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(54) Title: ENZYME SOLUTION, ENZYME-CONTAINING NON-WOVEN FABRIC, AND METHODS OF PREPARATION AND USE THEREOF

(57) Abstract: Disclosed is an enzyme solution comprising a nonionic surfactant, an enzyme, a normal-temperature enzyme stabilizer, an isothiazolinone, a benzisothiazolinone, sodium benzoate, a solubilizer, a pH adjuster, and water. In some embodiments, the enzyme solution also contains a chelating agent. The enzyme solution according to the present disclosure may be used to clean medical devices, and has good compatibility with non-woven fabrics comprising viscose fiber and terylene fiber. The enzyme solution dispersed in the non-woven fabric not only has good enzyme stability, but also has good mold-resistance and bacteria-resistance properties. Furthermore, the enzyme-containing non-woven fabric according to the present disclosure is less likely to cause damage to medical devices, and is less likely to cause corrosion to the metal or rubber components of the medical devices.



**ENZYME SOLUTION, ENZYME-CONTAINING NON-WOVEN FABRIC, AND
METHODS OF PREPARATION AND USE THEREOF**

CROSS REFERENCE TO RELATED APPLICATIONS

5 This application claims priority to Chinese Application No. 201510023223.4, filed January 16, 2015, the disclosure of which is incorporated by reference in its entirety herein.

TECHNICAL FIELD

10 The present disclosure relates to the field of rinsing and disinfection, and particularly relates to an enzyme solution, an enzyme-containing non-woven fabric, and methods of preparation and use thereof.

BACKGROUND OF THE INVENTION

15 Rinsing and disinfection (or sterilization) represents a key step in the treatment of medical devices after use. For heavily contaminated medical devices, the step of pre-rinsing or pre-cleaning can significantly increase the success rate of subsequent rinsing and disinfection, prolong the service life of the medical devices, and reduce the risk of contamination. For example, in hospitals, doctors will, after removing an endoscope from the body of a patient, immediately use a wet tissue or a wet gauze containing rinsing solution to wipe off
20 contaminants on the outer surface of the endoscope to complete the pre-cleaning, prior to detaching the endoscope from a light source or a video processor.

 At present, most hospitals perform pre-cleaning of endoscopes by using traditional gauze dipped with a diluted enzyme solution. However, the enzyme in the diluted enzyme solution has relatively poor stability, which may lead to a decrease in the success rate of pre-cleaning.
25 Moreover, the traditional gauze has relatively poor compatibility with the enzyme solution. The enzyme activity will decrease rapidly after the enzyme solution is dispersed into the traditional gauze, which may also affect the success rate of pre-cleaning.

DETAILED DESCRIPTION OF THE INVENTION

30 It is to be understood that various other embodiments can be contemplated and modifications thereof can be made by those skilled in the art in light of the teachings of the

present specification without departing from the scope or spirit of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense.

Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physico-chemical properties used in the specification and the claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can be suitably altered depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein. The recitation of numerical ranges by endpoints includes all numbers subsumed within that range and any range within that range. For example, 1 to 5 includes 1, 1.1, 1.3, 1.5, 2, 2.75, 3, 3.80, 4 and 5 etc.

Enzyme solution

In some aspects, the present disclosure provides an enzyme solution comprising 0.1 to 10 wt.% of a nonionic surfactant; 0.01 to 1.2 wt.% of an enzyme; 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer; 0.75 to 6 wt.% of an isothiazolinone; 0.1 to 1 wt.% of a benzoisothiazolinone; 0.1 to 1 wt.% of sodium benzoate; 6.9 to 10 wt.% of a solubilizer; 0.15 to 0.5 wt.% of a pH adjuster;; and 60 to 85 wt.% of water, based on the total weight of the enzyme solution; the enzyme solution having a pH value of 6 to 10. In some aspects of the present disclosure, the enzyme solution comprises 0.1 to 0.7 wt.% of sodium benzoate. In some aspects of the present disclosure, the enzyme solution comprises 0.1 to 0.5 wt.% of sodium benzoate. In some aspects of the present disclosure, the enzyme solution comprises about 5 to 13 % normal-temperature enzyme stabilizer. In some aspects, the present disclosure the enzyme solution comprises about 10 to 11 % normal-temperature enzyme stabilizer.

Nonionic surfactant

In the enzyme solution according to the present disclosure, the nonionic surfactant helps to decrease the surface tension of the enzyme solution and increase the wetting and cleaning capability of the enzyme solution.

A number of suitable nonionic surfactants may be used in the enzyme solution of the present disclosure. According to certain embodiments, the nonionic surfactant comprises at

least one component selected from the group consisting of (i) a polymer based on at least one of ethylene oxide, propylene oxide and butylene oxide, (ii) an alkyl glucoside, (iii) a fatty alcohol polyoxyethylene ether, and (iv) an ammonium oxide.

According to certain embodiments, the polymer based on the at least one of ethylene oxide, propylene oxide and butylene oxide comprises at least one component selected from the group consisting of ethylene oxide / butylene oxide copolymer, and ethylene oxide / propylene oxide / butylene oxide copolymer. According to certain embodiments, EH-6 commercially available from The Dow Chemical Company can be selected as the polymer based on the at least one of ethylene oxide, propylene oxide and butylene oxide.

According to certain embodiments, the alkyl glucoside has a molecular weight of 320 to 350. According to certain embodiments, the alkyl glucoside comprises at least one component selected from the group consisting of decyl glucoside, octyl glucoside and dodecyl glucoside. According to certain embodiments, Glucopon 425N/HH commercially available from BASF Corporation can be selected as the alkyl glucoside.

According to certain embodiments, the fatty alcohol polyoxyethylene ether has the general formula of $\text{RO}(\text{CH}_2\text{CH}_2\text{O})_n\text{H}$, wherein $n = 8$ to 16. According to certain embodiments, the fatty alcohol polyoxyethylene ether comprises at least one component selected from the group consisting of C7 to C9 fatty alcohol polyoxyethylene ether, C12 to C16 fatty alcohol polyoxyethylene ether, and C9 to C11 fatty alcohol polyoxyethylene ether. According to certain embodiments, A1058 commercially available from Harcros Corporation can be selected as the fatty alcohol polyoxyethylene ether.

The nonionic surfactant is in an amount of 0.1 to 10 wt.%, based on the total weight of the enzyme solution. When the nonionic surfactant is in an amount of less than 0.1 wt.%, the cleaning capability of the enzyme solution may decrease; and when the nonionic surfactant is in an amount of more than 10 wt.%, the enzyme solution may suffer from excessive foaming, resulting in decreased cleaning capability of the enzyme solution.

Enzyme

In the enzyme solution according to the present disclosure, the enzyme helps to decompose the proteins, saccharides, fats, and celluloses in the contaminants associated with medical devices.

According to certain embodiments, the enzyme comprises at least one component selected from the group consisting of a proteinase, an amylase, a lipase, and a cellulase.

According to certain embodiments, Alcalase, Esperase, Everlase, Savinase 16XL, Liquanase, or Polarzyme commercially available from Novozymes Corporation can be selected as the proteinase. According to certain embodiments, Properase commercially available from Genencor Corporation can also be selected as the proteinase.

According to certain embodiments, Stainzyme, Termamyl 300L, BAN 480L, or Duramyl commercially available from Novozymes Corporation can be selected as the amylase.

According to certain embodiments, Lipolase commercially available from Novozymes Corporation or Purafect commercially available from Genencor Corporation can be selected as the lipase.

According to certain embodiments, Carezyme 4500 or Endolase commercially available from Novozymes Corporation can be selected as the cellulase.

The enzyme is in an amount of 0.01 to 1.2 wt.% based on the total weight of the enzyme solution. According to certain embodiments, the enzyme in the enzyme solution comprises 0.05 to 0.6 wt.% of a proteinase, 0.01 to 0.2 wt.% of an amylase, 0.01 to 0.2 wt.% of a lipase, and 0.01 to 0.2 wt.% a cellulase, based on the total weight of the enzyme solution. When the enzyme is in an amount of less than 0.01 wt.%, the cleaning capability of the enzyme solution may decrease; and when the enzyme is in an amount of more than 1.2 wt.%, the stability of the enzyme solution may decrease.

