not straightforward and can be cumbersome. In addition, the loading processes cannot be performed easily. In some cases, the loading of certain active ingredients cannot be realized or have a low loading efficiency and loading content. These limit the applications that can be used for such delivery systems.

There is a need to provide a core-shell particle that overcomes, or at least ameliorates, one or more of the disadvantages described above.

Summary

According to a first aspect, there is provided a core-shell particle comprising a polymer conjugate encapsulating an active agent, wherein said polymer conjugate comprises a biocompatible polymer and a polyacidic polymer.

Advantageously, the core-shell particle may encapsulate the active agent within the core of the particle at a first pH and then release the active agent from the core of the particle at a second pH. Hence, the core-shell particle may act as a delivery vehicle which is sensitive to pH changes.

Advantageously, the core-shell particle may be stable due to the conjugation between the biocompatible polymer and the polyacidic polymer.

According to a second aspect, there is provided a process for forming a core-shell particle comprising a polymer conjugate encapsulating an active agent, wherein said polymer conjugate comprises a biocompatible polymer and a polyacidic polymer, the process comprising the steps of (a) providing a mixture comprising said biocompatible polymer, said polyacidic polymer and said active agent in an acidic environment; and (b) drying said mixture to obtain said core-shell particle.

Advantageously, the biocompatible polymer may self-assemble in the presence of the polyacid polymer in the acidic environment to form the core-shell particle, wherein the shell is hydrophilic. While self-assembling, the biocompatible polymer sequesters and encapsulates the active agent such that the active agent is within the core of the particle.

There is provided a delivery vehicle comprising the core-shell particle as described herein, wherein the core-shell particle releases the active agent from the core when the particle is at a neutral pH.

In another aspect, there is provided a delivery vehicle comprising the core-shell particle as described herein, wherein said core-shell particle releases said active agent from said core when said particle is at a pH greater than the pKa of the polyacidic polymer; wherein said release of said active agent is sustained over a period of time.

As the core-shell particle is formed in an acidic environment, when the pH of the core-shell particle is increased, the core-shell particle may disassemble and release the active agent from the core.

There is provided a method for delivering an active agent to a desired site comprising the steps of (a) providing the core-shell particle as described herein in an

acidic environment; and (b) increasing the pH of said core-shell particle to thereby release and deliver said active agent.

In yet another aspect, there is provided a method for delivering an active agent to a desired site comprising the steps of: (a) providing the core-shell particle as described herein in an acidic environment; and (b) increasing the pH of said core-shell particle to thereby release and deliver said active agent; wherein said desired site is a hair or a surface of an animal.

Definitions

The following words and terms used herein shall have the meaning indicated:

Claims

1. A core-shell particle comprising a polymer conjugate encapsulating an active agent, wherein said polymer conjugate comprises a biocompatible polymer and a polyacidic polymer.

2. The core-shell particle according to claim 1, wherein said biocompatible polymer is an amphiphilic polymer.

3. The core-shell particle according to claim 2, wherein said amphiphilic polymer is a block co-polymer comprising at least one hydrophobic polymer and at least one hydrophilic polymer block.

4. The core-shell particle according to claim 3, wherein said hydrophilic polymer block forms the shell of said particle and said hydrophobic polymer block forms the core of said particle.

5. The core-shell particle according to any one of claims 1 to 4, wherein said biocompatible polymer comprises monomers selected from the group consisting of halogenated alkylene, ether, sulfonated ether, alkylene, ketone, sulfone, alkylene oxide, urethane, acetate, alcohol, carbonate, lactone, lactide, glycolide, ester, anhydride, acrylate, pyrrolidone, saccharide and combinations thereof; or preferably

