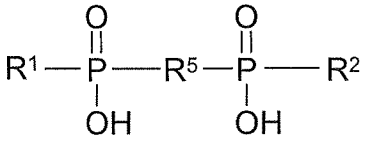
It is thus important to minimize the thermal expansion of test specimens in order to obtain a good, dimensionally stable product (finished printed circuit board).

It is an object of the present invention to modify polymers for prepregs, printed circuit boards and laminates such that they are subject only to very low thermal expansion – if any at all – and dimensional stability is fulfilled.

In one aspect, there is provided a mixture of at least one diphosphinic acid of the formula (I)



(I)

in which

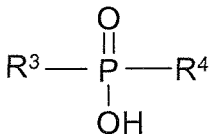
~~R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,~~

~~R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene~~

R^1, R^2 are the same or different and are each H, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl,

R^5 is ethylene, butylene, hexylene or octylene

with at least one dialkylphosphinic acid of the formula (II)



(II)

in which

~~R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl.~~

R^3, R^4 are the same or different and, independently of R^1 and R^2, are each ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl.

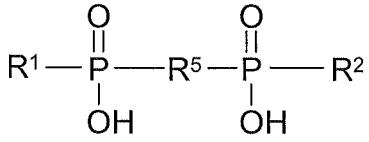
Preferably, R^1, R^2 are the same or different and are each H, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl; R^3, R^4 are the same or different and, independently of R^1 and R^2, are each methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl,

diisobutyryl peroxide, cumene peroxyneodecanoate, tert-butyl peroxyneodecanoate, tert-butyl peroxypivalate, tert-amyl peroxypivalate, dipropyl peroxydicarbonate, dibutyl peroxydicarbonate, dimyristyl peroxydicarbonate, dilauroyl peroxide, 1,1,3,3-tetramethylbutyl peroxy-2-ethylhexanoate, tert-amyl peroxy-2-ethylhexylcarbonate, tert-butyl peroxyisobutyrate, 1,1-di(tert-butylperoxy)cyclohexane, tert-butyl peroxybenzoate, tert-butyl peroxyacetate, tert-butyl peroxydiethylacetate, tert-butyl peroxyisopropylcarbonate, 2,2-di(tert-butylperoxy)butane, tert-amyl hydroperoxide and/or 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane.

The solvent preferably comprises straight-chain or branched alkanes, alkyl-substituted aromatic solvents, water-immiscible or only partly water-miscible alcohols or ethers, water and/or acetic acid.

The alcohol is preferably methanol, propanol, i-butanol and/or n-butanol or comprises mixtures of these alcohols with water.

Another aspect relates to the use of a mixtures of at least one diphosphinic acid of the formula (I)



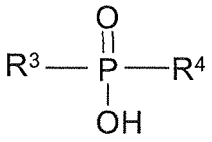
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

and with at least one dialkylphosphinic acid of the formula (II)



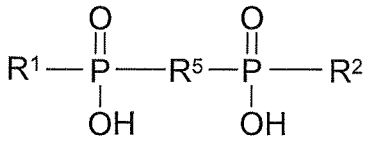
(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

~~as disclosed herein~~ as an intermediate for further syntheses, as a binder, as a crosslinker or accelerator in the curing of epoxy resins, polyurethanes and unsaturated polyester resins, as polymer stabilizers, as crop protection compositions, as sequestrants, as a mineral oil additive, as an anticorrosive, in washing and cleaning composition applications and in electronics applications.

A further aspect relates to the use of a mixture~~s~~ of at least one diphosphinic acid of the formula (I)



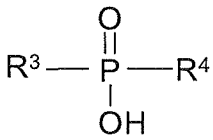
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

~~and~~ with at least one dialkylphosphinic acid of the formula (II)



(II)

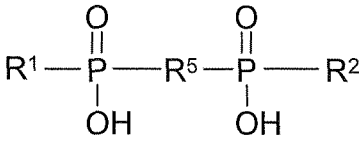
in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

~~as disclosed herein~~ as a flame retardant, especially as a flame retardant for clearcoats and intumescent coatings, as a flame retardant for wood and other cellulosic products, as a reactive and/or nonreactive flame retardant for polymers, for production of flame-retardant polymer molding compositions, for production of flame-retardant polymer moldings

and/or for rendering polyester and pure and blended cellulose fabrics flame-retardant by impregnation, and as a synergist.

