molecules in the core. Due to the presence of the different dye molecules, the nanocapsule is capable of possessing different and distinctive light-emitting properties. Compared with other reported capsules such as liposomes or micelles which rapidly release the contained entities when introduced into a host and lead to instability of the capsules *in vivo*, the nanocapsules provide a much lower dye and oxygen permeability due to the more condensed structure on the shell, resulting in a higher photostability for most dyes. However, such nanocapsules are susceptible to clearance by the reticuloendothelial system, which limits the circulation duration of the nanocapsules *in vivo*.

There is a need to provide a fluorescent probe that overcomes, or at least ameliorates, one or more of the disadvantages described above.

Summary

According to the disclosure, there is provided a micellar particle having at least a core-shell configuration, wherein a fluorescent molecule is encapsulated within the core and wherein the shell is formed from an inorganic compound.

According to a first aspect, there is provided a micellar particle having at least a core-shell configuration, wherein a non-polymeric fluorescent molecule is encapsulated within the core, the core being formed from a hydrophobic component of an amphiphilic polymer and wherein the shell comprises a ceramic.

The micellar particle may include a corona portion that extends outwards from the shell, hence the micellar particle may have a core-shell-corona configuration. The

micellar particle may then be termed as a core-shell-corona micellar particle.

Advantageously, the disclosed particle may be colloidally stable. The disclosed particle may have a diameter lesser than 100 nm. Hence, the disclosed particle may evade clearance by the reticuloendothelial system, leading to prolonged circulation time *in vivo*. The disclosed particle may be photoluminescent without using

any toxic heavy metals. Hence, the disclosed particle may have low or no cytotoxicity to a biological host. The disclosed particle may have a high quantum yield. The disclosed particle may be less vunerable to photobleaching leading to good photostability. The disclosed particle may be easily modified with external surface modification with desired ligand(s).

According to another aspect, there is provided a process for forming a micellar particle having at least a core-shell configuration comprising the steps of:

a. mixing a reactant solution comprising an amphiphilic polymer or monomers thereof, a non-polymeric fluorescent molecule and shell precursors in an organic solvent; and

b. mixing the reactant solution from step (a) with an aqueous liquid to form the micellar particle in which the non-polymeric fluorescent molecule is encapsulated within the core, the core being formed from a hydrophobic component of the amphiphilic polymer and the shell is formed from the shell precursors,

wherein the shell comprises a ceramic.

According to another aspect, there is provided the use of a micellar particle as defined herein as a bioimaging agent or a biodetection agent.

Definitions

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

The terms "micelle" or "micellar particle" as used herein refer to an assembly of amphiphilic block copolymers into a microphase separated, core/shell/corona or core/corona architecture in a selective organic solvent. A micelle is an aggregate of amphiphilic polymers dispersed in a liquid. A typical micelle in an aqueous

solution forms an aggregate with the hydrophilic components in contact with the surrounding solvent (forming the corona portion of the micelle), sequestering the hydrophobic components in the micelle centre (forming the core portion of the micelle). Micelles are approximately spherical in shape, but other shapes such as ellipsoids, cylinders, and rods are also contemplated. The shape and size of a micelle is a function of the molecular geometry of its molecules and solution conditions such as concentration, temperature, pH, and ionic strength. The disclosed micellar particle may comprise a shell portion that is at least partially formed at the interface between the core portion and corona portion of the micellar particle. Hence, the disclosed micellar particle may have a core-shell-corona configuration. The shell portion may be comprised of an inorganic component or compound.

Claims

1. A micellar particle having at least a core-shell configuration, wherein a non-polymeric fluorescent molecule is encapsulated within said core, said core being formed from a hydrophobic component of an amphiphilic polymer and wherein said shell comprises a ceramic.

2. The micellar particle as claimed in claim 1, further comprising a corona that extends from said shell.

3. The micellar particle as claimed in claim 2, wherein a hydrophilic component of said amphiphilic polymer forms the corona of said micellar particle.

4. The micellar particle as claimed in claim 3, wherein said amphiphilic polymer is a block copolymer or a block terpolymer.

5. The micellar particle as claimed in claim 3 or 4, wherein said amphiphilic polymer comprises a polyethylene-oxide monomer.

6. The micellar particle as claimed in claim 5, wherein said polyethylene-oxide functionalized polymer is selected from the group consisting of polyhedral oligosilsesquioxanes-PEO (POSS-PEO), PEO-polyhydroxybutyrate-PEO (PEO-PHB-PEO), polylactic-acid-PEO (PLA-PEO), PEO-PLA-PEO, PEO-polypropyleneoxide-PEO (PEO-PPO-PEO), polydimethylsiloxane-graft-PEO (PDMS-graft-PEO) and polystyrene-PEO (PS-PEO).

7. The micellar particle as claimed in any one of the preceding claims, wherein said ceramic is selected from the group consisting of

hydroxyapatite, zirconia, silica, titanium oxide and alumina.

