Title: COATING COMPOSITION OF FLAME RETARDANT FOR FOAM RESIN, POLYSTYRENE FOAM COMPRISING THE SAME, AND METHOD FOR PREPARING THE SAME FOAM

Abstract: Provided are a flame retardant coating composition coated on a flammable foam resin to provide superior flame retardancy thereto, which comprises liquid modified alkali silicate synthesized from liquid alkali silicate and alkali soluble silica powder with a weight proportion ranging from 90:10 to 99:1 as a substrate, a polystyrene foam comprising the same, and a method for preparing the foam.
COATING COMPOSITION OF FLAME RETARDANT FOR FOAM RESIN, POLYSTYRENE FOAM COMPRISING THE SAME, AND METHOD FOR PREPARING THE SAME FOAM

[Technical Field]

The present invention relates to a flame retardant coating composition, more particularly to a flame retardant coating composition coated on a highly flammable foam resin to offer superior flame retardancy, a polystyrene foam comprising the same, and a method for preparing the foam.

[Background Art]

In general, resin foams such as polystyrene foam are widely used in the industries, including construction, because they are light-weight and have superior insulating property. But, recently, its use is restricted because it may induce fire.

In order to solve this problem, a flame retardant resin foam is required.

As methods of obtaining flame retardant resin foams, a method of adding a flame retardant to a expandable resin, a method of adding a flame retardant to a base resin when manufacturing a foam resin by extrusion, a method of coating a flame retardant on the surface of a resin foam, a method of injecting a flame retardant into the pores of a resin foam, a method of coating a flame retardant on expandable beads and then expanding the beads to obtain foams, etc. are known.
However, an inexpensive flame retardant coating composition capable of providing high-level flame retardancy to polystyrene foams is currently unavailable.

The use of alkali metal silicates unharfmal to the human body, e.g., sodium silicate, which form foamed films at high temperature, as flame retardant substrate is widely known. However, alkali silicates are hydrophilic and there is difficulty in coating them on organic polystyrene foams. Even when coating is possible, it is difficult to obtain stable and uniform film, and good water resistance is not attained. Besides, an outstanding flame retardancy is not attained.

In addition, alkali silicates easily react with carbon dioxide in the air, resulting in increased viscosity or hardness. Therefore, storage property is not good, and the film formed on the bead surface may form dusts by reacting with carbon dioxide in the air.

[Disclosure]

[Technical Problem]

The present invention has been made in an effort to solve the above-described problems associated with the prior art. An object of the present invention is to provide a flame retardant coating composition capable of providing high-level flame retardancy to a polystyrene foam with low cost, a flame retardant polystyrene foam comprising the same, and a method for preparing the same.
[Technical Solution]

In one aspect, the present invention provides a flame retardant coating composition for a foam resin comprising liquid modified alkali silicate synthesized from liquid alkali silicate and alkali-soluble silica powder with a weight proportion ranging from 90:10 to 99:1 as a substrate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of silicone oil, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch and 0.1 to 5 parts by weight of silicone oil, based on
In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch, 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of silicone oil and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of silicone oil, 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch, 0.1 to 5 parts by weight of silicone oil and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.
modified alkali silicate,

In another aspect, the present invention provides a flame retardant coating composition for a foam resin further comprising 0.1 to 5 parts by weight of sugar or modified starch, 0.1 to 5 parts by weight of silicone oil, 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

In another aspect, the present invention provides a flame retardant polystyrene foam comprising the aforesaid flame retardant coating compositions for a foam resin.

In another aspect, the present invention provides a method for preparing a flame retardant polystyrene foam comprising the steps of: providing expandable polystyrene beads; loading the beads into a mold; and performing expanding form by hot steam; and before or after the above forming, treating the beads or the foam with the flame retardant coating composition for a foam resin.

[Advantageous Effects]

The flame retardant coating composition for a foam resin according to the present invention is an inexpensive flame retardant coating composition capable of providing high-level flame retardancy to foams. And, the polystyrene foam of the present invention comprising the flame retardant coating composition has a high-level flame retardancy so as to pass the second-grade flame retardance test. Furthermore, the preparation method of the polystyrene foam comprising the flame retardant coating composition according to the present invention is an
economical method applicable to existing manufacturing facilities without additional equipments.

[Description of Drawings]

FIG. 1 is a photograph showing the surface of the polystyrene foam prepared using the flame retardant coating composition of Example 1 after exposure to flames for 10 seconds using a gas torch.

FIG. 2 is a photograph showing the surface of the polystyrene foam prepared using the flame retardant coating composition of Comparative Example 1 after exposure to flames for 10 seconds using a gas torch.

FIG. 3 is a photograph showing the wet film obtained by applying the flame retardant coating composition of Example 1 once on the surface of polystyrene foams using a brush.

FIG. 4 is a photograph showing the wet film obtained by applying the flame retardant coating composition of Comparative Example 1 once on the surface of polystyrene foams using a brush.

FIG. 5 is a photograph showing the beads obtained by impregnating in the flame retardant coating composition of Example 1 and drying with a dryer.

FIG. 6 is a photograph showing the beads obtained by impregnating in the flame retardant coating composition of Comparative Example 1 and drying with a dryer.

FIG. 7 is a photograph showing the beads fused inside the polystyrene foam prepared in Example 64.
[Best Mode]

The inventor of the present invention has found that the addition of alkali-soluble silica powder to liquid alkali silicate results in a solution which has increased viscosity without increased stickiness, generates less dusts after curing, and is not easily dissolved in warm water. The inventor has also found that by coating the solution on the foam resin particles and foaming the same, a high-level flame retardant foam may be obtained.

