METHODS FOR DISPENSING AND ADHERING HOT MELT ENTRAINED POLYMERS TO SUBSTRATES

BACKGROUND OF THE INVENTION

1. FIELD OF INVENTION

[0001] This disclosure relates to an entrained polymer, and to a method for extruding the entrained polymer in a molten state, optionally in an in-line production process. More particularly, the invention relates to applying and adhering a molten active polymer to a substrate having a surface. The surface includes a material compatible with the molten active polymer so as to facilitate a thermal bond thereto.

2. DESCRIPTION OF RELATED ART

[0002] There are many items that are preferably stored, shipped and/or utilized in an environment that must be controlled and/or regulated. For example, in the moisture control field, containers and/or packages having the ability to absorb excess moisture trapped therein have been recognized as desirable. The control of moisture, oxygen, ethylene and other gaseous substances may be desirable in medical, electronics and food packaging applications.

[0003] Conventionally, desiccants, oxygen absorbers and other active agents have been used in raw form, e.g., as loose particulates housed in sachets or canisters within packaging, to control the internal environment of the package. For many applications, it is not desired to have such loosely stored active substances. To address this problem, the assignee of the present application had developed active entrained polymers comprising active agents, wherein such polymers can be extruded and/or molded into desired forms, e.g., container liners, plugs, film sheets, pellets and other such structures. Optionally, such active entrained polymers may include channeling agents, such as polyethylene glycol (PEG), which form channels between the surface of the entrained polymer and its interior to transmit a selected material (e.g., moisture) to the entrained active agent (e.g., desiccant to absorb the moisture). Entrained polymers may be two phase formulations (i.e., comprising a base polymer and active agent, without a channeling agent) or three phase formulations (i.e., comprising a base polymer, active agent and channeling agent). Entrained polymers are described, for example, in U.S. Pat. Nos. 5,911,937, 6,080,350, 6,124,006, 6,130,263, 6,194,079, 6,214,255, 6,486,231, 7,005,459, and U.S. Pat. Pub. No. 2016/0039955, each of which is incorporated herein by reference as if fully set forth.

[0004] For some packages, e.g., pouches or blister packs, it is desired to adhere an entrained polymer film or layer to a substrate (e.g., another polymer or a foil) to form the package. One way to do so is by applying an adhesive to the film or layer during production to adhere it to the

substrate. This may not be desirable because it requires a step of applying a separate adhesive and the adhesive may include solvents that can be deleterious to the package contents. An alternative is through a heat staking method which does not require application of a separate adhesive to adhere the entrained polymer film or layer to the substrate. As described in U.S. Pat. No. 8,142,603, which is incorporated by reference herein in its entirety, the heat staking method comprises the steps of: heating a foil substrate; applying an entrained polymer film to the foil; and applying sufficient pressure to the film and foil combination and sufficient heat to the foil so that the film adheres to the foil.

[0005] Heat staking is an improvement over use of conventional adhesives to adhere entrained polymer film to a substrate. However, in large scale production, heat staking typically requires providing a formed film in bulk and applying a cutting step or providing a pre-cut film. This may not always be desired by a package manufacturer, labeler or filler. There is a need for in-line production methods for applying and adhering a formed entrained polymer to a substrate without having to provide the entrained polymer in a preformed or precut shape. Ideally, the method would not require use of a separate adhesive material to adhere the entrained polymer to the substrate. Towards that end, there is a need for an entrained polymer that is amenable to such an in-line production process. Likewise, the entrained polymer may be provided as a formulation to be formed in the in-line production process.

[0006] U.S. Pat. No. 5,605,720 discloses a method of formulating and applying hot melt adhesives in a continuous in-line operation. However the apparatus and the method are directed to an adhesive polymer that is one-phase, low density and low viscosity. The apparatus and the method are inapplicable for multi-phase, high density and high viscosity materials.

BRIEF SUMMARY OF THE INVENTION

[0007] Accordingly, in one aspect, an entrained polymer composition is provided. The entrained polymer composition is formed of at least a base polymer and a particulate active agent.

[0008] Accordingly, in one aspect, the entrained polymer composition has a melt flow index in a range from 200 g/10 min to 5000 g/10 min, optionally from 500 g/10 min to 4500 g/10 min, optionally from 1000 g/10 min to 4000 g/10 min, optionally from 1200 g/10 min to 2500 g/10 min under the ASTM D1238 /ISO 1133 conditions.

[0009] Accordingly, in one aspect, the entrained polymer composition has a viscosity in a range from 1,000 cp to 50,000 cp, optionally from 3,000 cp to 40,000 cp, optionally from 3,000 cp to 20,000 cp, optionally from 3,000 cp to 15,000 cp, optionally from 3,000 cp to 10,000 cp, wherein the viscosity is measured with a rheometer at 190 °C after shearing at 5 Hz for two

minutes.

[0010] Accordingly, in one aspect, the entrained polymer composition is a monolithic material.

[0011] Accordingly, in one aspect, the entrained polymer composition is formed of a base polymer, a flow agent, a particulate active agent, and an optional channeling agent.

[0012] Accordingly, in one aspect, an entrained polymer composition is provided that when in a molten state forms an entrained polymer structure that adheres to a substrate.

[0013] Accordingly, in one aspect, a method is provided for forming and adhering an entrained polymer structure to a substrate. The method includes providing a substrate configured to receive application of a molten entrained polymer. A particulate entrained polymer in molten form is applied in a predetermined shape, to a surface of the substrate, to form a solidified entrained polymer structure on the substrate. The entrained polymer includes a monolithic material formed of at least a base polymer and a particulate active agent. The surface of the substrate is compatible with the molten entrained polymer so as to thermally bond with it. In this way, the entrained polymer bonds to the substrate and solidifies upon sufficient cooling of the entrained polymer. Preferably, the solidified entrained polymer structure adheres to the substrate without use of a separate adhesive material.

[0014] Optionally, in any embodiment, the entrained polymer is at least a two phase formulation.

[0015] Optionally, in any embodiment, the entrained polymer is at least a three phase formulation.

[0016] Optionally, in any embodiment, the entrained polymer includes a channeling agent.

[0017] Optionally, in any embodiment, the entrained polymer includes an additive.

[0018] Optionally, in any embodiment, the additive is a flow agent.

[0019] Optionally, in any embodiment, the substrate is a foil; and the surface of the substrate is a polymer sealing layer on the foil.

[0020] Optionally, in any embodiment, the method is carried out using a hot melt dispensing apparatus. The apparatus includes a feeder for providing a flow of particulate entrained polymer in molten form. The feeder is optionally an extruder. The apparatus further includes one or more hoses, each of which having an internal lumen in fluid communication with an exit of the feeder to receive flow of the particulate entrained polymer in molten form. The lumen terminates at an applicator to which the entrained polymer in molten form is conveyed. The applicator includes a dispenser for applying the entrained polymer in the predetermined shape to the surface of the substrate.

[0021] Optionally, in any embodiment, the lumen is heated to maintain a molten state of the entrained polymer when conveyed through the lumen.

[0022] Optionally, in any embodiment, the dispenser is heated to maintain a molten state of the entrained polymer and to facilitate precise formation of the entrained polymer into the predetermined shape.

