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EXPANDABILITY AND PROCESS FOR THE PREPARATION THEREOF

(57) **Abrégé/Abstract:**

Expandable granulates having a composition based on vinylaromatic polymers, essentially consisting of: 65-99.8% by weight of a copolymer obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I) and 0.15% by weight of an alpha-alkylstyrene; 0-25% by weight, calculated with respect to the polymer (a), of carbon black; at least one of the following products: - 0.01-5% by weight of graphite having an average diameter ranging from 0.5 to 50 µm; - 0.01-5% by weight of oxides and/or sulfates and/or lamellar dichalcogenides of metals of groups HA, IHA, HB, IVB or VIIIB, - 0.01-5% by weight of inorganic derivatives of silicon of the lamellar type; 0-5% by weight, calculated with respect to the polymer (a), of a nucleating agent; 1-6% by weight, calculated with respect to the total, of an expanding agent.

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(54) Title: EXPANDABLE GRANULATAES BASED ON VINYLAROMATIC POLYMERS HAVING AN IMPROVED EX-
PANDABILITY AND PROCESS FOR THE PREPARATION THEREOF

(57) Abstract: Expandable granulates having a composition based on vinylaromatic polymers, essentially consisting of: 65-99.8% by weight of a copolymer obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I) and 0.15% by weight of an alpha-alkylstyrene; 0-25% by weight, calculated with respect to the polymer (a), of carbon black; at least one of the following products: - 0.01-5% by weight of graphite having an average diameter ranging from 0.5 to 50 µm; - 0.01-5% by weight of oxides and/or sulfates and/or lamellar dichalcogenides of metals of groups HA, IHA, HB, IVB or VIIB, - 0.01-5% by weight of inorganic derivatives of silicon of the lamellar type; 0-5% by weight, calculated with respect to the polymer (a), of a nucleating agent; 1-6% by weight, calculated with respect to the total, of an expanding agent.

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EXPANDABLE GRANULATES BASED ON VINYL-AROMATIC POLYMERS HAVING AN IMPROVED EXPANDABILITY AND PROCESS FOR THE PREPARATION THEREOF

10 The present invention relates to expandable granulates, based on vinyl-aromatic polymers, having an improved expandability, and to the relative process for the preparation thereof.

15 More specifically, the present invention relates to compositions based on expandable polystyrene granulates (EPS) with an improved expandability, having enhanced thermal insulation properties and to the relative preparation process.

20 Vinyl aromatic polymers, and among these, in particular, polystyrene, are known products which have been used for a long time for preparing compact and/or expanded articles which can be adopted in various applicative fields, among which the most important are household appliances, the building industry, office machines, etc. A particular
25 interesting sector is the field of thermal insulation where

vinyl-aromatic polymers are essentially used in expanded form.

These expanded products are obtained by swelling in a pre-expander beads of expandable polymer previously impregnated with an expanding agent and moulding the swollen particles contained inside a closed mould by means of the contemporaneous effect of pressure and temperature. The swelling of the particles is generally effected with vapour, or another gas, maintained at a temperature slightly higher than the glass transition temperature (T_g) of the polymer.

It is known that the expanding capacity of vinyl-aromatic polymers such as EPS can be improved by incorporating suitable additives. According to European patent 217.516, for example, the expandability of vinyl-aromatic polymers can be improved by adding plasticizers such as rubbers and oils to the polymer. The additives contained in resins do in fact lead to a good, immediate expandability but, as they keep inside in the polymeric matrix, they cause the expanded product to collapse with a consequent deterioration in the density.

The use of oligomers of aliphatic olefins, as described in the US patent 5,783,612, also improves the expandability of polystyrene but reduces the processability range.

It has also been verified that the reduction in the

molecular weight of the polymer to values lower than 50,000 also implies an excellent expandability, but to the detriment of the processability and mechanical characteristics of the end-product.

5 In any case, whether the EPS be produced in the presence of expandability improver additives or without these, it is necessary for a quantity of expanding agent to be added, generally an aliphatic or cyclo-aliphatic hydrocarbon, which, in order to reach required densities, preferably
10 bly ranges from 6 to 8%.

 According to international patent application WO 03/53651, EPS granulates can be prepared by means of a continuous mass process which comprises:

- 15 i) melting the polymer in a single- or multi-screw extruder;
- ii) incorporating an expanding agent in the polymer in the molten state;
- iii) granulating the polymer thus obtained in a device which comprises a die, a cutting chamber and a cutting system;
20 and
- iv) re-annealing the annealed granules at room temperature and for a time of at least 30 prime minutes.

 According to this application it is necessary to re-anneal the granules to have a good cellular structure of
25 the expanded beads and therefore a good expandability.

An objective of the present invention is to provide an expandable granulate based on vinyl-aromatic polymers having an improved expandability and which can be processed with the technologies and operating conditions analogous to those of equivalent products available on the market.

A further objective of the present invention is also to provide a continuous mass process for the production of expandable granulates based on vinyl-aromatic polymers which overcomes the drawback of the necessarily long annealing time, typical of continuous mass processes.

Yet another objective of the present invention is to provide a continuous mass process for the production of expandable granulates based on vinyl-aromatic polymers which allows to obtain a polymer containing expandability additives which do not negatively influence the physical and mechanic properties of the expanded end-product and which also allows expanding agents to be used in a reduced quantity with respect to the traditional expandable vinyl-aromatic polymers.

