

DESCRIPTION

Title of Invention: SOLID CHEMICAL AGENT HOUSING BODY AND WATER
TREATMENT METHOD

Technical Field

[0001]

The present invention relates to a solid chemical housing body housing a water-soluble solid chemical. More specifically, the present invention relates to a solid chemical housing body which serves to continuously release its active substance into water to be treated, with the water-soluble solid chemical gradually dissolving by contact with the water to be treated, and a water treatment method for performing water treatment by using the solid chemical housing body.

Background Art

[0002]

As a technique for continuously releasing active substances into water to be treated, with a solid chemical having water solubility (hereinafter referred to as the water-soluble solid chemical) gradually dissolving, a technique is disclosed, in which a solid chemical dissolving apparatus includes an inner cylindrical body and an outer cylindrical body, and the rotation of the inner cylindrical body allows to change the degree of overlap of communication holes formed on both the inner cylindrical body and the outer cylindrical body, thereby adjusting the amount of the water to be treated flowing into the inner cylindrical body, and adjusting the dissolution rate of a water-soluble solid chemical filled in the inner cylindrical body (PTL 1).

Citation List

Patent Literature

[0003]

PTL 1: JP 3173540 Y

Summary of Invention

Technical Problem

[0004]

However, in order to adjust the dissolution rate of the water-soluble solid chemical by using the technique described in PTL 1, the amount of the water to be treated flowing into the inner cylindrical body needs to be adjusted by manually rotating the inner cylindrical body according to variations in flow rate or flow velocity and the like of the water to be treated, in every time. Thus, its management is laborious.

[0005]

To solve the above problems, it is an object of the present invention to provide a solid chemical housing body that enables continuous release of an active substance in a water-soluble solid chemical for a long period of time, and also convenient adjustment of the dissolution rate of the water-soluble solid chemical.

Solution to Problem

[0006]

The present inventors found that vertically stacking a water-soluble solid chemical inside a housing container via a water-soluble film enables convenient adjustment of the dissolution rate of the water-soluble solid chemical and continuous release of an active substance in the water-soluble solid chemical for a long period of time.

[0007]

The present invention is achieved based on the above findings and provides the following [1] to [14].

[1] A solid chemical housing body filled with a water-soluble solid chemical inside a housing container,

wherein the housing container comprises a housing space capable of housing a plurality of the water-soluble solid chemicals, an inlet for allowing water to be treated to flow into the housing space, and an outlet for allowing the water to be treated to flow out from the housing space;

some or all of the water-soluble solid chemicals are vertically stacked in the housing space via a water-soluble film; and

at least some of the water-soluble films are disposed upward from the inlet and the outlet.

- [2] The solid chemical housing body according to [1], wherein the housing container comprises an approximately cylindrical container body.
- [3] The solid chemical housing body according to [2], comprising an approximately cylindrical partition wall inside the container body, and an inner space of the partition wall as the housing space.
- [4] The solid chemical housing body according to [3], wherein the container body is formed by fitting an upper member and a lower member.
- [5] The solid chemical housing body according to any of [1] to [4], wherein the water-soluble film is a packing material packing the water-soluble solid chemical.
- [6] The solid chemical housing body according to any of [1] to [5], wherein the water-soluble film is obtained by making a film from a raw material containing a polyvinyl alcohol-based resin.
- [7] The solid chemical housing body according to any of [1] to [6], wherein the water-soluble film has a dissolution time in water at 23°C of 8 seconds or more and 99 seconds or less.
- [8] A water treatment method for performing water treatment by using a solid chemical housing body,
wherein the solid chemical housing body comprises a housing space capable of housing a plurality of the water-soluble solid chemicals, an inlet for allowing water to be treated to flow into the housing space, and an outlet for allowing the water to be treated to flow out from the housing space and is filled with the water-soluble solid chemical in the housing space; and
some or all of the plurality of the water-soluble solid chemicals are vertically stacked via a water-soluble film and at least some of the water-soluble films are disposed upward from the inlet and the outlet.
- [9] The water treatment method according to [8], wherein the water-soluble film disposed upward from the inlet and the outlet are partly dissolved during the dissolution of the water-soluble solid chemical disposed downward from the inlet and the outlet; and a remaining part of the water-soluble film partly dissolved prevents the contact of the water-soluble solid chemical disposed on the remaining part with the water to be treated.
- [10] The water treatment method according to [9], wherein the remaining part blocks a horizontal cross section of the housing space.
- [11] The water treatment method according to any of [8] to [10], wherein a water-soluble solid chemical containing a halogen-based oxidant as an active

substance and a water-soluble solid chemical containing an organic oxidizing agent as an active substance are housed in an individual solid chemical housing body to perform water treatment.

[12] The water treatment method according to [11], wherein a content of the halogen-based oxidant in the water-soluble solid chemical containing the halogen-based oxidant as an active substance is 10% by mass or more in terms of effective chlorine (Cl_2) regarding all effective halogen component as effective chlorine.

[13] The water treatment method according to [11], wherein a content of an organic bactericide in the water-soluble solid chemical containing the organic oxidizing agent as an active substance is 1 to 40% by mass.

[14] The water treatment method according to any of [8] to [13], wherein the water-soluble solid chemical comprises an excipient and a binder.

