CLAIMS

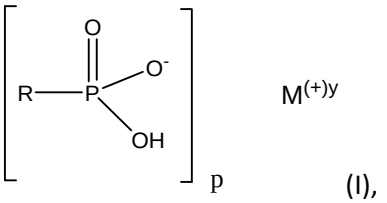
1. A process for preparing a thermally stable phosphorus containing flame retardant material comprising:

heating to a reaction temperature of 200°C or higher, preferably to a reaction temperature in a range from 220°C to 400°C,

a mixture comprising

i) a majority by weight, based on the weight of the mixture, of one or more high boiling, water miscible, acid stable solvents having a boiling point of greater than 200°C, and

ii) one or more phosphonic acid salts of formula (I):



(I),

wherein R is H, an alkyl, aryl, alkylaryl or arylalkyl group, p is a number of from 2 to 7, M is a metal, y is a number of from 2 to 7, so that $M^{(+)y}$ is a metal cation where (+)y represents the charge formally assigned to the cation,

to produce the flame-retardant material directly as a powder or in small particle form.

2. The process according to claim 1, further comprising, prior to the step of heating the mixture at temperatures of 200°C or higher,

a) providing the one or more salts of formula (I) in a solid or liquid form, preferably as a solution in an aqueous solvent, and

b) preparing the mixture by combining the one or more salts of formula (I) provided in a) with the one or more high boiling, water miscible, acid stable solvents under conditions and for a time sufficient to form a suspension or slurry.

3. The process according to claim 2, wherein the step of preparing the mixture occurs at one or more elevated temperatures in a range of from 30°C to 160°C.

4. The process according to any one of claims 1-3, wherein the one or more high boiling, water miscible, acid stable solvents comprise one or more sulfones.

5. The process according to claim 4, wherein the sulfones are of the formula $R_1R_2SO_2$, wherein R_1 and R_2 are independently chosen from C_{1-6} hydrocarbon groups or R_1 and R_2 taken together with S form a ring having 2, 3, 4, or 5 carbon atoms.

6. The process according to claim 5, wherein R_1 and R_2 are independently chosen from C_{1-3} alkyl, preferably wherein R_1 and R_2 are both methyl or both ethyl.

7. The process according to claim 5, wherein R_1 and R_2 taken together with S form a tri-, tetra-, or penta-methylene ring, preferably a tetra-methylene ring.

8. The process according to any one of the preceding claims, wherein p = y.

9. The process according to any one of the preceding claims, wherein the median particle size of the powder or small particles is 100 μm or less, preferably from 20 μm to 80 μm, as measured by laser diffraction according to ISO 13320.

10. The process according to any one of the preceding claims wherein, in formula (I), R is H, C_{1-12} alkyl, C_{6-10} aryl, C_{7-18} alkylaryl, or C_{7-18} arylalkyl, wherein said alkyl, aryl, alkylaryl, or arylalkyl are unsubstituted or are substituted by halogen, hydroxyl, amino, C_{1-4} alkylamino, di-C_{1-4} alkylamino, C_{1-4} alkoxy, carboxy or C_{2-5} alkoxycarbonyl; and M is Mg, Ca, Ba, Zn, Zr, B, Al, Si, Ti, Cu, Fe, Sn or Sb.

11. The process according to claim 10, wherein, in formula I, R is C_{1-12} alkyl and M is Ca, Zn, B, Al, Fe or Sn preferably, wherein R is C_{1-12} alkyl and M is Fe, Ca or Al.

12. A flame retardant material obtained according to the process of any one of claims 1-11, wherein the median particle size of the powder or small particles is about 100 μm or less, as measured by laser diffraction according to ISO 13320.

13. A flame retardant polymer composition comprising (a) a polymer substrate and (b) from 1 to 50 wt%, based on the total weight of the flame retardant polymer composition, of the flame retardant material obtained according to the process of any one of claims 1-11.

14. The flame retardant polymer composition according to claim 13, wherein the polymer substrate comprises one or more of a polyolefin homopolymer or copolymer, rubber, polyester, epoxy resin, polyurethane, polysulfone, polyimide, polyphenylene ether, styrenic polymer or copolymer, polycarbonate, acrylic polymer, polyamide, or polyacetal,

preferably wherein the polymer substrate comprises a poly-alkylene terephthalate or a glass filled polyalkylene terephthalate, high impact polystyrene (HIPS), epoxy resin or a glass reinforced epoxy resin, or polyamide or a glass filled polyamide, or

preferably wherein the polymer substrate comprises a polyphthalamide, or

preferably wherein the polymer substrate comprises polyamide 46, polyamide 6, polyamide 66, polyamide 4T, or polyamide 9T, polyamide MXD,6, polyamide 12,T, polyamide 10,T, polyamide 6,T/6,6, polyamide 6,T/D,T, polyamide 6,6/6,T/6,I, polyamide 6/6,T, or polyamide 6,T/6,I.