The Applicant has now found that these and other objectives, which will appear evident from the following description, can be obtained through expandable granulates with compositions based on vinyl-aromatic polymers preferably having a weight average molecular weight M_w ranging from 50,000 to 300,000 and essentially consisting of:

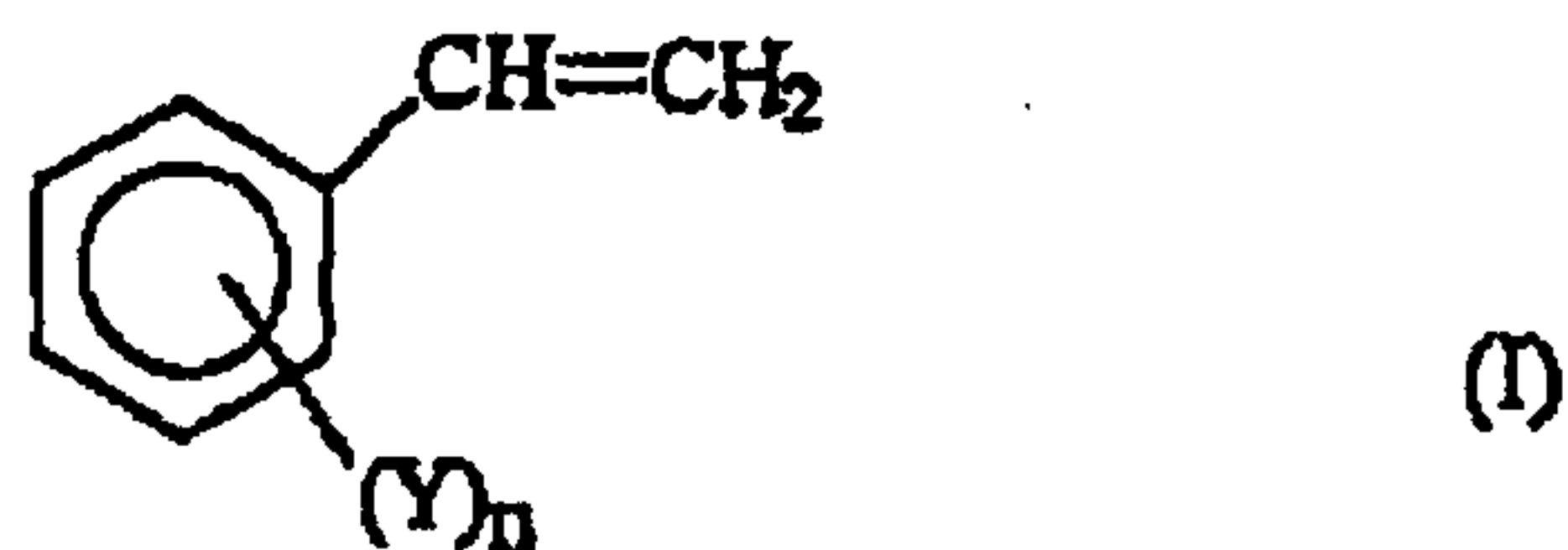
- a) 65-99.8% by weight of a copolymer obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I) and 0-15% by weight of an α -alkylstyrene in which the alkyl group contains from 1 to 4 carbon atoms;
- b) 0-25% by weight, calculated with respect to the polymer (a), of a carbon black having an average diameter ranging from 10 to 1000 nm and a surface area ranging from 5 to 200 m²/g;
- c) at least one of the following products:
- c1) 0.01-5% by weight, calculated with respect to the polymer (a), of graphite having an average diameter ranging from 0.5 to 50 μ m;
- c2) 0.01-5% by weight, calculated with respect to the polymer (a), of oxides and/or sulfates and/or lamellar dichalcogenides of metals of groups IIA, IIIA, IIB, IVB, VIB or VIIIB,
- c3) 0.01-5% by weight, calculated with respect to the polymer (a), of inorganic derivatives of silicon of the lamellar type;
- d) 0-5% by weight, calculated with respect to the polymer (a), of a nucleating agent; and
- e) 1-6% by weight, calculated with respect to 100 parts of the total of (a)-(d), of one or more expanding agents.

The term "expandable granulate", as used in the pre-

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sent description and claims, refers to a granule of an essentially polymeric nature produced by drawing of the polymer in the molten state, to which the additives (b)-(d) have been pre-added before the feeding to the extruder or
5 after melting. Consequently essentially spherical beads, produced by suspension are excluded.

According to the present invention, the vinyl-aromatic polymer preferably has a weight average molecular weight ranging from 70,000 to 200,000 and can be obtained by polymerizing at least one vinyl-aromatic monomer which corresponds to the following general formula:



