(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 October 2018 (11.10.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/185180 A1

(51) International Patent Classification:
C08K 3/22 (2006.01) *C08L 23/06* (2006.01)
C08K 3/34 (2006.01) *C08L 23/08* (2006.01)
C08K 3/36 (2006.01) *C08K 3/016* (2018.01)
C08K 7/24 (2006.01)

(21) International Application Number:
PCT/EP2018/058638

(22) International Filing Date:
04 April 2018 (04.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
17305417.2 07 April 2017 (07.04.2017) EP

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

WO 2018/185180 A1

(54) Title: FLAME-RETARDANT POLYMER COMPOSITION

(57) Abstract: A flame-retardant polymer composition comprising a polymer, a flame retardant, a high aspect ratio particulate mineral and an intumescent particulate mineral, articles comprising or made from said flame-retardant polymer composition and a method of making said flame-retardant polymer composition.

FLAME-RETARDANT POLYMER COMPOSITION

TECHNICAL FIELD

The present invention relates generally to flame-retardant polymer compositions comprising a polymer, a flame retardant, a high aspect ratio particulate mineral and an intumescent particulate mineral. The present invention further relates to articles comprising or made from said flame-retardant polymer compositions and methods of making said flame-retardant polymer compositions and said articles.

BACKGROUND

It is well-known in the art to produce flame-retardant polymer compositions for various functions. The requirements for the various flame-retardancy properties of a polymer composition may vary depending on the intended final use of the polymer composition. For example, the requirements relating to heat release, smoke production, vertical flame propagation, smoke density, smoke acidity and melt viscosity may vary depending on the intended final use of the polymer composition. It is therefore desirable to provide alternative and/or improved flame-retardant polymer compositions.

SUMMARY

In accordance with a first aspect of the present invention there is provided a flame-retardant polymer composition comprising a polymer, a flame retardant, a high aspect ratio particulate mineral and an intumescent particulate mineral.

In accordance with a second aspect of the present invention there is provided an article made from or comprising a flame-retardant polymer composition according to any aspect or embodiment of the present invention. In certain embodiments, the article is a cable covered with a flame-retardant polymer composition according to any aspect or embodiment of the present invention.

In accordance with a third aspect of the present invention there is provided a method of making a flame-retardant polymer composition according to any aspect or embodiment of the present invention, the method comprising mixing the polymer, the flame retardant, the high aspect ratio particulate mineral and the intumescent mineral.

In certain embodiments, the polymer is polyethylene, polyvinyl acetate, ethylene vinyl acetate or a combination thereof.

In certain embodiments, the flame retardant is aluminium hydroxide (ATH), magnesium hydroxide (MDH) or a combination thereof.

In certain embodiments, the high aspect ratio particulate mineral is talc, mica, wollastonite, halloysite or a combination of one or more thereof.

In certain embodiments, the intumescent particulate material is perlite. In certain embodiments, the intumescent particulate mineral is unexpanded perlite.

Certain embodiments of any aspect of the present invention may provide one of more of the following advantages:

- good (for example, reduced) flame-retardancy properties (e.g. good or reduced heat release, smoke production, flame spread, vertical flame propagation, smoke density, smoke acidity and melt viscosity);
- use of a reduced amount of polymer;
- use of a reduced amount of flame retardant.

The details, examples and preferences provided in relation to any particulate one or more of the stated aspects of the present invention will be further described herein and apply equally to all aspects of the present invention. Any combination of the embodiments, examples and preferences described herein in all possible variations thereof is encompassed by the present invention unless otherwise indicated herein, or otherwise clearly contradicted by context.

DETAILED DESCRIPTION

There is provided herein a flame-retardant polymer composition comprising a polymer, a flame retardant, a high aspect ratio particulate mineral and an intumescent particulate mineral. In certain embodiments, the flame-retardant polymer composition consists essentially of a polymer, a flame retardant, a high aspect ratio particulate mineral, an intumescent particulate mineral and optionally a siliceous mineral. In certain embodiments, the flame-retardant polymer composition consists of a polymer, a flame

retardant, a high aspect ratio particulate mineral, an intumescent particulate mineral and optionally a siliceous mineral. The term "consisting essentially of" may, for example, exclude an additional element, step or ingredient not explicitly recited unless the additional element, step or ingredient does not materially affect the basic and novel properties of the invention. Where the one or more additional element(s), step(s) or ingredient(s) is/are one or more additional component(s) of a composition, the total amount of the additional component(s) in the composition may, for example, be limited to 10 wt%. For example, the total amount of the additional component(s) in the composition may be limited to 9 wt% or 8 wt% or 7 wt% or 6 wt% or 5 wt% or 4 wt% or 3 wt% or 2 wt% or 1 wt%.

The polymer may, for example, be a thermoplastic polymer. The polymer may, for example, be present in the form of a polymer matrix. The other components of the flame-retardant polymer composition (e.g. the flame retardant, the lamellar particulate mineral, the intumescent particulate mineral) are dispersed in the polymer matrix. The polymer may, for example, be polyalkylene (e.g. polyethylene, polypropylene or polybutylene), polyvinyl ester (general formula $-[RCOOCHCH_2]-$), polystyrene, polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol, polyacrylonitrile, acrylonitrile butadiene styrene, polyamide, polylactic acid, polybenzimidazole, polybenzoxazole, polybenzthiazole, polycarbonate, polyether sulfone, polyetherether ketone, polyimide, polyetherimide, polyphenylene sulfide, polytetrafluoroethylene, polyvinyl acetate (e.g. ethylene vinyl acetate or poly(meth methacrylate)), or a combination of two or more thereof. In certain embodiments, the polymer is polyethylene, polyvinyl acetate, ethylene vinyl acetate or a combination of two or more thereof. Hereinafter, the present invention may tend to be discussed in terms of a blend of ethylene vinyl acetate and polyethylene. However, the present invention should not be construed as being limited to such embodiment.

The polymer may, for example, be present in the flame-retardant polymer composition in an amount of at least about 30 % based on the total weight of the flame-retardant polymer composition. For example, the polymer may be present in the flame-retardant polymer composition in an amount of at least about 35 wt% or at least about 40 wt% or at least about 45 wt% or at least about 50 wt% or at least about 55 wt% or at least about 60 wt% based on the total weight of the flame-retardant polymer composition.

The polymer may, for example, be present in the flame-retardant polymer composition in an amount up to about 80 wt%, for example up to about 75 wt%, for example up to about 70 wt%, for example up to about 65 wt% based on the total weight of the flame-retardant polymer composition. The polymer may, for example, be present in the flame-retardant polymer composition in an amount ranging from about 30 wt% to about 80 wt% or from about 30 wt% to about 70 wt% or from about 30 wt% to about 60 wt% or from about 40 wt% to about 80 wt% or from about 40 wt% to about 70 wt% or from about 40 wt% to about 60 wt% based on the total weight of the flame-retardant polymer composition.

The term “flame retardant” refers to any chemical that, when added to a polymer, can prevent fire, inhibit or delay the spread of fire and/or limit the damage caused by fire.