Another aspect relates to a flame-retardant thermoplastic or thermoset polymer molding composition and to polymer moldings, films, filaments and fibers comprising 0.5 to 50% by weight of a mixtures of at least one diphosphinic acid of the formula (I) as disclosed herein,



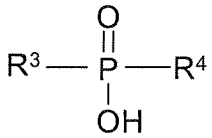
(I)

in which

R1, R2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



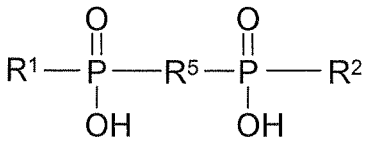
(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

55 50 to 99.5% by weight of thermoplastic or thermoset polymer or mixtures thereof, 0 to 55% by weight of additives and 0 to 55% by weight of filler or reinforcing materials, where the sum of the components is 100% by weight.

Another aspect relates to a flame-retardant thermoplastic or thermoset polymer molding composition and to polymer moldings, films, filaments and fibers comprising 2 to 30% by weight of a mixtures of at least one diphosphinic acid of the formula (I) as disclosed herein,



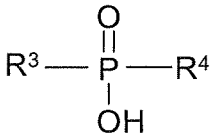
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

60 to 94% by weight of thermoplastic or thermoset polymer or mixtures thereof, 2 to 30% by weight of additives and 2 to 30% by weight of filler or reinforcing materials, where the sum of the components is 100% by weight.

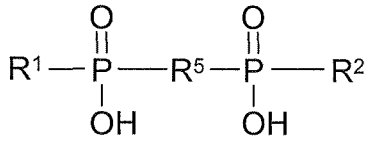
Preferred mixtures of diphosphinic acid of the formula (I) and dialkylphosphinic acid of the formula (II) are, for example:

ethylene-1,2-bis(ethylphosphinic acid) and diethylphosphinic acid,
ethylene-1,2-bis(ethylphosphinic acid) and butylethylphosphinic acid,
ethylene-1,2-bis(ethylphosphinic acid) and butylbutylphosphinic acid,
ethylene-1,2-bis(ethylphosphinic acid) and hexylethylphosphinic acid,
ethylene-1,2-bis(ethylphosphinic acid) and octylethylphosphinic acid,
ethylene-1,2-bis(ethylphosphinic acid) and hexylbutylphosphinic acid,
ethylene-1,2-bis(butylphosphinic acid) and diethylphosphinic acid,
ethylene-1,2-bis(butylphosphinic acid) and butylethylphosphinic acid,

ethylene-1,2-bis(butylphosphinic acid) and butylbutylphosphinic acid,
ethylene-1,2-bis(butylphosphinic acid) and hexylethylphosphinic acid,
ethylene-1,2-bis(butylphosphinic acid) and octylethylphosphinic acid,
ethylene-1,2-bis(butylphosphinic acid) and hexylbutylphosphinic acid,
butylene-1,2-bis(ethylphosphinic acid) and diethylphosphinic acid,

Claims

1. A mixture of at least one diphosphinic acid of the formula (I)



(I)

in which

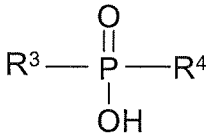
~~R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,~~

~~R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene~~

R^1, R^2 are the same or different and are each H, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl,

R^5 is ethylene, butylene, hexylene or octylene

with at least one dialkylphosphinic acid of the formula (II)



(II)

in which

~~R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl.~~

R^3, R^4 are the same or different and, independently of R^1 and R^2, are each ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl.