Normal-temperature enzyme stabilizer

In the enzyme solution according to the present disclosure, the normal-temperature enzyme stabilizer helps to maintain the activity of the enzyme under normal temperature (10 to 25°C) conditions.

A number of normal-temperature enzyme stabilizers may be suitable for use in the enzyme solution according to the present disclosure. In some embodiments, the normal-temperature enzyme stabilizer comprises at least one component selected from the group consisting of glycerol, propylene glycol, calcium chloride, magnesium chloride, and boric acid.

According to certain embodiments, the glycerol is commercially available from The Dow Chemical Company.

According to certain embodiments, the propylene glycol, calcium chloride, magnesium chloride, and boric acid are all commercially available from Sinopharm Chemical Reagent Co., Ltd., China.

5 The normal-temperature enzyme stabilizer is present in an amount of 0.03 to 15 wt.%, based on the total weight of the enzyme solution. According to certain embodiments, the normal-temperature enzyme stabilizer in the enzyme solution comprises 5 to 10 wt.% of glycerol and/or propylene glycol, and 0.03 to 0.7 wt.% of calcium chloride and/or magnesium chloride, based on the total weight of the enzyme solution. When the normal-temperature enzyme stabilizer is in an amount of less than 0.03 wt.%, the stability of the enzyme in the
10 enzyme solution under normal temperature (10 to 25°C) condition may decrease; and when the normal-temperature enzyme stabilizer is in an amount of more than 15 wt.%, the cleaning capability of the enzyme solution may decrease.

Isothiazolinone, benzoisothiazolinone, and sodium benzoate

15 In the enzyme solution according to the present disclosure, an isothiazolinone, a benzoisothiazolinone, and sodium benzoate are used in combination. Inclusion of an isothiazolinone, a benzoisothiazolinone, and sodium benzoate together in the enzyme solution not only helps to maintain good stability of the enzyme in the enzyme solution under relatively high temperature (higher than 25°C) condition, but also contributes to the good mold-resistance
20 and bacteria-resistance properties of the enzyme solution, as well as the good compatibility of the enzyme solution with non-woven fabrics.

According to certain embodiments, the isothiazolinone comprises at least one component selected from the group consisting of 5-chloro-2-methyl-4-isothiazolin-3-one (CMI) and 2-methyl-4-isothiazolin-3-one (MI). According to certain embodiments, Nipagurad CG,
25 commercially available from Clariant Corporation can be selected as the isothiazolinone.

According to certain embodiments, the benzoisothiazolinone comprises 1,2-benzoisothiazolin-3-one. According to certain embodiments, BIT (Prexel GXL) commercially available from Lonza Corporation can be selected as the benzoisothiazolinone.

According to certain embodiments, the sodium benzoate has the molecular formula of
30 $C_6H_5CO_2Na$. According to certain embodiments, the sodium benzoate is commercially available from Shanghai Shantou Guanghua Chemical Reagents Co., Ltd..

The enzyme solution comprises 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, and 0.1 to 1 wt.% of sodium benzoate, based on the total weight of the enzyme solution. When any one of the isothiazolinone, the benzoisothiazolinone, and the sodium benzoate is in an amount that is not consistent with the above ranges, the stability of the enzyme in the enzyme solution under relatively high temperature (higher than 25°C) condition may decrease, the mold-resistance or bacteria-resistance properties of the enzyme solution may decrease, and the compatibility of the enzyme solution with the non-woven fabric may also decrease.

According to certain embodiments, when the isothiazolinone and the benzoisothiazolinone are in a weight ratio of 3:1 to 30:1, and the isothiazolinone and the sodium benzoate are in a weight ratio of 1:1 to 30:1, the enzyme in the enzyme solution has particularly good stability under relatively high temperature (higher than 25°C) conditions, and the enzyme solution has particularly good mold-resistance and bacteria-resistance properties.

Solubilizer

In the enzyme solution according to the present disclosure, the solubilizer helps to promote the dissolution of the ingredients in the enzyme solution.

A number of solubilizers are suitable for use in the enzyme solution of the present disclosure. According to certain embodiments, the solubilizer comprises at least one component selected from the group consisting of xylene sulfonic acid, sodium xylene sulfonate, xylene sulfuric acid, sodium xylene sulfate, and alkyl amine oxide.

According to certain embodiments, SXS 93 commercially available from Kuantum Corporation can be selected as the sodium xylene sulfonate.

The solubilizer is present in an amount of 6.9 to 10 wt.%, based on the total weight of the enzyme solution. When the solubilizer is present in an amount less than 6.9 wt.%, some ingredients in the enzyme solution may not dissolve sufficiently; and when the solubilizer is in an amount of more than 10 wt.%, the activity of the enzyme in the enzyme solution may decrease.

pH adjuster

In the enzyme solution according to the present disclosure, the pH adjuster is used for adjusting the pH value of the enzyme solution.

5 A number of pH adjusters may be suitable for use in the enzyme solution of the present disclosure. According to certain embodiments, the pH adjuster comprises citric acid.

According to certain embodiments, the citric acid is commercially available from Sinopharm Chemical Reagent Co., Ltd., China.

10 The pH adjuster is present in an amount of 0.15 to 0.5 wt.%, based on the total weight of the enzyme solution. When the pH adjuster is present in an amount that is outside the above range, the enzyme solution may become too acidic (pH value being smaller than 6) or too alkaline (pH value being greater than 10), resulting in decreased activity of the enzyme in the enzyme solution.

According to certain embodiments, the enzyme solution has a pH in the range of 6 to 10. According to certain embodiments, the enzyme solution has a pH in the range of 7 to 9.

15

Water

In the enzyme solution according to the present disclosure, water is used as the solvent.

20 According to certain embodiments water is present in an amount of at least 60 wt.%, based on the total weight of the enzyme solution. According to certain embodiments water is present in an amount not greater than 85%, based on the total weight of the enzyme solution. When water is present in an amount less than 60 wt.%, some ingredients in the enzyme solution may not dissolve sufficiently, resulting in unwanted precipitation of some ingredients. When water is present in an amount of more than 85 wt.%, the ingredients in the enzyme solution may be overly diluted, thus decreasing the cleaning capability of the enzyme solution.

25

Chelator

The enzyme solution according to the present disclosure may also comprise 0.2 to 0.5 wt.% of a chelator, based on the total weight of the enzyme solution.

30 In the enzyme solution according to the present disclosure, the chelator may chelate metal ions which may be present as impurities in the enzyme solution, thus increasing the cleaning capability of the enzyme solution.

A number of chelating agents may be used as the chelator in the enzyme solution disclosed herein. According to certain embodiments, the chelator comprises at least one component selected from the group consisting of ethylenediamine tetraacetic acid (EDTA) and diethylenetriamine pentaacetic acid.

5 According to certain embodiments, the EDTA commercially available from Sinopharm Chemical Reagent Co., Ltd., China can be selected as the ethylenediamine tetraacetic acid.

 According to certain embodiments, Dissolvine D50 commercially available from AKZO-Nobel Corporation can be selected as the diethylenetriamine pentaacetic acid.

10 Corrosion inhibitor

 The enzyme solution according to the present disclosure may also comprise 0.5 to 10 wt.% of a corrosion inhibitor, based on the total weight of the enzyme solution.

 In the enzyme solution according to the present disclosure, the corrosion inhibitor helps to delay or prevent corrosion of the metal or rubber in contact with the enzyme solution.

15 A number of corrosion inhibitors may be suitable for use in the enzyme solution of the present disclosure. According to certain embodiments, the corrosion inhibitor comprises at least one component selected from the group consisting of a borate ester, a polyether, and a higher alcohol.

 According to certain embodiments, Crodacor BE-LQ-(AP) commercially available from
20 Croda Corporation can be selected as the borate ester.

