The present invention relates to a method of achieving a uniform distribution of reversible thermochromatic pigment within a spunmelt nonwoven fabric, by incorporating the reversible thermochromatic pigment into the polymer melt at the time of fiber or filament formation. It has been found that incorporating the pigment into the polymer melt enhances thermochromic uniformity as well as fabric durability. In addition, the reversible thermochromic fabric is processed in a single formation step, resulting in the present invention being more efficient than those methods practiced in the prior art.
MELTSPOUN THERMOCROMIC FABRICS

TECHNICAL FIELD

[0001] The present invention relates generally to a process of manufacturing nonwoven fabrics, and in particular, a process that incorporates a reversible thermochromic pigment into a polymer melt in order to achieve a durable and uniform distribution of thermochromic characteristics within a spunmelt nonwoven fabric.

BACKGROUND OF THE INVENTION

[0002] Reversible thermochromic chemistry allows for materials which are capable of changing from a first color to a second color in the presence of heat. Such substances have previously been used in combination with nonwoven and woven fabrics. Woven fabrics are those fabrics comprised of a plurality of warp and weft yarns that are interlaced on a loom. Nonwoven fabrics are comprised of natural or synthetic fiber, or a combination thereof, which are formed into a web or batt and then bonded or interlocked by means commonly known to one skilled in the art.

[0003] Nonwoven fabrics are highly versatile as they can be altered functionally and aesthetically, by use of suitable additives, to meet the needs of a multitude of end products, such as in apparel, industrial, and hygiene products. Reversible thermochromic pigment is one such additive that can change the appearance of a nonwoven fabric, and is generally useful in that such pigments are indicators of thermal history or attainment of temperature. By incorporating a thermochromic pigment onto a nonwoven fabric, the fabric provides a visual indication of a shift in temperature of the fabric through color change. A nonwoven fabric comprising a reversible thermochromic pigment will change colors with the temperature flux, meaning it can go back and forth between two colors depending on the degree of heat directed toward the fabric.

[0004] As evident in the prior art, thermochromic materials have been used in combination with nonwoven fabrics, as demonstrated by U.S. Pat. Nos. 6,228,804; 5,252,103; and 4,681,791, all hereby incorporated by reference.

[0005] U.S. Pat. No. 6,228,804 describes a color-change material comprising a reversible thermochromic layer that is superimposed onto a porous layer, wherein the porous layer includes a low-refractive-index pigment. The microencapsulated thermochromic material is dispersed into a film-forming compound containing a binder and applied to a substrate, such as a nonwoven.

[0006] U.S. Pat. No. 5,252,103 teaches a method of pigmenting fibrous cellulosic material that can be a nonwoven fabric, in which the material is initially treated with a cationic compound and then immersed in an aqueous solution of an anionic compound and a pigment. A thermochromic substance may be added to said aqueous solution in order to give color-changing properties to the pigmented fabric and a binder may be added to the solution to enhance fabric durability.

[0007] U.S. Pat. No. 4,681,791 discloses a method of forming a reversible thermochromic nonwoven fabric by means of coating the individual fibers prior to forming the fabric. The individual fibers are coated with thermochromic pigment and a binder mixture whereby the resultant fabric is believed to have better thermochromic uniformity.

[0008] As indicated above, the prior art encompasses multi-stepped processes to achieve a thermochromic nonwoven. The durability of the thermochromic pigment, however, is deteriorated affected due to the topical application of the pigment onto the fabric. Topical application of the thermochromic pigment can lead to color flaws in the fabric’s surface if the fabric is subjected to abrasion or the coating is not uniformly applied. The prior art clearly warrants a need for a more efficient mode of acquiring a durable thermochromic nonwoven fabric. The present invention discloses a rapid method of fabricating a uniform and durable, reversibly thermochromic nonwoven fabric.

SUMMARY OF THE INVENTION

[0009] The present invention relates to a method of achieving a uniform distribution of reversible thermochromic pigment within a spunmelt nonwoven fabric, by incorporating the reversible thermochromic pigment into the polymer melt at the time of fiber or filament formation. It has been found that incorporating the pigment into the polymer melt enhances thermochromic uniformity as well as fabric durability. In addition, the reversible thermochromic fabric is processed in a single formation step, resulting in the present invention being more efficient than those methods practiced in the prior art.

