Claims

1. Use of red phosphorous as a formaldehyde scavenger in a phenolic foam, wherein

the phenolic foam is a phenolic foam formed from a foamable phenolic resin composition, and a blowing agent,

the phenolic foam comprising 1 to 5 % by weight of red phosphorus based on the weight of the phenolic foam wherein said phenolic foam has a density of from 10 kg/m^3 to 100 kg/m^3, a closed cell content of at least 85% as determined in accordance with ASTM D6226 and wherein said foam has a $FIGRA_{0.2MJ}$ of 120 W/s or less, when measured according to EN13823 and a thermal conductivity of 0.023 W/m.K or less, at 10˚C, in accordance with EN 13166:2012.

2. Use of red phosphorous according to claim 1, wherein formaldehyde emissions from the foam are reduced by 30% to 60%, as measured by EN717-1 / EN16516 ISO16000-11, compared to a control foam which is the same phenolic foam without any red phosphorous being present in the foam.

3. Use of red phosphorous according to any of claims 1 or 2, wherein the phenolic foam comprises 2 to 5 % by weight of red phosphorus based on the weight of the phenolic foam.

4. Use of red phosphorous according to any preceding claim, wherein the blowing agent comprises at least one of the following:

at least one saturated or unsaturated C_3-C_6 hydrocarbon;

at least one saturated or unsaturated C_3-C_6 compound that is substituted at least once by one or more of fluorine and chlorine for example isopropyl chloride.

5. Use of red phosphorous according to any preceding claim, wherein the blowing agent comprises at least one of isopropyl chloride or a saturated C_3-C_6 hydrocarbon such as pentane for example isopentane.

6. Use of red phosphorous according to any preceding claim, wherein the blowing agent comprises a blend of isopropyl chloride and a saturated C_3-C_6 hydrocarbon such as pentane for example isopentane.

7. Use of red phosphorous according to any preceding claim, wherein the foam has a $FIGRA_{0.2MJ}$ of 110 W/s or less, for example 100 W/s or less, such as 90 W/s or less when measured according to EN13823.

8. Use of red phosphorous according to any preceding claim, wherein the blowing agent comprises at least one of hydrofluoroolefin or chlorinated hydrofluoroolefin.

9. Use of red phosphorous according to claim 8, wherein the blowing agent further comprises at least one of the following:

at least one saturated or unsaturated C_3-C_6 hydrocarbon;

at least one saturated or unsaturated C_3-C_6 compound that is substituted at least once by one or more of fluorine and chlorine atoms for example isopropyl chloride.

10. Use of red phosphorous according to claims 8 or 9 wherein the blowing agent comprises a blend of at least one of hydrofluoroolefin or chlorinated hydrofluoroolefin with a C_3-C_6 hydrocarbon such as pentane for example isopentane.

11. Use of red phosphorous according to any preceding claim, wherein the foam has a $FIGRA_{0.2MJ}$ of 100 W/s or less, for example 90 W/s or less, such as 80 W/s or less, such as 70W/s or less when measured according to EN13823.

12. Use of red phosphorous according to any preceding claim, wherein the foam has a compressive strength of at least 95kPa.

13. Use of red phosphorous according to any preceding claim, wherein the red phosphorus is in micronized form.

14. Use of red phosphorous according to any preceding claim, wherein the red phosphorous is in particulate form with a number average particle size in the range from 0.1 µm to 25 µm, for example 0.25 µm to 15 µm, such as 0.5 µm to 10 µm.

15. Use of red phosphorous according to any preceding claim, wherein said foam has a total heat release of 7.5 MJ or less, such as 7.0 MJ or less, or 6.5 MJ or less, or 6.25 MJ or less, or 6.0 MJ or less, or 5.75 MJ or less, or 5.5 MJ or less, or 5.25 MJ or less, or 5.15 MJ or less, or 5.0 MJ or less, or 4.8 MJ or less, or 4.6 MJ or less, or 4.4 MJ or less, when measured according to EN13823.

16. Use of red phosphorous according to any preceding claim, wherein said foam has a closed cell content of 90% or more, such as 95% or more, preferably 98% or more, as determined in accordance with ASTM D6226.

17. Use of red phosphorous according to any preceding claim, wherein the cells of the foam have an average cell diameter in the range of from 50 to 250 µm, suitably in the range of from 80 to 180 µm.

18. Use of red phosphorous according to any preceding claim, wherein said foam has a thermal conductivity of 0.020 W/m·K or less, suitably of 0.018 W/m·K or less, preferably 0.0175 W/m·K or less, or 0.0170 W/m·K or less, or 0.0165 W/m·K or less, 0.0162 W/m·K or less when measured at a mean temperature of 10°C, in accordance with EN 13166:2012.

19. Use of red phosphorous according to any preceding claim, said foam having a limiting oxygen index of 34% or more, optionally 35% or more, suitably 36% or more, such as 37% or more as determined in accordance with ISO 4589-2.

