

**NOXIOUS COMPONENT REMOVAL PROCESS
AND NOXIOUS COMPONENT REMOVAL AGENT THEREFOR** ✓

BACKGROUND OF THE INVENTION

5 **1. Field of the Invention**

 This invention relates to improvements in a process for removing a noxious component (such as chlorine and/or sulfur) from a material (referred to as "treatable material") containing chlorine and or sulfur, such as urban waste or trash and industrial waste, and to improvements in a noxious component removal agent to be used in the process, and more particularly to a technique in which the noxious component removal agent is reacted with noxious component-containing gas (hydrogen chloride, chlorine gas and/or sulfur oxide gas) generated upon thermal treatment of the trash and waste to form harmless gas and compounds.

15 **2. Description of the Prior Art**

 Recently waste such as urban waste or trash are increasing in its amount year by year so that its treatment is becoming problematic. Such urban waste includes waste or trash from general homes and offices and therefore is mainly constituted of combustible waste. This combustible waste includes a variety of chemical substances (for example, plastic) containing a large amount of polyvinyl chloride, and a variety of materials (for example, paper used in offices) containing a large amount of chlorine components such as chlorine-containing bleaching agent.

 In general, incineration has been usually employed for treating such waste. However, when the waste or treatable material containing chlorine components is incinerated, chlorine-containing gas such as hydrogen chloride gas and chlorine gas is generated thereby raising problems of environmental pollution and deterioration of incinerating facility under the action of the chlorine-containing gas. For the purpose of suppressing generation of such chlorine-containing gas, it has been carried out to incinerate

the waste or treatable material upon adding thereto a chlorine removal agent such as slaked lime, calcium carbonate or the like as disclosed, for example, in Japanese Patent Publication No. 2-10341. Additionally, it has been also known that after the treatable material cast in an incinerator is subjected to an incineration treatment, emitted gas undergoes a variety of purification treatments as occasion demands, for example, is introduced into a bag filter so as to be reacted with slaked lime thus preventing noxious chlorine-containing gas from being emitted to the atmospheric air.

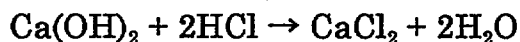
As discussed above, in case of incineration of the waste or treatable material, the chlorine-containing substances such as chloride and other chlorine compounds are problematic, in which chlorine-containing gas generated in the course of incineration damages the incinerator itself and corrodes steam pipes and further leads to problems of producing dioxin which is virulently poisonous. Accordingly, chlorine-containing gas has been usually reacted with slaked lime or the like in the bag filter thereby being prevented from being emitted to the atmospheric air. Such measures can be expected to obtain a certain effect under treatment of burnt gas so that chlorine-containing gas can be prevented from being dispersed to the atmospheric air. However, it is difficult to completely remove chlorine-containing substances by such measures because chlorine-containing substances remain in a residue formed after incineration of the treatable material. This forms part of cause of generating dioxin. Even by the measure of adding slaked lime or calcium carbonate during the incineration, chlorine-containing gas has not been able to be sufficiently prevented from its generation.

Further, it has been proposed that alkali material is sprayed into the incinerator in which the treatable material is incinerated as disclosed, for example, in Japanese Patent Provisional Publication No. 54-93864. In this proposition, however, chlorine-containing gas which has been once generated and filled in

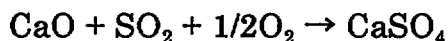
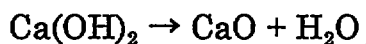
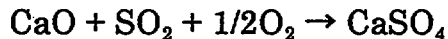
the incinerator is treated, which is similar to the above measure and therefore renders it impossible to completely remove chlorine-containing gas.

Furthermore, it has been also proposed that incineration of the treatable material is accomplished upon adding thereto alkali material containing calcium such as lime (CaCO_3), slaked lime (Ca(OH)_2) or the like, or that SO_x is passed through a filter filled with the alkali material to remove SO_x as disclosed, for example, in Japanese Patent Publication No. 2-10341, Japanese Patent Provisional Publication No. 1-296007, and Japanese Patent Provisional Publication No. 59-12733. Reactions made in these propositions are as follows:

In case of treatment of chlorine-containing gas (HCl):



In case of treatment of sulfur oxide containing gas (SO_2):



Besides, it has also been proposed to cause the treatable material to be subjected to thermal decomposition or dry distillation in place of incineration, thereby reducing the volume of the treatable material and carbonizing the treatable material, as disclosed in Japanese Patent Provisional Publication No. 5-33916, Japanese Patent (Kohyo) Publication No. 8-510789, and Japanese Patent Provisional Publication No. 9-155326. Additionally, the Japanese Patent Provisional Publication No. 5-33916 discloses spraying alkali material such as slaked lime into a furnace; however, no sufficient effect of removing chlorine-containing gas can be expected because the alkali material is brought into contact with chlorine-containing gas which has been once generated and filled in the furnace.

In view of the above, it has been eagerly desired to hasten establishment of techniques for sufficiently removing chlorine-containing gas or sufficiently preventing chlorine-containing gas from generation even upon thermal treatment of the treatable material, which chlorine-containing gas forms part of cause of production of dioxin which is known as being virulently poisonous for human body.

BRIEF SUMMARY OF THE INVENTION

As a result of a variety of experiments and investigations for removing noxious chlorine-containing substances or gases (such as hydrogen chloride gas and chlorine gas) in emitted gas generated upon thermal treatment of a waste or treatable material containing a large amount of chlorine components or compounds, the inventors of the present invention have found that the noxious chlorine-containing substances or gases can be effectively reacted with alkali metal compound (particularly alkali metal carbonate, alkali metal hydrogen carbonate and alkali metal hydroxide) so that the noxious chlorine-containing gases are effectively converted into harmless chlorides. Additionally, it has been confirmed that alkali metal component is also effective for converting noxious sulfur-containing gases into harmless sulfite.

The present invention has been envisaged depending upon the above knowledge and to provide an improved noxious component removal process using a particular noxious component removal agent containing alkali metal compound, in which noxious component-containing gases generated upon heating the treatable material are immediately reacted with the noxious removal agent thereby to form harmless compound, preventing emission of noxious component-containing gas into the atmospheric air.

It is an object of the present invention to provide an improved noxious component removal process which can overcome drawbacks encountered in conventional similar noxious component

removal processes, and an improved noxious component removal agent to be used in the process.

Another object of the present invention is to provide an improved noxious component removal process to be applied in a thermal treatment process for a waste or treatable material, by which generally no noxious component-containing gas is contained in emitted gas and also in a residue formed upon the thermal treatment of the treatable material, thereby generally completely preventing noxious substances (including dioxin) from being generated in the thermal treatment process.

Another object of the present invention is to provide an improved noxious component removal process in which noxious component-containing gas generated upon thermal treatment of a waste or treatable material can be generally completely removed during the thermal treatment thereby omitting the possibility of generating noxious substances (including dioxin), while a residue contains only harmless compound without containing noxious component-containing substances.

A further object of the present invention is to provide an improved noxious removal agent which is high in effect for removing noxious component-containing substances or gases and to be used at any steps in a noxious component removal process in which a waste or treatable material is thermally treated.

A first aspect of the present invention resides in a process for removing a noxious component from a treatable material containing the noxious component, comprising the following steps in the sequence set forth: (a) mixing the treatable material and a noxious component removal agent to form a mixture, the noxious component removal agent containing an alkali metal compound; and (b) heating the mixture to thermally decompose the treatable material to generate a noxious component-containing substance and cause the noxious component-containing substance to contact and

react with the noxious component removal agent to form a harmless compound.

5 A second aspect of the present invention resides in a process for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, comprising the following steps in the sequence set forth: (a) mixing the treatable material and a chlorine and sulfur removal agent to form a mixture, the chlorine and sulfur removal agent containing an alkali metal compound; and (b) heating the mixture to thermally
10 decompose the treatable material to generate at least one of a chlorine-containing substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with the chlorine and sulfur removal agent to form at least one of harmless chloride
15 and sulfite.

A third aspect of the present invention resides in a process for removing chlorine from a treatable material containing chlorine, comprising the following steps in the sequence set forth: (a) mixing the treatable material and a chlorine removal agent to form a
20 mixture, the chlorine removal agent containing an alkali metal compound; and (b) heating the mixture to thermally decompose the treatable material to generate a chlorine-containing substance and cause the chlorine-containing substance to contact and react with the chlorine removal agent to form a harmless chloride.

25 A fourth aspect of the present invention resides in a noxious component removal agent to be used in a process for removing noxious component from a treatable material containing the noxious component, the chlorine removal agent containing an alkali metal compound, the noxious removal agent being contactable
30 and able to react with a noxious component-containing substance generated from the treatable material upon heating the treatable material, so as to form a harmless compound.

A fifth aspect of the present invention resides in a chlorine and sulfur removal agent to be used in a process for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, the chlorine and sulfur removal agent containing an alkali metal compound, the chlorine and sulfur removal agent being contactable and able to react with at least one of a chlorine-containing substance and a sulfur-containing substance generated from the treatable material upon heating the treatable material, so as to form at least one of harmless chloride and sulfite.

A sixth aspect of the present invention resides in a chlorine removal agent to be used in a process for removing chlorine from a treatable material containing chlorine, the chlorine removal agent containing an alkali metal compound, the chlorine removal agent being contactable and able to react with a chlorine-containing substance generated from the treatable material upon heating the treatable material, so as to form a harmless chloride.

A seventh aspect of the present invention resides in a chlorine removal agent to be used in a process for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, comprising the following steps in the sequence set forth: mixing the treatable material and a chlorine and sulfur removal agent to form a mixture, the chlorine and sulfur removal agent containing an alkali metal compound; and heating the mixture to thermally decompose the treatable material to generate at least one of a chlorine-containing substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with the chlorine and sulfur removal agent to form at least one of harmless chloride and sulfite, wherein the chlorine removal agent contains an alkali metal compound.

An eighth aspect of the present invention resides in a system for removing at least one of chlorine and sulfur from a

5 treatable material containing at least one of chlorine and sulfur, comprising: a device for mixing the treatable material and a chlorine and sulfur removal agent to form a mixture, the chlorine and sulfur removal agent containing an alkali metal compound; a furnace into which the mixture of the treatable material and the chlorine and sulfur removal agent is supplied, the furnace being adapted to form therein a low oxygen concentration atmosphere; and a heating device for heating the mixture in the low oxygen concentration atmosphere in the furnace to thermally decompose the treatable material so as to accomplish dry distillation of the treatable material, in which the mixture generates at least one of a chlorine-containing substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with the chlorine and sulfur removal agent to form at least one of harmless chloride and sulfite.

10 According to the noxious component (such as chlorine and/or sulfur) removal process of the present invention, no generation of noxious component-containing gas is made throughout whole steps in a thermal treatment process of the treatable material and throughout whole temperature ranges in the thermal treatment process, which has not been achieved by conventional noxious component removal processes which use slaked lime or calcium carbonate as the chlorine removal agent. Additionally, the residue formed upon thermal treatment of the treatable material contains no noxious component-containing substances, containing harmless compound (such as chloride and/or sulfite). Thus, the noxious component removal process of the present invention exhibits a high noxious component removal effect particularly for the treatable material containing a large amount of noxious component-containing substances or compounds of the noxious component, such as urban waste or trash.

30 In the noxious component removal process of the present invention, the noxious component removal agent of the present

invention is mixed with the treatable material so as to immediately react with noxious component-containing gas generated upon heating the treatable material, thereby to form harmless gas and compound of the noxious component. It is to be noted that the
5 noxious component removal agent itself can be used at any steps other than a heating step for thermally decomposing the treatable material, in the course of a thermal treatment for the treatable material regardless of whether the noxious component removal agent is used at the heating step or not. In other words, the noxious
10 component removal agent itself can be used as it is even after the heating step and even in a flue, a variety of facilities for treating emitted gas, and other various conventional facilities such as an incinerator and the like. It will be understood that the noxious component (chlorine) removal agent itself of the present invention
15 may be employed at any steps in a conventional noxious component (chlorine) removal process and in a conventional incinerating process for wastes.

By virtue of the fact that noxious component-containing gas can be generally completely removed in the furnace for thermal
20 treatment of the treatable material, a thermal treatment furnace (including an incinerator) itself, steam pipes and the like can be effectively prevented from being corroded, thereby prolonging life of the furnaces and the facilities. Additionally, it is to be noted that the residue formed upon heating the treatable material do not contain
25 dioxin which is virulently poisonous for human body, thus largely improving safety from the circumferential and treatment-operational viewpoints.

Furthermore, according to the noxious component removal process of the present invention, emitted gas from the furnace is
30 harmless and combustible, and therefore the emitted gas may be reusable as fuel for a gas engine, a turbine, a boiler, a heat source of a water heating device, and fuel for a heater. Additionally, massed carbon components in the residue may be used as fuel, and inorganic

materials in the residue may be reusable as the material of glass or cement. It will be appreciated that the noxious component removal process of the present invention cannot be affected even if the waste or treatable material contains water. No noxious chlorine-containing gas exists in emitted gas from the furnace, and therefore the emitted gas may be further heated to make a secondary combustion as a post-treatment for the emitted gas, as occasion demands.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a chlorine and sulfur removal system for carrying out the fifth embodiment of the noxious component removal process according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

According to the present invention, a process for removing noxious component (such as chlorine and/or sulfur) from a treatable material (such as urban waste or trash, or industrial waste) containing the noxious component, comprises the following steps in the sequence set forth: (a) mixing the treatable material and a noxious component (chloride and/or sulfur) removal agent to form a mixture, the noxious removal agent containing an alkali metal compound; and (b) heating the mixture to thermally decompose the treatable material to generate a noxious component (chlorine and/or sulfur)-containing substance and cause the noxious component-containing substance to contact and react with the noxious component removal agent to form a harmless compound.

