

Composition

INTRODUCTION

The present invention relates to a composition comprising: (i) a polyolefin; (ii) a fatty acid salt of a metal selected from Ce, Mn, Al, Mg and mixtures thereof; and (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA. The invention also relates to a method for preparing the composition, to the use of the composition as an additive, and to an additive, preferably an additive masterbatch, comprising the composition. The invention further relates to a polymer composition comprising the additive, preferably an additive masterbatch, and a polymer base composition, and to a method of preparing a polymer composition comprising the additive and a polymer base composition. Additionally, the invention relates to an article comprising the polymer composition, to a method of preparing an article comprising the polymer composition, and to the use of the polymer composition to prepare an article.

BACKGROUND

The use of polymer materials is ubiquitous in modern life. Depending on the particular choice of polymer, polymer materials are able to offer a variety of desirable physical properties, which make them suitable for a wide variety of different applications. Moreover, polymers typically comprise a backbone of strong covalent bonds, making the polymer resistant to degradation. In normal use, this property is beneficial, as it enables the provision of durable articles for use by the consumer.

However, owing to the strength of the covalent backbone, polymer materials are typically difficult to degrade or depolymerise, meaning that there are limited options for their disposal. As a result, polymer waste is often consigned to landfill sites and frequently leaks into the environment. This is highly undesirable from an environmental perspective. There is thus a desire to reduce the use of conventional polymer materials which cannot be readily degraded.

A demand therefore exists for the development of degradable polymer materials, enabling articles comprising such materials to be more readily disposed of once they have fulfilled their intended use. This demand can be satisfied by the provision of a polymer degradation additive.

A polymer degradation additive comprises a polymer carrier along with additional ingredients intended to speed up polymer degradation, and may be supplied as a masterbatch. The masterbatch may be blended with a polymer base composition, and the resultant polymer composition may be moulded or extruded to form an article. The presence of the masterbatch in the polymer composition facilitates degradation of the article on disposal.

It is known that chemical degradation of the polymer base can be enhanced by the provision of a chemical depolymerisation catalyst in the masterbatch. These species promote oxidative depolymerisation of the covalent backbone of the polymer base. The provision of a biofood in the degradation additive is also known to enhance degradation by recruiting microorganisms to the polymer base, enabling these microorganisms to bio-assimilate the polymer base and/or degradation products. These two effects act concurrently and in complement to enhance degradation.

The strong degradation performance described above must be carefully balanced with the physical properties demanded of the polymer composition during normal use of an article. For example, the inclusion of the masterbatch should not compromise mechanical properties – e.g. flexural modulus, tensile modulus, or Izod impact values – relative to those of the polymer base composition alone. This is important so that the polymer composition can continue to perform its intended function, without any substantial decrease in performance which may be noticed by the end-user. The masterbatch should also not too greatly affect the visual appearance of the polymer composition as compared with the polymer base composition alone. This is important to ensure that articles comprising the masterbatch will not appear aesthetically unappealing to the consumer.

SUMMARY OF THE INVENTION

Viewed from a first aspect, the present invention provides a composition, comprising:

- (i) a polyolefin;
- (ii) a fatty acid salt of a metal selected from Ce, Mn, Al, Mg, and mixtures thereof; and
- (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA.

Viewed from a further aspect, the present invention provides a method for preparing a composition as hereinbefore described, comprising mixing:

- (i) a polyolefin;
- (ii) a fatty acid salt of a metal selected from Ce, Mn, Al, Mg, and mixtures thereof;
- and
- (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA.

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Viewed from a further aspect, the present invention provides an additive, preferably an additive masterbatch, comprising a composition as hereinbefore described.

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Viewed from a further aspect, the present invention provides the use of a composition as hereinbefore described as an additive, preferably an additive masterbatch.

Viewed from a further aspect, the present invention provides a polymer composition comprising:

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- (i) an additive, preferably an additive masterbatch, as hereinbefore described; and
- (ii) a polymer base composition.

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Viewed from a further aspect, the present invention provides a method for preparing a polymer composition as hereinbefore described, comprising blending an additive, preferably an additive masterbatch, as hereinbefore described with a polymer base composition.

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Viewed from a further aspect, the present invention provides an article comprising a polymer composition as hereinbefore described.

Viewed from a further aspect, the present invention provides the use of a polymer composition as hereinbefore described to prepare an article.

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Viewed from a further aspect, the present invention provides a method of preparing an article as hereinbefore described, comprising thermoforming, calendaring, moulding and/or extruding a polymer composition as hereinbefore described.

DEFINITIONS

As used herein, the term “polymer degradation additive” refers to a composition which improves the degradation properties of a polymer base composition with which it is

blended. The compositions of the present invention may be used as polymer degradation additives.

5 As used herein, the term “additive masterbatch” refers to an additive in a form which may be blended with a polymer base composition to form a polymer composition, with the aim of imparting certain desired properties to the resultant polymer composition.

10 As used herein the term “polymer base composition” refers to a composition with which an additive or an additive masterbatch is blended to form a polymer composition. Preferably the polymer base composition is the main ingredient of the resultant polymer composition by wt%, based on the total weight of the polymer composition. For example, the polymer composition may comprise the polymer base composition in an amount of at least 50 wt%, preferably at least 60 wt% and more preferably at least 90% based on the total weight of the polymer composition. Preferably the polymer base composition
15 comprises a polymer as its main ingredient by wt%. For example, the polymer base composition may comprise polymer in an amount of at least 70 wt%, preferably at least 80 wt%, more preferably at least 90% based on the total weight of the polymer composition. Other ingredients optionally present in the polymer base composition are conventional additives (other than polymer degradation additives).

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As used herein the term “polymer composition” refers to a composition resulting from the blending of an additive or an additive masterbatch with a polymer base composition.

25 As used herein, the term “homopolymer” refers to a polymer derived from one single species of monomer.

As used herein, the term “copolymer” refers to a polymer derived from more than one species of monomer. The term includes block copolymers, random copolymers, and alternating copolymers.

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As used herein the term “partially hydrolysed polyvinyl alcohol” is equivalent to the term “partially hydrolysed polyvinyl acetate”. Both refer to a polyvinyl alcohol prepared by hydrolysis of polyvinyl acetate. The extent of hydrolysis is described by the “degree of hydrolysis (DH)”, which denotes the percentage of acetate groups converted to alcohol
35 groups.

As used herein the term “polyvinyl acetate” refers to a polymer that comprises at least 50 % wt, preferably at least 75 % wt, more preferably at least 85 % wt, yet more preferably at least 90 % wt units derived from vinyl acetate.

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As used herein the term “polyolefin” refers to a polymer that comprises at least 50 % wt, preferably at least 75 % wt, more preferably at least 85 % wt, yet more preferably at least 90 % wt units derived from olefin(s). Preferred olefins are ethylene and propene, in particular propene.

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As used herein the term “polypropylene” refers to a polymer that comprises at least 50 % wt, preferably at least 75 % wt, more preferably at least 85 % wt, yet more preferably at least 90 % wt units derived from propene.

