

## DESCRIPTION

### Title of Invention

SOLID DRUG ACCOMMODATION BODY AND WATER  
TREATMENT METHOD

### Technical Field

[0001] The present invention relates to a solid chemical housing body having a water-soluble solid chemical housed therein, and specifically relates to a solid chemical housing body having the function of gradually dissolving a water-soluble solid chemical by contact with water to be treated and releasing the water-soluble solid chemical into the water to be treated. In addition, the present invention relates to a water treatment method for treating water by using this solid chemical housing body.

### Background Art

[0002] As a solid chemical housing body that gradually dissolves a water-soluble solid chemical into water to be treated, PTL1 discloses a solid chemical housing body including a housing space that can house a plurality of water-soluble solid chemicals, an inlet that allows water to be treated to flow into the housing space, and an outlet that allows the water to be treated to flow out of the housing space, wherein in the housing space, the water-soluble solid chemicals are stacked in a vertical direction via a water-soluble film, and at least a portion of the water-soluble film is arranged above the inlet and the outlet.

[0003] According to this solid chemical housing body, among the plurality of water-soluble solid chemicals housed in the housing container, a water-soluble solid chemical that is not exposed to a flow path of the water to be treated formed between the inlet and the outlet of the housing container is less wetted by the presence of the water-soluble film even while a water-soluble solid chemical directly under the water-soluble solid chemical that is not exposed is dissolving, and it is possible to reduce the water content of the water-soluble solid chemical and increase the residual rate of the active ingredient of the chemical as compared with when used under the same conditions except for the presence of the water-soluble film.

[0004] However, in the solid chemical housing body of PTL1, the water-soluble film may be dissolved by moisture (water vapor, a water droplet, rising water due to capillarity, or the like), allowing the solid chemical above the film to absorb moisture and swell, thereby form a bridge.

[0005] As a method for preventing bridging of a solid chemical, PTL2 discloses a method for preventing bridging by placing a weight (drop lid) on the uppermost portion of a solid chemical packed into a container to allow the weight of the weight to push down the solid chemical. PTL3 discloses, as an apparatus for continuous and automatic dissolution, a solid chemical continuous automatic dissolution apparatus equipped with a solid chemical dissolution device having a perforated inclined surface.

#### Citation List

##### Patent Literature

[0006] PTL1: JP 2018-167239 A

PTL2: JP 2013-240778 A

PTL3: JP 2000-117263 A

## Summary of Invention

### Technical Problem

[0007] In the technology disclosed in PTL1, the water-soluble film may dissolve due to moisture, causing the water-soluble solid chemical located above the film to swell to form a bridge.

[0008] When a weight is placed in the container in order to prevent bridging, a space corresponding to the volume of the weight is required, and the amount of the solid chemical packed has to be reduced. In addition, when a solid chemical dissolution device having a perforated inclined surface is used, a part having a complicated shape and structure is required in addition to the solid chemical packed cylinder.

[0009] An object of the present invention is to provide a solid chemical housing body configured to suppress the formation of a bridge by a solid chemical and gradually dissolve the whole amount of the solid chemical, and a water treatment method using this solid chemical housing body.

### Solution to Problem

[0010] The solid chemical housing body of the present invention comprises a housing container including a housing space that can house a plurality of water-soluble solid chemicals, an inlet that allows water to flow into the housing space, and an outlet that allows the water to flow out of the housing space, the solid chemical housing body having the water-soluble solid chemicals stacked and arranged in the housing space, wherein a water-insoluble film is interposed between layers of the solid chemicals.

[0011] In one aspect of the present invention, the housing container includes a container body formed by fitting an upper member and a lower member together, a partition wall that partitions the inside of the container body into the housing space and a non-housing space, a partition wall communication path that communicates between the housing space and the non-housing space so that water can flow between the housing space and the non-housing space, and functions as the inlet and the outlet, and a container communication path that communicates between the inside and the outside of the housing container so that water can flow between the outside of the container body and the non-containing space.

[0012] In one aspect of the present invention, the water-insoluble film is a synthetic resin film.

[0013] In one aspect of the present invention, the synthetic resin is polyethylene or polyvinyl chloride.

[0014] In one aspect of the present invention, the area of the film is  $\frac{1}{2}$  or more, and particularly preferably 80% or more, of the horizontal cross-sectional area of the housing space.

[0015] The water treatment method of the present invention is a water treatment method including dissolving a solid chemical to add the same to water to be treated, wherein the solid chemical housing body of the present invention is contacted with the water to be treated, thereby dissolving the solid chemical to add the solid chemical to the water to be treated.

