

(2),

wherein

a′ is an integer equal to 1 or 2,

b′ is an integer equal to 1 or 2,

each R′ is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof,

G′ is a divalent linking group selected from the group consisting of a single bond and groups comprising at least one carbon,

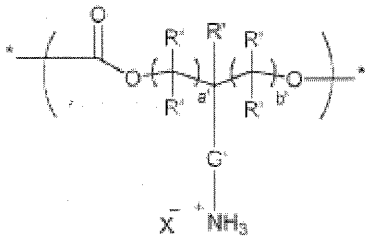
X^- is a negatively charged counterion, and

the drug and the amine polymer are bound by noncovalent interactions.

[0009a] In an aspect, there is provided an antimicrobial composition, comprising:

an anionic drug; and

an amine polymer comprising a first repeat unit of formula (2):



(2),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, and ethyl,

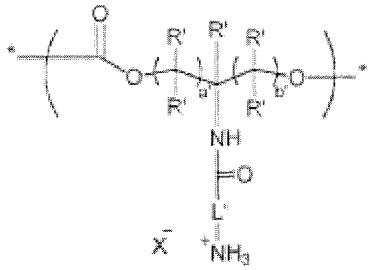
G' is a divalent linking group comprising i) at least one carbon and ii) a nitrogen bonded to the backbone of the amine polymer,

X^- is a negatively charged counterion, and

the drug and the amine polymer are bound by noncovalent interactions.

[0010] Also disclosed is an antimicrobial amine polymer, comprising:

a first repeat unit of formula (4):



(4),

wherein

a′ is an integer equal to 1 or 2,

b′ is an integer equal to 1 or 2,

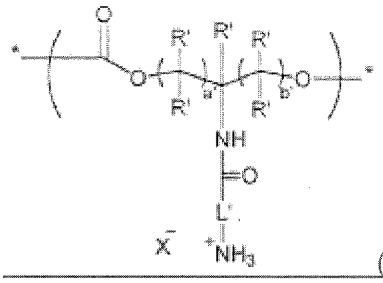
each R′ is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof,

L' is a divalent linking group comprising 2 to 10 carbons, and

X^- is a negatively charged counterion.

[0010a] In another aspect, there is provided an antimicrobial amine polymer, comprising:

a first repeat unit of formula (4):



(4),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

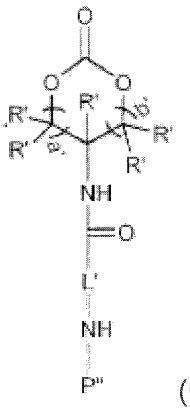
each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl and ethyl,

L' is a divalent linking group comprising 2 to 10 carbons, and

X^- is a negatively charged counterion.

[0011] Also disclosed is a method, comprising:

providing a mixture comprising i) a first cyclic carbonate monomer, ii) a nucleophilic initiator for ring opening polymerization, iii) an organocatalyst, and iv) a solvent, wherein the first cyclic carbonate monomer has a structure according to formula (6):



(6),

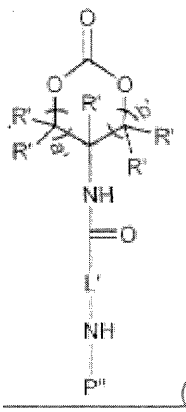
wherein a′ is an integer equal to 1 or 2, b′ is an integer equal to 1 or 2, each R′ is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof, L′ is a divalent linking group comprising 2 to 10 carbons, and P″ is a primary amine protecting group;

agitating the mixture, thereby forming a protected amine polymer by a ring opening polymerization; and

deprotecting the protected amine polymer, thereby forming an antimicrobial amine polymer.

[0011a] In another aspect, there is provided a method, comprising:

providing a mixture comprising i) a first cyclic carbonate monomer, ii) a nucleophilic initiator for ring opening polymerization, iii) an organocatalyst, and iv) a solvent, wherein the first cyclic carbonate monomer has a structure according to formula (6):



(6),

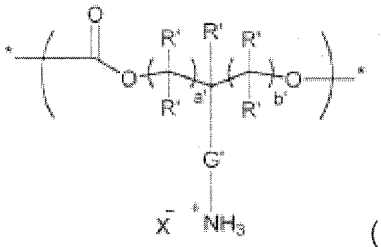
wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl and ethyl, L' is a divalent linking group comprising 2 to 10 carbons, and P'' is a primary amine protecting group;

agitating the mixture, thereby forming a protected amine polymer by a ring opening polymerization; and

deprotecting the protected amine polymer, thereby forming an antimicrobial amine polymer.