Advantageous Effects of Invention

[0008]

In the solid chemical housing body of the present invention, among a plurality of the water-soluble solid chemicals housed in the housing container, the agent not exposed to the water to be treated flowing through a flow path formed between the inlet and the outlet in the housing container is disposed on the water-soluble film upward from the agent which is exposed to the water to be treated flowing through the flow path and starts to dissolving. This agent disposed on the water-soluble film is, even when the agent directly under this agent starts to dissolving, prevented from contacting with the water to be treated and the wetting is reduced due to the presence of the water-soluble film. This enables the reduction of the moisture content of the water-soluble solid chemical and the increase of the residual rate of the active substance in the agent, as compared with the configuration under the same conditions except for the presence of the water-soluble film.

Therefore, the present invention enables continuous release of the active substance in the water-soluble solid chemical for a long period of time, and also convenient adjustment of the dissolution rate of the water-soluble solid chemical.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a schematic perspective view of a housing container according to one embodiment of a solid chemical housing body.

[Fig. 2] Fig. 2 is a vertical sectional view of the solid chemical housing body shown in Fig. 1.

[Fig. 3] Fig. 3 is a vertical sectional view of the solid chemical housing body for describing the first embodiment of the method for using the solid chemical housing body.

[Fig. 4] Fig. 4 is a schematic view of the method for using the solid chemical housing body.

[Fig. 5] Fig. 5 is a vertical sectional view of the solid chemical housing body for describing the second embodiment of the method for using the solid chemical housing body.

Description of Embodiments

[0010]

Hereinafter, the present invention will be described in detail.

A solid chemical housing body of the present invention is a solid chemical housing body filled with a water-soluble solid chemical inside a housing container, wherein the housing container has a housing space capable of housing a plurality of the water-soluble solid chemicals, an inlet for allowing water to be treated to flow into the housing space, and an outlet for allowing the water to be treated to flow out from the housing space; some or all of the water-soluble solid chemicals are vertically stacked in the housing space via a water-soluble film; and at least some of the water-soluble films are disposed upward from the inlet and the outlet.

Using the water-soluble solid chemical housed in the solid chemical housing body in this configuration enables continuous release of an active substance in the water-soluble solid chemical for a long period of time, and also convenient adjustment of the dissolution rate of the water-soluble solid chemical.

According to the present embodiment, the solid chemical housing body filled with the water-soluble solid chemical used for water treatment of a cooling water in a cooling tower will be described.

[0011]

[Housing container]

The housing container has an inlet allowing the water to be treated to flow into the container and an outlet allowing the water to be treated flowed into the

container to flow out from the container, at the lower part of the container. For example, the housing container has a cylindrical part, an upper surface and a lower surface which seal both ends of the cylindrical part, an inlet provided on the cylindrical part and/or the lower surface, and an outlet provided on the cylindrical part and/or the lower surface. The inlet may serve as the outlet.
[0012]

As shown in Fig. 1, for example, a housing container 10 having an approximately cylindrical container body 11 can be used. As shown in Fig. 2, a partition wall 12 is provided inside the container body 11. The inside of the container body 11 is partitioned by the partition wall 12 into a housing space 13 housing a water-soluble solid chemical S1 and a non-housing space 14 not housing a water-soluble solid chemical. The partition wall 12 has an opening at the lower part.

[0013]

(Container body 11)

The container body 11 consists of an upper member 11a and a lower member 11b.

The upper member 11a and the lower member 11b are fitted to form the container body 11.

The structure of the container body, which is dividable and can be easily integrated, enables easy operations involving new housing and additional supplying of the water-soluble solid chemical into the housing space.

The shape and size of the container body are not particularly limited as long as the container body can house the water-soluble solid chemical. The shape and size of the container body can be appropriately determined from the viewpoint of the size of the cooling tower, portability of the container, easy handling, and the like.

The shape of the container body may be any shape such as a cylindrical body whose cross-section surface has a circular shape, elliptical shape, and polygonal shape, or a shape whose whole outer surface is rounded.

From the viewpoint of easy handling of the container body, the container body preferably has such a size that can be lifted by one hand.

[0014]

The top of the upper member 11a, near the bottom of the side peripheral part of the lower member 11b, and the bottom of the lower member 11b have container communication paths 15a, 15b, and 15c.

Through these container communication paths 15a, 15b, and 15c, cooling water flows between the outside of the container body 11 and the non-housing space 14.

The shape, size, position, and number of the container communication paths 15a, 15b, and 15c are not particularly limited, as long as the cooling water can flow, and are appropriately determined according to the desired flow rate of the cooling water. The shape of the container communication paths 15a, 15b, and 15c includes a round hole shape, square hole shape, slit-like shape, and mesh shape. The container communication path 15a is disposed upward from the non-housing space 14, and this container communication path 15a communicates the non-housing space 14 with the outside of the housing container 10.

[0015]

(Partition wall 12)

The partition wall 12 has a cylindrical shape and is vertically provided from the top inner wall of the upper member 11a. In the container body 11 formed by fitting the upper member 11a and the lower member 11b, the inner space of the partition wall 12 is the housing space 13 and the outer space of the partition wall 12 is the non-housing space 14.

[0016]

The shape, size, and position of the partition wall 12 are determined, so that the operations such as new housing and additional supplying of the water-soluble solid chemical into the housing space may become easy.

Specifically, the shape, size, and position of the partition wall 12 is determined, so that the inner housing space 13 of the partition wall 12 may have a size, adding a room (play) to the size of the water-soluble solid chemical S1.

[0017]

The partition wall 12 is disposed so as not to contact with the bottom surface of the lower member 11b. A gap between a lower end of the partition wall 12 and the bottom surface of the lower member 11b facing the partition wall 12 is a partition wall communication path 16.

The cooling water flows between the housing space 13 and the non-housing space 14 through this partition wall communication path 16.