[0010] Prior art suggests the use of a binder to assist with the adhesion of the reversible thermochromic pigment to the fiber, with the intention of enhancing the color fastness of the fabric. The present invention does not require a binder to either adhere the thermochromic pigment to the nonwoven fabric or for the purpose of color durability enhancement. By integrating the reversible thermochromic pigment into the polymeric melt, the pigment is incorporated throughout the extruded filaments, forming a uniform reversible thermochromic fabric and a fabric resistant to surface color defects that may be caused by abrasion or washing of the nonwoven fabric.

[0011] Reversible thermochromic pigments function under a Lewis acid chemistry. At a specific temperature, electron donation occurs resulting in a shift of wavelength absorption properties that causes a color change. The reversible thermochromic pigment particles utilized in the present invention consist of the standard color changing components that are disclosed in U.S. Pat. No. 4,681,791, hereby incorporated by reference. The reversible thermochromic pigment of the present invention also contains UV absorber chemistry in order to prevent thermochromatic degradation in the presence of UV light. In the present invention, the manufacturing process time to produce a reversible thermochromic nonwoven is much shorter. The thermochromic concentrate is combined within a polymer melt blend creating a homogeneous mixture. The melt blend is extruded as the fibers or filaments are collected on a formous screen forming a web. It is also within the purview of the present invention that the nonwoven fabric comprises staple length fibers. The web is then bonded to form a nonwoven fabric. The resultant nonwoven fabric is one that can alter its appearance by changing color in response to heat.
DETAILED DESCRIPTION OF THE INVENTION

[0012] While the present invention is susceptible of embodiment in various forms, hereinafter is described a presently preferred embodiment of the invention, with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

[0013] In accordance to the present invention, the nonwoven fabric is spunmelt, as exemplified by meltblown fabrics or spunbond fabrics, and any combinations thereof. The fibers or filaments of the spunmelt can be selected from a group of polyesters, polyamides, or polyolefins, such as polypropylene, polyethylene, and the combinations thereof. The fibers or filaments may also be one of a multi-compoment configuration of the above mentioned polymers. The fibers may also be staple-length fibers wherein the molten polymer is extruded and drawn, resulting in a tow, which is cut into finite staple-lengths.

[0014] A spunbond process involves supplying a molten polymer, which is then extruded under pressure through a large number of oriﬁces in a plate known as a spinneret or die. The resulting continuous ﬁlaments are quenched and drawn by any of a number of methods, such as slot draw systems, attenuator guns, or Godet rolls. The continuous ﬁlaments are collected as a loose web upon a moving foraminous surface, such as a wire mesh conveyor belt. When more than one spinneret is used in line for the purpose of forming a multi-layered fabric, the subsequent webs is collected upon the uppermost surface of the previously formed web. The web is then at least temporarily consolidated, usually by means involving heat and pressure, such as by thermal point bonding. Using this bonding means, the web or layers of webs are passed between two hot metal rolls, one of which has an embossed pattern to impart and achieve the desired degree of point bonding, usually on the order of 10 to 40 percent of the overall surface area being so bonded.

[0015] A related means to the spunbond process for forming a layer of a nonwoven fabric is the melt blown process. Again, a molten polymer is extruded under pressure through oriﬁces in a spinneret or die. High velocity air impinges upon and entrains the ﬁlaments as they exit the die. The energy of this step is such that the formed ﬁlaments are greatly reduced in diameter and are fractured so that microﬁbers of ﬁnite length are produced. The extruded multiple and continuous ﬁlaments can be optionally imparted with a selected level of crimp, then cut into ﬁbers of ﬁnite staple length. These thermoplastic resin staple ﬁbers can then be subsequently used to form textile yarns or carded and integrated into nonwoven fabrics by appropriate means, as exempliﬁed by thermobonding, adhesive bonding, and hydroentanglement technologies. The process to form either a single layer or a multiple-layer fabric is continuous, that is, the process steps are uninterrupted from extrusion of the ﬁlaments to form the ﬁrst layer until the bonded web is wound into a roll.