The inventor has further found that the addition of modified starch to liquid modified alkali silicate results in good solubility, superior coatability for expandable resins or foam resins, improved water resistance, and improved heat fusion of foam resins.

The inventor has further found that the addition of silicone oil to liquid modified alkali silicate results in improvement of various physical properties, including fire resistance, water resistance, storage characteristics, efflorescence resistance, dust resistance, flexibility and releasability of cured film, etc.

The inventor has further found that the addition of organosilane to liquid modified alkali silicate leads to formation of a new binder, thereby resulting in enhanced adhesion and film strength together with improved fire resistance and water resistance.

The inventor has further found that the addition of modified starch along with silicone oil to liquid modified alkali silicate leads to formation of a new binder, thereby resulting in enhanced adhesion and film strength as well as superior
coatability for expandable resins or foam resins, improved water resistance, improved heat fusion of foam resins, and improved fire resistance, water repellency, storage characteristics, efflorescence resistance, dust resistance, flexibility and releasability of cured film, etc.

Hereunder is given a more detailed description of the present invention.

Flame retardant coating composition for foam resin

The flame retardant coating composition for a foam resin of the present invention is a flame retardant coating composition for providing flame resistance to polystyrene foams prepared by the bead method. In the bead method, raw expandable polystyrene beads are expanded and heat fused by heating to obtain polystyrene foams, commonly known by the trade name Styrofoam. The flame retardant coating composition of the present invention is either coated on raw expandable polystyrene beads or expandable polystyrene beads or injection coated in polystyrene foams to obtain flame retardant polystyrene foams. The flame retardance is attained due to the fire resistance, flame retardance, coatability, etc. of the flame retardant coating composition of the present invention.

In the flame retardant coating composition of the present invention, alkali silicate serves at once as flame retardant base, binder and solvent.

Cured alkali silicate prevents the cured film from transferring oxygen to polystyrene foams, when the cured film is subject to extreme heat such as flame. At 150 °C or higher, crystal water is liberated from, causing the cured film to expand and form a cell-type foamed film. The foamed film blocks oxygen
transfer and prevents the polystyrene foams from burning due to its insulating property.

Especially, the modified alkali silicate of the present invention prepared from the reaction of liquid alkali silicate and alkali-soluble silica powder results in increased film strength because of high silicon dioxide density and results in more foams per unit area, thereby resulting in better insulation and fire resistance, when compared with general water glass. The increased film strength reduces the generation of dusts during the production process, significantly reduces efflorescence caused by carbon dioxide included in the air, and makes the cured film less soluble even in hot water (80-100 °C).

Aggregation of beads may cause negative effects on material transfer and uniform foaming during the production process. In the present invention, this problem is solved because the beads aggregate less upon bead coating.

Further, the flame retardant coating composition of the present invention has superior coatability. Coatability also affects the flame retardance. When alkali-soluble silica powder is added to liquid alkali silicate, viscosity of the liquid alkali silicate increases without increase in stickiness. The high viscosity accompanied by low stickiness allows uniform and adequate coating on the surface of raw expandable polystyrene beads or expandable polystyrene beads over a large area even with a small amount, and reduces aggregation of the coated raw beads or beads. The less aggregation increases the rate of drying of the coating material coated on the raw beads or beads, and allows good heat fusion of the beads because the heating medium such as water vapor is
transferred uniformly during the second foaming. As a result, foams with no void are attained. The absence of voids provides superior flame retardance because air is not supplied well.

The flame retardant coating composition of the present invention is a liquid with low thixotropy. Because solid particulate materials are not included, there is no problem of dust generation upon drying or curing of film. The low thixotropy is due to the absence of hydrogen bonding between hydrophilic particles and water molecules of alkali silicate. This reduces aggregation of raw beads or beads during coating, and loss during transfer and storage, which is caused by sticking to the inner wall of the transfer pipe, etc.

In the present invention, the liquid modified alkali silicate prepared from the reaction of liquid alkali silicate and alkali-soluble silica powder is used as polystyrene flame retardant coating composition for a foam resin, or modified starch, silicone oil and/or organosilane are added to the liquid modified alkali silicate, in order to provide superior flame retardance, coatability, water resistance and formability.

Specific embodiments of the present invention are described below.

Liquid modified alkali silicate: reaction product of liquid alkali silicate and alkali-soluble silica powder

The flame retardant coating composition for a foam resin of the present invention may be obtained by adding alkali-soluble silica powder to liquid alkali silicate and dissolving the same. Thus obtained reaction product is liquid modified alkali silicate with increased silicon dioxide content.
To this end, the liquid alkali silicate is preferably selected from sodium silicate, potassium silicate and lithium silicate. Considering flame retardance, coatability and manufacturing productivity, sodium silicate, particularly commercially available water glass No. 2, is more preferred. Meta-sodium silicate in powder form or water glass No. 1 with little fluidity may be used as dissolved in water. In that case, a dry solid content of 30 to 50 weight % is preferred for appropriate fire resistance and coatability.

The silica powder may be either amorphous silica or crystalline silica. One with small particle size is preferred for the dissolution in the liquid alkali silicate. A particle size of 325-mesh all pass will be sufficient.

Preferable amorphous silica is one that can be silicated by alkali, such as white carbon, silica gel, fumed silica, fused silica, diatomaceous earth, etc. And, preferable crystalline silica is α-quartz comprising at least 50 % of soluble silicon dioxide (SiO₂). For example, the quartzite mined at the quartzite mine located at Gaegok-ri, Gapyeong-eup, Gapyeong-gun, Gyeonggi-do, Korea may be used.