According to the present embodiment, this partition wall communication path 16 serves as the "inlet" and the "outlet" and the container communication paths 15b and 15c serve as the "outlet".

[0018]

The shape, size, position, and number of the partition wall communication path 16 are not particularly limited, as long as the cooling water can flow, and are appropriately determined according to the desired flow rate of the cooling water. The shape includes a round hole shape, square hole shape, slit-like shape, and mesh shape. When the partition wall has a cylindrical shape, the partition wall communication path may be formed in a manner that the lower end of the partition wall is in contact with the bottom surface of the container body facing the partition wall and a gap is provided on at least a part between the partition wall and the bottom surface of the container body.

From the viewpoint of ensuring the flow of the cooling water between the housing space and the non-housing space, even when the water level of the cooling water flowing into the non-housing space is low, at least one of the partition wall communication path preferably extends to the bottom surface of the container body.

[0019]

The housing container 10 of the present embodiment is made of translucent polypropylene.

From the viewpoint of allowing convenient visual observation of the state of the water-soluble solid chemical inside the container, from the outside of the container, the container body and the partition wall preferably have transparency. In order to use in a cooling tower, the container is preferably made of plastics, from the viewpoint of easy handling and water resistance.

[0020]

[Water-soluble solid chemical]

Examples of the water-soluble solid chemical is not particularly limited and include, for example, a solid chemical that is a water treatment agent for sewage, as well as the water treatment agent for the cooling water in the cooling tower.

[0021]

Examples of the water-soluble solid chemical used as the water treatment agent for the cooling water in the cooling tower is not particularly limited and

include a halogen-based oxidant and an organic agent. When the halogen-based oxidant and the organic agent are used in combination, and in addition, an organic bactericide is reactive with the halogen-based oxidant, a solid chemical (A) containing a halogen-based oxidant as an active substance and a solid chemical (B) containing an organic oxidizing agent as an active substance are preferably housed in an individual housing container, from the viewpoint of preventing both agents from reacting promptly.

(Solid chemical (A))

The solid chemical (A) containing a halogen-based oxidant as an active substance provides sterilizing effect and slime inhibiting effect in the water treatment agent. Examples of the halogen-based oxidant include a halogenated hydantoin-based compound and an isocyanuric acid-based compound.

[0022]

The halogenated hydantoin-based compound is an organic halogen-based oxidant in a solid state and releases active halogen that has a strong oxidation power in contact with water.

From the viewpoint of the solubility in water, the halogenated hydantoin-based compound is suitable for continuously releasing active halogen for a long time. Examples of the halogen-based oxidant commercially available as an extended-release tablet include not only the halogenated hydantoin-based compound but also halogen-based oxidants that contains calcium hypochlorite, sodium chlorite, dichloroisocyanuric acid, trichloroisocyanuric acid, and the like as an active substance. The present inventors found that the solid chemical containing a halogenated hydantoin-based compound as the active substance has relatively low elution rate, among these halogen-based oxidants. According to the findings, from the viewpoint of sustaining excellent effects of agents by using a solid chemical containing organic bactericide in combination, the halogenated hydantoin-based compound is considered to be most suitable. Additionally, the halogenated hydantoin-based compound generates relatively low odor in contact with water, and thus preferably from the viewpoint of the safety in handling.

[0023]

Specific examples of the halogenated hydantoin-based compound include 1-bromo-3-chloro-5,5-dimethylhydantoin (hereinafter referred to as BCDMH), 1,3-dichloro-5,5-dimethylhydantoin, 1,3-dibromo-5,5-dimethylhydantoin, 1-bromo-3-chloro-5,5-diethylhydantoin, 1,3-dichloro-5,5-diethylhydantoin, and 1-bromo-3-

chloro-5-methyl-5-ethylhydantoin. These may be used singly or in combination of two or more. Among them, from the viewpoint of the balance between the elution rate in contact with water and the solid chemical (B) and easy availability, BCDMH and 1,3-dichloro-5,5-dimethylhydantoin are preferable.

[0024]

The form of the halogen-based oxidant as described above is preferably a tablet. The production method of the tablet is not particularly limited and the tablet can be produced by a known method. Typically, the tablet is produced by pressure forming using an additive such as an excipient or a binder. The elution rate of the tablet into the water to be treated can be modulated by adjusting the type and the addition amount of the excipient and the binder.

For the tablet, a commercial product can be used.

[0025]

From the viewpoint of allowing the halogen-based oxidant to elute in an appropriate elution rate, the content of the halogen-based oxidant in the solid chemical (A) is preferably 10% by mass or more, more preferably 30 to 90% by mass, and further preferably 40 to 70% by mass in terms of effective chlorine (Cl₂), regarding all effective halogen component as effective chlorine.

From the viewpoint of bactericidal action against Legionella bacteria, effective halogen (in terms of Cl₂) concentration in the water to be treated by the solid chemical (A) is preferably 0.1 mg/L or more, more preferably 0.1 to 5 mg/L, and further preferably 0.1 to 2 mg/L.

[0026]

(Solid chemical (B))

By using the solid chemical (B) containing an organic bactericide that has reactivity with the halogen-based oxidant, with the solid chemical (A) in combination, a synergetic effect of the bactericidal action can be obtained.

The organic bactericide has reactivity with the halogen-based oxidant. The organic bactericide reacts with the halogen-based oxidant to generate toxic halogen-based substances such as a chlorine gas, which makes it difficult to mix with the halogen-based oxidant to make one-part agent. Thus, the organic bactericide needs to be formulated into a separate agent from the halogen-based oxidant. Therefore, the solid chemical (B) which is formulated separated from the solid chemical (A), is used in the present embodiments.

