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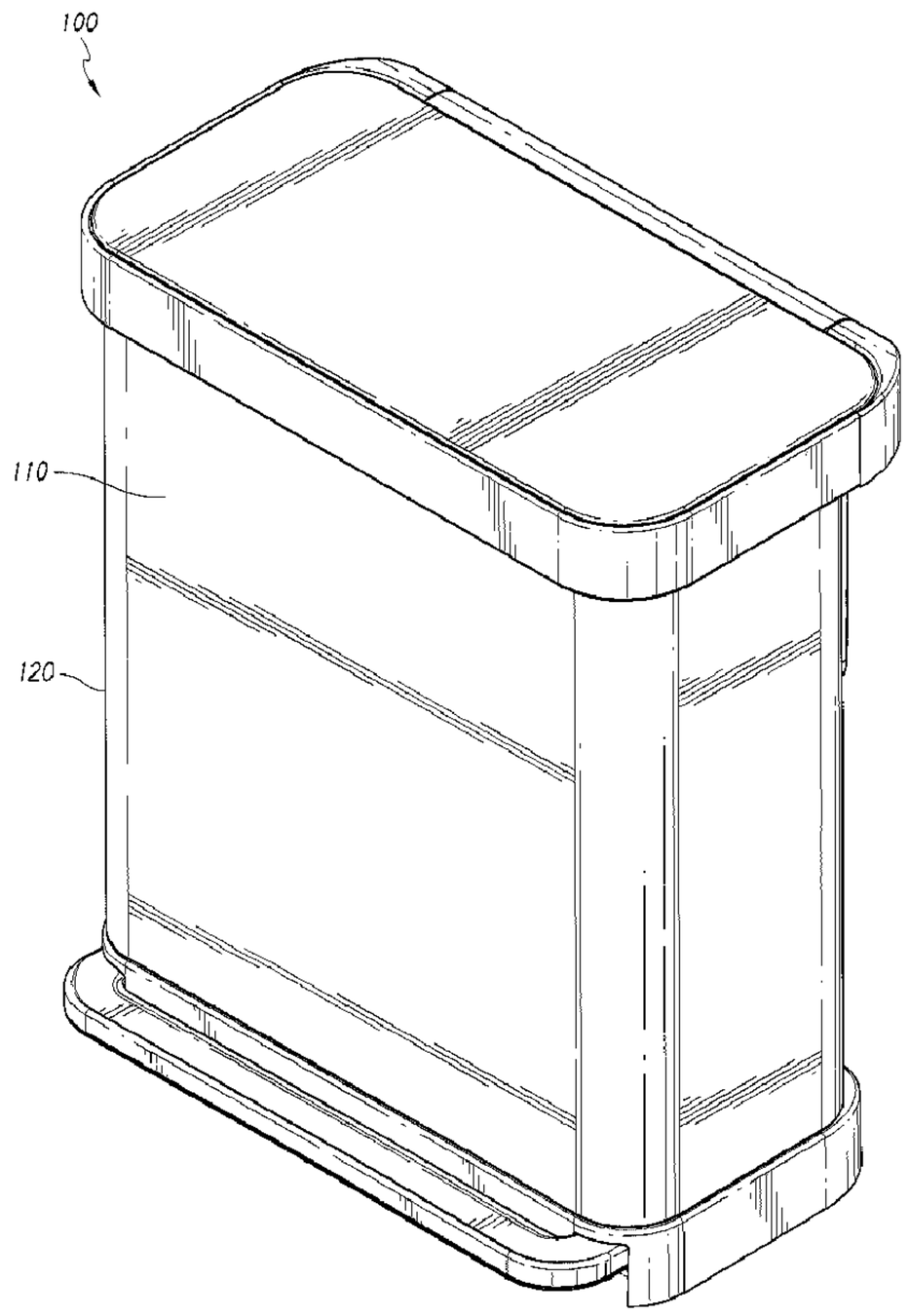
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(71) Demandeur/Applicant:
SIMPLEHUMAN, LLC, US

(72) Inventeurs/Inventors:
YANG, FRANK, US;
CHANG, DI-FONG, US;
CHEN, HON-LUN, US

(74) Agent: SMART & BIGGAR

(54) Titre : ARTICLES MENAGERS A REVETEMENT ANTIMICROBIEN ET METHODES DE FABRICATION ASSOCIEES
(54) Title: HOUSEHOLD GOODS WITH ANTIMICROBIAL COATINGS AND METHODS OF MAKING THEREOF



(57) Abrégé/Abstract:
Various trashcans, their coatings, and coatings for other household goods are disclosed. In certain implementations, the disclosed coatings are antimicrobial. Various methods for forming antimicrobial coatings for household goods are also disclosed. In some

CA 2948016 A1 2017/05/10

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(57) Abrégé(suite)/Abstract(continued):
embodiments, the antimicrobial coating comprises a substrate and an antimicrobial agent. In certain implementations the coating can be applied to a household good where the coating leaves a substantially streak-free finish. Some embodiments pertain to protective films that can be removed from a coated household good without leaving residue.

ABSTRACT OF THE DISCLOSURE

Various trashcans, their coatings, and coatings for other household goods are disclosed. In certain implementations, the disclosed coatings are antimicrobial. Various methods for forming antimicrobial coatings for household goods are also disclosed. In some embodiments, the antimicrobial coating comprises a substrate and an antimicrobial agent. In certain implementations the coating can be applied to a household good where the coating leaves a substantially streak-free finish. Some embodiments pertain to protective films that can be removed from a coated household good without leaving residue.

HOUSEHOLD GOODS WITH ANTIMICROBIAL COATINGS AND METHODS OF MAKING THEREOF

BACKGROUND

Field

[0002] The disclosure relates generally to the field of household goods with antimicrobial coatings and methods of making the same.

Description of the Related Art

[0003] Household goods and/or their components comprise surfaces that can be exposed to contaminants during use. For example, trashcans are often exposed to raw meat, food stuffs, and other forms of garbage. Soap dispensers are exposed to users' soiled hands. This exposure to contaminants can lead to bacterial and other microbial build-up and growth.

SUMMARY

[0004] Certain embodiments disclosed herein pertain to a coating for a household good. In some embodiments, the coating comprises a polymeric substrate configured to adhere to a surface of the household good. In some embodiments, the coating comprises an antimicrobial agent dispersed on or within the substrate.

[0005] Any of the embodiments described above, or described elsewhere herein, can include one or more of the following features.

[0006] In some embodiments, the antimicrobial agent comprises a zeolite. In some embodiments, the antimicrobial agent comprises ionic silver. In some embodiments, the antimicrobial agent comprises ionic copper. In some embodiments, the antimicrobial agent comprises ammonium.

[0007] In some embodiments, the antimicrobial agent comprises at least about **2**% and/or less than or equal to about **5**% weight percent of the substrate. In some embodiments, the antimicrobial agent comprises equal to or at least about **2**% and/or less than or equal to about **5**% ionic silver by weight. In some embodiments, antimicrobial agent comprises equal to or at least about **4.0**% and/or less than or equal to about **7.0**% ionic copper by weight. In some embodiments, the antimicrobial agent comprises equal to or at least about **0.1**% and/or

less than or equal to about **2.0%** ammonium by weight. In some embodiments, the antimicrobial agent comprises a zeolite having antimicrobial ions adhered to, deposited on, or diffused therein. In some embodiments, the antimicrobial agent comprises AGION®. In some embodiments, the antimicrobial agent is present in an amount of about **1.25** wt% relative to the substrate.

[0008] In some embodiments, the polymeric substrate comprises polyethylene. In some embodiments, the polymeric substrate comprises a material that resists or makes it easier to wipe away fingerprints and smudges.

[0009] In some embodiments, the coating is sufficiently durable so that it can withstand repeated cleanings or washings without losing its antimicrobial properties.

[0010] Some embodiments pertain to a coating for a household good comprising a polymeric substrate configured to adhere to a surface of the household good and an antimicrobial agent or a combination of antimicrobial agents dispersed on or within the substrate, such as wherein the one or more antimicrobial agents comprise one or more of a zeolite, ionic silver, ionic copper, or ammonium. In some embodiments, the coating is the antimicrobial agent.

[0011] In some embodiments, the polymeric substrate comprises polyethylene.

[0012] In some embodiments, the coating comprises equal to or greater than about **0.1%** and/or less than or equal to about **1.5%** antimicrobial agent by weight.

[0013] In some embodiments, the antimicrobial agent comprises equal to or greater than about **68%** and/or less than or equal to about **94%** zeolite by weight. In some embodiments, the antimicrobial agent comprises equal to or greater than about **2%** and/or less than or equal to about **5%** ionic silver by weight. In some embodiments, the antimicrobial agent comprises equal to or greater than about **4.0** % and/or less than or equal to about **7.0** % ionic copper by weight. In some embodiments, the antimicrobial agent comprises equal to or greater than about **0.1** % and/or less than or equal to about **2.0** % an ammonium ion (or ammonium salt) by weight. In some embodiments, the antimicrobial agent comprises AGION®. In some embodiments, the antimicrobial agent is present in an amount of about **1.25** wt% relative to the substrate.

[0014] In some embodiments, the polymeric substrate comprises a material that resists or makes it easier to wipe away fingerprints and smudges. In some embodiments, the

coating is sufficiently durable so that it can withstand repeated cleanings or washings without losing its antimicrobial properties.

[0015] Some embodiments pertain to a metal sheet comprising a coating that includes any one or more of the features described above.

[0016] Some embodiments pertain to a household product, such as a trashcan comprising a coating that includes any one or more of the features described in this specification. In some embodiments, the coating is located to the outside surface of the trashcan. In some embodiments, the trashcan comprises a metal body, the coating being located on the metal body.

[0017] Some embodiments pertain to a trashcan comprising a metal body, a lid coupled to the body and configured to move between open and closed positions, and a base on which the metal body is configured to rest. In some embodiments, an outside surface of the metal body comprises a coating, the coating comprising a substrate with an antimicrobial agent dispersed on or within the substrate, the antimicrobial agent comprising silver ions. In some embodiments, the coating is substantially even or homogeneous in thickness and/or composition and/or reflectivity across the surface of the substrate. For example, the coating can be substantially streak-free.

[0018] In some embodiments, the antimicrobial agent comprises a zeolite. In some embodiments, the substrate comprises polyethylene. In some embodiments, the antimicrobial agent comprises ionic copper. In some embodiments, the antimicrobial agent comprises ammonium. In some embodiments, the coating reduces an amount of bacteria of about **9.5** x $\mathbf{10^6}$ colony forming units (CFU)/carrier on the coating to less than about **5** CFU/carrier on the coating over a period of about **24** hours. In some embodiments, the coating reduces an amount of *E. coli* from about **2.3** x $\mathbf{10^5}$ CFU/carrier to less than about **5** CFU/carrier on the coating over a period of about **24** hours.

[0019] Some embodiments pertain to a trashcan comprising a metal body forming at least a portion of a container configured to receive refuse. In some embodiments, an outside surface of the metal body comprises a coating. In some embodiments, the coating comprises a substrate with an antimicrobial agent dispersed on or within the substrate. In some embodiments, the coating is substantially even or homogeneous in thickness and/or

composition and/or reflectivity across the surface of the substrate. For example, the coating can be substantially streak-free.

[0020] In some embodiments, the antimicrobial agent comprises one or more of a zeolite, ionic silver, ionic copper, or ammonium. In some embodiments, the antimicrobial agent comprises a zeolite having antimicrobial ions adhered to, deposited on, or diffused therein. In some embodiments, the antimicrobial agent comprises AGION®.

[0021] In some embodiments, the substrate comprises polyethylene.

[0022] In some embodiments, the coating is applied to a metal sheet used to prepare the metal body by applying a slurry comprising a solvent, a substrate material, and the antimicrobial agent to the metal sheet using a reverse-rolling device.

[0023] In some embodiments, the coating comprises a fingerprint resistant material or a material that allows fingerprints to be easily removed, such as by wiping without requiring a solution or excessive or forceful rubbing of the surface where the fingerprint is made.

