SYSTEM FOR CONTAINING ABRASIVE ARTICLE

FIELD OF THE DISCLOSURE

[0001] This disclosure, in general, relates to a system for containing an abrasive article, and particularly to a system including a package configured to hold an abrasive article, wherein the package includes a fluoropolymer.

BACKGROUND

[0002] Abrasive articles are used in various industries to machine work pieces by cutting, lapping, grinding, or polishing. Abrasive articles are often shipped from one location to another and stored for an amount of time prior to use. As some bonded abrasive articles have bond matrix materials that are susceptible to water vapor adsorption, humid environment can adversely affect performance and cause performance degradation of such bonded abrasive articles. Performance degradation can include, for example, an increase in wear rate of the abrasive article, a reduction in grind rate on a work piece, or a reduction in the amount of cutting before the abrasive article wears out. A need for improved abrasive article packaging exists.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

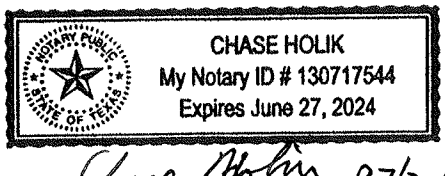
[0004] FIG. 1 includes an illustration of an exemplary system including a package and an abrasive article.

[0005] FIG. 2 includes a plot illustrating absolute humidity vs. exposure time of different systems.

[0006] FIG. 3 includes a plot illustrating absolute humidity vs. exposure time of additional systems.

[0007] FIG. 4 includes a plot illustrating absolute humidity vs. exposure time of additional systems.

[0008] The use of the same reference symbols in different drawings indicates similar or identical items. Embodiments are illustrated by way of example and are not limited in the accompanying figures. Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of



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the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the invention.

DETAILED DESCRIPTION

[0009] The following description in combination with the figures is provided to assist in understanding the teachings disclosed herein. The following discussion will focus on specific implementations and embodiments of the teachings. This focus is provided to assist in describing the teachings and should not be interpreted as a limitation on the scope or applicability of the teachings. However, other teachings can certainly be used in this application.

[0010] As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[0011] Also, the use of "a" or "an" is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural, or vice versa, unless it is clear that it is meant otherwise. For example, when a single item is described herein, more than one item may be used in place of a single item. Similarly, where more than one item is described herein, a single item may be substituted for that more than one item.

[0012] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The materials, methods, and examples are illustrative only and not intended to be limiting. To the extent that certain details regarding specific materials and processing acts are not described, such details may include conventional approaches, which may be found in reference books and other sources within the manufacturing arts.

[0013] Embodiments are drawn to a system for containing an abrasive article. The system can include a package defining an enclosed space configured to contain at least one abrasive article.

The package can be suited for shipping or storing abrasive articles including a hygroscopic bond material, such as a resin-based bond material or a hygroscopic inorganic material. The package can help to significantly reduce moisture uptake (i.e., water vapor adsorption) of abrasive articles contained therein, particularly when the package is exposed to a humid condition, and thus, can allow improved packaging and extended storage, reducing the likelihood of performance degradation of the abrasive article.

[0014] FIG. 1 includes an illustration of an exemplary system 100 including a package 102 defining an enclosed space 110. The package 102 can be configured to contain at least one abrasive article. As illustrated, a plurality of abrasive articles 104 are held in the enclosed space 110. In an embodiment, the abrasive article 104 can include an abrasive disc, a grinding wheel, an ultra-thin wheel, a cut-off wheel, a combination wheel, or any combination thereof. In another embodiment, the system 100 can include at least 1, at least 3, at least 5, at least 8, at least 10, at least 15, at least 20, at least 30, at least 50, or at least 500 abrasives articles 104 contained in the package 102.

[0015] The package 102 can be in the form of a bag, a pouch, or the like. In an embodiment, the package 102 can include a polymeric material. In an aspect, the polymeric material can include a fluoropolymer including, for example, polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV), or any combination thereof. In a particular embodiment, the fluoropolymer can include a homopolymer of polychlorotrifluoroethylene (PCTFE), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), or any combination thereof.

[0016] In another embodiment, the package 102 can be free of metal. For example, the package 102 can consist of a polymer. In a particular embodiment, the package 102 can consist of a fluoropolymer. More particularly, the package 102 can consist of at least one polymer selected from the group consisting of a homopolymer of polyvinylidene fluoride (PVDF), a copolymer of polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), a homopolymer of

polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV). In a particular aspect, the package 102 can consist of at least one fluoropolymer selected from the group consisting of a homopolymer of polychlorotrifluoroethylene (PCTFE), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of ethylene tetrafluoroethylene (ETFE), and a copolymer of ethylene chlorotrifluoroethylene (ECTFE). In a particular example, the package 102 can consist of a copolymer of ethylene tetrafluoroethylene (ETFE). In another particular example, the package 102 can consist of a copolymer of fluorinated ethylene propylene (FEP). In another particular example, the package 102 can consist of a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

[0017] In another embodiment, the package 102 can include a film, a sheet, or the like. In a particular embodiment, the package 102 can consist of a single layer, such as a single polymeric layer. In an exemplary implement, the package 102 can be formed with a single layer of a polymeric film, a single layer of a polymeric sheet, or the like. In an aspect, the polymeric layer can include a fluoropolymer described in embodiments of this disclosure. In a particular aspect, the polymeric layer can consist of a fluoropolymer. More particularly, the package 102 can consist of a single polymeric layer consisting of at least one polymer selected from the group consisting of polyvinylidene fluoride (PVDF), a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV). For instance, the package 102 can consist of a single polymeric layer consisting of ethylene tetrafluoroethylene (ETFE). In another example, the package 102 can consist of a single polymeric layer consisting of a copolymer of fluorinated ethylene propylene (FEP). In another particular example, the package 102 can consist of a single polymeric layer consisting of a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

[0018] In an embodiment, the package 102 can be flexible to facilitate packaging of abrasive articles 104. In an aspect, the package 102 can have a certain flexibility that can facilitate improved packaging of abrasive articles.

