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(54) Drug carrying contact lens

Medikamententragende Kontaktlinse

Lentille de contact de support de médicaments

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(56) References cited:
US-A1- 2004 241 207 **US-A1- 2010 113 901**
US-A1- 2012 153 520

- **GULSEN D ET AL: "Dispersion of microemulsion drops in HEMA hydrogel: a potential ophthalmic drug delivery vehicle", INTERNATIONAL JOURNAL OF PHARMACEUTICS, ELSEVIER BV, NL, vol. 292, no. 1-2, 23 March 2005 (2005-03-23), pages 95-117, XP004752474, ISSN: 0378-5173, DOI: 10.1016/J.IJPHARM.2004.11.033**

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a drug eluting technology in contact lenses as defined by the claims, particularly to a drug-carrying contact lens that can release drugs locally for a long period of time.

Description of the Related Art

[0002] Many people suffer from damaged or degenerating eyesight, such as myopia. Normally, the nearsighted wears glasses or contact lenses to obtain clear vision. For some people, the contact lens is a favorable option. The contact lenses may be categorized into the rigid contact lens and the soft contact lens. The soft contact lens is normally made of silicone hydrogels, PAA (polyacrylamide), or PHEMA (poly-2-hydroxy ethyl-methacrylate). The soft contact lens is more comfortable and cheaper for the users and thus becomes the mainstream in the market. Although the material of the soft contact lens has been greatly improved, the irritation problem of wearing contact lenses still exists. The user wearing contact lenses usually feels eyes dry and irritable because humidity decreases in user's eyes. Thus, the user has to apply a wetting agent to the contact lenses. When infected or irritated, eyes need some eyedrops or refreshing liquids. However, most of eyedrops or refreshing liquids are unlikely to apply to the eyes wearing contact lenses. In such a condition, the users should feel very inconvenient.

[0003] No matter whether the user wears contact lenses or not, the eyedrop, which has been dropped into eyes, would lose because of blinking, dilution, or rejection. Thus, the eyes can only absorb about 5% of the drug. Besides, the drug stays in eyes only for a short period of time. Once the drug enters the blood circulation, some side effects may occur.

[0004] A potential ophthalmic drug delivery vehicle is described in Gulsen D. et al: "Dispersion of microemulsion drops in HEMA hydrogel: a potential ophthalmic drug delivery vehicle", International Journal of Pharmaceutics, Elsevier BV, NL, vol. 292, no. 1-2, 23 March 2005, pages 95 - 117. A drug delivery system comprising a contact lens is described in US 2004/0241207 Al, while in US 2010/0113901 Al a contact lens integrated with a biosensor for the detection of glucose and other components in tears is described.

[0005] Accordingly, the present invention proposes a drug-carrying contact lens according to the claims to prevent or cure ocular diseases and overcome the abovementioned problems.

SUMMARY OF THE INVENTION

[0006] The primary objective of the present invention is to provide a drug-carrying contact lens according to the claims , wherein a high biocompatibility nanocarrier having superior drug encapsulation capability is used to wrap drugs or absorb drug molecules from a drug solution and make the drugs uniformly distributed in a contact lens, whereby the contact lens can locally release the drugs to the eyes to prevent or cure ocular diseases.

[0007] Another objective of the present invention is to provide a drug-carrying contact lens, wherein the drug molecules carried by the contact lens can be gradually released to the tissue of the eye for a long period of time (>24 hours), whereby the loss and side effects of the drug are minimized.

[0008] To achieve the abovementioned objectives, the present invention proposes a drug-carrying contact lens as defined by the claims, which comprises a contact lens containing at least one amphiphatic hybrid nanocarrier carrying drug molecules, whereby the drug molecules are encapsulated within the hybrid nanocarriers and uniformly distributed throughout the contact lens.

[0009] The amphiphatic hybrid nanocarrier is an amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier.

[0010] A method comprises steps: adding amphiphatic hybrid nanocarriers to a drug solution, and agitating them into a uniform first mixture solution; fully mixing the first mixture solution with a contact lens material to form a second mixture solution, and pouring the second mixture solution into at least one mold; light-curing the second mixture solution in the mold, and demolding the cured second mixture solution to obtain a first encapsulation-type drug-carrying contact lens.

[0011] In another embodiment, the method comprises steps: mixing a drug solution, an amphiphatic hybrid nanocarrier and a contact lens material, and agitating them into a uniform third mixture solution; spraying the third mixture solution onto the surface of a contact lens to form a film on the surface of contact lens, covered either all or part of the surface of a given contact lens; and obtain a second encapsulation-type drug-carrying contact lens.

[0012] In a further embodiment, the method comprises steps: mixing an amphiphatic hybrid nanocarrier and a contact lens material, and agitating them into a uniform fourth mixture solution; pouring the fourth mixture solution into at least one mold, light-curing the fourth mixture solution, and demolding the cured fourth mixture solution to obtain a nanocarrier-containing contact lens; soaking the nanocarrier-containing contact lens in a drug solution until concentration reaches

a dynamic equilibrium to obtain a drug-soaking type drug-carrying contact lens.

[0013] Below, the embodiments are described in detail in cooperation with the attached drawings to make easily understood the objectives, technical contents, characteristics and accomplishments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig.1 schematically shows the structural formula of an amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier and the self-assembly thereof according to one embodiment of the present invention;
Fig.2 shows a flowchart of a method for fabricating a first encapsulation-type drug-carrying contact lens;
Fig.3 shows a flowchart of a method for fabricating a second encapsulation-type drug-carrying contact lens;
Fig.4 shows a flowchart of a method for fabricating a drug-soaking type drug-carrying contact lens;
Fig.5 shows the test result of the water retentions of the drug-carrying contact lenses with respect to the quantities of the nanocarriers added to the contact lenses;
Fig.6 shows the drug release test result of Azithromycin contained by the encapsulation-type drug-carrying contact lens with respect to the temperature;
Fig.7(a) shows the drug release test result of Vitamin B12 respectively contained by the drug-carrying contact lens containing the drug carriers of the present invention and the drug-carrying contact lens free of drug carriers;
Fig.7(b) shows the drug release test result of the drug-carrying contact lenses of the present invention respectively containing different concentrations of Vitamin B12;
Fig.8(a) shows the SEM image of the amphiphatic organic-inorganic chitosan-silica hybrid nanocarriers of the present invention; and
Fig.8(b) shows the SEM image of the drug-carrying contact lens of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention pertains to a local drug delivery technology, wherein a contact lens releases a drug locally to prevent or cure ocular diseases. In the present invention, a high biocompatible nanocarrier having superior drug-encapsulation capability wraps and carries a drug, and uniformly distributed in a contact lens as defined by the claims. The contact lens can gradually release the drug to the eye for a reasonably long period of time (>24 hours), whereby the loss and side effects of the drug are minimized.

