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(54) **Title:** AQUEOUS DISPERSIONS FOR USE AS COATINGS WITH VARIABLE WATER VAPOR PERMEANCE RATINGS

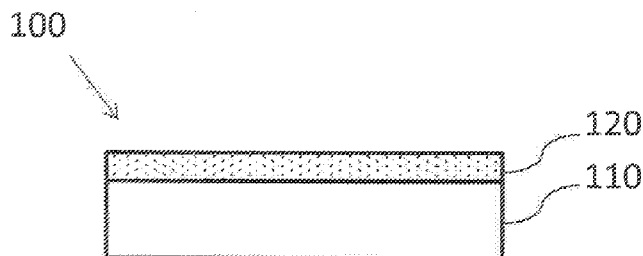


FIG. 1A

(57) **Abstract:** Certain embodiments described herein are directed articles that include a cellulosic substrate (or a non-cellulosic substrate) and an aqueous dispersion disposed on the substrate. In certain examples, the dispersion is effective to provide a water vapor perm rating of about 2 perms or less at 25% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH as tested by ASTM E96, when the dispersion is cured as a coating on the substrate. In some embodiments, the substrate can be (or can be part of) a building substrate such as, for example, kraft paper placed on insulation (e.g., fiberglass insulation) or oriented strand board. In some instances, the aqueous dispersion can include a plant oil macromonomer or a waterborne epoxy resin.



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**AQUEOUS DISPERSIONS FOR USE AS COATINGS  
WITH VARIABLE WATER VAPOR PERMEANCE RATINGS**

**TECHNOLOGICAL FIELD**

5           This application is related to aqueous dispersions that are effective for use as coatings. More particularly, certain embodiments described herein are directed to aqueous dispersions effective to provide a coating on a substrate to have variable water vapor permeance values as a function of relative humidity (RH).

10           Building materials can include films or facing materials attached to them to provide desired physical properties for insulation.

          In many instances of manufacture, the facing materials used are kraft paper with an asphalt or bituminous coating and other polymeric materials to provide both support for the underlying fibers and to provide a liquid water and/or water vapor retarder.

15           A smart vapor retarder can be used as sheeting for covering insulation materials installed in wall and ceiling cavities. A build-up of excess moisture in the insulation is avoided by allowing the excess moisture to escape by vapor diffusion through the film thickness of the vapor retarder. A smart vapor retarder is a coating or film formed by a material, a polyamide, for example, that changes its water moisture vapor permeability in direct relationship with increases and/or decreases of the ambient humidity conditions. This  
20           transformation allows drying to occur through the process of vapor diffusion, thereby improving the speed of drying of the insulation and building materials. The film allows trapped moisture to escape, thereby alleviating a consequent formation of mold and water damage typically resulting from excess trapped moisture

          For example, U.S. Patent Application Publication No. 2004/0103603, which is  
25           incorporated by reference herein, describes the attachment of a vapor retarder, such as polyamide films, to insulation or other building materials such as gypsum board, particle board, etc. This vapor retarder imparts a water vapor diffusion resistance, permeance and/or transmission which depend on the ambient humidity.

30           One disadvantage of a smart vapor retarder is that the material cost may be higher than a conventional vapor retarder. For example, a polyamide material cost may be approximately three times the material cost of an inexpensive water vapor retarder material, such as, polyethylene. The higher material cost is a disincentive for the construction industry to use a smart vapor retarder, instead of using a less costly, vapor barrier film of polyethylene having little water vapor diffusion properties. Accordingly, it would be advantageous for a

smart vapor retarder to have a reduced material content, which would reduce the material cost, and serve as an incentive for the construction industry to use a smart vapor retarder. One additional disadvantage is in the use of polyethylene. Polyethylene is a commonly used vapor retarder in the insulation industry, with a very low, but constant permeability that does not allow for moisture transfer under varying levels of humidity. However, for efficient moisture transfer, heightened permeability is desired at higher humidity.

One further disadvantage is that the precursors of coatings include chemicals that can have a detrimental environmental effect due to high amounts of volatile organic compounds (VOCs). The film or facing material typically includes petroleum products, which can result in substantial off-gassing of volatile organic compounds (VOCs) during preparation and/or use of the material. Other VOCs can be co-reactants, such as copolymers of sheet material such as disclosed in US 8,852,749, which discloses compositions comprising moisture barriers with variable permeances based on compounds that are synthesized or polymerized from highly volatile comonomers.

## 15 SUMMARY

In some aspects, the aqueous dispersions described herein can be used in place of, or in addition to, petroleum based products. For example, the aqueous dispersions can be used to reduce the release of VOCs in manufacturing processes as well as replace petroleum based products with those made from renewable resources. In addition, the substantial absence of any VOCs provides a more environmentally friendly coating. In other aspects, the aqueous dispersion is substantially free of polyamide, e.g., nylon 6, whereas in other aspects, a polyamide can be included in the aqueous dispersions.

In one aspect, an article comprising a cellulosic substrate and an aqueous dispersion, disposed on the substrate, that is effective to provide a water vapor perm rating as a function of RH of about 2 perms or less at 25% average RH as tested by ASTM D1653, or 1 perm or less at 25% average RH tested by ASTM E96 when the aqueous dispersion is cured as a coating on the cellulosic substrate.

Both methods, ASTM D1653 and ASTM E96 use a desiccant and water procedure (Dry and Wet Cups) to provide a measure of the permeance. The permeance is measured as the time rate of water vapor transmission through a unit area of flat material or construction induced by vapor pressure difference between two major surfaces of the material or construction under specified temperature and humidity conditions. The permeance is quantified in perm, wherein 1 perm is 1 grain of water vapor per hour, per square foot, per inch of mercury difference of water vapor partial pressure above and below the area. ASTM

E96 is typically used in the insulation industry while ASTM D1653 is used for coatings such as paints, varnish, lacquers, etc. Results between the two methods typically correlate when tested under similar conditions.

In some embodiments, the cellulosic substrate can be a building substrate such as, for example, kraft paper placed on insulation (e.g., fiberglass insulation) or oriented strand board. In other embodiments, the substrate can include non-woven sheeting material, gypsum wallboard, or other building substrates.

In certain embodiments, the cured coating can be further effective to provide a water vapor perm rating of less than or equal to 5 perms at 45% average RH as tested by ASTM D1653, or less than 5 perms at 45% average RH as tested by ASTM E96. In other embodiments, the cured coating is further effective to provide a water vapor perm rating of about 12 perms to about 24 perms at 75% average RH as tested by ASTM D1653, or about 6 perms to about 12 perms at 75% average RH as tested by ASTM E96. In some examples, the cured coating is further effective to provide a water vapor perm rating of greater than 25 perms at 95% average RH as tested by ASTM D1653, or greater than 17 perms at 95% average RH as tested by ASTM E96. In certain examples, the aqueous dispersion comprises a plant oil macromonomer dispersion, e.g., a seed oil macromonomer dispersion, a vegetable oil macromonomer dispersion, a seed oil macromonomer emulsion, a vegetable oil macromonomer emulsion, etc. In other embodiments, the dispersion can include a reactant added to the aqueous dispersion. In some examples, the aqueous dispersion comprises a plant oil macromonomer dispersion, e.g., a vegetable oil macromonomer dispersion, and the reactant comprises a free radically polymerized monomer, e.g., a derivatized benzene comprising an unsaturated moiety such as, for example, styrene. In other examples, the aqueous dispersion comprises a waterborne epoxy resin dispersion and the reactant comprises an amine, e.g., an aliphatic amine or a non-aliphatic amine. In some instances, the waterborne epoxy resin dispersion comprises a waterborne solid epoxy resin dispersion, e.g., an aqueous dispersion of the solid epoxy resin, and a nonionic surfactant. In certain embodiments, the aqueous dispersion can include at least one filler, a stain-resistance additive or other additives.

In another aspect, an article comprising a cellulosic substrate and a plant oil macromonomer dispersion disposed on the cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 (or ASTM E96), when the plant oil macromonomer dispersion is cured as a coating on the cellulosic substrate is provided. In some embodiments, the variable water vapor perm rating as tested by ASTM D1653 is about

2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH; or as tested by ASTM E96 is about 2.5 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH. In some embodiments, the dispersion can include one or more of a filler, a flame retardant, a surfactant, a stain-resistance additive, and a biocide. In certain embodiments, the cellulosic substrate can be kraft paper, oriented strand board, gypsum wallboard, or other substrates used in the building industry.

In an additional aspect, an article comprising a cellulosic substrate and a waterborne epoxy resin dispersion, e.g., an aqueous epoxy resin dispersion, disposed on the cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 is about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH; or as tested by ASTM E96 is about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 17 perms at 95% average RH. In some instances, the waterborne epoxy resin is a waterborne solid epoxy resin, e.g., a waterborne solid epoxy resin comprising a diglycidyl ether of bisphenol-A. In other embodiments, one or more reactants, fillers, surfactants, stain-resistance additives, biocide, or other additives can be present in the dispersion. In certain embodiments, the cellulosic substrate can be kraft paper, oriented strand board, gypsum wallboard, or other substrates used in the building industry.

In another aspect, a method of providing a coating that has variable water vapor perm ratings as tested by ASTM D1653 (or ASTM E96), the method comprising disposing an aqueous dispersion on a substrate, and curing the disposed aqueous dispersion on the substrate to provide a coating comprising a variable water vapor perm rating as tested by ASTM D1653 (or ASTM E96) is described. In some embodiments, the variable water perm rating as tested by ASTM D1653 is about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH; or as tested by ASTM E96 is about 1 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 17 perms at 95% average RH.

In certain instances, the method can include co-spraying the aqueous dispersion and a reactant on the substrate. In some embodiments, the method can include adding a reactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate. In additional embodiments, the method can include co-spraying the aqueous dispersion and a surfactant on the substrate. In some examples, the method can include adding a surfactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate. In other embodiments, the method can include co-spraying the aqueous dispersion, a reactant and a surfactant on the substrate. In some examples, the method can include adding a surfactant and a reactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate. In further examples, the method can include rolling the aqueous dispersion onto the substrate. If desired one or more thickening agents, surfactants or other materials can be added to facilitate the rolling process. In some embodiments, the aqueous dispersion can be co-sprayed with a polyamide onto the substrate or a polyamide can be added to the dispersion prior to disposal. In certain examples, one or more biocidal agents can be added to or co-sprayed with the aqueous dispersion.

In another aspect, a kit comprising an aqueous dispersion, a reactant and instructions for using the aqueous dispersion and the reactant is provided. In some embodiments, the reactant is effective to mix with the aqueous dispersion to provide a cured coating on a substrate, in which the cured coating provides a variable water vapor perm rating as tested by ASTM D1653 / E96, in which the cured coating has a water vapor perm rating of about 2 perm or less at 25% average RH as tested by ASTM D1653, or less than 1 perm at 25% average RH as tested by ASTM E96 when the aqueous dispersion is cured as a coating on the substrate.

In certain embodiments, the aqueous dispersion and the reactant of the kit are configured for co-spraying onto the substrate. In some embodiments, the kit can include an aqueous carrier effective to disperse a vegetable oil macromonomer, a waterborne epoxy resin or both. In some instances, the kit may also include one or more of a nonionic surfactant, a biocidal agent, a building substrate, and a spraying device.

In another aspect, a method of facilitating use of a building substrate is provided. In some examples, the method comprises providing an aqueous dispersion effective to provide a cured coating on a substrate, in which the cured coating provides a variable water vapor perm rating as tested by ASTM D1653 (or ASTM E96), in which the cured coating has a water vapor perm rating of about 1 perm or less at 25% average RH as tested by ASTM D1653 (or

ASTM E96) when the aqueous dispersion is cured as a coating on the substrate, and providing instructions for using the aqueous dispersion to form the coating.

In certain embodiments, the method comprises providing a reactant for use with the aqueous dispersion to provide the cured coating. In other embodiments, the method  
5 comprises providing one or more of a surfactant, a biocidal agent, a filler and combinations thereof for use with the reactant and the aqueous dispersion to provide the cured coating.

In an additional aspect, a composition effective to provide a cured coating on a substrate, in which the cured coating has a water perm rating as tested by ASTM D1653 is about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH,  
10 is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH; or as tested by ASTM E96 is about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH is described. In some  
15 embodiments, the composition comprises an aqueous dispersion, a surfactant and a reactant effective to react with the dispersed material in the aqueous dispersion to provide the cured coating.

In certain examples, the dispersed material comprises a plant oil macromonomer, e.g., a vegetable oil macromonomer. In other examples, the reactant is a derivatized benzene comprising an unsaturated moiety. In some examples, the dispersed material comprises a  
20 waterborne solid epoxy resin. In further examples, the reactant is an amine, e.g., an aliphatic amine or a non-aliphatic amine. In certain embodiments, the composition can include one or more of a surfactant, a biocidal agent, a filler or other materials.

In other configurations, an article comprising a non-cellulosic substrate, and an aqueous dispersion disposed on the substrate and effective to provide a variable water vapor  
25 perm rating as a function of humidity, in which the water vapor perm rating is about 2 perms or less at 25% average RH as tested by ASTM D1653, or about 1 perm or less at 25% average RH as tested by ASTM E96, when the aqueous dispersion is cured as a coating on the non-cellulosic substrate is provided.

In some aspects, an article comprising a non-cellulosic substrate, and a plant oil  
30 macromonomer dispersion disposed on the non-cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 (or ASTM E96), when the plant oil macromonomer dispersion is cured as a coating on the non-cellulosic substrate is described.



In other aspects, an article comprising a non-cellulosic substrate, and a waterborne epoxy resin dispersion disposed on the non-cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 (or ASTM E96), when the waterborne epoxy resin dispersion is cured as a coating on the non-cellulosic substrate is disclosed.

Additional features, aspects, examples and embodiments are described in more details below.

### **BRIEF DESCRIPTION OF THE FIGURES**

Certain embodiments are described with reference to the accompanying figures in which:

FIGs. 1A and 1B are articles (100) comprising a substrate (110) with a coating (120) disposed thereon or coatings (1202) and (1204) disposed on opposite surfaces;

FIG. 2 is a graph showing water vapor perm values as a function of RH for three test compositions and a nylon 6 control; and

FIG. 3 is a graph showing water perm values for a nylon 6 control and an epoxy resin based coating.

FIGs. 4 and 5 are graphs showing water perm values for samples according to the present disclosure.

It will be recognized by the person of ordinary skill in the art, given the benefit of this disclosure, that certain dimensions or features in the figures may have been enlarged, distorted or shown in an otherwise unconventional or non-proportional manner to provide a more user-friendly version of the figures. Where dimensions or values are specified in the description below, the dimensions or values are provided for illustrative purposes only. Reference to front, back, top and bottom are provided for exemplary purposes and are not limiting.

### **DETAILED DESCRIPT OF THE PREFERRED EMBODIMENT(S)**

Certain embodiments are described below with reference to singular and plural terms in order to provide a user friendly description of the technology disclosed herein. These terms are used for convenience purposes only and are not intended to limit the materials and articles described herein as including or excluding certain features unless otherwise noted as being present in a particular embodiment described herein.

In certain examples, the articles, compositions and methods described herein can provide desirable attributes and physical properties including, for example, variable water vapor permeance ratings (also referred to herein as variable water vapor perm ratings).

Unless otherwise noted, the water vapor permeance ratings described herein are measured according to ASTM D1653, dated 2013, which is also referred to as the “dry cup” method. It should be noted that ASTM E96, Procedure A can also be used instead of ASTM D1653 to determine the water vapor perm ratings. ASTM D1653 and ASTM E96 are similar methodologies except the cup size used in the protocols are different. The particular testing temperature used is specified in the method and may be, for example, 15-40 °C and is typically around 21-23 °C. Reference to a “variable water vapor perm rating” refers to the change in the measured water vapor perm rating at different RH values. A lower water vapor perm rating is indicative of higher resistance to water vapor flow. For example, in some embodiments of the articles and compositions described herein, the water vapor perm rating desirably increases with increasing RH to permit water vapor to pass through more readily, e.g., changes from less than 2 perms at 25% RH to about 25 perms or more at 95% RH as tested by ASTM D1653, or less than 1 perm at 25% RH to about 17 perms or more at 95% RH as tested by ASTM E96. The variability in the water perm ratings need not be linear as a function of RH, and in certain instances, the variability may be logarithmic, exponential or otherwise non-linear over a selected RH range.

In embodiments, the permeance profiles for the foregoing cured coating on a cellulosic substrate, the article comprising a cellulosic substrate and a plant oil macromonomer, the article comprising a cellulosic substrate and a waterborne epoxy, the method of providing a coating composition, the cured coating provided by the kit, the method of facilitating use of a building substrate, or the cured coating obtained from the composition can include any combination of the following permeance values.