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As used herein the term “stearate” refers to the anion of stearic acid.

As used herein the term “depolymerisation catalyst” refers to a metal salt which catalyses the depolymerisation of a polymer.

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As used herein the term “fatty acid” refers to an aliphatic carboxylic acid.

As used herein the term “biofood” refers to a compound which may be consumed by microorganisms and which promotes the proliferation of said microorganisms.

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As used herein the term “polyhydric alcohol” refers to an organic compound with one hydroxyl group bonded directly to each carbon atom.

As used herein the term “hydroxyl acid” is equivalent to the term “hydroxy acid” and refers to a compound comprising at least one carboxylic acid group and at least one hydroxyl group.

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DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a composition comprising

(i) a polyolefin,

- (ii) a fatty acid salt of a metal selected from Ce, Mn, Al, Mg, and mixtures thereof, and
- (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA.

5 Preferably, the composition comprises a fatty acid metal salt of each of two, more preferably of each of three, still more preferably of each metal selected from Ce, Mn, Al, and Mg.

10 Preferably, the composition of the present invention is an additive, more preferably an additive masterbatch.

The present invention also relates to an additive, more preferably an additive masterbatch, comprising a composition as hereinbefore described and to the use of a composition as hereinbefore described as an additive, more preferably an additive masterbatch.

20 The present invention additionally relates to a polymer composition comprising an additive, more preferably an additive masterbatch, as hereinbefore described and a polymer base composition.

Advantageously, the composition or the polymer composition of the present invention offers improved degradation performance. This means that articles comprising the composition or the polymer composition more readily degrade, including following UV aging and/or light exposure. Advantageously, the mechanical and visual properties of the composition or the polymer composition of the present invention do not differ significantly from the mechanical properties of the polyolefin which does not comprise the fatty acid salt of metal and the partially hydrolysed PVA, or a polymer base composition which does not comprise the additive or the additive masterbatch of the present invention, respectively. For example, the flexural modulus, tensile modulus, Izod impact value, and haze value of the composition or the polymer composition of the present invention are not significantly different from those of the polyolefin which does not comprise the fatty acid salt of metal and the partially hydrolysed PVA, or a polymer base composition which does not comprise the additive or the additive masterbatch of the present invention, respectively.

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Polyolefin

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a polyolefin. The composition, preferably an additive, more preferably an additive masterbatch, may comprise multiple polyolefins. For example, the composition, preferably an additive, more preferably an additive masterbatch, may comprise two, three, or more polyolefins. Preferably, the composition of the present invention comprises a single polyolefin.

The polyolefin of the present invention may be a copolymer, for example a bipolymer, a terpolymer, or a quaterpolymer. Preferably, the polyolefin of the present invention is a homopolymer.

Preferably, the polyolefin is selected from a polyolefin comprising monomers derived from a C2-C12 olefin, more preferably a C2-C8 olefin. Still more preferably, the polyolefin is selected from a polyethylene (e.g. a high density polyethylene or a low density polyethylene) or a polypropylene. Most preferably, the polyolefin is polypropylene.

Preferably, the polyolefin is in the form of a powder or particles.

Preferably, the polyolefin of the present invention has an M_w of 100,000 to 600,000, more preferably 200,000 to 500,000, still more preferably 300,000 to 400,000. Preferably, the polyolefin of the present invention has an M_n of 10,000 to 80,000, more preferably 30,000 to 60,000, still more preferably 40,000 to 50,000. Preferably, the polyolefin of the present invention has an M_z of 600,000 to 1,750,000, more preferably 800,000 to 1,500,000, still more preferably 1,000,000 to 1,300,000.

Preferably, the polyolefin, more preferably polypropylene, of the present invention has a melt flow rate (MFR) 2 to 65 g/10 min at loading 2.16 kg at 230 °C, more preferably 2 to 25 g/10 min, still more preferably about 2 to 12 g/10 min, most preferably 12 g/10 min. Alternatively, the polyolefin, more preferably polypropylene, of the present invention preferably has a melt flow rate (MFR) of 50 to 60 g/10 min at loading 2.16 kg at 230 °C or a melt flow rate (MFR) of 2 to 5 g/10 min at loading 2.16 kg at 230 °C.

Preferably, the polyolefin, more preferably polyethylene, of the present invention has a melt flow rate (MFR) 0.5 to 20 g/10 min at loading 2.16 kg at 190 °C, more preferably 0.5

to 15 g/10 min, still more preferably about 0.6 to 10 g/10 min, most preferably 0.6 to 4 g/10 min.

MFR may be measured according to ASTM D 1238 (Year 2020).

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Preferably the polyolefin is the main ingredient of the composition, preferably an additive, more preferably an additive masterbatch, by wt%, based on the total weight of the composition. The composition, preferably an additive, more preferably an additive masterbatch, of the present invention preferably comprises 50 to 90 wt%, more preferably 59 to 75 wt% polyolefin, based on the total weight of the composition.

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Fatty acid salts of metals selected from Ce, Mn, Al, Mg and mixtures thereof

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of a metal selected from Ce, Mn, Al, Mg, and mixtures thereof. In other words, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises one or more of: a fatty acid salt of Ce; a fatty acid salt of Mn; a fatty acid salt of Al; or a fatty acid salt of Mg.

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A purpose of this ingredient is to act as a depolymerisation catalyst. Such a depolymerisation catalyst promotes oxidative depolymerisation of a polymer backbone, leading to advantageous levels of polymer degradation in a composition or a polymer composition comprising an additive, preferably an additive masterbatch, of the present invention.

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Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of each of two metals selected from Ce, Mn, Al, and Mg. In other words, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise one or more of the following combinations: a fatty acid salt of Ce and a fatty acid salt of Al; a fatty acid salt of Ce and a fatty acid salt of Mn; a fatty acid salt of Ce and a fatty acid salt of Mg; a fatty acid salt of Mn and a fatty acid salt of Al; a fatty acid salt of Mn and a fatty acid salt of Mg; or a fatty acid salt of Al and a fatty acid salt of Mg.

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Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of each of three metals selected from Ce, Mn, Al, and Mg. In other words, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise one or more of the following combinations: a fatty acid salt of Ce, a fatty acid salt of Mn, and a fatty acid salt of Al; a fatty acid salt of Ce, a fatty acid salt of Al, and a fatty acid salt of Mg; a fatty acid salt of Ce, a fatty acid salt of Mn, and a fatty acid salt of Mg; or a fatty acid salt of Mn, a fatty acid salt of Al, and a fatty acid salt of Mg.

Most preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of each of Ce, Mn, Al, and Mg. In other words, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise a fatty acid salt of Ce, a fatty acid salt of Mn, a fatty acid salt of Al, and a fatty acid salt of Mg.

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise multiple (for example two, three, or more) fatty acid salts of metals selected from Ce, Mn, Al, and Mg and mixtures thereof. In other words, the composition, preferably an additive, more preferably an additive masterbatch, may comprise multiple fatty acids salts of Ce, multiple fatty acid salts of Mn, multiple fatty acid salts of Al, and/or multiple fatty acid salts of Mg.