[0027]

From the viewpoint of bactericidal efficacy in combination with the halogen-based oxidant, the active substance in the organic bactericide preferably includes an isothiazoline-based compound.

Specific examples of the isothiazoline-based compound include, 5-chloro-2-methyl-4-isothiazoline-3-one (hereinafter referred to as Cl-MIT), 2-methyl-4-isothiazolin-3-one, 4,5-dichloro-2-methyl-4-isothiazolin-3-one, 2-ethyl-4-isothiazolin-3-one, 2-n-octyl-4-isothiazolin-3-one, 5-chloro-2-ethyl-4-isothiazolin-3-one, 5-chloro-2-t-octyl-4-isothiazolin-3-one, 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one, 4,5-dichloro-2-cyclohexyl-4-isothiazolin-3-one, and 1,2-benzoisothiazoline-3-one. These may be used singly or in combination of two or more. Among them, Cl-MIT is preferable from the viewpoint of solubility in water, bactericidal efficacy, and easy availability. In particular, a combination of the solid chemical (A) of the halogen-based oxidant containing BCDMH as the active substance and the solid chemical (B) of the organic bactericide containing Cl-MIT as the active substance, from the viewpoint of bactericidal action against Legionella bacteria is preferable.

[0028]

From the viewpoint of obtaining excellent bactericidal action, the elution amount of the organic bactericide as the active substance in the solid chemical (B) is determined as follows. When the active substance is, for example, Cl-MIT and the active substance of the halogen-based oxidant in the solid chemical (A) is BCDMH, the concentration of Cl-MIT in the water to be treated (unit: mg/L) relative to the concentration of effective halogen of BCDMH (in terms of Cl₂) in the water to be treated (unit: mg/L) is preferably 0.00001 to 100 times, more preferably 0.01 to 30 times, and further preferably 0.1 to 1 times. The concentration of Cl-MIT in the water to be treated is preferably 0.0001 to 5 mg/L, more preferably 0.001 to 3 mg/L, and further preferably 0.001 to 2 mg/L.

[0029]

The solid chemical (B) may contain not only the organic bactericide, but also other known compounds which are used from the viewpoint of corrosion proof and scale prevention in the water treatment agent. Examples include a triazole-based compound, a phosphonic acid-based compound, a sulfamic acid-based compound, ametryn, 2,2-dibromo-3-nitrilopropionamide, bronopol, 2,2-dibromo-2-nitroethanol, zinc pyrithione, thiabendazole, and a flocculant from acrylic acid-based and maleic acid-based low molecular weight polymers. These

may be used singly or two or more. However, the addition amount of these compounds is within a range of not impairing the bactericidal action by the solid chemicals (A) and (B).

[0030]

The form of the solid chemical (B) is not particularly limited, similar to the form of the solid chemical (A), but from the viewpoint of easy adjustability of the amount used and easy handling, a tablet such as pellet state and tablet state, or granulated state are preferable, and from the viewpoint of workability upon housing in the container, a tablet is more preferable. The production method of the tablet is not particularly limited and the tablet can be produced by a known method. Typically, the tablet is produced by pressure forming using an additive such as an excipient or a binder. The elution rate of the tablet into the water to be treated can be modulated by adjusting the type and the addition amount of the excipient and the binder. For these additives, for example, magnesium stearate, silica, magnesium oxide and the like can be used.

For the solid chemical (B) containing the organic bactericide as an active substance, a commercial product can be used.

[0031]

For the solid chemical (B), from the viewpoint of allowing the organic bactericide to have an appropriate elution rate, the content of the organic bactericide is preferably 1 to 40% by mass, more preferably 2 to 35% by mass, and further preferably 5 to 30% by mass.

[0032]

The form of the water-soluble solid chemical is not particularly limited and from the viewpoint of easy adjustability of the amount used and easy handling, a tablet such as pellet state and tablet state, or granulated state are preferable, and from the viewpoint of workability upon housing in the container, a tablet is more preferable. The production method of the tablet is not particularly limited and the tablet can be produced by a known method. Typically, the tablet is produced by pressure forming using an additive such as an excipient or a binder. The elution rate of the tablet into the water to be treated can be modulated by adjusting the type and the addition amount of the excipient and the binder.

[0033]

[Water-soluble film]

Examples of the water-soluble film include films derived from synthetic resins and natural products, such as polyvinyl alcohol (hereinafter, PVA), polyethylene oxide, polyvinyl ether, polyvinyl pyrrolidone, pullulan, and a cellulose derivative. According to the type of the water-soluble solid chemical, an optimal one among them can be appropriately used.

[0034]

When the water-soluble solid chemical is the water treatment agent, for example, a PVA-based film is preferably used.

PVA-based film is obtained by making a film from a raw material containing a polyvinyl alcohol-based resin (hereinafter referred to as the "PVA-based resin").

[0035]

For the PVA-based resin, a resin obtained by saponifying a vinyl ester-based polymer that can be obtained by polymerizing a vinyl ester-based compound can be used. According to the present embodiment, the PVA-based resin can be used not only singly but also in combination of two or more.

[0036]

One or two or more of the vinyl ester-based compounds, such as vinyl acetate, vinyl formate, vinyl trifluoroacetate, vinyl propionate, vinyl butyrate, vinyl caprate, vinyl laurate, vinyl versate, vinyl palmitate, and vinyl stearate can be used.

[0037]

The water-soluble film used in the present invention preferably has a complete dissolution time in water at 23°C (the time required to dissolve 95% or more of a film having a thickness of 50 μm) of 8 seconds or more and 99 seconds or less, more preferably of 12 seconds or more and 99 seconds or less, further preferably of 57 seconds or more and 99 seconds or less.

