PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference LQGS-SSXS-121162452	**FOR FURTHER ACTION** See Form PCT/IPEA/416	
International application No. **PCT/AU2023/050281**	International filing date *(day/month/year)* 6 April 2023	Priority date *(day/month/year)* 6 April 2022

International Patent Classification (IPC) or national classification and IPC

See Supplemental Box

Applicant

QENOS PTY LTD

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of **4** sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] a total of **46** sheets, as follows:
      - [X] sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions).
      - [ ] sheets containing rectifications not taken into account by this Authority because they were not available at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4*bis*, 70.2(e), 70.16 and 91.2).
      - [X] Superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)).

   b. [ ] a separate electronic file containing a sequence listing *(sent to the International Bureau only)*.
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
1 December 2023	19 March 2024
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Dylan Thomas AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61 2 6283 2512

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2023/050281

Box No. I Basis of the report

1. With regard to the **language**, this report has been established on the basis of:

[X] The international application in the language in which it was filed:

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of :

[ ] international search (under Rules 12.3(a) and 23.1 (b)).

[ ] publication of the international application (under Rule 12.4(a)).

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a) and (b)).

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished, or

[X] the description: pages **1-39, 43-46 and 49** , as originally filed/furnished

pages **40-42, 47 and 48** , received by this Authority on **22 February 2024** with the letter of **22 February 2024**

[X] the claims: Nos. , as originally filed/furnished

Nos. , as amended (together with any statement) under Article 19,

Nos. **1-35** , received by this Authority on **22 February 2024** with the letter of **22 February 2024**

[X] the drawings: pages **1/5-5/5** , as originally filed/furnished

pages , received by this Authority on with the letter of

[ ] a sequence listing - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing (specify):

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (*c-bis*)):

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing (specify):

5. [ ] This report has been established:

[ ] taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-*bis*) and 70.2(e)).

[ ] without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.4*bis* and 70.2(e)).

6. With regard to top-up searches (Rules 66.1*ter* and 70.2(f)):

[X] A top-up search was carried out by this Authority on 7 March 2024.

[ ] Additional relevant documents have been discovered during the top-up search.

[ ] No top-up search was carried out by this Authority because it would serve no useful purpose.

7. [ ] Supplementary international search report(s) from Authority(ies) has/have been received and taken into account in establishing this report (Rule 45*bis*.8(b) and (c)).

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY	International Application No. PCT/AU2023/050281

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims **1-35**	**YES**
	Claims **NONE**	**NO**
Inventive step (IS)	Claims **1-35**	**YES**
	Claims **NONE**	**NO**
Industrial applicability (IA)	Claims **1-35**	**YES**
	Claims **NONE**	**NO**

2. CITATIONS AND EXPLANATIONS:

CITATIONS

D1: EP 2520615 A1 (CURWOOD, INC.) 07 November 2012
D2: WO 2020206301 A1 (BEMIS COMPANY, INC.) 08 October 2020
D3: WO 2014088585 A1 (PERFECSEAL, INC.) 12 June 2014
D4: WO 2010104628 A1 (EXXONMOBIL CHEM PATENTS INC) 16 September 2010
D5: WO 2018108542 A1 (ABU DHABI POLYMERS CO LTD BOROUGE) 21 June 2018
D6: WO 0056806 A1 (HERCULES INC) 28 September 2000
D7: WO 2008033410 A1 (INGENIA POLYMERS INC) 20 March 2008
D8: EP 0288227 A2 (EXXON CHEMICAL PATENTS INC) 26 October 1988

NOVELTY (N)

Claims 1-35 are novel and therefore do meet the requirements of PCT Article 33(2).

INVENTIVE STEP (IS)

Document D1 is considered to represent the closest prior art. D1 discloses barrier film compositions comprising polyethylene, nucleating agent and hydrocarbon resin but does not disclose the barrier film compositions are made by a process comprising the use of a high barrier polyolefin masterbatch as recited by the claims. The use of a high barrier polyolefin masterbatch is not obvious to a person skilled in the art from the cited documents, when taken individually or in any combination. I also note that the present claims are distinguished from D4 in that D4 does not disclose a method or process wherein a nucleating agent is used as a mixture or masterbatch to produce a barrier film composition. Claims 1 to 35 therefore involve an inventive step and comply with PCT Article 33(3).

INDUSTRIAL APPLICABILITY (IA)

The invention defined in the claims is considered to meet the requirements of Industrial Applicability under Article 33(4) of the PCT because it can be made by, or used in, industry.

C08J 3/22 (2006.01)
C08J 5/18 (2006.01)
C08K 5/01 (2006.01)
C08K 5/092 (2006.01)
C08K 5/098 (2006.01)

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1 December 2023

International Preliminary Examining Authority
IP Australia (as PCT Receiving Office)
PO Box 200
Woden ACT 2606

Dear Commissioner

International Patent Application No PCT/AU2023/050281
Titled 'Process of preparing masterbatch compositions and their use'
In the Name of Qenos Pty Ltd
Our Ref: LQGS:SSXS:121162452

Demand for International Preliminary Examination and Response to Written Opinion

We refer to the Written Opinion of the International Preliminary Examining Authority dated 24 May 2023 in relation to the above application.

We attach a Demand for International Preliminary Examination, together with the prescribed fee.

Amendment under PCT Article 34(2)

Pursuant to PCT Art 34, the Applicant requests claim pages 50–54 of the application be cancelled and replaced with amended claim pages: 50–55. A marked-up version of the replacement pages identifying the nature and location of the amendments is attached.

The amendments are summarised as follows:

- Original claims 2–4, 15, 16, 18 and 19 have been cancelled without prejudice and the numbering and dependencies of the subsequent claims have been updated accordingly.
- New claims 12, 13, 14 have been added. Support is provided in paragraphs [0039], [0045], [00169] and [00176].
- New claims 15 and 16 are process claims based on original claims 2, 3, 15, 16 and 19. The concentration of hydrocarbon resin has been limited to '0.1% to 7% w/w', support for which is provided by at least paragraphs [0045] and [00219].
- New claim 17 is supported by paragraph [00176].
- New claim 18 is supported by paragraphs [0045] and [00219].
- Original claims 24–26 have been redrafted as claims 23–28 for clarity.
- New claims 29 and 30 have been added, support for which is provided by at least paragraphs [00148], [00149], [00181], [00182], [00154] and [00221].
- New claim 31 is supported by original claim 6.

- New claim 33 is supported e.g., by paragraph [0094], Figure 4 and the Examples.
- New claims 34 and 35 are supported by at least paragraphs [0071] and [00253] of the specification as originally filed)
- The numbering and dependencies of the claims have been updated.

Response to Written Opinion

Novelty

The Examiner contends original claims 1–5, 7, 8, 10–23 and 27 lack novelty in view of EP 2520615 A1 (***D1***) and claims 1–5, 7, 8, 9–23 and 27 lack novelty in view of WO 2020/206301 A1 (***D2***).

The Examiner has acknowledged the novelty of original claims 6 and 24–26.

The Applicant submits that amended claims 1–35 are novel over D1 and D2 for the reasons provided below.

D1: EP 2520615 A1

D1 relates to thermoformable multilayer films suitable for packaging, formed from high density polymer blends comprising HDPE, hydrocarbon resin and a nucleating agent. (See e.g., Abstract; [0001]; Figure 1, Examples).

The Examiner cites Example 4a (Table 12) as allegedly anticipating the process of claim 1. The Applicant respectfully disagrees.

Example 4a discloses a multilayer film comprising three layers, of which only the third layer comprises a HDPE (M6020 HDPE), LDPE, nucleating agent (HPN-20E) and hydrocarbon resin (Regalite T1140). At paragraph [202], D1 discloses that the third layer of the film is produced in a **conventional** manner, namely, by compounding hydrocarbon resin into bulk M6020 HDPE at 15 wt.% to form a compound, blending that compound with a nucleating agent masterbatch (Polybatch® CLR 122), and then extruding the blend to form the third layer of the film.

The Examiner states:

> Although not explicitly stated in D1, I consider the compounding of the hydrocarbon resin into HDPE to be a step of melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon masterbatch as recited in step b) of...claim 1.

We respectfully submit that the Examiner's interpretation of the compounding step disclosed in D1 is incorrect and does not reflect the technical teaching of D1 or the common general knowledge in the field. In particular, the step of melt mixing a hydrocarbon resin in bulk HDPE as described in D1 does not form a hydrocarbon resin **masterbatch** – rather, this step forms the bulk composition that is ultimately extruded to form the film (after blending with the nucleating masterbatch). This is readily apparent, for example, from the concentration of hydrocarbon resin in the compound (15 wt.%) versus the concentration of hydrocarbon resin in the film layer (14.7 wt.%). Conversely, the concentration in a masterbatch (concentrate) by default will be substantially higher than the concentration in the composition ultimately extruded into the film. (See e.g., the definition of masterbatch at paragraph [0072] of the specification).

In contrast to D1, claim 1 defines a process for producing a homogenous high barrier polyolefin (HBP) masterbatch which comprises the following three steps:

> a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;
>
> b) melt mixing a hydrocarbon resin in polyethylene **to form a hydrocarbon resin masterbatch**; and
>
> c) melt mixing the nucleating agent masterbatch of step a) with the **hydrocarbon resin masterbatch of step b**),
>
> to thereby form a homogenous **high barrier polyolefin (HBP) masterbatch**.