The flame retardant may, for example, work by one or more of endothermic degradation, thermal shielding, dilution of gas phase and gas phase radical quenching. Flame retardants that work by endothermic degradation remove heat from the substrate and thus cool the material. Flame retardants that work by thermal shielding create a thermal insulation barrier between the burning and unburned parts of the material, for example by forming a char, which separates the flame from the material and slows heat transfer to the unburned material. Flame retardants that work by dilution of the gas phase produce inert gases (e.g. carbon dioxide and/or water) by thermal degradation and thus dilute the combustible gases, thus lowering the partial pressures of the combustible gases and oxygen and slowing the reaction rate. Flame retardants that work by gas phase radical quenching release substances such as hydrogen chloride and hydrogen bromide that react with H and OH radicals in the flame, forming less reactive radicals (e.g. Cl and Br radicals), which have much lower potential to propagate the radical oxidation reactions. In certain embodiments, the flame retardant used in the flame-retardant polymer compositions disclosed herein work by endothermic degradation and/or dilution of the gas phase.

The flame retardant may, for example, be a particulate mineral flame retardant, an organohalogen and/or a phosphorous and/or nitrogen-containing compound.

The particulate mineral flame retardant may, for example, be aluminium hydroxide (ATH – $Al(OH)_3$), magnesium hydroxide (MDH – $Mg(OH)_2$), a combination of huntite and hydromagnesite, a particulate mineral hydrate, red phosphorous, a borate, or a

combination of one or more thereof. In certain embodiments, the particulate mineral flame retardant is aluminium hydroxide, magnesium hydroxide or a combination of huntite and hydromagnesite. Hereinafter, the present invention may tend to be discussed in terms of aluminium hydroxide or magnesium hydroxide. However, the present invention should not be construed as being limited to such embodiment.

The aluminium hydroxide may, for example, be gibbsite, bayerite, nordstrandite, doyleite or a combination of one or more thereof. The magnesium hydroxide may, for example, be brucite, chlorite or a combination of one or more thereof.

The particulate mineral flame retardant may, for example, be coated with surface treatment agent such as a fatty acid (e.g. stearic acid), fatty acid ester (e.g. stearate) or silane. This may, for example, assist in compounding with the polymer matrix.

The organohalogen compound may, for example, be an organochloride (e.g. chlorendic acid derivatives, chlorinated paraffin), an organobromide (e.g. decabromodiphenyl ether, decabromodiphenyl ethane, brominated polystyrenes, brominated carbonate oligomers, brominated epoxy oligomers, tetrabromophthalic anhydride, tetrabromobisphenol A, hexabromocyclododecane), a halogenated organophosphate (e.g. tris(1,3-dichloro-2-propyl)phosphate, tetrakis(2-chlorethyl)dichloroisoentyldiphosphate), or a combination of one or more thereof.

Organohalogen compounds may, for example, be used in combination with a synergist to enhance their efficacy. Synergists include antimony-containing compounds such as antimony trioxide, antimony pentoxide and sodium antimonite.

The phosphorous and/or nitrogen-containing compound may, for example, be red phosphorous, a phosphate, a polyphosphate (e.g. melamine polyphosphate), an organophosphate (e.g. triphenyl phosphate (TPP), resorcinol bis(diphenylphosphate) (RDP), bisphenol A diphenyl phosphate (BADP), tricresyl phosphate (TCP)), a phosphonate (e.g. dimethyl methylphosphonate (DMMP), a phosphinate (e.g. aluminium diethyl phosphinate), a halogenated organophosphate (e.g. tris(1,3-dichloro-2-propyl)phosphate, tetrakis(2-chlorethyl)dichloroisoentyldiphosphate), a phosphazene, a polyphosphazene, a triazine or a combination of one or more thereof.

The flame retardant may, for example, be present in the flame-retardant polymer composition in an amount of at least about 50 % based on the total weight of filler in the flame-retardant polymer composition. In other words, at least about 50 wt% of the filler (non-polymer) present in the flame-retardant polymer composition is the flame retardant. For example, the flame retardant may be present in the flame-retardant polymer composition in an amount of at least about 52 wt% or at least about 54 wt% or at least about 55 wt% or at least about 57 wt% or at least about 59 wt% or at least about 60 wt% based on the total weight of filler in the flame-retardant polymer composition. For example, the flame retardant may be present in the flame-retardant polymer composition in an amount up to about 70 wt% or up to about 69 wt% or up to about 68 wt% or up to about 67 wt% or up to about 66 wt% or up to about 65 wt% or up to about 64 wt% or up to about 63 wt% or up to about 62 wt% or up to about 61 wt% or up to about 60 wt% based on the total weight of filler in the flame-retardant polymer composition.

The flame retardant may, for example, be present in the flame-retardant polymer composition in an amount of at least about 15 wt% based on the total weight of the flame-retardant polymer composition. For example, the flame retardant may be present in the flame-retardant polymer composition in an amount of at least about 20 wt% or at least about 25 wt% or at least about 30 wt% or at least about 32 wt% or at least about 34 wt% or at least about 35 wt% or at least about 36 wt% or at least about 38 wt% or at least about 40 wt% or at least about 42 wt% or at least about 44 wt% or at least about 45 wt% based on the total weight of the flame-retardant polymer composition. For example, the flame retardant may be present in the flame-retardant polymer composition in an amount up to about 60 wt% or up to about 58 wt% or up to about 56 wt% or up to about 55 wt% or up to about 54 wt% or up to about 52 wt% or up to about 50 wt% based on the total weight of the flame-retardant polymer composition.

The term “high aspect ratio particulate mineral” refers to a mineral having particles that are acicular or lamellar. Lamellar particles generally have a small, flat and flaky or platy appearance. Acicular particles generally have a long, thin fibre or needle-like appearance.

The high aspect ratio particulate mineral may, for example, be selected from talc, mica, wollastonite, halloysite and combinations of one or more thereof.

A particulate talc mineral refers to lamellar particulate material made of hydrated magnesium silicate having the chemical formula $H_2Mg_3(SiO_3)_4$ or $Mg_3Si_4O_{10}(OH)_2$, or the mineral chlorite (hydrated magnesium aluminium silicate), a combination thereof, or a mineral substance derived therefrom and having similar properties.

The particulate talc mineral may, for example, be obtained from a natural source by grinding. For example, the particulate talc mineral may be obtained by or obtainable by delamination of talc suspended in a liquid.

Natural talc particulate is typically obtained by crushing and then grinding a mineral source of talc, which may be followed by a particle size classification step, in order to obtain a product having a desired particle size distribution. The particulate solid material may be ground autogenously, i.e. by attrition between the particles of the solid material themselves, or, alternatively, in the presence of a particulate grinding medium comprising particles of a different material from the talc particulate to be ground. These processes may be carried out with or without the presence of a dispersant and biocides, which may be added at any stage of the process.

In certain embodiments, the talc particulate is obtained and/or obtainable by a process according to that described in US-A-6348536, the entire contents of which are hereby incorporated by reference.

More particularly, the talc particulate may be prepared by a process comprising:

(a) talc with a predetermined initial particle size is suspended in a liquid,

(b) the suspension is subjected to a delamination operation adapted so as to produce a separation of the leaves of the particles and so as to obtain a particle size less than the initial particle size,

(c) optionally subjecting the suspension to a selection as to eliminate particles with a size greater than a predetermined size,

(d) drying the suspension, and

(e) optionally treating the particles so as to limit the creation of strong bonds between them.

The starting talc is typically chosen having an initial particle size which is greater than the desired particle size. In certain embodiments, the starting talc is suspended in water in the presence of a dispersing agent such that the weight of dry matter based on

the total weight of the suspension is from about 10 % to about 60 %. The suspension is typically homogenous. The grinding operation during delamination is, in certain embodiments, carried out as to obtain a $d_{50laser}$ of from about 10 µm to about 50 µm. The selection step may comprise hydrodynamic selection, which may be carried out in a turbine selector or in a hydrocyclone or in a centrifuge with an endless extraction screw. The suspension is advantageously dried in such a way as to reach a residual liquid level below 1 %.