[0016] The drug-carrying contact lens of the present invention comprises a contact lens containing at least one amphiphatic hybrid nanocarrier as defined by the claims. The amphiphatic hybrid nanocarrier carries hydrophilic or hydrophobic drug molecules. The amphiphatic hybrid nanocarriers and the drug molecules carried by the amphiphatic hybrid nanocarriers are distributed throughout the contact lens or on the surface of the contact lens. The amphiphatic hybrid nanocarrier is an optically transparent, in visible region, nanosphere having a diameter of 20-300 nm. The amphiphatic hybrid nanocarriers with a concentration of 0.01-5wt% in a contact lens were fabricated. The drugs carried by the amphiphatic hybrid nanocarriers included Vitamin A, Vitamin B12, Vitamin C, Vitamin E, azithromycin, fluorometholone facetate, bacitracin, neomycin, polymyxin B sulfate, Oxytetracycline HCl, erythromycin, dexamethasone, prednisolone acetate, timolol maleate, or hydrocortisone.

[0017] The amphiphatic hybrid nanocarrier is an amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier. The chitosan used by the present invention is a biocompatible material and has been widely used in biomedical-related applications. The present invention modifies chitosan into an amphiphatic organic-inorganic nanocarrier (silica-CHC), which exhibits high biocompatibility and can self-assemble in aqueous solutions. The core-shell structure of the 6 amphiphatic hybrid nanocarrier functions as a physical barrier to regulate drug delivery and decreases drug loss caused by the swelling phenomenon of the polymeric molecules in an aqueous solution.

[0018] According to the light or heat sensitivity of the drug, the drug-carrying contact lenses of the present invention can be categorized into the encapsulation-type drug-carrying contact lens and the soaking-type drug-carrying contact lens. The drugs insensitive to light and heat may be used in the encapsulation-type drug-carrying contact lens. The drugs sensitive to light or heat may be used in the drug soaking-type drug-carrying contact lens. The encapsulation-type drug-carrying contact lenses may be further classified into the contact lens wherein the drug molecules are directly mixed with the contact lens material, and the contact lens wherein the drug molecules are sprayed onto the surface thereof to form a drug-containing film. No matter what type the drug-carrying contact lens of the present invention belongs to, it can always achieve the function of gradual and local drug delivery.

[0019] Below are described in detail the methods for fabricating various types of the drug-carrying contact lenses of the present invention. Before the methods are described, the amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier used by the present invention is briefly introduced.

[0020] Refer to Fig.1 showing the structural formula of the amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier and the self-assembly thereof. The backbone I of chitosan has carboxyl-modified hydrophilic terminals II and long carbon chain-modified hydrophobic terminals III, whereby the chitosan can self-assemble in an aqueous solution to form a hybrid nanoparticle having a core-shell structure. The method for fabricating the nanocarrier includes the steps: dissolving 0.25 g of the amphiphatic organic chitosan having carboxyl-modified hydrophilic terminals and long carbon chain-modified hydrophobic terminals in 50 ml of deionized water, and agitating them at an ambient temperature for 24 hours to form an amphiphatic organic chitosan solution having a concentration of 0.5 wt.-%; gradually adding 160 μl of APTMS (or APTES) and 0.012 g of EDC to the amphiphatic organic chitosan solution, and agitating them at an ambient temperature for 24 hours to form an organic-inorganic mixture solution, wherein APTMS and APTES respectively denote 3-aminopropyltrimethoxysilane and 3-aminopropyltriethoxysilane and both function as coupling agents of inorganic silanyl groups, and wherein EDC denotes 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide and functions as a catalyst; using an dialysis membrane and a 75 v% alcohol solution to dialyze the organic-inorganic mixture solution for 24 hours, and then using dehydrated alcohol to dialyze the organic-inorganic mixture solution for 24 hours to obtain a dialyzed product; drying the dialyzed product with an oven to obtain the powder of the amphiphatic organic-inorganic chitosan-silica hybrid nanocarriers (abbreviated as silica-CHC thereinafter) shown in the drawing.

[0021] In one embodiment, the method for fabricating the contact lens material includes the steps: uniformly mixing HEMA (2-hydroxyethyl methacrylate) with 0.5-5v% MAA (methacrylate acid) to form a base material; uniformly mixing the HEMA-MAA mixture solution with GDMA (ethylene glycol dimethylacrylate) and AIBN (2,2'-Azobisisobutyronitrile) to form a material of the drug-carrying contact lens in the present invention, wherein GDMA functions as a cross-linking agent and AIBN functions as a photoinitiator. The abovementioned contact lens material is only an exemplification of the contact lens materials used in the present invention. Various contact lens materials available in the market may also be used to fabricate the drug-carrying contact lens according to the present invention.

[0022] With reference to Fig.2 a flowchart of a method for fabricating a first encapsulation-type drug-carrying contact lens is shown. In Step S10, dissolve drug molecules in a polar organic solvent, such as ethanol, PEG (Poly Ethylene Glycol), PPG (Poly Propylene Glycol), DMSO (dimethyl sulfoxide), THF (tetrahydrofuran), or an arbitrary combination thereof, and dilute the organic solution with deionized water to obtain a drug molecule solution having a given concentration. Next, in Step S12, add the silica-CHC powder into the drug molecule solution, and agitate them at an ambient temperature for 24 hours to obtain a first mixture solution. Next, in Step S14, process the first mixture solution centrifugally at a rotation speed of 8000 rpm for 20 minutes, take out the upper layer of the liquid to get the encapsulation rate, and take out the lower layer of the liquid, and mix it with the contact lens material uniformly to form a second mixture solution, and pour the mixture solution into a mold. Next, in Step S16, cure the second mixture solution in the mold with ultraviolet light, demold the cured second mixture solution to obtain a semi-finished product, and flush the semi-product with a buffer solution to remove the unreacted monomers on the surface to obtain a first encapsulation-type drug-carrying contact lens.

