

ANTIMICROBIAL-COATED HYDROGEL FORMING ABSORBENT POLYMERS

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BACKGROUND

10 A wide variety of disposable absorbent articles designed not only to be efficient in the absorption of body fluids such as urine, blood, menses and the like, but also to be sanitary and comfortable in-use, are known in the literature. Disposable absorbent products of this type generally comprise a fluid-permeable topsheet material, an absorbent core, and a fluid-impermeable backsheet
15 material. Various shapes, sizes and thicknesses of such articles have been explored in an attempt to make their use more comfortable and convenient.

For some time now, studies for such disposable absorbent articles have been primarily focused on the absorptive capacity of the article. As a result, various absorbent polymers with high absorptive power have been developed.
20 Such known absorbent polymers (also known as hydrogel-forming absorbent polymers) are capable of absorbing from about thirty to sixty grams of water per gram of polymer.

More recently, research has been focused on the removal of foul odors and the prevention of skin diseases such as dermatitis, rash and redness caused
25 by wearing a disposable absorbent article for a relatively long time. Many body fluids have an unpleasant odor, or develop such odors when in contact with air and/or bacteria for prolonged periods. Additionally, urine and/or other exudates absorbed into the absorbent article are converted to ammonia by urease produced by skin-flora, *i.e.*, a group of normal microorganisms on the skin. This
30 ammonia, in turn, causes dermatitis, rash and/or other forms of skin irritation. Such disease of the skin in infants can be a serious medical matter which, in extreme cases, can result in death.

Antimicrobial agents and bactericides are chemical compositions that are used to prevent microbiological contamination and deterioration of products,
35 materials, and systems. Particular areas of application of antimicrobial agents

and compositions are, for example, cosmetics, disinfectants, sanitizers, wood preservation, food, animal feed, cooling water, metalworking fluids, hospital and medical uses, plastics and resins, petroleum, pulp and paper, textiles, latex, adhesives, leather and hides, paint slurries, and disposable diapers.

5 For example, Japanese Patent 4-17058 discloses a disposable diaper which is said to prevent the occurrence of diaper rash caused by the growth of saprophytes such as the bacteria *colibacillus* and *Candida*. The disclosed disposable diaper consists of a water-permeable top sheet, a water-impermeable back sheet, and a water-absorbent layer sandwiched between these sheets. The
10 water-absorbent layer is further disclosed as consisting of a) an ammonia-adsorbent, water-absorbent organic polymer selected from the group consisting of polyacrylate polymers, starch-acrylonitrile graft copolymer hydrolizates, starch-acrylic acid graft copolymers, polyvinyl alcohol-acrylate copolymers, polymers produced by further crosslinking of a crosslinked acrylate with a crosslinking
15 agent, and modified carboxymethyl cellulose; and b) benzalkonium chloride and/or chlorhexidine gluconate, contained within the water-absorbent organic polymer. The reference further discloses forming the organic polymer / bactericide material by combining the starting materials of the organic polymer (e.g., microparticulate silicon dioxide, a copolymer such as crosslinked potassium
20 polyacrylate, and a cross-linking agent such as ethylene glycol diglycidyl) and the bactericide. The resulting mixture is then heated to bring about a crosslinking reaction, thereby forming a crosslinked structure, the bactericide being incorporated within the structure.

25 While the diaper disclosed by Japanese Patent No. 4-17058 is said to result in absorption by the organic polymer of ammonia contained in the wearer's urine, and the bactericide is said to inhibit the production ammonia (formed by decomposition of the urea contained in the urine) by bacteria, we have discovered certain disadvantages with this technology.

30 For example, because the bactericide is incorporated within the polymer, the bactericide does not begin acting until the polymer swells with the urine. In other words, the product does not provide immediate efficacy upon, e.g., urination.

35 In addition, water-absorbent polymers (whether manufactured as set forth in Japanese Patent No. 4-17058, or without incorporating a bactericide within the polymer) tend to produce dust during manufacture. Such dust production has

several disadvantages including, health risks to workers who inhale the dust, increased cleanings of the machinery to remove the dust, and loss of product in the form of unclaimed dust.

Based on the foregoing, there is a need for an antimicrobial hydrogel-forming absorbent polymer ("A-HFAP") that provides immediate efficacy, when employed in a disposable absorbent article, upon excretion of body fluid by the user. There is also a need for a process for making such an A-HFAP that results in minimal dust production. There is also a need for an absorbent article product containing such an A-HFAP, which maintains the antimicrobial in a region away from the wearer's skin, even after wetting.

SUMMARY

The present invention is directed to an antimicrobial hydrogel-forming absorbent polymer comprising a hydrogel-forming absorbent polymer, and an antimicrobial; wherein the hydrogel-forming absorbent polymer is coated with the antimicrobial. Such a material satisfies the need for a hydrogel-forming absorbent polymer and antimicrobial combination which, when employed in a disposable absorbent article, provides immediate efficacy upon excretion of body fluid by the user.

The present invention further relates to a process for making such an antimicrobial hydrogel-forming absorbent polymer, the process comprising coating a hydrogel-forming absorbent polymer with an antimicrobial. Such a process satisfies the need for process which minimizes dust production otherwise associated with the manufacture of hydrogel-forming absorbent polymers.

The present invention further relates to a disposable absorbent article comprising an antimicrobial hydrogel-forming absorbent polymer. Such a structure satisfies the need for an absorbent article which efficaciously reduces malodor and rash, yet maintains the active ingredients away from the user's skin.

These and other features, aspects, and advantages of the present invention will become evident to those skilled in the art from a reading of the present disclosure and accompanying drawings with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims which particularly point out and distinctly claim the invention, it is believed the present invention will be better understood from the following description of preferred embodiments taken in

conjunction with the accompanying drawings, in which like reference numerals identify identical elements and wherein:

Figure 1 is a plan view of a disposable diaper embodiment of the present invention, having portions cut away to reveal underlying structure, the inner
5 surface of the diaper facing the viewer;

Figure 2 is a cross-sectional view of one embodiment of the disposable diaper of Figure 1, taken along transverse center line 110 of Figure 1;

Figure 3 is an enlarged view of an alternative embodiment of the disposable diaper of Figure 1, the view corresponding to a portion of Figure 2;
10 and

Figure 4 shows the key elements of the finished product acquisition test.

DETAILED DESCRIPTION

The following is a list of definitions for terms used herein.

"A-HFAP" means antimicrobial hydrogel-forming absorbent polymer.

15 "Body fluids" includes urine, menses and vaginal discharges.

"Comprising" means that other steps and other ingredients which do not affect the end result can be added. This term encompasses the terms "consisting of" and "consisting essentially of".

"Disposable" describes absorbent articles which are not intended to be
20 laundered or otherwise restored or reused as an absorbent article (*i.e.*, they are intended to be discarded after a single use and, preferably, to be recycled; composted or otherwise disposed of in an environmentally compatible manner).

"HFAP" means hydrogel-forming absorbent polymer.

"Unitary" absorbent article refers to an absorbent article which is formed of
25 separate parts united together to form a coordinated entity so that they do not require separate manipulative parts like a separate holder and liner.

All percentages are by weight of total composition unless specifically stated otherwise.

All ratios are weight ratios unless specifically stated otherwise.

30 The present invention, in its product and process aspects, is described in detail as follows.

The present invention relates to an antimicrobial hydrogel-forming absorbent polymer comprising a HFAP, and an antimicrobial; wherein the HFAP is coated with the antimicrobial.

In preferred embodiments, the weight ratio of HFAP to antimicrobial is from about 100:0.01 to about 100:2, more preferably from about 100:0.02 to about 100:1, more preferably still from about 100:0.05 to about 100:0.5.

Hydrogel-Forming Absorbent Polymer

5 The water-insoluble, water-swellaable absorbent polymers useful in the present invention are commonly referred to as "hydrogel-forming absorbent polymers" (HFAPs), "hydrocolloids", or "superabsorbent" polymers and can include polysaccharides such as carboxymethyl starch, carboxymethyl cellulose, and hydroxypropyl cellulose; nonionic types such as polyvinyl alcohol, and
10 polyvinyl ethers; cationic types such as polyvinyl pyridine, polyvinyl morpholinone, and N,N-dimethylaminoethyl or N,N-diethylaminopropyl acrylates and methacrylates, and the respective quaternary salts thereof. Typically, HFAPs useful in the present invention have a multiplicity of anionic, functional groups, such as sulfonic acid, and more typically carboxy, groups. Examples of polymers
15 suitable for use herein include those which are prepared from polymerizable, unsaturated, acid-containing monomers. Thus, such monomers include the olefinically unsaturated acids and anhydrides that contain at least one carbon to carbon olefinic double bond. More specifically, these monomers can be selected from olefinically unsaturated carboxylic acids and acid anhydrides, olefinically
20 unsaturated sulfonic acids, and mixtures thereof.