Although variable depending on the particular silica and liquid alkali silicate, a preferred proportion of the liquid alkali silicate to the silica powder is from 90 : 10 to 99 : 1, based on weight. When the addition amount of the silica is less than 1, fire resistance and water resistance may be insufficient. Particularly, flame retardance becomes deteriorated since the coating composition is lost during foaming and heat fusion by water vapor or upon exposure to raindrops, etc. When the addition amount of the silica exceeds 4, water resistance and drying characteristics are improved, but, with amorphous
silica, storage characteristics are deteriorated as the coating material becomes gelatinized. When the addition amount of the silica exceeds 10, the composition cannot be used for coating because curing occurs. In the case of crystalline silica, gelation or curing does not occur, but when the addition amount of the silica exceeds 10, undissolved silica may precipitate, thereby causing dust generation during drying, increased aggregation of coated raw beads or beads because of greatly increased thixotropy, poor coatability, and increased hardness.

Thus prepared liquid modified alkali metal silicate has a significantly increased silicon dioxide content, as compared with conventional sodium silicate (23-38 weight %).

**Liquid modified alkali silicate and modified starch**

Another embodiment of the flame retardant coating composition of the present invention is attained by mixing the liquid modified alkali silicate with sugar or modified starch by dissolving.

The addition of sugar or modified starch by dissolving or dispersing results in improved coatability and coating adhesivity of the flame retardant coating composition to raw expandable polystyrene beads, expandable polystyrene beads or polystyrene foams, increased water resistance, and improved heat fusion of foam resins.

Liquid sugar is added to the liquid modified alkali metal silicate. For instance, glucose, dextrose, malto-dextrine, fructose, sucrose, syrup with low dextrose, oligosaccharide, etc. may be used either alone or in combination. The
hydroxyl groups of the sugar are chemically bonded to the siloxane groups of the silicate, thereby resulting in improved coatability, adhesion, storage characteristics, film flexibility, and water resistance.

Starch basically consists of glucose. It is a mixture of amylase (unbranched fraction) and amylopectin (branched fraction). Through gelatinization into α-form, thickening effect is improved and film formation upon drying becomes possible.

The modified starch used in the present invention refers to a starch modified by physical or enzymatic treatment. The modified starch may be gelatinized in advance and dissolved or dispersed in alkali. Upon drying, the modified starch may form film (retrogradation to β-form).

Examples of the modified starch that can be used include refined starch, bleached starch obtained by bleaching refined starch using an oxidizing agent, refined tapioca starch obtained by removing crude fiber, crude protein, crude ash, etc. from cassava powder, modified starch obtained by substituting hydroxyl groups of starch molecules with sodium hypochlorite, cationic starch obtained by substituting hydroxyl groups of starch molecules with a quaternary ammonium compound, acetylated starch obtained by substituting hydroxyl groups of starch molecules with ester, phosphate-crosslinked starch obtained by linking two hydroxyl groups of two starch molecules, and epichlorohydrin-crosslinked starch.

Preferably, the sugar or modified starch is added in an amount from 0.1 to 5 parts by weight, based on 100 parts by weight of the alkali silicate. When the addition amount is below 0.1 part by weight, improvement of water resistance,
etc. cannot be expected. And, when the addition amount exceeds 5 parts by weight, fire resistance is deteriorated abruptly.

**Liquid modified alkali silicate and silicone oil**

In another embodiment of the flame retardant coating composition of the present invention, silicone oil is added to the liquid modified alkali silicate.

The addition of silicone oil results in improvement of flexibility of foams, fire resistance, water resistance, storage characteristics, efflorescence resistance of cured film, aggregation characteristics of coated beads, dust resistance, releasability during foaming, etc.

The siloxane groups of increased silicon dioxide and silicate make the hydrophobic silicone oil miscible with the liquid modified alkali silicate.

The silicone oil used in the present invention is a straight-chain oil consisting of dimethylpolysiloxane. Modified oils with various organic groups introduced in part of the methyl groups of the dimethylpolysiloxane, e.g., amino-modified, epoxy-modified, carboxyl-modified, carbinol-modified, methacryl-modified, mercapto-modified, phenol-modified, single-end modified, heterofunctional group-modified, polyether-modified, methylstyrene-modified, alkyl-modified, higher fatty acid ester-modified, fluorine-modified oils, may also be used. Preferably, the silicone oil has a viscosity in the range from 50 to 5000 cs (centi-stokes). When the viscosity is below 50 cs, the silicone oil is not mixed with the liquid modified alkali silicate, but remains separated. Consequently, a larger amount of silicone oil is required to attain the wanted properties. And, when the viscosity exceeds 5000 cs, the process of mixing becomes difficult.
Preferably, the silicone oil is added in amount from 0.1 to 5 parts by weight, based on 100 parts by weight of the liquid modified alkali silicate. When the addition amount is less than 0.1 part by weight, the effect of addition is slight. And, when the addition amount exceeds 5 parts by weight, the effect of addition does not increase further, and the beads are not heat-fused well.

**Liquid modified alkali silicate and organosilane**

In another embodiment of the flame retardant coating composition of the present invention, organosilane is added to the liquid modified alkali silicate. The addition of organosilane results in improved flexibility, fire resistance and water resistance of foams, improved efflorescence resistance of cured film, and improved adhesion of the coating composition.

