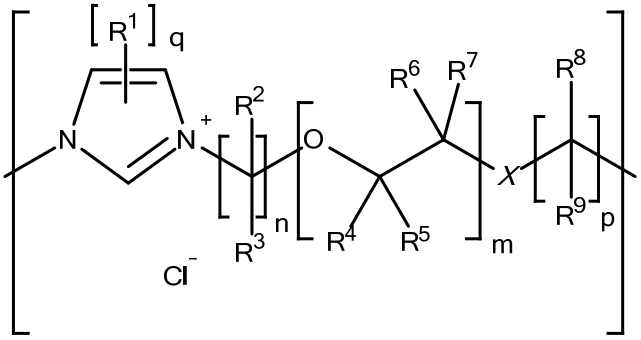
Claims

1. An antimicrobial composite material, comprising:
a cationic antimicrobial compound; and
a bacterial-enzyme-degradable anionic copolymer, wherein
the bacterial-enzyme-degradable anionic copolymer and the cationic antimicrobial compound are attached to one another through electrostatic interaction.

2. The antimicrobial composite material according to Claim 1, wherein the cationic antimicrobial compound is selected from one or more of the group consisting of a polyimidazolium, an oligoimidazolium, and a cationic antimicrobial peptide.

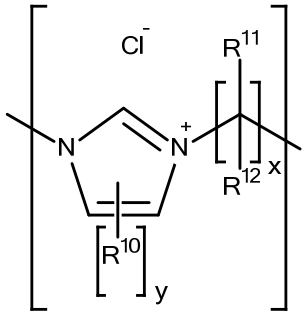
3. The antimicrobial composite material according to Claim 2, wherein the cationic antimicrobial peptide is selected from one or more of the group Cecropin A, Cecropin B, Cecropin P1, Dermaseptin 1, Indolicidin, Lactofermicin B, Magainin I, Magainin II, Melittin, Polistes Mastoparan, Tachyplesin I, optionally wherein the cationic antimicrobial peptide is Melittin.

4. The antimicrobial composite material according to Claim 2, wherein the polyimidazolium has a repeating unit of formula (I):



(I)

or is a copolymer comprising the repeating unit of formula (I) and a repeating unit of formula (II):



(II)

wherein:

R^1 and R^{10}, when present, independently represent C_{1-6} alkyl;

each R^2 to R^8 and R^{11} independently represent H or C_{1-6} alkyl;

each R^9 and R^{12} independently represents H, C_{1-6} alkyl or CO_2R^{13};

R^{13} represents H or C_{1-6} alkyl;

X represents $CR^{14}R^{15}$, O or S;

R^{14} and R^{15} independently represent H, C_{1-6} alkyl or CO_2R^{13};

m is a number selected from 0 to 5;

n is a number selected from 2 to 10;

p is a number selected from 0 to 5;

q is a number selected from 0 to 3;

x is a number selected from 2 to 10;

y is a number selected from 0 to 3; and

solvates thereof,

provided that, when the polyimidazolium is a copolymer, the repeating unit of formula (I) and the repeating unit of formula (II) are not the same, optionally wherein:

R^1 and R^{10}, when present, independently represent C_{1-3} alkyl;

each R^2 to R^8 and R^{11} independently represents H or methyl;

each R^9 and R^{12} independently represents H, C_{1-3} alkyl or CO_2R^{13};

R^{13} represents H or C_{1-3} alkyl;

X represents $CR^{14}R^{15}$ or O;

R^{14} and R^{15} independently represent H, C_{1-3} alkyl or CO_2R^{13};

m is a number selected from 0 to 4;

n is a number selected from 2 to 8;

p is a number selected from 0 to 3;

q is a number selected from 0 to 1;