[0012] Further disclosed is a method comprising:

forming an aqueous mixture containing an amine polymer comprising a first repeat unit of formula (2):



(2),

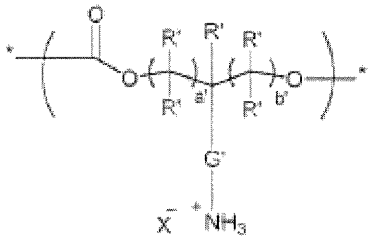
wherein a′ is an integer equal to 1 or 2, b′ is an integer equal to 1 or 2, each R′ is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof, G′ is a divalent linking group selected from the group consisting of a single bond and groups comprising at least one carbon, and X^- is a negatively charged counterion;

forming a second aqueous mixture comprising an anionic drug; and

combining the first mixture and the second mixture, thereby forming an antimicrobial composition, wherein the amine polymer and the drug are bound by non-covalent interactions.

[0012a] In another aspect, there is provided a method, comprising:

forming an aqueous mixture containing an amine polymer comprising a first repeat unit of formula (2):



(2),

wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, and ethyl, G' is a divalent linking group comprising i) at least one carbon and ii) a nitrogen bonded to the backbone of the amine polymer, and X^- is a negatively charged counterion;

forming a second aqueous mixture comprising an anionic drug; and

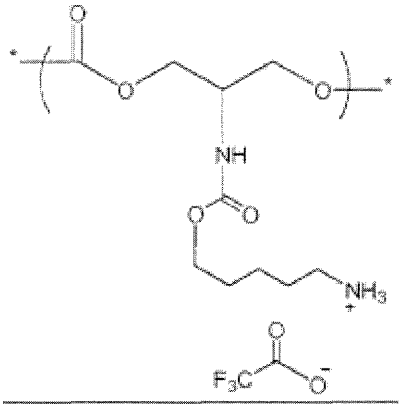
combining the first mixture and the second mixture, thereby forming an antimicrobial composition, wherein the amine polymer and the drug are bound by non-covalent interactions.

[0013] Also disclosed is a method of treating a microbe, comprising contacting the microbe with the above-described composition, thereby killing the microbe.

[0014] ~~Another~~ In another aspect, there is provided a method ~~is disclosed~~, comprising disposing the above-described composition on a surface of a substrate and removing any solvent, thereby forming an antimicrobial layer on the surface of the substrate.

[0015] ~~Also disclosed~~ In another aspect, there is provided an article comprising the above-described composition disposed on a surface of a medical device.

[0015a] In another aspect, there is provided an antimicrobial amine polymer, comprising a first repeat unit having a structure



[0016] The above-described and other features and advantages of the present ~~invention~~ disclosure will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

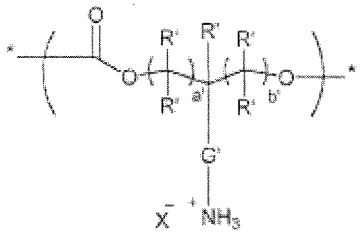
CLAIMS

What is claimed is:

1. An antimicrobial composition, comprising:

an anionic drug; and

an amine polymer comprising a first repeat unit of formula (2):



(2),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, and ethyl,

G' is a divalent linking group comprising i) at least one carbon and ii) a nitrogen bonded to the backbone of the amine polymer,

X^- is a negatively charged counterion, and

the drug and the amine polymer are bound by noncovalent interactions.

2. The composition of claim 1, wherein a' is 1 and b' is 1.

3. The composition of claim 1, wherein the amine polymer has a minimum inhibitory concentration (MIC) of more than 0 mg/L and less than 200 mg/L against a microbe.