15. The flame retardant polymer composition according to claim 13, wherein the polymer substrate comprises a polyphenylene ether/styrenic resin blend, acrylonitrile butadiene styrene (ABS), polyvinyl chloride/ABS blend, methacrylonitrile/ABS blend, α-methylstyrene containing ABS, polyester/ABS, polycarbonate/ABS, impact modified polyester, or impact modified polystyrene.

16. The flame retardant polymer composition according to any one of claims 13-15, further comprising (c) one or more compounds chosen from additional flame retardants, synergists, and flame retardant adjuvants.

17. The flame retardant polymer composition according to claim 16, wherein the one or more compounds are chosen from halogenated flame retardants, alkyl or aryl phosphine oxides, alkyl or aryl polyphosphine oxides, alkyl or aryl phosphates, alkyl or aryl phosphonates, alkyl or aryl phosphinates, salts of alkyl or aryl phosphinic acid, carbon black, graphite, carbon nanotubes, siloxanes, polysiloxanes, polyphenylene ether, melamine, melamine derivatives, melamine condensation products, melamine salts, metal hydroxides, metal oxides, metal oxide hydrates, metal borates, metal carbonates, metal sulfates, metal phosphates, metal phosphites, metal hypophosphites, metal silicates, and mixed metal salts,

preferably wherein the one or more compounds are chosen from aluminum tris(dialkylphosphinate), aluminum hydrogen phosphite, benzylic phosphine oxides, poly benzylic phosphine oxides, melam, melem, melon, melamine phosphates, melamine metal phosphates, melamine cyanurate, melamine borate, talc, clays, calcium silicate, aluminosilicate, aluminosilicate as hollow tubes, calcium carbonate, magnesium carbonate, barium sulfate, calcium sulfate, boron phosphate, calcium molybdate, exfoliated vermiculite, zinc stannate, zinc hydroxystannate, zinc sulfide, zinc borate, zinc molybdate, zinc phosphate, magnesium oxide, magnesium hydroxide, aluminum oxide, aluminum oxide hydroxide, aluminum trihydrate, silica, tin oxide, antimony oxide (Ill and V), antimony (III and

V) oxide hydrate, titanium oxide, zinc oxide, zinc oxide hydrate, zirconium oxide, and zirconium hydroxide, or

preferably wherein the one or more compounds are chosen from aluminum tris(dimethylphosphinate), aluminum tris(diethylphosphinate), aluminum tris(dipropylphosphinate), aluminum tris(dibutylphosphinate), methylene-diphenylphosphine oxide-substituted polyaryl ether, xylylenebis(diphenylphosphine oxide), 1,2-bis-(9,10-dihydro-9-oxy-10-phosphaphenanthrene-10-oxide)ethane, 4,4′-bis(diphenylphosphinylmethyl)-1,1′-biphenyl, melam, melem, and dimelamine zinc pyrophosphate.

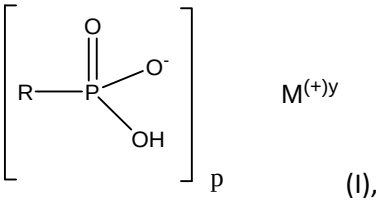
18. A method for improving the flame retardancy of a polymer, comprising:

heating at a reaction temperature of 200°C or higher

a mixture comprising

i) a majority by weight, based on the weight of the mixture, of one or more high boiling, water miscible, acid stable solvents having a boiling point of greater than 200°C, and

ii) one or more phosphonic acid salts of formula (I):



(I),

wherein R is H, an alkyl, aryl, alkylaryl or arylalkyl group, p is a number of from 2 to 7, M is a metal, y is a number of from 2 to 7, so that $M^{(+)y}$ is a metal cation where (+)y represents the charge formally assigned to the cation,

to form a flame-retardant material;

separating the flame retardant material from the solvent to yield the flame retardant material as a powder or in small particle form;

and combining the flame retardant material with the polymer.