[0023] Optionally, in any embodiment, the dispenser includes a valve that alternates between a closed state and an open state so as to precisely form the entrained polymer structure in the predetermined shape.

[0024] Optionally, in any embodiment, the particulate active agent is a granular material that is more abrasive than the base polymer.

[0025] Optionally, in any embodiment, the active agent is a desiccant, optionally a molecular sieve, a silica gel, a clay, or another desiccant that is a granular material that is more abrasive than the base polymer.

[0026] Optionally, in any embodiment, the entrained polymer exhibits a melt flow index (MFI) of greater than 500 g/10 min (ASTM D1238 /ISO 1133 standard method at 190 °C and 2.16 kg).

[0027] Optionally, in any embodiment, the entrained polymer exhibits a viscosity of less than 40,000 cP (analyzed using a rheometer with parallel plate geometry, 190 °C, shear rate 5 Hz for two minutes).

[0028] Optionally, in any embodiment, one or both of the substrate and solidified entrained polymer structure are flexible materials.

[0029] Optionally, in any embodiment, solid entrained polymer pellets are provided into the feeder and melted to form the entrained polymer in molten form.

[0030] Optionally, in any embodiment, the solidified entrained polymer structure is in the form of: a sheet, a film, a bead, a dot, a strip or a swirl.

[0031] Optionally, in any embodiment, the solidified entrained polymer structure is in the form of a film having a thickness of from 0.1 mm to 1.5 mm, optionally from 0.2 mm to 1.2 mm, optionally from 0.3 mm to 0.8 mm. Optionally, if the substrate is a foil, the surface of the substrate is a polymer sealing layer on the foil, and the substrate is a portion of a package for a moisture-sensitive product, optionally wherein the package is a flexible package, a pouch or a blister pack.

[0032] Optionally, in any embodiment, the method is carried out as part of an automated, in-line package production process.

[0033] Optionally, in any embodiment, the solidified entrained polymer structure adheres to

the substrate without use of a separate adhesive material.

[0034] Optionally, in any embodiment, the active agent is from 30% to 80%, optionally from 30% to 75%, optionally from 30% to 70%, optionally from 35% to 70%, optionally from 40% to 65%, optionally from 45% to 55%, by weight of the entrained polymer.

[0035] Optionally, in any embodiment, a composite is made according to methods disclosed herein. The composite includes the substrate and the solidified entrained polymer structure adhered thereto. Optionally, in any embodiment, the composite is a portion of a flexible package, pouch or blister pack.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0036] The invention will be described in conjunction with the following drawings in which like reference numerals designate like elements and wherein:

[0037] Fig. 1 is a perspective view of a plug formed of an entrained polymer that may be deposited onto a substrate according to methods of the disclosed concept.

[0038] Fig. 2 is a cross section taken along line 2-2 of Fig. 1;

[0039] Fig. 3 is a cross section similar to that of Fig. 2, showing a plug formed of another embodiment of an entrained polymer that may be deposited onto a substrate according to methods of the disclosed concept;

[0040] Fig. 4 is a schematic illustration of an entrained polymer that may be used according to methods of the disclosed concept, in which the active agent is an absorbing or adsorbing material.

[0041] Fig. 5 is a cross sectional view of a sheet formed of an entrained polymer, adhered to a barrier sheet substrate according to methods of the disclosed concept;

[0042] Fig. 6 is a cross section of a package that may be formed according to methods of the disclosed concept.

[0043] Fig. 7 is a schematic illustration of an optional embodiment of a hot melt dispensing apparatus delivering an entrained polymer in molten form to a substrate.

[0044] Fig. 8 is a photograph illustrating an entrained polymer film adhered to a sheet using an optional embodiment of a hot melt dispensing apparatus.

[0045] Fig. 9 is a photograph illustrating an entrained polymer strip adhered to a sheet using an optional embodiment of a hot melt dispensing apparatus.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Definitions

[0046] As used herein, the term “active” is defined as capable of acting on, interacting with

or reacting with a selected material (e.g., moisture or oxygen) according to the disclosed concept. Examples of such actions or interactions may include absorption, adsorption or release of the selected material.

[0047] As used herein, the term "active agent" is defined as a material that (1) is immiscible with the base polymer and when mixed and heated with the base polymer and the channeling agent, will not melt, i.e., has a melting point that is higher than the melting point for either the base polymer or the channeling agent, and (2) acts on, interacts or reacts with a selected material. The term "active agent" may include but is not limited to materials that absorb, adsorb or release the selected material(s). An active agent that is particulate in form is referred to herein as a "particulate active agent". An active agent that is mineral in form is referred to herein as a "mineral active agent". Active agents according to the disclosed concept may be particulate active agent, but (unless otherwise claimed) the invention should not be viewed as limited to particulate active agents. Nevertheless, the invention is particularly suited for entrained polymers formed with a mineral active agent, for example molecular sieve or silica gel.

[0048] As used herein, the term "base polymer" is a polymer optionally having a gas transmission rate of a selected material that is substantially lower than, lower than or substantially equivalent to, that of the channeling agent. By way of example, such a transmission rate would be a water vapor transmission rate in embodiments where the selected material is moisture and the active agent is a water absorbing desiccant. The primary function of the base polymer is to provide structure for the entrained polymer. Suitable base polymers may include thermoplastic polymers, e.g., polyolefins such as polypropylene and polyethylene, polyisoprene, polybutadiene, polybutene, polysiloxane, polycarbonates, polyamides, ethylene-vinyl acetate copolymers, ethylene-methacrylate copolymer, poly(vinyl chloride), polystyrene, polyesters, polyanhydrides, polyacrylonitrile, polysulfones, polyacrylic ester, acrylic, polyurethane and polyacetal, or copolymers or mixtures thereof.

[0049] Referring to such a comparison of the base polymer and channeling agent water vapor transmission rate, in one embodiment, the channeling agent has a water vapor transmission rate of at least two times that of the base polymer. In another embodiment, the channeling agent has a water vapor transmission rate of at least five times that of the base polymer. In another embodiment, the channeling agent has a water vapor transmission rate of at least ten times that of the base polymer. In still another embodiment, the channeling agent has a water vapor transmission rate of at least twenty times that of the base polymer. In still another embodiment, the channeling agent has a water vapor transmission rate of at least fifty times that of the base polymer. In still another embodiment, the channeling agent has a water vapor

transmission rate of at least one hundred times that of the base polymer.

[0050] As used herein, the term "base polymer material" is defined as a material that includes a base polymer and optionally an additive. When no additive is added, the base polymer material is made of the base polymer. Optionally, the base polymer and the additive are miscible.

[0051] As used herein, the term "additive" is defined as a material added to the base polymer to alter certain properties. Optionally, an additive is a flow agent to modulate at least the melt flow index or the viscosity of the base polymer and thus those of the entrained polymer.

[0052] As used herein, the term "channeling agent" or "channeling agents" is defined as a material that is immiscible with the base polymer or base polymer material and has an affinity to transport a gas phase substance at a faster rate than the base polymer or the base polymer material. Optionally, a channeling agent is capable of forming channels through the entrained polymer when formed by mixing the channeling agent with the base polymer or the base polymer material. Optionally, such channels are capable of transmitting a selected material through the entrained polymer at a faster rate than in solely the base polymer or the base polymer material.

