from alpha-olefins having from 4 to 10 carbon atoms, which has a ratio MFR_{21}/MFR_2 of from 13 to 30 and an MWD of 5 or less.

Such multimodal ethylene terpolymers are disclosed, for example, in WO 2016/083208. As far as definitions (such as for the “modality” of a polymer) and production methods for these ethylene terpolymers are concerned it is referred to WO 2016/083208. Furthermore, all embodiments and preferred embodiments of such ethylene terpolymers as described in WO 2016/083208 which have a density in the range a density of from 910 to 925 kg/m^3 are also preferred embodiments of the multimodal ethylene terpolymer (III) in the present application, whether or not explicitly described herein.

The multimodal ethylene terpolymer (III) preferably has an MFR_2 in the range of from 0.6 to 2.5 g/10min, and particularly preferred from 1.2 to 1.8 g/10min.

Preferably, the multimodal ethylene terpolymer (III) has a density of from 910 to 925 kg/m^3, more preferably of from 913 to 922 kg/m^3, and particularly preferred of from 915 to 920 kg/m^3.

The multimodal ethylene terpolymer (III) preferably has a ratio MFR_{21}/MFR_2 of from 13 to 30, more preferably of from 15 to 25.

The at least two alpha-olefin comonomers having from 4 to 10 carbon atoms of the multimodal ethylene terpolymer (III) are preferably 1-butene and 1-hexene.

Preferably, the total amount of comonomers present in the multimodal ethylene terpolymer (III) is from 0.5 to 10 mol%, preferably from 1.0 to 8 mol%, more preferably from 1.0 to 5 mol%, still more preferably from 1.5 to 5.0 mol% and most preferably from 2.5 to 4.0 mol%.

The multimodal ethylene terpolymer (III), which preferably is a bimodal terpolymer, preferably comprises, or consists of, an ethylene polymer component (A) and an ethylene polymer component (B), wherein the ethylene polymer component (A) has higher MFR_2 than the ethylene polymer component (B).

More preferably, the ethylene polymer component (A) has an MFR_2 of from 1 to 50 g/10min, preferably of from 1 to 40 g/10min, more preferably of from 1 to 30 g/10min, even more preferably of from 2 to 20 g/10min, still more preferably of from 2 to 15 g/10min and most preferably of from 2 to 10 g/10min.

The ratio of the MFR_2 of ethylene polymer component (A) to the MFR_2 of the ethylene polymer component (B) is from 2 to 50, preferably from 5 to

40, more preferably from 10 to 30, still more preferably from 10 to 25 and most preferably from 11 to 25.

Preferably, the ethylene polymer component (A) comprises a different comonomer than the ethylene polymer (B).

Preferably, the ethylene polymer component (A) has lower amount (mol%) of comonomer than ethylene polymer component (B), more preferably, the ratio of [the amount (mol%) of alpha-olefin comonomer having from 4 to 10 carbon atoms comonomer present in ethylene polymer component (A)] to [the amount (mol%) of at least two alpha-olefin comonomers having from 4 to 10 carbon atoms of the final multimodal ethylene terpolymer] is of from 0.10 to 0.60, preferably of from 0.15 to 0.50.

Preferably, the alpha-olefin comonomer having from 4 to 10 carbon atoms of ethylene polymer component (A) is 1-butene and the alpha-olefin comonomer having from 4 to 10 carbon atoms of ethylene polymer component (B) is 1-hexene.

Preferably, the ethylene polymer component (A) has different, preferably higher, density than the density of the ethylene polymer component (B).

The density of the ethylene polymer component (A) is preferably from 925 to 950 kg/m^3, more preferably from 930 to 945 kg/m^3.

Preferably, the multimodal ethylene terpolymer (III) comprises the ethylene polymer component (A) in an amount of from 30 to 70 wt.%, preferably from 40 to 60 wt.%, more preferably from 35 to 50 wt.%, still more preferably from 40 to 50 wt.%; and the ethylene polymer component (B) in an amount of from 70 to 30 wt.%, preferably from 60 to 40 wt.%, more preferably from 50 to 65 wt.%, still more preferably from 50 to 60 wt.%, based on the total amount (100 wt.%) of the multimodal ethylene terpolymer (III).

