

## DESCRIPTION

### METHOD FOR DECOMPOSING HARMFUL SUBSTANCE AND APPARATUS FOR DECOMPOSING HARMFUL SUBSTANCE

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#### Technical Field

[0001] The present invention relates to a technique to trap harmful gases such as an odor and so forth and to make these harmful gases harmless and, more particularly, relates to the technique to carry out the above-described trapping of the harmful gases using a photocatalyst.

#### Background Art

[0002] When a photocatalyst represented by titanium oxide or the like is irradiated with light having an energy equal to or higher than a band gap that the photocatalyst has, positive holes and electrons are generated in an inner part of the photocatalyst. The positive holes and electrons thus generated are diffused over a surface of the photocatalyst to react on a substance adsorbed on the surface of the photocatalyst and on a substance present in the proximity of the surface of the photocatalyst. Many air purifying apparatuses utilizing such a quality of the photocatalyst as described above have been commercialized and many patent applications have been filed. It is noted that, from among various kinds of photocatalyst, titanium oxide photocatalyst has been utilized most due to its superiority in a power of oxidization and a chemical stability. This titanium oxide photocatalyst absorbs light having a wavelength equal to about 400 nm or shorter. Thus, a photocatalytic reaction as described above is progressed.

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[0003] Fig. 3 shows a plan view of an air purifying apparatus using both of ozone and the photocatalyst in combination. As shown in Fig. 3, this air purifying apparatus

includes a filter portion 31, an ozone generating portion 32, a photocatalyst device 33, and an activated carbon portion 34 in an order from an upstream portion of a passage of flow of air to a downstream portion of the passage of flow of air which is a fluid to be processed. Photocatalyst device 33 includes: a case member configured to form the air flow passage; a photocatalyst filter installed in an inside of the case member to support a photocatalyst function layer on a base substrate having a multiple number of vacancies; and ultra-violet ray irradiating means for performing an irradiation for the photocatalyst filter. Then, the photocatalyst filter is arranged for all quantities of the air to be processed to be caused to transmit through and to be caused to flow through the photocatalyst filter.

[0004] When the air introduced into the air purifying apparatus passes through the case member of photocatalyst device 33, the photocatalyst filter activated by the light irradiation of the ultraviolet ray irradiating means causes the contained harmful substances to be decomposed. This makes the air harmless and, thereafter, the air can be exhausted (For example, refer to a Patent Literature 1).

[0005] In addition, Fig. 4 shows a longitudinal cross sectional view of another air purifying apparatus in which a deodorizing filter using both of an adsorbent including at least one kind of activated carbon and zeolite and the photocatalyst in combination. As shown in Fig. 4, in the air purifying apparatus, a tubular deodorizing filter 41 including the photocatalyst is provided, and an excitation light source 42 is disposed in the proximity of deodorizing filter 41 and at the upstream portion of deodorizing filter 41, and deodorizing filter 41 is configured to be rotated in order for an irradiated position of filter 41 with a

light from excitation light source 42 to be varied. Thus, gases adsorbed over whole deodorizing filter 41 can be processed and decomposed. Hence, a regeneration rate of deodorizing filter 41 can be improved and it becomes possible  
5 for a superior performance at an initial stage to be continued for a long term (for example, refer to Patent Literature 2).

[0006] Patent Literature 1: a Japanese Patent Application First Publication (tokkai) No. 2002-272824.

10 [0007] Patent Literature 2: a Japanese Patent Application First Publication (tokkai) No. 2002-263175.

[0008] On the other hand, the photocatalytic reaction is progressed only on the surface of the photocatalyst or only in the proximity of the surface of the photocatalyst. Thus,  
15 in a case where an extremely lean concentration harmful gas at a ppm level or ppb level is decomposed and purified through the photocatalyst, a process in which the harmful gasses are diffused over the surface of the photocatalyst is easy to be a rate determining step of a decomposition  
20 purification reaction. Especially, in a case where one of the harmful gases whose adsorption characteristic onto the photocatalyst is small is an object for a decomposition purification, a decomposition purifying speed becomes remarkably slow.

25 [0009] In this respect, above-described Patent Literature 1 describes a combination use of both of ozone and photocatalyst in combination. However, an improvement in the purifying speed due to the combination use of ozone and photocatalyst is not necessarily made clear.