With the complete dissolution time in the above range, the active substance of the water-soluble solid chemical can be continuously released for a long period of time.

Here, the complete dissolution time in water at 23°C refers to a measurement value of the time required to completely dissolve a film, according to the method described in Example below as [Water solubility evaluation of film]. When using a film having a thickness other than 50 μm , the value is converted into the film having a thickness of 50 μm according to the following expression (1).

Conversion dissolution time (seconds) = $[50/\text{thickness of film } (\mu\text{m})]^2 \times$
sample dissolution time (seconds) expression (1)

[0038]

The water-soluble film used in the present invention preferably has a disintegration time in water at 23°C (the time required to break a film having a thickness of 50 μm) of 40 seconds or less, and more preferably of 30 seconds or less.

With the disintegration time in the above range, the active substance of the water-soluble solid chemical can be continuously released for a long period of time.

Herein, the disintegration time in water at 23°C refers to a measurement value of the time required to break a film, according to the method described in Example below as [Water solubility evaluation of film]. When using a film having a thickness other than 50 μm , the value is converted into the film having a thickness of 50 μm according to the following expression (2).

Conversion disintegration time (seconds) = $[50/\text{thickness of film } (\mu\text{m})]^2 \times$
sample disintegration time (seconds) expression (2)

[0039]

[Water treatment method]

By using the above solid chemical housing body, an embodiment for performing water treatment of the cooling water in a cooling tower will be described. In the following embodiment, the partition wall communication path 16 of the housing container serves as the "inlet", and the partition wall communication path 16 and the container communication paths 15b and 15c serve the "outlet".

<First embodiment>

Based on Fig. 3 and Fig. 4, the first embodiment will be described. Arrows in Fig. 3 indicates the flow direction of the cooling water.

[0040]

As shown in Fig. 4(a), the water-soluble solid chemicals S1 to S3 packed with a water-soluble film 17 are housed in the housing space 13. In the first embodiment, the housing container 10 housing the water-soluble solid chemicals S1 to S3 in the housing space 13 is disposed in a cooling tower, so that the dropping cooling water can hit the top outer wall of the housing container 10.

When a sound absorbing mat is disposed in a counterflow (round type) cooling tower, the container is preferably mounted thereon. Otherwise, the container may be mounted on a spray plate, and the like. The container can also be disposed in a cooling tower by using a supporting member such as a suspension cord, a stage, and the like.

Regarding a crossflow (square type) cooling tower, a mount of the housing container 10 may be provided in the cooling tower, for example, in proximity to a louver of the side peripheral part of the cooling tower, and the housing container 10 may be disposed on the mount. In these aspects, for example, a channel and the like are preferably provided so as to lead the cooling water from the filler of the cooling tower to the top of the housing container 10.

[0041]

As shown in Fig. 3, the cooling water flows through the container communication path 15a into the non-housing space 14 and flows from the non-housing space 14 through the partition wall flow pass 16 into the housing space 13.

The cooling water flowing into the housing space 13 firstly allows to elute the water-soluble film 17 that packs the water-soluble solid chemical S1 placed at the lowest part in the housing space 13, and then allows to elute the water-soluble solid chemical S1. The cooling water in which the water-soluble solid chemical S1 is eluted (eluent) flows out through the container communication paths 15b and 15c to the outside of the housing container 10. With such a flow of the cooling water, the water treatment of the cooling water in a cooling tower is performed by using the water-soluble solid chemical.

According to the size of the non-housing space or the inlet velocity and the outlet velocity of the cooling water, the amount of the cooling water retained in the non-housing space varies, and the larger the retention amount is, the more the elution rate of the water-soluble solid chemical can be inhibited.

[0042]

When the water-soluble solid chemical S1 is eluted, the water-soluble film 17 that packs the water-soluble solid chemical S2 disposed directly on the water-soluble solid chemical S1 starts to elute from its lower part. In the above process, a state like a membrane over the horizontal cross section in the housing space 13, as shown in Fig 4(b), that is, a state in which a gap between the water-soluble solid chemical S2 and the housing space 13 is blocked by the water-

soluble film 17 is formed. In this state, water vapor generated by the evaporation of the cooling water that flowed into the housing space remains downward of the membrane, which enables to inhibit the phenomenon in which the water-soluble solid chemical S3 disposed upward from the membrane is wetted by water vapor.

The wetting of the water-soluble solid chemical is considered to be also caused by capillary action of the water-soluble solid chemical itself. According to the present embodiment, the water-soluble film 17 remaining between the water-soluble solid chemicals S1 and S2, and the water-soluble film 17 between the water-soluble solid chemicals S2 and S3 prevent drawing up of the cooling water by capillary action of the water-soluble solid chemical, which enables to inhibit the wetting by capillary action of the water-soluble solid chemical.

The inhibition of the wetting of the water-soluble solid chemical can reduce the moisture content of the water-soluble solid chemical and increase the residual rate of the active substance of the water-soluble solid chemical.

[0043]

<Second embodiment>

Based on Fig. 4 and Fig. 5, the second embodiment of the water treatment method of the present invention for performing water treatment of the cooling water in a cooling tower by using the solid chemical housing body according to one embodiment of the present invention will be described. Arrows in Fig. 5 indicates the flow direction of the cooling water.