[0023] With reference to Fig.3 a flowchart of another method for fabricating a second encapsulation-type drug-carrying contact lens is shown. In Step S20, mix uniformly the abovementioned drug molecule solution (the fabrication method thereof has been described hereinbefore and will not repeat here), the amphiphatic hybrid nanocarriers and the polymer of the contact lens material to form a third mixture solution. The polymer contains PHEMA (poly (2-hydroxyethyl methacrylate)) and PMAA (poly(methacrylate acid)) by a ratio of 100: 0.5-5, such as the contact lens material mentioned above. Next, in Step S22, spray the third mixture solution onto an existing contact lens to form a film having a thickness of 0.5-10μm. Thus, the film contains the amphiphatic hybrid nanocarriers carrying drug molecules as a second encapsulation-type drug-carrying contact lens in Step S24.

[0024] With reference to Fig.4 a flowchart of another method for fabricating a drug-soaking type drug-carrying contact lens is shown. In Step S30, add the silica-CHC powder into deionized water, and agitate them at an ambient temperature for 24 hours, and process them centrifugally at a rotation speed of 8000 rpm to obtain a solution of the amphiphatic hybrid nanocarriers. Next, in Step S32, take out the lower layer of the amphiphatic hybrid nanocarrier solution, and mix it with the abovementioned contact lens material uniformly to obtain a fourth mixture solution. Next, in Step S34, pour the fourth mixture solution into a mold, cure the fourth mixture solution in the mold with ultraviolet light, demold the cured fourth mixture solution to obtain a semi-finished product, and flush the semi-finished product with a buffer solution several times to remove the unreacted monomers to obtain a nanocarrier-containing contact lens. Next, in Step S36, dissolve the drug molecules in a polar organic solvent or deionized water to obtain a drug molecule solution, and soak the nanocarrier-containing contact lens in the drug molecule solution for 24 hours so that the concentration can reach a dynamic equilibrium, and take out the contact lens to obtain a drug-soaking type drug-carrying contact lens.

Water retention test

[0025] The water retentions of the drug-carrying contact lenses fabricated according to the abovementioned methods are tested with respect to the quantities of the nanocarriers added to the contact lenses. Firstly, the nanocarrier-containing

contact lens is dried in an oven, the contact lens (W_d) is weighed, and then the contact lens is soaked in physiological saline at an ambient temperature for 3 days to saturate the contact lens, the surface thereof is dried, and weighedagain (W_w). Next, the contact lens is placed in an enclosed container, the contact lens is weighed periodically (W_t), and the water retention is obtained according to the equation:

$$\text{water retention (\%)} = 100\% \times (W_t - W_d)/(W_w - W_d)$$

[0026] The test results are shown in Fig. 5. The MAA monomer is usually added to the ordinary contact lenses to increase the water retention. In addition to the MAA monomer, the drug carriers also play the same role in the present invention. From Fig.5, it is known that the water retention of the contact lens containing silica-CHC is higher than that of the contact lens containing only MAA by 10-25 % (24-72 h). This is because the chemical structure of the silica-CHC has many Si-OH groups, which can increase the hydrophilicity and water retention ability.

Drug-release test

[0027] The drug-release tests are respectively performed on the first encapsulation-type drug-carrying contact lens and the drug-soaking type contact lens of the present invention to understand the drug-release thereof.

[0028] In one embodiment, the encapsulation-type drug-carrying contact lens adopts a hydrophobic antibiotic-azithromycin, which is an oral azalide group antibiotic that is a subgroup of macrolides, and which is a broad-spectrum antibiotic effective to Gram-positive bacteria, Gram-negative bacteria, anaerobic bacteria, Chlamydia, helicoids, etc. The results of the drug-release tests are shown in Fig.6. Fig.6 shows that the release quantity of azithromycin increases with the temperature. Such a phenomenon may be attributed to the fact: the higher the temperature, the higher the oscillation frequency of the drug molecules and the greater the quantity of the drug molecules diffusing out. In the present invention, the drug-release amount can be quantitatively controlled according to the application environment. Therefore, the present invention has a potential to realize a customized drug-carrying contact lens.

[0029] In one embodiment, the drug-soaking type drug-carrying contact lens adopts vitamin B12, which is a hydrophilic drug and effective to pernicious anaemia, and which is a red crystalline powder likely to absorb humidity, easy to dissolve in water and alcohol, and slightly unstable in the environment of light, strong acid, and base. The results of the drug-release tests are shown in Fig.7(a) and Fig.7(b). Fig.7(a) shows that the drug-carrying contact lens containing the drug carriers of the present invention releases the hydrophilic drug (vitamin B12) more slowly than the drug-carrying contact lens free of drug carriers. Such a phenomenon is attributed to the fact: the porous core-shell structure (with pores of about 2-10 nm according to the BET analysis) of the drug carrier of the present invention effectively reduced the diffusion of the wrapped drug molecules, which is induced by the swelling of polymer in an aqueous solution. Fig.7(b) shows that the drug-release rate increases with the concentration of the drug molecules. Such a phenomenon is attributed to the fact that the greater the concentration difference, the higher the driving force of drug molecule diffusion.

Image analysis

[0030] The results of the SEM (Scanning Electron Microscopy) analysis are shown in Fig. 8(a) and Fig. 8(b). Fig. 8(a) shows that the amphiphatic organic-inorganic chitosan-silica hybrid nanocarriers of the present invention are self-assembled in water to form a particle having a diameter of about 100 nm. Fig.8(b) shows that the amphiphatic organic-inorganic chitosan-silica hybrid nanocarriers are distributed in the drug-carrying contact lens of the present invention.

[0031] In conclusion, the present invention uses highly biocompatible nanocarriers having a superior drug encapsulation capability to wrap the drug or absorb the drug molecules from the drug solution. Thereby, the drug molecules are uniformly distributed in the contact lens and can be gradually (>24h) and locally released to the eye of the user wearing the 13 contact lens of the present invention. Therefore, the present invention can prevent or cure ocular diseases with the loss and side effects of the drug being reduced. The present invention is easy to fabricate and thus has a wide application.

[0032] The embodiments described above are to demonstrate the technical thoughts and characteristics of the present invention and enable the persons skilled in the art to understand, make and use the present invention. However, the embodiments described above are only to exemplify the present invention but not to limit the scope of the present invention.

Claims

1. A drug-carrying contact lens comprising:

   a contact lens containing at least one amphiphatic hybrid nanocarrier carrying drug molecules, wherein said amphiphatic hybrid nanocarrier is used in a concentration of 0.01-5 wt-% and is an amphiphatic organic-inorganic chitosan-silica hybrid nanocarrier.