The organosilane used in the present invention, also commonly called as silane or silane coupling agent, refers to an organosilicon compound in which an alkoxy, chloro or alkyl group is bonded to a silicon atom. It may form hydrogen bonding with moisture in the air. Examples of the organosilane that can be used include alkoxy silane, aminosilane, epoxysilane, acrylic silane, vinylic silane, mercaptosilane, etc. Among them, alkoxy silane, particularly methylthmethoxysilane, is preferred.

Preferably, the organosilane is added in an amount from 0.1 to 1 part by weight, based on 100 parts by weight of the liquid modified alkali silicate. When the addition amount is less than 0.1 part by weight, the effect of addition is slight. And, when the addition amount exceeds 1 part by weight, the coating composition may be gelatinized.
The gel formed when the addition amount of the organosilane exceeds 1 part by weight based on 100 parts by weight of the liquid modified alkali silicate results from the reaction with the silicate, and may function as another binder at high temperature in addition to the silicate. However, when the addition amount of the organosilane exceeds 1 part by weight, the gel is formed accompanied by abrupt exothermic reaction. The addition of boric acid or borax in advance may prevent the gel formation. Further, the addition of the boric acid or borax results in improved flame retardance of the flame retardant coating composition.

In case boric acid or borax is added, the preferred addition amount of the organosilane is from 1 to 10 parts by weight, based on 100 parts by weight of the liquid modified alkali silicate. When the addition amount of the organosilane is below 1 part by weight, the boric acid or borax needs not be added because gelation does not occur. And, when the addition amount of the organosilane exceeds 10 parts by weight, adhesion does not increase further.

And, the amount of the boric acid or borax added before the addition of the organosilane is preferably from 0.5 to 10 parts by weight, based on 100 parts by weight of the liquid modified alkali silicate. When the addition amount is less than 0.5 part by weight, gelation cannot be prevented. And, when the addition amount exceeds 10 parts by weight, water resistance decreases without further improvement of the prevention effect of gelation and improvement of flame retardance.

The silicone oil or organosilane used in the present invention has siloxane groups and various other functional groups offering good fire resistance,
and, thus, provides heating control and self-extinguishing properties to the flame retardant coating composition.

**Liquid modified alkali silicate, modified starch and silicone oil**

In another embodiment of the flame retardant coating composition of the present invention, modified starch and silicone oil are added to the liquid modified alkali silicate.

The concomitant addition of modified starch and silicone oil results in improved adhesion, in addition to the effects attained by the addition of modified starch and silicone oil described above. That is, the modified starch reacts with the silicone oil to form a new binder, thereby improving adhesion of the flame retardant coating composition to beads. It is considered that the new binder is attained from the reaction of the functional group of the modified starch with the siloxane group of the silicone oil. Actually, the reaction product resulting from the addition of the silicone oil in an aqueous solution of the modified starch while stirring forms soft but strong white film upon drying, like an emulsion-type binder.

To this end, the modified starch and the silicone oil are added in an amount of 0.1 to 5 parts by weight and 0.1 to 5 parts by weight, respectively, based on 100 parts by weight of the liquid modified alkali silicate. The proportion of the two components may be varied depending on applications.

**Liquid modified alkali silicate, modified starch and organosilane**

In another embodiment of the flame retardant coating composition of the present invention, modified starch and organosilane are added to the liquid modified alkali silicate.
In addition to the effects attained by the addition of each of the modified starch and the organosilane, the concomitant addition of modified starch and organosilane further provides the advantage of increased adhesion to beads. This seems to be due to the functional groups of the modified starch and the organosilane.

To this end, the modified starch and the organosilane are added in an amount of 0.1 to 5 parts by weight and 0.1 to 1 part by weight, respectively, based on 100 parts by weight of the liquid modified alkali silicate. Or, considering the reactivity of the organosilane with the silicate, 0.1 to 5 parts by weight of the modified starch, 1 to 10 parts by weight of the organosilane, and 0.5 to 10 parts by weight of boric acid or borax may be added to 100 parts by weight of the liquid modified alkali silicate. The proportion of the components may be varied depending on applications.

Liquid modified alkali silicate, silicone oil and organosilane

In another embodiment of the flame retardant coating composition of the present invention, silicone oil and organosilane are added to the liquid modified alkali silicate.

In addition to the effects attained by the addition of each of the silicone oil and the organosilane, the concomitant addition of silicone oil and organosilane further provides the advantage of improved adhesion to beads and film strength. This seems to be due to the coupling effect of the organosilane.

To this end, the silicone oil and the organosilane are added in an amount of 0.1 to 5 parts by weight and 0.1 to 1 part by weight, respectively, based on 100
parts by weight of the liquid modified alkali silicate. Or, considering the reactivity of the organosilane with the silicate, 0.1 to 5 parts by weight of the silicone oil, 1 to 10 parts by weight of the organosilane, and 0.5 to 10 parts by weight of boric acid or borax may be added to 100 parts by weight of the liquid modified alkali silicate. The proportion of the components may be varied depending on applications.

**Liquid modified alkali silicate, modified starch, silicone oil and organosilane**

In another embodiment of the flame retardant coating composition of the present invention, modified starch, silicone oil and organosilane are added to the liquid modified alkali silicate.

In addition to the effects attained by the addition of each of the modified starch, the silicone oil and the organosilane, the concomitant addition of modified starch, silicone oil and organosilane further provides the advantage of improved adhesion to beads, film strength, etc. This seems to be due to the coupling effect of the organosilane, as well as the functional groups of the modified starch and the organosilane, and the formation of binder by the silicone oil and the modified starch.

