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(54) **CONTACT LENS FOR DETECTING GLUCOSE LEVEL IN TEARS AND METHOD FOR MAKING THE SAME**

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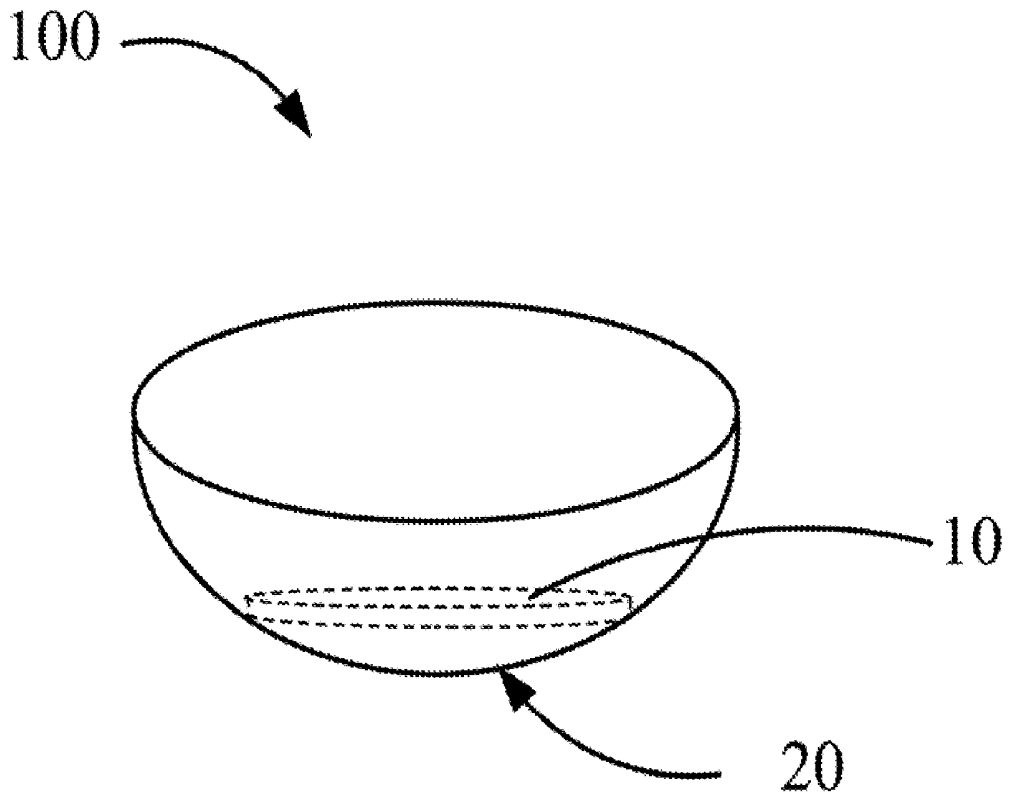
(57) **ABSTRACT**

A contact lens for detecting body glucose in tears includes a gel substrate, a plurality of platinum nanoparticles dispersed in the gel substrate, and a biosensor received in the gel substrate. The biosensor receives the glucose from tears as glucose oxidase and the glucose acid and hydrogen peroxide (H_2O_2) produced are decomposed to water and hydrogen peroxide. The platinum nanoparticles function as a catalytic agent to accelerate the degradation of the hydrogen peroxide into water and oxygen, avoiding or reducing hypoxia of the eye.



