reported in the literature are non-biodegradable and/or require several steps of synthesis. With the high volume of poorly degradable single-use consumer products already destined for landfills, the problem would be exacerbated by the addition of non-biodegradable antimicrobial materials that destroy bacteria and fungi responsible for slow landfill degradation.

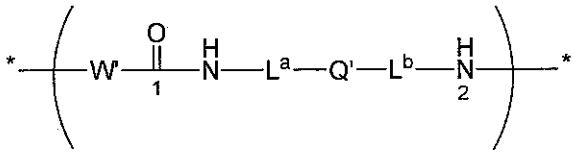
[0007] A number of biodegradable cationic polycarbonates having high potency towards pathogenic microbes and low toxicity. These cationic polycarbonates degrade in aqueous solution especially in an alkaline environment which is often found in consumer care products. On the other hand, the synthesis of polycarbonates requires several steps like monomer synthesis, ring-opening polymerization and post-quaternization, which can translate into high consumer prices.

[0008] Currently, biodegradable, safe and cost-effective antimicrobial agents are needed for use in personal care products that can kill multidrug-resistant bacteria and fungi, remove biofilms, and prevent drug resistance.

SUMMARY

[0009] In an aspect, a cationic polymer is disclosed, comprising:

a cationic repeat unit of formula (1):



(1),

wherein

W' is a single bond or a divalent linking group having a structure *-C(=O)-L'-*, wherein L' is divalent radical comprising 1-20 carbons and L' is linked to carbon 1,

L' is a divalent radical comprising 1-20 carbons,

L^a and L^b are independent divalent hydrocarbon groups comprising 2-20 carbons, and

Q' is a divalent radical comprising a positive-charged nitrogen which is covalently bonded to 4 carbons, and

adjacent repeat units of the cationic polymer are covalently linked in a head-to-tail arrangement, wherein nitrogen labeled 2 is designated a tail and W' is designated a head.

[0010] In another aspect, disclosed is a method of killing a microbe, comprising contacting the microbe with an above-described cationic polymer.

[0011] In another aspect, disclosed is an antimicrobial composition, comprising an above-described cationic polymer and at least one other chemical component.

[0012] The above-described and other features and advantages of the present invention 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

[0013] **Figure 1** is a ^{1}H NMR spectrum of cationic polymer P48a.

[0014] **Figure 2** is a ^{1}H NMR spectrum of cationic polymer P48b.

[0015] **Figure 3** is a ^{1}H NMR spectrum of cationic polymer P49a.

[0016] **Figure 4** is a ^{1}H NMR spectrum of cationic polymer P49b.

[0017] **Figure 5** is a bar graph showing the killing efficiency of cationic polymers P32c and P32d against Staphylococcus aureus (S. aureus) at polymer concentrations of 0.5MIC, 1.0MIC and 2.0MIC.

[0018] **Figure 6** is a bar graph showing the killing efficiency of cationic polymers P32c and P32d against Pseudomonas aeruginosa (P. aeruginosa) at polymer concentrations of 0.5MIC, 1.0MIC and 2.0MIC.

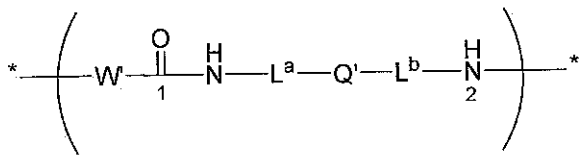
[0019] **Figure 7** is a bar graph showing the killing efficiency of cationic polymers P32c and P32d against Candida albicans (C. albicans) at polymer concentrations of 0.5MIC, 1.0MIC and 2.0MIC.

CLAIMS

What is claimed is:

1. A cationic polymer, comprising:

a cationic repeat unit of formula (1):



(1),

wherein

W' is a single bond or a divalent linking group having a structure *-C(=O)-L'-*, wherein L' is divalent radical comprising 1-20 carbons and L' is linked to carbon 1,

L' is a divalent radical comprising 1-20 carbons,

L^a and L^b are independent divalent hydrocarbon groups comprising 2-20 carbons, and

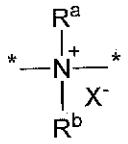
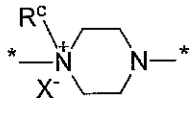
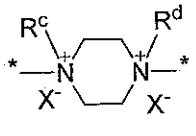
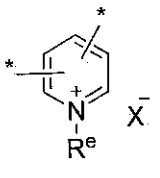
Q' is a divalent radical comprising a positive-charged nitrogen which is covalently bonded to 4 carbons, and

adjacent repeat units of the cationic polymer are covalently linked in a head-to-tail arrangement, wherein nitrogen labeled 2 is designated a tail and W' is designated a head.

2. The cationic polymer of claim 1, wherein L' is selected from the group consisting of methylene, 1,2-ethylene, 1,1-ethylene, 1,3-propylene, 1,1-propylene, 1,4-butylene, 1,1-butylene, 1,5-pentylene, and 1,1-pentylene.