Advantageous Effects of Invention

[0016] In the solid chemical housing body of the present invention, the interposition of a water-insoluble film between layers of the solid chemicals suppresses transmission of moisture (water vapor, a water droplet, rising water due to capillarity, or the like) to the solid chemical above the film, suppressing swelling of the solid chemical. As a result, the formation of a bridge by the solid chemical is suppressed. Because of this, according to the solid chemical housing body of the present invention and the water treatment method using this solid chemical housing body, a component of the solid chemical can be sustainably dissolved in water to be treated over a long period of time.

#### Brief Description of Drawings

[0017] [Fig. 1] Fig. 1 is a perspective view schematically showing a housing container according to one embodiment of the solid chemical housing body.

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

[Fig. 3] Fig. 3 is a schematic illustrative diagram of a state of packing of solid chemicals in the solid chemical housing body.

[Fig. 4] Fig. 4 is an illustrative diagram of a state of dissolution of solid chemicals in the solid chemical housing body.

#### Description of Embodiments

[0018] Hereinafter, the present invention will be described in detail. In the present embodiment, a case in which the water to be treated is cooling water of a cooling tower will be described, but the water to be treated may be other water such as circulating water of a swimming pool.

[0019] [Housing container]

The housing container of the solid chemical housing body of the present invention has an inlet that allows water to be treated to flow into the container, and an outlet that allows the water to be treated that has flowed into the container to flow out of the container. For example, the housing container includes a cylindrical portion, an upper surface portion and a lower surface portion that seal both ends of the cylindrical portion, an inlet provided in the cylindrical portion and/or the lower surface portion, and an outlet provided in the cylindrical portion and/or the lower surface portion. The inlet may also serve as the outlet.

[0020] Fig. 1 is a perspective view showing an example of the housing container, and Fig. 2 is a longitudinal cross-sectional view thereof. This housing container 10 has a container body 11 having an approximately cylindrical shape. As shown in Fig. 2, the inside of the container body 11 is partitioned by a cylindrical partition wall 12 into a housing space 13 that houses a water-soluble solid chemical and a non-housing space 14 that does not house a water-soluble solid chemical.

[0021] <Container body 11>

The container body 11 is composed of an upper member 11a and a lower member 11b. The upper member 11a has a top portion 11t, a cylindrical hanging wall 11r that hangs down from the outer circumferential edge of the top portion 11t, and a cylindrical partition wall 12 that hangs down from the top portion 11t. The hanging wall 11r and the partition wall 12 are coaxially provided. The lower member 11b has a bottom surface 11f and a side circumferential surface 11s.

[0022] The hanging wall 11r, the partition wall 12, and the side circumferential surface 11s may have a shape other than a cylindrical

shape, and the shape may be, for example, an elliptic cylindrical shape, a square shape, or a polygonal cylindrical shape having five or more sides.

[0023] Preferably, the upper member 11a and the lower member 11b have a structure (for example, a fitting structure) that can allow these to be separated and easily integrated. In the present embodiment, the hanging wall 11r of the upper member 11a and the upper portion of the side circumferential surface 11s of the lower member 11b are detachably fitted together.

[0024] Holes 15a serving as a container communication path through which water can flow are provided in the top portion 11t of the upper member 11a. The holes 15a are arranged between the partition wall 12 and the hanging wall 11r in the top portion 11t. A plurality of holes 15a are arranged at approximately equal intervals in the circumferential direction. The non-housing space 14 communicates with the outside above the housing container 10 through these holes 15a.

[0025] Holes 15b serving each as a container communication path through which water can flow are provided near the intersection of the side circumferential surface 11s and the bottom surface 11f of the lower member 11b. A plurality of holes 15b are arranged at approximately equal intervals in the circumferential direction.

[0026] Holes 15c serving each as a container communication path through which water can flow are provided in the bottom surface 11f of the lower member 11b. A plurality of holes 15c are arranged approximately evenly over the whole of the bottom surface 11f.

[0027] <Partition wall 12>

The partition wall 12 is provided in such a way as to hang from the top portion 11t of the upper member 11a. The inside of the partition

wall 12 is the housing space 13. The diameter (inner diameter) of the partition wall 12 is preferably about 20 to 200 mm, particularly about 50 to 70 mm. When the partition wall 12 is non-cylindrical, the horizontal cross-sectional area of the housing space 13 is preferably about 300 to 30000 mm<sup>2</sup>, particularly about 2000 to 4000 mm<sup>2</sup>.

[0028] The outer diameter of the partition wall 12 is smaller than the inner diameter of the side circumferential surface 11s, and the space between the partition wall 12 and the side circumferential surface 11s serves as the non-housing space 14.