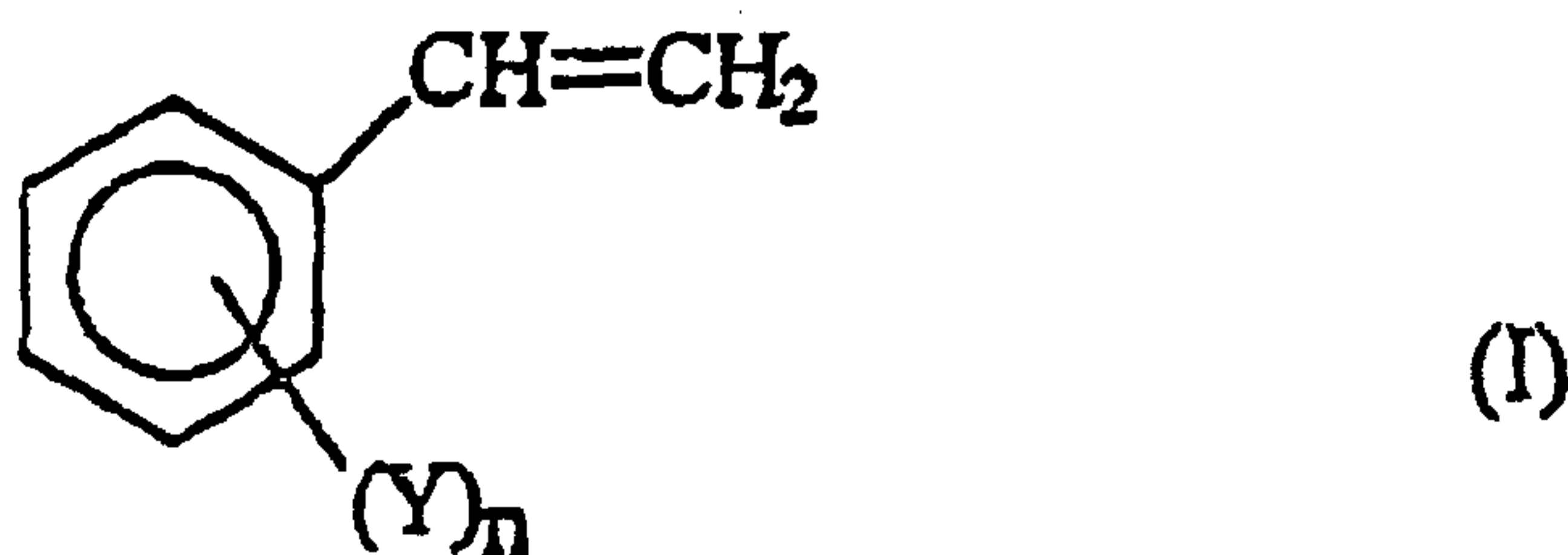
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wherein n is zero or an integer ranging from 1 to 5 and Y is a halogen, such as chlorine or bromine, or an alkyl or alkoxyl radical having from 1 to 4 carbon atoms.

Examples of vinyl-aromatic monomers having the general
20 formula defined above are: styrene, methylstyrene, ethylstyrene, butylstyrene, dimethylstyrene, mono-, di-, tri-, tetra- and penta-chlorostyrene, bromo-styrene, methoxystyrene, acetoxy-styrene, etc. Styrene is the preferred vinyl-aromatic monomer.

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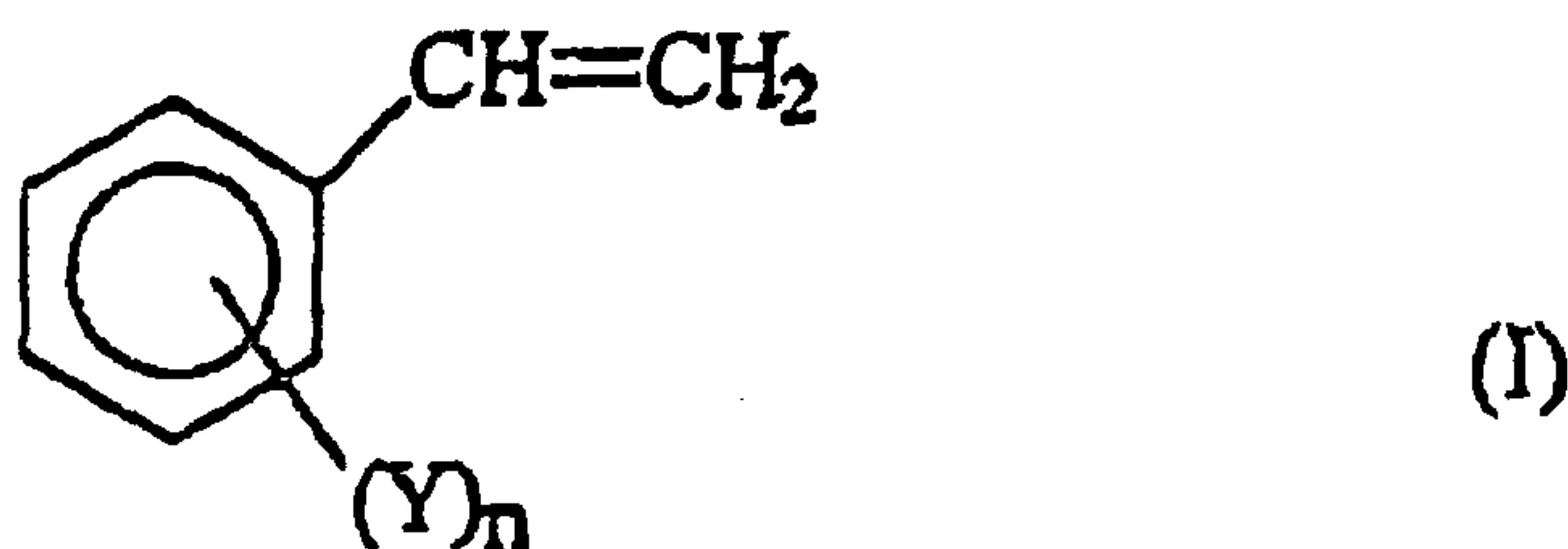
According to another aspect of the present invention, there is provided expandable granulates, having compositions based on vinyl-aromatic polymers, essentially comprising: a) 65-99.8% by weight of a copolymer obtained by polymerizing
 5 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I)