Examples of the harmful component (chlorine and/or sulfur) removal agent to be used in the above noxious component removal process are:

(1) alkali metal hydrogen carbonate, alkali metal carbonate and the like, such as sodium hydrogen carbonate (NaHCO_3), sodium carbonate (Na_2CO_3), sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), and natural soda (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$);

(2) alkali metal hydroxide such as sodium hydroxide (NaOH), potassium hydroxide (KOH), lithium hydroxide (LiOH), rubidium hydroxide (RbOH), and cesium hydroxide (CsOH); and

(3) alkali metal carbonate and alkali metal hydrogen
5 carbonate such as potassium carbonate (K_2CO_3), potassium
hydrogen carbonate ($KHCO_3$), and potassium sodium carbonate
($KNaCO_3 \cdot 6H_2O$).

It will be understood that the above-listed compounds are
used singly or in combination as the noxious component removal
10 agent. In other words, the noxious component removal agent
contains at least one of sodium hydrogen carbonate, sodium
carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide,
potassium hydroxide, lithium hydroxide, rubidium hydroxide
(RbOH), and cesium hydroxide (CsOH), potassium carbonate,
15 potassium hydrogen carbonate, and potassium sodium carbonate,
and the like.

The noxious component removal agent to be used in the
form of mass, plate, porous body, particle (including power, granule,
or mixture of powder and granule), solution (aqueous solution, or
20 other solutions), or suspension. These forms are used singly or in
combination.

The amount of the noxious component removal agent to be
used is usually within a range of from 0.05 to 10 % by weight relative
to the treatable material at a starting time which is before a time at
25 which the treatable material is mixed with the noxious component
removal agent. However, in case the treatable material including
substances or compounds containing a large amount of chlorine
component, such as polyvinyl chloride, polyvinylidene chloride,
other chlorine-containing synthetic resins and/or chlorine-
30 containing rubbers, the amount of the noxious component removal
agent to be used is within a range of from 10 to 17 % weight relative
to the treatable material at the starting time. The amount of the
noxious component removal agent may be selected to be larger than

the chemical equivalent of chlorine-containing substance or gas (a substance or gas containing chlorine) generated from the treatable material upon heating, regardless of the weight of the treatable material. Otherwise, the amount of the noxious component removal agent may be selected to suppress the emission levels of chlorine-containing gases below permissible emission standards. Also in case the treatable material includes substances or compounds containing a large amount of sulfur component, the amount of the noxious component is selected similarly to the above.

10 The noxious component removal agent is mixed with the treatable material and heated at a thermal decomposition temperature ranging from 200 to 1000 °C in a low oxygen concentration atmosphere. In other words, mixing of the noxious component removal agent and the treatable material is made before
15 heating for thermally decomposing the treatable material, i.e., before the temperature of the treatable material rises to a level at which the thermal decomposition of the treatable material occurs. At the decomposition temperature, chlorine compounds, sulfur compounds and substances containing chlorine and/or sulfur are
20 thermally decomposed. The low oxygen concentration atmosphere means an atmosphere in which the concentration of oxygen is low, which can be accomplished by closing the inlet and outlet of a thermal treatment furnace or tank such as a heating furnace, upon casting the mixture of the treatable material and the noxious
25 component removal agent into the furnace. It will be understood that the low oxygen concentration atmosphere corresponds to a condition in which atmospheric air remains within the furnace whose inlet and outlet have been closed. In other words, the low oxygen concentration atmosphere corresponds to a condition in which the
30 mixture is put in the furnace which is substantially sealed so as to prevent fresh air from being supplied into the furnace, in which a pressure in the furnace leaks out of the furnace. Accordingly, the low oxygen concentration atmosphere does not require a complete

closing or sealing state of the furnace and includes also a condition in which the side of the inlet of the furnace is closed with the treatable material itself, in which a gas pressure within the furnace is raised under heating so that supply of air from the outside of the furnace is hardly made. The low oxygen concentration atmosphere may be a thermal decomposition atmosphere in which the treatable material thermally decomposes to generate so-called thermal decomposition gas of the treatable material. Thus, the low oxygen concentration atmosphere accomplishes dry distillation of the treatable material.

It will be understood that the noxious component removal agent is basically mixed with the treatable material upon being cast or sprayed onto the treatable material in the furnace. The noxious component removal agent may be additionally cast or sprayed onto the mixture of the treatable material and the noxious component removal agent in the furnace.

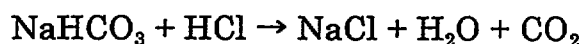
As a result of the above heating in the low oxygen concentration atmosphere, substantially no gas component of chlorine-containing compounds (compounds containing chlorine) and/or sulfur-containing compounds (compounds containing sulfur) remain in emitted gas from the furnace, and therefore a post-treatment (such as a heating treatment or secondary burning) for the emitted gas can be made as occasion demands. It is a matter of course that the emitted gas may be discharged to the atmospheric air as it is.

While the noxious component removal agent has been described as being mixed with the treatable material before heating or thermal decomposition of the treatable material, it will be understood that noxious component removal agent may be also effective for removing chlorine even upon contacting with dry distillation gas or emitted gas (gas generated under dry distillation of the treatable material) discharged from the furnace after heating or thermal decomposition of the treatable material. It will be also

understood that the noxious component removal material may be supplied or sprayed onto the treatable material which is thermally decomposing. Furthermore, it will be appreciated that the noxious component removal agent according to the present invention may be
 5 used to be brought into contact with chlorine-containing substance and/or sulfur-containing substance which are in any step of a noxious component removal process other than the process according to the present invention, for the purpose of removing chlorine from noxious gas or a material containing chlorine.

10 Here, a first embodiment of the noxious component or chlorine removal process according to the present invention will be discussed. In this embodiment, the noxious component or chlorine removal agent contains alkali metal hydrogen carbonate and/or alkali metal carbonate, i.e., at least one of sodium hydrogen
 15 carbonate (NaHCO_3), sodium carbonate (Na_2CO_3), sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), natural soda (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$).

In this instance, sodium hydrogen carbonate (NaHCO_3) is used as the chlorine removal agent, in which the sodium hydrogen
 20 carbonate is mixed with the treatable material and heated thereby bringing about the following reaction with hydrogen chloride (HCl) which is a major chlorine-containing compound contained in gases generated from the treatable material upon heating.



25 According to this reaction, if Na and CO components exist in the reaction system, chlorine reacts with Na to form NaCl which is a part of a residue formed upon heating the treatable material, and additionally water (H_2O) and gas (CO_2) are formed. As a result, no chlorine-containing gas is generated and emitted from the furnace,
 30 realizing that the emitted gas and the residue are rendered harmless. It will be understood that chlorine-containing compound or gas is a source for producing dioxin which is virulently poisonous.

According to the present invention, prior to a thermal treatment is applied to the treatable material containing chlorine-containing substance which will generate chlorine-containing gas upon heating, alkali metal carbonate and/or alkali metal hydrogen carbonate are added to and mixed with the treatable material as the chlorine removal agent thereby form the mixture. By heating this mixture in the low oxygen concentration atmosphere, the chlorine-containing substance is thermally decomposed at a predetermined temperature thereby generating harmful chlorine-containing gas. This chlorine-containing gas immediately reacts with the chlorine removal agent thus to form harmless chloride.

Hereinafter, experiments for carrying out the chlorine removal process according to this embodiment will be discussed, in which comparison in experimental result is made between Examples (according to this embodiment) and Comparative Examples (not within the scope of the present invention).

Experiment 1

The chlorine removal process of this embodiment was carried out by using ,as the treatable material, polyvinylidene chloride which contained a large amount of chlorine components. As shown in Table 1, 20 g of the chlorine removal agent (sodium hydrogen carbonate) was added to 4 g of the treatable material to form a mixture to be heated, in Example 1-1. No chlorine removal agent was added to 4g of the treatable material in Comparative Example 1-1. A chlorine removal agent (slaked or hydrated lime) which was not within the scope of the present invention was add in an amount of 20 g to 4 g of the treatable material to form a mixture to be heated, in Comparative Example 1-2. A chlorine removable agent (calcium carbonate) which was not within the scope of the present invention was added in an amount of 20 g to 4 g of the treatable material to form a mixture to be heated, in Comparative Example 1-3. The chlorine removal agent was in the form of powder

having an average particle size of 100 μ m, in all Example and Comparative Examples.

More specifically, in the experiment for each Example or Comparative Example, 4 g of the treatable material was put into a tank or furnace, and then 20 g of the chlorine removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture, except for Comparative Example 1-1. Then, the tank was tightly sealed so that the inside the tank was isolated from the outside air or atmospheric air in order that the mixture was subjected to dry distillation upon heating. The thus sealed tank was stepwise heated with a heating coil, in which heating was made at eight temperature steps of 250 °C, 300 °C, 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C. In this heating process, the temperature at each of the eight steps was kept for 5 minutes, in which a concentration of hydrogen chloride gas in the tank was measured at each temperature rising time (at which the temperature was rising from one temperature step to the next temperature step) and at each temperature keeping time (at which the temperature at each temperature step was keeping). The temperature rising time is indicated as "Rising time" while the temperature keeping time is indicated as "Keeping time" in Table 3. The tank was provided with a gas discharge pipe through which gas and pressure generated in the tank upon heating was discharged out of the tank. The measurement of the hydrogen chloride gas concentration was accomplished by using a detector tube according to JIS (Japanese Industrial Standard) – K0804, in which the detector tube was inserted into the gas discharge pipe to measure the hydrogen chloride gas concentration. Results of the hydrogen chloride gas concentration measurement were shown in Table. 3. It is to be noted that ten times of the above experiment were repeated to obtain ten actual measured values of the hydrogen gas concentration for each Example and Comparative Example, in which the measured value (shown in Table 3) for each Example indicates

the highest value in the measured values while the measured value (shown in Table 3) for each Comparative Example indicates the lowest value in the measured values. Additionally, "ND" in Table 3 indicates the fact that no hydrogen chloride gas was detected in any
5 of 10 times hydrogen chloride gas concentration measurements to obtain the ten actual measured values. Further, manners of post-treatment for the chlorine removal agent were inspected and shown as "Post-treatment for chlorine removal agent" in Table 3.

Experiment 2

10 In this experiment, the treatable material was prepared by mixing polyvinylidene chloride with a simulated trash in order that the treatable material was similar to standard urban trash and in order to carry out the experiment under a further severe condition. As shown in Table 2, 5g of sodium hydrogen carbonate was added as
15 the chlorine removal agent to the treatable material which was prepared by mixing 1 g of polyvinylidene chloride to 20 g of the simulated trash thereby to form the mixture to be heated, in Example 1-2. Sodium hydrogen carbonate in an amount of 2.5 g was added as the chlorine removal agent to the treatable material which
20 was prepared by mixing 0.5 g of polyvinylidene chloride to 20 g of the simulated trash thereby forming the mixture to be heated, in Example 1-3. Sodium hydrogen carbonate in an amount of 0.5 g was added as the chlorine removal agent to the treatable material which was prepared by mixing 0.1 g of polyvinylidene chloride to 20 g of the
25 simulated trash thereby forming the mixture to be heated, in Example 1-4. Sodium hydrogen carbonate in an amount of 5 g was added as the chlorine removal agent to the treatable material which was prepared by mixing 20 cc of city water to 20 g of the simulated trash thereby forming the mixture to be heated, in Example 1-5.

30 The above simulated trash similar to standard urban trash was prepared by mixing and crushing the following components:

20 % by weight of plastic including polyethylene, polypropylene, polystyrene, and polyvinylidene chloride;

50 % by weight of paper including tissue paper, news paper, wrapping paper, paper box, and paper packing for drink;

5 20 % by weight of cloth including rag; and

10 % by weight of garbage including used tea leaves.

In the experiment for each Example, the above-mentioned predetermined amount of the treatable material was put into the tank, and then the above-mentioned predetermined amount of the chlorine removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture. Then, the tank was tightly closed to maintain an air-tight seal so that the inside the tank was isolated from the outside air or atmospheric air. Thereafter, the experiment was carried out similarly to that in Experiment 1 to obtain results (or measured values) shown in Table 3. Results (or measured values) of the hydrogen chloride gas concentration measurement were shown in Table 3.

As appreciated from the above, it has been revealed that the hydrogen carbonate or carbonate containing an alkali metal, serving as the chlorine removal agent, can convert noxious chlorine-containing gas into harmless chloride under a reaction in which the alkali metal reacts with chlorine to form chloride of alkali metal. A preliminary test (Comparative Example 1-1) was conducted in which polyvinylidene chloride containing a large amount of chlorine component was used as the treatable material. As a result of this test, it was confirmed that a large amount of hydrogen chloride was generated as shown in the column of Comparative Example 1-1 in Table 3.

Subsequently, comparative tests (Comparative Examples 1-2 and 1-3) were conducted in which slaked lime and calcium carbonate were respectively used as the conventional chlorine removal agents. As a result, generation of hydrogen chloride could be suppressed to some extent; however, it was confirmed that such a

suppression effect due to the conventional chlorine removal agents was not sufficient and was required to be further improved.

In view of the above, as a result of a variety of investigations and considerations, the inventors had paid attention to hydrogen carbonate and carbonate containing alkali metal and selected sodium hydrogen carbonate as the chlorine removal agent, and conducted tests (Examples 1-1 to 1-5). As a result of the tests, it has been revealed that generation of hydrogen chloride could be generally completely suppressed at any temperature regions, and that sodium hydrogen carbonate was very excellent as the chlorine removal agent.