8. The micellar particle as claimed in any one of the preceding claims, wherein said non-polymeric fluorescent molecule is an organic molecule.

9. The micellar particle as claimed in claim 8, wherein said non-polymeric fluorescent molecule is selected from the group consisting of Coumarin545T, DCJTB, acridine orange, proflavine, N-(30sulfopropyl)acridinium, phenylalanine, tryptophan, tyrosine, anthracene, 9-cyanoanthracene, 9,10-Diphenylanthracene, naphthalene, 1-anilino-8-naphthalene sulfonate, 6-propionyl-2-(dimethylaminonaphthalene), perylene, phenanthrene, pyrene, puranine, p-quaterphenyl, rubrene, p-terphenyl, [60] fullerene, [70] fullerene, auramine O, malachite green, crystal violet, 1,3,5,7,8-pentamethylpyrromethene-difluoroborate, disodium-1,3,5,7,8-pentamethylpyrromethene-2,6-disulfonate-difluoroborate, 1,3,5,7,8-pentamethyl-2,6-diethylpyrromethene-difluoroborate, 8-Acetoxymethyl-2,6-diethyl-1,3,5,7-tetramethyl pyrromethene fluoroborate, 1,2,3,5,6,7-hexamethyl-8-cyanopyrromethene-difluoroborate, 2,3,5,6-1H,4H-Tetrahydro-8-methylquinolizino-[9,9a,1-gh]-coumarin, 7-amino-4-methylcoumarin, 7-amino-4-trifluoromethylcoumarin, 7-dimethylamino-4-trifluoromethylcoumarin, 7-diethylamino-4-trifluoromethylcoumarin, 2,3,5,6-1H,4H-Tetrahydro-8-trifluormethylquinolizino-[9,9a,1-gh]coumarin, 7-diethylaminocoumarin, 7-ethylamino-4-trifluormethylcoumarin, cryptocyanine, Cy3, Cy5, Cy7, 1,1'0diethyl-2,2'-dicarbocyanine iodide, HITCI, indocyanine green, IR 140, cresyl violet, nile blue, nile red, oxazeine 1, oxazine 170, oxazine 750, 2,5-Bis-(4-

biphenylyl)-1,3,4-oxadiazole, 2,5-Bis-(4-biphenylyl)-oxazole, 2-(1-Naphthyl)-5-phenyloxazole, 2-(4-Biphenylyl)-6-phenylbenzoxazole, 1,4-Di[2-(5-phenyloxazolyl)]benzene, 2,5-Diphenyloxazole, thionine, methylene blue, eosin Y, erythrosine B, fluorescein disodium salt uranin, dichlorofluorescein disodium salt, tetrachlorotetraiodofluorescein, pyronine Y, pyronine B, rhodamine B, Rhodamine 6G, rhodamine 101, rhodamine 110, sulforhodamine, sulforhodamine 101, tetramethylrhodamine, quinine sulfate, DAPI, N-methylcarbazole, 4-dicyanomethylene-2-methyl-6-(p-dimethylaminostyryl)-4H-pyran, DCM-OH and N-acetyl-L-tryptophanamide.

10. The micellar particle as claimed in any one of claims 2 to 9, wherein said corona of said micellar particle is functionalized with a linker group.

11. The micellar particle as claimed in claim 10, wherein said linker group is selected from a carboxylic acid group or an amine group.

12. The micellar particle as claimed in any one of the preceding claims, wherein said micellar particle has an average particle size in the nano-sized range.

13. The micellar particle as claimed in claim 12, wherein the average particle size of said micellar particle is less than 10 nm.

14. The micellar particle as claimed in any one of the preceding claims, wherein said shell has a thickness that is in the range of 5% to 95% of the diameter of said micellar particle.

15. The micellar particle as claimed in any one of the preceding claims, further comprising a therapeutic agent encapsulated within said core.

16. A process for forming a micellar particle having at least a core-shell configuration comprising the steps of:

a. mixing a reactant solution comprising an amphiphilic polymer or monomers thereof, a non-polymeric fluorescent molecule and shell precursors in an organic solvent; and

b. mixing said reactant solution from step (a) with an aqueous liquid to form said micellar particle in which said non-polymeric fluorescent molecule is encapsulated within said core, said core being formed from a hydrophobic component of said amphiphilic polymer and said shell is formed from said shell precursors,

wherein said shell comprises a ceramic.

17. The process as claimed in claim 16, wherein said organic solvent is selected from the group consisting of tetrahydrofuran, dioxane, chloroform and dichloromethane.

18. The process as claimed in claim 16 or 17, wherein said shell precursor is selected from the group consisting of a hydroxyapatite precursor, a zirconia precursor, a silica precursor, a titanium oxide precursor and an alumina precursor.

19. The process as claimed in any one of claims 16 to 18, wherein said reactant solution further comprises a swelling agent.