said biocompatible polymer is selected from the group consisting of saturated or unsaturated carbon hydrogen chains, polyvinylchloride, polytetrafluoroethylene, polyethersulfone, polyethylene, polyetheretherketone, polysulfone, polypropylene, poly(ethylene glycol), poly(propylene glycol), polyurethanes, ethylene vinyl acetate copolymers, collagen, poly isobutylene, ethylene vinyl alcohol copolymers, polyethylene polycarbonate, poly-ε-caprolactone, polylactide, polyglycolide, carbomers, polyesters, polyethers, polyanhydrides, polyacrylates, polyvinyl acetates, polyvinyl pyrrolidones, polysaccharides, polyether, derivatives thereof and combinations thereof; or more preferably

said polysaccharide is selected from the group consisting of hyaluronic acid, hydroxyalkylcelluloses, carboxyalkylcelluloses, and derivatives thereof.

6. The core-shell particle according to any one of claims 1, wherein said polyacidic polymer is selected from the group consisting of alginic acid, polysulfonamide, polypeptide, poly(carboxylic acid), polycarboxylate and combinations thereof; preferably

said poly(carboxylic acid) is selected from the group consisting of poly(acrylic acid), poly(methacrylic acid), poly(2-ethylacrylic acid) and poly(2-propylacrylic acid); or more preferably

said polypeptide is poly(aspartic acid) or poly(glutamic acid).

7. The core-shell particle of claim 3, wherein said hydrophobic polymer contains saturated or unsaturated carbon hydrogen chains; preferably said hydrophobic polymer is poly(propylene oxide) or poly(butyl methacrylate).

8. The core-shell particle of claim 2, wherein said amphiphilic polymer is a copolymer of poly(ethylene glycol)-poly(propylene glycol), a poloxamer, polyoxyethylene stearate or polysorbate.

9. The core-shell particle according to claim 1, wherein said active agent is a fluidic active agent or a particulate active agent; preferably said active agent is a fluidic active agent selected from silicone oil.

10. The core-shell particle of claim 1, wherein said active agent is encapsulated in the core of said particle.

11. The core-shell particle of claim 9, wherein said active agent is a particulate active agent selected from the group consisting of a therapeutic agent, a cosmetic agent and a cosmeceutical agent.

12. The core-shell particle of claim 1, wherein said particle has a particle size in the nano-size range or the micro-size range; preferably said particle size of said particle is from 10 nm to 10,000 nm or 200 nm to 5000 nm.

13. The core-shell particle according to claim 1, wherein said biocompatible polymer and said polyacidic polymer are in a respective polymers unit molar ratio of from 100:90 to 100:0.1.

14. The core-shell particle according to claim 1, wherein said active agent is loaded into said core at a loading concentration of from 1% to 80%.

15. The core-shell particle according to claim 1, wherein said biocompatible polymer and said polyacidic polymer cross-links at a crosslinking density of at least 5%, at least 10%, or at least 15%.

16. A process for forming a core-shell particle comprising a polymer conjugate encapsulating an active agent, wherein said polymer conjugate comprises a biocompatible polymer and a polyacidic polymer, the process comprising the steps of:

a) providing a mixture comprising said biocompatible polymer or monomers thereof, said polyacidic polymer or salt thereof and said active agent in an acidic environment; and

b) drying said mixture to obtain said core-shell particle.

17. The process according to claim 16, wherein providing step (a) comprises the step of homogenizing or emulsifying.

18. The process according to claim 16, wherein said drying step (b) comprises the step of heating, freeze drying, vacuum drying or spray drying.

19. The process according to claim 16, wherein said polyacidic polymer has a pKa value and said acidic environment is at a pH lower than said pKa value; preferably said pH is less than 7.5, less than 7, or about 6.

20. A delivery vehicle comprising the core-shell particle of claim 1, wherein said core-shell particle releases said active agent from said core when said particle is at a pH greater than the pKa of the polyacidic polymer;

wherein said release of said active agent is sustained over a period of time.

21. A method for delivering an active agent to a desired site comprising the steps of:

a) providing the core-shell particle of claim 1 in an acidic environment; and

b) increasing the pH of said core-shell particle to thereby release and deliver said active agent;

wherein said desired site is a hair or a surface of an animal.