As noted by the Examiner, the term 'masterbatch' is defined at paragraph [0072] (the Examiner erroneously referenced paragraph [0067]) of the PCT specification as a 'concentrate or premix composition'. (See also paragraphs [00111]–[00114] and [00140]). Masterbatches are not extruded into a film or into a formed article – rather, they are concentrates that are blended (diluted) with bulk polyolefin to form the bulk polyolefin composition that is subsequently extruded to form a barrier layer or film, (or formed into an article). This is described, e.g., in paragraphs [0070], [00172] and illustrated in Figure 2(c), Figure 3 and Figure 4 of the PCT specification.

D1 does not disclose each (or the combination) of the melt-mixing steps recited in claim 1. Indeed, D1 does not disclose or contemplate the formation of a **hydrocarbon resin masterbatch** or **high barrier polyolefin (HBP) masterbatch**, at all.

Each of the amended claims recites the feature of a hydrocarbon resin masterbatch, high barrier polyolefin (HBP) masterbatch, or both. As D1 does not disclose these features, amended claims 1–35 are novel.

D2: WO 2020/206301 A1

D2 is directed to multilayer films having a composition and structure suitable to provide a moisture barrier, which are more easily thermoformed than traditional HDPE films, and are suitable for recycling. (See e.g., paragraphs [001], [006], [019]).

The Examiner considers the second layer of the film in Example 2 of D2 anticipates the process of the present invention. The Applicant respectfully disagrees.

D2 discloses that the second layer of the film of Example 1 comprises 80.25% HDPE3, 18.75% hydrocarbon resin masterbatch and 1% nucleating agent masterbatch (see Table 1). Accordingly, the second layer of Example 1 contains approximately 7.5% hydrocarbon resin. (See also paragraph [083]).

D2 discloses that the second layer in Example 2 comprises 61.5% HDPE3, 37.5% hydrocarbon masterbatch and 1% nucleating agent masterbatch (see Table 1, page 22). Accordingly, the second layer of Example 2 contains approximately 15 wt.% hydrocarbon resin. (See also paragraph [083]).

The only information about the composition of the second layer provided by D2 is that the hydrocarbon resin and nucleating agent components were derived from a particular hydrocarbon resin masterbatch (HC MB) and a particular nucleating agent masterbatch (NA MB) mixed with HDPE3 (See the legend under Table 2 on page 23). However, no information whatsoever is provided by D2 in relation to the process by which these components were mixed prior to formation of the second layer.

Therefore, contrary to the Examiner's assertion, D2 does not disclose the processes claimed in the present application.

For example, D2 does not disclose that the NA MB and HC MB were melt-mixed with HDPE3 to form an intermediary **high barrier polyolefin masterbatch** as claimed in claim 1. Similarly, D2 does not disclose blending a **high barrier polyolefin masterbatch** with bulk HDPE to form a high barrier polyolefin composition that was subsequently extruded into a barrier layer or film (as claimed in claims 12–14, 20 and 21). In addition, as noted above, D2 discloses a concentration of hydrocarbon resin in the second layer of 7.5 wt% or 15 wt%, whereas amended claims 16 and 17 recite a concentration of hydrocarbon resin of '0.1% to 7% w/w'.

As D2 does not disclose each feature of the amended claims, the amended claims are novel over D2.

Inventive step

The Examiner considers original claims 1–27 lack an inventive step in view of each of D1 and D2 as the features of the claims are either disclosed in the cited references or are obvious in light of the cited references.

The Applicant respectfully disagrees and submits the invention as presently defined by amended claims 1-35 is not obvious in light of D1 or D2.

D1 is focused on the formation of thermoformable multilayer films. D1 utilises a conventional process of compounding hydrocarbon resin MB directly into bulk HDPE to form a compound, blending the compound with a nucleating agent masterbatch, and then extruding the blend to form the third layer of a multilayer film. However, D1 does not teach or suggest a process involving the formation of a **hydrocarbon resin masterbatch**, or a **high barrier polyolefin masterbatch**, or blending a **high barrier polyolefin masterbatch** with bulk polyethylene to form a high barrier polyolefin composition which can be extruded to form a barrier layer or a film incorporating said barrier layer having beneficial barrier properties.

D2 is concerned with improving the recyclability of multilayer films and polymer products. Although D2 refers to a layer within a multilayer film being comprised of a hydrocarbon resin masterbatch, a nucleating masterbatch and polyethylene, D2 provides no information about the manner in which the hydrocarbon resin masterbatch, nucleating masterbatch and polyethylene components of the multilayer film were blended.

D2 also directs the skilled person that higher concentrations of hydrocarbon resin are required to achieve suitable properties. For example, at paragraph [087] D2 teaches that film layers comprising at least 7.5 wt% hydrocarbon resin achieve the beneficial property of a 'melt flow rate of at least 20% or between 20% and 50%', which enhances thermoformability and achieves a primary objective of D2. Similarly, it is apparent from the data in Table 1 that a film layer comprising 15 wt% hydrocarbon resin has superior barrier properties (moisture vapour transmission rate, MVTR) than the equivalent layer having a lower hydrocarbon resin concentration of only 7.5 wt%.

As described and exemplified in the patent specification, the present invention involves the use of masterbatch technology in a unique manner neither taught nor contemplated by the prior art, to achieve beneficial MVTR performance at substantially lower HCR concentrations that that contemplated in the cited art. This is demonstrated in the Examples, including e.g., the formation of homogenous masterbatch compositions which can provide a synergistic interaction between the hydrocarbon resin and nucleating agent, and the achievement of desirable barrier properties, such as low water vapour transmission rates, at low hydrocarbon resin concentrations (e.g., less than 7 wt.%).

Neither D1 nor D2 teaches or suggests the presently claimed invention and there is nothing in either document that would lead the skilled person to the presently claimed invention, or induce the skilled person to modify the teaching in D1 or D2 in such a manner that would lead to the present invention.

For at least the reasons above, it is submitted that the presently claimed invention involves an inventive step and is not obvious in view of D1 or D2.

Closing comments

If this response is not considered to fully address all of the issues raised in the Written Opinion, the Applicant respectfully requests an opportunity to respond to a further Written Opinion before an International Preliminary Report on Patentability (***IPRP***) is established on the application.

Yours faithfully

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Attach

CLAIMS

1. A process for preparing a high barrier polyolefin masterbatch comprising the steps of:

   a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;

   b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and

   c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),

   to produce a homogenous high barrier polyolefin masterbatch.

2. A process for preparing a high barrier polyolefin masterbatch comprising the step of:

   melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,

   wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and

   wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

3. The process of claim 1 or 2, wherein any one or more of the melt mixing steps comprises sufficient residence time to produce a uniform dispersion of the nucleating agent and hydrocarbon resin.

4. The process of any one of claims 1 to 3, wherein any one or more of the melt mixing steps to form:

   the nucleating agent masterbatch;

   the hydrocarbon resin masterbatch; or

   the high barrier polyolefin masterbatch,

   further comprises the step of adding one or more additives.

5. The process of any one of claims 1 to 4, wherein:

   the nucleating agent is present in the high barrier polyolefin masterbatch in an amount of from about 0.2% to about 15% w/w; and

   the hydrocarbon resin is present in the high barrier polyolefin masterbatch in an amount of from about 2.5% to about 80% w/w.

6. The process of any one of claims 1 to 5, wherein the polyethylene is HDPE.

7. The process of any one of claims 1 to 6, wherein the hydrocarbon resin has a weight average molecular weight lower than the polyethylene.

8. The process of any one of claims 1 to 7, wherein the hydrocarbon resin is a cyclic olefin copolymer or hydrocarbon resin derived from crude olefin feed selected from the group consisting of C5 olefin feed streams, C9 olefin feed streams, terpene olefins, norbornene, pure monomers, and a combination thereof.

9. The process of any one of claims 1 to 8, wherein the nucleating agent comprises a metal salt.

10. The process of any one of claims 1 to 9, wherein the nucleating agent comprises a branched alkyl phosphonic acid, a hydrophthalic acid metal salt, a bicycloheptane dicarboxylic acid metal salt, or a combination thereof.

11. A high barrier polyolefin masterbatch produced by the process of any one of claims 1 to 10.

12. A process for producing a high barrier polyolefin composition comprising blending the high barrier polyolefin masterbatch of claim 11 with bulk polyolefin.

13. A high barrier polyolefin composition produced by the process of claim 12.

14. The high barrier polyolefin composition of claim 13 comprising:

nucleating agent in an amount of from about 0.01% to about 1% w/w;

and hydrocarbon resin in an amount of from about 0.1% to about 10% w/w.

15. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the nucleating agent is present in the nucleating agent masterbatch in an amount of from about 0.1% to about 30% w/w; and

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w,

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

16. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent mixture as defined in claim 2 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w, and

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

17. A high barrier polyolefin composition produced by the process of claim 15 or 16.

18. The high barrier polyolefin composition of claim 13, 14 or 17 comprising 0.5% to 7%, 0.5% to 6%, 0.5% to 5% or 0.5% to 4% w/w hydrocarbon resin.

19. The high barrier polyolefin composition of any one of claims 13, 14, 17 or 18, wherein the nucleating agent and hydrocarbon resin are present in a ratio of about 1:4 to about 1:200.

20. A barrier layer formed from the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19.

21. A film comprising the barrier layer of claim 20, wherein the film has a vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

22. A method of reducing the water vapour transmission rate of a film, the method comprising incorporating the barrier layer of claim 20 into the film, whereby the film has a water vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

23. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1;

b) melt mixing bulk polyethylene and no greater than 10% weight of the high barrier polyolefin masterbatch of part (a) to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

24. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin masterbatch,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

25. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

26. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

27. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent mixture comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

28. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent mixture and a hydrocarbon resin masterbatch,

wherein the nucleating agent mixture comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

29. The method of any one of claims 23 to 28, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is a polyethylene.

30. The method of any one of claims 23 to 29, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is the same or different.

31. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein any one or more of the mixing steps, melt mixing steps and/or blending steps is conducted with a twin-screw compounder.

32. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein a synergistic effect between the nucleating agent and hydrocarbon resin is at least 5% greater than the additive effect of the nucleating agent and hydrocarbon resin.

33. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin to form a homogenous polyolefin composition having uniform dispersion of the nucleating agent and hydrocarbon resin,

wherein the blending step achieves sufficient homogeneity to produce a synergistic effect.

34. A blown moulded article comprising the film of claim 21.

35. An injection moulded article comprising the film of claim 21.

CLAIMS

1. A process for preparing a high barrier polyolefin masterbatch comprising the steps of:

   a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;

   b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and

   c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),

   to produce a homogenous high barrier polyolefin masterbatch.

~~4. A process for preparing a high barrier polyolefin masterbatch comprising the step of:~~

~~melt mixing the nucleating agent masterbatch of claim 2 with the hydrocarbon resin masterbatch of claim 3,~~

~~wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.~~

~~5~~2. A process for preparing a high barrier polyolefin masterbatch comprising the step of:

melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,

wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and

wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

~~6. The process of any one of claims 1 to 5, wherein any one or more of the melt mixing steps is conducted with a twin screw compounder.~~

~~7~~3. The process of ~~any one of~~ claims 1 ~~or~~to ~~6~~2, wherein any one or more of the melt mixing steps ~~is melt mixed with~~comprises sufficient residence time to produce a uniform dispersion of the nucleating agent and hydrocarbon resin~~sufficient homogeneity~~.

~~8~~4. The process of any one of claims 1 to ~~7~~3, wherein any one or more of the melt mixing steps to form:

the nucleating agent masterbatch;

the hydrocarbon resin masterbatch; or

the high barrier polyolefin masterbatch,

further comprises the step of adding one or more additives.

9. The process of any one of claims 1 ~~or 4~~ to 8, wherein:

the nucleating agent is present in the high barrier polyolefin masterbatch in an amount of from about 0.2% to about 15% w/w; and

the hydrocarbon resin is present in the high barrier polyolefin masterbatch in an amount of from about 2.5% to about 80% w/w.

10. The process of any one of claims 1 to 9, wherein the polyethylene is HDPE.

11. The process of any one of claims 1 ~~or 3~~ to 10, wherein the hydrocarbon resin has a weight average molecular weight lower than the polyethylene.

12. The process of any one of claims 1 ~~or 3~~ to 11, wherein the hydrocarbon resin is a cyclic olefin copolymer or hydrocarbon resin derived from crude olefin feed selected from the group consisting of C5 olefin feed streams, C9 olefin feed streams, terpene olefins, norbornene, pure monomers, and a combination thereof.

13. The process of any one of claims 1~~, 2 or 4~~ to ~~12~~3, wherein the nucleating agent comprises a metal salt.

14. The process of any one of claims 1~~, 2 or 4~~ to 13, wherein the nucleating agent comprises a branched alkyl phosphonic acid, a hydrophthalic acid metal salt, a bicycloheptane dicarboxylic acid metal salt, or a combination thereof.

17. A high barrier polyolefin masterbatch produced by the process of any one of claims 1 ~~or 4~~ to 13.

~~18. Use of the:~~

~~kit of claim 15 or 16, or~~

~~the high barrier polyolefin masterbatch of claim 17,~~

~~blending the nucleating agent masterbatch and the hydrocarbon resin masterbatch as defined in claim 15 with a bulk polyolefin;~~

~~blending the nucleating agent mixture and the hydrocarbon resin masterbatch as defined in claim 16 with a bulk polyolefin; or~~

~~blending the high barrier polyolefin masterbatch of claim 16 with a bulk polyolefin.~~

~~19. A high barrier polyolefin composition produced by the use of claim 17 or 18, comprising:~~

~~the nucleating agent in an amount of from about 0.01% to about 1% w/w; and~~

~~the hydrocarbon resin in an amount of from about 0.1% to about 10% w/w~~

12 A process for producing a high barrier polyolefin composition comprising blending the high barrier polyolefin masterbatch of claim 11 with bulk polyolefin.

13. A high barrier polyolefin composition produced by the process of claim 12.

14. The high barrier polyolefin composition of claim 13 comprising:

nucleating agent in an amount of from about 0.01% to about 1% w/w;

and hydrocarbon resin in an amount of from about 0.1% to about 10% w/w.

15. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the nucleating agent is present in the nucleating agent masterbatch in an amount of from about 0.1% to about 30% w/w; and

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w,

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

16. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent mixture as defined in claim 2 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w, and

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

17. A high barrier polyolefin composition produced by the process of claim 15 or 16.

18. The high barrier polyolefin composition of claim 13, 14 or 17 comprising 0.5% to 7%, 0.5% to 6%, 0.5% to 5% or 0.5% to 4% w/w hydrocarbon resin.

1920. The high barrier polyolefin composition of any one of claims ~~10~~13, 14, 17 or 18, wherein the nucleating agent and hydrocarbon resin are present in a ratio of about 1:4 to about 1:200.

2021. A barrier layer formed from the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 1919 or 20.

2122. A film comprising the barrier layer of claim 2021, wherein the film has a vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film ~~of equivalent thickness~~ which does not comprise the barrier layer of claim 2021.

2223. A method of reducing the water vapour transmission rate of a film, the method comprising incorporating the barrier layer of claim 201 into the film, whereby the film has a water vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film ~~of equivalent thickness~~ which does not ~~have~~ comprise the barrier layer of claim 201.

~~24. A method of decreasing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising:~~

~~melt mixing a blend comprising polyethylene and no greater than 10% weight of a composition, wherein the composition is formed by melt mixing:~~

~~a nucleating agent masterbatch comprising a nucleating agent homogeneously dispersed in a polyolefin; and~~

~~a hydrocarbon resin masterbatch comprising a hydrocarbon resin homogeneously dispersed in a polyolefin,~~

~~wherein the hydrocarbon resin masterbatch and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 50:1.~~

~~25. A method of decreasing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising the step of:~~

~~melt mixing a blend comprising no less than 90% weight of a polyethylene and no greater than 10% weight of a composition, wherein the composition is formed by mixing:~~

~~a nucleating agent masterbatch comprising a nucleating agent homogeneously dispersed in a polyolefin; and~~

~~a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene,~~

~~wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 50:1.~~

~~26. A method for decreasing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising the step of:~~

~~melt mixing a blend comprising no less than 90% weight of a polyethylene and no greater than 10% weight of a composition, the composition comprising:~~

~~a nucleating agent homogenously dispersed in a polyolefin; and~~

~~a hydrocarbon resin masterbatch comprising a hydrocarbon resin homogenously dispersed in a polyolefin,~~

~~wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1.~~

22. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1;

b) melt mixing bulk polyethylene and no greater than 10% weight of the high barrier polyolefin masterbatch of part (a) to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

24. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin masterbatch,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

25. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

26. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

27. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent mixture comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

28. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent mixture and a hydrocarbon resin masterbatch,

wherein the nucleating agent mixture comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

29. The method of any one of claims 23 to 28, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is a polyethylene.

30. The method of any one of claims 23 to 29, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is the same or different.

31. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein any one or more of the mixing steps, melt mixing steps and/or blending steps is conducted with a twin-screw compounder.

32~~27~~. The process of any one of claims 1~~ or 4~~ to 10, 12, 15 or 16~~14~~, ~~the kit of claim 15 or 16,~~ the high barrier polyolefin masterbatch of claim 11~~17~~, ~~the use of claim 18,~~ the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19~~19 or 20~~, the barrier layer of claim 2~~01~~, the film of claim 2~~12~~, or the method of any one of claims 2~~23~~ to 30~~26~~, wherein a synergistic effect between the nucleating agent and hydrocarbon resin is at least 5% greater than the additive effect of the nucleating agent and hydrocarbon resin.

33. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin to form a homogeneous polyolefin composition having uniform dispersion of the nucleating agent and hydrocarbon resin,

wherein the blending step achieves sufficient homogeneity to produce a synergistic effect.

34. A blown moulded article comprising the film of claim 21.

35. An injection moulded article comprising the film of claim 21.

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22 February 2024

International Preliminary Examining Authority
IP Australia (as PCT Receiving Office)
PO Box 200
Woden ACT 2606

Dear Commissioner

International Patent Application No PCT/AU2023/050281
Titled 'Process of preparing masterbatch compositions and their use'
In the Name of Qenos Pty Ltd
Our Ref: LQGS:IWWM:121162452

Response to Written Opinion

We refer to the Written Opinion of the International Preliminary Examining Authority (***IPEA***) dated 22 December 2023 in relation to the above application.

Amendment under PCT Article 34(2)

Pursuant to PCT Art 34(2), the Applicant requests pages 40 to 42, 47, 48 and 50 to 55 be cancelled and replaced with amended pages 40 to 42, 47, 48 and 50 to 55. A marked-up version of the replacement pages identifying the nature and location of the amendments is attached.

The amendments are summarised as follows:

- Paragraph [00283] has been amended to correct a clerical error.
- Paragraphs [00285], [00286], [00289], [00290], [00299], [00304] and [00307], and the header row of Table 1 and Table 3 of the description have been amended to correct clerical errors. The basis for the corrections can be found in Figure 6 as originally filed.
- Claims 23 and 24 have been amended to correct a clerical error. Support for amendments is provided eg, by original claim 24.
- Amended claim 33 is supported, eg, by paragraphs [0100], [0106] and [0169] of the specification as originally filed.