Defoamer

 The enzyme solution according to the present disclosure may also comprise 0.1 to 0.3 wt.% of a defoamer, based on the total weight of the enzyme solution.

25 In the enzyme solution according to the present disclosure, the defoamer helps to decrease or inhibit foaming of the enzyme solution.

 A number of defoamers may be suitable for use in the enzyme solution of the present disclosure. According to certain embodiments, the defoamer comprises at least one component selected from the group consisting of a silicone oil, a polyether, and a higher alcohol.

30 According to certain embodiments, DK1247 commercially available from the Dow Corning Corporation can be selected as the defoamer.

Method of preparing an enzyme solution

In some aspects, the present disclosure provides a method of preparing an enzyme solution, comprising the step of mixing the ingredients of the enzyme solution according to the present disclosure.

According to certain embodiments, the method of preparing the enzyme solution comprises the steps of sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer into 30 to 60 wt.% of water to obtain a first solution; adding 0.15 to 0.5 wt.% of a pH adjuster to the first solution to obtain a second solution having a pH value of 6 to 10; and adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

According to certain embodiments, the method of preparing the enzyme solution comprises the steps of sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer, 0.2 to 0.5 wt.% of a chelator, 0.5 to 10 wt.% of a corrosion inhibitor, and 0.1 to 0.3 wt.% of a defoamer into 30 to 60 wt.% of water to obtain a first solution; adding 0.15 to 0.5 wt.% of a pH adjuster into the first solution to obtain a second solution having a pH value of 6 to 10; and adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

For detailed discussion of the ingredients of the enzyme solution, refer to the “Enzyme solution” section of the present specification.

Enzyme-containing non-woven fabric

In some aspects, the present disclosure provides an enzyme-containing non-woven fabric, comprising a non-woven fabric and the enzyme solution according to the present disclosure dispersed in the non-woven fabric, wherein the non-woven fabric comprises 20 to 50 wt.% of viscose fiber and 50 to 80 wt.% of terylene fiber based on the total weight of the non-woven fabric; and the enzyme solution and the non-woven fabric are in a weight ratio of 1.5:1 to 7:1.

For detailed discussion of the enzyme solution, refer to the “Enzyme solution” section of the present specification.

A number of viscose fibers may be suitable for use in the present disclosure. According to certain embodiments, the viscose fiber can be prepared by the following method: alkalinizing natural cellulose to obtain alkalinized cellulose, reacting the alkalinized cellulose with carbon disulfide to obtain cellulose xanthate, dissolving the cellulose xanthate in a diluted alkaline solution to obtain a viscous solution (viscose), and fabricating the viscous solution (viscose) into the viscose fiber by a known wet spinning and post-treatment process.

A number of terylene fibers may be suitable for use in the present disclosure. According to certain embodiments, the terylene fiber can be prepared by the following method: subjecting pure terephthalic acid (PTA) or dimethyl terephthalate (DMT) and ethylene glycol (EG) to esterification or transesterification, followed by polycondensation reaction to obtain polyethylene terephthalate (PET), and fabricating the polyethylene terephthalate into terylene fiber by a known spinning and post-treatment process.

When the viscose fiber or the terylene fiber are in an amount that is not consistent with the above ranges, the enzyme in the enzyme solution may be adsorbed by the non-woven fabric, reducing the compatibility of the enzyme solution with the non-woven fabric.

When the enzyme solution and the non-woven fabric are in a weight ratio of less than 1.5:1, the cleaning capability of the enzyme solution in the enzyme-containing non-woven fabric may decrease; and when the enzyme solution and the non-woven fabric are in a weight ratio of greater than 7:1, it may exceed the maximum loading of the enzyme solution in the non-woven fabric.

Method of preparing the enzyme-containing non-woven fabric

In some aspects, the present disclosure provides a method of preparing the enzyme-containing non-woven fabric, comprising the step of allowing the enzyme solution according to the present disclosure to disperse into a non-woven fabric, the enzyme solution and the non-woven fabric being in a weight ratio of 1.5:1 to 7:1.

For detailed discussion of the enzyme solution, refer to the “Enzyme solution” section of the present specification.

For detailed discussion of the non-woven fabric, refer to the “Enzyme-containing non-woven fabric” section of the present specification.

Use of the enzyme-containing non-woven fabric

5 In some aspects, the present disclosure provides use of the enzyme-containing non-woven fabric according to the present disclosure in cleaning medical devices.

The enzyme-containing non-woven fabric according to the present disclosure can be used to contact medical devices for the purpose of cleaning the medical devices.

10 The following embodiments are intended to describe the present disclosure in an illustrative rather than limitative manner.

Embodiment 1 is an enzyme solution comprising 0.1 to 10 wt.% of a nonionic surfactant; 0.01 to 1.2 wt.% of an enzyme; 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer; 0.75 to 6 wt.% of an isothiazolinone; 0.1 to 1 wt.% of a benzoisothiazolinone; 0.1 to 1 wt.% of sodium benzoate; 6.9 to 10 wt.% of a solubilizer; 0.15 to 0.5 wt.% of a pH adjuster; and 60 to 85 wt.% of water, based on the total weight of the enzyme solution; the enzyme solution having a pH value of 6 to 10.

Embodiment 2 is an enzyme solution according to embodiment 1, wherein the nonionic surfactant comprises at least one component selected from the group consisting of (i) a polymer based on at least one of ethylene oxide, propylene oxide and butylene oxide, (ii) an alkyl glucoside, (iii) a fatty alcohol polyoxyethylene ether, and (iv) an ammonium oxide.

Embodiment 3 is an enzyme solution according to embodiment 1 or 2, wherein the enzyme comprises at least one component selected from the group consisting of a proteinase, an amylase, a lipase and a cellulase.

25 Embodiment 4 is an enzyme solution according to embodiment 3, wherein the proteinase is in an amount of 0.05 to 0.3 wt.%, the amylase is in an amount of 0.01 to 0.1 wt.%, and the cellulase is in an amount of 0.01 to 0.1 wt.%, based on the total weight of the enzyme solution.

Embodiment 5 is an enzyme solution according to any one of embodiments 1 to 4, wherein the isothiazolinone comprises at least one component selected from the group consisting of 5-chloro-2-methyl-4-isothiazolin-3-one and 2-methyl-4-isothiazolin-3-one.

Embodiment 6 is an enzyme solution according to any one of embodiments 1 to 5, wherein the benzoisothiazolinone comprises 1,2-benzoisothiazolin-3-one.

Embodiment 7 is an enzyme solution according to any one of embodiments 1 to 6, wherein the isothiazolinone and the benzoisothiazolinone are in a weight ratio of 3:1 to 30:1, and the isothiazolinone and the sodium benzoate are in a weight ratio of 1:1 to 30:1.

Embodiment 8 is an enzyme solution according to any one of embodiments 1 to 7, wherein the normal-temperature enzyme stabilizer comprises at least one component selected from the group consisting of glycerol, propylene glycol, calcium chloride, magnesium chloride, and boric acid.

Embodiment 9 is an enzyme solution according to embodiment 8, wherein the glycerol and/or propylene glycol is in an amount of 5 to 10 wt.%, and the calcium chloride and/or magnesium chloride is in an amount of 0.03 to 0.7 wt.%, based on the total weight of the enzyme solution.

Embodiment 10 is an enzyme solution according to any one of embodiments 1 to 9, wherein the solubilizer comprises at least one component selected from the group consisting of xylene sulfonic acid, sodium xylene sulfonate, xylene sulfuric acid, sodium xylene sulfate, and alkyl amine oxide.

Embodiment 11 is an enzyme solution according to any one of embodiments 1 to 10, wherein the pH adjuster comprises citric acid.

Embodiment 12 is an enzyme solution according to any one of embodiments 1 to 11, wherein the enzyme solution further comprises 0.2 to 0.5 wt.% of a chelator, based on the total weight of the enzyme solution.

Embodiment 13 is an enzyme solution according to embodiment 12, wherein the chelator comprises at least one component selected from the group consisting of ethylenediamine tetraacetic acid and diethylenetriamine pentaacetic acid.