[0019] In an embodiment, the package 102 can have a certain tensile strength that can facilitate improved packaging of abrasive articles 104. In an aspect, the package 102 can include a tensile strength of at least 5 MPa, at least 8MPa, or at least 12 MPa. In another aspect, the package 102 can include a tensile strength of at most 80 MPa, at most 75 MPa, or at most 70MPa. Moreover, the package 102 can include a tensile strength in a range including any of the minimum and maximum values noted herein. For example, the package 102 can include a tensile strength in a range from 5 MPa to 80 MPa. As disclosed herein, tensile strength is measured according to ASTM D882.

[0020] In a further embodiment, the package 102 can have a certain average thickness that can facilitate improved packaging of abrasive articles 104. In an aspect, the package 102 can include an average thickness of at least at least 30 microns, at least 40 microns, at least 50 microns, or at least 100 microns. In another aspect, the package 102 can include an average thickness of at most 800 microns, at most 750 microns, at most 700 microns, or at most 600 microns. Moreover, the package 102 can have a certain average thickness in a range including any of the minimum and maximum values noted herein. For example, the package 102 can have an average thickness in a range from at least 30 microns to at most 600 microns or in a range from at least 50 microns to at most 750 microns.

[0021] In an embodiment, the package 102 can have a certain water vapor transmission rate ("WVTR" hereinafter) that can facilitate improved packaging and storage of abrasive articles 104. In an aspect, the package 102 can include a WVTR of at most 7 g/m^2-day, at most 6 g/m^2-day, at most 5 g/m^2-day, or at most 4 g/m^2-day. In a particular aspect, the package 102 can include a WVTR less than 2.8 g/m^2-day or at most 2.5 g/m^2-day. The WVTR is determined at 37.8 $^{\circ}C$ and 100% relative humidity (RH) according to ASTM F1249-01. In another aspect, the package 102 can include a WVTR of at least 0.001 g/m^2-day, at least 0.005 g/m^2-day, or at least 0.01 g/m^2-day. Moreover, the WVTR can be in a range including any of the minimum and maximum values noted herein. For example, the package 102 can include a WVTR in a range from 0.001 g/m^2-day to 7 g/m^2-day or in a range from 0.001 g/m^2-day to 4 g/m^2-day or in a range from 0.001 g/m^2-day to 2.5 g/m^2-day.

[0022] In an embodiment, the package 102 can have a certain density that can facilitate improved packaging and moisture uptake of abrasive articles 104. In an aspect, the package 102 can include a density of at least 1.4 g/cc, at least 1.5 g/cc, or at least 1.6 g/cc. In another aspect, the package 102 can include a density of at most 2.4 g/cc, at most 2.3 g/cc, or at most 2.2 g/cc. Moreover, the density can be in a range including any of the minimum and maximum values noted herein. For example, the package 102 can include a density in a range from 1.4 g/cc to 2.4 g/cc.

[0023] In an embodiment, the package 102 can include a fluoropolymer having a certain crystallinity that can facilitate improved packaging and moisture uptake of abrasive articles 104.

[0024] In an embodiment, the package 102 can be heat-sealable. In another embodiment, the package may be sealed by an adhesive, a mechanical fastener, or any combination thereof. In an aspect, the adhesive can include a tape, a pressure sensitive adhesive, or any combination thereof. In another aspect, a strip fastener may be used to facilitate sealing of the package. In a further aspect, the package can be resealed.

[0025] In an embodiment, the package 102 can include a seal 108 having a certain width, W, that can facilitate improved sealing and moisture uptake of the package 102. In an aspect, the width, W, of the seal 108 can be at least 1 cm, at least 2 cm, at least 4 cm, or at least 5 cm. In another aspect, the width W can be at most 20 cm, such as at most 15 cm or at most 10 cm. Moreover, the seal 108 can have a width, W, in a range including any of the minimum and maximum values noted herein. For example, the width, W, of the seal 108 can be at least 1 cm to at most 20 cm.

[0026] In some instances, the system 100 may optionally include a desiccant contained in the enclosed space 110. An exemplary desiccant can include a metal oxide or hydroxide scavenger, a metal sulfate scavenger, a metal halide scavenger, a metal silicate, other inorganic scavengers, an organometallic scavenger, a metal ligand, organic scavengers, or any combination thereof. In an example, a metal includes an alkali metal, such as lithium; an alkaline earth metal, such as beryllium, calcium, magnesium, or barium; a transition metal, such as iron, manganese, palladium, zirconium, cobalt, copper, zinc, titanium, or chromium; other metals, such as aluminum; alloys thereof, or any combination thereof. An exemplary metal oxide scavenger includes dehydrated or partially dehydrated oxides of the above metals, such as calcium oxide, barium oxide, cobalt oxide, magnesium oxide, alumina, titanium oxide, zirconia, zinc oxide, or any combination thereof. An exemplary metal halide can include a halide or perchlorate of a

metal listed above, or an exemplary metal sulfate can include a sulfate of a metal listed above, such as sodium sulfate, calcium sulfate, barium sulfate, copper sulfate, or any combination thereof. Another inorganic scavenger can include a montmorillonite clay, a zeolite, activated carbon, silica gel, alumina gel, bauxite, or any combination thereof.

[0027] In a particular aspect, the desiccant can include molecular sieves, clay, or any combination thereof. A particular example of clay can include a smectite, such as a bentonite or a montmorillonite, a sepiolite, or any combination thereof. In another particular example, clay can include a 2:1 ratio of tetrahedral to octahedral crystal sheets. In a further example, the desiccant can include bentonite, montmorillonite, sepiolite, or any combination thereof. In some particular implementations, the desiccant can consist essentially of at least one of bentonite, montmorillonite, and sepiolite.

[0028] The abrasive articles 104 can be formed utilizing techniques known in the art. In an embodiment, the abrasive articles 104 can include a bonded abrasive article including a bonded abrasive body. In an aspect, the bonded abrasive body can include a bond material and abrasive particles contained within the bond material. In an example, the bond material can include an organic material, such as a resin-based material. In another instance, the bond material can include an inorganic material. In a particular example, the bond material can consist essentially of an organic material. A non-limiting example of organic material can include phenolic resin, boron-modified resin, nano-particle-modified resin, urea-formaldehyde resin, acrylic resin, epoxy resin, polybenzoxazine, polyester resin, isocyanurate resin, melamine-formaldehyde resin, polyimide resin, other suitable thermosetting or thermoplastic resins, or any combination thereof. An exemplary phenolic resin can include resole and novolac. The bond material can be hygroscopic and absorb water over time as it traverses the package 102. It is believed that after moisture in the product exceeds certain level, the grinding performance such as, grinding and cutting can be degraded.