In certain embodiments, the talc particulate is prepared by a process comprising:

(a) delaminating a liquid suspension of a relatively coarse talc particulate having an initial particle size with a $d_{50laser}$ which is greater than a desired $d_{50laser}$ (e.g., greater than a desired $d_{50laser}$ of from about 10 µm to about 50 um, or from about 10 µm to about 35 µm), to obtain a talc particulate having a particle size less than the initial particle size;

(b) at least partially drying the suspension thereby obtaining a talc particulate having the desired $d_{50laser}$ and optionally a desired lamellarity index.

In certain embodiments, the inorganic particulate, for example, talc particulate is not chemically treated during processing to obtain the desired particle size and lamellarity.

A particulate mica mineral refers to a group of lamellar phyllosilicate minerals having the general formula $X_2Y_{4-6}Z_8O_{20}(OH,F)_4$, where X is K, Na, Ca, Ba, Rb or Cs (usually K, Na, or Ca), Y is Al, Mg, Fe, Mn, Cr, Ti, Li (usually Al, Mg or Fe), and Z is Si, Al, Fe^{3+} or Ti (usually Si or Al). Micas can be dioctahedral (Y = 4) or trioctahedral (Y = 6). Common mica has K or Na as X, brittle mica has Ca as X. Mica minerals have nearly perfect basal cleavage and are monoclinic, with a tendency towards pseudohexagonal crystals.

A particulate wollastonite mineral refers to a calcium inosilicate mineral ($CaSiO_3$) that may contain small amounts of iron, magnesium and/or manganese substituting for calcium. Wollastonite contains chains of $[SiO_4]$ tetrahedral sharing common vertices, running parallel to the b-axis. The chain motif repeats after three tetrahedral. Wollastonite crystals are generally acicular in shape.

A particulate halloysite mineral refers to a lamellar or acicular monoclinic aluminosilicate clay mineral with the empirical formula $Al_2Si_2O_5(OH)_4$. Halloysite can be

hydrated or unhydrated. The halloysite may, for example, have a moisture content equal to or less than about 5 wt% or equal to or less than about 4 wt% or equal to or less than about 3 wt% based on the total weight of the halloysite mineral.

When a particulate mineral (e.g. particulate mineral flame retardant, high aspect ratio particulate mineral, intumescent particulate mineral) is obtained from naturally occurring sources, it may be that some mineral impurities will inevitably contaminate the ground material. For example, naturally occurring talc may occur in association with other minerals such as dolomite. Also, in some circumstances, minor additions of other minerals may be included, for example, one or more of dolomite, kaolin, calcined kaolin, wollastonite, bauxite, or mica, could also be present. In general, however, the particulate minerals used in the invention will each contain less than 5% by weight, for example less than 2 wt%, for example less than 1% by weight of other minerals.

In some embodiments, the particulate minerals (e.g. particulate mineral flame retardant, high aspect ratio particulate mineral and/or intumescent particulate mineral) each independently undergoes minimal processing following mining or extraction. In a further embodiment, the particulate mineral is subjected to at least one physical modification process. The skilled artisan will readily know physical modification processes appropriate for use, which may be now known or hereafter discovered; appropriate physical modification processes include, but are not limited to, comminution (e.g. crushing, grinding, milling), drying, and classifying (e.g. air classification, hydrodynamic selection, screening and/or sieving). In yet other embodiments, the particulate minerals are each independently subjected to at least one chemical modification process. The skilled artisan will readily know chemical modification processes appropriate for use in the present inventions, which may be now known or hereafter discovered; appropriate chemical modification processes include but are not limited to, silanization and calcination. The particulate talc material may, for example, be surface treated or surface untreated. The surface treatment may, for example, serve to modify a property of the talc particulate and/or the liquid composition into which it is incorporated. In certain embodiments, the surface treatment is present in an amount up to about 5 wt. %, based on the total weight of particulate mineral, for example, from about 0.001 wt. % to about 5 wt. %, or from about 0.01 wt. % to about 2 wt. %, or from about 0.1 wt. % to about 2 wt. %, or from about 0.5 wt. % to about 1.5 wt. %, based on the total weight of particulate mineral. In certain embodiments, the particulate mineral is not surface treated.

The high aspect ratio particulate mineral (e.g. halloysite) may, for example, have a moisture content equal to or less than about 5 % based on the total weight of the high aspect ratio particulate mineral. For example, the high aspect ratio particulate mineral (e.g. halloysite) may have a moisture content equal to or less than about 4.5 wt% or equal to or less than about 4 wt% or equal to or less than about 3.5 wt% or equal to or less than about 3 wt% based on the total weight of the high aspect ratio particulate mineral. For example, the high aspect ratio particulate mineral may have a moisture content of at least about 0.5 wt% or at least about 1 wt% based on the total weight of the high aspect ratio particulate mineral.

The high aspect ratio particulate mineral may, for example, have an aspect ratio ranging from about 2 to about 150. For example, the high aspect ratio particulate mineral may have an aspect ratio ranging from about 2 to about 145 or from about 2 to about 140 or from about 2 to about 135 or from about 2 to about 130 or from about 2 to about 125 or from about 2 to about 120 or from about 2 to about 115 or from about 2 to about 110 or from about 2 to about 105 or from about 2 to about 100. For example, the high aspect ratio particulate mineral may have an aspect ratio ranging from about 3 to about 95 or from about 4 to about 90 or from about 5 to about 85 or from about 6 to about 80 or from about 7 to about 75 or from about 8 to about 70 or from about 9 to about 65 or from about 10 to about 60.

As used in herein, the expression “aspect ratio” means the diameter of the circle of area equivalent to that of a face of the particle divided by the mean thickness of that particle. Aspect ratio may be determined using electron microscopy methods. For example, for a given particle, for a superimposed circle having an area equivalent to that of the face of the particle, where the diameter of that circle is d, the thickness of the particle is t, the aspect ratio of the particle is d divided by t.

Alternatively or additionally, the aspect ratio for platy minerals such as talc and mica may also, for example, be calculated by particle size analysis using the Parslow/Jennings or Pabst Equation.

$$\text{Aspect Ratio} = \frac{3\pi}{4} \cdot \left(d_{50\,(\text{laser})} / d_{50\,(\text{sedigraph})}\right)^2$$

The high aspect ratio particulate mineral may, for example, have a d_{50} (sedigraph) ranging from about 0.5 μm to about 20 μm. For example, the high aspect ratio particulate mineral may have a d_{50} (sedigraph) ranging from about 1 μm to about 20 μm or from about 2 μm to about 19 μm or from about 3 μm to about 18 μm or from about 4 μm to about 17 μm or from about 5 μm to about 16 μm or from about 6 μm to about 15 μm or from about 7 μm to about 14 μm or from about 8 μm to about 13 μm or from about 9 μm to about 12 μm or from about 10 μm to about 11 μm.

The high aspect ratio particulate mineral may, for example, have a d_{10} (sedigraph) ranging from about 0.05 μm to about 2 μm. For example, the high aspect ratio particulate mineral may have a d_{10} (sedigraph) ranging from about 0.1 μm to about 1.9 μm or from about 0.2 μm to about 1.8 μm or from about 0.3 μm to about 1.7 μm or from about 0.4 μm to about 1.6 μm or from about 0.5 μm to about 1.5 μm or from about 0.6 μm to about 1.4 μm or from about 0.7 μm to about 1.3 μm or from about 0.8 μm to about 1.2 μm or from about 0.9 μm to about 1.1 μm.

