A process for effectively dyeing a composite item, such as a composite yarn, composite fabric or composite article, is provided involving the steps of immersing the composite item in an aqueous bath containing a dyeing auxiliary agent that provides a charged surface to the composite item, contacting the charged surface with a composition comprising a dye that interacts with the charged surface, reacts with the charged surface, or both, and drying the dyed composite item, and the dyed composite items obtained therefrom, as well as the use of the dyeing auxiliary agent on heretofore difficult to dye fibers, yarns, fabrics or articles such as mineral or metal fibers and products obtained therefrom.
METHOD FOR IMPROVED DYEING OF DIFFICULT TO DYE ITEMS, YARNS, FABRICS OR ARTICLES

BACKGROUND OF THE INVENTION

[0001] 1. Field of Invention

The present invention relates to a method for effectively dyeing composite yarns, composite fabrics or composite articles in a simple process that can be performed post-production if desired, and the dyed composite yarns, fabrics or articles provided therefrom, as well as a method for dyeing items made from previously difficult or impossible to dye materials and the dyed items provided therefrom.

[0002] 2. Discussion of the Background

There are a wide variety of yarn products currently used in commerce, from monofilaments to multifilament yarns to composite yarns formed from diverse materials. Such composite yarns can contain thermoplastic based fibers, elastomeric fibers, mineral fibers (such as fiberglass), aramids and other high performance fibers, metal fibers, etc., in any combination and configuration to provide a broad array of properties in the final composite yarn. For examples of such composite yarns, see U.S. Pat. Nos. 4,777,789; 5,177,948; 5,628,172; 5,845,476; 6,351,932; 6,363,703 and 6,367,290.

[0005] One drawback in the use of such composite yarns is that in combining fibers from such diverse sources as metal, glass and plastic, there is no readily available method for dyeing the composite product, absent the use of multiple dye steps, or dyeing the individual components prior to assembly in the final composite yarn. An additional drawback is that using a single type of dye for a composite yarn or product can often lead to problems with washfastness of the dye with one or more of the components making up the composite yarn or product.

[0006] Accordingly, there is a need for a method for dyeing yarns, fabrics and finished articles containing two or more different types of fibers or yarns (i.e. composite yarns, composite fabrics or composite articles, respectively), which can be readily performed by the consumer, or by the manufacturer after production of the finished product, and which can provide washfastness of the dyed product.

SUMMARY OF THE INVENTION

[0007] Accordingly, one object of the present invention is to provide a process for dyeing a composite yarn.

[0008] A further object of the present invention is to provide a process for dyeing a composite fabric.

[0009] Another object of the present invention is to provide a process for dyeing a composite article comprising a composite yarn or fabric.

[0010] Another object of the present invention is to provide a process for improving the washfastness of a dyed yarn, fabric or article, particularly when the dyed yarn, fabric or article is made of multiple different fiber types, such as in a composite yarn, fabric or article.

[0011] These and other objects of the present invention, either individually or collectively, have been satisfied by the discovery of a method for dyeing a difficult to dye item, such as a composite item or an item made from mineral such as glass, or metal, comprising:

[0012] immersing an item in an aqueous bath comprising a dyeing auxiliary agent to provide an item having a charged surface;

[0013] dyeing the item having a charged surface in a bath comprising a dye that can interact with and/or bond to the charged surface to provide a dyed item;

[0014] separating the dyed item from the bath; and, optionally,

[0015] drying the dyed item,

wherein the item is a composite item selected from the group consisting of composite yarns, composite fabrics and composite articles or is an item made from a mineral based material such as glass or graphite, an item made from a metal based material, such as steel, copper, brass, aluminum, etc. or is a difficult to dye polymer such as an aramid, PEEK or fluorocarbon polymer.

DETAILED DESCRIPTION OF THE INVENTION

[0017] The term “fiber” as used herein refers to a fundamental component used in the assembly of yarns and fabrics. Generally, a fiber is a component which has a length dimension which is much greater than its diameter or width. This term includes ribbon, strip, staple, and other forms of chopped, cut or discontinuous fiber and the like having a regular or irregular cross section. “Fiber” also includes a plurality of any one of the above or a combination of the above.