[0029] Abrasive particles known in the art can be used in forming the abrasive article 104. For example, the abrasive particles can include silica, alumina (fused or sintered), zirconia, zirconia/alumina oxides, silicon carbide, garnet, diamond, cubic boron nitride, silicon nitride, ceria, titanium dioxide, titanium diboride, boron carbide, tin oxide, tungsten carbide, titanium carbide, iron oxide, chromia, flint, emery, dolomite, or any combination thereof.

[0030] In some instances, the bonded abrasive body can optionally include an additive including such as a filler material, secondary abrasive particles, or the like. The fillers can include active and/or inactive fillers. A non-exhaustive list of active fillers can include Cryolite, PAF (a mixture of K_3AlF_6 and $KAlF_4$), KBF_4, K_2SO_4, barium sulfate, sulfides (FeS_2, ZnS), NaCl/KCl, low melting metal oxides, or combinations thereof. A non-exhaustive list of inactive fillers can include CaO, $CaCO_3$, $Ca(OH)_2$, $CaSiO_3$, Kyanite (a mixture of Al_2O_3-SiO_2), Saran (Polyvinylidene chloride), Nephenline (Na, K) $AlSiO_4$, wood powder, coconut shell flour, stone dust, feldspar, kaolin, quartz, other forms of silica, short glass fibers, asbestos fibers, balotini, surface-treated fine grain (silicon carbide, corundum etc.), pumice stone, cork powder and combinations thereof. The secondary abrasive grains can include, for example, ceramic oxides (e.g., coated or non-coated fused Al_2O_3, monocrystal Al_2O_3), minerals (e.g., garnet and emery), nitrides (e.g., Si_3N_4, AlN) and carbides (e.g., SiC).

[0031] In some implementations, the abrasive article 104 can include one or more reinforcement layers. A reinforcement layer can be made of any number of various materials. An exemplary reinforcement layer can include a polymeric film (including primed films), such as a polyolefin film (e.g., polypropylene including biaxially oriented polypropylene), a polyester film (e.g., polyethylene terephthalate), or a polyamide film; a cellulose ester film; a metal foil; a mesh; a foam (e.g., natural sponge material or polyurethane foam); a cloth (e.g., cloth made from fibers or yams comprising fiberglass, polyester, nylon, silk, cotton, poly-cotton or rayon); a paper; a vulcanized paper; a vulcanized rubber; a vulcanized fiber; a nonwoven material; or any combination thereof, or treated versions thereof. A cloth backing can be woven or stitch bonded. In particular examples, the reinforcement layer can be selected from a group consisting of paper, polymer film, cloth, cotton, poly-cotton, rayon, polyester, poly-nylon, vulcanized rubber, vulcanized fiber, fiberglass fabric, metal foil or any combination thereof. In other examples, the reinforcement layer includes a woven fiberglass fabric.

[0032] The system 100 described in embodiments herein can notably reduce moisture (e.g., water vapor) uptake by the bonded abrasive articles 104, which can help to reduce the likelihood of degradation of performance, such as G-ratio, of the abrasive articles. In an aspect, the abrasive articles 104 can have a moisture uptake of at most 0.5% or at most 0.4% when exposed to 90% RH at 21 $^{\circ}$C for 7 days. Moisture uptake of the abrasive articles 104 can be determined as follows. The system 100 can be exposed to the condition of 21 ^{o}C and 90% RH for a period

of time, such as 7 days or longer. The percentage of the weight changes of the abrasive articles are referred to as moisture uptake, Wu, in this disclosure, and can be determined by the formula, Wu=[(Wa-Wo)/Wo]×100%, where Wo is the weight of the abrasive articles prior to exposure, and Wa is the weight after the exposure.

[0033] In another aspect, the abrasive articles 104 can have a Relative G-Ratio of at least 0.7 after exposing the system 100 in the condition of 21°C and 90% relative humidity (RH) over at least 7 days, such as at least 14 days, at least 21 days, at least 28 days, or at least 35 days. In still another aspect, the abrasive articles 104 can have a Relative G-Ratio of at least 0.7, such as at least 0.8, at least 0.85, at least 0.9, or even at least 0.95, such as approximately 1.0, after the system 100 is exposed to the condition of 21°C and 90% RH over at least 7 days. The Relative G-Ratio is determined by dividing the G-Ratio of the abrasive articles after exposure by the G-Ratio of the dry abrasive articles prior to exposure. As used herein, a dry abrasive article refers to the abrasive article that has been dried at 120 °C for 24 hours. Further, as used herein, the values of Relative G-Ratio, G-Ratio, and water vaper uptake can refer to the respective average value of the abrasive articles contained in the same package.

[0034] Many different aspects and embodiments are possible. Some of those aspects and embodiments are described herein. After reading this specification, skilled artisans will appreciate that those aspects and embodiments are only illustrative and do not limit the scope of the present invention. Embodiments may be in accordance with any one or more of the embodiments as listed below.

EMBODIMENTS

[0035] Embodiment 1. A system for containing an abrasive article comprising:

[0036] a package defining an enclosed space configured to hold one or more abrasive articles, wherein the package consists of a fluoropolymer.

[0037] Embodiment 2. The system of embodiment 1, wherein the fluoropolymer comprises polyvinylidene fluoride (PVDF), a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV), or any combination thereof.

[0038] Embodiment 3. A system comprising:

an abrasive article; and

a package including the abrasive article in an enclosed space defined by the package, wherein the package comprises a WVTR of less than 2.8 g/m2-day at 37.8 °C and 100% RH according to ASTM F1249 and consists of a single polymeric layer.

[0039] Embodiment 4. The system of embodiment 2, wherein the polymeric layer comprises a fluoropolymer.