[0029] A gap between the lower end of the partition wall 12 and the opposing bottom surface 11f of the lower member 11b serves as a partition wall communication path 16 that communicates between the housing space 13 and the non-housing space 14. In the present embodiment, the distance between the lower end of the partition wall 12 and the bottom surface 11f (the vertical width of the partition wall communication path 16) is preferably 1 to 50 mm, and particularly preferably 3 to 10 mm.

[0030] In the present embodiment, the partition wall communication path 16 functions as an "inlet" and an "outlet," and the holes (container communication paths) 15b and 15c function as an "outlet."

[0031] The shape, the size, the arrangement, and the number of the partition wall communication path 16 are not particularly limited as long as water can flow therethrough, and can be appropriately determined depending on the desired flow rate of cooling water. The partition wall communication path may be formed in an embodiment such that the lower end of the partition wall is in contact with the opposing bottom surface of the container main body and that a water flow hole is provided

in a portion between the partition wall and the bottom surface of the container main body.

[0032] The housing container 10 of the present embodiment is made of a transparent or translucent synthetic resin such as polypropylene, and can allow the state of the water-soluble solid chemical inside the container to be easily visually observed from the outside of the container. This synthetic resin preferably has water resistance and chemical resistance.

[0033] [Water-soluble solid chemical]

The water-soluble solid chemical is not particularly limited, and examples thereof include a solid chemical that can be used as a water treatment agent for cooling water in a cooling tower.

[0034] The water-soluble solid chemical that can be used as a water treatment agent for cooling water in a cooling tower is suitably a cooling water multi-chemical including phosphonic acid, an azole-based corrosion inhibitor for copper, calcium hydroxide, and the like, may be a solid chlorine-based oxidizing agent such as calcium hypochlorite, trichloroisocyanuric acid, dichloroisocyanuric acid, chlorous acid, or bromochloro-5,5-dimethylhydantoin (BCDMH), or a chemical other than the same.

[0035] The form of the water-soluble solid chemical is preferably a disk-shaped tablet.

[0036] The tablet preferably has a diameter of 5 to 100 mm, particularly 10 to 30 mm, and a thickness of 1 to 50 mm, particularly 10 to 20 mm.

[0037] The number of layers of tablets arranged inside the container is preferably about 2 to 10, particularly about 5 or 6.

[0038] [Water-insoluble film]

The water-insoluble film is suitably a film made of a water-insoluble and water-impermeable synthetic resin, and may be of a metal, a ceramic, or the like. Suitable examples of the synthetic resin include polyethylene and polyvinyl chloride.

[0039] The thickness of the water-insoluble film made of a synthetic resin is preferably 1000  $\mu\text{m}$  or less, for example about 10 to 100  $\mu\text{m}$ . The shape of the water-insoluble film is not particularly limited and can be appropriately determined.

[0040] In the present invention, the area of the water-insoluble film may be 1/2 or more of the horizontal cross-sectional area of the housing space 13 (the horizontal cross-sectional area when the solid chemical housing body is placed such that the axial direction of the partition wall is the vertical direction), and is preferably 80% or more, more preferably 85% or more, and particularly preferably 88% or more. When this film is too large, the circumferential edge portion of the film overlaps the inner circumferential surface of the partition wall 12 when the film is arranged inside the housing space 13, resulting in poor workability. In addition, when the film overlaps the bottom of the container after the solid chemical has been dissolved, the circumferential edge portion of the film may block the hole 15c in the bottom of the container. The area of the water-insoluble film may be, for example, 150% or less, 120% or less, or 100% or less of the horizontal cross-sectional area of the housing space 13. The size of the film is particularly preferably less than or equal to the horizontal cross-sectional size of the housing space 13.

[0041] [Method for packing solid chemical]

In order to pack a solid chemical consisting of a tablet into the housing space 13, it is preferable to do as follows. That is, first, the

upper member 11a and the lower member 11b are separated, and the upper member 11a is turned upside down so that the partition wall 12 stands up from the top portion 11t. Then, a plurality of tablets are laid out on the top portion 11t. As many tablets as possible are laid out such that these do not overlap each other and have the side circumferential surfaces thereof butted against or close to each other.

[0042] Next, one film (first film) is arranged in such a way as to cover the layer (first layer) of the tablets laid out.