As tested by ASTM E96, the permeance is about 2.5 perm or less at 25% average RH, such as 2.3 perm or less, 2.2 perm or less, 2.0 perm or less, 1.8 perm or less, 1.6 perm or less, 1.4 perm or less, 1.2 perm or less, 1.1 perm or less. The permeance is at least 0.02 perm at 25% average RH. The permeance can range from 0.02 perm to 2.5 perms at 25% average RH, such as from 0.5 perm to 2.4 perms, or 0.8 perm to 2.3 perms.

As tested by ASTM E96, the permeance is about 5 perms or less at 45% average RH, such as 4.8 perms or less, 4.5 perms or less, 4.2 perm or less, 4.0 perms or less, 3.8 perms or less, 3.6 perms or less, 3.4 perms or less, 3.2 perms or less. The permeance is at least 1.0 perm at 45% average RH. The permeance can range from 1.0 perm to 5 perms at 45% average RH, such as from 2.0 perms to 4.5 perms, or 2.5 perms to 4.0 perms. In at least one embodiment, the difference between the permeance at 45% average RH and 25% average RH

is at least 0.5 perm, such as at least 0.8 perm, at least 1.0 perm, at least 1.1 perms, or at least 1.2 perms.

As tested by ASTM E96, the permeance is at least 5.5 perms at 75% average RH, such as at least 5.7 perms, at least 6.0 perms, at least 6.5 perms, at least 7.0 perms, at least 7.3 perms, at least 7.5 perms, at least 7.8 perms, or at least 8.0 perms. The permeance is not greater than 12.0 perms at 75% average RH, such as not greater than 11.5 perms, not greater than 11.0 perms, not greater than 10.5 perms, not greater than 10.0 perms, not greater than 9.5 perms, not greater than 9.0 perms, or not greater than 8.5 perms. The permeance can range from 6.0 perms to 12.0 perms at 75% average RH, such as from 6.5 perms to 10.5 perms, or 7.0 perms to 9.0 perms at 75% average RH. In at least one embodiment, the difference between the permeance at 75% average RH and 45% average RH is at least 2 perms, such as at least 3 perms, at least 3.5 perms, at least 3.7 perms, or at least 4 perms. In at least one embodiment, the difference between the permeance at 75% average RH and 25% average RH is at least 3 perms, such as at least 4 perms, at least 4.5 perms, at least 4.7 perms, or at least 5 perms.

As tested by ASTM E96, the permeance is at least 11 perms at 95% average RH, such as at least 12.0 perms, at least 15.0 perms, at least 20.0 perms, at least 21.0 perms, at least 22.0 perms, at least 23.0 perms, at least 25.0 perms, or at least 30.0 perms. The permeance is not greater than 55.0 perms at 95% average RH. The permeance can range from 11.0 perms to 55.0 perms at 95% average RH, such as from 25 perms to 54 perms, or 30 perms to 53 perms at 95% average RH. In at least one embodiment, the difference between the permeance at 95% average RH and 75% average RH is at least 3 perms, such as at least 5 perms, at least 10 perms, at least 15 perms, or at least 20 perms. In at least one embodiment, the difference between the permeance at 95% average RH and 45% average RH is at least 6 perms, such as at least 10 perms, at least 20 perms, at least 22 perms, or at least 25 perms.

The permeance profiles of the cured coatings are non-linear across the range of the average relative humidity. In at least one embodiment, as tested by ASTM E96, the permeance is between 1 perm and 2.5 perms at 25% average RH, between 3.0 perms and 4.0 perms at 45% average RH, between 7.0 perm and 15.0 perms at 75% average RH.

In some examples, the articles described herein can include a coating that is substantially free of polyamides but has water vapor perm ratings similar to those commonly provided by a coating comprising polyamides, e.g., nylon 6, on a substrate. For example, the article can include a cured coating that has substantially the same perm ratings as a function of humidity as the perm ratings provided by a coating comprising a polyamide such as nylon

6 even though the instant coatings may be substantially free of polyamides. In some  
embodiments, the substantially free polyamide coating may have perm ratings within about  
15-25% of the perm rating of a coating comprising nylon 6 at 25% average RH, within about  
15-20% of the perm rating of a coating comprising nylon 6 at 45% average RH, within about  
5 15-20% of the perm rating of a coating comprising nylon 6 at about 75% average RH and  
within about 15-20% of the perm rating of a coating comprising nylon 6 at 95% average  
humidity.

In some embodiments, the coatings provided herein can be present on a cellulosic  
substrate that is part of a building material such as, for example, kraft paper coated fiberglass  
10 insulation, oriented strand board, gypsum wallboard, or other materials commonly used in the  
building industry that permit water vapor to enter or exit a building structure. In another  
embodiment, the substrate can be a woven or a non-woven material. In certain embodiments,  
the articles described herein can include a composition comprising an aqueous dispersion of  
material that can be disposed and/or cured on a surface of a substrate to provide desirable  
15 water vapor perm ratings at different RH values. In certain examples, suitable materials for  
dispersal include those which do not phase separate at a temperature of about 25-40 °C and  
can be generally coated or sprayed onto a substrate in an aqueous carrier, e.g., an aqueous  
carrier that is not considered a strong base or a strong acid, to provide a substantially  
homogeneous cured coating on the substrate. In some examples, the aqueous dispersion may  
20 comprise solid particles suspended in an aqueous carrier. In other examples, the aqueous  
dispersion may comprise an oil that is emulsified or suspended in an aqueous carrier. As  
described herein, to facilitate dispersion of a desired material in an aqueous carrier, it may be  
desirable to include one or more detergents, surfactants, salts or other suitable materials that  
can assist in suspension or emulsification of the materials in the aqueous carrier. During  
25 application of the materials, the aqueous carrier desirably is removed, e.g., through passive  
evaporation, active evaporation (for example, using an air current), wicking, decanting,  
heating or otherwise removal of the aqueous carrier to provide a coating with a variable water  
vapor perm rating on the surface of the substrate. In some instances, the water vapor perm  
rating of the cured coating is about 2 perm or less at 25% average RH as tested by ASTM  
30 D1653, or about 1 perm or less at 25% average RH as tested by ASTM E96, when the  
aqueous dispersion is cured as a coating on the substrate. In other embodiments, the water  
vapor perm rating of the cured coating is less than or equal to 5.0 perms at 45% average RH  
as tested by ASTM D1653, or less than or equal to 2.5 perms at 45% average RH as tested by  
ASTM E96. In additional embodiments, the water vapor perm rating of the cured coating is

about 12 perms to about 24 perms at 75% average RH as tested by ASTM D1653, or about 6 to 12 perms at 75% average RH as tested by ASTM E96. In other examples, the water vapor perm rating of the cured coating is greater than 25 perms at 95% average RH as tested by ASTM D1653, or greater than 17 perms or less at 95% average RH as tested by ASTM E96.

5 Where a coating displays the water vapor perm rating noted above at different RH values, the change in perm rating as humidity increases may, as noted herein, be linear or non-linear. Where cellulosic substrates are used, the substrate may be a woven or non-woven substrate comprising cellulose based materials, e.g., paper or paper fibers, strands, etc. or other cellulose based materials which are present in a non-woven material or are woven together  
10 optionally with non-cellulose materials.

In other instances, the substrate may be a non-cellulosic substrate. Non-cellulosic substrates are substrates that do not include any cellulose based materials. For example, woven and non-woven non-cellulosic substrates may be used with the aqueous dispersions described herein. In some configurations, the non-cellulosic substrate may be comprise a  
15 woven material including one or more fabrics. Where non-woven cellulosic materials are used, the non-woven can be selected, for example, from a polypropylene, a polyethylene, a polystyrene, a polyester, a polyurethane, a fiberglass, a spunbond polymer, and a point-bonded polymer. The non-woven may be a wet-laid non-woven, an air laid non-woven or non-woven materials that can be produced using other processes.

20 In certain examples, the aqueous dispersions described herein can include one or more plant oils. Illustrative plant oils include oils extracted from seeds and oils extracted from plant structures other than seeds. In some embodiments, the plant oil is a plant oil macromonomer. As used herein, the term macromonomer refers to a molecule that includes a terminal moiety that can function as a monomer. A single mole of macromonomer provides a  
25 single monomeric unit to the chain of a polymer. As described herein, a macromonomer can be polymerized and/or cured by reaction with a suitable reactant. In some instances, the plant oil macromonomer may be a fruit oil macromonomer, a tree oil macromonomer, a shrub oil macromonomer, a herb oil macromonomer, a flower oil macromonomer, a bush oil macromonomer, a vegetable oil macromonomer (VOMM) and combinations thereof.

30 In certain embodiments, the aqueous dispersion may comprise a vegetable oil macromonomer from one or more of a leaf vegetable plant, a seed vegetable plant, a fruit vegetable plant, a root vegetable plant, a flower vegetable plant, a bud vegetable plant, a flax plant and combinations thereof. In some embodiments, the vegetable oil macromonomer may be produced by a bean plant, a soybean plant, a carrot plant, a beet plant, a turnip plant, a

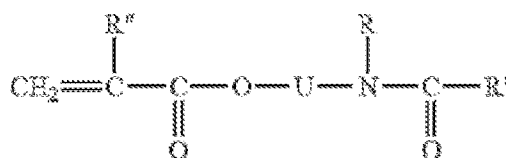
radish plant or other vegetable plants. In certain embodiments, the vegetable oil macromonomer can be naturally produced, can be produced from naturally occurring materials or may be synthetic or may be a derivative of a naturally produced vegetable oil macromonomer. For example, the VOMM may be one or more of those described in U.S. Patent No. 8,450,414.

In some embodiments, the VOMM can be derivatized prior to use by reacting the naturally produced oil with one or more derivatizing agents. For example, many VOMMs (and many plant oils) include one or more sites of unsaturation. These sites of unsaturation may be advantageously used and/or may be consumed by auto-oxidation as the dispersion/coating dries. Derivatized forms may be particularly suitable for emulsion copolymerization with other species to provide a coating on a substrate as described herein. In one embodiment, an unsaturated plant oil can be reacted with a primary or secondary amine followed by reaction with one or more other species to provide a monomeric form suitable for polymerization. In one embodiment, a vegetable oil can be converted to a fatty amide (meth)acrylate monomer by reaction with ethanolamine or substituted ethanolamine (e.g., N-methyl ethanolamine, N-oleoylethanolamine, N-ethylethanolamine, N-propylethanolamine, N-butylethanolamine, N-tert-butylethanolamine, N-(tert-butoxycarbonyl)ethanolamine, N-(allyloxycarbonyl) ethanolamine, benzyl N-(2-hydroxyethyl)carbamate, ethyl-N-(2-hydroxyethyl)-carbamate, or diethanolamine) followed by reaction with either (meth)acryloyl chloride or (meth)acrylic acid. For example, a plant oil such as linseed oil, soybean oil, safflower oil, tung oil and coconut oil can be reacted with substances, e.g., (meth)acryloyl chloride or (meth)acrylic acid. In another embodiment, a urethane fatty amide (meth)acrylate monomer can be produced by reaction of hydroxyethyl(meth)acrylate reacted with isophorone diisocyanate. For example, hydroxyethyl(meth)acrylate can be reacted with isophorone diisocyanate in a first reaction, e.g., the hydroxyl(meth)acrylate is reacted in equimolar proportion with isophorone diisocyanate. In a separate reaction, a plant oil, for example, soybean oil, coconut oil, safflower oil, tung oil or linseed oil is reacted with ethanolamine (or substituted ethanolamine) to form the hydroxyl functional fatty amide. The products of the two reactions can be reacted to provide a urethane fatty amide (meth)acrylate monomer.

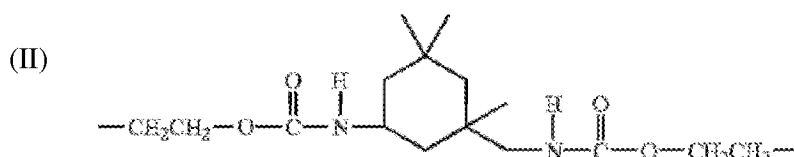
In certain embodiments, the resulting macromonomer can be suspended or dispersed in an aqueous carrier optionally with a surfactant or detergent. Polymerization of the macromonomer can occur by the addition of a suitable reactant that can react with the reactive sites of the macromonomer to provide a dispersed polymer. While not limiting,

many suitable reactants include one or more sites of unsaturation, e.g., comonomers with vinyl unsaturation or other sites of unsaturation. Illustrative reactants that are suitable for reaction with the macromonomers include, but are not limited to, vinyl acetate, vinyl chloride, vinyl ester of a saturated tertiary branched carboxylic acid, acrylonitrile, acrylamide, 2-ethylhexyl acrylate, 2-ethylhexyl methacrylate, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, glycidyl acrylate, glycidyl methacrylate, acrylic acid, methacrylic acid, butyl acrylate, butyl methacrylate, methyl methacrylate, methyl acrylate, p-acetoxystyrene, polyvinyl alcohol, ethylene vinyl alcohol and styrene or other derivatized forms of benzene that include one or more unsaturated side chains, e.g., benzylic side chains.

In certain embodiments, a generic formula of a vegetable oil macromonomer is shown below as formula (I)



where R is CH<sub>3</sub>, H or CH<sub>2</sub>CHOH, R' is a saturated or unsaturated straight chain alkyl group of a fatty acid of a vegetable oil (e.g., a straight chain alkyl group having from about 12 to about 24 carbons with 0, 1, 2, 3, 4 or 5 sites of unsaturation within the chain), R'' is CH<sub>3</sub> or H, and U is CH<sub>2</sub>CH<sub>2</sub>, CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub> or a group of formula (II)

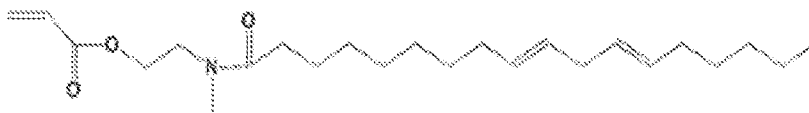


In some embodiments, the group R' may be the hydrocarbon chain from lauric acid, myristic acid, palmitic acid, stearic acid, eleostearic acid, caprylic acid, capric acid, lignoceric acid, palmitoleic acid, oleic acid, linoleic acid, alpha-linolenic acid, or gamma-linolenic acid.

In certain embodiments, R is CH<sub>3</sub>, R' is a 16-18 carbon straight chain alkyl group with 1-3 vinyl groups, R'' is methyl and U is CH<sub>2</sub>CH<sub>2</sub>. In other examples, R is CH<sub>3</sub>, R' is a 16-18 carbon straight chain alkyl group with 1-3 vinyl groups, R'' is hydrogen and U is

CH<sub>2</sub>CH<sub>2</sub>. In some examples, R is CH<sub>3</sub>, R' is a 17 carbon straight chain alkyl group with 2 vinyl groups, R'' is methyl and U is CH<sub>2</sub>CH<sub>2</sub>. In some examples, R is CH<sub>3</sub>, R' is a 17 carbon straight chain alkyl group with 2 vinyl groups, R'' is hydrogen and U is CH<sub>2</sub>CH<sub>2</sub>. In some examples, R is CH<sub>3</sub>, R' is a 17 carbon straight chain alkyl group with 2 vinyl groups (one at carbon 8 and one at carbon 11 as counted from the carbonyl group bonded to R'), R'' is methyl and U is CH<sub>2</sub>CH<sub>2</sub>. In other examples, R is CH<sub>3</sub>, R' is a 17 carbon straight chain alkyl group with 2 vinyl groups (one at carbon 8 and one at carbon 11 as counted from the carbonyl group bonded to R'), R'' is hydrogen and U is CH<sub>2</sub>CH<sub>2</sub>. In yet other embodiments, a VOMM having formula (III) (referred to below as SoyAA-1) can be used

(III)



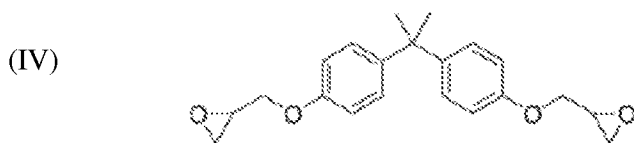
and can be combined in an aqueous dispersion with one or more of vinyl acetate, vinyl chloride, vinyl ester of a saturated tertiary branched carboxylic acid, acrylonitrile, acrylamide, 2-ethylhexyl acrylate, 2-ethylhexyl methacrylate, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, glycidyl acrylate, glycidyl methacrylate, acrylic acid, methacrylic acid, butyl acrylate, butyl methacrylate, methyl methacrylate, methyl acrylate, p-acetoxystyrene, polyvinyl alcohol, ethylene vinyl alcohol and styrene or other derivatized forms of benzene that include one or more unsaturated side chains, e.g., benzylic side chains. The combination of formula (III) with one or more of these compounds can result in polymerization, which can provide the coatings having the variable water vapor perm ratings described herein once the dispersions are disposed on a suitable substrate and a final coating is formed.