[0040] Embodiment 5. The system of any one of embodiments 3 to 4, wherein the polymeric layer is free of metal.

[0041] Embodiment 6. The system of any one of embodiments 3 to 5, wherein the polymeric layer consists of at least one fluoropolymer selected from the group consisting of a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV).

[0042] Embodiment 7. The system of any one of embodiments 1 to 6, wherein the package consists of a single polymeric layer, wherein the single polymeric layer consists of at least one fluoropolymer selected from the group consisting of a homopolymer of polychlorotrifluoroethylene (PCTFE), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of ethylene tetrafluoroethylene (ETFE), and a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

[0043] Embodiment 8. The system of any one of embodiments 1 to 7, wherein the package consists of a copolymer of ethylene tetrafluoroethylene (ETFE).

[0044] Embodiment 9. The system of any one of embodiments 1 to 7, wherein the package consists of a copolymer of fluorinated ethylene propylene (FEP).

[0045] Embodiment 10. The system of any one of embodiments 1 to 7, wherein the package consists of a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

[0046] Embodiment 11. The system of any one of embodiments 1 to 10, wherein the package comprises a tensile strength of at least 5 MPa, at least 8MPa, or at least 12 MPa as measured by ASTM D882.

[0047] Embodiment 12. The system of any one of embodiments 1 to 11, wherein the package comprises a tensile strength of at most 80 MPa, at most 75 MPa, or at most 70MPa as measured by ASTM D882.

[0048] Embodiment 13. The system of any one of embodiments 1 to 12, wherein the package comprises a tensile strength within a range of at least 5 MPa and at most 80 MPa as measured by ASTM D882.

[0049] Embodiment 14. The system of any one of embodiments 1 to 13, wherein the package comprises an average thickness of at least 30 microns, at least 40 microns, at least 50 microns, or at least 100 microns.

[0050] Embodiment 15. The system of any one of embodiments 1 to 14, wherein the package comprises an average thickness of at most 800 microns, at most 700 microns, or at most 600 microns.

[0051] Embodiment 16. The system of any one of embodiments 1 to 15, wherein the package comprises an average thickness within a range of at least 30 microns and at most 800 microns.

[0052] Embodiment 17. The system of any one of embodiments 1 to 2, wherein the package comprises a WVTR of at most 7 g/m2-day, at most 6 g/m2-day, at most 5 g/m2-day, or at most 4 g/m2-day at 37.8 °C and 100% RH according to ASTM F1249-01.

[0053] Embodiment 18. The system of any one of embodiments 1 to 2, wherein the package comprises a WVTR less than 2.8 g/m2-day or at most 2.5 g/m2-day at 37.8 °C and 100% RH according to ASTM F1249-01.

[0054] Embodiment 19. The system of any one of embodiments 1 to 18, wherein the package comprises a WVTR of at least 0.001 g/m2-day, at least 0.005 g/m2-day, or at least 0.01 g/m2-day at 37.8 °C and 100% RH according to ASTM F1249-01.

[0055] Embodiment 20. The system of any one of embodiments 1 to 19, wherein the package comprises a density of at least 1.4 g/cc, at least 1.5 g/cc, or at least 1.6 g/cc.

[0056] Embodiment 21. The system of any one of embodiments 1 to 20, wherein the package comprises a density of at most 2.4 g/cc, at most 2.3 g/cc, or at most 2.2 g/cc.

[0057] Embodiment 22. The system of any one of embodiments 1 to 21, wherein the package is heat-sealable.

[0058] Embodiment 23. The system of any one of embodiments 1 to 22, wherein the package is sealed by an adhesive.

[0059] Embodiment 24. The abrasive system of any one of embodiments 1 to 23, wherein the package comprises a seal, wherein the seal has a width of at least 1 cm, at least 2 cm, at least 4 cm, or at least 5 cm.

[0060] Embodiment 25. The system of any one of embodiments 1 to 24, wherein the abrasive article has a moisture uptake of at most 0.5% or at most 0.4% when exposed to 90% relative humidity at 21 °C for 7 days.

[0061] Embodiment 26. The system of any one of embodiments 1 to 25, wherein the abrasive article comprises a bonded body including a bond material and abrasive particles contained within the bond material.

[0062] Embodiment 27. The system of embodiment 26, wherein the bond material comprises an organic material.

[0063] Embodiment 28. The system of embodiment 26 or 27, wherein the bond material consists essentially of an organic material.

[0064] Embodiment 29. The system of any one of embodiments 1 to 28, wherein the system comprises at least 1, at least 3, at least 5, at least 8, at least 10, at least 15, at least 20, at least 30, at least 50, or at least 500 bonded abrasives articles contained in the package.

[0065] Embodiment 30. The system of any one of embodiments 1 to 29, wherein the abrasive article comprises an abrasive disc, a grinding wheel, an ultra-thin wheel, a cut-off wheel, a combination wheel, or any combination thereof.

[0066] Embodiment 31. The system of embodiment 1, 3, or 4, wherein the package comprises a monolithic body made of the fluoropolymer.

[0067] Embodiment 32. The system of any one of embodiments 1 to 31, further comprising a desiccant contained within the package.

EXAMPLES

[0068] Example 1

[0069] 8-inch grinding discs were packaged using a single layer of the films disclosed in Table 1 below. All the samples were exposed to the condition of 21 ^{o}C and 90% RH for 30 days. Absolute humidity inside the package was measured according every 10 hours within 100-hour exposure time, then every 100 hours, and at the completion of the exposure. At least 3 packages formed with the same film were tested for each time point, and the average for each time point was used to generate the plot illustrated in FIG. 2.

Table 1

Sample	Package material	Thickness	Sealing method
1	Polyethylene film	4 mils	Tape
2	Aluminum foil	6 mils	Heat sealed at approximately 200F
3	PET film	20 mils	Tape
4	PVDF film	30 mils	Tape

[0070] FIG. 2 includes a plot of absolute humidity vs. exposure time for all the samples. As illustrated, absolute humidity of Samples 1 and 3 increased quickly within 20-hour exposure time and remained much higher compared to Samples 2 and 4 over the entire testing time period. The absolute humidity of Sample 4 was approximately 9 and increased to approximately 10 over 30 days, which was significantly slower compared to Samples 1 and 3. Sample 4 had an increase in absolute humidity from 8 to 9 over the exposure time period.