[0043] On top of this first film, tablets are laid out in the same manner as above to form a second layer, a film (second film) is placed on top thereof, and this process is repeated. After the final layer of tablets is laid out, the upper member 11a and the lower member 11b are fitted and joined together without placing a film on the tablet layer as the final layer. Next, the upper member 11a is turned upside down such that the upper member 11a is above the lower member 11b, to form the solid chemical housing body shown in Fig. 3. In Fig. 3, T represents a tablet, and F represents a water-insoluble film.

[0044] [Dissolved form of solid chemical in solid chemical housing body]

When the solid chemical housing body formed as described above is arranged in a water falling region, water flows into the non-housing space 14 of the housing container 10 through the holes 15a and collects at the bottom of the housing container 10, as shown in Fig. 3. This collecting water W comes into contact with tablets T in the lowermost layer, the tablets T in the lowermost layer gradually dissolve, and the solid chemical-containing water flows out downward through the holes 15b and 15c.

[0045] As the dissolution of the tablets T in the lowermost layer progresses and the thickness of the tablet layer as the lowermost layer becomes smaller, all the tablet layers above this tablet layer gradually move downward.

[0046] When the tablets T in the lowermost layer finish dissolving, the first film F from the bottom overlaps the bottom surface 11f of the lower member 11b, and after that, the tablets T in the tablet layer located second from the bottom when the solid chemical housing body is in brand-new condition dissolve.

[0047] Thereafter, the tablets dissolve sequentially up to the uppermost tablet layer in the same manner. Fig. 4 shows a situation in which the bottom 3 layers out of the 6 tablet layers have dissolved, leaving 3 layers remaining.

[0048] In the present embodiment, a water-insoluble film F is interposed between any two adjacent tablet layers, and the area of the water-insoluble film F is preferably set to 1/2 or more of the horizontal cross-sectional area of the housing space 13, and these suppress the contact of moisture (water vapor, a water droplet, rising water due to capillarity, or the like) from the water W inside the container with the tablets T above the film F. Because of this, swelling of the tablets above the film F is suppressed, and bridging of the solid chemicals inside the solid chemical housing body is suppressed. As a result, the chemical is continuously added to the water to be treated.

#### Example 1

[0049] The solid chemical housing body shown in Fig. 1 was arranged inside a cooling tower having an open circulation type cooling water

system for 3 weeks, and was observed for the presence or absence of the occurrence of a bridge. The main conditions are as follows.

<Container body 10>

Diameter (inner diameter) of side circumferential surface 11s: 83.85 mm

Distance between side circumferential surface 11s and partition wall 12: 8.55 mm

Inner diameter of partition wall 12: 60.78 mm

Height of partition wall 12: 61.0 mm

Distance between lower end of partition wall 12 and bottom surface 11f: 4.4 mm

Diameter and number of holes 15a: 4.6 mm, 16 holes

Diameter and number of holes 15b: 3.0 mm, 16 holes

Diameter and number of holes 15c: 10.0 mm, 10 holes

<Solid chemical>

Types: Phosphonic acid,azole-based corrosion inhibitor for copper

Tablet diameter: 21.7 mm

Tablet thickness: 10.7 mm

<Water-insoluble film>

Resin: Polyethylene

Thickness: 0.04 mm (40  $\mu$ m)

Diameter: 70%, 80%, 85%, 90%, 92%, 95%, 100%, 110%, or 120% of the inner diameter of the partition wall 12 (49%, 64%, 72%, 81%, 88%, 94%, 100%, 121%, or 144% as the ratio of the area of the water-insoluble film F to the horizontal cross-sectional area of the housing space 13 (hereinafter sometimes referred to as the "film area ratio"))

[0050] <Experimental method>

The upper member 11a was removed from the lower member 11b, and on the top portion 11t, 5 tablets of the solid chemical T were laid out in such a way as not to overlap each other, and one polyethylene film F was placed thereon. This was counted as one layer, and this process was repeated until there were 5 layers in total. Next, the upper member 11a and the lower member 11b were joined together to form a solid chemical housing body.

[0051] In this solid chemical housing body, the solubility of the solid chemical was evaluated in an open circulation cooling water system having a water temperature of 30°C. That is, the above solid chemical housing body was placed on top of the packing material inside a countercurrent type (round type) open type cooling tower having a refrigeration capacity of 30 USRT and operating 24 h/day, and the solid chemical was dissolved by the circulating water sprayed.

[0052] After 3 weeks, the solid chemical housing body was removed, and the presence or absence of a bridge was determined.

[0053] <Results and discussion>

Observation results of the situation of the occurrence of a bridge are shown in Table 1.