[0024] In some embodiments, about **24** hours after bacterial exposure on the coating, an amount of bacteria remaining on the coating is at least about **95%** less than upon initial exposure. In some embodiments, about **24** hours after bacterial exposure on the coating, an amount of bacteria remaining on the coating is at least about **99.99%** less than upon initial exposure. In some embodiments, about **24** hours after bacterial exposure on the coating, an amount of bacteria remaining on the coating is reduced by about **95%** to about **100%**. In some embodiments, the coating reduces an amount of *E. coli* from about **2.3** x $\mathbf{10^5}$ CFU/ **50** mm x **50** mm carrier to less than or equal to about **5** CFU/carrier over a period of about **24** hours. In some embodiments, the coating reduces an amount of *S. aureus* from about **3.85** x $\mathbf{10^5}$ CFU/ **50** mm x **50** mm carrier to less than or equal to about **5** CFU/carrier over a period of about **24** hours.

[0025] Some embodiments pertain to methods of coating a metal surface. In some embodiments, the method of coating a metal surface comprises obtaining a solution of a polymer substrate in solvent. In some embodiments, the method comprises dispersing an antimicrobial agent on or within the solution forming a mixture. In some embodiments, the method comprises agitating the mixture to form a substantially uniform slurry. In some embodiments, the method comprises obtaining a sheet of material. In some embodiments,

the method comprises applying the slurry onto the sheet of material as a layer. In some embodiments, the method comprises curing the slurry on the sheet to provide a coated sheet. In some embodiments, the resultant coated metal sheet is substantially streak-free. Some embodiments pertain to a method of manufacturing a metallic sheet having an antimicrobial coating. In some embodiments, the method comprises providing a metallic sheet. In some embodiments, the method comprises applying a slurry comprising an antimicrobial agent and a solvent onto the metallic sheet. In some embodiments, the method comprises drying the slurry on the metallic sheet to provide the antimicrobial coating. In some embodiments, the metallic sheet is shaped to provide a portion of a surface of a household good. In some embodiments, the slurry is applied to the metallic sheet using a reverse-rolling device.

[0026] In some embodiments, the method comprises applying an acrylic and/or silicone and/or silicone rubber adhesive over the coated portion of the coated metal sheet and thereafter applying a protective film over such adhesive on the coated metal sheet.

[0027] In some embodiments, the antibacterial agent used in the method comprises a zeolite (and/or any one of ionic silver, ionic copper, or ammonium).

[0028] Some embodiments pertain to a metal sheet comprising a coating, layer, and/or sheet. In some embodiments, the coating comprises a polymeric substrate configured to adhere to a surface of the household good. In some embodiments, the coating comprises an antimicrobial agent dispersed on or within the substrate. In some embodiments, the coating is an antimicrobial agent. In some embodiments, the coating comprises a protective film that protects the coating from abrasions during shipment of the metal sheet. In some embodiments, the coating comprises an acrylic and/or silicone and/or silicone rubber adhesive that adheres the protective film to the coating. In some embodiments, the adhesive leaves substantially no residue on the coating after removal of the protective film.

[0029] Some embodiments pertain to a coating for a household good comprising a coating comprising an antimicrobial agent. In some embodiments, the coating further comprises a fingerprint resistant agent, such as an agent that resists the formation of visible fingerprints and/or that an agent that allows fingerprints to be easily removed. In some embodiments, the coating is applied to a surface of a household good. Any feature, structure, component, or step that is described and/or illustrated in any embodiment in this specification can be used with or instead of any feature, structure, component, or step that is described

and/or illustrated in any other embodiment in this specification. Everything disclosed and/or illustrated in this specification is intended to be interchangeable and combinable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Figure **1** illustrates a trashcan having an antimicrobial coating.

[0031] Figure **2** is front view of the trashcan of the Figure **1** and a close-up, cross-sectional view of a portion of the trashcan.

[0032] Figures **3**A-B are photographs of sheets of material comprising one or more coatings containing an antimicrobial agent.

[0033] Figures **4**A-B are close-up views of portions of the photographs of Figures **3**A-B.

[0034] Figure **5** is a graph showing *Escherichia coli* growth on uncoated versus coated metal sheets.

[0035] Figure **6** is a graph showing *Staphylococcus aureus* growth on uncoated versus coated metal sheets.

[0036] Figure **7** is a flow chart showing a process of preparing an antimicrobial coating on a metal sheet.

[0037] Figure **8** illustrates diagram of a sheet being coated using a reverse-rolling process.

[0038] Figure **9** is a flow chart showing a process of protecting an antimicrobial coating on a metal sheet.

[0039] Figures **10**A-B are photographs of partially removed protective films applied to sheets of material comprising coatings containing an antimicrobial agent.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0040] A variety of antimicrobial coatings and methods of forming and using the same are described below to illustrate various examples that may be employed to achieve one or more desired improvements. These examples are only illustrative and not intended in any way to be restrictive. Furthermore, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. No features, structure, or step disclosed herein is essential or indispensable.

Overview

[0041] Some embodiments disclosed herein pertain to a coating for a household good. In certain implementations, the coating is antimicrobial. As used herein, the term "antimicrobial," and its derivatives, describes the property of killing microbes and/or preventing or slowing microbial growth. As used herein, the term "microbe," and its derivatives, means an organism that is too small to be seen by the unaided eye, such as various bacteria, archaea, fungi, and protists.

[0042] As will be described in more detail below, in some embodiments, the coating comprises a substrate and an antimicrobial agent distributed in that substrate. In certain embodiments, the coating is applied to a metal (e.g., stainless steel or aluminum), which is formed into a portion of a household product (e.g., a trashcan). In some variants, the coating comprises the antimicrobial agent, substrate, and a compound that facilitates avoiding or wiping-off fingerprints. Such a combined coating can be applied to a surface (e.g., a metal sheet), which can be formed into a portion of a household product.

[0043] As shown in Figures **1** and **2**, certain embodiments are disclosed herein in the context of a coating **120** for a trashcan **100** comprising sheet metal **110**, as the coating may have particular utility in this context. However, the various aspects of the present disclosure can be used on sheet goods generally and for other household goods having metal or non-metal components. For example, some illustrative household goods are: soap dispensers, mirrors (e.g. metal trim on mirrors, stands, etc.), soap dishes, grocery bag dispensers, shower/sink caddies, utensil holders, organizers (e.g., for drawers or countertops), paper towel holders, dishracks, wall mount liquid pumps (e.g., for soap, shampoo, etc.), toilet plunger handles, appliance handles (e.g., for microwaves, refrigerators, dishwashers, ovens, coffee makers, etc.), appliances (e.g., refrigerators, microwaves, dishwashers, ovens, blenders, coffee makers, trash compactors, BBQ grills, etc.), sink accessories (e.g., handles, faucets, etc.), liquid dispensers (e.g., for drinkables), washers, driers, components for the same, and the like. In some variants, the coating is applied to the handles, trim, or removable inner buckets of trashcans (e.g., removable inserts that fit within a larger trashcan body). In some embodiments, the coatings described herein can be applied to handheld devices or touchscreens.

[0044] In some embodiments, the household good is broadly a metal good. In some variants, the household good comprises stainless steel. In some embodiments, the metal of the household good comprises one or more of stainless steel, brass, copper, steel, aluminum, iron, platinum, gold, silver, zinc, other metals, metal alloys of the same, and the like. In certain embodiments, the household good is made of a nonmetal material (e.g., plastic, glass, etc.) and/or a composite material.

[0045] In certain variants, the coating is configured to adhere to one or more surfaces of the household good. In some implementations, the coating is applied to a material sheet surface used to make a household good. For example, as discussed in more detail below, the coating can be applied to a sheet of metal that is subsequently formed into a portion of the household good, such as the body and/or lid of a trashcan. In some variants, for example, the coating can be applied to the inside and outside surfaces of the household good (e.g., both sides of a stainless steel sheet used to prepare a trashcan). In certain variants, the coating is applied to only select surfaces of the household good. For example, in some implementations, the coating is applied only to the outside of the household good, (e.g., trashcan, etc.). In other variants, the coating is applied only to the inside of the household good (e.g., trashcan, etc.). In some embodiments, the coating is applied to one or more of the inside, outside, lid, handle, or pedal of the household good (e.g., trashcan, etc.).

[0046] In some variants, the coatings and methods of coating materials described herein increase and/or maximize antimicrobial effects of an antimicrobial agent in the coating without substantially affecting the appearance of the household good. For example, in some embodiments, the antimicrobial coating is smooth and uniform without visible streaking and/or is clear (or substantially clear). In some embodiments, the antimicrobial coating is substantially smooth and/or substantially uniform and/or substantially even or consistent in reflectivity across a particular surface of the coating or a particular portion of a surface of the coating, without substantial visible streaking and/or is clear (or substantially clear). Figures **3**A-B and **4**A-B shows side-by-side examples of an antimicrobial coating that are streaked or smooth and uniform without visible streaking. For instance, the coatings of Figures **3**B and **4**B are substantially streak-free, while those of Figures **3**A and **4**A are not. In certain implementations, the antimicrobial coating shows unobstructed views of the surfaces underneath the coating, such as the top of the surface to which the coating is applied. In

certain implementations, the coating is colorless or substantially colorless. In some implementations, the coating has a blue tint.

[0047] In certain implementations, the coating is generally planar and/or substantially flat. In some embodiments, the coating is substantially uniform and/or smooth. In some variants, the coating is generally contiguous. In some embodiments, the aforementioned properties of the coating make it appear substantially streak-free where streaks are not generally visible upon casual visual observation.

Certain Substrates

[0048] In certain implementations, as disclosed above, the coating comprises a substrate and one or more antimicrobial agents. In certain implementations, the antimicrobial is dispersed under, within (e.g., homogenously throughout the substrate or as a gradient), or on the substrate (e.g., adhered and/or functionalized to the substrate surface). In some embodiments, the substrate is any material that provides a support for the antimicrobial agent while allowing access to the antimicrobial agent by bacteria or other microbes that come into contact with the coating. In some implementations, the substrate is substantially clear (e.g., selected to be substantially optically transparent to the naked eye).

[0049] In certain implementations, the substrate comprises a polymeric material. For example, the substrate can comprises polyethylene. In some variants, the substrate comprises a mixture of more than one polymeric material.

[0050] While polymeric substrates are described here, any other matrices could be used, keeping in mind that the goal of the substrate (i.e., the matrix, the support, etc.) is, in some embodiments, to provide a material that is capable of supporting an antimicrobial agent while adhering to a household good in a manner that does not substantially distort the appearance of that good. For example, in some embodiments, the substrate comprises a crosslinkable polymer matrix or copolymer matrix.

[0051] In some embodiments, the substrate itself is formulated using one or more polymers that themselves have antimicrobial effects. For example, in certain implementations, the substrate comprises a polymeric material comprising one or more polymeric antimicrobial materials, such as polyethyleneimine, NIPAM, or other cationic or polycationic polymers.

Certain Antimicrobial Agents

[0052] Some embodiments pertain to an antimicrobial agent bound to a surface (e.g., a metal portion) of a household good. In some embodiments, the antimicrobial is adhered to the surface of a household good via a substrate as described elsewhere herein. In some embodiments, the substrate and antimicrobial agent form a coating. In certain embodiments, the antimicrobial agent itself provides a coating and/or is the coating on the household good. In certain implementations, as described above and as shown in Figure **2**, the coating comprises an antimicrobial agent **220** dispersed within a substrate **210**. In certain implementations, as shown in the expanded cross-sectional view of Figure **2**, at least a portion of the antimicrobial agent **220** is exposed on the outside surface of the coating **120**. In some variants, the antimicrobial agent **220** is able to directly contact microbes that are on the surface of the coating **120** because the antimicrobial agent **220** escapes and/or protrudes from (e.g., is sticking out of) the substrate **210**. In some embodiments, the antimicrobial agent can diffuse over time to the surface of the coating to interact directly with microbes on the surface of the household good.