[0071] Example 2

[0072] Single layers of fluoropolymer films were tested for water vapor transmission rates at 37.8°C and 100% RH according to ASTM F1249-01 using MOCON Permatran W700 Analyzer. FEP films were purchased from Inoflon® Fluoropolymers. PVDF films were purchased from Arkema S.A.. Duplicate specimens of each film sample were placed in the permeation cell with one side of the specimen exposed to the testing condition and the other side exposed to a dry nitrogen carrier gas at the flow rate of 10 to 100 sccm. Testing results are included in Table 2 below. WVTR is the average of the specimens.

Table 2

Material	Average Thickness (mil)	WVTR ($g/[m^2\text{-day}]$)
PVDF (Kynar® 2750)	20.3	2.5
PVDF (Kynar® 2750)	15.6	3.4
PVDF (Kynar® 2750)	8.7	6.5
PVDF (Kynar® 2500)	19.4	2.6
PVDF (Kynar® 2500)	14.9	3.3
PVDF (Kynar® 2500)	8.0	6.3
PVDF (Kynar® 740)	19.7	1.5
PVDF (Kynar® 740)	12.2	2.7
PVDF (Kynar® 740)	7.6	4.6
FEP	9.9	0.3

[0073] Example 3

[0074] Cut pieces of grinding wheels approximately 5” x 5” x 0.7” in dimension were packaged in single layers of films disclosed in Table 3. FEP films were purchased from Inoflon® Fluoropolymers. All samples were placed inside a humidity chamber monitored at 90% RH at 21^{o}C for 7 days.

Table 3

Sample	Package material	Thickness (mil)	Sealing method
5	Aluminum foil	6	Heat Sealed
6	Polyethylene film	8	Heat Sealed
7	FEP	8 to 10	Tape

[0075] FIG. 3 includes a plot of absolute humidity inside the packages vs. exposure time. Absolute humidity was measured hourly on the first day and then daily. At least 3 packages per Sample were tested for each time point and the average of each time point was used to generate the plot. As illustrated, compared to environmental humidity, all packaged samples had lower

absolute humidity over the exposure time. Sample 7 demonstrated much slower increase in absolute humidity, from approximately 9 to less than 10 over 7 days, compared to Sample 6, from 6 to 11 over 4 days. Sample 5 had minimal increase in absolute humidity over 7 days.

[0076] Example 4

[0077] Cut pieces of grinding wheels approximately 5" x 5" x 0.7" in dimension were packaged in single layers of films disclosed in Table 4. PVDF films were purchased from Arkema Innovative Chemistry under the commercial designation of Kynar® 740. All samples were placed inside a humidity chamber monitored at 90% RH at 21°C for 7 days.

Table 4

Sample	Package material	Thickness (mil)	Sealing method
5	Aluminum foil	6	Heat Sealed
6	Polyethylene film	8	Heat Sealed
8	PVDF	2	Heat Sealed
9	PVDF	12	Heat Sealed
10	PVDF	20	Heat Sealed

[0078] FIG. 4 includes a plot of absolute humidity inside the packages vs. exposure time. Absolute humidity was measured hourly on the first day and then daily. At least 3 packages per Sample were tested for each time point and the average of each time point was used to generate the plot. As illustrated, compared to environmental humidity, all packaged samples had lower absolute humidity over the exposure time period. Sample 8 demonstrated an increase in absolute humidity from 8.5 to 12, Sample 9 from 8 to 10, and Sample 10 had minimum increase over 7 days of exposure.

[0079] Example 5

[0080] Additional cut pieces of grinding wheels approximately 5" x 5" x 0.7" in dimension were packaged using aluminum foil, PE film, FEP film (from Inoflon® Fluoropolymers), and Kynar® PVDF films of different grades. The samples were placed inside a humidity chamber monitored at 90% RH at 21°C for 4 days. Tests results are included in Table 5 below.

Table 5

Sample	Material	Thickness (mil)	Starting Humidity	% approach to environment after 4 days	% approach to environment after 8 days	Change in weight of the wheel after 7 days (%)
11	Standard Al foil	6	9.1	-5%	-12%	0.000
12	Standard PE film	8	5.7	57%	N/A	0.105
13	FEP	8	8.7	13%	13%	0.035
14	Kynar® 740	2	8.6	47%	56%	0.069
15	Kynar® 740	12	8.3	31%	39%	0.000
16	Kynar® 740	20	9.0	-1%	6%	0.000
17	Kynar® 2500	8	7.3	49%	62%	0.070
18	Kynar® 2500	15	6.9	33%	44%	0.069
19	Kynar® 2500	20	6.6	25%	35%	0.035
20	Kynar® 2750	8	7.1	56%	69%	0.071
21	Kynar® 2750	15	7.0	35%	48%	0.071
22	Kynar® 2750	20	6.9	21%	31%	0.000

[0081] Negative approach indicates rate of absorption of moisture by the wheel sample is greater than the rate of moisture transmission through the packaging. No change in humidity indicates rate of absorption of moisture by the wheel sample is equal to the rate of moisture transmission through the packaging. Positive change in humidity indicates rate of absorption of moisture by the wheel sample is less than the rate of moisture transmission through the packaging.

[0082] The present embodiments represent a departure from the state of the art. It was unexpectedly and surprisingly discovered that a system including a package consisting of a fluoropolymer can facilitate significantly improved protection of abrasive articles from moisture uptake compared to PE and PET films. Compared to standard PE films, fluoropolymer films noted in embodiments herein have improved WVTR. Moreover, WVTR in combination with any or all of properties including crystallinity of fluoropolymer and/or density, thickness,

flexibility, and/or tensile strength of the package are factors that facilitate improved packaging and protection against moisture uptake and degradation of performance of abrasive articles.

[0083] Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the order in which activities are listed is not necessarily the order in which they are performed.