Thus, the above reveals that if hydrogen carbonate and/or carbonate containing alkali metal (to be able to react with chloride) is added to the treatable material to form the mixture to be subjected to the thermal treatment, chlorine-containing gas generated from the treatable material can effectively dechlorinated and become harmless.

Hereinafter, discussion will be made depending upon the above experimental results shown in Table 3.

First in case that polyvinylidene chloride was used as the treatable material containing a large amount of chlorine component and that no chlorine removal agent was used as shown in Comparative Example 1-1, a large amount of hydrogen chloride gas was generated throughout a wide temperature region in the thermal treatment or heating process. Generation of hydrogen chloride gas could be suppressed to some extent as compared with Comparative Example 1-1, in Comparative Examples 1-2 and 1-3 where slaked lime and calcium carbonate were added as the chlorine removal agent to the treatable material, respectively. However, it was confirmed that such suppression for hydrogen chloride gas was insufficient.

In contrast, in Example 1-1 where sodium hydrogen carbonate was added as the chlorine removal agent to the treatable

material, no generation of hydrogen chloride gas could be detected throughout the whole temperature regions in the heating process, demonstrating that the sodium hydrogen carbonate was very excellent for the chloride removal agent. Additionally, also in
5 Examples 1-3, 1-4 and 1-5 where various amounts of sodium hydrogen carbonate were added as the chlorine removal agent to the treatable material containing the simulated trash and polyvinylidene chloride, no generation of hydrogen chloride gas could be detected throughout the whole temperature regions in the
10 heating process.

In case of Example 1-5 where sodium hydrogen carbonate was added as the chlorine removal agent to the treatable material containing the simulated trash and water, generation of hydrogen chloride gas could hardly be detected throughout the whole
15 temperature regions although a slight amount of hydrogen chloride gas was detected to be generated at the temperature rising and keeping times at 450 °C and at the temperature rising time at 500 °C. This demonstrates that the effect of sodium hydrogen carbonate as the chlorine removal agent could hardly be affected in
20 presence of water in the treatable material, and considerably high as compared with Comparative Example 1-2 where slaked lime was used as the chlorine removal agent.

In conclusion, it has been confirmed that addition of hydrogen carbonate and/or carbonate containing alkali metal (to be
25 able to react with chloride) to the treatable material in the thermal treatment or heating process can effectively accomplish dechlorination of chlorine-containing gas generated from the treatable material thereby causing the chlorine-containing gas to become harmless.

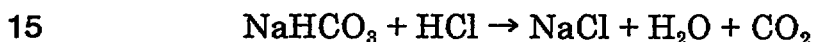
30 It is to be noted that experiments similar to the above were conducted heating the treatable material at a higher temperature condition over 600 °C, which exhibited similar experimental results to the above. The temperature for heating the mixture of the

5 treatable material and the chlorine removal agent is preferably within a range of not higher than 1000 °C from the view point of the fact that a facility for carrying out the chlorine removal process of the present invention is required to be large-sized if the temperature is raised over 1000 °C.

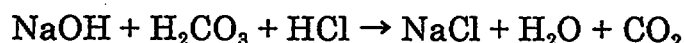
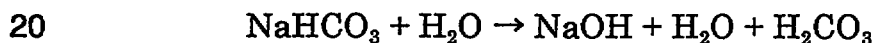
Next, discussion will be made on mechanisms of reaction between hydrogen carbonate or carbonate containing alkali metal (sodium) and chlorine-containing gas, realizing unexpected results in which both emitted gas and residue are made harmless.

10 (1) In case of using sodium hydrogen carbonate as the chlorine removal agent:

When sodium hydrogen carbonate (NaHCO_3) is added to the treatable material which is to generate hydrogen chloride (HCl), sodium hydrogen carbonate and hydrogen chloride react as follows:

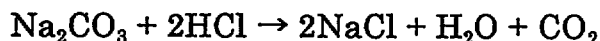


In the presence of water in reaction between sodium hydrogen carbonate and the treatable material which is to generate hydrogen chloride, reaction is made according to the following chemical equations:



(2) In case of using sodium carbonate as the chlorine removal agent:

25 When sodium hydrogen carbonate (Na_2CO_3) is added to the treatable material which is to generate hydrogen chloride (HCl), sodium hydrogen carbonate and hydrogen chloride as follows:



(3) In case of using sodium sesqui carbonate as the chlorine removal agent:

30 Sodium sesqui carbonate is represented by a chemical formula, $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$ and can react with hydrogen chloride similarly to the cases of (1) and (2) thereby converting

noxious hydrogen chloride into harmless chloride (NaCl). Sodium sesqui carbonate naturally exists as and called "trona".

In the above experiments, the residue was left in the tank after the heating process had been completed. The residue was
5 subjected to inspection, upon which it was detected that the residue did not contain noxious chlorine-containing gas component and contained harmless chloride or sodium chloride. The residue was put into water and stirred for 10 minutes, in which sodium chloride was dissolved in water while carbonized materials remained. It was also
10 detected that the carbonized materials did not contain chlorine-containing gas component.

Accordingly, chlorine-containing compound and chlorine component in the treatable material can be converted into sodium chloride (NaCl), water (H_2O) and carbon dioxide gas (CO_2), and
15 therefore hydrogen chloride forming part of a source of dioxin cannot be formed thereby realizing the unexpected result of making both emitted gas and residue harmless.

It will be appreciated that, in this embodiment, the substance containing carbonate containing an alkali metal, such as
20 sodium carbonate, sodium hydrogen carbonate, sodium sesqui carbonate, natural soda ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$) is used as the chlorine removal agent. Sodium carbonate can form monohydrate compound and decahydrate compound and is known as soda. Sodium sesqui carbonate naturally exists as trona.

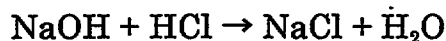
As will be understood, in the heating process in which the
25 reactions according to the above chemical reactions are made, NaCl is formed. NaCl is a harmless chloride and can be effectively removed under a rinsing or dissolving treatment with water or the like. After the rinsing treatment, solid residual materials or
30 carbonized materials remain in the tank and reusable. Accordingly, the residual materials can be separated into respective materials which are different in characteristics by any separating means. The separated respective materials are dried and massed to be usable as

fuel or the like. Additionally, liquid (such as water) used for the above rinsing treatment hardly contains no noxious substances and therefore can be discharged as it is to a river and the sea.

More specifically, the residue taken out from the tank
5 contains harmless chloride or sodium chloride (NaCl). In order to extract the carbonized materials, the residue is put into a water tank containing water, and stirred for a predetermined time thereby dissolving sodium chloride. Subsequently, solid materials in the water tank are taken out from the water tank and then are subjected
10 to a centrifugal dehydration to separate water content from the solid materials. The thus dehydrated solid materials are dried and hardened into a mass. Water remaining in the water tank and the separated water content are drained through a separate draining and treatment means. It will be appreciated that carbon contents in
15 the hardened mass can be used as fuel while inorganic contents in the hardened mass can be used as materials for glass and cement. Further, as discussed above, the residue can be separated into respective materials which are different in characteristics by any separating means, upon which the separated respective materials
20 are dried and massed to be effectively used as fuel or the like.

Next, a second embodiment of the noxious component or chlorine removal process according to the present invention will be discussed. In this embodiment, the noxious component or chlorine removal agent contains at least one alkali metal hydroxide, i.e., at
25 least one of sodium hydroxide (NaOH), potassium hydroxide (KOH), lithium hydroxide (LiOH), rubidium hydroxide (RbOH), and cesium hydroxide (CsOH).

As an instance, sodium hydroxide (NaOH) is used as the chlorine removal agent, in which the sodium hydroxide is mixed with
30 the treatable material and heated thereby bringing about the following reaction with hydrogen chloride (HCl) which is a major chlorine-containing compound contained in gases generated from the treatable material upon heating:



According to this reaction, hydrogen chloride reacts with sodium hydroxide to form sodium chloride (NaCl) forming part of the residue and water (H₂O). As a result, no chlorine-containing gas is generated and emitted from the furnace, realizing that the emitted gas and the residue are rendered harmless. It will be understood that chlorine-containing compound or gas is a source for producing dioxin which is virulently poisonous for human body.

According to the present invention, when a heating treatment is applied to the treatable material containing chlorine-containing substance which will generate chlorine-containing gas upon heating, alkali metal hydroxide is added to and mixed with the treatable material as the chlorine removal agent thereby form the mixture. By heating this mixture in the low oxygen concentration atmosphere, the chlorine-containing substance is thermally decomposed at a predetermined temperature thereby generating harmful chlorine-containing gas. This chlorine-containing gas immediately reacts with the chlorine removal agent thus to form harmless chloride.

Hereinafter, experiments for carrying out the chlorine removal process according to this embodiment will be discussed, in which comparison in experimental result is made between Examples (according to this embodiment) and Comparative Examples (not within the scope of the present invention).

The chlorine removal process of this experiment was carried out by using ,as the treatable material, polyvinylidene chloride which contained a large amount of chlorine components. As shown in Table 4, 20 g of the chlorine removal agent (pulverized sodium hydroxide) was added to 4 g of the treatable material to form a mixture to be heated, in Example 2-1. The chlorine removal agent (pulverized potassium hydroxide) in amount of 20 g was added to 4 g of the treatable material to form a mixture to be heated, in Example 2-2. No chlorine removal agent was added to 1g and to 4g of the

treatable material ,respectively, in Comparative Examples 2-1 and 2-2. A chlorine removal agent (slaked or hydrated lime) which was not within the scope of the present invention in an amount of 20 g was added to 4 g of the treatable material to form a mixture to be heated, in Comparative Example 2-3. A chlorine removable agent (calcium carbonate) which was not within the scope of the present invention in an amount of 20 g was added to 4 g of the treatable material to form a mixture to be heated, in Comparative Example 2-4. The chlorine removal agent was in the form of powder having an average particle size of 100 μ m, in all Example and Comparative Examples.

In the experiment for each Example or Comparative Example, the treatable material in the above-mentioned amount was put into a tank or furnace, and then 20 g of the chlorine removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture, except for Comparative Examples 2-1 and 2-2. Then, the tank was tightly sealed so that the inside the tank was isolated from the outside air or atmospheric air in order that the mixture was subjected to dry distillation upon heating. The thus sealed tank was stepwise heated with a heating coil, in which heating was made at eight temperature steps of 250 °C, 300 °C, 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C and 600 to 1000 °C. In this heating process, the temperature at each of the nine steps was kept for 5 minutes, in which a concentration of hydrogen chloride gas in the tank was measured at each temperature rising time (at which the temperature was rising from one temperature step to the next temperature step) and at each temperature keeping time (at which the temperature at each temperature step was keeping). The temperature rising time is indicated as "Rising time" while the temperature keeping time is indicated as "Keeping time" in Table 4. The tank was provided with a gas discharge pipe through which gas and pressure generated in the tank upon heating was discharged out of the tank. The measurement of the hydrogen

chloride gas concentration was accomplished by using a detector tube according to JIS (Japanese Industrial Standard) – K0804, in which the detector tube was inserted into the gas discharge pipe to measure the hydrogen chloride gas concentration. Results of the hydrogen chloride gas concentration measurement were shown in Fig. 4. It is to be noted that ten times of the above experiment were repeated to obtain ten actual measured values of the hydrogen gas concentration for each Example and Comparative Example, in which the measured value (shown in Table 4) for each Example indicates the highest value in the measured values while the measured value (shown in Table 4) for each Comparative Example indicates the lowest value in the measured values. Additionally, “ND” in Table 4 indicates the fact that no hydrogen chloride gas was detected in any of 10 times hydrogen chloride gas concentration measurements to obtain the ten actual measured values. Further, manners of post-treatment for the chlorine removal agent were inspected and shown as “Post-treatment for chlorine removal agent” in Table 4.

As appreciated from the above, it has been revealed that the alkali metal hydroxide serving as the chlorine removal agent can effectively convert noxious chlorine-containing gas into harmless chloride under a reaction in which the alkali metal reacts with chlorine to form chloride of alkali metal. Preliminary tests (Comparative Examples 2-1 and 2-2) were conducted in which polyvinylidene chloride containing a large amount of chlorine component was used as the treatable material. As a result of these tests, it was confirmed that a large amount of hydrogen chloride was generated as shown in the column of Comparative Examples 2-1 and 2-2 in Table 4.

Subsequently, comparative tests (Comparative Examples 2-3 and 2-4) were conducted in which slaked lime and calcium carbonate were respectively used as the conventional chlorine removal agents. As a result, generation of hydrogen chloride could be suppressed to some extent; however, it was confirmed that such a

suppression effect due to the conventional chlorine removal agents was not sufficient and was required to be further improved.

In view of the above, as a result of a variety of investigations and considerations, the inventors had paid attention to alkali metal hydroxide and selected potassium hydroxide as the chlorine removal agent, and conducted tests (Examples 2-1 and 2-2). As a result of the tests, it has been revealed that generation of hydrogen chloride could be generally completely suppressed at any temperature regions, and that potassium hydroxide was very excellent as the chlorine removal agent. Thus, the above reveals that if alkali metal hydroxide is added to the treatable material to form the mixture to be subjected to the thermal treatment, chlorine-containing gas generated from the treatable material can effectively dechlorinated and become harmless.

Here, discussion will be made depending upon the above experimental results shown in Table 4.

