In film and sheet applications, foaming has faced many difficulties linked to the rough surface that is formed. This is often called an “orange peel” effect. This is a particular problem in packaging solutions where the film needs to be printed as it leads to unclear pictures or text.

A further issue with foamed films and sheets is that smaller thicknesses compared to moulding leads to a serious drop in mechanical properties. Processability is also challenging. Conventional foamed films often do not have sufficiently good appearance and mechanical properties to find their place on the market.

Regarding the foaming itself, the dispersion of the cells and the size of the cells are important to limit the above mentioned drawbacks. A uniform distribution of cells and a low size per cell may reduce orange peel effect and minimise the reduction in the mechanical properties. Control of these parameters will depend on several characteristics including the polymer(s) containing the foaming agent, the foaming agent itself and the processing conditions.

To date, many foamed polyethylene products have failed to provide the minimum requirements for the packaging market.

In order for a foaming process to lead to valuable articles such as films and sheets, the polymer bubbles that are formed during the foaming process need to be stretchable yet limited in size. It will be clear therefore that a polymer with excellent melt strength is required to allow the formation of stretchable bubbles that can adopt an even size distribution.

Summary

The present inventors have now found that the combination of a broad molecular weight distribution multimodal linear low density polyethylene (LLDPE) with a low density polyethylene (LDPE) can provide an ideal composition for foaming.

The multimodal LLDPE/LDPE composition provides melt strength and stretchability so that the composition can be foamed without breaks to form a foamed film or sheet. The composition allows the formation of cells with even

structure and the foamed articles, such as the foamed sheets and films of the invention have sufficient mechanical properties for the foamed packaging market. Moreover, the processability of the polymer composition of the invention is excellent during the foaming process.

Without wishing to be limited by theory, it is believed that blending the broad molecular weight multimodal LLDPE with LDPE has a synergetic effect on the cell structure and the quality of the foaming. Whilst the examples concentrate on the use of chemical foaming agents it is envisaged that the results will extend to other foaming technologies such as physical foaming (with gaseous foaming agents).

The disclosure provides a polymer composition comprising 35 to 89.9 wt% of a multimodal linear low density polyethylene (LLDPE) having an MFR_{21}/MFR_2 of 50 to 200 and/or a Mw/Mn of at least 10, 10 to 50 wt% of a low density polyethylene (LDPE); and 0.1 to 15.0 wt% of foaming agent component, based on the total amount (100wt%) of the polymer composition.

In one aspect, the present disclosure provides a polymer composition comprising 35 to 89.9 wt% of a multimodal linear low density polyethylene (LLDPE) having an MFR_{21}/MFR_2, (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg), of 50 to 200, 10 to 50 wt% of a low density polyethylene (LDPE) and 0.1 to 15.0 wt% of foaming agent component based on the total amount (100wt%) of the polymer composition.

The disclosure also provides a polymer composition comprising:

(I) a first composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10; and 10 to 50 wt% of an LDPE, based on the total amount (100wt%) of the polymer composition; and

(II) 0.1 to 15.0 wt% of a foaming agent component based on the weight of the first composition.

In a preferred example of the disclosure, the polymers of the polymer composition are selected from said multimodal LLDPE and LDPE. I.e. it is preferred that multimodal LLDPE and LDPE are the sole polymeric components present in the polymer composition.

Optionally, and preferably, the polymer composition may comprise additives, typically conventional additives, used in conventional amounts. Additives may form 0 to 10 wt% of the polymer composition, such as 0 to 5 wt%, preferably 0.01 to 5wt%. Some of optional additives may be in form of well-known masterbatches and may be carried on a polymeric carrier. Any polymer carrier is

excluded from the above definition polymeric components, but forms part of the additive package.

The disclosure also provides a foamed article. In particular, the disclosure provides a foamed article comprising, such as consisting of, a polymer composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or a Mw/Mn of at least 10, 10 to 50 wt% of an LDPE and 0 to 10 wt% of optional additives based on the total amount (100wt%) of the polymer composition.

In another aspect, the present disclosure provides a foamed article comprising a composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE based on the total amount (100wt%) of the polymer composition.

The disclosure also provides a foamed layer element comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or a Mw/Mn of at least 10 and 10 to 50 wt% of a low density polyethylene (LDPE). Optional additives may also be present in an amount of 0 to 10 wt%, as defined above.

In another aspect, the present disclosure provides a foamed layer element comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE.

The foamed layer element can be a foamed monolayer film or sheet or one or more foamed layer(s) of a multilayer film or a multilayer sheet.

The disclosure also provides a monolayer foamed film or sheet comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE. Optional additives may also be present in an amount of 0 to 10 wt%, as defined above.

The disclosure also provides multilayer film or sheet wherein at least one layer of said film or sheet is foamed and wherein the foamed layer comprises 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE. Optional additives may also be present in an amount of 0 to 10 wt%, as defined above.

In another aspect, the present disclosure provides a multilayer film or sheet comprising at least 3 layers, two outer layers and a core layer and wherein said core layer is foamed and comprises 35 to 90 wt% of a multimodal linear low density

polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE.