4. The composition of claim 1, wherein the amine polymer has no repeat unit comprising a quaternary amine group.

5. The composition of claim 1, wherein the amine polymer is a polycarbonate and/or a polyestercarbonate.

6. The composition of claim 1, wherein the amine polymer is a diblock copolymer.

7. The composition of claim 1, wherein the amine polymer is a triblock copolymer.

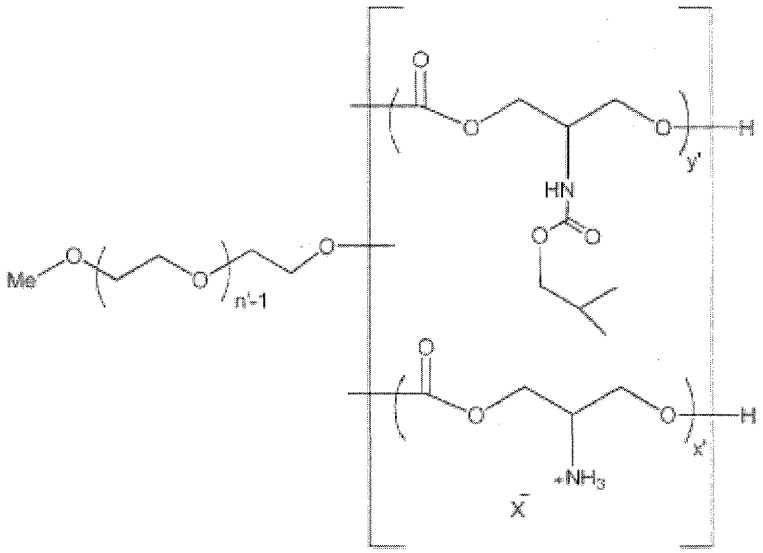
8. The composition of claim 1, wherein the amine polymer is a star polymer comprising 6 or more independent block copolymer arms, wherein each of the arms comprises a first block comprising a poly(alkylene oxide) backbone linked to a second block comprising the first repeat unit, and the first block is linked by an end group to a covalently crosslinked microgel core of the star polymer.

9. The composition of claim 1, wherein the amine polymer is a pendant group of a covalently crosslinked hydrogel.

10. The composition of claim 1, wherein the drug is diclofenac (DCF).

11. The composition of claim 1, wherein the drug is penicillin G (PenG).

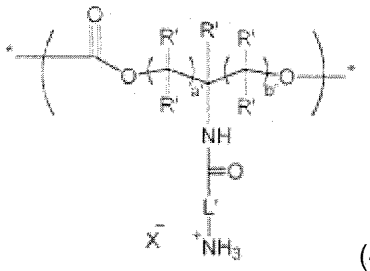
12. The composition of claim 1, wherein the amine polymer has the structure:



wherein X^- is an negatively charged counterion, n' is 50 or more, x' is 10 or more, and y' is 10 or more.

13. An antimicrobial amine polymer, comprising:

a first repeat unit of formula (4):



(4),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl and ethyl,

L' is a divalent linking group comprising 2 to 10 carbons, and

X^- is a negatively charged counterion.

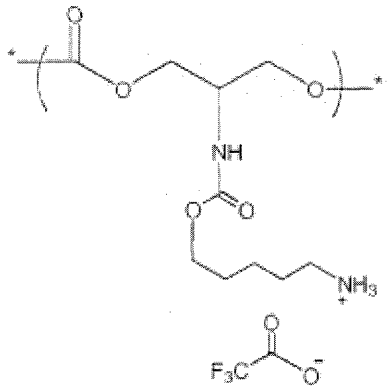
14. The amine polymer of claim 13, wherein the amine polymer consists essentially of a homopolymer chain of the first repeat unit linked to a monomeric alkoxy end group or a monomeric aryloxy end group.

15. The amine polymer of claim 14, wherein the amine polymer has a degree of polymerization of about 15 to about 45.

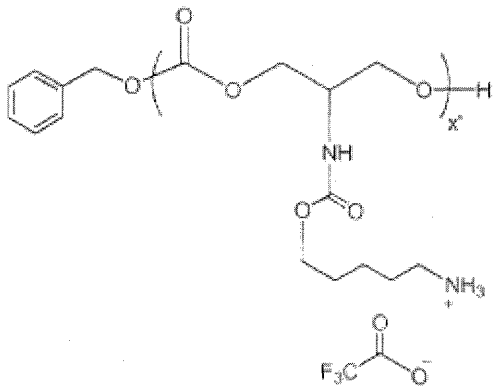
16. The amine polymer of claim 14, wherein the amine polymer has a minimum inhibitory concentration (MIC) in water against *Escherichia coli* of about 30 mg/L to about 125 mg/L.

17. The amine polymer of claim 14, wherein the amine polymer has a minimum inhibitory concentration (MIC) in water against *Streptococcus aureus* of about 30 mg/L to about 125 mg/L.