2. The drug-carrying contact lens according to claim 1, wherein said amphiphatic hybrid nanocarriers and drug molecules carried thereby are distributed inside said contact lens or on a surface of said contact lens.

3. The drug-carrying contact lens according to claim 2 further comprising a polymeric material, wherein said polymeric material is mixed with said amphiphatic hybrid nanocarriers and said drug molecules to form a mixture solution, and wherein said mixture solution is sprayed onto said surface of said contact lens to form a film.

4. The drug-carrying contact lens according to claim 3, wherein said polymeric material contains PHEMA ((poly 2-Hydroxy ethylmethacrylate)) and PMAA (poly(methacrylate acid)) by a ratio of 100:0.5-5.

5. The drug-carrying contact lens according to claim 1, wherein said amphiphatic hybrid nanocarrier is an optically transparent nanosphere having a diameter of 20-300 nm.

6. The drug-carrying contact lens according to claim 1, wherein said amphiphatic hybrid nanocarriers has a concentration of 0.01-5 wt%.

7. The drug-carrying contact lens according to claim 1, wherein said drug molecule is a hydrophilic or hydrophobic drug molecule.

8. The drug-carrying contact lens according to claim 1, wherein said drug molecule is selected from a group consisting of vitamin B12, vitamin C, azithromycin, fluorometholone facetate, bacitracin, neomycin, polymyxin B sulfate, oxytetracycline HCl, erythromycin, dexamethasone, prednisolone acetate, timolol maleate, and hydrocortisone.

Patentansprüche

1. Wirkstofftragende Kontaktlinse, welche
   eine Kontaktlinse umfasst, die wenigstens eine amphipathische Hybrid - Nanoträgersubstanz beinhaltet, die Wirkstoffmoleküle trägt, wobei die besagte amphipathische Hybrid - Nanoträgersubstanz in einer Konzentration von 0,01 - 5 Gew.-% verwendet wird und eine amphipathische organisch-anorganische Chitosan - Silica - Hybrid - Nanoträgersubstanz ist.

2. Wirkstofftragende Kontaktlinse nach Anspruch 1, wobei die besagte amphipathische Hybrid - Nanoträgersubstanz und die damit beförderten Wirkstoffmoleküle im Inneren der besagten Kontaktlinse oder an einer Oberfläche der besagten Kontaktlinse verteilt sind.

3. Wirkstofftragende Kontaktlinse nach Anspruch 2, welche außerdem ein Kunststoffmaterial umfasst, wobei das besagte Kunststoffmaterial mit der besagten amphipathischen Hybrid - Nanoträgersubstanz und den besagten Wirkstoffmolekülen vermischt wird, um eine Mischungslösung herzustellen, wobei die besagte Mischungslösung auf die besagte Oberfläche der besagten Kontaktlinse aufgesprüht wird, um eine Schicht auszubilden.

4. Wirkstofftragende Kontaktlinse nach Anspruch 3, wobei das besagte Kunststoffmaterial PHEMA ((Poly-(2-Hydroxyethylmethacrylat)) und PMAA (Poly-(Methacrylsäure)) in einem Verhältnis von 100:0,5-5 umfasst.

5. Wirkstofftragende Kontaktlinse nach Anspruch 1, wobei die besagte amphipathische Hybrid - Nanoträgersubstanz optisch transparente Nanokügelchen mit einem Durchmesser zwischen 20-300 nm umfasst.

6. Wirkstofftragende Kontaktlinse nach Anspruch 1, wobei die besagte amphipathische Hybrid - Nanoträgersubstanz in einer Konzentration von 0,01-5 Gew.-% vorliegt.

7. Wirkstofftragende Kontaktlinse nach Anspruch 1, wobei das besagte Wirkstoffmolekül ein hydrophiles oder hydrophobes Wirkstoffmolekül ist.

8. Wirkstofftragende Kontaktlinse nach Anspruch 1, wobei das besagte Wirkstoffmolekül aus einer Gruppe ausgewählt ist, welche Vitamin B 12, Vitamin C, Azithromycin, Fluorometholonacetat, Bacitracin, Neomycin, Polymyxin - B - sulfat, Oxytetracyclin - HCl, Erythromycin, Dexamethason, Prednisolonacetat, Timololmaleat und Hydrocortisone umfasst.

Revendications

1. Lentille de contact de support de médicament comprenant :

   une lentille de contact qui contient au moins une nanoparticule hybride amphiphatique portant des molécules de médicament, ladite nanoparticule hybride amphiphatique étant utilisée dans une concentration de 0,01-5 % en poids et étant une nanoparticule hybride de silice et chitosan organique inorganique amphiphatique.

2. Lentille de contact de support de médicament selon la revendication 1, les nanoparticules hybrides amphiphatiques et les molécules de médicament portées par celles-ci étant distribuées à l'intérieur de ladite lentille de contact ou sur une surface de ladite lentille de contact.

3. Lentille de contact de support de médicament selon la revendication 2 comprenant de plus un matériau polymère, ledit matériau polymère étant mélangé auxdites nanoparticules hybrides amphiphatiques et auxdites molécules de médicament pour former une solution de mélange et ladite solution de mélange étant pulvérisée sur ladite surface de ladite lentille de contact pour former une pellicule.

4. Lentille de contact de support de médicament selon la revendication 3, ledit matériau polymère contenant du PHEMA ((poly 2-hydroxy-éthylméthacrylate)) et du PMMA (poly(acide de méthacrylate)) dans un rapport de 100:0,5-5.

5. Lentille de contact de support de médicament selon la revendication 1, ladite nanoparticule hybride amphiphatique étant une nanosphère transparente optiquement ayant un diamètre de 20 à 300 nm.

6. Lentille de contact de support de médicament selon la revendication 1, ladite nanoparticule hybride amphiphatique ayant une concentration de 0,01 à 5 % en poids.

7. Lentille de contact de support de médicament selon la revendication 1, ladite molécule de médicament étant une molécule de médicament hydrophile ou hydrophobe.

8. Lentille de contact de support de médicament selon la revendication 1, ladite molécule de médicament étant sélectionnée dans un groupe composé de vitamine B12, vitamine C, azithromycine, facétate de fluorométholone, bacitracine, néomycine, sulfate de polymyxine B, oxytétracycline HC1, érythromycine, déxaméthasone, acétate de prédnisolone, maléate de timolol et hydrocortisone.