The high aspect ratio particulate mineral may, for example, have a d_{90} (sedigraph) ranging from about 3 μm to about 50 μm. For example, the high aspect ratio particulate mineral may have a d_{90} (sedigraph) ranging from about 4 μm to about 45 μm or from about 5 μm to about 40 μm or from about 6 μm to about 39 μm or from about 7 μm to about 38 μm or form about 8 μm to about 37 μm or from about 9 μm to about 36 μm or from about 10 μm to about 35 μm or from about 11 μm to about 34 μm or from about 12 μm to about 33 μm or from about 13 μm to about 32 μm or from about 14 μm to about 31 μm or from about 15 μm to about 30 μm or from about 16 μm to about 29 μm or from about 17 μm to about 28 μm or from about 18 μm to about 27 μm or from about 19 μm to about 26 μm or from about 20 μm to about 25 μm.

The high aspect ratio particulate mineral may, for example, have a d_{95} (sedigraph) ranging from about 3 μm to about 60 μm. For example, the high aspect ratio particulate mineral may have a d_{95} (sedigraph) ranging from about 4 μm to about 55 μm or from about 5 μm to about 50 μm or from about 5 μm to about 45 μm or from about 5 μm to about 40 μm or from about 6 μm to about 39 μm or from about 7 μm to about 38 μm or form about 8 μm to about 37 μm or from about 9 μm to about 36 μm or from about 10 μm to about 35 μm or from about 11 μm to about 34 μm or from about 12 μm to about 33 μm or from about 13 μm to about 32 μm or from about 14 μm to about 31 μm or from about 15 μm to about 30 μm or from about 16 μm to about 29 μm or from about

17 µm to about 28 µm or from about 18 µm to about 27 µm or from about 19 µm to about 26 µm or from about 20 µm to about 25 µm.

The high aspect ratio particulate mineral may, for example, have a d_{50} (laser) ranging from about 5 µm to about 40 µm. For example, the high aspect ratio particulate mineral may have a d_{50} (laser) ranging from about 6 µm to about 39 µm or from about 7 µm to about 38 µm or from about 8 µm to about 37 µm or from about 9 µm to about 36 µm or from about 10 µm to about 35 µm or from about 11 µm to about 34 µm or from about 12 µm to about 33 µm or from about 13 µm to about 32 µm or from about 14 µm to about 31 µm or from about 15 µm to about 30 µm or from about 16 µm to about 29 µm or from about 17 µm to about 28 µm or from about 18 µm to about 27 µm or from about 19 µm to about 26 µm or from about 20 µm to about 25 µm.

The high aspect ratio particulate mineral may, for example, have a d_{10} (laser) ranging from about 2 µm to about 10 µm. For example, the high aspect ratio particulate mineral may have a d_{10} (laser) ranging from about 3 µm to about 9 µm or from about 4 µm to about 8 µm or from about 5 µm to about 7 µm or from about 6 µm to about 7 µm.

The high aspect ratio particulate mineral may, for example, have a d_{90} (laser) ranging from about 20 µm to about 80 µm. For example, the high aspect ratio particulate mineral may have a d_{90} (laser) ranging from about 20 µm to about 75 µm or from about 20 µm to about 70 µm or from about 25 µm to about 65 µm or from about 30 µm to about 60 µm or from about 35 µm to about 55 µm or from about 40 µm to about 50 µm or from about 45 µm to about 50 µm.

The high aspect ratio particulate mineral may, for example, have a d_{95} (laser) ranging from about 20 µm to about 100 µm. For example, the high aspect ratio particulate mineral may have a d_{95} (laser) ranging from about 20 µm to about 95 µm or from about 20 µm to about 90 µm or from about 20 µm to about 85 µm or from about 20 µm to about 80 µm or from about 25 µm to about 75 µm or from about 30 µm to about 70 µm or from about 35 µm to about 65 µm or from about 40 µm to about 60 µm or from about 45 µm to about 55 µm or from about 50 µm to about 55 µm.

The high aspect ratio particulate mineral (e.g. talc) may, for example, have a lamellarity index equal to or greater than about 2.8. For example, the high aspect ratio particulate mineral (e.g. talc) may have a lamellarity index equal to or greater than about 2.9 or

equal to or greater than about 3.0 or equal to or greater than about 3.1 or equal to or greater than about 3.2 or equal to or greater than about 3.3 or equal to or greater than about 3.4 or equal to or greater than about 3.5 or equal to or greater than about 3.6 or equal to or greater than about 3.7 or equal to or greater than about 3.8 or equal to or greater than about 3.9 or equal to or greater than about 4 or equal to or greater than about 4.1 or equal to or greater than about 4.2 or equal to or greater than about 4.3 or equal to or greater than about 4.4 or equal to or greater than about 4.5 or equal to or greater than about 4.6 or equal to or greater than about 4.7 or equal to or greater than about 4.8 or equal to or greater than about 4.9 or equal to or greater than about 5 or equal to or greater than about 5.1 or equal to or greater than about 5.2 or equal to or greater than about 5.3 or equal to or greater than about 5.4 or equal to or greater than about 5.5 or equal to or greater than about 5.6 or equal to or greater than about 5.7 or equal to or greater than about 5.8 or equal to or greater than about 5.9 or equal to or greater than about 6 or equal to or greater than about 6.1 or equal to or greater than about 6.2 or equal to or greater than about 6.3 or equal to or greater than about 6.4 or equal to or greater than about 6.5 or equal to or greater than about 6.6 or equal to or greater than about 6.7 or equal to or greater than about 6.8 or equal to or greater than about 6.9 or equal to or greater than about 7.

The high aspect ratio particulate mineral (e.g. talc) may, for example, have a lamellarity index equal to or less than about 20. For example, the high aspect ratio particulate mineral (e.g. talc) may have a lamellarity index equal to or less than about 15 or equal to or less than about 10 or equal to or less than about 9.5 or equal to or less than about 9 or equal to or less than about 8.5 or equal to or less than about 8 or equal to or less than about 7.5.

In certain embodiments, the high aspect ratio particulate mineral is talc having a d_{10} (sedigraph) ranging from about 0.2 μm to about 0.8 μm and a d_{50} (sedigraph) ranging from about 2 μm to about 3.5 μm. In certain embodiments, the high aspect ratio particulate mineral (talc) further has a d_{95} (sedigraph) ranging from about 5 μm to about 25 μm. In certain embodiments, the high aspect ratio particulate mineral (talc) further has a d_{95} (sedigraph) ranging from about 5 μm to about 15 μm and a lamellarity index ranging from about 3 to about 4. In certain embodiments, the high aspect ratio particulate mineral (talc) further has a d_{95} (sedigraph) ranging from about 15 μm to about 25 μm and a lamellarity index ranging from about 5 to about 9.

In certain embodiments, the high aspect ratio particulate mineral is talc having a d_{10} (laser) ranging from about 2 μm to about 8 μm and a d_{50} (laser) ranging from about 8 μm to about 25 μm. In certain embodiments, the high aspect ratio particulate mineral (talc) further has a d_{95} (laser) ranging from about 25 μm to about 65 μm. In certain embodiments, the high aspect ratio particulate mineral (talc) has a d_{50} (laser) ranging from about 8 μm to about 15 μm and a d_{95} (laser) ranging from about 20 μm to about 30. In certain embodiments, the high aspect ratio particulate mineral (talc) has a d_{50} (laser) ranging from about 8 μm to about 15 μm and a d_{95} (laser) ranging from about 20 μm to about 30 and a lamellarity index ranging from about 3 to about 5. In certain embodiments, the high aspect ratio particulate mineral (talc) has a d_{50} (laser) ranging from about 8 μm to about 15 μm and a d_{95} (laser) ranging from about 25 μm to about 35 μm and/or a lamellarity index ranging from about 3 to about 4. In certain embodiments, the high aspect ratio particulate mineral (talc) has a d_{50} (laser) ranging from about 15 μm to about 30 μm (e.g. from about 15 μm to about 25 μm) and a d_{95} (laser) ranging from about 50 μm to about 70 μm (e.g. from about 55 μm to about 65 μm) and/or a lamellarity index ranging from about 5 to about 9.