[0053] As used herein, the term "channels" or "interconnecting channels" is defined as passages formed of the channeling agent that penetrate through the base polymer and may be interconnected with each other.

[0054] As used herein, the term "entrained polymer" is defined as a monolithic material formed of at least a base polymer material with an active agent and optionally also a channeling agent entrained or distributed throughout. An entrained polymer thus includes a polymer with at least two phases or at least three phases. An entrained polymer having an active agent that is particulate in form is referred to herein as a "particulate entrained polymer". An entrained polymer having an active agent that is mineral in form is referred to herein as a "mineral entrained polymer".

[0055] As used herein, the term "entrained polymer composition" is defined as an entrained polymer or a formulation giving rise to an entrained polymer.

[0056] As used herein, the term "monolithic," "monolithic structure" or "monolithic composition" is defined as a composition or material that does not consist of two or more discrete macroscopic layers or portions. Accordingly, a "monolithic composition" does not include a multi-layer composite.

[0057] As used herein, the term "phase" is defined as a portion or component of a monolithic structure or composition that is uniformly distributed throughout, to give the structure or composition its monolithic characteristics.

[0058] As used herein, the term "selected material" is defined as a material that is acted upon, by, or interacts or reacts with an active agent and is capable of being transmitted through the channels of the entrained polymer. For example, in embodiments in which a desiccant is used as an active agent, the selected material may be moisture or a gas that can be absorbed by the desiccant. In embodiments in which a releasing material is used as an active agent, the selected material may be an agent released by the releasing material, such as moisture, fragrance, or an antimicrobial agent. In embodiments in which an adsorbing material is used as an active agent, the selected material may be certain volatile organic compounds and the adsorbing material may be activated carbon.

[0059] As used herein, the term "three phase" is defined as a monolithic composition or structure comprising three or more phases. An example of a three phase composition that may be used according to the disclosed concept would be an entrained polymer formed of a base polymer, active agent, and channeling agent. Optionally, a three phase composition or structure may include an additional phase, e.g., a colorant.

Entrained Polymers Suitable for Methods of Invention

[0060] One of the difficulties in processing molten particulate or mineral entrained polymers is providing a substantially consistent shear of the molten material conveyed through an extruder and thereafter maintaining the molten state of the material through the point of dispensing. This would not typically be problematic for a simple "one phase" polymer or a mixture of molten polymers. However, including a granular, abrasive mineral component in the formulation, such as a typical desiccant (e.g., molecular sieve or silica gel), introduces complexity to the process. Such granular mineral components interfere with achieving the consistent shear necessary to convey the entrained polymer through the extruder and to maintain it in a molten state when dispensed so as to apply the molten entrained polymer in a predetermined shape to a surface of a substrate to form thereon a solidified entrained polymer structure (e.g., film). Those problems

are particularly acute when the granular mineral components are at high loading levels.

[0061] From the perspectives of material science and fluid mechanics, the viscosity of the entrained polymer is known to vary and decreases with increasing shear rate. This non-newtonian, pseudoplastic material creates challenges in mixing and handling as its thixotropic structure progressively breaks down on shearing and slowly rebuilds at rest. The term "thixotropic structure" is based on the following definition for "thixotropy": a term used in rheology which means that the viscosity of material decreases significantly with the time of shearing and then, increases significantly when the force introducing the flow is removed.

[0062] The inventors have found that a standard particulate or mineral entrained polymer in accordance with U.S. Pat. No. 7,005,459 is difficult to process using standard tank melting systems because no shear is introduced in the standard tank melting systems; rather, only heat is used. In the absence of shear thinning, the high viscosity at low shear stress is too great and thus will not allow the material to flow/ dispense as its thixotropic behavior wants to resist any flowing. The high viscosity is compounded by the high density of the particulate or mineral entrained polymer. A particulate or mineral entrained polymer compound in molten form requires constant pressure and shearing through an extruder for flowing to occur, which may be facilitated using a pressurized tank melting system. A pressurized tank melting system uses a pneumatic cylinder to push a plate against the entrained polymer.

[0063] In addition to the challenges described above, the rheology of the entrained polymer needs to enable clean melt filament formation upon discharge onto the surface of the substrate. Otherwise, the resulting defects, such as angel hair and tails, render the dispensing process inefficient and costly. Further, for effective bonding to the surface of the substrate, the entrained polymer and the surface of the substrate need to be chemically compatible.

[0064] The inventors have developed an entrained polymer composition for an in-line process utilizing a standard tank melting system without mixing, and an applicator to efficiently dispense the molten entrained polymer in a predetermined shape to the surface of a substrate.

[0065] In one embodiment, the entrained polymer composition comprises at least a base polymer material and an active agent. In another embodiment, the entrained polymer composition comprises at least a base polymer material, an active agent, and a channeling agent.

[0066] In another embodiment, the base polymer material comprises a base polymer and an optional additive.

[0067] Suitable base polymers may include thermoplastic polymers, e.g., polyolefins such as polypropylene and polyethylene, polyisoprene, polybutadiene, polybutene, polysiloxane,

polycarbonates, polyamides, ethylene-vinyl acetate copolymers, ethylene-methacrylate copolymer, poly(vinyl chloride), polystyrene, polyesters, polyanhydrides, polyacrylonitrile, polysulfones, polyacrylic ester, acrylic, polyurethane and polyacetal, or copolymers or mixtures thereof.

[0068] The additive may be a filler, a flow agent, a colorant, a plasticizer, or a stabilizer. In one embodiment, the additive is a flow agent. In an optional embodiment, the flow agent is a low molecular weight polyolefin, a low molecular weight oligomeric olefin, a polyolefin, or a modified polyolefin. In another optional embodiment, the flow agent is a natural, derived or synthetic wax. Naturally occurring waxes include animal, vegetable and mineral types, with the most common being the microcrystalline and paraffin mineral types. Synthetic waxes are polyethylene, polypropylene and Fischer-Tropsch waxes. These waxes may be homopolymers, where the polymer chain is based upon one monomer unit, such as ethylene, or they may be copolymers based upon two or more units, such as ethylene and vinyl acetate. Synthetic homopolymers or copolymers may also be functionalized in a modification step. The types of wax are not particularly limited in the chemical structure. In an optional embodiment, the flow agent is a paraffin, a low molecular weight polyethylene, a low molecular weight polyethylene derivative, ethylene bis(stearamide) (EBS), or cetyl palmitate.

[0069] Suitable channeling agents may include a polyglycol such as polyethylene glycol (PEG), ethylene-vinyl alcohol (EVOH), polyvinyl alcohol (PVOH), glycerin polyamine, polyurethane and polycarboxylic acid including polyacrylic acid or polymethacrylic acid. Alternatively, the channeling agent 35 can be, for example, a water insoluble polymer, such as a propylene oxide polymerisate-monobutyl ether, such as Polyglykol B01/240, produced by CLARIANT. In other embodiments, the channeling agent could be a propylene oxide polymerisate monobutyl ether, such as Polyglykol B01/20, produced by CLARIANT, propylene oxide polymerisate, such as Polyglykol D01/240, produced by CLARIANT, ethylene vinyl acetate, nylon 6, nylon 66, or any combination of the foregoing.

