ANTI-PATHOGEN COMPOSITIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Application Nos. 62/893,513, filed August 29, 2019, and 63/007,743, filed April 9, 2020, the entirety of each of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Pathogens, such as bacteria, fungi, viruses, and algae can stably exist on a dry surface or in water for hours, days, or even months. *See* Kramer, *et al.*, *BMC Infect. Dis.*, 6:130 (2016) (reviewing varying survival rates of bacteria on dry surfaces); Pinon, *et al.*, *Intervirology*, 61:214-222 (2018) (reviewing survival rates for viruses in water). SARS-CoV-2, the virus that causes coronavirus disease 2019 (COVID-19), which to date has infected close to a million people worldwide and has already killed thousands, is currently understood to exist for hours or even days in aerosols and on various surfaces. *See* van Doremalen, *et al.*, *New England J. of Med.*, DOI: 10.1056/NEJMc2004973 (March 17, 2020), and G. Kampf, *et al.*, *J. of Hospital Infection*, 104:246e251 (2020). Moreover, some pathogens can live for more than a month in water. These pathogens can cause serious infection or death.

SUMMARY

[0002a] In a first aspect, the present disclosure refers to an anti-pathogen solid composition comprising

about 0.01% to about 5% by weight of an active component, wherein the active component comprises particles of an activated transition metal or transition metal oxide; and

about 1% to about 99.99% by weight of a polymer,

wherein:

the particles of the activated transition metal or transition metal oxide have a size of about 1 nm to about 1000 nm or about 1 μm to 100 μm; and

the polymer is selected from polypropylenes, polystyrenes, polyethylenes, polyesters, polycarbonates, polyurethanes, polyvinylchlorides, biopolymers, and combinations thereof.

[0002b] In another aspect, the present disclosure refers to an anti-pathogen solid composition comprising

about 0.01% to about 5% by weight of an active component, wherein the active component comprises particles of an activated transition metal or transition metal oxide; and

about 1% to about 99.99% by weight of a stainless steel.

[0002c] In yet another aspect, the present disclosure refers to an anti-pathogen suspension comprising particles of an active component and a water or saline solution, wherein the active component comprises particles of at least one activated transition metal or transition metal oxide; optionally wherein the suspension is a lotion, ointment, gel, paste, or a cream.

[0002d] In a further aspect, the present disclosure refers to the anti-pathogen suspension as disclosed herein for neutralizing pathogens on a surface.

[0002e] In another aspect, the present disclosure refers to the anti-pathogen suspension disclosed herein for use in neutralizing pathogens on a surface.

[0002f] In yet another aspect, the present disclosure refers to a use of the anti-pathogen suspension disclosed herein, in the manufacture of a medicament for neutralizing pathogens on a surface, optionally wherein the surface is human skin.

[0002g] In a further aspect, the present disclosure refers to a water-permeable pouch comprising an active component, wherein the active component is or comprises particles of an activated transition metal or transition metal oxide; optionally wherein the water-permeable pouch further comprises a pH indicator.

[0002h] In another aspect, the present disclosure refers to a method for neutralizing pathogens in a water sample, the method comprising a step of contacting the water sample with the water-permeable pouch as disclosed herein for a period of time sufficient to neutralize the pathogens in the water sample; optionally wherein the method further comprises contacted the water sample with ZnO to neutralize the pH.

[0002i] In yet another aspect, the present disclosure refers to an anti-pathogen liquid composition comprising particles of an active component and a water or saline solution, wherein the active component comprises at least one activated transition metal or transition metal oxide.

[0002j] In a further aspect, the present disclosure refers to a fabric treated with the anti-pathogen liquid composition as disclosed herein.

[0003] There is a need for anti-pathogen compositions capable of neutralizing pathogens on contact, allowing for control of harmful pathogens. The present disclosure encompasses the recognition that certain metals (e.g., in particular certain transition metals) are useful for neutralizing pathogens. Moreover, the present disclosure encompasses the insight that the ability of certain metals to neutralize pathogens can be increased when subjected to certain conditions. Certain metals, as described herein, after being subjected to certain conditions (i.e., to thereby become "activated"), can further be incorporated into compositions comprising, for example, a polymer, a biopolymer/biocomposite, or a saline solution, and retain the metal's ability to neutralize pathogens on contact. Such compositions are safe for use on every day surfaces in the home, as well as in medical facilities, manufacturing/industrial sites, commercial sites, and even directly on human skin.