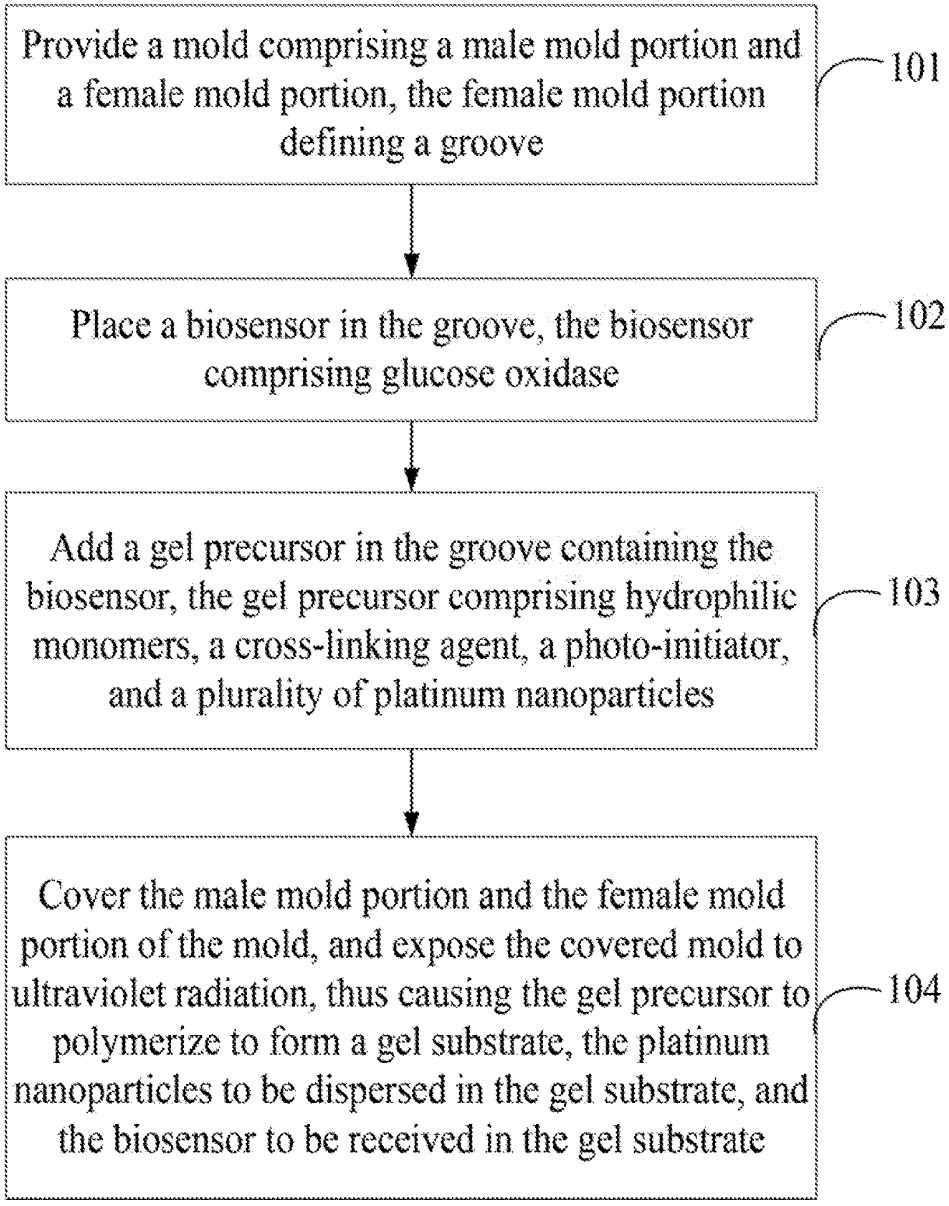

Provide a mold comprising a male mold portion and a female mold portion, the female mold portion defining a groove
101
Place a biosensor in the groove, the biosensor comprising glucose oxidase
102
Add a gel precursor in the groove containing the biosensor, the gel precursor comprising hydrophilic monomers, a cross-linking agent, a photo-initiator, and a plurality of platinum nanoparticles
103
Cover the male mold portion and the female mold portion of the mold, and expose the covered mold to ultraviolet radiation, thus causing the gel precursor to polymerize to form a gel substrate, the platinum nanoparticles to be dispersed in the gel substrate, and the biosensor to be received in the gel substrate
104

