Claims

1. An anti-microbial coating comprising an alkyl urea polyalkylene imine polymer and an anionic polymer, the alkyl urea polyalkylene imine polymer being a polyalkylene imine polymer having at least one alkyl group attached to the polyalkylene imine polymer backbone by way of at least one urea linkage that includes a nitrogen heteroatom on the polyalkylene imine polymer backbone.

2. An anti-microbial coating as claimed in claim 1, wherein the anionic polymer is an anionic polyelectrolyte, such as an anionic glycosaminoglycan or polysaccharide, or a polycarboxylic acid polymer, such as a polyacrylic acid polymer or a salt thereof, or wherein the anionic polymer is dextran sulfate.

3. An anti-microbial coating as claimed in any preceding claim, wherein the alkyl urea polyalkylene imine polymer is an alkyl urea polyethylene imine polymer or an alkyl urea polypropylene imine polymer; and/ or wherein the alkyl urea polyalkylene imine polymer is a polyalkylene imine polymer which is substituted with one or more methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl or decyl urea groups, or with one or more cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, cyclononyl or cyclodecyl urea groups; and/ or wherein the alkyl urea polyalkylene imine polymer is a polyalkylene imine polymer which is substituted with one or more alkyl groups comprising alkylene chains linked to the polyalkylene imine polymer with two or more urea linkages.

4. An anti-microbial coating as claimed in any preceding claim, further comprising a cationic polymer. which is distinct from the alkyl urea polyalkylene imine polymer, such as an unsubstituted polyalkylene imine polymer; and/ or further comprising a guanidine compound which comprises one or more guanide groups, wherein the guanidine compound comprises one or more chlorhexidine groups, and/or one or more alexidine groups, and/or one or more poly(hexamethylene) guanide segments, and/or one or more poly(hexamethylene) biguanide (PHMB) segments.

5. A liquid coating composition suitable for forming an anti-microbial coating according to any of claims 1-4, the liquid coating composition comprising an alkyl urea polyalkylene imine polymer and an anionic polymer, wherein the liquid coating composition is optionally formulated as a solution, suspension, dispersion, or emulsion, in a liquid medium which is aqueous, alcoholic, aqueous/alcoholic, or organic solvent.

6. A liquid coating composition according to claim 5, comprising at least 0.005% w/v of said alkyl urea polyalkylene imine polymer, and/or comprising no more than 25% w/v of said alkyl urea polyalkylene imine polymer, and/ or comprising at least 0.001% w/v of said anionic polymer; and/ or comprising no more than 0.5% w/v of said anionic polymer.

7. A liquid coating composition according to claim 6, comprising between 0.01 – 7.0% w/v of said alkyl urea polyalkylene imine polymer; and/or comprising between 0.001 – 0.20% w/v of said anionic polymer.

8. A liquid coating composition according to any of claims 5-7, further comprising a cationic polymer which is distinct from the alkyl urea polyalkylene imine polymer.

9. A liquid coating composition according to claim 8, wherein the w/w ratio of cationic polymer : alkyl urea polyalkylene imine polymer is in the range 50:1 – 1:5; and/ or wherein the w/w ratio of the combined quantity of cationic polymer and alkyl urea polyalkylene imine polymer to the quantity of anionic polymer is in the range 500:1 – 15:1; and or wherein the total quantity of said cationic polymer, said alkyl urea polyalkylene imine polymer, and said anionic polymer in the composition is no more than 10% w/v of the composition; and/or wherein the total quantity of said cationic polymer, said alkyl urea polyalkylene imine polymer, and said anionic polymer in the composition is at least 0.05% w/v of the composition.

10. A liquid coating composition according to any of claims 5-9, further comprising a guanidine compound.

11. A liquid coating composition according to claim 10, wherein the guanidine compound comprises a cross-linkable polymer bearing one or more guanidine or biguanidine groups, and wherein the liquid coating composition further comprises a cross-linking agent for cross-linking the polymer; and optionally wherein the guanidine compound comprises a cross-linkable polymer bearing one or more cross-linkable carboxylic acid groups.

