CLAIMS

1. A biocompatible SERS-active polymer membrane configured to detect biomarkers in a sample for use in determining a state of wound healing in a diabetic individual, comprising:

a flexible and porous polymer membrane; and

SERS-active nanoparticles formed on the flexible and porous polymer membrane, wherein the flexible and porous polymer membrane comprises cellulose or an elastomeric polymer comprising polydimethylsiloxane,

wherein the flexible and porous polymer membrane is functionalized with an anchoring agent to render an amine functional group or a mercapto functional group for binding to a SERS-active nanoparticle,

wherein the anchoring agent comprises (3-aminopropyl)triethoxysilane, (3-mercaptopropyl)trimethoxysilane, or mercaptopropylsilatrane, and

wherein the biomarkers comprise a matrix metalloproteinase, tumor necrosis factor alpha, and/or an interleukin.

2. The biocompatible SERS-active polymer membrane of claim 1, wherein the SERS-active nanoparticle comprises silver, gold, or copper.

3. The biocompatible SERS-active polymer membrane of claim 1 or 2, wherein:

the SERS-active nanoparticles formed on the flexible and porous polymer membrane are spaced apart at 150 nm or less, and/or

the SERS-active nanoparticles formed on the flexible and porous polymer membrane have a thickness of up to 60 nm.

4. A method of forming the biocompatible SERS-active polymer membrane of any one of claims 1 to 3, the method comprising:

providing a flexible and porous polymer membrane, wherein the flexible and porous polymer membrane comprises cellulose or an elastomeric polymer comprising polydimethylsiloxane; and

depositing SERS-active nanoparticles on the flexible and porous polymer membrane,

wherein providing the flexible and porous polymer membrane comprises contacting the flexible and porous polymer membrane with an anchoring agent to have an amine functional group or a mercapto functional group functionalized thereon for binding to a SERS-active nanoparticle, and

wherein the anchoring agent comprises (3-aminopropyl)triethoxysilane, (3-mercaptopropyl)trimethoxysilane, or mercaptopropylsilatrane.

5. The method of claim 4, wherein the flexible and porous polymer membrane comprises an elastomeric polymer and the method further comprises stretching the flexible and porous polymer membrane up to 60% prior to depositing the SERS-active nanoparticles.

6. The method of claim 4 or 5, wherein depositing the SERS-active nanoparticles comprises:

placing the flexible and porous polymer membrane into a coater operable to deposit the SERS-active nanoparticles thereon; or

placing the flexible and porous polymer membrane onto an electron beam evaporator to deposit the SERS-active nanoparticles thereon; or

sputtering a precursor of the SERS-active nanoparticles onto the flexible and porous polymer membrane to have the SERS-active nanoparticles formed thereon.

7. The method of claim 6, wherein depositing the SERS-active nanoparticles is carried out at a deposition current of 10 mA to 20 mA.

8. The method of any one of claims 4 to 7, wherein depositing the SERS-active nanoparticles is carried out for a duration of up to 60 s.

9. The method of any one of claims 4 to 8, wherein depositing the SERS-active nanoparticles comprises depositing the SERS-active nanoparticles at a rate of up to 1 nm/s.

10. A method of determining a state of wound healing in a diabetic individual, the method comprising:

contacting a sample extracted from a wound of the diabetic individual with a thiolating agent to have one or more biomarkers suspected to be contained in the sample form one or more modified proteins, wherein the biomarkers comprise a matrix metalloproteinase, tumor necrosis factor alpha, and/or an interleukin;

incubating the biocompatible SERS-active polymer membrane of any one of claims 1 to 3 with the one or more modified proteins to immobilise the one or more modified proteins on SERS-active nanoparticles of the biocompatible SERS-active polymer membrane;

providing one or more Raman probes attached with one or more antibodies, wherein each of the one or more antibodies binds specifically to one corresponding modified protein from the one or more modified proteins, wherein the one or more antibodies comprise an antibody of matrix metalloproteinase, an antibody of tumor necrosis factor alpha, and/or an antibody of interleukin;

contacting the one or more Raman probes with the biocompatible SERS-active polymer membrane having the one or more modified proteins immobilised thereon; and

subjecting the biocompatible SERS-active polymer membrane to SERS spectroscopy to generate one or more SERS signals corresponding to the one or more biomarkers, respectively.

11. The method of claim 10, further comprising:

contacting the biocompatible SERS-active polymer membrane of any one of claims 1 to 3 with a serum albumin to have the serum albumin immobilized on surfaces of the flexible and porous polymer membrane which are not occupied by the one or more modified proteins.

12. The method of claim 10 or 11, wherein the thiolating agent comprises a Traut's reagent.