First in case of carrying out the thermal treatment of polyvinylidene chloride (the treatable material containing a large amount of chlorine component) using no chlorine removal agent as shown in Comparative Examples 2-1 and 2-2, a large amount of hydrogen chloride gas was generated throughout a wide temperature region in the thermal treatment or heating process. Generation of hydrogen chloride gas could be suppressed to some extent as compared with Comparative Examples 2-1 and 2-2, in Comparative Examples 2-3 and 2-4 where slaked lime and calcium carbonate were added as the chlorine removal agent to the treatable material, respectively. However, it was confirmed that such suppression for hydrogen chloride gas was insufficient.

In contrast, in Examples 2-1 and 2-2 where 20 g of sodium hydroxide and 20 g of potassium hydroxide were added as the chlorine removal agent respectively to the same treatable materials, a slight amount of hydrogen chloride was found to be generated at the rising times of 350 °C and 450 °C in Example 2-1 and at the

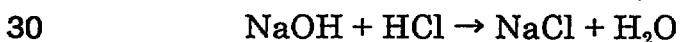
keeping time of 450 °C in Example 2-2; however, no hydrogen chloride gas generation was found throughout whole temperature regions of the thermal treatment or in heating process, thereby exhibiting good experimental results as compared with those of Comparative Examples 2-1 to 2-4. In conclusion, it has been confirmed that addition of alkali metal hydroxide (to be able to react with chloride) to the treatable material in the thermal treatment or heating process can effectively accomplish dechlorination of chlorine-containing gas generated from the treatable material thereby causing the chlorine-containing gas to become harmless.

It is to be noted that experiments similar to the above were conducted heating the treatable material at a higher temperature condition over 600 °C, which exhibited similar experimental results to the above. The temperature for heating the mixture of the treatable material and the chlorine removal agent is preferably within a range of not higher than 1000 °C from the view point of the fact that a facility for carrying out the chlorine removal process of the present invention is required to be large-sized if the temperature is raised over 1000 °C.

Discussion will be made on mechanisms of reaction between alkali metal hydroxide and chlorine-containing gas, realizing unexpected results in which both emitted gas and residue are made harmless.

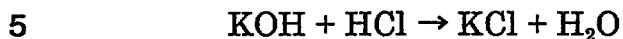
(1) In case of using sodium hydroxide (NaOH) as the chlorine removal agent:

When sodium hydroxide is added to the treatable material which is to generate hydrogen chloride (HCl), sodium hydroxide reacts with hydrogen chloride to form harmless sodium chloride and water as follows:



(2) In case of using potassium hydroxide (KOH) as the chlorine removal agent:

When potassium hydroxide is added to the treatable material which is to generate hydrogen chloride (HCl), potassium hydroxide reacts with hydrogen chloride to form potassium chloride and water, as follows:



In the above experiments, the residue was left in the tank after the heating process had been completed. The residue was subjected to inspection, upon which it was detected that the residue did not contain noxious chlorine-containing gas component and
10 contained harmless chloride (sodium chloride or potassium chloride). The residue was put into water and stirred for 10 minutes, in which sodium or potassium chloride was dissolved in water while carbonized materials remained. It was also detected that the carbonized materials did not contain chlorine-containing gas
15 component.

Accordingly, chlorine-containing compound and chlorine component in the treatable material can be converted into sodium or potassium chloride and water, and therefore hydrogen chloride forming part of a source of dioxin cannot be formed thereby realizing
20 the unexpected results of making both emitted gas and residue harmless. It will be appreciated that the same results can be obtained even if at least one of other alkali metal hydroxides such as lithium hydroxide (LiOH), rubidium hydroxide (RbOH), and cesium hydroxide (CsOH) are used as the chlorine removal agent.

25 Thus, it will be understood that, in this embodiment, at least one alkali metal hydroxide, i.e., sodium hydroxide (NaOH), potassium hydroxide (KOH), lithium hydroxide (LiOH), rubidium hydroxide (RbOH), and/or cesium hydroxide (CsOH) is used as the chlorine removal agent.

30 As will be understood, in the heating process in which the reactions according to the above chemical reactions are made, NaCl and KCl are formed. NaCl and KCl are harmless chlorides and can be effectively removed under a rinsing or dissolving treatment with

water or the like. After the rinsing treatment, solid residual materials or carbonized materials remain in the tank and reusable. Accordingly, the residual materials can be separated into respective materials which are different in characteristics by any separating means. The separated respective materials are dried and massed to be usable as fuel or the like. Additionally, liquid (such as water) used for the above rinsing treatment hardly contains no noxious substances and therefore can be discharged as it is to a river and the sea.

More specifically, the residue taken out from the tank contains harmless sodium chloride (NaCl) and potassium chloride (KCl). In order to extract the carbonized materials, the residue is put into a water tank containing water, and stirred for a predetermined time thereby dissolving sodium and potassium chlorides. Subsequently, solid materials in the water tank are taken out from the water tank and then are subjected to a centrifugal dehydration to separate water content from the solid materials. The thus dehydrated solid materials are dried and massed. Water remaining in the water tank and the separated water content are drained through a separate draining and treatment means. It will be appreciated that carbon contents in the massed solid materials can be used as fuel while inorganic contents in the massed solid materials can be used as materials for glass and cement. Further, as discussed above, the residue can be separated into respective materials which are different in characteristics by any separating means, upon which the separated respective materials are dried and massed to be effectively used as fuel or the like.

Next, a third embodiment of the noxious component or chlorine removal process according to the present invention will be discussed. This embodiment is particularly applicable to the chlorine removal process for polyvinyl chloride, polyvinylidene chloride, a synthetic resin containing chlorine, a rubber containing chlorine and/or the like. In this embodiment, the noxious component chlorine

removal agent contains alkali metal hydrogen carbonate and/or alkali metal carbonate, i.e., at least one of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, and natural soda. Additionally, polyvinyl chloride and polyvinylidene chloride
5 are used as the treatable material in this embodiment.

As an instance, sodium hydrogen carbonate (NaHCO_3) is used as the chlorine removal agent, in which the sodium hydrogen carbonate is mixed with the treatable material and heated thereby bringing about the following reaction with hydrogen chloride (HCl)
10 which is a major chlorine-containing compound contained in gases generated from the treatable material upon heating: $\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$. According to this reaction, if Na and CO components exist in the reaction system, chlorine reacts with Na to form NaCl which is a part of a residue formed upon heating the
15 treatable material, and additionally water (H_2O) and gas (CO_2) are formed. As a result, no chlorine-containing gas is generated and emitted from the furnace, realizing that the emitted gas and the residue are rendered harmless. It will be understood that chlorine-containing compound or gas is a source for producing dioxin which is
20 virulently poisonous.

According to this embodiment, when the heating treatment is applied to the treatable material containing chlorine-containing substance which will generate chlorine-containing gas upon heating, alkali metal carbonate and/or alkali metal hydrogen
25 carbonate are added to and mixed with the treatable material as the chlorine removal agent thereby form the mixture. By heating this mixture in the low oxygen concentration atmosphere, the chlorine-containing substance is thermally decomposed at a predetermined temperature thereby generating harmful chlorine-containing gas.
30 This chlorine-containing gas immediately reacts with the chlorine removal agent thus to form harmless chloride.

Hereinafter, experiments for carrying out the chlorine removal process according to this embodiment will be discussed, in

which comparison in experimental result is made between Examples (according to this embodiment) and Comparative Examples (not within the scope of the present invention).

5 The chlorine removal process of this experiment was carried out by using, as the treatable material, polyvinyl chloride and polyvinylidene chloride which contained a large amount of chloride components. As shown in Table 5, 20 g of the chlorine removal agent (sodium hydrogen carbonate) was added to 4 g of the treatable material (polyvinyl chloride) to form a mixture to be
10 heated, in Example 3-1. The chlorine removal agent (sodium hydrogen carbonate) in an amount of 20g was added to 4 g of the treatable material (polyvinylidene chloride) to form a mixture to be heated, in Example 3-2. No chlorine removal agent was added to 4g of the treatable material (polyvinylidene chloride) in Comparative
15 Example 3-1. A chlorine removal agent (calcium carbonate) which was not within the scope of the present invention was add in an amount of 20 g to 4 g of the treatable material (polyvinylidene chloride) to form a mixture to be heated, in Comparative Example 3-2. A chlorine removable agent (slaked lime) which was not within
20 the scope of the present invention was added in an amount of 20 g to 4 g of the treatable material (polyvinylidene chloride) to form a mixture to be heated, in Comparative Example 3-3. The chlorine removal agent was in the form of powder having an average particle size of 100 μ m, in all Example and Comparative Examples.

25 In the experiment for each Example or Comparative Example, 4 g of the treatable material was put into a tank or furnace, and then 20 g of the chlorine removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture, except for Comparative Example 3-1. Then, the tank was
30 tightly sealed so that the inside the tank was isolated from the outside air or atmospheric air in order that the mixture was subjected to dry distillation upon heating. The thus sealed tank was stepwise heated with a heating coil, in which heating was made at

eight temperature steps of 250 °C, 300 °C, 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C. In this heating process, the temperature at each of the eight steps was kept for 5 minutes, in which a concentration of hydrogen chloride gas in the tank was measured at each temperature rising time (at which the temperature was rising from one temperature step to the next temperature step) and at each temperature keeping time (at which the temperature at each temperature step was keeping). The temperature rising time is indicated as "Rising time" while the temperature keeping time is indicated as "Keeping time" in Table 5. The tank was provided with a gas discharge pipe through which gas and pressure generated in the tank upon heating was discharged out of the tank. The measurement of the hydrogen chloride gas concentration was accomplished by using a detector tube according to JIS (Japanese Industrial Standard) – K0804, in which the detector tube was inserted into the gas discharge pipe to measure the hydrogen chloride gas concentration. Results of the hydrogen chloride gas concentration measurement were shown in Table 5. It is to be noted that ten times of the above experiment were repeated to obtain ten actual measured values of the hydrogen gas concentration for each Example and Comparative Example, in which the measured value (shown in Table 5) for each Example indicates the highest value in the measured values while the measured value (shown in Table 5) for each Comparative Example indicates the lowest value in the measured values. Additionally, "ND" in Table 5 indicates the fact that no hydrogen chloride gas was detected in any of 10 times hydrogen chloride gas concentration measurements to obtain the ten actual measured values. Further, manners of post-treatment for the chlorine removal agent were inspected and shown as "Post-treatment for chlorine removal agent" in Table 5.

As appreciated from the above, it has been revealed that the hydrogen carbonate or carbonate containing an alkali metal, serving as the chlorine removal agent, can convert noxious

chlorine-containing gas into harmless chloride under a reaction in which the alkali metal reacts with chlorine to form chloride of alkali metal. A preliminary test (Comparative Example 3-1) was conducted in which polyvinylidene chloride containing a large amount of chlorine component was used as the treatable material. As a result of this test, it was confirmed that a large amount of hydrogen chloride was generated as shown in the column of Comparative Example 3-1 in Table 5.

Subsequently, comparative tests (Comparative Examples 1-2 and 1-3) were conducted in which calcium carbonate and slaked lime were respectively used as the conventional chlorine removal agents. As a result, generation of hydrogen chloride could be suppressed to some extent; however, it was confirmed that such a suppression effect due to the conventional chlorine removal agents was not sufficient and was required to be further improved.

As a result of the tests (Examples 3-1 and 3-2), it has been revealed that generation of hydrogen chloride could be generally completely suppressed at any temperature regions, and that sodium hydrogen carbonate was very excellent as the chlorine removal agent.

Thus, the above discussion demonstrates that if hydrogen carbonate and/or carbonate containing alkali metal (to be able to react with chloride) is added to the treatable material to form the mixture to be subjected to the thermal treatment, chlorine-containing gas generated from the treatable material can effectively dechlorinated and become harmless.

Here, discussion will be made depending upon the above experimental results shown in Table 5.

First in case that polyvinylidene chloride was used as the treatable material containing a large amount of chlorine component and that no chlorine removal agent was used as shown in Comparative Example 3-1, a large amount of hydrogen chloride gas was generated throughout a wide temperature region in the thermal

treatment or heating process. Generation of hydrogen chloride gas could be suppressed to some extent as compared with Comparative Example 3-1, in Comparative Examples 3-2 and 3-3 where calcium carbonate and slaked lime were added as the chlorine removal agent to the treatable material, respectively. However, it was confirmed that such suppression for hydrogen chloride gas was insufficient.

In contrast, in Example 3-2 where sodium hydrogen carbonate was added as the chlorine removal agent to the treatable material, no generation of hydrogen chloride gas could be detected throughout the whole temperature regions in the heating process, demonstrating that the sodium hydrogen carbonate was very excellent as the chloride removal agent. In Example 3-1 where sodium hydrogen carbonate was added as the chlorine removal agent to the other treatable material (polyvinyl chloride), generation of hydrogen chloride gas could be completely suppressed throughout the whole temperature regions in the heating process.

In conclusion, it has been confirmed that addition of hydrogen carbonate and/or carbonate containing alkali metal (to be able to react with chloride) to the treatable material containing polyvinyl chloride or the like in the thermal treatment or heating process can effectively accomplish dechlorination of chlorine-containing gas generated from the treatable material thereby causing the chlorine-containing gas to become harmless. It is to be noted that experiments similar to the above were conducted heating the treatable material at a higher temperature condition over 600 °C, which exhibited similar experimental results to the above. The temperature for heating the mixture of the treatable material and the chlorine removal agent is preferably within a range of not higher than 1000 °C from the view point of the fact that a facility for carrying out the chlorine removal process of the present invention is required to be large-sized if the temperature is raised over 1000 °C.