[0084] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims. Reference herein to a material including one or more components may be interpreted to include at least one embodiment wherein the material consists essentially of the one or more components identified. The term "consisting essentially" will be interpreted to include a composition including those materials identified and excluding all other materials except in minority contents (e.g., impurity contents), which do not significantly alter the properties of the material. Additionally, or in the alternative, in certain non-limiting embodiments, any of the compositions identified herein may be essentially free of materials that are not expressly disclosed. The embodiments herein include range of contents for certain components within a material, and it will be appreciated that the contents of the components within a given material total 100%.

[0085] The specification and illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The specification and illustrations are not intended to serve as an exhaustive and comprehensive description of all of the elements and features of apparatus and systems that use the structures or methods described herein. Separate embodiments may also be provided in combination in a single embodiment, and conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range. Many other embodiments may be apparent to skilled artisans only after reading this specification. Other embodiments may be used and derived from the disclosure, such that a structural substitution,

logical substitution, or another change may be made without departing from the scope of the disclosure. Accordingly, the disclosure is to be regarded as illustrative rather than restrictive.

What is claimed is:

1. A system for containing an abrasive article comprising:

a package defining an enclosed space configured to hold one or more abrasive articles, wherein the package consists of a fluoropolymer.

2. The system of claim 1, wherein the fluoropolymer comprises polyvinylidene fluoride (PVDF), a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV), or any combination thereof.

3. A system comprising:

an abrasive article; and

a package including the abrasive article in an enclosed space defined by the package, wherein the package comprises a WVTR of less than 2.8 g/m^2-day at 37.8 $^\circ$C and 100% RH according to ASTM F1249 and consists of a single polymeric layer.

4. The system of claim 2, wherein the polymeric layer comprises a fluoropolymer.

5. The system of any one of claims 3 to 4, wherein the polymeric layer is free of metal.

6. The system of any one of claims 3 to 5, wherein the polymeric layer consists of at least one fluoropolymer selected from the group consisting of a homopolymer of polychlorotrifluoroethylene (PCTFE), a homopolymer of polyvinylfluoride (PVF), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of perfluoroalkoxy alkane (PFA), a copolymer of ethylene tetrafluoroethylene (ETFE), a copolymer of ethylene chlorotrifluoroethylene (ECTFE), a terpolymer of poly(trifluoroethylene-co-hexafluoropropylene-co-vinylidene fluoride) (THV).

7. The system of any one of claims 1 to 6, wherein the package consists of a single polymeric layer, wherein the single polymeric layer consists of at least one fluoropolymer selected from the group consisting of a homopolymer of polychlorotrifluoroethylene (PCTFE), a copolymer of fluorinated ethylene propylene (FEP), a copolymer of ethylene tetrafluoroethylene (ETFE), and a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

8. The system of any one of claims 1 to 7, wherein the package consists of a copolymer of ethylene tetrafluoroethylene (ETFE).

9. The system of any one of claims 1 to 7, wherein the package consists of a copolymer of fluorinated ethylene propylene (FEP).

10. The system of any one of claims 1 to 7, wherein the package consists of a copolymer of ethylene chlorotrifluoroethylene (ECTFE).

11. The system of any one of claims 1 to 10, wherein the package comprises a tensile strength of at least 5 MPa, at least 8MPa, or at least 12 MPa as measured by ASTM D882.

12. The system of any one of claims 1 to 11, wherein the package comprises a tensile strength of at most 80 MPa, at most 75 MPa, or at most 70MPa as measured by ASTM D882.

13. The system of any one of claims 1 to 12, wherein the package comprises a tensile strength within a range of at least 5 MPa and at most 80 MPa as measured by ASTM D882.

14. The system of any one of claims 1 to 13, wherein the package comprises an average thickness of at least 30 microns, at least 40 microns, at least 50 microns, or at least 100 microns.

15. The system of any one of claims 1 to 14, wherein the package comprises an average thickness of at most 800 microns, at most 700 microns, or at most 600 microns.

16. The system of any one of claims 1 to 15, wherein the package comprises an average thickness within a range of at least 30 microns and at most 800 microns.

17. The system of any one of claims 1 to 2, wherein the package comprises a WVTR of at most 7 g/m^2-day, at most 6 g/m^2-day, at most 5 g/m^2-day, or at most 4 g/m^2-day at 37.8 $^{\circ}C$ and 100% RH according to ASTM F1249-01.

18. The system of any one of claims 1 to 2, wherein the package comprises a WVTR less than 2.8 g/m^2-day or at most 2.5 g/m^2-day at 37.8 $^{\circ}C$ and 100% RH according to ASTM F1249-01.

19. The system of any one of claims 1 to 18, wherein the package comprises a WVTR of at least 0.001 g/m^2-day, at least 0.005 g/m^2-day, or at least 0.01 g/m^2-day at 37.8 $^{\circ}C$ and 100% RH according to ASTM F1249-01.

20. The system of any one of claims 1 to 19, wherein the package comprises a density of at least 1.4 g/cc, at least 1.5 g/cc, or at least 1.6 g/cc.

21. The system of any one of claims 1 to 20, wherein the package comprises a density of at most 2.4 g/cc, at most 2.3 g/cc, or at most 2.2 g/cc.

22. The system of any one of claims 1 to 21, wherein the package is heat-sealable.

23. The system of any one of claims 1 to 22, wherein the package is sealed by an adhesive.

24. The abrasive system of any one of claims 1 to 23, wherein the package comprises a seal, wherein the seal has a width of at least 1 cm, at least 2 cm, at least 4 cm, or at least 5 cm.

25. The system of any one of claims 1 to 24, wherein the abrasive article has a moisture uptake of at most 0.5% or at most 0.4% when exposed to 90% relative humidity at 21 °C for 7 days.

26. The system of any one of claims 1 to 25, wherein the abrasive article comprises a bonded body including a bond material and abrasive particles contained within the bond material.

27. The system of claim 26, wherein the bond material comprises an organic material.

28. The system of claim 26 or 27, wherein the bond material consists essentially of an organic material.

29. The system of any one of claims 1 to 28, wherein the system comprises at least 1, at least 3, at least 5, at least 8, at least 10, at least 15, at least 20, at least 30, at least 50, or at least 500 bonded abrasives articles contained in the package.