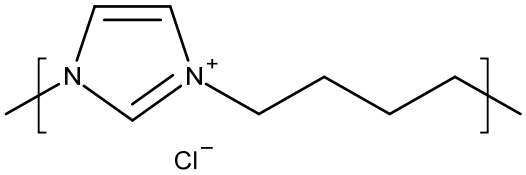
x is a number selected from 2 to 8; and

y is a number selected from 0 to 1, yet further optionally wherein

each R^2 to R^8 and R^{11} independently represents H;
each R^9 and R^{12} independently represents H, methyl or CO_2H;
X represents $CR^{14}R^{15}$ or O;
R^{14} and R^{15} independently represent H, methyl or CO_2H;
m is a number selected from 0 to 3;
n is a number selected from 2 to 7;
p is a number selected from 0 to 2;
q and y are 0; and
x is a number selected from 2 to 7, yet further optionally wherein:
each R^2 to R^8 and R^{11} independently represents H;
each R^9 and R^{12} independently represents H, methyl or CO_2H;
X represents $CR^{14}R^{15}$ or O;
R^{14} and R^{15} independently represent H, methyl or CO_2H;
m is a number selected from 0 to 2;
n is a number selected from 2 to 7;
p is a number selected from 0 to 2;
q and y are 0; and
x is a number selected from 2 to 7, yet further optionally wherein
the number average molecular weight is from 500 to 7,000 Daltons, yet further optionally , wherein the polyimidazolium has the repeating unit of formula (I), optionally wherein:
each of R^2 to R^8 are H;
each R^9 represents H, methyl or CO_2H;
X represents CH_2 or O;
m is a number selected from 0 to 2;
n is a number selected from 2 to 6;
p is a number selected from 0 to 2; and
q is 0.

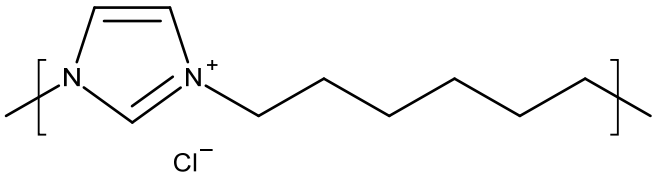
5. The antimicrobial composite material according to Claim 4, wherein one or both of the following apply:
(ia) when X is O, p is 1 or 2; and
(ib) the polyimidazolium is terminated by amino (NH_2) groups.

6. The antimicrobial composite material according to any one of Claims 4 to 5, wherein the repeating unit is selected from the group consisting of:
(i)



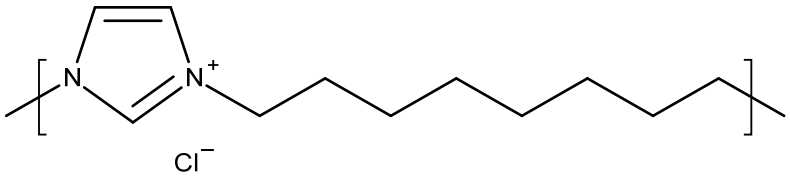
, optionally wherein the number average molecular weight of the polymer is from 500 to 2,500 Daltons;

(ii)



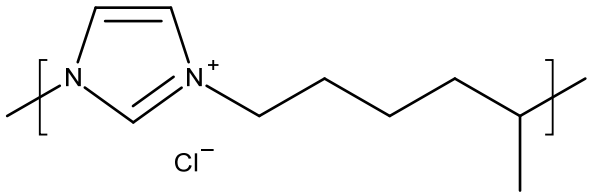
, optionally wherein the number average molecular weight of the polymer is from 500 to 2,500 Daltons;

(iii)



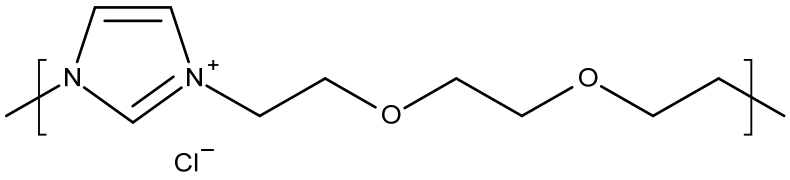
, optionally wherein the number average molecular weight of the polymer is from 500 to 2,500 Daltons;

(iv)



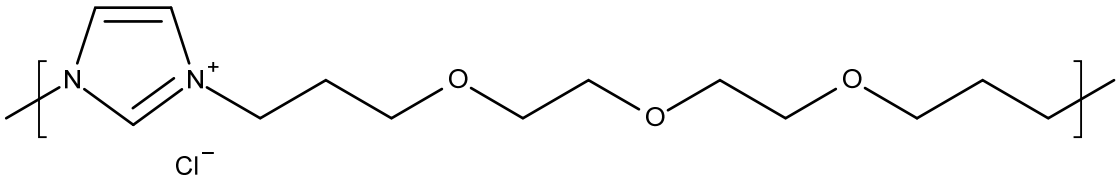
, optionally wherein the number average molecular weight of the polymer is from 500 to 2,000 Daltons;

(v)



, optionally wherein the number average molecular weight of the polymer is from 4,000 to 5,500 Daltons;