[0053] In some embodiments, the antimicrobial agent comprises an antimicrobial zeolite. In some embodiments, the antimicrobial zeolite comprises one or more antimicrobial metal ions, antimicrobial metals, or antimicrobial organic ions. In some embodiments, the antimicrobial agent and/or antimicrobial zeolite comprises water. For instance, in some embodiments, where the antimicrobial agent comprises a zeolite, some portion of water can be trapped in or adhered to the zeolite. In some embodiments, the antimicrobial zeolite or antimicrobial agent comprises one or more of ionic silver, ionic copper or copper metal, or ammonium. In some embodiments, the antimicrobial zeolite and/or the antimicrobial agent comprises each of silver ions, copper (ionic or metallic), and ammonium. In some embodiments, the antimicrobial agent comprises AGION®, available from Sciessent LLC of Wakefield, Massachusetts. In some embodiments, the weight percent of zeolite (e.g., an aluminosilicate portion of the zeolite without water, antimicrobial anions, or antimicrobial organic cations) in the antimicrobial zeolite and/or the antimicrobial agent is equal to or greater than about **68**% and/or less than or equal to about **94**%. In some embodiments, the weight percent of zeolite in the antimicrobial agent and/or antimicrobial zeolite is equal to or at least: about **60**%, about **65**%, about **70**%, about **80**%, about **90**%, about **95**%, about **99**%,

values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the weight percent of zeolite in the antimicrobial agent and/or antimicrobial zeolite is less than or equal to: about **99**%, about **95**%, about **90**%, about **85**%, about **80**%, about **75**%, about **70**%, about **65**%, about **60**%, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the antimicrobial agent comprises one or more antimicrobial zeolites and/or other antimicrobial entities (e.g., silver ions, ionic copper, ammonium, etc.).

[0054] In some embodiments, ionic silver can be present in an amount equal to or greater than about **2**% and/or less than or equal to about **5**% by weight of the antimicrobial zeolite and/or by weight of the antimicrobial agent. In some embodiments, the weight percent of ionic silver in the antimicrobial zeolite (and/or in the antimicrobial agent) is equal to or greater than at least: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the weight percent of ionic silver in the antimicrobial zeolite (and/or in the antimicrobial agent) is less than or equal to: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise.

[0055] In some variants, ionic copper or copper metal can be present in an amount equal to or greater than about **4**% and/or less than or equal to about **7**% by weight of the antimicrobial zeolite (and/or by weight of the antimicrobial agent). In some embodiments, the weight percent of ionic copper or copper metal in the antimicrobial zeolite (and/or in the antimicrobial agent) is equal to or at least: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the weight percent of ionic copper or copper metal in the antimicrobial zeolite (and/or in the antimicrobial agent) is less than or equal to: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise.

[0056] In various embodiments, ammonium can be present in an amount equal to or greater than about **0**% and/or less than or equal to about **2**% by weight of the antimicrobial zeolite (and/or in the antimicrobial agent). In some embodiments, the weight percent of ammonium in the antimicrobial zeolite (and/or in the antimicrobial agent) is equal to or at least: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, weight percent of ammonium in the antimicrobial zeolite (and/or in the antimicrobial agent) is less than or equal to: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, values between the aforementioned values, ranges spanning those values, or otherwise.

[0057] In some embodiments, the antimicrobial agent comprises water. For instance, zeolites can also be hygroscopic and can naturally absorb water from the environment. In some embodiments, water can be present in an amount equal to or greater than about **0**% to less than or equal to about **18**% by weight of the antimicrobial zeolite (and/or of the antimicrobial agent). In some embodiments, the weight percent of water in the antimicrobial zeolite (and/or the antimicrobial agent) is equal to or at least: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, about **15.0**%, about **20.0**%, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the weight percent of water in the antimicrobial zeolite (and/or in the antimicrobial agent) is less than or equal to: about **0.5**%, about **1.0**%, about **2.0**%, about **3.0**%, about **4.0**%, about **5.0**%, about **6.0**%, about **7.0**%, about **8.0**%, about **9.0**%, about **10.0**%, about **15.0**%, about **20.0**%, values between the aforementioned values, ranges spanning those values, or otherwise. In certain implementations, the antimicrobial zeolite comprises about **18**% water by weight ("AC**10**N"), about **5**% water by weight ("AC**10**D"), or about **2**% water by weight ("AC**10**H").

[0058] In some embodiments, one or more antimicrobial agents are supported by a sub-support structure that, by itself, may or may not be antimicrobial. For instance, in some embodiments, one or more antimicrobial agents are supported on a nanoparticle (e.g., a particle with an average particle sizes ranging from equal to or greater than about **10** nm to

less than or equal to about **1000** nm) or microparticle (e.g., a particle with an average particle sizes ranging from equal to or greater than about **1** μm to less than or equal to about **1000** μm). In some embodiments, the sub-support comprises a zeolite. In some embodiments, the sub-support structure can comprise any one of ionic silver, ionic copper, ammonium, and/or water in any of the weight percentages described elsewhere herein. In some embodiments, as described above, the antimicrobial agent comprises a zeolite sub-support with one or more antimicrobial ions adhered to it (or diffused within it). In some embodiments, the average particle size of the zeolite (or other sub-support structure) is equal to or less than: about **100** μm, about **10** μm, about **1** μm, values ranging between the aforementioned values, values between the aforementioned values or otherwise. In some embodiments, the average particle size of the zeolites (and/or other sub-support structure) is less than about **6** μm.

[0059] In some variants, the antimicrobial agent lacks a zeolite (e.g., a zeolite sub-support structure) or other sub-support structure and instead comprises one or more of free silver (e.g., silver ions, a silver salt, metallic, etc.), copper (copper ions, a copper salt, or metallic copper, etc.), organosilanes, ammonium, or cationic materials (e.g., **3**-(trimethoxysilyl)-propyldimethyloctadecyl ammonium chloride, etc.) that provide antimicrobial effect. For instance, in some embodiments, the coating comprises silver ions.

[0060] In some embodiments, the substrate that supports the antimicrobial agent comprises the bulk dry weight of the coating. In some embodiments, the antimicrobial agent makes up equal to or less than about **1.25** wt% (i.e., weight percent) of the total coating weight. In some embodiments, the coating comprises equal to or greater than about **0.1**% and/or less than or equal to about **1.5**% antimicrobial agent by weight. In some embodiments, the coating comprises equal to or greater than about **1.1**% and/or less than or equal to about **1.3**% antimicrobial agent by weight. In some embodiments, the coating comprises equal to or greater than about **1.1**% and/or less than or equal to about **1.2**% antimicrobial agent by weight. In some embodiments, the weight percent of antimicrobial agent in the coating is at least: about **0.0001**%, about **0.001**%, about **0.01**%, about **0.1**%, about **0.5**%, about **1.0**%, about **1.25**, about **1.5**%, about **2.0**%, values between the aforementioned values, values greater than the aforementioned values, values less than the aforementioned, or otherwise. In some embodiments, the weight percent of the antimicrobial agent in the sub-support is less than or equal to: about **0.0001**%, about **0.001**%, about **0.01**%, about **0.1**%, about **0.5**%, about

1.0%, about **1.25**, about **1.5**%, about **2.0**%, values between the aforementioned values, ranges spanning those values, or otherwise.

[0061] As described below in Examples **2** and **3**, and as shown in Figures **5** and **6**, the antimicrobial coating kills substantially all of the bacteria present on the coating after a period of about **24** hours of exposure to the coating. As shown in the *Escherichia coli* (*E. coli*) results from Example **2** (and Figure **5**), both coatings comprising about **1.25** wt% AGION® or about **1.5** wt% AGION® kill substantially all of the *E. coli* present on the coating after a period of about **24** hours of exposure to the coating. As shown in the *Staphylococcus aureus* ("*S. aureus*") results from Example **2** (and as shown in Figure **6**), the coating comprising about **1.25** wt% AGION® kills this form of bacteria slightly more effectively than the about **1.5** wt% AGION® coating after a period of about **24** hours of exposure to the coating. This result surprisingly shows that a lower amount of AGION® can be used to achieve a nearly **100**% kill rate relatively to larger doses. Without being bound to any particular mechanism, it is thought that the lower dose of AGION® (e.g., **1.25** wt% or less) allows it to be better distributed within the coating layer (e.g., by preventing aggregation) giving it a more efficient and effective antibacterial effect.

[0062] In embodiments, where the antimicrobial agent is provided without a sub-support structure (e.g., free of the zeolite), the weight % of antimicrobial agent in the coating can be reduced to account for the lack of this sub-support.

[0063] In some embodiments, about **24** hours after bacterial exposure on the coating, an amount of bacteria remaining on the coating is reduced by equal to or at least about **95**% to about **100**%. In some embodiments, **24** hours after bacterial exposure on the antibacterial coating, the amount of bacteria present is reduced by equal to or at least: about **75**%, about **85**%, about **95**%, about **98**%, about **99**%, about **99.9**%, about **99.99**%, about **99.999**%, about **99.9999**%, or about **99.99999**%. In some embodiments, the coating reduces the amount of *E. coli* from about **2.3** x $\mathbf{10^5}$ CFU/carrier to about **0** CFU/carrier and/or less than or equal to about **5** CFU/carrier (with a limit of detection of about **5** CFU/carrier) over a period of about **24** hours. In some embodiments, as shown in Table **1**, relative to a control, the coating reduces the amount of bacteria from about **2.35** x $\mathbf{10^7}$ colony forming units (CFU)/carrier (on a control surface) to about **0** CFU/carrier and/or less than or equal to about **5** CFU/carrier (with a limit of detection of about **5** CFU/carrier) over a period of about **24**

hours. In some embodiments, the coating reduces the amount of *S. aureus* from about **3.85** x 10^5 CFU/carrier to about **0** CFU/carrier and/or less than or equal to about **5** CFU/carrier (with a limit of detection of about **5** CFU/carrier) over a period of about **24** hours. In some embodiments, as shown in Table **2**, relative to a control, the coating reduces the amount of bacteria from about **9.5** x 10^6 colony forming units (CFU)/carrier (on a control surface) to about **0** CFU/carrier and/or less than or equal to about **5** CFU/carrier (with a limit of detection of about **5** CFU/carrier) over a period of about **24** hours. In some embodiments, the coating has the above described antimicrobial effects on one or more bacteria selected from *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, *S. aureus*, *E. coli*, or the like. In some embodiments, the coating has antimicrobial effects on gram positive and/or gram negative bacteria.

Features of Certain Antimicrobial Coatings

[0064] As described above, the antimicrobial coating can be applied to household goods. In some embodiments, the coating is sufficiently durable for long-term use (e.g., is able to maintain integrity and substantially unreduced efficacy over a period of at least one year with regular and normal usage). In some variants, the look of the household good remains substantially unchanged and/or the antimicrobial properties remain substantially unchanged during long term use (e.g., for periods of one, two, three, four or more years as could be measured over time or with accelerated stress conditions).

[0065] In some embodiments, the coating is sufficiently durable to withstand repeated cleanings or washings. For instance, because household goods such as trashcans and sink accessories are typically washed repeatedly over their lifetimes, in certain variants, the coating is configured to maintain its antimicrobial properties after repeated cleanings that include scrubbing and washing with soapy water. In some embodiments, a durable coating maintains its antimicrobial properties after at least about **25**, at least about **50**, at least about **100**, or more washes with a standard wash cloth and soapy water. In certain variants, the coating maintains its antimicrobial activity after at least about **25**, at least about **50**, at least about **100**, or more washes with a paper towel and a household cleaner (e.g., bleach, an ammonia-based cleaner (e.g., WINDEX® cleaner), etc.).

[0066] In some variants, the coating maintains its antimicrobial properties under accelerated wear conditions (e.g., under heat stress, increased humidity, exposure simulated

sunlight, etc.) intended to simulate the lifetime of the good. In some embodiments, the coating maintains its antimicrobial properties after being abraded (e.g., abrasions or scratches caused by steel wool or other abrading agents). In some variants, the coating maintains its antimicrobial properties after about **1000** wipes using a dry kimwipe. In some embodiments, a product that maintains its antimicrobial properties includes products that retain at least about **75%**, at least about **85%**, at least about **90%**, at least about **95%**, at least about **99%**, or more of its initial antimicrobial property before use.

[0067] In some embodiments, the durability of the coating can be measured using the contact angle of a droplet of water or oil on the coating surface. In certain variants, the contact angle of a droplet of water on the coating changes less than about **10%** under one or more of the washing and wear conditions described above. In some embodiments, the contact angle of a droplet of water on the coating changes less than about **20%** and/or less than about **40%** under one or more of the washing and wear conditions described above. In some embodiments, the contact angle of a droplet of oil on the coating changes less than about **10%** under one or more of the washing and wear conditions described above. In some embodiments, the contact angle of a droplet of oil on the coating changes less than about **20%** or less than about **40%** under one or more of the washing and wear conditions described above.