In other embodiments, the aqueous dispersion can include one or more waterborne epoxy materials or resins that can polymerize to provide a coating. In some embodiments, the waterborne epoxy material can be a Type I or a Type II epoxy material. Type I epoxy materials generally are low molecular weight materials that can be cured with a reactant that can also function as an emulsifier. Type I epoxy resins are often based on bisphenol A or bisphenol F and have an epoxide equivalent weight of less than 250. Type II epoxy materials are high molecular weight materials that tend to be present in solid form with epoxide equivalent weights of more than 450, e.g., about 750-1500 EEWs. Type II solid epoxy resins can be dispersed at about 50-55% solids in water and typically are used with an emulsifier or surfactant. The reactant used with a Type II system can diffuse into the dispersed solid



particles and crosslink the epoxy groups. Illustrative reactants for use with Type I and Type II epoxy resins may be those with one or more free amine groups as discussed herein. Illustrative commercially available waterborne epoxy resins include, but are not limited to, EPI-REZ<sup>TM</sup> epoxy waterborne resins (available from Momentive), Ancarez<sup>TM</sup>555 (available from Air Products), the THW grades of waterborne epoxy resins (available from Epotec) or other commercially available epoxy resins. In certain examples, the epoxy resin can be selected such that substantially zero VOCs are present in the aqueous dispersion to provide the coatings described herein with the desirable variable water vapor perm values. For example, where a Type II epoxy resin is used, glycol ether is often added to aid in processing. In the aqueous dispersions provided herein, however, glycol ether (and other VOCs) may be omitted even where a Type II epoxy resin system is implemented.

In some embodiments, the waterborne epoxy material can include a single reactive epoxy group at one end of the molecule, e.g., can react as a macromonomer. In other embodiments, the waterborne epoxy material can include two or more reactive epoxy groups in the molecule. In certain examples, the waterborne epoxy material can have a formula as shown in formula (IV), or be a derivative of formula (IV)



which is generally a diglycidyl ether of bisphenol-A. In some instances, the epoxy material can be reacted with a reactant that comprises one or more amine groups, e.g., an aliphatic amine or an aliphatic diamine, which can result in opening of the epoxy ring and coupling of the amine group to the epoxy material. If the amine is a diamine, a similar reaction can occur with an additional epoxy group to build up the polymer. In addition, cross-linking may occur at the amine sites by reaction with an epoxy group. Suitable amines for use with the epoxy materials described herein include primary aliphatic amines, secondary aliphatic amines, primary aliphatic diamines, secondary aliphatic diamines and mixed diamines (e.g., where one amine site is primary and one amine site is secondary). In other instances, non-aliphatic amines may be used in place of an aliphatic amine. If desired, amine reactants with branching or unsaturation sites can also be used to polymerize the epoxy materials described herein. In some embodiments, the reactant may be one or more of the Anquamine reactants commercially available from Air Products, e.g., Anquamine 721, 701, 401, 360, 287, 735 or 419.

In certain embodiments, the dispersions described herein can include one or more additives or materials to facilitate polymerization, deposition or otherwise alter the properties of the dispersion and any resulting coating on a substrate. In some embodiments, the additive may be a surfactant that can assist in dispersion of the macromonomers and/or epoxy materials in an aqueous carrier. If desired, the surfactant may be ionic or non-ionic. The surfactant can be present in an effective amount to either assist in dispersal of the material in the aqueous carrier or to reduce surface tension of the aqueous dispersion as it is disposed on the substrate or both. In some instances, the surfactant can also assist in providing a coating that has substantially the same thickness along the planar surface of a substrate. Where macromonomers and/or epoxy materials are used, it may be desirable to use a non-ionic surfactant. In some embodiments, the surfactant may be substituted or derivatized with groups other than carbon, hydrogen and oxygen. For example, the surfactant can include halo groups, (e.g., fluoro, chloro, bromo, or iodo groups), phospho groups, sulfo groups or other groups. In some embodiments, the surfactant can be present in an effective amount to reduce the surface tension of the aqueous dispersion as it is coated onto a substrate to provide for easier coating and/or a more uniform coating. Illustrative commercially available surfactants are available from 3M (e.g., Novec fluorosurfactants such as FC-4430, FC-4432, FC-4434), Sigma Aldrich (e.g., Triton<sup>TM</sup> surfactants, Zonyl<sup>®</sup> surfactants), Maflon (e.g., PDM112, Hexafor 647, 648, 670, 675 or 678D), AkzoNobel and other companies that provide surfactants.

In other embodiments, the dispersions can include one or more fillers or filler materials. For example, in some embodiments the filler can include one or more of a clay, a montmorillonite, a calcium filler, a bentonite, a muscovite, an illite, a cookeite, a kaolonite, a chlorite or other filler materials. The filler may comprise inorganic materials, organic materials or combinations thereof. In some examples, the filler may provide reinforcement in the cured coating, may provide flame retardancy in the cured coating, may improve the physical properties of the cured coating (e.g., increase the coefficient of linear thermal expansion (CLTE) as compared to the CLTE of a cured coating without the filler), or may provide other desired features, e.g., may increase the overall viscosity of the aqueous dispersion to facilitate more uniform coating on a substrate. Illustrative commercially available fillers, include, but are not limited to, Bentolite<sup>®</sup>, Cloisite<sup>®</sup>, Nanofil<sup>®</sup>, Nanothix<sup>®</sup>, and Permونت<sup>®</sup> fillers available from Southern Clay Products, Inc.

In certain examples, the dispersions can include one or more biocidal agents. The biocidal agent can be effective to deter or prevent growth of organisms on the coating and/or

surface of the substrate. In some embodiments, the biocidal agent can be effective as a fungicide, e.g., a moldicide, to prevent growth of mold or other fungus on the surface of the substrate. The biocidal agent can prevent growth of mold and fungus on or in the dispersion. In other embodiments, the biocidal agent can be effective to prevent growth of bacteria,  
5 mold, fungus, moss, algae or other organisms on the surface of the substrate. Where present, the biocidal agent may be present in an effective amount to deter or prevent growth of bioorganisms.

In some embodiments, the dispersions can include stain-resistance additives. In some examples, the stain-resistance additive can act to reduce or prevent materials from being  
10 adsorbed into the coating and can generally assist in sealing the coating from penetration by materials other than water and gases. For example, the stain-resistance additive can provide oil resistance or oil repellency to prevent non-polar species from becoming trapped in the coating. The stain-resistance additives may also inhibit fading of the coating if exposed to heat, ultraviolet light or other forms of energy. Illustrative stain-resistance additives are  
15 commercially available, for example, from 3M (e.g., SRC-220, PM-5000, PM-1680, PM-4800) and AkzoNobel (e.g., Elotex<sup>®</sup> stain-resistance additives).

In certain embodiments, the dispersions described herein can comprise one or more polyamides or polyamide precursors mixed with macromonomer or epoxy resin. In some instances, the polyamide may be produced from naturally occurring polyamide precursors  
20 such as those present in castor oil. In other embodiments, the polyamide may be Nylon 6 precursors, e.g., caprolactam, that can be mixed in monomeric form with the macromonomer or the epoxy resin. Where a polyamide precursor is present, it is desirably used in an amount that does not result in phase separation in the aqueous dispersion. In some instances, the polyamide precursors can be used as a reactant in the aqueous dispersion. In other  
25 embodiments, a polyamide, e.g., Nylon 6, can be added to the aqueous dispersion either before or during coating. In yet one further embodiment, the coating can be adjacent to a polyamide layer. The polyamide layer can include Nylon 6. In one embodiment, the polyamide layer can range from 0.005 mil to 2 mil, such as from 0.008 mil to 0.1 mil, or from 0.01 mil to 0.05 mil.

In certain examples, the aqueous dispersions described herein can be used to provide a  
30 cured coating on a building substrate, e.g., kraft paper or fiberglass insulation, oriented strand board or as a coating on a house wrap or other material used that can be used to seal a building envelope. Referring to FIG. 1A, an article 100 is shown comprising a substrate 110 with a coating 120 disposed thereon. The exact thickness of the substrate 110 and the coating

120 can vary, but in most cases the thickness of the substrate 110 will be substantially larger than the thickness of the coating 120. While the thickness of the coating 120 is shown as being substantially the same in the planar direction of the substrate 110, such uniformity is not required. In particular, so long as the thickness of the coating 120 is effective to provide the variable water vapor perm values described herein, the thickness need not be uniform in every area of the substrate 110. In another embodiment and as shown in FIG. 1B, an article 100 comprises a substrate 110 and two coatings 1202 and 1204 on opposite surfaces of the substrate 110. The thickness of the coatings 1202 and 1204 can be the same or different. The thicknesses can be chosen to provide the variable water vapor perm values described herein.

In at least one embodiment, the thickness of coating 120, 1202, or 1204 can be at least 0.001 cm, such as at least 0.01 cm, at least 0.05 cm, at least 0.1 cm, at least 0.12 cm, at least 0.14 cm, at least 0.16 cm, at least 0.18 cm, at least 0.20 cm, or at least 0.22 cm. In another embodiment, the thickness of coating 120, 1202, or 1204 can be not greater than 1 cm, such as not greater than 0.9 cm, not greater than 0.8 cm, not greater than 0.7 cm, not greater than 0.6 cm, not greater than 0.55 cm, not greater than 0.5 cm, not greater than 0.45 cm, not greater than 0.4 cm, not greater than 0.35 cm, not greater than 0.3 cm, not greater than 0.28 cm, not greater than 0.26 cm, or not greater than 0.24 cm. In yet one further embodiment, the thickness of coating 120, 1202, or 1204 can range from 0.001 cm to 1 cm, such as from 0.05 cm to 0.5 cm, or from 0.1 cm to 0.25 cm.

In certain embodiments, the substrate 110 can be any suitable substrate commonly used in the building industry. For example, buildings typically have some form of insulation in the wall, floor and/or ceiling cavities. This insulation is often fiberglass insulation that can include a vapor retarder to prevent moisture from entering the insulated cavities. Common vapor retarders are kraft paper coated with asphalt. Kraft paper itself has a high rate of moisture transmission. When used with an asphalt coating and/or adhesive, the kraft paper can act as a suitable vapor retarder. Reduced moisture in the wall cavity can prevent a reduction in the thermal conductivity within the wall cavity, which can further assist in reduction of energy costs. In some instances, the substrate 110 may be kraft paper that can be applied to a larger building substrate, e.g., fiberglass insulation, using an adhesive or other suitable attachment means. The exact weight of the kraft paper can vary, and illustrative weights include, but are not limited to, about 25 pounds to about 75 pounds per ream (3000 ft<sup>2</sup>), for example about 39 pounds. If desired, the kraft paper can be omitted, and the coating 120 can be disposed directly on the fiberglass insulation to provide a coating. In some examples where the kraft paper is omitted, it may be desirable to include a web, scrim,

permeable film or some other material on the fiberglass insulation to receive the aqueous dispersion that forms the coating. In other embodiments, the substrate may be oriented strand board that is applied as sheathing on external surfaces of a building or between various floors of a building. The oriented strand board can be coated directly without any intervening film  
5 or material to provide an oriented strand board substrate having variable water vapor perm ratings. In other instances, the coating can be applied directly to drywall or other materials commonly used to finish interior surfaces of a building structure. For example, gypsum boards can be coated with the aqueous dispersion to provide a gypsum wallboard with variable water perm ratings. Similarly, wood paneling, wood planks, plywood, fiber board or  
10 other materials used to finish exterior or interior walls or ceilings can be coated with the aqueous dispersions described herein to provide variable water vapor perm ratings. Additional building substrates that can be coated with the aqueous dispersions will be readily selected by the person of ordinary skill in the art, given the benefit of this disclosure.

In yet one further embodiment, the article 100 can further include striping (not shown)  
15 to bond the article to a base material. The striping can include an adhesive. In one embodiment, the striping can include asphalt. In yet another embodiment, the striping can be water vapor impermeable. The striping can be adjusted to adjust the water vapor perm ratings through the article and the base material. More striping reduces the water vapor perm rating, less striping increases the water vapor permeance. Accordingly, the striping serves as  
20 a vapor retarder across the article and the bonded base material.

In one embodiment, the base material can be any non-woven sheeting material, a gypsum wallboard, a wooden wallboard, a brick wall, or other building substrates. In one particular embodiment, the base material can be a porous material. In one particular embodiment, the base material can be a foam material.

In certain embodiments, the coating 110 can be disposed on the substrate 120 by  
25 rolling, spraying, roll coating or other means that can dispose a layer of the aqueous dispersion on the substrate. If desired, additional aqueous dispersion can be added to a cured coating layer to build up the thickness of the layers of the coating. In some embodiments, it may be desirable to first coat the substrate with a first aqueous dispersion, e.g., one including  
30 a VOMM, and then after curing the first layer coat the substrate again with a second aqueous dispersion, e.g., one including a waterborne epoxy resin system. In other instances, different aqueous dispersions can be mixed with each other and coated onto the substrate simultaneously. Once cured, the coating on the substrate desirably provides variable water vapor perm ratings, e.g., about 2 perm or less at 25% average RH, is less than or equal to 5

perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 30 perms at 95% average RH as tested by ASTM D1653; or about 2.5 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 12 perms at 95% average RH as tested by ASTM E96.

In some embodiments, the aqueous dispersion can be co-sprayed onto the substrate with a reactant so reaction does not occur prematurely in the aqueous dispersion. For example, where the aqueous dispersion comprises a VOMM, the dispersion can be co-sprayed with styrene or some other reactant directly onto the substrate to form the coating. Additionally, one or more surfactants, biocidal agents, filler materials or other additives can also be co-sprayed into the surface of the substrate. In some instances, one component of the coating can be rolled onto the substrate and another component, e.g., the reactant, can be sprayed onto the rolled aqueous dispersion on the substrate. If desired, however, the components can all be mixed in the aqueous dispersion and then disposed on the substrate in a desired manner. In some instances, the aqueous dispersions may have a viscosity that is too low to facilitate easy deposition onto a substrate. In such instances, it may be desirable to include a viscosity modifier, e.g., a thixotropic agent, an anti-thixotropic agent, or the like to provide a desirable viscosity suitable for coating or otherwise disposing the aqueous dispersion onto a desired substrate.

In certain examples, the aqueous dispersions provided herein can be used either to provide pre-coated building substrates or to permit on-site coating of building substrates. For example, fiberglass insulation batts with kraft paper can be pre-coated with one or more of the components followed by coating of an additional component on-site to provide the final operative coating. In other instances, the coating can be produced at the production site such that an installer need not do anything to provide the coating. In yet other cases, the installer may spray the aqueous dispersion onto a substrate after it has been installed to provide the coating on the installed substrate. In some instances, the substrate may be a cellulosic substrate, e.g., one based on wood or prepared, at least in part, using wood, wood fibers, wood products or other plant materials that include cellulose.

In certain examples, the components of the coatings described herein may be packaged in the form of a kit. In one embodiment, the kit can include a coating dispersion and an applicator to provide the coating dispersion onto a substrate. The applicator can be a brush, a spray nozzle, or a roller. In another embodiment, the kit can include a precursor to the coating dispersion. For example, materials suitable for providing an aqueous dispersion,

e.g., a macromonomer or a waterborne epoxy resin, can be packaged separate from a reactant and any other additives, e.g., fillers, surfactants or the like. The components can be mixed by a user, and the mixed components may then be coated onto a substrate. In some embodiments, the kit may be packaged as a 2-part kit where the various components of the coating are mixed in-line prior to spraying or depositing on the substrate.

For example, one canister or reservoir can include a polymerizable component and the other canister or reservoir can include a reactant and/or other additives. During application, the system or device, e.g., a sprayer or similar device, can mix the two different components in-line prior to spraying. In some examples, an aqueous carrier can be added to the components immediately prior to mixing. In some instances, the aqueous carrier can be mixed with the components using an impeller, gas or other means to facilitate dispersion of the components in the aqueous carrier.

One aspect to the present coatings is the low content of VOCs during preparation and/or curing of the coatings. VOC content can be determined by ASTM D3960 and be quantified mass of VOC per mass unit of coating solids. In one embodiment, as tested by ASTM D3960, the VOC content of the herein described coatings is less than 3 wt%, such as less than 1 wt%, less than 0.5 wt%, less than 100 ppm, less than 50 ppm, less than 40 ppm, less than 30 ppm, less than 20 ppm, less than 10 ppm, less than 5 ppm, less than 1 ppm, less than 0.5 ppm, or less than 0.1 ppm.

