

CLAIMS

We Claim:

1. A co-extruded multi-layer polymeric barrier film comprising at least three layers:
 - (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of 0.910 to 0.924 g/cm³;
 - (ii) a core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film,
wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and
 - (iii) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³.
2. The co-extruded multi-layer polymeric barrier film according to claim 1, wherein the inner sealant layer and the outer sealant layer comprises an adhesive or tie resin in an amount effective to improve adhesion of the sealant layers to the core barrier layer.
3. A co-extruded multi-layer polymeric film comprising five layers:
 - (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
 - (ii) a first and a second interposed layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the first interposed layer, and an adhesive or tie resin in an amount effective to improve adhesion of the first and the second interposed layer to at least one other layers in the co-extruded multi-layer polymeric film, wherein

the first and the second interposed layer has a total density in the range of from about 0.910 to 0.924 g/cm³;

- (iii) a core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film, wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and
- (iv) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³.

4. The co-extruded multi-layer polymeric film of claim 3 wherein the first interposed layer is sandwiched between the inner sealant layer and the core barrier layer, and the second interposed layer is sandwiched between the outer sealant layer and the core barrier layer.

5. The co-extruded multi-layer polymeric film of claim 3 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer comprises a polymer fraction of linear low density polyethylene and a second copolymer fraction of an ethylene/octene-1 copolymer, an ethylene/hexene-1 copolymer, or an ethylene/butene-1 copolymer.

6. The co-extruded multi-layer polymeric film of claim 5, wherein the interpolymer has a density of 0.915 g/cm³ and a melt index of 0.80-1.0 dg/min.

7. The co-extruded multi-layer polymeric film of claim 3 wherein the ethylene/ α -olefin interpolymer comprises at least one metallocene linear low density polyethylene (mLLDPE) having a density of 0.912 g/cm³.

8. The co-extruded multi-layer polymeric film of Claim 3, wherein the percent weight or thickness of the EVOH layer relative to the entire film is selected from the following numbers: 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6,

2.7, 2.8, 2.9, 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 5.0.

9. The co-extruded multi-layer polymeric film of Claim 3, wherein the mole percent of ethylene in said EVOH copolymer is selected from the following numbers: 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, and 55.

10. The co-extruded multi-layer polymeric film of claim 3 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a melt index in the range of 0.2 to 2.0 dg/min.

11. The co-extruded multi-layer polymeric film of claim 3 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a zero shear viscosity ratio (ZSVR) in the range of 1.15 to 2.5.

12. The co-extruded multi-layer polymeric film of claim 3 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a molecular weight distribution, expressed as the ratio of the weight average molecular weight to number average molecular weight (M_w/M_n) in the range of 2.0 - 4.0.

13. A co-extruded multi-layer polymeric film comprising seven layers:

- (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
- (ii) a first and a second outer interposed layer, and
a first and a second inner interposed layer, wherein all the interposed layers comprise an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the first interposed

layer, wherein all the interposed layers have a total density in the range of from about 0.910 to 0.924 g/cm³, and wherein the first and second inner interposed layers comprise an adhesive or tie resin in an amount effective to improve adhesion of the first and the second inner interposed layer to at least one layer in the co-extruded multi-layer polymeric film;

- (iii) a core barrier layer adjacent to and located between the first and the second inner interposed layers, the core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film, wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and
- (iv) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³.

14. The co-extruded multi-layer polymeric film of claim 13 wherein the first interposed layer is sandwiched between the inner sealant layer and the core barrier layer, and the second interposed layer is sandwiched between the outer sealant layer and the core barrier layer.

15. The co-extruded multi-layer polymeric film of claim 13 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer comprises a polymer fraction of linear low density polyethylene and a second copolymer fraction of an ethylene/octene-1 copolymer, an ethylene/hexene-1 copolymer, or an ethylene/butene-1 copolymer.

16. The co-extruded multi-layer polymeric film of claim 15, wherein the interpolymer has a density of 0.915 g/cm³ and a melt index of 0.80-1.0 dg/min.

17. The co-extruded multi-layer polymeric film of claim 13 wherein the ethylene/ α -olefin interpolymer comprises at least one metallocene linear low density polyethylene (mLLDPE) having a density of 0.912 g/cm³.

18. The co-extruded multi-layer polymeric film of Claim 13, wherein the percent weight or thickness of the EVOH layer relative to the entire film is selected from the following numbers: 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 5.0.
19. The co-extruded multi-layer polymeric film of Claim 13, wherein the mole percent of ethylene in said EVOH copolymer is selected from the following numbers: 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, and 55.
20. The co-extruded multi-layer polymeric film of Claim 13 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a melt index in the range of 0.2 to 2.0 dg/min.
21. The co-extruded multi-layer polymeric film of Claim 13 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a zero shear viscosity ratio (ZSVR) in the range of 1.15 to 2.5.
22. The co-extruded multi-layer polymeric film of Claim 13 wherein the ethylene/ α -olefin interpolymer in at least one of the inner sealant layer, the outer sealant layer, the first interposed layer, or the second interposed layer has a molecular weight distribution, expressed as the ratio of the weight average molecular weight to number average molecular weight (M_w/M_n) in the range of 2.0 - 4.0.
23. The co-extruded multi-layer polymeric film of Claim 3, wherein said at least one outer sealant layer, said at least one inner sealant layer, said core layer, said first at least one interposed layer, and said second at least one interposed layer, individually, comprises from a single layer up to and including 45 layers.