The fatty acid salt may be a salt of an unsaturated fatty acid or of a saturated fatty acid. Preferably, the fatty acid salt is a salt of a saturated fatty acid.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention the fatty acid salt is a salt of a C4-28 fatty acid, more preferably a C14-24 fatty acid, still more preferably a C16-20 fatty acid. Most preferably the fatty acid salt is a salt of a C18 fatty acid.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention the fatty acid salt is a salt of a fatty acid containing an even number of carbon atoms. Preferably, in the compositions, preferably an additive, more preferably an additive masterbatch, of the present invention the fatty acid salt is a salt of a monocarboxylic fatty acid.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention, the fatty acid salt is a salt of stearic acid.

5 Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises several fatty acid salts, each fatty acid salt may be a salt of the same or of a different fatty acid. Preferably, each fatty acid salt present in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention is a salt of the same fatty acid.

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Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises 5 to 20 wt%, more preferably 7 to 15 wt%, still more preferably 11 to 14 wt% of fatty acid salts of metals selected from Ce, Mn, Al, Mg and mixtures thereof, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Ce, the composition, preferably an additive, more preferably an additive masterbatch, preferably comprises 0 to 20 wt%, preferably 0.5 to 12.5 wt%, more preferably 0.5 to 7.5 wt%, still more preferably 1 to 5 wt%, yet more preferably 1.5 to 3 wt% of a fatty acid salt of Ce, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mn, the composition, preferably an additive, more preferably an additive masterbatch, preferably comprises 0 to 20 wt%, preferably 0.5 to 12.5 wt%, more preferably 0.5 to 7.5 wt%, still more preferably 1 to 5 wt%, yet more preferably 1.5 to 3 wt% of a fatty acid salt of Mn, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Al, the composition, preferably an additive, more preferably an additive masterbatch, preferably comprises 0 to 20 wt%, preferably 0.5 to 12.5 wt%, more preferably 0.5 to 7.5 wt%, still more preferably 1 to 5

wt%, yet more preferably 1.5 to 3 wt% of a fatty acid salt of Al, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

5 Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mg, the composition, preferably an additive, more preferably an additive masterbatch, preferably comprises 0 to 20 wt%, preferably 0.5 to 12.5 wt%, more preferably 0.5 to 7.5 wt%, still more preferably 1 to 5 wt%, yet more preferably 1.5 to 3 wt% of a fatty acid salt of Mg, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Ce and a fatty acid salt of Al, the weight ratio of said fatty acid salt of Ce to said fatty acid salt of Al is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Ce and a fatty acid salt of Mg, the weight ratio of said fatty acid salt of Ce to said fatty acid salt of Mg is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mg and a fatty acid salt of Al, the weight ratio of said fatty acid salt of Mg to said fatty acid salt of Al is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Ce and a fatty acid salt of Mn, the weight ratio of said fatty acid salt of Ce to said fatty acid salt of Mn is preferably 0:1 to 1:0, preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mg and a fatty acid salt of Mn, the weight ratio of said fatty acid salt of Mg to said fatty acid salt of Mn is preferably 0:1 to 1:0, preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

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Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Al and a fatty acid salt of Mn, the weight ratio said fatty acid salt of Al to said fatty acid salt of Mn is preferably 0:1 to 1:0, preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

Polyvinyl alcohol (PVA)

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention also comprises polyvinyl alcohol. One purpose of the polyvinyl alcohol, in combination with any additional biofoods present in the composition, preferably an additive, more preferably an additive masterbatch, is to recruit microorganisms to a polymer base. This enhances biodegradation of a composition or a polymer composition comprising the additive, preferably an additive masterbatch, of the present invention. It has also been found that the inclusion of polyvinyl alcohol leads to improved flexural modulus and/or improved degradation performance, including following UV aging, in compositions and polymer compositions comprising the additive, preferably an additive masterbatch, of the present invention, as compared with comparative compositions and polymer compositions lacking a polyvinyl alcohol.

The polyvinyl alcohol may be an unhydrolysed polyvinyl acetate or fully hydrolysed polyvinyl acetate. In other words, the polyvinyl alcohol may have a degree of hydrolysis of 0%mol or 100%mol. Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention the polyvinyl alcohol is a partially hydrolysed polyvinyl alcohol. In other words, the degree of hydrolysis is greater than 0%mol and less than 100%mol. Preferably, the degree of hydrolysis is 40 to 80%mol, more preferably 45 to 55%mol.

Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises 0.1 to 50wt%, more preferably 0.5 to 30 wt%, still more preferably 5 to 25 wt%, yet more preferably 10 to 20 wt% of partially hydrolysed PVA, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention the weight ratio of fatty acid salts of metals selected

from Ce, Mn, Al, Mg and mixtures thereof to the partially hydrolysed PVA is 0.2: 1 to 25: 1, preferably 0.5 : 1 to 10 : 1, more preferably 0.6 : 1 to 1.5 : 1, most preferably 0.6 : 1 to 1.3 : 1. Alternatively, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention the weight ratio of fatty acid salts of metals selected from Ce, Mn, Al, Mg and mixtures thereof to the partially hydrolysed PVA is preferably 0.1: 1 to 2: 1, more preferably 0.1 : 1 to 1 : 1, still more preferably 0.1 : 1 to 0.7 : 1, most preferably 0.1 : 1 to 0.3 : 1.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises Ce stearate, Mn stearate, Al stearate and Mg stearate and the weight ratio of said stearates of Ce, Mn, Al, and Mg to the PVA is 0.2: 1 to 25: 1, preferably 0.5 : 1 to 10 : 1, more preferably 0.6 : 1 to 1.5 : 1, most preferably 0.6 : 1 to 1.3 : 1.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mn and a fatty acid salt of at least one metal selected from Ce, Al, and Mg. In this embodiment, preferably weight ratios are as follows. Preferably the weight ratio of said fatty acid salt of Ce to said fatty acid salt of Mn is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1. Preferably the weight ratio of said fatty acid salt of Al to said fatty acid salt of Mn is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1. Preferably the weight ratio of said fatty acid salt of Mg to said fatty acid salt of Mn is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

Preferably, in the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises Mn stearate and at least one metal stearate selected from Ce stearate, Al stearate and Mg stearate. In this embodiment, preferably weight ratios are as follows. Preferably the weight ratio of Ce stearate to Mn stearate is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1. Preferably the weight ratio of Al stearate to Mn stearate is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1. Preferably the weight ratio of Mg stearate to Mn stearate is 0:1 to 1:0, more preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

Biofood

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention preferably also includes a further biofood (e.g. polyhydric alcohol, hydroxy acid) in addition to the polyvinyl alcohol hereinbefore described. A purpose of the further biofood, in combination with the polyvinyl alcohol, is to recruit microorganisms to a polymer base. This enhances biodegradation of a polymer composition comprising the composition of the present invention.

Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a polyhydric alcohol, preferably a polyhydric alcohol comprising 2 to 24 carbon atoms, more preferably a polyhydric alcohol comprising 2 to 12 carbon atoms, still more preferably a polyhydric alcohol comprising 4 to 6 carbon atoms. Preferred polyhydric alcohols include sorbitol and erythritol. Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises sorbitol.

Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a carboxylic acid, more preferably a hydroxy acid, still more preferably a hydroxy acid comprising 1 to 12 carbon atoms, yet more preferably a hydroxy acid comprising 2 to 10 carbon atoms, most preferably a hydroxy acid comprising 4 to 8 carbon atoms. The carboxylic acid or the hydroxy acid may contain one carboxylic acid group or more than one carboxylic acid group, for example two carboxylic acid groups or three carboxylic acid groups.

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise 1,4-cyclohexanedimethanol dibenzoate.

Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a polyhydric alcohol, the weight ratio of polyhydric alcohol to the partially hydrolysed PVA is preferably 0.05 : 1 to 4 : 1, more preferably 0.08 : 1 to 2 : 1, still more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1.

Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a carboxylic acid, preferably a hydroxy acid, the weight ratio of hydroxy acid to the partially hydrolysed PVA is preferably 0.02 : 1 to 4 : 1,

more preferably 0.08 : 1 to 2 : 1, still more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1.

Additional fatty acid metal salts

5 The compositions, preferably an additive, more preferably an additive masterbatch, of the present invention may additionally comprise a fatty acid salt of a metal not selected from Ce, Mn, Al, Mg and mixtures thereof. Such fatty acid salts may be salts of any fatty acid as hereinbefore described.

10 The compositions, preferably an additive, more preferably an additive masterbatch, of the present invention may comprise a fatty acid salt of Zn.

Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Zn and a fatty acid salt of Ce, the
15 weight ratio of said fatty acid salt of Zn to said fatty acid salt of Ce is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

Where the composition, preferably an additive, more preferably an additive masterbatch,
20 of the present invention comprises a fatty acid salt of Zn and a fatty acid salt of Al, the weight ratio of said fatty acid salt of Zn to said fatty acid salt of Al is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

Where the composition, preferably an additive, more preferably an additive masterbatch,
25 of the present invention comprises a fatty acid salt of Zn and a fatty acid salt of Mg, the weight ratio of said fatty acid salt of Zn to said fatty acid salt of Mg is preferably 3:1 to 1:3, more preferably 2:1 to 1:2, still more preferably 1.5:1 to 1:1.5, most preferably about 1:1.

30 Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Mn and a fatty acid salt of Zn, the weight ratio of said fatty acid salt of Zn to said fatty acid salt of Mn is preferably 0:1 to 1:0, more preferably 0.2:1 to 1:0, most preferably about 0.5:1 to 1:0.

Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Zn, the composition preferably comprises 0 to 12.5 wt%, more preferably 0.5 to 7.5 wt%, still more preferably about 1 to 5 wt%, yet more preferably 1.5 to 3 wt% of a fatty acid salt of Zn, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

Preferably, the composition, preferably an additive, more preferably an additive masterbatch, of the present invention does not comprise a fatty acid salt of Zn. Preferably the composition, preferably an additive, more preferably an additive masterbatch, of the present invention does not comprise Zn. This has the advantage of allowing the composition of the present invention to better meet with regulatory requirements which limit the allowable concentration of Zn.

Preferably, the composition, preferably an additive, more preferably an additive masterbatch of the present invention comprises a fatty acid salt of Ca.

Where the composition, preferably an additive, more preferably an additive masterbatch, of the present invention comprises a fatty acid salt of Ca, the composition preferably comprises 0 to 12.5 wt%, more preferably 0.25 to 7.5 wt%, still more preferably about 0.5 to 4 wt%, yet more preferably 0.5 to 2.5 wt% of a fatty acid salt of Ca, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

25 *Additives*

The composition, preferably an additive, more preferably an additive masterbatch, of the present invention may include a wide variety of additives. Examples of additives that are optionally present in the composition of the invention include nucleating agents, dyes, pigments, colour pigments, plasticisers, hardeners, stabilisers, coupling agents, antioxidants, acid scavengers and compatibilizers.

Preferred additives include phosphites, including tris(2,4-di-tert.-butylphenyl)phosphite, pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), and polypropylene g-Maleic anhydride. Preferably, the composition of the present invention

comprises each of tris(2,4-di-tert.-butylphenyl)phosphite, pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), and polypropylene g-Maleic anhydride.

Any additives present in the composition, preferably an additive, more preferably an additive masterbatch, are preferably present in an amount of 0 to 10 wt%, more preferably 0.25 to 7.5 wt%, still more preferably about 0.5 to 4 wt%, yet more preferably 0.5 to 2.5 wt%, based on the total weight of the composition, preferably an additive, more preferably an additive masterbatch.

10 *Compositions*

Preferred compositions of the present invention comprise:

- (i) a polyolefin, preferably polyethylene or polypropylene;
- (ii) a fatty acid salt of each of two metals selected from Ce, Mn, Al, and Mg;
- (iii) a polyvinyl alcohol, preferably a partially hydrolysed polyvinyl alcohol; and
- 15 (iv) optionally, a further biofood, preferably selected from a polyhydric alcohol and/or a hydroxy acid.

Further preferred compositions of the present invention comprise

- (i) a polyolefin, preferably polyethylene or polypropylene;
- 20 (ii) a fatty acid salt of each of three metals selected from Ce, Mn, Al, and Mg;
- (iii) a polyvinyl alcohol, preferably a partially hydrolysed polyvinyl alcohol; and
- (iv) optionally, a further biofood, preferably selected from a polyhydric alcohol and/or a hydroxy acid.

25 Further preferred compositions of the present invention comprise:

- (i) a polyolefin, preferably polyethylene or polypropylene;
- (ii) a fatty acid salt of each of Ce, Mn, Al, and Mg;
- (iii) a polyvinyl alcohol, preferably a partially hydrolysed polyvinyl alcohol; and
- (iv) optionally, a further biofood, preferably selected from a polyhydric alcohol and/or
- 30 a hydroxy acid.

Additive or additive masterbatch

Preferably the compositions of the present invention are additives, more preferably additive masterbatches.

Viewed from a further aspect, the present invention provides an additive, preferably an additive masterbatch, comprising a composition as hereinbefore described. Preferably, the additive and/or additive masterbatch of the present invention consists of a composition as hereinbefore described.

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Viewed from a further aspect, the present invention provides the use of a composition as hereinbefore described as an additive, preferably an additive masterbatch.

10

Preferred additives and additive masterbatches of the present invention are as described above for the compositions of the present invention.