Without diminishing the scope of possible embodiments, the following list is an item list of embodiments in accordance with the present disclosure:

Item 1. An article comprising:  
a cellulosic substrate;

an aqueous dispersion disposed on the substrate and effective to provide a variable water vapor perm rating as a function of humidity, in which the water vapor perm rating is about 2 perm or less at 25% average RH, as tested by ASTM D1653; or 2 perm or less at 25% average RH, as tested by ASTM E96, when the aqueous dispersion is cured as a coating on the cellulosic substrate.

Item 2. The article of item 1, in which the cured coating is further effective to provide a water vapor perm rating of less than or equal to 5 perms at 45% average RH as tested by ASTM D1653, or less than or equal to 5 perms at 45% average RH as tested by ASTM E96.

Item 3. The article of item 2, in which the cured coating is further effective to provide a water vapor perm rating of about 12 perms to about 24 perms at 75% average RH as tested by

ASTM D1653, or about 6 perms to about 12 perms at 75% average RH as tested by ASTM E96.

Item 4. The article of item 3, in which the cured coating is further effective to provide a water vapor perm rating of greater than 25 perms at 95% average RH as tested by ASTM D1653, or  
5 greater than 11 perms at 95% average RH as tested by ASTM E96.

Item 5. The article of item 1, in which the aqueous dispersion comprises a plant oil macromonomer dispersion.

Item 6. The article of item 5, in which the plant oil macromonomer dispersion comprises a seed oil macromonomer dispersion.

10 Item 7. The article of item 5, in which the plant oil macromonomer dispersion comprises a vegetable oil macromonomer dispersion.

Item 8. The article of item 1, further comprising a reactant added to the aqueous dispersion.

Item 9. The article of item 8, in which the aqueous dispersion comprises a plant oil macromonomer dispersion and the reactant comprises a derivatized benzene comprising an  
15 unsaturated moiety.

Item 10. The article of item 9, in which the plant oil macromonomer dispersion is a vegetable oil macromonomer dispersion and the derivatized benzene is styrene.

Item 11. The article of item 8, in which the aqueous dispersion comprises a waterborne epoxy resin dispersion and the reactant comprises an amine.

20 Item 12. The article of item 11, in which the waterborne epoxy resin dispersion comprises a waterborne solid epoxy resin dispersion and a surfactant.

Item 13. The article of item 8, further comprising at least one filler added to the waterborne macromonomer dispersion and the reactant.

Item 14. The article of item 13, further comprising a stain-resistance additive in the  
25 dispersion.

Item 15. The article of item 1, in which the aqueous dispersion is substantially free of polyamides.

Item 16. An article comprising:  
a cellulosic substrate; and  
30 a plant oil macromonomer dispersion disposed on the cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or ASTM E96, when the plant oil macromonomer dispersion is cured as a coating on the cellulosic substrate.



- Item 17. The article of item 16, in which the variable water perm rating is about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH, is less  
5 than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96.
- Item 18. The article of item 17, in which the plant oil macromonomer dispersion is a seed oil macromonomer dispersion.
- Item 19. The article of item 17, in which the plant oil macromonomer dispersion is a  
10 vegetable oil macromonomer dispersion.
- Item 20. The article of item 19, in which the vegetable oil macromonomer dispersion further comprises a reactant.
- Item 21. The article of item 20, in which the reactant comprises a derivatized benzene comprising an unsaturated moiety.
- 15 Item 22. The article of item 20, further comprising a filler in the dispersion.
- Item 23. The article of item 22, in which the filler is effective to provide flame retardancy.
- Item 24. The article of item 22, further comprising a surfactant in the dispersion.
- Item 25. The article of item 24, in which the surfactant is a nonionic surfactant.
- 20 Item 26. The article of item 25, further comprising a stain-resistance additive in the dispersion.
- Item 27. The article of item 19, in which the vegetable oil macromonomer comprises SoyAA-1.
- Item 28. The article of item 21, in which the vegetable oil macromonomer comprises  
25 SoyAA-1 and the reactant comprises styrene.
- Item 29. The article of item 23, in which the vegetable oil macromonomer comprises SoyAA-1, the reactant comprises styrene and the filler comprises a montmorillonite.
- Item 30. The article of item 25, in which the vegetable oil macromonomer  
comprises SoyAA-1, the reactant comprises styrene, the filler comprises a montmorillonite  
30 and the nonionic surfactant comprises a nonionic fluorosurfactant.
- Item 31. The article of item 16, in which the cellulosic substrate comprises a non-woven cellulosic substrate.
- Item 32. The article of item 16, in which the cellulosic substrate is kraft paper.

- Item 33. The article of item 16, in which the cellulosic substrate is oriented strand board.
- Item 34. The article of item 16, further comprising a building material coupled to the cellulosic substrate.
- 5 Item 35. The article of item 34, in which the building material is fiberglass insulation.
- Item 36. An article comprising:  
a cellulosic substrate; and  
a waterborne epoxy resin dispersion disposed on the cellulosic substrate and  
effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or  
10 ASTM E96, when the waterborne epoxy resin dispersion is cured as a coating on the  
cellulosic substrate.
- Item 37. The article of item 36, in which the variable water perm rating is about 2  
perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is  
about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95%  
15 average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH, is less  
than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75%  
average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96.
- Item 38. The article of item 37, in which the waterborne epoxy resin is a waterborne  
solid epoxy resin.
- 20 Item 39. The article of item 38, in which the waterborne solid epoxy resin comprises a  
diglycidyl ether of bisphenol-A.
- Item 40. The article of item 38, further comprising a reactant added to the aqueous  
dispersion.
- Item 41. The article of item 40, in which the reactant comprises an amine.
- 25 Item 42. The article of item 40, further comprising a filler in the dispersion.
- Item 43. The article of item 42, in which the filler is effective to provide flame  
retardancy.
- Item 44. The article of item 42, in which the filler comprises a montmorillonite.
- Item 45. The article of item 42, further comprising a surfactant in the dispersion.
- 30 Item 46. The article of item 45, in which the surfactant is a nonionic surfactant.
- Item 47. The article of item 46, further comprising a stain-resistance additive in the  
dispersion.

Item 48. The article of item 46, in which the waterborne epoxy resin comprises a diglycidyl ether of bisphenol-A, the reactant comprises an amine and the filler comprises a montmorillonite.

Item 49. The article of item 46, in which the cellulosic substrate comprises a non-woven cellulosic substrate.

Item 50. The article of item 46, in which the cellulosic substrate is kraft paper.

Item 51. The article of item 46, in which the cellulosic substrate is oriented strand board.

Item 52. The article of item 46, further comprising a building material coupled to the cellulosic substrate.

Item 53. The article of item 52, in which the building material is fiberglass insulation.

Item 54. The article of item 52, in which the cellulosic substrate is kraft paper and the building material is fiberglass insulation.

Item 55. The article of item 46, further comprising a polyamide in the dispersion.

Item 56. A method of providing a coating that has variable water vapor perm ratings as tested by ASTM D1653 or ASTM E96, the method comprising:

disposing an aqueous dispersion on a substrate; and

curing the disposed aqueous dispersion on the substrate to provide a coating

comprising a variable water vapor perm rating as tested by ASTM D1653 or ASTM

E96.

Item 57. The method of item 56, further comprising disposing an effective amount of the aqueous dispersion on the substrate to provide the variable water perm rating, about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or, about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96.

Item 58. The method of item 56, further comprising co-spraying the aqueous dispersion and a reactant on the substrate.

Item 59. The method of item 56, further comprising adding a reactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate.

Item 60. The method of item 56, further comprising co-spraying the aqueous dispersion and a surfactant on the substrate.

Item 61. The method of item 56, further comprising adding a surfactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate.

Item 62. The method of item 56, further comprising co-spraying the aqueous dispersion, a reactant and a surfactant on the substrate.

5 Item 63. The method of item 56, adding a surfactant and a reactant to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate.

Item 64. The method of item 56, further comprising rolling the aqueous dispersion onto the substrate.

10 Item 65. The method of item 56, further comprising adding a thickening agent to the aqueous dispersion prior to rolling it onto the substrate.

Item 66. The method of item 56, further comprising co-spraying the aqueous dispersion with a polyamide onto the substrate.

Item 67. The method of item 56, further comprising adding a polyamide to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate.

15 Item 68. The method of item 56, further comprising co-spraying a biocidal agent with the aqueous dispersion onto the substrate.

Item 69. The method of item 56, further comprising adding a biocidal agent to the aqueous dispersion prior to disposal of the aqueous dispersion on the substrate.

20 Item 70. The method of item 56, further comprising providing a cellulosic substrate to receive the aqueous dispersion.

Item 71. A kit comprising:  
an aqueous dispersion;  
a reactant effective to mix with the aqueous dispersion to provide a cured  
coating on a substrate, in which the cured coating provides a variable water vapor  
25 perm rating as tested by ASTM D1653 or ASTM E96, in which the cured coating has  
a water vapor perm rating of about 2 perm or less at 25% average RH as tested by  
ASTM D1653 or ASTM E96 when the aqueous dispersion is cured as a coating on the  
substrate; and

instructions for using the aqueous dispersion and the reactant.

30 Item 72. The kit of item 71, in which the aqueous dispersion and the reactant are configured for co-spraying onto the substrate.

Item 73. The kit of item 71, further comprising an aqueous carrier effective to disperse a vegetable oil macromonomer.

- Item 74. The kit of item 71, further comprising an aqueous carrier effective to disperse a waterborne solid epoxy resin.
- Item 75. The kit of item 71, further comprising a nonionic surfactant.
- Item 76. The kit of item 75, further comprising a biocidal agent.
- 5 Item 77. The kit of item 76, further comprising a building substrate.
- Item 78. The kit of item 71, further comprising a spraying device.
- Item 79. The kit of item 71, in which the aqueous dispersion comprises a vegetable oil macromonomer and the reactant is styrene.
- Item 80. The kit of item 71, in which the aqueous dispersion is a diglycidyl ether of  
10 bisphenol-A and the reactant is an amine.
- Item 81. A method of facilitating use of a building substrate, the method comprising:  
providing an aqueous dispersion effective to provide a cured coating on a substrate, in which the cured coating provides a variable water vapor perm rating as tested by ASTM D1653 or ASTM E96, in which the cured coating has a water vapor perm rating of about 2  
15 perm or less at 25% average RH as tested by ASTM D1653 or ASTM E96 when the aqueous dispersion is cured as a coating on the substrate; and providing instructions for using the aqueous dispersion to form the coating.
- Item 82. The method of item 81, further comprising providing a reactant for use with the aqueous dispersion to provide the cured coating.
- 20 Item 83. The method of item 82, further comprising providing a surfactant for use with the reactant and the aqueous dispersion to provide the cured coating.
- Item 84. The method of item 83, further comprising providing a biocidal agent for use with the surfactant, the reactant and the aqueous dispersion to provide the cured coating.
- Item 85. The method of item 84, further comprising providing a filler for use with the  
25 biocidal agent, the surfactant, the reactant and the aqueous dispersion to provide the cured coating.
- Item 86. A composition effective to provide a cured coating on a substrate, in which the cured coating has a water perm rating of about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75%  
30 average RH, and is greater than 17 perms at 95% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96, the composition comprising an aqueous dispersion, a

surfactant and a reactant effective to react with dispersed material in the aqueous dispersion to provide the cured coating.

Item 87. The composition of item 86, in which the dispersed material comprises a plant oil macromonomer.

5 Item 88. The composition of item 87, in which the plant oil macromonomer is a vegetable oil macromonomer.

Item 89. The composition of item 88, in which the surfactant is a nonionic surfactant.

Item 90. The composition of item 89, in which the reactant is a derivatized benzene comprising an unsaturated moiety.

10 Item 91. The composition of item 90, further comprising at least one biocidal agent.

Item 92. The composition of item 86, in which the dispersed material comprises a waterborne solid epoxy resin.

Item 93. The composition of item 92, in which the reactant is an amine.

Item 94. The composition of item 93, in which the surfactant is a nonionic surfactant.

15 Item 95. The composition of item 94, further comprising at least one biocidal agent.

Item 96. The composition of item 86, in which the substrate comprises a cellulosic substrate.

Item 97. The composition of item 96, wherein the cellulosic substrate is kraft paper.

20 Item 98. The composition of item 86, in which the substrate comprises a non-cellulosic substrate.

Item 99. The composition of item 98, in which the non-cellulosic substrate is fiberglass.

Item 100. The composition of item 86, further comprising a polyamide layer.

Item 101. An article comprising:  
a non-cellulosic substrate;

25 an aqueous dispersion disposed on the substrate and effective to provide a variable water vapor perm rating as a function of humidity, in which the water vapor perm rating is about 2 perms or less at 25% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH as tested by ASTM E96, when the aqueous dispersion is cured as a coating on the non-cellulosic substrate.

30 Item 102. The article of item 101, in which the cured coating is further effective to provide a water vapor perm rating of less than or equal to 5 perms at 45% average RH as tested by ASTM D1653, or less than or equal to 5 perms at 45% average RH as tested by ASTM E96.

Item 103. The article of item 102, in which the cured coating is further effective to provide a water vapor perm rating of about 12 perms to about 24 perms at 75% average RH as tested by ASTM D1653, or about 6 perms to about 12 perms at 75% average RH as tested by ASTM E96.

5 Item 104. The article of item 103, in which the cured coating is further effective to provide a water vapor perm rating of greater than 25 perms at 95% average RH as tested by ASTM D1653, or greater than 11 perms at 95% average RH as tested by ASTM E96.

Item 105. The article of item 101, in which the aqueous dispersion comprises a plant oil macromonomer dispersion.

10 Item 106. The article of item 105, in which the plant oil macromonomer dispersion comprises a vegetable oil macromonomer dispersion.

Item 107. The article of item 101, in which the non-cellulosic substrate is selected from the group consisting of a polypropylene, a polyethylene, a polystyrene, a polyester, a polyurethane, a fiberglass, a spunbond polymer, a point-bonded polymer, and a non-woven  
15 material.

Item 108. The article of item 101, further comprising a reactant added to the aqueous dispersion.

Item 109. The article of item 108, in which the aqueous dispersion comprises a plant oil macromonomer dispersion and the reactant comprises a derivatized benzene comprising an  
20 unsaturated moiety.

Item 110. The article of item 109, in which the plant oil macromonomer dispersion is a vegetable oil macromonomer dispersion and the derivatized benzene is styrene.

Item 111. The article of item 118, in which the aqueous dispersion comprises a waterborne epoxy resin dispersion and the reactant comprises an amine.

25 Item 112. The article of item 111, in which the waterborne epoxy resin dispersion comprises a waterborne solid epoxy resin dispersion and a nonionic surfactant.

Item 113. The article of item 108, further comprising at least one filler added to the waterborne macromonomer dispersion and the reactant.

Item 114. The article of item 13, further comprising a stain resistance additive in the  
30 dispersion.

Item 115. The article of item 1, in which the aqueous dispersion is substantially free of polyamides.

Item 116. An article comprising:  
a non-cellulosic substrate; and

a plant oil macromonomer dispersion disposed on the non-cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or ASTM E96, when the plant oil macromonomer dispersion is cured as a coating on the non-cellulosic substrate.

- 5 Item 117. The article of item 116, in which the variable water perm rating is about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or , about 1 perm or less at 25% average RH, is less than or equal to 2.5 perms at 45% average RH, is about 6 perms to about 12 perms at 75%  
10 average RH, and is greater than 17 perms at 95% average RH as tested by ASTM E96..
- Item 118. The article of item 117, in which the plant oil macromonomer dispersion is a vegetable oil macromonomer dispersion.
- Item 119. The article of item 116, in which the non-cellulosic substrate is selected from the group consisting of a polypropylene, a polyethylene, a polystyrene, a polyester, a  
15 polyurethane, a fiberglass, a spunbond polymer, a point-bonded polymer, and a non-woven material.
- Item 120. The article of item 119, in which the vegetable oil macromonomer dispersion further comprises a reactant.
- Item 121. The article of item 120, in which the reactant comprises a derivatized benzene  
20 comprising an unsaturated moiety.
- Item 122. The article of item 120, further comprising a filler in the dispersion.
- Item 123. The article of item 122, in which the filler is effective to provide flame retardancy.
- Item 124. The article of item 122, further comprising a surfactant in the dispersion.
- 25 Item 125. The article of item 124, in which the surfactant is a nonionic surfactant.
- Item 126. The article of item 125, further comprising a stain-resistance additive in the dispersion.
- Item 127. The article of item 119, in which the vegetable oil macromonomer comprises SoyAA-1.
- 30 Item 128. The article of item 121, in which the vegetable oil macromonomer comprises SoyAA-1 and the reactant comprises styrene.
- Item 129. The article of item 123, in which the vegetable oil macromonomer comprises SoyAA-1, the reactant comprises styrene and the filler comprises a montmorillonite.