30 [0010] In addition, in the above-described Patent Literature 2, the photocatalyst and the adsorbent including at least one kind of activated carbon and zeolite are described. However, even if such an adsorbent as

described above is used, the harmful substances cannot be adsorbed after the adsorbent has reached to an adsorption saturation. Hence, the purifying action becomes low and a replacement of the adsorbent is required. This already  
5 used adsorbent becomes a general waste and an industrial waste and a problem is raised from a standpoint of an increase in waste.

#### **Disclosure of the Invention:**

[0011] It is, with the above-described problem solved,  
10 an object of the present invention to provide a decomposition technique for the harmful substances having a high harmful substance removal efficiency or the decomposition technique for the harmful substances which can reduce a quantity of waste.

15 [0012] Ordinarily, a concentration of an odor substance developed at a dwelling space is in an order from a ppb level to several ppm level. In a case where such a lean concentration gas as described above is decomposed, it is known that a decomposition speed of gas becomes larger in  
20 proportion to a gas concentration. In addition, in a case of a light intensity in several mW/cm<sup>2</sup> order emitted from a black-light or a cold cathode lamp for the photocatalyst purpose, the decomposition speed becomes higher as the light intensity becomes stronger. From these things, as the light  
25 intensity and the gas concentration become stronger and higher, it naturally follows that a harmful substance removal effect such as a deodorization effect becomes stronger. Hence, in the apparatus for decomposing the harmful substances such as deodorization apparatus  
30 constituted by members, on each of which the photocatalyst is supported such as ceramic filters and to which the photocatalyst is applied, and by the light source, the apparatus is arranged in order for gases including the

harmful substances such as odor gas to be streamed through one of surfaces of the members such as ceramic filters, on each of which the photocatalyst is supported and which is located at a light source side. Thus, the gases including the harmful substances such as odor gas and so forth are passed through and contacted with one of the surfaces of the members, on each of which the photocatalyst is supported, whose light intensity is the highest in a state where the gas concentration is the highest. Hence, it becomes possible to enhance a reaction efficiency.

[0013] Furthermore, all of lights with which the photocatalyst is irradiated are not adsorbed into the photocatalyst to contribute to the reaction but part of lights or majority of lights are reflected on a photocatalyst layer and leaks externally. The lights leaked externally cannot contribute to a deodorizing reaction. Hence, an energy is accordingly wastefully consumed. In order to reduce such a consumption as described above as low as possible, it is necessary to take a structure such that the light from the light source is difficult to be leaked externally. One of the methods, for example, includes a method in which the light source is interposed between two sheets of members such as ceramic filters, on each of which the photocatalyst is supported. In this way, since the light source is interposed between the members such as two sheets of ceramic filters, on each of which the photocatalyst is supported, the light reflected on one of the members, on each of which the photocatalyst is supported, such as one of ceramic filters becomes incident on the other of the members, on each of which the photocatalyst is supported, such as the other ceramic filter and the light can be utilized as a progress of a photocatalytic reaction on the photocatalyst coated on the surface on which the light is

reflected and becomes incident. Consequently, it becomes possible to enhance a light utilization efficiency.

[0014] Specifically, according to the decomposition method for the harmful substances which decomposes the harmful substances by means of the photocatalyst irradiated with the light from the light source installed in a region enclosed by these surfaces, these surfaces being arranged in order for light with which one surface of the members is irradiated to be reflected on the surface of the other members, the light irradiated surfaces of the members, on each of which the photocatalyst is supported, contributes to the photocatalytic reaction or, even if the light is reflected from one of the surfaces of the members, on each of which the photocatalyst is supported, on the surface of another of the members, on each of which the photocatalyst is supported, the surface of the other of the members is irradiated with the reflected light. Hence, the utilization efficiency of the light energy can be improved.

[0015] In addition, according to the decomposition method for the harmful substances by means of the photocatalyst by arranging the surfaces of the members, on each of which the photocatalyst is supported, opposite with one another, the light source installed between these surfaces performing an irradiation of light in order for the photocatalyst to decompose the harmful substances, the light irradiated surface of the members, on each of which the photocatalyst is supported, contributing to the photocatalytic reaction or, even if this light is reflected from the surface of the one member, the surface of the other member, on which the photocatalyst is supported, is irradiated with this light. Hence, the utilization efficiency of the light energy can be improved.

[0016] In addition, according to the decomposition method

for the harmful substances which decomposes the harmful substances by means of the photocatalyst by arranging the light source at an inner part of a tubular member, on which the photocatalyst is supported, a light irradiation is performed through the light source for the photocatalyst to decompose the harmful substances through the photocatalyst, the light with which the surface of the member on which the photocatalyst is supported contributes to the photocatalytic reaction or, even if this light is reflected, a surface of another member, on which the photocatalyst is supported is irradiated with this reflected light.