2. The mixture as claimed in claim 1, wherein R^1, R^2, ~~R^3~~ and R^4 are the same or different and are each ~~H, methyl,~~ ethyl and/or butyl, ~~n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl; R^3, R^4 are the same or different and, independently of R^1 and R^2, are each methyl, ethyl, n-~~

~~propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, n-hexyl, isohexyl and/or phenyl,~~ and R^5 is ethylene or~~,~~ butylene~~, hexylene or octylene~~.

~~3. The mixture as claimed in claim 1 or 2, wherein R^1, R^2, R^3 and R^4 are the same or different and are each ethyl and/or butyl, and R^5 is ethylene or butylene.~~

43. The mixture as claimed in one or more of claims 1 to 32, which comprises 0.1 to 99.9% by weight of diphosphinic acid of the formula (I) and 99.9 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

54. The mixture as claimed in one or more of claims 1 to 43, which comprises 60 to 99.9% by weight of diphosphinic acid of the formula (I) and 40 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

65. The mixture as claimed in one or more of claims 1 to 54, which comprises 80 to 99.9% by weight of diphosphinic acid of the formula (I) and 20 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

76. The mixture as claimed in one or more of claims 1 to 65, which comprises 90 to 99.9% by weight of diphosphinic acid of the formula (I) and 10 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

87. The mixture as claimed in one or more of claims 1 to 76, which comprises 95 to 99.9% by weight of diphosphinic acid of the formula (I) and 5 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

98. The mixture as claimed in one or more of claims 1 to 87, which comprises 98 to 99.9% by weight of diphosphinic acid of the formula (I) and 2 to 0.1% by weight of dialkylphosphinic acid of the formula (II).

109. The mixture as claimed in one or more of claims 1 to 98, wherein the diphosphinic acid is
ethylene-1,2-bis(ethylphosphinic acid), ethylene-1,2-bis(propylphosphinic acid), ethylene-1,2-bis(butylphosphinic acid), ethylene-1,2-bis(pentylphosphinic acid), ethylene-1,2-bis(hexylphosphinic acid), butane-1,2-bis(ethylphosphinic acid), butane-1,2-bis(propylphosphinic acid), butane-1,2-bis(butylphosphinic acid), butane-1,2-bis(pentylphosphinic acid), butane-1,2-bis(hexylphosphinic acid), hexane-1,2-bis(ethylphosphinic acid), hexane-1,2-bis(propylphosphinic acid),

hexane-1,2-bis(butylphosphinic acid), hexane-1,2-bis(pentylphosphinic acid) or hexane-1,2-bis(hexylphosphinic acid), and the dialkylphosphinic acid is diethylphosphinic acid, dipropylphosphinic acid, dibutylphosphinic acid, dipentylphosphinic acid or dihexylphosphinic acid.

~~11~~10. The mixture as claimed in one or more of claims 1 to ~~10~~9, which comprises 98 to 99.9% by weight of ethylene-1,2-bis(ethylphosphinic acid) and 2 to 0.1% by weight of diethylphosphinic acid.

~~12~~11. The mixture as claimed in one or more of claims 1 to ~~11~~10, which further comprises at least one synergist, the latter being
a nitrogen-containing compound such as melem, melam, melon, melamine borate, melamine cyanurate, melamine phosphate, dimelamine phosphate, pentamelamine triphosphate, trimelamine diphosphate, tetrakismelamine triphosphate, hexakismelamine pentaphosphate, melamine diphosphate, melamine tetraphosphate, melamine pyrophosphate, melamine polyphosphate, melam polyphosphate, melem polyphosphate and/or melon polyphosphate;
aluminum compounds such as aluminum hydroxide, halloysite, sapphire products, boehmite, nanoboehmite;
magnesium compounds such as magnesium hydroxide;
tin compounds such as tin oxides;
antimony compounds such as antimony oxides;
zinc compounds such as zinc oxide, zinc hydroxide, zinc oxide hydrate, zinc carbonate, zinc stannate, zinc hydroxystannate, zinc silicate, zinc phosphate, zinc borophosphate, zinc borate and/or zinc molybdate;
silicon compounds such as silicates and/or silicones;
phosphorus compounds such as phosphinic acids and salts thereof, phosphonic acids and salts thereof and/or phosphine oxides, phosphazenes and/or piperazine (pyro)phosphates;
carbodiimides, piperazines, (poly)isocyanates, styrene-acrylic polymers and/or carbonylbiscaprolactam;