30. The system of any one of claims 1 to 29, wherein the abrasive article comprises an abrasive disc, a grinding wheel, an ultra-thin wheel, a cut-off wheel, a combination wheel, or any combination thereof.

31. The system of claim 1, 3, or 4, wherein the package comprises a monolithic body made of the fluoropolymer.

32. The system of any one of claims 1 to 31, further comprising a desiccant contained within the package.

ABSTRACT

A system for containing an abrasive article can include a package defining an enclosed space configured to hold one or more abrasive articles. In an embodiment, the package can consist of a fluoropolymer. The package can include a water vapor transmission rate of at most 7 g/m^2-day at 37.8 $^{\circ}C$ and 100% RH according to ASTM F1249 and consist of a single polymeric layer.

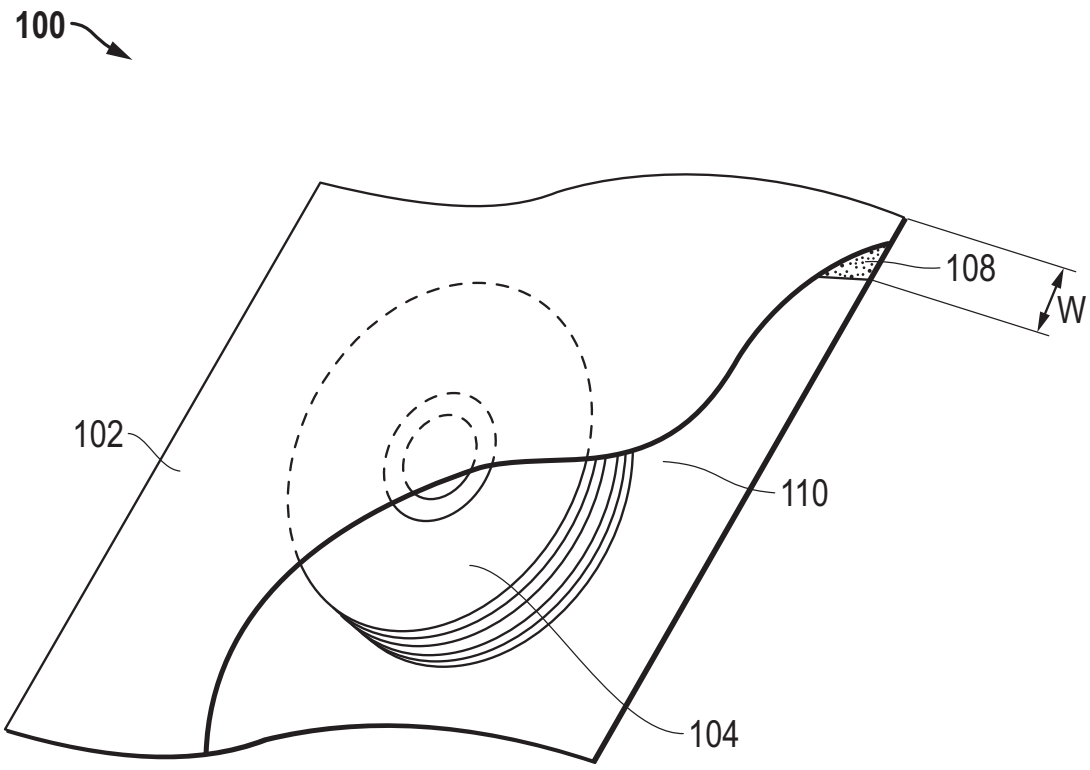
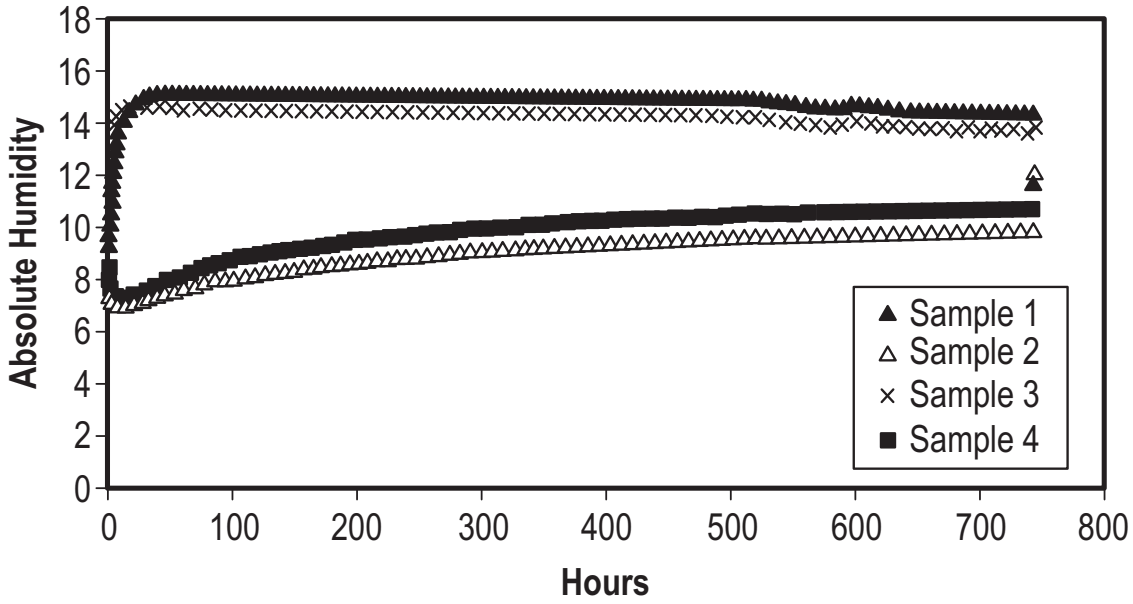


