

SPECIFICATION

TITLE OF THE INVENTION

METHOD FOR RECOVERING STYRENE MONOMER FROM IMPACT-RESISTANT POLYSTYRENE

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to a method for recovering styrene monomers from impact-resistant polystyrene which obtains the styrene monomers by heating and decomposing the impact-resistant polystyrene, and its objective is to provide a method for recovering styrene monomers that are useful industrial materials from impact-resistant polystyrene at high yields with high purity. Conventional, no effective methods for recycling these wastes have been established.

Prior Art

Impact-resistant polystyrene (HI-PS) is a milky white resin obtained by graft-polymerizing styrene with butadiene rubber, and this has a high impact-resistant strength that is 5 to 10 times as high as that of polystyrene.

Impact-resistant polystyrene of this type with such a superior impact-resistant strength have been widely used as various products such as televisions, air conditioners and food containers, and some of impact-resistant polystyrene products we see in daily life are, for example, containers for beverages such as Yakult (trade name).

Conventionally, among wastes from such impact-resistant polystyrene products, one part of them has been recycled to form office products, etc.; however, most of those wastes derived from home products have been buried as non-flammable wastes.

Under these circumstances, the container and package recycling Law (law for promoting distinctive collection and re-cycled products related to containers and packages) came into force on July 1, 1997, and specified corporate organizations have been obliged to carry out the recycling operations of PET bottles. In addition to this, from the year 2000 on, the same law has come into force on plastic containers and packages other than PET bottles, and accordingly, wastes from impact-resistant polystyrene products such as containers, etc. for lactic acid beverages have to be recycled.

However, at present, most of wastes from impact-resistant polystyrene products have been buried as non-flammable wastes upon their disposal as described above, and no effective methods for recycling impact-resistant polystyrene products have been established.

The present invention has been devised to solve the above-mentioned problems, and its objective is to provide a method for recovering styrene monomers from impact-resistant polystyrene in which styrene monomers, which are industrially useful materials, can be recovered from wastes from impact-resistant polystyrene at high yields.

MEANS TO SOLVE THE PROBLEMS

The present invention has been devised to solve the above-mentioned problems, and the invention according to claim 1 relates to a method for

recovering styrene monomers from impact-resistant polystyrene, which obtains the styrene monomers by heating and decomposing the impact-resistant polystyrene, and which is characterized in that a sulfate and/or manganese dioxide is used as a catalyst.

The invention according to claim 2 relates to the method of claim 1 for recovering styrene monomers from impact-resistant polystyrene, which is characterized in that the sulfate is a metal sulfate.

The invention according to claim 3, which relates to the method of claim 1 for recovering styrene monomers from impact-resistant polystyrene, is characterized in that the sulfate is at least not less than one member selected from the group consisting of magnesium sulfate, manganese sulfate, calcium sulfate, antimony sulfate, sodium sulfate, iron (II) sulfate, zinc sulfate, aluminum sulfate and potassium sulfate.

The invention according to claim 4, which uses the method of claim 1 for recovering styrene monomers from impact-resistant polystyrene, is characterized in that the heating temperature of the polystyrene resin is set to not more than 350° C.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

The method for recovering styrene monomers from impact-resistant polystyrene of the present invention is characterized in that, upon thermally decomposing the impact-resistant polystyrene, a sulfate and/or manganese dioxide is used as a catalyst.

The reason for this is that the application of these catalysts makes it possible to thermally decompose polystyrene comparatively at low

temperatures, and also to reduce the amount of low molecular weight components contained in thermally decomposed vapors. Moreover, these catalysts can be easily obtained at comparatively low costs, thereby reducing the catalyst costs.

The following description will discuss the method for recovering styrene monomers from impact-resistant polystyrene in accordance with the present invention.

In the method for recovering styrene monomers from impact-resistant polystyrene in accordance with the present invention, a sulfate and/or manganese dioxide is used as a catalyst.

Specifically, examples of the sulfate include sulfate anhydrides, such as zinc sulfate, aluminum sulfate, antimonyl sulfate, antimony (III) sulfate, ammonium sulfate, ammonium aluminum sulfate, ammonium chromium (III) sulfate, ammonium cobalt (II) sulfate, ammonium iron (II) sulfate, ammonium iron (III) sulfate, ammonium manganese (II) sulfate, iridium (III) sulfate, lead sulfate, lead sulfate ore, cadmium sulfate, potassium sulfate, gallium (III) sulfate, potassium aluminum sulfate, potassium chromium (III) sulfate, calcium sulfate, normal silver sulfate, guanidinium aluminum sulfate, chromium (II) sulfate, chromium (III) sulfate, cobalt (II) sulfate, cobalt (III) sulfate, zirconium (IV) sulfate, mercury (I) sulfate, hydrogen 3-indryl sulfate, hydrogen potassium sulfate, tin (II) sulfate, strontium sulfate, cerium (III) sulfate, cerium (IV) sulfate, titanium (III) sulfate, titanium (IV) sulfate, iron (II) sulfate, iron (III) sulfate, copper (II) sulfate, dodecyl sodium sulfate, thorium (IV) sulfate, sodium sulfate, sodium aluminum sulfate, lead (II) sulfate, lead (IV) sulfate, nickel (II) sulfate, nickel (II) aluminum sulfate,