12. A liquid coating composition according to claim 10 or claim 11, comprising at least 0.2% w/v of said guanidine compound; and/or comprising no more than 10% w/v of said guanidine compound; and/or comprising 0.5 – 3.5% w/v of said guanidine compound; and/or wherein the total quantity of said guanidine compound, said alkyl urea polyalkylene imine polymer and said anionic polymer in the composition is no more than 25% w/v of the composition; and/or wherein the total quantity of said guanidine compound, said alkyl urea

polyalkylene imine polymer and said anionic polymer in the composition is at least 0.5% w/v of the composition.

13. A liquid coating composition according to any of claims 10-12, wherein the liquid coating composition further comprises a cationic polymer which is distinct from the alkyl urea polyalkylene imine polymer and wherein the total quantity of said guanidine compound, said cationic polymer, said alkyl urea polyalkylene imine polymer and said anionic polymer in the composition is no more than 25% w/v of the composition; and/or wherein the total quantity of said guanidine compound, said cationic polymer, said alkyl urea polyalkylene imine polymer and said anionic polymer in the composition is at least 0.5 % w/v of the composition

14. A liquid coating composition according to claim 5, comprising:

(A) 0.02-4.5 % w/v of said alkyl urea polyalkylene imine polymer;
0.001-0.20% w/v of said anionic polymer; and
optionally 0.1-5% w/v of a cationic polymer which is an unsubstituted polyalkylene imine polymer;
or

(B) 0.01-7.0% w/v of said alkyl urea polyalkylene imine polymer;
0.002-0.1% w/v of said anionic polymer
0.05-3.5% w/v of a guanidine compound which comprises one or more guanidine or biguanidine groups; and
optionally 0.05-4% w/v of a cationic polymer which is an unsubstituted polyalkylene imine polymer;
or

(C) 0.01 - 2% w/v of said alkyl urea polyalkylene imine polymer;
0.005 – 0.3% w/v of said anionic polymer;
0.1 – 1% w/v of a cationic polymer which is an unsubstituted polyalkylene imine polymer; and optionally
0.001 - 0.2% w/v of benzalkonium chloride and/or benzethonium chloride;
where these components total 0.1-4% w/v of the composition;
or

(D) 0.05 - 7% w/v of said alkyl urea polyalkylene imine polymer;

0.3 – 8% w/v of a cationic polymer which is an unsubstituted polyalkylene imine polymer;

0.5 – 3.5% w/v of a guanidine compound comprising one or more guanidine or biguanidine groups; and optionally

0.001 - 0.2% w/v of benzalkonium chloride and/or benzethonium chloride, and/or

0.005 – 0.3% w/v of said anionic polymer,

where these components total 1-19% w/v of the composition.

15. A liquid coating composition according to any of claims 5-14, further comprising one or more binders, optionally one or more binders selected from polyamine, polyacrylate and polyurethane binders, in an amount of 0.1-30% w/v; and/or further comprising one or more surfactants.

16. A method of applying a coating as claimed in any of claims 1-4 to a substrate or article, wherein the substrate or article is inert (non-living); the method comprising a step (a) of applying the liquid coating composition of any of claims 5-15 to the substrate or article, optionally by incubating the substrate or article in the liquid coating composition, and/or immersing the substrate or article in the liquid coating composition, and/or washing the substrate or article with the liquid coating composition, and/or dipping the substrate or article into the liquid coating composition either once or more than once, and/or causing the liquid coating composition to flow over the substrate or article, and/or spraying the liquid coating composition onto the substrate or article, and/or painting the liquid coating composition onto the substrate or article, and/or wiping the liquid coating composition onto the substrate or article, and/or brushing the liquid coating composition onto the substrate or article, and/or padding the liquid coating composition onto the substrate or article, and/or rolling the liquid coating compositions onto the substrate or article, and/or applying the liquid coating composition to the substrate or article using any other application technique or combination or sequence or application techniques, including physical vapour deposition and/or electrophoretic deposition; wherein step (a) is followed by an optional further step (b) of drying or curing the coated substrate or article or allowing the coated substrate or article to dry or cure.