Embodiment 14 is an enzyme solution according to any one of embodiments 1 to 13, wherein the enzyme solution further comprises 0.5 to 10 wt.% of a corrosion inhibitor, based on the total weight of the enzyme solution.

Embodiment 15 is an enzyme solution according to embodiment 14, wherein the corrosion inhibitor comprises at least one component selected from the group consisting of a borate ester, a silicate and polyaspartic acid.

Embodiment 16 is an enzyme solution according to any one of embodiments 1 to 15, wherein the enzyme solution further comprises 0.1 to 0.3 wt.% of a defoamer, based on the total weight of the enzyme solution.

Embodiment 17 is an enzyme solution according to embodiment 16, wherein the defoamer
5 comprises at least one component selected from the group consisting of a silicone oil, a polyether and a higher alcohol.

Embodiment 18 is an enzyme solution according to any one of embodiments 1 to 17, wherein the enzyme solution has a pH value of 7 to 9.

Embodiment 19 is a method of preparing an enzyme solution, comprising the step of
10 mixing the ingredients of the enzyme solution according to any one of embodiments 1 to 18.

Embodiment 20 is the method according to embodiment 19, comprising the steps of sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer into 30 to 60
15 wt.% of water to obtain a first solution; adding 0.15 to 0.5 wt.% of a pH adjuster to the first solution to obtain a second solution having a pH value of 6 to 10; and adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

Embodiment 21 is the method according to embodiment 19, comprising the steps of sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant,
20 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer, 0.2 to 0.5 wt.% of a chelator, 0.5 to 10 wt.% of a corrosion inhibitor, and 0.1 to 0.3 wt.% of a defoamer into 30 to 60 wt.% of water to obtain a first solution; adding 0.15 to 0.5 wt.% of a pH adjuster into the first solution to obtain a second solution having a pH value of 6 to 10; and adding 0.01 to 1.2
25 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

Embodiment 22 is an enzyme-containing non-woven fabric, comprising a non-woven fabric and the enzyme solution according to any one of embodiments 1 to 18 dispersed in the non-woven fabric, wherein the non-woven fabric comprises 20 to 50 wt.% of viscose fiber and
30 50 to 80 wt.% of terylene fiber based on the total weight of the non-woven fabric; and the enzyme solution and the non-woven fabric are in a weight ratio of 1.5:1 to 7:1.

Embodiment 23 is a method of preparing an enzyme-containing non-woven fabric, comprising the step of allowing the enzyme solution according to any one of embodiments 1 to 18 to disperse into a non-woven fabric, wherein the non-woven fabric comprises 20 to 50 wt.% of viscose fiber and 50 to 80 wt.% of terylene fiber based on the total weight of the non-woven fabric; and the enzyme solution and the non-woven fabric are in a weight ratio of 1.5:1 to 7:1.

Embodiment 24 is use of the enzyme-containing non-woven fabric according to embodiment 22 in cleaning medical devices.

EXAMPLES

The examples and comparative examples provided below are intended to aid in understanding the present invention and should not be construed as limiting the scope of the present invention. All parts and percentages are by weight unless otherwise specified.

The raw materials used in the examples and comparative examples of the present invention are shown in Table 1 below.

Table 1 Raw materials used in the examples and comparative examples

Ingredient	Trade name	Chemical name	CAS number	Supplier
Solubilizer	SXS 93	Sodium xylene sulfonate	1300-72-7	Kuantum
Nonionic surfactant	EH-6	Polymer of methylethylene oxide with ethylene oxide and mono(2-ethylhexyl)ether	64366-70-7	Dow
Nonionic surfactant	A1058	Fatty alcohol polyoxyethylene ether	154518-36-2	Harcros
Nonionic surfactant	Glucopon 425N/HH	Alkyl glucoside	68515-73-1, 110615-47-9	BASF

Isothiazolinone	Nipagurad CG	5-chloro-2-methyl-4-isothiazolin-3-one (CMI) and 2-methyl-4-isothiazolin-3-one (MI)	2682-20-4, 55965-84-9	Clariant
Benzoisothiazolinone	BIT (Prexel GXL)	1,2-benzoisothiazolin-3-one	2634-33-5	Lonza
Sodium benzoate	Sodium benzoate	Sodium benzoate	532-32-1	Shanghai Shantou Guanghua Chemical Reagents Co., Ltd.
Normal-temperature enzyme stabilizer	Calcium chloride	Calcium chloride	10043-52-4	Sinopharm Chemical Reagent Co., Ltd.
Normal-temperature enzyme stabilizer	Borax	Boric acid	10043-35-3	Sinopharm Chemical Reagent Co., Ltd.
Normal-temperature enzyme stabilizer	Glycerol	Glycerol	56-81-5	Dow
Corrosion inhibitor	Crodacor BE-LQ-(AP)	Borate ester	26038-87-9, 26038-90-4	Croda
Chelator	Dissolvine D50	Diethylenetriamine pentaacetic acid	000140-01-2	AKZO-Nobel
Chelator	EDTA	Ethylendiamine tetraacetic acid	60-00-4	Sinopharm Chemical Reagent Co., Ltd.
Defoamer	DK1247	Silicone oil	63148-62-9	Dow Corning
pH adjuster	Citric Acid	Citric acid	77-92-9	Sinopharm Chemical Reagent Co., Ltd.

Enzyme	Savinase (protease)	Proteinase	9014-1-1	Novozymes
Enzyme	Liquanase (protease)	Proteinase	9014-01-1	Novozymes
Enzyme	Termamyl	Amylase	9000-90-2	Novozymes
Enzyme	Lipolase	Lipase	9001-62-1	Novozymes
Enzyme	Carezyme	Cellulase	9012-54-8	Novozymes

Preparation of an enzyme solution

Under the conditions of normal temperature (10 to 25°C) and normal pressure (about 1 atmospheric pressure), add the ingredients of an enzyme solution, based on the total weight of the enzyme solution, into a glass or stainless steel container and mix the ingredients according to the following steps to obtain the enzyme solution: sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer into 30 to 60 wt.% of water to obtain a first solution; adding 0.15 to 0.5 wt.% of a pH adjuster to the first solution to obtain a second solution having a pH value of 6 to 10; and adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

Additionally, the first solution may, as needed, further comprise 0.2 to 0.5 wt.% of a chelator, 0.5 to 10 wt.% of a corrosion inhibitor, and 0.1 to 0.3 wt.% of a defoamer, based on the total weight of the enzyme solution.

Preparation of enzyme-containing non-woven fabric

Under the conditions of normal temperature (10 to 25°C) and normal pressure (about 1 atmospheric pressure), disperse the enzyme solution into a non-woven fabric in a weight ratio of 1.5:1 to 7:1 of the enzyme solution to the non-woven fabric, to obtain an enzyme-containing non-woven fabric.

According to certain embodiments, the enzyme solution can be dispersed into the non-woven fabric by appropriate means such as sprinkling, and soaking etc. to obtain the enzyme-containing non-woven fabric.

In the present disclosure, the cleaning capability of the enzyme solution is evaluated as per “Testing of the cleaning capability of the enzyme solution”.

In the present disclosure, the activity of the enzyme in the enzyme-containing non-woven fabric is evaluated as per “Testing of enzyme activity”.

In the present disclosure, the compatibility of the non-woven fabric with the enzyme solution in the enzyme-containing non-woven fabric is evaluated as per “Testing of the compatibility of the enzyme solution with the non-woven fabric”.

5 In the present disclosure, the stability of the enzyme in the enzyme-containing non-woven fabric is evaluated as per “Testing of enzyme stability”.

In the present disclosure, the mold-resistant and bacteria-resistant capabilities of the enzyme-containing non-woven fabric is evaluated as per “Microbial challenge testing”.

In the present disclosure, the level of damage to medical devices by the enzyme-containing non-woven fabric is evaluated as per “Endoscope damage testing”.

10 In the present disclosure, the corrosiveness of the enzyme solution in the enzyme-containing non-woven fabric is evaluated as per “Corrosiveness testing”.