nitrosyl sulfate, disodium magnesium sulfate, neodymium (III) sulfate, vanadium (III) sulfate, barium sulfate, hydroxyl ammonium sulfate, praseodymium (III) sulfate, magnesium sulfate, magnesium dipotassium sulfate, manganese (II) sulfate, manganese (III) sulfate, lanthanum (III) sulfate, lignin sulfate, lithium sulfate, rubidium sulfate, rubidium aluminum sulfate, and manganese (III) cesium sulfate; and sulfate hydrates, such as zinc sulfate monohydrate, zinc sulfate hexahydrate, zinc sulfate heptahydrate, aluminum sulfate hexahydrate, aluminum sulfate decahydrate, aluminum sulfate 16-hydrate, aluminum sulfate 18-hydrate, aluminum sulfate 27-hydrate, ammonium chromium (III) sulfate 12-hydrate, ammonium cobalt (II) sulfate hexahydrate, ammonium iron (II) sulfate hexahydrate, ammonium iron (III) sulfate 12-hydrate, ammonium manganese (II) sulfate hexahydrate, cadmium sulfate monohydrate, cadmium sulfate $8/3$ -hydrate, cadmium sulfate heptahydrate, potassium aluminum 24-hydrate, potassium aluminum sulfate 12-hydrate, potassium aluminum sulfate 16-hydrate, potassium chromium (III) sulfate 12-hydrate, potassium chromium (III) sulfate hexahydrate, potassium chromium (III) sulfate trihydrate, potassium chromium (III) sulfate monohydrate, calcium sulfate dihydrate, chromium (II) sulfate heptahydrate, chromium (III) sulfate 18-hydrate, chromium (III) sulfate trihydrate, cobalt (II) sulfate hexahydrate, cobalt (II) sulfate monohydrate, cobalt (III) sulfate 18-hydrate, zirconium (IV) sulfate monohydrate, zirconium (IV) tetrahydrate, cerium (III) sulfate octahydrate, cerium (IV) sulfate tetrahydrate, titanium (IV) sulfate tetrahydrate, iron (II) sulfate monohydrate, iron (II) sulfate tetrahydrate, iron (II) sulfate pentahydrate, iron (II) sulfate heptahydrate, iron (III) sulfate trihydrate, iron

(III) sulfate hexahydrate, iron (III) sulfate heptahydrate, iron (III) sulfate 7.5-hydrate, iron (III) sulfate nonahydrate, iron (III) sulfate decahydrate, iron (III) sulfate 12-hydrate, copper (II) sulfate pentahydrate, thorium (IV) sulfate dihydrate, thorium (IV) sulfate tetrahydrate, thorium (IV) sulfate hexahydrate, thorium (IV) sulfate octahydrate, thorium (IV) sulfate nonahydrate, sodium sulfate heptahydrate, sodium sulfate decahydrate, sodium aluminum sulfate 24-hydrate, nickel (II) sulfate monohydrate, nickel (II) sulfate dihydrate, nickel (II) sulfate tetrahydrate, nickel (II) sulfate heptahydrate, disodium magnesium sulfate 2.5-hydrate, disodium magnesium tetrahydrate, vanadium (II) sulfate heptahydrate, vanadium (III) sulfate trihydrate, vanadium (III) sulfate nonahydrate, magnesium sulfate monohydrate, magnesium sulfate 1.5-hydrate, magnesium sulfate dihydrate, magnesium sulfate trihydrate, magnesium sulfate hexahydrate, magnesium sulfate heptahydrate, magnesium dipotassium sulfate tetrahydrate, magnesium dipotassium sulfate hexahydrate, manganese (II) sulfate monohydrate, manganese (II) sulfate dihydrate, manganese (II) sulfate tetrahydrate, manganese (II) sulfate pentahydrate, manganese (II) sulfate heptahydrate, and manganese (III) cesium sulfate 12-hydrate.

Among the above-mentioned sulfates, metal sulfates are preferably used, and among the metal sulfates, magnesium sulfates, calcium sulfates, antimony sulfates, manganese sulfates, sodium sulfates, iron (II) sulfates, zinc sulfates, aluminum sulfates, potassium sulfates and hydrates of these sulfates are more preferably used.