To this end, the modified starch, the silicone oil and the organosilane are added in an amount of 0.1 to 5 parts by weight, 0.1 to 5 parts by weight and 0.1 to 1 part by weight, respectively, based on 100 parts by weight of the liquid modified alkali silicate. Or, considering the reactivity of the organosilane with the silicate, 0.1 to 5 parts by weight of the modified starch, 0.1 to 5 parts by
weight of the silicone oil, 1 to 10 parts by weight of the organosilane and 0.5 to 10 parts by weight of boric acid or borax may be added to 100 parts by weight of the liquid modified alkali silicate. The proportion of the components may be varied depending on applications.

The compositions comprising the liquid modified alkali metal silicate described above can be summarized as follows. However, the present invention is not limited thereto.

A first embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; and ii) 0.1 to 5 parts by weight of sugar or modified starch.

A second embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; and ii) 0.1 to 5 parts by weight of silicone oil.

A third embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; and ii) 0.1 to 1 part by weight of organosilane.

A fourth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 1 to 10 parts by weight of organosilane; and iii) 0.5 to 10 parts by weight of boric acid or borax.

A fifth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 0.1 to 10 parts by weight of silicone oil; and iii) 0.1 to 1 part by weight of organosilane.

A sixth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 0.1 to 10 parts by weight of silicone oil; and iii) 0.1 to 10 parts by weight of sugar or modified starch.

A seventh embodiment comprises i) 100 parts by weight of liquid modified
alkali metal silicate; ii) 0.1 to 1 part by weight of organosilane; and iii) 1 to 10 parts by weight of sugar or modified starch.

An eighth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 0.1 to 10 parts by weight of silicone oil; iii) 1 to 10 parts by weight of organosilane; and iv) 0.5 to 10 parts by weight of boric acid or borax.

A ninth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 1 to 10 parts by weight of organosilane; iii) 0.5 to 10 parts by weight of boric acid or borax; and iv) 1 to 10 parts by weight of sugar or modified starch.

A tenth embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 0.1 to 10 parts by weight of silicone oil; iii) 0.1 to 1 part by weight of organosilane; and iv) 0.1 to 10 parts by weight of sugar or modified starch.

An eleventh embodiment comprises i) 100 parts by weight of liquid modified alkali metal silicate; ii) 0.1 to 10 parts by weight of silicone oil; iii) 1 to 10 parts by weight of organosilane; iv) 0.5 to 10 parts by weight of boric acid or borax; and v) 0.1 to 10 parts by weight of sugar or modified starch.

**Addition of other additives**

Each of the flame retardant coating compositions of the present invention may further comprise 0.01 to 3 parts by weight of a pigment based on 100 parts by weight of the liquid modified alkali silicate, in order to provide color to polystyrene foams. When the pigment is added in an amount less than 0.01 part by weight, it is difficult to provide color to polystyrene foams. And, an
amount exceeding 3 parts by weight does not provide a richer color.

In addition, the flame retardant coating composition of the present invention may further comprise 0.01 to 2 parts by weight of a liquid flame retardant based on 100 parts by weight of the liquid modified alkali silicate, in order to further improve flame retardance. When the liquid flame retardant is added in an amount less than 0.01 part by weight, further improvement of flame retardance may not be attained. And, when the liquid flame retardant is added in an amount exceeding 2 parts by weight, flame retardance is not improved further, and precipitation may occur. The liquid flame retardant is added to the flame retardant coating composition of the present invention to provide self-distinguishing property. Compounds soluble in water and alkali, e.g., phosphor compounds or dicyandiamides, are preferred.

Previously known inorganic particles may be added as flame retardant. But, in that case, a small amount is preferred considering the possibility of dust generation during drying, deterioration of storage characteristics caused by precipitation, and flexibility and transparency of cured film, and the like.

Flame retardant polystyrene foam

The flame retardant polystyrene foam of the present invention may be prepared by coating the flame retardant coating composition for a foam resin on raw expandable polystyrene beads or pre-foamed expandable polystyrene beads, loading the same in a mold, and performing heat fusion by applying heat. Depending on the manufacturing environment, drying may or may not be performed during the coating.
Alternatively, the flame retardant coating composition of the present invention may be injection coated in already foamed and/or heat-fused polystyrene foams to prepare flame retardant polystyrene foams. Preferred coating amount is 50 to 500 parts by weight, based on 100 parts by weight of expandable polystyrene beads. The larger the coating amount, the higher is the flame retardance. When the coating amount is less than 50 parts by weight, it is difficult to attain wanted flame retardance. And, when the coating amount exceeds 500 parts by weight, it is difficult to attain perfect fusion of beads. The coating amount for coating on raw polystyrene beads or for injection coating in polystyrene foams is determined likewise.

The coating method is not particularly limited. Any of dip coating, spray coating, beat coating, screw coating, injection coating, etc. may be used.

Following the coating, it is preferable to perform foaming by drying. The drying may be performed by natural drying, hot air drying, microwave drying, or CO₂ curing drying using the reaction of alkali silicate with carbon dioxide.

Such prepared flame retardant polystyrene foam of the present invention exhibits flame retardance corresponding to or better than 3rd grade or 2nd grade flame retardance, depending on the source materials of the flame retardant coating composition, proportions thereof and coating amount.

