[0004] Although Type 1A and Type 1B glass compositions are commonly used in pharmaceutical packages, they do suffer from several deficiencies, including a tendency for the interior surfaces of the pharmaceutical package to shed glass particulates or "delaminate" following exposure to pharmaceutical solutions.

[0005] In addition, use of glass in pharmaceutical packaging may also be limited by the mechanical performance of the glass. Specifically, the high processing speeds utilized in the manufacture and filling of glass pharmaceutical packages may result in mechanical damage on the surface of the package, such as abrasions, as the packages come into contact with processing equipment, handling equipment, and/or other packages. This mechanical damage significantly decreases the strength of the glass pharmaceutical package resulting in an increased likelihood that cracks will develop in the glass, potentially compromising the sterility of the pharmaceutical contained in the package.

[0006] Accordingly, a need exists for alternative glass containers for use as pharmaceutical packages which have improved resistance to mechanical damage and which exhibit a reduced propensity to delaminate.

SUMMARY

[0006a] In one aspect, the present disclosure relates to a delamination resistant glass pharmaceutical container comprising:

an aluminosilicate glass having a Class HGA 1 hydrolytic resistance when tested according to ISO 720-1985 testing standard;

a compressive stress layer with a depth of layer of greater than 25 μm; and

a surface compressive stress of greater than or equal to 350 MPa, wherein the delamination resistant glass pharmaceutical container is ion exchange strengthened and the ion exchange strengthening comprises treating the delamination resistant glass pharmaceutical container in a molten salt bath for a time less than or equal to 5 hours at a temperature less than or equal to 450°C.

[0006b] In another aspect, the present disclosure relates to a delamination resistant glass pharmaceutical container:

a glass body having an interior surface and an exterior surface, wherein at least the interior surface of the glass body has a delamination factor of less than or equal to 10; and

a heat-tolerant coating bonded to at least a portion of the exterior surface of the glass body, wherein the exterior surface of the glass body with the heat-tolerant coating has a coefficient of friction of less than about 0.7,

wherein the coefficient of friction is a maximum coefficient of friction measured relative to a second glass container in a vial-on-vial testing jig under a normal load of 30 N, the second glass container having a body formed from a same glass composition and comprising the heat-tolerant coating on an at least a portion of the outer surface of a body of the second glass container and subjected to the same environmental conditions prior to measurement.

[0006c] In another aspect, the present disclosure relates to a delamination resistant glass pharmaceutical container:

a glass body having an interior surface and an exterior surface, wherein at least the interior surface of the glass body has a delamination factor of less than or equal to 10; and

a heat-tolerant coating bonded to at least a portion of the exterior surface of the glass body, wherein:

the heat-tolerant coating is thermally stable at a temperature of at least 260°C for 30 minutes;

the exterior surface of the glass body with the heat-tolerant coating has a coefficient of friction of less than about 0.7; and

the coefficient of friction is a maximum coefficient of friction measured relative to a second glass container in a vial-on-vial testing jig under a normal load of 30 N, the second glass container having a body formed from a same glass composition and comprising the heat-tolerant coating on an at least a portion of the outer surface of a

body of the second glass container and subjected to the same environmental conditions prior to measurement.

[0007] According to one example, a glass container may include a glass body having an interior surface and an exterior surface. At least the interior surface of the glass body may have a delamination factor of less than or equal to 10 and a threshold diffusivity of greater than about 16 μm^2/hr at a temperature less than or equal to 450°C. A heat-tolerant coating may be bonded to at least a portion of the exterior surface of the glass body. The heat-tolerant coating may be thermally stable at a temperature of at least 260°C for 30 minutes.

[0008] In another example, a glass container may include a glass body having an interior surface and an exterior surface. At least the interior surface of the glass body may have a delamination factor of less than or equal to 10 and a threshold diffusivity of greater than about 16 μm^2/hr at a temperature less than or equal to 450°C. A heat-

tolerant coating may be bonded to at least a portion of the exterior surface of the glass body. The exterior surface of the glass body with the heat-tolerant coating may have a coefficient of friction of less than about 0.7.

[0009] In another example, a glass container may include a glass body having an interior surface and an exterior surface. At least the interior surface of the glass body may have a threshold diffusivity of greater than about 16 μm^2/hr at a temperature less than or equal to 450°C. An interior region may extend between the interior surface of the glass body and the exterior surface of the glass body. The interior region may have a persistent layer homogeneity. A heat-tolerant coating may be bonded to at least a portion of the exterior surface of the glass body. The heat-tolerant coating may be thermally stable at a temperature of at least 260°C for 30 minutes.