[0017] In addition, according to the decomposition method for the harmful substances in which the member on each of which the photocatalyst is supported or the tubular member is a filter like member, a porous member, or another member through which gases are enabled to be passed, the harmful substances can be decomposed and removed when the harmful substances are passed through the filter like member, the porous member, or the other member through which the gases are enabled to be passed. In a case where the porous member is used, a surface area of the porous member becomes large. Hence, a presence quantity of the photocatalyst becomes accordingly large. Thus, the decomposition removal efficiency is augmented. It is noted that any member through which the harmful substances are enabled to be passed can be applied even if the member is another than the filter like member or the porous member.

[0018] In addition, according to the decomposition method for the harmful substances in which the gases containing the harmful substances are introduced into the members, on each of which the photocatalyst is supported, or the tubular member to first pass through one surface of the members, on each of which the photocatalyst is

supported, or a surface of the tubular member whose light irradiation intensity is the highest, the harmful substances can efficiently be decomposed and removed.

[0019] In addition, according to the decomposition method for the harmful substances in which the members, on each of which the photocatalyst is supported, or the tubular member is ceramics, a performance recovery by means of a water cleaning for the members, on each of which the photocatalyst is supported, or the tubular member is possible and the waste quantity can be reduced.

[0020] In addition, an apparatus for decomposing the harmful substances according to each of the decomposition methods described above can be achieved.

[0021] In addition, the decomposition apparatus for the harmful substances, according to the decomposition apparatus in which a straightening vane is disposed on a flow passage of the gases within the harmful substance decomposition apparatus, can circulate the gases over the whole member, on which the photocatalyst is supported, even if the gas flow quantity is small and can improve the decomposition and removal efficiencies of the harmful substances due to a high contact efficiency between the harmful substances and the photocatalyst.

#### **Brief Description of the Drawings:**

[0022] [Fig.1] configuration views of a deodorizing apparatus.

[0023] [Fig.2] configuration views of another deodorizing apparatus.

[0024] [Fig.3] a plan view of an air purifying apparatus using both of ozone and a photocatalyst in combination.

[0025] [Fig. 4] a longitudinal cross sectional view of an air purifying apparatus using an adsorbent including at least one kind of activated carbon and the photocatalyst.

**Best Mode For Carrying Out the Invention:**

[0026] Preferred embodiments according to the present invention will hereinafter be described with reference to the drawings.

5 [0027] (First Embodiment)

Fig. 1 shows configuration views of a deodorizing apparatus used in a first preferred embodiment. In Fig. 1, (a) shows a cross sectional view of the deodorizing apparatus and (b) shows a side view of the deodorizing apparatus.

10 [0028] This deodorizing apparatus is arranged as follows: that is, with two sheets of ceramic filters, to each of which the photocatalyst is applied, and a light source to excite the photocatalytic reaction used in combination, the light source is interposed between the two sheets of ceramic filters to enable an efficient use of the light from the light source. Furthermore, after gases including odor gases are introduced between the two sheets of ceramic filters in order for the gases including odor gases to first pass through one of surfaces of the ceramic filters at which  
15 an intensity of the light irradiation is the highest.

[0029] Specifically, the deodorizing apparatus includes: an intake port 1 to introduce the air installed at a lower part of the deodorizing apparatus; a fan 2 installed at an upper part of intake port 1 to provide a driving force for gas introduction; a plurality of lamps 3 extended  
25 longitudinally in parallel to each other to be used for a light source; two sheets of ceramic filters 4, 5 installed to face against each other via these lamps 3; side chambers 6, 7 adjoined to ceramic filters 4, 5; side chambers 8, 9 connected to side chambers 6, 7 to introduce the gases into exhaust ports; and exhaust ports 10, 11 connected to side chambers 8, 9 to exhaust gases.

[0030] When, in this deodorizing apparatus, fan 2 is

driven, gases are introduced from intake port 1 to arrive at a center part of the deodorizing apparatus at which the lamps 3 are installed which are the light source. Then, the gases are passed through ceramic filters 4, 5 arranged at both sides of lamps 3. When the gases are passed through ceramic filters 4, 5, each of the photocatalysts, which are supported on the surfaces of ceramic filters 4, 5, which is irradiated with light is contacted with the gases so that odor component gases in the gases are decomposed. The gases which are passed through ceramic filters 4, 5 and in which the odor component gases are decomposed and removed are passed to side chambers 8, 9 via side chambers 6, 7 and exhausted from exhaust ports 10, 11.

