SUMMARY

[0004] The present disclosure relates to a medical delivery device having a barrel with a hydrophobic inner surface and a stopper that can provide air and liquid impermeability while also possessing one or more of: a low break loose force, a low average glide force, and a low glide force variation.

[0004a] In a first aspect, the present disclosure provides a medical delivery device comprising: a barrel having an inner surface; and a stopper contacting at least a portion of the inner surface of the barrel; said stopper having a compressibility (C%) between 4.5% to 7.9% measured against said barrel, wherein the compressibility (C%) is calculated with a formula: C% = ((v-y)/v) x 100, where (v) is a maximum outer diameter of the stopper having a sealing surface of the stopper in a non-compressed state and (y) is the inner diameter of the inner surface of the barrel, wherein said inner surface of barrel has a water contact angle greater than 90º, and wherein the stopper includes two or more ribs having a compressibility (C%) between 4.5% to 7.9% and a sealing surface, wherein the stopper is covered with one or more fluoropolymer layers and the stopper has a sliding surface less than about 2 mm where the sliding surface is a sum of the contact widths of all the ribs having a sealing surface.

[0004b] In an example, the present disclosure provides a medical delivery device comprising: a barrel having a first end, a second end, and an inner surface; a stopper contacting at least a portion of the inner surface of the barrel, the stopper having a compressibility between about 4.5% and about 7.9% when measured against the barrel; and an injection member coupled to the barrel, wherein the inner surface of the barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface less than about 2 mm.

[0004c] In an example, the present disclosure provides a medical delivery device comprising: a barrel having an inner surface; and a stopper contacting at least a portion of the inner surface of the barrel; said stopper having a compressibility between about 4.5% to about 7.9% measured against said barrel, wherein said inner surface of barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface from about 2 mm to about 3.2 mm.

[0004d] In an example, the present disclosure provides a medical delivery device comprising: a barrel having a first end, a second end, and an inner surface; a stopper contacting at least a portion of the inner surface of the barrel, the stopper having a compressibility between about 4.5% and about 7.9% when measured against the barrel; and an injection member coupled to the barrel, wherein the inner surface of the barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface from about 2 mm to about 3.2 mm.

[0004e] In an example, the present disclosure provides a medical delivery device comprising: a barrel having an inner surface; and a stopper contacting at least a portion of the inner surface of the barrel; said stopper having a compressibility greater between about 7.9% and about 17% measured against said barrel, wherein said inner surface of barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface greater than about 2 mm.

[0004f] In an example, the present disclosure provides a medical delivery device comprising: a barrel having a first end, a second end, and an inner surface; a stopper contacting at least a portion of the inner surface of the barrel, the stopper having a compressibility greater than about 7.9% when measured against the barrel; and an injection member coupled to the barrel, wherein the inner surface of the barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface greater than about 2.

[0004g] In an example, the present disclosure provides a medical delivery device comprising: a barrel having an inner surface; and a stopper contacting at least a portion of the inner surface of the barrel; said stopper having a compressibility between about 7.9% and about 17% measured against said barrel, wherein said inner surface of barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface less than about 2 mm.

[0004h] In an example, the present disclosure provides a medical delivery device comprising: a barrel having a first end, a second end, and an inner surface; a stopper contacting at least a portion of the inner surface of the barrel, the stopper having a compressibility between about 7.9% and about 17% when measured against the barrel;

and an injection member coupled to the barrel, wherein the inner surface of the barrel has a water contact angle greater than 90º, and wherein the stopper has a sliding surface less than about 2 mm.

[0005] One embodiment relates to a medical delivery device that includes a barrel and a stopper contacting at least a portion of the inner surface of the barrel. The inner surface of the barrel is hydrophobic. The surface energy of the barrel portion that is in contact with the stopper is such that the water contact angle is above 90º. The stopper has a glide force variation less than about 1.3 N when calculated according to the Glide Force Variation test method described herein. In some embodiments, the stopper has an average glide force less than about 4 N. In addition, the stopper further includes a sliding surface that is less than about 2.0 mm measured at a compressibility from about 4.5% to about 7.9%. Additionally, the stopper may have a break loose force of less than about 7.0 N.