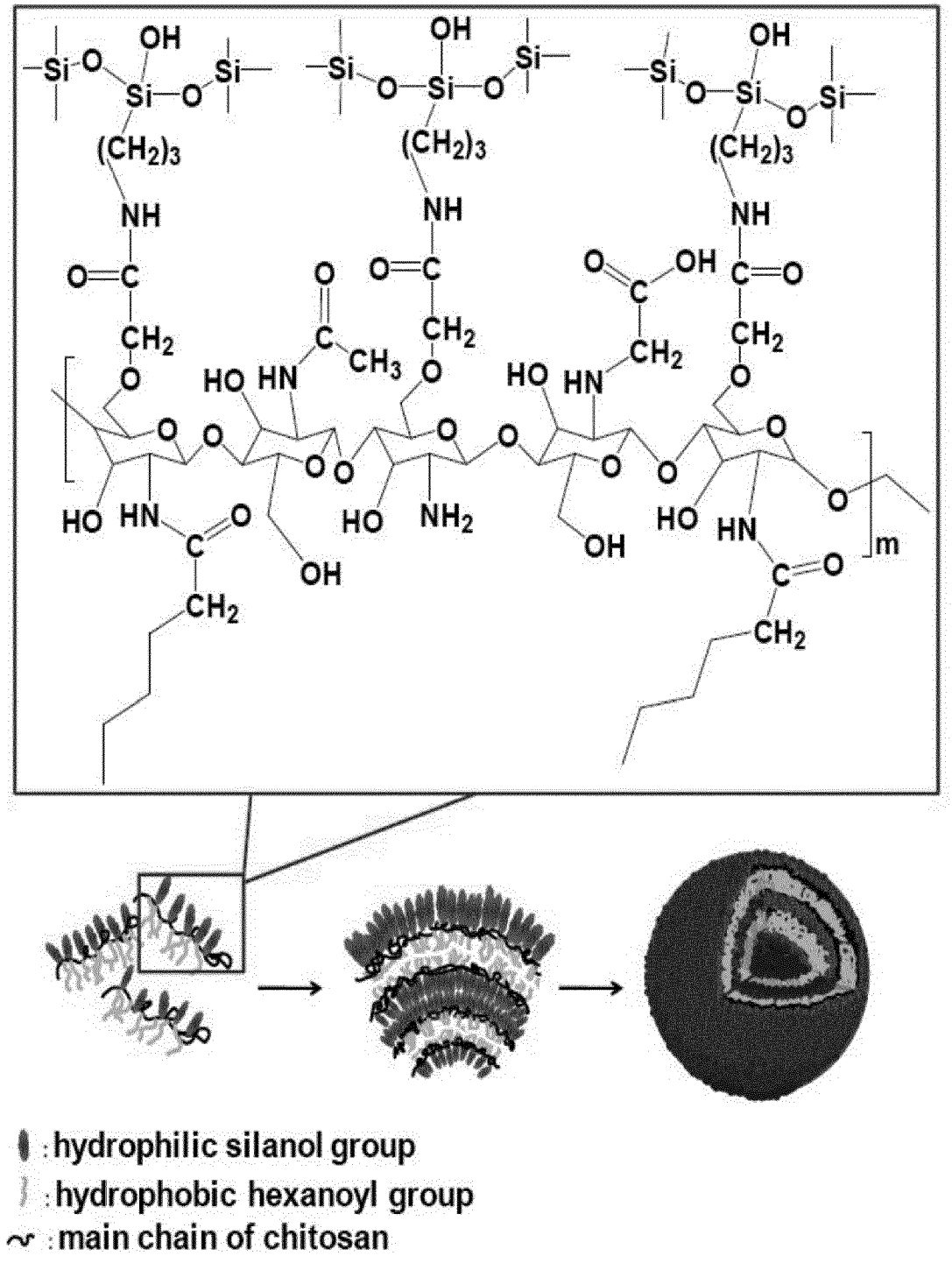
: hydrophilic silanol group
: hydrophobic hexanoyl group
: main chain of chitosan

Fig.1

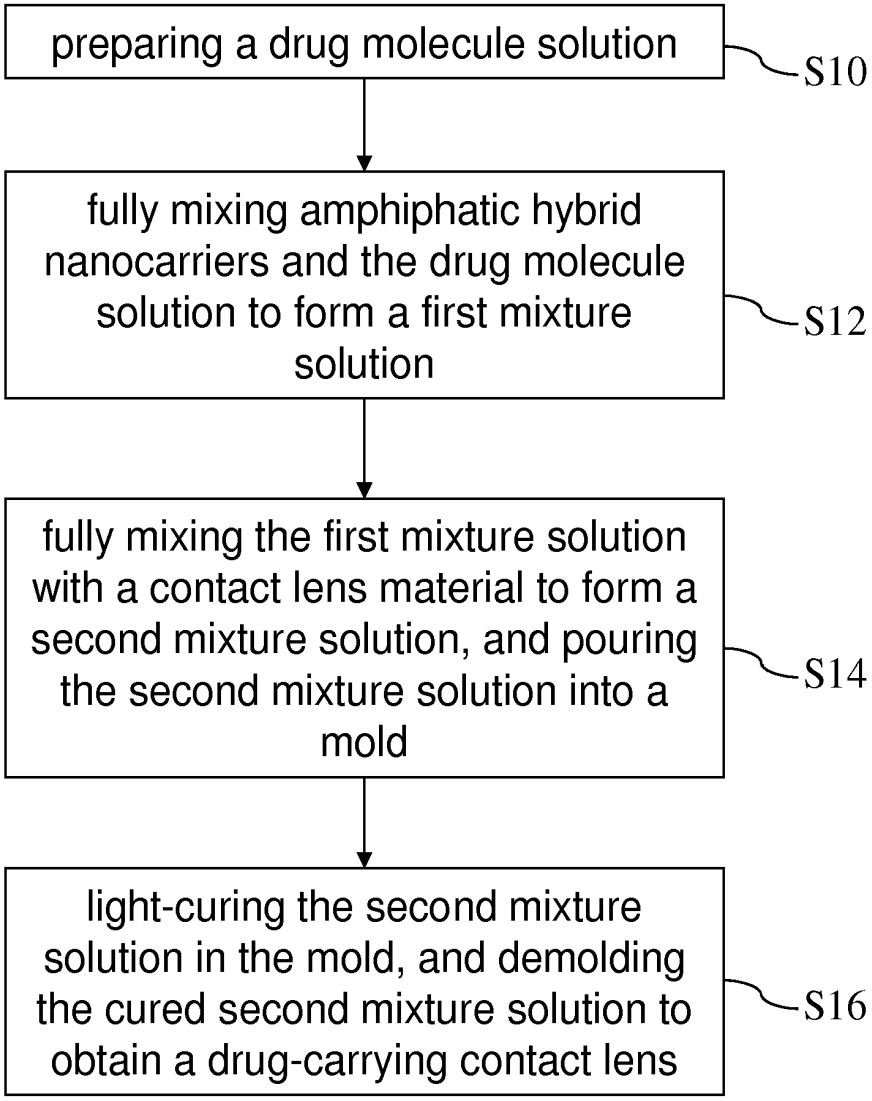
preparing a drug molecule solution
S10
fully mixing amphiphatic hybrid nanocarriers and the drug molecule solution to form a first mixture solution
S12
fully mixing the first mixture solution with a contact lens material to form a second mixture solution, and pouring the second mixture solution into a mold
S14
light-curing the second mixture solution in the mold, and demolding the cured second mixture solution to obtain a drug-carrying contact lens
S16