3. The cationic polymer of claim 1, wherein the quaternary nitrogen is a backbone nitrogen of the cationic polymer.

4. The cationic polymer of claim 1, wherein Q' is selected from group consisting of


(4),

(5),

(6), and

(7),

wherein

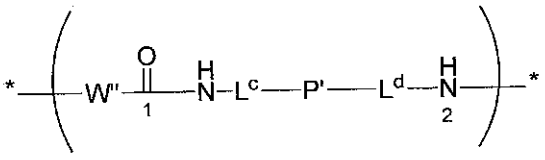
R^a, R^b, R^c, R^d, R^e are independent monovalent hydrocarbon groups comprising 1-20 carbons, and

each X^- is an independent negative-charged counterion.

5. The cationic polymer of claim 4, wherein R^a is methyl and R^b is benzyl.

6. The cationic polymer of claim 4, wherein R^c, R^d, and R^e are independently selected from the group consisting of methyl and benzyl.

7. The cationic polymer of claim 1, wherein the cationic polymer comprises a random distribution of i) the cationic repeating units and ii) a polymeric repeat unit of formula (8):


(8),

wherein

nitrogen labeled 2 is designated a tail,

W" is designated a head,

W" is a single bond or a divalent linking group having a structure *-C(=O)-L"-*, wherein L" is divalent radical comprising 1-20 carbons and L" is linked to carbonyl carbon 1,

L^c and L^d are independent divalent linking groups selected from the group consisting of a single bond, and hydrocarbon groups comprising 1-6 carbons, and

P' is a divalent poly(alkylene oxide) chain.

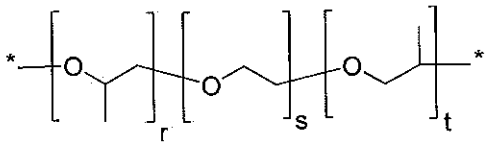
8. The cationic polymer of claim 7, wherein P' is a block copolymer chain comprising a poly(propylene oxide) block and a poly(ethylene oxide) block.

9. The cationic polymer of claim 7, wherein the cationic polymer comprises the polymeric repeating units in an amount of more than 0 mol% to about 10 mol% based on total moles of repeating units of the cationic polymer.

10. The cationic polymer of claim 7, wherein the cationic polymer comprises the polymeric repeating units in an amount of about 2.5 mol% to about 10 mol% based on total moles of repeating units of the cationic polymer.

11. The cationic polymer of claim 7, wherein L" is selected from the group consisting of methylene, 1,2-ethylene, 1,1-ethylene, 1,3-propylene, 1,1-propylene, 1,4-butylene, 1,1-butylene, 1,5-pentylene, and 1,1-pentylene.

12. The cationic polymer of claim 7, wherein P' is a triblock copolymer having a structure according to formula (9):



(9),

wherein

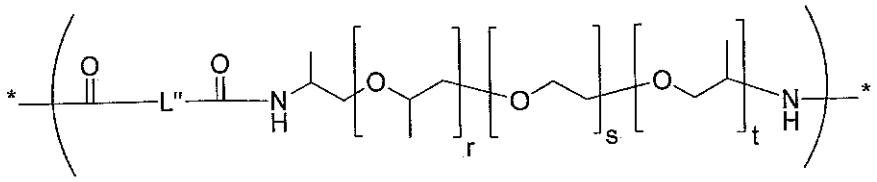
r, s, and t represent degrees of polymerization of respective blocks of alkylene oxide repeat units enclosed in the brackets,

r, s, and t independently have average values greater than 1.

13. The cationic polymer of claim 7, wherein P' has a number average molecular weight (Mn) of about 500 to about 5000 or

about 1500 to about 2500.

14. The cationic polymer of claim 7, wherein the polymeric repeat units have structures in accordance with formula (10):



(10),

wherein

L" is a divalent group comprising 1-20 carbons,

r, s, and t represent average numbers of respective alkylene oxide repeat units, and

r, s, and t independently have average values greater than 1.

15. The cationic polymer of claim 14, wherein s/(r+t) has a value of about 2 to about 12.

16. A method of killing a microbe, comprising contacting the microbe with the cationic polymer of claim 1.

17. The method of claim 16, where the microbe is selected from the group consisting of Gram-positive microbes, Gram-negative microbes, fungi, and combinations thereof.

18. An antimicrobial composition comprising the cationic polymer of claim 1 and at least one other chemical component.

19. The antimicrobial composition of claim 18, wherein the antimicrobial composition is selected from the group consisting of soaps, shampoos, skin lotions, skin creams, cosmetics, mouthwashes, wound care agents, deodorants, surface cleaning agents, and laundry detergents.

20. The antimicrobial composition of claim 18, wherein the antimicrobial composition is toxic to a microbe selected from the group consisting of Gram-positive microbes, Gram-negative microbes, fungi, and combinations thereof.