nitrogen compounds from the group of oligomeric esters of tris(hydroxyethyl) isocyanurate with aromatic polycarboxylic acids, or benzoguanamine, acetoguanamine, tris(hydroxyethyl) isocyanurate, allantoin, glycoluril, cyanurates, cyanurate-epoxide compounds, urea cyanurate, dicyanamide, guanidine, guanidine phosphate and/or sulfate.

~~13~~12. The mixture as claimed in one or more of claims 1 to ~~12~~11, which comprises 99 to 1% by weight of mixture of at least one diphosphinic acid of the formula (I) and at least one dialkylphosphinic acid of the formula (II) as claimed in at least one of claims 1 to 11 and 1 to 99% by weight of synergist.

~~14~~13. A process for preparing the mixtures as claimed in at least one of claims 1 to ~~11~~10, which comprises reacting a phosphinic acid source with an alkyne in the presence of an initiator.

~~15~~14. The process as claimed in claim ~~14~~13, wherein the phosphinic acid source is ethylphosphinic acid and the alkyne is acetylene, methylacetylene, 1-butyne, 1-hexyne, 2-hexyne, 1-octyne, 4-octyne, 1-butyn-4-ol, 2-butyn-1-ol, 3-butyn-1-ol, 5-hexyn-1-ol, 1-octyn-3-ol, 1-pentyne, phenylacetylene, trimethylsilylacetylene and/or diphenylacetylene and the initiator is a free-radical initiator having a nitrogen-nitrogen or an oxygen-oxygen bond and the reaction temperature is between 50 and 150°C.

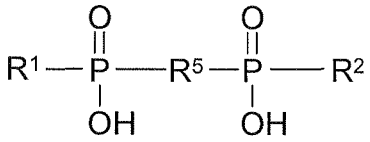
~~16~~15. The process as claimed in claims ~~14~~13 or ~~15~~14, wherein the free-radical initiator is 2,2'-azobis(2-amidinopropane) dihydrochloride, 2,2'-azobis(N,N'-dimethyleneisobutyramidine) dihydrochloride, azobis(isobutyronitrile), 4,4'-azobis(4-cyanopentanoic acid) and/or 2,2'-azobis(2-methylbutyronitrile) or hydrogen peroxide, ammonium peroxodisulfate, potassium peroxodisulfate, dibenzoyl peroxide, di-tert-butyl peroxide, peracetic acid, diisobutyryl peroxide, cumene peroxyneodecanoate, tert-butyl peroxyneodecanoate, tert-butyl peroxypivalate, tert-amyl peroxypivalate, dipropyl peroxydicarbonate, dibutyl peroxydicarbonate, dimyristyl peroxydicarbonate, dilauroyl peroxide, 1,1,3,3-

tetramethylbutyl peroxy-2-ethylhexanoate, tert-amyl peroxy-2-ethylhexylcarbonate, tert-butyl peroxyisobutyrate, 1,1-di(tert-butylperoxy)cyclohexane, tert-butyl peroxybenzoate, tert-butyl peroxyacetate, tert-butyl peroxydiethylacetate, tert-butyl peroxyisopropylcarbonate, 2,2-di(tert-butylperoxy)butane, tert-amyl hydroperoxide and/or 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane.

~~17~~16. The process as claimed in one or more of claims ~~14~~13 to ~~16~~15, wherein the solvent comprises straight-chain or branched alkanes, alkyl-substituted aromatic solvents, water-immiscible or only partly water-miscible alcohols or ethers, water and/or acetic acid.