[0018] As used herein, the term “high performance fiber” means that class of synthetic or natural non-glass fibers having high values of tenacity greater than 10 g/denier, such that they lend themselves for applications where high abrasion and/or cut resistance is important. Typically, high performance fibers have a very high degree of molecular orientation and crystallinity in the final fiber structure.

[0019] The term “filament” as used herein refers to a fiber of indefinite or extreme length such as found naturally in silk. This term also refers to manufactured fibers produced by, among other things, extrusion processes. Individual filaments making up a fiber may have any one of a variety of cross sections to include round, serrated or crumeral, bean-shaped or others.

[0020] The term “yarn” as used herein refers to a continuous strand of textile fibers, filaments or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. Yarn can occur in a variety of forms to include a spun yarn consisting of staple fibers usually bound together by twist; a multi filament yarn consisting of many continuous filaments or strands; or a mono filament yarn which consist of a single strand.

[0021] The term “air interlacing” as used herein refers to subjecting multiple strands of yarn to an air jet to combine the strands and thus form a single, intermittently commingled strand. This treatment is sometimes referred to as “air tacking.” This term is not used to refer to the process of “intermingling” or “entangling” which is understood in the
art to refer to a method of air compacting a multifilament yarn to facilitate its further processing, particularly in weaving processes. A yarn strand that has been intermingled typically is not combined with another yarn. Rather, the individual multifilament strands are entangled with each other within the confines of the single strand. This air compacting is used as a substitute for yarn sizing and as a means to provide improved pick resistance. This term also does not refer to well known air texturizing performed to increase the bulk of single yarn or multiple yarn strands. Methods of air interlacing in composite yarns and suitable apparatus therefore are described in U.S. Pat. Nos. 6,349, 531; 6,341,483; and 6,212,914, the contents of which are hereby incorporated by reference.

[0022] The term “composite yarn” refers to a yarn prepared from two or more yarns, which can be the same or different. Composite yarn can occur in a variety of forms wherein the two or more yarns are in differing orientations relative to one another. The two or more yarns can, for example, be parallel, wrapped one around the other(s), twisted together, or combinations of any or all of these, as well as other orientations, depending on the properties of the composite yarn desired. Examples of such composite yarns are provided in U.S. Pat. Nos. 4,777,789; 5,177,948; 5,628,172; 5,845,476; 6,351,932; 6,363,703 and 6,367,290, the contents of which are hereby incorporated by reference.

[0023] The term “composite fabric” is used herein to indicate a fabric prepared from two or more different types of yarn or composite yarn. The fabric construction can be any type, including but not limited to, woven, knitted, non-woven, etc. The two or more different types of yarn or composite yarn include, but are not limited to, those made from natural fibers, synthetic fibers and combinations thereof.

[0024] The term “composite article” is used herein to indicate a final article that comprises at least two different types of materials. The composite article can be prepared from a composite fabric, or can be prepared from a conventional fabric containing only one type of yarn, but is put together using a yarn or sewing thread made of a different material. Alternatively, the conventional fabric can be sewn together using a composite yarn as the sewing thread. Composite articles can be any form, including but not limited to, gloves, aprons, socks, filters, shirts, pants, undergarments, one-piece jumpsuits, etc. All of these types of articles, as well as other permutations that are readily evident to those of skill in the art, are included in the present invention definition of “composite article”.

[0025] The present invention relates to a method for dyeing a composite yarn, composite fabric or composite article. The method comprises immersion of the composite yarn, fabric or article in an aqueous solution/emulsion/dispersion of a dyeing auxiliary agent to provide a composite yarn, fabric or article having a charged surface, dyeing the composite yarn, fabric or article having the charged surface by contacting it with a dye that interacts with the charged surface to bond thereto, draining excess water from the dyed yarn, fabric or article, optionally followed by drying the dyed composite yarn, fabric or article using a heated, preferably at a temperature of from 50-100°C. Preferably the heater has forced blowing hot air at the desired temperature to assist in carrying off the moisture being liberated from the dyed product. Alternatively, the heater can operate under reduced pressure if desired, to further lower the temperature and remove moisture being liberated.

