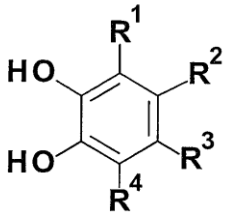
Claims

Claim 1

A nanoparticle comprising: at least one zwitterionic ligand represented by a formula (I); and a metal particle containing iron oxide, the at least one zwitterionic ligand being coordinately bound to the metal particle:

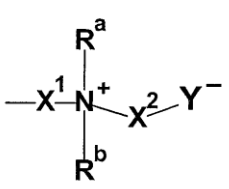


(I)

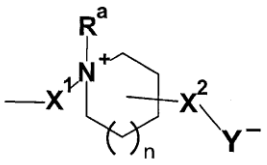
wherein:

in the at least one zwitterionic ligand,

R^1 is a group represented by a formula (a) or a formula (b), and R^2 is H or halogen,



(a)、



(b)

X^1 is a bond or methylene, or X^1 is optionally ethylene when R^1 is a group represented by the formula (a),

X^2 is C_{1-5} alkylene, or X^2 is optionally a bond when R^1 is a group represented by the formula (b),

R^a and R^b are methyl,

Y^- is SO_3^- or CO_2^-,

R^3 and R^4 are the same as or different from each other

and represent H, C_{1-3} alkyl, or halogen,

n is 1,

and,

i) when R^1 is a group represented by the formula (a) and X^1 is methylene, R^2 optionally forms ethylene together with R^a or R^b.

Claim 2

The nanoparticle as set forth in claim 1, wherein:

in the at least one zwitterionic ligand, R^1 is a group represented by the formula (a), and R^2 is H or halogen.

Claim 3

The nanoparticle as set forth in claim 2, wherein:

in the at least one zwitterionic ligand,

R^2 is H or halogen,

X^1 is a bond, methylene, or ethylene,

X^2 is C_{2-4} alkylene,

R^a and R^b are methyl,

R^3 and R^4 are the same as or different from each other and represent H, C_{1-3} alkyl, or halogen,

and, when X^1 is methylene, R^2 optionally forms ethylene together with R^a or R^b.

Claim 4

The nanoparticle as set forth in claim 3, wherein:

in the at least one zwitterionic ligand,

R^2 is H or F,

X^2 is ethylene or propylene, and

R^3 and R^4 are H.

Claim 5

The nanoparticle as set forth in claim 4, wherein:

in the at least one zwitterionic ligand,

R^2 is H, and

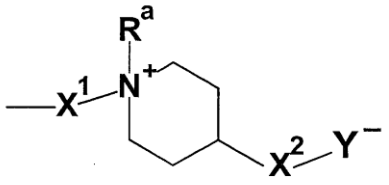
X^1 is a bond or ethylene.

Claim 6

The nanoparticle as set forth in claim 1, wherein:

in the at least one zwitterionic ligand,

R^1 is a group represented by the following formula (b-1),



(b－1)

R^2 is H or halogen,

X^1 is a bond or methylene,

X^2 is C_{1-5} alkylene or a bond,

R^a is methyl, and

Y^- is SO_3^- or CO_2^-.

Claim 7

The nanoparticle as set forth in any one of claims 1 through 6, wherein the metal particle contains only iron oxide.

Claim 8

The nanoparticle as set forth in any one of claims 1 through 7, wherein: the at least one zwitterionic ligand is coordinately bound to an outer surface of the metal particle containing iron oxide; and the metal particle is coated with the at least one zwitterionic ligand.

Claim 9

The nanoparticle as set forth in any one of claims 1 through 7, wherein said nanoparticle is a composite comprising the at least one zwitterionic ligand and the metal particle containing iron oxide, the at least one zwitterionic ligand being coordinately bound to the metal particle.

Claim 10

The nanoparticle as set forth in any one of claims 1 through 7, wherein said nanoparticle is a cluster comprising

two or more zwitterionic ligand compounds and two or more metal particles, each of the two or more metal particles containing iron oxide, and at least one zwitterionic ligand compound being coordinately bound to each of the two or more metal particles.