It will be understood that the same reactions as those in the first embodiment are made when sodium hydrogen carbonate,

sodium carbonate or sodium sesqui carbonate reacts with hydrogen chloride generated from the treatable material (polyvinyl chloride or polyvinylidene chloride) to form harmless sodium chloride, water and carbon dioxide.

5 In the above experiments, the residue was left in the tank after the heating process had been completed. The residue was subjected to inspection, upon which it was detected that the residue did not contain noxious chlorine-containing gas component and contained harmless chloride or sodium chloride. The residue was put
10 into water and stirred for 10 minutes, in which sodium chloride was dissolved in water while carbonized materials remained. It was also detected that the carbonized materials did not contain chlorine-containing gas component.

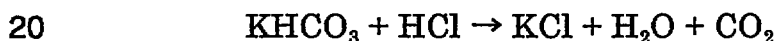
 Accordingly, chlorine-containing compound and chlorine
15 component in the treatable material can be converted into sodium chloride (NaCl), water (H₂O) and carbon dioxide gas (CO₂), and therefore hydrogen chloride forming part of a source of dioxin cannot be formed thereby realizing the unexpected result of making both emitted gas and residue harmless.

20 It will be appreciated that, in this embodiment, sodium carbonate, sodium hydrogen carbonate, and/or sodium sesqui carbonate, natural soda is used as the chlorine removal agent. Sodium carbonate can form monohydrate compound and decahydrate compound and is known as soda. Sodium sesqui
25 carbonate naturally exists as trona. As will be understood, in the heating process in which the reactions according to the above chemical reactions are made, NaCl is formed. NaCl is a harmless chloride and can be effectively removed under a rinsing or dissolving treatment with water or the like. After the rinsing treatment, solid
30 residual materials or carbonized materials remain in the tank and reusable. Accordingly, the residual materials can be separated into respective materials which are different in characteristics by any separating means. The separated respective materials are dried and

massed to be usable as fuel or the like. Additionally, liquid (such as water) used for the above rinsing treatment hardly contains no noxious substances and therefore can be discharged as it is to a river and the sea.

5 Next, a fourth embodiment of the noxious component or chlorine removal process according to the present invention will be discussed. In this embodiment, the noxious component or chlorine removal agent contains alkali metal hydrogen carbonate and/or alkali metal carbonate, i.e., at least one of potassium hydrogen
10 carbonate (KHCO_3) and potassium carbonate (K_2CO_3), and used in the chlorine removal process for the treatable material which is polyvinyl chloride, polyvinylidene chloride, a synthetic resin containing chlorine, a rubber containing chlorine, and/or the like.

 As an instance, sodium hydrogen carbonate (KHCO_3) is
15 used as the chlorine removal agent, in which the sodium hydrogen carbonate is mixed with the treatable material and heated thereby bringing about the following reaction with hydrogen chloride (HCl) which is a major chlorine-containing compound contained in gases generated from the treatable material upon heating.



 According to this reaction, if Na and CO components exist in the reaction system, chlorine reacts with Na to form NaCl which is a part of a residue formed upon heating the treatable material, and additionally water (H_2O) and gas (CO_2) are formed. As a result, no
25 chlorine-containing gas is generated and emitted from the furnace, realizing that the emitted gas and the residue are rendered harmless. It will be understood that chlorine-containing compound or gas is a source for producing dioxin which is virulently poisonous.

 According to this embodiment, when the heating
30 treatment is applied to the treatable material containing chlorine-containing substance which will generate chlorine-containing gas upon heating, alkali metal carbonate and/or alkali metal hydrogen carbonate are added to and mixed with the treatable material as the

chlorine removal agent thereby to form the mixture. By heating this mixture in the low oxygen concentration atmosphere, the chlorine-containing substance is thermally decomposed at a predetermined temperature thereby generating harmful chlorine-containing gas.
5 This chlorine-containing gas immediately reacts with the chlorine removal agent thus to form harmless chloride.

Hereinafter, experiments for carrying out the chlorine removal process according to this embodiment will be discussed, in which comparison in experimental result is made between Examples
10 (according to this embodiment) and Comparative Examples (not within the scope of the present invention).

The chlorine removal process of this embodiment was carried out by using, as the treatable material, polyvinylidene chloride or the simulated (standard) trash which contained a large
15 amount of chlorine components. The simulated trash was the same as that used in the experiments for the first embodiment. As shown in Table 6, 10 g of the chlorine removal agent (pulverized potassium hydrogen carbonate) was added to 4 g of the treatable material (polyvinylidene chloride) to form a mixture to be heated, in Example
20 4-1. The chlorine removal agent (pulverized potassium hydrogen carbonate) in an amount of 10 g was added to 4 g of the treatable material (the simulated trash) to form a mixture to be heated, in Example 4-2. No chlorine removal agent was added to 4g of the treatable material (polyvinylidene chloride) in Comparative
25 Example 4-1. A chlorine removal agent (slaked lime) which was not within the scope of the present invention was added in an amount of 20 g to 4 g of the treatable material to form a mixture to be heated, in Comparative Example 4-2. A chlorine removable agent (calcium carbonate) which was not within the scope of the present invention
30 was added in an amount of 20 g to 4 g of the treatable material (polyvinylidene chloride) to form a mixture to be heated, in Comparative Example 4-3. The chlorine removal agent was in the

form of powder having an average particle size of 100 μm , in all Examples and Comparative Examples.

Specifically, in the experiment for each Example or Comparative Example, the predetermined amount of the treatable material was put into a tank or furnace, and then 20 g of the chlorine removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture, except for Comparative Example 4-1. Then, the tank was tightly sealed so that the inside the tank was isolated from the outside air or atmospheric air in order that the mixture was subjected to dry distillation upon heating. The thus sealed tank was stepwise heated with a heating coil, in which heating was made at eight temperature steps of 250 °C, 300 °C, 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C. In this heating process, the temperature at each of the eight steps was kept for 5 minutes, in which a concentration of hydrogen chloride gas in the tank was measured at each temperature rising time (at which the temperature was rising from one temperature step to the next temperature step) and at each temperature keeping time (at which the temperature at each temperature step was keeping). The temperature rising time is indicated as "Rising time" while the temperature keeping time is indicated as "Keeping time" in Table 6. The tank was provided with a gas discharge pipe through which gas and pressure generated in the tank upon heating was discharged out of the tank. The measurement of the hydrogen chloride gas concentration was accomplished by using a detector tube according to JIS (Japanese Industrial Standard) – K0804, in which the detector tube was inserted into the gas discharge pipe to measure the hydrogen chloride gas concentration. Results of the hydrogen chloride gas concentration measurement were shown in Table. 6. It is to be noted that ten times of the above experiment were repeated to obtain ten actual measured values of the hydrogen gas concentration for each Example and Comparative Example, in which the measured value (shown in Table 6) for each Example indicates

the highest value in the measured values while the measured value (shown in Table 6) for each Comparative Example indicates the lowest value in the measured values. Additionally, "ND" in Table 6 indicates the fact that no hydrogen chloride gas was detected in any
5 of 10 times hydrogen chloride gas concentration measurements to obtain the ten actual measured values. Further, manners of post-treatment for the chlorine removal agent were inspected and shown as "Post-treatment for chlorine removal agent" in Table 6.

As appreciated from the above, it has been revealed that
10 the hydrogen carbonate or carbonate containing an alkali metal, serving as the chlorine removal agent, can effectively convert noxious chlorine-containing gas into harmless chloride under a reaction in which the alkali metal reacts with chlorine to form chloride of alkali metal. A preliminary test (Comparative Example
15 4-1) was conducted in which polyvinylidene chloride containing a large amount of chlorine component was used as the treatable material. As a result of this test, it was confirmed that a large amount of hydrogen chloride was generated as shown in the column of Comparative Example 4-1 in Table 6.

20 Subsequently, comparative tests (Comparative Examples 4-2 and 4-3) were conducted in which slaked lime and calcium carbonate were respectively used as the conventional chlorine removal agents. As a result, generation of hydrogen chloride could be suppressed to some extent; however, it was confirmed that such a
25 suppression effect due to the conventional chlorine removal agents was not sufficient and was required to be further improved.

In view of the above, as a result of a variety of investigations and considerations, attention had been paid to potassium hydrogen carbonate and potassium carbonate and
30 selected potassium hydrogen carbonate as the chlorine removal agent in the experiments, and conducted tests (Examples 4-1 and 4-2). As a result of the tests, it has been revealed that generation of hydrogen chloride could be generally completely suppressed at any

temperature regions, and that sodium hydrogen carbonate was very excellent as the chlorine removal agent. Thus, the above reveals that if potassium hydrogen carbonate and/or potassium carbonate (to be able to react with chloride) is added to the treatable material to form
5 the mixture to be subjected to the thermal treatment, chlorine-containing gas generated from the treatable material can effectively dechlorinated and become harmless.

Hereinafter, discussion will be made depending upon the above experimental results shown in Table 6.

10 First in case that polyvinylidene chloride was used as the treatable material containing a large amount of chlorine component and that no chlorine removal agent was used as shown in Comparative Example 4-1, a large amount of hydrogen chloride gas was generated throughout a wide temperature region in the thermal
15 treatment or heating process. Generation of hydrogen chloride gas could be suppressed to some extent as compared with Comparative Example 4-1, in Comparative Examples 4-2 and 4-3 where slaked lime and calcium carbonate were added as the chlorine removal agent to the treatable material, respectively. However, it was
20 confirmed that such suppression for hydrogen chloride gas was insufficient.

In contrast, in Example 4-1 where potassium hydrogen carbonate was added as the chlorine removal agent to the treatable material, no generation of hydrogen chloride gas could be detected
25 throughout the whole temperature regions in the heating process, demonstrating that the potassium hydrogen carbonate was very excellent for the chloride removal agent. Additionally, in Examples 4-2 where potassium hydrogen carbonate was added as the chlorine removal agent to the treatable material (the simulated trash),
30 generation of a slight amount of hydrogen chloride was found; however, no substantial generation of hydrogen chloride gas could be detected throughout the whole temperature regions in the heating process.

It is to be noted in the above experiments, that potassium hydrogen carbonate (KHCO_3) was decomposed to separate CO_2 at a temperature lower than a level at which hydrogen chloride (HCl) was generated from the treatable material, thereby forming an atmosphere where residual KH smoothly reacted with HCl generated, as follows:



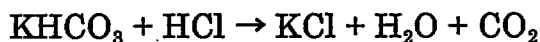
Accordingly, HCl and KH smoothly react with each other to form harmless chloride (KCl).

10 In contrast, in case of calcium carbonate (CaCO_3) or slaked lime (Ca(OH)_2), it was assumed that harmless chloride (CaCl) was formed similarly to the above; however, reaction therefor was not smooth as compared with the above case of the chlorine removal agent containing potassium.

15 In conclusion, it has been confirmed that addition of potassium hydrogen carbonate and/or potassium carbonate (to be able to react with chloride) to the treatable material in the thermal treatment or heating process can effectively accomplish dechlorination of chlorine-containing gas generated from the treatable material thereby causing the chlorine-containing gas to become harmless. It is to be noted that experiments similar to the above were conducted heating the treatable material at a higher temperature condition over 600°C , which exhibited similar experimental results to the above. The temperature for heating the mixture of the treatable material and the chlorine removal agent is preferably within a range of not higher than 1000°C from the view point of the fact that a facility for carrying out the chlorine removal process of the present invention is required to be large-sized if the temperature is raised over 1000°C .

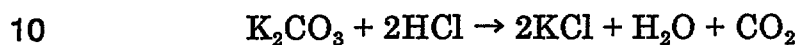
30 Discussion will be made on reactions carried out in the chlorine removal process of this embodiment. In case that potassium hydrogen carbonate (KHCO_3) is used as the chlorine removal agent,

the following reaction is made between potassium hydrogen carbonate and hydrogen chloride (HCl):



Thus, potassium hydrogen carbonate reacts with hydrogen chloride thereby to form harmless potassium chloride and carbon dioxide gas.

In case of using potassium carbonate (K_2CO_3) as the chlorine removal agent, the following reaction is made between potassium carbonate and hydrogen chloride:



Thus, potassium carbonate reacts with hydrogen chloride thereby to form harmless potassium chloride, water and carbon dioxide gas.

In the above experiments, the residue was left in the tank after the heating process had been completed. The residue was subjected to inspection, upon which it was detected that the residue did not contain noxious chlorine-containing gas component and contained harmless chloride or potassium chloride. The residue was put into water and stirred for 10 minutes, in which potassium chloride was dissolved in water while carbonized materials remained. It was also detected that the carbonized materials did not contain chlorine-containing gas component. Accordingly, chlorine-containing compound and chlorine component in the treatable material can be converted into potassium chloride (KCl), water (H_2O) and carbon dioxide gas (CO_2), and therefore hydrogen chloride forming part of a source of dioxin cannot be formed thereby realizing the unexpected result of making both emitted gas and residue harmless. It will be appreciated that, in this embodiment, alkali metal hydrogen carbonate and/or alkali metal carbonate, such as potassium hydrogen carbonate and/or potassium carbonate is used as the chlorine removal agent.