[0026] As the dyeing auxiliary agent for use in the present invention, one can use any conventional organic material capable of forming a coating on the surface of the individual fibers making up the composite yarn. The dyeing auxiliary agent should be capable of providing the surface of the coated fiber or yarn with a charged coating, either by formation of a coating on the surface or by directly bonding to the surface of the fiber or yarn, or some combination of these. Suitable dyeing auxiliary agents for the present invention include, but are not limited to, a silicone based quaternary ammonium salt, more preferably a copolymer (which may or may not include partially or fully hydrolyzed forms) of a long chain (C12-C26) alkylmethylenaminotrihydroxydicylatedpropyl ammonium halide and a chloroalkyltri(hydroxy)oxysilane. Particularly preferred for use as the dyeing auxiliary agent is a copolymer (which may or may not include partially or fully hydrolyzed forms) of octadecylamidomethyltrimethyloxysilylpropyl ammonium chloride and chloropropyltri(hydroxy)silane. Suitable such dyeing auxiliary agents include, but are not limited to, the Bioshield line of antimicrobial agents available from NovaBioGenetics, Inc., antimicrobials such as those used to prepare the Biokryl products from Acordis, or the antimicrobial agents from Aegis Environments such as AEM 5700 Antimicrobial, AEM 5772 Antimicrobial and AEGIS Antimicrobial. The dyeing auxiliary agent of the present invention is preferably used as an aqueous solution/emulsion/dispersion (depending on the solubility of the agent itself). When the dyeing auxiliary agent is one of these conventional organic (i.e. non-silver ion containing) antimicrobial agents, it is noted that the present process renders the antimicrobial aspects of the auxiliary ineffective or substantially so. If antimicrobial properties are also desired, a second coating with the antimicrobial dyeing auxiliary can be performed after the dyeing step, in accordance with U.S. patent application Ser. No. 10/785,060, the contents of which are hereby incorporated by reference. When necessary for the creation of an emulsion or dispersion, any conventional emulsifier or dispersant can be used, so long as it can be readily washed away from the surface of the yarn, fabric or article using water and a detergent. Preferably the dyeing auxiliary agent is present in the dyeing auxiliary bath in an amount of from 0.1-2% by weight, more preferably from 0.1-1% by weight, most preferably from 0.3-0.7% by weight. If the dyeing auxiliary agent is received from the supplier at a higher percentage than desired, the agent can be diluted as needed to provide the desired strength of solution/emulsion/dispersion.

[0027] For providing the desired dyability properties to a composite yarn, the present process can be used with the composite yarn at any stage prior to, during or after assembly of the yarn. If used in a continuous type process (within the context of the present invention a continuous process includes both truly continuous processes and semi-continuous processes in which there are periodic stops for product type changes, other line modifications or for any other reason), the application of the dyeing auxiliary agent can be performed after assembly but prior to take up on a yarn package or bobbin. The application in such a continuous process can be done by immersion through a bath, followed by drying using an in-line dryer. Drying can
Alternatively be performed in such a continuous process by use of a heated drying roll around which the composite yarn is wrapped. The yarn treated with the dyeing auxiliary agent can be dried prior to the dyeing step, or can be taken directly into the dye bath and dried after dyeing. Drying time can be adjusted based upon the size of the drying roll and the number of wraps of yarn around the roll. In a batch type process, the composite yarn is assembled, taken up on a bobbin, then the entire composite yarn package (yarn wound around the bobbin) is immersed in the dyeing auxiliary agent bath. After immersion for a period of time sufficient to provide complete penetration of the dyeing auxiliary agent throughout the bobbin (preferably from 5-60 seconds), the package is preferably removed from the bath, excess water drained, and the package placed in a heater at the drying temperature. Alternatively, after removal from the bath containing the dyeing auxiliary agent, the treated bobbin can be dyed, followed by drying.

[0028] Further the steps of the present process can be performed sequentially (application of the dyeing auxiliary agent, followed by treatment with the dye) or simultaneously (application of a mixture of the dyeing auxiliary agent and dye in the same bath or application step).