Testing of the cleaning capability of the enzyme solution

15 Fabricate an X-OMAT BT medical X-ray film commercially available from Kodak Corporation (the X-OMAT BT medical X-ray film has the model number of XBT-1 and has gelatin on its surface) into a testing piece having a length of 8.0 ± 1.0 mm and a width of 3.0 ± 1.0 mm.

Adjust a thermostated water bath to a specified temperature ($37-40^\circ\text{C}$) and maintain the temperature.

20 Measure 80 ml of an enzyme solution to be tested using a 100 ml beaker.

Place the beaker containing the enzyme solution to be tested into the thermostated water bath and incubate until the system is at a stable temperature.

Lean the testing piece against the mouth of the beaker and put it into the thermostated enzyme solution to be tested, and start timing.

25 Observe with naked eyes and record the time t_1 when the gelatin coating on the testing piece begins to dissolve and the time t_2 when the gelatin coating completely dissolves.

Calculate the rinsing time t , $t = t_2 - t_1$.

If the rinsing time t is smaller than 8 minutes, then it indicates that the rinsing capability of the enzyme solution tested is acceptable.

30

Testing of enzyme activity

Perform the testing with a Gallery instrument commercially available from Thermo Fisher Corporation and according to the standard testing method “Testing of the activity of a proteinase in a mixed sample” provided by Novozymes Corporation.

5

Testing of compatibility of enzyme solution with non-woven fabric

Test the activity of the enzyme in a freshly prepared enzyme solution and record the activity as a_1 .

Mix the enzyme solution with a non-woven fabric in a weight ratio of 1.5:1 to 7:1 to obtain an enzyme-containing non-woven fabric, let the fabric stand for two weeks, then squeeze the enzyme solution out of the fabric and test the activity of the enzyme in the squeezed enzyme solution and record the activity as a_2 .

$$\text{Suppose } X_1 = (a_1 - a_2)/a_1 \times 100\%.$$

If $X_1 < 5\%$, then it indicates that the enzyme solution in the enzyme-containing non-woven fabric has good compatibility with the non-woven fabric.

15

Testing of enzyme stability

The testing of enzyme stability includes “testing of enzyme stability under normal temperature (10 to 25°C) condition” and “testing of enzyme stability under relatively high temperature (higher than 25°C) condition”.

20

Testing of enzyme stability under normal temperature (10 to 25°C) condition

Test the activity of the enzyme in a freshly prepared enzyme solution and record the activity as a_1 .

Mix the enzyme solution with a non-woven fabric in a weight ratio of 1.5:1 to 7:1 to obtain an enzyme-containing non-woven fabric.

25

Let the fabric stand for 3 months under the conditions of “25°C and 30 to 80% humidity”.

Squeeze the enzyme solution out of the fabric and test the activity of the enzyme in the squeezed enzyme solution and record the activity as a_3 .

$$\text{Suppose } X_2 = (a_1 - a_3)/a_1 \times 100\%.$$

If $X_2 < 15\%$, then it indicates that the enzyme solution in the enzyme-containing non-woven fabric has good enzyme stability under normal temperature (20 to 25°C) condition.

Testing of enzyme stability under relatively high temperature (higher than 25°C) condition:

- 5 Test the activity of the enzyme in a freshly prepared enzyme solution and record the activity as a_1 .

Mix the enzyme solution with a non-woven fabric in a weight ratio of 1.5:1 to 7:1 to obtain an enzyme-containing non-woven fabric.

Let the fabric stand for 2 weeks under the conditions of “54°C and 75% humidity”.

- 10 Squeeze the enzyme solution out of the fabric and test the activity of the enzyme in the squeezed enzyme solution and record the activity as a_4 .

Suppose $X_3 = (a_1 - a_4)/a_1 \times 100\%$.

- 15 If $X_2 < 25\%$, then it indicates that the enzyme solution in the enzyme-containing non-woven fabric has good enzyme stability under relatively high temperature (higher than 25°C) condition.

Microbial challenge testing

Perform the microbial challenge testing according to the method of GB-15979-2002:

Weigh 50 grams of an enzyme-containing non-woven fabric using an electronic balance.

- 20 Select a suspension of a mold (*Aspergillus niger*, *Penicillium citrinum*, *Gliocladium virens*, *Chaetomium globosum* and *Aureobaidium pullulans*) or a suspension of a bacterium (*E. coli*, *Staphylococcus aureus*, *Bacillus megaterium*, *Pseudomonas fluorescens* and *Bacillus subtilis*).

- 25 Inject 1 ml of the suspension of a mold or a bacterium to be tested into the enzyme solution, and stir to homogeneity with a sterile glass rod to obtain a microbial solution sample having a concentration of the mold or the bacterium of about 10^5 to 10^6 /ml.

Let the above microbial solution sample stand at a certain temperature in a thermostated incubator for 28 days (the incubation temperature for the mold is $28 \pm 1^\circ\text{C}$, and the incubation temperature for the bacterium is $36 \pm 1^\circ\text{C}$).

- 30 Every seven days, perform viable count or plate streaking of the mold or bacterium. If there is no colony growth, then it indicates that the enzyme solution passes the challenge testing

for the mold or the bacterium, and if there is colony growth, then it indicates that the enzyme solution fails the challenge testing for the mold or the bacterium and has the risk of mold or bacterium growth therein.

5 Endoscope damage testing

Rub the outer surface of an endoscope back and forth with an enzyme-containing non-woven fabric at “100 N, 10 cm/s” for 100 times. If the outer surface of the endoscope has no obvious scratches under visual inspection after the rubbing, then it indicates that the enzyme-containing non-woven fabric is less likely to cause damage to medical devices.

10

Corrosiveness testing

Perform the corrosiveness testing in accordance with the requirements in “Technical Standard For Disinfection - 2002” drafted by the Ministry of Health of China:

15 Grind the surface of a piece of metal sheet (stainless steel sheet) or rubber sheet (styrene butadiene rubber), wash the sheet clean and weigh the sheet, and record the weight as a_5 .

Put the metal sheet or rubber sheet into 200 ml of an enzyme solution to be tested and soak the sheet for 72 hours, then remove the sheet.

20 First flush the metal sheet or rubber sheet with water, then clean the surface of the sheet with a brush or other soft tool (products of corrosion present on the surface of the sheet, if there is any, must be removed from the sheet), and then weigh the sheet and record the weight as a_4 .

Suppose $X_4 = (a_5 - a_4)$.

If $X_4 = 0$, then it indicates that the enzyme solution does not corrode the metal sheet or rubber sheet, and thus passes the corrosiveness testing for the metal sheet or rubber sheet.

25 If $X_4 > 0$, then it indicates that the enzyme solution corrodes the metal sheet or rubber sheet, and thus fails the corrosiveness testing for the metal sheet or rubber sheet.

Examples 1 to 13 and Comparative Examples 1 to 7

Enzyme solution and enzyme-containing non-woven fabric are prepared respectively according to the ingredients and amounts thereof listed in Table 2a, Table 2b and Table 2c (the

amounts listed in the Table 2a , Table 2b and Table 2c are all counted by weight percentage) by the methods described above.

5 “Testing of the cleaning capability of the enzyme solution”, “testing of the compatibility of the enzyme solution with the non-woven fabric”, “testing of enzyme stability”, “microbial challenge testing”, “endoscope damage testing” and “corrosiveness testing” were respectively performed according to the methods described above. The results are respectively shown in Table 3, Table 4, Table 5, Table 6, Table 7, and Table 8.