[0068] In some embodiments, the coating maintains its antimicrobial activity even after polishing and/or drawing. Polishing can include abrasion with a cloth and a polishing agent under typical polishing conditions. In certain implementations, the coatings provided herein may advantageously protect the appearance of metal goods, making polishing of the surfaces of the household good unnecessary. In some embodiments, this property can advantageously give products even longer lasting antimicrobial properties.

[0069] In some embodiments, the antimicrobial properties of the coatings are accomplished without leaching of copper from the coating. In some embodiments, the antimicrobial properties of the coatings are accomplished without leaching of silver from the coating. In some embodiments, the antimicrobial properties of the coatings are accomplished without leaching of copper and/or ammonium from the coating.

[0070] In some embodiments, the coating is fingerprint or smudge resistant. The terms “fingerprint resistant,” or “smudge resistant” refer to the ability of a surface to resist

the visible transfer of residue from physical interactions with a user, the minimization, hiding, or obscuring of tactilely-transferable residue on a surface, and/or combinations thereof. In certain implementations, a fingerprint-resistant surface is substantially resistant to both water-based material and oil-based material transfer when contacted by a user. In some embodiments, a fingerprint-resistant surface is substantially resistant to one or more of inorganic-based material and organic-based material transfer when contacted by a user. In some embodiments, fingerprint resistance is measured using the amount of transferred residue after a user makes physical contact with the household good. For instance, after physical contact (e.g., from the skin of a user), some amount of residue can transfer to the household good. The mass of the residue on the coated household good after each interaction can be quantified, for example, by weighing the mass (or by weighing the mass of a representative test sheet of that material). In some embodiments, the mass transferred from a user to the coated household good is less than or equal to: about **1** mg, about **0.02** mg, or **0.001** mg per instance of physical contact (for instance by dragging a hand across the test surface) to a portion of the household good that is sized **4**" x **4**". In some embodiments, the fingerprint resistance is qualitatively measured using the human eye and a fingerprint/smudge resistant material shows less visible residue after physical contact than a non-resistant surface. In some embodiments, the fingerprint resistance of a material is measured by determining the reflectivity before contact (e.g., when clean) or after one or more instances of physical contact (as described above). In some implementations, when the fingerprint resistant material is coated on a mirrored-surface (or a chromed-surface, stainless steel, or another otherwise reflective surface of a household good), the fingerprint resistant material maintains at least about **75**%, at least about **95**%, or at least about **99**% of the reflectance of the surface compared to that before an instance of physical contact. In some embodiments, coatings that are fingerprint or smudge resistant may be more desirable to consumers for aesthetic reasons.

[0071] In certain implementations, the antimicrobial agent is deposited directly into a fingerprint mitigating (fingerprint resistant) material to form the coating material and the two are added to any surface of the household good together. In some embodiments, the fingerprint resistant material (e.g., compound) is applied separately (before or after) the antimicrobial compound. In some embodiments, antimicrobial coatings and fingerprint

resisting coatings are added as separate layers that can be sandwiched on top of one another. A plurality of layers can be added by exposing sheets of, for example, metal to antimicrobial coating and fingerprint proof coating conditions repetitively. In certain implementations, the antimicrobial agent and the fingerprint resistant material are added in patterns on a surface (e.g., patches, stripes, etc.) that give the household good both antimicrobial and fingerprint resistant properties on substantially the entire coated surface.

Certain Methods Related to the Antimicrobial Coating

[0072] Some embodiments pertain to methods of preparing a coated household good. A flow chart describing an embodiment of a method **700** is provided in Figure **7**. As shown, in certain variants, the antimicrobial agent is dispersed within a solution, such as a solution of polymer and solvent **701**. This mixture is agitated to form a substantially uniform slurry **702**. After the slurry is formed, a sheet of material is obtained **703** and the slurry it is layered onto a sheet of material to form a coated sheet **704**. For example, the slurry can be applied to a sheet of metal, such as stainless steel **704**. In some embodiments, the sheet can be cured for a period of time to afford a coated sheet **705**. In certain implementations, the dried coated sheet can then be cut and shaped in appropriate ways to form walls, lids, foot pedals, and handles for metal household goods including trashcans.

[0073] In some embodiments, prior to application to the sheet, the antimicrobial agent is slurried with the polymer in a solvent to form a mixture. In some variants, the slurry is agitated continuously prior to application to the metal sheet in order to maintain a homogenous dispersion. In some embodiments, the dispersion is distributed into a coating device that spreads an even layer of the slurry onto the sheet. The solvent can then be evaporated from the slurry, leaving an antimicrobial surface on the sheet that comprises a smooth layer of polymer with the antimicrobial agent dispersed within it. In some embodiments, the evaporation of the solvent cures the polymer/antimicrobial agent. In certain implementations, after curing, at least a portion of the antimicrobial agent protrudes from the substrate and is available to directly interact with microbes on the surface of a coated household good. In some embodiments, the antimicrobial agent can diffuse over time to the surface of the coating to interact directly with microbes on the surface of the household good. In certain implementations, the antimicrobial agent is consumed during the killing of

microbes, while in other embodiments it is not. In some embodiments, direct contact with the microbe and the antibacterial agent is not necessary.

[0074] It has been found that several coating techniques for surfaces are not amenable to distributing streak-free antimicrobial coatings. For instance, coatings applied using a metered-rolling process result in streaked coatings (see Figure **3**A and **4**A). In a metered-rolling process, a rolling element rolls in the direction of a sheet that passes over the rolling element. In a metered-rolling device, the rolling element is at least partially submerged in a reservoir of a coating agent. As the rolling element rolls, it draws coating agent from this reservoir and deposits it on a sheet as the sheet moves by. This process coats the sheet as the sheet travels along in the direction of rolling.

[0075] In contrast, in various embodiments described herein, the coating device uses a non-metered-rolling process (e.g., a reverse-rolling technique) to apply the slurry to the sheet. Figure **8** shows an embodiment of a system **800** that can be used to apply a coating **810** by reverse-rolling. For instance, in certain variants, in the non-metered, reverse-rolling process, the metal sheet **820** is drawn below a first rolling element **830** (e.g., a coating roller) of the coating device in a first direction **822**. The first rolling element **830** is in fluidic communication with a reservoir **840** containing a slurry of antimicrobial agent, polymer, and/or solvent that is formed between the first rolling element **830** and a second rolling element **832** (e.g., a doctor roll). The first rolling element **830** draws the slurried mixture from the reservoir **840** and deposits it on a surface of the first rolling element **831** which distributes the slurried mixture to the sheet as the sheet passes below the first rolling element **830**. During reverse-rolling, the region of the first rolling element **830** that is approximately adjacent to the sheet **820** travels (e.g., rolls) in a second direction **834**, which is opposite to the first direction **822** (the direction of movement of the sheet). In some implementations, when reverse-rolling is used, the final coating is substantially or completely streak-free to the unaided eye (see, e.g., Figures **3**B and **4**B).

[0076] Without being bound to any particular mechanism, it is believed that the antimicrobial agent adds contrast the coating. If applied using certain methods, the contrast of a coating having an antimicrobial agent, as disclosed herein, becomes large enough to be visible by the naked eye. In some embodiments, whether a coating is streak-free can be measured using the naked eye. In some implementations, whether a coating is streak-free can

be quantified. In some embodiments, for instance, streak-free coatings are those having a transmittance variation between any two points on the surface that varies by less than: about **75%**, about **50%**, about **30%**, about **20%**, about **10%**, about **5%**, about **2%**, or about **1%** transmittance. In some embodiments, for instance, streak-free coatings are those having a reflectance variation between any two points on the surface that varies by less than: about **50%**, about **25%**, or about **5%** reflectance. In certain implementations, the coating is applied using other solution-based techniques (e.g., spray coating, spin-coating, dip-coating, inkjetting, or the like) that result in streak-free materials.

[0077] In some embodiments, as the slurry cures, it forms a homogeneous distribution of antimicrobial agent within the coating. In some embodiments, a gradient of antimicrobial agent can be formed in the coating by, for example, depositing additional layers of slurry (with different concentrations of antimicrobial agent) onto the sheet. In some embodiments, a gradient can be formed by changing the curing rate (e.g., by slowing or increasing the curing speed using lower or higher cure temperatures etc.). In some embodiments, a gradient can be formed by depositing additional layers of higher or lower concentration slurry over partially cured other layers of slurry. In some embodiments, a gradient can be formed by changing the concentration of antimicrobial agent and/or polymer in solution. For example, in certain implementations, in more dilute solutions, the cure rate can be slowed so that more of the antimicrobial agent can settle in the direction of gravity during the curing process, forming a more concentrated layer in that direction. Any of the methods described in this specification can be used to form antimicrobial agent gradients that are either more concentrated at the surface of the coating or more concentrated at the surface of the household good (which can be especially useful in applications where, for example, the antimicrobial diffuses towards the surface of the coating over time). In some variants, gradients can be used to advantageously maintain or increase antimicrobial effect over time.

[0078] In some embodiments, uneven application of coatings to surfaces is reduced or minimized using the disclosed methods and/or substantially even (or uniform) coatings result. In certain implementations, visible streaking in the coating can be caused by the uneven application of the coating to the surface of the trashcan. In certain implementations, the methods used to deposit the coating result in a substantially uniform coating thickness on the sheet material. In certain implementations, the thickness of the

coating can be equal to or greater than about **10** μm and/or less than or equal to about **20** μm. In some embodiments, the thickness can be less than or equal to: about **100** μm, about **80** μm, about **70** μm, about **60** μm, about **50** μm, about **40** μm about **30** μm, about **20** μm, about **10** μm, about **5** μm, values between the aforementioned values, ranges spanning those values, or otherwise. In some embodiments, the coating is of substantially uniform thickness. In some embodiments, the thickness of the coating varies by less than or equal to: about **100**%, about **90**%, about **80**%, about **70**%, about **60**%, about **50**%, about **40**%, about **30**%, about **20**%, about **10**%, about **5**%, about **2**%, values between the aforementioned values, ranges spanning those values, or otherwise as measured between any two points on a coated surface. In some embodiments, this level of uniformity results in a coating that appears substantially streak-free. In some embodiments, the coating is generally planar, substantially flat, substantially smooth and uniform, and/or substantially contiguous, such that streaks are not generally visible upon casual visual observation.

[0079] In some embodiments, the methods described herein result in a material that is substantially optically transparent. For example, in certain implementations, the optical transmittance of the coating over the visible spectrum is at least: about **65**%, about **75**%, about **85**%, about **95**%, about **98**%, values between the aforementioned values, ranges spanning those values, or otherwise.

Certain Protective Coverings

[0080] Some embodiments pertain to protective coverings for the coatings disclosed herein. A flow chart describing an embodiment of a method **900** is provided in Figure **9**. As shown, in certain variants, a plurality of metal sheets is obtained **901**. In some embodiments, sheets of a different material can be used (plastic, composite, etc.). A slurry of antimicrobial agent in a polymer/solvent solution is layered onto a plurality of metal sheets **902** which are then cured to form a coated sheets **903**. A protective film is then adhered to the coated sheets using an adhesive **904**. The sheets are then stacked **905** and transported to a fabricating facility **906**. At the facility, the protective films and adhesive is removed without leaving residue from the adhesive on the coated sheet **907**. The sheets are then cut and shaped to form household goods **908**. In certain implementations, as described above, the dried coated sheet be cut and shaped in appropriate ways to form walls, lids, foot pedals, and handles for metal household goods including trashcans. In some implementations, finished

goods can be protected by applying an adhesive and a protective film to antimicrobially coated household goods.

[0081] During shipping of sheets to make a household good or a household good itself, the surfaces of the sheet or sheet good can be protected by depositing films onto those surfaces. Rubber adhesives can be used to adhere protective films onto portions of the sheets or household goods. However, it has been found that some rubber adhesives leave deposits (e.g., residue, etc.) on the coatings (see Figure **10**A). This can result in streaks and other visual imperfections **1020** on the coating **1001** after the protective film **1010** is removed, as is pointed-to by the arrow in Figure **10**A. In certain instances, the residue can leave an unwanted sticky region on the coating. In certain instances, these residues cannot be readily washed away from the coatings.