 Some non-acid monomers can also be included, usually in minor amounts, in preparing the HFAPs herein. Such non-acid monomers can include, for example, the water-soluble or water-dispersible esters of the acid-containing monomers, as well as monomers that contain no carboxylic or sulfonic acid
25 groups at all. Optional non-acid monomers can thus include monomers containing the following types of functional groups: carboxylic acid or sulfonic acid esters, hydroxyl groups, amide-groups, amino groups, nitrile groups, quaternary ammonium salt groups, aryl groups (e.g., phenyl groups, such as those derived from styrene monomer). These non-acid monomers are well-
30 known materials and are described in greater detail, for example, in U.S. Patent 4,076,663 (Masuda et al), issued February 28, 1978; and in U.S. Patent 4,062,817 (Westerman), issued December 13, 1977.

 Olefinically unsaturated carboxylic acid and carboxylic acid anhydride monomers include the acrylic acids typified by acrylic acid itself, methacrylic acid, ethacrylic acid, 3-chloroacrylic acid, cyanoacrylic acid, methacrylic acid (crotonic
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acid), phenylacrylic acid, acryloxypropionic acid, sorbic acid, chlorosorbic acid, angelic acid, cinnamic acid, p-chlorocinnamic acid, sterylacrylic acid, itaconic acid, citraconic acid, mesaconic acid, glutaconic acid, aconitic acid, maleic acid, fumaric acid, tricarboxyethylene and maleic acid anhydride.

5 Olefinically unsaturated sulfonic acid monomers include aliphatic or aromatic vinyl sulfonic acids such as vinylsulfonic acid, allyl sulfonic acid, vinyl toluene sulfonic acid and styrene sulfonic acid; acrylic and methacrylic sulfonic acid such as sulfoethyl acrylate, sulfoethyl methacrylate, sulfopropyl acrylate, sulfopropyl methacrylate, 2-hydroxy-3-methacryloxypropyl sulfonic acid and 2-
10 acrylamide-2-methylpropane sulfonic acid.

Preferred HFAPs for use in the present invention contain carboxy groups. These polymers include hydrolyzed starch-acrylonitrile graft copolymers, partially neutralized hydrolyzed starch-acrylonitrile graft copolymers, starch-acrylic acid graft copolymers, partially neutralized starch-acrylic acid graft copolymers, saponified vinyl acetate-acrylic ester copolymers, hydrolyzed acrylonitrile or
15 acrylamide copolymers, slightly network crosslinked polymers of any of the foregoing copolymers, partially neutralized polyacrylic acid, and slightly network crosslinked polymers of partially neutralized polyacrylic acid. These polymers can be used either solely or in the form of a mixture of two or more different
20 polymers. Examples of these polymer materials are disclosed in U.S. Patent 3,661,875, U.S. Patent 4,076,663, U.S. Patent 4,093,776, U.S. Patent 4,666,983, and U.S. Patent 4,734,478.

More preferred polymer materials for use in making the HFAPs are slightly network crosslinked polymers of partially neutralized polyacrylic acids and starch
25 derivatives thereof. More preferably, the HFAPs comprise from about 50 to about 95%, preferably about 75%, neutralized, slightly network crosslinked, polyacrylic acid (*i.e.*, poly (sodium acrylate/acrylic acid)). Network crosslinking renders the polymer substantially water-insoluble and, in part, determines the absorptive capacity and extractable polymer content characteristics of the HFAPs.
30 Processes for network crosslinking these polymers and typical network crosslinking agents are described in greater detail in U.S. Patent 4,076,663.

Further, surface crosslinked HFAPs can be preferably used in the present invention. They have a higher level of crosslinking in the vicinity of the surface than in the interior. As used herein, "surface" describes the outer-facing
35 boundaries of the particle, fiber, etc. For porous HFAPs (*e.g.*, porous particles,

etc.), exposed internal boundaries can also be included. By a higher level of crosslinking at the surface, it is meant that the level of functional crosslinks for the HFAP in the vicinity of the surface is generally higher than the level of functional crosslinks for the polymer in the interior.

5 The gradation in crosslinking from surface to interior can vary, both in depth and profile. Thus, for example, the depth of surface crosslinking can be shallow, with a relatively sharp transition to a lower level of crosslinking. Alternatively, for example, the depth of surface crosslinking can be a significant fraction of the dimensions of the HFAP, with a broader transition.

10 Depending on size, shape, porosity as well as functional considerations, the degree and gradient of surface crosslinking can vary within a given HFAP. For particulate HFAPs, surface crosslinking can vary with particle size, porosity, etc. Depending on variations in surface:volume ratio within the HFAP (e.g., between small and large particles), it is not unusual for the overall level of crosslinking to vary within the material (e.g., be greater for smaller particles).

15 Surface crosslinking is generally accomplished after the final boundaries of the HFAP are essentially established (e.g., by grinding, extruding, foaming, etc.) However, it is also possible to effect surface crosslinking concurrent with the creation of final boundaries. Furthermore, some additional changes in boundaries can occur even after surface crosslinks are introduced.

20 A number of processes for introducing surface crosslinks are disclosed in the art. These include those where: (i) a di- or poly-functional reagent(s) (e.g., glycerol, 1,3-dioxolan-2-one, polyvalent metal ions, polyquaternary amines) capable of reacting with existing functional groups within the HFAP is applied to the surface of the HFAP; (ii) a di- or poly-functional reagent that is capable of reacting with other added reagents and possibly existing functional groups within the HFAP such as to increase the level of crosslinking at the surface is applied to the surface (e.g., the addition of monomer plus crosslinker and the initiation of a second polymerization reaction); (iii) no additional polyfunctional reagents are added, but additional reaction(s) is induced amongst existing components within the HFAP either during or after the primary polymerization process such as to generate a higher level of crosslinking at or near the surface (e.g., heating to induce the formation of anhydride and or esters crosslinks between existing polymer carboxylic acid and/or hydroxyl groups and suspension polymerization processes wherein the crosslinker is inherently present at higher levels near the

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surface); and (iv) other materials are added to the surface such as to induce a higher level of crosslinking or otherwise reduce the surface deformability of the resultant hydrogel. Combinations of these surface crosslinking processes either concurrently or in sequence can also be employed. In addition to crosslinking
5 reagents, other components can be added to the surface to aid/control the distribution of crosslinking (e.g., the spreading and penetration of the surface crosslinking reagents.)

Suitable general methods for carrying out surface crosslinking of HFAPs according to the present invention are disclosed in U.S. Patent 4,541,871
10 (Obayashi), issued September 17, 1985; published PCT application WO92/16565 (Stanley), published October 1, 1992; published PCT application WO90/08789 (Tai), published August 9, 1990; published PCT application WO93/05080 (Stanley), published March 18, 1993; U.S. Patent 4,824,901 (Alexander), issued April 25, 1989; U.S. Patent 4,789,861 (Johnson), issued January 17, 1989; U.S.
15 Patent 4,587,308 (Makita), issued May 6, 1986; U.S. Patent 4,734,478 (Tsubakimoto), issued March 29, 1988; U.S. Patent 5,164,459 (Kimura et. al.), issued November 17, 1992; published German patent application 4,020,780 (Dahmen), published August 29, 1991; and published European patent application 509,708 (Gartner), published October 21, 1992.

20 While the HFAP is preferably of one type (i.e., homogeneous), mixtures of polymers can also be used in the present invention. For example, mixtures of starch-acrylic acid graft copolymers and slightly network crosslinked polymers of partially neutralized polyacrylic acid can be used in the present invention.

The HFAP particles used in the present invention can have a size, shape
25 and/or morphology varying over a wide range. The HFAP particles do not have a large ratio of greatest dimension to smallest dimension (e.g., granules, flakes, pulverulents, interparticle aggregates, interparticle crosslinked aggregates, and the like) and can be in the form of fibers, foams, and the like. The HFAPs can also comprise mixtures with low levels of one or more additives, such as for
30 example powdered silica, surfactants, glue, binders, and the like. The components in this mixture can be physically and/or chemically associated in a form such that the hydrogel-forming polymer component and the non-hydrogel-forming polymer additive are not readily physically separable.