[0070] Suitable active agents according to the disclosed concept include absorbing materials, such as desiccating compounds. If the active agent is a desiccant, any suitable desiccant for a given application may be used. Typically, physical absorption desiccants are preferred for many applications. These may include molecular sieves, silica gels, clays and starches. Alternatively, the desiccant may be a chemical compound that forms crystals containing water or compounds which react with water to form new compounds.

[0071] Optionally, in any embodiment, the active agent may be an oxygen scavenger.

[0072] Suitable absorbing materials may also include: (1) metals and alloys such as, but not limited to, nickel, copper, aluminum, silicon, solder, silver, gold; (2) metal-plated particulates such as silver-plated copper, silver-placed nickel, silver-plated glass microspheres; (3) inorganics such as $BaTiO_3$, $SrTiO_3$, SiO_2, Al_2O_3, ZnO, TiO_2, MnO, CuO, Sb_2O_3, WC, fused silica, fumed silica, amorphous fused silica, sol-gel silica, sol-gel titanates, mixed titanates, ion exchange resins, lithium-containing ceramics, hollow glass microspheres; (4) carbon-based materials such as carbon, activated charcoal, carbon black, ketchem black, diamond powder; (5) elastomers, such as polybutadiene, polysiloxane, and semi-metals, ceramic and; (6) other fillers and pigments.

[0073] In another example, the absorbing material may be a carbon dioxide scavenger, such as calcium oxide. In the presence of moisture and carbon dioxide, the calcium oxide is converted to calcium carbonate. Accordingly, calcium oxide may be used as the absorbing material in applications where absorption of carbon dioxide is needed. Such applications include preserving fresh foods (e.g., fruits and vegetables) that give off carbon dioxide.

[0074] Other suitable active agents according to the disclosed concept include releasing materials. Such materials may comprise any suitable material that will release the selected material from the releasing material. The selected material released from the releasing material could be in the form of a solid, gel, liquid or gas. These substances can perform a variety of functions including: serving as a fragrance, flavor, or perfume source; supplying a biologically active ingredient such as pesticide, pest repellent, antimicrobials, bait, aromatic medicines, etc.; providing humidifying or desiccating substances; delivering air-borne active chemicals, such as corrosion inhibitors; ripening agents and odor-masking agents.

[0075] Suitable biocides for use as releasing materials in the entrained polymers of the disclosed concept may include, but are not limited to, pesticides, herbicides, nematacides, fungicides, rodenticides and/or mixtures thereof. In addition to the biocides, the covering of the disclosed concept can also release nutrients, plant growth regulators, pheromones, defoliants and/or mixture thereof.

[0076] Quaternary ammonium compounds can also be used as releasing materials according to the disclosed concept. Such compounds not only function as surfactants, but also impart to the surface of the entrained polymer aseptic properties or establish conditions for reducing the number of microbial organisms, some of which can be pathogenic. Numerous other antimicrobial agents, such as benzalkonium chloride and related types of compounds such as hexachlorophene, may also be used as releasing agents according to the disclosed concept.

[0077] Other potential releasing materials include fragrances, including natural, essential oils and synthetic perfumes, and blends thereof. Typical perfumery materials which may form part of, or possibly the whole of, the active ingredient include: natural essential oils such as lemon oil, mandarin oil, clove leaf oil, petitgrain oil, cedar wood oil, patchouli oil, lavandin oil, neroli oil, ylang oil, rose absolute or jasmin absolute; natural resins such as labdanum resin or olibanum resin; single perfumery chemicals which may be isolated from natural sources or manufactured synthetically, as for example alcohols such as geraniol, nerol, citronellol, linalol, tetrahydrogeraniol, betaphenylethyl alcohol, methyl phenyl carbinol, dimethyl benzyl carbinol, menthol or cedrol; acetates and other esters derived from such alcohols-aldehydes such as citral, citronellal, hydroxycitronellal, lauric aldehyde, undecylenic aldehyde, cinnamaldehyde, amyl cinnamic aldehyde, vanillin or heliotropin; acetals derived from such aldehydes; ketones such as methyl hexyl ketone, the ionones and methylionones; phenolic compounds such as eugenol and isoeugenol; synthetic musks such as musk xylene, musk ketone and ethylene brassylate.

[0078] It is believed that the higher the active agent concentration in the mixture, the greater the absorption, adsorption or releasing capacity (as the case may be) will be of the final composition. However, too high an active agent concentration could cause the entrained polymer to be more brittle, and the molten mixture of active agent, base polymer material and channeling agent to be more difficult to either thermally form, extrude or injection mold.

[0079] In one embodiment, the active agent loading level can range from 10% to 80% including any sub-range or value encompassed within by weight with respect to the total weight of the entrained polymer. In an optional embodiment, the active agent loading is no less than 20%, optionally no less than 30%, optionally no less than 40%, optionally no less than 50% by weight with respect to the total weight of the entrained polymer. In another optional embodiment, the active agent loading is no more than 70%, optionally no more than 60%, optionally no more than 50% by weight with respect to the total weight of the entrained polymer. In another optionally embodiment, the active agent loading is from 20% to 80%, optionally from 20% to 60%, optionally from 20% to 50%, optionally from 20% to 40%, optionally from 30% to 80%, optionally from 30% to 60%, optionally from 30% to 50%, optionally from 30% to 40%, optionally from 40% to 80%, optionally from 40% to 60%, optionally from 40% to 50%.

[0080] Optionally, the channeling agent may be provided in a range of 1% to 10% including any sub-range or value encompassed within by weight of the entrained polymer. In an optional embodiment, the channeling agent may be provided at a range from 1% to 8%, optionally from

1% to 6%, optionally from 1% to 5%, optionally from 1% to 4%, optionally from 1% to 3%, optionally from 2% to 8%, optionally from 2% to 6%, optionally from 2% to 5%, optionally from 2% to 4%, optionally from 2% to 3%, optionally from 3% to 8%, optionally from 3% to 6%, optionally from 3% to 5%, optionally from 3% to 4%, optionally from 4% to 8%, optionally from 4% to 6%, optionally from 4% to 5%. In another optional embodiment, the channeling agent may be provided at 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, or 10%.

[0081] Optionally, the base polymer may range from 10% to 50% including any sub-range or value encompassed within by weight of the entrained polymer. In an optional embodiment, the base polymer is no less than 20%, optionally no less than 30%, optionally no less than 40% by weight with respect to the total weight of the entrained polymer. In another optional embodiment, the base polymer is no more than 40%, optionally no more than 30% by weight with respect to the total weight of the entrained polymer. In another optional embodiment, the base polymer may range from 15% to 40%, optionally 20% to 35%, optionally 25% to 30% by weight of the entrained polymer.