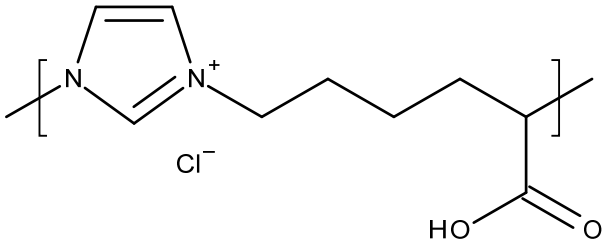
(vi)



,

optionally wherein the number average molecular weight of the polymer is from 4,000 to 5,000 Daltons; and

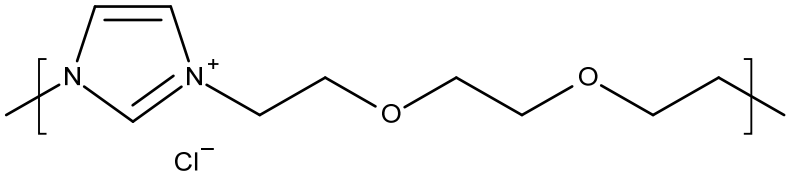
(vii)



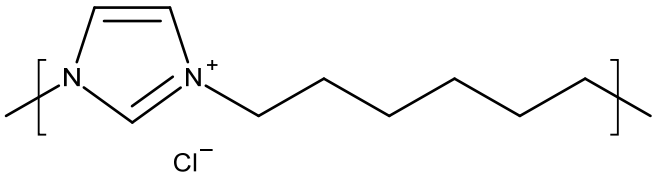
, optionally wherein the number average molecular weight of the polymer is from 500 to 2,000 Daltons.

7. The antimicrobial composite material according to Claim 4, wherein the repeating unit of formula (I) and formula (II) are selected from the group consisting of:

(i)

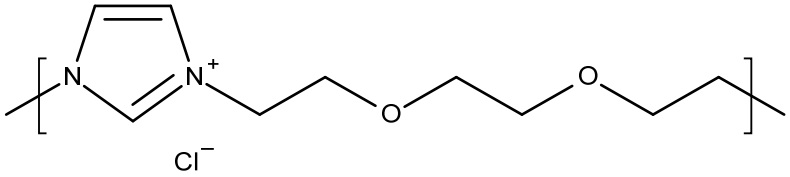


as the repeating unit of formula (I) and

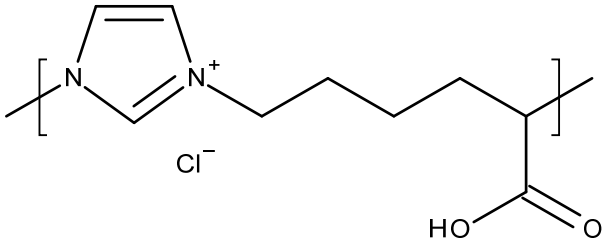


as the repeating unit of formula (II) , optionally wherein the number average molecular weight of the copolymer is from 1,000 to 5,000 Daltons; and

(ii)

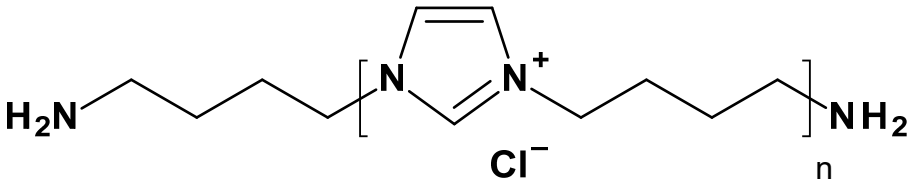


as the repeating unit of formula (I) and



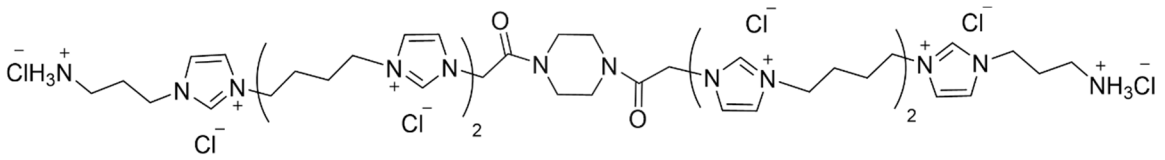
as the repeating unit of formula (II) , optionally wherein the number average molecular weight of the copolymer is from 1,000 to 5,000 Daltons.