The HFAPs can be essentially non-porous or have substantial internal
35 porosity.

For particles as described above, particle size is defined as the dimension determined by sieve size analysis. Thus, for example, a particle that is retained on a U.S.A. Standard Testing Sieve with 710 micron openings (e.g., No. 25 U.S. Series Alternate Sieve Designation) is considered to have a size greater than 710 microns; a particle that passes through a sieve with 710 micron openings and is retained on a sieve with 500 micron openings (e.g., No. 35 U.S. Series Alternate Sieve Designation) is considered to have a particle size between 500 and 710 microns; and a particle that passes through a sieve with 500 micron openings is considered to have a size less than 500 microns. The mass median particle size of a given sample of hydrogel-forming absorbent polymer particles is defined as the particle size that divides the sample in half on a mass basis, i.e., one-half of the sample by weight will have a particle size less than the mass median size and one-half of the sample will have a particle size greater than the mass median size. A standard particle-size plotting method (wherein the cumulative weight percent of the particle sample retained on or passed through a given sieve size opening is plotted versus sieve size opening on probability paper) is typically used to determine mass median particle size when the 50% mass value does not correspond to the size opening of a U.S.A. Standard Testing Sieve. These methods for determining particle sizes of the hydrogel-forming absorbent polymer particles are further described in U.S. Patent 5,061,259 (Goldman *et. al*), issued October 29, 1991.

For particles of HFAPs useful in the present invention, the particles will generally range in size from about 1 to about 2000 microns, more preferably from about 20 to about 1000 microns. The mass median particle size will generally be from about 20 to about 1500 microns, more preferably from about 50 microns to about 1000 microns, and even more preferably from about 100 to about 800 microns.

Within these size ranges, it can be preferable to choose either larger or smaller particles depending on the need for faster or slower absorption kinetics. For example, for non-porous particles, the swelling rate will generally decrease with increasing particle size. It can also be preferable to choose either larger or smaller particles or narrower size cuts (fractions) of larger or smaller particles from the bulk polymer in order to increase the gel layer permeability (i.e., increase the Saline Flow Conductivity (SFC) value). For particles of some HFAPs, it has been found that narrower size range cuts containing generally larger particle

sizes within the above specified size ranges have higher SFC values without any significant degradation in other HFAP properties such as Performance Under Pressure (PUP) capacity and level of extractable polymer. Thus, for example, it can be useful to use a size cut having a mass median size in the range of from about 500 to about 710 microns wherein only minimal mass fractions of the particulates have sizes either greater than about 710 microns or less than about 500 microns. Alternatively, a broader size cut wherein the particles generally have a size in the range of from about 150 microns to about 800 microns can be useful.

10 Antimicrobial

The antimicrobial agent useful in the present invention may be any chemical capable of preventing the growth of or killing microorganisms, and is capable of binding to an HFAP; more preferably, capable of binding to the surface of an HFAP. Preferred antimicrobials are those that can prevent the growth of or kill microorganisms typically found in body fluids, more preferably those body fluids typically collected by a disposable absorbent article. Preferred antimicrobials include, but are not limited to, quaternary ammonium, phenolic, amide, acid, and nitro compounds, and mixtures thereof; more preferably quaternary ammonium, acid and phenolic; more preferably still quaternary ammonium compounds.

Preferred quaternary ammonium compounds include, but are not limited to, 2-(3-anilinoethyl)3,4-dimethyl-oxazolinium iodide, alkylisoquinolium bromide, benzalkonium chloride, benzethonium chloride, cetylpyridium chloride, chlorhexidine gluconate, chlorhexidine hydrochloride, lauryl trimethyl ammonium, methylbenzethonium chloride, stearyltrimethylammonium chloride, 2,4,5-trichloro phenoxide, and mixtures thereof; more preferably benzalkonium chloride and chlorhexidine gluconate; more preferably still benzalkonium chloride.

Preferred phenolic compounds include, but are not limited to, benzyl alcohol, *p*-chlorophenol, chlorocresol, chloroxylenol, cresol, *o*-cymene-5-ol (BIOSOL), hexachlorophene, hinokitiol, isopropylmethylphenol, parabens (having methyl, ethyl, propyl, butyl, isobutyl, isopropyl, and/or sodium methyl substituents), phenethyl alcohol, phenol, phenoxyethanol, *o*-phenylphenol, resorcin, resorcin monoacetate, sodium parabens, sodium phenolsulfonate, thioxolone, 2,4,4'-trichloro-2'-hydroxydiphenyl ether, zinc phenolsulfonate, and mixtures thereof; more preferably sodium parabens.

Preferred amides include, but are not limited to, diazolidinyl urea, 2,4-imidazolidinedione (HYDATOIN), 3,4,4'-trichlorocarbanilide, 3-trifluoromethyl-4-4'-dichlorocarbanilide, undecylenic acid monoethanolamide, and mixtures thereof; more preferably diazolidinyl urea and 2,4-imidazolidinedione; more preferably still
5 2,4-imidazolidinedione.

Preferred acids include, but are not limited to, benzoate, benzoic acid, citric acid, dehydroacetic acid, potassium sorbate, sodium citrate, sodium dehydroacetate, sodium salicylate, sodium salicylic acid, sorbic acid, undecylenic acid, zinc undecylenate, and mixtures thereof; more preferably benzoic acid, citric
10 acid, salicylic acid and sorbic acid, more preferably still citric acid and sorbic acid.

Preferred nitro compounds include, but are not limited to, 2-bromo-2-nitro-2,3-propanediol (BRONOPOL), and methyldibromo glutaronitrile and propylene glycol (MERGUARD), and mixtures thereof.

Process for Producing an Antimicrobial Hydrogel-Forming Absorbent Polymer

15 The invention further relates to a process for making an antimicrobial hydrogel-forming absorbent polymer, the process comprising coating HFAP particles with an antimicrobial. As used herein, "coating" means that the antimicrobial will be on at least a portion of the surface area of the HFAP. Preferably, the antimicrobial is applied onto all of the surface of the HFAP.
20 Without wishing to be bound by theory, it is believed that the antimicrobial is bonded to the surface of the HFAP by Coulumb interaction. When the A-HFAP is hydrated, most of the antimicrobial remains ionically attracted to the HFAP. However, some antimicrobial may diffuse to interparticulate space and fibers.

In a case where the antimicrobial is in the form of a small particle or
25 powder, the antimicrobial can be applied by any of various techniques and apparatus used for applying (e.g., coating) a material to another material. In another case where the antimicrobial is in the form of a liquid, the antimicrobial can be applied (e.g., coated onto the HFAP) by any of various techniques and apparatus used for applying a liquid to a material. As a result, A-HFAPs of the
30 present invention can be obtained as described above.

In a preferred embodiment, an antimicrobial is dissolved into a solvent to make a solution. The antimicrobial can be dissolved in the solvent by any of various techniques and apparatus used for dissolving a material to a solvent known in the art. In more preferred embodiments, an inorganic solvent is used as
35 the solvent; preferably water. Preferably, the concentration of the antimicrobial in

the solution by weight is from about 2% to 25%, more preferably, from about 5% to 15%.

5 In certain embodiments, an antimicrobial which is insoluble in an organic solvent can be used. In more preferred embodiments, a polar organic solvent is used as the solvent. In such embodiments, a mixture solvent of a hydrophilic organic solvent and water is used as the solvent for the antimicrobial. Non-limiting examples of the preferred organic solvent includes: the low molecular weight alcohols such as methanol, ethanol, or propanol; acetone; dimethylformamide(DMF); dimethylsulfoxide(DMSO); hexylmethylphosphoric triamide(HMPT); and mixtures thereof. In alternative preferred embodiments, 10 non-polar solvents such as hexane, toluene, xylene, and benzene can be used as one of the organic solvents.

After preparing the solution, the solution is applied onto the HFAP thereby making an intermittent mixture. More specifically, an amount of the solution is 15 applied onto the HFAP. The solution can be applied by any of various techniques and apparatus used for applying a solution to a material including coating, dumping, pouring, dropping, spraying, atomizing, condensing, or immersing the liquid mixture onto the absorbent gelling particles; to cause partial or complete coating of the HFAP with the antimicrobial. Thus, in the intermittent mixture the solution will be on (e.g., coat) at least a portion of the surface area of the HFAP. 20 Preferably, the solution will be on all of the surface of the HFAP particles.