Item 130. The article of item 125, in which the vegetable oil macromonomer comprises SoyAA-1, the reactant comprises styrene, the filler comprises a montmorillonite and the nonionic surfactant comprises a nonionic fluorosurfactant.

5 Item 131. The article of item 116, in which the cellulosic substrate comprises a non-woven non-cellulosic substrate.

Item 132. The article of item 116 further comprising a cellulosic substrate.

Item 133. The article of item 132, in which the cellulosic substrate is selected from kraft paper, oriented strand board, or a combination thereof.

10 Item 134. The article of item 132 further comprising a building material coupled to the cellulosic substrate.

Item 135. The article of item 134, in which the building material is fiberglass insulation.

Item 136. An article comprising:  
a non-cellulosic substrate; and  
a waterborne epoxy resin dispersion disposed on the non-cellulosic substrate  
15 and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or ASTM E96, when the waterborne epoxy resin dispersion is cured as a coating on the non-cellulosic substrate.

Item 137. The article of item 136, in which the variable water perm rating is about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is  
20 about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or, about 1 perm or less at 25% average RH, is less than or equal to 2.5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 17 perms at 95% average RH as tested by ASTM E96.

25 138. The article of item 137, in which the waterborne epoxy resin is a waterborne solid epoxy resin.

Item 139. The article of item 138, in which the waterborne solid epoxy resin comprises a diglycidyl ether of bisphenol-A.

Item 140. The article of item 138, further comprising a reactant added to the aqueous dispersion.

30 Item 141. The article of item 140, in which the reactant comprises an amine.

Item 142. The article of item 140, further comprising a filler in the dispersion.

Item 143. The article of item 142, in which the filler is effective to provide flame retardancy.

Item 144. The article of item 142, in which the filler comprises a montmorillonite.

- Item 145. The article of item 142, further comprising a surfactant in the dispersion.
- Item 146. The article of item 145, in which the surfactant is a nonionic surfactant.
- Item 147. The article of item 146, further comprising a stain-resistance additive in the dispersion.
- 5 Item 148. The article of item 146, in which the waterborne epoxy resin comprises a diglycidyl ether of bisphenol-A, the reactant comprises an amine and the filler comprises a montmorillonite.
- Item 149. The article of item 146, in which the cellulosic substrate comprises a non-woven cellulosic substrate.
- 10 Item 150. The article of item 136, in which the non-cellulosic substrate is selected from the group consisting of a polypropylene, a polyethylene, a polystyrene, a polyester, a polyurethane, a fiberglass, a spunbond polymer, a point-bonded polymer, and a non-woven material.
- Item 151. The article of item 146, further comprising a building material coupled to the
- 15 non-cellulosic substrate.
- Item 152. The article of item 151, in which the building material is fiberglass insulation.
- Item 153. The article of item 146, further comprising a polyamide in the dispersion.

20 Certain specific examples are described below to facilitate a better understanding of the technology described herein.

#### Example 1

All coating systems were applied on kraft paper with a wirewound bar and allowed to dry at ambient for one week before evaluation. The coated paper was placed in perm cups with flanged edges and the cups were placed in an environmental chamber that provided

25 mean RH levels of 25%, 45%, 75% and 95% to evaluate the water permeability following the ASTM D1653 and / or E96 protocol. The coated side of the paper was kept facing the high humidity side in all evaluations. Each cup containing the coated paper along with water/desiccant was weighed before being placed in the environmental chamber and weighed

30 every day thereafter for 10 days. A 2 mil nylon 6 film was employed as an internal control in every test. Each system was analyzed in triplicate and the average was reported. The experimental conditions were as described in Table 1. The target perm values for the coatings are listed in Table 2.

**Table 1. Experimental Setup**

<b>Cup Containing</b>	<b>Environmental Chamber RH</b> <b>(Air Temperature in Chamber: 70 – 73 °F)</b>	
	<b>50%</b>	<b>90%</b>
Desiccant	25% mean RH for test sample	45% mean RH for test sample
Water	75% mean RH for test sample	95% mean RH for test sample

**Table 2. Target Perm Values**

<b>Average Relative Humidity (RH)</b>	<b>ASTM D1653</b>	<b>ASTM E96</b>
	<b>Perms</b>	<b>Perms</b>
25%	≤ 2.0	≤ 1.0
50%	≤ 5.0	≤ 2.5
75%	12 – 24	6 – 12
95%	> 25	> 17

5 A number of aqueous dispersions were evaluated including:

Michem<sup>®</sup> Emulsion D310 (MED310), a multi-purpose aqueous dispersion of a high melt polyamide supplied by Michelman, Inc. at 22-24% solids by weight, < 100 cPs (spindle #3, 60 rpm), pH 9.7 – 10.7;

10 Neocar<sup>®</sup> 820 (an ultra-small particle size, hydrophobic modified acrylic latex, supplied by Arkema, Inc.);

ENCOR<sup>®</sup> 443 is a styrene-acrylic latex (41% solids by weight, viscosity 600 cPs, density 8.7 lb/gal, and pH 7.0);

A SoyAA-1:styrene (46:54 by weight) latex (50% solids by weight) referred to as EK 3-32R2 in the Table 3 below;

15 Ancarez<sup>®</sup> AR555 (a waterborne solid epoxy resin dispersion delivered at 55% solids in water, epoxy equivalent weight 550, supplied by Air Products and Chemicals, Inc.). The epoxy resin is based on diglycidyl ether of bisphenol-A; and

Anquamine<sup>®</sup> 401 (a modified aliphatic amine supplied at 70% solids in water, theoretical amine hydrogen equivalent weight 200, employed here as a reactant for Ancarez 20 AR555, supplied by Air Products and Chemicals, Inc.).

Additives employed in this Example include:

Oxylink<sup>®</sup> 3101 is an aqueous dispersion containing nano zinc oxide (44% solids in water, pH 7-9, VOC < 0.2%, viscosity < 10 mPa·sec, density 1.5 – 1.6 g/mL, supplied by Buhler, Inc.)

5 Nanofil aqueous dispersion (Nanofil 116 is a natural montmorillonite clay, supplied by Southern Clay Products, Inc., the aqueous dispersion was prepared in our lab)

SRC-220 (an aqueous fluorinated polyurethane stain-resistance additive, supplied by 3M)

FC-4434 (a nonionic fluorinated surfactant, supplied by 3M)

10 Nanobyk<sup>®</sup> 3810 (a cerium oxide nanoparticle dispersion in water, supplied by BYK Additives)

Cobalt Hydrocure<sup>®</sup> (a drier containing 6% cobalt metal, supplied by OM Group, Inc.)

To obtain a baseline value for the substrate and the control, the first evaluation was conducted with kraft paper, nylon, and kraft paper + nylon along with kraft paper coated individually with the polyamide emulsion and SoyAA-1/styrene latex. The perm values  
15 obtained during the evaluation are listed in Table 3.

**Table 3. ASTM D1653 Perm Results – I**

<b>Average RH</b>	<b>Desired Perms</b>	<b>Substrate with no Coating</b>	<b>Perms</b>
25% RH	$\leq 2.0$	Kraft paper	28.46
		Nylon	1.58
		Kraft paper + Nylon	3.18
45% RH	$\leq 5.0$	Kraft paper	-
		Nylon	4.19
		Kraft paper + Nylon	10.26
75% RH	12 - 24	Kraft paper	157.51
		Nylon	14.79
		Kraft paper + Nylon	17.51
95% RH	$> 25$	Kraft paper	363.32
		Nylon	68.63
		Kraft paper + Nylon	66.87
<b>Average RH</b>	<b>Desired Perms</b>	<b>Coating on Kraft Paper</b>	<b>Perms</b>
25% RH	$\leq 2.0$	MED 310	21.00
		EK 3-32R2	17.54
45% RH	$\leq 5.0$	MED 310	29.77
		EK 3-32R2	10.10
75% RH	12 - 24	MED 310	157.69
		EK 3-32R2	64.03
95% RH	$> 25$	MED 310	275.00
		EK 3-32R2	54.42

Example 2

Three systems were evaluated, i.e., a) SoyAA-1/styrene (referred to as EK 3-32R2 in  
5 Tables 4 and 5 below) with 1% Oxylink, b) SoyAA-1/styrene (repeat), and c) nylon (repeat)  
at 45% and 90% RH levels. The repeats were necessary to determine the repeatability of the

systems. The results are provided in Table 4. The ASTM D1653 protocol was used for the testing.

**Table 4. ASTM D1653 Perm Results – II**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
45% RH	≤ 5.0	EK 3-32R2	8.77	16.38
		EK 3-32R2 + 1% Oxylink	8.90	14.69
95% RH	> 25	EK 3-32R2	120.14	14.70
		EK 3-32R2 + 1% Oxylink	77.56	17.55

At 45% RH level, a good reproducibility was noted between the second and third iterations for nylon and SoyAA-1/styrene. At the 95% RH level, only the nylon sample showed good reproducibility. Of the three samples tested with SoyAA-1/styrene, one sample gave extremely high water loss readings, indicating that the sample might have had some tear that allowed water vapor to move freely. Overall, incorporating 1% Oxylink to the SoyAA-1/styrene latex seemed to have a positive effect on the permeability values of the coated kraft paper, i.e., it moved the perm values closer to the target perm values (Table 5).

**Table 5. ASTM D1653 Perm Results – III**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
25% RH	≤ 2.0	EK 3-32R2	7.92	15.47
		EK 3-32R2 + 1% Oxylink	7.36	16.62
75% RH	12 - 24	EK 3-32R2	89.74	12.98
		EK 3-32R2 + 1% Oxylink	66.60	14.45

At 25% RH level, the system with 1% Oxylink performed better than the system without Oxylink.

### Example 3

Blends of MED 310 with SoyAA-1/styrene (46:54 by weight and referred to as EK 3-32R2 in Table 6 below) in the ratios of a) 65:35, b) 35:65, and c) 50:50 (all on solids by weight), and a blend of MED 310 with ENCOR 443 at 50:50 by weight on solids were

applied on kraft paper and evaluated at 25% and 75% RH levels. The results are provided in Table 6. The ASTM D1653 protocol was used for the testing.

**Table 6. ASTM D1653 Perm Results – IV**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
25% RH	≤ 2.0	MED 310 : EK 3-32R2 35:65	38.36	10.68
		MED 310 : EK 3-32R2 50:50	37.96	9.04
		MED 310 : Encor 433 50:50	42.07	9.43
75% RH	12 - 24	MED 310 : EK 3-32R2 35:65	99.18	10.41
		MED 310 : EK 3-32R2 50:50	142.29	10.04
		MED 310 : Encor 433 50:50	159.11	8.98

5

The MED 310 blends exhibited phase separation upon application to the kraft paper that was manifest as areas with uneven gloss and appearance. The phase separation is believed to compromise the water vapor permeability of the coated system as noted from the high permeability values. Consequently, these systems were not evaluated at 45% and 95% RH levels.

10

#### Example 4

The following systems were applied on kraft paper and evaluated at 25% and 75% RH levels:

Ancarez AR555, a waterborne solid epoxy resin dispersion supplied at 55% solids in water,

15

Encor 443,

Encor 443 + 3% Oxylink 3101,

SoyAA-1/styrene (46:54 by weight and referred to as EK 3-32R2 in Table 7 below ) + 1% Oxylink 3101,

1% Oxylink 3101,

20

SoyAA-1/styrene (46:54 by weight) + 3% Oxylink 3101,

SoyAA-1/styrene (46:54 by weight) + 1% Nanofil aqueous dispersion,

SoyAA-1/styrene (46:54 by weight) + 3% Nanofil,

SoyAA-1/styrene (46:54 by weight) with 0.5% SRC-220,

SoyAA-1/styrene (46:54 by weight) + 0.1% FC-4434, and

25

SoyAA-1/styrene (46:54 by weight) + 0.4% Nanobyk 3810

The samples described in Table 7 were coated at 5 mils wet film thickness. The ASTM D1653 protocol was used for the testing. In this evaluation, the SoyAA-1/styrene + 1% Oxylink 3101 was applied at 3 mils wet film thickness while the SoyAA-1/styrene + 3% Oxylink 3101 was applied at 1 mil wet film thickness. The perm results together with the coating weights for this evaluation are listed in Table 7.

**Table 7. ASTM D1653 Perm Results – V**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
25% RH	≤ 2.0	Ancarez AR 555	5.03	5.69
		Encor 443	42.40	4.84
		Encor 443 with 3% Oxylink 3101	40.70	5.02
		EK 3-32R2 with 1% Oxylink 3101	43.10	4.06
		EK 3-32R2 with 3% Oxylink 3101	37.33	2.24
		EK 3-32R2 with 1% Nanofil	6.20	8.37
		EK 3-32R2 with 3% Nanofil	6.78	7.73
		EK 3-32R2 with 0.5% SRC-220	10.14	8.02
		EK 3-32R2 with 0.1% FC 4434	7.32	8.70
		EK 3-32R2 with 0.4% Nanobyk 3810	9.15	7.81
75% RH	12 - 24	Ancarez AR 555	32.72	5.88
		Encor 443	123.97	3.72
		Encor 443 with 3% Oxylink 3101	121.37	4.77
		EK 3-32R2 with 1% Oxylink 3101	119.66	3.41
		EK 3-32R2 with 3% Oxylink 3101	121.64	2.43
		EK 3-32R2 with 1% Nanofil	48.12	7.68
		EK 3-32R2 with 3% Nanofil	26.83	9.93
		EK 3-32R2 with 0.5% SRC-220	23.00	8.83
		EK 3-32R2 with 0.1% FC 4434	38.47	9.28
		EK 3-32R2 with 0.4% Nanobyk 3810	63.57	8.61

To meet the target perm ratings at 25% and 75% RH, the coating weights for the systems need to be increased.



Example 5

Separate systems including Ancarez 550 and Neocar 820 were tested. The systems that were applied on kraft paper were comprised of:

- 1) Ancarez AR555 with 1% Nanofil
- 5 Ancarez AR555 with 3% Nanofil
- Ancarez AR555 with SRC-220 and FC-4434
- Ancarez AR555 with SRC-220
- Ancarez AR555 with FC-4434
- Neocar 820 with 1% Nanofil
- 10 Neocar 820 with 3% Nanofil
- Neocar 820 with SRC-220 and FC-4434
- Neocar 820 with SRC-220
- Neocar 820 with FC-4434

The perm results of this evaluation are provided in Table 8. The ASTM D1653  
15 protocol was used for the testing.

**Table 8. ASTM D1653 Perm Results – VI**

<b>Average RH</b>	<b>Desired Perms</b>	<b>Coating on Kraft Paper</b>	<b>Perms</b>	<b>Coating Weight (g/ft<sup>2</sup>)</b>
25% RH	≤ 2.0	Ancarez AR 555 + 1% Nanofil	4.11	17.16
		Ancarez AR 555 + 3% Nanofil	6.51	14.24
		Ancarez AR 555 + SRC-220 + FC-4434	5.96	14.86
		Ancarez AR 555 + SRC-220	7.61	12.98
		Ancarez AR 555 + FC-4434	5.59	14.35
		Neocar 820 + 1% Nanofil	8.54	13.01
		Neocar 820 + 3% Nanofil	8.65	13.00
		Neocar 820 + SRC-220 + FC-4434	6.84	14.10
		Neocar 820 + SRC-220	6.08	14.36
		Neocar 820 + FC-4434	10.00	11.30
75% RH	12 - 24	Ancarez AR 555 + 1% Nanofil	40.52	12.24
		Ancarez AR 555 + 3% Nanofil	39.01	13.58
		Ancarez AR 555 + SRC-220 + FC-4434	35.25	13.17
		Ancarez AR 555 + SRC-220	39.72	12.01
		Ancarez AR 555 + FC-4434	36.92	12.51
		Neocar 820 + 1% Nanofil	51.61	11.62
		Neocar 820 + 3 % Nanofil	23.19	13.08
		Neocar 820 + SRC-220 + FC-4434	17.49	12.78
		Neocar 820 + SRC-220	16.41	11.76
		Neocar 820 + FC-4434	43.56	11.82

Example 6

The most promising systems from Tables 5 and 6 were selected for evaluation at 45%  
5 and 95% RH.