Lamellarity index characterizes the shape and flatness of particles (large dimension/thickness). The term “lamellarity index” is defined by the following ratio:

$$\frac{d_{50laser} - d_{50sedi}}{d_{50sedi}}$$

in which “$d_{50laser}$” is the value of the mean particle size (d_{50}) obtained using a laser particle size analyser as described herein and “d_{50sedi}” is the value of the median diameter obtained by sedimentation using a sedigraph (standard ISO 13317-3), as described herein. Reference may be made to the article by G. Baudet and J. P. Rona, Ind. Min. Mines et Carr. Les techn. June, July 1990, pp 55-61, which shows that this index is correlated to the mean ratio of the largest dimension of the particle to its smallest dimension.

In the sedimentation technique referred to above, particle size properties referred to herein for the talc particulate materials are as measured in a well-known manner by sedimentation of the particulate material in a fully dispersed condition in an aqueous medium using a Sedigraph 5100 machine as supplied by Micromeritics Instruments Corporation, Norcross, Georgia, USA (www.micromeritics.com), referred to herein as a “Micromeritics Sedigraph 5100 unit”, and based on application of Stokes’ Law. Such a

machine provides measurements and a plot of the cumulative percentage by weight of particles having a size, referred to in the art as the 'equivalent spherical diameter' (e.s.d), less than given e.s.d values. The mean particle size d_{50sedi} is the value determined in this way of the particle e.s.d at which there are 50% by weight of the particles which have an equivalent spherical diameter less than that d_{50} value. The d_{95sedi} value is the value at which 95% by weight of the particles have an esd less than that d_{95sedi} value. Particle size properties may be determined in accordance with ISO 13317-3, or any method equivalent thereto. In certain embodiments, the particle size ranges measured by sedigraph relate to the lamellar minerals. In certain embodiments, the particle size ranges measured by sedigraph relate to talc.

In the laser technique referred to above, particle size properties referred to herein for the particulate talc materials are measured by wet Malvern laser scattering (standard ISO 13320-1). In this technique, the size of particles in powders, suspensions and emulsions may be measured using the diffraction of a laser beam, based on the application of Mie theory. Such a machine, for example a Malvern Mastersizer S (as supplied by Malvern instruments) provides measurements and a plot of the cumulative percentage by volume of particles having a size, referred to in the art as the "equivalent spherical diameter" (e.s.d), less than given e.s.d values. The mean particle size d_{50} is the value determined in this way of the particle e.s.d. at which there are 50% by weight of the particles which have an equivalent spherical diameter less than that d_{50} value. For the avoidance of doubt, the measurement of particle size using laser light scattering is not an equivalent method to the sedimentation method referred to above. In certain embodiments, the particle size ranges measured by the laser technique refer to acicular minerals. In certain embodiments, the particle size ranges measured by laser relate to wollastonite and/or halloysite.

As used herein, d_{50} (sedigraph) and d_{50} (laser) refer to the d_{50} values measured respectively, according to the sedigraph or laser techniques described above.

The high aspect ratio particulate mineral (e.g. talc) may, for example, have a BET surface area equal to or greater than about 1 m^2/g. For example, the high aspect ratio particulate mineral (e.g. talc) may have a BET surface area equal to or greater than about 2 m^2/g or equal to or greater than about 3 m^2/g or equal to or greater than about 4 m^2/g or equal to or greater than about 5 m^2/g or equal to or greater than about 6 m^2/g or equal to or greater than about 7 m^2/g or equal to or greater than about 8 m^2/g

or equal to or greater than about 9 m^2/g or equal to or greater than about 10 m^2/g. In certain embodiments, the high aspect ratio particulate mineral has a BET surface area equal to or greater than about 10 m^2/g or equal to or greater than about 11 m^2/g or equal to or greater than about 12 m^2/g or equal to or greater than about 13 m^2/g or equal to or greater than about 14 m^2/g or equal to or greater than about 15 m^2/g.

The high aspect ratio particulate mineral (e.g. talc) may, for example, have a BET surface area equal to or less than about 30 m^2/g. For example, the high aspect ratio particulate mineral (e.g. talc) may have a BET surface area equal to or less than about 25 m^2/g or equal to or less than about 24 m^2/g or equal to or less than about 23 m^2/g or equal to or less than about 22 m^2/g or equal to or less than about 21 m^2/g or equal to or less than about 20 m^2/g.

The high aspect ratio particulate mineral (e.g. talc) may, for example, have a BET surface area ranging from about 1 m^2/g to about 25 m^2/g or from about 10 m^2/g to about 25 m^2/g or from about 10 m^2/g to about 20 m^2/g.

In certain embodiments, the high aspect ratio particulate mineral is talc having a BET surface area ranging from about 10 m^2/g to about 30 m^2/g or from about 10 m^2/g to about 25 m^2/g or from about 10 m^2/g to about 20 m^2/g.

In certain embodiments, the high aspect ratio particulate mineral is mica having a BET surface area ranging from about 5 m^2/g to about 20 m^2/g or from about 5 m^2/g to about 15 m^2/g or from about 5 m^2/g to about 10 m^2/g.

In certain embodiments, the high aspect ratio particulate mineral is halloysite having a BET surface area ranging from about 10 m^2/g to about 30 m^2/g or from about 15 m^2/g to about 25 m^2/g or from about 18 m^2/g to about 22 m^2/g.

In certain embodiments, the high aspect ratio particulate mineral is wollastonite having a BET surface area ranging from about 1 m^2/g to about 10 m^2/g or from about 1 m^2/g to about 5 m^2/g or from about 1 m^2/g to about 3 m^2/g.

As used herein, “BET surface area” refers to the area of the surface of the particles of the particulate talc material with respect to unit mass, determined according to the BET method by the quantity of nitrogen adsorbed on the surface of said particles so as to

form a monomolecular layer completely covering said surface (measurement according to the BET method, AFNOR standard X11-621 and 622 or ISO 9277). In certain embodiments, BET surface area is determined in accordance with ISO 9277 or any method equivalent thereto.

In certain embodiments, the high aspect ratio particulate mineral is talc having a d_{50} (sedigraph) ranging from about 1 µm to about 8 µm (e.g. from about 2 µm to about 8 µm) and BET surface area of at least about 10 m^2/g. In certain embodiments, the high aspect ratio particulate mineral is talc having a d_{50} (sedigraph) ranging from about 8 µm to about 15 µm and a BET surface area of at least about 5 m^2/g. In certain embodiments, the high aspect ratio particulate mineral is talc having a d_{50} (sedigraph) ranging from about 1 µm to about 8 µm (e.g. from about 2 µm to about 8 µm) and a lamellarity index of at least about 3.

