CLAIMS

1. A process for producing a phosphorus-containing flame retardant, comprising
preparing a reaction mixture, the reaction mixture comprising

(a) an unsubstituted or alkyl or aryl substituted phosphonic acid,

(b) a solvent for the phosphonic acid, and

(c) a metal which is capable of forming a polycation, preferably a 2+, 3+ or 4+ polycation, or a suitable metal compound which is represented by the formula $M_p^{(+)y} X_q$ where M is a metal, (+)y represents the charge of the metal cation, y is 2 or higher, X is an anion, and the values for p and q provide a charge balanced metal compound; and

heating the reaction mixture at a reaction temperature of 140 °C or higher for an amount of time sufficient to produce the phosphorus-containing flame retardant,
wherein the molar ratio of component (a) to component (c) in the reaction mixture ranges from 4:1 to 50:1.

2. The process according to claim 1, wherein the reaction mixture is prepared at a preparation temperature below the reaction temperature, preferably in the range from 15 °C to 40 °C.

3. The process according to claim 1 or 2, wherein the components (a) and (b) of the reaction mixture are in the form of a solution, and preparing the reaction mixture comprises mixing the component (c) with the solution.

4. The process according to claim 1, wherein the reaction temperature is 150 °C or higher.

5. The process according to claim 1, wherein the reaction temperature ranges from 140 °C to 260 °C.

6. The process according to claim 1, wherein the solvent is chosen from water, sulfones, sulfoxides, halogenated hydrocarbons, aromatic hydrocarbons, and ethers.

7. The process according to claim 1, wherein the solvent comprises water.

8. The process according to claim 1, wherein component (c) of the reaction mixture comprises a suitable metal compound which is represented by the formula $M_p^{(+)y} X_q$ where M is a metal, (+)y

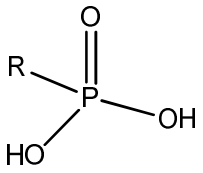
represents the charge of the metal cation, y is 2, 3 or 4, X is an anion, and the values for p and q provide a charge balanced metal compound, preferably wherein the suitable metal compound is chosen from a metal oxide, halide, alkoxide, hydroxide, carbonate, carboxylate, or phosphonate.

9. The process according to claim 8, wherein y is 3.

10. The process according to claim 9, wherein M is chosen from Al, Ga, Sb, Fe, Co, B, and Bi, preferably Al or Fe.

11. The process according to claim 10, wherein the suitable metal compound is chosen from alumina, aluminum trichloride, aluminum trihydroxide, aluminum isopropoxide, aluminum carbonate, aluminum acetate, iron(III) oxide, iron(III) chloride, iron(III) isopropoxide, and iron(III) acetate.

12. The process according to claim 1, wherein the unsubstituted or alkyl or aryl substituted phosphonic acid is represented by formula (I)



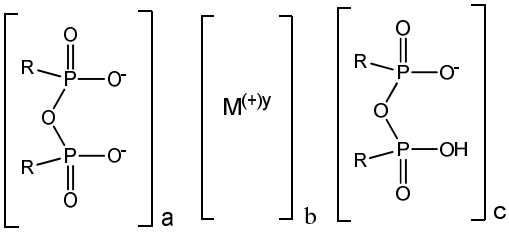
(I),

wherein R is H, C_{1-12} alkyl, C_{6-10} aryl, C_{7-18} alkylaryl, or C_{7-18} arylalkyl, wherein the 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.

13. The process according to claim 12, wherein R is unsubstituted C_{1-12} alkyl, C_6 aryl, C_{7-10} alkylaryl, or C_{7-10} arylalkyl, preferably unsubstituted C_{1-6} alkyl.

14. The process according to claim 13, wherein R is methyl, ethyl, propyl, isopropyl, butyl, or t-butyl.

15. A phosphorus-containing flame retardant produced according to the process of any one of claims 1 through 14 directly in the form of a powder or small particles, wherein the phosphorus-containing flame retardant comprises a compound of empirical formula (III)



(III),

wherein R is an alkyl or aryl group;

M is a metal chosen from Al, Ga, Sb, Fe, Co, B, and Bi and y is 3, such that $M^{(+)y}$ is a metal cation where (+)y represents the charge formally assigned to the cation;

a, b, and c represent the ratio of the components to which they correspond relative to one another in the compound and satisfy the charge-balance equation 2(a)+c=b(y); and

a and c are not zero.

16. The phosphorus-containing flame retardant according to claim 15, wherein component (c) of the reaction mixture comprises the suitable metal compound represented by the formula $M_p^{(+)y}$ X_q and y is 3, preferably wherein M is Al or Fe.

17. A flame retardant polymer composition comprising (i) a polymer and (ii) the phosphorus-containing flame retardant according to claim 15 or 16.