[0010] In another example, a glass container may include a glass body having an interior surface and an exterior surface. The interior surface may have a persistent surface homogeneity. At least the interior surface of the glass body may have a threshold diffusivity of greater than about 16 μm^2/hr at a temperature less than or equal to 450°C. A heat-tolerant coating may be bonded to at least a portion of the exterior surface of the glass body. The heat-tolerant coating maybe thermally stable at a temperature of at least 260°C for 30 minutes.

[0011] In another example, a glass container may include a glass body having an interior surface and an exterior surface. The glass body may be formed from an alkali aluminosilicate glass composition which has a threshold diffusivity of greater than about 16 μm^2/hr at a temperature less than or equal to 450°C and a type HGA1 hydrolytic resistance according to ISO 720. The glass composition may be substantially free of boron and compounds of boron such that at least the interior surface of the glass body has a delamination factor of less than or equal to 10. A heat-tolerant coating may be bonded to at least a portion of the exterior surface of the glass body. The heat-tolerant coating may be thermally stable at a temperature of at least 260°C for 30 minutes.

[0012] In another example, a glass container may include a glass body having an interior surface and an exterior surface. The glass body may be formed from a glass composition comprising: from about 74 mol.% to about 78 mol.% SiO_2; from about 4 mol.% to about 8 mol.% alkaline earth oxide, wherein the alkaline earth oxide comprises MgO and CaO and a ratio (CaO (mol.%)/(CaO (mol.%)+MgO (mol.%))) is less than or equal to 0.5; X mol.% Al_2O_3, wherein X is greater than or equal to about 4 mol.% and less than or equal to about 8 mol.%; and Y mol.% alkali oxide, wherein the alkali oxide comprises Na_2O in an amount greater than or equal to about 9 mol.% and less than or equal to about 15 mol.%, a ratio of Y:X is greater than 1. The glass body may have a delamination factor less than or equal to 10. A heat-tolerant coating may be positioned on the exterior surface of the glass body and comprise a low-friction layer and a coupling agent layer, the low-friction layer comprising a polymer chemical composition and the coupling agent layer comprising at least one of: a mixture of a first silane chemical composition, a hydrolysate thereof, or an oligomer thereof, and a second silane chemical composition, a hydrolysate thereof, or an oligomer thereof, wherein the first silane chemical composition is an aromatic silane chemical composition and the second silane chemical composition is an aliphatic silane chemical composition; and a chemical composition formed from the oligomerization of at least the first silane chemical composition and the second silane chemical composition.

[0013] In another example, a glass container may include a glass body having an interior surface and an exterior surface. The glass body may be formed from a glass composition comprising from about 74 mol.% to about 78 mol.% SiO_2; alkaline earth oxide comprising both CaO and MgO, wherein the alkaline earth oxide comprises CaO in an amount greater than or equal to about 0.1 mol.% and less than or equal to about 1.0 mol.% and a ratio (CaO (mol.%)/(CaO (mol.%)+MgO (mol.%))) is less than or equal to 0.5; X mol.% Al_2O_3, wherein X is greater than or equal to about 2 mol.% and less than or equal to about 10 mol.%; and Y mol.% alkali oxide, wherein the alkali oxide comprises from about 0.01 mol.% to about 1.0 mol.% K_2O and a ratio of Y:X is greater than 1, wherein the glass body has a delamination factor less than or equal to 10. A heat-tolerant

coating may be positioned on the exterior surface of the glass body and comprise a low-friction layer and a coupling agent layer. The low-friction layer may include a polymer chemical composition and the coupling agent layer may include at least one of a mixture of a first silane chemical composition, a hydrolysate thereof, or an oligomer thereof, and a second silane chemical composition, a hydrolysate thereof, or an oligomer thereof, wherein the first silane chemical composition is an aromatic silane chemical composition and the second silane chemical composition is an aliphatic silane chemical composition; and a chemical composition formed from the oligomerization of at least the first silane chemical composition and the second silane chemical composition.

[0014] Additional features and advantages of the examples of the glass containers described herein will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the examples described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0015] It is to be understood that both the foregoing general description and the following detailed description describe various examples and are intended to provide an overview or framework for understanding the nature and character of the claimed subject matter. The accompanying drawings are included to provide a further understanding of the various examples, and are incorporated into and constitute a part of this specification. The drawings illustrate the various examples described herein, and together with the description serve to explain the principles and operations of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 schematically depicts a cross section of a glass container with a heat-tolerant coating, according to one or more embodiments shown and described herein;

[0017] FIG. 2 schematically depicts a portion of the sidewall of the glass container of FIG. 1;