[0054]

Table 1: Evaluation results when polyethylene film was used as partition material

| Film diameter ratio (%) | Film area ratio (%) | Presence or absence of occurrence of bridge |
|-------------------------|---------------------|---------------------------------------------|
| 70                      | 49                  | △                                           |
| 80                      | 64                  | △                                           |
| 85                      | 72                  | △                                           |
| 90                      | 81                  | ○                                           |
| 92                      | 88                  | ◎                                           |
| 95                      | 94                  | ◎                                           |
| 100                     | 100                 | ◎                                           |
| 110                     | 121                 | ◎*                                          |
| 120                     | 144                 | ◎*                                          |

◎: No bridge occurred

○: Fewer bridges occurred

△: Few bridges occurred

[0055] As shown in Table 1, according to the present invention, it was possible to suppress the occurrence of a bridge, and in particular, by setting the film area ratio to 88% or more, it was possible to sufficiently prevent the occurrence of a bridge.

[0056] When the film area ratio was 121% or more, no bridge occurred, but work such as folding was required when the solid chemical was packed into the container, resulting in poor workability. In addition, the polyethylene film that collected at the bottom of the container inhibited contact between the tablets and water. Therefore, it has been recognized that the size of the film is preferably less than or equal to the horizontal cross-sectional size of the housing space 13.

[0057] [Comparative Example 1]

An experiment was carried out under the same conditions as in Example 1, except that a polyvinyl alcohol-based water-soluble film having a thickness of 0.05 mm (diameter: 100% of the inner diameter of the partition wall 12, film area ratio: 100%) was used as the film. As a result, after 3 weeks, a bridge had occurred inside the solid chemical housing body. The evaluation result for the presence or absence of the

occurrence of a bridge in Comparative Example 1 was  $\triangle$  as shown in Table 1, and few bridges occurred, but Comparative Example 1 was inferior in bridge suppressing effect to a case in which the film area ratio was 100%, which was the same as Comparative Example 1 (evaluation result  $\odot$ : no bridge occurred), in Example 1.

[0058] [Comparative Example 2]

An experiment was carried out under the same conditions as in Example 1, except that no film was used. As a result, after 3 weeks, bridges had occurred remarkably. Comparative Example 2 was inferior in bridge suppressing effect to all cases (film area ratio: 49% to 144%) in Example 1.

[0059] Although the present invention has been described in detail by using specific aspects, it will be apparent to those skilled in the art that various changes can be made without departing from the spirit and scope of the present invention.

The present application is based on Japanese Patent Application No. 2022-079601 filed on May 13, 2022, which is incorporated by reference in its entirety.

#### Reference Signs List

[0060] 10 Housing container

11 Container body

11a Upper member

11b Lower member

12 Partition wall

13 Housing space

14 Non-housing space

15a, 15b, 15c Hole (container communication path)

16 Partition wall communication path

F Water-insoluble film

T Water-soluble solid chemical tablet

## CLAIMS

### [Claim 1]

A solid chemical housing body comprising a housing container comprising a housing space that can house a plurality of water-soluble solid chemicals, an inlet that allows water to flow into the housing space, and an outlet that allows the water to flow out of the housing space, the solid chemical housing body having the water-soluble solid chemicals stacked and arranged in the housing space, wherein a water-insoluble film is interposed between layers of the solid chemicals.

### [Claim 2]

The solid chemical housing body according to claim 1, wherein the housing container comprises:

- a container body formed by fitting an upper member and a lower member together;

- a partition wall that partitions an inside of the container body into the housing space and a non-housing space;

- a partition wall communication path that communicates between the housing space and the non-housing space so that water can flow between the housing space and the non-housing space, and functions as the inlet and the outlet, and

- a container communication path that communicates between an inside and an outside of the housing container so that water can flow between an outside of the container body and the non-housing space.

### [Claim 3]

The solid chemical housing body according to claim 1, wherein the water-insoluble film is a synthetic resin film.

[Claim 4]

The solid chemical housing body according to claim 3, wherein the synthetic resin is polyethylene or polyvinyl chloride.

[Claim 5]

The solid chemical housing body according to claim 1, wherein an area of the film is 1/2 or more of a horizontal cross-sectional area of the housing space.

[Claim 6]

The solid chemical housing body according to claim 1, wherein an area of the film is 80% or more of a horizontal cross-sectional area of the housing space.

[Claim 7]

The solid chemical housing body according to claim 1, wherein a form of the water-soluble solid chemical is a tablet.

[Claim 8]

A water treatment method comprising dissolving a solid chemical to add the same to water to be treated, wherein the solid chemical housing body according to any one of claims 1 to 7 is contacted with the water to be treated, thereby dissolving the solid chemical to add the solid chemical to the water to be treated.