18. The amine polymer of claim 14, wherein the first repeat unit has a structure



19. The amine polymer of claim 14, wherein the amine polymer has a structure



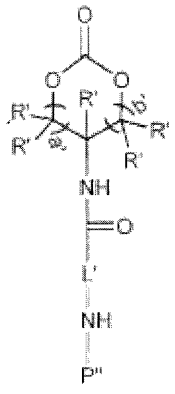
wherein x' is a positive integer having a value of about 15 to about 30.

20. The amine polymer of claim 13, wherein the amine polymer is a linear random copolymer consisting essentially of i) the first repeat unit, ii) a hydrophobic second repeat unit comprising an ester or carbonate backbone group, and iii) a monomeric alkoxy end group or monomeric aryloxy end group.

21. The amine polymer of claim 20, wherein the linear random copolymer has a degree of polymerization of about 10 to about 30.

22. A method, comprising:

providing a mixture comprising i) a first cyclic carbonate monomer, ii) a nucleophilic initiator for ring opening polymerization, iii) an organocatalyst, and iv) a solvent, wherein the first cyclic carbonate monomer has a structure according to formula (6):



(6),

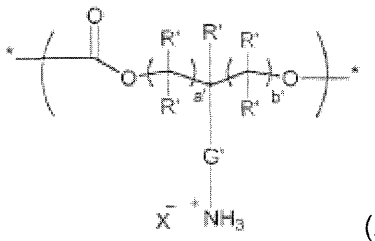
wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl and ethyl, L' is a divalent linking group comprising 2 to 10 carbons, and P" is a primary amine protecting group;

agitating the mixture, thereby forming a protected amine polymer by a ring opening polymerization; and

deprotecting the protected amine polymer, thereby forming an antimicrobial amine polymer.

23. A method, comprising:

forming an aqueous mixture containing an amine polymer comprising a first repeat unit of formula (2):



(2),

wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, and ethyl, G' is a divalent linking group comprising i) at least one carbon and ii) a

nitrogen bonded to the backbone of the amine polymer, and X^- is a negatively charged counterion;

forming a second aqueous mixture comprising an anionic drug; and

combining the first mixture and the second mixture, thereby forming an antimicrobial composition, wherein the amine polymer and the drug are bound by non-covalent interactions.

24. A method, comprising:

disposing the composition of claim 1 on a surface of a substrate and removing any solvent, thereby forming an antimicrobial layer on the surface of the substrate.

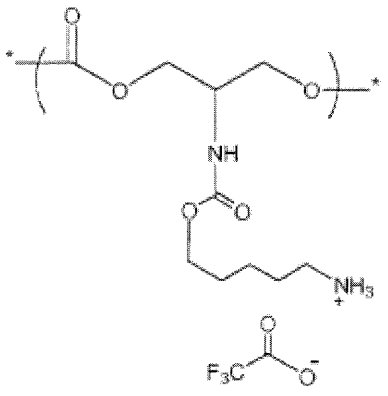
25. The method of claim 24, wherein the substrate is a medical device.

26. An article comprising the composition of claim 1 disposed on a surface of a medical device.

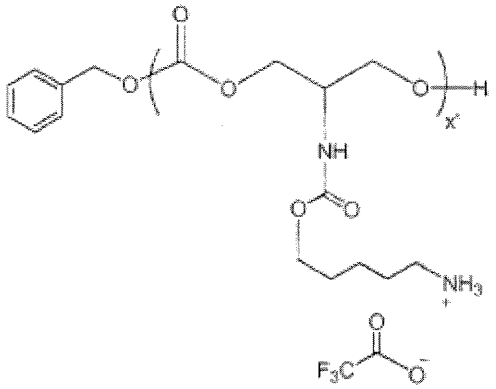
27. The article of claim 26, wherein the medical device is a catheter.

28. The article of claim 26, wherein the medical device is a material suitable for a wound dressing.

29. An antimicrobial amine polymer, comprising a first repeat unit having a structure



30. The amine polymer of claim 29, wherein the amine polymer has a structure



wherein x′ is a positive integer having a value of about 15 to about 30.