Table 2a

	Ingredient	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7	Ex. 1	Ex. 2
Non-woven fabric	Non-woven fabric	100%	100%	50% viscose	50% viscose	50% viscose	50% viscose	50% viscose	50% viscose	50% viscose
		bamboo	viscose	fiber+	fiber+	fiber+	fiber+	fiber+	fiber+	fiber+
		fibers	fiber	50% terylene	50% terylene	50% terylene	50% terylene	50% terylene	50% terylene	50% terylene
SXS 93	Solubilizer	0.69	6.9	0.69	6.9	6.9	6.9	6.9	6.9	6.9
EH-6	Nonionic surfactant	0.1	1	0.1	1	1	1	1	1	1
A1058	Nonionic surfactant	0.04	0.5	0.04	0.5	0.5	0.5	0.5	0.5	0.5
Nipagurad CG	Isothiazolinone	0.3	1.5	0.3	0.5	0.5	1.5	1.5	1.5	1.5
BIT (Prexel GXL)	Benzoisothiazolone	0	0.1	0	0.1	1	0.1	0	0.1	1
Sodium	Sodium	0	0.5	0	0.5	0.5	0	0.5	0.5	0.5

benzoate	benzoate																			
Calcium chloride	Normal-temperature enzyme stabilizer	0.0025	0.025	0.0025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Borax	Normal-temperature enzyme stabilizer	0.192	0	0.192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycerol	Normal-temperature enzyme stabilizer	0.3	10	0.3	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Crodacor BE-LQ-(AP)	Corrosion inhibitor	0	0.5	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dissolvine D50	Chelator	0	0.5	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DK1247	Defoamer	0.02	0.15	0.02	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Water in the first solution	Water	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Citric acid	pH adjuster	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

Savinase	Enzyme	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Liquanase	Enzyme	0	0	0	0	0	0	0	0	0	0
Termamyl	Enzyme	0.2	0.05	0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lipolase	Enzyme	0.01	0.05	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Carezyme	Enzyme	0.007	0	0.007	0	0	0	0	0	0	0
Water added into the second solution	Water	57.66	37.74	57.65	38.75	37.85	38.25	37.85	37.75	36.85	

Table 2b

	Ingredient	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8	Ex. 9
Non-woven fabric	Non-woven fabric	50% viscose fiber+ 50% terylene fiber	550% viscose fiber+ 50% terylene fiber	50% viscose fiber+ 50% terylene fiber	50% viscose fiber+ 50% terylene fiber	50% viscose fiber+ 50% terylene fiber	50% viscose fiber+ 50% terylene fiber	50% viscose fiber + 50% terylene fiber
SXS 93	Solubilizer	6.9	6.9	6.9	6.9	6.9	6.9	6.9
EH-6	Nonionic surfactant	1	1	1	1	1	1	1

A1058	Nonionic surfactant	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Glucopon 425N/HH	nonionic surfactant	0	0	0	0	0	0	0	0
Nipaguard CG	Isothiazolinone	3	3	1.5	1.5	1.5	1.5	1.5	1.5
BIT (Prexel GXL)	Benzoisothiazolinone	0.1	1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium benzoate	Sodium benzoate	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5
Calcium chloride	Calcium chloride	0.025	0.025	0.025	0.025	0	0.025	0.025	0.025
Magnesium chloride	Magnesium chloride	0	0	0	0	0.69	0	0	0.69
Borax	Normal-temperature	0	0	0	0	0	0	0	0
	enzyme stabilizer								
Glycerol	Normal-temperature	10	10	10	10	10	10	10	10
	enzyme stabilizer								
Crodacor BE-LQ-(AP)	Corrosion inhibitor	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EDTA	Chelator	0	0	0	0	0	0.2	0	0
Dissolvine D50	Chelator	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5
DK1247	Defoamer	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Water in the first solution	Water	40	40	40	40	40	40	40	40
Citric acid	pH adjuster	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Savinase	Enzyme	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.05

Termamyl	Enzyme	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.01
Lipolase	Enzyme	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.001
Water added into the second solution	Water	36.25	35.35	37.45	37.15	36.08	37.05	36.40	

Table 2c

	Ingredient	Ex. 10	Ex. 11	Ex. 12	Ex. 13
Non-woven fabric	Non-woven fabric	50% viscose fiber+	50% viscose fiber+	50% viscose fiber+	50% viscose fiber+
SXS 93	Solubilizer	6.9	6.9	6.9	6.9
EH-6	Nonionic surfactant	1	1	1	1
A1058	Nonionic surfactant	0.5	0.5	0.5	0.5
Glucopon 425N/HH	nonionic surfactant	0	0	0	0
Nipagurad CG	Isothiazolinone	0.75	4	5	6
BIT(Prexel GXL)	Benzoisothiazolinone	0.1	0.1	0.1	0.1
Sodium benzoate	Sodium benzoate	0.5	0.5	0.5	0.5
Calcium chloride	Normal-temperature enzyme stabilizer	0.025	0.025	0.025	0.025
Magnesium chloride	Normal-temperature enzyme stabilizer	0	0	0	0
Borax	Normal-temperature enzyme stabilizer	0	0	0	0
Glycerol	Normal-temperature enzyme stabilizer	10	10	10	10
Crodacor BE-LQ-(AP)	Corrosion inhibitor	0.5	0.5	0.5	0.5
EDTA	Chelator	0	0	0	0
Dissolvine D50	Chelator	0.5	0.5	0.5	0.5
DK1247	Defoamer	0.15	0.15	0.15	0.15
Water in the first solution	Water	40	40	40	40
Citric acid	pH adjuster	0.18	0.18	0.18	0.18
Savinase	Enzyme	0.3	0.3	0.3	0.3
Termamyl	Enzyme	0.05	0.05	0.05	0.05
Lipolase	Enzyme	0.05	0.05	0.05	0.05
Water added into the second solution	Water	38.50	35.25	34.25	33.25

Table 3 Cleaning capability of the enzyme solution

Example 1	4 minutes and 30 seconds
Example 2	4 minutes and 50 seconds
Example 3	4 minutes and 05 seconds
Example 4	4 minutes and 35 seconds
Example 5	4 minutes and 11 seconds
Example 6	4 minutes and 56 seconds
Example 7	4 minutes and 31 seconds
Example 8	4 minutes and 10 seconds

Example 9	4 minutes and 30 seconds
Example 10	4 minutes and 25 seconds
Example 11	4 minutes and 05 seconds
Example 12	4 minutes and 07 seconds
Example 12	4 minutes and 07 seconds

According to Table 2a, 2b, 2c and 3, the enzyme solution in the enzyme-containing non-woven fabric provided in Examples 1 to 13 has good cleaning capability.

Table 4 Compatibility of enzyme solution with non-woven fabric

	X ₁ (%)
Example 1	0
Example 2	0
Example 3	0
Example 4	0
Example 5	0
Example 6	0
Example 7	0
Example 8	0
Example 9	0
Example 10	0
Example 11	0
Example 12	0
Example 13	0
Comparative Example 1	30
Comparative Example 2	15
Comparative Example 3	19

According to Table 2a, 2b, 2c and 4, the following can be known.

In the enzyme-containing non-woven fabric provided in Examples 1 to 13, the non-woven fabric contains an appropriate amount of viscose fiber and terylene fiber, and the enzyme solution contains 0.75 to 6 wt.% of isothiazolinone, 0.1 to 1 wt.% of benzoisothiazolinone and 0.1 to 1 wt.% of sodium benzoate, therefore the non-woven fabric has good compatibility with the enzyme.

In the enzyme-containing non-woven fabric provided in Comparative Example 1, the non-woven fabric only contains bamboo fibers, and the enzyme solution contains neither

benzothiazolinone nor sodium benzoate, therefore the non-woven fabric is less compatible with the enzyme.

In the enzyme-containing non-woven fabric provided in Comparative Example 2, the non-woven only contains viscose fiber, therefore the non-woven fabric is less compatible with the enzyme.

In the enzyme-containing non-woven fabric provided in Comparative Example 3, although the non-woven fabric contains an appropriate amount of viscose fiber and terylene fiber, the enzyme solution does not contain an appropriate amount of isothiazolinone, benzothiazolinone and sodium benzoate, therefore the non-woven fabric is less compatible with the enzyme.