[0082] Optionally, the flow agent may range from 5% to 50%, any sub-range or value encompassed within by weight of the entrained polymer. In an optional embodiment, the flow agent is no less than 10%, optionally no less than 20%, optionally no less than 30% by weight with respect to the total weight of the entrained polymer. In another optional embodiment, the flow agent is no more than 40%, optionally no more than 30% by weight with respect to the total weight of the entrained polymer. In another optional embodiment, the flow agent may range from 10% to 40%, optionally from 10% to 35%, optionally from 20% to 40%, optionally from 20% to 30% by weight with respect to the total weight of the entrained polymer. Optionally, a colorant is added, e.g., at about 2% by weight of the total weight of the entrained polymer.

[0083] The entrained polymer suitable for an in-line melt adhesion process of the current invention can also be characterized by its melt flow index (MFI). Typically, a base polymer such as a polypropylene, has an MFI of about 12 g/10 min (ASTM D1238 /ISO 1133standard conditions, omitted hereafter in relation to MFI). A sample desiccant entrained polymer consistent with the disclosure in U.S. Pat. No. 7,005,459 has an MFI below 12 g/10 min. The entrained polymer of the invention has an MFI ranging from 200 g/10 min to 5000 g/10 min. In an optional embodiment, the MFI of the entrained polymer is no less than 500 g/10 min, optionally no less than 1000 g/10 min, optionally no less than 1500 g/10 min, optionally no less than 2000 g/10 min. In another optional embodiment, the MFI of the entrained polymer is no

more than 4000 g/10 min, optionally no more than 3500 g/10 min, optionally no more than 3000 g/10 min, optionally no more than 2500 g/10 min. In another optional embodiment, the MFI of the entrained polymer is in the range from 500 g/10 min to 4000 g/10 min, optionally from 500 g/10 min to 3500 g/10 min, optionally from 500 g/10 min to 3000 g/10 min, optionally from 500 g/10 min to 2500 g/10 min, optionally from 500 g/10 min to 2000 g/10 min, optionally from 500 g/10 min to 1500 g/10 min, optionally from 1000 g/10 min to 4000 g/10 min, optionally from 1000 g/10 min to 3500 g/10 min, optionally from 1000 g/10 min to 3000 g/10 min, optionally from 1000 g/10 min to 2500 g/10 min, optionally from 1000 g/10 min to 2000 g/10 min, optionally from 1000 g/10 min to 1500 g/10 min, optionally from 1200 g/10 min to 4000 g/10 min, optionally from 1200 g/10 min to 3500 g/10 min, optionally from 1200 g/10 min to 3000 g/10 min, optionally from 1200 g/10 min to 2500 g/10 min, optionally from 1200 g/10 min to 2000 g/10 min, optionally from 1500 g/10 min to 4000 g/10 min, optionally from 1500 g/10 min to 3500 g/10 min, optionally from 1500 g/10 min to 3000 g/10 min, optionally from 1500 g/10 min to 2500 g/10 min. The relatively high MFI facilitates the flow of the molten entrained polymer in the in-line dispensing and adhesion process.

[0084] The entrained polymer suitable for an in-line melt adhesion process of the current invention can additionally or alternatively be characterized by its viscosity. A sample desiccant entrained polymer consistent with the disclosure in U.S. Pat. No. 7,005,459 has a viscosity on the order of 100,000 cP (analyzed using a rheometer with parallel plate geometry, 190 °C, shear rate 5 Hz for two minutes) (conditions used throughout and omitted hereafter in relation to viscosity). The entrained polymer of the current invention has a viscosity ranging from 1,000 cP to 50,000 cP. In an optional embodiment, the viscosity of the entrained polymer is no more than 40,000 cp, optionally no more than 20,000 cP, optionally no more than 15,000 cp, optionally no more than 12,000 cp, optionally no more than 10,000 cp, optionally no more than 8,000 cp, optionally no more than 6,000 cp, optionally no more than 4,000 cp, optionally no more than 2,000 cp. In another optional embodiment, the viscosity of the entrained polymer is in a range from 3,000 cp to 40,000 cp, optionally from 3,000 cp to 30,000 cp, optionally from 3,000 cp to 20,000 cp, optionally from 3,000 cp to 15,000 cp, optionally from 3,000 cp to 12,000 cp, optionally from 4,000 cp to 40,000 cp, optionally from 4,000 cp to 30,000 cp, optionally from 4,000 cp to 20,000 cp, optionally from 4,000 cp to 15,000 cp, optionally from 4,000 cp to 12,000 cp, optionally from 6,000 cp to 40,000 cp, optionally from 6,000 cp to 30,000 cp, optionally from 6,000 cp to 20,000 cp, optionally from 6,000 cp to 15,000 cp, optionally from 6,000 cp to 12,000 cp, optionally from 8,000 cp to 40,000 cp, optionally from 8,000 cp to

30,000 cp, optionally from 8,000 cp to 20,000 cp, optionally from 8,000 cp to 15,000 cp, optionally from 8,000 cp to 12,000 cp, optionally from 10,000 cp to 40,000 cp, optionally from 10,000 cp to 30,000 cp, optionally from 10,000 cp to 20,000 cp, optionally from 10,000 cp to 15,000 cp, optionally from 10,000 cp to 12,000 cp, optionally from 12,000 cp to 40,000 cp, optionally from 12,000 cp to 30,000 cp, optionally from 12,000 cp to 20,000 cp, optionally from 12,000 cp to 15,000 cp. The relatively low viscosity facilitates the flow of the molten entrained polymer in the in-line dispensing and adhesion process.

[0085] The current invention provides an entrained polymer that is highly active, has good flow properties for large scale high throughput in-line application on a substrate, and enables precise control of dispense to form intricate patterns on a wide range of surfaces or enclosures. The in-line process may use a pre-formed monolithic entrained polymer as the starting material. However, the requisite components, such as base polymer, particular active agent, additive, and channeling agent, may also be mixed and heated to a molten form in the same process immediately prior to application on a substrate. Similarly, an intermediate material containing a subset of the requisite components may be mixed with other requisite component(s) to form the entrained polymer composition used in the in-line application process. The compositional make-up described above using a monolithic entrained polymer as an example applies similarly to the entrained polymer composition.

[0086] FIGs. 1-6 illustrate entrained polymers 10 and various packaging assemblies formed of entrained polymers according to the disclosed concept. The entrained polymers 10 each include a base polymer material 25, a channeling agent 35 and an active agent 30. As shown, the channeling agent 35 forms interconnecting channels 45 through the entrained polymer 10. At least some of the active agent 30 is contained within these channels 45, such that the channels 45 communicate between the active agent 30 and the exterior of the entrained polymer 10 via channel openings 48 formed at outer surfaces of the entrained polymer 10. The active agent 30 can be, for example, any one of a variety of absorbing, adsorbing or releasing materials, as described in further detail below. While a channeling agent, e.g., 35, is preferred, the disclosed concept broadly includes entrained polymers that optionally do not include channeling agents.

[0087] Referring to FIG. 1, an insert 20, constructed from the entrained polymer according to an optional embodiment is illustrated. The insert 20 is in the form of a plug 55 that may be deposited into a container or other enclosure, or deposited onto a substrate (e.g., foil).