[0044]

As shown in Fig. 4(a), water-soluble solid chemicals S1 to S3 packed with a water-soluble film 17 are housed in the housing space 13. In the second embodiment, the housing container 10 housing the water-soluble solid chemicals S1 to S3 in the housing space 13 is allowed to float on a water surface of the cooling water in a cooling water pit in a cooling tower, so as to expose at least the top outer wall of the housing container 10 on a water surface. The cooling water pit may be an upper pit, in which sprayed cooling water is stored, or a lower pit.

In the present embodiment, the container needs to be a material or a form that can float on the water surface. When the container alone is difficult to float, the use of a container set combined with a frame serving as a "float" enables the container to float.

To prevent the container from floating in a wide range, the container may be anchored or a fence to fix the floating area, or the like may be provided.

[0045]

As shown in Fig. 5, the cooling water is flowed through the container communication paths 15b and 15c into the non-housing space 14 and is flowed from the non-housing space 14 through the partition wall flow pass 16 into the housing space 13. The water-soluble solid chemical S1 in the housing space 13 is eluted when in contact with the cooling water flowed thereinto.

The cooling water flowing into the housing space 13 firstly allows to elute the water-soluble film 17 that packs the water-soluble solid chemical S1 placed at the lowest part in the housing space 13, and then allows to elute the water-soluble solid chemical S1. The cooling water in which the water-soluble solid chemical S1 is eluted (eluent) flows out through the container communication paths 15b and 15c to the outside of the housing container 10. With such a flow of the cooling water, the water treatment of the cooling water in a cooling tower is performed by using the water-soluble solid chemical.

In the present embodiment, the container communication path 15a plays a role as a vent. However, when the dropping cooling water hit the top outer wall of the housing container 10, the cooling water may flow from the container communication path 15a into the non-housing space 14.

In the present embodiment, as in the <first embodiment>, the inhibition of the wetting of the water-soluble solid chemical S3 can reduce the moisture content of the water-soluble solid chemical and increase the residual rate of the active substance of the water-soluble solid chemical.

[0046]

<Other embodiments>

According to the above embodiment, the tablets of the water-soluble solid chemical are packed one by one with the water-soluble film 17, but a plurality of tablets may be collectively packed with the water-soluble film.

Alternatively, the water-soluble solid chemical and the water-soluble film may be disposed alternately from the bottom in the housing space 13 to make a stacked structure of the water-soluble solid chemical and the water-soluble film. In this case, the layer consists of the water-soluble solid chemical may be one layer or two or more layers, and the layer consists of the water-soluble film may also be one layer or two or more layers. The layer consists of the water-soluble

solid chemical may be formed by one tablet of the water-soluble solid chemical, or may be formed by two or more tablets of the water-soluble solid chemicals.

Alternatively, granulated water-soluble solid chemicals may be spread in the container, and then the water-soluble film may be covered thereon, and further granulated water-soluble solid chemicals may be spread thereon. A set consists of the granulated water-soluble solid chemicals and a water-soluble film may be stacked more than one set.

In each embodiment, the water-soluble film preferably has a larger size than the size of the horizontal cross section of the housing space 13. This makes the rim of the water-soluble film contact with the inner peripheral surface of the housing space 13 and can provide a function of inhibiting moisture from infiltrating upwards from a gap between the rim of the water-soluble film and the inner peripheral surface of the housing space 13.

Examples

[0047]

Hereinafter, the present invention will be specifically described by Examples, but the present invention is not particularly limited by the following Examples.

[0048]

[Water solubility evaluation of film]

The dissolution time of respective commercially available water-soluble films was measured under the following conditions.

<Apparatus>

- 1L Beaker
- 35 mm Slide mount (manufactured by FUJIFILM Imaging Systems Co., Ltd.), the size of the window is 35 mm wide × 24 mm
- Magnetic stirrer
- Stir bar (length: 40 mm × ϕ 8 mm)

<Sample>

- Respective films commercially available as water-soluble films [PVA film (Table 1), water-soluble paper (Table 2), oblate (Table 3)]

<Test conditions>

- Water temperature: 23°C
- Rotational speed of stir bar: 500 rpm

- Film size in contact with water: 35 mm × 24 mm
- Gap between slide mount and beaker inner wall: 1 mm
- Upper end of window of slide mount: 700 mL line of beaker

<Procedure>

1. A film was cut to a size of 45 mm × 45 mm and fixed to the slide mount by pinching.
2. In a 1L beaker, 800 mL of pure water at 23°C was provided.
3. The beaker was set on the stirrer with a stir bar and stirred at 500 rpm.
4. The slide mount pinching a film was fixed with a clip and placed in the beaker orthogonally to the flow direction.
5. The time until the film was broken and the time until most of the film in the frame (95%) was dissolved were measured. The former was defined as the "disintegration time", the latter was defined as the "complete dissolution time".

Table 1 Solubility of PVA film

Film name (manufacturer)	Disintegration time [seconds]	Complete dissolution time [seconds]
XR V (SEKISUI CHEMICAL CO.,LTD.)	25	92
dry XR V (SEKISUI CHEMICAL CO.,LTD.)	28	99
VF-HP 220 (KURARAY CO., LTD.)	7	16
VF-HP 270 (KURARAY CO., LTD.)	5	12
VF-HH 220 (KURARAY CO., LTD.)	8	17
VF-H123 (KURARAY CO., LTD.)	35	57
M8900 (KURARAY CO., LTD.)	4	8
M8630 (KURARAY CO., LTD.)	5	9
M7031 (KURARAY CO., LTD.)	8	18
SOLUBLON PT #400 (AICELLO CORPORATION)	9	19
Hi-Selon C-200 (30 μm)(The Nippon Synthetic Chemical Industry Co.,Ltd.)	6	14

In the above Table 1, "dry XR V" refers to a material made by drying the XR V in a thermostat at 60°C for 1 day (24 hours).