[0029] The dye to be used in the present process can be any dye that is capable of interacting with and/or bonding with the residual group from the dyeing auxiliary agent that remains on the surface of the fiber, yarn, fabric or article to be dyed. In the case of the preferred embodiment wherein the dyeing auxiliary agent is the silicone based quaternary ammonium salt, preferred dyes are acid dyes and direct dyes. Of particular interest is that the process of the present invention provides the ability to use direct dyes on a single or multi-component fiber, yarn, fabric or article, while providing significant improvements in washfastness that are difficult to achieve in conventional direct dye processes. However, depending on the choice of dyeing auxiliary agent used, other dyes may be readily selected by one of ordinary skill in the art, including but not limited to, metalized and premetalized dyes, fiber-reactive dyes (which would react then with the dyeing auxiliary agent instead of the fiber surface itself), or other dyes having functionality capable of reacting with or interacting with the charged surface created by the dyeing auxiliary agent.

[0030] For dying a composite fabric, the present process can be used at any stage after formation of the fabric, either in a continuous type process or in a batch type process. As in the composite yarn case, the continuous type process for a composite fabric can be performed by applying the dyeing auxiliary agent after formation of the fabric (i.e. after weaving, knitting or forming the non-woven web), but prior to take up of the fabric on a roll. The application of the dyeing auxiliary agent can be done by immersion through a bath, followed by drying the fabric using an in-line dryer. As in the composite yarn case, the composite fabric can also be rendered readily dyeable in a batch type process by immersion of an entire roll of the fabric, draining of the excess water, and placing the roll in a heater at the drying temperature, with dyeing prior to or after the drying step.

[0031] In a preferred embodiment of the present process, the process is used on a composite article to render the composite article readily dyeable in a single dyeing step. This embodiment is most preferred in that it can be readily accomplished by the producer of the article using a conventional dyeing process.

[0032] In a further embodiment of the invention, the same process can be used to dye items made from materials that are, up to now, either difficult or impossible to effectively dye, such as mineral based materials (such as glass, or graphite), metal based materials (such as steel, copper, brass, or aluminum) and difficult to dye polymers, such as aramids, polyether ether ketone (PEEK) or polyfluorocarbons. The items made from these materials may be in any form, including, but not limited to, fibers, yarns, fabrics, articles, solid substrates or other items made from these materials. To extend the present process to non-fiber based articles, the non-fiber based article is coated with an aqueous solution of the dyeing auxiliary agent (using any conventional coating method such as spraying, dipping in a bath, roll coating, etc), then contacting the treated surface with the desired dye to permit the dye to interact with the residue of the dyeing auxiliary agent on the surface of the non-fiber based article, then drying the dyed article.

[0033] The present process can be used on any articles, including those made from synthetic fibers or yarns, those made from natural fibers or yarns, leather products, and articles that contain any or all of these. Suitable articles include, but are not limited to, any article of clothing or protective wear, such as shoes, socks, gloves, as well as filtering media.

[0034] A further preferred embodiment of the present invention provides for recycling of the spent liquid containing the dyeing auxiliary agent, for use on other composite yarns, composite fabrics or composite articles. Applicants have found that by recycling the spent dyeing auxiliary agent containing liquid, multiple repetitions of the process can be performed without the need to replenish the level of dyeing auxiliary agent. Even then, all that is needed is to add enough dyeing auxiliary agent to the liquid to bring the amount of agent up to the desired level.

[0035] One major advantage in this method is that the composite yarn, fabric or article that has been treated with the dyeing auxiliary agent can be readily dyed in a single step to provide a substantially uniform dye uptake of the various components of the composite yarn, fabric or article, regardless of their identity. In other words, the present invention process renders such previously undyeable materials as fiberglass, metal fibers and aramids dyeable, permitting composite yarns, fabrics or articles made of diverse materials to be uniformly dyed in a single dyeing step. The color of the dye is not particularly limited, so long as the dye being used can interact and/or bond with the dyeing auxiliary agent on the outer surface of the fibers/yarns. This makes possible dyed composite products that heretofore have been either unavailable, or too expensive to prepare due to the requirement of multiple dyeing steps. The materials making up the composite yarns, fabrics or articles can include, but are not limited to, polyolefins (such as low or high density polyethylene), amamids, nylons, polyesters, metal fibers, and glass or other mineral based fibers.

[0036] While the process of the present invention can be performed at any bath pH, it is preferred that the pH be slightly basic, more preferably ≥8, most preferably ≥9.