[0006] A second embodiment relates to a medical delivery device that includes a barrel and a stopper contacting at least a portion of the inner surface of the barrel. The inner surface of the barrel is hydrophobic. The surface energy of the barrel portion that is in contact with the stopper is such that the water contact angle is above 90º. The stopper has a glide force variation less than about 1.3 N when calculated according to the Glide Force Variation test method described herein. In some embodiments, the stopper has an average glide force less than about 7 N. In addition, the stopper further includes a sliding surface from about 2.0 mm to about 3.2 mm measured at a compressibility from about 4.5% to about 7.9%. Additionally, the stopper may have a break loose force from about 4.0 N to about 10 N.

[0007] A third embodiment relates to a medical delivery device that includes a barrel and a stopper contacting at least a portion of the inner surface of the barrel. The inner surface of the barrel is hydrophobic. The surface energy of the barrel portion that is in contact with the stopper is such that the water contact angle is above 90º. The stopper has a glide force variation less than about 1.3 N when calculated according to the Glide Force Variation test method described herein. In some embodiments, the

WHAT IS CLAIMED IS:

1. A medical delivery device comprising:

a barrel having an inner surface; and

a stopper contacting at least a portion of the inner surface of the barrel; said stopper having a compressibility (C%) between 4.5% to 7.9% measured against said barrel, wherein the compressibility (C%) is calculated with a formula: $C\% = ((v-y)/v) \times 100$, where (v) is a maximum outer diameter of the stopper having a sealing surface of the stopper in a non-compressed state and (y) is the inner diameter of the inner surface of the barrel,

wherein said inner surface of barrel has a water contact angle greater than 90º, and

wherein the stopper includes two or more ribs having a compressibility (C%) between 4.5% to 7.9% and a sealing surface,

wherein the stopper is covered with one or more fluoropolymer layers and the stopper has a sliding surface less than about 2 mm where the sliding surface is a sum of the contact widths of all the ribs having a sealing surface.

2. The medical delivery device of claim 1, wherein said inner surface of the barrel has a water contact angle between 96º and 120º.

3. The medical delivery device of claim 1, wherein said inner surface is free or substantially free of lubricants.

4. The medical delivery device of claim 1, wherein the one or more fluoropolymer layers comprise a composite material having a barrier layer and a porous layer, the barrier layer comprising at least one member selected from densified expanded polytetrafluoroethylene, expanded polytetrafluoroethylene, polytetrafluoroethylene, fluorinated ethylene propylene, polyethylene, polypropylene, polyvinylidene fluoride, polyvinylfluoride, perfluoropropylevinylether, Parylene AF-4, Parylene VT-4, Parylene C, Parylene N, or a perfluoroalkoxy polymer and copolymers and combinations thereof.

5. The medical delivery device of claim 1, wherein said one or more fluoropolymer layers comprise densified expanded polytetrafluoroethylene or expanded polytetrafluoroethylene.

6. The medical delivery device of claim 1, wherein stopper has a break loose force less than 7 N.

7. The medical delivery device of claim 1, wherein the stopper has a glide force variation less than 1.3 N when calculated according to the Glide Force Variation test method.

8. The medical delivery device of claim 1, wherein the stopper has an average glide force less than 4 N.

9. The medical delivery device of claim 1, further comprising:

an injection member coupled to the barrel, and wherein the barrel has a first end and a second end.

10. The medical delivery device of claim 9, wherein the stopper has a glide force variation less than about 1.3 N when calculated according to the Glide Force Variation test method.

11. The medical delivery device of claim 10, wherein the stopper has an average glide force less than about 4 N.

12. The medical delivery device of claim 11, wherein the stopper has a break loose force less than about 7 N.

13. The medical delivery device of claim 10, wherein the inner surface of the barrel has a water contact angle from 96º to 120º.

14. The medical delivery device of claim 10, wherein an elution rate of drug through the medical delivery device is directly proportional to force applied to the stopper.

15. The medical delivery device of claim 10, wherein the barrel is free or substantially free of lubricant.

16. The medical delivery device of claim 10, wherein the injection member provides a variable actuation force to the stopper.

17. The medical delivery device of claim 10 wherein the medical delivery device is an auto-injector or pen.