The amount of the antimicrobial which is sufficient to effect an efficacious antimicrobial properties can vary based on a number of factors such as the chemical composition of the HFAP and the physical forms of the HFAP, e.g., 25 particle size of the HFAP, and the chemical composition and molecular weight of the antimicrobial, as well as on the method of applying the antimicrobial.

After making the intermittent mixture, at least a portion of the solvent is removed from the intermittent mixture. Preferably, at least about 80%, more preferably more than 95%, most preferably about 100% of the solvent is removed 30 from the intermittent mixture. The removal of the solvent can be made by any of various techniques and apparatus used for separating or removing liquids from liquid-solid mixtures, including evaporation, filtration, washing, or a combination thereof.

In a preferred embodiment, the antimicrobial is applied onto the HFAP 35 after the treatment of the surface crosslinking of the HFAP particles. On the

other hand, in another embodiment the antimicrobial is applied onto the HFAP before the treatment of the surface crosslinking of the HFAP. In addition, in a further embodiment the application of the antimicrobial and the treatment of the cross linking can be carried out at the same time.

5 In preferred embodiments, the resultant A-HFAP can have a number of shapes and sizes. For example, the absorbent materials can be typically in the form of particles, sheets, films, cylinders, blocks, fibers, filaments, or other shaped elements. More preferably, the absorbent material is particulate.

10 Absorbent Articles Employing the Antimicrobial Hydrogel-Forming Absorbent Polymer

The A-HFAPs according to the present invention can be used for many purposes in many fields of use. For example, the A-HFAPs can be used for packing containers; drug delivery devices; wound cleaning devices; burn treatment devices; ion exchange column materials; construction materials; 15 agricultural or horticultural materials such as seed sheets or water-retentive materials; and industrial uses such as sludge or oil dewatering agents, materials for the prevention of dew formation, desiccants, and humidity control materials.

Because of the unique absorbent and antimicrobial properties of the A-HFAPs of the present invention, they are especially suitable for use as 20 absorbent cores in absorbent articles, especially disposable absorbent articles. As used herein, the term "absorbent article" refers to articles which absorb and contain body fluids and more specifically refers to articles which are placed against or in proximity to the body of the wearer to absorb and contain the various fluids discharged from the body.

25 In general, an absorbent article comprises: (a) a liquid pervious topsheet which is located adjacent to the wearer's body; (b) a liquid impervious backsheet which is located distant from the wearer's body and adjacent to the wearer's clothing; and (c) an absorbent core positioned between the topsheet and the backsheet. The absorbent core comprises at least one of the above described A- 30 HFAPs of the present invention. Preferably, the absorbent core further comprises a substrate web wherein the absorbent material is attached to the substrate web. Alternatively, the absorbent core further comprises an envelope web encasing the absorbent material. In a further alternative embodiment, the absorbent core further comprises two layered tissues wherein the absorbent material is 35 distributed between the two layered tissues.

In more preferred embodiments, the A-HFAP in the absorbent core has a basis weight of from about 60 g/m² to about 1500 g/m², more preferably from about 100 g/m² to about 1000 g/m², most preferably from about 150 g/m² to about 500 g/m² of the absorbent material.

5 In some preferred embodiments, the absorbent core or absorbent member can further comprise fibers or fluff pulp (fibrous or fiber material), more specifically, non-absorbent-gelling fibers. Such fiber material can be used as reinforcing members in the absorbent core, improving fluid handling of the core, as well as a co-absorbent with the absorbent polymers. Preferably, the
10 absorbent core or member includes from about 40% to about 100% by weight of the A-HFAP and from about 60% to about 0% by weight of such non-absorbent-gelling fiber material distributed within the absorbent material.

In a preferred embodiment, the A-HFAP is in a concentration of at least 40%, more preferably from about 60 to 100% by weight in at least one region of
15 the core or absorbent member. In a more preferred embodiment, the absorbent member comprises fibrous matrix wherein the A-HFAP is distributed in the fibrous matrix.

Any type of fiber material which is suitable for use in conventional absorbent products can be used in the absorbent core or absorbent member
20 herein. Specific examples of such fiber material include cellulose fibers, improved cellulose fibers, rayon, polypropylene, and polyester fibers such as polyethylene terephthalate (DACRON), hydrophilic nylon (HYDROFIL), and the like. Examples of other fiber materials for use in the present invention include hydrophilized hydrophobic fibers, such as surfactant-treated or silica-treated
25 thermoplastic fibers derived, for example, from polyolefins such as polyethylene or polypropylene, polyacrylics, polyamides, polystyrenes, polyurethanes and the like. In fact, hydrophilized hydrophobic fibers which are in and of themselves not very absorbent and which, therefore, do not provide webs of sufficient absorbent capacity to be useful in conventional absorbent structures, are suitable for use in
30 the absorbent core by virtue of their good wicking properties. This is because, in the absorbent core herein, the wicking propensity of the fibers is as important, if not more important, than the absorbent capacity of the fiber material itself due to the high rate of fluid uptake and lack of gel blocking properties of the absorbent core. Synthetic fibers are generally preferred for use herein as the fiber

component of the absorbent core. Most preferred are polyolefin fibers, preferably polyethylene fibers.

Other cellulosic fiber materials which can be useful in certain absorbent cores or absorbent members herein are chemically stiffened cellulosic fibers.

5 Preferred chemically stiffened cellulosic fibers are the stiffened, twisted, curled cellulosic fibers which can be produced by internally crosslinking cellulose fibers with a crosslinking agent. Suitable stiffened, twisted, curled cellulose fibers useful as the hydrophilic fiber material herein are described in greater detail in U.S. Patent 4,888,093 (Dean et al), issued December 19, 1989; U.S. Patent
10 4,889,595 (Herron et al), issued December 26, 1989; U.S. Patent 4,889,596 (Schoggen et al), issued December 26, 1989; U.S. Patent 4,889,597 (Bourbon et al), issued December 26, 1989; and U.S. Patent 4,898,647 (Moore et al), issued February 6, 1990.

A preferred embodiment of the disposable absorbent article is a diaper.
15 As used herein, the term "diaper" refers to a garment generally worn by infants and incontinent persons that is worn about the lower torso of the wearer. A preferred diaper configuration for a diaper comprising an absorbent core is described generally in U.S. Patent 3,860,003 (Buell), issued January 14, 1975. Alternatively preferred configurations for disposable diapers herein are also
20 disclosed in U.S. Patent 4,808,178 (Aziz et al), issued February 28, 1989; U.S. Patent 4,695,278 (Lawson), issued September 22, 1987; U.S. Patent 4,816,025 (Foreman), issued March 28, 1989; and U.S. Patent 5,151,092 (Buell et al.), issued September 29, 1992.

A preferred embodiment of an absorbent article of the present invention is
25 the unitary disposable absorbent article, diaper 20, shown in Figure 1. Figure 1 is a plan view of the diaper 20 of the present invention in its flat-out, uncontracted state (i.e., with elastic induced contraction pulled out) with portions of the structure being cut-away to more clearly show the construction of the diaper 20 and with the portion of the diaper 20 which faces the wearer, the inner surface
30 40, facing the viewer. As shown in Figure 1, the diaper 20 preferably comprises a containment assembly 22 comprising a liquid pervious topsheet 24; a liquid impervious backsheet 26 joined to the topsheet; and an absorbent core 28 positioned between the topsheet 24 and the backsheet 26. The absorbent core 28 has a pair of opposing longitudinal edges 60, an inner surface 62 and an outer
35 surface 64. The diaper preferably further comprises side panels 30; elasticized

leg cuffs 32; elasticized waistbands 34; and a fastening system 36 preferably comprising a pair of securement members 37 and a landing member 38.