[0037] The present process provides the ability to readily treat yarns, fabrics and articles made from more than one
type of material and impart improved dyeability and wash-fastefulness to the entire product, regardless of its composition. Further, the present process does not require the use of pressurized equipment, as is often conventionally done when attempting to infiltrate an entire bobbin of yarn or roll of fabric. The present process is readily performed on finished articles by the article manufacturer, or on assembled composite yarns or composite fabrics by the yarn or fabric manufacturer, with relative ease and with little added cost. Even better is the ability to recycle the dyeing auxiliary agent bath (with or without dye included) used in the process for added cost savings.

14. The method of claim 1, wherein said dyeing auxiliary agent is a silicone based quaternary ammonium salt.
15. The method of claim 14, wherein said silicone based quaternary ammonium salt is a copolymer of a long chain (C_{12}-C_{20}) alkyl(dimethylaminotrihydroxysilyl)propyl ammonium halide and a chloroalkyltrihydroxysilane.
16. The method of claim 14, wherein said silicone based quaternary ammonium salt is a copolymer of octadecylandimethyl(trihydroxysilyl)propyl ammonium chloride and chloropropyltrihydroxysilane.
17. The method of claim 1, wherein said drying step is performed at a temperature of from 50-100° C.
18. The method of claim 1, wherein said drying step is performed at a temperature of from 70-90° C.
19. A dyed composite item selected from the group consisting of composite yarns, composite fabrics and composite articles, and prepared by the method of claim 1.
20. A method for dyeing a difficult-to-dye item, comprising:
coating a difficult-to-dye item with an aqueous bath comprising a dyeing auxiliary agent to provide a charged surface on the material or item;
contacting the charged surface with a composition comprising a dye capable of interacting with the charged surface, reacting with the charged surface, or both to provide a dyed composite item; and

drying the dyed item.
21. The method of claim 20, wherein said dyeing auxiliary agent is in said aqueous bath in an amount of from 0.1-2% by weight of the total bath.
22. The method of claim 20, wherein said dyeing auxiliary agent is a silicone based quaternary ammonium salt.
23. The method of claim 22, wherein said silicone based quaternary ammonium salt is a copolymer of a long chain (C_{12}-C_{20}) alkyl(dimethylaminotrihydroxysilyl)propyl ammonium halide and a chloroalkyltrihydroxysilane.
24. The method of claim 22, wherein said silicone based quaternary ammonium salt is a copolymer of octadecylamidodimethyl(trihydroxysilyl)propyl ammonium chloride and chloropropyltrihydroxysilane.
25. The method of claim 20, wherein said drying step is performed at a temperature of from 50-100° C.
26. The method of claim 20, wherein said drying step is performed at a temperature of from 70-90° C.
27. The method of claim 20, wherein said process is a continuous process.
28. The method of claim 20, wherein said process is a batch process.
29. The method of claim 20, wherein said difficult-to-dye item is a member selected from the group consisting of mineral based materials, metal based materials, aramids, poly(ether-ether-ketone)s and fluorocarbon polymers.
30. The method of claim 29, wherein said difficult-to-dye item is a member selected from the group consisting of aramids, poly(ether-ether-ketone)s and fluorocarbon polymers.
31. The method of claim 20, wherein said difficult-to-dye item is a member selected from the group consisting of mineral based materials.
32. The method of claim 20, wherein said difficult-to-dye item is a member selected from the group consisting of metal based materials.
33. The method of claim 31, wherein said mineral based material is a mineral fiber.
34. The method of claim 32, wherein said metal based material is a metal fiber.
35. The method of claim 33, wherein said mineral fiber is a glass fiber.
36. The method of claim 31, wherein said mineral based material is graphite.
37. The method of claim 34, wherein said metal fiber is a steel fiber.
38. The method of claim 32, wherein said metal based material is copper.
39. The method of claim 32, wherein said metal based material is brass.
40. The method of claim 32, wherein said metal based material is aluminum.
41. The method of claim 31, wherein said mineral based material is glass.
42. A dyed glass item, prepared by the method of claim 41.
43. A dyed metal item, prepared by the method of claim 32.
44. A dyed fiber, wherein the fiber is a member of the group consisting of aramid fibers, prepared by the method of claim 30.