SoyAA-1/styrene (46:54 by weight and listed as EK 3-32R2 in Table 9) + FC-4434

Ancarez AR555

Ancarez AR555 + 1% Nanofil

Ancarez AR555 + SRC-220 + FC-4434

Ancarez AR555 + FC-4434

Neocar 820 + 3% Nanofil

5 Neocar 820 + SRC-220 + FC-4434

Neocar 820 + SRC-220

The perm results of this evaluation are listed in Table 9. The ASTM D1653 protocol was used for the testing.

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**Table 9. ASTM D1653 Perm Perm Results – VII**

<b>Average RH</b>	<b>Desired Perms</b>	<b>Coating on Kraft Paper</b>	<b>Perms</b>	<b>Coating Weight (g/ft<sup>2</sup>)</b>
45% RH	≤ 5.0	EK 3-32R2 + 0.1% FC-4434	11.13	8.11
		Ancarez AR 555	10.31	5.19
		Ancarez AR 555 + 1% Nanofil	6.89	7.29
		Ancarez AR 555 + SRC-220 + FC-4434	7.34	9.74
		Ancarez AR 555 + FC-4434	6.91	7.87
		Neocar 820 + 3% Nanofil	7.09	8.38
		Neocar 820 + SRC-220 + FC-4434	6.13	7.48
		Neocar 820 + SRC-220	11.92	3.99
95% RH	> 25	EK 3-32R2 + 0.1% FC-4434	81.79	10.06
		Ancarez AR 555	114.38	6.59
		Ancarez AR 555 + 1% Nanofil	153.54	6.92
		Ancarez AR 555 + SRC-220 + FC-4434	117.54	10.42
		Ancarez AR 555 + FC-4434	129.31	9.14
		Neocar 820 + 3% Nanofil	100.07	9.84
		Neocar 820 + SRC-220 + FC-4434	41.22	8.27
		Neocar 820 + SRC-220	58.13	6.46

At 45% RH, none of the above systems met the target perm rating but all met the target at 95% RH.

#### Example 7

Several additional systems were evaluated at 45% and 95% RH:

5 SoyAA-1/styrene (46:54 by weight and listed as EK 3-32R2 in Table 10) + 1% Nanofil

SoyAA-1/styrene (46:54 by weight) + 3% Nanofil

Neocar 820 + 1% Nanofil

Ancarez AR555 + SRC-220

10 Ancarez AR555 + 3% Nanofil

Ancarez AR555 crosslinked with Anquamine 401 (epoxy:amine ratio 2:1)

The perm results of this evaluation are listed in Table 10. The ASTM D1653 protocol was used for the testing.

15 **Table 10. ASTM D1653 Perm Results – VIII**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
45% RH	≤ 5.0	EK 3-32R2 + 1% Nanofil	18.77	6.02
		EK 3-32R2 + 3% Nanofil	18.36	9.09
		Neocar 820 + 1% Nanofil	11.89	6.70
		Ancarez AR 555 + SRC-220	10.93	7.90
		Ancarez AR 555 + 3% Nanofil	6.91	10.26
		Ancarez AR 555 crosslinked with Anquamine 401	3.55	12.79
95% RH	> 25	EK 3-32R2 + 1% Nanofil	88.72	7.69
		EK 3-32R2 + 3% Nanofil	123.03	8.39
		Neocar 820 + 1% Nanofil	22.77	9.72
		Ancarez AR 555 + SRC-220	93.47	9.67
		Ancarez AR 555 + 3% Nanofil	145.89	9.12
		Ancarez AR 555 crosslinked with Anquamine 401	26.00	13.03

Only Ancarez AR 555 crosslinked with Anquamine 401 system met the desired perms as Table 10 showed.

Example 8

The following samples were evaluated at all four RH levels.

- 5            SoyAA-1/styrene (46:54 by weight and listed as EK 3-85 in Table 11) (5 mils)  
             SoyAA-1/styrene (46:54 by weight)with 1% Nanofil + FC-4434 (3 mils)  
             SoyAA-1/styrene (46:54 by weight)with 1% Nanofil + FC-4434 (5 mils)  
             SoyAA-1/styrene (46:54 by weight)+ FC-4434 (5 mils)  
             Neocar 820 + FC-4434
- 10           The perm results of this evaluation are listed in Table 11. The ASTM D1653 protocol was used for the testing.

**Table 11. ASTM D1653 Perm Results – IX**

<b>Average RH</b>	<b>Desired Perms</b>	<b>Coating on Kraft Paper</b>	<b>Perms</b>	<b>Coating Weight (g/ft<sup>2</sup>)</b>
25% RH	≤ 2.0	EK 3-85	7.89	7.27
		EK 3-85 + Nanofil + FC-4434 (3 mils)	9.47	4.45
		EK 3-85 + Nanofil + FC-4434 (5 mils)	6.88	7.63
		EK 3-85 + FC-4434	10.02	6.55
		Neocar 820 + FC-4434	5.22	4.89
45% RH	< 5.0	EK 3-85	7.53	7.94
		EK 3-85 + Nanofil + FC-4434 (3 mils)	8.93	4.43
		EK 3-85 + Nanofil + FC-4434 (5 mils)	7.89	7.88
		EK 3-85 + FC-4434	7.14	7.93
		Neocar 820 + FC-4434	6.94	8.25
75% RH	12 - 24	EK 3-85	24.73	7.76
		EK 3-85 + Nanofil + FC-4434 (3 mils)	53.11	3.99
		EK 3-85 + Nanofil + FC-4434 (5 mils)	23.45	7.57
		EK 3-85 + FC-4434	33.10	7.02
		Neocar 820 + FC-4434	15.12	8.35
95% RH	> 25	EK 3-85	64.20	8.20
		EK 3-85 + Nanofil + FC-4434 (3 mils)	119.17	5.26
		EK 3-85 + Nanofil + FC-4434 (5 mils)	54.69	9.91
		EK 3-85 + FC-4434	113.07	6.37
		Neocar 820 + FC-4434	107.53	6.97

None of the tested systems met the target perm ratings at 25%, 45% and 75% RH due to low coating weights on the kraft paper substrate. However, all systems met the target perm ratings at 95% RH.

Example 9

5 In the next round of testing, the following systems were evaluated at all four RH levels:

SoyAA-1/styrene (46:54 and listed as EK 4-23 in Table 12)

SoyAA-1/styrene (46:54 and listed as EK 4-25 in Table 12)

AR555 + 1% Nanofil +0.1% FC-4434

10 AR555 + 1% Nanofil +0.2% FC-4434

AR555 + 1% Nanofil +0.5% SRC-220

AR555 + 1% Nanofil + 0.2% FC-4434 + 0.5% SRC-220

AR555 + 1% Nanofil + 0.1% FC-4434 + 1% SRC-220

SoyAA-1/styrene (46:54 and listed as EK 3-85 in Table 12)+ 1% Nanofil + 0.1%

15 FC-4434

SoyAA-1/styrene (46:54)+ 1% Nanofil + 0.2% FC-4434

SoyAA-1/styrene (46:54)+ 1% Nanofil + 0.1% FC-4434 + 0.5% SRC-220

SoyAA-1/styrene (46:54)+ 1% Nanofil + 0.2% FC-4434 + 0.5% SRC-220

SoyAA-1/styrene (46:54)+ 1% Nanofil + 0.1% FC-4434 + 1% SRC-220

20 SoyAA-1/styrene (46:54)+ 2% Nanofil + 0.1% FC-4434

The perm results of this evaluation are listed in Table 12. The ASTM D1653 protocol was used for the testing.

**Table 12. ASTM D1653 Perm Results – X**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
25% RH	≤ 2.0	EK 4-23	8.34	7.23
		EK 4-25	9.39	6.91
		AR 555 + 1% Nanofil + 0.1% FC4434	3.81	12.53
		AR 555 + 1% Nanofil + 0.2% FC4434	3.76	12.83
		AR 555 + 1% Nanofil + 0.5% SRC 220	4.53	11.34
		AR 555 + 1% Nanofil + 0.2% FC	4.41	11.93

		4434 + 0.5% SRC 220		
		AR 555 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	3.81	12.43
		EK 3-85 + 1% Nanofil + 0.1% FC 4434	8.67	7.12
		EK 3-85 + 1% Nanofil + 0.2% FC 4434	8.29	7.15
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 0.5% SRC 220	6.27	8.42
		EK 3-85 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	7.66	7.53
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	6.59	8.00
		EK 3-85 + 2% Nanofil + 0.1% FC 4434	6.07	9.19
45% RH	< 5.0	EK 4-23	5.48	6.71
		EK 4-25	5.60	6.90
		AR 555 + 1% Nanofil + 0.1% FC4434	4.40	12.72
		AR 555 + 1% Nanofil + 0.2% FC4434	5.01	11.83
		AR 555 + 1% Nanofil + 0.5% SRC 220	4.43	10.26
		AR 555 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	5.06	11.95
		AR 555 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	4.61	11.95
		EK 3-85 + 1% Nanofil + 0.1% FC 4434	5.69	9.47
		EK 3-85 + 1% Nanofil + 0.2% FC 4434	5.45	8.38
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 0.5% SRC 220	5.49	9.91
		EK 3-85 + 1% Nanofil + 0.2% FC	5.45	10.38



		4434 + 0.5% SRC 220		
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	5.60	9.70
		EK 3-85 + 2% Nanofil + 0.1% FC 4434	5.60	8.72
75% RH	12 - 24	EK 4-23	30.49	7.03
		EK 4-25	36.56	7.34
		AR 555 + 1% Nanofil + 0.1% FC 4434	44.70	13.30
		AR 555 + 1% Nanofil + 0.2% FC 4434	42.79	13.28
		AR 555 + 1% Nanofil + 0.5% SRC 220	45.98	12.37
		AR 555 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	43.40	11.52
		AR 555 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	43.20	12.07
		EK 3-85 + 1% Nanofil + 0.1% FC 4434	31.36	8.50
		EK 3-85 + 1% Nanofil + 0.2% FC 4434	40.85	6.96
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 0.5% SRC 220	26.28	8.81
		EK 3-85 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	34.07	7.91
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	36.38	8.09
		EK 3-85 + 2% Nanofil + 0.1% FC 4434	28.49	12.41
95% RH	> 25	EK 4-23	43.60	7.57
		EK 4-25	110.92	6.18
		AR 555 + 1% Nanofil + 0.1% FC	152.52	12.75

		4434		
		AR 555 + 1% Nanofil + 0.2% FC 4434	131.98	12.25
		AR 555 + 1% Nanofil + 0.5% SRC 220	144.36	11.35
		AR 555 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	137.05	11.44
		AR 555 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	136.66	12.42
		EK 3-85 + 1% Nanofil + 0.1% FC 4434	85.95	7.61
		EK 3-85 + 1% Nanofil + 0.2% FC 4434	55.73	8.11
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 0.5% SRC 220	47.94	8.13
		EK 3-85 + 1% Nanofil + 0.2% FC 4434 + 0.5% SRC 220	44.67	9.66
		EK 3-85 + 1% Nanofil + 0.1% FC 4434 + 1% SRC 220	60.48	8.13
		EK 3-85 + 2% Nanofil + 0.1% FC 4434	74.16	9.68

None of the systems met the target perm rating at 25% RH, whereas some tested systems met the perm ratings at 45% RH, 75% RH and 95% RH.

#### Example 10

5 The following samples were evaluated at all four RH levels. The results are listed in Table 13. The ASTM D1653 protocol was used for the testing.

SoyAA-1/styrene (46:54 by weight and listed as EK 3-85 in Table 13) (2 month sample)

SoyAA-1/styrene (46:54 by weight and listed as EK 3-32R6 in Table 13)+ 0.1%

10 Cobalt Hydrocure II metal on resin solids

SoyAA-1/styrene (46:54 by weight)+ 3% Additol as supplied on resin solids

SoyAA-1/styrene (46:54 by weight)+ 1% Oxycoat as supplied on resin solids

SoyAA-1/styrene (46:54 by weight)+ 2% Nanofil +0.2% FC-4434

SoyAA-1/styrene (46:54 by weight)+ 2% Nanofil + 0.1% FC-4434 + 0.5% SRC-

220

SoyAA-1/styrene (46:54 by weight)+ 2% Nanofil + 0.2% FC-4434 + 1% SRC-

5

220

AR555 + 2% Nanofil + 0.1% FC-4434

AR555 + 2% Nanofil + 0.2% FC-4434

AR555 + 2% Nanofil + 0.1% FC-4434 + 0.5% SRC-220

AR555 + 2% Nanofil + 0.2% FC-4434 + 1% SRC-220

10

**Table 13. ASTM D1653 Perm Results – XI**

Average RH	Desired Perms	Coating on Kraft Paper	Perms	Coating Weight (g/ft <sup>2</sup> )
25% RH	≤ 2.0	EK 3-85 (2 month sample)	7.64	7.88
		EK 3-32R6 + 0.1% Cobalt Hydrocure II metal on resin solids	10.29	7.40
		EK 3-32R6 + 3% Additol as supplied on resin solids	11.89	3.98
		EK 3-32R6 + 1% Oxycoat as supplied on resin solids	10.50	4.28
		EK 3-85 + 2% Nanofil +0.2% FC4434	6.61	4.90
		EK 3-85 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC 220	7.94	9.06
		EK 3-85 + 2% Nanofil + 0.2% FC4434 + 1% SRC 220	8.37	8.24
		AR555 + 2% Nanofil + 0.1% FC4434	10.18	7.84
		AR555 + 2% Nanofil + 0.2% FC4434	5.05	8.71
		AR555 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC220	6.75	9.89
		AR555 + 2% Nanofil + 0.2% FC4434 + 1% SRC220	8.15	10.01

45% RH	< 5.0	EK 3-85 (2 month sample)	-	-
		EK 3-32R6 + 0.1% Cobalt Hydrocure II metal on resin solids	6.13	9.58
		EK 3-32R6 + 3% Additol as supplied on resin solids	6.72	5.92
		EK 3-32R6 + 1% Oxycoat as supplied on resin solids	7.45	5.75
		EK 3-85 + 2% Nanofil +0.2% FC4434	7.85	7.92
		EK 3-85 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC 220	6.99	7.33
		EK 3-85 + 2% Nanofil + 0.2% FC4434 + 1% SRC 220	7.52	6.96
		AR555 + 2% Nanofil + 0.1% FC4434	6.84	9.93
		AR555 + 2% Nanofil + 0.2% FC4434	9.58	7.86
		AR555 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC220	5.38	9.23
		AR555 + 2% Nanofil + 0.2% FC4434 + 1% SRC220	5.75	9.48
75% RH	12 - 24	EK 3-85 (2 month sample)	20.78	6.54
		EK 3-32R6 + 0.1% Cobalt Hydrocure II metal on resin solids	26.07	7.53
		EK 3-32R6 + 3% Additol as supplied on resin solids	28.81	4.79
		EK 3-32R6 + 1% Oxycoat as supplied on resin solids	40.59	4.69
		EK 3-85 + 2% Nanofil +0.2% FC4434	22.26	10.57
		EK 3-85 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC 220	21.41	10.26
		EK 3-85 + 2% Nanofil + 0.2% FC4434 + 1% SRC 220	20.36	9.52

		AR555 + 2% Nanofil + 0.1% FC4434	39.81	10.52
		AR555 + 2% Nanofil + 0.2% FC4434	39.93	11.95
		AR555 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC220	44.93	10.73
		AR555 + 2% Nanofil + 0.2% FC4434 + 1% SRC220	38.06	11.25
95% RH	> 25	EK 3-85 (2 month sample)	-	-
		EK 3-32R6 + 0.1% Cobalt Hydrocure II metal on resin solids	163.82	7.51
		EK 3-32R6 + 3% Additol as supplied on resin solids	151.02	6.13
		EK 3-32R6 + 1% Oxycoat as supplied on resin solids	119.80	6.11
		EK 3-85 + 2% Nanofil + 0.2% FC4434	120.13	7.13
		EK 3-85 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC 220	110.79	8.73
		EK 3-85 + 2% Nanofil + 0.2% FC4434 + 1% SRC 220	135.97	8.86
		AR555 + 2% Nanofil + 0.1% FC4434	229.11	9.68
		AR555 + 2% Nanofil + 0.2% FC4434	190.38	10.51
		AR555 + 2% Nanofil + 0.1% FC4434 + 0.5% SRC220	192.27	9.89
		AR555 + 2% Nanofil + 0.2% FC4434 + 1% SRC220	238.66	11.16

Example 10

The following systems were selected for testing along with a Nylon 6 control

**Table 14a**

<b>SoyAA-1/styrene + 2% Nanofil + 0.1% FC-4434</b>		
<b>Raw Materials</b>	<b>Grams</b>	<b>% Solids</b>
SoyAA-1/styrene (46:54 by weight)	94.99	50.0
Nanofil base	4.92	19.3
FC-4434	0.09	
Total	100.00	

**Table 14b**

<b>Ancarez AR555 + 1% Nanofil + 0.1% FC-4434</b>		
<b>Raw Materials</b>	<b>Grams</b>	<b>% Solids</b>
Ancarez AR555	97.05	55.0
Nanofil base	2.85	19.3
FC-4434	0.10	
Total	100.00	

**Table 14c**

<b>Ancarez AR555 + 1% Nanofil +0.1% FC-4434 + 1% SRC-220</b>		
<b>Raw Materials</b>	<b>Grams</b>	<b>% Solids</b>
Ancarez AR555	96.09	55.0
Nanofil Base	2.82	19.3
FC-4434	0.10	
SRC-220	0.99	
Total	100.00	

5

The Nanofil base mentioned in the above tables was prepared under high shear in a Ross mixer by slowly adding Nanofil 116 to water as per the proportion described in Table 15.