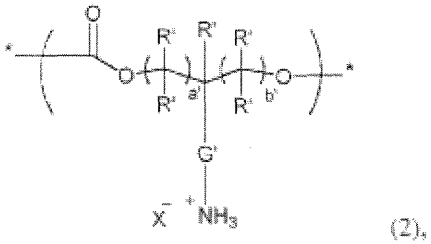
CLAIMS

What is claimed is:

1. An antimicrobial composition, comprising:

an anionic drug; and

an amine olymer comprising a first repeat unit of formula (2):



(2),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof,

G' is a divalent linking group selected from the group consisting of a single bond and groups comprising at least one carbon,

X^- is a negatively charged counterion, and

the drug and the amine polymer are bound by noncovalent interactions.

2. The composition of claim 1, wherein G' comprises a nitrogen bonded to the backbone of the amine polymer.

3. The composition of claim 1, wherein a' is 1 and b' is 1.

4. The composition of claim 1, wherein the amine polymer has a minimum inhibitory concentration (MIC) of more than 0 mg/L and less than 200 mg/L against a microbe.

5. The composition of claim 1, wherein the amine polymer has no repeat unit

comprising a quaternary amine group.

6. The composition of claim 1, wherein the amine polymer is a polycarbonate and/or a polyestercarbonate.

7. The composition of claim 1, wherein the amine polymer is a diblock copolymer.

8. The composition of claim 1, wherein the amine polymer is a triblock copolymer.

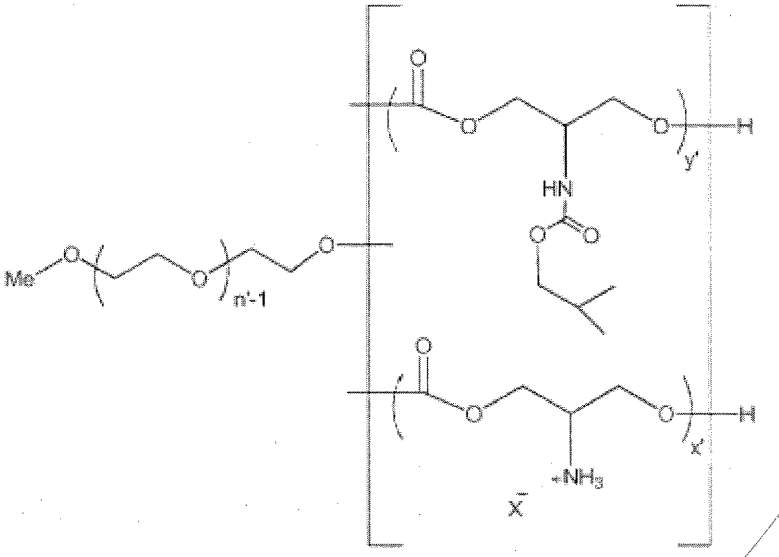
9. The composition of claim 1, wherein the amine polymer is a star polymer comprising 6 or more independent block copolymer arms, wherein each of the arms comprises a first block comprising a poly(alkylene oxide) backbone linked to a second block comprising the first repeat unit, and the first block is linked by an end group to a covalently crosslinked microgel core of the star polymer.

10. The composition of claim 1, wherein the amine polymer is a pendant group of a covalently crosslinked hydrogel.

11. The composition of claim 1, wherein the drug is diclofenac (DCF).

12. The composition of claim 1, wherein the drug is penicillin G (PenG).

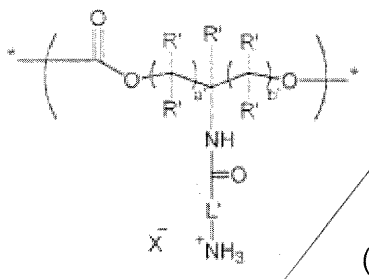
13. The composition of claim 1, wherein the amine polymer has the structure:



wherein X^{-} is an negatively charged counterion, n' is 50 or more, x' is 10 or more, and y' is 10 or more.

14. An antimicrobial amine polymer, comprising:

a first repeat unit of formula (4):



(4),

wherein

a' is an integer equal to 1 or 2,

b' is an integer equal to 1 or 2,

each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof,

L' is a divalent linking group comprising 2 to 10 carbons, and

X^- is a negatively charged counterion.

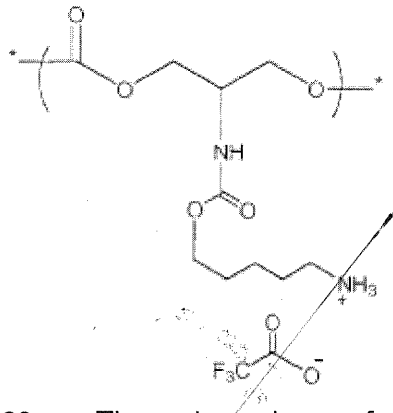
15. The amine polymer of claim 14, wherein the amine polymer is a homopolymer of the first repeat unit, the homopolymer having a monomeric alkoxy end group or a monomeric aryloxy end group.