In certain embodiments, the high aspect ratio particulate mineral is wollastonite having a d_{50} (laser) ranging from about 4 µm to about 10 µm. In certain embodiments, the wollastonite further has a d_{95} (laser) ranging from about 30 µm to about 40 µm. In certain embodiments, the wollastonite further has a d_{10} (laser) ranging from about 0.5 µm to about 3 µm. In certain embodiments, the wollastonite further has an aspect ratio ranging from about 4 to about 10. In certain embodiments, the wollastonite further has a d_{95} (laser) ranging from about 30 µm to about 40 µm and a d_{10} (laser) ranging from about 0.5 µm to about 3 µm and an aspect ratio ranging from about 4 to about 10.

In certain embodiments, the high aspect ratio particulate mineral is mica having a d_{50} (sedigraph) ranging from about 1 µm to about 9 µm or ranging from about 2 µm to about 8 µm or ranging from about 3 µm to about 7 µm. In certain embodiments, the mica further has a d_{90} (sedigraph) ranging from about 20 µm to about 35 µm. In certain embodiments, the mica further has a d_{10} (sedigraph) ranging from about 0.05 µm to about 2 µm.

The high aspect ratio particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount of at least about 5 % based on the total weight of the flame-retardant polymer composition. For example, the high aspect ratio particulate mineral may be present in the flame-retardant polymer composition in an amount of at least about 5.5 wt% or at least about 6 wt% or at least about 6.5 wt% or at least about 7 wt% or at least about 7.5 wt% or at least about 8 wt% or at least about

8.5 wt% or at least about 9 wt% or at least about 9.5 wt% or at least about 10 wt% or at least about 10.5 wt% or at least about 11 wt% or at least about 11.5 wt% or at least about 12 wt% based on the total weight of the flame-retardant polymer composition.

The high aspect ratio particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount up to about 25 % based on the total weight of the flame-retardant polymer composition. For example, the high aspect ratio particulate mineral may be present in the flame-retardant polymer composition in an amount up to about 24 wt% or up to about 23 wt% or up to about 22 wt% or up to about 21 wt% or up to about 20 wt% or up to about 19 wt% or up to about 18 wt% or up to about 17 wt% or up to about 16 wt% or up to about 15 wt% based on the total weight of the flame-retardant polymer composition.

For example, the high aspect ratio particulate mineral may be present in the flame-retardant polymer composition in an amount ranging from about 5 wt% to about 25 wt% or from about 10 wt% to about 20 wt% or from about 12 wt% to about 18 wt% or from about 13 wt% to about 16 wt% based on the total weight of the flame-retardant polymer composition.

The term “intumescent particulate mineral” refers to any mineral that can swell as a result of heat exposure, thus increasing its volume and decreasing its density. Intumescent particulate minerals generally produce a char upon combustion which can act as a thermal insulation barrier between the burning and unburned materials.

The intumescent particulate mineral may, for example, be selected from perlite (e.g. unexpanded perlite), graphite, sodium silicate, ammonium polyphosphate and combinations of one or more thereof. Hereinafter, the present invention may tend to be discussed in terms of perlite or unexpanded perlite. However, the invention should not be construed as being limited to such embodiments.

Perlite is a hydrated natural glass that may contain, for example, about 72 to about 75% SiO_2, about 12 to about 14% Al_2O_3, about 0.5 to about 2% Fe_2O_3, about 3 to about 5% Na_2O, about 4 to about 5% K_2O, about 0.4 to about 1.5% CaO (by weight), and small amounts of other metallic elements. Perlite may be distinguished from other natural glasses by a higher content (such as about 2 to about 5% by weight) of chemically-bonded water, the presence of a vitreous, pearly luster, and characteristic

concentric or arcuate onion skin-like (i.e., perlitic) fractures. Perlite may be expanded or non-expanded. Perlite products may be prepared by milling and thermal expansion, and may possess unique physical properties such as high porosity, low bulk density, and chemical inertness. Average particle size for the milled expanded perlite ranges from 5 to 200 microns, pore volume ranges from 2 to 10 L/mg with median pore size from 5 to 20 microns. Prior to processing, perlite may be gray to green in color with abundant spherical cracks that cause it to break into small pearl-like masses.

The intumescent mineral may, for example, have a d_{50} (laser) ranging from about 1 µm to about 20 µm. For example, the intumescent mineral may have a d_{50} (laser) ranging from about 2 µm to about 20 µm or from about 3 µm to about 19 µm or from about 4 µm to about 18 µm or from about 5 µm to about 17 µm or from about 6 µm to about 16 µm or from about 7 µm to about 15 µm or from about 8 µm to about 14 µm or from about 9 µm to about 13 µm or from about 10 µm to about 12 µm.

The intumescent mineral may, for example, have a d_{10} (laser) ranging from about 0.1 µm to about 3 µm. For example, the intumescent mineral may have a d_{10} (laser) ranging from about 0.2 µm to about 2.5 µm or from about 0.5 µm to about 2 µm or from about 1 µm to about 2 µm.

The intumescent mineral may, for example, have a d_{90} (laser) ranging from about 5 µm to about 50 µm. For example, the intumescent mineral may have a d_{90} (laser) ranging from about 6 µm to about 50 µm or from about 7 µm to about 50 µm or from about 8 µm to about 50 µm or from about 9 µm to about 50 µm or from about 10 µm to about 50 µm or from about 12 µm to about 48 µm or from about 14 µm to about 46 µm or from about 15 µm to about 45 µm or from about 16 µm to about 44 µm or from about 18 µm to about 42 µm or from about 20 µm to about 40 µm or from about 22 µm to about 38 µm or from about 24 µm to about 36 µm or from about 25 µm to about 35 µm or from about 26 µm to about 34 µm or from about 28 µm to about 32 µm.

The intumescent particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount of at least about 5 % based on the total weight of the flame-retardant polymer composition. For example, the intumescent particulate mineral may be present in the flame-retardant polymer composition in an amount of at least about 6 wt% or at least about 7 wt% or at least about 8 wt% or at

least about 9 wt% or at least about 10 wt% based on the total weight of the flame-retardant polymer composition.

The intumescent particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount up to about 15 % based on the total weight of the flame-retardant polymer composition. For example, the intumescent mineral may be present in the flame-retardant polymer composition in an amount up to about 14 wt% or up to about 13 wt% or up to about 12 wt% or up to about 11 wt% or up to about 10 wt%.

In certain embodiments, the flame-retardant polymer composition further comprises a siliceous mineral. The term “siliceous mineral” refers to any mineral comprising greater than 50 wt% silica (SiO_2). The siliceous mineral may, for example, be selected from fumed silica, fused silica (fused quartz), quartz, tridymite, cristobalite, coesite, stishovite, zeolite, diatomaceous earth (DE), perlite and combinations thereof. Hereinafter, the present invention may tend to be discussed in terms of fumed silica, fused silica or diatomaceous earth. However, the invention should not be construed as being limited to such embodiments.

The siliceous particulate mineral may, for example, have a d_{50} (laser) ranging from about 1 µm to about 30 µm. For example, the siliceous mineral may have a d_{50} (laser) ranging from about 1 µm to about 28 µm or from about 1 µm to about 26 µm or from about 1 µm to about 25 µm or from about 1 µm to about 24 µm or from about 1 µm to about 22 µm or from about 1 µm to about 20 µm or from about 1 µm to about 18 µm or from about 1 µm to about 16 µm or from about 1 µm to about 15 µm. For example, the siliceous mineral may have a d_{50} (laser) ranging from about 2 µm to about 20 µm or from about 3 µm to about 19 µm or from about 4 µm to about 18 µm or from about 5 µm to about 17 µm.