~~18~~17. The process as claimed in claim ~~17~~16, wherein the alcohol is methanol, propanol, i-butanol and/or n-butanol or comprises mixtures of these alcohols with water.

~~19~~18. ~~The use of mixtures as claimed in at least one of claims 1 to 11~~ The use of a mixture of at least one diphosphinic acid of the formula (I)



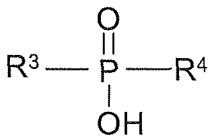
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



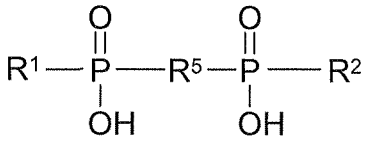
(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

as an intermediate for further syntheses, as a binder, as a crosslinker or accelerator in the curing of epoxy resins, polyurethanes and unsaturated polyester resins, as polymer stabilizers, as crop protection compositions, as sequestrants, as a mineral oil additive, as an anticorrosive, in washing and cleaning composition applications and in electronics applications.

2019. ~~The use of mixtures as claimed in at least one of claims 1 to 13~~The use of a mixture of at least one diphosphinic acid of the formula (I)



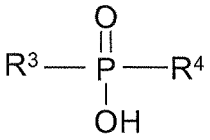
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



(II)

in which

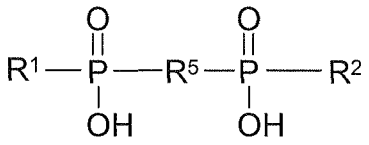
R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

as a flame retardant, especially as a flame retardant for clearcoats and intumescent coatings, as a flame retardant for wood and other cellulosic products, as a reactive and/or nonreactive flame retardant for polymers, for production of

flame-retardant polymer molding compositions, for production of flame-retardant polymer moldings and/or for rendering polyester and pure and blended cellulose fabrics flame-retardant by impregnation, and as a synergist.

~~21~~20. A flame-retardant thermoplastic or thermoset polymer molding composition or polymer molding, film, filament or fiber comprising 0.5 to 50% by weight of

~~mixtures as claimed in at least one of claims 1 to 13,~~a mixture of at least one diphosphinic acid of the formula (I)



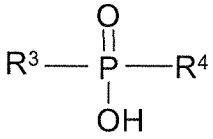
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



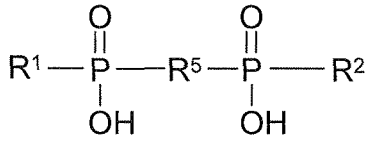
(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

50 to 99.5% by weight of thermoplastic or thermoset polymer or mixtures thereof, 0 to 55% by weight of additives and 0 to 55% by weight of filler or reinforcing materials, where the sum of the components is 100% by weight.

~~22~~21. A flame-retardant thermoplastic or thermoset polymer molding composition or polymer molding, film, filament or fiber comprising 2 to 30% by weight of a mixture of at least one diphosphinic acid of the formula (I) ~~mixtures as claimed in at least one of claims 1 to 13,~~



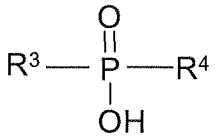
(I)

in which

R^1, R^2 are the same or different and are each independently H, C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl, C_7-C_{18}-alkylaryl,

R^5 is C_1-C_{18}-alkylene, C_2-C_{18}-alkenylene, C_6-C_{18}-arylene, C_7-C_{18}-alkylarylene

with at least one dialkylphosphinic acid of the formula (II)



(II)

in which

R^3, R^4 are the same or different and are each independently C_1-C_{18}-alkyl, C_2-C_{18}-alkenyl, C_6-C_{18}-aryl and/or C_7-C_{18}-alkylaryl,

60 to 94% by weight of thermoplastic or thermoset polymer or mixtures thereof, 2 to 30% by weight of additives and 2 to 30% by weight of filler or reinforcing materials, where the sum of the components is 100% by weight.