As already mentioned above, any polymer composition, article, element, film or sheet of the invention may comprise conventional polymer additives in addition to the foaming agent component. Optionally, the foaming agent component and some or all of those additives may be carried on a support medium (i.e. a carrier) which can be a polymer as well known in the art. Any optional carrier polymers of such additives are not to be included in the calculation of the wt% amount of the

multimodal LLDPE or LDPE but are regarded as part of the additive package present.

Alternatively viewed the disclosure provides multilayer film or sheet wherein at least one layer of said film or sheet is foamed and wherein the foamed layer consists of a polymer composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE based on the total amount (100wt%) of the polymer composition.

In an alternative example, the disclosure provides a monolayer foamed film or sheet consisting of a composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE based on the total amount (100wt%) of the polymer composition.

The disclosure also provides a process for manufacturing a foamed article comprising:

providing a first composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE based on the total amount (100wt%) of the first polymer composition.;

adding to said first composition 0.1 to 15 wt% of a foaming agent component based on the weight of the first composition to form a second composition;

processing the second composition by passing the second composition through an extruder and a die to form a foamed article.

The disclosure also provides a process for manufacturing a foamed layer element comprising:

providing a first composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE;

adding to said first composition 0.1 to 15 wt% of a foaming agent component based on the weight of the first composition to form a second composition;

processing the second composition by passing the second composition through an extruder and a die to form a foamed layer element.

The disclosure also provides a process for manufacturing a foamed film or sheet comprising:

providing a first composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 and/or an Mw/Mn of at least 10 and 10 to 50 wt% of an LDPE;

adding to said first composition 0.1 to 15 wt% of a foaming agent component based on the weight of the first composition to form a second composition;

processing the second composition by passing the second composition through an extruder and a die to form a foamed sheet or film.

Detailed Description of Invention

The present invention relates to the formation of a foamed article, preferably a foamed film or sheet comprising a foamed blend of multimodal LLDPE and LDPE. Films of the invention are preferably blown films, manufactured using conventional film blowing techniques.

A foamed layer of a foamed article is produced in the presence of a foaming agent in order to introduce gas into the extruded polymer melt and hence cells into the final foamed article. Foamed articles will have a lower density than the corresponding unfoamed article. The reduction in density is ideally at least 50 kg/m^3, such as at least 100 kg/m^3.

Whilst the invention will be primarily described in relation to films, it will be appreciated that the preferred embodiments below also apply to the sheet aspects of the invention or articles in general.

Multimodal LLDPE

The articles or polymer composition of the invention comprise a multimodal LLDPE. The term “multimodal” means, if otherwise not specified, multimodality with respect to molecular weight distribution and includes bimodal polymers.

Usually, a polyethylene comprising at least two polyethylene fractions, which have been produced under different polymerisation conditions resulting in

Claims

1. A polymer composition comprising 35 to 89.9 wt% of a multimodal linear low density polyethylene (LLDPE) having an MFR_{21}/MFR_2, (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg), of 50 to 200, 10 to 50 wt% of a low density polyethylene (LDPE) and 0.1 to 15.0 wt% of foaming agent component based on the total amount (100wt%) of the polymer composition.

2. A polymer composition as claimed in claim 1 wherein the foaming agent component comprises sodium borohydride, ammonium carbonate, sodium bicarbonate, and modified sodium bicarbonate, e.g. sodium bicarbonate modified with a proton donor such as citric acid.

3. A polymer composition as claimed in any preceding claim comprising 50 to 74.9 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200, 25 to 49.9 wt% of an low density polyethylene and 0.1 to 15 wt% of foaming agent component.

4. A foamed article comprising a composition comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE based on the total amount (100wt%) of the polymer composition.

5. A foamed layer element comprising 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE.

6. A foamed layer element as claimed in claim 5 which is a foamed monolayer film or sheet or a foamed layer of a multilayer film or sheet.

7. A foamed layer element as claimed in claim 5 to 6 wherein the final density of the foamed layer element is 600 to 800 kg/m^3.

8. A foamed layer element as claimed in claim 5 to 7 wherein the foamed layer element is foamed by 10 to 30 wt%.

9. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 8 wherein the multimodal LLDPE has a density of 915 to 935 kg/m^3.

10. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 9 wherein the multimodal LLDPE has an MFR_2 of 0.01 to 20 g/10min (measured according to ASTM D1238 at 190ºC and under a load of 2.16 kg).

11. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 10 wherein the multimodal LLDPE has an Mw/Mn of 10 or more such as 10 to 30.

12. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 11 wherein the LDPE has a MFR_2 of 0.1-20 g/10 min (measured according to ASTM D1238 at 190ºC and under a load of 2.16 kg).

13. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 12 wherein the LDPE has a density of 915 to 935 kg/m^3.

14. A foamed layer element or polymer composition as claimed in claim 1 to 3 or 5 to 13 wherein the multimodal LLDPE has an MFR_{21} of 10 to 200 g/10min (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg).

15. A multilayer film or sheet comprising at least 3 layers, two outer layers and a core layer and wherein said core layer is foamed and comprises 35 to 90 wt% of a multimodal linear low density polyethylene having an MFR_{21}/MFR_2 of 50 to 200 (measured according to ASTM D1238 at 190ºC and under a load of 21.6 kg and 2.16 kg) and 10 to 50 wt% of an LDPE.

16. A film or sheet as claimed in claim 6 or 15 having a thickness of 50 to 1000 µm.