**Table 15. Nanofil Base**

<b>Raw Material</b>	<b>Grams</b>	<b>% Solids</b>
Nanofil 116	19.30	100
Water	80.70	-
Total	100.00	

10

An additional system including a reduced cross-linker was also tested as shown in Table 16.

**Table 16**

<b>Ancarez AR555 with Reduced Crosslinker</b>		
<b>Raw Materials</b>	<b>Grams</b>	<b>% Solids</b>
Ancarez AR555	98.35	55
Anquamine 401	1.65	70
Total	100.00	

5

Each of the systems represented by the four formulations in Tables 14a-14c and 16 were applied on three (3) sheets of 6" x 12" kraft paper. The coating weights expressed in g/ft<sup>2</sup> and determined over 1 inch squares of the coated sheets are listed in Table 17.

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**Table 17. Coating Weights**

<b>System</b>	<b>Weight (g/ft<sup>2</sup>)</b>
AR555 + 1% Nanofil + 0.1% FC-4434	1.703
SoyAA-1/styrene (EK 3-85) + 2% Nanofil + 0.1% FC-4434	2.810
AR555 + 1% Nanofil + 0.1% FC-4434 + 1% SRC-220	1.803
AR555 with reduced crosslinker (Table 16)	1.867

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Some of the results of the testing are shown in FIG. 2. The ASTM D1653 protocol was used for the testing. As can be seen from the graph, the tested coatings provided perm ratings similar to those provided by the Nylon 6 control. For reference purposes, the SoyAA-1/styrene sample is labeled as EK 3-85 in the graph. At 25% RH, the Ancarez AR555 + 1% Nanofil + 0.1% FC4434 provided a perm rating of 3.81 perms, the other two coatings provided a perm rating of about 6.1 perms while the Nylon 6 film control sample had 1.58 perms. The SoyAA-1/styrene system provided a perm rating of about 5.6 perms at 45% average RH while the Nylon 6 film had 9.78 perms. At 75% RH, only the Neocar 820 + SRC-220 + FC4434 system provided similar perm to the Nylon 6 film sample. All samples showed greater than 17 perms at 95% RH.

Example 11

The following system was selected for testing along with a Nylon 6 control following ASTM E 96 standard test method:

**Table 18**

<b>Ancarez AR555 + Anquamine 401</b>		
<b>Raw Materials</b>	<b>Grams</b>	<b>% Solids</b>
Ancarez AR555	66.67	55
Anquamine 401	33.33	70
Total	100.00	

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The ASTM E96 water vapor permeance test results for the Nylon 6 film control sample and the Ancarez AR555 + Anquamine 401 coating system on kraft paper sample are shown in Table 19 and plotted in FIG. 3.

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**Table 19. ASTM E96 Test Results**

<b>Water Vapor Permeance Test Results Per ASTM E96 for Ancarez AR555 + Anquamine 401</b>				
<b>Item</b>	<b>Dry Cup</b>	<b>Wet Cup</b>	<b>Dry Cup</b>	<b>Wet Cup</b>
Chamber RH (%)	50		90	
Mean RH (%)	25	75	45	95
Target permeance values	< 1	6 – 12	< 2.5	> 17
Permeance (perms)	0.79	6.86	1.68	17.28
<b>Water Vapor Permeance Test Results Per ASTM E96 for 2 mil Nylon 6 Film</b>				
<b>Item</b>	<b>Dry Cup</b>	<b>Wet Cup</b>	<b>Dry Cup</b>	<b>Wet Cup</b>
Chamber RH (%)	50		90	
Mean RH (%)	25	75	45	95
Permeance (perms)	0.62	9.71	1.81	34.81

The results in Table 19 and plotted in FIG. 3 show that the tested coating on kraft provided perm ratings similar to those provided by the Nylon 6 control for three of all four average RH values except the 95% RH. At 25% RH, the Ancarez AR555 + Anquamine 401

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coating system provided a perm rating of 0.79 perms while the Nylon 6 film had 0.62 perms. The Ancarez AR555 + Anquamine 401 coating system on kraft provided a perm rating of 1.68 perms while the Nylon 6 film control sample had 1.81 perms at 45% RH. Even though the Ancarez AR555 + Anquamine 401 coating system on kraft provided a 6.86 perms rating at 75% RH, which is lower than the Nylon 6 film (9.71 perms), it still meets the target of 6 – 12 perms. At 95% RH the Ancarez AR555 + Anquamine 401 coating system on kraft provided a 17.28 perms rating, which is slightly greater than the target of 17 perms.

#### Example 12

Anquamine 401 is diluted with water by adding 4 weight parts water to 1 weight part of Anquamine 401 (AQ401). The dilution is mixed with moderate shear at ambient conditions for 15 minutes to avoid formation of foam. Then, Ancarez AR555 is added to the diluted Anquamine 401 solution in a ratio of 3 weight parts Ancarez AR555 to 1.25 weight parts of diluted Anquamine 401 and stirred for 15 minutes at moderate shear and ambient condition. The resulting blend was applied onto kraft paper sheets. Table 20 lists the weight ratio of the ingredient. Tables 21A and 21B show the results of the ASTM E96 tests. The results are also summarized in FIG. 4.

Table 20

	<b>Weight</b>	<b>Wt %</b>	<b>Solids %</b>	<b>Solids</b>
Ancarez AR555	1.80	70.59	55	39.82
Anquamine 401	0.60	23.53	70	16.47
Water	0.15	5.88		0.00
	2.55	100.00		55.29
Desired coverage (g/m <sup>2</sup> ) - Min	55			
Desired coverage (g/m <sup>2</sup> ) - Max	60			
Wet coating weight in lb required/m <sup>2</sup> - Min	0.2406			
Wet coating weight in lb required/m <sup>2</sup> - Max	0.2624			

Table 21 A

Test A: Water Vapor Permeance for Coated Kraft Sample			
Sample	Replicate	Water Vapor Permeance, perms	
		25% Mean RH	45% Mean RH
Formulation: AR555 + AQ401	1	1.33	3.86
	2	1.29	3.90
	3	1.07	3.29
	<i>Mean</i>	<i>1.23</i>	<i>3.68</i>
	<i>SD</i>	<i>0.14</i>	<i>0.34</i>
	Replicate	Water Vapor Permeance, perms	
		75% Mean RH	95% Mean RH
	1	11.17	31.99
	2	10.31	27.57
	3	11.70	30.91
	<i>Mean</i>	<i>11.06</i>	<i>30.16</i>
	<i>SD</i>	<i>0.70</i>	<i>2.30</i>

Table 21 B

Test B: Water Vapor Permeance for Coated Kraft Sample			
Sample	Replicate	Water Vapor Permeance, perms	
		25% Mean RH	45% Mean RH
Formulation: AR555 + AQ401	B7	0.74	2.09
	B8	0.51	1.45
	B9	0.68	1.79
	<i>Mean</i>	<i>0.64</i>	<i>1.78</i>
	<i>SD</i>	<i>0.12</i>	<i>0.32</i>
	Replicate	Water Vapor Permeance, perms	
		75% Mean RH	95% Mean RH
	B10	7.45	20.51
	B11	8.19	22.86
	B12	7.10	19.30
	<i>Mean</i>	<i>7.58</i>	<i>20.89</i>
	<i>SD</i>	<i>0.56</i>	<i>1.81</i>

Example 13

Anquamine 401 is diluted with water by adding 4 weight parts water to 1 weight part of Anquamine 401. The dilution is mixed with moderate shear at ambient conditions for 15 minutes to avoid formation of foam. Then, 1 weight part of SoyAA-1 latex (known as EK 5-02/22) is blended with 1.25 weight part of the diluted Anquamine 401. Thereafter, 3 weight parts of Ancarez AR555 is added to 2.25 weight parts of the diluted Anquamine 401/SoyAA-1 latex blend. The resulting blend had a weight ratio of Ancarez AR555 : Anquamine 401 : Soy AA-1 latex of 3 : 1.25 : 1. The resulting blend was applied onto kraft paper sheets. Tables 22A and 22B show the results of the ASTM E96 tests. The results are also summarized in FIG. 5.

Table 22 A

<b>Test C: Water Vapor Permeance for Coated Kraft Sample</b>			
<b>Sample</b>	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>25% Mean RH</b>	<b>45% Mean RH</b>
<b>VOMM Formulation: SoyAA-1 latex + AR555 + AQ401</b>	1	2.32	5.87
	2	2.11	2.30
	3	1.67	2.00
	<i>Mean</i>	<i>2.03</i>	<i>3.39</i>
	<i>SD</i>	<i>0.33</i>	<i>2.15</i>
	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>75% Mean RH</b>	<b>95% Mean RH</b>
	1	7.21	10.11
	2	8.28	13.52
	3	8.15	10.63
	<i>Mean</i>	<i>7.88</i>	<i>11.42</i>
	<i>SD</i>	<i>0.59</i>	<i>1.84</i>

Table 22 B

<b>Test D: Water Vapor Permeance for Coated Kraft Sample</b>			
<b>Sample</b>	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>25 % Mean RH</b>	<b>45 % Mean RH</b>
<b>VOMM Formulation: SoyAA-1 latex + AR555 + AQ401</b>	1	1.29	3.21
	2	0.87	2.30
	3	0.86	2.00
	<i>Mean</i>	<i>1.01</i>	<i>2.50</i>
	<i>SD</i>	<i>0.25</i>	<i>0.63</i>
	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>75 % Mean RH</b>	<b>95 % Mean RH</b>
	1	4.74	12.23
	2	5.70	14.58
	3	4.92	12.85
	<i>Mean</i>	<i>5.12</i>	<i>13.22</i>
	<i>SD</i>	<i>0.51</i>	<i>1.22</i>

Comparison samples were prepared with polyethylene dispersions, PE1 and PE2. PE1 is Michem<sup>®</sup> Emulsion 93235 (a nonionic polyethylene emulsion); PE1 is Michem<sup>®</sup> Emulsion 61335 (an anionic polyethylene emulsion). For PE1, the SoyAA-1 latex : polyether ratio was 1 : 1. For PE2, the SoyAA-1 latex : polyether ratio was 3 : 2. The resulting blend was applied onto kraft paper sheets. Tables 23A and 23B show the results of the ASTM E96 evaluation.

Table 23A

Comparative Test A: Water Vapor Permeance for Coated Kraft Sample			
Sample	Replicate	Water Vapor Permeance, perms	
		25% Mean RH	45% Mean RH
VOMM Formulation : SoyAA-1 latex + PE1	1	12.69	23.07
	2	13.58	24.75
	3	11.00	19.71
	<i>Mean</i>	<i>12.42</i>	<i>22.51</i>
	<i>SD</i>	<i>1.31</i>	<i>2.56</i>
	Replicate	Water Vapor Permeance, perms	
		75% Mean RH	95% Mean RH
	1	38.36	63.67
	2	31.75	53.73
	3	32.69	54.53
	<i>Mean</i>	<i>34.27</i>	<i>57.31</i>
	<i>SD</i>	<i>3.57</i>	<i>5.52</i>

Table 23B

Comparative Test B: Water Vapor Permeance for Coated Kraft Sample			
Sample	Replicate	Water Vapor Permeance, perms	
		25% Mean RH	45% Mean RH
VOMM Formulation: SoyAA-1 latex + PE1	1	5.01	9.03
	2	4.84	8.64
	3	4.70	8.35
	<i>Mean</i>	<i>4.85</i>	<i>8.67</i>
	<i>SD</i>	<i>0.15</i>	<i>0.34</i>
	Replicate	Water Vapor Permeance, perms	
		75% Mean RH	95% Mean RH
	1	20.25	39.16
	2	19.32	36.44
	3	18.68	37.49
	<i>Mean</i>	<i>19.42</i>	<i>37.70</i>
	<i>SD</i>	<i>0.79</i>	<i>1.37</i>

Table 23C

Comparative Test C: Water Vapor Permeance for Coated Kraft Sample			
Sample	Replicate	Water Vapor Permeance, perms	
		25% Mean RH	45% Mean RH
VOMM Formulation 2: SoyAA-1 latex + PE2 Additive	1	13.15	22.37
	2	12.81	21.56
	3	11.76	20.04
	<i>Mean</i>	<i>12.57</i>	<i>21.32</i>
	<i>SD</i>	<i>0.72</i>	<i>1.18</i>
	Replicate	Water Vapor Permeance, perms	
		75% Mean RH	95% Mean RH
	1	36.68	56.32
	2	36.41	56.54
	3	33.70	52.63
	<i>Mean</i>	<i>35.59</i>	<i>55.17</i>
	<i>SD</i>	<i>1.65</i>	<i>2.20</i>

Table 23D

<b>Comparative Test D: Water Vapor Permeance for Coated Kraft Sample</b>			
<b>Sample</b>	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>25% Mean RH</b>	<b>45% Mean RH</b>
<b>VOMM Formulation 2 : SoyAA-1 latex + PE2 Additive</b>	1	8.75	15.94
	2	6.88	12.21
	3	6.63	11.92
	<i>Mean</i>	<i>7.42</i>	<i>13.36</i>
	<i>SD</i>	<i>1.16</i>	<i>2.24</i>
	<b>Replicate</b>	<b>Water Vapor Permeance, perms</b>	
		<b>75% Mean RH</b>	<b>95% Mean RH</b>
	1	20.97	31.18
	2	18.85	28.54
	3	17.64	27.93
	<i>Mean</i>	<i>19.15</i>	<i>29.22</i>
	<i>SD</i>	<i>1.68</i>	<i>1.73</i>

When introducing elements of the examples disclosed herein, the articles "a," "an," "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising," "including" and "having" are intended to be open-ended and mean that there may be additional elements other than the listed elements. It will be recognized by the person of ordinary skill in the art, given the benefit of this disclosure, that various components of the examples can be interchanged or substituted with various components in other examples.

Although certain aspects, examples and embodiments have been described above, it will be recognized by the person of ordinary skill in the art, given the benefit of this disclosure, that additions, substitutions, modifications, and alterations of the disclosed illustrative aspects, examples and embodiments are possible.



## CLAIMS

1. An article comprising:
  - a cellulosic substrate;
  - an aqueous dispersion disposed on the substrate and effective to provide a variable water vapor perm rating as a function of humidity, in which the water vapor perm rating is about 2 perm or less at 25% average RH, as tested by ASTM D1653; or 2 perm or less at 25% average RH, as tested by ASTM E96, when the aqueous dispersion is cured as a coating on the cellulosic substrate.
2. The article of claim 1, in which the cured coating is further effective to provide a water vapor perm rating of less than or equal to 5 perms at 45% average RH as tested by ASTM D1653, or less than or equal to 5 perms at 45% average RH as tested by ASTM E96.
3. The article of claim 2, in which the cured coating is further effective to provide a water vapor perm rating of about 12 perms to about 24 perms at 75% average RH as tested by ASTM D1653, or about 6 perms to about 12 perms at 75% average RH as tested by ASTM E96.
4. The article of claim 3, in which the cured coating is further effective to provide a water vapor perm rating of greater than 25 perms at 95% average RH as tested by ASTM D1653, or greater than 11 perms at 95% average RH as tested by ASTM E96.
5. The article of claim 1, in which the aqueous dispersion comprises a plant oil macromonomer dispersion.
6. The article of claim 1, further comprising a reactant added to the aqueous dispersion.
7. The article of claim 1, in which the aqueous dispersion is substantially free of polyamides.
8. An article comprising:
  - a cellulosic substrate; and
  - a plant oil macromonomer dispersion disposed on the cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or ASTM E96, when the plant oil macromonomer dispersion is cured as a coating on the cellulosic substrate.
9. The article of claim 8, in which the variable water perm rating is about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH, is less than or equal to 5

perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96.