Moreover, the above-mentioned catalyst, as it is, may be used, or the above-mentioned catalyst supported on a carrier may be used. With respect

to the carrier, although not being particularly limited, those carriers, such as diatomaceous earth, alumina, silica gel, active carbon and zeolite, are preferably used.

With respect to the method for allowing the carrier to support the catalyst, it is not particularly limited; and a known method such as a dipping method and a co-precipitation method may be used.

When impact-resistant polystyrene (hereinafter, referred to as HI-PS) is decomposed by using the above-mentioned catalyst, HI-PS is simply heated in the presence of the catalyst in a heat-resistant reaction device such as a thermal decomposing device.

The heating temperature of the polystyrene resin, which is determined depending on the kinds of a catalyst to be used, is preferably set to not more than 350° C.

More specifically, for example, the preferable heating temperature ranges for the respective catalysts are shown as follows: in the case of manganese dioxide, the temperature range is 240 to 330° C, in the case of magnesium sulfate, the temperature range is 230 to 330° C, in the case of manganese sulfate, the temperature range is 220 to 320° C, in the case of calcium sulfate, the temperature range is 220 to 300° C, in the case of antimony sulfate, the temperature range is 210 to 340° C, in the case of sodium sulfate, the temperature range is 230 to 320° C. In the case of iron (II) sulfate, the temperature range is 250 to 320° C, in the case of zinc sulfate, the temperature range is 215 to 340° C, in the case of aluminum sulfate, the temperature range is 235 to 320° C, and in the case of potassium sulfate, the temperature range is 260 to 340° C.

Here, the amount of addition of each catalyst is not particularly limited; however, it is preferable to set it in the range of 10 to 20 weight % with respect to HI-PS.

HI-PS is heated to the above-mentioned predetermined temperature in the presence of the catalyst so that it is turned into thermally decomposed vapors of polystyrene. The thermally decomposed vapors contain, as impurities, for example, low boiling-point components such as benzene and toluene and high boiling-point components such as dimers and trimers; therefore, these are finally subjected to a refining process so as to recover styrene monomers with high purity.

The refining process is carried out by using a known method; and for example, a vacuum distilling process, etc. may be used.

Here, butadiene rubber, graft-polymerized in HI-PS, remains in the reaction device without being decomposed.

Examples

The following description will discuss the method for recovering styrene monomers from impact-resistant polystyrene by using a catalyst of the present invention by means of examples so as to clarify the effects of the present invention. However, the present invention is not intended to be limited by these examples.

(Example 1)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 60 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 10 g of manganese dioxide calcined at 500° C, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of ϕ 5 mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4).

Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 238.5 to 333.2° C, and the inlet temperature of the cooling tube was 146.5 to 174.3° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 80.7981 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.855 % and 3.782 % respectively. Here, FIG. 2 is a chart showing the results of the gas

chromatography analyses, and FIG. 3 show numeric value data of the results of the gas chromatography analyses.

(Example 2)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 40 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 16 g of magnesium sulfate calcined at 800° C, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 274 to 335.5° C, and the inlet temperature of the

cooling tube was 149.8 to 171.4° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 87.5956 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.1522 % and 1.6041 % respectively. Here, FIG. 4 is a chart showing the results of the gas chromatography analyses, and FIG. 5 show numeric value data of the results of the gas chromatography analyses.

(Example 3)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 10 g of manganese sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied

by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 228.8 to 297.3° C, and the inlet temperature of the cooling tube was 146.2 to 168.1° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 87.8054 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 4.8626 % and 1.9443 % respectively. Here, FIG. 6 is a chart showing the results of the gas chromatography analyses, and FIG. 7 show numeric value data of the results of the gas chromatography analyses.

(Example 4)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 10 g of calcium sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring

blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 200 to 302.7° C, and the inlet temperature of the cooling tube was 153 to 211° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 86.7463 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 6.109 % and 2.9067 % respectively. Here, FIG. 8 is a chart showing the results of the gas chromatography analyses, and FIG. 9 show numeric value data of the results of the gas chromatography analyses.

(Example 5)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 10 g of

antimony sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 202 to 302.3° C, and the inlet temperature of the cooling tube was 163 to 189.6° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 82.9151 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 6.1744 % and 4.2618 % respectively. Here, FIG. 10 is a chart showing the results of the gas chromatography analyses, and FIG. 11 show numeric value data of the results of the gas chromatography analyses.

(Example 6)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 10 g of sodium sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had been distilled, the liquid temperature was 245 to 294.6° C, and the inlet temperature of the cooling tube was 153.5 to 161.9° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 81.5469 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 6.338 % and

3.2322 % respectively. Here, FIG. 12 is a chart showing the results of the gas chromatography analyses, and FIG. 13 show numeric value data of the results of the gas chromatography analyses.