Fig.2

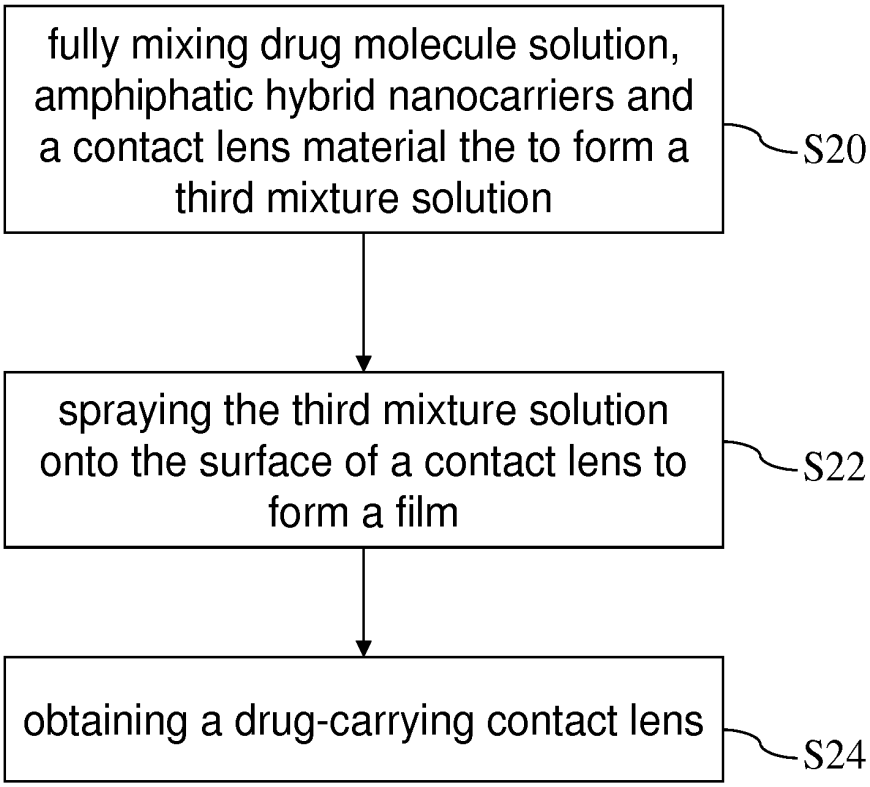
fully mixing drug molecule solution, amphiphatic hybrid nanocarriers and a contact lens material the to form a third mixture solution
S20
spraying the third mixture solution onto the surface of a contact lens to form a film
S22
obtaining a drug-carrying contact lens
S24

Fig.3

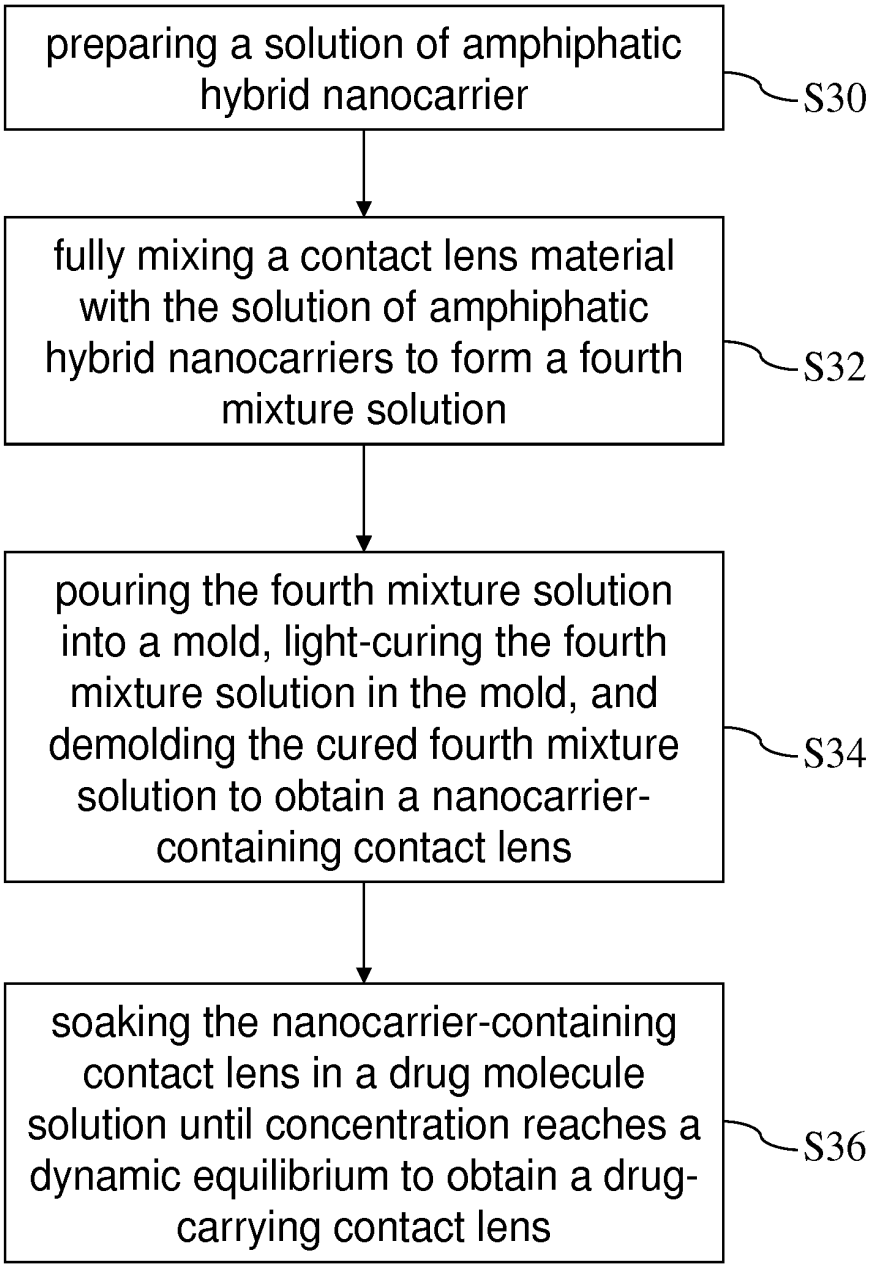
preparing a solution of amphiphatic hybrid nanocarrier
S30
fully mixing a contact lens material with the solution of amphiphatic hybrid nanocarriers to form a fourth mixture solution
S32
pouring the fourth mixture solution into a mold, light-curing the fourth mixture solution in the mold, and demolding the cured fourth mixture solution to obtain a nanocarrier-containing contact lens
S34
soaking the nanocarrier-containing contact lens in a drug molecule solution until concentration reaches a dynamic equilibrium to obtain a drug-carrying contact lens
S36