17. A method of applying a coating as claimed in any of claims 1-3 to a substrate or article, wherein the substrate or article is inert (non-living); the method comprising the sequential steps of:

(a) applying a first liquid composition comprising one or more of said alkyl urea polyalkylene imine polymer and said anionic polymer to the substrate or article one or more times to form a first layer; followed by

(b) applying a second liquid composition different from the first liquid composition and comprising one or more of said alkyl urea polyalkylene imine polymer and said anionic polymer to the substrate or article one or more times to form a second layer;

such as to form an anti-microbial coating as claimed in any of claims 1-3 on the substrate or article.

18. A method of applying a coating to a substrate or article as claimed in claim 17, further comprising :

(c) applying a third liquid composition comprising one or more of said alkyl urea polyalkylene imine polymer and said anionic polymer to the substrate or article one or more times to form a third layer;
and optionally repeating step (c) to form fourth and subsequent layers.

19. A method of applying a coating as claimed in claim 4 to a substrate or article, wherein the substrate or article is inert (non-living); the method comprising the sequential steps of:

(a) applying a first liquid composition comprising one or more of said alkyl urea polyalkylene imine polymer, said anionic polymer, said cationic polymer and said guanidine compound to the substrate or article one or more times to form a first layer; followed by

(b) applying a second liquid composition different from the first liquid composition and comprising one or more of said alkyl urea polyalkylene imine polymer, said anionic polymer, said cationic polymer and said guanidine compound to the substrate or article one or more times to form a second layer;

such as to form an anti-microbial coating as claimed in claim 4 on the substrate or article.

20. A method of applying a coating to a substrate or article as claimed in claim 19, further comprising (c) applying a third liquid composition comprising one or more of said alkyl urea polyalkylene imine polymer, said anionic polymer, said cationic polymer and said guanidine compound to the substrate or article one or more times to form a third layer;

and optionally repeating step (c) to form fourth and subsequent layers.

21. A method of applying a coating to a substrate or article as claimed in any of claims 17-20, wherein each of said first, second and/or third and/or subsequent liquid compositions is formulated as a solution, suspension, dispersion or emulsion, optionally in an aqueous, alcoholic, aqueous-alcoholic, or organic liquid medium; and/or wherein the substrate or article comprises a non-porous material.

22. A method of applying a coating to a substrate or article according to any of claims 17-21, wherein the first, the second and/or the third liquid composition comprises one or more binders.

23. A method of applying a coating to a substrate or article according to any of claims 16-22, further comprising a step of applying a binder composition to the substrate or article.

24. A method of applying a coating to a substrate or article according to any of claims 16-23, wherein the substrate or article comprises one or more of a plastic material, an elastomeric material, or a synthetic rubber, and/or a polymeric material including a polyurethane or silicone and/or silica material and/or a natural or synthetic biopolymer or bioabsorbable material; and/or marble, stone, composite material, wood, and/or rubber; and/or a metal and/or metal alloy including stainless steel; and/or a ceramics material; and/or glass; and/or an organic material including an animal-derived material such as collagen and/or a decellularised graft; or mixtures and combinations thereof; and/or wherein the substrate or article comprises a fabric or textile, such as a woven or non-woven fabric, including natural or synthetic fibres or fabric or textile material; including a melt-blown polymer material, or nylon or rayon or polyester or polyester cellulose or polyethylene or polypropylene, optionally wherein the substrate or article is a medical device such as a catheter or implant, including a heart valve, stent, graft and/or scaffold, or an endoscope; or a medical implement such as a dish or spatula or a surgical tool; or diagnostic equipment; or an item of personal protective equipment (PPE) such as a mask, gown including a surgical gown, face shield, medical scrubs, eye protection, or gloves; or an item for use in cleaning, purification or sterilisation, such as a cloth, sponge, filter or wipe; or wherein the substrate is a surface which is regularly touched or handled by people, such as a door or a handle of a door or window, or a support or guard rail, or a surface of any object in a public or semi-public place including public transport, or in an institution including a school, college, hospital, medical centre, government or local council centre, courthouse or prison, or in a

private or semi-private venue including a shop, entertainment centre, restaurant, or private home.