Table 5 Enzyme stability

	X ₂ in the testing of enzyme stability under normal temperature (10 to 25°C) condition (%)	X ₃ in the testing of enzyme stability under relatively high temperature (higher than 25°C) condition (%)
Example 1	0	14
Example 2	0	21
Example 3	0	7
Example 4	2	14
Example 5	0	14
Example 6	0	15
Example 7	1	14
Example 8	0	14
Example 9	5	5
Example 10	2	14
Example 11	0	7
Example 12	0	7
Example 13	1	14
Comparative Example 1	17	51
Comparative Example 4	0	36
Comparative Example 5	0	43
Comparative Example 6	2	30
Comparative Example 7	0	32

According to Table 2a, 2b, 2c and 4, the following can be known.

In the enzyme-containing non-woven fabric provided in Examples 1 to 13, the enzyme solution contains 0.03 to 15 wt.% of normal-temperature enzyme stabilizer, therefore the enzyme solution dispersed in the non-woven fabric has good enzyme stability under normal temperature (10 to 25°C) condition.

In the enzyme-containing non-woven fabric provided in Examples 1 to 13, the enzyme solution contains 0.75 to 6 wt.% of isothiazolinone, 0.1 to 1 wt.% of benzoisothiazolinone and 0.1 to 1 wt.% of sodium benzoate, therefore the enzyme solution dispersed in the non-woven fabric has good enzyme stability under relatively high temperature (higher than 25°C) condition.

In the enzyme-containing non-woven fabric provided in Comparative Example 1, the enzyme solution contains 0.3 wt.% of isothiazolinone, does not contain benzoisothiazolinone or sodium benzoate, therefore the enzyme solution dispersed in the non-woven fabric has insufficient enzyme stability under relatively high temperature (higher than 25°C) condition.

In the enzyme-containing non-woven fabric provided in Comparative Example 4, the enzyme solution contains 0.5 wt.% of isothiazolinone, 0.1 wt.% of benzoisothiazolinone and 0.5 wt.% of sodium benzoate, the amount of isothiazolinone is not enough, therefore the enzyme solution dispersed in the non-woven fabric has insufficient enzyme stability under relatively high temperature (higher than 25°C) condition.

In the enzyme-containing non-woven fabric provided in Comparative Example 5, the enzyme solution contains 0.5 wt.% of isothiazolinone, 1 wt.% of benzoisothiazolinone and 0.5 wt.% of sodium benzoate, the amount of isothiazolinone is not enough, therefore the enzyme solution dispersed in the non-woven fabric has insufficient enzyme stability under relatively high temperature (higher than 25°C) condition.

In the enzyme-containing non-woven fabric provided in Comparative Example 6, the enzyme solution contains 1.5 wt.% of isothiazolinone and 0.1 wt.% of benzoisothiazolinone, does not contain sodium benzoate, therefore the enzyme solution dispersed in the non-woven fabric has insufficient enzyme stability under relatively high temperature (higher than 25°C) condition.

In the enzyme-containing non-woven fabric provided in Comparative Example 7, the enzyme solution contains 1.5 wt.% of isothiazolinone and 0.5 wt.% of sodium benzoate, does not contain benzoisothiazolinone, therefore the enzyme solution dispersed in the non-woven fabric has insufficient enzyme stability under relatively high temperature (higher than 25°C) condition.

Table 6 Microbial challenge testing

	Mold challenge testing	Bacteria challenge testing
Example 1	Passed	Passed
Example 2	Passed	Passed
Example 3	Passed	Passed
Example 4	Passed	Passed
Example 5	Passed	Passed
Example 6	Passed	Passed
Example 7	Passed	Passed
Example 8	Passed	Passed
Example 9	Passed	Passed
Example 10	Passed	Passed
Example 11	Passed	Passed
Example 12	Passed	Passed
Example 13	Passed	Passed
Comparative Example 3	Failed	Failed
Comparative Example 4	Failed	Failed
Comparative Example 5	Failed	Failed
Comparative Example 6	Failed	Failed
Comparative Example 7	Failed	Failed

According to Table 2a, 2b, 2c and 6, the following can be known.

In the enzyme-containing non-woven fabric provided in Examples 1 to 13, the enzyme solution contains 0.75 to 6 wt.% of isothiazolinone, 0.1 to 1 wt.% of benzoisothiazolinone and 0.1 to 1 wt.% of sodium benzoate,, therefore the enzyme solution dispersed in the non-woven fabric has good mold-resistant and bacteria-resistant properties.

In the enzyme-containing non-woven fabric provided in Comparative Example 3, the enzyme solution contains 0.3 wt.% of isothiazolinone, does not contain benzoisothiazolinone or sodium benzoate, therefore the enzyme solution dispersed in the non-woven fabric has insufficient mold-resistant and bacteria-resistant properties.

In the enzyme-containing non-woven fabric provided in Comparative Example 4, the enzyme solution contains 0.5 wt.% of isothiazolinone, 0.1 wt.% of benzoisothiazolinone and 0.5 wt.% of sodium benzoate, the amount of isothiazolinone is not enough,, therefore the enzyme solution dispersed in the non-woven fabric has insufficient mold-resistant and bacteria-resistant properties.

In the enzyme-containing non-woven fabric provided in Comparative Example 5, the enzyme solution contains 0.5 wt.% of isothiazolinone, 1 wt.% of benzoisothiazolinone and 0.5 wt.% of sodium benzoate, the amount of isothiazolinone is not enough, therefore the enzyme solution dispersed in the non-woven fabric has insufficient mold-resistant and bacteria-resistant properties.

In the enzyme-containing non-woven fabric provided in Comparative Example 6, the enzyme solution contains 1.5 wt.% of isothiazolinone and 0.1 wt.% of benzoisothiazolinone, does not contain sodium benzoate, therefore the enzyme solution dispersed in the non-woven fabric has insufficient mold-resistant and bacteria-resistant properties.

In the enzyme-containing non-woven fabric provided in Comparative Example 7, the enzyme solution contains 1.5 wt.% of isothiazolinone and 0.5 wt.% of sodium benzoate, does not contain benzoisothiazolinone, therefore the enzyme solution dispersed in the non-woven fabric has insufficient mold-resistant and bacteria-resistant properties.

Table 7 Endoscope damage testing

	Scratches on the outer surface of the endoscope
Example 1	No obvious scratches
Example 2	No obvious scratches
Example 3	No obvious scratches
Example 4	No obvious scratches
Example 5	No obvious scratches
Example 6	No obvious scratches
Example 7	No obvious scratches

Example 8	No obvious scratches
Example 9	No obvious scratches
Example 10	No obvious scratches
Example 11	No obvious scratches
Example 12	No obvious scratches
Example 13	No obvious scratches

According to Table 2a, 2b and 7, the enzyme-containing non-woven fabric provided in Examples 1 to 9 is less likely to cause damage to medical devices.

Table 8 Corrosiveness testing

	Metal sheet (stainless steel)	rubber sheet (styrene butadiene rubber)
Example 1	No corrosion occurred	No corrosion occurred
Example 2	No corrosion occurred	No corrosion occurred
Example 3	No corrosion occurred	No corrosion occurred
Example 4	No corrosion occurred	No corrosion occurred
Example 5	No corrosion occurred	No corrosion occurred
Example 6	No corrosion occurred	No corrosion occurred
Example 7	No corrosion occurred	No corrosion occurred
Example 8	No corrosion occurred	No corrosion occurred
Example 9	No corrosion occurred	No corrosion occurred
Example 10	No corrosion occurred	No corrosion occurred
Example 11	No corrosion occurred	No corrosion occurred
Example 12	No corrosion occurred	No corrosion occurred
Example 13	No corrosion occurred	No corrosion occurred

According to Table 2a, 2b, 2c and 8, the enzyme-containing non-woven fabric provided in Examples 1 to 13 is less likely to cause corrosion to the metal or rubber components of medical devices.

In summary of the above, the enzyme solution according to the present disclosure has good cleaning capability. Moreover, the enzyme solution according to the present disclosure comprises appropriate amount of isothiazolinone, benzoisothiazolinone and sodium benzoate, therefore the enzyme solution has good compatibility with the non-woven fabric comprising viscose fiber and terylene fiber. The enzyme solution dispersed in the non-woven fabric not only has good enzyme stability, but also has good mold-resistant and bacteria-resistant properties. Furthermore, the enzyme-containing non-woven fabric according to the present disclosure is less likely to cause damage to medical devices, and is less likely to cause corrosion to the metal or rubber components of medical devices.