As will be understood, in the heating process in which the reactions according to the above chemical reactions are made, KCl is

formed. KCl is a harmless chloride and can be effectively removed under a rinsing or dissolving treatment with water or the like. After the rinsing treatment, solid residual materials or carbonized materials remain in the tank and reusable. Accordingly, the residual materials can be separated into respective materials which are different in characteristics by any separating means. The separated respective materials are dried and massed to be usable as fuel or the like. Additionally, liquid (such as water) used for the above rinsing treatment hardly contains no noxious substances and therefore can be discharged as it is to a river and the sea. More specifically, the residue taken out from the tank contains harmless chloride or potassium chloride (KCl). In order to extract the carbonized materials, the residue is put into a water tank containing water, and stirred for a predetermined time thereby dissolving sodium chloride. Subsequently, solid materials in the water tank are taken out from the water tank and then are subjected to a centrifugal dehydration to separate water content from the solid materials. The thus dehydrated solid materials are dried and massed. Water remaining in the water tank and the separated water content are drained through a separate draining and treatment means. It will be appreciated that carbon contents in the massed solid materials can be used as fuel while inorganic contents in the hardened mass can be used as materials for glass and cement. Further, as discussed above, the residue can be separated into respective materials which are different in characteristics by any separating means, upon which the separated respective materials are dried and massed to be effectively used as fuel or the like.

Next, a fifth embodiment of the noxious component removal process according to the present invention will be discussed. This noxious component removal process is for removing noxious component (such as chlorine and/or sulfur) from a treatable material (such as urban waste or trash, or industrial waste) containing the noxious component (such as chlorine and/or sulfur). The treatable

material may contain polyvinyl chloride, polyvinylidene chloride, a synthetic resin containing chlorine, a rubber containing chlorine, so-called shredder dust (dust or trash produced by a paper-shredder), articles formed of polyvinyl chloride or polyvinylidene chloride, used
5 tires, and formed polystyrene.

The noxious component removal process of this embodiment comprises the following steps in the sequence set forth: (a) mixing the treatable material and a noxious component (chloride and/or sulfur) removal agent to form a mixture, the noxious removal
10 agent containing an alkali metal compound; and (b) heating the mixture to thermally decompose the treatable material to generate a noxious component (chlorine and/or sulfur)-containing substance and cause the noxious component-containing substance to contact and react with the noxious component removal agent to form a
15 harmless compound.

In this embodiment, the noxious component removal agent contains at least one of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide, i.e., at least one of sodium hydrogen carbonate (NaHCO_3), sodium carbonate (Na_2CO_3),
20 sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), natural soda (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), sodium hydroxide (NaOH), potassium hydroxide (KOH), potassium carbonate (K_2CO_3), and potassium hydrogen carbonate (KHCO_3), potassium sodium carbonate ($\text{KNaCO}_3 \cdot 6\text{H}_2\text{O}$).

In this embodiment, sodium hydrogen carbonate, potassium hydrogen carbonate, sodium carbonate, sodium hydroxide or potassium hydroxide is used to be mixed with the treatable material which contains a large amount of chlorine and sulfur. According to this embodiment, prior to a heating treatment is
25 applied to the treatable material including chlorine-containing substance and sulfur-containing substance (substance containing sulfur) which will respectively generate chlorine-containing gas and sulfur-containing gas (gas containing sulfur) upon heating, the
30

chloride removal agent is added to and mixed with the treatable material thereby to form the mixture. By heating this mixture in the low oxygen concentration atmosphere, the chlorine-containing substance is thermally decomposed at a predetermined temperature thereby generating harmful chlorine-containing gas and sulfur-containing gas. This chlorine-containing gas and sulfur-containing gas immediately react with the noxious component removal agent thus to form harmless chloride (NaCl , KCl) and sulfite (Na_2SO_3 , K_2SO_3).

10 This embodiment will be discussed with reference to Fig. 1 illustrating a chlorine and sulfur removal system by which the process of this embodiment is carried out.

 The chlorine and sulfur removal system comprises a mixing means or device 1 for mixing the treatable material (such as pulverized waste or trash) and the noxious component removal agent (such as sodium hydrogen carbonate) to form a mixture. A thermal treatment furnace 2 is formed cylindrical and rotatable. The mixture formed by the mixing device 1 is supplied into the furnace 2. The mixture may be formed by other means or devices than the mixing device 1. The thermal treatment furnace 2 is provided with a rotating transferring means or device (not shown) which is adapted to transfer the mixture under stirring. In the furnace 2, the mixture of the treatable material and the noxious component removal agent is heated in the low oxygen concentration atmosphere to accomplish thermal decomposition of the treatable material. The furnace 2 is provided with a heating coil 2 for heating the content of the furnace 2.

 A residue treatment means or device 4 is provided to treat the residue (ash) formed upon heating the treatable material in the furnace 2. The residue is taken out of the furnace 2 and subjected to a solid-liquid separation. In this solid-liquid separation, the residue is rinsed with liquid such as water so that formed chloride and/or sulfite are separated and removed and then taken out from a liquid

discharge section 4a. The residual solid such as metals and carbonized materials are taken out from a solid take-out section 4b. Emitted gas from the thermal treatment furnace 2 is introduced into an emitted gas treatment means or device 5. It will be understood
5 that the emitted gas has been made harmless because the noxious components in the treatable material is removed under the action of the noxious component removal agent. A necessary treatment is made to the introduced emitted gas in the emitted gas treatment device 5. The treated gas from the gas treatment device 5 is then
10 introduced into a gas recovery means or device 6 for recover the gas or into a secondary combustion means or device 7 to make secondary combustion of the gas to be discharged.

In this noxious component removal process using the above noxious component removal system, the treatable material
15 containing the noxious component(s) and the noxious component removal agent (such as sodium hydrogen carbonate) are cast into the mixing device 1 and sufficiently mixed with each other, and then cast into the thermal treatment furnace 2. The treatable material may be pulverized prior to being cast, or pulverized simultaneously
20 with mixing between the treatable material and the noxious component removal agent. The amount of the noxious component removal agent is within a range of from 5 to 30 % by weight relative to the treatable material. The thermal treatment or heating of the mixture in the thermal treatment furnace 2 is accomplished within
25 temperature and time ranges to cover the temperature and time of generation of HCl gas and SO_x gas from the treatable material, the temperature (for example, 600 °C) and time (for example, 1 hour) having been determined under a previous investigation. These temperature and time are in relation to a condition (such as the size
30 and the heating coil) of the thermal treatment furnace, the treatment amount of the treatable material, the treatment time of the thermal treatment of the treatable material, the treatment temperature of the thermal treatment of the treatable material.

Therefore, the above temperature and time are required to be previously determined under a sufficient investigation and to accumulate the data to be taken for the temperature and time.

5 The thermal treatment in this process is under a heating condition for accomplishing dry distillation (or thermal decomposition) of the treatable material and therefore is not under another heating condition for accomplishing combustion or incineration of the treatable material. Under this thermal treatment, noxious HCl gas and SOx gas can be effectively react with each other
10 upon contact of them, so that noxious HCl gas and SOx gas are converted respectively into harmless chloride and sulfite.

 In order to maintain this heating condition, a total reaction atmosphere or circumference inside the thermal treatment furnace can meet necessary conditions and be stable. For example,
15 the stable low oxygen concentration atmosphere is formed inside the thermal treatment furnace. In other words, it is necessary to supply fresh air only around the treatable material during the heating or thermal treatment. If fresh air is supplied to around the treatable material, there is the possibility of combustion of the treatable
20 material being initiated to make reaction stable. Otherwise, it has been experimentally confirmed that the heating condition can be maintained even by supplying fresh air into the thermal treatment furnace in such a manner that fresh air reaches whole the pulverized treatable material under a condition where unburned state of the
25 treatable material is kept.

 During the thermal treatment in the furnace, decomposition gas containing HCl gas and SOx gas are generated, in which HCl and SOx components immediately react with the noxious component removal agent or sodium hydrogen carbonate thereby to
30 form harmless chloride (such as NaCl) and sulfite (Na_2SO_3), so that noxious HCl and SOx are removed from the decomposition gas. The residue formed upon the thermal treatment of the treatable material

contains no noxious HCl and SO_x. Thus, the decomposition gas and the residue can be simultaneously made harmless.

5 The residue is taken out through the residue treatment device 4 and rinsed with water or a solution thereby to separate the chloride and the sulfite from the residue, leaving solid residual material. The solid residual material contains useful metals which are effectively reusable.

10 Hereinafter, experiments for carrying out the noxious component removal process according to this embodiment will be discussed, in which comparison in experimental result is made between Examples (according to this embodiment) and Comparative Examples (not within the scope of the present invention). The experiments have revealed that the noxious component removal agent of this embodiment effectively react with HCl gas and SO_x gas
15 so as to make harmless emitted gas and residue.

In the experiments, the noxious component removal process of this embodiment was carried out by using a refused derived fuel (referred hereinafter to as "RDF") as the treatable material. The RDF was formed from a waster or refuse and contains
20 the following components:

garbage including refuse of meat, fish, bone, egg-shell, vegetable, fruit and the like;

plastic waste including polyethylene, polypropylene, polystyrene, polyvinylidene chloride, and the like;

25 papers including tissue paper, advertisement bill, paper bag, paper box, and paper packing for drink, and the like; and

combustibles including fiber matters such as fabric, wood piece, rubber, leather and the like.

As a result of analysis, it had been confirmed that RDF
30 used in the experiments contained 60.173 % by weight of carbon (C), 16.277 % by weight of oxygen (O), 10.745 % by weight of silicon (Si), 7.045 % by weight of calcium (Ca), 3.314 % by weight of aluminum (Al), 0.888 % by weight of magnesium (Mg), 0.505 % by weight of

phosphorus (P), 0.466 % by weight of chlorine (Cl), 0.331 % by weight of sulfur (S), and 0.155 % by weight of potassium (K), 0.101 % by weight of sodium (Na).

The experiments in connection with the present invention
5 (Examples) used RDF (not subjected to thermal treatment or incineration) as the treatable material, whereas the experiments for the comparison purpose (Comparative Examples) used treated RDF (subjected to the thermal or incineration). For reference, in general, RDF whose main component is plastic contains 0.29 to 0.89 % by
10 weight of chlorine component, and RDF whose main component is paper contains 0.2 % by weight of chlorine component. Additionally, it is general that the treated RDF contains about 1.0 % by weight of sulfur component.

As shown in Table 7, concerning Examples, 10 g of the
15 chlorine removal agent (sodium hydrogen carbonate) was added to 40 g of the treatable material (crushed RDF) to form a mixture to be heated, in Example 5-1. The chlorine removal agent (sodium hydrogen carbonate) in an amount of 4g was added to 40 g of the treatable material (crushed RDF) to form a mixture to be heated, in
20 Example 5-2. The chlorine removal agent (potassium hydrogen carbonate) in an amount of 3 g was added to 40 g of the treatable material (crushed RDF) to form a mixture to be heated, in Example 5-3. The chlorine removal agent (sodium carbonate and potassium carbonate) in an amount of 3 g was added to 20 g of the treatable
25 material (crushed RDF) to form a mixture to be heated, in Example 5-4. The chlorine removal agent (sodium hydroxide) in an amount of 3 g was added to 20 g of the treatable material (crushed RDF) to form a mixture to be heated, in Example 5-5. The chlorine removal agent (potassium hydroxide) in an amount of 3 g was added to 20 g of the
30 treatable material (crushed RDF) to form a mixture to be heated, in Example 5-6. The chlorine removal agent (sodium hydrogen carbonate) in an amount of 10 g was added to 40 g of the treatable material (RDF which had not been crushed and in the form of mass)

to form a mixture to be heated, in Example 5-7. The chlorine removal agent was in the form of powder having an average particle size of 100 μm , in all Examples

Concerning Comparative Examples in which no noxious
5 component removal agent was used, 40 g of the treated RDF which had been crushed was used as the treatable material in Comparative Example 5-1. The treated RDF which had been crushed was used in an amount of 20 g as the treatable material in Comparative Example 5-2. The treated RDF which had been not crushed and in the form of
10 mass was used in an amount of 20 g as the treatable material in Comparative Example 5-3.

The experiment for each Example was conducted as follows: A predetermined amount of the treatable material was put into a tank or furnace, and then 20 g of the noxious component
15 removal agent was added to and mixed with the treatable material in the tank to form the above-mentioned mixture. In the experiment for each Comparative Example, a predetermined amount of the treatable material was put into a tank or furnace. Then, the tank was tightly sealed so that the inside the tank was isolated from the
20 outside air or atmospheric air in order that the mixture or only the treatable material was subjected to dry distillation upon heating. The thus sealed tank was stepwise heated with a heating coil, in which heating was made at eight temperature steps of 250 °C, 300 °C, 350 °C, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C. In this heating step, the
25 temperature at each of the eight steps was kept for 5 minutes, in which a concentration of HCl gas and a concentration of SO₂ in the tank was measured at each temperature rising time (at which the temperature was rising from one temperature step to the next temperature step) and at each temperature keeping time (at which
30 the temperature at each temperature step was keeping). The temperature rising time is indicated as "Rising time" while the temperature keeping time is indicated as "Keeping time" in Tables 7 and 8. The tank was provided with a gas discharge pipe through

which gas and pressure generated in the tank upon heating was discharged out of the tank. The measurement of the hydrogen chloride gas concentration was accomplished by using a detector tube according to JIS (Japanese Industrial Standard) – K0804, in which the detector tube was inserted into the gas discharge pipe to measure HCl and SO₂ gas concentrations. Results of HCl and SO₂ gas concentration measurement were shown in Tables 7 and 8. It is to be noted that ten times of the above experiment were repeated to obtain ten actual measured values of the hydrogen gas concentration for each Example and Comparative Example, in which the measured value (shown in Table 7) for each Example indicates the highest value in the measured values while the measured value (shown in Table 8) for each Comparative Example indicates the lowest value in the measured values. Additionally, “ND” in Tables 7 and 8 indicates the fact that no hydrogen chloride gas was detected in any of 10 times HCl and SO₂ gas concentration measurements to obtain the ten actual measured values. Further, manners of post-treatment for the noxious component removal agent were inspected and shown as “Post-treatment for chlorine removal agent” in Tables 7 and 8.