FIG. 1

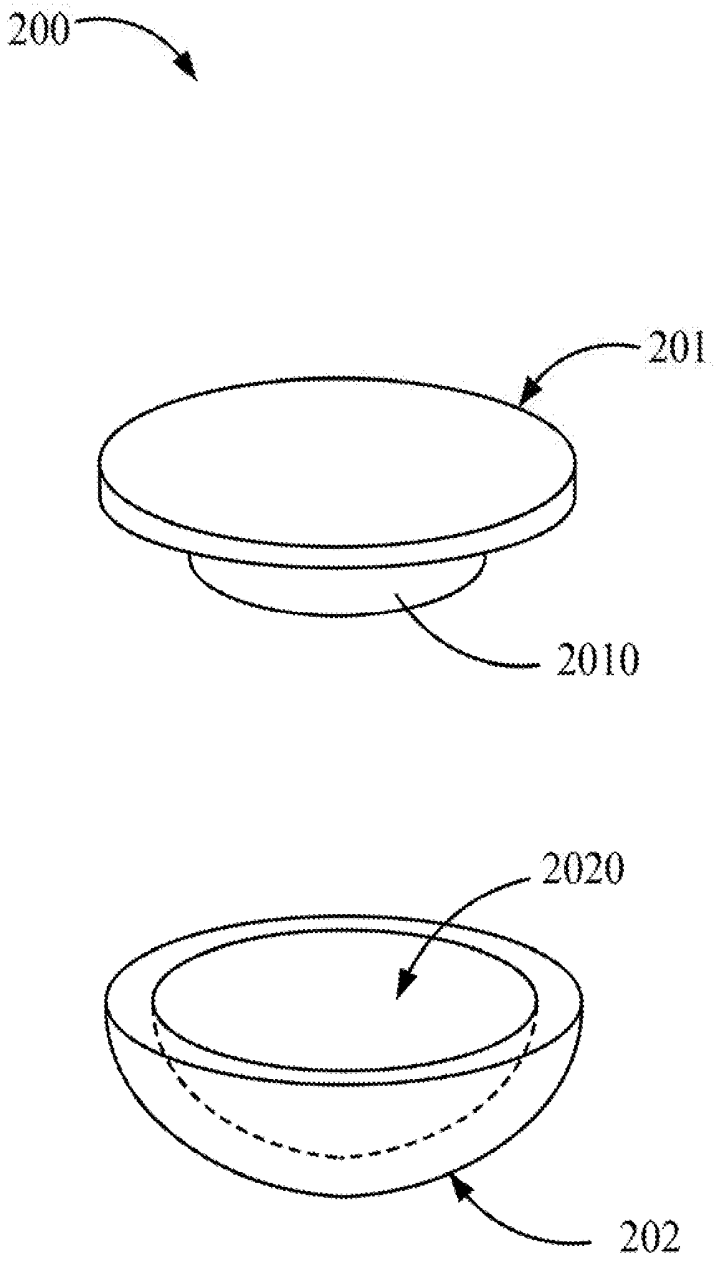


FIG. 2

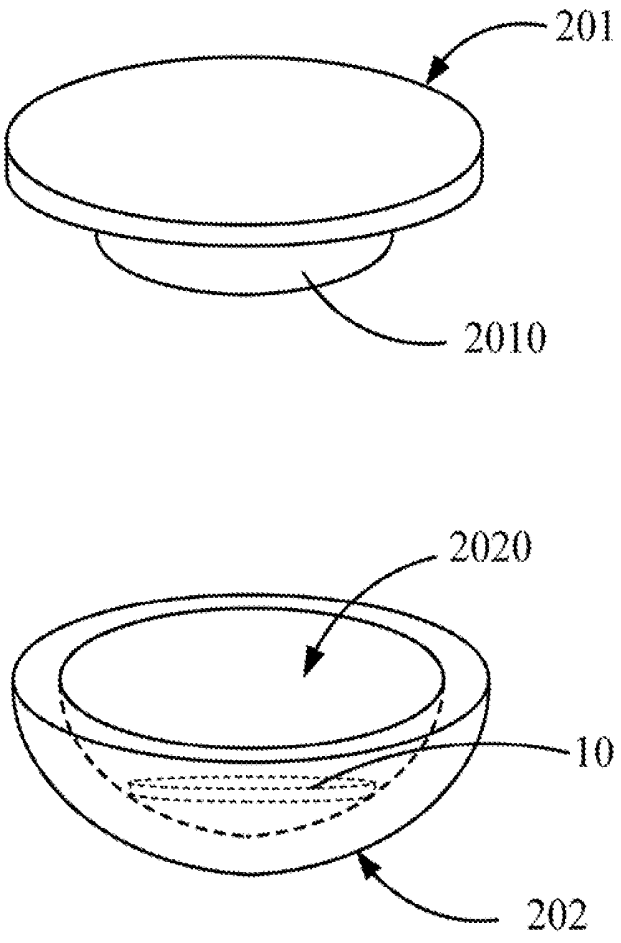


FIG. 3

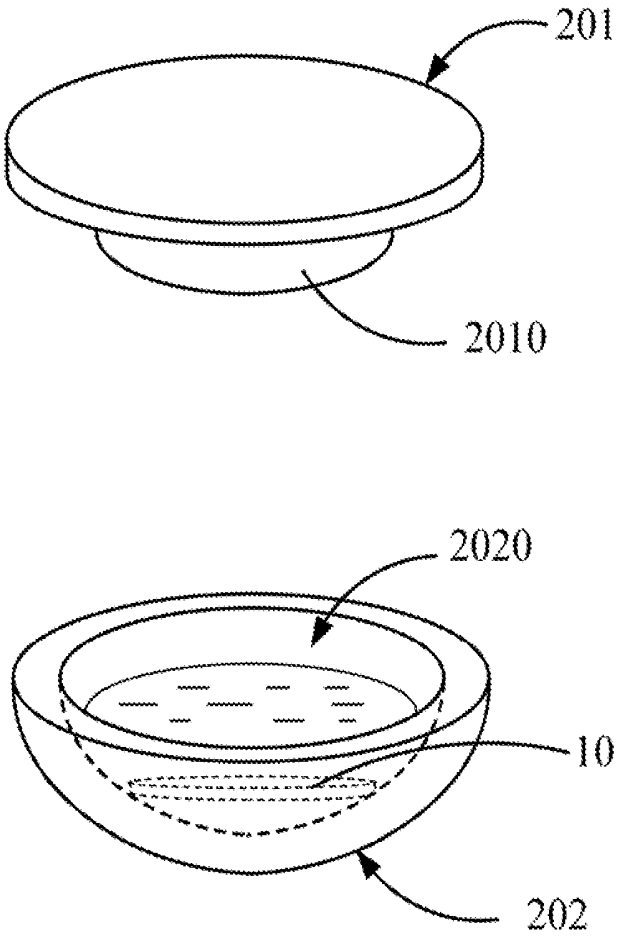


FIG. 4

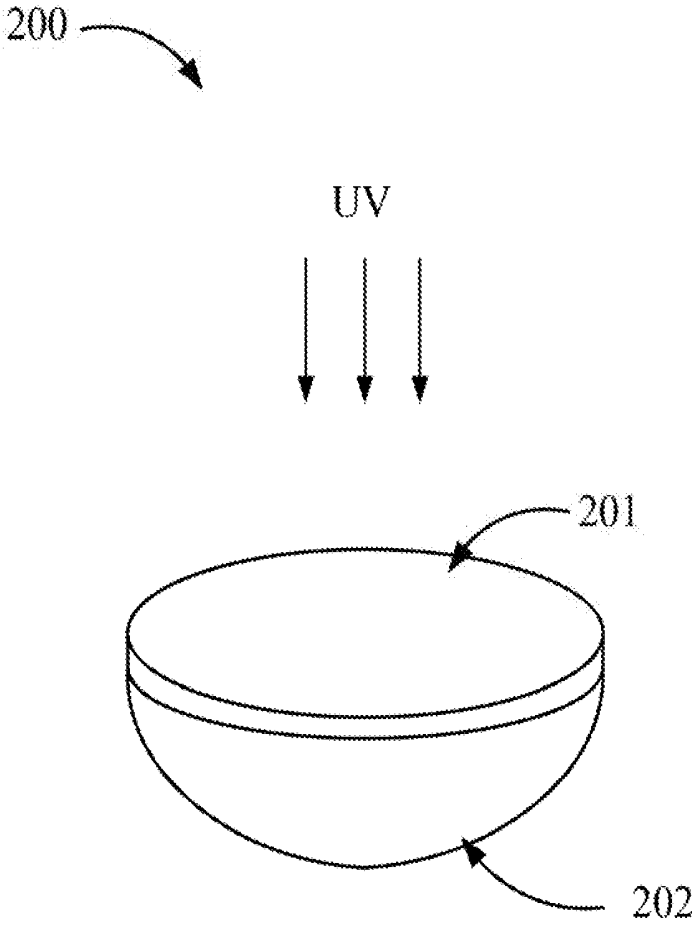


FIG. 5

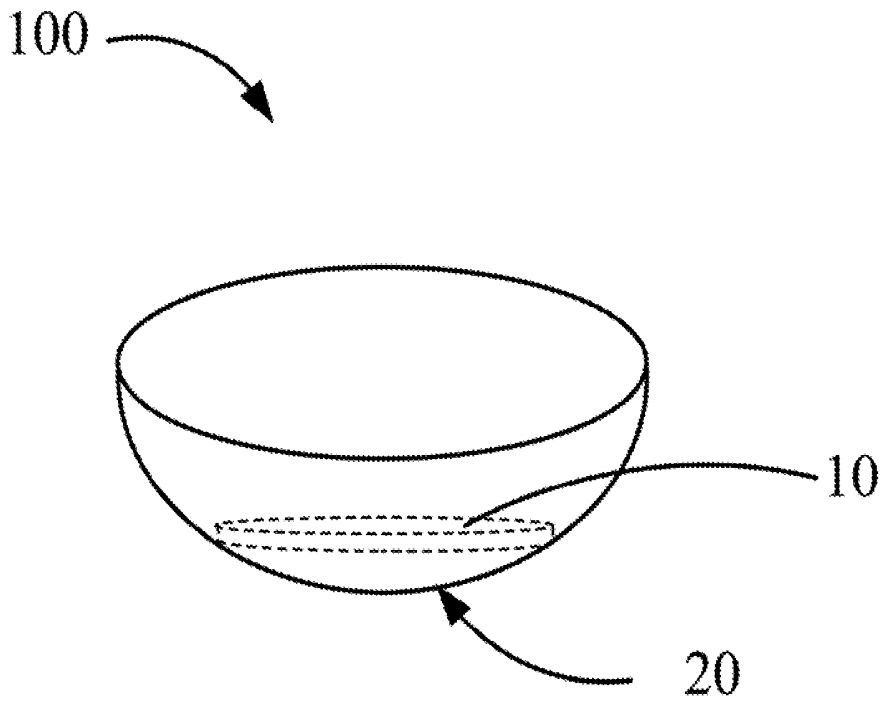


FIG. 6

CONTACT LENS FOR DETECTING GLUCOSE LEVEL IN TEARS AND METHOD FOR MAKING THE SAME

FIELD

[0001] The subject matter herein generally relates to health, and more particularly, to a contact lens for detecting body glucose level by reference to tears and a method for making the contact lens.

BACKGROUND

[0002] Monitoring glucose levels in blood regularly is very important in diabetes management. Body fluids, including tears, are potential sources for tracking glucose levels. Tracking glucose levels in tears is non-invasive and convenient. Currently, some available contact lenses can monitor the glucose levels in tears. However, a user who wears these glucose monitoring contact lens for a long time may suffer from hypoxia, and hypoxia may cause eye damage such as acute red eye, corneal swelling, blurred vision, and eye infections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Implementations of the present technology will now be described, by way of example only, with reference to the attached figures.

[0004] FIG. **1** is a flowchart of an exemplary embodiment of a method for making a contact lens for detecting glucose level in tears.

[0005] FIG. **2** is a diagram of a mold comprising a female mold portion and a male mold portion used in the method of FIG. **1**.

[0006] FIG. **3** is a diagram showing a biosensor placed in the female mold portion of FIG. **2**.

[0007] FIG. **4** is a diagram showing a gel precursor added in the female mold portion of FIG. **3**.

[0008] FIG. **5** is a diagram showing the female mold portion and the male mold portion covered and exposed to ultraviolet radiation.

[0009] FIG. **6** is a diagram of the contact lens formed after the ultraviolet radiation of FIG. **5**.

DETAILED DESCRIPTION

[0010] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale, and the proportions of certain parts may be exaggerated to illustrate details and features of the present disclosure better.