The diaper 20 is shown in Figure 1 to have an inner surface 40 (facing the viewer in Figure 1), an outer surface 42 opposed to the inner surface 40, a rear waist region 44, a front waist region 46 opposed to the rear waist region 44, a crotch region 48 positioned between the rear waist region 44 and the front waist region 46, and a periphery which is defined by the outer perimeter or edges of the diaper 20 in which the side edges are designated 50 and the end edges are designated 52. The inner surface 40 of the diaper 20 comprises that portion of the diaper 20 which is positioned adjacent to the wearer's body during use (*i.e.*, the inner surface 40 generally is formed by at least a portion of the topsheet 24 and other components joined to the topsheet 24). The outer surface 42 comprises that portion of the diaper 20 which is positioned away from the wearer's body (*i.e.*, the outer surface 42 is generally formed by at least a portion of the backsheet 26 and other components joined to the backsheet 26). As used herein, the term "joined" encompasses configurations whereby an element is directly secured to the other element by affixing the element directly to the other element, and configurations whereby the element is indirectly secured to the other element by affixing the element to intermediate member(s) which in turn are affixed to the other element. The rear waist region 44 and the front waist region 46 extend from the end edges 52 of the periphery to the crotch region 48.

The diaper 20 also has two centerlines, a longitudinal centerline 100 and a transverse centerline 110. The term "longitudinal", as used herein, refers to a line, axis, or direction in the plane of the diaper 20 that is generally aligned with (*e.g.* approximately parallel with) a vertical plane which bisects a standing wearer into left and right halves when the diaper 20 is worn. The terms "transverse" and "lateral", as used herein, are interchangeable and refer to a line, axis or direction which lies within the plane of the diaper that is generally perpendicular to the longitudinal direction (which divides the wearer into front and back body halves).

The containment assembly 22 of the diaper 20 is shown in Figure 1 as comprising the main body (chassis) of the diaper 20. The containment assembly 22 preferably comprises a topsheet 24, a backsheet 26 and an absorbent core 28 having a pair of opposing longitudinal edges 60, an inner surface 62, an outer surface 64. The inner surface 62 generally faces the body of the wearer while the outer surface 64 generally faces away from the body of the wearer. When

the absorbent article comprises a separate holder and a liner, the containment assembly 22 generally comprises the holder and the liner (*i.e.*, the containment assembly 22 comprises one or more layers of material to define the holder while the liner comprises an absorbent composite such as a topsheet, a backsheet, and an absorbent core.) For unitary absorbent articles, the containment assembly 22 preferably comprises the topsheet 24, the backsheet 26 and the absorbent core 28 of the diaper with other features added to form the composite diaper structure.

Figure 1 shows a preferred embodiment of the containment assembly 22 in which the topsheet 24 and the backsheet 26 have length and width dimensions generally larger than those of the absorbent core 28. The topsheet 24 and the backsheet 26 extend beyond the edges of the absorbent core 28 to thereby form the periphery of the diaper 20. While the topsheet 24, the backsheet 26, and the absorbent core 28 may be assembled in a variety of well known configurations, exemplary containment assembly configurations are described generally in U.S. Patent 3,860,003 entitled "Contractible Side Portions for Disposable Diaper" which issued to Kenneth B. Buell on January 14, 1975; and U.S. Patent 5,151,092 entitled "Absorbent Article With Dynamic Elastic Waist Feature Having A Predisposed Resilient Flexural Hinge" which issued to Kenneth B. Buell et al., on September 29, 1992; each of which is incorporated herein by reference.

The absorbent core 28 may be any absorbent member which is generally compressible, conformable, non-irritating to the wearer's skin, and capable of absorbing and retaining liquids such as urine and other certain body exudates. As shown in Figure 1, the absorbent core 28 has a garment-facing side, a body-facing side, a pair of side edges, and a pair of waist edges. The absorbent core 28 may be manufactured in a wide variety of sizes and shapes (*e.g.*, rectangular, hourglass, "T"-shaped, asymmetric, etc.) and, in addition to including an A-HFAP of the present invention, may also include a wide variety of liquid-absorbent materials commonly used in disposable diapers and other absorbent articles such as comminuted wood pulp which is generally referred to as airlaid. Examples of other suitable absorbent materials include creped cellulose wadding; meltblown polymers including coform; chemically stiffened, modified or cross-linked cellulosic fibers; tissue including tissue wraps and tissue laminates; absorbent foams; absorbent sponges; superabsorbent polymers; absorbent gelling materials; or any equivalent material or combinations of materials.

The configuration and construction of the absorbent core 28 may vary (e.g., the absorbent core may have varying caliper zones, a hydrophilic gradient, a superabsorbent gradient, or lower average density and lower average basis weight acquisition zones; or may comprise one or more layers or structures).

5 Further, the size and absorbent capacity of the absorbent core 28 may also be varied to accommodate wearers ranging from infants through adults. However, the total absorbent capacity of the absorbent core 28 should be compatible with the design loading and the intended use of the diaper 20.

One embodiment of the diaper 20 has an asymmetric, modified T-shaped
10 absorbent core 28 having ears in the front waist region but a generally rectangular shape in the rear waist region. Exemplary absorbent structures for use as the absorbent core 28 of the present invention that have achieved wide acceptance and commercial success are described in U.S. Patent 4,610,678 entitled "High-Density Absorbent Structures" issued to Weisman et al. on
15 September 9, 1986; U.S. Patent 4,673,402 entitled "Absorbent Articles With Dual-Layered Cores" issued to Weisman et al. on June 16, 1987; U.S. Patent 4,888,231 entitled "Absorbent Core Having A Dusting Layer" issued to Angstadt on December 19, 1989; and U.S. Patent 4,834,735, entitled "High Density Absorbent Members Having Lower Density and Lower Basis Weight Acquisition
20 Zones", issued to Alemany et al. on May 30, 1989. The absorbent core may further comprise the dual core system containing an acquisition/distribution core of chemically stiffened fibers positioned over an absorbent storage core as detailed in U.S. Patent 5,234,423, entitled "Absorbent Article With Elastic Waist Feature and Enhanced Absorbency" issued to Alemany et al., on August 10,
25 1993; and in U.S. Patent 5,147,345, entitled "High Efficiency Absorbent Articles For Incontinence Management" issued to Young, LaVon and Taylor on September 15, 1992.

The topsheet 24 is preferably positioned adjacent the inner surface 62 of the absorbent core 28 and is preferably joined thereto and to the backsheet 26 by
30 attachment means (not shown) such as those well known in the art. Suitable attachment means are described with respect to joining the backsheet 26 to the absorbent core 28. In a preferred embodiment of the present invention, the topsheet 24 and the backsheet 26 are joined directly to each other in the diaper periphery and are indirectly joined together by directly joining them to the
35 absorbent core 28 by any suitable attachment means.

The topsheet 24 is preferably compliant, soft feeling, and non-irritating to the wearer's skin. Further, the topsheet 24 is preferably liquid pervious permitting liquids (e.g., urine) to readily penetrate through its thickness. A suitable topsheet 24 may be manufactured from a wide range of materials such as woven and nonwoven materials; polymeric materials such as apertured formed thermoplastic films, apertured plastic films, and hydroformed thermoplastic films; porous foams; reticulated foams; reticulated thermoplastic films; and thermoplastic scrims. Suitable woven and nonwoven materials can be comprised of natural fibers (e.g., wood or cotton fibers), synthetic fibers (e.g., polymeric fibers such as polyester, polypropylene, or polyethylene fibers) or from a combination of natural and synthetic fibers. The topsheet 24 is preferably made of a hydrophobic material to isolate the wearer's skin from liquids which have passed through the topsheet 24 and are contained in the absorbent core 28 (*i.e.* to prevent rewet). If the topsheet 24 is made of a hydrophobic material, at least the upper surface of the topsheet 24 is treated to be hydrophilic so that liquids will transfer through the topsheet more rapidly. This diminishes the likelihood that body exudates will flow off the topsheet 24 rather than being drawn through the topsheet 24 and being absorbed by the absorbent core 28. The topsheet 24 can be rendered hydrophilic by treating it with a surfactant. Suitable methods for treating the topsheet 24 with a surfactant include spraying the topsheet 24 material with the surfactant and immersing the material into the surfactant. A more detailed discussion of such a treatment and hydrophilicity is contained in U.S. Patents 4,988,344 entitled "Absorbent Articles with Multiple Layer Absorbent Layers" issued to Reising, et al on January 29, 1991 and U.S. Patent 4,988,345 entitled "Absorbent Articles with Rapid Acquiring Absorbent Cores" issued to Reising on January 29, 1991.