The siliceous particulate mineral may, for example, have a d_{10} (laser) ranging from about 0.1 µm to about 5 µm. For example, the siliceous mineral may have a d_{10} (laser) ranging from about 0.2 µm to about 4 µm or from about 0.3 µm to about 3 µm or from about 0.4 µm to about 2.5 µm or from about 0.5 µm to about 2 µm or from about 1 µm to about 2.5 µm or from about 1 µm to about 2 µm.

The siliceous particulate mineral may, for example, have a d_{90} (laser) ranging from about 5 µm to about 50 µm. For example, the siliceous mineral may have a d_{90} (laser) ranging from about 6 µm to about 48 µm or from about 8 µm to about 46 µm or from about 9 µm to about 45 µm or from about 10 µm to about 44 µm or from about 11 µm to about 42 µm or from about 12 µm to about 40 µm.

The siliceous particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount of at least about 0.5 wt% based on the total weight of the flame-retardant polymer composition. For example, the siliceous mineral may be present in the flame-retardant polymer composition in an amount of at least about 1 wt% or at least about 1.5 wt% or at least about 2 wt% or at least about 2.5 wt% based on the total weight of the flame-retardant polymer composition.

The siliceous particulate mineral may, for example, be present in the flame-retardant polymer composition in an amount up to about 5 % based on the total weight of the flame-retardant polymer composition. For example, the siliceous mineral may be present in the flame-retardant polymer composition in an amount up to about 4.5 wt% or up to about 4 wt% or up to about 3.5 wt% or up to about 3 wt% or up to about 2.5 wt% based on the total weight of the flame-retardant polymer composition.

The flame-retardant polymer composition may, for example, comprise further additives. For example, the flame-retardant polymer composition may further comprise one or more of coupling agents (e.g. maleic anhydride grafted polyolefins), compatibilizers (e.g. maleic anhydride grafted polyolefins), opacifying agents, pigments, colorants, slip agents (for example Erucamide), antioxidants, anti-fog agents, anti-static agents, anti-block agents, moisture barrier additives, gas barrier additives, dispersants, hydrocarbon waxes, stabilizers, co-stabilizers, lubricants, agents to improve tenacity, agents to improve heat-and-form stability, agents to improve processing performance, process aids (for example Polybatch® AMF-705), mould release agents (e.g. fatty acids, zinc, calcium, magnesium, lithium salts of fatty acids, organic phosphate esters, stearic acid, zinc stearate, calcium stearate, magnesium stearate, lithium stearate, calcium oleate, zinc palmiate), antioxidants and plasticizers.

Each of the further additives may independently be present in the flame-retardant polymer composition in an amount ranging from about 0 % to about 2 % based on the total weight of the flame-retardant polymer composition. For example, each of the

further additives may be present in the flame-retardant polymer composition in an amount ranging from about 0 % to about 1.5 % or from about 0 % to about 1 % or from about 0 % to about 0.5 %. The flame-retardant polymer composition may, for example, comprise no more than about 10 wt% or no more than about 5 wt% or no more than about 4 wt% or no more than about 3 wt% or no more than about 2 wt% of further additives based on the total weight of the flame-retardant polymer composition.

Each of the components of the flame-retardant polymer composition disclosed herein may be present in any amount within the ranges specified herein provided that the total wt% of the flame-retardant polymer composition is 100 wt%.

The flame-retardant polymer composition may, for example, be a class C or above (e.g. class C, $B2_{ca}$, $B1_{ca}$) polymer composition when measured by the Construction Products Regulation (CPR). Flame spread and heat release are measured by EN50399 and flame propagation is measured by EN60332-1-2.

Class $B1_{ca}$ materials have a flame spread (test EN 50399) equal to or less than 1.75 m, a total heat release (THR_{1200} equal to or less than 10 MJ, a peak of heat release rate equal to or less than 20 kW, a fire growth rate index equal to or less than 120 W/s and a flame spread (test EN60332-1-2) equal to or less than 425 mm. Test EN 50399 is carried out using a 30 kW burner special assembly.

Class $B2_{ca}$ materials have a flame spread (test EN 50399) equal to or less than 1.5 m, a total heat release (THR_{1200} equal to or less than 15 MJ, a peak of heat release rate equal to or less than 30 kW, a fire growth rate index equal to or less than 150 W/s and a flame spread (test EN60332-1-2) equal to or less than 425 mm. Test EN 50399 is carried out using a 20.5 kW burner.

Class C materials have a flame spread (test EN 50399) equal to or less than 2.0 m, a total heat release (THR_{1200} equal to or less than 30 MJ, a peak of heat release rate equal to or less than 60 kW, a fire growth rate index equal to or less than 300 W/s and a flame spread (test EN60332-1-2) equal to or less than 425 mm. Test EN 50399 is carried out using a 20.5 kW burner.

When product testing by the Construction Products Regulation as described above, data indicating the tendency to release smoke, tendency to release flaming droplets/particles and smoke acidity is also provided.

In certain embodiments, the flame-retardant polymer composition may be an s2 or s1 product.

In certain embodiments, the flame-retardant polymer composition may be a d1 or d0 product.

In certain embodiments, the flame-retardant polymer composition may be an a2 or a1 product.

The flame-retardant polymer composition may, for example, have a higher class ranking when measured by the Construction Products Regulation in comparison to a comparative composition that is identical except that it comprises an additional amount of the flame retardant (e.g. ATH or MDH) in place of the high aspect ratio particulate mineral, intumescent mineral and optional siliceous mineral. In other words, the flame-retardant polymer compositions provide improved flame-retardancy properties by replacing some of the flame retardant (e.g. ATH or MDH) by a high aspect ratio particulate mineral, intumescent mineral and optional siliceous mineral.

There is further provided herein articles made from or comprising a flame-retardant polymer composition according to any aspect or embodiment disclosed herein. The article may, for example, be a cable covered with a flame-retardant polymer composition as disclosed herein. The thickness of the flame-retardant polymer composition covering the cable may, for example, be equal to or less than about 1 mm. For example, the thickness of the flame-retardant polymer composition may be equal to or less than about 0.9 mm or equal to or less than about 0.8 mm or equal to or less than about 0.7 mm or equal to or less than about 0.6 mm. The thickness of the flame-retardant polymer composition covering the cable may, for example, be at least about 0.1 mm or at least about 0.2 mm. The article may, for example, an elastomeric seal. The article may, for example, be an elastomeric bearing. The article may, for example, be a flexible sheet, for example for waterproofing and/or thermal insulation. The article may, for example, be an electrical appliance.

There is further provided herein methods of making a flame-retardant polymer composition according to any aspect or embodiment disclosed herein.

The flame-retardant polymer compositions described herein may, for example, be made by compounding the polymer with the flame retardant, high aspect ratio particulate mineral, intumescent particulate mineral and any optional additives. Compounding *per se* is a technique which is well known to persons skilled in the art of polymer processing and manufacture and consists of preparing plastic formulations by mixing and/or blending polymers and optional additives in a molten state. It is understood in the art that compounding is distinct from blending or mixing processes conducted at temperatures below that at which the constituents become molten. Compounding may, for example, be used to form a masterbatch composition. Compounding may, for example, involve adding a masterbatch composition to a polymer to form a further polymer composition.

The flame-retardant polymer compositions described herein may, for example, be extruded. For example, compounding may be carried out using a screw, e.g. a twin screw, compounder, for example, a Baker Perkins 25 mm twin screw compounder. For example, compounding may be carried out using a multi roll mill, for example a two-roll mill. For example, compounding may be carried out using a co-kneader or internal mixer. The methods disclosed herein may, for example, include compression moulding or injection moulding. The polymer and/or flame retardant and/or high aspect ratio particulate mineral and/or intumescent minerals and/or optional additives may be premixed and fed from a single hopper.