[0011] The disclosure is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings, in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

[0012] The term "comprising," when utilized, means "including, but not necessarily limited to"; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

[0013] FIG. **1** illustrates a flowchart of an embodiment for a method for making a contact lens for detecting glucose level in tears. The exemplary method is provided by way of example, as there are a variety of ways to carry out the method. Each block shown in the figure represents one or more processes, methods, or subroutines, carried out in the exemplary method. Furthermore, the illustrated order of blocks is by example only, and the order of the blocks can change. Additional blocks may be added or fewer blocks may be utilized, without departing from this disclosure. The exemplary method can begin at block **101**.

[0014] At block **101**, referring to FIG. **2**, a mold **200** is provided that comprises a male mold portion **201** and a female mold portion **202**. The female mold portion **202** defines a groove **2020**. The male mold portion **201** comprises a protruding block **2010**. When the male mold portion **201** covers the female mold portion **202**, the protruding block **2010** and the groove **2020** cooperatively define a molding space (not shown) which matches the contact lens **100** in shape.

[0015] At block **102**, referring to FIG. **3**, a biosensor **10** is placed in the groove **2020**. The biosensor **10** can detect and indicate glucose level in tears.

[0016] At block **103**, referring to FIG. **4**, a gel precursor is added in the groove **2020** containing the biosensor **10**. The gel precursor comprises hydrophilic monomers, a cross-linking agent, a photo-initiator, and a plurality of platinum (Pt) nanoparticles. Each of the platinum nanoparticles has a diameter of about 5 nm to about 200 nm.

[0017] In at least one exemplary embodiment, the hydrophilic monomers have a mass percentage of about 68.4% to about 99.2% of a total mass of the gel precursor. The cross-linking agent has a mass percentage of about 0.03% to about 14.2% of the total mass of the gel precursor. The photo-initiator has a mass percentage of about 0.12% to about 18.6% of the total mass of the gel precursor. The platinum nanoparticles have a mass percentage of about 0.001% to about 0.2% of the total mass of the gel precursor.

[0018] In at least one exemplary embodiment, the hydrophilic monomers can be selected from a group consisting of 2-hydroxyethyl methacrylate (HEMA), N,N'-dimethylacrylamide (DMA), methyl methacrylate (MMA), N-vinyl pyrrolidone (NVP), polyethylene glycol maleate (PEGMA), 3-[tris(trimethylsilyl)silyl]propylmethacrylate (TRIS), polydimethylsiloxane (PDMS), hydroxyethyl acrylate (HEA), hydroxypropyl methacrylate (HPMA), dimethylaminoethyl methacrylate (DMAEMA), methyl acrylate (MA), and any combination thereof.

[0019] The cross-linking agent can be selected from a group consisting of ethylene glycol dimethacrylate (EGDMA), trimethylolpropane trimethacrylate (TMPTMA), N,N'-methylenediacrylamide (MBAA), and any combination thereof.

[0020] The photo-initiator can be selected from a group consisting of benzoin methyl ether, diethoxyacetophenone, benzoylphosphine oxide initiator, 1-hydroxycyclohexyl phenyl ketone, Darocure type initiator, Irgacure type initiator, and any combination thereof. The benzoylphosphine oxide

initiator may be selected from a group consisting of 2,4,6-trimethylbenzoyldiphenylophosphine oxide, bis-(2,6-dichlorobenzoyl)-4-N-propylphenylphosphine oxide, and bis-(2,6-dichlorobenzoyl)-4-N-butylphenylphosphine oxide. The Irgacure type initiator can be Irgacure-1173 (the trade name, available commercially from Chemical Industries Basel Corporation as a clear liquid).

[0021] At block **104**, referring to FIGS. **5** and **6**, the male mold portion **201** of the mold **200** covers the female mold portion **202** to define the molding space, and the covered mold **200** is exposed to ultraviolet radiation. The gel precursor polymerizes in the molding space under the ultraviolet radiation to form a gel substrate **20**. The platinum nanoparticles are dispersed in the gel substrate **20**, and the biosensor **10** received in the gel substrate **10**. Thus, the contact lens **100** is formed.