An alternative preferred topsheet comprises an apertured formed film. Apertured formed films are preferred for the topsheet because they are pervious to body exudates and yet non-absorbent and have a reduced tendency to allow liquids to pass back through and rewet the wearer's skin. Thus, the surface of the formed film which is in contact with the body remains dry, thereby reducing body soiling and creating a more comfortable feel for the wearer. Suitable formed films are described in U.S. Patent 3,929,135, entitled "Absorptive Structures Having Tapered Capillaries", which issued to Thompson on December 30, 1975; U.S. Patent 4,324,246 entitled "Disposable Absorbent Article Having A Stain Resistant Topsheet", which issued to Mullane, et al. on April 13, 1982; U.S.

Patent 4,342,314 entitled "Resilient Plastic Web Exhibiting Fiber-Like Properties", which issued to Radel. et al. on August 3, 1982; U.S. Patent 4,463,045 entitled "Macroscopically Expanded Three-Dimensional Plastic Web Exhibiting Non-Glossy Visible Surface and Cloth-Like Tactile Impression", which issued to Ahr et al. on July 31, 1984; and U.S. 5,006,394 "Multilayer Polymeric Film" issued to Baird on April 9, 1991.

The backsheet 26 of the present invention is that portion of the diaper 20 which is generally positioned away from the wearer's skin and which prevents the exudates absorbed and contained in the absorbent core 28 from wetting articles which contact the diaper 20 such as bedsheets and undergarments. Thus, the backsheet 26 is preferably impervious to liquids (e.g., urine) and is preferably manufactured from a thin plastic film, although other flexible liquid impervious materials may also be used. (As used herein, the term "flexible" refers to materials which are compliant and will readily conform to the general shape and contours of the human body.) However, the backsheet 26 permits vapors to escape from the diaper 20. A suitable material for the backsheet 26 is a thermoplastic film having a thickness of from about 0.012 mm (0.5 mil) to about 0.051 mm (2.0 mils), preferably comprising polyethylene or polypropylene.

The backsheet 26 of the present invention may comprise a single member such as the film described above, or may comprise a number of materials joined together to form the backsheet 26. For example, the backsheet may have a central region 74 comprising one film or other member and one or more outer regions 76 joined to the central region 74 comprising the same or different films or other materials. In one preferred embodiment, the backsheet 26 comprises a central region 76 comprising a liquid impervious, non-apertured film and two opposing outer regions 76 comprising an air pervious, apertured film. The means by which any portions of such a backsheet are joined may include any means known in the art such as adhesives, heat, pressure, heat and pressure and ultrasonic bonds. Further, the backsheet 26 may comprise any number of layers of material joined together to form a laminate. If the backsheet 26 is a laminate, the layers need not be uniform throughout the backsheet. For example, the central region 74 of the backsheet 26 may comprise more layers or layers of different material than the outer regions 76.

The backsheet 26 is preferably positioned adjacent the outer surface 64 of the absorbent core 28 and is preferably joined thereto by any suitable attachment

means known in the art. For example, the backsheet 26 may be secured to the absorbent core 28 by a uniform continuous layer of adhesive, a patterned layer of adhesive, or an array of separate lines, spirals, or spots of adhesive. Adhesives which have been found to be satisfactory are manufactured by H. B. Fuller Company of St. Paul, Minnesota and marketed as HL-1258. An example of a suitable attachment means comprising an open pattern network of filaments of adhesive is disclosed in U.S. Patent 4,573,986 entitled "Disposable Waste-Containment Garment", which issued to Minetola et al. on March 4, 1986. Another suitable attachment means comprising several lines of adhesive filaments swirled into a spiral pattern is illustrated by the apparatus and methods shown in U.S. Patent 3,911,173 issued to Sprague, Jr. on October 7, 1975; U.S. Patent 4,785,996 issued to Ziecker, et al. on November 22, 1978; and U.S. Patent 4,842,666 issued to Werenicz on June 27, 1989. Each of these patents are incorporated herein by reference. Alternatively, the attachment means may comprise heat bonds, pressure bonds, ultrasonic bonds, dynamic mechanical bonds, or any other suitable attachment means or combinations of these attachment means as are known in the art.

Embodiments of the present invention are also contemplated wherein the absorbent core is not joined to the backsheet 26, and/or the topsheet 24 in order to provide greater extensibility in the front waist region 46 and the rear waist region 44. Alternative embodiments are contemplated wherein an additional member, such as a liquid impervious barrier material(s) (not shown), is positioned between the outer surface 64 of the absorbent core 28 and the backsheet 28. Any such barrier member may or may not be joined to the absorbent core 28. Further, the backsheet 26 may or may not be joined to any barrier material(s) that are positioned between the backsheet 26 and the absorbent core 28.

Another preferred embodiment of the disposable absorbent article is a catamenial product. Preferred catamenial products comprise a formed-film, apertured topsheet as disclosed in U.S. Patent 4,285,343 (McNair), issued August 25, 1981; U.S. Patent 4,608,047 (Mattingly), issued August 26, 1986; and U.S. Patent 4,687,478 (Van Tilburg), issued August 18, 1987.

Preferred catamenial products can comprise wings, side flaps, and other structures and elements, as described in co-pending, commonly-assigned U.S. application serial No. 984,071, to Yasuko Morita, entitled "Absorbent Article

Having Elasticized Side Flaps", Attorney Docket No. JA-09RM, filed November 30, 1992.

5 A particularly preferred disposable absorbent article comprising the A-HFAP has a reduced tendency for surface wetness. Such an article facilitates maintaining the antimicrobial away from the user's skin, even after wetting. A disposable absorbent article comprising a backsheet, a topsheet, an acquisition/distribution layer, and an absorbent core; the absorbent core comprising the A-HFAP of the present invention. Such an absorbent article preferably has a total finished product acquisition rate (test method discussed below) greater than or equal to about 1.9 ml/sec at first gush and greater than or equal to about 0.3 ml/sec at fourth gush. The folded stackheight of such an absorbent article is preferably less than about 9.9 mm per pad, more preferably less than about 6 mm. Preferably the topsheet of such a product retains no more than about 0.05 g to about 1 g of fluid as measured by the finished product wetness test (discussed below); more preferably no more than about 0.5 g of fluid; more preferably, no more than about 0.2 g of fluid; more preferably still, no more than about 0.15 g of fluid.

Referring to Figure 2, an exemplary embodiment of such a disposable absorbent article in the form of a diaper is provided. Figure 2 is a cross-sectional view of such an embodiment of the disposable diaper of Figure 1, taken along transverse center line 110 of Figure 1. This view shows fragmentary cross-sectional views of the backsheet 26, core cover 22, absorbent core 28, topsheet 24, and elasticized leg cuffs 32. This embodiment differs from that shown in Figure 1, in that an additional element, acquisition/distribution layer 105 has been added.

Figure 3 is an enlarged view of an alternative embodiment of the disposable diaper of Figure 1, the view corresponding to a portion of Figure 2. In this embodiment, topsheet 24 comprises first topsheet layer 115 and second topsheet layer 120. First topsheet layer 115 and second topsheet layer 120 are preferably heat bonded together. Acquisition/distribution layer 105 comprises a first acquisition/distribution layer 125 and a second acquisition/distribution layer 130. First acquisition/distribution layer 125 is preferably spiral glue bonded to second topsheet layer 120. Preferably first acquisition/distribution layer 125 and second acquisition/distribution layer 130 are not bonded together.

Either embodiment set forth in Figure 2 or Figure 3 provides reduced tendency for surface wetness; and consequently facilitates maintaining the antimicrobial away from the user's skin, even after wetting. In other words, such an embodiment reduces the chance that liquid, *e.g.*, urine having come in contact with the A-HFAP and now possibly containing antimicrobial, will flow back to the user's skin, bringing the antimicrobial in contact with the user's skin.

Preferred topsheet 24 and acquisition/distribution layer 105 materials for such a reduced surface wetness absorbent article include the following:

Preferred topsheet 24 material is P-8 nonwoven available from Fiberweb North America, Inc. (Simpsonville, South Carolina, U.S.A.). It is a conventional thermobonded carded web of about 20 to 22 g/m². made of polypropylene fibers of about 2.2 dtex and an easily removable surfactant (spin finish), *i.e.*, at a first fluid insult, it is very hydrophilic, but at repeated wetting it is essentially as hydrophobic as the base polypropylene.