[Mode for Invention]

The following examples are intended to illustrate the present invention and should not be construed as limiting the scope of the present invention.
Examples

Example 1

15 g of silica gel (ss-sil230, S-ChemTech) with an average particle size of 3.4 µm was added to 500 g of liquid sodium silicate Water Glass No. 2. Dissolution was performed by stirring at 500 rpm for 10 minutes to obtain a flame retardant coating composition comprising liquid modified sodium silicate.

Comparative Example 1

Water Glass No. 2 was prepared as a flame retardant coating composition.

Test Example

Each of the flame retardant coating compositions prepared in Example 1 and Comparative Example 1 was dip coated on expandable polystyrene beads at 1:1 mixing proportion of the beads and coating composition. In wet state, the beads were loaded in a 100Φ cylindrical mold and heat-fusion molded by foaming at a water vapor pressure of 0.5 kgf/cm². Flame was applied to the prepared polystyrene foams for 10 seconds using a gas torch. The result can be seen in FIG. 1 and FIG. 2. The polystyrene foams prepared from the flame retardant coating composition of the present invention (FIG. 1) exhibited no burning or generation of gases. Numerous foamed films of silicate were observed on the surface contracted by exposure to the flame. The polystyrene foams prepared from Water Glass No. 2 (FIG. 2) exhibited no burning or generation of gases, either. However, the surface contracted by exposure to the flame was wider and deeper, and the foamed films of silicate were larger and
less.

In order to test coatability and adhesion of the prepared flame retardant coating compositions, each of the coating compositions was coated on polystyrene foams using a brush (thickness of wet film = ~4 mil). The result can be seen in FIG. 3 and FIG. 4. Whereas the liquid modified sodium silicate of Example 1 were uniformly coated (FIG. 3), aggregation was observed for Comparative Example 1 (FIG. 4).

Also, in order to test aggregation property of the prepared flame retardant coating compositions, each of the coating compositions was dip coated on expandable polystyrene beads at 1:1 mixing proportion of the beads and coating composition, and dried using a dryer while stirring. The result can be seen in FIG. 5 and FIG. 6. Whereas the liquid modified sodium silicate of Example 1 exhibited less aggregation (FIG. 5), Comparative Example 1 showed more aggregation (FIG. 6).

And, in order to test water resistance of the flame retardant coating compositions, each of the coating compositions was coated on polystyrene foams with a thickness of 4 mil and an area of 200 cm² using a square applicator. After drying, the polystyrene foams were immersed in 90 °C of hot water for 10 minutes. Then, the polystyrene foams were dried and the loss of the coating composition was calculated. In Example 1, the loss of the coating composition was 15 weight %, and in Comparative Example 1, the loss of the coating composition was 88 weight %.

Also, in order to test adhesion force, each of the coating compositions
was coated on polystyrene foams with a thickness of 2 mil and an area of 200 cm\(^2\) using a square applicator. After drying, lines were drawn on the resultant film to result in 5 x 5 squares of size 2 mm x 2 mm. A cellophane tape was attached and then detached. In Example 1, the loss ratio of the coating composition was 8/25, and in Comparative Example 1, the loss ratio of the coating composition was 17/25.

**Example 2**

Preparation of flame retardant coating composition: Liquid alkali silicate/amorphous silica

96 kg of sodium silicate Water Glass No. 2 was put in a plastic drum. While stirring at 500 rpm with a paddle stirrer, 4 kg of 400-mesh all pass white carbon (TIXOSIL 38 AB, Rhodia Silica Korea) was put as amorphous silica. Stirring was further performed for 10 minutes to obtain a flame retardant coating composition. In water resistance test (90 °C hot water), loss of the coating composition was 13 weight %. In adhesion strength test (cellophane tape test), the loss ratio of the coating composition was 8/25.

**Examples 3 to 18**

Flame retardant coating compositions were prepared using the liquid modified alkali silicate prepared in Example 1 and the components listed in Tables 1 and 2 below.

**Comparative Example 2**

A flame retardant coating composition was prepared using commercially available sodium silicate Water Glass No. 2 and the components listed in Table 2.
Comparative Example 3

A flame retardant coating composition was prepared using commercially available sodium silicate Water Glass No. 3 and the components listed in Table 2.

Table 1

<table>
<thead>
<tr>
<th>(Parts by weight)</th>
<th>Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Modified SS</td>
<td>100</td>
</tr>
<tr>
<td>Water Glass No. 2</td>
<td>-</td>
</tr>
<tr>
<td>Water Glass No. 3</td>
<td>-</td>
</tr>
<tr>
<td>Carboxyl-modified</td>
<td>0.5</td>
</tr>
<tr>
<td>Cation-modified</td>
<td>-</td>
</tr>
<tr>
<td>Silicone oil 1000 cs</td>
<td>-</td>
</tr>
<tr>
<td>Silicone oil 50 cs</td>
<td>-</td>
</tr>
<tr>
<td>Methylmethoxy silane</td>
<td>-</td>
</tr>
<tr>
<td>Vinyltrimethoxy silane</td>
<td>-</td>
</tr>
<tr>
<td>Boron compound</td>
<td>-</td>
</tr>
<tr>
<td>Pigment Red</td>
<td>0.1</td>
</tr>
<tr>
<td>Liquid DCDA</td>
<td>-</td>
</tr>
<tr>
<td>Substrate</td>
<td>Modified SS 100</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>Water Glass No. 2</td>
</tr>
<tr>
<td></td>
<td>Water Glass No. 3</td>
</tr>
<tr>
<td>Modified starch</td>
<td>Carboxyl-modified 1.0</td>
</tr>
<tr>
<td></td>
<td>Cation-modified</td>
</tr>
<tr>
<td>Silicone oil</td>
<td>1000 cs - 0.5</td>
</tr>
<tr>
<td></td>
<td>50 cs - 4.0</td>
</tr>
<tr>
<td>Organo-silane</td>
<td>Methylmethoxysilane - 1.0</td>
</tr>
<tr>
<td></td>
<td>Vinyltrimethoxysilane 5.0</td>
</tr>
<tr>
<td>Boron compound</td>
<td>Borax 3</td>
</tr>
<tr>
<td>Pigment</td>
<td>Red 0.1</td>
</tr>
<tr>
<td>Liquid flame retardant</td>
<td>DCDA - 2.0</td>
</tr>
<tr>
<td></td>
<td>TPP - 1.0</td>
</tr>
</tbody>
</table>