Most preferably, the multimodal ethylene terpolymer (III) consists of the ethylene polymer components (A) and (B) as the sole polymer components. Accordingly, the split between ethylene polymer component (A) to ethylene polymer component (B) is (30 to 70):(70 to 30), preferably (40 to 60):(60 to 40), more preferably (35 to 50):(65 to 50) and most preferably (40 to 50):(60 to 50).

In a particularly preferred embodiment, the multimodal ethylene terpolymer (III) is a bimodal terpolymer, i.e. comprises a low molecular weight and a high molecular weight component, and has an MFR_2 of from 1.2 to 1.8 g/10min, and/or

the PE3 component, based on the total weight of the composition of the core layer (C).

Preferably, the outer surface layer (O) is made of a composition comprising from 60 to 90 wt.%, preferably from 65 to 85 wt.% and more preferably from 70 to 80 wt.% of the PE3 component, based on the total weight of the composition of the outer surface layer (O).

Preferably, both the core layer (C) and the outer surface layer (O) are made of a composition comprising from 60 to 90 wt.%, preferably from 65 to 85 wt.% and more preferably from 70 to 80 wt.% of the PE3 component, based on the total weight of the composition of the respective layer, wherein the contents of the PE3 component are the same or different.

In one embodiment, at least one of the multiple layers is made of a composition comprising from 80 to 100 wt.%, preferably from 90 to 98 wt.% and more preferably from 92 to 97 wt.% of the PE3 component, based on the total weight of the respective layer composition.

Preferably, the sub-inner surface layer (I1) and/or the sub-outer surface layer (O1) is made of a composition comprising from 80 to 100 wt.%, preferably from 90 to 98 wt.% and more preferably from 92 to 97 wt.% of the PE3 component based on the total weight of the composition of the respective layer, wherein the contents of the PE3 component are the same or different.

PE4 component

In one embodiment, at least one of the multiple layers is made of a composition comprising from 1 to 30 wt.%, preferably from 5 to 20 wt.%, of a low density polyethylene (LDPE) component (PE4), based on the total weight of the respective layer composition.

Low density polyethylenes (LDPE) are well known in the art and are produced in high pressure processes usually performed in a tubular reactor or an autoclave. Such LDPE and their production are, for example, described in WO 2017/055174, page 9, line 29, to page 12, line 6, to which it is referred.

Preferably, the PE4 component has a molecular weight distribution MWD (M_w/M_n) of from 3 to 12, preferably from 5 to 9, determined according the GPC viscosity method described herein.

In one embodiment, the outer surface layer (O) is made of a composition comprising from 1 to 40 wt.%, preferably from 5 to 30 wt.% and more preferably from 5 to 20 wt.% of the PE4 component, based on the total weight of the composition of the outer surface layer (O).

In one embodiment, both the core layer (C) and the outer surface layer (O) are made of a composition comprising from 1 to 40 wt.%, preferably from 5 to 30 wt.% and more preferably from 5 to 20 wt.% of the PE4 component, based on the total weight of the composition of the respective layer.

In one embodiment, the sub-inner surface layer (I1) and/or the sub-outer surface layer (O1) are made of a composition comprising from 1 to 40 wt.%, preferably from 5 to 30 wt.% and more preferably from 5 to 20 wt.% of the PE4 component, based on the total weight of the composition of the respective layer, wherein the contents of the PE4 component are the same or different.

Any of the multiple layers of the polyolefin film may be made of a composition comprising one or more polyethylene components. According to the invention at least one of the multiple layers is made of a composition comprising from 70 to 100 wt.% of a multimodal high density polyethylene (HDPE) polymer component (PE1), based on the total weight of the respective layer composition.

Inner surface layer (I)

The inner surface layer (I) may be made of any polyethylene composition. The expression “polyethylene composition” denotes a composition that comprises or consists of at least one type of ethylene polymer. The polyethylene composition may comprise ethylene homopolymers and ethylene copolymers, containing one or more types of comonomers.

Preferably, the polyethylene composition comprises at least 85 wt.% of at least one type of ethylene polymer (including ethylene homopolymers and/or ethylene copolymers), based on the total weight of the polyethylene composition. More preferably, the polyethylene film comprises from 90 to 100 wt.%, still more preferably from 95 to 100 wt.% and most preferably from 98 to 100 wt.% of at least one type of ethylene polymer, based on the total weight of the polyethylene film.