Response to Written Opinion

The claims under consideration are amended claims 1 to 35 as enclosed with this letter.

The Applicant provides the following comments in response to the Written Opinion.

Novelty

The Examiner contends that claims 11, 13, 14, 19-22, 33 and 35 are not novel in light of EP 2520615 A1 (***D1***), WO 2020206301 A1 (***D2***), WO 2014088585 A1 (***D3***) and WO 2010104628 A1 (***D4***).

Claims 11, 13, 14, 19-21 and 35 are 'product by process' claims. The Examiner contends that, regardless of whether the process of manufacture is new, the resultant products are known and novelty cannot be

acknowledged. Without agreeing with the Examiner's position, as a preliminary point the applicant notes that the law in relation to product by process claims varies between PCT member states.

At this time, the applicant submits that the processes by which the products claimed in 11, 13, 14, 19-21 and 35 are produced are novel and result in products that were not previously known which have properties that were neither achieved nor disclosed in any of cited references D1-D4. As claim 22 recites the novel barrier layer of claim 21, it is submitted that claim 22 is also novel.

In relation to the process of amended claim 33, the applicant submits that the process is novel by virtue of producing a **'homogenous** polyolefin composition having **uniform dispersion** of the nucleating agent and hydrocarbon resin', which is not achieved by the conventional processes taught in D1-D4.

Inventive step

The Examiner contends that claims 1 to 22, 25 to 28 and 33 to 35 do not involve an inventive step in light of D1, D2, D3 and D4. We respectfully disagree for the following reasons.

(a) The present invention

As described and exemplified in the patent specification, the present invention involves the use of masterbatch technology in a unique manner neither taught nor contemplated by the prior art, to achieve improved barrier performance, such as Moisture Vapour Transfer Rate (***MVTR***), at substantially lower hydrocarbon resin concentrations than that contemplated in the cited art.

Independent claim 1 is directed to:

> A process for preparing a high barrier polyolefin masterbatch comprising the steps of:
>
> a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;
>
> b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and
>
> c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),
>
> to produce a homogenous high barrier polyolefin masterbatch.

Similarly, independent claim 2 is directed to:

> A process for preparing a high barrier polyolefin masterbatch comprising the step of:
>
> melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,
>
> wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and
>
> wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

Hence, both claim 1 and claim 2 involve the formation of a high barrier polyolefin masterbatch.

(b) Cited prior art

The Examiner acknowledges that D1 is silent regarding a hydrocarbon resin masterbatch and the use thereof to form a high barrier polyolefin masterbatch, but contends that:

(i) 'this difference cannot contribute towards a patentable invention because masterbatch techniques are well known in the art of plastics';

(ii) 'there does not appear to be any surprising technical effect associated with the formation of a masterbatch over other combination/compounding techniques, this difference is no more than an obvious alternative to the barrier compositions disclosed in D1'.

We respectfully disagree with the Examiner's characterisation of the present invention and his conclusions.

In relation to the Examiner's contention (i), the present invention is not merely the use of masterbatch techniques. In any event, merely because individual steps of a process may be known in the art, **it does not follow that the novel process per se involving a unique arrangement and implementation of steps is obvious**. On the contrary, the inventive concept can reside **in the manner and/or in the order in which the steps are carried out**, which produces a **new technical effect**.

Claims 1 and 2 recite a specific and novel sequence of individual blending steps to create a **homogenous high barrier polyolefin masterbatch** comprising hydrocarbon resin and nucleating agent, which is subsequently blended with bulk polyolefin. In contrast, D1 merely directs the skilled person to use **conventional (standard) compounding techniques** in which hydrocarbon resin is added directly to bulk HDPE. There is **no teaching or suggestion** in D1 directing a person skilled in the art to deviate from conventional compounding techniques by using masterbatch technology, let alone to prepare a homogenous high barrier polyolefin masterbatch according to the process steps recited in claims 1 and 2. Furthermore, there is no suggestion in D1 that blending the components according to the process of claim 1 or 2 would improve the barrier properties of a polyolefin film. As such, the Examiner's view expressed in contention (i) above does not reflect the teaching in D1 and appears to be based on **impermissible hindsight**.

Regarding contention (ii) above, we respectfully submit that the present application does provide **working examples showing a surprising technical effect associated with the formation of a homogenous high barrier polyolefin masterbatch comprising hydrocarbon resin and nucleating agent**. For example:

- Example 1 (see paragraphs [00284] to [00290] and Figure 6 of the present application) shows that by using the process of the present invention while maintaining the same amount of nucleating agent and hydrocarbon resin, an improved Water Vapour Transfer Rate (***WVTR***) is obtained (Figure 6 (h) shows a 58% improvement compared to a film without hydrocarbon resin and nucleating agent, and is also better than the results achieved using 'conventional' processes shown in (d) and (e)). This result is significantly better than the expected additive effect, and is indicative of a surprising synergistic effect.
- Example 2 (see paragraphs [00298] and [00299] and Table 3 of the present application) shows the synergistic effect based on comparing the actual WVTR observed from the combination of the hydrocarbon resin and nucleating agent in the sample of the invention, and the expected additive WVTR calculated from adding WVTR of the hydrocarbon resin and nucleating agent when used separately in the comparison films. This comparison shows that in all the inventive samples the synergistic effect observed delivered more than 5% increase over the expected additive WVTR.

We therefore respectfully submit that the Examiner is incorrect in his contention (ii) and the Examples provided in the specification demonstrate a technical effect attributable to the claimed sequence of blending steps and thus, an inventive step.

In relation to claim 25, the Examiner refers to Example 4a and paragraph [0202] of D1 and contends that D1 discloses that the addition of nucleating agent and hydrocarbon resin improved barrier properties of a polyolefin film. We respectfully submit that the disclosure in D1 does not deprive the present invention of an inventive step for at least the following reasons.

Firstly, the present invention is not the mere addition of nucleating agent and hydrocarbon resin, but rather a **new blending process** by which the nucleating agent and hydrocarbon resin are blended to form a **high barrier masterbatch composition** which is subsequently blended with bulk polyolefin.

The process of the present invention improves the barrier properties of the film beyond that achieved using conventional techniques known in the art.

In contrast to the process of claim 25, Example 4a is made **using conventional (standard) compounding techniques** in which hydrocarbon resin is added directly to bulk HDPE. As such, Example 4a does not teach the skilled person to prepare a **high barrier masterbatch composition** according to claim 25, nor is there any suggestion or motivation provided in D1 to modify the conventional process in a manner that would arrive directly at the process claimed in claim 25, let alone with any expectation of improving barrier properties of a polyolefin film.

Secondly, paragraph [0202] referred to by the Examiner summarises the comparison of Example 4a with two comparative examples, Example 9a (where the third layer consists of only M6020 HDPE) and Example 8a (where the third layer includes the same nucleating agent and LDPE as Example 4a). It is clear from paragraph [0202] that adding nucleating agent, or hydrocarbon resin and nucleating agent to HDPE lowers the MVTR when compared to a layer with unmodified HDPE. However, [0202] is **completely silent** regarding what effect the processing method has on the MVTR of the film. Paragraph [0203] of D1 (not [0202] as indicated in the Written Opinion) and Table 13 provide further examples of three layer films where the third layer blend contains the same constituents as Example 4a, but the amount of hydrocarbon resin is varied. Similar to paragraph [0202], paragraph [0203] is **completely silent** regarding what effect the **processing method** has on the MVTR of the film. Furthermore, there is no teaching or suggestion in these paragraphs or elsewhere in D1 to modify the conventional processes used, let alone to prepare a **high barrier masterbatch composition comprising hydrocarbon resin and nucleating agent** which is ultimately blended with bulk polyolefin.

For similar reasons, none of D2, D3 or D4 direct a person skilled in the art to modify conventional blending processes, let alone in a manner that would lead directly to the processes claimed in the present application with an expectation of improving barrier properties of a polyolefin film.

To summarise,

- Claims 1 and 2 recite a specific and novel sequence of individual blending steps to create a homogenous high barrier polyolefin masterbatch comprising hydrocarbon resin and nucleating agent, which is subsequently blended with bulk polyolefin.
- There is no teaching or suggestion in D1, D2, D3 or D4 to modify the conventional processes used, let alone to prepare a high barrier masterbatch composition comprising hydrocarbon resin and nucleating agent which is ultimately blended with bulk polyolefin. Nor is there any teaching or suggestion that doing so would improve barrier performance.
- Figure 6 of Example 1 of the present application shows a surprising technical effect associated with the claimed processes which involve the formation of a homogenous high barrier polyolefin masterbatch comprising hydrocarbon resin and nucleating agent, which improves barrier performance beyond that achieved using conventional techniques known in the art.

For at least the reasons above, it is submitted that the presently claimed invention involves an inventive step and is not obvious in view of D1, D2, D3 or D4.

Drawings

The Applicant refers to the Examiner's comment in Box VII of the Written Opinion regarding Figures 2 to 4 and directs the Examiner to the letter from the Applicant of 22 May 2023 providing replacement drawings, which were included in the published PCT specification of the present application.

Claim 33

Claim 33 has been amended to address the issue noted in Box VIII of the Written Opinion.

Claims 23 and 24

Claims 23 and 24 have been amended to align the claims with the disclosure of the specification as originally filed thereby addressing the issue raised in Box I, Item 4 of the Written Opinion.