Claim 11

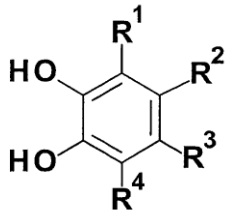
A contrast agent for magnetic resonance imaging comprising a nanoparticle recited in any one of claims 1 through 10.

Claim 12

The contrast agent as set forth in claim 11, wherein said contrast agent is a positive contrast agent.

Claim 13

Use of a zwitterionic ligand compound represented by the following formula (I) for producing a nanoparticle recited in claim 1:

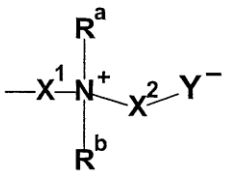


(I)

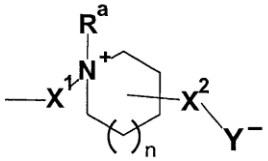
in the at least one zwitterionic ligand,

R^1 is a group represented by a formula (a) or a formula

(b), and R^2 is H or halogen,



(a)、



(b)

X^1 is a bond or methylene, or X^1 is optionally ethylene when R^1 is a group represented by the formula (a),

X^2 is C_{1-5} alkylene, or X^2 is optionally a bond when R^1 is a group represented by the formula (b),

R^a and R^b are methyl,

Y^- is SO_3^- or CO_2^-,

R^3 and R^4 are the same as or different from each other and represent H, C_{1-3} alkyl, or halogen,

n is 1,

and,

i) when R^1 is a group represented by the formula (a) and X^1 is methylene, R^2 optionally forms ethylene together with R^a or R^b.

Claim 14

The compound as set forth in claim 13 or a salt thereof, wherein:

R^1 is a group represented by the formula (a) or the formula (b), and R^2 is H or halogen,

X^1 is a bond or methylene, or X^1 is optionally ethylene

when R^1 is a group represented by the formula (a),

X^2 is C_{1-5} alkylene, or X^2 is optionally a bond when R^1 is a group represented by the formula (b),

R^a and R^b are methyl, and

Y^- is SO_3^- or CO_2^-.

Claim 15

The compound as set forth in claim 14 or a salt thereof, which is selected from the group consisting of:

4-{[(2,3-dihydroxyphenyl)methyl](dimethyl)azaniumyl}butane-1-sulfonate,

3-{[(6-fluoro-2,3-dihydroxyphenyl)methyl](dimethyl)azaniumyl}propane-1-sulfonate,

5-{[(2,3-dihydroxyphenyl)methyl](dimethyl)azaniumyl}pentanoate,

{1-[(2,3-dihydroxyphenyl)methyl]-1-methylpiperidin-1-ium-4-yl}acetate,

1-[(2,3-dihydroxyphenyl)methyl]-1-methylpiperidin-1-ium-4-carboxylate,

4-{[2-(2,3-dihydroxyphenyl)ethyl](dimethyl)azaniumyl}butanoate,

2-{[2-(2,3-dihydroxyphenyl)ethyl](dimethyl)azaniumyl}ethane-1-

sulfonate, and

3-[(2,3-dihydroxyphenyl)(dimethyl)azaniumyl]propane-1-sulfonate.

Claim 16

The compound as set forth in claim 15 or a salt thereof, which is selected from the group consisting of:

{1-[(2,3-dihydroxyphenyl)methyl]-1-methylpiperidin-1-ium-4-yl}acetate, and

2-{[2-(2,3-dihydroxyphenyl)ethyl](dimethyl)azaniumyl}ethane-1-sulfonate.

Claim 17

The compound as set forth in claim 15 or a salt thereof, which is selected from the group consisting of:

4-{[(2,3-dihydroxyphenyl)methyl](dimethyl)azaniumyl}butane-1-sulfonate, and

3-{[(6-fluoro-2,3-dihydroxyphenyl)methyl](dimethyl)azaniumyl}propane-1-sulfonate.