FIG. 1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10
12
14
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18
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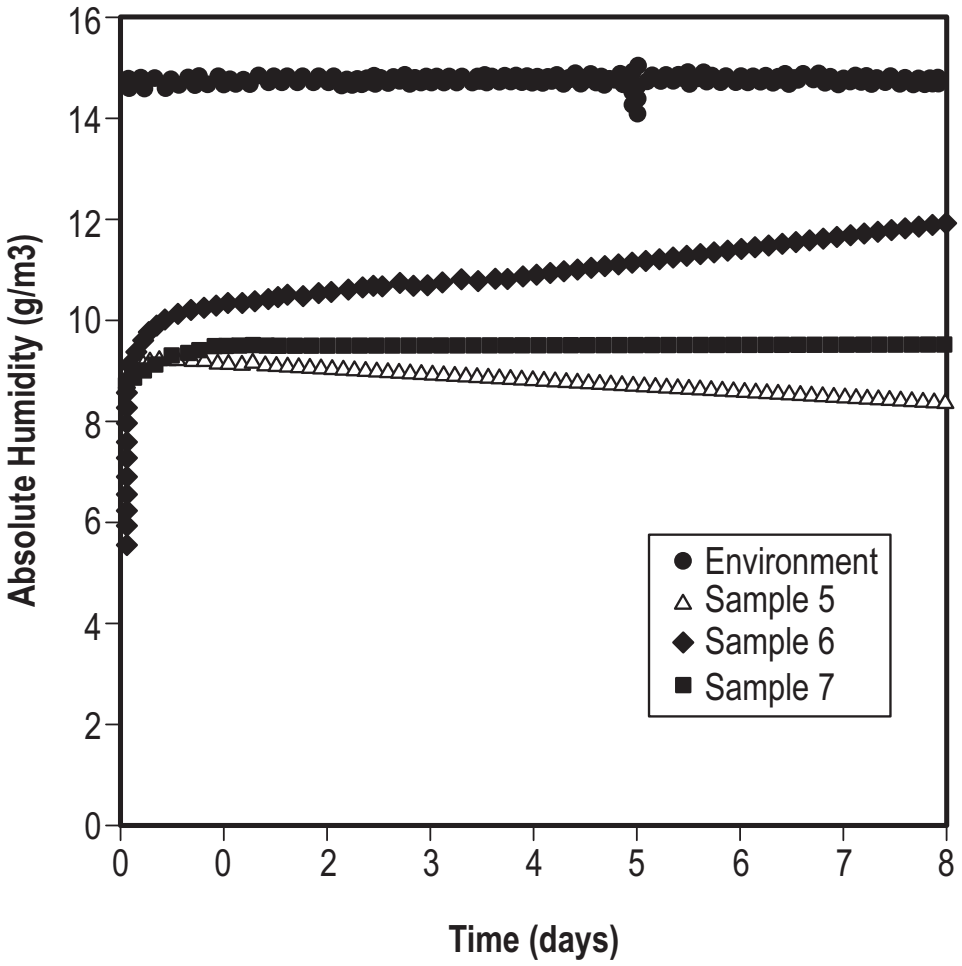
100
200
300
400
500
600
700
800
Sample 1
Sample 2
Sample 3
Sample 4

FIG. 2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Absolute Humidity (g/m3)
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2
3
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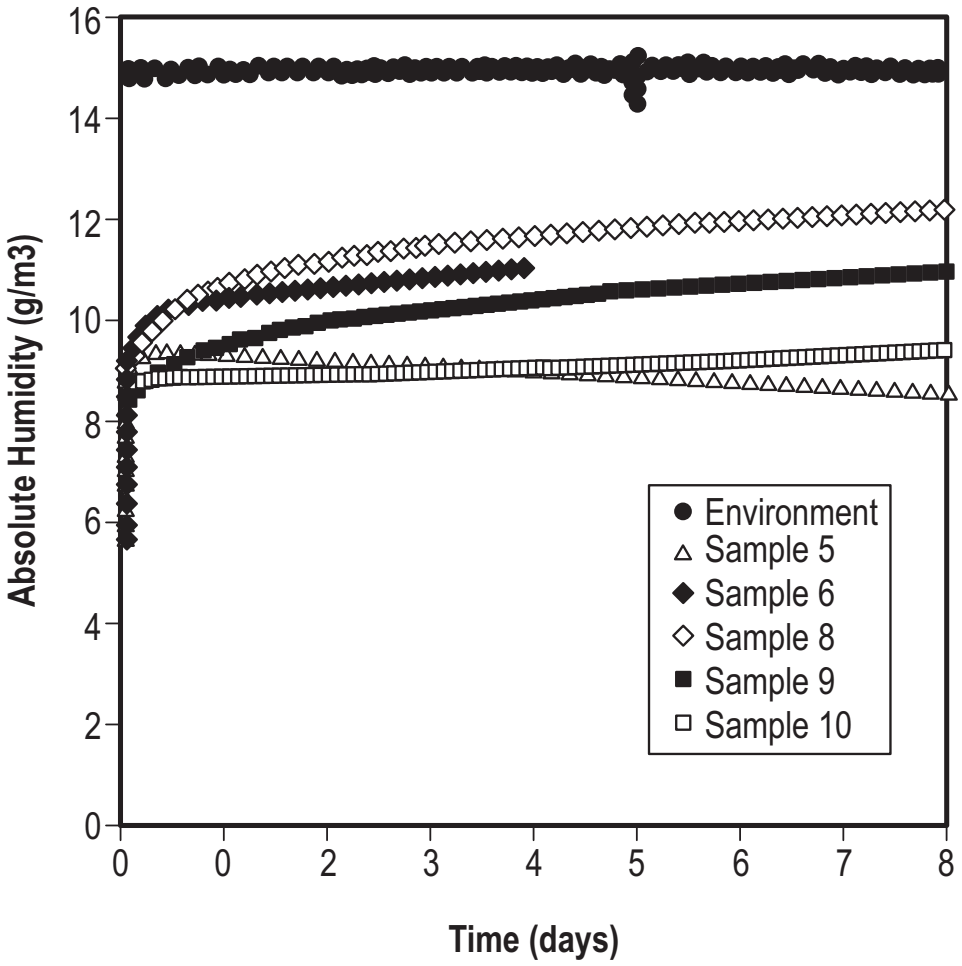
5
6
7
8
Time (days)
Environment
Sample 5
Sample 6
Sample 7

FIG. 3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Absolute Humidity (g/m3)
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2
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5
6
7
8
Time (days)
Environment
Sample 5
Sample 6
Sample 8
Sample 9
Sample 10

FIG. 4