[0082] Certain embodiments are configured to ameliorate at least one of these problems, or other problems. For example, some embodiments adhere or otherwise connect a protective film to a coated sheet of material such that removal of the film does not leave an appreciable residue on the coated material. In some embodiments, acrylic or silicone rubber adhesive is used to adhere the film to the coated sheet of material, which has been found to reduce or eliminate appreciable residue on the coating **1001** after removal of the film **1011** (see Figure **10**B which lacks residue). In certain implementations, the use of acrylic or silicone or rubber adhesive leads to a more visually appealing result once the protective film is removed. In some variants, the substantially complete removal of residue helps avoid areas (e.g., on top of the residue) where the antimicrobial activity of the coating could be blocked. In some embodiments, rubber may be used as an adhesive (with or without one or more other adhesives).

[0083] Some embodiments pertain to methods of applying protective films to antimicrobial coatings. In certain implementations, the adhesive is applied to a coated sheet of material using a solution-based technique (e.g., spray coating, spin-coating, dip-coating, inkjetting, rolling, or the like). Once applied, a protective film (e.g., a polymeric material) is deposited onto the adhesive, such as by rolling the film onto the coated sheet of material.

Summary

[0084] Several illustrative embodiments of coatings and methods of coating have been disclosed. Although this disclosure has been described in terms of certain illustrative

embodiments and uses, other embodiments and other uses, including embodiments and uses which do not provide all of the features and advantages set forth herein, are also within the scope of this disclosure. Components, elements, features, acts, or steps can be arranged or performed differently than described and components, elements, features, acts, or steps can be combined, merged, added, or left out in various embodiments. All possible combinations and subcombinations of elements and components described herein are intended to be included in this disclosure. No single feature or group of features is necessary or indispensable.

[0085] Certain features that are described in this disclosure in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation also can be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations, one or more features from a claimed combination can in some cases be excised from the combination, and the combination may be claimed as a subcombination or variation of a subcombination.

[0086] Any portion of any of the steps, processes, structures, and/or devices disclosed or illustrated in one embodiment, flowchart, or example in this disclosure can be combined or used with (or instead of) any other portion of any of the steps, processes, structures, and/or devices disclosed or illustrated in a different embodiment, flowchart, or example. The embodiments and examples described herein are not intended to be discrete and separate from each other. Combinations, variations, and other implementations of the disclosed features are within the scope of this disclosure.

[0087] The terms "approximately," "about," and "substantially" as used herein represent an amount close to the stated amount that still performs a desired function or achieves a desired result. For example, in some embodiments, as the context may dictate, the terms "approximately", "about", and "substantially" may refer to an amount that is within less than or equal to **10%** of the stated amount. The term "generally" as used herein represents a value, amount, or characteristic that predominantly includes or tends toward a particular value, amount, or characteristic.

[0088] Some embodiments have been described in connection with the accompanying drawings. Moreover, while operations may be depicted in the drawings or described in the specification in a particular order, such operations need not be performed in the particular order shown or in sequential order, or that all operations be performed, to achieve desirable results. Other operations that are not depicted or described can be incorporated in the example methods and processes. For example, one or more additional operations can be performed before, after, simultaneously, or between any of the described operations. Additionally, the operations may be rearranged or reordered in other implementations. Also, the separation of various components in the implementations described above should not be understood as requiring such separation in all implementations, and it should be understood that the described components and systems can generally be integrated together in a single product or packaged into multiple products. Additionally, other implementations are within the scope of this disclosure.

[0089] Conditional language used herein, such as, among others, "can," "could," "might," "may," "e.g.," and the like, unless specifically stated otherwise or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment. The terms "comprising," "including," "having," and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term "or" is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term "or" means one, some, or all of the elements in the list.

[0090] Conjunctive language such as the phrase "at least one of X, Y, and Z," unless specifically stated otherwise, is otherwise understood with the context as used in general to convey that an item, term, etc. may be either X, Y, or Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require the presence of at least one of X, at least one of Y, and at least one of Z.

[0091] Further, while illustrative embodiments have been described, any embodiments having equivalent elements, modifications, omissions, and/or combinations are also within the scope of this disclosure. Moreover, although certain aspects, advantages, and novel features may be described herein, not necessarily all such advantages may be achieved in accordance with any particular embodiment. For example, some embodiments within the scope of this disclosure may achieve one advantage, or a group of advantages, as taught herein without necessarily achieving other advantages taught or suggested herein. Further, some embodiments may achieve different advantages than those taught or suggested herein.

[0092] In summary, various embodiments and examples of antimicrobial coatings and protective films have been disclosed. This disclosure extends beyond the specifically disclosed embodiments and examples to other alternative embodiments and/or other uses of the embodiments, as well as to certain modifications and equivalents thereof. Moreover, this disclosure expressly contemplates that various features and aspects of the disclosed embodiments can be combined with, or substituted for, one another. Accordingly, the scope of this disclosure should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims.

EXAMPLES

EXAMPLE **1**: Fabrication of Coated Metal

[0093] Coatings were prepared using a metered-rolling process and a reverse-rolling technique. Prior to coating, a slurry of polyethylene polymer and solvent was prepared. To this solution was added **1.25** wt% of AC**10**D grade AGION® (relative to the dry weight of polyethylene) forming a mixture. This mixture was stirred to achieve a uniform slurry. Once a uniform was achieved, it was added to the reservoir of a metered-rolling device which distributed the slurry on a stainless steel sheet via a roller rotating in the same direction of the sheet movement. The sheet was allowed to cure. Figures **3**A and **4**A show the resultant coated sheet.

[0094] A second slurry was formed using the same ingredients and techniques described above. This mixture was added to the reservoir of a reverse-rolling device which distributed the slurry on a stainless steel sheet via a roller rotating in the direction opposite the direction of the sheet. The sheet was allowed to cure. Figures **3**B and **4**B show the resultant coated sheet.

[0095] As shown in the figures, the reverse-rolling technique resulted in an antimicrobial coating that was streak-free and uniform relative to the antimicrobial coating formed using the metered-rolling technique.

EXAMPLE **2**: Antimicrobial Testing

[0096] Several experiments were performed using the Japanese Industrial Standard ("JIS") method Z **2801** antimicrobial evaluation method to show the antimicrobial activity of a sheet metal coated using the reverse-rolling process described in Example **1**. The JIS method Z **2801** is a quantitative test designed to assess the performance of antimicrobial finishes on hard, non-porous surfaces. The method can be conducted using contact times ranging from ten minutes up to **24** hours. For a JIS Z **2801** test, non-antimicrobial control surfaces are used as the baseline for calculations of microbial reduction. The method can be used to determine the antimicrobial activity of a diverse array of surfaces including plastics, metals, and ceramics. The test microorganism(s) selected for this test were *Escherichia coli* ***8739*** (a Gram-negative bacteria) and *Staphylococcus aureus* ***6538*** (a Gram-positive bacteria).

Testing Method

[0097] The test microorganism was prepared by growth in a Tryptic Soy Broth. The suspension of test microorganism was standardized by dilution in a nutritive broth (this affords microorganisms the opportunity to proliferate during the test). Control and test substances were wiped clean with **70%** ethanol and allowed to dry prior to testing. Control and test surfaces (**50** mm x **50** mm) were inoculated with microorganisms (where the testing parameter was **0.400** mL at a concentration of **4** x $\mathbf{10^5}$ CFU/Carrier), and then the microbial inoculum was covered with a thin, sterile film (**40** mm x **40** mm). Covering the inoculum spreads it, prevents it from evaporating, and ensures close contact with the antimicrobial surface. Microbial concentrations were determined at "time zero" by elution followed by dilution and plating to Tryptic Soy Agar. A control was run to verify that the neutralization/elution method effectively neutralizes the antimicrobial agent in the antimicrobial surface being tested. Inoculated, covered control and antimicrobial test surfaces were allowed to incubate undisturbed in a humid environment for **24** hours, at **36**°C ± **1**°C. After incubation, microbial concentrations were determined. Reduction of microorganisms relative to the control surface were calculated. The neutralizer was D/E Broth (**10** mL). The

enumeration plate media was tryptic soy agar. The enumeration plate was incubated for **24±6** hours at **36**°C±**1**°C.

[0098] Results were calculated using the following formulae:

$$\text{Percent Reduction} = \left(\frac{B-A}{B}\right) \times 100$$

Where B = Number of viable test microorganisms on the control carriers after the contact time; and A = Number of viable test microorganisms on the test carriers after the contact time.

$$\text{Log}_{10}\text{Reduction} = \text{Log}\left(\frac{B}{A}\right)$$

Where B = Number of viable test microorganisms on the control carriers after the contact time; and A = Number of viable test microorganisms on the test carriers after the contact time.

Results of E. Coli Testing

Table **1**.

Test Microorganism	Contact Time	Carrier Type	CFU/Carrier	Percent Reduction Compared to Control at Contact Time	Log_{10} Reduction Compared to Control at Contact Time
E. coli 8739	Time Zero	Inoculum Only	2.30E+05	N/A	
	24 Hours	Control	2.35E+07		
		B 1.50	<5.00E+00	>99.99998%	>6.67
		E 1.25	<5.00E+00	>99.99998%	>6.67

[0099] The data collected using *E. Coli* on **50** mm x **50** mm carriers (covered by **40** mm x **40** mm films) is shown in Table **1**. Figure **5** shows a graph plotting *E. Coli* CFU/Carrier against the control and experimental samples. The limit of detection for this study is **5** CFU/Carrier. Values less than the limit of detection are shown as <**5**.**00**E+**00** on the table and zero on the graph.

Results of S. Aureus Testing

Table **2**.

Test Microorganism	Contact Time	Carrier Type	CFU/Carrier	Percent Reduction Compared to Control at Contact Time	Log_{10} Reduction Compared to Control at Contact Time
S. aureus 6538	Time Zero	Inoculum Only	3.85E+05	N/A	
	24 Hours	Control	9.50E+06		
		B 1.50	5.00E+00	99.99995%	6.28
		E 1.25	<5.00E+00	>99.99995%	>6.28

[0100] The data collected using *S. Aureus* on **50** mm x **50** mm carriers (covered by **40** mm x **40** mm films) is shown in Table **2**. Figure **6** shows a graph plotting *S. Aureus* CFU/Carrier against the control and experimental samples. The limit of detection for this study is **5** CFU/Carrier. Values less than the limit of detection are shown as <**5.00**E+**00** on the table and zero on the graph.

EXAMPLE **3**: Antimicrobial Testing

[0101] Below are experiments performed using the Sciessent LLC antimicrobial evaluation methods to show the antimicrobial activity of a sheet metal (**2**" x **2**") coated using the reverse-rolling process described in Example **1**. Certain samples were abraded before testing. The bacteria used were *E. coli* and *S. Aureus*.

Table **3**. *E. Coli* (ATCC#: **25922**) Testing

Sample Identification	Organism Count (CFU/ml)		
	Zero Contact Time	24 Hours Contact Time	Percent Reduction**
Assay (+)	2.5×10^5	2.0×10^7	No Reduction
Assay (-)	<10*	<10*	N/A
Untreated coated metal samples Sciessent ID# 150811-1A		4.6×10^7	No Reduction
Coated metal samples (1.5% AC10D in coating) Sciessent ID# 150806-3B, Rep 1		3.2×10^4	99.93%
Coated metal samples (1.5% AC10D in coating) Sciessent ID# 150806-3B, Rep 2		2.8×10^4	99.94%
Coated metal samples (1.5% AC10D in coating) – Abraded Sciessent ID# 150806-3B, Rep 1		1.04×10^3	99.99%
Coated metal samples (1.5% AC10D in coating) – Abraded Sciessent ID# 150806-3B, Rep 2		5.4×10^2	99.999%

Testing was performed in accordance with standard operating procedures of Sciessent LLC.

* ≤**10** = Limits of Detection; ** is percent reduction calculated using: untreated T**24** contact time.