The resulting melt may, for example, be cooled, for example in a water bath, and then pelletized. The resulting melt may be calendared to form a sheet or film.

The flame-retardant polymer compositions described herein may, for example, be shaped into a desired form or article. Shaping of the flame-retardant polymer compositions may, for example, involve heating the composition to soften it. The polymer compositions described herein may, for example, be shaped by molding (e.g. compression molding, injection molding, stretch blow molding, injection blow molding, overmolding), extrusion, casting, or themoforming.

The foregoing broadly describes certain embodiments of the present invention without limitation. Variations and modifications as will be readily apparent to those skilled in the art are intended to be within the scope of the present invention as defined in and by the appended claims.

CLAIMS

1. A flame-retardant polymer composition comprising:
   a polymer;
   a flame retardant;
   a high aspect ratio particulate mineral; and
   an intumescent particulate mineral.

2. The flame-retardant polymer composition of claim 1, wherein the polymer is polyethylene, polyvinyl acetate, ethylene vinyl acetate or a combination of two or more thereof.

3. The flame-retardant polymer composition of claim 1 or 2, wherein the polymer is a blend of ethylene vinyl acetate and polyethylene.

4. The flame-retardant polymer composition of any preceding claim, wherein the polymer is present in the flame-retardant polymer composition in an amount at least about 30 % of the total weight of the flame-retardant polymer composition, for example at least about 35 % of the total weight of the flame-retardant polymer composition.

5. The flame-retardant polymer composition of any preceding claim, wherein the polymer is present in the flame-retardant polymer composition in an amount up to about 80 % of the total weight of the flame-retardant polymer composition, for example up to about 70 % of the total weight of the flame-retardant polymer composition.

6. The flame-retardant polymer composition of any preceding claim, wherein the flame retardant is a particulate mineral flame retardant, an organohalogen and/or a phosphorous and/or nitrogen-containing compound.

7. The flame-retardant polymer composition of claim 6, wherein the particulate mineral flame retardant is aluminium hydroxide (ATH), magnesium hydroxide (MDH) or a combination of huntite and hydromagnesite.

8. The flame-retardant polymer composition of any preceding claim, wherein the flame retardant is present in the flame-retardant polymer composition in an

amount of at least about 50 wt% of the total weight of filler in the flame-retardant polymer composition.

9. The flame-retardant polymer composition of any preceding claim, wherein the flame retardant is present in the flame-retardant polymer composition in an amount of at least about 15 wt% of the total weight of the flame-retardant polymer composition.

10. The flame-retardant polymer composition of any preceding claim, wherein the flame retardant is present in the flame-retardant polymer composition in an amount up to about 60 wt% of the total weight of the flame-retardant polymer composition.

11. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is selected from talc, mica, wollastonite, halloysite and combinations of one or more thereof.

12. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral has an aspect ratio ranging from about 2 to about 150.

13. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral has a d_{50} (sedigraph) ranging from about 0.5 to about 20.

14. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral has a d_{10} (sedigraph) ranging from about 0.05 µm to about 2 µm.

15. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral has a d_{95} (sedigraph) ranging from about 3 µm to about 60 µm.

16. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is talc having a lamellarity index equal to or greater than about 2.8, for example equal to or greater than about 3.5.

17. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is talc having a d_{50} (sedigraph) equal to or

greater than about 1 μm, for example equal to or greater than about 1.5 μm or equal to or greater than about 2 μm.

18. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is talc having a d_{50} (sedigraph) equal to or less than about 20 μm, for example equal to or less than about 10 μm or equal to or less than about 5 μm.

19. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is talc having a d_{50} (laser) equal to or greater than about 5 μm, for example equal to or greater than about 10 μm or equal to or equal to or greater than about 15 μm.

20. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is talc having a d_{50} (laser) equal to or less than about 40 μm, for example equal to or less than about 35 μm or equal to or less than about 30 μm.

21. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is present in the flame-retardant polymer composition in an amount at least about 5 wt% of the total weight of the flame-retardant polymer composition.

22. The flame-retardant polymer composition of any preceding claim, wherein the high aspect ratio particulate mineral is present in the flame-retardant polymer composition in an amount up to about 25 wt% of the total weight of the flame-retardant polymer composition.

23. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is selected from perlite, graphite, sodium silicate, ammonium polyphosphate and combinations of one or more thereof.

24. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is perlite, for example unexpanded perlite.

25. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is perlite having a d_{50} (laser) ranging from about 1 μm to about 20 μm.

26. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is perlite having a d_{10} (laser) ranging from about 0.1 µm to about 3 µm.

27. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is perlite having a d_{90} (laser) ranging from about 5 µm to about 50 µm.

28. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is present in the flame-retardant polymer composition in an amount of at least about 5 % of the total weight of the polymer composition.

29. The flame-retardant polymer composition of any preceding claim, wherein the intumescent particulate mineral is present in the flame-retardant polymer composition in an amount up to about 15 % of the total weight of the polymer composition.

30. The flame-retardant polymer composition of any preceding claim further comprising a siliceous mineral.

31. The flame-retardant polymer composition of claim 30, wherein the siliceous mineral is fumed silica, fused silica or diatomaceous earth.

32. The flame-retardant polymer composition of claim 30 or 31, wherein the siliceous mineral has a d_{50} (laser) ranging from about 1 µm to about 30 µm.

33. The flame-retardant polymer composition of any one of claims 30 to 32, wherein the siliceous mineral has a d_{10} (laser) ranging from about 0.1 µm to about 5 µm.

34. The flame-retardant polymer composition of any one of claims 30 to 33, wherein the siliceous mineral has a d_{95} (laser) ranging from about 5 µm to about 50 µm.

35. The flame-retardant polymer composition of any preceding claim, wherein the siliceous mineral is present in the flame-retardant polymer composition in an amount of at least about 1 % of the total weight of the polymer composition.

36. The flame-retardant polymer composition of any preceding claim, wherein the siliceous mineral is present in the flame-retardant polymer composition in an amount up to about 5 % of the total weight of the polymer composition.

37. An article made from and/or comprising a flame-retardant polymer composition of any preceding claim.

38. The article of claim 37, wherein the article is a cable covered with a flame-retardant polymer composition of any preceding claim.

39. A method of making a flame-retardant polymer composition of any preceding claim, the method comprising mixing the polymer, the flame retardant, the high aspect ratio particulate mineral, the intumescent particulate mineral and optionally the siliceous mineral.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/058638

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08K3/22 C08K3/34 C08K3/36 C08K7/24 C08L23/06
C08L23/08 C08K3/016
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08K C08L H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/178220 A1 (BARUSSEAU SYLVIE [FR] ET AL) 25 September 2003 (2003-09-25) examples B-E; tables 2,3	1-10, 12-15, 21-23, 28,29, 37-39
X	DATABASE CA [Online] CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; ZOU, QIANG ET AL: "Preparation method of high flame retardant anti-corrosion modified polyvinyl alcohol resin-controlled cable material", XP002780881, retrieved from STN Database accession no. 165:365975 abstract	1-23,28, 29,37-39

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 May 2018	28/05/2018

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 1 127 937 A1 (HILTI AG [LI]) 29 August 2001 (2001-08-29) claims 12, 14, 17-20, 23, 24	1,6,7, 11, 23-29, 37,39

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Information on patent family members

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