24. The co-extruded multi-layer polymeric film of Claim 13, wherein said at least one outer sealant layer, said at least one inner sealant layer, said core layer, said first at least one interposed layer, and said second at least one interposed layer, individually, comprises from a single layer up to and including 45 layers.
25. The co-extruded multi-layer polymeric film of Claim 3, wherein the total thickness of the film is from about 1 mil to about 5 mils.
26. The co-extruded multi-layer polymeric film of Claim 13, wherein the total thickness of the film is from about 1 mil to about 5 mils.
27. A bag for packaging flowable materials comprising a recyclable barrier co-extruded multi-layer polymeric film and a non-barrier co-extruded multi-layer polymeric film, wherein the barrier co-extruded multi-layer polymeric film comprises
- (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
 - (ii) a first and a second interposed layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the first interposed layer, and an adhesive or tie resin in an amount effective to improve adhesion of the first and the second interposed layer to at least one other layers in the co-extruded multi-layer polymeric film, wherein the first and the second interposed layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
 - (iii) a core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film, or about 5% or less of the combined weight or thickness of the barrier and non-barrier films, wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and

- (iv) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³.

28. A bag for packaging flowable materials comprising a recyclable barrier co-extruded multi-layer polymeric film and a non-barrier co-extruded multi-layer polymeric film, wherein the barrier co-extruded multi-layer polymeric film comprises

- (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
- (ii) a first and a second outer interposed layer, and
a first and a second inner interposed layer, wherein all the interposed layers comprise an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the first interposed layer, wherein all the interposed layers have a total density in the range of from about 0.910 to 0.924 g/cm³, and wherein the first and second inner interposed layers comprise an adhesive or tie resin in an amount effective to improve adhesion of the first and the second inner interposed layer to at least one layer in the co-extruded multi-layer polymeric film;
- (iii) a core barrier layer adjacent to and located between the first and the second inner interposed layers, the core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film, or about 5% or less of the combined weight or thickness of the barrier and non-barrier films, wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and
- (iv) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by

weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³.

29. The bag of Claim 27, wherein the thickness of each of the barrier film and the non-barrier film is from about 1 mil to about 5 mils.
30. The bag of Claim 28, wherein the thickness of each of the barrier film and the non-barrier film is from about 1 mil to about 5 mils.
31. The bag of Claim 27, wherein the thickness of the non-barrier film is greater than the barrier film.
32. The bag of Claim 28, wherein the thickness of the non-barrier film is greater than the barrier film.
33. The bag of Claim 31, wherein the thickness of the non-barrier film is about 3.8 mil and the thickness of the barrier film is about 1.8 mil.
34. The bag of Claim 32, wherein the thickness of the non-barrier film is about 3.8 mil and the thickness of the barrier film is about 1.8 mil.
35. The bag of Claim 27, wherein the EVOH layer in the barrier co-extruded multi-layer polymeric film has a percent weight or thickness relative to the entire film selected from the following numbers: 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 5.0.
36. The bag of Claim 28, wherein the EVOH layer in the barrier co-extruded multi-layer polymeric film has a percent weight or thickness relative to the entire film selected from the following numbers: 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1,

2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 5.0.

37. The bag of Claim 27, wherein the bag is configured to empty from about 95% to about 99.9% of its contents without incorporating any evacuation aid device.

38. The bag of Claim 28, wherein the bag is configured to empty from about 95% to about 99.9% of its contents without incorporating any evacuation aid device.

39. A bag for packaging post mix syrup comprising at least one screw-on fitment, a recyclable barrier co-extruded multi-layer polymeric film, and a non-barrier co-extruded multi-layer polymeric film, wherein the barrier co-extruded multi-layer polymeric film comprises

- (i) an inner sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the total inner sealant layer, wherein the inner sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
- (ii) a first and a second interposed layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by weight or thickness of the first interposed layer, and an adhesive or tie resin in an amount effective to improve adhesion of the first and the second interposed layer to at least one other layers in the co-extruded multi-layer polymeric film, wherein the first and the second interposed layer has a total density in the range of from about 0.910 to 0.924 g/cm³;
- (iii) a core barrier layer comprising ethylene-vinyl alcohol (EVOH) comprising about 0.1% to about 10% by total weight or thickness of the co-extruded multi-layer polymeric film, or about 5% or less of the combined weight or thickness of the barrier and non-barrier films, wherein the EVOH comprises at least 38% ethylene in the EVOH copolymer; and
- (iv) an outer sealant layer comprising an ethylene/ α -olefin copolymer fraction having a density in the range of 0.894 to 0.920 g/cm³ in an amount of at least about 50% by

weight or thickness of the total outer sealant layer, wherein the outer sealant layer has a total density in the range of from about 0.910 to 0.924 g/cm³; and wherein the bag passes a standard 40 inch drop test when filled with post mix syrup.