More preferably, the topsheet 24 material is S-2355, available from Havix Co., Japan. This is a bi-layer composite material, and made of two kinds of synthetic surfactant treated bicomponent fibers by using carding and air-through technologies. First topsheet layer 115 is preferably a polypropylene/polypropylene bicomponent fiber, *e.g.*, a lower melting temperature polypropylene in sheath and a higher melting temperature polypropylene in the core of the fiber. Second topsheet layer 120 is preferably a polyethylene/polyethylene telephthalate bicomponent fiber, *e.g.*, a lower melting temperature polyethylene in the sheath and a higher melting temperature and more resilient polyethylene telephthalate in the core of the fiber. The first topsheet layer 115 preferably has a weak hydrophilic surfactant and the second topsheet layer preferably has a normal hydrophilic surfactant. The total basis weight of a typical material is about 20 to 22 g/m².

Preferably the acquisition/distribution layer 105 comprises carded, resin bonded hioft nonwoven materials such as, for example, FT-6860, available from Polymer Group, Inc., North America (Landisville, New Jersey, U.S.A.). They are made of polyethylene telephthalate fibers of 6 dtex, and has a basis weight of about 43 g/m². Alternatively, acquisition/distribution layer 105 comprises chemically treated stiffened cellulosic fiber material, available from Weyerhaeuser Co. (United States) under the trade designation of CMC. In another preferred embodiment, the acquisition/distribution layer 105 comprises conventional

cellulosic fluff material, also known as wood pulp fiber, available from Weyerhaeuser Co. (United States) under the trade name FLINT RIVER.

It should be further understood that the present invention is also applicable to other absorbent articles known commercially by other names, such as incontinent briefs, adult incontinent products, training pants, diaper inserts, facial tissues, paper towels, and the like.

Test Methods

a. General

All tests are carried out at about 23 +/- 2°C and at about 50 +/- 10% relative humidity

Unless specified explicitly, the specific synthetic urine used in the test methods is commonly known as JAYCO SYNURINE and is available from Jayco Pharmaceuticals Company of Camp Hill, Pennsylvania. The formula for the synthetic urine is: 20g/l of KCl, 2.0 g/l of Na₂SO₄, 0.85 g/l of (NH₄)H₂PO₄; 0.15 g/l (NH₄)₂HPO₄, 0.19 g/l of CaCl₂, and 0.23 g/l of MgCl₂. All of the chemicals are of reagent grade. The pH of the synthetic urine is in the range of from about 6.0 to about 6.4.

b. Finished Product Acquisition Test

Referring to Figure 4, an absorbent structure 10 is loaded with a 75 ml gush of synthetic urine at a rate of 15 ml/s using a pump (Model 7520-00, supplied by Cole Parmer Instruments, Chicago, U.S.A.), from a height of 5 cm above the sample surface. The time to absorb the urine is recorded by a timer. The gush is repeated every 5 minutes at precisely 5 minute gush intervals until the article is sufficiently loaded. Current test data are generated by loading four forms.

The test sample, which comprises an absorbent core and includes a topsheet and a backsheet, is arranged to lie flat on a foam platform 11 within a perspex box (only base 12 of which is shown). A perspex plate 13 having a 5 cm diameter opening substantially in its middle is placed on top of the sample. Synthetic urine is introduced to the sample through a cylinder 14 fitted, and glued into the opening. Electrodes 15 are located on the lowest surface of the plate, in contact with the surface of the absorbent structure 10. The electrodes are connected to the timer. Loads 16 are placed on top of the plate to simulate, for example, a baby's weight. A pressure of 50 g/cm² is typically utilized for this test.

As test fluid is introduced into the cylinder it typically builds up on top of the absorbent structure thereby completing an electrical circuit between the electrodes. This starts the timer. The timer is stopped when the absorbent structure has absorbed the gush of urine, and the electrical contact between the electrodes is broken.

The acquisition rate is defined as the gush volume absorbed (ml) per unit time (seconds). The acquisition rate is calculated for each gush introduced into the sample. Of particular interest in view of the current invention are the first and the last of the four gushes.

This test is primarily designed to evaluate products having an absorbent capacity of about 300 ml to about 400 ml. If products with significantly different capacities should be evaluated, the settings in particular of the fluid volume per gush should be adjusted appropriately to about 20% of the theoretical capacity, and the deviations should be recorded.

c. Finished Product Wetness Test

A disposable absorbent article is placed on the apparatus set forth in Figure 4, as discussed under the finished product acquisition test, above, with the following differences. 225 ml of synthetic urine is loaded into the absorbent article sample. The load occurs via 3 gushes, of 75 ml each, at 3 min. intervals. No additional pressure is applied, other than any negligible pressure that may come from the perspex plate.

Following completion of 225 ml of synthetic urine loading, the perspex plate is removed. Two pieces of filter paper (supplied by Hollingsworth & Vose, United Kingdom, of the type ERT FF3.W/S), having dimensions of 12 cm by 12 cm, are weighed, and then placed on the urine loaded diaper. A load of 2 kg over a 10 cm by 10 cm area is applied to the filter paper (*i.e.*, 0.28 psi) for 2 minutes. The filter paper is removed and weighed a second time. The diaper rewet value is defined as the increase in weight (g) of the filter paper.

d. In Bag Stack Height

Essentially, the in bag stack height is measured by measuring the height of a stack of absorbent products as it is packed into cartons or bags as supplied to the market, and dividing the height by the number of articles in this stack.

It either can be measured by taking one of the bags and carrying out the measurement, or by simulating the pressure of a packed bag in a suitable device

(such as a stress-strain measurement device such as provided by INSTRON Instruments).

This test has primarily been developed for "bi-folded" products, i.e., products which have only one folding line in the cross (width) direction of the article at about the middle part of the article, such that the front and rear part of the article overlay in the bag. For non-folded or tri-folded products (with three layers overlying), the results need to be corrected accordingly.

e. Basis Weight

Basis weights are often referred to for various materials. These can be generated by essentially dividing the weight of a specimen by the area of it. The size of the area as well as the number of rewired replicates depend on the homogeneity of the specimen.

f. Hydrophilicity / Hydrophobicity

Hydrophilicity (and hence, wettability) are typically defined in terms of contact angle and the surface tension of the fluids and solids involved. This is discussed in detail in, e.g., the American Chemical Society publication entitled "Contact Angle, Wettability and Adhesion", edited by R.F. Gould (copyright 1964). In the context of the current invention, materials can be categorized into three groups:

Materials which are "highly hydrophilic" (abbreviated "h+"): These generally have a contact angle of less than about 80 degrees. Examples include cellulosic fibers and olefinic polymers when they are treated with an effective and strong surfactant (at least when exposed the first time to wetting).

Materials which are "essentially hydrophobic" (abbreviated "h-"): These generally have a contact angle of more than about 100 degrees. Examples include pure olefines (polyethylene/polypropylene) without surfactants (neither at the surface, nor resin incorporated).

Materials which are "moderately hydrophilic" (abbreviated "ho"): These have a contact angle of about 90 degrees. Examples include polypropylene/polyethylene with less effective resin incorporated surfactants, and other less hydrophilic surfactants applied to the surface of such olefins.

The following examples further describe and demonstrate the preferred embodiments within the scope of the present invention. The examples are given solely for the purpose of illustration, and are not to be construed as limitations of

the present invention since many variations thereof are possible without departing from its spirit and scope.

Example 1

5 This example shows how to manufacture a HFAP for use in the present invention.

4,000 parts of an aqueous solution of 37% acrylic monomer composed of 74.95 mol% of sodium acrylate, 25 mol% of acrylic acid, and 0.05 mol% of trimethylolpropane triacrylate is polymerized by being stirred with 2.0 parts of sodium persulfate and 0.08 part of 1-ascorbic acid, to produce a gel hydrated
10 polymer finely divided in a particle diameter of about 5 mm. The gel hydrated polymer is dried with a hot air dryer at 150°C, pulverized with a hammer type pulverizing device, and sifted with a 20-mesh metallic gauze to separate a 20-mesh pass powder as an absorbent polymer A (having an average particle diameter of about 350 microns).

15 By mixing 100 parts of the absorbent polymer A with 0.5 part of glycerol, 2 parts of water, and 2 parts of ethyl alcohol and then heat treating the resultant mixture at 210°C, an absorbent polymer B having the surface region thereof secondarily cross-linked is obtained.

