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 105 °C or higher for an amount of time sufficient to produce the phosphorus-containing flame retardant.

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 about 15 °C to about 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 about 150 °C or higher.

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

6. The process according to any one of the preceding claims, wherein the molar ratio of component (a) to component (c) in the reaction mixture ranges from about 4:1 to about 50:1.

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

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

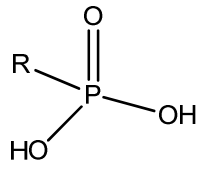
9. The process according to claim 1, wherein component (c) of the reaction mixture comprises a suitable metal compound which is represented by the formula $M_p^{(+)y} X_q$ where M is a metal, (+)y represents the charge of the metal cation, y is 2, 3 or 4, X is an anion, and the values for p and q provide a charge balanced metal compound, preferably wherein the suitable metal compound is chosen from a metal oxide, halide, alkoxide, hydroxide, carbonate, carboxylate, or phosphonate.

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

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

12. The process according to claim 11, 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.

13. 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.

14. The process according to claim 13, 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.

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

16. A phosphorus-containing flame retardant produced according to the process of any one of claims 1 through 15 directly in the form of a powder or small particles.

17. The phosphorus-containing flame retardant according to claim 16, 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.

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