16. The amine polymer of claim 15, wherein the amine polymer has a degree of polymerization of about 15 to about 45.

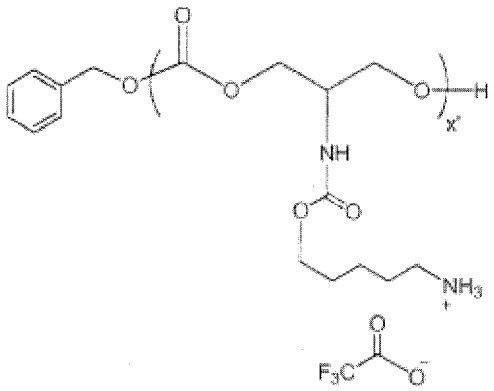
17. The amine polymer of claim 15, wherein the amine polymer has a minimum inhibitory concentration (MIC) in water against *Escherichia coli* of about 30 mg/L to about 125 mg/L.

18. The amine polymer of claim 15, wherein the amine polymer has a minimum inhibitory concentration (MIC) in water against *Streptococcus aureus* of about 30 mg/L to about 125 mg/L.

19. The amine polymer of claim 15, wherein the first repeat unit has a structure



20. The amine polymer of claim 15, wherein the amine polymer has a structure

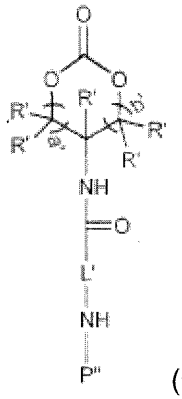


wherein x' is a positive integer having a value of about 15 to about 30.

21. The amine polymer of claim 14, wherein the amine polymer is a linear random copolymer consisting essentially of i) the first repeat unit, ii) a hydrophobic second repeat unit comprising an ester or carbonate backbone group, and iii) a monomeric alkoxy end group or monomeric aryloxy end group.

22. The amine polymer of claim 21, wherein the linear random copolymer has a degree of polymerization of about 10 to about 30.

23. A method, comprising:
providing a mixture comprising i) a first cyclic carbonate monomer, ii) a nucleophilic initiator for ring opening polymerization, iii) an organocatalyst, and iv) a solvent, wherein the first cyclic carbonate monomer has a structure according to formula (6):



(6),

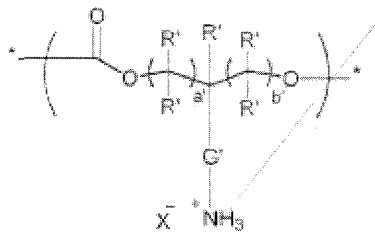
wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl, ethyl, and combinations thereof, L' is a divalent linking group comprising 2 to 10 carbons, and P" is a primary amine protecting group;

agitating the mixture, thereby forming a protected amine polymer by a ring opening polymerization; and

deprotecting the protected amine polymer, thereby forming an antimicrobial amine polymer.

24. A method, comprising:

forming an aqueous mixture containing an amine polymer comprising a first repeat unit of formula 2):



(2),

wherein a' is an integer equal to 1 or 2, b' is an integer equal to 1 or 2, each R' is an independent monovalent radical selected from the group consisting of hydrogen, methyl,

ethyl, and combinations thereof, G' is a divalent linking group selected from the group consisting of a single bond and groups comprising at least one carbon, and X^- is a negatively charged counterion;

forming a second aqueous mixture comprising an anionic drug; and

combining the first mixture and the second mixture, thereby forming an antimicrobial composition, wherein the amine polymer and the drug are bound by non-covalent interactions.

25. A method of treating a microbe, comprising contacting the microbe with the composition of claim 1, thereby killing the microbe.

26. A method, comprising:

disposing the composition of claim 1 on a surface of a substrate and removing any solvent, thereby forming an antimicrobial layer on the surface of the substrate.

27. The method of claim 26, wherein the substrate is a medical device.

28. An article comprising the composition of claim 1 disposed on a surface of a medical device.

29. The article of claim 28, wherein the medical device is a catheter.

30. The article of claim 28, wherein the medical device is a material suitable for a wound dressing.