[0022] The biosensor **10** comprises an electrode (not shown) that comprises glucose oxidase (GOx). When the biosensor **10** contacts glucose in tears, since the gel substrate **20** is microscopically porous, the glucose can enter the gel substrate **20** and react with oxygen in the ambient environment under the function of glucose oxidase, to form glucose acid and hydrogen peroxide (H_2O_2). The hydrogen peroxide can degrade to form water and oxygen. The glucose level in tears is in proportion to the concentration of the hydrogen peroxide, and the concentration of the hydrogen peroxide is in proportion to the concentration of oxygen. Thus, the glucose level in tears can be measured by determining the concentration of oxygen. Furthermore, the platinum nanoparticles can function as a catalytic agent that can accelerate the degradation of the hydrogen peroxide, namely, accelerate the generation of water and oxygen. The reaction between the glucose and the biosensor **10** is as follows:

$$\text{glucose} + O_2 \xrightarrow{\text{GOx}} \text{glucose-acid} + H_2O_2$$

$$H_2O_2 \xrightarrow{\text{Pt}} 2H_2O + O_2$$

Example 1

[0023] A biosensor **10** was placed in the groove **2020** of a female mold portion **202**. A gel precursor was added in the groove **2020**. The gel precursor comprised HEMA, EGDMA, Irgacure1173, and a plurality of platinum nanoparticles. In the gel precursor, the HEMA had a mass percentage of 98%, the EGDMA had a mass percentage of 0.82%, the Irgacure1173 had a mass percentage of 1.06%, the platinum nanoparticles had a mass percentage of 0.12%, and each platinum nanoparticle had a diameter of 52 nm. The male mold portion **201** covered the female mold portion **202**, and the covered mold **200** was exposed to ultraviolet radiation of 365 nm for 12 minutes, thereby forming the contact lens **100**.

Example 2

[0024] A biosensor **10** was placed in the groove **2020** of a female mold portion **202**. A gel precursor was added in the groove **2020**. The gel precursor comprised HEMA, NVP, TRIS, TMPTMA, Irgacure1173, and a plurality of platinum nanoparticles. In the gel precursor, the HEMA had a mass percentage of 25.1%, the NVP had a mass percentage of 42.6%, the TRIS had a mass percentage of 30.45%, the TMPTMA had a mass percentage of 0.87%, the Irgacure1173 had a mass percentage of 0.92%, the platinum nanoparticles had a mass percentage of 0.06%, and each platinum nanoparticle had a diameter of 105 nm. The male mold portion **201** covered the female mold portion **202**, and the covered mold **200** was exposed to ultraviolet radiation of 365 nm for 23 minutes, thereby forming the contact lens **100**.

[0025] FIG. **6** illustrates an exemplary embodiment of a contact lens **100**. The contact lens **100** comprises a gel substrate **20** and a number of platinum nanoparticles dispersed in the gel substrate **20**. Each of the platinum nanoparticles has a diameter of about 5 nm to about 200 nm. The platinum nanoparticles have a mass percentage of about 0.001% to about 0.2% of the total mass of the gel substrate **10**.

[0026] The gel substrate **20** further comprises a biosensor **10** received therein. The biosensor **10** comprises glucose oxidase which can detect glucose level in tears.

[0027] In at least one exemplary embodiment, the gel substrate **20** is made of hydrogel or silicone hydrogel.

[0028] With the above configuration, the contact lens **100** comprises the biosensor **10** for detecting glucose level in tears. Furthermore, the platinum nanoparticles dispersed in the gel substrate **20** accelerate the generation of water and oxygen, thus the contact lens **100** can prevent the user from suffering from hypoxia.

[0029] Depending on the embodiment, certain of the steps of methods hereinbefore described may be removed, others may be added, and the sequence of steps may be altered. It is also to be understood that the description and the claims drawn to a method may include some indication in reference to certain steps. However, the indication used is only to be viewed for identification purposes and not as a suggestion as to an order for the steps.

[0030] It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A method for making a contact lens for detecting glucose level in tears comprising:

providing a mold comprising a male mold portion and a female mold portion, the female mold portion defining a groove;

placing a biosensor in the groove, the biosensor comprising glucose oxidase;

adding a gel precursor in the groove containing the biosensor, the gel precursor comprising hydrophilic monomers, a cross-linking agent, a photo-initiator, and a plurality of platinum nanoparticles; and

covering the male mold portion with the female mold portion; and

exposing the covered mold to ultraviolet radiation.