and 0-15% by weight of an α -alkylstyrene in which the alkyl group contains from 1 to 4 carbon atoms; b) 0.01%-20% by
 10 weight, calculated with respect to the polymer (a), of a carbon black having an average diameter ranging from 10 to 1000 nm and a surface area ranging from 5 to 200 m²/g; c) 0.01-5% by weight, calculated with respect to the polymer (a), of natural, synthetic or expandable graphite having an average diameter
 15 ranging from 0.5 to 50 μ m and a specific area of 5-20 m²/g; d) at least one of the following additives (d1)-(d2):
 d1) 0.01-5% by weight, calculated with respect to the polymer (a), of oxides and/or sulfates and/or lamellar dichalcogenides of metals of groups IIA, IIIA, IIB, IVB, VIB or
 20 VIIIB, d2) 0.01-5% by weight, calculated with respect to the polymer (a), of inorganic derivatives of silicon of the lamellar type; e) 0-5% by weight, calculated with respect to the polymer (a), of a nucleating agent; and f) 1-6% by weight, calculated with respect to 100 parts of the total of (a)-(e),
 25 of one or more expanding agents.

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According to still another aspect of the present invention, there is provided a process for the continuous mass preparation of expandable granulates of vinyl-aromatic polymers which essentially consists in the following steps in series: i) 5 mixing a vinyl-aromatic polymer in the form of granules or already in the molten state, obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general-formula (I)



10 and 0-15% by weight of an α -alkylstyrene wherein the alkyl group contains from 1 to 4 carbon atoms, with the additives (b)-(d) as defined and in the quantities indicated above; ii) incorporating one or more expanding agents in the polymeric composition brought to the molten state; iii) granulating the 15 composition thus obtained in a device which comprises a die, a cutting chamber and a cutting system.

The term "vinyl-aromatic monomer", according to the

present invention, also implies that the vinyl-aromatic monomers having general formula (I) can be used alone or in a mixture of up to 50% by weight with other copolymerizable monomers. Examples of these monomers are (meth)acrylic acid, C₁-C₄ alkyl esters of (meth)acrylic acid, such as methyl acrylate, methylethylmethacrylate, ethyl acrylate, ethylmethacrylate, isopropyl acrylate, butyl acrylate, amides and nitriles of (meth)acrylic acid such as acrylamide, methacrylamide, acrylonitrile, methacrylonitrile, butadiene, ethylene, divinylbenzene, maleic anhydride, etc. Preferred copolymerizable monomers are acrylonitrile and methylethylmethacrylate.

The vinyl-aromatic monomers, and possible other copolymerizable monomers, are also copolymerized with an α -alkylstyrene in quantities preferably ranging from 2 to 10%, to give the copolymer (a). The preferred α -alkylstyrene according to the present invention is α -methylstyrene, α -ethylstyrene or α -propylstyrene. α -methylstyrene is particularly preferred.

Any expanding agent capable of being incorporated in a polymeric matrix can be used in a combination with the vinyl-aromatic polymers used for producing the expandable granulates, object of the present invention. In general, liquid substances can be used, with a boiling point ranging from 10 to 100°C, preferably from 20 to 80°C. Typical exam-

ples are aliphatic or cyclo-aliphatic hydrocarbons containing from 3 to 6 carbon atoms such as n-pentane, isopentane, cyclopentane or their mixtures; halogenated derivatives of aliphatic hydrocarbons containing from 1 to 3 carbon atoms such as, for example, dichlorodifluoromethane, 1,2,2-trifluoroethane, 1,1,2-trifluoroethane; carbon dioxide and water. In order to promote the retention of the expanding agent in the polymeric matrix, additives capable of forming bonds of both the weak type (for example hydrogen bridges) and strong type (for example acid-base adducts) can be used with the expanding agent. Examples of these additives are methyl alcohol, isopropyl alcohol, dioctylphthalate, dimethyl carbonate, derivatives containing an amine group.

The carbon black filler has an average diameter ranging from 10 to 1000 nm, preferably from 100 to 1000, a specific surface ranging from 5 to 200 m²/g, preferably from 10 to 100 m²/g, (measured according to ASTM D-6556), a sulfur content ranging from 0.1 to 2000 ppm, preferably from 1 to 500 ppm, an ash residue ranging from 0.001 to 1%, preferably from 0.01 to 0.3% (measured according to ASTM D-1506), a loss with heat (measured according to ASTM D-1509) ranging from 0.001 to 1%, preferably from 0.01 to 0.5%, a DBPA (measured according to ASTM D-2414) of 5-100 ml/(100 g), preferably 20-80 ml/(100 g) and an iodine number (meas-

ured according to ASTM D-1510) ranging from 0.01 to 20 g/kg, preferably from 0.1 to 10 g/kg.

The carbon black filler can be added to the vinyl-aromatic polymer in such quantities as to give a final concentration in the polymer of 0-25% by weight, preferably 0.01 to 20%, even more preferably from 0.1 to 5%.

The carbon black used in the present invention can be prepared according to the following main technologies:

- furnace process (partial combustion of a liquid containing aromatic hydrocarbons);
- thermal black process (method based on the decomposition of natural gas or liquid hydrocarbons in the absence of air or flame);
- acetylene black process (thermal decomposition process, 800-1000°C, at atmospheric pressure);
- lampblack process (combustion of various liquids or raw materials in the absence of air).

Greater details can be found, for example, in the Kirk-Othmer encyclopaedia, edition 4, volume 4.

The natural or synthetic graphite can have a size ranging from 0.5 to 50 μm , preferably from 1 to 13 μm , with a specific area of 5-20 m^2/g . An example is the product UF 2 of Kropfmuhl having a diameter of 4.5 μm . The graphite can also be of the expandable type.