[0031] In this way, by passing the gases from lamps 3 to ceramic filters 4, 5, the gases whose concentration of the odor component gases is in a highest state pass through a portion of the surfaces of ceramic filters 4, 5 on which the strongest light irradiation is carried out so that the harmful substances can be decomposed and removed efficiently. In addition, the light source is installed between the two sheets of ceramic filters in order for the light with which one of the ceramic filters is irradiated to be reflected from the one ceramic filter and to be incident on the other ceramic filter. The utilization efficiency of the light energy can be improved.

[0032] In addition, if lamps 3 which are the light source may perform a uniform light irradiation for ceramic filters 4, 5, neither lamps 3 may be installed longitudinally in parallel to each other nor may be plural but may be only one.

[0033] In addition, titanium oxide is most preferable for the photocatalyst applied to each of the ceramic filters. However, any substance having the photocatalyst function

such as zinc oxide, strontium titanate, barium titanate, compounds in which these photocatalysts are appropriately combined, or so forth may be used.

[0034] Furthermore, the ceramic filters are not limited  
5 to the two sheets. Any number of sheets of ceramic filters may be used if such a positional relationship that the irradiated light is reflected on the other ceramic filter is provided. Otherwise, lamps 3 which are the light source may be installed at an inner part of a hollow cylindrical  
10 or a tubular ceramic filter.

[0035] (Second Embodiment)  
Fig. 2 shows a configuration view of the deodorizing apparatus used in a second preferred embodiment. In Fig. 2, (a) shows a cross sectional view of the deodorizing  
15 apparatus and (b) shows a side view of the deodorizing apparatus.

[0036] In the deodorizing apparatus in the second embodiment, a plurality of straightening vanes 12 are attached onto side chambers 6, 7 of the deodorizing apparatus  
20 in the first embodiment to be vertical with respect to the gases moving in an upward direction.

[0037] The attachment of these straightening vanes 12 on side chambers 6, 7 causes a large circulation resistance of gases. Even if a gas flow quantity is small, the gases  
25 can be caused to flow uniformly over side chambers 6, 7. This action permits a uniform gas circulation over the whole part of ceramic filters 4, 5. Thus, the contact efficiency between the odor component gas and the photocatalyst becomes high and the deodorizing effect can be improved.

30 [0038] It is noted that straightening vanes 12 may not be vertical with respect to the gas moving in the upward direction if the above-described advantage can be obtained. In addition, a single sheet of straightening vane may be

attached for each of side chambers 6, 7.

CLAIMS

[1] A method for decomposing harmful substances, comprising:

5       arranging surfaces of members, on each of which a photocatalyst is supported, in order for light with which one of the surfaces is irradiated to be reflected on another surface; and performing a light irradiation of the photocatalyst through a light source installed in a region  
10       enclosed by these surfaces.

[2] A method for decomposing harmful substances, comprising:

      arranging surfaces of the members, on each of which  
15       a photocatalyst is supported, to be opposite with one another; and

      performing a light irradiation for the photocatalyst through a light source interposed between these surfaces to decompose the harmful substances.  
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[3] A method for decomposing harmful substances, comprising:

      installing the light source at an inner part of a tubular member, on which a photocatalyst is supported; and

25       performing a light irradiation for the photocatalyst through the light source to decompose the harmful substances through the photocatalyst.

[4] The method for decomposing harmful substances as  
30       claimed in any one of the preceding claims 1 through 3, wherein the members on each of which the photocatalyst is supported or the tubular member is a filter like member, a porous member or another member through which gases are

enabled to be passed.

[5]        The method for decomposing harmful substances as claimed in any one of the preceding claims 1 through 4, wherein the gases containing the harmful substances are introduced into the members on each of which the photocatalyst is supported or the tubular member to first pass through the surface of the members, on each of which the photocatalyst is supported, and whose intensity of light irradiation is the highest.

[6]        The method for decomposing harmful substances as claimed in any one of the preceding claims 1 through 5, wherein the members on each of which the photocatalyst is supported or the tubular member is ceramics.

[7]        An apparatus for decomposing harmful substances as claimed in any one of the preceding claims 1 through 5, wherein the harmful substances are decomposed according to the decomposing method as described in any one of the preceding claims 1 through 6.

[8]        The apparatus for decomposing harmful substances as claimed in claim 7, wherein a straightening vane is installed on a flow passage of gases within the decomposing apparatus for the harmful decomposing apparatus.