Example 2

20 This example shows how to manufacture an A-HFAP of the present invention.

10 g of benzalkonium chloride (available, e.g., from Wako Chemical (Osaka, Japan) is dissolved into 100 ml of distilled ionized water. After complete dissolution, the solution is introduced to an air tank which is connected to a spray
25 nozzle and air pump. 500g of the absorbent polymer B from Example 1 is evenly placed on a stainless steel plate to form thin layers of ca. 3 mm thickness. 25 g of the benzalkonium chloride aqueous solution is sprayed onto the 500 g of absorbent polymer B particles at room temperature. The particles are then placed into a food mixer and agitated for 15 minutes. The benzalkonium
30 chloride-coated absorbent polymer B particles are subsequently subjected to drying at 95°C in a dynamic oven for one hour, or through hot air drying for 10 minutes to reduce the moisture level to less than 1% of the absorbent polymer B particles. The dry particles are gently ground into granules of equal or less than 800 µm in size, resulting in nominal production of polymer dust. The resulting
35 particles contain 0.5% benzalkonium chloride.

Example 3

This example shows how to manufacture another embodiment of an A-HFAP of the present invention.

5 In this case, the same procedure as in Example 2 is followed, except that the absorbent polymer B is replaced with Aqualic CA-L76 (a cross-linked sodium polyacrylate; available from Nippon Shokubai Co. Ltd, Osaka, Japan). The process results in nominal production of polymer dust, following coating with the benzalkonium chloride.

Example 4

10 This example shows the an absorbent core comprising an A-HFAP of the present invention, for use in a disposable absorbent article.

Wood pulp of Southern Pine is disintegrated and opened in an air flowing chamber. Fibers having an average length of about 3 mm are allowed to fall on a vacuum plate. During the fiber laydown procedure, the A-HFAP of Example 3 is
15 sprinkled into the wood pulp fibers. A core containing 230 to 400 g/m² of wood pulp fibers and 160 to 360 g/m² of the A-HFAP is formed. The core is suitable for use in infant and/or adult incontinent diaper applications. A typical composition of an L-size infant diaper application is as follows:

	Component	Weight (gm)	Percent (wt)
20	Wood pulp fiber	15	55
	Hydrogel-forming absorbent polymer	12	44
	Antimicrobial	0.024	0.09

Example 5

25 This example shows a disposable baby diaper comprising an A-HFAP of the present invention.

The dimensions listed are for a diaper intended for use with a child in the 6-10 kilogram size range. These dimensions can be modified proportionately for different size children, or for adult incontinence briefs, according to standard practice.

30 1. Backsheet 0.020-0.038 mm fluid-impermeable film manufactured per U.S. Patent No. 4,687,478; width at top and bottom 33cm; notched inwardly on both sides to a width-at-center of 28.5 cm; length 50.2 cm.

2. Topsheet: carded and thermally bonded staple-length polypropylene fibers (Hercules type 151 polypropylene); width at top and bottom

33 cm; notched inwardly on both sides to a width-at-center of 28.5 cm; length 50.2 cm.

3. Absorbent core: comprises 28.6 g of cellulose wood pulp and 4.9 g of the A-HFAP of Example 3; 8.4 mm thick, calendered; width at top and bottom 28.6 cm; notched inwardly at both sides to a width-at-center of 10.2 cm; length 44.5 cm.

4. Elastic leg bands: four individual rubber strips (2 per side); width 4.77 mm; length 370 mm; thickness 0.178 mm (all the foregoing dimensions being in the relaxed state).

10 The diaper is prepared in standard fashion by positioning the core material covered with the topsheet on the backsheet and gluing.

The elastic bands (designated "inner" and "outer", corresponding to the bands closest to, and farthest from, the core, respectively) are stretched to ca. 50.2 cm and positioned between the topsheet/backsheet along each longitudinal side (2 bands per side) of the core. The inner bands along each side are positioned ca. 55 mm from the narrowest width of the core (measured from the inner edge of the elastic band). this provides a spacing element along each side of the diaper comprising the flexible topsheet/backsheet material between the inner elastic and the curved edge of the core. The inner bands are glued down along their length in the stretched state. The topsheet/backsheet assembly is flexible, and the glued-down bands contract to elasticize the sides of the diaper.

The resulting diaper provides combined fluid adsorption and antimicrobial properties.

Example 6

25 This example shows an adult incontinent product comprising an A-HFAP of the present invention.

Following the preparation procedures of Example 4, a heavy weight core is formed having 24 to 40 g of wood pulp fiber and 10 to 20 g of the A-HFAP. The core is subsequently interposed between a fluid-impermeable poly backsheet and a fluid-permeable topsheet to form an adult incontinent product.

Example 7

This example shows a light weight pantiliner product comprising an A-HFAP of the present invention.

35 A light weight pantiliner suitable for use between menstrual periods comprises a pad. The pad has a surface area 117 cm²; and contains 3 g of

wood pulp fiber and 1.5 g A-HFAP of Example 3. The pad is subsequently interposed between a porous formed-film topsheet according to U.S. Patent No. 4,463,045 and a fluid-impermeable backsheet is manufactured per U.S. Patent No. 4,687,478, to form a light weight pantiliner product. The resulting pantiliner provides combined fluid adsorption and antimicrobial properties.

Example 8

This example shows a sanitary pad comprising an A-HFAP of the present invention.

A catamenial product in the form of a sanitary napkin having two flaps extending outward from its absorbent core is prepared per the design of U.S. Patent No. 4,687,478, Van Tillburg, issued Aug. 18, 1987. However, the pad utilized has a surface area of 117 cm²; and containing 6 to 12 g of wood pulp fiber and 1 to 3 g of the A-HFAP of Example 2. The fluid-permeable topsheet is manufactured per U.S. Patent No. 4,463,045. The fluid-impermeable backsheet is manufactured per U.S. Patent No. 4,687,478. The resulting sanitary pad provides combined fluid adsorption and antimicrobial properties.

The aspects and embodiments of the present invention set forth in this document have many surprising advantages, including improved efficacy and improved processability. For example, by coating the surface area of the HFAP with the antimicrobial, rather than incorporating the antimicrobial within the HFAP, the antimicrobial will act immediately upon fluid entering the absorbent core. In contrast, if the antimicrobial were incorporated within the HFAP, its efficacy would be delayed until the HFAP began swelling with the fluid.

In addition, the coating of HFAP with, e.g., the antimicrobial, results in reducing the release of HFAP dust particles into the air. This reduction of HFAP dust particles produces a safer environment for workers, less downtime spent cleaning processing equipment, and prevention of loss of material.

All publications, patent applications, and issued patents mentioned hereinabove are hereby incorporated in their entirety by reference.

It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to one skilled in the art and are to be included in the spirit and purview of this application and scope of the appended claims.

WHAT IS CLAIMED IS:

1. An antimicrobial hydrogel-forming absorbent polymer comprising:
 - a) a hydrogel-forming absorbent polymer, and
 - b) an antimicrobial;

wherein the hydrogel-forming absorbent polymer is coated with the antimicrobial.

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2. The antimicrobial hydrogel-forming absorbent polymer of Claim 1, wherein the antimicrobial is benzalkonium chloride or chlorhexidine.
3. The antimicrobial hydrogel-forming absorbent polymer of Claim 2, wherein the antimicrobial is benzalkonium chloride.
4. The antimicrobial hydrogel-forming absorbent polymer of Claim 1, wherein the ratio of antimicrobial to polymer is from about 100:0.01 to about 100:2.
5. A process for making an antimicrobial hydrogel-forming absorbent polymer, the process comprising coating a hydrogel-forming absorbent polymer with an antimicrobial.
6. The process of Claim 5, wherein the antimicrobial is benzalkonium chloride.
7. An antimicrobial hydrogel-forming absorbent polymer produced by the process of Claim 5.
8. A disposable absorbent article comprising the antimicrobial hydrogel-forming absorbent polymer of Claim 1.
9. A disposable diaper comprising the antimicrobial hydrogel-forming absorbent polymer of Claim 1.
10. A disposable absorbent article comprising:
 - a) a backsheet;
 - b) a topsheet;
 - c) an acquisition/distribution layer; and



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- 5 c) an absorbent core comprising the antimicrobial hydrogel-forming
 absorbent polymer of Claim 1;
 wherein the absorbent article has a finished product acquisition rate greater than
 or equal to about 1.9 ml/sec at first gush and greater than or equal to about 0.3
 ml/sec at fourth gush, and a folded stackheight of less than about 9.9 mm per
10 pad; and wherein the topsheet retains no more than about 0.5 g to about 1 g of
 fluid as measured by the finished product wetness test.