Conclusion

If the response is not considered to fully address all of the issues raised in the Written Opinion, the applicant respectfully requests an opportunity to respond to a further Written Opinion before an International Preliminary Report on Patentability (***IPRP***) is established on the application.

Yours faithfully

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Attach

least 40%, at least 50%, or at least 60%, over a comparative film of equivalent thickness that either does not have a barrier layer, or which has a barrier layer that is not prepared with a HBP composition as described herein (e.g., a barrier layer that does not comprise a nucleating agent and hydrocarbon resin substantially homogeneously dispersed within the barrier composition). Thus, the barrier layer according to the present invention enables a film exhibiting a greater reduction in OTR to be obtained, when compared to the OTR of a comparative film.

[00278] Thus, by blending bulk HDPE with a nucleating agent and hydrocarbon resin, via a polyolefin carrier, to form a HBP composition, through the use of masterbatch compositions in accordance with the embodiments disclosed herein, and forming a barrier layer from the HBP composition, the inventors surprisingly found that a reduction in WVTR may be achieved.

[00279] The effects observed are unexpected due to the relatively small quantities of hydrocarbon resin and nucleating agent employed.

[00280] A further advantage of the present invention is that nucleating agent and hydrocarbon resin (preferably hydrogenated hydrocarbon resin) may be used with many different types of polyolefins, such as polyethylene, preferably HDPE, including those conventionally regarded as less responsive to nucleation. Thus, improved barrier properties can advantageously be imparted to a wider range of polyolefins, including but not limited to polyethylene and HDPE.

[00281] The improved films described herein have value in packaging applications where a low rate of water vapour transmission and/or oxygen transmission rate along with retaining good mechanical properties such puncture and tear resistance, can be desired to help increase the shelf life of packaged material. In turn, the improved barrier properties may enable the thickness of the barrier layer and films containing the barrier layer to be reduced, thereby saving cost, in addition to environmental advantages.

[00282] The invention will now be described with reference to the following examples. However, it is to be understood that the examples are provided by way of illustration of the invention and that they are in no way limiting to the scope of the invention.

EXAMPLE 1: Effect of the process on synergism

Materials:

[00283] The following materials were used in the Examples described below:

HDPE(b) – Qenos Alkatane HDF895 – high density polyethylene homopolymer: 0.8 MI_2, 58 MFR, density of 0.962 g/cm^3

NA – Milliken Hyperform 20E – 66.6% cyclohexanedicarboxylic acid, calcium salt (1:1) and 33.3% zinc stearate ~~[ALLENS NOTE: please confirm]~~

HCR – Hydrogenated cycloaliphatic hydrocarbon resin: softening point 124°C, Mn 400, Mw 700 ~~[ALLENS NOTE: please confirm]~~

Experiments using industry standard operating procedures

[00284] Table 1 shows early experiments from the inventors, both conducted with a twin-screw extruder. These experiments do not use the process of the present invention, but rather use industry standard operating procedures.

[00285] **Compound 1**: When the effect (in terms of ~~increased~~change in WVTR) of films comprising (a) 2% HCR and (b) 0.1% NA are added together, the expected additive change in WVTR is (c) 39%. The WVTR of a film comprising both 2% HCR and 0.1% NA gives a change in WVTR ~~increase~~ of 36%.

[00286] **Compound 2**: When the effect (in terms of ~~increased~~ change in WVTR) of films comprising (a) 2% HCR and (b) 0.1% NA are added together, the expected additive change in WVTR is (c) 34%. The WVTR of a film comprising both 2% HCR and 0.1% NA gives a change in WVTR ~~increase~~ of 38%.

[00287] These results show that when using industry-standard operating procedures, the WVTR improvement is at best comparable to the additive effect, indicating that no synergistic effect is observed.

Table 1: WVTR results using industry standard operating procedures

	WVTR values			
	(a) Comparison film **2% HCR**	**(b) Comparison film** **0.1% NA**	**(c) Expected change in WVTR** **(a) + (b)**	**(d) Actual change in WVTR** **0.1% NA + 2% HCR**
Compound 1	15%	24%	(a) + (b) = 39%	36%
Compound 2	11%	23%	(a) + (b) = 34%	38%

Effect on WVTR using different processes

[00288] Figure 6 shows that the use of different processes for preparing masterbatches affords different results, even when using the same type of extruder.

Comparison films:

(a) No HCR or NA used in the film

(b) 2% HCR only

(c) 0.1% NA only

Films with the same NA and HCR amounts, prepared according to different methods:

(d) 0.1% NA + 2% HCR (SSC) – single-screw extruder compound; single pass

(e) 0.1% NA + 2% HCR (TSC) Pass 1 – twin-screw extruder compound; single pass

(f) 0.1% NA + 2% HCR (TSC) Pass 2 – twin-screw extruder compound; two passes

(g) 0.1% NA + 2% HCR (TSC) Pass 3 – twin-screw extruder compound; three passes
(h) 0.1% NA + 2% HCR (TSC) – twin-screw extruder compound; single pass, using the process of the invention

[00289] The results indicate that the poorest result is obtained in a single-screw extruder (d). A single pass in a twin-screw extruder (e) produces a film which is comparable to an additive effect and increasing passes (f) and (g) give ~~higher~~improved WVTR performance in the resultant film.

[00290] However, by using the process of the invention while maintaining the same amount of NA and HCR (h), a substantially higher change in WVTR is obtained, much higher than the expected additive effect, indicating that a synergistic effect may be obtained.

EXAMPLE 2: Comparison films and films of the invention

Materials:

[00291] The following materials were used in the Examples described below:

HDPE(a) – Qenos Alkatane HD0195FX – high density polyethylene homopolymer: 1.4 MI_2, 45 MFR, density of 0.955 g/cm^3

HDPE(b) – Qenos Alkatane HDF895 – high density polyethylene homopolymer: 0.8 MI_2, 58 MFR, density of 0.962 g/cm^3

HDPE(c) – Qenos Alkatane HDF995X – high density polyethylene homopolymer: 0.9 MI_2, 70 MFR, density of 0.965 g/cm^3

HDPE(d) – Qenos Alkatane GF7660 – high density polyethylene copolymer: 0.3 MI_2, 120 MFR, density of 0.959 g/cm^3

HDPE(e) – Qenos Alkatane HD1090 – high density polyethylene copolymer: 10 MI_2, density of 0.956 g/cm^3

NA – Milliken Hyperform 20E – 66.6% cyclohexanedicarboxylic acid, calcium salt (1:1) and 33.3% zinc stearate

HCR – Hydrogenated cycloaliphatic hydrocarbon resin: softening point 124°C, Mn 400, Mw 700

Table 2: Barrier layer compositions and film properties

Sample	**Barrier layer components**	**Film thickness (µm)**	**WVTR Normalised to 40 µm (g/m^2/day)**	**ΔWVTR (%)**	**OTR Normalised to 40 µm (cc/m^2/day)**	**ΔOTR (%)**	**MD Tear Strength (mN)**
C1:	comparison film containing HDPE(b) only	45.5	3.39	-			289.5

Column (c) shows the difference between the (a) and (b), indicating the value of the synergistic effect.

Table 3: Synergist effect

Sample	(a) Actual change in WVTR (g/m²/day%)	(b) Expected additive change in WVTR (g/m²/day%)	(c) Difference between (a) and (b) (g/m²/day%)
S1	50.4	C2 + C4 = 9.7	40.7
S2	56.9	C3 + C4 = 35.6	21.3
S5	50.0	C8 + C10 = 28.2	21.8
S6	53.1	C9 + C10 = 28.2	24.9
S7	45.8	C12 + C13 = 36.7	9.1

[00299] The above examples show that in all the inventive examples the synergistic effect observed delivered more than 5% increase over the expected additive change in WVTR.

General method for film formation:

[00300] Films were produced from the HDPE blends and comparative HDPE blends using a blown film extrusion process on a blown film line. A film containing bulk HDPE resin only (i.e., with no nucleating agent or hydrocarbon resin) was also prepared for comparison.

[00301] Using the blown film process, the HDPE was melted then extruded through an annular die vertically upwards to give a tube of controlled diameter and thickness. The extruded melt was air cooled in the vicinity of the die via a cooling ring and the tube of film inflated to a bubble of the required diameter by air introduced through the centre of the die mandrel. The film was hauled through a pair of nip rollers to contain a constant volume of inflation air within the bubble formed between the nip rollers and the die. The bubble was then collapsed in a collapsing frame and flattened through nip rollers to form a layflat film that can be wound up either as tubular film or slit into sheet film.

[00302] Films were formed by blown film extrusion using the following process parameters:

- Film gauge: 40-50 µm
- Blow up ratio (BUR): 2.5
- Frost line height: 300 mm (low) or 800 mm (high)
- Lay flat width: 40-45 cm
- Zone temperatures: 190°C max 20
- Screw revolution: 300 rpm

WVTR Testing:

[00303] The formed films were assessed for WVTR at a temperature of about 38°C and at about 90% external relative humidity, in accordance with test method ASTM E398-20, using the Permatran-W Model 1/50 G by Mocon.

[00304] Improvement in WVTR (i.e., reduction in water vapour transmission) was determined assessing the difference in WVTR obtained for a film prepared with bulk HDPE resin only and a film formed with a HDPE blend. The improvement may be expressed as a change ~~or~~ in WVTR (ΔWVTR) using the following equation:

$$\Delta \text{WVTR} = \frac{\text{WVTR (HDPE only)} - \text{WVTR (sample)}}{\text{WVTR (HDPE only)}}$$

[00305] It can be seen from the above results that films formed from HBP compositions containing (i) 0.1% NA + 1 – 3% HCR, using Method 2 (i.e., samples S1 and S2); and (ii) 0.05 – 0.1% NA + 1 – 2% HCR, using Method 3 (i.e., S3 and S4) provided significantly improved barrier results balanced with good film mechanical properties over the comparison films.