Particularly preferred additives and additive masterbatches of the present invention comprise:

15

(i) polyolefin;

(ii) Ce stearate, Mn stearate, Al stearate and Mg stearate;

(iii) partially hydrolysed PVA; and

(iv) polyhydric alcohol, preferably sorbitol,

wherein

20

the weight ratio of said combined stearates of Ce, Mn, Al, and Mg to said PVA is 0.2: 1 to 25: 1, preferably 0.5 : 1 to 10 : 1, more preferably 0.6 : 1 to 1.5 : 1, most preferably 0.6 : 1 to 1.3 : 1;

the weight ratio of said polyhydric alcohol to said PVA is 0.05 : 1 to 4 : 1, preferably 0.08 : 1 to 2 : 1, more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1; and

25

the weight ratio of each of Ce stearate, Al stearate and Mg stearate to Mn stearate is 0:1 to 1:0, preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

Further particularly preferred additives and additive masterbatches of the present invention comprise:

30

(i) polyolefin;

(ii) Ce stearate, Mn stearate, Al stearate, and Mg stearate;

(iii) partially hydrolysed PVA

(iv) polyhydric alcohol, preferably sorbitol; and

(v) hydroxy acid comprising 4 to 8 carbon atoms

wherein

the weight ratio of said stearates of Ce, Mn, Al, and Mg to said PVA is 0.2: 1 to 25: 1, preferably 0.5 : 1 to 10 : 1, more preferably 0.6 : 1 to 1.5 : 1, most preferably 0.6 : 1 to 1.3 : 1;

the weight ratio of said polyhydric alcohol to said PVA is 0.05 : 1 to 4 : 1, preferably 0.08 : 1 to 2 : 1, more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1;

the weight ratio of said hydroxy acid to said PVA is 0.02 : 1 to 4 : 1, preferably 0.08 : 1 to 2 : 1, more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1; and

the weight ratio of each of Ce stearate, Al stearate and Mg stearate to Mn stearate is 0:1 to 1:0, preferably to 0.1:1 to 0.9:1, most preferably 0.4:1 to 0.7:1.

Manufacture

The present invention also relates to a method for preparing a composition, an additive, or an additive masterbatch as hereinbefore described, comprising mixing:

- (i) a polyolefin,
- (ii) a fatty acid salt of a metal selected from Ce, Mn, Al, Mg and mixtures thereof, and
- (iii) a polyvinyl alcohol, preferably a partially hydrolysed polyvinyl alcohol.

Preferred methods for preparing the composition, the additive, or the additive masterbatch of the present invention comprise mixing all ingredients in powder form at ambient temperature (e.g. 25 to 45°C) to obtain dry blending.

Preferred methods for preparing the composition, the additive, or the additive masterbatch of the present invention further comprise melt mixing the dry blending by using extruder, preferably twin screw extruder, at 190 to 220 °C, then pelletizing and storing the pellets in sealed bag at 25 to 45°C.

Preferred methods of the present invention comprise mixing a fatty acid salt of each of two metals selected from Ce, Mn, Al, Mg and mixtures thereof with (i) and (iii).

Preferred methods of the present invention comprise mixing a fatty acid salt of each of three metals selected from Ce, Mn, Al, Mg and mixtures thereof with (i) and (iii).

Preferred methods of the present invention comprise mixing a fatty acid salt of each of Ce, Mn, Al, and Mg with (i) and (iii).

The present invention also relates to a method for preparing a polymer composition as hereinbefore described, comprising blending an additive, preferably an additive masterbatch, as hereinbefore described with a polymer base composition as hereinbefore described.

Preferred methods for preparing the polymer composition of the present invention comprise blending all ingredients by physical mixing at ambient temperature and/or extrusion at 190 to 220 °C.

10

Polymer composition

Viewed from a further aspect, the present invention provides a polymer composition. The polymer composition comprises at least two components. The components are:

- (i) an additive, preferably an additive masterbatch, as hereinbefore described; and
- (ii) a polymer base composition.

15

Preferably the polymer base composition comprises a polyolefin. The polymer base composition may comprise a copolymer, for example a bipolymer, a terpolymer, or a quaterpolymer. Preferably, the polymer base composition comprises a homopolymer.

20

Preferably, the polymer base composition comprises a polyolefin comprising monomers derived from a C2-C12 olefin, more preferably a C2-C8 olefin. Still more preferably, the polymer base composition comprises a polyolefin selected from a polyethylene (e.g. a high density polyethylene or a low density polyethylene) or a polypropylene. Most preferably, the polymer base composition comprises polypropylene.

25

Preferably, the polymer base composition is in the form of a powder or particles.

Preferably, the polymer base composition has an M_w of 100,000 to 600,000, more preferably 200,000 to 500,000, still more preferably 300,000 to 400,000. Preferably, the polymer base composition has an M_n of 10,000 to 80,000, more preferably 30,000 to 60,000, still more preferably 40,000 to 50,000. Preferably, the polymer base composition has an M_z of 600,000 to 1,750,000, more preferably 800,000 to 1,500,000, still more preferably 1,000,000 to 1,300,000.

35

The polymer composition of the present invention benefits from a number of advantageous properties. For example, the mechanical and physical properties of the polymer composition do not differ greatly from those of the polymer base composition. Preferably the mechanical and physical properties are determined by the methods described in the examples.

The polymer composition of the present invention preferably has a tensile modulus of greater than 1200 MPa, more preferably greater than 1400 MPa, still more preferably greater than 1500 MPa. The polymer composition of the present invention preferably has an Izod impact value at 23 °C of greater than 1.40 KJ/m². The polymer composition of the present invention preferably has a flexural modulus of greater than 1600 MPa, preferably greater than 1700 MPa. The polymer composition of the present invention preferably has a haze value of between 40 to 60.

The polymer composition of the present invention preferably exhibits a reduction in a flexural modulus (e.g. tested according to method specified in ISO 19069-2 (2016)) of 0 to 10%, preferably 0 to 5% compared to the polymer composition without the additive hereinbefore described.

Advantageously, the polymer composition of the present invention also has improved degradation performance, including following UV aging and/or light exposure.

The polymer composition of the present invention preferably exhibits a reduction in M_w following UV aging (e.g. tested according to method specified in BSI PAS 9017:2020), e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%. The polymer composition of the present invention preferably exhibits a reduction in M_w following light exposure, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%.

Advantageously, the polymer composition of the present invention combines strong degradation performance with mechanical and visual properties which do not differ significantly from those of the polymer base composition.

The polymer composition of the present invention preferably has a flexural modulus of greater than 1600 MP, preferably greater than 1700 MPa, and exhibits a reduction in M_w following UV aging, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%. The polymer composition of the present invention more preferably has a flexural modulus of greater than 1600 MP, preferably greater than 1700 MPa, and exhibits a reduction in M_w following light exposure, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%.

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10 Preferably the polymer composition of the present invention comprises 0.1 to 20 wt%, preferably 0.1 to 10 wt%, more preferably 0.5 to 5 wt%, most preferably 1 to 3 wt% of said additive, preferably said additive masterbatch, based on the total weight of polymer composition.