The oxides and/or sulfates and/or lamellar dichalco-

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genides of metals of groups IIA, IIIA, IIB, IVB, VIB or VIIIB are preferably those of Ca, Mg, Ba, for the group IIA, those of aluminum, for the group IIIA, those of Fe, for the group VIIIB, those of Mo, for the group VIB, and
5 those of zinc and titanium for the group IIB and IVB respectively. The dichalcogenides are preferably those of sulfur, selenium or tellurium.

The inorganic silicon derivative is a product of the clay family, such as kaolinite and talc, micas, clays and
10 montmorillonites, with a size ranging from 0.5 to 50 μm . The silicon derivative is preferably talc. An example is the product Minstron R10TM of Luzenac with a size of 3.4 μm .

The nucleating agent is selected from polyethylene, polyamide waxes, having a molecular weight ranging from 500
15 to 10,000 or from S-B, S-B-S, SIS, SEBS, SEP block copolymers both of the linear and branched type, wherein:
S = Styrene; B = Butadiene; I = Isoprene; E = Ethylene; P = Propylene. The concentration ranges from 0 to 5% by weight, preferably from 0.01 to 4.5% .

20 At the end of the addition of the expanding agent and other additives, a polymeric composition is obtained which can be transformed to produce expanded articles having a density ranging from 5 to 50 g/l, preferably from 8 to 25 g/l, obtained after expansion, at a temperature slightly
25 higher than the glass transition temperature of the polymer

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and for the necessary times, of the expandable granulates object of the present invention.

These materials also have a certain thermal insulation capacity expressed by a thermal conductivity ranging from 5 27 to 50 mW/mK, measured at 10°C according to ISO 8301, preferably from 30 to 45 mW/mK, which is generally lower than that of equivalent non-filled expanded materials currently on the market, for example EXTIRTM A-5000 of Polimeri Europa S.p.A.

10 Conventional additives, generally used with commercial materials, such as pigments, stabilizers, flame-retardants, mineral fillers, refracting and/or reflecting additives such as titanium dioxide, antistatic agents, detaching agents, anti-shock agents, etc., can be added to the ex-
15 pandable granulates of vinyl-aromatic polymers, object of the present invention. In particular, among the additives, flame-retardant agents are preferred in a quantity ranging from 0.1 to 8% by weight, with respect to the weight of the resulting polymeric composition. Flame-retardant agents
20 particularly suitable for the expandable granulates, based on vinyl-aromatic polymers, object of the present invention, are aliphatic, cyclo-aliphatic, brominated aromatic compounds such as hexabromocyclododecane, pentabromo-
monochlorocyclohexane and pentabromophenyl allyl ether.

25 A further object of the present invention relates to a

process for the continuous mass preparation of expandable granulates, based on vinyl-aromatic polymers, which consists in the following steps in series:

- 5 i) mixing a vinyl-aromatic polymer in the form of granules or already in the molten state, obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I) and 0.15% by weight of an α -alkylstyrene wherein the alkyl group contains from 1 to 4 carbon atoms, with the additives
10 (b)-(d) indicated above;
- ii) incorporating one or more expanding agents in the polymeric composition brought to the molten state;
- 15 iii) granulating the composition thus obtained in a device which comprises a die, a cutting chamber and a cutting system.

According to the present invention, step (i) can be carried out by feeding the polymeric granulate already formed, optionally mixed with processing waste products, and the additives (b)-(d), into an extruder. The single
20 components are mixed herein, the polymeric part is subsequently melted and the expanding agent is then added.

Alternatively, the polymer can be used in the molten state coming directly from the polymerization plant (in solution), in particular from the devolatilization unit. The
25 molten polymer is fed to suitable devices, for example an

extruder or static mixer, where it is mixed with the additives and then with the expanding agent and is subsequently extruded to give the expandable granulate, object of the present invention.

5 The vinyl-aromatic polymer according to the present invention can consist of a copolymer containing from 50 to 100% by weight of a vinyl-aromatic polymer and 0-15% by weight of an α -alkylstyrene in which the alkyl group contains from 1 to 4 carbon atoms, the possible complement to
10 100 consisting of one or more copolymerizable monomers selected from those indicated above. Alternatively, the vinyl-aromatic polymer can consist of a mixture of two (co)polymers, the first consisting of 50-100% by weight of vinyl-aromatic monomer and 0-50% by weight of copolymeriz-
15 able monomer and the second of a vinyl-aromatic monomer- α -alkylstyrene monomer copolymer, in such a ratio as to give a final concentration of α -alkylstyrene preferably equal to 2-10% by weight. Even if not necessary, the granules of the polymeric composition can optionally be re-annealed at a
20 temperature lower than or equal to the glass transition temperature (T_g) or slightly higher, for example the T_g increased by up to 8°C, optionally under pressure.

Details on the continuous mass preparation of polymers and vinyl-aromatic compositions according to the present
25 invention can be found in international patent application

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WO 03/53651.

The granulates obtained with the process, object of the present invention, are not necessarily subjected to re-annealing but are subjected to pre-treatment generally applied to the traditional expandable materials and which essentially consists of:

1. covering the granulates with an antistatic liquid agent such as amines, tertiary ethoxylated alkylamines, ethylene oxide-propylene oxide copolymers, sorbitol esters, glycerin, etc. This agent is essentially used for adhesion of the coating and for reducing the staticity;
2. applying the coating to said granulates, said coating essentially consisting of a mixture of mono-, di- and tri-esters of glycerin (or other alcohols) with fatty acids and of metallic stearates such as zinc and/or magnesium stearates.