OTR Testing:

[00306] The formed films were assessed for OTR at a temperature of about 23°C and at about 0% external relative humidity, in accordance with test method ASTM D3985-05, using the Ox-Tran 2/22 by Mocon.

[00307] Improvement in OTR (i.e., reduction in oxygen transmission) was determined assessing the difference in OTR obtained for a film prepared with bulk HDPE resin only and a film formed with a HDPE blend. The improvement may be expressed as a change ~~or~~ in OTR (ΔOTR) using the following equation:

$$\Delta \text{OTR} = \frac{\text{OTR (HDPE only)} - \text{OTR (sample)}}{\text{OTR (HDPE only)}}$$

[00308] The examples provided herein show that one or more embodiments of barrier layers and films prepared by the process of the invention may provide useful alternatives to barrier layers and films known in the art, or, particularly in preferred embodiments, one or more advantages, such as, for example one or more of the following:

improved balance of mechanical properties, such as stiffness, or puncture and tear resistance;

lowered cost of production, for example, due to relatively low levels of hydrocarbon resin used;

CLAIMS

1. A process for preparing a high barrier polyolefin masterbatch comprising the steps of:

   a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;

   b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and

   c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),

   to produce a homogenous high barrier polyolefin masterbatch.

2. A process for preparing a high barrier polyolefin masterbatch comprising the step of:

   melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,

   wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and

   wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

3. The process of claim 1 or 2, wherein any one or more of the melt mixing steps comprises sufficient residence time to produce a uniform dispersion of the nucleating agent and hydrocarbon resin.

4. The process of any one of claims 1 to 3, wherein any one or more of the melt mixing steps to form:

   the nucleating agent masterbatch;

   the hydrocarbon resin masterbatch; or

   the high barrier polyolefin masterbatch,

   further comprises the step of adding one or more additives.

5. The process of any one of claims 1 to 4, wherein:

   the nucleating agent is present in the high barrier polyolefin masterbatch in an amount of from about 0.2% to about 15% w/w; and

   the hydrocarbon resin is present in the high barrier polyolefin masterbatch in an amount of from about 2.5% to about 80% w/w.

6. The process of any one of claims 1 to 5, wherein the polyethylene is HDPE.

7. The process of any one of claims 1 to 6, wherein the hydrocarbon resin has a weight average molecular weight lower than the polyethylene.

8. The process of any one of claims 1 to 7, wherein the hydrocarbon resin is a cyclic olefin copolymer or hydrocarbon resin derived from crude olefin feed selected from the group consisting of C5 olefin feed streams, C9 olefin feed streams, terpene olefins, norbornene, pure monomers, and a combination thereof.

9. The process of any one of claims 1 to 8, wherein the nucleating agent comprises a metal salt.

10. The process of any one of claims 1 to 9, wherein the nucleating agent comprises a branched alkyl phosphonic acid, a hydrophthalic acid metal salt, a bicycloheptane dicarboxylic acid metal salt, or a combination thereof.

11. A high barrier polyolefin masterbatch produced by the process of any one of claims 1 to 10.

12. A process for producing a high barrier polyolefin composition comprising blending the high barrier polyolefin masterbatch of claim 11 with bulk polyolefin.

13. A high barrier polyolefin composition produced by the process of claim 12.

14. The high barrier polyolefin composition of claim 13 comprising:

nucleating agent in an amount of from about 0.01% to about 1% w/w;

and hydrocarbon resin in an amount of from about 0.1% to about 10% w/w.

15. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the nucleating agent is present in the nucleating agent masterbatch in an amount of from about 0.1% to about 30% w/w; and

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w,

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

16. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent mixture as defined in claim 2 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w, and

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

17. A high barrier polyolefin composition produced by the process of claim 15 or 16.

18. The high barrier polyolefin composition of claim 13, 14 or 17 comprising 0.5% to 7%, 0.5% to 6%, 0.5% to 5% or 0.5% to 4% w/w hydrocarbon resin.

19. The high barrier polyolefin composition of any one of claims 13, 14, 17 or 18, wherein the nucleating agent and hydrocarbon resin are present in a ratio of about 1:4 to about 1:200.

20. A barrier layer formed from the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19.

21. A film comprising the barrier layer of claim 20, wherein the film has a vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

22. A method of reducing the water vapour transmission rate of a film, the method comprising incorporating the barrier layer of claim 20 into the film, whereby the film has a water vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

23. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the ~~nucleating agent~~ hydrocarbon resin masterbatch and the nucleating agent ~~hydrocarbon resin~~ masterbatch are in a ratio of about 1:5 to about 50:1;

b) melt mixing bulk polyethylene and no greater than 10% weight of the high barrier polyolefin masterbatch of part (a) to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

24. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin masterbatch,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the ~~nucleating agent~~ hydrocarbon resin masterbatch and the nucleating agent ~~hydrocarbon resin~~ masterbatch are in a ratio of about 1:5 to about 50:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

25. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

26. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

27. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent mixture comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

28. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent mixture and a hydrocarbon resin masterbatch,

wherein the nucleating agent mixture comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

29. The method of any one of claims 23 to 28, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is a polyethylene.

30. The method of any one of claims 23 to 29, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is the same or different.

31. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein any one or more of the mixing steps, melt mixing steps and/or blending steps is conducted with a twin-screw compounder.

32. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein a synergistic effect between the nucleating agent and hydrocarbon resin is at least 5% greater than the additive effect of the nucleating agent and hydrocarbon resin.

33. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin to form a homogenous polyolefin composition having uniform dispersion of the nucleating agent and hydrocarbon resin~~,~~

~~wherein the blending step achieves sufficient homogeneity to produce a synergistic effect~~.

34. A blown moulded article comprising the film of claim 21.

35. An injection moulded article comprising the film of claim 21.

least 40%, at least 50%, or at least 60%, over a comparative film of equivalent thickness that either does not have a barrier layer, or which has a barrier layer that is not prepared with a HBP composition as described herein (e.g., a barrier layer that does not comprise a nucleating agent and hydrocarbon resin substantially homogeneously dispersed within the barrier composition). Thus, the barrier layer according to the present invention enables a film exhibiting a greater reduction in OTR to be obtained, when compared to the OTR of a comparative film.

[00278] Thus, by blending bulk HDPE with a nucleating agent and hydrocarbon resin, via a polyolefin carrier, to form a HBP composition, through the use of masterbatch compositions in accordance with the embodiments disclosed herein, and forming a barrier layer from the HBP composition, the inventors surprisingly found that a reduction in WVTR may be achieved.

[00279] The effects observed are unexpected due to the relatively small quantities of hydrocarbon resin and nucleating agent employed.

[00280] A further advantage of the present invention is that nucleating agent and hydrocarbon resin (preferably hydrogenated hydrocarbon resin) may be used with many different types of polyolefins, such as polyethylene, preferably HDPE, including those conventionally regarded as less responsive to nucleation. Thus, improved barrier properties can advantageously be imparted to a wider range of polyolefins, including but not limited to polyethylene and HDPE.

[00281] The improved films described herein have value in packaging applications where a low rate of water vapour transmission and/or oxygen transmission rate along with retaining good mechanical properties such puncture and tear resistance, can be desired to help increase the shelf life of packaged material. In turn, the improved barrier properties may enable the thickness of the barrier layer and films containing the barrier layer to be reduced, thereby saving cost, in addition to environmental advantages.

[00282] The invention will now be described with reference to the following examples. However, it is to be understood that the examples are provided by way of illustration of the invention and that they are in no way limiting to the scope of the invention.

EXAMPLE 1: Effect of the process on synergism

Materials:

[00283] The following materials were used in the Examples described below:

HDPE(b) – Qenos Alkatane HDF895 – high density polyethylene homopolymer: 0.8 MI_2, 58 MFR, density of 0.962 g/cm^3

NA – Milliken Hyperform 20E – 66.6% cyclohexanedicarboxylic acid, calcium salt (1:1) and 33.3% zinc stearate

HCR – Hydrogenated cycloaliphatic hydrocarbon resin: softening point 124°C, Mn 400, Mw 700

Experiments using industry standard operating procedures

[00284] Table 1 shows early experiments from the inventors, both conducted with a twin-screw extruder. These experiments do not use the process of the present invention, but rather use industry standard operating procedures.

[00285] **Compound 1**: When the effect (in terms of change in WVTR) of films comprising (a) 2% HCR and (b) 0.1% NA are added together, the expected additive change in WVTR is (c) 39%. The WVTR of a film comprising both 2% HCR and 0.1% NA gives a change in WVTR of 36%.

[00286] **Compound 2**: When the effect (in terms of change in WVTR) of films comprising (a) 2% HCR and (b) 0.1% NA are added together, the expected additive change in WVTR is (c) 34%. The WVTR of a film comprising both 2% HCR and 0.1% NA gives a change in WVTR of 38%.

[00287] These results show that when using industry-standard operating procedures, the WVTR improvement is at best comparable to the additive effect, indicating that no synergistic effect is observed.

Table 1: WVTR results using industry standard operating procedures

	WVTR values			
	(a) Comparison film **2% HCR**	**(b) Comparison film** **0.1% NA**	**(c) Expected change in WVTR** **(a) + (b)**	**(d) Actual change in WVTR** **0.1% NA + 2% HCR**
Compound 1	15%	24%	(a) + (b) = 39%	36%
Compound 2	11%	23%	(a) + (b) = 34%	38%

Effect on WVTR using different processes

[00288] Figure 6 shows that the use of different processes for preparing masterbatches affords different results, even when using the same type of extruder.