**Table 2**

(Parts by weight)
In Tables 1 and 2, modified SS refers to the liquid modified alkali silicate prepared in Example 1, DCDA refers to dicyandiamide, and TPP refers to triphenyl phosphate.

Physical properties

Physical properties of the compositions prepared in Examples 3 to 18 and Comparative Examples 2 and 3 were measured and are presented in Tables 3 and 4 below. O means good and X means poor. Precipitation was observed with eyes after allowing a sealed beaker containing each solution to stand for 28 days. Storage characteristics was observed with eyes after allowing a sealed beaker containing each solution to stand for 28 days by determining whether viscosity increased, and/or gelation or curing had occurred.

Table 3

<table>
<thead>
<tr>
<th>Physical properties</th>
<th>Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Precipitation</td>
<td>O</td>
</tr>
<tr>
<td>Storage stability (28 days)</td>
<td>O</td>
</tr>
<tr>
<td>Water resistance (weight %)</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4

<table>
<thead>
<tr>
<th>Physical properties</th>
<th>Ex.</th>
<th>Comp. Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examples 19 to 33 and Comparative Examples 4 and 5

Preparation of flame retardant EPS board

Each 152 g of the flame retardant coating compositions prepared in Examples 1 to 17 and Comparative Examples 2 and 3 was dip coated on 76 g of expandable polystyrene beads. Without drying, the beads were loaded in a mold equipped with a 22 cm x 22 cm x 10 cm wire gauze, and foamed in a chamber for 20 seconds at a water vapor pressure of 0.8 kgf/cm² to obtain flame retardant polystyrene foams.

Flexibility was evaluated by touching the board with fingers. © means superior, O means good, Δ means moderate, and X means hard. Heat fusion property was evaluated by observing the fracture surface of the board. ® means that 80 % or more of bead particles were broken, O means 65 % or more of bead particles were broken, and X means less than 65 % of bead particles were broken. Water repellency was evaluated by observing water drops sprayed on the board. O means that water drops roll on the surface, and X means that they do not. Flame retardance was evaluated by flame retardance

<table>
<thead>
<tr>
<th></th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Storage stability (28 days)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Water resistance (weight %)</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>11</td>
<td>14</td>
<td>95</td>
<td>89</td>
</tr>
</tbody>
</table>
test according to KS F 2271-1998. O means pass, and X means fail.

Physical properties and flame retardance test result are given in Table 5 below.

Table 5

<table>
<thead>
<tr>
<th>(Parts by weight)</th>
<th>Ex.</th>
<th>Comp. Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19</td>
<td>20 21 22 23 24 25 26 27 28 29 30 31 32 33 34</td>
</tr>
<tr>
<td>Flexibility</td>
<td>O</td>
<td>O   O</td>
</tr>
<tr>
<td>Heat fusion</td>
<td>O</td>
<td>O   O</td>
</tr>
<tr>
<td>Water repelency</td>
<td>X</td>
<td>X   O</td>
</tr>
<tr>
<td>2nd grade</td>
<td>O</td>
<td>X   O</td>
</tr>
<tr>
<td>3rd grade</td>
<td>O</td>
<td>O   O</td>
</tr>
</tbody>
</table>

Examples 35 to 50 and Comparative Examples 6 and 7

Preparation of flame retardant EPS board

Each 152 g of the flame retardant coating compositions prepared in Examples 1 to 17 and Comparative Examples 2 and 3 was dip coated on 76 g of pre-foamed expandable polystyrene beads. Without drying, the beads were loaded in a mold equipped with a 22 cm x 22 cm x 10 cm wire gauze, and foamed in a chamber for 20 seconds at a water vapor pressure of 0.8 kgf/cm² to obtain flame retardant polystyrene foams.

Physical properties and flame retardance test result are given in Table 6 below.
Table 6

<table>
<thead>
<tr>
<th>(Parts by weight)</th>
<th>Ex.</th>
<th>Comp. Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>Flexibility</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Heat fusion</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Water repellency</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>2nd grade</td>
<td>○</td>
<td>×</td>
</tr>
<tr>
<td>3rd grade</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Examples 51 to 66 and Comparative Examples 8 and 9

Preparation of flame retardant EPS board

Each 152 g of the flame retardant coating compositions prepared in Examples 1 to 17 and Comparative Examples 2 and 3 was spray coated on 76 g of pre-foamed expandable polystyrene beads. After drying with hot air of 80 °C while stirring, the beads were loaded in a mold equipped with a 22 cm x 22 cm x 10 cm wire gauze, and foamed in a chamber for 20 seconds at a water vapor pressure of 0.8 kgf/cm² to obtain flame retardant polystyrene foams.

Physical properties and flame retardance test result are given in Table 6 below.