[0050]

Table 2 Solubility of water-soluble paper-based film

Film name (manufacturer)	Disintegration time [seconds]	Complete dissolution time [seconds]
A3015 (NIPPON PAPER PAPHYIA CO.,LTD.)	4	13

[0051]

Table 3 Solubility of starch-based film

Film name (manufacturer)	Disintegration time [seconds]	Complete dissolution time [seconds]
Oblate (Takikawa Oblate Company, Limited.)	3	not completely dissolved after 30 minutes

[0052]

As the water-soluble film used in the present invention, an optimal one may appropriately be selected according to the type and use of the water-soluble solid chemical. In the above method, the complete dissolution time is preferably 8 seconds or more and 99 seconds or less.

A starch-based water-soluble film is not completely dissolved after the elapse of 30 minutes. When used in the present invention, this film is presumed to attach the surface of the water-soluble solid chemical and to facilitate the dissolution, and therefore is not preferable.

[0053]

[Evaluation test on moisture content of water-soluble solid chemical and residual rate of active substance]

<Solid chemical housing body>

The following sample was housed in the solid chemical housing body shown in Fig. 5.

The following was used as the water-soluble solid chemical.

The water-soluble solid chemical: a water-soluble solid chemical containing 7% by mass of total phosphoric acid and 7% by mass of Cl-MIT

<Sample>

Comparative Example 1 4 tablets of the water-soluble solid chemical (no film)

Example 1 4 tablets of the water-soluble solid chemical (tablets are packed one by one with a poval film "VF-HP220" (thickness: 40 μ m) manufactured by KURARAY CO., LTD.)

Example 2 4 tablets of the water-soluble solid chemical (tablets are packed one by one with a PVA film "ADVASOL XRV" ("XRV" in Table 1) (thickness: 50 μ m) manufactured by SEKISUI CHEMICAL CO.,LTD.)

<Procedure>

1. The sample was housed in a cylindrical housing container.
2. The housing container housing the sample was set in a round type showering cooling tower.
3. The sample was taken out after 1 week and the residual rate of the component was examined from insoluble residue.

[0054]

<Measurement method for moisture content>

The moisture content of the water-soluble solid chemical was measured according to the following procedure.

The sample taken out from the cooling tower was placed in a thermostat at 40°C and dried until no mass change was observed. The moisture content was calculated from the loss of weight before and after drying.

[0055]

<Measurement method for residual rate of total phosphoric acid>

The residual rate of total phosphoric acid in the water-soluble solid chemical was measured according to the following procedure.

Dry solid chemical was dissolved in pure water to be 1 g/L, subjected to thermolysis, and then measured by molybdenum blue absorption photometry using Ratio Beam Spectrophotometer U-5100 (Hitachi High-Technologies Corporation).

<Measurement method for Cl-MIT>

The residual rate of Cl-MIT in the water-soluble solid chemical was measured according to the following procedure.

Dry solid chemical was dissolved in pure water to be 1 g/L and measured by using high-performance liquid chromatography Agilent 1260 (Agilent Technologies Japan, Ltd.).

[0056]

<Result and consideration>

The results of the moisture content of the total tablets remaining after 1 week are shown below.

Comparative Example 1: 66.2%

Example 1: 45.4%

Example 2: 34.1%

As shown above, the results demonstrated that the use of the water-soluble film largely decrease the moisture content of the water-soluble solid chemical.

When focused on the top water-soluble solid chemical in particular, considerable wetting was demonstrated in Comparative Example 1, but in Example 2, the moisture content was 5.45% and the wetting was decreased. This is because the water-soluble film blocked the gap between the water-soluble solid chemical and the housing space and reduced the influence of the water vapor. The comparison between Example 1 and Example 2 demonstrated that the film of Example 2 was more suitable for blocking the gap between the water-soluble solid chemical and the housing space.

[0057]

The residual rates of total phosphoric acid in all 4 tablets of the water-soluble solid chemical after 1 week are shown below.

Comparative Example 1: 0.5%

Example 1: 23.3%

Example 2: 52.1%

The residual rates of Cl-MIT in all 4 tablets of the water-soluble solid chemical after 1 week are shown below.

Comparative Example 1: 28.4%

Example 1: 49.8%

Example 2: 66.1%

By using the film as above, remaining properties of the component was largely improved. This is considered to be caused that no progress of wetting prevented the component from eluting.

[0058]

[Demonstration test for "wetting" due to water vapor]

The housing container forming the solid chemical housing body shown in Fig. 5 was used and the occurrence of wetting due to ingress of water vapor at a ceiling inside the container, not directly hit by water, was demonstrated according to the method described below.

<Procedure>

1. The poval film "VF-HP220" (thickness: 40 μ m) manufactured by KURARAY CO., LTD. was adhered to a ceiling surface of the cylindrical housing container with an adhesive (one-component RTV rubber KE-347 manufactured by Shin-Etsu Chemical Co., Ltd.).
2. The container was set in a round type cooling tower without any water-soluble solid chemical for 2 days.

<Result and consideration>

After the elapse of 2 days, the water-soluble film was completely eliminated, and it was demonstrated that the water-soluble film was wetted by water vapor and then dissolved and eliminated.

These results demonstrated that the occurrence of wetting by water vapor (humidity) is caused with 100% humidity, even when the film was not directly hit by water.

[0059]

[Demonstration test of relation between wetting of film and elution of component]

<Solid chemical housing body>

The following sample was housed in the solid chemical housing body shown in Fig. 5.