25. A liquid coating composition as claimed in any of claims 5-15 for use in preventing or reducing the growth or spread or the quantity of one or more micro-organisms on a body part of a living human or animal, and/or for inactivating one or more micro-organisms on a body part of a living human or animal, wherein the liquid coating composition is to be applied to the body part by washing and/or rinsing the body part with the liquid coating composition and/or by spraying, rubbing, padding, rolling, depositing and/or brushing the liquid coating composition onto the body part; optionally wherein the body part is the skin, such as the hands or face or feet, of a human.

26. A composition for use as claimed in claim 25, wherein the liquid coating composition further comprises glycerol and/or benzalkonium chloride and/or benzethonium chloride, optionally in a quantity of between 0.005-1.0 % w/v, and/or is formulated for administration to the skin of a human or animal.

27. A composition for use in a method as claimed in any of claims 25-26, wherein the one or more microorganisms comprise bacteria, including gram negative, gram positive and drug resistant bacteria, including antibiotic resistant bacteria, including *C. difficile*; including nosocomial pathogens; including but not limited to any one or more of *E. coli*, *S. aureus*, *E. hirae* and *P. aeruginosa* strains and methicillin-resistant *S. aureus* (MRSA) strains; and/or viruses, including enveloped and non-enveloped viruses; including but not limited to adenovirus, norovirus, vaccinia virus and coronavirus strains; and/or fungi, such as yeast, including but not limited to *C. albicans* strains.

28. A method for preventing or reducing the growth or spread or the load or quantity of one or more micro-organisms on a surface, and/or for inactivating one or more micro-organisms on a surface, and/or for preventing the formation of and/or disrupting and/or removing a biofilm on a surface, comprising the step of contacting the surface with a substrate or article that comprises a coating as claimed in any of claims 1-4, wherein the surface is not a body part of a living human or animal.

29. A method as claimed in claim 28, wherein the surface is a surface which is susceptible to contamination by micro-organisms, such as a surface in a primary, secondary or tertiary healthcare, public, commercial or private setting, such as a surface of an item of medical equipment or a medical device, or a frequently contacted surface in a public space.

30. A method as claimed in claim 28 or claim 29, for inactivating or preventing or reducing the growth or spread or the quantity of bacteria, including gram negative, gram positive and drug resistant bacteria, including antibiotic resistant bacteria, including *C. difficile*; including nosocomial pathogens; including but not limited to any one or more of *E. coli*, *S. aureus*, *E. hirae* and *P. aeruginosa* strains and methicillin-resistant *S. aureus* (MRSA) strains; and/or viruses, including enveloped and non-enveloped viruses; including but not limited to adenovirus, norovirus, vaccinia virus and coronavirus strains; and/or fungi, such as yeast, including but not limited to *C. albicans* strains.

31. An anti-microbial skin sanitiser product, such as a hand sanitiser product or face sanitiser product, comprising a liquid coating composition as claimed in any of claims 5-15; which skin sanitiser product is optionally formulated with one or more additional ingredients such as glycerol and/or benzethonium chloride and/or benzalkonium chloride, optionally in a quantity of 0.001-1.0 % w/v.

32. An anti-microbial skin sanitiser product as claimed in claim 31, for use in inactivating or preventing or reducing the growth or spread or the quantity of bacteria, including gram negative, gram positive and drug resistant bacteria, including antibiotic resistant bacteria, including *C. difficile*; including nosocomial pathogens; including but not limited to any one or more of *E. coli*, *S. aureus*, *E. hirae* and *P. aeruginosa* strains and methicillin-resistant *S. aureus* (MRSA) strains; and/or viruses, including enveloped and non-enveloped viruses; including but not limited to adenovirus, norovirus, vaccinia virus and coronavirus strains; and/or fungi, such as yeast, including but not limited to *C. albicans* strains.

33. A substrate or article comprising an anti-microbial coating according to any of claims 1-5, which substrate or article is not a part of a living human or animal body; optionally wherein the substrate or article is a medical device such as a catheter or implant, including a heart valve, stent or scaffold, or an endoscope; or a medical implement such as a dish or spatula or a surgical tool; or diagnostic equipment; or an item of personal protective equipment (PPE) such as a mask, gown, or gloves; or an item for use in cleaning, purification or sterilisation, such as a cloth, sponge, filter or wipe.