10. The article of claim 8, in which the plant oil macromonomer dispersion is a seed oil macromonomer dispersion.

11. The article of claim 8, in which the plant oil macromonomer dispersion is a vegetable oil macromonomer dispersion.

12. An article comprising:

a cellulosic substrate; and

a waterborne epoxy resin dispersion disposed on the cellulosic substrate and effective to provide a variable water vapor perm rating, as tested by ASTM D1653 or ASTM E96, when the waterborne epoxy resin dispersion is cured as a coating on the cellulosic substrate.

13. The article of claim 12, in which the variable water perm rating is about 2 perms or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 12 perms to about 24 perms at 75% average RH, and is greater than 25 perms at 95% average RH as tested by ASTM D1653, or about 2 perm or less at 25% average RH, is less than or equal to 5 perms at 45% average RH, is about 6 perms to about 12 perms at 75% average RH, and is greater than 11 perms at 95% average RH as tested by ASTM E96.

14. The article of claim 12, in which the waterborne epoxy resin is a waterborne solid epoxy resin.

15. The article of claim 14, in which the waterborne solid epoxy resin comprises a diglycidyl ether of bisphenol-A.

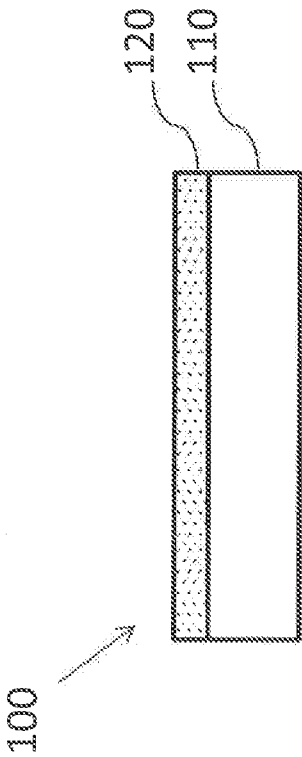


FIG. 1A

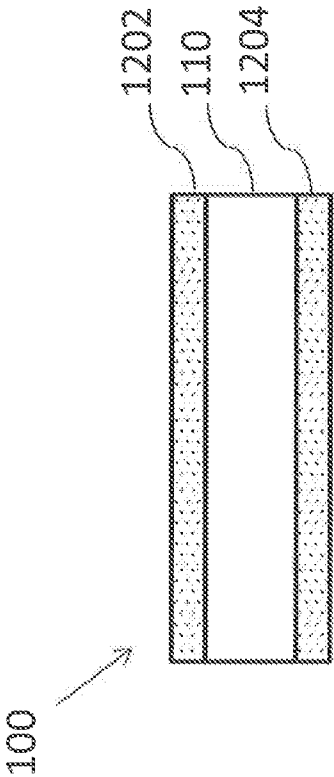


FIG. 1B

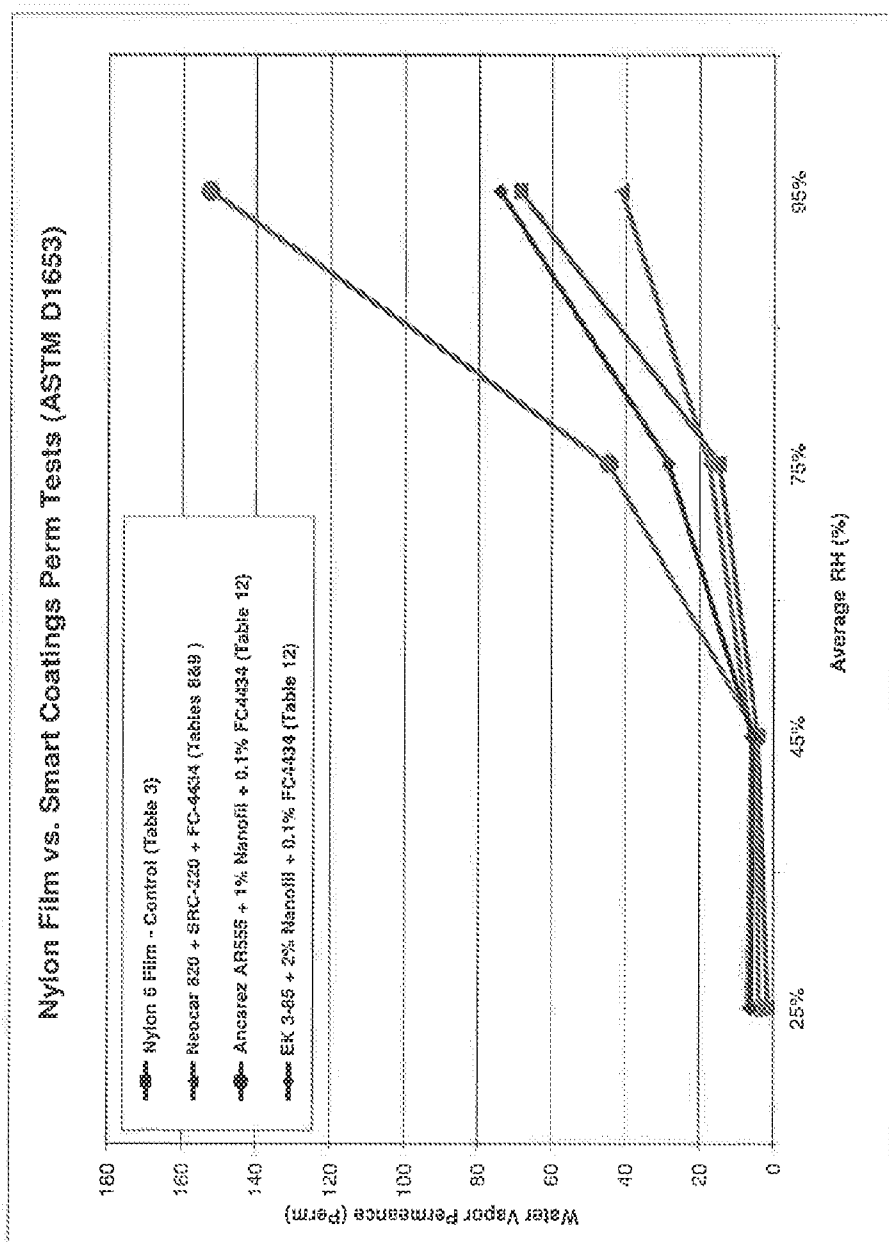


FIG. 2

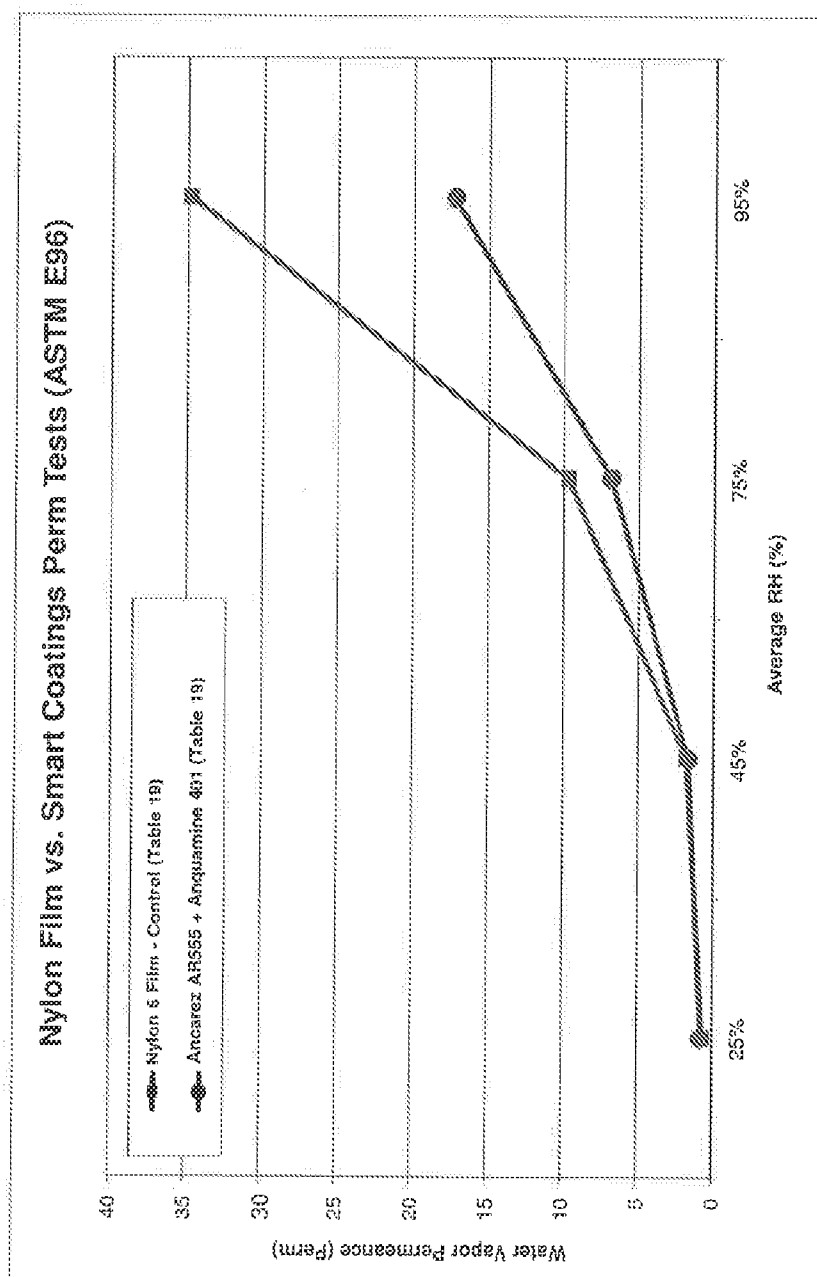


FIG. 3

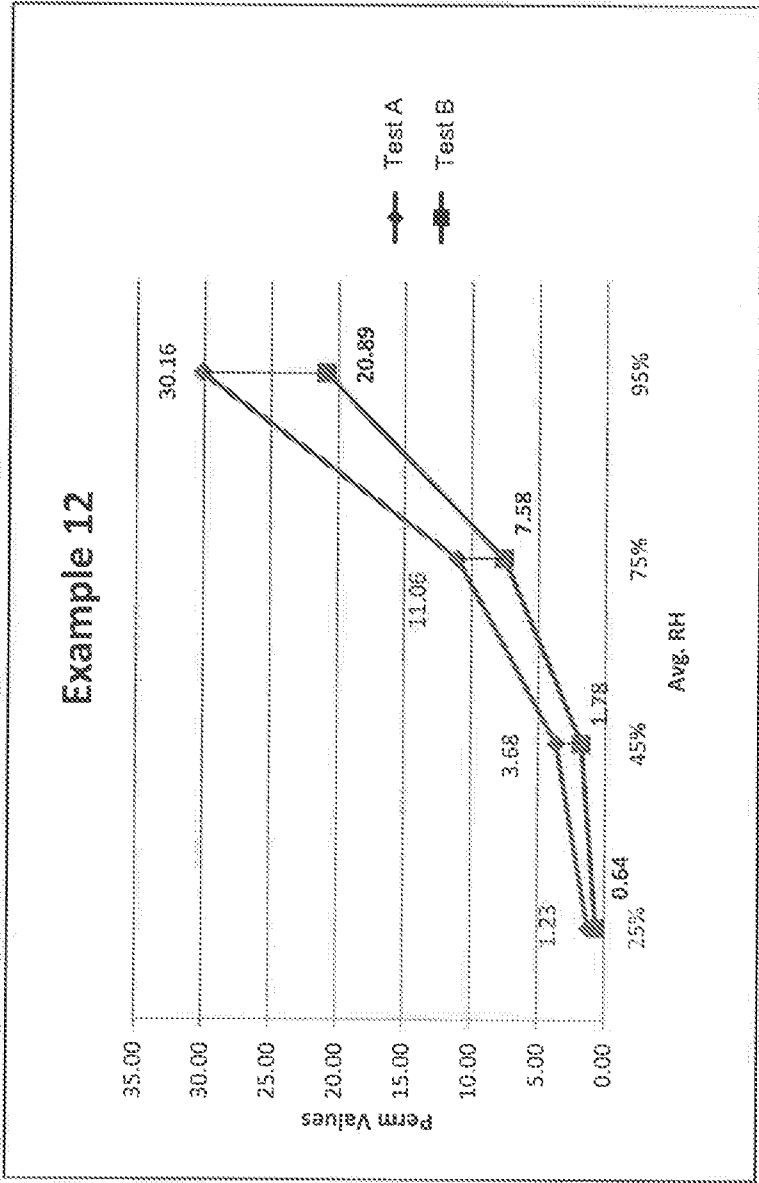


FIG. 4

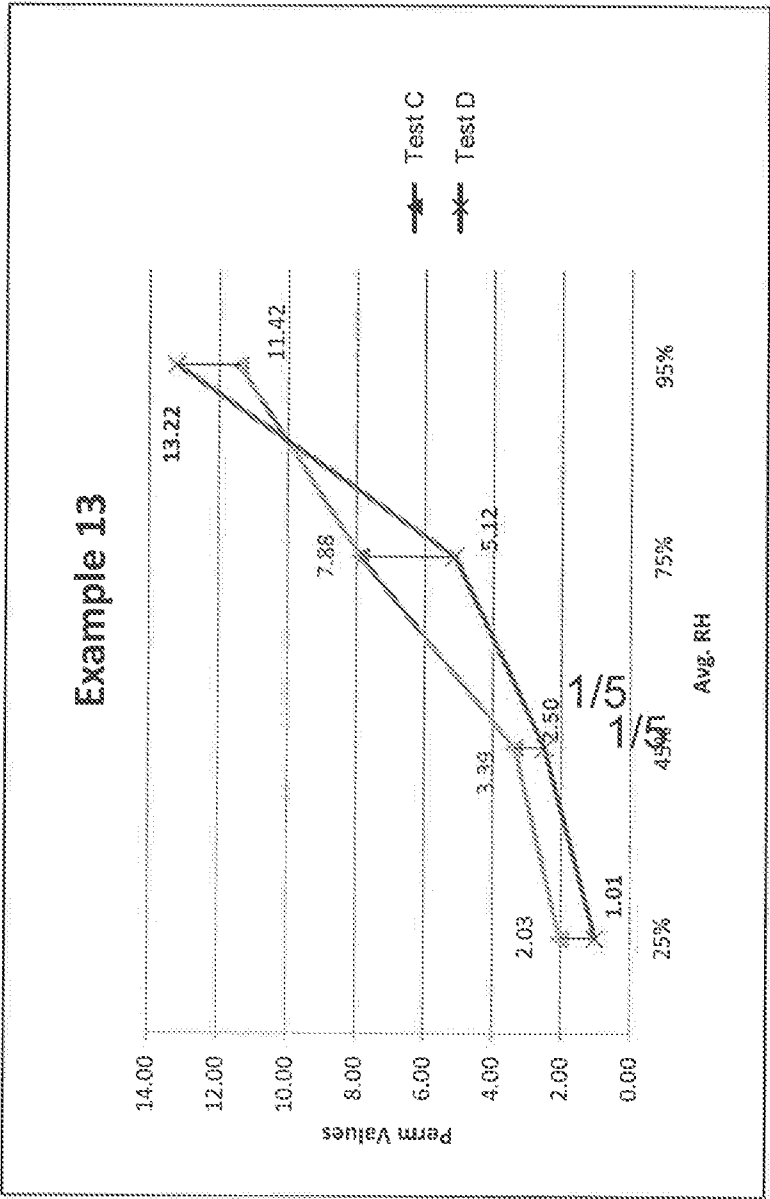


FIG. 5

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2014/071694****A. CLASSIFICATION OF SUBJECT MATTER****B32B 9/00(2006.01)i, B32B 23/00(2006.01)i, B32B 33/00(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

B32B 9/00; B05D 3/02; B65D 81/18; E04B 1/64; B32B 11/06; C08K 3/34; D21H 17/00; A61F 7/00; B32B 23/00; B32B 33/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) &amp; Keywords: substrate, aqueous, permeance, vapor, water

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2006-0178463 A1 (SACKS, RALPH) 10 August 2006 See abstract; and claims 1, 2, 20, 21.	12-15
A	US 2007-0036949 A1 (BOGRETT et al.) 15 February 2007 See abstract; and claim 73.	1-15
A	US 2006-0217790 A1 (OTA et al.) 28 September 2006 See abstract; and claims 1, 2.	1-15
A	US 2009-0152268 A1 (WHITEMAN et al.) 18 June 2009 See abstract; and claim 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

10 April 2015 (10.04.2015)

Date of mailing of the international search report

**13 April 2015 (13.04.2015)**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2014/071694**

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