Comparison films:

(a) No HCR or NA used in the film

(b) 2% HCR only

(c) 0.1% NA only

Films with the same NA and HCR amounts, prepared according to different methods:

(d) 0.1% NA + 2% HCR (SSC) – single-screw extruder compound; single pass

(e) 0.1% NA + 2% HCR (TSC) Pass 1 – twin-screw extruder compound; single pass

(f) 0.1% NA + 2% HCR (TSC) Pass 2 – twin-screw extruder compound; two passes

(g) 0.1% NA + 2% HCR (TSC) Pass 3 – twin-screw extruder compound; three passes
(h) 0.1% NA + 2% HCR (TSC) – twin-screw extruder compound; single pass, using the process of the invention

[00289] The results indicate that the poorest result is obtained in a single-screw extruder (d). A single pass in a twin-screw extruder (e) produces a film which is comparable to an additive effect and increasing passes (f) and (g) give improved WVTR performance in the resultant film.

[00290] However, by using the process of the invention while maintaining the same amount of NA and HCR (h), a substantially higher change in WVTR is obtained, much higher than the expected additive effect, indicating that a synergistic effect may be obtained.

EXAMPLE 2: Comparison films and films of the invention

Materials:

[00291] The following materials were used in the Examples described below:

HDPE(a) – Qenos Alkatane HD0195FX – high density polyethylene homopolymer: 1.4 MI_2, 45 MFR, density of 0.955 g/cm^3

HDPE(b) – Qenos Alkatane HDF895 – high density polyethylene homopolymer: 0.8 MI_2, 58 MFR, density of 0.962 g/cm^3

HDPE(c) – Qenos Alkatane HDF995X – high density polyethylene homopolymer: 0.9 MI_2, 70 MFR, density of 0.965 g/cm^3

HDPE(d) – Qenos Alkatane GF7660 – high density polyethylene copolymer: 0.3 MI_2, 120 MFR, density of 0.959 g/cm^3

HDPE(e) – Qenos Alkatane HD1090 – high density polyethylene copolymer: 10 MI_2, density of 0.956 g/cm^3

NA – Milliken Hyperform 20E – 66.6% cyclohexanedicarboxylic acid, calcium salt (1:1) and 33.3% zinc stearate

HCR – Hydrogenated cycloaliphatic hydrocarbon resin: softening point 124°C, Mn 400, Mw 700

Table 2: Barrier layer compositions and film properties

Sample	**Barrier layer components**	**Film thickness (µm)**	**WVTR Normalised to 40 µm (g/m^2/day)**	**ΔWVTR (%)**	**OTR Normalised to 40 µm (cc/m^2/day)**	**ΔOTR (%)**	**MD Tear Strength (mN)**
C1:	comparison film containing HDPE(b) only	45.5	3.39	-			289.5

Column (c) shows the difference between the (a) and (b), indicating the value of the synergistic effect.

Table 3: Synergist effect

Sample	(a) Actual change in WVTR (%)	(b) Expected additive change in WVTR (%)	(c) Difference between (a) and (b) (%)
S1	50.4	C2 + C4 = 9.7	40.7
S2	56.9	C3 + C4 = 35.6	21.3
S5	50.0	C8 + C10 = 28.2	21.8
S6	53.1	C9 + C10 = 28.2	24.9
S7	45.8	C12 + C13 = 36.7	9.1

[00299] The above examples show that in all the inventive examples the synergistic effect observed delivered more than 5% increase over the expected additive change in WVTR.

General method for film formation:

[00300] Films were produced from the HDPE blends and comparative HDPE blends using a blown film extrusion process on a blown film line. A film containing bulk HDPE resin only (i.e., with no nucleating agent or hydrocarbon resin) was also prepared for comparison.

[00301] Using the blown film process, the HDPE was melted then extruded through an annular die vertically upwards to give a tube of controlled diameter and thickness. The extruded melt was air cooled in the vicinity of the die via a cooling ring and the tube of film inflated to a bubble of the required diameter by air introduced through the centre of the die mandrel. The film was hauled through a pair of nip rollers to contain a constant volume of inflation air within the bubble formed between the nip rollers and the die. The bubble was then collapsed in a collapsing frame and flattened through nip rollers to form a layflat film that can be wound up either as tubular film or slit into sheet film.

[00302] Films were formed by blown film extrusion using the following process parameters:

- Film gauge: 40-50 μm
- Blow up ratio (BUR): 2.5
- Frost line height: 300 mm (low) or 800 mm (high)
- Lay flat width: 40-45 cm
- Zone temperatures: 190°C max 20
- Screw revolution: 300 rpm

WVTR Testing:

[00303] The formed films were assessed for WVTR at a temperature of about 38°C and at about 90% external relative humidity, in accordance with test method ASTM E398-20, using the Permatran-W Model 1/50 G by Mocon.

[00304] Improvement in WVTR (i.e., reduction in water vapour transmission) was determined assessing the difference in WVTR obtained for a film prepared with bulk HDPE resin only and a film formed with a HDPE blend. The improvement may be expressed as a change in WVTR (ΔWVTR) using the following equation:

$$\Delta \text{WVTR} = \frac{\text{WVTR (HDPE only)} - \text{WVTR (sample)}}{\text{WVTR (HDPE only)}}$$

[00305] It can be seen from the above results that films formed from HBP compositions containing (i) 0.1% NA + 1 – 3% HCR, using Method 2 (i.e., samples S1 and S2); and (ii) 0.05 – 0.1% NA + 1 – 2% HCR, using Method 3 (i.e., S3 and S4) provided significantly improved barrier results balanced with good film mechanical properties over the comparison films.

OTR Testing:

[00306] The formed films were assessed for OTR at a temperature of about 23°C and at about 0% external relative humidity, in accordance with test method ASTM D3985-05, using the Ox-Tran 2/22 by Mocon.

[00307] Improvement in OTR (i.e., reduction in oxygen transmission) was determined assessing the difference in OTR obtained for a film prepared with bulk HDPE resin only and a film formed with a HDPE blend. The improvement may be expressed as a change in OTR (ΔOTR) using the following equation:

$$\Delta \text{OTR} = \frac{\text{OTR (HDPE only)} - \text{OTR (sample)}}{\text{OTR (HDPE only)}}$$

[00308] The examples provided herein show that one or more embodiments of barrier layers and films prepared by the process of the invention may provide useful alternatives to barrier layers and films known in the art, or, particularly in preferred embodiments, one or more advantages, such as, for example one or more of the following:

improved balance of mechanical properties, such as stiffness, or puncture and tear resistance;

lowered cost of production, for example, due to relatively low levels of hydrocarbon resin used;

CLAIMS

1. A process for preparing a high barrier polyolefin masterbatch comprising the steps of:

   a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;

   b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and

   c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),

   to produce a homogenous high barrier polyolefin masterbatch.

2. A process for preparing a high barrier polyolefin masterbatch comprising the step of:

   melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,

   wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and

   wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

3. The process of claim 1 or 2, wherein any one or more of the melt mixing steps comprises sufficient residence time to produce a uniform dispersion of the nucleating agent and hydrocarbon resin.

4. The process of any one of claims 1 to 3, wherein any one or more of the melt mixing steps to form:

   the nucleating agent masterbatch;

   the hydrocarbon resin masterbatch; or

   the high barrier polyolefin masterbatch,

   further comprises the step of adding one or more additives.

5. The process of any one of claims 1 to 4, wherein:

   the nucleating agent is present in the high barrier polyolefin masterbatch in an amount of from about 0.2% to about 15% w/w; and

   the hydrocarbon resin is present in the high barrier polyolefin masterbatch in an amount of from about 2.5% to about 80% w/w.

6. The process of any one of claims 1 to 5, wherein the polyethylene is HDPE.

7. The process of any one of claims 1 to 6, wherein the hydrocarbon resin has a weight average molecular weight lower than the polyethylene.

8. The process of any one of claims 1 to 7, wherein the hydrocarbon resin is a cyclic olefin copolymer or hydrocarbon resin derived from crude olefin feed selected from the group consisting of C5 olefin feed streams, C9 olefin feed streams, terpene olefins, norbornene, pure monomers, and a combination thereof.

9. The process of any one of claims 1 to 8, wherein the nucleating agent comprises a metal salt.

10. The process of any one of claims 1 to 9, wherein the nucleating agent comprises a branched alkyl phosphonic acid, a hydrophthalic acid metal salt, a bicycloheptane dicarboxylic acid metal salt, or a combination thereof.

11. A high barrier polyolefin masterbatch produced by the process of any one of claims 1 to 10.

12. A process for producing a high barrier polyolefin composition comprising blending the high barrier polyolefin masterbatch of claim 11 with bulk polyolefin.

13. A high barrier polyolefin composition produced by the process of claim 12.

14. The high barrier polyolefin composition of claim 13 comprising:

nucleating agent in an amount of from about 0.01% to about 1% w/w;

and hydrocarbon resin in an amount of from about 0.1% to about 10% w/w.

15. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the nucleating agent is present in the nucleating agent masterbatch in an amount of from about 0.1% to about 30% w/w; and

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w,

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

16. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent mixture as defined in claim 2 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w, and

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

17. A high barrier polyolefin composition produced by the process of claim 15 or 16.

18. The high barrier polyolefin composition of claim 13, 14 or 17 comprising 0.5% to 7%, 0.5% to 6%, 0.5% to 5% or 0.5% to 4% w/w hydrocarbon resin.