Fig.4

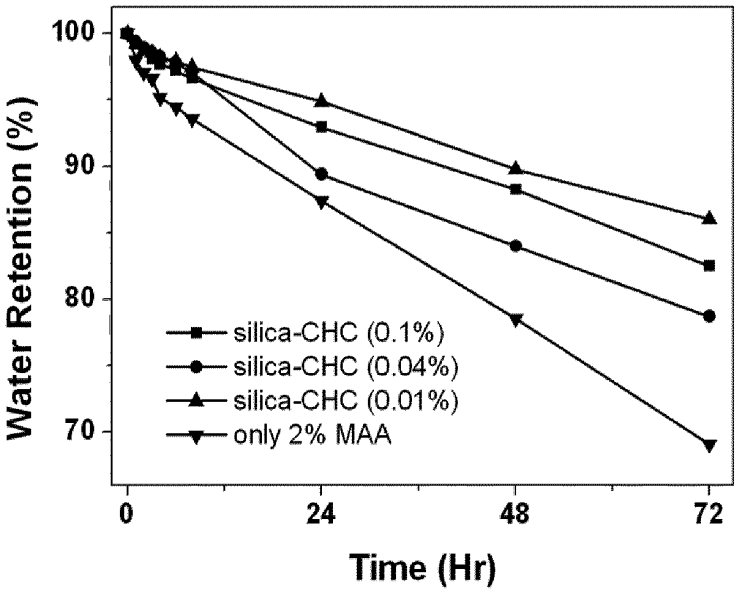
Water Retention (%)
100
90
80
70
0
24
48
72
Time (Hr)
silica-CHC (0.1%)
silica-CHC (0.04%)
silica-CHC (0.01%)
only 2% MAA

Fig.5

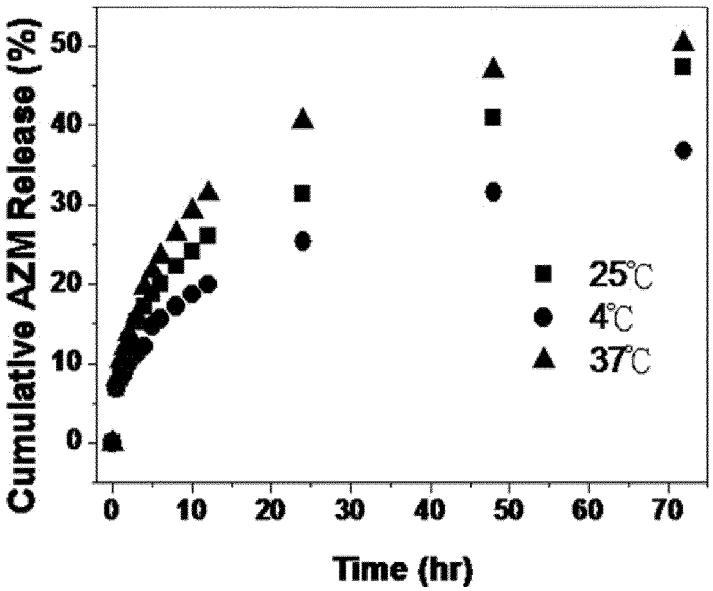
Cumulative AZM Release (%)
50
40
30
20
10
0
0
10
20
30
40
50
60
70
Time (hr)
25℃
4℃
37℃

Fig.6

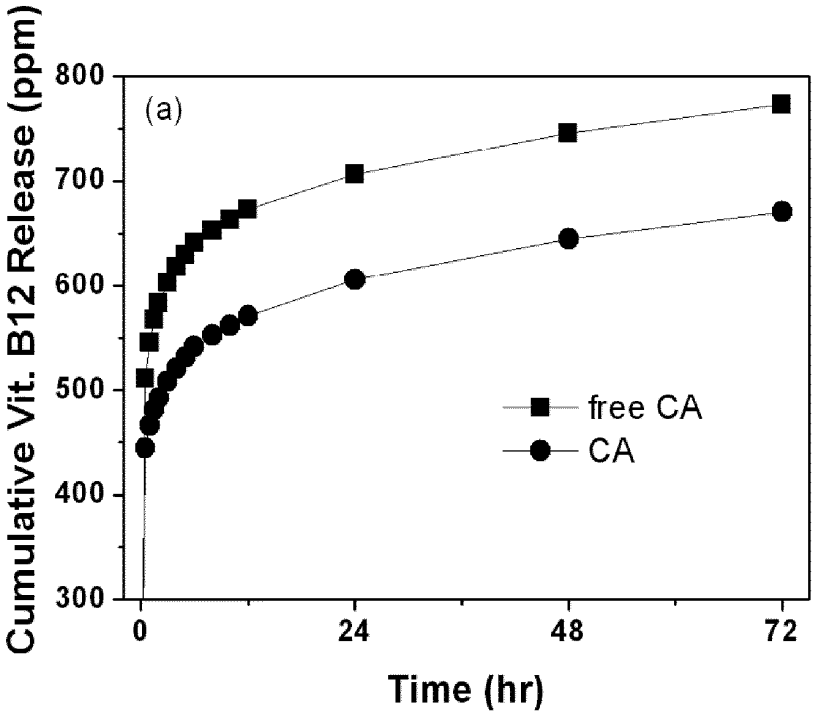
(a)
Cumulative Vit. B12 Release (ppm)
800
700
600
500
400
300
0
24
48
72
Time (hr)
free CA
CA