Some illustrative but non-limiting examples are provided for a better understanding of the present invention and for its embodiment.

20 EXAMPLE 1

The following products are fed into an extruder, directly from the devolatilization section of the polymerization plant: 95.1 parts of molten polystyrene EdistirTM N1782 having an MFI, measured at 200°C/5 kg of 8 g/10', having a Mw of 180,000, 4 parts of carbon black T990 (with an aver-

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age diameter of 362 nm, BET of 10 m²/g) of CancarbTM of Houston, 0.5 parts of graphite, also adding 0.4% of SIS Euro-
preneTM SOLT 9326 having 31.3% of PS and 68.7% of PB+PI rubber, sold by the company Polimeri Europa.

- 5 After bringing the polystyrene to 200°C, 4% of a mixture of n/i-pentane 80/20 is injected, as expanding agent, through a specific line.

The polymer containing the expanding agent is extruded through the holes of the die, cut with knives, dried, then
10 200 ppm of glycerin are added and the mixture is lubricated with 0.1% by weight of magnesium stearate and 0.3% by weight of glycerylmonostearate.

The granules are then by steam expanded at 3 and 7 minutes, and the density is evaluated the following day to
15 guarantee a correct drying. The expandability result is indicated in the table below.

EXAMPLE 2

Example 1 is repeated by feeding 95.35 parts of molten polystyrene N1782, 4 parts of carbon black T990, 0.25 parts
20 of graphite and also adding 0.4% of SIS.

4% of a mixture of n/i-pentane 80/20 is fed to the extruder as expanding agent. The expandability result is indicated in the table below.

COMPARATIVE EXAMPLE 1

- 25 Example 1 is repeated but without adding graphite.

As can be seen from the table below, the product expands only a little.

COMPARATIVE EXAMPLE 2

Comparative example 1 is repeated but re-annealing the granules at a temperature 5°C higher than the Tg.

As can be seen from the table below, the re-annealing improves the expandability without reaching the value of Example 1.

COMPARATIVE EXAMPLE 3

Comparative example 1 is repeated but feeding 6% of a mixture of n/i-pentane 80/20 and re-annealing the granules at a temperature 5°C higher than the Tg.

As can be seen from the table below, the product expands as in Example 1 but having 6% of pentane.

COMPARATIVE EXAMPLE 4

Comparative Example 2 is repeated but excluding the carbon black.

As can be seen from the table below, the product expands only a little.

EXAMPLE 3

Example 1 is repeated, feeding to the extruder 94.6 parts of molten polystyrene N1782, 4 parts of carbon black T990, 1 part of graphite and also adding 0.4% of SIS.

4% of a mixture of n/i-pentane 80/20 is also fed to the extruder as expanding agent. The expandability result

is indicated in the table below.

EXAMPLE 4

Example 1 is repeated but substituting the SIS with 0.4% of polyethylene wax having a molecular weight of 1000 (such as Polywax 1000 of Clariant). The expandability result is indicated in the table below.

EXAMPLE 5

Example 1 is repeated but substituting the polystyrene Edistir N1782 with a copolymer having 4% by weight of alpha-methylstyrene and with an MFI of 20 g/10' measured at 200°C/5 kg. The expandability result is indicated in the table below: the density reaches 13 g/l after 7 minutes.

EXAMPLE 6

The following products are fed to an extruder: 93.9 parts of molten polystyrene Edistir N1782, 4 parts of carbon black T990, 0.5 parts of graphite, 1.2 parts of stabilized hexabromocyclododecane (EBCD), sold by Great Lakes as BRE 5300, 0.4 parts of diphenylbutane, and also adding 0.4% of SIS Europrene SOLT 9326.

After mixing the additives, 4% of a mixture of n/i-pentane 80/20 is fed to the extruder, as expanding agent, through a specific injection line.

The polymer containing the expanding agent is extruded through the holes of the die, cut with knives, dried, 200 ppm of glycerin are added and the mixture is lubricated

with 0.1% by weight of metallic stearates and 0.3% by weight of glycerylmonostearate.

The granules are then expanded and moulded to obtain test samples for the fire test according to the regulation
5 DIN 4102. The test is carried out after conditioning in an oven: the product passes the test B2.

EXAMPLE 7

Example 1 is repeated feeding to the extruder: 99.2 parts of molten polystyrene N1782 and 0.8 parts of Minstron
10 R10 talc produced by Luzenac with a size of 3.4 μm .

4% of a mixture of n/i-pentane 80/20 is fed to the extruder, as expanding agent. The expandability result is indicated in the table below.

TABLE

15		Vaporization time (min)	Density after 24 hrs (g/l)
	EXAMPLE 1	3	15.5
	EXAMPLE 1	7	17
	EXAMPLE 2	3	16
	EXAMPLE 3	3	14.5
	EXAMPLE 4	3	16.1
	EXAMPLE 5	3	15.7
20	EXAMPLE 5	7	13
	EXAMPLE 7	3	14.8
	COMPARATIVE 1	3	20
	COMPARATIVE 2	3	18
	COMPARATIVE 3	3	15.6
	COMPARATIVE 4	3	27

