curved along a longitudinal axis of the body portion.

4. The plunger of claim 1, wherein radial surfaces of the body portion extending between the ribs include flat portions.

5. The plunger of claim 4, wherein the radial surfaces of the body portion extending between the ribs further include frustoconical portions on axial ends of the flat portions.

6. The plunger of claim 1, wherein a trim edge of the body portion is adjacent to the trailing surface thereof.

7. The plunger of claim 6, wherein the trim edge has an outer diameter less than outer diameters of the ribs.

8. The plunger of claim 1, wherein the leading surface includes a roughened portion.

9. The plunger of claim 1, wherein the leading surface as a generally cone-shaped configuration.

10. The plunger of claim 1, wherein at least one of the ribs has a curved axial profile.

11. The plunger of claim 1, wherein at least one of the ribs includes a cylindrical portion extending between curved, axial end portions thereof.

12. The plunger of claim 1, further comprising a plurality of protrusions extending away from the trailing surface of the body portion.

13. The plunger of claim 1, further comprising an intermediate rib disposed between the trailing rib and the leading rib, the intermediate rib having an annular configuration.

14. The plunger of claim 13, wherein the at least one of the trailing rib or the intermediate rib is axially smaller than the leading rib.

15. The plunger of claim 14, wherein both the trailing rib and the intermediate rib are axially smaller than the leading rib.

16. A drug delivery assembly comprising: a plunger including:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and

a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal;

a chamber with an annular sidewall extending between a first, open end and a second end having a dispensing opening, the plunger received within the chamber so that the ribs thereof seal against an interior surface of the sidewall; and

a drive member configured to drive the plunger through the chamber to the second end thereof.

17. The drug delivery assembly of claim 16, wherein a contact area of the ribs on the interior surface of the sidewall remains substantially constant while the plunger is driven through the chamber.

18. The drug delivery assembly of claim 16, wherein a trim edge of the plunger is spaced from the interior surface of the sidewall while the plunger is driven through the chamber.

19. The drug delivery assembly of claim 16, wherein the ribs are axially spaced apart from one another at least double a distance of plunger travel within the chamber during air transport.

20. The drug delivery assembly of claim 16, further comprising an intermediate rib disposed between the trailing rib and the leading rib, the intermediate rib having an annular configuration.

21. The drug delivery assembly of claim 16, wherein radial surfaces of the sidewall extending between the ribs are concavely curved along a longitudinal axis of the body portion.

22. An autoinjector device comprising:

a housing;

a syringe assembly at least partially received within the housing and including a syringe barrel with an annular sidewall extending between a first, open end and a second end having a dispensing opening;

an actuating mechanism at least partially received within the housing and including a plunger received within the syringe barrel, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another by recessed side surfaces, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration and sized so that the ribs seal against an interior surface of the sidewall of the syringe barrel, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal;

a drive mechanism; and

a drive member configured to be driven by the drive mechanism to push the plunger through the syringe barrel to the second end thereof to thereby force a medicament within the syringe barrel through the dispensing opening.

23. The autoinjector device of claim 22, further comprising an intermediate rib disposed between the trailing rib and the leading rib, the intermediate rib having an annular configuration.

24. The autoinjector device of claim 22, wherein radial surfaces of the sidewall extending between the ribs are concavely curved along a longitudinal axis of the body portion.

25. An on-body injector device comprising:

a housing having an interior and a bottom wall within an opening extending therethrough, the housing configured to be secured to the tissue of a user;

a reservoir with an annular sidewall extending between a first, open end and a second end having a dispensing opening;

a drive mechanism including a plunger received within the reservoir, the plunger comprising:

a body portion having a sidewall, a leading surface, and a trailing surface, wherein the body portion does not include a cavity having an opening defined in the trailing surface configured to receive a plunger rod therein, and a ribbed portion comprising a plurality of ribs projecting radially outwardly from the sidewall of the body portion and spaced axially apart from one another by recessed side surfaces, the plurality of ribs comprising at least a trailing rib and a leading rib, each of the ribs including an annular configuration and being sized so that the ribs seal against an interior surface of the sidewall of the reservoir, wherein the body portion is configured to occupy a first configuration in the absence of an axial load, and a second configuration in the presence of an axial load, compression from the axial load causing the body portion in the second configuration to have an axial dimension that is less than an axial dimension of the first configuration, and wherein the ribbed portion has a first radial dimension when the body portion occupies the first configuration and a second radial dimension when the body portion occupies the second configuration, the first and second radial dimensions being substantially equal; and

a drive member configured to drive the plunger through the reservoir to the second end thereof;

an insertion mechanism including a delivery member configured to shift from a retracted position within the housing to a deployed position extending outside of the housing through the opening thereof;

a fluid pathway assembly configured to fluidly couple the reservoir to the insertion mechanism; and

an actuator configured to cause the drive mechanism to drive the plunger through the reservoir to the second end thereof in response to an actuation thereof to thereby dispense medicament within the reservoir through the insertion mechanism.

26. The on-body injector device of claim 25, further comprising an intermediate rib disposed between the trailing rib and the leading rib, the intermediate rib having an annular configuration.

27. The on-body injector device of claim 25, wherein radial surfaces of the sidewall extending between the ribs are concavely curved along a longitudinal axis of the body portion.