15 Preferably the polymer base composition is the main ingredient of the polymer composition by wt%, based on the total weight of the polymer composition. Preferably the polymer composition of the present invention comprises 80 to 99.9 wt%, preferably 90 to 99.9 wt%, more preferably 95 to 99.5 wt%, most preferably 97 to 99 wt% of the polymer base composition as hereinbefore described, based on the total weight of the polymer composition.

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Preferably, the polymer composition of the present invention consists of an additive, preferably an additive masterbatch, as hereinbefore described and a polymer base composition.

25

The present invention also relates to a method of preparing a polymer composition as hereinbefore described comprising blending an additive, preferably an additive masterbatch as hereinbefore described with a polymer base composition.

30

Articles and uses

The present invention also relates to articles comprising a polymer composition as hereinbefore described. Example articles include food containers and packaging for food.

The articles of the present invention benefit from a number of advantageous properties. For example, the mechanical and physical properties of the article do not differ greatly from articles comprising a polymer base composition and lacking an additive, preferably an additive masterbatch, as hereinbefore described.

5

The articles of the present invention preferably have a tensile modulus of greater than 1200 MPa, more preferably greater than 1400 MPa, still more preferably greater than 1500 MPa. The articles of the present invention preferably have an Izod impact value at 23 °C of greater than 1.40 kJ/m². The articles of the present invention preferably have a flexural modulus of greater than 1600 MPa, preferably greater than 1700 MPa. The polymer composition of the present invention preferably has a haze value of between 40 to 60.

10

The articles of the present invention preferably exhibit a reduction in a flexural modulus (e.g. tested according to method specified in ISO 19069-2 (2016)) of 0 to 10%, preferably 0 to 5% compared to the article lacking the additive hereinbefore described.

15

Advantageously, the articles of the present invention also have improved degradation performance, including following UV aging and/or light exposure.

20

The articles of the present invention preferably exhibit a reduction in M_w following UV aging (e.g. tested according to method specified in BSI PAS 9017:2020), e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%. The articles of the present invention preferably exhibit a reduction in M_w following light exposure, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%.

25

Advantageously, the articles of the present invention combine strong degradation performance with mechanical and visual properties which do not differ significantly from those of the polymer base composition.

30

The articles of the present invention preferably have a flexural modulus of greater than 1600 MP, preferably greater than 1700 MPa, and exhibit a reduction in M_w following UV aging, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%. The articles of the present invention more

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preferably have a flexural modulus of greater than 1600 MP, preferably greater than 1700 MPa, and exhibit a reduction in M_w following light exposure, e.g. as described in the examples, of greater than 80%, preferably greater than 90%, most preferably greater than 95%.

5

The present invention also relates to a method for forming articles comprising calendering, moulding and/or extruding a polymer composition as hereinbefore described. Preferably, the moulding process is selected from an injection moulding process, a blow moulding process, a stretch blow moulding process, a thin wall injection

10 moulding process, or a thermoforming process. Preferably, the extruding process is selected from a cast film process or a blow film process. Where a thin wall injection moulding process is used, preferably the polymer base composition comprises a polymer having an MFR of 50 to 70 g/10 min, more preferably about 60 g/10 min. Where a thermoforming process is used, preferably the polymer base composition comprises a

15 polymer having an MFR of 2 to 5 g/10 min. Where a blown film process is used, preferably the polymer base composition comprises a polymer having an MFR of 10 to 15 g/10 min, more preferably about 12 g/10 min. MFR may be measured according to ASTM D 1238 (Year 2020).

20

The present invention also relates to the use of a polymer composition as hereinbefore described to form an article.

EXAMPLES

25

Materials

The polymers and compounds used in the Examples were all available commercially. The polymers and compounds used are summarised in the table below.

Cerium stearate	Depolymerisation catalyst
Aluminium stearate	Depolymerisation catalyst
Magnesium stearate	Depolymerisation catalyst
Manganese stearate	Depolymerisation catalyst
Zinc stearate	Depolymerisation catalyst
Sorbitol	Biofood
1,4-cyclohexane dimethanol dibenzoate	Biofood

Partially hydrolysed polyvinyl alcohol (DH < 50%)	Biofood
Hydroxy acid	Biofood
Homopolypropylene powder (MFR = 12 g/10min, Melting Point = 163 °C)	Polyolefin
Polypropylene (MFR = 2 - 4 g/10 min)	Polymer base composition
Polypropylene (MFR = 60 g/10 min)	Polymer base composition
Stearic acid	Lubricant
Tris(2,4-di-tert.-butylphenyl)phosphite	Antioxidant
Pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate)	Antioxidant
Calcium Stearate	Acid scavenger
Polypropylene g-Maleic anhydride	Compatibiliser

Homopolypropylene powder (P701J) was used as the polyolefin carrier ingredient in the compositions. It was obtained from SCG Chemicals PLC. Its molecular weight properties were as follows, as determined by gel permeation chromatography:

- 5 $M_w = 262,202$ Da
 $M_n = 31,091$ Da
 $M_z = 905,368$ Da

Preparation of Compositions

- 10 The Example compositions were prepared as masterbatches. A dry blend of all ingredients was prepared by using a high-speed mixing equipment (Micron Labomixer) at ambient temperature, without heating, for 2-5 mins. The resulting dry blend was subjected to a twin screw extrusion (Thermo Scientific HAAKE TSE or HAAKE TSE16 mm instrument) with the extruder temperature set at 210-220°C, then pelletizing.
- 15 The resultant composition (masterbatch) in the form of pellets was then stored indoors under ambient temperature (25 to 45 °C, Thailand), well-ventilated conditions in a sealed polypropylene bag.

- 20 The resultant masterbatch compositions are summarised in Table 1, wherein the amounts of the ingredients are specified in wt% unless otherwise specified. All ingredients were provided in pure, undiluted form.

	1	2	3	4	CE1	PO1	PO2
Cerium stearate	2.70	2.70	2.70	2.70	3.33	-	-
Zinc stearate	-	-	2.70	-	3.33	-	-
Aluminium stearate	2.70	2.70	2.70	2.70	3.33	-	-
Magnesium stearate	2.70	2.70	2.70	2.70	-	-	-
Manganese stearate	5.00	5.00	-	5.00	-	-	-
Hydroxy acid	3.50	1.75	-	1.75	1.75		
Sorbitol	-	-	2.50	2.50	-	-	-
1,4-cyclohexane dimethanol dibenzoate	-	-	-	-	10.00	-	-
Partially hydrolysed polyvinyl alcohol	20.00	10.00	10.00	10.00	-	-	-
Homo Polypropylene powder (MFR 12 g/10 min)	59.40	71.15	71.70	68.65	74.25	-	-
Polypropylene (MFR 2-4 g/10 min)	-	-	-	-	-	100	-
Polypropylene (MFR 60 g/10 min)	-	-	-	-	-	-	100
Tris(2,4-di-tert.-butylphenyl)phosphite	1.00	1.00	1.00	1.00	1.00	-	-
Pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate)	1.00	1.00	1.00	1.00	1.00	-	-
Calcium Stearate	1.00	1.00	1.00	1.00	1.00	-	-
Polypropylene g-Maleic anhydride	1.00	1.00	1.00	1.00	1.00	-	-
Stearic acid	-	-	1.00	-	-	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 1

Preparation of Samples for Testing

For biodegradability testing (UV aging test and light exposure test), the above masterbatch compositions were blended at 2 wt% with a polypropylene base

composition. The blended polymer composition was casted into a film with thickness of 400 micron at casting a condition 210 °C using a Collins Cast Film Machine. The cast film sample was then cut into a 5 x 5 cm specimen.