8. The antimicrobial composite material according to Claim 2, wherein the polyimidazolium is:



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9. The antimicrobial composite material according to Claim 2, wherein the oligoimidazolium is MR-107 (OIM1-6-1PzAc):

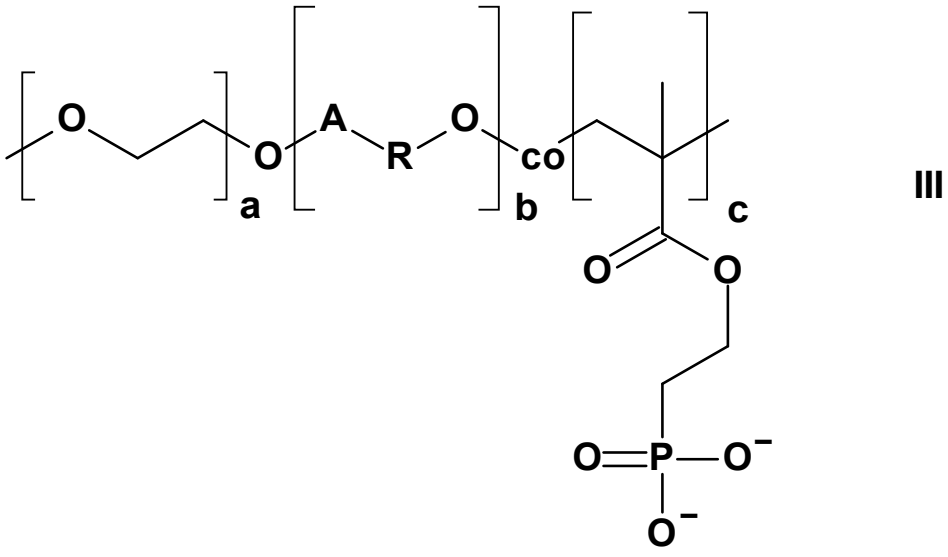


MR-107 (OIM1-6-1PzAc).

10. The antimicrobial composite material according to any one of the preceding claims, wherein one or more of the following apply:

(i) the bacterial-enzyme-degradable anionic copolymer comprises a repeating unit that bears a phosphonate group; and

(ii) the bacterial-enzyme-degradable anionic copolymer has the formula (III):



III

(III)

where:

R is a C_1 to C_{10} linear or branched alkyl chain;

A represents C=O or $P(OR_a)=O$;

R_a represents a linear or branched C_1 to C_6 alkyl group;

a represents a block polyethylene glycol unit having a number average molecular weight of from 500 to 10,000 Daltons;

b and c together represent a random copolymer block, where b and c each independently have a value of from 8 to 100, optionally wherein one or more of the following apply:

(a) a represents a block polyethylene glycol unit having a number average molecular weight of about 2,000 Daltons;

(b) b and c each independently have a value of from 10 to 50, such as 15 to 20, such as 18;

(c) A represents C=O; and

(d) R represents $–(CH_2)_5–$;

(iii) the bacterial-enzyme-degradable anionic copolymer has a number average molecular weight of from 6,000 to 10,000 Daltons, such as from 7,000 to 8,000 Daltons.

11. The antimicrobial composite material according to any one of the preceding claims, wherein one or more of the following apply:

(a) the bacterial-enzyme-degradable anionic copolymer is degradable by a bacterial-secreted lipase or a bacterial-secreted phosphoesterase, such as a bacterial-secreted lipase;

(b) the weight to weight ratio of the cationic antimicrobial compound and the bacterial-enzyme-degradable anionic copolymer is selected to provide a material with a zeta potential of from +10 to -10 mV, such as from +6 to -6 mV, such as from 0 to -5.3 mV; and

(c) the weight to weight ratio of the cationic antimicrobial compound and the bacterial-enzyme-degradable anionic copolymer is from 1:5 to 5:1, such as from 1:2 to 2:1, such as about 1:1.7.

12. A pharmaceutical composition comprising an antimicrobial composite material according to any one of Claims 1 to 11 and one or more of a pharmaceutically acceptable excipient and carrier.

13. An antimicrobial composite material according to any one of Claims 1 to 11, or a pharmaceutical composition as described in Claim 12, for use as a medicament.

14. Use of an antimicrobial composite material according to any one of Claims 1 to 11, or a pharmaceutical composition as described in Claim 12, in the manufacture of a medicament to treat a microbial and/or fungal infection in a subject in need thereof.

15. A method of manufacture of an antimicrobial composite material according to any one of Claims 1 to 11, the method comprising the steps of:

(i) providing a solution of a cationic antimicrobial compound and providing a solution of a bacterial-enzyme-degradable anionic copolymer as described in any one of Claims 1 to 11; and

(ii) mixing the solutions together to form a mixture and agitating the mixture for a period of time to form the antimicrobial composite material.