The experimental results will be discussed hereinafter with reference to Tables 7 and 8.

Regarding hydrogen chloride gas (HCl):

(a) In case that the treatable material was crushed, a slight amount of HCl gas was detected in Example 5-4; however, no HCl gas was detected in other Examples so that the noxious component removal agents were highly effective for suppressing generation of HCl gas. This HCl gas generation suppression effect was considerably high as compared with Comparative Examples 5-1 and 5-2.

(b) In case that the treatable material was not crushed and used in the form of mass, a slight amount of HCl gas was detected at the temperature steps of 350 to 450 °C in Example 5-7 as compared with the case that the treatable material was crushed; however, it

was confirmed that the results in Example 5-7 was considerably good as compared with those in Comparative Examples.

Regarding sulfur oxide gas (SO₂):

(a) In case that the treatable material was crushed, a slight amount of SO₂ gas was detected at the temperature steps of 400 to 450 °C in Examples 5-1 to 5-6; however, the results of Examples were very good as a whole so that the noxious component removal agents were highly effective for suppressing generation of SO₂ gas. This SO₂ gas generation suppression effect was considerably high as compared with Comparative Examples 5-1 and 5-2.

(b) In case that the treatable material was not crushed and used in the form of mass, a slight amount of SO₂ gas was detected at the temperature steps of 350 to 450 °C in Example 5-7 as compared with the case that the treatable material was crushed; however, it was confirmed that the results in Example 5-7 was considerably good as compared with those in Comparative Example 5-3.

As a result of the above experimental results and investigations, it has been confirmed that HCl and SO_x can be generally completely made harmless by using the noxious component removal agent containing the alkali metal compound which effectively reacts with HCl and SO_x to form harmless chloride and sulfite. Thus, the above reveals that if the noxious component removal agent is added to the treatable material to form the mixture to be subjected to the thermal treatment, chlorine-containing gas and sulfur-containing gas generated from the treatable material can effectively become harmless.

It is to be noted that experiments similar to the above were conducted heating the treatable material at a higher temperature condition over 600 °C, which exhibited similar experimental results to the above. The temperature for heating the mixture of the treatable material and the chlorine removal agent may be selected according to form of facilities for accomplish the thermal treatment,

time of the thermal treatment, amount of the treatable material and the like.

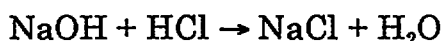
Subsequently, discussion will be made on mechanisms of reaction between the noxious component removal agent and noxious gas (chlorine-containing gas and sulfur-containing gas), realizing unexpected results in which both emitted gas and residue are made harmless.

(1) Regarding hydrogen chloride gas (HCl):

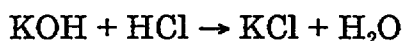
It was confirmed that sodium hydrogen carbonate (NaHCO_3), sodium carbonate (Na_2CO_3), sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), natural soda (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), sodium hydroxide (NaOH), potassium hydroxide (KOH), potassium carbonate (K_2CO_3), and potassium hydrogen carbonate (KHCO_3) can react with noxious HCl thereby to convert HCl into harmless chloride (NaCl and KCl) according to reaction formulae discussed before. It will be understood that sodium potassium carbonate and sodium carbonate hydrate can also react with noxious HCl similarly to the above.

Particularly in case of using the alkali metal hydrogen carbonate as the noxious component removal agent, the following tendency is predominant: First, CO_2 is separated at a temperature below a level (not lower than 250°C) at which hydrogen chloride (HCl) is generated upon decomposition of the treatable material, forming NaOH or KOH . It is supposed that this forms an atmosphere in which reaction between NaOH or KOH and HCl is made smoothly. Here, the following reactions are made:

In case of sodium hydrogen carbonate,



In case of potassium hydrogen carbonate,



Thus, NaOH or KOH smoothly reacts with HCl thereby to newly form harmless chloride (NaCl, KCl).

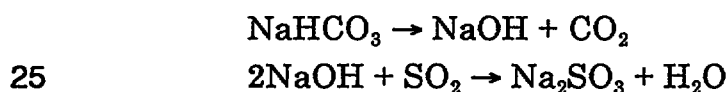
After the thermal treatment, the residue was left in the tank after the heating process had been completed. The residue was subjected to inspection, upon which it was detected that the residue did not contain noxious chlorine-containing gas component and contained harmless chloride (sodium chloride or potassium chloride). The residue was put into water and stirred for 10 minutes, in which the chloride was dissolved in water while carbonized materials remained. It was also detected that the carbonized materials did not contain chlorine-containing gas component.

Accordingly, chlorine-containing compound and chlorine component in the treatable material can be converted into sodium chloride (NaCl), potassium chloride (KCl), water (H₂O) and carbon dioxide gas (CO₂), and therefore hydrogen chloride forming part of a source of dioxin cannot be formed thereby realizing the unexpected result of making both emitted gas and residue harmless.

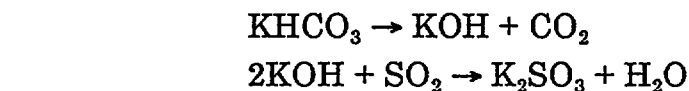
(2) Regarding sulfur oxide gas (SO_x):

It was confirmed that the noxious component removal agent reacts with noxious SO_x thereby to convert SO_x into harmless sulfite as follows:

In case that sodium hydrogen carbonate is used as the noxious component removal agent,



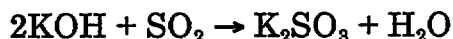
In case that potassium hydrogen carbonate is used as the noxious component removal agent,



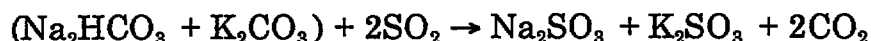
In case that sodium hydroxide is used as the noxious component removal agent,



In case that potassium hydroxide is used as the noxious component removal agent,



In case that sodium potassium carbonate is used as the
5 noxious component removal agent,



Particularly in case of using the alkali metal hydrogen carbonate as the noxious component removal agent, the following tendency is predominant: First, CO_2 is separated at a temperature
10 below a level (not lower than 300°C) at which sulfur oxide (SO_2) is generated upon decomposition of the treatable material, forming NaOH or KOH . It is supposed that this forms an atmosphere in which reaction between NaOH or KOH and SO_2 is made smoothly. Here, the following reactions are made:

15 In case of sodium hydrogen carbonate,



In case of potassium hydrogen carbonate,



20 $2\text{KOH} + \text{SO}_2 \rightarrow \text{K}_2\text{SO}_3 + \text{H}_2\text{O}$

Thus, NaOH or KOH smoothly reacts with SO_2 thereby to newly form harmless sulfite (Na_2SO_3 , K_2SO_3).

It was confirmed sodium carbonate (Na_2CO_3), sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), natural soda
25 (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), potassium carbonate (K_2CO_3), and sodium carbonate hydrate can react with noxious SO_2 thereby to convert SO_2 into harmless chloride sulfite (Na_2SO_3 , K_2SO_3) according to reaction formulae discussed hereinbefore.

Upon the above-mentioned inspection of the residue, it
30 was detected that the residue did not contain noxious sulfur-containing gas (SO_x gas) component and contained harmless sulfite (Na_2SO_3 , K_2SO_3). The residue was put into water and stirred for 10 minutes, in which the alkali metal sulfite was dissolved in water

while carbonized materials remained. It was also detected that the carbonized materials did not contain sulfur-containing (SOx) gas component.

Accordingly, sulfur-containing compound and sulfur
5 component in the treatable material can be converted into sodium sulfite (Na_2SO_3) in powder form, and potassium sulfite (K_2SO_3) in powder form, water (H_2O) and carbon dioxide gas (CO_2), and therefore SOx gas can be prevented from generation thus realizing the unexpected result of making both emitted gas and residue
10 harmless.

It will be appreciated that, in this embodiment, the noxious component removal agent contains at least one of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide, i.e., at least one of sodium hydrogen carbonate (NaHCO_3),
15 sodium carbonate (Na_2CO_3), sodium sesqui carbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), natural soda (containing $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), sodium hydroxide (NaOH), potassium hydroxide (KOH), potassium carbonate (K_2CO_3), and potassium hydrogen carbonate (KHCO_3), potassium sodium carbonate ($\text{KNaCO}_3 \cdot 6\text{H}_2\text{O}$). As will be
20 understood, in the heating process in which the reactions according to the above chemical reactions are made, noxious hydrogen chloride and/or sulfur oxide are converted into harmless chloride (NaCl , KCl) and/or sulfite (Na_2SO_3 , K_2SO_3), thereby making it possible to remove noxious components (hydrogen chloride and/or sulfur oxide) from the
25 decomposition gas generated from the treatable material upon heating. Thus, the decomposition gas or emitted gas from the furnace can be effectively made harmless. The chloride and/or sulfite form part of the residue and can be effectively removed under a rinsing or dissolving treatment with water or the like. After the
30 rinsing treatment, solid residual materials or carbonized materials remain in the tank and reusable. Accordingly, the residual materials can be separated into respective materials which are different in characteristics by any separating means. The separated respective

materials are dried and massed to be usable as fuel or the like. Additionally, liquid (such as water) used for the above rinsing treatment hardly contains no noxious substances and therefore can be discharged as it is to a river and the sea.

TABLE 1

Item	Sample	Example 1-1	Comparative Example 1-1	Comparative Example 1-2	Comparative Example 1-3
Treatable material	Polyvinylidene chloride	4g	4g	4g	4g
Chlorine removal agent	Sodium hydrogen carbonate	20g	—	—	—
	Slaked lime	—	—	20g	—
	Calcium carbonate	—	—	—	20g

TABLE 2

Item	Sample	Example 1-2	Example 1-3	Example 1-4	Example 1-5
Treatable material	Simulated trash	20g	20g	20g	20g
	Polyvinylidene chloride	1g	0.5g	0.1g	—
Chlorine removal agent	Sodium hydrogen carbonate	5g	2.5g	0.5g	5g
Water content	City water	—	—	—	20cc

TABLE 3

Item	Example 1-1	Example 1-2	Example 1-3	Example 1-4	Example 1-5	Comparative Example 1-1	Comparative Example 1-2	Comparative Example 1-3
Treatable material	Polyvinylidene chloride (4g)	Polyvinylidene chloride (1g)	Polyvinylidene chloride (0.5g)	Polyvinylidene chloride (0.1g)	—	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)
	—	Simulated trash (20g)	Simulated trash (20g)	Simulated trash (20g)	Simulated trash (20g)	—	—	—
	—	—	—	—	Water (20cc)	—	—	—
Chlorine removal agent	Sodium hydrogen carbonate (20g)	Sodium hydrogen carbonate (5g)	Sodium hydrogen carbonate (2.5g)	Sodium hydrogen carbonate (0.5g)	Sodium hydrogen carbonate (5g)	—	Slaked lime (20g)	Calcium carbonate (20g)
Measuring time	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not lower than)	HCl concentration (not lower than)	HCl concentration (not lower than)
Temp. °C	ND	ND	ND	ND	ND	ND	ND	ND
250	Rising time	ND	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND	ND
300	Rising time	ND	ND	ND	ND	450ppm	1ppm	15ppm
	Keeping time	ND	ND	ND	ND	1000ppm	4ppm	35ppm
350	Rising time	ND	ND	ND	ND	1000ppm	280ppm	350ppm
	Keeping time	ND	ND	ND	ND	1000ppm	15ppm	50ppm
400	Rising time	ND	ND	ND	ND	1000ppm	8ppm	20ppm
	Keeping time	ND	ND	ND	ND	1000ppm	ND	15ppm
450	Rising time	ND	ND	ND	ND	650ppm	5ppm	10ppm
	Keeping time	ND	ND	ND	ND	400ppm	ND	7ppm
500	Rising time	ND	ND	ND	ND	1000ppm	ND	3ppm
	Keeping time	ND	ND	ND	ND	580ppm	ND	ND
550	Rising time	ND	ND	ND	ND	1000ppm	ND	ND
	Keeping time	ND	ND	ND	ND	500ppm	ND	ND
600	Rising time	ND	ND	ND	ND	600ppm	ND	ND
	Keeping time	ND	ND	ND	ND	50ppm	ND	ND
Post-treatment for chlorine removal agent	Soluble in water	Soluble in water	Soluble in water	Soluble in water	Soluble in water	—	Slightly soluble in water	Slightly soluble in water

TABLE 4

Item		Example 2-1	Example 2-2	Comparative Example 2-1	Comparative Example 2-2	Comparative Example 2-3	Comparative Example 2-4
Item	Treatable material	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (1g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)
	Chlorine removal agent	Sodium hydroxide (20g)	Potassium hydroxide (20g)	—	—	Slaked lime (20g)	Calcium carbonate (20g)
Temp. °C	Measuring time	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not lower than)	HCl concentration (not lower than)	HCl concentration (not lower than)	HCl concentration (not lower than)
250	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
300	Rising time	ND	ND	ND	450ppm	1ppm	15ppm
	Keeping time	ND	ND	ND	1000ppm	4ppm	35ppm
350	Rising time	3ppm	ND	ND	1000ppm	280ppm	350ppm
	Keeping time	ND	ND	60ppm	1000ppm	15ppm	50ppm
400	Rising time	ND	ND	480ppm	1000ppm	8ppm	20ppm
	Keeping time	ND	ND	1000ppm	1000ppm	ND	15ppm
450	Rising time	1ppm	ND	1000ppm	650ppm	5ppm	10ppm
	Keeping time	ND	2ppm	1000ppm	400ppm	ND	7ppm
500	Rising time	ND	ND	500ppm	1000ppm	ND	3ppm
	Keeping time	ND	ND	400ppm	580ppm	ND	ND
550	Rising time	ND	ND	200ppm	1000ppm	ND	ND
	Keeping time	ND	ND	240ppm	500ppm	ND	ND
600	Rising time	ND	ND	60ppm	600ppm	ND	ND
	Keeping time	ND	ND	30ppm	50ppm	ND	ND
600~1000	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
Post-treatment for chlorine removal agent		Soluble in water	Soluble in water	—	—	Slightly soluble in water	Slightly soluble in water