- 5 Polypropylene (MFR = 2 - 4 g/10 min) (P303S) was used as the polymer base composition for preparing samples for biodegradability testing (UV aging test and light exposure test). It was obtained from SCG Chemicals PLC.

10 For visual and mechanical property testing (flexural modulus, tensile modulus, Izod impact), the above masterbatch compositions were blended at 2 wt% with a polypropylene base composition. Samples for testing were then prepared according to the relevant standard protocol (see below)

15 Polypropylene (MFR = 60 g/10 min) (P901J) was used as the polymer base composition for preparing samples for visual and mechanical property testing. It was obtained from SCG Chemicals PLC.

Test Methods

UV aging test according to BSI PAS 9017:2020 (4.3.2)

20 This test is a measure of polymer degradation under conditions of UV irradiation.

Laboratory equipment for UV irradiation was developed in accordance with BSI PAS 9017:2020, with the irradiation source temperature, and irradiation cycle being consistent with those stipulated in the standard. The cycle of the equipment was set to the following:

- 25
- Irradiance: 0.35 W/m² (±0.02 W/m²) using daylight filter at 340 nm
 - UV cycle time: 8 h
 - Dark cycle time: 16 h
 - Air chamber temperature: 60 °C (±2 °C)
 - Uninsulated black panel temperature: 70 °C (±2 °C)

30 Samples were subject to UV aging for a total of 28 days.

Gel permeation chromatography was then used to determine the following parameters:

- 35
- Percentage molecular Weight (M_w) reduction compared to the starting M_w before UV aging
 - Number average molecular weight (M_n)

- Z-average molecular weight (M_z)

The results are shown in Table 4.

5 *Light exposure test*

This test is a measure of polymer degradation under conditions of normal light exposure.

10 Samples were placed inside a glass box with a closed glass lid, size 12 x 24 x 10 inch (WxLxH). The glass box was placed on the building deck in ambient conditions in Thailand during June-August 2021. (Day time temperature and relative humidity are 40-50°C and 60-80% respectively. Night time temperature and relative humidity are 25-35°C and 60-80% respectively), for 3 months.

Gel permeation chromatography was then used to determine the following parameters:

- Percentage molecular Weight (M_w) reduction compared to the starting M_w before
15 light exposure
- Number average molecular weight (M_n)
- Z-average molecular weight (M_z)

The results are shown in Table 5.

20

Gel permeation chromatography (GPC) Analysis:

25 Samples either after light exposure or after UV ageing tests were submitted for molecular weight analysis by GPC, using GPC-IR4, GPC-IR6, POLYMERCHAR. Samples were dissolved in o-dichlorobenzene (o-DCB) using n-heptane as a flow marker, at 150 °C for 90 min. Undissolved matters were filtered off before injecting into the GPC column (column temperature 150 °C).

Mechanical property test

30 This test is a measure of different mechanical properties of samples formed from compositions of the present invention.

35 A dumbbell shape specimen for flexural modulus, tensile modulus and Izod impact analyses were prepared by hand mixing a polymer base composition and masterbatch. The resulting blend was then subjected to an injection moulding process to form a dumbbell specimen (WxLxH = 2x17x0.5 cm). The specimens were then conditioned at

25 °C, relative humidity 60%, for 24-48 hours before being measured for each individual property.

Samples were tested for the following mechanical properties:

5

- Flexural modulus according to ISO 19069-2 (2016)
- Tensile modulus according to ISO 19069-2 (2016)

10

- Izod impact according to ISO 180 (2019)

The results are shown in Table 2.

Visual appearance test

15

This test is a measure of the aesthetic appearance of samples formed from compositions of the present invention.

20

A Haz BYK Haze instrument was used to measure the haze value of the samples. A hand mix blending of 2wt% masterbatch (pellet form) with polymer base composition (in pellet form) was prepared. Then, a mould injection instrument was used to form the polymer composition into a 5x5 cm (WxL) specimen with a 1 mm in thickness. Haze value was then measured after conditioning for 24 hours (25°C, relative humidity 60%).

The results are shown in Table 3.

25

Results

Example 1 - mechanical properties

	1	2	3	4	CE1	PO2
Flexural modulus (MPa)	1,733	1,749	1,773	1,715	1,549	1,785
Tensile modulus (MPa)	1,500	1,526	1,557	1,477	1,701	1,861
Izod Impact @ 23°C (KJ/m ²)	1.45	1.47	1.70	1.42	1.72	1.48

Table 2

The samples according to the present invention had a flexural modulus not significantly different from that of the polymer base composition (PO2). This effect was observed across all samples of the present invention, including with different fatty acid salts, biofoods, and ratios of compositional ingredients. CE1, which lacks a PVA, showed a relatively lower flexural modulus, which was weakened relative to the polymer base composition (PO2). The samples of the present invention are therefore advantageously better able to be form durable articles which retain a defined shape, as compared with CE1.

The samples according to the present invention had a tensile modulus not greatly different from that of the polymer base composition (PO2). This effect was observed across all samples of the present invention, including with different fatty acid salts, biofoods, and ratios of compositional ingredients.

Similarly, the samples according to the present invention retained a high Izod value at room temperature conditions, with the values for each sample not deviating far from that the polymer base composition (PO2). In some cases, the Izod impact value was even improved relative to the polymer base composition. These results are advantageous as it means that the samples of the present invention are able to be formed into durable articles which resist damage from impact at ambient usage conditions.

Overall, the results of Example 1 show that blending a polymer base composition with 2 wt% of the masterbatch compositions of the present invention does not compromise key mechanical properties, as compared with a polymer base composition alone. This is advantageous as it means that articles comprising such masterbatch compositions retain desirable properties for everyday use.

Example 2 – visual appearance

	3	CE1	PO2
Haze	51.90	55.80	44.70

Table 3

Sample 3 according to the present invention showed a haze value which does not differ greatly from that of the polymer base composition (PO2). Articles comprising masterbatch compositions according to the present invention therefore do not suffer greatly in visual appearance compared to the polymer base composition, meaning such articles remain aesthetically pleasing to the end-user.

Example 3 – UV aging

	1	2	CE1
Starting M_w before UV aging (Da)	364,200	375,200	364,000
M_w after UV aging (Da)	10,300	36,000	363,900
M_w Decrease (%)	97.2	90.4	0
M_n after UV aging (Da)	3,900	4,900	48,900
M_z after UV aging (Da)	23,300	27,700	1,104,900

Table 4

10

Samples 1 and 2 according to the present invention comprising PVA showed strong performance in polymer degradation following UV aging. Each of these inventive samples showed a significant percentage decrease in M_w as compared with the starting M_w . The values of M_n and M_z following UV aging were also desirably low. This strong performance was observed for both samples 1 and 2, demonstrating that the advantageous levels of degradation are maintained at different ratios of catalyst:biofood.