The following was used as the water-soluble solid chemical.

The water-soluble solid chemical: a water-soluble solid chemical containing 7% by mass of benzotriazole

<Sample>

Example 1 4 tablets of the water-soluble solid chemical (tablets are packed one by one with a poval film "VF-HP220" (thickness: 40 μm) manufactured by KURARAY CO., LTD.)

Example 2 4 tablets of the water-soluble solid chemical (tablets are packed one by one with a PVA film "ADVASOL XRV" ("XRV" in Table 1) (thickness: 50 μm) manufactured by SEKISUI CHEMICAL CO.,LTD.)

<Procedure>

1. The sample was housed in a cylindrical housing container.
2. The housing container housing the sample was set in a round type showering cooling tower.
3. The sample was taken out after 1 week and the moisture content of the top water-soluble solid chemical (the fourth tablet from the bottom) and residual rate of benzotriazole were examined.

[0060]

<Measurement method for moisture content>

The moisture content of the water-soluble solid chemical was measured according to the following procedure.

The sample taken out from the cooling tower was placed in a thermostat at 40°C and dried until no mass change was observed. The moisture content was calculated from the loss of weight before and after drying.

[0061]

<Measurement method for residual rate of benzotriazole>

The residual rate of benzotriazole in the water-soluble solid chemical was measured according to the following procedure.

Dry solid chemical was dissolved in pure water to be 1 g/L and measured by using high-performance liquid chromatography Agilent 1260 (Agilent Technologies Japan, Ltd.).

[0062]

<Result and consideration>

The results of the moisture content of the top water-soluble solid chemical (the fourth tablet from the bottom) after 1 week and the residual rate of benzotriazole are shown below.

Example 1: moisture content (24.7%), residual rate of benzotriazole (80.0%)

Example 2: moisture content (5.4%), residual rate of benzotriazole (100%)

As shown above, it was demonstrated that the component was lost with the moisture content of 24.7%, but no component was lost with the moisture content of 5.4%.

Reference Signs List

[0063]

10 housing container

11 container body

12 partition wall

13 housing space

14 non-housing space

15a, 15b, 15c container communication path

16 partition wall communication path

17 water-soluble film

S1, S2, S3 water-soluble solid chemical

CLAIMS

[Claim 1]

A solid chemical housing body filled with a water-soluble solid chemical inside a housing container,

wherein the housing container comprises a housing space capable of housing a plurality of the water-soluble solid chemicals, an inlet for allowing water to be treated to flow into the housing space, and an outlet for allowing the water to be treated to flow out from the housing space;

some or all of the water-soluble solid chemicals are vertically stacked in the housing space via a water-soluble film; and

at least some of the water-soluble films are disposed upward from the inlet and the outlet.

[Claim 2]

The solid chemical housing body according to claim 1, wherein the housing container comprises an approximately cylindrical container body.

[Claim 3]

The solid chemical housing body according to claim 2 comprising an approximately cylindrical partition wall inside the container body, and an inner space of the partition wall as the housing space.

[Claim 4]

The solid chemical housing body according to claim 3, wherein the container body is formed by fitting an upper member and a lower member.

[Claim 5]

The solid chemical housing body according to any of claims 1 to 4, wherein the water-soluble film is a packing material packing the water-soluble solid chemical.

[Claim 6]

The solid chemical housing body according to any of claims 1 to 5, wherein the water-soluble film is obtained by making a film from a raw material containing a polyvinyl alcohol-based resin.

[Claim 7]

The solid chemical housing body according to any of claims 1 to 6, wherein the water-soluble film has a dissolution time in water at 23°C of 8 seconds or more and 99 seconds or less.

[Claim 8]

A water treatment method for performing water treatment by using a solid chemical housing body,

wherein the solid chemical housing body comprises a housing space capable of housing a plurality of the water-soluble solid chemicals, an inlet for allowing water to be treated to flow into the housing space, and an outlet for allowing the water to be treated to flow out from the housing space, and is filled with the water-soluble solid chemical in the housing space; and

some or all of the plurality of the water-soluble solid chemicals are vertically stacked via a water-soluble film and at least some of the water-soluble films are disposed upward from the inlet and the outlet.

[Claim 9]

The water treatment method according to claim 8, wherein the water-soluble film disposed upward from the inlet and the outlet are partly dissolved during the dissolution of the water-soluble solid chemical disposed downward from the inlet and the outlet; and a remaining part of the water-soluble film partly dissolved prevents the contact of the water-soluble solid chemical disposed on the remaining part with the water to be treated.

[Claim 10]

The water treatment method according to claim 9, wherein the remaining part blocks a horizontal cross section of the housing space.

[Claim 11]

The water treatment method according to any of claims 8 to 10, wherein a water-soluble solid chemical containing a halogen-based oxidant as an active substance and a water-soluble solid chemical containing an organic oxidizing agent as an active substance are housed in an individual solid chemical housing body to perform water treatment.

[Claim 12]

The water treatment method according to claim 11, wherein a content of the halogen-based oxidant in the water-soluble solid chemical containing the halogen-based oxidant as an active substance is 10% by mass or more in terms of effective chlorine (Cl₂) regarding all effective halogen component as effective chlorine.

[Claim 13]

The water treatment method according to claim 11, wherein a content of an organic bactericide in the water-soluble solid chemical containing the organic oxidizing agent as an active substance is 1 to 40% by mass.

[Claim 14]

The water treatment method according to any of claims 8 to 13, wherein the water-soluble solid chemical comprises an excipient and a binder.