In a preferred embodiment, the polyethylene composition consists of ethylene homopolymers and/or ethylene copolymers.

The inner surface layer (I) may be made of a composition comprising one or more of the PE1, PE2, PE3 and PE4 components described above.

Preferably, the inner surface layer (I) is made of a composition comprising from 70 to 100 wt.% of a multimodal high density polyethylene (HDPE) polymer component (PE1), based on the total weight of the inner surface layer (I) composition.

More preferred, the inner surface layer (I) is made of a composition comprising from 90 to 100 wt.% of the PE1 component, preferably from 95 to 100 wt.%, more preferably from 98 to 100 wt.% and most preferably from 99 to 100 wt.% of the PE1 component, based on the total weight of the inner surface layer (I) composition.

Outer surface layer (O)

The outer surface layer (O) may be made of any polyethylene composition, as defined above with respect to the inner surface layer (I).

The outer surface layer (O) may be made of a composition of the embodiments as described above with respect to the PE1, PE2, PE3 and PE4 components.

In one embodiment, the outer surface layer (O) is made of a composition comprising from 70 to 100 wt.% of the PE1 component, based on the total weight of the outer surface layer (O) composition.

In one embodiment, the outer surface layer (O) is made of a composition comprising from 90 to 100 wt.% of the PE1 component, preferably from 95 to 100 wt.%, more preferably from 98 to 100 wt.% and most preferably from 99 to 100 wt.% of PE1 component, based on the total weight of the outer surface layer (O) composition.

In one embodiment, the outer surface layer (O) is made of a composition comprising from 60 to 90 wt.%, preferably 65 to 80 wt.%, of the PE3 component. Preferably, the composition further comprises from 10 to 40 wt.%, more preferably 20 to 35 wt.%, of the PE2 component, or from 10 to 40 wt.% , more preferably 20 to 35 wt.%, of the PE1 component, or from 10 to 40 wt.%, more preferably 20 to 35 wt.%, of the PE4 component, based on the total weight of the outer surface layer (O) composition.

In one embodiment, the outer surface layer (O) is made of a composition comprising from 60 to 90 wt.%, preferably from 65 to 80 wt.%, of the PE3

component and from 10 to 40 wt.%, more preferably 20 to 35 wt.%, of a combination of at least two of the components PE2, PE1 and PE4, based on the total weight of the outer surface layer (O) composition.

In one embodiment, the outer surface layer (O) is made of the same composition as the inner surface layer (I).

Core layer (C)

The core layer (C) may be made of any polyethylene composition, as defined above with respect to the inner surface layer (I).

The core layer (C) may be made of a composition of the embodiments as described above with respect to the PE1, PE2, PE3 and PE4 components.

In one embodiment, the core layer (C) is made of a composition comprising from 60 to 100 wt.%, preferably from 65 to 95 wt.%, of the PE3 component. Preferably, the composition comprises from 60 to 99 wt.%, more preferably from 65 to 95 wt.%, of the PE3 component and from 1 to 40 wt.%, more preferably from 5 to 35 wt.%, of the PE2 component, or from 1 to 40 wt.%, more preferably from 5 to 35 wt.%, of the PE1 component, or from 1 to 40 wt.%, more preferably from 5 to 35 wt.%, of the PE4 component, based on the total weight of the composition of the core layer (C).

In one embodiment, the core layer (C) is made of a composition comprising from 60 to 99 wt.%, preferably from 65 to 95 wt.%, of the PE3 component and from 1 to 40 wt.%, more preferably from 5 to 35 wt.% of a combination of at least two of the components PE2, PE1 and PE4, based on the total weight of the composition of the core layer (C).

In one embodiment, the core layer (C) comprises a (weight) ratio of the PE3 component to the PE2 component of from 60:40 to 95:5, preferably from 65:35 to 90:10, more preferably from 70:30 to 85:15, such as 75:25.

In one embodiment, the core layer (C) comprises a (weight) ratio of the PE3 component to the PE1 component or the PE4 component of from 60:40 to 95:5, preferably from 65:35 to 90:10, more preferably from 70:30 to 85:15, such as 75:25.

In one embodiment, the core layer (C) comprises a (weight) ratio of the PE3 component to [the PE1 component and the PE2 component] of from 60:40 to