Table **4**. *S. Aureus* (ATCC#: **6538**) Testing

Sample Identification	Organism Count (CFU/ml)		
	Zero Contact Time	24 Hours Contact Time	Percent Reduction**
Assay (+)	2.3×10^5	6.5×10^6	No Reduction
Assay (-)	<10*	<10*	N/A
Untreated coated metal samples Sciessent ID# 150811-1A		5.0×10^7	No Reduction
Coated metal samples (1.5% AC10D in coating) Sciessent ID# 150806-3B, Rep 1		7.8×10^4	99.84%
Coated metal samples (1.5% AC10D in coating) Sciessent ID# 150806-3B, Rep 2		5.9×10^4	99.90%
Coated metal samples (1.5% AC10D in coating) Sciessent ID# 150806-3B, Rep 3		3.3×10^4	99.93%
Coated metal samples (1.5% AC10D in coating) – Abraded Sciessent ID# 150806-3B, Rep 1		7.0×10^1	99.9999%
Coated metal samples (1.5% AC10D in coating) – Abraded Sciessent ID# 150806-3B, Rep 2		<10*	99.9999%
Coated metal samples (1.5% AC10D in coating) – Abraded Sciessent ID# 150806-3B, Rep 3		<10*	99.9999%

Testing was performed in accordance with standard operating procedures of Sciessent LLC.

* ≤**10** = Limits of Detection; ** is percent reduction calculated using: untreated T**24** contact time.

EXAMPLE **4**: Application of Protective Film to Coated Sheets

[0102] Protective film coatings were applied to a portion of sheet metal coated using the reverse-rolling process described in Example **1**. In one experiment, to the coated sheet was sprayed a rubber adhesive (coinciding to Figure **10**A). In a second experiment, to the coated sheet was sprayed an acrylic and/or silicone rubber adhesive (coinciding to Figure **10**B). Soon after application of each adhesive, film protective layers were applied to the adhesives on the coated sheets. After **24** hours, the protective films were removed. After removal of the protective film, a residue was noted on the coated sheet where a rubber adhesive was used. The residue was washed several times with ethanol but remained on the

coated surface (see Figure **10**A). No such residue was noted on the coated sheet where an acrylic and/or silicone rubber adhesive was used (Figure **10**B).

EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A trashcan comprising:

a metal body shaped to provide at least a portion of a container that is configured to receive refuse;

wherein a surface of the metal body comprises a coating, the coating comprising a substrate with an antimicrobial agent dispersed within the substrate.

2. The trashcan of claim **1**, wherein the coating is substantially streak-free.

3. The trashcan of claim **1** or **2**, wherein the substrate comprises polyethylene.

4. The trashcan of claim **1**, wherein the coating is applied to a metal sheet used to form the metal body by applying a slurry comprising a solvent, a substrate material, and the antimicrobial agent to the metal sheet using a reverse-rolling device.

5. The trashcan of any one of claims **1** to **4**, wherein the coating comprises a fingerprint resistant material.

6. The trashcan of any one of claims **1** to **5**, wherein **24** hours after an initial bacterial exposure to the coating, an amount of bacteria remaining on the coating is at least about **95%** less than at the initial bacterial exposure.

7. The trashcan of any one of claims **1** to **6**, wherein the coating reduces an amount of *E. coli* from about **2.3** x $\mathbf{10^5}$ colony forming units (CFU) per **50** mm x **50** mm carrier to less than about **5** CFU/carrier over a period of about **24** hours.

8. The trashcan of any one of claims **1** to **7**, wherein the coating reduces an amount of *S. aureus* from about **3.85** x $\mathbf{10^5}$ CFU per **50** mm x **50** mm carrier to less than about **5** CFU/carrier over a period of about **24** hours.

9. A coating for a household good comprising:

a polymeric substrate configured to adhere to a surface of the household good;

an antimicrobial agent dispersed within the substrate;

wherein the coating is substantially streak-free.

10. The coating of Claim **9**, wherein the amount of antimicrobial agent in the coating ranges from about **0.1%** to about **1.5%** by weight.

11. The coating of Claim **9** or **10**, wherein the amount of antimicrobial agent in the coating ranges from about **1.1%** to about **1.2%** by weight.

12. The coating of any one of Claims **9** to **11**, wherein the polymeric substrate comprises a material that resists or makes it easier to wipe away fingerprints and smudges.

13. The coating of any one of Claims **9** to **12**, wherein the coating is sufficiently durable so that it can withstand repeated cleanings or washings without losing its antimicrobial properties

14. A metal sheet comprising:

a coating comprising a polymeric substrate configured to adhere to a surface of a household good and an antimicrobial agent dispersed on or within the substrate;

a protective film that protects the coating from abrasions during shipment of the metal sheet; and

one or more of an acrylic adhesive or silicone rubber adhesive, that adheres the protective film to the coating and that leaves substantially no residue on the coating after removal of the protective film.

15. The metal sheet of Claim **14**, wherein the coating is substantially streak-free.

16. A method of manufacturing a metallic sheet having an antimicrobial coating, the method comprising:

providing a metallic sheet;

applying a slurry comprising an antimicrobial agent and a solvent onto the metallic sheet; and

drying the slurry on the metallic sheet to provide the antimicrobial coating.

17. The method of Claim **16**, wherein the metallic sheet is shaped to provide a portion of a surface of a household good.

18. The method of Claim **16** or **17**, wherein the slurry is applied to the metallic sheet using a reverse-rolling device.

Application number / Numéro de demande : 2948016

3A - 3B - 4A - 4B - 10A 10-13

Unscannable items received with this application

(Request original documents in File Prep. Section on the 10th floor)

Documents reçu avec cette demande ne pouvant être balayés

(Commander les documents originaux dans la section de la préparation des dossiers au 10e étage)