[0004] In some ~~embodiments~~examples, the present disclosure provides a composition comprising an anti-pathogen solid composition comprising an active component, wherein the active component comprises particles (e.g., ionic particles, microparticles or nanoparticles) of at least one activated metal. The present disclosure encompasses the insight that activated metal is particularly useful for neutralizing (i.e., inhibiting growth, replication, or otherwise killing) pathogens (e.g., bacteria, fungi, viruses, algae (e.g., cyanobacteria, dinoflagellates and diatoms), or microorganisms causing disease), in particular those that are capable of harming plants or animals (including humans or other mammals). For example, the present disclosure encompasses the insight that the compositions and suspensions provided herein are capable of neutralizing many common pathogens, including methicillin resistant staphylococcus aureus (MRSA), legionella, *E. coli*, and coronaviruses (e.g., SARS-CoV-2) upon contact. The activation of the metal by the methods described herein provides for an unexpected increase in percentage of pathogens that are neutralized upon contact, at a shorter period of time.

[0005] Moreover, anti-pathogen solid compositions described herein can be flexibly formed into a variety of shapes, or alternatively, flexibly cover a surface. Such a surface would have anti-pathogen properties that are critical both in the healthcare industry, as well as in the home, in agriculture, in food (e.g., for safety and storage), in transportation, and the like. For example, in some ~~embodiments~~examples, a solid composition comprises about 0.01% to about 5% by weight of an active component, wherein the active component comprises particles (e.g., ionic particles, microparticles or nanoparticles) of an activated transition metal or transition metal oxide; and about 1% to about 99.99% by weight of a polymer.

[0006] The present disclosure further encompasses the insight that the active component can also be suspended into a solution, and be used to sterilize water, e.g., drinking water, or further incorporated into an ointment, cream, lotion, or the like, for use in neutralizing pathogens on human skin (i.e., a hand sanitizer).

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1A is an image of unactivated molybdenum particles in saline, taken by an OMAX 40X-2500X LED Digital Trinocular Microscope.

CLAIMS

1. An anti-pathogen solid composition comprising an active component, wherein the active component comprises particles of at least one activated metal.

2. The anti-pathogen solid composition of claim 1, wherein the at least one activated metal is a transition metal or a transition metal oxide.

3. The anti-pathogen solid composition of claims 1 or 2, wherein the at least one activated metal is selected from Mo, Zn, Cu, Au, Ag, or an oxide thereof.

4. The anti-pathogen solid composition of claim 3, wherein the at least one activated metal is Mo, Mo(IV), Mo(V) or Mo(VI), or an oxide thereof.

5. The anti-pathogen solid composition of claim 3, wherein the at least one activated metal is selected from Mo, MoO_2, MoO_3, MoO_5, Mo_2O_6, H_2MoO_5, Zn, ZnO, Cu, Cu_2O, CuO, Au, AuO, Au_2O_3, Ag, and Ag_2O.

6. The anti-pathogen solid composition claim 5, wherein the at least one activated metal is Mo, MoO_2, MoO_3, H_2MoO_5, or Mo_2O_6.

7. The anti-pathogen solid composition of any one of claims 1-3, wherein the at least one activated metal is Mo, or an oxide thereof, having a cubic, spherical, monoclinic, hexagonal, orthorhombic, tetragonal, triclinic, or rhombohedral crystal structure.

8. The anti-pathogen solid composition of any one of claims 1-7, wherein the anti-pathogen solid composition comprises about 0.1% to about 99% by weight of the active component.

9. The anti-pathogen solid composition of any one of claim 1-8, wherein the anti-pathogen solid composition comprises about 0.1% to about 50% by weight of the active component.

~~10. The anti-pathogen solid composition of any one of claim 1-9, wherein the anti-pathogen solid composition comprises about 0.1% to about 15% by weight of the active component.~~

~~11. The anti-pathogen solid composition of any one of claims 1-10, wherein the anti-pathogen solid composition comprises about 0.1% to about 5% by weight of the active component.~~

~~12. The anti-pathogen solid composition of any one of claims 1-11, wherein the anti-pathogen solid composition comprises about 0.1% to about 3% by weight of the active component.~~

~~13. The anti-pathogen solid composition of any one of claims 1-12, wherein the anti-pathogen solid composition comprises about 0.1% to about 2% by weight of the active component.~~