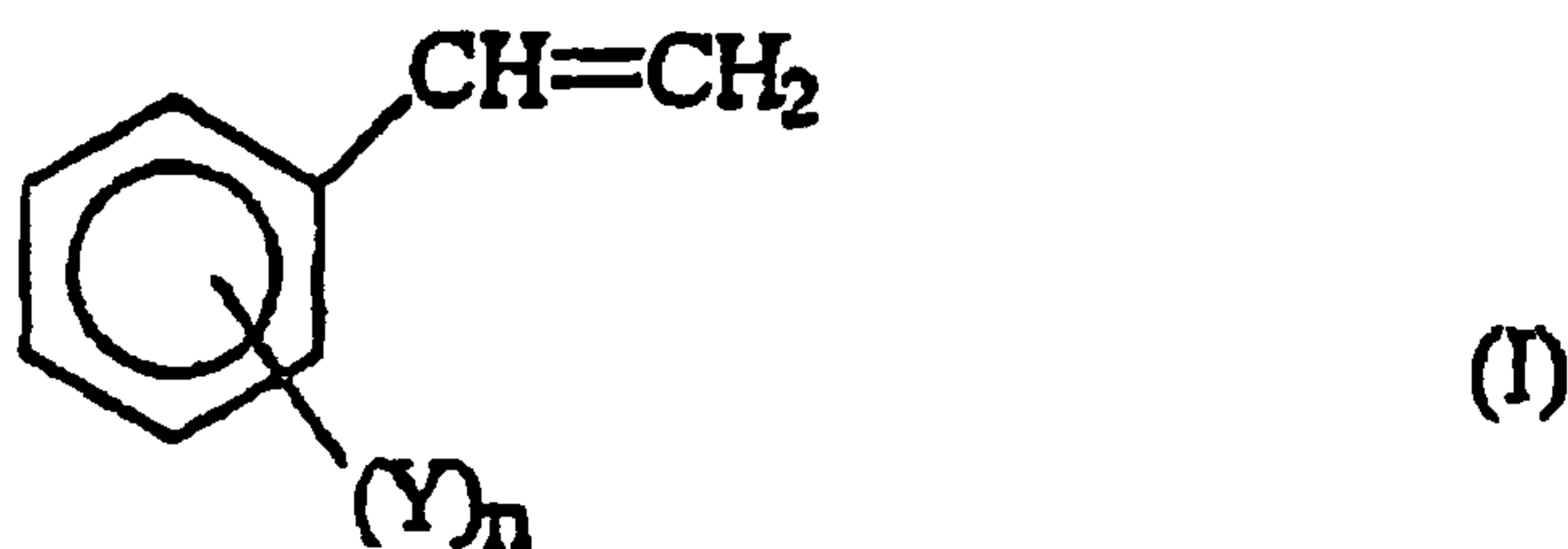
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CLAIMS:

1. Expandable granulates, having compositions based on vinyl-aromatic polymers, essentially comprising:

- 5 a) 65-99.8% by weight of a copolymer obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general formula (I)



wherein n is zero or an integer ranging from 1 to 5 and Y is a halogen, or an alkyl or alkoxy radical having from 1
10 to 4 carbon atoms

and 0-15% by weight of an α -alkylstyrene in which the alkyl group contains from 1 to 4 carbon atoms;

- b) 0.01%-20% by weight, calculated with respect to the polymer (a), of a carbon black having an average diameter
15 ranging from 10 to 1000 nm and a surface area ranging from 5 to 200 m^2/g ;

c) 0.01-5% by weight, calculated with respect to the polymer (a), of natural, synthetic or expandable graphite having an average diameter ranging from 0.5 to 50 μm and a
20 specific area of 5-20 m^2/g ;

d) at least one of the following additives (d1)-(d2):

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d1) 0.01-5% by weight, calculated with respect to the polymer (a), of oxides and/or sulfates and/or lamellar dichalcogenides of metals of groups IIA, IIIA, IIB, IVB, VIB or VIIIB,

5 d2) 0.01-5% by weight, calculated with respect to the polymer (a), of inorganic derivatives of silicon of the lamellar type;

e) 0-5% by weight, calculated with respect to the polymer (a), of a nucleating agent; and

10 f) 1-6% by weight, calculated with respect to 100 parts of the total of (a)-(e), of one or more expanding agents.

2. The expandable granulates of vinyl-aromatic polymers according to claim 1, having a weight average molecular weight
15 Mw ranging from 50,000 to 300,000.

3. The expandable granulates of vinyl-aromatic polymers according to claim 1 or 2, wherein the alkylstyrene is present in a quantity ranging from 2 to 10% by weight.

4. The expandable granulates of vinyl-aromatic polymers
20 according to claim 1, 2 or 3, wherein the alkylstyrene is α -methylstyrene.

5. The expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4, wherein the carbon black has an average diameter ranging from 10 to 1000 nm, a specific
25 surface ranging from 5 to 200 m²/g, a sulfur content ranging from 0.1 to 2000 ppm, an ash residue ranging from 0.001 to 1%, a loss with heat ranging from 0.001 to 1%, a DBPA of

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5-100 ml/(100 g), and an iodine number ranging from 0.01 to 20 g/kg.

6. The expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4, wherein the oxides
5 and/or sulfates and/or lamellar dichalcogenides of metals of groups IIA, IIIA, IIB, IVB, VIB, VIIIB are those of Ca, Mg, Ba, for the group IIA, those of aluminum, for the group IIIA, those of Fe, for the group VIIIB, those of Mo, for the group VIB, and those of zinc and titanium for the group IIB and IVB
10 respectively and wherein the lamellar dichalcogenides are those of sulfur, selenium or tellurium.

7. The expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4, wherein the inorganic derivative of silicon is a product of the group of clays,
15 micas, clays and montmorillonites with an average size ranging from 0.5 to 50 μm .