Although the aforementioned detailed description contains many specific details for purpose of illustration, one of ordinary skill in the art will appreciate that many variations, changes, substitutions, and alterations to the details are within the scope of the invention as claimed. Accordingly, the disclosure described in the detailed description is set forth without imposing any limitations on the claimed invention. The proper scope of the present invention should be determined by the following claims and their appropriate legal equivalents. All of the references cited are herein incorporated by reference in their entirety.

CLAIMS:

1. An enzyme solution comprising, based on the total weight of the enzyme solution:
 - 0.1 to 10 wt.% of a nonionic surfactant;
 - 0.01 to 1.2 wt.% of an enzyme;
 - 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer;
 - 0.75 to 6 wt.% of an isothiazolinone;
 - 0.1 to 1 wt.% of a benzoisothiazolinone;
 - 0.1 to 1 wt.% of sodium benzoate;
 - 6.9 to 10 wt.% of a solubilizer;
 - 0.15 to 0.5 wt.% of a pH adjuster; and
 - 60 to 85 wt.% of water;the enzyme solution having a pH value of 6 to 10.
2. The enzyme solution according to claim 1, wherein the nonionic surfactant comprises at least one component selected from the group consisting of (i) a polymer based on at least one of ethylene oxide, propylene oxide or butylene oxide, (ii) an alkyl glucoside, (iii) a fatty alcohol polyoxyethylene ether, and (iv) an ammonium oxide.
3. The enzyme solution according to claim 1, wherein the enzyme comprises at least one component selected from the group consisting of a proteinase, an amylase, a lipase and a cellulase.
4. The enzyme solution according to claim 1, wherein the normal-temperature enzyme stabilizer comprises at least one component selected from the group consisting of glycerol, propylene glycol, calcium chloride, magnesium chloride, and boric acid.

5. The enzyme solution according to claim 1, wherein the isothiazolinone comprises at least one component selected from the group consisting of 5-chloro-2-methyl-4-isothiazolin-3-one and 2-methyl-4-isothiazolin-3-one.
6. The enzyme solution according to claim 1, wherein the benzoisothiazolinone comprises 1,2-benzoisothiazolin-3-one.
7. The enzyme solution according to claim 1, wherein the isothiazolinone and the benzoisothiazolinone are in a weight ratio of 3:1 to 30:1, and the isothiazolinone and the sodium benzoate are in a weight ratio of 1:1 to 30:1.
8. The enzyme solution according to claim 1, wherein the solubilizer comprises at least one component selected from the group consisting of xylene sulfonic acid, sodium xylene sulfonate, xylene sulfuric acid, sodium xylene sulfate, and alkyl amine oxide.
9. The enzyme solution according to claim 1, wherein the pH adjuster comprises citric acid.
10. The enzyme solution according to claim 1, wherein the enzyme solution further comprises 0.2 to 0.5 wt.% of a chelator based on the total weight of the enzyme solution.
11. The enzyme solution according to claim 10, wherein the chelator comprises at least one component selected from the group consisting of ethylenediamine tetraacetic acid and diethylenetriamine pentaacetic acid.
12. The enzyme solution according to claim 1, wherein the enzyme solution further comprises 0.5 to 10 wt.% of a corrosion inhibitor based on the total weight of the enzyme solution.

13. The enzyme solution according to claim 12, wherein the corrosion inhibitor comprises at least one component selected from the group consisting of a borate ester, a silicate, and polyaspartic acid.

14. The enzyme solution according to claim 1, wherein the enzyme solution further comprises 0.1 to 0.3 wt.% of a defoamer, based on the total weight of the enzyme solution.

15. The enzyme solution according to claim 14, wherein the defoamer comprises at least one component selected from the group consisting of a silicone oil, a polyether, and a higher alcohol.

16. A method of preparing an enzyme solution, comprising the step of mixing the ingredients of the enzyme solution according to any one of claims 1 to 15.

17. The method according to claim 16, wherein based on the total weight of the enzyme solution, the method comprises the steps of:

sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1 to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer into 30 to 60 wt.% of water to obtain a first solution;

adding 0.15 to 0.5 wt.% of a pH adjuster to the first solution to obtain a second solution having a pH value of 6 to 10; and

adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

18. The method according to claim 16, wherein based on the total weight of the enzyme solution, the method comprises the steps of:

sequentially adding 6.9 to 10 wt.% of a solubilizer, 0.1 to 10 wt.% of a nonionic surfactant, 0.75 to 6 wt.% of an isothiazolinone, 0.1 to 1 wt.% of a benzoisothiazolinone, 0.1

to 1 wt.% of sodium benzoate, 0.03 to 15 wt.% of a normal-temperature enzyme stabilizer, 0.2 to 0.5 wt.% of a chelator, 0.5 to 10 wt.% of a corrosion inhibitor, and 0.1 to 0.3 wt.% of a defoamer into 30 to 60 wt.% of water to obtain a first solution;

adding 0.15 to 0.5 wt.% of a pH adjuster to the first solution to obtain a second solution having a pH value of 6 to 10; and

adding 0.01 to 1.2 wt.% of an enzyme and 3 to 51 wt.% of water into the second solution to obtain the enzyme solution.

19. An enzyme-containing non-woven fabric, comprising a non-woven fabric and an enzyme solution according to any one of claims 1 to 15 dispersed in the non-woven fabric;

wherein, based on the total weight of the enzyme solution, the non-woven fabric comprises 20-50 wt.% of viscose fiber and 50-80 wt.% of terylene fiber; and

the enzyme solution and the non-woven fabric are in a weight ratio of 1.5:1 to 7:1.

20. A method of preparing an enzyme-containing non-woven fabric, comprising the step of allowing the enzyme solution according to any one of claims 1 to 15 to disperse into a non-woven fabric, wherein the non-woven fabric comprises 20 to 50 wt.% of viscose fiber and 50 to 80 wt.% of terylene fiber based on the total weight of the non-woven fabric; and the enzyme solution and the non-woven fabric are in a weight ratio of 1.5:1 to 7:1.

21. Use of the enzyme-containing non-woven fabric according to claim 19 in cleaning medical devices.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/013313

A. CLASSIFICATION OF SUBJECT MATTER INV. A61L2/16 B08B1/00 C11D3/386 C11D3/48 C11D11/00 C11D17/04 ADD. According to International Patent Classification (IPC) or to both national classification and IPC														
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A61L B08B C11D Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>WO 2010/129871 A1 (3M INNOVATIVE PROPERTIES CO [US]; LIU TING [CN]; LIU ZHILAN [CN]; LI Y) 11 November 2010 (2010-11-11) claims; examples -----</td> <td>1-21</td> </tr> <tr> <td>A</td> <td>WO 2004/015051 A1 (COLGATE PALMOLIVE CO [US]) 19 February 2004 (2004-02-19) page 16, line 24 - page 17, line 2; claims; example 1 -----</td> <td>1-21</td> </tr> <tr> <td>A</td> <td>WO 2004/094080 A1 (NOVAPHARM RES AUSTRALIA [AU]; KRITZLER STEVEN [AU]) 4 November 2004 (2004-11-04) claims; examples ----- -/-</td> <td>1-21</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	WO 2010/129871 A1 (3M INNOVATIVE PROPERTIES CO [US]; LIU TING [CN]; LIU ZHILAN [CN]; LI Y) 11 November 2010 (2010-11-11) claims; examples -----	1-21	A	WO 2004/015051 A1 (COLGATE PALMOLIVE CO [US]) 19 February 2004 (2004-02-19) page 16, line 24 - page 17, line 2; claims; example 1 -----	1-21	A	WO 2004/094080 A1 (NOVAPHARM RES AUSTRALIA [AU]; KRITZLER STEVEN [AU]) 4 November 2004 (2004-11-04) claims; examples ----- -/-	1-21
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International application No

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Information on patent family members

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