2. The method of claim **1**, further comprising, causing the gel precursor to polymerize to form a gel substrate, dispersing the platinum nanoparticles in the gel substrate, and receiving the biosensor in the gel substrate, thereby forming the contact lens.

3. The method of claim 1, wherein each of the plurality of platinum nanoparticles has a diameter of about 5 nm to about 200 nm.

4. The method of claim 1, wherein the hydrophilic monomers have a mass percentage of about 68.4% to about 99.2% of a total mass of the gel precursor, the cross-linking agent has a mass percentage of about 0.03% to about 14.2% of the total mass of the gel precursor, the photo-initiator has a mass percentage of about 0.12% to about 18.6% of the total mass of the gel precursor, and the plurality of platinum nanoparticles has a mass percentage of about 0.001% to about 0.2% of the total mass of the gel precursor.

5. The method of claim 1, wherein the hydrophilic monomers are selected from a group consisting of 2-hydroxyethyl methacrylate, N,N'-dimethylacrylamide, methyl methacrylate, N-vinyl pyrrolidone, polyethylene glycol maleate, 3-[tris(trimethylsilyl)silyl]propylmethacrylate, polydimethylsiloxane, hydroxyethyl acrylate, hydroxypropyl methacrylate, dimethylaminoethyl methacrylate, methyl acrylate, and any combination thereof.

6. The method of claim 1, wherein the cross-linking agent is selected from a group consisting of ethylene glycol dimethacrylate, trimethylolpropane trimethacrylate, N,N'-methylenediacrylamide, and any combination thereof.

7. The method of claim 1, wherein the photo-initiator is selected from a group consisting of benzoin methyl ether, diethoxyacetophenone, benzoylphosphine oxide initiator, 1-hydroxycyclohexyl phenyl ketone, Darocure type initiator, Irgacure type initiator, and any combination thereof.

8. The method of claim 7, wherein the benzoylphosphine oxide initiator is selected from a group consisting of 2,4,6-trimethylbenzoyldiphenylophosphine oxide, bis-(2,6-dichlorobenzoyl)-4-N-propylphenylphosphine oxide, and bis-(2,6-dichlorobenzoyl)-4-N-butylphenylphosphine oxide.

9. A contact lens for detecting glucose level in tears comprising:

a gel substrate;

a plurality of platinum nanoparticles dispersed in the gel substrate; and

a biosensor received in the gel substrate, the biosensor comprising glucose oxidase.

10. The contact lens of claim 9, wherein each of the plurality of platinum nanoparticles has a diameter of about 5 nm to about 200 nm.

11. The contact lens of claim 9, wherein the plurality of platinum nanoparticles has a mass percentage of about 0.001% to about 0.2% of the total mass of the gel substrate.

12. The contact lens of claim 9, wherein the gel substrate is made of hydrogel or silicone hydrogel.

* * * * *

专利名称(译)	用于检测泪液中葡萄糖水平的隐形眼镜及其制造方法		
公开(公告)号	US20190015022A1	公开(公告)日	2019-01-17
申请号	US15/658483	申请日	2017-07-25
[标]申请(专利权)人(译)	鸿海精密工业股份有限公司		
申请(专利权)人(译)	鸿海精密工业股份有限公司.		
当前申请(专利权)人(译)	鸿海精密工业股份有限公司.		
[标]发明人	CHIEN HSIU WEN		
发明人	CHIEN, HSIU-WEN		
IPC分类号	A61B5/145 A61B5/1486 A61B5/00 G02C11/00 G02B1/04 B29D11/00		
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优先权	106123257 2017-07-11 TW		
外部链接	Espacenet USPTO		

摘要(译)

用于检测泪液中的体内葡萄糖的隐形眼镜包括凝胶基质，分散在凝胶基质中的多个铂纳米颗粒，以及容纳在凝胶基质中的生物传感器。生物传感器接收来自眼泪的葡萄糖作为葡萄糖氧化酶，并且产生的葡萄糖酸和过氧化氢（H2O2）被分解成水和过氧化氢。铂纳米颗粒用作催化剂以加速过氧化氢降解为水和氧，从而避免或减少眼睛的缺氧。