TABLE 5

Item	Example 3-1	Example 3-2	Comparative Example 3-1	Comparative Example 3-2	Comparative Example 3-3
	Treatable material	Polyvinyl chloride (4g)	Polyvinylidene chloride (1g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)
Chlorine removal agent	Sodium hydrogen carbonate (20g)	Sodium hydrogen carbonate (20g)	—	Calcium carbonate (20g)	Slaked lime (20g)
Measuring time	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not lower than)	HCl concentration (not lower than)	HCl concentration (not lower than)
Temp. °C					
250	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
300	Rising time	ND	ND	15ppm	1ppm
	Keeping time	ND	ND	35ppm	4ppm
350	Rising time	ND	ND	350ppm	280ppm
	Keeping time	ND	ND	50ppm	15ppm
400	Rising time	ND	ND	20ppm	8ppm
	Keeping time	ND	ND	15ppm	ND
450	Rising time	ND	ND	10ppm	5ppm
	Keeping time	ND	ND	7ppm	ND
500	Rising time	ND	ND	3ppm	ND
	Keeping time	ND	ND	ND	ND
550	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
600	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
Post-treatment for chlorine removal agent	Soluble in water	Soluble in water	—	Slightly soluble in water	Slightly soluble in water

TABLE 6

Item	Example 4-1	Example 4-2	Comparative Example 4-1	Comparative Example 4-2	Comparative Example 4-3
Treatable material	Polyvinylidene chloride (4g)	—	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)	Polyvinylidene chloride (4g)
	—	Simulated trash (40g)	—	—	—
Chlorine removal agent	Potassium hydrogen carbonate (10g)	Potassium hydrogen carbonate (10g)	—	Slaked lime (20g)	Calcium carbonate (20g)
Measuring time	HCl concentration (not higher than)	HCl concentration (not higher than)	HCl concentration (not lower than)	HCl concentration (not lower than)	HCl concentration (not lower than)
Temp. °C	ND	ND	ND	ND	ND
250	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
300	Rising time	ND	ND	1ppm	15ppm
	Keeping time	ND	ND	4ppm	35ppm
350	Rising time	ND	2ppm	280ppm	350ppm
	Keeping time	ND	7ppm	15ppm	50ppm
400	Rising time	ND	5ppm	8ppm	20ppm
	Keeping time	ND	2ppm	ND	15ppm
450	Rising time	ND	ND	5ppm	10ppm
	Keeping time	ND	ND	ND	7ppm
500	Rising time	ND	ND	ND	3ppm
	Keeping time	ND	ND	ND	ND
550	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
600	Rising time	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND
Post-treatment for chlorine removal agent	Soluble in water	Soluble in water	—	Slightly soluble in water	Slightly soluble in water

TABLE 7

[illegible]

TABLE 8

		Comparative Example 5-1		Comparative Example 5-2		Comparative Example 5-3	
Treatable material		Treated RDF Crushed 40g		Treated RDF Crushed 20g		Treated RDF Mass 40g	
Noxious comp. removal agent		_____		_____		_____	
Temp. °C	Measuring time	HCl concent- ration (not lower than)	SO ₂ concent- ration (not lower than)	HCl concent- ration (not lower than)	SO ₂ concent- ration (not lower than)	HCl concent- ration (not lower than)	SO ₂ concent- ration (not lower than)
250	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
300	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
350	Rising time	ND	7ppm	ND	20ppm	2ppm	6ppm
	Keeping time	16ppm	40ppm	13ppm	17ppm	35ppm	60ppm
400	Rising time	70ppm	35ppm	30ppm	13ppm	1000ppm	60ppm
	Keeping time	60ppm	30ppm	3ppm	7ppm	130ppm	20ppm
450	Rising time	10ppm	7ppm	1ppm	4ppm	10ppm	10ppm
	Keeping time	2ppm	3ppm	ND	ND	ND	5ppm
500	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
550	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
600	Rising time	ND	ND	ND	ND	ND	ND
	Keeping time	ND	ND	ND	ND	ND	ND
Post-treatment for noxious comp. removal agent		_____		_____		_____	

WHAT IS CLAIMED IS:

1. A process for removing a noxious component from a treatable material containing the noxious component, comprising the following steps in the sequence set forth:
 - 5 mixing the treatable material and a noxious component removal agent to form a mixture, said noxious component removal agent containing an alkali metal compound; and
 - heating said mixture to thermally decompose the treatable material to generate a noxious component-containing substance and
 - 10 cause the noxious component-containing substance to contact and react with said noxious component removal agent to form a harmless compound.
2. A process for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, comprising the following steps in the sequence set forth:
 - 15 mixing the treatable material and a chlorine and sulfur removal agent to form a mixture, said chlorine and sulfur removal agent containing an alkali metal compound; and
 - 20 heating said mixture to thermally decompose the treatable material to generate at least one of a chlorine-containing substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with said chlorine and sulfur removal agent to
 - 25 form at least one of harmless chloride and sulfite.
3. A process for removing chlorine from a treatable material containing chlorine, comprising the following steps in the sequence set forth:
 - 30 mixing the treatable material and a chlorine removal agent to form a mixture, said chlorine removal agent containing an alkali metal compound; and



heating said mixture to thermally decompose the treatable material to generate a chlorine-containing substance and cause the chlorine-containing substance to contact and react with said chlorine removal agent to form a harmless chloride.

5

4. A process as claimed in Claim 3, wherein said chlorine removal agent contains at least one compound selected from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

10

5. A process as claimed in Claim 3, wherein said chlorine removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, 15 potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.

6. A process as claimed in Claim 3, wherein the heating step 20 includes the step of heating said mixture in a low oxygen atmosphere.

7. A process as claimed in Claim 3, wherein the heating step includes the step of heating said mixture in a furnace which is 25 substantially sealed so as to prevent fresh air from being supplied into said furnace, in which a pressure in said furnace leaking out of said furnace.

8. A process as claimed in Claim 3, wherein the heating step 30 includes the step of heating said mixture to cause said treatable material to make its dry distillation.



9. A process as claimed in Claim 3, wherein said chlorine removal agent is in form of at least one selected from the group consisting of mass, plate, porous body, particle, solution and suspension.

5

10. A process as claimed in Claim 3, the treatable material is at least one selected from the group consisting of polyvinyl chloride, polyvinylidene chloride, a synthetic resin containing chlorine, and a rubber containing chlorine.

10

11. A process as claimed in Claim 3, wherein said chlorine removal agent in said mixing step is in an amount ranging from 0.05 to 10 % by weight relative to the treatable material at a time before said mixing step.

15

12. A process as claimed in Claim 3, wherein said chlorine removal agent in said mixing step is in an amount ranging from 10 to 70 % by weight relative to the treatable material in case that the treatable material is at least one selected from the group consisting of polyvinyl chloride, polyvinylidene chloride, a synthetic resin containing chlorine, and a rubber containing chlorine.

20

13. A process as claimed in Claim 3, wherein said chlorine removal agent in said mixing step is in an amount of not less than a chemical equivalent of chlorine to be generated from the treatable material.

25

14. A process as claimed in Claim 3, further comprising the step of adding said chlorine removal agent to said mixture in said heating step.

30

15. A process as claimed in Claim 14, wherein the adding step includes adding said chlorine removal agent to said mixture before a



temperature of the treatable material reaches a level at which a thermal decomposition of the treatable material occurs.

16. A process as claimed in Claim 14, wherein the adding step
5 includes adding said chlorine removal agent to said mixture after a temperature of the treatable material reaches a level at which a thermal decomposition of the treatable material occurs.

17. A process as claimed in Claim 3, further comprising
10 supplying said chlorine removal agent to the treatable material in a furnace by at least one measure selected from the group consisting of casting and spraying.

18. A process as claimed in Claim 3, wherein said heating step
15 includes heating the treatable material at a temperature ranging from 200 to 1000 °C.

19. A noxious component removal agent to be used in a process
20 for removing noxious component from a treatable material containing the noxious component, said noxious component removal agent containing an alkali metal compound, said noxious component removal agent being contactable and able to react with a noxious component-containing substance generated from the treatable material upon heating said treatable material, so as to form a
25 harmless compound.

20. A chlorine and sulfur removal agent to be used in a process
for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, said chlorine
30 and sulfur removal agent containing an alkali metal compound, said chlorine and sulfur removal agent being contactable and able to react with at least one of a chlorine-containing substance and a sulfur-containing substance generated from the treatable material



upon heating said treatable material, so as to form at least one of harmless chloride and sulfite.

21. A chlorine removal agent to be used in a process for
5 removing chlorine from a treatable material containing chlorine,
said chlorine removal agent containing an alkali metal compound,
said chlorine removal agent being contactable and able to react with
a chlorine-containing substance generated from the treatable
10 material upon heating said treatable material, so as to form a
harmless chloride.

22. A chlorine removal agent as claimed in Claim 21, wherein
said alkali metal compound is at least one compound selected from
the group consisting of alkali metal carbonate, alkali metal
15 hydrogen carbonate, and alkali metal hydroxide.

23. A chlorine removal agent as claimed in Claim 21, wherein
said alkali metal compound is at least one compound selected from
the group consisting of at least one compound selected from the
20 group consisting of sodium hydrogen carbonate, sodium carbonate,
sodium sesqui carbonate, natural soda, sodium hydroxide,
potassium hydroxide, lithium hydroxide, rubidium hydroxide, and
cesium hydroxide, potassium carbonate, potassium hydrogen
carbonate, and potassium sodium carbonate.

25 24. A chlorine removal agent to be used in a process for
removing at least one of chlorine and sulfur from a treatable
material containing at least one of chlorine and sulfur, comprising
the following steps in the sequence set forth: mixing the treatable
30 material and a chlorine and sulfur removal agent to form a mixture,
said chlorine and sulfur removal agent containing an alkali metal
compound; and heating said mixture to thermally decompose the
treatable material to generate at least one of a chlorine-containing



substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with said chlorine and sulfur removal agent to form at least one of harmless chloride and sulfite,

5 said chlorine removal agent containing an alkali metal compound.

25. A chlorine removal agent as claimed in Claim 24, wherein said chlorine removal agent contains at least one compound selected
10 from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

26. A chlorine removal agent as claimed in Claim 24, wherein said alkali metal compound is at least one compound selected from
15 the group consisting of at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen
20 carbonate, and potassium sodium carbonate.

27. A system for removing at least one of chlorine and sulfur from a treatable material containing at least one of chlorine and sulfur, comprising:

25 a device for mixing the treatable material and a chlorine and sulfur removal agent to form a mixture, said chlorine and sulfur removal agent containing an alkali metal compound;

 a furnace into which said mixture of the treatable material and said chlorine and sulfur removal agent is supplied, said furnace
30 being adapted to form therein a low oxygen concentration atmosphere; and

 a heating device for heating said mixture in the low oxygen concentration atmosphere in said furnace to thermally decompose



the treatable material so as to accomplish dry distillation of said treatable material, in which said mixture generates at least one of a chlorine-containing substance and a sulfur-containing substance and cause at least one of the chlorine-containing substance and the sulfur-containing substance to contact and react with said chlorine and sulfur removal agent to form at least one of harmless chloride and sulfite.

28. A process as claimed in Claim 1, wherein said noxious component removal agent contains at least one compound selected from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

29. A process as claimed in Claim 1, wherein said noxious component removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.

30. A process as claimed in Claim 2, wherein said chlorine and sulfur removal agent contains at least one compound selected from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

31. A process as claimed in Claim 2, wherein said chlorine and sulfur removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.



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32. A process as claimed in Claim 19, wherein said noxious component removal agent contains at least one compound selected from the group consisting of alkali metal carbonate, alkali metal
5 hydrogen carbonate, and alkali metal hydroxide.

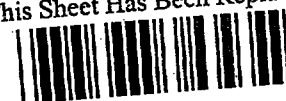
33. A process as claimed in Claim 19, wherein said noxious component removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium
10 carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.

15 34. A process as claimed in Claim 20, wherein said chlorine and sulfur removal agent contains at least one compound selected from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

20 35. A process as claimed in Claim 20, wherein said chlorine and sulfur removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, and
25 cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.

36. A process as claimed in Claim 27, wherein said chlorine and sulfur removal agent contains at least one compound selected
30 from the group consisting of alkali metal carbonate, alkali metal hydrogen carbonate, and alkali metal hydroxide.

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37. A process as claimed in Claim 27, wherein said chlorine and sulfur removal agent contains at least one compound selected from the group consisting of sodium hydrogen carbonate, sodium carbonate, sodium sesqui carbonate, natural soda, sodium hydroxide, 5 potassium hydroxide, lithium hydroxide, rubidium hydroxide, and cesium hydroxide, potassium carbonate, potassium hydrogen carbonate, and potassium sodium carbonate.

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