~~14. The anti-pathogen solid composition of any one of claims 1-13, wherein the anti-pathogen solid composition comprises about 0.1% to about 1% by weight of the active component.~~

~~15. The anti-pathogen solid composition of any one of claims 1-14, wherein the particles of the at least one active metal have a size of about 1 µm to about 1000 µm.~~

~~16. The anti-pathogen solid composition of any one of claims 1-15, wherein the particles of the at least one active metal have a size of about 10 µm to about 85 µm.~~

~~17. The anti-pathogen solid composition of any one of claims 1-16, wherein the particles of the at least one active metal have a size of about 10 µm to about 50 µm.~~

~~18. The anti-pathogen solid composition of any one of claims 1-17, wherein the particles of the at least one active metal have a size of about 20 µm to about 50 µm.~~

~~19. The anti-pathogen solid composition of any one of claims 1-18, wherein the particles of the at least one active metal have a size of about 30 μm to about 50 μm.~~

~~20. The anti-pathogen solid composition of any one of claims 1-19, wherein the particles of the at least one active metal have a size of about 40 μm to about 50 μm.~~

~~21. The anti-pathogen solid composition of any one of claims 1-20, wherein the particles of the at least one active metal have a size of about 40 μm to about 45 μm.~~

~~22. The anti-pathogen solid composition of any one of claims 1-21, further comprising a second metal or metal oxide.~~

~~23. The anti-pathogen solid composition of claim 22, wherein the second metal is selected from Ni, Zn, Mn, Au, Ag, Cu, and Pd, or oxides thereof.~~

~~24. The anti-pathogen solid composition of claims 22 or 23, wherein the second metal is selected from Zn or ZnO.~~

~~25. The anti-pathogen solid composition of any one of claims 22-24, wherein the anti-pathogen solid composition comprises about 0.1% to about 99% by weight of the second metal.~~

~~26. The anti-pathogen solid composition of any one of claims 22-25, wherein the anti-pathogen solid composition comprises about 0.1% to about 75% by weight of the second metal.~~

~~27. The anti-pathogen solid composition of any one of claims 22-26, wherein the anti-pathogen solid composition comprises about 0.1% to about 50% by weight of the second metal.~~

~~28. The anti-pathogen solid composition of any one of claims 22-27, wherein the anti-pathogen solid composition comprises about 0.1% to about 15% by weight of the second metal.~~

~~29. The anti-pathogen solid composition of any one of claims 22-28, wherein the anti-pathogen solid composition comprises about 0.1% to about 5% by weight of the second metal.~~

~~30. The anti-pathogen solid composition of any one of claims 22-29, wherein the anti-pathogen solid composition comprises about 0.1% to about 3% by weight of the second metal.~~

~~31. The anti-pathogen solid composition of any one of claims 22-30, wherein the anti-pathogen solid composition comprises about 0.1% to about 1% by weight of the second metal.~~

~~32. The anti-pathogen solid composition of any one of claims 1-31, further comprising an antioxidant.~~

~~33. The anti-pathogen solid composition of claim 32, wherein the antioxidant is pentaerythritol tetrakis[3-[3,5-di-tert-butyl-4-hydroxyphenyl]propionate (Irganox® 1010) and tris(2,4-di-tert.-butylphenyl)phosphite (Irgafos® 168).~~

~~34. The anti-pathogen solid composition of any one of claims 1-33, wherein the anti-pathogen solid composition is or comprises a material selected from polymers, biopolymers, plastics, ceramics, rubbers, paints, ointments, glasses, silicones, papers, fabric, metals, and combinations thereof.~~

~~35. The anti-pathogen solid composition of claim 34, wherein the anti-pathogen solid composition is or comprises a polymer.~~

~~36. The anti-pathogen solid composition of claim 35, wherein the polymer is selected from polypropylenes, polystyrenes, polyethylenes, polyesters, polycarbonates, polyurethanes, polyvinylchlorides, and combinations thereof.~~

~~37. The anti-pathogen solid composition of claims 35 or 36, wherein the polymer is a polypropylene.~~

~~38. The anti-pathogen solid composition of any one of claims 1-37, wherein the anti-pathogen solid composition is flexibly formed to cover a surface.~~

~~39. The anti-pathogen solid composition of claim 34, wherein the material is a metal (e.g., a stainless steel).~~

~~40. The anti-pathogen solid composition of claim 39, wherein the metal is or comprises a stainless steel.~~

~~4~~1. An anti-pathogen solid composition comprising~~:~~

about 0.01% to about 5% by weight of an active component, wherein the active component comprises particles of an activated transition metal or transition metal oxide; and

about 1% to about 99.99% by weight of a polymer,

wherein:

the particles of the activated transition metal or transition metal oxide have a size of about 1 nm to about 1000 nm or about 1 μm to 100 μm; and

the polymer is selected from polypropylenes, polystyrenes, polyethylenes, polyesters, polycarbonates, polyurethanes, polyvinylchlorides, biopolymers, and combinations thereof.