19. The high barrier polyolefin composition of any one of claims 13, 14, 17 or 18, wherein the nucleating agent and hydrocarbon resin are present in a ratio of about 1:4 to about 1:200.

20. A barrier layer formed from the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19.

21. A film comprising the barrier layer of claim 20, wherein the film has a vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

22. A method of reducing the water vapour transmission rate of a film, the method comprising incorporating the barrier layer of claim 20 into the film, whereby the film has a water vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

23. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin masterbatch and the nucleating agent masterbatch are in a ratio of about 1:5 to about 50:1;

b) melt mixing bulk polyethylene and no greater than 10% weight of the high barrier polyolefin masterbatch of part (a) to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

24. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin masterbatch,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent masterbatch are in a ratio of about 1:5 to about 50:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

25. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

26. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

27. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent mixture comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

28. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent mixture and a hydrocarbon resin masterbatch,

wherein the nucleating agent mixture comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

29. The method of any one of claims 23 to 28, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is a polyethylene.

30. The method of any one of claims 23 to 29, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is the same or different.

31. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein any one or more of the mixing steps, melt mixing steps and/or blending steps is conducted with a twin-screw compounder.

32. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein a synergistic effect between the nucleating agent and hydrocarbon resin is at least 5% greater than the additive effect of the nucleating agent and hydrocarbon resin.

33. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin to form a homogenous polyolefin composition having uniform dispersion of the nucleating agent and hydrocarbon resin.

34. A blown moulded article comprising the film of claim 21.

35. An injection moulded article comprising the film of claim 21.

CLAIMS

1. A process for preparing a high barrier polyolefin masterbatch comprising the steps of:

   a) melt mixing a nucleating agent in polyethylene to form a nucleating agent masterbatch;

   b) melt mixing a hydrocarbon resin in polyethylene to form a hydrocarbon resin masterbatch; and

   c) melt mixing the nucleating agent masterbatch of step a) with the hydrocarbon resin masterbatch of step b),

   to produce a homogenous high barrier polyolefin masterbatch.

2. A process for preparing a high barrier polyolefin masterbatch comprising the step of:

   melt mixing a nucleating agent mixture and a hydrocarbon resin with polyethylene,

   wherein the nucleating agent mixture comprises a nucleating agent and a polyolefin, and

   wherein the melt mixing step is sufficient to produce a homogenous high barrier polyolefin masterbatch.

3. The process of claim 1 or 2, wherein any one or more of the melt mixing steps comprises sufficient residence time to produce a uniform dispersion of the nucleating agent and hydrocarbon resin.

4. The process of any one of claims 1 to 3, wherein any one or more of the melt mixing steps to form:

   the nucleating agent masterbatch;

   the hydrocarbon resin masterbatch; or

   the high barrier polyolefin masterbatch,

   further comprises the step of adding one or more additives.

5. The process of any one of claims 1 to 4, wherein:

   the nucleating agent is present in the high barrier polyolefin masterbatch in an amount of from about 0.2% to about 15% w/w; and

   the hydrocarbon resin is present in the high barrier polyolefin masterbatch in an amount of from about 2.5% to about 80% w/w.

6. The process of any one of claims 1 to 5, wherein the polyethylene is HDPE.

7. The process of any one of claims 1 to 6, wherein the hydrocarbon resin has a weight average molecular weight lower than the polyethylene.

8. The process of any one of claims 1 to 7, wherein the hydrocarbon resin is a cyclic olefin copolymer or hydrocarbon resin derived from crude olefin feed selected from the group consisting of C5 olefin feed streams, C9 olefin feed streams, terpene olefins, norbornene, pure monomers, and a combination thereof.

9. The process of any one of claims 1 to 8, wherein the nucleating agent comprises a metal salt.

10. The process of any one of claims 1 to 9, wherein the nucleating agent comprises a branched alkyl phosphonic acid, a hydrophthalic acid metal salt, a bicycloheptane dicarboxylic acid metal salt, or a combination thereof.

11. A high barrier polyolefin masterbatch produced by the process of any one of claims 1 to 10.

12. A process for producing a high barrier polyolefin composition comprising blending the high barrier polyolefin masterbatch of claim 11 with bulk polyolefin.

13. A high barrier polyolefin composition produced by the process of claim 12.

14. The high barrier polyolefin composition of claim 13 comprising:

nucleating agent in an amount of from about 0.01% to about 1% w/w;

and hydrocarbon resin in an amount of from about 0.1% to about 10% w/w.

15. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the nucleating agent is present in the nucleating agent masterbatch in an amount of from about 0.1% to about 30% w/w; and

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w,

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

16. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent mixture as defined in claim 2 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin,

wherein:

the hydrocarbon resin is present in the hydrocarbon resin masterbatch in an amount of from about 5% to about 80% w/w, and

wherein the high barrier polyolefin composition comprises:

the nucleating agent in an amount of from 0.01% to 1% w/w; and

the hydrocarbon resin in an amount of from 0.1% to 7% w/w.

17. A high barrier polyolefin composition produced by the process of claim 15 or 16.

18. The high barrier polyolefin composition of claim 13, 14 or 17 comprising 0.5% to 7%, 0.5% to 6%, 0.5% to 5% or 0.5% to 4% w/w hydrocarbon resin.

19. The high barrier polyolefin composition of any one of claims 13, 14, 17 or 18, wherein the nucleating agent and hydrocarbon resin are present in a ratio of about 1:4 to about 1:200.

20. A barrier layer formed from the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19.

21. A film comprising the barrier layer of claim 20, wherein the film has a vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

22. A method of reducing the water vapour transmission rate of a film, the method comprising incorporating the barrier layer of claim 20 into the film, whereby the film has a water vapour transmission rate, as measured by ASTM F 1249-20, which is reduced by at least about 10% relative to an equivalent film which does not comprise the barrier layer of claim 20.

23. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1;

b) melt mixing bulk polyethylene and no greater than 10% weight of the high barrier polyolefin masterbatch of part (a) to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

24. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin masterbatch,

wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the nucleating agent masterbatch and the hydrocarbon resin masterbatch are in a ratio of about 1:5 to about 50:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

25. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) mixing a nucleating agent masterbatch comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin having a lower molecular weight lower than that of the polyethylene, to form a high barrier polyolefin masterbatch,

wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1;

b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

c) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

26. A method of reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

    a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent masterbatch and a hydrocarbon resin,

    wherein the nucleating agent masterbatch comprises a nucleating agent uniformly dispersed in a polyolefin,

    and wherein the hydrocarbon resin and the nucleating agent masterbatch are combined in the ratio of about 1:5 to about 60:1

    to form a high barrier polyolefin composition; and

    b) forming a barrier layer from the high barrier polyolefin composition;

    wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

27. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

    a) mixing a nucleating agent mixture comprising a nucleating agent uniformly dispersed in a polyolefin, and a hydrocarbon resin masterbatch comprising a hydrocarbon resin uniformly dispersed in a polyolefin, to form a high barrier polyolefin masterbatch,

    wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1;

    b) melt mixing bulk polyethylene at no less than 90% weight and the high barrier polyolefin masterbatch of part (a) at no greater than 10% weight to form a high barrier polyolefin composition; and

    c) forming a barrier layer from the high barrier polyolefin composition;

    wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

28. A method for reducing the water vapour transmission rate and oxygen transmission rate of a polyethylene film, the method comprising incorporating into the film a barrier layer, wherein the barrier layer is formed by:

a) melt mixing bulk polyethylene in an amount not less than 90% weight with a nucleating agent mixture and a hydrocarbon resin masterbatch,

wherein the nucleating agent mixture comprises a nucleating agent uniformly dispersed in a polyolefin, and the hydrocarbon resin masterbatch comprises a hydrocarbon resin uniformly dispersed in a polyolefin,

and wherein the hydrocarbon resin masterbatch and the nucleating agent are combined in a ratio of about 5:1 to about 150:1,

to form a high barrier polyolefin composition; and

b) forming a barrier layer from the high barrier polyolefin composition;

wherein the water vapour transmission rate and oxygen transmission rate of the film is less than the water vapour transmission rate and oxygen transmission rate of an equivalent film which does not comprise the barrier layer.

29. The method of any one of claims 23 to 28, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is a polyethylene.

30. The method of any one of claims 23 to 29, wherein the polyolefin in any one or more of the nucleating masterbatch, the hydrocarbon resin masterbatch, and the nucleating agent mixture is the same or different.

31. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein any one or more of the mixing steps, melt mixing steps and/or blending steps is conducted with a twin-screw compounder.

32. The process of any one of claims 1 to 10, 12, 15 or 16, the high barrier polyolefin masterbatch of claim 11, the high barrier polyolefin composition of any one of claims 13, 14, 17, 18 or 19, the barrier layer of claim 20, the film of claim 21, or the method of any one of claims 22 to 30, wherein a synergistic effect between the nucleating agent and hydrocarbon resin is at least 5% greater than the additive effect of the nucleating agent and hydrocarbon resin.

33. A process for producing a high barrier polyolefin composition comprising the step of:

blending a nucleating agent masterbatch as defined in claim 1 and a hydrocarbon resin masterbatch as defined in claim 1 with a bulk polyolefin to form a homogenous polyolefin composition having uniform dispersion of the nucleating agent and hydrocarbon resin,

wherein the blending step achieves sufficient homogeneity to produce a synergistic effect.

34. A blown moulded article comprising the film of claim 21.

35. An injection moulded article comprising the film of claim 21.