8. The expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4, wherein the nucleating agent is selected from polyethylene, polyamide waxes having a
20 molecular weight ranging from 500 to 10,000 or from S-B, S-B-S, SIS, SEBS, SEP block copolymers of both the linear and branched type.

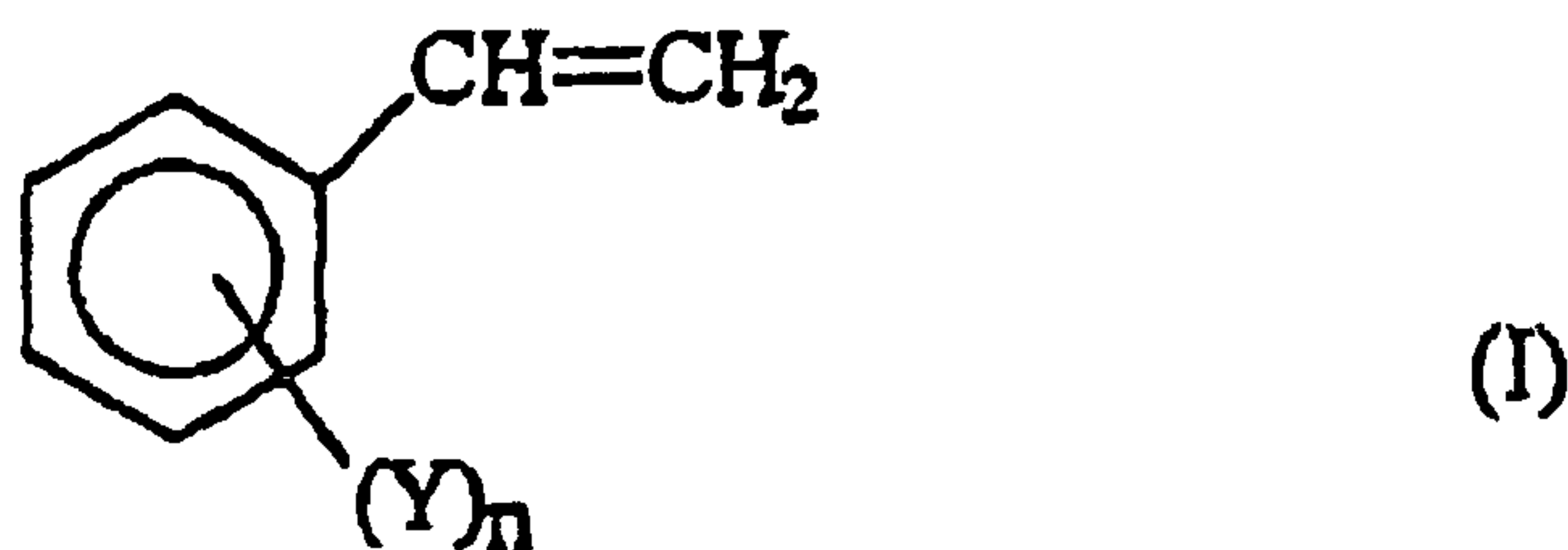
9. The expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4, comprising
25 flame-retardant agents in a quantity ranging from 0.1 to 8% by weight, with respect to the total weight of the resulting polymeric composition.

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10. Expanded articles having a density ranging from 5 to 50 g/l, having a thermal conductivity ranging from 27 to 50 mW/mK obtained after expansion, at a temperature slightly higher than the glass transition temperature of the polymer, of
5 the expandable granulates of vinyl-aromatic polymers according to any one of claims 1 to 4.

11. A process for the continuous mass preparation of expandable granulates of vinyl-aromatic polymers which essentially consists in the following steps in series:

10 i) mixing a vinyl-aromatic polymer in the form of granules or already in the molten state, obtained by polymerizing 85-100% by weight of one or more vinyl-aromatic monomers having general-formula (I)



15 wherein n is zero or an integer ranging from 1 to 5 and Y is a halogen, or an alkyl or alkoxy radical having from 1 to 4 carbon atoms

and 0-15% by weight of an α -alkylstyrene wherein the alkyl group contains from 1 to 4 carbon atoms, with the additives
20 (b)-(d) of claim 1 in the quantities indicated above;

ii) incorporating one or more expanding agents in the polymeric composition brought to the molten state;

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iii) granulating the composition thus obtained in a device which comprises a die, a cutting chamber and a cutting system.

12. The process according to claim 11, wherein the
5 expandable granulates are re-annealed at a temperature lower than or equal to the glass transition temperature (T_g), or slightly higher than the T_g , optionally under pressure.

13. The process according to claim 11 or 12, wherein the
10 vinyl-aromatic polymer comprises 2-10% by weight of α -alkylstyrene monomer.

14. The process according to claim 13, wherein the
vinyl-aromatic polymer consists of a mixture of two
(co)polymers, the first consisting of 50-100% by weight of
vinyl-aromatic monomer and 0-50% by weight of copolymerizable
15 monomer and the second of a vinyl-aromatic monomer- α -
alkylstyrene monomer copolymer, in such a ratio as to give a
final concentration of α -alkylstyrene equal to 2-10% by weight.

15. The process according to any one of claims 11 to 14,
wherein the vinyl-aromatic polymer already in the molten state
20 comes from a devolatilization step of a polymerization plant.

16. The process according to any one of claims 11 to 14,
wherein the vinyl-aromatic polymer already in the molten state
comes from a pre-melting step of already formed polymeric
granules, already mixed with processing waste products and/or
25 with the additives (b)-(d) of claim 1 in the quantities
indicated above.