(Example 7)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 60 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 15 g of iron sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 226.3 to 307.7° C, and the inlet temperature of

the cooling tube was 158.5 to 185.1° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 83.8343 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.4205 % and 3.4163 % respectively. Here, FIG. 14 is a chart showing the results of the gas chromatography analyses, and FIG. 15 show numeric value data of the results of the gas chromatography analyses.

(Example 8)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 13.5 g of zinc sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied

by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 217 to 345.8° C, and the inlet temperature of the cooling tube was 151.3 to 156.8° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 87.7999 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.0973 % and 2.1685 % respectively. Here, FIG. 16 is a chart showing the results of the gas chromatography analyses, and FIG. 17 show numeric value data of the results of the gas chromatography analyses.

(Example 9)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 12.5 g of aluminum sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring

blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 206.3 to 317.8° C, and the inlet temperature of the cooling tube was 152.1 to 176.7° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 84.7884 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.0945 % and 3.3919 % respectively. Here, FIG. 18 is a chart showing the results of the gas chromatography analyses, and FIG. 19 show numeric value data of the results of the gas chromatography analyses.

(Example 10)

A thermal decomposing process of impact-resistant polystyrene was carried out through the following method by using an experimental device as shown in Fig. 1.

To a flask (1) were loaded 50 g of impact-resistant polystyrene obtained by pulverizing containers of Yakult (trade name) and 12.5 g of

potassium sulfate, and a net plate (2) was placed at an upper position inside the flask (1), and Raschig rings of $\phi 5$ mm, made of ceramics, were put onto the net plate (2) so as to form a filled substance layer (3).

This was subjected to a heating process by heating the inside of the flask (1) by a mantle heater (5) while being mixed and stirred by stirring blades (4). Here, a ribbon heater (not shown) was used to heat the outlet of the flask (1). This is to improve the recovery of the initial portion of the distilled liquid.

A collecting bin (7) was connected to the outlet of the flask (1) through a cooling tube (6) so that components that had been condensed and liquefied by cooling water were recovered in the collecting bin (7). The liquid temperature inside the flask (1) was measured by a thermometer (8) and the inlet temperature of the cooling tube (6) was measured by a thermometer (9).

Here, with respect to temperatures while the liquid had being distilled, the liquid temperature was 288.6 to 329.5° C, and the inlet temperature of the cooling tube was 155.5 to 191.3° C.

The components of the recovered liquid in the collecting bin (7) were analyzed by gas chromatography; and the results show that the content of styrene monomers is as high as 86.0946 %, and the contents of toluene and ethylbenzene, which are low-molecular components, are as low as 5.5804 % and 2.1234 % respectively. Here, FIG. 20 is a chart showing the results of the gas chromatography analyses, and FIG. 21 show numeric value data of the results of the gas chromatography analyses.

As described above, the method for recovering styrene monomers by heating and decomposing impact-resistant polystyrene of the present

invention is a recovering method of styrene monomers from impact-resistant polystyrene wherein a sulfate and/or manganese dioxide are used as a catalyst; therefore, this method makes it possible to recover styrene monomers that are industrially useful materials from impact-resistant polystyrene wastes at high yield with high purity. This method is effective since no effective method for recycling these wastes have been established conventionally.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing one example of a thermal decomposing device used in the present invention.

FIG. 2 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 1.

FIG. 3 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 1.

FIG. 4 s a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 2.

FIG. 5 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 2.

FIG. 6 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

3.

FIG. 7 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

3.

FIG. 8 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

4.

FIG. 9 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

4.

FIG. 10 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

5.

FIG. 11 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 5.

FIG. 12 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

6.

FIG. 13 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 6.

FIG. 14 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example

7.

FIG. 15 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 7.

FIG. 16 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 8.

FIG. 17 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 8.

FIG. 18 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 9.

FIG. 19 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 9.

FIG. 20 is a chart that shows the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 10.

FIG. 21 shows numeric value data of the results of gas chromatography analyses on distilled products (crude styrene monomers) obtained in Example 10.

CLAIMS



What is claimed is:

1. A method for recovering styrene monomers from impact-resistant polystyrene, which obtains the styrene monomers by heating and decomposing the impact-resistant polystyrene, wherein a sulfate and/or manganese dioxide is used as a catalyst.
2. The method for recovering styrene monomers from impact-resistant polystyrene according to claim 1, wherein the sulfate is a metal sulfate.
3. The method for recovering styrene monomers from impact-resistant polystyrene according to claim 1, wherein the sulfate is at least not less than one member selected from the group consisting of magnesium sulfate, manganese sulfate, calcium sulfate, antimony sulfate, sodium sulfate, iron (II) sulfate, zinc sulfate, aluminum sulfate and potassium sulfate.
4. The method for recovering styrene monomers from impact-resistant polystyrene according to claim 1, wherein the heating temperature of the polystyrene resin is set to not more than 350° C.