[0088] Referring to FIG. 2, a cross-sectional view is shown of the plug 55 that has been constructed from an entrained polymer 10 comprising the base polymer 25 that has been

uniformly blended with the active agent 30 and the hydrophilic agent or channeling agent 35. In the illustration of FIG. 2, the entrained polymer has been solidified so that interconnecting channels 45 have formed throughout the entrained polymer 10 to establish passages throughout the solidified plug 55. As may be appreciated from both FIGS. 1 and 2, the passages terminate in channel openings 48 at exterior surfaces of the plug 55.

[0089] FIG. 3 illustrates the embodiment of a plug 55 similar in construction and makeup to the plug 55 of FIG. 2, where interconnecting channels 45 are very fine compared to those of FIG. 2. This can result from the use of a dimer agent (i.e., a plasticizer) together with a channeling agent 35. The dimer agent may enhance the compatibility between the base polymer 25 and the channeling agent 35. This enhanced compatibility is facilitated by a lowered viscosity of the blend, which may promote a more thorough blending of the base polymer material 25 and channeling agent 35, which under normal conditions can resist combination into a uniform solution. Upon solidification of the entrained polymer 10 having a dimer agent added thereto, the interconnecting channels 45 which are formed therethrough have a greater dispersion and a smaller porosity, thereby establishing a greater density of interconnecting channels throughout the plug 55.

[0090] Interconnecting channels 45, such as those disclosed herein, facilitate transmission of a desired material, such as moisture, gas or odor, through the base polymer material 25, which generally resists permeation of these materials, thus acting as a barrier thereto. For this reason, the base polymer material 25 itself acts as a barrier substance within which an active agent 30 may be entrained. The interconnecting channels 45 formed of the channeling agent 35 provide pathways for the desired material to move through the entrained polymer 10. Without these interconnecting channels 45, it is believed that relatively small quantities of the desired material would be transmitted through the base polymer material 25 to or from the active agent 30. In the case in which the desired material is transmitted to the active agent 30, it may be absorbed by the active agent 30, for example in embodiments in which the active agent 30 is an active agent such as a desiccant or an oxygen absorber. In the case in which the desired material is transmitted from the active agent 30, it may be released from the active agent 30, for example in embodiments in which the active agent 30 is a releasing material, such as a fragrance or gas releasing material.

[0091] FIG. 4 illustrates an embodiment of an entrained polymer 10 according to the disclosed concept, in which the active agent 30 is an absorbing or adsorbing material. The arrows indicate the path of the selected material, for example moisture or gas, from an exterior

of the entrained polymer 10, through the channels 45, to the particles of active agent 30, which absorb or adsorb the selected material.

[0092] FIG. 5 illustrates embodiments of an end product of the method according to the disclosed concept. An entrained polymer structure 75 formed of the entrained polymer 10 of the invention is used in combination with a barrier sheet 80 to form a composite according to an aspect of the invention. The characteristics of the entrained polymer structure 75 are similar to those described with respect to the plug 55. The barrier sheet 80 may be a substrate such as foil and/or a polymer with low moisture or oxygen permeability. The substrate 80 is compatible with the entrained polymer structure 75 and is thus configured to thermally bond to the entrained polymer structure 75, when the entrained polymer structure 75 solidifies after dispensing, as discussed below.

[0093] FIG. 6 illustrates an embodiment in which the entrained polymer structure 75 and the substrate 80 are combined to form a packaging wrap having active characteristics at an interior surface formed by the entrained polymer 10 in the entrained polymer structure 75, and vapor resistant characteristics at an exterior surface formed by the barrier sheet or substrate 80. In this embodiment, the entrained polymer structure 75 occupies a portion of the barrier sheet or substrate 80. Methods according to the disclosed concept for making the entrained polymer structure 75 and adhering it to the substrate 80 are described below.

[0094] In one embodiment, the sheets of FIG. 5 are joined together to form an active package 85, as shown in FIG. 6. As shown, two laminates or composites are provided, each formed of an entrained polymer structure 75 joined with a barrier sheet or substrate 80. The sheet laminates are stacked, with the entrained polymer structures 75 facing one another, so as to be disposed on an interior of the package, and are joined at a sealing region 90, formed about a perimeter of the sealed region of the package interior.

[0095] The primary purpose of the entrained polymer of the current invention is for use in an in-line production process to apply a particulate or mineral entrained polymer to a compatible substrate and to adhere the (initially molten and subsequently solidified) entrained polymer to the substrate via a thermal bond. However, the use of the entrained polymer of the current invention is not so limited. The current invention provides a high density, high melt flow index, and low viscosity active polymer adaptable for a high throughput in-line production process.

Exemplary Methods According to Current Invention

[0096] Methods for applying and adhering an entrained polymer structure to a suitable substrate according to aspects of the invention will now be described.

[0097] The current invention also provides a method for forming and adhering an entrained polymer structure to a substrate, using the entrained polymer or the entrained polymer composition discussed above. The method is illustrated below, using as an example a pre-formed monolithic entrained polymer as the starting material.

[0098] First, the entrained polymer is introduced to a feeder. Heat is applied to convert the entrained polymer to a molten state.

[0099] Second, the flow of the entrained polymer in a molten state is conveyed to an applicator. Heat may be necessary along the flow path to maintain the flow rate and the plasticity of the molten entrained polymer.

[00100] Third, the molten entrained polymer is dispensed via a dispenser on a surface of a substrate in a desired pattern or shape. The loading is controlled in a precise manner via, for example, pneumatic pressure applied to the applicator, advance rate of substrate, and discharge time of dispenser. The surface compatibility enables bonding of the entrained polymer with the substrate. Upon sufficient cooling, the deposited entrained polymer solidifies and forms an entrained polymer structure on the surface of the substrate. The pattern or shape of the deposit is not particularly limited. For example, the entrained polymer structure may be in a form of a sheet, a film, a bead, a dot, a strip or a swirl.

[00101] The method is not limited to using pre-formed entrained polymer as the starting material. Likewise, the components of the entrained polymer may also be mixed and heated to form a molten composition sharing the same compositional features of the pre-formed entrained polymer.

[00102] The inventors have discovered certain adaptations to single screw extruder equipment and to processes for using the same that overcome the process difficulties discussed above. The extruder, as with typical extruders, provides for transport and melting of feed and pressure build-up of melted polymer for dispensing. Typically, an extruder includes a hollow chamber with heating zones and a threaded shaft or screw which rotates along its central axis. The extruder typically includes a hopper at one end, which provides for feeding of polymer material into the extruder, typically in the form of 2 - 10 mm sized solid pellets.

[00103] Referring now to Fig. 7, there is shown an optional embodiment of a hot melt dispensing apparatus 100 for carrying out methods for forming and adhering an entrained polymer structure to a substrate. The hot melt dispensing apparatus 100 includes a feeder 102 (optionally, an extruder or a loader) for providing a flow of particulate or mineral entrained polymer in molten form. The feeder 102 includes an exit 106 to which a hose 104 (optionally

more than one hose) is coupled. The hose 104 includes an internal lumen 108 that is in fluid communication with the exit 106 to receive flow of the particulate or mineral entrained polymer in molten form. The lumen 108 terminates at an applicator 110 to which the entrained polymer in molten form is conveyed. The applicator 110 comprises a dispenser 112 configured to deliver the entrained polymer in molten form to a surface or enclosure in precise amounts and configurations (i.e., in a predetermined shape).