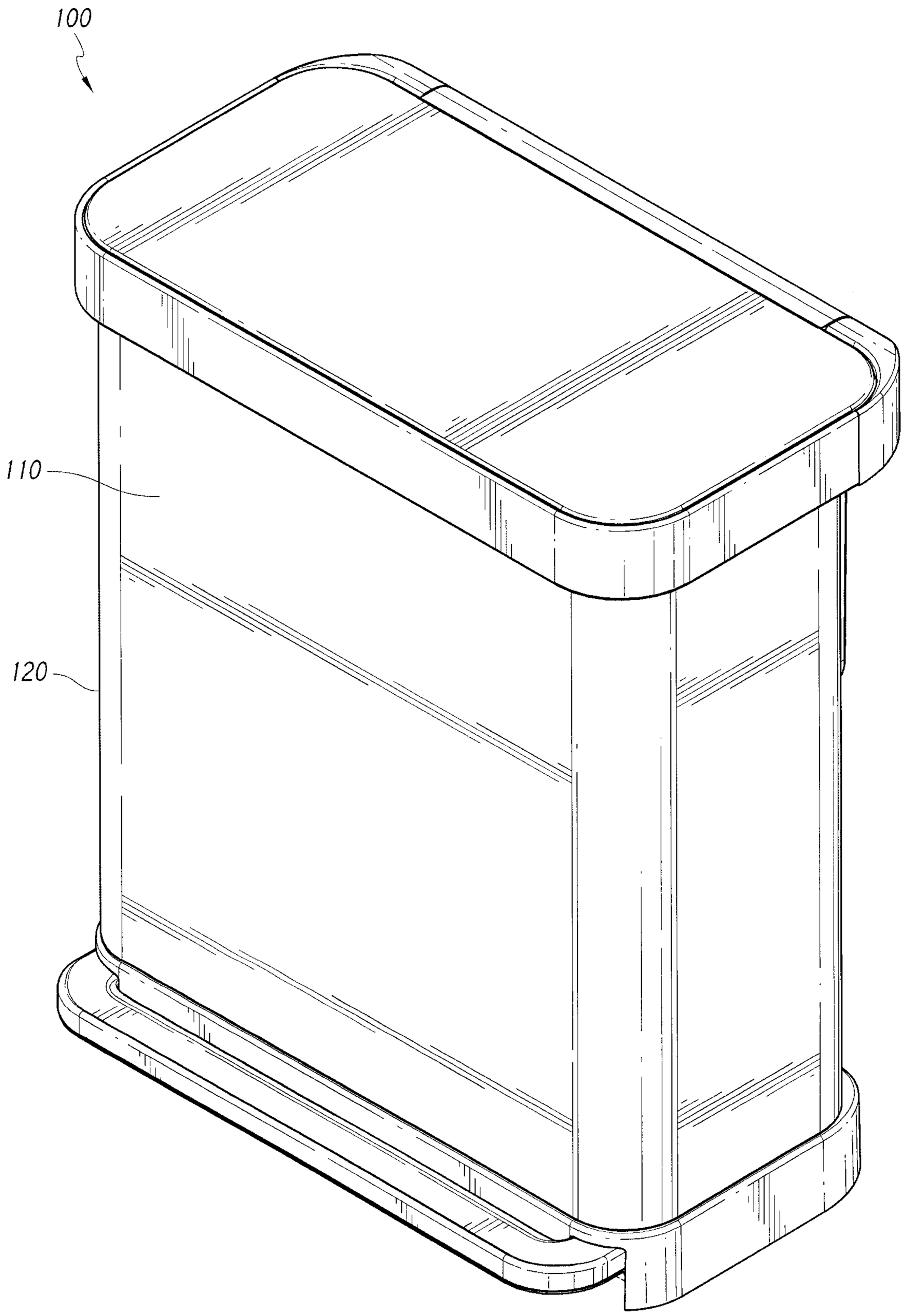


FIG. 1

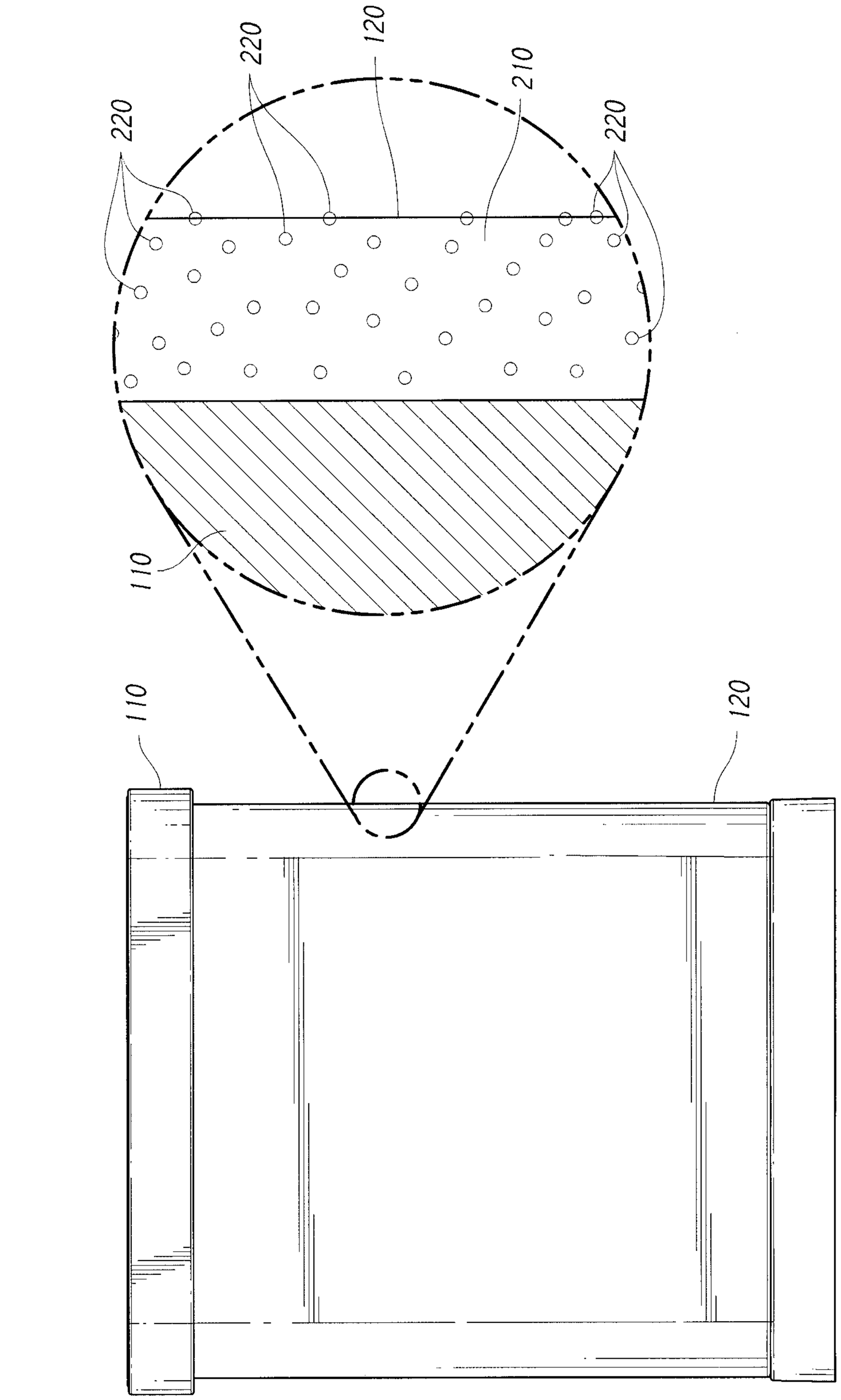


FIG. 2

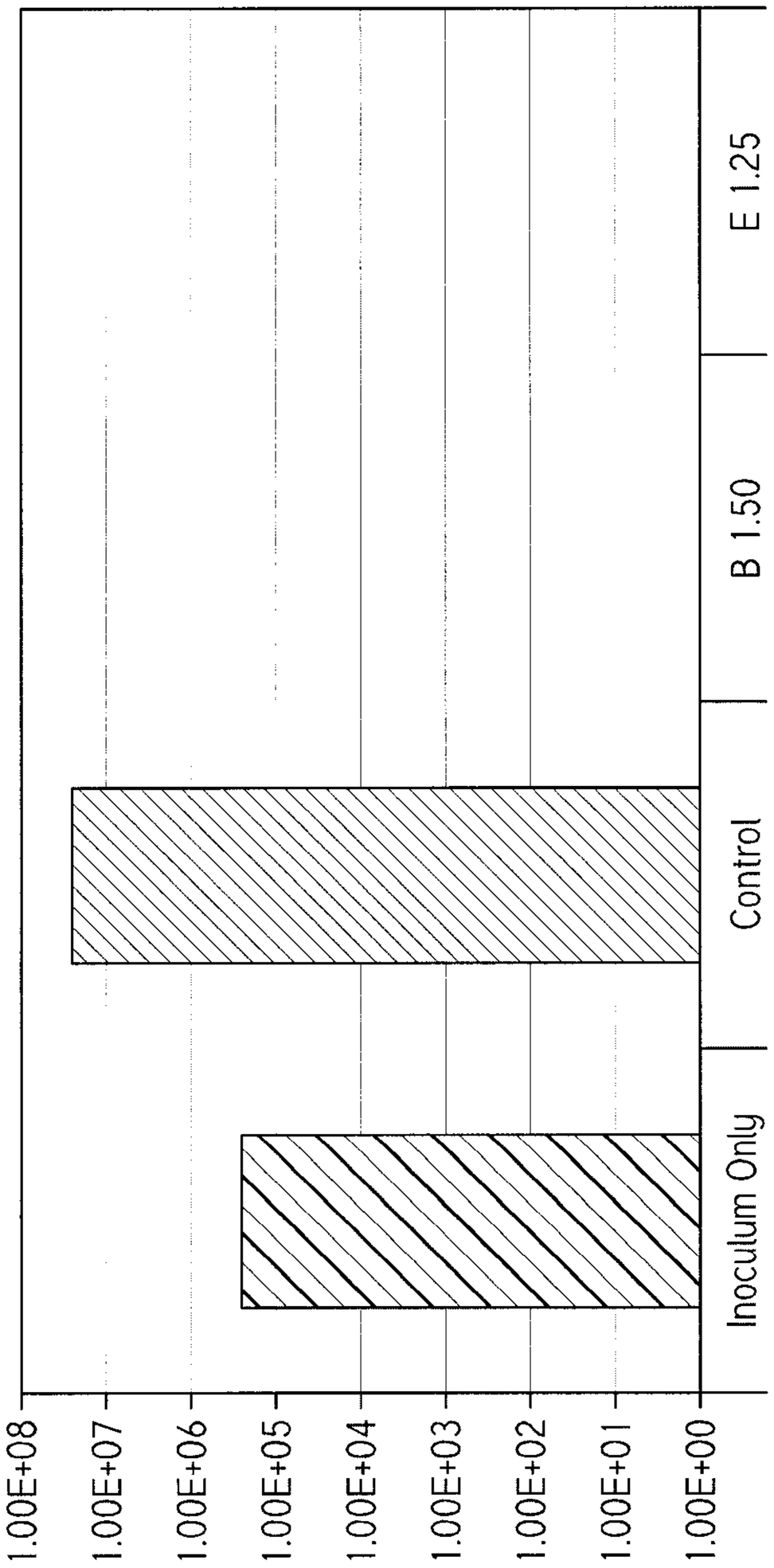

CFU/Carrier
1.00E+08
1.00E+07
1.00E+06
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
Inoculum Only
Time Zero
Control
B 1.50
24 Hours
E 1.25
Carrier Type

FIG. 5

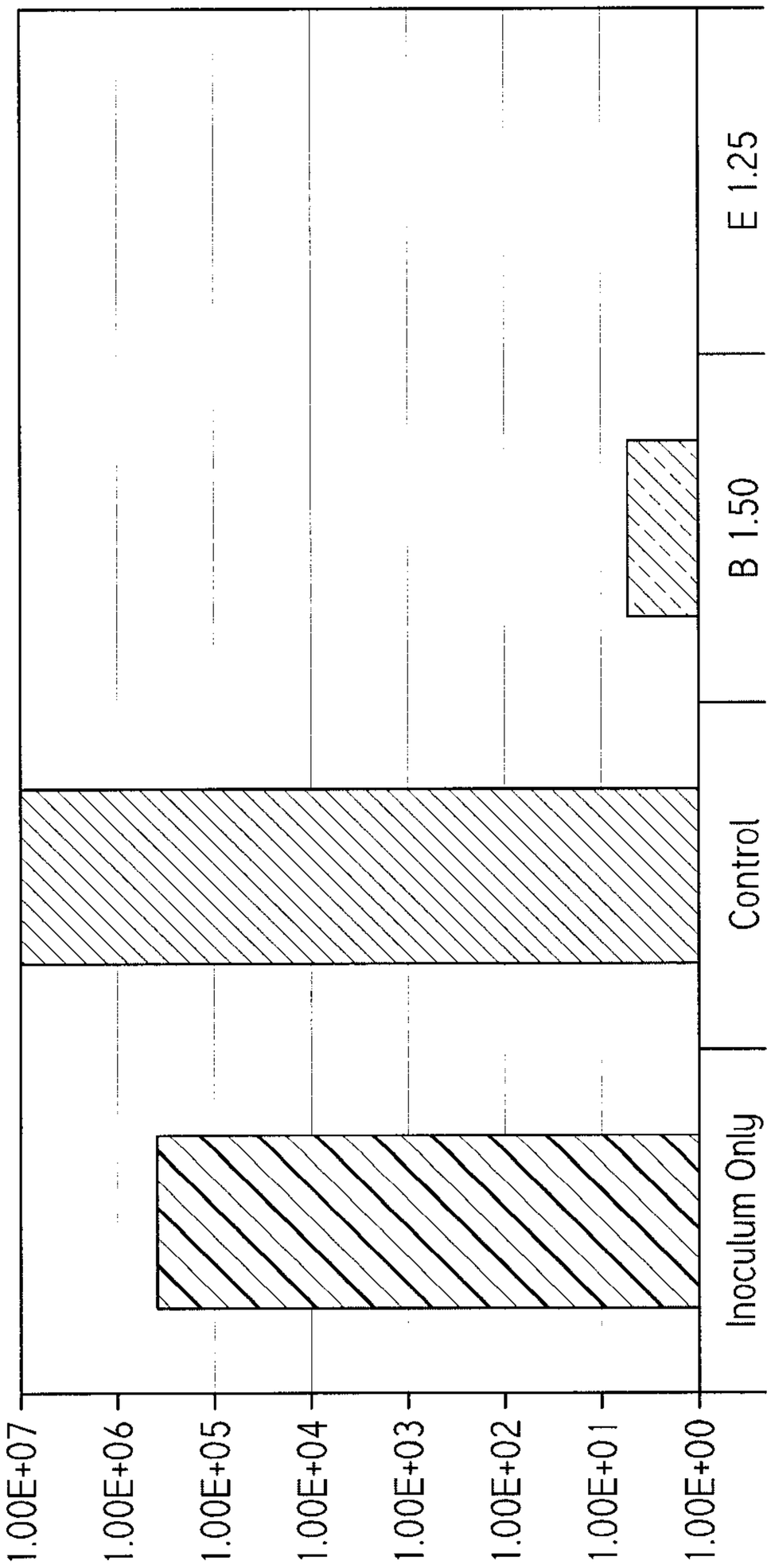

CFU/Carrier
1.00E+07
1.00E+06
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
Inoculum Only
Time Zero
Control
B 1.50
24 Hours
E 1.25
Carrier Type

FIG. 6

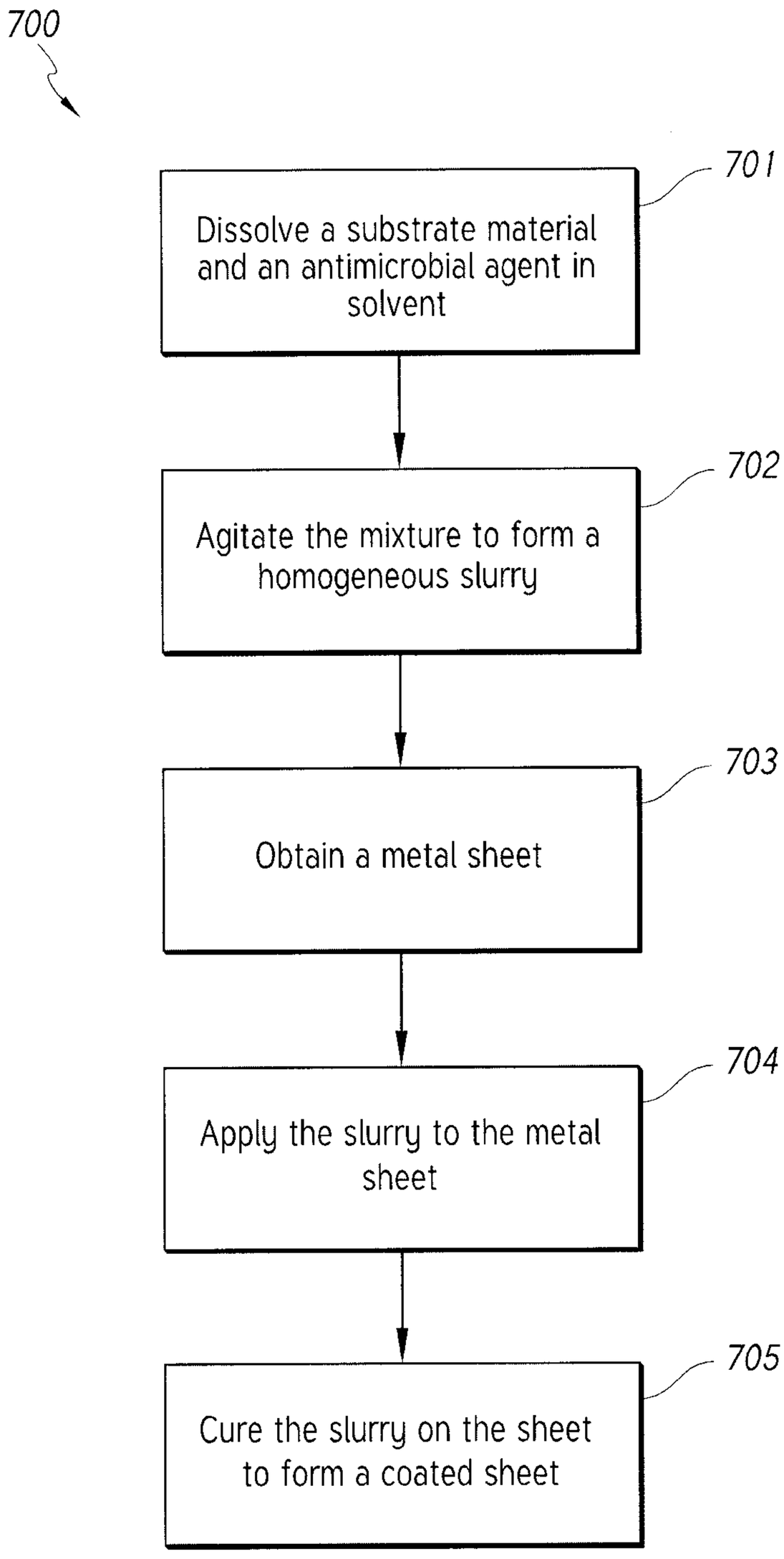

700
701
Dissolve a substrate material and an antimicrobial agent in solvent
702
Agitate the mixture to form a homogeneous slurry
703
Obtain a metal sheet
704
Apply the slurry to the metal sheet
705
Cure the slurry on the sheet to form a coated sheet