Fig.7(a)

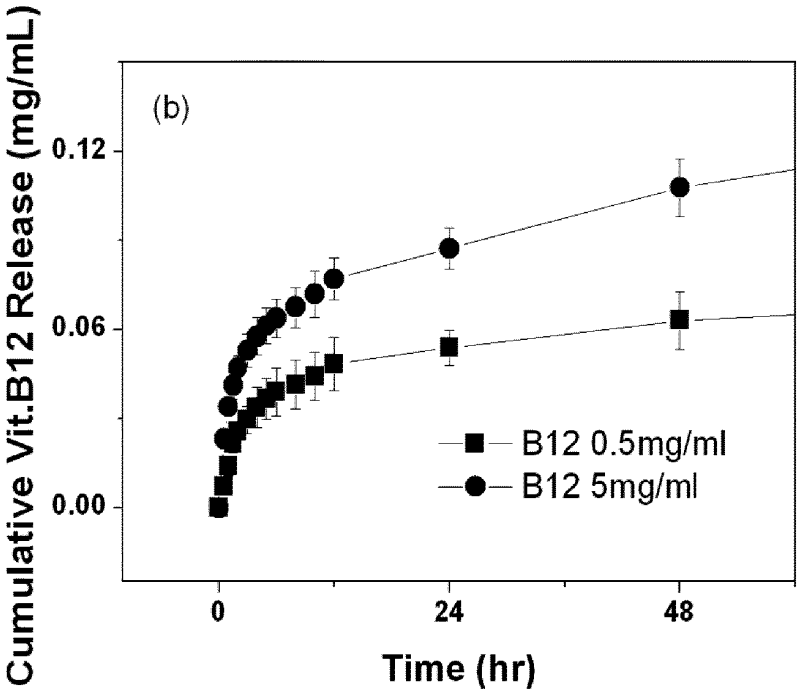
(b)
Cumulative Vit.B12 Release (mg/mL)
0.12
0.06
0.00
0
24
48
Time (hr)
B12 0.5mg/ml
B12 5mg/ml

Fig.7(b)

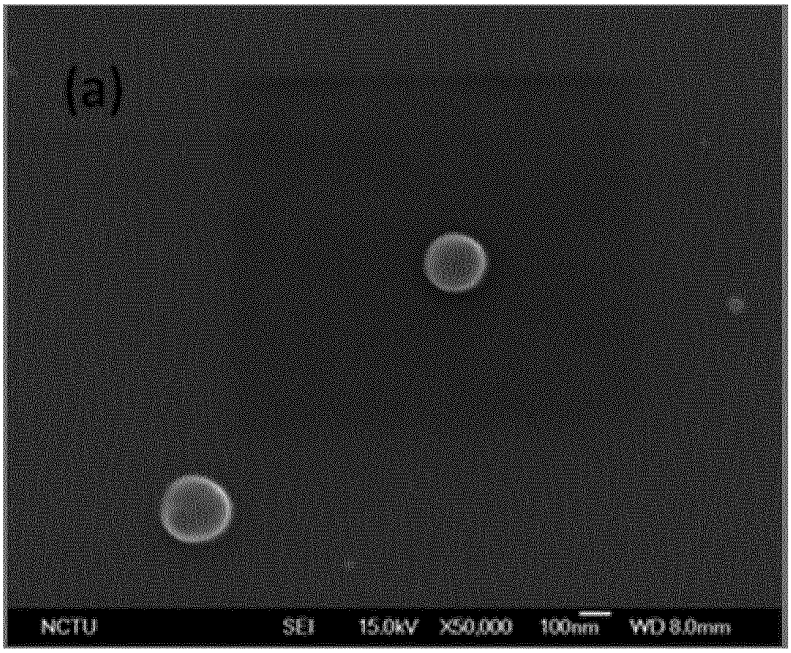
(a)
NCTU
SEI
15.0kV X50,000 100nm WD 8.0mm

Fig.8(a)

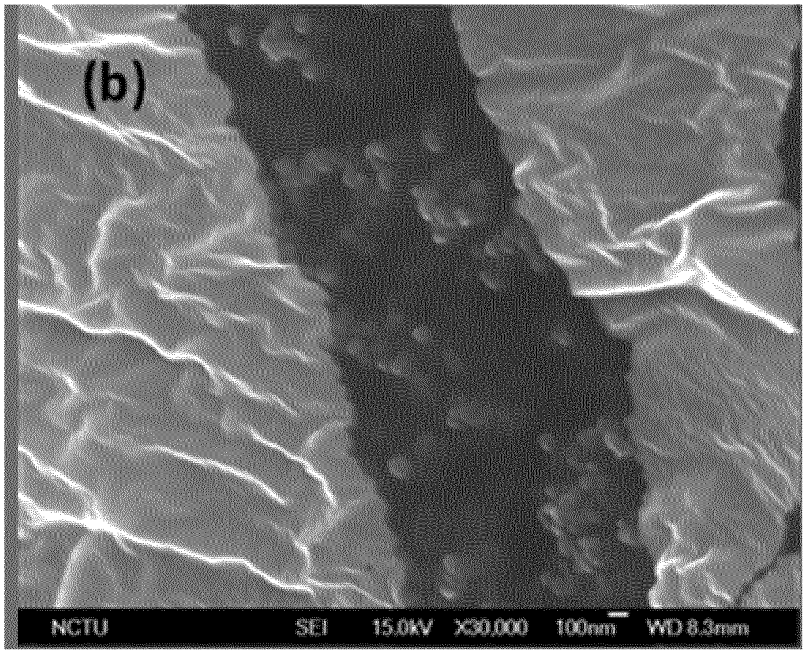
(b)
NCTU
SEI
15.0kV X30,000 100nm WD 8.3mm

Fig.8(b)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20040241207 A1 **[0004]**
- US 20100113901 A1 **[0004]**

Non-patent literature cited in the description

- Dispersion of microemulsion drops in HEMA hydrogel: a potential ophthalmic drug delivery vehicle. **GULSEN D. et al.** International Journal of Pharmaceutics. Elsevier BV, 23 March 2005, vol. 292, 95-117 **[0004]**