[00104] In the embodiment shown, the dispenser 112 has deposited a particulate or mineral entrained polymer in molten form to the surface 116 of a substrate 114, forming and adhering an entrained polymer structure 118 thereon. Optionally, the substrate 114 is a foil and the surface 116 is a polymer sealing layer (which is compatible with the base polymer material of the particulate or mineral entrained polymer) to help effectuate a thermal bond between the structure 118 and the surface 116. The lumen 108 and/or the dispenser 112 (preferably both) are heated to maintain a molten state of the entrained polymer when conveyed from the feeder 102, through the lumen 108 and out the dispenser 112. Heating the dispenser 112 in this way also may help facilitate precise formation of the entrained polymer into the predetermined shape.

[00105] Optionally, the method using the apparatus 100 is carried out as part of an automated, in-line production process. To facilitate this, for example, a conveyor belt may transport substrate 114 in a discontinuous or a continuous manner for automated depositing of molten entrained polymer thereon. For example, the conveyor belt may move in direction D to transport the units or a sheet of substrate 114 as part of the in-line process. The in-line process may be, for example, a package production process. The entrained polymer structure 118 and substrate 114 together form a composite, which may be a portion of a flexible package, pouch or blister pack, for example.

[00106] Optionally, the dispenser 112 comprises a valve that alternates between a closed state and an open state so as to precisely form the entrained polymer structure 118 in the predetermined shape. Optionally, the dispenser 112 comprises a hot melt precision slot-die extrusion coating head. This type of dispenser configuration may help ensure accurate heat distribution and stability, and provide precise repeatability. The entrained polymer will flow through a deposition nozzle of the dispenser because the applied shear thinning and pressure shears the bond and induces a breakdown in the material elasticity, therefore causing material to flow. The elasticity recovers immediately after leaving the nozzle and the entrained polymer solidifies to maintain its shape and strength. The result is a strip or other structure of a solidified entrained polymer that is configured to thermally bond to a compatible substrate.

[00107] Optionally, in any embodiment, a storage or material supply tank may be configured to store a pseudoplastic high viscosity material and supply the material (e.g., solid entrained polymer pellets) to a pump. The pump is configured to apply a force to the material by shear thinning the pseudoplastic high viscosity material to reduce material viscosity, thus causing the material to flow.

[00108] If an extruder is used to feed hot melt entrained polymer, means are required to position and dispense the material onto a substrate. This for example may be provided by a flexible or rigid hose that is connected to and in fluid communication with an exit of the extruder, as discussed above. The flexible hose includes a lumen through which the molten entrained polymer is conveyed, the lumen being heated preferably at or above the temperature of the polymer exiting the extruder. Such a high temperature is configured to prevent heat loss that could inhibit flow. The entrained polymer may flow through a deposition nozzle because the applied shear thinning and pressure shears the bond and induces a breakdown in the material elasticity therefore causing material to flow. The elasticity recovers immediately after leaving the nozzle and the entrained polymer solidifies to maintain its shape and strength. The result is a strip or other structure in a desired shape of a solidified entrained polymer that is configured to thermally bond to a compatible substrate.

[00109] Optionally, in any embodiment, the lumen 108 of the hose 104 that is in contact with the molten entrained polymer is heated to a temperature at or above that of the material exiting the extruder. Optionally, in any embodiment, the dispenser 112 is heated to maintain the molten state of the entrained polymer and to facilitate precise formation of the entrained polymer into the predetermined shape in the dispensing step. Optionally, in any embodiment, the apparatus 100 is incrementally heated such that the dispensed molten entrained polymer is in a heated and pliable state (in the form of a hot melt with inherent adhesive properties) in the dispensing step to facilitate controlled and variable dispensing onto the substrate 114. This may be achieved, for example, through heating the hoses and/or dispenser, as described above. Optionally, in any embodiment, the dispenser 112 is configured to be adaptable (e.g., with replacement heads) to dispense a variety of entrained polymer shapes and material volumes from a single material source as needed.

[00110] Optionally, in any embodiment, to integrate the method of the disclosed concept into a processing line, the molten entrained polymer composition of the present invention may be conveyed into a metering pump supplying the heated hoses and the use of pneumatically controlled dispensers to finitely control the dispensing. Optionally, processing feedback may be

used to control the supply of material from the extruder to the metering pump and from the metering pump to the dispenser. For example, programmable logic controllers may be used to adjust the on/off and speed of the feeder (e.g., extruder) to maintain a supply of molten material to the metering pump(s). Optionally, a metering pump could be coupled to a manifold that would supply multiple heated hoses and dispensers.

[00111] The primary intended use of methods according to the invention are for applying a particulate or mineral entrained polymer to a compatible substrate to adhere the (initially molten and subsequently solidified) entrained polymer to the substrate via a thermal bond. However, alternative aspects of the invention may include methods for dispensing the entrained polymer to a substrate or into a compartment wherein a thermal bond is not created and alternative means of securing the entrained polymer and substrate are required. In such a case, much of the process in terms of running the material through the extruder and adaptations to the extruder equipment would be the same. However, a mechanical interlock, a tie layer between the entrained polymer and the substrate, an adhesive additive mixed into the polymer or some other means (as an alternative to a thermal bond) may be provided to secure the entrained polymer to the substrate or compartment. For example, in the electronics industry, a substrate or compartment may include electronic components and empty space surrounding the electronic components for which it is desired to provide an active material, e.g., entrained polymer. Rather than injection molding a separate part comprising an entrained polymer and then assembling such part to the substrate or compartment, methods according to an aspect of the disclosed concept would enable one to dispense and fill a desired space on a substrate or compartment with a particulate or mineral entrained polymer. Such an in-line process would obviate the need for a separate assembling step. In the event the substrate or compartment surface is incompatible with the entrained polymer such that no thermal bond can be formed, a mechanical interlock or structure may be provided to secure the solidified entrained polymer in place. For example, a cover may be placed over the substrate or compartment to form an assembly, thereby retaining the entrained polymer in place.

Exemplary Products According to Current Invention

[00112] The composite formed of the entrained polymer structure and the substrate adhered thereto may be a portion of a flexible package, pouch or blister pack. FIG. 6 shows an example of the products manufactured by the invented entrained polymer and the method of manufacture. These products containing the active agent may be used directly.

[00113] The invention will be illustrated in more detail with reference to the following

Examples, but it should be understood that the invention is not deemed to be limited thereto.

EXAMPLE 1

[00114] Desiccant entrained polymer samples according to Table 1 below were prepared in the form of extruded pellets.