FIG. 7

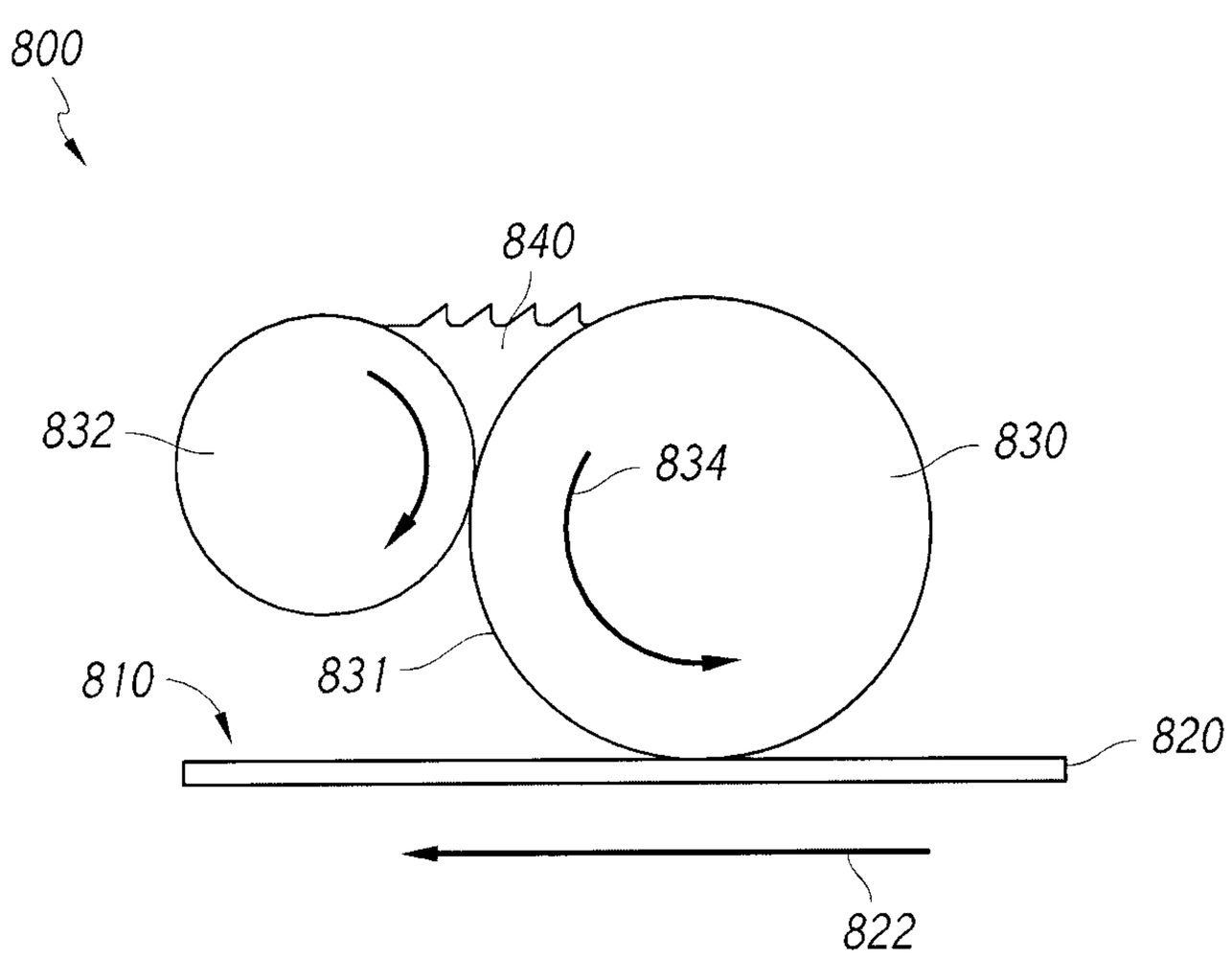


FIG. 8

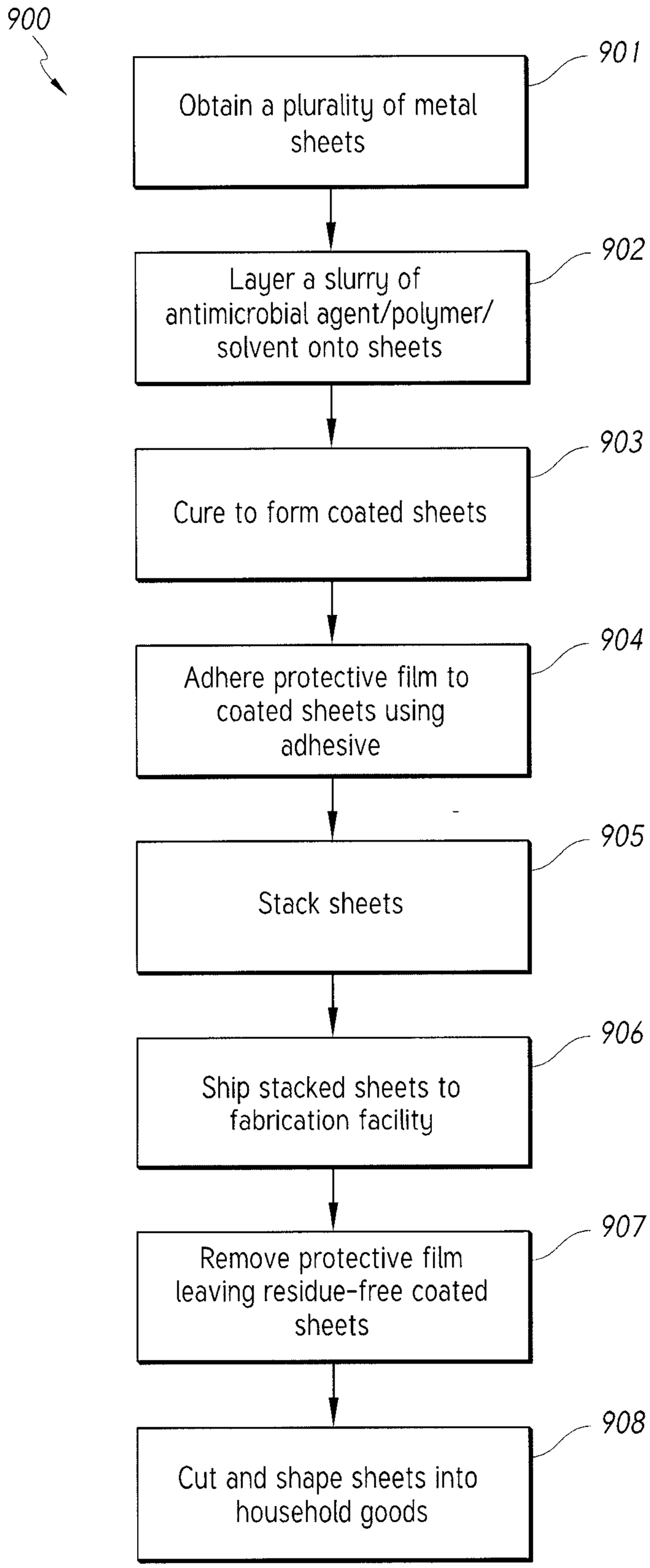
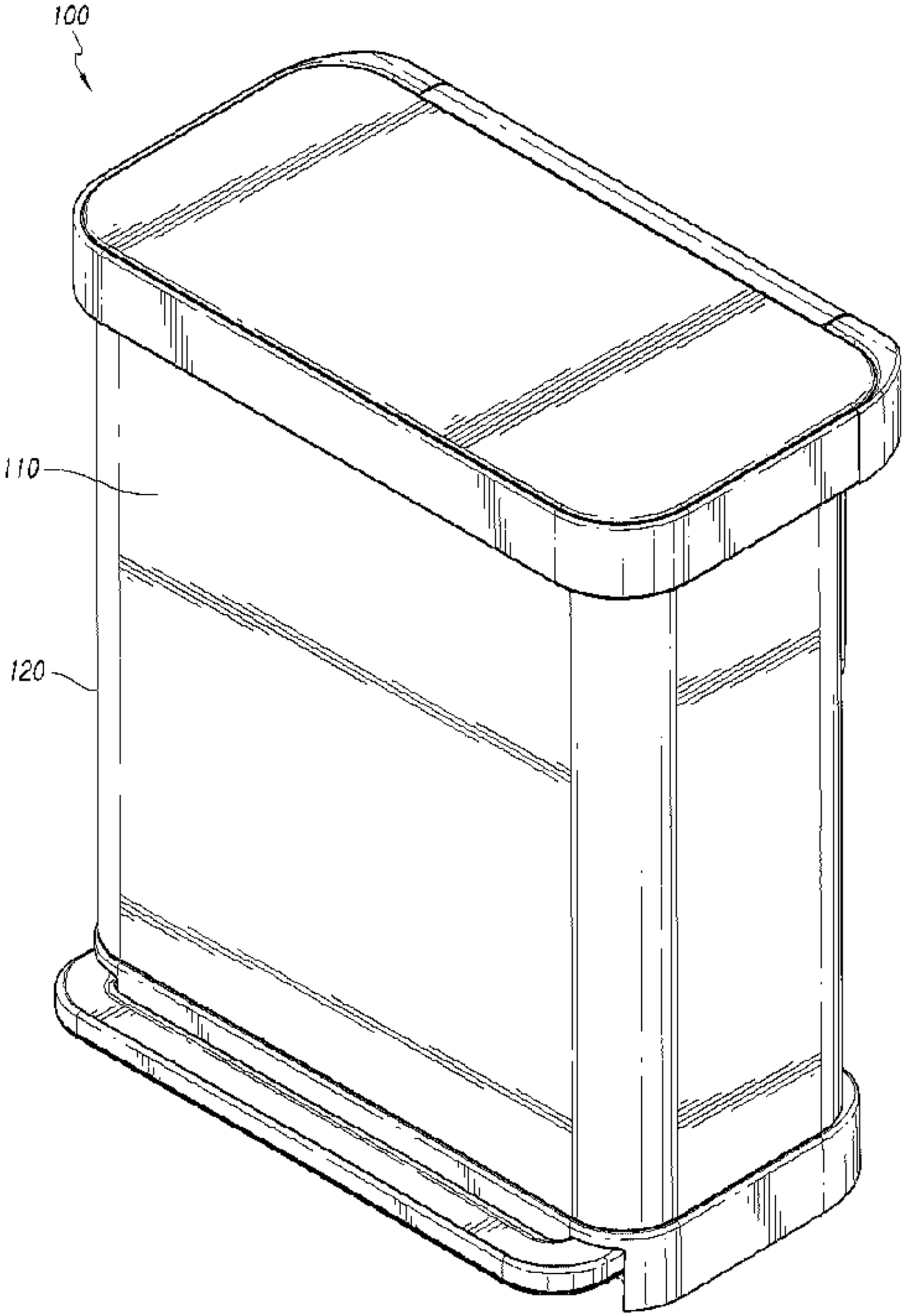

900
Obtain a plurality of metal sheets
901
Layer a slurry of antimicrobial agent/polymer/ solvent onto sheets
902
Cure to form coated sheets
903
Adhere protective film to coated sheets using adhesive
904
Stack sheets
905
Ship stacked sheets to fabrication facility
906
Remove protective film leaving residue-free coated sheets
907
Cut and shape sheets into household goods
908

FIG. 9


100
110
120