~~4~~2. An anti-pathogen solid composition comprising~~:~~

about 0.01% to about 5% by weight of an active component, wherein the active component comprises particles of an activated transition metal or transition metal oxide; and

about 1% to about 99.99% by weight of a stainless steel.

3. The anti-pathogen solid composition of claim 1 or 2, wherein the activated transition metal or transition metal oxide is selected from Mo, Zn, Cu, Au, Ag, or an oxide thereof, optionally wherein the at least one activated transition metal is Mo, Mo(IV), Mo(V) or Mo(VI), or an oxide thereof.

4. The anti-pathogen solid composition of claim 3, wherein the activated transition metal or transition metal oxide is selected from Mo, MoO_2, MoO_3, MoO_5, Mo_2O_6, H_2MoO_5, Zn, ZnO, Cu,

Cu_2O, CuO, Au, AuO, Au_2O_3, Ag, and Ag_2O, optionally wherein the at least one activated transition metal is Mo, MoO_2, MoO_3, H_2MoO_5, or Mo_2O_6.

5. The anti-pathogen solid composition of any one of claims 1-4, wherein the activated transition metal or transition metal oxide is Mo, or an oxide thereof, having a cubic, spherical, monoclinic, hexagonal, orthorhombic, tetragonal, triclinic, or rhombohedral crystal structure.

6. The anti-pathogen solid composition of any one of claims 1-5, wherein the particles of the activated transition metal or transition metal oxide have a size about 10 µm to about 50 µm, 20 µm to about 50 µm, about 30 µm to about 50 µm, about 40 µm to about 50 µm, or about 40 µm to about 45 µm.

7. The anti-pathogen solid composition of any one of claims 1-6, further comprising a second metal or metal oxide, optionally wherein the second metal is selected from Ni, Zn, Mn, Au, Ag, Cu, and Pd, or oxides thereof, optionally wherein the second metal is selected from Zn or ZnO.

8. The anti-pathogen solid composition of claim 7, wherein the anti-pathogen solid composition comprises about 0.1% to about 99, about 0.1% to about 75%, about 0.1% to about 50%, about 0.1% to about 15%, about 0.1% to about 5%, about 0.1% to about 3%, or about 0.1% to about 1% by weight of the second metal.

9. The anti-pathogen solid composition of any one of claims 1-8, further comprising an antioxidant; optionally wherein the antioxidant is pentaerythritol tetrakis[3-[3,5-di-tert-butyl-4-hydroxyphenyl]propionate (Irganox® 1010) and tris(2,4-di-tert.-butylphenyl)phosphite (Irgafos® 168).

10. The anti-pathogen solid composition of any one of claims 1 and 3-9, wherein the polymer is a polypropylene.

11. The anti-pathogen solid composition of any one of claims 1-10, wherein the anti-pathogen solid composition is flexibly formed to cover a surface.

1243. An anti-pathogen suspension comprising particles of an active component and a water or saline solution, wherein the active component comprises particles of at least one activated transition metal or transition metal oxide; optionally wherein the suspension is a lotion, ointment, gel, paste, or a cream.

~~44. The anti-pathogen suspension of claim 43, wherein the pH of the suspension is about 5.5 or less.~~

~~45. The anti-pathogen suspension of claim 44, wherein the pH of the suspension is about 4.0 or less.~~

~~46. The anti-pathogen suspension of claim 45, wherein the pH of the suspension is about 2.0 or less.~~

~~47. The anti-pathogen suspension of claim 46, wherein the pH of the suspension is about 1.5 or less.~~

~~48. The anti-pathogen suspension of any one of claims 43-47, wherein the weight ratio of the activated metal to the saline solution is from about 1:100 to about 1:1.~~