Table 7

<table>
<thead>
<tr>
<th>(Parts by weight)</th>
<th>Ex.</th>
<th>Comp. Ex.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>51</td>
<td>52</td>
</tr>
</tbody>
</table>
FIG. 7 is a photograph showing the beads fused inside the polystyrene foam prepared in Example 64. The photograph shows that the film formed from the flame retardant coating composition of the present invention does not interfere heat fusion.

Examples 67 to 82 and Comparative Examples 10 and 11

Preparation of flame retardant EPS board

Each of the flame retardant coating compositions prepared in Examples 1 to 17 and Comparative Examples 2 and 3 was injection coated in polystyrene foams having an absolute dry specific gravity of 0.015, and dried in the air. The injection coating was performed by touching the nozzle on the surface of the polystyrene foams, and infiltrating the flame retardant coating composition into the voids between the heat-fused foam particles at a pressure of 15 kgf/cm².

Physical properties and flame retardance test result are given in Table 8 below.

Table 8

<table>
<thead>
<tr>
<th>Flexibility</th>
<th>Heat fusion</th>
<th>Water repellency</th>
<th>2nd grade</th>
<th>3rd grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>1</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>2</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>3</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>4</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>5</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>6</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>7</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>8</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>9</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>10</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>11</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>12</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>13</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>14</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>15</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>16</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>17</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Table 8

(Parts by weight) | Ex. | Comp. Ex.

33
As will be apparent to those skilled in the art, various modifications and adaptations of the present invention above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.
[CLAIMS]

[Claim 1]

A flame retardant coating composition for a foam resin comprising liquid modified alkali silicate synthesized from liquid alkali silicate and alkali-soluble silica powder with a weight proportion ranging from 90 : 10 to 99 : 1 as a substrate.

[Claim 2]

The flame retardant coating composition for a foam resin according to claim 1, which further comprises at least one selected from the group consisting of sugar, modified starch, silicone oil, organosilane, boric acid and borax.

[Claim 3]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of sugar or modified starch, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 4]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of silicone oil, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 5]
The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 6]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 7]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of sugar or modified starch and 0.1 to 5 parts by weight of silicone oil, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 8]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of sugar or modified starch and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 9]
The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of silicone oil and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 10]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of silicone oil, 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 11]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of sugar or modified starch, 0.1 to 5 parts by weight of silicone oil and 0.1 to 1 part by weight of organosilane, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 12]

The flame retardant coating composition for a foam resin according to claim 2, which comprises 0.1 to 5 parts by weight of sugar or modified starch, 0.1 to 5 parts by weight of silicone oil, 1 to 10 parts by weight of organosilane and 0.5 to 10 parts by weight of boric acid or borax, based on 100 parts by weight of the liquid modified alkali silicate.
[Claim 13]

The flame retardant coating composition for a foam resin according to claim 1, which further comprises 0.01 to 3 parts by weight of pigment, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 14]

The flame retardant coating composition for a foam resin according to claim 1, which further comprises 0.01 to 2 parts by weight of liquid flame retardant, based on 100 parts by weight of the liquid modified alkali silicate.

[Claim 15]

A flame retardant polystyrene foam comprising the flame retardant coating composition for a foam resin according to claim 1.

[Claim 16]

A flame retardant polystyrene foam comprising the flame retardant coating composition for a foam resin according to claim 3.

[Claim 17]

A flame retardant polystyrene foam comprising the flame retardant coating composition for a foam resin according to claim 13.
[Claim 18]

A flame retardant polystyrene foam comprising the flame retardant coating composition for a foam resin according to claim 14.

[Claim 19]

A method for preparing a flame retardant polystyrene foam comprising the steps of:

- providing expandable polystyrene beads;
- loading the beads into a mold and performing expanding form by hot steam; and
- before or after the above forming, treating the beads or the foam with the flame retardant coating composition for a foam resin according to claim 1.

[Claim 20]

The method according to claim 19, wherein the beads are raw expandable polystyrene beads or pre-foamed expandable polystyrene beads.

[Claim 21]

The method according to claim 19, wherein the treating with the flame retardant coating composition for a foam resin is performed by coating the beads with the flame retardant coating composition for a foam resin before foaming.
[Claim 22]

The method according to claim 19, wherein the beads are dried before foaming by a method selected from the group consisting of natural drying, hot air drying, microwave drying and CO₂ drying.

5

[Claim 23]

The method according to claim 19, wherein the treating with the flame retardant coating composition for a foam resin is performed by injecting the flame retardant coating composition for a foam resin into foams after foaming.

10
Figures

Figure 1
Figure 7
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

C09D 1/02(2006.01)1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 C09D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS(ONLINE), DELPHION, eKIPASS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 4338374 A (WOELLNER-WERKE) 06 Jul 1982 See the whole document</td>
<td>1-23</td>
</tr>
<tr>
<td>A</td>
<td>US 4686244 A (DOW CORNING CORP ) 11 Aug 1987 See the whole document</td>
<td>1-23</td>
</tr>
<tr>
<td>A</td>
<td>JP 2003251736 A (OSAKA YUSHI KOGYO K K et al.) 09 Sept 2003 See the whole document</td>
<td>1-23</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C

* Special categories of cited documents
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search

28 APRIL 2008 (28 04 2008)

Date of mailing of the international search report


Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Seogu, Daejeon 302-701, Republic of Korea

Facsimile No 82-42-472-7140

Authorized officer

SIHN, YOUNG SIHN

Telephone No 82-42-481-8162
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP15251736 A</td>
<td>09.09.2003</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (patent family annex) (April 2007)