15

In contrast, CE1, which lacks PVA, showed a negligible percentage decrease in M_w as compared with the starting M_w . Similarly, the M_z and M_n of CE1 following UV aging were considerably higher than the examples of the present invention. As such, the samples according to the present invention comprising PVA show advantageously improved degradation following UV aging, as compared with CE1 lacking a PVA.

20

Example 4 - light exposure

25

	2	3
Starting M_w before UV aging (Da)	375,200	346,000
M_w after UV aging (Da)	12,600	10,400
M_w Decrease (%)	96.6	97.0

M _n after UV aging (Da)	4,300	3,500
M _z after UV aging (Da)	26,300	29,500

Table 5

Samples 2 and 3 according to the present invention each showed strong performance in polymer degradation following light exposure. Each of these inventive samples showed a significant percentage decrease in M_w as compared with the starting M_w. The values of M_n and M_z following light exposure were also desirably low.

This strong performance was observed for each of the two samples, demonstrating that the advantageous levels of degradation are maintained at different ratios of the compositional ingredients.

As both samples 2 and 3 showed high levels of degradation, the advantageous effects of the present invention were demonstrated for compositions comprising different identities of fatty acid salts.

As both sample 2 and sample 3 showed high levels of degradation, the advantageous effects of the present invention are demonstrated for compositions comprising different identities of biofood.

Summary

Overall, the results of all examples show that the masterbatch compositions of the present invention are highly suitable as polymer degradation additives. Indeed, samples comprising the polymer compositions of the present invention pass the criteria set by *BSI/PAS 9017:2020*. Samples comprising the polymer compositions of the present invention also experience minimal impact on mechanical properties and visual appearance, meaning that articles comprising the compositions are suitable for use by the end-user. Highly desirable levels of polyolefin degradation, following both UV aging and light exposure, are observed for samples comprising the compositions of the present invention. This effect is demonstrated across different compositions of the present invention, comprising different wt% values and ratios of compositional ingredients, different biofoods, and different catalysts. Degradation following UV aging is significantly inferior when using comparative compositions lacking a PVA.

Claims

1. A composition comprising:
 - (i) a polyolefin,
 - 5 (ii) a fatty acid salt of each of three metals selected from Ce, Mn, Al, and Mg; and
 - (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA.
2. The composition as claimed in 1, wherein said polyolefin is selected from polypropylene and polyethylene, preferably polypropylene.
- 10 3. The composition as claimed in any preceding claim, wherein said fatty acid salt is a salt of a fatty acid comprising of 14 to 24 carbon atoms, preferably 16 to 20 carbon atoms, still more preferably 18 carbon atoms, most preferably wherein said fatty acid salt is a salt of stearic acid.
- 15 4. The composition as claimed in any preceding claim, further comprising a polyhydric alcohol, preferably a polyhydric alcohol comprising 2 to 24 carbon atoms, more preferably a polyhydric alcohol comprising 2 to 12 carbon atoms, still more preferably a polyhydric alcohol comprising 4 to 6 carbon atoms, most preferably sorbitol.
- 20 5. The composition as claimed in claim 4, wherein the weight ratio of said polyhydric alcohol to said PVA is 0.05 : 1 to 4 : 1, preferably 0.08 : 1 to 2 : 1, more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1.
- 25 6. The composition as claimed in any preceding claim, further comprising a carboxylic acid, preferably a hydroxy acid, more preferably a hydroxy acid comprising 1 to 12 carbon atoms, still more preferably a hydroxy acid comprising 2 to 10 carbon atoms, most preferably a hydroxy acid comprising 4 to 8 carbon atoms.
- 30 7. The composition as claimed in claim 6, wherein the weight ratio of said carboxylic acid to said PVA is 0.02 : 1 to 4 : 1, preferably 0.08 : 1 to 2 : 1, more preferably 0.10 : 1 to 1.6 : 1, most preferably 0.10 : 1 to 0.35 : 1.
- 35 8. The composition as claimed in any preceding claim, wherein the weight ratio of fatty acid salts of metals selected from Ce, Mn, Al, Mg, and mixtures thereof to said PVA

is 0.2: 1 to 25: 1, preferably 0.5 : 1 to 10 : 1, more preferably 0.6 : 1 to 1.5 : 1, most preferably 0.6 : 1 to 1.3 : 1.

5 9. The composition as claimed in any preceding claim, comprising a fatty acid salt of Mn and a fatty acid salt of at least one metal selected from Ce, Al, and Mg, and wherein the weight ratio of each fatty acid salt of Ce, Al and Mg to said fatty acid salt of Mn is 0.1:1 to 0.9:1, preferably 0.4:1 to 0.7:1.

10 10. The composition as claimed in any preceding claim, wherein said PVA is partially hydrolysed and has a degree of hydrolysis of 40-80%mol, preferably 45-55%mol.

11. The composition as claimed in any preceding claim, further comprising an additive selected from an antioxidant, an acid scavenger, a compatibilizer, a lubricant, and mixtures thereof.

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12. The composition as claimed in any preceding claim, comprising a fatty acid salt of each of Ce, Mn, Al, and Mg.

20 13. A method for preparing a composition according to any preceding claim, comprising mixing:

- (i) a polyolefin,
- (ii) a fatty acid salt of each of three metals selected from Ce, Mn, Al, and Mg; and
- (iii) a polyvinyl alcohol (PVA), preferably a partially hydrolysed PVA.

25 14. An additive, preferably an additive masterbatch, comprising a composition according to any one of claims 1 to 13.

15. A polymer composition comprising:

- (i) an additive, preferably an additive masterbatch, according to claim 14; and
- 30 (ii) a polymer base composition.

16. The polymer composition as claimed in claim 15, wherein said polymer base composition is a polyolefin, preferably a polyethylene or a polypropylene, most preferably a polypropylene.

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17. The polymer composition as claimed in claim 15 or 16, comprising 0.1 to 20 wt%, preferably 0.1 to 10 wt%, more preferably 0.5 to 5 wt%, most preferably 1 to 3 wt% of said additive, preferably an additive masterbatch, based on the total weight of the polymer composition.

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18. The polymer composition as claimed in any one of claims 15 to 17, wherein said polymer composition exhibits a reduction in a flexural modulus (e.g. tested according to method specified in ISO 19069-2 (2016)) of 0 to 10%, preferably 0 to 5%, as compared to the flexural modulus of the same polymer composition lacking an additive according to claim 15, and/or wherein said polymer composition exhibits a reduction in M_w following a 28 days UV aging (e.g. tested according to method specified in BSI PAS 9017:2020) of greater than 90%, more preferably greater than 95%.

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19. An article comprising a polymer composition of any one of claims 15 to 18.