20. Use of red phosphorous according to any preceding claim, wherein said foam has a stable moisture content of from 3% to 8%, for example 3% to 5%, by weight when determined at (23 ± 2)°C and a relative humidity of (50 ± 5)% in accordance with EN1249:1998.

21. Use of red phosphorous according claims 9 to 20, wherein the at least one chlorinated hydrofluoroolefin is selected from 1-chloro-3,3,3-trifluoropropene (HCFO-1233zd) and 1-chloro-2,3,3,3-tetrafluoropropene (HCFO-1224yd).

22. Use of red phosphorous according claims 9 to 21, wherein the at least one hydrofluoroolefin comprises 1,1,1,4,4,4-hexafluoro-2-butene (HFO-1336mzz).

23. Use of red phosphorous according to any preceding claim, wherein the hydrocarbon comprises at least one butane, suitably isobutane, and/or at least one pentane, for example isopentane.

24. Use of red phosphorous as a formaldehyde scavenger in a phenolic foam, wherein the phenolic foam formed by foaming and curing a phenolic resin foamable composition comprising a phenolic resin, a surfactant, an acid catalyst, a blowing agent, and 1 to 5 % by weight of red phosphorus based on the weight of the phenolic foam, wherein said phenolic foam has a density of from 10 kg/m^3 to 100 kg/m^3, a closed cell content of at least 85% as determined in accordance with ASTM D6226 and wherein said foam has a $FIGRA_{0.2MJ}$ of 120 W/s or less (such as 110 W/s or less, or 100 W/s or less, or 95 W/s or less, or 90 W/s or less, or 85 W/s or less) when measured according to EN13823 and wherein the phenolic foam has a thermal conductivity of 0.023 W/m.K or less, at 10˚C, in accordance with EN 13166:2012.

25. Use of red phosphorous according to claim 24, wherein the blowing agent comprises at least one hydrofluoroolefin and at least one chlorinated hydrofluoroolefin; and said blowing agent further comprises at least one C_3-C_6 hydrocarbon.

26. Use of red phosphorous according to claim 25 wherein the at least one chlorinated hydrofluoroolefin is selected from 1-chloro-3,3,3-trifluoropropene (HCFO-1233zd) and 1-chloro-2,3,3,3-tetrafluoropropene (HCFO-1224yd).

27. Use of red phosphorous according to any Claim 25 or Claim 26, wherein the at least one hydrofluoroolefin comprises 1,1,1,4,4,4-hexafluoro-2-butene (HFO-1336mzz).

28. Use of red phosphorous according to any of Claims 25 to 27, wherein the at least one C_3-C_6 hydrocarbon comprises at least one butane, suitably isobutane, and/or at least one pentane, optionally isopentane.

29. Use of red phosphorous according to any preceding claim, wherein the blowing agent comprises 1-chloro-3,3,3-trifluoropropene and/or 1-chloro-2,3,3,3-tetrafluoropropene and 1,1,1,4,4,4-hexafluoro-2-butene.

30. Use of red phosphorous according to any preceding claim wherein the phenolic resin composition comprises a phenolic resin that has a weight average molecular weight of from 700 to 2000, and/or wherein the phenolic resin has a number average molecular weight of from 330 to 800, such as from 350 to 700.

31. Use of red phosphorous according to any preceding claim wherein the phenolic resin has a molar ratio of phenol groups to aldehyde groups in the range of from 1:1 to 1:3, suitably from 1:1.5 to 1:2.3.

32. Use of red phosphorous according to any preceding claim wherein the water content of the phenolic resin foamable composition is in the range of from 5 wt.% to 12 wt.%, such as from 6 wt.% to 10 wt.%, based on the total weight of the phenolic resin foamable composition.

33. Use of red phosphorous according to any preceding claim wherein the phenolic resin has a water content in the range of from 7.5 wt.% to 14% such as 10 wt.% to 14 wt.% based on the weight of the phenolic resin.

34. Use of red phosphorous according to any preceding claim, wherein the phenolic resin has a viscosity of from 2,500 mPa·s to 18,000 mPa·s when measured at 25°C, such as from 2500 mPa·s to 16,000 mPa·s when measured at 25°C for example from 4,000 mPa·s to 8,000 mPa·s when measured at 25°C.

35. Use of red phosphorous according to any preceding claim, wherein the blowing agent is present in an amount of from 1 to 20 parts by weight per 100 parts by weight of the phenolic resin.

36. Use of red phosphorous according to any preceding claim having a compressive strength in the range of from 95 kPa to 200 kPa as determined in accordance with EN826.

37. Use of red phosphorous according to any preceding claim having a density of from 15 kg/m^3 to 60 kg/m^3, such as from 20 kg/m^3 to 50 kg/m^3, suitably of from 24 kg/m^3 to 48 kg/m^3.

38. Use of red phosphorous according to any preceding claim wherein the foam has a density from 34.5 kg/m^3 to 40 kg/m^3; such as from 35 kg/m^3 to 39 kg/m^3, for example from 36 kg/m^3 to 38 kg/m^3.