~~49. The anti-pathogen suspension of claim 48, wherein the weight ratio of the activated metal to the saline solution is from about 1:100 to about 1:25.~~

~~50. The anti-pathogen suspension of claim 49, wherein the weight ratio of the activated metal to the saline solution is from about 1:100 to about 1:50.~~

~~51. The anti-pathogen suspension of claim 50, wherein the weight ratio of the activated metal to the saline solution is from about 1:100 to about 1:75.~~

~~52. The anti-pathogen suspension of claim 51, wherein the weight ratio of the activated metal to the saline solution is about 1:100.~~

~~53. The anti-pathogen suspension of any one of claims 43-52, wherein the suspension is a lotion, ointment, gel, paste, or a cream.~~

13~~54~~. The anti-pathogen suspension of claim 12~~A method~~ for neutralizing pathogens on a surface~~, the method comprising a step of contacting the surface with the anti-pathogen suspension of any one of claims 43-53~~.

14. The anti-pathogen suspension of claim 12 for use in neutralizing pathogens on a surface.

15. Use of the anti-pathogen suspension of claim 12, in the manufacture of a medicament for neutralizing pathogens on a surface, optionally wherein the surface is human skin.

~~55. The method of claim 54, wherein the surface is human skin.~~

16~~56~~. The anti-pathogen suspension of claim 13 or 14, or the ~~method~~ use of claim~~s 54 or 55~~15, wherein the pathogens are selected from Gram positive bacteria, Gram negative bacteria, fungi, viruses, and algae~~.~~; optionally

~~57. The method of any one of claims 54-56,~~ wherein the pathogens are selected from micrococcus, staphylococcus, bacillus, pseudomonas, legionella, salmonella, listeria, clostridium perfringens, *Acinetobacter baumannii*, *Escherichia coli*, coronaviruses, rhinoviruses, influenza, norovirus, adenovirus, parainfluenza, respiratory syncytial virus, and enterovirus.

17~~58~~. A water-permeable pouch comprising an active component, wherein the active component is or comprises particles of an activated transition metal or transition metal oxide; optionally wherein the water-permeable pouch further comprises a pH indicator.

~~59. The water-permeable pouch of claim 58, further comprising a pH indicator.~~

18~~60~~. A method for neutralizing pathogens in a water sample, the method comprising a step of contacting the water sample with the water-permeable pouch of claim~~s~~ 17~~58 or 59~~ for a period of time sufficient to neutralize the pathogens in the water sample; optionally~~.~~

~~61. The method of claim 60,~~ wherein the method further comprises contacted the water sample with ZnO to neutralize the pH.

19~~62~~. An anti-pathogen liquid composition comprising particles of an active component and a water or saline solution, wherein the active component comprises at least one activated transition metal or transition metal oxide.

20~~63~~. The anti-pathogen suspension of claim 12 or the anti-pathogen liquid composition of claim 19~~62~~, wherein the pH of the liquid composition is about 5.5 or less~~.~~,

~~64. The anti-pathogen liquid composition of claim 63, wherein the pH of the liquid composition is~~ about 4.0 or less,~~.~~

~~65. The anti-pathogen liquid composition of claim 64, wherein the pH of the liquid composition is~~ about 2.0 or less, or~~.~~

~~66. The anti-pathogen liquid composition of claim 65, wherein the pH of the liquid composition is~~ about 1.5 or less.

21~~67~~. The anti-pathogen suspension of claim 12 or 20 or the anti-pathogen liquid composition of claim 19 or 20~~any one of claims 62-66~~, wherein the weight ratio of the activated transition metal or transition metal oxide to the water or saline solution is from about 1:100 to about 1:1, ~~.~~

~~68. The anti-pathogen liquid composition of claim 67, wherein the weight ratio of the activated metal to the water or saline solution is~~ from about 1:100 to about 1:25,~~.~~

~~69. The anti-pathogen liquid composition of claim 68, wherein the weight ratio of the activated metal to the water or saline solution is~~ from about 1:100 to about 1:50~~,~~.

~~70. The anti-pathogen liquid composition of claim 69, wherein the weight ratio of the activated metal to the water or saline solution is~~ from about 1:100 to about 1:75, or~~.~~

~~71. The anti-pathogen liquid composition of claim 70, wherein the weight ratio of the activated metal to the water or saline solution is~~ about 1:100.

~~72~~22. A fabric treated with the anti-pathogen liquid composition of any one of claims 19-21~~62-70~~.