[0016] The spunmelt nonwoven fabric of the present invention has a preferred basis weight range of 0.50-2.50 osy, with a most preferred basis weight range of 1.0-2.0 osy. Incorporated into the spunmelt polymeric melt of the nonwoven fabric is a reversible thermochromic pigment. In the present invention, the nonwoven fabric is lavender at room temperature, however the color of the fabric can be any one of an array of colors based on the thermochromic pigment used and is not meant to be a limiting factor of the present invention. The reversible thermochromic nonwoven fabric has a preferred temperature indicating range of 40°C-60°C, with the most preferred temperature indicating range of 45°C-55°C. The nonwoven fabric of the present invention changes from lavender to white when exposed to temperatures within the fabrics temperature indicating range. Once the temperature has risen above or below the temperature indicating range of the thermochromic nonwoven fabric, the fabric reverts back to the lavender color.

[0017] The reversible thermochromic pigment utilized in the present invention contains particles preferably 3-5 microns in size, with a most preferred particle size of 3 microns. The chemistry of the reversible thermochromic pigment is a conventional construct, consisting of an electron-donating color former, electron-accepting developer in which the compound contains a phenolic hydroxyl group, carboxylic acid with 2-5 carbon atoms or carboxylic salts, and a thermally controlled color-changing agent which can be an alcohol, ester, or ketone, to name a few. Such thermochromic pigments are available from Polymer Dynamix, including the reversible thermochromic pigment of the present invention, which is commercially known as TC-4555-PP. The thermochromic pigment is added to the polymer melt at a preferred range from about 0.5%-5%, having a more preferred range of 1%-5%, and a most preferred range of 2%-4%.

[0018] The polymeric melt may also contain additional additives such as UV absorbent chemistry in order to inhibit degradation of the electron-accepting developer in the presence of UV light. UV absorbent chemistries operate to transfer photochemical energy into thermal energy. Other additives that assist with product enhancements, such as static control, stain resistance, flame retardancy, fluidic absorbency or repellency may also be utilized with the present invention. The reversible thermochromic pigment particles, which are incorporated into the polymeric melt, may also contain a coating, such as a wax, to assist with processing.

[0019] In one embodiment of the present invention, the spunmelt nonwoven fabric is a spunbond polypropylene with a basis weight of 1.50 osy and has a reversible temperature indicating range of 45°C-55°C. The reversible thermochromatic pigment was added at 3% by weight to the polymer melt. The resultant color-changing fabric can be useful in a variety of commercial applications such as bedding, apparel, and hygiene.

What is claimed is:
I. A process of making a reversible thermochromic nonwoven fabric comprising:
   a. providing a thermoplastic resin;
   b. providing a reversible thermochromic pigment;
   c. blending said thermoplastic resin and said reversible thermochromic pigment into a homogeneous blend;
   d. extruding said homogeneous blend as continuous theromplastic filaments;
e. collecting and consolidating said thermoplastic filaments into a nonwoven fabric; and

f. said nonwoven fabric exhibiting the ability to change color in response to heat.

2. A process of making a reversible thermochromic nonwoven fabric as in claim 1, wherein said thermoplastic resin is selected from the group consisting of polyamides, polyester, polyolefins, and the combinations thereof.

3. A process of making a reversible thermochromic nonwoven fabric as in claim 2, wherein said polyolefin is polypropylene.

4. A process of making a reversible thermochromic nonwoven fabric as in claim 1, wherein said reversible thermochromic pigment is a melt additive comprising an electron-donating color former, electron-accepting developer, a thermally controlled color-changing agent, and ultra-violet absorbent chemistry.

5. A process of making a reversible thermochromic nonwoven fabric as in claim 1, wherein said fabric exhibits the ability to change color within a temperature indicating range of 40°C to 60°C.

6. A process of making a protective composite wrap as in claim 1, wherein said consolidating means is a thermal calendaring process.


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