Table 1

Sample	Components	Weight %	Melt Flow Index[1] (g/10 min)	Estimated Viscosity[2] (cP)	Dispense Outcome
1	Molecular Sieve 4A Carbowax 4000 Polypropylene	40 2 58	307.8		
2	Molecular Sieve 4A Carbowax 4000 Polypropylene	60 2 38	197.5		
3	Molecular Sieve 4A Carbowax 4000 LDPE PE 143 Wax	50 2 24 24	1563.9	< 10,000	Excellent
4	Molecular Sieve 4A Carbowax 4000 LDPE PE 143 Wax	50 2 2 46	NA due to splatter		
5	Molecular Sieve 4A Carbowax 4000 LDPE PE 143 Wax	40 2 30 28	2310	< 10,000	Excellent
6	Molecular Sieve 4A Carbowax 4000 LDPE PE 143 Wax	40 2 8 50	548		
7	Molecular Sieve 4A Carbowax 4000 LDPE PE 105 Wax	50 2 24 24	152	54,000	
8	Molecular Sieve 4A Carbowax 4000 LDPE PE 105 Wax	50 2 2 46	186.1		
9	Molecular Sieve 4A Carbowax 4000 LDPE PE 105 Wax	40 2 30 28	273.2	37,000	
10	Molecular Sieve 4A Carbowax 4000 LDPE PE 105 Wax	40 2 8 50	605.7		

[1] Melt flow index were measured according to the ASTM D1238 /ISO 1133 method.
[2] Viscosity was measured using a rheometer with a parallel plate geometry, at 190 °C, with shearing at a rate of 5 Hz for two minutes.

EXAMPLE 2

[00115] Based on the MFI and the performance of the material in the MFI measurement, Samples 3 and 4 in Example 1 were selected for the hot-melt in-line process according to one aspect of the invented method.

[00116] The inventors reconfigured an extruder to create an extruder assembly and developed a desiccant entrained polymer composition to practice a method according to an optional aspect of the invention. The extruder assembly successfully extruded a mineral entrained polymer from a pellet form, conveyed the molten material through a heated hose and dispensed it out of a heated hot melt gun or dispenser to form an entrained polymer structure adhered to a foil substrate.

[00117] A typical extruder would dispense directly through a die to produce a particular shape of material, e.g., solid or hollow strands or tubes. Uniquely, an extruder assembly according to the disclosed concept, included a heated hose coupled to the exit of the extruder and a heated dispenser coupled to the dispensing end of the hoses. The lumen of the hose was heated to a temperature at or above the material exiting the extruder so as to maintain the entrained polymer in a molten state as the polymer was conveyed under pressure from the extruder through the hose. Closing the dispenser allowed pressure to build up in the system. Opening and closing of the dispenser allowed the material to flow in a very controlled and precise manner. The base polymer used in the formulation was compatible with a polymer coating (polymer seal layer) on the foil substrate. This allowed the molten state of the mineral entrained polymer (which was further maintained via the heated dispenser) to mix and adhere to the coated substrate, due to similar properties of the contacting materials. The result was a solidified entrained polymer structure formed and adhered onto the foil substrate.

[00118] FIGs. 8 and 9 are photographs illustrating an entrained polymer film and strip, respectively, adhered to a sheet using an optional embodiment of a hot melt dispensing apparatus.

[00119] While the invention has been described in detail and with reference to specific examples thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

CLAIMS

1. A method for forming and adhering an entrained polymer structure to a substrate, comprising the steps of:

a. extruding an entrained polymer composition in molten form, wherein the entrained polymer composition comprises a mixture of a base polymer and a particulate active agent;

b. providing a substrate having a surface for receiving application of the entrained polymer composition, and

c. applying the entrained polymer composition in molten form in a predetermined shape to the surface of the substrate to form thereon a solidified entrained polymer structure, wherein the entrained polymer composition adheres to the surface of the substrate by thermal bonding, wherein the entrained polymer structure is formed upon cooling and solidification of the entrained polymer composition, the solidified entrained polymer structure comprising a boundary, the surface of the substrate extending outwardly beyond the boundary.

2. The method of claim 1, wherein the surface of the substrate extends outwardly beyond the boundary in all directions.

3. The method of claim 1, wherein the entrained polymer composition comprises a channeling agent, the solidified entrained polymer structure comprising passages formed of the channeling agent that penetrate through the base polymer.

4. The method of claim 1, wherein the substrate is a foil and the surface of the substrate comprises is a polymer sealing layer on the foil.

5. The method of claim 1, the entrained polymer comprising a flow agent selected from the group consisting of: a polyolefin, a polyolefin derivative, a natural wax, a synthetic wax, polyethylene, polyethylene derivatives, ethylene bis(stearamide), and cetyl palmitate.

6. The method of claim 1, wherein the particulate active agent is present in a range of from 30% to 60% by weight with respect to the total weight of the entrained polymer

composition.

7. The method of claim 1, wherein the particulate active agent is a molecular sieve, which is present in a range of from 20% to 80% by weight with respect to the total weight of the entrained polymer composition.

8. The method of claim 1, wherein the particulate active agent is a silica gel, which is present in a range of from 20% to 80% by weight with respect to the total weight of the entrained polymer composition.

9. The method of claim 1, wherein the method is carried out using a hot melt dispensing apparatus comprising:

i. an extruder for blending and melting the entrained polymer composition and providing a flow of the entrained polymer composition in molten form through the apparatus;

ii. a hose having an internal lumen in fluid communication with an exit of the extruder to receive the flow of the entrained polymer composition in molten form; and

iii. an applicator in fluid communication with the hose, the applicator comprising a dispenser for dispensing the molten entrained polymer composition,

wherein the lumen terminates at the applicator to which the entrained polymer composition in molten form is conveyed through the hose, and wherein the dispenser applies the entrained polymer composition in molten form to the surface of the substrate in the predetermined shape.

10. The method of claim 9, wherein the lumen is heated as the entrained polymer composition is conveyed through the hose to the dispenser to maintain the molten form of the entrained polymer composition.

11. The method of claim 9, wherein the dispenser is heated to maintain the molten form of the entrained polymer composition for applying to the surface of the substrate and to facilitate precise formation of the entrained polymer composition into the predetermined shape.

12. The method of claim 9, the dispenser comprising a valve that alternates between a closed state and an open state so as to precisely form the entrained polymer composition in the predetermined shape.

13. The method of claim 1, wherein the solidified entrained polymer structure is in the form of a film having a thickness of from 0.1 mm to 1.5 mm, the substrate is a foil and the surface of the substrate is a polymer sealing layer on the foil.

14. The method of claim 1, wherein the method is carried out using a hot melt dispensing apparatus comprising an extruder which conveys the entrained polymer composition in molten form to a dispenser that applies the entrained polymer composition in molten form to the surface of the substrate, the dispenser comprising a valve that alternates between a closed state and an open state so as to precisely form the entrained polymer composition in the predetermined shape.

15. The method of claim 14, wherein the solidified entrained polymer structure is in the form of a film having a thickness of from 0.1 mm to 1.5 mm, the substrate is a foil and the surface of the substrate is a polymer sealing layer on the foil.

16. The method of claim 15, wherein the particulate active agent is a molecular sieve which is present in a range of from 30% to 60% by weight with respect to the total weight of the entrained polymer composition.

17. A composite made according to the method of claim 16, the composite comprising the entrained polymer structure and the substrate to which the entrained polymer structure is adhered.

18. A package comprising the composite of claim 17.

19. The package of claim 18, wherein the package is a pouch for a moisture-sensitive product.

20. The package of claim 18, wherein the package is a blister pack.